Central Reaction Rate Ratios Using a Detailed Model of Jezebel

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Outline

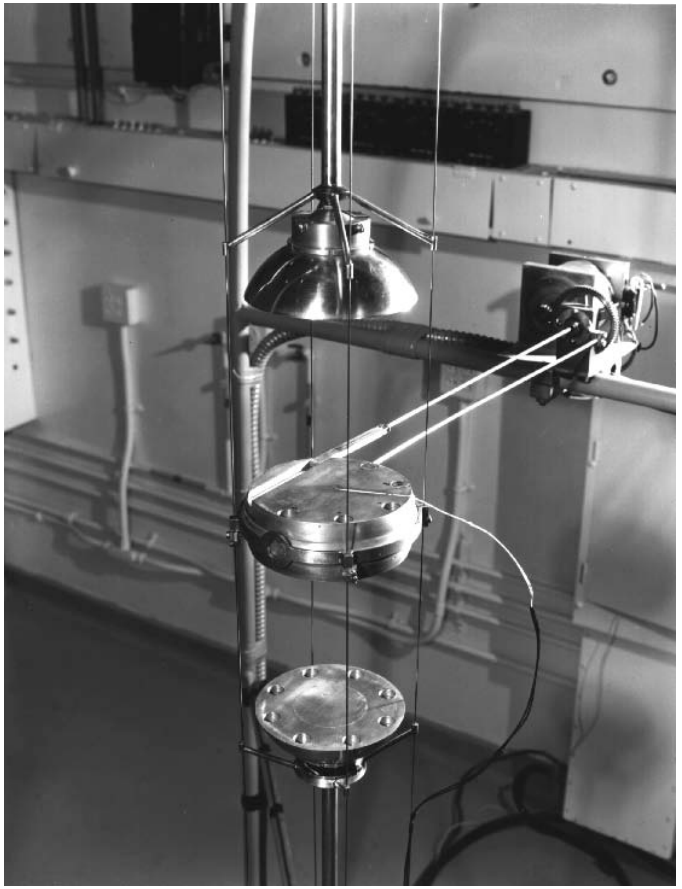
- Purpose
- Original Jezebel CSEWG and ICSBEP
- Detailed Jezebel Models
- Central Reactivity Rate Ratios
  - Details of Grundl Detector
  - Details of Foils
- Results

Purpose

- Reduce modeling uncertainties associated with Jezebel
- Understand the total uncertainty
  - Modeling
  - Experimental
- Better models for the central reaction rate ratios/foil activation measurements
  - Improve the calculated results

Jezebel Critical Assembly

- WG Pu,
  - 95.2 at% ^{239}Pu
  - 17.04 kg Pu
  - 15.61 g/cm^3
  - Radius 6.3849 cm
- First critical in 1954 and operated for about 5 yrs
- Two configurations recommended by Experimentalists



