Fast Simulations with Hybrid Baseline 2

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Overview

- Implemented a new configuration for the hybrid tracking
- Added 15% radiation length stand-in mRICH material at -186 cm
- Benchmark plots
- Comparisons with some modified configurations

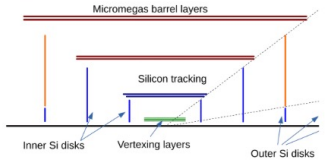
Baseline 2 Configuration

Barrel layout

Si pixel pitch 10 um for vtx and barrel layers

Tracking WG Input for Next Iteration: Barrel

- **Barrel**: pretty settled by now - converging on hybrid setup
  - 3 D-MAPS Vertex layer
  - 2 D-MAPS tracking layer
  - 4 (2x2) MMG layer
  - No MPGD layer after DIRC since ECAL's first layer is Si (AstroPix) layer with $\sigma \approx 500/\sqrt{12}\ \mu\text{m} = 144\ \mu\text{m}$
  - Design leaves plenty of room for possible future upgrades
    - ToF (AC-LGAD/LAPPD)
    - miniTPC (GridPix)
    - high-p_T solution (RICH)



- Covers $-1.1 < \eta < 1.1$
- Minimal mass except at edges due to service (FEE, cables, …)

Thomas Ullrich, https://indico.bnl.gov/event/13175/contributions/54419/

Si Vertex	Radius (mm)	Length (cm)	% X/X0
Layer 1	33	28	0.05
Layer 2	44.1	28	0.05
Layer 3	55.1	28	0.05

- Three vtx layers for redundancy and low pT-threshold
- Radii from 1st engineering CAD model release based on possible stitched sensor size in phi
- Length = 28 cm: max length of a single sensor on wafer, allows for services on one side only; helps low material in negative direction

Si Barrel	Radius (cm)	Length (cm)	% X/X0
Layer 1	13.38	35.74	0.55
Layer 2	18	48.08	0.55

- 0.55% X/X0 might be conservative; Rey showed significant performance improvement for lower material in these layers; material optimisations to be looked into considering RD104 services reduction, inputs from engineers, etc. not necessarily for the proposal

Barrel MPGD Tracker (MM)	Radius (cm)	Length (cm)	Area (m^2)	Resolution (um)	% X/X0
Layer 1	47.72	127.47	3.82	150	0.4
Layer 2	49.57	127.47	3.97		
Layer 3	75.61	201.98	9.59		
Layer 4	77.47	201.98	9.83		

- Cheaper than silicon, no detrimental effect on performance
- Further optimisation of number of layers requires pattern recognition in presence of background, not for the proposal

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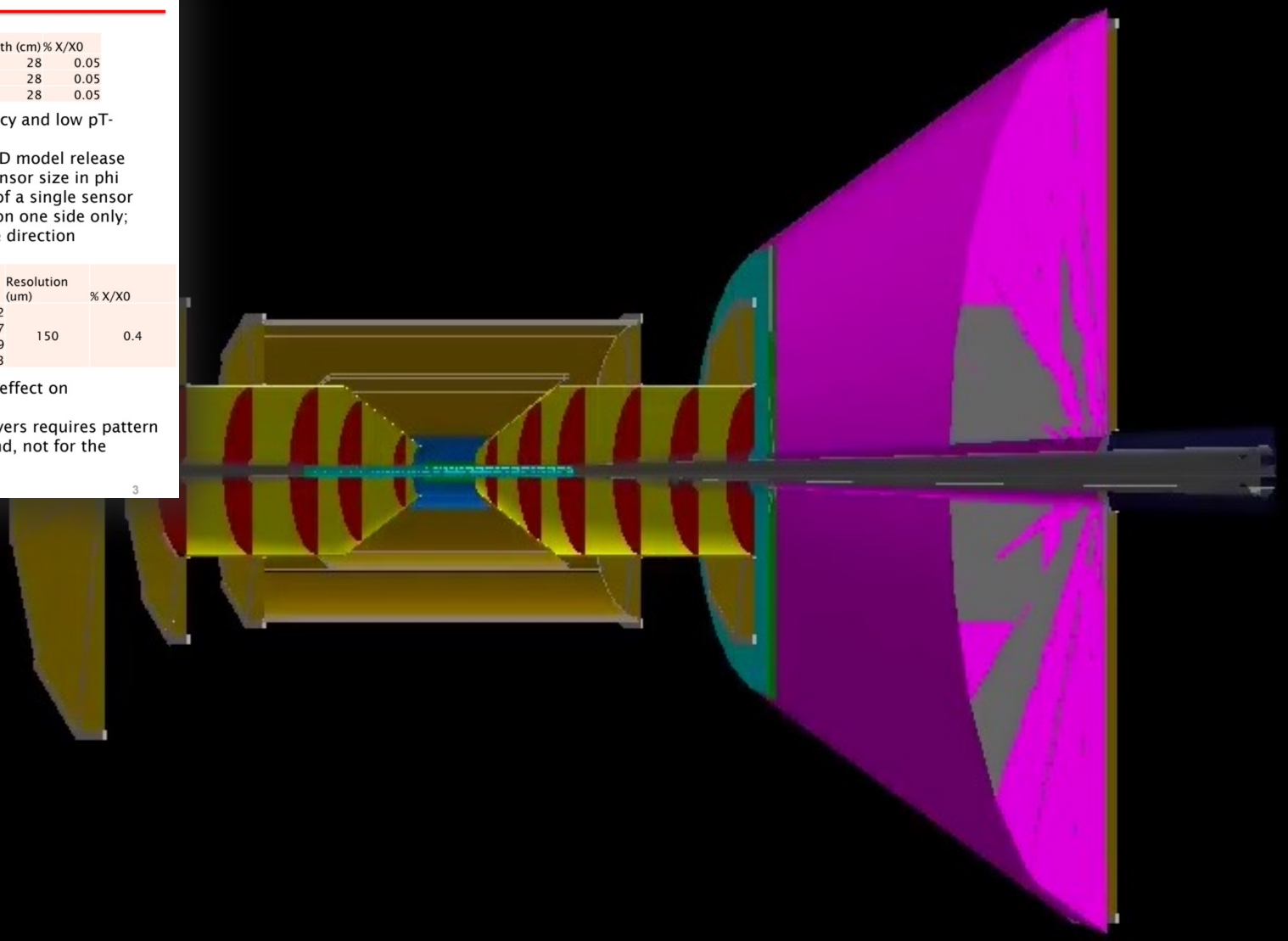
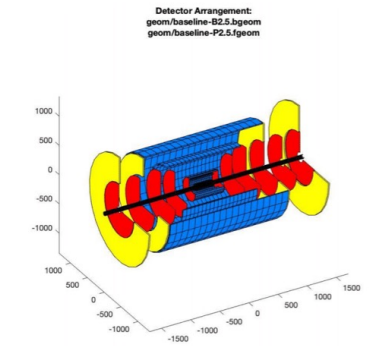


Baseline 2 Configuration

Forward/backward regions: new configuration

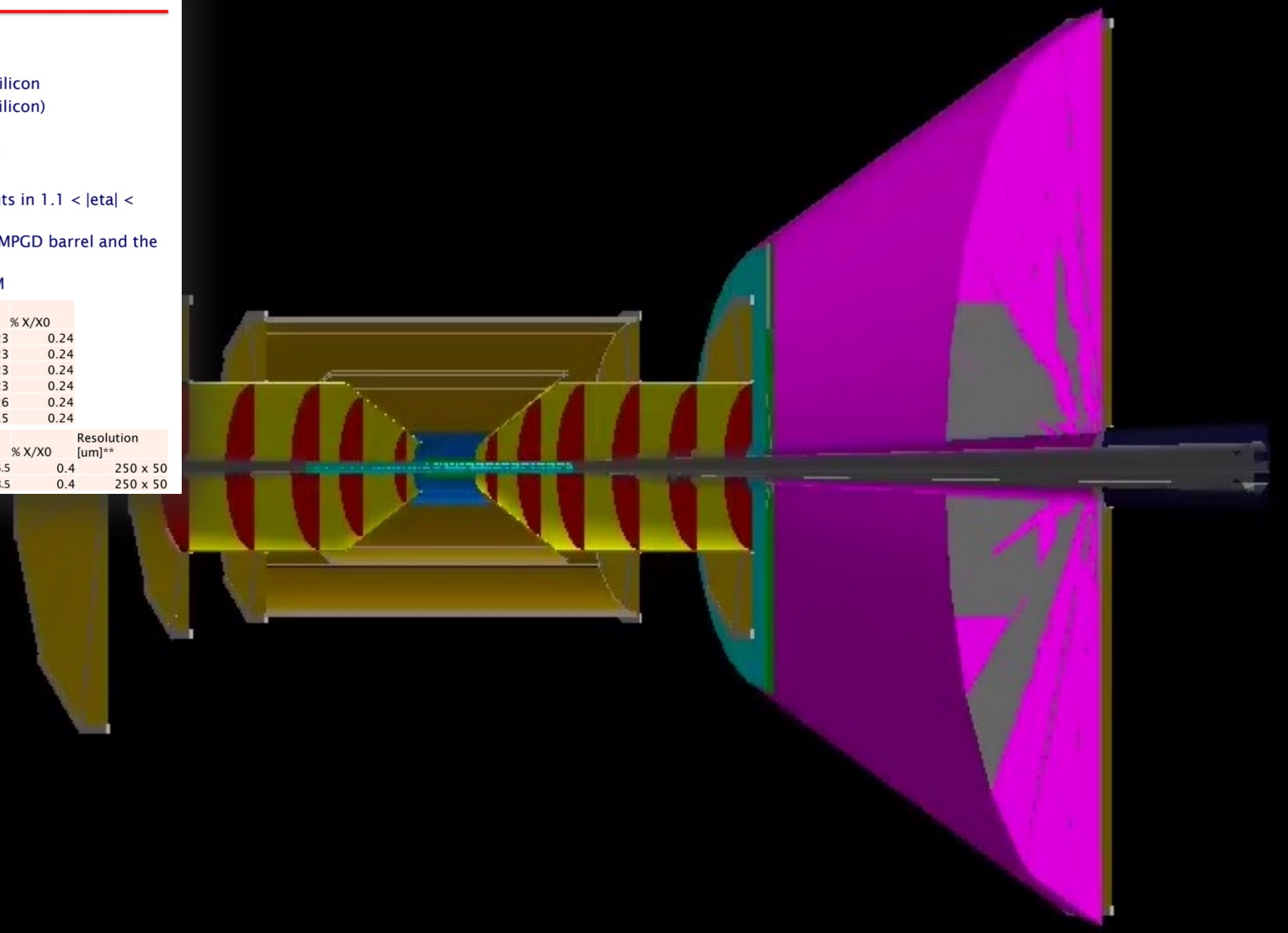


* +170 cm should be possible, checking position of dRICH
** Resolution can be improved for this small size GEMs

- Forward region
  - Six silicon disks, 10 um pixel pitch
  - Disks 1 to 3 in the same position as all-silicon
  - Disk 6 at +165* cm (was +121cm in all-silicon)
    - Better Bdl
    - Increased the pseudorapidity coverage
  - Disks 3 to 6 equidistant
  - 2x GEM rings to increase number of points in 1.1 < |eta| < 1.7
    - Z position chose to cap / close up the MPGD barrel and the overall tracking volume
    - No overlap needed between Si and GEM

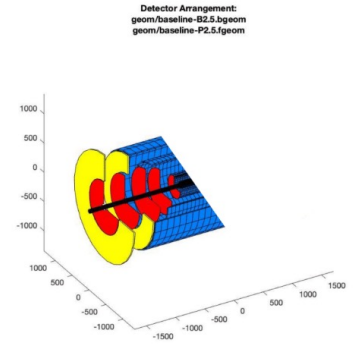
Si Disks	Z Position (cm)	Inner Radius (cm)	Outer Radius (cm)	% X/X0
Fwd Disk 6	165		43.23	0.24
Fwd Disk 5			43.23	0.24
Fwd Disk 4			43.23	0.24
Fwd Disk 3	73	3.5	43.23	0.24
Fwd Disk 2	49	3.18	36.26	0.24
Fwd Disk 1	25	3.18	18.5	0.24

