Cylindrical GEMs and all-silicon tracker variants

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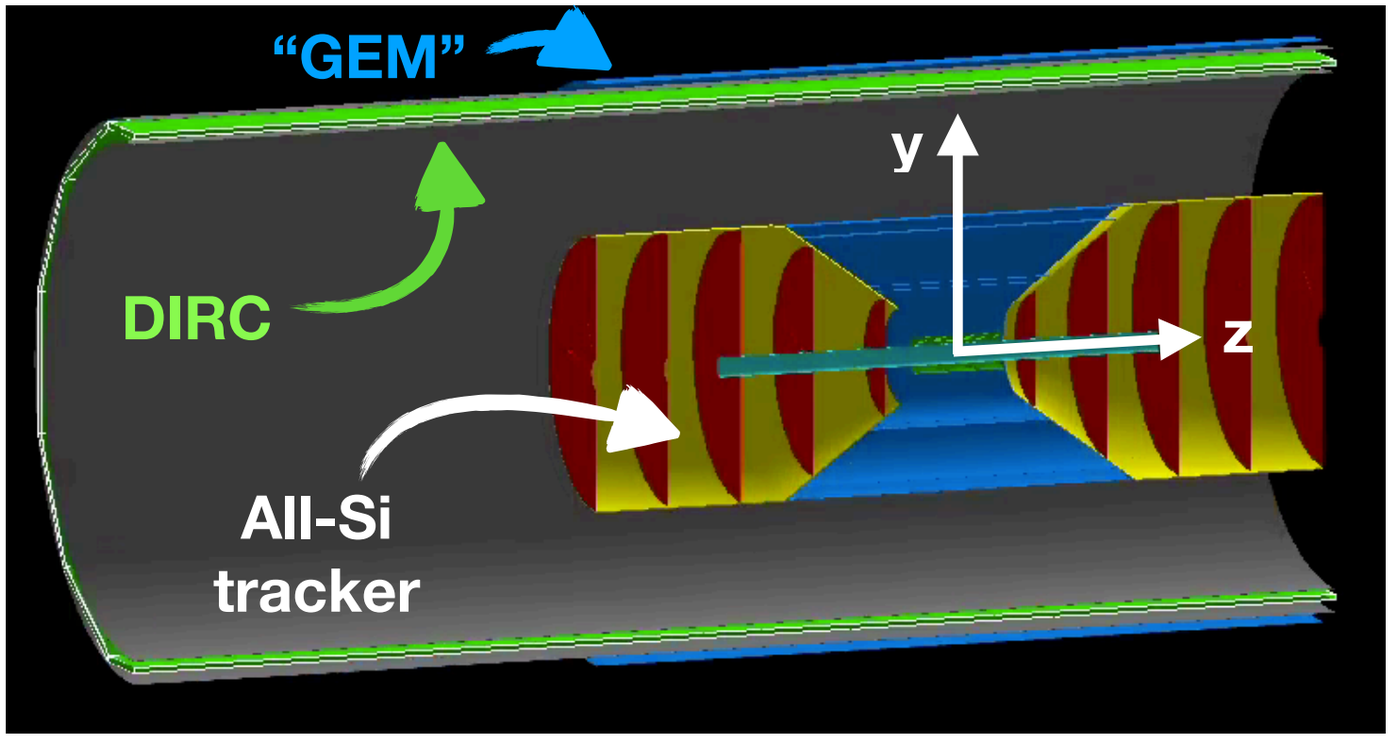
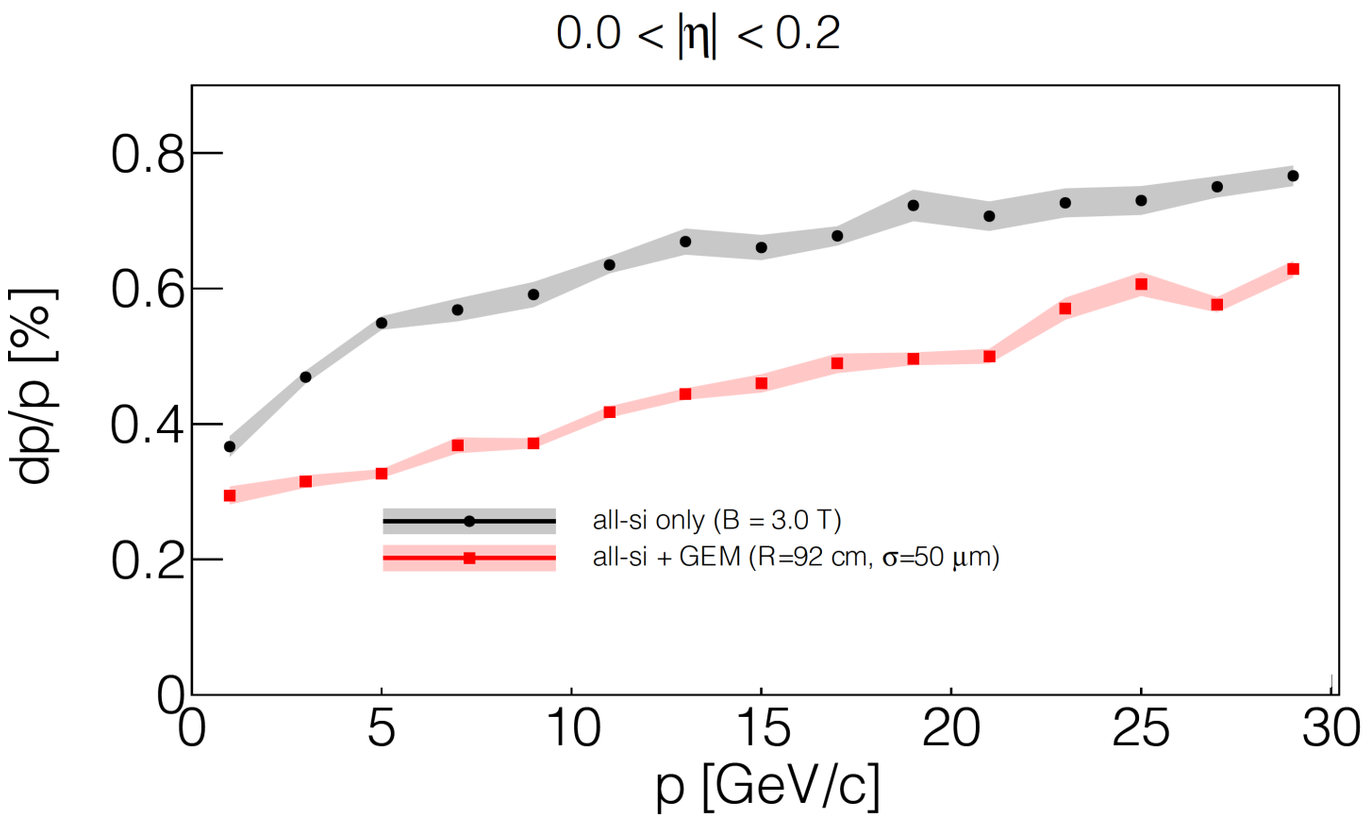
EIC RNC Meeting

