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New NSUF Supported Capability Development – Fuel Motion Monitoring System (Hodoscope)

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Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy

Idaho National Laboratory

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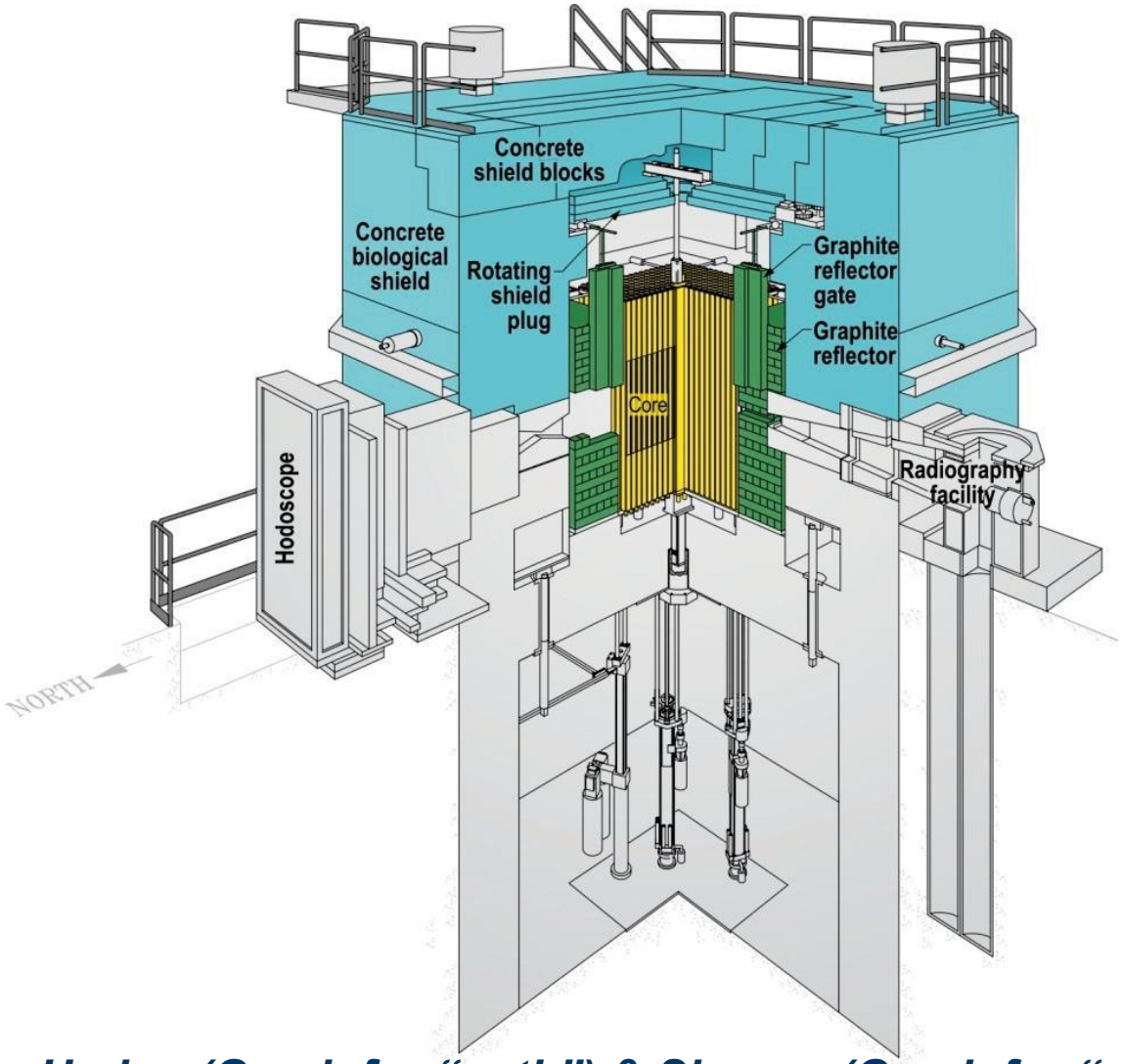
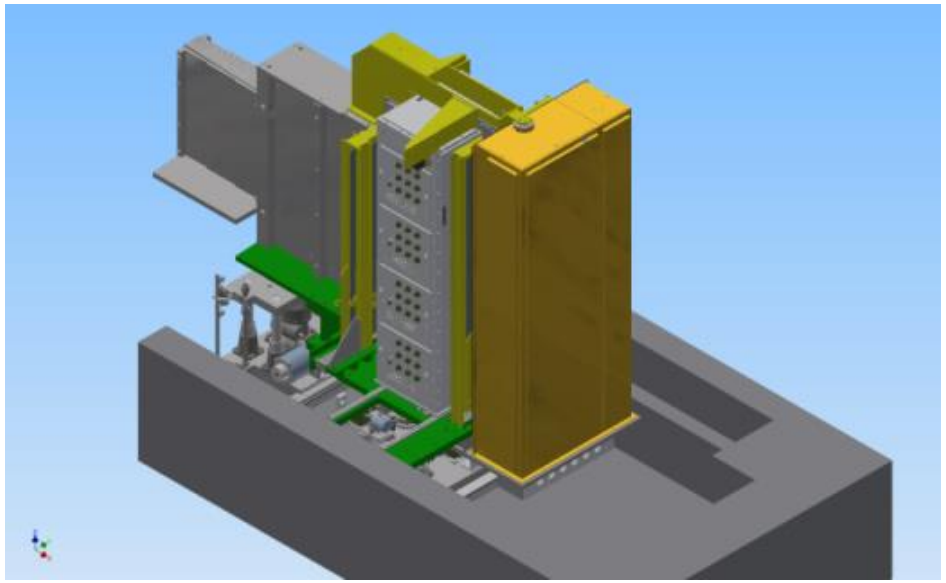
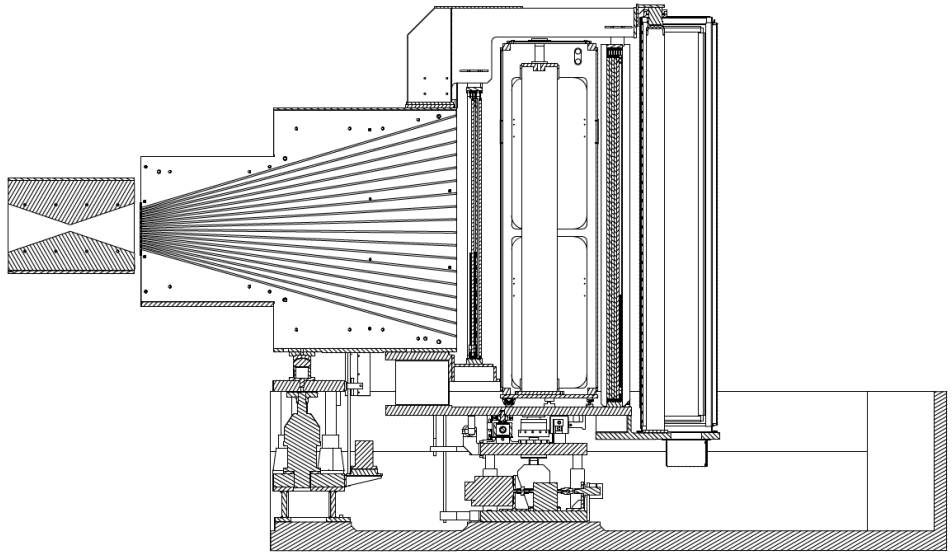
TREAT Fast-Neutron Hodoscope



