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

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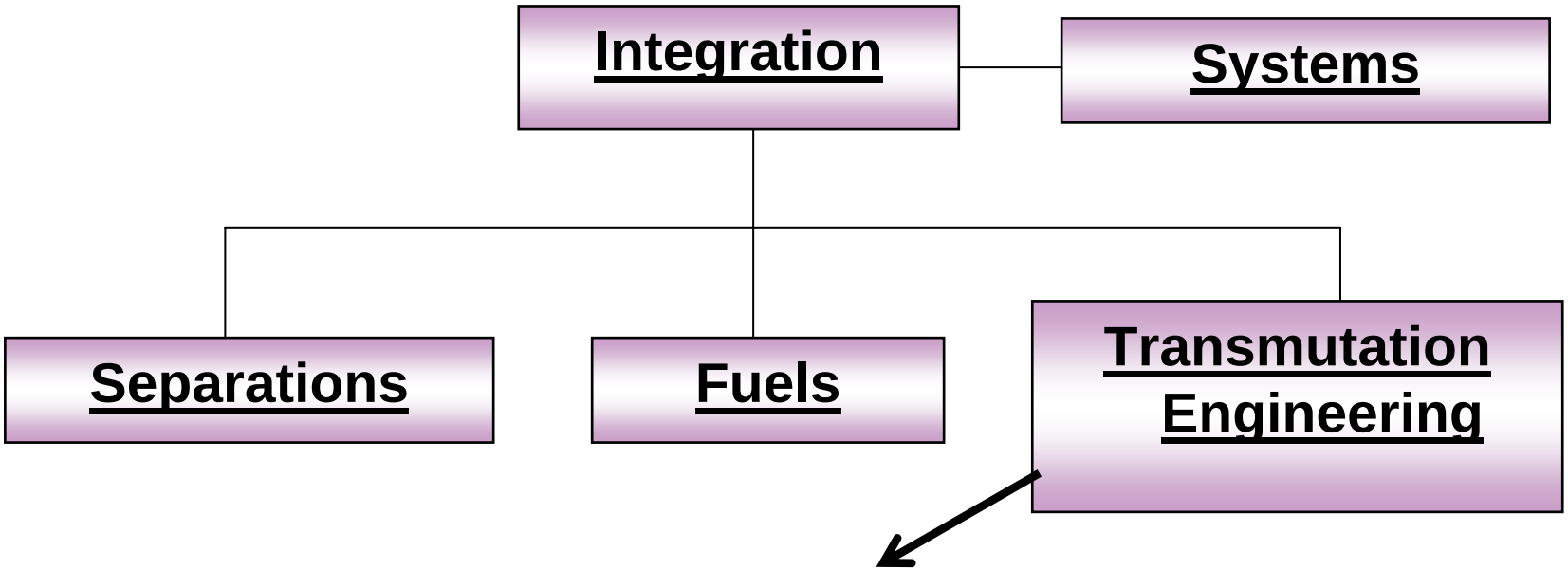
Transmutation

Los Alamos National Laboratory

Workshop for Universities
Hilton Hotel, Gaithersburg, MD
March 4, 2004

THIS RESEARCH AREA INCLUDES



- **Develop engineering basis for the transmutation of Plutonium, Minor Actinides and long-lived fission products. Support for key program decisions:**
  - Fuel Cycle implementation strategy
  - Transmutation System Selection (GenIV Reactor, Transmuter Reactor, ADS)
  - GenIV, Reactor, ADS transmutation efficiency

Transmutation Engineering is Organized into Three Research Areas

Physics

- Nuclear data in thermal, epi-thermal and fast spectra
- Nuclear Safety data
- Codes and Models

Materials

- Structural material degradation during irradiation: material limits
- Lead-Bismuth Coolant, sensor technology and corrosion mitigation for fast spectrum reactor and ADS

