Update of Nuclear Data Efforts at LANL

AFCI Nuclear Physics Working Group

November 4-5, 2010

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XCP-5

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Current Measurement & Theory Efforts at LANL

- **We are in the midst of a fission revival!**
  - This should not be surprising, nuclear energy, nuclear weapons, and many other programs have at their heart, nuclear fission
  - We have not seen a significant surge in our efforts on this vital topic in a long time
- **Significantly upgrade our experimental capabilities**
  - TPC – High precision fission cross sections
  - Chi-Nu – Extended measurement of fission outputs (0.1-12MeV)
  - Looking for ideas to measure fission product yields (SPIDER / Gamma)
  - Preparing for new critical assembly measurements
- **Significant advances in fission theory**
  - Several approaches to computing barriers, (n,f), PFNS, other xs, …
    - Particularly excited at how separate parts are combining
  - Exploring how to better integrate experimental uncertainties
- **But… we need to make sure other efforts don't fall by the wayside**

IAEA TM on Neutron Cross-Section Covariances

- **From Doug Muir et al. presentation to CSEWG on the need to better understand experimental uncertainties, particularly correlations**
- **“Uncertainties in Experimental Data**
  - In view of the strong need for input from experimentalists in the evaluation of data covariances, the group reaffirmed the need for nuclear data measurers to pay more attention to the documentation of experimental uncertainties.
  - The group noted that this topic is not adequately addressed in the training of nuclear scientists. This fact is compounded by the pressures to publish results in archival journals, and the limitations on the content that can be included in such publications.”
- **This group is working to make specific recommendations on what this documentation needs to include**
  - We need to ensure the appropriate input gets into this process
  - We need to ensure that our future measurement activities follow these recommendations

