FNAL Pbar Target Station

Overview and Target Issues

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High-Power Targetry Workshop

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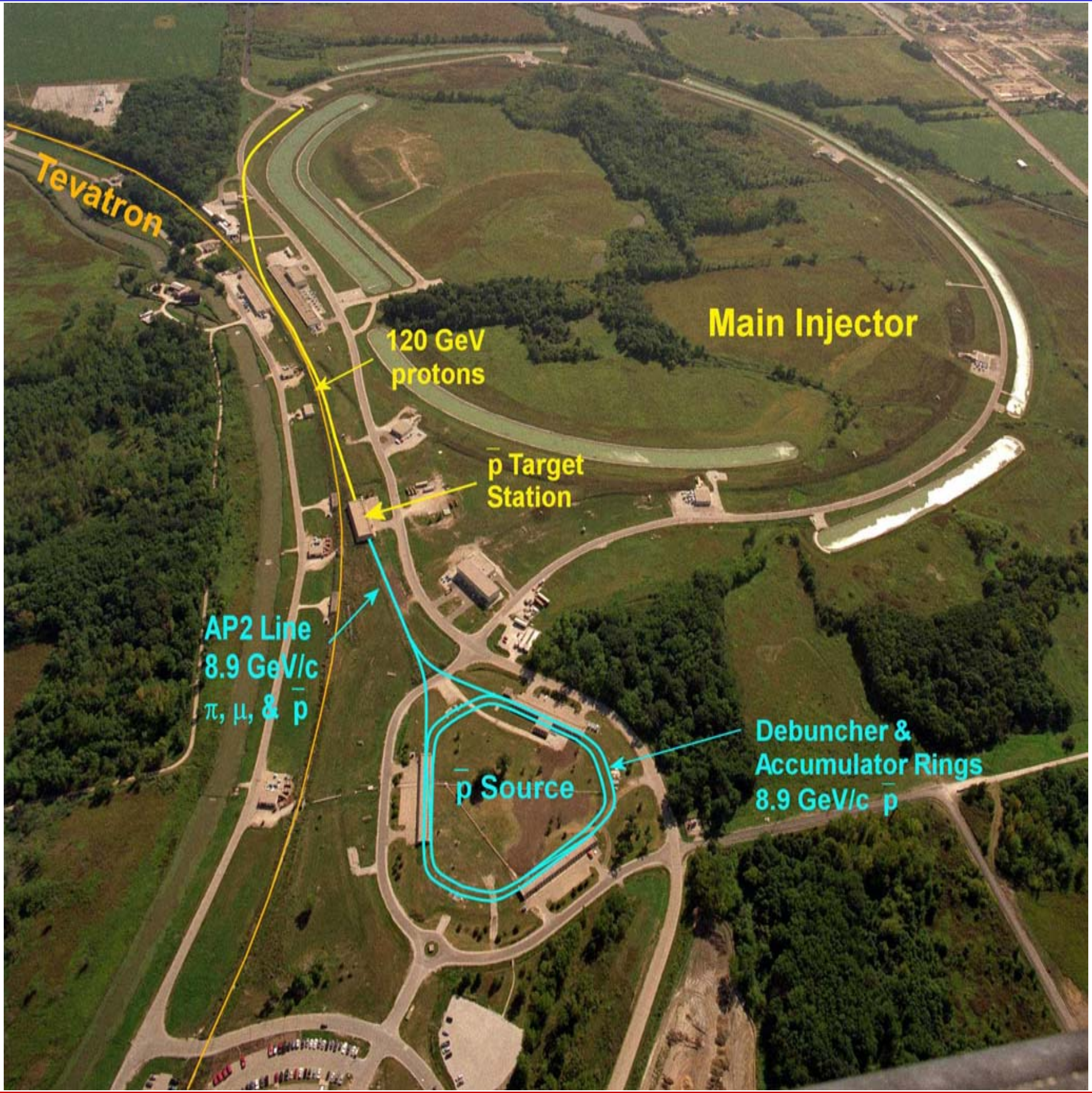
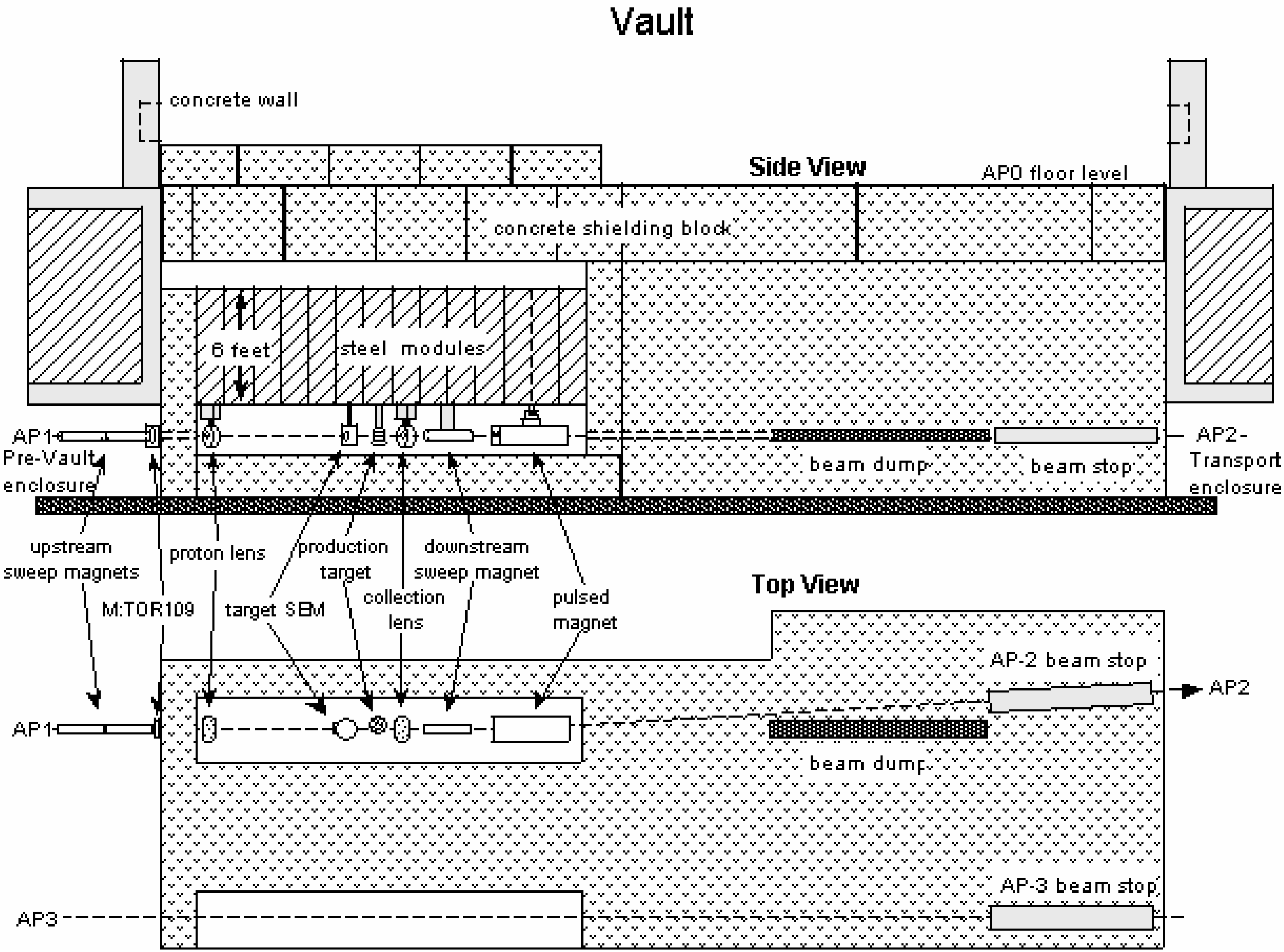
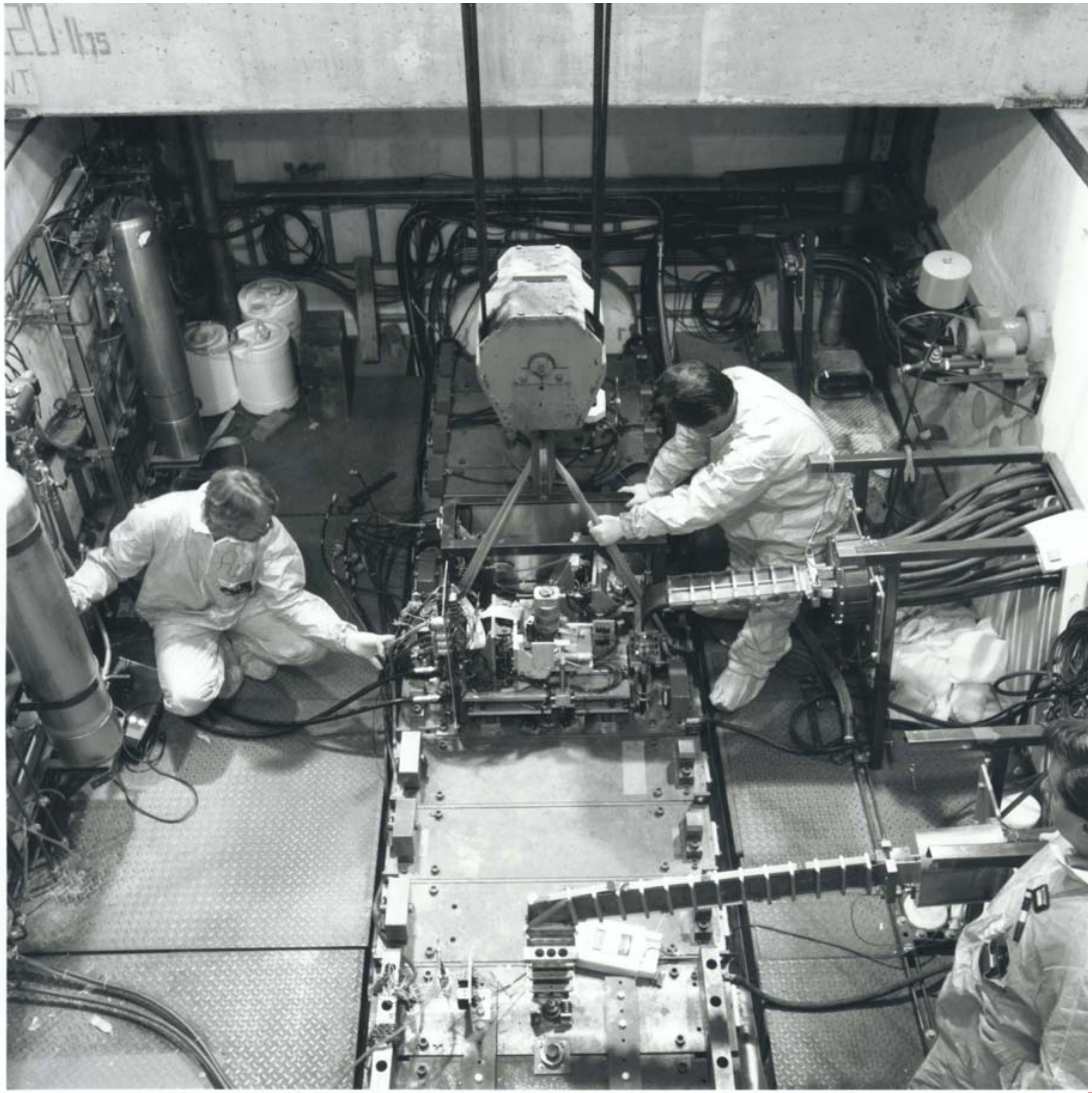
Aerial photograph of Pbar Source



