ADVANCED REACTOR, FUEL CYCLE, AND ENERGY PRODUCTS WORKSHOP FOR UNIVERSITIES

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Fuel Development

Idaho National Laboratory

Workshop for Universities
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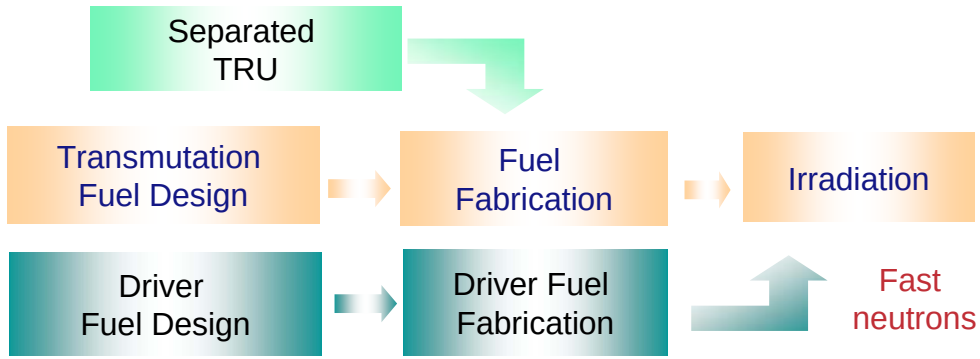
Fuel Development and Qualification is a critical element of the GNEP program

- **Fuel development will be on the critical path for deployment of TRU-burning systems (5 year R&D cycle)**
- **It is not possible to totally decouple the various elements of the demonstration program**
  - Fuel testing requires close coordination with separations for supply of TRU materials



Metal and oxide TRU fuels are candidates for the first generation transmutation fuel

Metal Fuel

- Successful small-scale fabrication and irradiation on limited amount of TRU samples
- Large-scale fabrication without loss of Am must be demonstrated
- Fuel-clad interactions at high burnup must be investigated
- Effect of lanthanides on FCCI must be addressed

Oxide Fuels (powder processing)

- Successful small-scale fabrication and irradiation on limited amount of TRU samples (France, Japan)
- Effect of group TRU on fabrication process unknown
- Effect of lanthanides on fabrication
- Large-scale fabrication amenable to hot-cell operations must be developed
- Limitations on linear power

- Am recovery and use in moderated targets
- Fabrication using powder metallurgy
- Development of advanced clad materials (possibility of using liners)

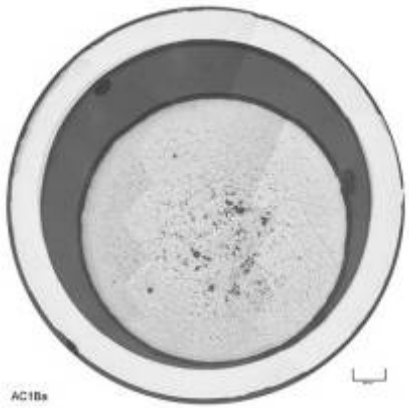
- Vibro-pac fuel technology

  Risk trade-off: fabrication versus performance

Long-Term Fuel Technologies (> 20 years)

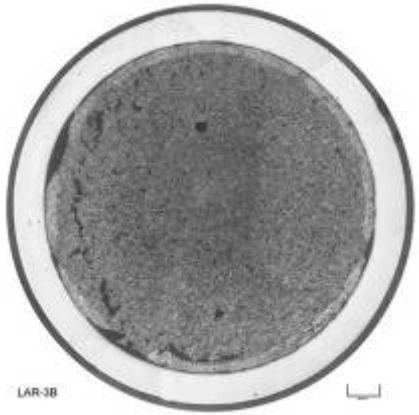
- **Nitride - candidate for 2nd or 3rd generation**
  - –High TRU loading potential
  - –Fabrication process requires further work
  - –N-15 enrichment.
- **Dispersion - candidate for 2nd or 3rd generation**
  - –High burnup potential
  - –Fabrication process requires further work
  - –Separations process must be developed