Prompt Fission Neutron Spectrum

FIGURES

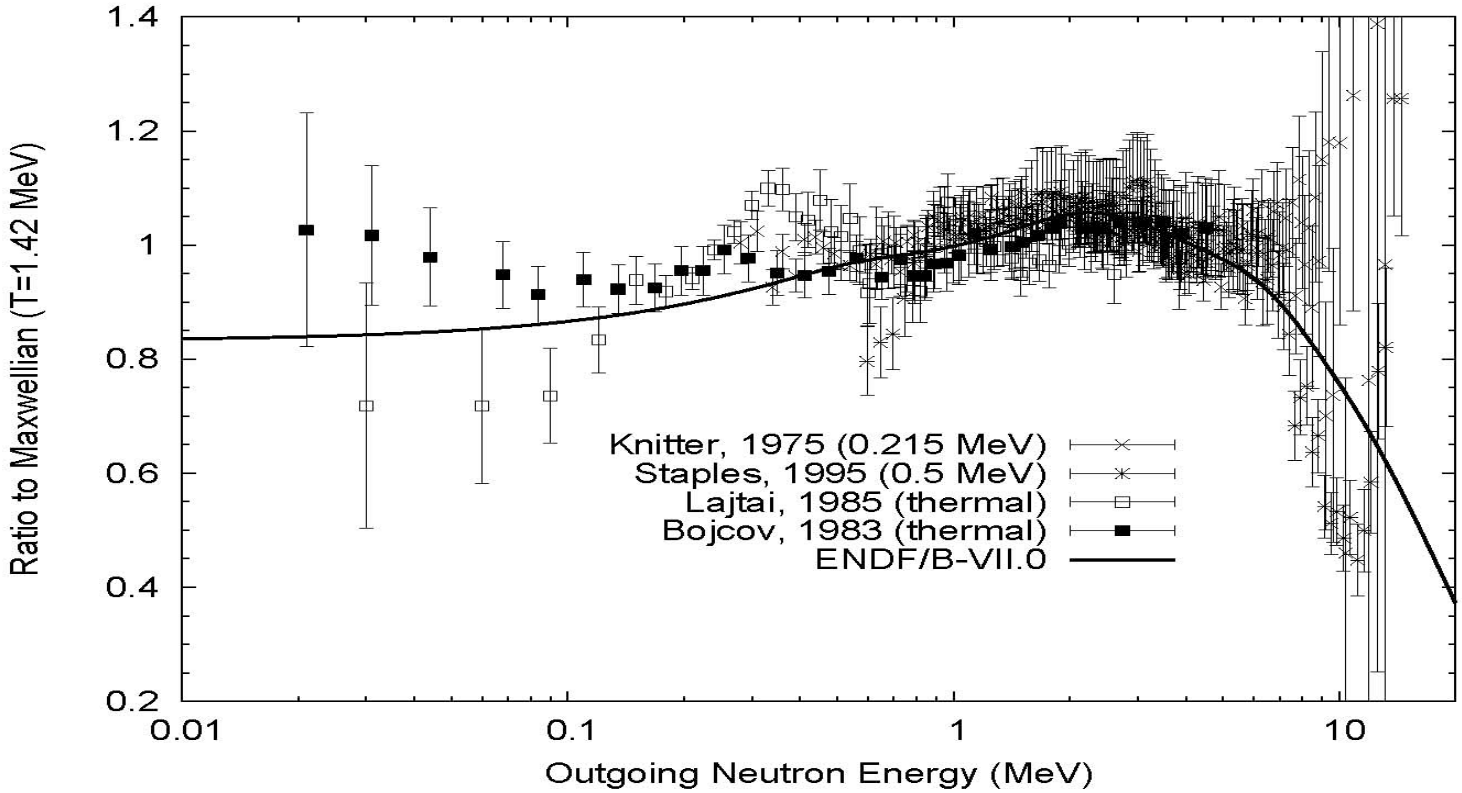
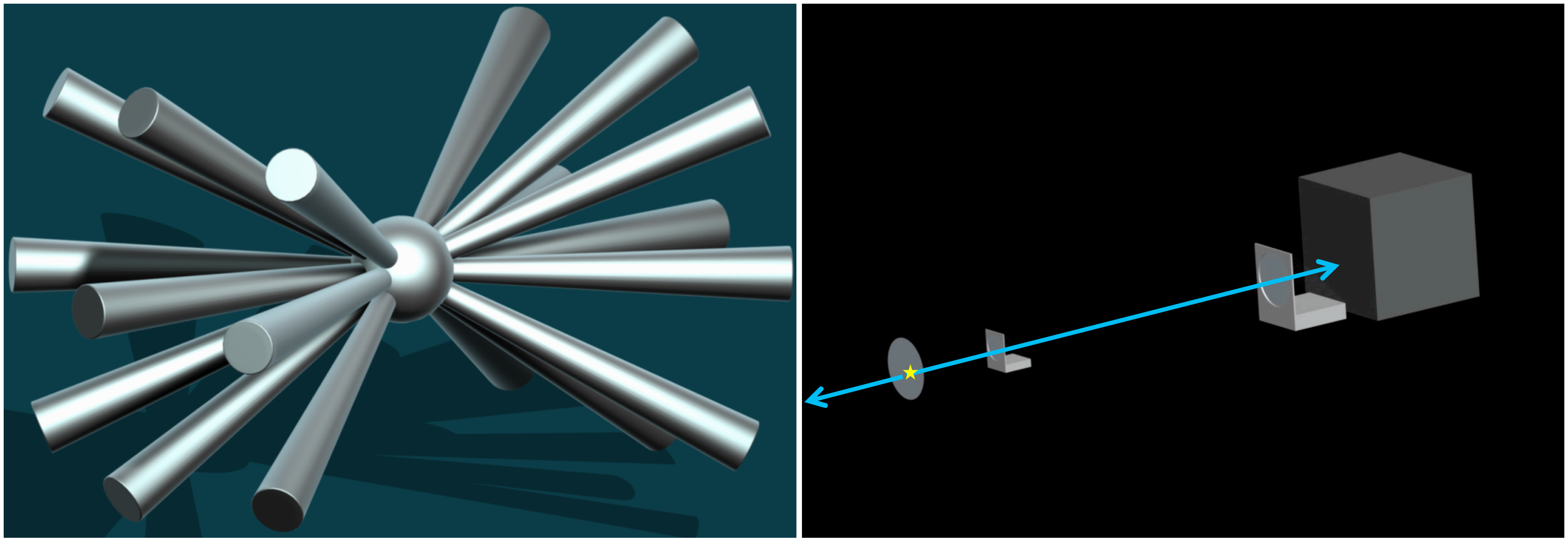


