BROOKHAVEN NATIONAL LABORATORY

BIOLOGY DEPARTMENT

E898, BNL-2 RUN

FINAL REPORT

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TABLE OF CONTENTS

SUMMARY

During the Fall of 1996, a second group of radiobiological and physics experiments were performed using the BNL's AGS in a beam of ^{56}Fe ions (Experiment 898, BNL-2). These experiments were part of NASA's Space Radiation Health Program (SRHP) heavy ion radiobiology research program. The run's primary goals were:

1. The continuation of the use of the 1 GeV/nucleon iron beam for biology and physics experiments employing a tested dosimetry system, and an improved logistic support organization
2. The establishment of the capability and protocols for experiments using 0.6 GeV/nucleon iron beams.

A total of 18 groups participated in the BNL-2 run, 12 groups were returnees from 1995's BNL-1, and 6 groups were new participants. These groups represented 16 institutions from United States, and totaled 63 scientist. Their experiments were dedicated to the study of the physics characteristics and the biological effects of ^{56}Fe ion beams on detectors, and a hierarchy of biological systems ranging from isolated DNA, to cells, tissues and animals. A total of 1400 biological samples were irradiated at the AGS A-1 beam line, employing 85 hours of beam time.
In addition, 44 hours were used for physics experiments, and a total of 22 hours were necessary for beam characterization, dosimetry, and calibration.

During the BNL-2 run, AGS provided iron beams with two energies: 1 GeV/nucleon for biology and physics, and as a test mode, 0.6 GeV/nucleon mainly for physics and for a limited group of biology experiments. More than 90% of the experiments and beam time was carried out during the iron 1 GeV/nucleon run. In general, the users were able to complete close to 100% of their experiment. In addition, for the first time, AGS was able to deliver 0.6 GeV/nucleon iron beams. The run was successful, demonstrating that this tune modality can be included in future run beam manifests.

Several changes have been introduced for BNL-2 logistic support. Among them, a new Medical Dept. liaison, a better coordination of laboratory arrangements, the use of a general questionnaire to support logistics requirements, a streamlined safety training, and an improved run schedule organization and implementation. All these changes were reflected in a better utilization of the available beam time considering the increase of number of users (53.6%) and samples exposed (57%). Finally, the growing maturity of the facilities, personnel supporting the run, and users, was reflected in an increase beam availability, more flexible problems solving strategies and the optimization of the beam time allocated to the users.

BNL-1 AND BNL-2 PARTICIPANTS

ID	Scientist on site	Affiliation	Title
B1a	M. Barcellos-Hoff	Lawrence Berkeley National Lab., CA	P.I.
	S. Ravani	Idem	Res. Assistant
B1b	P. Cooper	Lawrence Berkeley National Lab., CA	P.I.
	B. Rydberg	Idem	Co-P.I.
	M. Lobrich	Idem	Post-Doc
	B. Fouladi	Idem	Grad. Stud.
	E. Kwoh.	Idem	Res. Assistant
B1c	A. Kronenberg	Lawrence Berkeley National Lab., CA	P.I.
	S. Gauny	Idem	Senior Res.
	C. Cherbonnel	Idem	Ass.
	C. Wiese	Idem	Post-Doc.
			Post-Doc.
B1d	G. Nelson,	NASA-Jet Propulsion Lab., CA	P.I
	W. Schubert	Idem	Co-I.
	D. Schranck	Idem	Co-I
	R. Kern	Idem	Co-I
	G. Kasarians	Idem	Co-I
B1e	J. Miller	Lawrence Berkeley National Lab., CA	P.I.
	L. Heilbronn	Idem	Ph.D., Co-W
	C. Zeitlin	Idem	Ph.D., Co-W
	K. Frankel	Idem	Ph.D., Co-W
	B. Ludewigt	Idem	Ph.D., Co-W
	R.P. Singh	Idem	Ph.D., Co-W
	M Nyman	Idem	Ph.D., Co-W
	K. Holabird	Idem	Ph.D., Co-W
	W. Holley	Idem	Ph.D., Co-W
	W. Schimmerling	NASA, Headquarters, D.C.	Ph.D., Co-W
	T. Borak	Colorado State University, CO	Prof., Co-W
	S. Rademacher	Idem	Grad. Stud.
	C. Stronach	Virginia State University, VA	Prof., Co-W
B1f	M. Vazquez	Brookhaven National Laboratory, N.Y.	P.I.
B2	D. Chen*	Los Alamos National Laboratory, NM	P.I
B3	T. Yang	NASA-Johnson Space Center, TX	P.I.
	H. Wu.	Idem	Ph.D
	S. Yamada	Idem	Ph.D.
	K. George.	Idem	Tech. Ass.
	A. Tavakoli	Idem	Tech. Ass.
B7	B. Rabin	University Maryland at Baltimore MD	P.I.
	J. Joseph.	USDA-ARS, MA	Co-P.I
	S. Erat	Idem	Technician
	B. Shukitt-Hale	Idem	Technician
B8	T. Jorgensen*	Georgetown University Medical C., DC	P.I.
	P. Russell	Idem	Res. Assoc
	M. Moskovitch	Idem	Ph.D.
B9	B. Sutherland	Brookhaven National Laboratory, N.Y.	P.I.
	P. Bennet	Idem	Sci. Res Assis.
B10	L. Lutze-Mann	University of California, CA	P.I.
	I. Samuels	Idem.	Res. Assoc.
TOTAL:	47 Scientist from 12 institutions; 12 PI s, 6 Co-PI, 3 post-docs, 2 graduate student; 4 research assistants, 2 research associates, 14 Ph.D.s, 4 technicians.		

