nuSTORM D&S Progress Report

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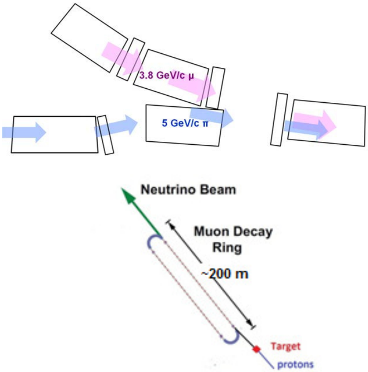
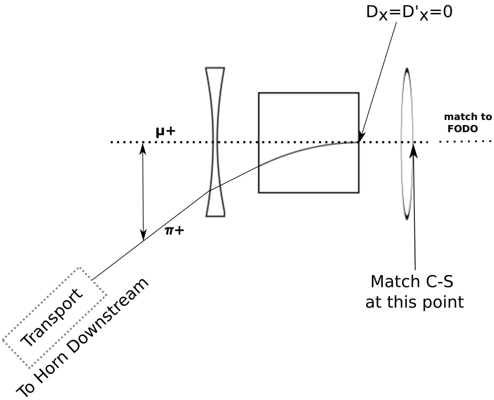
Stochastic Injection(Reminder from last nuSTORM workshop)

- New injected beam separated with circulating beam by their different momenta.
- No need for a separate decay channel;
- No need for full-aperture fast kickers;
- Beam pulse as long as the Main Injector Circumference (3000 m) can be used.



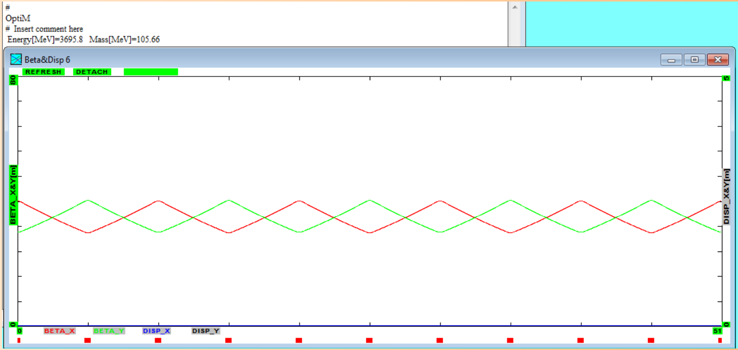
Consideration 1 from last workshop

Previously when we matched the transport line to the ring, we were matching C-S functions at the end of the "common section", which is composed of a bending dipole and two quads. See figure to the right.



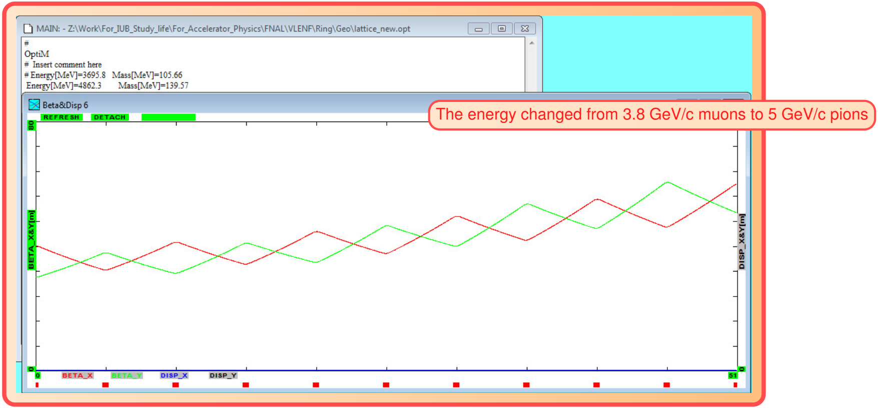
Consideration 1 from last workshop (cont.)

Now consider a well-designed FODO cell, with periodic transverse optics for 3.8 GeV/c μ's, see the example below:



Consideration 1 from last workshop (cont.)

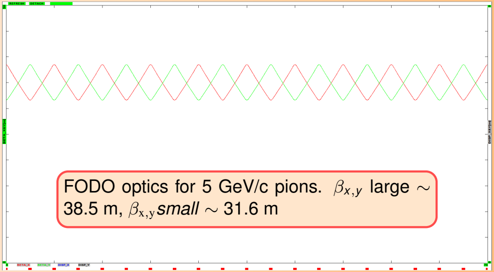
If the C-S parameters are matched for 5 GeV/c π's at the beginning of this FODO section, the optics won't be quite as good and periodic – The beta functions blow up, so does the beam size.



