Studies on Muon Collider's Target with G4Beamline (11/10/2025)

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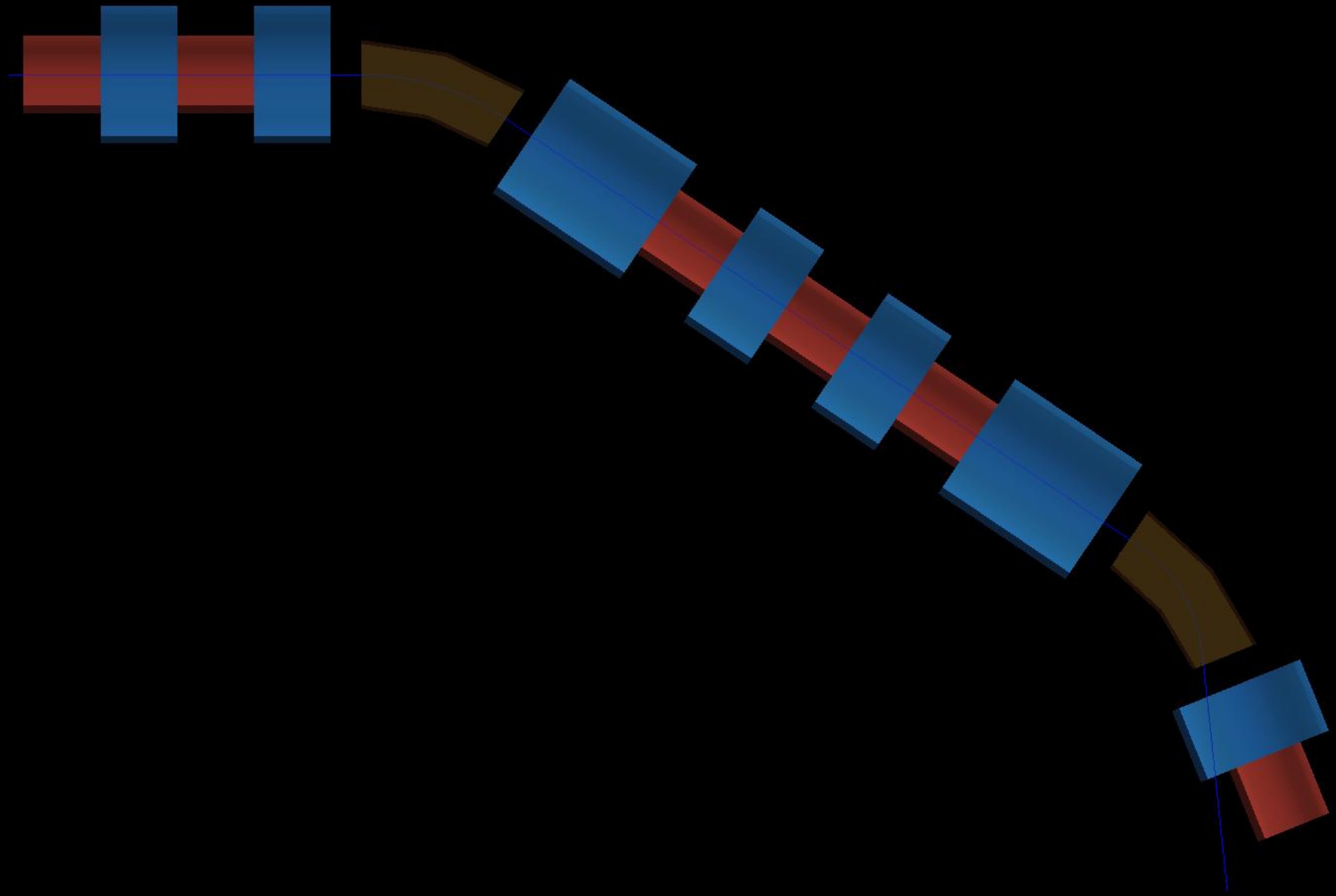
