Transmission Losses in the Muon Front End

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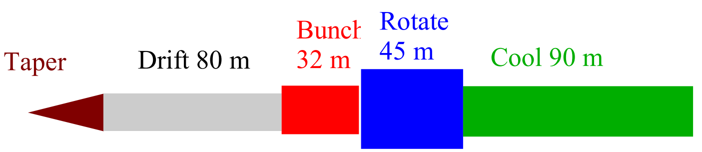
Overview

- There are significant transmission losses in the front end
- How much?
- What are the implications?
- Simulation in ICOOL 3.10
  - 50,000 particles in initial sample
  - Simulation is with the “Discrete” lattice
    - Realistic solenoid
    - Discrete RF frequencies
    - RF windows
  - I now have Pavel's G4BL deck, would like to repeat the study
- Rate normalisation, beam powers, etc is for Neutrino Factory
  - I don't know Muon Collider parameters
  - May need to be re-normalised

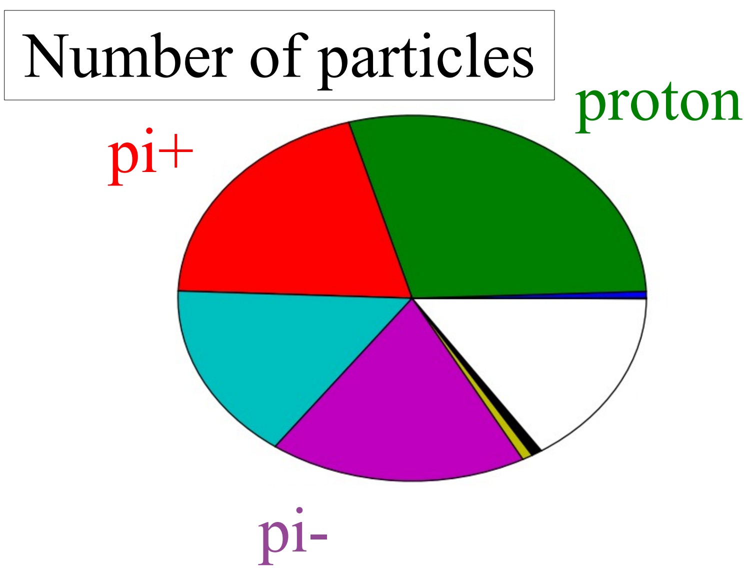


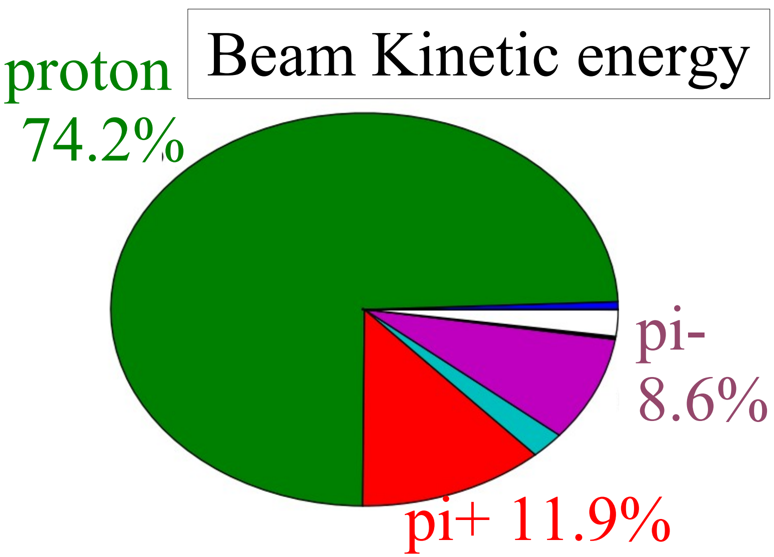
NuFact Order of Magnitude

- 10^{21} useful decays at the storage rings per year (per sign?)
  - 10^{7} seconds per year
  - Decay ring 30% efficiency
  - => $3*10^{14}$ muons per second
  - Average kinetic energy ~ 200 MeV (including high E tail)
  - => 9 kW muon beam power in front end
  - Assume 30 % muon (pion) transmission through front end
  - => 30 kW peak muon (pion) beam power in front end
- What about secondaries?
  - Look at MARS file (courtesy of Harold)
  - Track through ICOOL
- Aside:
  - 4 MW / 8 GeV gives $3*10^{15}$ protons/second
  - $3*10^{22}$ protons/year
  - => require ~0.1 good decays per proton at the storage ring
  - => require ~0.3 muons per proton at the storage ring (per sign?)

