The IDEA drift chamber

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Outline

- Challenges of tracking at future e^+e^- colliders
- IDEA Tracking System
- Features leading the detector design
- IDEA drift chamber:
  - Layout
  - Mechanical structure
  - Material budget
  - Particle Id
  - Tracking performance from simulations
- Expected performance from fast simulation on physics cases
- Conclusion

Challenges of tracking at future e^+e^- colliders

High Lumi e^+e^- colliders:

- EW factories (3×10^{12} $e^+e^- \rightarrow Z$, 10^8 $e^+e^- \rightarrow W^+W^-$)
- $t\bar{t}$ and Higgs boson factories (10^6 $e^+e^- \rightarrow t\bar{t}$, 10^6 $e^+e^- \rightarrow HZ$)
- flavor factories (5×10^{12} $e^+e^- \rightarrow b\bar{b}$, $c\bar{c}$, 10^{11} $e^+e^- \rightarrow \tau^+\tau^-$)

FCC-ee parameters		Z	W^+W^-	ZH	ttbar
$\sqrt{s}$	GeV	91.2	160	240	350-365
Luminosity / IP	10^{34} $cm^{-2}s^{-1}$	230	28	8.5	1.7
Bunch spacing	ns	19.6	163	994	3000
"Physics" cross section	pb	35,000	10	0.2	0.5
Total cross section (Z)	pb	40,000	30	10	8
Event rate	Hz	92,000	8.4	1	0.1
"Pile up" parameter [μ]	10^{-6}	1,800	1	1	1

Physics rates up to 100 kHz (at Z pole) → fast detectors and electronic

Tracker:

- High momentum ($\delta p/p^2 \leq$ few x 10^{-5}) and angular resolution $\Delta\vartheta \leq 0.1$ mrad (to monitor beam spread) for charged particle momenta ranging at the Z pole from a few hundred MeV/c to several tens of GeV/c
- Large angular coverage
- Large tracking radius to recover momentum resolution since magnetic field is limited to ~ 2 T to contain the vertical emittance at Z pole
- High transparency due to the low momentum particles from Z, H decays → Multiple Scattering (MS) contribution to the resolution is not negligible!
- Particle identification → to distinguish identical topology final states

Vertexing:

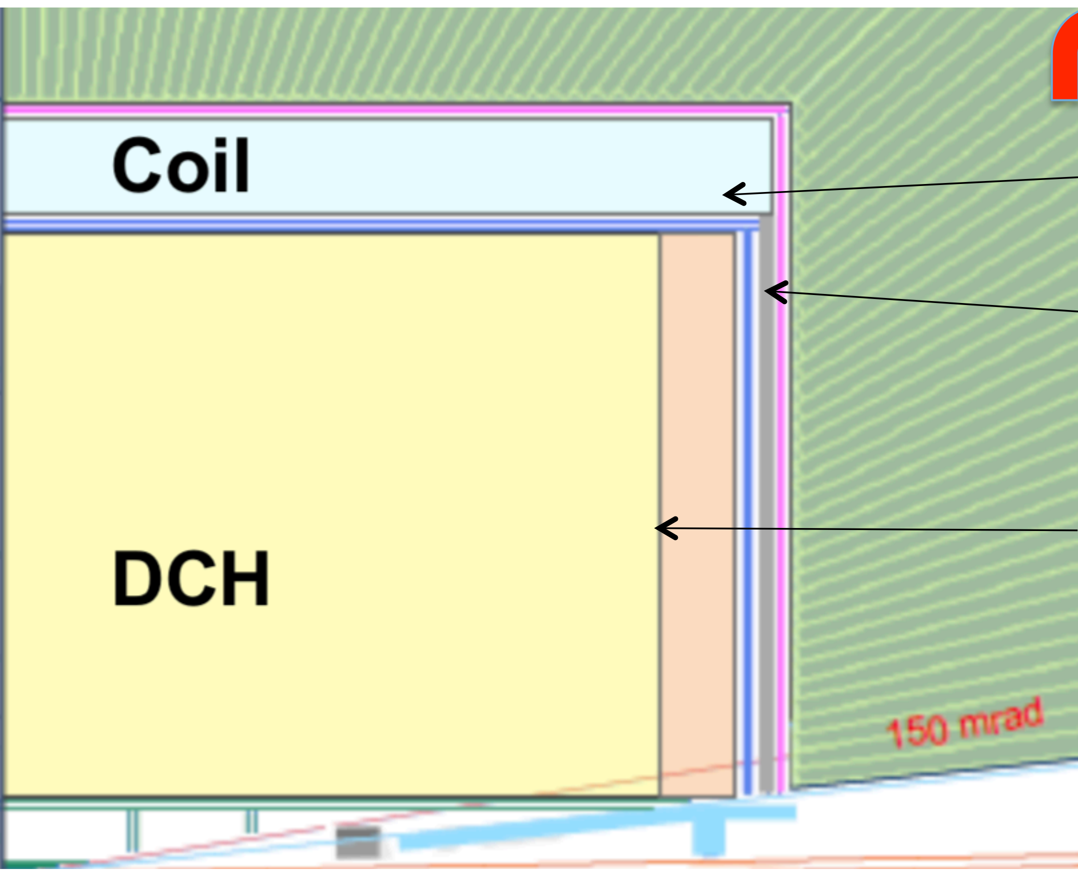
- Few μm track impact parameter resolution
- High transparency

IDEA Tracking System

IDEA → Innovative Detector for Electron-positron Accelerators (Details in the D. Contardo's talk in this Workshop)

FCC-ee at CERN

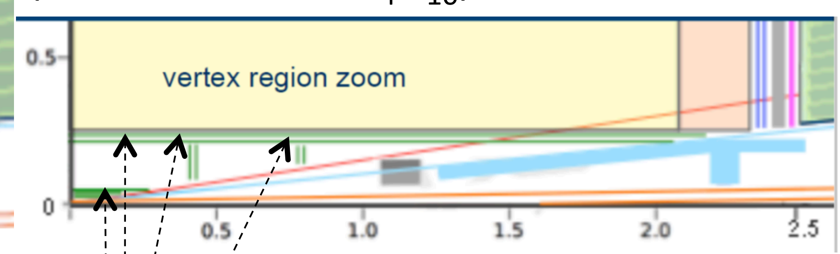
CEPC at IHEP-China



Solenoid: 2 T, length = 5 m,
r = 2.1-2.4 m, 0.74 X_0, 0.16 λ @ 90º

Si Wrapper:
2 layers of µ-strips (50 µm x 10 cm)
in both barrel and forward regions

Drift Chamber : 4 m long, r = 35-200 cm,
112 layers, He based gas mixture
(90% He – 10% i-C_4H_{10})



Vertex:

inner: 3 Si pixel (20 µm x 20 µm) layers, 0.3% X_0

outer: 2 Si pixel (50 µm x 1mm) layers, 0.5% X_0

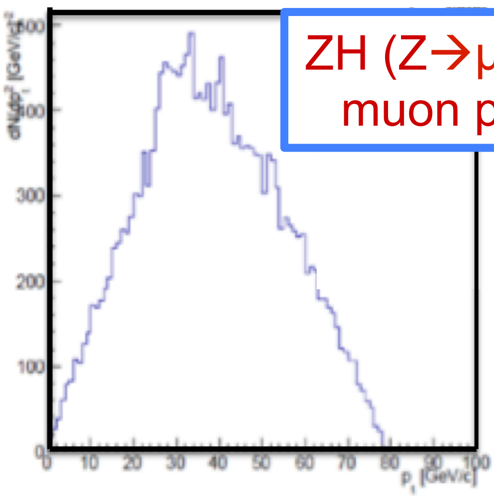
forward: 4 Si pixel (50 µm x 50 µm) layers, 0.3% X_0

Ion backflow and space charge buildup → no TPC-like detector in tracking system!!

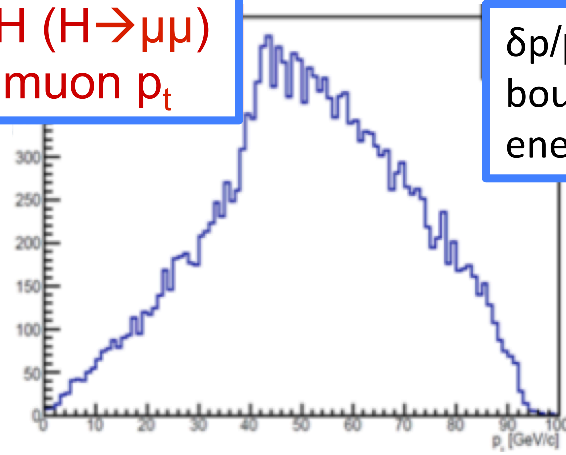
Features leading the detector design

- High granularity → to cope with occupancy at inner radii
- Transparency → particle momentum range far from the asymptotic limit where MS is negligible, also need to limit γ conversions and hadronic interactions

ZH (Z→μμ) muon p_t



ZH (H→μμ) muon p_t



$\delta p/p^2 \leq$ few x 10^{-5}, bounded by the beam energy spread

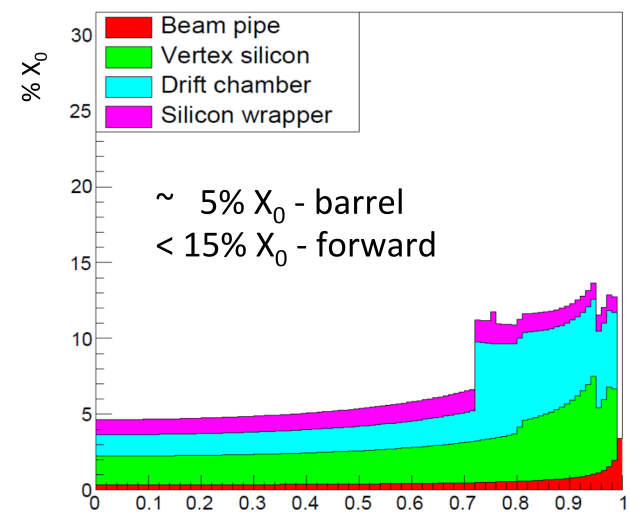
Trasparency is more relevant than the asymptotic resolution in this p_T range!

$$\frac{\Delta p_T}{p_T}|_{res.} \approx \frac{12\,\sigma_{r\phi}\,p_T}{0.3\,B_0 L_0^2}\sqrt{\frac{5}{N+5}}$$

$$\frac{\Delta p_T}{p_T}|_{m.s.} \approx \frac{0.0136\,\mathrm{GeV/c}}{0.3\beta\,B_0 L_0}\sqrt{\frac{d_{tot}}{X_0\,\sin\theta}}$$

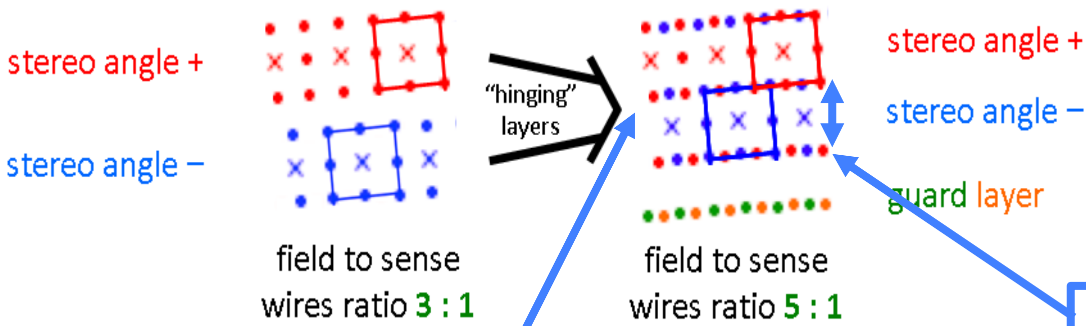
Drasal, Riegler, https://doi.org/10.1016/j.nima.2018.08.078