GEM Rings	Z Position (cm)***	Inner Radius (cm)	Outer Radius (cm)	% X/X0	Resolution [um]**
Fwd Disk 1	+102	43.5	75.5	0.4	250 x 50
Fwd Disk 2	+164.5	43.5	88.5	0.4	250 x 50



Baseline 2 Configuration

Forward/backward regions: new configuration



* -150 cm should be possible, checking position of mRICH
** Resolution can be improved for this small size GEMs

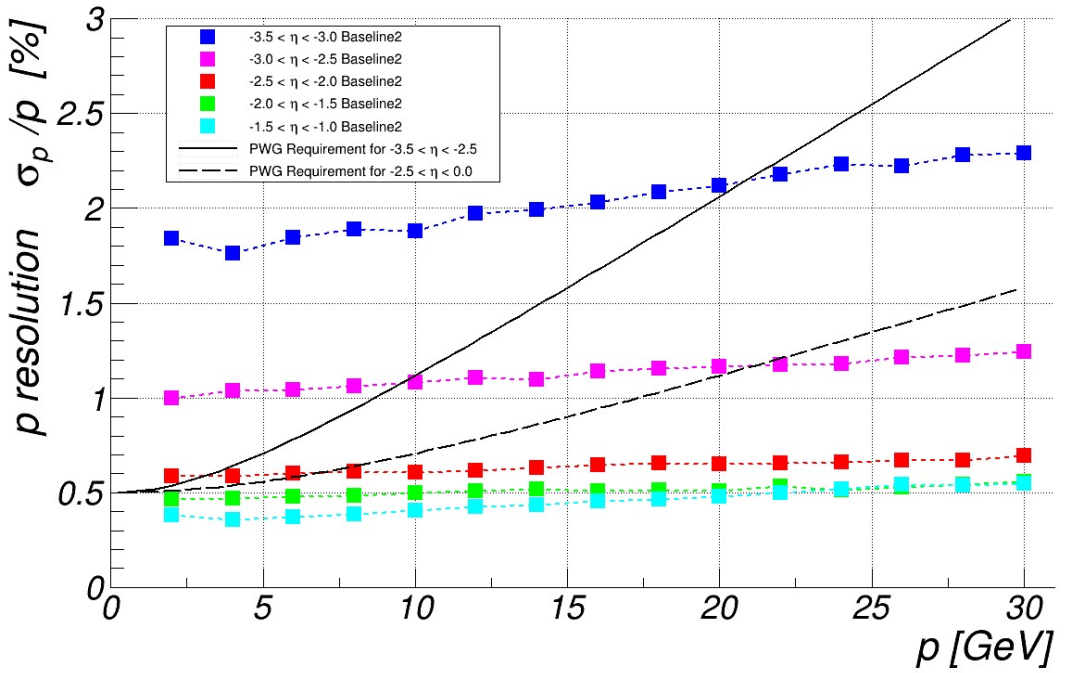
- Backward region
  - Five silicon disks, 10 um pixel pitch
  - Disks 1 to 3 in the same position as all-silicon
  - Disk 5 at -145 cm* (was -121cm in all-silicon)
    - Better Bdl
    - Increased the pseudorapidity coverage
  - Disk 4 equidistant from 3 and 5
  - 2x GEM rings to increase number of points in 1.1 < |eta| < 1.7
    - Z position chose to cap / close up the MPGD barrel and the overall tracking volume
    - No overlap needed between Si and GEM

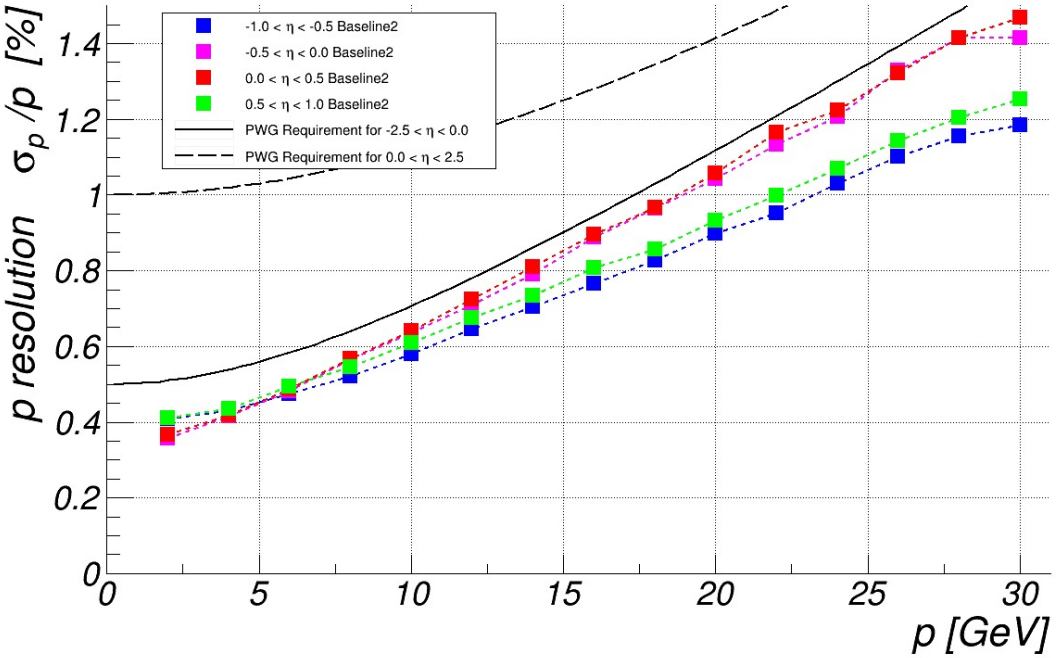
Si Disks	Z Position (cm)	Inner Radius (cm)	Outer Radius (cm)	% X/X0
Rear Disk 5	-145		43.23	0.24
Rear Disk 4	-109		43.23	0.24
Rear Disk 3	-73	3.5	43.23	0.24
Rear Disk 2	-49	3.18	36.26	0.24
Rear Disk 1	-25	3.18	18.5	0.24

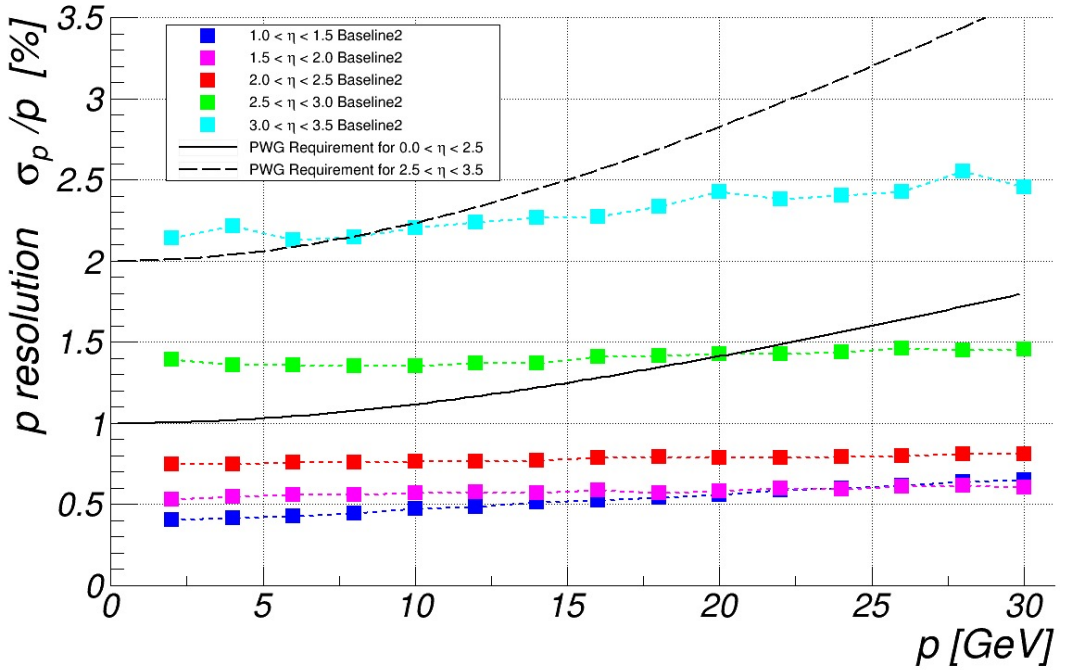
GEM Rings	Z Position (cm)	Inner Radius (cm)	Outer Radius (cm)	% X/X0	Resolution [um]**
Rear Disk 1	-102	43.5	75.5	0.4	250 x 50
Rear Disk 2	-144.5	43.5	88.5	0.4	250 x 50

Momentum Resolution

- Barrel:
  - Meets requirements everywhere
- Backward:
  - Meets requirements for tracks with η > -2.5
  - Below η = -2.5 only high momentum tracks meet requirements
- Forward:
  - Meets requirements for η < 3.0
  - For tracks with η > 3.0 only tracks above p = 10 GeV meet requirements

