

IPNS MODERATOR SYSTEM OVERVIEW

Paul Brod

IPNS Division

9/28/2006



THE UNIVERSITY OF
CHICAGO



Office of
Science
U.S. DEPARTMENT OF ENERGY



Outline

- Introduction
- IPNS Moderator History
- Configuration, Construction and Inner Reflector Assembly
- Installation
- Operation
- Cooling system
- Methane Systems
- Operational Issues

What Does A Moderator Do?

- Converts high energy neutrons to low energy neutrons with an energy spectrum and pulse characteristics suitable for scattering science
- How?
 - Neutrons exchange energy in collisions with nuclei of an appropriate material
- Desired Characteristics
 - Low loss by leakage
 - Low loss by capture
 - Chemical stability
- Hydrogen is best element

Moderators at Spallation Neutron Sources

SOURCE	MODERATORS
IPNS	CH ₄ (s) - 28 K CH ₄ (l) - 100 K
KENS	CH ₄ (s) - 27K H ₂ O (l) – room temperature
LANSCE	H ₂ O (l) - 283 K H ₂ (l) - 20 K
ISIS	H ₂ O (l) - 316 K CH ₄ (l) - 100 K H ₂ (l) - 20 K
SINQ	D ₂ O (l) – temperature ? D ₂ (l) - 25 K

History of Moderator Materials at IPNS

- C, H, F Ambient HDPE
- C, H, F Liquid Methane/Be reflector
- C - LN2 cooled HDPE / H, F - Ambient HDPE
- C - LHe cooled HDPE / H, F - Ambient HDPE
- C - Solid Methane / H, F - Ambient HDPE
- C - Solid Methane / H, F - Liquid Methane
- C - Liquid Hydrogen / H, F - Liquid Methane (enriched target)
- C, H Solid Methane / F Liquid Methane

IPNS Moderators

■ 2 Solid Methane, 28 K

- “**C**” Moderator – 10x10x7.6 cm³ coupled, re-entrant geometry, unpoisoned
 - SASI
 - POSY I, II
 - SAND
- “**H**” Moderator – 10x10x4.5 cm³ Cd decoupled, Gd poisoned
 - HRMECS
 - QENS
 - GLAD

