The IDS-NF Target Baseline

IDS-NF Plenary Meeting

Rutherford Appleton Lab

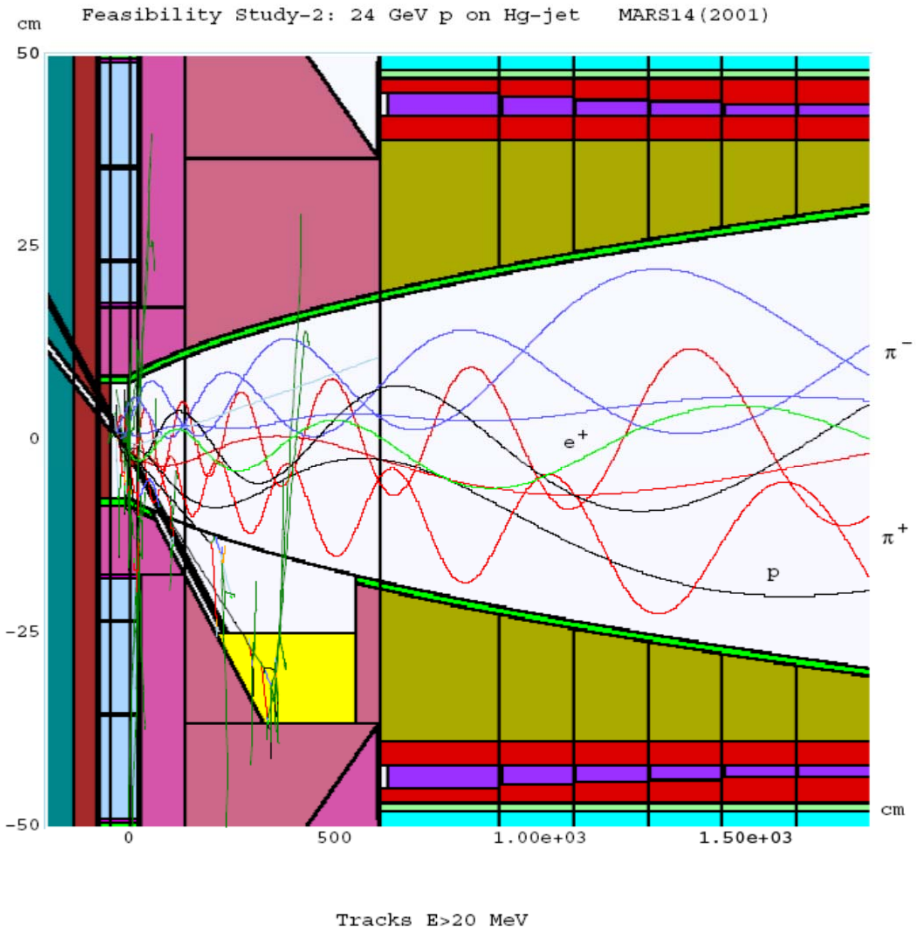
September 20-25, 2010

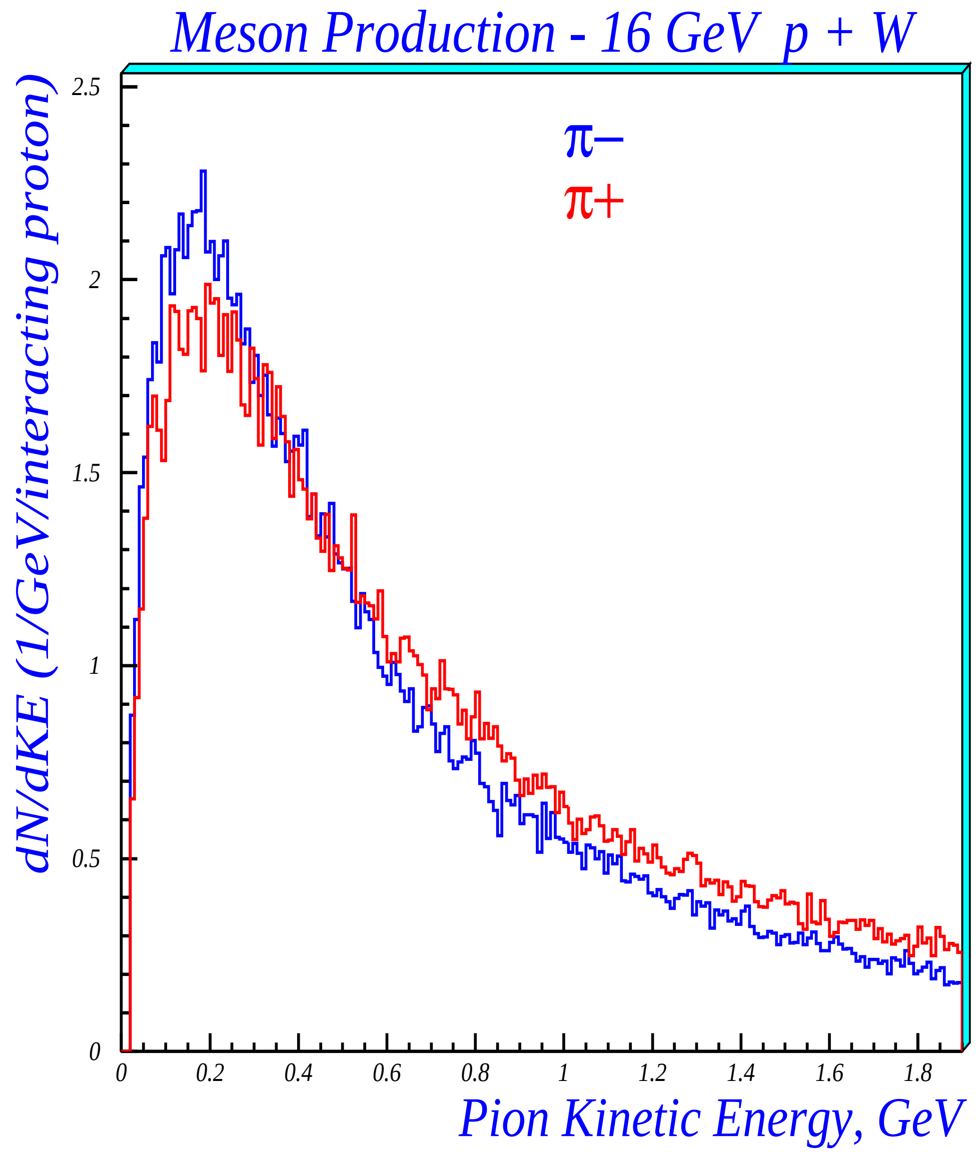
Harold G. Kirk
Brookhaven National Laboratory

