

# CALORIMETRY EXCHANGE PROGRAM

ANNUAL REPORT



JANUARY–DECEMBER 2006

**B. Srinivasan, Joseph Waggoner, Kattathu Mathew,  
Michael Soriano, Usha Narayanan and Jon Neuhoff**





**NBL- ME 2007  
CALEX PROGRAM ANNUAL REPORT**

**U. S. DEPARTMENT OF ENERGY**

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Michael Soriano, Usha Narayanan and Jon Neuhoff**

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## **NBL: HISTORY AND MISSION**

The New Brunswick Laboratory is owned and operated by the United States Department of Energy through the Office of Science (SC). The laboratory was established in 1949 as an analytical chemistry laboratory in New Brunswick, New Jersey to provide support to the United States Atomic Energy Commission. At that time, it was staffed by scientists from the National Bureau of Standards who had contributed significantly to nuclear material measurement programs in the Manhattan Project. At the New Brunswick Laboratory, they provided the technical expertise and skills to solve problems related to quantitative analyses of uranium-bearing materials. Over the years, these scientists and others following them have expanded the capabilities of the laboratory to include chemical and mass spectrometric analyses of plutonium and other trans-uranium elements, research and development activities in chemical analyses techniques, preparation of certified reference materials, and operation of the nuclear safeguards measurement evaluation program. In 1977, the laboratory moved from New Jersey to its present location at the Argonne National Laboratory site in Illinois.

The major mission of the New Brunswick Laboratory is to provide technical assistance to the Department of Energy in the following areas: measurement evaluation program operation, certified (nuclear) reference materials preparation, measurement techniques development, and measurement services to domestic and international customers. In addition to fulfilling these tasks, the laboratory helps the Department in three other areas: conducting technical audits, resolving shipper/receiver differences in material transfers, and assisting in nuclear nonproliferation programs.





## **ACKNOWLEDGEMENTS**

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## ABSTRACT

The New Brunswick Laboratory has been tasked by the United States Department of Energy (DOE) Office of Science (SC) to evaluate the quality of measurement techniques in nuclear materials accounting practices at Department of Energy facilities. Both destructive and non-destructive methods of analyses come under this purview. The destructive methods are evaluated in the Safeguards Measurement Evaluation (SME) program, and the non-destructive methods in the Calorimetry Exchange (CALEX) Program. This report describes the activities in the CALEX Program during January-December 2006.

Two DOE facilities participated in the 2006 CALEX Program. They analyzed Calex I, a plutonium oxide reference material standard, by calorimetry and high resolution gamma spectrometry, both non-destructive techniques; the former technique measured heat (or power) output, and the latter plutonium isotopes and  $^{241}\text{Am}$  abundances. NBL evaluated the measurement results and two other quantities calculated from the results, *viz.* plutonium mass and effective specific power, with reference to accepted values. The accepted values were obtained from results of destructive analyses of the material performed at the time of fabrication of the standard. Appropriate corrections for radioactive decay were made to the accepted values to correspond to the measurement dates in 2006. This annual report provides performance evaluation summaries of 2006 measurement results on quarterly and annual basis.

During 2006, progress was made towards certifying a second working reference material standard, Calex II, for use in the CALEX program. Calex II is a higher wattage plutonium standard (6 watts) relative to Calex I (1 watt). It was made in 1995. The plutonium oxide material in the standard was characterized by destructive analyses as in the case of Calex I. The characterization experiments were completed in 2000, but a formal report of analyses was not issued at that time because of a difference of about 0.3% in the plutonium assay values in two independent coulometric determinations, one at the Los Alamos National Laboratory (LANL) and the other at NBL. The magnitude of this discrepancy was unexpectedly large with no clear explanation. In 2003-2004, NBL made another effort to analyze the material for plutonium assay using archived samples obtained from the Hanford site. This effort was not successful. In August 2006, NBL and LANL personnel (Usha Narayanan and B. Srinivasan of NBL, and Laurie Walker of LANL) reviewed the 1995-2000 results, and decided to issue a report of analyses (same as working reference material certificate) despite the 0.3% discrepancy in plutonium

assay. NBL issued the formal report in May 2007. Through this effort, Calex II is now ready to be used as a measurement evaluation working reference material standard.

Two years ago, NBL obtained eight samples of the Calex II material (5 grams each) from SRS while the latter was repacking the material in one of two standards in their possession; apparently, the standard suffered some external damage that required re-packing. NBL plans to analyze these samples to provide a more accurate value for plutonium assay with higher precision. In the interim, the characterized values shown in the May 2007 report of analyses will be used for evaluation of Calex II measurement results.

In 2006, NBL began the work towards developing a new Safeguards Measurement Evaluation System (SMES) that will replace the existing FoxPro based system. The design and a major fraction of the first phase of the work were completed in 2006. The new system will allow the participants to enter their measurement results directly into the system, and retrieve evaluation reports through the internet. The new system is expected to become functional in 2008.

## A. INTRODUCTION

The New Brunswick Laboratory (NBL) is a nuclear material measurement laboratory of the U.S. Department of Energy (DOE) in the Office of Science (SC). An important aspect of NBL's mission is to conduct the measurement evaluation program, a program designed to provide independent verification of internal analytical quality control practices at DOE facilities performing nuclear material accountability measurements.

The measurement evaluation program consists of two parts: the Safeguards Measurement Evaluation (SME) Program for evaluating destructive analyses results (e.g., titration, mass spectrometry), and the Calorimetry Exchange (CALEX) Program for evaluating results from non-destructive analyses techniques. In the CALEX program, the participants measure the heat (also known as power) output, and plutonium isotopes and  $^{241}\text{Am}$  abundance of working reference material standards by non-destructive methods (calorimetry and gamma ray spectrometry). NBL evaluates the measurement results against reference or accepted values, and issues performance evaluation reports.

The specific goals and objectives of the CALEX Program are as follows:

1. Maintain a permanent data base of the measurement results. The measurement results include mass of plutonium, calorimetric power, effective specific power ( $P_{\text{eff}}$ ), plutonium isotopes abundances and  $^{241}\text{Am}$  isotope abundance.
2. Provide feed back to participants through performance evaluation reports. The purpose of the report is to validate internal quality control practices.
3. Evaluate program needs such as reference material needs for calibration and test material needs for measurement evaluation.
4. Coordinate the work in making new reference material and test material standards. Some NDA standards require large quantities of fissile materials. The fabrication of the standards is usually done in collaboration with national laboratories.
5. Characterize the material in the standards and issue reports of analyses to define the reference/accepted values.
6. Expand the CALEX program to include evaluation of results obtained from non-destructive assay methods, in general. Examples of other non-destructive techniques are active well coincidence measurements for uranium, and passive neutron techniques for plutonium.

7. Conduct the measurement evaluation program annual meeting and provide opportunities for program participants for exchange of technical information.

## **B. CALORIMETRIC STANDARDS**

Two working reference material standards, Calex I and Calex II, are available for use in the measurement evaluation program. Both standards contain high purity plutonium oxide material. The composition of plutonium isotopes and  $^{241}\text{Am}$  abundances in the two standards are quite different. The characterized values for the plutonium content, plutonium isotopes abundances and  $^{241}\text{Am}$  abundance in the standards are from destructive analyses experiments – coulometry for plutonium content, thermal ionization mass spectrometry for plutonium isotopes, and gamma spectrometry for  $^{241}\text{Am}$ . Mass of plutonium, effective specific power and calorimetric power are calculated from the destructive analyses results. The non-destructive measurement results are evaluated against the corresponding destructive analyses results, the latter representing the reference values.

### **B.1. Calex I**

Rocky Flats Plant made six identical units of Calex I working reference material standards in 1979. The plutonium oxide material in the standard was characterized in 1982 by destructive analyses methods. Some of the characterized values were subsequently verified in 1987. No formal report of analyses/certificate was issued at that time. Notwithstanding its absence, the CALEX program has adopted the values shown in Table 1 as accepted values for evaluating calorimetry and gamma spectrometry measurement results. For evaluating the measurement results, the reference values are corrected for radioactive decay of plutonium isotopes and growth of  $^{241}\text{Am}$  using half-lives given in Table 2. This table also lists the specific power for plutonium and americium isotopes needed to calculate the effective specific power ( $P_{\text{eff}}$ ) of Calex I material. (NBL is preparing a formal report of analyses of the Calex I material that will serve as the working reference material certificate. It will be issued in early 2008).

**Table 1. Characterized values for Calex I working reference material standard as of 05/29/1979**

Parameter	Values
PuO <sub>2</sub> mass	454.60 g
Pu concentration	87.8191 wt %
Pu mass*	399.23 g
<sup>238</sup> Pu**	0.0102 wt %
<sup>239</sup> Pu**	93.7336 wt %
<sup>240</sup> Pu**	5.8560 wt %
<sup>241</sup> Pu**	0.3712 wt %
<sup>242</sup> Pu**	0.0290 wt %
<sup>241</sup> Am <sup>#</sup>	0.0061 wt %
P <sub>eff</sub> <sup>†</sup>	2.3012 mW/g
Calorimetric power <sup>††</sup>	918.71 mW

\*The Pu mass in the standards is calculated as the product of PuO<sub>2</sub> mass and Pu concentration.

\*\*Pu isotopic abundance in wt %, i.e., 100 X (g Pu isotope / g Pu).

<sup>#</sup> <sup>241</sup>Am concentration in wt %, i.e., 100 X (g <sup>241</sup>Am / g Pu)

<sup>†</sup>P<sub>eff</sub> values in mW/g Pu are calculated as a sum of products of isotopic abundance and respective specific power, the latter given in Table 2. <sup>241</sup>Am contribution is included.

<sup>††</sup>The calorimetric power is calculated as a product of Pu mass and P<sub>eff</sub>.

**Table 2. Radioactive decay half-lives for plutonium isotopes and <sup>241</sup>Am, and effective specific power of each isotope**

Isotope	Half life (years)	Specific power (mw/g)
<sup>238</sup> Pu	87.74	567.57
<sup>239</sup> Pu	24119	1.9288
<sup>240</sup> Pu	6564	7.0824
<sup>241</sup> Pu	14.348	3.412
<sup>242</sup> Pu	376300	0.1159
<sup>241</sup> Am	433.6	114.2

## B.2. Calex II

Los Alamos National Laboratory made ten identical units of Calex II working reference material standards in 1995. The plutonium oxide material in the standard was characterized during the period 1995-2000. No formal report of analyses was issued at that time (see section A). Nonetheless, it was recognized that Calex II will serve as a valuable standard for the measurement evaluation program even with the uncertainty of about 0.2% in knowing the plutonium content. A formal report of analyses was issued in May 2007 based on the destructive analyses data gathered during 1995-2000. The formal report is included in Appendices A and B to this report. The reference or accepted values as shown in the report are reproduced in Table 3. The Calex II is expected to remain as a useful measurement evaluation standard for several years for plutonium measurements by non-destructive analysis techniques.

**Table 3. Characterized values for Calex II working reference material standard as of 07/24/1995**

Parameter	Values
PuO <sub>2</sub> mass	2000.0 g
Pu concentration	87.62 wt %
Pu mass*	1752.4 g
<sup>238</sup> Pu**	0.08032 wt %
<sup>239</sup> Pu**	86.5366 wt %
<sup>240</sup> Pu**	12.1689 wt %
<sup>241</sup> Pu**	1.0074 wt %
<sup>242</sup> Pu**	0.20673 wt %
<sup>241</sup> Am <sup>#</sup>	0.4753 wt %
P <sub>eff</sub> <sup>†</sup>	3.5642 mW/g
Calorimetric power <sup>††</sup>	6245.9 mW

\*The Pu mass in the standards is calculated as the product of PuO<sub>2</sub> mass and Pu concentration.

\*\*Pu isotopic abundance in wt %, i.e., 100 X (g Pu isotope / g Pu).

<sup>#</sup><sup>241</sup>Am concentration in wt %, i.e., 100 X (g <sup>241</sup>Am / g Pu)

<sup>†</sup>P<sub>eff</sub> values in mW/g Pu are calculated as a sum of products of isotopic abundance and respective specific power, the latter given in Table 2. <sup>241</sup>Am contribution is included.

<sup>††</sup>The calorimetric power is calculated as a product of Pu mass and P<sub>eff</sub>.



This annual report does not contain an evaluation of Calex II measurement results. A special report is under preparation that will provide a comprehensive evaluation of all Calex II results gathered so far. It will be issued in early 2008.

### **C. DOE FACILITIES PARTICIPATING IN 2006 PROGRAM**

Hanford and LLNL participated in the CY 2006 CALEX program. Hanford reported 17 isotopic measurements and 14 power measurements for CY 2006. LLNL reported 62 isotopic measurements and 62 power measurements for CY 2006.

Both facilities followed their own established procedures in making colorimetric power and gamma spectrometer measurements. Certain differences in measurement duration, measurement frequency, and calibration procedures exist in the two procedures. Therefore, the performance evaluation reports given here for the two facilities cannot be used as a basis for inter-laboratory comparison.

### **D. EVALUATION OF CY 2006 RESULTS, REPORTING FORMAT AND CONCLUSIONS**

The statistical evaluation methods and the formats used in reporting the evaluation results are described in this section along with the conclusions on performance evaluation.

#### **D.1. Statistical evaluation methods**

- The participating facilities reported measurement results of calorimetric power and isotopic abundances ( $^{238}\text{Pu}$ ,  $^{239}\text{Pu}$ ,  $^{240}\text{Pu}$ ,  $^{241}\text{Pu}$ ,  $^{242}\text{Pu}$  and  $^{241}\text{Am}$ ). They also reported effective specific power ( $P_{\text{eff}}$ ) calculated from the measured values for isotopic abundances.
- The above results, except  $^{242}\text{Pu}$  abundance, were entered into a database and checked for correctness in data entry.  $^{242}\text{Pu}$  is a minor isotope with low abundance and contributes very little to heat output. Ignoring  $^{242}\text{Pu}$  will not result in significant error in the evaluation or in the conclusions.

- The measured value for plutonium mass was calculated from the reported results for power and  $P_{\text{eff}}$ .  $\text{Power}/P_{\text{eff}}$  yielded plutonium mass.
- The measured values of plutonium mass, calorimetric power,  $P_{\text{eff}}$ , and isotope abundance were compared against accepted reference values. The accepted reference values were calculated from destructive analyses results (Table 1) with appropriate corrections for radioactive decay.
- The measurement results were evaluated in terms of M/A, M-A and % RD. M stands for measured and A for accepted values. The % RD (percent relative difference) was calculated using the following equation:

$$\% \text{ RD} = 100 \times (M - A) / A$$

- The mean for each of the three quantities (M/A, M-A, and % RD), the standard deviation ( $\sigma$ ), and the standard error of the mean ( $\sigma/\sqrt{n}$ , where n refers to the number of measurements) were calculated for the whole-year data and also for every calendar quarter. In this report, the standard error of the mean ( $\sigma/\sqrt{n}$ ) is referred to as the standard uncertainty.

## D.2. Reporting format

The evaluation results are presented in three different types of tables and graphs.

1. Quarterly summary tables: These tables summarize the results of evaluation of power,  $P_{\text{eff}}$  and isotopic abundance measurements made in every calendar quarter. The quarterly means of M-A and % RD are reported, along with respective standard deviations and standard uncertainties. In addition, the tables contain a comparison of results from the present quarter with those from the immediately preceding quarter.
2. Quarterly graphs for each facility: Quarterly graphs are presented for power,  $P_{\text{eff}}$  and isotopic abundance measurements. These figures show the variation of M/A values. The results for all four quarters are shown in the same graph, suitably offset to mark the

differences from one quarter to the next. The uncertainties reported by the facilities are shown as vertical lines. The mean M/A values and uncertainties from NBL statistical evaluation are shown as horizontal lines. The middle horizontal line represents the mean and the envelopes represent the uncertainties. M/A of 1 means no difference between measured and accepted values.

3. Annual summary tables: These tables summarize the evaluation results of plutonium mass, power,  $P_{\text{eff}}$  and isotopic abundance measurements. The annual means of M-A and % RD are reported along with standard deviations and standard uncertainties. The tables also show a comparison of results for the current year with those from the immediately preceding year.
4. Annual graphs: In these graphs % RDs and 95 % confidence intervals (twice the standard uncertainty) are displayed for each facility. These graphs are not meant to be used as inter-laboratory comparison graphs for reasons mentioned earlier. The 95% confidence intervals were calculated by multiplying the standard uncertainty of the mean ( $\sigma/\sqrt{n}$ ) by the coverage factor,  $k$ ; (for example,  $k \approx 2$  for  $n=55$ ,  $k \approx 2.13$  for  $n=16$ ,  $k \approx 2.13$  for  $n=8$ ).
5. Annual graphs for each facility: These figures show annual variation of M/A values and constructed in a manner similar to quarterly graphs.
6. Whole year data tables for each facility: These tables contain the original data submitted by the facility - measurement date, instrument used, measured values M, and the uncertainties in the measured values as provided by the facilities. These tables also contain accepted values A, ratios M/A, differences M-A, and percent relative deviations.

### D.3. Conclusions

Two DOE facilities, Hanford and LLNL, participated in the 2006 CALEX Program. An evaluation summary of the Calex I measurement results is shown in Table 4. The mean relative deviations from the respective accepted values are shown along with uncertainties as 95% confidence intervals. If the % RD taken together with the corresponding uncertainty overlaps with zero, then it indicates no difference between measured and accepted values. If the overlap remains on the

positive side, then it indicates positive bias in measurements. If the overlap remains on the negative side, then it indicates negative bias in measurements.

**Table 4. Performance evaluation of Calex I measurement results from Hanford and LLNL. The % RDs are shown along with uncertainties as 95% confidence intervals (i.e., the standard uncertainty multiplied by the coverage factor,  $k$ ).**

Measured Quantity	% RD	
	Hanford	LLNL
Pu mass	- 0.42 ± 0.36	0.22 ± 0.05
Power	- 0.54 ± 0.19	0.10 ± 0.06
$P_{\text{eff}}$	- 0.16 ± 0.06	- 0.13 ± 0.02
$^{238}\text{Pu}$	- 4.81 ± 2.36	- 2.07 ± 0.86
$^{239}\text{Pu}$	- 0.03 ± 0.01	0.01 ± 0.01
$^{240}\text{Pu}$	0.57 ± 0.17	- 0.12 ± 0.11
$^{241}\text{Pu}$	0.23 ± 0.30	0.07 ± 0.13
$^{241}\text{Am}$	- 1.18 ± 0.19	- 0.69 ± 0.11

The following conclusions emerge from an examination of the results in Table 4:

- Hanford was able to measure the plutonium mass in Calex 1 within about 0.4 % with small negative bias. LLNL measurements are within 0.22% with a positive bias. Similar results were obtained in the CY 2005 program.
- Hanford power measurements show significant negative bias and LLNL measurements show a small positive bias.
- $P_{\text{eff}}$  values from both Hanford and LLNL show negative bias. Evaluating  $P_{\text{eff}}$  is equivalent to collective evaluation of isotope abundance measurement results.

## E. NEW DATABASE DEVELOPMENT

In 2006, work began to develop a new Safeguards Measurement Evaluation database application system (SMES) that will permit laboratories to submit their measurement results

electronically and retrieve evaluation reports via the internet. SMES is being developed by computer professionals from Chickasaw Nation Industries - computer support contractor to DOE Chicago Office - and will be maintained by them. It is being designed with full consideration given to quality assurance, security and confidentiality. SMES is currently approved for internal use at NBL and is expected to be available to DOE facilities in FY 2008.

### **E.1. SMES Design**

- **User self-service:** One of the main objectives of the SMES application is to provide access to participants to enter their own data, validate the entries, and retrieve the evaluation reports.
- **Security through the Web:** SMES will provide secure access through the Internet by using User ID/passwords, role-based access and encryption with considerations of confidentiality of data submitted and reports generated.
- **Quality assurance/documentation:** The SMES application is being developed and tested, and validated by computer professionals (DOE-CH contractor) using modern development techniques. The DOE standards for software development, change control and quality assurance are being followed.
- **Modular programming:** The SMES employs modular programming techniques and reusable code, and will be easy to maintain. The design allows for future expansions of the program, such as increase in the number of participants and evaluation of results from new methods of analyses.
- **Modern technology:** The SMES employs modern web-based technologies and uses a well supported modern database system (SQL).

### **E.2. Specifications**

- **Java enterprise server architecture:** SMES is designed around the Java 2 Enterprise Edition (J2EE) architecture. The system uses a dedicated J2EE Application Server.

- SQL database storage: SMES data is securely stored on an SQL database server for quick retrieval and updating of data; data backups are automated.
- Secure platform independent thin client: Laboratories will be able to enter their own measurement results to SMES via the Internet, eliminating the need to mail the data to NBL. SMES will support the most popular current web browsers with Secure Socket Layers (SSL) and will require no special browser add-ons.
- Role-based security: The system provides a number of access roles including those required for data entry, data validation and published report retrieval. SMES will provide access to participating laboratories and oversight agencies (e.g., DOE area office). Note that participant laboratories will have access only to their own data and reports.
- Historical Data: All historical data contained in the FoxPro database will be migrated to SMES.
- Calculation Techniques: The time proven statistical analysis tools (e.g., outlier tests, calculation of mean and standard deviation of %RDs, tests to determine day-to-day and analyst-to-analyst variations, determination of 95% C.I. etc.) originally written for the FoxPro application will be retained.

#### **F. PLANS FOR CY 2008**

- The Calex II standard is an important reference material standard for calorimetry, and is expected to become an important standard for plutonium determination using neutron based techniques.
- The Calex II measurements made by DOE facilities so far will be evaluated and a special report will be issued.
- Special effort will be made to persuade LANL and SRS to resume participation in the CALEX program.

- The CALEX program will be expanded to include measurement evaluation of other non-destructive techniques (especially those based on neutron measurements).
- A formal report of destructive analyses results of Calex I material will be issued.





**G. Pu MASS TABLES AND GRAPHS**



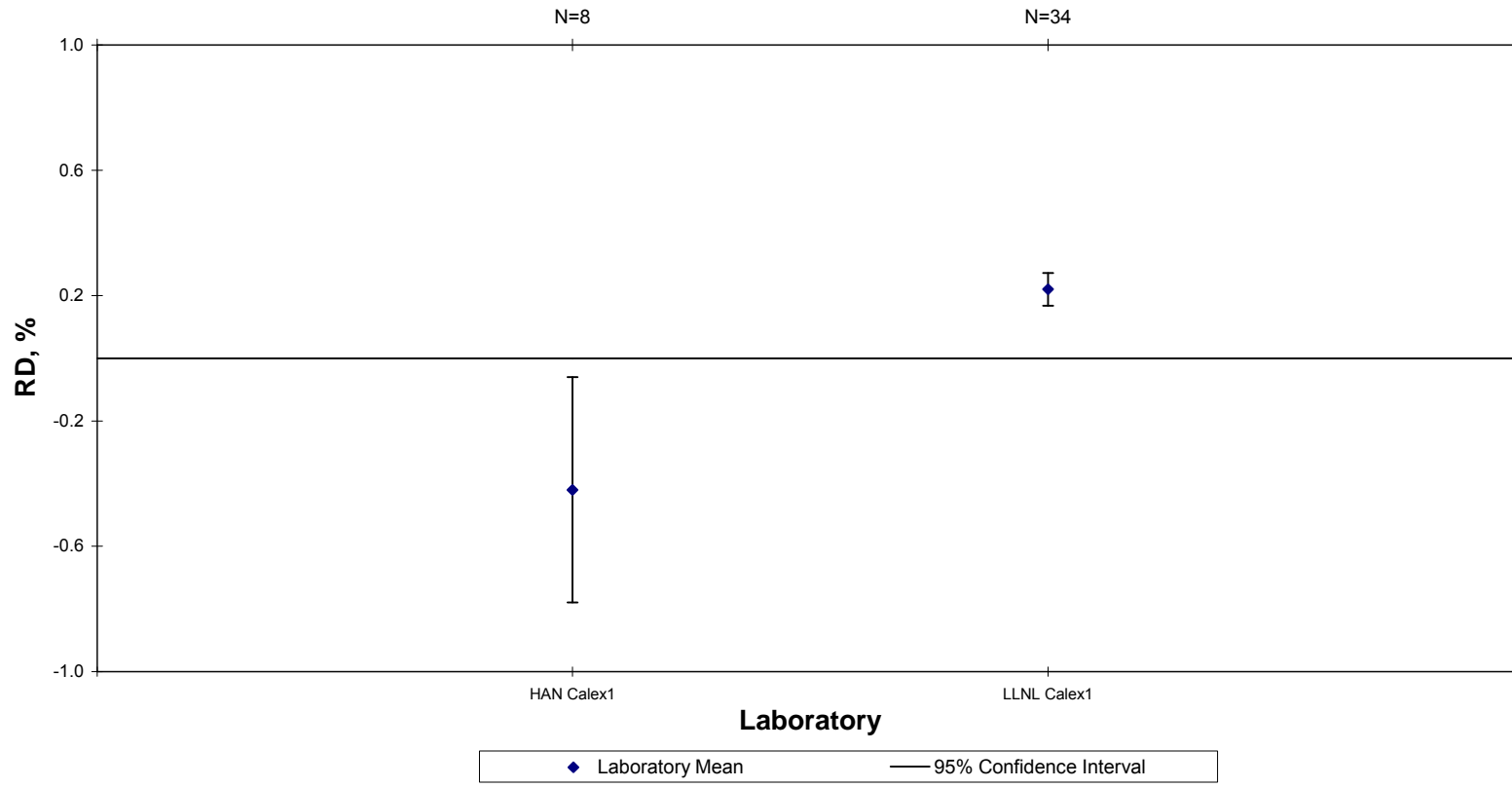
**RESULTS OF ANALYSIS OF PU MASS - CALEX I  
2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (g)	-1.687	0.873
Standard Deviation (g)	1.729	0.591
Uncertainty in Mean (g)	0.611	0.101
Mean Error (%)	-0.42%	0.22%
Standard Deviation (%)	0.43%	0.15%
Uncertainty in the Mean (%)	0.15%	0.03%
Number of Data Points	8	34
Number of Outliers	1	4

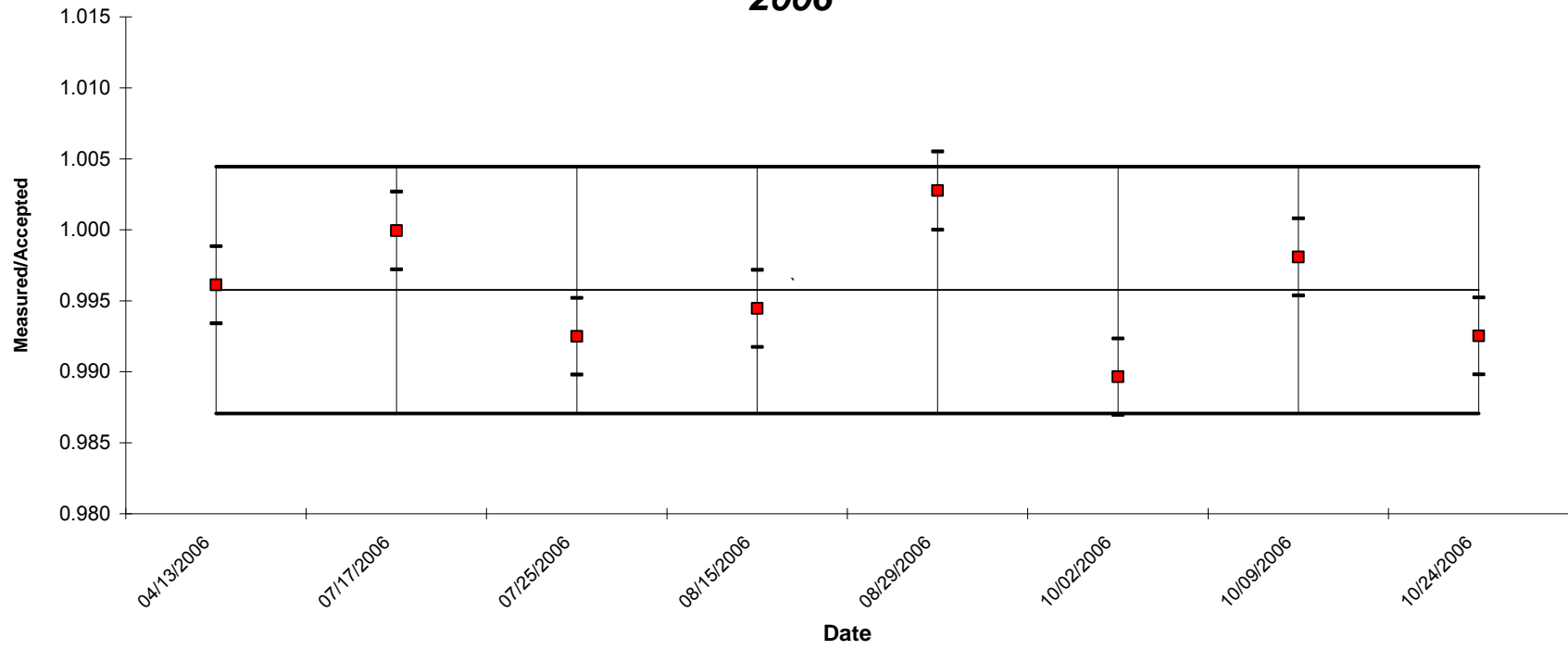
**Difference from Last Year in:**

Mean Error (g)	-0.585	0.713
Standard Deviation (g)	0.018	-0.360
Uncertainty in Mean (g)	0.411	-0.067
Mean Error (%)	-0.14%	0.18%
Standard Deviation (%)	0.00%	-0.09%
Uncertainty in the Mean (%)	0.10%	-0.01%
Number of Data Points	-35	-4
Number of Outliers	1	4

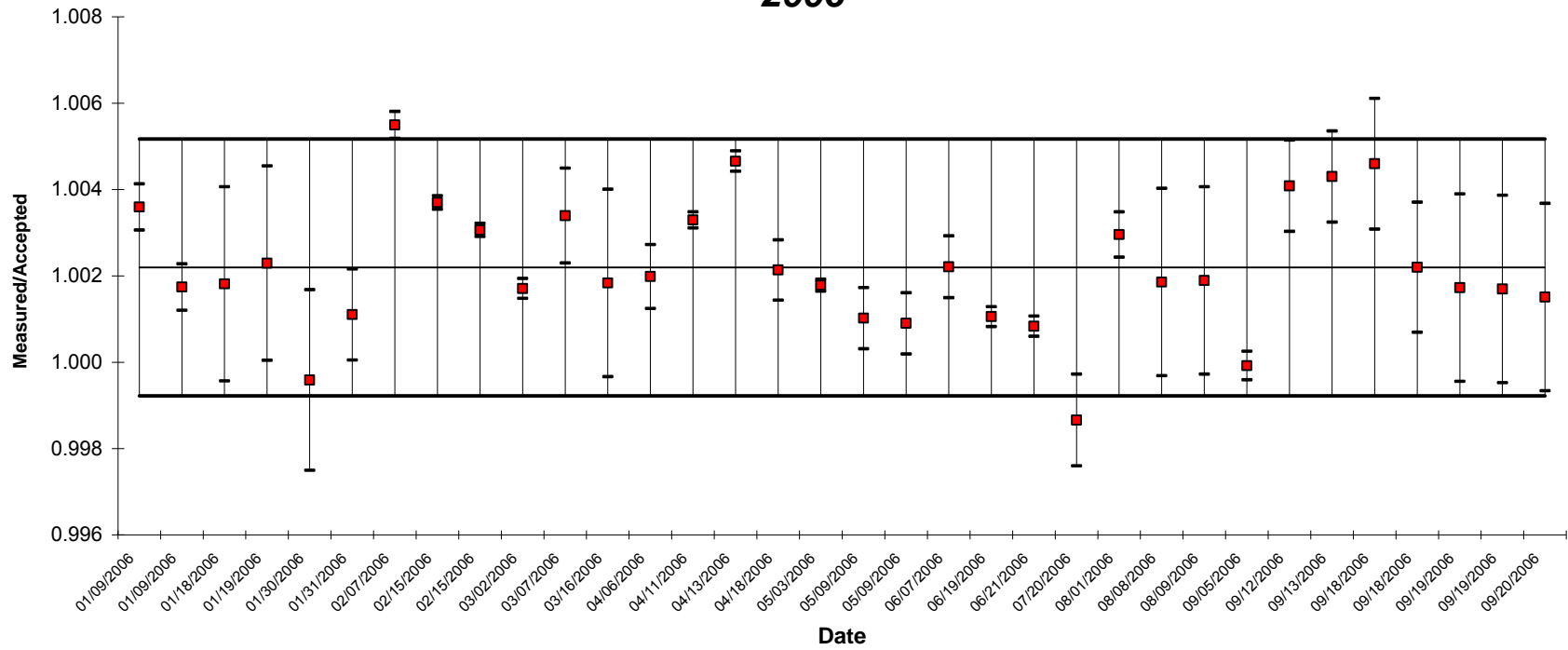
# New Brunswick Laboratory Calorimetry Exchange Program Pu Mass, 2006



**HAN**  
**Pu-Mass, Calex 1**  
**2006**



**LLNL  
Pu-Mass, Calex 1  
2006**



**Pu Mass DATA**  
Calendar Year 2006

HAN: Calex I

#	Date Measured	Instr. ID	Measured Mass	Uncert. 1 STD	Accepted Mass	Ratio M/A	Grams Error	Percent Error
1	04/13/2006	2740	396.25	0.14%	397.79	0.9961	-1.54	-0.39%
2	07/17/2006	2740	397.76	0.14%	397.78	0.9999	-0.02	-0.01%
3	07/25/2006	2740	394.80	0.14%	397.78	0.9925	-2.98	-0.75%
4	08/15/2006	2740	395.58	0.14%	397.78	0.9945	-2.20	-0.55%
5	08/29/2006	2740	398.88	0.14%	397.78	1.0028	1.10	0.28%
<b>6</b>	<b>09/11/2006</b>	<b>2740</b>	<b>394.60</b>	<b>0.14%</b>	<b>397.77</b>	<b>0.9920</b>	<b>-3.17</b>	<b>-0.80%</b>
7	10/02/2006	2740	393.66	0.14%	397.77	0.9897	-4.12	-1.03%
8	10/09/2006	2740	397.01	0.14%	397.77	0.9981	-0.76	-0.19%
9	10/24/2006	2740	394.80	0.14%	397.77	0.9925	-2.97	-0.75%
<b>Mean:</b>						0.9958	-1.687	-0.42%
<b>Standard Deviation:</b>						0.0043	1.729	0.43%
<b>Standard Uncertainty:</b>						0.0015	0.611	0.15%

Statistical outliers are in bold and are not included in graphs and tables.

**Pu Mass DATA**  
Calendar Year 2006

LLNL: Calex I

#	Date Measured	Instr. ID	Measured Mass	Uncert. 1 STD	Accepted Mass	Ratio M/A	Grams Error	Percent Error
1	01/09/2006	II	399.23	0.03%	397.80	1.0036	1.43	0.36%
2	01/09/2006	II	398.49	0.03%	397.80	1.0017	0.69	0.17%
3	01/18/2006	I	398.51	0.11%	397.79	1.0018	0.72	0.18%
4	01/19/2006	III	398.70	0.11%	397.79	1.0023	0.91	0.23%
5	01/30/2006	I	397.63	0.10%	397.80	0.9996	-0.16	-0.04%
6	01/31/2006	II	398.24	0.05%	397.80	1.0011	0.44	0.11%
7	02/07/2006	III	399.98	0.02%	397.80	1.0055	2.19	0.55%
8	02/15/2006	III	399.26	0.01%	397.79	1.0037	1.47	0.37%
9	02/15/2006	III	399.01	0.01%	397.79	1.0031	1.22	0.31%
10	<b>02/16/2006</b>	III	<b>399.07</b>	<b>0.01%</b>	<b>397.79</b>	<b>1.0032</b>	<b>1.28</b>	<b>0.32%</b>
11	<b>02/16/2006</b>	III	<b>400.22</b>	<b>0.01%</b>	<b>397.79</b>	<b>1.0061</b>	<b>2.43</b>	<b>0.61%</b>
12	03/02/2006	I	398.47	0.01%	397.79	1.0017	0.68	0.17%
13	03/07/2006	I	399.14	0.05%	397.79	1.0034	1.35	0.34%
14	03/16/2006	III	398.51	0.11%	397.78	1.0018	0.73	0.18%
15	<b>03/16/2006</b>	III	<b>445.72</b>	<b>0.12%</b>	<b>397.78</b>	<b>1.1205</b>	<b>47.94</b>	<b>12.05%</b>
16	04/06/2006	I	398.58	0.04%	397.79	1.0020	0.79	0.20%
17	04/11/2006	II	399.09	0.01%	397.78	1.0033	1.31	0.33%
18	04/13/2006	III	399.63	0.01%	397.78	1.0047	1.85	0.47%
19	04/18/2006	I	398.64	0.03%	397.79	1.0021	0.85	0.21%
20	05/03/2006	I	398.49	0.01%	397.78	1.0018	0.71	0.18%
21	05/09/2006	I	398.19	0.04%	397.78	1.0010	0.41	0.10%
22	05/09/2006	III	398.14	0.04%	397.78	1.0009	0.36	0.09%
23	06/07/2006	II	398.66	0.04%	397.78	1.0022	0.88	0.22%
24	06/19/2006	II	398.20	0.01%	397.78	1.0011	0.42	0.11%
25	06/21/2006	I	398.11	0.01%	397.78	1.0008	0.33	0.08%
26	<b>07/05/2006</b>	I	<b>420.06</b>	<b>0.01%</b>	<b>397.78</b>	<b>1.0560</b>	<b>22.28</b>	<b>5.60%</b>
27	07/20/2006	III	397.24	0.05%	397.77	0.9987	-0.53	-0.13%
28	08/01/2006	II	398.95	0.03%	397.78	1.0030	1.18	0.30%
29	08/08/2006	III	398.51	0.11%	397.77	1.0019	0.74	0.19%
30	08/09/2006	I	398.53	0.11%	397.77	1.0019	0.75	0.19%
31	09/05/2006	I	397.75	0.02%	397.78	0.9999	-0.03	-0.01%
32	09/12/2006	III	399.40	0.05%	397.77	1.0041	1.63	0.41%
33	09/13/2006	I	399.48	0.05%	397.77	1.0043	1.71	0.43%
34	09/18/2006	II	399.60	0.08%	397.77	1.0046	1.83	0.46%
35	09/18/2006	II	398.64	0.08%	397.77	1.0022	0.87	0.22%
36	09/19/2006	I	398.46	0.11%	397.77	1.0017	0.69	0.17%
37	09/19/2006	I	398.44	0.11%	397.77	1.0017	0.67	0.17%
38	09/20/2006	III	398.37	0.11%	397.77	1.0015	0.60	0.15%
<b>Mean:</b>						1.0022	0.873	0.22%
<b>Standard Deviation:</b>						0.0015	0.591	0.15%
<b>Standard Uncertainty:</b>						0.0003	0.101	0.03%

Statistical outliers are in bold and are not included in graphs and tables.



