Chicane Beam Dynamics

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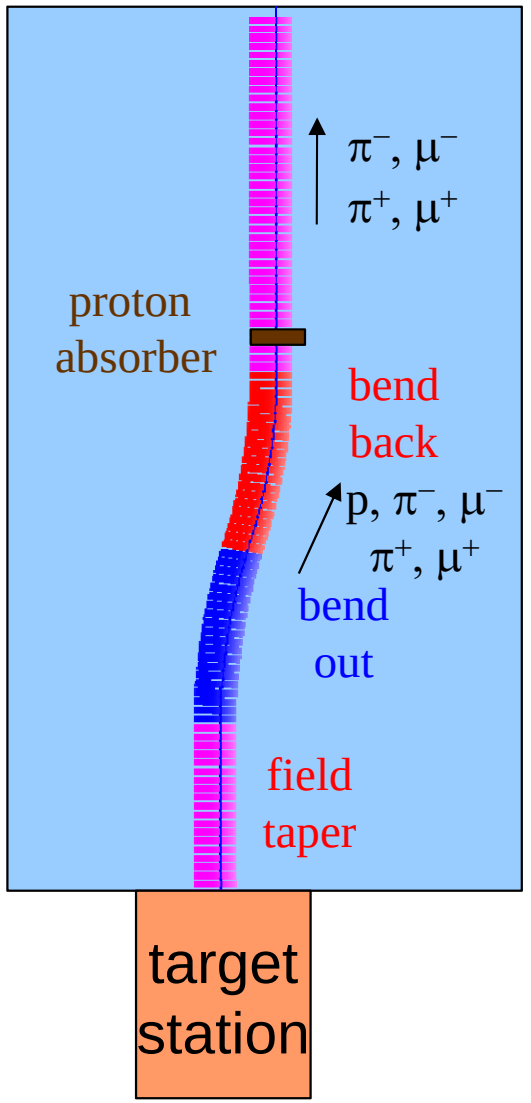
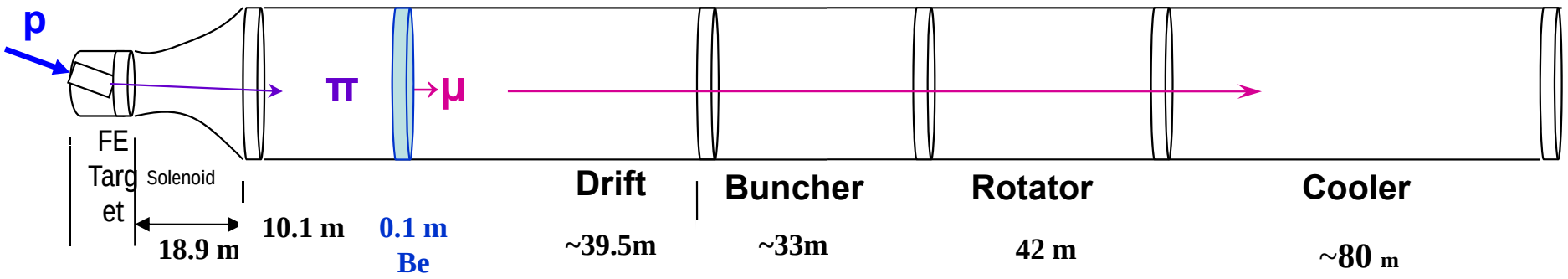
Chicane/Absorber Design Concept

- **Bent solenoid chicane induces vertical dispersion in beam**
  - bend out – 5m, 12.5°
  - Single chicane will contain both signs
    - Opposite signs have dispersion in opposite sense
  - Little disruption to the central beam
  - High momentum particles scrape

- **Subsequent proton absorber to remove low momentum protons**
  - Non-relativistic protons don't have much energy, even for relatively large momenta (~10cm Be)



