The Front End

MAP Review

Fermi National Accelerator Lab

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Outline

Define Front End

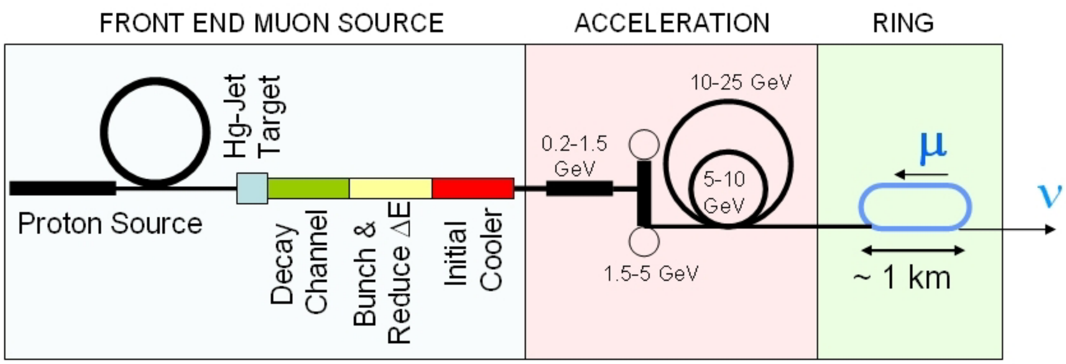
Major Sub-systems

Key Challenges

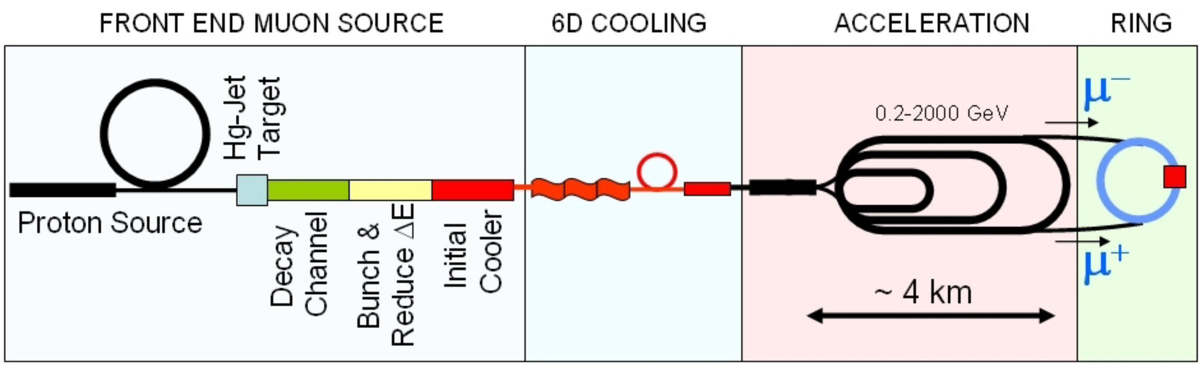
Milestones

The Muon Collider/Neutrino Factory Front End

- The Front End is that portion of the facility after the proton driver which is common to both the Muon Collider and the Neutrino Factory
- The proton source will have different bunch structures and possibly beam power.



Neutrino Factory



Muon Collider

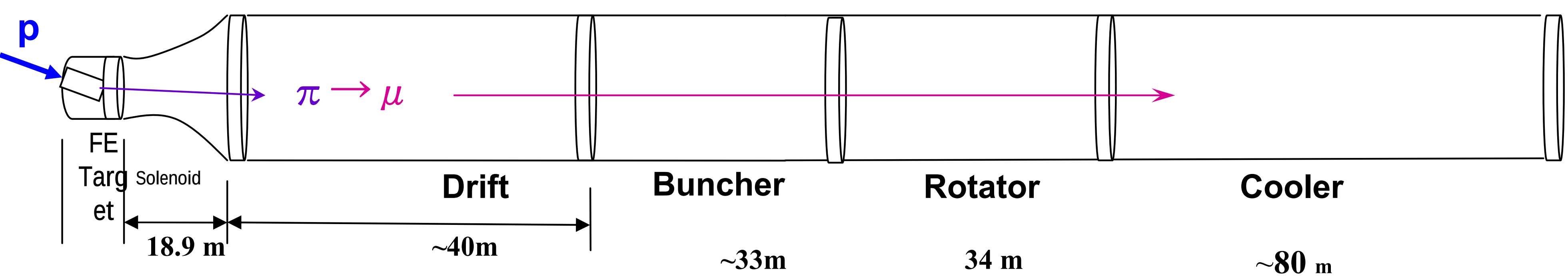
The Major Front End Sub-Systems

Target/Capture

Drift ($\pi \rightarrow \mu$)