**H. POWER MEASUREMENTS TABLES AND GRAPHS**



**RESULTS OF ANALYSIS OF POWER -  
1st QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (mW)	****	1.454
Standard Deviation (mW)	****	2.095
Uncertainty in Mean (mW)	****	0.560
Mean Error (%)	****	0.14%
Standard Deviation (%)	****	0.20%
Uncertainty in the Mean (%)	****	0.05%
Number of Data Points	0	14
Number of Outliers	0	0
<b>Difference from Last Quarter in:</b>		
Mean Error (mW)	****	2.651
Standard Deviation (mW)	****	-0.359
Uncertainty in Mean (mW)	****	-0.180
Mean Error (%)	****	0.26%
Standard Deviation (%)	****	-0.04%
Uncertainty in the Mean (%)	****	-0.02%
Number of Data Points	-6	2
Number of Outliers	0	0

**RESULTS OF ANALYSIS OF POWER - CALEX I  
2nd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (mW)	-5.265	1.252
Standard Deviation (mW)	****	1.719
Uncertainty in Mean (mW)	****	0.417
Mean Error (%)	-0.51%	0.12%
Standard Deviation (%)	****	0.17%
Uncertainty in the Mean (%)	****	0.04%
Number of Data Points	1	17
Number of Outliers	0	1

**Difference from Last Quarter in:**

Mean Error (mW)	****	-0.202
Standard Deviation (mW)	****	-0.376
Uncertainty in Mean (mW)	****	-0.143
Mean Error (%)	****	-0.02%
Standard Deviation (%)	****	-0.03%
Uncertainty in the Mean (%)	****	-0.01%
Number of Data Points	1	3
Number of Outliers	0	1

**RESULTS OF ANALYSIS OF POWER - CALEX I  
3rd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (mW)	-5.917	-0.062
Standard Deviation (mW)	3.088	2.957
Uncertainty in Mean (mW)	1.029	0.790
Mean Error (%)	-0.57%	-0.01%
Standard Deviation (%)	0.30%	0.29%
Uncertainty in the Mean (%)	0.10%	0.08%
Number of Data Points	9	14
Number of Outliers	0	0

**Difference from Last Quarter in:**

Mean Error (mW)	-0.652	-1.314
Standard Deviation (mW)	****	1.238
Uncertainty in Mean (mW)	****	0.373
Mean Error (%)	-0.06%	-0.13%
Standard Deviation (%)	****	0.12%
Uncertainty in the Mean (%)	****	0.04%
Number of Data Points	8	-3
Number of Outliers	0	-1

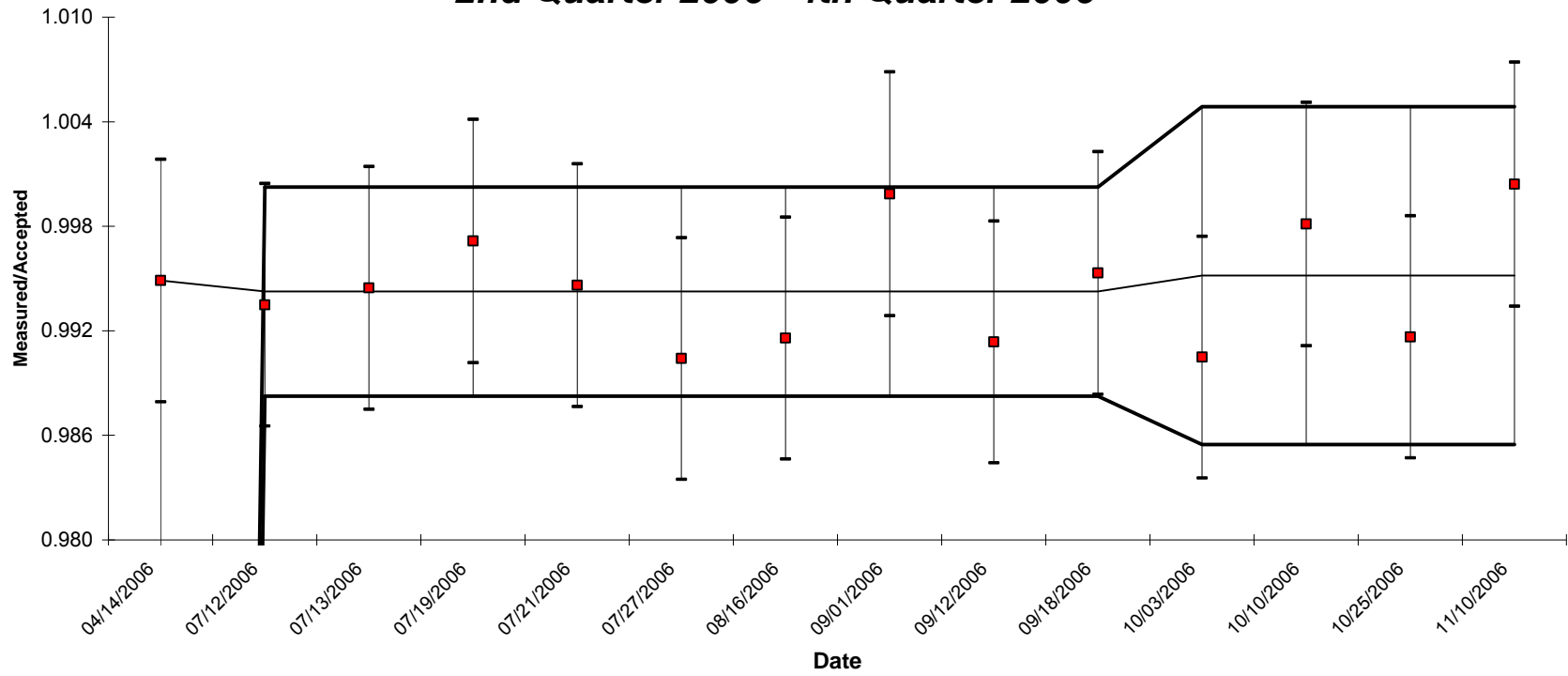
**RESULTS OF ANALYSIS OF POWER - CALEX I  
4th QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (mW)	-4.972	1.187
Standard Deviation (mW)	4.994	2.193
Uncertainty in Mean (mW)	2.497	0.548
Mean Error (%)	-0.48%	0.12%
Standard Deviation (%)	0.48%	0.21%
Uncertainty in the Mean (%)	0.24%	0.05%
Number of Data Points	4	16
Number of Outliers	0	0

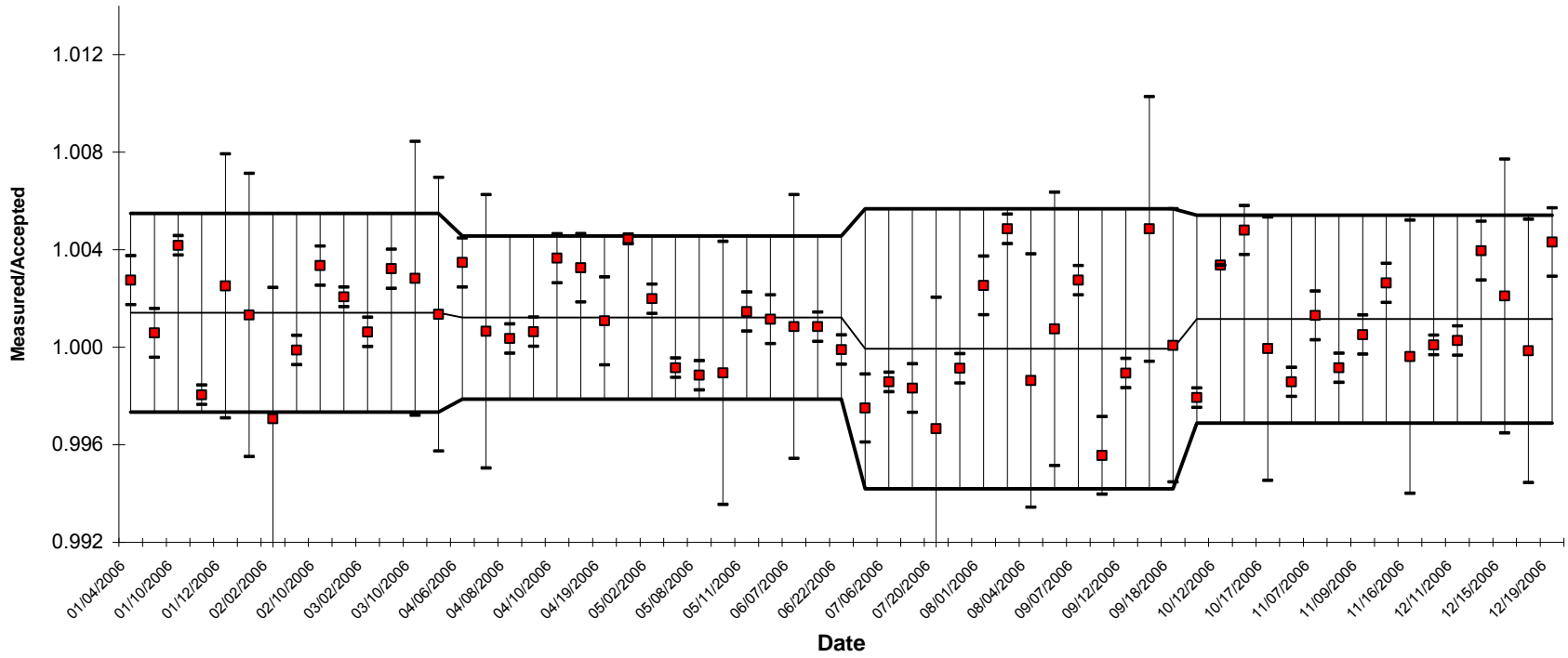
**Difference from Last Quarter in:**

Mean Error (mW)	0.945	1.249
Standard Deviation (mW)	1.906	-0.764
Uncertainty in Mean (mW)	1.468	-0.242
Mean Error (%)	0.09%	0.13%
Standard Deviation (%)	0.18%	-0.08%
Uncertainty in the Mean (%)	0.14%	-0.03%
Number of Data Points	-5	2
Number of Outliers	0	0

**HAN**  
**CALEX 1 POWER DATA**  
**2nd Quarter 2006 - 4th Quarter 2006**



**LLNL**  
**POWER DATA, Calex 1**  
**1st Quarter 2006 - 4th Quarter 2006**





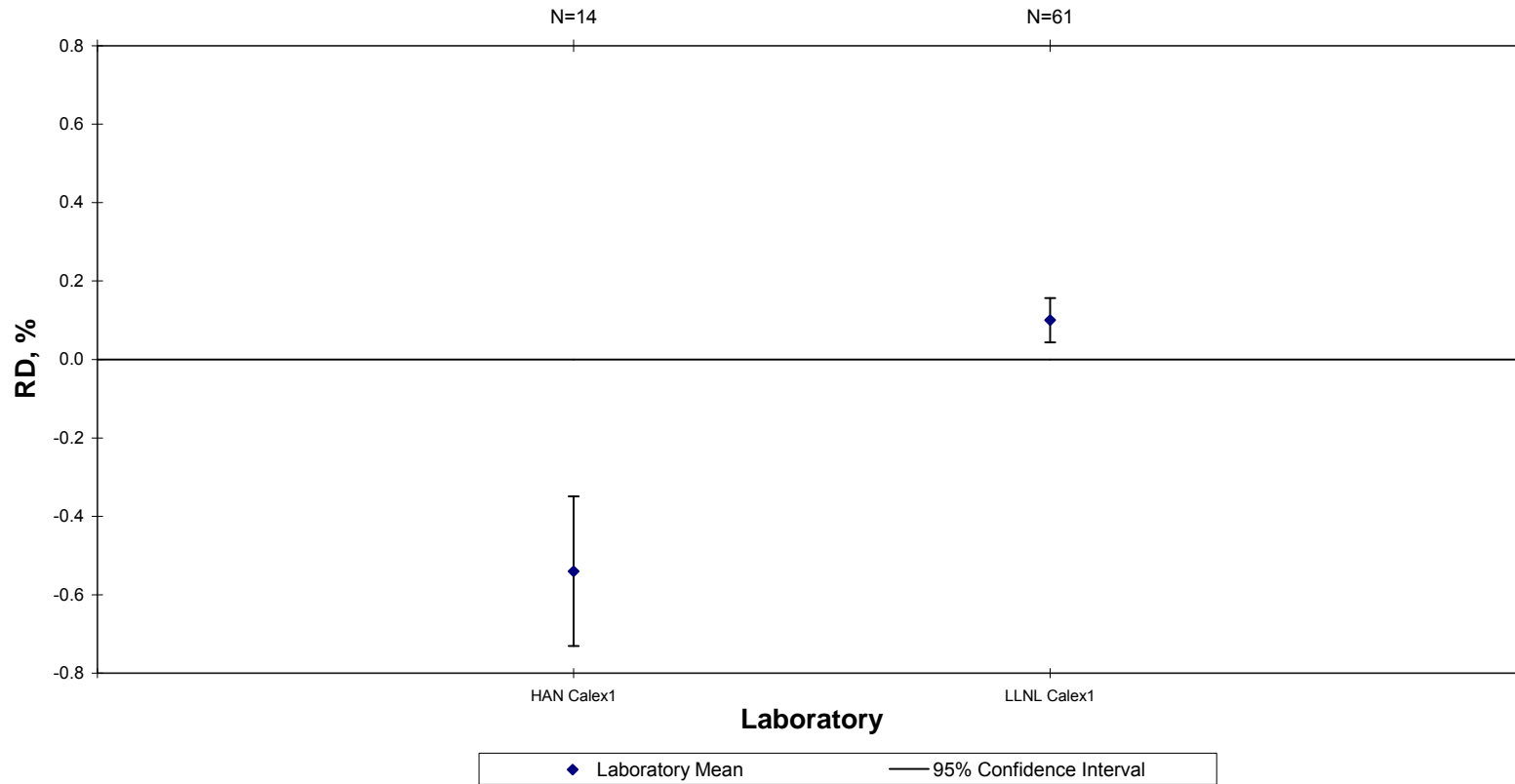
**RESULTS OF ANALYSIS OF POWER - CALEX I  
2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (mW)	-5.601	0.979
Standard Deviation (mW)	3.439	2.274
Uncertainty in Mean (mW)	0.919	0.291
Mean Error (%)	-0.54%	0.10%
Standard Deviation (%)	0.33%	0.22%
Uncertainty in the Mean (%)	0.09%	0.03%
Number of Data Points	14	61
Number of Outliers	0	1

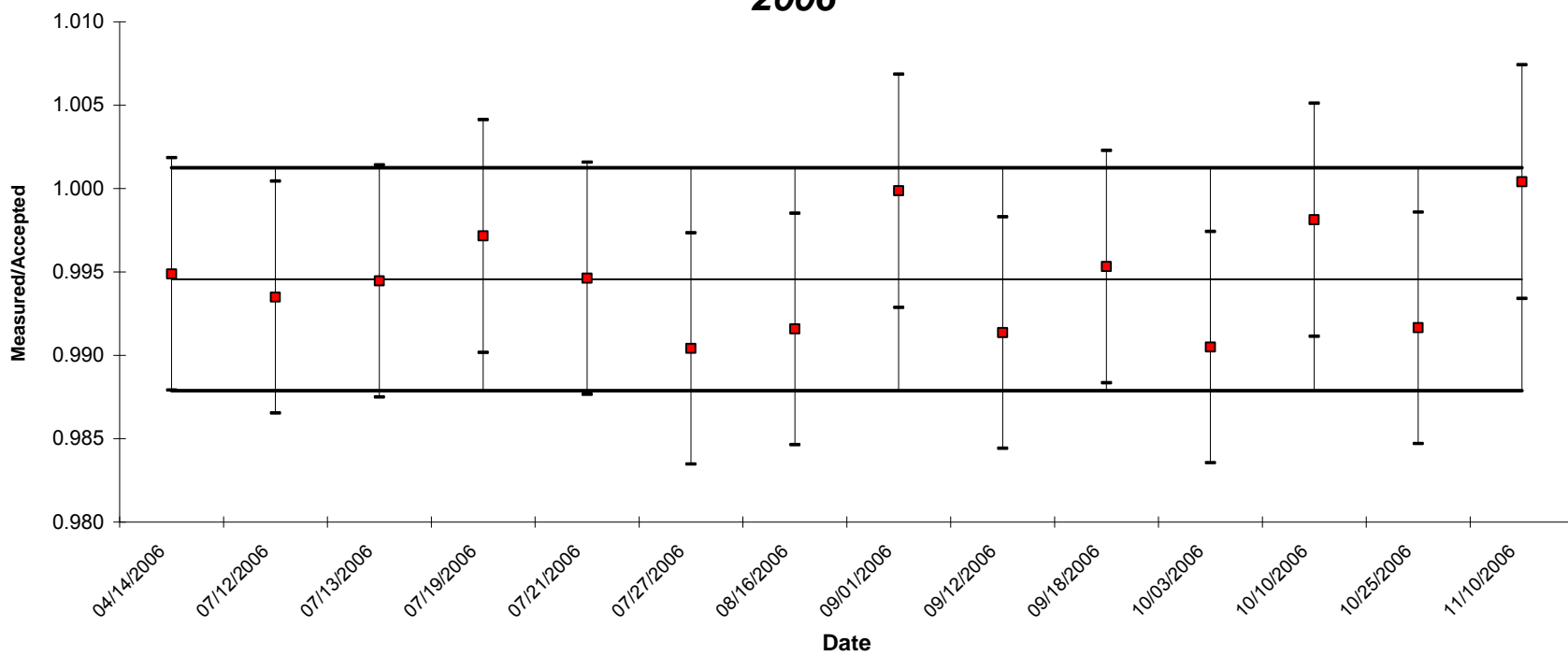
**Difference from Last Year in:**

Mean Error (mW)	-1.745	1.273
Standard Deviation (mW)	-0.571	-0.809
Uncertainty in Mean (mW)	0.251	-0.132
Mean Error (%)	-0.16%	0.13%
Standard Deviation (%)	-0.06%	-0.08%
Uncertainty in the Mean (%)	0.02%	-0.01%
Number of Data Points	-22	7
Number of Outliers	-1	1

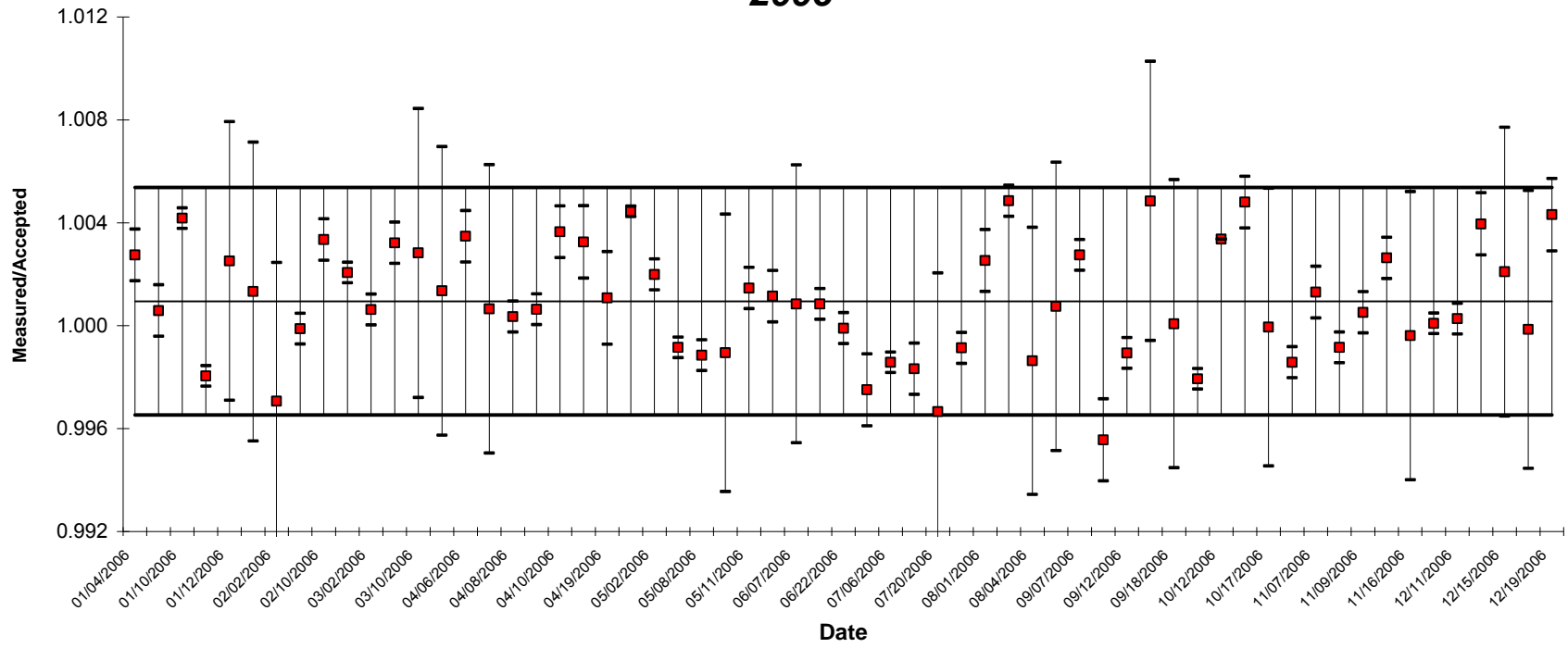
# New Brunswick Laboratory Calorimetry Exchange Program Power, 2006



# HAN CALEX 1 POWER DATA 2006



# LLNL POWER DATA, Calex 1 2006



**Power DATA**  
Calendar Year 2006

HAN: Calex I

#	Date Measured	Instr. ID	Measured mW	Uncert. 1 STD	Accepted mW	Ratio M/A	mW Error	Percent Error	
1	04/14/2006	10	1023.7000	0.35%	1028.9649	0.9949	-5.2649	-0.51%	
2	07/12/2006	10	1022.7000	0.35%	1029.3963	0.9935	-6.6963	-0.65%	
3	07/13/2006	9	1023.7000	0.35%	1029.4011	0.9945	-5.7011	-0.55%	
4	07/19/2006	10	1026.5000	0.35%	1029.4299	0.9972	-2.9299	-0.28%	
5	07/21/2006	8	1023.9000	0.35%	1029.4395	0.9946	-5.5395	-0.54%	
6	07/27/2006	7	1019.6000	0.35%	1029.4683	0.9904	-9.8683	-0.96%	
7	08/16/2006	7	1020.9000	0.35%	1029.5642	0.9916	-8.6642	-0.84%	
8	09/01/2006	9	1029.5000	0.35%	1029.6406	0.9999	-0.1406	-0.01%	
9	09/12/2006	8	1020.8000	0.35%	1029.6930	0.9914	-8.8930	-0.86%	
10	09/18/2006	10	1024.9000	0.35%	1029.7216	0.9953	-4.8216	-0.47%	
11	10/03/2006	7	1020.0000	0.35%	1029.7929	0.9905	-9.7929	-0.95%	
12	10/10/2006	9	1027.9000	0.35%	1029.8261	0.9981	-1.9261	-0.19%	
13	10/25/2006	10	1021.3000	0.35%	1029.8971	0.9917	-8.5971	-0.83%	
14	11/10/2006	7	1030.4000	0.35%	1029.9729	1.0004	0.4271	0.04%	
<b>Mean:</b>							0.9946	-5.6006	-0.54%
<b>Standard Deviation:</b>							0.0033	3.4385	0.33%
<b>Standard Uncertainty:</b>							0.0009	0.9190	0.09%

Statistical outliers are in bold and are not included in graphs and tables.

**Power DATA**  
Calendar Year 2006

LLNL: Calex I

#	Date Measured	Instr. ID	Measured mW	Uncert. 1 STD	Accepted mW	Ratio M/A	mW Error	Percent Error
1	01/04/2006	30	1031.3000	0.05%	1028.4729	1.0027	2.8271	0.27%
2	01/09/2006	30	1029.1000	0.05%	1028.4977	1.0006	0.6023	0.06%
3	01/10/2006	18	1032.8000	0.02%	1028.5026	1.0042	4.2974	0.42%
4	01/11/2006	32	1026.5000	0.02%	1028.5076	0.9980	-2.0076	-0.20%
5	01/12/2006	33	1031.1000	0.27%	1028.5126	1.0025	2.5874	0.25%
6	01/17/2006	33	1029.9000	0.29%	1028.5373	1.0013	1.3627	0.13%
7	02/02/2006	33	1025.6000	0.27%	1028.6165	0.9971	-3.0165	-0.29%
8	02/03/2006	32	1028.5000	0.03%	1028.6214	0.9999	-0.1214	-0.01%
9	02/10/2006	30	1032.1000	0.04%	1028.6559	1.0033	3.4441	0.33%
10	02/14/2006	30	1030.8000	0.02%	1028.6757	1.0021	2.1243	0.21%
11	03/02/2006	32	1029.4000	0.03%	1028.7544	1.0006	0.6456	0.06%
12	03/09/2006	30	1032.1000	0.04%	1028.7888	1.0032	3.3112	0.32%
13	03/10/2006	33	1031.7000	0.28%	1028.7937	1.0028	2.9063	0.28%
14	03/13/2006	33	1030.2000	0.28%	1028.8085	1.0014	1.3915	0.14%
15	04/06/2006	30	1032.5000	0.05%	1028.9258	1.0035	3.5742	0.35%
16	04/07/2006	33	1029.6000	0.28%	1028.9307	1.0007	0.6693	0.07%
17	04/08/2006	32	1029.3000	0.03%	1028.9356	1.0004	0.3644	0.04%
18	04/10/2006	32	1029.6000	0.03%	1028.9454	1.0006	0.6546	0.06%
19	04/10/2006	18	1032.7000	0.05%	1028.9454	1.0036	3.7546	0.36%
20	04/11/2006	18	1032.3000	0.07%	1028.9502	1.0033	3.3498	0.33%
21	04/19/2006	18	1030.1000	0.09%	1028.9893	1.0011	1.1107	0.11%
22	04/27/2006	18	1033.6000	0.01%	1029.0283	1.0044	4.5717	0.44%
23	05/02/2006	18	1031.1000	0.03%	1029.0526	1.0020	2.0474	0.20%
24	05/05/2006	32	1028.2000	0.02%	1029.0672	0.9992	-0.8672	-0.08%
25	05/08/2006	32	1027.9000	0.03%	1029.0818	0.9989	-1.1818	-0.11%
26	05/09/2006	33	1028.0000	0.27%	1029.0867	0.9989	-1.0867	-0.11%
27	05/11/2006	30	1030.6000	0.04%	1029.0964	1.0015	1.5036	0.15%
28	06/06/2006	30	1030.4000	0.05%	1029.2225	1.0011	1.1775	0.11%
29	06/07/2006	33	1030.1000	0.27%	1029.2274	1.0008	0.8726	0.08%
30	06/08/2006	18	1030.1000	0.03%	1029.2322	1.0008	0.8678	0.08%
<b>31</b>	<b>06/14/2006</b>	<b>18</b>	<b>1037.4000</b>	<b>0.09%</b>	<b>1029.2612</b>	<b>1.0079</b>	<b>8.1388</b>	<b>0.79%</b>
32	06/22/2006	32	1029.2000	0.03%	1029.2999	0.9999	-0.0999	-0.01%
33	07/06/2006	18	1026.8000	0.07%	1029.3674	0.9975	-2.5674	-0.25%
34	07/06/2006	32	1027.9000	0.02%	1029.3674	0.9986	-1.4674	-0.14%
35	07/18/2006	30	1027.7000	0.05%	1029.4251	0.9983	-1.7251	-0.17%
36	07/20/2006	33	1026.0000	0.27%	1029.4347	0.9967	-3.4347	-0.33%
37	08/01/2006	32	1028.6000	0.03%	1029.4923	0.9991	-0.8923	-0.09%
38	08/01/2006	18	1032.1000	0.06%	1029.4923	1.0025	2.6077	0.25%
39	08/03/2006	30	1034.5000	0.03%	1029.5019	1.0049	4.9981	0.49%
40	08/04/2006	33	1028.1000	0.26%	1029.5067	0.9986	-1.4067	-0.14%
41	08/08/2006	33	1030.3000	0.28%	1029.5259	1.0008	0.7741	0.08%
42	09/07/2006	30	1032.5000	0.03%	1029.6692	1.0027	2.8308	0.27%
43	09/07/2006	18	1025.1000	0.08%	1029.6692	0.9956	-4.5692	-0.44%
44	09/12/2006	32	1028.6000	0.03%	1029.6930	0.9989	-1.0930	-0.11%
45	09/15/2006	33	1034.7000	0.27%	1029.7073	1.0048	4.9927	0.48%
46	09/18/2006	33	1029.8000	0.28%	1029.7216	1.0001	0.0784	0.01%
47	10/10/2006	18	1027.7000	0.02%	1029.8261	0.9979	-2.1261	-0.21%
48	10/12/2006	30	1033.3000	0.00%	1029.8356	1.0034	3.4644	0.34%
49	10/16/2006	30	1034.8000	0.05%	1029.8545	1.0048	4.9455	0.48%
50	10/17/2006	33	1029.8000	0.27%	1029.8593	0.9999	-0.0593	-0.01%
51	10/18/2006	32	1028.4000	0.03%	1029.8640	0.9986	-1.4640	-0.14%
52	11/07/2006	30	1031.3000	0.05%	1029.9587	1.0013	1.3413	0.13%
53	11/09/2006	32	1029.1000	0.03%	1029.9682	0.9992	-0.8682	-0.08%
54	11/09/2006	18	1030.5000	0.04%	1029.9682	1.0005	0.5318	0.05%
55	11/13/2006	18	1032.7000	0.04%	1029.9870	1.0026	2.7130	0.26%
56	11/16/2006	33	1029.6000	0.28%	1030.0012	0.9996	-0.4012	-0.04%
57	12/08/2006	32	1030.2000	0.02%	1030.1046	1.0001	0.0954	0.01%
58	12/11/2006	32	1030.4000	0.03%	1030.1187	1.0003	0.2813	0.03%
59	12/12/2006	30	1034.2000	0.06%	1030.1234	1.0040	4.0766	0.40%
60	12/15/2006	33	1032.3000	0.28%	1030.1375	1.0021	2.1625	0.21%
61	12/18/2006	33	1030.0000	0.27%	1030.1515	0.9999	-0.1515	-0.01%
62	12/19/2006	18	1034.6000	0.07%	1030.1562	1.0043	4.4438	0.43%
<b>Mean:</b>						1.001	0.9795	0.10%
<b>Standard Deviation:</b>						0.0022	2.2745	0.22%
<b>Standard Uncertainty:</b>						0.0003	0.2912	0.03%

Statistical outliers are in bold and are not included in graphs and tables.

