Comments performance parametrization for alternative magnet systems

FCC Hadron Detector Meeting
Mar. 3rd, 2015

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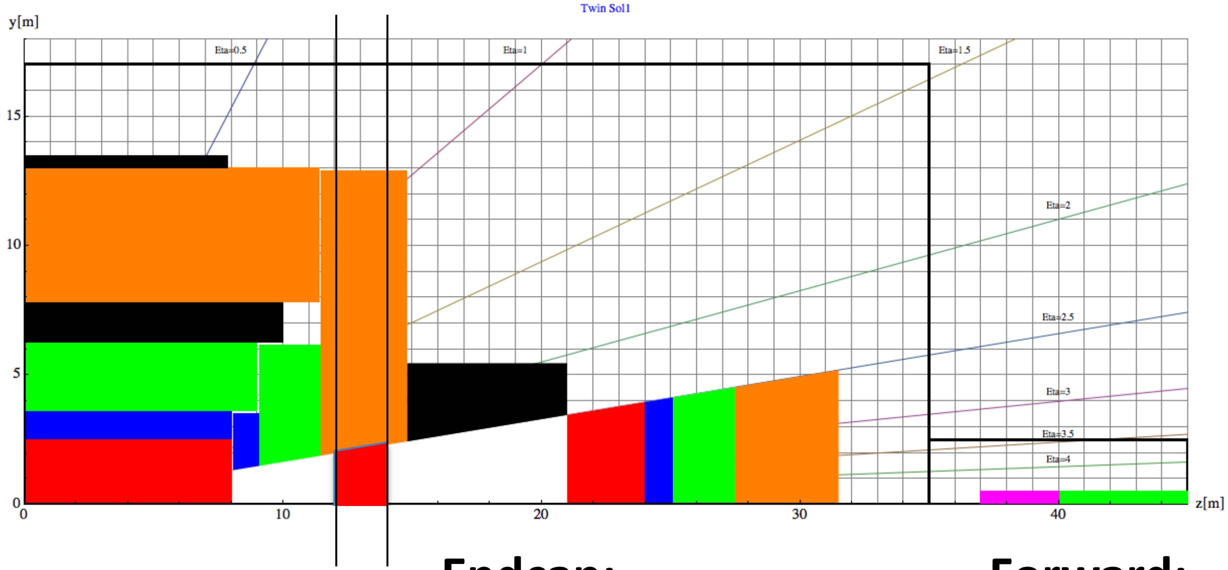
Baseline Geometry, Twin Solenoid



Barrel:

Tracker available space:
R=2.1cm to R=2.5m, L=8m

EMCAL available space:
R=2.5m to R= 3.6m → dR= 1.1m

HCAL available space:
R= 3.6m to R=6.0m → dR=2.4m

Coil+Cryostat:
R= 6m to R= 7.825 → dR = 1.575m, L=10.1m

Muon available space:
R= 7.825m to R= 13m → dR = 5.175m

Coil2:
R=13m to R=13.47m → dR=0.475m, L=7.6m

Endcap:

EMCAL available space:
z=8m to z= 9.1m → dz= 1.1m

HCAL available space:
z= 9.1m to z=11.5m → dz=2.4m

Muon available space:
z= 11.5m to z= 14.8m → dz = 3.3m

Forward:

Dipole:
z= 14.8m to z= 21m → dz=6.2m

FTracker available space:
z=21m to R=24m, L=3m

FEMCAL available space:
Z=24m to z= 25.1m → dz= 1.1m

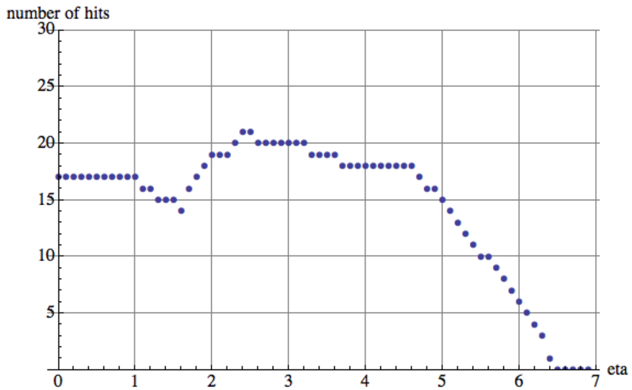
FHCAL available space:
z= 25.1m to z=27.5m → dz=2.4m

