AGR-3/4 Radial Destructive Exams

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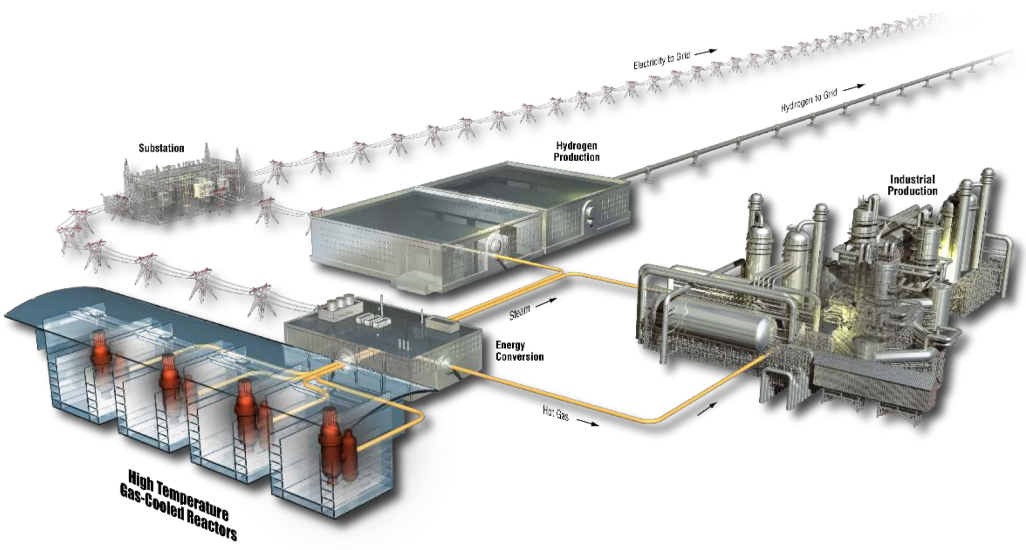
AGR TRISO Fuels Program Review
Idaho Falls, ID
July 18-19, 2017

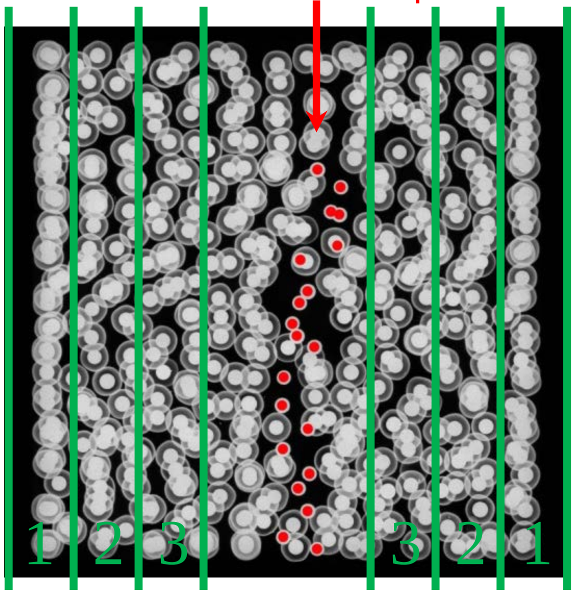


Outline

- Compact radial deconsolidation
  - Process flow charts
  - Search for designed-to-fail (DTF) particles
  - Status of radial deconsolidations
- Physical sampling of inner and outer rings
  - Status
  - Schedule

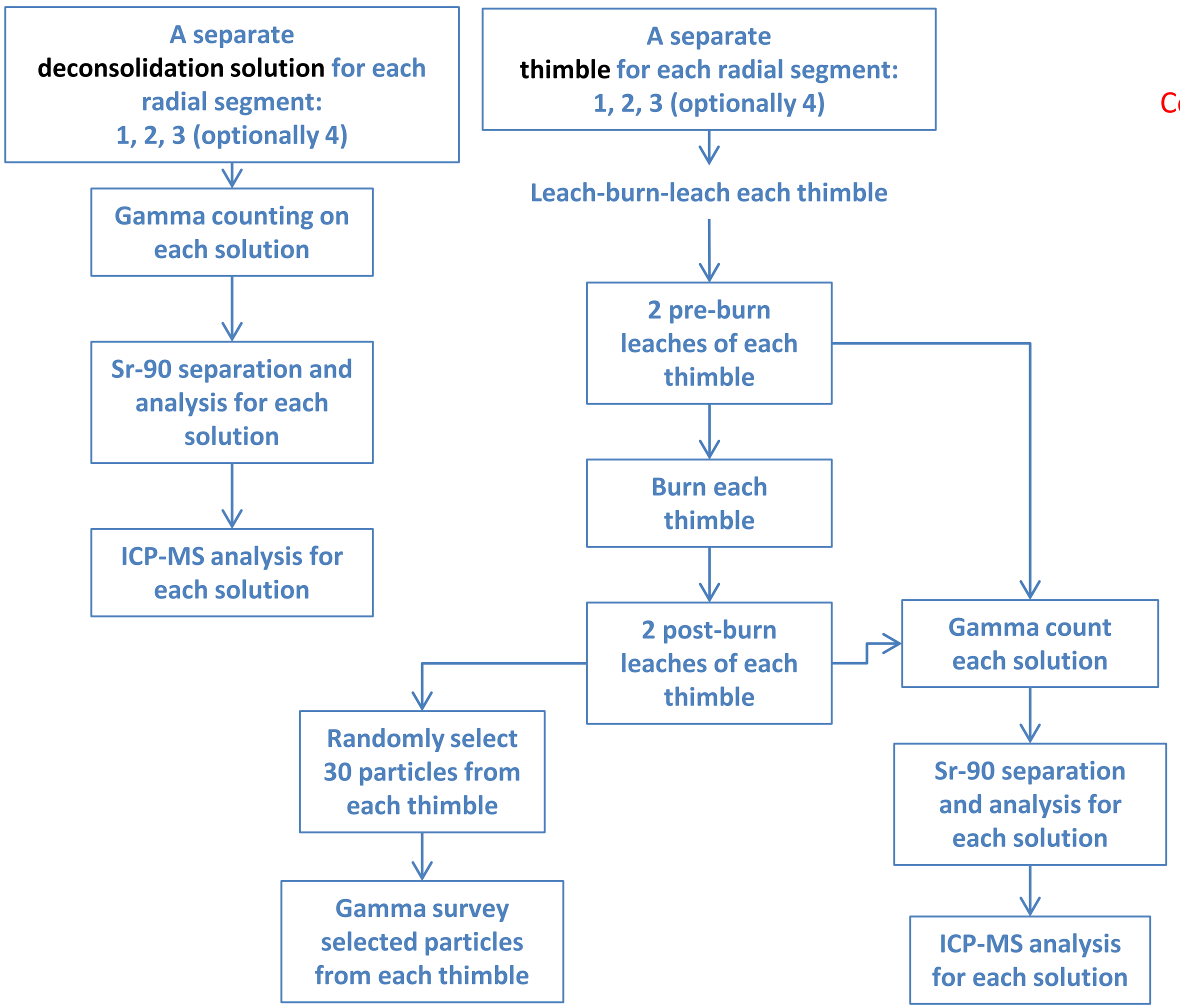
Compact Radial Deconsolidation

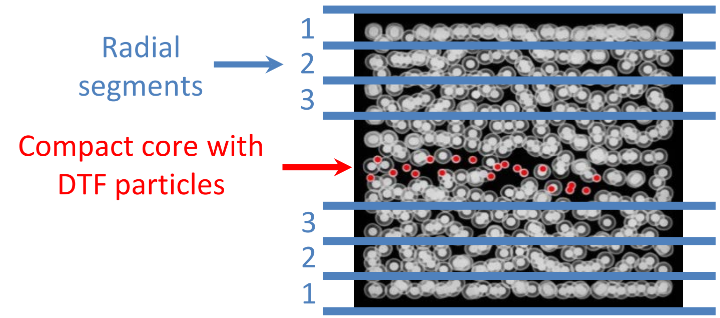
- Remove radial portions of the compact in 3 or 4 segments
- Use leach-burn-leach (LBL) process to measure fission product inventory outside of particle SiC layers as a function of radial position in the compact
- Analyze groups of particles from different radial positions in the compact
- Avoid deconsolidating DTF particles until after harvesting 3 or 4 radial segments from the compact
- Compare measured fission product profile with model prediction