FIGURE 1. Prompt fission neutron spectrum for low-energy (<0.5 MeV) neutron-induced fission of ^{239}Pu.

Chi-Nu (@ LANSCE WNR)
Measuring the Fission Neutron Emission Distribution

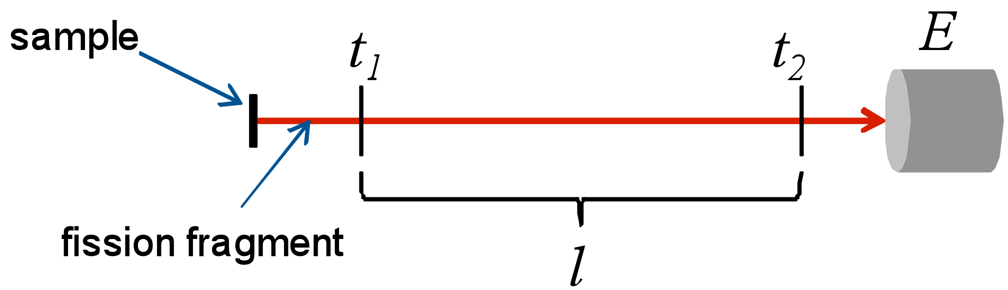
- **Experimental data for Pu239 will be delivered for low- and high-energies**
  - Low-energy data (0.1 MeV to MeV) scheduled for June 2013
  - High-energy data (MeV to 12 MeV) scheduled for June 2015
    - Potentially available in 2014 given accelerator upgrades plus other good luck
  - Attempting to include the evaluation process as part of the data reduction activities
- **U235 and U238 data will follow but no schedule is currently set**
- **FY11 activities**
  - Out-of-beam detector calibration
  - Development of the newly acquired data acquisition system
  - Beam line design/construction (new building is planned for WNR to be built this year)
- **FY12 activities**
  - Characterization of the new beam flight path
  - Installation and in-beam detector calibration
  - Preliminary data taken with final (low-energy) data scheduled for FY13

SPectrometer for Ion DEtermination in fission Research (SPIDER)



- Nine pairs of spectrometer arms will provide mass measurements of both fragments
- Target consists of 50-200 µg/cm^2 actinide sample on a thin (~30 µg/cm2) backing foil
- Multi-channel plate (MCP) detectors provide ~100 ps timing resolution. The fragments pass trough thin carbon film, and electrostatic mirrors bend the electrons towards the MCPs
- Axial ionization chambers have been shown to provide 0.4% energy resolution for the light fragment group, and 0.7% for the heavy group. A segmented readout plane provides δE/E measurements for charge identification
- Total detection efficiency is 5%

The (2E, 2V) method will be used to measure FPYs with about 1 amu resolution

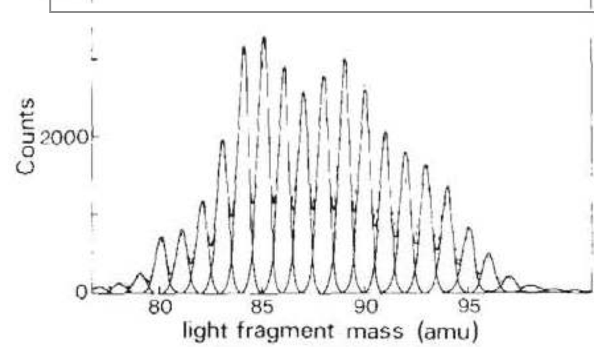


$$M = \frac{2Et^2}{l^2}$$

$$\frac{\delta M}{M} = \sqrt{\left(\frac{\delta E}{E}\right)^2 + \left(2\frac{\delta t}{t}\right)^2 + \left(2\frac{\delta l}{l}\right)^2}$$

