

Summary of the Workshop on Advanced Nuclear Energy Systems

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Radiological experiments at the APS: Background

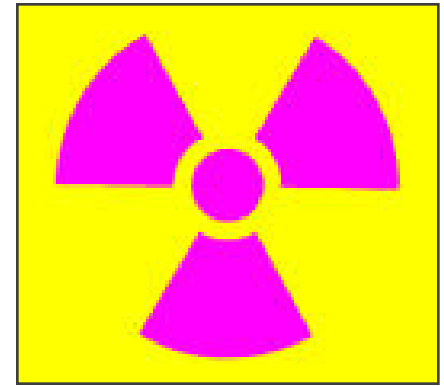


- Management understood importance of synchrotrons for actinide science
- Since first light in 1995 APS has approved 933 experiments involving radioactive samples
- Community has been rather narrowly focused on basic chemistry, physics, and environmental sciences
- Workshop Jan 2010 to determine interest of broader Advanced Nuclear Energy Systems community (materials sciences)

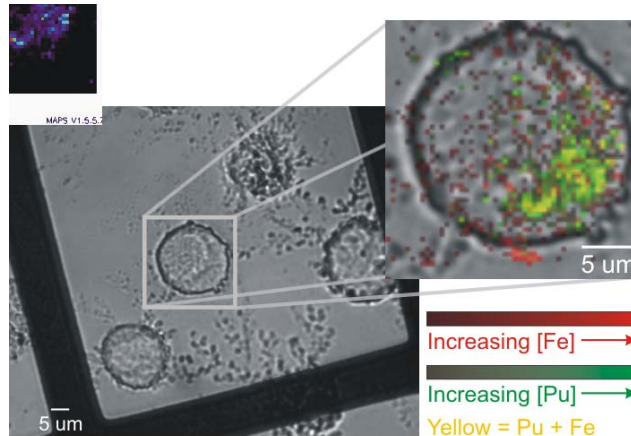
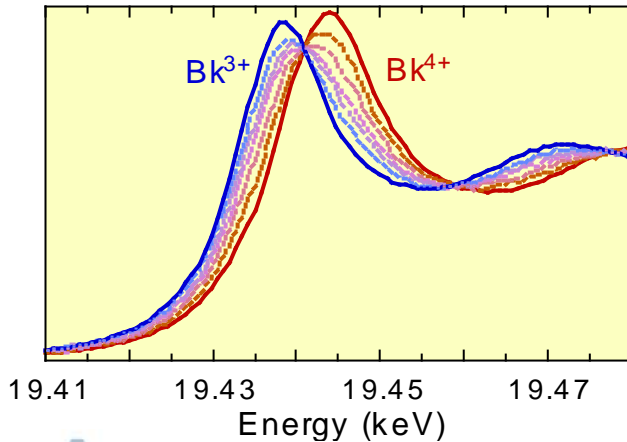
Why use synchrotron radiation?

Hard x-rays ideal probe for radioactive samples:

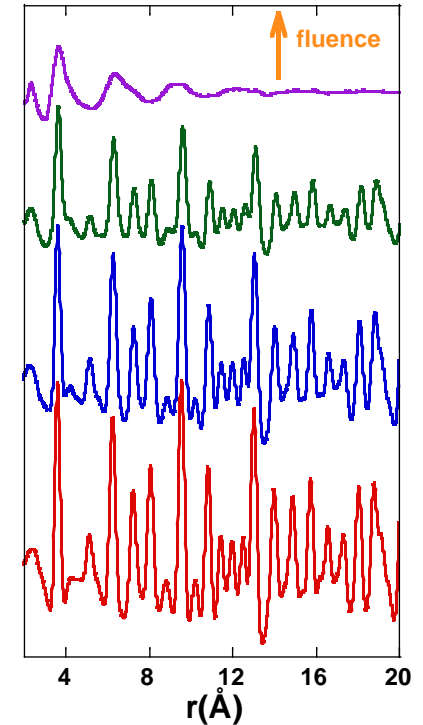
- wide range of experiments available
- small, intense beams permit small sample sizes
- higher energy x-rays permit sample encapsulation



Spectroscopy:



Imaging:



Scattering:



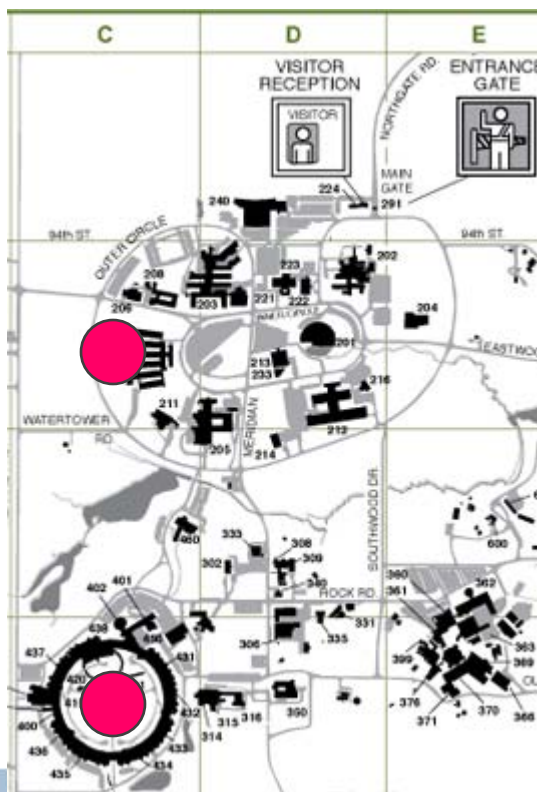
Radiological experiments at the APS: Philosophy

- SAMPLES MUST BE ENCAPSULATED AT ALL TIMES
- Amount of material, and how it is contained, are determined via a risk-based approach spelled out by APS ESAF Experimental Hazard Class 8.1
- Bare sample handling done in Building 200
- No restrictions on which beamlines available for running radioactive samples; can pick best beamline for problem at hand
- 21 Sectors have run radioactive samples



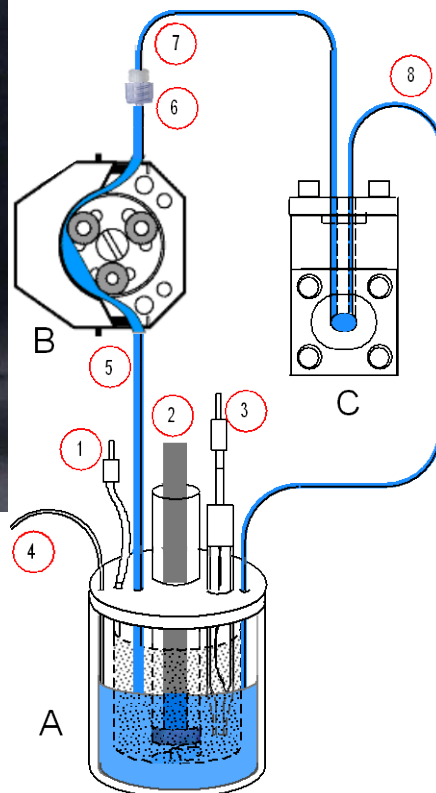
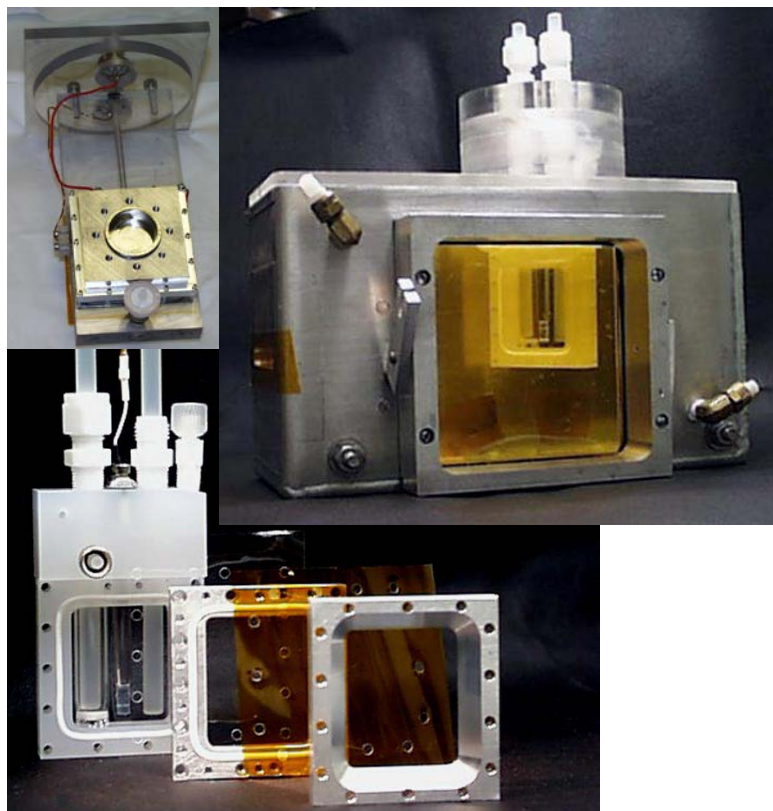
Actinide Facility: BES Chemical Sciences