BNL-2 NEW PARTICIPANTS

ID	Scientist on site	Affiliation	Title
B12	T. Hei R. Miller C. Piao	Columbia University, NY Idem Idem	P.I. Staff. Ass. Staff Ass.
B13	E. Balcer-Kubiczek G. Harrison	University of Maryland at Baltimore, MD Idem	P.I. Ph.D.
B14	N. Metting	Pacific Northwest National Lab., WA	P.I.
B15	C. Waldren* M. Lenarczyk	Colorado State University, CO Idem	P.I. Ph.D.
B16	J. Lett G. Mariano A. Cox	Colorado State University, CO Idem USAF, Armstrong Laboratory, TX	P.I. Grad. Student Co-P.I.
B17	A. Lindgren G. Lindgren K. Beethun J. Edwards L. Miranda	Bemidji State University, MN Idem Idem Idem Idem	P.I. Coworker Coworker Coworker Coworker
TOTAL:	16 Scientist, from 6 Institutions, 6 PI s, 1 Co-PI, 2 Ph.D.s, 1 graduate student, 6 coworkers.		

*** Not present during the run**

PARTICIPANTS STATISTICS

	BNL-1,2	BNL-2	Total
Principal Investigators	12	6	18
Co-PIs	6	1	7
Ph.D.s	14	2	16
Post-docs	3	-	3
Res.Associates	2	-	2
Res. Assistants	4	-	4
Coworkers	-	6	6
Technicians	4	-	4
Graduate Students	2	1	3
Total:	47	16	63

RUN DATES

	Scheduled	Actual
Run Dates	10/21-28	10/21-30
First extraction	10/19-20	10/19 1630 (from AGS to swichtyard)
Tuned into cave	10/21 0800	10/21 0700
Beam delivered for Biology:		
• 1 GeV/a ^{56}Fe	10/21 0800	10/22 2200
End run	10/28 0800	10/30 0630
• 0.6 GeV/a ^{56}Fe		10/30 1015
End of run	10/28 0000	10/30 2342

Beam Time Description

Total Clock Time (from 10/21 0700 to 10/30 2342)	232.7 hr.
Total beam time (idem, beam on)	198 hr.
Total beam-off time	31 hr.
Beam time for Biology:	
1 GeV/a	81.74 hr.
0.6 GeV/a	3.26 hr.
Beam time for Physics:	
1 GeV/a	40 hr.
0.6 GeV/a	4 hr.
Beam time for dosimetry, calibration, etc.	
1 GeV/a	20 hr.
0.6 GeV/a	2 hr.
Cave access time (1400 samples x 2 min. aprox.)	47 hr.
Totals:	198 hr

BEAM CHARACTERISTICS

^{56}Fe beam	600 MeV/nucleon	1000 MeV/nucleon
Fluence (particles/cm^2/spill)		
Maximum Extracted	3.5×10^7	3.0×10^8
On target	9.0×10^6	7.5×10^7
Minimum Extracted	5.4×10^5	6.0×10^5
On target	1.4×10^5	1.5×10^5
Spill rate	30 spills/min	30 spills/min
Spill length	500 msec	500 msec
Beam spot diameter	7.5 cm	7.5 cm
Beam spot size variation with the tune	None	None
Beam cut off lenght.	<1%	<1%
Actual Energy	580+/-10 MeV/nucleon	1060+/-10 MeV/nucleon
AGS energy dispersion		
Instantaneus	1.8×10^{-4} T = 0.18 MeV	1.9×10^{-4} T = 0.19 MeV
Sweep	3.9×10^{-3} T = 3.9 MeV	4.1×10^{-3} T = 4.1 MeV
Actual LET	173 keV/µm	148 keV/µm
Dose/rate recorded.		
Maximum	2 Gy/min (0.066 Gy/spill)	15 Gy/min (0.5 Gy/spill)
Minimum	0.03 Gy/min (0.001 Gy/spill)	0.03 Gy/min (0.001 Gy/spill)
Minimum dose exposure	0.001 Gy	0.001 Gy
No of hours for beam characterization and dosimetry	2	20