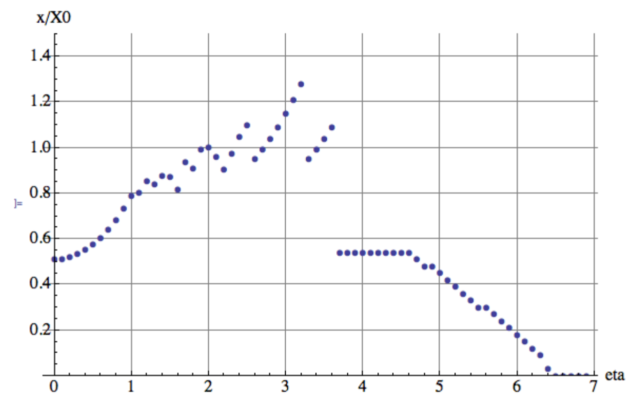
FMuon available space:
z= 27.5m to z=31.5m → dz=4m

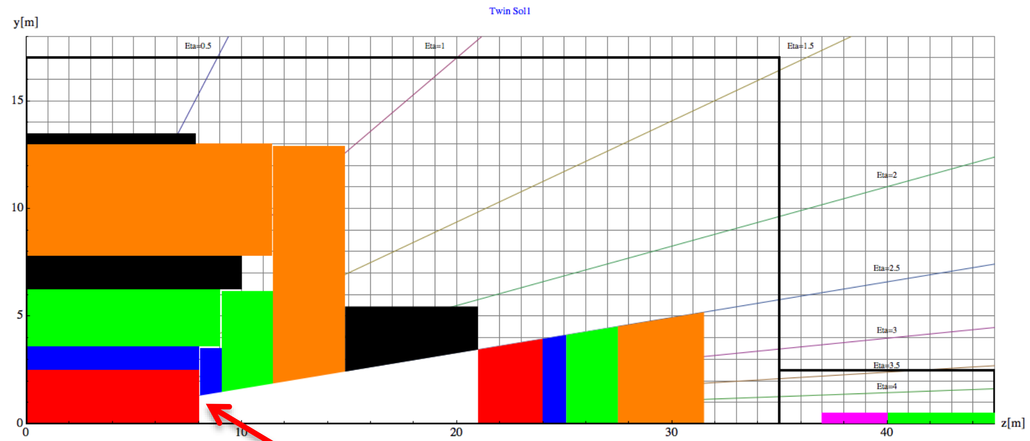
Tracker

Material composition in Volume (%):
Si 20%, C 42%, Cu 2%, Al 6%, Plastic 30%
X_0 of this mix: 14.37cm

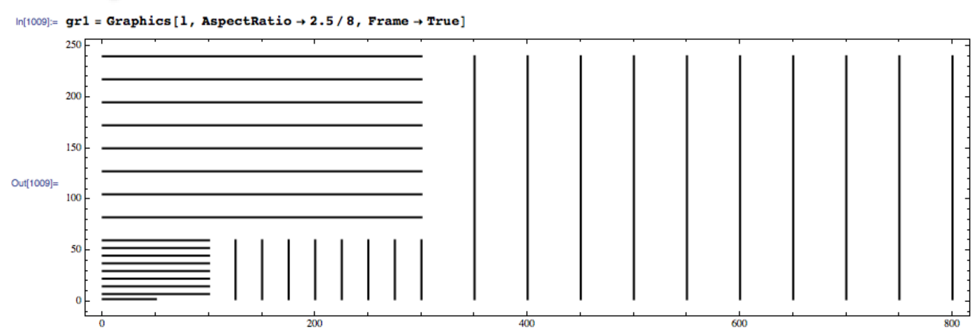
We assume 3% of radiation length per layer, i.e. each layer has a thickness of 0.43cm.