To recap



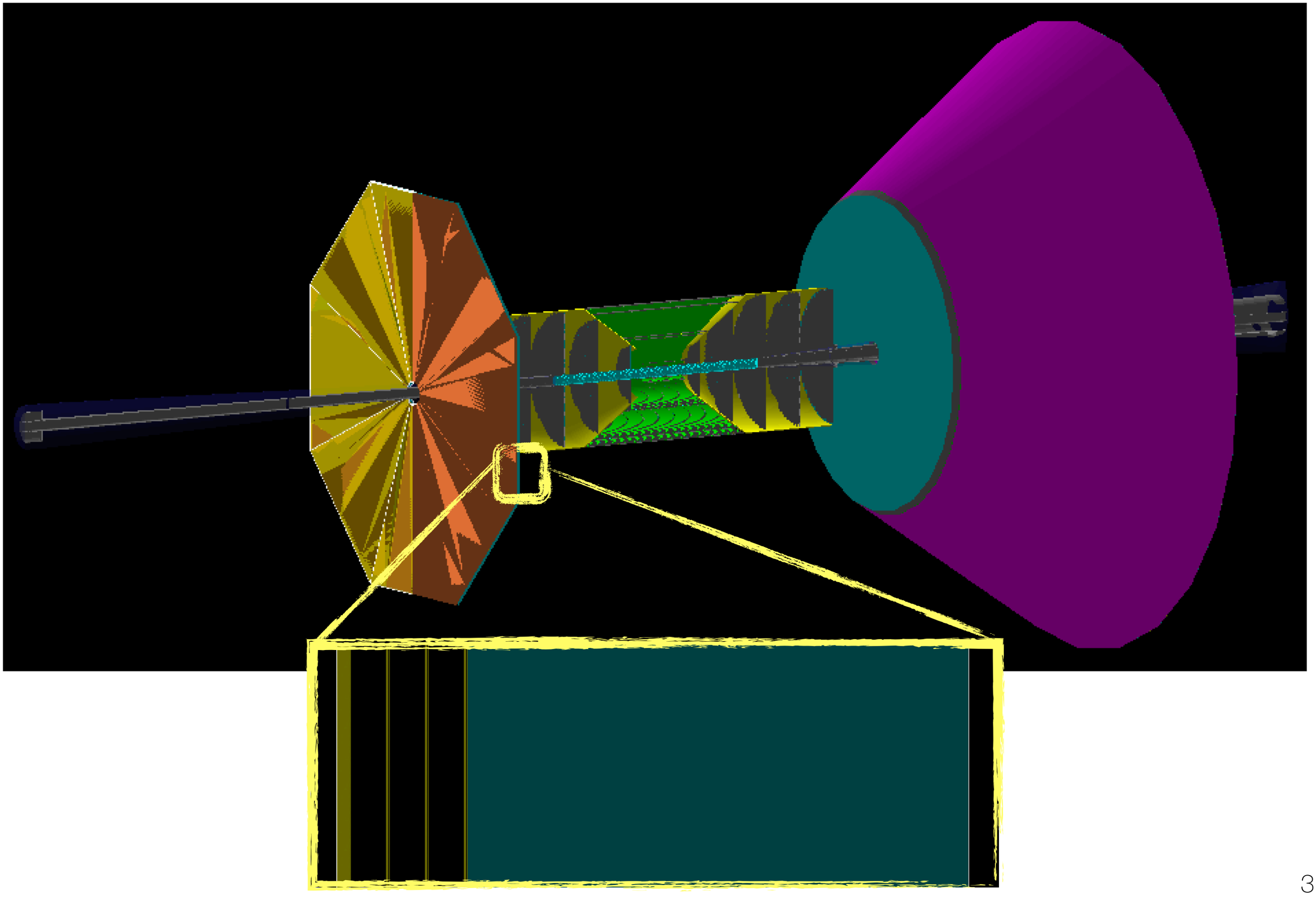


Studied impact of complementing the all-silicon tracker in the barrel region using a ($50\,\mu\mathrm{m}$ resolution) GEM