IDEA: Material vs. cos(θ)



IDEA drift chamber: Layout

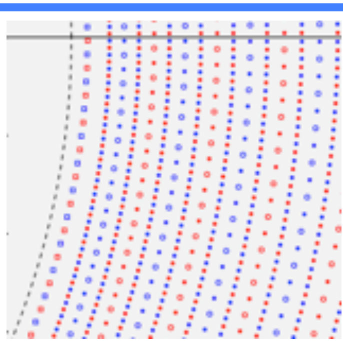
- Design inherits some aspects of Drift Chambers previously built and operated (KLOE, MEG II) in order to reach a compromise between granularity and transparency requests



12 to 15 mm wide square (easier implementation of a full stereo configuration) cells, max drift time 360 ns
5:1 field to sense wires ratio (more field wires → better E-field isotropy and smaller E×B asymmetries)
56,448 cells in total

(12÷14.5 mm at z=0)

The wire net created by the combination of + and – orientation generates a more uniform equipotential surface



sense wires	20 μm diameter W(Au) => 56448 wires
(**thin!!**) field wires	40 μm diameter Al(Ag) => 229056 wires
Field between sense and guard wires	50 μm diameter Al(Ag) => 58464 wires
	343968 wires in total

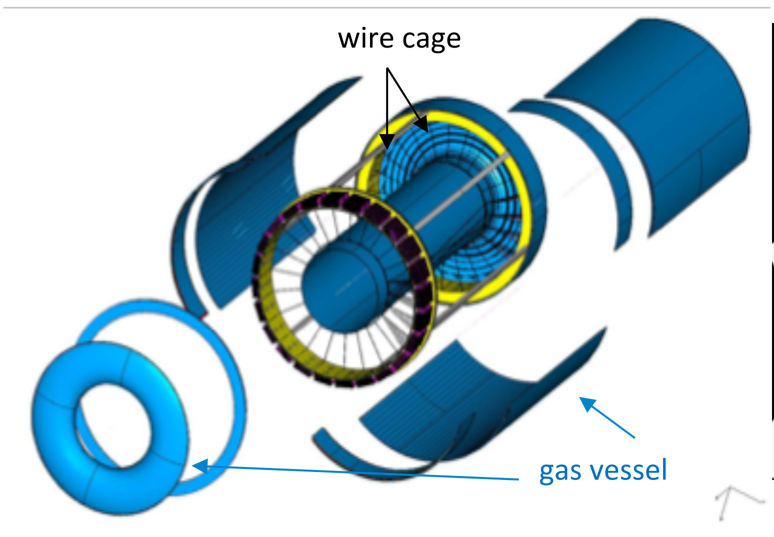
14 co-axial super-layers, 8 layers each (**112 layers in total**) with alternating sign stereo angles ranging from 50 to 250 mrad, in 24 equal azimuthal (15°) sectors

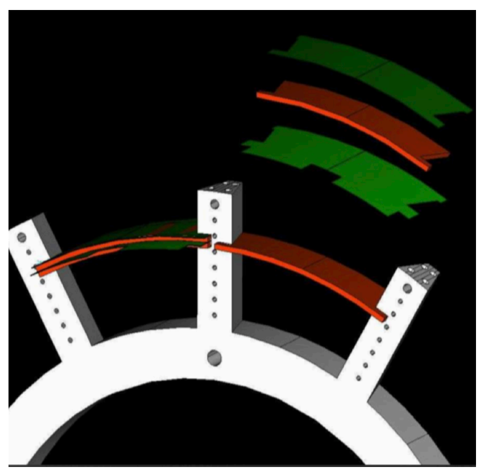
IDEA drift chamber: mechanical structure

- Fully Innovative features to combine granularity (high wire number!) and transparency requests

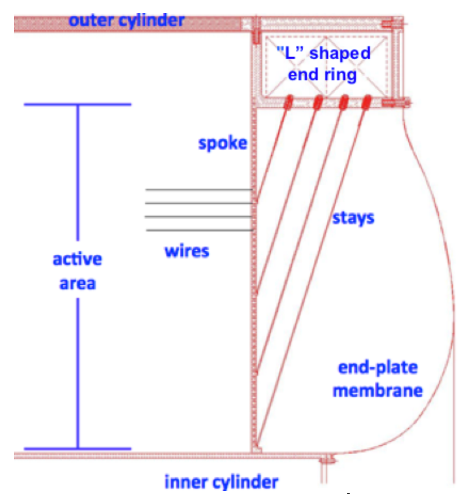
- Gas envelope and wire supporting structure separated:
  - to reduce material to ≈ 10^{-3} X_0 for the inner cylinder and to a few 10^{-2} X_0 for the end-plates (including FEE, HV supply and signal cables)
  - Gas envelope can freely deform without affecting the internal wire position and tension

- Novel wiring procedure "feed-through-less" (already adopted for MEG II):
  - to increase chamber granularity and field/sense wire ratio but reducing multiple scattering and total tension on end plates due to wires by using thinner wires.





Wire PCB and spacers

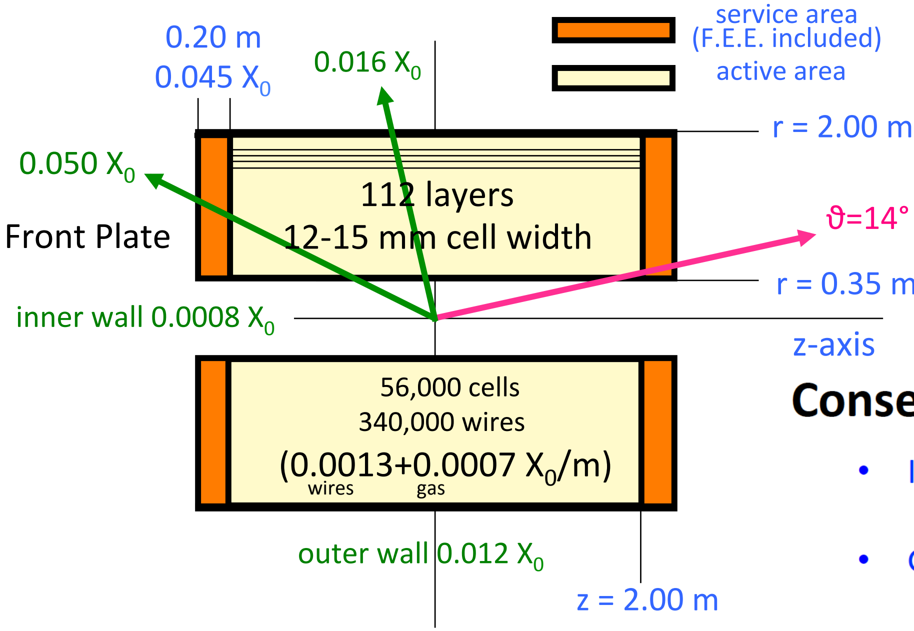


Tension recovery scheme

IDEA drift chamber:Material budget

tracking efficiency ε ≈ 1
for ϑ > 14° (260 mrad)
97% solid angle

$0.016\ X_0$ to barrel calorimeter
$0.050\ X_0$ to end-cap calorimeter



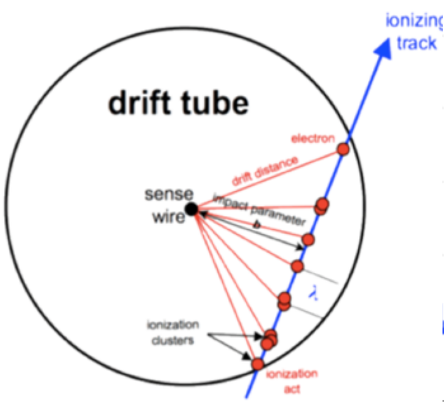
extrapolated from already built chambers or studies

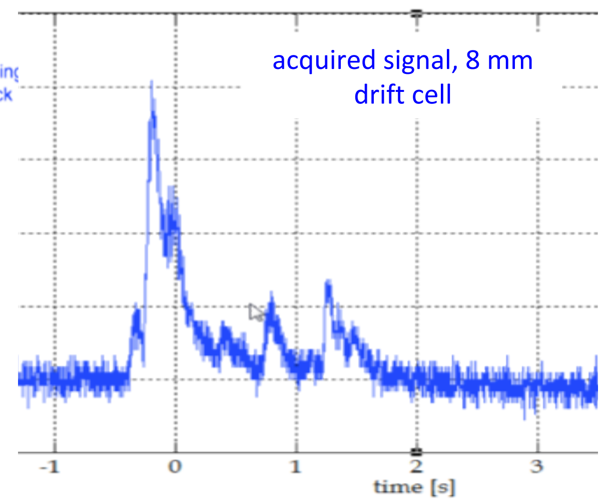
Conservative estimates:

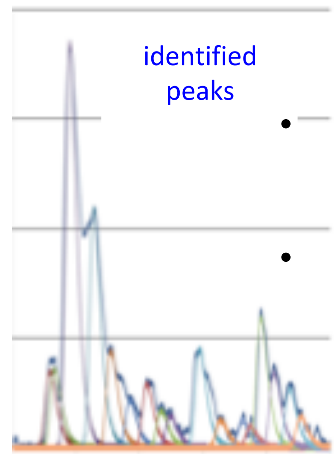
- Inner wall (from CMD3 drift chamber) — **$8.4\times10^{-4}\ X_0$**
  200 µm Carbon fiber
- Gas (from KLOE drift chamber) — **$7.1\times10^{-4}\ X_0/m$**
  90% He – 10% iC_4H_{10}
- Wires (from MEG2 drift chamber) — **$1.3\times10^{-3}\ X_0/m$**
  20 µm W sense wires $4.2\times10^{-4}\ X_0/m$
  40 µm Al field wires $6.1\times10^{-4}\ X_0/m$
  50 µm Al guard wires $2.4\times10^{-4}\ X_0/m$
- Outer wall (from Mu2e I-tracker studies) — **$1.2\times10^{-2}\ X_0$**
  2 cm composite sandwich (7.7 Tons)
- End-plates (from Mu2e I-tracker studies) — **$4.5\times10^{-2}\ X_0$**
  wire cage + gas envelope
  incl. services (electronics, cables, ...)

