Targetry Studies at BNL

Harold G. Kirk
Brookhaven National Laboratory

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Outline

1. Targetry Issues
2. The Targets
3. The Target System
4. Summary and Plans

Targetry Challenges

Study 1 Requirements

- 1.5 MW 16 GeV proton driver
- Low-Z Carbon target

Study 2 Requirements

- 1 MW 24 GeV proton driver
- High-Z Mercury target

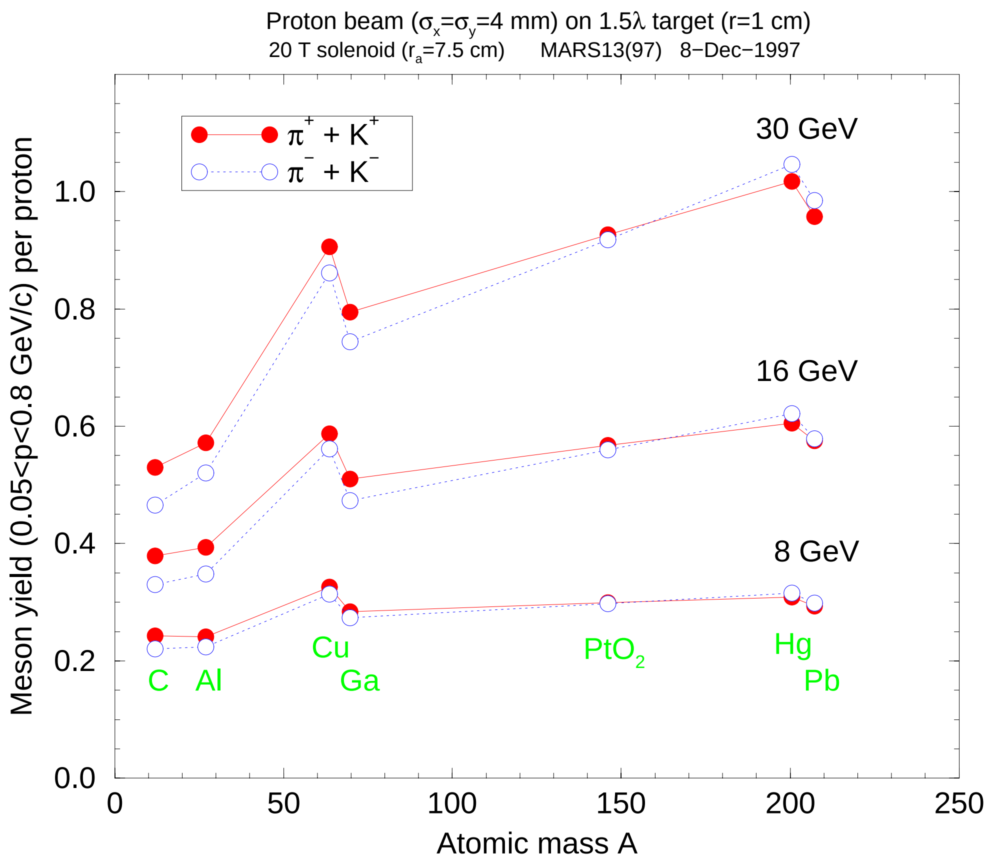
Future upgrades

- 4 MW proton driver
- Target: ?

Capture in 20 T SC Solenoid

- Magnetohydrodynamic behavior of target
- Target dispersal in 20 T field

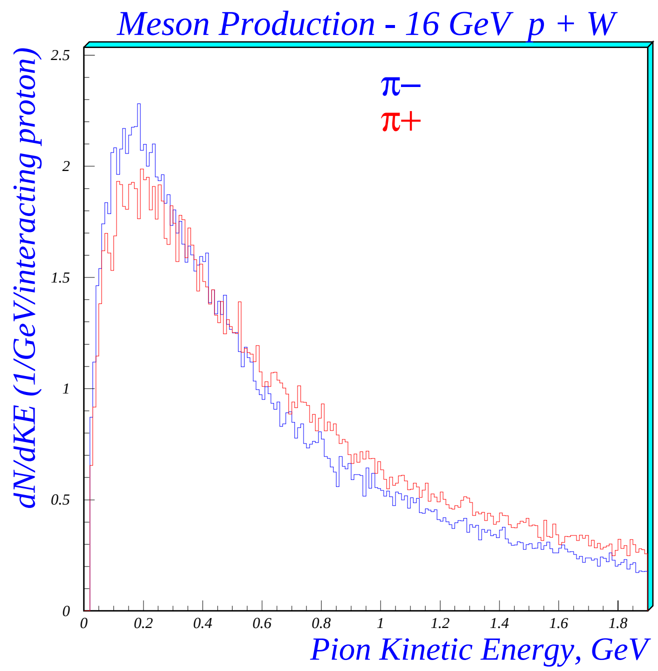
Target Types



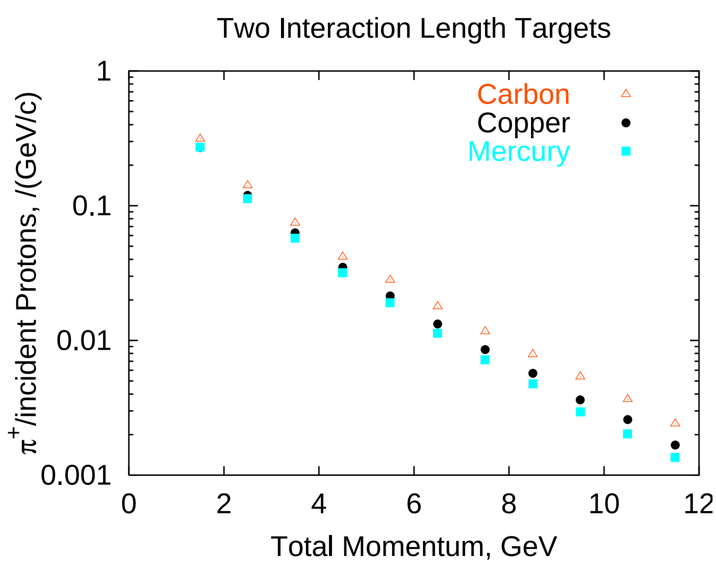
- Low-Z: Less peak energy dissipation
- Mid-Z: Stronger material
- High-Z: Higher pion yield

