# Chicane Optimization

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# Introduction

- Concept originated by Chris Rogers
- Chicane introduced after target to remove particles except for muons and pions
- High energy protons hit side of chicane
- Low energy protons removed by absorber downstream of chicane

# Protons in Chicane

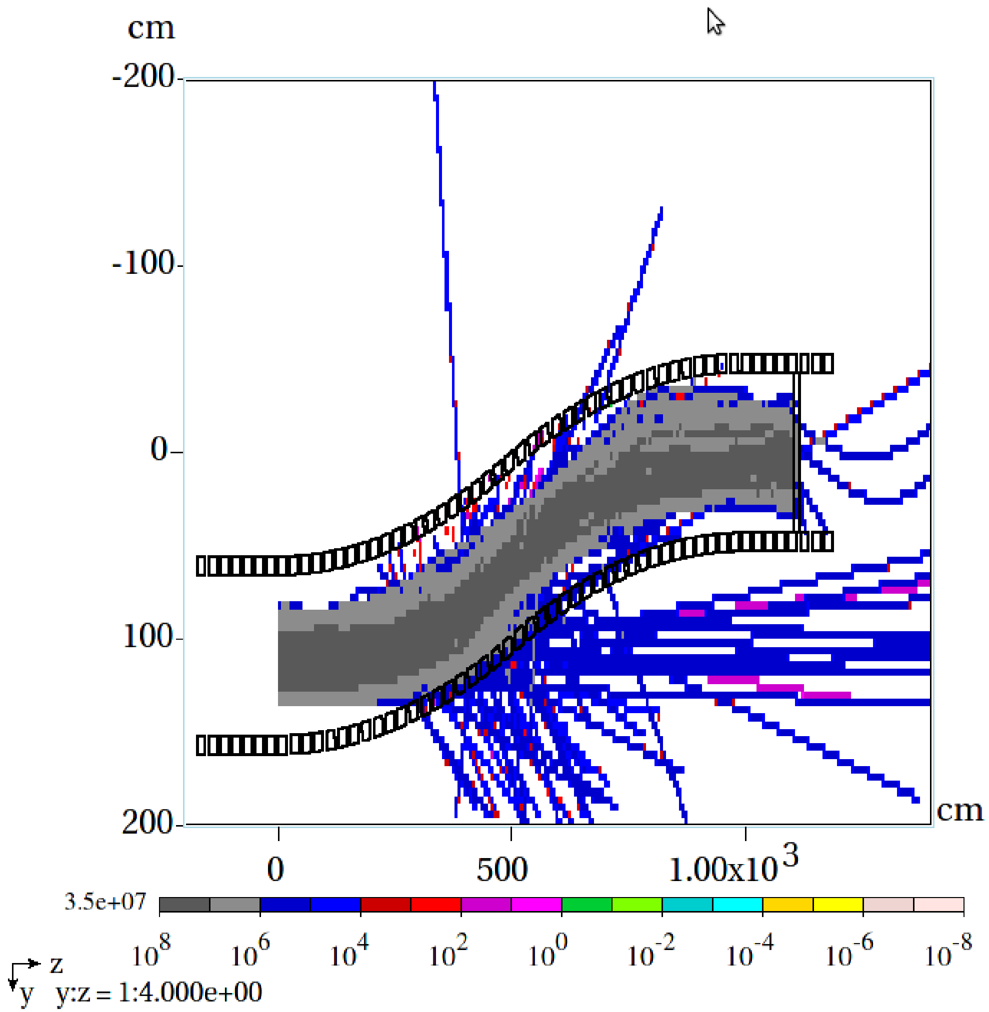



Image: Pavel Snopok

# Introduction

- Goal of my procedure: optimize chicane by itself
  - Chicane angle and length
  - Downstream absorber thickness
- Chicane field is 2 T
  - Could be done for other fields
- 25 cm radius aperture downstream of chicane
  - No aperture in chicane
  - 6.58 kW of protons per MW on target at chicane start within 25 cm radius

