Advancements in Drift Chamber Design and Particle Identification for the IDEA Experiment

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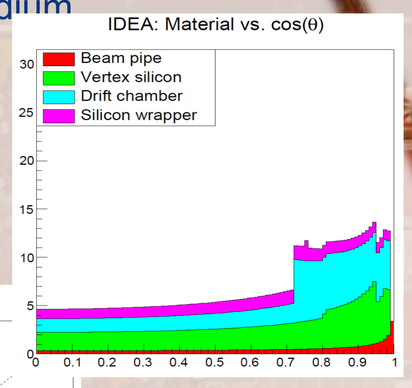
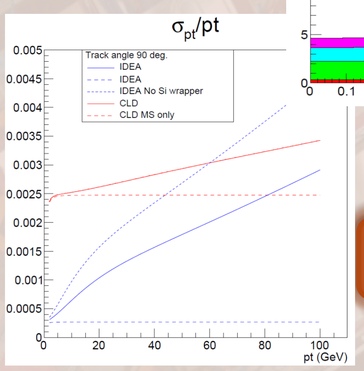
A. Design features of the IDEA Drift Chamber

- IDEA DCH designed to provide **efficient tracking, high precision momentum measurement and excellent particle identification** for particles of low and medium momenta. Main features are:
- **High granularity**
- **Transparency** against multiple scattering
- An **excellent particle identification** and separation

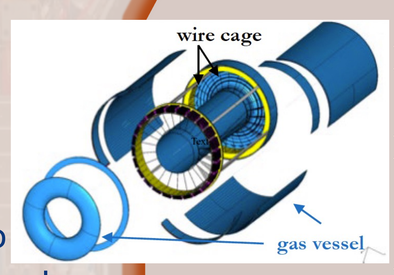


- Due to the **minimization of the multiple scattering** contribution, the IDEA tracking system performs better, over almost the entire momentum range of interest, than an alternative tracking system based only on Si detectors (CLD).
  - For 10 GeV (50 GeV) **μ** emitted at an angle of 90° w.r.t the detector axis, the p_T resolution is about 0.05 % (0.15%) with the very light IDEA DCH.



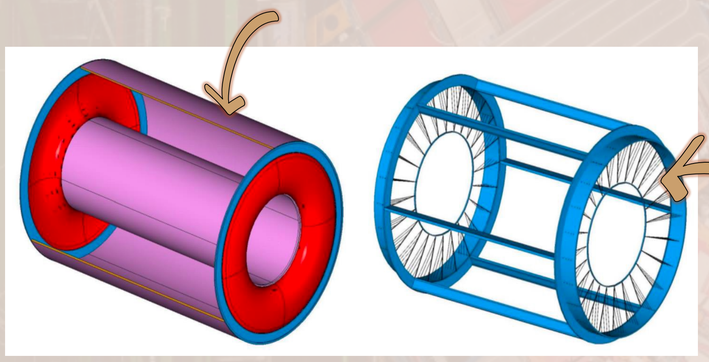
B. Mechanical structure (1)

- The mechanical design of the drift chamber is driven by two main objectives:
  - ✓ Maximizing its **transparency** in terms of radiation length.
  - ✓ Maximizing its **mechanical stability.**
- New concept of construction allows to reduce material to ≈ 10^{-3} X_0 for the barrel and to a few x 10^{-2} X_0 for the end-plates.



Gas containment

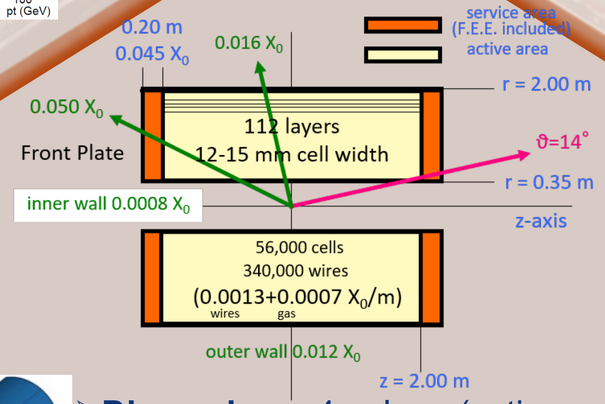
Gas vessel can freely deform without affecting the internal wire position and mechanical tension.