■ 1 Liquid Methane “F” 100K – 10x10x5 cm³ Cd decoupled, Gd poisoned

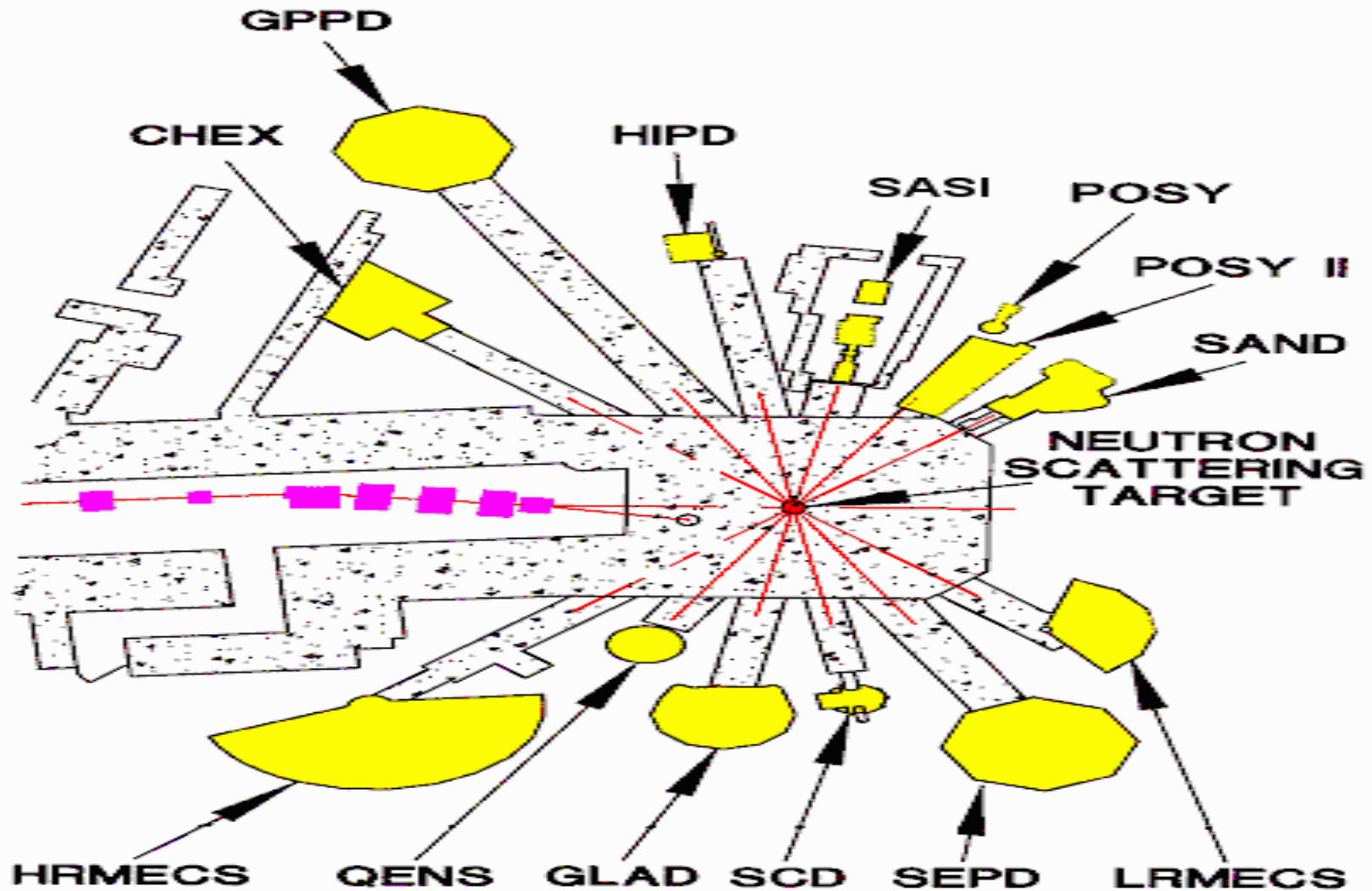
- SCD, SEPD, LRMECS, HIPD, GPPD, CHEX

Methane as a Moderator

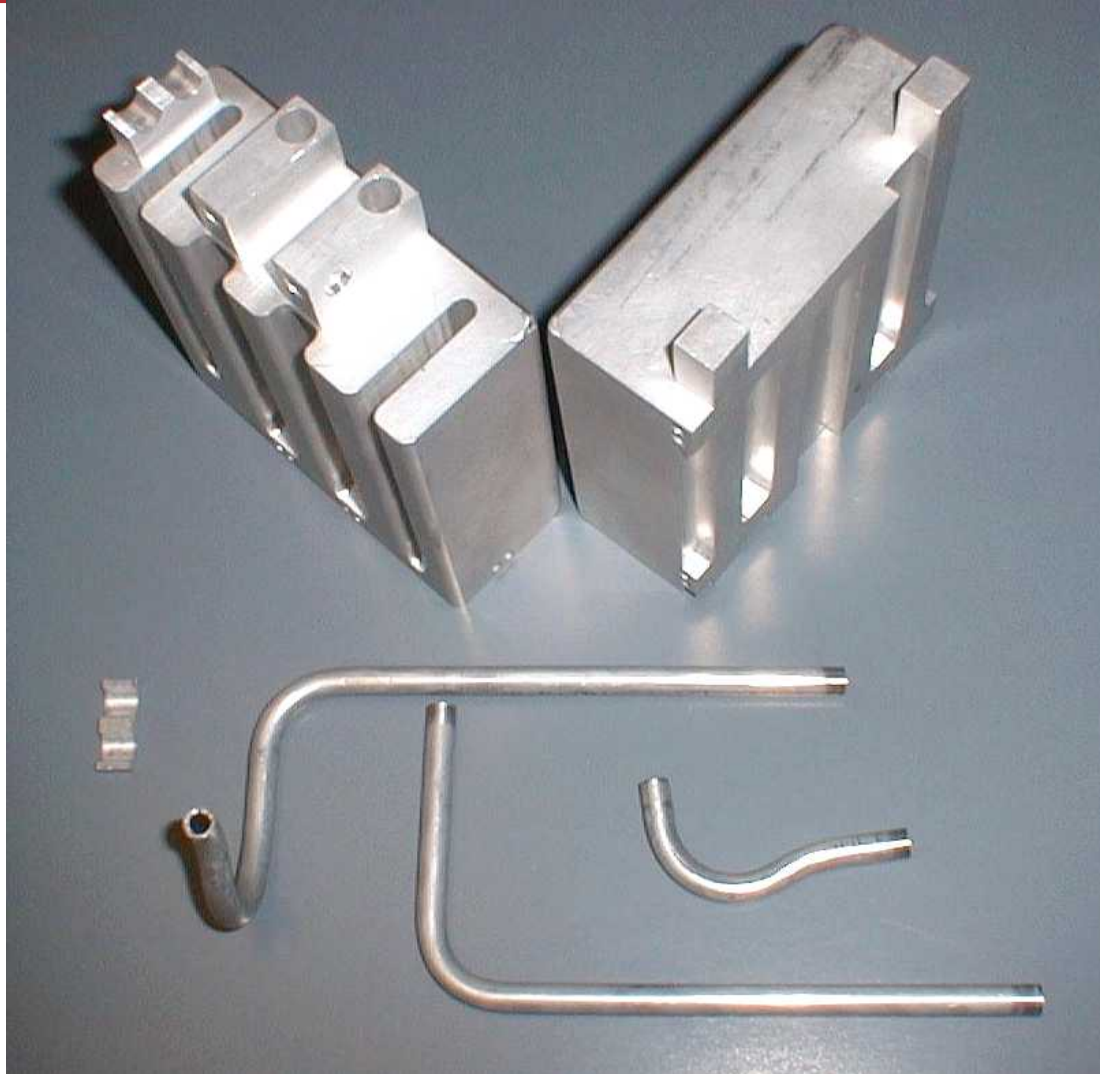
High efficiency

- High H atom density, $\sim 1.8X$ LH₂
- Inter- and Intra-molecular rotational and vibrational energy exchange modes in good range
- Neutron temperature very near methane temperature
- $\sim 3.5X$ cold neutron flux as LH₂

