Current and future FCC-ee vertex detector layouts and their performance

FCC-ee vertex detector R&D workshop, INFN Pisa

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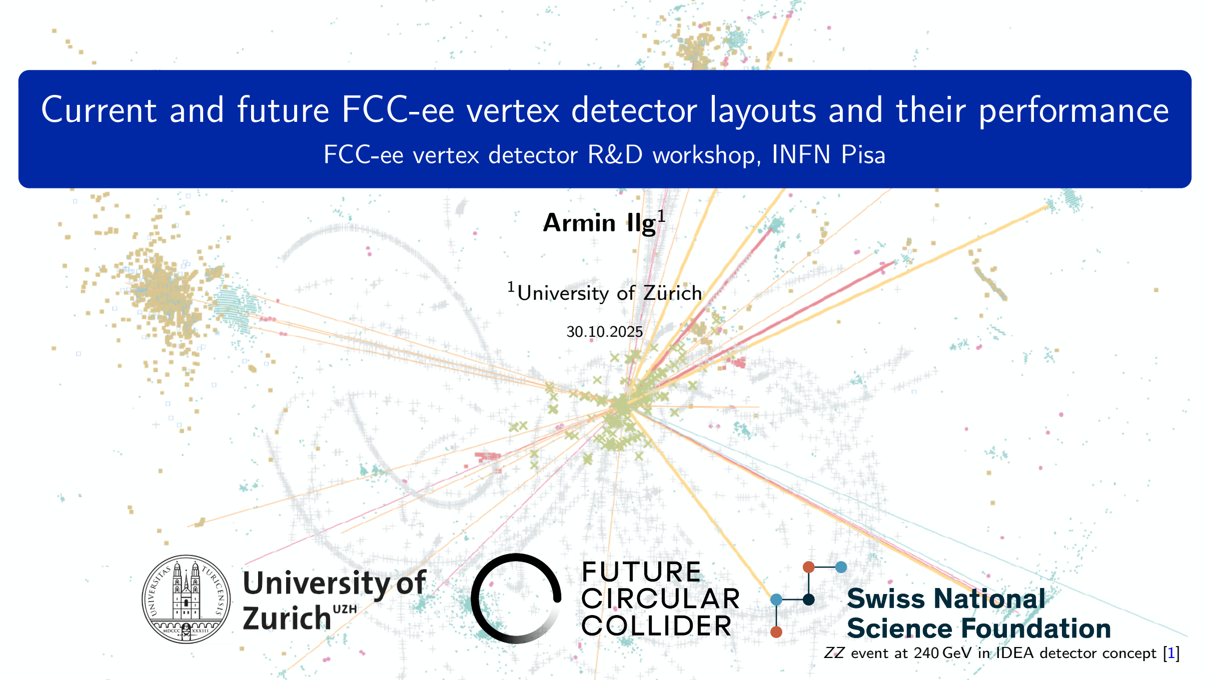
University of Zurich UZH

FUTURE CIRCULAR COLLIDER

Swiss National Science Foundation



ZZ event at 240 GeV in IDEA detector concept [1]

Recipe for a vertex detector at FCC-ee

Goal: Supreme impact parameter resolution: $\sigma_{d_0} = a \oplus b/(p \sin^{3/2}\theta) = 3 \oplus 15/(p \sin^{3/2}\theta)\mu\text{m}$

- Good single-hit resolution
- Material budget per layer of $\lesssim 0.3\,\% X_0$

→ So far, only monolithic active pixel sensors (MAPS) are envisioned to deliver this

Layout

- Beam pipe as thin and light as possible
- (Inner) vertex detector: ≥ 3 hits per track, first layer as close as possible to IP
- Outer vertex in front of gas tracker: Up to $\sim 35\,\text{cm}$ in r (high hit rate, precise hit before tracker). Relaxed material budget and resolution requirements: How relaxed?
- Forward coverage constrained by lumical Is a light pixel layer before lumical possible?
- Redundancy in design, alignment, calibration… → More/double layers?

Collision environment at Z pole

- Radiation tolerant components (less than HL-LHC), high hit rate (see backup for past studies)
- Tracking efficiency under beam background: $\sigma_t < 20\,\text{ns}$ for bunch resolution and integration time $\leq 1\,\mu\text{s}$? Much better for beam background rejection?

Layout and performance of CLD detector concept

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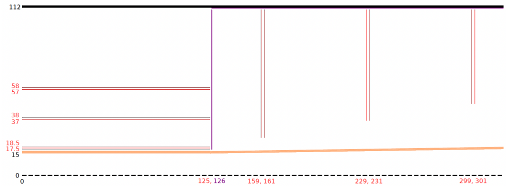
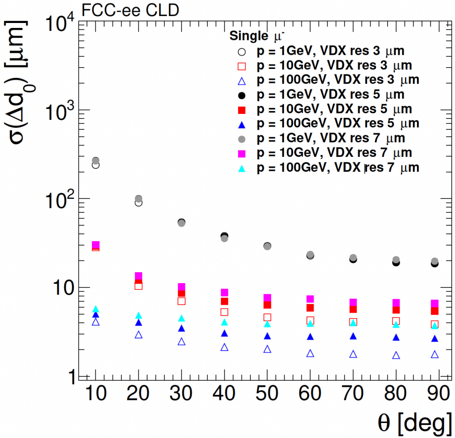
CLD $\rightarrow$ Rescaled CLICDet vertex detector



CLD vertex detector layout [2]

$\rightarrow$ Also currently used for ILD@FCC-ee



Full sim, CLD_o2_v05 [3]

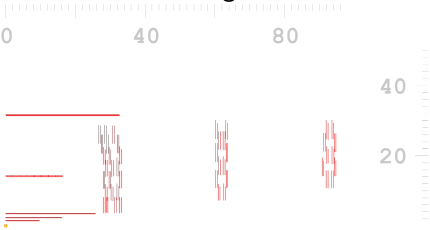
- $r_{\mathrm{min}} = 13\,\mathrm{mm}$
- Three double-layer barrel layers and disks, 0.6–0.7% X_0 per double layer
- No engineering studies since CLICDet developments $\rightarrow$ Simple DD4hep full sim. implementation
- No specific sensor chosen, assume 3 μm single-point resolution

$\rightarrow b \approx 18\,\mu\mathrm{m\,GeV}^{-1}$

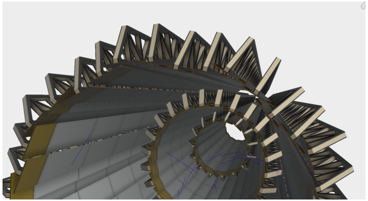
$3 \times 3\,\mu\mathrm{m}^2$ single-hit resolution is ok

