The Muon Collider/Neutrino Factory Solenoid Capture System

Solenoid Capture Workshop

Brookhaven National Lab

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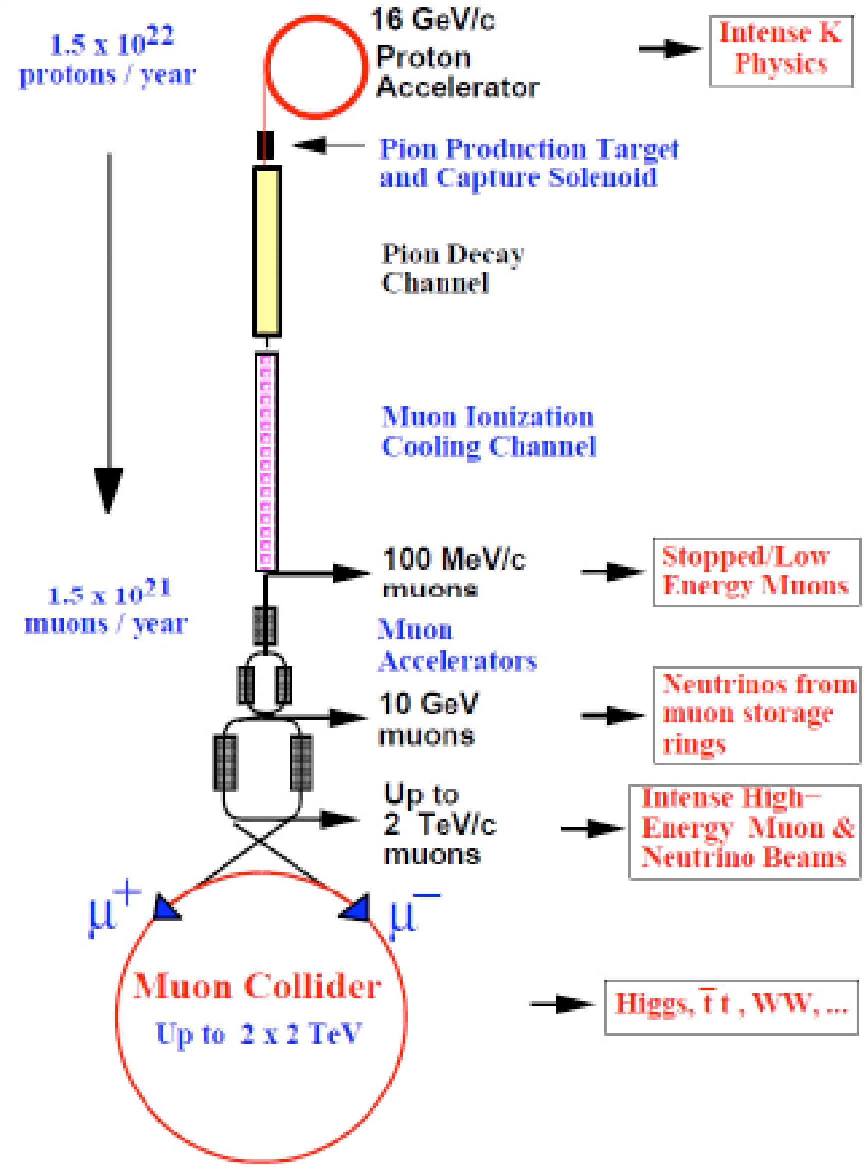
The Muon Collider Concept

Key technical issues:

- Requires a multi-MW proton driver
- A production target system to produce copious pions
- A cooling system to reduce the phase space of the collected muons
- High gradient rf for rapid acceleration



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The Neutrino Factory

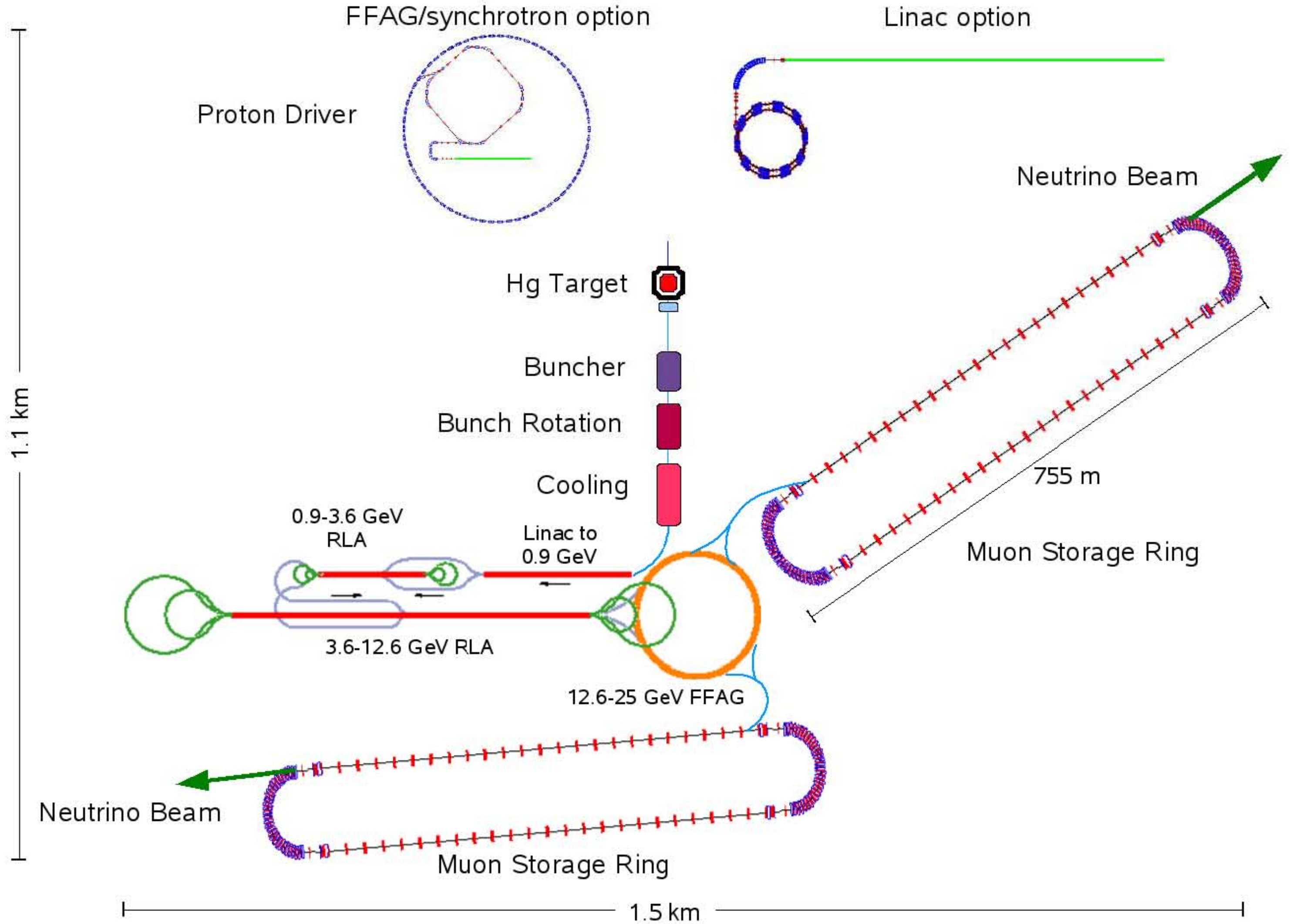
The muons in a storage ring decay such that:

