Second round of thoughts thoughts after reading your detector requirements

First round in May , no much feedback after it

Obvious/constraints on the FCC-ee detector

B = 2 T
Hermetic detector
Excellent muon id (eg: enough interaction lengths outside)
Excellent granular e/gamma calorimeter

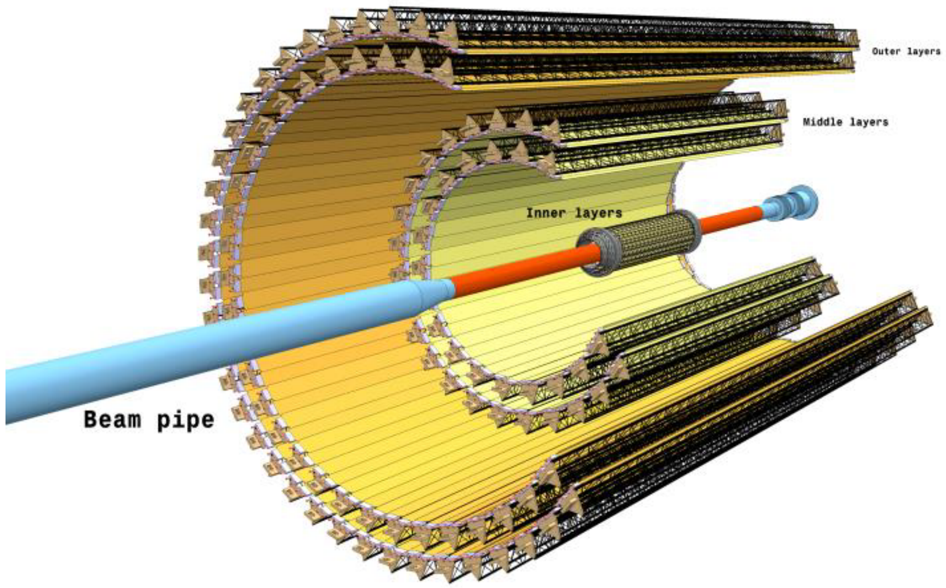
Usual dilemma : perfect tracking vs no material upstream of ECAL . If you perform good enough tracking with little material you have a good optimization point.

Little material is important for systematic errors (WG1/WG2)

Common requirement of many WGs :
performing vertex detector for b and charm tagging

ALICE ITS :
0.3 -1 % X0/layer
7 layers pixel 30*30 μm
r_max = 40 cm

need * 3 for θ coverage



In Alice it is readout at 100 kHz, but can be significantly increased (ref: Walter Snoeys)

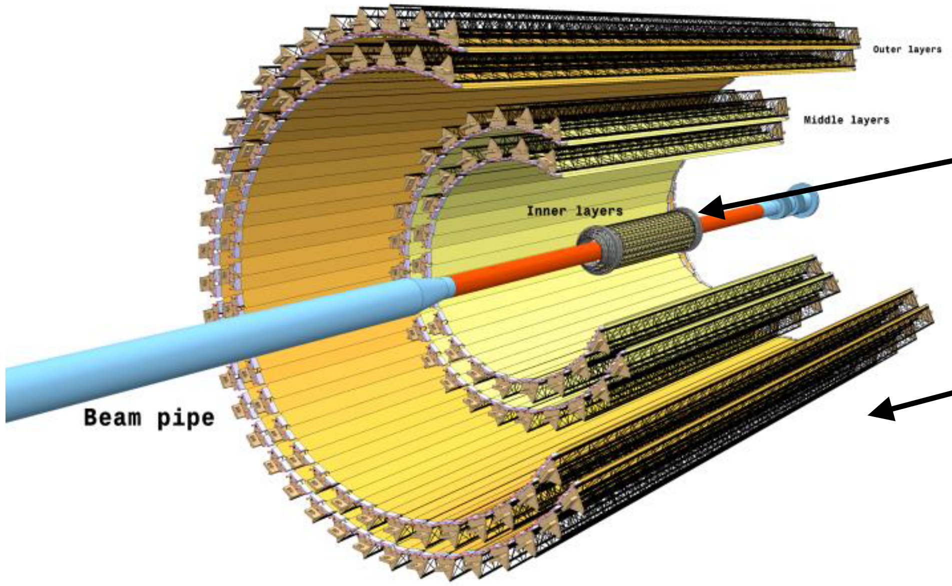
Occupancy will be extremely low. This detector will provide full 3d reconstruction of all charged tracks within angular acceptance and with very low momentum threshold + dE/dx information. No need of a TPC.

Momentum resolution :
Extreme for muon → Requires L > 2m
Moderate for hadrons → "ITS" measures O(1%) at 20 GeV

Sagitta of a 100 GeV muon with L=2m is 3mm

The space between the last "ITS" layer and the pre-shower (see later) can be filled with an ultra light drift chamber similar to KLOE/ MEG II