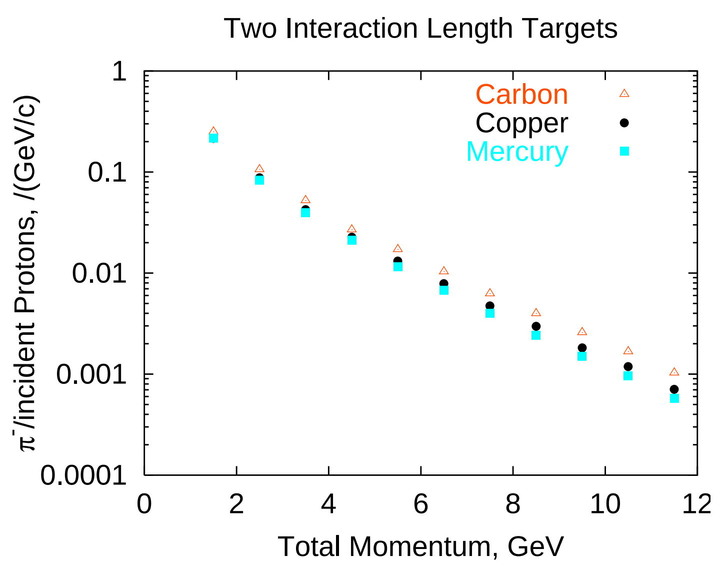
Pion Production

High-Z is best for maximal soft pion production

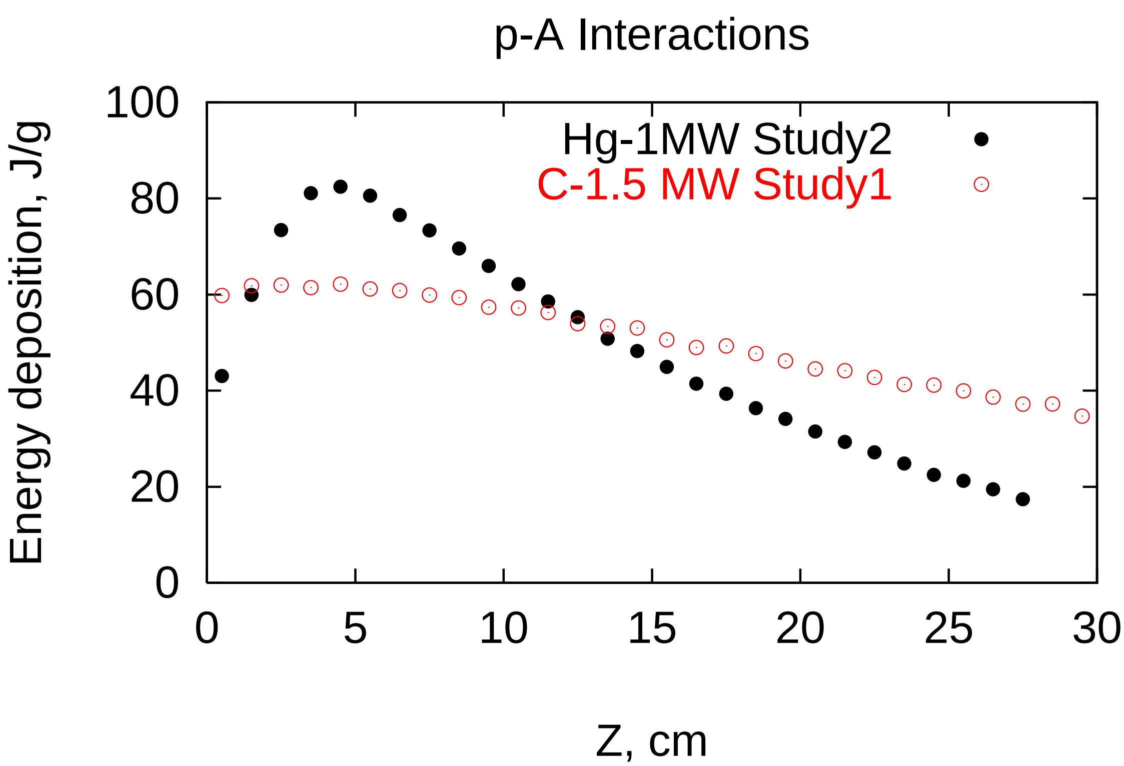


However: Low-Z is best for higher momentum pion production

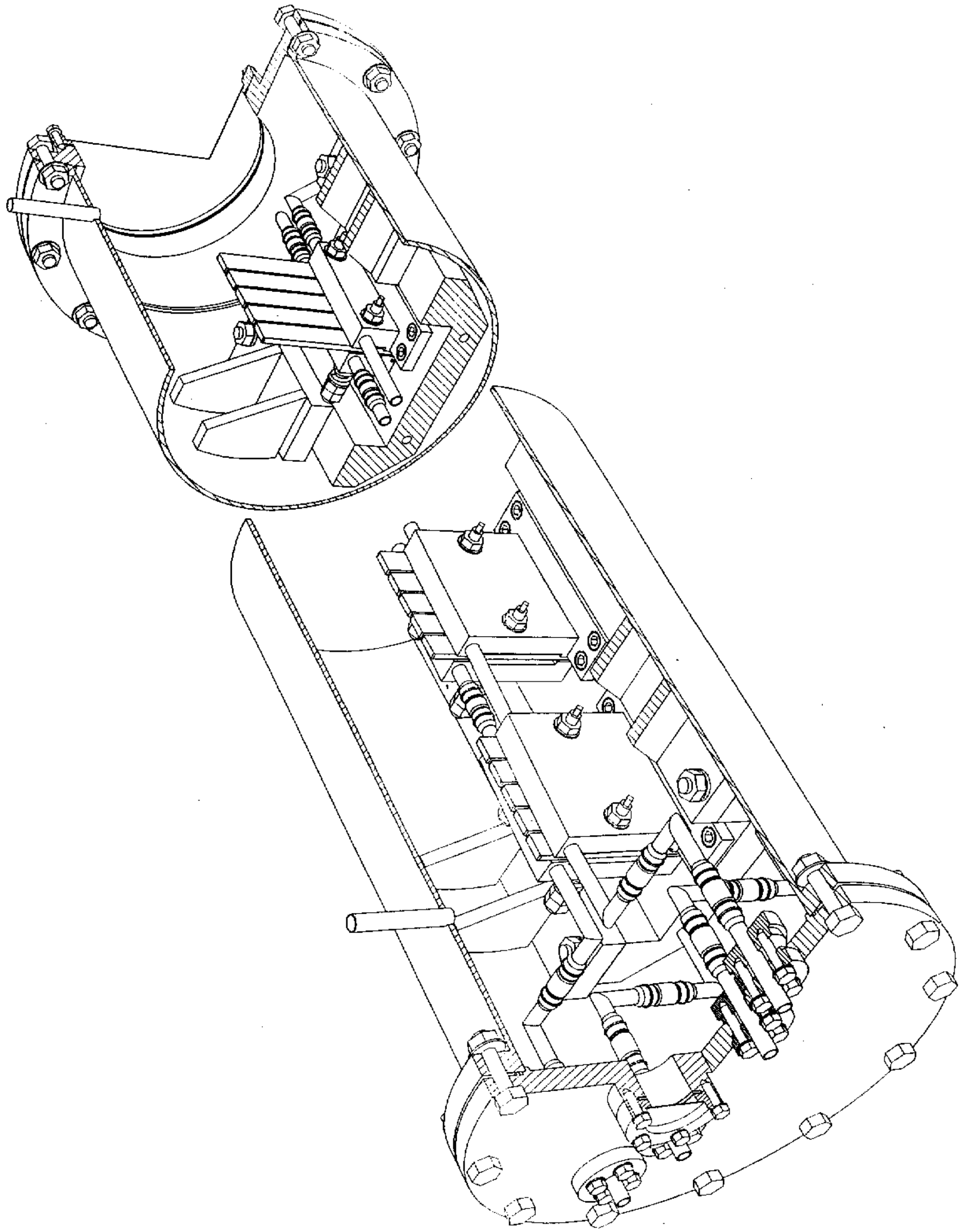




Low-Z Targets: Carbon

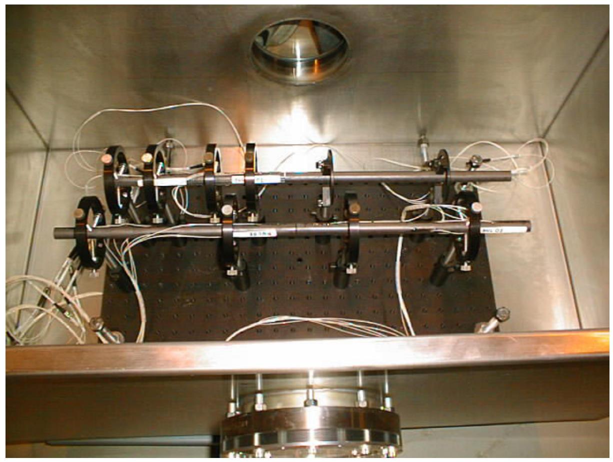


- Less peak energy dissipation
- Stationary 1MW Target Possible -Numi
- ORNL sublimation studies
- Doubtful beyond 1.5 MW

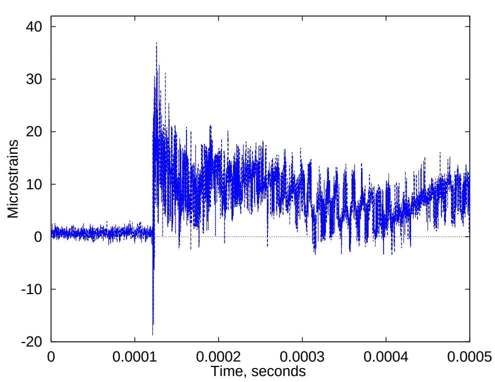


Perspective view of the target design.