$\mu^+ \rightarrow e^+ \bar{\nu}_e \nu_\mu$ and $\mu^- \rightarrow e^- \nu_e \bar{\nu}_\mu$

Further, the ν's are projected forward with an opening angle ~ 1/γ.

This gives rise to a very powerful ν beam capable of being projected over long baseline distances.

Layout of a Neutrino Factory



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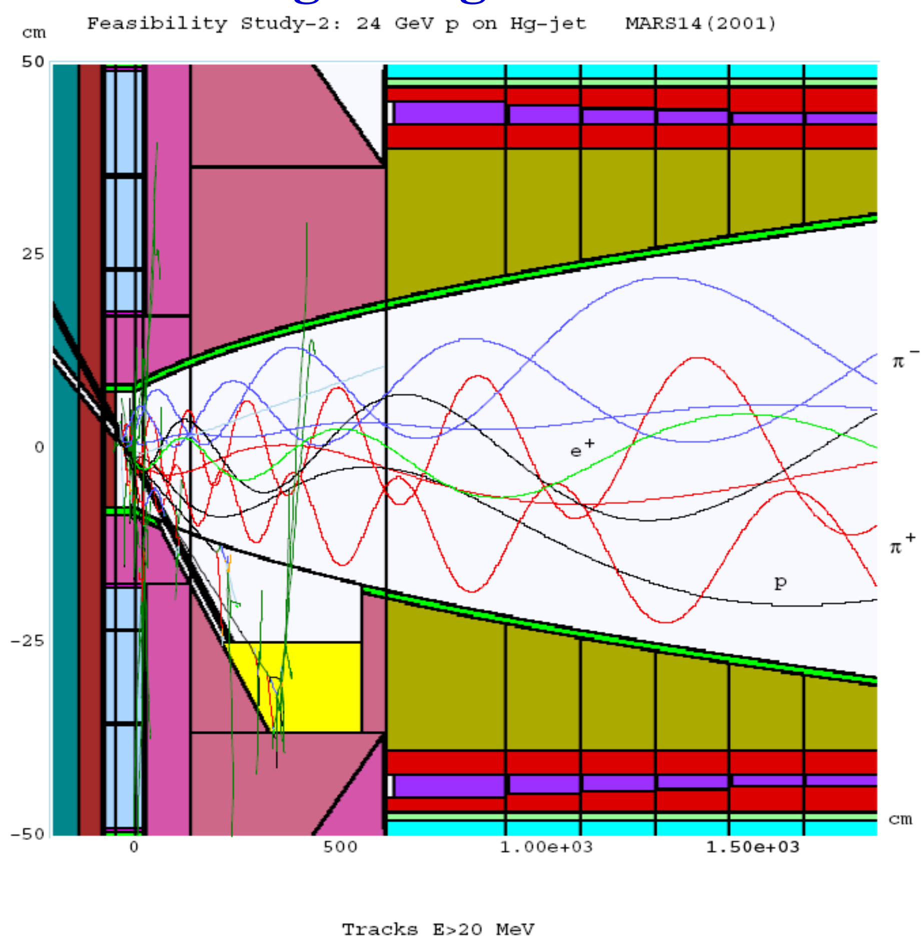
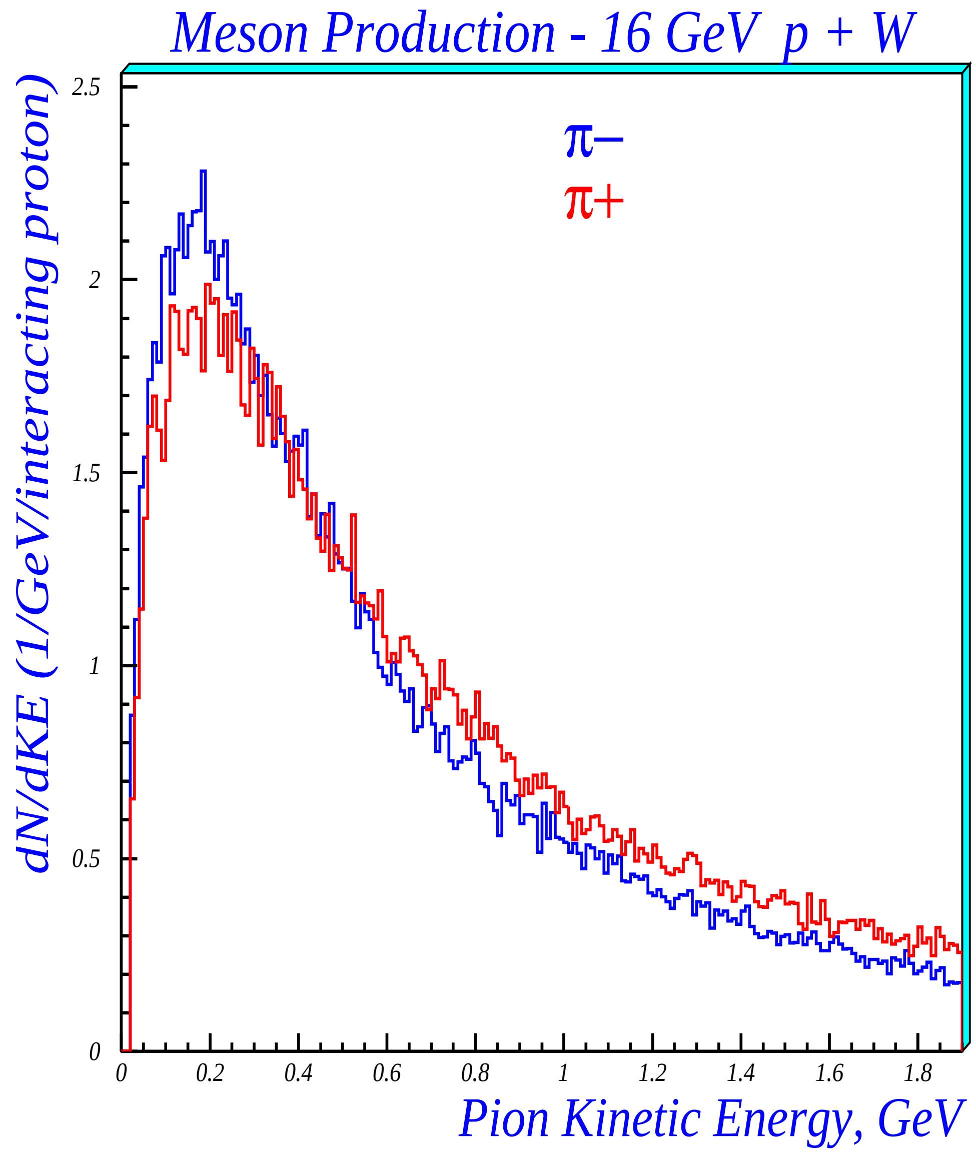
The Neutrino Factory Target Concept