**I.  $P_{\text{eff}}$  VALUES TABLES AND GRAPHS**





**RESULTS OF ANALYSIS OF P\_EFFECTIVE - CALEX I  
1st QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error ( $\mu\text{W/g}$ )	-1.150	-3.500
Standard Deviation ( $\mu\text{W/g}$ )	3.612	1.952
Uncertainty in Mean ( $\mu\text{W/g}$ )	2.554	0.460
Mean Error (%)	-0.04%	-0.14%
Standard Deviation (%)	0.14%	0.08%
Uncertainty in the Mean (%)	0.10%	0.02%
Number of Data Points	2	18
Number of Outliers	0	4

**Difference from Last Quarter in:**

Mean Error ( $\mu\text{W/g}$ )	0.446	0.073
Standard Deviation ( $\mu\text{W/g}$ )	-0.622	0.433
Uncertainty in Mean ( $\mu\text{W/g}$ )	1.739	-0.160
Mean Error (%)	0.02%	0.00%
Standard Deviation (%)	-0.02%	0.02%
Uncertainty in the Mean (%)	0.07%	0.00%
Number of Data Points	-25	12
Number of Outliers	0	4

**RESULTS OF ANALYSIS OF P\_EFFECTIVE - CALEX I  
2nd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error ( $\mu\text{W/g}$ )	-3.222	-3.370
Standard Deviation ( $\mu\text{W/g}$ )	****	1.282
Uncertainty in Mean ( $\mu\text{W/g}$ )	****	0.287
Mean Error (%)	-0.12%	-0.13%
Standard Deviation (%)	****	0.05%
Uncertainty in the Mean (%)	****	0.01%
Number of Data Points	1	20
Number of Outliers	0	1

**Difference from Last Quarter in:**

Mean Error ( $\mu\text{W/g}$ )	-2.072	0.130
Standard Deviation ( $\mu\text{W/g}$ )	****	-0.670
Uncertainty in Mean ( $\mu\text{W/g}$ )	****	-0.173
Mean Error (%)	-0.08%	0.01%
Standard Deviation (%)	****	-0.03%
Uncertainty in the Mean (%)	****	-0.01%
Number of Data Points	-1	2
Number of Outliers	0	-3

**RESULTS OF ANALYSIS OF P\_EFFECTIVE - CALEX I  
3rd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error ( $\mu\text{W/g}$ )	-6.344	-3.481
Standard Deviation ( $\mu\text{W/g}$ )	1.254	1.877
Uncertainty in Mean ( $\mu\text{W/g}$ )	0.443	0.455
Mean Error (%)	-0.25%	-0.13%
Standard Deviation (%)	0.05%	0.07%
Uncertainty in the Mean (%)	0.02%	0.02%
Number of Data Points	8	17
Number of Outliers	1	2

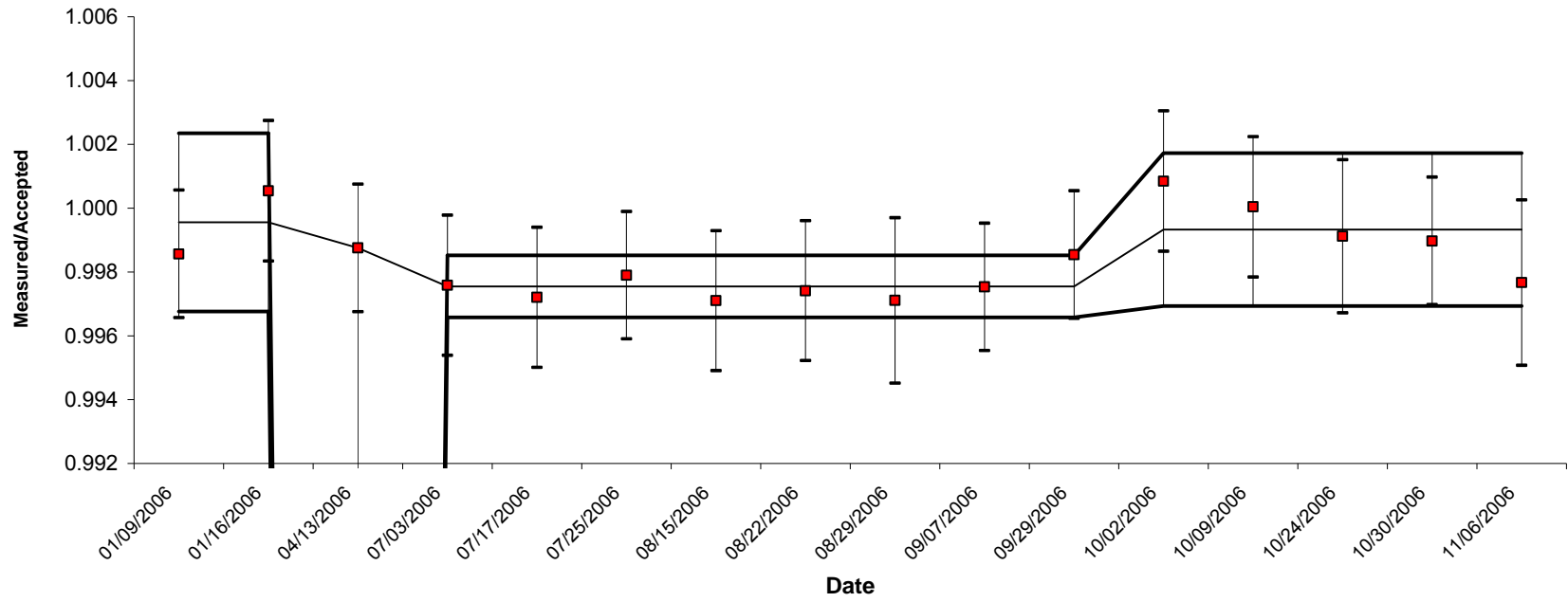
**Difference from Last Quarter in:**

Mean Error ( $\mu\text{W/g}$ )	-3.122	-0.111
Standard Deviation ( $\mu\text{W/g}$ )	****	0.595
Uncertainty in Mean ( $\mu\text{W/g}$ )	****	0.168
Mean Error (%)	-0.13%	0.00%
Standard Deviation (%)	****	0.02%
Uncertainty in the Mean (%)	****	0.01%
Number of Data Points	7	-3
Number of Outliers	1	1

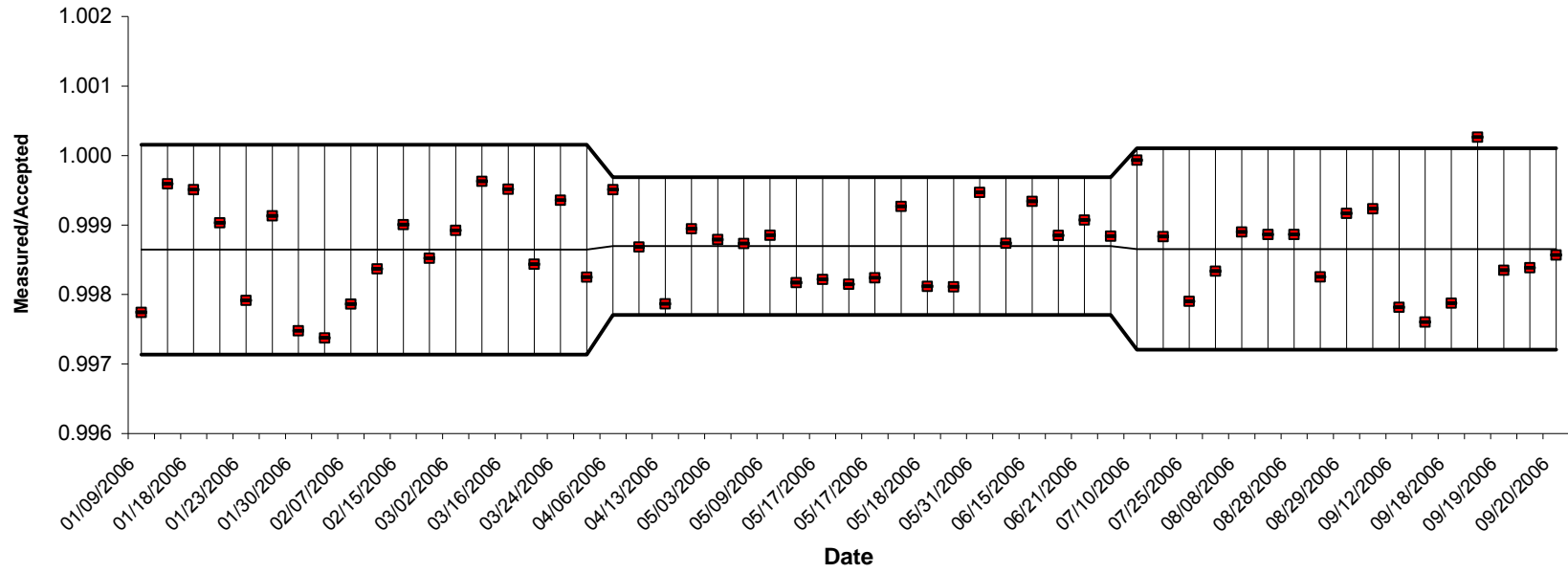
**RESULTS OF ANALYSIS OF P\_EFFECTIVE - CALEX I  
4th QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error ( $\mu\text{W/g}$ )	-1.734	****
Standard Deviation ( $\mu\text{W/g}$ )	3.104	****
Uncertainty in Mean ( $\mu\text{W/g}$ )	1.388	****
Mean Error (%)	-0.07%	****
Standard Deviation (%)	0.12%	****
Uncertainty in the Mean (%)	0.05%	****
Number of Data Points	5	0
Number of Outliers	0	0
<b>Difference from Last Quarter in:</b>		
Mean Error ( $\mu\text{W/g}$ )	4.610	****
Standard Deviation ( $\mu\text{W/g}$ )	1.850	****
Uncertainty in Mean ( $\mu\text{W/g}$ )	0.945	****
Mean Error (%)	0.18%	****
Standard Deviation (%)	0.07%	****
Uncertainty in the Mean (%)	0.03%	****
Number of Data Points	-3	-17
Number of Outliers	-1	-2

**HAN**  
**P-EFFECTIVE, Calex 1**  
**1st Quarter 2006 - 4th Quarter 2006**



**LLNL**  
**P-EFFECTIVE, Caalex 1**  
**1st Quarter 2006 - 3rd Quarter 2006**



**RESULTS OF ANALYSIS OF P\_EFFECTIVE - CALEX I  
2006**

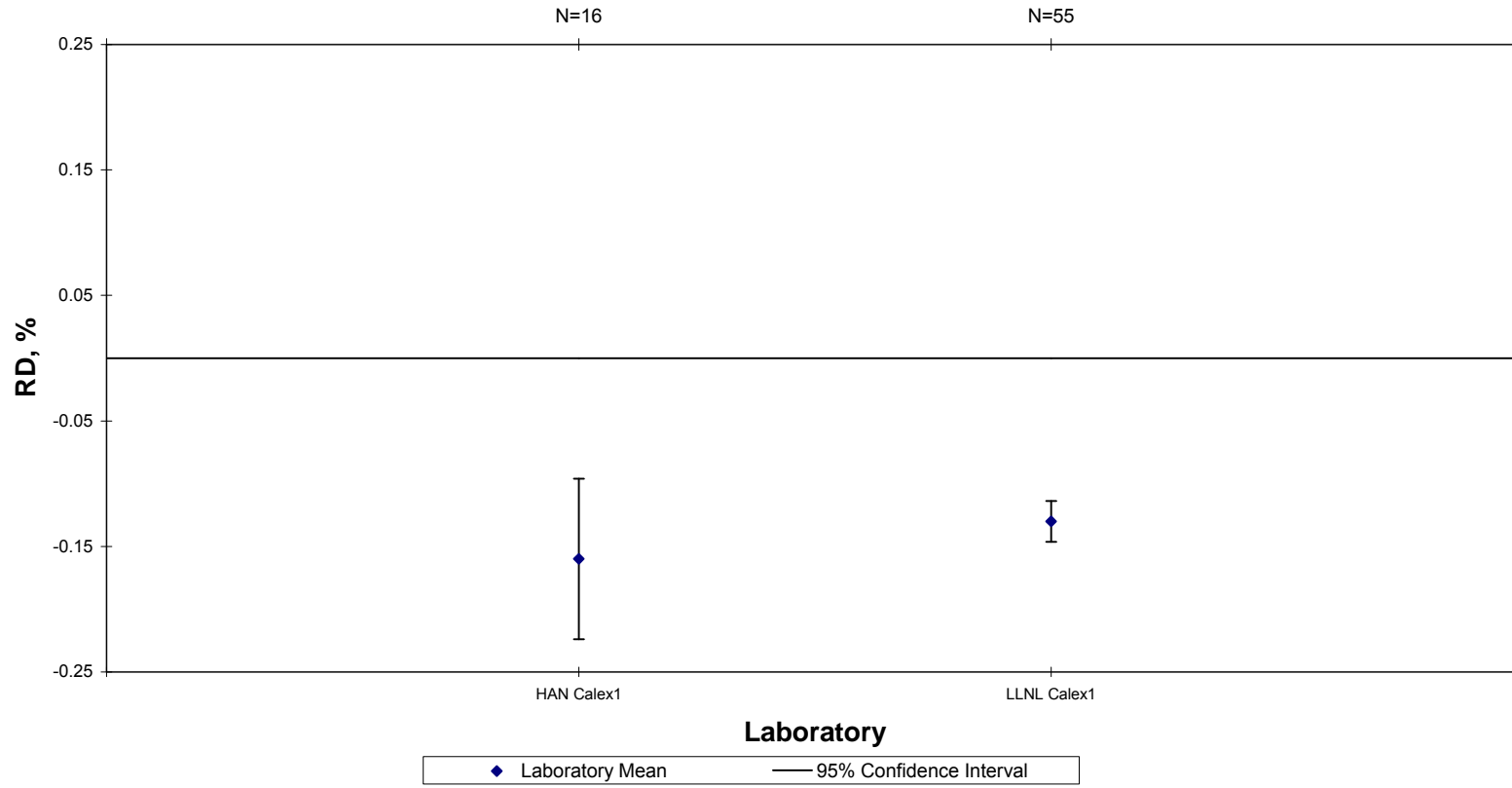
	<b>HAN</b>	<b>LLNL</b>
Mean Error ( $\mu\text{W/g}$ )	-4.059	-3.447
Standard Deviation ( $\mu\text{W/g}$ )	3.152	1.681
Uncertainty in Mean ( $\mu\text{W/g}$ )	0.788	0.227
Mean Error (%)	-0.16%	-0.13%
Standard Deviation (%)	0.12%	0.06%
Uncertainty in the Mean (%)	0.03%	0.01%
Number of Data Points	16	55
Number of Outliers	1	7

**Difference from Last Year in:**

Mean Error ( $\mu\text{W/g}$ )	-1.895	-0.228
Standard Deviation ( $\mu\text{W/g}$ )	-1.333	-0.563
Uncertainty in Mean ( $\mu\text{W/g}$ )	0.333	-0.097
Mean Error (%)	-0.08%	-0.01%
Standard Deviation (%)	-0.05%	-0.03%
Uncertainty in the Mean (%)	0.01%	0.00%
Number of Data Points	-81	7
Number of Outliers	1	7

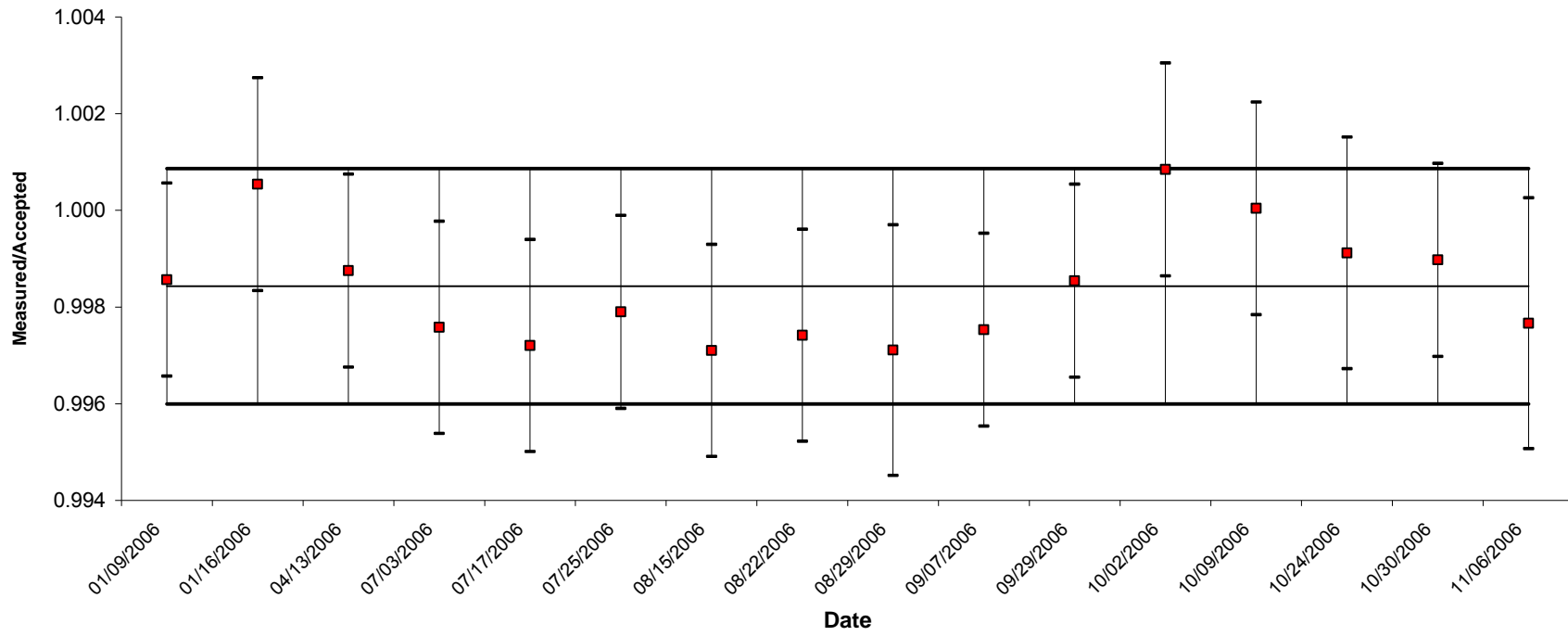
# New Brunswick Laboratory Calorimetry Exchange Program

## $P_{eff}$ , 2006

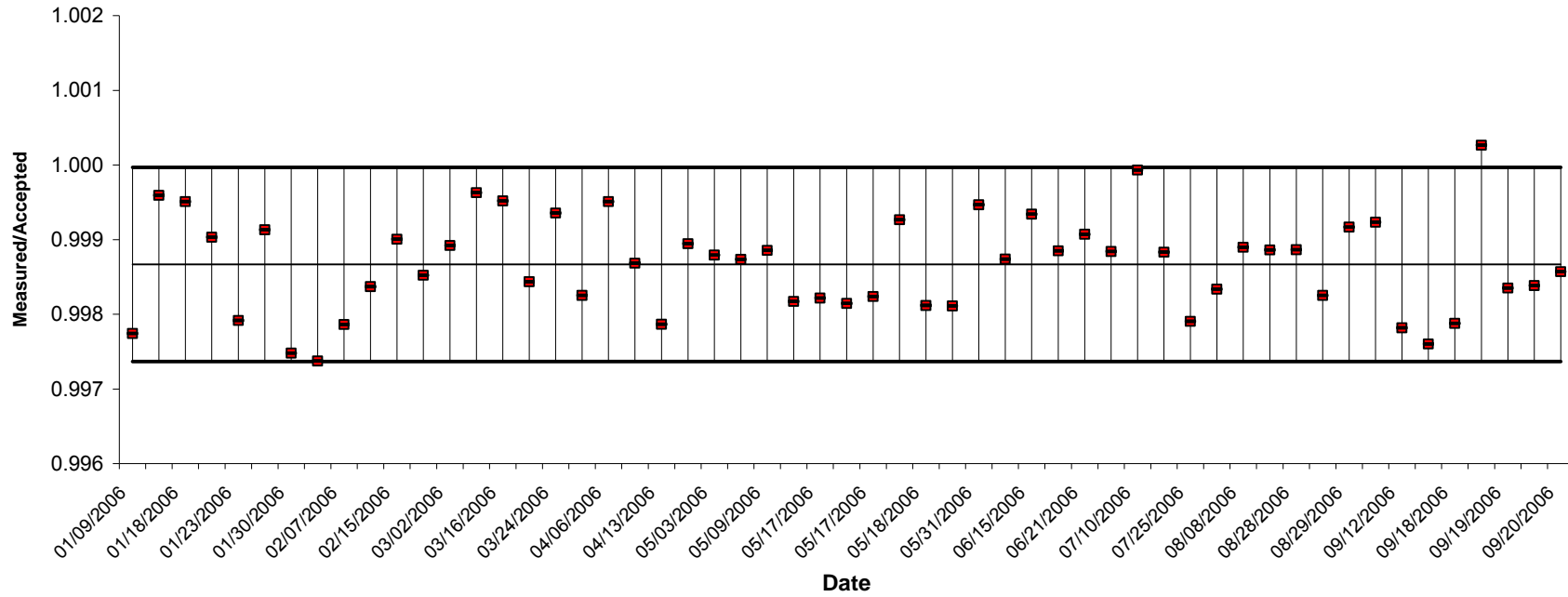




**HAN**  
**P-EFFECTIVE, Calex 1**  
**2006**



**LLNL  
P-EFFECTIVE, Calex 1  
2006**



**P\_Effective DATA**  
Calendar Year 2006

HAN: Calex I

#	Date Measured	Instr. ID	Measured P-eff ( $\mu\text{W/g}$ )	Uncert. 1 STD	Accepted P-eff ( $\mu\text{W/g}$ )	Ratio M/A	$\mu\text{W/g}$ Error	Percent Error
1	01/09/2006	2740	2581.8000	0.10%	2585.5045	0.999	-3.7045	-0.14%
2	01/16/2006	2740	2587.0000	0.11%	2585.5959	1.001	1.4041	0.05%
3	04/13/2006	2740	2583.5000	0.10%	2586.7222	0.999	-3.2222	-0.12%
4	07/03/2006	2740	2581.5000	0.11%	2587.7574	0.998	-6.2574	-0.24%
5	07/17/2006	2740	2580.7000	0.11%	2587.9350	0.997	-7.2350	-0.28%
6	07/25/2006	2740	2582.6000	0.10%	2588.0363	0.998	-5.4363	-0.21%
7	08/15/2006	2740	2580.8000	0.11%	2588.3015	0.997	-7.5015	-0.29%
8	08/22/2006	2740	2581.7000	0.11%	2588.3898	0.997	-6.6898	-0.26%
9	08/29/2006	2740	2581.0000	0.13%	2588.4779	0.997	-7.4779	-0.29%
10	09/07/2006	2740	2582.2000	0.10%	2588.5910	0.998	-6.3910	-0.25%
<b>11</b>	<b>09/11/2006</b>	<b>2740</b>	<b>2586.9000</b>	<b>0.10%</b>	<b>2588.6413</b>	<b>0.999</b>	<b>-1.7413</b>	<b>-0.07%</b>
12	09/29/2006	2740	2585.1000	0.10%	2588.8670	0.999	-3.7670	-0.15%
13	10/02/2006	2740	2591.1000	0.11%	2588.9045	1.001	2.1955	0.08%
14	10/09/2006	2740	2589.1000	0.11%	2588.9921	1.000	0.1079	0.00%
15	10/24/2006	2740	2586.9000	0.12%	2589.1794	0.999	-2.2794	-0.09%
16	10/30/2006	2740	2586.6000	0.10%	2589.2547	0.999	-2.6547	-0.10%
17	11/06/2006	2740	2583.3000	0.13%	2589.3418	0.998	-6.0418	-0.23%
<b>Mean:</b>						0.9984	-4.0594	-0.16%
<b>Standard Deviation:</b>						0.0012	3.1520	0.12%
<b>Standard Uncertainty:</b>						0.0003	0.788	0.03%

Statistical outliers are in bold and are not included in graphs and tables.

## P\_Effective DATA

Calendar Year 2006

LLNL: Calex I

#	Date	Instr. ID	Measured P-eff ( $\mu\text{g/g}$ )	Uncert. 1 STD	Accepted P-eff ( $\mu\text{g/g}$ )	Ratio M/A	$\mu\text{g/g}$ Error	Percent Error
1	01/09/2006	II	2579.6700	0.00%	2585.5045	0.99774338	-5.8345	-0.23%
2	01/09/2006	II	2584.4500	0.00%	2585.5045	0.999592149	-1.0545	-0.04%
3	01/18/2006	I	2584.3500	0.00%	2585.6220	0.999508049	-1.2720	-0.05%
4	01/19/2006	III	2583.1300	0.00%	2585.6350	0.999031186	-2.5050	-0.10%
<b>5</b>	<b>01/23/2006</b>	<b>II</b>	<b>2577.4300</b>	<b>0.00%</b>	<b>2585.6871</b>	<b>0.996806613</b>	<b>-8.2571</b>	<b>-0.32%</b>
6	01/23/2006	II	2580.3000	0.00%	2585.6871	0.997916569	-5.3871	-0.21%
7	01/27/2006	III	2583.4900	0.00%	2585.7392	0.999130152	-2.2492	-0.09%
8	01/30/2006	I	2579.2600	0.00%	2585.7783	0.997479173	-6.5183	-0.25%
9	01/31/2006	II	2579.0000	0.00%	2585.7913	0.997373609	-6.7913	-0.26%
10	02/07/2006	III	2580.3500	0.00%	2585.8823	0.997860575	-5.5323	-0.21%
11	02/15/2006	III	2581.7700	0.00%	2585.9862	0.998369597	-4.2162	-0.16%
12	02/15/2006	III	2583.4100	0.00%	2585.9862	0.999003784	-2.5762	-0.10%
<b>13</b>	<b>02/16/2006</b>	<b>III</b>	<b>2583.0300</b>	<b>0.00%</b>	<b>2585.9992</b>	<b>0.998851817</b>	<b>-2.9692</b>	<b>-0.11%</b>
<b>14</b>	<b>02/16/2006</b>	<b>III</b>	<b>2575.5900</b>	<b>0.00%</b>	<b>2585.9992</b>	<b>0.995974786</b>	<b>-10.4092</b>	<b>-0.40%</b>
15	02/23/2006	III	2582.2700	0.00%	2586.0900	0.998522867	-3.8200	-0.15%
16	03/02/2006	I	2583.3900	0.00%	2586.1807	0.998920918	-2.7907	-0.11%
17	03/07/2006	I	2585.2800	0.00%	2586.2454	0.999626718	-0.9654	-0.04%
18	03/16/2006	III	2585.1100	0.00%	2586.3618	0.999516	-1.2518	-0.05%
<b>19</b>	<b>03/16/2006</b>	<b>III</b>	<b>2311.3200</b>	<b>0.00%</b>	<b>2586.3618</b>	<b>0.893656874</b>	<b>-275.0418</b>	<b>-10.63%</b>
20	03/22/2006	I	2582.3900	0.00%	2586.4393	0.998434411	-4.0493	-0.16%
21	03/24/2006	III	2584.8000	0.00%	2586.4651	0.999356226	-1.6651	-0.06%
22	03/24/2006	III	2581.9400	0.00%	2586.4651	0.998250469	-4.5251	-0.17%
23	04/06/2006	I	2585.3600	0.00%	2586.6321	0.999508202	-1.2721	-0.05%
24	04/11/2006	II	2583.2900	0.00%	2586.6965	0.998683069	-3.4065	-0.13%
25	04/13/2006	III	2581.2000	0.00%	2586.7222	0.997865175	-5.5222	-0.21%
26	04/18/2006	I	2584.0600	0.00%	2586.7865	0.99894599	-2.7265	-0.11%
27	05/03/2006	I	2583.8500	0.00%	2586.9790	0.998790481	-3.1290	-0.12%
28	05/09/2006	I	2583.7800	0.00%	2587.0559	0.998733734	-3.2759	-0.13%
29	05/09/2006	III	2584.0900	0.00%	2587.0559	0.998853562	-2.9659	-0.11%
30	05/15/2006	I	2582.4000	0.00%	2587.1328	0.998170639	-4.7328	-0.18%
<b>31</b>	<b>05/16/2006</b>	<b>II</b>	<b>2579.1500</b>	<b>0.00%</b>	<b>2587.1456</b>	<b>0.99690949</b>	<b>-7.9956</b>	<b>-0.31%</b>
32	05/17/2006	I	2582.5400	0.00%	2587.1584	0.998214875	-4.6184	-0.18%
33	05/17/2006	I	2582.3600	0.00%	2587.1584	0.998145301	-4.7984	-0.19%
34	05/17/2006	I	2582.6000	0.00%	2587.1584	0.998238067	-4.5584	-0.18%
35	05/18/2006	I	2585.2700	0.00%	2587.1711	0.999265182	-1.9011	-0.07%
36	05/18/2006	III	2582.3000	0.00%	2587.1711	0.99811721	-4.8711	-0.19%
37	05/25/2006	III	2582.3700	0.00%	2587.2606	0.998109738	-4.8906	-0.19%
38	05/31/2006	I	2585.9600	0.00%	2587.3373	0.999467677	-1.3773	-0.05%
39	06/07/2006	II	2584.1600	0.00%	2587.4266	0.99873751	-3.2666	-0.13%
40	06/15/2006	III	2585.8200	0.00%	2587.5285	0.999339717	-1.7085	-0.07%
41	06/19/2006	II	2584.6000	0.00%	2587.5794	0.998848576	-2.9794	-0.12%
42	06/21/2006	I	2585.2000	0.00%	2587.6049	0.999070608	-2.4049	-0.09%
43	06/27/2006	I	2584.6800	0.00%	2587.6812	0.998840197	-3.0012	-0.12%
<b>44</b>	<b>07/05/2006</b>	<b>I</b>	<b>2445.7300</b>	<b>0.00%</b>	<b>2587.7828</b>	<b>0.945106367</b>	<b>-142.0528</b>	<b>-5.49%</b>
45	07/10/2006	II	2587.6700	0.00%	2587.8462	0.999931912	-0.1762	-0.01%
46	07/20/2006	III	2584.9500	0.00%	2587.9730	0.998831904	-3.0230	-0.12%
47	07/25/2006	II	2582.6100	0.00%	2588.0363	0.997903314	-5.4263	-0.21%
<b>48</b>	<b>07/28/2006</b>	<b>I</b>	<b>2565.5800</b>	<b>0.00%</b>	<b>2588.0742</b>	<b>0.991308518</b>	<b>-22.4942</b>	<b>-0.87%</b>
49	08/01/2006	II	2583.8200	0.00%	2588.1248	0.998336711	-4.3048	-0.17%
50	08/08/2006	III	2585.3600	0.00%	2588.2132	0.998897618	-2.8532	-0.11%
51	08/09/2006	I	2585.2800	0.00%	2588.2258	0.998861846	-2.9458	-0.11%
52	08/28/2006	II	2585.5200	0.00%	2588.4653	0.998862144	-2.9453	-0.11%
53	08/28/2006	I	2583.9400	0.00%	2588.4653	0.998251744	-4.5253	-0.17%
54	08/29/2006	III	2586.3200	0.00%	2588.4779	0.999166344	-2.1579	-0.08%
55	09/05/2006	I	2586.5800	0.00%	2588.5659	0.999232818	-1.9859	-0.08%
56	09/12/2006	III	2583.0000	0.00%	2588.6538	0.99781593	-5.6538	-0.22%
57	09/13/2006	I	2582.4600	0.00%	2588.6664	0.997602472	-6.2064	-0.24%
58	09/18/2006	II	2583.2300	0.00%	2588.7291	0.997875753	-5.4991	-0.21%
59	09/18/2006	II	2589.4100	0.00%	2588.7291	1.000263025	0.6809	0.03%
60	09/19/2006	I	2584.4700	0.00%	2588.7417	0.998349893	-4.2717	-0.17%
61	09/19/2006	I	2584.5600	0.00%	2588.7417	0.998384659	-4.1817	-0.16%
62	09/20/2006	III	2585.0500	0.00%	2588.7542	0.998569119	-3.7042	-0.14%
Mean:						0.9987	-3.4471	-0.13%
Standard Deviation:						0.0006	1.6806	0.06%
Standard Uncertainty:						0.0001	0.4202	0.01%

Statistical outliers are in bold and are not included in graphs and tables.

**J. <sup>238</sup>Pu ISOTOPE ABUNDANCE TABLES AND GRAPHS**



**RESULTS OF ANALYSIS OF PU238 - CALEX I  
1st QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0001%	-0.0002%
Standard Deviation (weight%)	0.0006%	0.0002%
Uncertainty in the Mean (weight%)	0.0005%	0.0001%
Mean Error (%)	0.67%	-1.99%
Standard Deviation (%)	7.68%	2.72%
Uncertainty in the Mean (%)	5.43%	0.64%
Number of Data Points	2	18
Number of Outliers	0	4

**Difference from Last Quarter in:**

Mean Error (weight%)	0.0003%	0.0001%
Standard Deviation (weight%)	0.0001%	-0.0001%
Uncertainty in the Mean (weight%)	0.0004%	0.0000%
Mean Error (%)	3.28%	1.56%
Standard Deviation (%)	1.66%	-1.10%
Uncertainty in the Mean (%)	4.27%	-0.92%
Number of Data Points	-25	12
Number of Outliers	0	4

**RESULTS OF ANALYSIS OF PU238 - CALEX I  
2nd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0005%	-0.0001%
Standard Deviation (weight%)	****	0.0003%
Uncertainty in the Mean (weight%)	****	0.0001%
Mean Error (%)	-5.78%	-1.40%
Standard Deviation (%)	****	3.53%
Uncertainty in the Mean (%)	****	0.79%
Number of Data Points	1	20
Number of Outliers	0	1

**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0006%	0.0001%
Standard Deviation (weight%)	****	0.0001%
Uncertainty in the Mean (weight%)	****	0.0000%
Mean Error (%)	-6.45%	0.59%
Standard Deviation (%)	****	0.81%
Uncertainty in the Mean (%)	****	0.15%
Number of Data Points	-1	2
Number of Outliers	0	-3



**RESULTS OF ANALYSIS OF PU238 - CALEX I  
3rd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0006%	-0.0002%
Standard Deviation (weight%)	0.0002%	0.0003%
Uncertainty in the Mean (weight%)	0.0001%	0.0001%
Mean Error (%)	-7.35%	-2.95%
Standard Deviation (%)	1.96%	3.16%
Uncertainty in the Mean (%)	0.69%	0.77%
Number of Data Points	8	17
Number of Outliers	1	2

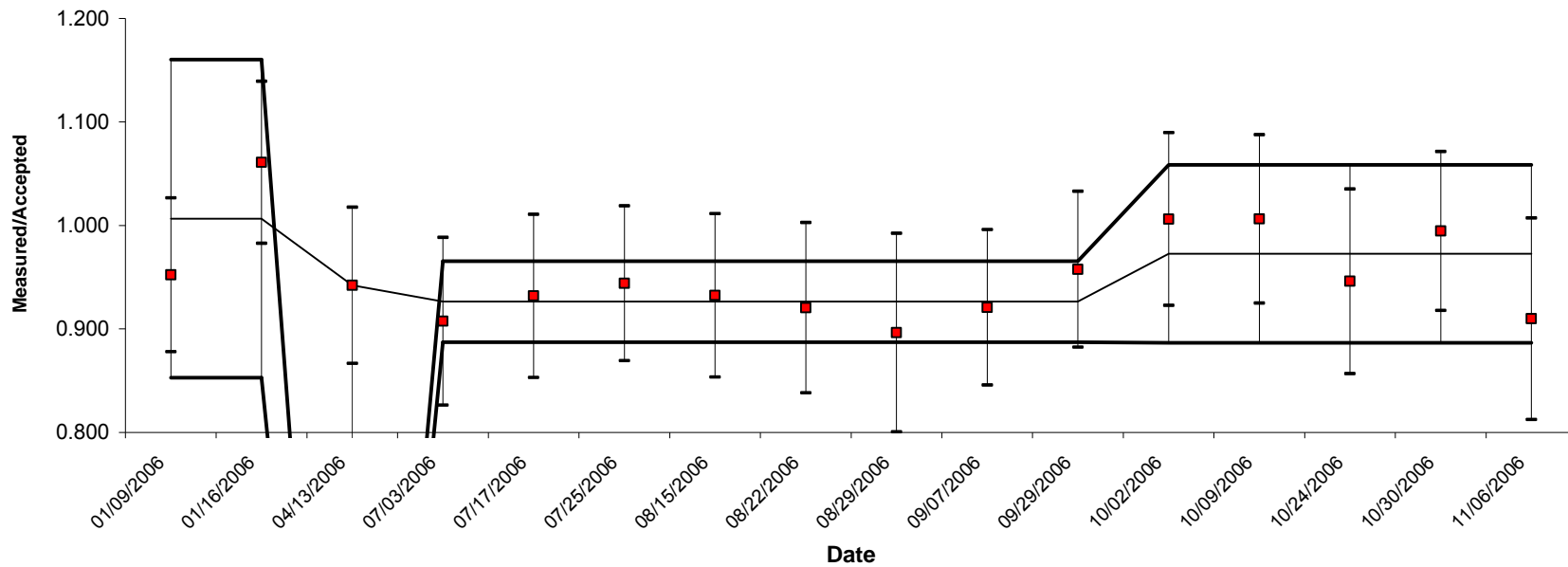
**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0001%	-0.0001%
Standard Deviation (weight%)	****	0.0000%
Uncertainty in the Mean (weight%)	****	0.0000%
Mean Error (%)	-1.57%	-1.55%
Standard Deviation (%)	****	-0.37%
Uncertainty in the Mean (%)	****	-0.02%
Number of Data Points	7	-3
Number of Outliers	1	1

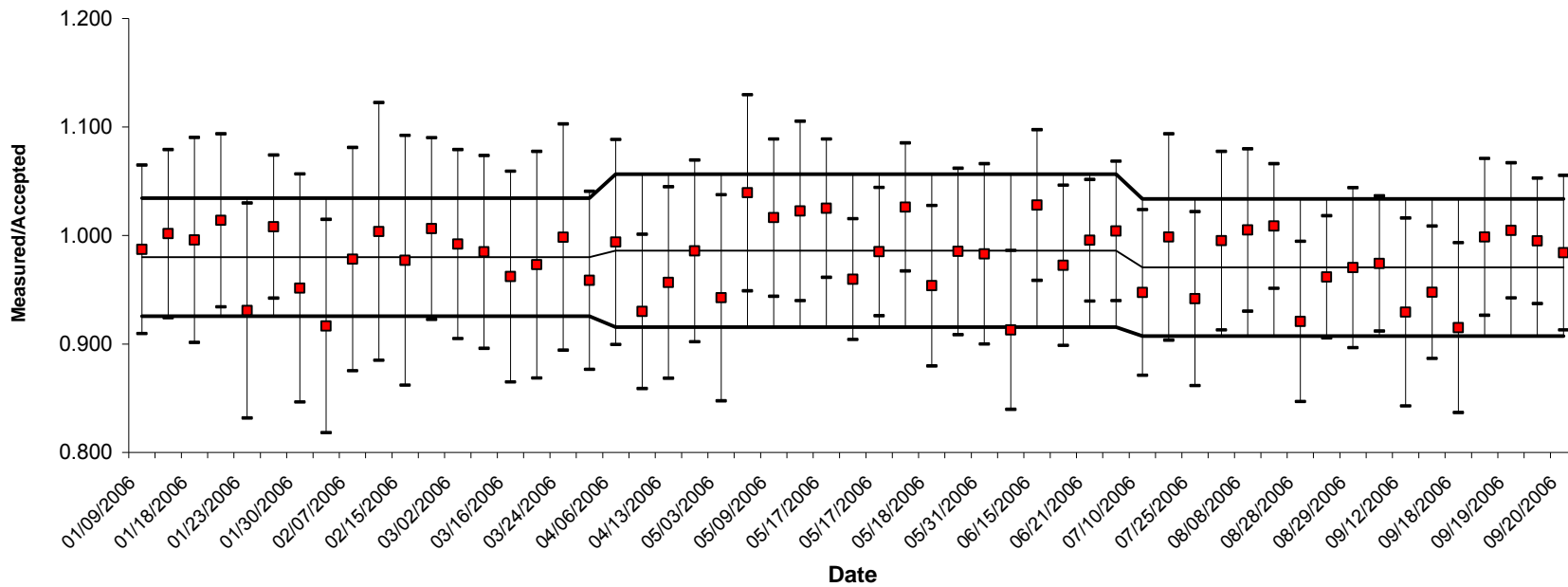
**RESULTS OF ANALYSIS OF PU238 - CALEX I  
4th QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0002%	****
Standard Deviation (weight%)	0.0004%	****
Uncertainty in the Mean (weight%)	0.0002%	****
Mean Error (%)	-2.73%	****
Standard Deviation (%)	4.30%	****
Uncertainty in the Mean (%)	1.92%	****
Number of Data Points	5	0
Number of Outliers	0	0
<b>Difference from Last Quarter in:</b>		
Mean Error (weight%)	0.0004%	****
Standard Deviation (weight%)	0.0002%	****
Uncertainty in the Mean (weight%)	0.0001%	****
Mean Error (%)	4.62%	****
Standard Deviation (%)	2.34%	****
Uncertainty in the Mean (%)	1.23%	****
Number of Data Points	-3	-17
Number of Outliers	-1	-2