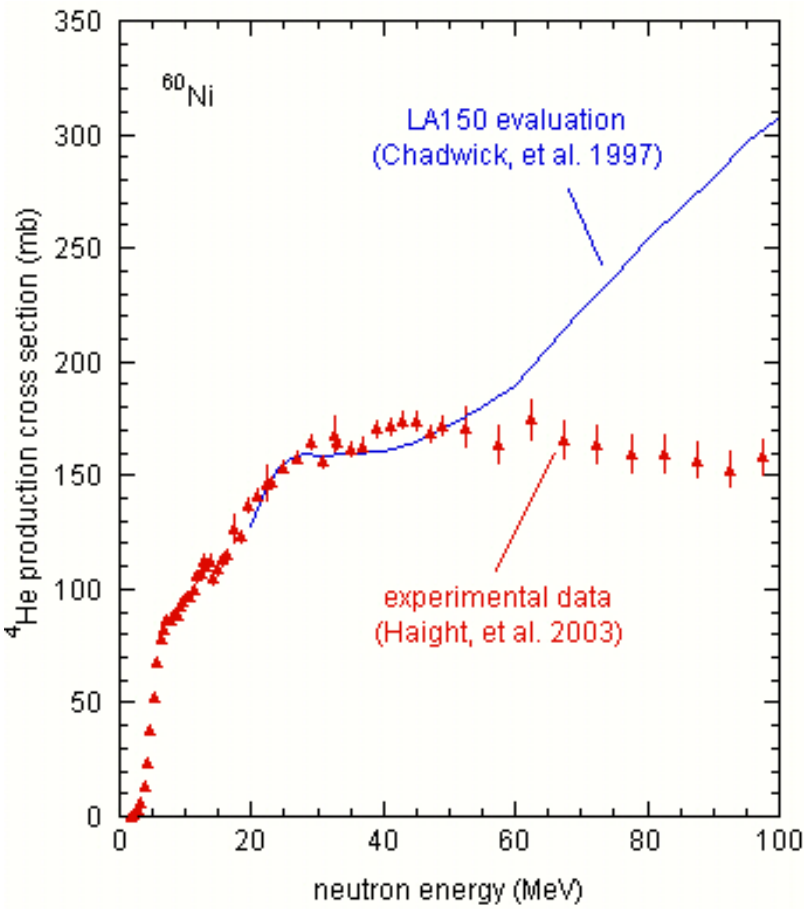
ADS

- Coupling of accelerator to sub-critical reactor
- Operation and safety of ADS
- Target technology
- Accelerator Reliability

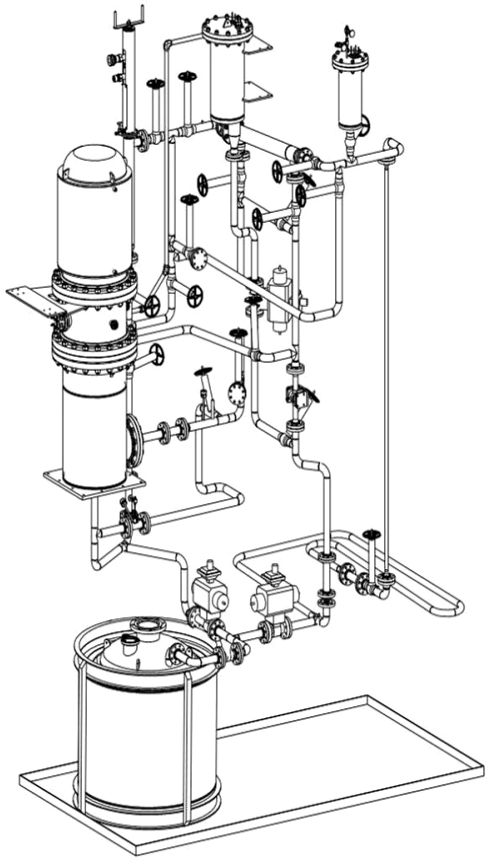
FY03 ACCOMPLISHMENTS: Physics

FY2003 Highlights:

- Cugnon/Schmidt physics models incorporated in MCNPX
- Am-241 evaluation completed
- Neutron-induced He production data from nickel analyzed and published



FY03 ACCOMPLISHMENTS: Coolant Technology



Development of Lead Alloy Technology (DELTA) loop Features:
- Test Bed for Component Development
- Removable Test Sections
- Natural Circulation

FY03 Highlights

- Loop Conditioning Completed
- Oxygen Sensor Improvements Implemented
- Long term Corrosion testing initiated

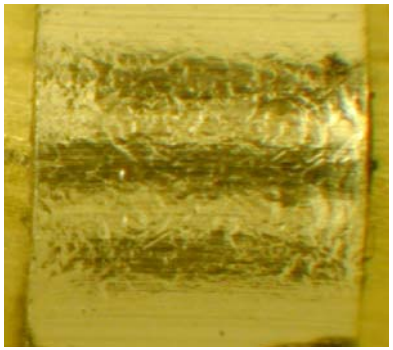
Lead Bismuth Advantages

- Non Reactive (leak safety)
- High Temperature Capability
- Natural Circulation (open lattice)
- Beneficial Physics (neutron economy)
- For both Reactor and ADS application

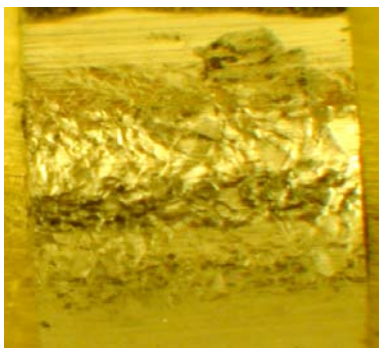
FY03 ACCOMPLISHMENTS: Structural Materials

FY 2003 Highlights

- Mechanical Testing and Microstructure of LANSCE, PSI irradiated samples.
- Data Evaluations published in Rev. 4 of Materials Handbook.
- Continued collaborations with TRADE and MEGAPIE
- Initiated the atomistic modelling of Helium in a Body-Center Cubic Iron matrix