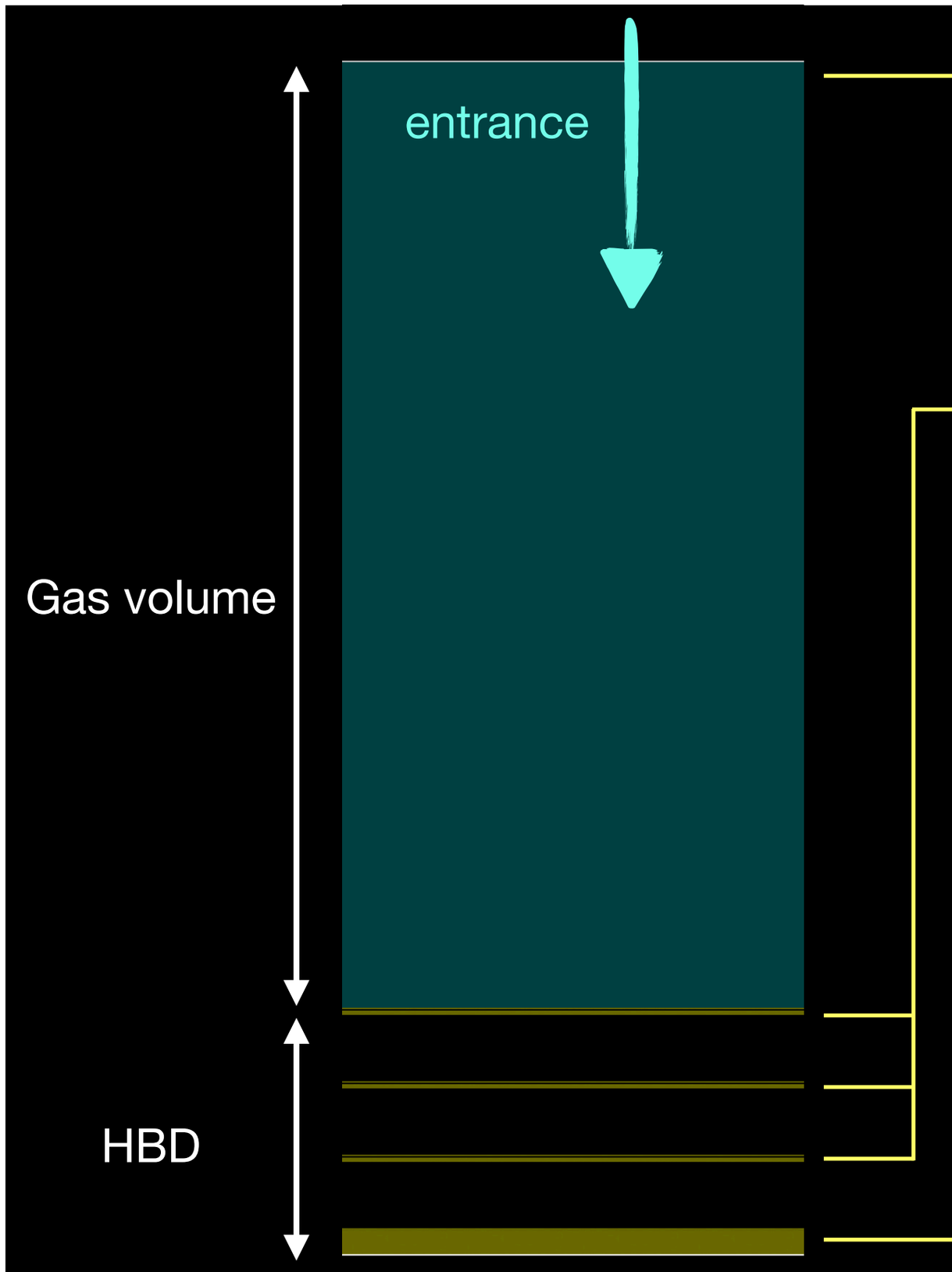
E. Sichtermann proposed to look at the performance of the detector in a configuration where the outermost silicon barrel layer is replaced with a similar GEM, and we also keep the second GEM out of the DIRC

Current implementation of cylindrical GEM is just a silicon disk with $50\,\mu\mathrm{m}$ resolution, which is OK as the outermost subsystem

Existing GEMs in Fun4All



(plane) GEM implementation in Fun4All



Gas volume

- 25 μm of mylar
- 2 cm of methane
- 10 μm of graphite

Hadron-Blind Detector (HBD)