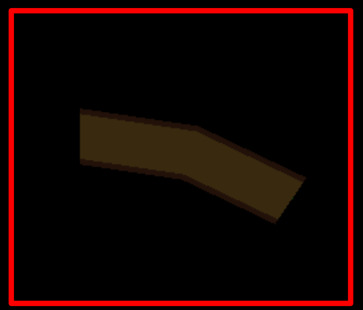
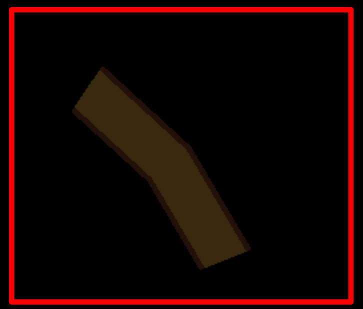
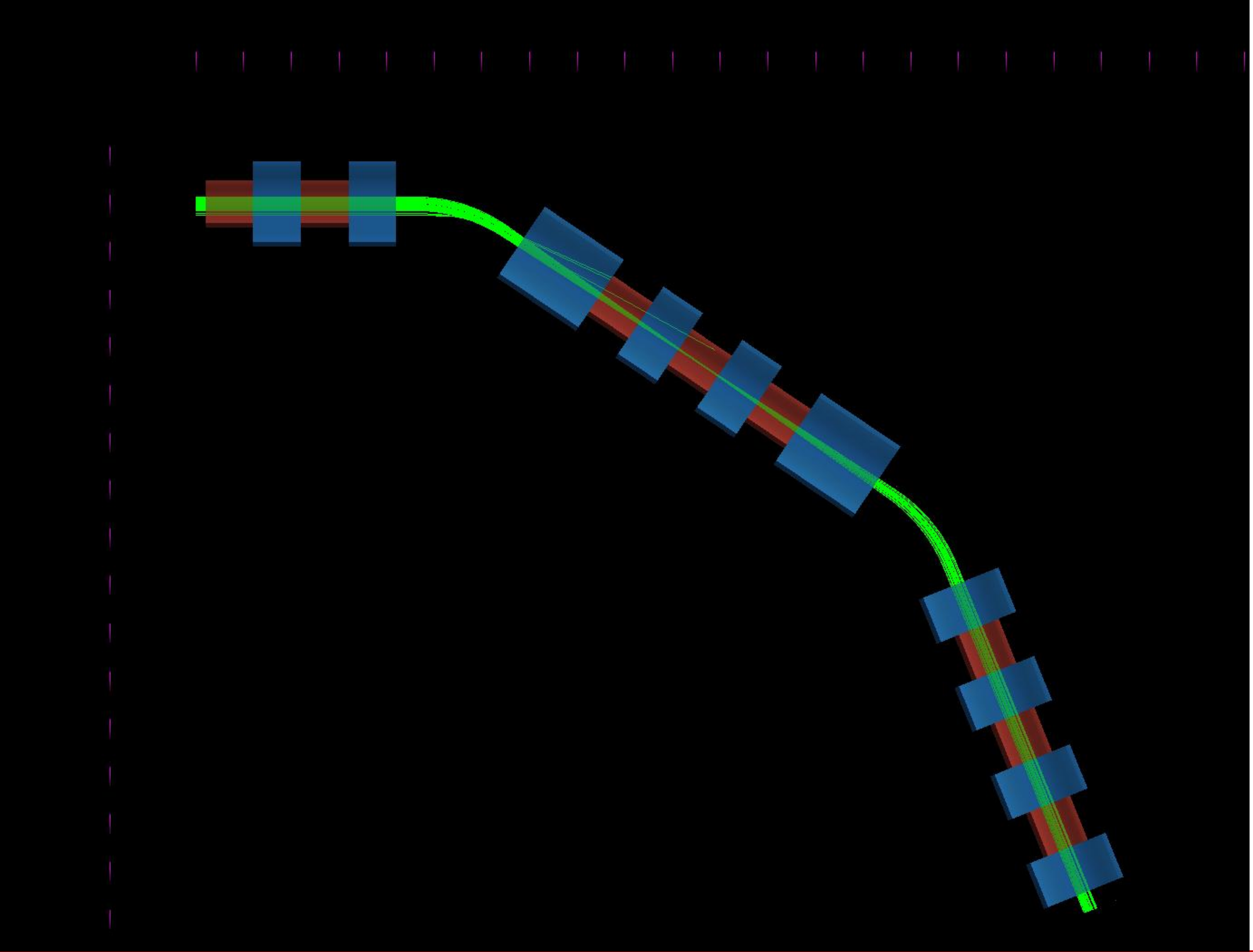




