First Look at Muon Chicane

Chris Rogers,
ASTeC,
Rutherford Appleton Laboratory
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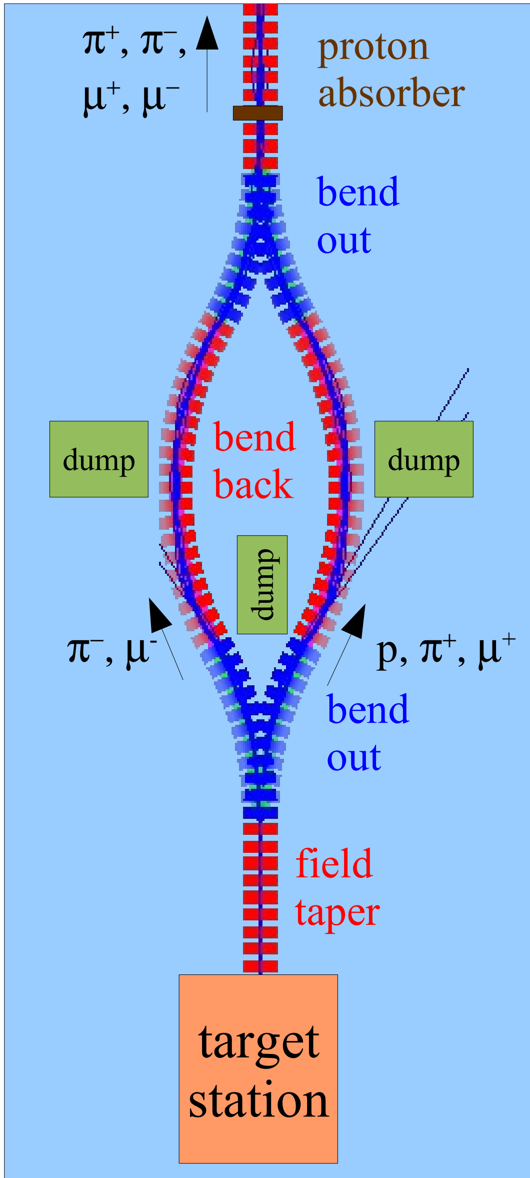
Overview

- Previously showed a proton absorber can take out protons with momentum <~ 500 MeV/c
  - "Shallow" study, needs more work
- Now go on to look at what can be achieved with chicane
  - Aim is to take out all particles with momentum >~ 500 MeV/c
  - Remember that muon momentum acceptance is ~ 100 - 400 MeV/c
- Preliminary design
  - Considerations
  - Initial parameter scans
  - Setting up for optimisation

Chicane concept

- Initial concept is “pair of double chicanes”
  - High energy particles hit a beam dump
  - Chicane area becomes radioactive
    - Probably part of target remote handling area
  - Beam dump has to handle significant beam energy
- Concentrate here on chicane optics (first look)
  - Propose using bent solenoid optics
  - Good acceptance for this momentum range
    - e.g. used by mu2e experiments
    - e.g. used by 6d cooling channels
    - e.g. used by stellarators



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  - Good acceptance for this momentum range
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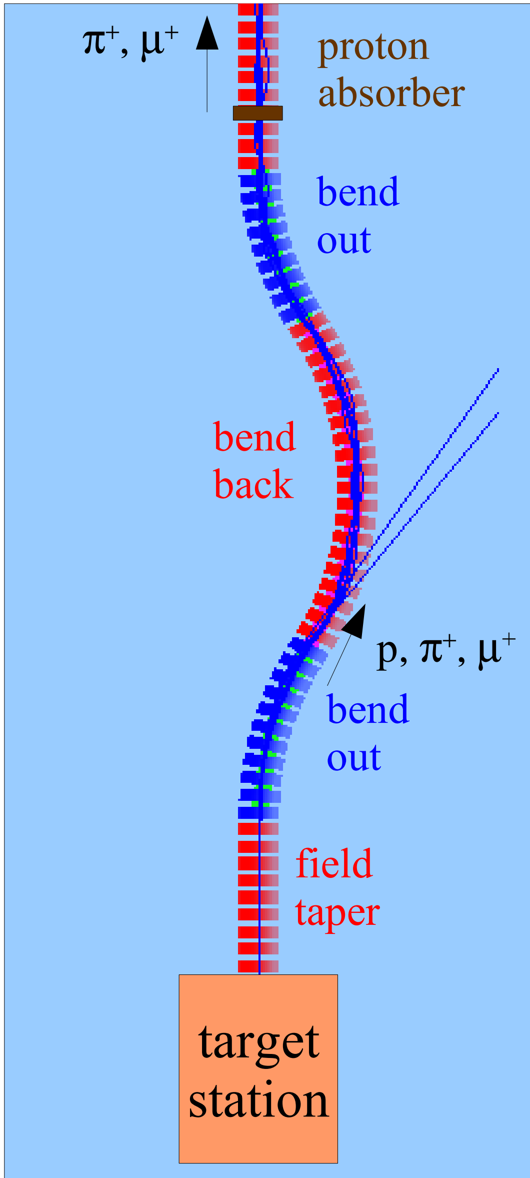
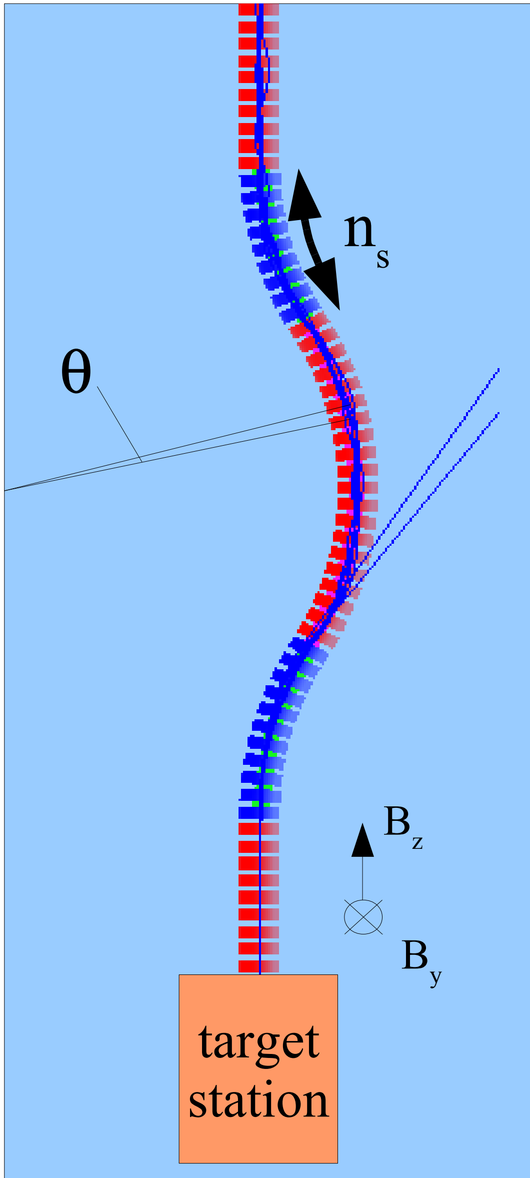
    - e.g. used by stellarators
- For now only present optics
  - Beam dumps not straightforward
  - Comment on particle charge later