3x{

- 3.2 μm Copper
- 32 μm Kapton
- 3.2 μm Copper
- 97.5 μm FR4 frame

}

+

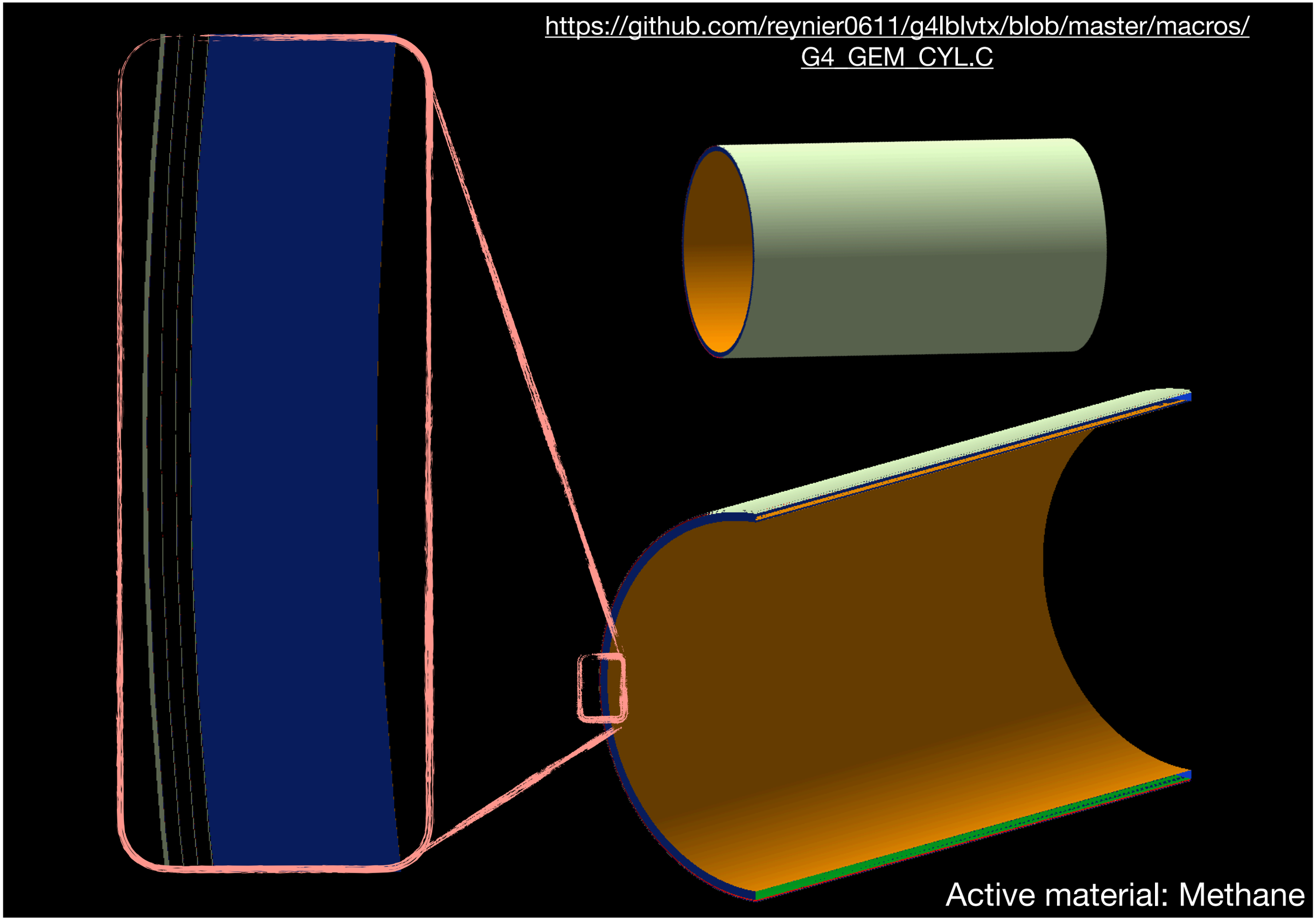
- 50 μm Kapton
- 4 μm Copper
- 0.5 mm FR4 frame

HBD: https://arxiv.org/pdf/1103.4277.pdf

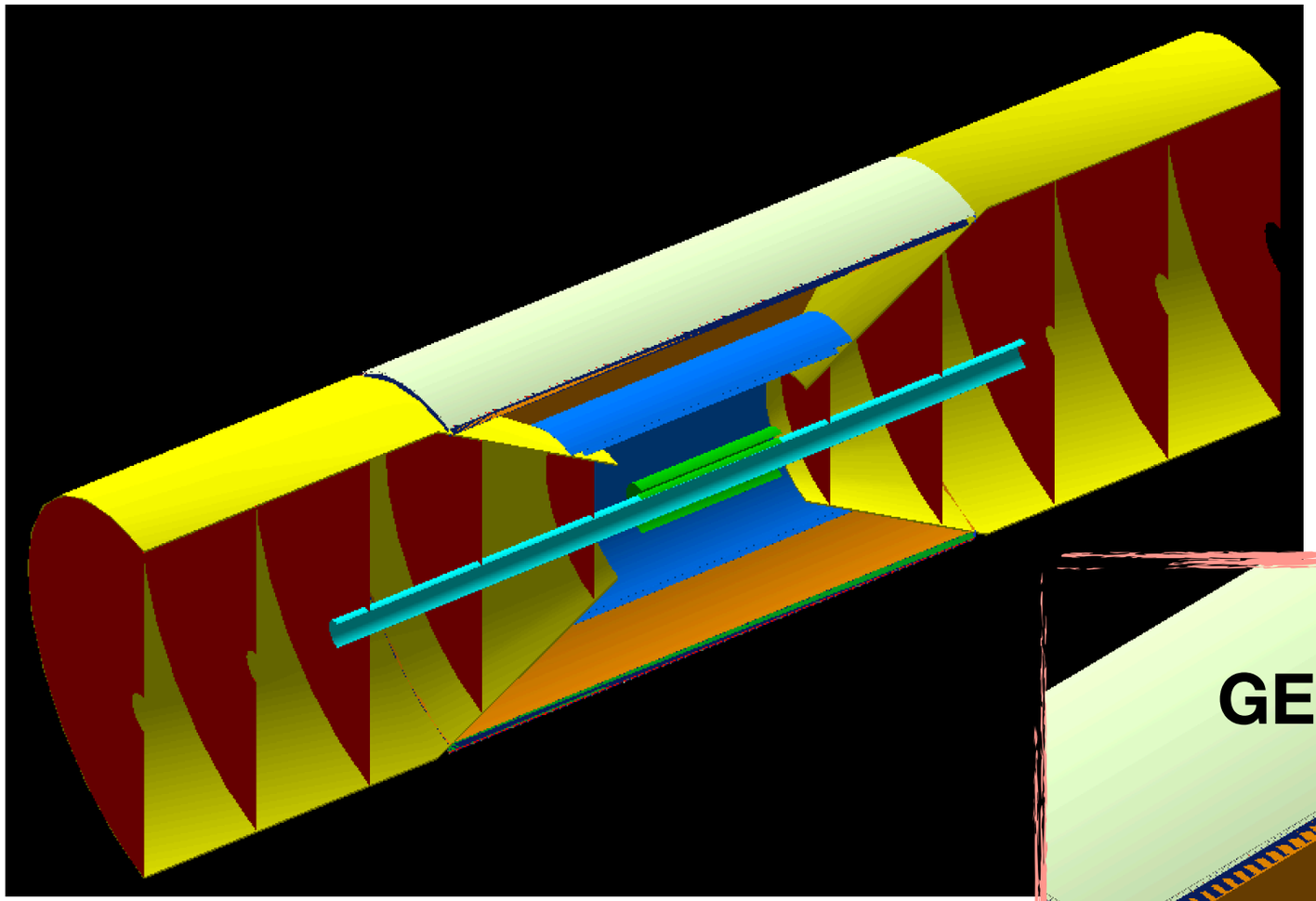
see line 411 here: https://sphenix-collaboration.github.io/doxygen/d4/d18/PHG4SectorConstructor_8cc_source.html