The Neutrino Factory Target Concept

Maximize Pion/Muon Production

- **Soft-pion Production**
- **High-Z materials**
- **High-Magnetic Field**





Palmer, PAC97

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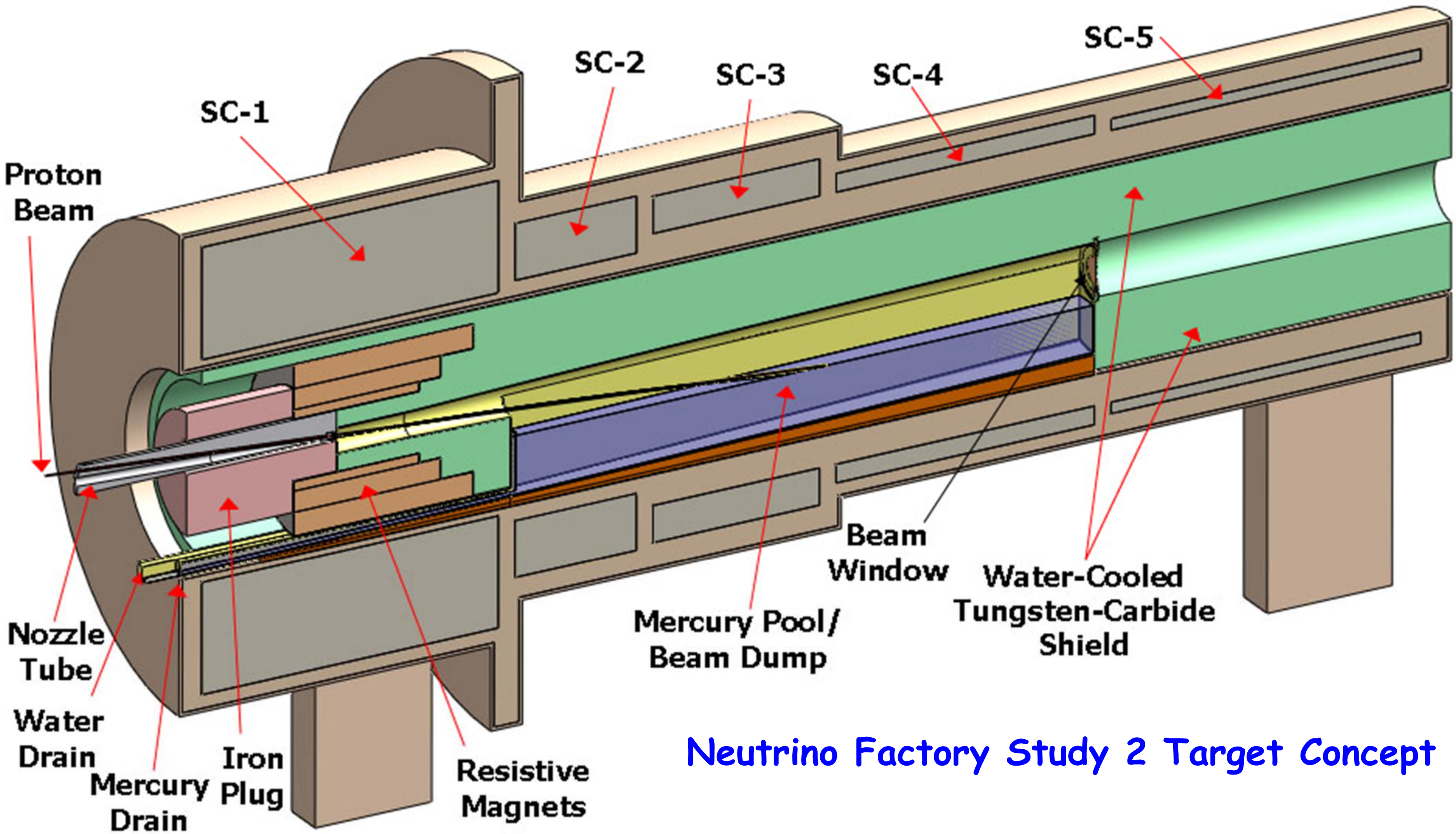
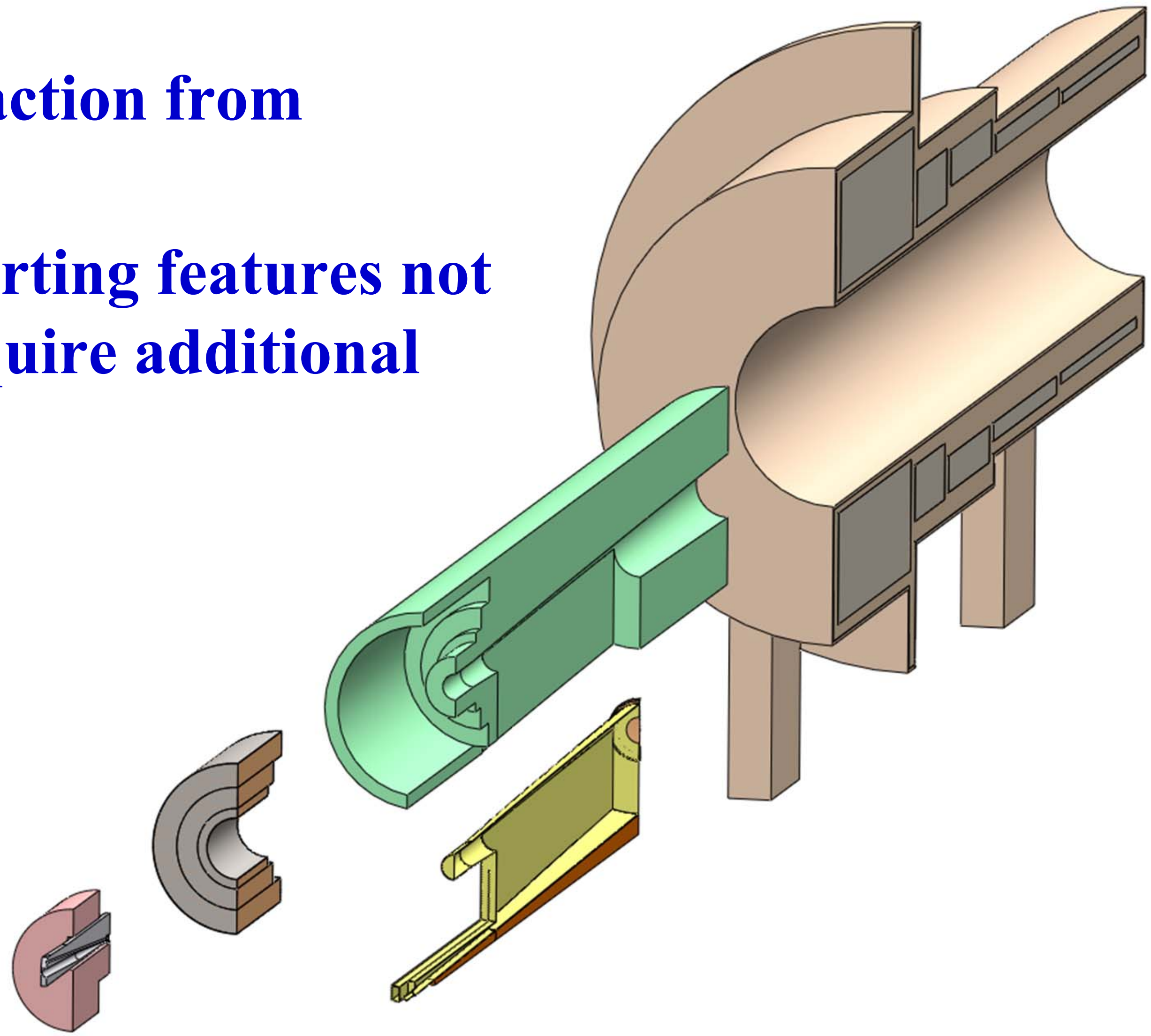
The Study 2 Target System



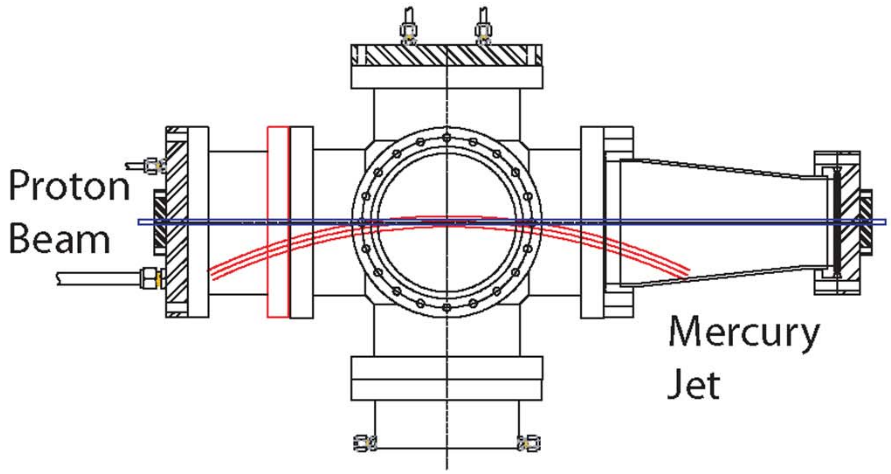
Neutrino Factory Study 2 Target Concept

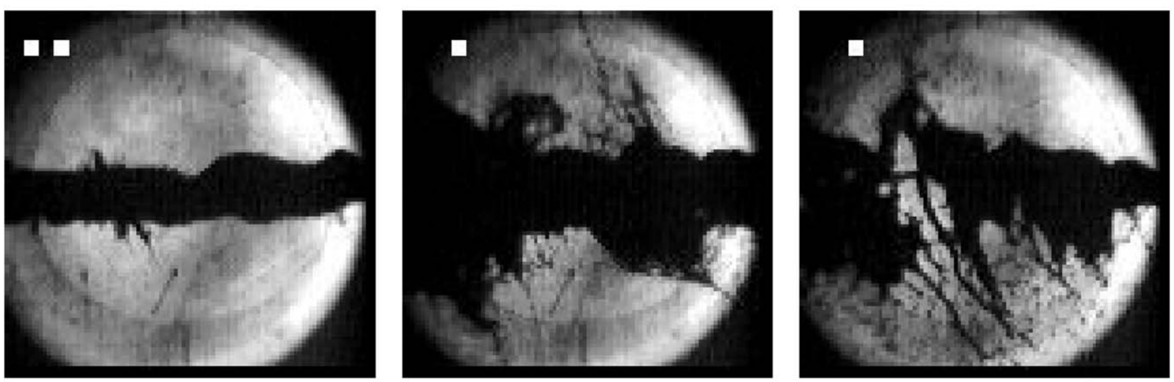
Target System Exploded View

- All insertion/extraction from upstream end
- Locating & supporting features not shown – will require additional space



Target Concept Validation: AGS E951 at BNL





Features:

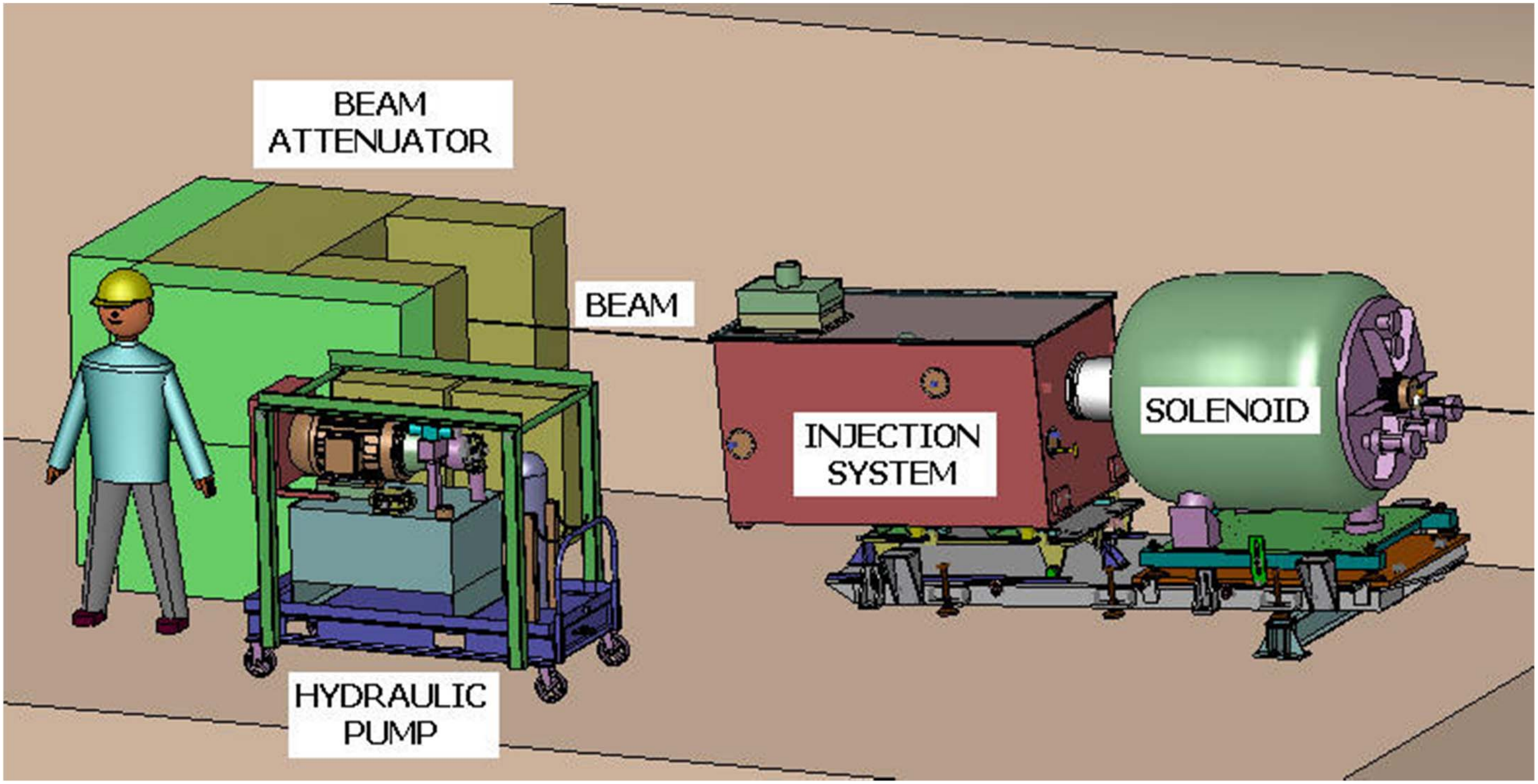
- 24 GeV, 4T*p* Proton Beam
- 1 cm, 2.5m/s Hg Jet
- No Magnetic Field

