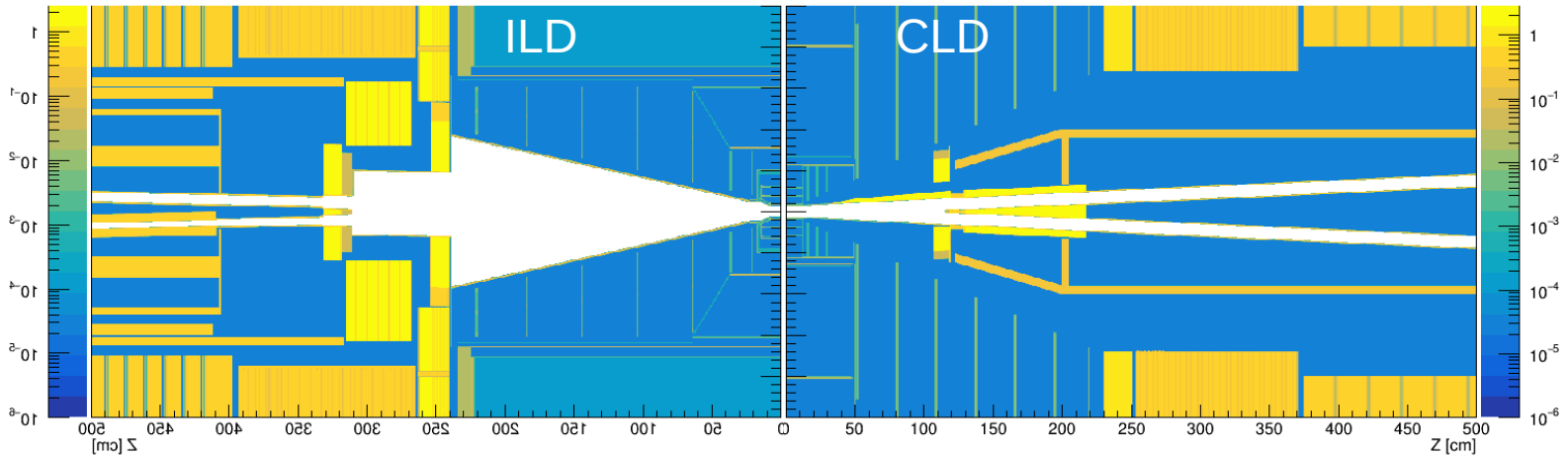
adapting ILD geometry for a circular collider

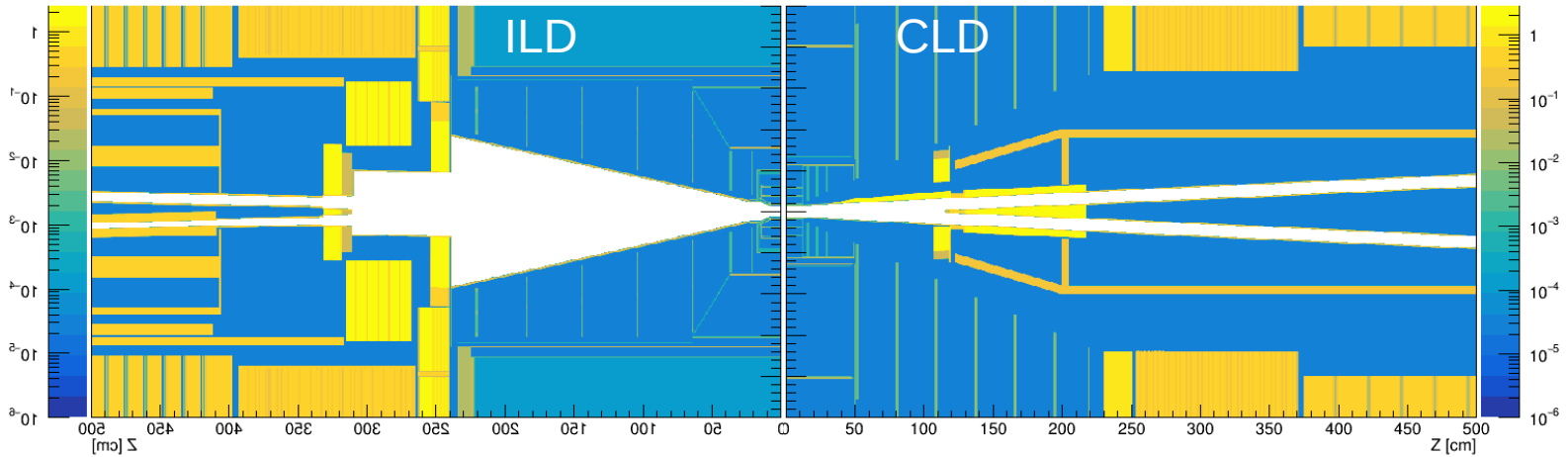


extract from ILD strategy 2022:

> ILD has been developed for the ILC, and has been tuned to the particular beam conditions at the ILC. FCC-ee has very different beam parameters, which will impact the way the experiment is operated. ILD is ready to engage with these studies, and to make the case for an ILD-like detector at FCC-ee in particular. Whether or not this will eventually lead to a proposal to FCC-ee for a concrete detector concept should be decided after a period of study and based on the findings of the study.

https://confluence.desy.de/display/ILD/ILD+Strategy

adapting ILD geometry for a circular collider

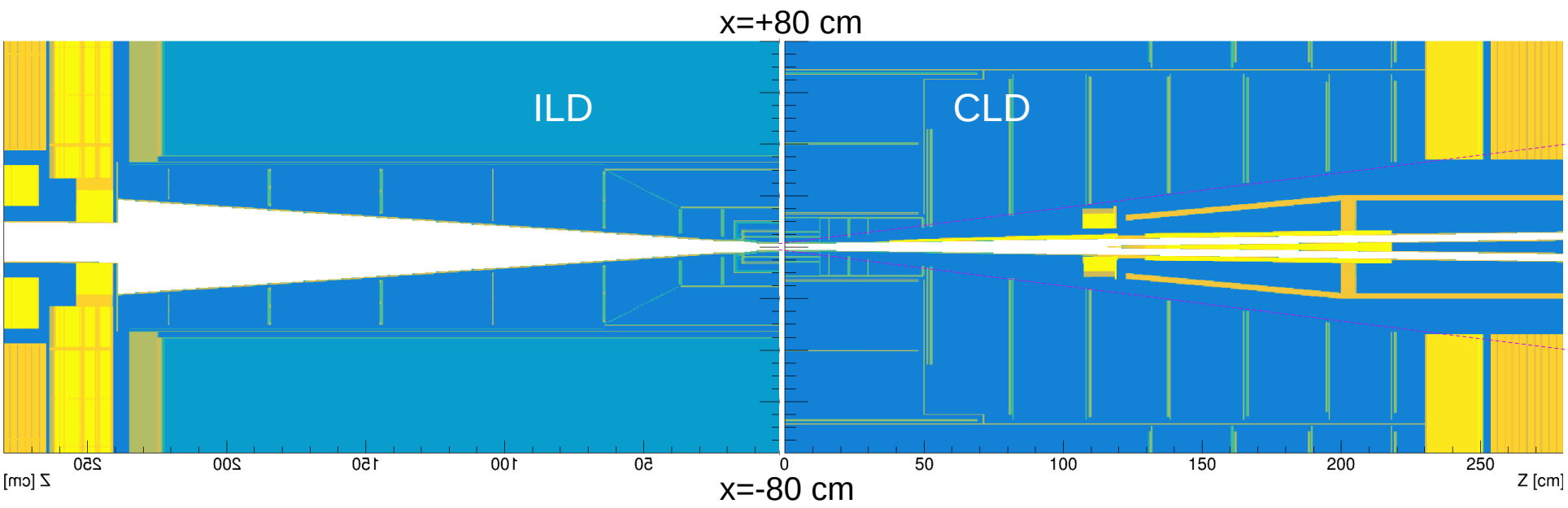


keep ILD's TPC, main calorimeters, etc
import FCCee-like MDI
reduce B-field to 2T (all energies? only Z-pole?)

looking for your suggestions!

~minimal changes, borrowing from CLD a.k.a. FCCee_o2_v02 : arXiv:1911.12230 [ILD/SiD → CLIC → CLD]

do not address ILD's sub-detector design (eg increased cooling needs, etc ...)



