ILD Vertex Detector: Do we have the right parameters ?

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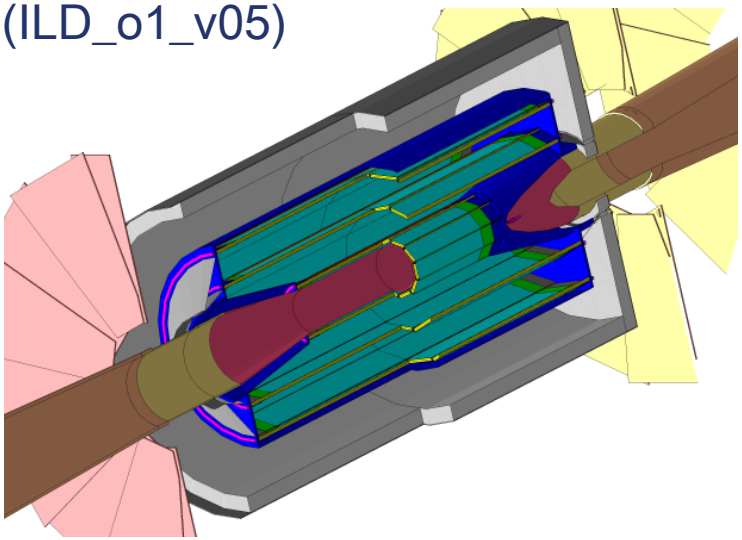
Design goal

- Performance goal
  - $\sigma_{IP} < 5 \oplus 10/p \sin^{\frac{3}{2}}\theta \ (\mu m)$
- Detector specifications
  - Spatial resolution near IP < 3 um
  - Material budget : below 0.15% X0/layer
  - First layer : at a radius of ~ 16 mm
  - Pixel occupancy : not exceeding a few %
  - Power consumption: low enough to minimize the material budget
  - Radiation hardness : 1kGy and 10^{11} n_{eq}/cm^2 per year.

Baseline design

VXD in Mokka ILD_o1_v05
- 3 x double layers(2mm apart)

Mokka geometry
(ILD_o1_v05)

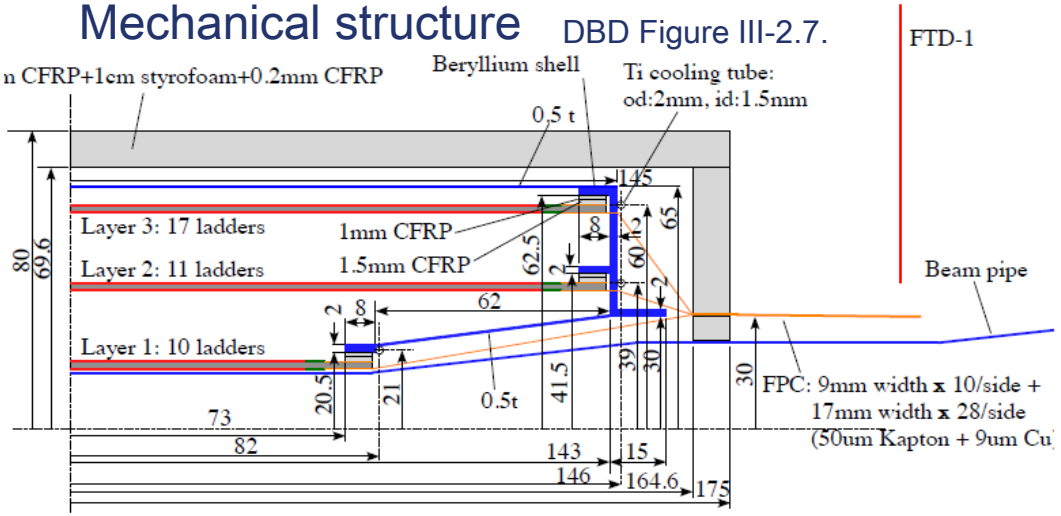


DBD Table III-2.1.

