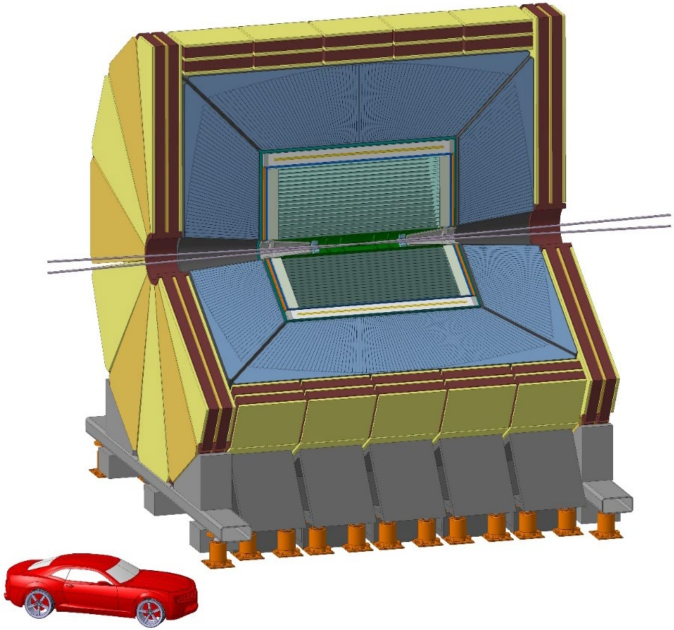
# A proposal of a drift chamber for the IDEA detector concept for a future $e^+e^-$ collider

Innovative
Detector for
Electron-positron
Accelerators



More details in F. Bedeschi:
"A detector concept proposal for a circular e+e- collider",
Talk at this conference

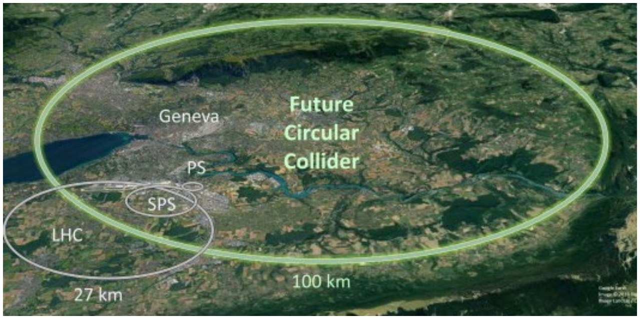
Tassielli G.F. - *INFN* Lecce & Mathematics and Physics Dept., *University of Salento*

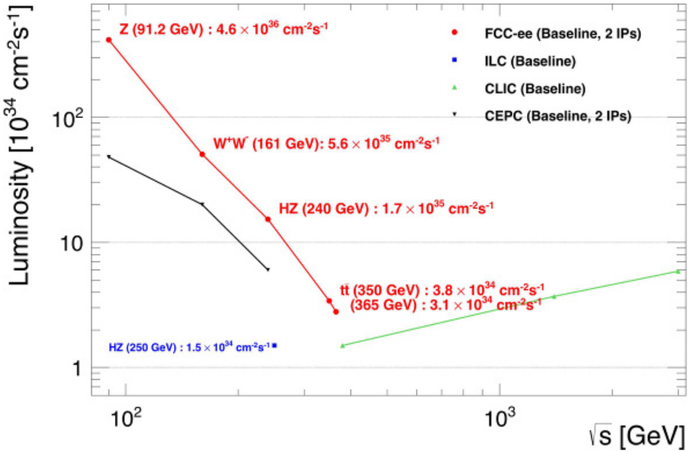
# Outline

- FCC-ee
- Tracking requirements
- The IDEA tracking system
- The IDEA drift chamber
  - Novel approach at construction technique of high granularity and high transparency Drift Chambers
  - Cluster Counting/Timing and P.Id. expected performance
- Expected simulated performance
- Ongoing R&D
- Summary

# FCC-ee

FCC-ee: high-luminosity circular electron-positron collider allowing for high-precision measurements of the properties of the Z, the W, the top quark and the Higgs boson.




"FCC-ee: The Lepton Collider"
Eur. Phys. J. Special Topics 228, 261-623 (2019)
https://doi.org/10.1140/epjst/e2019-900045-4

| | **Z** | **WW** | **ZH** | $t\bar{t}$ | |
|---|---|---|---|---|---|
| $\sqrt{s}$ | 91.2 | 161 | 240 | 350 | 365 |
| Ave. bunch spac. (ns) | **19.6** | 163 | 994 | 2763 | 3396 |
| **Events produced** | **$5\cdot10^{12}$** | **$10^8$** | **$10^6$** | **$10^6$** | |
| Running time (years) | 4 | 1 | 3 | 5 | |

# Tracking requirements

Central tracker system:

- state-of-the-art momentum and angular resolution for charged particles;
- B field limited to ~ 2 T to contain the vertical emittance at Z pole. Large tracking radius needed to recover momentum resolution.
- High transparency required given typical momenta in Z, H decays (far form the asymptotic limit where the Multiple Scattering contribution is negligible).
- Particle ID is a valuable additional ability.

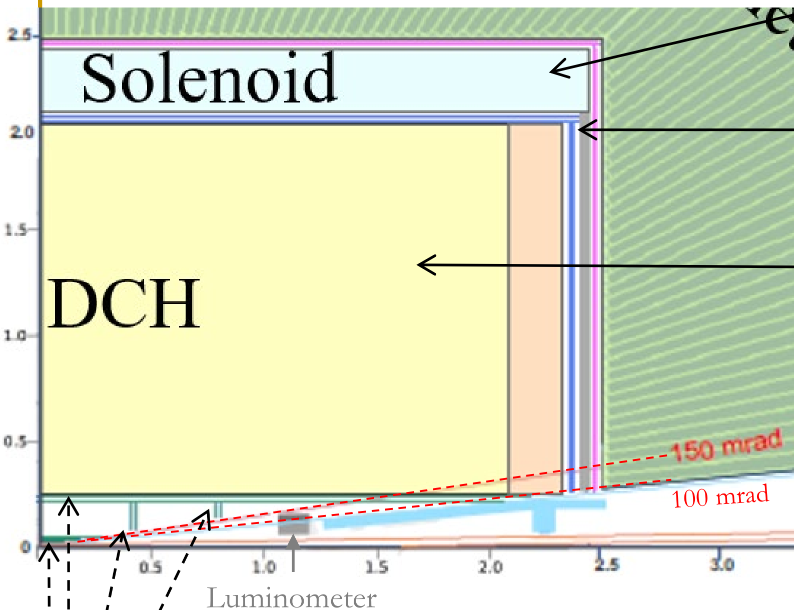
Vertexing:

- excellent b- and c-tagging capabilities : few μm precision for charged particle origin;
- small pitch, thin layers, limited cooling, first layer as close as possible to IP.

Challenges:

- Physics event rates up to 100 kHz (at Z pole)
  strong requirements on sub-detectors and DAQ systems

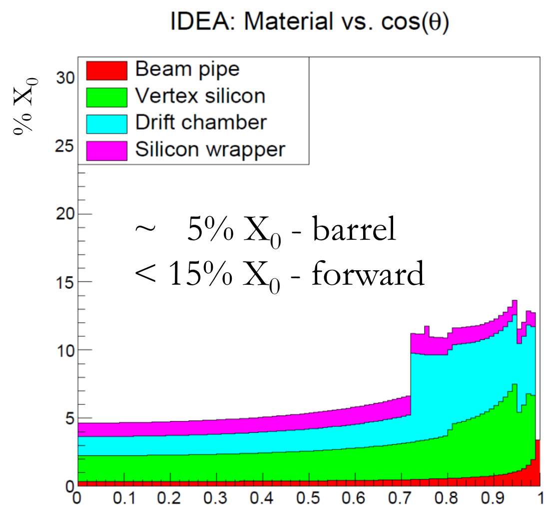
# The IDEA tracking system




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

**Si Wrapper**:
2 layers of μ-strips (50 μm x 1 mm)
*both barrel and forward regions*

**DCH**: 56448 (~1.2 cm) cells
He based gas mixture
(90% He – 10% $i\text{-}C_4H_{10}$)



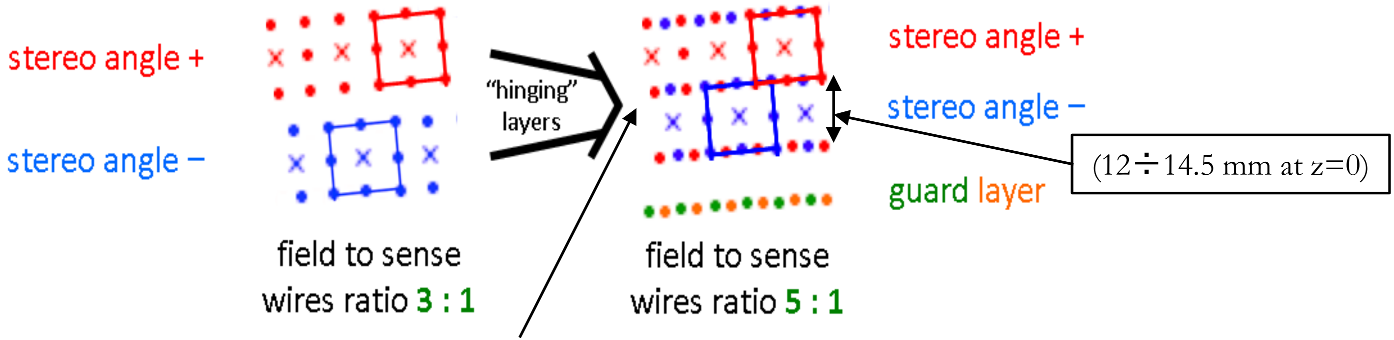

**Vertex**:

*inner*: 3 single Si pixel (20 μm x 20 μm) layers of 0.3% $X_0$

*outer*: 2 single Si pixel (50 μm x 50 μm) layers of 0.5% $X_0$

*forward*: 4 single Si pixel (50 μm x 50 μm) layers of 0.3% $X_0$

# The IDEA drift chamber



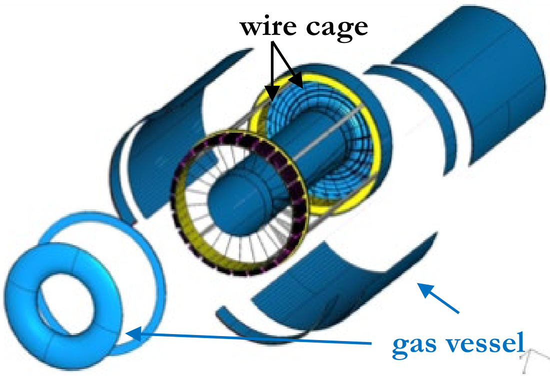

The wire net created by the combination of + and – orientation generates a more uniform equipotential surface

| | | | |
|---|---|---|---|
| sense wires: | 20 mm diameter W(Au) | => | 56448 wires |
| field wires: | 40 mm diameter Al(Ag) | => | 229056 wires |
| f. and g. wires: | 50 mm diameter Al(Ag) | => | 58464 wires |
| | **343968 wires in total** | | |