(cylindrical) GEM implementation in Fun4All

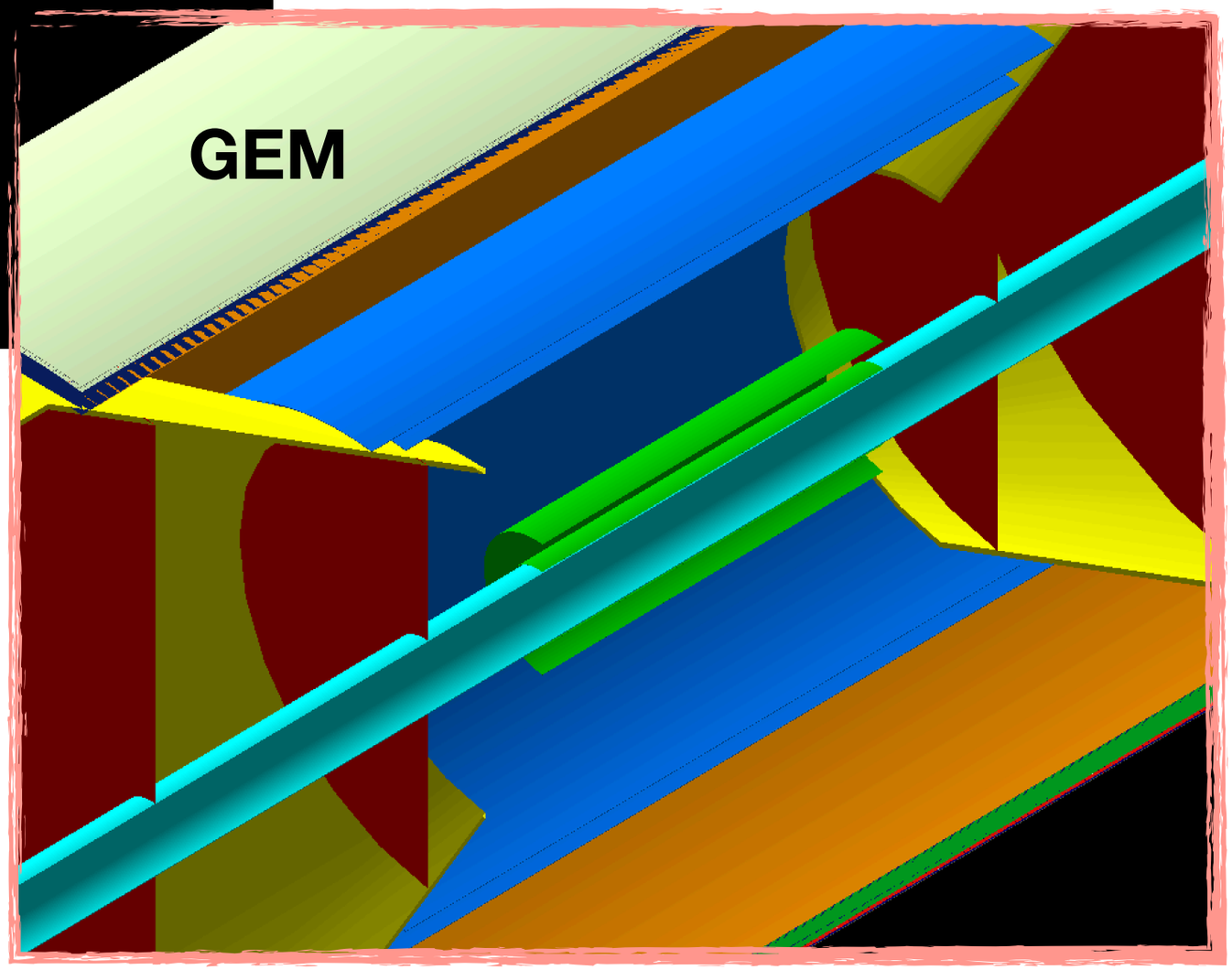
https://github.com/reynier0611/g4lblvtx/blob/master/macros/G4_GEM_CYL.C