	R (mm)	$\|z\|$ (mm)	$\|\cos\theta\|$	σ (μm)	Readout time (μs)
Layer 1	16	62.5	0.97	2.8	50
Layer 2	18	62.5	0.96	6	10
Layer 3	37	125	0.96	4	100
Layer 4	39	125	0.95	4	100
Layer 5	58	125	0.91	4	100
Layer 6	60	125	0.9	4	100

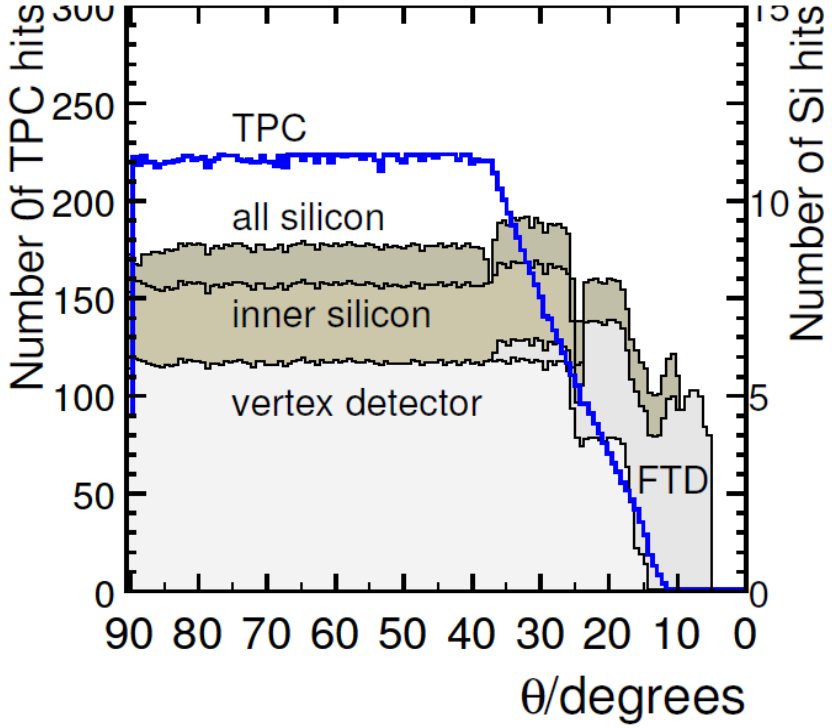
Mechanical structure

DBD Figure III-2.7.



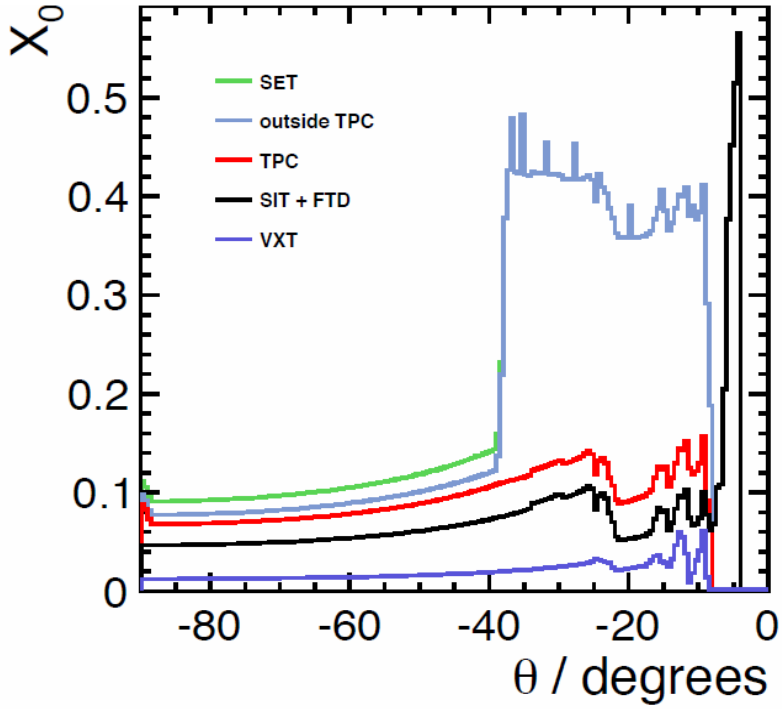
Alternative geometry
- 5 single-sided layers, R from 15 to 60 mm
- Not included in ILDConfigs

