SEPTEMBER 2017

NAA IN-CORE NEUTRON MONITORING SYSTEM

INSTALLING A PHOTONIS CFUF43 INCORE FISSION CHAMBER TO CHARACTERIZE UT TRIGA REACTOR STEADY STATE NEUTRON FLUX VARIATIONS FOR NAA APPLICATIONS

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Agenda

- Background
- Proposed Solution
- System Design
- Testing
- Results
- References and Special Thanks

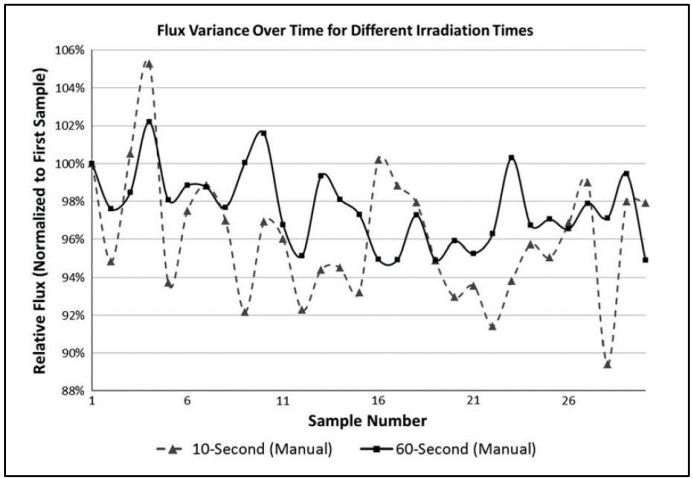
Background – UT NAA LAB

- Neutron Activation Analysis (NAA)
- Sensitive method for elemental trace concentration
- Variety of sample types

Detection Limits for NAA	
Detection Limit (µg)	**Elements**
<0.01	Al, Sb, Ar, As, Br, Cs, Co, Cu, Dy, Er, Eu, Ga, Ge, Au, Ho, In, I, Ir, Kr, La, Lu, Mn, Pd, Pr, Re, Rh, Sm, Ag, Na, Sr, Ti, W, U, V, Yb, Y
0.01-0.1	Ba, Cd, Cl, Gd, Hf, Hg, Mo, Ni, Os, Pt, K, Ru, Sc, Si, Ta, Te, Tb, Th, Tm, Xe
>0.1	Bi, Ca, Ce, Cr, F, Fe, Mg, Nd, Ne, Nb, Rb, Ru, Se, Tl, Zn, Zr

Background –Flux Variance

- Steady-State Power Neutron Population Variance
- Comparison Method
  - Certified Standards
  - Longer Processing Times
- Goal
  - Accurate, Real-Time Neutron monitoring for NAA



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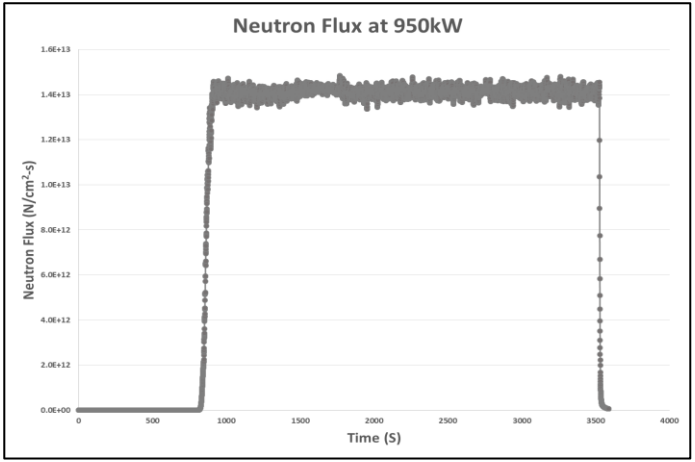
Background Reactor Fluctuation

- Characterization of steady-state reactor neutron flux variance.
- Average flux over irradiation time does not accurately reflect the variance for short irradiation times.
- Neutron Fluence needed.