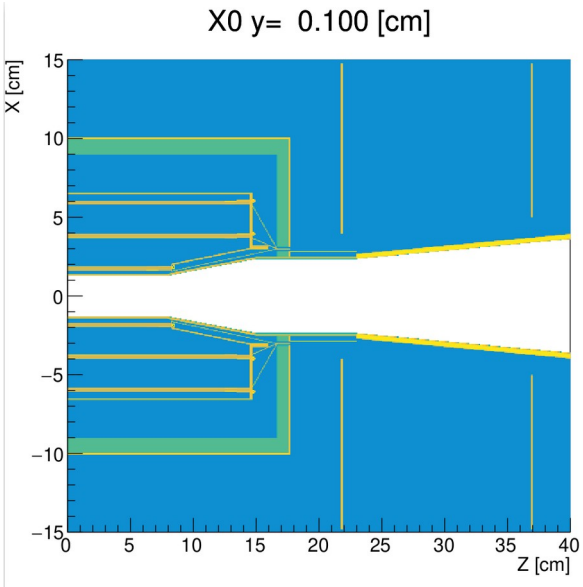
inner tracking:

- remove ILD's [VTX, SIT, FTD]
- keep TPC inner radius
- import squeezed Vertex & Inner silicon from CLD

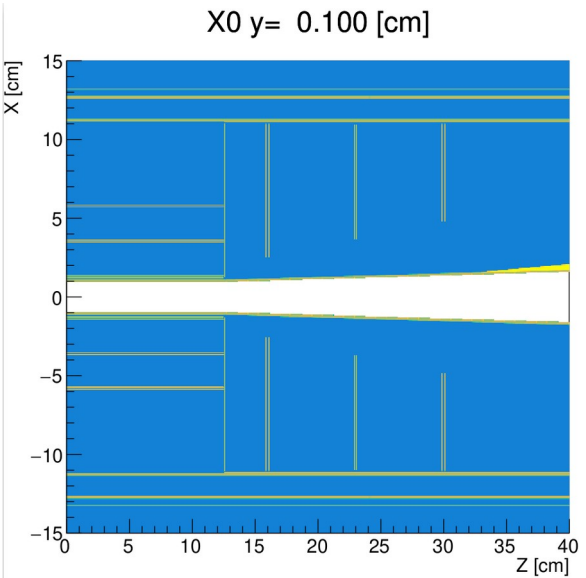
n.b. CLD/FCCee philosophy: <100 mrad belongs to machine [except Lumical]

beampipe, vertex

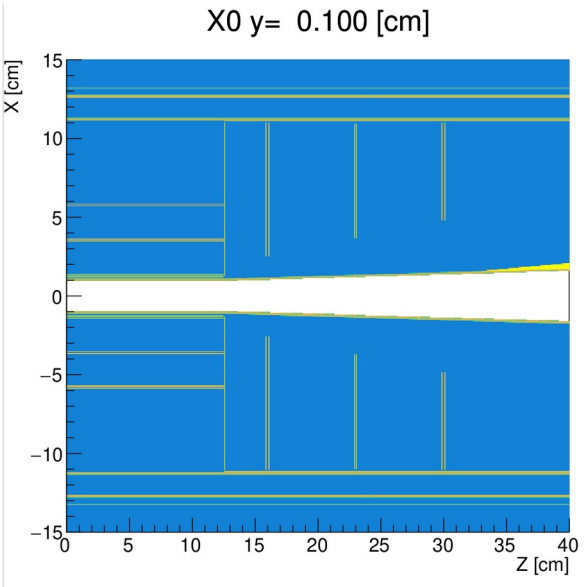
ILD_l5_v02



FCCee_o2_v02



ILD@FCC



CLD beampipe smaller (r=10mm) & less flared → thanks to less beamstrahlung

ILD's VTX design does not match → for now, switch to CLD barrel+endcap design

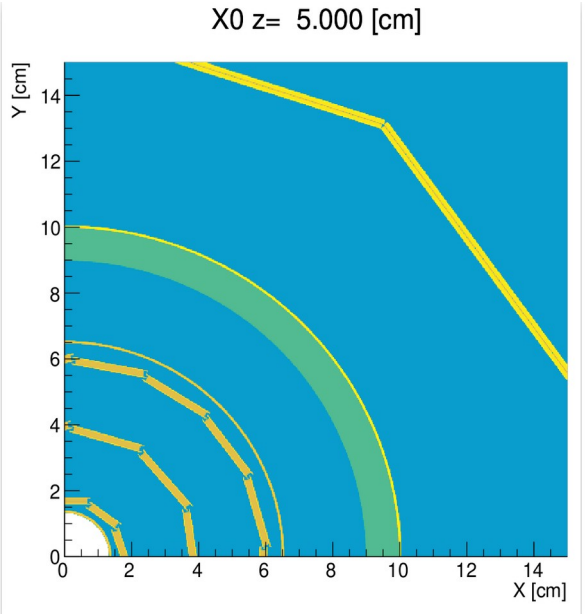
n.b. much less detailed design than in ILD: cables, mechanics, cryostat, faraday cage, ...

in CLD, "service" material accounted by increasing Si thickness

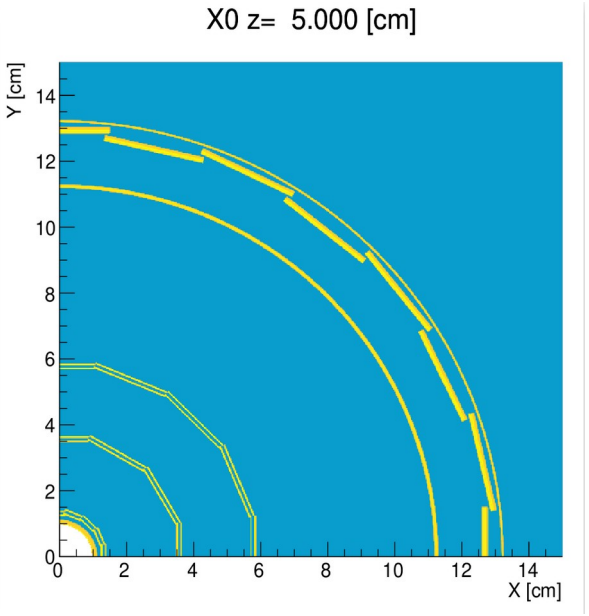
→ vertex experts may want to make a more detailed proposal ?