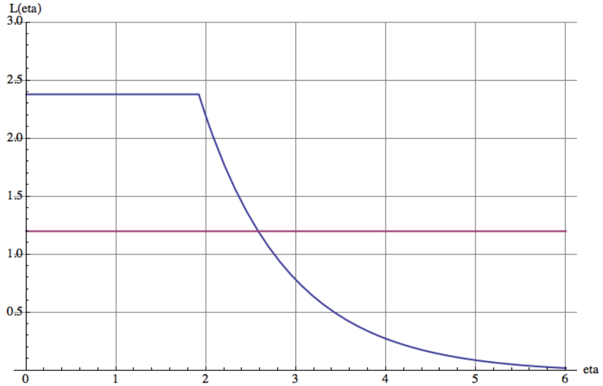


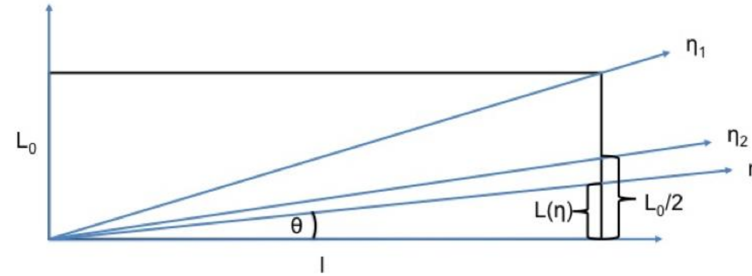


R_{out}=2.4m
Half the leaver arm at eta=2.6→ L=8m

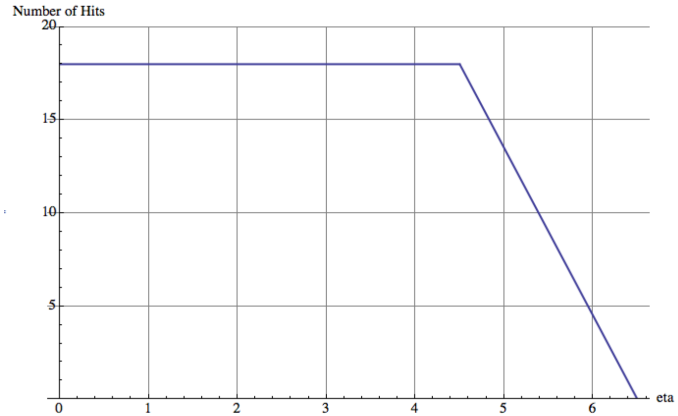


Tracker





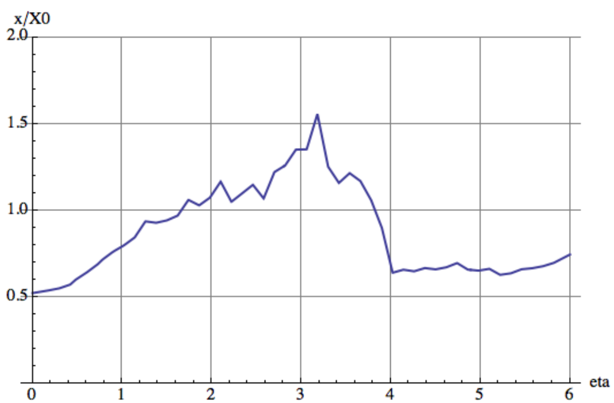
$$\eta_1 = -\ln\tan\left(\frac{1}{2}\arctan\frac{L_0}{l}\right) \qquad \eta_2 = -\ln\tan\left(\frac{1}{2}\arctan\frac{L_0}{2l}\right)$$