BNL-2 Run Statistics and Incidents

Date	Shift	HIP Avail.	Non-HIP*	Remarks
10/21/96	2	6	2	1 GeV Iron run start, beam tuned into the cave
	3	6	2	TBD
10/22/96	1	7.5	1.5	TBD
	2	8	0	No incidents.
	3	8	0	Biology run start.
10/23/96	1	5.5	2.5	Tandem failures.
	2	2	6	Problems with the AGS and Booster RF
	3	4	4	Tandem power supply problems
10/24/96	1	7.5	0.5	Beamstop failures.
	2	6.5	1.5	TTB beamstop failure
	3	6.5	1.5	TBD
10/25/96	1	8	0	No incidents.
	2	8	0	No incidents.
	3	8	0	No incidents.
10/26/96	1	7.5	0.5	Tandem sparked, A1 detector check
	2	8	0	No incidents.
	3	7.5	0.5	TBD
10/27/96	1	9	0	No incidents. Daylight savings.
	2	8	0	No incidents.
	3	8	0	No incidents.
10/28/96	1	8	0	No incidents.
	2	5.5	2.5	Security fault with the AGS/HEBT gate reset
	3	7.5	0.5	High gain PUE's studies in the Booster
10/29/96	1	7.5	0.5	Tandem beamstop failure.
	2	5	3	Setting up for 600 MeV Iron.
	3	7.5	0.5	Power supply problems.
10/30/96	1	8	0	1 Gev Iron run completed.
	2	6	2	600 MeV Iron run start
	3	7.5	0.5	BNL-2 run end.
Totals:	29	198 hr. (86.5%)	31 hr. (13.5%)	

* Beam off due to AGS problems,

BNL-2 EXPERIMENTERS AND RUN STATISTICS

Exp. ID	Principal Investigator	Energy	Beam Time requested	Beam Time used	Dose Range (cGy)	Dose/Rate (cGy/min)	Number of Samples (*)
B1a	Barcellos-Hoff	1 GeV	5	3	3 - 160	50 - 100	48
B1b	Cooper	1 GeV	14	15	50 - 10000	150 - 1000	195
B1c	Kronenberg	1 GeV 600 MeV	20	20 1	31.5 - 200	30 - 100	180 17
B1d	Nelson	1 GeV	7	6	468 - 4678	500 - 1000	134
B1e	Miller	1 GeV 600 MeV	40	40 4	-	-	-
B1f	Vazquez	1 GeV 600 MeV	2	1.29 0.46	5 - 400 5 - 200	16 - 500 3.2 - 81.5	30 (380) 14 (160)
B2	Chen	1 GeV	3	0.60	50 - 300	50 - 60	20
B3	Yang	1 GeV	6	5.25	25 - 400	100 - 400	94
B7	Rabin	1 GeV	6	4.5	10 - 100	50	78
B8	Jorgensen	1 GeV	3	2.5	0 - 180000	700 - 1100	11
B9	Sutherland	1 GeV 600 MeV	2	1.25 0.25	0.02 - 80 0.1 - 80	0.3 - 30	76 15
B10	Lutze-Mann	1 GeV	5	4	50 - 100	100 - 200	100
B12	Hei	1 GeV	6	3.25	10 300	16 - 78	52
B13	B.-Kubiczek	1 GeV	3	2.35	50 - 250	295	65
B14	Metting	1 GeV 600 MeV	2	2 1.55	10 - 80 20	15 - 80 35	48 (144) 1 (44)
B15	Waldren	1 GeV	6	0.75	8.5 - 230	7.7 - 66.9	34
B16	Lett	1 GeV	4	4	100 - 750	1 -2	33
B17	Lindgren	1 GeV	7	6	4 - 100	?	165
Total			141 hr.	129.19 hr.	0.02 to 180000	0.3 to 1100	1400

(*) Total number of specimens.

DESCRIPTION OF EXPERIMENTS

B1a PI: M. H. Barcellos-Hoff, Lawrence Berkeley National Laboratory

Title: Ephitelial Transformation and Carcinogenesis

Endpoint:

1) Recombination experiments of iron-irradiated BALB/c female mice normal donor epithelial cells transplanted to irradiated or normal recipient stromal fat pads (from same mice strain) was conducted. The percentage of fat pad filled will be estimated and the type of outgrowth will be classified as normal or abnormal.
2) Radiation-induced changes in the extracellular matrix (ECM) production in mammary gland of mice, will be examined qualitatively by immunolocalization of ECM proteins in stromal and ephitelial cells as a function of time post-exposure.

B1b PI: P. Cooper, Lawrence Berkeley National Laboratory

Title: DNA Damage and Repair in Mammalian Cells

Endpoints:

1) DSB induction and Repair in: CHO hamster-human hybrid cells and human fibroblasts
2) Cell survival in human fibroblasts
3) Transcription-coupled repair in human fibroblasts and XPG mutant cell line.
4) Induction of small and intermediate DNA fragments as a function of dose in human fibroblasts

B1c PI: A. Kronenberg, Lawrence Berkeley National Laboratory

Title: Mutagenesis in Human and Rodent Cells

Endpoints:

1) Quantification of mutations at the level of hprt locus, tk locus and aprt locus, in irradiated cells (TK6 and WTK-1).
2) Chemical modulation of DNA damage on mutation frequencies and mutation spectra in the same cell lines.
3) Dose-response relationships for cell killing and mutation induction for subclones of TK6 and WTK1 cells that are suppressed for x-ray induced apoptosis due to ectopic expression of bcl-2 or bclXL.

