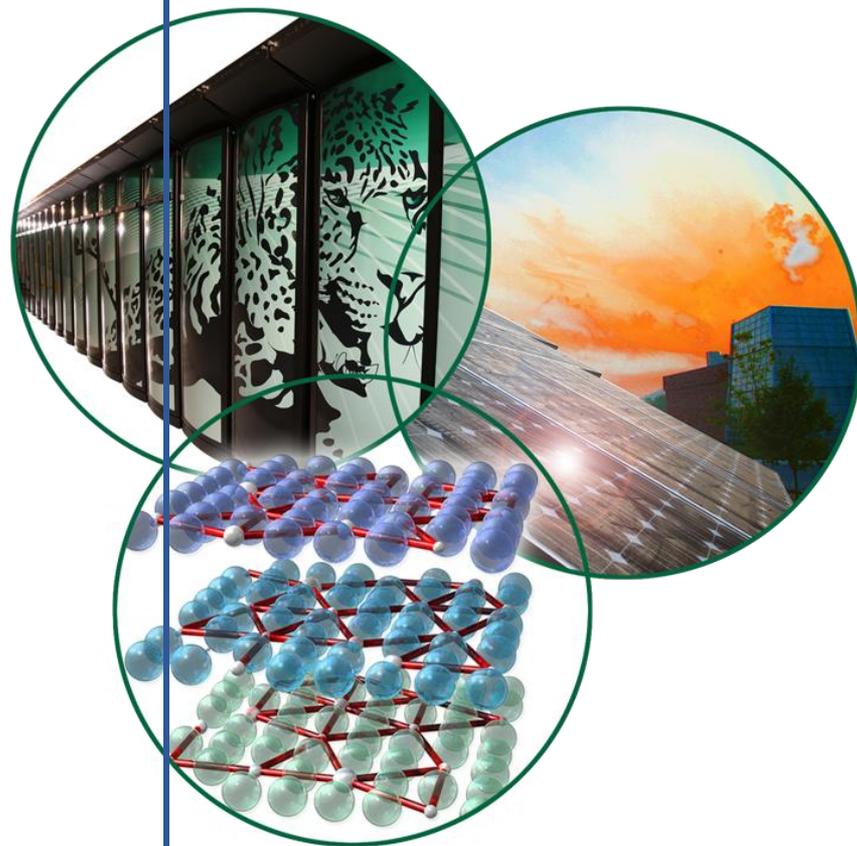


# NSED Monthly Report

## August 2012

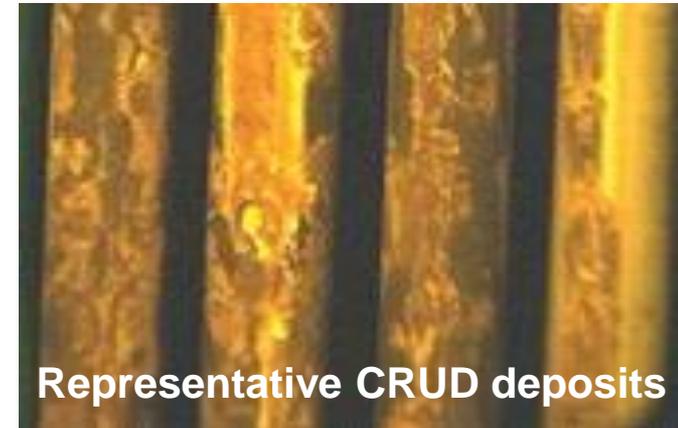
### Nuclear Science & Engineering Directorate



# CASL multiphysics modeling of CRUD-induced power shift phenomena in operational reactors

## Description

- Vogtle Unit 1 cycle 13 observed CRUD Induced Power Shift (CIPS) while cycles 12 and 14 did not.
  - CRUD results from deposition of corrosion products on the surface of fuel rods
  - Boron, contained in the coolant, deposits in the CRUD causing undesirable changes in the core axial power distribution
- Experimental data available through CASL partners allows comparisons between calculation and observed reactor behavior
- Analysis performed with CASL baseline tools ANC-VIPRE-BOA representing improved coupling of legacy codes for cycles 12-14



Representative CRUD deposits

## Computational Tools

- ANC – Westinghouse Advanced Nodal Code (industry standard neutronics)
- VIPRE-W – Westinghouse Sub-channel thermal hydraulics using heat transfer corrections from CFD calculations
- BOA – EPRI Boron-induced Offset Anomaly coolant/fuel chemistry code
- Improved coupling performed by Virtual Reactor Integration Focus Area implementing Crank-Nicholson capability and CFD information

## Analysis Results

- Improvements in coupling result in a significant reduction in predicted CRUD thickness and boron deposition and hence a lower indication of CIPS
- Results demonstrate the importance of boron feedback and the need for higher fidelity modeling to address the accuracy of the CRUD sources

# Virtual Reactor for Reactor Applications (VERA):

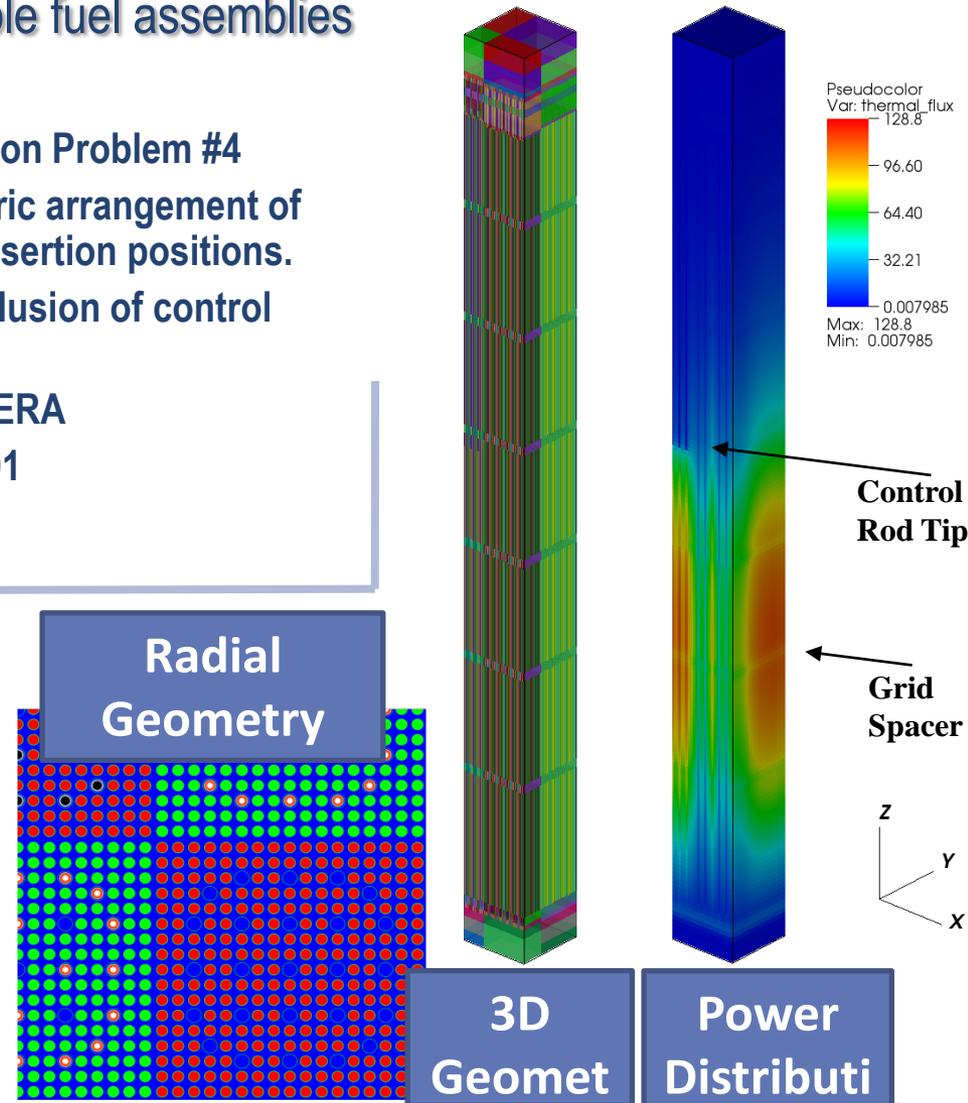
Initial results gained from 3D modeling of multiple fuel assemblies

## Overview

- VERA Snapshot 2.1 used to model AMA Progression Problem #4
- Progression Problem #4 consists of a 3D symmetric arrangement of 3x3 array of fuel assemblies with 21 control rod insertion positions.
- Challenges are the size of the 3D problem and inclusion of control rods
- First initial results obtained with Denovo-based VERA
- Completes L2 Milestones VRI.P5.01 and AMA.P5.01