The IDEA/ALLEGRO vertex detector

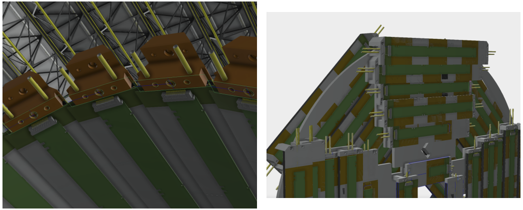
IDEA → Original FCC-ee vertex layout



→ Also currently used for ALLEGRO



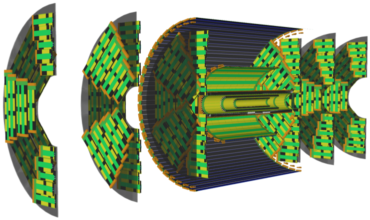
- $r_{min} = 13.7$ mm
- Three inner barrel single-layers (0.25% X_0), two outer barrel layers and three disks
- Engineered design (INFN-Pisa) integrated into machine-detector interface (INFN-LNF [4])
- IDEA baseline: ARCADIA [5] (inner barrel, $25 \times 25\,\mu m^2$) and ATLASPix3 [6] (outer barrel and disks, $150 \times 50\,\mu m^2$) sensors

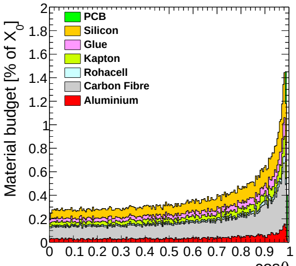


- Assume 3 µm / 14 × 43 µm resolution for performance studies

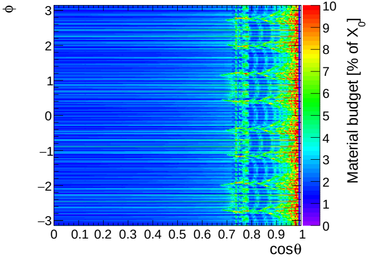
The IDEA/ALLEGRO vertex detector in full simulation

- Detailed description of support and on-detector readout structures
- Insensitive sensor peripheries described → Check for hermeticity!

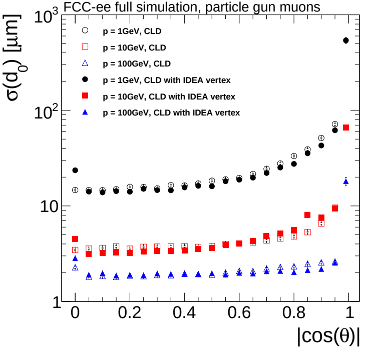




Layer 1



Complete vertex, 2D



IDEA vertex inserted in CLD using conformal tracking, k4DetPerformance

- $\cos(\theta) = 0$: No hit in first layer (gap between sensors)

→ $b \approx 14\,\mu\text{m GeV}^{-1}$

MAPS in 65 nm TPSCo process

- More logic per cm^2
- Lower power consumption $\rightarrow$ Air cooling
- Enables 12-inch wafers $\rightarrow$ Wafer-scale bent sensors!

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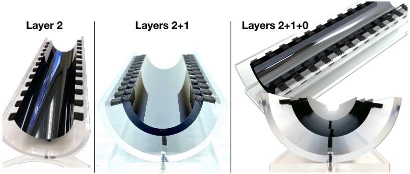
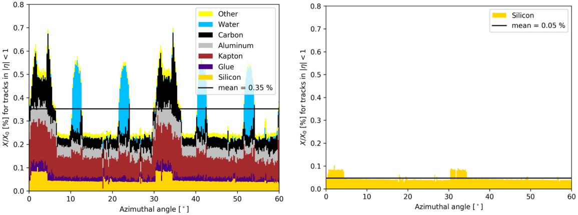
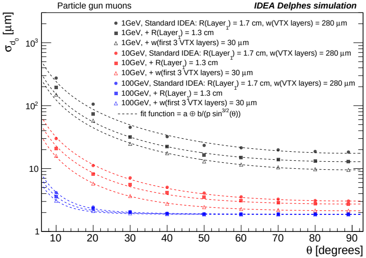


Layer assembly concept for ALICE ITS3



Material budget in ALICE ITS2 (left, [7]) and silicon only (M. Mager)



Fast simulation study of reduced-material vertex detector variants [8]

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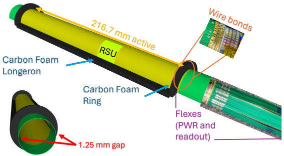
Ultra-light inner vertex concept for FCC-ee

Layer 1 and 2: $r = 13.7, 20.35\,\mathrm{mm}$

- 10 and 13 repeated sensor units long → $|\cos(\theta)| < 0.992/0.99$
- Peripheries, gap between half-barrels → Rotation in ϕ to fill gaps
- Readout and power from both sides

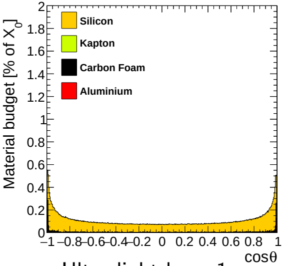


Layer 1 layout

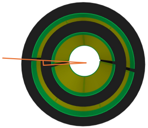
Layer 3 and 4: $r = 27, 33.65\,\mathrm{mm}$

- Two sensors per side, readout only on sides, power on sides and centre (power wire)
- 8 (10) RSUs on +z (-z) side for layer 3, inverted for layer 4
  → $|\cos(\theta)| < 0.991/0.986$

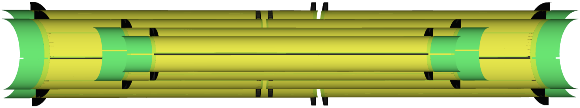
Assume 50 µm of Si + 16 µm of Si-equivalent (metal layer along sensor)



Ultra-light layer 1



Layer 1+2 front

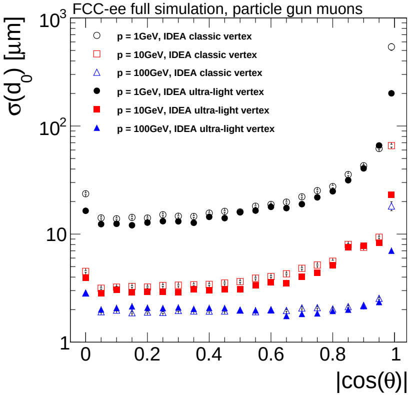


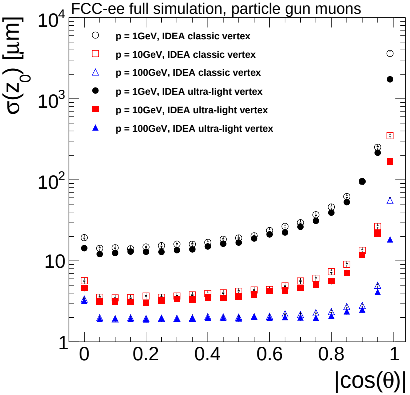
Longitudinal cross section of all four layers

$0.075\%\ X_0$ at $\cos(\theta) = 0$

→ > 3 improvement!