**HAN**  
**<sup>238</sup>Pu, Calex 1**  
**1st Quarter 2006 - 4th Quarter 2006**



**LLNL**  
**<sup>238</sup>Pu, Calex 1**  
**1st Quarter 2006 - 3rd Quarter 2006**



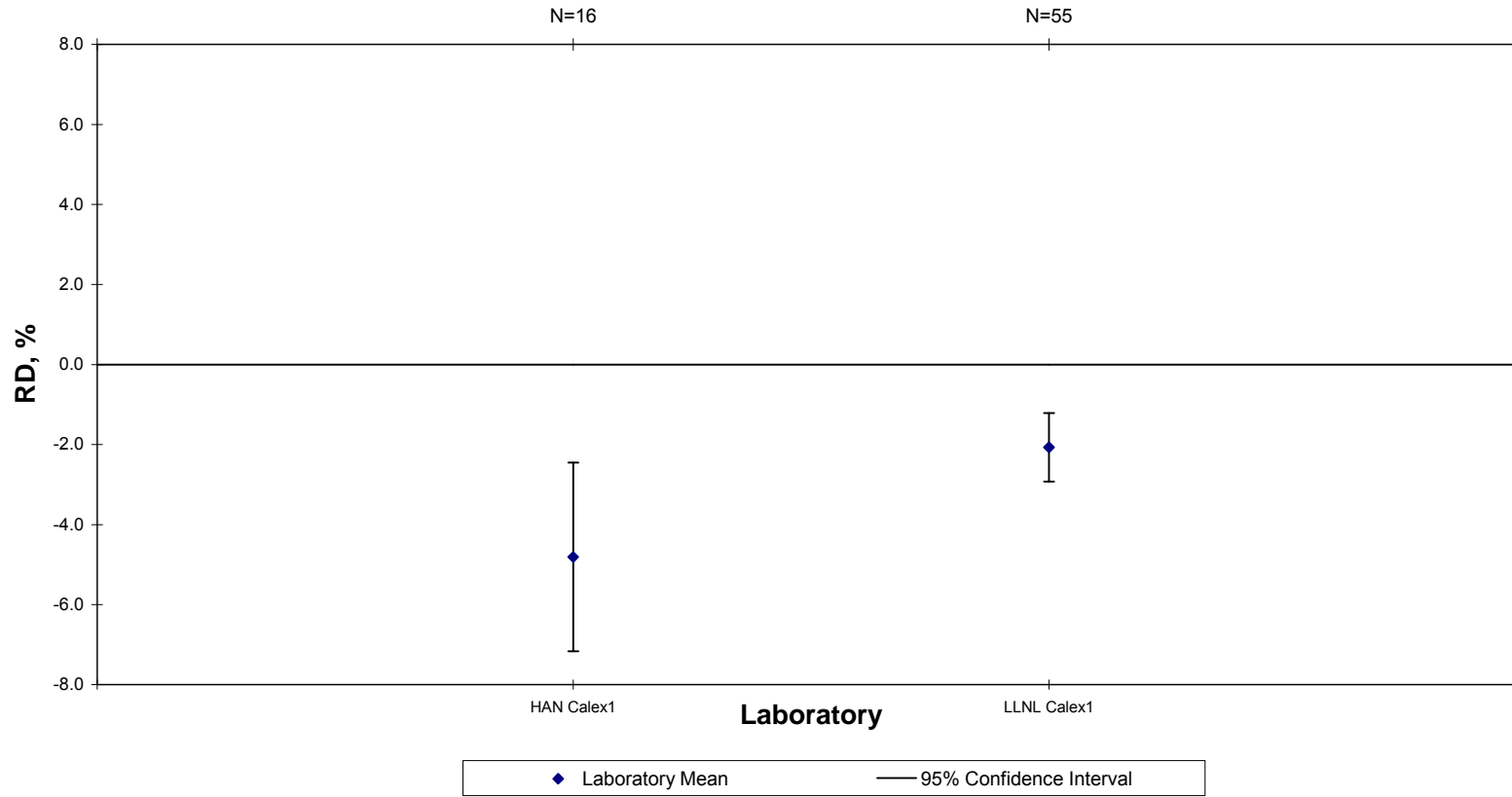
**RESULTS OF ANALYSIS OF PU238 - CALEX I  
2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0004%	-0.0002%
Standard Deviation (weight%)	0.0004%	0.0003%
Uncertainty in the Mean (weight%)	0.0001%	0.0000%
Mean Error (%)	-4.81%	-2.07%
Standard Deviation (%)	4.43%	3.17%
Uncertainty in the Mean (%)	1.11%	0.43%
Number of Data Points	16	55
Number of Outliers	1	7

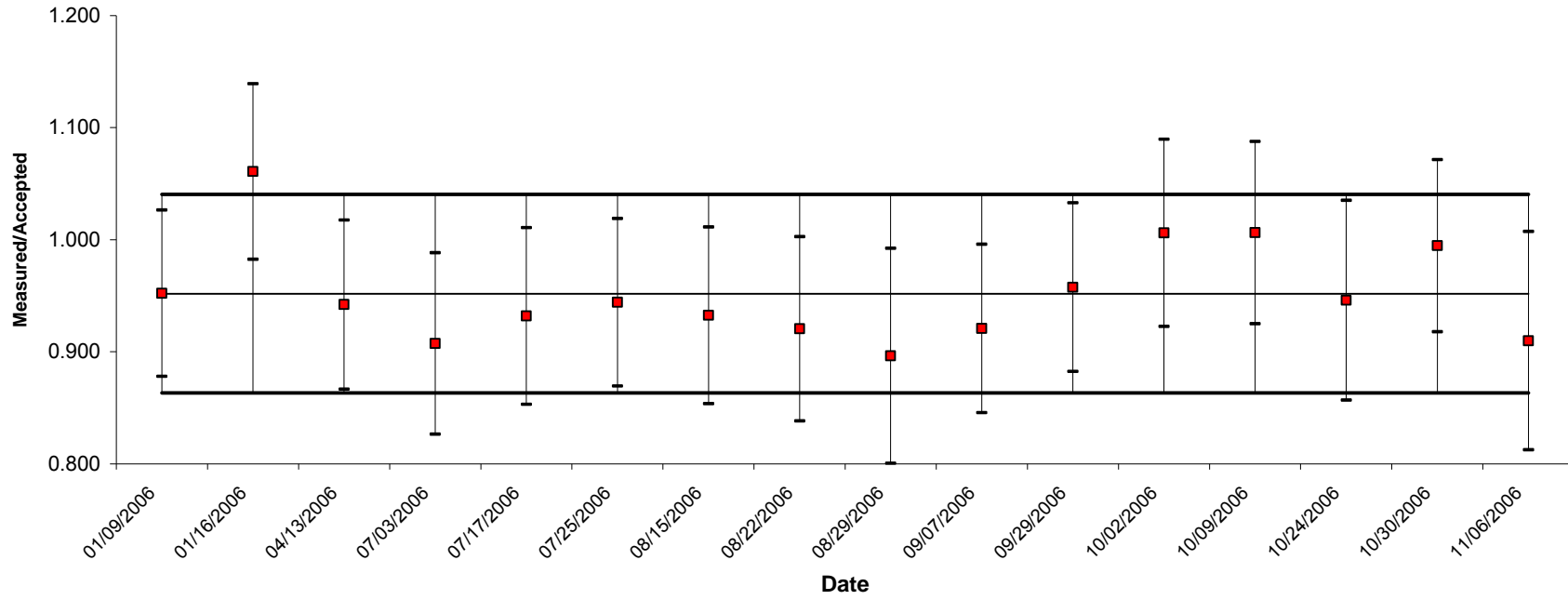
**Difference from Last Year in:**

Mean Error (weight%)	0.0000%	0.0000%
Standard Deviation (weight%)	-0.0001%	0.0000%
Uncertainty in the Mean (weight%)	0.0000%	0.0000%
Mean Error (%)	-0.34%	0.30%
Standard Deviation (%)	-1.61%	-0.29%
Uncertainty in the Mean (%)	0.50%	-0.07%
Number of Data Points	-81	7
Number of Outliers	1	7

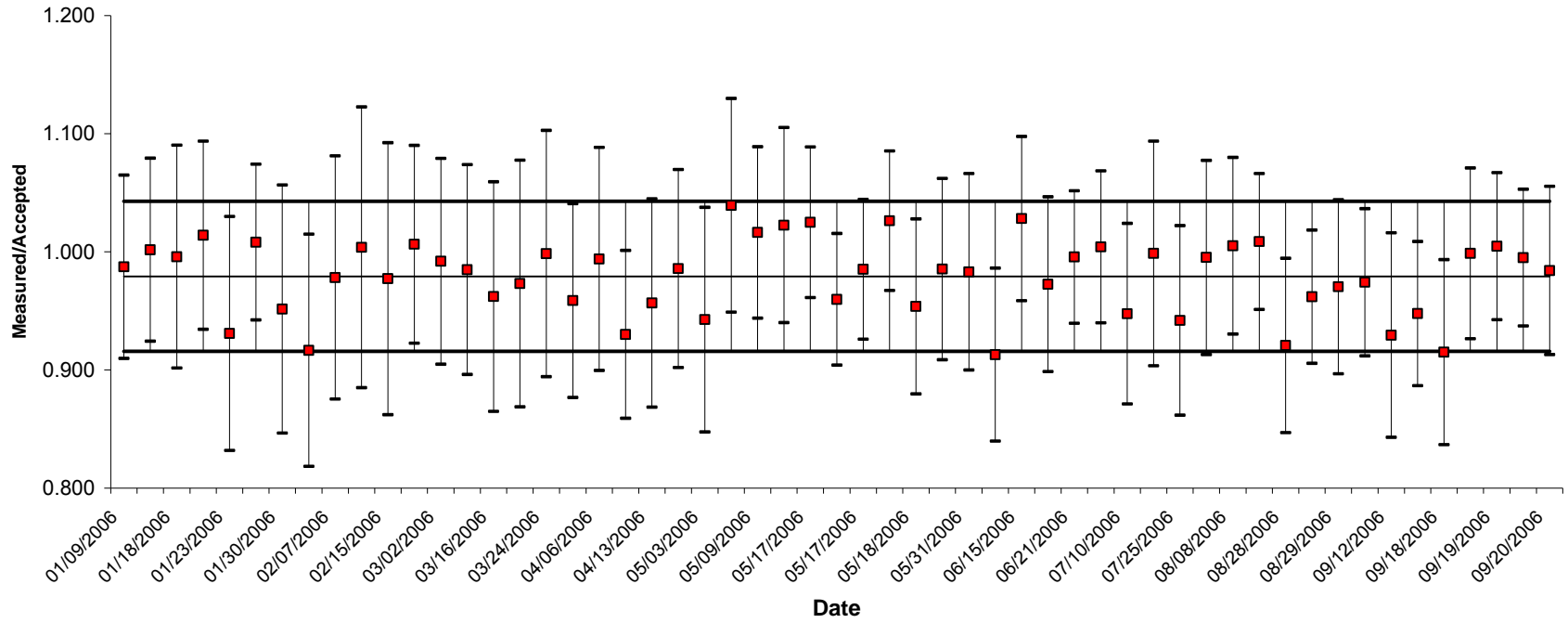
New Brunswick Laboratory Calorimetry Exchange Program  
Percent  $^{238}\text{Pu}$ , 2006



**HAN**  
**<sup>238</sup>Pu, Calex 1**  
**2006**



**LLNL**  
**<sup>238</sup>Pu, Calex 1**  
**2006**





## WEIGHT PERCENT Pu238 DATA

Calendar Year 2006

HAN: Calex I

#	Date Measured	Instr. ID	Measured Pu238	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	2740	0.0079%	3.90%	0.0083%	0.9523	-0.0004%	-4.77%
2	01/16/2006	2740	0.0088%	3.69%	0.0083%	1.0610	0.0005%	6.10%
3	04/13/2006	2740	0.0078%	4.00%	0.0083%	0.9422	-0.0005%	-5.78%
4	07/03/2006	2740	0.0075%	4.46%	0.0083%	0.9075	-0.0008%	-9.25%
5	07/17/2006	2740	0.0077%	4.23%	0.0083%	0.9320	-0.0006%	-6.80%
6	07/25/2006	2740	0.0078%	3.96%	0.0083%	0.9443	-0.0005%	-5.57%
7	08/15/2006	2740	0.0077%	4.23%	0.0083%	0.9326	-0.0006%	-6.74%
8	08/22/2006	2740	0.0076%	4.47%	0.0083%	0.9206	-0.0007%	-7.94%
9	08/29/2006	2740	0.0074%	5.35%	0.0083%	0.8965	-0.0009%	-10.35%
10	09/07/2006	2740	0.0076%	4.08%	0.0083%	0.9209	-0.0007%	-7.91%
<b>11</b>	<b>09/11/2006</b>	<b>2740</b>	<b>0.0076%</b>	<b>4.01%</b>	<b>0.0083%</b>	<b>0.9210</b>	<b>-0.0007%</b>	<b>-7.90%</b>
12	09/29/2006	2740	0.0079%	3.93%	0.0082%	0.9577	-0.0003%	-4.23%
13	10/02/2006	2740	0.0083%	4.15%	0.0082%	1.0063	0.0001%	0.63%
14	10/09/2006	2740	0.0083%	4.04%	0.0082%	1.0064	0.0001%	0.64%
15	10/24/2006	2740	0.0078%	4.71%	0.0082%	0.9461	-0.0004%	-5.39%
16	10/30/2006	2740	0.0082%	3.86%	0.0082%	0.9947	-0.0000%	-0.53%
17	11/06/2006	2740	0.0075%	5.35%	0.0082%	0.9100	-0.0007%	-9.00%
<b>Mean:</b>						0.9519	-0.0004%	-4.81%
<b>Standard Deviation:</b>						0.0443	0.0004%	4.43%
<b>Standard Uncertainty:</b>						0.0111	0.0001%	1.11%

Statistical outliers are in bold and are not included in graphs and tables.

## WEIGHT PERCENT Pu238 DATA

Calendar Year 2006

LLNL: Calex I

#	Date Measured	Instr. ID	Measured Pu238	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	II	0.0082%	3.93%	0.0083%	0.9880	-0.0001%	-1.27%
2	01/09/2006	II	0.0083%	3.87%	0.0083%	1.0000	0.0000%	0.18%
3	01/18/2006	I	0.0083%	4.74%	0.0083%	1.0000	-0.0000%	-0.41%
4	01/19/2006	III	0.0084%	3.93%	0.0083%	1.0120	0.0001%	1.40%
<b>5</b>	<b>01/23/2006</b>	<b>II</b>	<b>0.0073%</b>	<b>6.64%</b>	<b>0.0083%</b>	<b>0.8795</b>	<b>-0.0010%</b>	<b>-11.97%</b>
6	01/23/2006	II	0.0077%	5.32%	0.0083%	0.9277	-0.0006%	-6.91%
7	01/27/2006	III	0.0084%	3.27%	0.0083%	1.0120	0.0001%	0.82%
8	01/30/2006	I	0.0079%	5.52%	0.0083%	0.9518	-0.0004%	-4.84%
9	01/31/2006	II	0.0076%	5.36%	0.0083%	0.9157	-0.0007%	-8.34%
10	02/07/2006	III	0.0081%	5.26%	0.0083%	0.9759	-0.0002%	-2.17%
11	02/15/2006	III	0.0083%	5.92%	0.0083%	1.0000	0.0000%	0.38%
12	02/15/2006	III	0.0081%	5.89%	0.0083%	0.9759	-0.0002%	-2.28%
<b>13</b>	<b>02/16/2006</b>	<b>III</b>	<b>0.0083%</b>	<b>5.46%</b>	<b>0.0083%</b>	<b>1.0000</b>	<b>-0.0000%</b>	<b>-0.22%</b>
<b>14</b>	<b>02/16/2006</b>	<b>III</b>	<b>0.0081%</b>	<b>7.62%</b>	<b>0.0083%</b>	<b>0.9759</b>	<b>-0.0002%</b>	<b>-2.76%</b>
15	02/23/2006	III	0.0083%	4.16%	0.0083%	1.0000	0.0001%	0.63%
16	03/02/2006	I	0.0082%	4.39%	0.0083%	0.9880	-0.0001%	-0.80%
17	03/07/2006	I	0.0082%	4.51%	0.0083%	0.9880	-0.0001%	-1.51%
18	03/16/2006	III	0.0080%	5.05%	0.0083%	0.9639	-0.0003%	-3.79%
<b>19</b>	<b>03/16/2006</b>	<b>III</b>	<b>0.0083%</b>	<b>3.72%</b>	<b>0.0083%</b>	<b>1.0000</b>	<b>0.0000%</b>	<b>0.20%</b>
20	03/22/2006	I	0.0081%	5.37%	0.0083%	0.9759	-0.0002%	-2.69%
21	03/24/2006	III	0.0083%	5.22%	0.0083%	1.0000	-0.0000%	-0.15%
22	03/24/2006	III	0.0079%	4.28%	0.0083%	0.9518	-0.0003%	-4.13%
23	04/06/2006	I	0.0082%	4.75%	0.0083%	0.9880	-0.0000%	-0.60%
24	04/11/2006	II	0.0077%	3.82%	0.0083%	0.9277	-0.0006%	-6.99%
25	04/13/2006	III	0.0079%	4.61%	0.0083%	0.9518	-0.0004%	-4.33%
26	04/18/2006	I	0.0082%	4.25%	0.0083%	0.9880	-0.0001%	-1.42%
27	05/03/2006	I	0.0078%	5.04%	0.0083%	0.9398	-0.0005%	-5.74%
28	05/09/2006	I	0.0086%	4.35%	0.0083%	1.0361	0.0003%	3.94%
29	05/09/2006	III	0.0084%	3.57%	0.0083%	1.0120	0.0001%	1.64%
30	05/15/2006	I	0.0085%	4.04%	0.0083%	1.0241	0.0002%	2.26%
<b>31</b>	<b>05/16/2006</b>	<b>II</b>	<b>0.0074%</b>	<b>4.18%</b>	<b>0.0083%</b>	<b>0.8916</b>	<b>-0.0009%</b>	<b>-10.31%</b>
32	05/17/2006	I	0.0085%	3.11%	0.0083%	1.0241	0.0002%	2.51%
33	05/17/2006	I	0.0079%	2.90%	0.0083%	0.9518	-0.0003%	-4.02%
34	05/17/2006	I	0.0082%	3.00%	0.0083%	0.9880	-0.0001%	-1.48%
35	05/18/2006	I	0.0085%	2.88%	0.0083%	1.0241	0.0002%	2.63%
36	05/18/2006	III	0.0079%	3.88%	0.0083%	0.9518	-0.0004%	-4.62%
37	05/25/2006	III	0.0082%	3.89%	0.0083%	0.9880	-0.0001%	-1.47%
38	05/31/2006	I	0.0081%	4.23%	0.0083%	0.9759	-0.0001%	-1.70%
39	06/07/2006	II	0.0076%	4.01%	0.0083%	0.9157	-0.0007%	-8.69%
40	06/15/2006	III	0.0085%	3.38%	0.0083%	1.0241	0.0002%	2.81%
41	06/19/2006	II	0.0080%	3.80%	0.0083%	0.9639	-0.0002%	-2.74%
42	06/21/2006	I	0.0082%	2.82%	0.0083%	0.9880	-0.0000%	-0.44%
43	06/27/2006	I	0.0083%	3.20%	0.0083%	1.0000	0.0000%	0.42%
<b>44</b>	<b>07/05/2006</b>	<b>I</b>	<b>0.0095%</b>	<b>2.42%</b>	<b>0.0083%</b>	<b>1.1446</b>	<b>0.0012%</b>	<b>14.47%</b>
45	07/10/2006	II	0.0078%	4.03%	0.0083%	0.9398	-0.0004%	-5.24%
46	07/20/2006	III	0.0082%	4.76%	0.0083%	0.9880	-0.0000%	-0.14%
47	07/25/2006	II	0.0078%	4.26%	0.0083%	0.9398	-0.0005%	-5.82%
<b>48</b>	<b>07/28/2006</b>	<b>I</b>	<b>0.0084%</b>	<b>3.03%</b>	<b>0.0083%</b>	<b>1.0120</b>	<b>0.0001%</b>	<b>1.33%</b>
49	08/01/2006	II	0.0082%	4.13%	0.0083%	0.9880	-0.0000%	-0.48%
50	08/08/2006	III	0.0083%	3.72%	0.0083%	1.0000	0.0000%	0.51%
51	08/09/2006	I	0.0083%	2.85%	0.0083%	1.0000	0.0001%	0.87%
52	08/28/2006	II	0.0076%	4.01%	0.0083%	0.9157	-0.0007%	-7.93%
53	08/28/2006	I	0.0079%	2.93%	0.0083%	0.9518	-0.0003%	-3.81%
54	08/29/2006	III	0.0080%	3.80%	0.0083%	0.9639	-0.0002%	-2.96%
55	09/05/2006	I	0.0080%	3.20%	0.0083%	0.9639	-0.0002%	-2.58%
56	09/12/2006	III	0.0077%	4.66%	0.0083%	0.9277	-0.0006%	-7.05%
57	09/13/2006	I	0.0078%	3.22%	0.0083%	0.9398	-0.0004%	-5.23%
58	09/18/2006	II	0.0076%	4.28%	0.0083%	0.9157	-0.0007%	-8.49%
59	09/18/2006	II	0.0082%	3.62%	0.0083%	0.9880	-0.0000%	-0.13%
60	09/19/2006	I	0.0083%	3.10%	0.0083%	1.0000	0.0000%	0.48%
61	09/19/2006	I	0.0082%	2.91%	0.0083%	0.9880	-0.0000%	-0.49%
62	09/20/2006	III	0.0081%	3.62%	0.0083%	0.9759	-0.0001%	-1.58%
<b>Mean:</b>						0.9759	-0.0002%	-2.07%
<b>Standard Deviation:</b>						0.0315	0.0003%	3.17%
<b>Standard Uncertainty:</b>						0.0042	0.0000%	0.43%

Statistical outliers are in bold and are not included in graphs and tables.

**K.  $^{239}\text{Pu}$  ISOTOPE ABUNDANCE TABLES AND GRAPHS**



**RESULTS OF ANALYSIS OF PU239 - CALEX I  
1st QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0323%	0.0129%
Standard Deviation (weight%)	0.0062%	0.0248%
Uncertainty in the Mean (weight%)	0.0044%	0.0058%
Mean Error (%)	-0.03%	0.01%
Standard Deviation (%)	0.01%	0.03%
Uncertainty in the Mean (%)	0.00%	0.01%
Number of Data Points	2	18
Number of Outliers	0	4

**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0146%	0.0118%
Standard Deviation (weight%)	-0.0416%	-0.0105%
Uncertainty in the Mean (weight%)	-0.0048%	-0.0086%
Mean Error (%)	-0.01%	0.01%
Standard Deviation (%)	-0.04%	-0.01%
Uncertainty in the Mean (%)	-0.01%	-0.01%
Number of Data Points	-25	12
Number of Outliers	0	4

**RESULTS OF ANALYSIS OF PU239 - CALEX I  
2nd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0598%	0.0105%
Standard Deviation (weight%)	****	0.0224%
Uncertainty in the Mean (weight%)	****	0.0050%
Mean Error (%)	-0.06%	0.01%
Standard Deviation (%)	****	0.02%
Uncertainty in the Mean (%)	****	0.01%
Number of Data Points	1	20
Number of Outliers	0	1

**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0275%	-0.0024%
Standard Deviation (weight%)	****	-0.0024%
Uncertainty in the Mean (weight%)	****	-0.0008%
Mean Error (%)	-0.03%	0.00%
Standard Deviation (%)	****	-0.01%
Uncertainty in the Mean (%)	****	0.00%
Number of Data Points	-1	2
Number of Outliers	0	-3

**RESULTS OF ANALYSIS OF PU239 - CALEX I  
3rd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0142%	0.0018%
Standard Deviation (weight%)	0.0089%	0.0278%
Uncertainty in the Mean (weight%)	0.0032%	0.0068%
Mean Error (%)	-0.02%	0.00%
Standard Deviation (%)	0.01%	0.03%
Uncertainty in the Mean (%)	0.00%	0.01%
Number of Data Points	8	17
Number of Outliers	1	2

**Difference from Last Quarter in:**

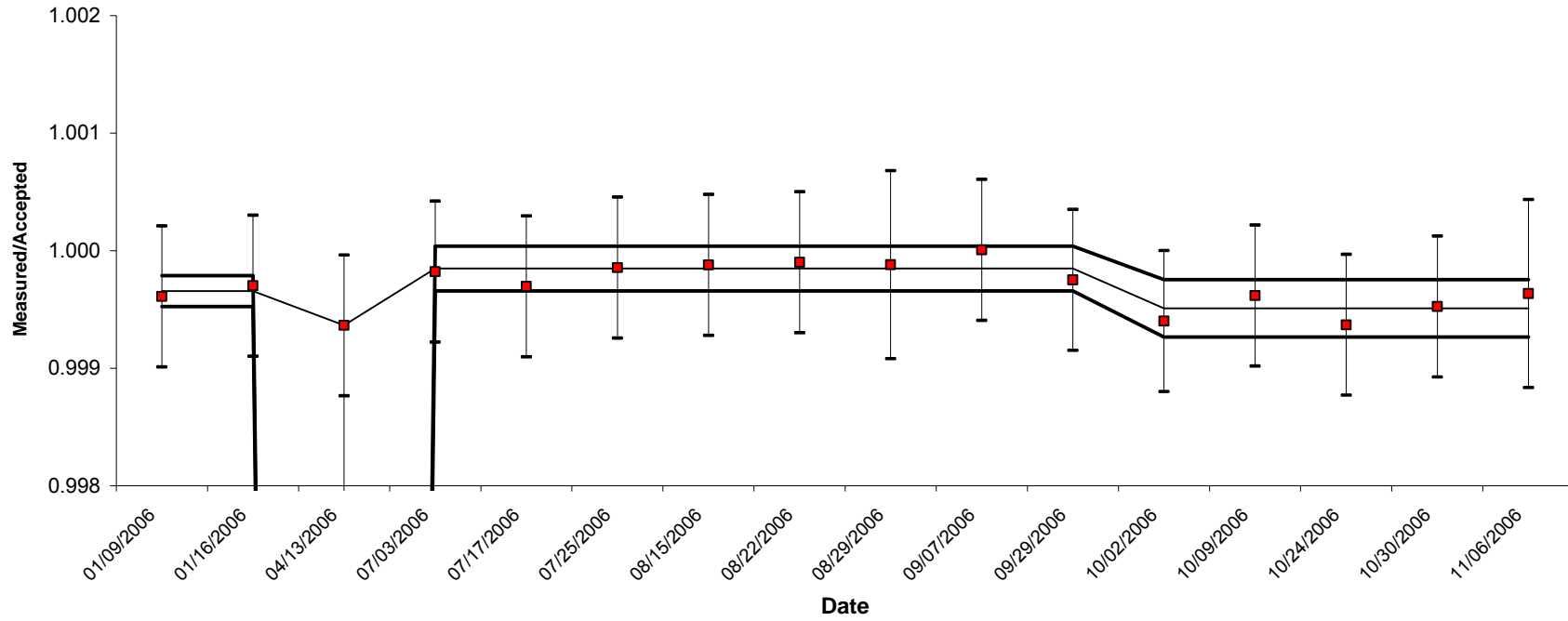
Mean Error (weight%)	0.0456%	-0.0087%
Standard Deviation (weight%)	****	0.0054%
Uncertainty in the Mean (weight%)	****	0.0018%
Mean Error (%)	0.04%	-0.01%
Standard Deviation (%)	****	0.01%
Uncertainty in the Mean (%)	****	0.00%
Number of Data Points	7	-3
Number of Outliers	1	1

**RESULTS OF ANALYSIS OF PU239 - CALEX I  
4th QUARTER 2006**

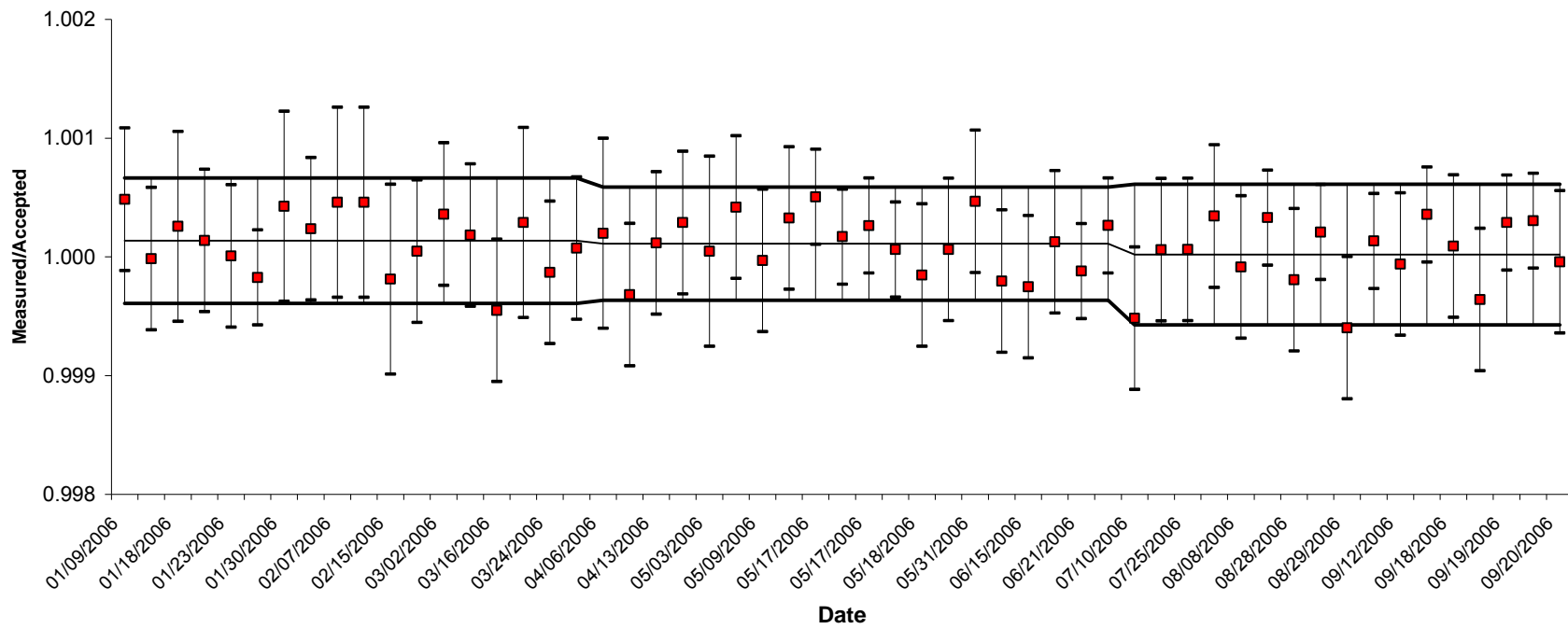
	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0461%	****
Standard Deviation (weight%)	0.0115%	****
Uncertainty in the Mean (weight%)	0.0051%	****
Mean Error (%)	-0.05%	****
Standard Deviation (%)	0.01%	****
Uncertainty in the Mean (%)	0.01%	****
Number of Data Points	5	0
Number of Outliers	0	0
<b>Difference from Last Quarter in:</b>		
Mean Error (weight%)	-0.0319%	****
Standard Deviation (weight%)	0.0026%	****
Uncertainty in the Mean (weight%)	0.0019%	****
Mean Error (%)	-0.03%	****
Standard Deviation (%)	0.00%	****
Uncertainty in the Mean (%)	0.01%	****
Number of Data Points	-3	-17
Number of Outliers	-1	-2



**HAN**  
**<sup>239</sup>Pu, Calex 1**  
**1st Quarter 2006 - 4th Quarter 2006**



**LLNL**  
**<sup>239</sup>Pu, Calex 1**  
**1st Quarter 2006 - 3rd Quarter 2006**



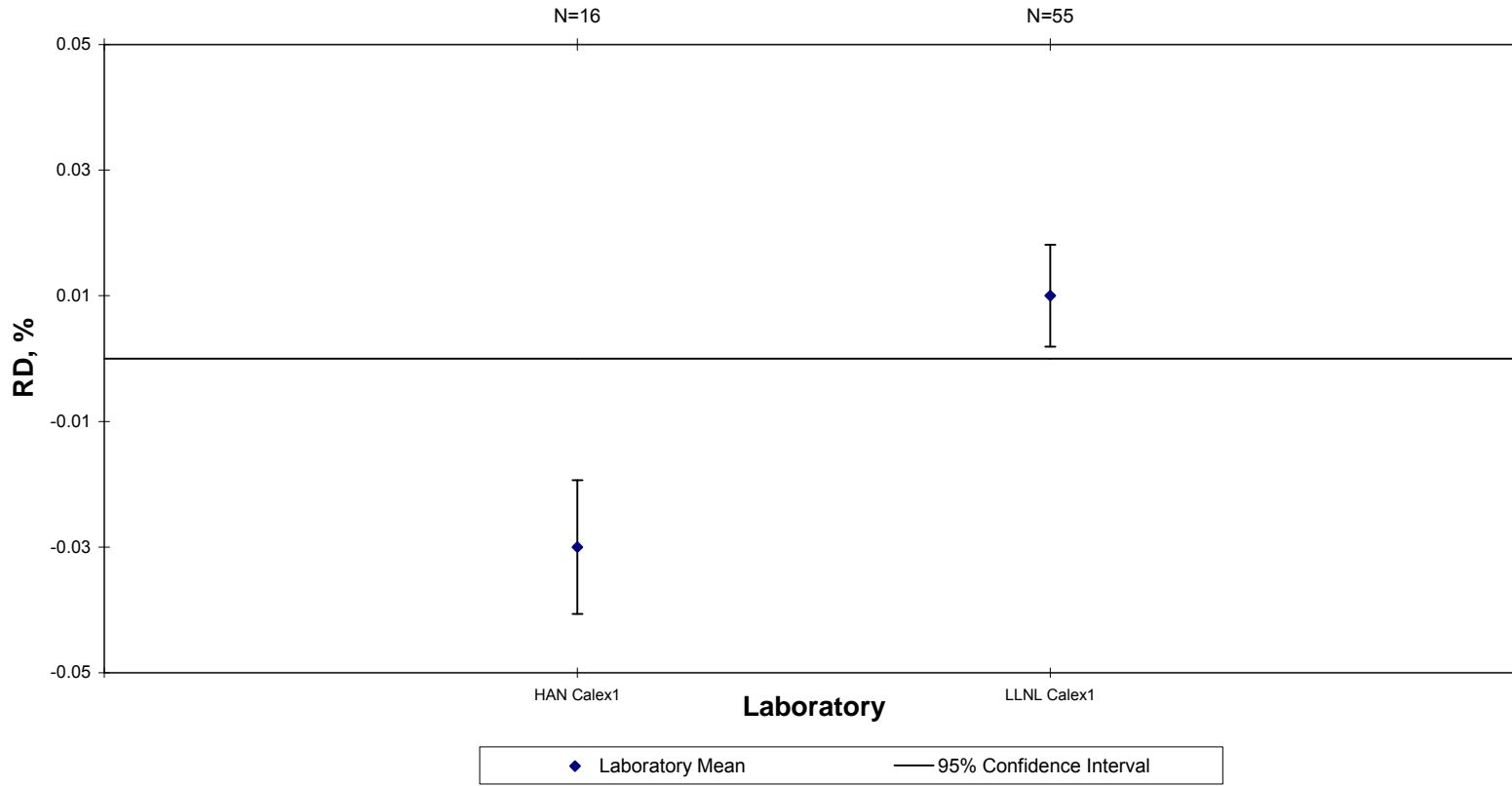
**RESULTS OF ANALYSIS OF PU239 - CALEX I  
2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0293%	0.0086%
Standard Deviation (weight%)	0.0188%	0.0249%
Uncertainty in the Mean (weight%)	0.0047%	0.0034%
Mean Error (%)	-0.03%	0.01%
Standard Deviation (%)	0.02%	0.03%
Uncertainty in the Mean (%)	0.01%	0.00%
Number of Data Points	16	55
Number of Outliers	1	7

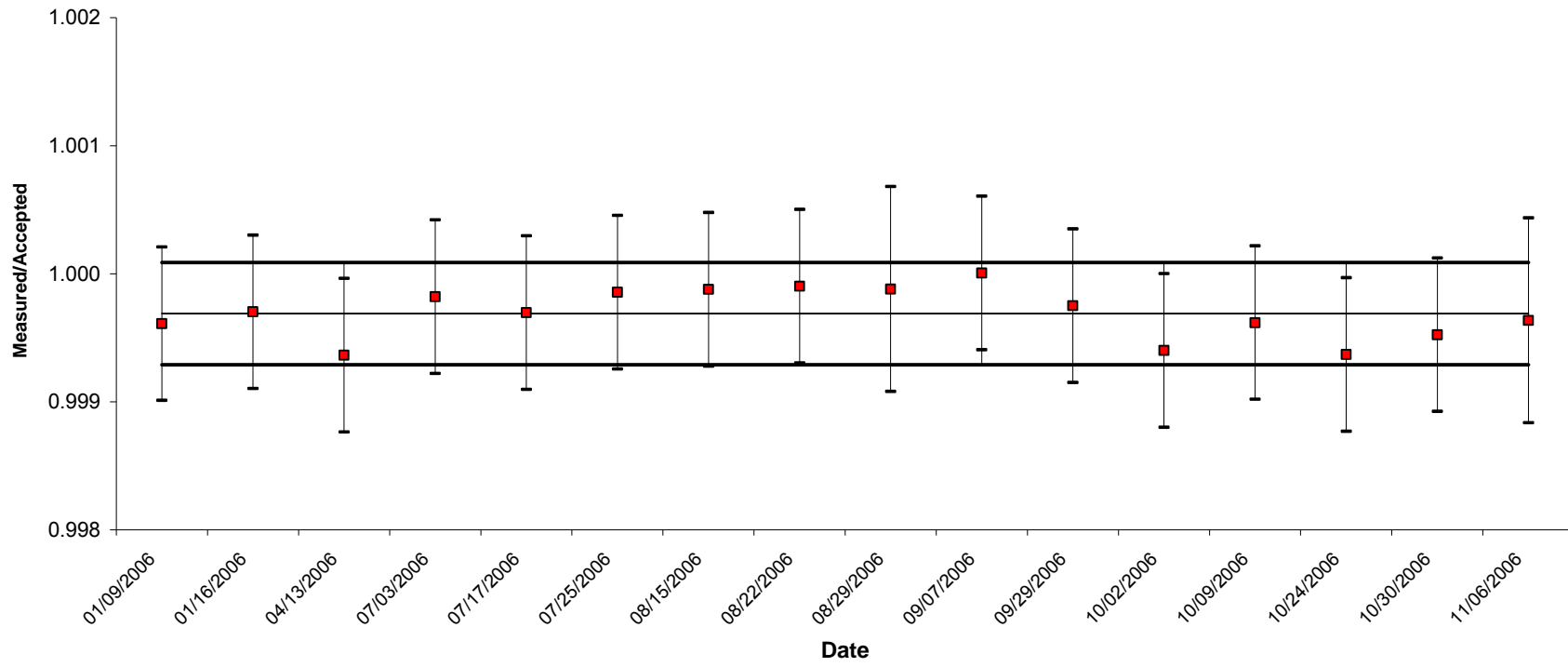
**Difference from Last Year in:**

Mean Error (weight%)	-0.0075%	0.0064%
Standard Deviation (weight%)	-0.0316%	0.0063%
Uncertainty in the Mean (weight%)	-0.0004%	0.0007%
Mean Error (%)	-0.01%	0.01%
Standard Deviation (%)	-0.03%	0.01%
Uncertainty in the Mean (%)	0.00%	0.00%
Number of Data Points	-81	7
Number of Outliers	1	7