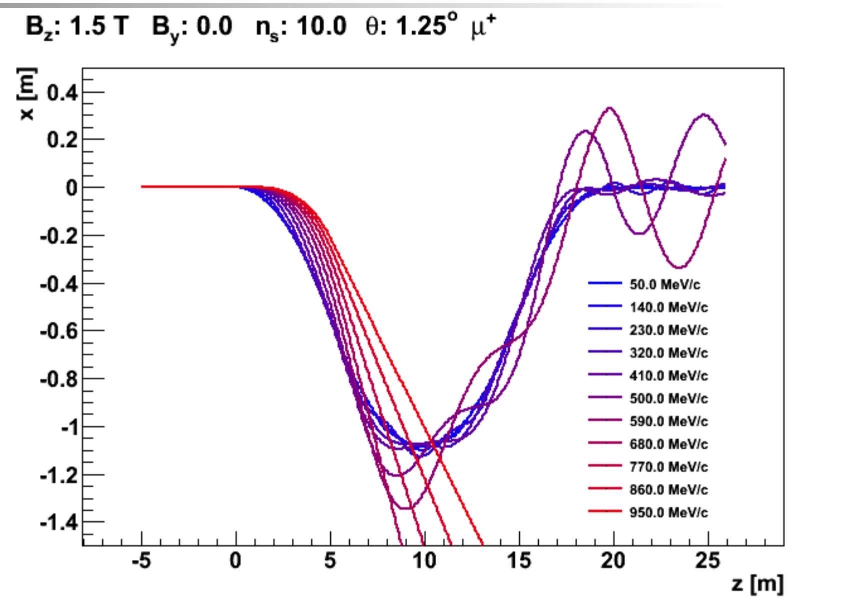
Chicane optics

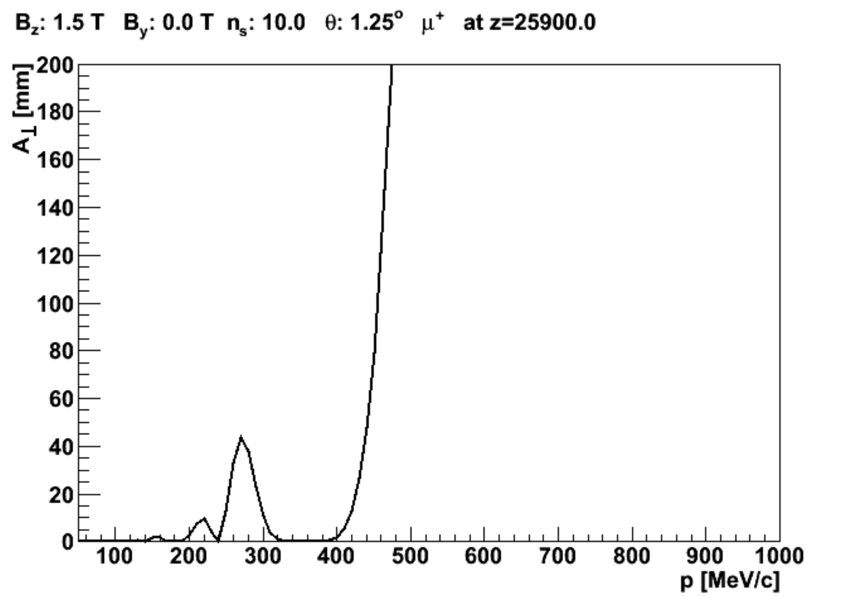
- Four independent parameters
  - Number of coils in the bends
  - Bending angle per coil
  - Solenoid field strength
  - Dipole field strength
- Optimise for reasonable performance over large momentum range
  - Aim is to get decent performance over dp/p ~ +/- 100%
  - Power law expansion (multipole approach) doesn't work here
  - Work numerically with tracking code