**High wire number requires a non standard wiring procedure and needs a feed-through-less wiring system. The novel wiring procedure developed and used for the construction of the ultra-light MEG-II drift chamber must be used.**

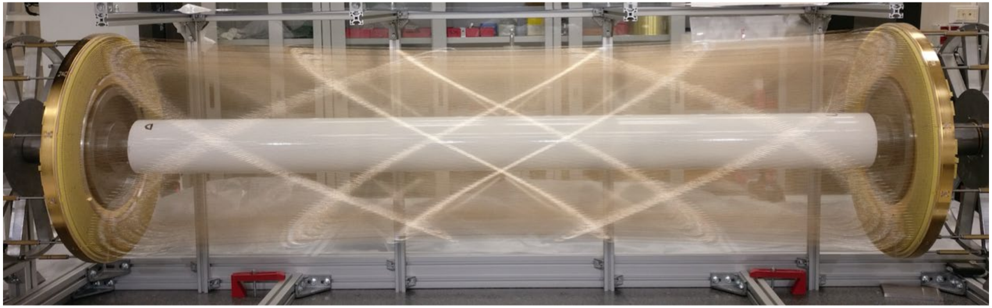
MEG-II: muon to e-gamma search experiment at Paul Scherrer Institut - "The design of the MEG II experiment", Eur. Phys. J. C (2018) 78:380 - https://doi.org/10.1140/epjc/s10052-018-5845-6

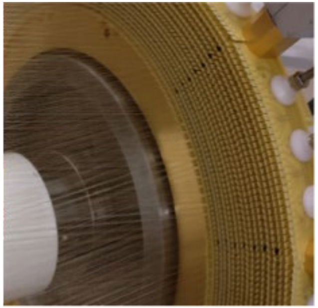
# Novel approach at construction technique of high granularity and high transparency Drift Chambers




Based on the MEG-II DCH new construction technique the IDEA DCH can meet these goals:

- Gas containment – wire support functions separation:
  allows to reduce material to $\approx 10^{-3}\ X_0$ for the inner cylinder and to a few x $10^{-2}\ X_0$ for the end-plates, including FEE, HV supply and signal cables
- Feed-through-less wiring:
  allows to increase chamber granularity and field/sense wire ratio to reduce multiple scattering and total tension on end plates due to wires by using thinner wires

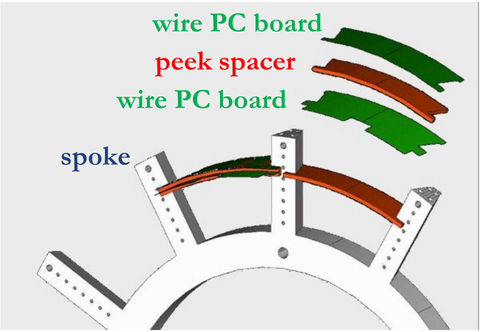




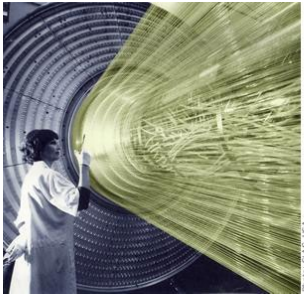
# Novel approach at construction technique of high granularity and high transparency Drift Chambers

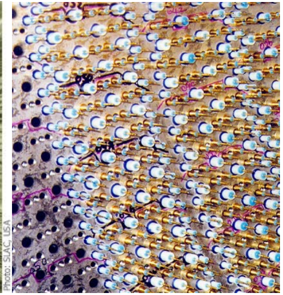
The solution adopted for MEG II:

- 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* $< 20\ \mu m$);
- wire tension defined by homogeneous winding and wire elongation ($\Delta L = 100 \mu m$ *corresponds to* $\approx 0.5\ g$);
- 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.



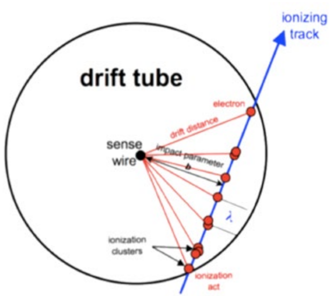

**($\sim$ 12 wires/cm$^2$) impossible to be built with a conventional technique based on feedthrough:**

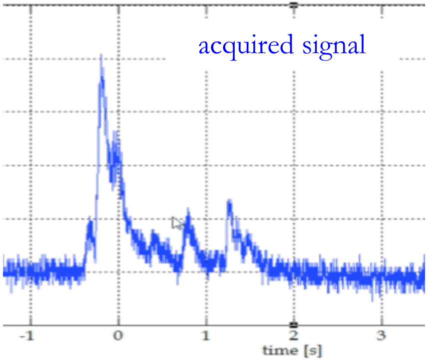


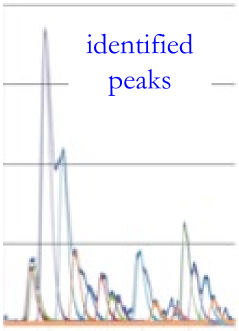


# Cluster Counting/Timing and P.Id. expected performance

In He based gas mixtures the signals from each ionization act can be spread in time to few ns. With the help of a fast read-out electronics they can be efficiently identify.
Counting the number of ionization acts per unit length (dN/dx) is possible to identify the particles (P.Id.) with a better resolution than dE/dx method.




## dE/dx

truncated mean cut (70-80%) reduces the amount of collected information. n = 112 and a 2m track at 1 atm give **$\sigma \approx 4.3\%$**

## $dN_{cl}/dx$

$\delta_{cl}$ = 12.5/cm for He/i$C_4H_{10}$=90/10 and a 2m track give

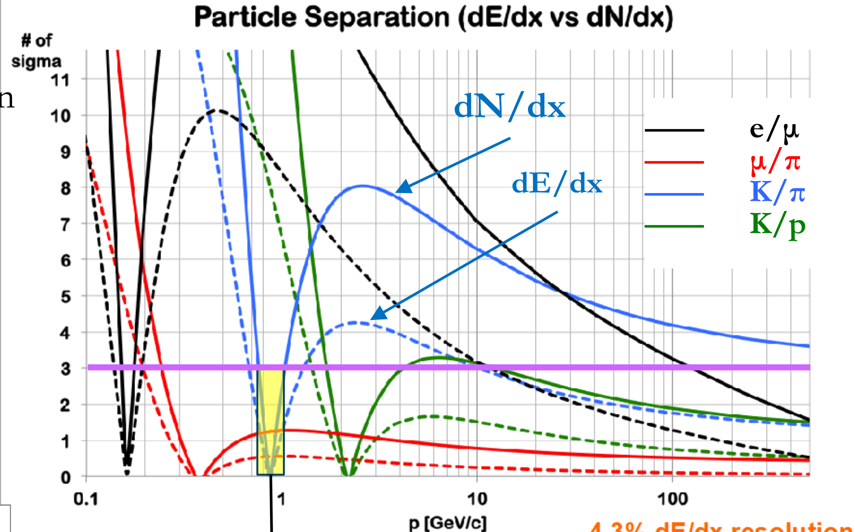
**$\sigma \approx 2.0\%$**

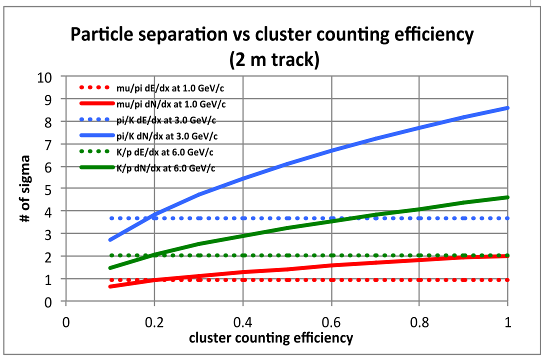
*Moreover, C.C. may improve the spatial resolution < 100 μm for 8 mm drift cells in He based gas mixtures*

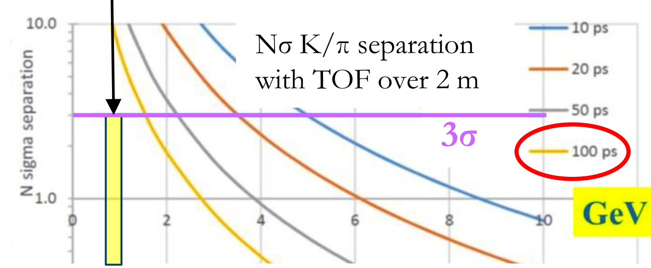
# Cluster Counting/Timing and P.Id. expected performance