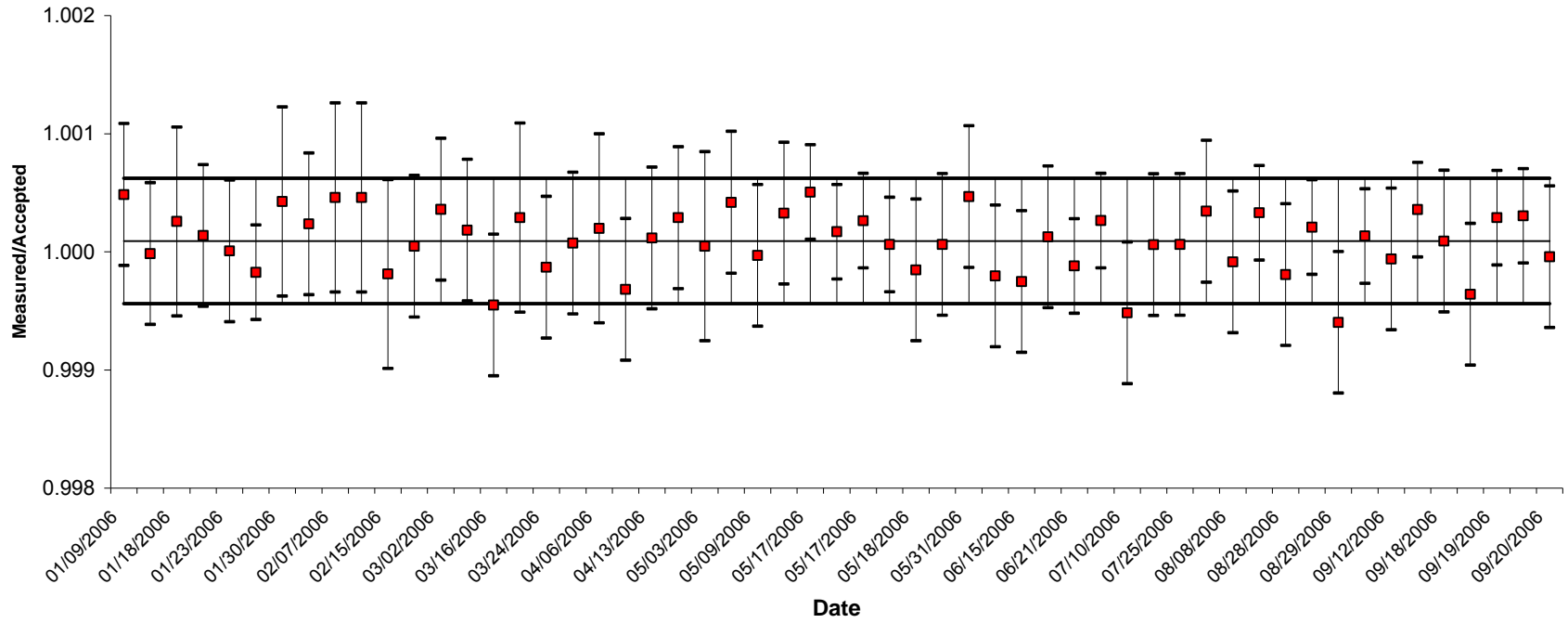
New Brunswick Laboratory Calorimetry Exchange Program  
Percent <sup>239</sup>Pu, 2006



**HAN**  
**<sup>239</sup>Pu, Calex 1**  
**2006**



**LLNL**  
**<sup>239</sup>Pu, Calex 1**  
**2006**



## WEIGHT PERCENT Pu239 DATA

Calendar Year 2006

HAN: Calex I

#	Date Measured	Instr. ID	Measured Pu239	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	2740	93.9624%	0.03%	93.9991%	0.9996	-0.0367%	-0.04%
2	01/16/2006	2740	93.9712%	0.03%	93.9991%	0.9997	-0.0279%	-0.03%
3	04/13/2006	2740	93.9406%	0.03%	94.0004%	0.9994	-0.0598%	-0.06%
4	07/03/2006	2740	93.9847%	0.03%	94.0015%	0.9998	-0.0168%	-0.02%
5	07/17/2006	2740	93.9731%	0.03%	94.0017%	0.9997	-0.0286%	-0.03%
6	07/25/2006	2740	93.9883%	0.03%	94.0018%	0.9999	-0.0135%	-0.01%
7	08/15/2006	2740	93.9907%	0.03%	94.0021%	0.9999	-0.0114%	-0.01%
8	08/22/2006	2740	93.9930%	0.03%	94.0022%	0.9999	-0.0092%	-0.01%
9	08/29/2006	2740	93.9911%	0.04%	94.0023%	0.9999	-0.0112%	-0.01%
10	09/07/2006	2740	94.0030%	0.03%	94.0024%	1.0000	0.0006%	0.00%
<b>11</b>	<b>09/11/2006</b>	<b>2740</b>	<b>93.9074%</b>	<b>0.03%</b>	<b>94.0025%</b>	<b>0.9990</b>	<b>-0.0951%</b>	<b>-0.10%</b>
12	09/29/2006	2740	93.9793%	0.03%	94.0027%	0.9998	-0.0234%	-0.02%
13	10/02/2006	2740	93.9464%	0.03%	94.0027%	0.9994	-0.0563%	-0.06%
14	10/09/2006	2740	93.9670%	0.03%	94.0028%	0.9996	-0.0358%	-0.04%
15	10/24/2006	2740	93.9438%	0.03%	94.0030%	0.9994	-0.0592%	-0.06%
16	10/30/2006	2740	93.9584%	0.03%	94.0031%	0.9995	-0.0447%	-0.05%
17	11/06/2006	2740	93.9690%	0.04%	94.0032%	0.9996	-0.0342%	-0.04%
<b>Mean:</b>						0.9997	-0.0293%	-0.03%
<b>Standard Deviation:</b>						0.0002	0.0188%	0.02%
<b>Standard Uncertainty:</b>						0.0001	0.0047%	0.01%

Statistical outliers are in bold and are not included in graphs and tables.

## WEIGHT PERCENT Pu239 DATA

Calendar Year 2006

LLNL: Calex I

#	Date Measured	Instr. ID	Measured Pu239	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	II	94.0447%	0.03%	93.9991%	1.0005	0.0456%	0.05%
2	01/09/2006	II	93.9976%	0.03%	93.9991%	1.0000	-0.0014%	-0.00%
3	01/18/2006	I	94.0233%	0.04%	93.9992%	1.0003	0.0241%	0.03%
4	01/19/2006	III	94.0122%	0.03%	93.9992%	1.0001	0.0130%	0.01%
<b>5</b>	<b>01/23/2006</b>	<b>II</b>	<b>93.9824%</b>	<b>0.04%</b>	<b>93.9992%</b>	<b>0.9998</b>	<b>-0.0169%</b>	<b>-0.02%</b>
6	01/23/2006	II	93.9999%	0.03%	93.9992%	1.0000	0.0007%	0.00%
7	01/27/2006	III	93.9830%	0.02%	93.9993%	0.9998	-0.0163%	-0.02%
8	01/30/2006	I	94.0394%	0.04%	93.9993%	1.0004	0.0401%	0.04%
9	01/31/2006	II	94.0216%	0.03%	93.9994%	1.0002	0.0223%	0.02%
10	02/07/2006	III	94.0427%	0.04%	93.9995%	1.0005	0.0432%	0.05%
11	02/15/2006	III	94.0428%	0.04%	93.9996%	1.0005	0.0432%	0.05%
12	02/15/2006	III	93.9819%	0.04%	93.9996%	0.9998	-0.0177%	-0.02%
<b>13</b>	<b>02/16/2006</b>	<b>III</b>	<b>94.0222%</b>	<b>0.03%</b>	<b>93.9996%</b>	<b>1.0002</b>	<b>0.0226%</b>	<b>0.02%</b>
<b>14</b>	<b>02/16/2006</b>	<b>III</b>	<b>94.1208%</b>	<b>0.05%</b>	<b>93.9996%</b>	<b>1.0013</b>	<b>0.1213%</b>	<b>0.13%</b>
15	02/23/2006	III	94.0041%	0.03%	93.9997%	1.0000	0.0045%	0.00%
16	03/02/2006	I	94.0337%	0.03%	93.9998%	1.0004	0.0339%	0.04%
17	03/07/2006	I	94.0171%	0.03%	93.9999%	1.0002	0.0173%	0.02%
18	03/16/2006	III	93.9576%	0.03%	94.0000%	0.9995	-0.0424%	-0.05%
<b>19</b>	<b>03/16/2006</b>	<b>III</b>	<b>93.9603%</b>	<b>0.03%</b>	<b>94.0000%</b>	<b>0.9996</b>	<b>-0.0396%</b>	<b>-0.04%</b>
20	03/22/2006	I	94.0272%	0.04%	94.0001%	1.0003	0.0271%	0.03%
21	03/24/2006	III	93.9877%	0.03%	94.0001%	0.9999	-0.0124%	-0.01%
22	03/24/2006	III	94.0070%	0.03%	94.0001%	1.0001	0.0069%	0.01%
23	04/06/2006	I	94.0189%	0.04%	94.0003%	1.0002	0.0187%	0.02%
24	04/11/2006	II	93.9704%	0.03%	94.0003%	0.9997	-0.0299%	-0.03%
25	04/13/2006	III	94.0115%	0.03%	94.0004%	1.0001	0.0111%	0.01%
26	04/18/2006	I	94.0276%	0.03%	94.0004%	1.0003	0.0272%	0.03%
27	05/03/2006	I	94.0051%	0.04%	94.0006%	1.0000	0.0044%	0.00%
28	05/09/2006	I	94.0401%	0.03%	94.0007%	1.0004	0.0394%	0.04%
29	05/09/2006	III	93.9978%	0.03%	94.0007%	1.0000	-0.0029%	-0.00%
30	05/15/2006	I	94.0316%	0.03%	94.0008%	1.0003	0.0308%	0.03%
<b>31</b>	<b>05/16/2006</b>	<b>II</b>	<b>94.0416%</b>	<b>0.03%</b>	<b>94.0008%</b>	<b>1.0004</b>	<b>0.0408%</b>	<b>0.04%</b>
32	05/17/2006	I	94.0484%	0.02%	94.0008%	1.0005	0.0476%	0.05%
33	05/17/2006	I	94.0168%	0.02%	94.0008%	1.0002	0.0159%	0.02%
34	05/17/2006	I	94.0256%	0.02%	94.0008%	1.0003	0.0248%	0.03%
35	05/18/2006	I	94.0067%	0.02%	94.0009%	1.0001	0.0058%	0.01%
36	05/18/2006	III	93.9864%	0.03%	94.0009%	0.9998	-0.0145%	-0.02%
37	05/25/2006	III	94.0069%	0.03%	94.0010%	1.0001	0.0059%	0.01%
38	05/31/2006	I	94.0450%	0.03%	94.0010%	1.0005	0.0440%	0.05%
39	06/07/2006	II	93.9820%	0.03%	94.0011%	0.9998	-0.0192%	-0.02%
40	06/15/2006	III	93.9776%	0.03%	94.0012%	0.9997	-0.0236%	-0.03%
41	06/19/2006	II	94.0132%	0.03%	94.0013%	1.0001	0.0119%	0.01%
42	06/21/2006	I	93.9901%	0.02%	94.0013%	0.9999	-0.0112%	-0.01%
43	06/27/2006	I	94.0263%	0.02%	94.0014%	1.0003	0.0248%	0.03%
<b>44</b>	<b>07/05/2006</b>	<b>I</b>	<b>93.8812%</b>	<b>0.02%</b>	<b>94.0015%</b>	<b>0.9987</b>	<b>-0.1203%</b>	<b>-0.13%</b>
45	07/10/2006	II	93.9531%	0.03%	94.0016%	0.9995	-0.0485%	-0.05%
46	07/20/2006	III	94.0074%	0.03%	94.0017%	1.0001	0.0057%	0.01%
47	07/25/2006	II	94.0077%	0.03%	94.0018%	1.0001	0.0059%	0.01%
<b>48</b>	<b>07/28/2006</b>	<b>I</b>	<b>93.0383%</b>	<b>0.02%</b>	<b>94.0018%</b>	<b>0.9898</b>	<b>-0.9635%</b>	<b>-1.03%</b>
49	08/01/2006	II	94.0342%	0.03%	94.0019%	1.0003	0.0323%	0.03%
50	08/08/2006	III	93.9940%	0.03%	94.0020%	0.9999	-0.0080%	-0.01%
51	08/09/2006	I	94.0331%	0.02%	94.0020%	1.0003	0.0311%	0.03%
52	08/28/2006	II	93.9840%	0.03%	94.0023%	0.9998	-0.0182%	-0.02%
53	08/28/2006	I	94.0219%	0.02%	94.0023%	1.0002	0.0196%	0.02%
54	08/29/2006	III	93.9462%	0.03%	94.0023%	0.9994	-0.0561%	-0.06%
55	09/05/2006	I	94.0149%	0.02%	94.0024%	1.0001	0.0126%	0.01%
56	09/12/2006	III	93.9968%	0.03%	94.0025%	0.9999	-0.0056%	-0.01%
57	09/13/2006	I	94.0361%	0.02%	94.0025%	1.0004	0.0336%	0.04%
58	09/18/2006	II	94.0111%	0.03%	94.0026%	1.0001	0.0086%	0.01%
59	09/18/2006	II	93.9688%	0.03%	94.0026%	0.9996	-0.0337%	-0.04%
60	09/19/2006	I	94.0298%	0.02%	94.0026%	1.0003	0.0272%	0.03%
61	09/19/2006	I	94.0312%	0.02%	94.0026%	1.0003	0.0286%	0.03%
62	09/20/2006	III	93.9986%	0.03%	94.0026%	1.0000	-0.0040%	-0.00%
Mean:						1.0001	0.0086%	0.01%
Standard Deviation:						0.0003	0.0250%	0.03%
Standard Uncertainty:						0.0000	0.0034%	0.00%

Statistical outliers are in bold and are not included in graphs and tables.



**L:  $^{240}\text{Pu}$  ISOTOPE ABUNDANCE TABLES AND GRAPHS**



**RESULTS OF ANALYSIS OF PU240 - CALEX I  
1st QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0361%	-0.0113%
Standard Deviation (weight%)	0.0077%	0.0261%
Uncertainty in the Mean (weight%)	0.0054%	0.0061%
Mean Error (%)	0.62%	-0.19%
Standard Deviation (%)	0.13%	0.44%
Uncertainty in the Mean (%)	0.09%	0.10%
Number of Data Points	2	18
Number of Outliers	0	4

**Difference from Last Quarter in:**

Mean Error (weight%)	0.0147%	-0.0106%
Standard Deviation (weight%)	-0.0404%	-0.0096%
Uncertainty in the Mean (weight%)	-0.0039%	-0.0085%
Mean Error (%)	0.25%	-0.18%
Standard Deviation (%)	-0.69%	-0.17%
Uncertainty in the Mean (%)	-0.07%	-0.15%
Number of Data Points	-25	12
Number of Outliers	0	4

**RESULTS OF ANALYSIS OF PU240 - CALEX I  
2nd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0633%	-0.0082%
Standard Deviation (weight%)	****	0.0212%
Uncertainty in the Mean (weight%)	****	0.0047%
Mean Error (%)	1.08%	-0.14%
Standard Deviation (%)	****	0.36%
Uncertainty in the Mean (%)	****	0.08%
Number of Data Points	1	20
Number of Outliers	0	1

**Difference from Last Quarter in:**

Mean Error (weight%)	0.0272%	0.0031%
Standard Deviation (weight%)	****	-0.0049%
Uncertainty in the Mean (weight%)	****	-0.0014%
Mean Error (%)	0.46%	0.05%
Standard Deviation (%)	****	-0.08%
Uncertainty in the Mean (%)	****	-0.02%
Number of Data Points	-1	2
Number of Outliers	0	-3

**RESULTS OF ANALYSIS OF PU240 - CALEX I  
3rd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0191%	-0.0019%
Standard Deviation (weight%)	0.0089%	0.0281%
Uncertainty in the Mean (weight%)	0.0032%	0.0068%
Mean Error (%)	0.33%	-0.03%
Standard Deviation (%)	0.15%	0.48%
Uncertainty in the Mean (%)	0.05%	0.12%
Number of Data Points	8	17
Number of Outliers	1	2

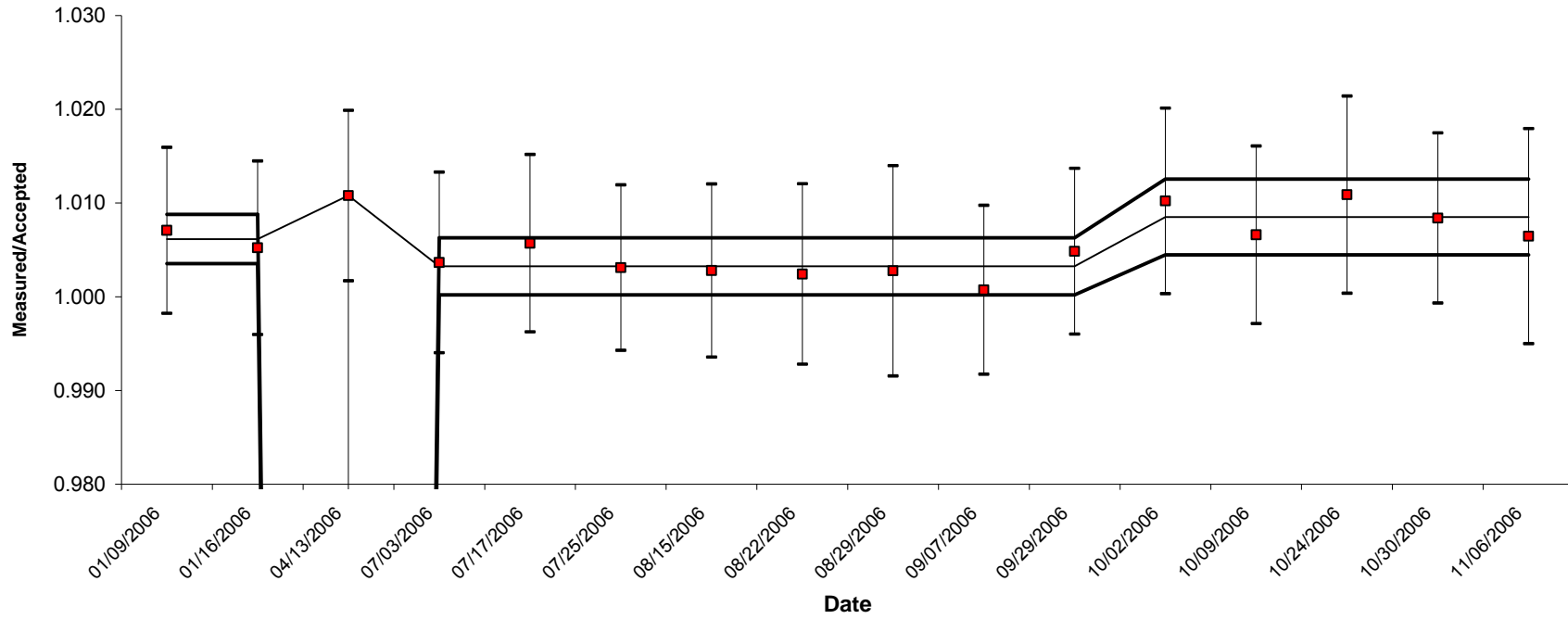
**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0442%	0.0063%
Standard Deviation (weight%)	****	0.0069%
Uncertainty in the Mean (weight%)	****	0.0021%
Mean Error (%)	-0.75%	0.11%
Standard Deviation (%)	****	0.12%
Uncertainty in the Mean (%)	****	0.04%
Number of Data Points	7	-3
Number of Outliers	1	1

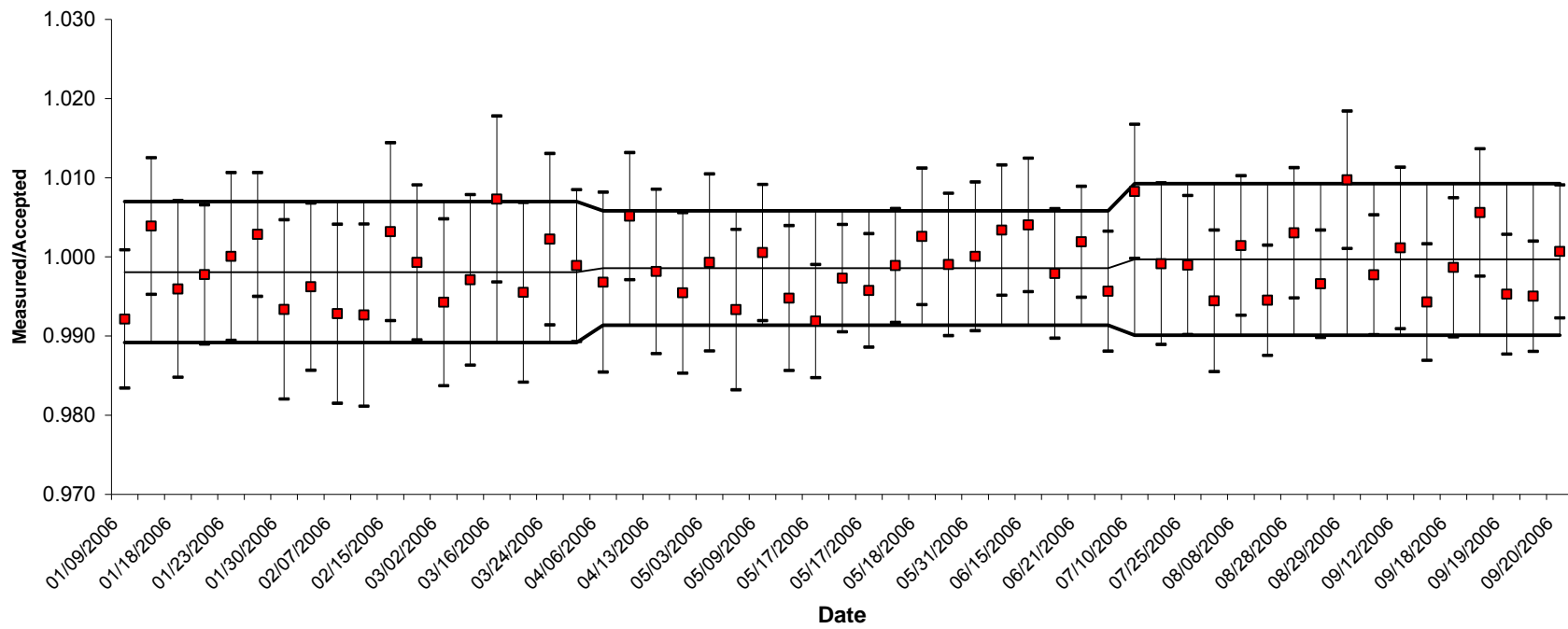
**RESULTS OF ANALYSIS OF PU240 - CALEX I  
4th QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0499%	****
Standard Deviation (weight%)	0.0119%	****
Uncertainty in the Mean (weight%)	0.0053%	****
Mean Error (%)	0.85%	****
Standard Deviation (%)	0.20%	****
Uncertainty in the Mean (%)	0.09%	****
Number of Data Points	5	0
Number of Outliers	0	0
<b>Difference from Last Quarter in:</b>		
Mean Error (weight%)	0.0308%	****
Standard Deviation (weight%)	0.0030%	****
Uncertainty in the Mean (weight%)	0.0021%	****
Mean Error (%)	0.52%	****
Standard Deviation (%)	0.05%	****
Uncertainty in the Mean (%)	0.04%	****
Number of Data Points	-3	-17
Number of Outliers	-1	-2

**HAN**  
**<sup>240</sup>Pu, Calex 1**  
**1st Quarter 2006 - 4th Quarter 2006**



**LLNL**  
**<sup>240</sup>Pu, Calex 1**  
**1st Quarter 2006 - 3rd Quarter 2006**





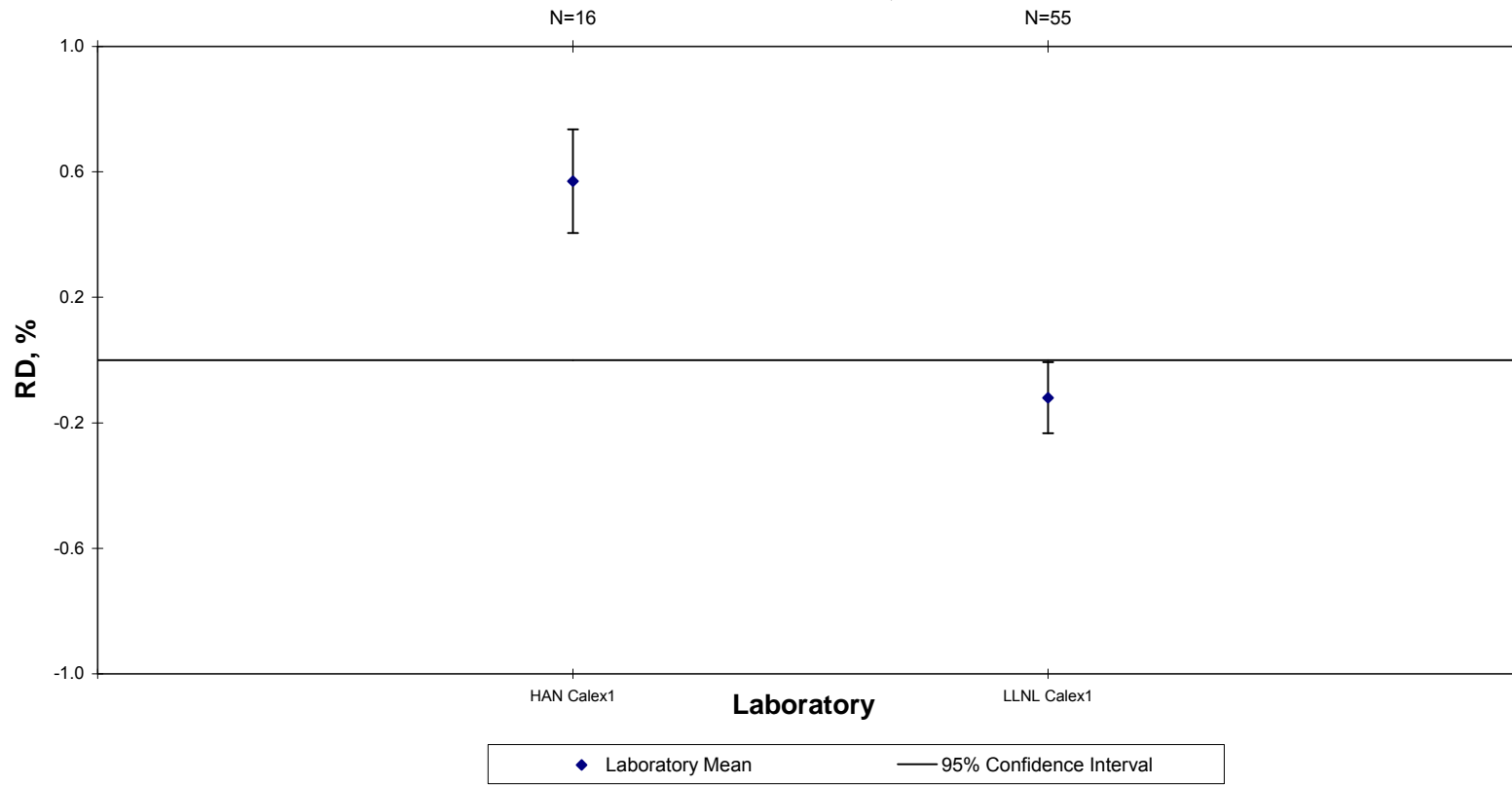
**RESULTS OF ANALYSIS OF PU240 - CALEX I  
2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0336%	-0.0073%
Standard Deviation (weight%)	0.0184%	0.0249%
Uncertainty in the Mean (weight%)	0.0046%	0.0034%
Mean Error (%)	0.57%	-0.12%
Standard Deviation (%)	0.31%	0.42%
Uncertainty in the Mean (%)	0.08%	0.06%
Number of Data Points	16	55
Number of Outliers	1	7

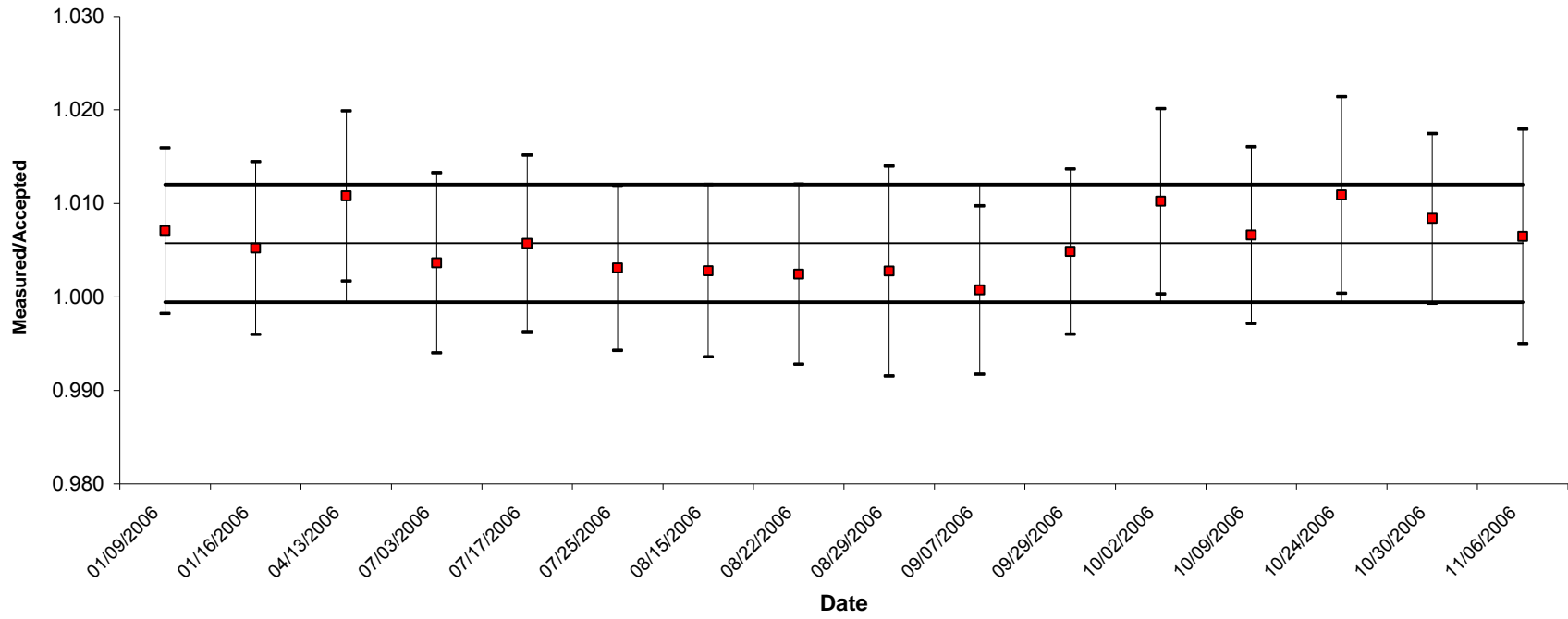
**Difference from Last Year in:**

Mean Error (weight%)	0.0076%	-0.0029%
Standard Deviation (weight%)	-0.0317%	0.0006%
Uncertainty in the Mean (weight%)	-0.0005%	-0.0001%
Mean Error (%)	0.13%	-0.05%
Standard Deviation (%)	-0.55%	0.01%
Uncertainty in the Mean (%)	-0.01%	0.00%
Number of Data Points	-81	7
Number of Outliers	1	7

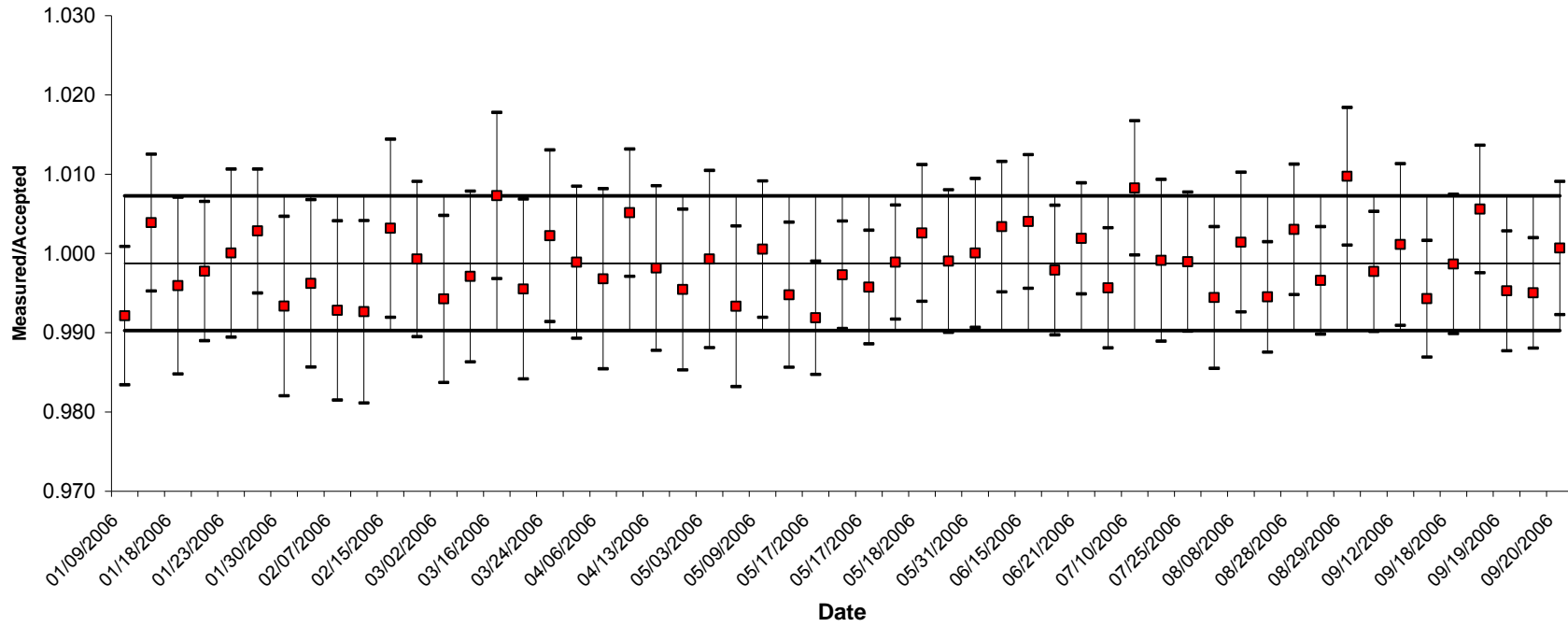
New Brunswick Laboratory Calorimetry Exchange Program  
Percent <sup>240</sup>Pu, 2006



**HAN**  
**<sup>240</sup>Pu, Calex 1**  
**2006**



**LLNL**  
**<sup>240</sup>Pu, Calex 1**  
**2006**



## WEIGHT PERCENT Pu240 DATA

Calendar Year 2006

HAN: Calex I

#	Date Measured	Instr. ID	Measured Pu240	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	2740	5.9021%	0.44%	5.8606%	1.0071	0.0415%	0.71%
2	01/16/2006	2740	5.8912%	0.46%	5.8606%	1.0052	0.0306%	0.52%
3	04/13/2006	2740	5.9238%	0.45%	5.8605%	1.0108	0.0633%	1.08%
4	07/03/2006	2740	5.8819%	0.48%	5.8605%	1.0037	0.0214%	0.36%
5	07/17/2006	2740	5.8940%	0.47%	5.8605%	1.0057	0.0335%	0.57%
6	07/25/2006	2740	5.8787%	0.44%	5.8605%	1.0031	0.0182%	0.31%
7	08/15/2006	2740	5.8769%	0.46%	5.8605%	1.0028	0.0164%	0.28%
8	08/22/2006	2740	5.8747%	0.48%	5.8605%	1.0024	0.0142%	0.24%
9	08/29/2006	2740	5.8767%	0.56%	5.8605%	1.0028	0.0162%	0.28%
10	09/07/2006	2740	5.8648%	0.45%	5.8605%	1.0007	0.0043%	0.07%
<b>11</b>	<b>09/11/2006</b>	<b>2740</b>	<b>5.9598%</b>	<b>0.43%</b>	<b>5.8605%</b>	<b>1.0169</b>	<b>0.0993%</b>	<b>1.69%</b>
12	09/29/2006	2740	5.8889%	0.44%	5.8605%	1.0048	0.0284%	0.48%
13	10/02/2006	2740	5.9204%	0.49%	5.8605%	1.0102	0.0599%	1.02%
14	10/09/2006	2740	5.8992%	0.47%	5.8605%	1.0066	0.0387%	0.66%
15	10/24/2006	2740	5.9243%	0.52%	5.8605%	1.0109	0.0638%	1.09%
16	10/30/2006	2740	5.9097%	0.45%	5.8605%	1.0084	0.0492%	0.84%
17	11/06/2006	2740	5.8984%	0.57%	5.8605%	1.0065	0.0379%	0.65%
<b>Mean:</b>						1.0057	0.0336%	0.57%
<b>Standard Deviation:</b>						0.0031	0.0184%	0.31%
<b>Standard Uncertainty:</b>						0.0008	0.0046%	0.08%

Statistical outliers are in bold and are not included in graphs and tables.