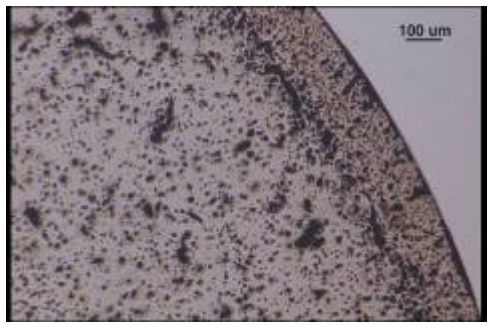
FY06 ACCOMPLISHMENTS (AFCI)



Pu-40Zr

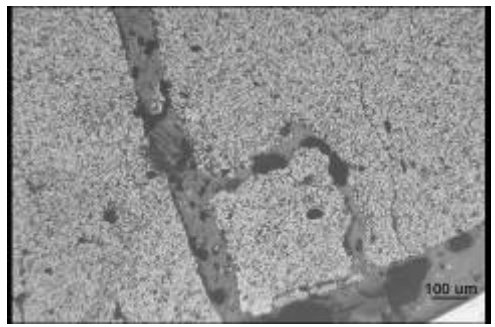
6.8 at.% , 6.4x10^{20} f/cm^3





U-29Pu-4Am-2Np-30Zr

6.0 at.% , 8.9x10^{20} f/cm^3



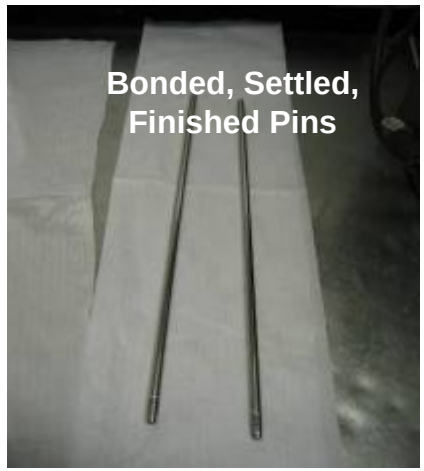
$(U_{0.5}Pu_{0.25}Am_{0.15}Np_{0.1})N$

4.6 at.% , 5.8x10^{20} f/cm^3

Successful fabrication and delivery of 2 Metal and 2 Nitride Fuel Pins to CEA-Phénix reactor

LANL Nitride Pellets

INL Metal Casting



Packaged in TN-BGC 1

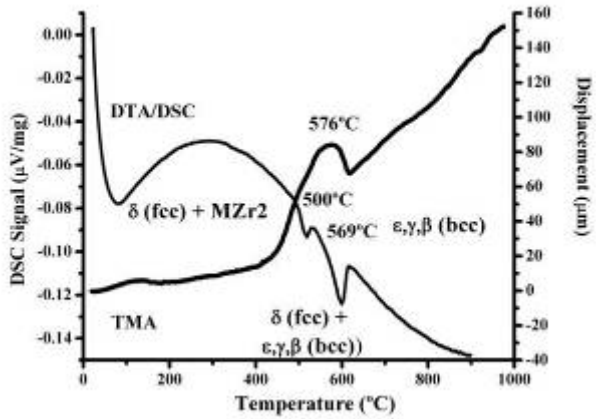
Loaded in Sea/Land Container

Shipped to France

Transport to US Port

WORK IN PROGRESS FOR FY07 (GNEP)