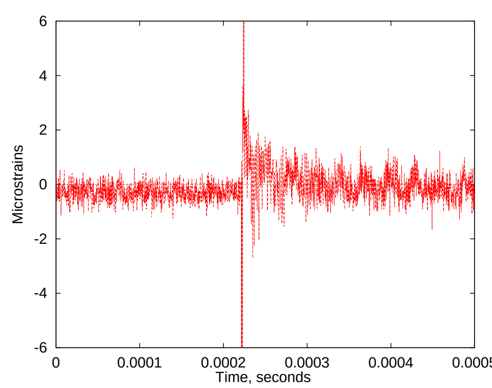
E951 Carbon Rods Test



ATJ



Carbon-Carbon



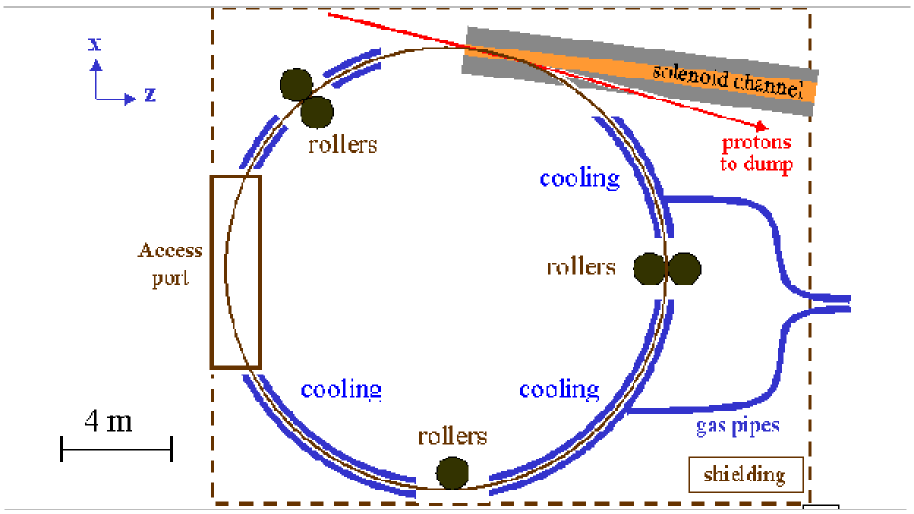
- The strain amplitudes for the anisotropic carbon-carbon composite are a factor of ~10 less than for ATJ carbon.

Carbon Target Properties

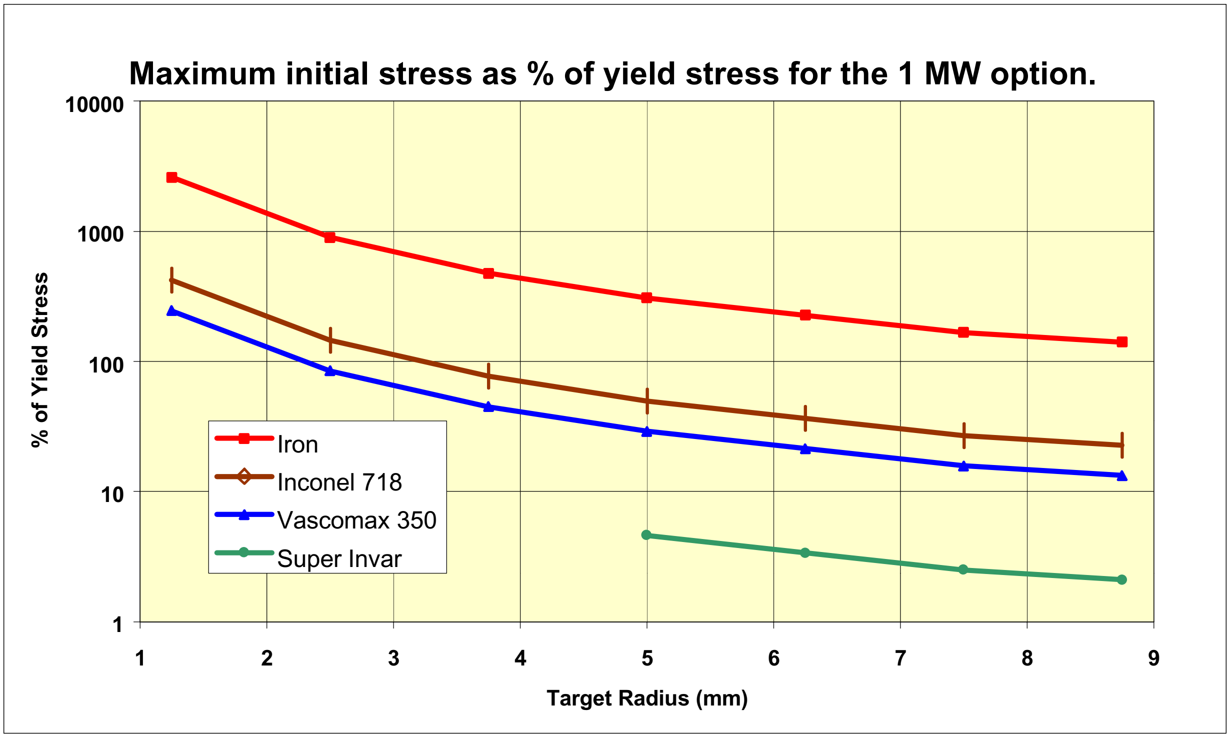
	ATJ	Carbon-Carbon Composite	
		Z	(U,V)
Elastic Modulus, GPa	9.6	117	48
Exp. coefficient, 1/°C	2.46×10^{-6}	$\sim$0	$\sim$0