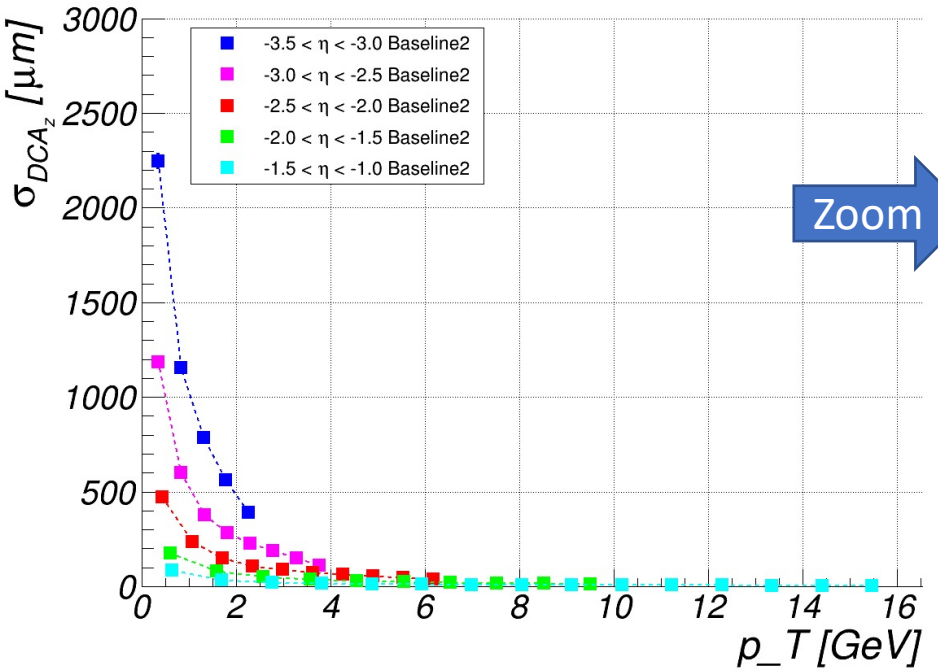




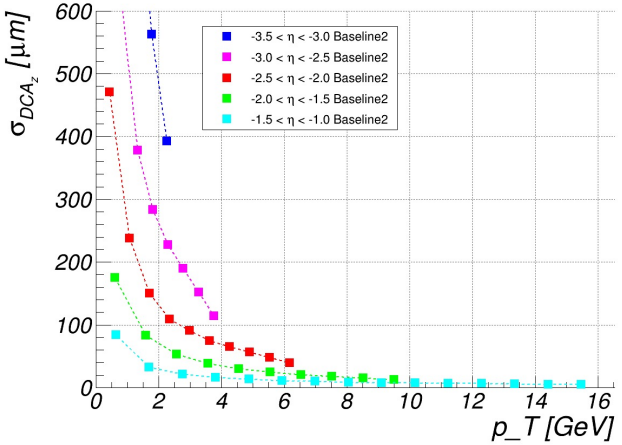


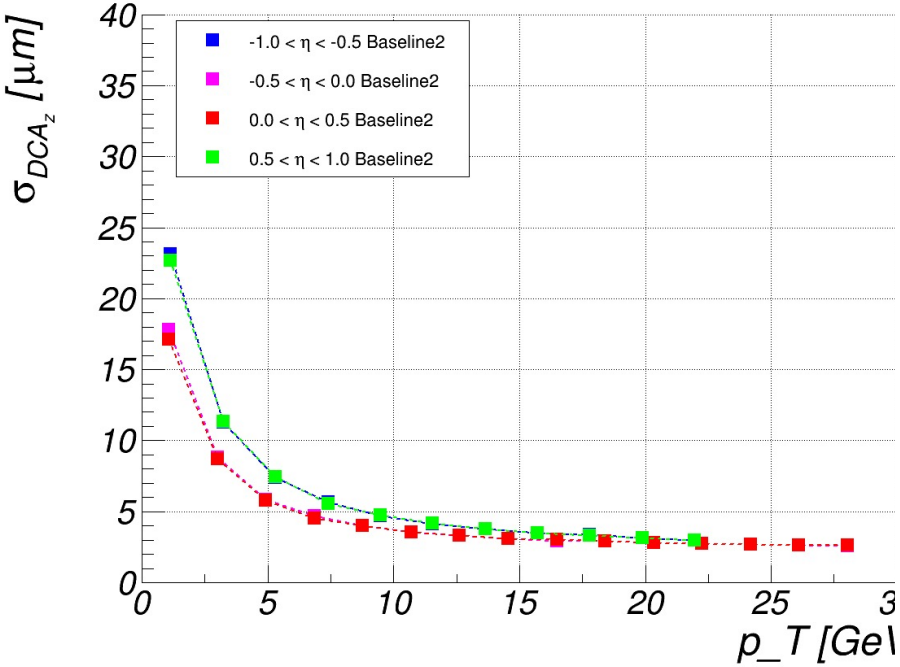
Longitudinal Pointing Resolution

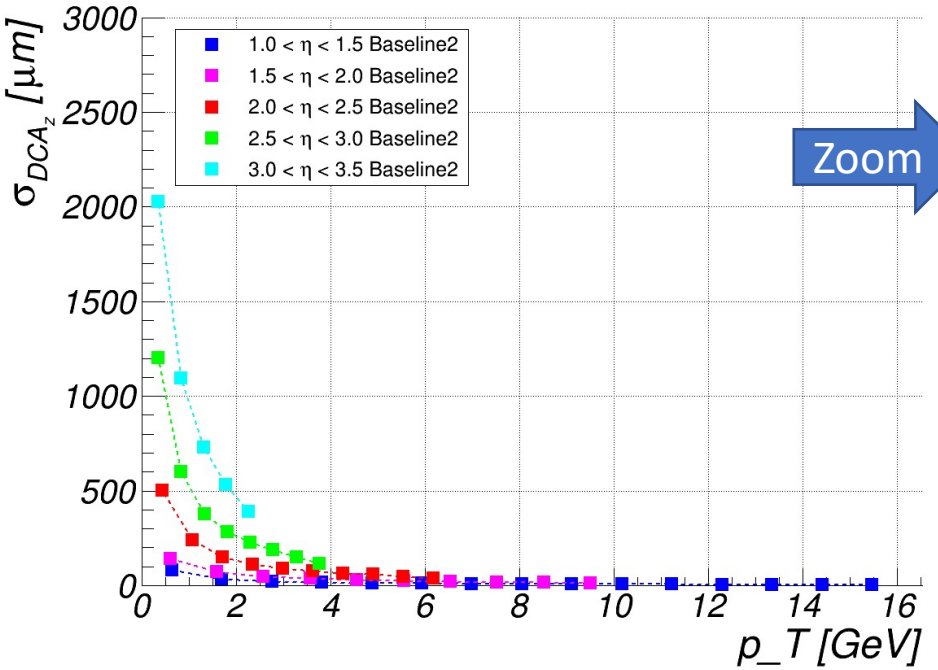
- No PWG requirements available for comparison



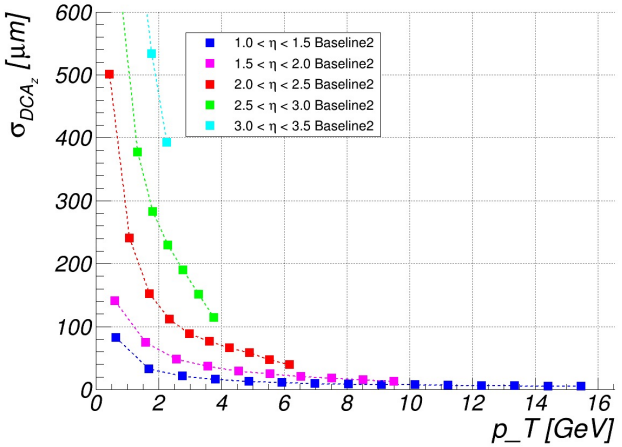
Zoom





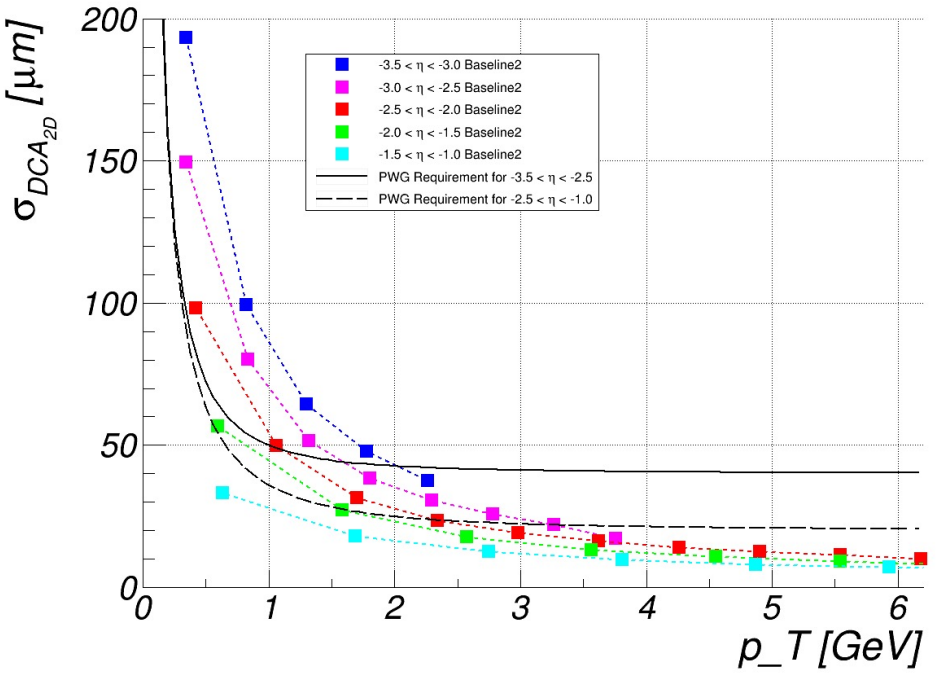


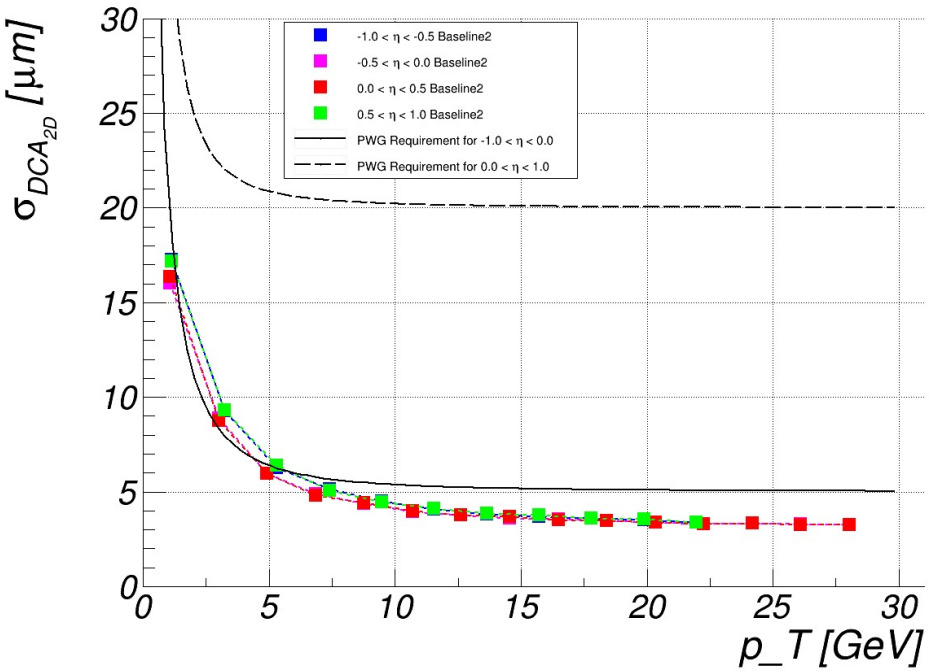
Zoom

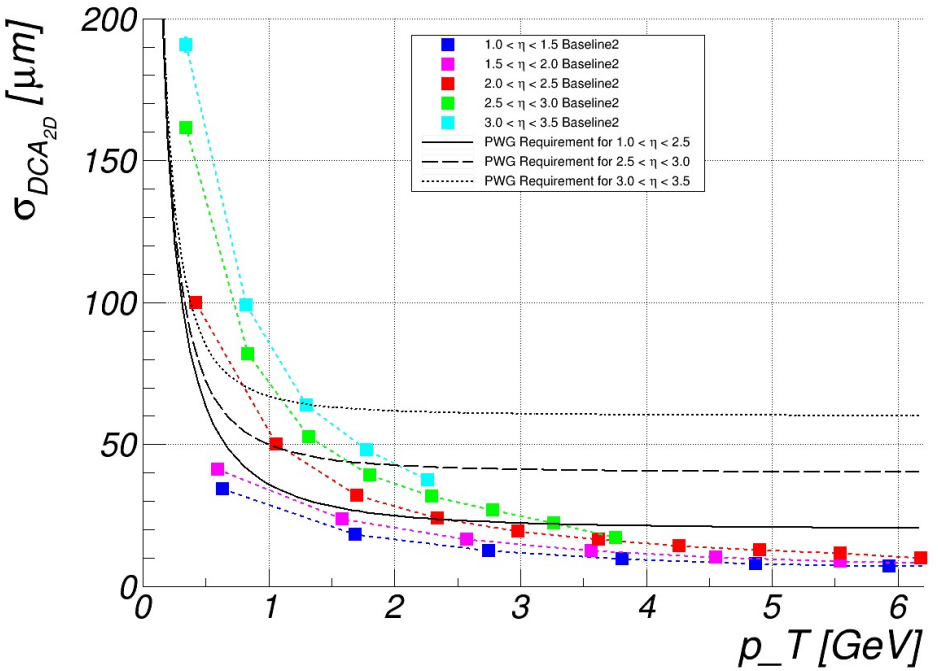


Transverse Pointing Resolution

- Barrel:
  - Very close to meeting requirements everywhere
- Backward:
  - Meets requirements for η > -1.5
  - Meets requirements for tracks with p_t > ~1.5 GeV and η > -3.0
- Forward:
  - Meets requirements for η < 2.0
  - Meets requirements for tracks with p_t > ~1.5 GeV and η < 3.0



