The tracking system of the IDEA detector concept for a future e+e- collider

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The IDEA detector concept for future e+e- colliders proposes a tracking system composed by a Si based inner system, an ultra-low mass Drift Chamber central system with Particle Identification capabilities and a Si based outer layer surrounding the drift chamber. The designed tracking system allows to fulfill the high momentum and angular resolutions requirements for the whole momentum range, particularly for low momenta, thanks to the extremely low material budget. Moreover, the use of the Cluster Counting technique allows for particle identification (PID) resolution below 3%, a factor two better than the resolution attainable with traditional dE/dx techniques. Details about the construction of the drift chamber, including both the speculation about new materials for the field wires and new techniques for soldering the wires, the development of an improved layout of the drift cells , and the choice of the gas mixture will be described. The expected tracking system performance together with the Improved PID obtained with the cluster counting technique will be reported.

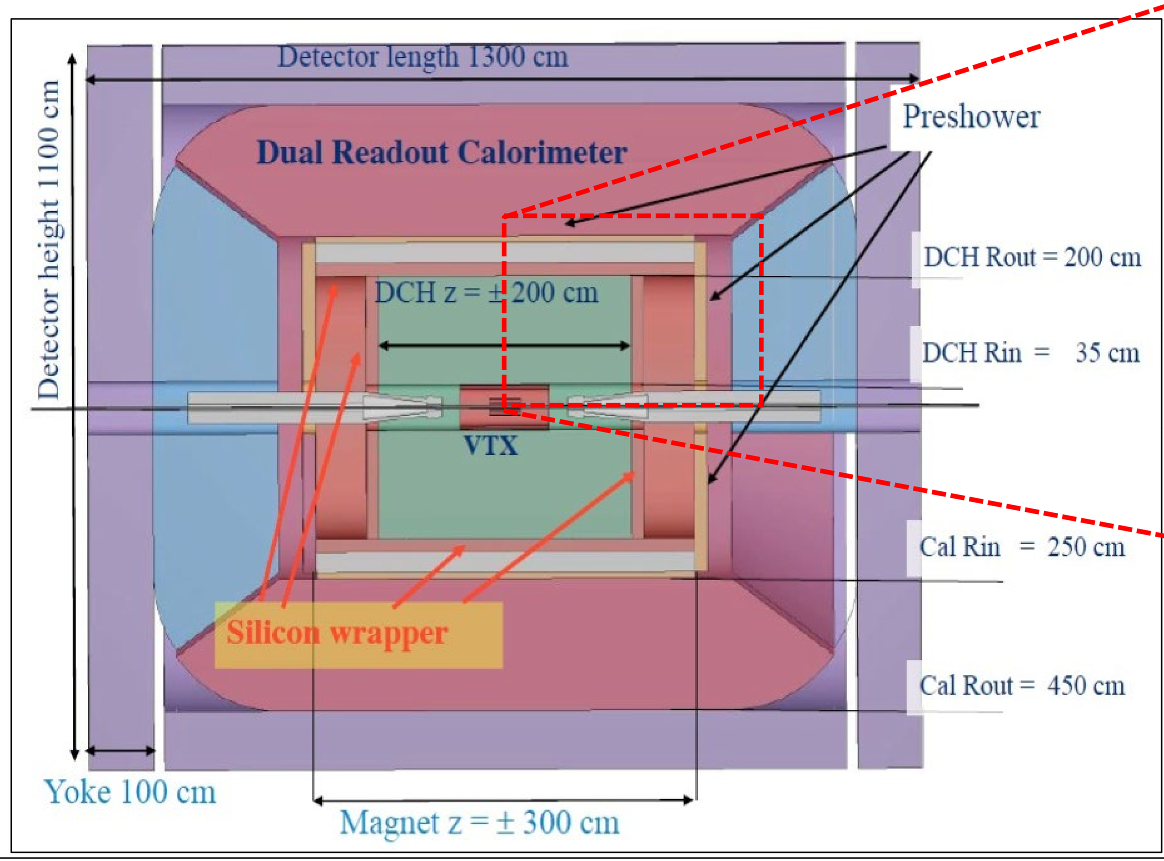
Requirement

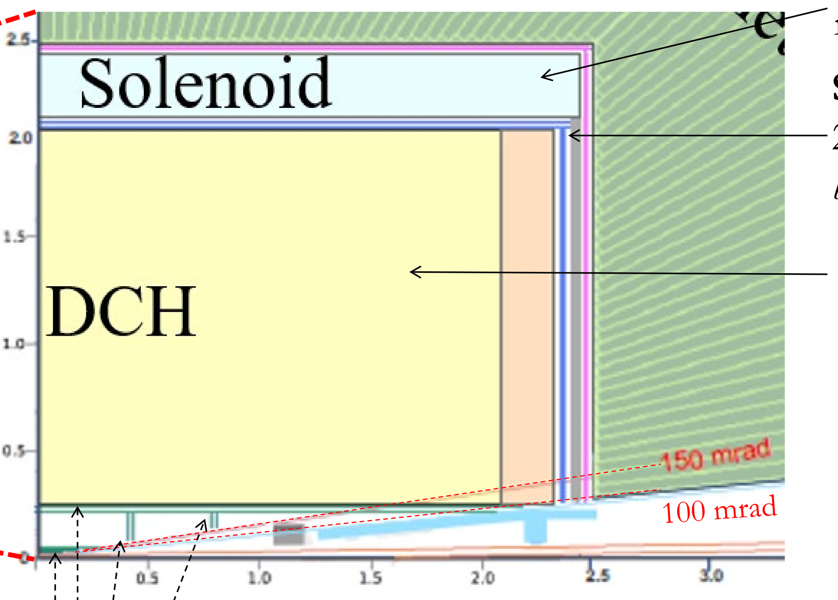
- Extremely high luminosities:
  - large statistics (high statistical precision) - control of systematics (@10^{-5} level)
- Large beam crossing angle (30mrad)
  - very complex MDI
  - emittance blow-up with detector solenoid field (< 2T)
- Physics event rates up to 100 kHz (at Z pole)
  - strong requirements 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
  - definition at <10^{-5} - detector hermeticity (no cracks!)
  - stabilitydetector acceptance 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)

IDEA tracking system

detector concept:

- Central tracking device:
  - light Drift CHamber
- Silicon detectors for precision measurements
  - vertex region
  - silicon wrapper
- Thin solenoid with 2T field (according to MDI limits)
- Dual readout calorimeter
  - supplemented by a pre-shower detector
- Muon chambers in the solenoid return yoke



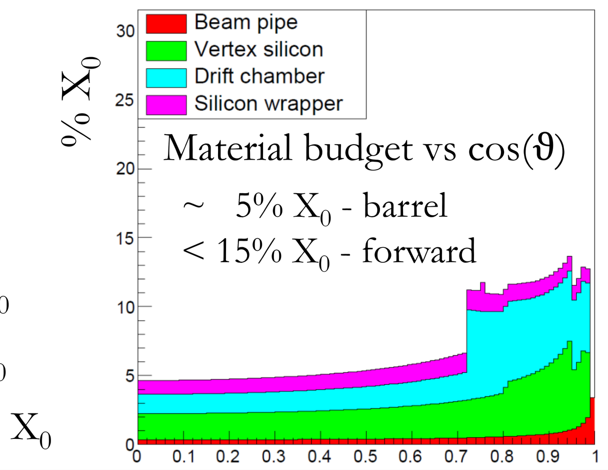


Solenoid: 2 T, length = 5 m, r = 2.1-2.4 m, 0.74 X_0, 0.16 λ @ 90°

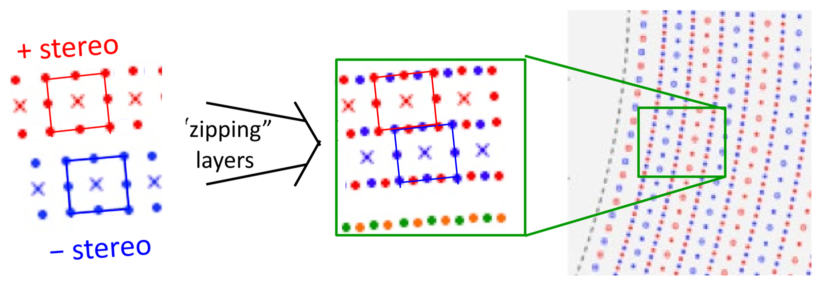
Si Wrapper:
2 layers of μ-strips (50 μm x 1 mm)
both barrel and forward regions