Mid-Z Targets: Alloys

B. King: Use robust moving metal targets

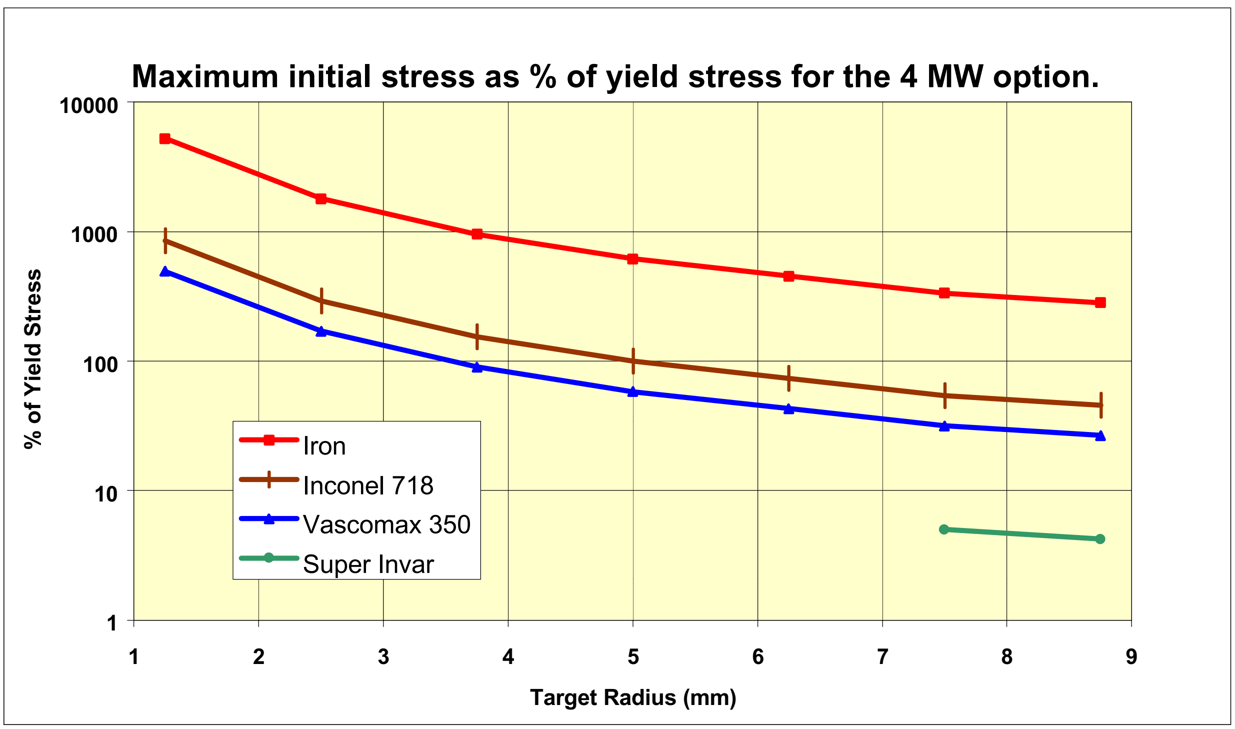


- Many different alloys available
- ANSYS beam/metal calculations- N. Simos
- Iron based alloys- P. Thieberger



Maximum initial stress as % of yield stress for the 1 MW option.
% of Yield Stress
10000
1000
100
10
1
1
2
3
4
5
6
7
8
9
Target Radius (mm)
Iron
Inconel 718
Vascomax 350
Super Invar

Fig. 3



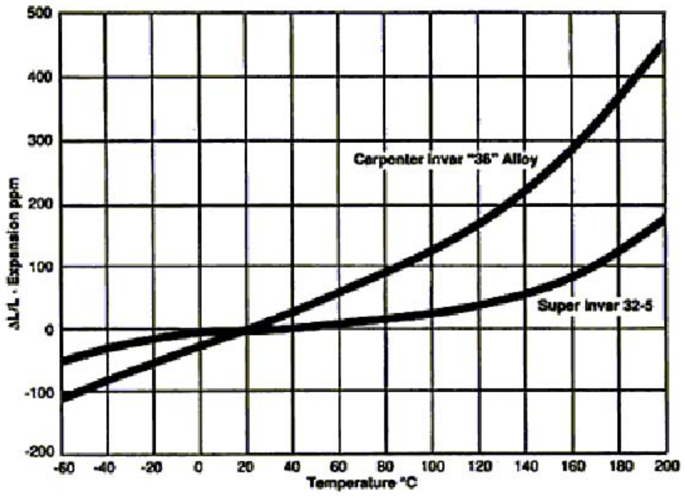
Maximum initial stress as % of yield stress for the 4 MW option.
% of Yield Stress
10000
1000
100
10
1
1
2
3
4
5
6
7
8
9
Target Radius (mm)
Iron
Inconel 718
Vascomax 350
Super Invar

Fig. 4

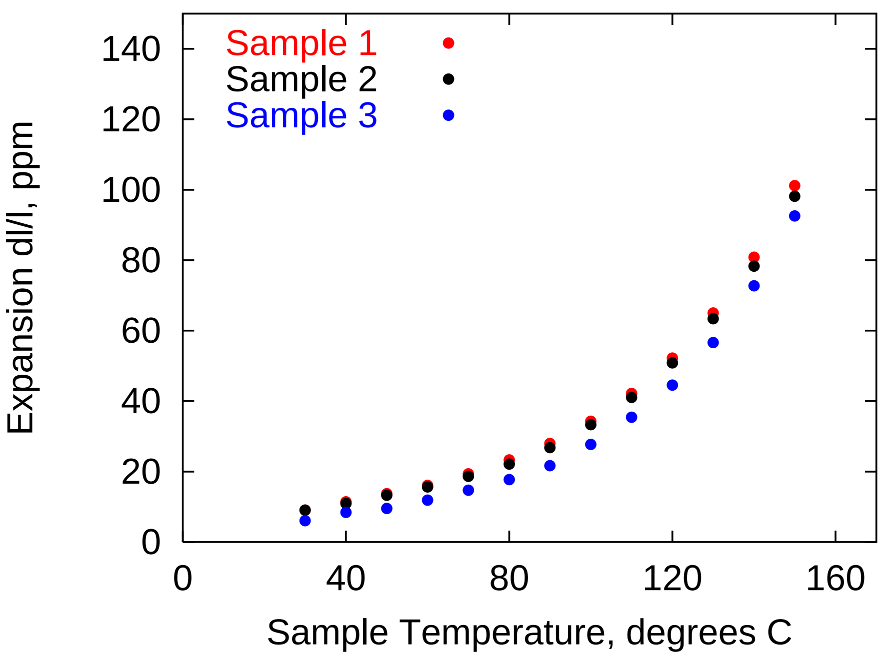
Mid-Z Target
Velocities and Lengths

	Velocity m/s	Length m
1 MW Option		
Super Invar	7.5	175
Vascomax C-350	0.85	16.8
4 MW Option		
Super Invar	12.0	274
Vascomax C-350	3.0	34

Super-Invar Linear Expansion



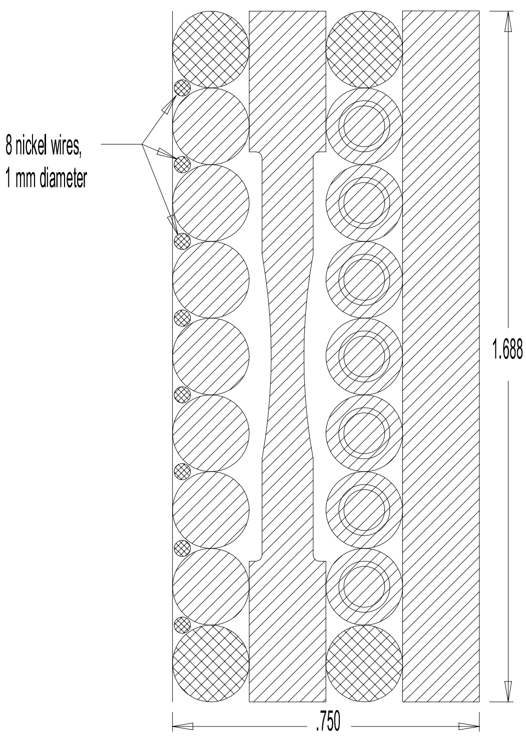
Measured Super-Invar Samples



BLIP Irradiation

- 1 1/2 Week running
- 200 MeV/c protons
- Total integrated flux 5 x 10^{20} protons