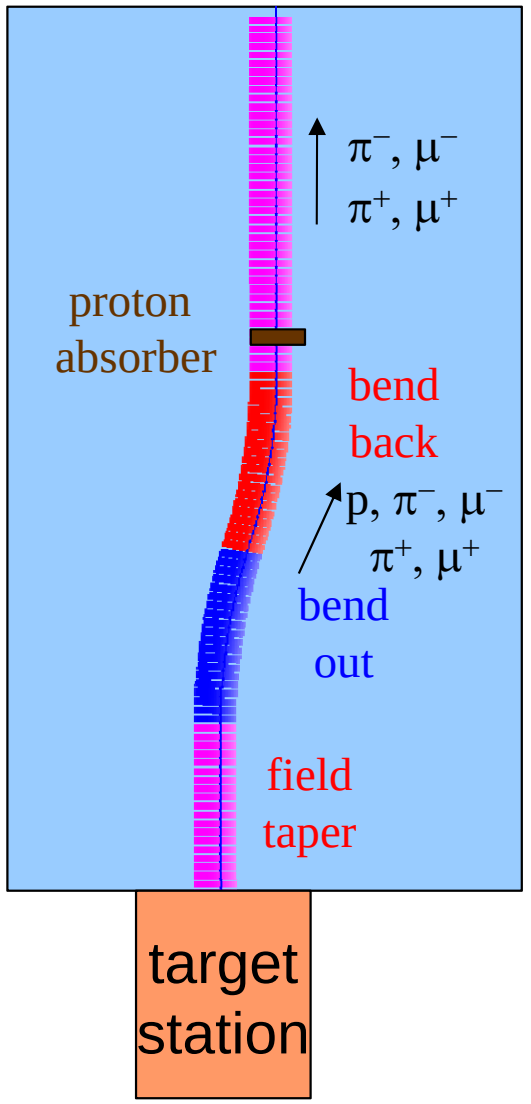
Front End with Absorber-Rematch



- **with absorber**
  - particle 1-270 MeV/c
  - particle 2-185 MeV/c
  - absorber at 29m
    - 10cm Be
    - particle 1-237 MeV/c
    - particle 2-144 MeV/c
  - Bunch N=10
  - Rotate N=10.04
  - Cool -201.25MHz
    - p_{ref}=230 MeV/c

Add chicane to absorber

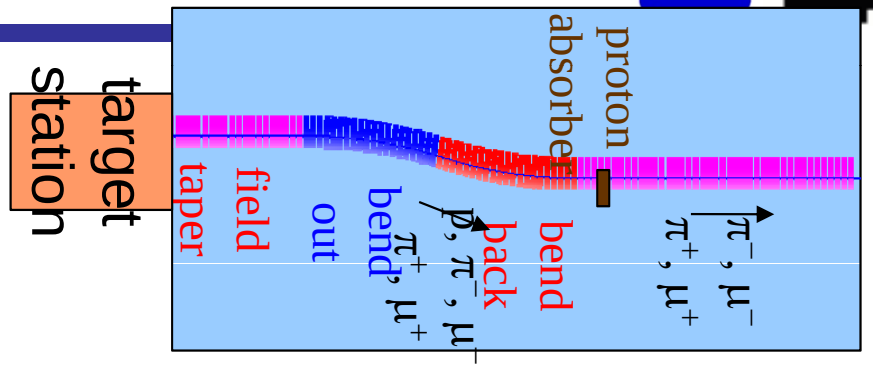
- **ICOOL version**
  - 2 Bent Solenoids – 10m
  - 5m, 1.5T, 12.5º,0.27GeV/c
  - 5m, 1.5T, -12.5º ,0.27GeV/c
    - **bend radius is 22.92m (1/r=0.043636)**
    - B_y=0
- **Match to channel**
  - add 1m drift



- **ICOOL BSOL element:**

```
SREGION        ! bentsol
5.0  1   1e-2
1  0.   1.0
BSOL
1 1.5 0.0 1 0.27 0.0  0.043636  0.0 0.0 0.0  0. 0. 0. 0. 0.
VAC
NONE
  0. 0. 0. 0. 0.   0. 0. 0. 0. 0.
```