## Results

- Initial results for problem #4 marks important milestone in progression of capability
- Improved cross section treatment and processing will further enhance current results
- Runtime on OLCF's Jaguar: 155 minutes on 4608 cores

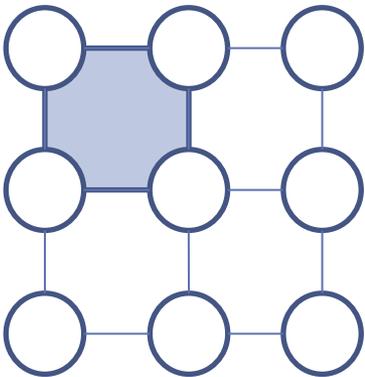


# Initial integration of subchannel analysis capability into the CASL Virtual Environment for Reactor Applications (VERA)

The widely-used subchannel analysis code COBRA-TF from Penn State University is integrated into VERA (L3 milestone VRI.VERA.P5.01, 5/31/2012)

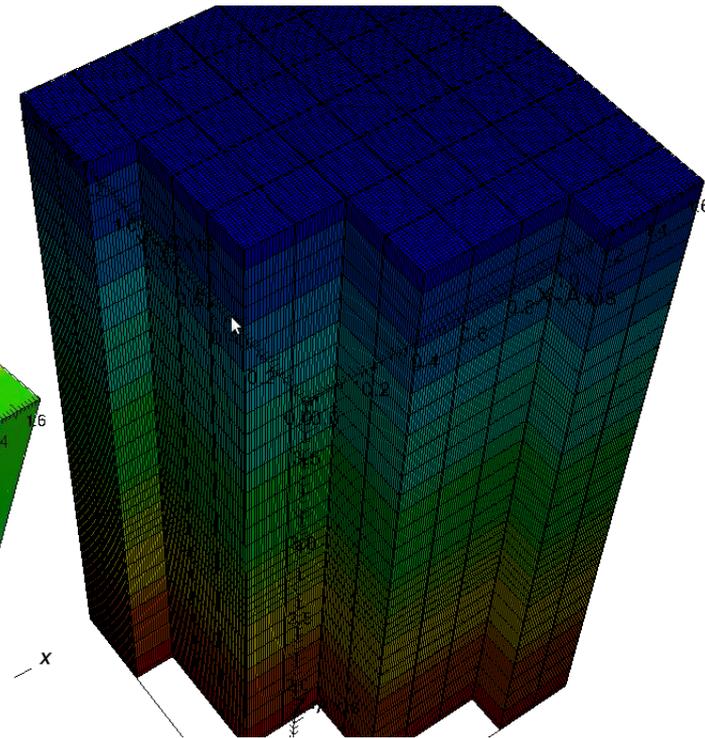
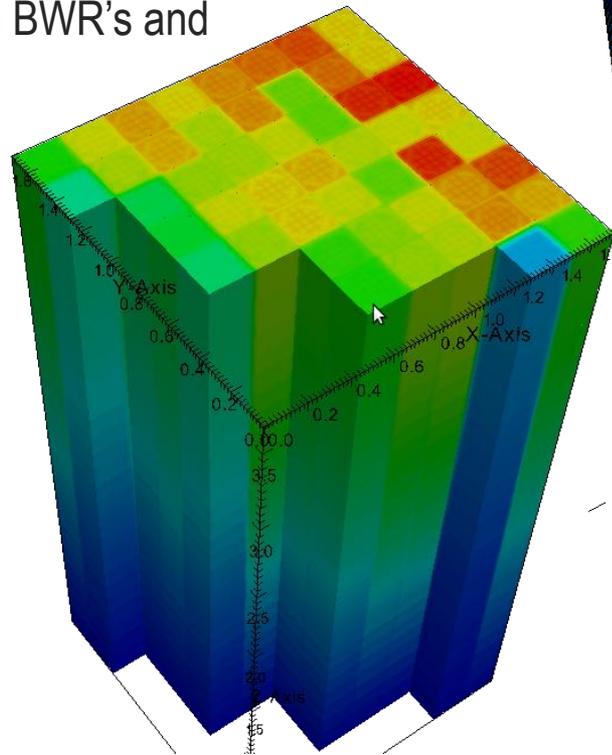
## Overview

- simulates fluid flow and heat transfer within fuel rod bundles
- 3-field representation (liquid, vapor, droplets)
- allows for future application to BWR's and transient problems



## Subchannel "mesh"

- An efficient industry-relevant complement to CASL's current CFD capabilities



## Quarter-core PWR model

- liquid enthalpy (left)
- pressure (above)

# CASL modeling of coolant chemistry & CRUD growth

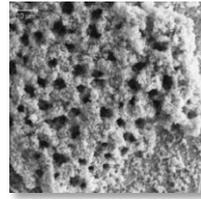
First time one-of-a-kind multiphysics modeling of CRUD growth

Boron concentration within crud layer (colored contours) grown within MAMBA over 60 days of operation

Variations in crud thickness and boron due to T variations on cladding surface

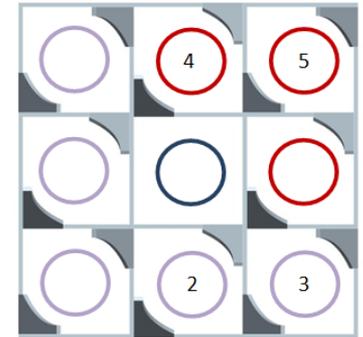
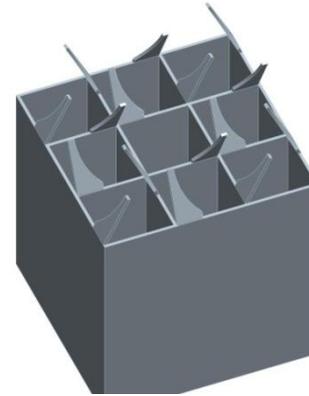
Reduced crud and boron due to turbulence behind mixing vanes

**80 cm section of fuel rod**

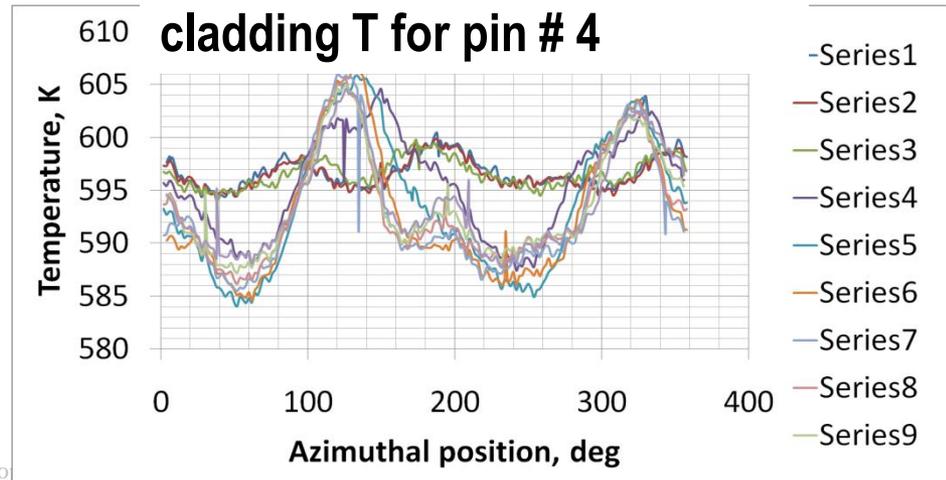


Surprising large azimuthal variation noted in computed fluid/cladding temperature