IDEA drift chamber: Particle Id with cluster counting technique

- He based gas mixtures → signals from each ionization act spread in time to few ns
- Fast read-out electronics (~GHz sampling) → to efficiently identify them.
- Counting dNcl/dx (# of ionization acts per unit length) → make possible to identify particles (P.Id.) with a better resolution than dE/dx







- record the arrival time of the clusters generated in every ionisation act ($\approx 12\,\mathrm{cm}^{-1}$)
- reconstruct the trajectory at the most likely position

dE/dx

- Requires high stability on HV and gas parameters and electronics calibration
- truncated mean cut (70-80%) reduces the amount of information. For n = 112 and a 2m track at 1 atm → **σ ≈ 4.3%**

$$\frac{\sigma_{dE/dx}}{(dE/dx)} = 0.41 \cdot N^{-0.43} \cdot \left(L_{track}[m] \cdot P[atm]\right)^{-0.32}$$

P. Reak and A.H. Walenta, IEEE Trans. Nucl. Sci. NS-27 (1980) 54

dN_{cl}/dx

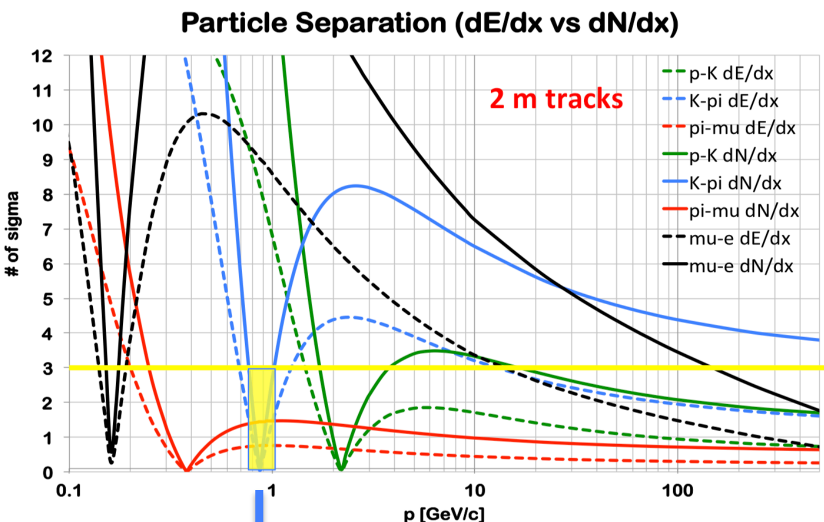
- Requires fast electronics and sophisticated counting algorithms
- Less dependent on gain stability issues
- δ_{cl} = 12.5/cm for He/iC_4H_{10}=90/10 and a 2m track → **σ ≈ 2.0%**

$$\frac{\sigma_{dN_{cl}/dx}}{(dN_{cl}/dx)} = \left(\delta_{cl} \cdot L_{track}\right)^{-1/2} = N_{cl}^{-1/2}$$

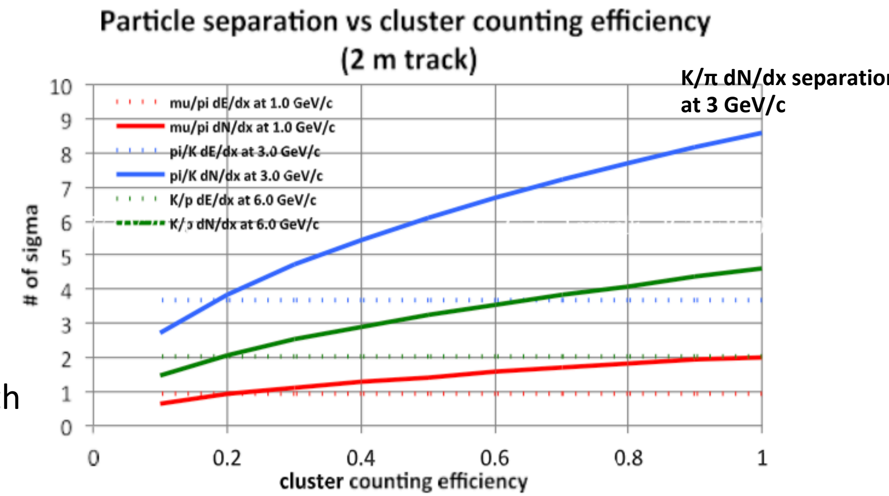
Poisson

IDEA drift chamber: Particle Id expected performance

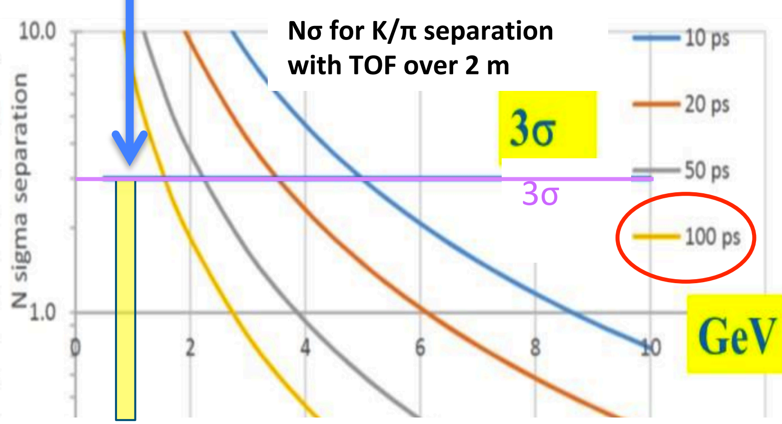
- Analytical calculations (to be cross-checked with detailed simulations and data!) → predict excellent K/π separation over the full range of momenta except 0.85<p<1.05 GeV

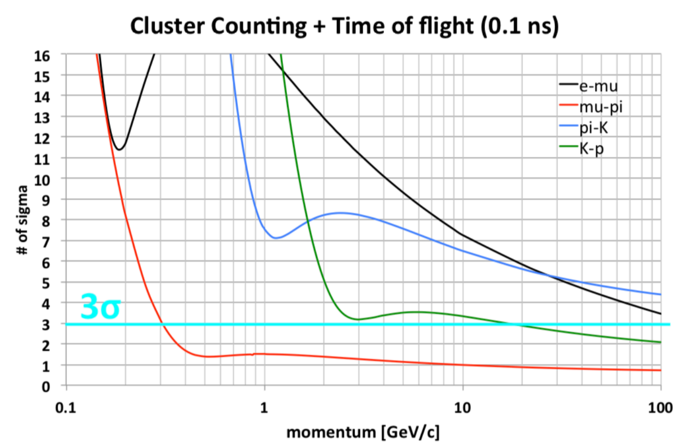


He/iC$_4$H$_{10}$ 90/10 δ_{cl}=12 cm^{-1}
σ(dE/dx)/(dE/dx)=4.3%
80% cluster counting efficiency



Could be recovered with timing layer, with an (unchallenging) 100 ps resolution!

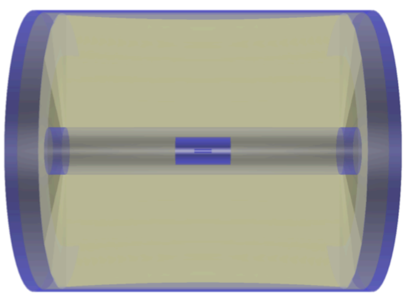


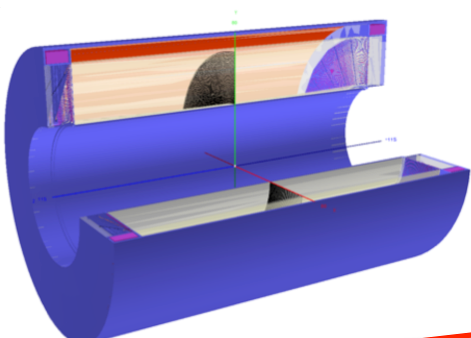


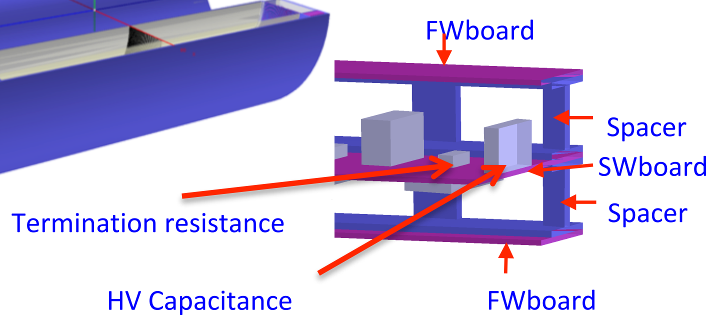
IDEA drift chamber: Tracking performance from simulation

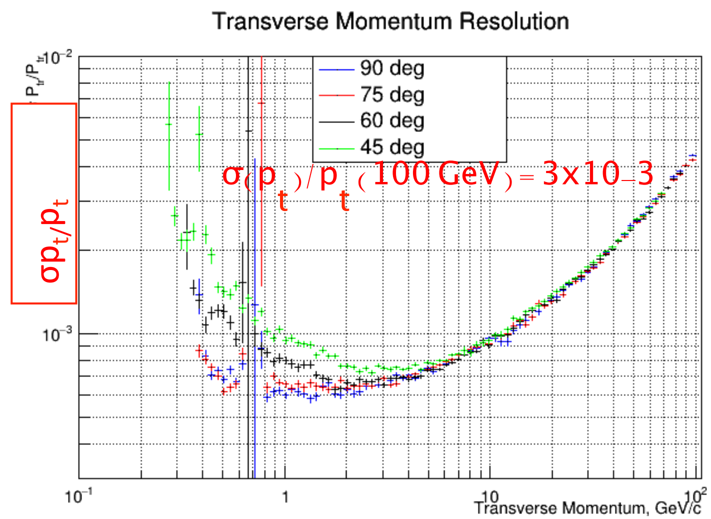
- Full Geant4 simulation of the IDEA tracking system →drift chamber simulated at a good level of geometry details, including detailed description of the endplates
- Vertex detector and Si wrapper included in the track fit taking into account material contributions
- A preliminary Vertex detector and Drift Chamber description implemented inside the FCC-sw

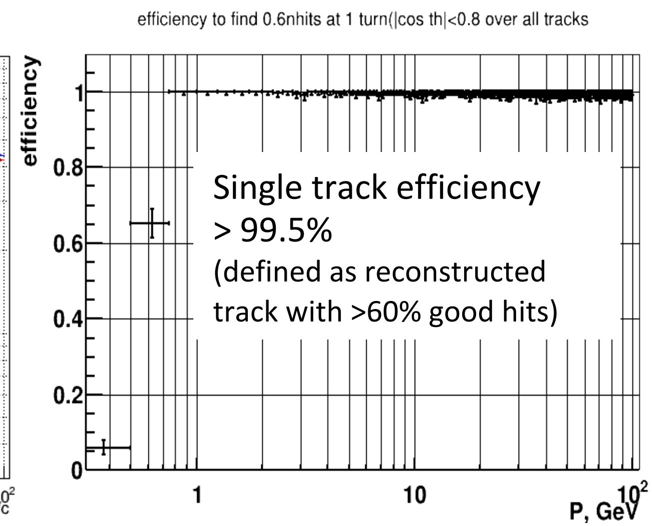
(more plots in backup)