Buncher/Rotator

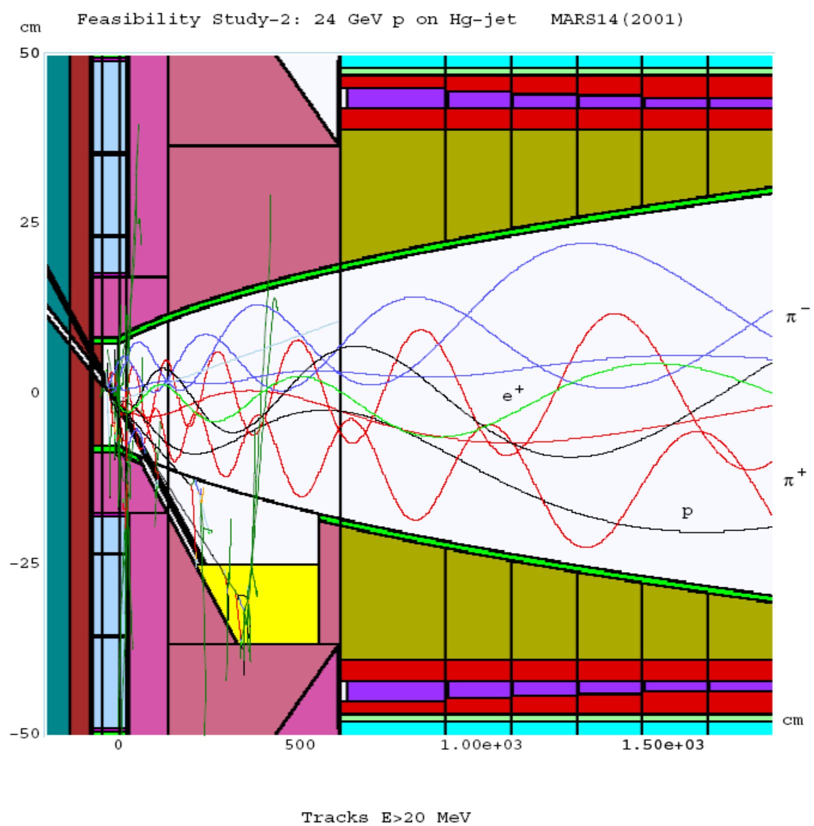
Cooler

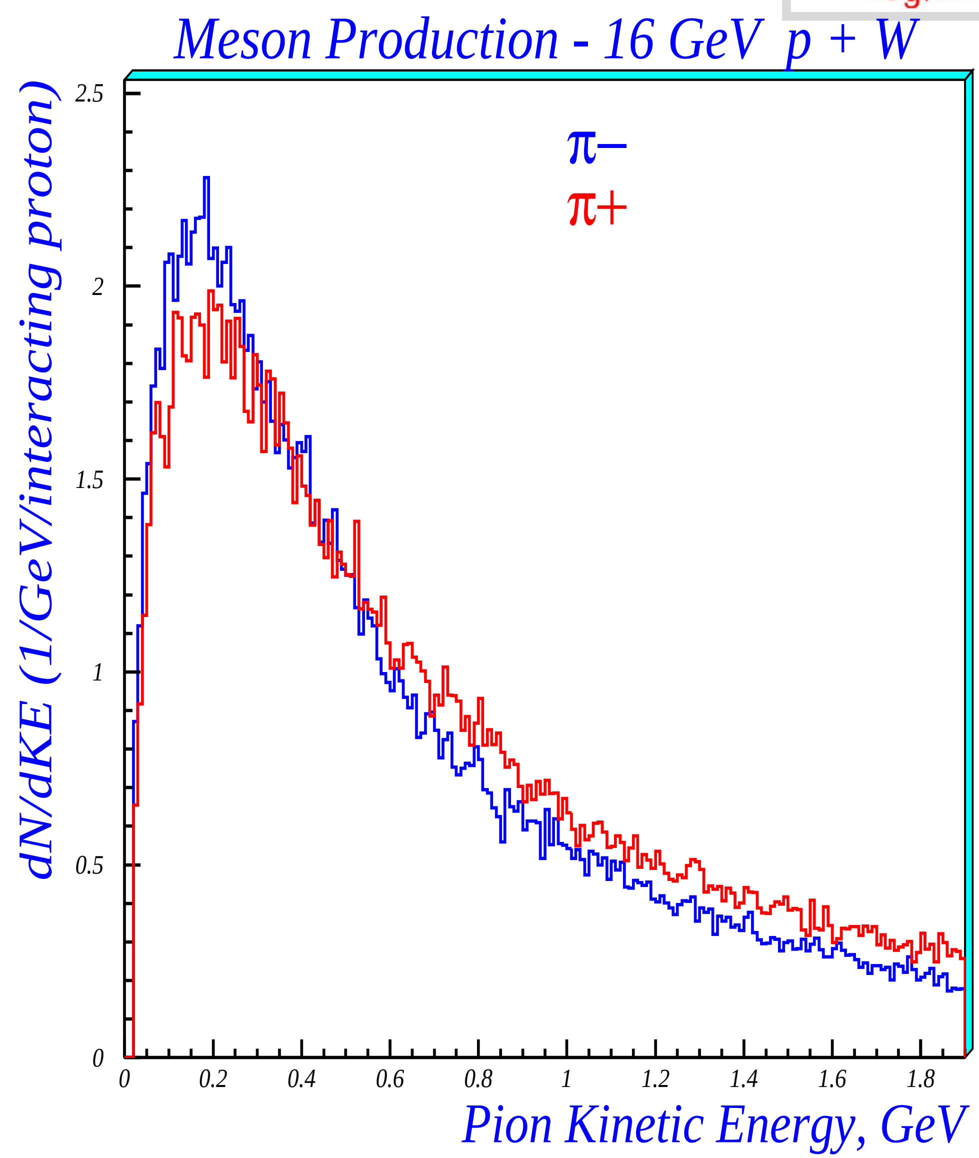


The Target Concept

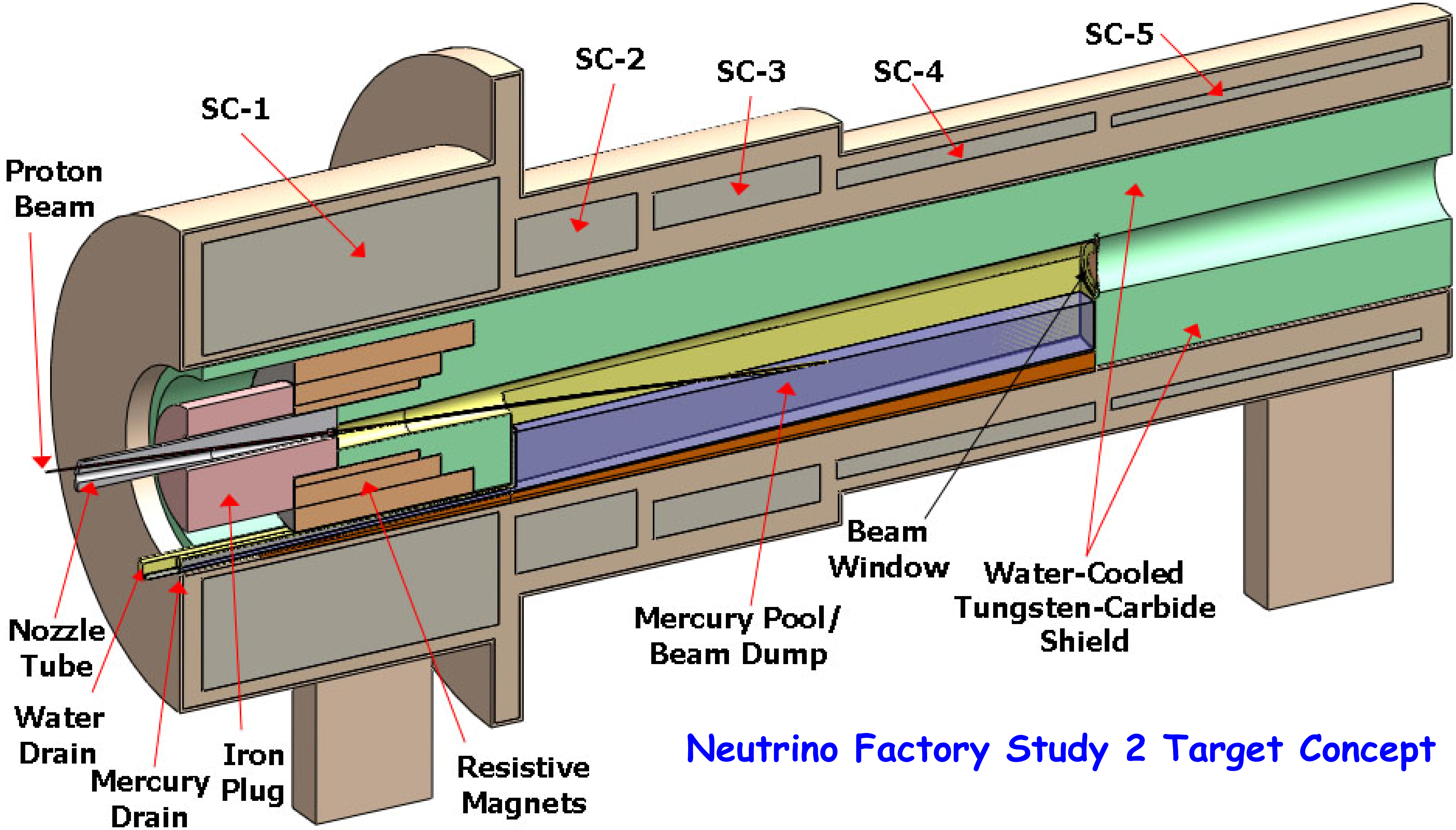
Maximize Pion/Muon Production

- **Soft-pion production**
- **High-Z materials**
- **High-magnetic field**