## WEIGHT PERCENT Pu240 DATA

Calendar Year 2006

LLNL: Calex I

#	Date Measured	Instr. ID	Measured Pu240	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	II	5.8146%	0.44%	5.8606%	0.9922	-0.0460%	-0.78%
2	01/09/2006	II	5.8834%	0.43%	5.8606%	1.0039	0.0228%	0.39%
3	01/18/2006	I	5.8368%	0.56%	5.8606%	0.9959	-0.0238%	-0.41%
4	01/19/2006	III	5.8475%	0.44%	5.8606%	0.9978	-0.0131%	-0.22%
<b>5</b>	<b>01/23/2006</b>	<b>II</b>	<b>5.8797%</b>	<b>0.62%</b>	<b>5.8606%</b>	<b>1.0033</b>	<b>0.0192%</b>	<b>0.33%</b>
6	01/23/2006	II	5.8608%	0.53%	5.8606%	1.0000	0.0003%	0.00%
7	01/27/2006	III	5.8772%	0.39%	5.8606%	1.0028	0.0166%	0.28%
8	01/30/2006	I	5.8216%	0.57%	5.8606%	0.9933	-0.0390%	-0.66%
9	01/31/2006	II	5.8384%	0.53%	5.8606%	0.9962	-0.0222%	-0.38%
10	02/07/2006	III	5.8184%	0.57%	5.8606%	0.9928	-0.0422%	-0.72%
11	02/15/2006	III	5.8174%	0.58%	5.8606%	0.9926	-0.0431%	-0.74%
12	02/15/2006	III	5.8792%	0.56%	5.8606%	1.0032	0.0186%	0.32%
<b>13</b>	<b>02/16/2006</b>	<b>III</b>	<b>5.8366%</b>	<b>0.53%</b>	<b>5.8606%</b>	<b>0.9959</b>	<b>-0.0239%</b>	<b>-0.41%</b>
<b>14</b>	<b>02/16/2006</b>	<b>III</b>	<b>5.7395%</b>	<b>0.86%</b>	<b>5.8606%</b>	<b>0.9793</b>	<b>-0.1210%</b>	<b>-2.07%</b>
15	02/23/2006	III	5.8564%	0.49%	5.8606%	0.9993	-0.0042%	-0.07%
16	03/02/2006	I	5.8269%	0.53%	5.8606%	0.9942	-0.0336%	-0.57%
17	03/07/2006	I	5.8436%	0.54%	5.8606%	0.9971	-0.0170%	-0.29%
18	03/16/2006	III	5.9034%	0.52%	5.8606%	1.0073	0.0428%	0.73%
<b>19</b>	<b>03/16/2006</b>	<b>III</b>	<b>5.9001%</b>	<b>0.44%</b>	<b>5.8606%</b>	<b>1.0067</b>	<b>0.0396%</b>	<b>0.67%</b>
20	03/22/2006	I	5.8342%	0.57%	5.8606%	0.9955	-0.0263%	-0.45%
21	03/24/2006	III	5.8736%	0.54%	5.8606%	1.0022	0.0131%	0.22%
22	03/24/2006	III	5.8541%	0.48%	5.8606%	0.9989	-0.0064%	-0.11%
23	04/06/2006	I	5.8418%	0.57%	5.8606%	0.9968	-0.0188%	-0.32%
24	04/11/2006	II	5.8906%	0.40%	5.8606%	1.0051	0.0301%	0.51%
25	04/13/2006	III	5.8497%	0.52%	5.8605%	0.9982	-0.0108%	-0.18%
26	04/18/2006	I	5.8339%	0.51%	5.8605%	0.9955	-0.0267%	-0.46%
27	05/03/2006	I	5.8564%	0.56%	5.8605%	0.9993	-0.0042%	-0.07%
28	05/09/2006	I	5.8215%	0.51%	5.8605%	0.9933	-0.0391%	-0.67%
29	05/09/2006	III	5.8637%	0.43%	5.8605%	1.0005	0.0032%	0.05%
30	05/15/2006	I	5.8300%	0.46%	5.8605%	0.9948	-0.0305%	-0.52%
<b>31</b>	<b>05/16/2006</b>	<b>II</b>	<b>5.8204%</b>	<b>0.42%</b>	<b>5.8605%</b>	<b>0.9932</b>	<b>-0.0402%</b>	<b>-0.69%</b>
32	05/17/2006	I	5.8130%	0.36%	5.8605%	0.9919	-0.0476%	-0.81%
33	05/17/2006	I	5.8447%	0.34%	5.8605%	0.9973	-0.0159%	-0.27%
34	05/17/2006	I	5.8356%	0.36%	5.8605%	0.9958	-0.0249%	-0.43%
35	05/18/2006	I	5.8541%	0.36%	5.8605%	0.9989	-0.0064%	-0.11%
36	05/18/2006	III	5.8757%	0.43%	5.8605%	1.0026	0.0152%	0.26%
37	05/25/2006	III	5.8549%	0.45%	5.8605%	0.9990	-0.0056%	-0.10%
38	05/31/2006	I	5.8609%	0.47%	5.8605%	1.0001	0.0004%	0.01%
39	06/07/2006	II	5.8803%	0.41%	5.8605%	1.0034	0.0198%	0.34%
40	06/15/2006	III	5.8841%	0.42%	5.8605%	1.0040	0.0236%	0.40%
41	06/19/2006	II	5.8482%	0.41%	5.8605%	0.9979	-0.0123%	-0.21%
42	06/21/2006	I	5.8717%	0.35%	5.8605%	1.0019	0.0111%	0.19%
43	06/27/2006	I	5.8351%	0.38%	5.8605%	0.9957	-0.0254%	-0.43%
<b>44</b>	<b>07/05/2006</b>	<b>I</b>	<b>5.8455%</b>	<b>0.33%</b>	<b>5.8605%</b>	<b>0.9974</b>	<b>-0.0150%</b>	<b>-0.26%</b>
45	07/10/2006	II	5.9089%	0.42%	5.8605%	1.0083	0.0484%	0.83%
46	07/20/2006	III	5.8554%	0.51%	5.8605%	0.9991	-0.0051%	-0.09%
47	07/25/2006	II	5.8544%	0.44%	5.8605%	0.9990	-0.0061%	-0.10%
<b>48</b>	<b>07/28/2006</b>	<b>I</b>	<b>5.8234%</b>	<b>0.36%</b>	<b>5.8605%</b>	<b>0.9937</b>	<b>-0.0371%</b>	<b>-0.63%</b>
49	08/01/2006	II	5.8279%	0.45%	5.8605%	0.9944	-0.0326%	-0.56%
50	08/08/2006	III	5.8689%	0.44%	5.8605%	1.0014	0.0084%	0.14%
51	08/09/2006	I	5.8284%	0.35%	5.8605%	0.9945	-0.0321%	-0.55%
52	08/28/2006	II	5.8783%	0.41%	5.8605%	1.0030	0.0178%	0.30%
53	08/28/2006	I	5.8406%	0.34%	5.8605%	0.9966	-0.0199%	-0.34%
54	08/29/2006	III	5.9176%	0.43%	5.8605%	1.0097	0.0571%	0.97%
55	09/05/2006	I	5.8471%	0.38%	5.8605%	0.9977	-0.0134%	-0.23%
56	09/12/2006	III	5.8671%	0.51%	5.8605%	1.0011	0.0066%	0.11%
57	09/13/2006	I	5.8270%	0.37%	5.8605%	0.9943	-0.0335%	-0.57%
58	09/18/2006	II	5.8527%	0.44%	5.8605%	0.9987	-0.0078%	-0.13%
59	09/18/2006	II	5.8933%	0.40%	5.8605%	1.0056	0.0328%	0.56%
60	09/19/2006	I	5.8329%	0.38%	5.8605%	0.9953	-0.0276%	-0.47%
61	09/19/2006	I	5.8313%	0.35%	5.8605%	0.9950	-0.0292%	-0.50%
62	09/20/2006	III	5.8645%	0.42%	5.8605%	1.0007	0.0040%	0.07%
Mean:						0.9988	-0.0073%	-0.12%
Standard Deviation:						0.0042	0.0249%	0.42%
Standard Uncertainty:						0.0006	0.0034%	0.06%

Statistical outliers are in bold and are not included in graphs and tables.

**M.  $^{241}\text{Pu}$  ISOTOPE ABUNDANCE TABLES AND GRAPHS**





**RESULTS OF ANALYSIS OF PU241 - CALEX I  
1st QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0003%	-0.0002%
Standard Deviation (weight%)	0.0010%	0.0004%
Uncertainty in the Mean (weight%)	0.0007%	0.0001%
Mean Error (%)	0.32%	-0.21%
Standard Deviation (%)	0.96%	0.37%
Uncertainty in the Mean (%)	0.68%	0.09%
Number of Data Points	2	18
Number of Outliers	0	4

**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0003%	-0.0002%
Standard Deviation (weight%)	0.0001%	-0.0005%
Uncertainty in the Mean (weight%)	0.0005%	-0.0003%
Mean Error (%)	-0.31%	-0.16%
Standard Deviation (%)	0.09%	-0.54%
Uncertainty in the Mean (%)	0.51%	-0.28%
Number of Data Points	-25	12
Number of Outliers	0	4

**RESULTS OF ANALYSIS OF PU241 - CALEX I  
2nd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0010%	0.0001%
Standard Deviation (weight%)	****	0.0004%
Uncertainty in the Mean (weight%)	****	0.0001%
Mean Error (%)	0.98%	0.07%
Standard Deviation (%)	****	0.35%
Uncertainty in the Mean (%)	****	0.08%
Number of Data Points	1	20
Number of Outliers	0	1

**Difference from Last Quarter in:**

Mean Error (weight%)	0.0007%	0.0003%
Standard Deviation (weight%)	****	0.0000%
Uncertainty in the Mean (weight%)	****	0.0000%
Mean Error (%)	0.66%	0.28%
Standard Deviation (%)	****	-0.02%
Uncertainty in the Mean (%)	****	-0.01%
Number of Data Points	-1	2
Number of Outliers	0	-3

**RESULTS OF ANALYSIS OF PU241 - CALEX I  
3rd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0000%	0.0004%
Standard Deviation (weight%)	0.0003%	0.0006%
Uncertainty in the Mean (weight%)	0.0001%	0.0001%
Mean Error (%)	-0.04%	0.36%
Standard Deviation (%)	0.27%	0.58%
Uncertainty in the Mean (%)	0.09%	0.14%
Number of Data Points	8	17
Number of Outliers	1	2

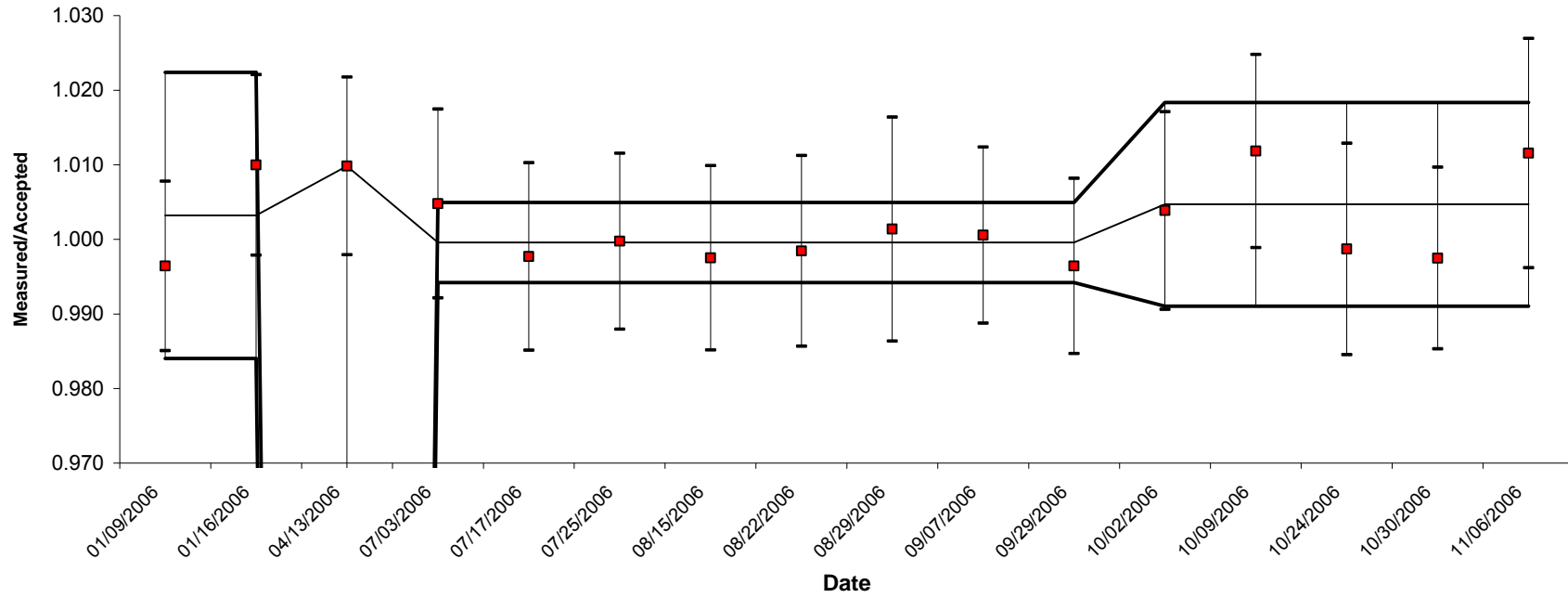
**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0010%	0.0003%
Standard Deviation (weight%)	****	0.0002%
Uncertainty in the Mean (weight%)	****	0.0000%
Mean Error (%)	-1.02%	0.29%
Standard Deviation (%)	****	0.23%
Uncertainty in the Mean (%)	****	0.06%
Number of Data Points	7	-3
Number of Outliers	1	1

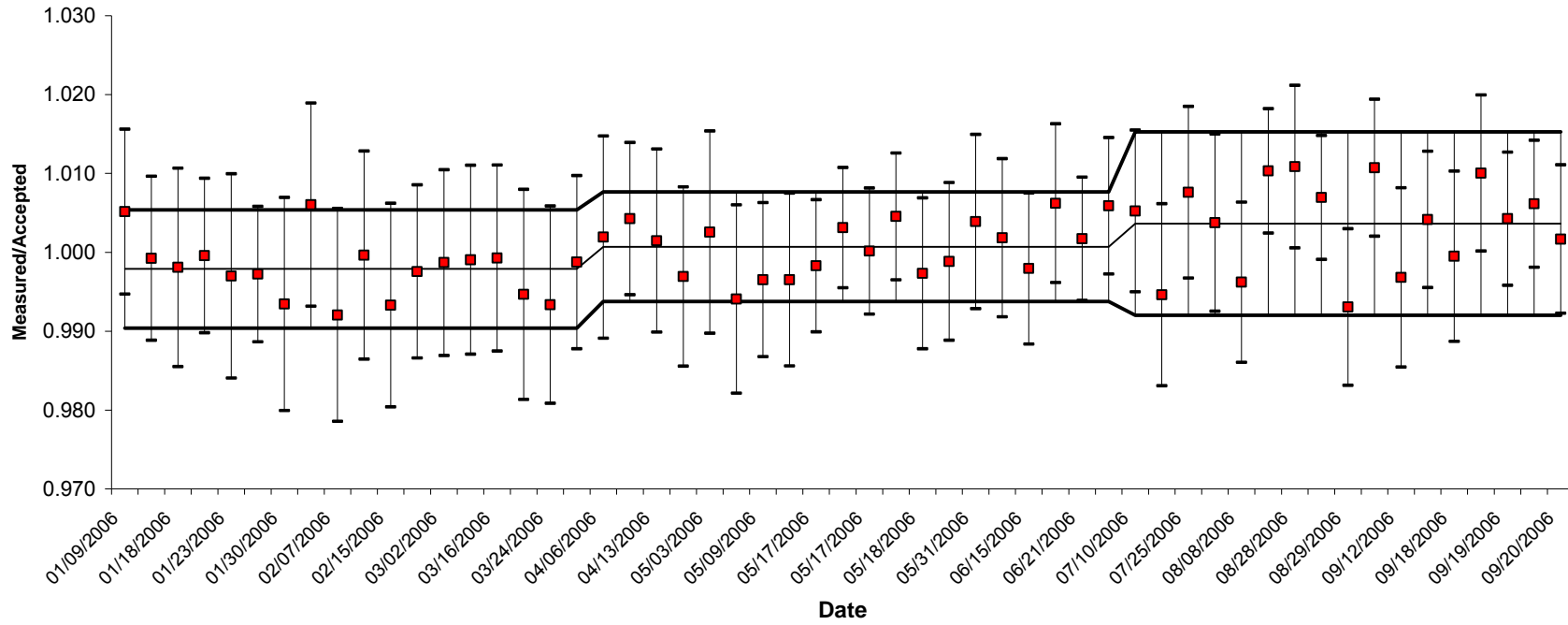
**RESULTS OF ANALYSIS OF PU241 - CALEX I  
4th QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0005%	****
Standard Deviation (weight%)	0.0007%	****
Uncertainty in the Mean (weight%)	0.0003%	****
Mean Error (%)	0.47%	****
Standard Deviation (%)	0.68%	****
Uncertainty in the Mean (%)	0.31%	****
Number of Data Points	5	0
Number of Outliers	0	0
<b>Difference from Last Quarter in:</b>		
Mean Error (weight%)	0.0005%	****
Standard Deviation (weight%)	0.0004%	****
Uncertainty in the Mean (weight%)	0.0002%	****
Mean Error (%)	0.51%	****
Standard Deviation (%)	0.41%	****
Uncertainty in the Mean (%)	0.22%	****
Number of Data Points	-3	-17
Number of Outliers	-1	-2

**HAN**  
**<sup>241</sup>Pu, Calex 1**  
**1st Quarter 2006 - 4th Quarter 2006**



**LLNL**  
**<sup>241</sup>Pu, Calex 1**  
**1st Quarter 2006 - 3rd Quarter 2006**



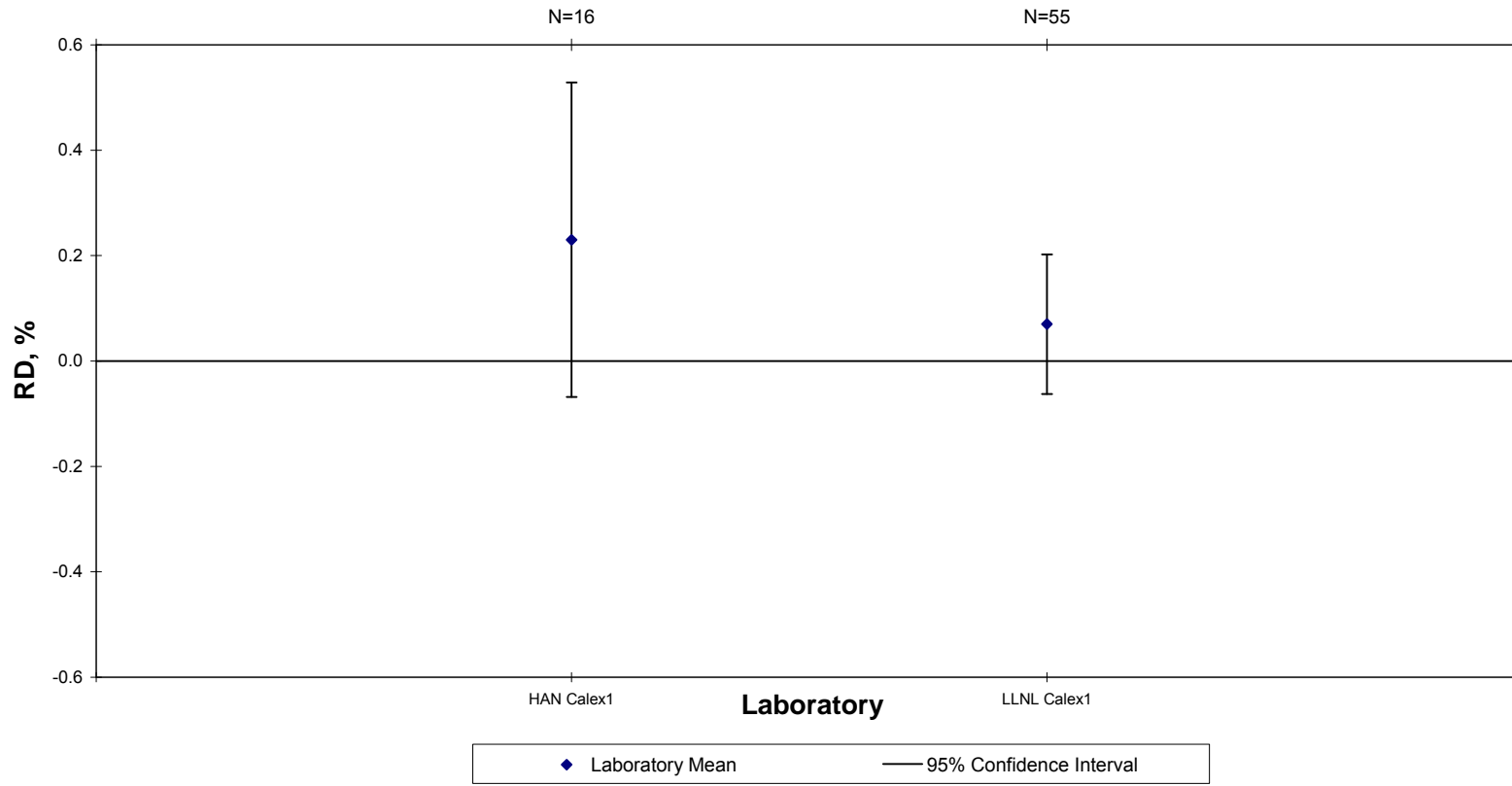
**RESULTS OF ANALYSIS OF PU241 - CALEX I  
2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	0.0002%	0.0001%
Standard Deviation (weight%)	0.0006%	0.0005%
Uncertainty in the Mean (weight%)	0.0001%	0.0001%
Mean Error (%)	0.23%	0.07%
Standard Deviation (%)	0.56%	0.49%
Uncertainty in the Mean (%)	0.14%	0.07%
Number of Data Points	16	55
Number of Outliers	1	7

**Difference from Last Year in:**

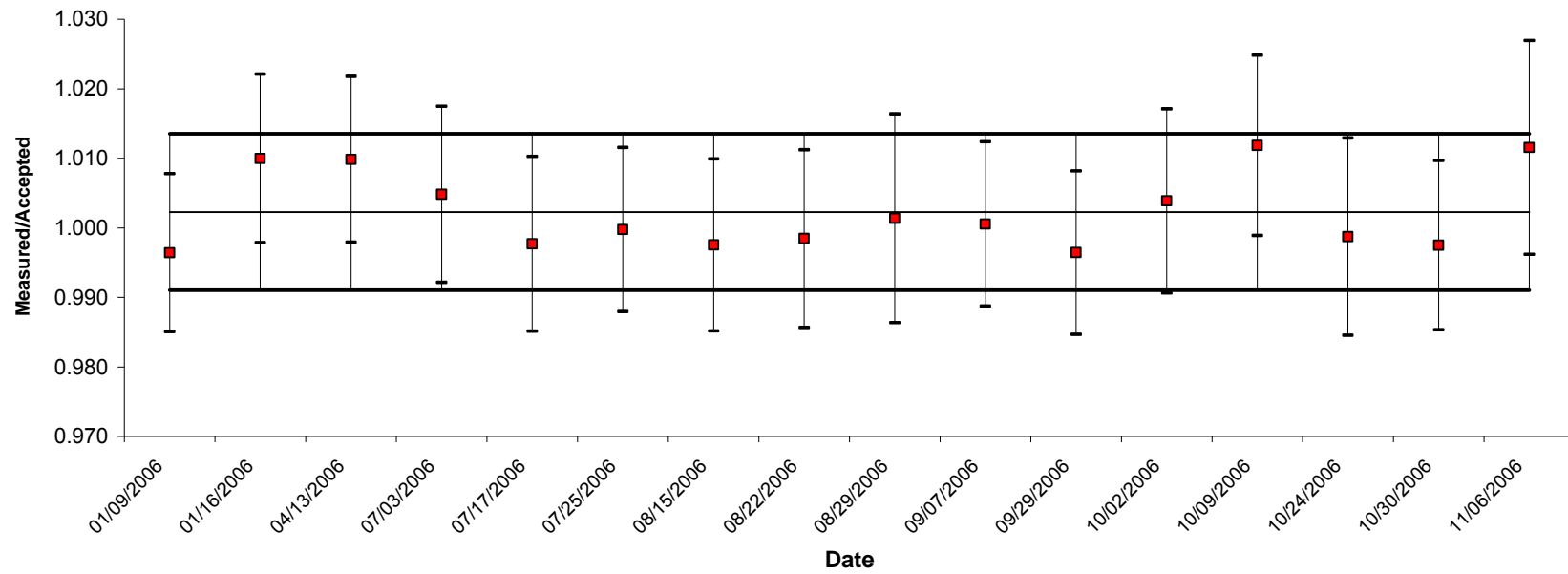
Mean Error (weight%)	-0.0001%	0.0001%
Standard Deviation (weight%)	-0.0001%	-0.0001%
Uncertainty in the Mean (weight%)	0.0000%	0.0000%
Mean Error (%)	-0.10%	0.08%
Standard Deviation (%)	-0.13%	-0.04%
Uncertainty in the Mean (%)	0.07%	-0.01%
Number of Data Points	-81	7
Number of Outliers	1	7

New Brunswick Laboratory Calorimetry Exchange Program  
Percent <sup>241</sup>Pu, 2006

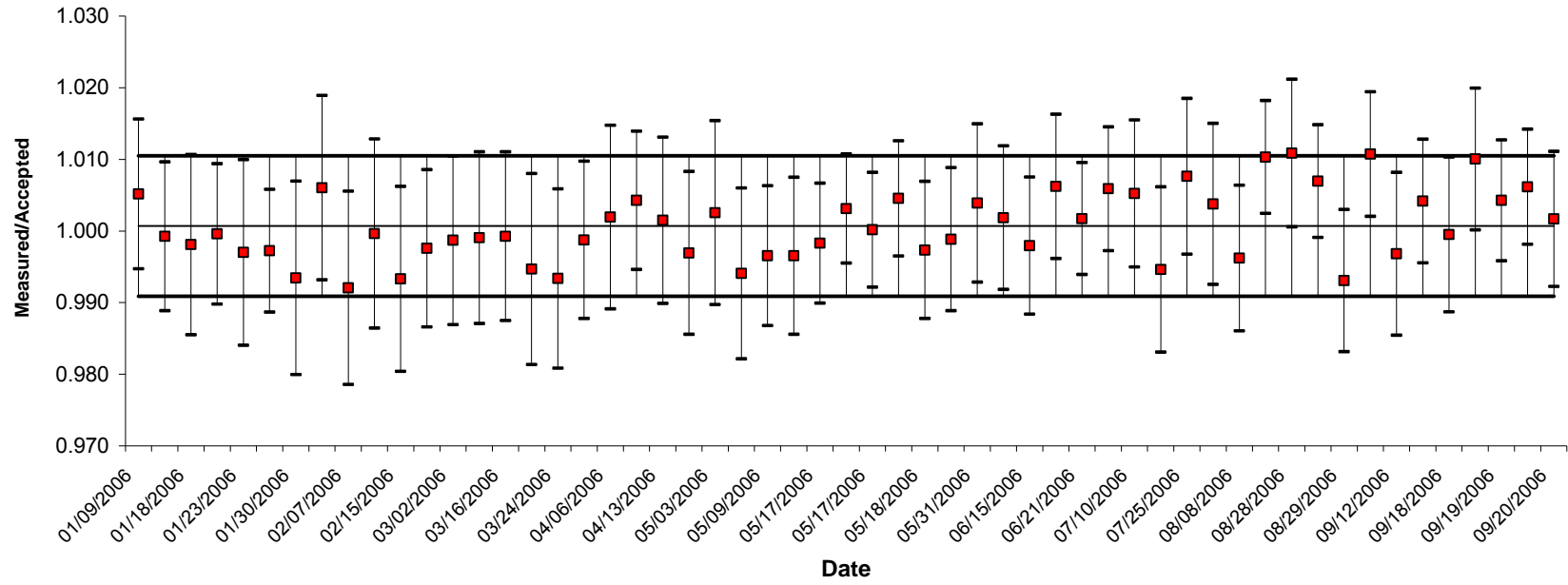




**HAN**  
**<sup>241</sup>Pu, Calex 1**  
**2006**



**LLNL**  
**<sup>241</sup>Pu, Calex 1**  
**2006**



## WEIGHT PERCENT Pu241 DATA

Calendar Year 2006

HAN: Calex I

#	Date Measured	Instr. ID	Measured Pu241	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	2740	0.1026%	0.57%	0.1030%	0.9961	-0.0004%	-0.36%
2	01/16/2006	2740	0.1039%	0.60%	0.1029%	1.0097	0.0010%	1.00%
3	04/13/2006	2740	0.1027%	0.59%	0.1017%	1.0098	0.0010%	0.98%
4	07/03/2006	2740	0.1011%	0.63%	0.1006%	1.0050	0.0005%	0.48%
5	07/17/2006	2740	0.1002%	0.63%	0.1004%	0.9980	-0.0002%	-0.23%
6	07/25/2006	2740	0.1003%	0.59%	0.1003%	1.0000	-0.0000%	-0.03%
7	08/15/2006	2740	0.0998%	0.62%	0.1000%	0.9980	-0.0002%	-0.25%
8	08/22/2006	2740	0.0998%	0.64%	0.1000%	0.9980	-0.0002%	-0.16%
9	08/29/2006	2740	0.1000%	0.75%	0.0999%	1.0010	0.0001%	0.14%
10	09/07/2006	2740	0.0998%	0.59%	0.0997%	1.0010	0.0001%	0.06%
<b>11</b>	<b>09/11/2006</b>	<b>2740</b>	<b>0.1000%</b>	<b>0.58%</b>	<b>0.0997%</b>	<b>1.0030</b>	<b>0.0003%</b>	<b>0.31%</b>
12	09/29/2006	2740	0.0991%	0.59%	0.0995%	0.9960	-0.0004%	-0.36%
13	10/02/2006	2740	0.0998%	0.66%	0.0994%	1.0040	0.0004%	0.39%
14	10/09/2006	2740	0.1005%	0.64%	0.0993%	1.0121	0.0012%	1.18%
15	10/24/2006	2740	0.0990%	0.71%	0.0991%	0.9990	-0.0001%	-0.13%
16	10/30/2006	2740	0.0988%	0.61%	0.0990%	0.9980	-0.0002%	-0.25%
17	11/06/2006	2740	0.1001%	0.76%	0.0990%	1.0111	0.0011%	1.16%
<b>Mean:</b>						1.0023	0.0002%	0.23%
<b>Standard Deviation:</b>						0.0056	0.0006%	0.56%
<b>Standard Uncertainty:</b>						0.0014	0.0001%	0.14%

Statistical outliers are in bold and are not included in graphs and tables.

## WEIGHT PERCENT Pu241 DATA

Calendar Year 2006

LLNL: Calex I

#	Date Measured	Instr. ID	Measured Pu241	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	II	0.1035%	0.52%	0.1030%	1.0049	0.0005%	0.52%
2	01/09/2006	II	0.1029%	0.52%	0.1030%	0.9990	-0.0001%	-0.08%
3	01/18/2006	I	0.1026%	0.63%	0.1028%	0.9981	-0.0002%	-0.19%
4	01/19/2006	III	0.1028%	0.49%	0.1028%	1.0000	-0.0000%	-0.04%
<b>5</b>	<b>01/23/2006</b>	<b>II</b>	<b>0.1015%</b>	<b>0.77%</b>	<b>0.1028%</b>	<b>0.9874</b>	<b>-0.0012%</b>	<b>-1.21%</b>
6	01/23/2006	II	0.1025%	0.65%	0.1028%	0.9971	-0.0003%	-0.30%
7	01/27/2006	III	0.1024%	0.43%	0.1027%	0.9971	-0.0003%	-0.28%
8	01/30/2006	I	0.1020%	0.68%	0.1027%	0.9932	-0.0007%	-0.66%
9	01/31/2006	II	0.1033%	0.64%	0.1027%	1.0058	0.0006%	0.60%
10	02/07/2006	III	0.1018%	0.68%	0.1026%	0.9922	-0.0008%	-0.79%
11	02/15/2006	III	0.1024%	0.66%	0.1025%	0.9990	-0.0000%	-0.04%
12	02/15/2006	III	0.1018%	0.65%	0.1025%	0.9932	-0.0007%	-0.67%
<b>13</b>	<b>02/16/2006</b>	<b>III</b>	<b>0.1038%</b>	<b>0.60%</b>	<b>0.1025%</b>	<b>1.0127</b>	<b>0.0014%</b>	<b>1.36%</b>
<b>14</b>	<b>02/16/2006</b>	<b>III</b>	<b>0.1025%</b>	<b>0.95%</b>	<b>0.1025%</b>	<b>1.0000</b>	<b>0.0001%</b>	<b>0.06%</b>
15	02/23/2006	III	0.1021%	0.55%	0.1024%	0.9971	-0.0002%	-0.24%
16	03/02/2006	I	0.1021%	0.59%	0.1023%	0.9980	-0.0001%	-0.13%
17	03/07/2006	I	0.1021%	0.60%	0.1022%	0.9990	-0.0001%	-0.09%
18	03/16/2006	III	0.1020%	0.59%	0.1021%	0.9990	-0.0001%	-0.07%
<b>19</b>	<b>03/16/2006</b>	<b>III</b>	<b>0.1022%</b>	<b>0.49%</b>	<b>0.1021%</b>	<b>1.0010</b>	<b>0.0001%</b>	<b>0.13%</b>
20	03/22/2006	I	0.1014%	0.67%	0.1020%	0.9941	-0.0005%	-0.53%
21	03/24/2006	III	0.1013%	0.63%	0.1020%	0.9931	-0.0007%	-0.66%
22	03/24/2006	III	0.1018%	0.55%	0.1020%	0.9980	-0.0001%	-0.12%
23	04/06/2006	I	0.1020%	0.64%	0.1018%	1.0020	0.0002%	0.19%
24	04/11/2006	II	0.1022%	0.48%	0.1017%	1.0049	0.0004%	0.43%
25	04/13/2006	III	0.1018%	0.58%	0.1017%	1.0010	0.0002%	0.15%
26	04/18/2006	I	0.1013%	0.57%	0.1016%	0.9970	-0.0003%	-0.31%
27	05/03/2006	I	0.1017%	0.64%	0.1014%	1.0030	0.0003%	0.26%
28	05/09/2006	I	0.1008%	0.60%	0.1014%	0.9941	-0.0006%	-0.59%
29	05/09/2006	III	0.1010%	0.49%	0.1014%	0.9961	-0.0004%	-0.35%
30	05/15/2006	I	0.1009%	0.55%	0.1013%	0.9961	-0.0004%	-0.35%
<b>31</b>	<b>05/16/2006</b>	<b>II</b>	<b>0.1016%</b>	<b>0.51%</b>	<b>0.1013%</b>	<b>1.0030</b>	<b>0.0003%</b>	<b>0.30%</b>
32	05/17/2006	I	0.1011%	0.42%	0.1012%	0.9990	-0.0002%	-0.17%
33	05/17/2006	I	0.1016%	0.38%	0.1012%	1.0040	0.0003%	0.31%
34	05/17/2006	I	0.1013%	0.40%	0.1012%	1.0010	0.0000%	0.02%
35	05/18/2006	I	0.1017%	0.40%	0.1012%	1.0049	0.0005%	0.45%
36	05/18/2006	III	0.1010%	0.48%	0.1012%	0.9980	-0.0003%	-0.27%
37	05/25/2006	III	0.1010%	0.50%	0.1011%	0.9990	-0.0001%	-0.12%
38	05/31/2006	I	0.1014%	0.55%	0.1011%	1.0030	0.0004%	0.39%
39	06/07/2006	II	0.1012%	0.50%	0.1010%	1.0020	0.0002%	0.19%
40	06/15/2006	III	0.1006%	0.48%	0.1009%	0.9970	-0.0002%	-0.20%
41	06/19/2006	II	0.1014%	0.50%	0.1008%	1.0060	0.0006%	0.62%
42	06/21/2006	I	0.1010%	0.39%	0.1008%	1.0020	0.0002%	0.17%
43	06/27/2006	I	0.1013%	0.43%	0.1007%	1.0060	0.0006%	0.59%
<b>44</b>	<b>07/05/2006</b>	<b>I</b>	<b>0.2348%</b>	<b>0.21%</b>	<b>0.1006%</b>	<b>2.3340</b>	<b>0.1342%</b>	<b>133.38%</b>
45	07/10/2006	II	0.1011%	0.51%	0.1005%	1.0060	0.0005%	0.52%
46	07/20/2006	III	0.0999%	0.58%	0.1004%	0.9950	-0.0005%	-0.54%
47	07/25/2006	II	0.1011%	0.54%	0.1003%	1.0080	0.0008%	0.76%
<b>48</b>	<b>07/28/2006</b>	<b>I</b>	<b>0.1008%</b>	<b>0.42%</b>	<b>0.1003%</b>	<b>1.0050</b>	<b>0.0006%</b>	<b>0.55%</b>
49	08/01/2006	II	0.1006%	0.56%	0.1002%	1.0040	0.0004%	0.38%
50	08/08/2006	III	0.0998%	0.51%	0.1001%	0.9970	-0.0004%	-0.38%
51	08/09/2006	I	0.1012%	0.39%	0.1001%	1.0110	0.0010%	1.03%
52	08/28/2006	II	0.1010%	0.51%	0.0999%	1.0110	0.0011%	1.09%
53	08/28/2006	I	0.1006%	0.39%	0.0999%	1.0070	0.0007%	0.70%
54	08/29/2006	III	0.0992%	0.50%	0.0999%	0.9930	-0.0007%	-0.69%
55	09/05/2006	I	0.1008%	0.43%	0.0998%	1.0100	0.0011%	1.07%
56	09/12/2006	III	0.0994%	0.57%	0.0997%	0.9970	-0.0003%	-0.32%
57	09/13/2006	I	0.1001%	0.43%	0.0997%	1.0040	0.0004%	0.42%
58	09/18/2006	II	0.0996%	0.54%	0.0996%	1.0000	-0.0000%	-0.05%
59	09/18/2006	II	0.1006%	0.49%	0.0996%	1.0100	0.0010%	1.00%
60	09/19/2006	I	0.1000%	0.42%	0.0996%	1.0040	0.0004%	0.43%
61	09/19/2006	I	0.1002%	0.40%	0.0996%	1.0060	0.0006%	0.62%
62	09/20/2006	III	0.0997%	0.47%	0.0996%	1.0010	0.0002%	0.17%
Mean:						1.0007	0.0001%	0.07%
Standard Deviation:						0.0050	0.0005%	0.49%
Standard Uncertainty:						0.0007	0.0001%	0.07%

Statistical outliers are in bold and are not included in graphs and tables.

