IDEA drift chamber

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High Energy Circular Electron Positron Collider
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Outline

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- IDEA Tracking System
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- Particle Id with Cluster Counting:
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  - Measurements
- Conclusion

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
√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,challenging)→ fast detectors and FE electronic and DAQ

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 → flavour and τ physics, rare processes

Vertexing:

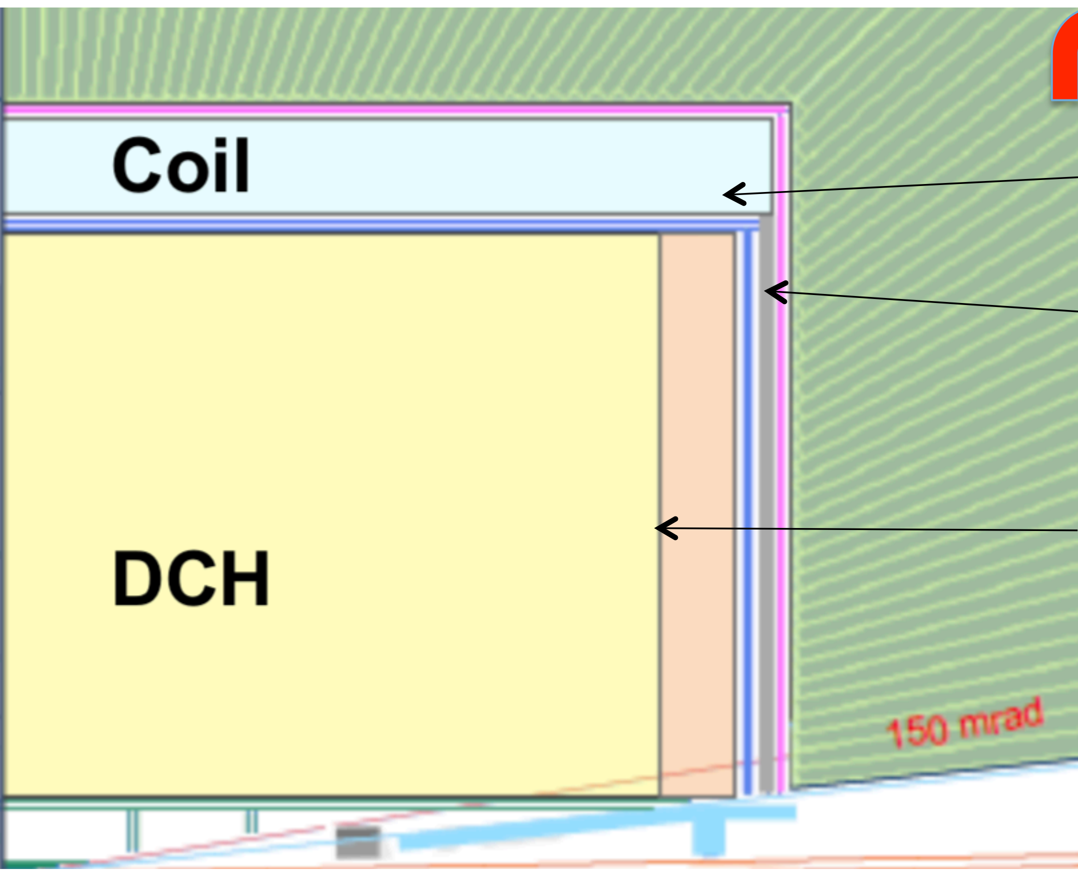
- Few μm track impact parameter resolution
- High transparency

IDEA Tracking System

IDEA → **I**nnovative **D**etector for **E**lectron-positron **A**ccelerators (see J. Liu's talk in this workshop)

FCC-ee at CERN

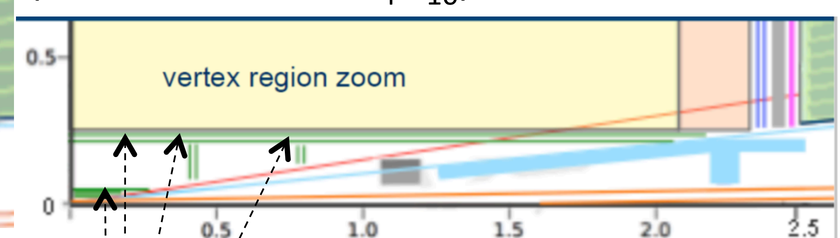
CEPC at IHEP-China



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

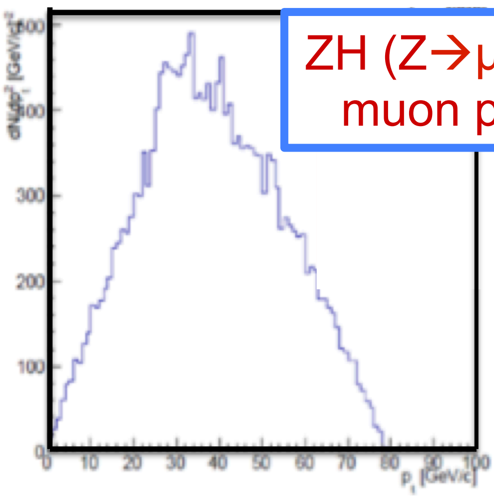
outer: 2 Si pixel (50 μm x 1mm) layers, 0.5% X_0

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

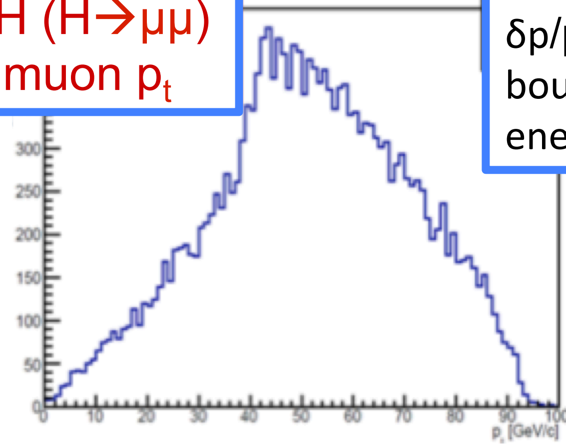
Requirements on Drift Chamber design

DCH designed to provide **efficient tracking, high precision momentum measurement and excellent particle identification** → *High granularity, Transparency, Cluster counting technique*

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

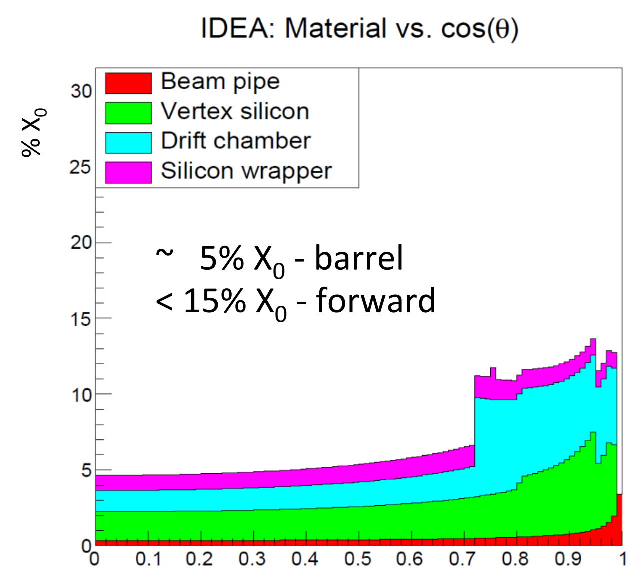
Particle momentum range far from the asymptotic limit where MS is negligible

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

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

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

Minimise material budget is crucial



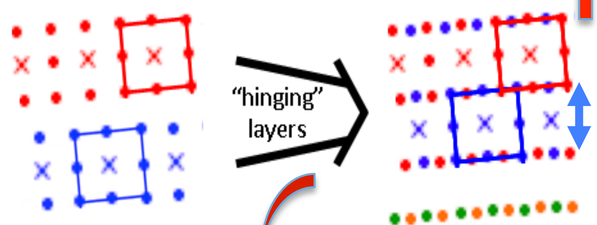
IDEA drift chamber: full stereo configuration

Design inherits some aspects of Drift Chambers previously built and operated to reach a compromise between granularity and transparency requests

Alternating sign stereo angles ranging from 50 to 250 mrad

stereo angle +

stereo angle –



field to sense wires ratio **3 : 1**

field to sense wires ratio **5 : 1**

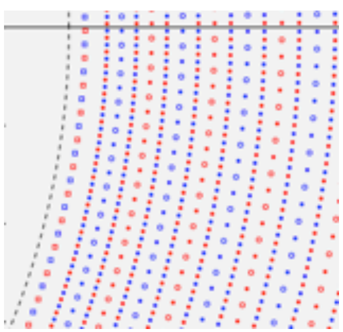
stereo angle +

stereo angle –

guard layer

12÷14.5 mm (at z=0) wide square cells
max drift time 360 ns

combination of + and –wire orientation produces a more uniform equipotential surface → 5:1 field to sense wires ratio (more field wires) →better E-field isotropy and smaller E×B asymmetries)