B1d PI: G. Nelson, NASA, Jet Propulsion Laboratory

Title: Studies of Mutations and Chromosomal Aberrations in the Nematode *C. elegans*.

Endpoints:

1) Chromosomal aberrations versus fluence responses of wild type, rad-8 and rad-9 mutants
2) Mutation versus fluence relationships for a tester strain of genotype nT1(IV)/dpy-13 IV; nT1(V)/ unc-46 V.
3) Inactivation of developmental program assessed by measuring brood size versus fluence in wild type and glp-4 mutants held at restrictive and permissive temperature.

B1e PI: J. Miller, Lawrence Berkeley National Laboratory

Title: Small Angle Fragment Fluence Spectra at Depth in Cells and Tissues

Endpoints:

Measure projectile fragment fluences as a function of LET for heavy ions incident on biological systems and tissue equivalent targets of varying thickness. The detectors used were: solid state detector stack supplemented by plastic nuclear track detectors.

B1f PI: M. Vazquez, Brookhaven National Laboratory

Title: The effects of High Energy Heavy Ions on Neural Plasticity

Endpoints:

1) Retinal ganglion cell neurite regeneration in culture in culture (neurite density, elongation rate, explant area)..
2) Neuronal viability in retinal explants.

B2 PI: D. Chen, Los Alamos National Laboratory

Title: Effect of Charged Particle Track Structure on Radiation Mutagenesis

Endpoints:

1) Measure cell survival and mutagenesis at the hprt locus in human skin fibroblast.
2) Molecular analysis of the radiation-induced human 6tgr mutants
3) Analysis of premature chromosome condensation (PCC). The number of PCC fragments ibn at least 25 cells per sample was scored.

B3 PI: T C. Yang, NASA, Johnson Space Center

Title: Quantitative Studies on the Oncogenic and Cytogenetic Effects of Energetic Iron Particles in Mammalian Cells.

Endpoints:

1) Determination of the cell survival and transformation frequency in mouse embryonic cells (C3H10T1/2), and cytogenetic (chromosome aberrations) studies in human fibroblast and lymphocytes.
2) Determine the effects of DMSO on the induction of chromosome damages..

B7 PI: B. Rabin, University of Maryland Baltimore County

Title: Effects of Exposure to Heavy Particles

Endpoints:

1) Evaluation of the behavioral toxicity of iron particles in rats using the conditioned taste aversion (CTA) test, motor behavior parameters using the wire suspension task, and neurochemical endpoints to 2.5 Gy of Iron ions..
2) Determine the effect of exposure on striatal membrane fluidity and the effects of cholesterol or s-adenosylmethionine pretreatment on subsequent cholinergic enhancement of Dopamine release from striatal slices.

B8 PI: T. Jorgensen, Georgetown University

Title: DNA Strand Breaks Produced in Mammalian Cells by Heavy Ion Irradiation.

Endpoints:

1) DNA strand break induction in logarithmically growing V79 cells.
2) Effects of free radicals scavengers and repair measurements.

B9 PI: B. Sutherland, Brookhaven National Laboratory

Title: DNA Damage and Restoration in Mammalian Cells and Tissues

Endpoints:

1) Measure induction of DSB in human DNA isolated in agarose and cultured human and murine cells in agarose.
2) Determination of repair kinetics.

B11 PI: L. Lutze-Mann, University of California San Francisco

Title: Molecular Analysis of HZE Damage in Transgenic Mice

Endpoints:

1) Quantification of radiation-induced mutations in nondividing tissue germ cells and stem cells from C57BL/6 transgenic mice.
2) Determination of the nature of these mutations by RFLP
3) DNA sequence analysis of recovered mutants.
4) Determination of mutation frequency at the hprt locus in peripheral blood.

B12 PI: T. Hei, Columbia University

Title: Cytogenetic and Neoplastic Transforming Effects of Heavy Ions in Mammalian Cells

Endpoints:

1) Determine the transformation stage of irradiated cells (BEP2D, AGI522, MCF12, C3H10T1/2 and SHE) using the following endpoints: a) growth kinetics, b) resistance to serum-induced terminal differentiation, c) anchorage independent growth, d) tumorigenicity, and e) metastasis.

B13 PI: E. Balcer-Kubiczek, University of Maryland at Baltimore

Title: Molecular Damage by 1 GeV/amu Fe Ions.

Endpoints:

1) Characterize the gene transcriptional response of cultured human cells (MCF-7) by measuring messenger RNA (mRNA) expression of the p53, wild-type p53-activated fragment 1 (WAF-1/CIP1) genes as a function dose and time post-irradiation.

B14 PI: N. Meeting, Pacific Northwest National Laboratory

Title: The Effect of Heavy Ion Exposure on a Mechanism of Cell Cycle Regulation.

Endpoints:

1) Measure the subcellular localization of the cell-cycle regulatory proteins cdc-2, cyclin B, weel, and cdc25 in mammalian cells (HeLa S3) as a function of hit traversals.
2) Correlation of these parameters with mitotic delay.