Key Results:

- Dispersal velocities $\leq$ 10m/s
- Dispersal Delay $\geq$ 40μs

Experiment ran April 2001

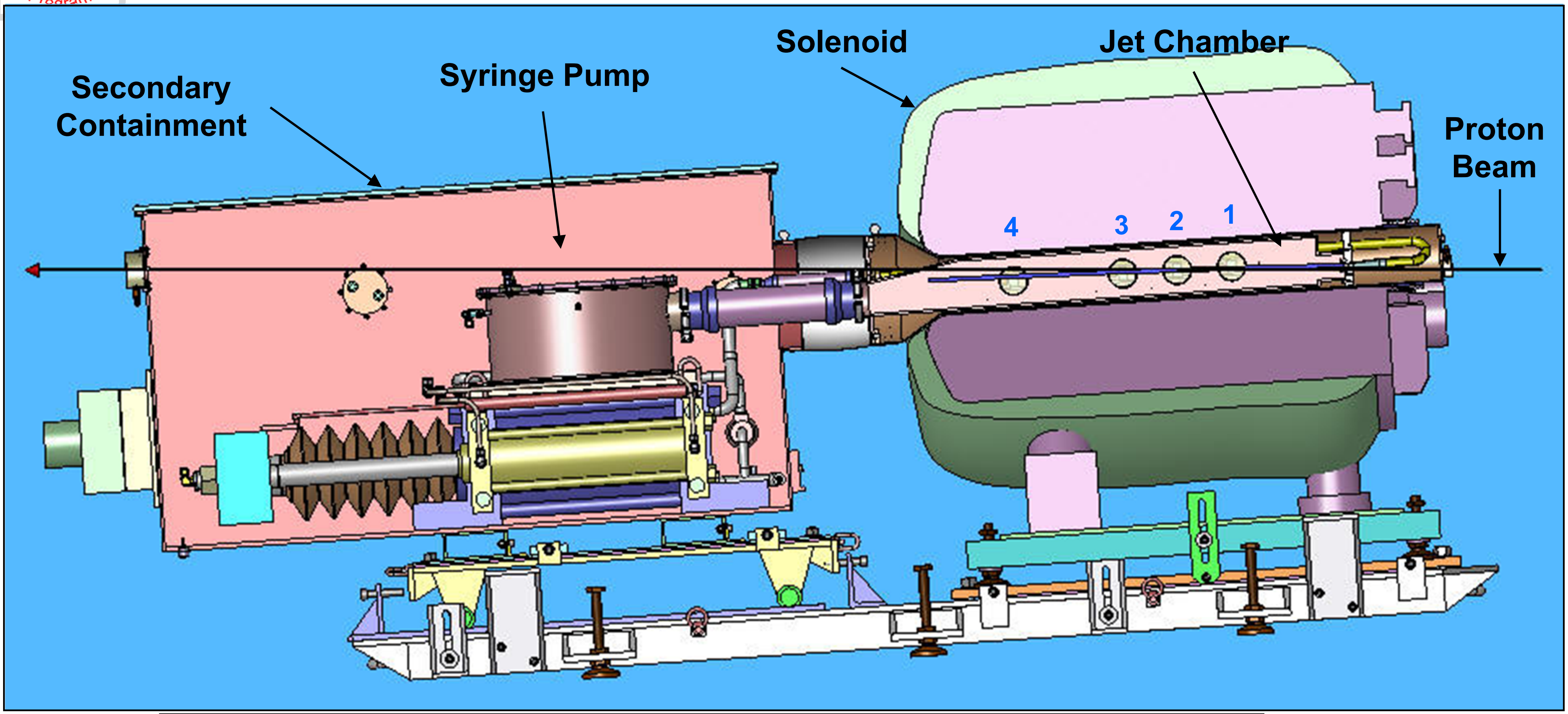
Target Concept Validation MERIT at CERN

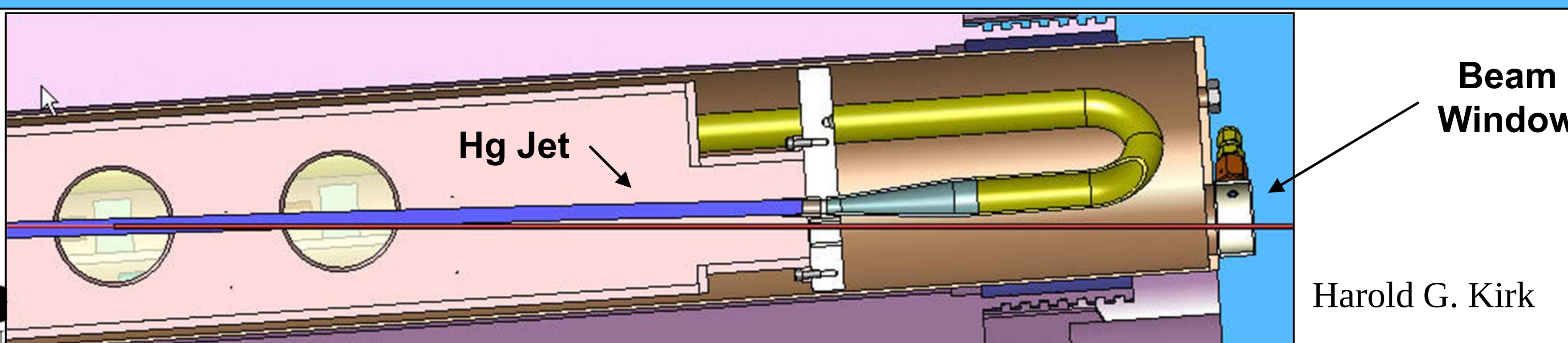


MERcury Intense Target

Experiment ran Oct./Nov. 2007

Cross-sectional view of the MERIT Experiment





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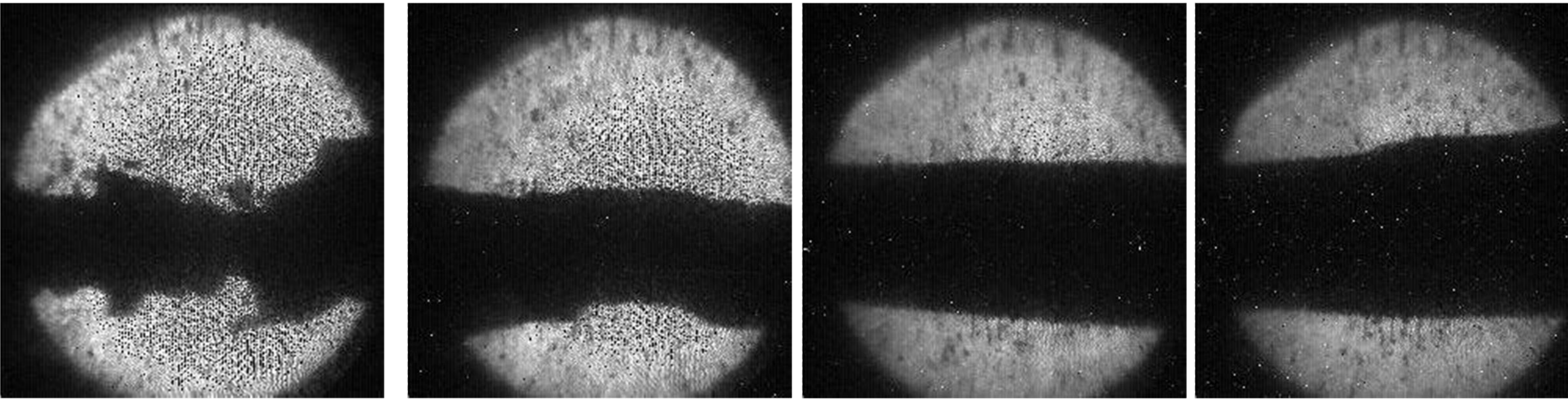
Stabilization of Jet by High Magnet Field

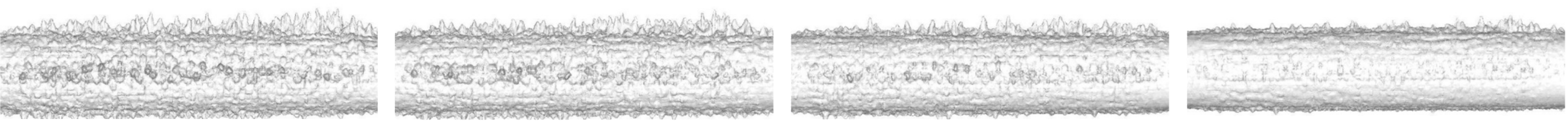


0T 5 T 10 T 15 T

Jet velocities: 15 m/s

Substantial surface perturbations mitigated by high-magnetic field.