**Spacer with mixing vanes**



**CFD computed cladding T for pin # 4**



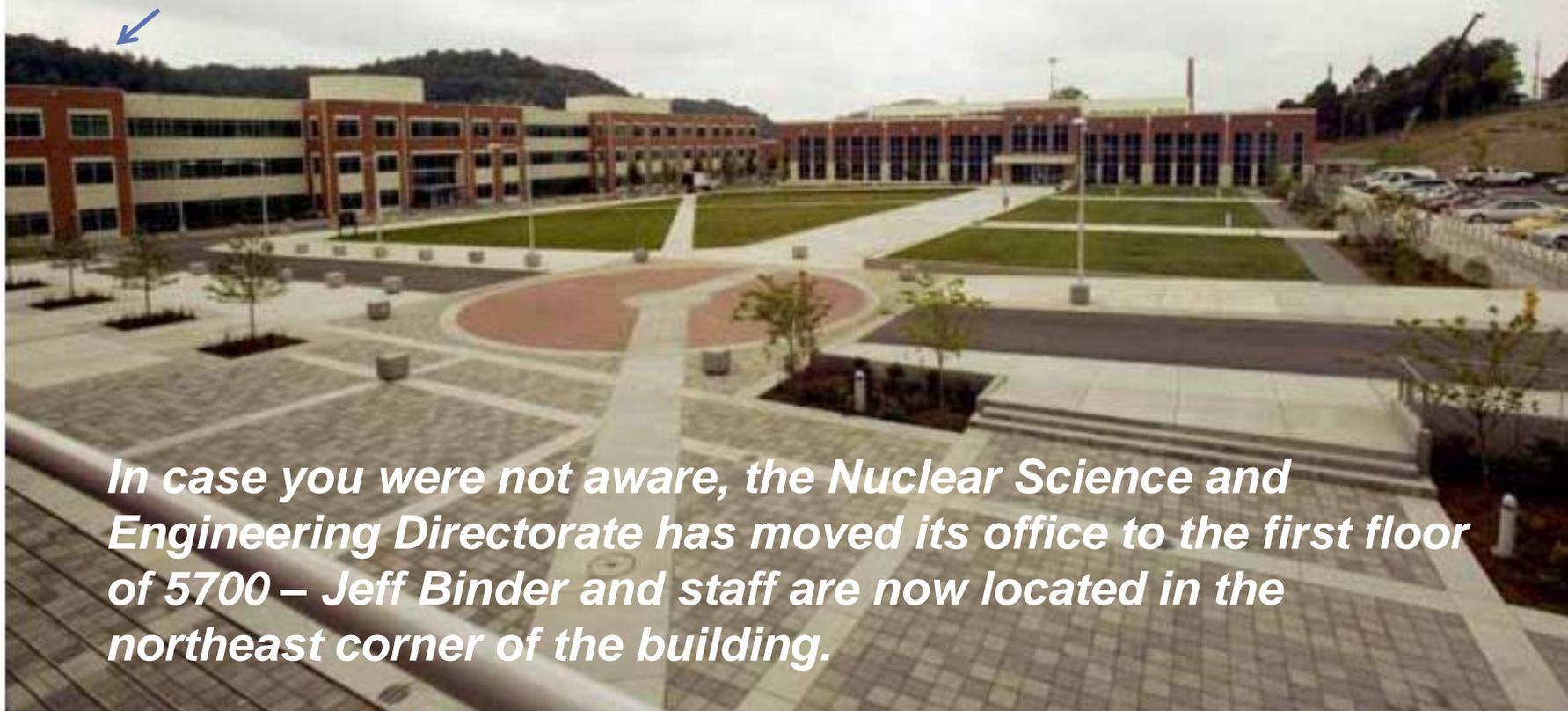
# Scott Aaron received the International Nuclear Target Development Society (INTDS) Lifetime Achievement Award



Scott Aaron was given this honor at the 26th INTDS World Conference in Mainz, Germany in August 2012

# CONGRATULATIONS

# Directorate office move



*In case you were not aware, the Nuclear Science and Engineering Directorate has moved its office to the first floor of 5700 – Jeff Binder and staff are now located in the northeast corner of the building.*

# High level visits and tours



Leland Cogliani, U.S. Senate Committee on Appropriations professional staff, toured the CASL VOCC hosted by Doug Kothe



Lee Flower and Keith Kruger of Haynes International, Inc. visited ORNL hosted by Jess Gehin



Jennifer Uhle, Deputy Director of the Nuclear Regulatory Commission Office of Nuclear Regulatory Research, toured key ORNL nuclear facilities and received overviews of ORNL nuclear programs and capabilities relevant to Fukushima support. Cecil Parks and Julie Stringfield hosted Ms. Uhle



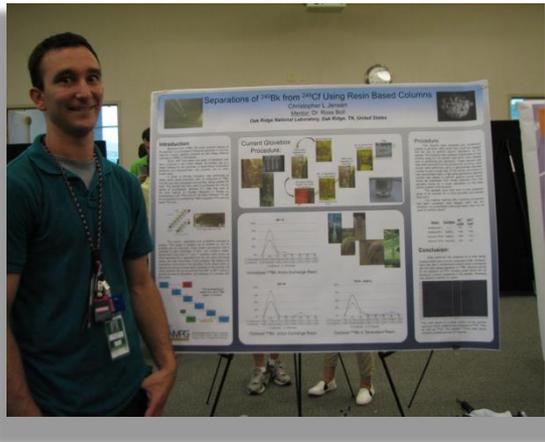
Stephen Kittredge, Legislative Assistant to U.S. Senator Rob Portman of Ohio, visited ORNL and toured CASL VOCC, HFIR and REDC

# Intern activities - nonproliferation seminars:

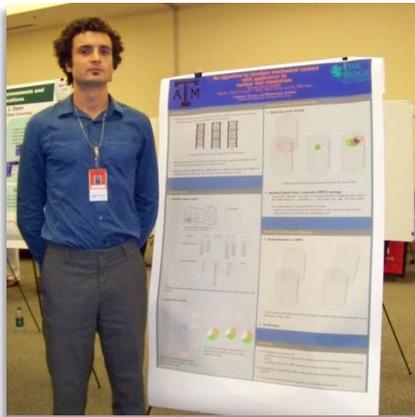
- Les Fishbone, BNL, “Field Test of SNRIs for Inventory Change Verification at a Low-Enriched-Uranium Fuel-Fabrication Plant”
- Martyn Swinhoe, LANL “Modeling and Simulation for Safeguards”
- Sarah Frazar, PNNL, “International Safeguards Infrastructure Development”
- Susan Pepper, BNL, “Job Opportunities at the IAEA”



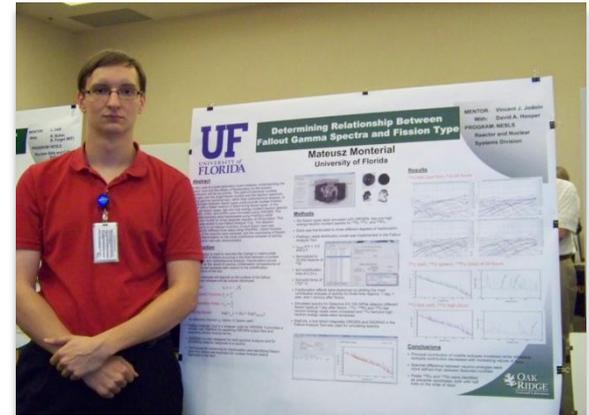
- August 9, 2012 Graduate School Fair and Student Poster Session
  - All student programs were represented (SULI, HERE, and NESLS)
- Judged Contest for NESLS students:
  - 28 students participated
  - Judges included: Steve Zinkle, Jess Gehin, Kevin Clarno, Matt Jessee



**1<sup>st</sup> Place Chris  
Jensen**



**2<sup>nd</sup> Place Damien  
Lebrun-Grandi**



**3<sup>rd</sup> Place Mateusz  
Monterial**

# Radioisotope Production

- Completed Hydroxide Precipitation on Cm material slated for Target Fabrication.
- Consolidating/recovering rework material which will be stored until Heavy Element Campaign 76

Heavy Element  
Campaign C-75



- Transferred 3<sup>rd</sup> LANL Cm source from 4501 to 7930 hot cells
- Completed dissolution of 20 cans of Am-Cm-Ln material
- Performing equipment set up for upcoming M19RTL-1 Actinide/Lanthanide MXS separation run.
- First deliverable for MK-18A disposition study which identifies the options to be evaluated was completed.

Americium-Curium  
Processing



- Shipped QSA-65-0010-2 part III 1.29 mg Cf-252 on time
- Shipped Eckert and Ziegler order 65-0082-1
- Submitted revised cost estimate to DOE NP for use in contract negotiations with Cf-252 Consortium
- Initiated Remote Hot-Cell Target Fabrication Equipment Upgrade Project

Cf-252 Source  
Production



- Implemented Selenium Transportation Safety Document (TSD)
- Processed a Selenium Shipment

Selenium Processing



- Production Campaign # 101, started on August 4, has successfully yielded 78 mCi of Ac-225.
- 57 mCi of Ac-225 shipped in five different shipments to four different customers during this month.
- Next processing campaign scheduled for week of October 1st

Actinium Production



# Enriched stable isotope technical services and shipping

Twenty-two shipments of 141 enriched stable isotopes were made in August (largest monthly total in memory)

- 155 shipments of 464 enriched stable isotopes have been made in FY12 to date

Thirty-three custom technical services were completed in August

- 176 technical services have been completed in FY12 to date
- Included among these were a Pt-195 rod and foil, an Er-167 foil, a number of metal conversions and a number of conversions of Ba and Sr carbonates to chlorides
- A batch of 91.09% enriched Hg-199 weighing 2.039 g and valued at ~\$131 K was transferred from the Reserve Inventory to the Isotope Sales Inventory to replenish the diminished inventory level

- Old sources enriched in Cf-251 have been recovered from the 7930 storage pool
- Cold testing is underway to develop tooling and techniques for opening the zirconium capsules containing the Cf source material

Californium-251  
Recovery LDRD



- Chris Jensen is continuing separations studies using Bk-249 for his master's research at Tennessee Tech University.
- He is researching the possibility of using oxidation state changes for separation of Cf and Bk on resin columns.