beampipe, vertex

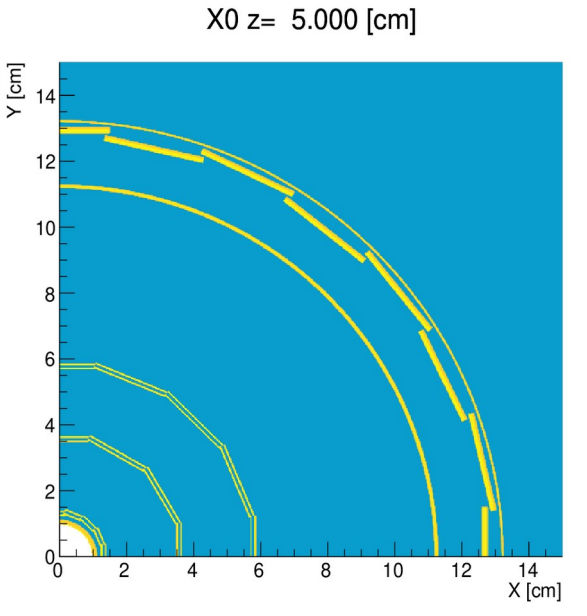
ILD_l5_v02



FCCee_o2_v02

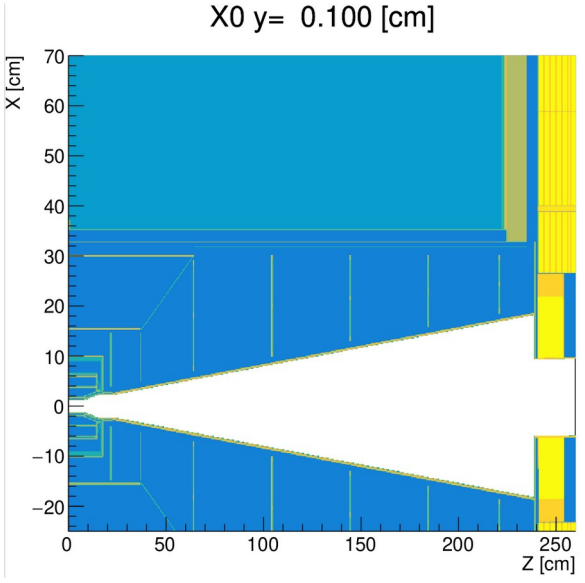


ILD@FCC

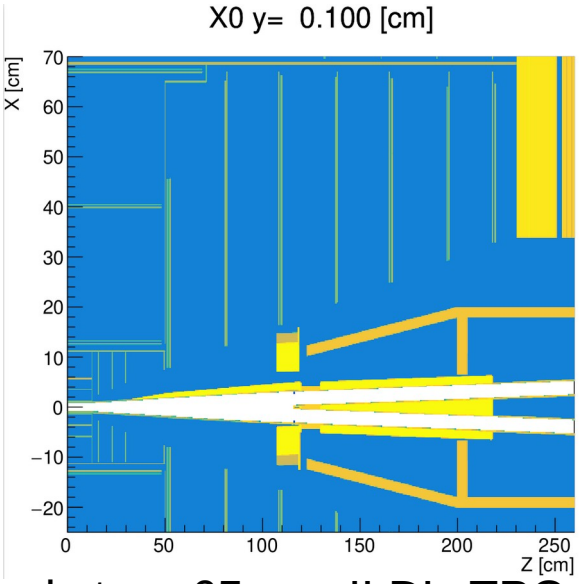


inner tracking

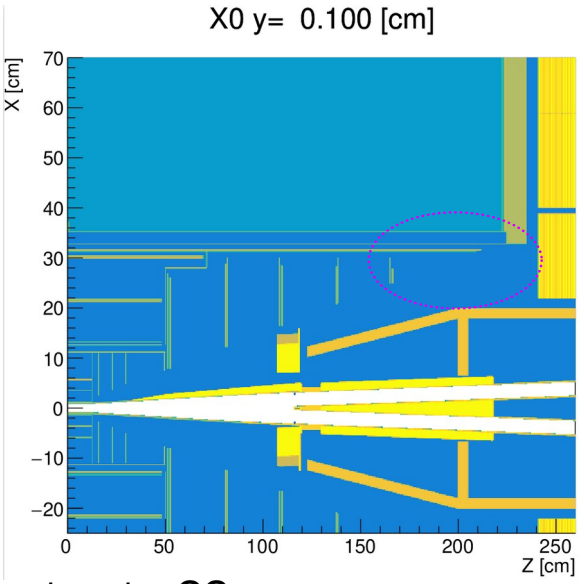
ILD_l5_v02



FCCee_o2_v02



ILD@FCC

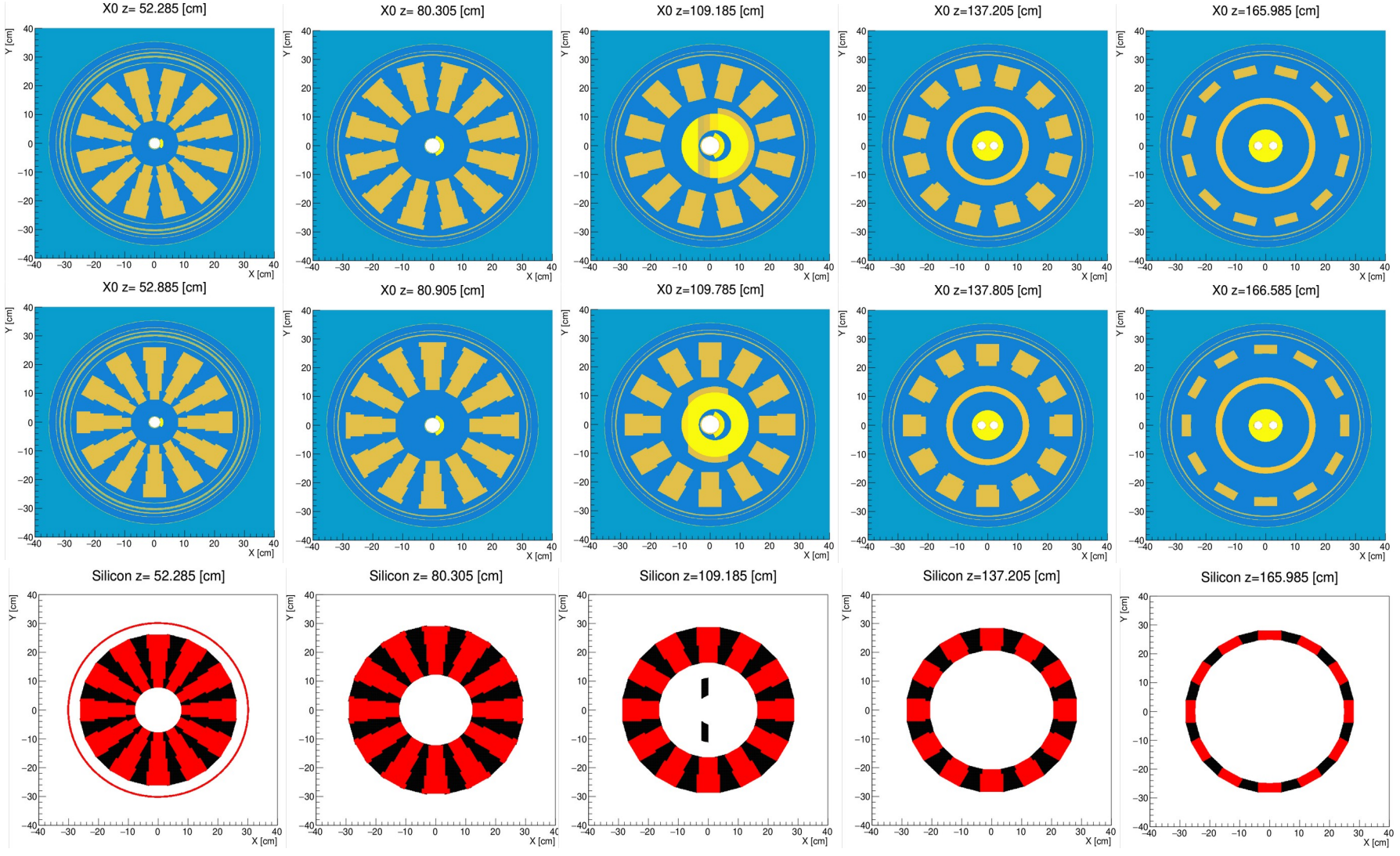


CLD's inner tracking extends to r~65 cm; ILD's TPC starts at ~32 cm

attempted to squeeze CLD design into available space

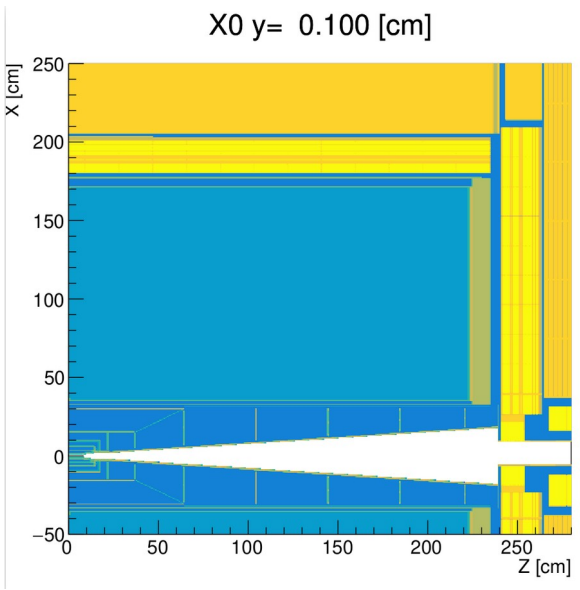
* kept 3 barrel layers (could reduce to 2?)
* lose 2 most forward disks (not enough space between 100mrad and TPC)
* more serious redesign needed ?

ILD@FCC : inner endcap tracker: overlapping double petal layers made of 15x15 mm^2 sensors