MHD simulations (R. Samulyak):



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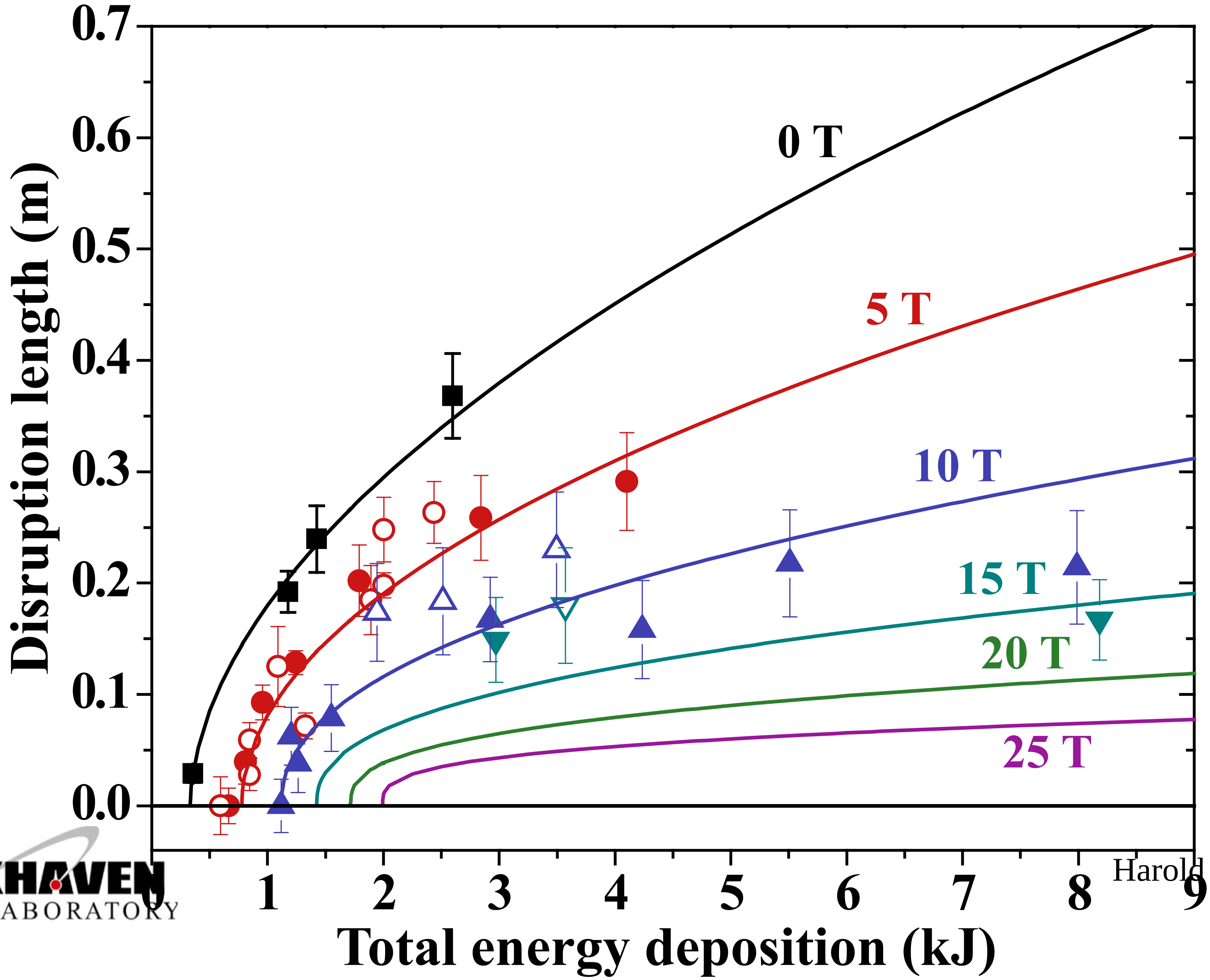
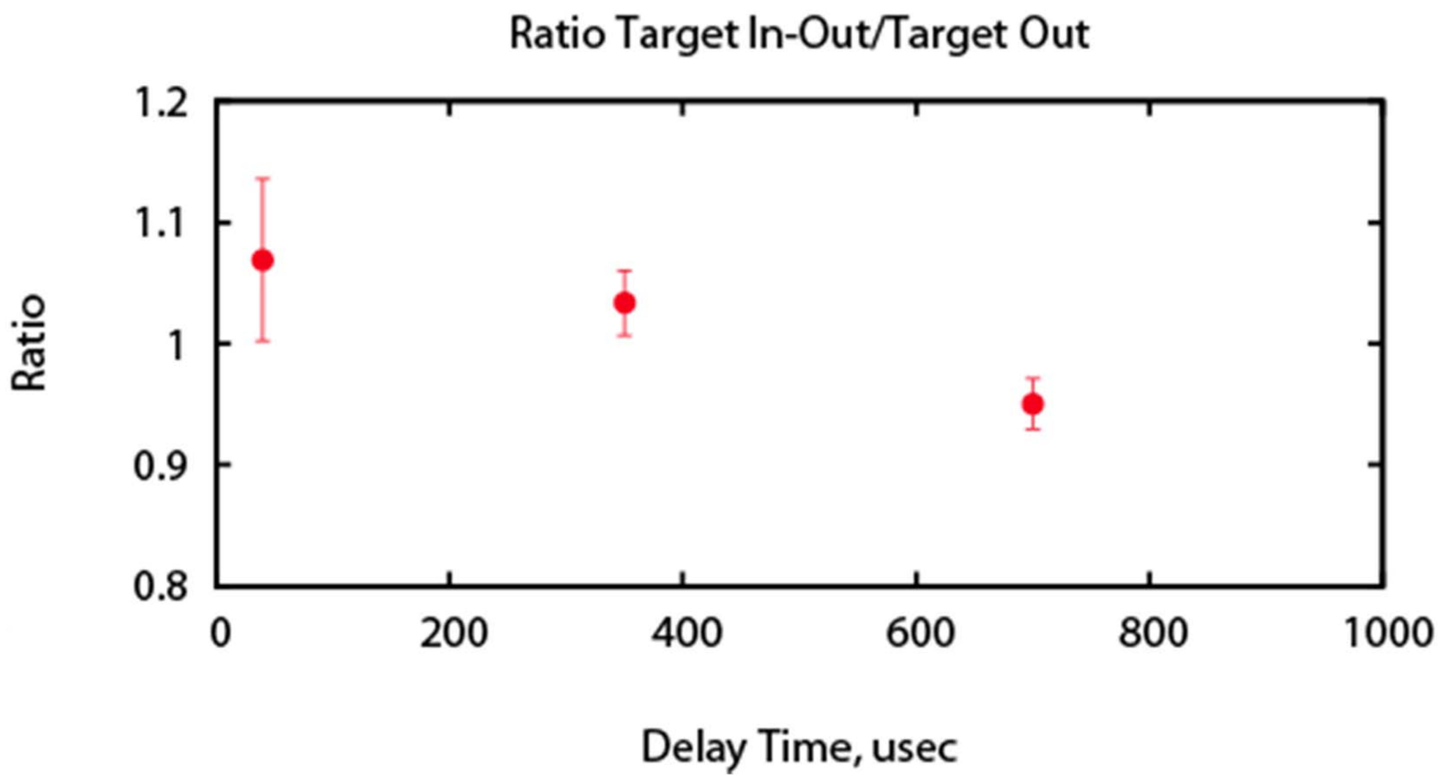
Hg Jet/Proton Beam Disruption



Pump-Probe Data Analysis

Production Efficiency: **Normalized Probe / Normalized Pump**



No loss of pion production for bunch delays of 40 and 350 μs,

A 5% loss (2.5-σ effect) of pion production for bunches delayed by 700 μs.

