Information and News

- Main focus of this meeting:
  - Get overview of tools available for study and optimization of detector for FCC-ee

Short introduction:

- FCC-ee detector concept aka IDEA
  - A Brief reminder of what it is and what brought us here
- Now available: ALICE software tool for vertex detector layout

Detector: Calorimetry

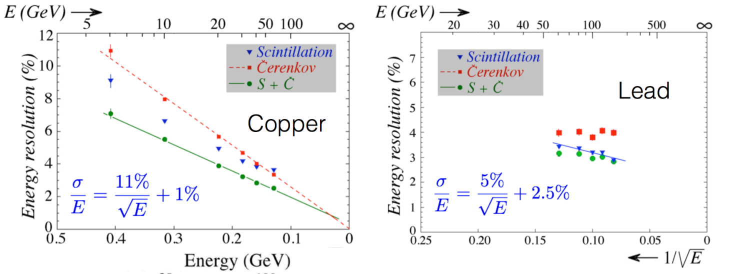
WG11 Meeting
19 Sep 2016

Double readout calorimeter at FCC-ee

Gabriella Gaudio
INFN – Sezione di Pavia

Dual Readout method in sampling calorimeter

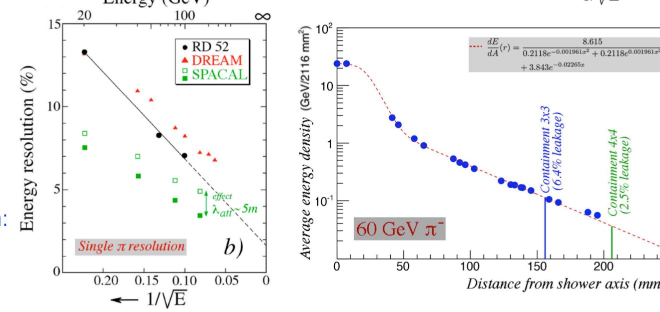
Electromagnetic Resolution



Hadronic Resolution (Pb Module)

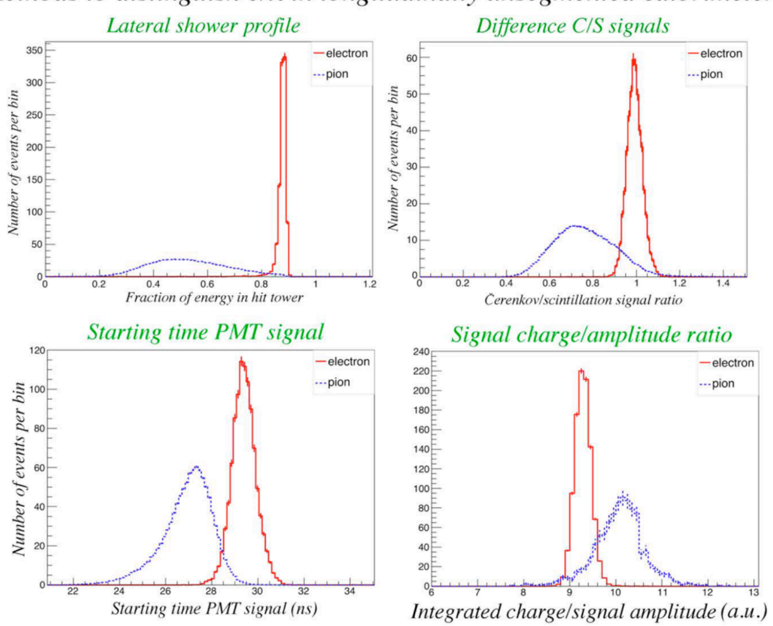
$$\frac{\sigma}{E} = \frac{53\%}{\sqrt{E}} + 1.7\%$$

To include corrections on:
- light attenuation
- lateral leakage



Particle ID in sampling dual readout calorimeter

Methods to distinguish e/π in longitudinally unsegmented calorimeter



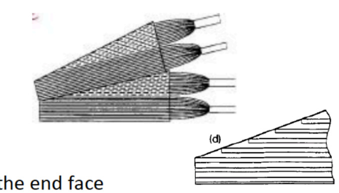
Combination of cuts: >99% electron efficiency, <0.2% pion mis-ID

From RD52 experiment to 4π calorimeter

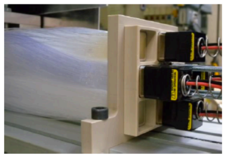
Best solution found: Copper Dual Readout (em + had) fiber calorimeter , high fiber filling fraction, not longitudinally segmented, read out with fast electronics (< ns).