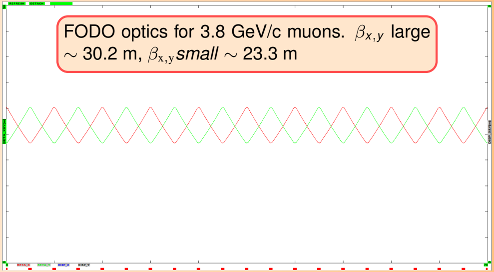
Consideration 1 from last workshop (cont.)

Our goal is to make sure pions survive in the decay straight, before they have the possibility to decay into muons.This suggests that we need to design a FODO cell with different sets of periodic solutions for 3.8 GeV/c muons and 5 GeV/c pions, and match the transport line optics to pions' parameters, to guarantee safe transverse motion of pions before they are absorbed by a dump at downstream of this injection straight.

A current FODO design is shown here, where for the same magnet configuration, different periodic C-S parameters were obtained.



FODO optics for 5 GeV/c pions. $\beta_{x,y}$ large $\sim$ 38.5 m, $\beta_{x,y}$ *small* $\sim$ 31.6 m

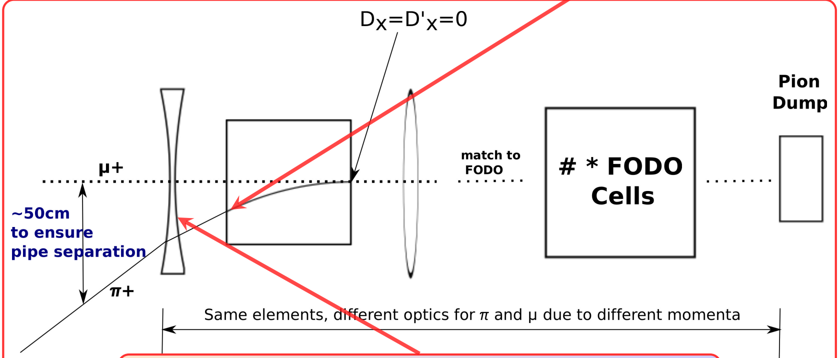


FODO optics for 3.8 GeV/c muons. $\beta_{x,y}$ large $\sim$ 30.2 m, $\beta_{x,y}$ *small* $\sim$ 23.3 m

Consideration 2

To perform the stochastic injection we need to design the common section to combine separated pions and muons pipes together. The schematic drawing is shown here.

A sector dipole for muons will have one edge effect for pions

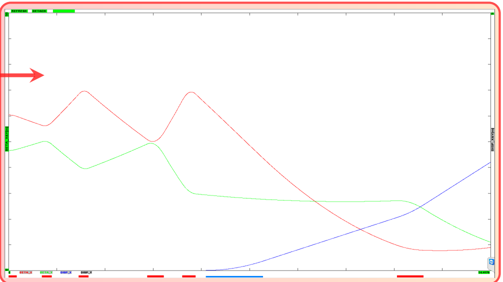


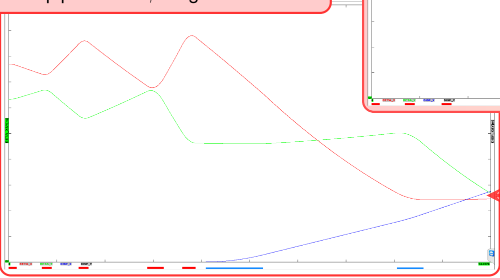
A pure defocusing quadrupole for muons becomes a combined function dipole for pions.(With two edge effects)

Consideration 2 (cont.)

The same beamline shown above gives different optics for muons and pions:

Start matching for 3.8 GeV/c muon, from the FODO cells to the beam separation point. At the end of this section, the reference on-momentum pion(5 GeV/c) will be separated with the on-momentum muon by $\sim$48 cm, according to the single particle tracking from MAD8. It is enough to divide the beam pipe to two. β large $\sim$ 35 meters





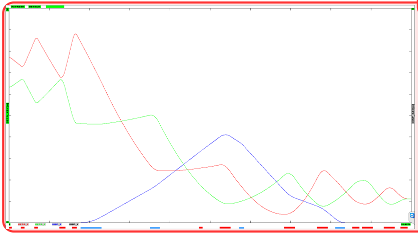
For 5 GeV/c pion. β large $\sim$ 44 meters.