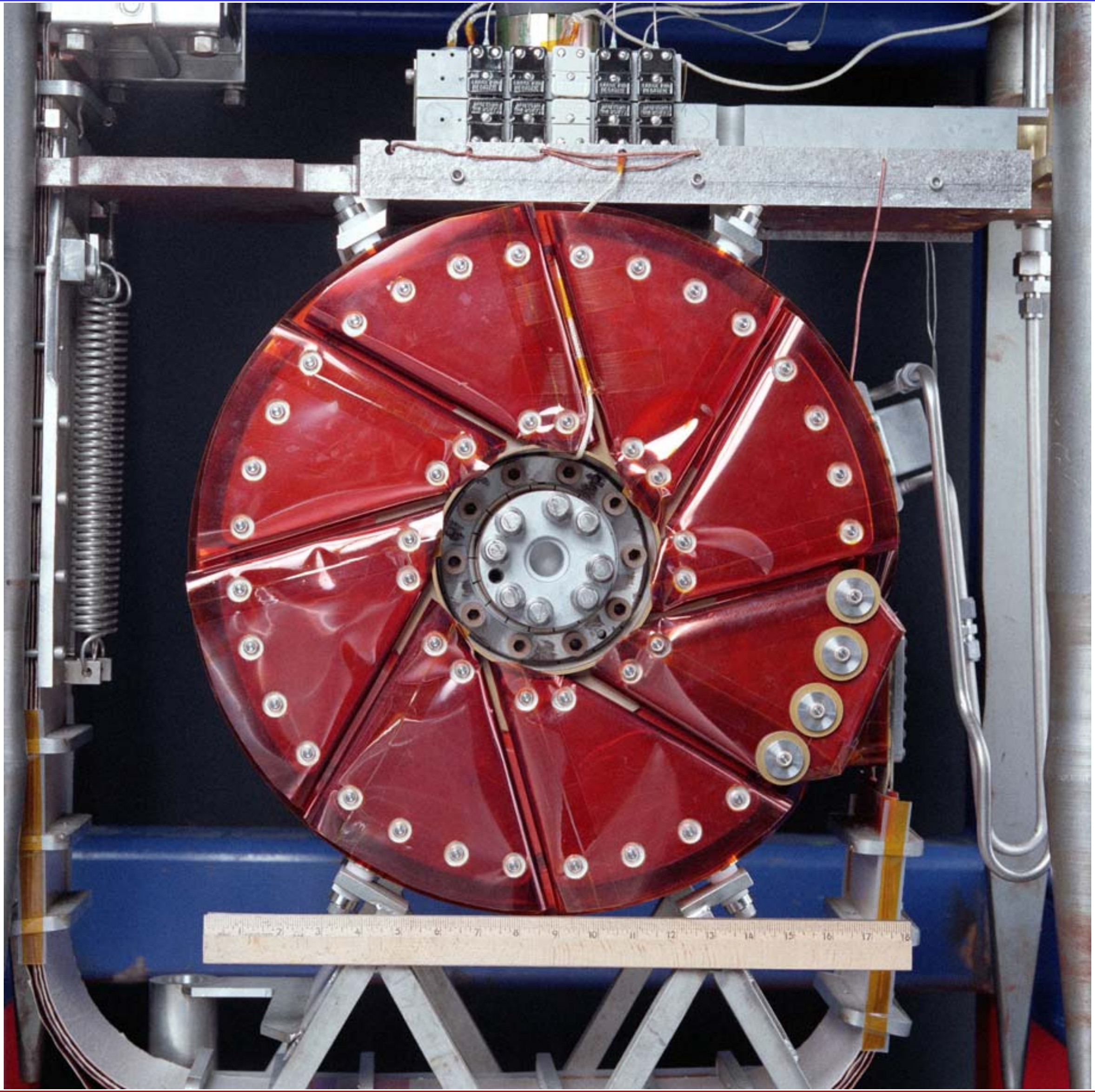
Pbar Target Vault



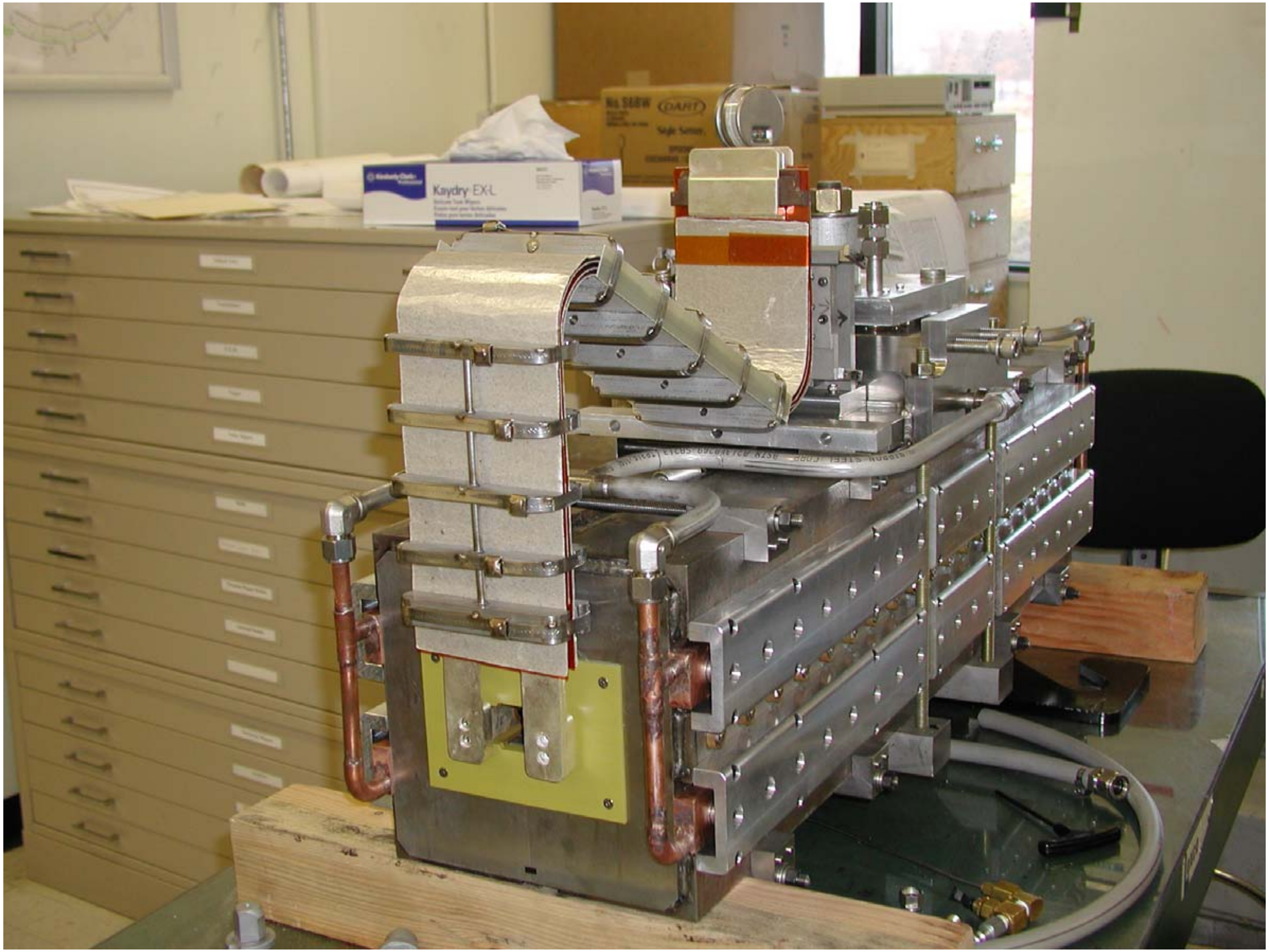
Workers in target vault



Lithium Lens

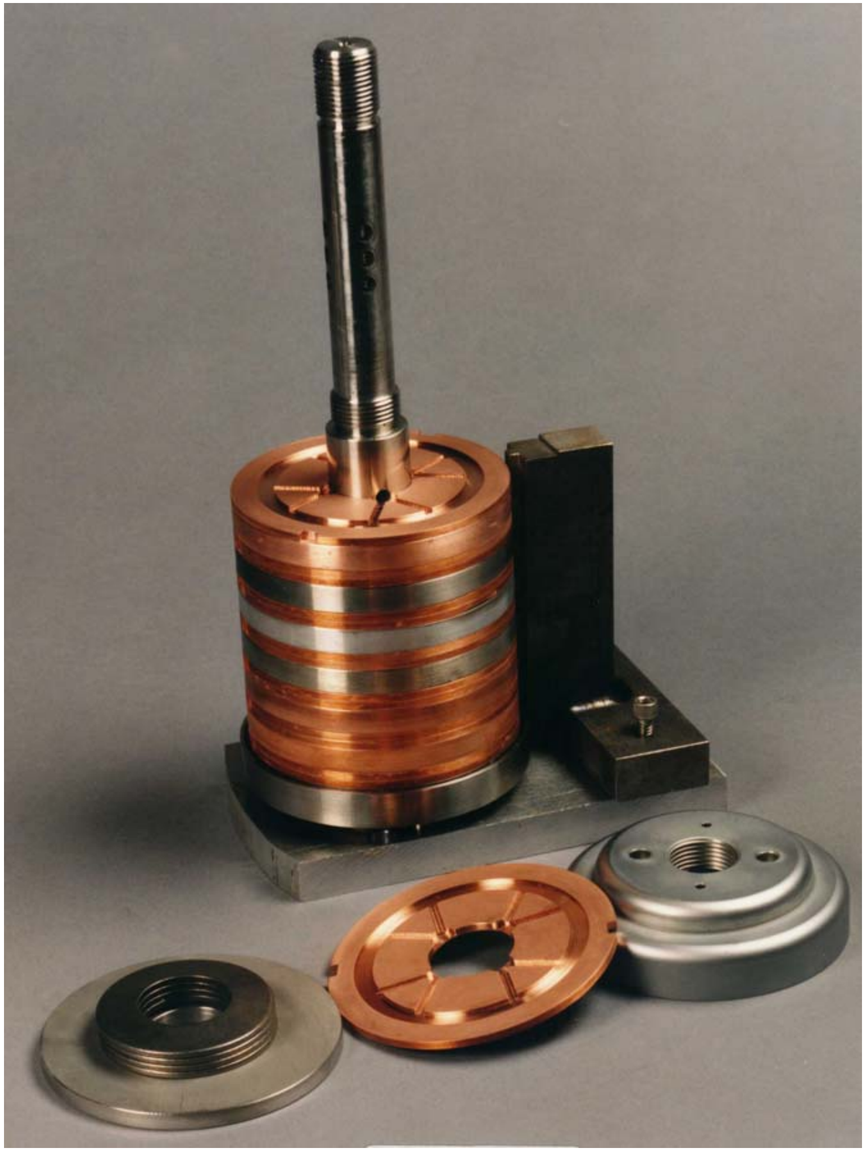


Single turn 3-degree pulsed magnet

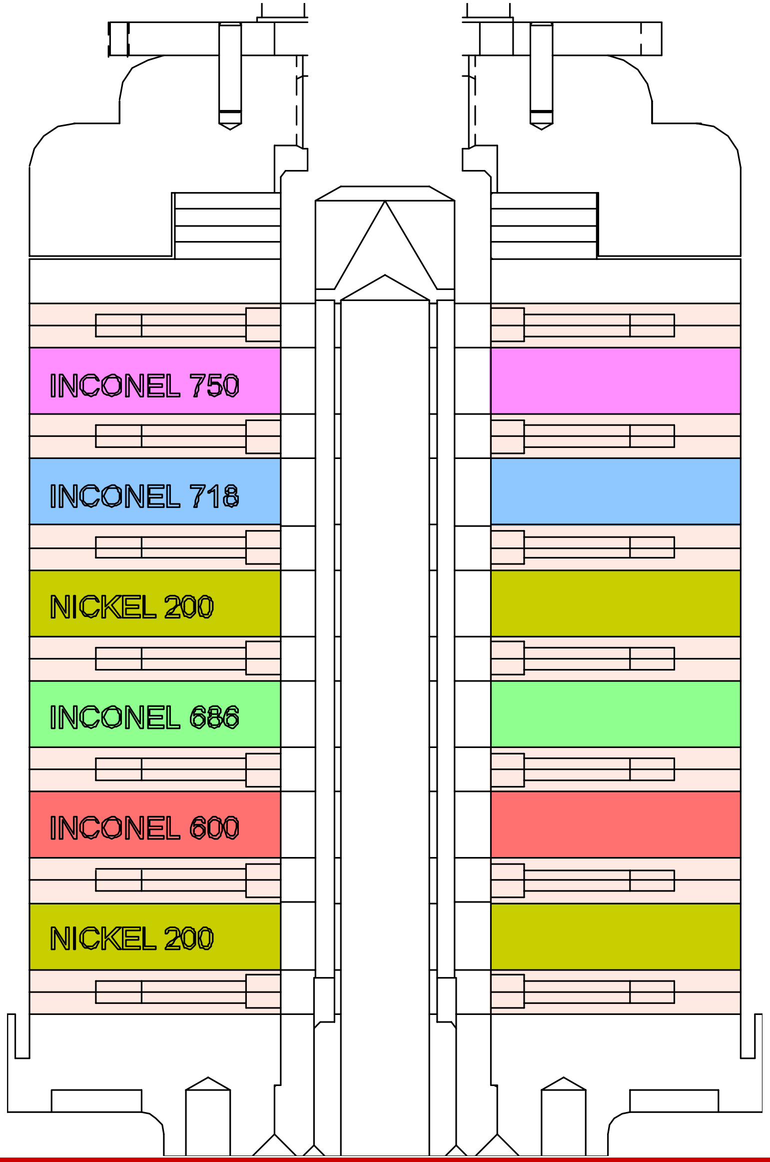


Gear drive target assembly

Target stack showing cooling disk