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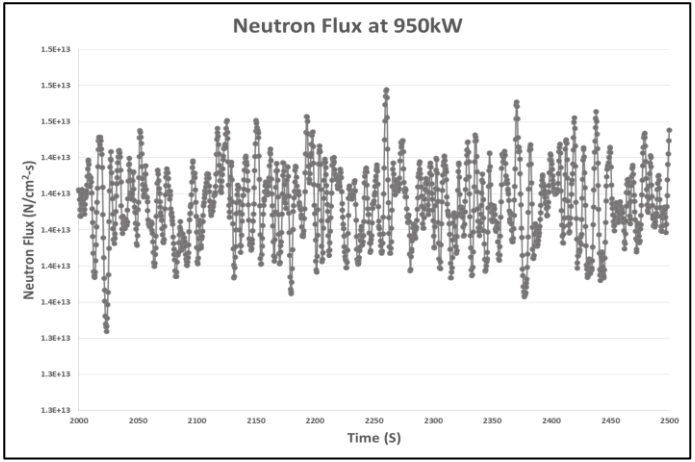

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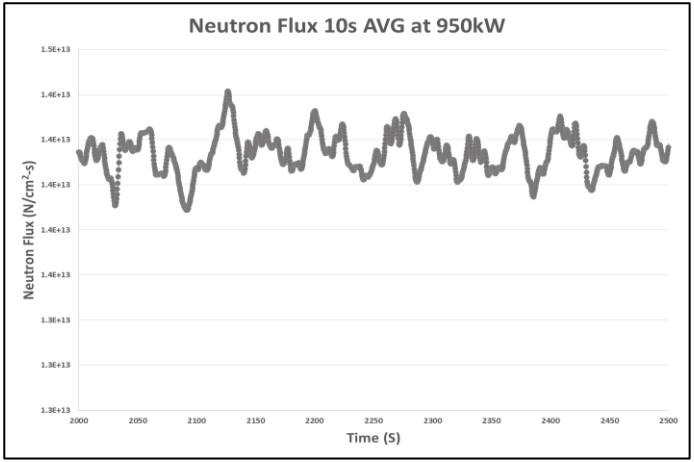

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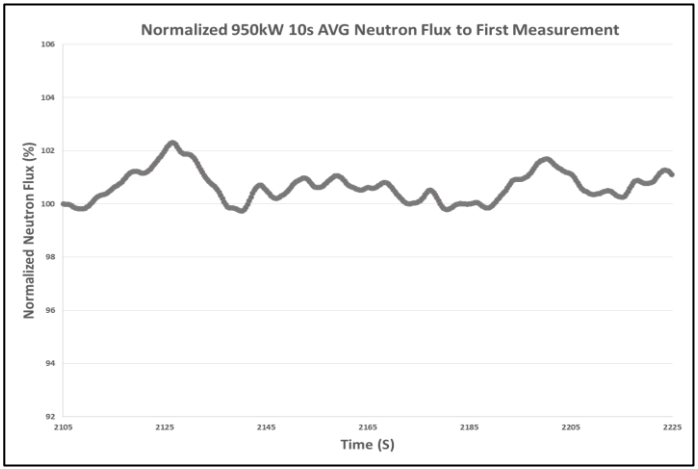

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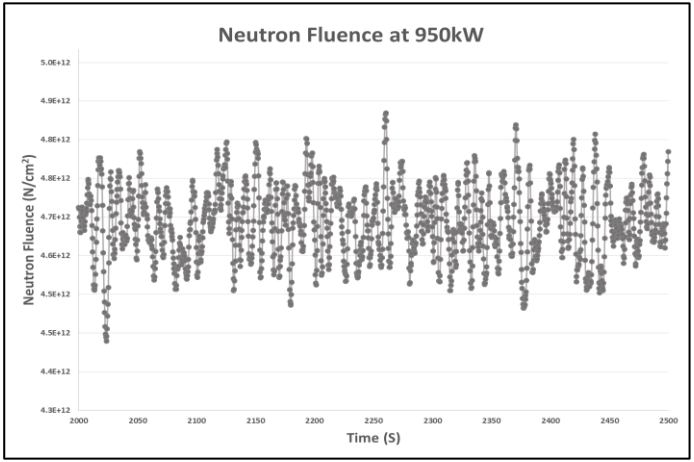