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

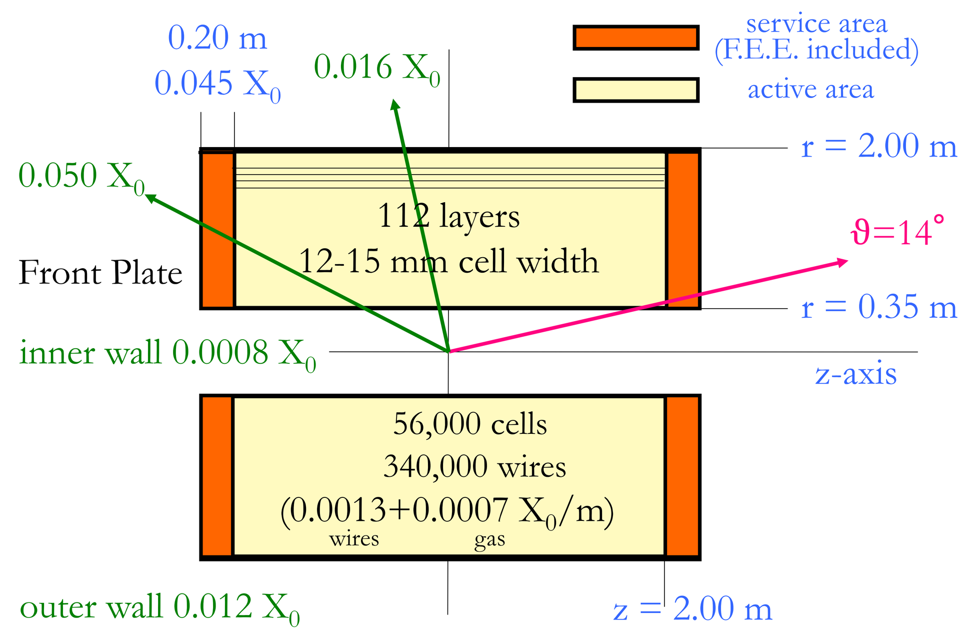
Vertex + inner Wrapper:
inner: 3 single Si pixel (20 μm x 20 μm) layers of 0.3% X_0
outer: 2 single Si pixel (50 μm x 50 μm) layers of 0.5% X_0
forward: 4 single Si pixel (50 μm x 50 μm) layers of 0.3% X_0



DCH



- full stereo layout, two alternating stereo views
- 12÷15 mm wide square cells
- 5 : 1 field to sense wires ratio
- 14 co-axial super-layers, 8 layers each (112 total) in 24 equal azimuthal (15°) sectors
- alternating sign stereo angles ranging from 50 to 250 mrad



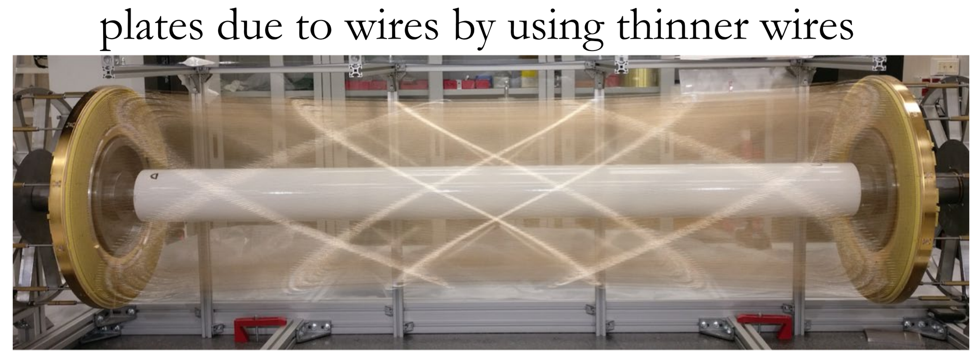
sense wires:	20 μm diameter W(Au)	=>	56448 wires
field wires:	40 μm diameter Al(Ag)	=>	229056 wires
f. and g. wires:	50 μm diameter Al(Ag)	=>	58464 wires
	343968 wires in total		