- Expected excellent K/π separation over the entire range except 0.85<p<1.05 GeV (blue lines)
- Could recover with timing layer

*analytic evaluation, to be checked with detailed simulations and test beams*

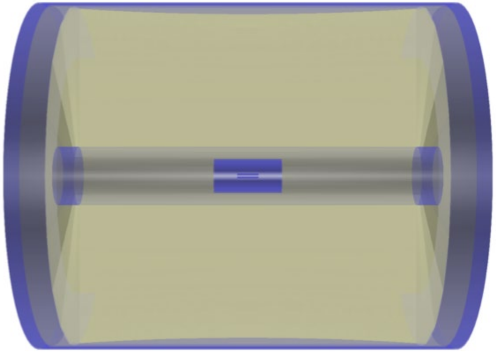


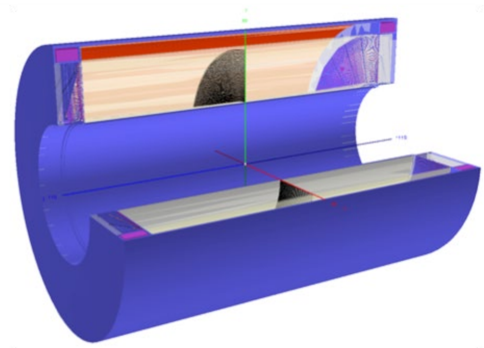



# Expected simulated performance

- A full geant4 simulation of the IDEA tracking system was developed to test the tracking performance
- The DCH is simulated at a good level of geometry details, including detailed description of the endcaps;
- SVX and Si wrapper are simulated as simple layer or overall equivalent material;
- KF with simple track selection criteria was used: *only a quality cut on Chi2/nDof < 25 was applied*;
- A preliminary SVX and DCH description inside the FCC-sw was implemented

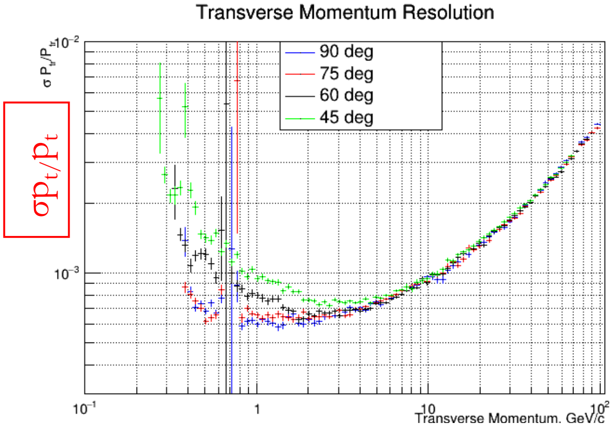


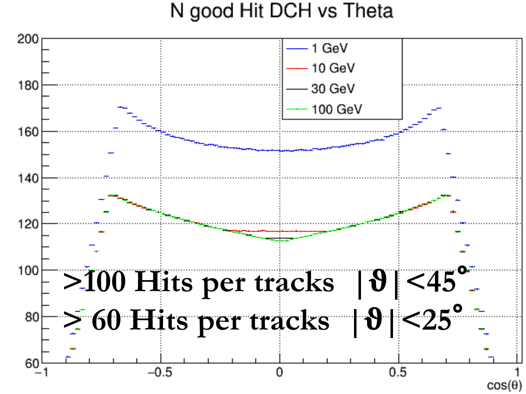


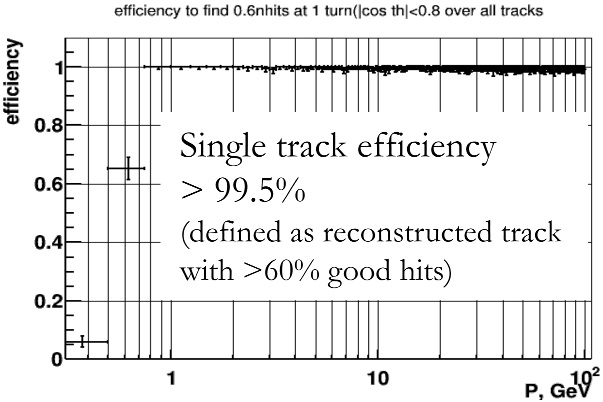
More details in: G. Tassielli: "Tracking performance with the updated geometry of the IDEA detector ", 11th FCC-ee workshop, CERN, January 2019"
N. A. Tehrani: “Simulation and tracking studies for a drift chamber at the FCC-ee experiment”, CERN-ACC-2019-0043

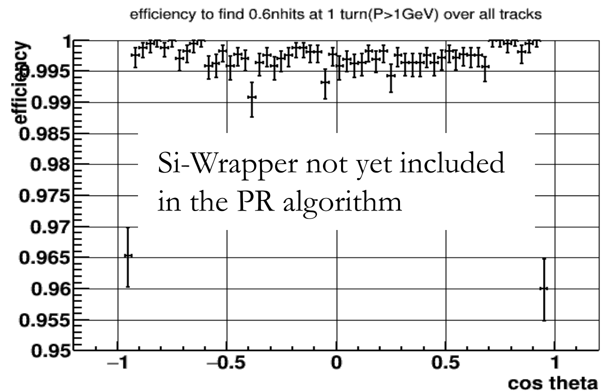
# Expected simulated performance

assumed: $\sigma_d = 100\ \mu m$ and
(conservative for Si) $\sigma_{Si} = pitch/\sqrt{12}\ \mu m$



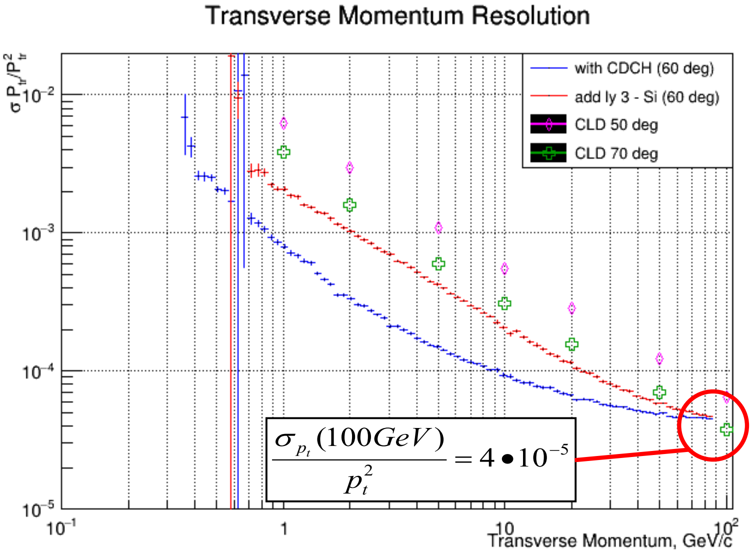



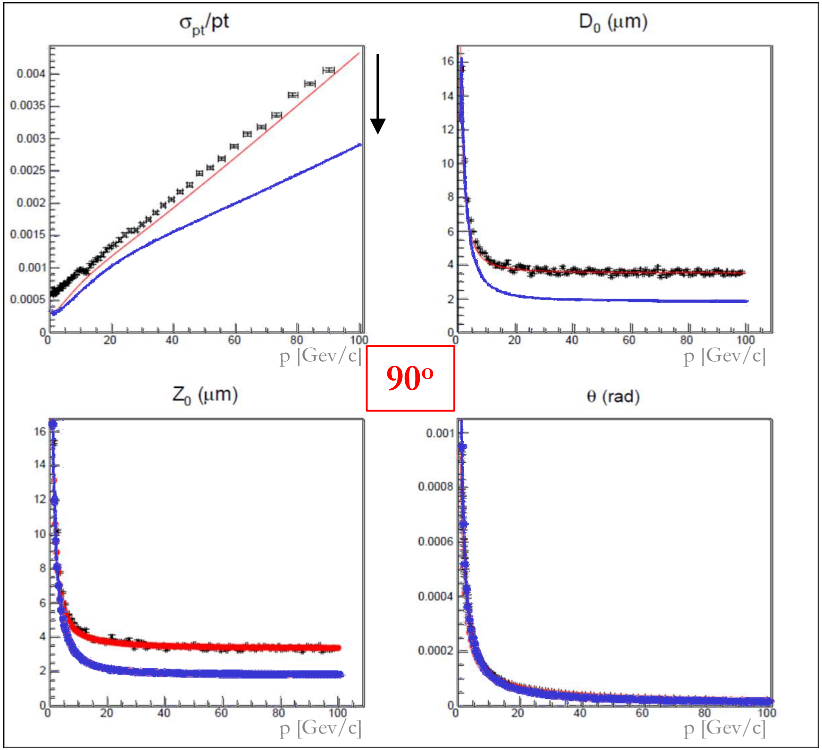
# Expected simulated performance

Transparency more relevant than asymptotic resolution, the particle range is far from the asymptotic limit where MS is negligible.




CLD: a detector concept for FCC-ee with a full Si-tracker system, inspired by CLIC detector.

