FRONTEND OPTIMIZATION STUDIES

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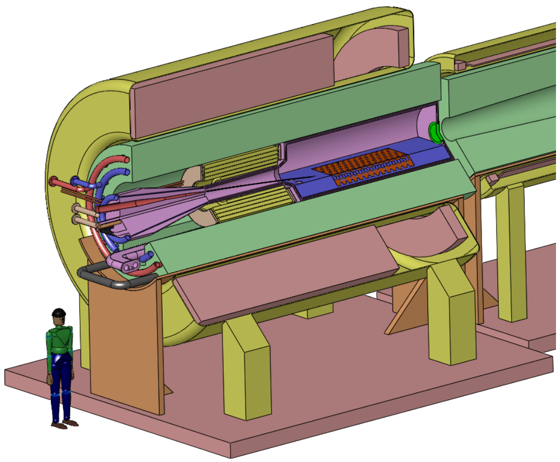
OUTLINE

Goal : Optmize number of useful muons and limit the proton beam power energy transmitted to the first RF cavity in the buncher



Involved systems:

- Carbon target and carbon dump geometry
- Capture field
- Chicane design
- Be absorber

1- Target geometry parameters: Carbon target length, radius, and tilt angle to solenoid axis
2- Target Capture field: constant field length - taper length - end field
3- Chicane parameters: Length - curvature – focsuing field
4- Be absorber thickness and location
5- Energy deposition in the target area + Chicane will be evaluated and involved in the optimization.

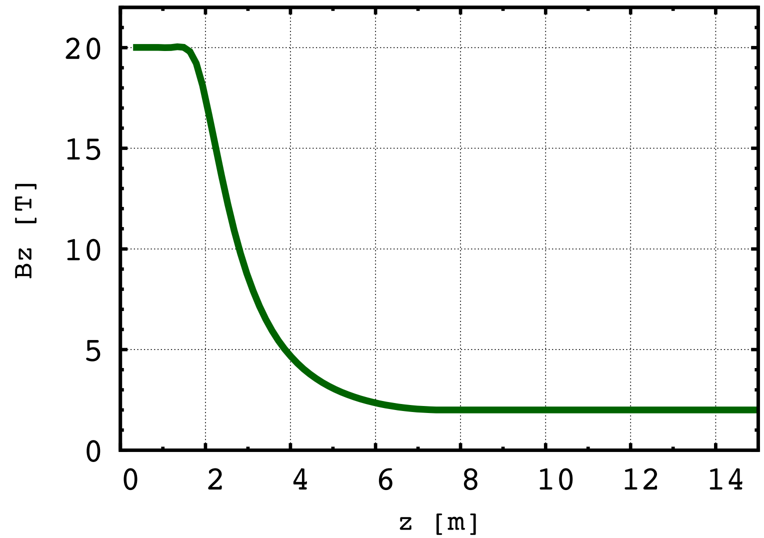
CARBON TARGET GEOMETRY OPTIMIZATION

- Target geometry parameters:
  Carbon target length -- radius -- tilt angle to solenoid axis

- Objective: optmize at z = 50 m
  Σ π+μ+κ within
  $0 < p_z < 450$ MeV/c (to compensate for the Be absorber effect) & $0 < p_t < 150$ MeV/c

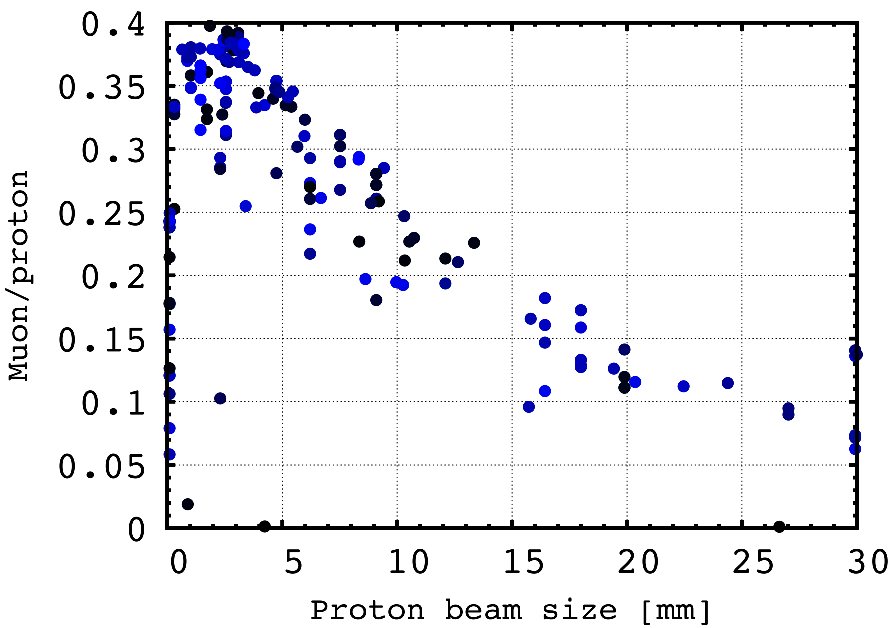
Initial lattice in G4Beamline – using GEANT4 physics list QGSP (Benchmarekd with HARP data – Bungau *et al* PRSTAB 2014)