IPNS Experimental Hall



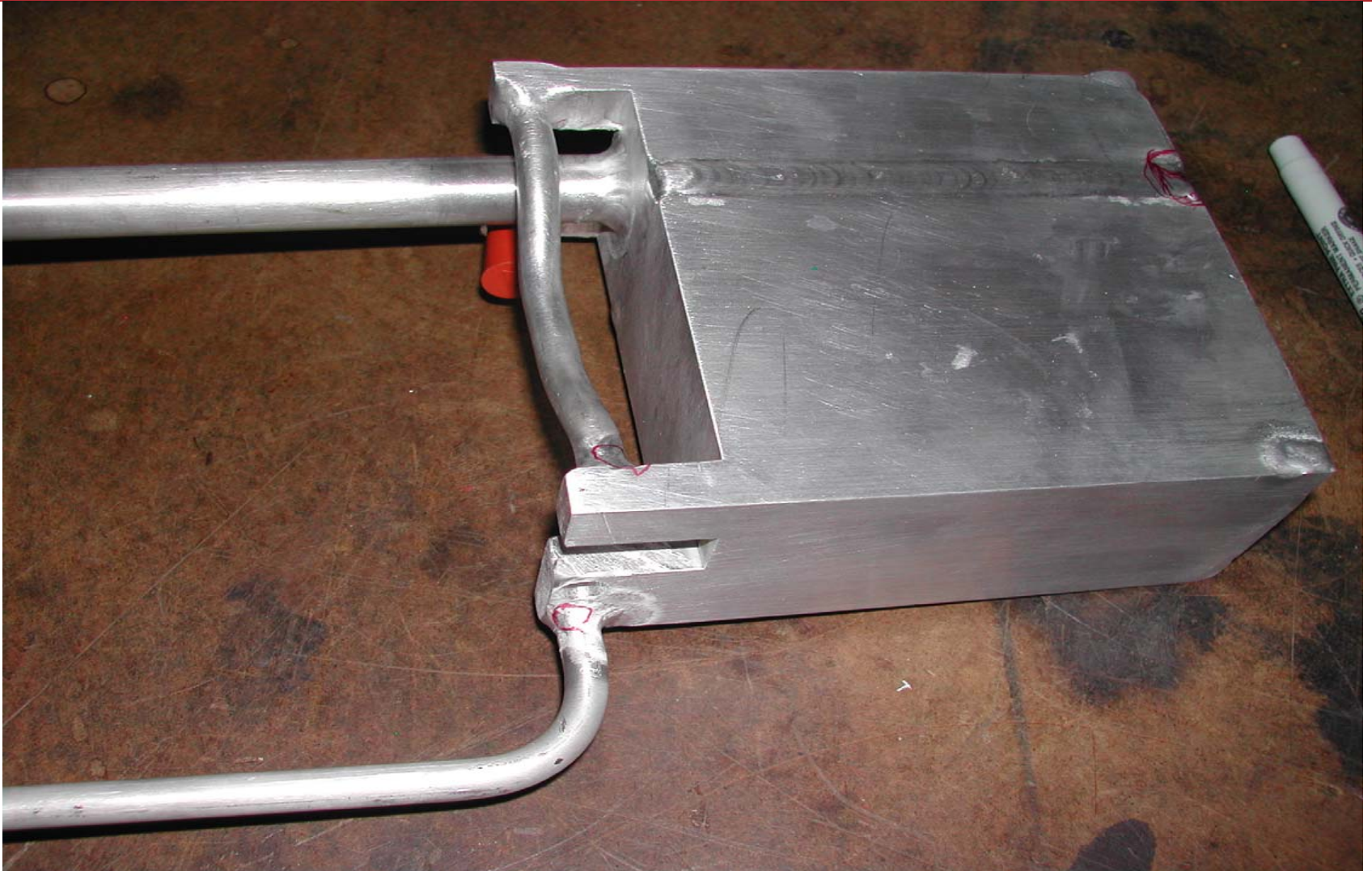
Vertical Groove C Moderator Parts



H Moderator Interior



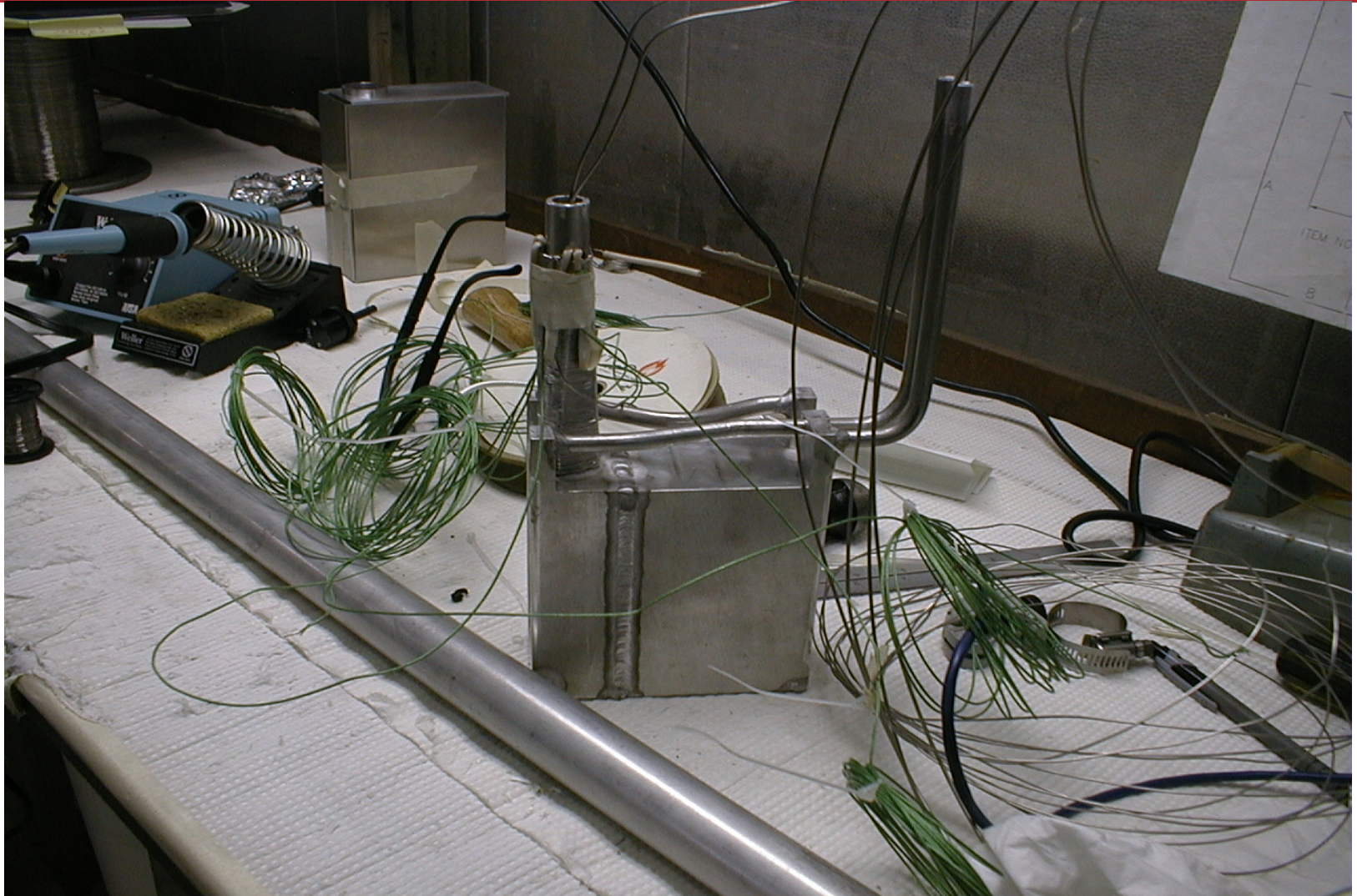
H Moderator Exterior



Vertical Groove C Moderator



H Moderator



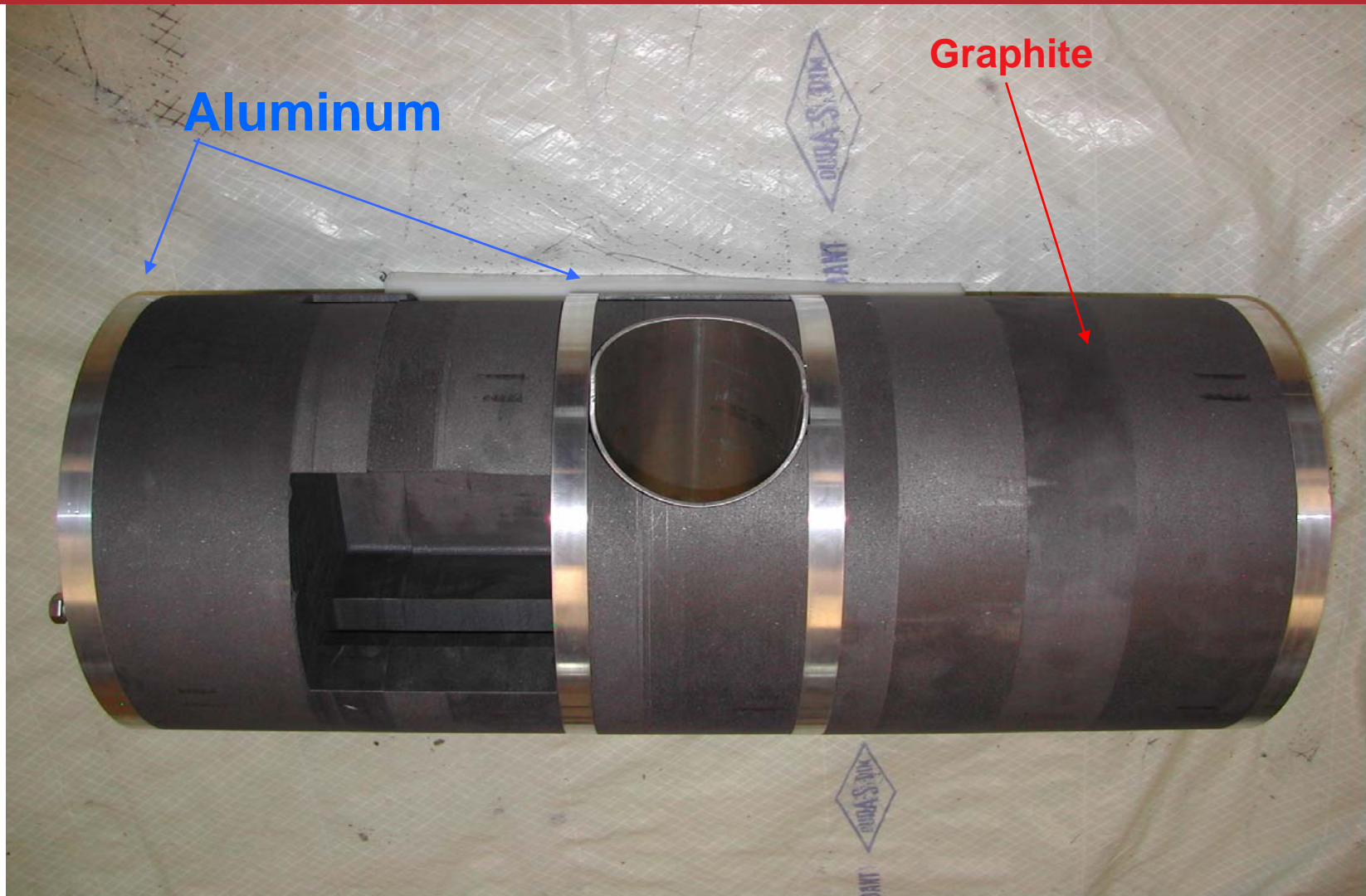
C Moderator



Moderator/Reflector Assembly



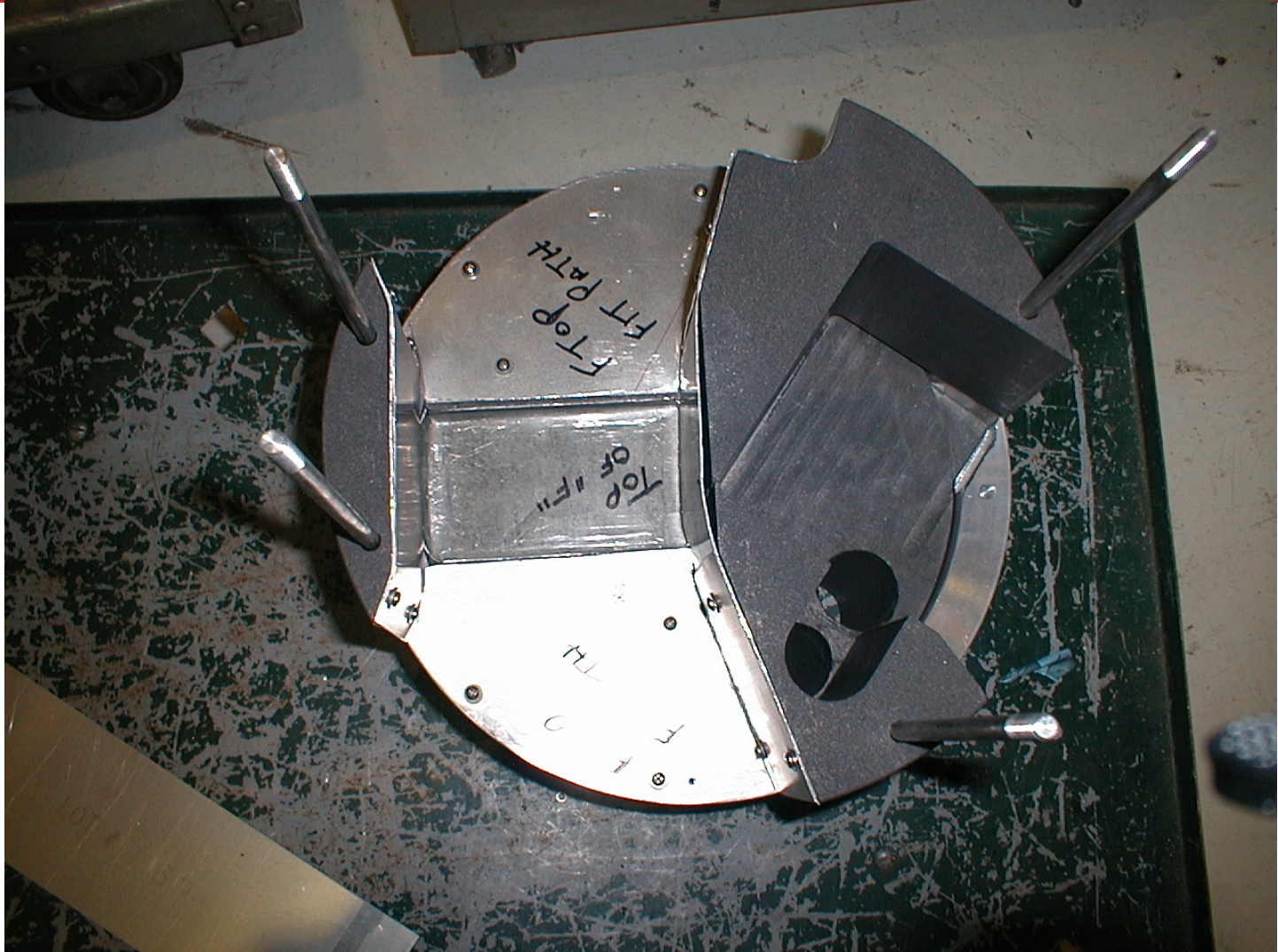
Inner Reflector Assembly



Parts Is Parts (Inner Reflector)