Suggestions on **what needs to be done**..

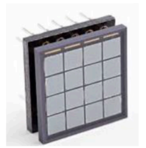
- Projective geometry *(NIM A337 (1994) 326- 341)*



- Use of SiPm → two advantages:
  - Get rid of the "fiber forest", readout closer to the end face
  - transversal segmentation as small as needed
- Rad hardness Cherenkov clear fibers (Cherenkov l.y. could become worse .. in case use quarts, but more expensive)
- Industrial production of grooved Copper
- Custom fast electronics
- …



Fiber bunches + PMT



SiPM matrix directly coupled to end of detector

An ultra-light drift chamber with particle identification capabilities

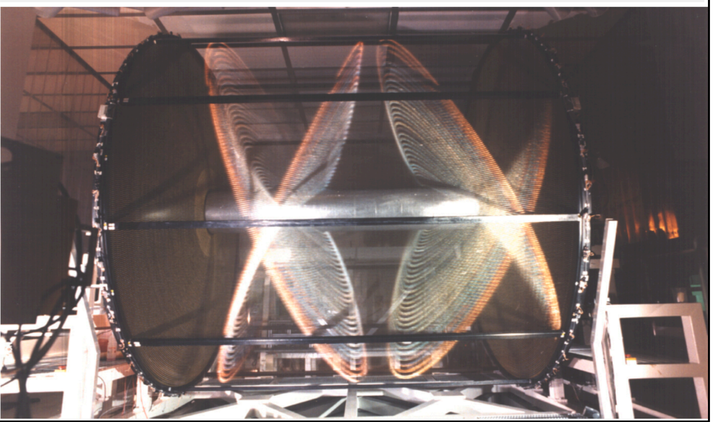
F. Grancagnolo
INFN – Lecce, ITALY

Detector: Tracking

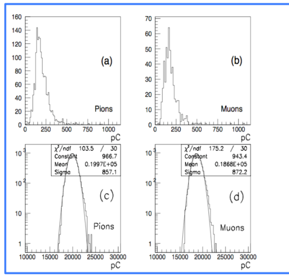
WG11 Detector Design Meeting
CERN
17 October 2016

The KLOE Drift Chamber

45 m^3 > 52,000 wires He/iC_4H_{10}



dE/dx

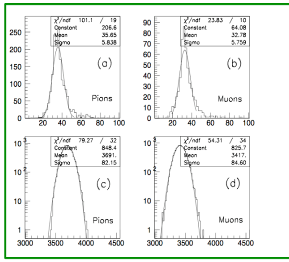


100 samples 3.7 cm
$(\sigma[\%]=40.7\ n^{-0.43}\ L[m]^{-0.32})$
$\sigma = 3.7\%$
$\approx 2.0\sigma$ separation