Berkelium Purification



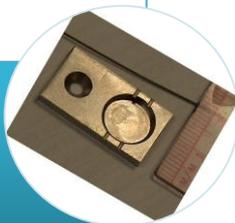
- Initiated development of  $^{40}\text{K}$  production proposal.

Proposal Initiatives



- 500 mCi  $^{252}\text{Cf}$  electrodeposition was shipped to and received by Argon National Laboratory on August 17 for use in CARIBU project.

Californium-252  
Electrodepositions



- Completed the first cycle of irradiation of 4 Single Pellet Test Target
- Transferred 1 target to REDC for chemical analysis and 3 targets to 3525 for fission gas analysis and PIE
- Began assembly of Al targets for dissolution tests.

Pu-238





# GNSTD highlights and activities

## Preservation of high-purity U-233 used in uranium analysis

- Ten items containing a total of 285 grams of U-233 were received from Building 3019 and stored at ORNL facilities
- These items represent some of the purest U-233 in the world and are crucial components in the most accurate method of uranium analyses (isotope dilution mass spectrometry) needed for nuclear nonproliferation, safeguards and forensics
- Without this activity, these materials would be subject to planned downblending and disposal

## Monitoring to support the materials consolidation and conversion (MCC) project

- Technical monitoring teams of DOE Lab nuclear material experts are coordinated by ORNL to visit designated Russian sites where civilian high enriched uranium (HEU) is consolidated and downblended to low enriched uranium (LEU)
- There were two site visits in August: One to Luch in Podolsk and the other to Krylov in St. Petersburg, Russia
- The Luch visit validated Russian HEU conversion along with conversion of Ukrainian HEU repatriated to Russia
- The Krylov visit satisfied the semiannual confirmation that the site remains an LEU facility after having released all HEU for conversion under the MCC project

## Commissioning of a secure radiological transportation vehicle in Kazakhstan

- Kimberly Anderson traveled to Kurchatov, Kazakhstan, to attend the commissioning as part of the broader cooperative effort to help combat nuclear and radiological terrorism around the world
- The delivery of this vehicle to the Institute of Atomic Energy–National Nuclear Center of Kazakhstan was the latest accomplishment under a partnership between NNSA, the Kingdom of the Netherlands, and the republic of Kazakhstan

# GNSTD meetings & workshops



GNSTD

## Federal Bureau of Investigation Explosives Training

- GNSTD personnel attend an FBI Explosives Training class held at the FBI Training Academy in Quantico, VA
- Observations from the class will be used to improve training classes in the ORNL Safeguards Laboratory



## Cooperative Border Security System Management Workshop

- Terry Donaldson was an instructor and discussion facilitator at the Cooperative Border Security System Management Workshop in Centurion, South Africa, for about 40 representatives from a dozen state members of the Southern Africa Development Community
- The workshop was co-sponsored by NNSA International Nonproliferation Export Control Program (INECP) and DOD/Defense Threat Reduction Agency and AFRICOM

## Center for Strategic & International Studies (CSIS) Meeting

- GNSTD's Kimberly Gilligan was invited to join a CSIS sponsored meeting of the next generation of Turkish and US nuclear weapons policy, nonproliferation, and disarmament experts
- This dialogue provided the opportunity for next generation experts to meet and exchange ideas about nuclear weapons issues facing the two countries

# RNSD highlights and activities

RNSD

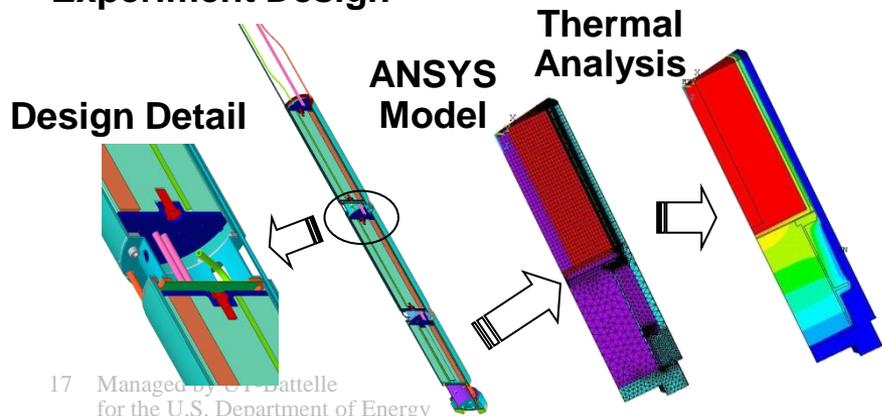
- A new lattice physics capability being developed for the SCALE code system is producing analyses six times faster than the existing capability
- Analysis of potential use of mixed-oxide (MOX) fuel for the Sequoyah pressurized water reactor and the Brown's Ferry boiling water reactor was conducted
  - The ratio of selected nuclides in a MOX core was compared to that of a standard  $UO_2$  core
  - An updated Environmental Impact Statement that considers use of MOX fuel at the sites will reference the analyses
  - This activity is in support of the NNSA Plutonium Disposition Program
- RNSD coordinated the multi-lab development and implementation of a two-week (one week of class and one week of experiments) nuclear criticality safety training course for the Department of Energy (DOE) complex
- ORNL provided the DOE Office of Nuclear Energy Used Fuel Disposition Campaign a Level 2 milestone report assessing the impacts of fuel reconfiguration on the criticality safety of storage and transport packages



# Materials Irradiation - August

Project	Format	Sponsor	Stage					Notes
			Newly proposed	In Design	In Fabrication	In Reactor	Removed	
Titan Metal	Rabbit	DOE, FE US-Japan				18 in Cycle 443 2 in Cycle 444		Tungsten and steel
Titan Metal Perforated	Rabbit	DOE, FE US-Japan				9		Tungsten SiC, steel
Composite Flexure	Rabbit	DOE, FE			8	Cycle 444		SiC
Mini-Composite	Rabbit	DOE, FE		4		Cycle 445		SiC
Round-bar Tensile	Rabbit	DOE, FE		4+				Steel
Hydrided Clad	Target	DOE, NE			3	1	2	Zircaloy
Ibiden	Rabbit	WFO, Ibiden			38	Cycle 444 & 445		Graphite
Nippon	Rabbit	WFO, Nippon		31		2013		Graphite
UO2 TEM disks	Rabbit	Texas A&M		1		Cycle 445		UO2
Titan Tensile	Rabbit	DOE			16	Cycle 445		V-4Cr4Ti, SiC, Graphite, steel
EPRI	Large VXF	EPRI			3	Cycle 445		Steel, Inconel
Toyo Creep	Target	Toyo Tanso		3		Cycle 446		Graphite
SiC differential swelling	Large VXF	ORNL		1				SiC