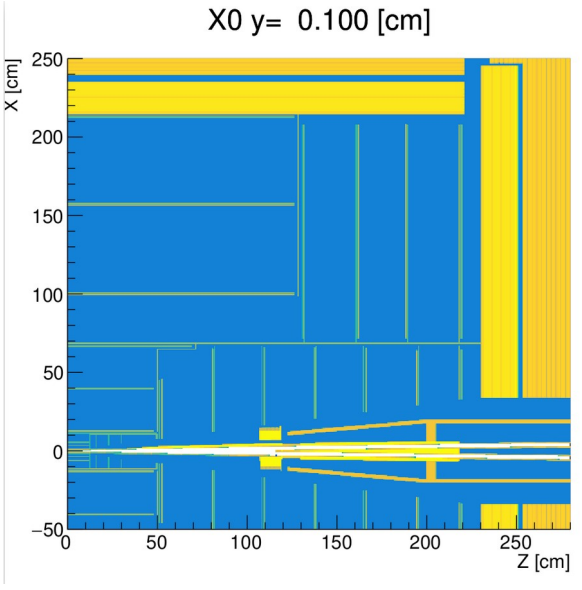


overall tracking region

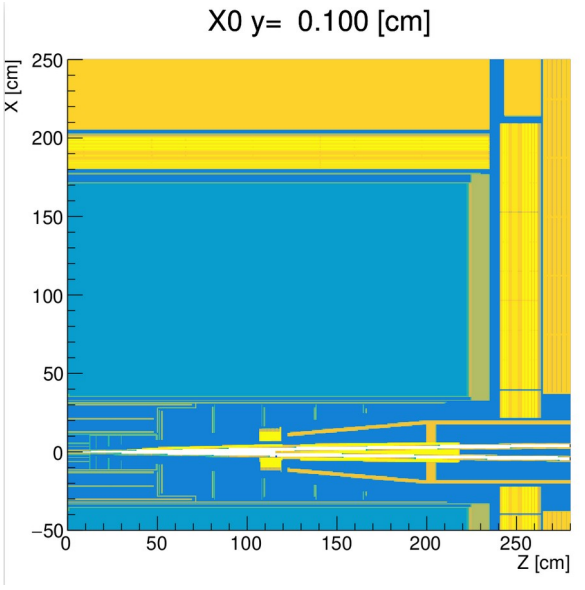
ILD_l5_v02



FCCee_o2_v02

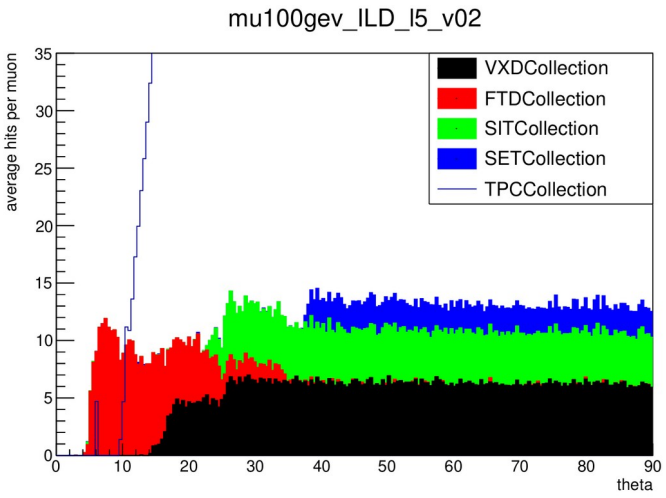


ILD@FCC

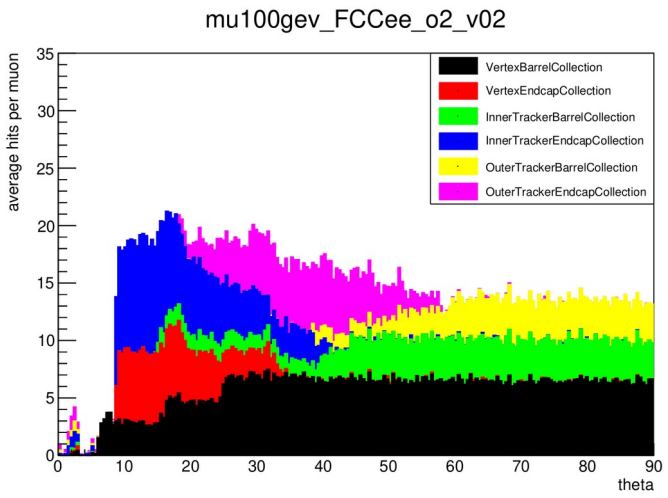


average number of tracker hits created by 100 GeV muon

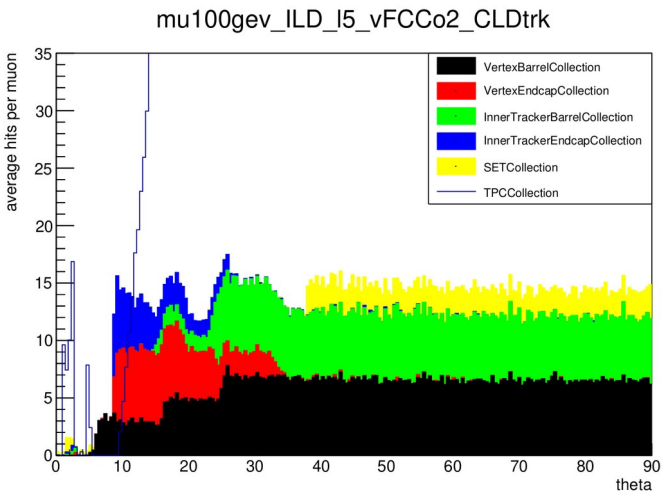
ILD_l5_v02



FCCee_o2_v02

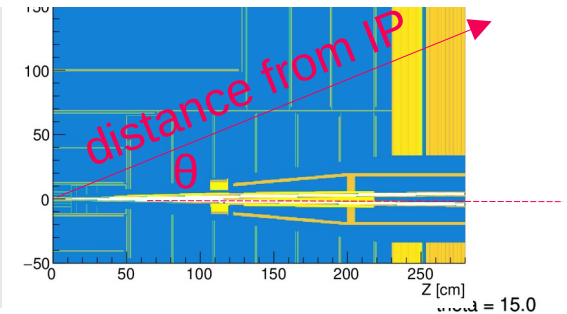


ILD@FCC



FCC model: less hits in region 5~9 deg.

material budget

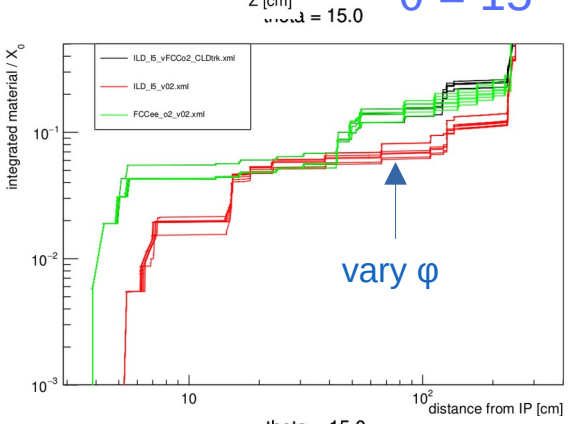


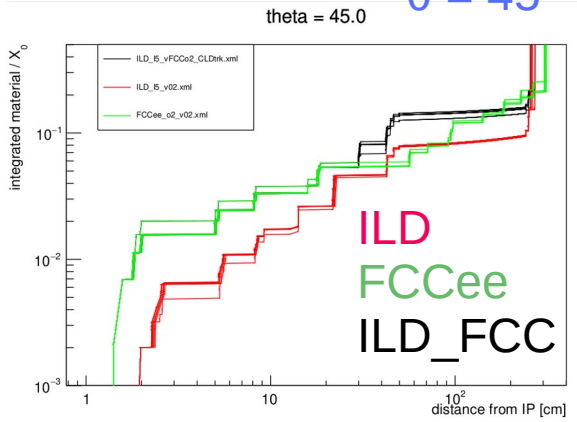
θ = 15°

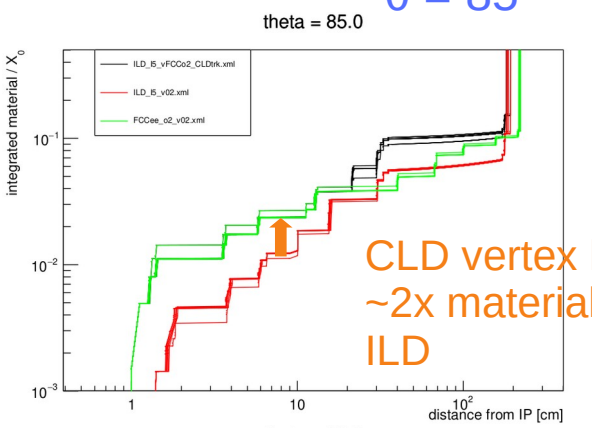
θ = 45°

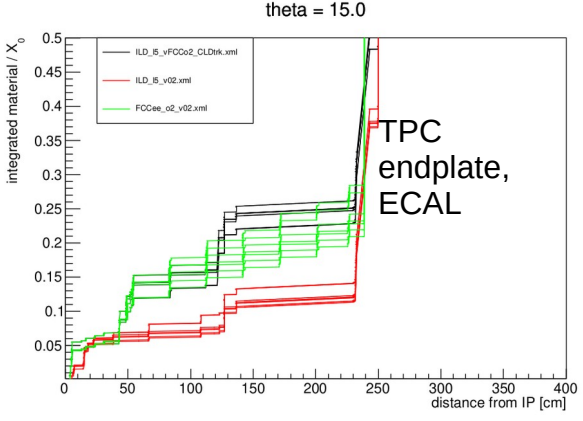
θ = 85°

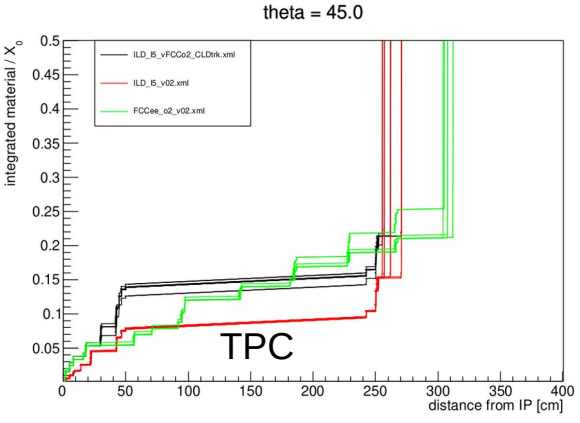
integrated material / X_0

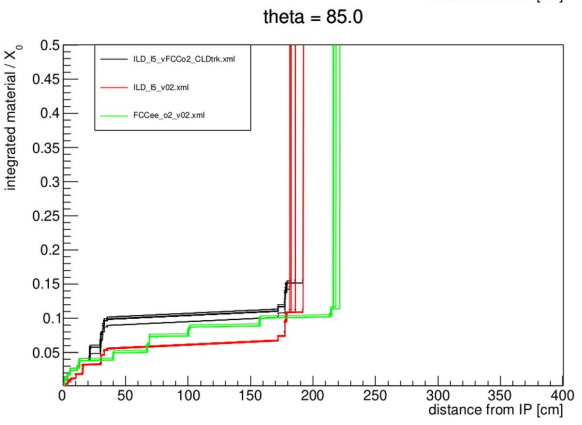












distance from IP [cm]

summary

→ ILD’s MDI region needs big changes for circular collider

→ borrow elements from CLD model to adapt ILD
  * often less detailed descriptions than what we’re used to

→ feedback needed !

backup & old stuff

0th version of ILD simulation model for a circular collider

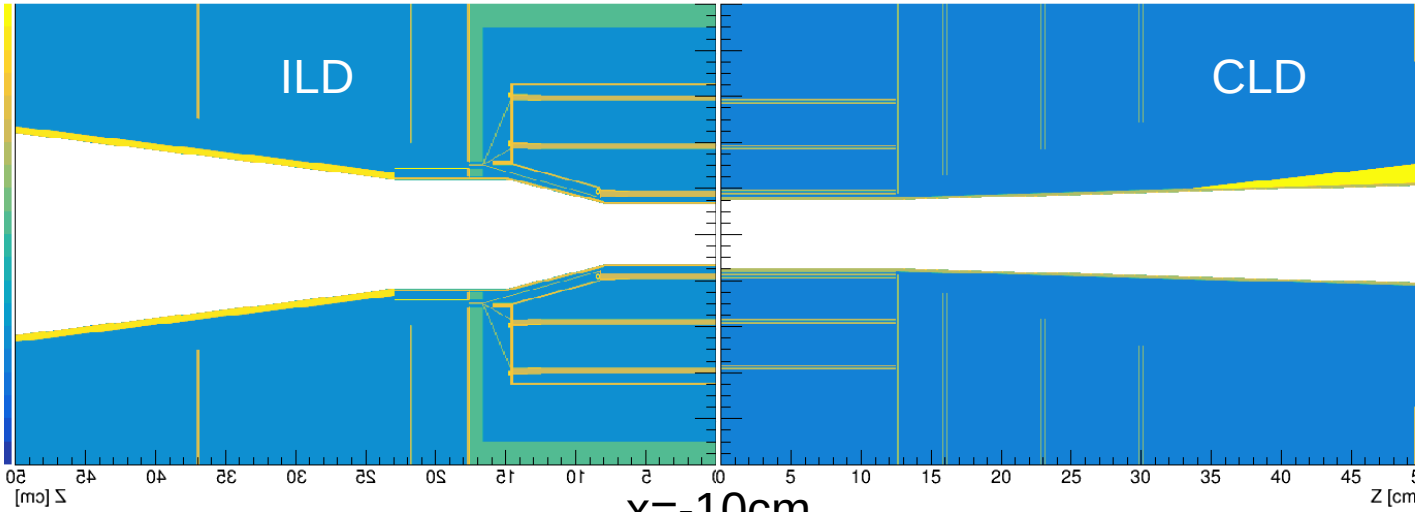
→ replace ILD's MDI region with that of CLD