Perspective 3-D view of the FMMS, from the northeast

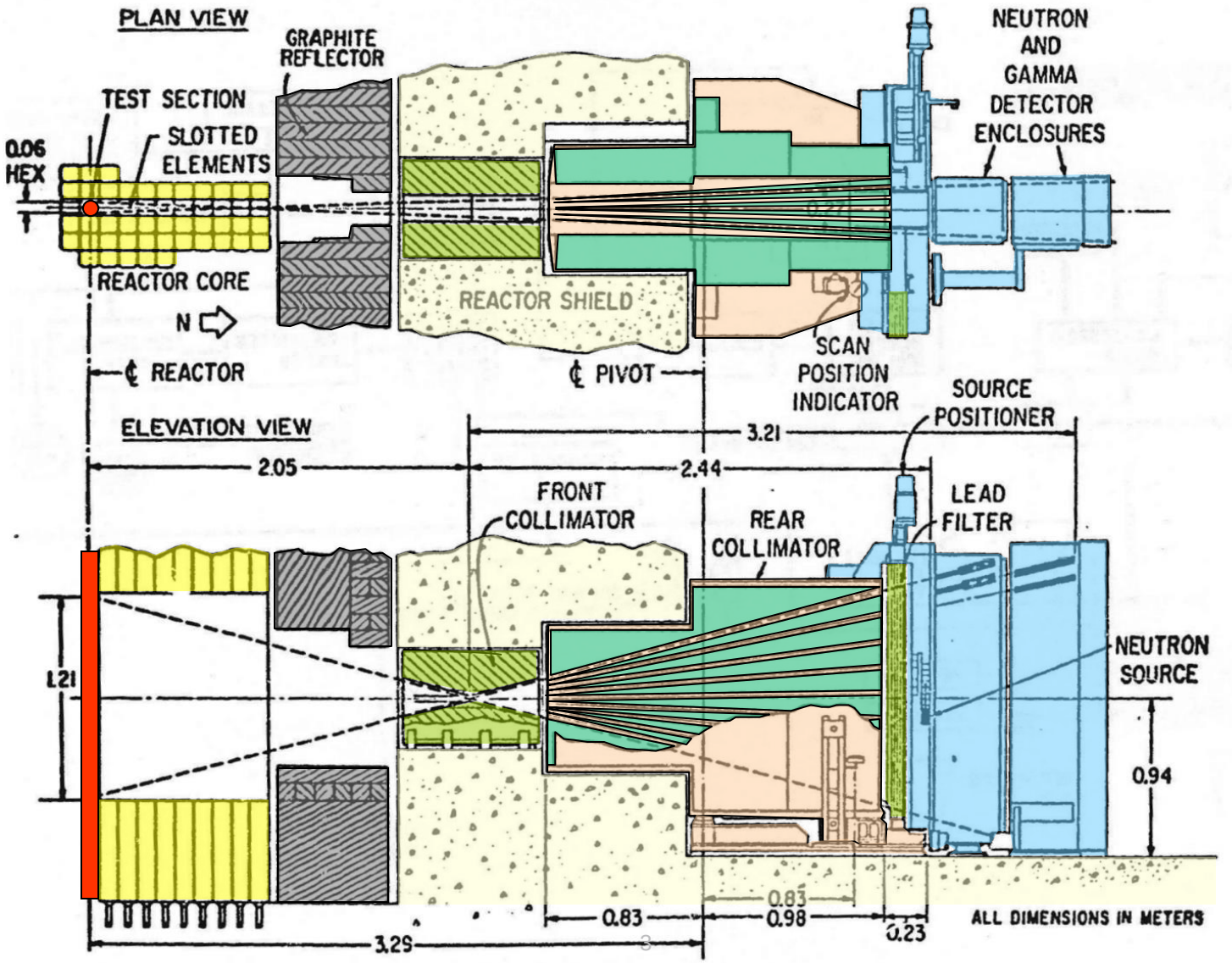


2-D cross-section line drawing of the FMMS

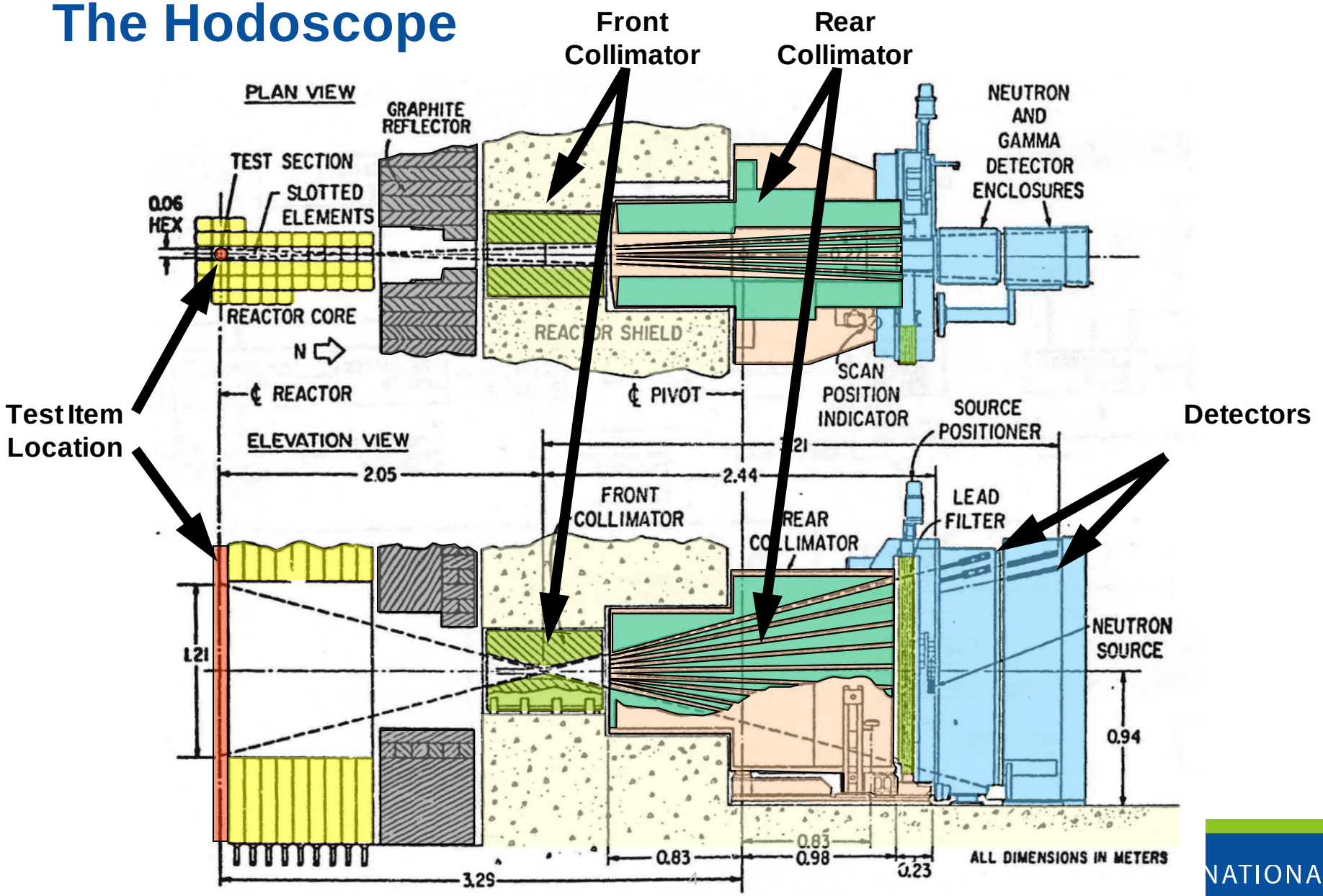