Ultra-light vertex detector performance





→ Significant improvements for low-momenta particles

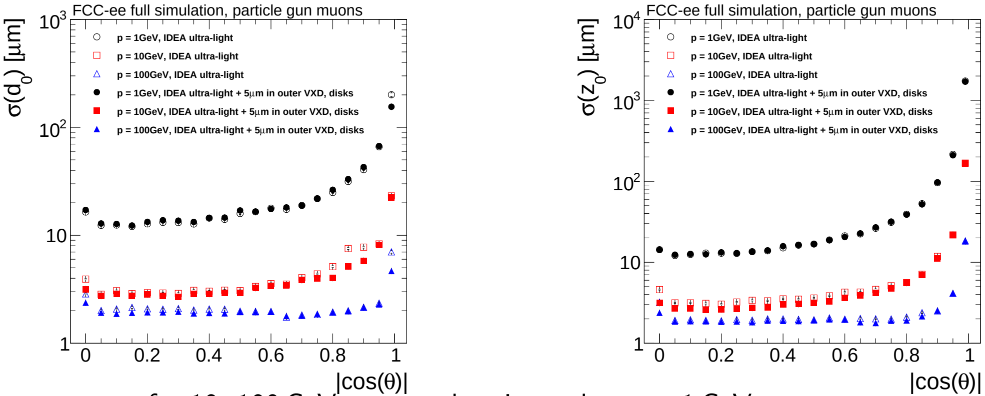
- Even though there's no first layer hit in ≈ 10% of the cases ($|\cos\theta| = 0$: 100%)

- $b \approx 12.5\,\mu\text{m GeV}^{-1}$
- Reason for $\sigma(d_0)$ deterioration at 100 GeV unclear

Impact of improved disks

IDEA middle ($r = 13\,\text{cm}$) and outer barrel ($r = 31.5\,\text{cm}$) and disks currently foresee ATLASPix3 sensors, with resolution of $43 \times 14\,\mu\text{m}^2$ ($\text{pitch}/\sqrt{12}$)

→ How good would IDEA vertex be if we had instead $5 \times 5\,\mu\text{m}^2$ resolution?



→ Improvement for 10, 100 GeV muons, deteriorated σ_{d_0} at 1 GeV (not yet understood)

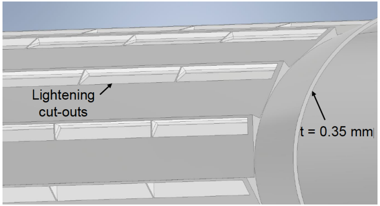
- Full track reco in IDEA/ALLEGRO → Check impact on momentum resolution as well

Importance of first layer radius

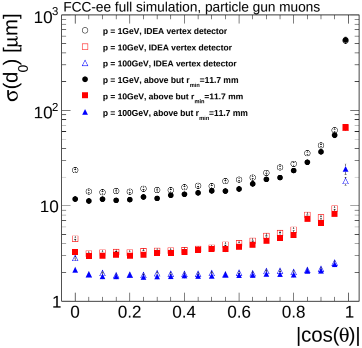
The first layer radius is important for the asymptotic impact parameter resolution (a)

Idea to put staves of sensors directly onto beam pipe

- Cooled through beam pipe cooling (paraffin) → Less air cooling needed
- Electrical insulation with kapton layer below sensor

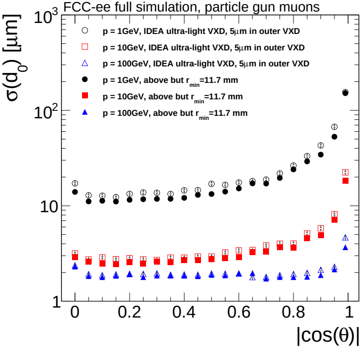


First design effort to move to $r = 11.7\,\mathrm{mm}$ in IDEA (G. Ammirabile)



IDEA classic

$\rightarrow b \approx 12\,\mu\mathrm{m\,GeV}^{-1}$



IDEA ultra-light

$\rightarrow b \approx 11.8\,\mu\mathrm{m\,GeV}^{-1}$

Importance of first layer radius

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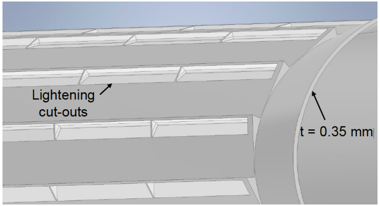

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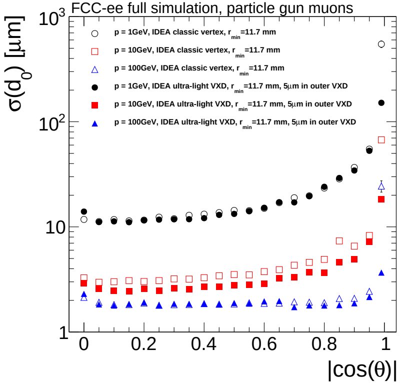


→ $p = 10\,\text{GeV}$: Significant benefit of low-X_0 VXD

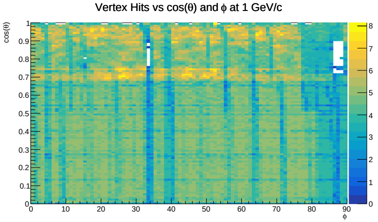
→ $p = 1\,\text{GeV}$: Lower r_{min} → Less travel distance for particles after scattering off beam pipe material → Better σ_{d_0}

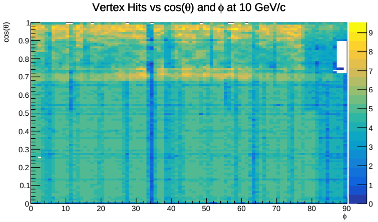
Ultra-light vertex detector – the issue of hermeticity

Work with UZH summer student **Mohamed Ahmed**

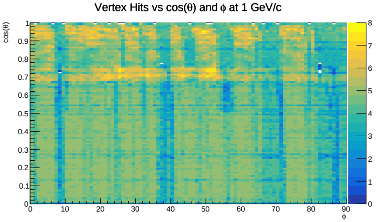
Gaps between the half-layers and peripheries within the the stitched sensor → Implemented exactly as in ITS3 TDR (93 % sensitive only, +2.5% without auxiliary pads)

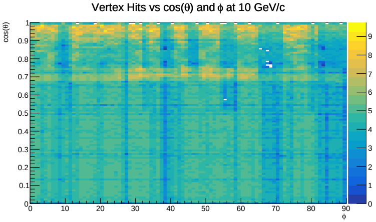
Before rotation optimisation





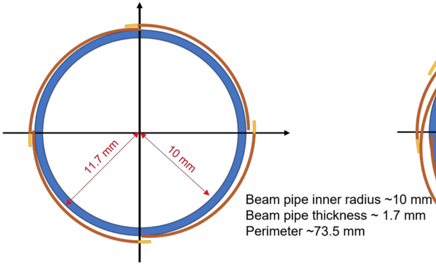
After rotation optimisation

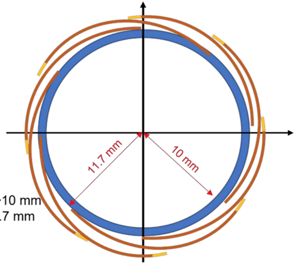




Snail-shape vErtEx Detector (FCC-SEED) proposal by French institutes, also submitted as FCC Detector R&D EoI