Equations of motion and solution



- **Equations of motion:**
- $x'' = h + by'$
- $y'' = -bx'$
  - b= B_o /Bp and h=1/R; R= 22.918m, B_0=1.5T , Bp (T-m) = p (GeV/c)/0.3

$$y(s) = C_1 - \frac{h}{b}s + \frac{h}{b^2}\sin(bs) + C_2\frac{1}{b}\sin(bs) + C_4\frac{1}{b}(\cos(bs) - 1)$$

$$x(s) = C_3 + \frac{h}{b^2}(1 - \cos(bs)) + C_2\frac{1}{b}(1 - \cos(bs)) + C_4\frac{1}{b}\sin(bs)$$

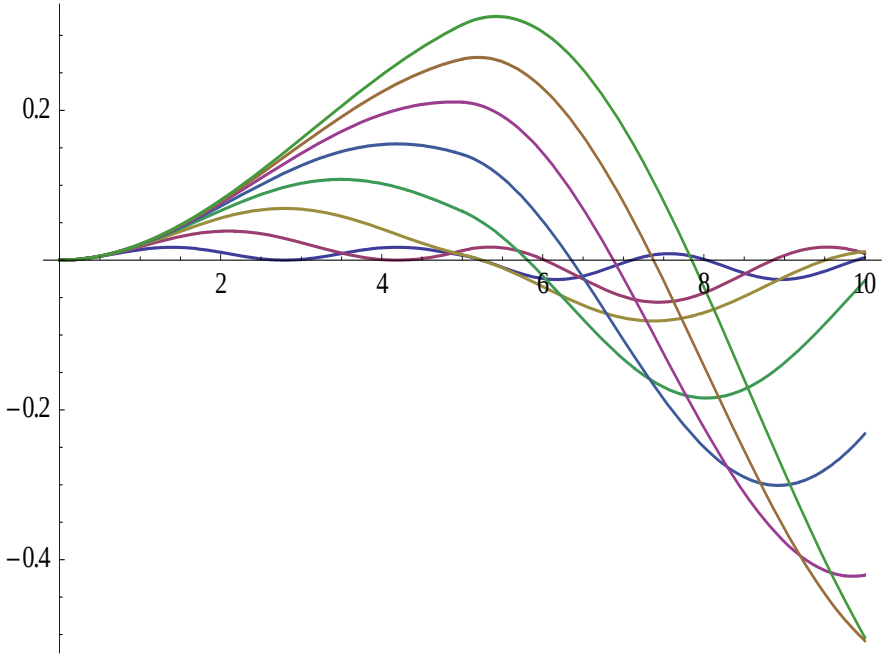
- C_1=y(0), C_2=y'(0), C_3=x(0), C_4= x'(0)

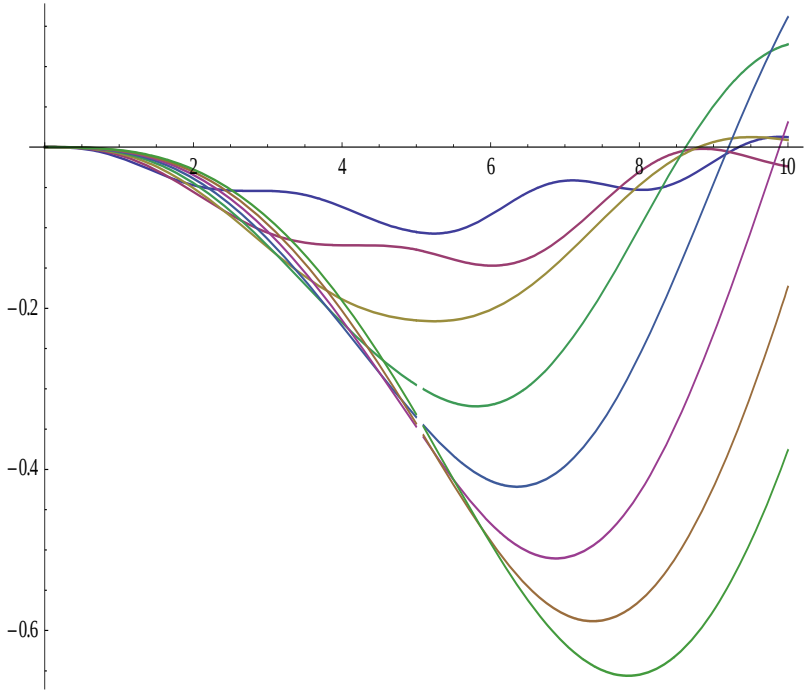
$$y(s) = -\frac{h}{b}s + \frac{h}{b^2}\sin(bs)\,; x(s) = \frac{h}{b^2}(1 - \cos(bs)) \;:\; \mathbf{s<5m}$$