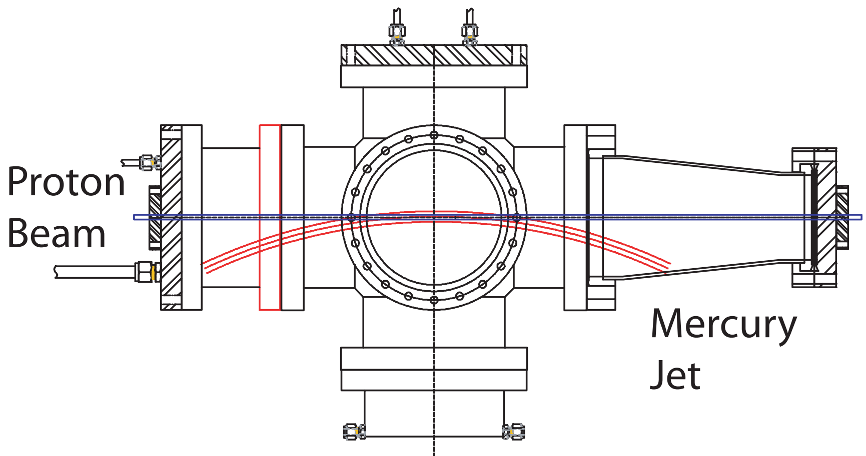
The Inner Target

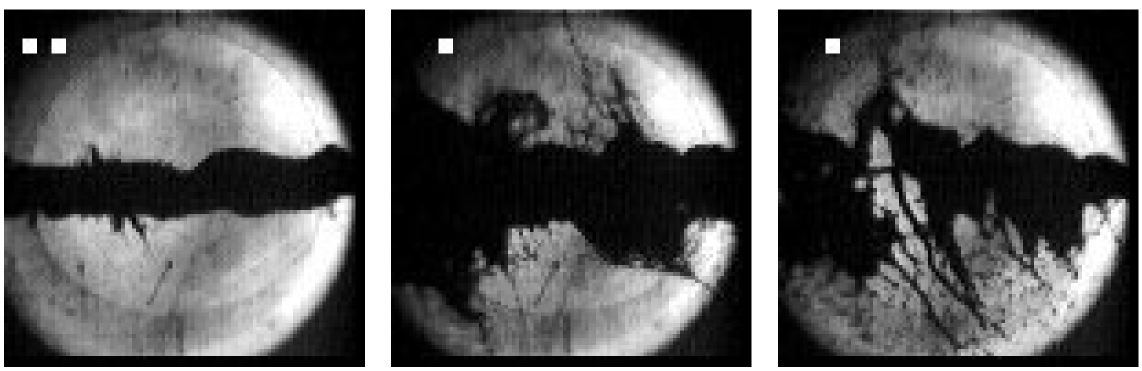


Post-irradiation

24 Rads at 2m

E951 Mercury Jet





Key Results

- Proton beam intensities upto 4 TP
- Dispersal velocities $\approx$ 10 m/s
- Dispersal delay $\approx$ 40 μs

High-Z Targets: Mercury

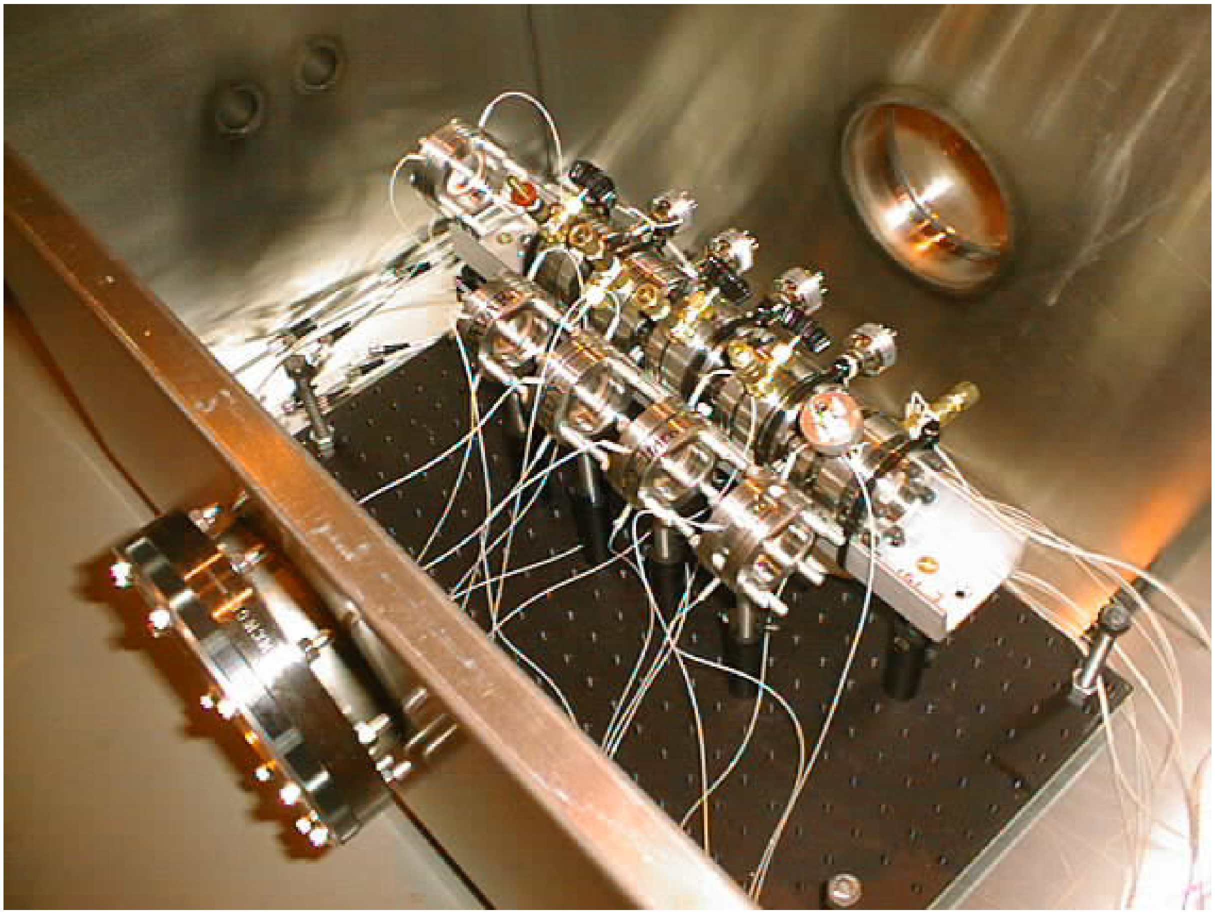
Key properties

- Maximal soft-pion production
- High pion absorption
- High peak energy dissipation
- Could be extended to 4 MW and beyond

Key issues

- Jet dynamics in a high-field solenoid
- Nature of target disruption
- Achievment of near-laminar flow for a 20 m/s jet

E951
Windows Test Setup



Window Material:

10 mil Aluminum

11 mil Havar

13 mil Titanium Alloy

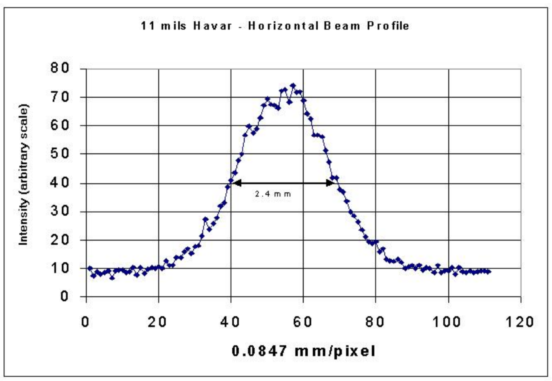
1 mm Inconel

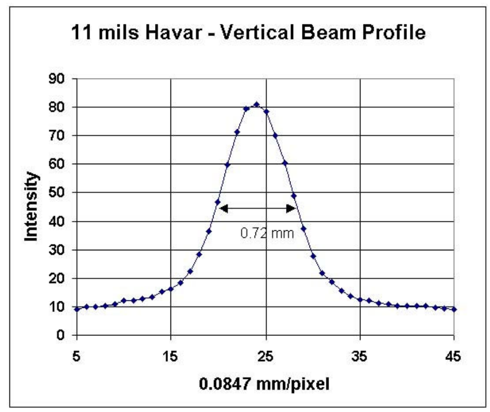
6 mm Inconel

P.Thieberger

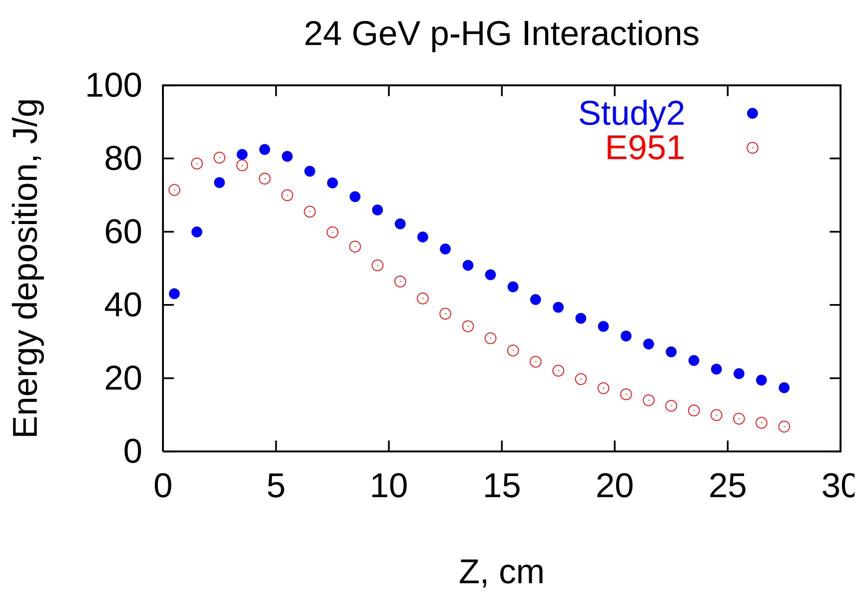
E951 Proton Beam Spot

New spot size from Autoradiography

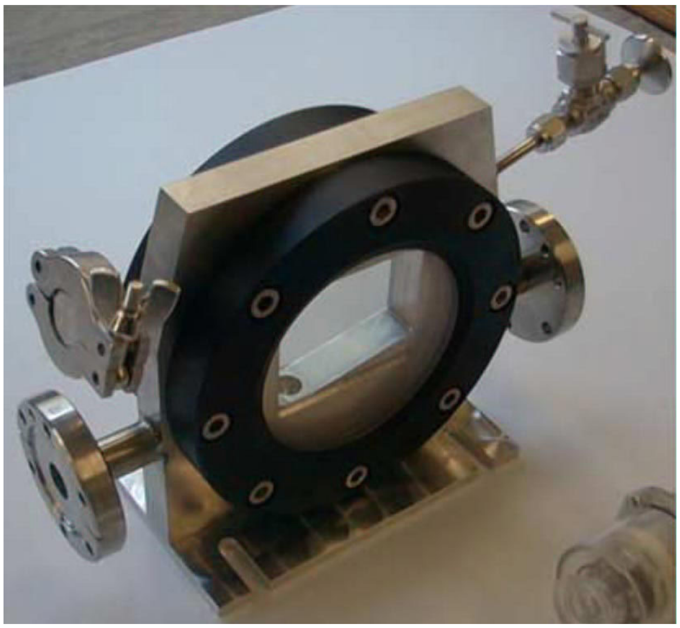




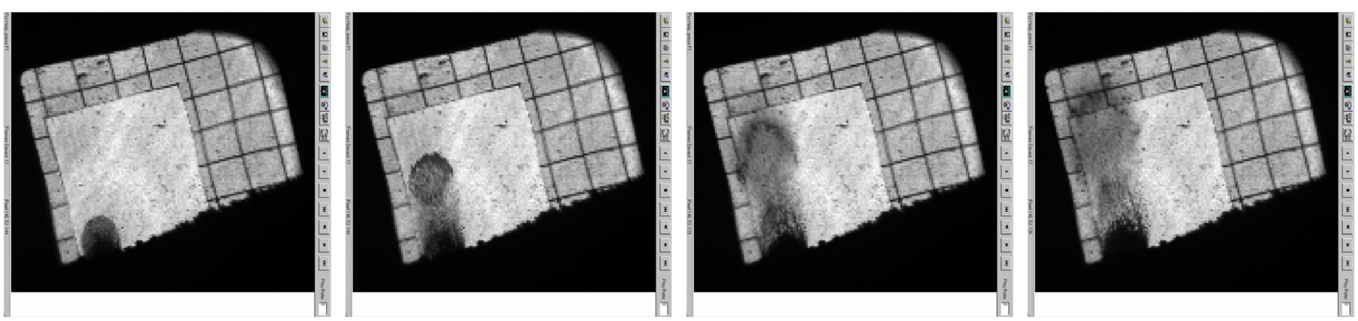
Results: RMS $\sigma_x = 0.93$ mm ; $\sigma_y = 0.28$ mm



The CERN Passive Trough



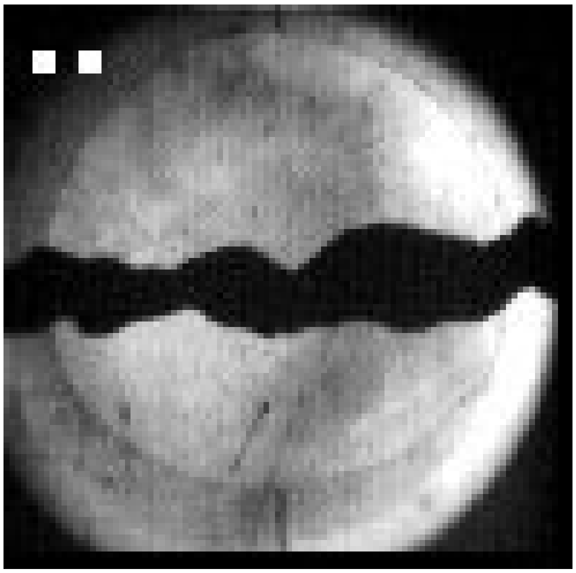
Exposures at the AGS and at CERN ISOLDE.



T= 300 μs 600 μs 900 μs 1200 μs

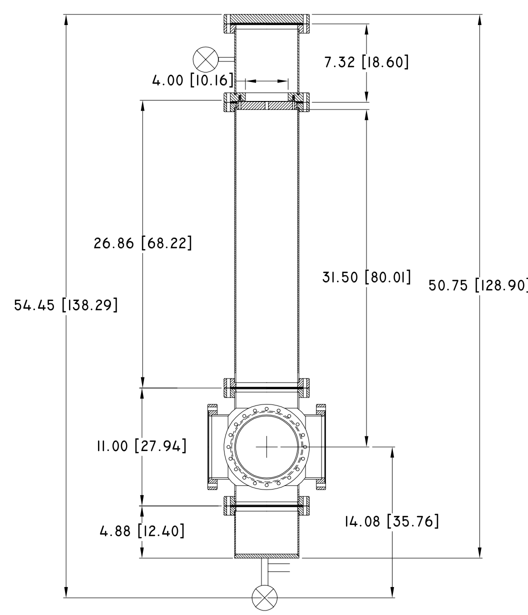
Dispersal velocity measured as a function of proton pulse intensity.