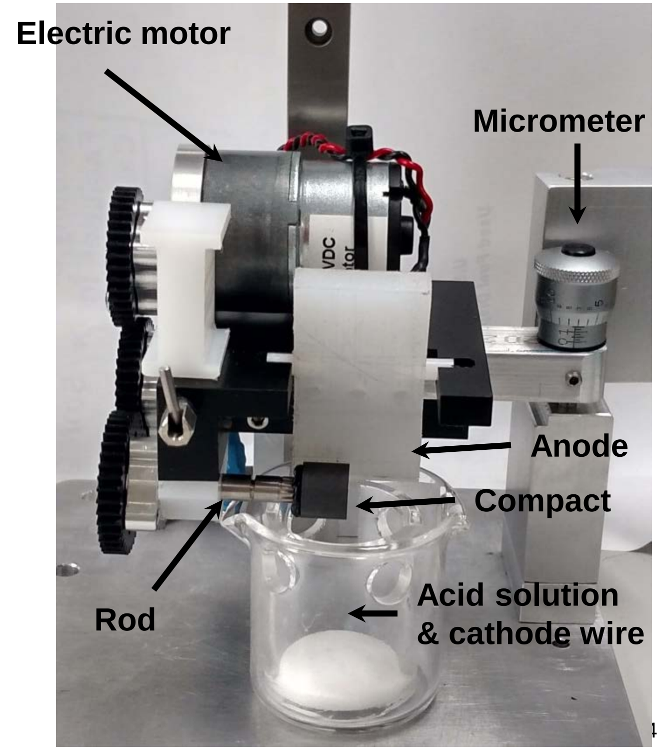


Radial Deconsolidation Analysis Flow Chart

- Analyses on radial segments

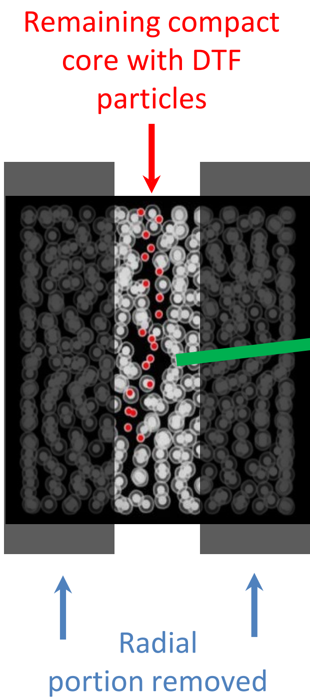






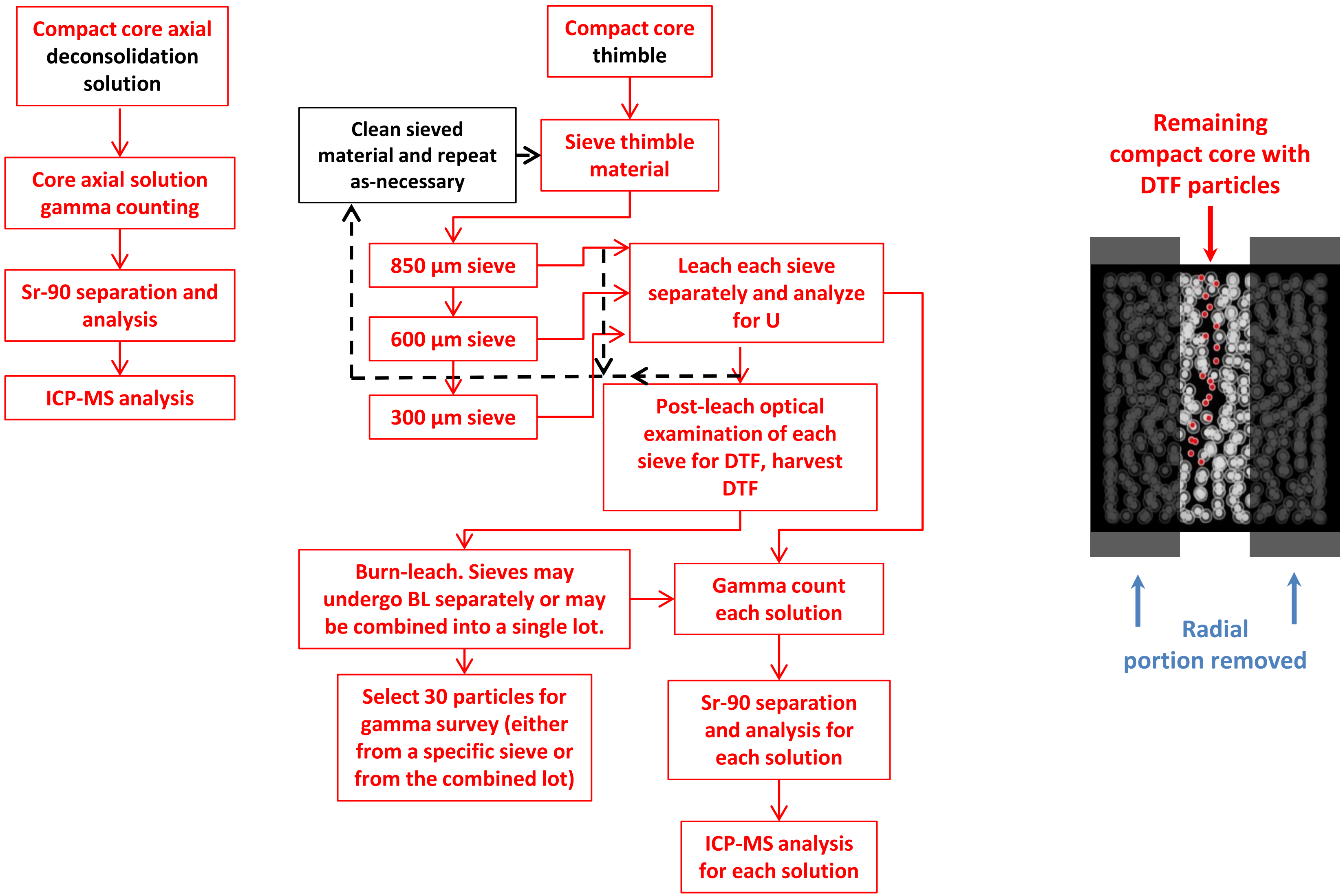
Axial Deconsolidation Following Radial Deconsolidation Steps

- Traditional axial deconsolidation on compact core remaining from radial deconsolidation



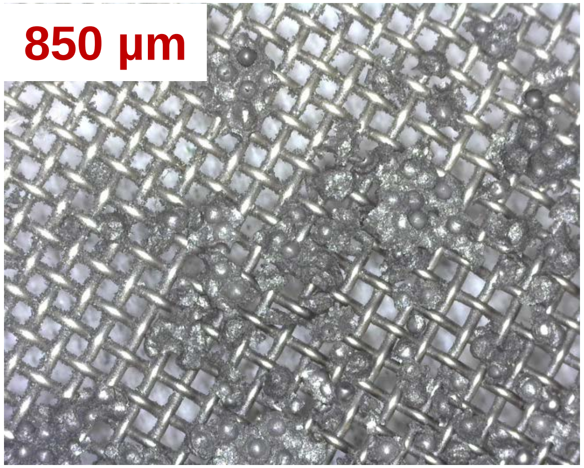
Radial Deconsolidation Analysis Flow Chart