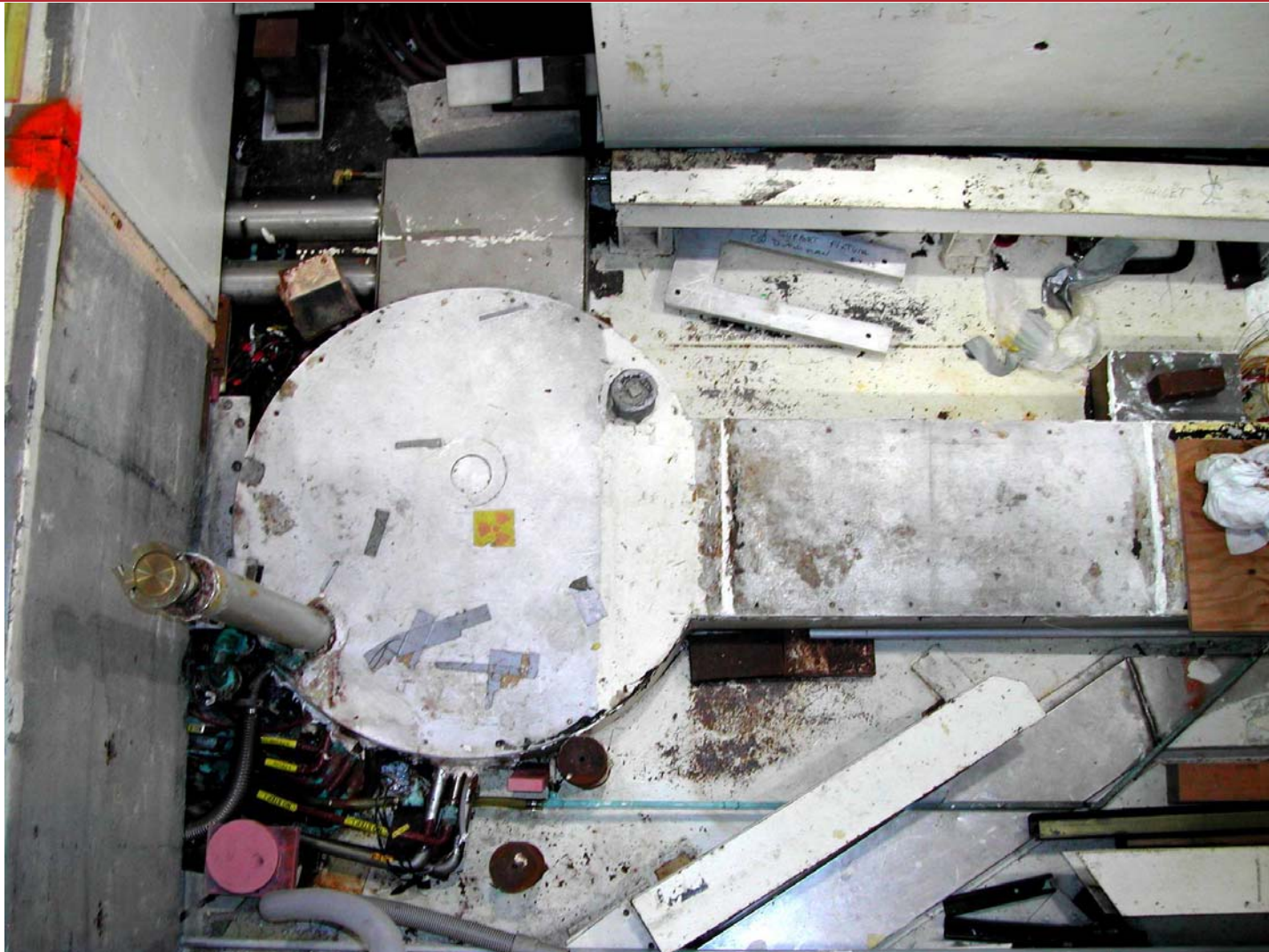
F Moderator Flight Path



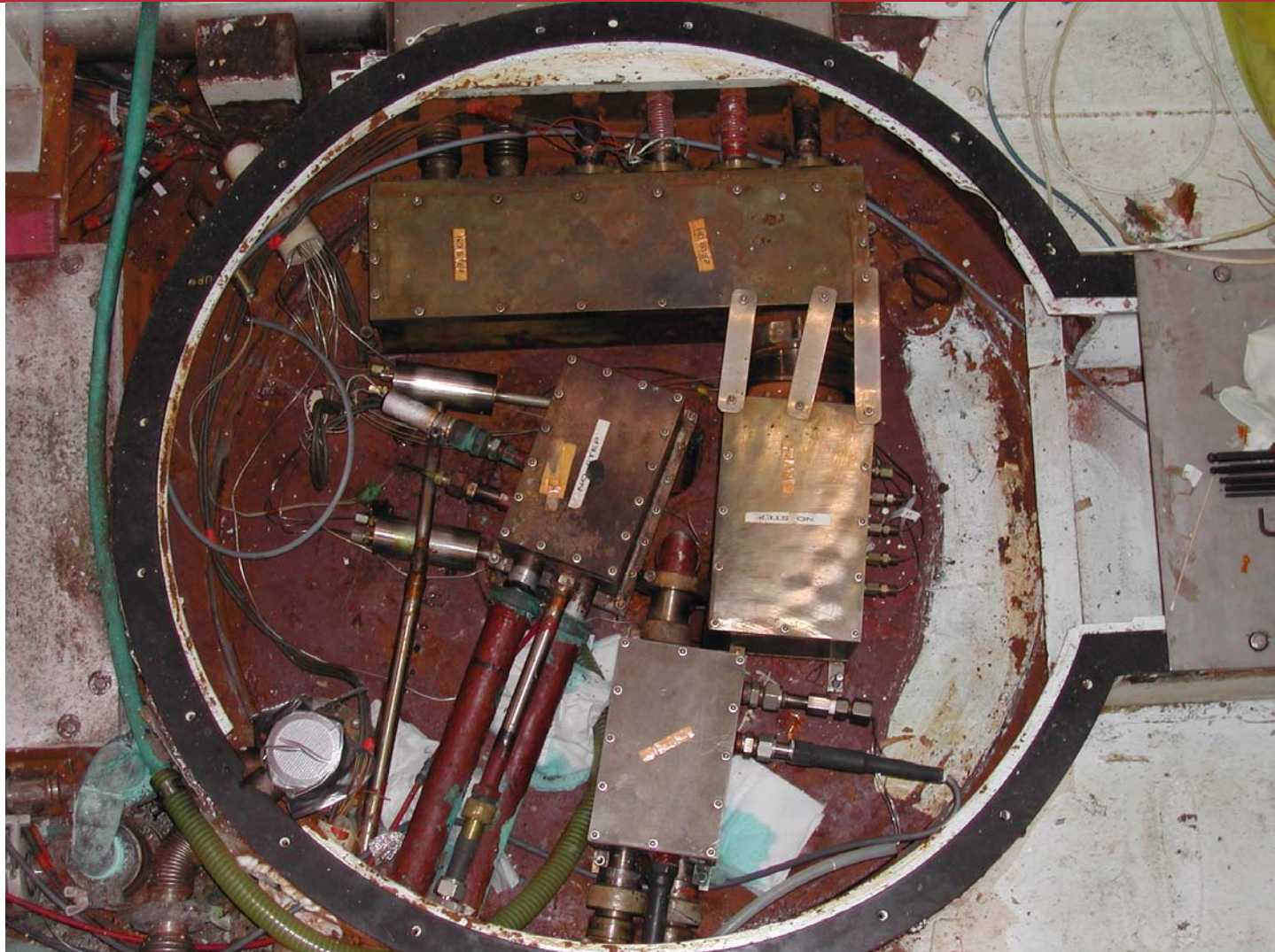
Moderator/Reflector Assembly



Banjo Area



Vacuum Connection Boxes Inside Banjo



Reflector Removal



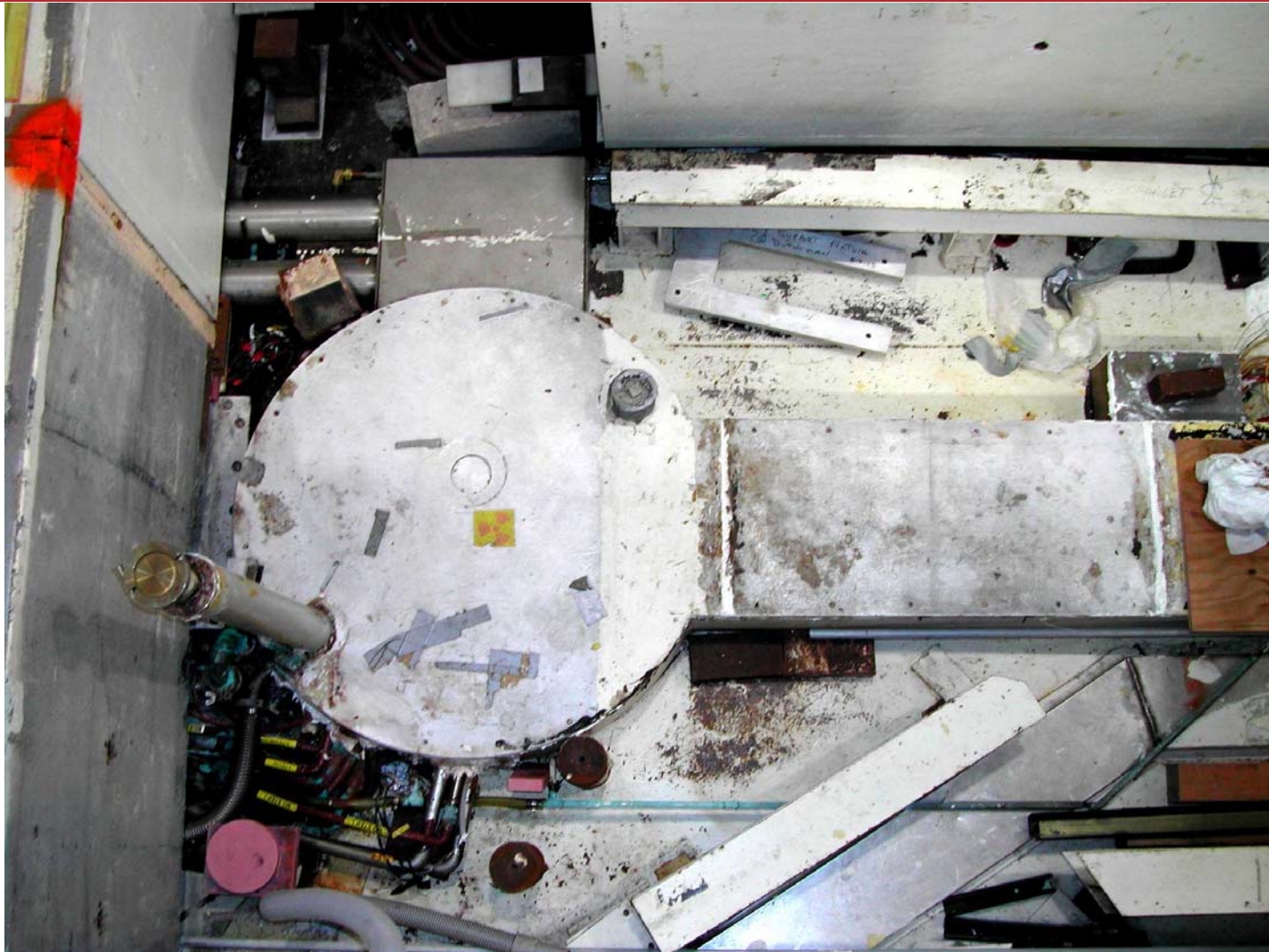
Reflector Installation