- Stitching only along z, overlap between curved sensors → Full detector coverage
- More flexible in sensor size and detector layout
- So far looked at option on the left





Layer	1	2	3	4	5
Radius (mm)	12-13	24	36	48	60
Zmax (mm)	90	120	120	120	120
Perimeter (mm)	75	151	226	302	377
# Chips per ladder	6	8	8	8	8
# ladders	4	8	12	16	20

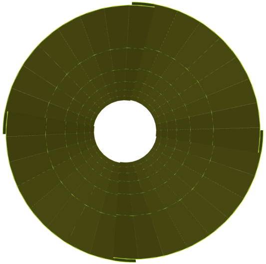
Layer	1-2	3-4	5-6
Radius (mm)	12-13	35-36	59-60
Zmax (mm)	90	120	120
Max perimeter (mm)	82	226	377
# Chips per ladder	6	8	8
# ladders	4	12	20

Single chip dimension	$30 \times 22.2\ mm^2$
Sensitive area chip dimension	$30 \times 19.2\ mm^2$

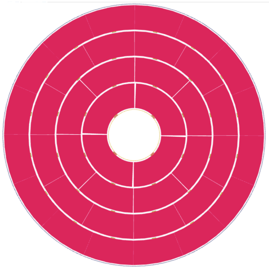
See A. Besson and J. Andrea's talk at 8th FCC Physics Workshop

→ Implemented FCC-SEED in DD4hep and tested it within CLD detector concept (vertex disks unchanged currently).

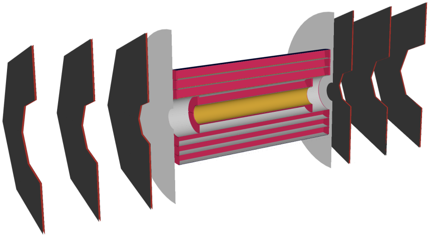
FCC-SEED: **Preliminary** full simulation layout



First layer sensors only



Carbon foam rings



Work with UZH summer student **Mohamed Ahmed**

- First layer at r_{min} of 11.8 mm, after 100 µm of Kapton
- Carbon foam longerons and rings, similar to ultra-light VXD design
- Thin layer of carbon fibre between sensors, flex (same as in IDEA inner vertex) on top of periphery
- Outer carbon fibre shell (same as in IDEA inner vertex)
- No off-detector services or supports or "end-of-stave" structures yet

FCC-SEED: **Preliminary** performance

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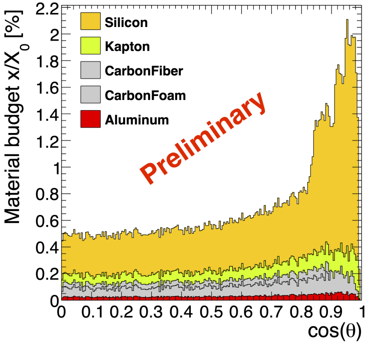
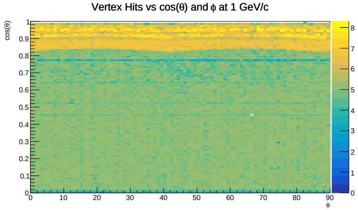
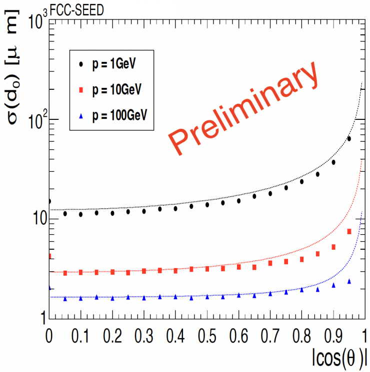






- 0.5 % X_0 in five layers → 0.1 % X_0 per layer

→ $b \approx 11.1\,\mu\mathrm{m\,GeV}^{-1}$ for $r_{min} = 11.8\,\mathrm{mm}$

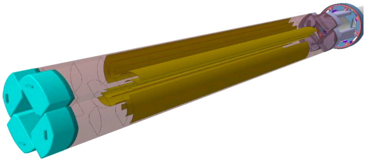
Detailed presentation in last detector concept meeting

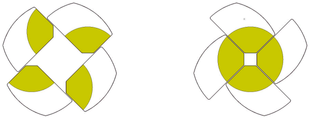
Next steps: MR to k4geo, revisit stitching gaps, replace CLD disks, optimise (reduce) support material, add cables/fibres and end-of-ladder structure

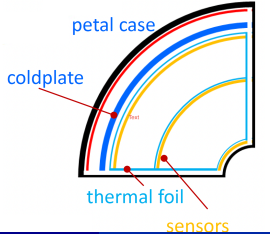
ALICE3-like vertex detector idea

ALICE ITS3 is cool. But what about ALICE3?

ALICE3-like vertex detector idea



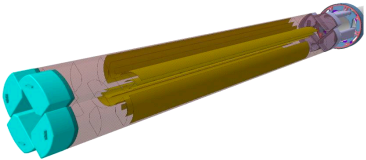


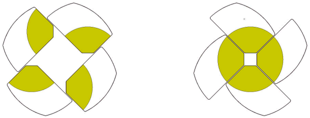


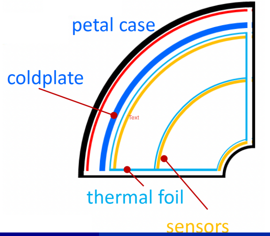
ALICE3 IRIS

- $r_{\mathrm{min}} = 5\,\mathrm{mm}$, retractable
- 3 curved layers of sensors, 4 secondary vacuua
- Retractable to increase $r_{\mathrm{min}} \rightarrow$ During LHC filling
- Liquid CO2 cooling ($T_{\mathrm{sensor}} \sim -25\,^{\circ}\mathrm{C}$)
- Secondary beam pipe of only 300 μm Be thickness (FCC-ee: 700 μm of AlBeMet167 + 1 mm of paraffin)

ALICE3-like vertex detector idea







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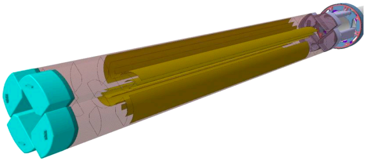
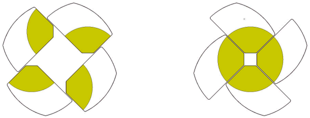
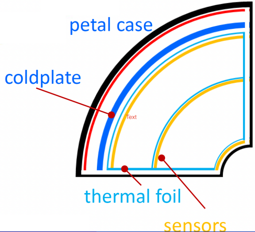
Considerations for FCC-ee

- r_{min} not below 10 mm
- Maybe 4 layers, and 1–2 sec. vacuua?
- Retractability prob. not useful (top-up injection)
- T_{room} ok for sensors
- Beam power @ ALICE3: $\sim 30\,\text{W}\,\text{m}^{-1}$ (FCC-ee: $\sim 300\,\text{W}\,\text{m}^{-1}$)
- IPC hit rate tolerable?