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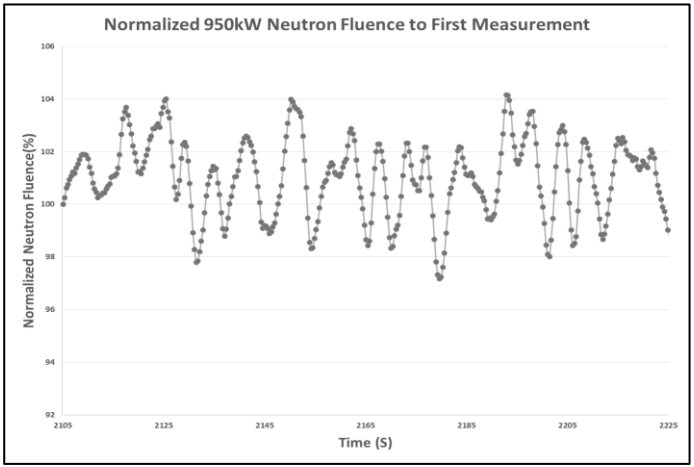

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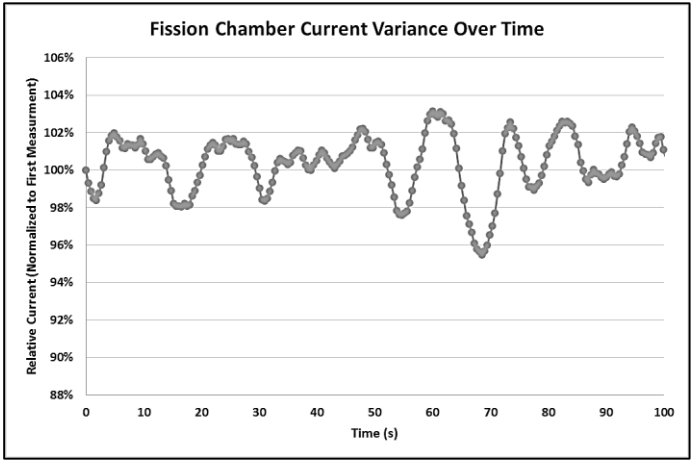
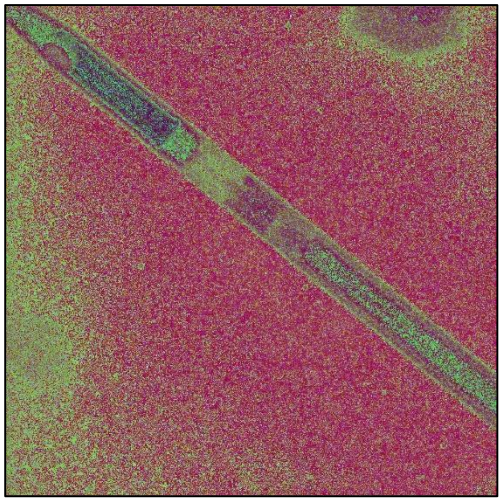


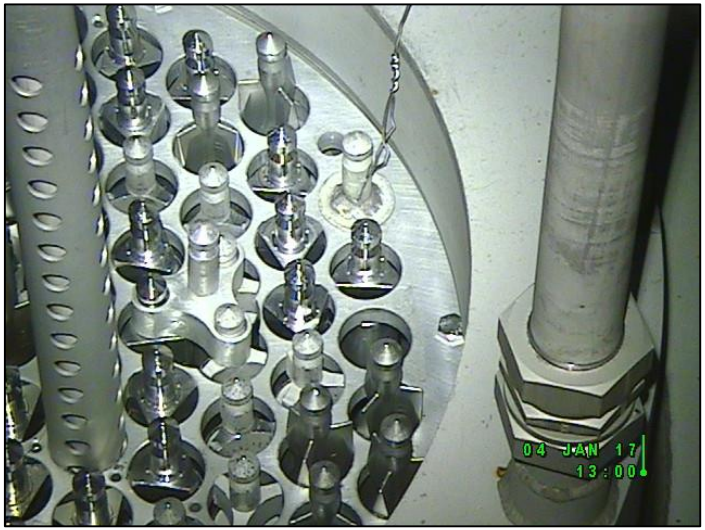
Proposed Solution

- Photonis CFUF43 Fission Chamber
  - Argon filled Ion Chamber with >90% ^{235}U enriched sensitive layer ~349µg.
  - Sealed Hardened SS Case
    - Diameter: 4.7mm
    - Length: 86mm (30m Cable)
  - Range: 10^{10}-10^{14} $\frac{n}{cm^2 s}$
  - 350°C Maximum Temperature
  - Current Mode Operation