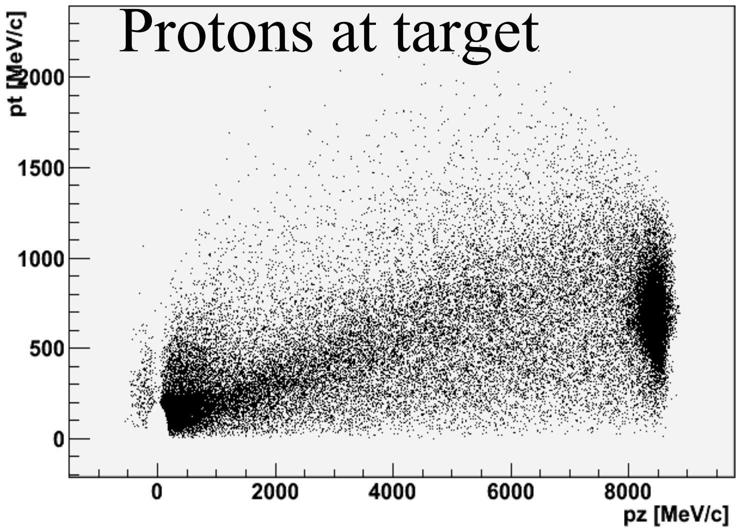
Order of Magnitude

- What about secondaries?
  - Look at MARS file (c/o Harold)
  - Track through ICOOL...