- Not a beamline
- Radiological Facility
- A infrastructure to assist APS users working with radioactive samples
- Samples transported to Building 200



Purpose-built equipment for sample containment

X-ray spectroscopy and X-ray scattering



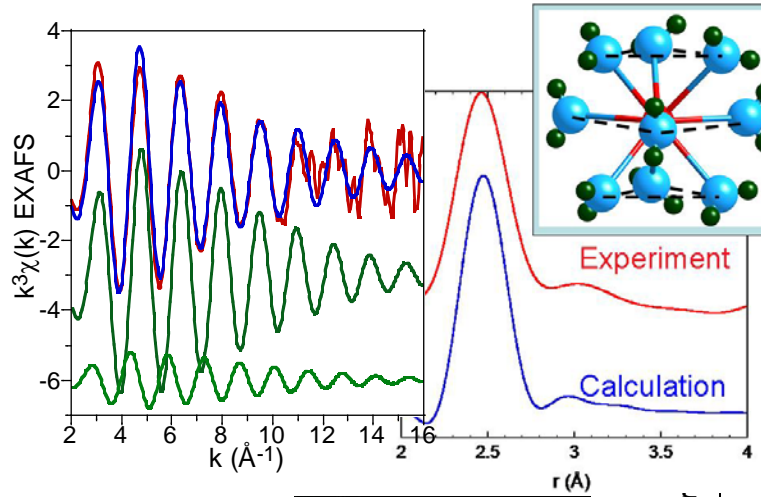
Containment boxes made available to APS users

What experiments have been done?

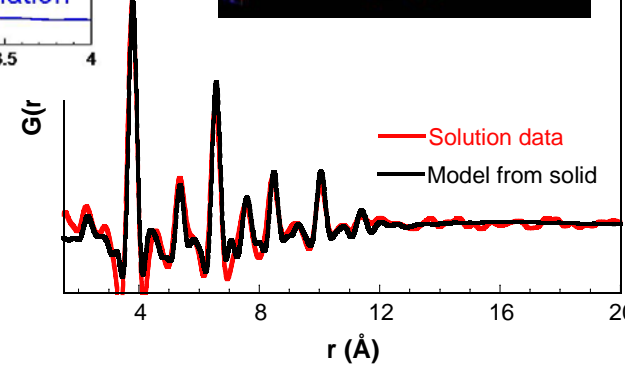
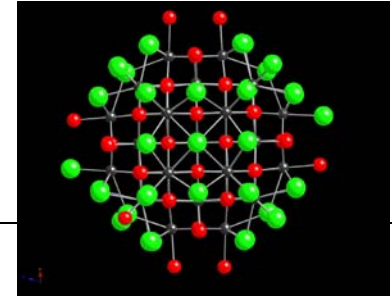
Amorphous systems

| | | | | | | | | | | | | | | | | | |
|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| H | | | | | | | | | | | | | | | | | He |
| Li | Be | | | | | | | | | | | B | C | N | O | F | Ne |
| Na | Mg | | | | | | | | | | | Al | Si | P | S | Cl | Ar |
| K | Ca | Sc | Ti | V | Cr | Mn | Fe | Co | Ni | Cu | Zn | Ga | Ge | As | Se | Br | Kr |
| Rb | Sr | Y | Z | Nb | Mo | Tc | Ru | Rh | Pd | Ag | Cd | In | Sn | Sb | Te | I | Xe |
| Cs | Ba | La | Hf | Ta | W | Re | Os | Ir | Pt | Au | Hg | Tl | Pb | Bi | Po | At | Rn |
| Fr | Ra | Ac | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr | |

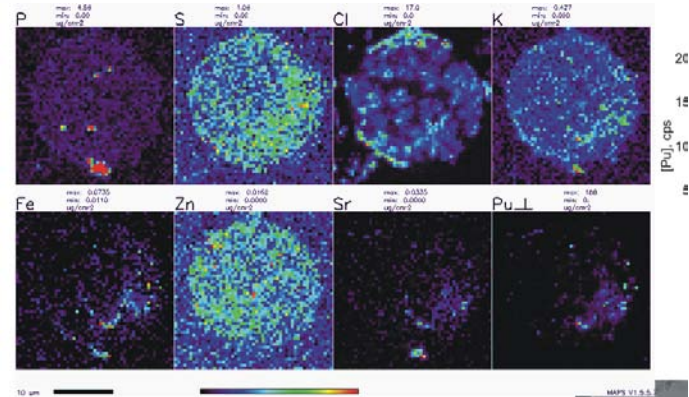
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| La | Ce | Pr | Nd | Pm | Sm | Eu | Gd | Tb | Dy | Ho | Er | Tm | Yb | Lu |
| Ac | Th | Pa | U | Np | Pu | Am | Cm | Bk | Cf | Es | Fm | Md | No | Lr |



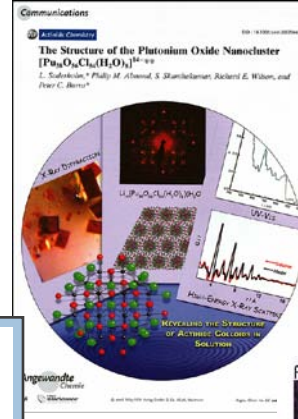
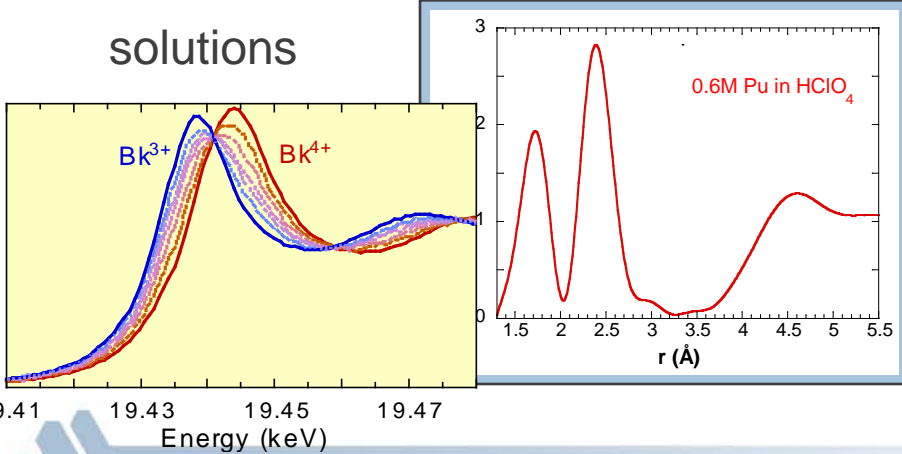
colloids