ALICE3-like vertex detector idea







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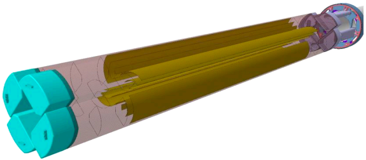
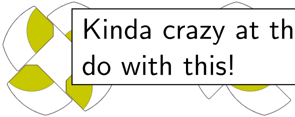
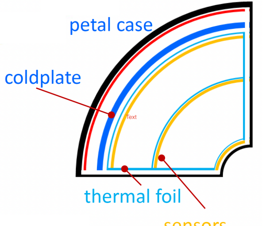
- IPC hit rate tolerable?
- Clearly whole MDI region would need to be redesigned from scratch...

ALICE3-like vertex detector idea







ALICE3 IRIS

- $r_{\text{min}} = 5\,\text{mm}$, retractable
- 3 curved layers of sensors, 4 secondary vacuua
- Retractable to increase $r_{\text{min}} \rightarrow$ During LHC filling
- Secondary beam pipe of only 300 µm Be thickness (FCC-ee: 700 µm of AlBeMet167 + 1 mm of paraffin)

Considerations for FCC-ee

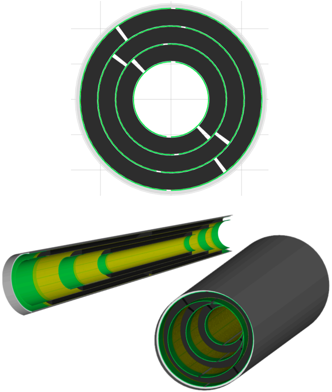
- r_{min} not below 10 mm
- Maybe 4 layers, and 1–2 sec. vacuua?
- Retractability prob. not useful (top-up injection)
- Beam power @ ALICE3: $\sim 30\,\text{W}\,\text{m}^{-1}$ (FCC-ee: $\sim 300\,\text{W}\,\text{m}^{-1}$)
- IPC hit rate tolerable?
- Clearly whole MDI region would need to be redesigned from scratch...

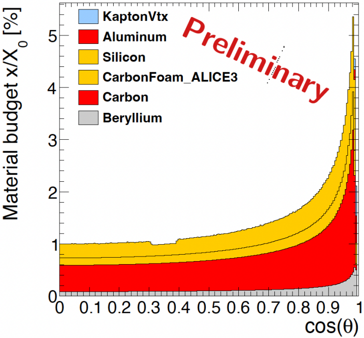
Kinda crazy at the moment... But just for fun... Let's see what we could do with this!

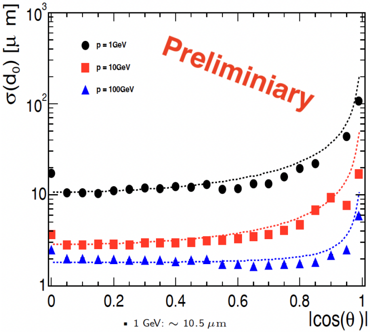
ALICE3-like vertex detector idea – first performance evaluation

University of Zurich[UZH]

Work with UZH summer student **Mohamed Ahmed**

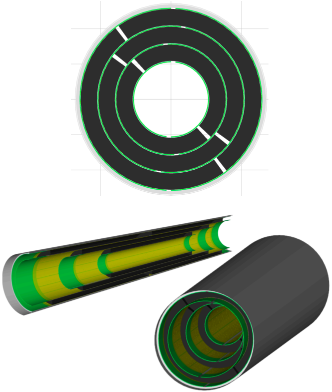


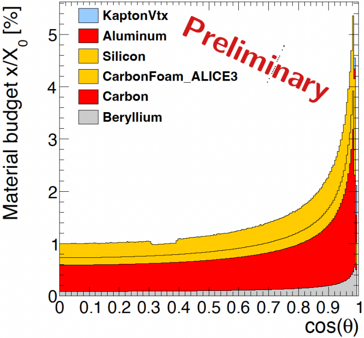


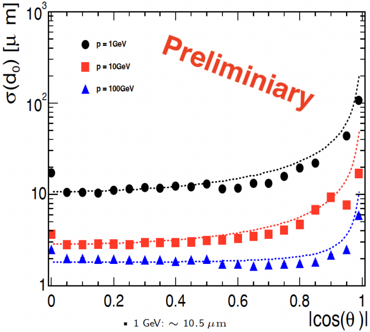


$b \approx 10.5\,\mu\text{m}\,\text{GeV}^{-1}$ achieved, expected a bit better → Under investigation

Work with UZH summer student **Mohamed Ahmed**







$b \approx 10.5\,\mu\text{m}\,\text{GeV}^{-1}$ achieved, expected a bit better → Under investigation

Would need many more studies to see if feasible/worth it at FCC-ee!

Silicon layer outside gaseous tracker

$\mathcal{O}(10\,\mu m)$ in r–ϕ for momentum resolution

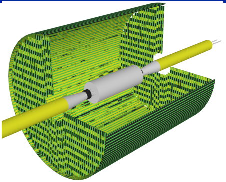
- Disk: Expand tracker coverage in forward region. $\mathcal{O}(10\,\mu m)$ in θ for precise detector acceptance definition?
- Is resolution of $\mathcal{O}(100\,\mu m)$ in z (barrel) enough? Benefit of $\mathcal{O}(10\,\mu m)$?
- Potentially σ_t of $\mathcal{O}(\leq 100\,ps)$ for PID
  $\rightarrow$ Silicon microstrip, LGADs, or MAPS?

Implemented silicon wrapper in DD4hep

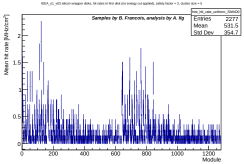
- Two barrel and disks, ≥ 2 hit down to $|\cos\theta| < 0.989$
- Tiles with large $(4 \times 4\,cm^2)$ sensors
- Next iteration: One layer, rings in disks

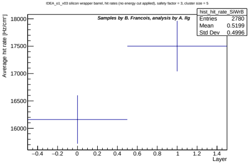
Questions:

- Inner timing layer as well?
- Same technology as outer vertex possible?

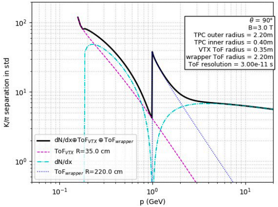


Complete SiWr in DD4hep

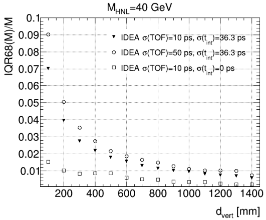




Hit rate in first SiWr disk (top) and barrel (bottom)



Outer + inner TOF at 3 T



Relative mass resolution on HNL as a function of its flight distance [9]

What does all of this teach us?

About vertex detector layouts:

- r_{min} crucial also for low-momentum tracks. First layer on beam pipe? Secondary vacuum?
  - → Limited by IPC hit rate and cooling → Also influences sensor choice (charge sharing)
- Non-hermetic layers don't prevent good IP resolutions, but advantages of hermetic design clearly visible (especially for first layer)
- Good spatial resolution in outer vertex desirable
  - → What material budget can we afford there? Liquid or air cooling?
  - → Inner T.O.F layer? Which technology?
- Benefit of close-to-IP disks? Potential benefits of pixel sensors in front of lumical?
- Redundancy in design: How many layers, double-sided?