Pbar target assembly presently in use



Preparing for more protons on target

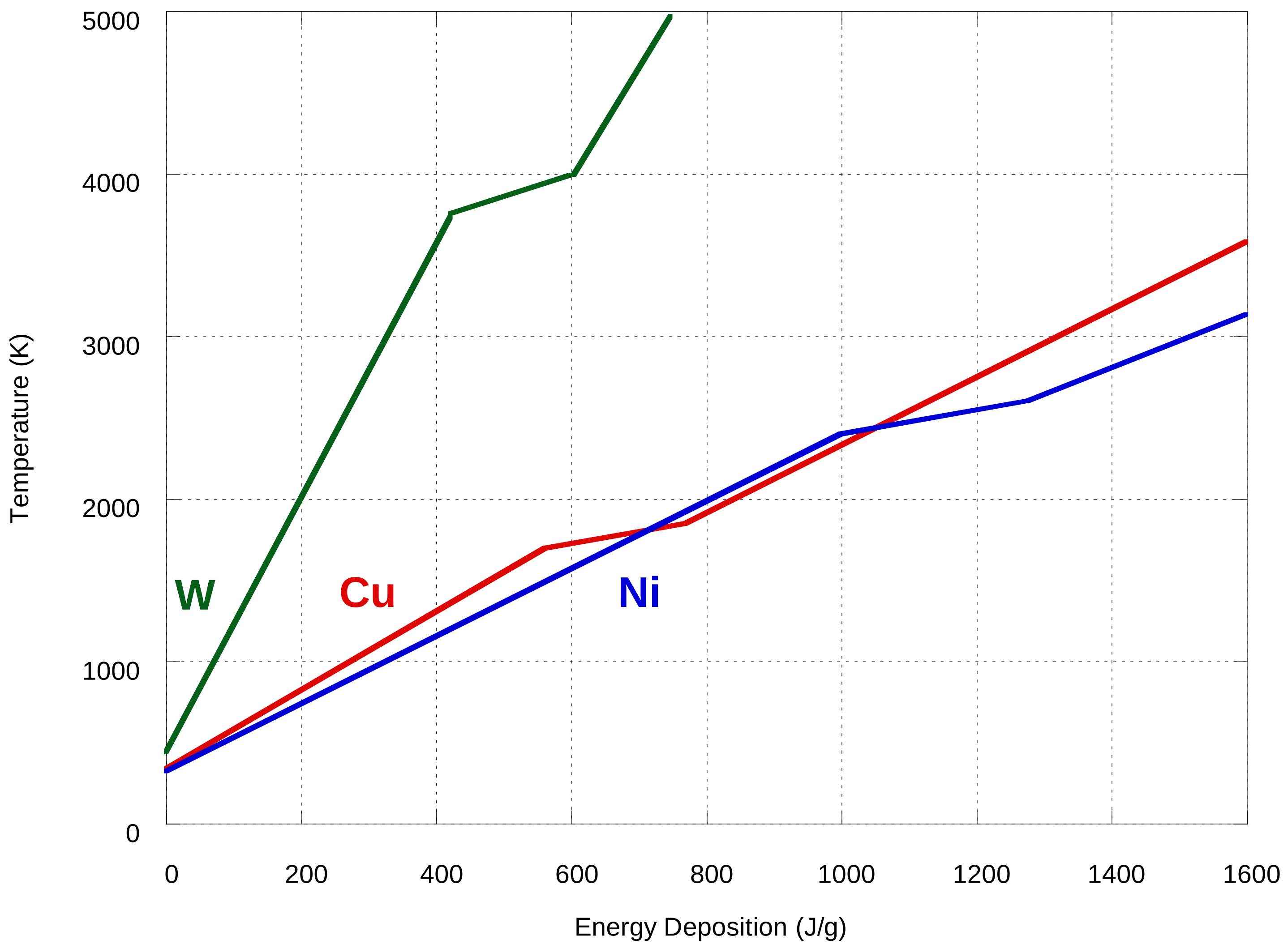
- Beam Studies
  - Quantify spot size vs. pbar yield relationship for spot sizes below σ=0.15 mm
  - Look for evidence of yield reduction due to melting
  - Attempt to create single pulse damage to copper disk
- Alternative target material
  - Identify target materials that are superior to Nickel in longevity while minimizing the loss of normalized yield
  - Examine damage to old targets
- Beam Sweeping
  - Commission sweeping system to reduce peak energy deposition in the target
  - Investigate the possibility of running with only the upstream sweeping system