20% truncated mean
$\sigma = 4.5\%$
$\approx 1.4\sigma$ separation

μ–π 200 MeV/c

dN_{cl}/dx



Poisson distribution
$\sigma = 1.7\%$
$\approx 5\sigma$ separation

Experimental distribution
$\sigma = 2.5\%$
$\approx 3.2\sigma$ separation

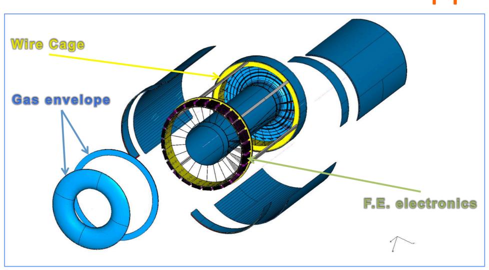
μ–π 200 MeV/c

A proposal for FCCee

- **112 para-axial layers** at alternating sign stereo angles, arranged in **16 equal azimuthal sectors**;
- **32 square, single sense wire, drift cells** per sector (512 total per layer) increasing linearly as a function of layer radius;
- **Cell sizes** ranging from **6.3 mm to 25 mm** from inner to outer radius;
- **Alternating sign stereo angles** in consecutive layers ranging from **40 to 160 mrad** (constant azimuthal angular displacement)
- **Length:** **5000 mm**; fully efficient up to **cosϑ = 0.97** (≥16 hit)
- **Inner Wall:** made of 25 μm of Kapton plus 0.1μm of Au (**1.2×10^{-4} X_0**) at **Radius = 500 mm**;
- **Outer Wall:** Sandwich of 8-ply C-fiber (0° and 90°, total of 250 μm) - 2.5 mm Rohacell30 - 8-ply C-fiber (**8.0×10^{-3} X_0**) at **Radius = 2060 mm** (must support **20 Tons** - check for buckling over 5 m);
- **End plates:**
  - **Wire cage** (in analogy to Mu2e I-Tracker): 0.9 g/cm² - **3×10^{-2} X_0** (incl. power distr., decoupling C's, term. resistors and signal and HV cables).
  - **Gas envelope** made of 8 ply (quasi-isotropic, 10×38 μm = 380 μm) C-fiber plus 0.3 μm Au, for a total of 0.090 g/cm² – **3.0×10^{-3} X_0**;
- **Gas: 90% He - 10% iC4H10** ($\delta = 4\times10^{-4}$ g/cm³, X_0 = 1410 m), - 12.5 p.i./cm, gas gain: 4×10^5 at V ≈ 1700 V on 50 μm wire, v_{drift} ~ 2.5 cm/μs – **0.47×10^{-3} X_0/1m track**
- **Wires:** - **57,344 sense** (50μm Sn coated Ti); **290,816 field and guard** (100μm Sn coated C); for a total equivalent thickness of **1.34×10^{-3} X_0/1m track**

Cluster Counting

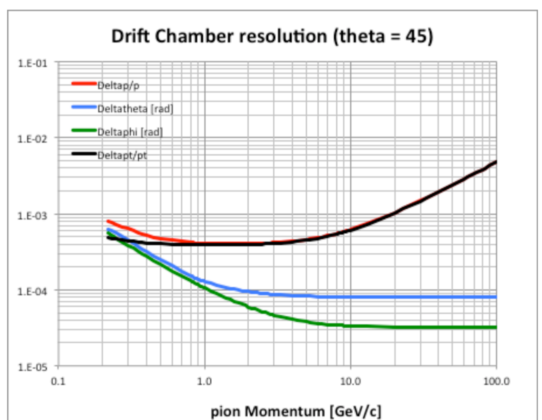
Gas containment and Wire support



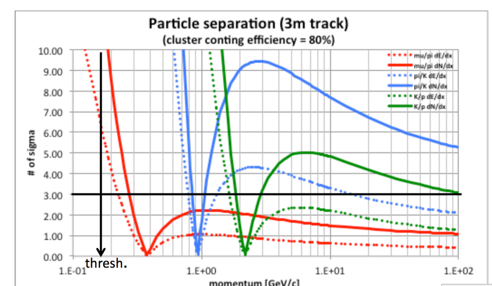
Gas containment — **Gas envelope** can freely deform without affecting the internal wire position and tension.

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

Expected spatial resolution



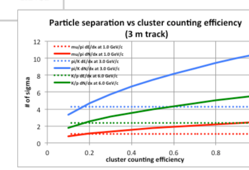
Expected p. id. capabilities



$\sigma_{dE/dx}/dE/dx =$
$= 5.4\ L[m]^{-0.37}\ \%$
(Lehraus parametrization)
3.6% for L=3m

cluster counting efficiency
$\varepsilon = 80\%$

$\sigma_{dN_{cl}/dx}/dN_{cl}/dx =$
$= \varepsilon\times L\times 12.5/cm =$
1.8% for L=3m



Particle separation power as a function of cluster counting efficiency for 2m tracks.
Cluster counting outperforms dE/dx for counting efficiencies as low as 20%.