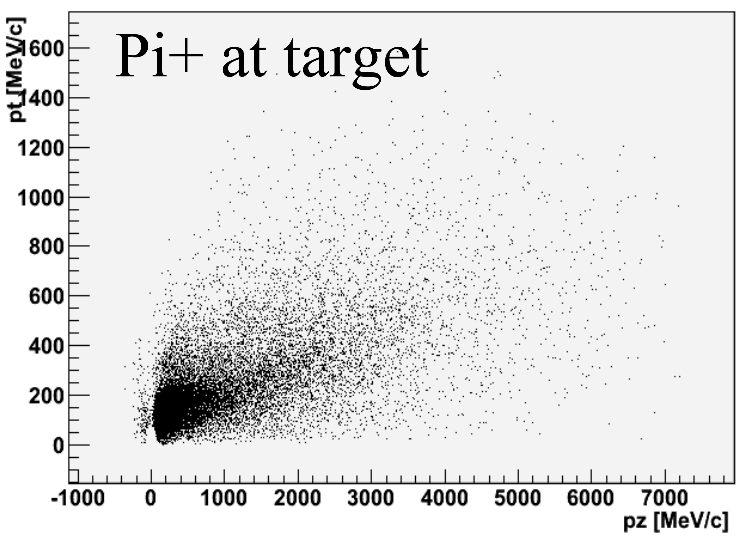


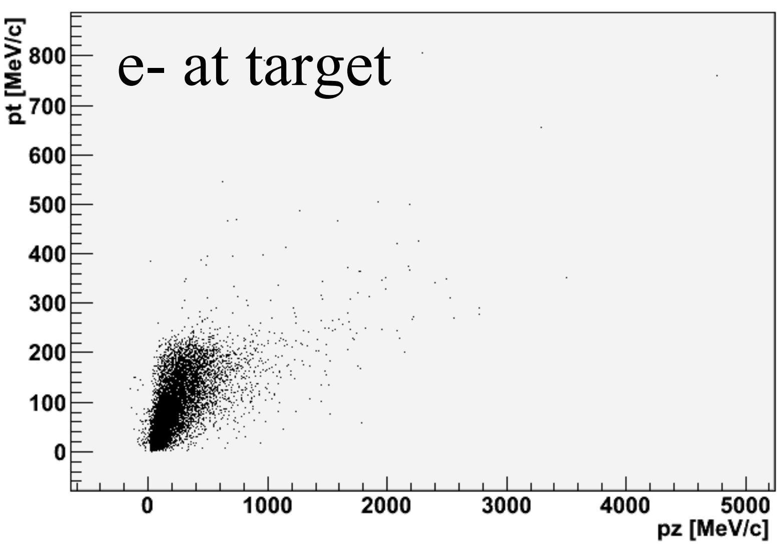


Particle distributions

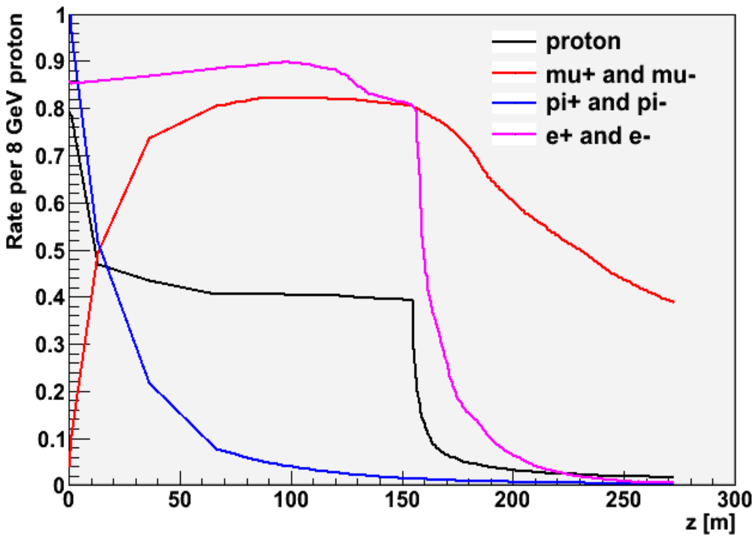


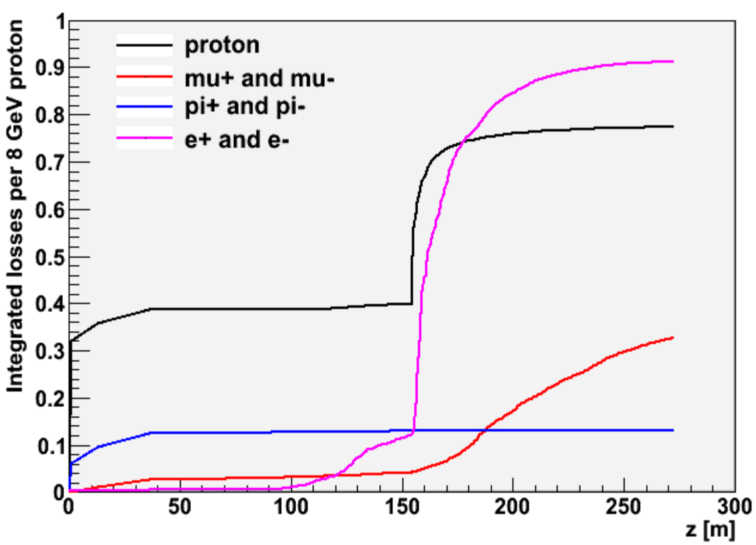
- Looks like we have to worry about protons
  - Spallation protons at low energy
  - Fringe of primary protons at high energy(?)
- And electrons?
- (Nb scales are not the same for each plot)