Coverage and material budget



Number of hit points

6 hits down to ~ 26 degree



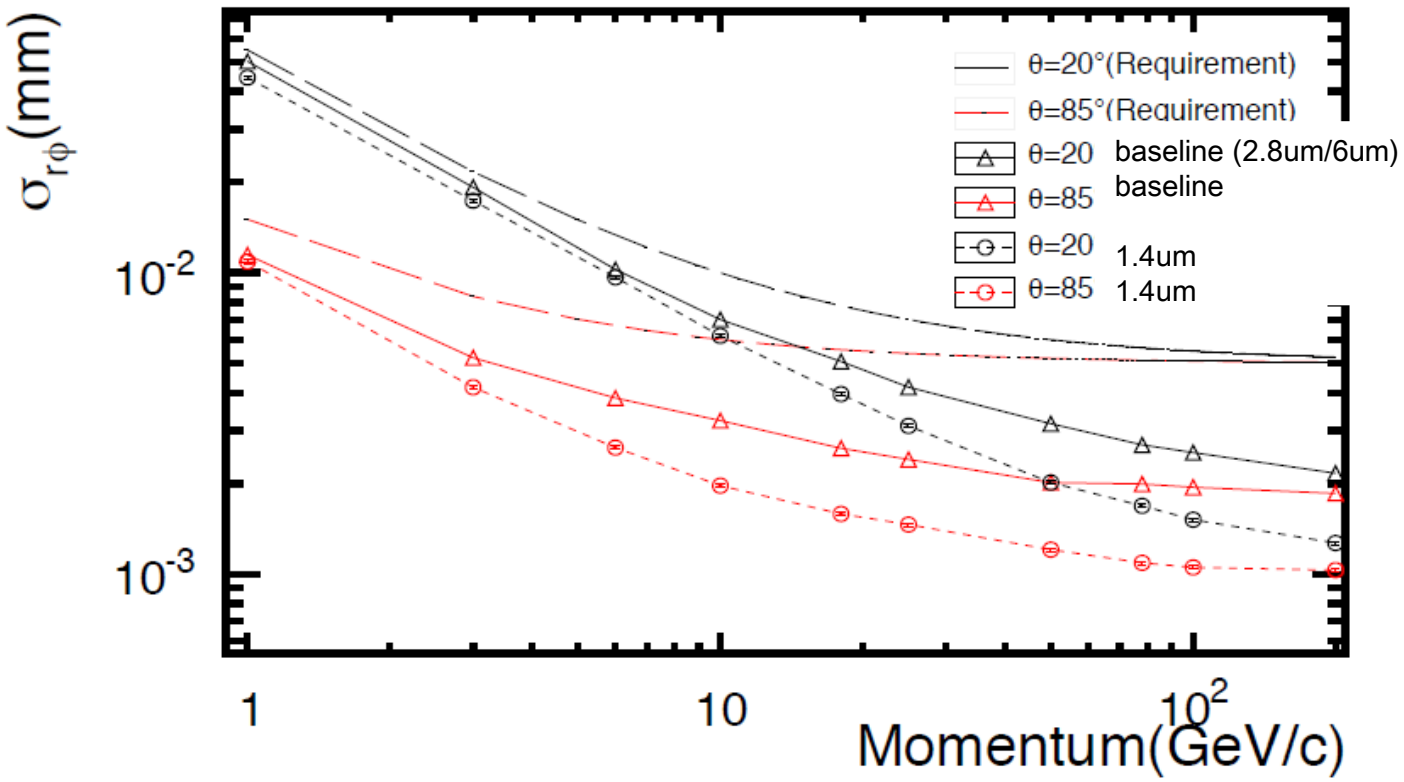
Material budget

< 3%X^0 above ~ 20 degree

~ 0.20%X^0/layer at 90 degree

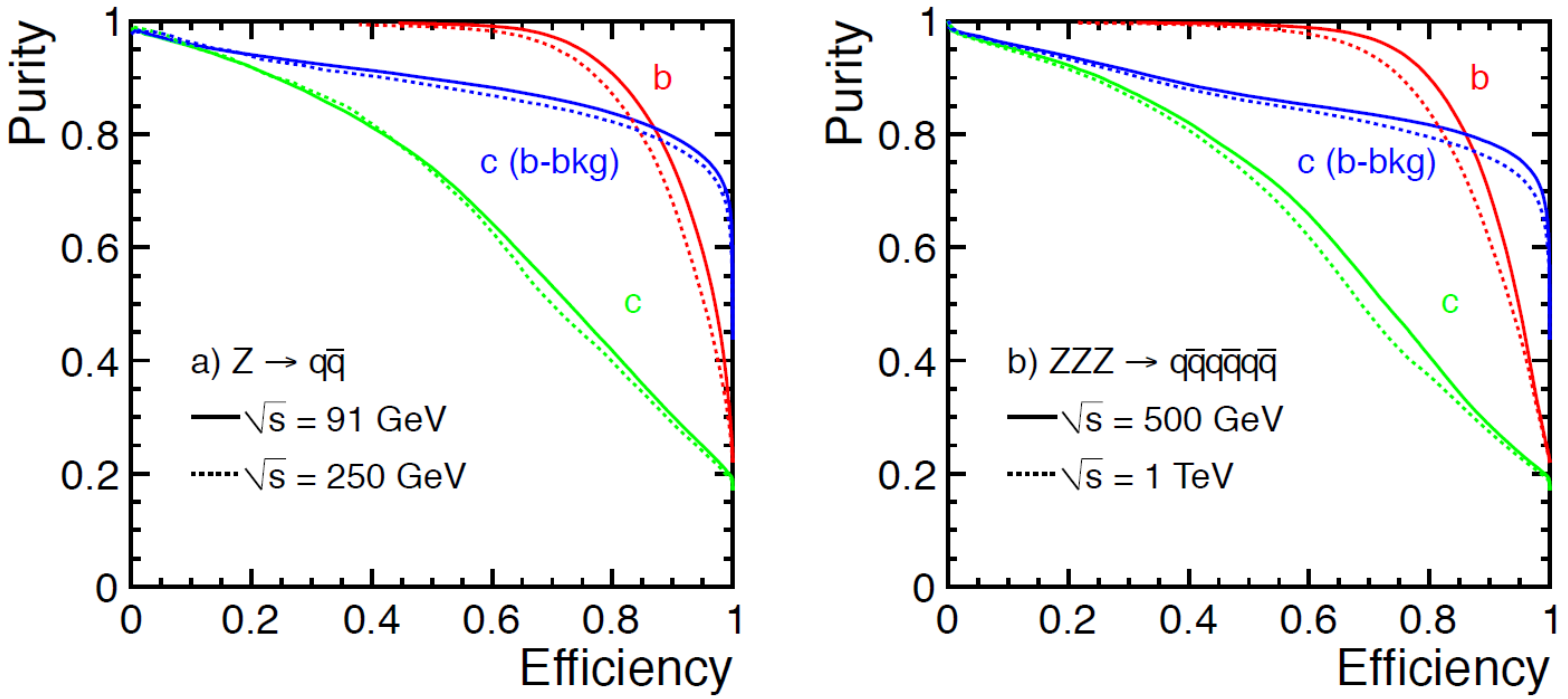
(goal : 0.15%X^0/layer)

Impact parameter resolution



- ✓ Resolution of the inner most layer matters.
- ✓ *Spatial resolution looks too good*
- ✓ Changing FPCCD outer 4 layers 5x5um^2→ 10x10um^2 does not affect the impact parameter resolution significantly. Tracking efficiency w. BG would be affected.

Flavour tagging



➔ VXD baseline configuration was used for DBD benchmark studies successful.