**N. <sup>241</sup>Am ISOTOPE ABUNDANCE TABLES AND GRAPHS**



**RESULTS OF ANALYSIS OF AM241 - CALEX I  
1st QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0030%	-0.0018%
Standard Deviation (weight%)	0.0004%	0.0010%
Uncertainty in the Mean (weight%)	0.0003%	0.0002%
Mean Error (%)	-1.10%	-0.65%
Standard Deviation (%)	0.14%	0.37%
Uncertainty in the Mean (%)	0.10%	0.09%
Number of Data Points	2	18
Number of Outliers	0	4

**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0016%	-0.0002%
Standard Deviation (weight%)	-0.0007%	0.0000%
Uncertainty in the Mean (weight%)	0.0001%	-0.0002%
Mean Error (%)	-0.59%	-0.04%
Standard Deviation (%)	-0.29%	0.01%
Uncertainty in the Mean (%)	0.02%	-0.06%
Number of Data Points	-25	12
Number of Outliers	0	4

**RESULTS OF ANALYSIS OF AM241 - CALEX I  
2nd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0034%	-0.0020%
Standard Deviation (weight%)	****	0.0012%
Uncertainty in the Mean (weight%)	****	0.0003%
Mean Error (%)	-1.25%	-0.76%
Standard Deviation (%)	****	0.44%
Uncertainty in the Mean (%)	****	0.10%
Number of Data Points	1	20
Number of Outliers	0	1

**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0004%	-0.0002%
Standard Deviation (weight%)	****	0.0002%
Uncertainty in the Mean (weight%)	****	0.0001%
Mean Error (%)	-0.15%	-0.11%
Standard Deviation (%)	****	0.07%
Uncertainty in the Mean (%)	****	0.01%
Number of Data Points	-1	2
Number of Outliers	0	-3



**RESULTS OF ANALYSIS OF AM241 - CALEX I  
3rd QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0035%	-0.0018%
Standard Deviation (weight%)	0.0009%	0.0010%
Uncertainty in the Mean (weight%)	0.0003%	0.0002%
Mean Error (%)	-1.28%	-0.65%
Standard Deviation (%)	0.33%	0.37%
Uncertainty in the Mean (%)	0.12%	0.09%
Number of Data Points	8	17
Number of Outliers	1	2

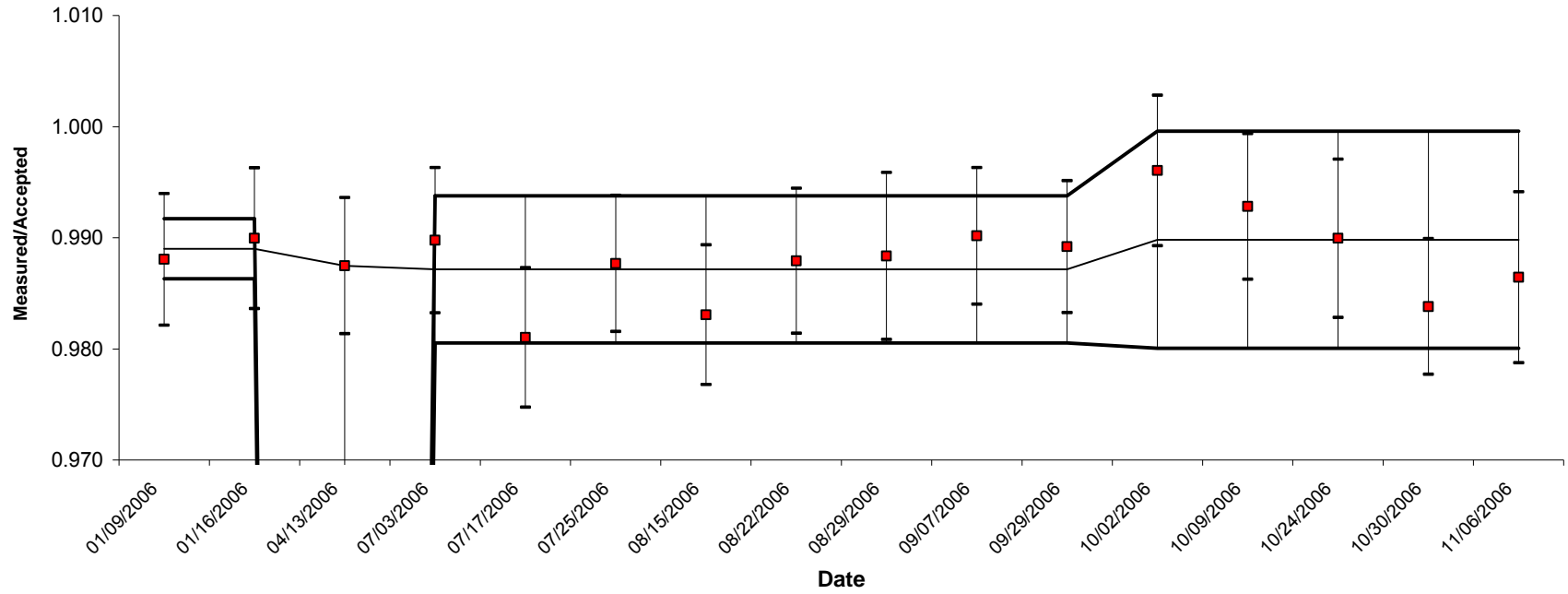
**Difference from Last Quarter in:**

Mean Error (weight%)	-0.0001%	0.0002%
Standard Deviation (weight%)	****	-0.0002%
Uncertainty in the Mean (weight%)	****	-0.0001%
Mean Error (%)	-0.03%	0.11%
Standard Deviation (%)	****	-0.07%
Uncertainty in the Mean (%)	****	-0.01%
Number of Data Points	7	-3
Number of Outliers	1	1

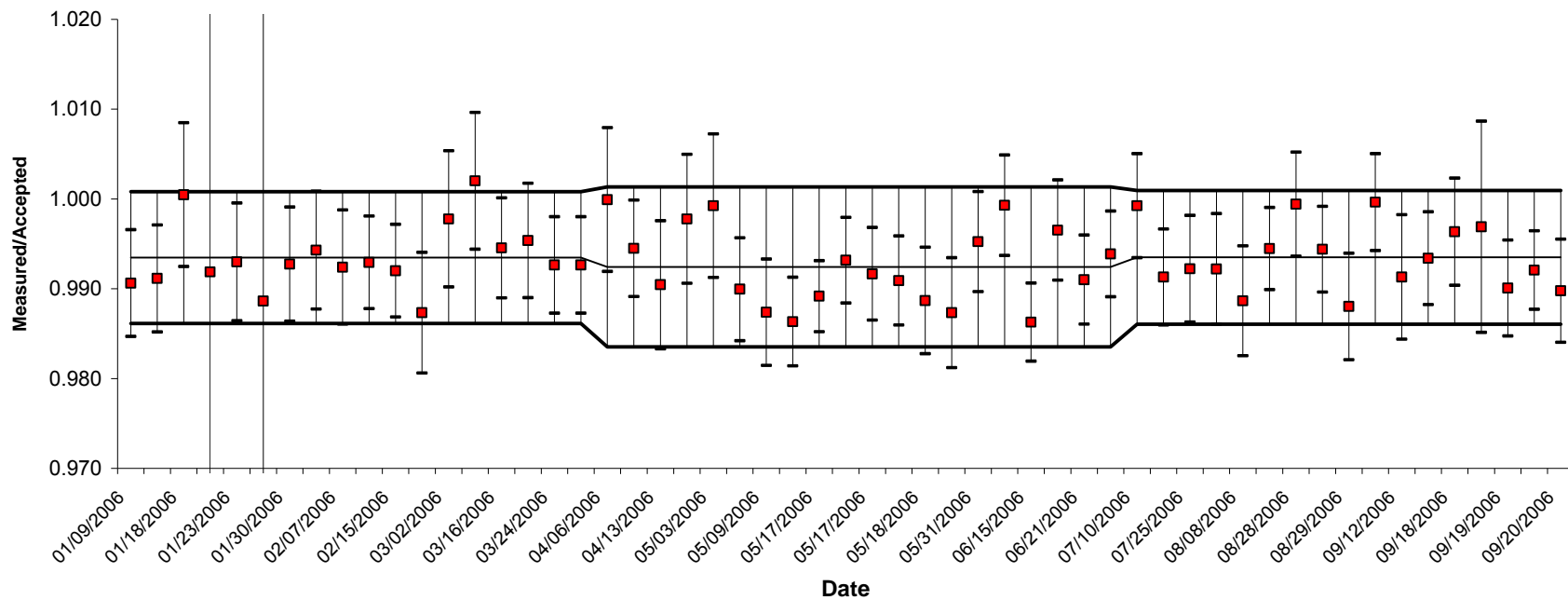
**RESULTS OF ANALYSIS OF AM241 - CALEX I  
4th QUARTER 2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0028%	****
Standard Deviation (weight%)	0.0013%	****
Uncertainty in the Mean (weight%)	0.0006%	****
Mean Error (%)	-1.02%	****
Standard Deviation (%)	0.49%	****
Uncertainty in the Mean (%)	0.22%	****
Number of Data Points	5	0
Number of Outliers	0	0
<b>Difference from Last Quarter in:</b>		
Mean Error (weight%)	0.0007%	****
Standard Deviation (weight%)	0.0004%	****
Uncertainty in the Mean (weight%)	0.0003%	****
Mean Error (%)	0.26%	****
Standard Deviation (%)	0.16%	****
Uncertainty in the Mean (%)	0.10%	****
Number of Data Points	-3	-17
Number of Outliers	-1	-2

**HAN**  
**<sup>241</sup>Am, Calex 1**  
**1st Quarter 2006 - 4th Quarter 2006**



**LLNL**  
**<sup>241</sup>Am, Calex 1**  
**1st Quarter 2006 - 3rd Quarter 2006**



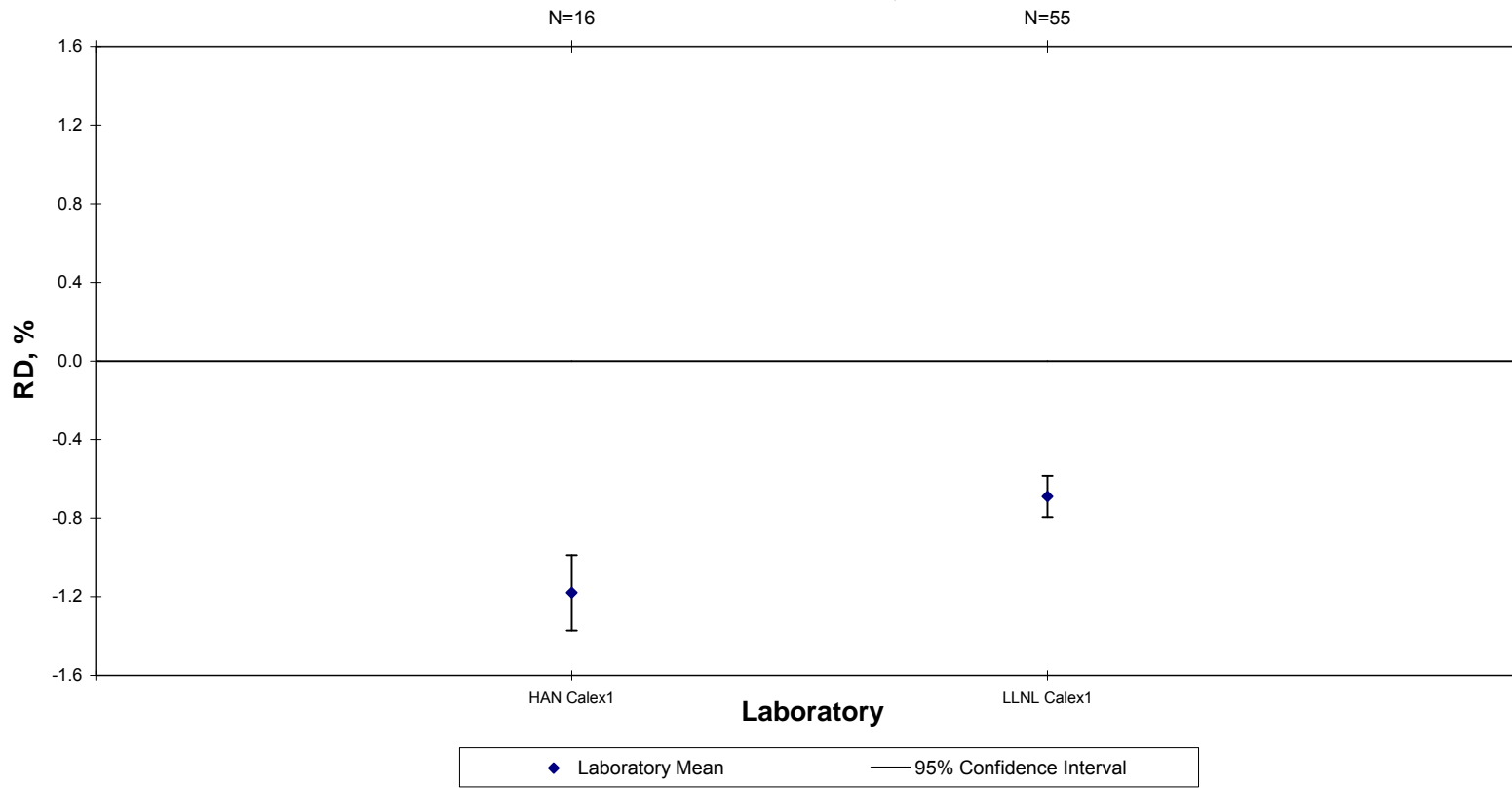
**RESULTS OF ANALYSIS OF AM241 - CALEX I  
2006**

	<b>HAN</b>	<b>LLNL</b>
Mean Error (weight%)	-0.0032%	-0.0019%
Standard Deviation (weight%)	0.0010%	0.0011%
Uncertainty in the Mean (weight%)	0.0002%	0.0001%
Mean Error (%)	-1.18%	-0.69%
Standard Deviation (%)	0.36%	0.39%
Uncertainty in the Mean (%)	0.09%	0.05%
Number of Data Points	16	55
Number of Outliers	1	7

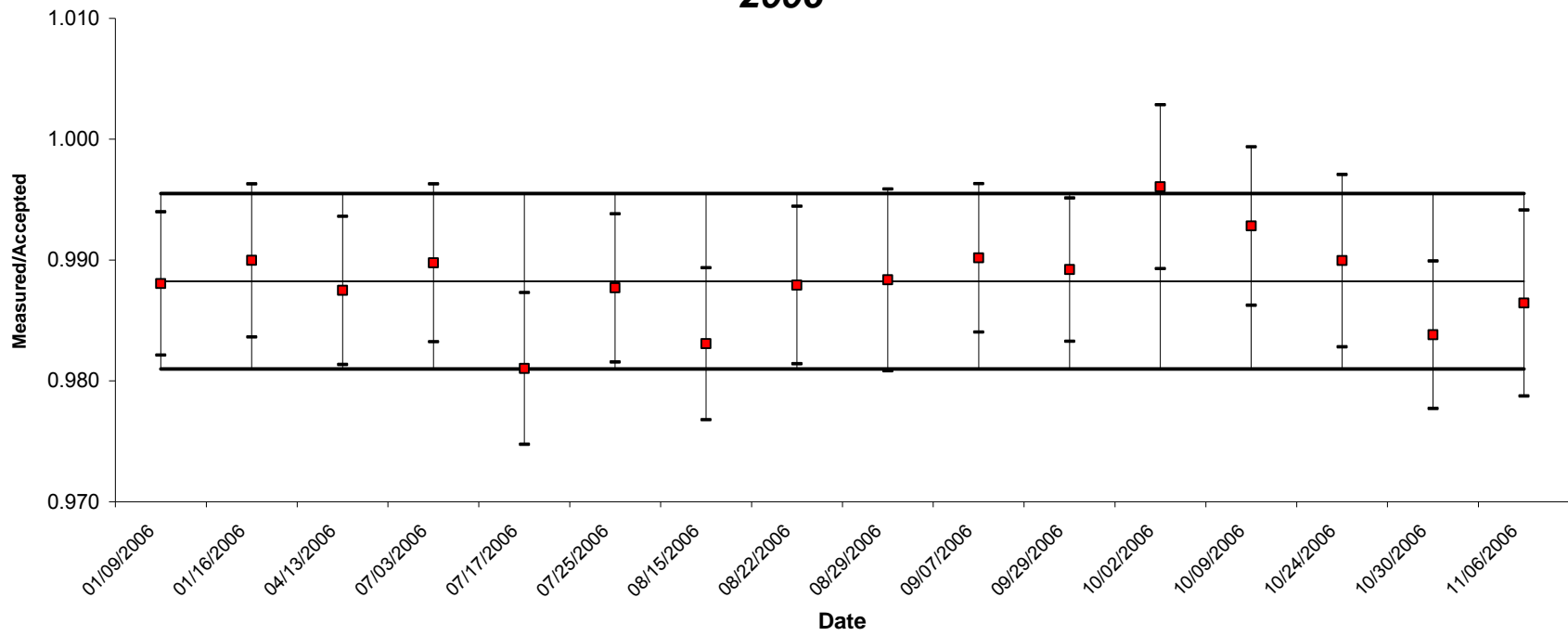
**Difference from Last Year in:**

Mean Error (weight%)	-0.0020%	-0.0003%
Standard Deviation (weight%)	-0.0002%	0.0000%
Uncertainty in the Mean (weight%)	0.0001%	-0.0001%
Mean Error (%)	-0.74%	-0.09%
Standard Deviation (%)	-0.10%	-0.03%
Uncertainty in the Mean (%)	0.04%	-0.01%
Number of Data Points	-81	7
Number of Outliers	1	7

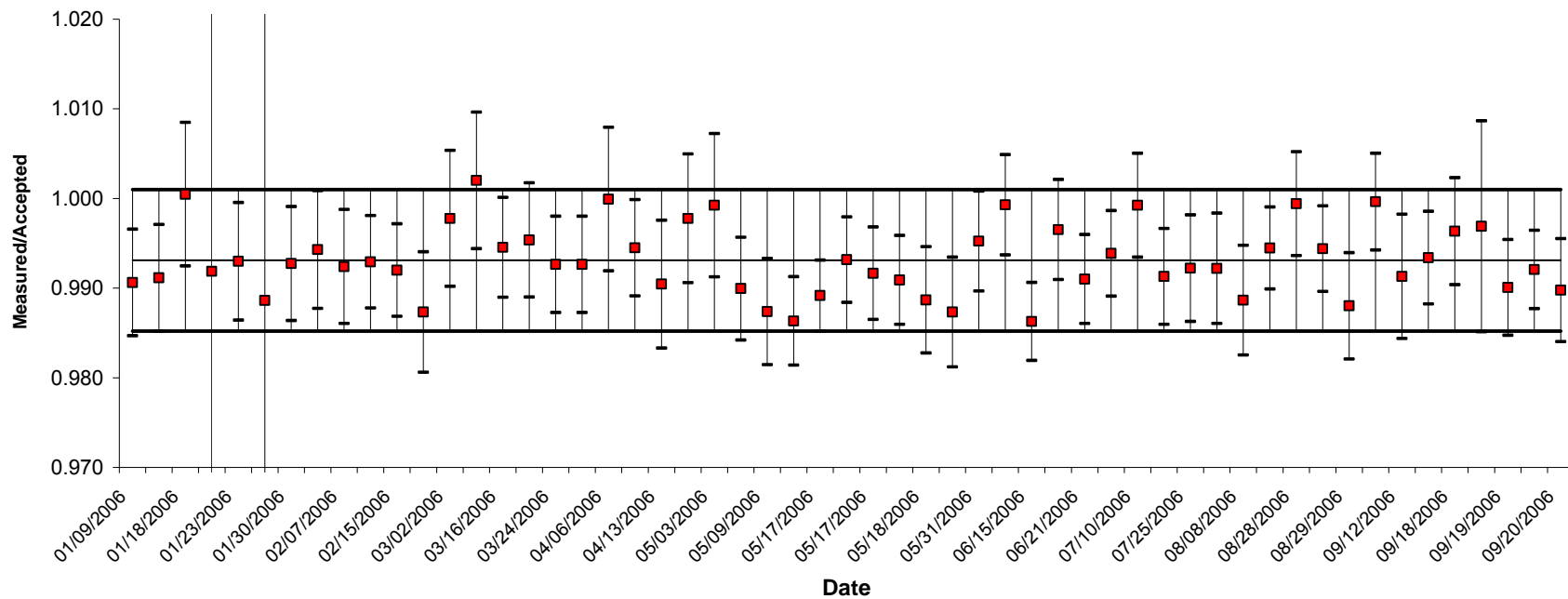
New Brunswick Laboratory Calorimetry Exchange Program  
Percent <sup>241</sup>Am, 2006



**HAN**  
**<sup>241</sup>Am, Calex 1**  
**2006**



**LLNL**  
**<sup>241</sup>Am, Calex 1**  
**2006**





## WEIGHT PERCENT Am241 DATA

Calendar Year 2006

HAN: Calex I

#	Date Measured	Instr. ID	Measured Am241	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	2740	0.2654%	0.30%	0.2686%	0.9881	-0.0032%	-1.19%
2	01/16/2006	2740	0.2660%	0.32%	0.2687%	0.9900	-0.0027%	-1.00%
3	04/13/2006	2740	0.2664%	0.31%	0.2698%	0.9874	-0.0034%	-1.25%
4	07/03/2006	2740	0.2680%	0.33%	0.2708%	0.9897	-0.0028%	-1.02%
5	07/17/2006	2740	0.2658%	0.32%	0.2709%	0.9812	-0.0051%	-1.90%
6	07/25/2006	2740	0.2677%	0.31%	0.2710%	0.9878	-0.0033%	-1.23%
7	08/15/2006	2740	0.2667%	0.32%	0.2713%	0.9830	-0.0046%	-1.69%
8	08/22/2006	2740	0.2681%	0.33%	0.2714%	0.9878	-0.0033%	-1.21%
9	08/29/2006	2740	0.2683%	0.38%	0.2715%	0.9882	-0.0032%	-1.16%
10	09/07/2006	2740	0.2689%	0.31%	0.2716%	0.9901	-0.0027%	-0.98%
<b>11</b>	<b>09/11/2006</b>	<b>2740</b>	<b>0.2688%</b>	<b>0.30%</b>	<b>0.2716%</b>	<b>0.9897</b>	<b>-0.0028%</b>	<b>-1.04%</b>
12	09/29/2006	2740	0.2689%	0.30%	0.2718%	0.9893	-0.0029%	-1.08%
13	10/02/2006	2740	0.2708%	0.34%	0.2719%	0.9960	-0.0011%	-0.39%
14	10/09/2006	2740	0.2700%	0.33%	0.2720%	0.9926	-0.0020%	-0.72%
15	10/24/2006	2740	0.2694%	0.36%	0.2721%	0.9901	-0.0027%	-1.00%
16	10/30/2006	2740	0.2678%	0.31%	0.2722%	0.9838	-0.0044%	-1.62%
17	11/06/2006	2740	0.2686%	0.39%	0.2723%	0.9864	-0.0037%	-1.36%
<b>Mean:</b>						0.9882	-0.0032%	-1.18%
<b>Standard Deviation:</b>						0.0036	0.0010%	0.36%
<b>Standard Uncertainty:</b>						0.0009	0.0002%	0.09%

Statistical outliers are in bold and are not included in graphs and tables.

## WEIGHT PERCENT Am241 DATA

Calendar Year 2006

LLNL: Calex I

#	Date Measured	Instr. ID	Measured Am241	Uncert. 1 STD	Accepted Weight%	Ratio M/A	Weight% Error	Percent Error
1	01/09/2006	II	0.2661%	0.30%	0.2686%	0.9907	-0.0025%	-0.94%
2	01/09/2006	II	0.2662%	0.30%	0.2686%	0.9911	-0.0024%	-0.89%
3	01/18/2006	I	0.2688%	0.40%	0.2687%	1.0004	0.0001%	0.05%
4	01/19/2006	III	0.2666%	25.00%	0.2687%	0.9922	-0.0022%	-0.81%
<b>5</b>	<b>01/23/2006</b>	<b>II</b>	<b>0.2656%</b>	<b>0.37%</b>	<b>0.2688%</b>	<b>0.9881</b>	<b>-0.0032%</b>	<b>-1.18%</b>
6	01/23/2006	II	0.2669%	0.33%	0.2688%	0.9929	-0.0019%	-0.70%
7	01/27/2006	III	0.2658%	2.70%	0.2688%	0.9888	-0.0031%	-1.14%
8	01/30/2006	I	0.2669%	0.32%	0.2689%	0.9926	-0.0020%	-0.73%
9	01/31/2006	II	0.2674%	0.33%	0.2689%	0.9944	-0.0015%	-0.57%
10	02/07/2006	III	0.2669%	0.32%	0.2690%	0.9922	-0.0020%	-0.76%
11	02/15/2006	III	0.2672%	0.26%	0.2691%	0.9929	-0.0019%	-0.71%
12	02/15/2006	III	0.2669%	0.26%	0.2691%	0.9918	-0.0022%	-0.80%
<b>13</b>	<b>02/16/2006</b>	<b>III</b>	<b>0.2676%</b>	<b>0.24%</b>	<b>0.2691%</b>	<b>0.9944</b>	<b>-0.0014%</b>	<b>-0.54%</b>
<b>14</b>	<b>02/16/2006</b>	<b>III</b>	<b>0.2666%</b>	<b>0.58%</b>	<b>0.2691%</b>	<b>0.9907</b>	<b>-0.0025%</b>	<b>-0.94%</b>
15	02/23/2006	III	0.2658%	0.34%	0.2692%	0.9874	-0.0034%	-1.27%
16	03/02/2006	I	0.2687%	0.38%	0.2693%	0.9978	-0.0006%	-0.22%
17	03/07/2006	I	0.2699%	0.38%	0.2693%	1.0022	0.0005%	0.20%
18	03/16/2006	III	0.2680%	0.28%	0.2694%	0.9948	-0.0015%	-0.55%
<b>19</b>	<b>03/16/2006</b>	<b>III</b>	<b>0.0267%</b>	<b>0.30%</b>	<b>0.2694%</b>	<b>0.0991</b>	<b>-0.2427%</b>	<b>-90.08%</b>
20	03/22/2006	I	0.2683%	0.32%	0.2695%	0.9955	-0.0012%	-0.46%
21	03/24/2006	III	0.2676%	0.27%	0.2695%	0.9929	-0.0020%	-0.73%
22	03/24/2006	III	0.2676%	0.27%	0.2695%	0.9929	-0.0020%	-0.73%
23	04/06/2006	I	0.2697%	0.40%	0.2697%	1.0000	-0.0000%	-0.01%
24	04/11/2006	II	0.2683%	0.27%	0.2698%	0.9944	-0.0015%	-0.55%
25	04/13/2006	III	0.2672%	0.36%	0.2698%	0.9904	-0.0026%	-0.95%
26	04/18/2006	I	0.2692%	0.36%	0.2698%	0.9978	-0.0006%	-0.22%
27	05/03/2006	I	0.2698%	0.40%	0.2700%	0.9993	-0.0002%	-0.07%
28	05/09/2006	I	0.2674%	0.29%	0.2701%	0.9900	-0.0027%	-1.01%
29	05/09/2006	III	0.2667%	0.30%	0.2701%	0.9874	-0.0034%	-1.26%
30	05/15/2006	I	0.2665%	0.25%	0.2702%	0.9863	-0.0037%	-1.37%
<b>31</b>	<b>05/16/2006</b>	<b>II</b>	<b>0.2692%</b>	<b>0.29%</b>	<b>0.2702%</b>	<b>0.9963</b>	<b>-0.0010%</b>	<b>-0.36%</b>
32	05/17/2006	I	0.2673%	0.20%	0.2702%	0.9893	-0.0029%	-1.08%
33	05/17/2006	I	0.2684%	0.24%	0.2702%	0.9933	-0.0018%	-0.68%
34	05/17/2006	I	0.2679%	0.26%	0.2702%	0.9915	-0.0023%	-0.83%
35	05/18/2006	I	0.2678%	0.25%	0.2702%	0.9911	-0.0025%	-0.91%
36	05/18/2006	III	0.2672%	0.30%	0.2702%	0.9889	-0.0031%	-1.13%
37	05/25/2006	III	0.2669%	0.31%	0.2703%	0.9874	-0.0034%	-1.27%
38	05/31/2006	I	0.2691%	0.28%	0.2704%	0.9952	-0.0013%	-0.48%
39	06/07/2006	II	0.2703%	0.28%	0.2705%	0.9993	-0.0002%	-0.07%
40	06/15/2006	III	0.2668%	0.22%	0.2705%	0.9863	-0.0037%	-1.37%
41	06/19/2006	II	0.2697%	0.28%	0.2706%	0.9967	-0.0009%	-0.35%
42	06/21/2006	I	0.2682%	0.25%	0.2706%	0.9911	-0.0024%	-0.90%
43	06/27/2006	I	0.2690%	0.24%	0.2707%	0.9937	-0.0017%	-0.61%
<b>44</b>	<b>07/05/2006</b>	<b>I</b>	<b>0.1394%</b>	<b>0.46%</b>	<b>0.2708%</b>	<b>0.5148</b>	<b>-0.1314%</b>	<b>-48.52%</b>
45	07/10/2006	II	0.2706%	0.29%	0.2709%	0.9989	-0.0002%	-0.08%
46	07/20/2006	III	0.2686%	0.27%	0.2710%	0.9911	-0.0024%	-0.87%
47	07/25/2006	II	0.2689%	0.30%	0.2710%	0.9923	-0.0021%	-0.78%
<b>48</b>	<b>07/28/2006</b>	<b>I</b>	<b>0.2694%</b>	<b>0.24%</b>	<b>0.2711%</b>	<b>0.9937</b>	<b>-0.0017%</b>	<b>-0.62%</b>
49	08/01/2006	II	0.2690%	0.31%	0.2711%	0.9923	-0.0021%	-0.78%
50	08/08/2006	III	0.2681%	0.31%	0.2712%	0.9886	-0.0031%	-1.13%
51	08/09/2006	I	0.2697%	0.23%	0.2712%	0.9945	-0.0015%	-0.55%
52	08/28/2006	II	0.2713%	0.29%	0.2714%	0.9996	-0.0002%	-0.06%
53	08/28/2006	I	0.2699%	0.24%	0.2714%	0.9945	-0.0015%	-0.56%
54	08/29/2006	III	0.2682%	0.30%	0.2715%	0.9878	-0.0033%	-1.20%
55	09/05/2006	I	0.2714%	0.27%	0.2715%	0.9996	-0.0001%	-0.04%
56	09/12/2006	III	0.2693%	0.35%	0.2716%	0.9915	-0.0024%	-0.87%
57	09/13/2006	I	0.2698%	0.26%	0.2716%	0.9934	-0.0018%	-0.66%
58	09/18/2006	II	0.2707%	0.30%	0.2717%	0.9963	-0.0010%	-0.37%
59	09/18/2006	II	0.2709%	0.59%	0.2717%	0.9971	-0.0008%	-0.31%
60	09/19/2006	I	0.2690%	0.27%	0.2717%	0.9901	-0.0027%	-0.99%
61	09/19/2006	I	0.2696%	0.22%	0.2717%	0.9923	-0.0022%	-0.79%
62	09/20/2006	III	0.2690%	0.29%	0.2717%	0.9901	-0.0028%	-1.02%
Mean:						0.9931	-0.0019%	-0.69%
Standard Deviation:						0.0039	0.0011%	0.39%
Standard Uncertainty:						0.0005	0.0001%	0.05%

Statistical outliers are in bold and are not included in graphs and tables.



## REPORT OF ANALYSIS

### CALEX II Working Reference Material

In June 1995, the Los Alamos National Laboratory (LANL) made ten identical units of working reference material (WRM) standards for use in the calorimetry exchange (CALEX) program. The standards contain known masses of plutonium oxide material sealed in an inner stainless steel can, then wrapped in two plastic bags, and finally sealed in an outer stainless steel can. New Brunswick Laboratory (NBL) and LANL analyzed the samples by destructive methods to characterize the plutonium concentration, plutonium isotope abundance, and  $^{241}\text{Am}$  abundance. The characterized values for these parameters and the mass of plutonium oxide material in each unit of the standard are shown in bold type in this report. LANL performed additional analyses to determine impurity elements and particle size.

#### A. Mass of material in each unit **2000.0 ± 0.2 gram as of 7/24/1995**

The expanded uncertainty of  $\pm 0.2$  g is a conservative estimate of uncertainties in weighing the empty and filled cans using a 1-place balance.

#### B. Plutonium concentration **(0.8762 ± 0.0018) gram Pu/gram material as of 7/24/1995**

The plutonium concentration of the material was determined at NBL and LANL by controlled potential coulometry, a destructive method of analysis. NBL used CRM122, a Plutonium Oxide Assay and Isotopic Standard for measurement quality control, and LANL used CRM126, a Plutonium Metal Assay Standard.

The NBL value for the plutonium concentration is  $0.87473 \pm 0.00028$  g Pu/g material and the LANL value is  $0.87734 \pm 0.00062$  g Pu/g material. The expanded uncertainties as 95% confidence intervals are calculated from standard deviations of the measurements and represent simple repeatability of the measurement sets with coverage factors  $k = 2.3$  for NBL and  $k = 2.8$  for LANL. The NBL and LANL determinations are not in statistical agreement with one another. The characterized value for plutonium concentration is therefore defined as the mid-point of the line segment with end points at 0.87445 and 0.87796, the lower value obtained from NBL determination ( $0.87473 - 0.00028$ ), and the higher value from LANL determination ( $0.87734 + 0.00062$ ). The expanded uncertainty in the plutonium concentration is one-half-length of this line segment. The plutonium concentration defined in this manner encompasses both NBL and LANL values.

#### C. Plutonium isotopic abundances as of 7/24/1995

	$^{238}\text{Pu}$	$^{239}\text{Pu}$	$^{240}\text{Pu}$	$^{241}\text{Pu}$	$^{242}\text{Pu}$
<b>Abundance (wt %)</b>	<b>0.08032</b>	<b>86.5366</b>	<b>12.1689</b>	<b>1.0074</b>	<b>0.20673</b>
<b>Uncertainty (95% C.I.)</b>	<b>0.00041</b>	<b>0.0035</b>	<b>0.0015</b>	<b>0.0015</b>	<b>0.00043</b>

The plutonium isotopic abundances were determined at NBL and LANL using thermal ionization mass spectrometry. The NBL and LANL results, except for  $^{238}\text{Pu}$ , are in statistical agreement with one another. The  $^{238}\text{Pu}$  abundance from LANL is about 7% higher than the NBL value possibly due to isobaric nuclide interference. Nonetheless, disagreement in  $^{238}\text{Pu}$  affects other isotopes also to some extent. Therefore, NBL values alone are used in characterizing the isotope abundances.