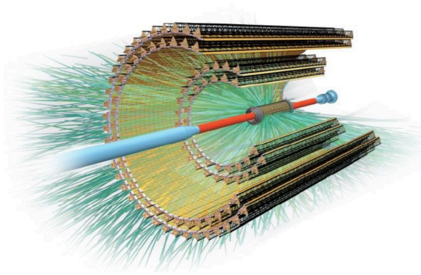
Detector: Vertexing

A new generation of MAPS for the ALICE Inner Tracking System

J.W. van Hoorne - CERN

WG11 – Detector Design Meeting

CERN, December 19th, 2016



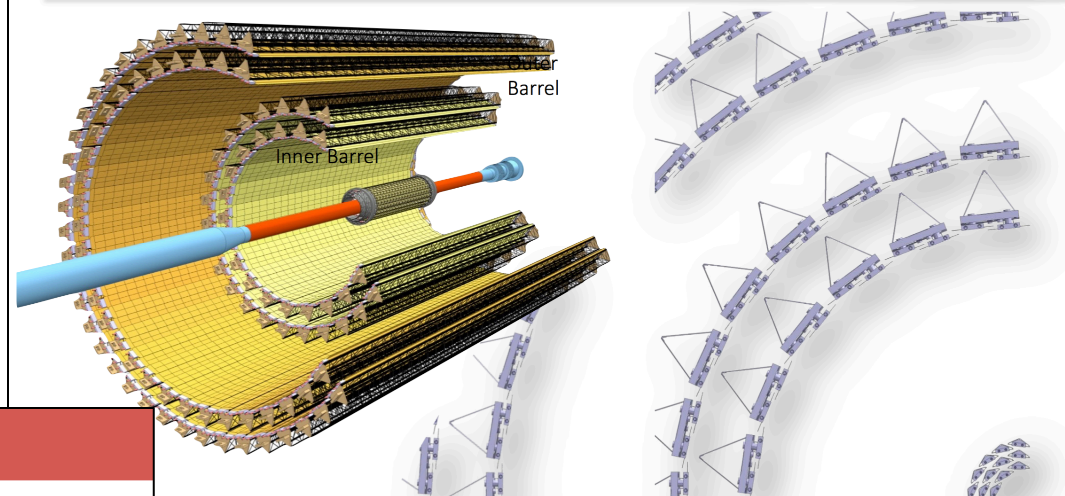
Layout of new ALICE Inner Tracking System

1. Introduction

7-layer geometry:

- r-coverage: 23 mm - 400 mm
- η-coverage: |η| ≤ 1.22 for tracks from 90% luminous region

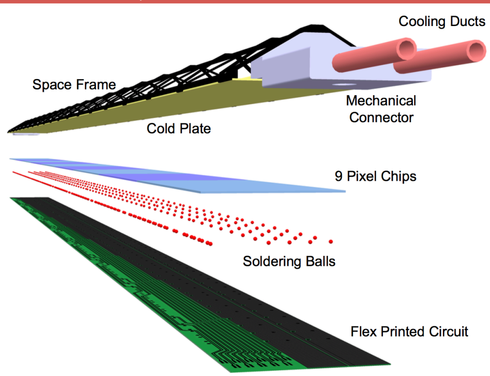
- 3 Inner Barrel layers: 0.3% x/X_0 per layer
- 4 Outer Barrel layers: 1% x/X_0 per layer

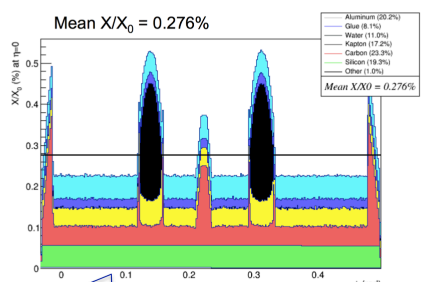


Layer n.	6	5	4	3	2	1	0
N. of staves	48	42	30	24	20	16	12
Stave length	1500 mm		900 mm		290mm		

What's up next? Ultra-light "silicon-only" vertex detector

3. Future developments





Sensor only amounts to 20% of total x/X_0

How to further reduce material thickness?

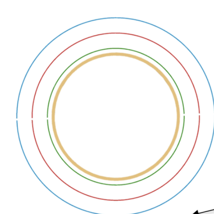
- eliminate active cooling: for a 30cm long stave possible for power densities below 20mW/cm²
- eliminate electrical substrate (flexible FPCs): possible if power density is sufficiently low (voltage drops on supply and biasing) and the (monolithic) sensor covers the full stave length

ALPIDE Chip: pixel matrix power density ~7mW/cm², the rest is dissipated in the periphery!

