The role of Si tracking components in the LDC concept

Aurore Savoy-Navarro, LPNHE-Universités de Paris 6&7/IN2P3-CNRS
aurore@lpnhep.in2p3.fr aurore.savoy@cern.ch

The work reported here is ongoing in the framework of the SiLC (Silicon tracking for the Linear Collider) R&D collaboration

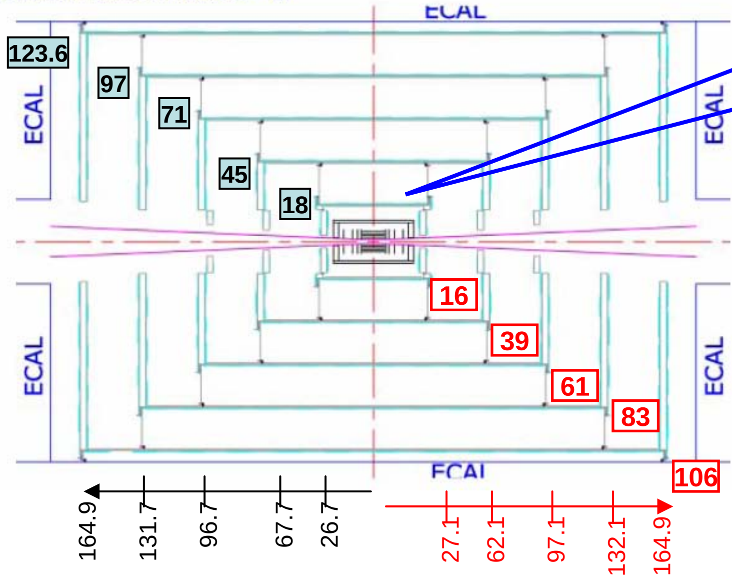
2005 ALCPG Meeting in Snowmass, 14th to 27th August 2005
LDC Concept Working Session 8/16/2005

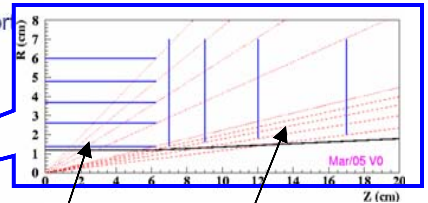
- What are the various possible Si tracking components in the LDC-like concept
- Their role, their design, their performances, their main issues
- Where do we stand?
- What can we achieve during this workshop?

The concepts: main difference = tracking strategy

SiD Concept

The outer silicon tracker has been separated into a portion supported from the ECAL and a portion supported from the beam pipe to allow servicing of the VXD.
Overlap between smaller and larger disk portions is provided by offsetting the por
at smaller radius towards Z = 0.

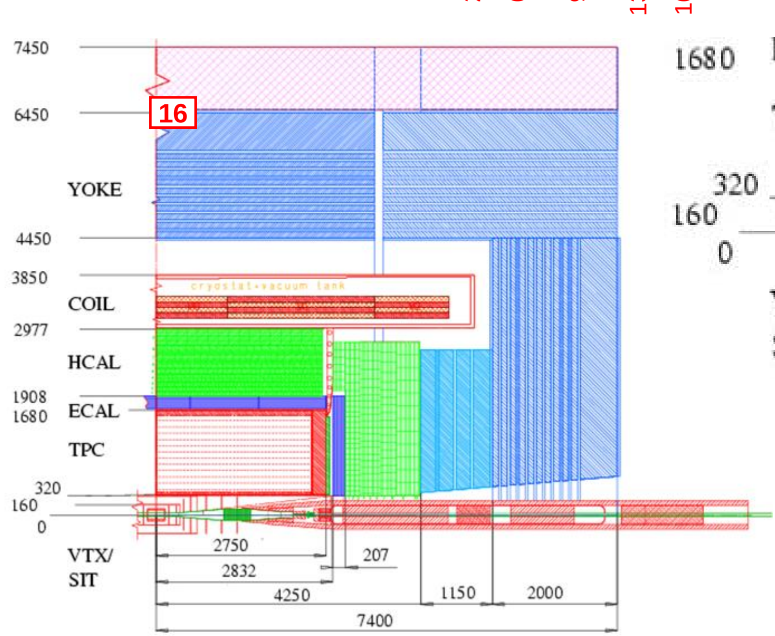


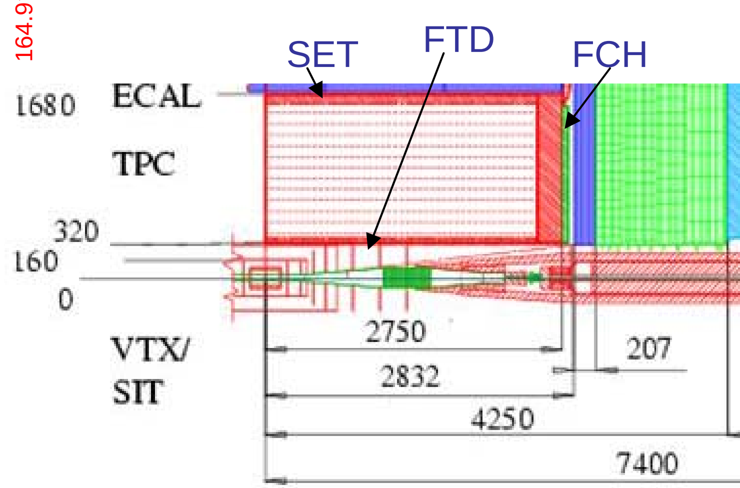


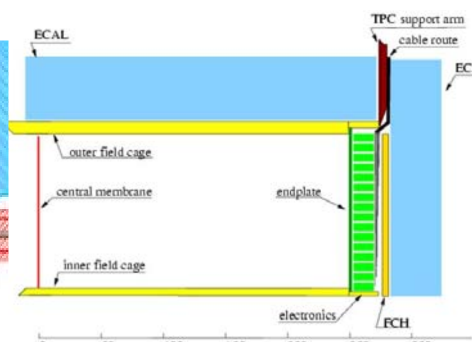
VXD

4 disks
Z(cm)=7, 9.9, 12, 17
Rmin=1.4, 1.6,1.8, 2
Max Radius~7cm

SiD tracking in numbers
Barrel: 5 layers S.S (Phi)
(up to 10 layers under consideration)
Rmin:18.6cm Rmax: 123.6cm
Zmin=26.7cm Zmax=164.9cm
Endcaps: 5 layers F.D.S.
(back to back double layer stereo)
Zmin=27.1cm Zmax=164.9cm
If 5 layers:
Overall surface ~100m2
Number of channels ~16M.