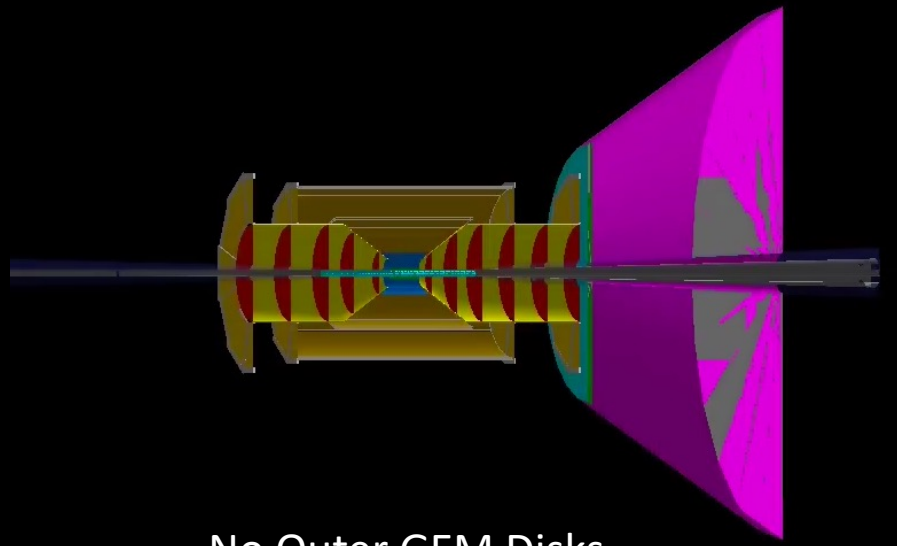




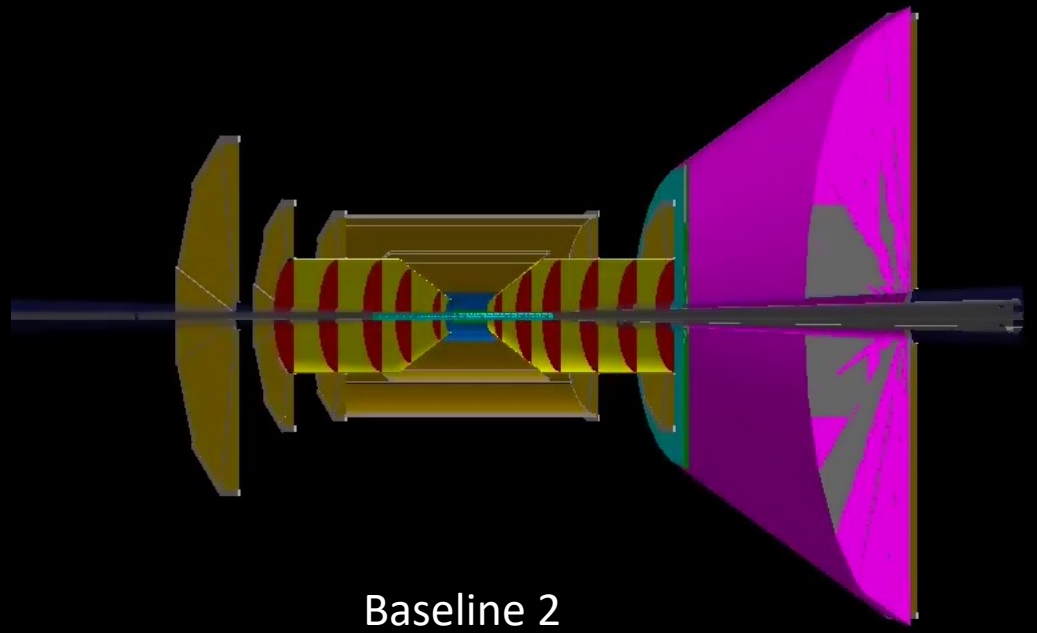
Comparisons with modified configurations

Modified configurations:

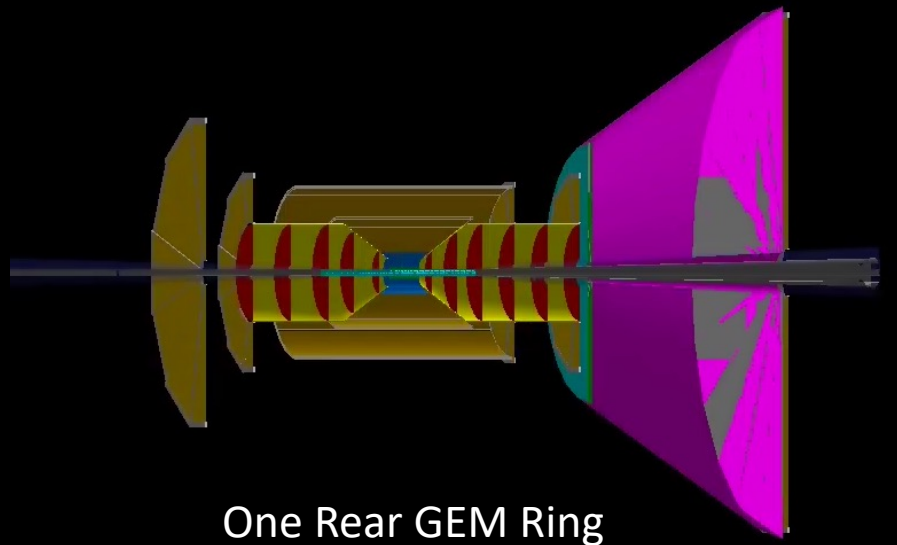
- No outer GEM disks
- Only one rear GEM ring