Test particles

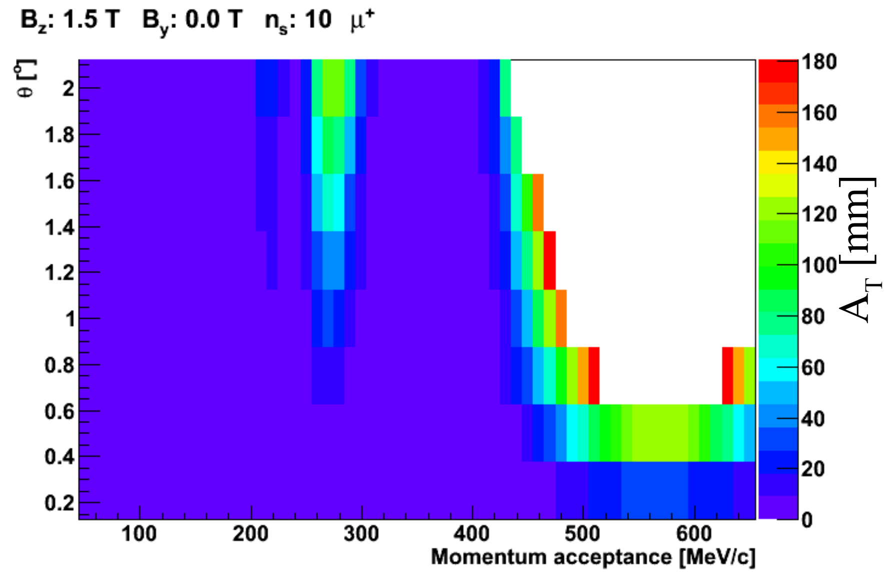
- Aim is to get clean cut on particles in chicane
  - Dispersion function 0 up to maximum momentum
  - Dispersion function large after maximum momentum
- Look at test particle amplitude vs momentum after chicane
  - Test particles initially on-axis
  - Measure how far from the axis they are
    - In x-px-y-py phase space
    - Normalised to matched beam ellipse

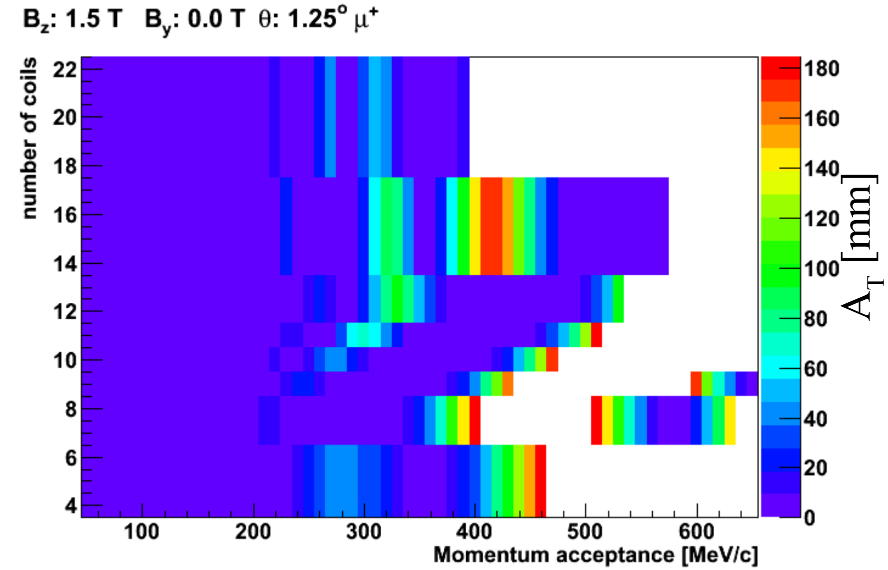




Test particles vs lattice geometry

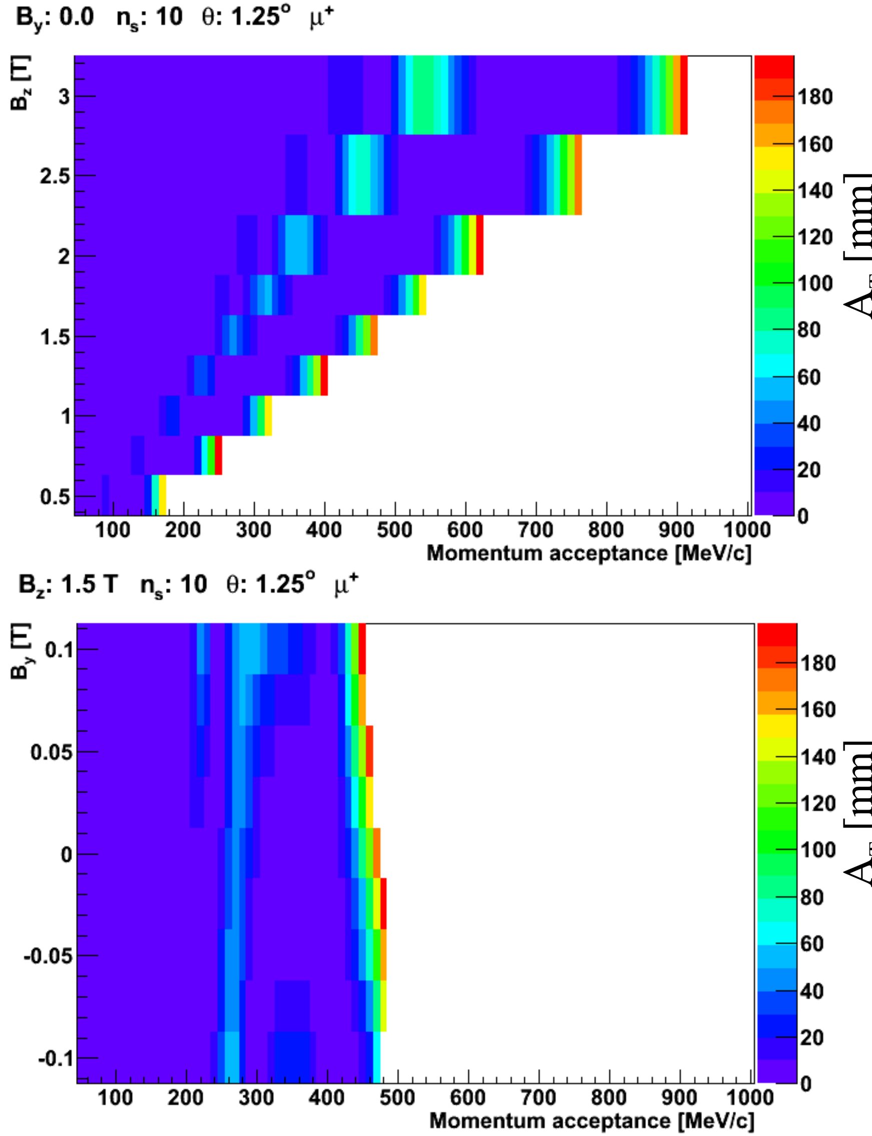
- How does this amplitude growth change with lattice parameters?
- Changing bend angle per coil
  - Excites amplitude growth at ~250 MeV/c
  - Improves momentum collimation
- Changing number of coils per bend
  - Excites few high amplitude regions