Print and save the fieldmaps only in these regions.





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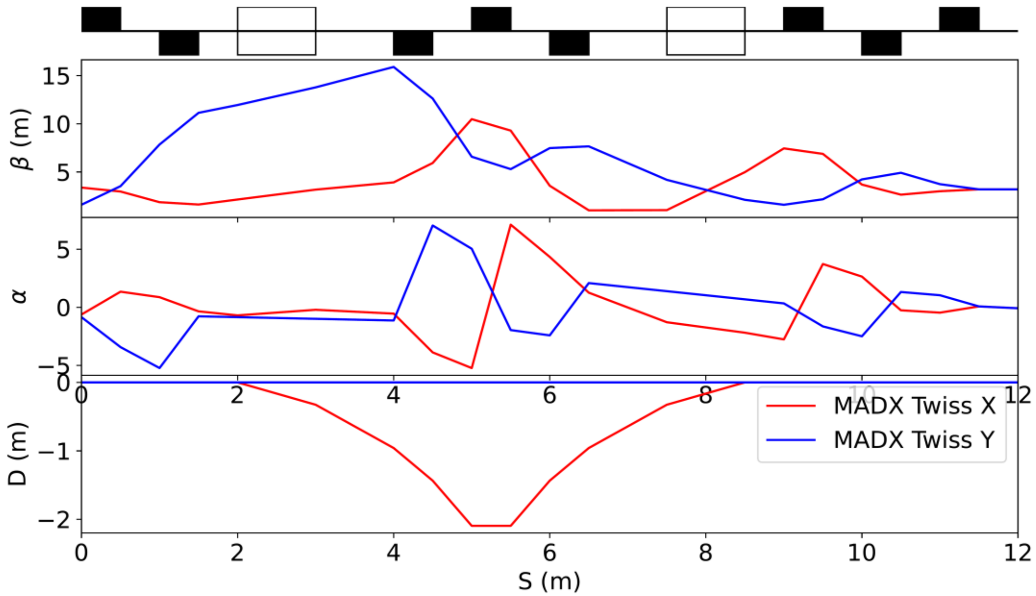
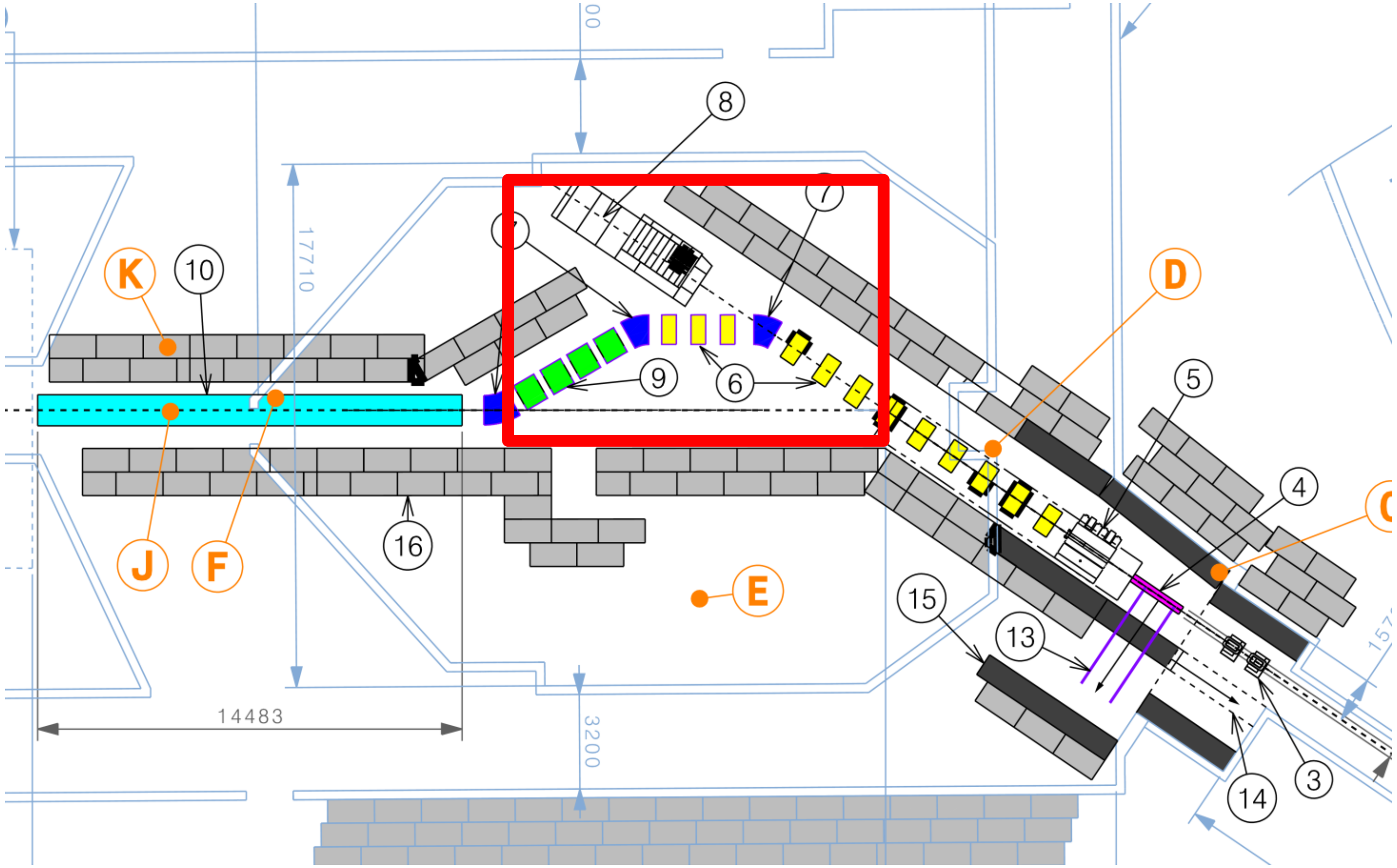
Fermilab