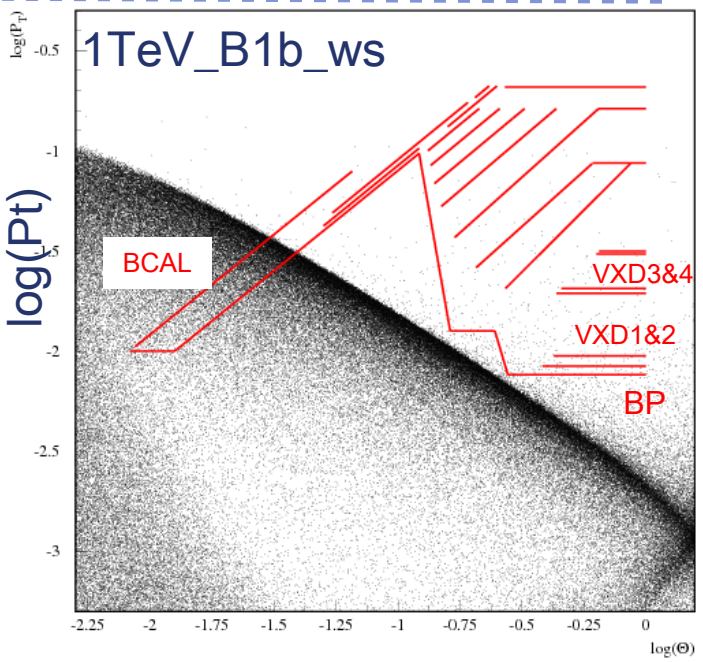
➔ Point resolution and detector materials of baseline design is good

Pair background hits

- Beam pipe and 1st VXD layers are designed to escape a dense region of pairs
- Direct hits and back scatterer from BCAL

- Studied by Mokka simulation.
  - > 30% ambiguities due to Geant4 parameters
  - Need Anti-DID. No 3D map available. Only "analytic map" has been used.

- Average pixel hit occupancies
  - 1~2% @ 500 GeV, 4~6% @ 1000 GeV conservative 9 pixels/tracker hits assumed.
  - ➔ need studies with a realistic digitizer and reconstruction codes to see impact on tracking eff. and physics performance



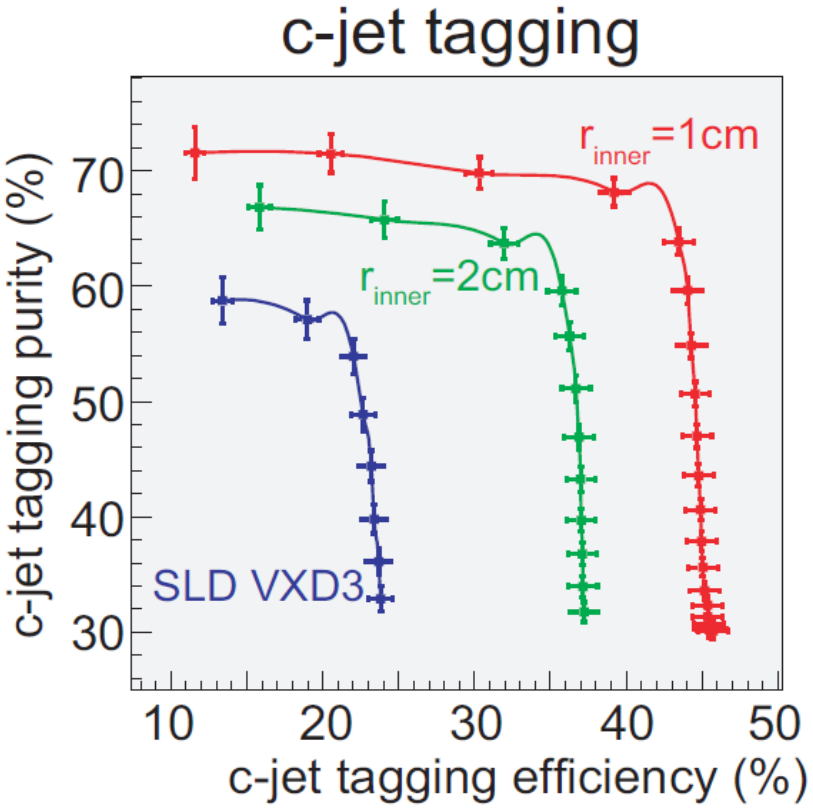
DBD Table III-5.4. VXD hits/cm2/BX

Layer	500 GeV	1000 GeV
1	6.320 ± 1.763	11.774 ± 0.992
2	4.009 ± 1.176	7.479 ± 0.747
3	0.250 ± 0.109	0.431 ± 0.128
4	0.212 ± 0.094	0.360 ± 0.108
5	0.048 ± 0.031	0.091 ± 0.044
6	0.041 ± 0.026	0.082 ± 0.042