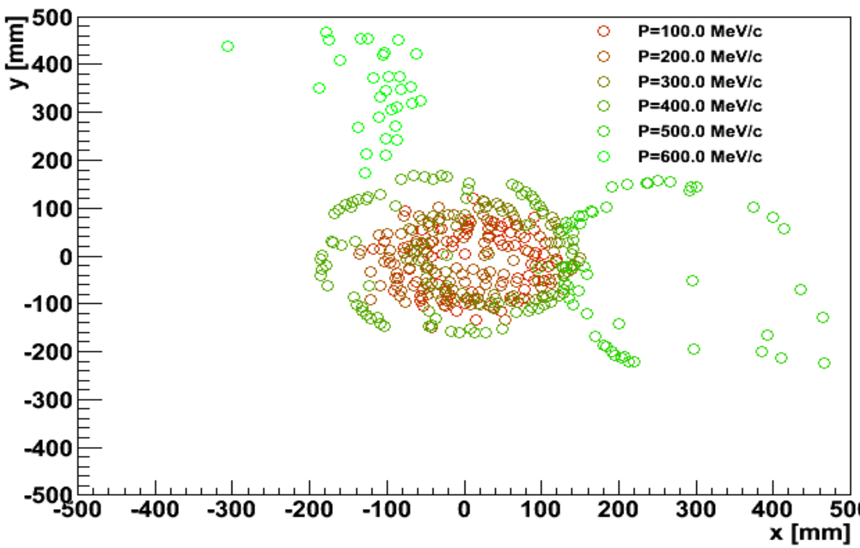
Test particles vs lattice field

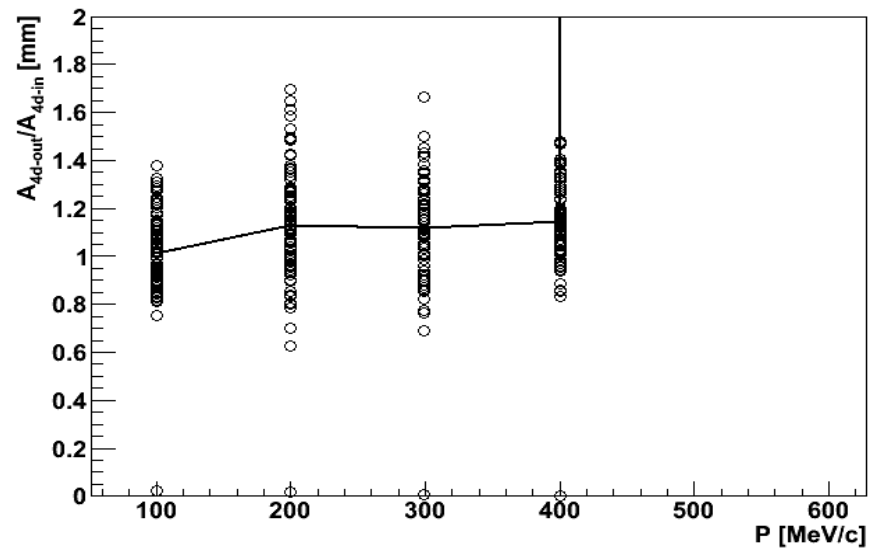
- Increasing B_z scales the lattice optics
- Increasing B_y degrades performance