- **A 2E, 2V instrument will provide fission product yield measurements**
- **LANSCE-WNR will provide neutrons in the energy region of interest (0.5 - 30 MeV)**

FPY measure with COSI-FAN-TUTI



HEU Critical Assemblies

Assembly		Exp	RE	Calc	C/E	Sigma Diff
HEU-MET-FAST-001	1	1.0000	0.0010	0.9998	0.9998	-0.2
HEU-MET-FAST-001	2	1.0000	0.0010	0.9999	0.9999	-0.1
HEU-MET-FAST-008		0.9989	0.0016	0.9960	0.9971	-1.8
HEU-MET-FAST-018		1.0000	0.0014	1.0004	1.0004	0.3
HEU-MET-FAST-015		0.9997	0.0017	0.9944	0.9947	-3.1
HEU-MET-FAST-065		0.9985	0.0013	0.9980	0.9995	-0.4
HEU-MET-FAST-051	14	0.9996	0.0002	0.9988	0.9992	-4
HEU-MET-FAST-051	15	0.9998	0.0001	0.9981	0.9983	-17
HEU-MET-FAST-051	16	0.9981	0.0001	0.9965	0.9984	-16
HEU-MET-FAST-051	17	0.9969	0.0001	0.9955	0.9986	-14
HEU-MET-FAST-051	18	0.9984	0.0001	0.9943	0.9959	-41
HEU-MET-FAST-007	1	0.9950	0.0024	0.9932	0.9981	-0.8
HEU-MET-FAST-007	19	0.9956	0.0015	0.9967	1.0011	0.7