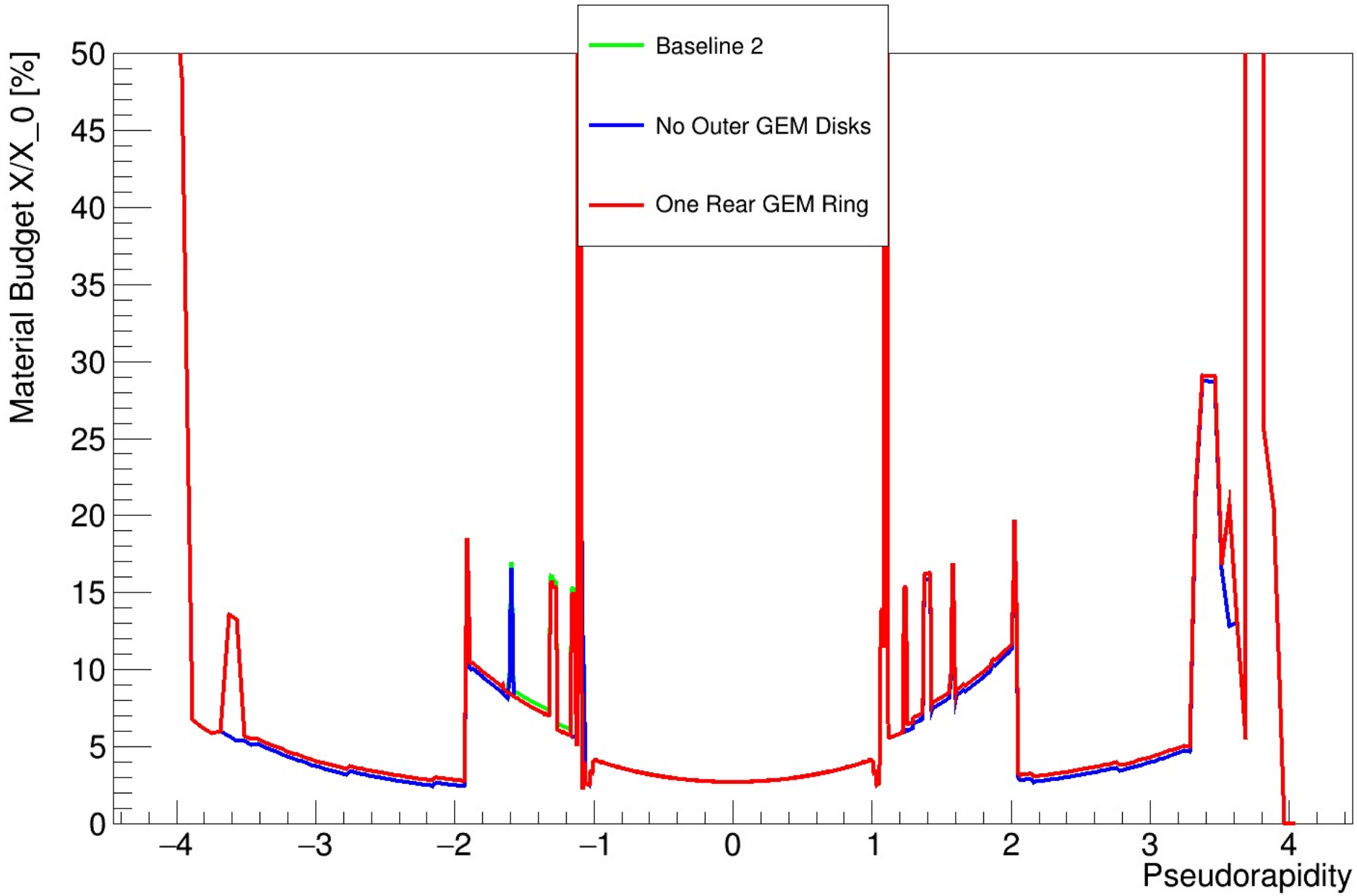
No Outer GEM Disks



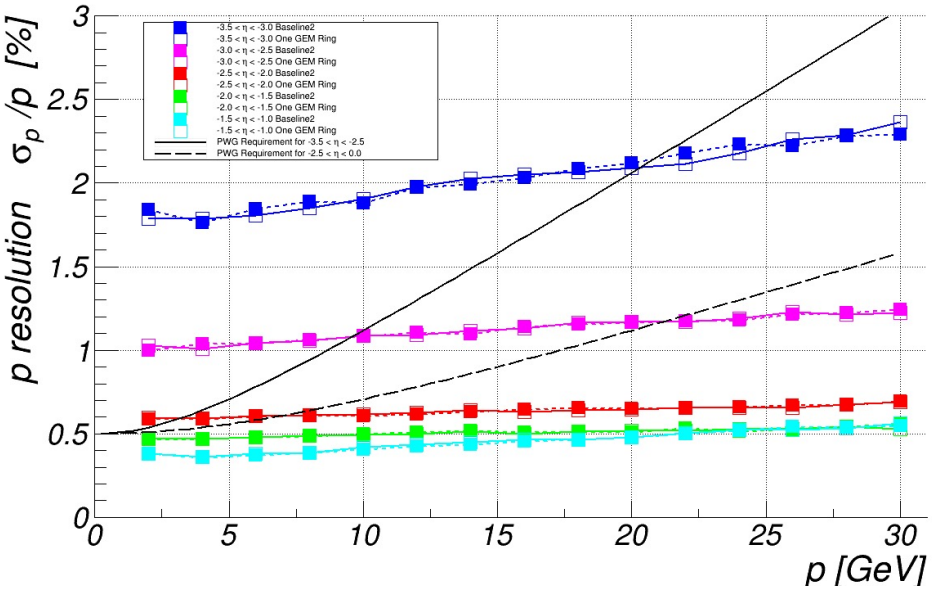
Baseline 2

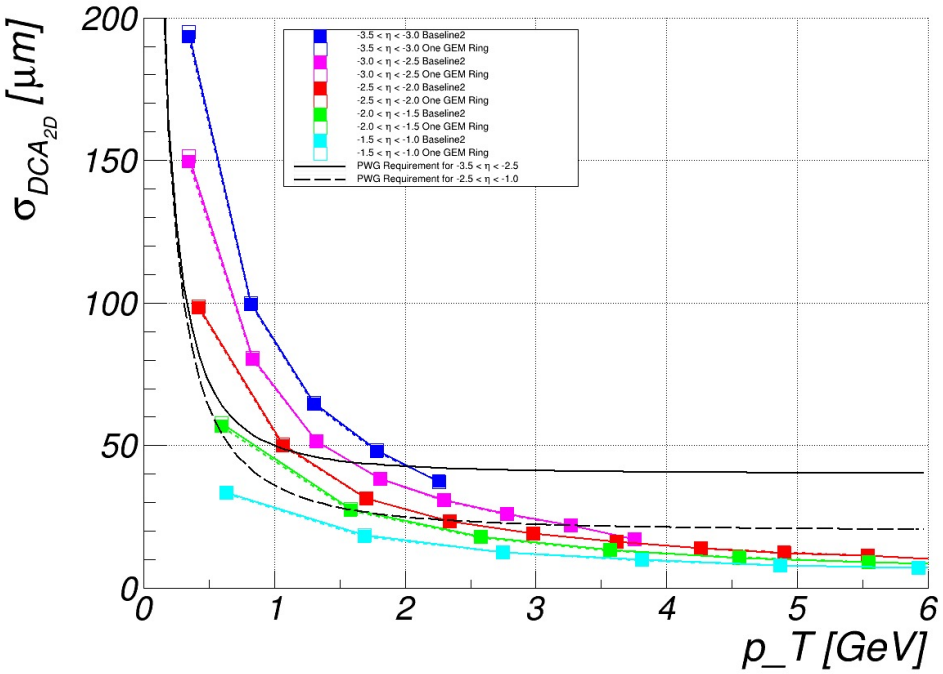


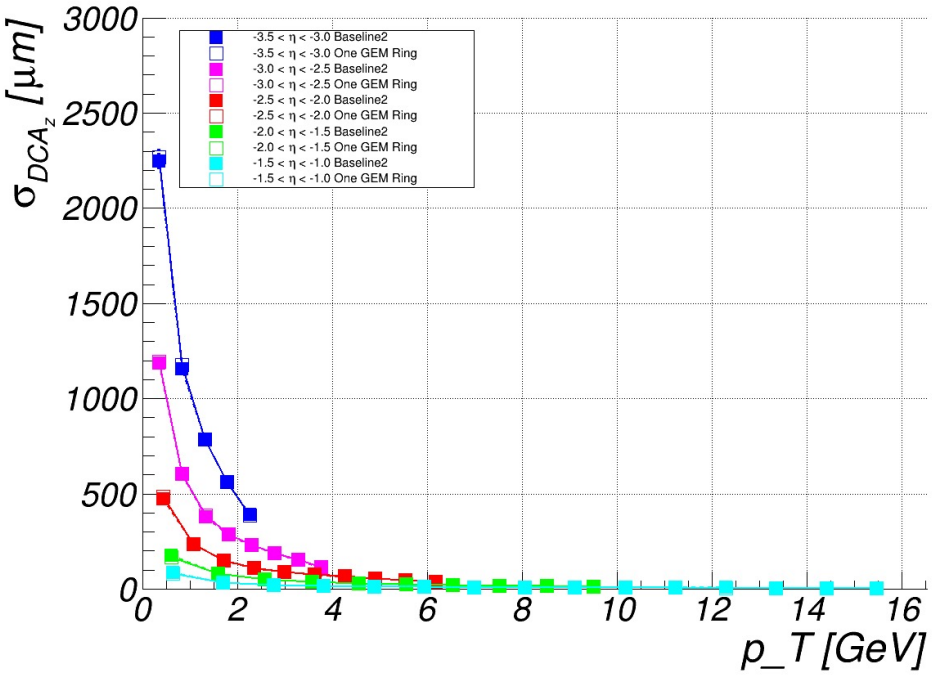
One Rear GEM Ring


Baseline 2
No Outer GEM Disks
One Rear GEM Ring
Material Budget X/X_0 [%]
50
45
40
35
30
25
20
15
10
5
0
−4
−3
−2
−1
0
1
2
3
4
Pseudorapidity

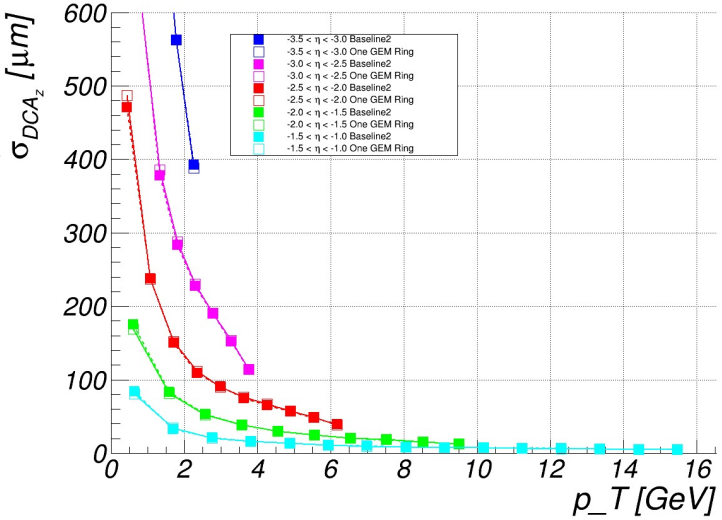
Baseline 2 – Two GEM Rings compared to One GEM Ring







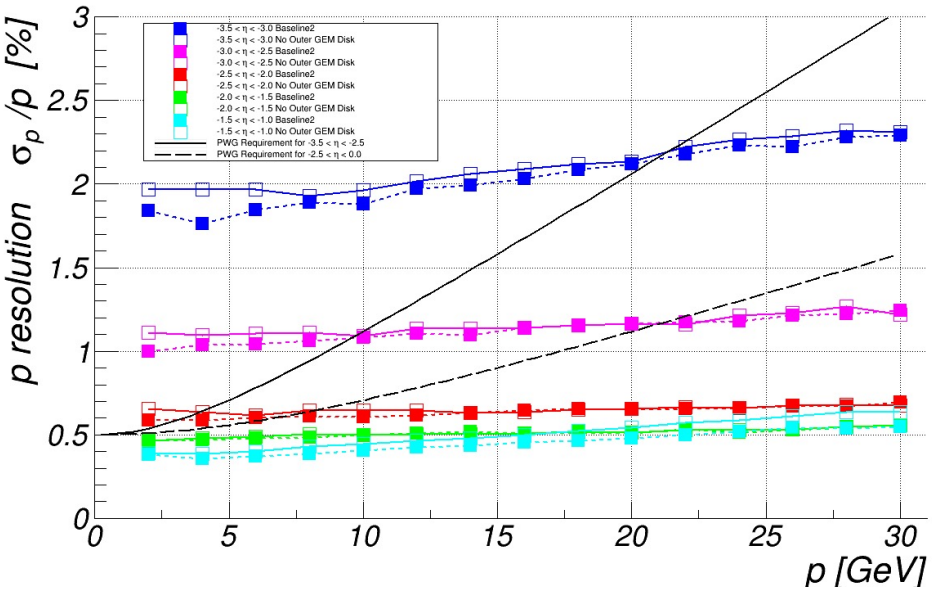
Zoom

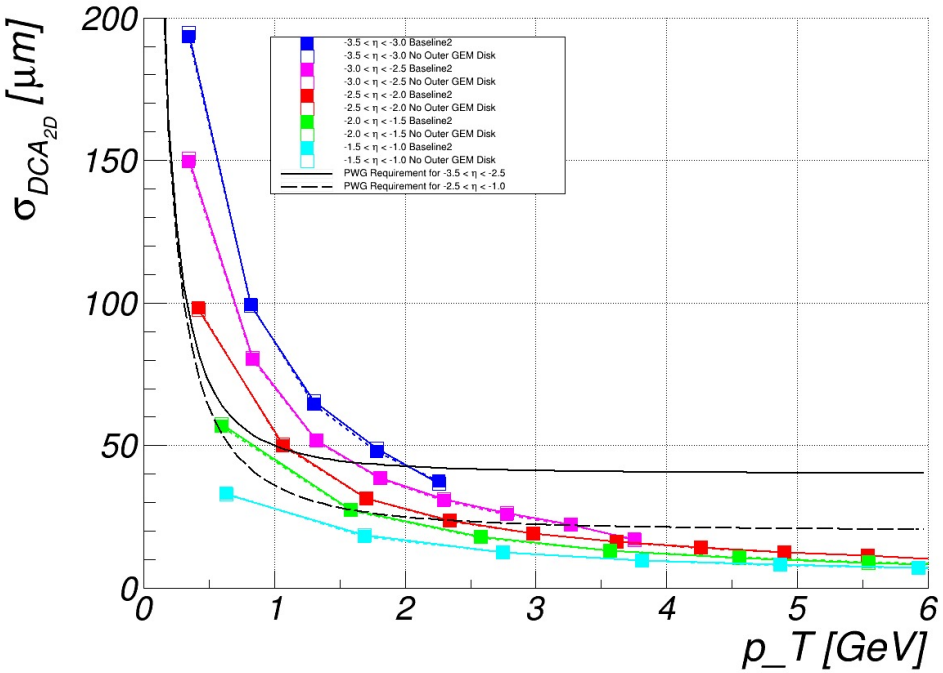


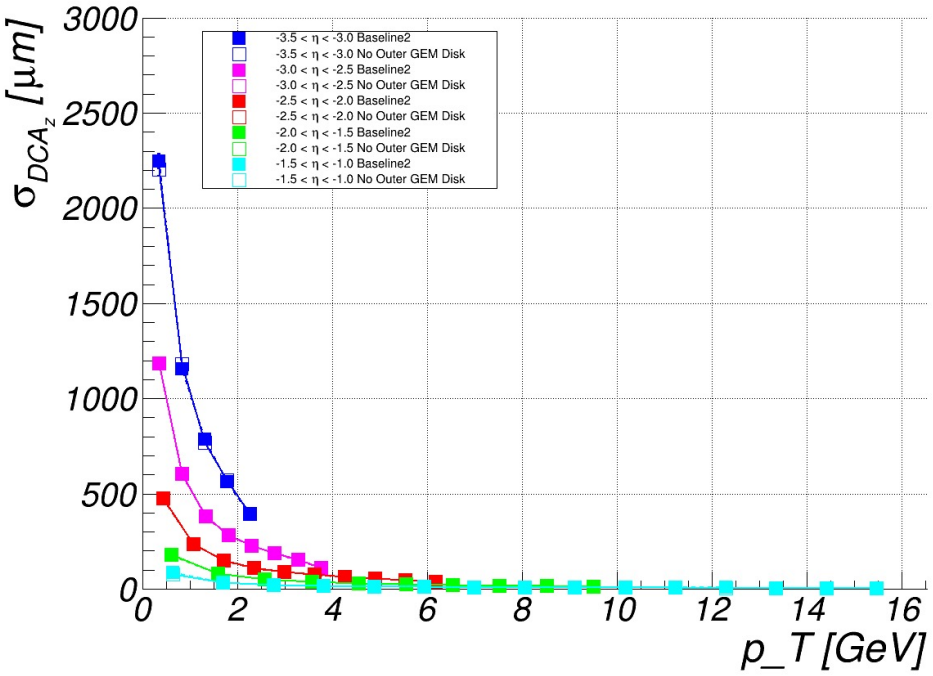
- $-1.0 > \eta > -1.5$
- $-1.5 > \eta > -2.0$
- $-2.0 > \eta > -2.5$
- $-2.5 > \eta > -3.0$
- $-3.0 > \eta > -3.5$

- ■ Baseline Configuration
- □ One GEM Ring

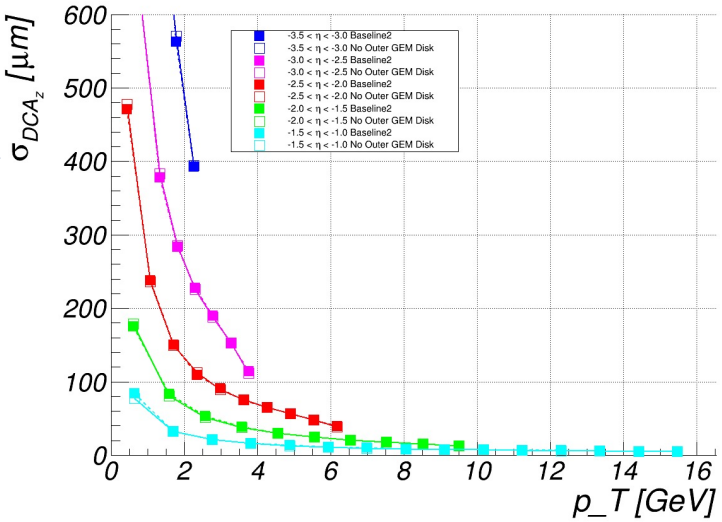
Baseline 2 - With and Without the Outer GEM Disks - Rear







