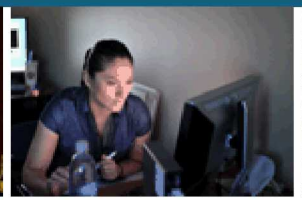
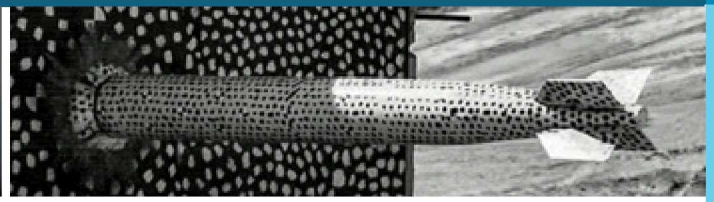
SAND2019-1310C

Experiments and Instrumentation at the Annular Core Research Reactor (ACRR)





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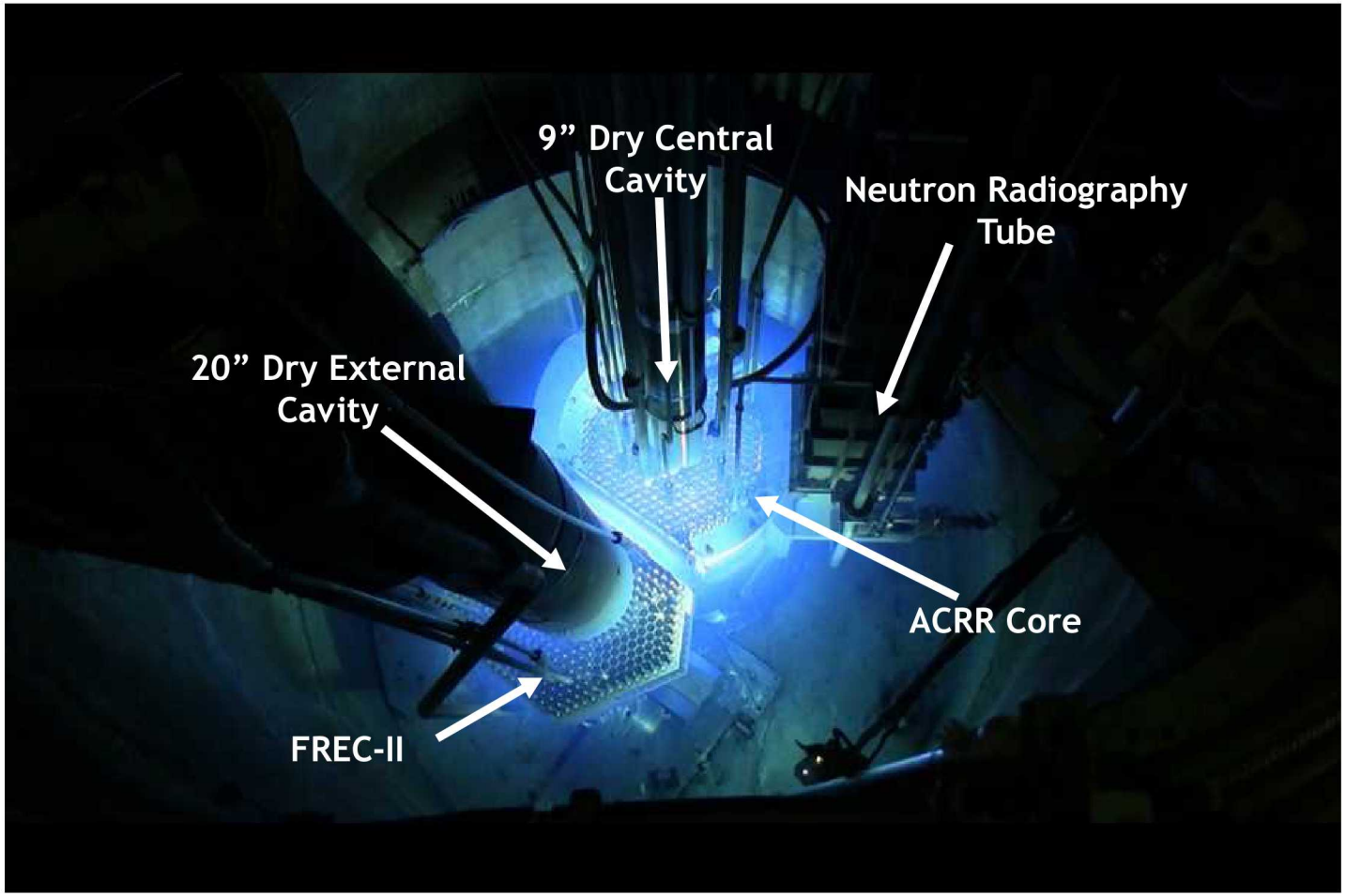
What is ACRR?