Finite beam

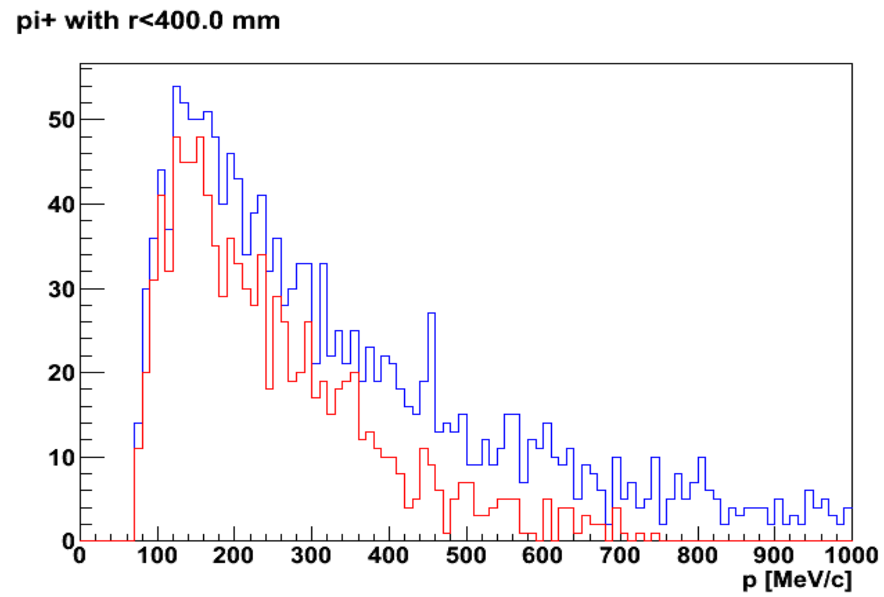
- What happens when a finite beam is passed through the chicane?
  - Assume Twiss parameters are more-or-less correct
  - Look at emittance increase of a shell of particles on 4D hyperellipsoid
    - Initial amplitude typical of particles in our beam~ 50 mm
    - Shell in x-px-y-py phase space, initially matched to 1.5 T solenoid





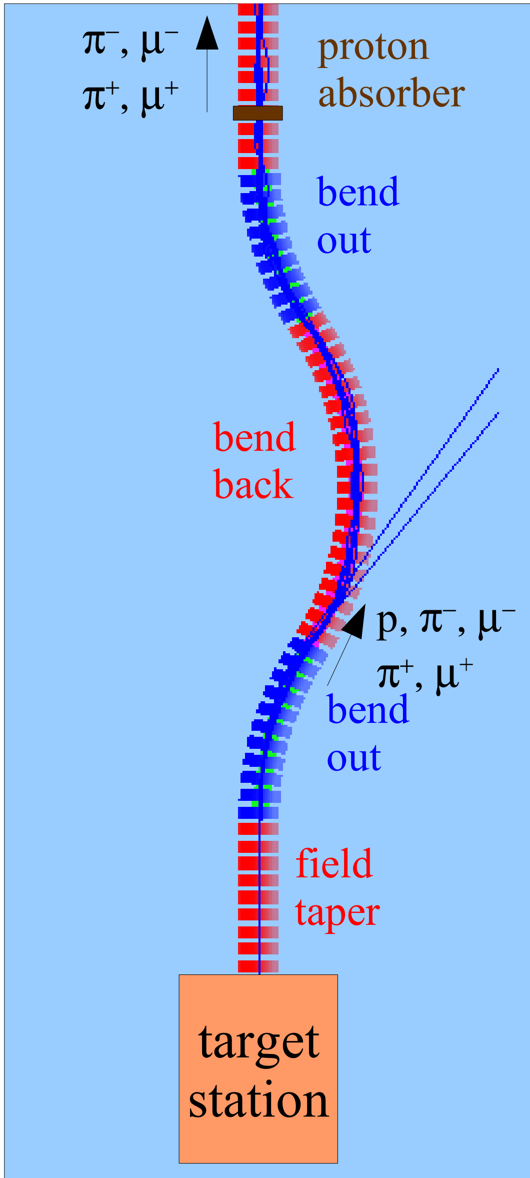
Realistic beam

- Get reasonable transmission for a realistic beam
  - ~25% fewer pions transmitted below 500 MeV/c



Comment on particle charge

- Lattice is charge invariant
  - No dipole field
  - Sign change only switches direction of angular momentum
  - Leaves focussing etc unchanged
- We only need a single arc of the chicane
  - Magic!
  - Or even just a bend