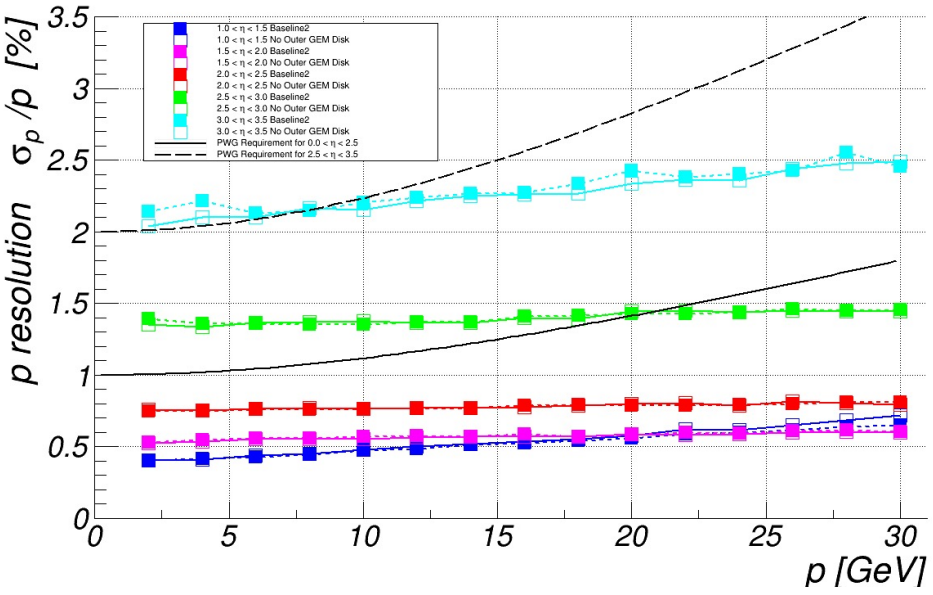
Zoom

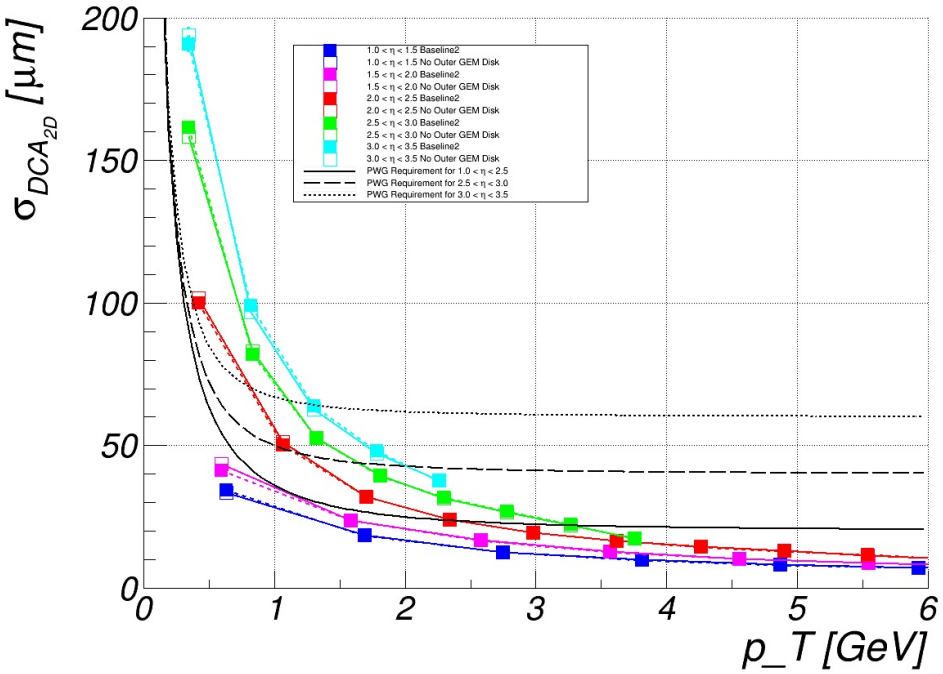


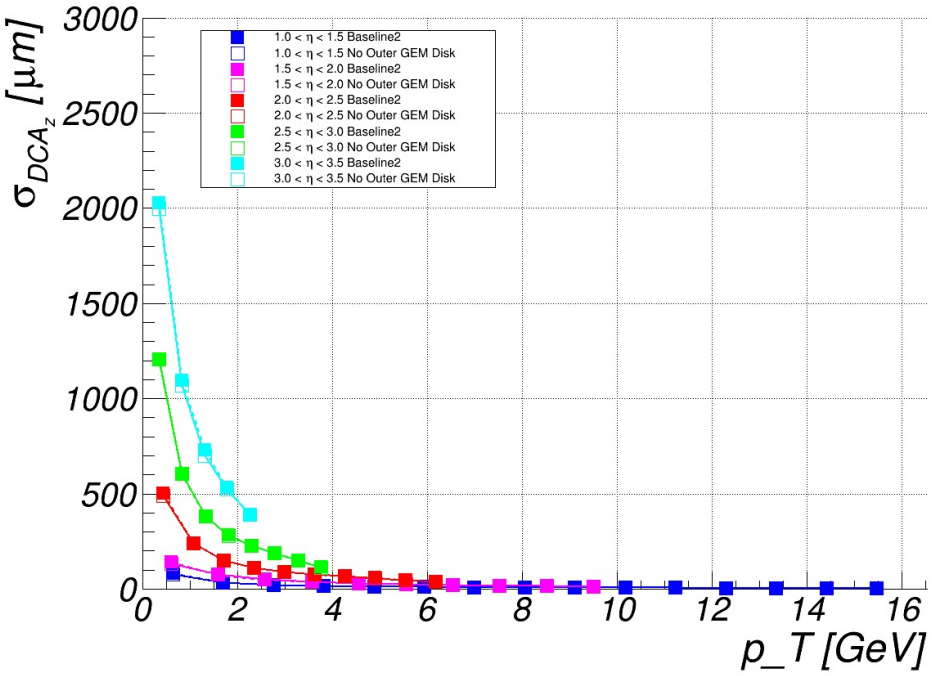
- $-1.0 > \eta > -1.5$
- $-1.5 > \eta > -2.0$
- $-2.0 > \eta > -2.5$
- $-2.5 > \eta > -3.0$
- $-3.0 > \eta > -3.5$

- ■ Baseline Configuration
- □ No Outer GEM Disk

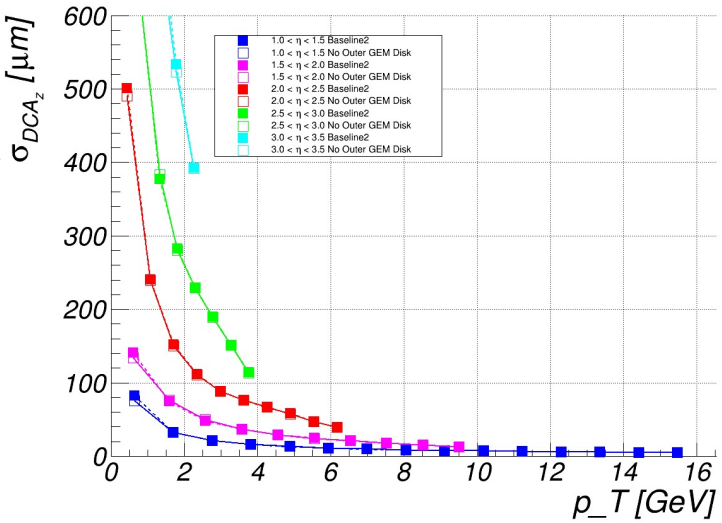
Baseline 2 - With and Without the Outer GEM Disks - Forward







Zoom



- $3.0 < \eta < 3.5$
- $2.5 < \eta < 3.0$
- $2.0 < \eta < 2.5$
- $1.5 < \eta < 2.0$
- $1.0 < \eta < 1.5$

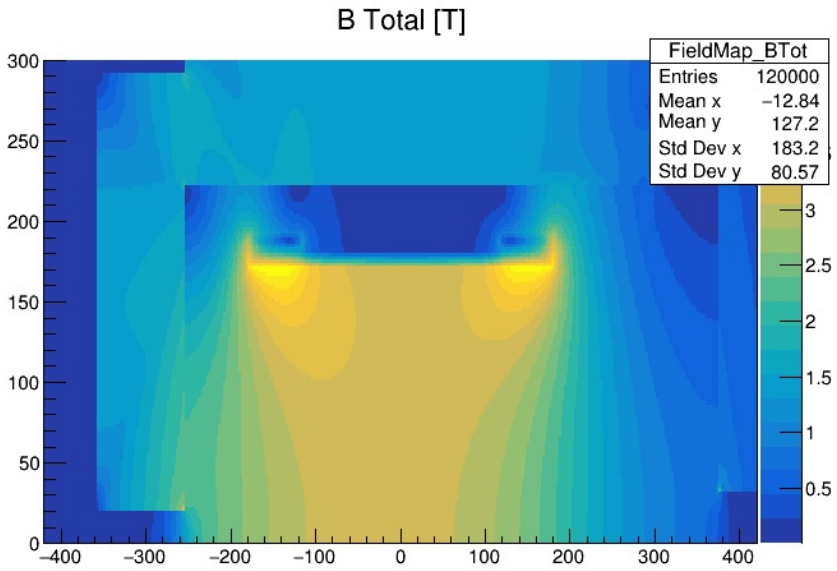
- ■ Baseline Configuration
- □ No Outer GEM Disk

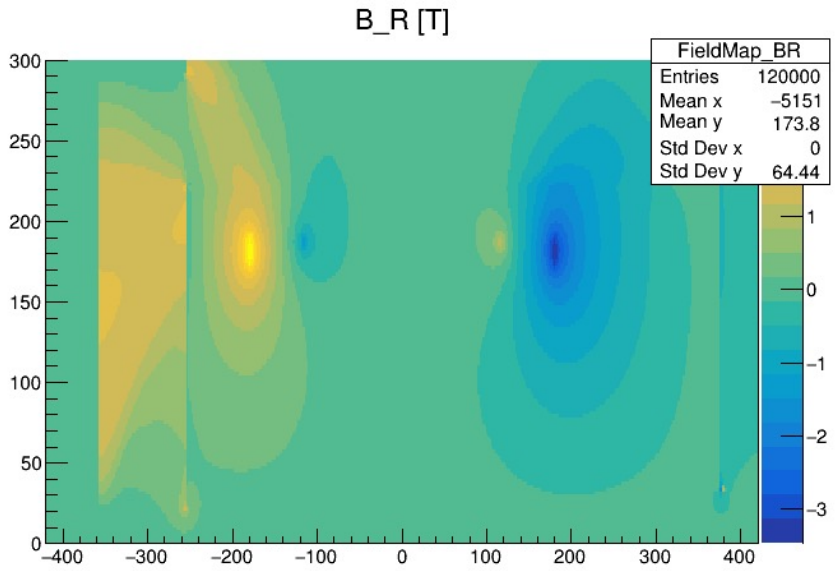
Summary

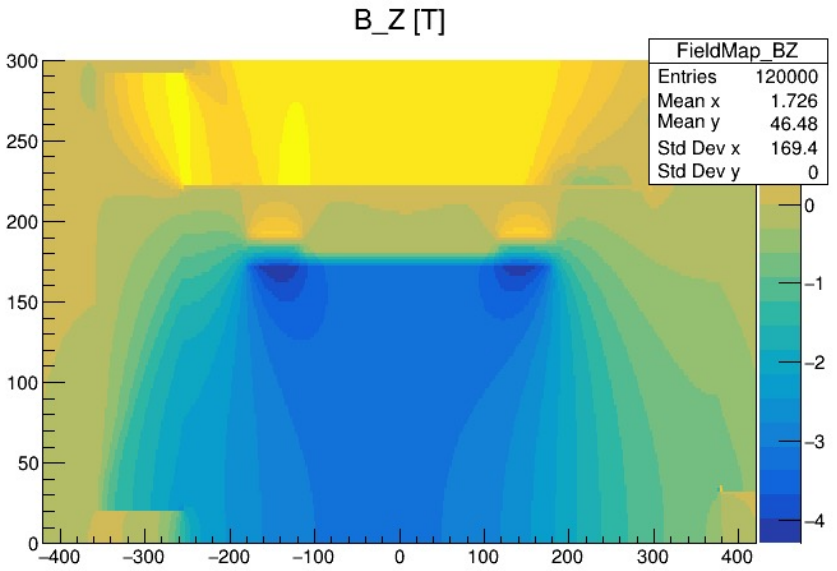
- Meets most momentum resolution requirements except for the most extreme negative pseudo-rapidities
- Does not meet transverse pointing resolution requirements for the far forward and far backward regions
- Very little effect on resolutions when removing the outer GEM disks
- Little effect on resolutions when removing the innermost rear GEM ring