Jezebel Schematic and Photo

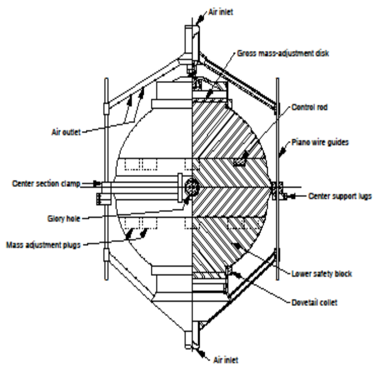
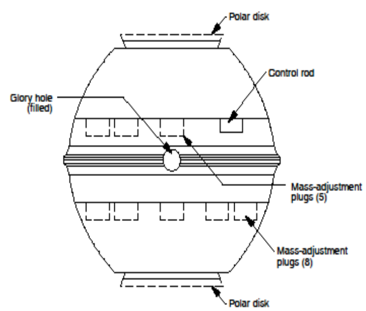
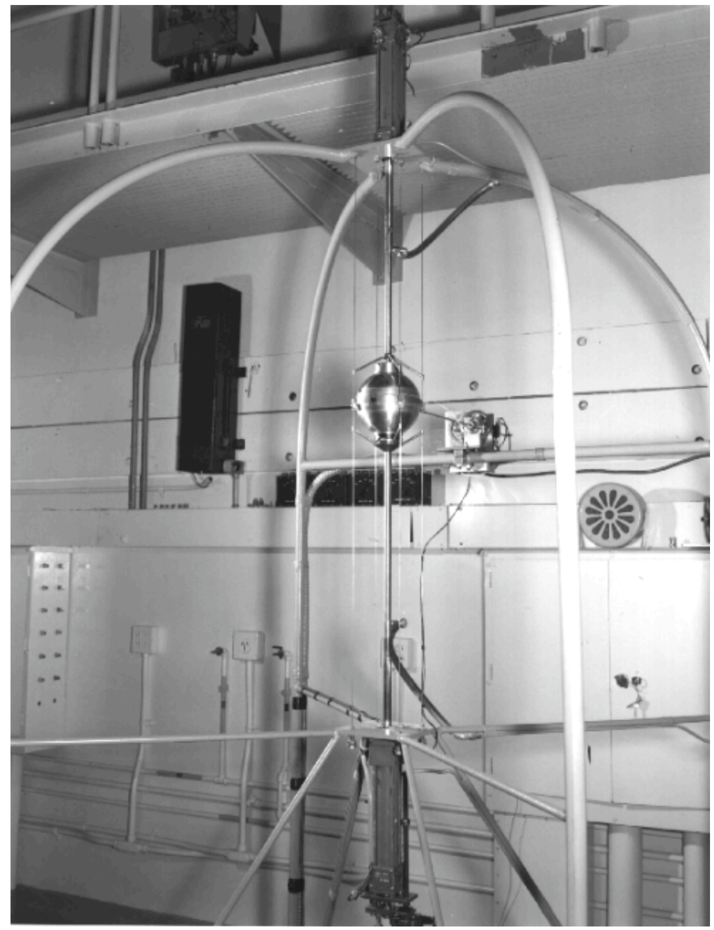
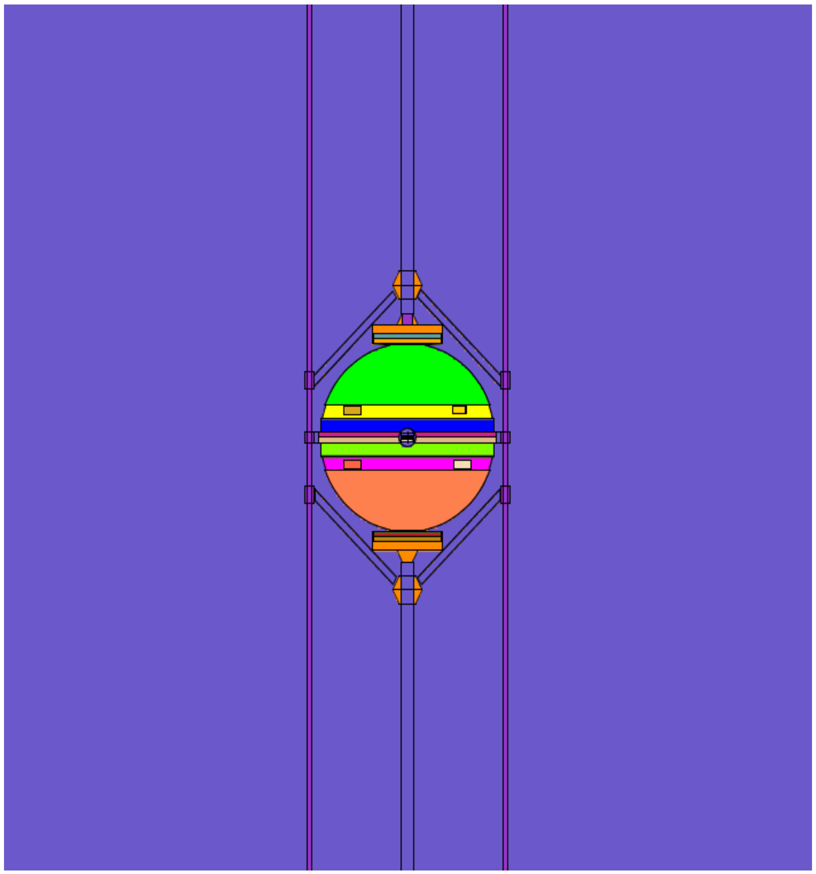