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

14 co-axial super-layers, 8 layers each
in 24 equal azimuthal (15°) sectors

112 layers in total
56,448 cells in total
343968 wires in total

IDEA drift chamber: gas containment and wire supporting

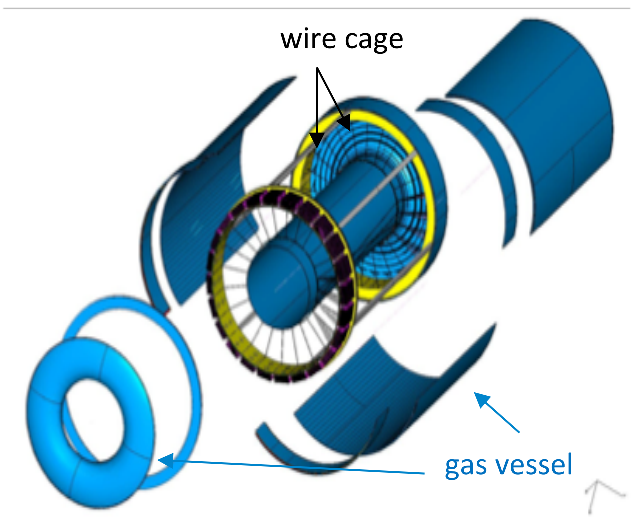
Gas envelope and wire supporting structure separated:

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)

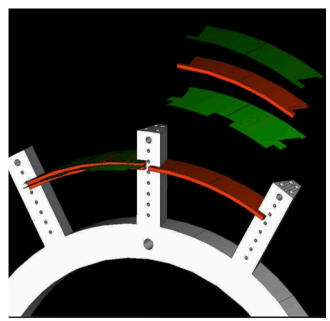
Gas envelope can freely deform without affecting the internal wire position and tension

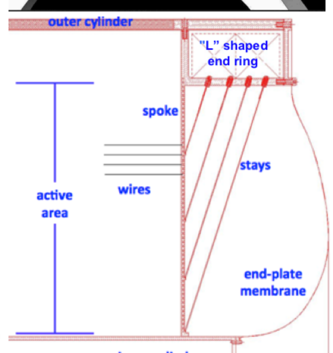
"feed-through-less" wiring (as in MEGII DC, see the G. Chiarello's talk in this session):

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.

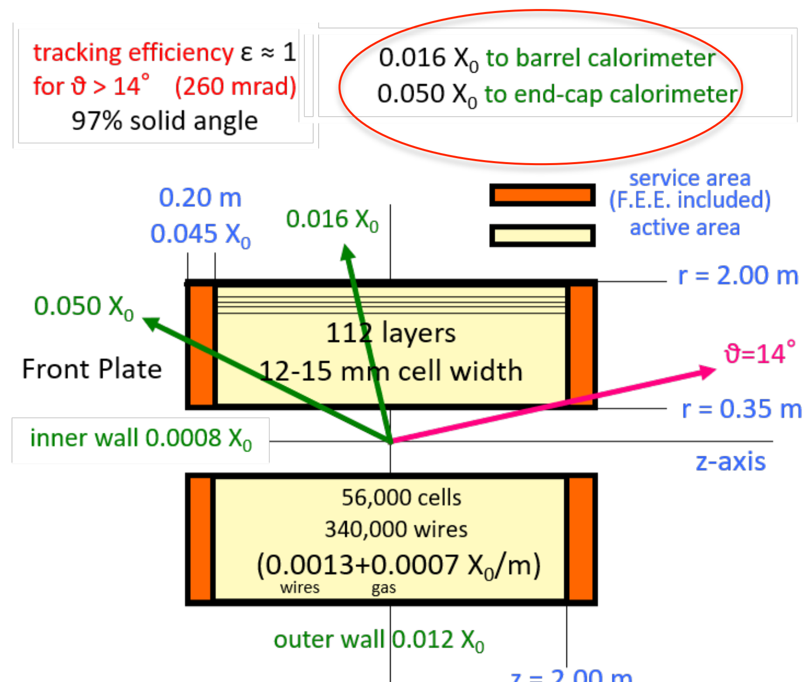


Wire PCB and spacers



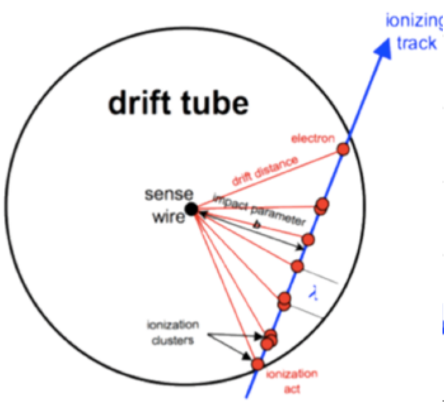


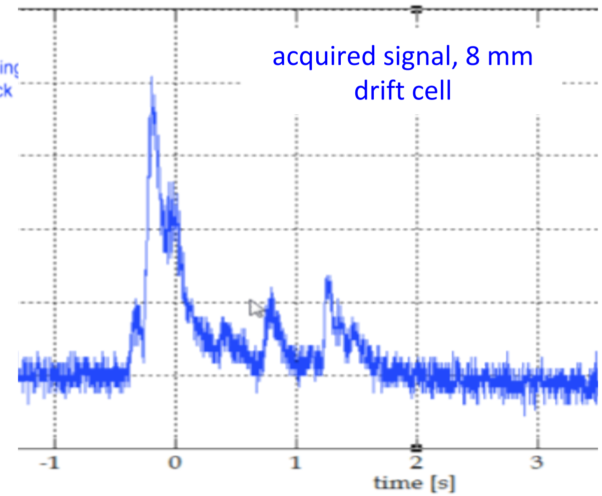
Tension recovery scheme

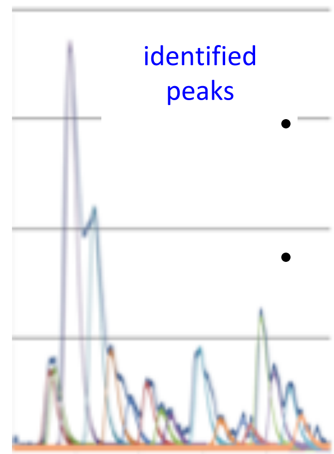


IDEA drift chamber: Particle Identification

- 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 dN_{cl}/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 ($\approx 12\,\text{cm}^{-1}$)
- 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

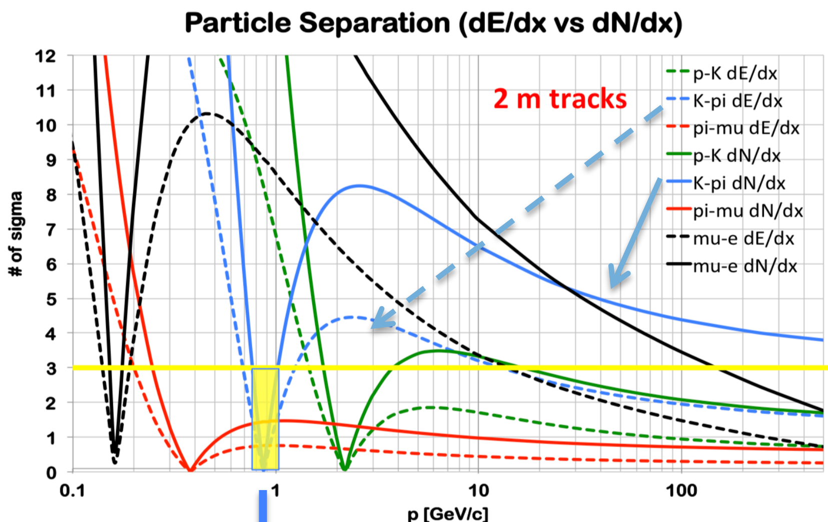
- Requires fast electronics and sophisticated counting algorithms
- Less dependent on gain stability issues
- δ_{cl} = 12.5/cm for He/iC_4H_{10}=90/10 and a 2m track → **σ ≈ 2.0%**

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

Poisson

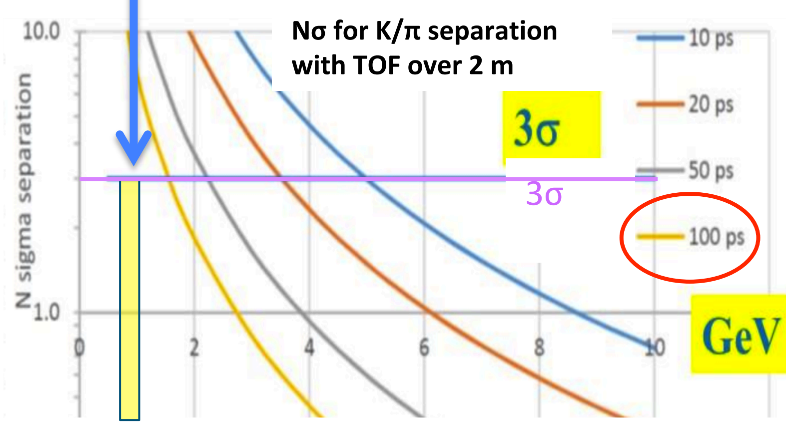
IDEA drift chamber: Particle Id expected performance