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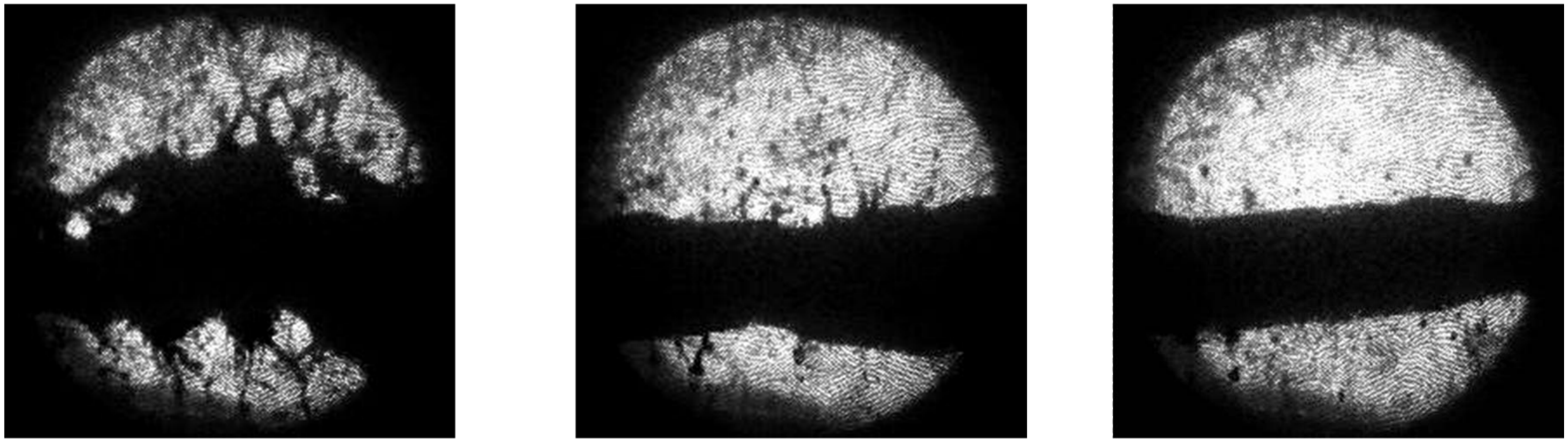
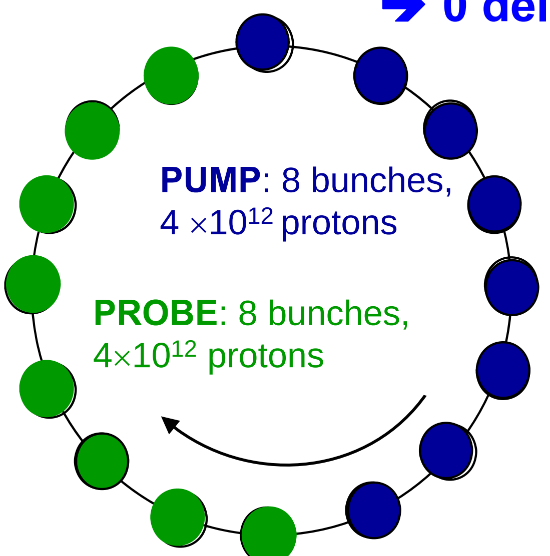
Study with 4 T*p* + 4 T*p* at 14 GeV, 10 T



Single-turn extraction
➔ 0 delay, 8 T*p*

4-T*p* probe extracted on subsequent turn
➔ 3.2 μs delay

4-T*p* probe extracted after 2nd full turn
➔ 5.8 μs Delay



Threshold of disruption is > 4 T*p* at 14 Gev, 10 T.

⇒Target supports a 14-GeV, 4-T*p* beam at 172 kHz rep rate without disruption.

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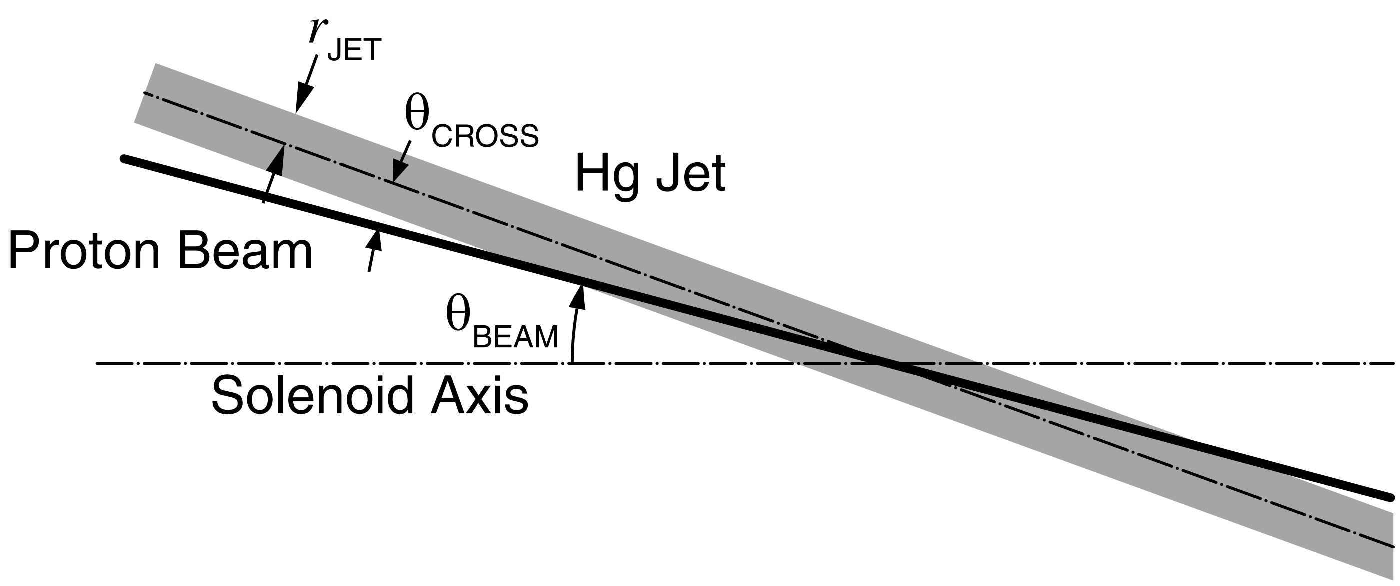
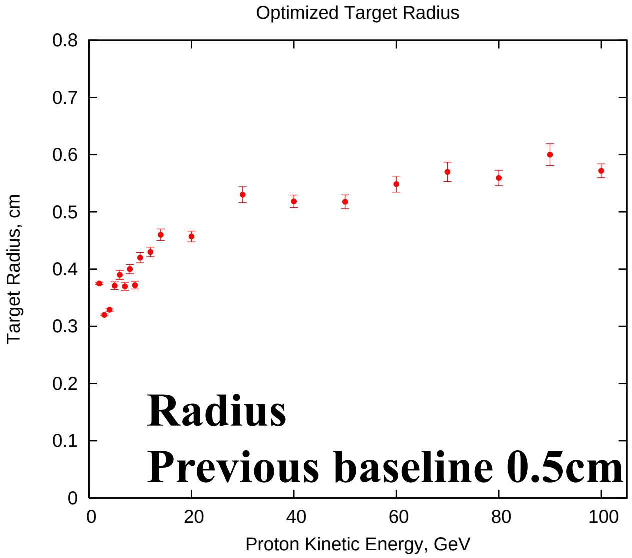
MARS15 Study of the Hg Jet Target Geometry

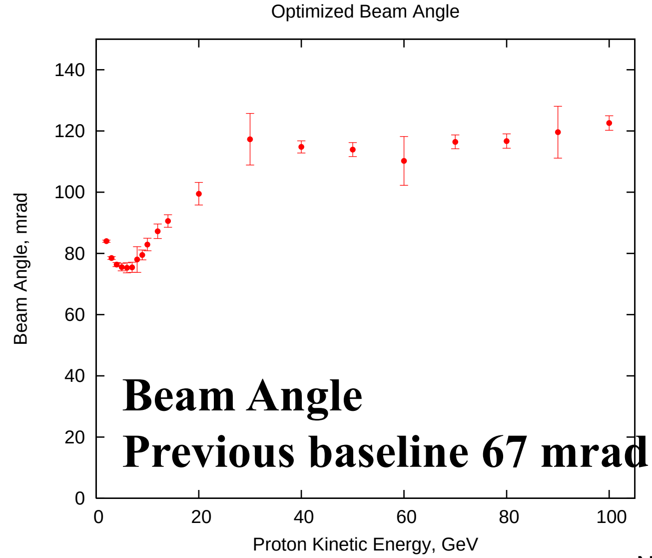


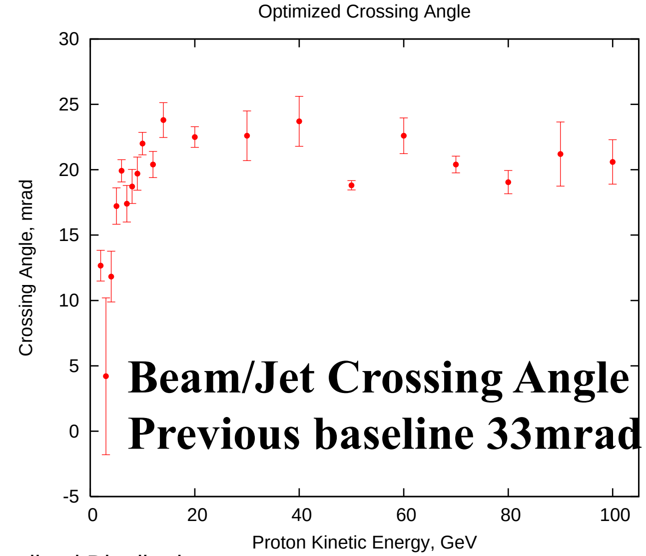
Previous results: Radius 5mm, θ_{beam} =67mrad
$\Theta_{crossing}$ = 33mrad

Optimized Meson Production

X. Ding, UCLA

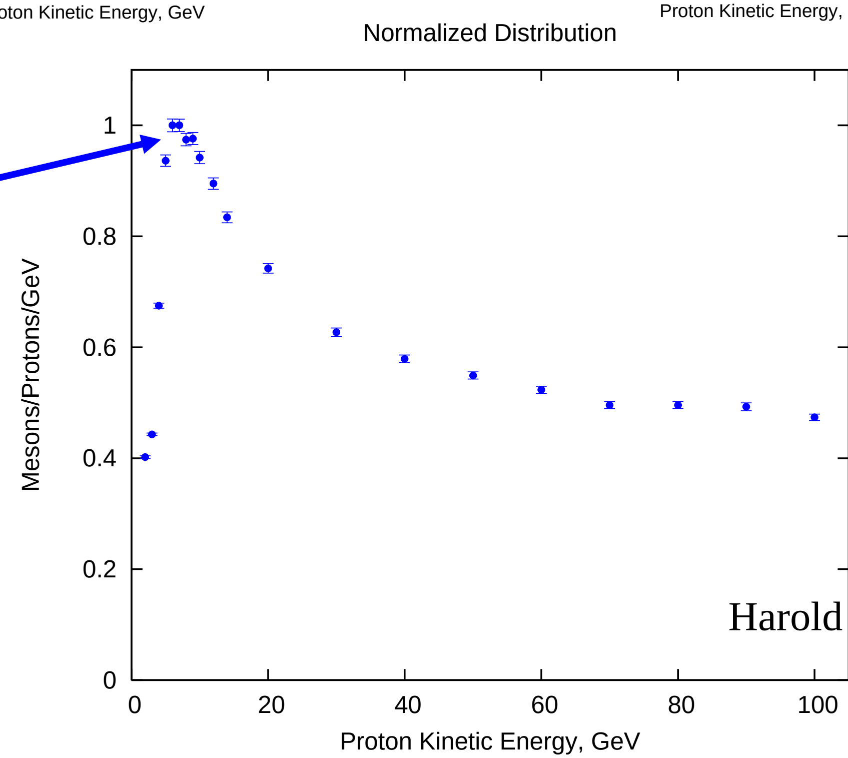






Production of soft pions is most efficient for a Hg target at E_p ~ 6-8 GeV,

Confirmation of low-energy drop-off by experiment (HARP, MIPP) highly desirable.