- $y(s) = -\frac{h}{b}s_0 + \frac{h}{b^2}\sin(bs_0) + \frac{h}{b}s - \frac{h}{b^2}\sin(bs) + \frac{h}{b}\cos(bs_0)\frac{1}{b}\sin(bs) + \frac{h}{b}\sin(bs_0)\frac{1}{b}(\cos(bs) - 1)$
- $x(s) = \frac{h}{b^2}(1 - \cos(bs_0)) - \frac{h}{b^2}(1 - \cos(bs)) + \frac{h}{b}\cos(bs_0)\frac{1}{b}(1 - \cos(bs)) + \frac{h}{b}\sin(bs_0)\frac{1}{b}\sin(bs)$,

$5<s+s_0<10$m; s_0=5m

reference particles in chicane

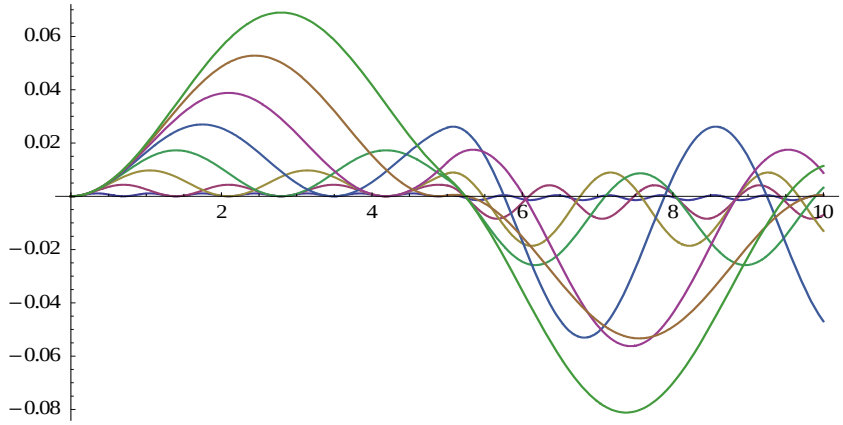




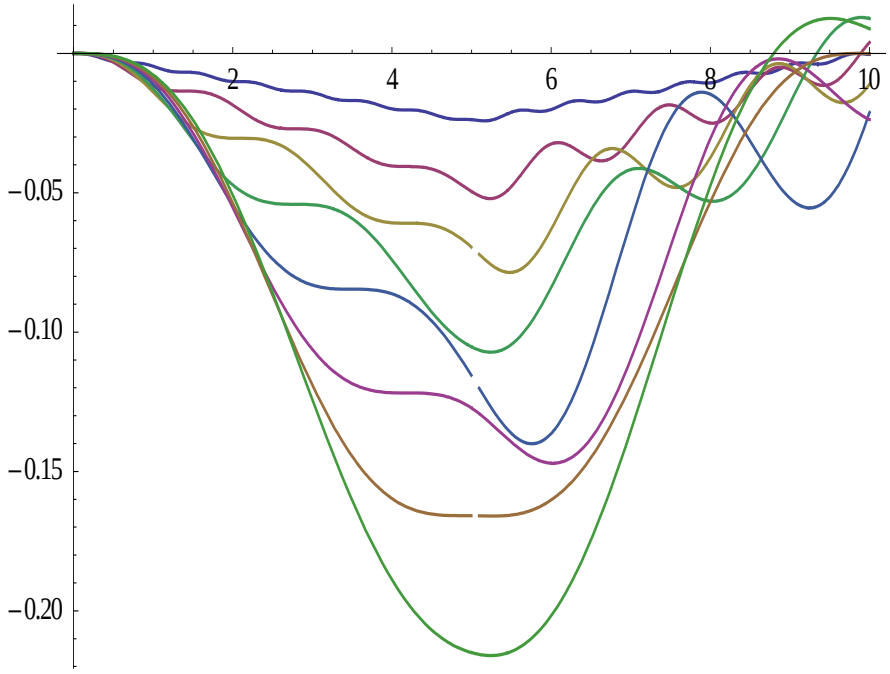
- **x deviation**
  - p=0.2, 0.3, 0.4, 0.5, 0.6, 0.7,0.8 ,0.9