Hodos (Greek for "path") & Skopus (Greek for "observer")

The Hodoscope



The Hodoscope



Photographs of the Hodoscope

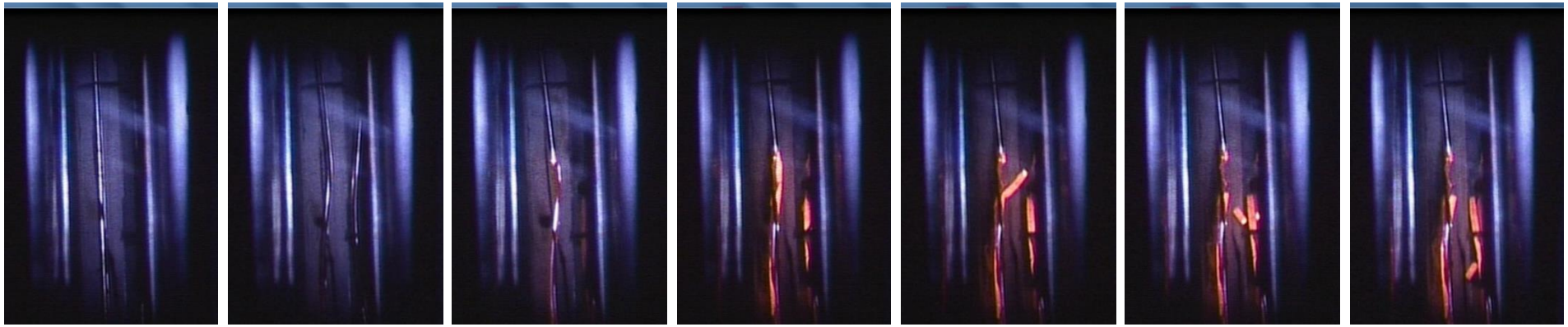
View of the Hodoscope system including cabinets