For a geometry with $L_0 = 2.4m$ and $l = 8m$ we have $\eta_1 = 1.9$ and $\eta_2 = 2.6$

$$L(\eta) = L_0 \quad \eta < \eta_1 \qquad\qquad L(\eta) = L_0\frac{\sinh\eta_1}{\sinh\eta} \quad \eta > \eta_1$$

$$\frac{\Delta p_T}{p_T}\Big|_{reso.} = \frac{\sigma\, p_T}{0.3BL(\eta)^2}\sqrt{\frac{720}{N(\eta)+4}} \qquad\qquad \frac{\Delta p_T}{p_T}\Big|_{m.s.} = \frac{0.0136}{0.3\,BL(\eta)}\sqrt{\frac{x}{X_0}(\eta)}$$



$$\frac{\Delta p_T}{p_T} = \sqrt{\left(\frac{\Delta p_T}{p_T}\Big|_{reso.}\right)^2 + \left(\frac{\Delta p_T}{p_T}\Big|_{m.s.}\right)^2}$$

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In[60]:= L0 = 2.4;
In[61]:= l = 8;
In[62]:= B = 6;
In[63]:= sig = 23 * 10 ^ (-6);
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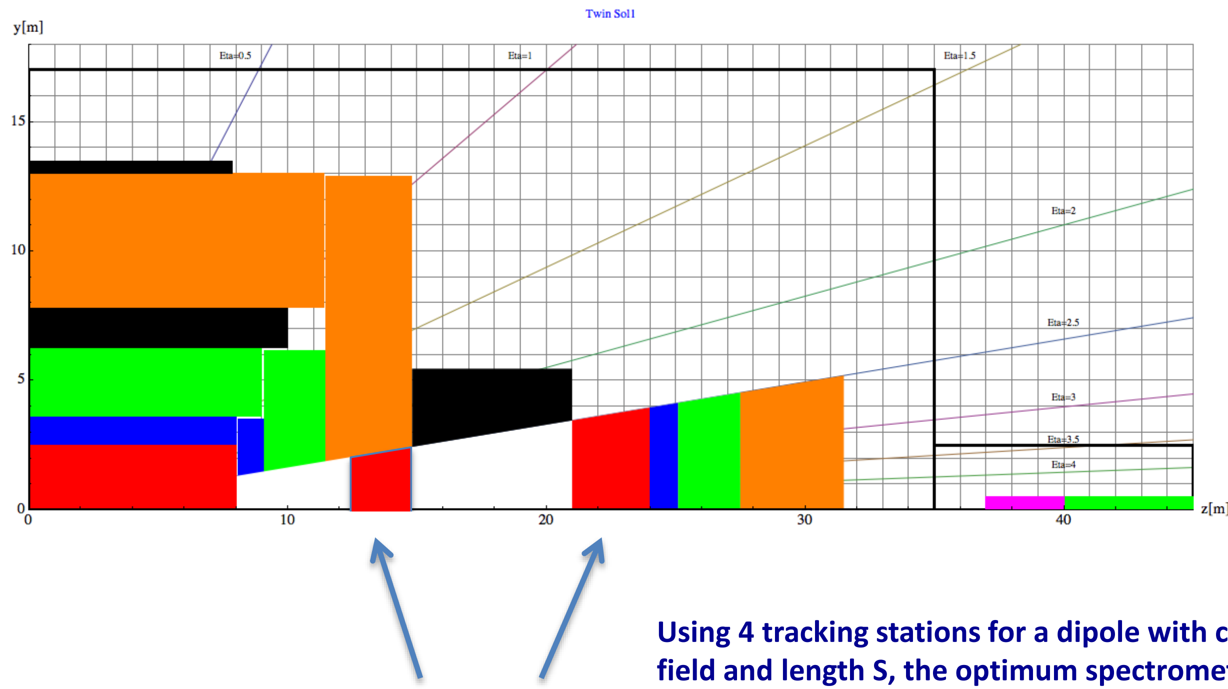
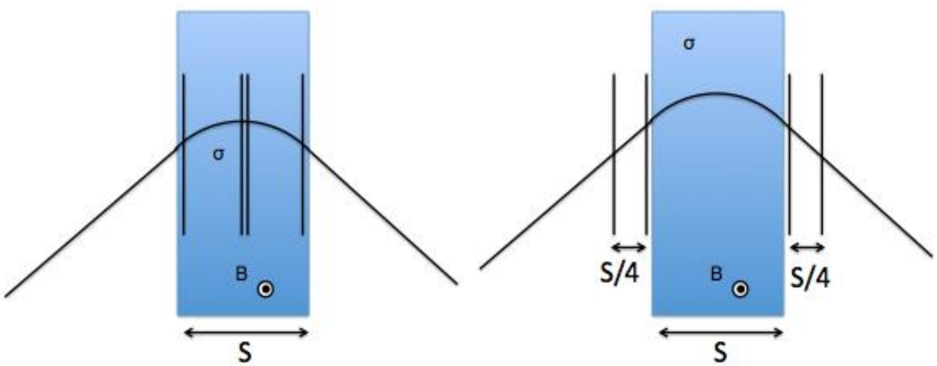
Forward Tracking Resolution, Position Resolution