# Chicane Geometry Scan

- Looked at chicane without absorber
- Scan in chicane length, angle
- Defined performance in terms of
  - Muon transmission from 80 to 260 MeV KE
    - Pions also, 80 to 320 MeV
  - Maximum energy of transmitted protons (cutoff)
    - No more than 2 W of protons above this energy per proton MW on target

# Choosing Optimal Solutions



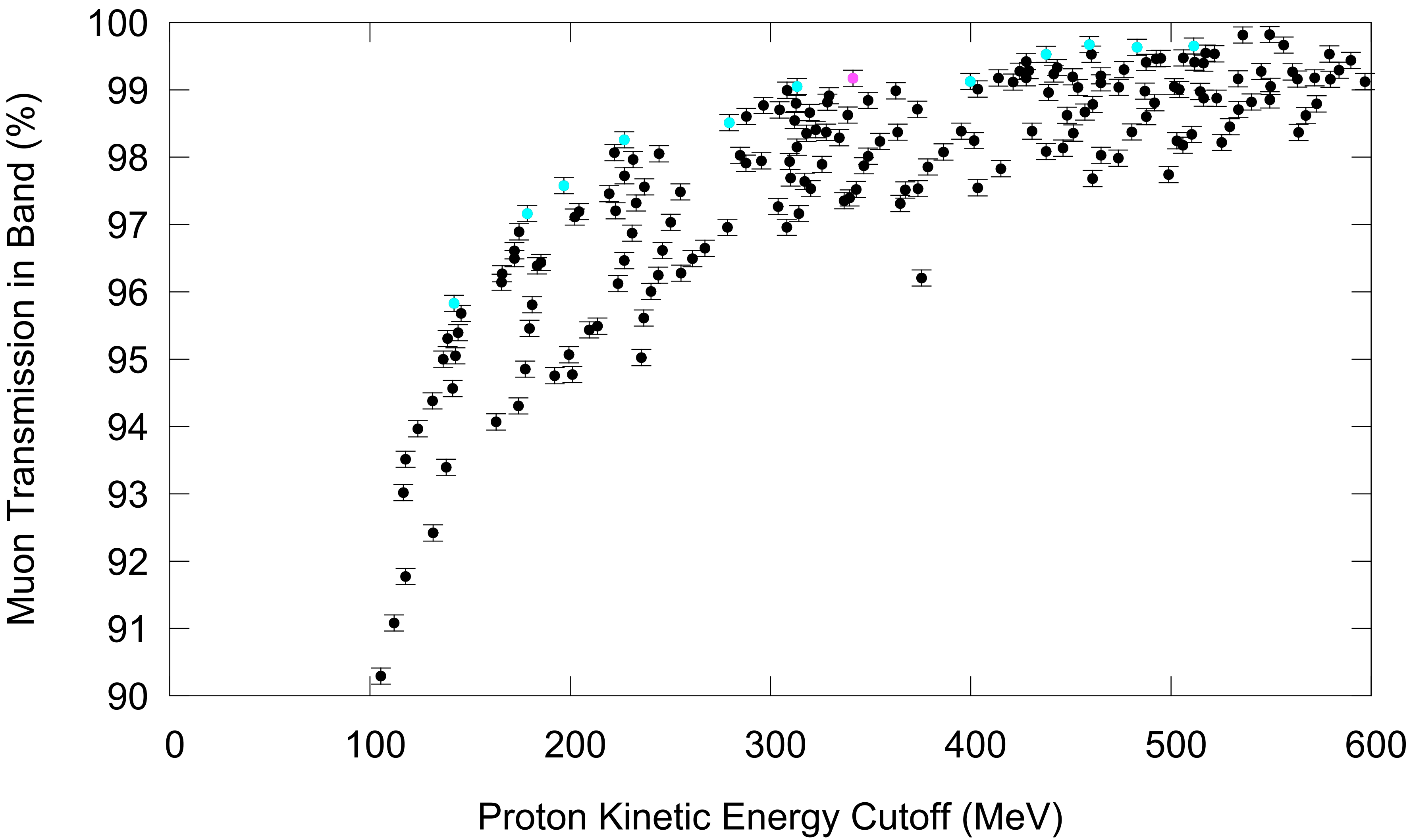
- Choose set of solutions with best transmission for a given proton energy cutoff
- Fit angle and length for these solutions to functions of proton kinetic energy cutoff