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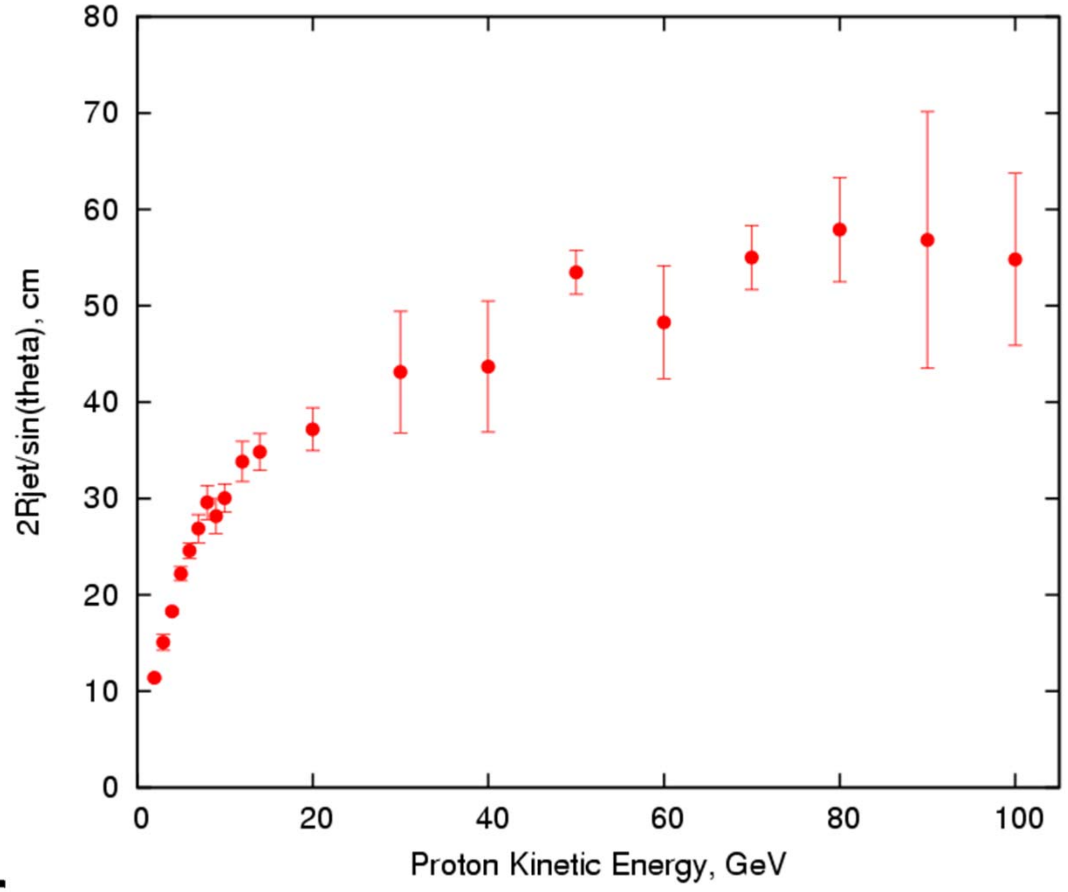
Protom Beam Path Length inside the Mercury Jet



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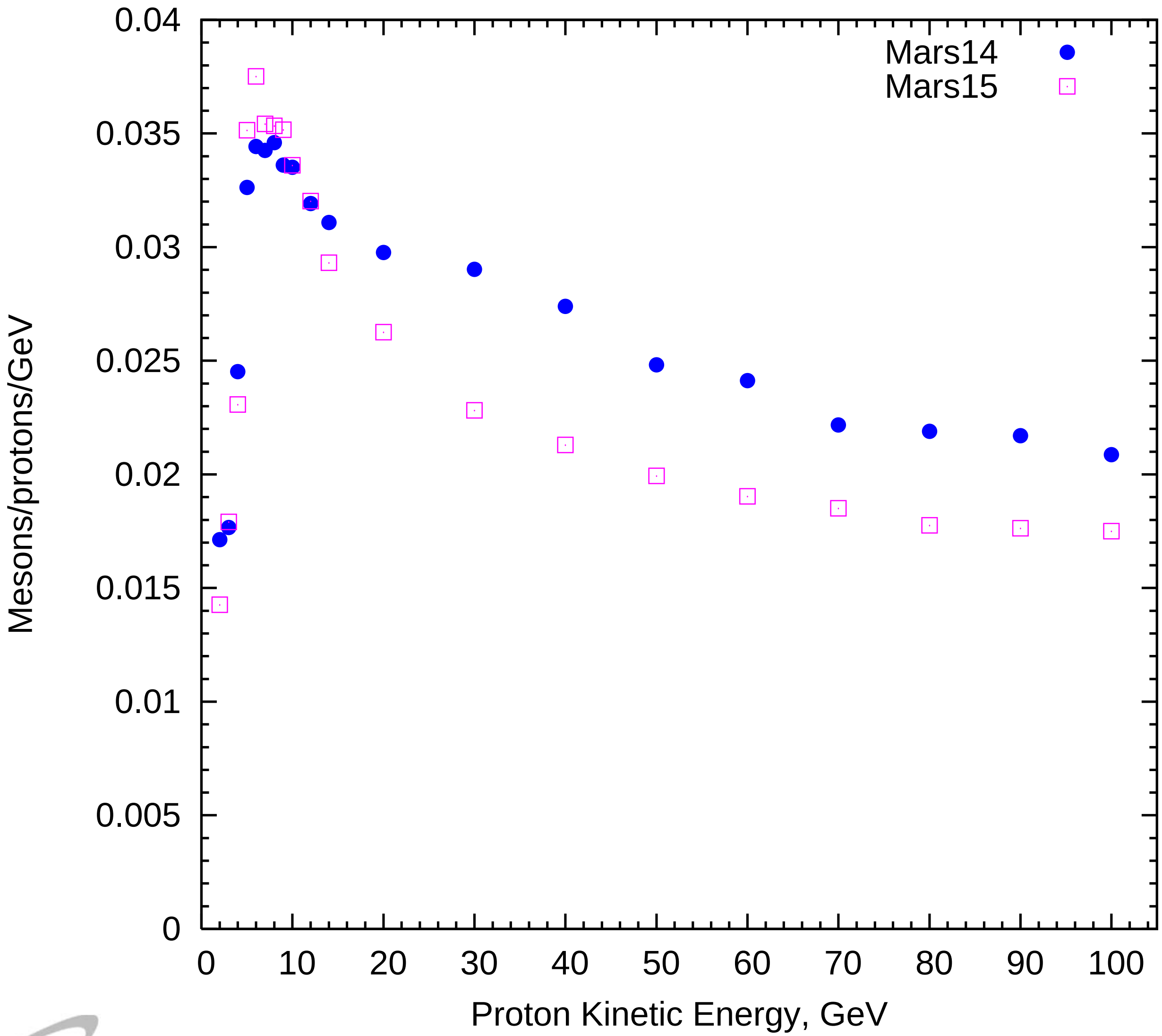
Nuclear interaction length for Hg is 14.6cm

Mars14 vs Mars15



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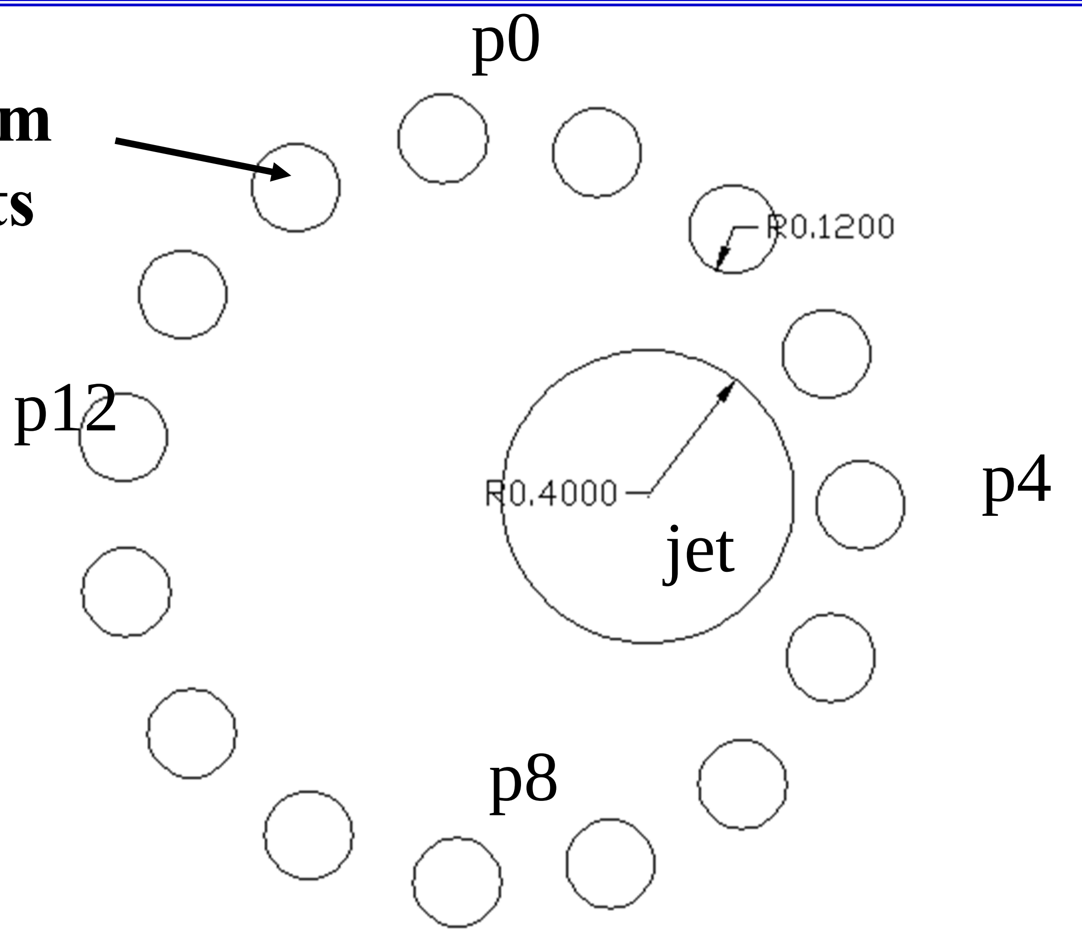
Normalized to Beam Power