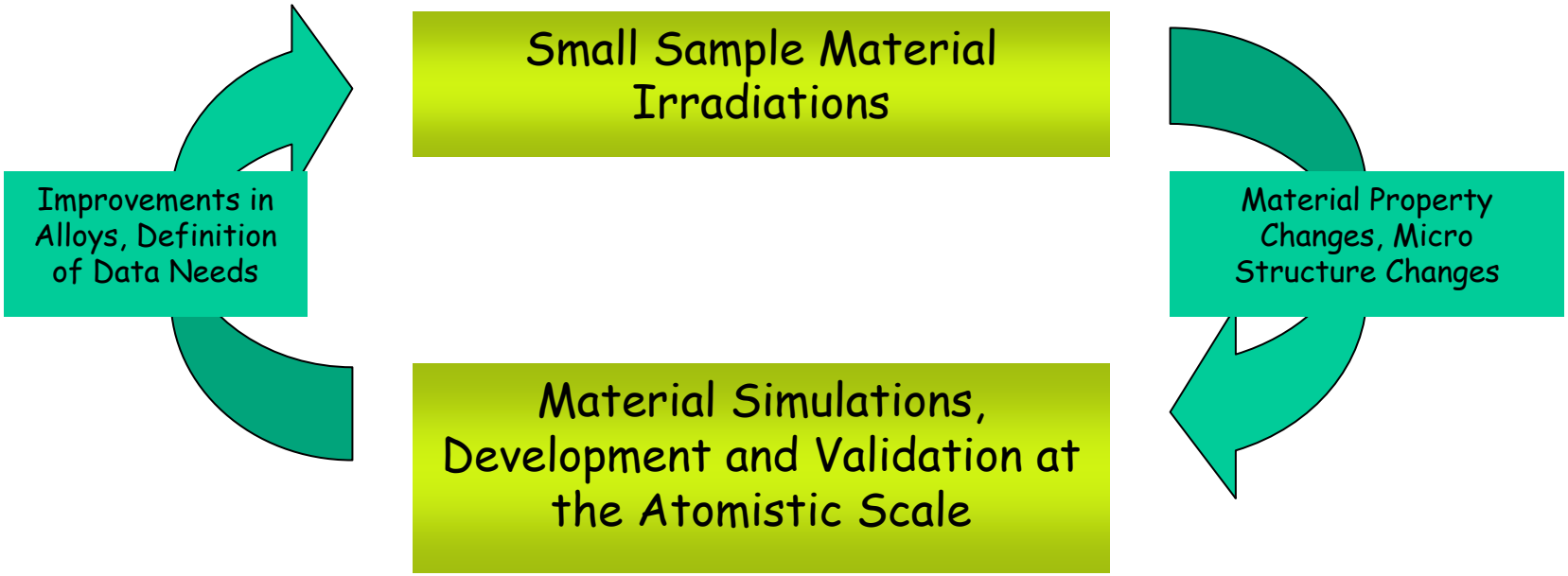


0 dpa
Mod 9Cr-1Mo



9.8 dpa
Mod 9Cr-1Mo

FY03 Accomplishments: Materials Modeling



Issue: Need Fast Neutron Facility to Perform Needed Experiments

FY03 Highlight:

Initiated the atomistic modelling of Helium in a Body-Center Cubic Iron matrix

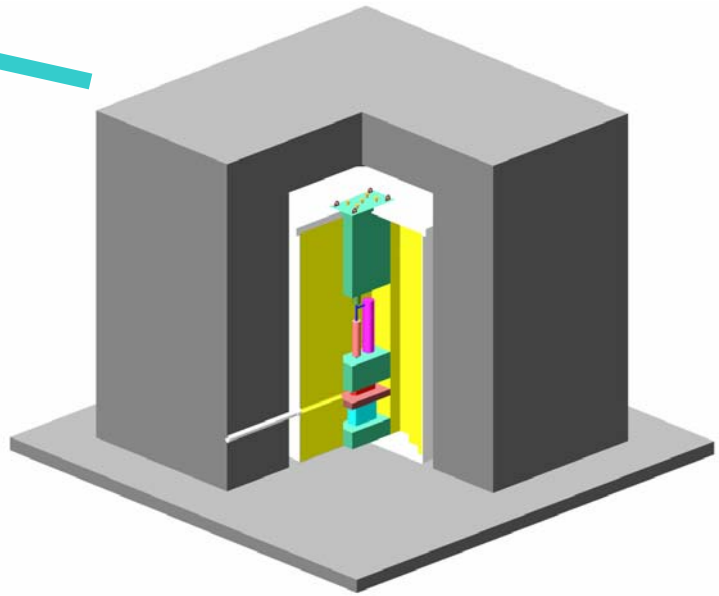
FY03 Accomplishments: Structural Materials

FY03 Highlight:

Fast Spectrum Irradiation Station Pre-Conceptual Design Completed for the LANSCE-Materials Test Station to provide an intense Fast Neutron Environment for Materials and Fuels testing.

MTS Attributes

- **Intense fast spectrum neutron source** for development of AFCI transmuter and GenIV reactor materials.
- **Closed loops** for prototypic coolants and temperatures and "run to failure" capability.
- **Transient testing** for demonstration of off-normal conditions.



FY03 Accomplishments: Accelerator Driven Systems

ADS is one of the options for the transmutation of the higher actinides. Japan and several European countries have committed significant funds to design and research activities. Collaborations with Europe are in progress.

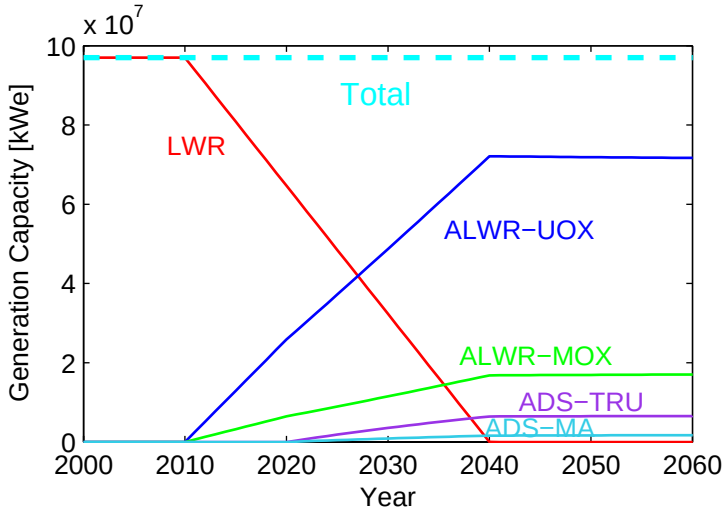
Reactor Issues:

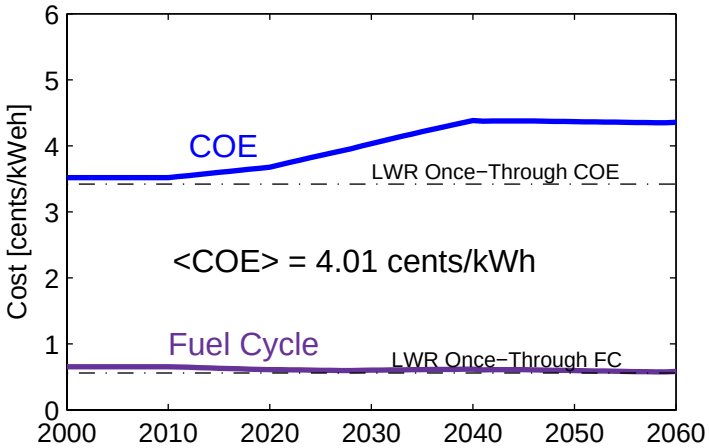
- **LWR, ALWR, Gen IV Reactor Transmutation Role**
  - Thermal Spectrum
  - Fast Spectrum
- **Acceptable Conversion Ratio for Fast Spectrum System**

ADS Issues:

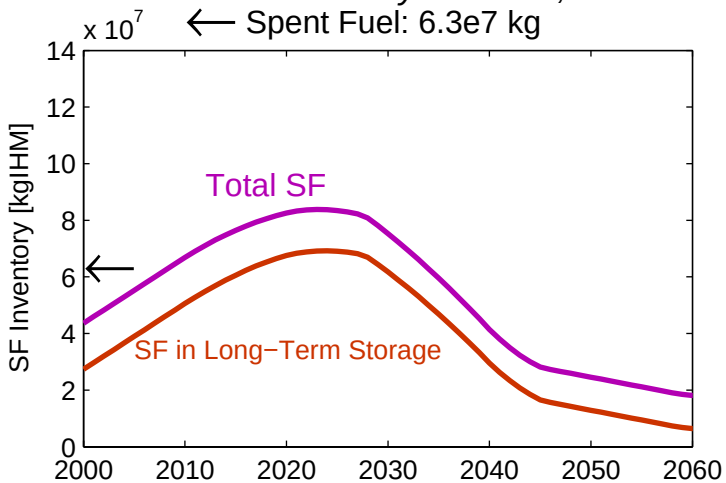
- **Operation and Safety**
- **Reliability**
- **Target and Materials**
- **Cost**

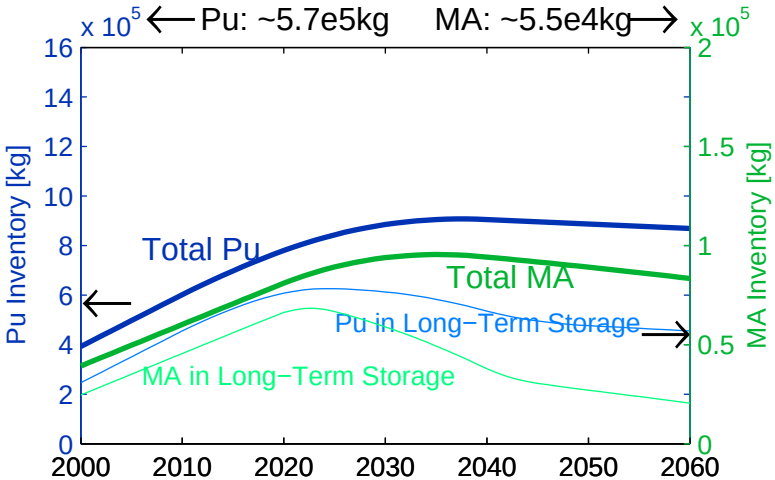
FY03 Accomplishments: ADS Scenario Analyses





YM statutory limit is 63,000 MTIHM. For three LWR waste forms, this limit is:



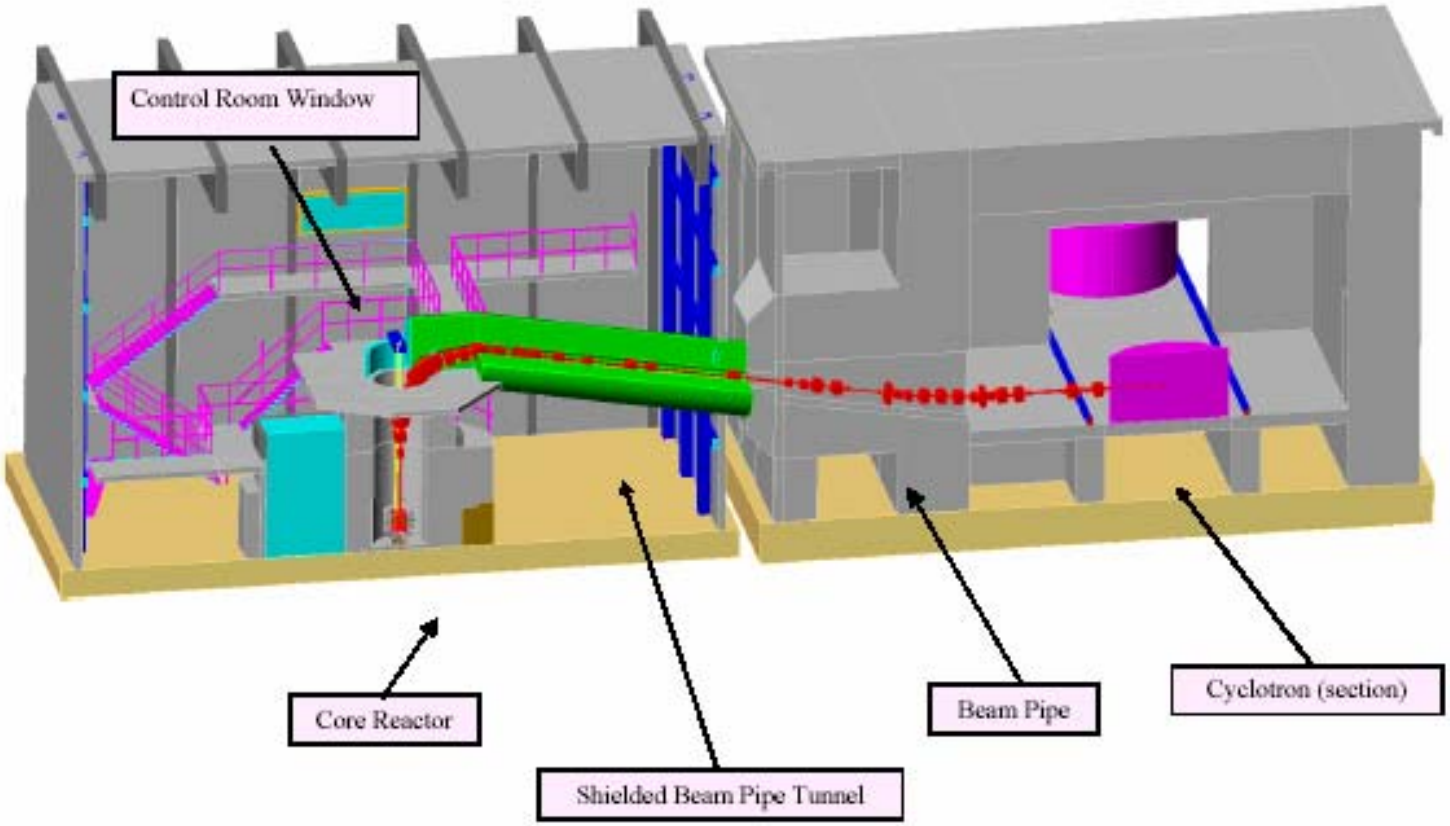


FY03 Accomplishments: ADS International Collaborations

Major International Collaborations Established:

- **MUSE: Coupled external sources to Fast Reactor Critical Facility (CEA-Cadarache)**
- **TRADE: Coupled Cyclotron to TRIGA Reactor in Italy**
- **MEGAPIE: Megawatt scale spallation source at PSI**
- **JPARC: Target Test Station and Low Power Sub-Critical Multiplier as part of Accelerator Complex**
- **Advanced Cavity Development at CEA-Saclay**

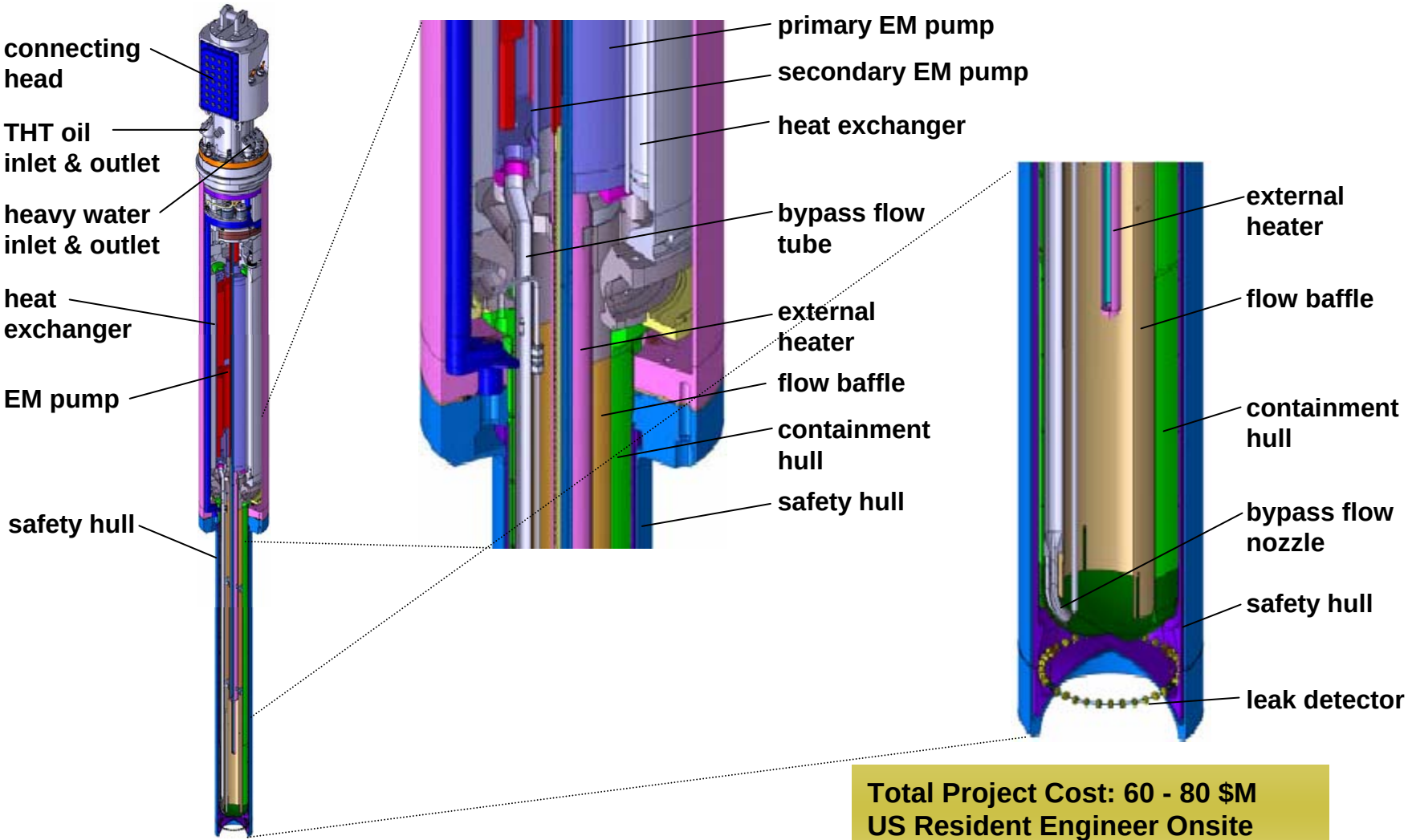
FY03 Accomplishments, ADS: TRADE Project Collaboration