- **y deviation**
- p=0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9

More reference particles



- **x motion**
  - p=0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35 ,0.4



- **y motion**
  - p=0.05, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35 ,0.4

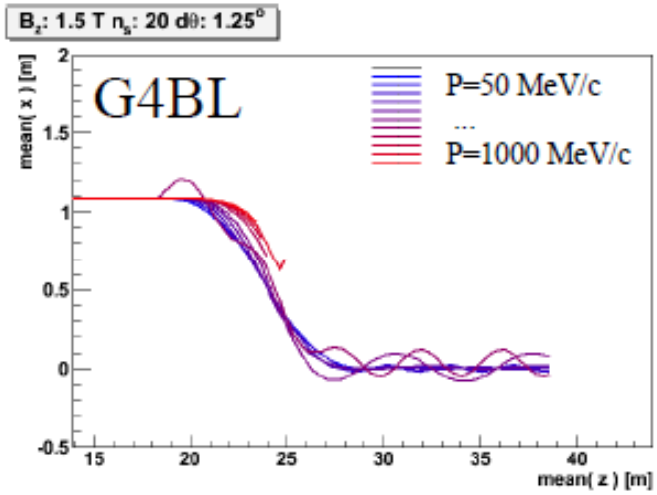
motion within chicane

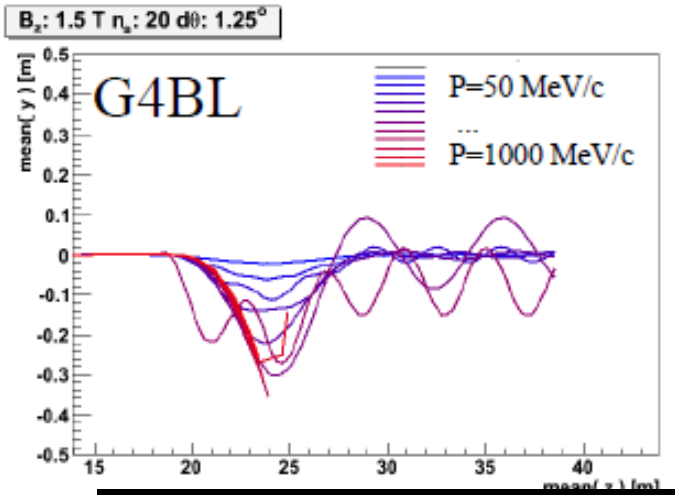
- **vertical dispersion**
  - $D=-h\ p\ s\ /(0.3B_0)$
    - $s<s_0$
  - $D=h\ p\ (s-s_0)\ /(0.3B_0)$
    - $s_0<s<2s_0$
- **oscillatory motion**
  - period is $\Lambda= 2\pi\ p/(0.3B_0)$
  - initial amplitude is
  - $A=hp^2/(0.3B_0)^2$