View of the Hodoscope system from the rear with the detector panel open

A Unique Tool

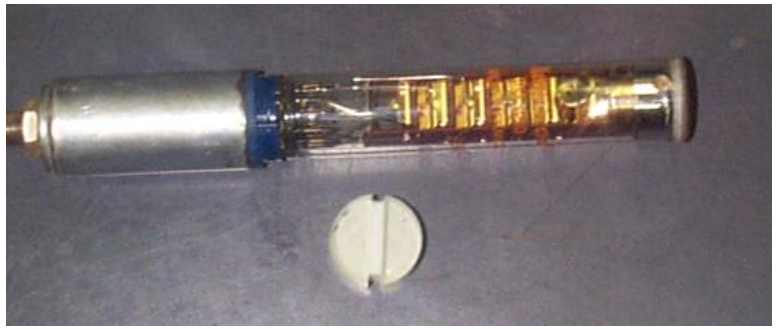
- Fuel motion monitoring is a critical diagnostic tool used in support of advanced fuel research and development
- The FMMS provides a highly-sensitive measure of when and where initial fuel system failures occur during transient nuclear events
- The expansion of the FMMS is needed to support upcoming experiments focused on longer fuel pins, complex geometries and multi-pin assemblies, and flowing-coolant test loops

TREAT Transient #1022



TIME

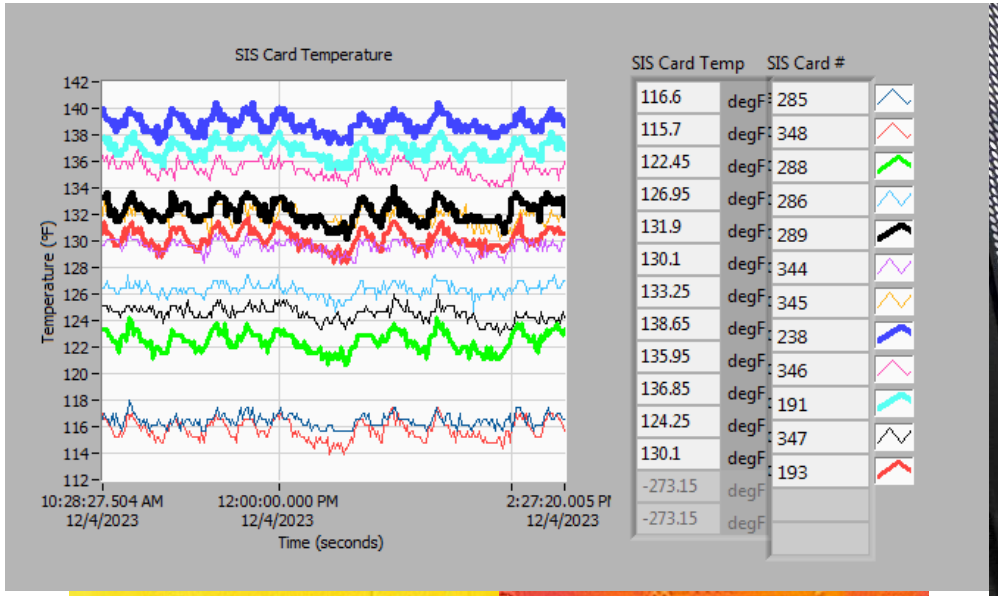
Hodoscope Detectors & Expansion

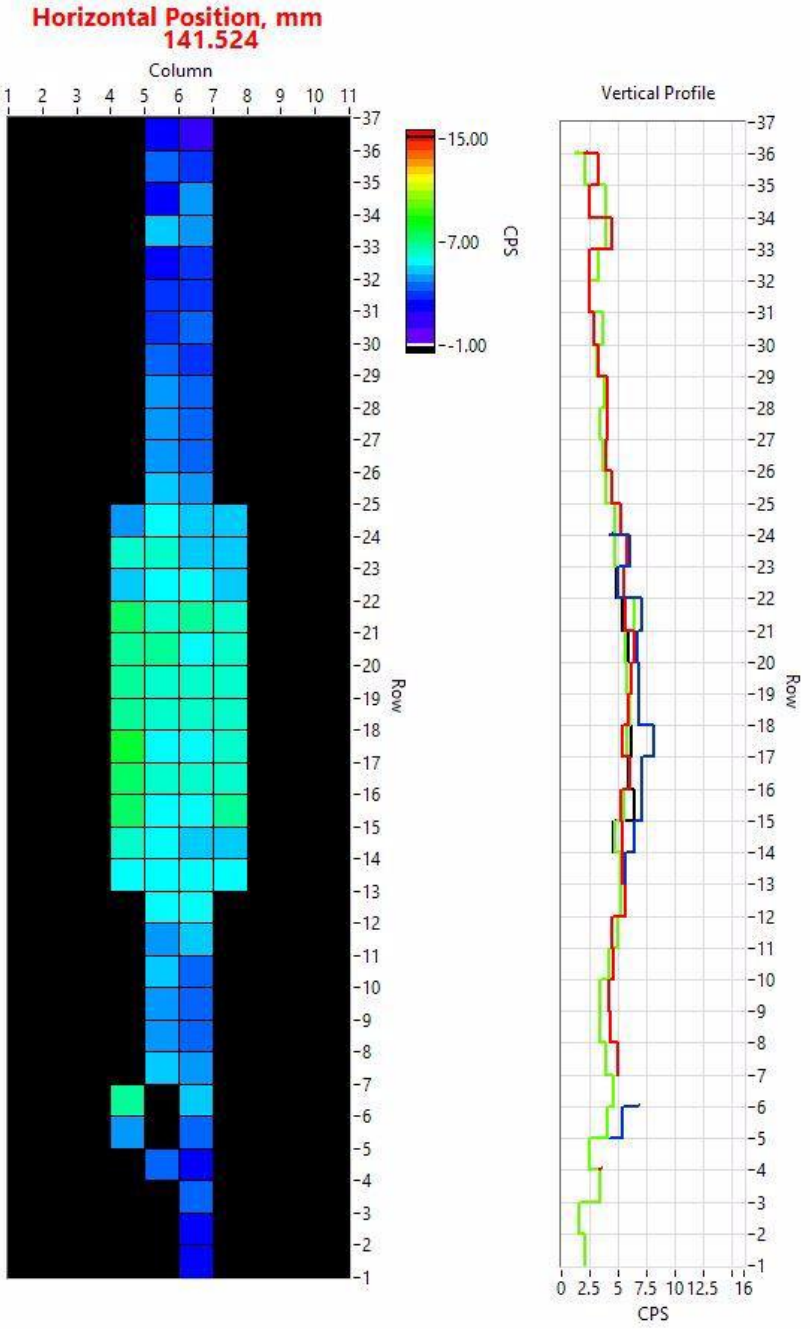


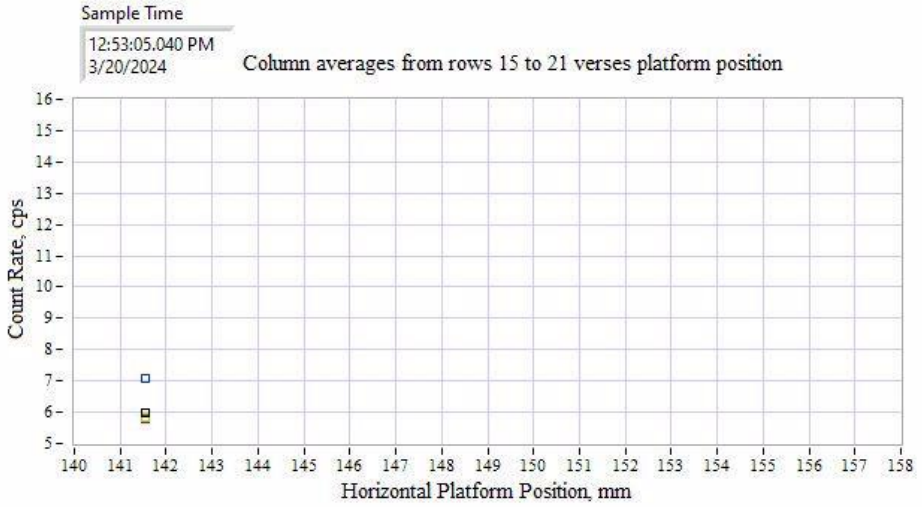
Proton Recoil Scintillator Detector

- There are 360 detector slots in the hodoscope collimator