# Expected simulated performance




Analytic model to evaluate full covariance matrix

**black point**: Full simulation
**red line**: analytic model with Si resolution as Full sim.
**blue line**: analytic model with improved Si resolutions*

* Vertex:
- inner 3x3 μm
- outer/forward 7x7 μm

Si wrapper: 7x90 μm

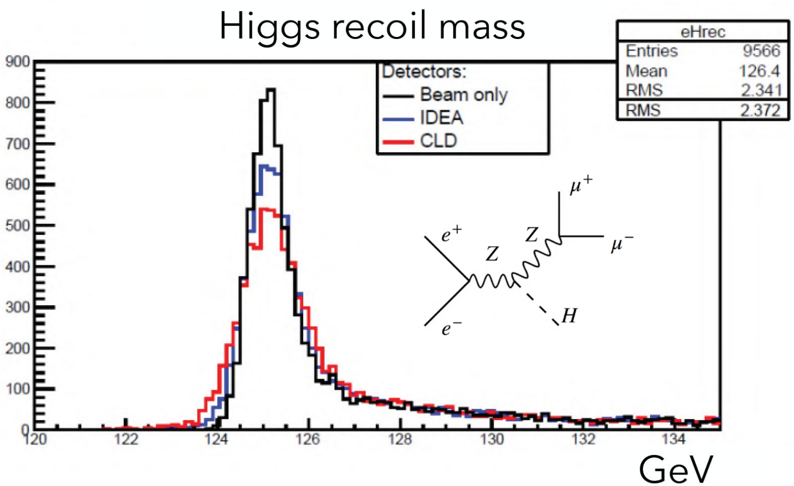
$$\frac{\sigma_{p_t}(100GeV)}{p_t^2}: \quad 4\cdot10^{-5} \rightarrow 2.9\cdot10^{-5}$$

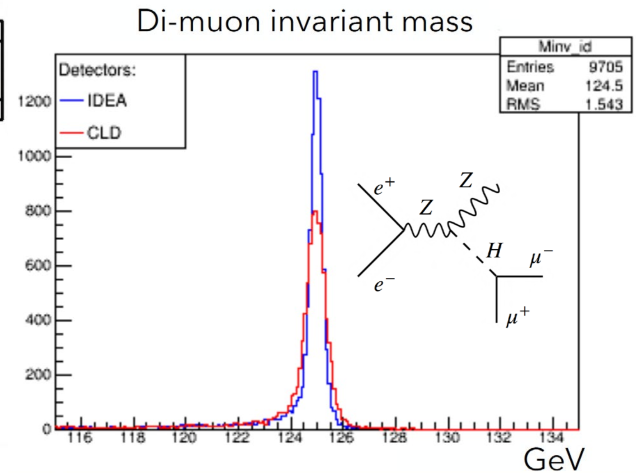
More details in F. Bedeschi: "Fast Simulation Tracking", Workshop on the Circular Electron-Positron Collider, Oxford, UK, April 2019"

# Expected simulated performance

Transparency more relevant than asymptotic resolution

Fast simulation studies



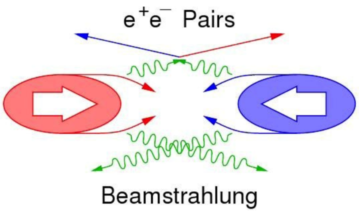

Beam only: assuming 0.136% beam spread and an ideal detector.

*Event generate with Pythia8: e+e- → ZH.*

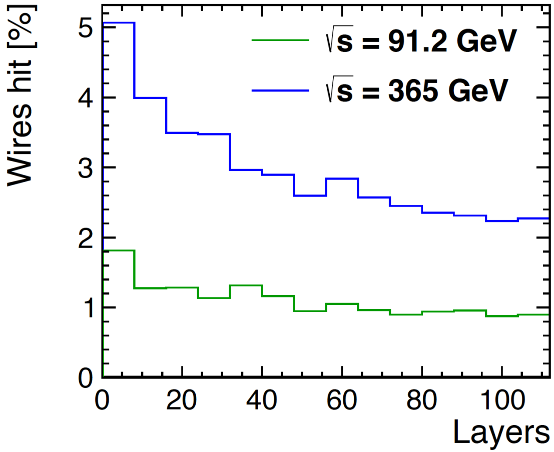
DELPHES model under test

# Expected simulated performance

Preliminary study of the machine background induced occupancy on the DCH, indicate that, it will be not an issue



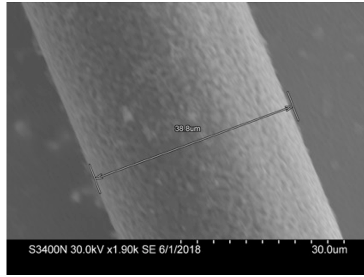

| Background | Average occupancy $\sqrt{s}$ = 91.2 GeV | Average occupancy $\sqrt{s}$ = 365 GeV |
|---|---|---|
| $e^+e^-$ pair background | 1.1% | 2.9% |
| $\gamma\gamma \rightarrow$ hadrons | 0.001% | 0.035% |
| Synchrotron radiation | negligible | 0.2% |

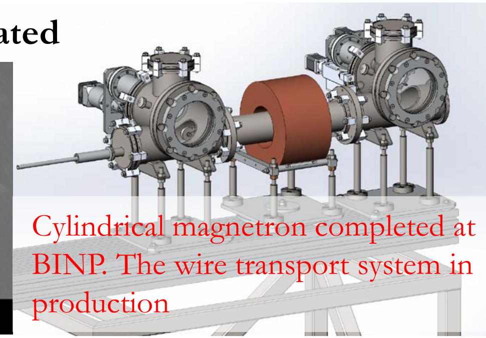


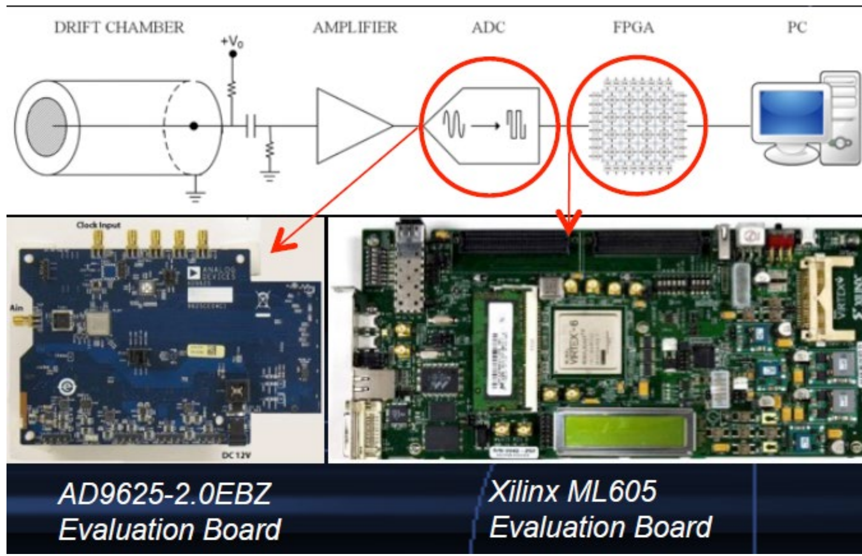
# Ongoing R&D

- 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

# Summary

- The central tracker of the IDEA concept is based on a full-stereo, high resolution, ultra-light Drift Chamber
- The Drift Chamber construction is feasible by adopting the MEG-II Drift Chamber construction technique
- The IDEA tracking system is completed by:
  - MAPS Si detectors as inner vertex tracker;
  - Si detectors wrapped around the Drift Chamber to improve the asymptotic resolution;
- Performance studies with Geant4 simulations and analytic calculations were performed in the contest of FCC-ee
- The Cluster Counting technique provides major improvements in PID performance over traditional dE/dx approaches, but more studies are on going.
- The IDEA tracking system is very light, providing excellent resolution over the momentum range of interest.

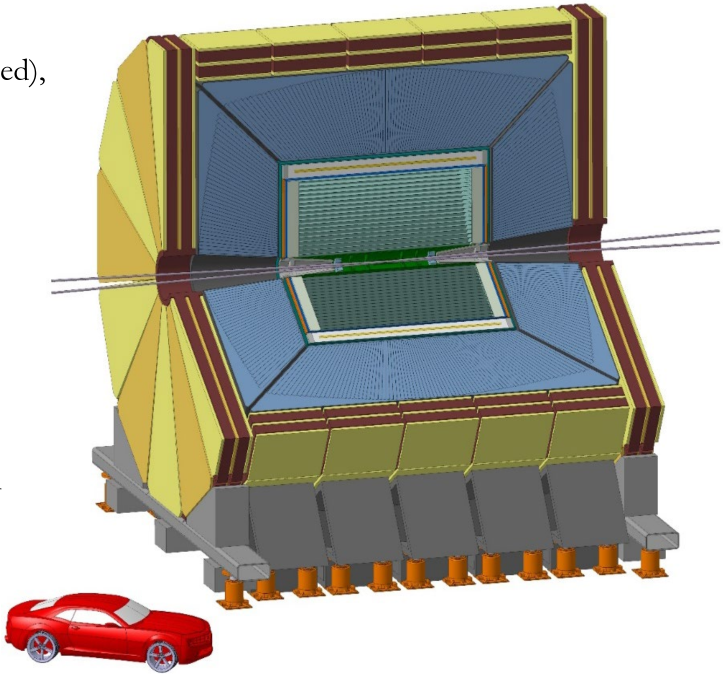
**Thanks for your attention**

# Backup

# The Innovative Detector for Electron-positron Accelerators

- Beam pipe:
  - r ~ 1.5 cm, 0.47% X0 @ 90°
- Si pixel vertex detector
  - MAPS layers (ALICE ITS upgrade based), r=1.7 - 3.4 cm
- Drift chamber (112 layers)
  - 4m long, r = 35 - 200 cm
- Si wrapper: μ-strips
- Superconducting solenoid:
  - 2 T, length = 5 m, r = 2.1-2.4
  - 0.74 $X_0$, 0.16 λ @ 90°
- Pre-shower:
  - 2 layers of μ-Rwell each one behind an absorber layer of 1 $X_0$
- Dual Readout fiber calorimeter
  - 2m deep/8 λ
- Muon chambers
  - μ-Rwell embedded in the magnet return yoke

**IDEA concept**



# 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)

# Applications of PID in $Z^0$ physics

Let's focus on the $Z^0$, where requirements are most clearly defined.