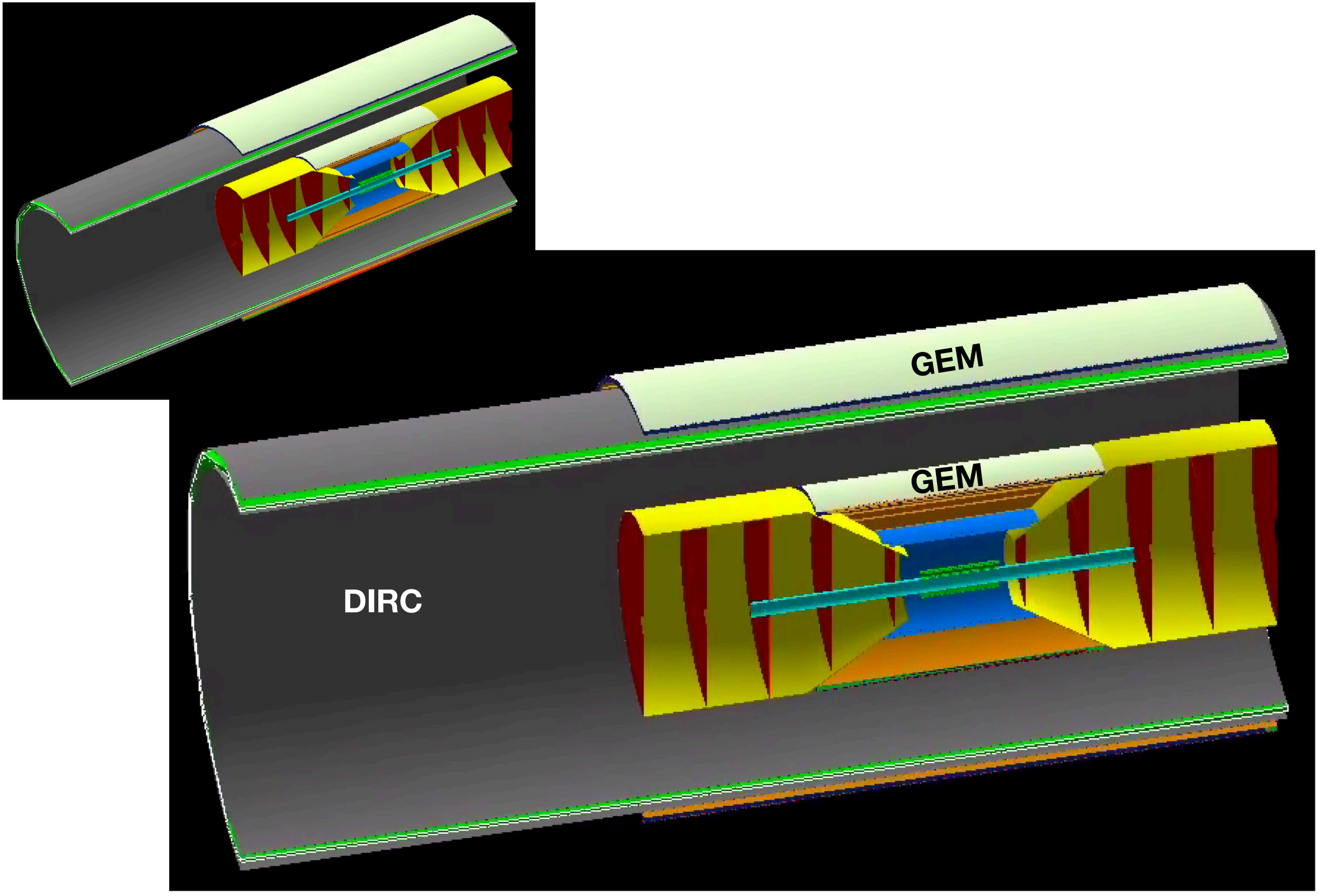
All-silicon tracker variant



* Identical to the standard all-silicon tracker configuration, except that the outermost two layers have been replaced with one GEM