About MAPS:

- Optimise power consumption (enabling air cooling)
- Minimisation of periphery → Lower material budget (stave-like design) or better hermeticity (2D-stitched designs)
- Timing: $\sigma_t < 20\,\text{ns}$ and $t_{\text{int}} \leq 1\,\mu\text{s}$? Background rejection?

2025 – 2027: Explore various kinds of vertex detector concepts and layouts, develop tools necessary to enable efficient comparison

Vertex detector concepts comparison

- Interfacing sensor simulation (from TCAD or AllPix2) with detector full simulation to realistically evaluate final tracking and vertexing performance
- Establishing figures of merits evaluation workflow (incl. case study designs)
- Establish workflow for machine background study

→ First rough exploration of vertex detector phase space

What should we now do? → Check vertex EoI

2025 – 2027: Explore various kinds of vertex detector concepts and layouts, develop tools necessary to enable efficient comparison

Vertex detector concepts comparison

- Interfacing sensor simulation (from TCAD or AllPix2) with detector full simulation to realistically evaluate final tracking and vertexing performance
- Establishing figures of merits evaluation workflow (incl. case study designs)
- Establish workflow for machine background study

→ First rough exploration of vertex detector phase space

I think that's still what we should do to answer questions on previous slide. Progress on all points is ongoing.

University of Zurich[UZH]

2025 – 2027: Explore various kinds of vertex detector concepts and layouts, develop tools necessary to enable efficient comparison

Vertex detector concepts comparison

- Interfacing sensor simulation (from TCAD or AllPix2) with detector full simulation to reali
- Esta
- Establish workflow for machine background study

2028 – 2030: Narrow down to just a couple of vertex detector concepts as input to detector CDRs, and to be studied in more detail in the TDR phase

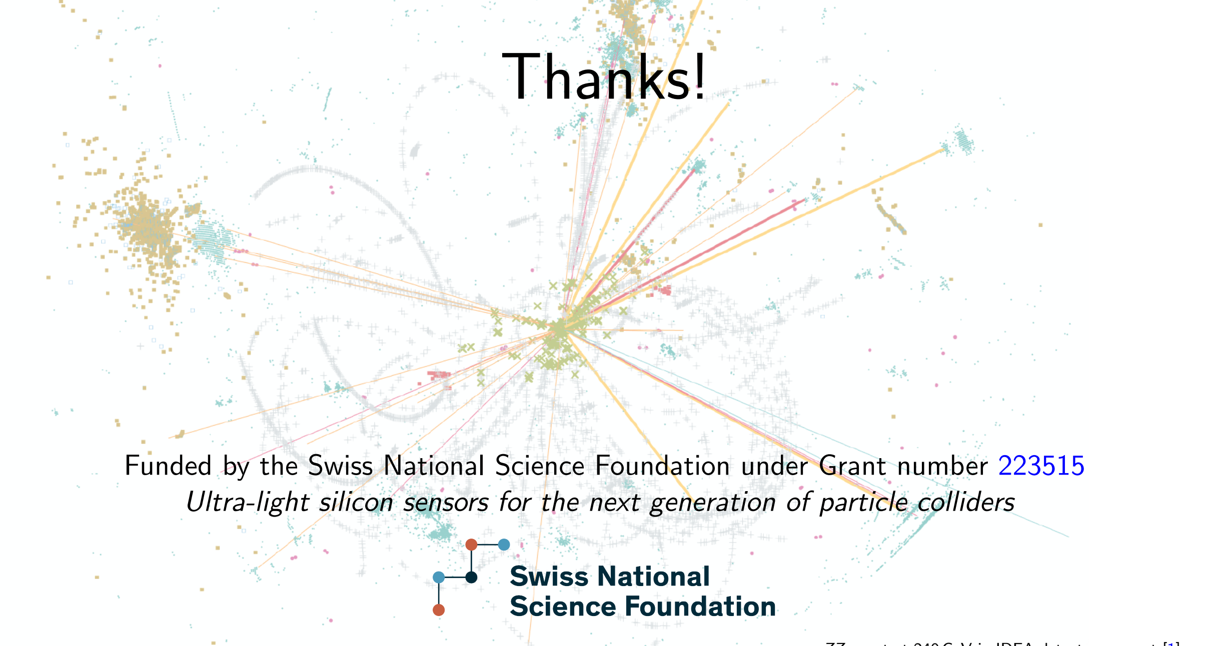
→ First rough exploration of vertex detector phase space

I think that's still what we should do to answer questions on previous slide. Progress on all points is ongoing.

Thanks!

Funded by the Swiss National Science Foundation under Grant number 223515
Ultra-light silicon sensors for the next generation of particle colliders

Swiss National Science Foundation



ZZ event at 240 GeV in IDEA detector concept [1]

University of Zurich[UZH]

[1] IDEA Study Group Collaboration, M. Abbrescia et al., *The IDEA detector concept for FCC-ee*, arXiv:2502.21223 [physics.ins-det].

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[6] I. Peric, et al., *High-Voltage CMOS Active Pixel Sensor*, IEEE Journal of Solid-State Circuits **56** (2021) 2488–2502.

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[11] M. Aleksa, et al., *Calorimetry at FCC-ee*, The European Physical Journal Plus **136** (2021) 1066.

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[13] A. Ciarma, M. Boscolo, G. Ganis, and E. Perez, *Machine Induced Backgrounds in the FCC-ee MDI Region and Beamstrahlung Radiation*, Proceedings of the 65th ICFA Advanced Beam Dynamics Workshop on High Luminosity Circular e+e- Colliders **eeFACT2022** (2022) Italy, https://jacow.org/eefact2022/doi/JACoW-eeFACT2022-TUZAT0203.html.

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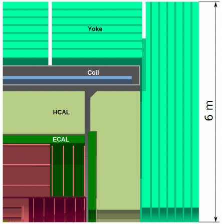
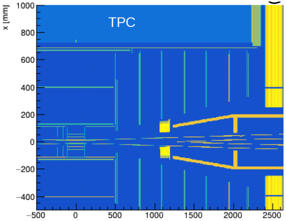
[15] E. Brondolin, et al., *Conformal tracking for all-silicon trackers at future electron–positron colliders*, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment **956** (2020) 163304, http://dx.doi.org/10.1016/j.nima.2019.163304.