The expanded uncertainties in the abundances as 95% confidence intervals are calculated from simple repeatability of the measurements using a coverage factor  $k = 3.2$ . NBL used CRM122, Plutonium Oxide Assay and Isotopic Standard for measurement quality control, and CRM 128, Plutonium-239/Plutonium-242, 1:1 Atom Ratio (Plutonium Isotopic Standard) for mass bias correction.

**D.  $^{241}\text{Am}$  abundance**      **(4164 ± 41) microgram/gram material as of 7/24/1995**  
**(4753 ± 48) microgram/gram Pu as of 7/24/1995**

The  $^{241}\text{Am}$  abundance was characterized at NBL and LANL using high resolution gamma ray spectrometry. Measurement quality control was through secondary  $^{241}\text{Am}$  standards prepared in the respective laboratories. The NBL and LANL results are in statistical agreement with one another. The characterized values for  $^{241}\text{Am}$  concentrations given above are calculated as the average of the two independent determinations. The expanded uncertainty in the characterized value is calculated from the uncertainties in the independent determinations with a coverage factor  $k = 2.2$ .

#### E. Impurity elements

Nickel, calcium, manganese, copper and uranium are present as impurities in measurable concentrations. LANL determined the concentrations (in microgram/gram) of Ni – 5; Ca – 40; Mn – 5; and Cu – 2 by DC Arc Spectrometry and uranium (U – 110) by radiochemical technique.

#### F. Particle size

The particle size of the material was measured at LANL. Most of the particles are in the range of 5  $\mu\text{m}$  to 60  $\mu\text{m}$  with the mean of about 25  $\mu\text{m}$ .

#### G. Half-lives

The plutonium concentration, plutonium isotope abundance and  $^{241}\text{Am}$  abundance change with time as a result of radioactive decay. Use the following half-life values for performing the radioactive decay corrections (reference: ASTM C 1458-00 Test Method).

Nuclide	Half-life (years)
$^{238}\text{Pu}$	$87.74 \pm 0.04$
$^{239}\text{Pu}$	$24119 \pm 16$
$^{240}\text{Pu}$	$6564 \pm 11$
$^{241}\text{Pu}$	$14.348 \pm 0.022$
$^{242}\text{Pu}$	$376300 \pm 900$
$^{241}\text{Am}$	$433.6 \pm 1.4$

**Acknowledgements**

Westinghouse Hanford Laboratory provided the plutonium oxide material and LANL fabricated the non-destructive assay CALEX II standards. NBL and LANL characterized the material by destructive methods of analyses. NBL in collaboration with LANL prepared the characterization analysis report.

April 2007

Jon W. Neuhoff  
Laboratory Director



## CALEX II Working Reference Material Report

### A. Introduction

Calorimetry is one of a few non-destructive measurement methods available for assay of plutonium bearing materials. Several DOE facilities routinely use this method in nuclear safeguards for material accountability. These facilities also participate in the New Brunswick Laboratory (NBL) calorimetry exchange (CALEX) program designed to provide an independent verification of their internal quality control practices in calorimetry.

The first working reference material standard, six units of Calex I, was made by Rocky Flats Laboratory in 1979. The standard contains about 400 g of weapon grade plutonium oxide material (~93%  $^{239}\text{Pu}$  and ~6%  $^{240}\text{Pu}$ ) with a power output of ~1 watt. This standard is still used in the CALEX program as a working reference material. The calorimetry practitioners recognized the need for additional standards of higher power output with an isotopic mix representative of higher burn-up plutonium (~87%  $^{239}\text{Pu}$  and ~12%  $^{240}\text{Pu}$ ). In response, Los Alamos National Laboratory (LANL) made ten units of Calex II standard with a heat output of about six watts. These units will serve as the second working material standards in the CALEX program.

### B. Description of Calex II Standard

LANL made ten identical units of the Calex II standard in June 1995 from plutonium oxide material (about 24 kg) supplied by the Westinghouse Hanford Laboratory. The material was divided into three equal batches, ignited at 950°C, and sieved through a 100 mesh (150  $\mu\text{m}$ ) screen. The three batches of material were well mixed<sup>1,2</sup> to attain homogeneity. The homogenized material was sealed in stainless steel containers, each container wrapped in two layers of plastic bags and then sealed in a slightly larger, uncontaminated outer container. The mass of plutonium oxide in each of the ten units is shown in Table 1.

**Table 1. Mass of plutonium oxide in Calex II standards.**

Item ID	Tare weight (g)	Oxide load weight (g)	Oxide weight (g)
Std 1	103.5	2103.5	2000.0
Std 2	102.7	2102.7	2000.0
Std 3	102.6	2102.6	2000.0
Std 4	106.2	2106.2	2000.0
Std 5	104.6	2104.6	2000.0
Std 6	106.2	2106.2	2000.0
Std 7	102.8	2102.8	2000.0
Std 8	102.2	2102.2	2000.0
Std 9	102.1	2102.1	2000.0
Std 10	106.2	2106.2	2000.0

**The characterized value for the mass of plutonium oxide in each unit is  $2000 \pm 0.2$  gram.**

The expanded uncertainty is a conservative estimate of uncertainties in weighing the empty and filled cans using a 1-place balance readable to 0.1 g. Radioactive decay of plutonium and  $^{241}\text{Am}$  isotopes leads to mass loss as a function of time but in imperceptible amounts.

### C. Characterization Analysis at NBL and LANL

During the preparation of the Calex II standards, fifteen random samples were taken for characterizing the plutonium oxide material using destructive methods of analyses. LANL, NBL, and Hanford received five samples each. LANL completed the analyses in 1995 itself, and NBL completed the work in 2000. The types of analyses carried out in these two laboratories are shown in Table 2. Appendices B.1 and B.2 show the NBL and LANL results. Appendix B.3 compares the analyses in these two laboratories.

**Table 2. Characterization analyses at NBL and LANL**

	NBL	LANL
Loss on ignition	√	√
Plutonium assay	√	√
Plutonium isotope abundance	√	√
$^{241}\text{Am}$ abundance	√	√
Impurities		√
Particle size		√
Calorimetry power		√
Isotopic specific power		√

### D. Mass Loss on Ignition

The material inside the Calex II standards is presumed to be moisture-free. However, the samples for destructive analyses were exposed to air during the time between sampling and dissolution for analyses. A known mass of the sample (about one gram) was heated at  $950^{\circ}\text{C}$  for two hours and the mass loss was determined. It represents the amount of moisture gained during the period between sampling and characterization. NBL made four moisture determinations on four samples; data for the fifth sample was lost due to experimental problem. LANL made five measurements on five samples. The mean values for mass loss from NBL and LANL measurements are shown in Table 3.

NBL and LANL results agree with one another within the limits of stated uncertainties. The expanded uncertainties as 95% confidence interval are calculated from the standard deviations of the measurements and coverage factor  $k$ .



**Table 3. Mass loss on ignition (weight %). The number of measurements is given by the *n* values.**

	NBL (n=4)	LANL (n=5)
Mean	0.025	0.026
Std. Dev.	0.013	0.025
Std. Err.	0.0065	0.011
Coverage factor, k	3.2	2.8
95% C.I.	0.021	0.031

### E. Plutonium Concentration

Both NBL and LANL determined the plutonium (elemental) concentration in the ignited samples by controlled potential coulometry. NBL made ten measurements from five samples; each sample was analyzed in duplicate. CRM 122, Plutonium Oxide – PuO<sub>2</sub> (Plutonium Assay and Isotopic Standard)<sup>3</sup> was used for quality control. The results were corrected for a negative bias of approximately 0.05% observed in the quality control standards. LANL made five measurements from five samples. CRM 126, Plutonium Metal (Plutonium Assay and Isotopic Standard), was used for instrument calibration.

The results of NBL and LANL measurements are reported in Table 4 as of July 24, 1995 after making appropriate corrections for radioactive decay. The expanded uncertainties as 95% confidence interval are calculated from the standard deviations of the measurements and represent uncertainties in the repeatability of the measurements only.

**Table 4. Plutonium concentration (in weight %) as of July 24, 1995. The number of measurements is given by the *n* values.**

	NBL (n=10)	LANL* (n=5)
Mean Pu concentration (weight %)	87.473	87.734
Std. Dev.	0.037	0.049
Std. Err.	0.012	0.022
Coverage factor, k	2.3	2.8
95% C.I.	0.028	0.062

\* The experimentally determined (LANL) value for the plutonium assay in the packaged material (i.e., without ignition) is  $87.690 \pm 0.056$  (n=5).

The NBL and LANL results for the plutonium concentration are not in statistical agreement with one another. The characterized value is determined by the union of these two independent measurements (Table 5). The lower limit of the characterized value is defined by the NBL value minus the 95% confidence interval uncertainty; the higher limit is defined by the LANL value plus the 95% confidence interval uncertainty. The plutonium concentration is taken to be the mid point of the interval; the expanded uncertainty at 95% confidence interval is represented by half the length of the interval.

**Table 5. Characterized value for plutonium concentration as of July 24, 1995**

NBL Low	LANL High	Mid Point	95% C.I.
87.445	87.796	87.621	0.176

The characterized value for **plutonium concentration** is **87.62 ± 0.18 weight % as of July 24, 1995**. The results are rounded to correspond to two significant figures in the uncertainty.

#### F. Plutonium Isotope Abundance

Both NBL and LANL determined the plutonium isotope abundance by thermal ionization mass spectrometry. NBL made 4 measurements; the fifth measurement was a statistical outlier and it was rejected. CRM122, Plutonium Oxide – PuO<sub>2</sub> (Plutonium Assay and Isotopic Standard)<sup>3</sup> was used as the quality control standard, and CRM 128, Plutonium-239/Plutonium-242, 1:1 Atom Ratio, (Plutonium Isotopic Standard)<sup>4</sup> was used for mass bias correction. LANL made five measurements.

The results of the Pu isotope abundance determinations as of July 24, 1995 are shown in Table 6. The experimental results have been corrected for radioactive decay of plutonium isotopes. The uncertainties as 95% confidence interval are calculated from the standard deviations of the measurements and represent uncertainties in the repeatability of the measurements only.

**Table 6. Plutonium isotope abundance in weight %. The number of measurements is given by the n values.**

	<sup>238</sup> Pu	<sup>239</sup> Pu	<sup>240</sup> Pu	<sup>241</sup> Pu	<sup>242</sup> Pu
NBL (n=4)					
Abundance (weight %)	0.08032	86.5366	12.16892	1.00744	0.20673
Std. Dev.	0.00026	0.0022	0.00096	0.00091	0.00027
Std. Err	0.00013	0.0011	0.00048	0.00046	0.00014
Coverage factor, k	3.2	3.2	3.2	3.2	3.2
95% C.I.	0.00041	0.0035	0.00153	0.00145	0.00043
LANL (n=5)					
Abundance (weight %)	0.0853	86.5304	12.1691	1.0085	0.20670
Std. Dev.	0.0017	0.0027	0.0011	0.0012	0.00040
Std. Err	0.00076	0.0012	0.00049	0.00054	0.00018
Coverage factor, k	2.8	2.8	2.8	2.8	2.8
95% C.I.	0.0021	0.0034	0.0014	0.0015	0.00050

The results from the two laboratories are in statistical agreement with one another, except for <sup>238</sup>Pu abundance. The higher <sup>238</sup>Pu abundance in LANL measurements (relative to NBL) is likely to arise from <sup>238</sup>U interference. NBL used samples purified by ion exchange, thereby eliminating isobaric interferences (<sup>238</sup>U and <sup>241</sup>Am), whereas LANL analyzed the samples without purification.

The characterized values for plutonium isotope abundances (Table 7) are defined using NBL measurements only. The expanded uncertainties as 95% confidence intervals represent uncertainties in the repeatability of the measurements. The results are rounded to correspond to two significant figures in the uncertainties.

**Table 7. Characterized values for plutonium isotopes abundances as of July 24, 1995**

	<sup>238</sup> Pu	<sup>239</sup> Pu	<sup>240</sup> Pu	<sup>241</sup> Pu	<sup>242</sup> Pu
<b>Abundance (weight %)</b>	<b>0.08032</b>	<b>86.5366</b>	<b>12.1689</b>	<b>1.0074</b>	<b>0.20673</b>
<b>Coverage factor, k</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>	<b>3.2</b>
<b>95% C.I.</b>	<b>0.00041</b>	<b>0.0035</b>	<b>0.0015</b>	<b>0.0015</b>	<b>0.00043</b>

**G. <sup>241</sup>Am Concentration**

Both NBL and LANL determined the <sup>241</sup>Am concentration by high resolution gamma ray spectrometry. NBL made ten measurements from five samples; each sample was analyzed in duplicate. LANL made four measurements; the fifth measurement result was a statistical outlier and was rejected. Quality control was through secondary <sup>241</sup>Am standards prepared in the respective laboratories.

The measurement results corrected for in-growth from <sup>241</sup>Pu and decay are expressed in terms of <sup>241</sup>Am per gram of material and <sup>241</sup>Am per gram of plutonium; the latter was calculated by dividing the former by the characterized value for plutonium concentration (g Pu/g material). These results are shown in Table 8. The expanded uncertainties as 95% confidence interval are calculated from the standard deviations of the measurements and represent uncertainties in the repeatability of the measurements only.

**Table 8. <sup>241</sup>Am abundance (in microgram per gram) as of July 24, 1995.**

	NBL (n=10)		LANL (n=4)	
	µg/g material	µg/g Pu	µg/g material	µg/g Pu
<sup>241</sup> Am abundance	4135	4727	4193	4779
Std. Dev.	86	98	53	60
Std. Err.	27	31	27	30
Coverage factor, k	2.3	2.3	3.2	3.2
95% C.I.	62	70	84	95

The NBL and LANL results are in statistical agreement with one another. The characterized value for the <sup>241</sup>Am concentration is calculated as the average of the averages from the two independent determinations (Table 9).

**Table 9. Characterized values for <sup>241</sup>Am isotope abundances as of July 24, 1995**

	<b>µg/g material</b>	<b>µg/g Pu</b>
<b><sup>241</sup>Am abundance</b>	<b>4164</b>	<b>4753</b>
<b>Coverage factor, k</b>	<b>2.2</b>	<b>2.2</b>
<b>95% C.I.</b>	<b>41</b>	<b>48</b>

## H. Impurity Analyses

LANL determined the concentrations of the following impurity elements: Ni, Ca, Mn, and Cu by DC arc spectrometry; and U by radiochemical technique. The results are shown in Table 10.

**Table 10. Impurity elements concentrations**

Impurity	Abundance µg/g material
Nickel	5
Calcium	40
Manganese	5
Copper	2
Uranium	110
Total	162

The sum of concentrations of the impurity elements is (162 ± 60) microgram per gram. The uncertainty is calculated by assuming 50% of the measured value as the uncertainty in each element abundance.

The purity of plutonium oxide (in weight %) in the material can be determined by the 100 minus impurities method. In this calculation, <sup>241</sup>Am is assumed to be an impurity element. The calculated value for purity of the material is 99.57% (by weight). This corresponds to plutonium concentration of 87.82% (by weight); it is about 0.23% higher relative to the coulometry value of 87.62% (by weight). The difference is larger than expected.

## I. Particle Size

LANL determined the particle size of the material to be in the range of 5 µm to 60 µm (with an average spherical equivalent mean of about 25 µm) as shown in Table 11.

**Table 11. Particle size analysis.**

	Spherical equivalent mean (µm)	Standard deviation
First determination	23.6	22.6
Second determination	25.3	22.9

## J. Wattage and Effective Specific Power Measurements

LANL made wattage and effective specific power ( $P_{\text{eff}}$ ) measurements on all ten units. Two different calorimeters were used for wattage measurements, and two different codes (FRAM and TRIFID) were used for calculating effective specific power ( $P_{\text{eff}}$ ) from isotope abundances measured by non-destructive method of gamma ray spectrometry. The mean of the ten calorimetric power measurements and the calculated effective specific power from FRAM and TRIFID are shown in Table 12. Also shown in the table is the effective power calculated from Pu isotope and  $^{241}\text{Am}$  abundances by destructive analysis. In this calculation isotopic specific powers given in the PANDA manual<sup>5</sup> are used.

**Table 12. Wattage and effective specific power measurements**

	Wattage (watt)	Effective specific power (watt/g Pu)		
		FRAM	TRIFID	Destructive Analysis
Result	6.2378	0.003563	0.003534	0.003564
Standard deviation	0.0045	0.000010	0.000012	0.000006
Standard error	0.0014	0.000003	0.000004	0.000003
Coverage factor, k	2.3	2.3	2.3	3.2
95% C.I.	0.0032	0.000007	0.000009	0.000010

The effective specific power values calculated from FRAM and destructive analysis method are in good agreement with one another, whereas the TRIFID value is about 0.8% lower.

## K. Mass of Plutonium

The mass of plutonium in the Calex II standard can be obtained in different ways from the measurement results given in this report:

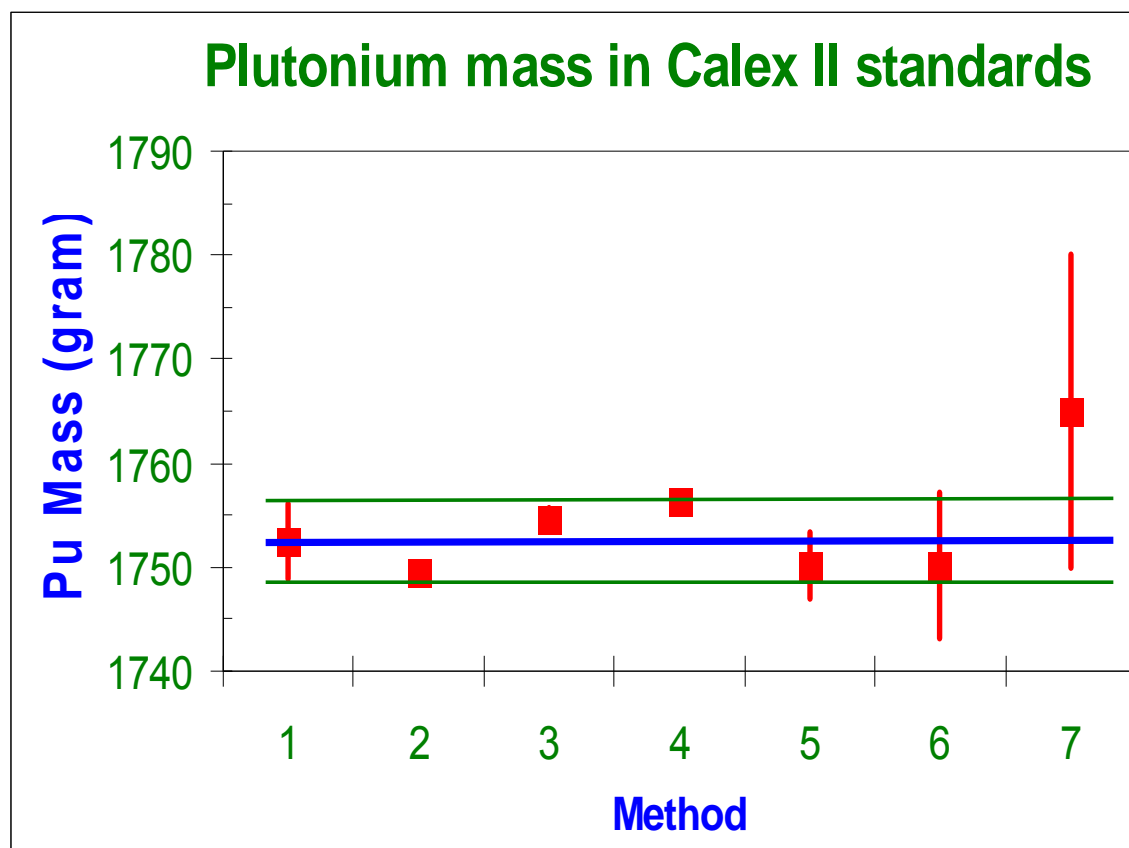
1. Mass of plutonium oxide material X characterized value for plutonium assay by coulometry
2. Mass of plutonium oxide material X NBL plutonium assay by coulometry
3. Mass of plutonium oxide material X LANL plutonium assay by coulometry
4. Mass of plutonium oxide material X plutonium assay from impurity analysis
5. Calorimetric power/effective specific power from characterized Pu isotope and  $^{241}\text{Am}$  abundances
6. Calorimetric power/effective specific power from FRAM
7. Calorimetric power/effective specific power from TRIFID

The plutonium masses calculated using the seven different methods are shown in Table 13. The calculated masses of plutonium are in the range of 1749.5 to 1765.0 gram. The relative deviations (in percent) of the plutonium mass for the different methods with respect to method 1 are shown in the Table 13. The %RD is in the range of -0.17 to 0.72 with method 7 showing the highest deviation.

**Table 13. Pu mass in Calex II standards.**

Method	Pu mass (g)	Uncertainty	% RD in Pu mass
1	1752.4	3.6	$\equiv 0$
2	1749.5	0.8	-0.17
3	1754.7	1.0	0.13
4	1756.3	0.4	0.22
5	1750.1	3.2	-0.13
6	1750.2	7.0	-0.13
7	1765.0	15.0	0.72

Plutonium masses calculated by the different methods are shown also in Figure 1.



**Figure 1.** Plutonium masses calculated using the seven different methods. The characterized value for the plutonium mass and its 95% confidence interval are indicated by the horizontal lines. Figure shows that the masses from methods 2 to 7 overlap with that from method 1 within the limits of the uncertainties.

## L. Half-lives

The plutonium concentration, plutonium isotope abundance, and the  $^{241}\text{Am}$  isotope abundance change with time due to radioactive decay. The half-life values (ASTM C 1458-00 Test method)<sup>6</sup> used in performing radioactive decay calculations are shown in Table 14.

**Table 14. Half-lives of nuclides in the CALEX II material.**

Nuclide	Half-life (years)
$^{238}\text{Pu}$	$87.74 \pm 0.04$
$^{239}\text{Pu}$	$24119 \pm 16$
$^{240}\text{Pu}$	$6564 \pm 11$
$^{241}\text{Pu}$	$14.348 \pm 0.022$
$^{242}\text{Pu}$	$376300 \pm 900$
$^{241}\text{Am}$	$433.6 \pm 1.4$

## M. Summary and Conclusions

LANL prepared ten units of Calex II standard with isotopic composition similar to that of higher burn-up ("fuel grade", 7 to 19%  $^{240}\text{Pu}$ ) plutonium material. NBL and LANL characterized the material for plutonium assay, plutonium isotope abundance, and  $^{241}\text{Am}$  abundance using destructive methods of analyses. The Calex II standards are now ready to be used as working reference material in the CALEX program. It can also be used as reference standard in plutonium assay by passive neutron measurement methods.

## Acknowledgements

Westinghouse Hanford Laboratory supplied the homogenized plutonium oxide material from which the standards were prepared. LANL fabricated the CALEX II non-destructive assay standards. The characterization analyses were done at NBL and LANL by destructive methods. The characterization analysis report was prepared at NBL in collaboration with LANL.

## References

1. Long, S. M., Hildner, S., Guitierrez, D., Mills, C., Garcia, W. & Gurule, C. (1995) Fabrication of 12%  $^{240}\text{Pu}$  Calorimetry Standards, INMM 36<sup>th</sup> Annual Meeting, Palm Desert, California.
2. 12% CALEX Standards (1995) LANL Report.
3. NBL Certificate of Analysis, CRM 122, Plutonium Oxide – PuO<sub>2</sub> – In Powder Form (Plutonium Assay and Isotopic Standard).
4. NBL Certificate of analysis, CRM 128, Plutonium-239/Plutonium-242, 1:1 Atom Ratio, In Nitrate Form (Plutonium Isotopic Standard) (1985).
5. Reilly, D., Ensslin, N., Smith Jr., H., & Kreiner S. (1991) Passive Nondestructive Assay of Nuclear Materials, U.S. Nuclear Regulatory Commission.
6. IAEA Handbook of Nuclear Data for Safeguards (2007), Retrieved on March 23, 2007 from <http://www-nds.iaea.org/sgnucdat/>

**Appendix B.1. CALEX II NBL results. The full set of data is presented in an NBL internal document and is available upon request.**

**Table 1. Weight loss on ignition at 950°C for two hours.**

Sample ID	Date	Loss on ignition (weight %)
95PU0128	5/6/96	0.0254
95PU0129	5/6/96	0.0069
95PU0130	5/3/96	no data
95PU0131	5/9/96	0.0343
95PU0132	5/8/96	0.0326
	Mean (n = 4)	0.0248
	Std. Dev.	0.013

**Table 2. Pu content (weight %) in ignited samples by controlled potential coulometry.**

Sample ID	Date	Pu content (weight%) in ignited sample	Decay correct to 10/26/99	Daily bias correction
95PU0128	11/12/99	87.2987	87.3004	87.2844
	11/4/99	87.2505	87.2515	87.2003
95PU0129	11/4/99	87.3508	87.3518	87.3005
	11/4/99	87.3299	87.3309	87.2796
95PU0130	11/17/99	87.3707	87.3730	87.3126
	11/17/99	87.3629	87.3652	87.3048
95PU0131	11/12/99	87.3499	87.3516	87.3356
	11/12/99	87.3233	87.3250	87.3090
95PU0132	11/12/99	87.3301	87.3318	87.3158
	11/4/99	87.3400	87.3410	87.2897
	Mean (n = 10)			87.2932
	Std. Dev			0.0366



**Table 3. Pu content in ignited CALEX II material.**

	as of 7/24/95
Mean Pu content	87.473
Std. Dev.	0.037

**Table 4. Pu isotopic abundance in atom % by TIMS as of 8/11/1998.**

Sample ID	Date	<sup>238</sup> Pu	<sup>239</sup> Pu	<sup>240</sup> Pu	<sup>241</sup> Pu	<sup>242</sup> Pu	Total	Remarks
95PU0128	8/11/98	0.0786	86.7140	12.1400	0.8632	0.2045	100.0003	
95PU0129	8/11/98	0.0789	86.7100	12.1410	0.8645	0.2050	99.9994	
95PU0130	8/11/98	0.0788	86.7150	12.1390	0.8627	0.2045	100.0000	
95PU0131	8/11/98	0.0792	86.7120	12.1410	0.8638	0.2044	100.0004	
95PU0132	8/11/98	0.0779	86.7030	12.1510	0.8635	0.2046	100.0000	
	Mean (n = 5)	0.0787	86.7108	12.1424	0.8635	0.2046	100.0000	
	Std. Dev.	0.00049	0.0048	0.0049	0.00067	0.00023		
	Mean (n = 4)	0.07888	86.71275	12.14025	0.86355	0.20460	100.0000	without 95PU0132
	Std. Dev.	0.00025	0.00222	0.00096	0.00078	0.00027		

**Table 5. Pu isotope abundance in (weight %) in CALEX II material as of 8/11/1998.**

Date	<sup>238</sup> Pu	<sup>239</sup> Pu	<sup>240</sup> Pu	<sup>241</sup> Pu	<sup>242</sup> Pu	Total	Remarks
Mean (n=4)	0.07852	86.6607	12.1835 1	0.87022	0.20705	100.000 0	without 95PU0132
Std. Dev.	0.00025	0.0022	0.00096	0.00078	0.00027		

**Table 6.  $^{241}\text{Am}$  content (microgram/gram material) by gamma spectrometry.**

Sample ID	Date	$^{241}\text{Am}$ ( $\mu\text{g/g}$ )
95PU0128	3/1/00	5976.1
	2/29/00	5961.1
95PU0129	2/29/00	5955.4
	2/29/00	5889.3
95PU0130	3/2/00	5705.2
	3/2/00	5659.2
95PU0131	3/1/00	5973.1
	3/1/00	5910.3
95PU0132	3/1/00	5881.1
	2/29/00	5718.6
	Mean (n = 10)	5862.9
	Std. Dev.	121.8

**Table 7. Effective specific power in CALEX II as of 7/24/95. Pu isotopes and  $^{241}\text{Am}$  are in weight % with respect to Pu content.**

Radionuclide	Specific power <sup>5</sup> (mW/g)	NBL isotopic abundance (weight %)	Effective specific power (mW/g Pu)
$^{238}\text{Pu}$	567.57	0.08032	0.4559
$^{239}\text{Pu}$	1.9288	86.5366	1.6691
$^{240}\text{Pu}$	7.0824	12.16892	0.8619
$^{241}\text{Pu}$	3.412	1.00744	0.0344
$^{242}\text{Pu}$	0.1159	0.20673	0.0002
$^{241}\text{Am}$	114.2	0.4752	0.5427
$P_{\text{eff}}^*$			3.5642

The effective specific power calculated here is based on the Pu isotope measurements at NBL.

\*  $P_{\text{eff}}$  represents sum of the effective specific powers of all isotopes.

**Appendix B.2. CALEX II LANL results. The full set of LANL data is presented in an internal document and is available from NBL upon request.**

**Table 1. Mass of PuO<sub>2</sub> material in the CALEX II standards.**

Item ID	Date	Tare weight (g)	Oxide load weight (g)	Oxide weight (g)
Std 1	6/8/95	103.5	2103.5	2000.0
Std 2	6/8/95	102.7	2102.7	2000.0
Std 3	6/8/95	102.6	2102.6	2000.0
Std 4	6/8/95	106.2	2106.2	2000.0
Std 5	6/8/95	104.6	2104.6	2000.0
Std 6	6/8/95	106.2	2106.2	2000.0
Std 7	6/8/95	102.8	2102.8	2000.0
Std 8	6/8/95	102.2	2102.2	2000.0
Std 9	6/8/95	102.1	2102.1	2000.0
Std 10	6/8/95	106.2	2106.2	2000.0

**Table 2. Weight loss on ignition.**

Sample ID	Date	Loss on ignition (weight %)
200017105	7/24/95	0.00
200017107	7/24/95	0.00
200017108	7/24/95	0.05
200017109	7/24/95	0.05
200017110	7/24/95	0.03
	Mean	0.026
	Std. Dev.	0.025

**Table 3. Pu content (weight %) in ignited as well as in as received samples by controlled potential coulometry.**

Sample ID	Date	Pu content in ignited sample (g Pu/g sample)	Pu content in as received sample (weight %)
200017105	7/24/95	87.70	87.66
200017107	7/24/95	87.72	87.71
200017108	7/24/95	87.68	87.62
200017109	7/24/95	87.78	87.77
200017110	7/24/95	87.79	87.69
	Mean	87.734	87.690
	Std. Dev.	0.049	0.056

**Table 4. Pu isotopic abundance in atom % by TIMS as of 7/24/1995**

Sample ID	Date	<sup>238</sup> Pu	<sup>239</sup> Pu	<sup>240</sup> Pu	<sup>241</sup> Pu	<sup>242</sup> Pu	Total
200017105	7/24/95	0.0834	86.5875	12.1248	1.0002	0.2043	100.0001
200017107	7/24/95	0.0866	86.5827	12.1246	1.0025	0.2038	100.0000
200017108	7/24/95	0.0874	86.5810	12.1256	1.0015	0.2048	100.0001
200017109	7/24/95	0.0871	86.5816	12.1271	0.9999	0.2045	100.0000
200017110	7/24/95	0.0843	86.5852	12.1267	0.9996	0.2043	100.0000
	Mean (n = 5)	0.0858	86.5836	12.1258	1.0007	0.2043	100.0002
	Std. Dev.	0.0018	0.0027	0.0011	0.0012	0.0004	

**Table 5. Pu isotopic abundance (in weight %) by TIMS as of 7/24/1995**

Sample ID	Date	<sup>238</sup> Pu	<sup>239</sup> Pu	<sup>240</sup> Pu	<sup>241</sup> Pu	<sup>242</sup> Pu	Total
200017105	7/24/95	0.0830	86.5343	12.1681	1.0079	0.2067	100.0000
200017107	7/24/95	0.0861	86.5295	12.1679	1.0102	0.2062	99.9999
200017108	7/24/95	0.0869	86.5278	12.1689	1.0092	0.2072	100.0000
200017109	7/24/95	0.0866	86.5284	12.1704	1.0077	0.2069	100.0000
200017110	7/24/95	0.0839	86.5320	12.1700	1.0074	0.2067	100.0000
	Mean (n = 5)	0.0853	86.5304	12.1691	1.0085	0.2067	100.0000
	Std. Dev.	0.0017	0.0027	0.0011	0.0012	0.0004	

**Table 6. <sup>241</sup>Am content (microgram/gram material) by gamma spectrometry.**

Sample ID	Date	<sup>241</sup> Am (µg/g)	Remarks
200017105	7/17/95	4270	
200017107	7/18/95	4830	kurtosis test outlier
200017108	7/18/95	4160	
200017109	7/17/95	4160	
200017110	7/18/95	4180	
	Mean (n = 5)	4320	all five results
	Std dev	289	
	Mean (n = 4)	4193	without 200017107
	Std dev	53	

**Table 7. Abundance of impurity elements (microgram/gram) in CALEX material. Impurities that were below detection limits are not shown.**

	Abundance (µg/g)
Nickel	5
Calcium	40
Manganese	5
Copper	2
Uranium	110
Total	162

**Table 8. Mass of Pu from impurity measurements (100 - impurities).**

	LANL
Impurity (weight %)	0.4355
PuO <sub>2</sub> mass (weight %)	99.5645
Pu atomic weight	239.199
O <sub>2</sub> atomic weight	16.000
Pu mass (weight %)	87.816

**Table 9. Particle size analysis in the range 0.7µm to 250µm.**

Date	Spherical equivalent mean (µm)	Standard deviation
1/3/80	23.6	22.6
1/3/80	25.3	22.9
Mean	24.5	

Uncertainty is 1 standard deviation

**Table 10. Calorimetric Wattage (measured between 6/8/95 and 7/24/95).**

Item ID	Calorimeter ID	Wattage
Std 1	4	6.234241
Std 2	3	6.232959
Std 3	3	6.232213
Std 4	3	6.235318
Std 5	3	6.238634
Std 6	3	6.240940
Std 7	4	6.234773
Std 8	4	6.244066
Std 9	4	6.241826
Std 10	4	6.243504
Mean cal 3 &4 (n = 10)		6.2378
Std. Dev		0.0045
Mean cal 3 (n = 5)		6.2360
Std. Dev		0.0037
Mean cal 4 (n = 5)		6.2397
Std. Dev		0.0048

There is 0.06% difference between averages calculated for calorimeter 3 and calorimeter 4.

**Table 11. Effective specific power in CALEX II as of 7/24/95. Pu isotopes and <sup>241</sup>Am are in weight % with respect to Pu content.**

	Specific power (mW/g)	Isotopic abundance (weight %)	Effective specific power (mW/g Pu)
<sup>238</sup> Pu	567.57	0.0853	0.4841
<sup>239</sup> Pu	1.9288	86.5304	1.6690
<sup>240</sup> Pu	7.0824	12.1691	0.8619
<sup>241</sup> Pu	3.412	1.0085	0.0344
<sup>242</sup> Pu	0.1159	0.2067	0.0002
<sup>241</sup> Am	114.2	0.4778	0.5456
P <sub>eff</sub> *			3.5952

The effective specific power calculated here is based on the Pu isotope measurements at LANL. Apparently <sup>238</sup>Pu measurement is compromised by interference from <sup>238</sup>U, an isobaric nuclide.

\* P<sub>eff</sub> represents sum of the effective specific powers of all isotopes.

### Appendix B.3. Comparison of CALEX II results from NBL and LANL.

All results compared as of 7/24/1995. Wherever necessary, experimental values were corrected for radioactive decay to 7/24/1995. %RD's are calculated with reference to NBL values.

$$\%RD = 100 * ((LANL-NBL)/NBL).$$

**Table 1. Weight loss on ignition at 950°C for two hours.**

	NBL	LANL
Mean	0.025	0.026
Std. Dev.	0.013	0.025
n	4	5
% RD	≡ 0	4 %

**Table 2. Pu content (weight %) by controlled potential coulometry.**

	NBL	LANL	
	As Ignited	As Ignited	As received
Mean	87.473	87.734	87.690
Std. Dev.	0.037	0.049	0.056
n	10	5	5
% RD	≡ 0	0.298	

**Table 3. Mass of Pu in Calex II from coulometry.**

	NBL	LANL	% RD (NBL ≡ 0)
Pu mass (g)	1749.5	1754.7	0.297
Pu (weight %)	87.473	87.734	0.298

**Table 4. Pu isotope abundance in weight % (i.e., 100 X g Pu isotope/g Pu).**

	<sup>238</sup> Pu	<sup>239</sup> Pu	<sup>240</sup> Pu	<sup>241</sup> Pu	<sup>242</sup> Pu	Total
NBL Mean (n = 4)	0.08032	86.5366	12.16892	1.00744	0.20673	100.00001
Std. Dev.	0.00026	0.0022	0.00096	0.00091	0.00027	
LANL Mean (n = 5)	0.0853	86.5304	12.1691	1.0085	0.2067	99.99998
Std. Dev.	0.0017	0.0027	0.0011	0.0012	0.0004	
% RD (NBL ≡ 0)	6.20	-0.007	0.001	0.103	0.005	



**Table 5. <sup>241</sup>Am abundance with respect to sample and with respect to Pu.**

	NBL		LANL	
	µg/g sample	µg/g Pu	µg/g sample	µg/g Pu
<sup>241</sup> Am	4135	4727	4193	4779
% RD	≡ 0	≡ 0	1.40	1.10

