Chicane and Front End

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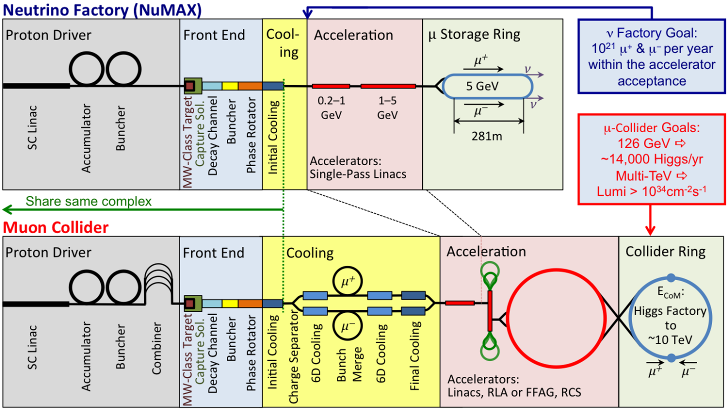
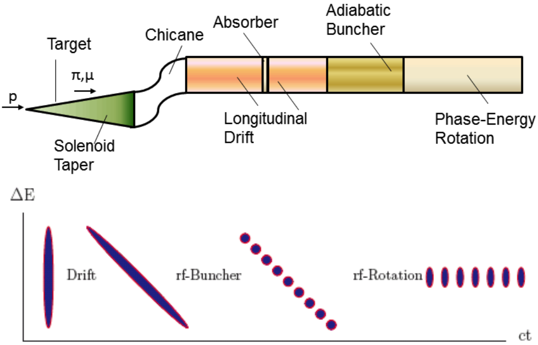


- Proton driver: provides intense proton beam.
- Target: pion production from protons hitting a liquid mercury jet or solid graphite target.
- Front end: generate the initial intense beam of muons.
- Cooling: reduce the size of the muon beam.

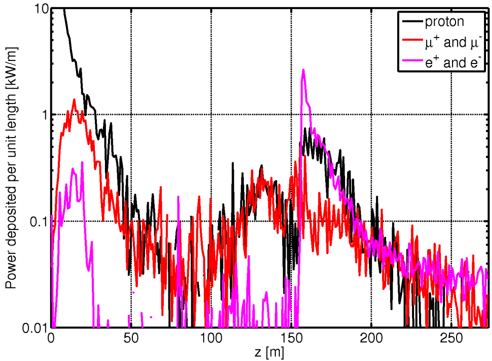
Front End components

Goals:

- Capture muons from the decay of pions that are produced by a high intensity proton beam impacting a target.
- Perform initial phase space manipulation to make muons well-suited to subsequent accelerator systems and/or experiments.

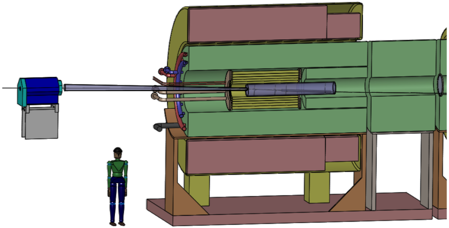


Background



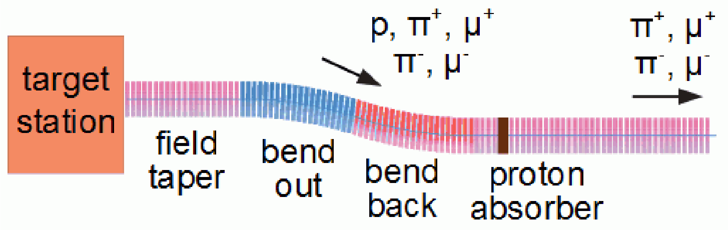
- In high-intensity sources muons are produced by firing high energy *p* onto a target to produce π.
- π decay to μ, which are captured and accelerated.
- Significant background from *p* and $\bar{e}$, which may result in
  - heat deposition on superconducting materials;
  - activation of the machine preventing manual handling.