$$L = L_0 + L_1 K \qquad \theta = \theta_0 + \theta_1 / K$$

| | | | |
|---|---|---|---|
| $L_0$ (m) | 1.6 | $L_1$ (m/GeV) | 9.1 |
| $\theta_0$ (mrad) | 69 | $\theta_1$ (mrad GeV) | 28 |

- No physical meaning to these fits

# Transmission vs. Cutoff

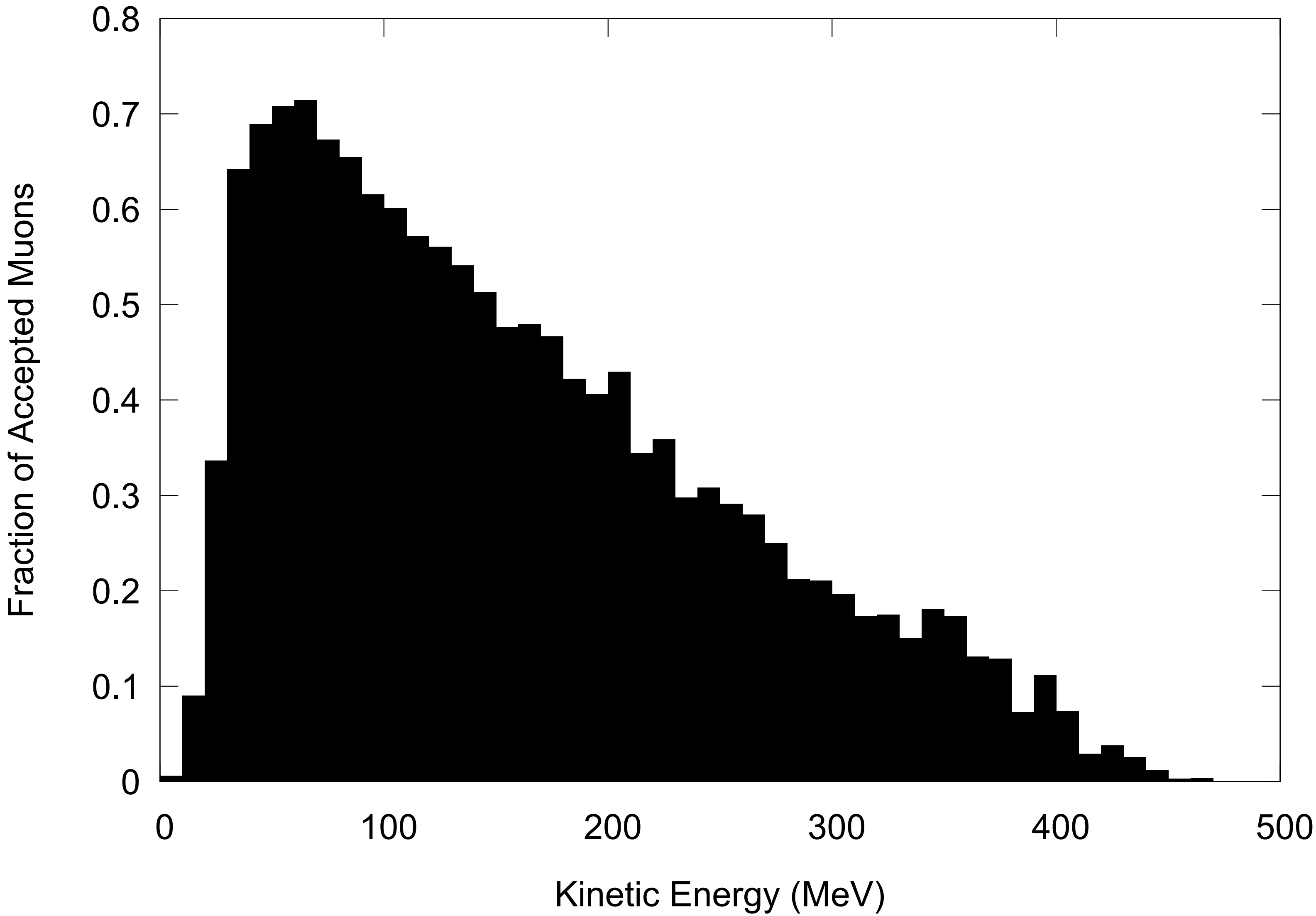


# Add the Absorber

- Track in G4beamline, downstream from chicane
- Measured criteria 31 m downstream from chicane start
  - Muons from 20 MeV to 390 MeV
  - Proton power
- Varied absorber thickness
- Two absorber positions
  - End of chicane
  - 30 m from chicane start
- Picked four chicane cutoffs