A good PID system, if available, would be exploited in many measurements, *e.g.*

- Complementary / redundant info to ECAL in searches for LFV Z decays;
- Separating π/K in tau final states;
- Help in flavour-tagging jets;
- Studies of particle production.

But in b physics and spectroscopy PID is *essential* !

**For more details, see G. Wilkinson talk at FCC France workshop on May 20:**
**https://indico.in2p3.fr/event/20792/contributions/81820/attachments/58703/78917/FCCee_PID_France.pdf**

14/5/20 PID at the FCC-ee Guy Wilkinson 4

# Tracking requirements

| Physics process | Measurands |
|---|---|
| $ZH, Z \to e^+e^-, \mu^+\mu^-$ | $m_H, \sigma(ZH)$ |
| $H \to \mu^+\mu^-$ | $\mathrm{BR}(H \to \mu^+\mu^-)$ |
| $H \to b\bar{b}/c\bar{c}/gg$ | $\mathrm{BR}(H \to b\bar{b}/c\bar{c}/gg)$ |

Central tracker system:

- state-of-the-art momentum and angular resolution for charged particles;
- B field limited to ~ 2 T to boost luminosity at Z pole. Large tracking radius needed to recover momentum resolution.
- High transparency required given typical momenta in Z, H decays.
- Particle ID is a valuable additional ability.

Vertexing:

- excellent b- and c-tagging capabilities : few μm precision for charged particle origin;
- small pitch, thin layers, limited cooling, first layer as close as possible from IP.

in numbers:

- **$\sigma(1/p_T) \lesssim 3\cdot10^{-5}$ GeV$^{-1}$ ($p_T \gtrsim 100$ GeV at 90°) $\simeq 2\cdot10^{-5} \oplus 1\cdot10^{-3}/(p \sin\theta)$ GeV$^{-1}$**
- **$\sigma(d_0) \simeq 2/5/20$ μm (100/10/1 GeV at 90°) $\simeq 5 \oplus 10/(p \sin^{3/2}\theta)$ μm**
- **$\sigma(\theta, \varphi) \sim 0.1$ mrad (45 GeV muons)**

# Expected performance

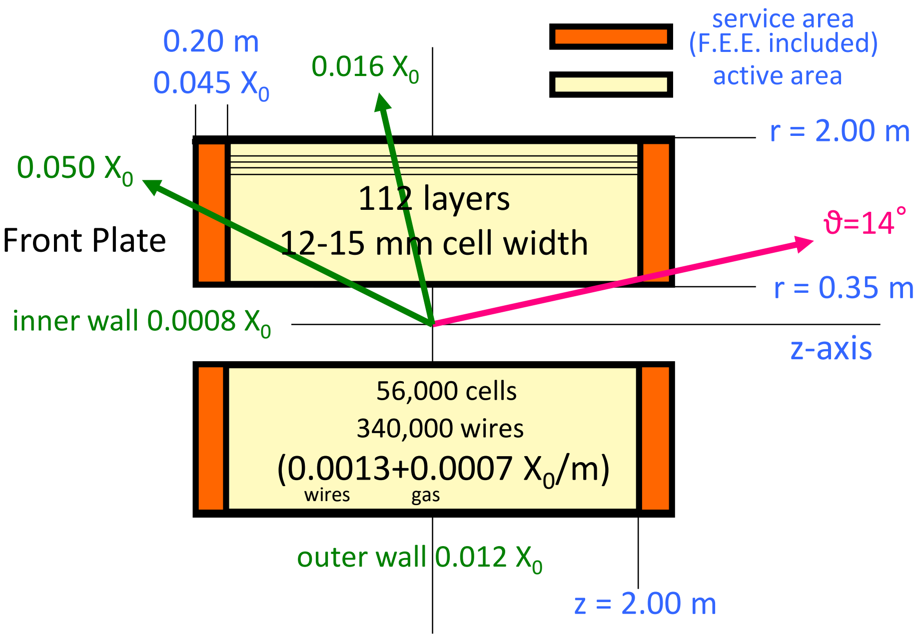
Machine background will be not an issue

- average machine background occupancy of the DCH is ~ 0.3% (3%) per bunch crossing at 91:2 (365) GeV, in the innermost layers.
- 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 therefore 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

# The IDEA drift chamber

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



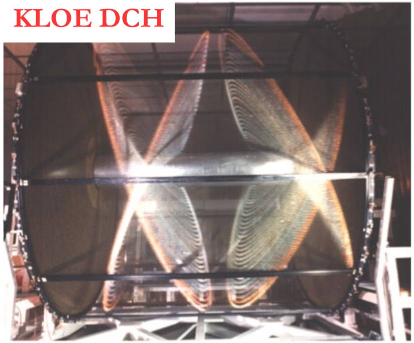

- **He based gas mixture** (90% He – 10% $i\text{-}C_4H_{10}$)
- **Full stereo configuration** with alternating sign stereo angles ranging from 50 to 250 mrad
- 12÷14.5 mm wide square cells 5 : 1 field to sense wires ratio
- 56,448 cells
- 14 co-axial super-layers, 8 layers each (112 total) in 24 equal azimuthal (15°) sectors ($N_i = 192 + (i - 1) \times 48$)

# Novel approach at construction technique of high granularity and high transparency Drift Chambers (From KLOE DCH to IDEA DCH)

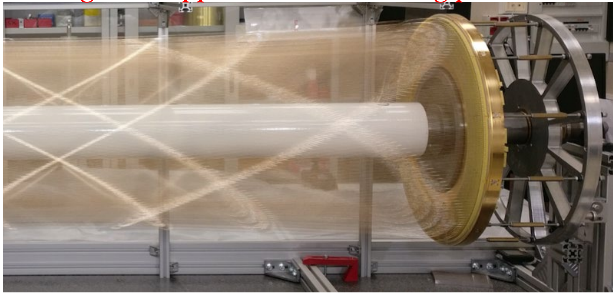
- Ancestor chamber: **KLOE** at INFN LNF Da$\phi$ne $\varphi$ factory (commissioned in 1998 and operated for over 20 years)
- **CluCou** Chamber proposed for the **4$^{th}$-Concept** at ILC (2009)
- **I-tracker** chamber proposed for the **Mu2e experiment** at Fermilab (2012)
- **DCH** for the **MEG-II upgrade** at PSI (under commissioning)

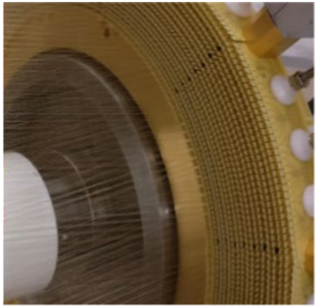
| | KLOE | MEG-II |
|---|---|---|
| stereo | **Fully (~ 80 mrad)** | **Fully (~120 mrad)** |
| diameter | **4 m** | **0.6 m** |
| length | **3.3 m** | **2.0 m** |
| structure | **C-fiber** | **C-fiber** |
| Gas (He-i$C_4H_{10}$) | **90% - 10%** | **85% - 15%** |
| Sense wires | **12000** | **2000** |
| Total wires | **52000** | **12000** |
| Weaker wire | **80 μm Al** | **40 μm Al** |
| cell size | **2x2 - 3x3 cm$^2$** | **0.7x0.7 - 1x1 cm$^2$** |
| Wire density | **~0.4 wires/cm$^2$** | **~12 wires/cm$^2$** |

KLOE DCH

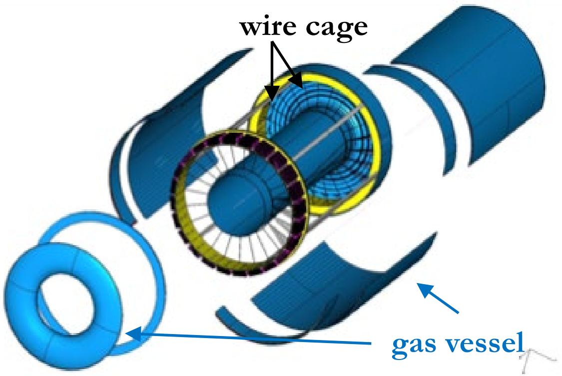


**MEG-II: High wire densities prevent the use of feed-through, needing novel approaches to the wiring procedures**





# Novel approach at construction technique of high granularity and high transparency Drift Chambers




Based on the MEG-II DCH new construction technique the IDEA DCH can meet these goals:

- Gas containment – wire support functions separation:

  allows to reduce material to ≈ $10^{-3}$ $X_0$ for the inner cylinder and to a few x $10^{-2}$ $X_0$ for the end-plates, including FEE, HV supply and signal cables

- Feed-through-less wiring:

  allows to increase chamber granularity and field/sense wire ratio to reduce multiple scattering and total tension on end plates due to wires by using thinner wires

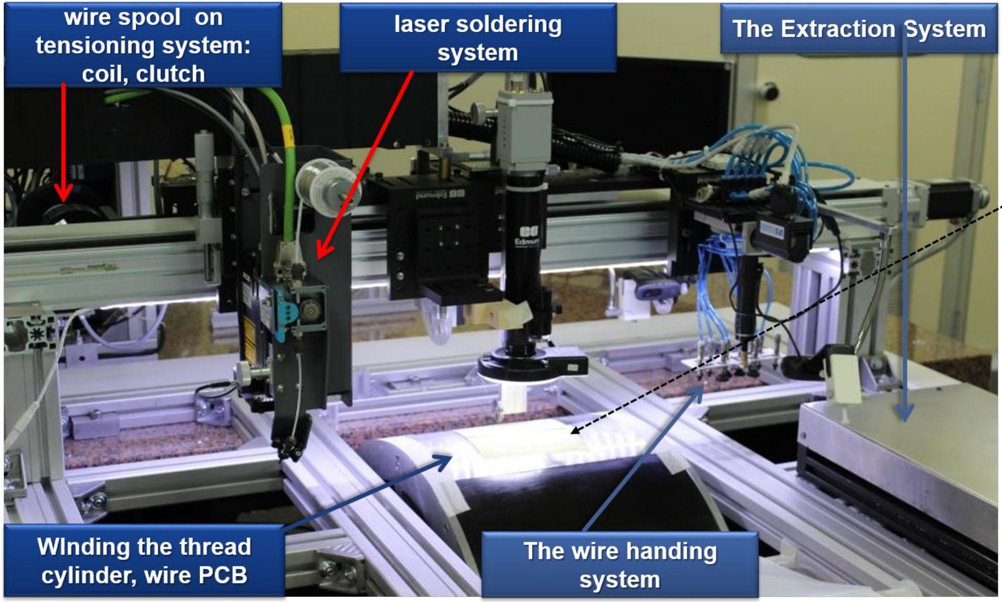
- Cluster timing:

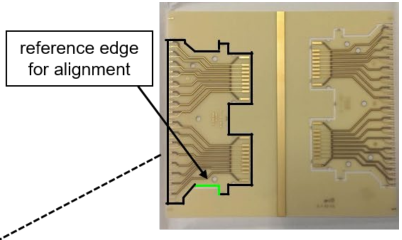
  allows to reach spatial resolution < 100 μm for 8 mm drift cells in He based gas mixtures (such a technique is going to be implemented in the MEG-II drift chamber under commissioning)

- Cluster counting:

  allows to reach $dN_{cl}/dx$ resolution < 3% for particle identification (a factor 2 better than dE/dx as measured in a beam test)

# The MEG-II Drift Chamber: Wiring procedure



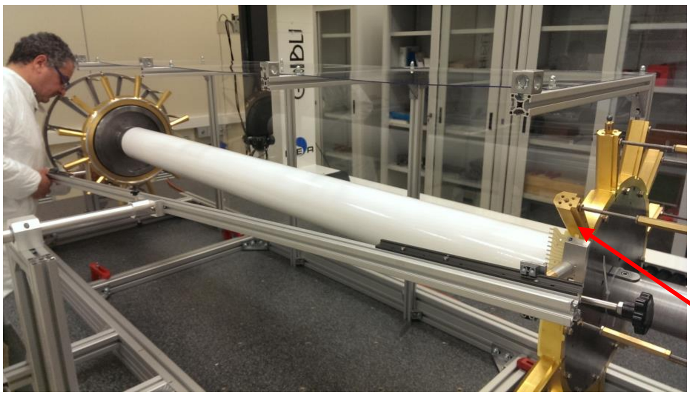

The main tasks of the wiring robot are:

- the wiring of a multiwire layer made of 32 parallel wires;
- settable wire tension (±0.05g);
- 20μm of accuracy on wire position;
- anchor the wires using a contact-less technique

# The MEG-II Drift Chamber: Assembling

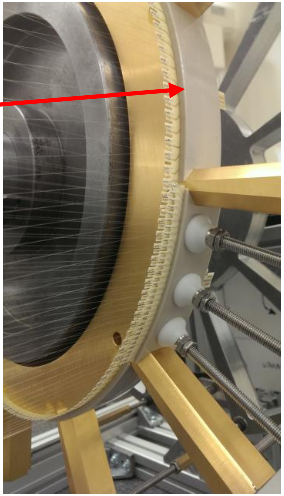
Procedure:

- The mounting arm (with the multi-wire layer) is then placed next to the end plates for the engagement procedure
- The mounting arm is fixed to a support structure to prevent damaging the wires
- This structure transfers the multi-layer wire on the end plates between two spokes
- Spacers, to separate the successive layer, are pressed and glued in position



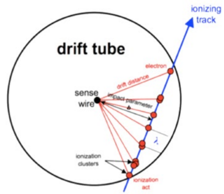
Spacer

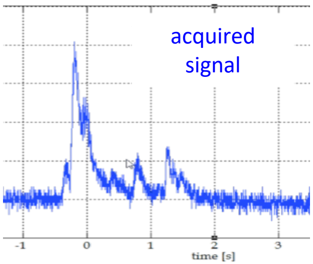
Spoke used as reference for the alignment of the pcb

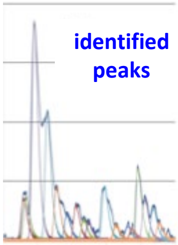


# Cluster Counting/Timing and P.Id. expected performance

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:




$$\{t_i^{cl}\} \qquad i = 1, N_{cl}$$

**dE/dx**

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

from *Walenta parameterization (1980)*

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.

**$dN_{cl}/dx$**

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

from *Poisson distribution*

$\delta_{cl}$ = 12.5/cm for He/i$C_4H_{10}$=90/10 and a 2m track give

**σ ≈ 2.0%**

A small increment of i$C_4H_{10}$ from 10% to 20% ($\delta_{cl}$ = 20/cm) improves resolution by 20% (σ ≈1.6%) at only a reasonable cost of multiple scattering contribution to momentum and angular resolutions.

*Moreover, C.C. allows can improve the spatial resolution < 100 μm for 8 mm drift cells in He based gas mixtures*

# IDEA DCH geometry (simulation)

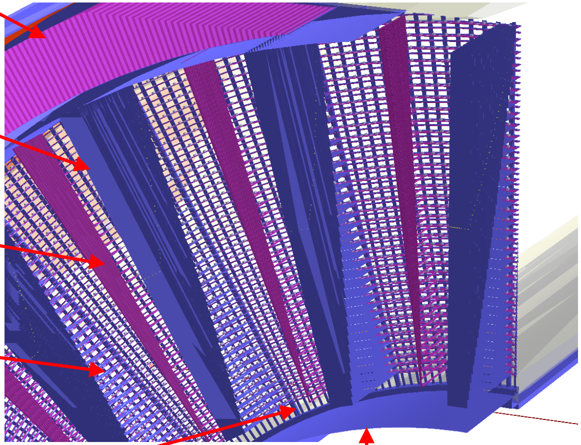
Electronics boards: 12 cm x 6 cm x 3mm G10 (FR4);

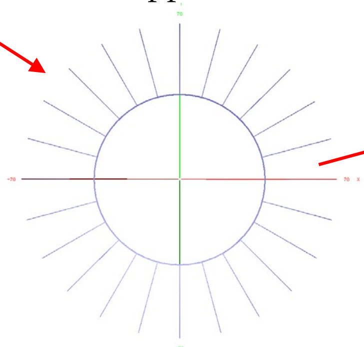
signal cables:
 2.032 cm x 25 μm Kapton
 + 40 μm 16 pairs of Copper wires;

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

Wire anchoring (see next slide);

Carbon fiber wire support.



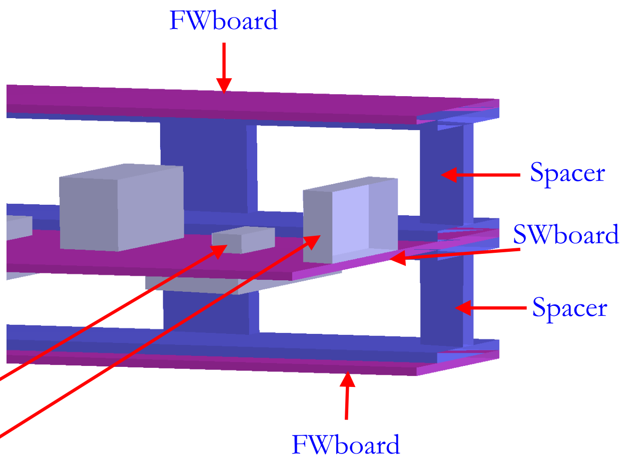


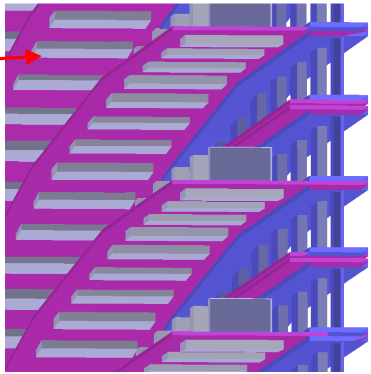
Connecting ring is described as a circular layer:
0.5 cm x 1.5 cm Carbon fiber

# IDEA DCH geometry (simulation)

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.



# IDEA tacking system – ly1 - SVX

| Layer | R [mm] | L [mm] | Si eq. thick. [μm] | $X_0$ [%] | pixel size [$mm^2$] | area [$cm^2$] | # 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 [$mm^2$] | area [$cm^2$] | # 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 |

# IDEA tacking system – ly1 - DCH

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

| | | |
|---|---|---|
| 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 |

| | 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 $1^{st}$ – 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 |

# IDEA tacking system – tentative layout

**Geometry is not yet optimized:**

| | Base Line | Option 1 | Option 2 | |
|---|---|---|---|---|
| | value | value | value | dim. |
| $R_{in}$ | 345 | 200* | 250 | mm |
| $R_{out}$ | 2000 | 2150 | 2000 | mm |
| active area length | 4000 | 4000 | 4000 | mm |
| total length | 4500 | 4500 | 4500 | mm |
| total cells | 56448 | 34560 | 52704 | n. |
| layers | 112 | 96 | 112 | n. |
| Superlayers | 14 | 12 | 14 | n. |
| Layers per Superlay. | 8 | 8 | 8 | n. |
| phi sector | 12 | 12 | 12 | n. |
| smaller cell | 11.85 | 14.2 | 11.65 | mm |
| larger cell | 14.7 | 22.5 | 15.25 | mm |
| min. stereo angle | 48 | 25 | 35 | mrad |
| max. stereo angle | 250 | 240 | 245 | mrad |

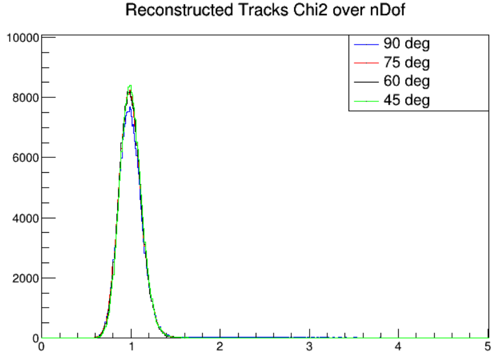
* not over the entire length, to avoid overlap with beam pipe etc.
A possible construction strategy is available.