Using 4 tracking stations for a dipole with constant magnetic field and length S, the optimum spectrometer resolution is achieved by placing 2 stations in the center and one on each end to measure the sagitta.

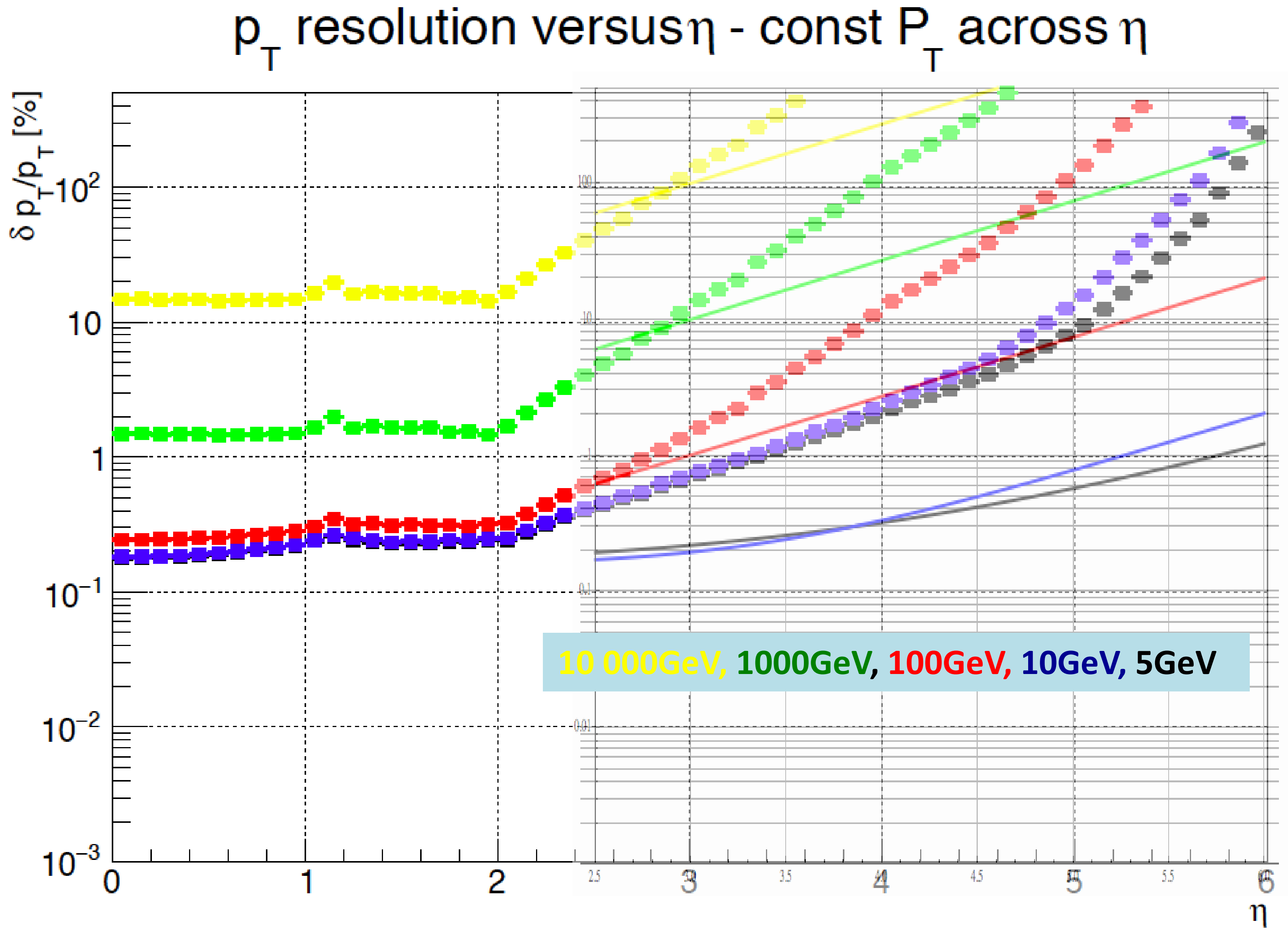


The same performance is achieved by placing the chambers outside the dipole at separation of S/4.