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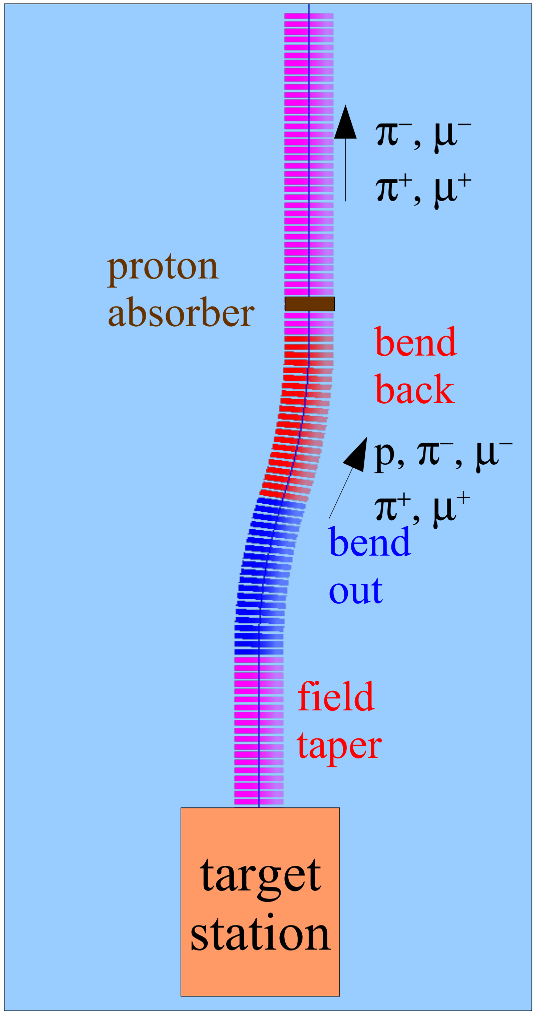
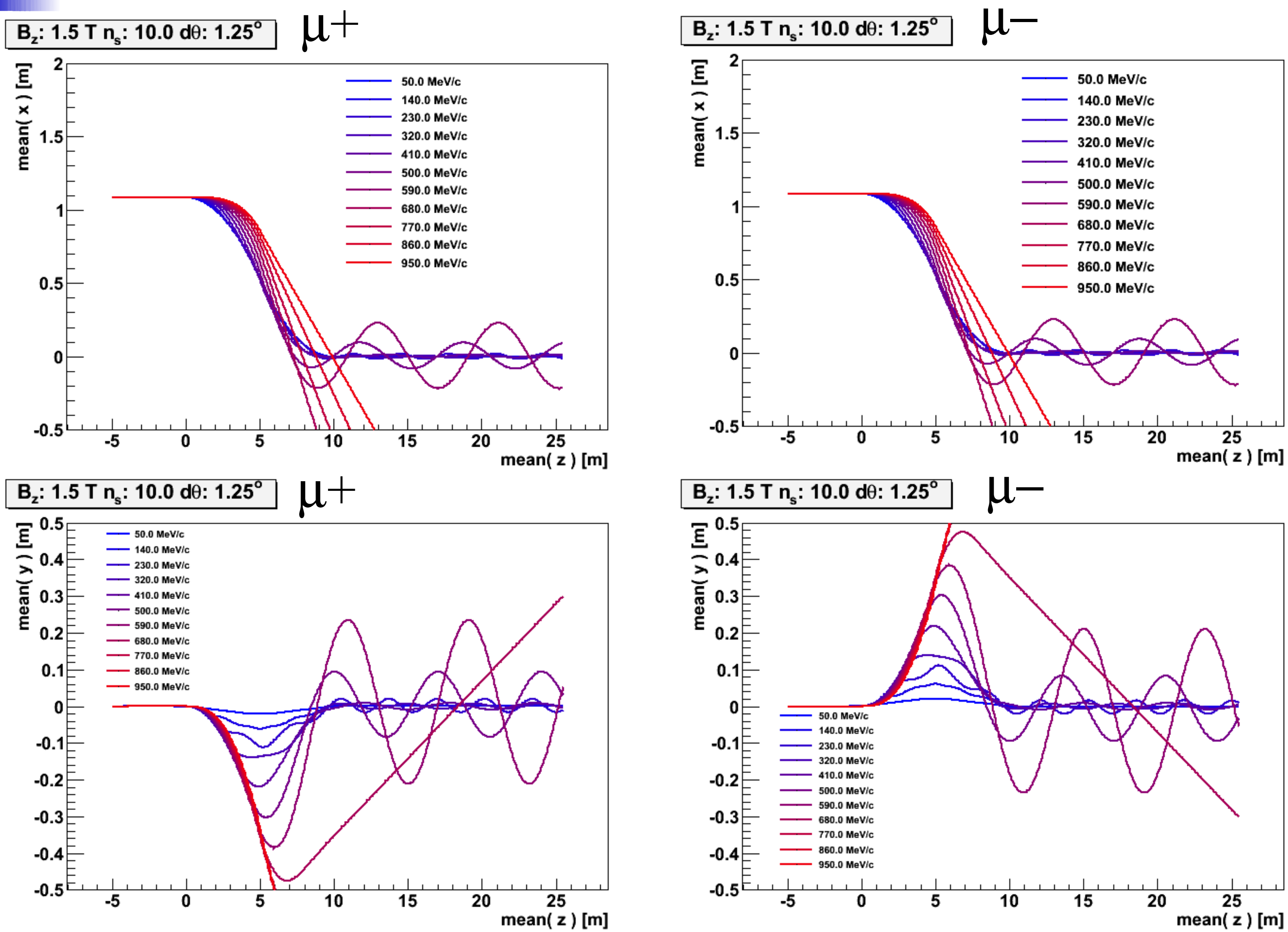
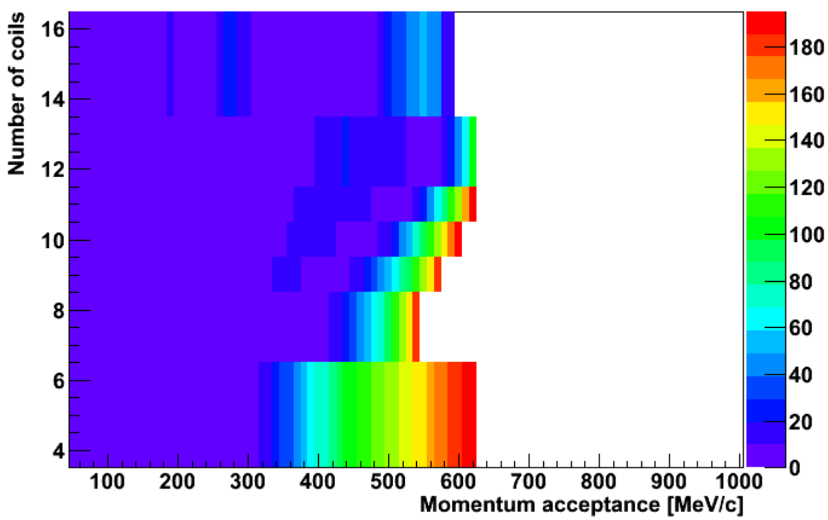
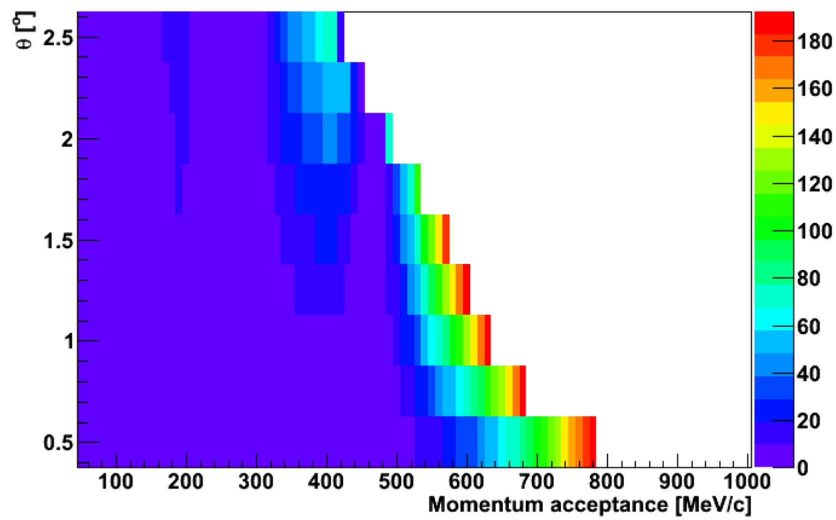