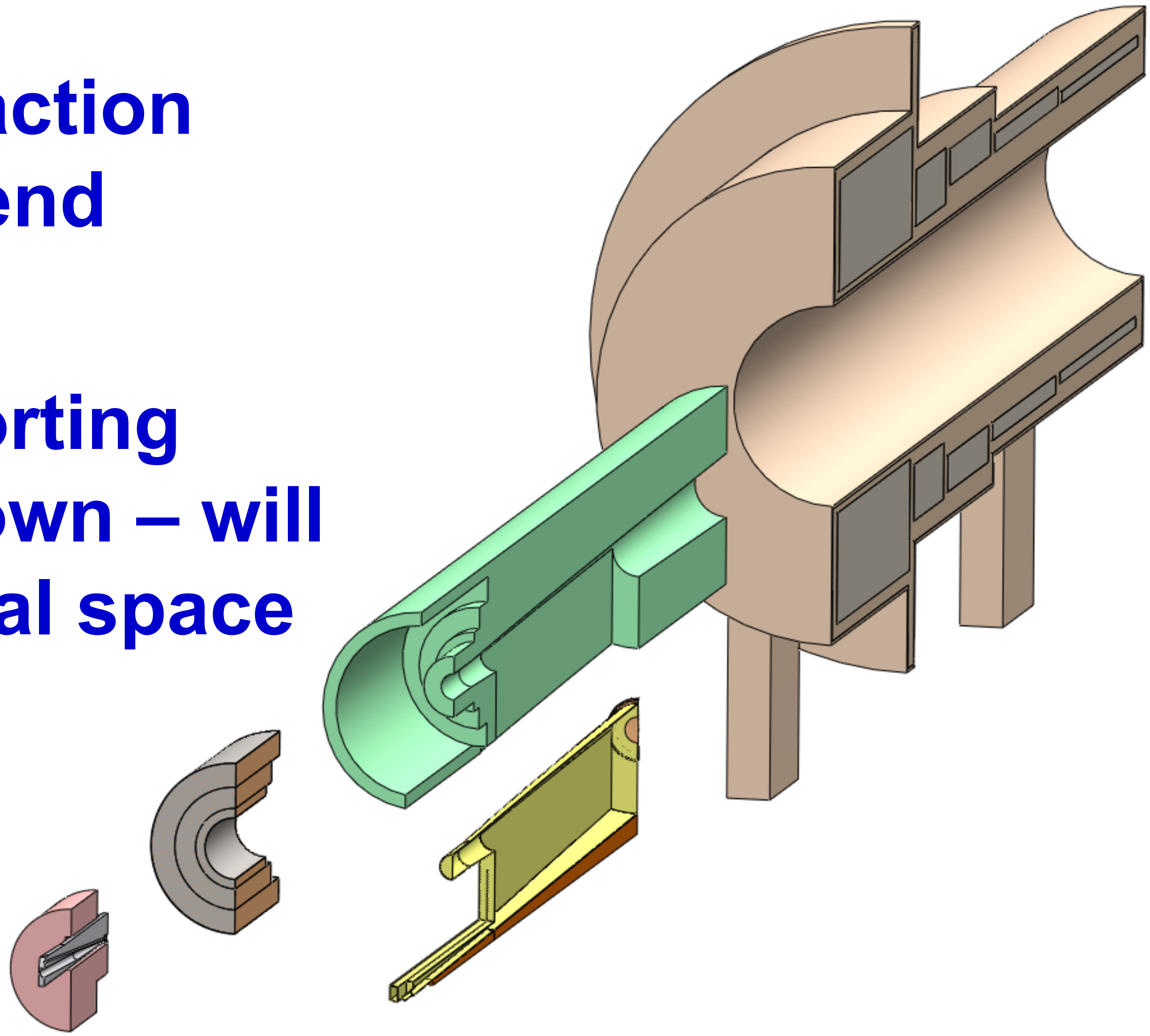
Cryostat Upstream End



Neutrino Factory Study 2 Target Concept

Upstream Target Exploded View

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



The Key Target Parameters

Proton Driver

- 4 MW Beam power