B15 PI: C. Waldren , Colorado State University

Title: HZE Radiation Genotoxicity in Cultured Mammalian Cells.

Endpoints:

1) Define mutant spectra in $S1^{-}$ mutants at 0.5 and 1 Gy dose level

B16 PI: J. Lett, Colorado State University

Title: Cell Cycle Responses of DNA Damage and Repair in L5178Y S/S Murine Leukemic Lymphoblsts Exposed to ^{56}Fe Ions.

Endpoints:

1) Cell-cycle survival responses of S/S cell to iron exposures at 37° C; 12 hr. at 24° C and then 37° C.
2) Determine the DNA damage produced in supercoiled chromosomal loops following iron ion irradiation.

B17 PI: A. Lindgren, Bemidji State University

Title: RBE of ^{56}Fe on Rodent Lens Epithelia.

Endpoints:

1) Determine the percentage of rodent (male Sprague Dowley rats) lens epithelial cells that have micronuclei and the fraction of the late anaphase to early telophase which shows abnormalities as a function of dose and time after exposure.

RESULTS AND ANALYSIS

1. Planning and Communications

In order to plan and organize the BNL-2 run, several monthly teleconferences were held during 1996. The description of the teleconferences is the following:

1. March 25
2. May 6
3 July 1
4 July 26
5 August 26
6 September 27
7 December 9.

In addition, to these meetings, on September 17, an Experiment Readiness Review (ERR) was held at Brookhaven National Lab., at Biology Dept. During the meeting all the parties involved in the planning and organization of the BNL-2 discussed the status of the run in all the aspects of its organization. Several issues were identified and discussed in order to improve the degree of readiness. From each teleconference, a report was generated and distributed among the participants, PIs, and managers of the program.

During the end of 1995 and the beginning of 1996, the NASA-BNL-Biology www homepage was put on line (http://bnlstb.bio.bnl.gov/www_root/webdocs/nasa/nasapage.htmlx). The homepage describes the goals, characteristics and organization of the program, and summarize the BNL-1 run.

2. Safety Training and Dry Runs

In August, September and October, 1996 a complete series of training sessions and dry-runs were carried out in order to prepare the new BNL-2 users. As a consequence of the BNL-1 run experience, the training for new participants was streamlined reducing the length of the lecture sessions, eliminating or combining some courses and granting waivers when appropriate. The definition and implementation of these changes was carried out by the Primary Liaison Scientist (M. E. Vazquez), Medical and AGS Dept. Safety and Training coordinators (E. Lessard, J. Bullis), and S&EP Div. personnel (D. Atchison, B. Fortunato). A total of 22 scientists were trained in the following courses, which were a pre-requisite for the dry-runs: a. Radiological Worker I (RW-1); b. General Employee Training (GET), and c. AGS Ring and Cave Access Training. The general outcome of the training was very favorable, with 100% success in all courses, and a considerable reduction in the time spent in lectures.

All new BNL-2 groups underwent training by the execution of dry-runs, consisting of familiarization with the facilities, a walk trough Bldg. 912, and a visit to the staging and target areas. There, the users inspected the installations and discussed the general operations for the actual run with M. Vazquez. Special attention was given to the sample holder and optical bench configuration. Thereafter, each group proceeded to simulate their run, timing the procedures. The use of the on-line dosimetry system

greatly improved the activities, since a very realistic scenario could be reproduced. The result of this intensive training was reflected in the new users run, which in general ended their actual runs ahead of time and without major problems. The following is a list of scientists and coworkers that completed the training described:

B1a	S. Ravani
B1b	C. Wiese
B1d	G. Kasarians and R. Kern.
B1e	W. Schimmerling and W. Holley
B3	S. Yamada
B8	M. Moskovich
B12	R. Miller and C. Piao
B13	E. Balcer-Kubiczek and G. Harrison
B14	N. Metting
B15	M. Lenarczyk
B16	J. Lett, A. Cox and G. Mariano
B17	A. Lindgren, G. Lindgren, K. Beethun, J. Edwards and L. Miranda.

3. Logistic Support

The organization and planning of the BNL-2 logistic support was carried out by M. Vazquez and J. Gatley with the collaboration of K. Conkling, B. Piatt, J. Bullis, M. Makar, D. Mallon, D. Maresca, M. Kershaw, J. Gatz, D. Lazarus and W. McGahern. The organization involved resources mainly from Medical Dept. and, to a lesser degree, from Biology and AGS Depts..

Medical Department played a pivotal role in the accomplishment of this complex task, under the leadership of its Chair Dr. N. Volkow and with the tremendous work of J. Gatley, the new liaison scientist. J. Gatley, in coordination with M. Vazquez, developed a system based on the BNL Ground Support Requirement Document (GSRD). This document allowed them to survey and identify the particular logistic needs of each group, and match these requirements with the most adequate resources available. This document was adopted after the BNL-1 run, and it is an adaptation to the local characteristics of the current NASA's GSRD successfully used for space shuttle missions. The liaisons held weekly meetings since July, in order to process the information received from the users. Medical Dept., then, identified and assigned several laboratories, offices and general-purpose facilities to the run. After a careful analysis of the users' needs and BNL resources, each group was assigned an individual or shared facility. These arrangements were communicated to the users before the run, with a specific response to the equipment requirements and its backups. Several equipment were repaired and certified for the BNL-2 run. In addition, the use of some of the shared equipment (incubators and hoods) was scheduled among the users through the run.