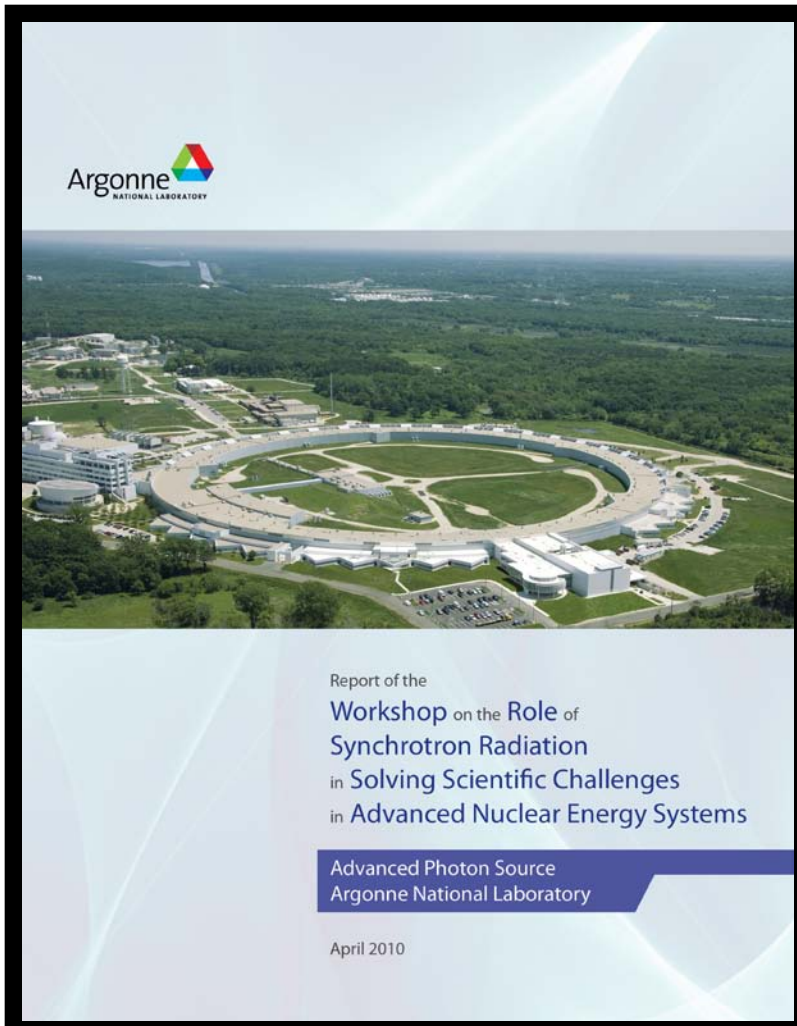
elemental mapping



solutions



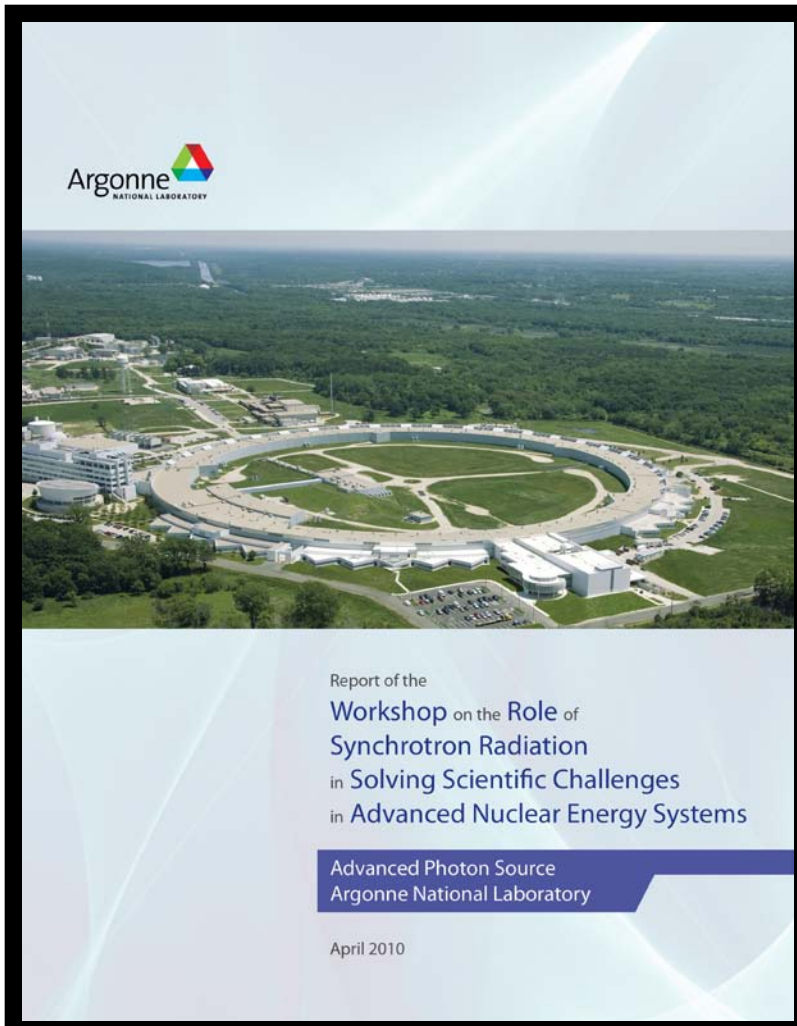
Workshop



- invitations widely distributed
- about 120 registrants
- wide variety of science
 - solutions/amorphous samples
 - corrosion and interfaces
 - radiation damage and effects
- lively discussion (sample quantities)
- followed up with workshop report