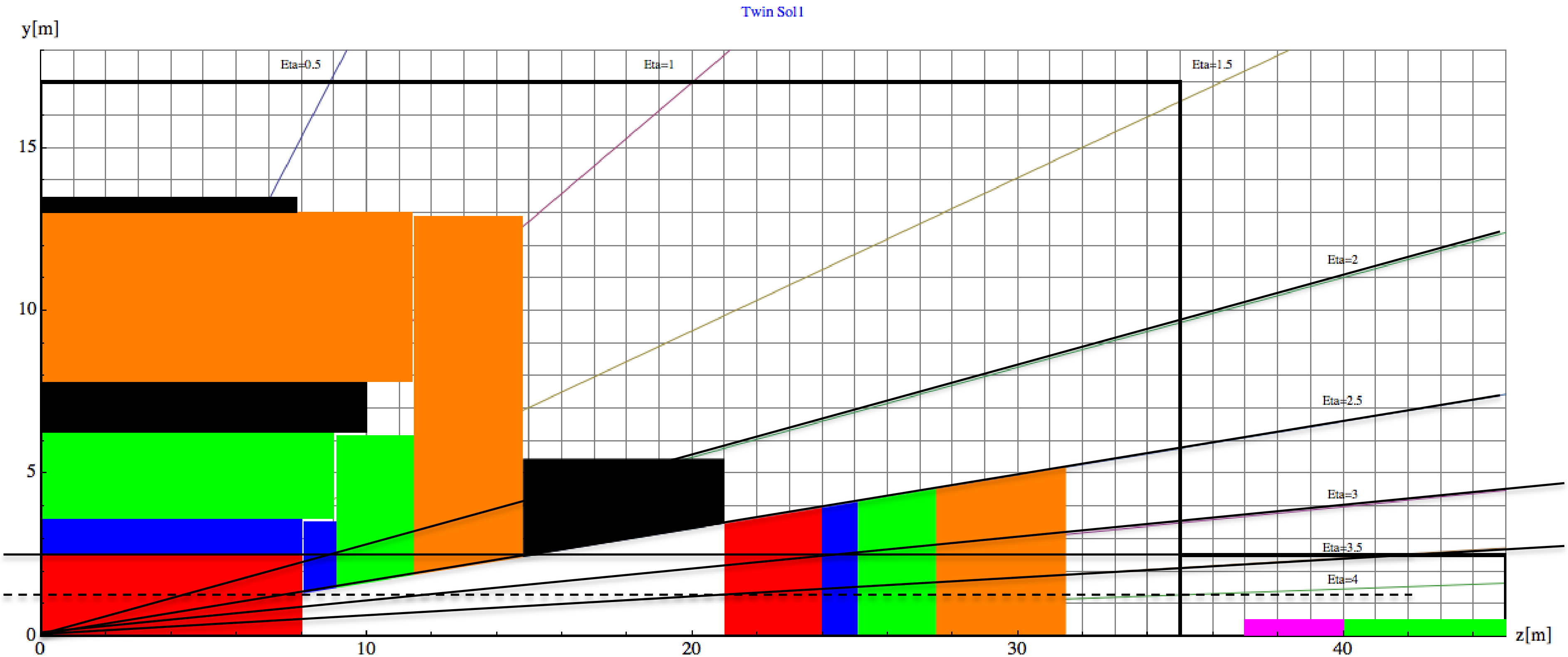
This is what LHCb uses, because if space is available it is more easy to implement the detectors outside, and also avoid occupancy from loopers in the field (details on catching Ks etc. are of curse to be considered …)