Damage to titanium cover and nickel target

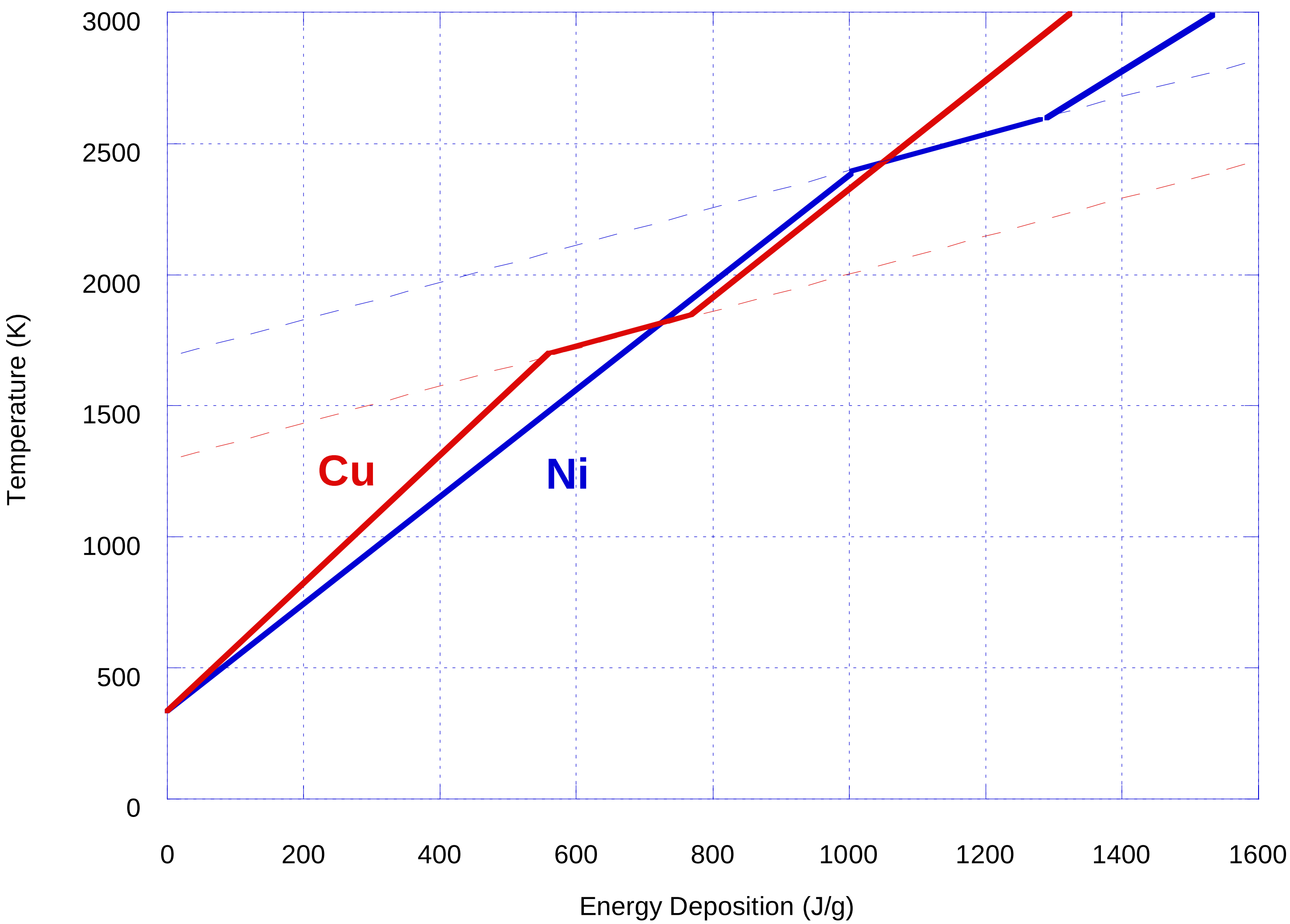
Target material comparison

Target Material	Iridium	Rhenium	Tungsten	Nickel	Copper
$A^{1/3}/\rho$ (m^3/Kg)	.255	.271	.295	.437	.445
$A^{1/3}/\rho$ (Normalized)	1.71	1.61	1.48	1	.98
Observed Yield (Normalized)			1.05	1	.99
Melting Point Energy (J/g)	460	610	630	1,250	770
Yield Strength (kPa)	160	270	500	230	72
Gruneisen parameter (kPa Kg/J)	80.6	66.0	31.0	15.8	17.2

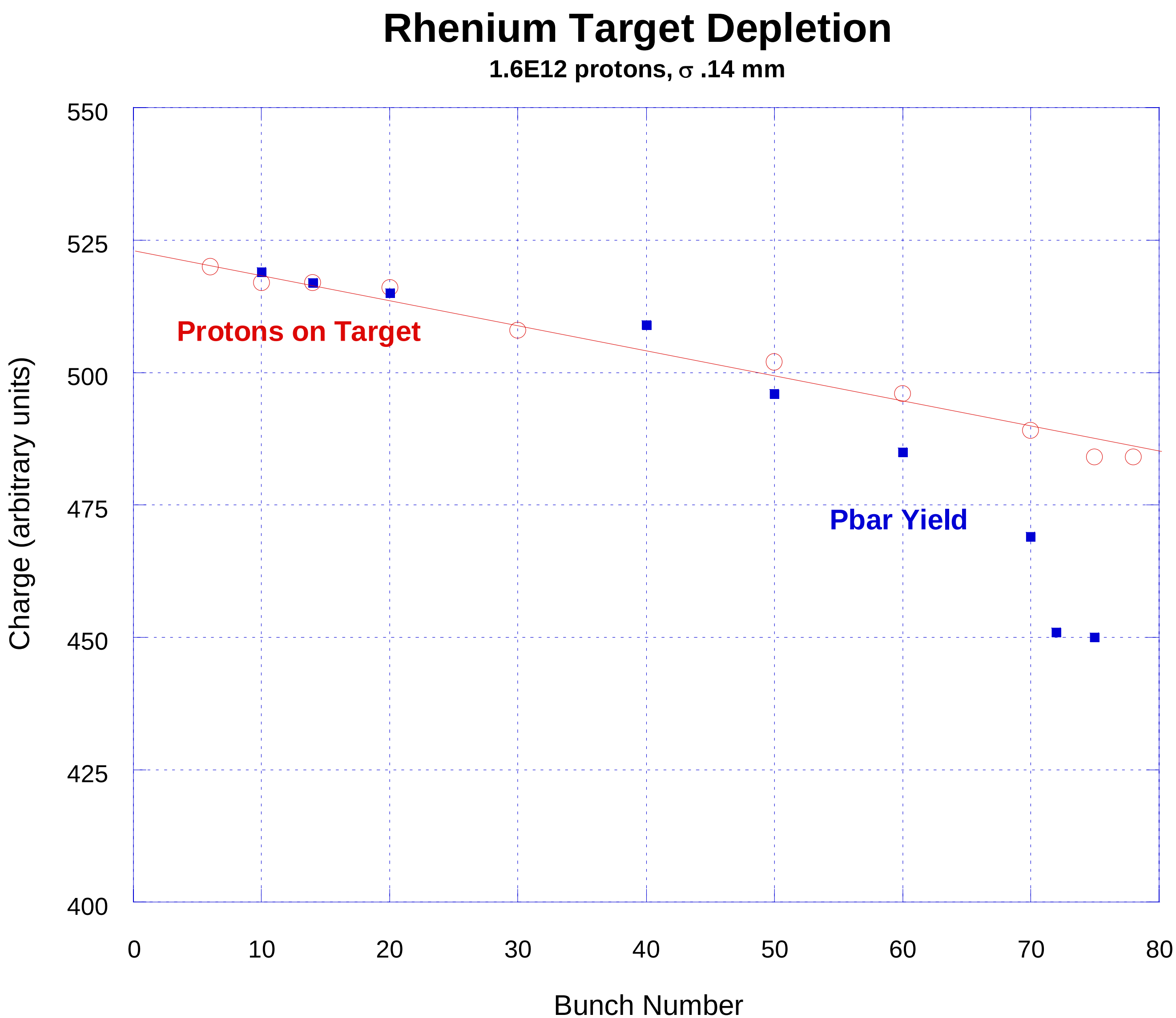
Energy deposition vs. peak target temperature