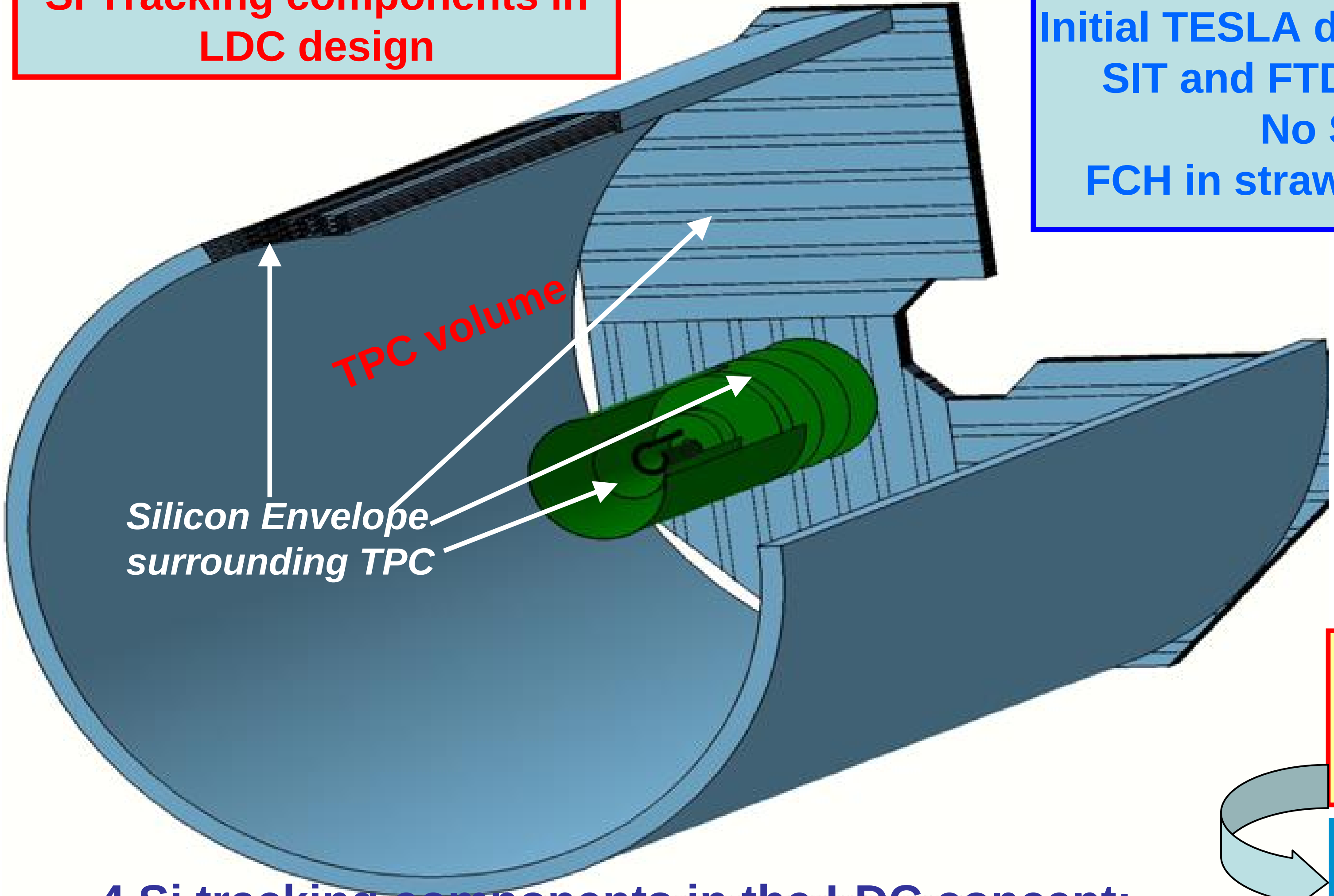


LDC Concept

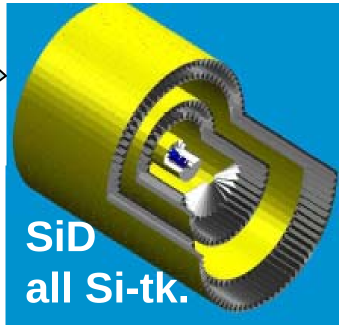
LDC trackers in numbers:
Barrel=TPC +SIT +SET, Rmin=16cm Rmax=168cm
Endcap=FTD+FCH, Zmin=16cm, Zmax=275cm
Overall Si-surface (Si envelope)~200m2 x 2, Nb of ch~4-6M

Si Tracking components in LDC design

Initial TESLA detector design:
SIT and FTD (Si techno)
No SET
FCH in straw tube techno



How it compares with SiD tracker?

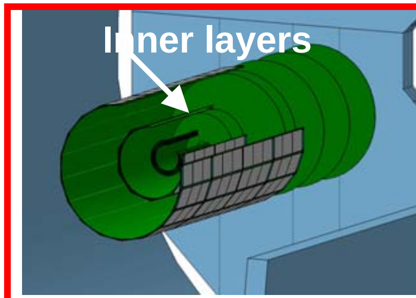


4 Si tracking components in the LDC concept:
internal and external Si tracking components
in
barrel and large angle (forward/end caps) regions
acting as intermediate trackers
and forming a complete coverage Si tracking system

Design, role, performances & main issues: Where do we stand component by component

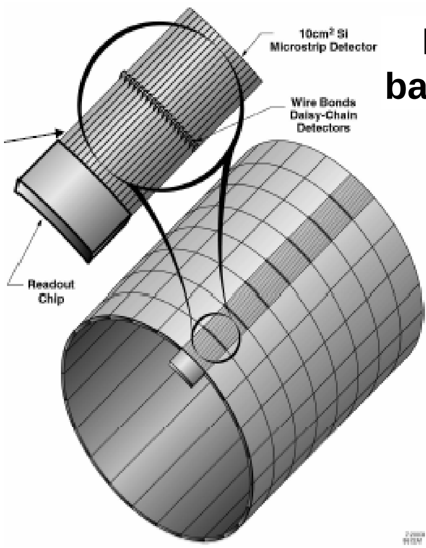
The central barrel

✓Robustness
✓Full coverage
✓Improved performances

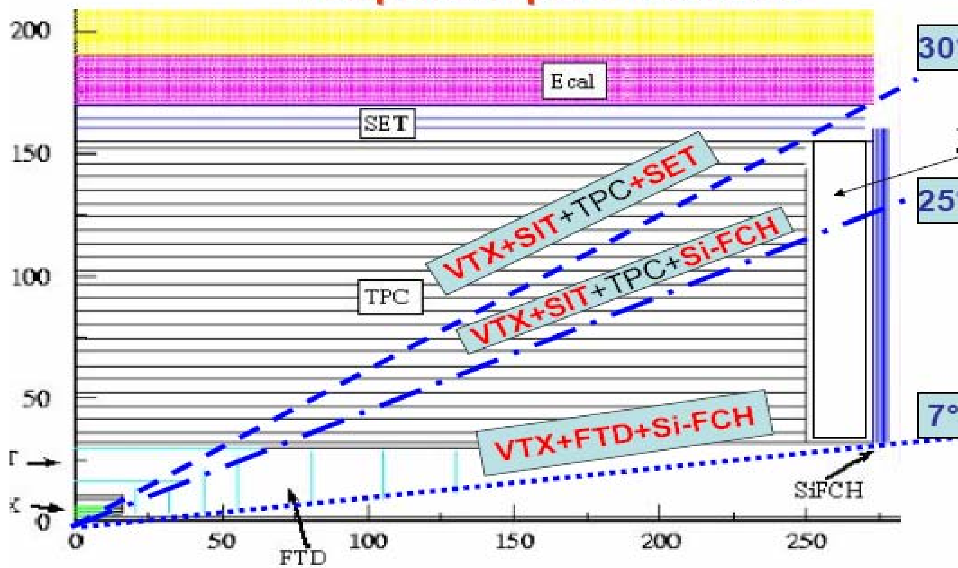


Link μvertex to larger area external layers

(7μ precision)

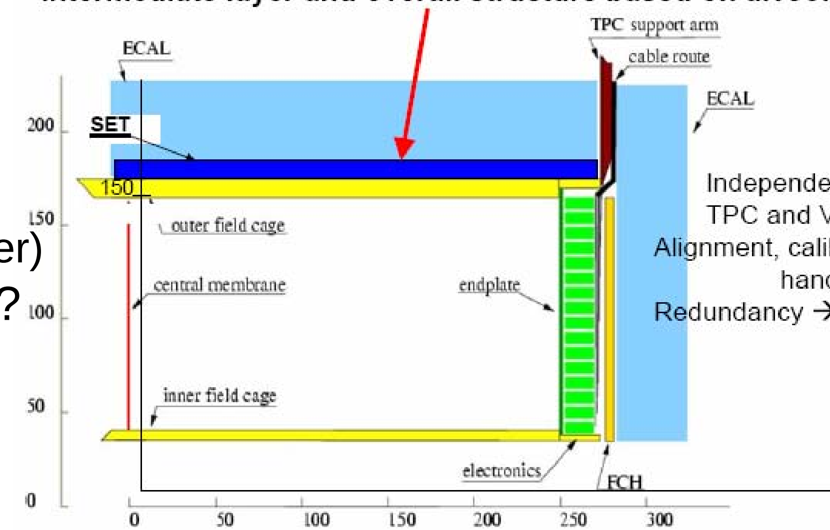


External barrel layers



If a TPC: SET (Silicon External Tracker) proposed in LC-DET-2001-075. Located between TPC and e.m. calorimeter

Optimized with 3 layers, two single sided external layers, one d.s. intermediate layer and overall structure based on alveoli.