Additional Jet Studies



- Jet character needs improvement.
- Performance of alternative high-Z liquids: Woodsmetal
- Repeat beam exposures with 16 TP

- Build new 2 m/s horizontal jets (Woodsmetal and Hg)
- Build 10 m/s vertical Hg jet



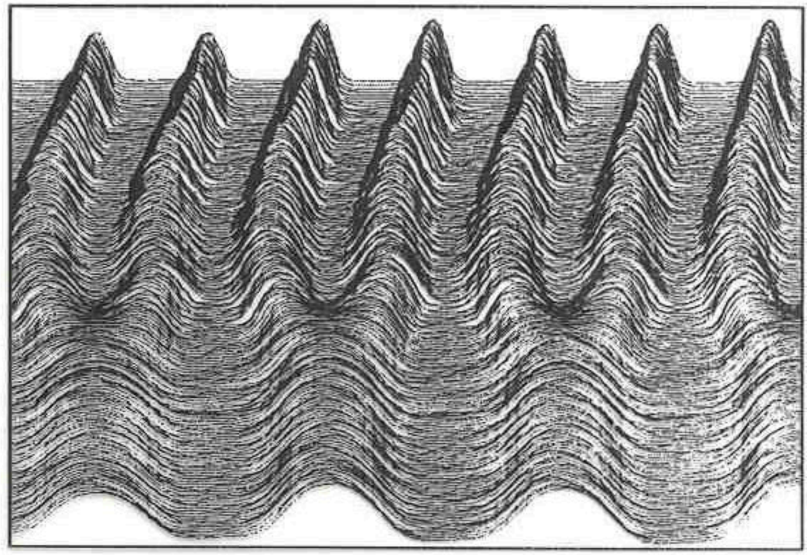
AGS Single Pulse Intensity Upgrades

- Improve Extraction Efficiency
  - Increase Pulsed Vertical Sextupole Strength
- Strengthen Ramping Sextupoles
  - Enhance horizontal chromaticity after transition
- Explore bunch merging techniques

Rf bunch merging

g-2 Experiment limited by production target to $7x10^{12}$ protons/bunch.