Target (as of 2015)



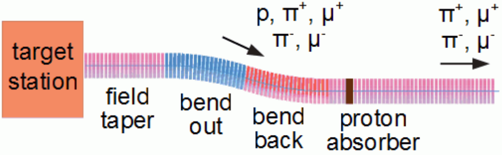
- Proton beam (6.75 GeV) passes through a solid graphite or liquid mercury jet at a small angle.
  - The yield of muons per unit beam power from a graphite target in 20 T is only slightly less than from a mercury target in 15 T.
- Pions are captured in the tapered (fast 5 m taper channel) SC solenoid going from 20 T (15 T) to 2-2.5 T.
- Target has to be able to withstand 4 MW of protons:
  - The limitation of a graphite target is perceived to be its short lifetime against radiation damage at high beam power.
  - Recent indications are that operation of graphite at high temperature (radiation cooling, ∼2000 K) would permit long life even at 4-MW beam power (deserves verification in beam tests).
- Shielding and energy deposition studies are underway.
- Proof-of-principle experiment MERIT has been carried out successfully.
- All the latest details are in the previous talk by Kirk McDonald.

Decay channel

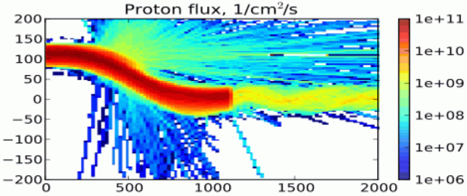


- Need a secondary particle handling system for a megawatt-class solid *C* target:
  - solenoidal chicane;
  - followed by a proton absorber.
- Challenges of optimization and integration of the system with the rest of the muon front end.
- Need to implement more elaborate (elliptical) coil shapes to handle both charges.
- Apply the same techniques downstream to study the the buncher and phase-rotator sections.
- Design proton dump, gaps in the chicane.

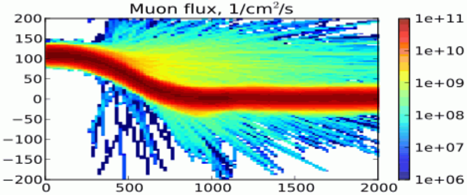
Chicane



Chicane schematics

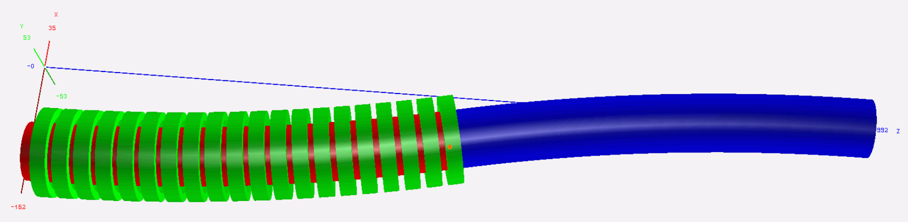


Proton flux, $1/cm^2/s$



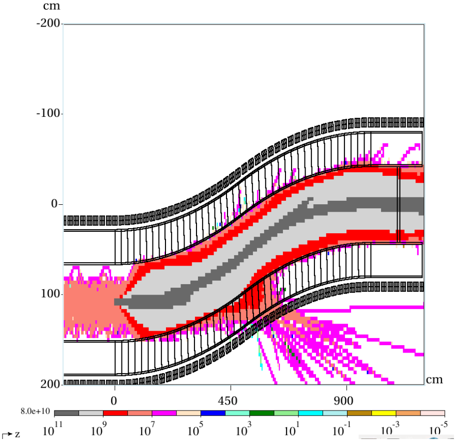
Muon flux, $1/cm^2/s$

Chicane

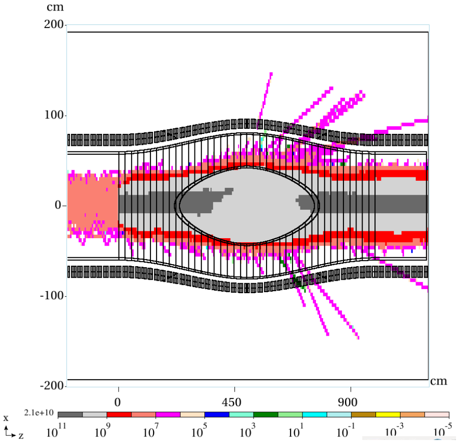


- Chicane is simulated using MARS for the most part.
- Some analysis and validation is done using ICOOL and G4beamline.
- ROOT-based geometry is used in MARS.
- 12.5° single bend.
- $z = 0$ corresponds to 19 m downstream of the target.
- 60% density W is used to take into account packing fraction of the beads.
- Starting point for the analysis was uniform 35 cm shielding.