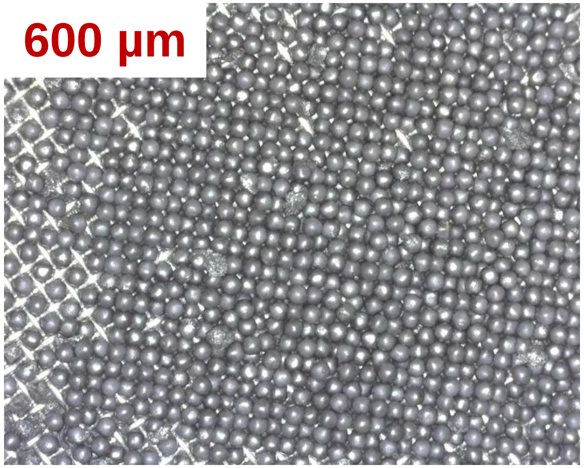
- Analyses on compact core from final axial step of deconsolidation

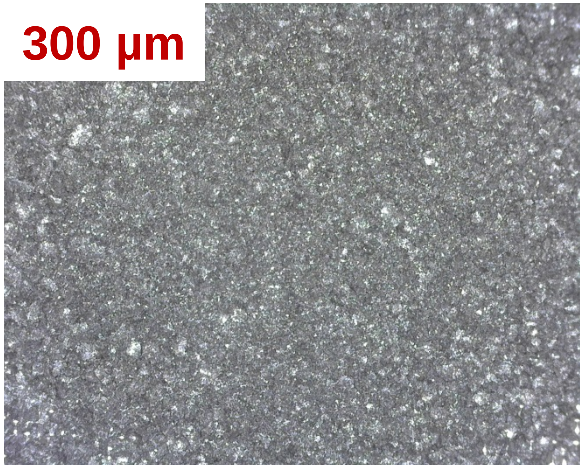


AGR-3/4 DTF Recovery

- Attempted DTF recovery following trial deconsolidation of unirradiated Compact Z109:
  - Sieve debris collected from axial deconsolidation of core
  - Material from the 850 µm sieve was further process (cleaned, re-sieved, etc.)
  - At no point did any DTF stand-out for harvesting
  - 11 kernels worth of U measured in burn-leach solutions of the 850 µm material
  - Other 9 kernels must be in other sieves (600 and 300 µm)
- Built sieves to put in hot cell
- Performing additional sieving of un-irradiated particles to determine partitioning of DTF





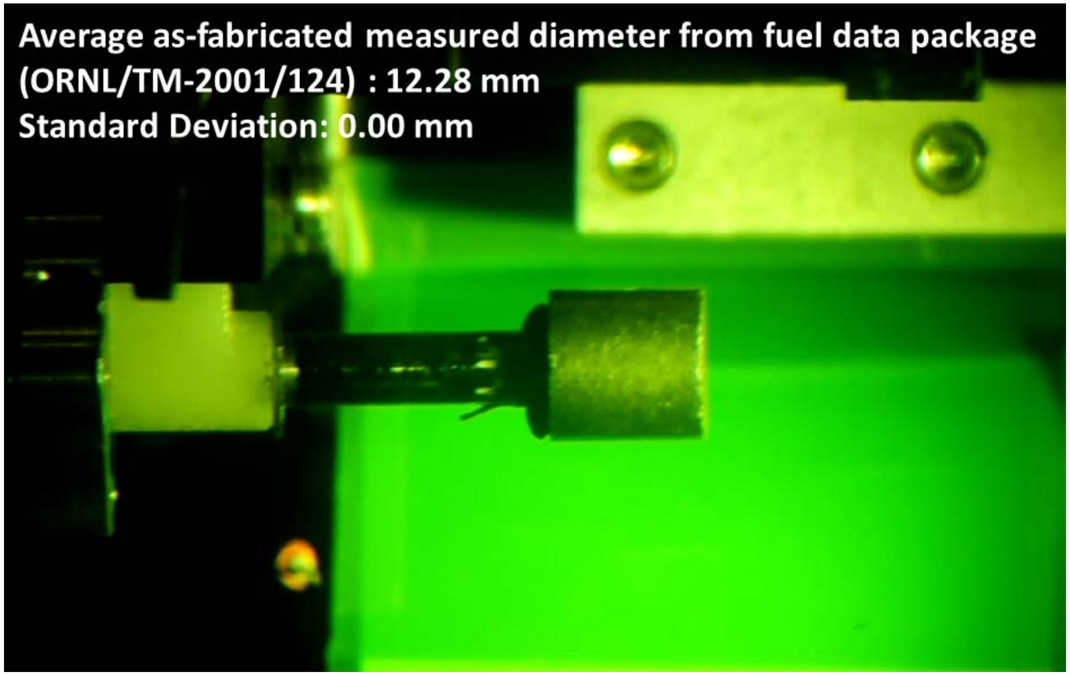


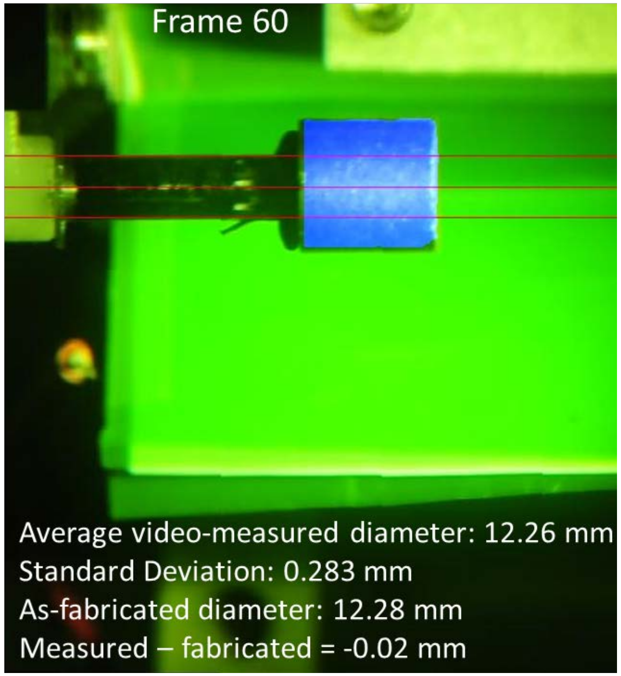
In-cell Radial Deconsolidation Status

- Completed two trial radial deconsolidations in Cell 5 at Analytical Laboratory (AL)
  - Un-irradiated compact LEUO3-10T-OP2-Z153
  - Matrix blank (matrix graphite only)
- Completed radial deconsolidations on two irradiated compacts in Cell 5 at AL towards **Level 3 Milestone** “complete radial deconsolidation of two AGR-3/4 compacts”
  - Radial deconsolidation of irradiated Compact 12-3 (1 radial segment and axial)
  - Full radial deconsolidation of irradiated Compact 12-1 (3 radial segments and axial)
  - Analyses in-progress

Trial Radial Deconsolidation Step 1

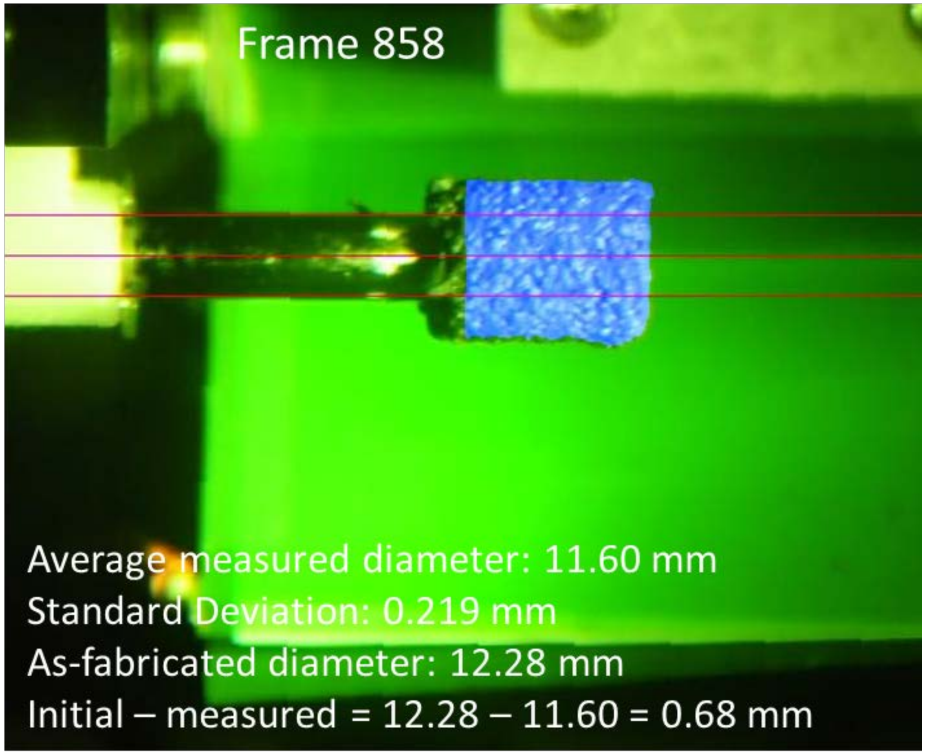
- Step 1: set up apparatus and camera, accurately measure pre-deconsolidation compact diameter