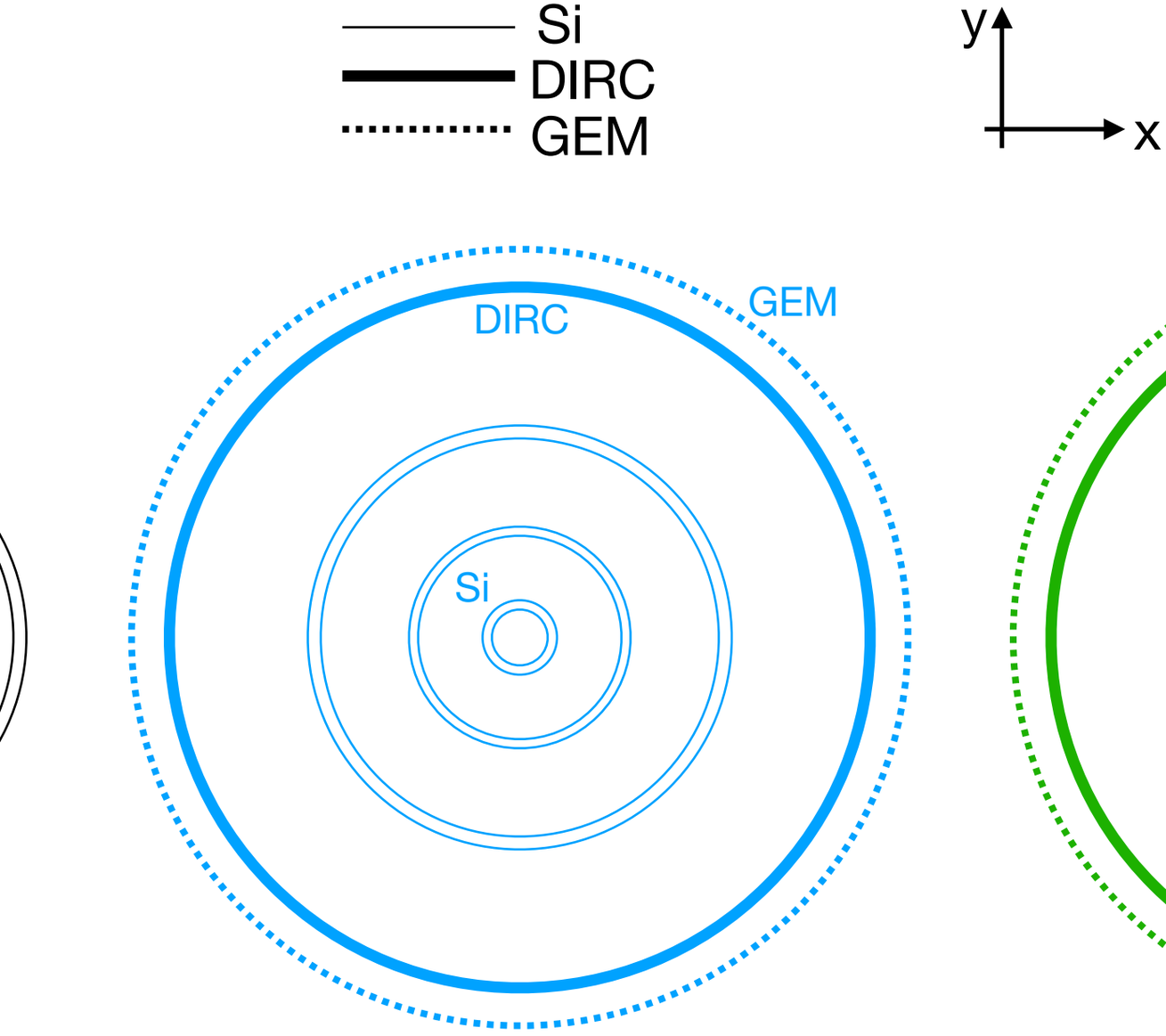


All-silicon tracker variant 2



Configurations

Si
DIRC
GEM

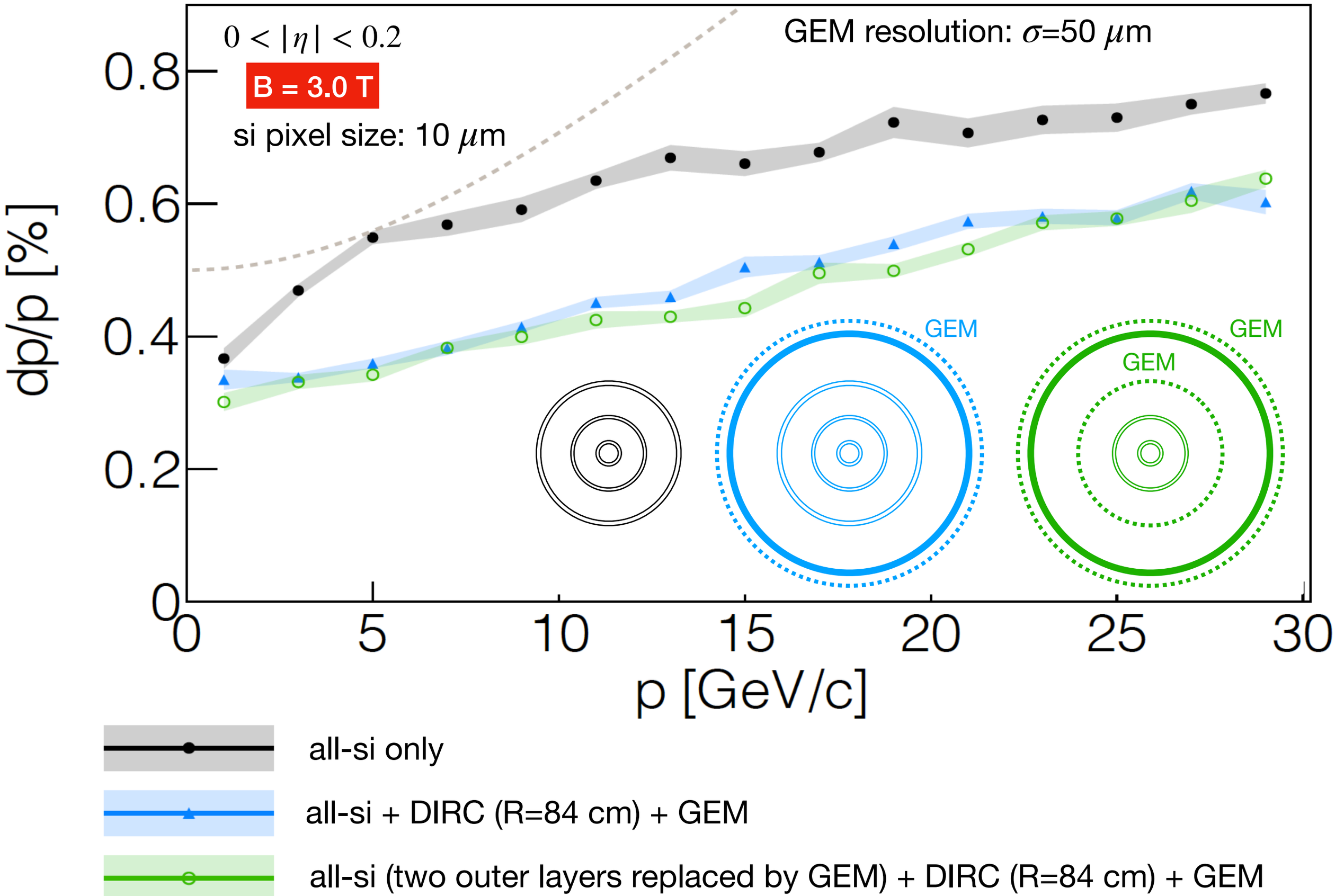


all-si only

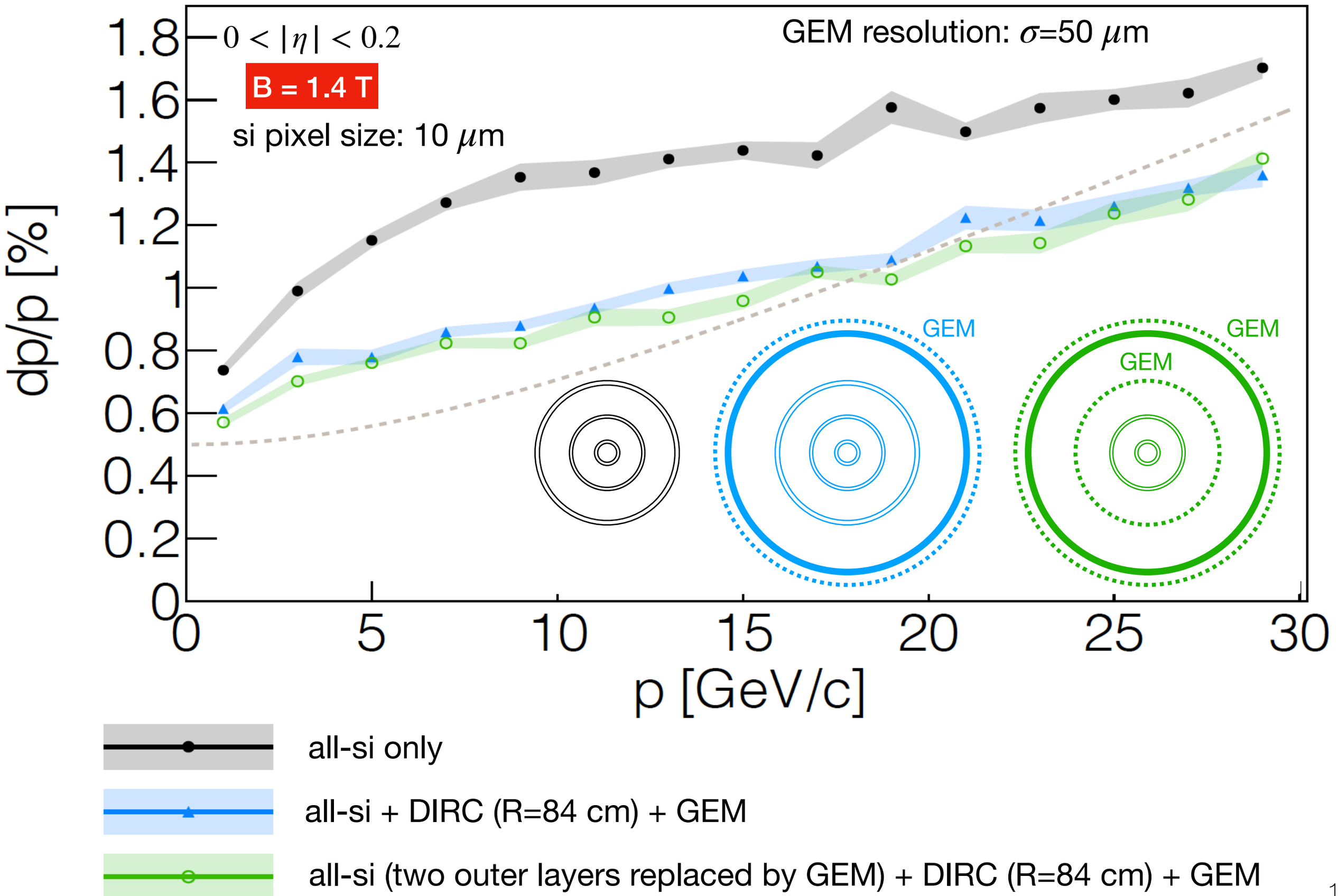
all-si + DIRC (R=84 cm) + GEM

all-si (two outer layers replaced by GEM) + DIRC (R=84 cm) + GEM

Results


$0 < |\eta| < 0.2$
B = 3.0 T
si pixel size: 10 μm
GEM resolution: σ=50 μm
GEM
GEM
GEM
dp/p [%]
0.8
0.6
0.4
0.2
0
0
5
10
15
20
25
30
p [GeV/c]
all-si only
all-si + DIRC (R=84 cm) + GEM
all-si (two outer layers replaced by GEM) + DIRC (R=84 cm) + GEM

Results


$0 < |\eta| < 0.2$
B = 1.4 T
si pixel size: 10 μm
GEM resolution: σ=50 μm
GEM
GEM
GEM
dp/p [%]
p [GeV/c]
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
0
5
10
15
20
25
30
all-si only
all-si + DIRC (R=84 cm) + GEM
all-si (two outer layers replaced by GEM) + DIRC (R=84 cm) + GEM

Summary

Implemented cylindrical GEMs in Fun4All.

Complementing the all-silicon tracker with a GEM at large R significantly improves the momentum resolution.

Momentum resolution for different configurations (tracker with outer two layers of silicon or one layer GEM) that include far-away GEM are consistent: The lever arm created by a far-away GEM reduces the importance of the all-silicon tracker outer layers.