Workshop Findings

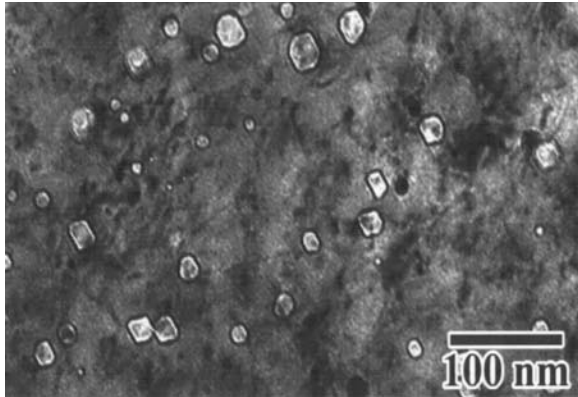


Community:

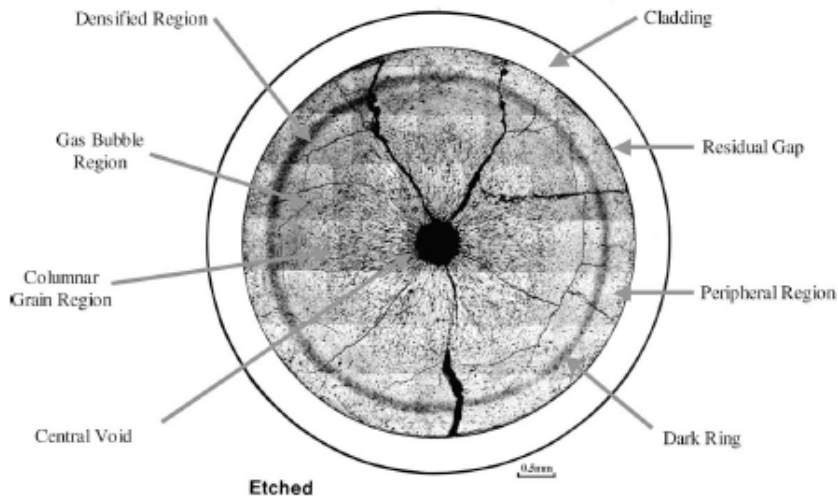
- applaud APS philosophy for radioactive samples (make all beamlines available)
- acknowledge that Radiological Facility sufficient for sample quantities
- requests assistance for encapsulation design and engineering
- requests space for sample handling adjacent to APS



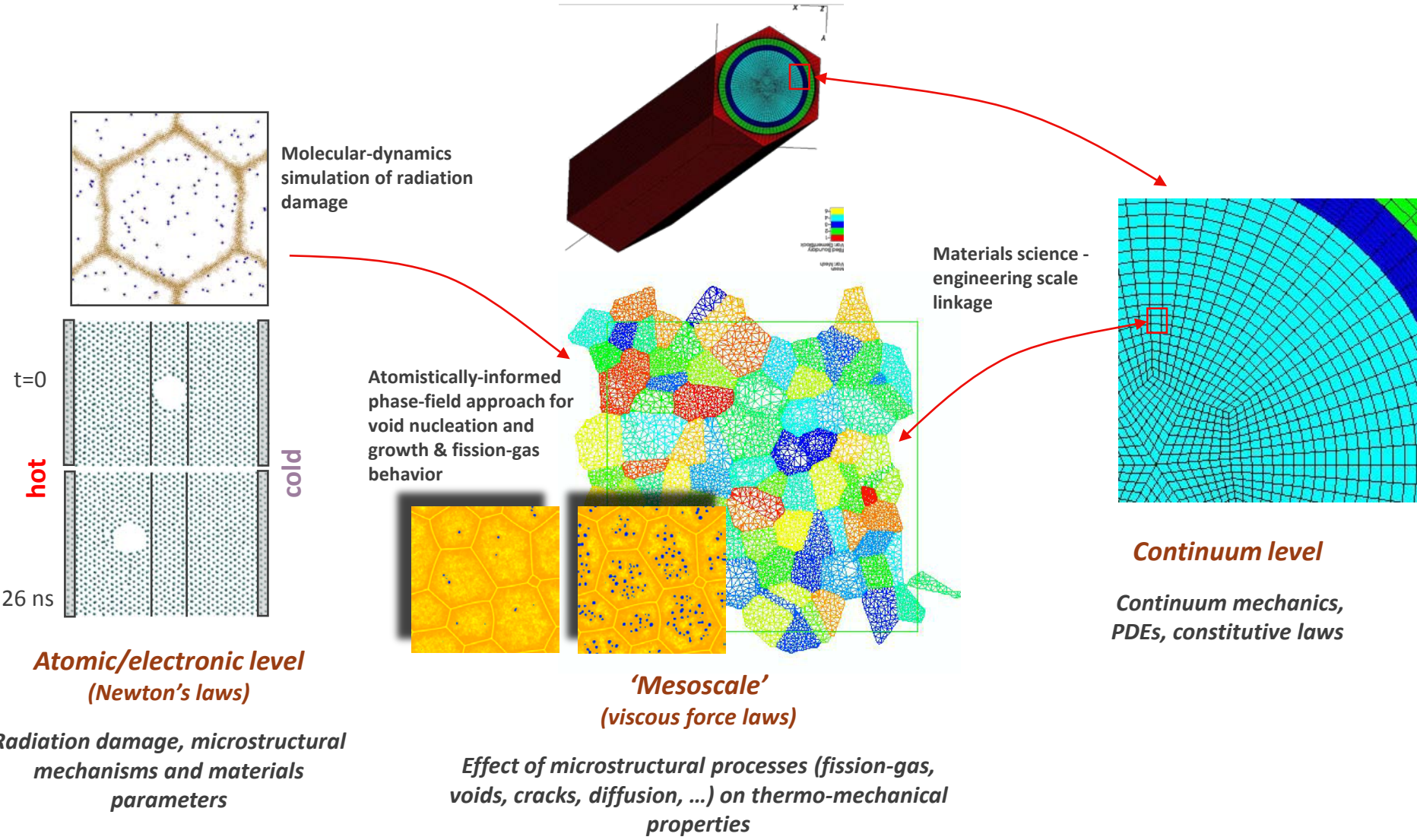
Structural Materials and Fuels: Example problems