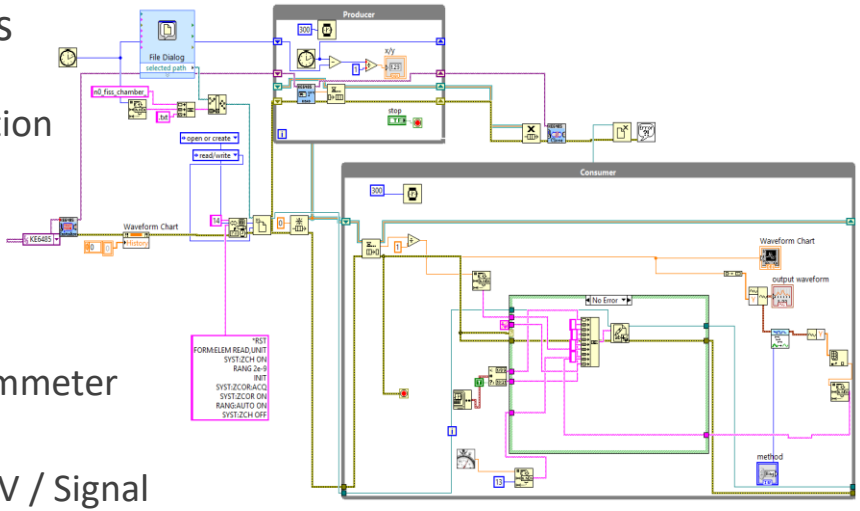
Proposed Solution

- Existing 5/8’’ hole in the reactor Top Grid Plate.
  - Allows for close monitoring of neutron population surrounding pneumatically inserted NAA samples
- Intended access point for foil and wire neutron flux monitoring.



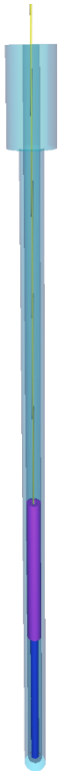
System Design

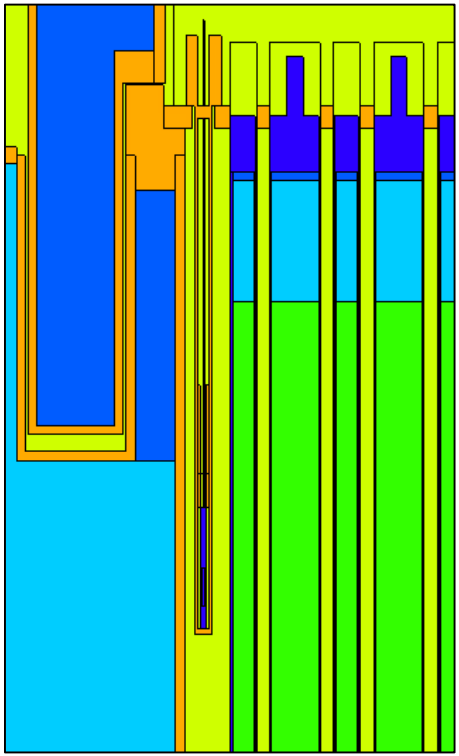
- National Instruments LabVIEW
  - Instrument Initialization
  - Data Logging
  - PC/Tablet Readout
- NI GPIB
- Keithley 6487
  - Power Supply/Picoammeter
- Junction Box
  - Single BNC Coaxial HV / Signal