FCC-ee detector *concepts* (modulo some variations)

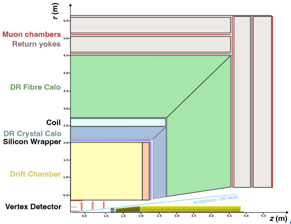
University of Zurich[UZH]



CLD [2]



ILD [10]



IDEA [1]

ALLEGRO [11]

- Light silicon vertex detector using monolithic active pixel sensors (MAPS)

CLD
- Si tracker
- dE/dx + ARC (?)
- CALICE-like highly-granular ECAL/HCAL
- Solenoid coil outside calorimeter system

ILD
- Si tracker + time projection chamber
- Si or ECAL with T.O.F
- CALICE-like highly-granular ECAL/HCAL
- Solenoid coil outside calorimeter system

IDEA
- Ultra-light drift chamber with d$N_{\text{ion.}}$/dx
- Si layer with T.O.F
- Dual-readout crystal ECAL
- Light solenoid up to 3 T
- DR fibre HCAL

ALLEGRO
- DC/SciFi/Straw tubes
- Si layer with T.O.F
- Noble liquid ECAL, Pb/W+LAr or W+LKr
- Solenoid in same cryostat as ECAL
- TileCal HCAL

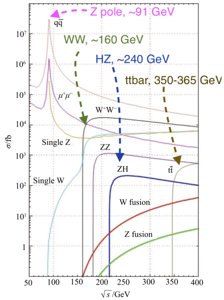
- Muon system in return yoke, pretty much det. concept independent (e.g. μ-RWELL in IDEA)

Experimental environment at the FCC-ee (Z pole)

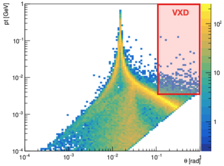
☺: e^+e^- collisions are *clean* - there's no QCD in the initial state

☹: Very high inst. luminosity of $140 \times 10^{34}\,\text{cm}^{-2}\text{s}^{-1}$ thanks to 37 MHz bunch collision rate ($t_{\text{BC}} = 27$ ns currently)

- Very high rate of interesting events (60 kHz of Z, 18 kHz of $\gamma\gamma \to$ hadrons, 30 kHz of bhabha pairs) that need to be read out and saved (and simulated!)
- "Pile-up" Z bosons of $\sim 60\,\text{kHz}/50\,\text{MHz} = 0.00162$
  - → Integrate over of a couple of bunch crossings?
  - → But need to check impact on uncertainties
- Considerable beam backgrounds, mainly from incoherent pairs
  - High hit rate innermost vertex layers, occupancy challenges in gaseous tracker and ECAL
  - → Challenge also for readout
  - Few 10^{13} 1 MeV $\text{n}_{\text{eq}}\text{cm}^{-2}$ and few tens of kGy per year in vertex detector



e^+e^- annihilation cross section [12]



Incoherent pairs at Z pole [13]

IPC hit rate methodology and previous results

Common assumptions so far:

- Incoherent pair creation (IPC) dominant. Radiative Bhabha scattering, synchrotron radiation, beamstrahlung are much lower
  - IPC simulated in GuineaPig MC generator and interfaced with Key4hep
- SIM hit to REC hit: Cluster size of 5, safety factor of 3, $25 \times 25\,\mu\text{m}^2$ pixels

Occupancy and hit rates:

- 2022, old lattice with 30 ns bunch spacing, CLD vertex detector, 70×10^{-6} per BC $\hat{=}$ $373\,\text{MHz}\,\text{cm}^{-2}$ [13]
- 2024, V23 lattice, IDEA vertex detector: 20×10^{-6} per BC $\hat{=}$ $170\,\text{MHz}\,\text{cm}^{-2}$
- 2024, V23 lattice, ultra-light vertex detector: 30×10^{-6} per BC $\hat{=}$ $250\,\text{MHz}\,\text{cm}^{-2}$
- 2025, V23 lattice, IDEA vertex detector with CAD beam pipe, GuineaPig particles set to (0,0,0), *SIM.filter.tracker = "edep0"*: 11×10^{-6} per BC $\hat{=}$ $90\,\text{MHz}\,\text{cm}^{-2}$, but bug in CAD beampipe (Air inside), samples by B. Francois

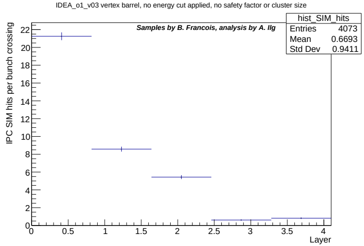
Expect further updates and changes!

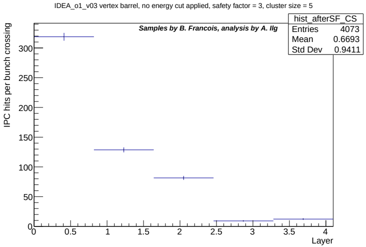
- Always highest at Z pole in innermost barrel and disk, rather flat along z and ϕ (see here)

Vertex hit rate – more details

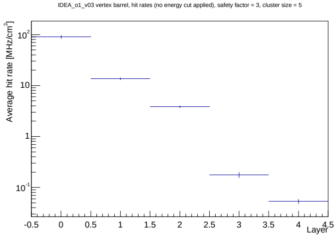
University of Zurich[UZH]

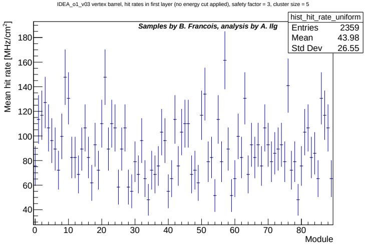
SIM hits



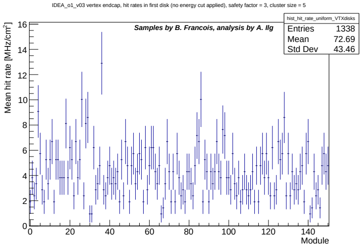


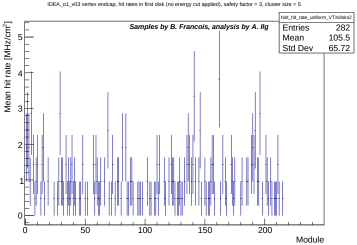
Vertex barrel hit rates

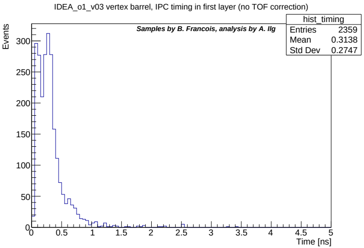


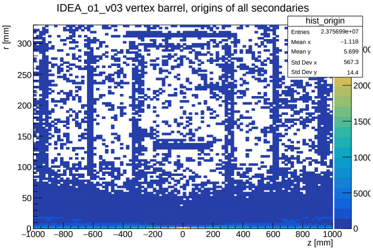


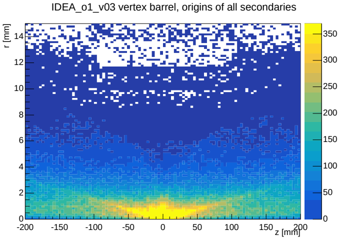
Vertex disk hit rates

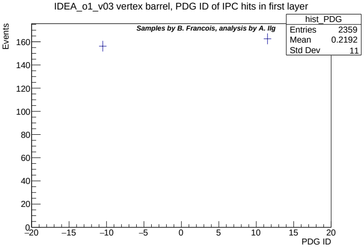


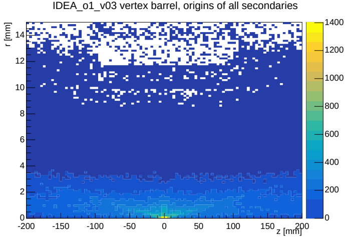


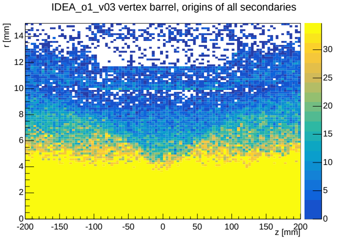

IDEA_o1_v03 vertex barrel, IPC timing in first layer (no TOF correction)
hist_timing
Entries 2359
Mean 0.3138
Std Dev 0.2747
Samples by B. Francois, analysis by A. Ilg
Events
Time [ns]