BACKUP

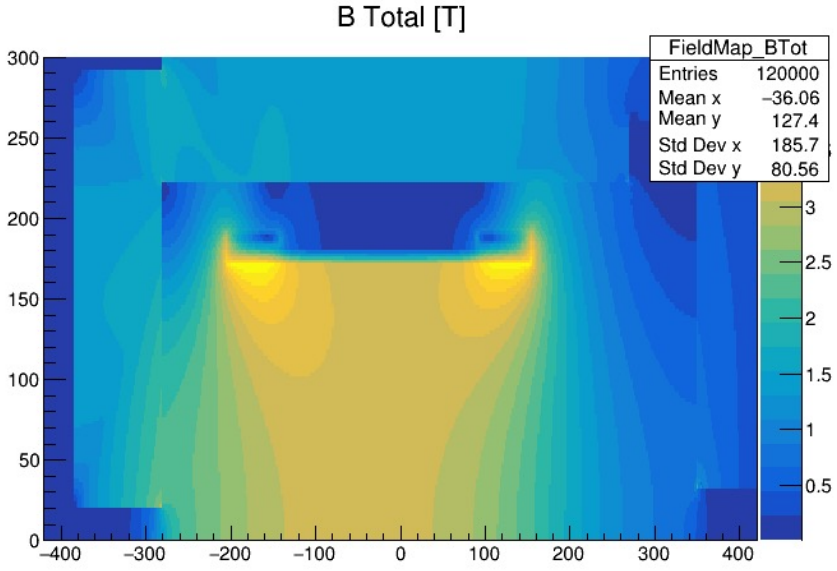
Original ATHENA 05/07 Field Map

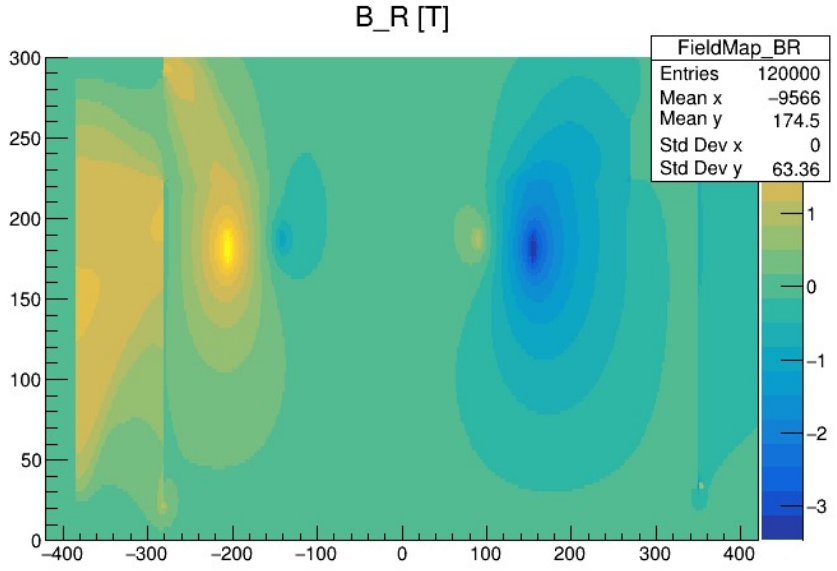


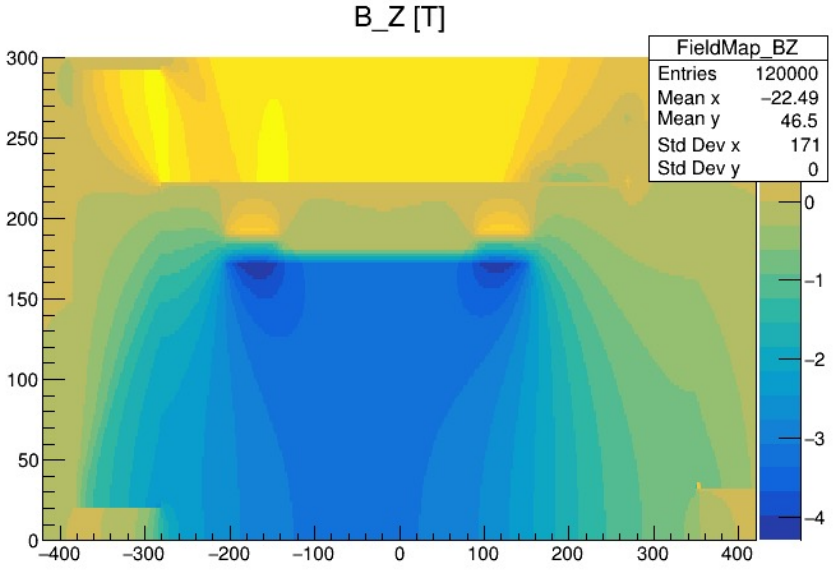




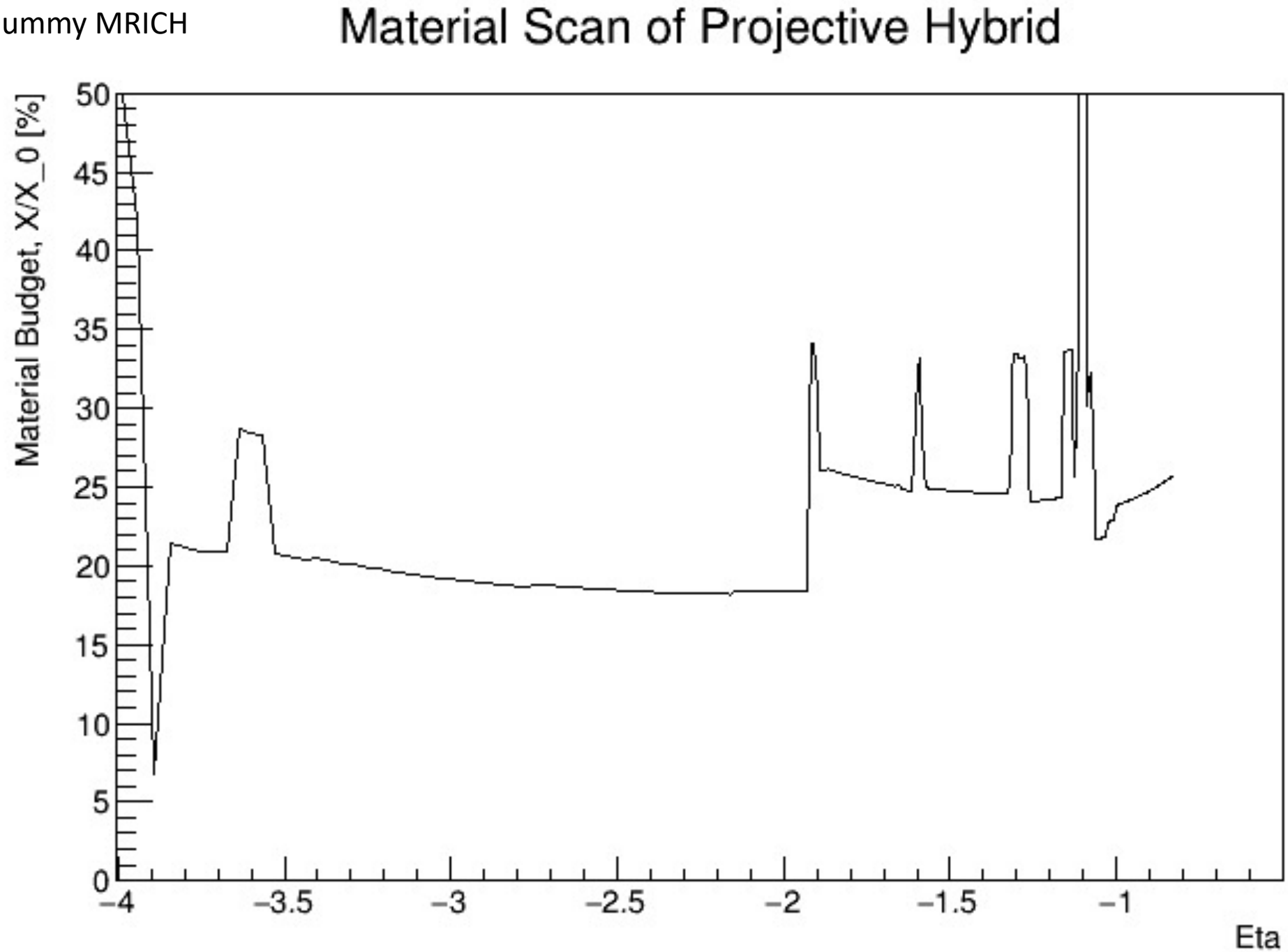
Shifted ATHENA 05/07 Field Map



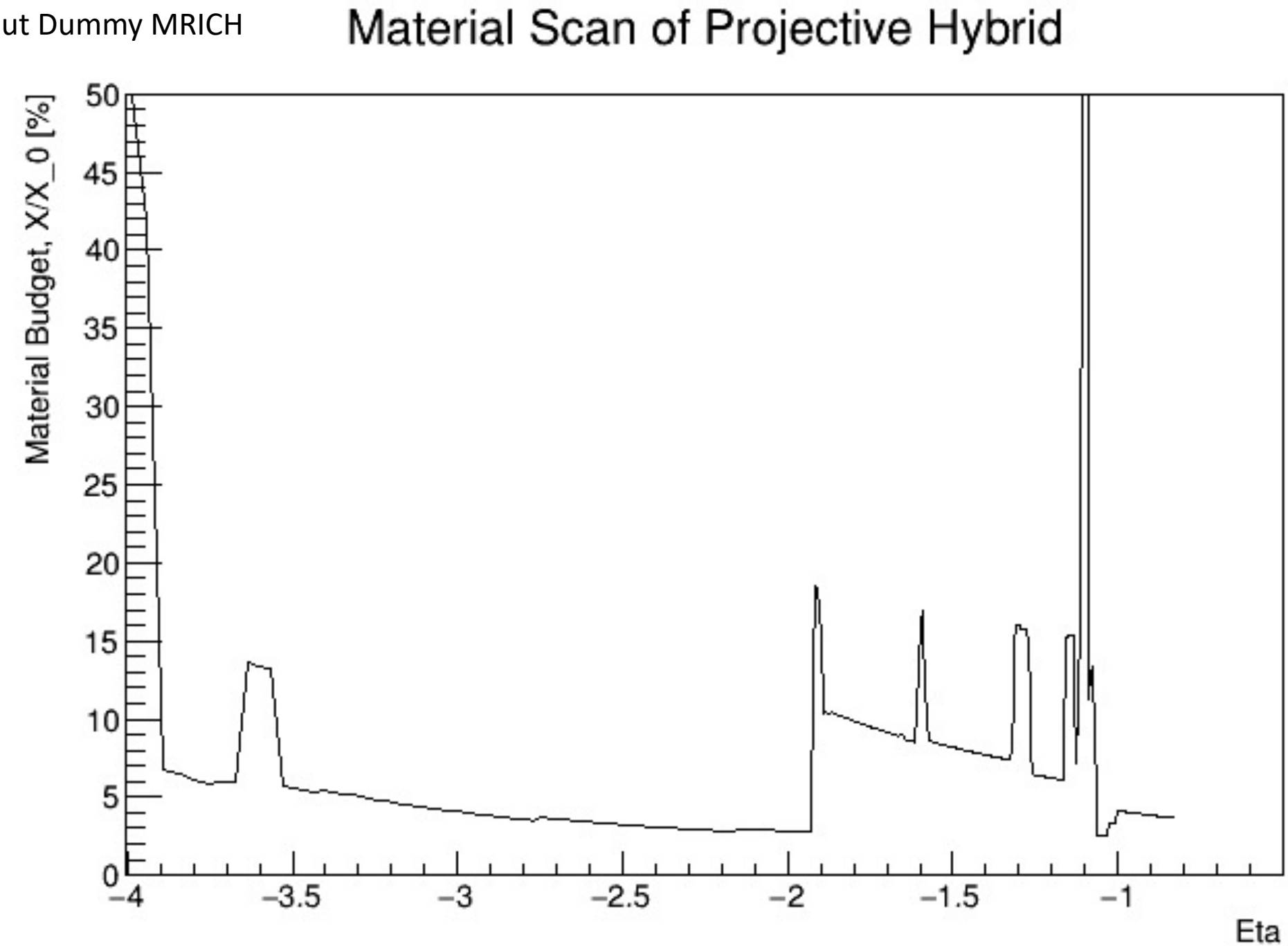