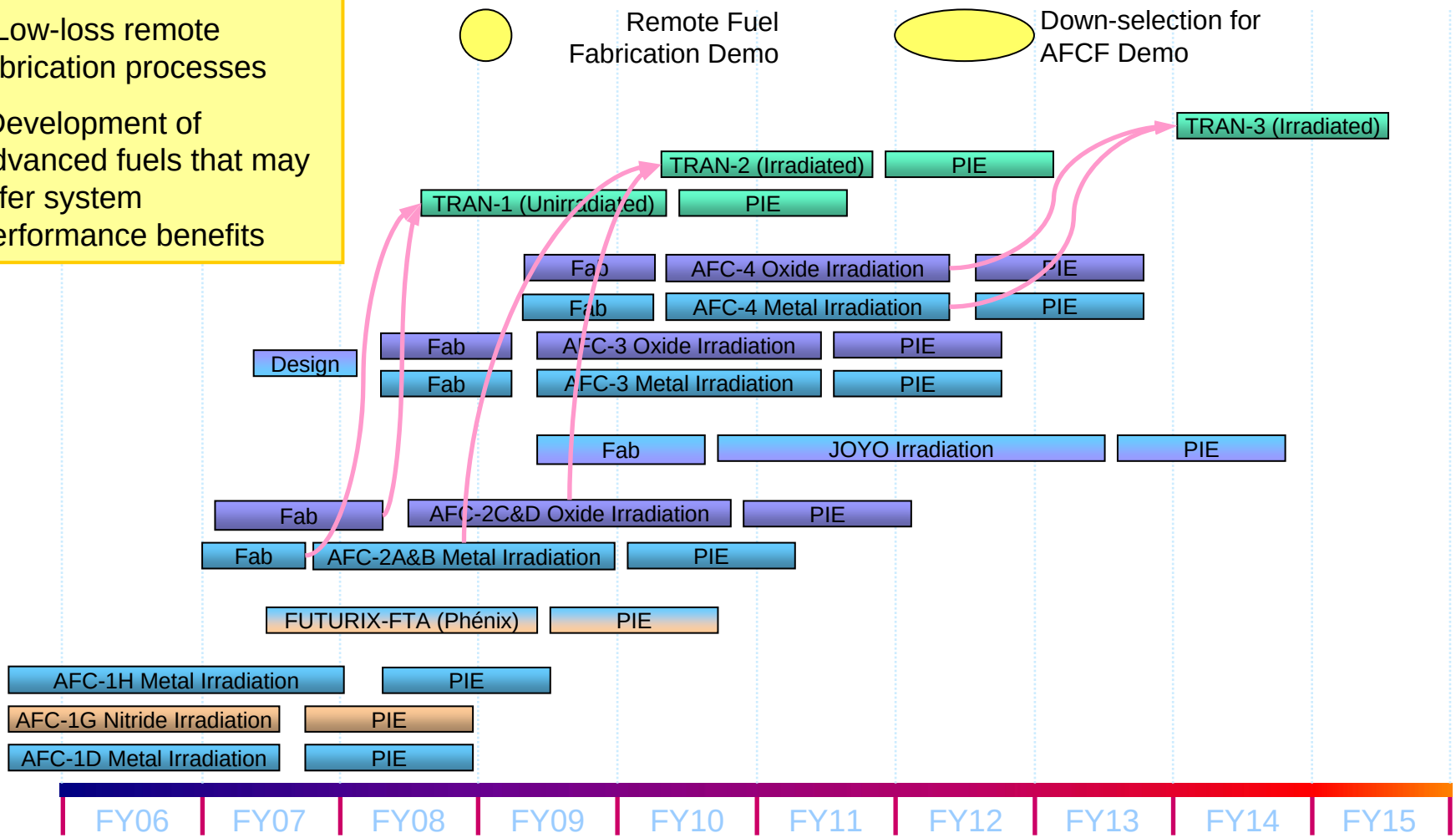
- *Fabrication of the AFC-2 irradiation experiment for insertion in ATR*
- *Development of low TRU loss fabrication processes for oxide and metal fuels*
- *Characterization of thermophysical properties of TRU fuels*
- *Evaluation/planning of transient test program*
- *Development of FRAPCON-3 based 'fuel design code'*
- *Continued irradiation of AFC-1 fuels to 40 at.% ^{239}Pu depletion*
- *TEM examination of alloys irradiated in GFR-F1 (800H, MA-754, MA-956, T122)*
- *Evaluation of processes for reduction of TRU oxides to metal*