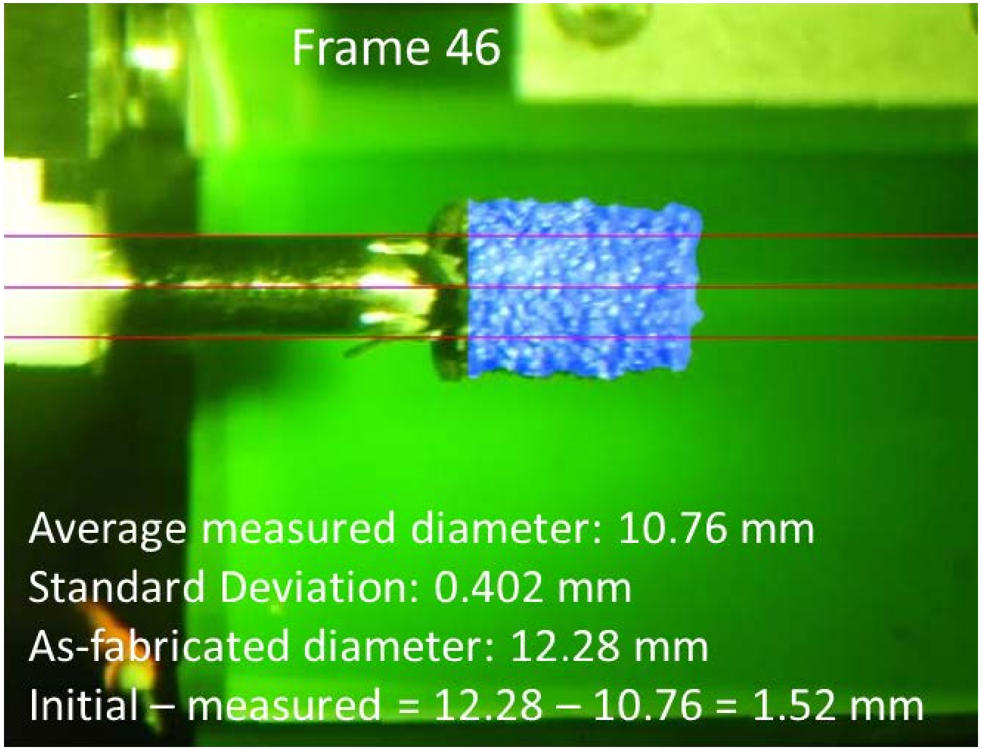
Trial Radial Deconsolidation Step 2

- Step 2: using the same lighting/camera setup as in Step 1, acquire video of rotating compact after 15 minutes of radial deconsolidation



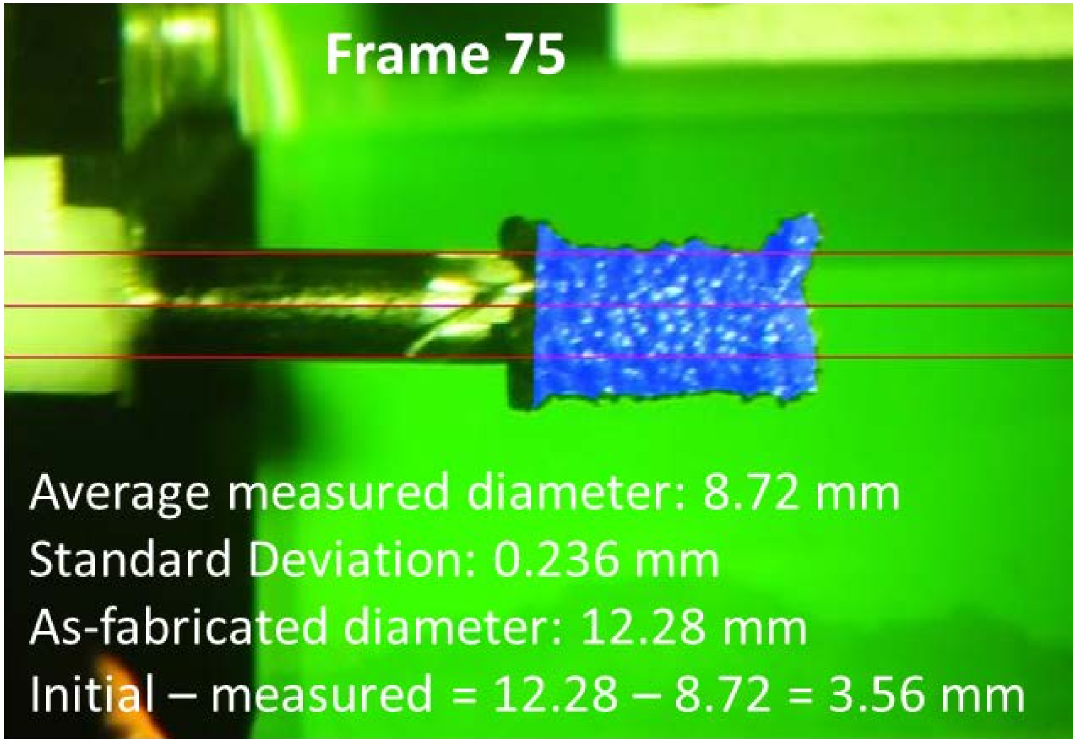
Trial Radial Deconsolidation Step 3

- Step 3: using the same lighting/camera setup as in Step 1, acquire video of rotating compact after additional 15 minutes of radial deconsolidation



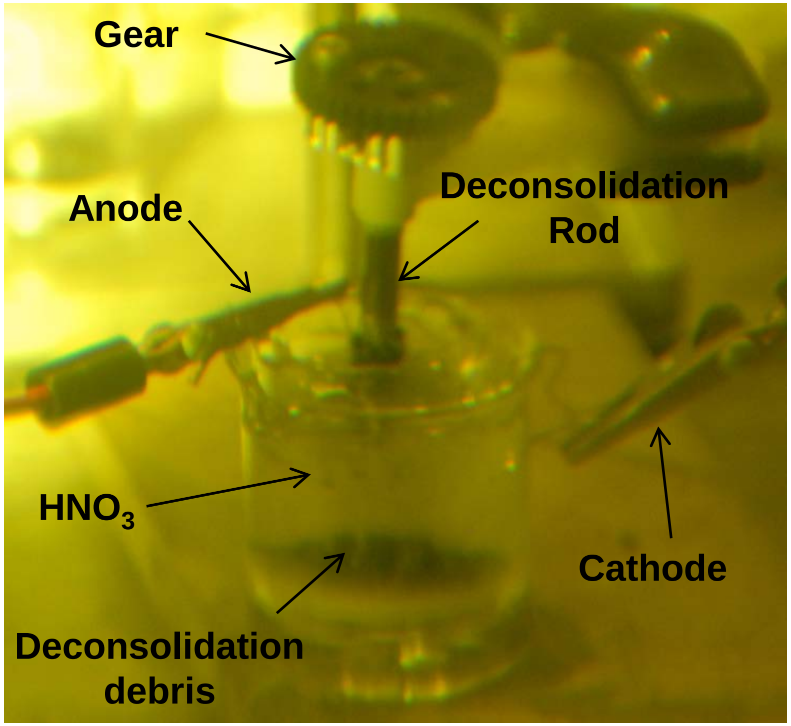
Trial Radial Deconsolidation Step 4

- Step 4: using the same lighting/camera setup as in Step 1, acquire video of rotating compact after additional 20 minutes of radial deconsolidation