* "ILD" = ILD_l5_v02
* "CLD" = FCCee_o1_v05

→ minimal rather obvious adjustments

1. beampipe / vertex detector region

x=+10cm

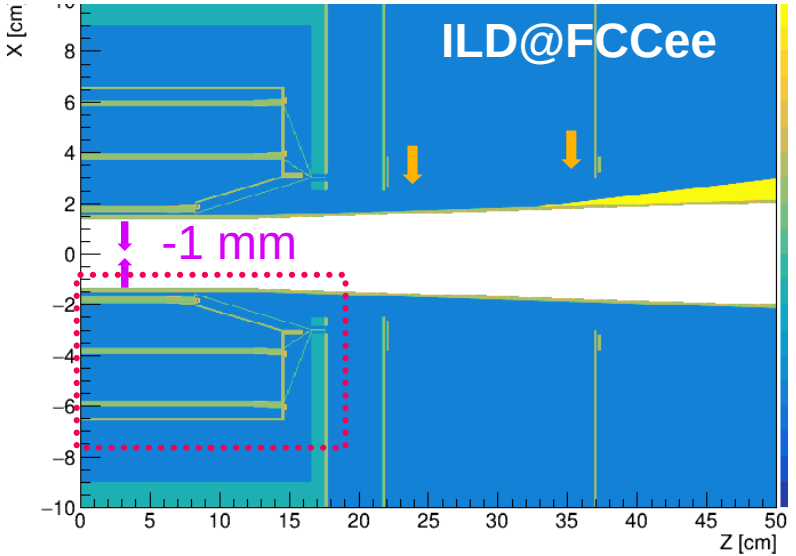


x=-10cm

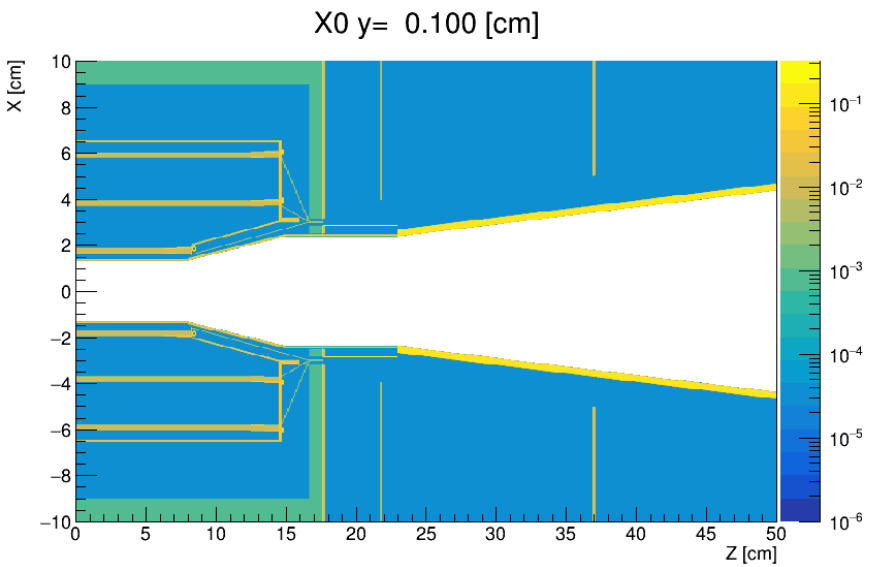
reduce central FCCee beampipe
radius by 1mm to just fit in ILD VTX

decrease inner radius of FTD1,2
z-position unchanged

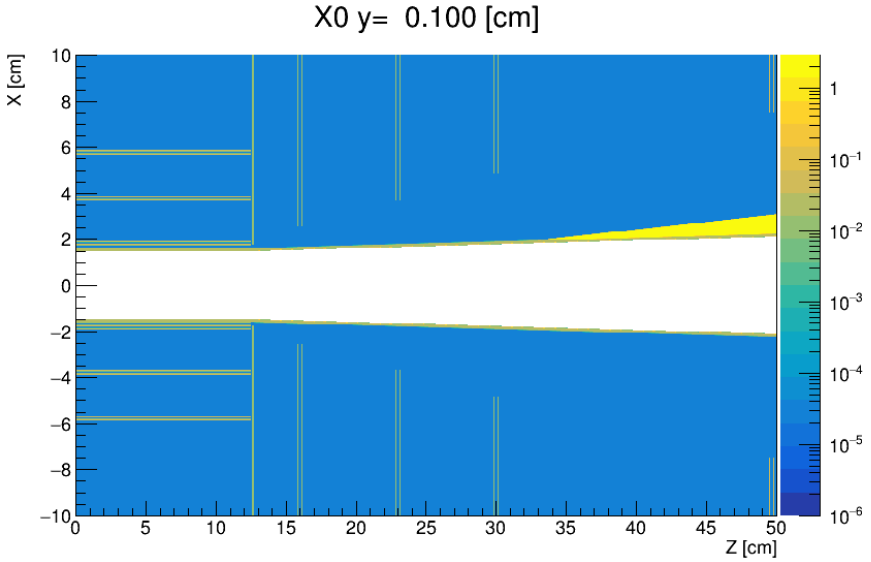
is VTX geom still realistic / optimal?
almost certainly not...



ILD



CLD

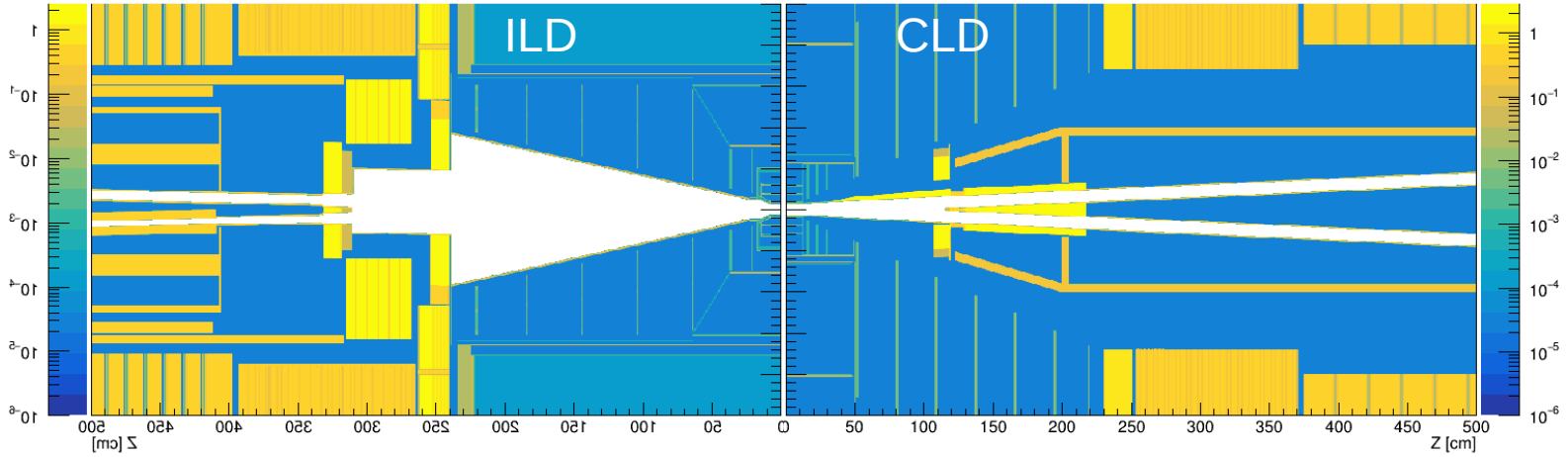


opportunity to also revisit ILD's first few FTD disks?