- The Hodoscope currently uses 96 detectors, the expansion will double this number
- Detectors are proton recoil scintillators – ZnS/epoxy matrix sandwiched between Lucite hemi-cylinders
- The expansion requires a comprehensive remanufacturing process:
  - cleaning and removal of old reflective paint
  - visible screening to detect cracks and voids
  - screening to assess light output and transmission
  - repolishing of the scintillation-light transmission surface

Progress Update







Column #7
Column #6
Column #5
Column #4

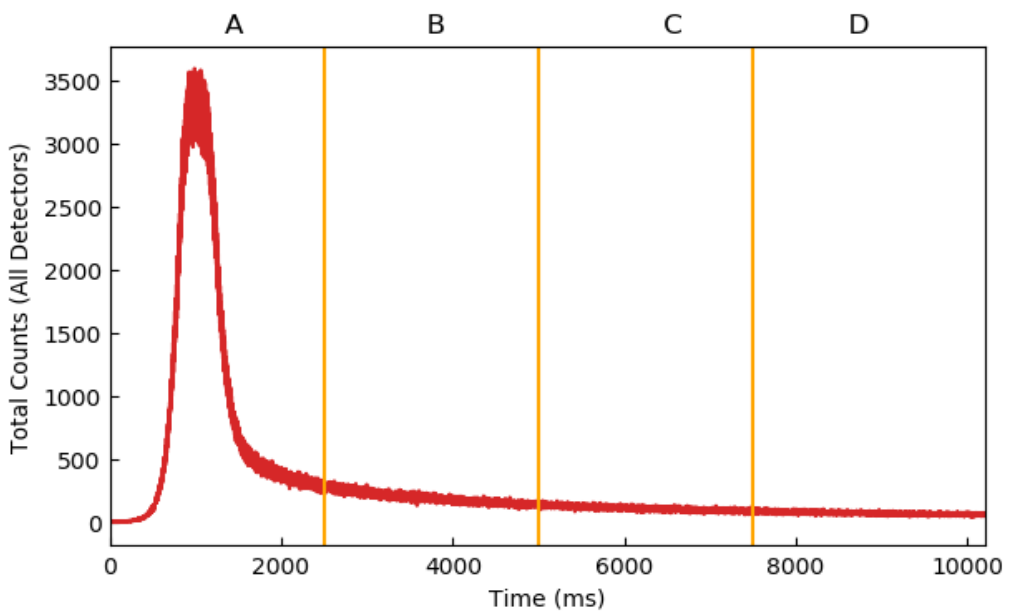
	Centroid, mm	Center Count Rate, cps	FWHM	Centroid Deltas
Column #7	145.108	14.244	4.907	2.853
Column #6	147.960	13.969	4.916	2.760
Column #5	150.720	13.844	4.856	2.877
Column #4	153.597	14.822	4.877	-8.490