- 5-15 GeV KE (8 GeV is currently favored)
- NF: 50 Hz / MC: 15 Hz
- NF: 3 bunch structure (320 μs total) / MC: 1 bunch

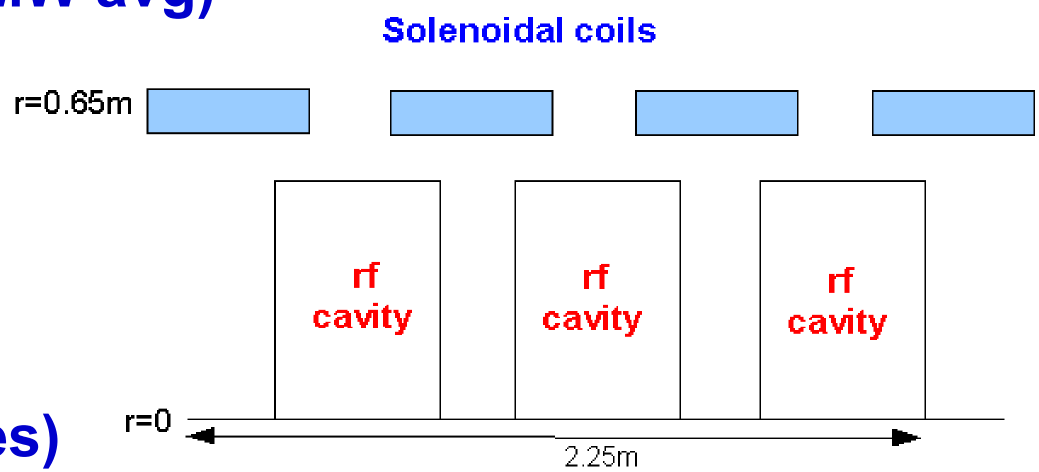
Target System

- 20-T solenoid magnet
- Liquid metal jet
- 20 m/s flow rate ("new" target every pulse @ 50 Hz)
- High-Z (Hg favored)