Jezebel Schematic and Photo

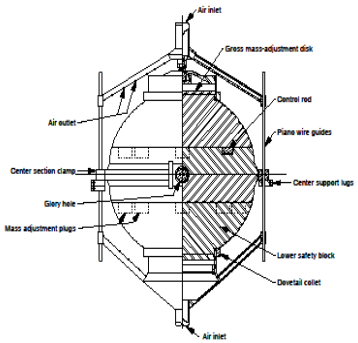
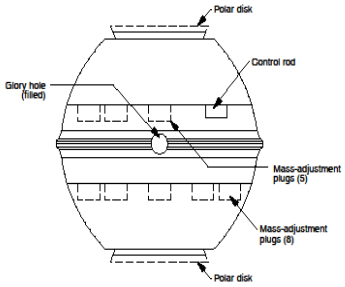
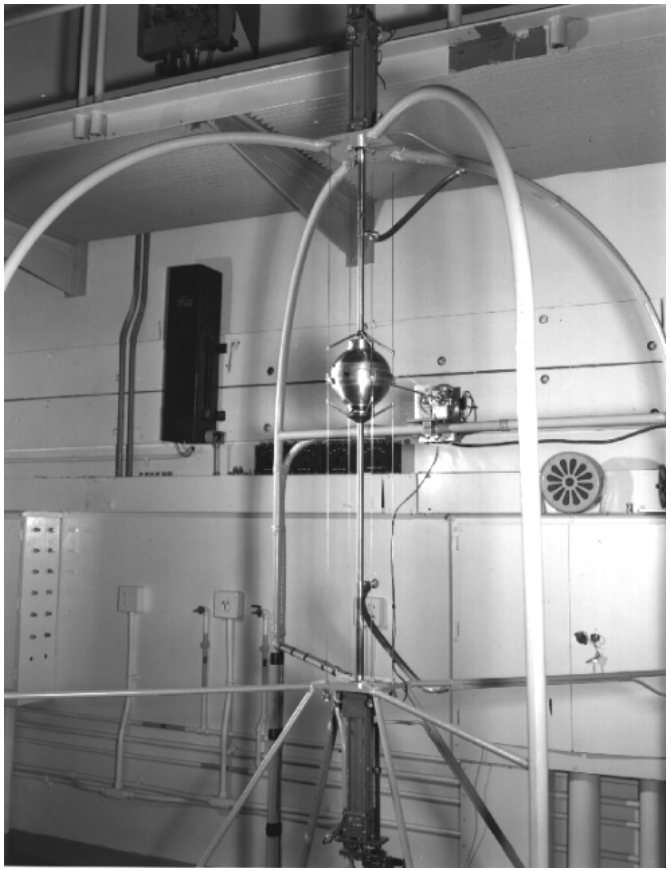


Figure 3. The Active Portion of the Original Jezebel Assembly.