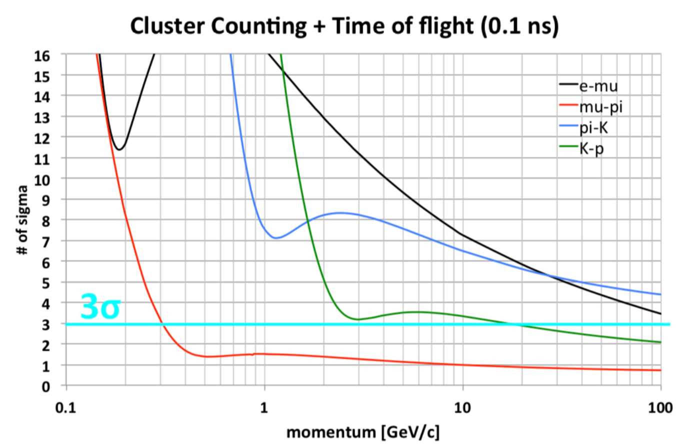
- Analytical calculations (to be cross-checked with detailed simulations and data!) → predict excellent K/π separation over the full range of momenta except 0.85<p<1.05 GeV



He/iC_4H_{10} 90/10 δ_{cl}=12 cm^{-1}
$\sigma_{(dE/dx)}/(dE/dx)$=4.3%
80% cluster counting efficiency

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

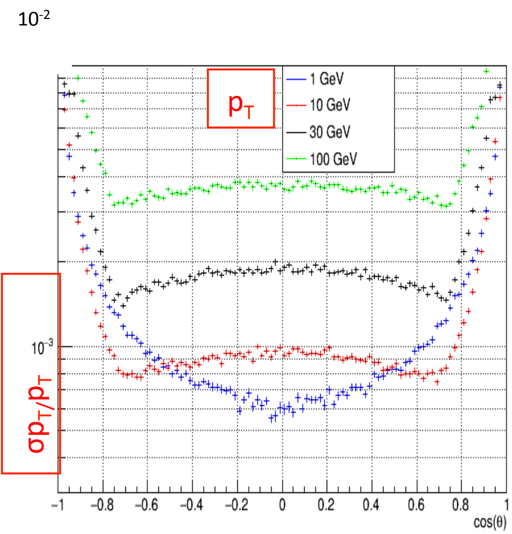


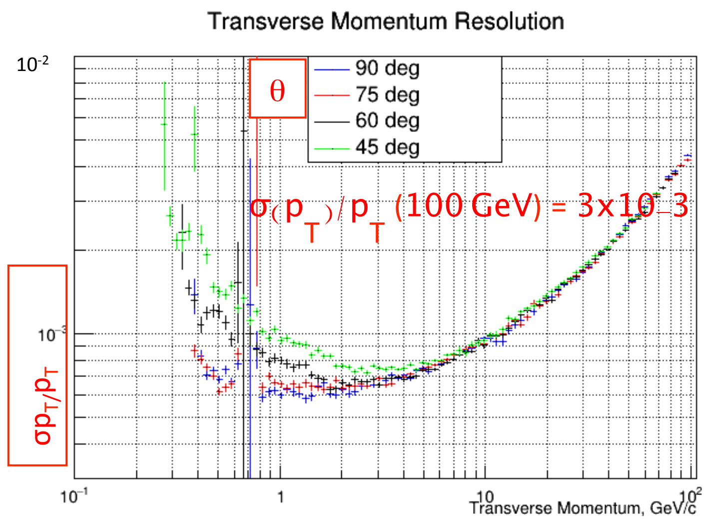


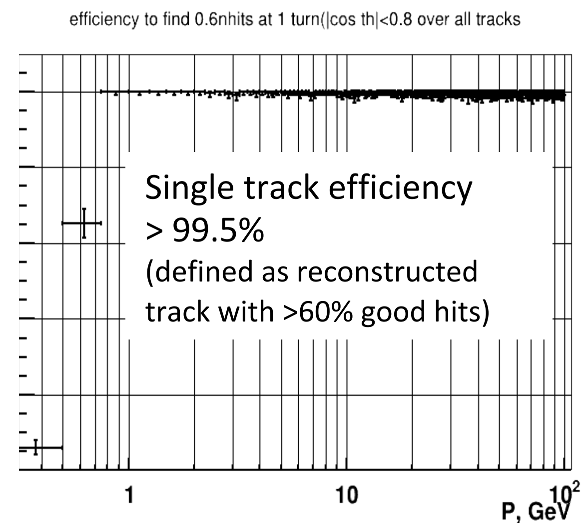
IDEA drift chamber: expected tracking performance

- Full Geant4 standalone simulation of the IDEA tracking system →drift chamber simulated at a good level of geometry details
- 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)



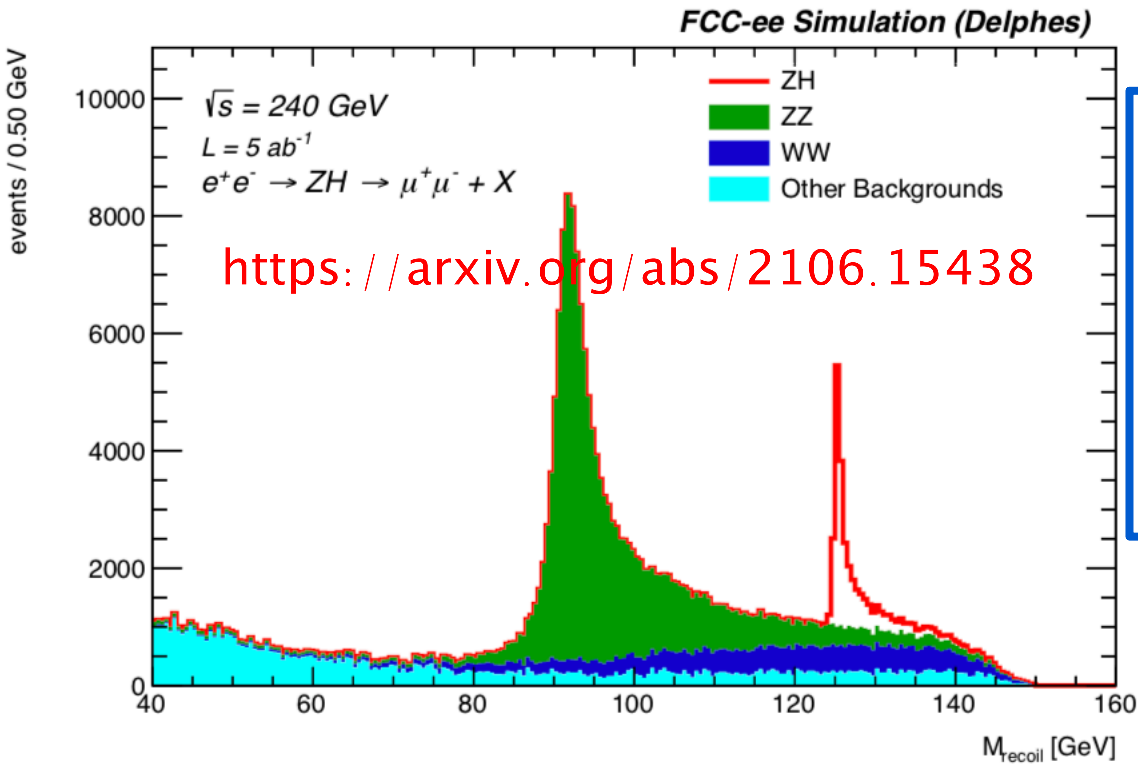




single muons, p_T resolutions as function of ϑ and p_T assuming σ_d = 100 μm and (conservative for Si) σ_{Si} = pitch/√12 μm

IDEA drift chamber: expected performance on physics events

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



Z recoil mass

Z → μμ final state

Nominal Higgs mass → 125 GeV

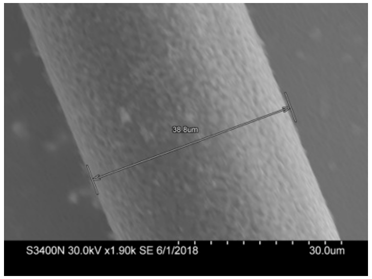
Events with

- $15 < p_T(\mu\mu) < 70$ GeV
- $|M_{\mu\mu} - M_Z| < 20$ GeV

DCH muon momentum resolution (in clean events) → 1% stat. unc. on inclusive σ_{ZH}
→ ~6MeV on m_H

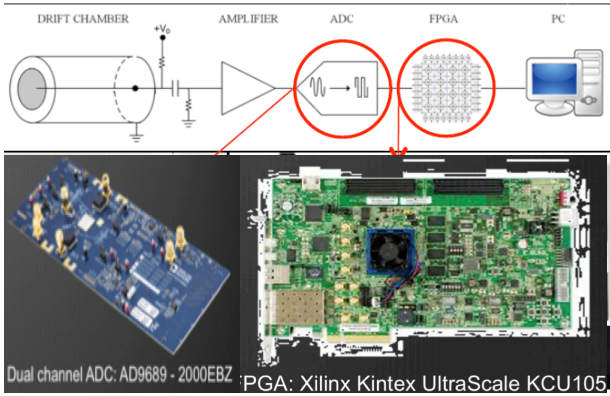
IDEA drift chamber: R&D program

35 μm C wire – Cu coated



- Studies on new materials for DCH wires → metal coated Carbon monofilaments to operate with safer wire tensions far away from the elastic limit (e.g. : a tension $T_c \geq 250$ N needs to be applied to 35μm C monofilament, but elastic limit is 830 N)