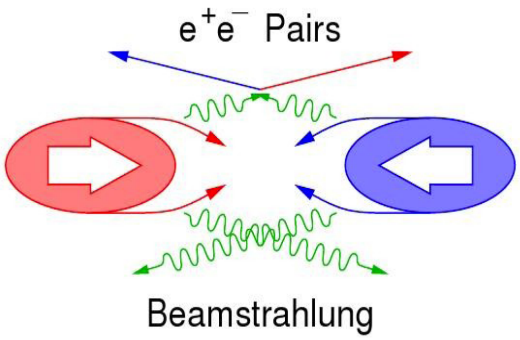




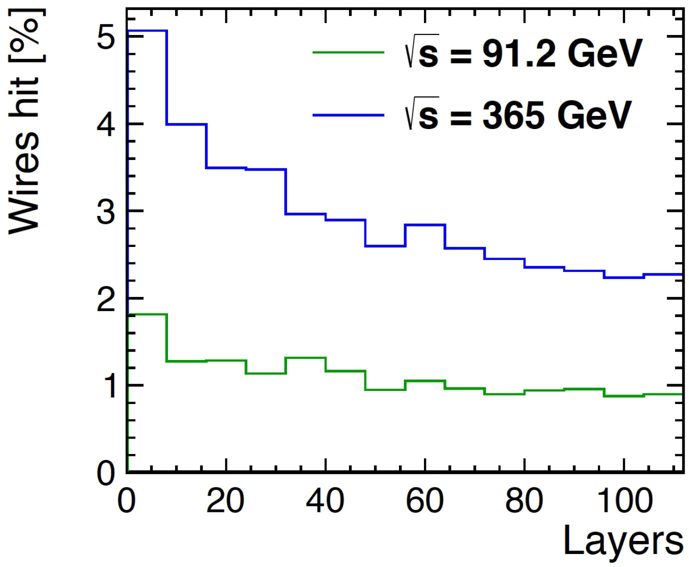
assuming σ_d = 100 μm and (conservative for Si) σ_{Si} = pitch/√12 μm

IDEA drift chamber: Tracking performance from simulation

- Machine background → preliminary study of the induced occupancy show that it will be not an issue

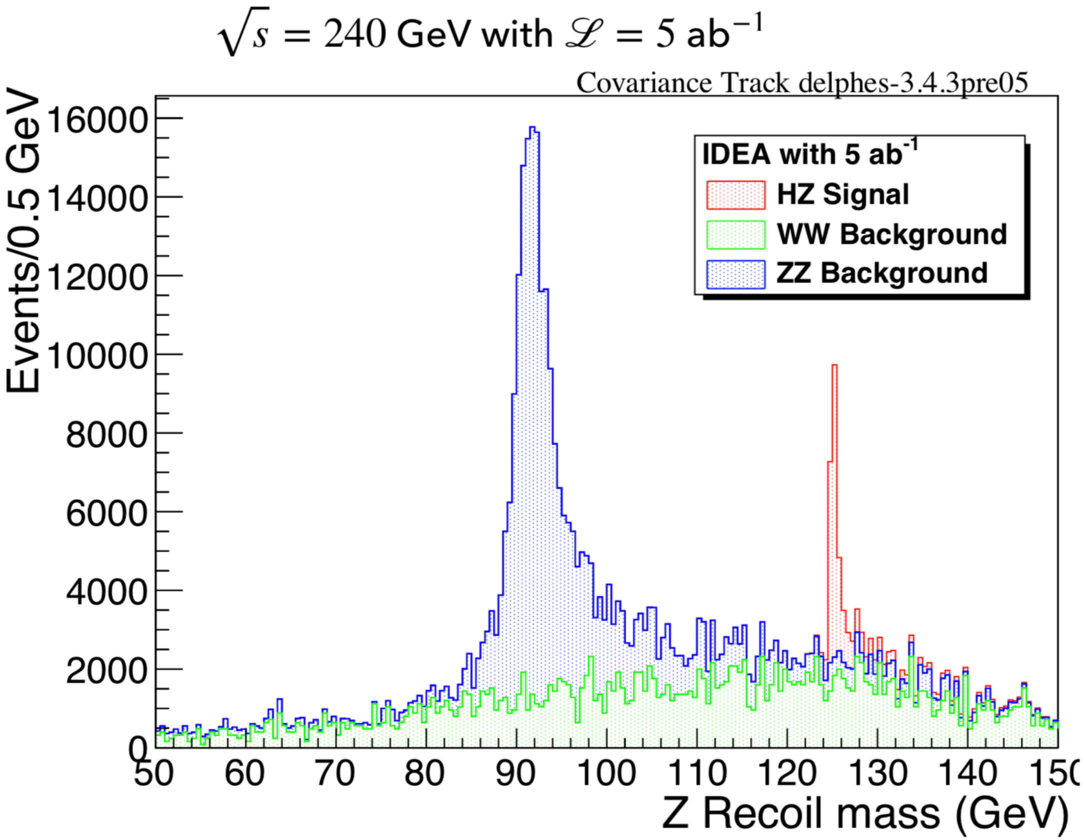


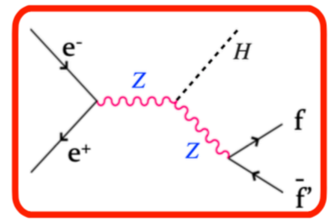
Background	Average occupancy	
	$\sqrt{s}$ = 91.2 GeV	$\sqrt{s}$ = 365 GeV
e^+e^- pair background	1.1%	2.9%
$\gamma\gamma \to$ hadrons	0.001%	0.035%
Synchrotron radiation	negligible	0.2%

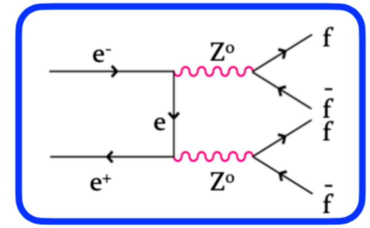


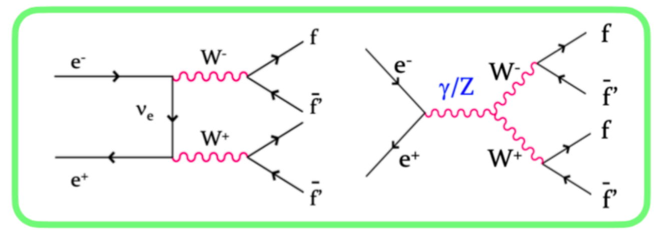
Expected performance from fast simulation on physics cases

- IDEA Fast simulation (Delphes) → Parameterized response of the detector + covariance matrix description for tracks









Z recoil mass

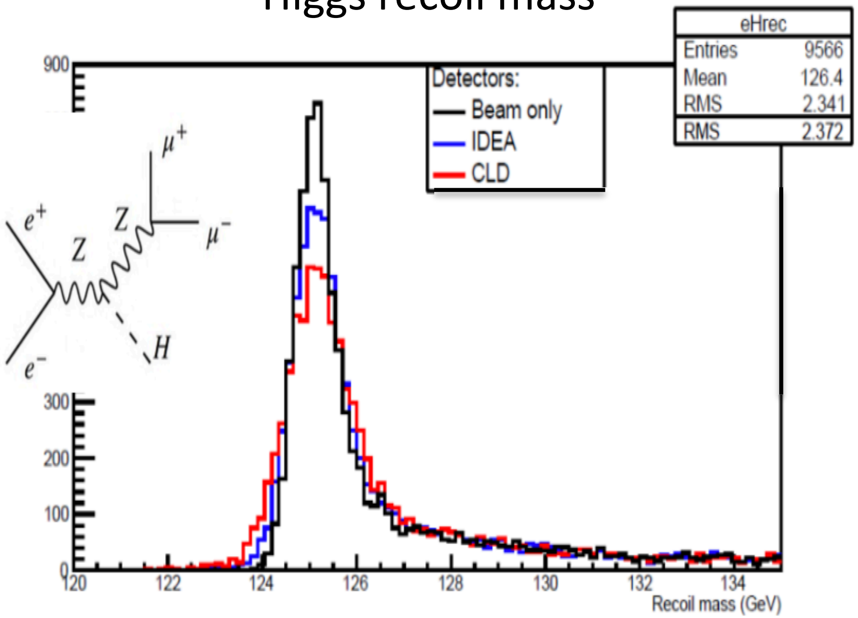
Z → μμ final state

Events with

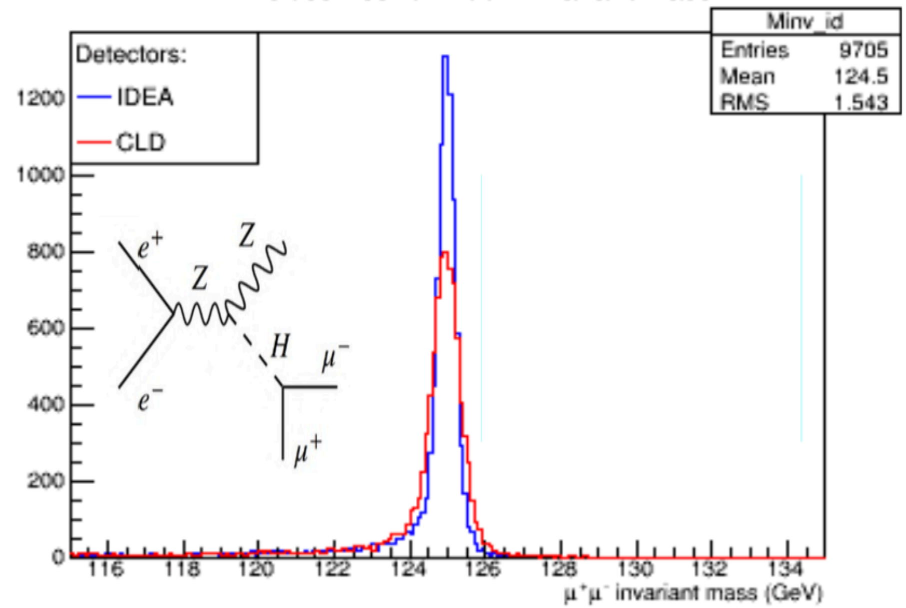
- $p(\mu) > 1$ GeV
- $\eta(\mu) < 2.44$
- $|M_{\mu\mu} - M_Z| < 20$ GeV

Expected performance from fast simulation on physics cases

Higgs recoil mass



Di-muon invariant mass



Beam only→ assumes 0.136% beam spread and an ideal detector
IDEA → Fast simulation studies
CLD → full Si-tracker system

Transparency ensures a better resolution!

Conclusion

- The IDEA drift chamber is a full-stereo, high momentum resolution, ultra-light detector concept
- Design combines innovative elements with proven solutions
- The Cluster Counting technique provides relevant improvements in PID performance over traditional dE/dx approaches, more studies are on going
- Performance studies with Geant4 simulations and analytic calculations were performed in the contest of FCC-ee on benchmark physics, and more refined studies are in progress.

Thank you for your attention!

