FRONTEND OPTIMIZATION STUDIES

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FRONT END OPTIMIZATION

OUTLINE

Goal: Optimize 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 – focusing field
4. Be absorber thickness and location
5. Energy deposition in the target area + Chicane will be evaluated and involved in the optimization.
Target geometry parameters:
- Carbon target length -- radius -- tilt angle to solenoid axis

Objective: optimize at \( z = 50 \) m
- \( \Sigma \pi+\mu+\kappa \) 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 (Benchmarked with HARP data – Bungau et al PRSTAB 2014)
- \( B_z = 20T - 2.0T \) 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 optimization process 6 hours on 192 cores at NERSC
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 $\rightarrow$ different target lengths & radii

<table>
<thead>
<tr>
<th>Beam radius [mm]</th>
<th>Target angle [degree]</th>
<th>Target length [mm]</th>
<th>$N_\mu/N_p$</th>
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<tbody>
<tr>
<td>1.85292</td>
<td>1.34088</td>
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<td>3.08659</td>
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CARBON TARGET GEOMETRY OPTIMIZATION

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

- The whole optimization process 6 hours on 192 cores at NERSC
- 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 $\sum KE_{\text{protons}}$
  → Maximize number of transmitted muons $\sum \pi + \mu + \kappa$ 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 $\sum KE_{\text{protons}} = 29$ GeV & $\sum N_{\text{mu}} = 4377$
Run 500 K particles through the chicane with automated optimization algorithm

\[ B_0 = 2.0 \, T \]

<table>
<thead>
<tr>
<th>H</th>
<th>L</th>
<th>Be thickness [mm]</th>
<th>( \Sigma K_{e^+} \text{protons} ) [GeV]</th>
<th>( \Sigma N_{\mu} )</th>
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<tbody>
<tr>
<td>0.057587951</td>
<td>10.23983</td>
<td>101.88068</td>
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## Chicane

\( B_0 = 2.5 \text{ T} \)

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<th>H</th>
<th>L</th>
<th>Be thickness [mm]</th>
<th>( \Sigma K_{e\text{protons}} ) [GeV]</th>
<th>( \Sigma N_{\mu} )</th>
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\( B_0 = 3.0 \text{ T} \)

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<tr>
<th>H</th>
<th>L</th>
<th>Be thickness [mm]</th>
<th>( \Sigma K_{e\text{protons}} ) [GeV]</th>
<th>( \Sigma N_{\mu} )</th>
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<tr>
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<td>12.35924</td>
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<td>0.856025</td>
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CONCLUSION & SUMMARY

- New objective for front end optimization
  - Handle excessive 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

- Optimization includes
  - Target geometry
  - Beam dump
  - Chicane field + chicane geometry
  - Be absorber
  - Re-tune buncher & phase rotation