- Studies on new polymeric fibers for DCH envelopes → (e.g. conductive polymeric matrices) to strongly reduce gas permeability (Helium), to enhance electrical conductivity for electrostatic and radiofrequency shielding, to improve the transparency

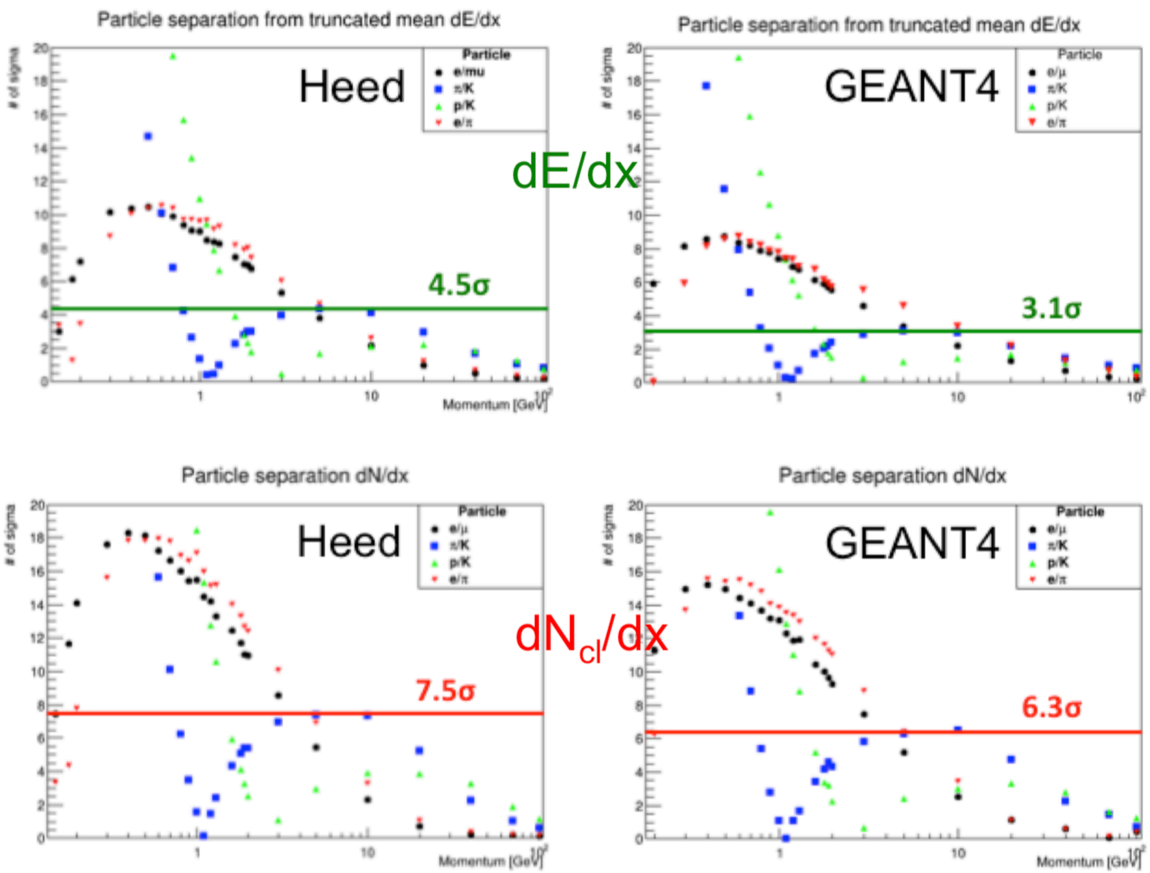


- Front-end, DAQ and pre-processing electronics for cluster counting → FEE: wideband (1 GHz) amplifier (25 dB) low mass, low power, low noise, multichannel (×8) ASIC, 12 bit & 2 GSa/s digitizers, multi-channel (16/32) FPGA for filtering and data reduction

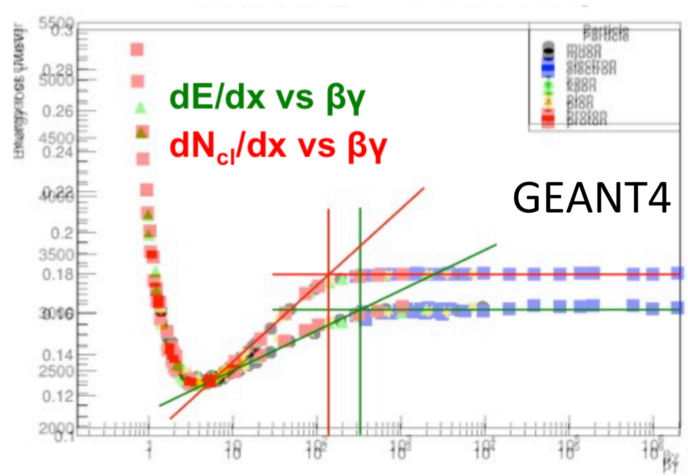
- Construction of scale 1:1 prototypes → to test the proposed innovative solutions for new materials

- Test beam facilities with identified beams of *e/μ/π/K/p* in the range 1-50 GeV/c → to experimentally determine the particle identification capabilities in the relativistic range

Particle Id with Cluster Counting: simulation



Strong synergy between IDEA and the 4th Conceptual Detector communities → "Cluster Counting regular meetings"



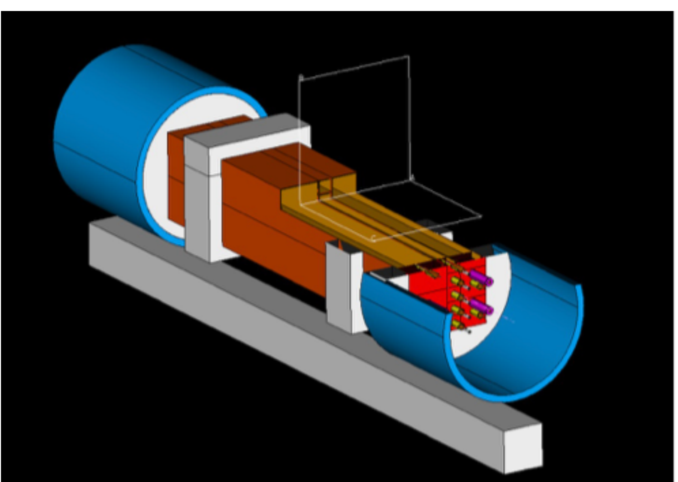
dNcl/dx Fermi plateau with respect to dE/dx is reached at lower values of βγ with a steeper slope

Defined a model for a fast simulation of the cluster density and the cluster size distribution according to the predictions of **Heed (Garfield++)**, to be used in GEANT4.

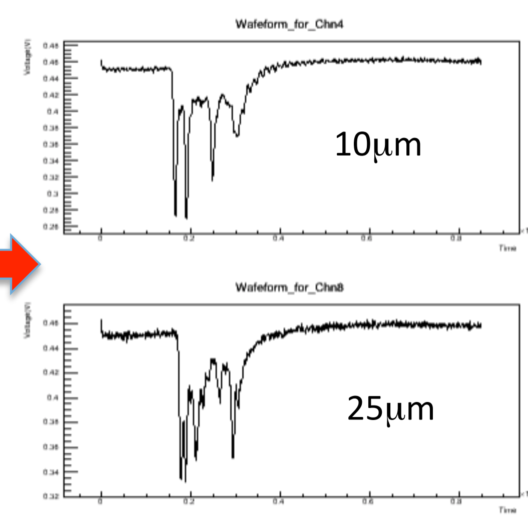
GEANT4 reproduces reasonably well the Heed predictions but PId in GEANT4, both with dE/dx and with dN$_{cl}$/dx, appears to be worse than in Heed

Particle Id with Cluster Counting: measurements

- Beam test in parasitic mode (we could be main user in spring 2022) now ongoing at CERN (H8) with drift tubes :
  - @fixed muon momentum → N_{cl} versus cell size (1x1cm^2, 2x2cm^2, 3x3cm^2), gas mixture (90/10 to 75/25 He/iC_4H_{10}), gas gain (1x10^5 to 5x10^5), sense wire diameters (15, 20, 25, 30 μm), angle between track and wire (0°, 30°, 45°, 60°) → **measure counting efficiency vs cluster density, estimate cluster size distribution, study number of clusters versus space charge effects**
  - @muon momentum scan (few GeV/c to about 250 GeV/c, $\beta\gamma$ = 40 ÷ 1800) and having chosen optimal conditions (gas mixture, gain, sense wire diameter, etc.) → **measure relativistic rise** both for dE/dx and dN_{cl}/dx and use the experimental results to fine tune simulation for flavor physics and for jet flavor tagging (both in fast and in full simulation)
  - test and optimize counting algorithms