We use this idea for now (is also easier to calculate ! It is just the Int B dl that counts)

Forward Tracker Resolution



Solenoid Field extended to Z=22m

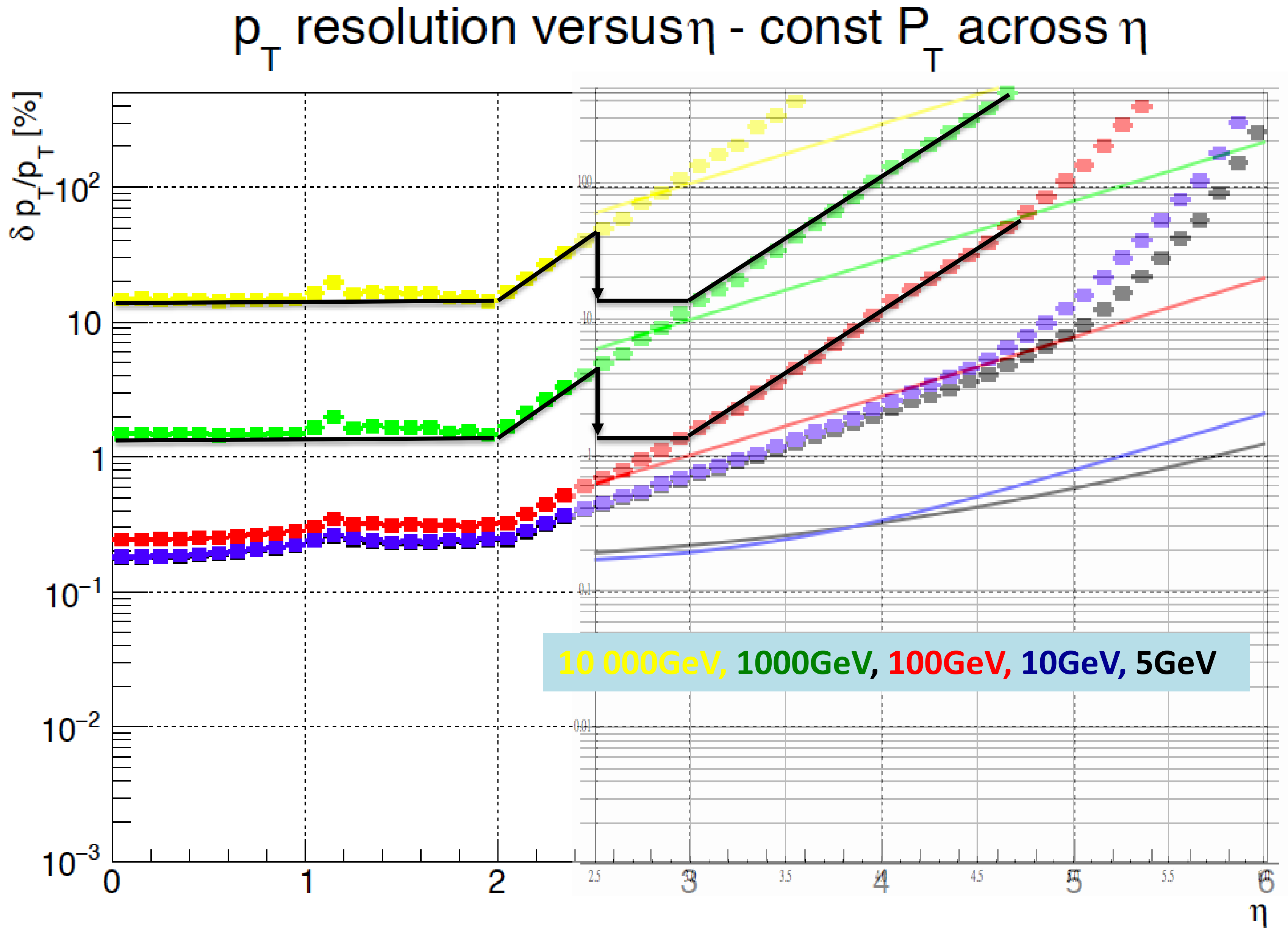


Replacing the dipole by a solenoid that extends the B=6T field up to Z=22m, we can extend shift the resolution curves by one unit of eta,

i.e. flat resolution (10% at p_T=10TeV/c) up to η =3 and ¼ of the resolution at η =3.5

This competed with our present performance parametrization of the Dipole up to η≈4.5