Key Buncher/Rotator Parameters

Buncher

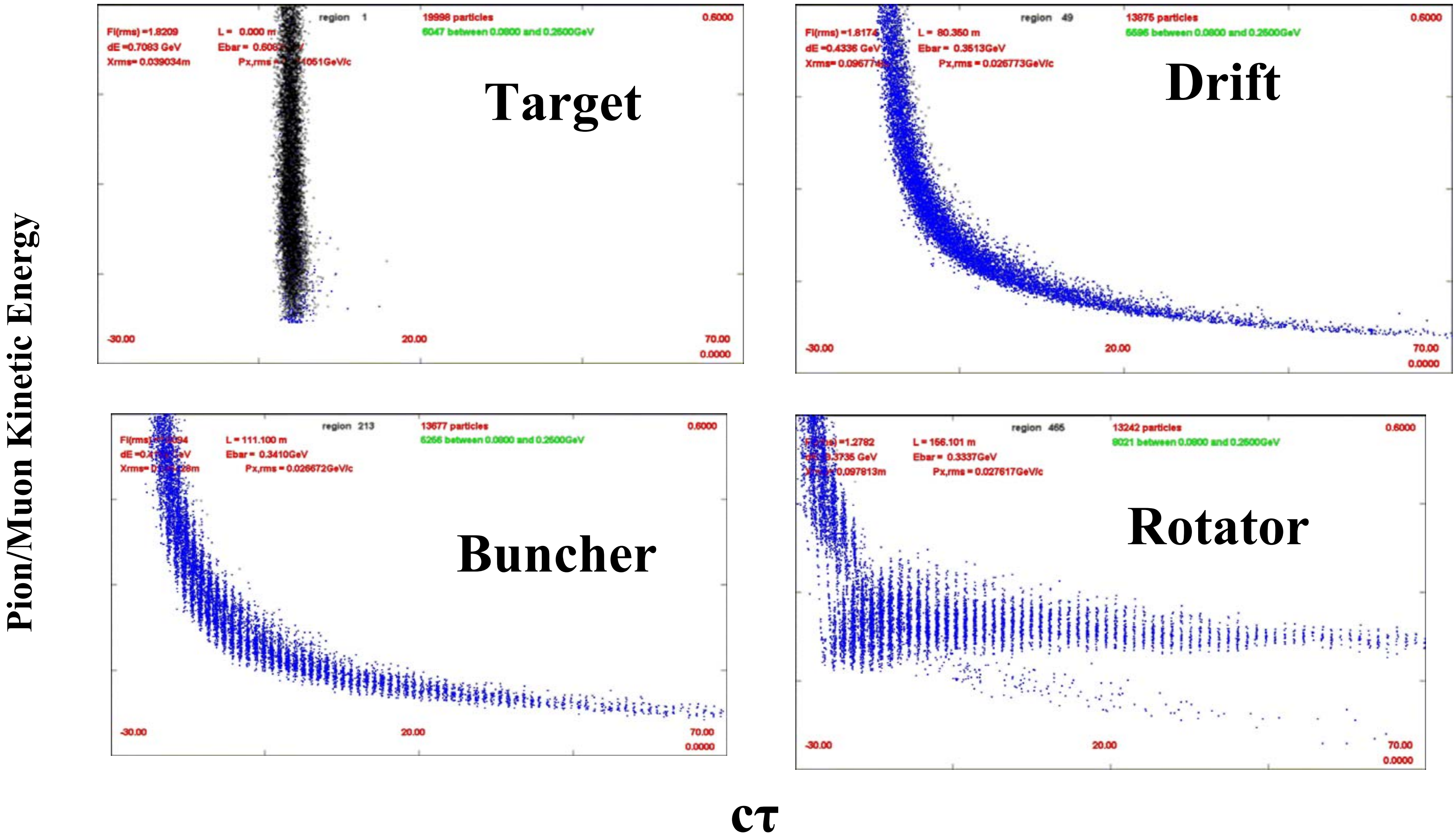
- 37 rf cavities
- 320 to 233.6 MHz (13 frequencies)
- 8 MV/m Peak rf gradient
- 24 MW Peak rf power (NF: 0.7 MW avg)
- 1.5T Peak magnetic field
- 33 m total length



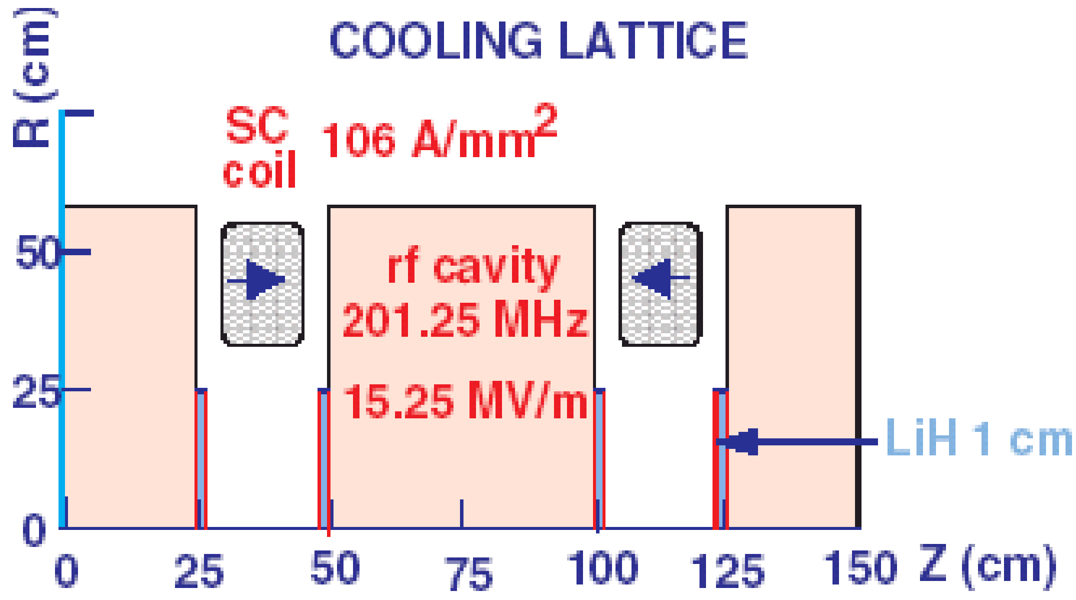
Rotator

- 56 rf cavities
- 230 to 202.3 MHz (15 frequencies)
- 12 MV/m Peak rf gradient
- 140 MW Peak rf power (MF: 4 MW avg)
- 1.5 T Peak magnetic field
- 42 m total length