System Design

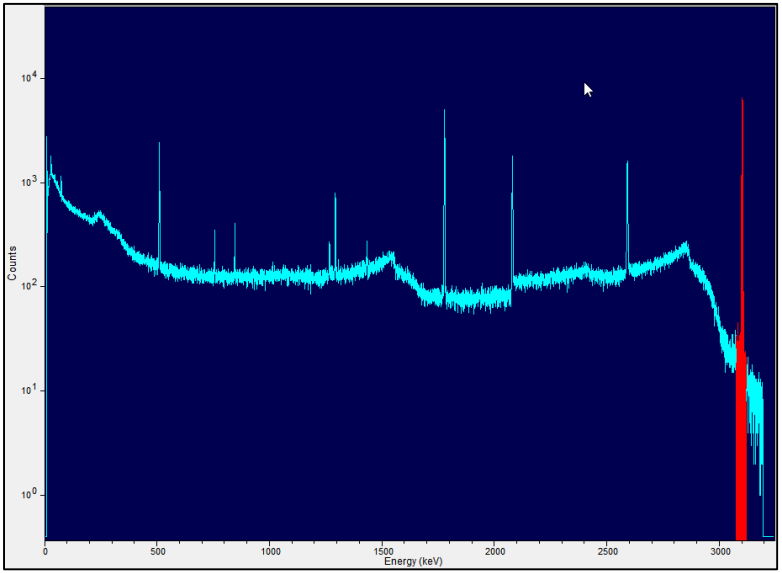
- Holder
  - Mobile
  - 6061 T6 Aluminum
  - Length: 16 Inches
    - 14.09 inches in core
    - 13.94 Inches to Fission Chamber Base
  - Diameter: 0.5 Inch
    - 0.14 inch wall thickness
- Sensitive Volume 1.06 inch
  - Self Alignment Spring
  - 12.27-13.33 Inches in core
  - Pneumatic sample center @ 12.8''