Muon flux

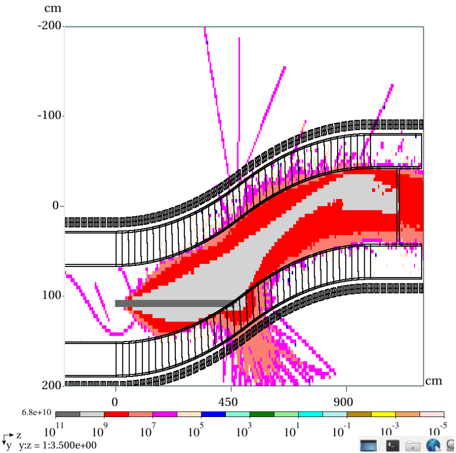


Top view

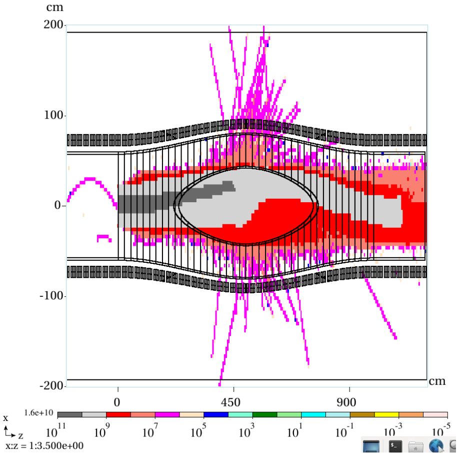


Side view

Proton flux

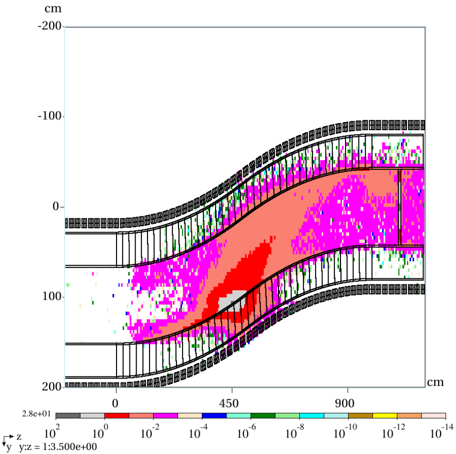


Top view

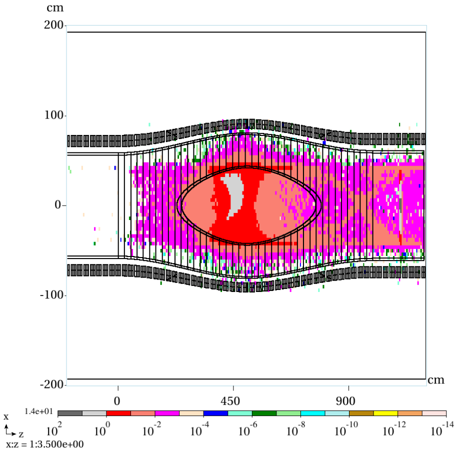


Side view

Deposited power density (total), mW/g



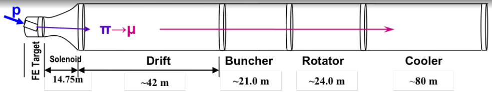
Top view

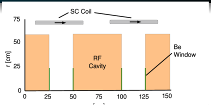


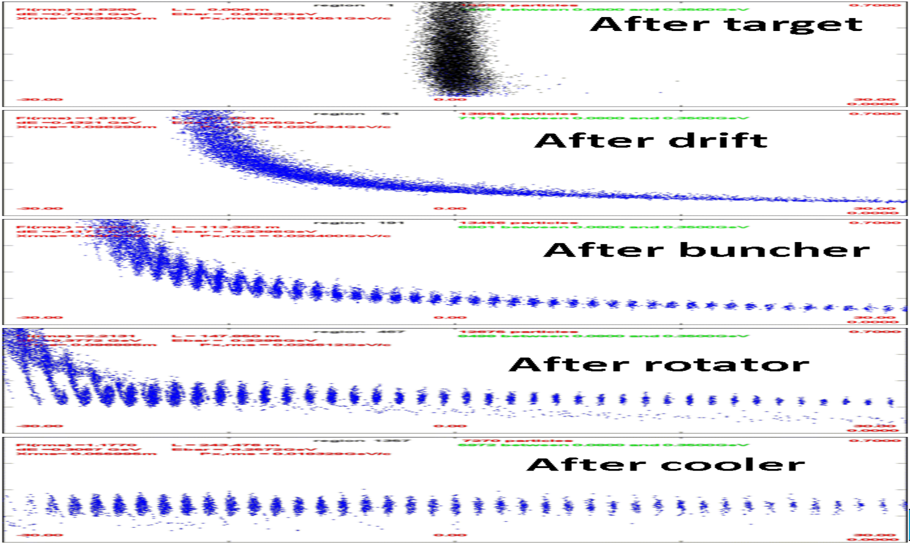
Side view

- We definitely don't need 35 cm of tungsten everywhere, only in the central coils, so the next step could be a tapered design.

Front end and beam evolution

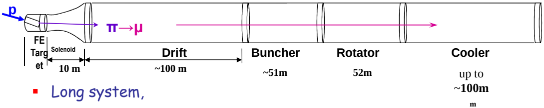




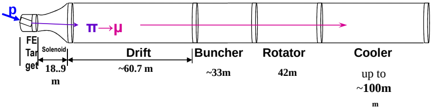


Optimization for IDS

- ISS study based on n_B = 18 (280 MeV/c to 154 MeV/c)
  - Buncher 0 to 12MV/m; Rotator 12.5MV/m, B=1.75T (**201.25 MHz**)



  - Long system,
- Try shorter version - n_B = 10 (233 MeV/c to 154 MeV/c)
  - slightly lower fields (1.5T, 15MV/m)
  - Buncher 0 to 9 MV/m, Rotator 12MV/m
  - Shorter bunch train



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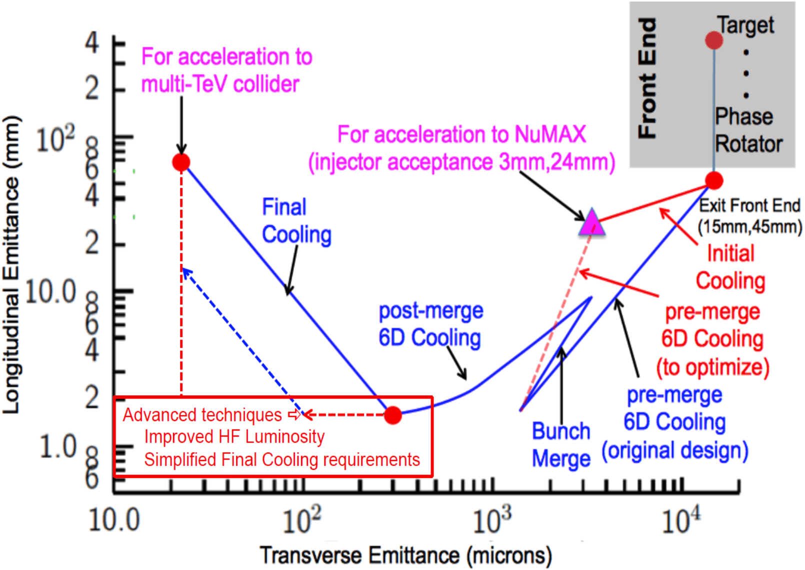
Neutrino Factory front end evolution

Emittance evolution



Summary

- We have the baseline components for the frontend that were studied in detail and optimized to a certain extent. End-to-end simulation studies were performed.
- A preliminary physics and engineering study of the target solenoid system, including study of the magnetic forces, stray field management and required shielding materials is necessary, taking into account both heat load on the cryogenic systems and radiation damage to the superconducting assembly.
- Selection of appropriate target material considering existing regulatory frameworks is required.
- Further study of the target systems, early integration studies including concepts for remote handling and radiation protection issues of the entire facility, focusing in the area up to the end of the chicane.
- More detailed study of the chicane: realistic (elliptical) coils, gaps for high-energy particles, re-optimization of the chicane and preliminary consideration of radiation load and relevant shielding is necessary.
- Once the target and chicane system designs are finalized, the end-to-end simulation and optimization of the frontend need to be performed.

Thank you!