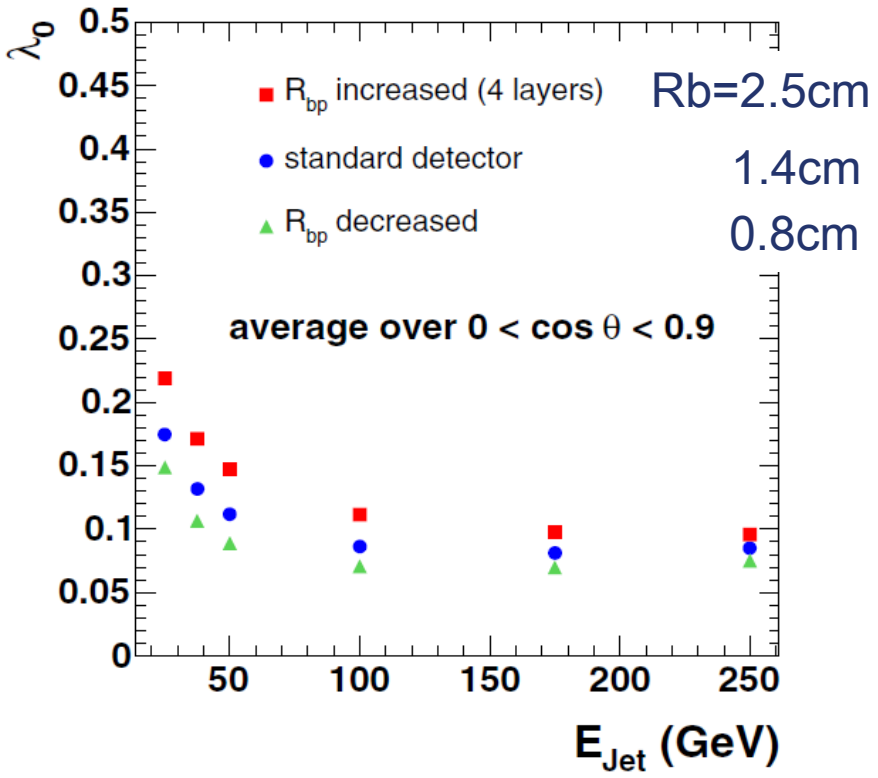
Issues in Post DBD era

- Performance with background hit
  - How much tolerance can we tolerate ?
  - Need realistic field map, realistic digitizer, track reconstruction with background filtering.
- Inner radius
  - 1 TeV → larger radius for less background with same R.O. time
  - 250 GeV → smaller radius for better resolution
- Outer layer - radius & pixel size
  - Little impact on impact parameter resolution.
  - Affect
    - performance of SiliconTracking & linking of TPC-SiT-VXD
    - larger pixel = lower power consumption
- Alternative geometry : 5 layers
- Vertexing with forward tracking

Performance vs inner radius : RDR



LCFIVertexing for $Z \rightarrow q\bar{q}$
ΔR=0.5cm ➔ $\Delta\eta \sim 5\%$
Impact on $\Delta Br(h \rightarrow c\bar{c})$?
LCFIPlus ?



Probability of misreconstructing B^0 vertex as $B^{\pm}$, vs B jet energy
For EJet=50GeV,
$\lambda_0 \sim 0.11(1.4cm) \Rightarrow 0.08(0.8cm)$
LCFIPlus ?

Summary

- ILD vertex detector performed well in DBD benchmarking.

- Several issues remain to be studied in DBD
  - Performance with realistic background conditions
    - with a realistic field map with anti-DID and QCs
    - tracking in bkg. environment.
    - Tracking with forward detectors

- Detector options not well studied in DBD
  - Inner radius : smaller for lower energy run, larger for higher energy
  - Outer layers : radius, pixel size …
  - 5 layers,