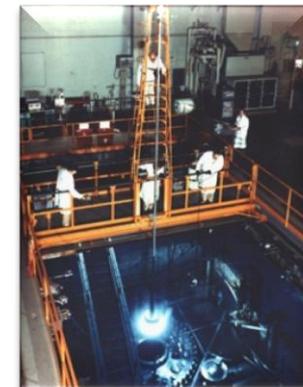
## Experiment Design



## Experiment Fabrication



## Irradiation

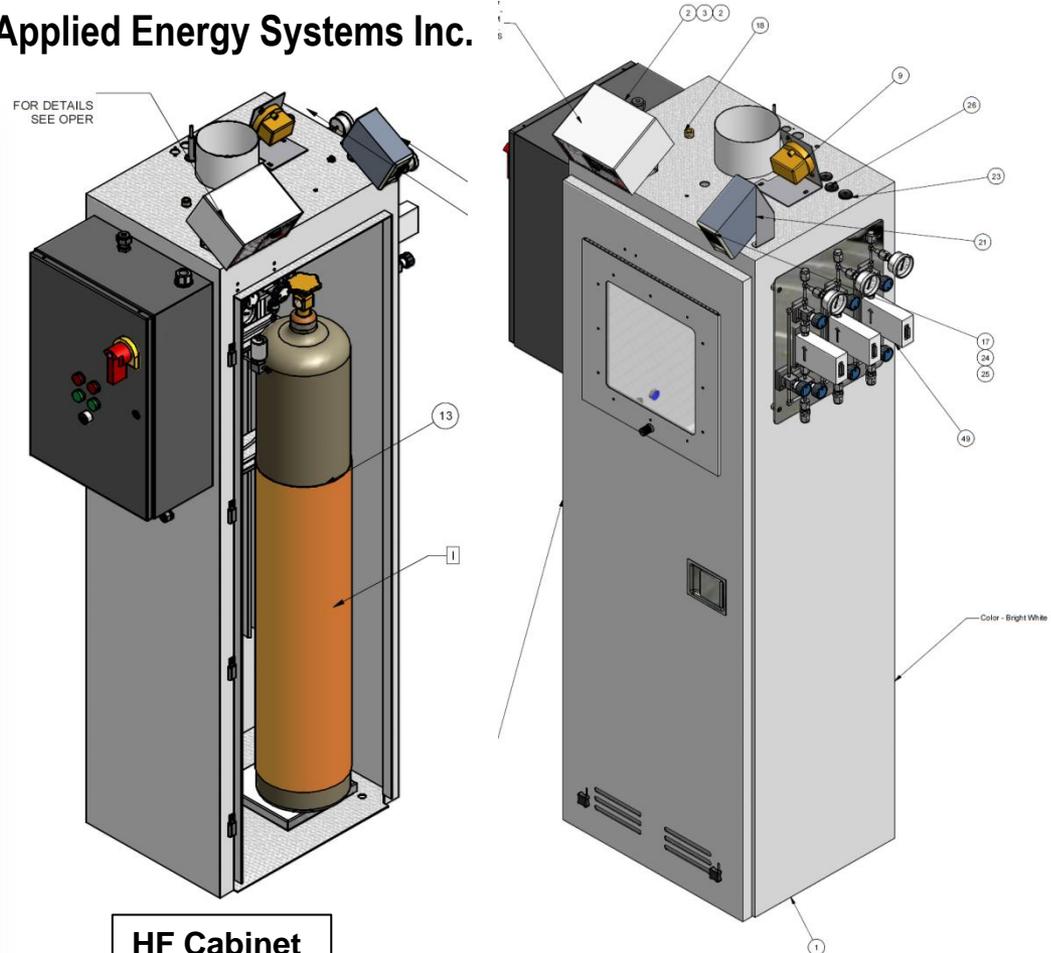


# Assembly of the thermal/hydraulic test loop for salt coolant continues

- Began review of project documentation to support installation of HF/ H2/ Ar system to clean FLiNaK salt
- Subcontractor for design/ installation is Applied Energy Systems Inc.



Hood for Salt Loop in Bldg 5800, D111



HF Cabinet

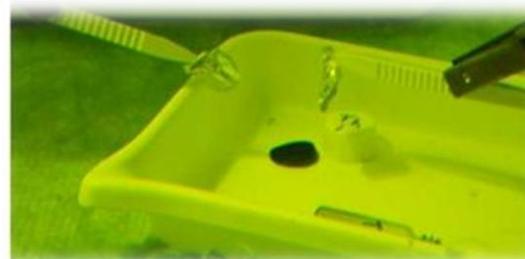
Ventilated Cabinet for mixing HF/ H2/ Ar

EMPO is providing project management assistance with this project

# FCID highlights and activities

## Actinium-225 Production from Proton-Irradiated Thorium-232

Isotope program researchers at Building 4501 received the third proton-irradiated thorium-232 foil target from Brookhaven National Laboratory (BNL) and continue to develop processing and separation/purification procedures for an alternative production source of actinium-225, a critical medical radioisotope that is in short supply.



Irradiated thorium metal target to be dissolved in the hot cell for purification and recovery of the actinium-225.

## SNS Target Test Facility Operational

The Target Test Facility (TTF), a full-scale mercury flow loop prototypic of the Spallation Neutron Source (SNS) target loop, has once again become operational after being idle for more than 1-1/2 years.

- The TTF is used for cavitation erosion research by FCID



- NA-22 funding has been awarded for FY13 research to quantify U and Pu in chloride salt solutions using the Hybrid K-Edge Densitometer (HKED) instrument installed at the REDC.
- NA-24 funding has been awarded for FY13 for HKED standards production.

Hybrid K-Edge Densitometer



- Results of Zr recovery from leached Dresden cladding by chlorination showed successful purification and decontamination.
- $\text{NO}_2$  voloxidation proved to be the only project previously under MOC to receive funding for FY13.

Voloxidation R&D



- In situ X-ray Diffraction data was refined revealing what appears diffusion limited reaction of  $\text{U}_3\text{O}_8$  to  $\text{UO}_3$ .
- TGA analysis of the oxidation of actual used fuel under a controlled atmosphere, conducted in REDC Cave B, correlated well with models.

Gas Phase Separations  
LDRD



- Full proposal submitted to DHS to develop  $\text{PuO}_2$  processing capability for nuclear forensics.

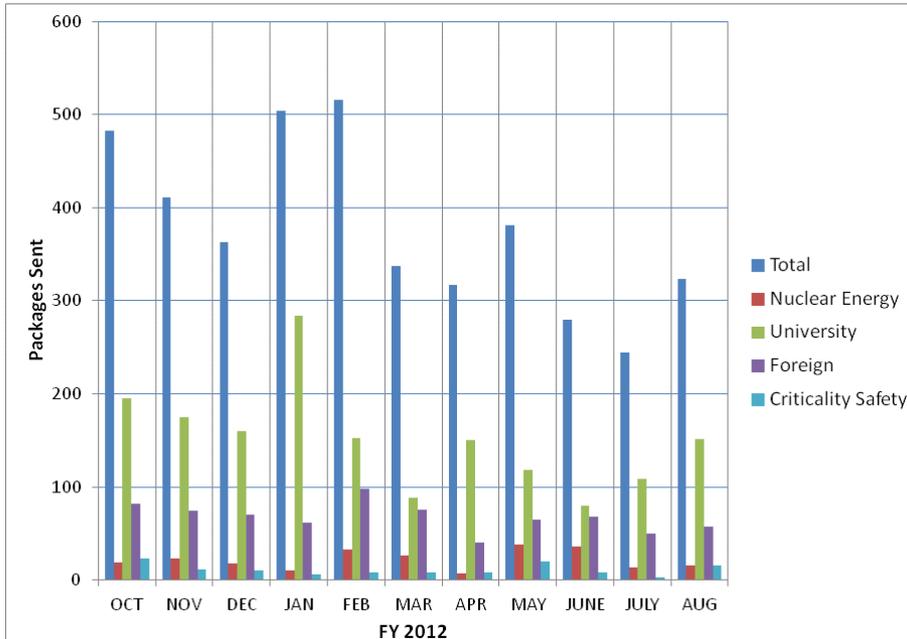
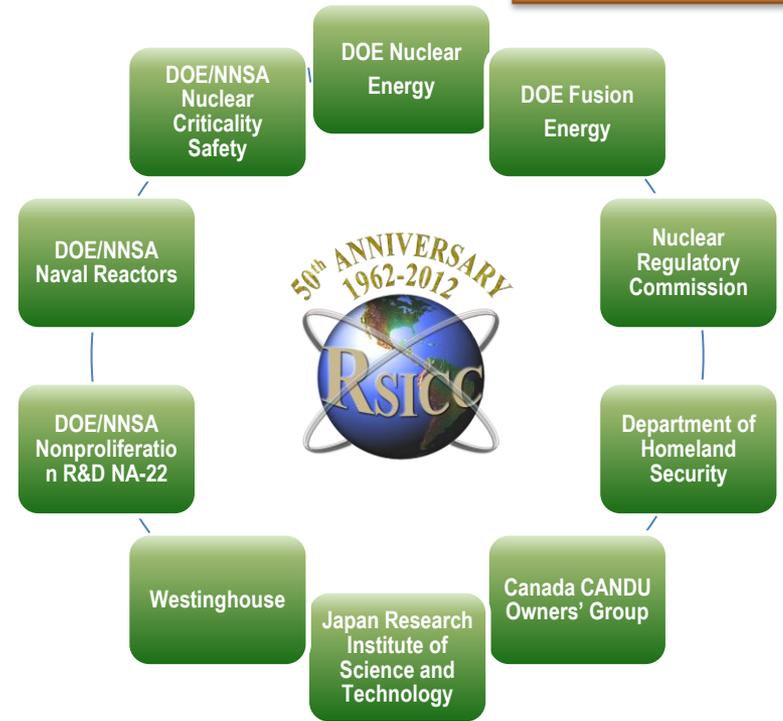
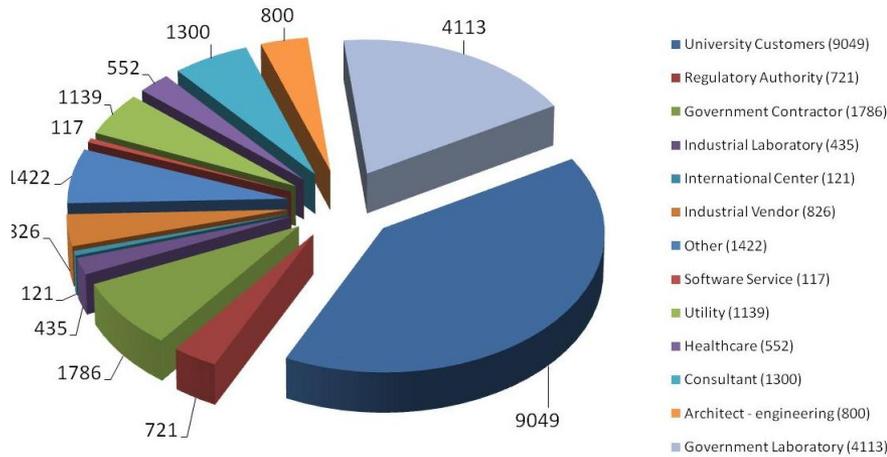
Proposals