Note on particle charge vs orbit



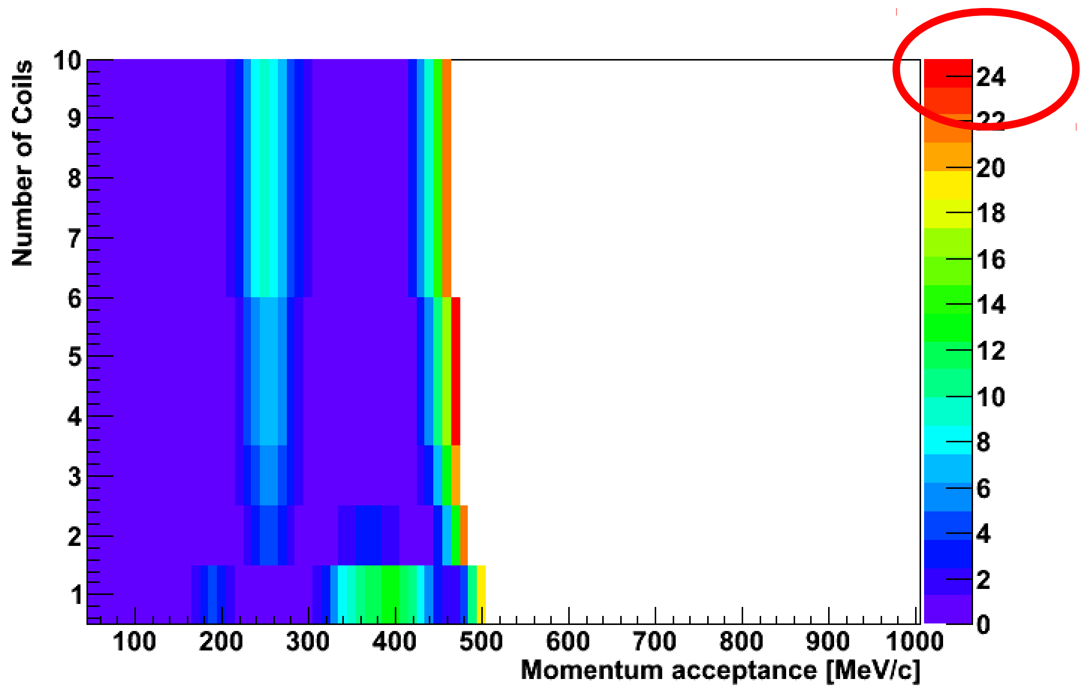
Single bend - optimisation





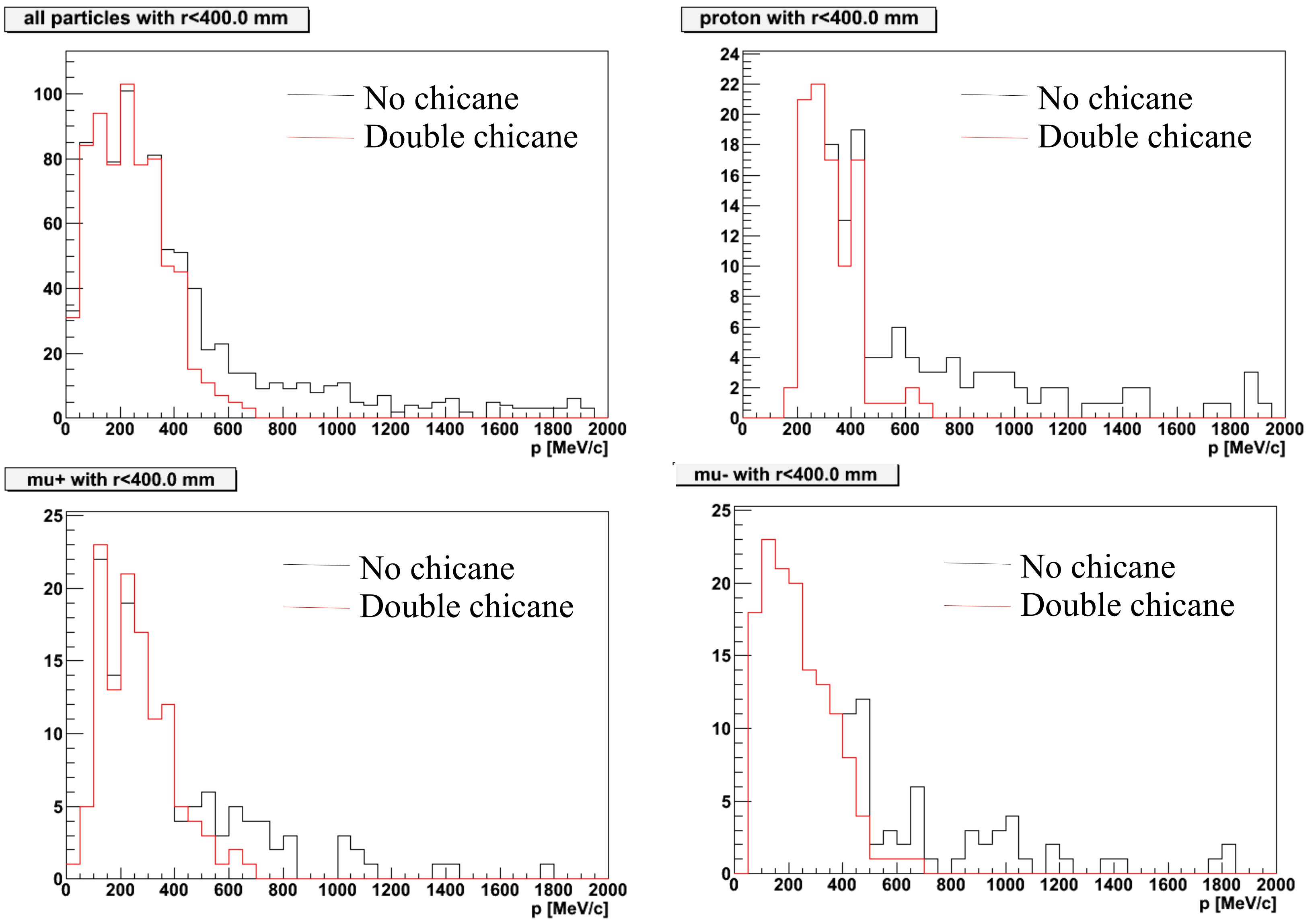
- Optimisation is similar for single chicane as for double chicane
  - Harder to excite these funny resonances at ~ few hundred MeV/c
  - Might be an optimisation for more coils
  - For now, stick with 1.25^{o} and 10 coils per bend

Field smoothness



- I split each coil into several subcoils
  - Each subcoil evenly rotated to make a smooth curve
  - Lower current density to keep total current constant
  - Gives same field on axis, but more smooth
- Some dependence on field smoothness

Transmission vs p (double chicane)