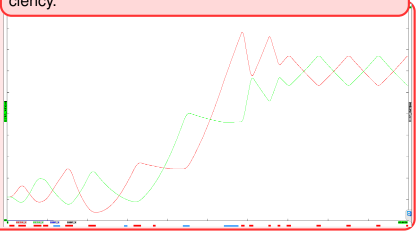
A sector dipole with one edge effect, and a combined-function dipole with two edge effects are used here

New Pion Transport Line Design

Taking these into account, a new design of pion transport was constructed (matching for pions from the separation point backwards to downstream of the horn, left). Inverse the beamline to generate input for G4Beamline(Automated by a csh script)

Inverse of the optics from left figure, to construct the lattice in G4BL. The transport is continued by the FODO periods(Not shown all), the virtualdetector will be placed at the end of the decay straight to see transport efficiency.

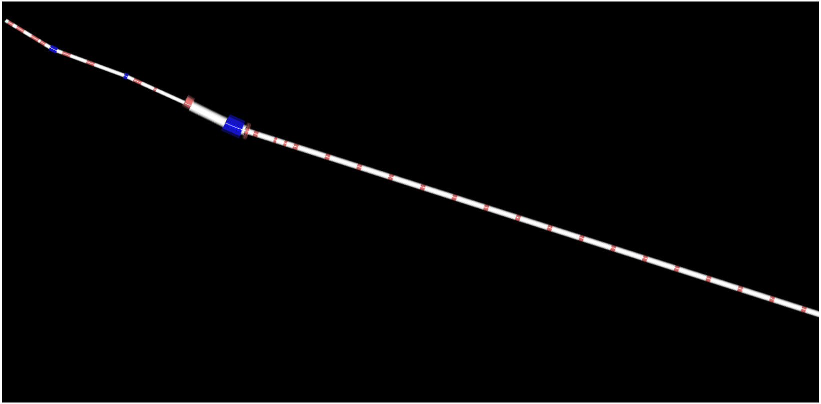




From FODO cell to downstream of the horn; Including the section talked previously, followed by a beamline solely for pions after separation.

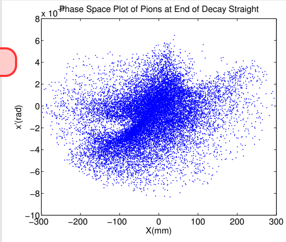
New Pion Transport Line Design (cont.)

Layout of the new transport for pions, notice the large aperture quad which is rotated and displaced to form an effective dipole with edge effects. Although it's large, the pole-tip field which is about 1.4 Tesla is still in non-superconducting range.

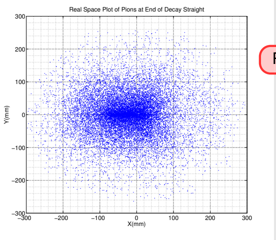


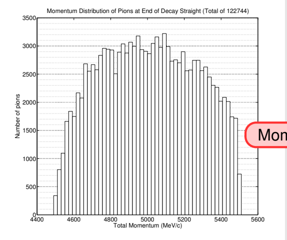
Transmission Efficiency(Without decay, at the end of decay straight. Pion source generated by MARS from S.Striganov)

Phase space plot



Real space plot



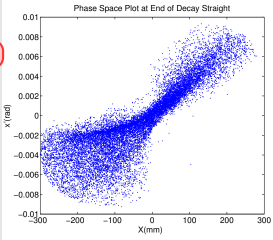


Momentum Distribution

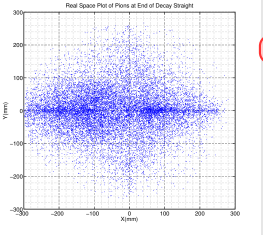
Fringe fields matter, 63.6% survived out of 193105 initial pions (per 1,600,000 POT) without it.