The Buncher/Rotator



Key Parameters of the Cooler



- 100 rf cavities
- 201.25 MHz
- 15 MV/m Peak rf gradient
- 400 MW Peak rf power (NF: 12 MW avg)
- 2.8 T Peak magnetic field
- 75 m Total length

Front End Challenges

Target

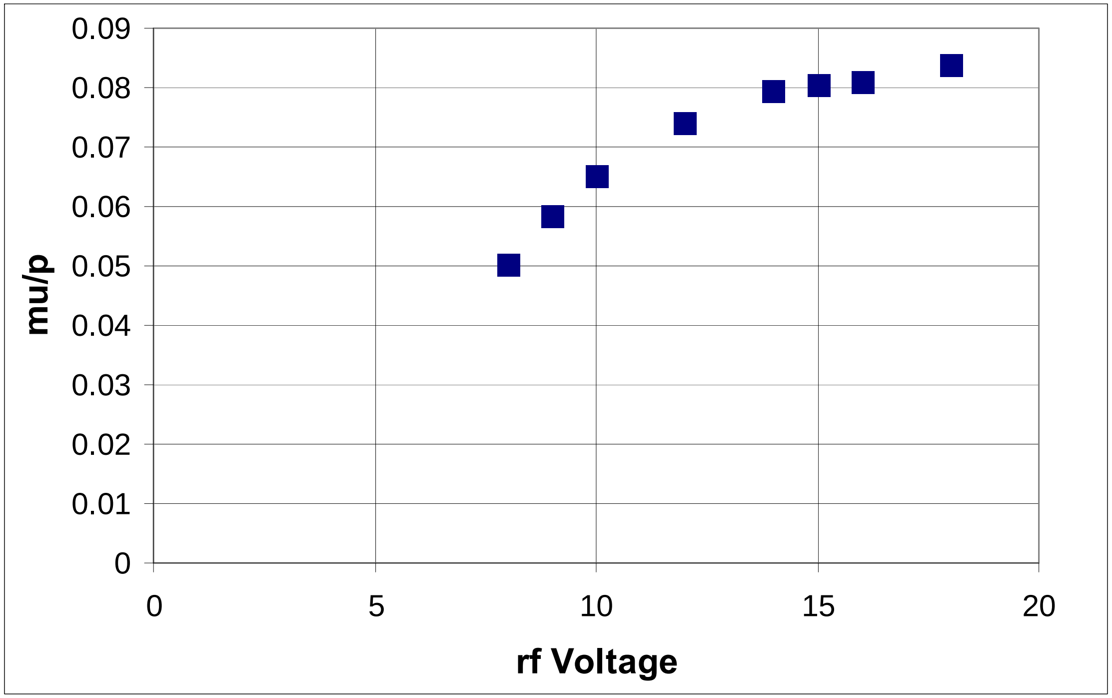
- Shielding of the SC coils
- Thermal Management
- Containment of Hg
- Delivery of stable 20 m/s Hg jet

Buncher/Rotator/Cooler

- Performance of rf cavities in magnetic field
- Shielding of beam line components
- Proof-of-principle cooling demonstration (MICE)