# Muon Transmission Post Absorber



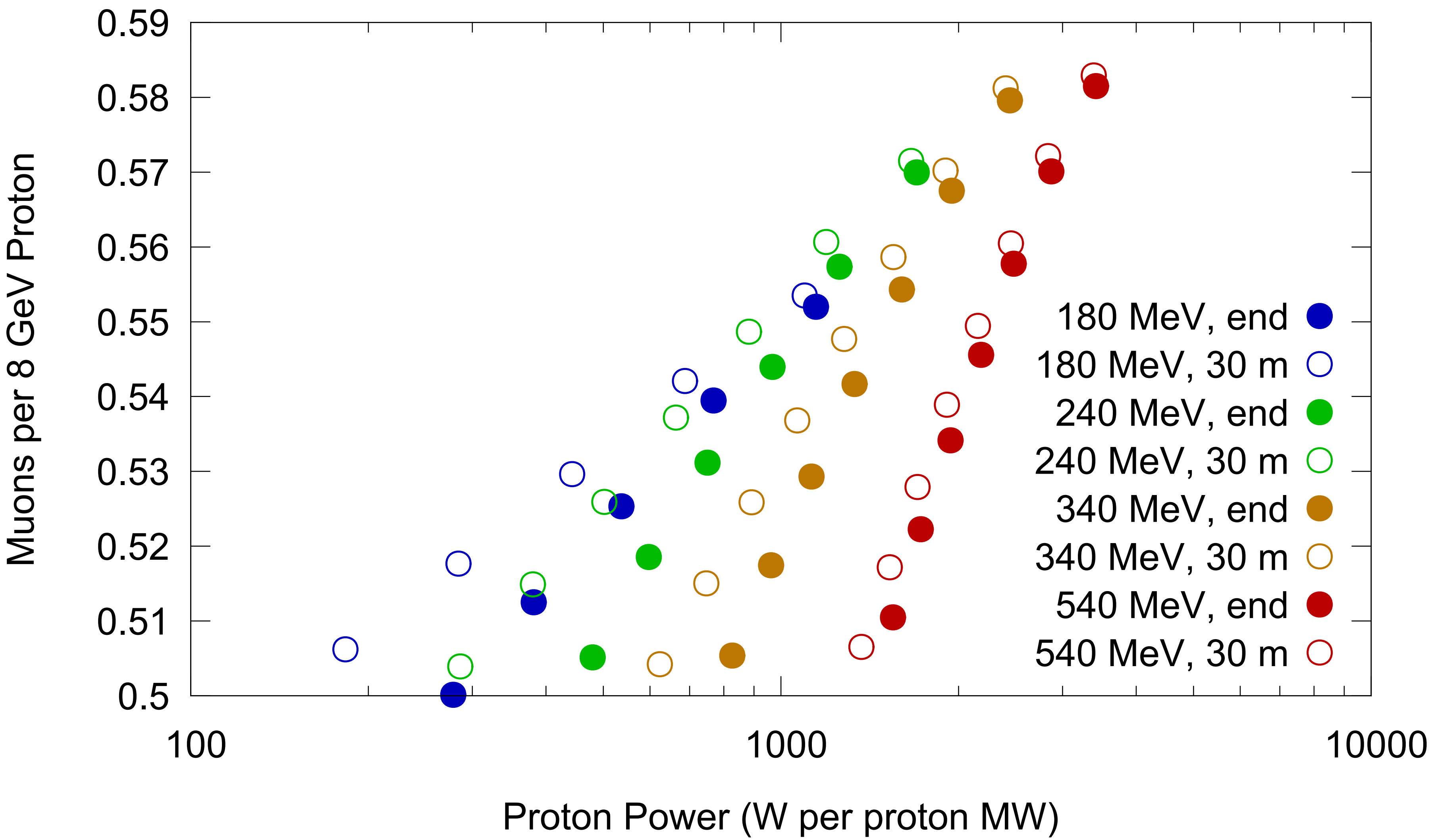


# Analysis

- Look at muons vs. proton power
- Favor low proton energy cutoff
  - Unless you allow a lot of power downstream
- Poor transmission to get to low proton powers
  - Need to pick tolerable proton power
- Moving absorber downstream helps
  - Effect exaggerated by overweighting high energy?
  - But may not win when NBPR considered
  - Would gain even more by moving further
  - Less benefit for more downstream proton power
- High energy muons overweighted
  - Effective muon loss even higher
  - Low proton energy cutoff even more strongly favored

# Muons vs. Proton Power





# Summary: Results to Now

- Have a solution for chicane parameters for a given proton kinetic energy cutoff
  - Some behavior not well analyzed and understood
- Significant tradeoff between muon transmission and downstream proton power
  - Need to determine this number
- Low proton energy cutoff in chicane is generally preferred

# Improvements to Procedure



- Use the current distribution from the target: 6.75 GeV protons, carbon target
- Use current apertures in solenoids (23 cm)
- Add an aperture to the chicane (right now there are no apertures)
- Weight the muon transmission by a function of energy instead of taking all muons within an interval
- Pick a value for the proton energy transmission permitted downstream. This will require some study to choose a reasonable value.

# New Procedure

1. Begin with new distribution at 10 m