Maximize Pion/Muon Production

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





Palmer, PAC97

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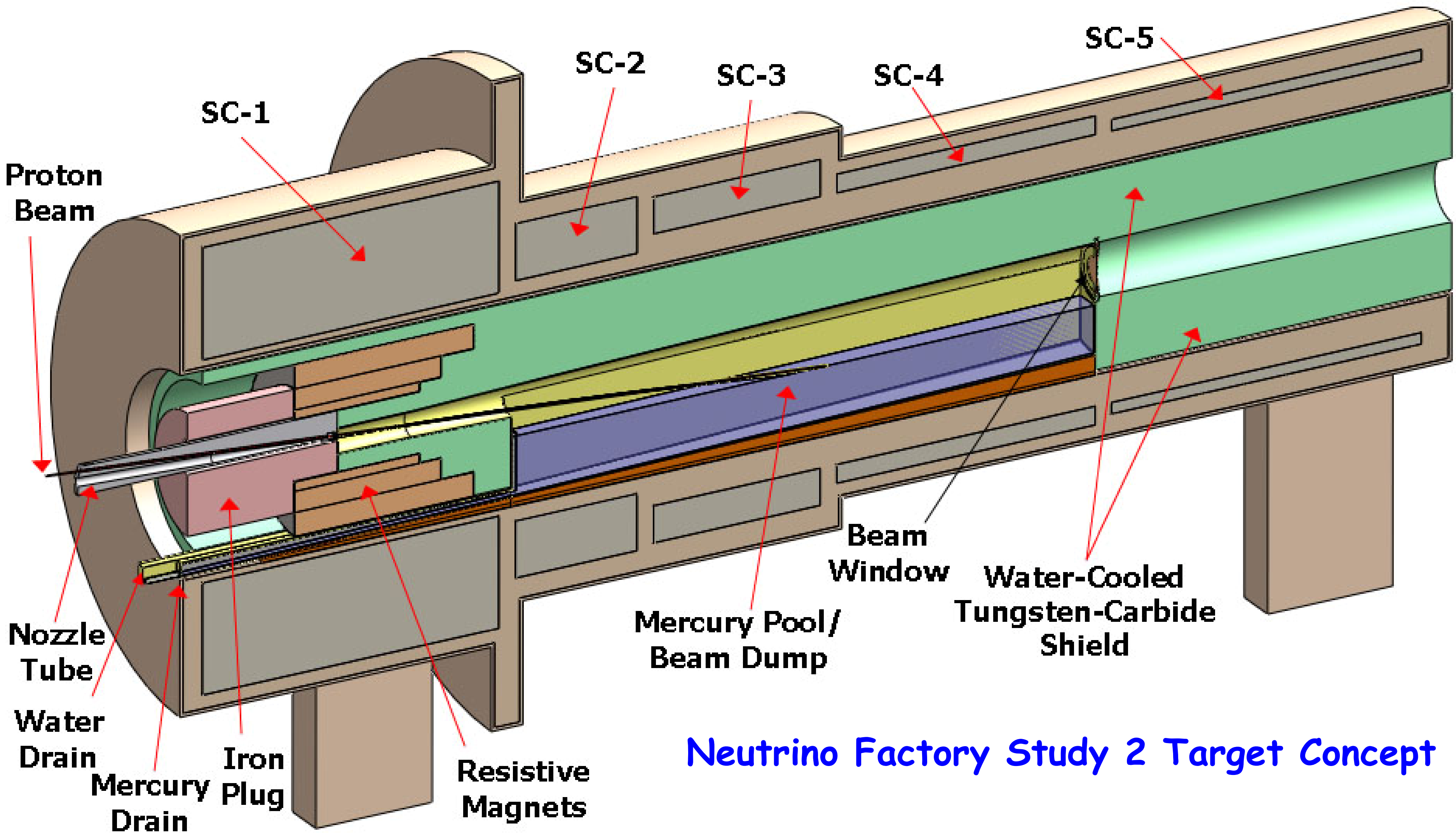
The Proton Beam Parameters