β (m)
α
D (m)
S (m)
MADX Twiss X
MADX Twiss Y


K
J
F
E
D
14483
17710
3200

Parameters (BDSIM→G4Beamline)

Beam Definition

BDSIM:

beam, particle="mu+", momentum=200*MeV,
distrType="gauss", sigmaX=50*mm, sigmaY=50*mm,
sigmaXp=50*mrad, sigmaYp=50*mrad, sigmaP=0.05;

→ G4Beamline:

beam particle=mu+ momentum=200 sigmaX=50 sigmaY=50 sigmaXp=0.05 sigmaYp=0.05 sigmaP=0.05

- Units: G4Beamline assumes **mm** and **radians**.
- sigmaXp=50*mrad → 0.05, same for Y.

Collimators

BDSIM:

c1: ecol, l=0.001*mm, xsize=300*mm, ysize=300*mm, material="graphite", outerDiameter=1500*mm;

→ G4Beamline:

tube c1 innerRadius=150 outerRadius=750 length=0.001 material=Graphite kill=1 color=0.5,0.5,0.5

- outerDiameter=1500 mm → outerRadius=750
- xsize/ysize map to aperture radius.
- kill=1 mimics absorber behavior (beamPipeIsInfiniteAbsorber=1).

Parameters (BDSIM→G4Beamline)

Quadrupoles

BDSIM:

ch_q1: quadrupole, l=0.5*m, k1=1.31029, aper1=200*mm;

→ G4Beamline:

multipole ch_q1 fieldLength=500 quadrupole=1.31029 apertureRadius=200 kill=1 fieldMaterial=Vacuum ironMaterial=Fe

Conversion notes:

- l=0.5*m → fieldLength=500
- k1 directly equals **quadrupole gradient**
- **(T/m)** aper1=200 mm → apertureRadius=200
- Add kill=1 for the iron boundary.
- Repeat with sign changes for Q2–Q8.

Conversion Formula

$$\text{Gradient (T/m)} = k_1 \times (B\rho)$$

where

$$B\rho = \frac{p}{q} = \frac{p\,[\text{GeV}/c]}{0.299792}$$

and p is the beam momentum.

Example (200 MeV/c beam)

$$B\rho = \frac{0.200}{0.299792} = 0.667\ T \cdot m$$

so

$$\text{Gradient} = k_1 \times 0.667$$

Drifts

BDSIM:

d_500: drift, l=500*mm;

d_1000: drift, l=1000*mm;

→ G4Beamline:

tube d_500 length=500 innerRadius=400 outerRadius=450 material=Vacuum

tube d_1000 length=1000 innerRadius=400 outerRadius=450 material=Vacuum

- Use pipe or tube for drifts.
- No magnetic field; just free drift space.

Parameters (BDSIM→G4Beamline)

Dipoles (sbend)

BDSIM:

s_dp_1: sbend, l=1000*mm, angle=-(3.14159/180)*34;

→ G4Beamline:

```
param Rc=1000/0.5934      # bending radius from Bρ relation
param Bdip=0.396 T
genericsectorbend s_dp_1 fieldLength=1000 fieldCenterRadius=$Rc DipoleField=$Bdip \
              fieldHeight=400 fieldInnerRadius=$Rc-130 fieldOuterRadius=$Rc+130 angle=-34
place s_dp_1 z=$z_b1
cornerarc z=$z_b1 centerRadius=$Rc angle=-34 radiusCut=400
```

Magnetic field:

$$B = \frac{p}{0.299792\, R}$$

where

p= beam momentum (GeV/c)

R= bending radius (m)

B= magnetic field in tesla

Example (200 MeV/c beam, R = 1.67 m):