Independent track finding TPC and VTX+SIT+SET: Alignment, calibration, distortions handling
Redundancy → reliability (safety)

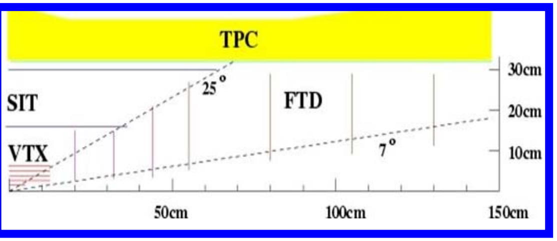
Questions:

- Tiling or not tiling? (medium size ladder)
- How many layers? DS (FDS) or not?
- Structure with alveoli?
- Large area support structure vs low material budget
- Metrology, alignment

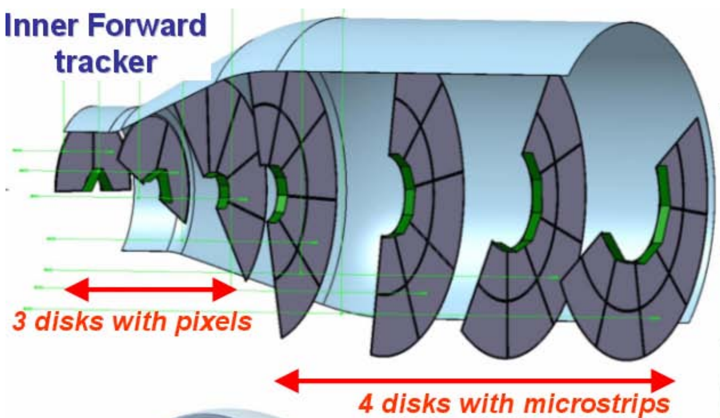
The internal forward Si component

see Klaus' talk for physics motivation and initial design

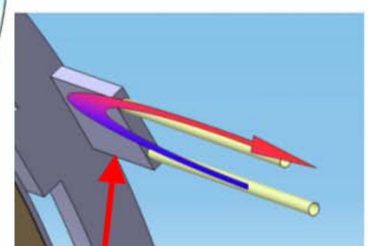
N.B. It is made of 2 parts: the first 3 or 4 disks (forward extension of μvertex) and the remaining ones

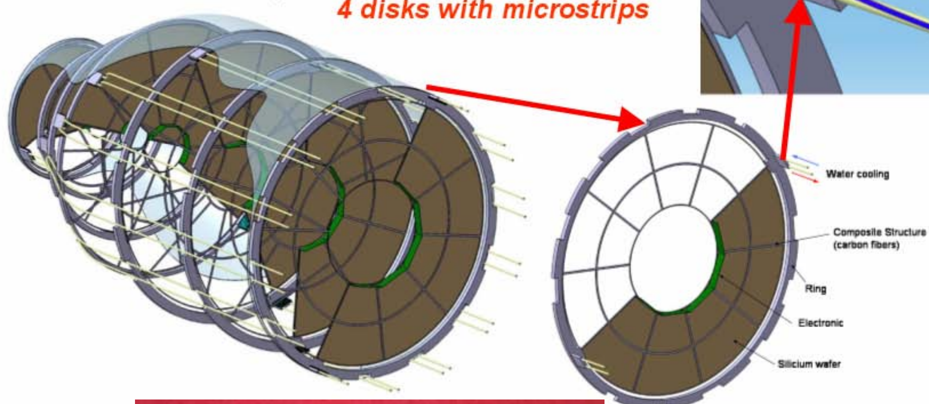


The TPC doesn't help at large angle The FTD will be the first part of the overall L.A.R. tracking system, completed by the Si-FCH (Standalone Si system)

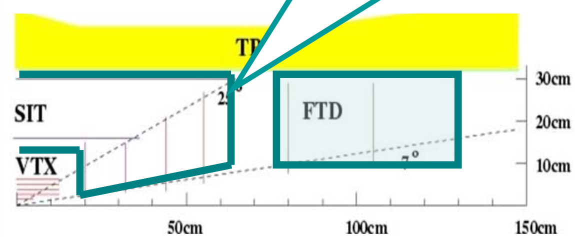


Cooling under study: based on water cooling with water T<10°C, flowing through the rings (to be checked on mechanical prototype)





Envelope for isolating and cooling

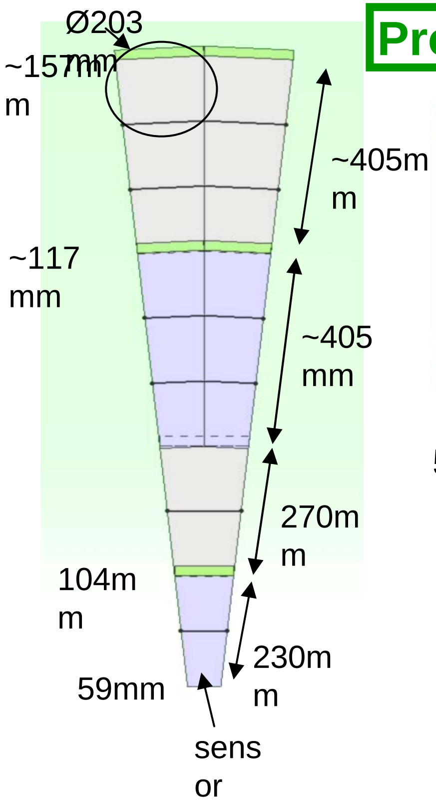


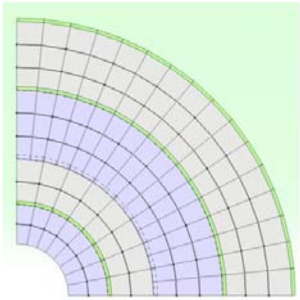
The cooling in this strategic place is trickier. The design of a realistic prototype to study this problem is underway.

Nota Bene: the first disks of the inner Forward Si tracker could/should be equipped with sensor techno as those developed for the μvertex. The VELO sensors of LHCb , could be of interest for some case as well (under investigation)

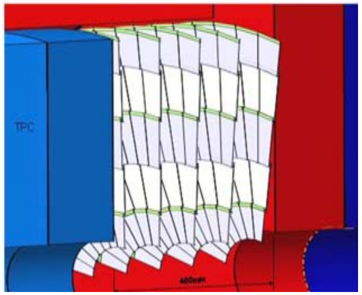
The Endcap Si components

Endcap components both internal and external are essential:Physics @ Ecm=1 TeV is demanding highly performing tracking at large angles. Lot of work going on