TRIGA Reactor Accelerator Driven Experiment Will Provide Coupled System Data at Power

Project Cost: $ 75M
US Resident Engineer Onsite

FY03 Accomplishments, ADS: The MEGAPIE project will demonstrate a lead-bismuth spallation target at the Paul Shearer Institute in 2006



Total Project Cost: 60 - 80 $M
US Resident Engineer Onsite

WORK IN PROGRESS FOR FY04

Physics:

- Iron and Chromium gas production measurements
- NP237 fission and capture measurements,
- ^{237}Np, ^{241}Am ,^{242m}Am, ^{242g}Am data evaluations

Structural Materials:

- Examination of FFTF irradiated low activation ferritic/martensitic steels at 400C to doses up to 60 dpa
- Ion Irradiations on HT-9 at U. Mich to a dose of 3 dpa.
- Effects of Shot Peening on Corrosion and Radiation Resistance of Austenitic and Ferritic/Martensitic Steels
- Final version issued for Rev. 4 of the Materials Handbook
- Atomistic Modeling of He in Body-centered Cubic (BCC)-Fe

ADS:

- Continued collaborations with TRADE and MEGAPIE
- Development of RACE experiment: Coupled electron accelerator (Idaho State) to TRIGA (U-Texas and Texas A&M)

PLANS FOR FY05-07

Focus of the program for the next 3 years will be on:

- Continued nuclear data measurements and evaluations of higher actinides to reduce transmutation uncertainty.
- Examination of FFTF and PSI irradiated materials.
- New irradiations in PHENIX.
- Development of an intense fast neutron source
- Development of optimum alloys and/or surface treatment for LBE corrosion resistance.
- Collaborations with Europe (EU) and Japan to advance ADS technology.