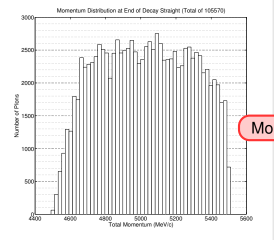
Transmission Efficiency(Without decay, at the end of decay straight. Pion source generated by MARS from S.Striganov) (cont.)

Phase space plot



Real space plot



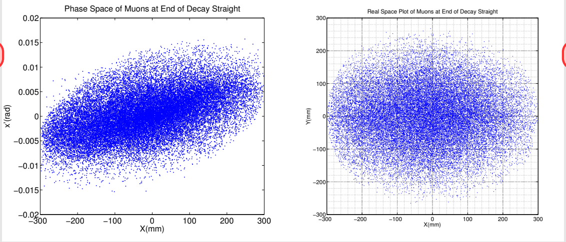


Momentum Distribution

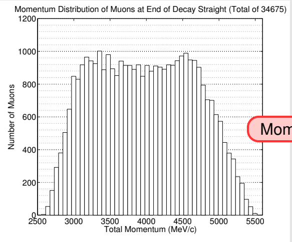
With fringe fields – 54% survived.

Muons generated in the decay straight (With fringe)

Phase space plot



Real space plot

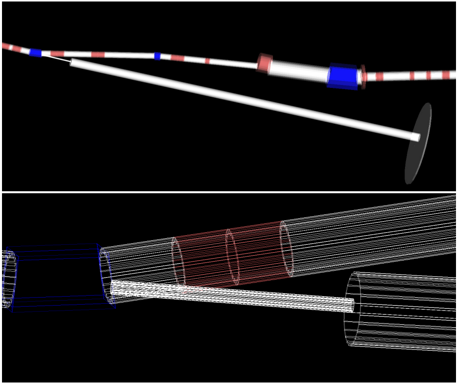


Momentum Distribution

Muons at the end of decay straight.(Total of 34675 muons. $\sim$ 18% of initial pions.)

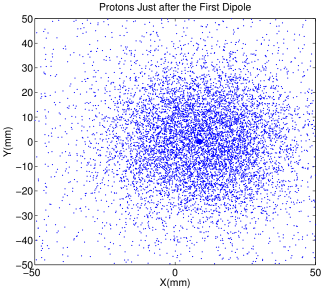
Proton Absorber

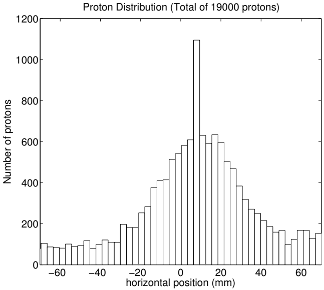
We need an absorber as the proton dump. We can use the first bending dipole to separate the protons with high energy and pions with lower energy. Considering the geometry, it is not hard to place the big absorber, but the proton pipe might have some space conflict with the quadrupole after the dipole mentioned above. See the schematic drawings from G4Beamline:(Proton pipe has 45 mm radius – Shown in the figure) The proton absorber in this figure has a radius of 3 meters.



Proton Absorber (cont.)

19000 protons out from 40000 were delivered from downstream of horn to downstream of first dipole. The distribution is shown below. Within the $\pm$ 45 mm region there are 11143 protons. ($\sim$ 58.7%)





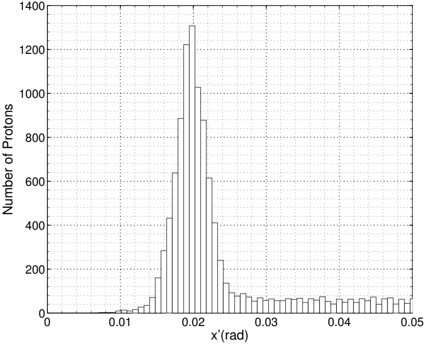
Proton Absorber (cont.)

Possible solution?

Use the horizontal spacing between coils and Titanium windows to avoid the pipe-magnet conflict(Might need more careful considerations.)

Proton Absorber (cont.)

The protons are bent by some degrees depending on their momenta, see the angle distribution in x direction below, this tells us if we want to do both signs for pions,(π^+ and π^-) there needs to be another bend for only protons after the first dipole shown before, to correct proton direction back to straight forward. The beamline is still under design.



To be continued...

- The other part of the DK ring is being designed.
- Ideas and comments are useful and welcomed.