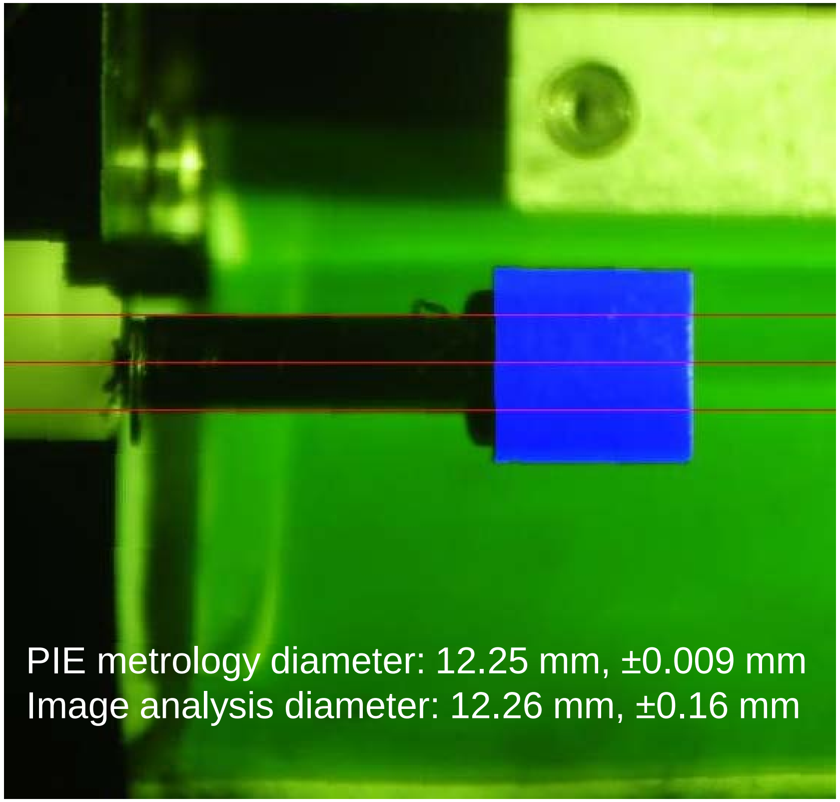
Trial Radial Deconsolidation Step 5

- Step 5: Use axial deconsolidation method to deconsolidate the compact core attached to the rod



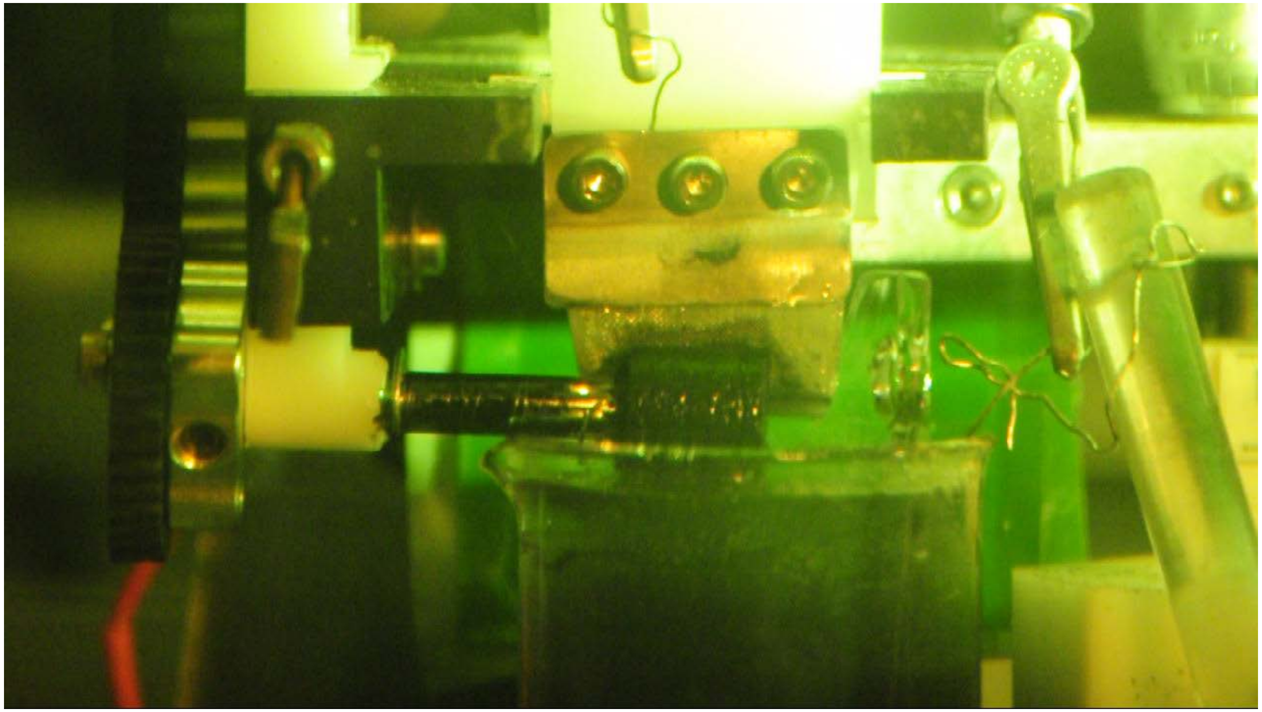
First Irradiated Compact 12-3 Radial Deconsolidation

- Step 1: set up camera and lighting, acquire video, compare diameter from image analysis with known diameter from PIE metrology



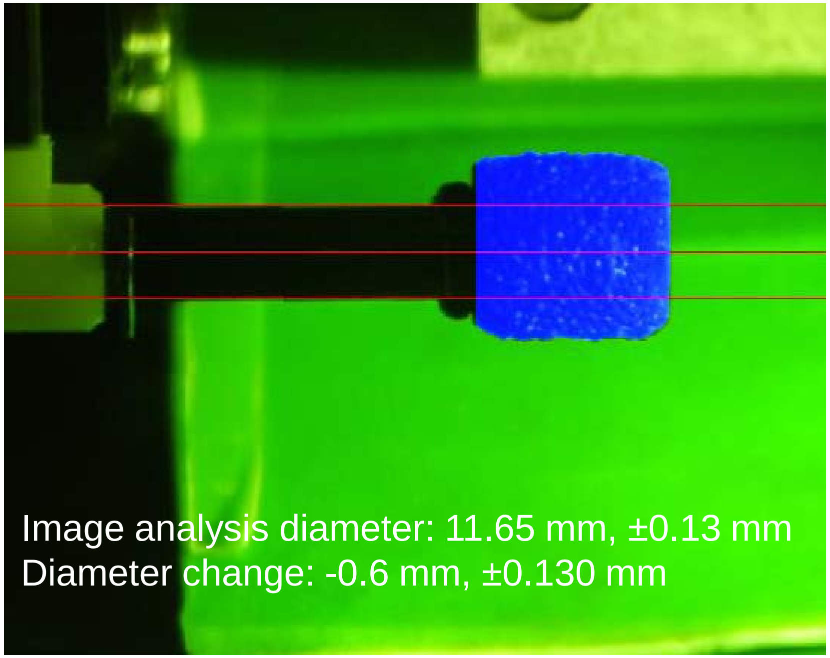
First Irradiated Compact 12-3 Radial Deconsolidation (video)

- Step 2: lower compact to deconsolidation solution, establish uniform contact with screen electrode, start rotation, turn on electrode power