PLANS FOR FY05-07: Physics

New Evaluations

FY05: ^{243}Am, ^{238,240,241}Pu

FY06: $^{243-245}$Cm

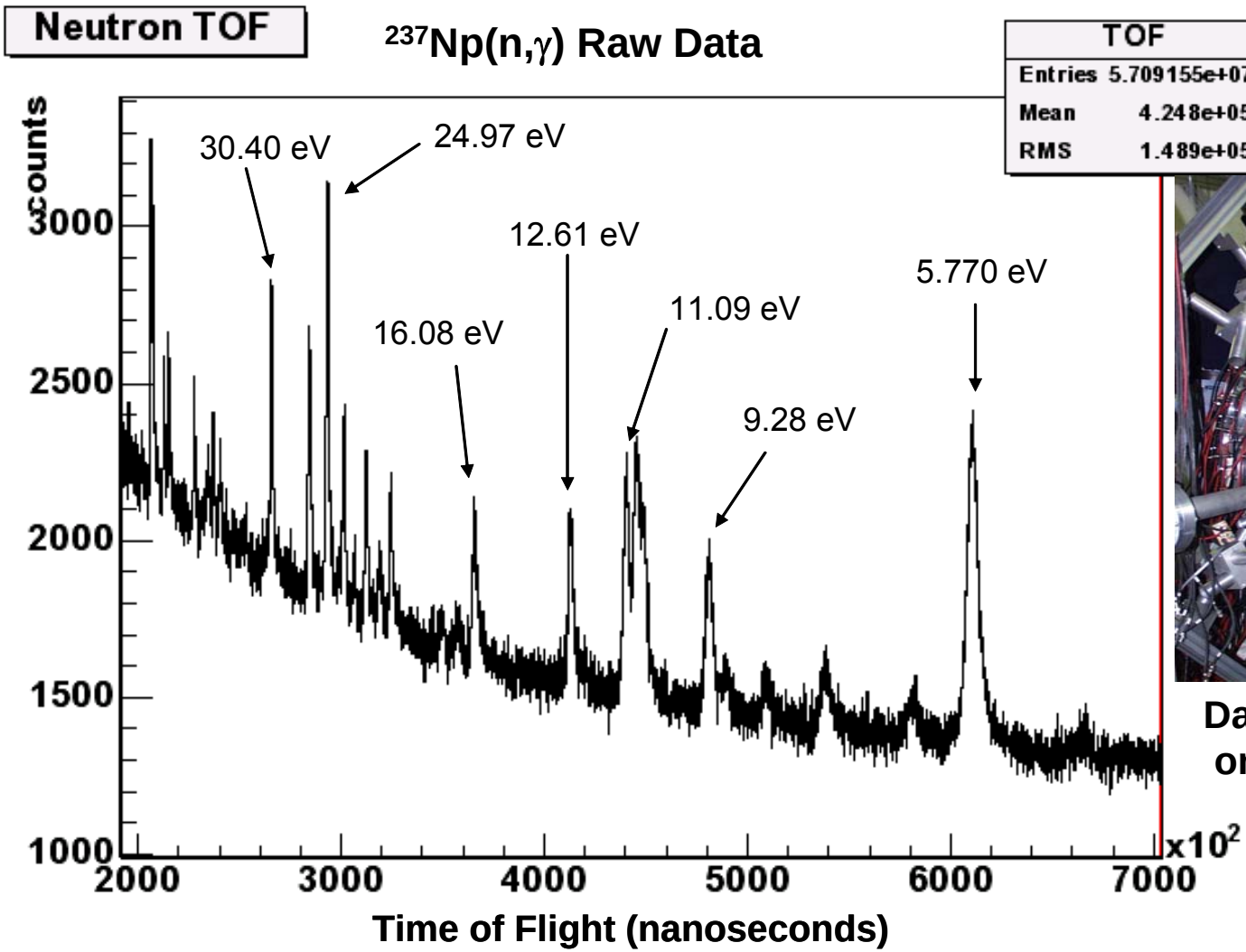
FY07: ^{242,244}Pu, ^{242}Cm, ^{238}Np

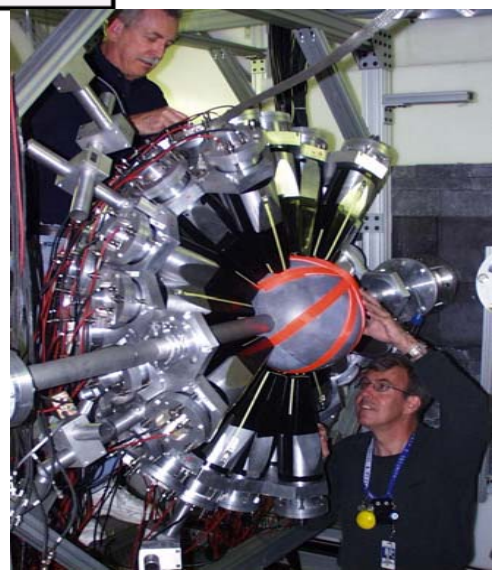
New Evaluations

- **Fission**
  Pu-238
  Am-242m, Am-243
  Pu-241, Am-241
  Cm-244
- **Capture**
  Pu-239, Am-241
  Pu-238, Pu-240, Pu-241
  Am-243, Cm-244
- **Inelastic**
  Bi-209
- **Fission neutron energy spectra**

PLANS FOR FY05-07:

Capture cross section will be measured using the DANCE instrument



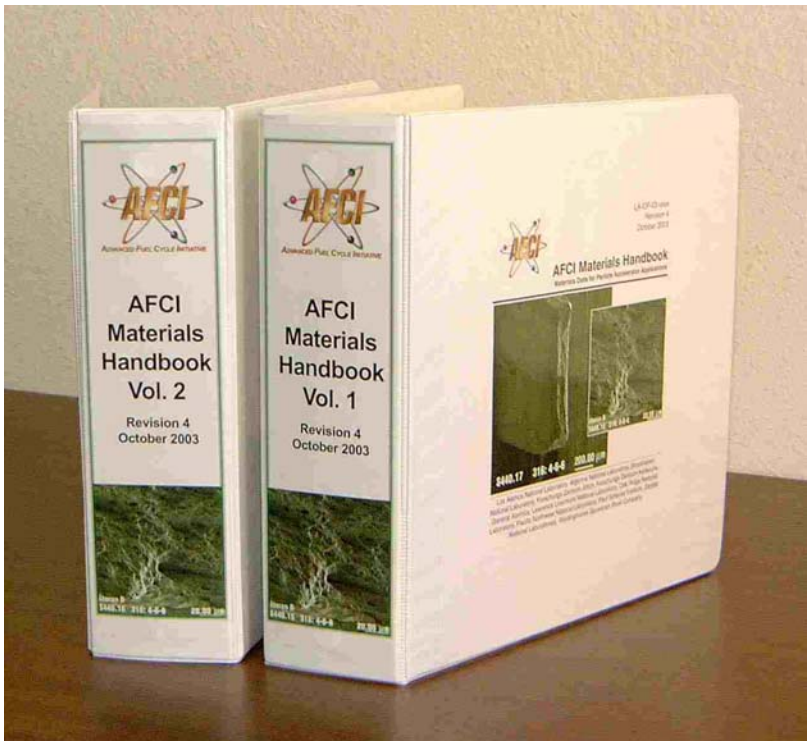


Data acquired for 16 h on a 0.5-mg sample.