- B_z = 20T - 2.0 T over taper length = 6.0 m
- Initial protons K.E. = 6.75 GeV
- Target radius fixed at 4 times the proton beam size



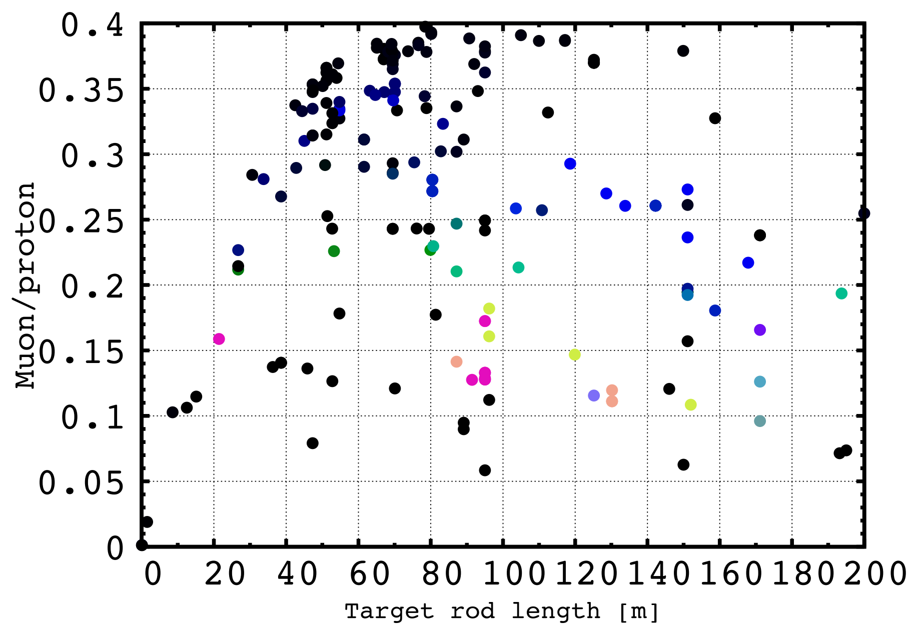
- The whole optmization process 6 hours on 192 cores at NERSC

CARBON TARGET GEOMETRY OPTIMIZATION

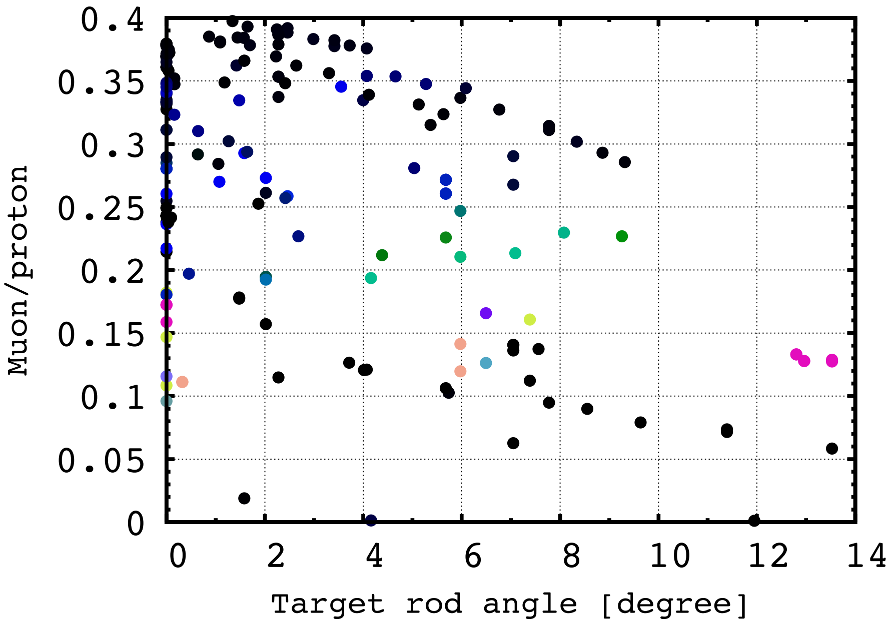


Optimal working point 2-3 mm
Different colors → different target lengths & angles

Optimal working point 70-120 cm
Different colors → different target angles & radii



CARBON TARGET GEOMETRY OPTIMIZATION



Optimal working point 1-3 degrees
Different colors → different target lengths & radii