➔ Can the circuit periphery be put at the periphery of the detector?

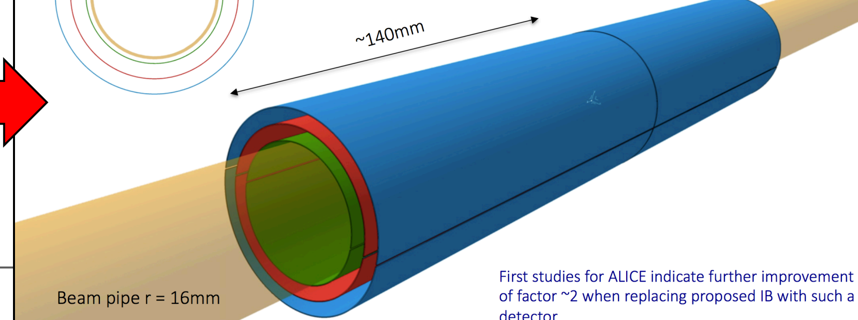
One layer built out of 4 pixel chips, with periphery at outside edge:

- chip dimensions: 140 x 56 (94) mm² -> fits on 200mm wafer!



Layer 0, 1, 2

L0: r ≈ 18mm (circumf. = 113mm)
L1: r ≈ 24mm (circumf. = 151mm)
L2: r ≈ 30 mm (circumf. = 188mm)



Beam pipe r = 16mm

First studies for ALICE indicate further improvement of factor ~2 when replacing proposed IB with such a detector

Detector: Synthesis (i)

Gigi Rolandi
1st FCC Physics Workshop
16 Jan 2017

Detector concepts for FCC-ee

or
which detector can be built for FCC-ee physics
with today's technology

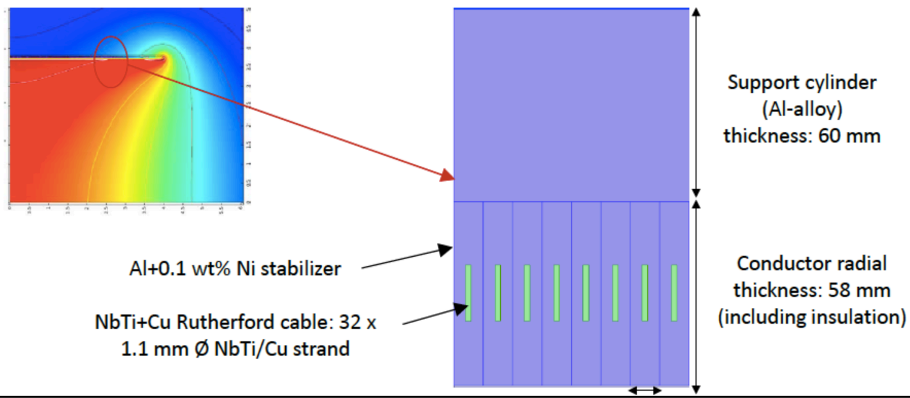
Bring together the three technologies

- DREAM calorimeter
- CluCou Tracker
- Alice-like vertexing

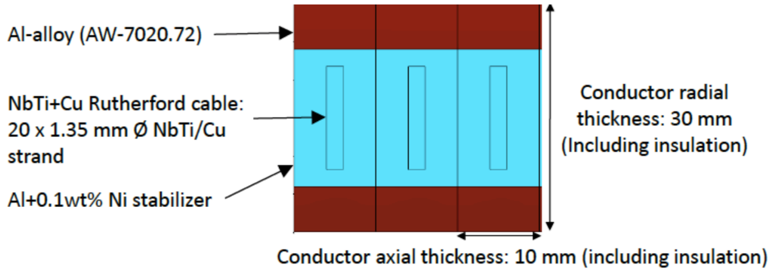
Combine with

- Preshower counter
    - Measure precisely impact points of charged particles and photons
- Magnetic field
    1. Outside calorimeter
    2. Or (cheaper) thin inside calorimeter