2. Scan chicane alone in angle and length, but no apertures within the chicane proper. Apertures are in place upstream and in a downstream constant solenoid.
3. For each chicane geometry, find an aperture profile that keeps all (or mostly all) muons that are accepted by the downstream solenoid
4. Re-run the scan in chicane angle and length with these apertures

# New Procedure



5. Plot muon weighted transmission vs. proton energy cutoff. For several approximate cutoff energies, choose a solution with the best transmission. Fit the chicane angle and length of these solutions to a function of cutoff energy.
6. Now add the absorber to the end of the chicane (no additional drift for now). Scan in cutoff energy (using the functional form to find chicane geometry) and absorber thickness.
7. Choose a solution with the best transmission for an acceptable downstream proton transmission.

# New Procedure

8. Design a NBPR for this chosen solution.

# Closing the Loop

- Energy deposition in the chicane
  - Find a shielding solution for the preferred chicane geometry
  - Determine impact on coil apertures
  - Find the chicane field for the real coils
  - Determine if solution is still optimal by repeating for nearby geometries
- New NBPR solution
  - Transmission vs. energy will be different
  - Rerun procedure with modified transmission function

# Closing the Loop

- Placement of absorber
  - Place absorber somewhat downstream
  - Re-design NBPR
  - Determine overall performance has improved
  - If performance has improved, absorber placement will need to be added as optimization variable
- Effect of solenoid field on performance