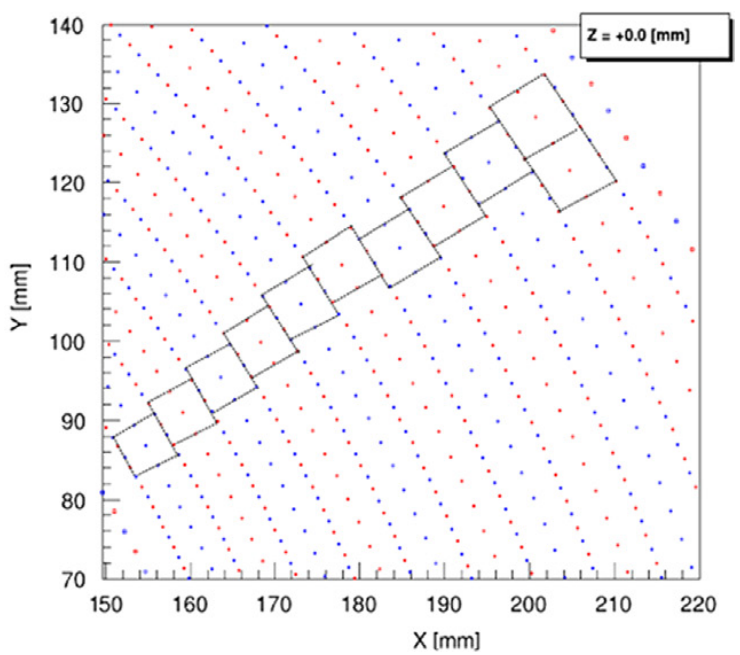
MEG II : gas (He-iBut 85:15), distance between sense wires 1 cm, has a radiation length of 0.4% for 150 cm. Resolution on each wire measurement is 110 μm.



Vertex, 3 layers   1% total

Outer layers 1% each

σ ~ 10 μm



Drift chamber from 50 to 200 cm

~ 1% total, including inner cage

150 measurement at 100 μm

Precise ~ 20-10 μm measurement at the pre-shower (see later)

$\Delta p_t/p_t \sim 0.2\%$ @ $p_t = 100$ GeV

Optimization tracker :

Vertex : beam-pipe and r-min What is charm tagging performance with 3 or 4 layers ?

What is the momentum resolution needed for a 100 GeV muon ? Which measurement is giving the most tight requirement. I would like to understand the difference in performance between 4-2-1 10^{-3} . WG3 ?

Material budget wrt momentum resolution:
How many silicon outer layers do we need ?
At which radius ?
Do we keep empty space between vertex and outer silicon layers ?

Preshower

Lead-silicon sandwich cylinder at R = 2 m.

- Measures precisely impact points of charged particles and photons.

- Defines the acceptance

4 silicon strips layers with small overlap for alignment and with thin 2-3 mm lead in front

10 m * 2 m * 2π = 125 m^2 /layer

Photons from a 100 GeV π^0 are separated by 2 mm

Electromagnetic calorimeter

After pre shower - inside the coil.

Energy resolution of 1 % at E=100 GeV

Ideally crystals , combined with pre-shower for h/e separation.

Which angular granularity do we need after a precise preshower ?

What is the role of the low X_0 tracking and very granular pre shower in measuring electron momentum ?

Optimization pre-shower + calorimeter

Silicon design, tilt angles, disambiguation of nearby photons

Lead-silicon balance e/h separation vs multiple scattering and precision in muon (hadron) tracking

Granularity of ECAL vs yet energy resolution

Interaction lengths and neutral hadron measurement before the coil.

Pid in front of the calorimeter (WG5/WG6)

TOF and/or quartz bars (“a la Belle”)

Is π/k separation to 10 GeV (?) important for charm tagging (all other groups)?

Is π/k separation sufficient for WG5/WG6 ? I would like to see something quantitative.

Can we integrate tracking at 2 m with <15 mu resolution + TOF/Quartz (2-3 cm depth)+ segmented Ecal ?

Temporary conclusions

1) Today's ITS technology can give affordable tracking full acceptance few % X_0 in r=40 cm. Good enough for everything except muon momentum resolution at 100 GeV.

2) Space between "ITS" and calorimeter can be filled with drift chamber ~ 1% X_0 . Tracking of displaced tracks.

3) Ecal at 2 meters high energy resolution with imbibed preshower with full silicon strip coverage. It can define acceptance and measure electron and photons precisely with good angular separation (τ id in ALEPH). Main requirement minimize material upstream (can we do with <5% ?)

4) Pid can be done with possibly no harm to photon detection if imbibed in the preshower . Important to understand the needed separation.

Next steps toward workshop in November

The most important question driving the design is :
1) What is the need in momentum resolution for muons ?

If 0.1% at 100 GeV R_preshower ~ 2 m
If 0.4% at 100 GeV R_preshower ~ 1 m **WG3**

2) Is this vertex with (+PID) sufficient for flavor separation needed for **WG1/2 WG3** and **WG4** ? Do we need 3 or 4 layers ?

3) Is PID important for charm tagging ? **WG3/WG4/WG1** If yes, what is the requirement ?

Barrel Endcap transition region is difficult and usually Endcaps are less performing than barrel.

4) Is it interesting to consider a long barrel ~ 10 m [atan (5/2)= 68^0] with optimized performance and a less performing endcap (eg: barrel chambers services) ? **ALL**

5) What is the design requirement for a sufficiently small systematic error on the acceptance of Z hadronic decays defining it only with charged tracks or only with photons? **WG1**

6)Identification and measurement of tau-jets is an important driving aspect of this design. Which 2-photon separation and hadron/photon separation detection is needed to identify all tau hadronic decay modes? What is the impact of the pre-shower two-track separation and of ECAL granularity? **WG1/ WG3**

7) Jet energy resolution : Which kind of jet resolution do you achieve with ideal measurement of
a) charged tracks + photons + neutral hadrons
b) At which level can you "deteriorate" neutral hadrons detection before you see the effect in the resolution (core and tails)
c) Which granularity you need in ECAL (after pre-shower) for energy measurement ? **WG3/WG4**

8) Is the wire chamber (r>50 cm) alone sufficient for K^0 reconstruction and in general for displaced vertices?
WG5/WG6/WG7

9) Do we have to inject special requirements for γγ events in the forward ? **WG5**