# Radiation Safety Information Computational Center (RSICC): Serving the Scientific Community for 50 years

**RSICC**

RSICC Customer Base



- **Software and data packages distributed FY2012: 4,159**
- **8 package updates and revisions August 2012**

# NNFD FY2012 cumulative facility metrics

## Hot Cell availability

## Facility upgrades and maintenance activities

95.60% Transuranic Processing Facility (7920)

97.50% Thorium- Uranium Recycle Center (7930)

96.00% Irradiated Fuels Examination Laboratory (3525)

98.00% Irradiated Material Examination and Testing Laboratory (3025E)

7920

- Programmed maintenance operations
- TSR Calibrations and Functional Testing
- Facility glove box change outs



- Lab 108 analytical chemistry glove boxes



7930

- Programmed maintenance operations
- E-9 exhaust fan control system installation complete
- Annual hoisting and rigging inspection complete

3525

- Programmed maintenance operations
- Completed installation of new glove boxes and the ventilation systems



3025E

- Programmed maintenance operations

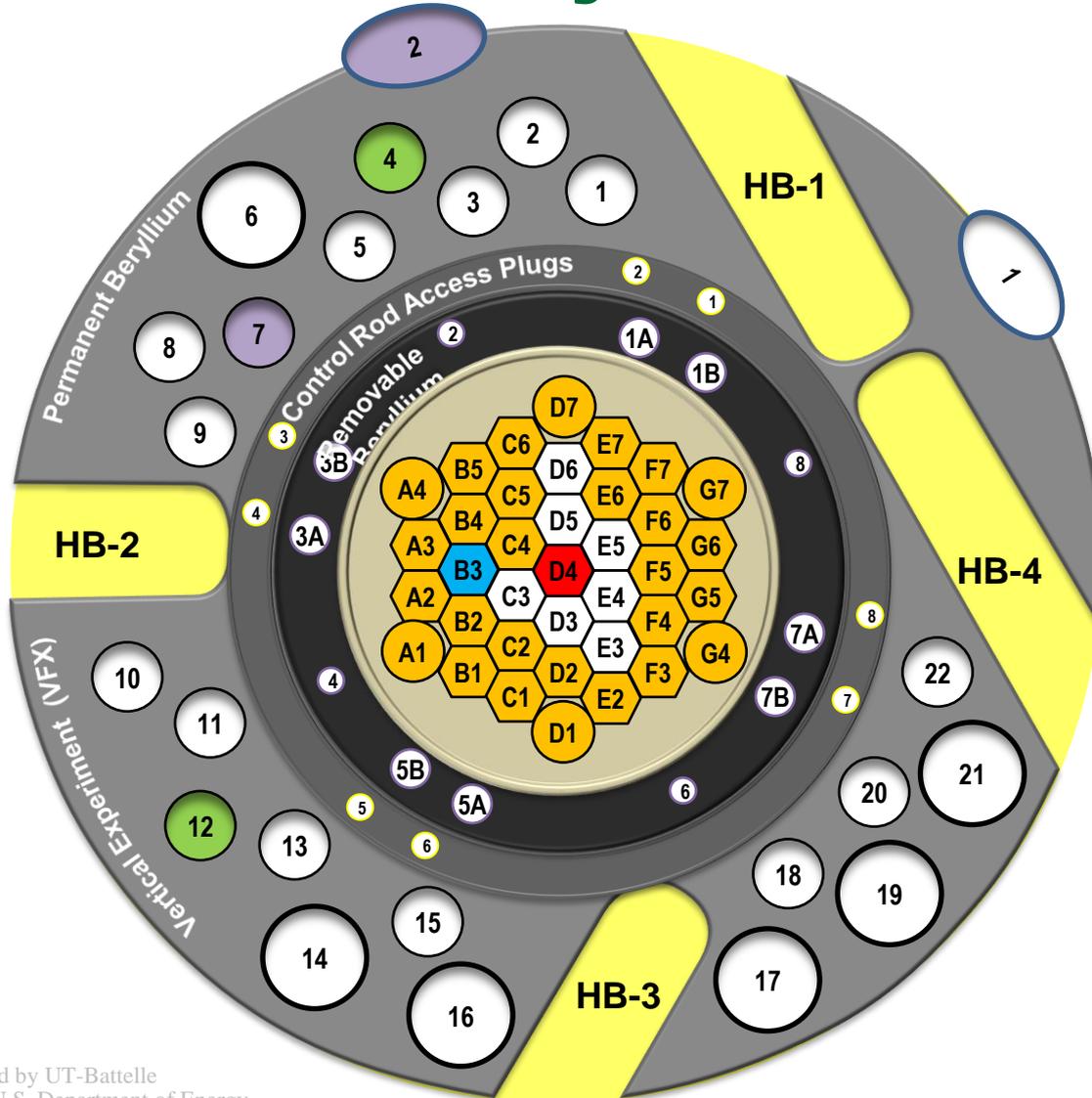
# HFIR operating cycle 443 reaches a new record for number of irradiation capsules in one cycle

HFIR

August 2012

SU	M	T	W	TH	F	SA
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30	31	

Reactor On



- Isotope Production
- Isotopes for Research
- Materials Experiment
- Fuels Experiment
- Pneumatic Facility NAA
- Hydraulic Facility
- Neutron Scattering
- Available Positions

# HFIR operating cycle 443 irradiations are dominated by materials and isotope R&D

## 113 Materials and Fuels Experiments

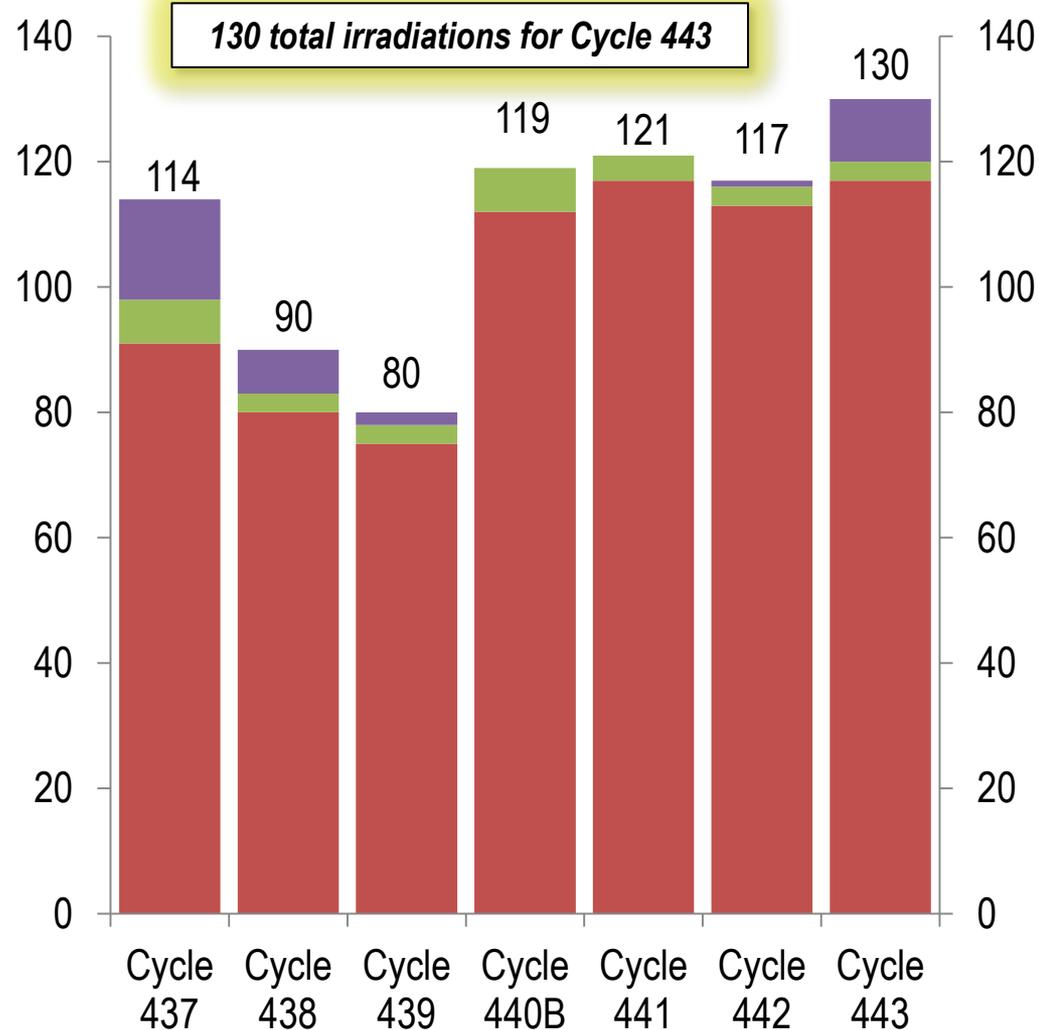
- Silicon Carbide
- V, Mo, & Cu alloys
- Zircaloy
- UO<sub>2</sub> Fuels
- Graphite
- Uranium
- Steels
- UCN Fuels