Backup slides

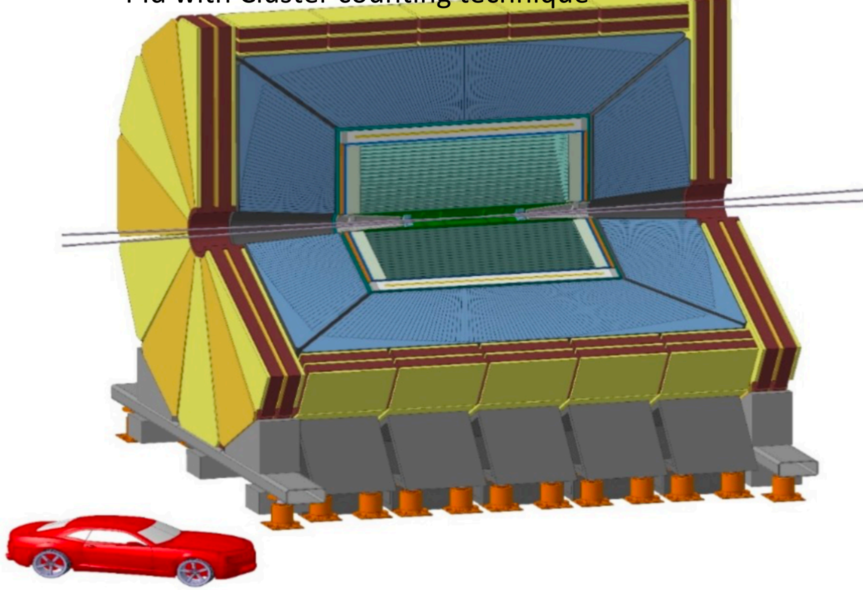
Vertex:

- Monolitic pixel (MAPS) with 20 µm pixel size and 3 µm single point resolution
- Hit efficiency 99.9%
- Low power → less 20 mW/cm^2

Drift chamber:

- He-iC_4H_{10} gas mixture → Max drift time 360 ns
- Maximum stereo angle ~ 30°

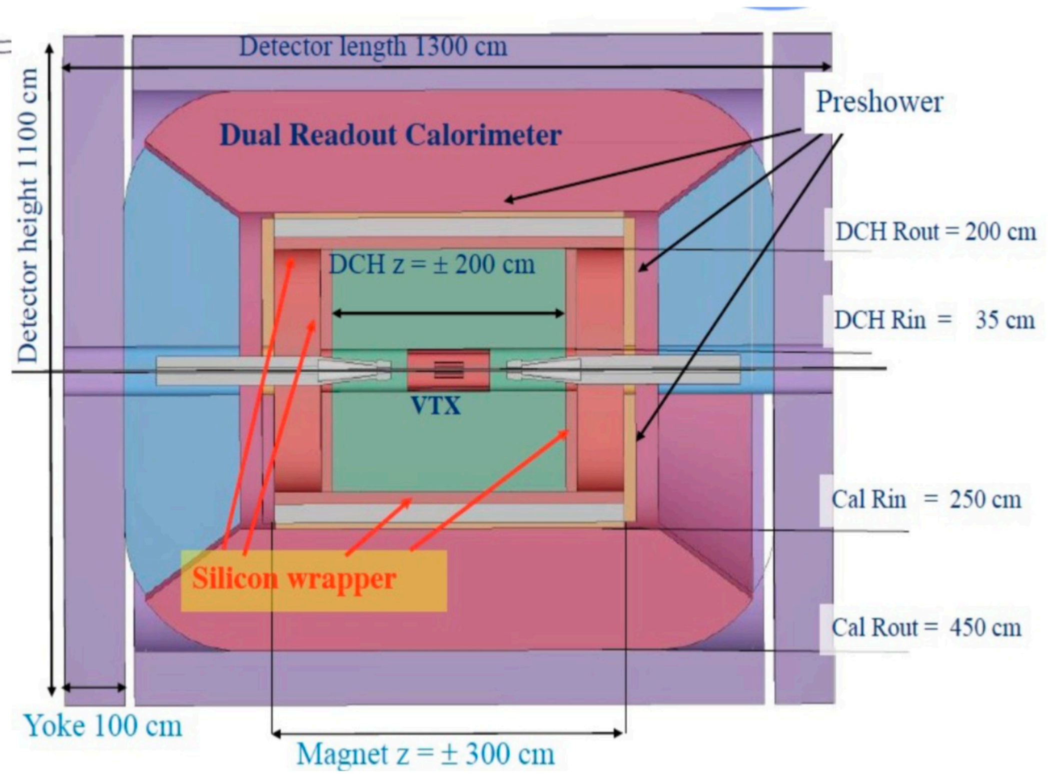
  PId with Cluster counting technique



Magnetic field:

- length = 5 m, r = 2.1-2.4
- Thin low-mass superconducting coil 0.74 X_0, 0.16 λ @ 90º
- 2T B field, inside the calorimeter

IDEA



Pre-shower:

- 2 layers of µ-Rwell each one behind an absorber layer

Calorimeter (inspired to DREAM/RD-52) :

- Dual readout calorimeter 2m deep/8 λ
- EM & Hadronic in one single sampling detector
- Cherenkov/Scintillation fiber, 1.5 mm fiber pitch
- Each of the 130 10^6 fibers connected to a SiPM

Muon chambers:

- 3 µ-Rwell stations embedded in the magnet return yoke

Challenges

- Extremely high luminosities:
  large statistics (high statistical precision) - control of systematics (@10^{-5} level)
- Large beam crossing angle (30mrad)
  very complex MDI
  emittance blow-up with detector solenoid field (< 2T)
- Physics event rates up to 100 kHz (at Z pole)
  strong requirements on sub-detectors and DAQ systems
- Bunch spacing down to 20 ns (at Z pole)
  "continuous" beams (no power pulsing)
- More physics challenges at Z pole:
  - luminosity measurement at 10^{-5} - luminometer acceptance ≈1-2 μm
  - detector acceptance definition at <10^{-5} - detector hermeticity (no cracks!)
  - stability of momentum measurement - stability of magnetic field wrt E_{cm} (10^{-6})
  - b/c/g jets separation - flavor and τ physics - vertex detector precision
  - particle identification (preserving hermeticity) - flavor physics (and rare processes)

The IDEA Tracking system

Vertex Detector

Layer	R [mm]	L [mm]	Si eq. thick. [μm]	X_0 [%]	pixel size [mm²]	area [cm²]	# of channels
1	17	±110	300	0.3	0.02×0.02	235	60M
2	23	±150	300	0.3	0.02×0.02	434	110M
3	31	±200	300	0.3	0.02×0.02	780	200M
4	320	±2110	450	0.5	0.05×1.0	85K	170M
5	340	±2245	450	0.5	0.05×1.0	96K	190M

Disks	R_{in} [mm]	R_{out} [mm]	z [mm]	Si eq. thick. [μm]	X_0 [%]	pixel size [mm²]	area [cm²]	# of channels
1	62	300	±400	300	0.3	0.05×0.05	5.4K	220M
2	65	300	±420	300	0.3	0.05×0.05	5.4K	220M
3	138	300	±900	300	0.3	0.05×0.05	4.4K	180M
4	141	300	±920	300	0.3	0.05×0.05	4.4K	180M

Drift Chamber

	R_{in} [mm]	R_{out} [mm]	z [mm]
drift chamber	350	2000	±2000
service area	350	2000	±(2000÷2250)

	inner wall	gas	wires	outer wall	service area
thickness [mm]	0.2	1000	1000	20	250
X_0 [%]	0.08	0.07	0.13	1.2	4.5

# of layers	112	min 11.8 mm – max 14.9 mm
# of cells	56448	192 at 1st – 816 at last layer
average cell size	13.9 mm	min 11.8 mm – max 14.9 mm
average stereo angle	134 mrad	min 43 mrad – max 223 mrad
transverse resolution	100 μm	80 μm with cluster timing
longitudinal resolution	750 μm	600 μm with cluster timing

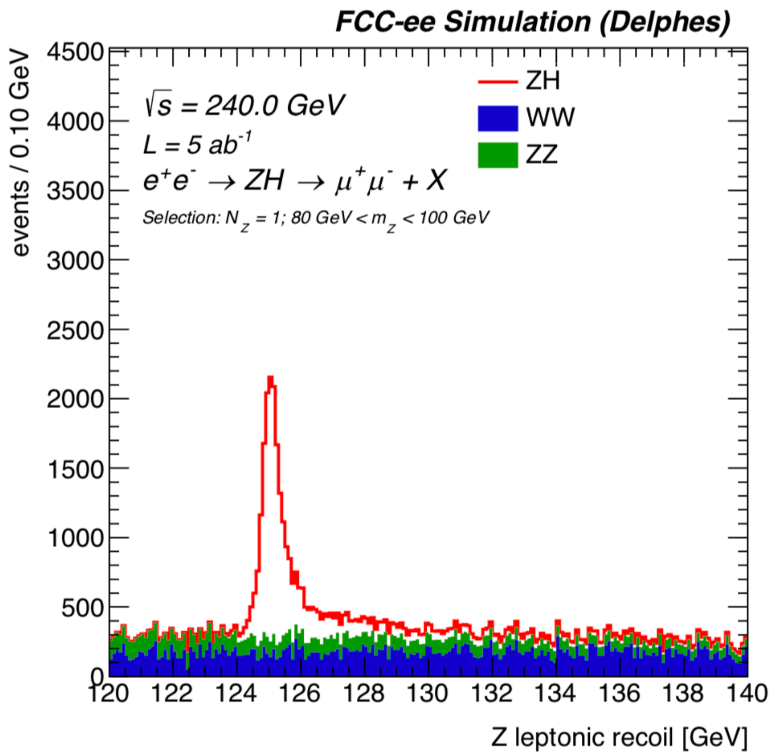
active volume	50 m^3	
readout channels	112,896	r.o. from both ends
max drift time	400 ns	800 × 8 bit at 2 GHz

Si wrapper

Layer	R [mm]	L [mm]	Si eq. thick. [μm]	X_0 [%]	pixel size [mm²]	area [cm²]	# of channels
1	2040	±2400	450	0.5	0.05×100	616K	12.3M
2	2060	±2400	450	0.5	0.05×100	620K	12.4M

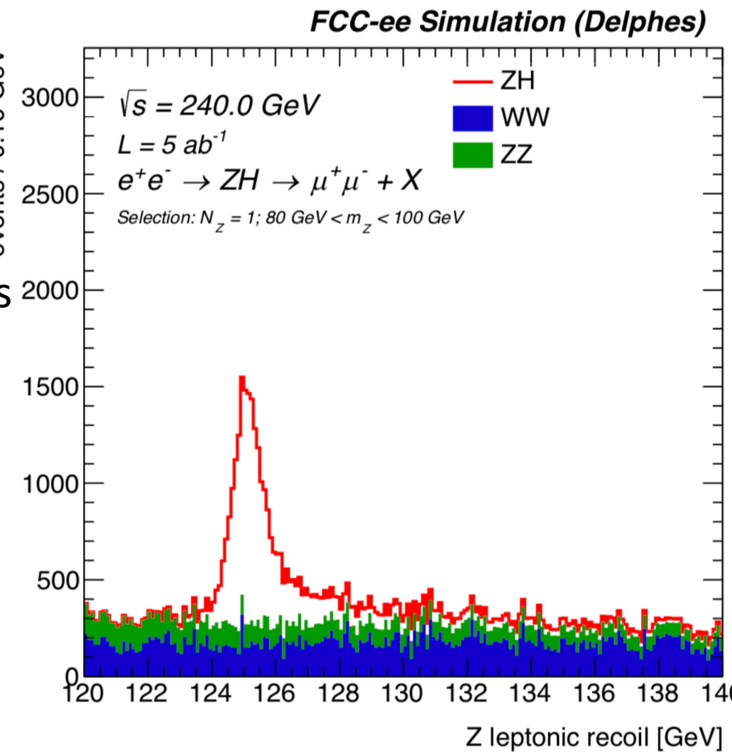
Disks	R_{in} [mm]	R_{out} [mm]	z [mm]	Si eq. thick. [μm]	X_0 [%]	pixel size [mm²]	area [cm²]	# of channels
1	350	2020	±2300	450	0.5	0.05×100	250K	5M
2	354	2020	±2320	450	0.5	0.05×100	250K	5M

Comparison of IDEA and CLD Simulation of the $e^+e^- \rightarrow ZH \rightarrow \mu^+\mu^- + X$



IDEAtrkCov

Z recoil mass



CLDtrkCov

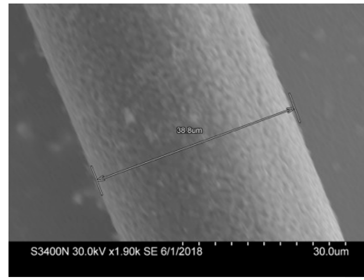
Zoom in on the ZH peak region
CLD has larger width and lower peak