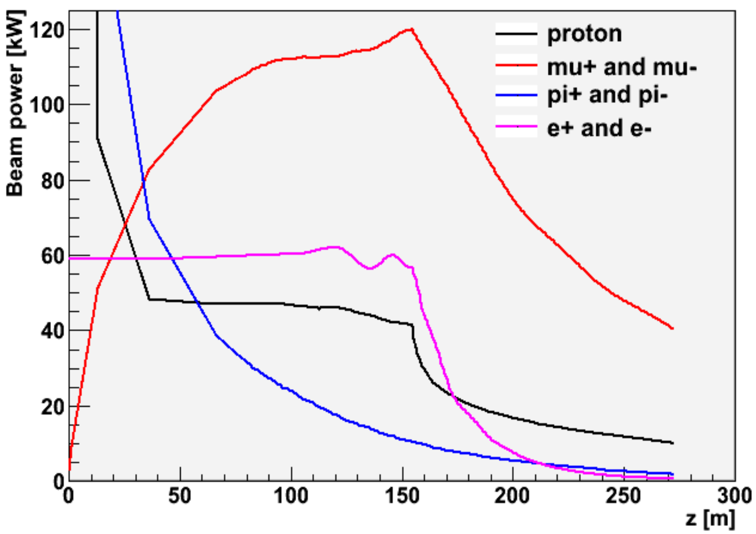
Tracking and Losses





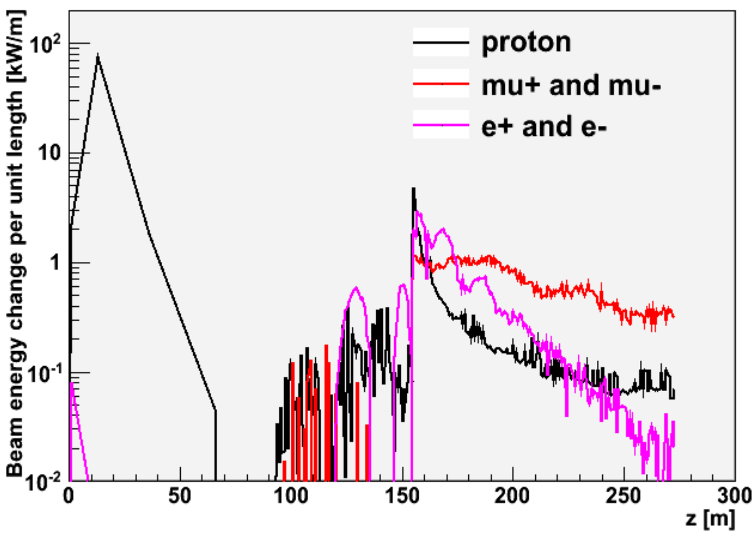
- Rate
  - Significant numbers of electrons, protons transported
  - 0.098/0.10 good mu+/mu- per proton
    - Ecalc9f with usual cuts:
    - A_t < 30 mm, A_l < 150 mm
    - 0.1 < pz < 0.3 GeV/c
    - Do I have too many muons?
- Losses
  - Lower plot shows integrated losses excluding decays
  - Lots of loss at entrance to cooling
    - Flipping magnetic lattice
    - Stopping power of absorbers greater for protons, electrons

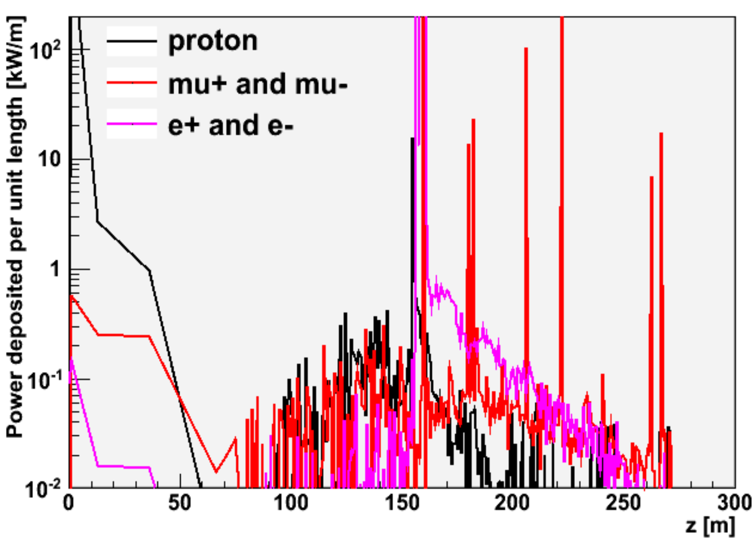
Beam power



- Beam power
  - Rather high
  - Obviously significant losses
  - Calculated using kinetic energy of beam
  - Normalised to 4 MW/8 GeV
- Beam power is factor 3 higher than order of magnitude estimate
  - But I have factor 2 more good muons than order of magnitude estimate(!)