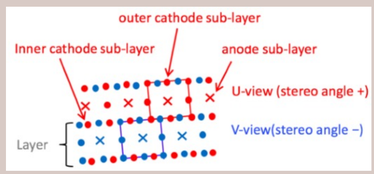
Wire cage

Wire support structure not subject to differential pressure can be light and feed-through-less

IDEA Drift Chamber



- **Dimensions**: 4 m long (active volume), 35cm to 2m radius
- **Low material budget**
  - Barrel: ~ 1.6% X_0
  - Forward directions: ~ 5% X_0
- Operating gas mixture: 90% He + 10% iC_4H_{10}
- **Sense** (anode): 20μm W(Au) → 56448 total
- **Field** (cathode): 40μm Al(Ag) → 285504 total
- **Guard** (cathode): 50μm Al(Ag) → 2016 total



5 : 1 field-to-sense wire ratio

C. Mechanical structure (2)

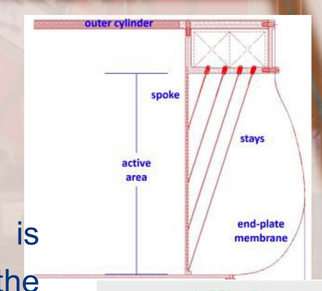
❑New tension recovery schema

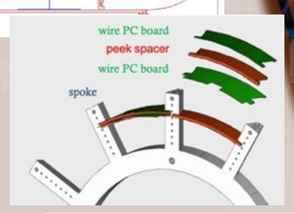
- ✓ Experience inherited from the MEG2 DCH
- ✓ inner and outer cylinder connected to 48 spokes, forming 24 identical sectors.
- ✓ To minimize the deformations due to the wire load, it is necessary to create a system of adjustable stays that steers the wire tension to the outer end plate rim .

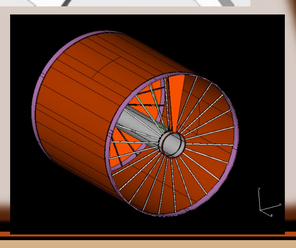
❑FEM simulation studies:

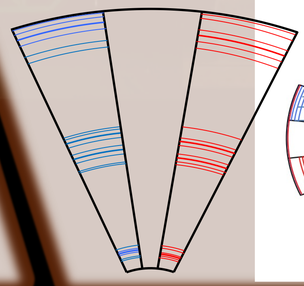
- ✓ Our main goal is to minimize the deformation of the spokes using prestressing force in the cables, while ensuring the structural integrity.
- ✓ varying input parameters in some possible ranges in order to see how the system responds.

❑A realistic complete model ready









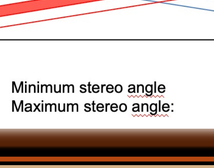
D. DCH full length prototype

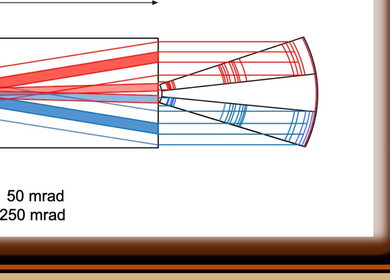
Activities to start the construction of a full-scale prototype

Goal: to test the chamber mechanical and electrostatic stability

TOTAL LAYERS: 8

Type	Wires	Wire Boards
Sense	168	8
Field	965	22
Guard	264	12
Total	1397	42

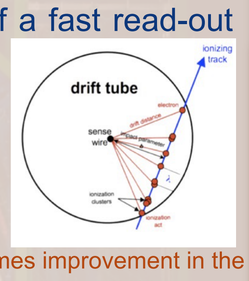




- Optimize the wiring strategy, the High Voltage and signal distribution, test performance of different versions of front-end, digitization and acquisition chain.
- Check the limits of the wires' electrostatic stability at full length and at nominal stereo angles.
- Test different wires: uncoated Al, C monofilaments, Mo sense wires, …, of different diameters
- Validate the concept of the wire tension recovery scheme with respect to the tolerances on the wire positions

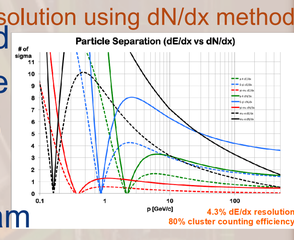
E. PID with Cluster Counting Technique

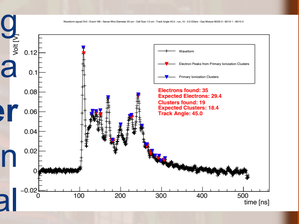
- **Principle**: In He based gas mixtures the signals from each ionization act can be spread in time to few ns. With the help of a fast read-out electronics they can be identified efficiently.
  - By counting the number of ionization acts per unit length (dN/dx), it is possible to identify the particles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



~ 2 times improvement in the resolution using dN/dx method

- **Analytic calculations**: Expected excellent K/π separation over the entire range except 0.85<p<1.05 GeV (blue lines).
- Results from test beam analysis proved that using the dN/dx method gives a **resolution 2 times better than the dE/dx** method in agreement with the analytical calculation.





For more details about test beam analysis results see Poster ID#798

F. Conclusions

- ✓ The ongoing developments in drift chamber design for the IDEA experiment demonstrate **strong progress, both in mechanical structure and reconstruction techniques.**
  - ✓ The integration of **cluster counting** significantly enhances particle identification capabilities, with the dN/dx method achieving up to **2.5 times better resolution** than traditional dE/dx measurements.
    - ✓ These features make the IDEA drift chamber as a **highly promising solution** for future high-precision tracking and PID in next-generation collider experiments.

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