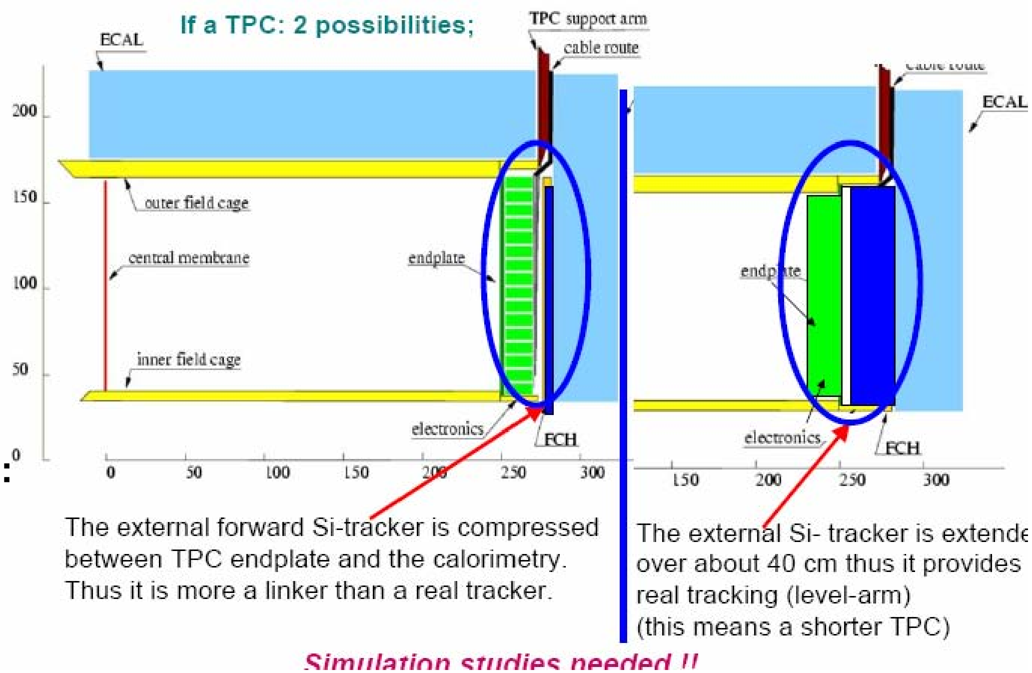


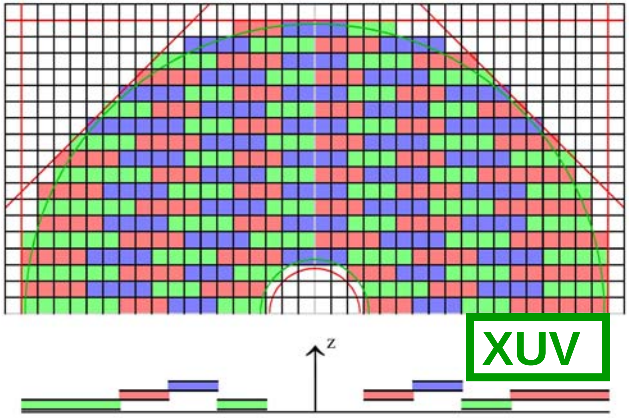


Projective



LDC design:
5 F.D.S stereo planes:
10240 sensors
3840 modules
2 to 4M channels



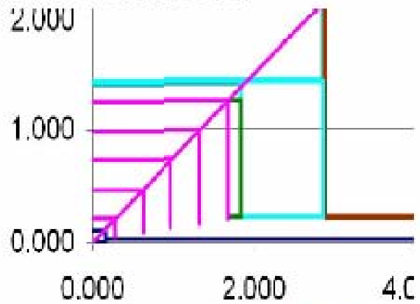


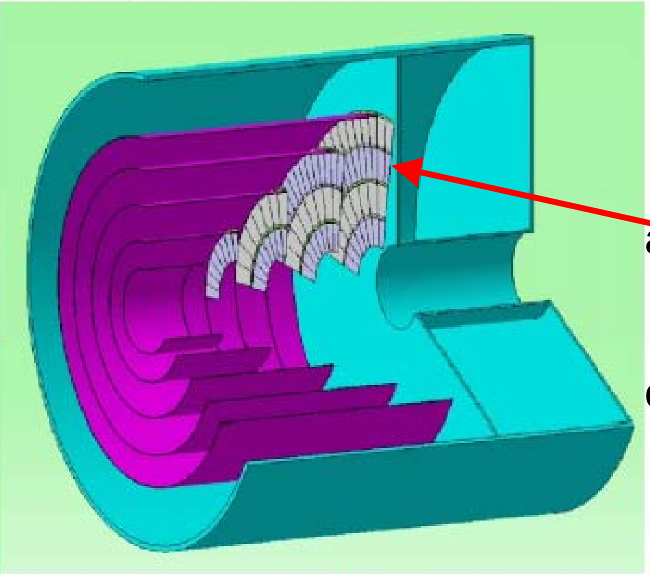
XUV

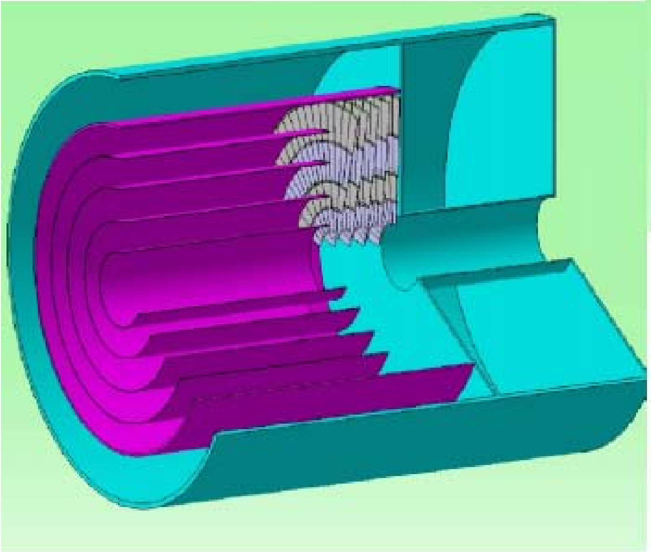
The XUV design is being revisited.
No more structure with alveoli.
Advantage of the XUV: use only one single type of sensor:
here 10x10 cm2 that can be arranged in modules of 3, 4 and 6 sensors.
This also fits easily with an octogonal overall support structure

Endcaps in the SiD concept

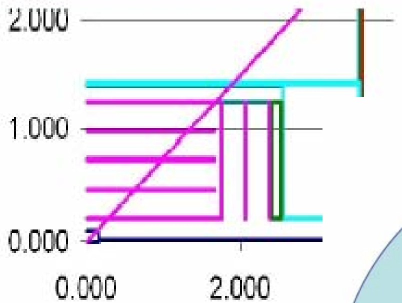
How it compares with the SiD Forward tracking ? Important key issue to evaluate the two detector concepts





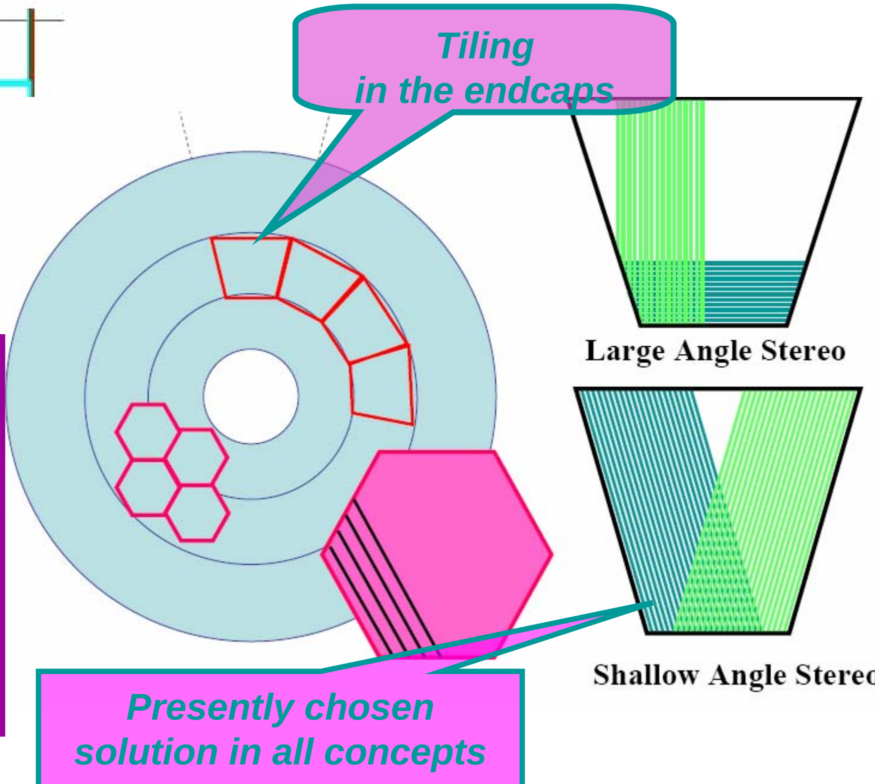


The designs in previous slide are directly applicable to SiD as well as to GLD.
The projective design is currently favoured for SiD. But XUV is also under study.



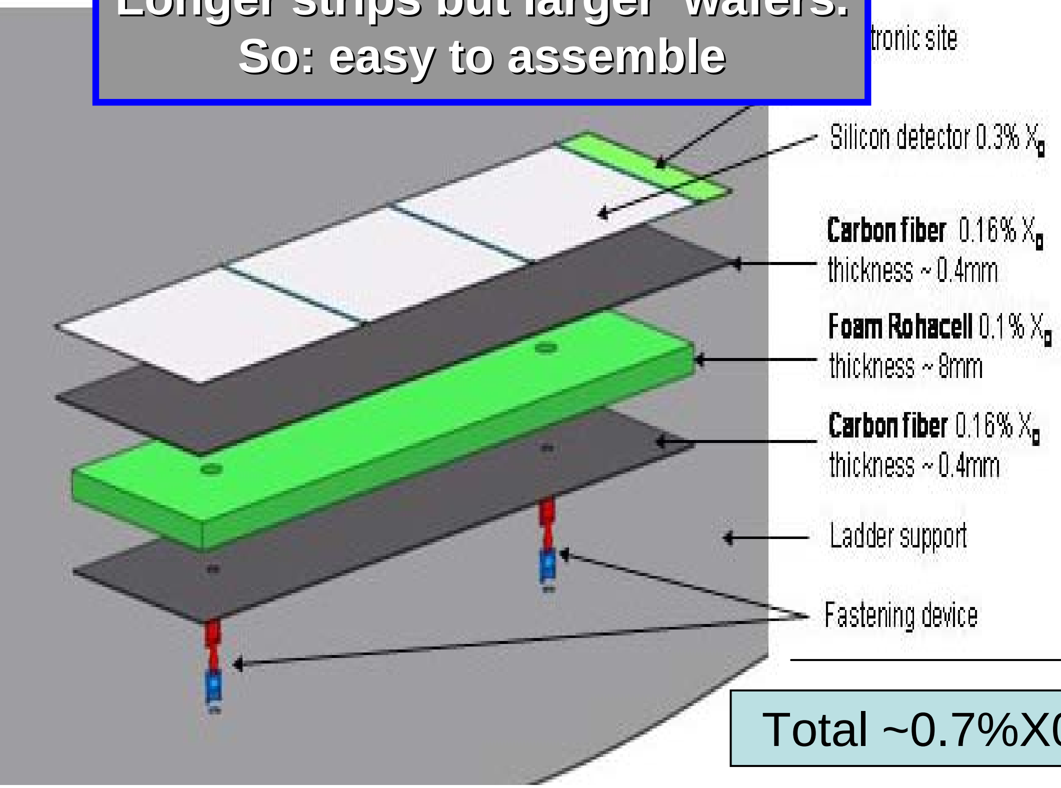
Two remarks valid for all detector concepts:

1) ***Performances at large angle will be a decisive parameter when comparing with or without TPC tracking systems***
2) ***Optimisation of the overlap between central and endcap parts: key issue wrt material budget***

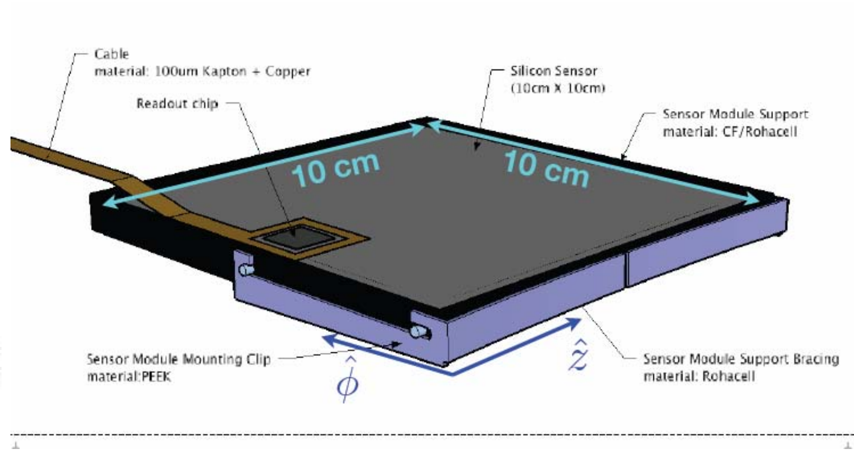


Elementary modules (revisiting existing techniques)

Longer strips but larger wafers.
So: easy to assemble



Total ~0.7%X0



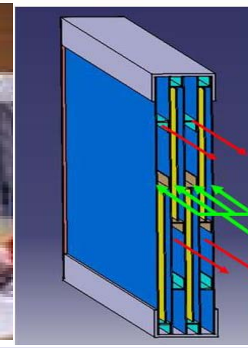
Occupancy studies tend to confirm that strips of 30 up to 60 cm length are adequate for most of the detector components.
Modules with single sensor are also considered in this R&D.

Key issues:

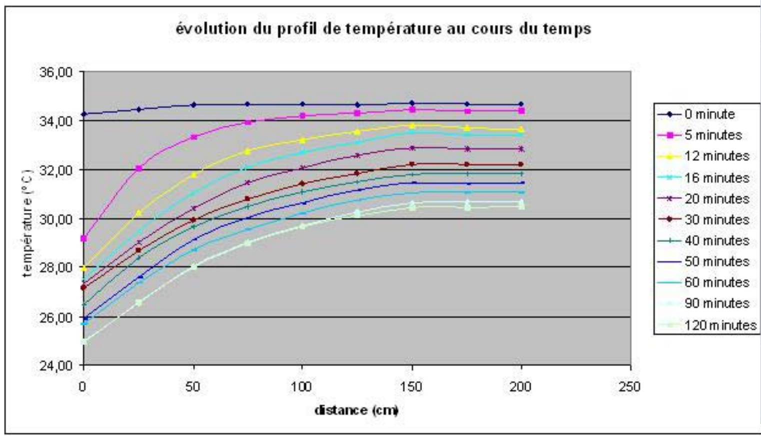
- ***Minimum material Budget***
- ***Best strips alignment***
- ***Most accurate positioning of the module on the support structure (large size!)***
- ***FE electronics connectics, packaging and cabling***
- ***Cooling***
- ***Easy to build (robotisation ?)***
- ***Transfer to Industry (large nb)***
- ***Universal tile vs various types***

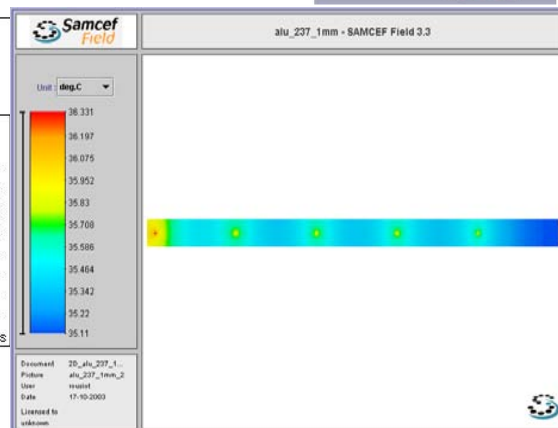
Be innovative!

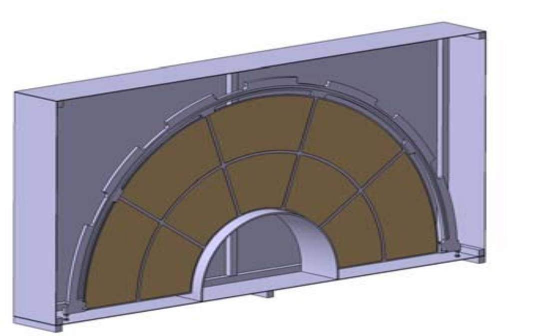
Thermo mechanical studies

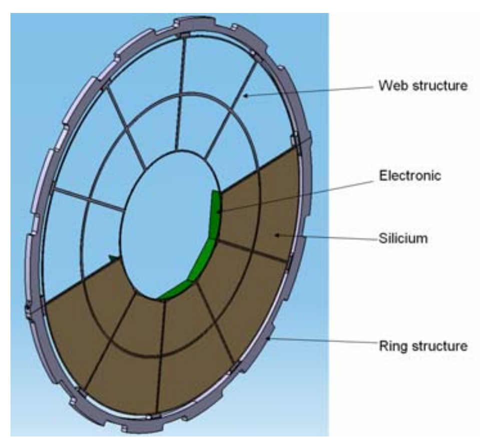


Extensive studies on realistic external central & forward prototypes gives: air conduction + convexion Is sufficient; What really matters Is the environtmental temperature









Now starting, cooling studies of the inner parts: a bit more tricky…

preliminary design of the mechanical prototype to test the cooling system for a disk of the inner forward