Proton Beam Energy	**8 GeV**
Rep Rate	**50 Hz**
Bunch Structure	**3 bunches, 320 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)**

The Target System

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**

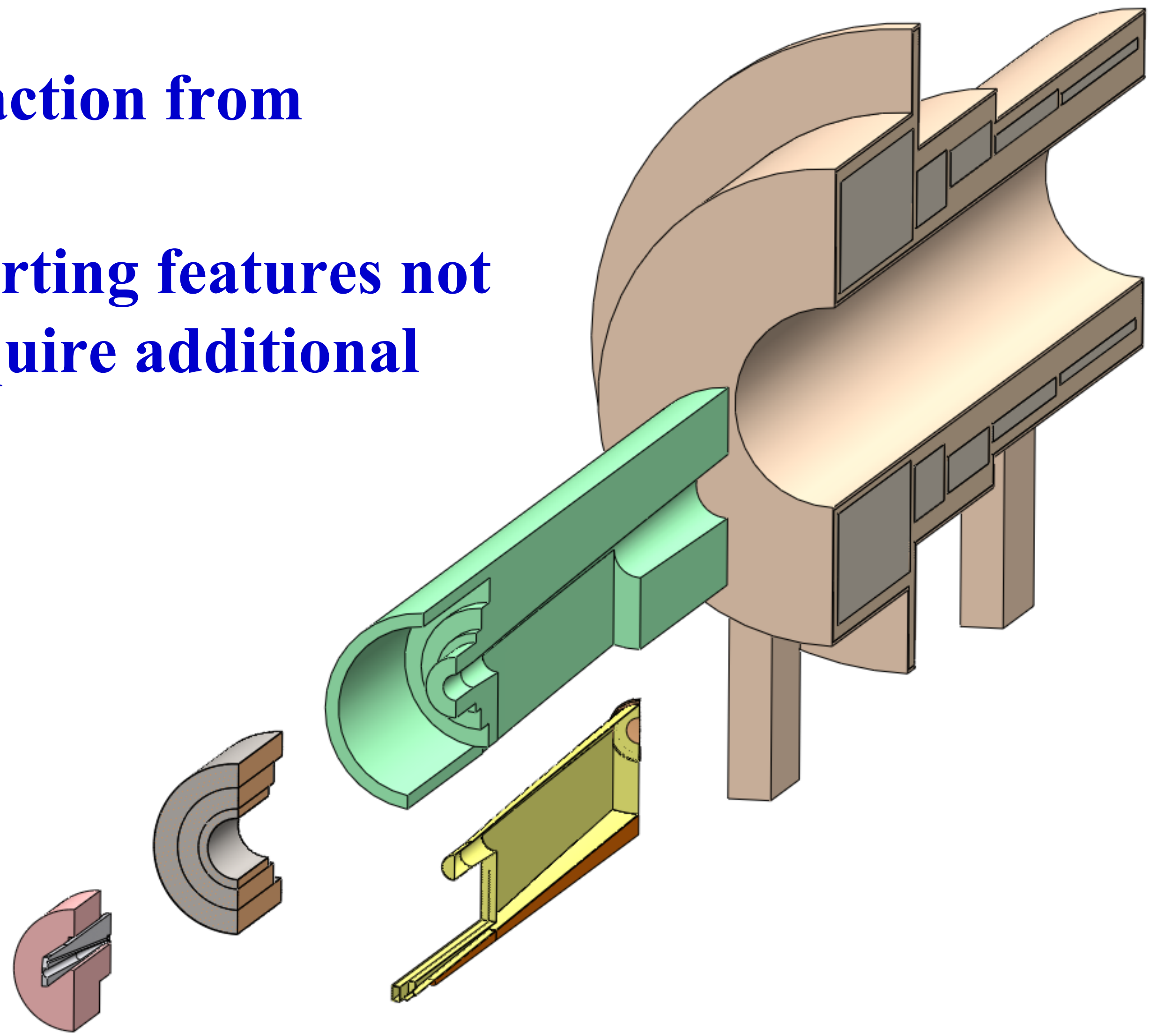
The NF Study 2 Target System



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