Energy deposition vs. peak target temperature



Apparent target depletion due to melting



Damage to Tungsten-Rhenium target

Damage to Tungsten target

Early target assembly

Holes in Copper Target

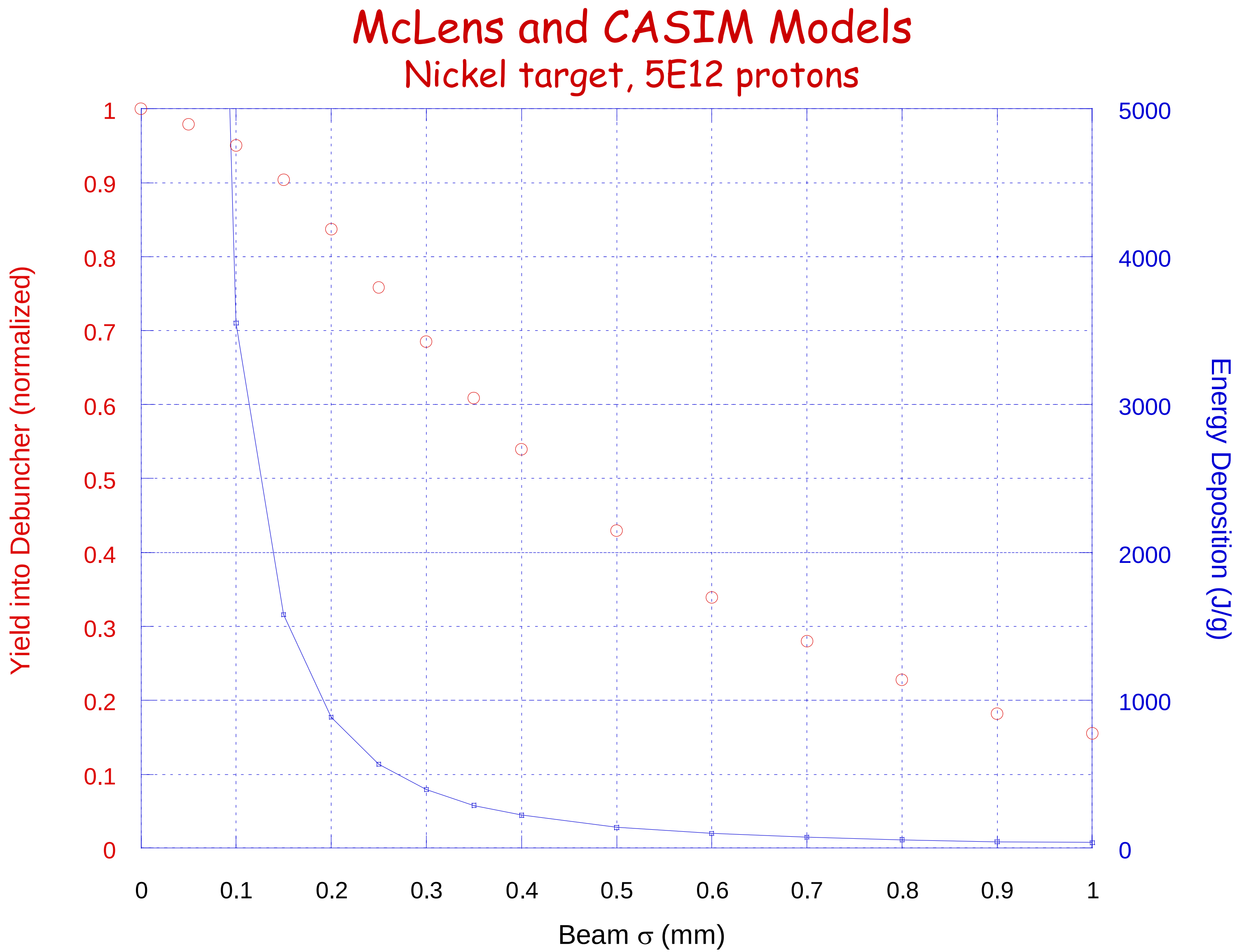
Old target assembly with cover removed

Bulges on titanium target cover

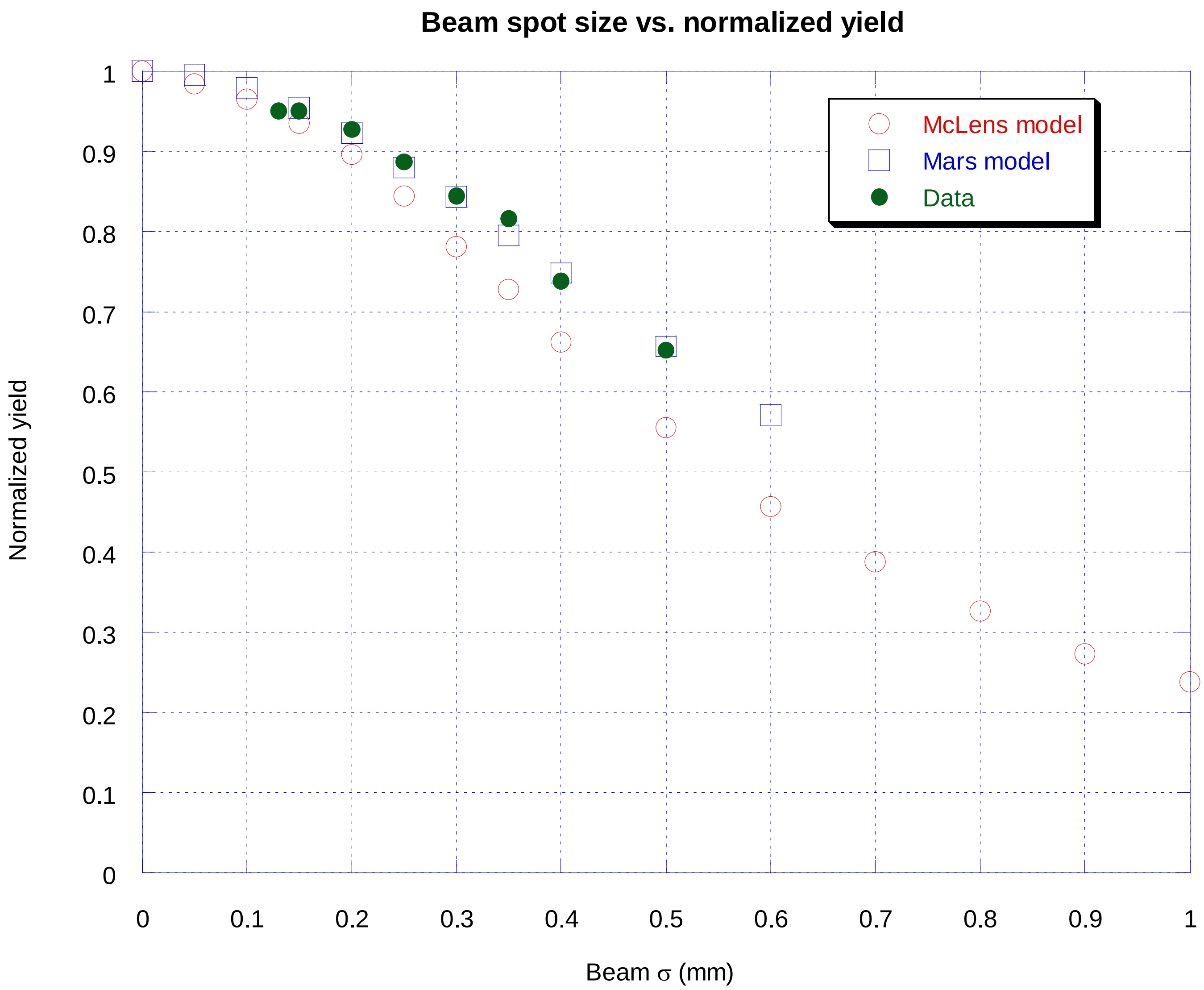
Target damage to nickel target (entry)