A total of 6 laboratories, 3 shared facilities (Animal Facility, Medical Tissue Culture Facility and the Conference Room B), and 9 individual offices was assigned and used in the run. One group (B14, N. Metting), worked at the Biology Dept. using 1 laboratory and 1 office. To support the computer and communication needs, several workstations (Mac and SUN) were available. In general, each office-lab. has their own telephone line. A FAX machine located in the Conference Room B was available 24 hr a day.

A key role in the run was carried out by the Brookhaven Laboratory Animal Facility (BLAF) at Medical Dept., which supported 4 groups that used animals (mice and rats) in their experiments. Approximately 400 animals (150 mice and 250 rats) were taken care of by the facility under the supervision of M. Kershaw. The personnel's work in providing logistic support in this area was outstanding.

As contribution to the logistic support for BNL-1 run, the Biology Dept. facilitated the use of its cesium source.. The source was employed by two groups (B14 and B16) for the completion of a small set of satellite low-LET irradiation. The experimenters used approximately 1 hour of machine operations, and the activities were supervised by R. Satkulis from Biology Dept.

As a consequence of the experience gained during the BNL-1 run, several modifications were suggested and finally adopted in regard the configuration and operational procedures at the staging area. Some of the changes were: the relocation of phones, the incubator was serviced, the access to the cell room was restricted, two monitors were installed in each room, a large white board was positioned outside the physics room, and the waste disposal procedures was streamlined. Overall, the support for tissue culture and animal experiments was satisfactory.

4. Run Operations

a. Run Schedule:

The design, organization and implementation of the BNL-2 run schedule was the responsibility of M. Vazquez. Several factors were taken into account: 1) individual user beam request and biological sample handling and processing constraints, 3) specific experimental design and beam time distribution, and 4) organization of activities at the staging area and Medical Dept..

The schedule design was based on the premises that a total of 141 hr. of beam time were approved by the BNL's SACR for BNL-2 proposals. In addition, AGS agreed to schedule 10 days of machine operations to provide a full week dedicated to physics and biological experiments. Despite the complexity inherent to accommodating 18 different groups with different biological systems and their specific constraints (tissue cultures to animals, different beam intensities and settings) AGS machine operation uncertainties, etc., we were able to accommodate the complete series of experiments

planned. Nine groups split their allocated beam time in several sessions, increasing the complexity of the schedule and its coordination. For example:

B1b	P. Cooper	4 sessions
B1c	A. Kronenberg	4 sessions
B1d	G. Nelson	2 sessions
B1e	J. Miller	4 sessions
B1f	M. Vazquez	2 sessions
B3	T. Yang	2 sessions
B9	B, Sutherland	2 sessions
B14	N. Metting	2 sessions
B 16	J. Lett	2 sessions

Several buffer-time periods were built-in each day, and one hour was included for dosimetry per shift in order to maximize the schedule flexibility, and to compensate any potential delays. In addition, the physics group was able to rearrange their run schedule in order to cover unexpected changes requested by the users or by machine failures. The run schedule was updated weekly and daily before the run, and sometimes by the hour during the run. Prints of the updated schedule were distributed among the participants. The effort to try to keep and distribute the daily changes in print caused a heavy workload, since there is no secretarial help, and/or adequate computer support for the task. A better system must be implemented such as a computer linked via network to a monitor, in which the updated schedule can be displayed.

During the run, M. Vazquez, J. Gatley and J. Miller, held daily meetings with the users in order to coordinate changes, report on the status of the run, and discuss changes in the schedule. The meetings were held at the Medical Dept., usually in the morning. Both liaisons, M. Vazquez and J. Gatley, scheduled their activities in order to cover any contingency, and both were available on-site around the clock during the run. In sum, we have been able to accommodate all the planned experiments on time, using less hours than originally requested, and ending the run on schedule.

b. BNL-2 Run

Two tune modalities were used during BNL-2: 0.6 and 1 GeV/amu iron beams. The first part of the run was dedicated to 1 GeV/amu iron tune using the general same characteristics as in BNL-1. The change of intensities was not a problem in this run, since the tuning for high to low or low to high intensities was carried out with a minimum loss of time and interruption of the operations.

The biology part of the run started with one and half shift delay due to AGS machine failures, dosimetry and beam characterization. During the first four days (10/21 to 10/25) the run operations were affected by several machine failures common for a startup (Fig. 1). This initial period was characterized by the disruption of several biological experiments in which time and handling were critical factors. Common problems were delays in the start of the experiment, or the interruption of

exposures within one experiment. The interruptions lasted between several minutes and 2 hours. These incidents initially stressed the users and the support personnel, but the use of backup samples, and the collaboration between users and the physics group allowed the completion of these experiments, despite the loss of some samples. On run day five, the AGS machine began to stabilize, improving the operations and continued in this mode for the rest of the run (Fig. 1).