Note that these studies assume no material (other than the DIRC) between all-silicon tracker and far-away GEM.

Discussion

GEM material budget

Material	thickness [cm]	X0 [cm]	X/X0 (%)
mylar	2.50E-03	28.7	0.009
methane	2	64850	0.003
graphite	1.00E-03	19.32	0.005
copper	3.20E-04	1.43	3*0.022
kapton	3.20E-03	28.57	3*0.011
copper	3.20E-04	1.43	3*0.022
FR4	9.75E-03	16.7608	3*0.058
kapton	5.00E-03	28.6	0.017
copper	4.00E-04	1.43	0.028
fr4	5.00E-02	16.7608	0.298
		Total	0.70

Material budget from arxiv:1103.4277

Component	Material	X_0 (cm)	Thickness (cm)	Area (%)	Rad. Length (%)
Vessel					
Window	Aclar/kapton	15.8/28.6	0.0075/0.0050	100	0.040
Mesh	SS	1.67	0.003	11.5	0.021
GEM	Kapton	28.6	0.005×3	64	0.034
GEM	Copper	1.43	0.0005×6	64	0.134
GEM frames	FR4	17.1	0.15×4	6.5	0.228
PCB	Kapton	28.6	0.005	100	0.017
PCB	Copper	1.43	0.0005	80	0.028
Facesheet	FR4	17.1	0.025×2	100	0.292
Panel core	Honeycomb	8170	1.905	100	0.023
Total vessel					0.82
Readout					
Readout board	FR4/copper	17.1/1.43	0.05/0.001	100	0.367
Preamps + sockets	Copper	1.43	0.0005	100	0.66
Total readout					1.03
Gas	CF_4	9240	51.5	100	**0.56**
Total					**2.4**