- 236 UO_2-BeO fueled elements
  - 1.5 in (3.8 cm) dia. x 20.5 in (52 cm)
  - 100 g U-235 per element – 35% enriched
- Operating Power Level
  - 2-4 MW_{th} Steady-State Mode
  - **300 MJ Pulse Mode (6 ms FWHM)**
- **Dry central cavity 9 in (23 cm) diameter**
  - Extends full length of pool through core
  - Neutron Flux 4E13 n/cm^2-s at 2 MW
  - Neutron Fluence 6E15 n/cm^2 at 300 MW
  - 90% > 1 eV, 58% > 10 keV, 46% > 100 keV
- **Epithermal/Fast Spectrum**
  - **Flux in cavity can be tailored for desired energy spectrum using buckets (LB44, CdPoly, PLG, LP)**
- Open-pool type reactor
  - Core cooled by natural convection
  - Pool cooled by HX and cooling tower
- FREC-II uses previous ACPR fuel
  - TRIGA type (UZrH)
  - Dry cavity 20 in (51cm) diameter
- Fuel burnup is minimal
- Tests can include and have included
  - Active electronics, active and passive explosives, fissile and fissionable material in large quantities, fuel melt studies, high-voltage and -power, flowing sodium/hydrogen, previously irradiated materials

Diagnostic Suite for Experiments

Passive dosimetry (provide integral values):

- Foils (cobalt, scandium, nickel, iron,...)
- Sulfur tablets
- CaF_2:Mn thermoluminescent dosimeter (TLDs)

Active dosimetry (provide time-dependent profiles):

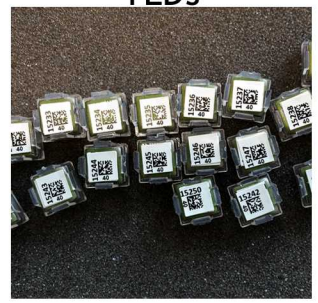
- Photoconductive detector (PCD)
- Self powered neutron detector (SPND, Cd-based)
- Calorimeter (Si, Bi, Sn, Zr,…)