import VXD, forward disks from CLD ? they look more idealistic that those in ILD

suggestions, requests from hardware experts are welcome

central forward region

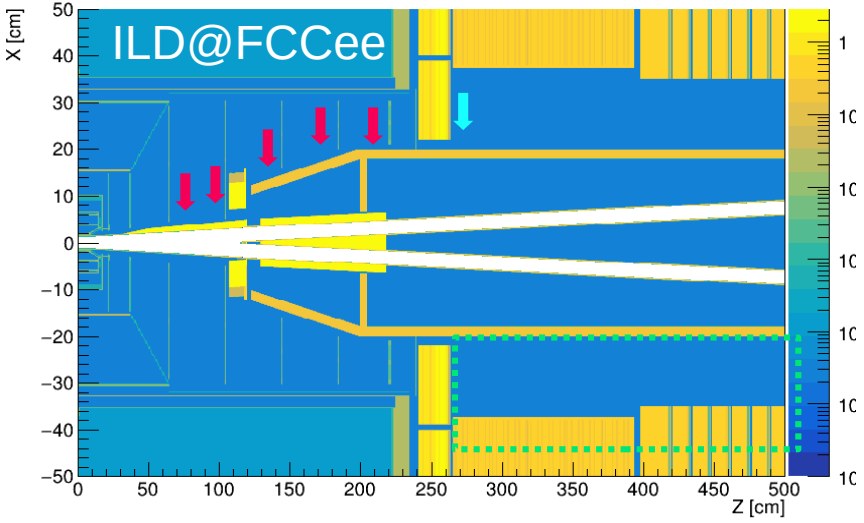


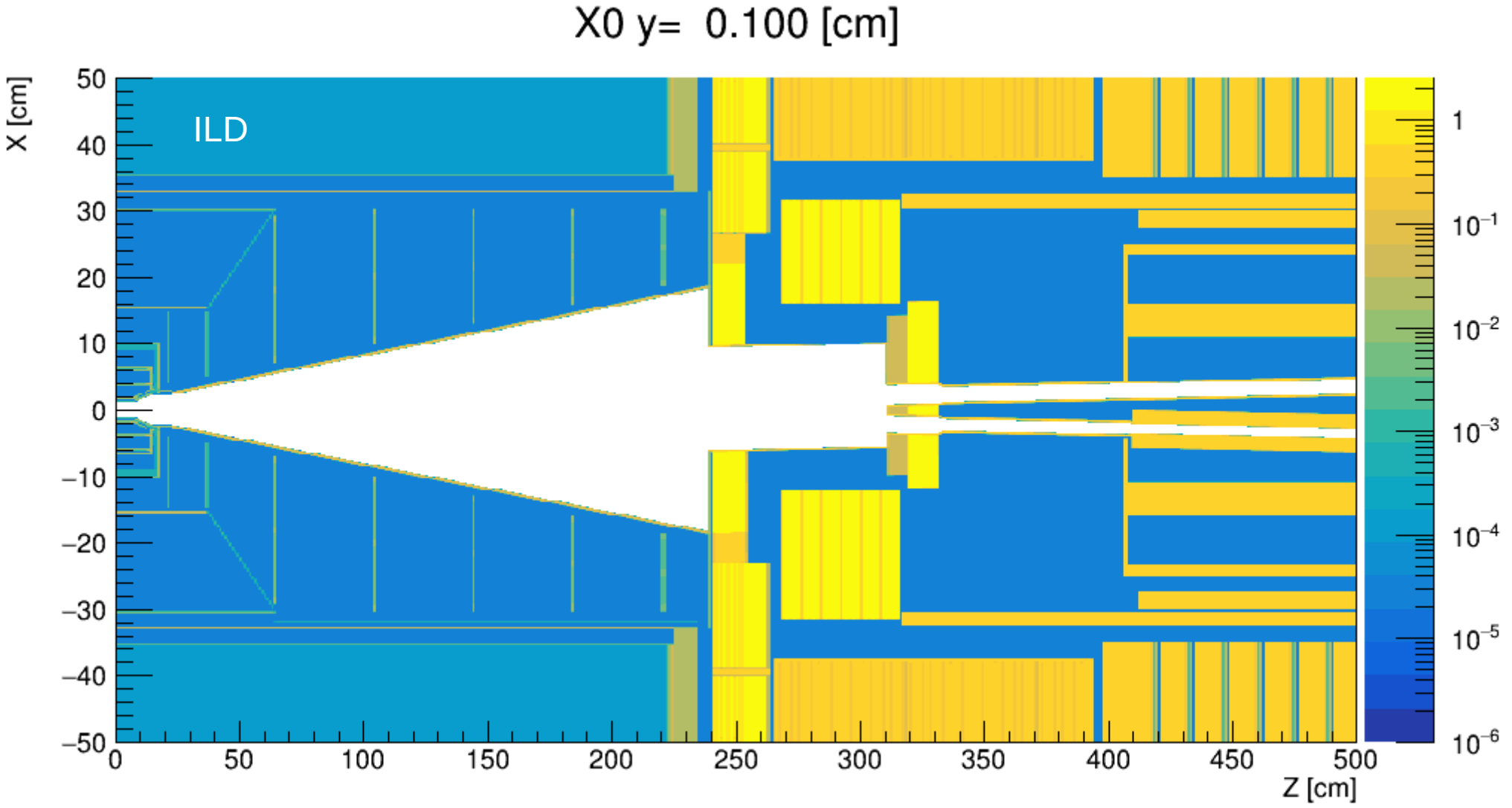
remove beamcal, lhcal;
replace beampipe, lumi-cal

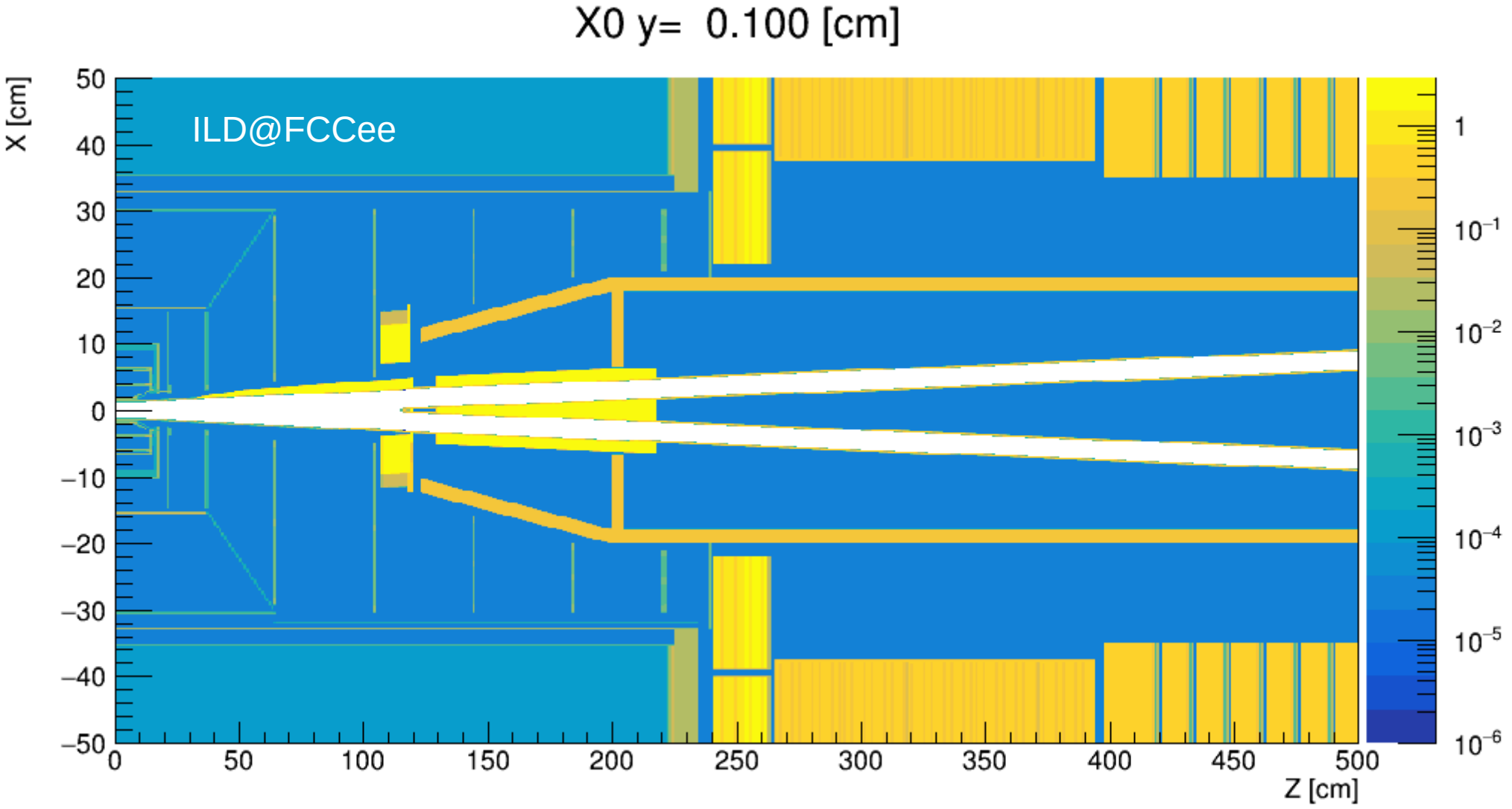
aggressively adjust inner radii of ftd disks
don’t change z positions

reduce inner radius of ecal ring
and center it on detector axis

don’t touch hcal/yoke for now




X0 y= 0.100 [cm]
ILD
X [cm]
Z [cm]
50
40
30
20
10
0
−10
−20
−30
−40
−50
0
50
100
150
200
250
300
350
400
450
500
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}


X0 y= 0.100 [cm]
ILD@FCCee
X [cm]
Z [cm]
50
40
30
20
10
0
−10
−20
−30
−40
−50
0
50
100
150
200
250
300
350
400
450
500
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}

```
+-----------------------------------------------------------------------------------------------------
+ Material scan between: x_0 = (   0.00,   0.00,   0.10) [cm] and x_1 = (   0.00,  10.50,   0.10) [cm] :
+-----------------------------------------------------------------------------------------------------
```

ILD

Num. Layer	Material Name	Thickness [cm]	Path Length [cm]	Integrated X0 [cm]
1	beam	1.350	1.35	0.000000
2	G4_Be	0.050	1.40	0.001417
3	Air	0.100	1.50	0.001421
4	Air	0.095	1.60	0.001424
5	G4_Si	0.005	1.60	0.001958
6	G4_Al	0.001	1.60	0.002070
7	G4_KAPTON	0.005	1.61	0.002245
8	SiC_foam	0.094	1.70	0.002944
9	SiC_foam	0.094	1.79	0.003642
10	G4_KAPTON	0.005	1.80	0.003817
11	G4_Al	0.001	1.80	0.003930
12	G4_Si	0.005	1.80	0.004463
13	Air	2.046	3.85	0.004531
14	G4_Si	0.005	3.86	0.005087
15	G4_Al	0.001	3.86	0.005204
16	G4_KAPTON	0.005	3.86	0.005387
17	SiC_foam	0.098	3.96	0.006115
18	SiC_foam	0.098	4.06	0.006843
19	G4_KAPTON	0.005	4.06	0.007025
20	G4_Al	0.001	4.06	0.007142
21	G4_Si	0.005	4.07	0.007699
22	Air	1.826	5.90	0.007759
23	G4_Si	0.005	5.90	0.008302
24	G4_Al	0.001	5.90	0.008416
25	G4_KAPTON	0.005	5.91	0.008594
26	SiC_foam	0.096	6.00	0.009305
27	SiC_foam	0.096	6.10	0.010015
28	G4_KAPTON	0.005	6.10	0.010193
29	G4_Al	0.001	6.10	0.010308
30	G4_Si	0.005	6.11	0.010851
31	Air	0.391	6.50	0.010864
32	G4_Be	0.049	6.55	0.012264
33	Air	2.451	9.00	0.012345
34	styropor	1.000	10.00	0.012915
35	G4_Al	0.050	10.05	0.018536
36	Air	0.050	10.10	0.018537
37	Air	0.400	10.50	0.018551
0	Average Material	10.500	10.50	0.018551