Inside Banjo



Banjo Area

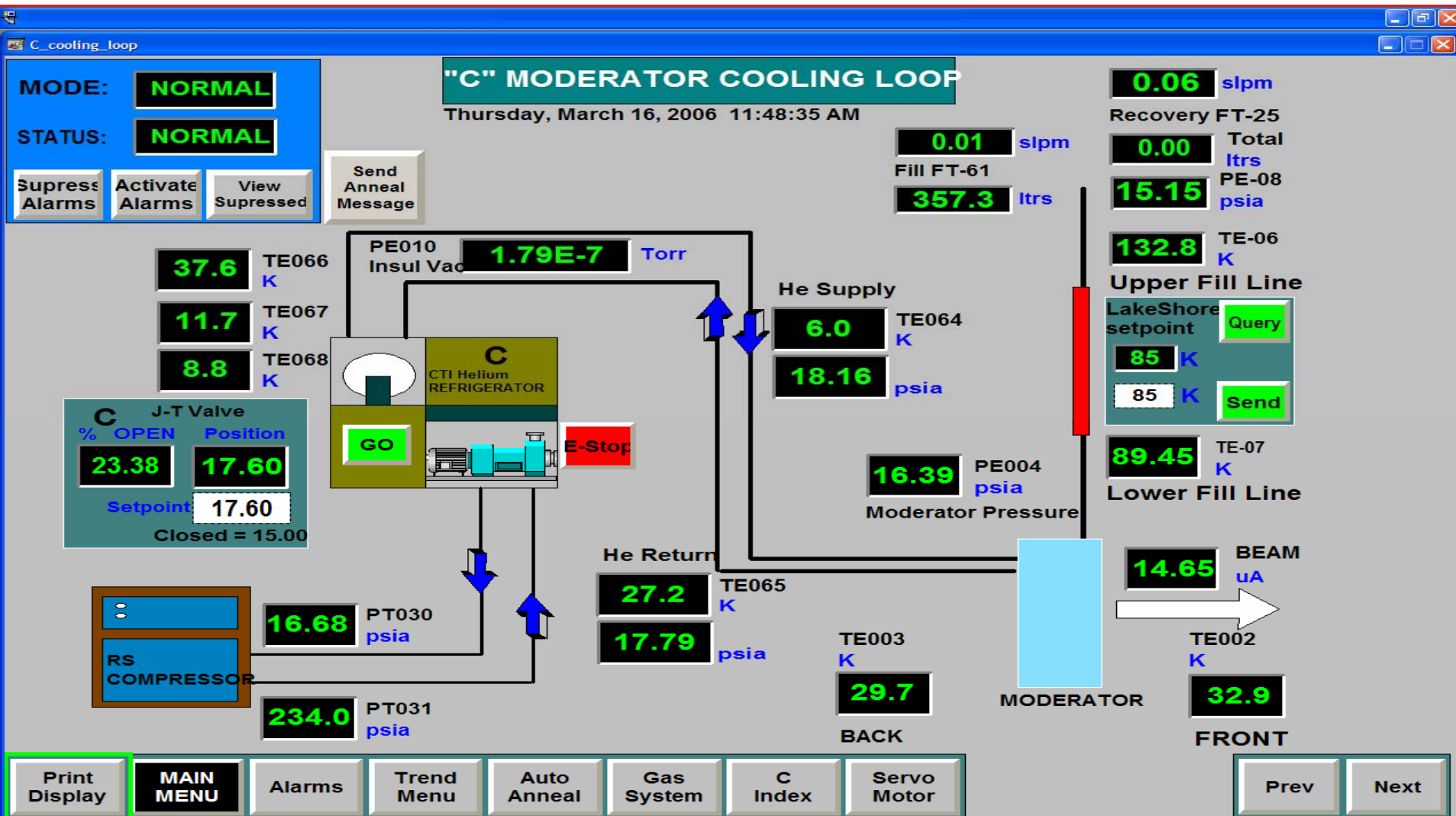


Run Cycle Operation

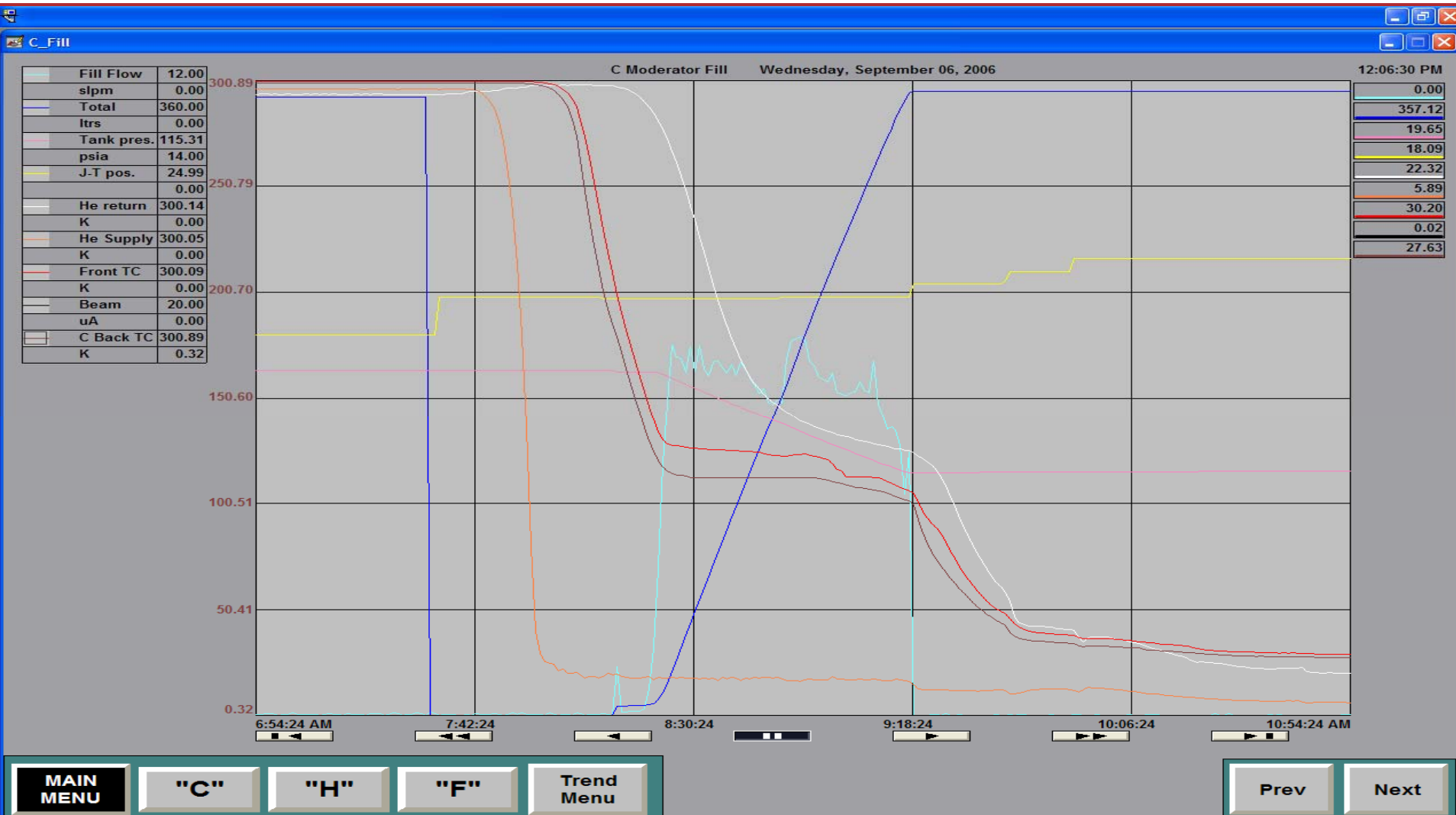
- Liquid Methane
 - Fill system with methane (gas)
 - Circulate and cool
 - Condense and circulate
 - Replace methane periodically