Front End Challenges: RF

D/ Neuffer



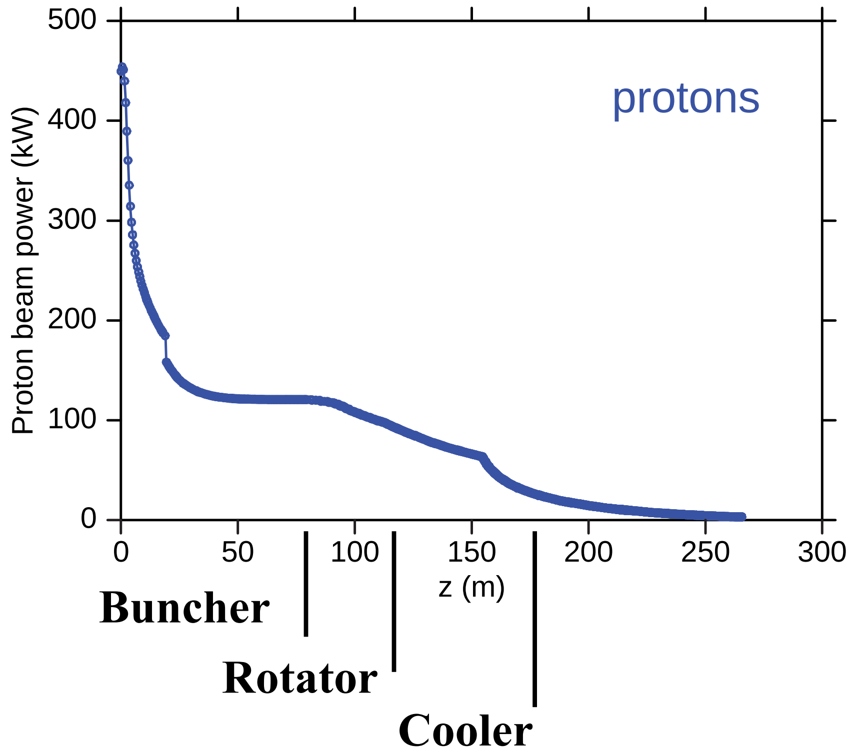
Machine performance reduced

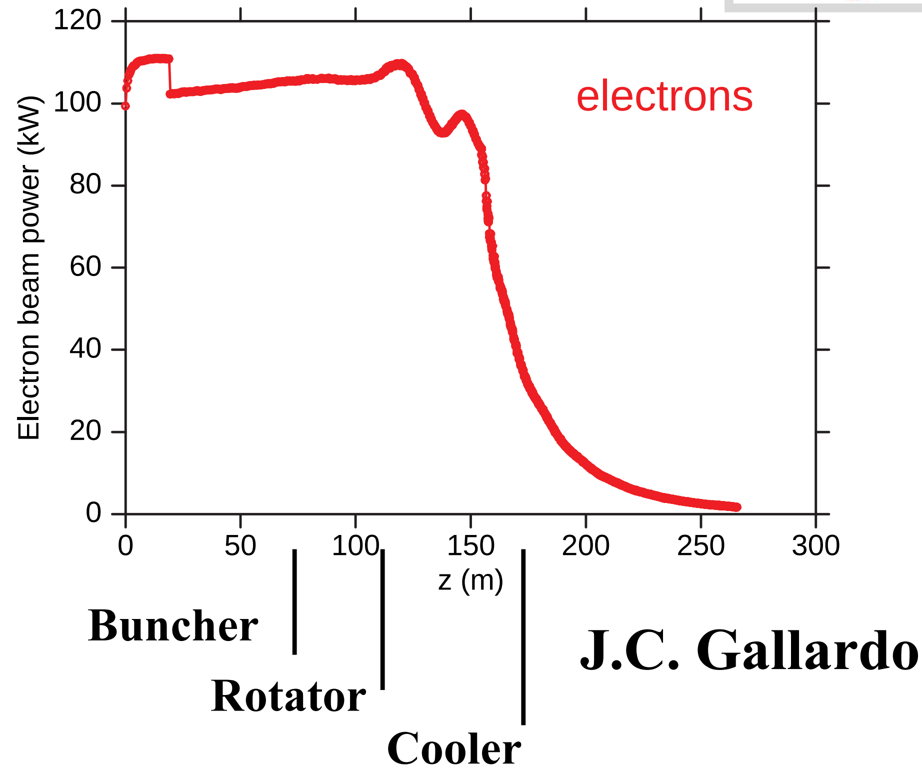
- **μ/p ratio reduced with rf gradient limitations**

Mitigation Strategies: Alan Bross, D. Li rf talks

- **Beryllium cavities**
- **High pressure (GH_2 filled) rf cavities**
- **Atomic Layer Deposition**
- **Magnetic insulation cavities**