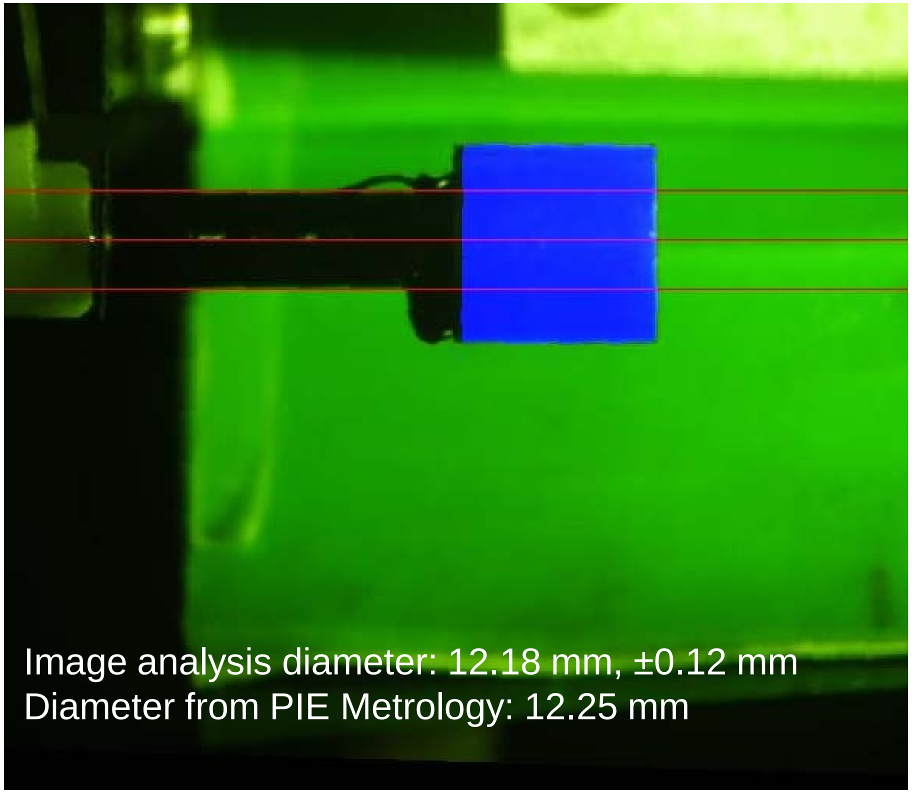
First Irradiated Compact 12-3 Radial Deconsolidation

- Step 3: Measure compact diameter after first 15 minutes of deconsolidation
- Same amount of material removed from irradiated Compact 12-3 after 15 minutes as from as-fabricated compact Z153 (~0.6 mm)
- Compact inadvertently knocked off rod
- Deconsolidation solution and particle analyses will be completed on material from first 15 minutes



Second Irradiated Compact 12-1 Radial Deconsolidation

- Radial deconsolidation completed 5/15/2017
- Radial deconsolidation performed in three steps, each 16 minutes long
- Axial deconsolidation of compact core completed 5/16/2017



Planned Radial Deconsolidations in 2017

- Complete at least one more radial deconsolidation of the following:
  - Capsule 3 (IR/OR-3 planned for physical sampling):
    - 3-3 - primary
    - 3-4
  - Capsule 7 (IR/OR-7 planned for physical sampling):
    - 7-3 - primary
    - 7-4
  - Capsule 12:
    - 12-4: use if problems arise during other deconsolidations
- Level 3 Milestone to complete 2 radial deconsolidations of irradiated compacts already fulfilled with compacts 12-3 and 12-1

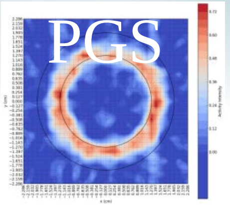
Safety Testing of AGR-3/4 Compacts

- For FY17:

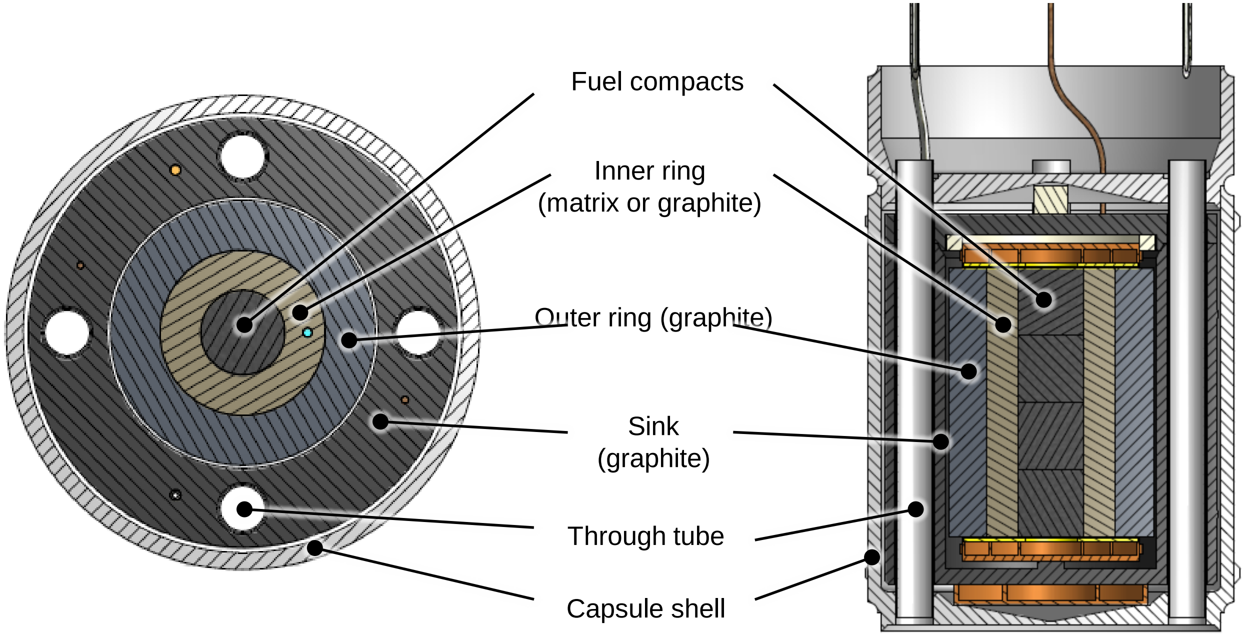
Compact	Test Temperature (°C)	Irradiation Temperature (°C)	Burnup (% FIMA)	Status
3-2	1600	1196	12.5	Early August
10-2	1200	1213	12.0	Late August

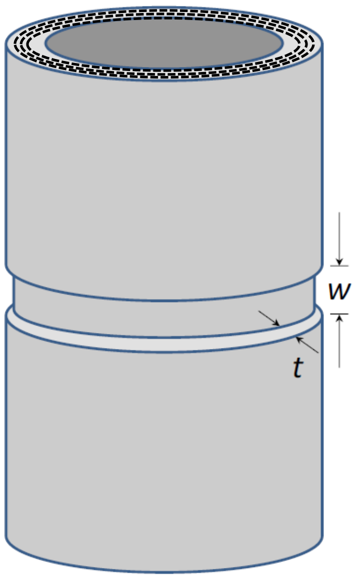
- See PLN-5382 for other planned AGR-3/4 safety tests