- Solid Methane
 - Start and cool down refrigerators
 - Cool moderator
 - Fill with methane (condensing gas)
 - Cool to operating temperature
 - Anneal every 2-3 days
 - Replace methane periodically

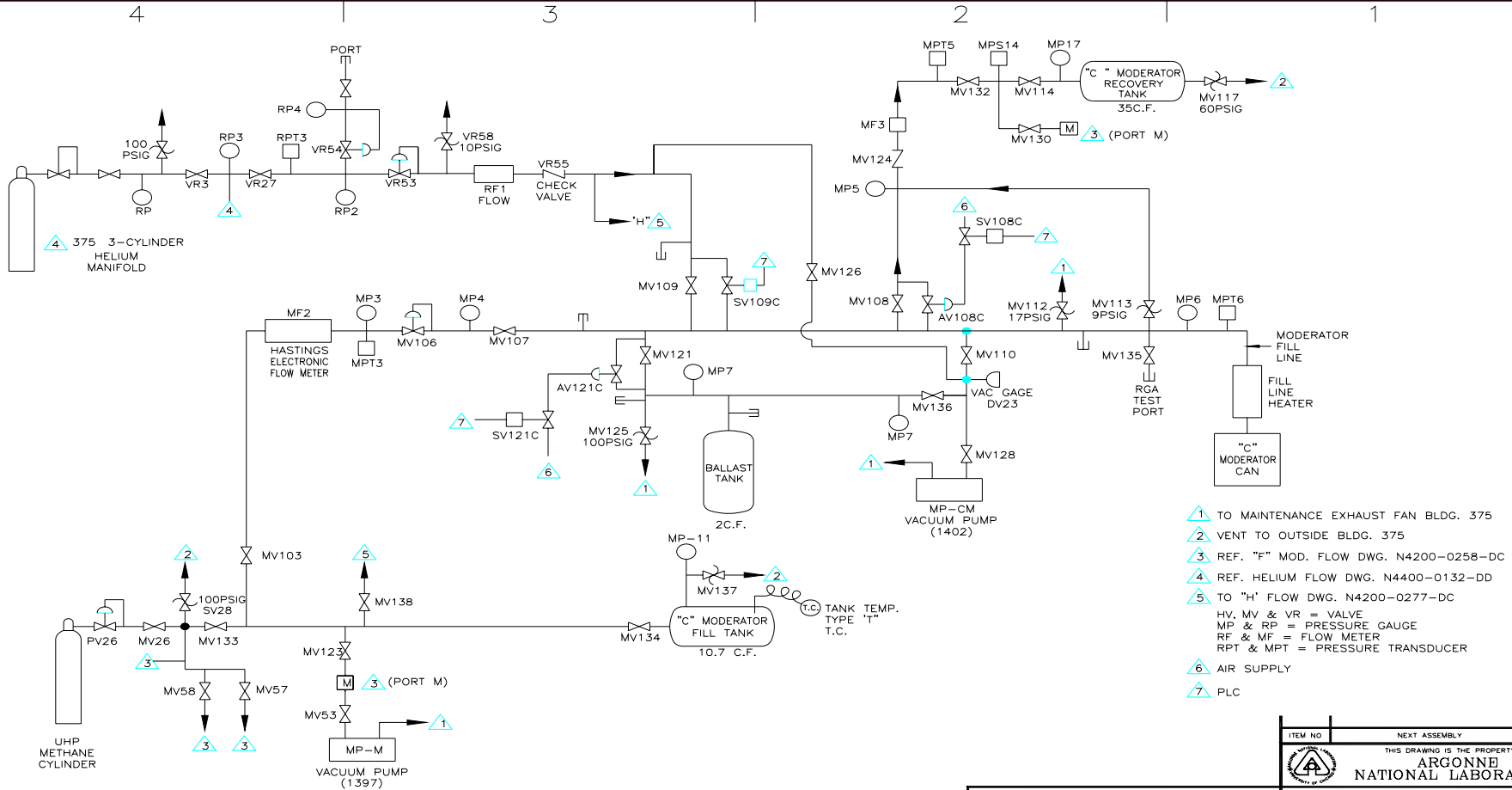
C Moderator Cooling Loop Display



Typical Moderator Cool Down



C Methane P&ID



- 1 TO MAINTENANCE EXHAUST FAN BLDG. 375
- 2 VENT TO OUTSIDE BLDG. 375
- 3 REF. "F" MOD. FLOW DWG. N4200-0258-DC
- 4 REF. HELIUM FLOW DWG. N4400-0132-DD
- 5 TO "H" FLOW DWG. N4200-0277-DC
- HV, MV & VR = VALVE
- MP & RP = PRESSURE GAUGE
- RF & MF = FLOW METER
- RPT & MPT = PRESSURE TRANSDUCER
- 6 AIR SUPPLY
- 7 PLC

DATE	DESCRIPTION	BY	CHKD	DATE
03	DCN. N4200-138	PJC		
02	MISC. CHANGES	PJC		
01	MISC. CHANGES	PJC		

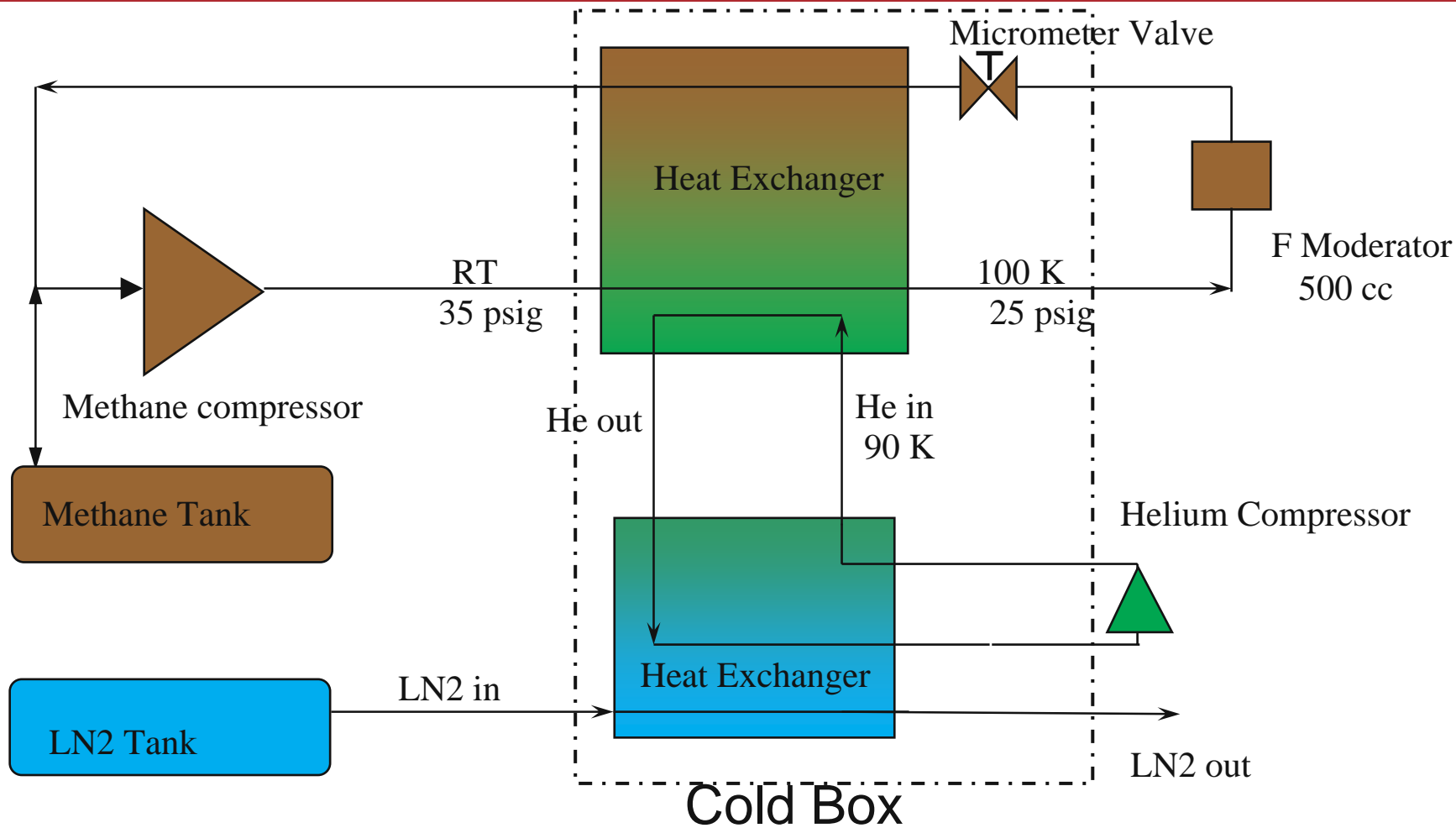
UNLESS OTHERWISE NOTED
 ALL DIMENSIONS ARE INCHES
 DECIMAL TOLERANCE
 .X .1
 .XX .02
 .XXX .005
 ANGULAR TOL ±1/2°
 FRACTIONAL TOL ±1/64
 REMOVE ALL BUBBS AND SHARP EDGES
 SURFACES TO BE IN ACCORDANCE
 WITH LATEST ASME B4.1
 DIMENSIONS & TOLERANCES IN
 ACCORDANCE WITH LATEST ASME Y14.5