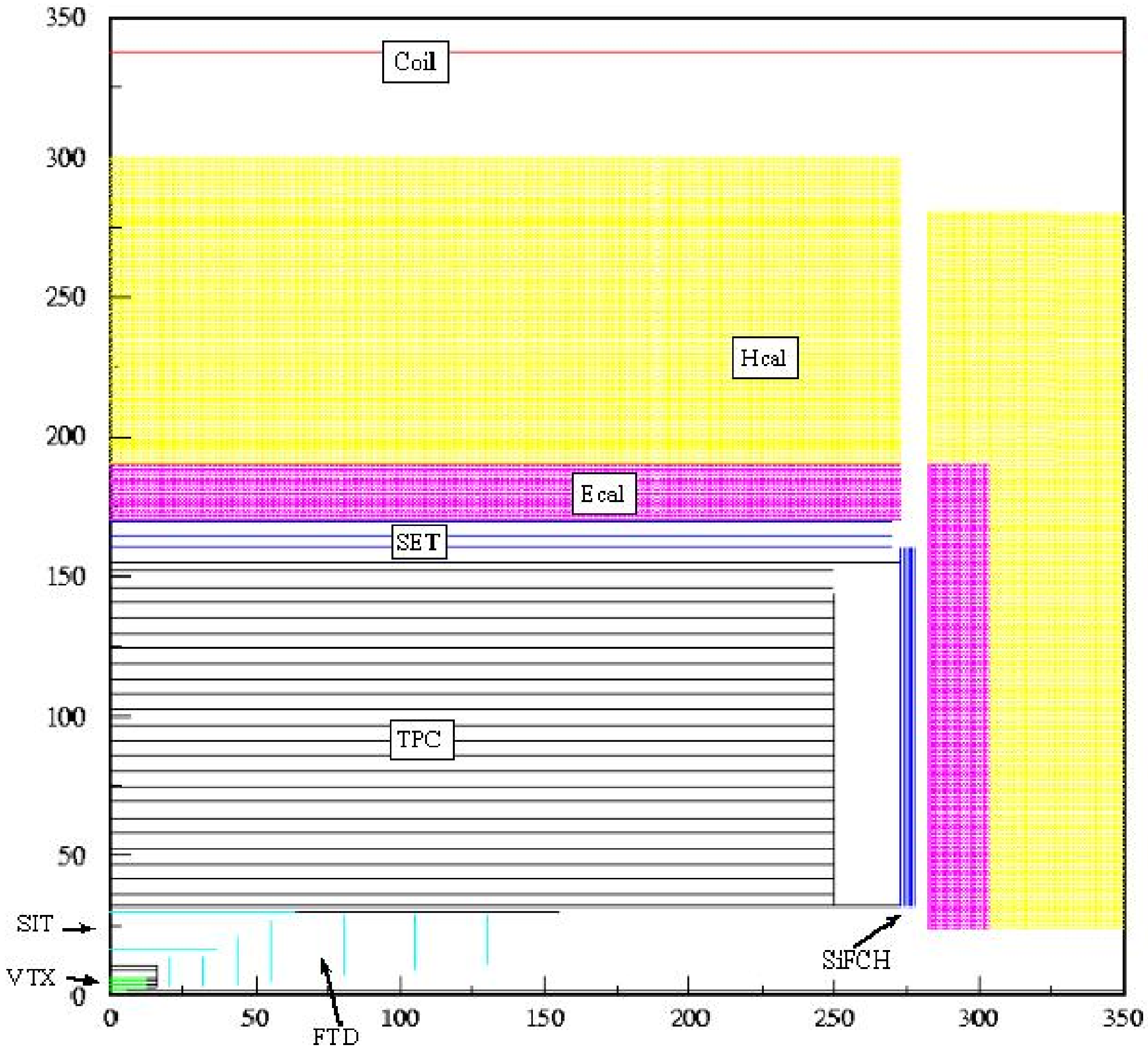
Other issues under study

- Alignment**S** ***(strips, sensors in elementary module, modules on support structure, support structures in overall detector)***
- Accurate positioning of elementary modules
- Mechanics: low material budget, easiness of construction (simple modular structure, transfer to industry), robustness, full coverage, low cost,
- Integration issues
- Electronics: lot of progress underway based on dsm techno with low noise, low power dissipation, compact, highly multiplexed, high perfomances.
- Simulation studies:

  Initial simulation studies on detector performances performed with SGV (fast but detailed enough MC)

  Now Silicon envelope and SiD geometries defined in GEANT4 DB and also in Brahms

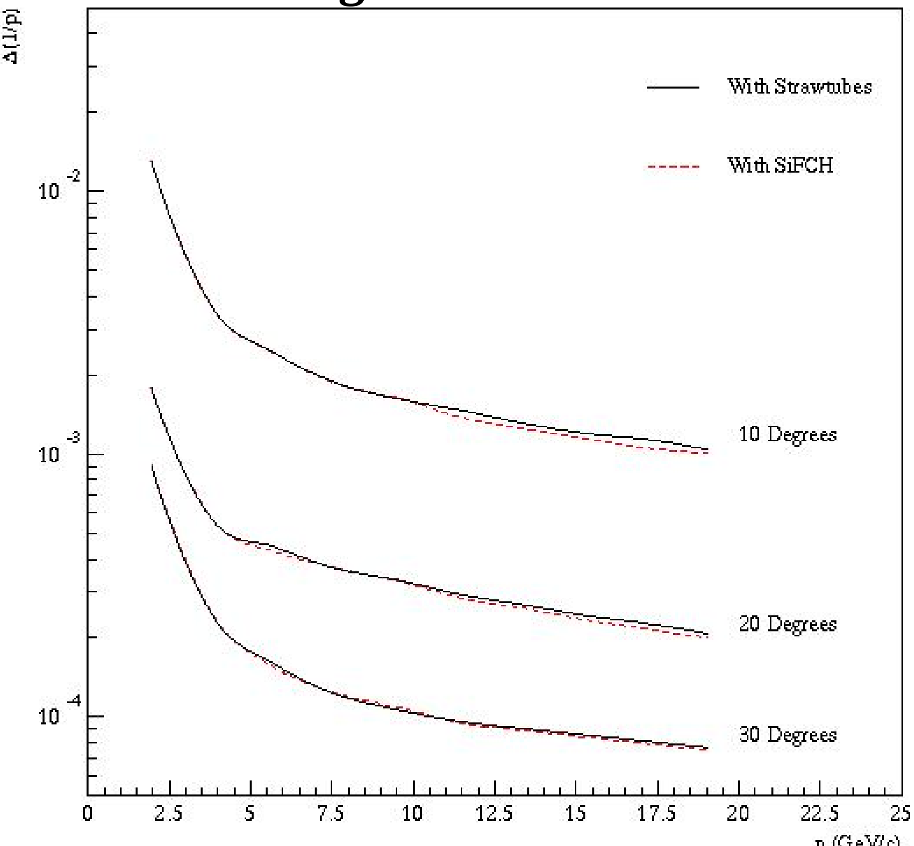
1) Simulation studies with SGV



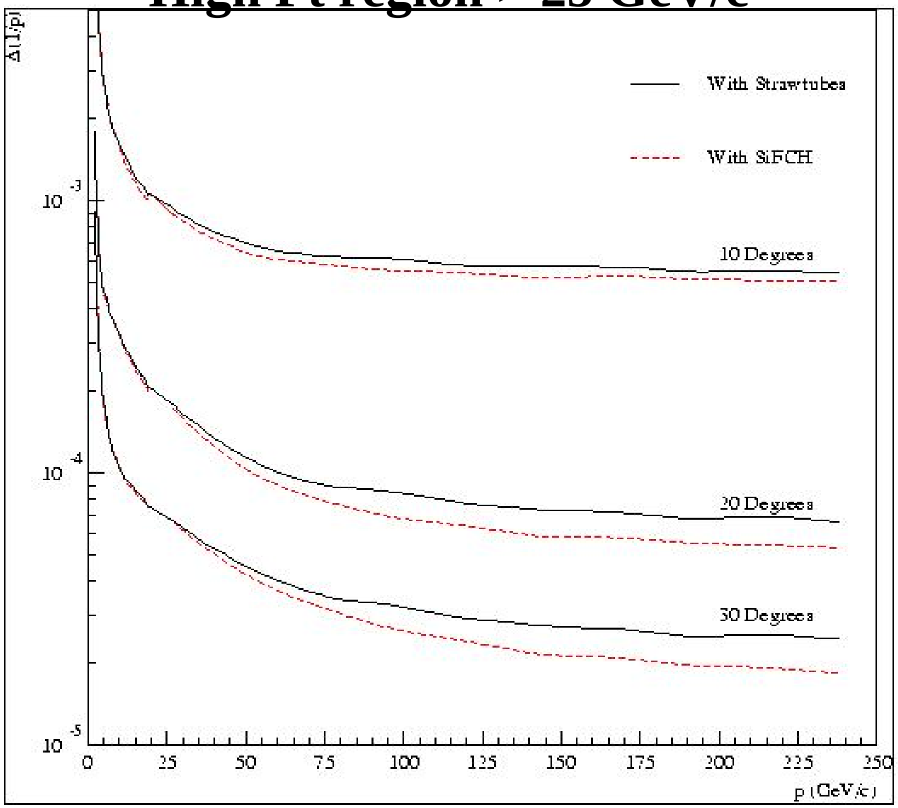
Although a fast simulation, SGV includes: multiple scattering, materials, spiraling of low momentum charged tracks etc…