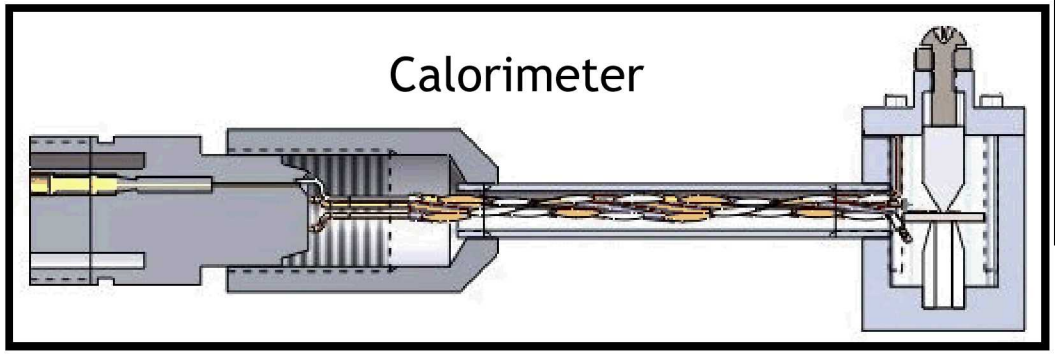
Foils

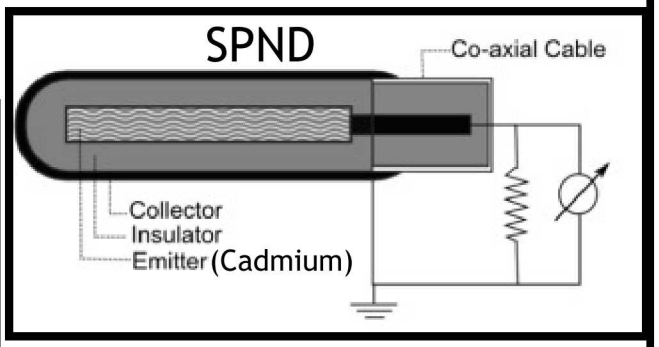
Typical Dosimetry Pack

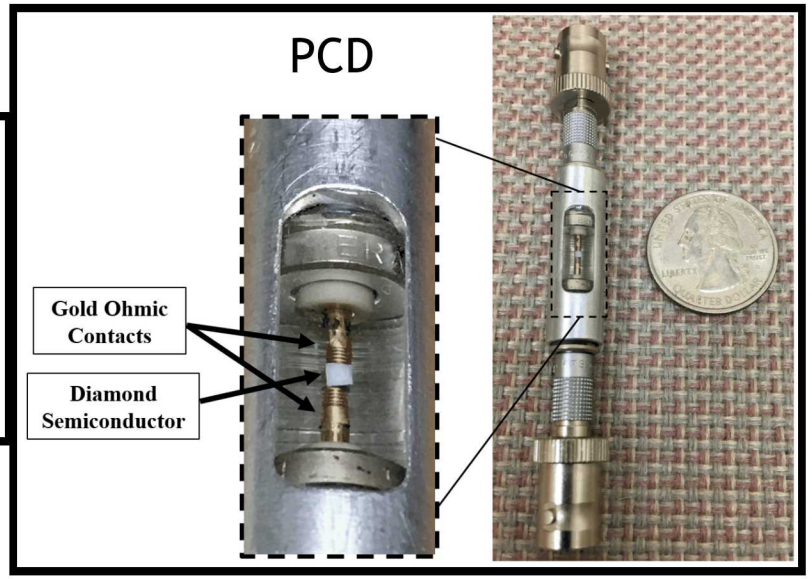
Sulfur Tablets

TLDs





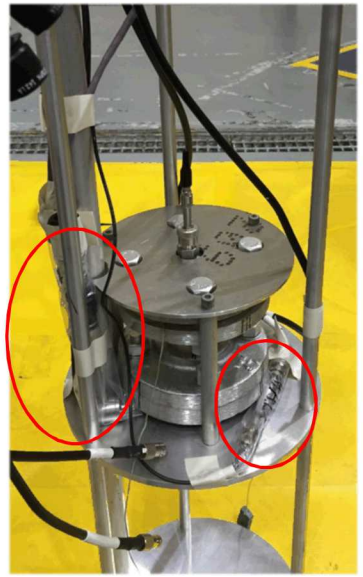


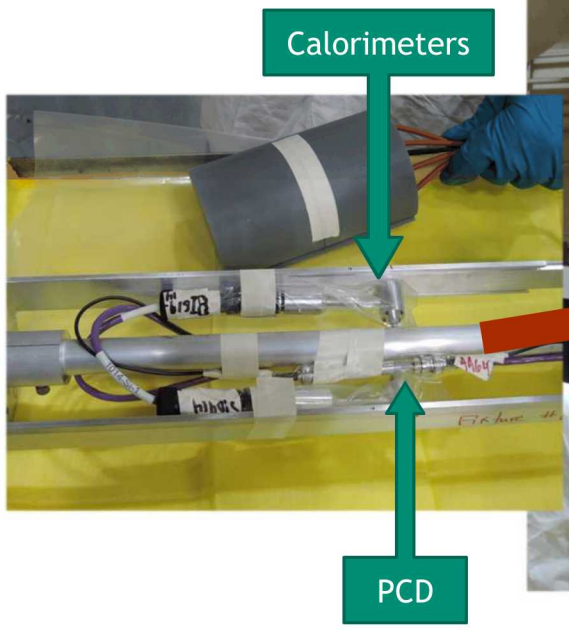


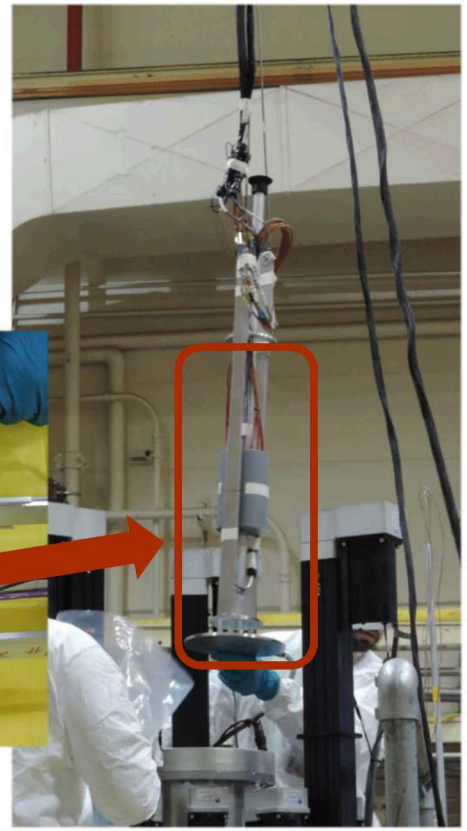
Experiment vs. Facility Diagnostics

Since we deliberately modify the radiation spectra and ratios of neutrons to gammas, experiments cannot rely on facility diagnostics