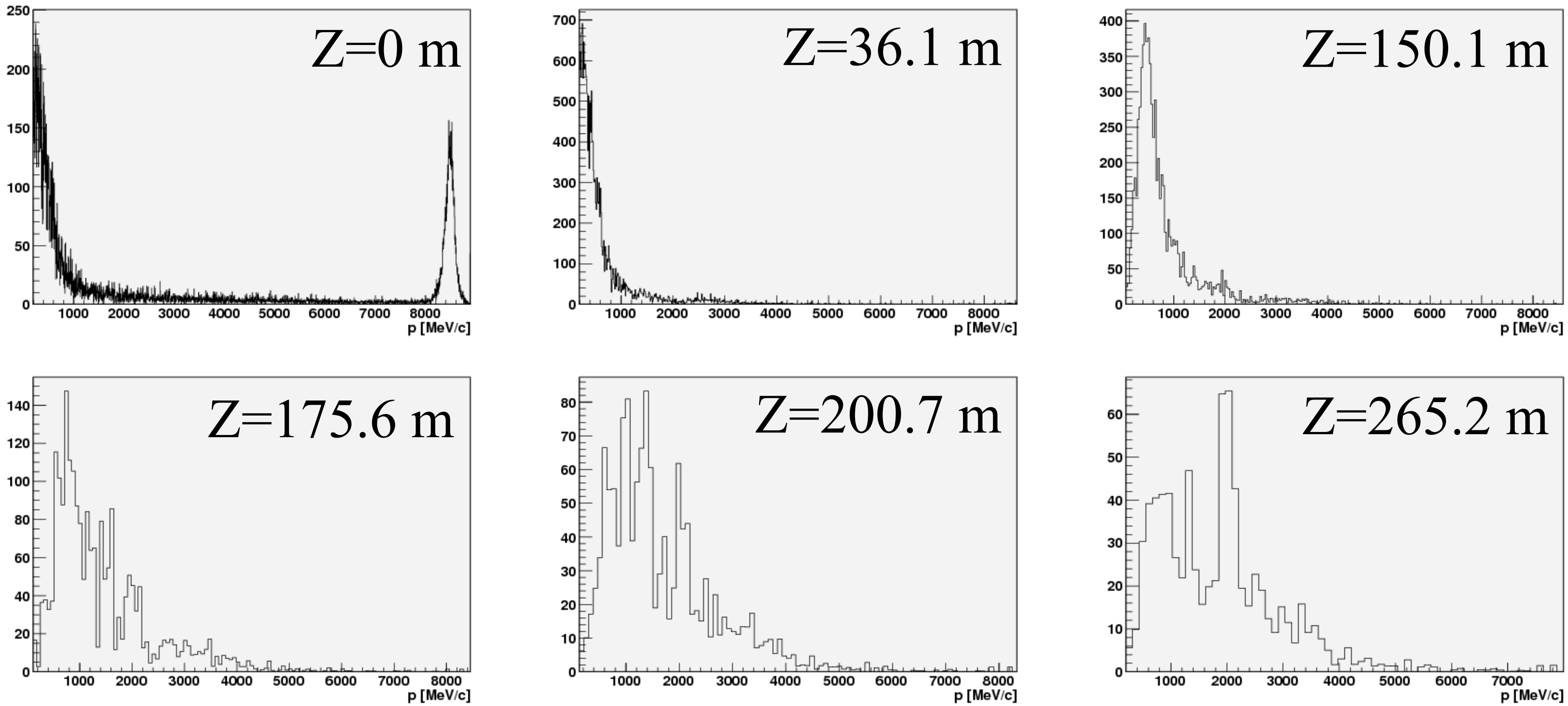
Heat deposition





- Top plot is change in beam power/length
  - Includes decay losses
  - Includes loss/gain from RF acceleration
  - Includes loss in windows/LiH
- Bottom plot is power deposited/length
  - Transmission losses excluding decays
- For comparison
  - ISIS rule of thumb is < 1 W/m proton loss
    - So that the machine doesn't become radioactive => remote handling
    - 2-3 orders of magnitude too high
    - What about leptons?
  - MICE spectrometers have 6 W of cooling
    - Repeat in G4 to see where losses are going
    - 1 W/m might be a reasonable constraint for total loss around SC magnets
- Looks a bit scary

Proton Momentum



- The protons making it through are spallation protons
- The high energy tail is long enough that it may be difficult to stop all of them using a proton absorber only => need a chicane

Conclusions

- Clearly heat deposition is significant
  - Worry about normalisation factor 2
- Three issues:
  - Activation of the linac
  - Heat load on superconductors
  - Radiation damage (to e.g. superconductors)
- These losses are 2-3 orders of magnitude too high
- Try:
  - Transverse collimation
    - Take out particles with large transverse amplitude at a convenient point away from sensitive hardware
  - Proton absorber
    - Protons stop quicker than pions/muons in material
- If that's not enough we will have to try:
  - Chicane to sweep out off-momentum particles
  - Revised lattice
- At the moment this looks like a bit of a feasibility issue