Forward Tracker Resolution

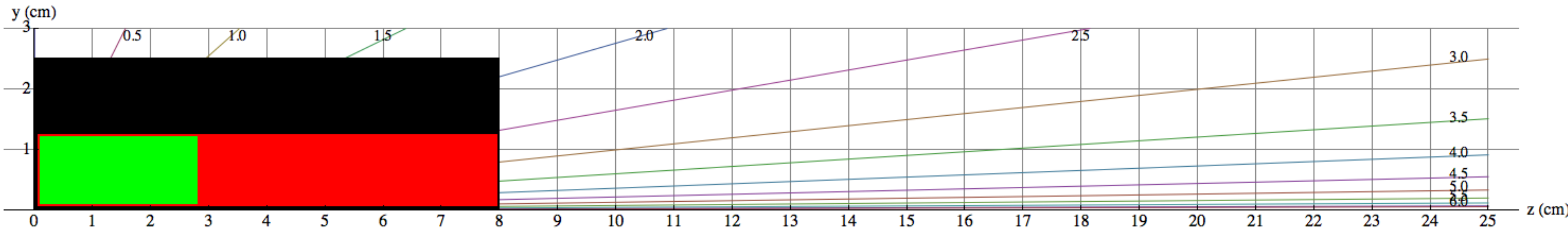


→Interesting ! Parametrized simulations will give indications

CMS Tracker r=1.2m, z=2.8m

FCC Baseline Tracker r=2.4m, z=8m

FCC extreme technology push tracker (r=1.2m, z=8m)



CMS Tracker r=1.2m, z=2.8m

FCC extended solenoid field tracker volume r=2.4m, z=22m

FCC extended solenoid field extreme technology push tracker volume (r=1.2m, z=22m)

Precision alignment over these large distances is certainly a challenge.