FCCee

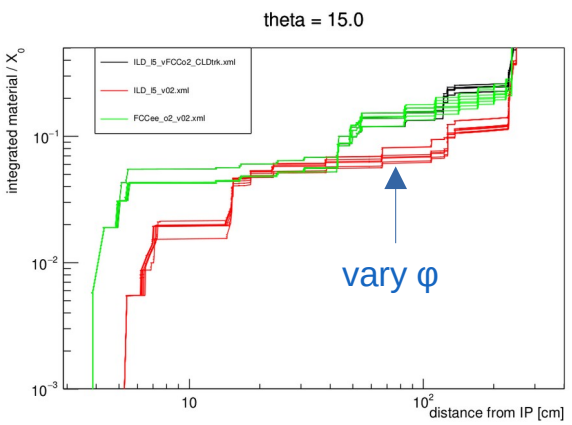
Num. Layer	Material Name	Thickness [cm]	Path Length [cm]	Integrated X0 [cm]
1	beam	0.999	1.00	0.000000
2	Gold	0.001	1.00	0.001495
3	Beryllium	0.120	1.12	0.004897
4	Air	0.080	1.20	0.004899
5	Air	0.050	1.25	0.004901
6	Silicon	0.023	1.27	0.007410
7	Silicon	0.005	1.28	0.007944
8	Air	0.100	1.38	0.007947
9	Silicon	0.005	1.38	0.008481
10	Silicon	0.023	1.41	0.010990
11	Air	2.093	3.50	0.011059
12	Silicon	0.024	3.52	0.013568
13	Silicon	0.005	3.53	0.014102
14	Air	0.100	3.63	0.014105
15	Silicon	0.005	3.63	0.014639
16	Silicon	0.024	3.66	0.017148
17	Air	2.043	5.70	0.017215
18	Silicon	0.024	5.72	0.019724
19	Silicon	0.005	5.73	0.020258
20	Air	0.100	5.83	0.020261
21	Silicon	0.005	5.83	0.020795
22	Silicon	0.023	5.86	0.023304
23	Air	4.643	10.50	0.023456
0	Average Material	10.500	10.50	0.023456

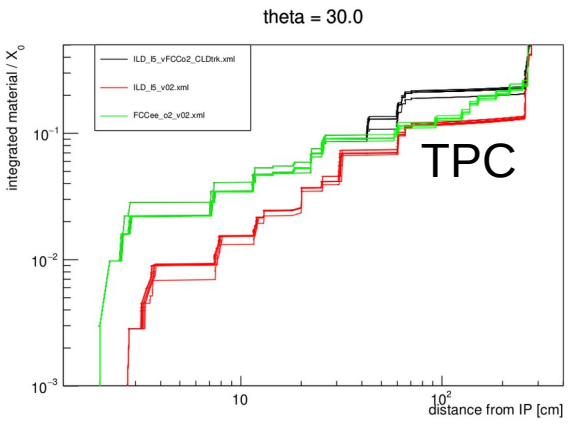
simplified material chosen to give expected radiation length

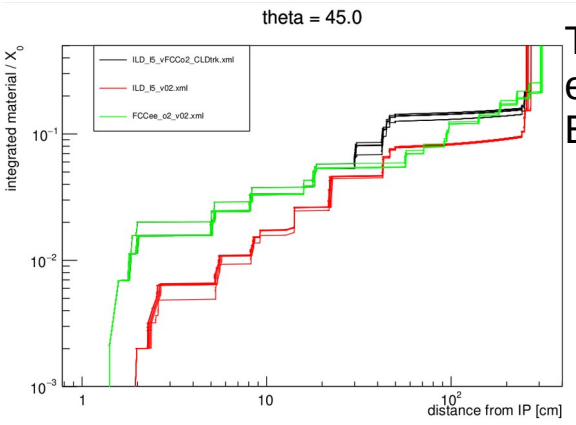
support, cooling, readout, cables, ...

material budget

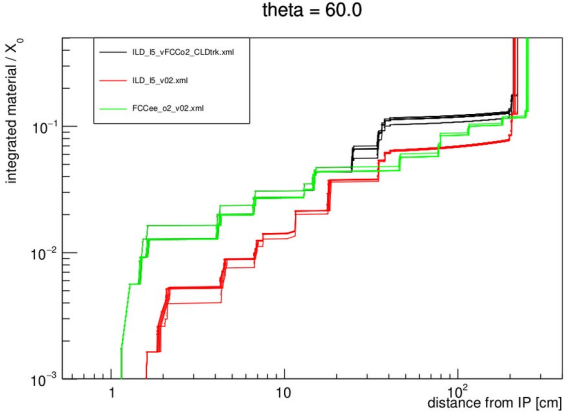
ILD FCCee ILD_FCC

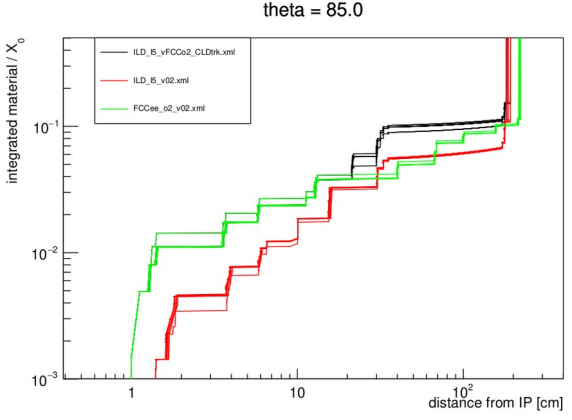


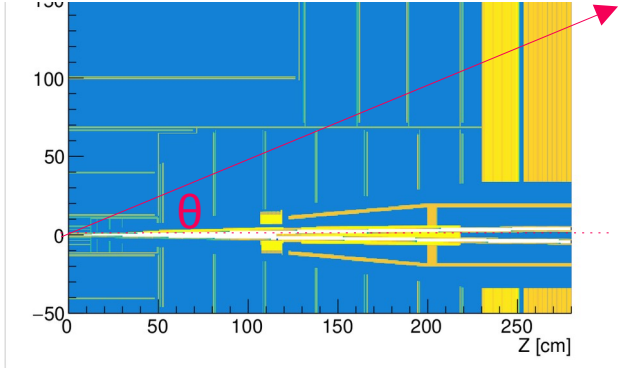




TPC endplate, ECAL



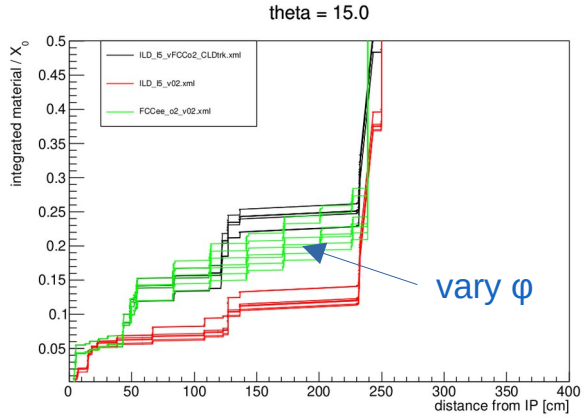


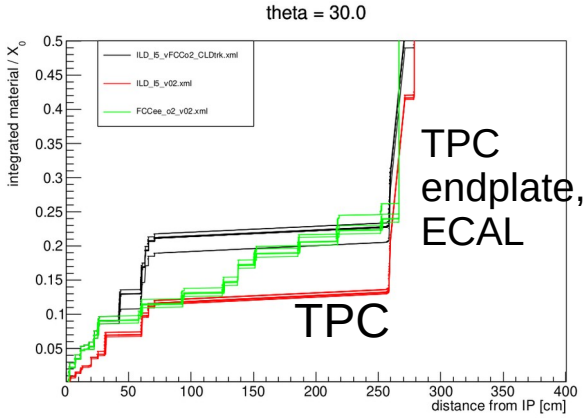


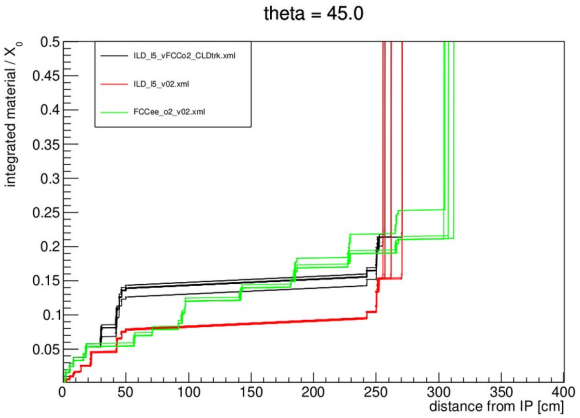
CLD vertex has ~2x more material than ILD