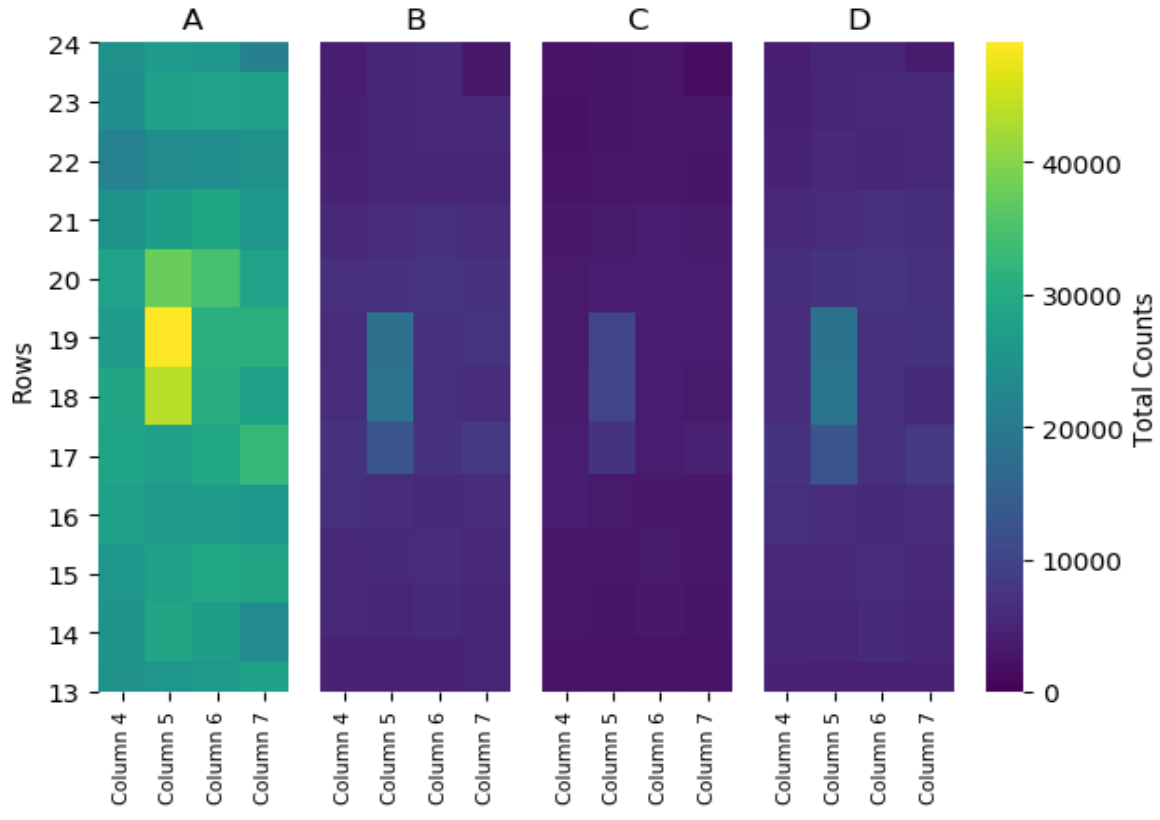
This video is a playback of a hodoscope horizontal platform sweep of the LOC-C-1-B experiment exposed to reactor operation at 80 kW. This was done to align the fuel in a single column and to check the single detector performance under the same neutron flux conditions. It also clearly shows the horizontal pixel overlap.