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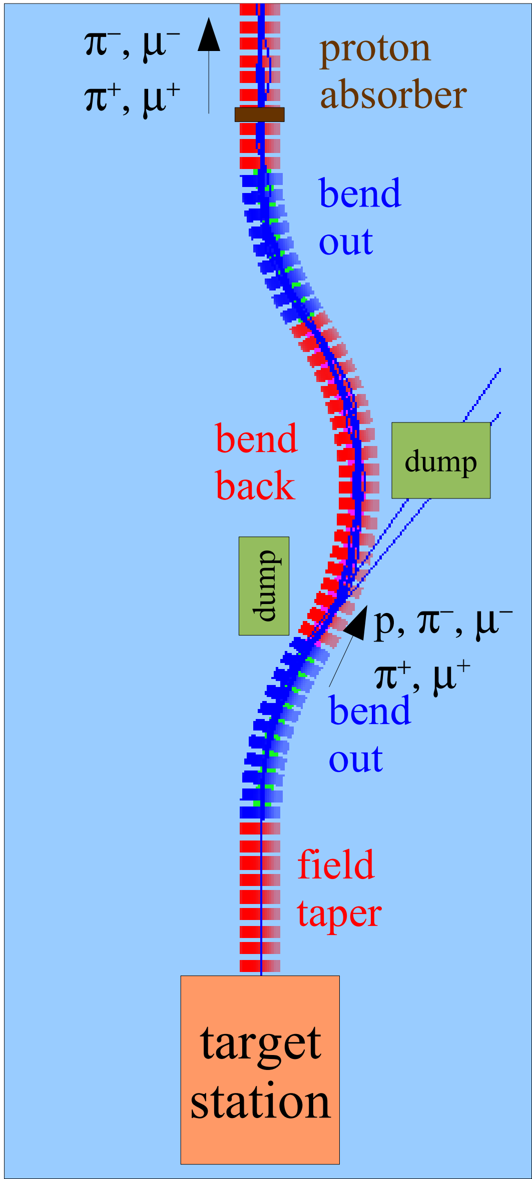
- We only need a single arc of the chicane
  - Magic!
  - Or even just a bend
- Need to do more pushing of beam through
- Still need to work on beam dumps
  - How does beam get out of solenoids?
  - Normal conducting insert?
  - Reduced field + gap – breaking coil geometry?
  - Shielding inside coils?
  - TBD...



Plans

- Reasonable optics design for the chicane
  - Not too much emittance growth
  - Good transmission below momentum cut-off
  - Good collimation above momentum cut-off
- Next consider beam dumps
- Reconsider proton absorber in context of chicane (Neuffer?)
- Have a look at transverse collimation (Snopok?)