1x1cm^2



Conclusion

- The IDEA DCH is a full-stereo, high momentum resolution, ultra-light detector accomplishing the FCC-ee/CEPC tracking requirements
- Mechanical design and wiring technique combine innovative elements with proven solutions
- Cluster Counting method is expected to provide an important improvement in PID wrt dE/dx technique
- Tracking performance studies with Geant4 simulations and analytic calculations in the contest of FCC-ee/CEPC on benchmark physics show very promising results
- A wide program of R&D activities on DCH is ongoing
- Cluster counting extensively studied with both simulations and experimental measurements@beam tests, strong synergy between IDEA and 4th concept → crucial for establishing the particle identification performance at FCC-ee, CEPC and SCTF

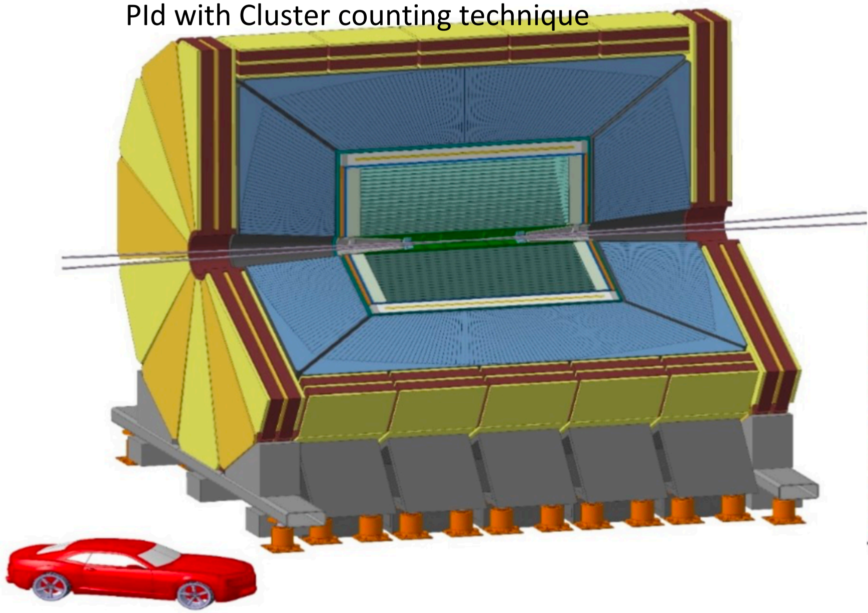
Thank you for your attention!

Backup slides

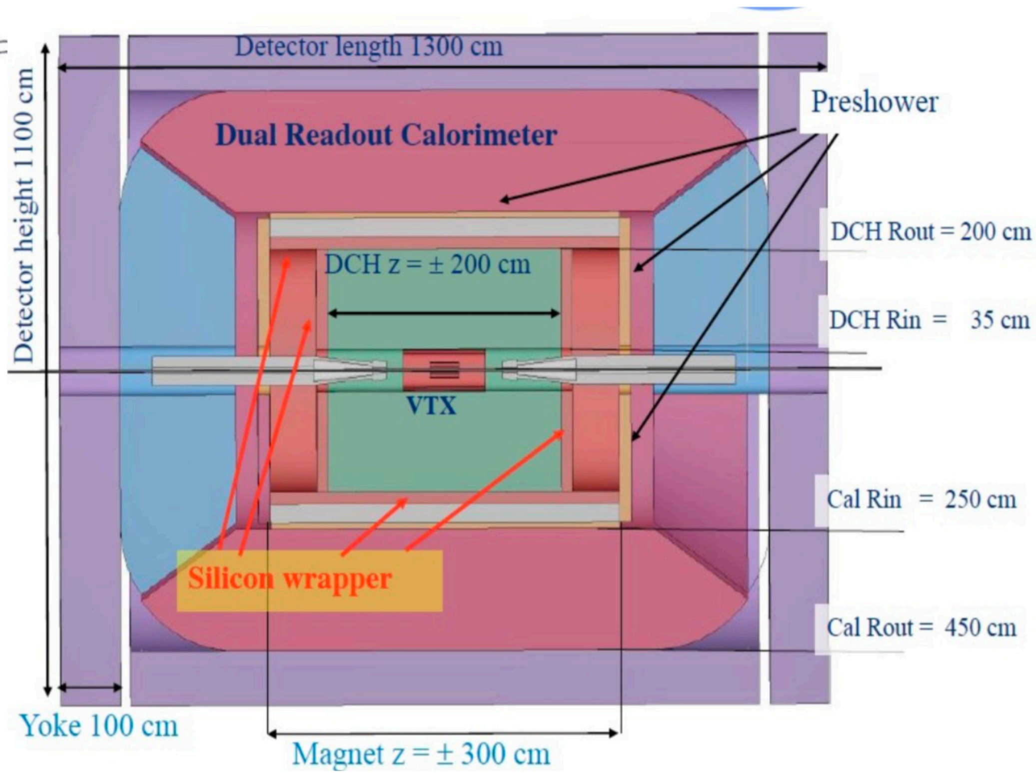
Vertex:
- Monolitic pixel (MAPS) with 20 μm pixel size and 3 μm single point resolution
- Hit efficiency 99.9%
- Low power → less 20 mW/cm^2

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

Drift chamber:
- He-iC_4H_{10} gas mixture → Max drift time 360 ns
- Maximum stereo angle ~ 30°
  PId with Cluster counting technique



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 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

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 m³	
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

IDEA DCH geometry

Material budget estimates 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, ...)

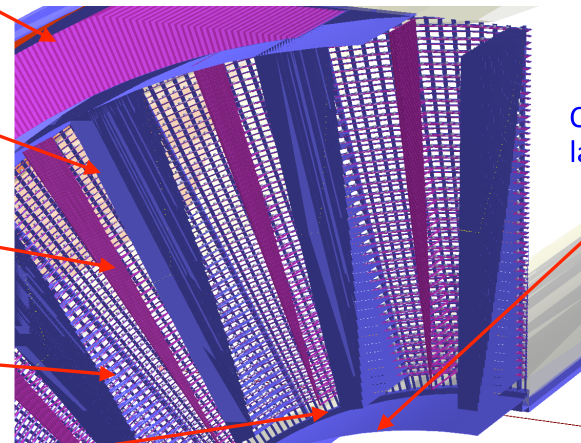
Electronics boards: 12 cm x 6 cm x 3mm G10 (FR4);

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

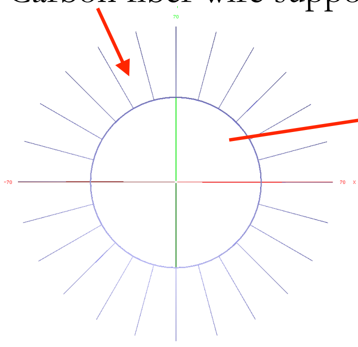
HV cables:
500 μm Copper wire
+ 500 μm Teflon insulation;

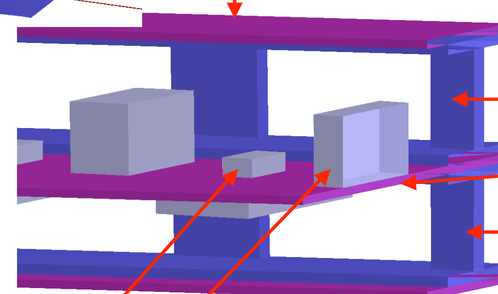
Wire anchoring;

Carbon fiber wire support.



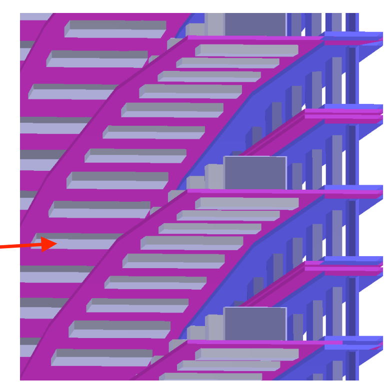
Connecting ring is described as a circular layer: 0.5 cm x 1.5 cm Carbon fiber





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.