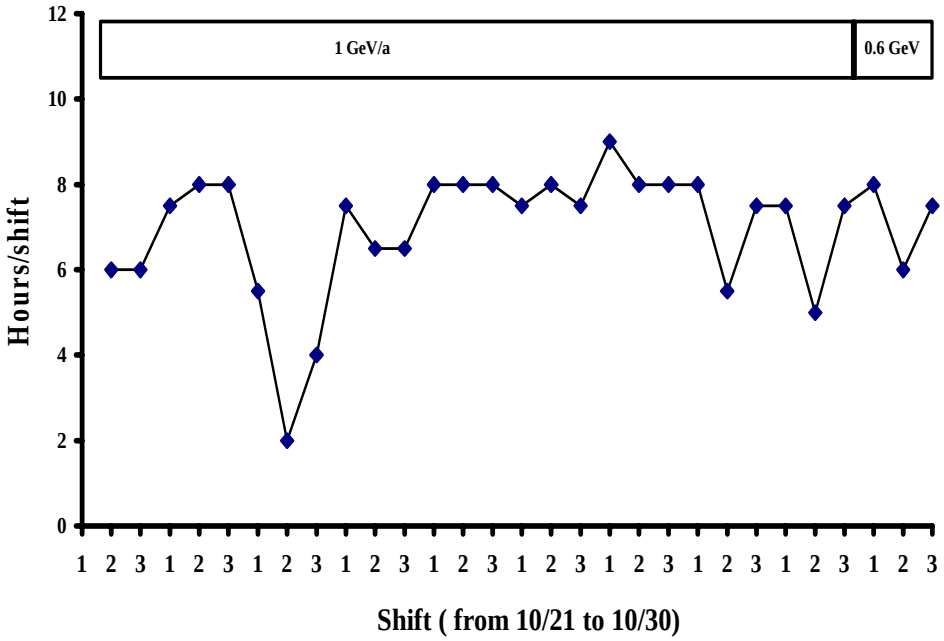

Figure 1. BNL-2 beam availability

The incidents reported above stressed the need to schedule time-critical experiments away from the beginning of the run. Potentially, animal and physics experiments could be schedule for this initial period.

At the end of BNL-2, iron beams were tuned to 0.6 GeV/amu in a test mode for beam characterization and a small set of physics and biological experiments. The transition between 1 to 0.6 GeV/amu tune was extremely smooth. It was initiated before the 1 GeV/amu tune and reestablished immediately after its end. The participants of this short run were:

B1c	A. Kronenberg
B1e	J. Miller
B1f	M. Vazquez
B9	B. Sutherland
B14	N. Meeting

Overall, the beam was available 86.5% of the time, representing an 11% increase of beam availability from BNL-1 (Fig. 2).

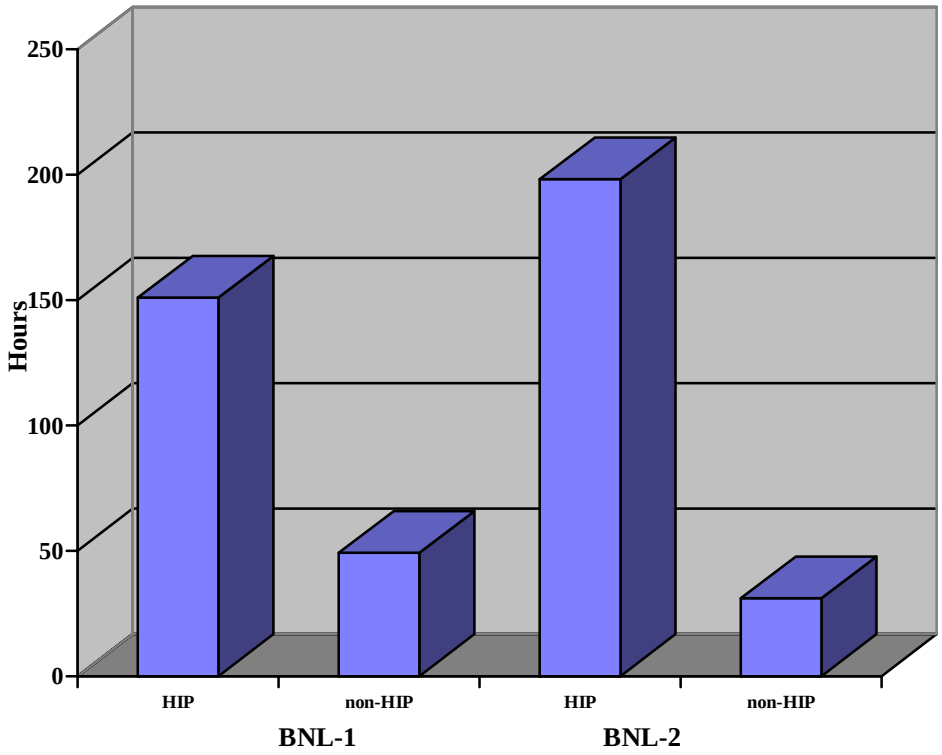

Figure 2. BNL-1 and BNL-2 Beam availability

c. Dosimetry

The staff coordinated by J. Miller provided 24 hours-a-day dosimetric support for all the users. The physics team was integrated by: J. Miller, R.P. Singh, C. Zeitlin, L. Heilbroin, W. Holley, M. Nyman, B. Ludewigt, T. Borak, and some support from AGS operations. The dosimetric system used during BNL-1 was employed with some improvements. This year, the problem of beam on/off control that occurred during the 95' run was corrected, and all the beam control operations were carried out from the trailer, facilitating substantially the users operations. R.P. Singh modified the dosimetry software in order to add information to the summary sheets, and also readouts of the outer rings for users.