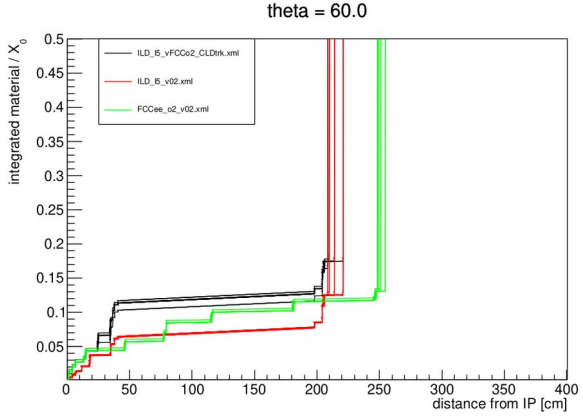
material budget comparison

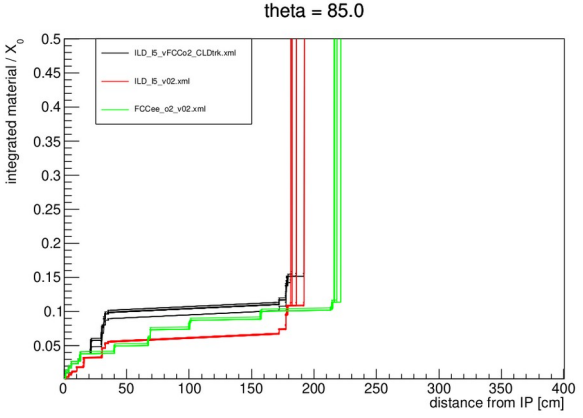
ILD FCCee ILD_FCC

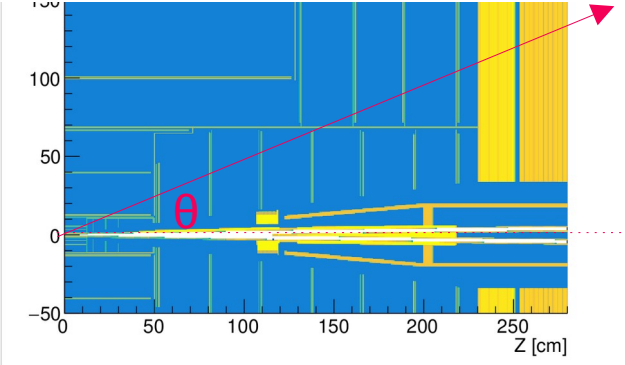












CLD vertex has ~2x more material than ILD

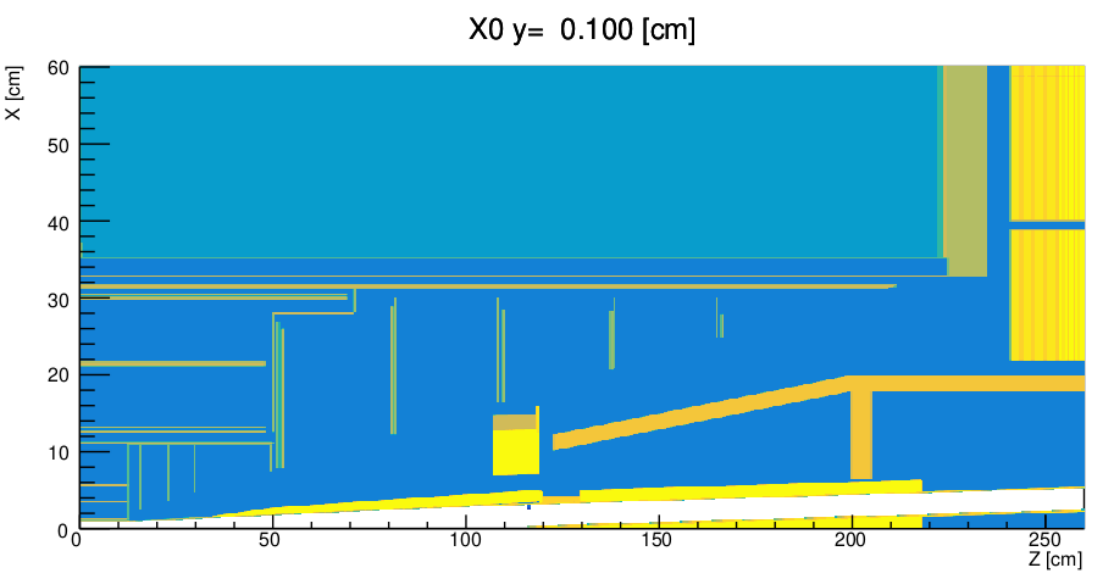
beampipe, MDI from CLD
(central beampipe radius → 10 mm)

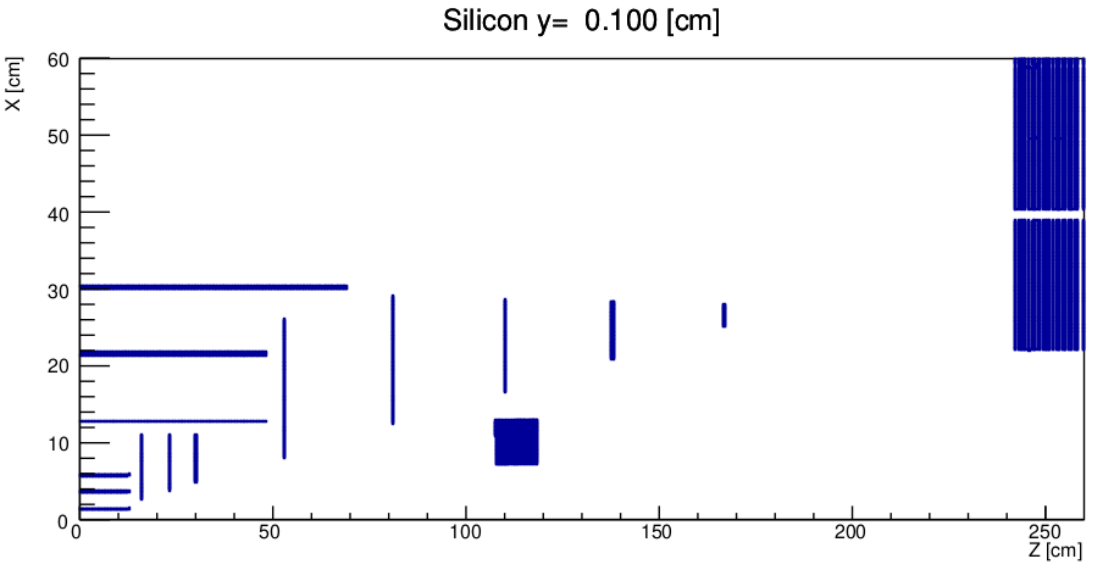
adjust CLD inner tracker to fit within ILD-TPC
→ lose last 2 disks

* increase inner radius of TPC ?

* more aggressive inner radius of forward tracker?

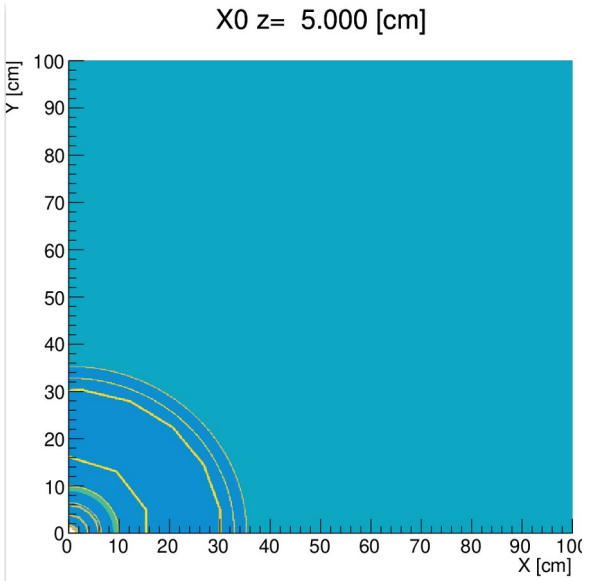
* @CLD <100 mrad belongs to MDI/machine



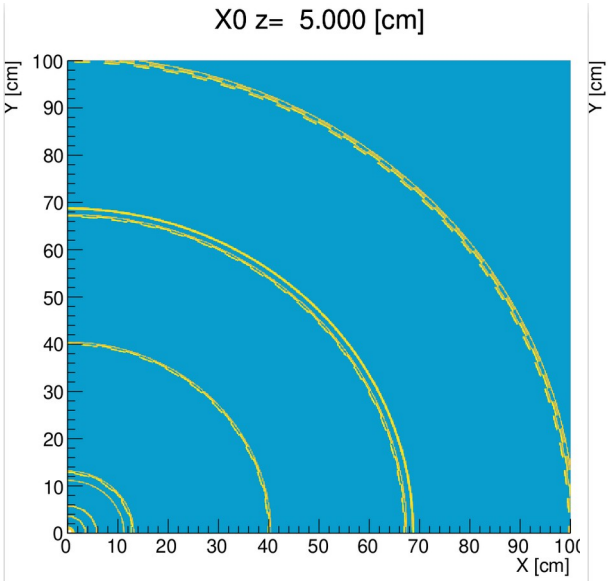


inner tracking

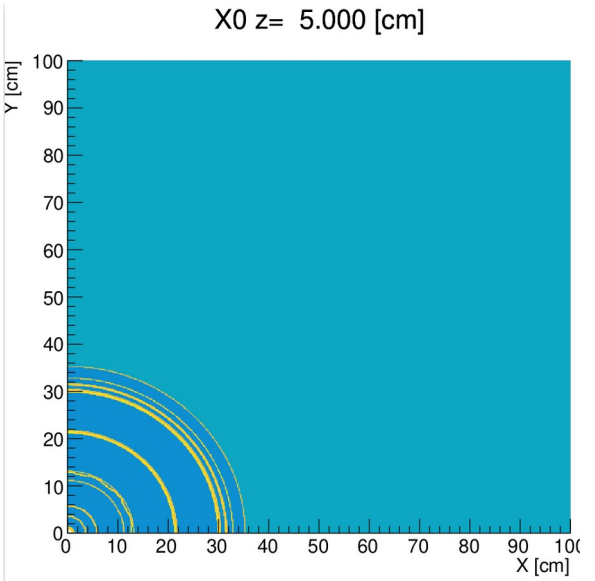
ILD_l5_v02



FCCee_o2_v02



ILD@FCC



CLD vertex