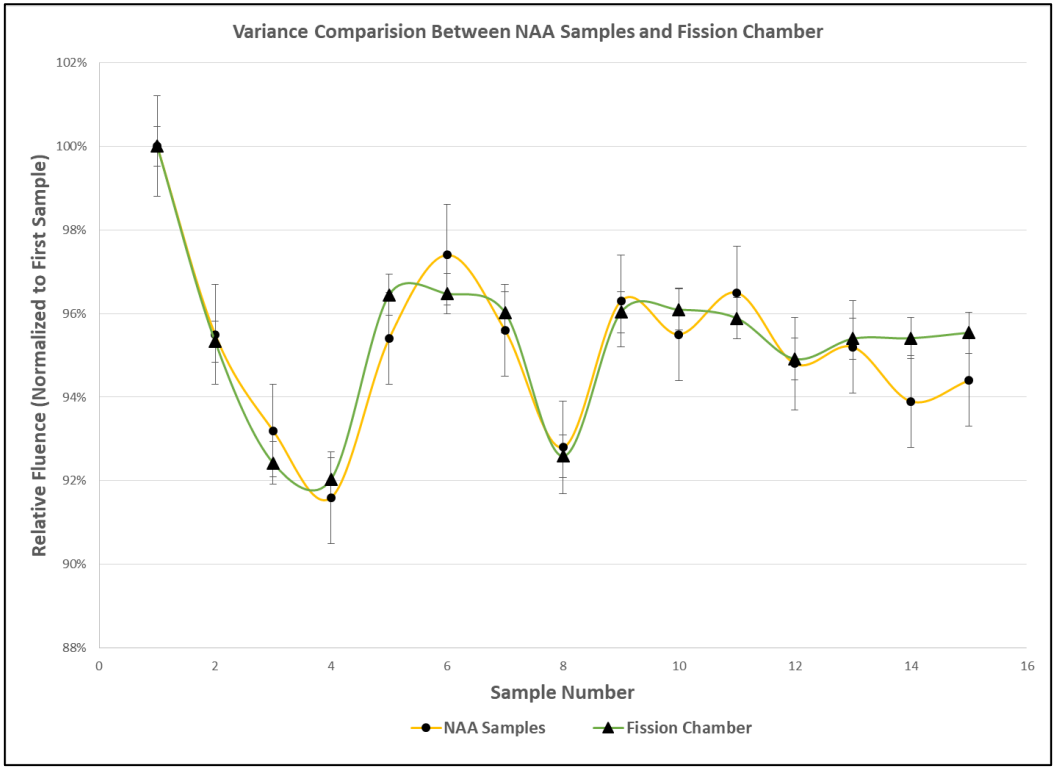


Testing

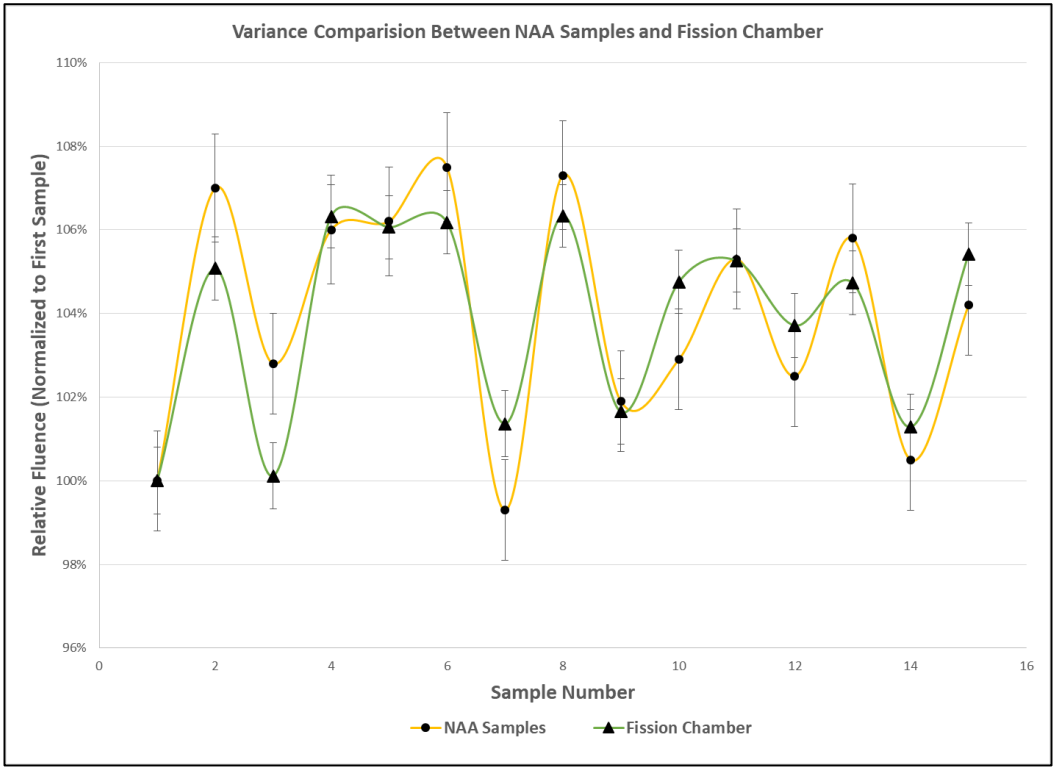
- Sulfur Flux Monitors
  - Activation of ^{36}S
  - ^{37}S : 3103.37 keV
- Irradiation
  - 950 kW
  - 10 Seconds
  - Multiple Monitors
- All Results Normalized for comparison.



Results

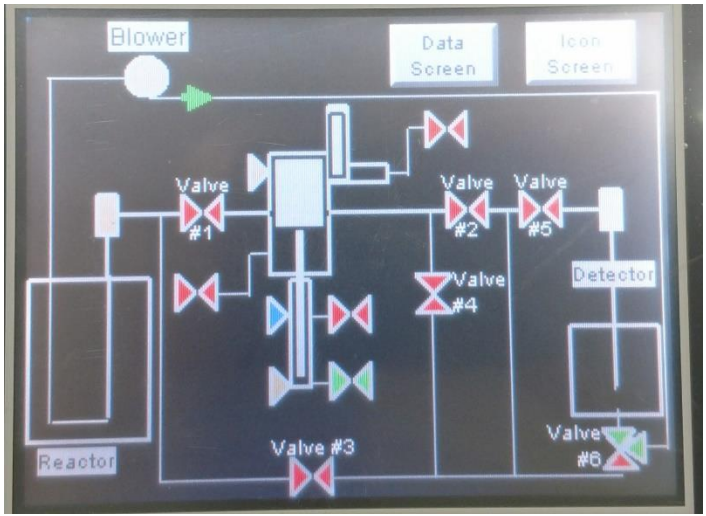

Variance Comparision Between NAA Samples and Fission Chamber
Relative Fluence (Normalized to First Sample)
102%
100%
98%
96%
94%
92%
90%
88%
0
2
4
6
8
10
12
14
16
Sample Number
NAA Samples
Fission Chamber

Results


Variance Comparision Between NAA Samples and Fission Chamber
Relative Fluence (Normalized to First Sample)
110%
108%
106%
104%
102%
100%
98%
96%
0
2
4
6
8
10
12
14
16
Sample Number
NAA Samples
Fission Chamber