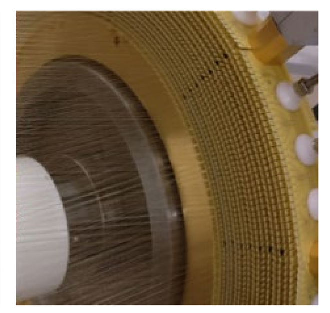
Based on the MEG-II DCH new construction technique:

- Gas containment – wire support functions separation:
  - allows to reduce material
- 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
- Faster construction (per number of wires):
  - a semiautomatic wiring robot allows to speedup the wiring time and to build the large CDCH in a reasonable time and with a high mechanical accuracy

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





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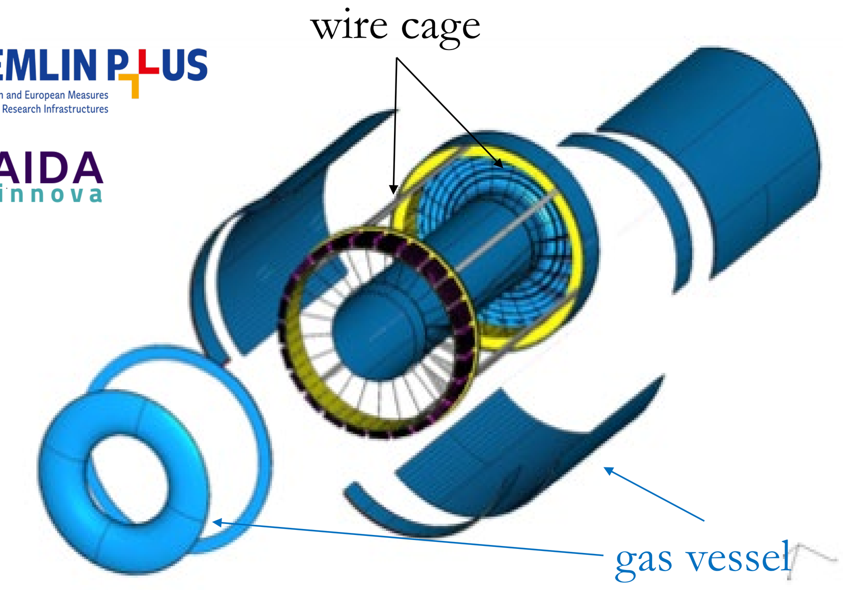
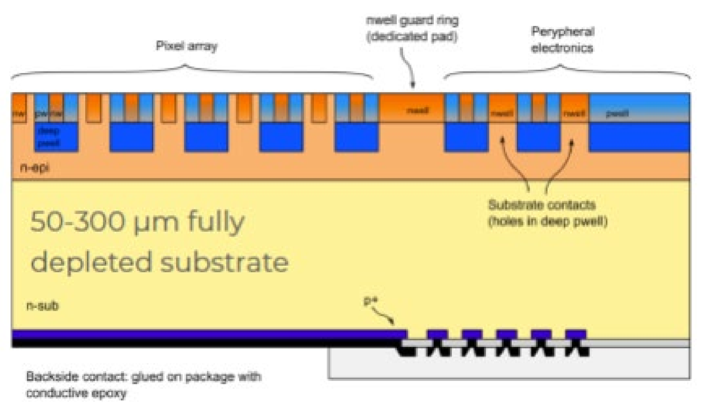
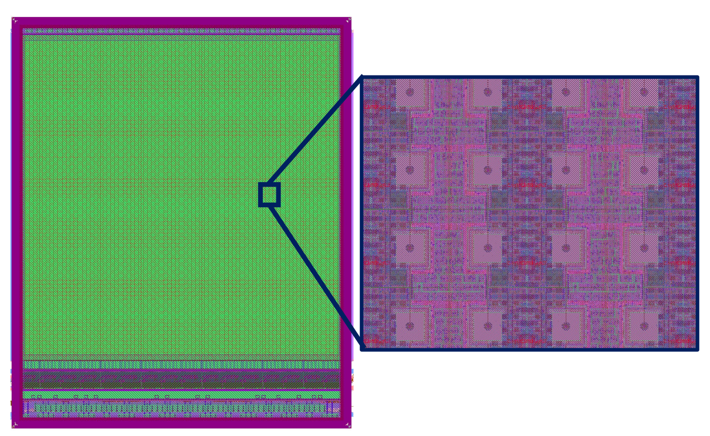


more details in F. Cuna poster "A proposal of a He based Drift Chamber as central tracker for the IDEA detector concept for a future e+e- collider"