$$B = \frac{0.200}{0.299792 \times 1.67} = 0.396 \text{ T}$$

→ hence param Bdip=0.396

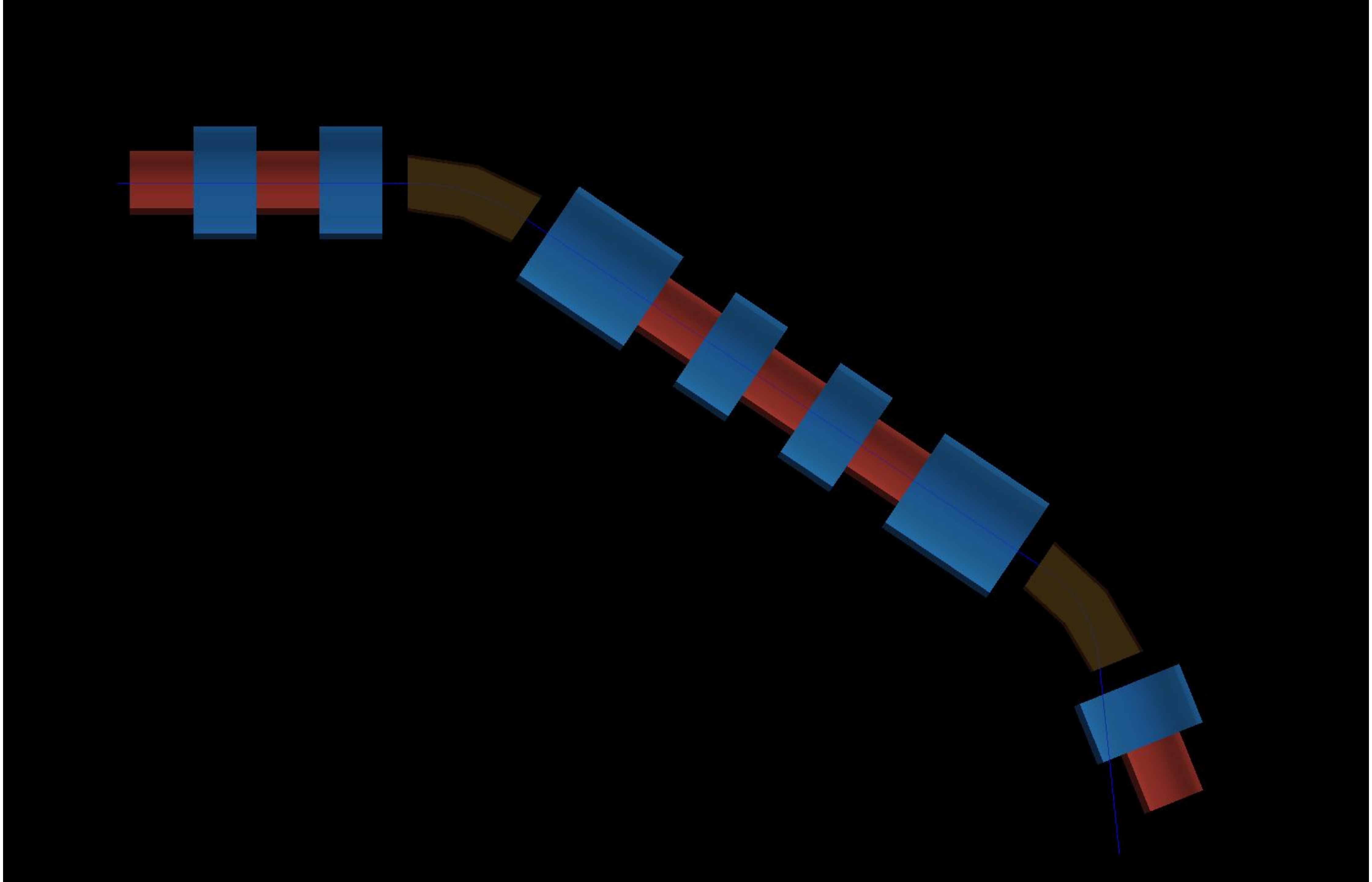
About the constant 0.299792:

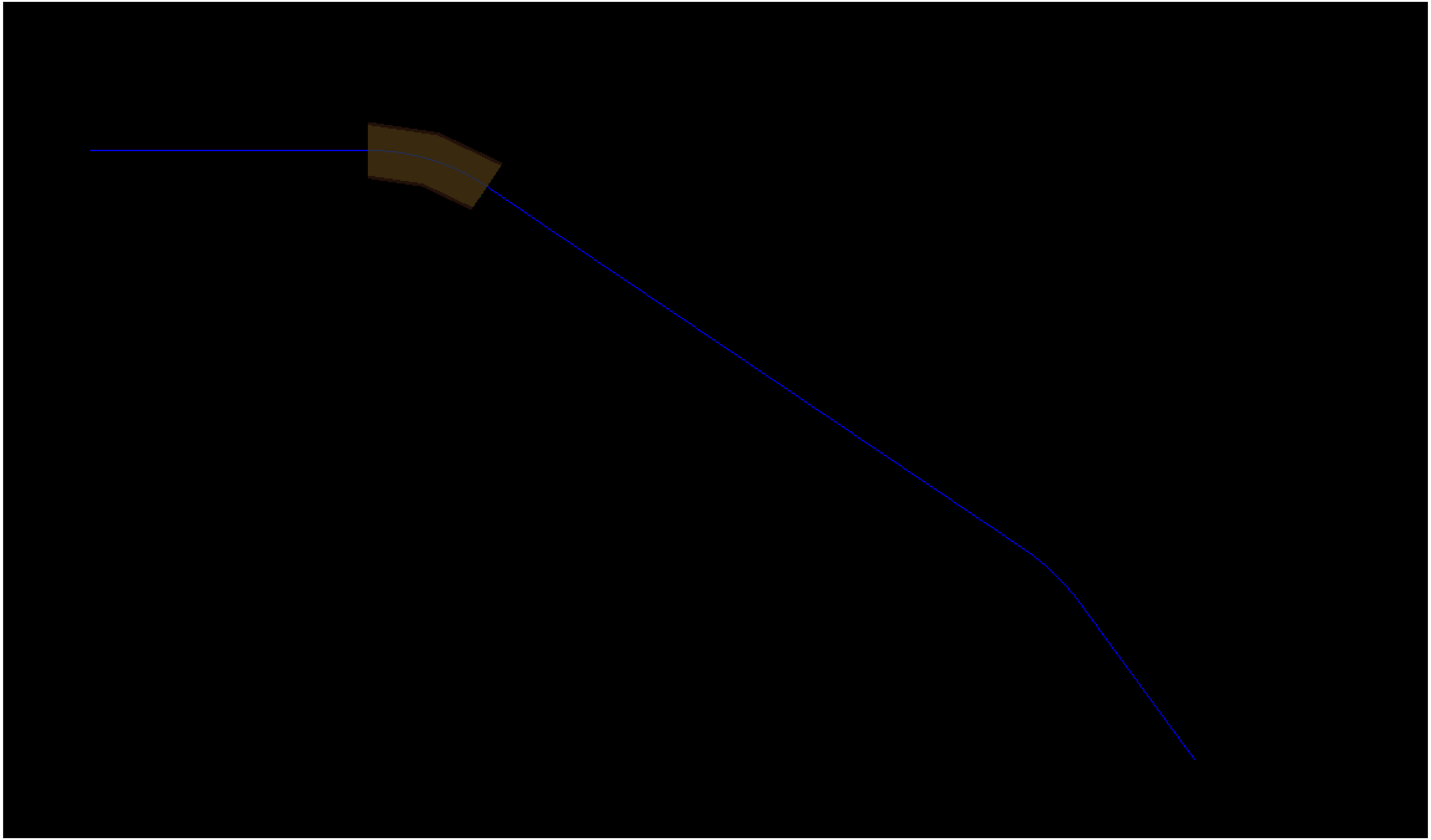
This factor comes from the Lorentz force relation $p = qBR$.

Expressed in GeV/c, T, and meters:

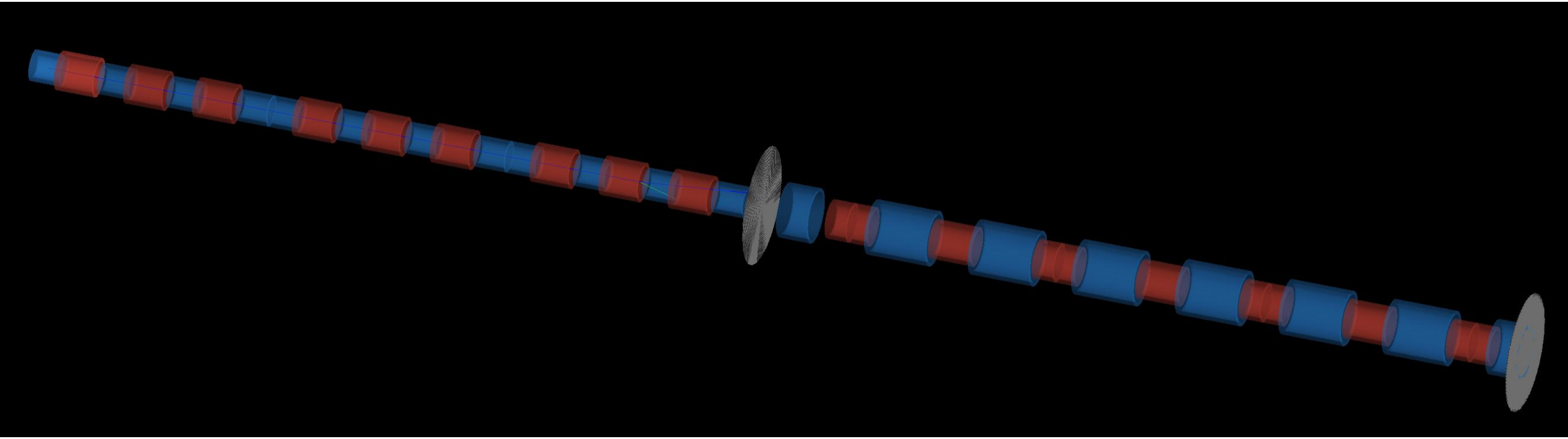
$$p[\mathrm{GeV}/c] = 0.299792 \times B[\mathrm{T}] \times R[\mathrm{m}]$$

0.299792= $c/10^9/e$— essentially the **speed of light in convenient accelerator units**.

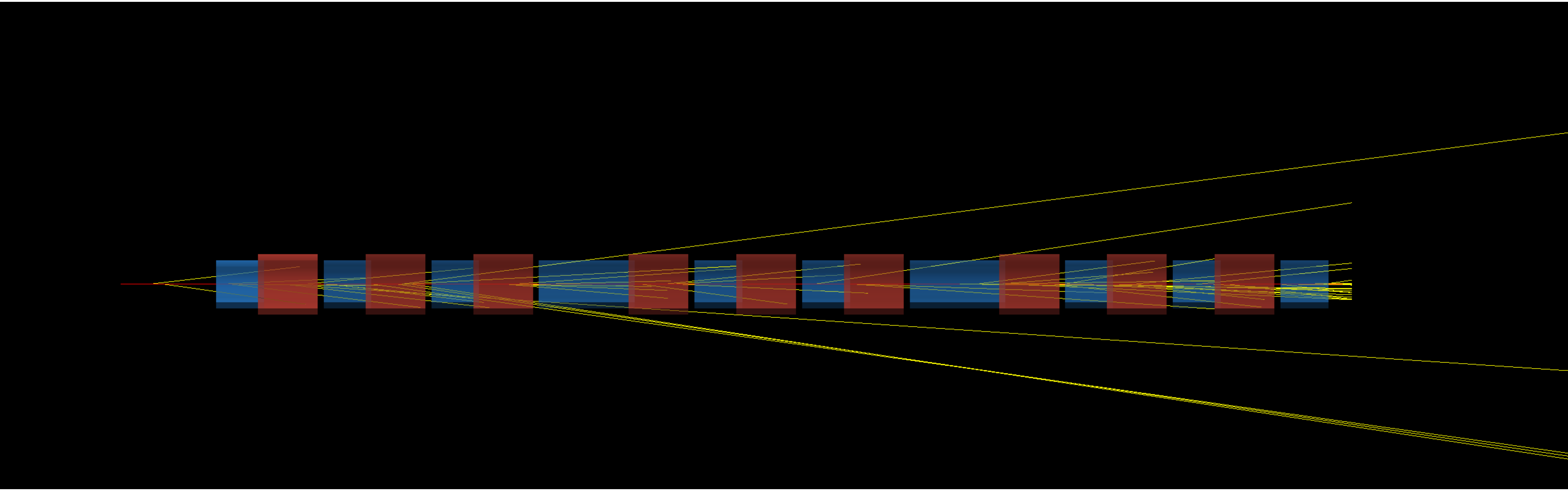




Pion Decay Channel



Pion Decay Channel (Triplet)



Pion Decay Channel (FODO)