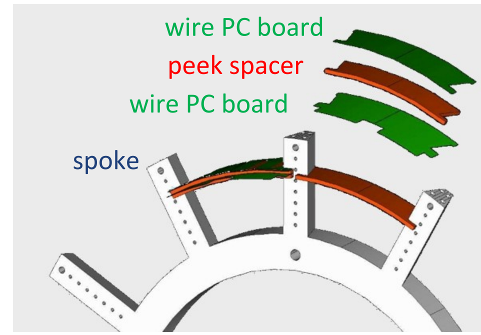


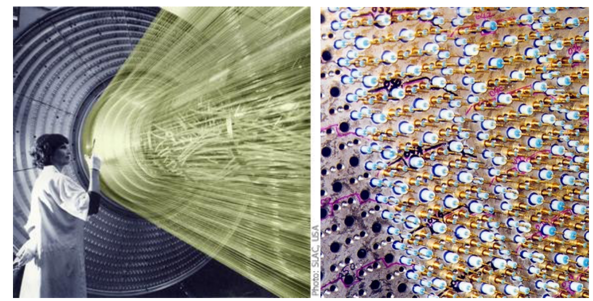
MEG II DCH

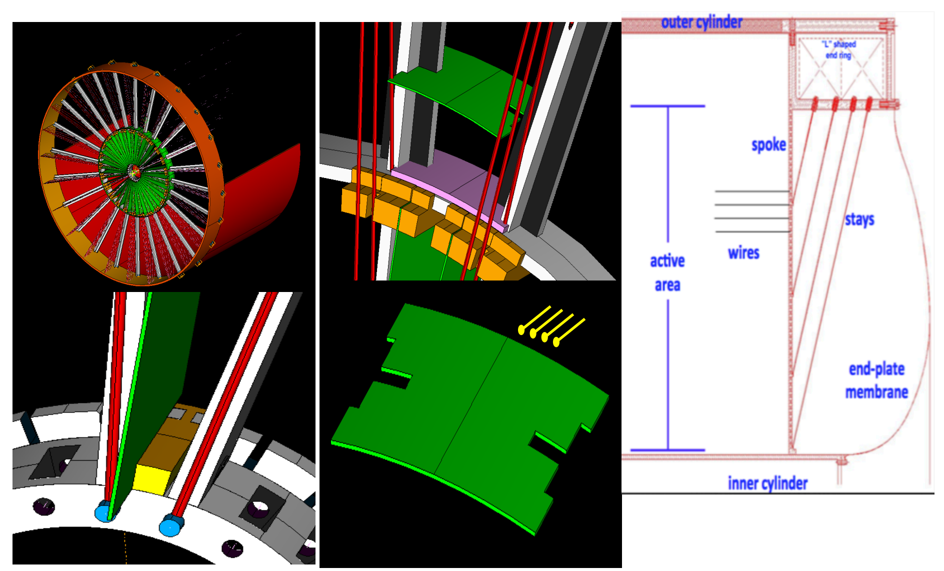
<ins>**~ 12 wires/cm² → impossible to built DCH with a conventional technique based on feedthrough)**</ins>

- 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 →







dE/dx and dN_{cl}/dx

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

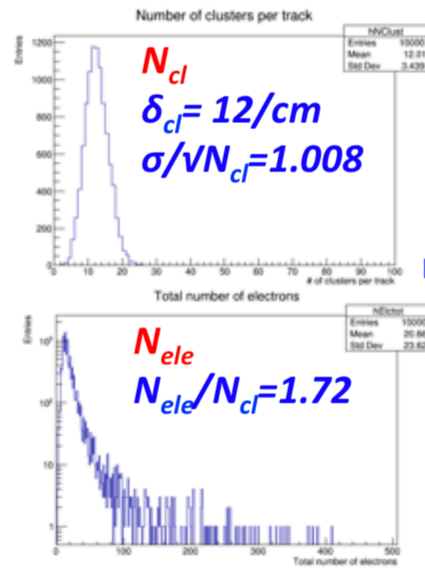
Walenta

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%

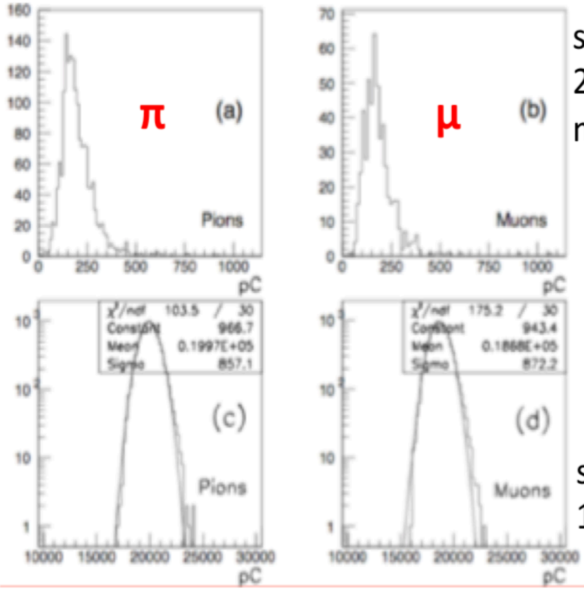
A small increment of iC_4H_{10} from 10% to 20% (δ_{cl} = 20/cm) improves resolution by 20% (σ ≈1.6%) at only a **reasonable** cost of multiple scattering contribution to momentum and angular resolutions.

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

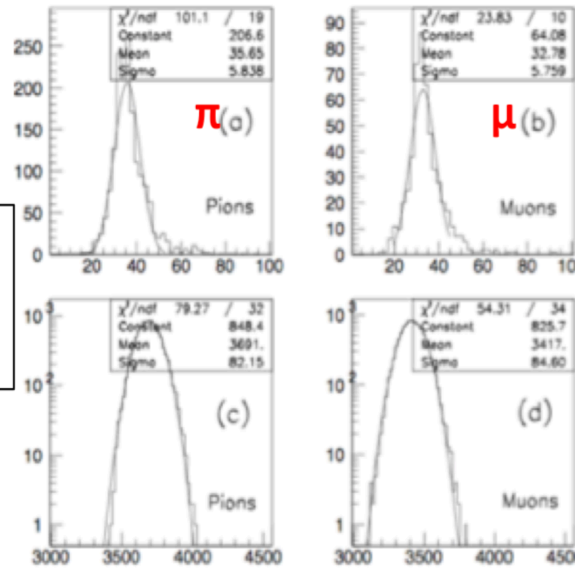
gas gain 2×10^5, 1.7 GHz – gain 10 amplifier, 2GSa/s – 1.1 GHz – 8 bit digitizer



single sample
20% truncated
mean

test beam data

sum over
100 samples



single sample

π: $\sigma/\sqrt{N_{cl}}=0.978$
μ: $\sigma/\sqrt{N_{cl}}=1.006$

sum over
100 samples

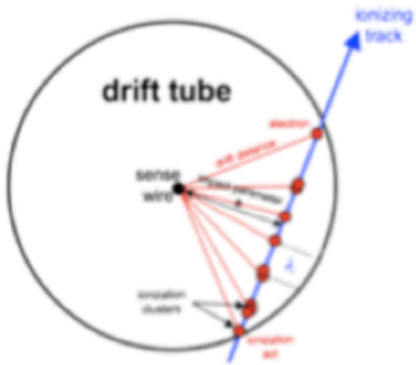
π: $\sigma/\sqrt{N_{cl}}=1.35$
μ: $\sigma/\sqrt{N_{cl}}=1.45$

integrated charge
expected 2.0 σ separation
measured 1.4 σ separation

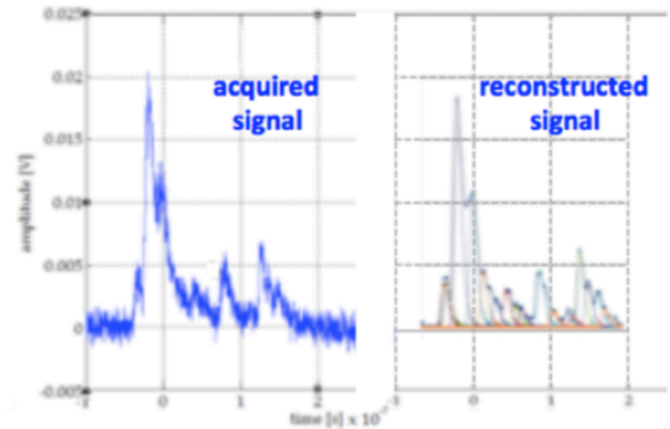
cluster counting
expected 5.0 σ separation
measured 3.2 σ separation

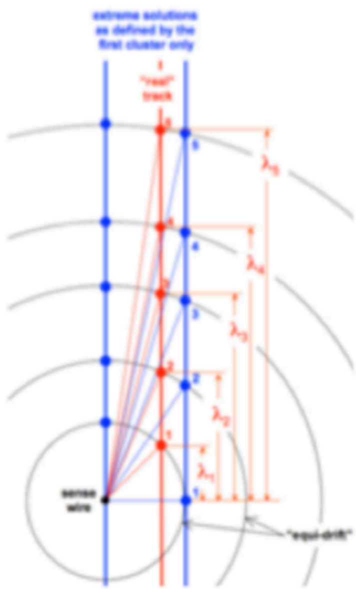
(NIM A386 (1997) 458-469 and references therein)

Cluster timing

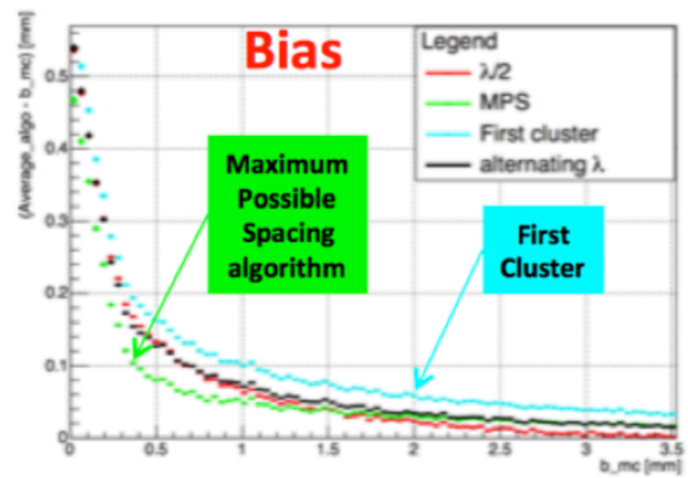


From the **ordered sequence of the electrons arrival times**, considering the average time separation between clusters and their time spread due to diffusion, **reconstruct the most probable sequence of clusters drift times:** $\{t_i^{cl}\} \quad i = 1, N_{cl}$