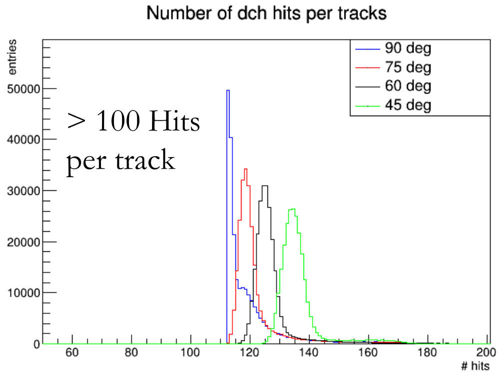
# IDEA – layout v1 – Expected tracking performance

$\chi^2$ /ndof

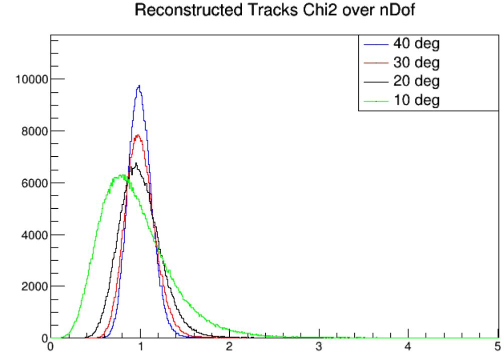
N hits fitted (DCH)

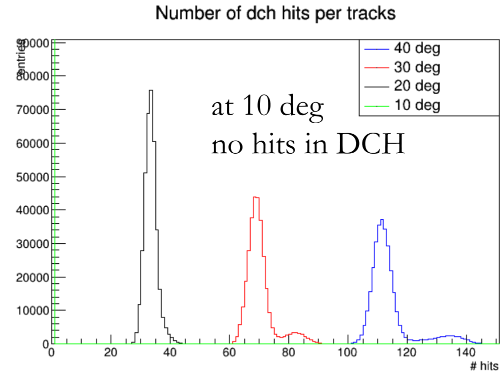
BARREL:



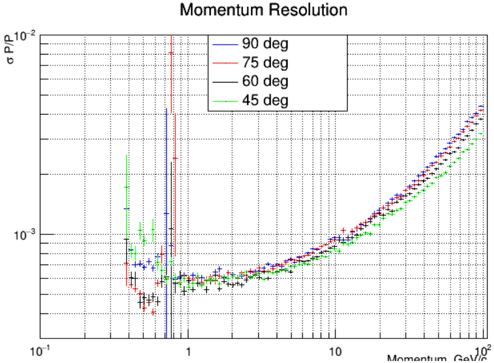

FORWARD:



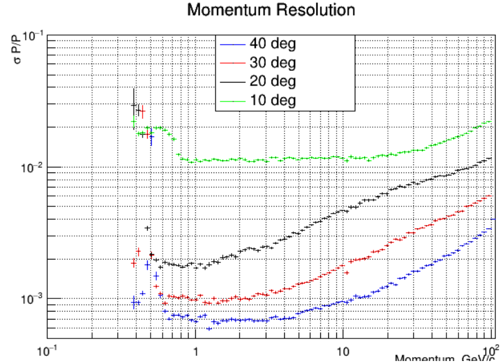



# IDEA – layout v1 – Expected tracking performance

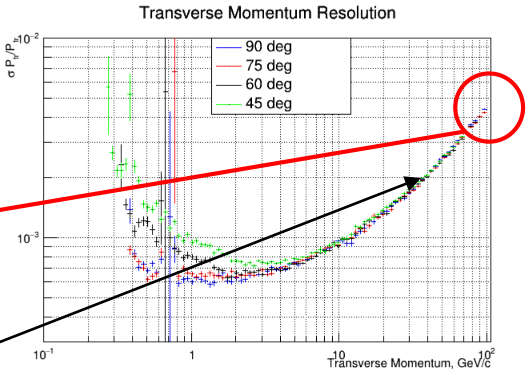
BARREL:

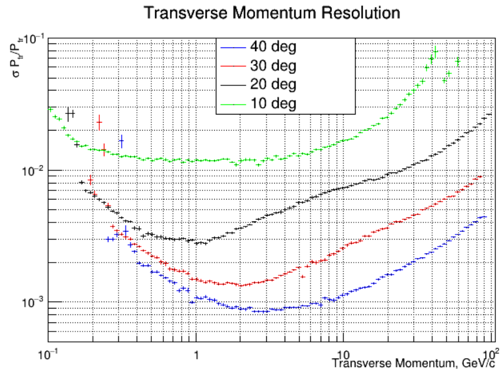



FORWARD:




p




$p_t$

$$\frac{\sigma_{p_t}}{p_t^2} = 4 \bullet 10^{-5}$$

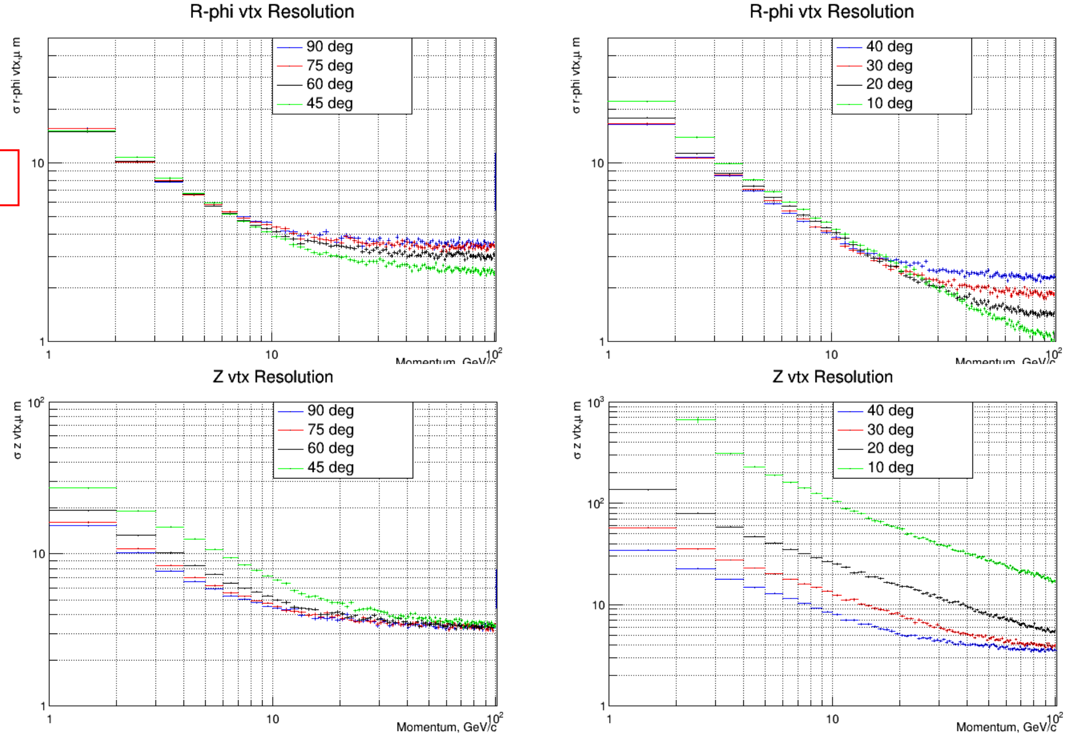
$$\frac{\sigma_{p_t}}{p_t^2} = 5 \bullet 10^{-5}$$

# IDEA – layout v1 – Expected tracking performance

BARREL: FORWARD:

impact parameter

Z

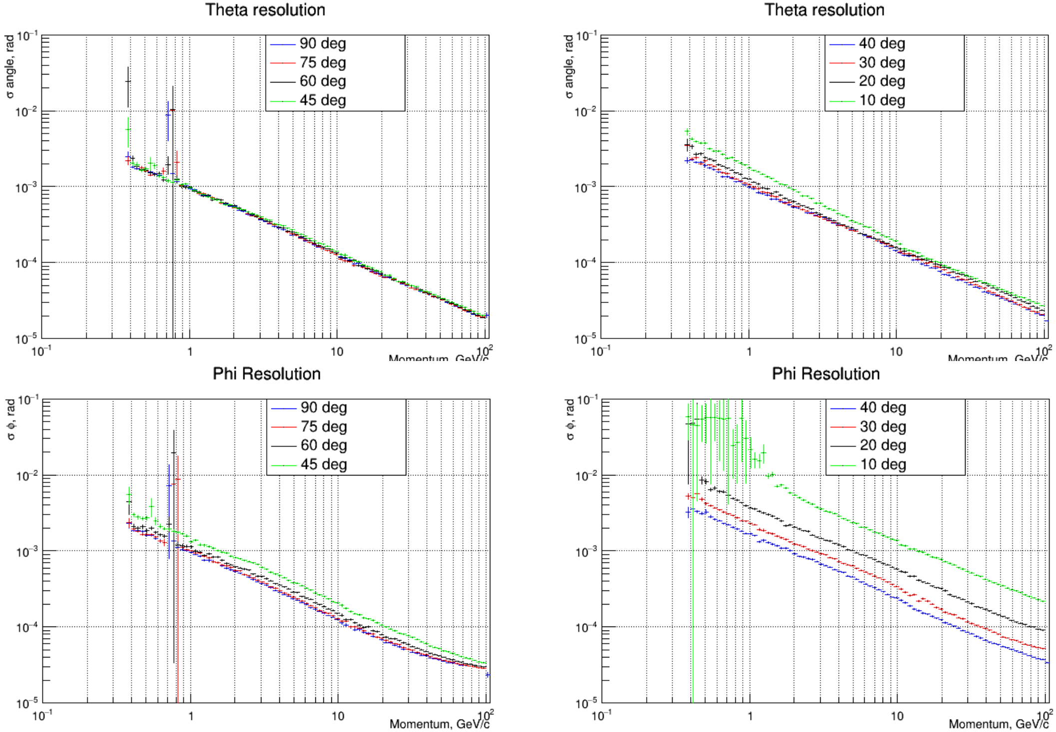


# IDEA – layout v1 – Expected tracking performance

BARREL: FORWARD:

theta

phi

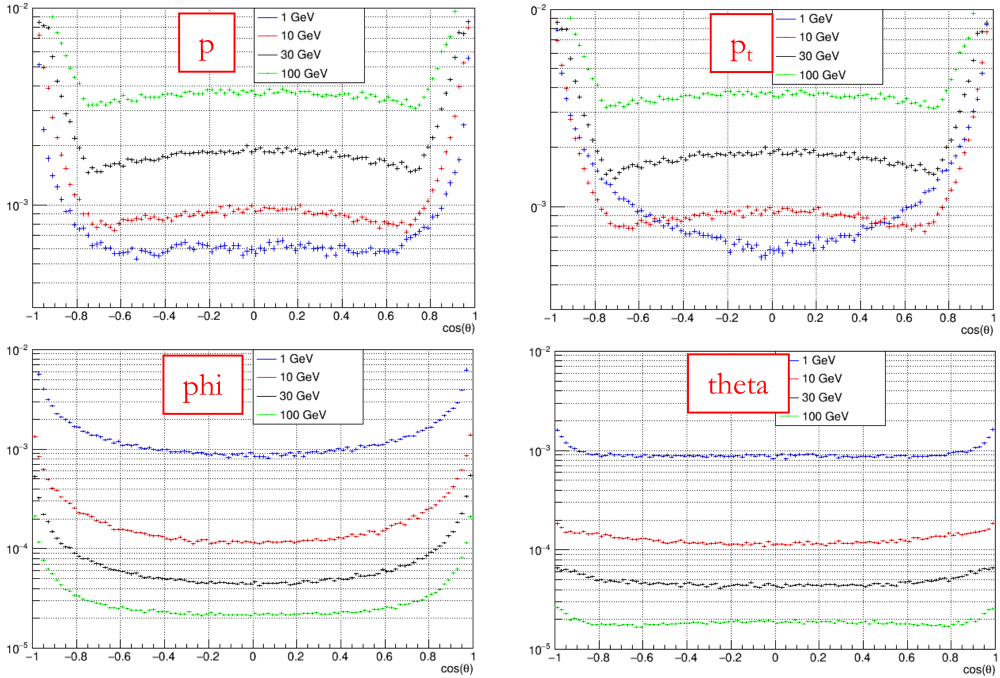


# IDEA tracking system – Expected tracking performance (single muon as function of $\vartheta$)

base line option

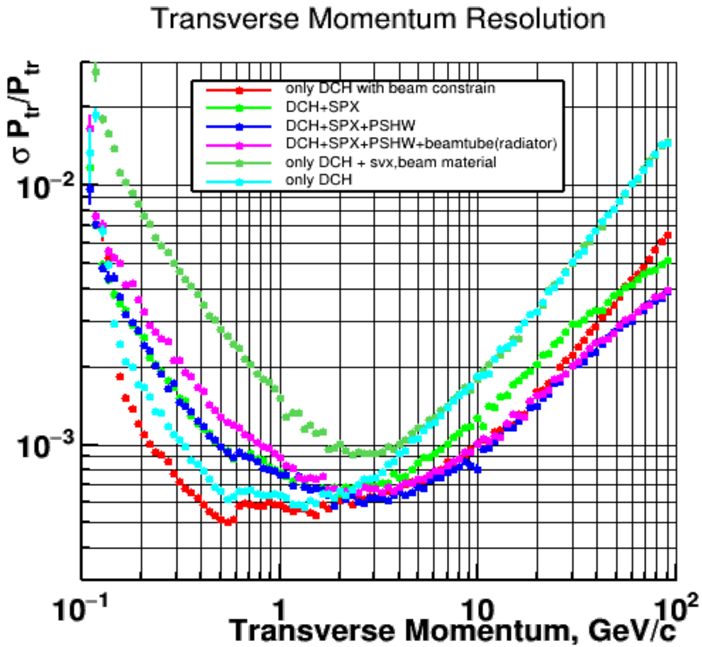
momentum resolution:

angular vertex resolution:



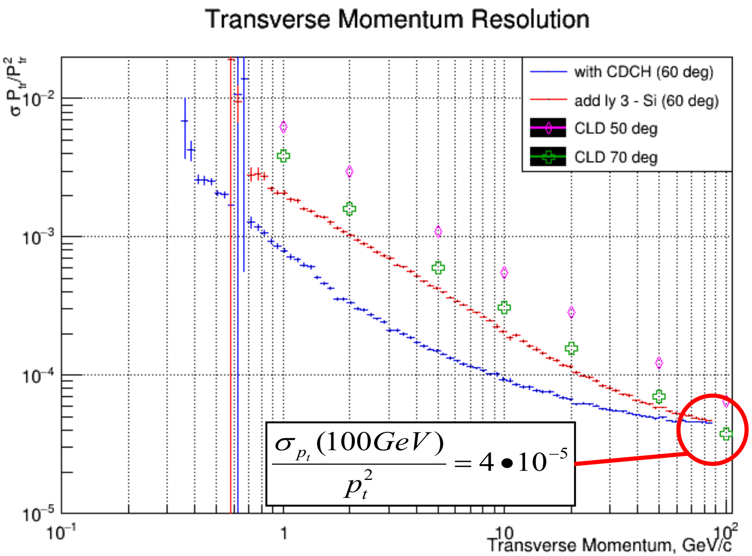
# IDEA tracking system – Expected tracking performance (single pi+ at fixed θ=65deg)

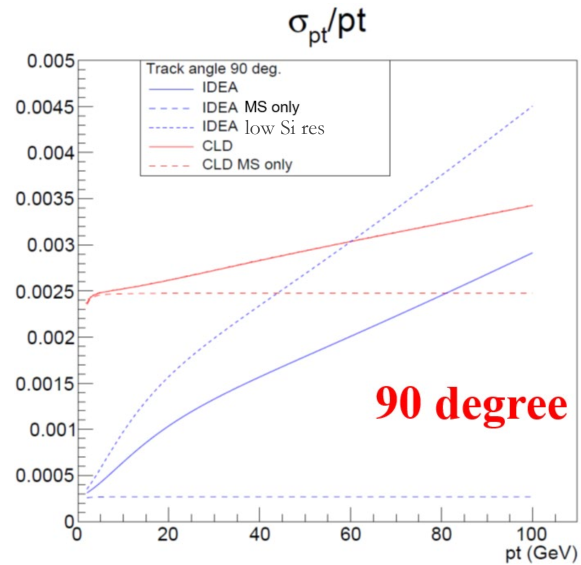
Note: DCH layout differs a bit from the final IDEA one, only to compare the relative effects



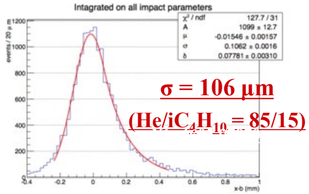
# Expected performance

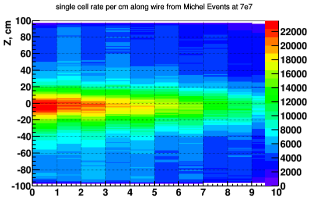
Transparency more relevant than asymptotic resolution

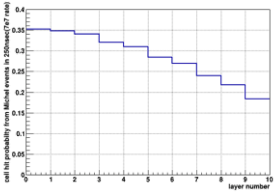


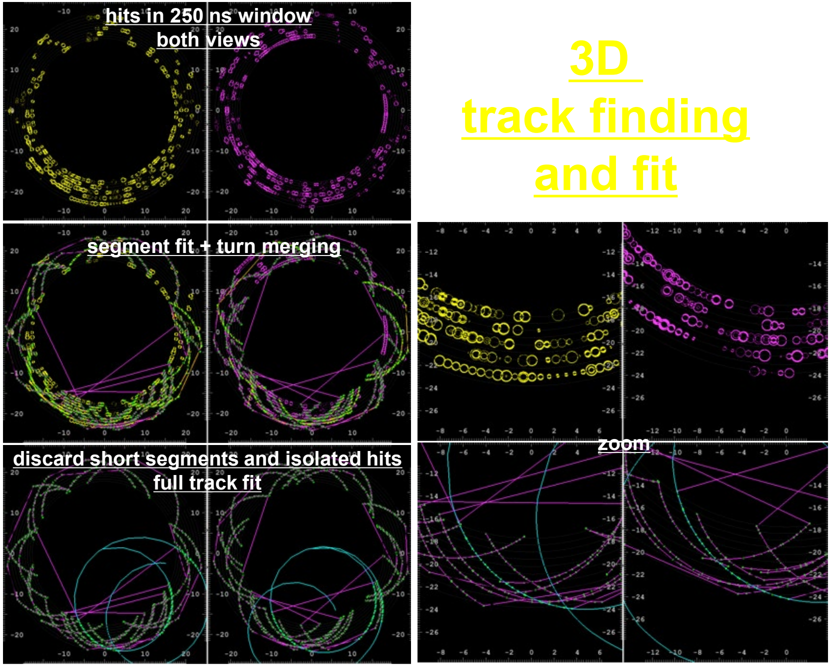



# The MEG-II Drift Chamber Performance




**3D track finding and fit**

signal track

michel tracks