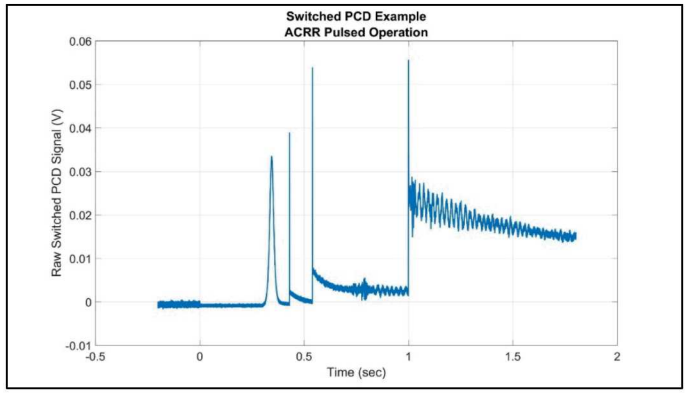
- Detectors in the fuel do not give us the true picture of what happens in the experiment
- Time profiles will be different
  - Prompt and delayed radiation ratios will change, so will detector response
- Experiments must include these diagnostics in their design



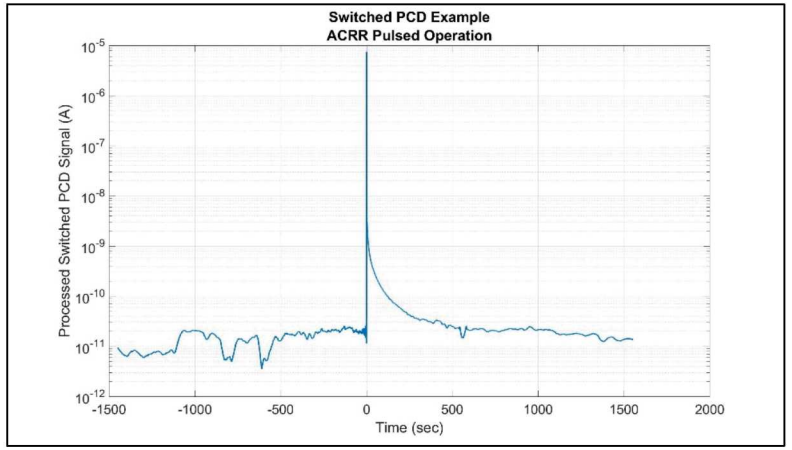




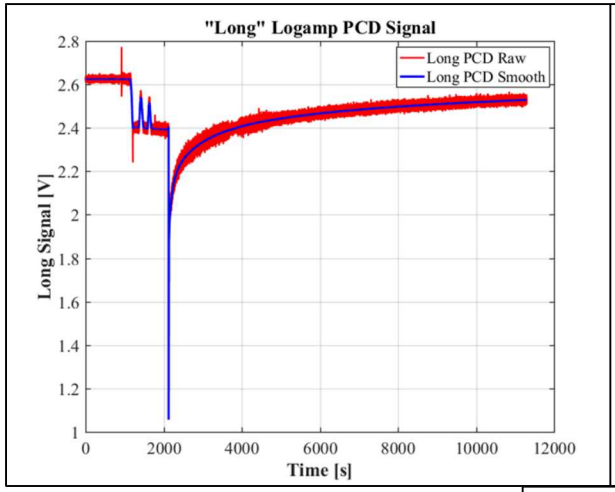
Detection Advances for PCD and Pulsed Reactor Time Profiles