Multiple Proton Beam Entry Points

Proton Beam Entry points



Entry points are asymmetric due to the beam tilt in a strong magnetic field

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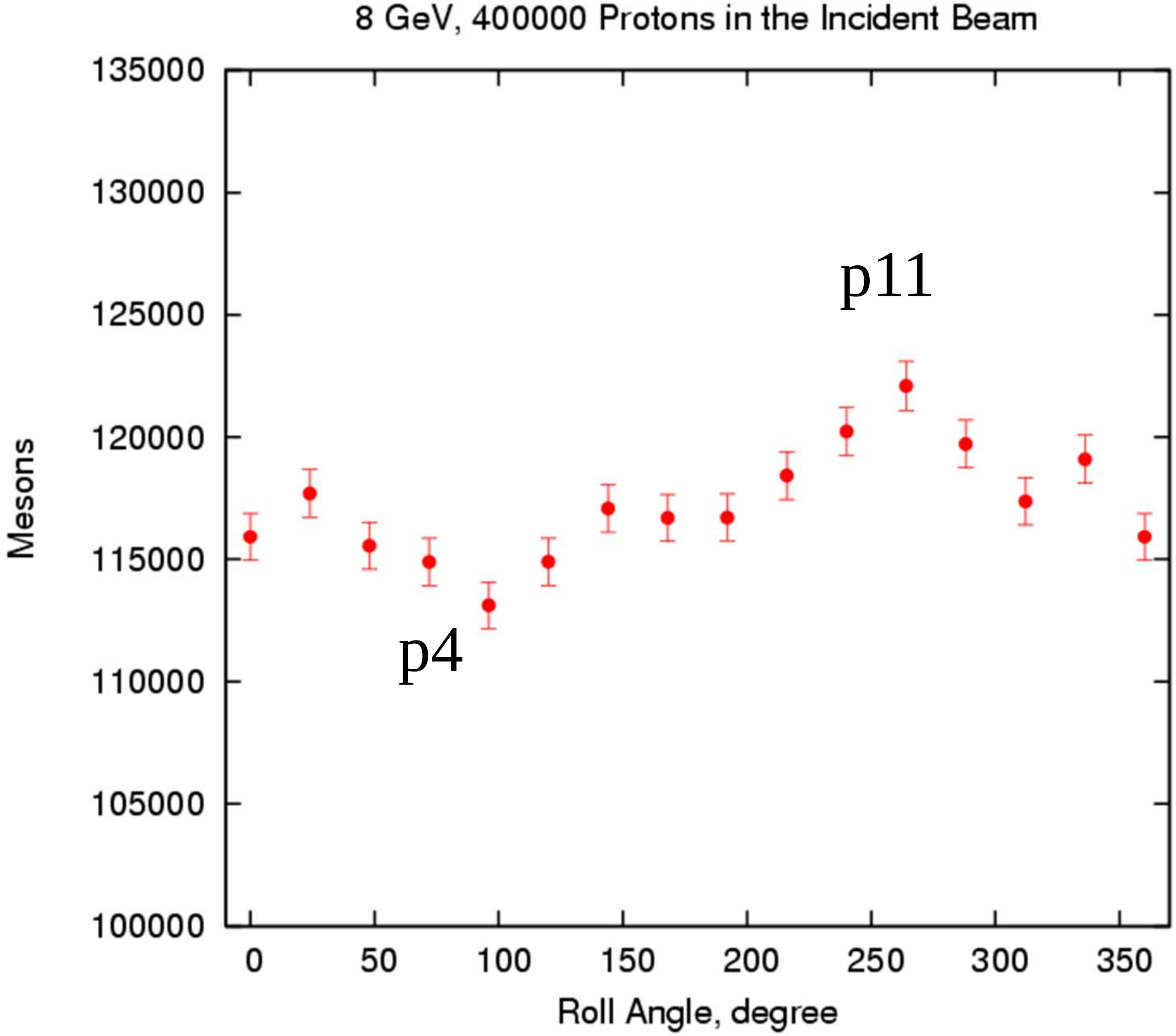
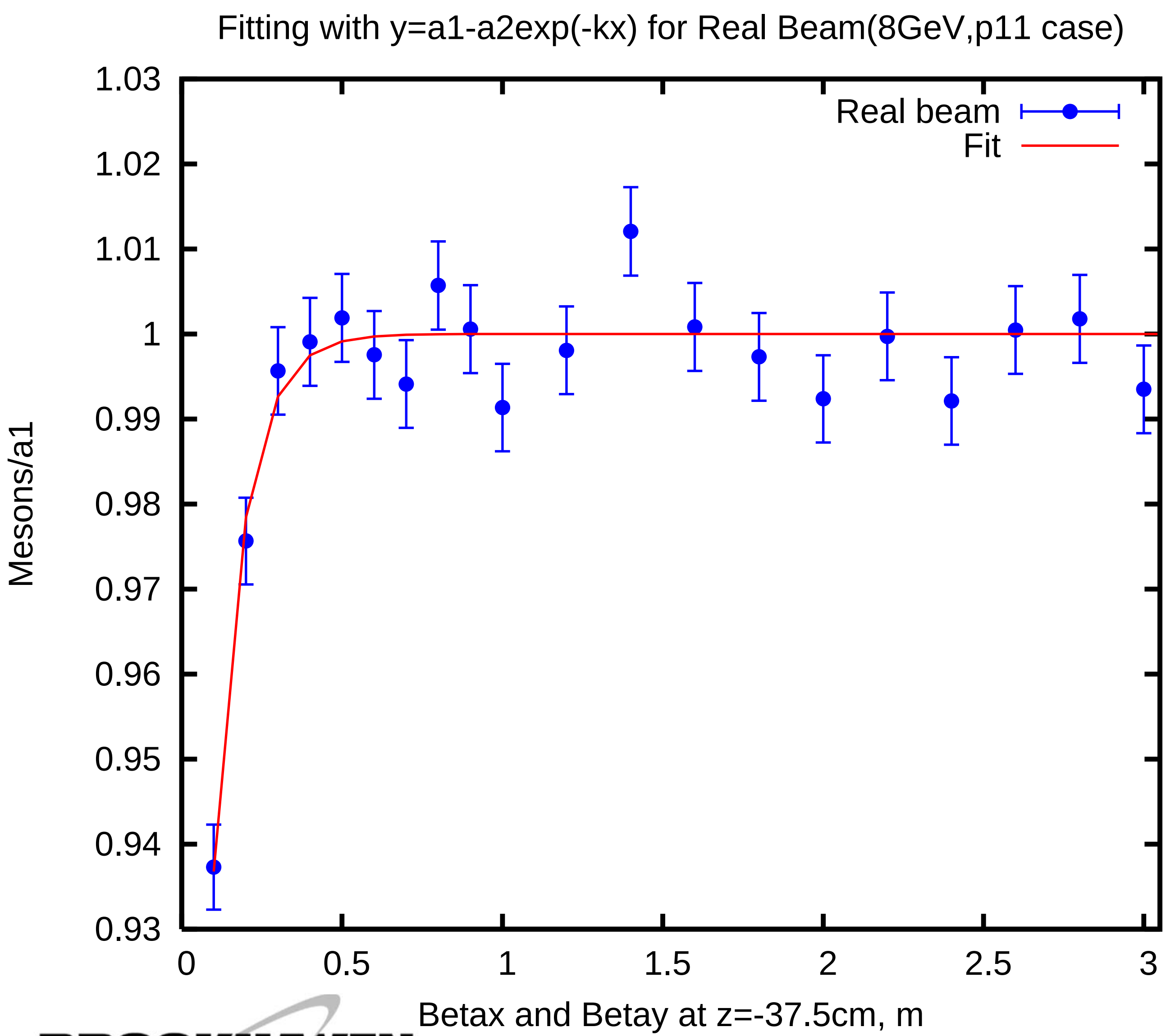
Proton beam entry points upstream of jet/beam crossing