Physical Sampling of AGR-3/4 Rings



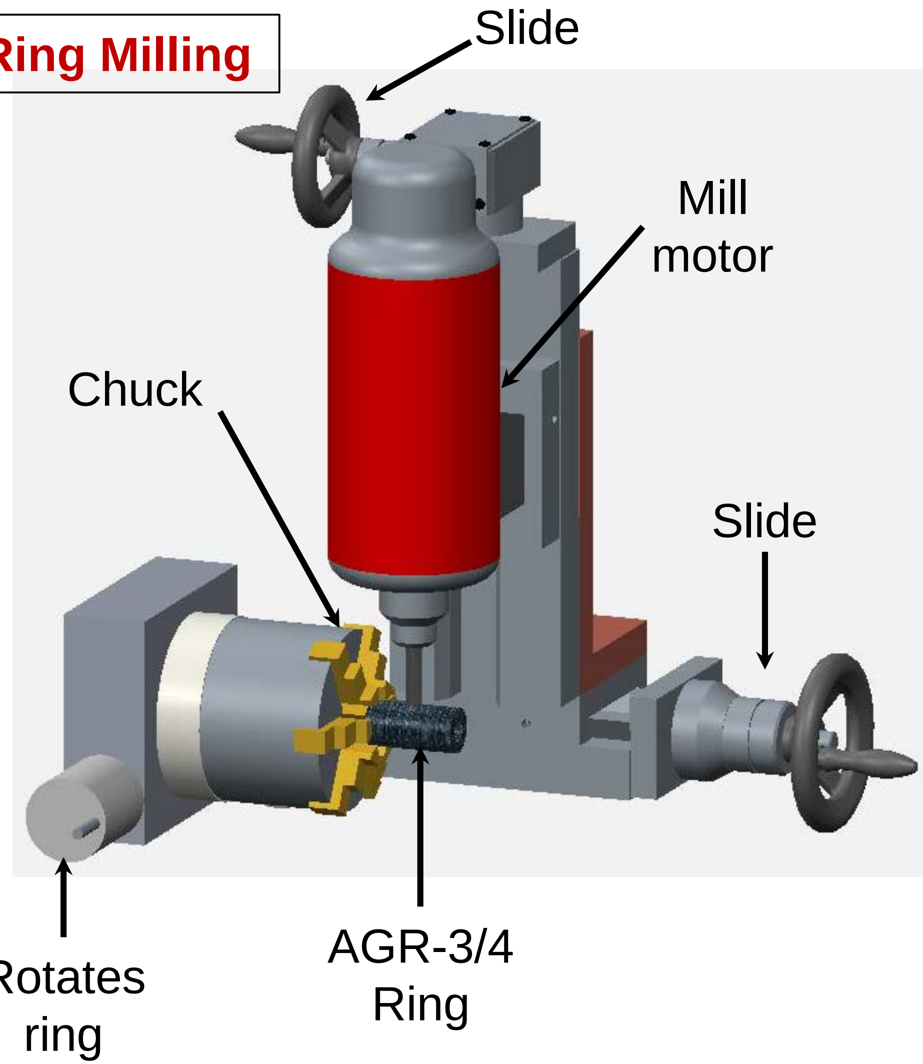
- Measure radial profile of fission products within select rings
- Use measured profile to calibrate tomographic gamma intensity maps from PGS into quantitative maps and compare with model predictions
- Physical sampling will progressively remove radial segments (width *w* and thickness *t*) from rings at one or two axial locations
- Collected material is gamma scanned and burn-leached for Sr-90 analysis



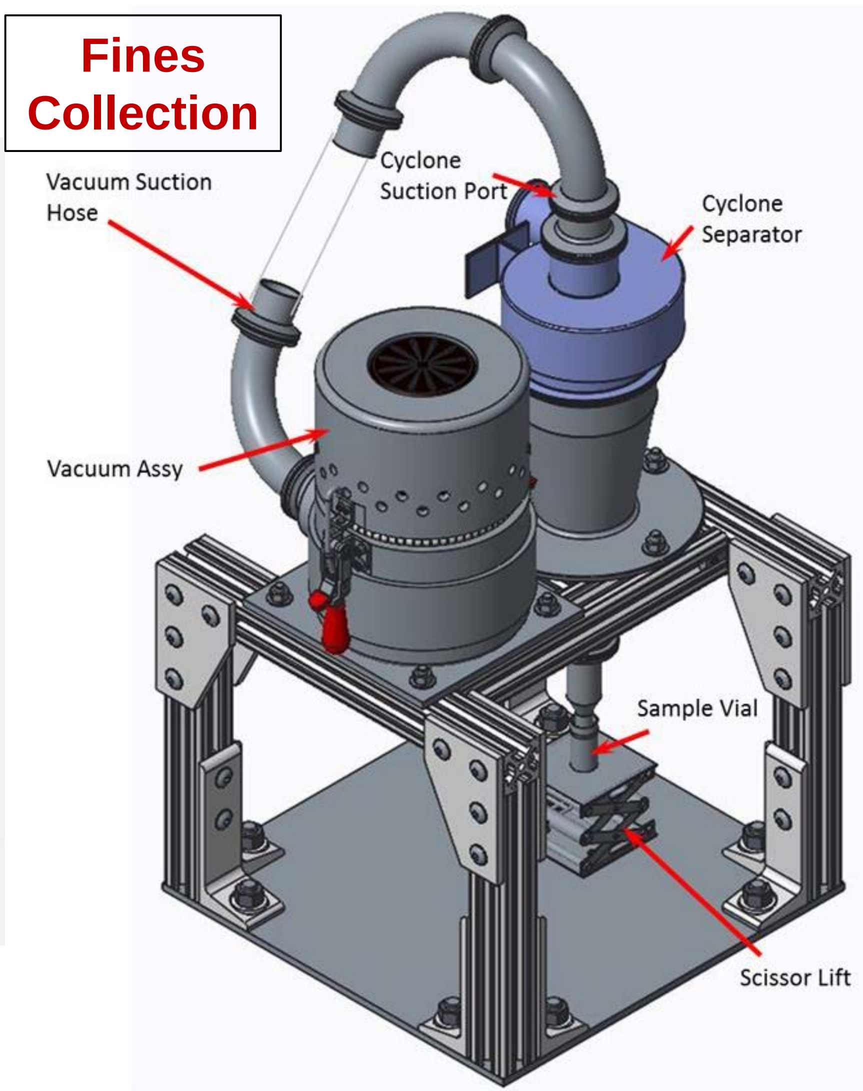


Physical Sampling Equipment Installed at HFEF Window 3M

Ring Milling

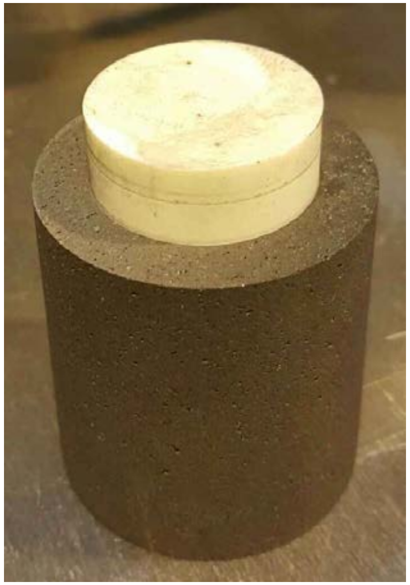


Fines Collection



Phase I, II, and III Qualification Activities were Completed

- Developed method to stabilize rings with epoxy for sampling
- Fabricated custom end-mill bit
  - True flat end
  - Side-cutting
  - Improves uniformity of removed ring material
- **Average collection efficiency of 99.5%** (varies between 99.1% and 99.8%
- Tested potential for cross-contamination between samples
- Phase III qualifications included:
  - Installation and checks in-cell at HFEF
  - Approved and released laboratory instruction HFEF-LI-0162



Development of Physical Sampling Equipment for AGR-3/4 Rings

Activity	Time Frame
Receive mill equipment enabling operations independent of existing cell mill	Completed June 2016
Phase 1 Qualification: assemble and check at North Holmes Laboratory	Completed March 2017
Collection efficiency testing	Completed April 2017
Cross-contamination testing	Completed 5/11/17
Phase 2 qualification at MFC Mockup	Completed 5/8/2017
Phase 3 qualification	**Completed 6/20/2017**
Begin ring sampling	**Started 6/21/2017 will continue until finished**
Completed sampling of 3 rings (IR/OR-03 and IR-07) *	**Completed 6/29/2017**

- Gamma counting of fines from ring milling at PNNL (select samples to be counted at INL)
- Burn leach and strontium analysis of ring samples to be done at PNNL

* Level 3 milestone to complete sampling of 4 rings for 6/30/2017 missed due to repeated electrical failures of in-cell equipment. 3 of 4 rings successfully sampled.