## 3 Commercial Isotope Production Capsules

- 3 Selenium (Se-75) - production

## Isotopes for Research

- Pu-238 research
- Th-229 research



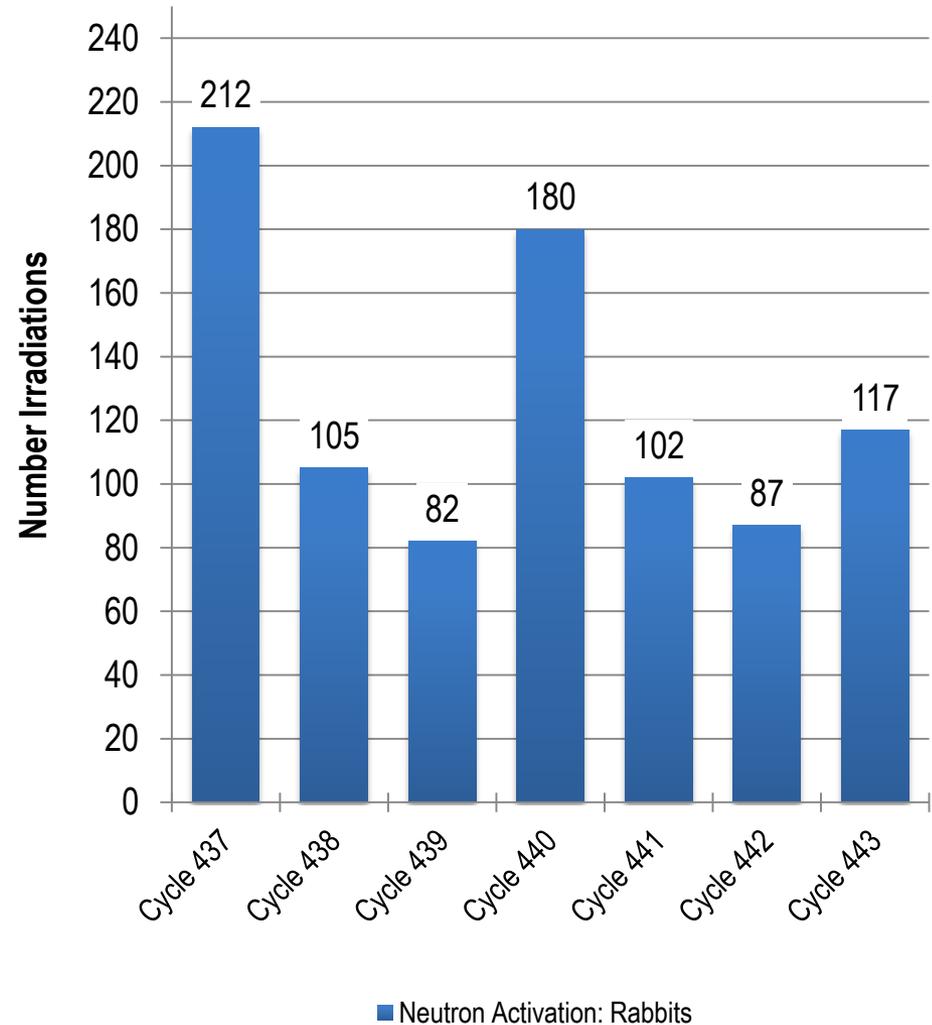
# Significant number of NAA irradiations during HFIR operating cycle 443

HFIR

## NAA irradiations during Cycle 443 include

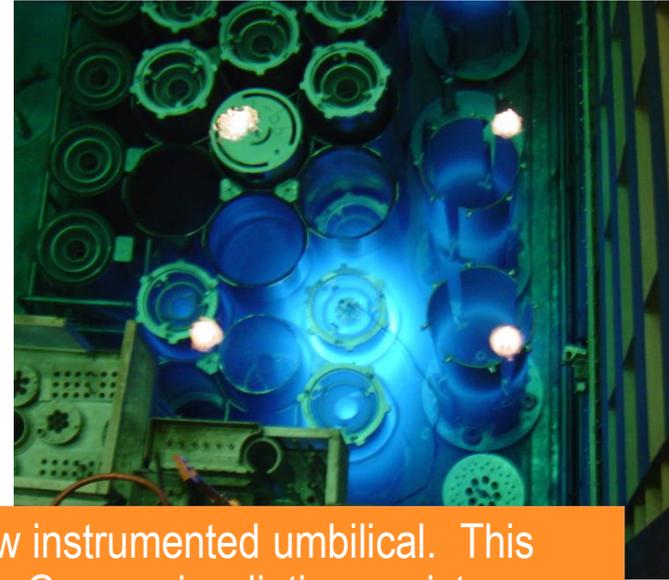
- 74 IAEA Pre-inspection checks
- 2 Yb-169 production for Y-12
- 4 containing thermal and threshold flux monitors
- 5 normal flux monitors
- 5 trace elements in human hair
- 16 iodine and silver on zeolite sorbents
- 1 radium 228 source for measurement of fundamental nuclear parameters for production of Th-229 (for Alpha Therapy radioisotope production)
- 1 rabbit for trace elements in an advanced material from US SOCOM
- 8 rabbits for neutron damage studies by VT graduate students
- 1 rabbit for trace elements in HFIR pool filter debris for summer student

**Total 117**



# HFIR gamma irradiations continue to support NASA and the FDA

- Completed a second set of irradiations for the FDA supporting research of spinal disc replacement materials and the associated wear properties of the polyethylene joint surfaces
- Performed instrumented NASA experiment supporting the fission surface power project.

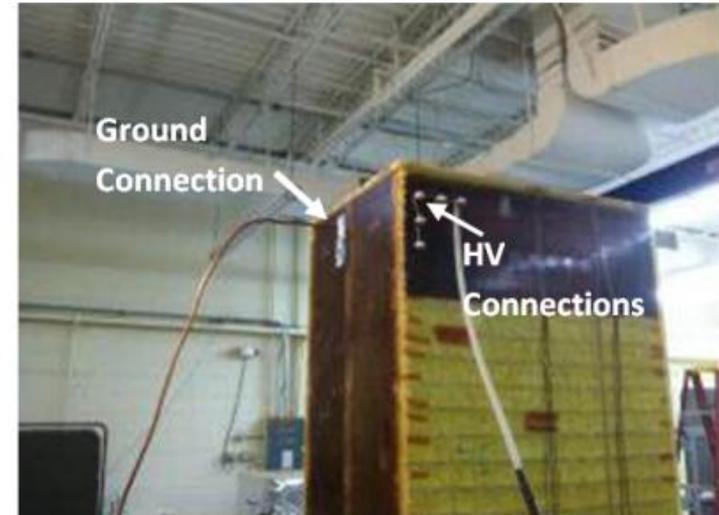


Installed new instrumented umbilical. This connects the Gamma irradiation canister through the pool wall penetration and up to the gas feeds and electrical connectors, allowing online monitoring (digital or analog) as well as temperature control via sweep gasses and heaters installed in the canister.