Multiple Proton Beam Entries



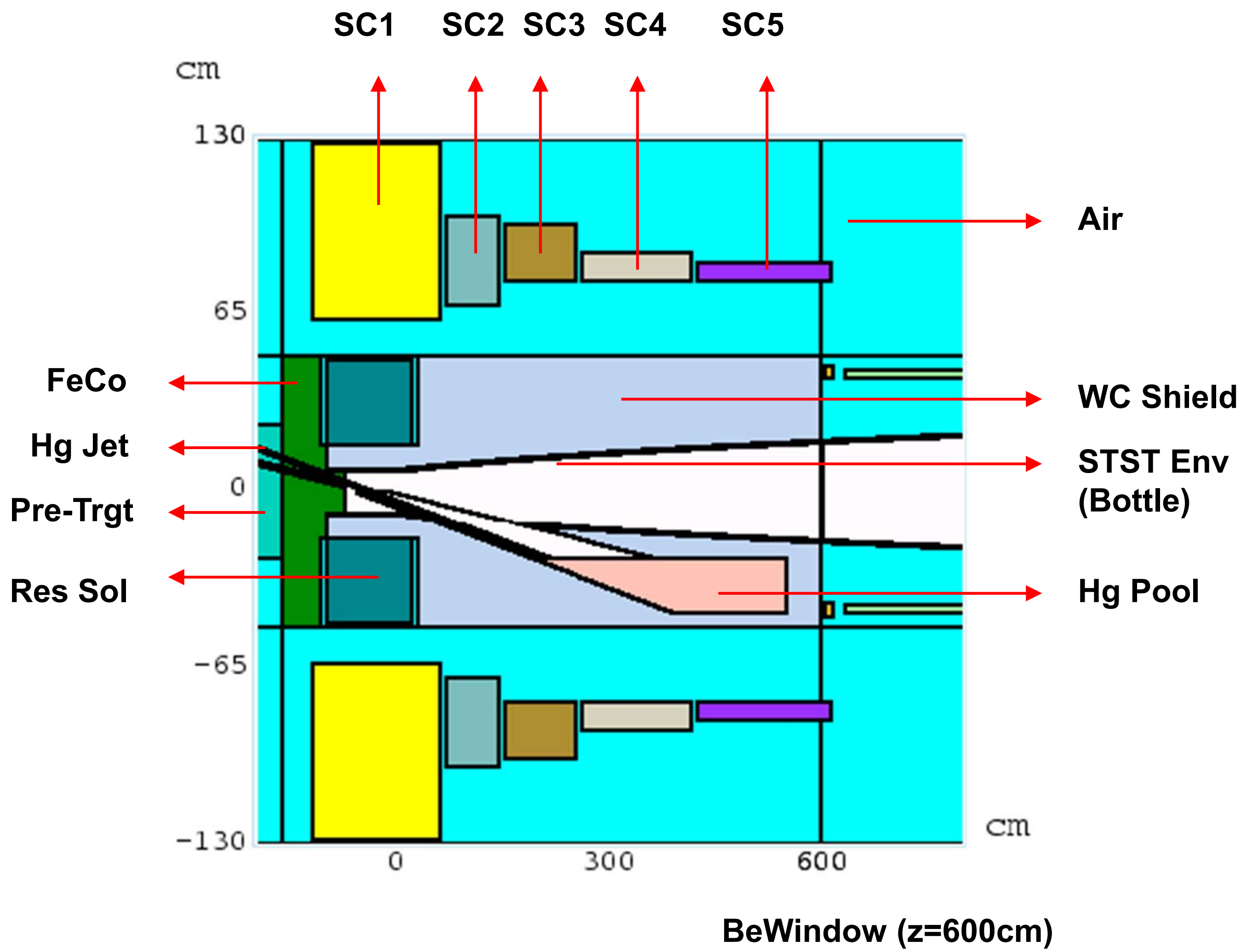
A 10% swing in meson production efficiency

Meson Production vs β^*



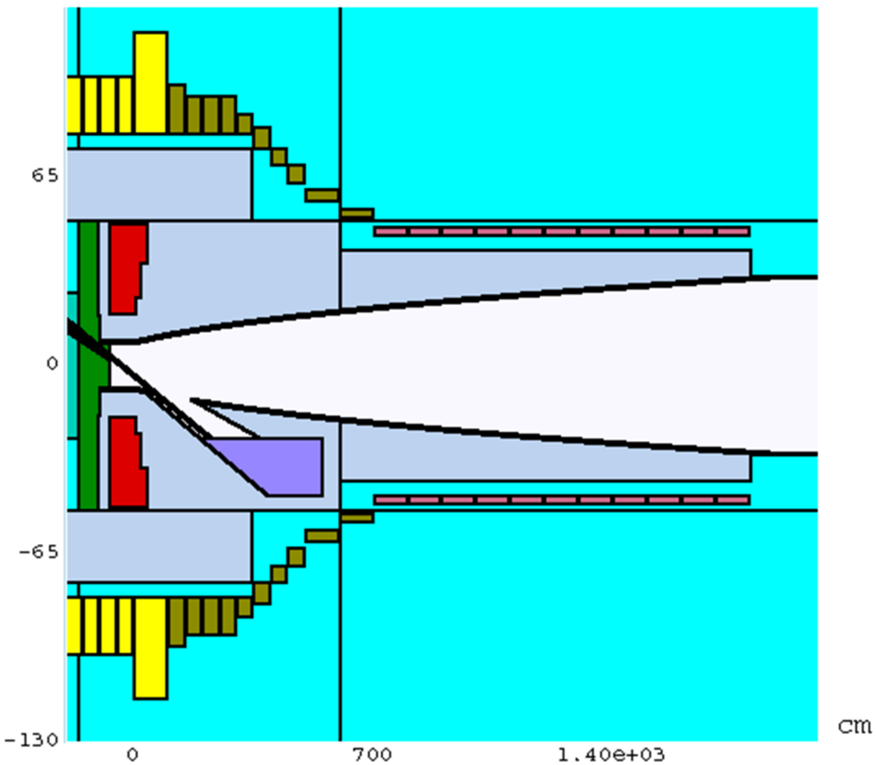
Meson Production loss ≤ 1% for $\beta^* \geq$ 30cm

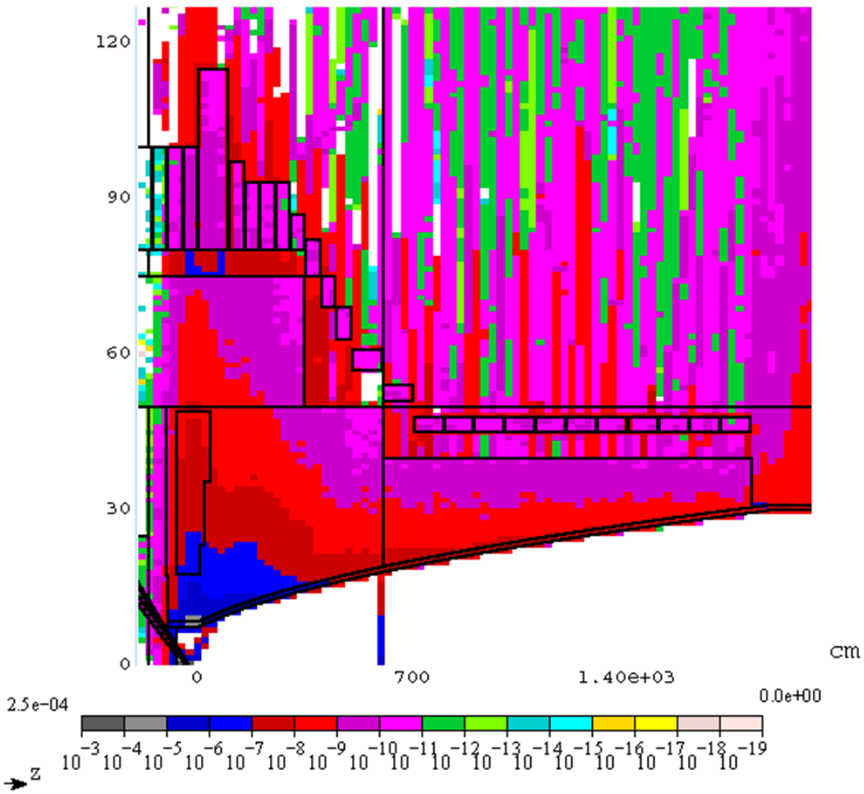
MARS Energy Deposition Studies



MARS15 study of Study 2 configuration yields 25KW energy deposition in SC1 alone

Reconfigure SC magnets





Increase the SC ID's. Fill released volume with shielding.

Rult: Total energy deposition in all SC's reduced to 2.4kW.

But SC magnets around target are now extremely difficult.

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Require an iterative approach

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Target Baseline Proton Beam Assumptions

Proton Beam Energy	**8 GeV**
Rep Rate	**50 Hz**
Bunch Structure	**3 bunches, 280 μsec total**
Bunch Width	**2 ± 1 ns**
Beam Radius	**1.2 mm (rms)**
Beam β*	**≥ 30cm**
Beam Power	**4 MW (3.125 × 1015 protons/sec)**

Target System Baseline

Target type	Free mercury jet
Jet diameter	8 mm
Jet velocity	20 m/s
Jet/Solenoid Axis Angle	96 mrad
Proton Beam/Solenoid Axis Angle	96 mrad
Proton Beam/Jet Angle	27 mrad
Capture Solenoid Field Strength	20 T

Backup Slides

Key Target Challenges

General Target Issues

- Thermal management (~3MW power deposited)
- Shielding (SC Solenoids required)
- Target integrity (Thermal Shock)
- Target regeneration (50Hz rep-rate)
- 20T environment

Liquid Hg specific issues

- Stable fluid flow (Nozzle performance)
- Hg handling system

The Key Parameters

Proton Driver

- **4 MW Beam Power**
- **5-15 GeV KE (8GeV is currently favored)**
- **50 Hz operation**
- **3 Bunch structure (280μs total favored)**

Target System

- **20T Solenoid Magnet**
- **Liquid Jet**
- **20 m/s flow rate (50Hz operations)**
- **High-Z (Hg favored)**