IDEA_o1_v03 vertex barrel, origins of all secondaries
hist_origin
Entries 2.375699e+07
Mean x −1.118
Mean y 5.699
Std Dev x 567.3
Std Dev y 14.4
r [mm]
z [mm]


IDEA_o1_v03 vertex barrel, origins of all secondaries
r [mm]
z [mm]

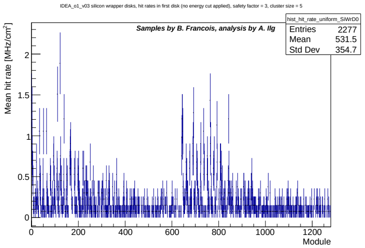

IDEA_o1_v03 vertex barrel, PDG ID of IPC hits in first layer
hist_PDG
Entries 2359
Mean 0.2192
Std Dev 11
Samples by B. Francois, analysis by A. Ilg
Events
PDG ID


IDEA_o1_v03 vertex barrel, origins of all secondaries
r [mm]
z [mm]

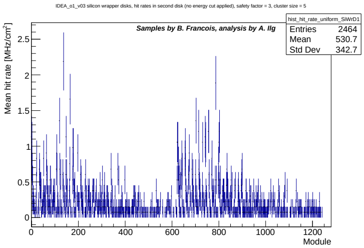

IDEA_o1_v03 vertex barrel, origins of all secondaries
r [mm]
z [mm]

Silicon wrapper hit rate results

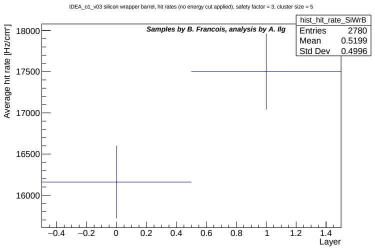
SiWr disk 0



SiWr disk 1



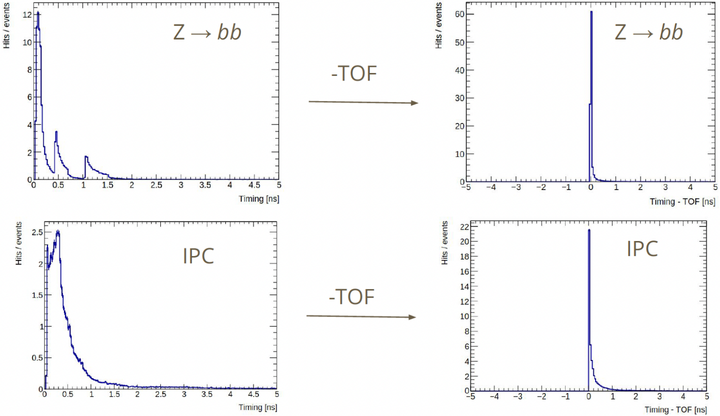
SiWr barrel



Disks: Assuming same tile size for all tiles (not true) → Overestimating hit rate in outer tiles

Timing of hits

N.B. timing of IPC may be misleading, we move all particles at the origin!



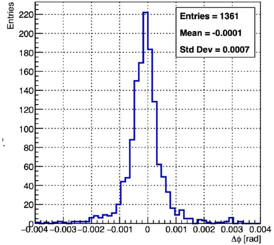
Work in progress, R. Simonielli, A. Koulouris, S. Franchellucci

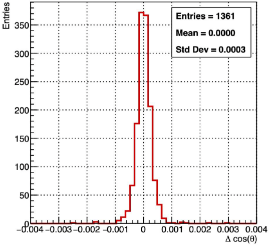
Track reconstruction in IDEA full simulation

University of Zurich[UZH]

Algorithmic reconstruction using Genfit2

- Providing track representation, track-fitting algorithms and graphic visualization
- Relying on ground truth

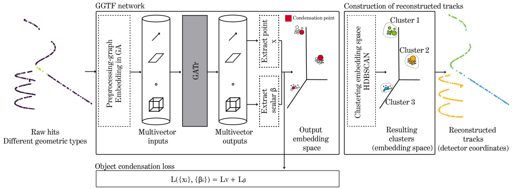


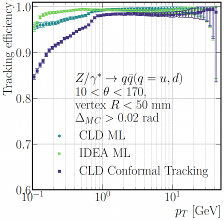


Vertex + drift chamber reco, $E = 5\,\text{GeV}$, θ between 15° and 80°, A. de Vita @ FCC Week 2025

ML-based track reconstruction

- GNN, detector agnostic
- Track refitting to be done still





Tracking efficiency [14]

Track reconstruction using conformal tracking

For CLD, simply use conformal tracking [15] (see talk by Leonhard)

For IDEA, eventually use

- ACTS tracking (talk by Samuel) → Not yet available for IDEA
- Genfit2 tracking or ML tracking (talk by Andrea) → Track refitting not yet done

For the moment simply insert IDEA vertex detector into CLD_o2_v05 and use conformal tracking!

Necessary changes

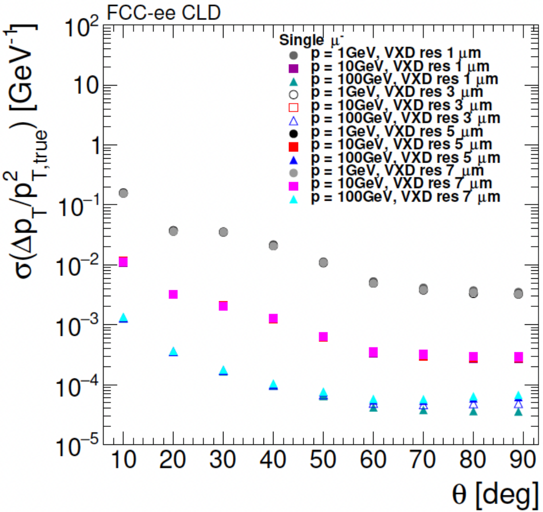
- Removing first Inner Tracker barrel layer ($r = 127$ mm)
- Removing first and second Inner Tracker disks ($r = 79.5$ and 123.5 mm)
- Unchanged conformal tracking max. distance (CT_MAX_DIST) and *MinClustersOnTrack*

Nota bene

- Tracking performance should be much better with drift chamber and silicon wrapper
- Assume spatial resolution of 3 μm for inner vertex barrel (same as CLD), and 14 μm × 43 μm for outer barrel and disks (CLD: vertex endcap: 3 μm, inner tracker endcap: 5 μm or 7 × 90 μm)

Not perfect, but works, reasonably meaningful for impact parameter resolution comparison

CLD study on resolution impact on momentum



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