Beam radius [mm]	Target angle [degree]	Target length [mm]	N_μ/N_p
1.85292	1.34088	785.00294	0.39745
2.59974	1.64588	801.56101	0.39305
3.08659	2.45955	801.56101	0.39184
2.71093	2.24632	1049.69876	0.39097
3.08659	2.45955	906.74622	0.38844

CARBON TARGET GEOMETRY OPTIMIZATION

- To do list
  - Add carboon beam dump
  - Integrate to the chicane (see next slide)
  - Consider the capture filed in the optimization

- The whole optmization process 6 hours on 192 cores at NERSC

NERSC

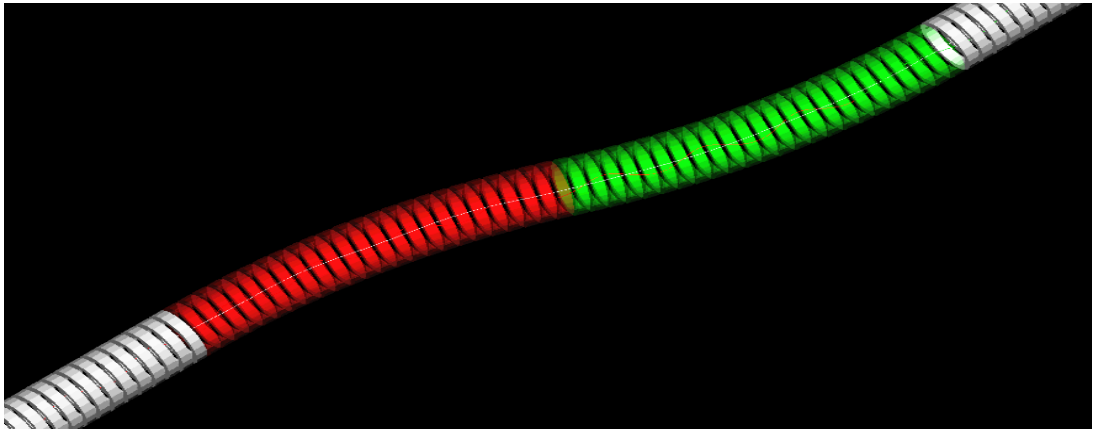
CHICANE

- Short taper (6 m) integrated with the new chicane from Pavel's G4BL lattice (same parameters as in ICOOL)
- Started optimizing the chicane parameters (initial values - D. Neuffer's icool lattice)
  - Chicane length L (initial value L = 6.0)
  - Chicane radius of curvature h (initial value = 0.05818 1/m)
  - Be absorber length (initial value = 100.0 mm)
  - On-axis field is a free parameter – optimization will be carried for B= 2.0 – 2.5 – 3.0 T
  - Chicane aperture 40 cm (might be a free parameter as well)

- Objectives → minimize total KE of transmitted protons Σ $KE_{protons}$

  → Maximize number of transmitted muons $\Sigma\ \pi+\mu+\kappa$ within $0 < p_z < 450$ MeV/c (to compensate for the Be absorber effect) & $0 < p_t < 150$ MeV/c

Run 100 K particles through the chicane with initial parameters $\Sigma\ KE_{protons} = 29$ GeV & $\Sigma\ N_{mu} = 4377$



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CHICANE

Run 500 K particles through the chicane with automated optmization algorithm

B_0= 2.0 T

H	L	Be thickness [mm]	Σ $Ke_{protons}$ [GeV]	Σ N_{mu}
0.057587951	10.23983	101.88068	0.547549	13522
0.057587951	10.23983	101.88068	0.547549	13506
0.057587951	10.23983	101.88068	0.547549	13506
0.057587951	10.23983	101.88068	0.547549	13506
0.04063443	10.99894	259.19359	0.380618	11975

Chicane

B_0= 2.5 T

H	L	Be thickness [mm]	Σ $Ke_{protons}$ [GeV]	Σ N_{mu}
0.020371496	21.82107	327.90203	0.741961	13143
0.058173286	9.66614	249.48609	0.230776	12303
0.020371496	23.3482	353.23063	0.0487631	12018
0.083906168	8.56258	101.88068	0.625911	12439
0.083906168	8.56258	101.88068	0.625911	12439

B0= 3.0 T

H	L	Be thickness [mm]	Σ $Ke_{protons}$ [GeV]	Σ N_{mu}
0.063239202	12.35924	101.88068	0.856025	17690
0.063239202	12.35924	101.88068	0.856025	17690
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0.059079316	15.31618	121.18716	0.04844	15307

Conclusion & Summary

- New objective for front end optimization
    - Handle excesseive proton beam + unwanted secondaries
    - Capture as much muons
- Energy deposition has to be integrated in the optimization study
  - Partitioning of energy deposited in
    - Beam dump
    - Chicane
    - Be absorber
- Optmization includes
    - Target geomtery
    - Beam dump
    - Chicane field + chicane geomtery
    - Be absorber
    - Re-tune buncher & phase roation