RECORD NUMBER P00436			
DRAWN BY	DATE	GP LEADER	DATE
CALAHAN			
CHECKED		PROJECT MGR	
RESPONSIBLE ENGINEER		APVD/RELEASED	
MATERIAL			

ITEM NO	NEXT ASSEMBLY	REQD
THIS DRAWING IS THE PROPERTY OF ARGONNE NATIONAL LABORATORY		
TITLE		
"C" IPNS MODERATOR FILL STATION FLOW DIAGRAM		
SCALE	SHEET	DRAWING NUMBER
NONE	1 OF 1	N4200-0266-DC
		REV 03

DWG NO. N4200-0266-DC

Liquid Methane System (simplified)

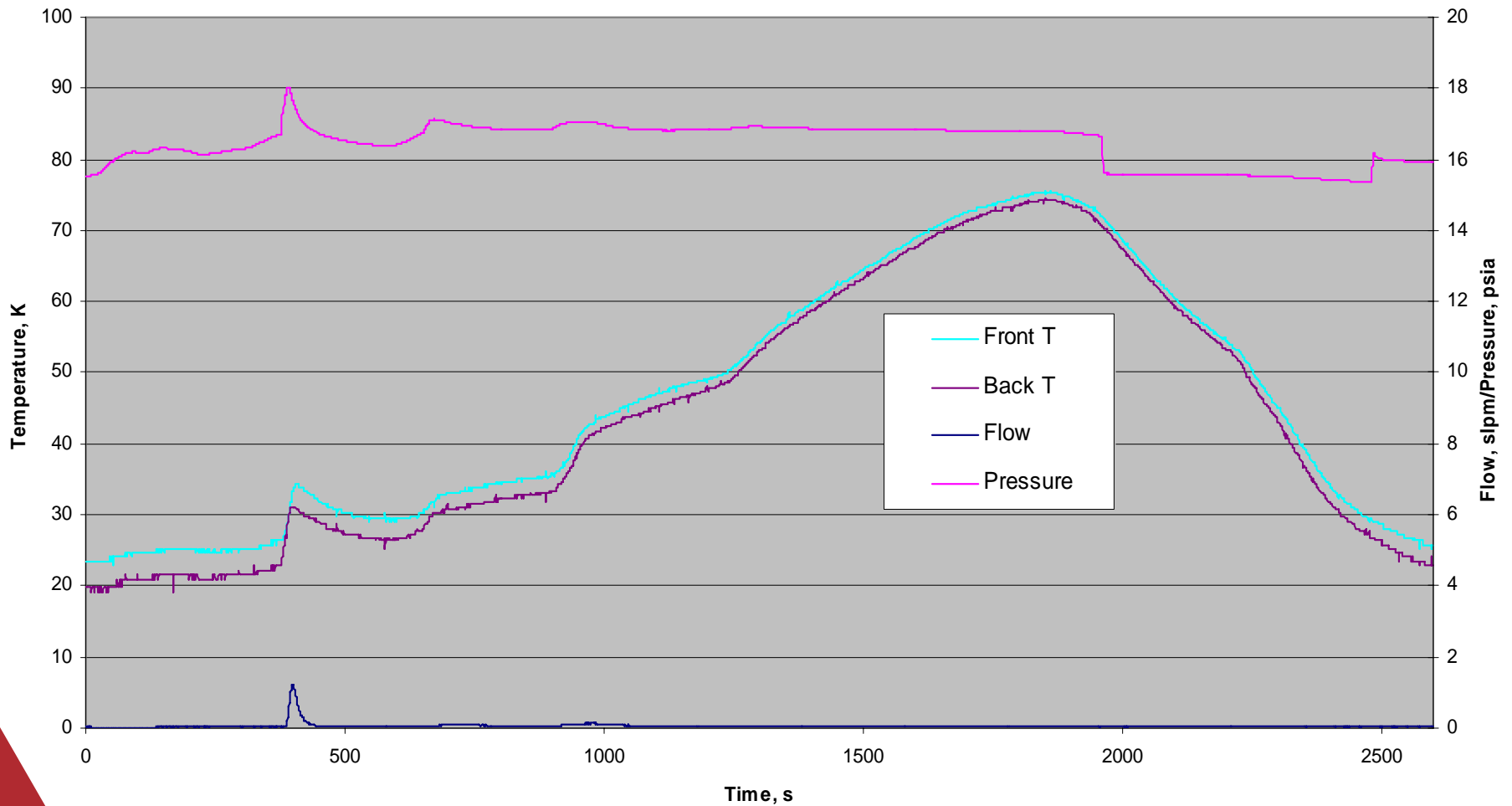


Operation Issues Of Methane Moderators

- Radiation damage products - CH_3^\cdot H^\cdot
 - Liquid
 - *Polymerization*
 - *Hydrogen formation*
 - Solid
 - *Stored Energy*
 - *Hydrogen Formation*
 - *Polymerization*