Si-FCH performance studies with SGV

Low Pt region < 25 GeV/c



High Pt region > 25 GeV/c



4 XUV planes are considered in TESLA TDR

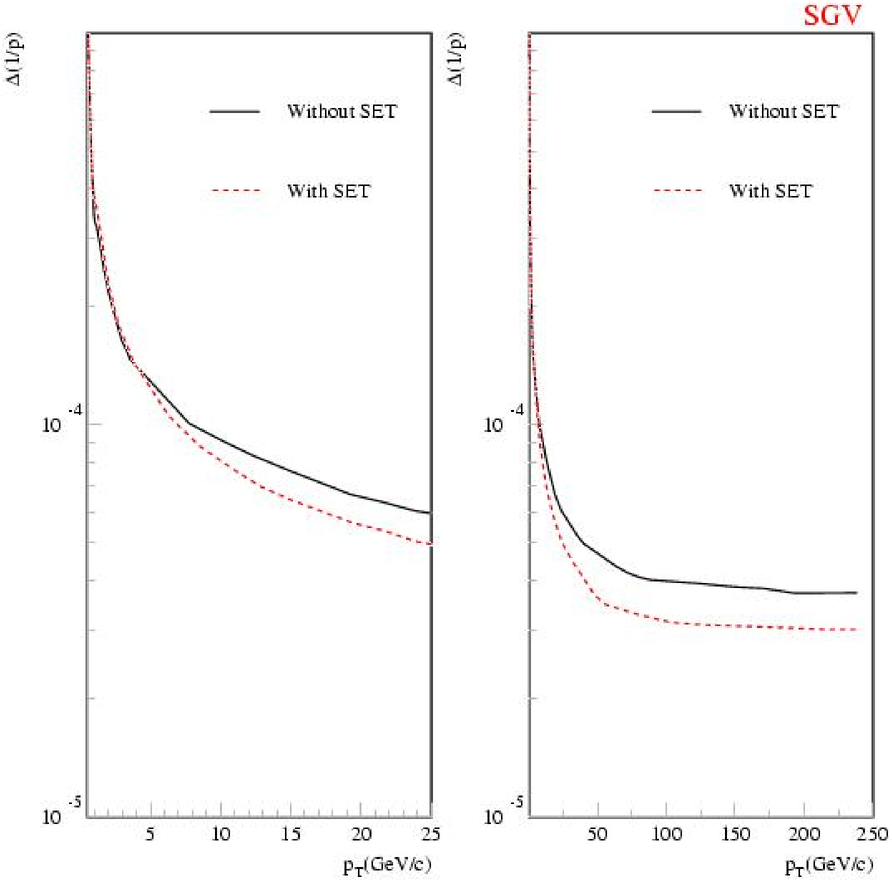
Momentum resolution if: TPC+straw tubes (100μm res./pt)

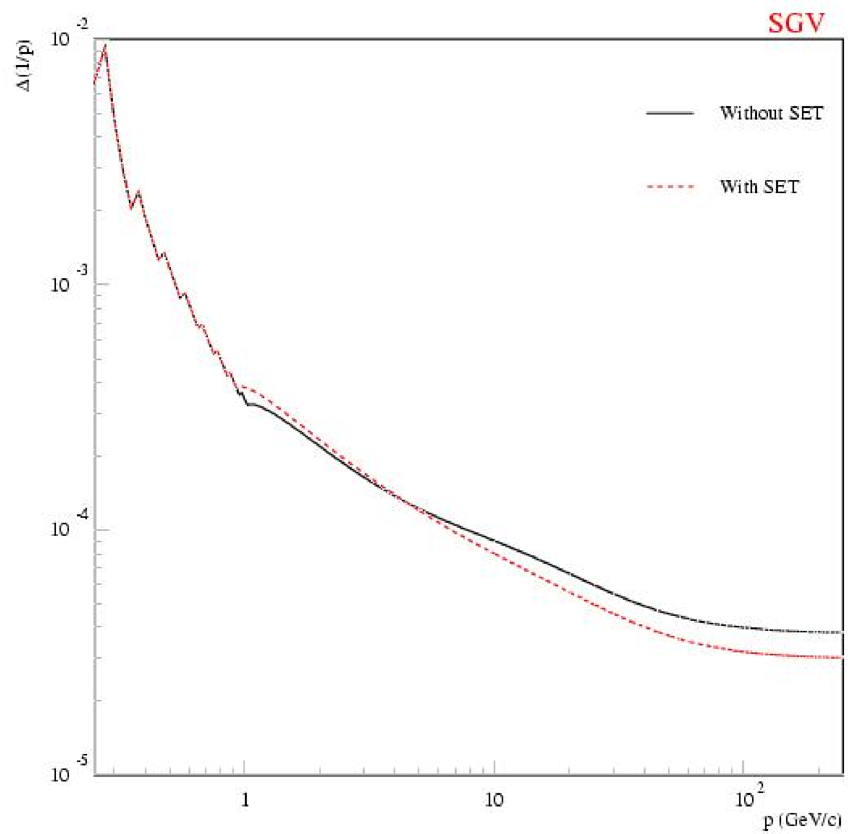
TPC+Si-FCH (25μm res./pt)

Si-FCH better than straw tubes for large impulsions and when angle/ beam increases

Special & detailed study to be done for the very low angle regions (<10 ° or so)

All P range: up to 250 GeV/c



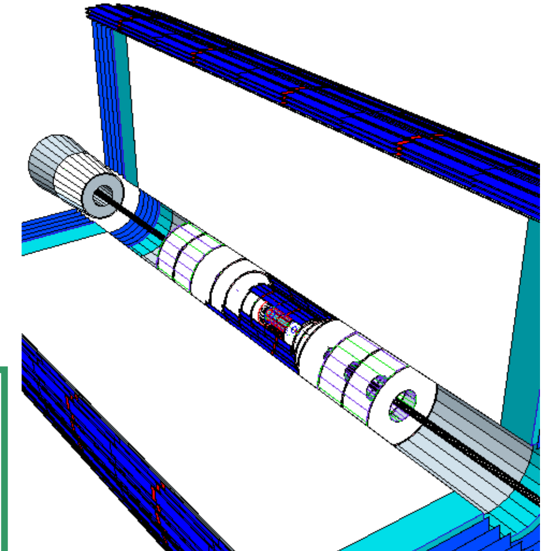


Assuming: **TPC reduced to 155cm in radius & resolution/pt=100 μm, an improvement up to 15-20% is observed at high momentum and, at low momentum the 2 resolution curves cross at 4.5 and 1 GeV/c (tracks below 1 GeV/c do not reach the SET)**

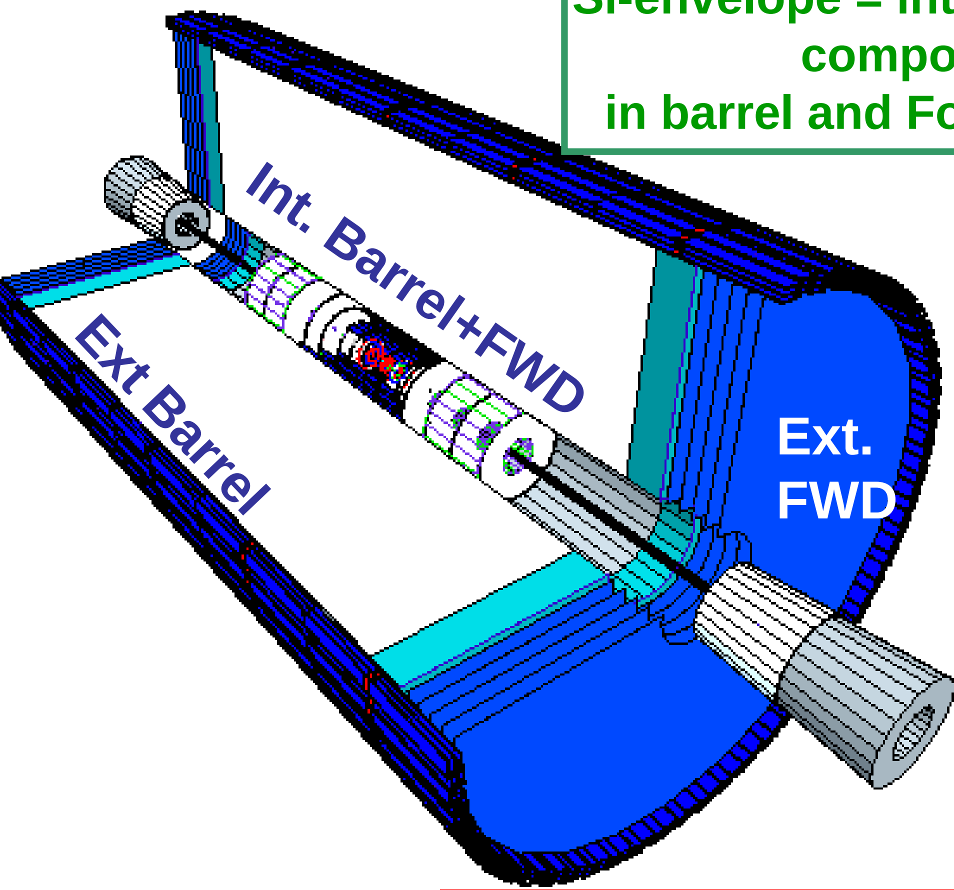
2) Geometry DB for Si tracking systems in G4