VTX + WRAPPER (Si)

- High precision impact parameter reconstruction with **low mass vertex detector**
  - at least 20 mm granularity
  - thickness < 0.3% of radiation length
  - low power <20 mW/cm2 to minimize services
- Supplemented by coarser/faster silicon detectors in front of the drift chamber
- Depleted Monolithic Active Pixels sensors
  - not necessarily the same technologies for both: different requirements
  - present technologies are very promising
  - R&D on different approaches (ARCADIA, ATLASPIX3)



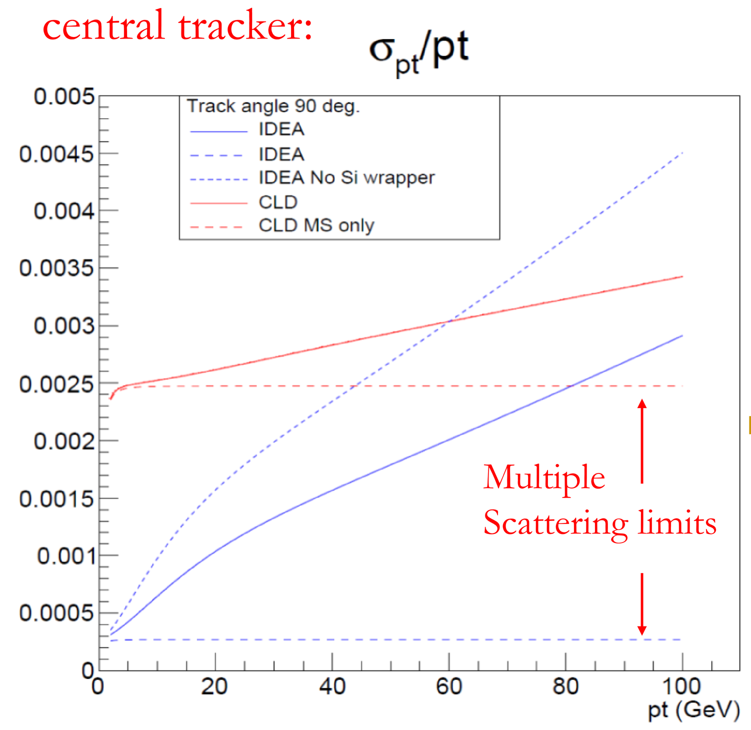


ARCADIA

- CMOS DMAPs Platform
  - Started as INFN project, collaborations with Switzerland and China
  - Project within AIDAInnova WP5
- Fully depleted monolithic sensor
- LFoundry 110 nm CMOS process
- Pixels:
  - sensor and back-side processing already tested on silicon
  - 25 × 25 mm^2 size
  - Area 50% analog – 50% digital
  - Small collection electrode (20% of pixel area)
  - versions with ALPIDE and BULKDRIVEN front-ends

AIDA innova

Precision silicon layer around the central tracker:



- Functionalities:
  - momentum resolution
  - extend tracking coverage in the forward/backward region by providing an additional point to particle with few measurements in the drift chamber
  - precise and stable ruler for acceptance definition
- Covered area ~90 m^2
  - Suitable technologies:
  - microstrips (2 layers)
  - double sided microstrip
  - DMAPS → single layer, high resolution on both coordinates, maybe simpler integration

- Local supports needs original solutions for the internal tracker (lightweight) and the wrapper (long-term stability)
- Just a couple of examples:
  - ALICE like staves, but built with subtractive technology
  - Stavelets with ATLASPIX3 modules as option for the Si Wrapper
- Different cooling options available
  - pipes material: Ti, steel, carbon, microchannel
  - CO2 or water cooling
  - alternative cooling of edge supports for the vertex (à la Belle II)