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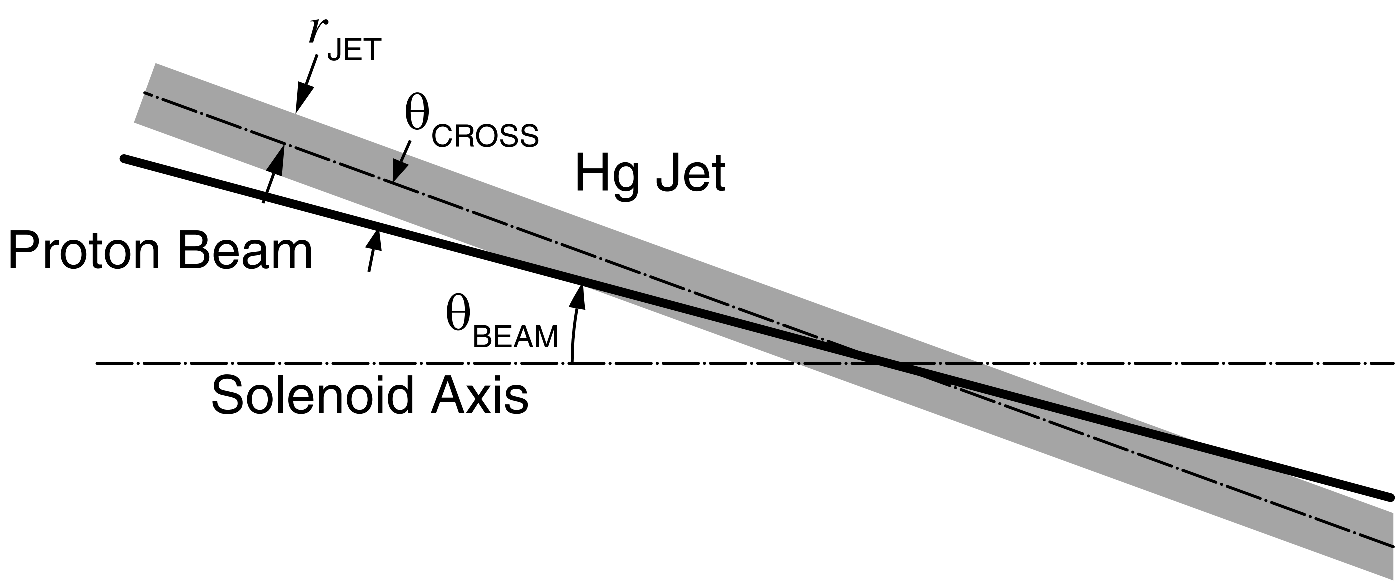
MARS15 Study of the Hg Jet Target Geometry



Previous results: Radius 5mm, θ_{beam} =67mrad

$\Theta_{crossing}$ = 33mrad

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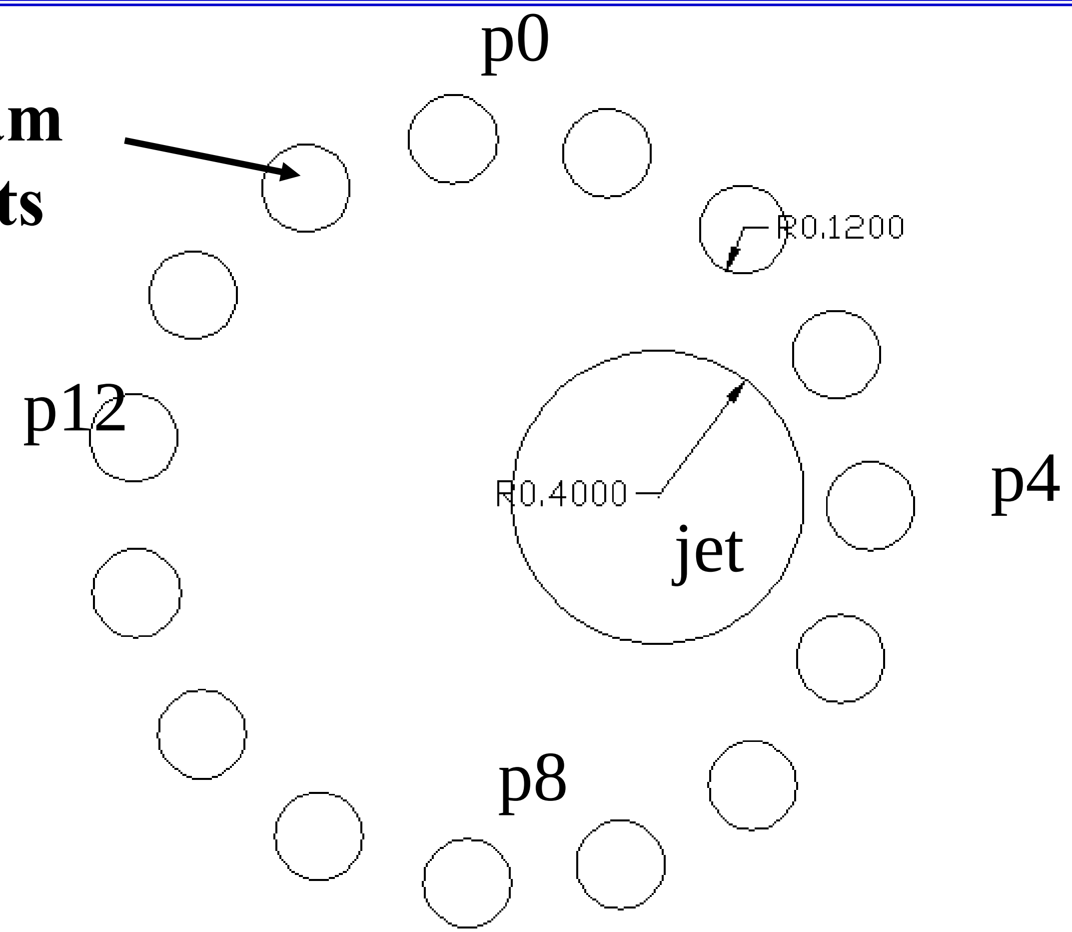
Multiple Proton Beam Entry Points