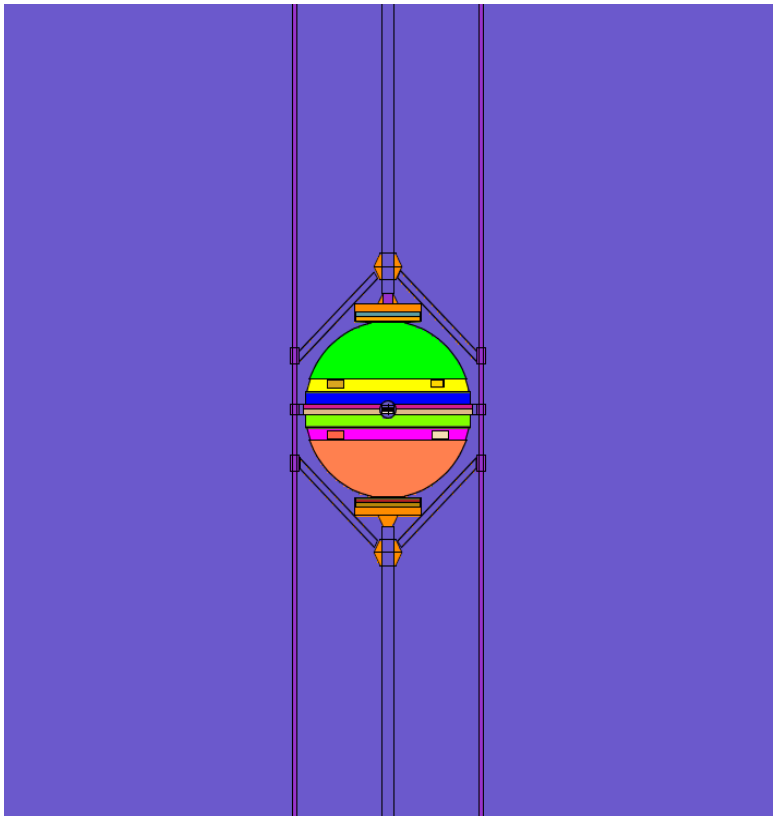
Current Benchmark Model

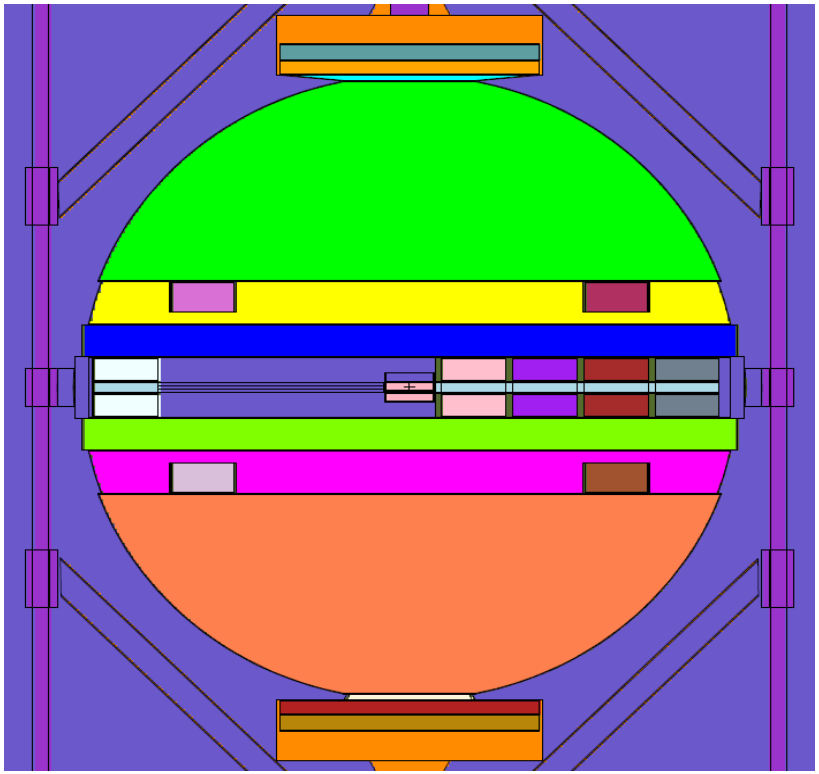
- One-Dimensional
- Numerous corrections
  - Asphericity
  - Internal Ni & Homogenization
  - Equatorial Band
  - Polar Supports
  - External Ni
  - Framework
  - Building-wall Reflection
  - Air Reflection
  - Trace Impurities
  - Elevated Temperatures

Detailed Benchmark Model

- Currently revising original evaluation by R. D. O'Dell and R. W. Brewer
- Each part is modeled based on as-built drawings and mock-up
  - Linear dimensions
  - Some part masses
- Individual part material properties from internal memos and logbooks
  - Pu part isotopic compositions
  - Impurities
  - Part masses

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

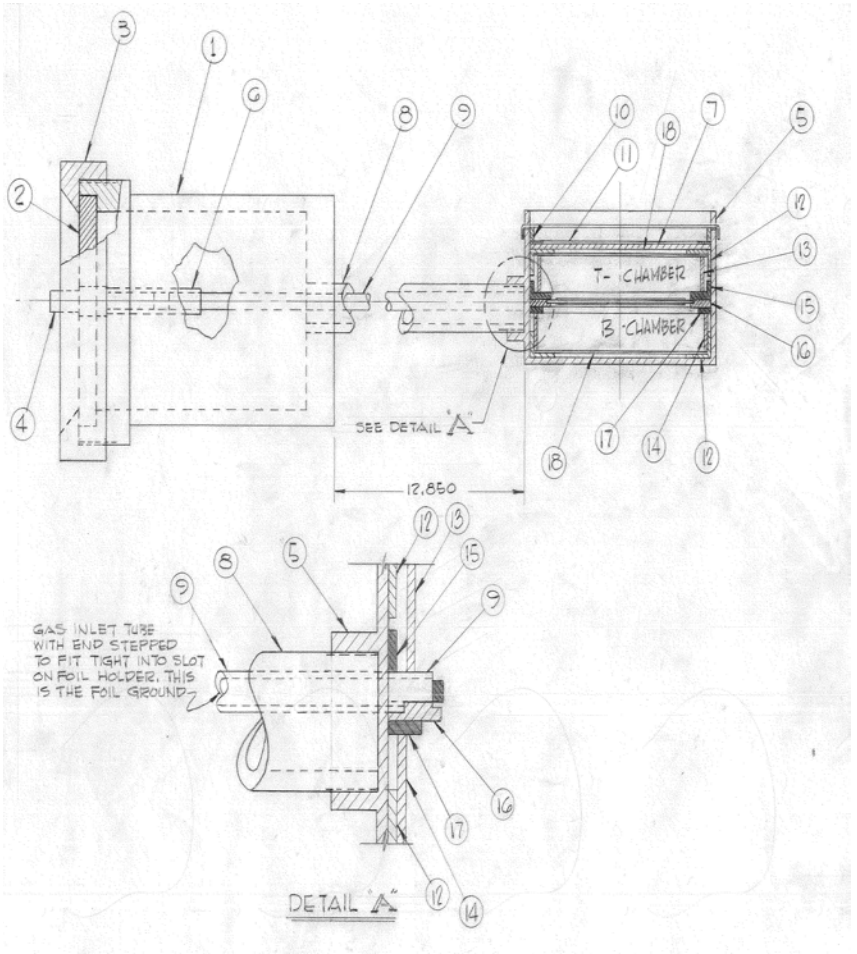
- Configuration B
  - 8 Pu Buttons
  - Control Rod inserted 1.375-inches
  - Thick polar discs
  - 16.909 kg Pu alloy
  - k_{eff} = 1.0001 0.0002
- Total uncertainty 0.0057