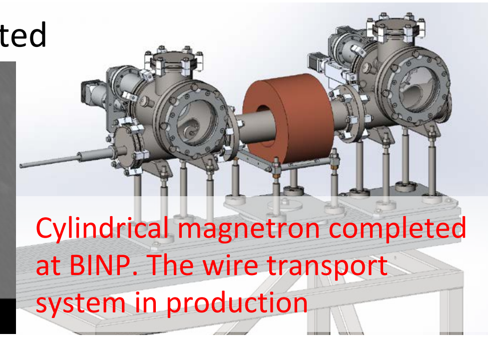
Ang LI, Gregorio Bernardi, FCCee Physics and Performance Meeting, January 18th 2021

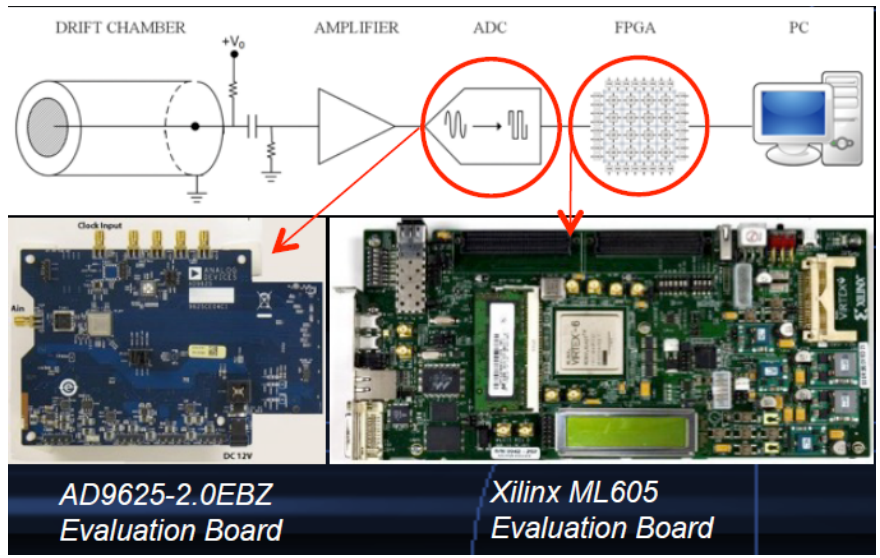
Ongoing R&D

- Mechanics design
- Light mechanics
- new wires:
  - new metallic alloys
  - new technology (e.g. Carbon monofilaments)
- Cluster Counting:
  - simulations – tests
  - electronics for online Cluster measurements

35 µm C wire – Cu coated







“Application of the Cluster Counting/Timing techniques to improve the …”
JINST Volume 12, July 2017
https://doi.org/10.1088/1748-0221/12/07/C07021

IDEA DCH geometry (simulation)

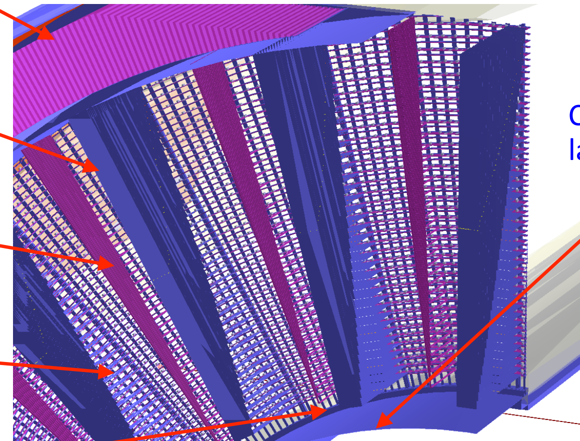
Electronics boards: 12 cm x 6 cm x 3mm G10 (FR4);

signal cables:
2.032 cm x 25 μm Kapton
+ 40 μm 16 pairs of Copper wires;

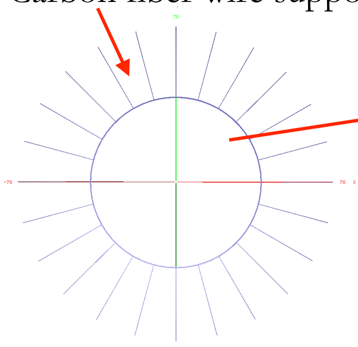
HV cables:
500 μm Copper wire
+ 500 μm Teflon insulation;

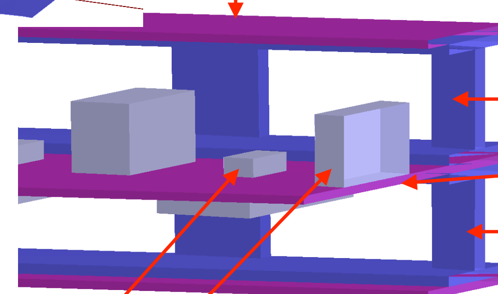
Wire anchoring;

Carbon fiber wire support.



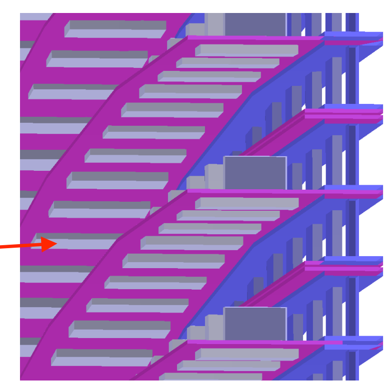
Connecting ring is described as a circular layer: 0.5 cm x 1.5 cm Carbon fiber





The wire anchoring system:

- Field wire board: 4 mm x 200 μm G10(FR4);
- Spacer: made of polycarbonate, instead of holes it is drawn with spokes but with the same area ratio.
- Sense wire board: 1 cm x 200 μm G10(FR4) plus components:
  1) termination resistance: 1.6 mm x 800 μm x 450 μm Aluminum;
  2) HV Capacitance: 3.17 mm x 1.57 mm x 1.7 mm Aluminum;
  3) HV resistance (only downstream): 5 mm x 2.5 mm x 550 μm Aluminum.

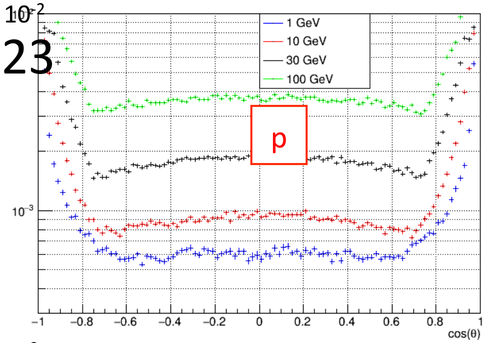


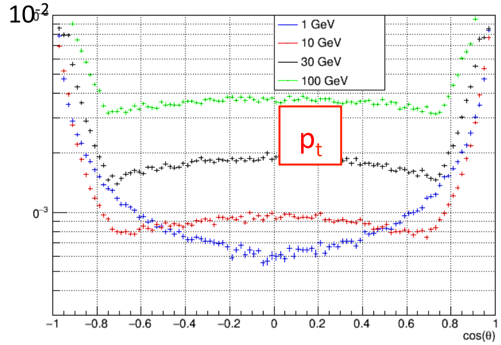
Full G4 simulation, IDEA tracking system – Expected tracking performance

(single muon as function of ϑ)

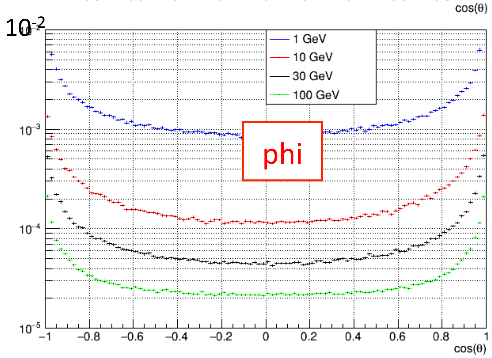
base line option

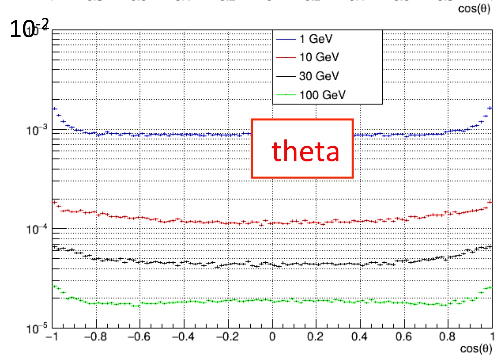
momentum resolution





angular vertex resolution

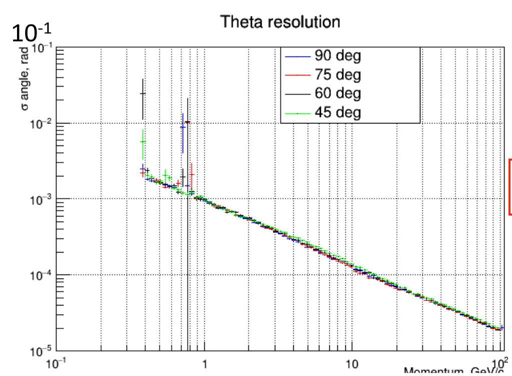


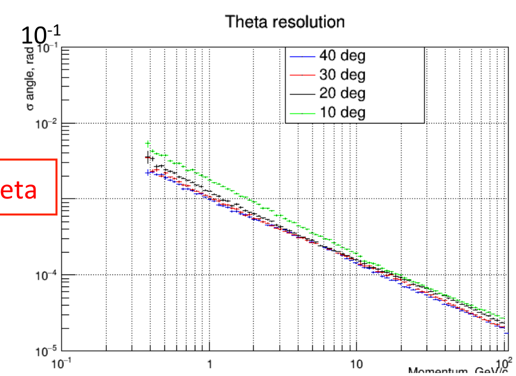


- The maximum drift time (400ns) will impose an overlap of some (20 at Z pole) bunch crossings bringing the hit occupancy to ~ 10% in the inner-most drift cells. Based on MEG-II experience, this occupancy, which allows over 100 hits to be recorded per track on average in the DCH, is deemed manageable.
- However, signals from photons can be effectively suppressed at the data acquisition level by requiring that at least three ionization clusters appear within a time window of 50 ns.
- In addition, cluster signals separated by more than 100 ns are not from the same signals, this effectively bring the BXs pile-up from 20 to 4

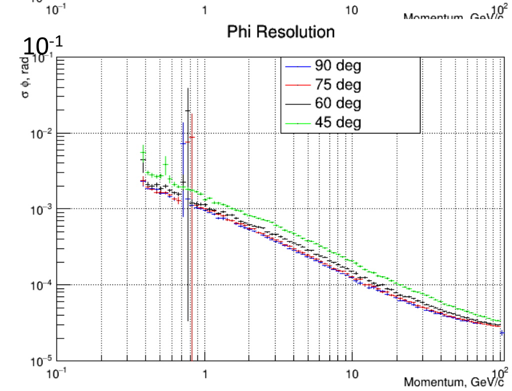
BARREL:

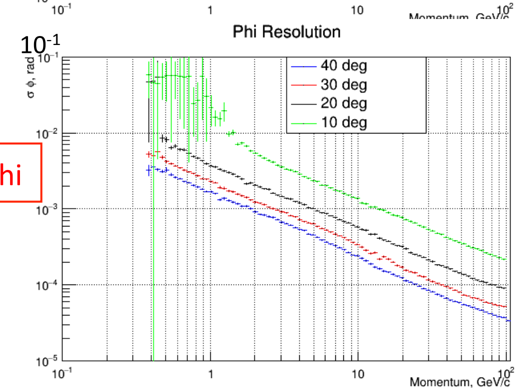
FORWARD:





theta



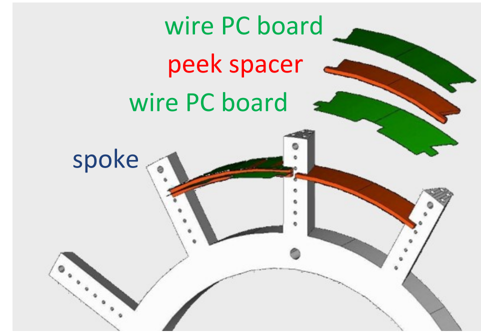


phi

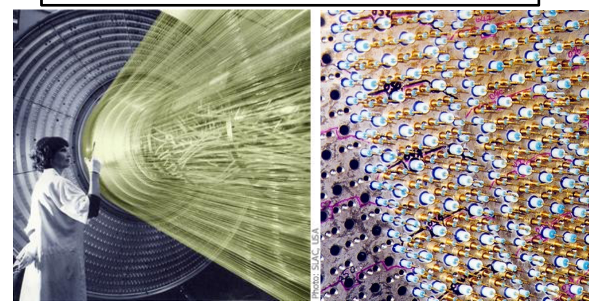
In MEG II (~ 12 wires/cm^2 → impossible to be built with a conventional technique based on feedthrough)

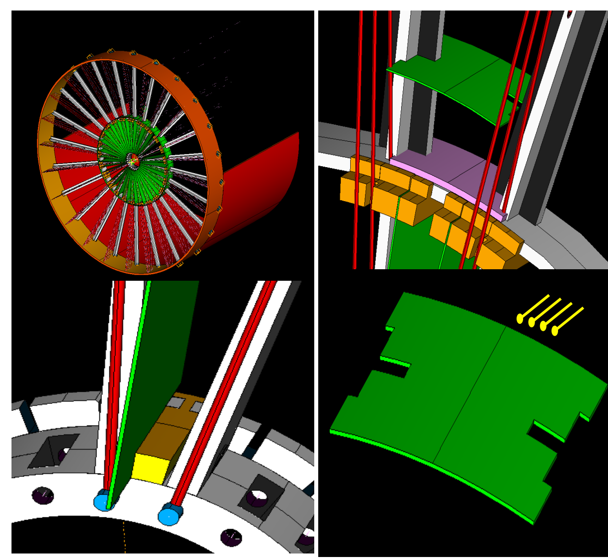
- end-plates numerically machined from solid Aluminum (mechanical support only);
- Field, Sense and Guard wires placed azimuthally by a Wiring Robot with better than one wire diameter accuracy;
- wire PC board layers (green) radially spaced by numerically machined peek spacers (red) (*accuracy < 20 μm*);
- wire tension defined by homogeneous winding and wire elongation (*ΔL = 100μm corresponds to ≈ 0.5 g*);
- Drift Chamber assembly done on a 3D digital measuring table;
- build up of layers continuously checked and corrected during assembly;
- End-plate gas sealing done with glue.

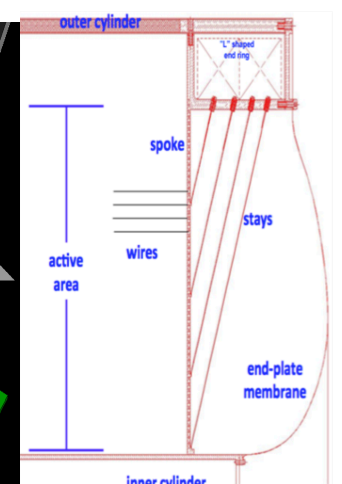
Wire tension recovery scheme in the CMD3 DC design →



(**~ 12 wires/cm^2**) impossible to be built with a conventional technique based on feedthrough:







dE/dx and dN_{cl}/dx

$$\frac{\sigma_{dE/dx}}{(dE/dx)} = 0.41 \cdot N^{-0.43} \cdot \left(L_{track}[m] \cdot P[atm]\right)^{-0.32}$$

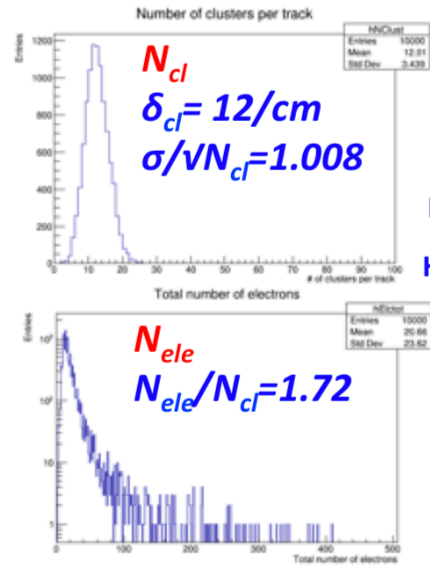
Walenta

Empirical parameterization of dE/dx resolution in gas (limited by Landau fluctuations)

"It has been experimentally confirmed that the relativistic rise is mainly due to the increased number of the primary clusters, rather than due to the energy of clusters."

P. Reak and A.H. Walenta, IEEE Trans. Nucl. Sci. NS-27 (1980) 54

$$\frac{\sigma_{dN_{cl}/dx}}{(dN_{cl}/dx)} = \left(\delta_{cl} \cdot L_{track}\right)^{-1/2} = N_{cl}^{-1/2}$$



HEED simulation 1 cm He/iC_4H_{10} - 90/10

dE/dx

truncated mean cut (70-80%) reduces the amount of collected information

***n* = 112** and a **2m track** at **1 atm** give

σ ≈ 4.3%

Increasing ***P*** to 2 atm improves resolution by 20% (σ ≈3.4%) but at a **considerable** cost of multiple scattering contribution to momentum and angular resolutions.

dN_{cl}/dx

δ_{cl} = 12.5/cm for He/iC_4H_{10}=90/10 and a **2m track** give

σ ≈ 2.0%

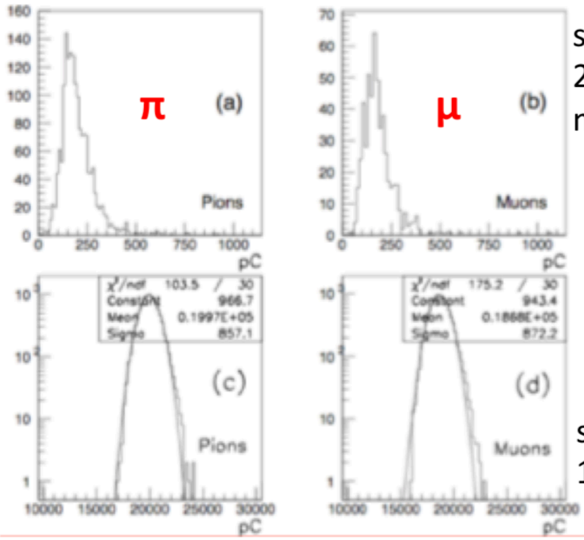
A small increment of iC_4H_{10} from 10% to 20% (δ_{cl} = 20/cm) improves resolution by 20% (σ ≈1.6%) at only a **reasonable** cost of multiple scattering contribution to momentum and angular resolutions.

Conditions to be satisfied for cluster counting→ pulses from electrons belonging to different clusters must have a little chance of overlapping in time and, at the same time, the time distance between pulses generated by electrons coming from the same cluster must be small enough to prevent over-counting. **The optimal counting condition can be reached only as a result of the equilibrium** between the fluctuations of those processes which forbid a **full cluster detection efficiency** and of the ones enhancing the **time separation among different ionization events**. *(F. Grancagnolo - PId with dE/dx, IAS Program on High Energy Physics (HEP 2021), Hong Kong, 15 January 2021)*

dE/dx and dN_{cl}/dx

μ/π separation at 200 MeV/c in He/iC_4H_{10} – 95/5 100 samples 3.7 cm

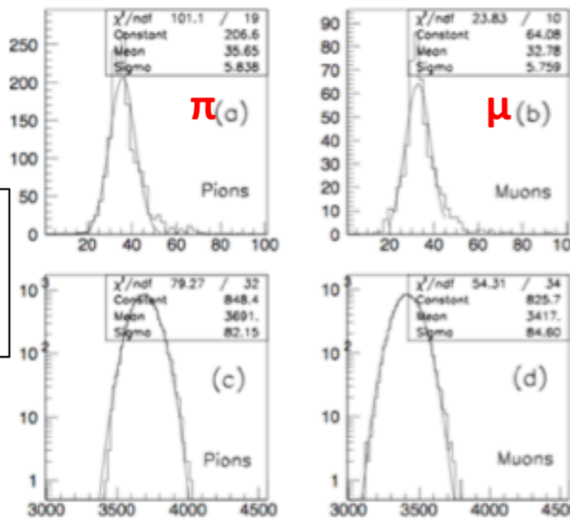
gas gain 2×10^5, 1.7 GHz – gain 10 amplifier, 2GSa/s – 1.1 GHz – 8 bit digitizer



single sample
20% truncated
mean

sum over
100 samples

test beam data



single sample

π: σ/√N_{cl}=0.978
μ: σ/√N_{cl}=1.006

sum over
100 samples

π: σ/√N_{cl}=1.35
μ: σ/√N_{cl}=1.45

integrated charge
expected 2.0 σ separation
measured 1.4 σ separation

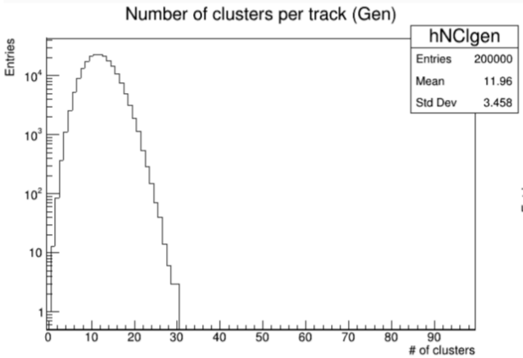
cluster counting
expected 5.0 σ separation
measured 3.2 σ separation

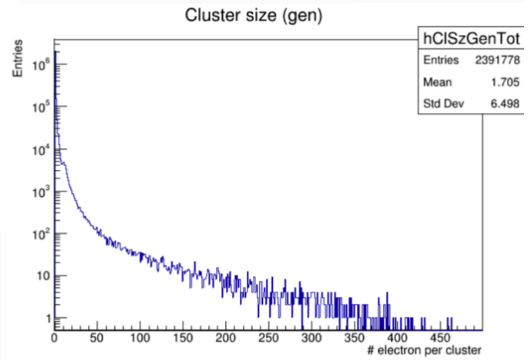
(*NIM A386 (1997) 458-469* and references therein)

Cluster counting simulation in Geant4

Muon at p=300MeV

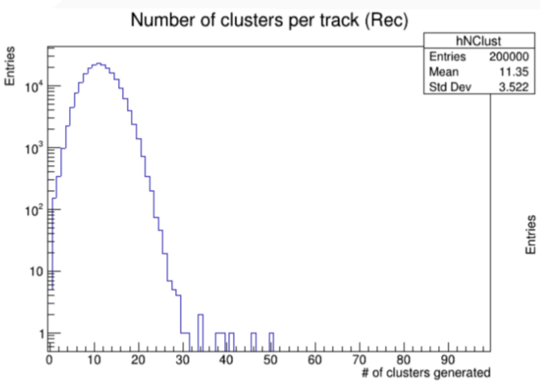
Garfield++

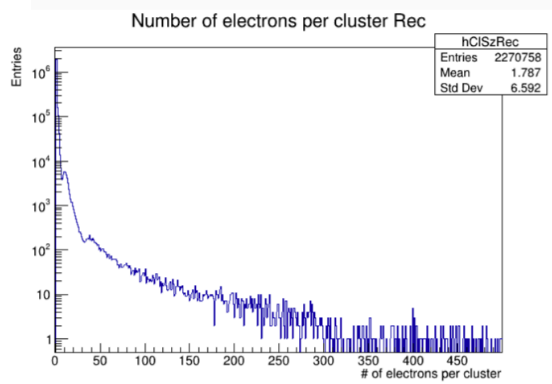




Muon at p=300MeV

Results from algorithm





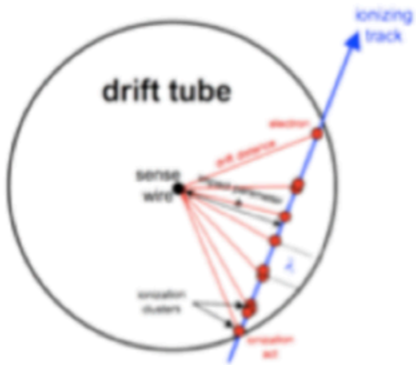
To investigate the potential of the Cluster Counting technique (for He based drift chamber) on physics events a reasonable simulation and parameterization of the ionization cluster generation in Geant4 is needed.