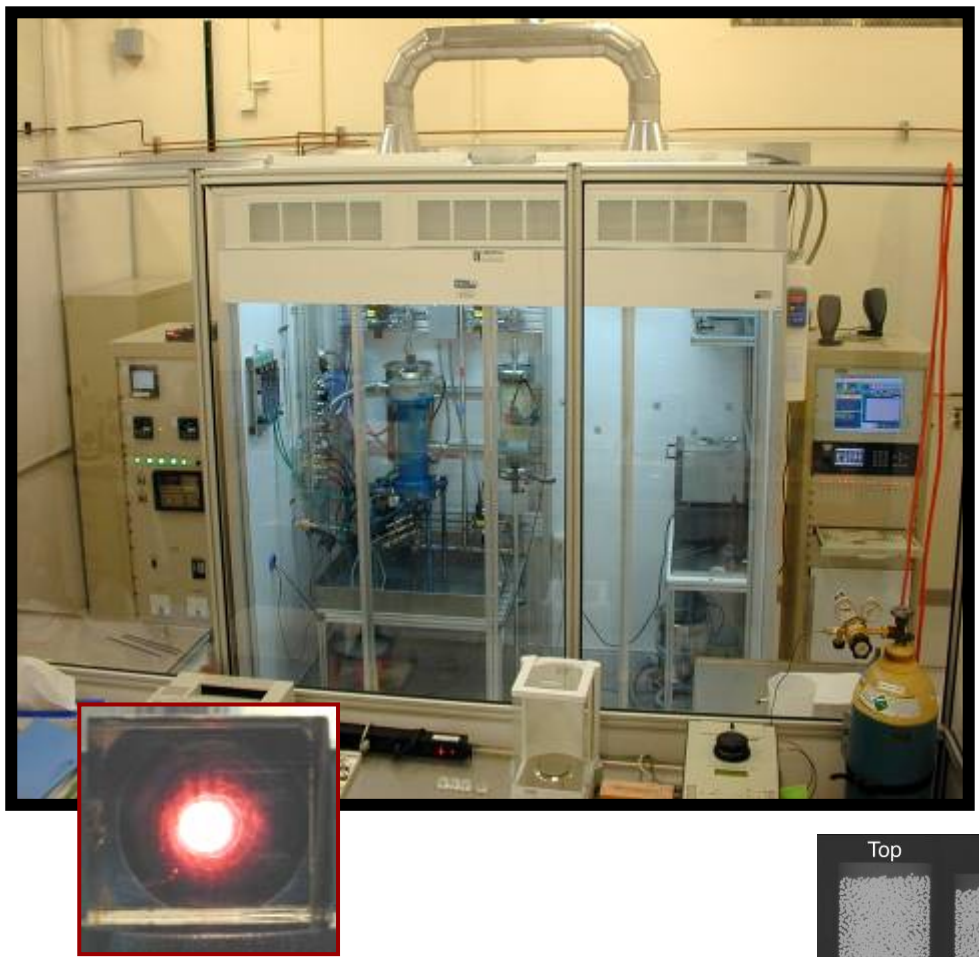
AFC-1D (EFT)	Linear Heat Rate (W/cm)	Fission Heat Rate (W/g)	^{239}Pu Depletion (atom%)	Heavy Metal Depletion (atom%)	^{241}Am Depletion (atom%)
Rodlet 1	137.29	119.30	19.80%	13.51%	38.07%
Rodlet 2	166.67	146.14	25.13%	15.21%	**47.49%**
Rodlet 3	242.54	219.55	27.52%	18.16%	24.03%
Rodlet 4	214.49	193.73	27.82%	19.55%	**52.55%**
Rodlet 5	163.35	173.71	**31.76%**	20.96%	--
Dummy	--	--	--	--	--

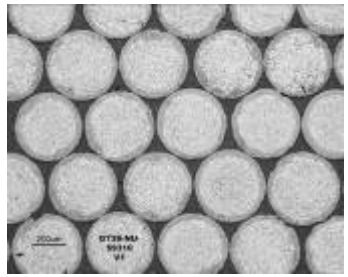
Planning for FY08+

- Irradiation testing of oxide and metal FR fuels
- Modeling specific fuel behavior
- Low-loss remote fabrication processes
- Development of advanced fuels that may offer system performance benefits