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
    - ^{63}Cu
- Nominal 4 ATM Ar



Experimental Central Reaction Rate Ratios

• F28/F25	• 0.2137 1.08%
• F23/F25	• 1.578 1.71%
• F37/F25	• 0.9620 1.66%
• F49/F25	• 1.448 2.00%
• V/F25	• 0.0023 13.04%
• ^{55}Mn/F25	• 0.0024 12.50%
• ^{63}Cu/F25	• 0.010 6.00%
• ^{93}Nb/F25	• 0.023 8.70%
• ^{197}Au/F25	• 0.083 2.41%

Detailed Jezebel Model

- Model changed often
  - ^{197}Au/F25 Model
    - 1 each ½-inch glory hole filler piece
    - 2 thin polar discs
    - 13 buttons
    - Control rod inserted 1.975 to 1.715 inches
    - Temperature 34.0 to 36.9 ºC
- In Nov 1958 many Jezebel parts were replaced resulting in a net reduction of 73.69 g Pu

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		
Non-Fissionable										
Msmt	V/U-25		Mn55/U25		Cu/U25		Nb93/U25		Au197/U25	
Expt	0.0023	0.1304	0.0024	0.1250	0.0100	0.0600	0.023	0.0870	0.083	0.0241
Calc Top	2.54E-09	0.0189	3.33E-09	0.0162	1.88E-08	0.0096	2.66E-08	0.0233	7.33E-08	0.0107
Calc Lower	2.28E-06	0.0075	2.42E-06	0.0075	2.42E-06	0.0075	2.40E-06	0.0075	2.40E-06	0.0075
Ratio	0.0011	0.0203	0.0014	0.0179	0.0078	0.0122	0.0111	0.0245	0.0305	0.0131
C/E - 1	-0.5151	0.1320	-0.427	0.1263	-0.223	0.0612	-0.518	0.0904	-0.632	0.0274

Bonner Sphere Measurements

- Lithium-Iodide Bonner spheres msmts performed in July of 1959
- Used to measure source strength
  - LiI crystal placed 41 cm from Assy
  - 13-ft off concrete floor
  - five Bonner spheres, 2”, 3”, 5”, 8” and 12” diameter
- Source strength $3x10^7$ n/sec, ½ of 1%
- Counting time 400 sec
- Research how this was used to derive experimental results

Conclusion

- PU-MET-FAST-001 will be revised to include the detailed model
- Detailed Model has a higher total uncertainty
  - Before passing both G. E. Hansen and H. C. Paxton said they believed that metal assemblies weren't known to better than 0.0050 in k_{eff}
  - This analysis tends to support their opinion
- Fissionable Central Reaction Rates agree well with calculation
- Non-fissionable Central Reaction Rates don't agree within uncertainties
  - Need more investigation
  - Suspect an unknown uncertainty in the model