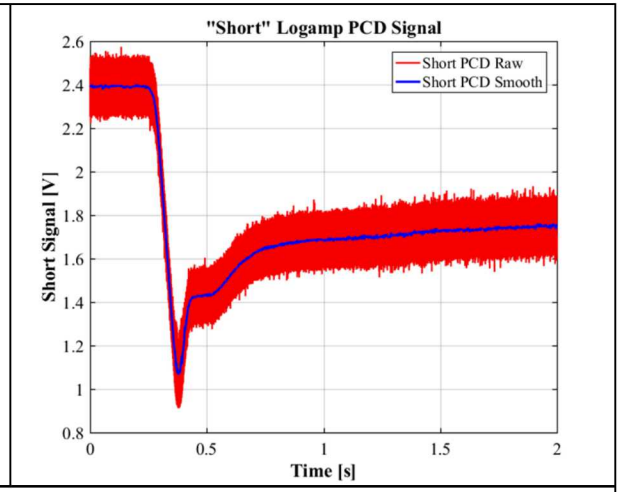


"Switched" PCD ~2008



"Log-Amp" PCD ~2015





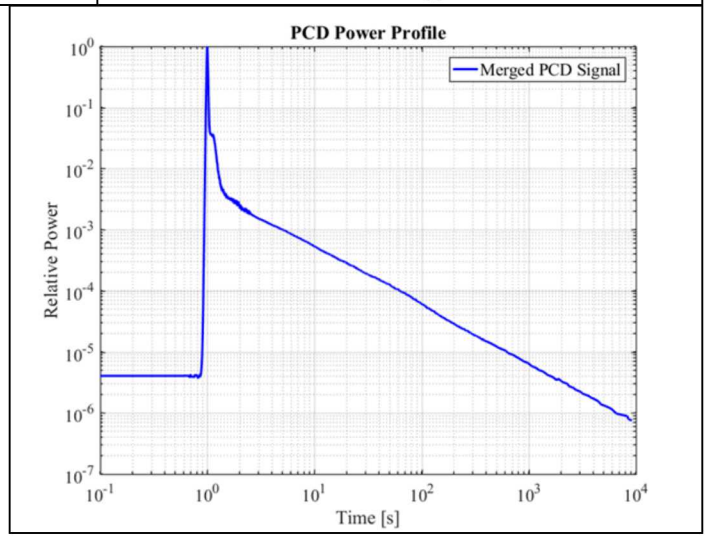
Compresses 7-8 orders of magnitude of current into a 0-5 V signal (picoamps to milliamps)

- Texas Instruments chip, suggested uses include compression of photodiode response to photons

No user-modifiable parameters or settings

Detects levels from dark current in PCD when out of reactor to max pulse response at ACRR

Each Log-Amp box/circuit is serialized and characterized on our semiconductor parameter analyzers



How this All Comes Together

The radiation field in ACRR has been characterized for free-field and for most of the spectrum modifying buckets

Using the characterization report the passive dosimetry results received from Sandia's Radiation Metrology Lab (RML), data can be easily converted to units of interest

With modeling or experiments, we can calculate transfer functions from free-field to test device internals

Ni Foil Result from the RML	Conversion Factor from the CdPoly Characterization Report	Calculated Neutron Fluence	Conversion Factors from the CdPoly Characterization Report	Calculated Values
3.546280E+4 $[Bq/g_{Ni-58}]$ →	2.939E+10 $(n/cm^2)/(Bq/g_{Ni-58})$ →	→ 1.042E+15 $[n/cm^2]$ →	3.245E-11 → $(Rad(Si) \text{ from neutrons})/(n/cm^2)$	3.38E4 Rad(Si) from neutrons
			1.800 → $(prompt\text{-}\gamma/cm^2)/(n/cm^2)$	1.88E15 $prompt\text{-}\gamma/cm^2$