Front End Challenges: Beamline Shielding

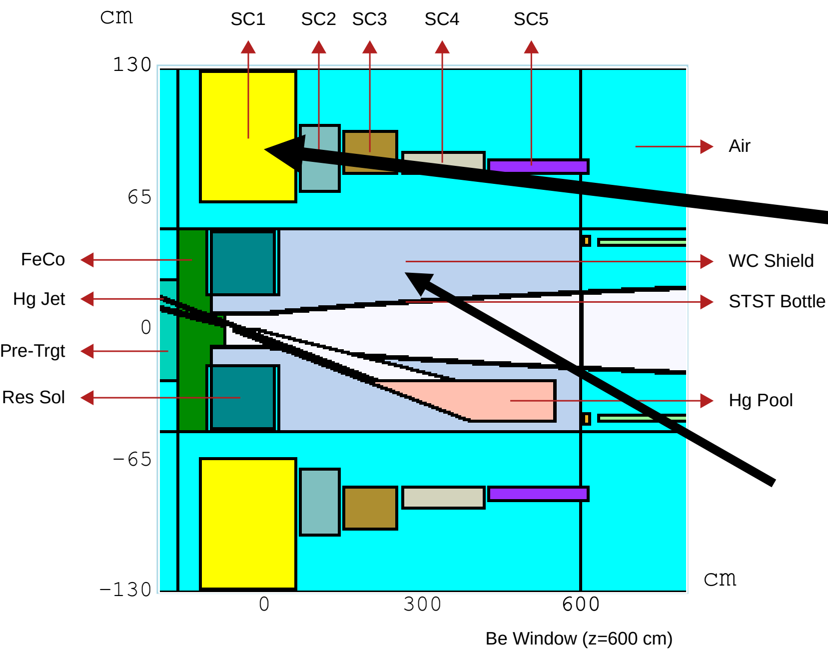




Mitigation Strategies

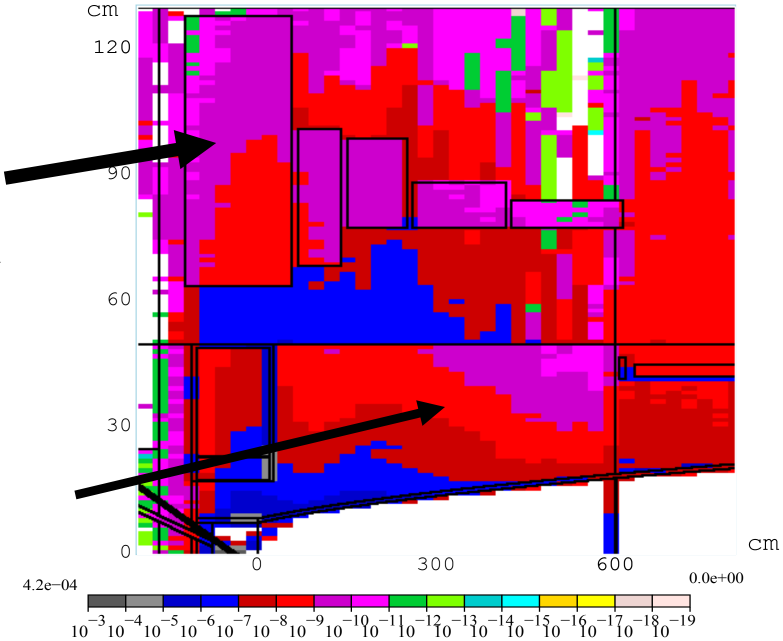
- **Upstream bent solenoid**
- **Beryllium "beam stop" plugs**

Front End Challenges: Target Shielding



25 KW of Energy deposition In SC1

~3 MW in Shielding



X. Ding

Mitigation Strategies:

- Increase SC IDs
- Replace Cu resistive insert with HTS insert
- Design and engineer thermal management solution

Front End Challenges: Hg Nozzle

Hg Jet

- 8 mm OD
- 20 m/s for 50Hz operations
- Hg jet performance in MERIT not optimal

Mitigation Strategies

- MHD simulations of jet/magnet/proton interactions
- Design and engineer nozzle delivery system
- Fabricate and test prototypical nozzle design

Front End Challenges: Hg Target

Mercury

- Low vapor pressure
- Toxic
- Disperses easily upon spilling

Mitigation Strategies

- Design and engineer double containment Hg system
- Explore alternatives:
  - PbBi eutectic
  - Tungsten powder flow

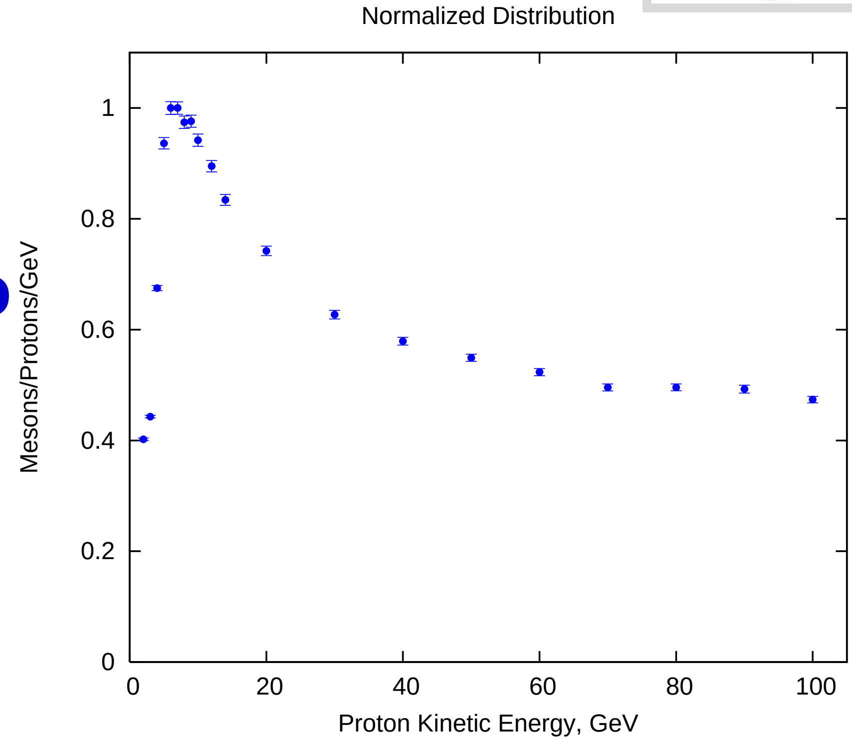
Front End Challenges: Pion Production

Current pion production modeling based on MARS15 simulations

HARP data does not support sharp falloff of pion production for proton KE < 8 GeV

Mitigation Strategies

- **Incorporate HARP (and MIPP) results into MARS (underway Mokhov, et al)**
- **Contribute high-Z target for production experiment at 5 and 8 GeV (MIPP proposal, Torun, et al.)**



Front End Milestones

FY10 Initial target configuration
FY10 IDS-NF IDR
FY11 Establish initial FE configuration
FY12 Down selection of 201 rf cavity design
FY12 Engineering design of Front End
FY13 Complete costing of Front End
FY14 IDS-NF RDR
FY14 Interim MC DFS

Summary

- A Front End baseline has been established
- Optimization studies have resulted in a 0.08 μ/p throughput ratio for 8 GeV incoming protons
- Key Front End challenges
  - Performance of rf cavities in magnetic field
  - Shielding of superconducting solenoids
- Mitigation strategies have been developed to address these challenges