Magnet concept 1 : 2T solenoid around HCAL

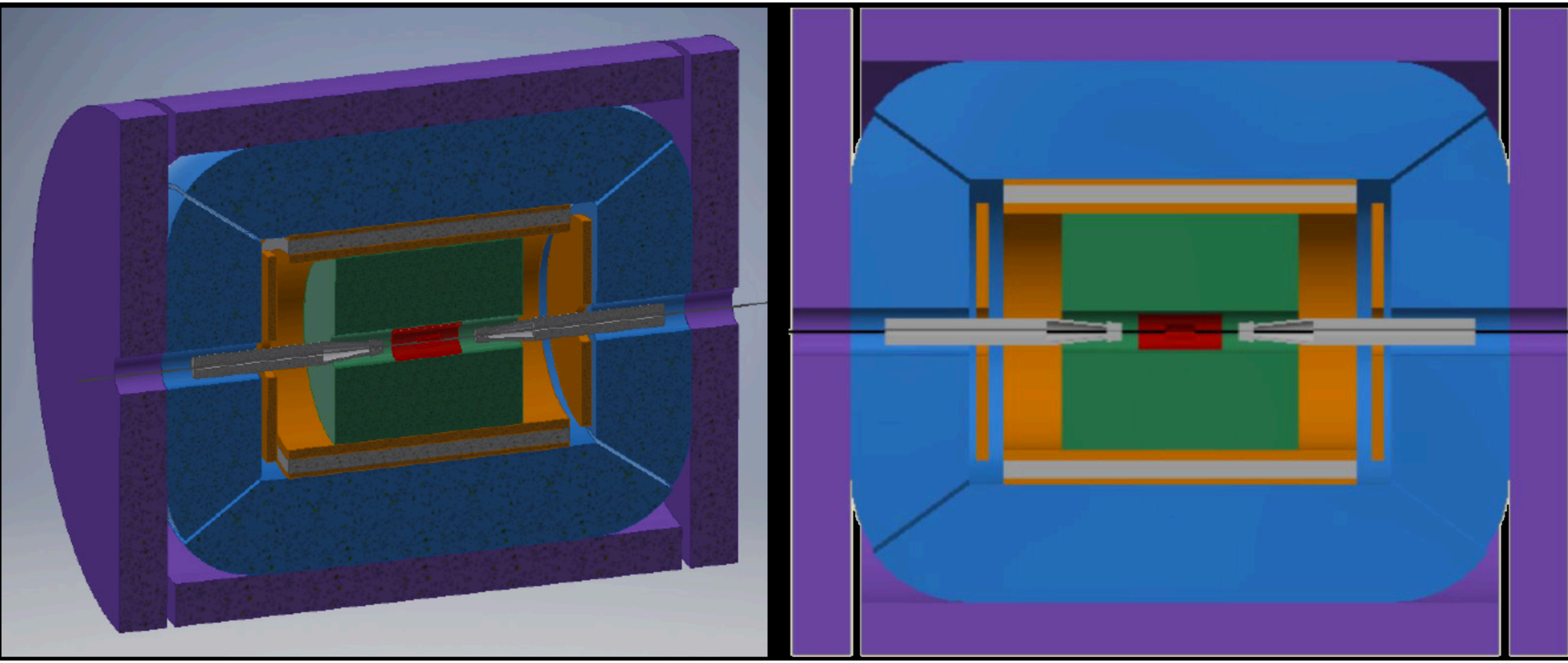


Magnet concept 2 : thin 2T solenoid around tracker



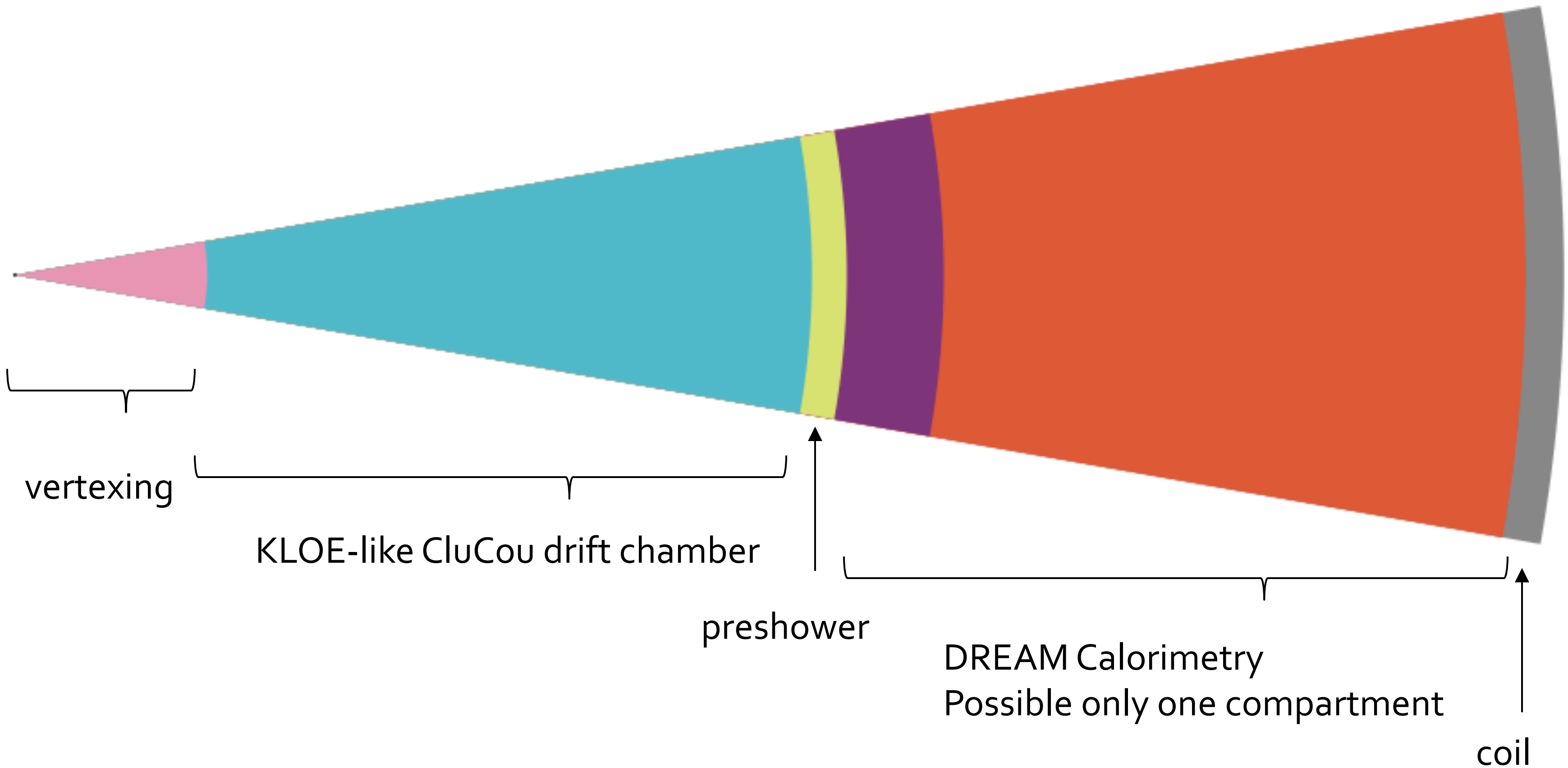
Detector: Synthesis (ii)

Detector concept now also know under name **IDEA**