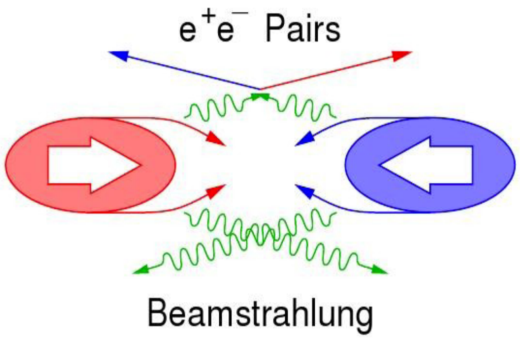
For any given first cluster (**FC**) drift time, the **cluster timing technique** exploits the drift time distribution of all successive clusters $\{t_i^{cl}\}$ to determine the most probable impact parameter, thus reducing the **bias** and the average **drift distance resolution** with respect to those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



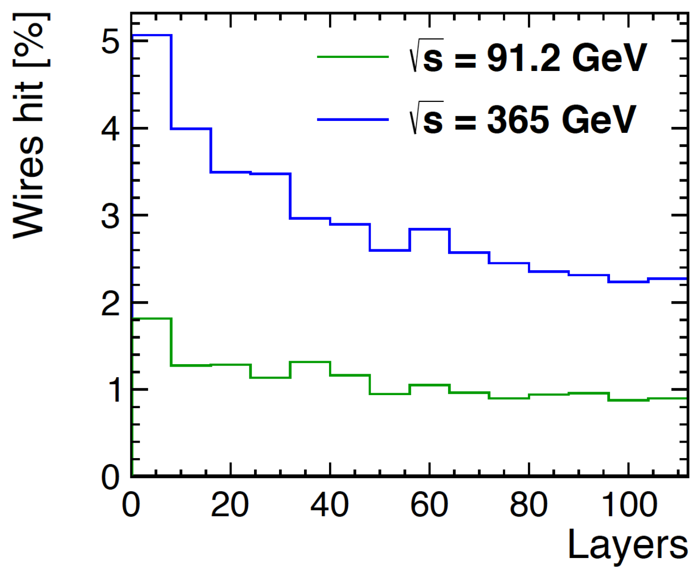
Spatial resolution could be improved → < 100 µm for 8 mm drift cells in He based gas mixtures

Machine background

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

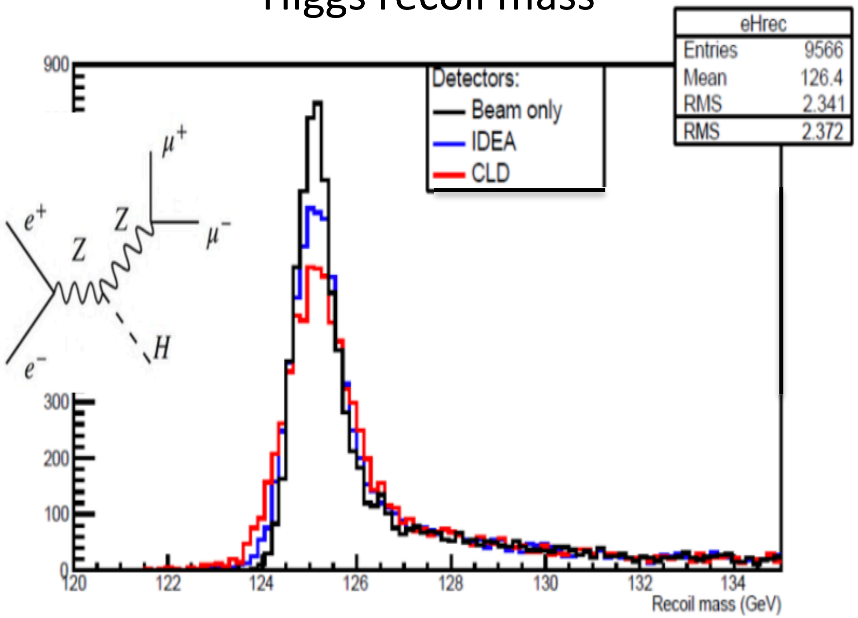


Background	Average occupancy	
	$\sqrt{s}$ = 91.2 GeV	$\sqrt{s}$ = 365 GeV
e^+e^- pair background	1.1%	2.9%
$\gamma\gamma \rightarrow$ hadrons	0.001%	0.035%
Synchrotron radiation	negligible	0.2%

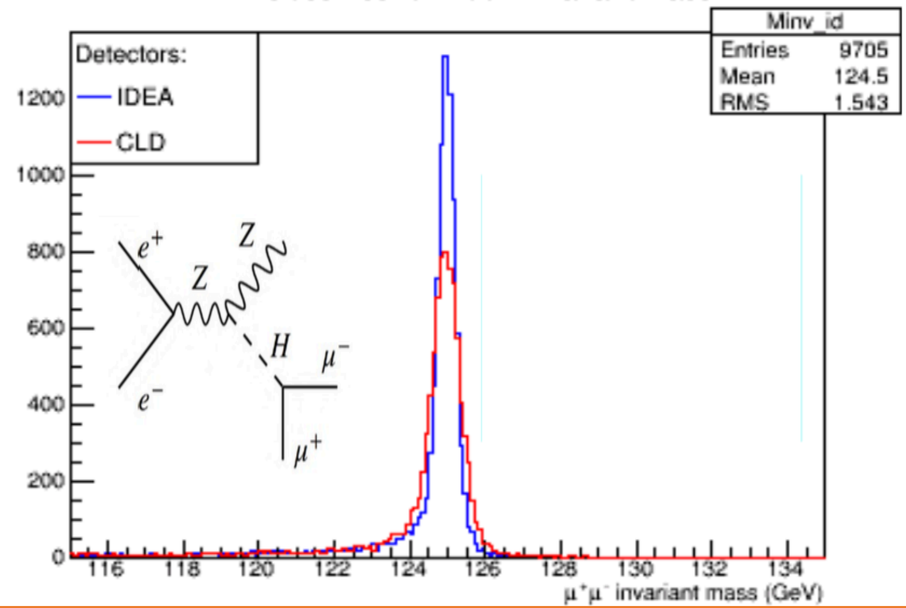


Expected performance: compare IDEA and CLD

Higgs recoil mass



Di-muon invariant mass



Beam only→ assumes 0.136% beam spread and an ideal detector

IDEA → Fast simulation studies

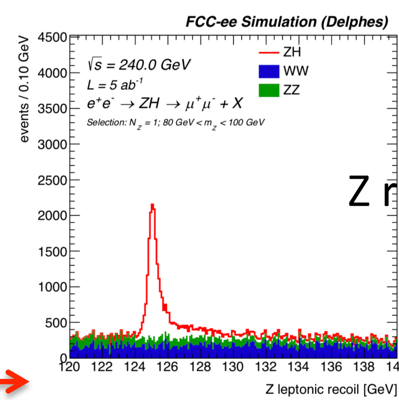
CLD → full Si-tracker system

Transparency ensures a better resolution!

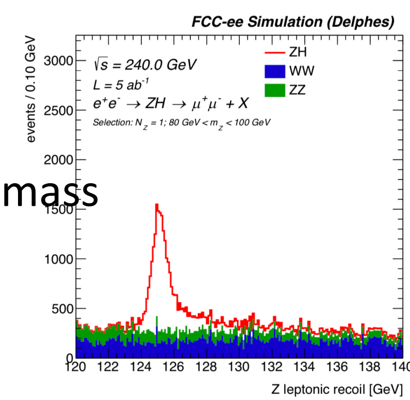
Ang LI, Gregorio Bernardi, FCCee Physics and Performance Meeting, January 18th 2021

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

Z recoil mass



IDEAtrkCov



CLDtrkCov

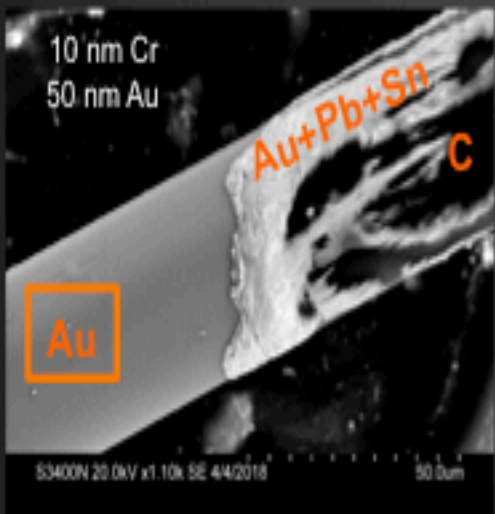
Zoom in on the ZH peak region
CLD has larger width and lower peak