Six Bunches were Split into 12 by Adiabatic Ramping of h=6 and h=12 RF Voltage

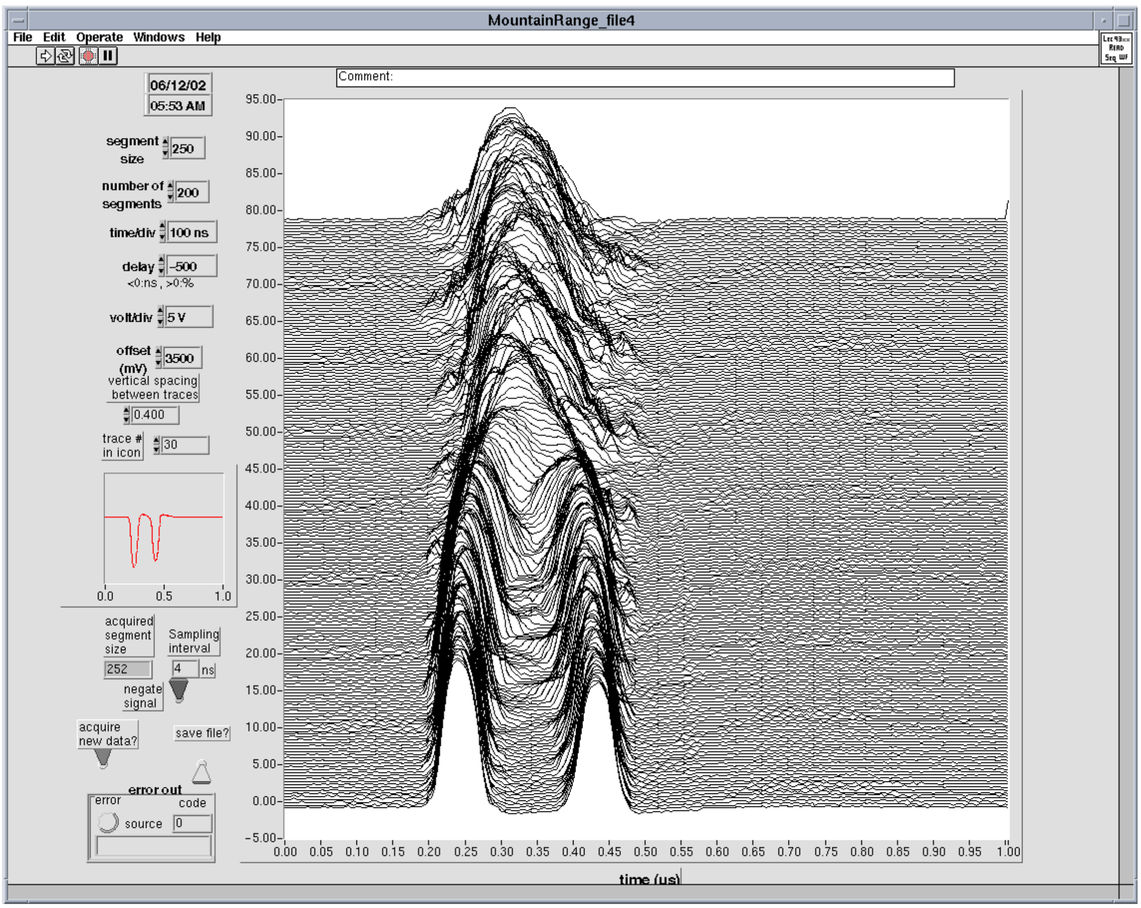


Splitting of 9×10^{12} bunches

BROOKHAVEN NATIONAL LABORATORY

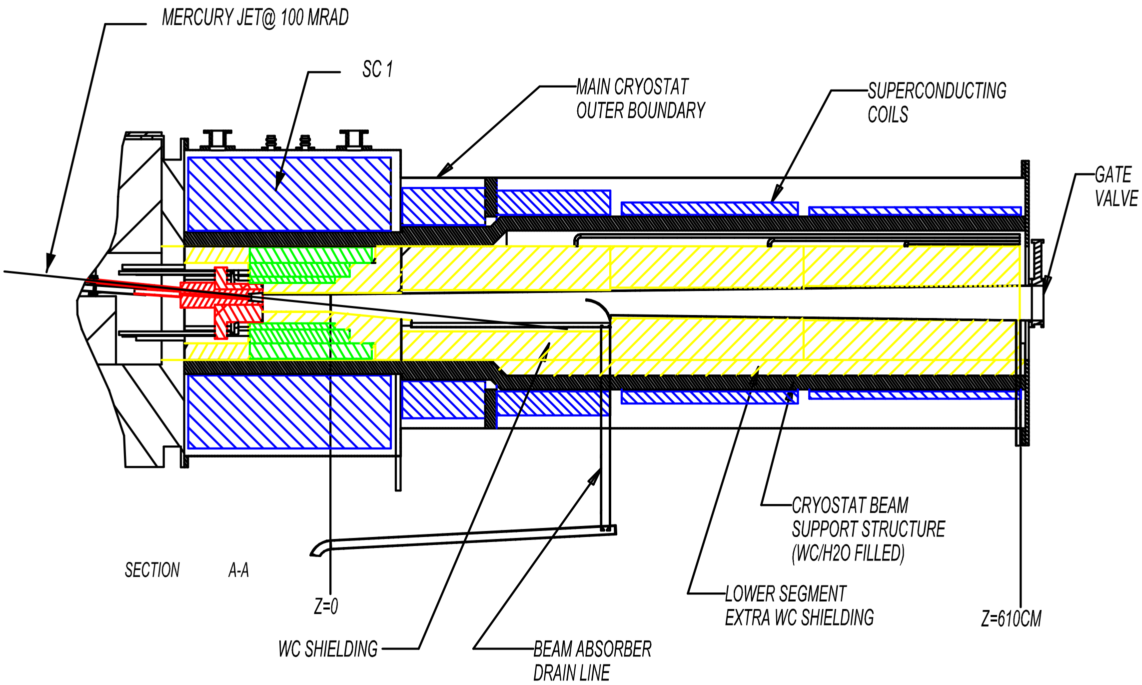
AGS Bunch Merging Studies

June 12, 2002



Achieved: 2×5 TP $\Rightarrow$ 10 TP

The Targetry System



The Targetry Concept

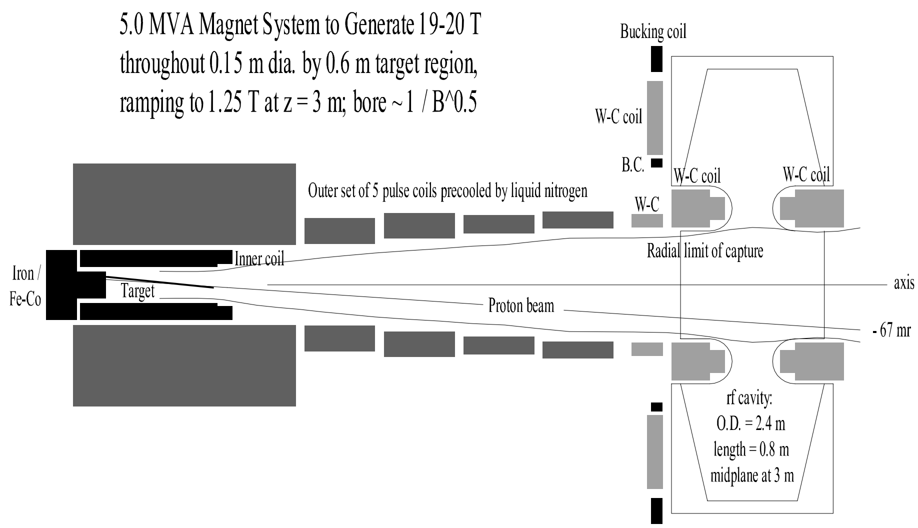
- Capture the low-energy soft pions
- Use high-Z target
- Capture in a 20 T solenoid field
- Conduct pions into a 1.25 T decay channel

R&D Issues

- Jet dynamics in a solenoidal field
- Target dispersal in a high magnetic field
- Component performance in an intense radiation environment

E951

20T Pulsed Solenoid

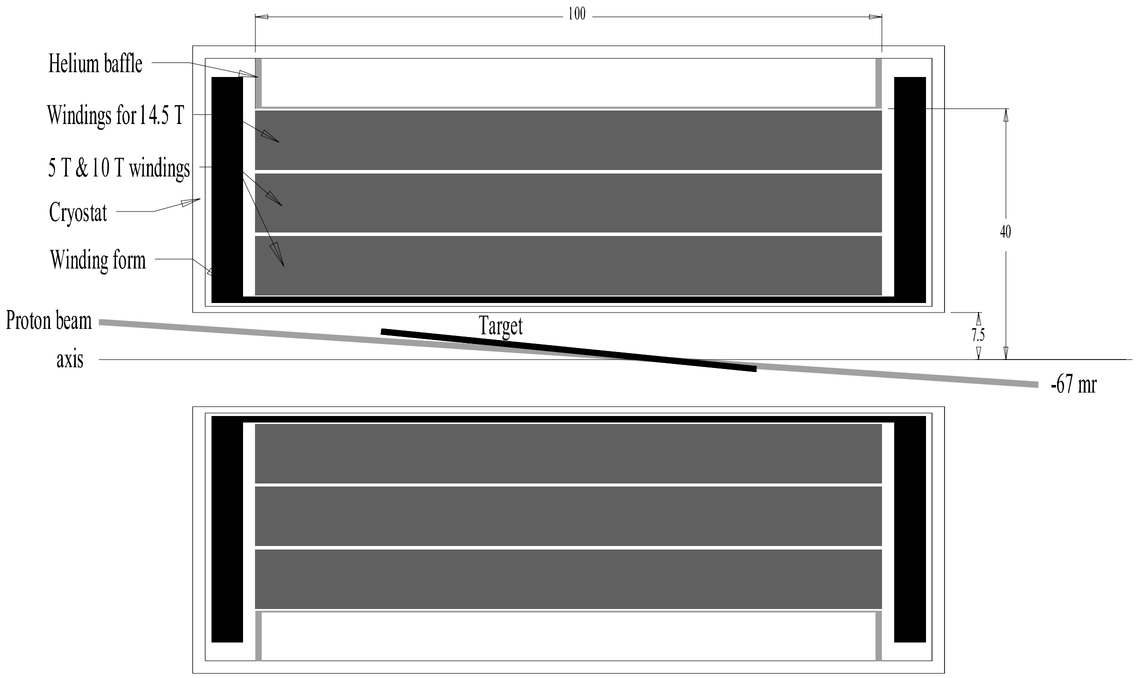


1. 5 MVA Pulsed Power Supply
2. 15 Metric Tonnes Coil Package
3. 80° K operation
4. Switch power from outer to inner coil
5. Cost $4.5M

E951

14.5T Pulsed Solenoid

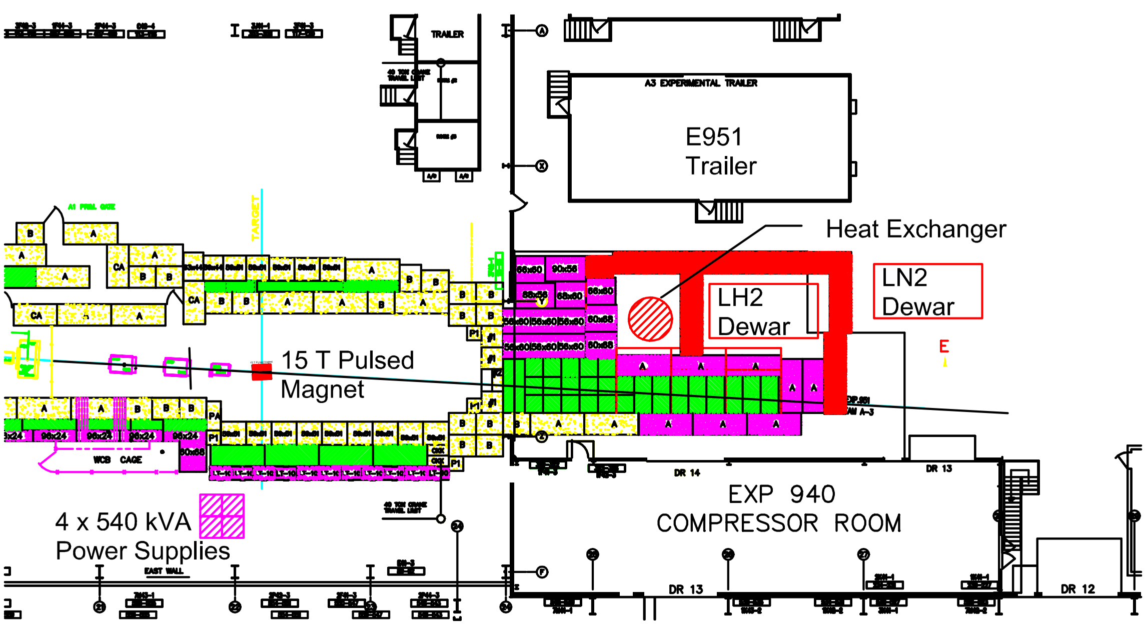
Windings, Coil Form & Cryostat for Cryogenic Pulse Magnet for 5 T, 10 T & 14.5 T



1. 2.2 MVA Pulsed Power Supply
2. 3.6 Metric Tonnes Coil Package
3. 30° K operation
4. Cost \$1.5M

Future Plans

- Work with the AGS to achieve a single bunch intensity of 16 TP deliverable to the A3 line.
  - Repeat Hg jet target
  - Explore other solid target candidates (Inconel, Invar, Carbon, etc.)
- Develop a 20 m/s Hg jet.
- Develop and build a 2 m/s Woodsmetal jet.
- Develop and build a high-field pulsed solenoid.



E951 Pulsed Solenoid

Task Profile