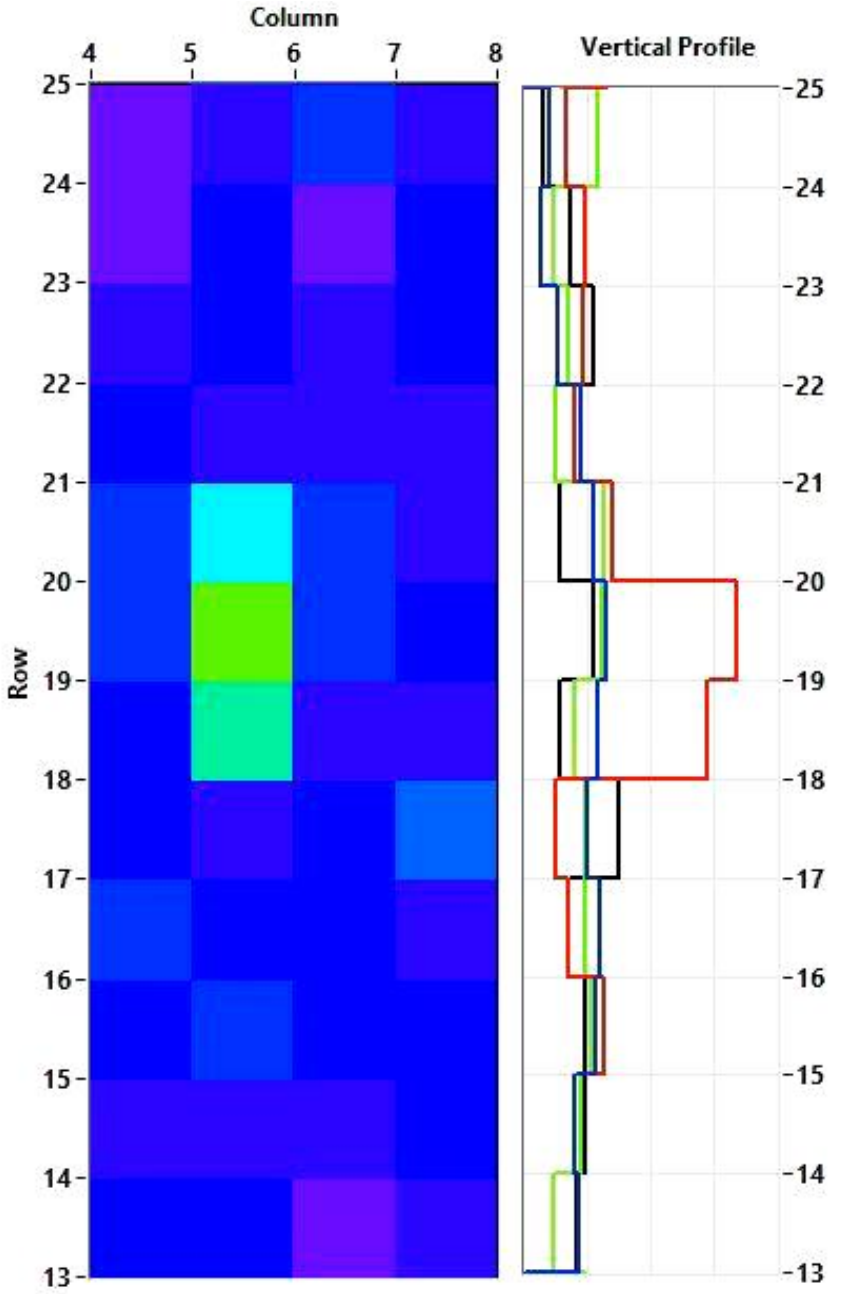
The video starts with the fuel out of view. The platform was moved horizontally about 0.2 mm per measurement from right to left and shows the detectors' response as the fuel migrates through the hodoscopes active viewing area until out of view. The last measurement is the final placement of the horizontal position with the fuel centered in column 6. About 61 measurements were taken and each measurement duration was at least 100 seconds or greater.

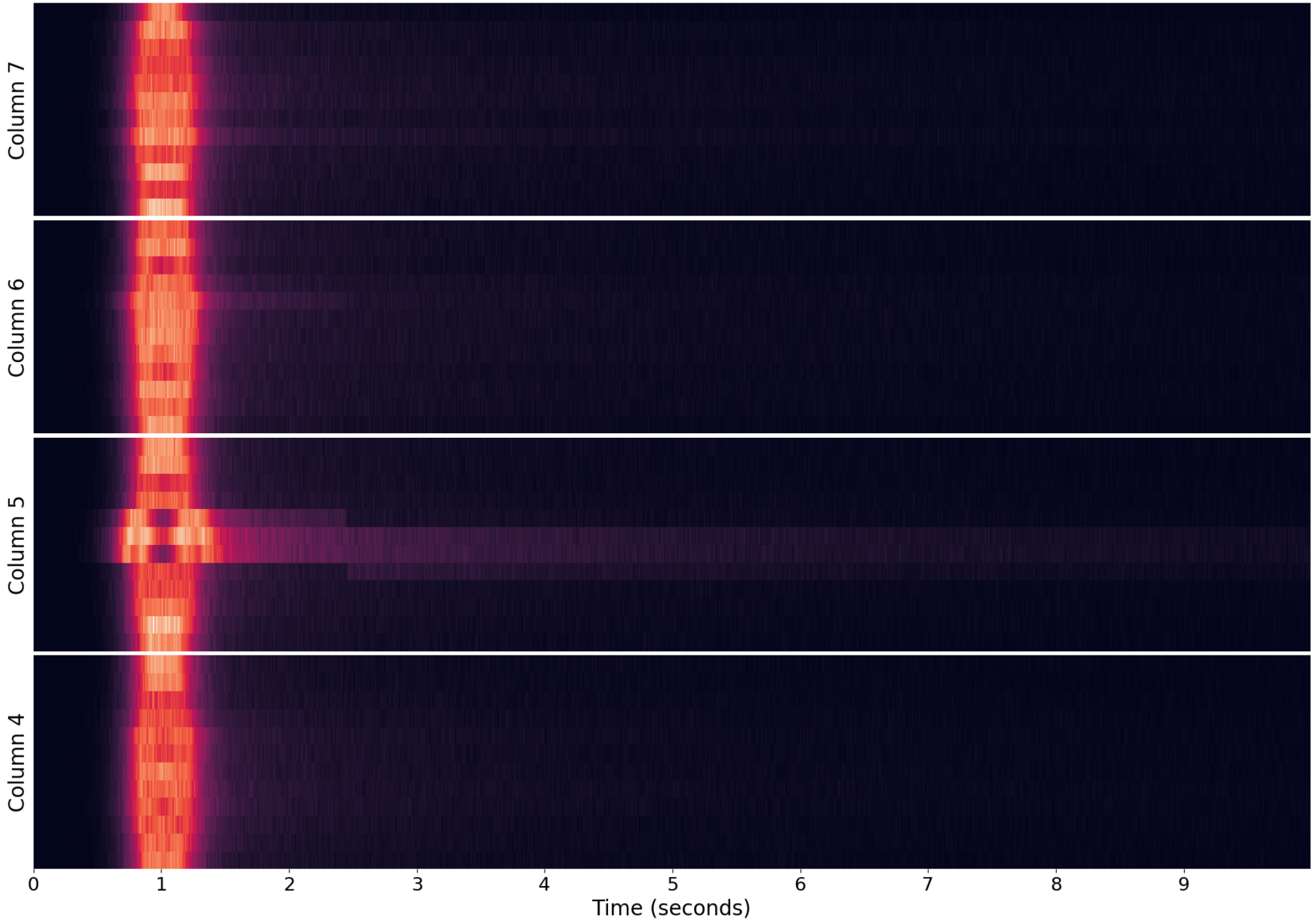
Measurements were recorded on March 3rd, 2024 by J. Hix, J. Johnson, & S. Thompson.