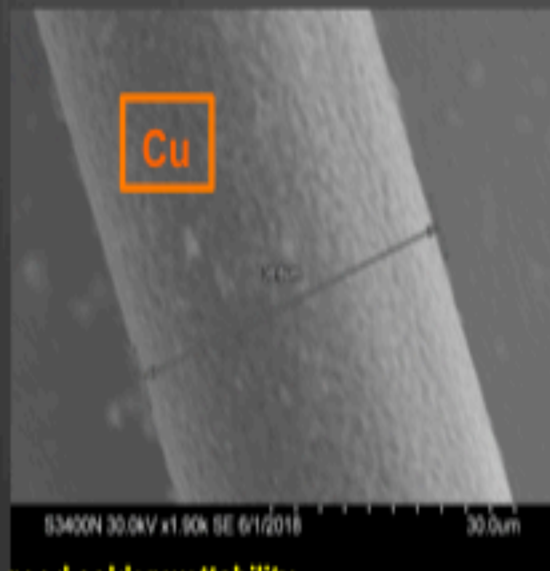
C wire metal coating

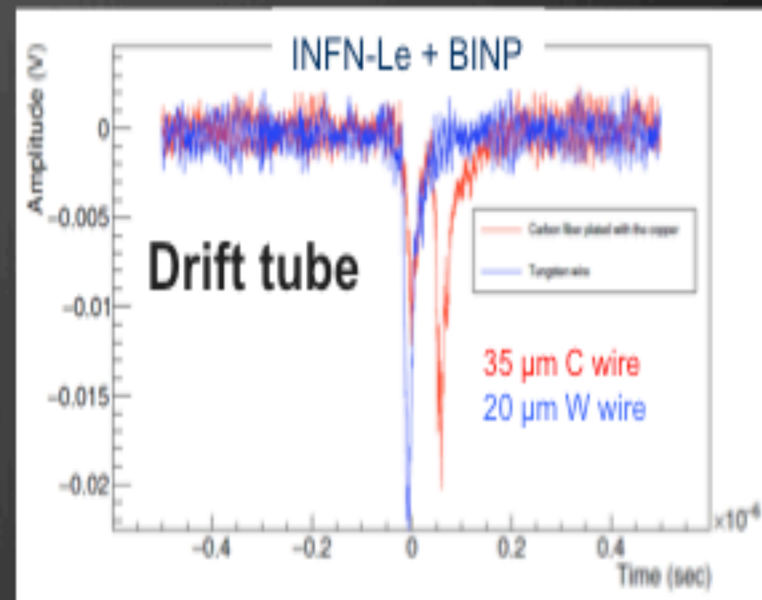
BINP
A. Popov
V. Logashenko

HiPIMS: High-power impulse magnetron sputtering

physical vapor deposition (PVD) of thin films based on magnetron sputter deposition (extremely high power densities of the order of kW/cm^2 in short pulses of tens of microseconds at low duty cycle <10%)

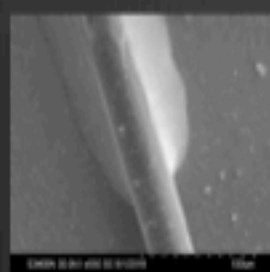


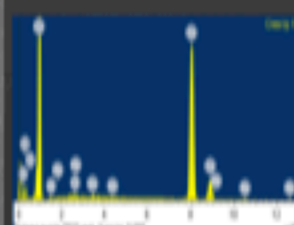


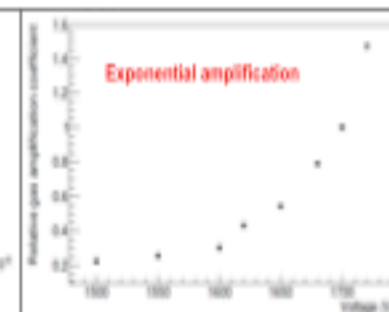


soldering attempt
Lead forms intermetallic compound with gold and completely dissolves the 50 nm Au layer.

good solder wettability on Cu

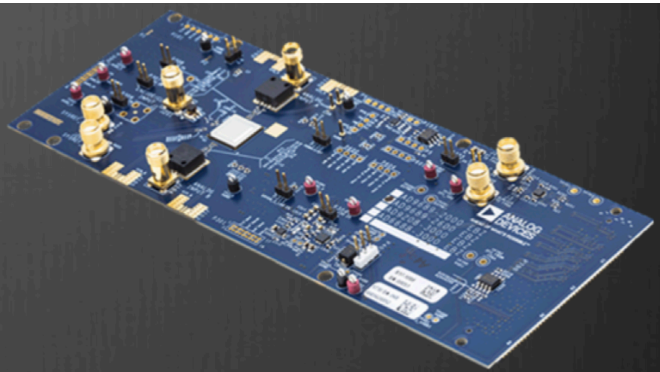






New hardware under test for a new **2ch board**

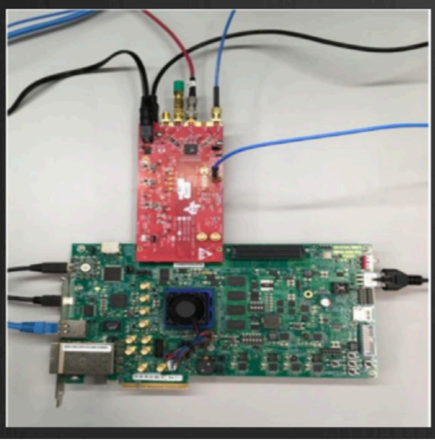
Dual channel ADC: AD9689 - 2000EBZ
FPGA: Xilinx Kintex UltraScale KCU105

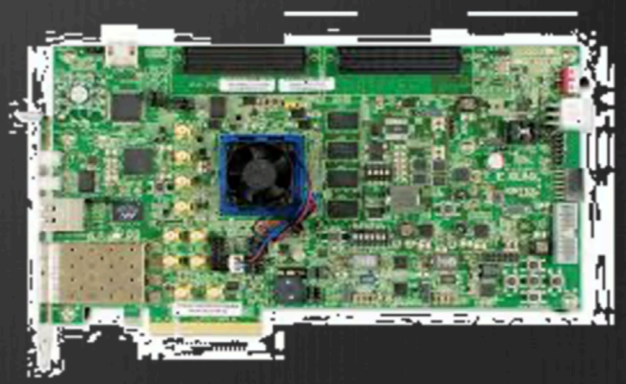


Dual channel ADC: AD9689 - 2000EBZ

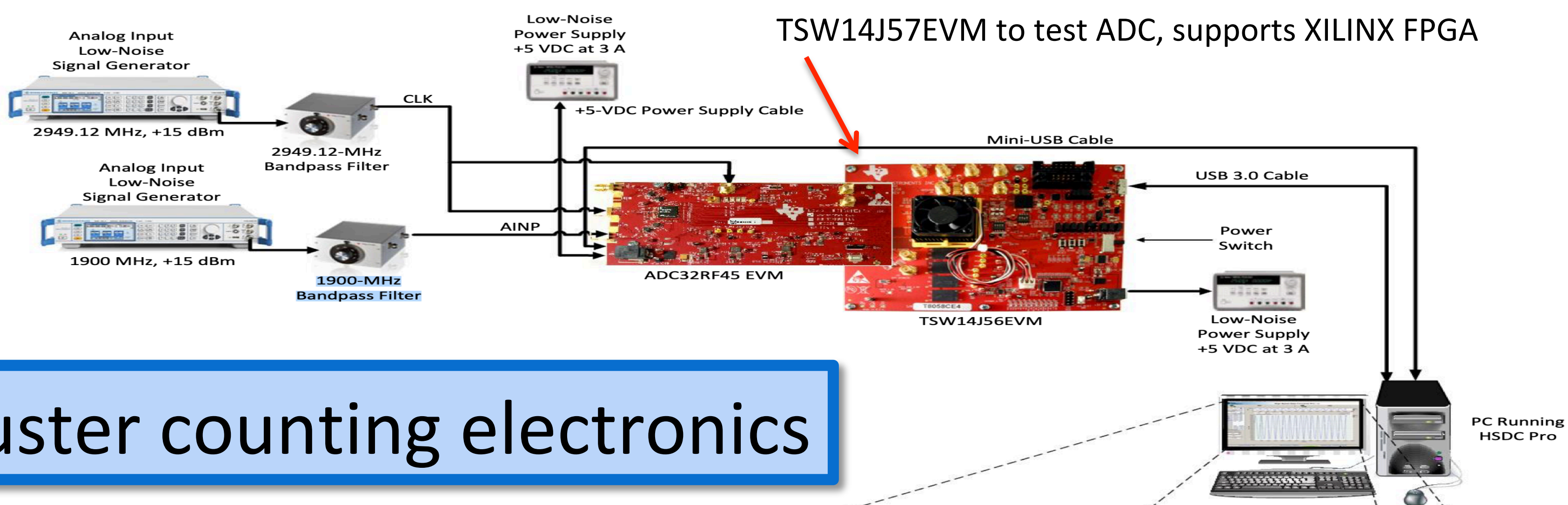
Considering also

Dual-Channel ADC: ADC32RF45, 14-Bit, 3GSPS from TEXAS INSTRUMENT directly compatible with **KCU105**, offering better performance in terms of
- noise,
- ENOB,
- channels isolation





FPGA: Xilinx Kintex UltraScale KCU105



Cluster counting electronics