The previous umbilical required replacement after approximately 3 years of use and exposure to high gamma fields in the HFIR pool.

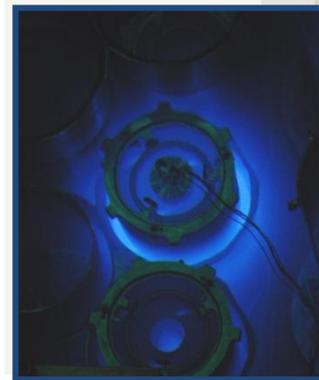
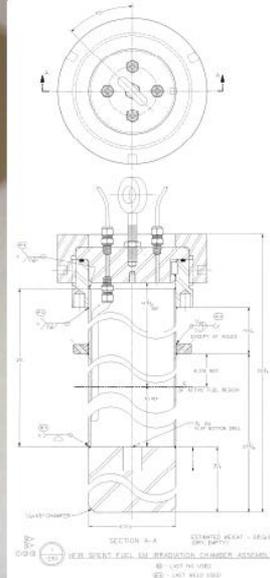
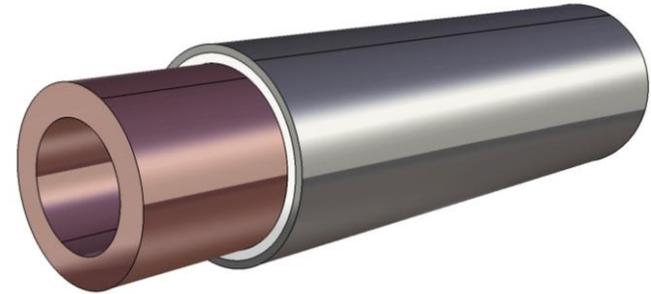
# High voltage work with US ITER completed

- FED worked with US ITER and UT-Magnet Development Lab to develop and conduct tests of electrical insulation of simulated coil winding
- Simulated coil winding fabricated on 14x40 array of stainless steel blocks with same insulation method to be used in ITER CS coils that will be manufactured by the U.S.
- Insulation held 3 kV<sub>dc</sub> turn-to-turn and 125 kV<sub>dc</sub> turn-to-ground without evidence of breakdown
  - This voltage level is within operating parameters of the ITER CS coil



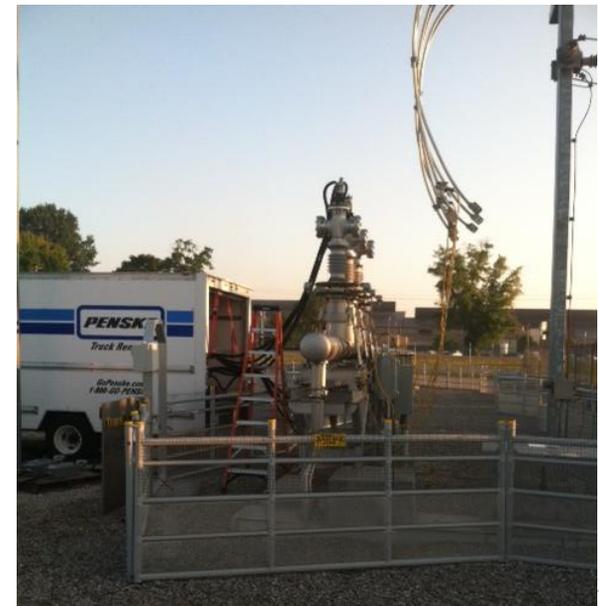
# Preparing for characterization of radiation HV performance of ITER ELM coil conductor

- FED working with PPPL and ASIPP on insulation performance of coil conductor to be used for ITER In-Vessel Coils (IVCs)
- Stainless-Steel Mineral Insulated Conductor developed by ASIPP will be examined in non-radiation and gamma radiation environment at HFIR to determine performance margin for final coil design and control system
- Over 15 samples of SSMIC (0.63 meters) will be characterized by FED over the next six months



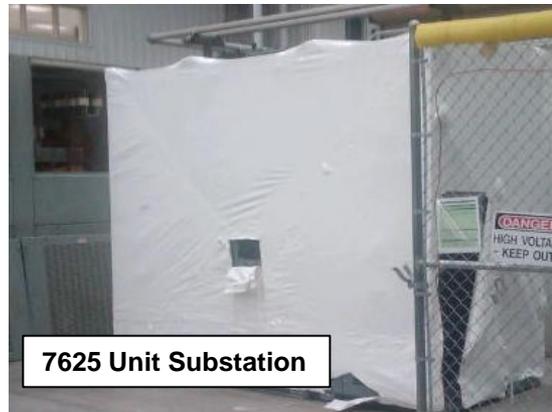
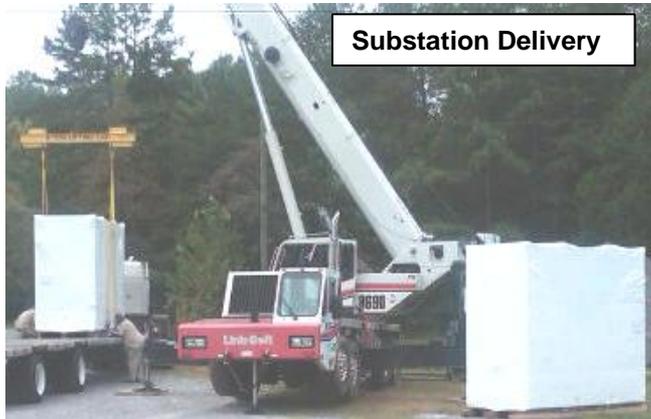
# Decommissioning tests of Southwire Columbus/AEP cable complete

- Since 2006, a 200-m long, HTS power cable has been providing 50 MW of power distribution capacity in the AEP Bixby substation located in southeast Columbus
  - ORNL has been working with Southwire since the mid-1990's on superconducting cable R&D with support from DOE
- The ORNL team worked with Southwire to prepare work-site and transport needed materials and supplies to perform the characterization in the AEP Bixby substation
- DC currents up to 6000 A were applied to all three phases and no significant degradation in cable superconducting performance was observed



# Building 7625/7627 power supply is being enhanced to support PMTS development

- Unit Substations delivered, unloaded and placed in position in 7625 and 7627
- Installed all cable tray and conduit for cabling



**EMPO is providing project management assistance with this project**

# ORNL northwest quad soils and slabs D&D and remediation

- Prepared D1 version of the Phased Construction Completion Report (PCCR)
- Submitted D1 of the PCCR for DOE/EPA/TDEC review
- Project removed ~ 109,000sf of legacy slabs in the central campus and the 2000 area is being prepared for use as a parking lot (see below)



Overview of Restored 2001/2024/2000 Site

# 4500 area gaseous waste reconfiguration and stabilization project

- 4556 Filter Pit clean out subcontractor completed removal and packaging of loose materials/equipment from the pit
- Completed removal/sizing/packages of all non-process components from pit
- Completed isolation/sizing/removal/packages of the LLLW drain system from pit
- Isolated by-pass and east blower ventilation branches from 3039 stack
- Reconfiguration contractor continued installation of HEPA Filter housings, fans and duct work
- Completed wall and ceiling penetrations for new duct work
- Continued assembly/installation of the electrical panels and associated conduit



HEPA Housing and Fans in A234, 4500N



Removing Electrical Equipment from 4556



4556 North Wall Following Equipment Removal

# Isotopes Area legacy material removal

- Addressed TDEC comments and prepared and submitted a D2 version of the project PCCR
- Received “Certificate of Disposal” from Energy Solutions – Clive for last month’s mixed waste shipment



Mixed Waste Lead Bricks from Isotopes Area

# EM project integration support

- UT-B completed the fabrication of the spacers required to fit the SNAP-7C/ Weather Bureau RTG in the ORNL GE-2000 waste cask for transport to NNS  
- Test fit scheduled for week of September 10th
- UT-B personnel continued to support NNS in their preparations to receive/ unload RTGs for Miscellaneous Facilities Project  
- Loading of the first RTG (SNAP 7B) scheduled for week of September 10<sup>th</sup>
- EM Contractor SEC/ Perma-Fix successfully removed the roof plugs from 3026D Cell A and began enhanced investigation of cell interior
- EM Contractor SEC/Perma-Fix began efforts to transition Building 3038 to UCOR  
- Removed numerous waste items for final disposition
- UT-B work planning initiated on both the 4501 Cell D Cleanout and the Building 2026 Legacy Material Removal



3026D Hot Cell Roof Plug Removal



SNAP 7C/ Weather Bureau RTG spacers