WG11 Meeting, Feb 20, 2017 **F. Bedeschi, INFN-Pisa**

Detector Wedge



Sorry for the colours,
I am colour blind

ALICE software tool: Vertex detector optimization

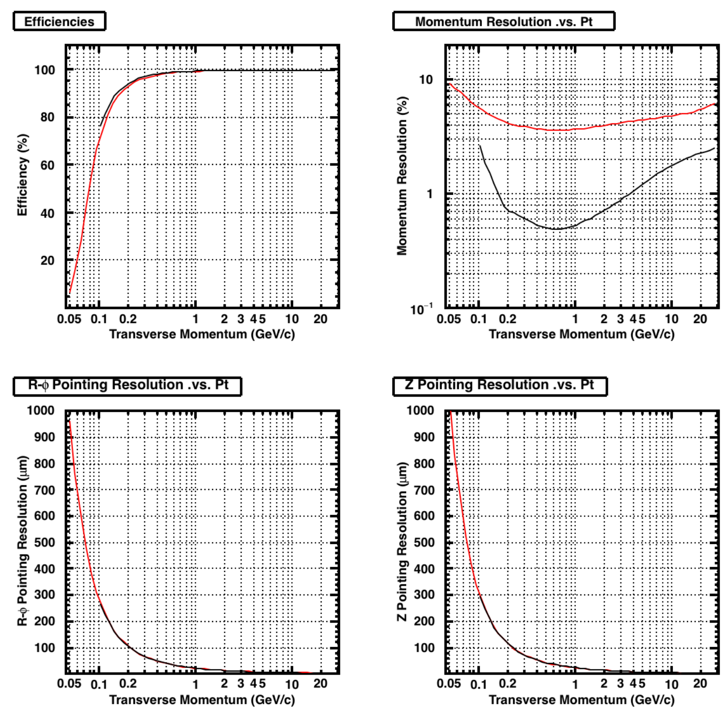
Mail from Ruben Shahoyan, ALICE, yesterday:

> *As far as I understand, currently you are interested in the* ***code for the fast evaluation of the basic properties (impact parameter, pT resolutions, reconstruction eff. etc.) for a given layout?*** *If you want, I can send you the standalone version (does not require Alice software installation) of the code with some comments, it is quite easy to run it with arbitrary cylindrical detector setup. If needed, can also meet (say, Fri. afternoon) with whoever will work on your detector layout optimization to clarify details.*

Runs right out of the box…

```
root [0] .L DetectorK.cxx+
root [1] .x testDetectorUp.C
Detector ALICE: "ITS"
  Name   r [cm]    X0    phi & z res [um] layerEff
0. vertex  0.00    0.0000     -    -   -
1. bpipe  2.00    0.0022     -    -   -
2. ddd1  2.32    0.0030      4      4 0.95
3. ddd2  3.13    0.0030      4      4 0.95
4. ddd3  3.91    0.0030      4      4 0.95
5. ddd4  19.41    0.0080      4      4 0.95
6. ddd5  24.71    0.0080      4      4 0.95
7. ddd6  35.33    0.0080      4      4 0.95
8. ddd7  40.53    0.0080      4      4 0.95
N ITS Layers: 7
```

…and produced plots



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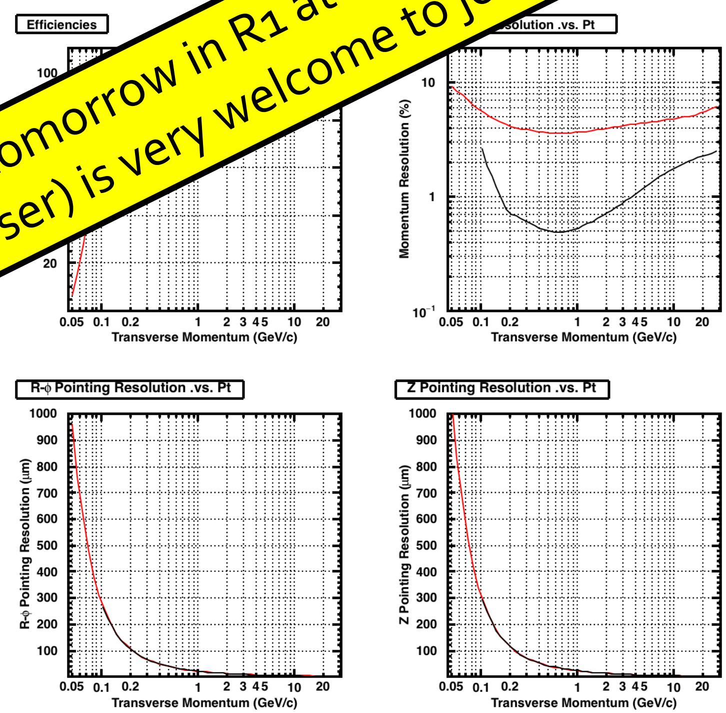
  Name  r [cm]   X0   phi & z res [um] layerEff
0. vertex  0.00   0.0000    -   -  -
1. bpipe  2.00   0.0022    -    -   -
2. ddd1  2.32   0.0030    4     4 0.
3. ddd2  3.13   0.0030    4
4. ddd3  3.91   0.0030
5. ddd4  19.41   0
6. ddd5  24.71   0.                   05
7. ddd6  35.33   0.0                4 0.95
8. ddd7  40.53   0.00        4      4 0.95
N ITS Layers: 7
```

...and produc



Will meet Ruben for a chat tomorrow in R1 at 14:30
Any interested user (or non-user) is very welcome to join