d. Cave Access

The structure and organization of the cave access system was under the responsibility of AGS operations, BNL EH&S (Ed Lessard) and LBNL. Basically, the same system employed during BNL-1 was adopted for BNL-2. The system was based on the permanent presence of a health physicist stationed outside the gate. In addition, the installation of monitors in the culture and animal rooms allowed the users a direct visual contact with the gate and the interior of the cave, greatly improving run activities.

e. Beam Uniformity Monitoring:

The assessment of beam uniformity was carried out using ionization chamber readings and densitometry of exposed x-ray films. The processing of the exposed films was carried out by J. Gatley at Medical Dept. throughout the run. It is worth noting that the use of the x-ray technique was not generalized, perhaps because some users were not well aware of the necessity of beam monitoring and sample set-up checking, as well as the absence of a system and protocols as an integral part of the run operations. For BNL-3, a more integrated approach will be recommended in order to improve this matter.

An interesting optical device was employed in a test mode by J. Sutherland from BNL for on-line, real-time beam uniformity monitoring. This system was employed in support of B. Sutherland's experiments and its results are not known yet. The system apparently worked very well, leaving open the question of the future availability of its data for all the users, or if similar systems can be used in a more generalized way.

List of personnel that participated in the planning, organization and execution of BNL-2 run

BNL Management:

- Associate Director for High Energy and Nuclear Physics**: Tom Kirk**

Scientific Advisory Committee:

- **Betsy Sutherland** (Chair), BNL
- **Victor Bond,** BNL
- **Richard Setlow,** BNL
- **Mike Fry,** ORNL
- **Les Braby,** PNL
- **Charles Geard,** Columbia University

AGS:

- Department Head: **Derek Lowenstein**
- Experimental Planning and Support Head: **Philip Pile**
- Accelerator Division Head: **Thomas Roser**

- Accelerator Physicist lead by: **Leif Aherns**
- Tanden Group leader: **Peter Thiesberg**
- A3 beam line instrumentation responsible: **I-Hung Chiang**
- AGS Radiation Safety Committee: **Ken Reece**
- AGS Experimental Safety Committee: **Ed Lessard**
- AGS Control Section lead by: **Don Barton**
- Liaison Engineering Group lead by: **Al Pendzick**, and specially **William McGahern**
- E898 liaison physicist: **Don Lazarus**
- Mechanical Service Technicians led by: **Fred Kobasiuk**
- Survey Group led by: **Frank Karl**
- Beam Service Technicians led by**: Paul Valli**
- Electronic Service Technicians led by: **Bill Anderson**
- AGS Instrumentation Group led by: **Pete Stillman**
- AGS Main Control Room and Operations led by: **Pete Ingrassia**
- Health Physics Group led by: **Chuck Schaefer**
- AGS Electricians led by **Bill Softye**
- AGS Riggers led by: **Nick Cipolla**
- Carpenter and Welder Support Service and Technical Support led by: **Roger Hubbard**

Medical Department:

- Dept. Chair: **Nora Volkow**
- E898 Medical Liaison: **John Gatley**
- Safety and Training and Building manager: **Jim Bullis**
- Administration: **Deborah Maresca, Darcy mallon, B. Coughlin and Donna Russo**
- Animal Care Facilities: **Maryann Kershaw**
- Tissue Culture Facility manager**: Michel Maker**
- Technical support**: Katherine Conckling, By Piatt**
- Property Representative**: Robert Brown and Gina Flippen**
- S & E. P**.: Mark Linsley and Robert Colichio**

Biology Department:

- Chairman: **William Studier**
- **Richard Setlow**
- **Betsy Sutherland**
- **Paula Bennet**
- **John Sutherland**
- E898 Primary Liaison Scientist: **Marcelo E. Vazquez**
- Administration: **Bonnie McGahern**

- Cesiun Source Manager: **Richard Satkoulis**

Safety & Environmental Protection Division:

- Manager: **William Fortunato**
- **Dean Atcheson**
- **George Rundlett**

NASA

- **Walter Schimmerling**

Lawrence Berkeley National Laboratory,

- **Jack Miller**
- **Lawrence Heilbronn**
- **Cary Zeitlin**
- **Bernhard Ludewigt**
- **R. P. Singh**
- **Mark Nyman**
- **W. Holabird**
- **W. Holley**

Colorado State University

- **Tomas Borak**
- **Steve Rademacher**