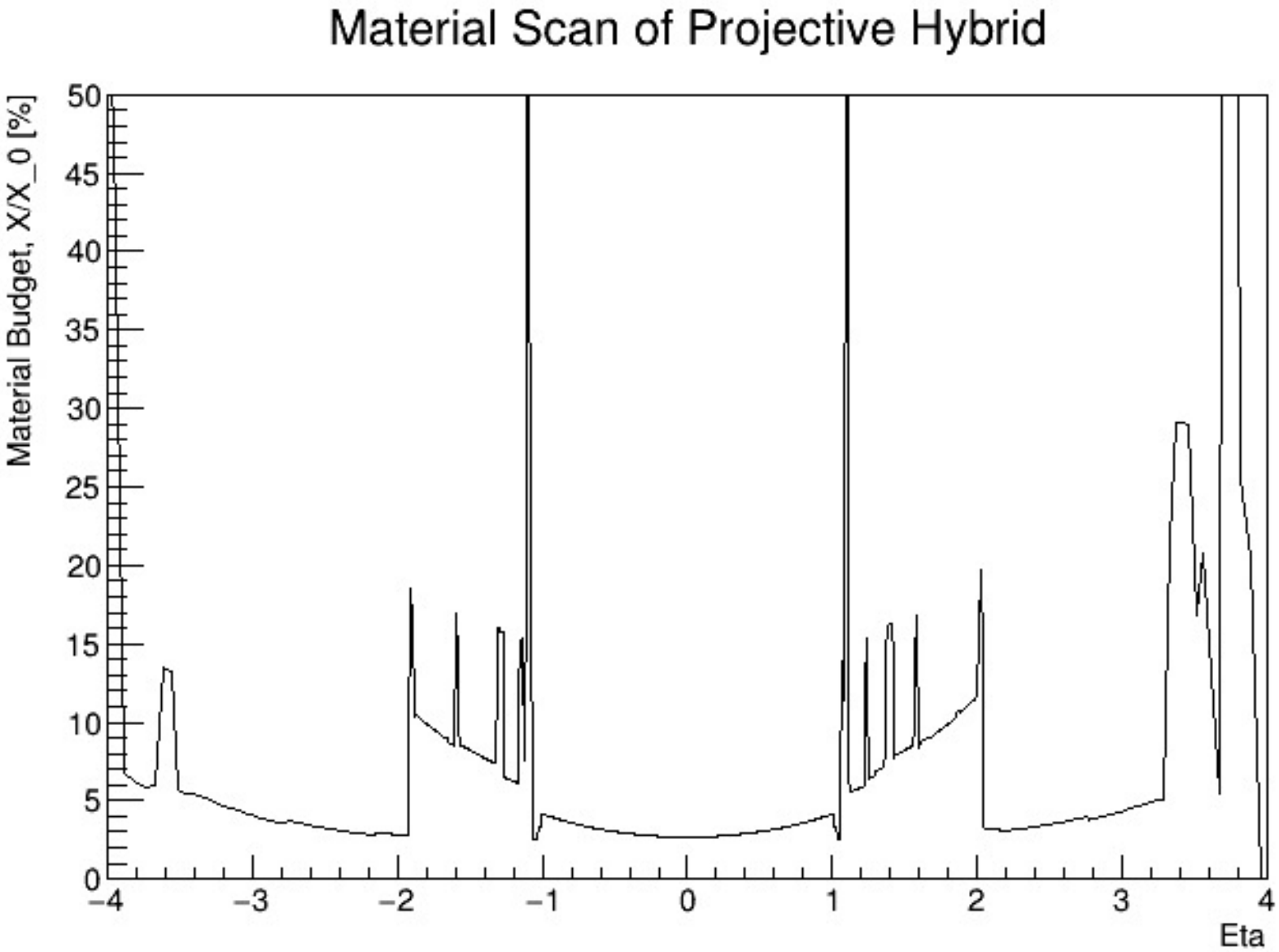
With Dummy MRICH



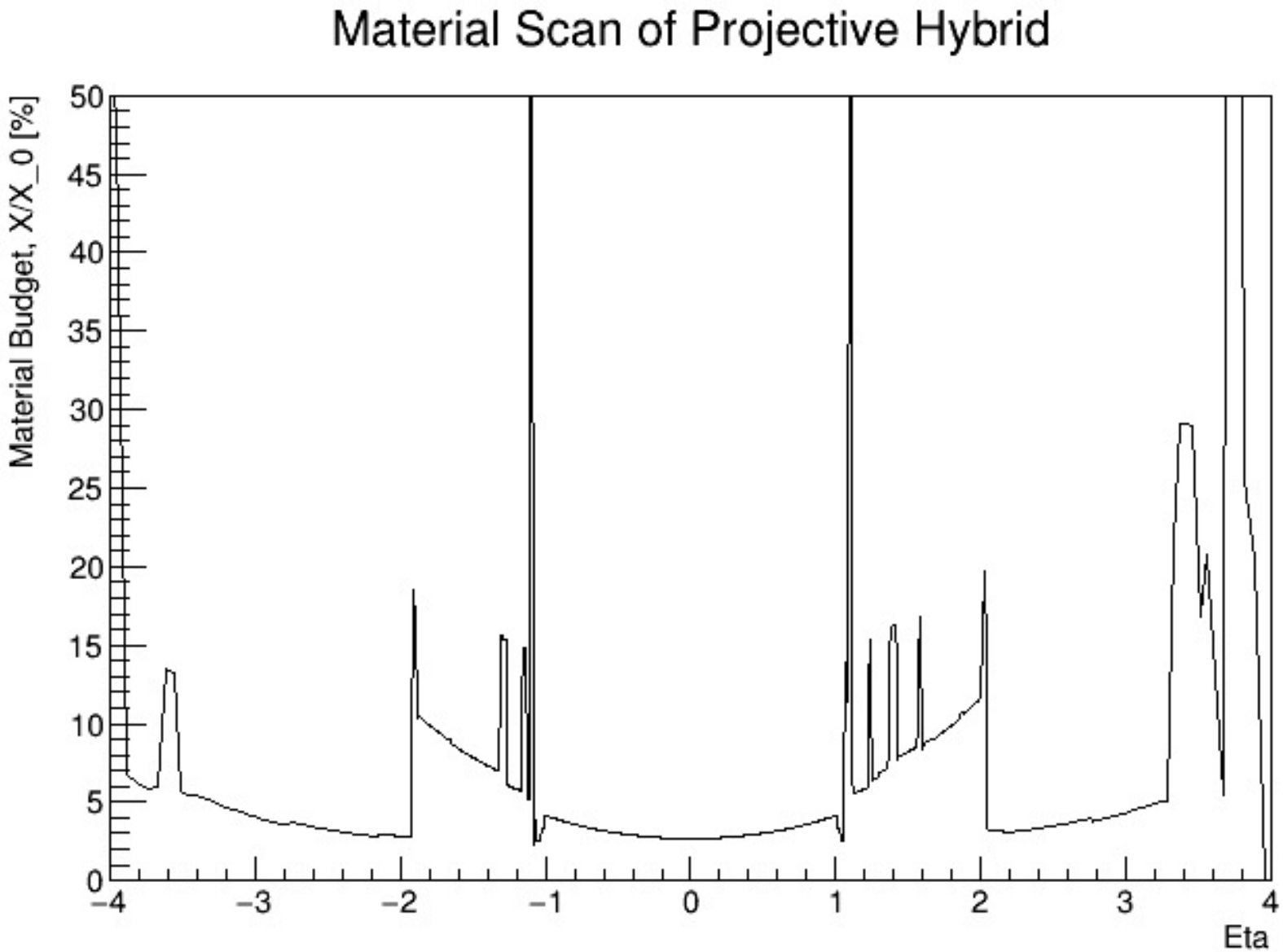
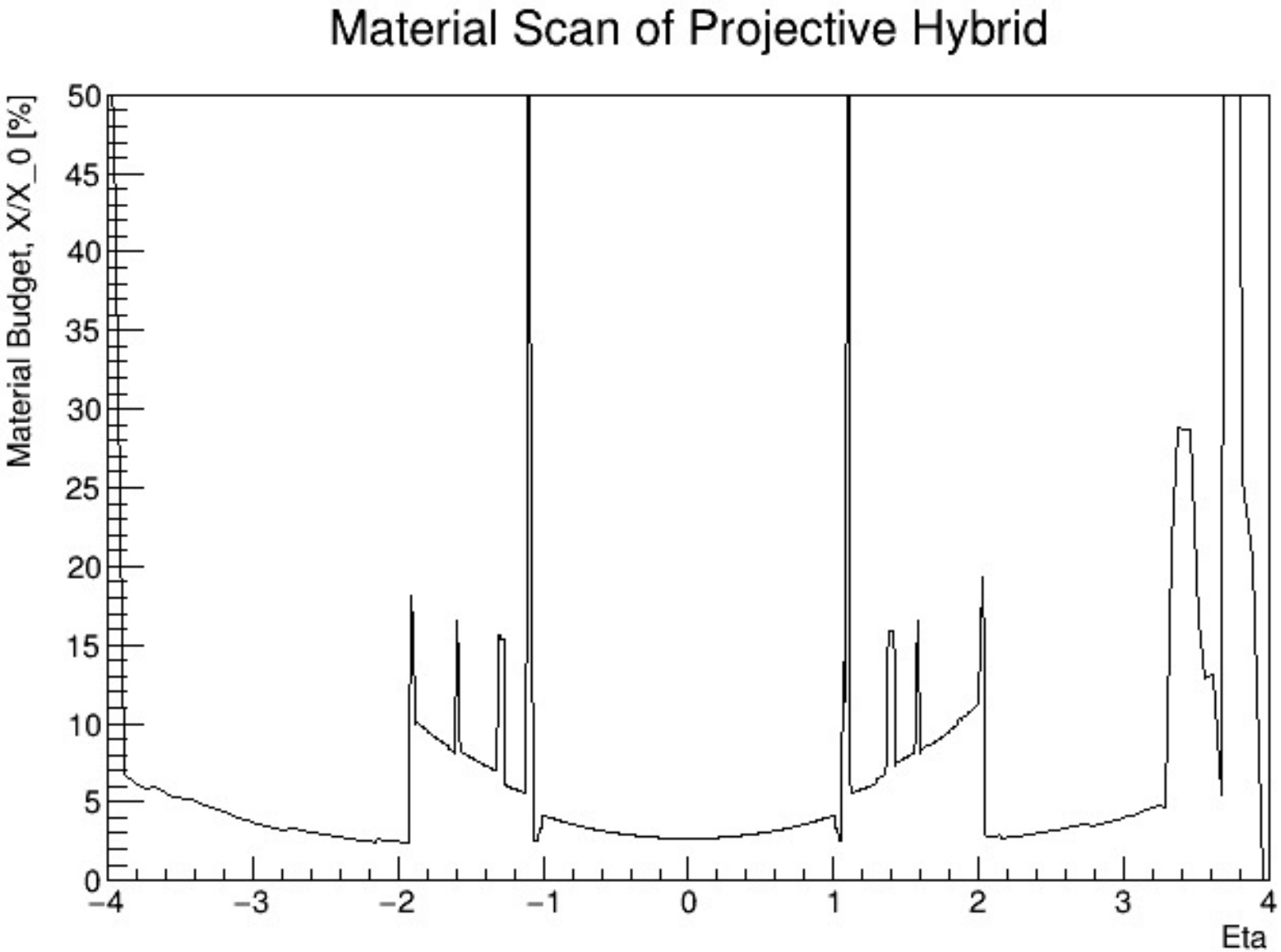
Without Dummy MRICH



Material Scan – Baseline 2



Material Scan – One Rear GEM Ring



Material Scan – No Outer GEM Disks