- very inhomogeneous samples
- materials problems at varying length scales
- samples can be very dense
 - 19 g/cm^3 for U metal
- samples can be very radioactive
 - $130 \text{ g irradiated UO}_2 = 14 \text{ Ci}$



Radiation Damage: Key Data for Model Validation



Explicit incorporation of microstructural processes based on atomic-level mechanisms is critical towards establishing a predictive fuels-performance capability

Beamline needs (unrealized opportunities)

High Energy Capabilities

- imaging (full field, fluorescence)
- tomography
- small angle scattering (gas voids)
- need for imaging and tomography

Uranium Absorption Length

| | |
|-----------|--------------|
| 5 keV | 1.2 microns |
| 17.14 keV | 5.17 microns |
| 100 keV | 380. microns |

Detectors

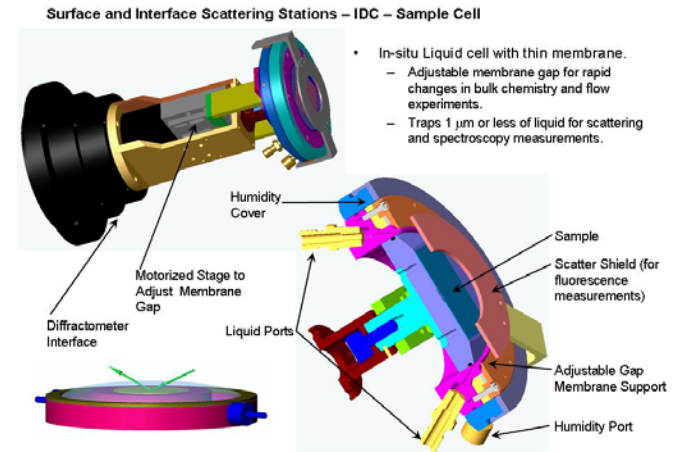
- improved energy discrimination
- higher count rates
- radiation field argues for high synchrotron flux (insertion device)



Sample Handling

Work with APS to design encapsulation and shielding

- encapsulation for working on geometrically challenging experiments
- sample shielding to ALARA requirements
 - sample containments weighing 200 kg



New stand-alone building adjacent to the APS

- minimize risk to APS facility
- handle DOE requirements regarding sample amounts (Rad Facility)
- need to handle open samples (Actinide Facility)
- need to handle massive sample containment (shielding)

Future Direction-Advanced Nuclear Energy Community

- Workshop identified large sector of nuclear energy experimental interests not being addressed by synchrotron community
- Opportunity to expand capabilities at the APS to address this community
- Opportunity to integrate basic and applied NE science and engineering with APS as the focal point
- House in Radiological Facility, a new, stand-alone building located adjacent to synchrotron ring