Proton Beam Entry points



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

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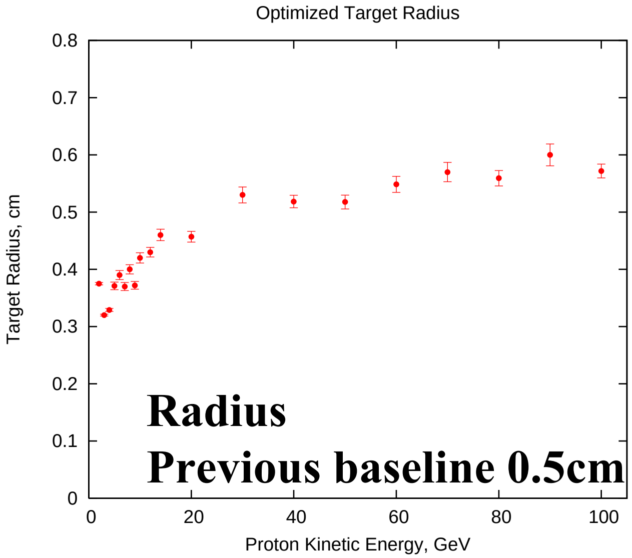
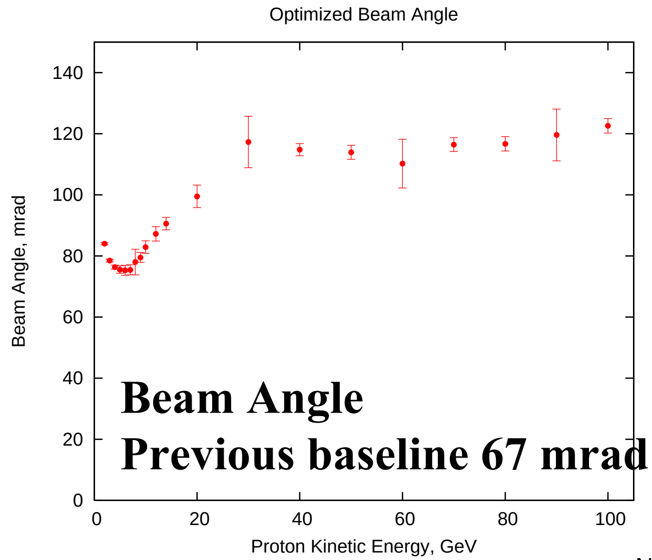
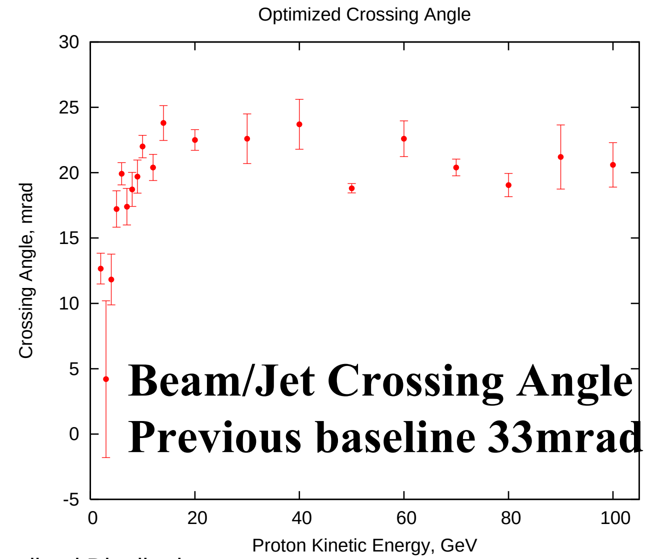
Proton beam entry points upstream of jet/beam crossing