Future Work

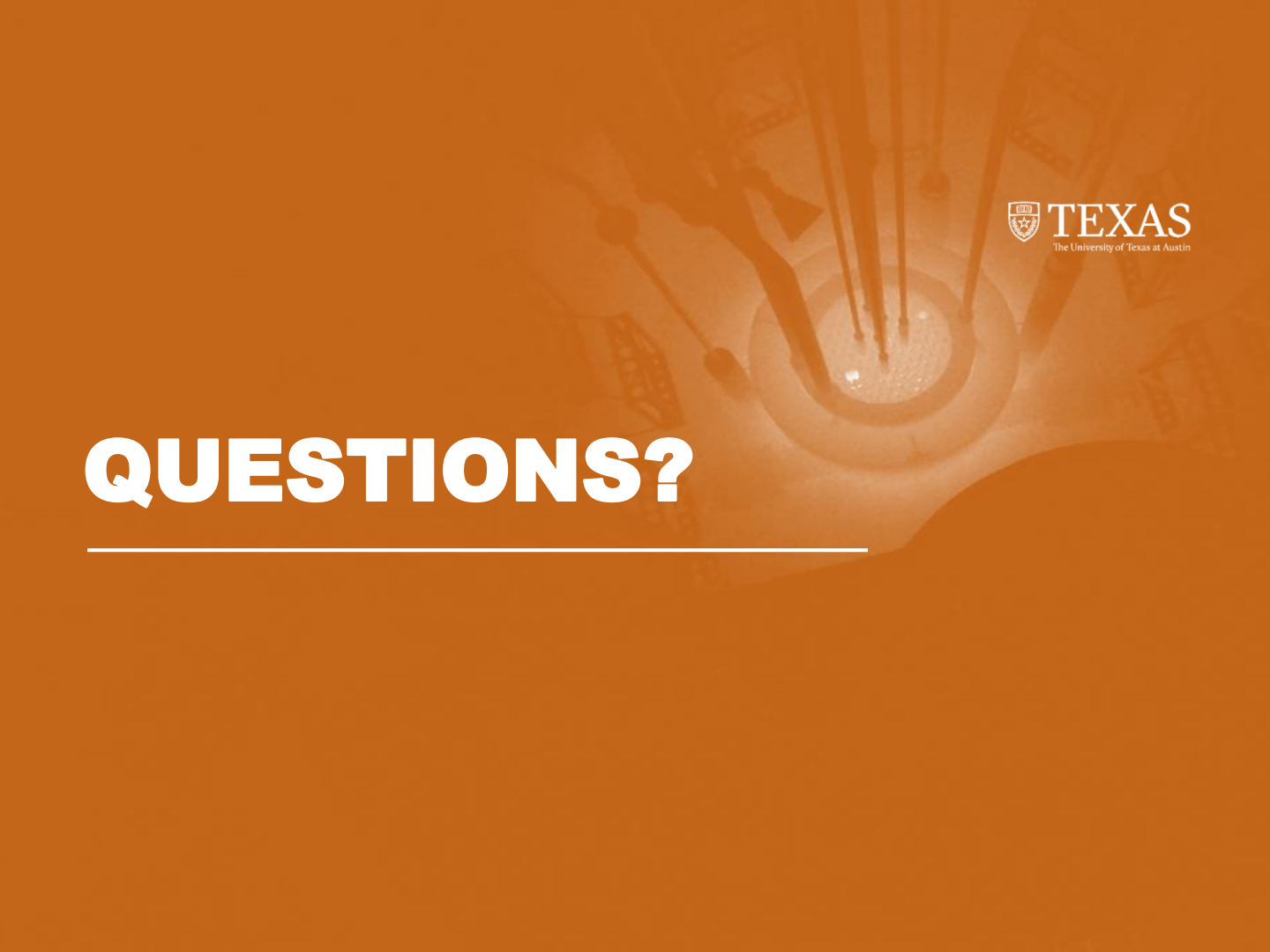
- NI PXI Platform
- Fast NAA Pneumatic System
- Improved Timing
- Automation



References

- Landsberger, S., & Dayman, K. (2013). Monitoring of neutron flux changes in short-lived neutron activation analysis. *Radioanalytical Nuclear Chemistry*.
- Photonis SAS. (2015). *CFUF 43/30 Fission Chamber: Specification Sheet*. Brive, France: Photonis.

Special Thanks to Dr. Steven Biegalski, Dr. Edward Artnak, and UT Nuclear Engineering Teaching Laboratory Staff.


TEXAS
The University of Texas at Austin
QUESTIONS?