PLANS FOR FY05-07: Structural Materials

Testing

Documentation



PLANS FOR FY05-07: Structural Materials

- **Determine the effect of high energy proton and neutron irradiation on the mechanical properties of structural materials for the AFCI project under prototypical conditions of irradiation temperature and flux.**
- **Use mechanical test data to determine structural design allowables for AFCI components**
- **Model development**
- **Support Gen IV materials program**
  - AFCI/Gen IV Materials Working Group
  - Future Irradiations and Testing of irradiated specimens

FY05-07, ADS: Coupled Accelerator-Multiplier Experiments are planned by IAC, UT, and TAMU

- IAC will provide an Electron accelerator that can produce $1x10^{12}$ n/s thru gamma,n reactions.
- This will be coupled to thru an existing beam port to one of several reactors available.

1 MW TRIGA Reactor at the University of Texas

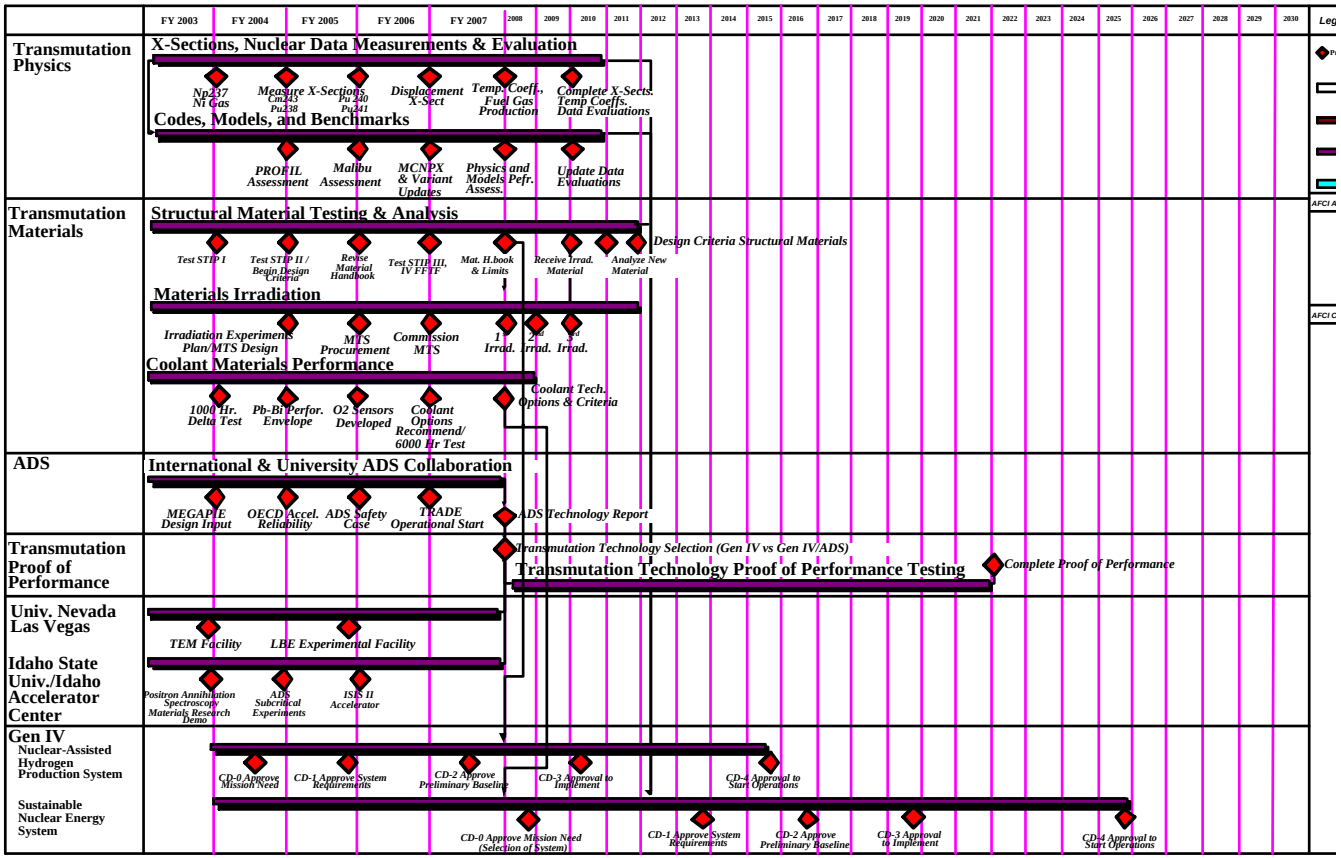
- Provides complementary information to the TRADE experiment
- Provides an excellent training facility for students

BUDGETS (FY03-04)

TASK AREA	Performers	FY 2003	FY 2004
Physics	LANL,ANL,BNL,ORNL	1594	2123
Structural Materials	LANL,PNNL	600	954
Coolant Technology	LANL	1178	1350
ADS	LANL,ANL	1170	805
University	NCState,UF,UM,UIUC,UCB	225	562
Integration	LANL	250	326
Total		5067	6120

FY05-07: Activities are Coordinated with 2007 Decision and Generation IV Needs

Advanced Fuel Cycle Initiative - Transmutation Engineering



Summary

- Transmutation Science and Engineering plays an important role in AFCI and provides technical basis for transmutation.
- ADS is an important option and will complement reactor-based transmutation of Plutonium and Minor Actinides.
- Small scale experiments and modeling plays a fundamental role in large scale and end of life predictions.
- Research needs are extensive and will be accomplished thru National Labs and International and University collaborations.