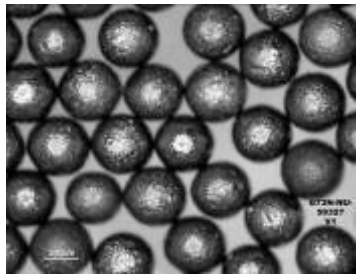


FY06: AGR-1 Fabrication

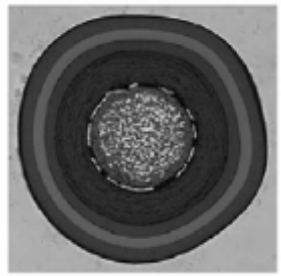


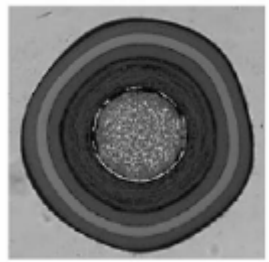


Sintered kernels



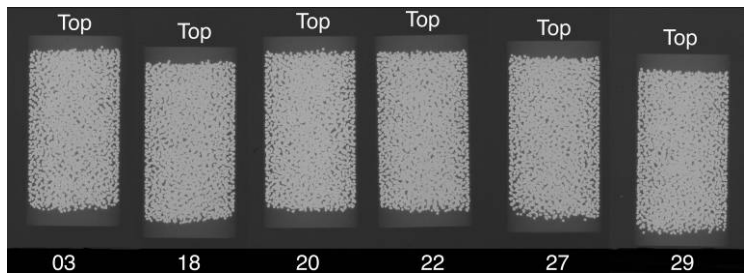
Loose kernels



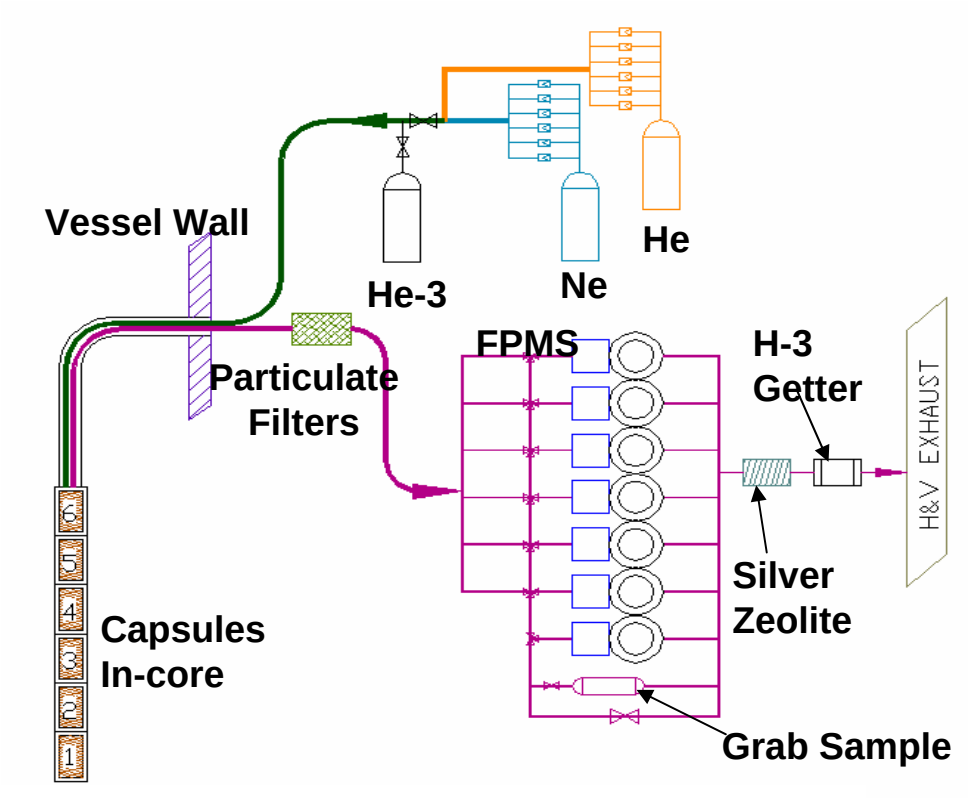


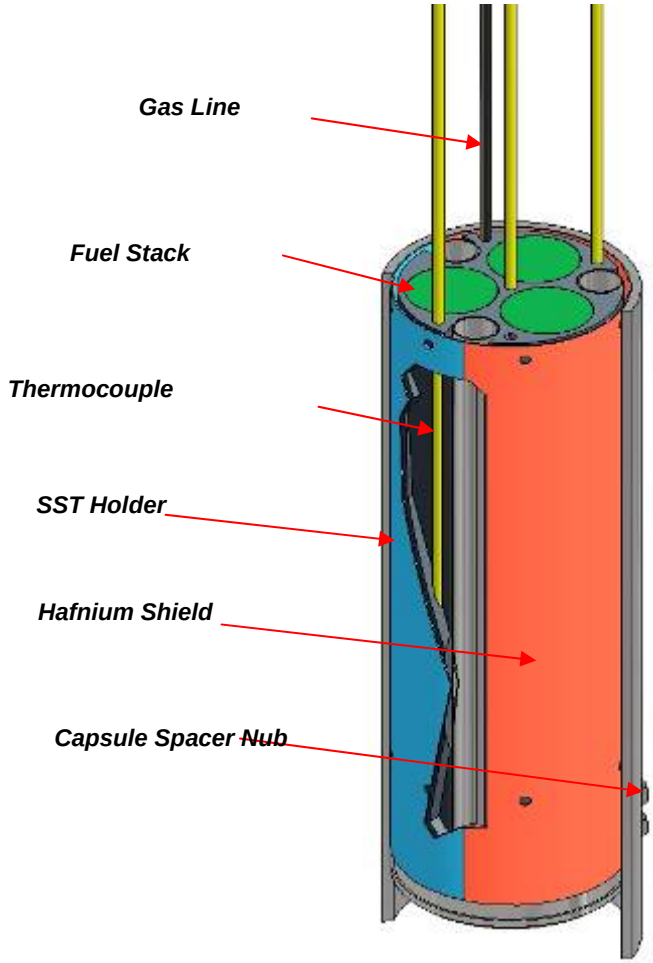
LEUCO coated particles

Fuel Compact

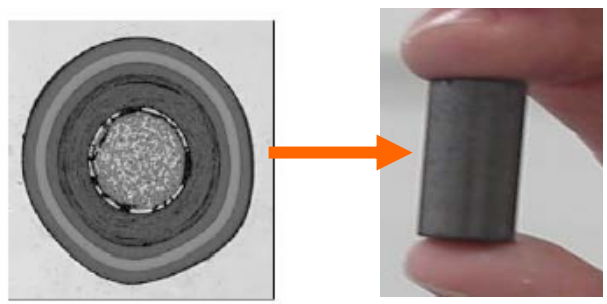


FY07: AGR-1 Irradiation Test Insertion





- AGR-1 is a shakedown irradiation to test the complexities of the multi-capsule concept
- 2.25 year irradiation duration
  - goal burnup ~ 15% FIMA
  - T_{max} < 1250°C, T_{avg} ~ 1150°C
  - fast fluence < 5 x 10^{25} n/m^2



PLANS FOR FY08-09 (TRISO)

- *UCO particle fabrication process scale up (20 kg)*
- *Validate fabrication processes for 425 μm UCO kernels*
- *Develop processes for improved packing of particles during compacting*
- *UO_2 coated particle development*
- *UCO particle and compact fabrication for the AGR-2 experiment*
- *Design and fabrication of AGR-2 experiment*
- *Complete irradiation of the AGR-1 experiment*
- *AGR-3 and AGR-4 experiment design*