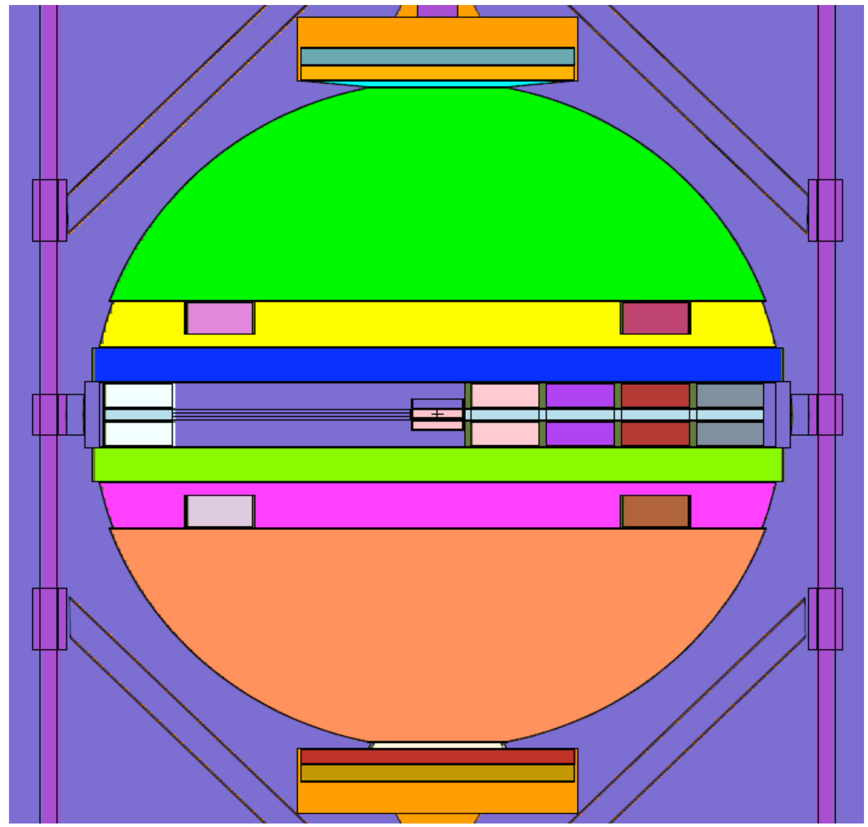
Figure 3. The Active Portion of the Original Jezebel Assembly.





Three-Dimensional Model Pictures





Detailed Model Configurations

- **Configuration A**
  - 13 Pu Buttons
  - Control Rod full insertion
  - Thin polar discs
  - 16.571 kg Pu alloy
  - k_{eff} = 1.0001 ± 0.0002
- **Total uncertainty ± 0.0052**