Optimized Meson Production

X. Ding, UCLA

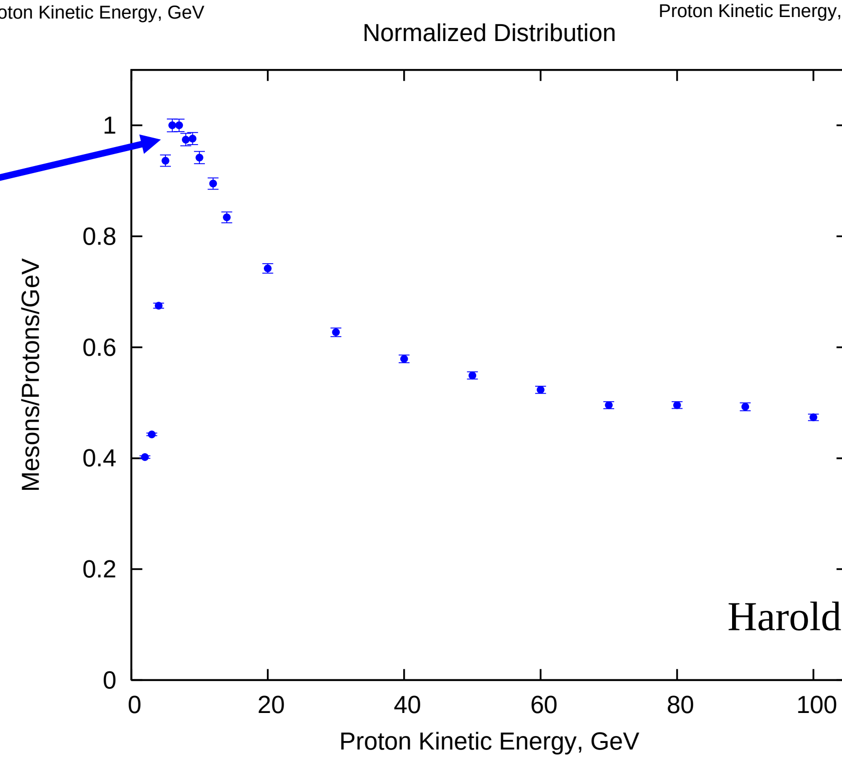




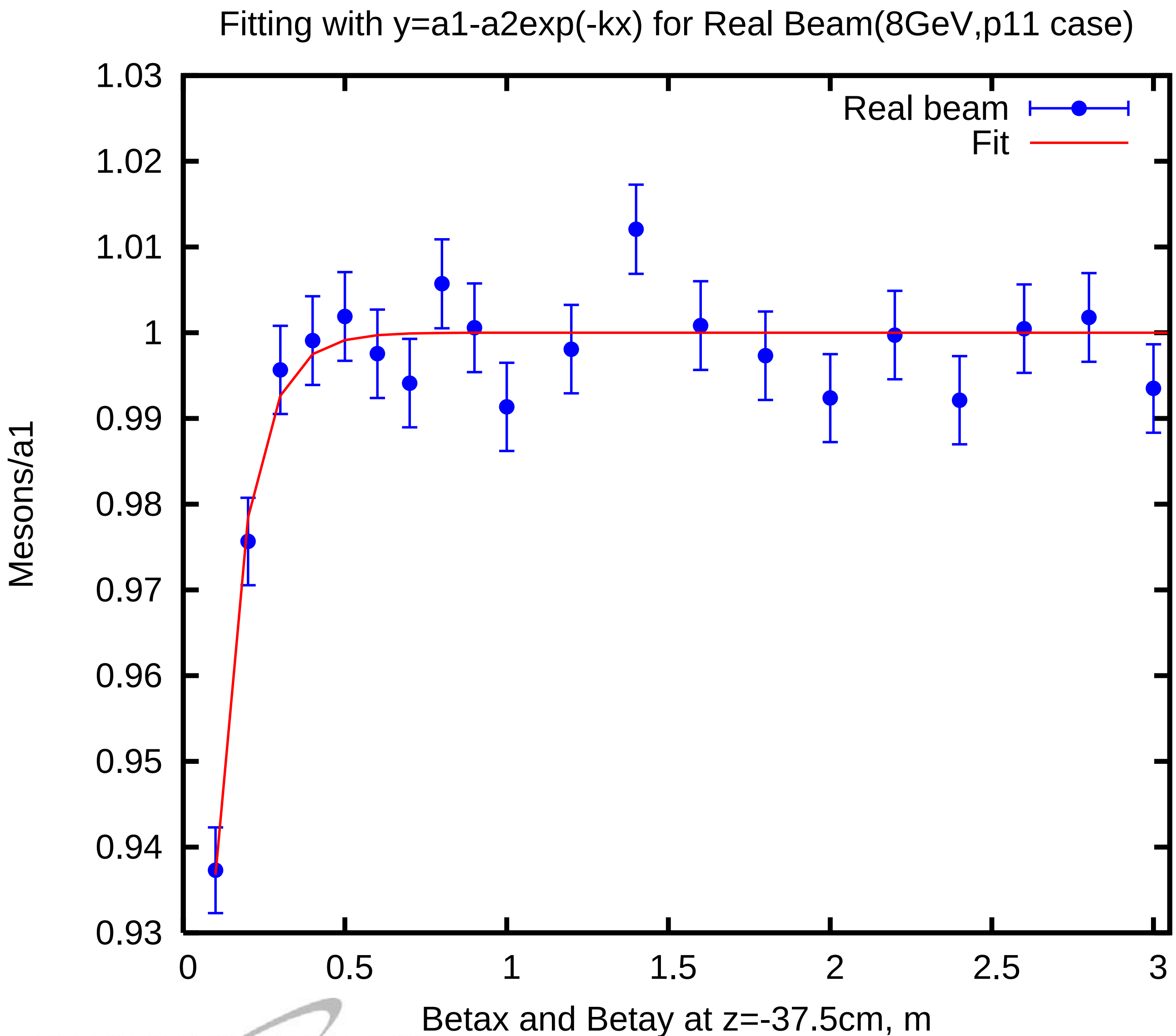


Production of soft pions is most efficient for a Hg target at E_p ~ 6-8 GeV,

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

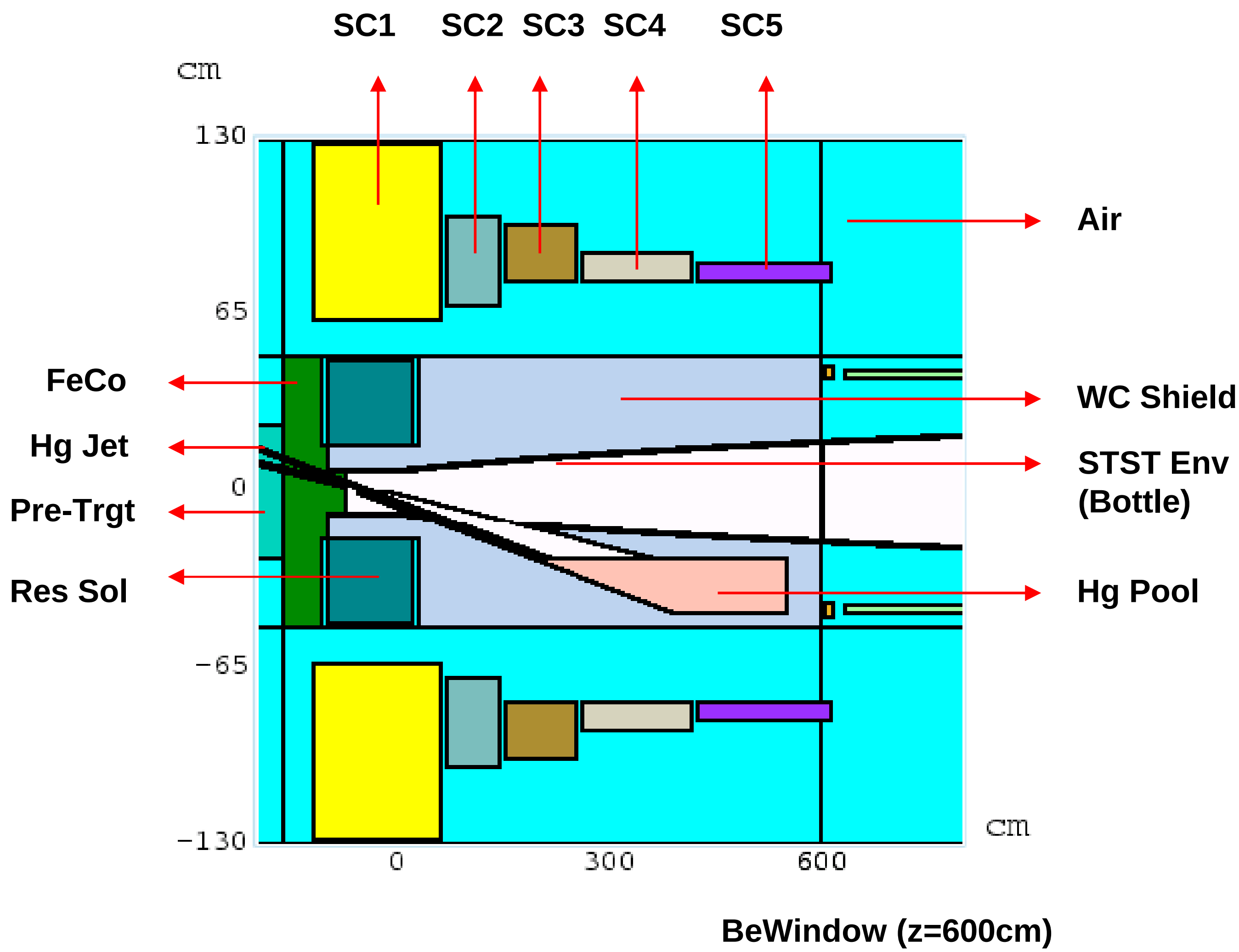


Meson Production vs β^*



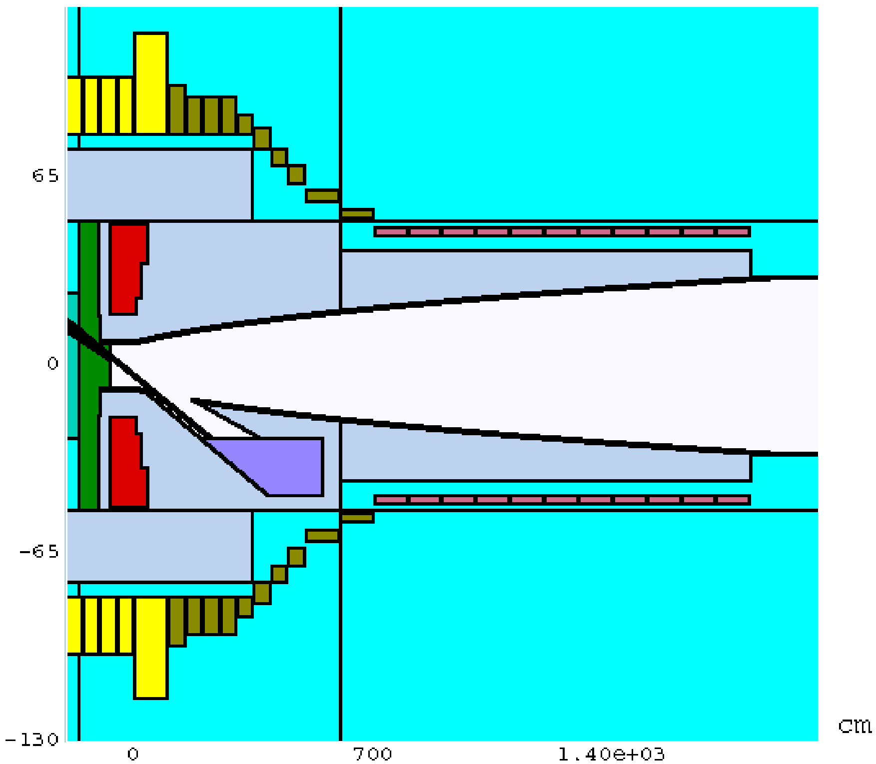
Meson Production loss ≤ 1% for $\beta^* \geq$ 30cm