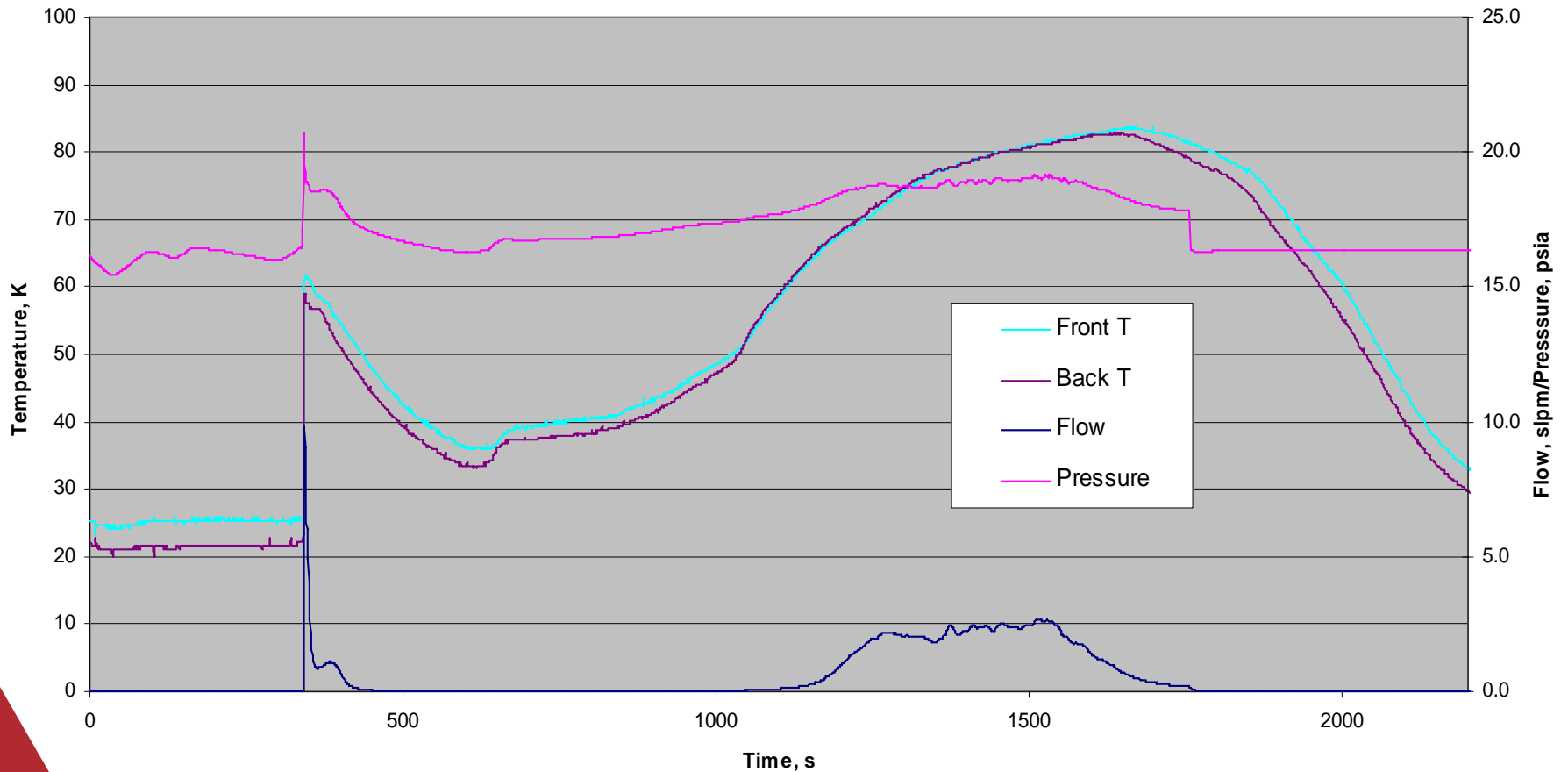
Anneal Temperature Response

C Anneal, 25 K Operation
185 uAh Irradiation

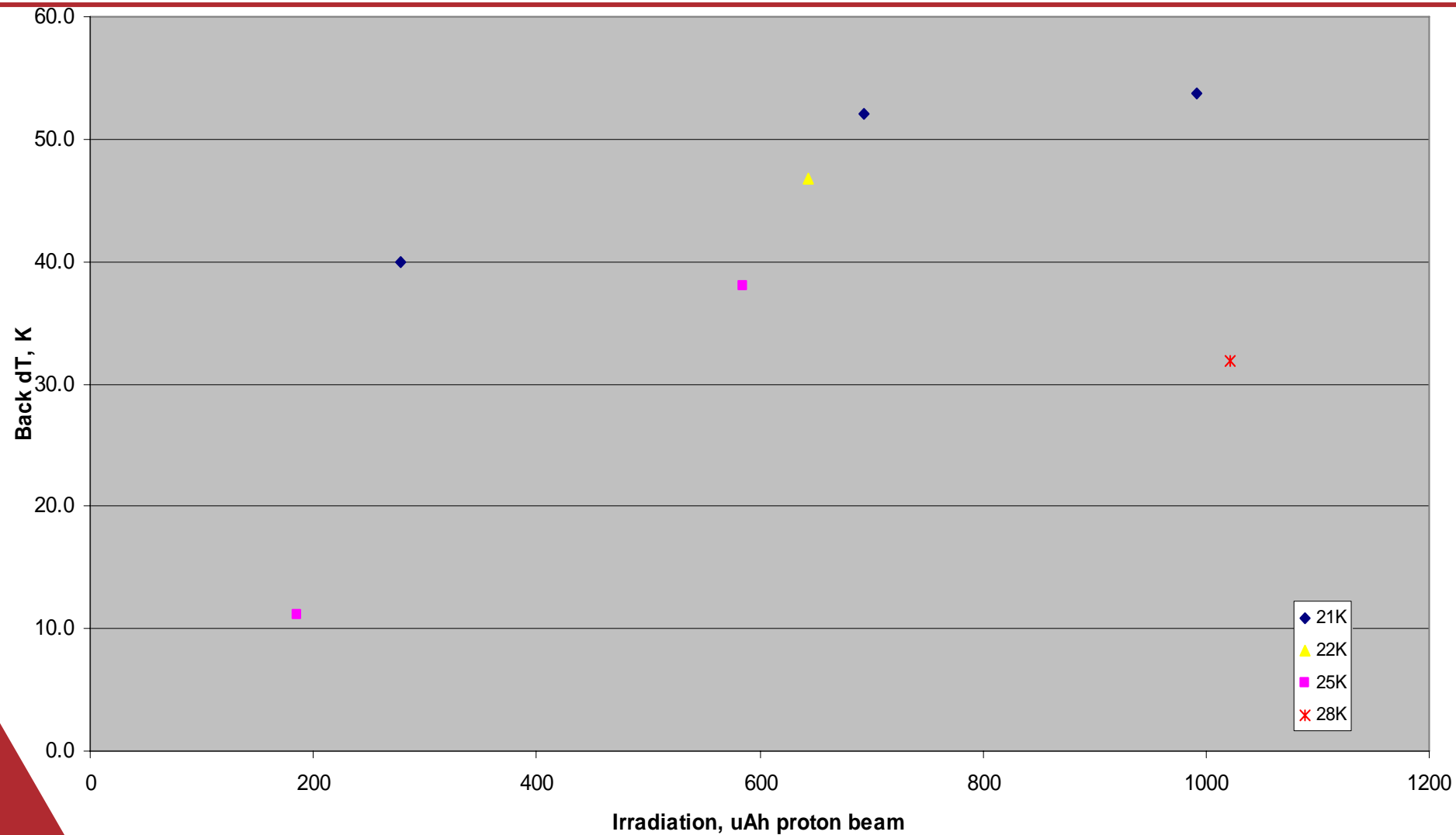


Anneal Temperature Response

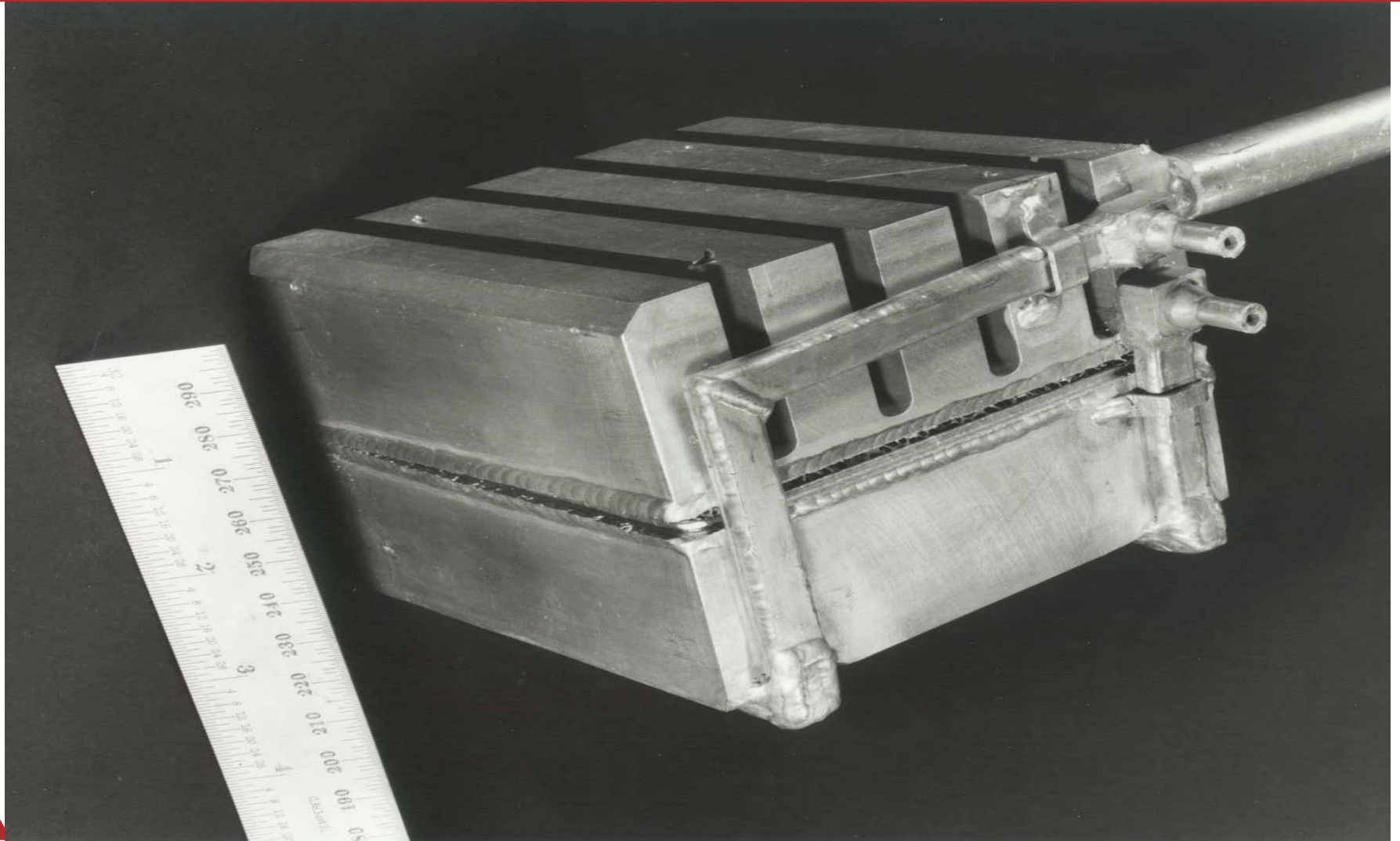
C Anneal, 25 K Operation
1279 uAh Irradiation



C Moderator Anneal Energy Release



Burst C Moderator



Acknowledgements

- Thanks to M. Wolbing, J. Baldwin, M. Schlueter and T. Tafoya for their efforts in operating and maintaining the high reliability of the moderator system.