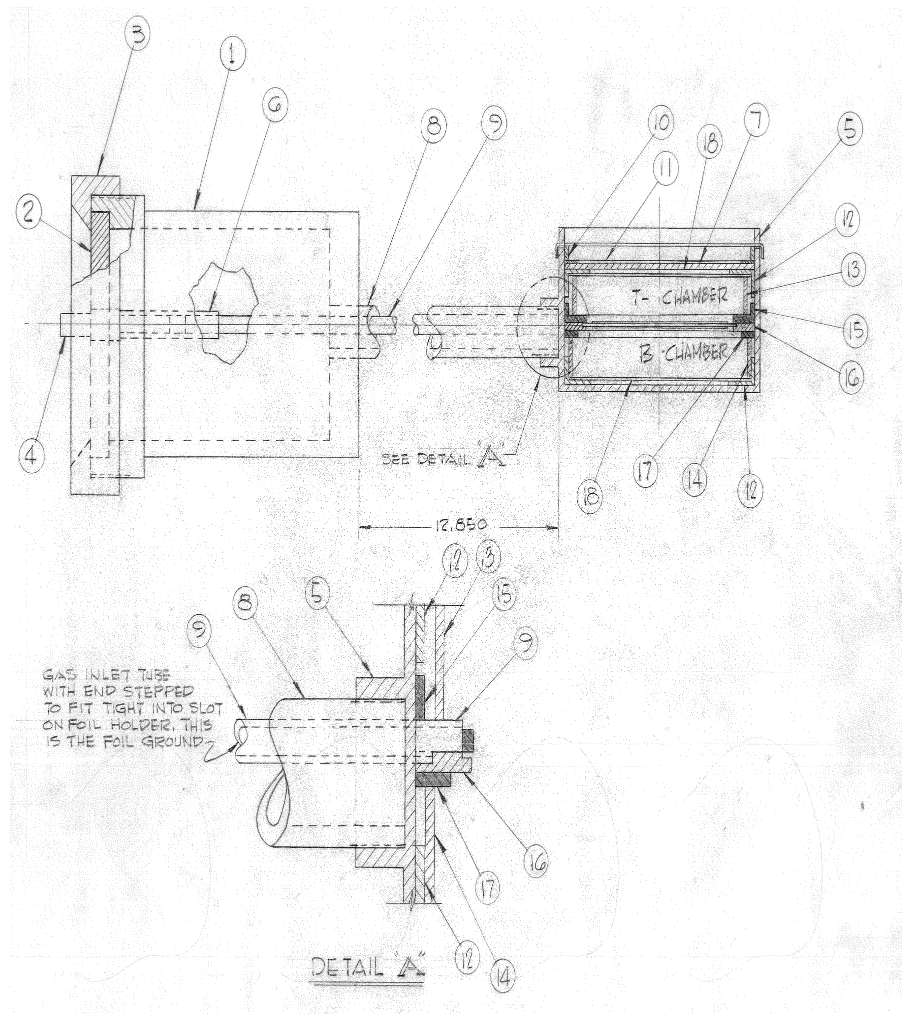
- **Configuration B**
  - 8 Pu Buttons
  - Control Rod inserted 1.375-inches
  - Thick polar discs
  - 16.909 kg Pu alloy
  - k_{eff} = 1.0001 ± 0.0002
- **Total uncertainty ± 0.0057**

Detailed Model Inconsistencies

- **No Isotopic information or impurities found for Pu buttons**
- **Configurations A and B could not be located in the Logbooks**
  - Configurations near A and B are in the logbooks
  - May be in another logbook
- **Some of the corrections difficult**
  - Asphericity
  - Air Reflection
  - Homogenization
- **Temperature coefficient of reactivity**
  - α-phase Pu is a negative effect
  - δ-phase Pu is positive
  - Measured effect was negative
  - Believe the larger parts are a mixture of α and δ-phase
- **Normalized isotopic and impurity compositions needed**
  - Standard practice when dealing with radio-chemists
  - Radio-chemists report 2-σ results
  - Analysts must ensure all constituents add to exactly 100%

Detailed Model of Grundl Detector

- **Foils modeled**
  - Impurities
  - Reported Masses
  - Enrichments
    - ^{238}U
    - ^{235}U
    - ^{237}Np
    - ^{239}Pu
- **Nominal 4 ATM Ar**



Results

Fissionable								
Msmt	U28/U25		U23/U25		Np37/U25		Pu49/U25	
Expt	0.2137	0.0108	1.578	0.0171	0.962	0.0166	1.448	0.0200
Calc Top	5.13E-07	0.0116	3.80E-06	0.0076	2.29E-06	0.0091	3.38E-06	0.0079
Calc Lower	2.41E-06	0.0075	2.36E-06	0.0075	2.27E-06	0.0075	2.30E-06	0.0076
Ratio	0.2129	0.0138	1.5962	0.0107	0.9651	0.0118	1.4716	0.0110
C/E - 1	-0.0036	0.0175	0.0115	0.0201	0.0032	0.0203	0.0163	0.0228

Questions For Which We Need Help

- **Is there a preferred order for marching through the other actinides?**
- **Are there other measurements which are falling by the wayside?**
- **How do we integrate new measurements into evaluations?**
- **How do we integrate experimental and theoretical uncertainties into simulations?**
  - And how do we best describe results?
- **Can you help motivate the basis for SPIDER? (fission yields)**
- **What other critical assembly measurements should we consider?**
  - How do we collaborate on the design, execution and documentation of these?