Preliminary studies are in progress:

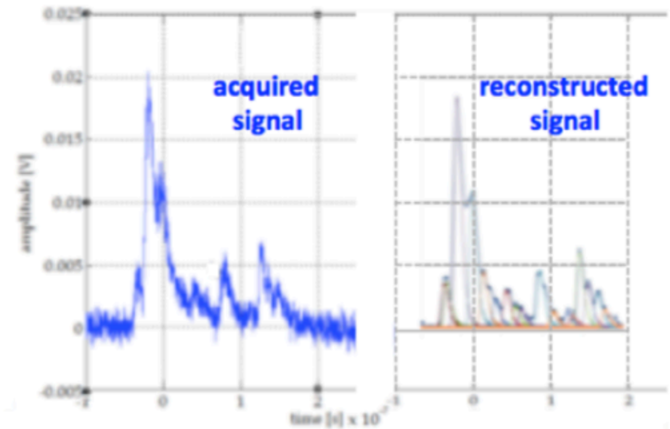
- Starting from Garfield results (number of clusters, cluster size, primary and secondary ionization energy, etc.),
- Developing a model for kinetic energy of clusters with cluster size equal to 1 and higher than 1
- Implementing different algorithm and comparing the results to the Garfield ones, to choose the best one to apply in Geant4.

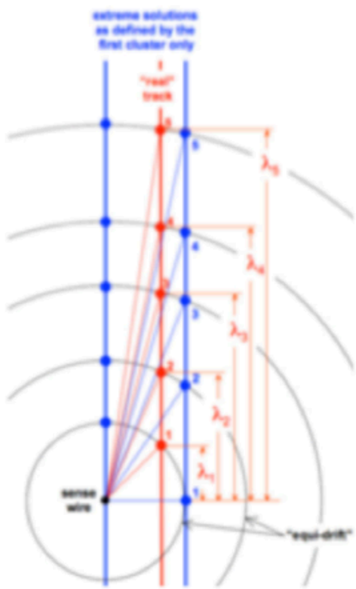
F. Cuna, G. Tassielli
private communication

Cluster Timing

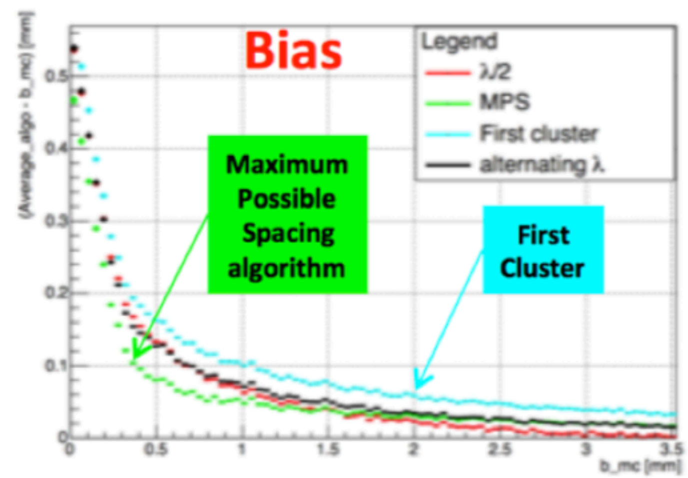


From the **ordered sequence of the electrons arrival times**, considering the average time separation between clusters and their time spread due to diffusion, **reconstruct the most probable sequence of clusters drift times:** $\{t_i^{cl}\} \quad i = 1, N_{cl}$





For any given first cluster (**FC**) drift time, the **cluster timing technique** exploits the drift time distribution of all successive clusters $\{t_i^{cl}\}$ to determine the most probable impact parameter, thus reducing the **bias** and the average **drift distance resolution** with respect to those obtained from with the FC method alone.



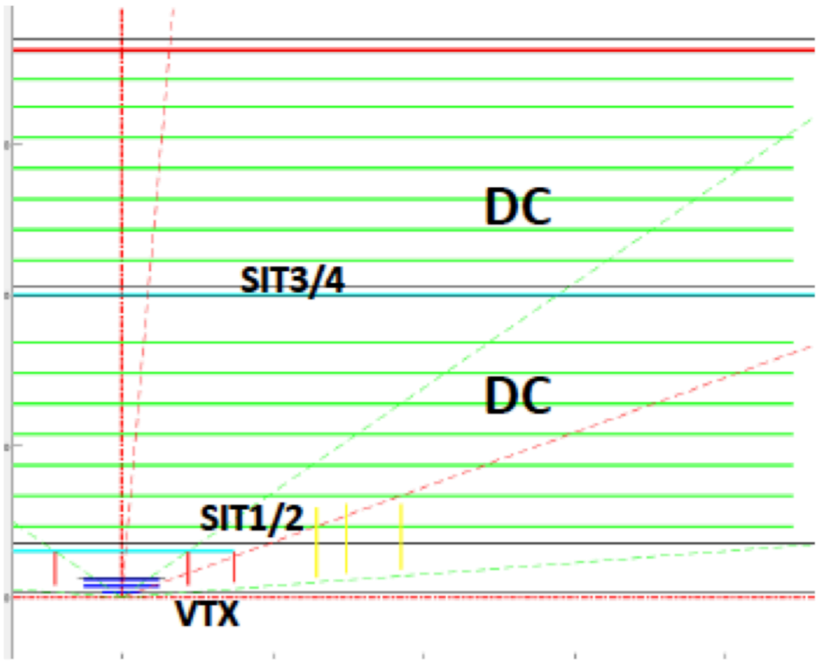
Spatial resolution could be improved → < 100 µm for 8 mm drift cells in He based gas mixtures

Drift chamber of CEPC reference detector

Also @CEPC → Under study the combination of Silicon and Drift Chamber Tracker (SDT)

Particle identification essential for flavor physics and jet study

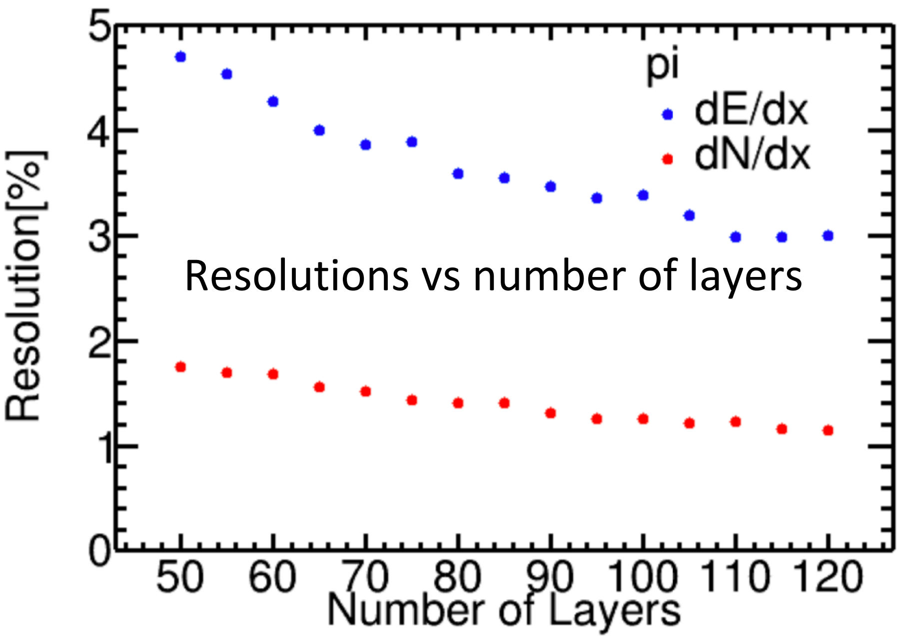
- Reduce combination background
- Improve mass resolution
- Improve jet energy resolution
- Benefit flavor tagging



Cell size: 1cm x 1cm
He based gas mixture
(50% He – 50% i-C_4H_{10})

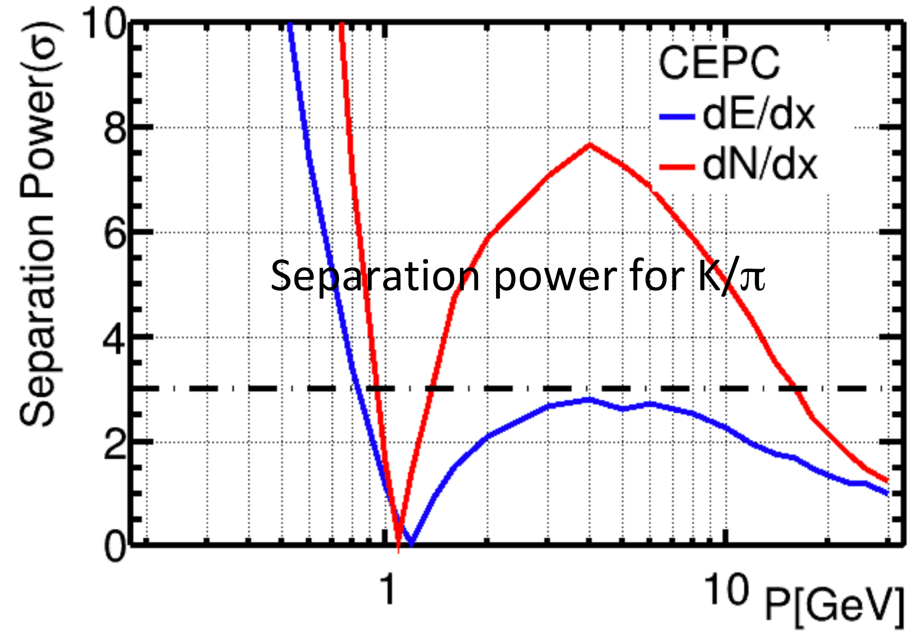
Drift chamber of CEPC reference detector

Resolutions vs number of layers



Resolutions vs number of layers

Separation power for K/π



Separation power for K/π

only simulated ionization