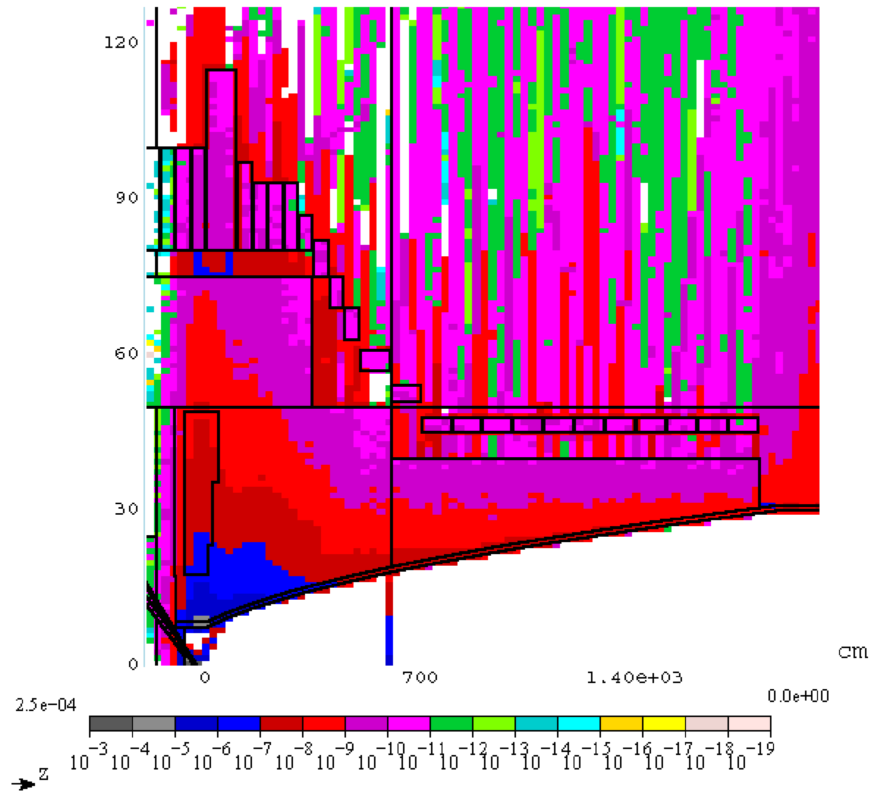
MARS Energy Deposition Studies



MARS15 study of Study 2 configuration yields 38KW energy deposition in SC1 alone

Reconfigure SC magnets





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

Total energy deposition in all SC's reduced to ~4kW.

But SC magnets around target are now extremely difficult.

Details to be provided by N. Souchlas

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