The Future

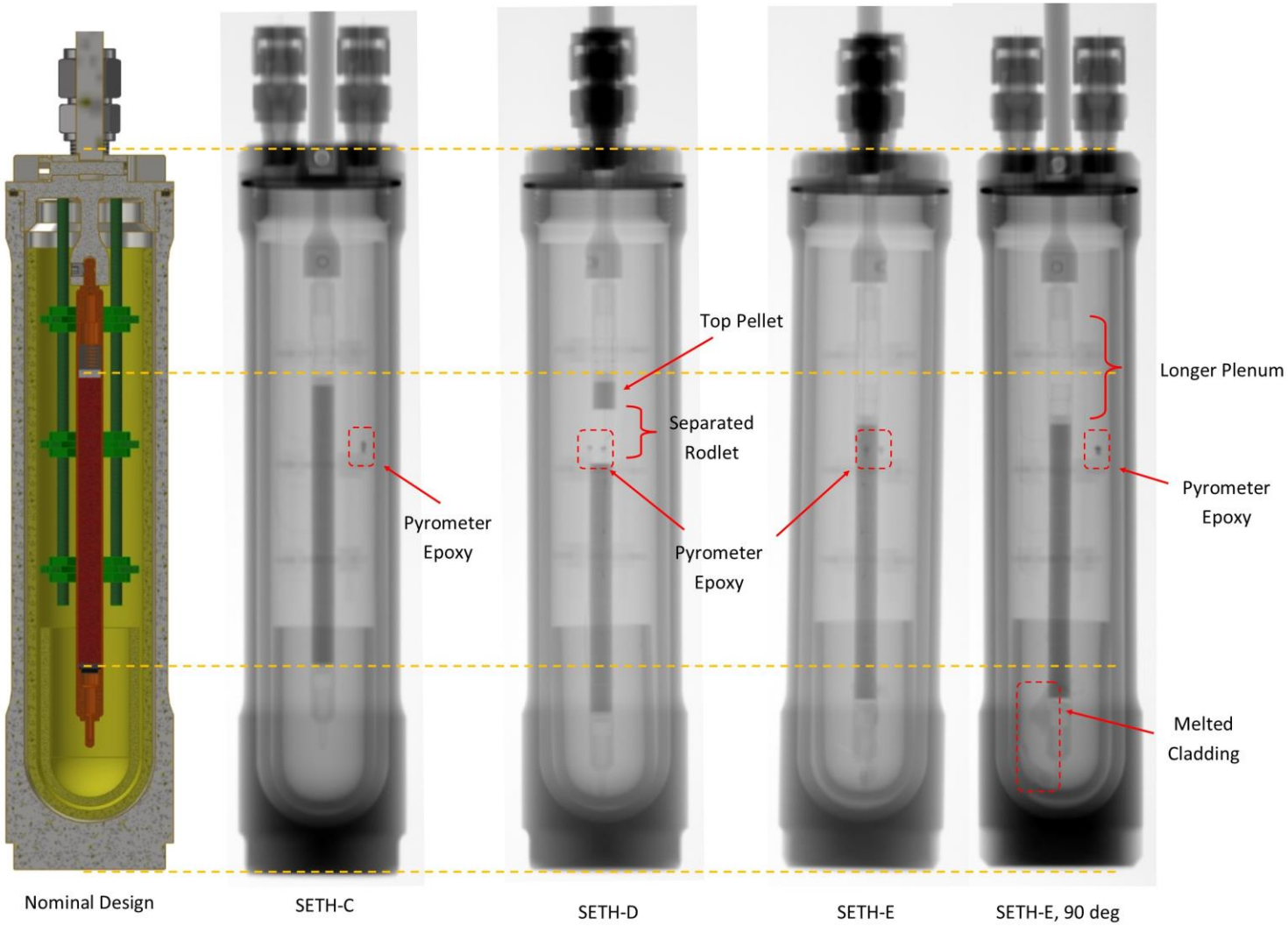

A
B
C
D
Total Counts (All Detectors)
Time (ms)


A
B
C
D
Rows
Column 4
Column 5
Column 6
Column 7
Total Counts


Column
4
5
6
7
8
Vertical Profile
Row
25
24
23
22
21
20
19
18
17
16
15
14
13
-25
-24
-23
-22
-21
-20
-19
-18
-17
-16
-15
-14
-13


Column 7
Column 6
Column 5
Column 4
0
1
2
3
4
5
6
7
8
9
Time (seconds)

SETH-E Neutron Radiography



Jason Schulthess et al. "Non-Destructive post-irradiation examination results of the first modern fueled experiments in TREAT," Journal of Nuclear Materials, Volume 541, 2020, https://doi.org/10.1016/j.jnucmat.2020.152442

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