Schedule for Physical Sampling of AGR-3/4 Rings

Rings	Projected Sampling Date	PGS Tomography Complete?
IR/OR-3	June 2017 - **COMPLETED**	Yes
IR/OR-7	June 2017 **- IR-7 COMPLETED** Late July 2017 - OR-7	Yes
IR/OR-5	July/August 2017	Yes
IR/OR-8	August 2017	Yes
IR/OR-4	TBD	IR-04 in progress (OR-4 not suited to tomography)
IR/OR-10	TBD	OR-10 scheduled to start 8/11/17

Questions and Discussion

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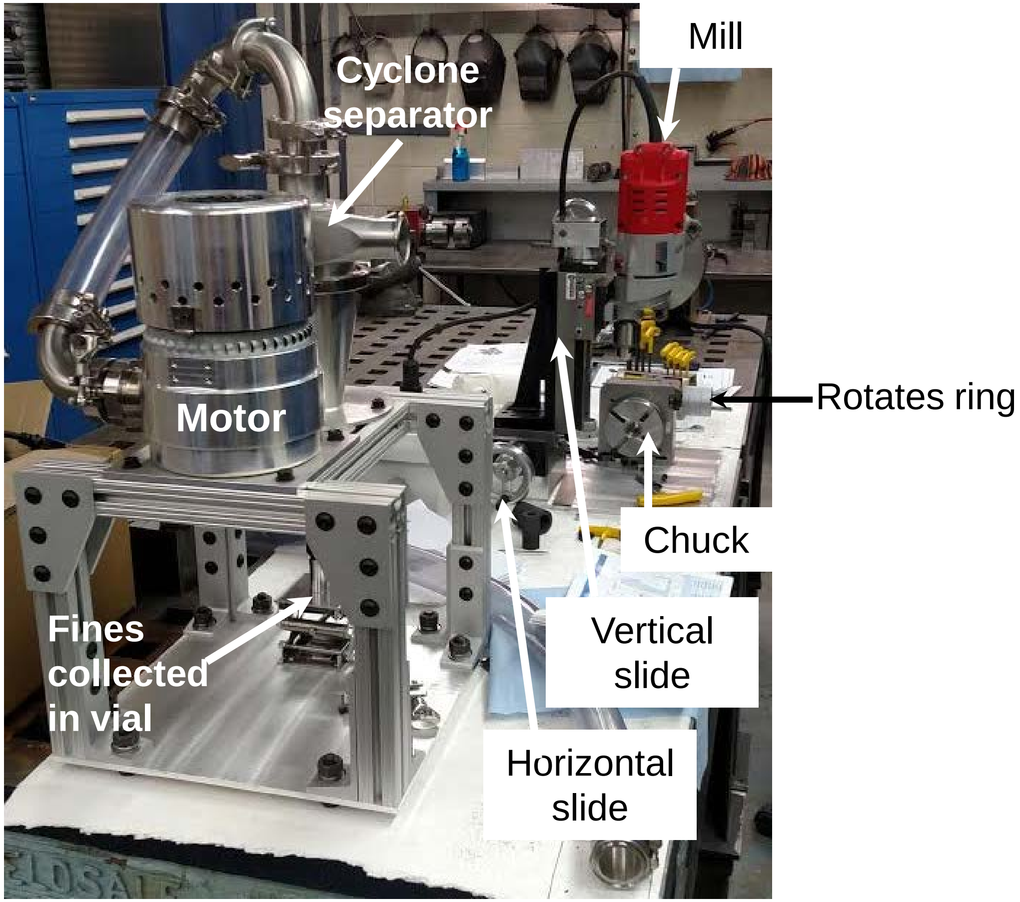
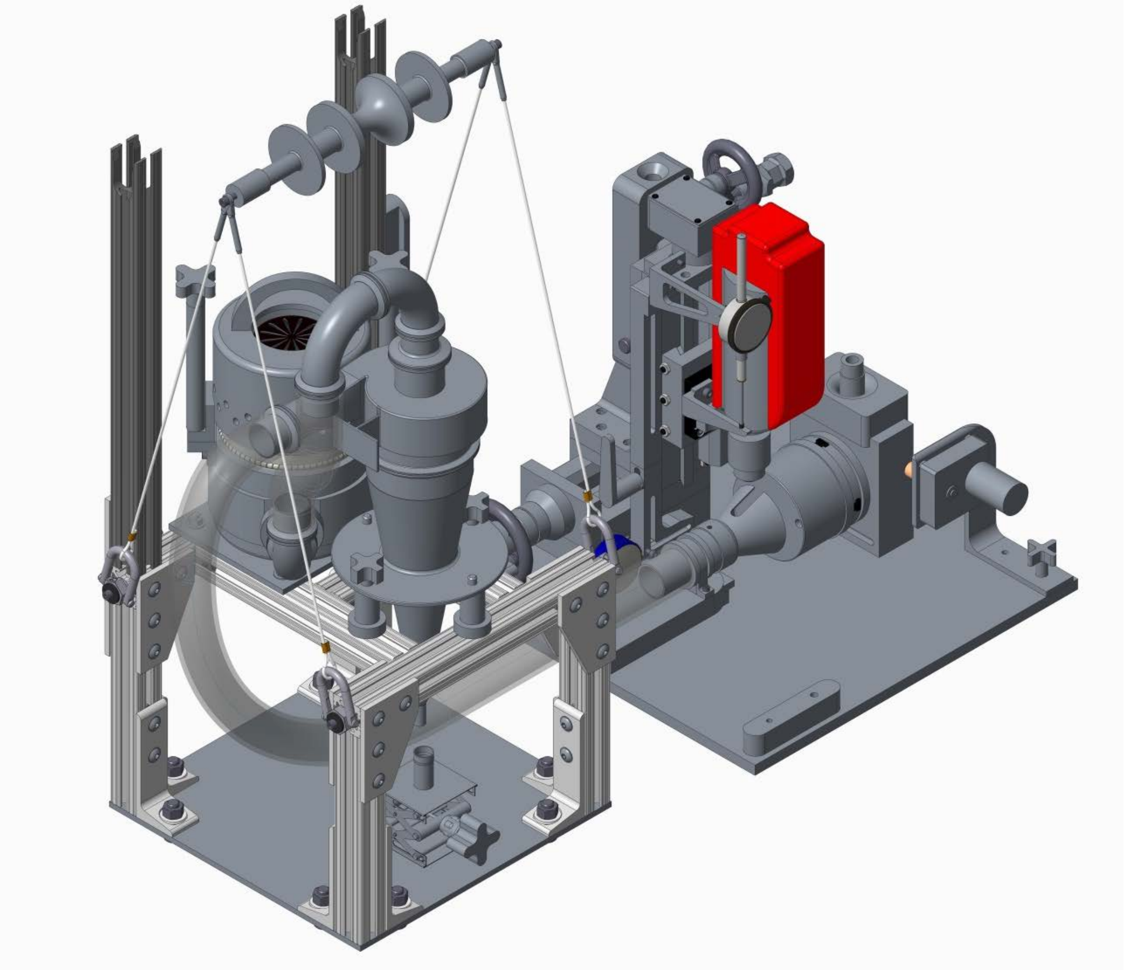
Physical Sampling Equipment

- Assembled at North Holmes lab at INL
- Some trial operations completed
- Fine-tuning of equipment operation in-progress prior to Phase 1



Physical Sampling Equipment



Epoxy for Filling Rings Prior to Sampling

- EpoHeat® not viscous enough and permeated through the entire PCEA ring
- Allows comparison of collected mass with volume indicated by mill equipment
- Permeation not a problem with IG-110

- Masterbond EP21LV works well
  - High viscosity and shorter working life, prevents pore filling/penetration
  - Does not infiltrate PCEA
  - Added white coloring to judge sampling depth during final cut