Target damage to nickel target (exit)

Pbar yield and peak energy deposition vs. spot size



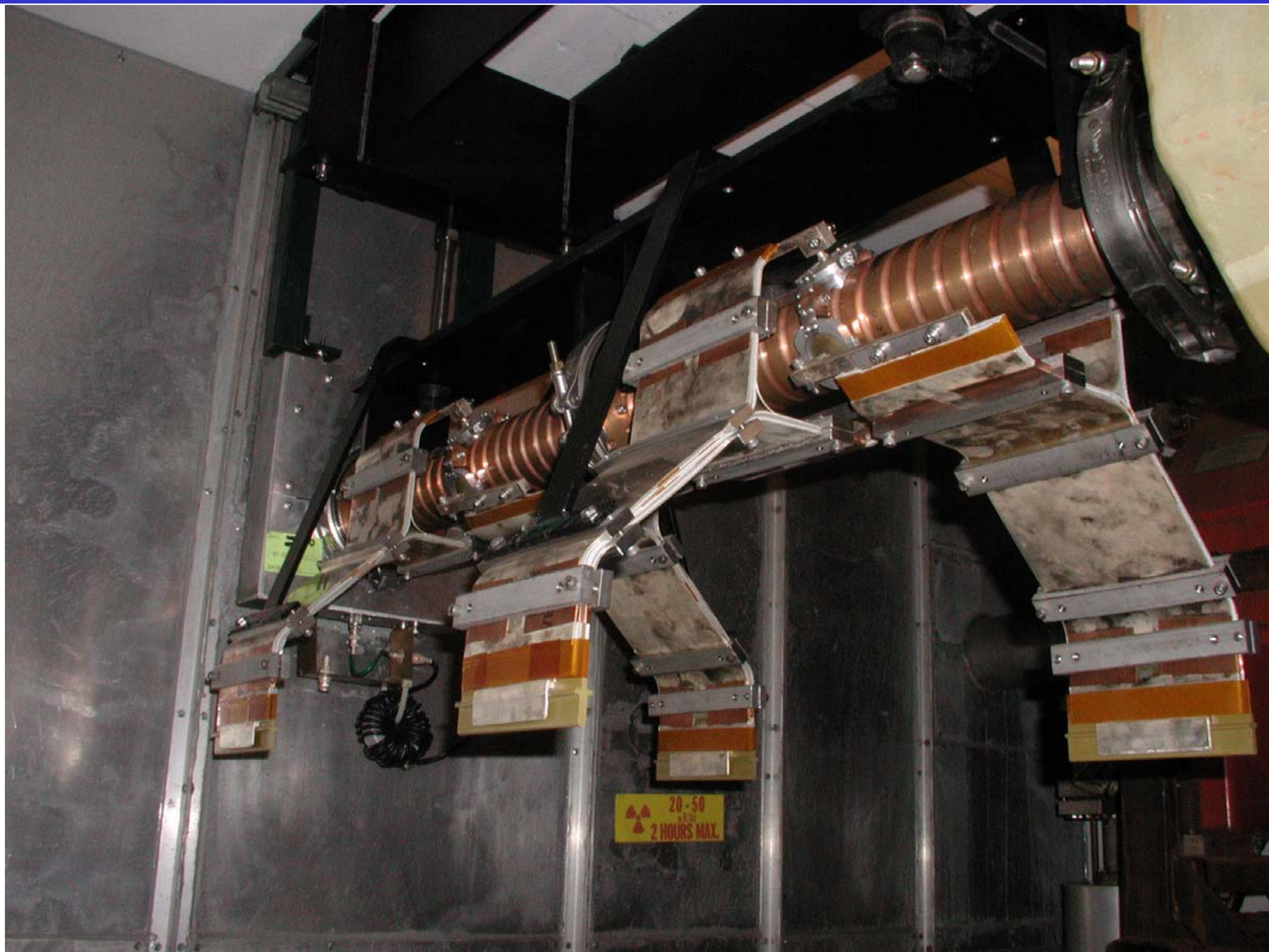
Comparison of model and data yield curves



Summary of target material endurance study

Material	Spot size	Starting Yield	Ending Yield	Protons On target	Yield reduction Scaled to 10^{18} protons
Nickel 200	σxy = 0.15, 0.16	1.000	0.970	5.7×10^{17}	5.3%
Nickel 200	σxy = 0.22, 0.16	0.990	0.935	6.6×10^{17}	8.3%
Inconel® 600	σxy = 0.15, 0.16	0.995	0.970	10.6×10^{17}	2.4%
Inconel® 600	σxy = 0.22, 0.16	0.990	0.960	10.7×10^{17}	2.8%
Inconel® 625	σxy = 0.22, 0.16	0.980	0.970	6.6×10^{17}	1.5%
Inconel® X-750	σxy = 0.15, 0.16	0.985	0.965	5.7×10^{17}	3.5%
Inconel® 686	σxy = 0.15, 0.16	0.970	0.935	1.0×10^{17}	38.2%
Stainless 304	σxy = 0.15, 0.16	1.000	0.965	6.1×10^{17}	5.8%

Upstream sweeping magnets installed in AP-1 line



Pbar target and beam sweeping, Summary

- Pbar Target and Beam Sweeping
  - Inconel® 600 identified as operational target material
    - Although Inconel® X-750 and Stainless 304 aren't bad
  - There may not be a benefit in reducing spot sizes to the original goal of σ = 0.10 mm
    - Beam studies show spot sizes below σ = 0.15 mm produce little or no antiproton yield as much as models predict
  - Target damage and yield reduction are not as severe as expected at small spot sizes
  - Single pulse target damage observed with copper
    - Energy deposition a factor of 3 above that required for the onset of melting
  - Yield reduction from target melting has not been observed
  - Upstream beam sweeping system is ready for testing with beam