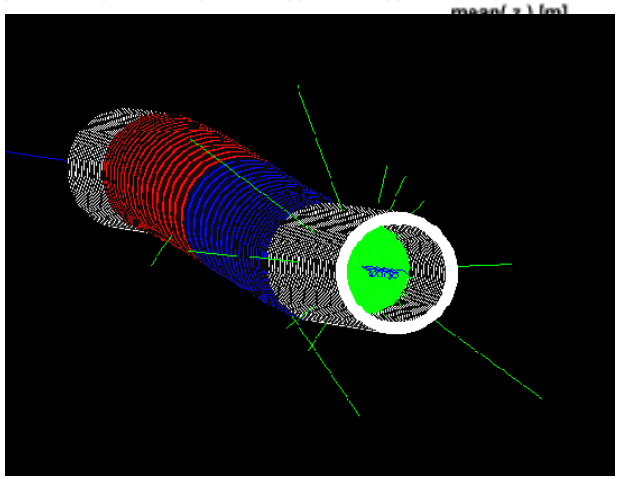
Chicane + absorber

- **Chicane effect:**
  - P > ~500MeV/c are lost
  - P < ~500MeV pass through
    - displaced by ~1.1m
  - Nominal Path length increased by only 8cm
    - orbits perturbed

- **absorber effect**
  - removes low energy particles
    - designed to remove protons
  - distorts energy distribution
    - energy phase-rotation distorted; must be rematched



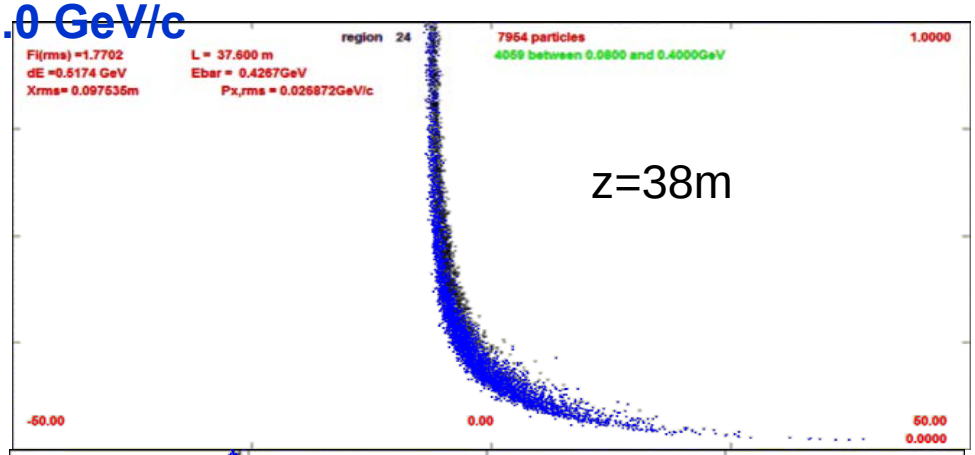


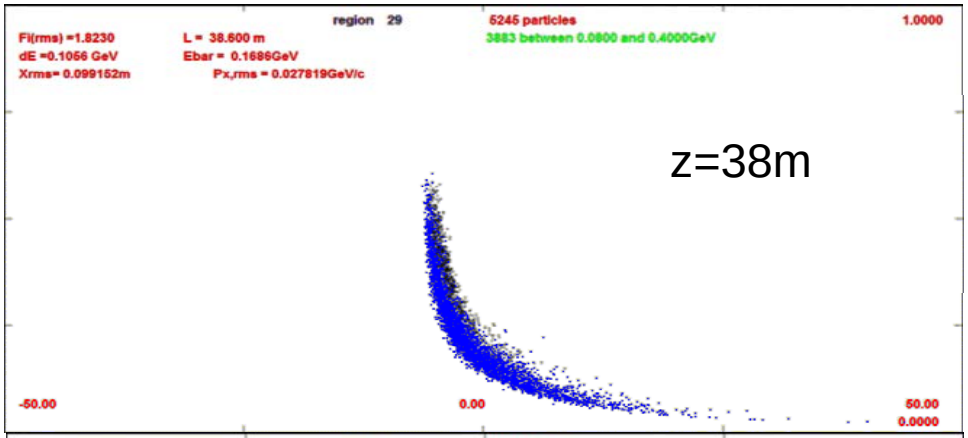


Compare-absorber vs absorber+chicane

This compares absorber only (10cm Be) to chicane (BSOL) + absorber

1.0 GeV/c





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