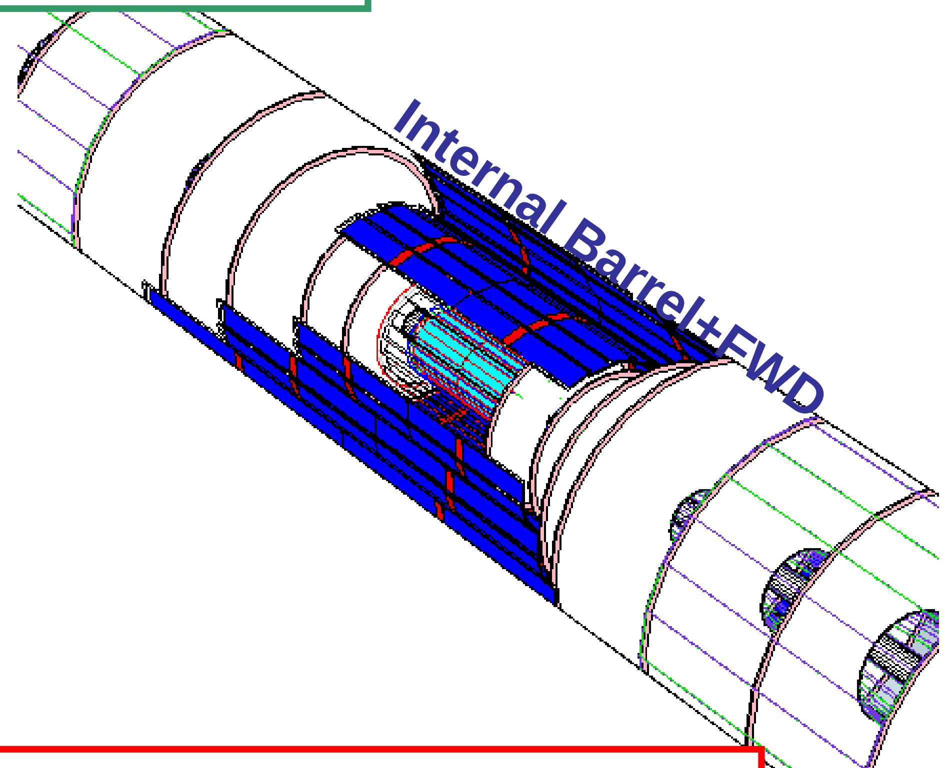
(V. Saveliev, DESY-Obninsk)

both fo the Si Envelope and SiD



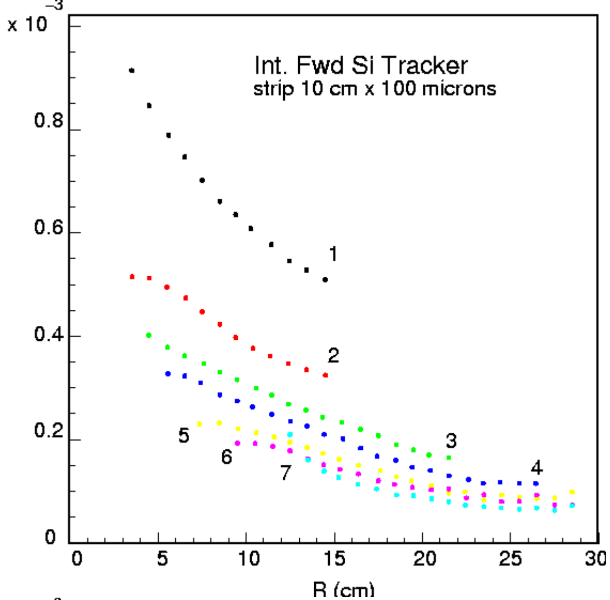
Si-envelope = internal & external components
in barrel and Forward regions

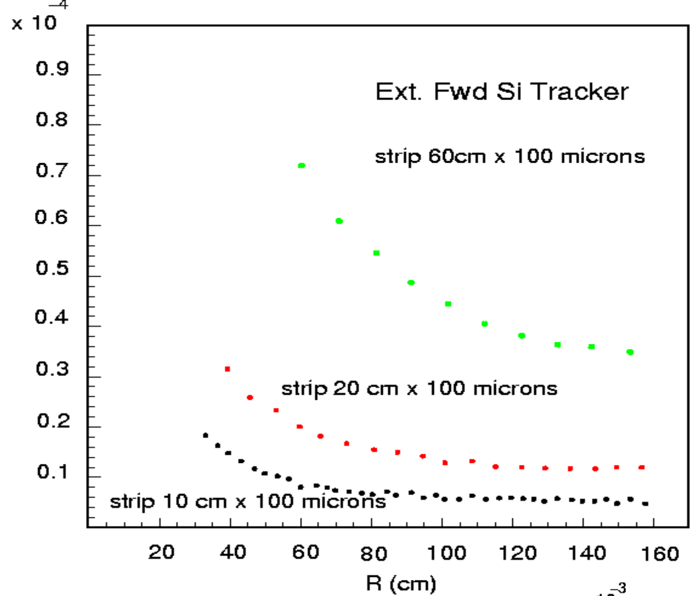




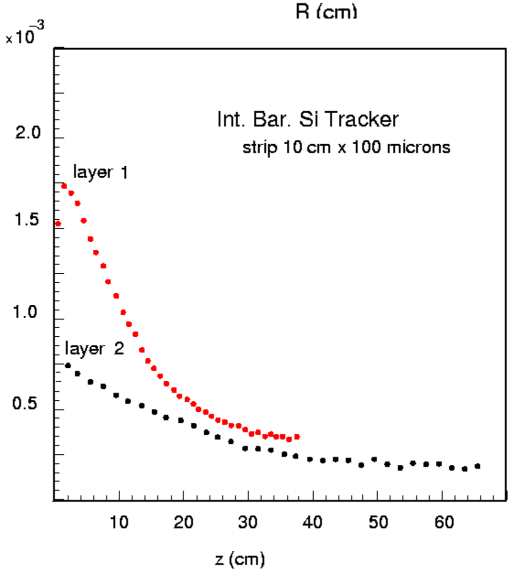
The DB definiton has been sent to the official DB:

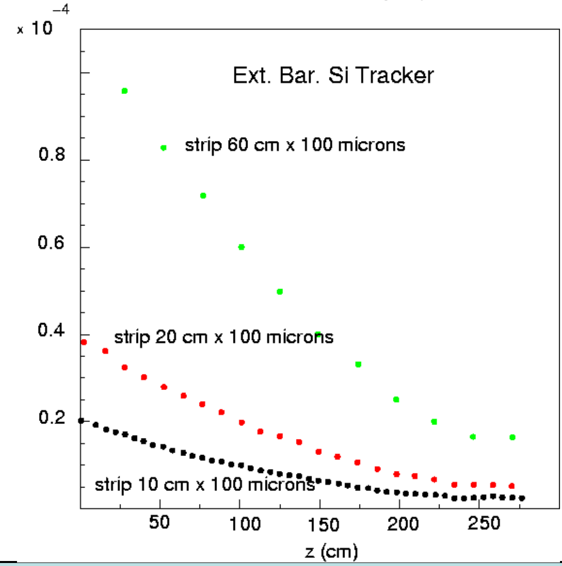
DETECTOR OCCUPANCIES

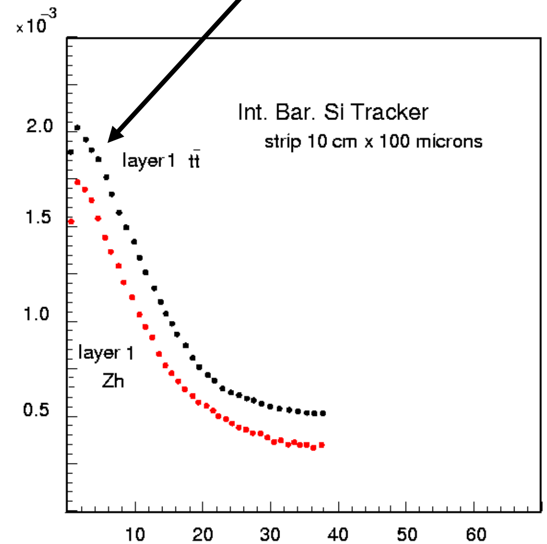




ttbar/ HZ gives ~20% higher occupancy





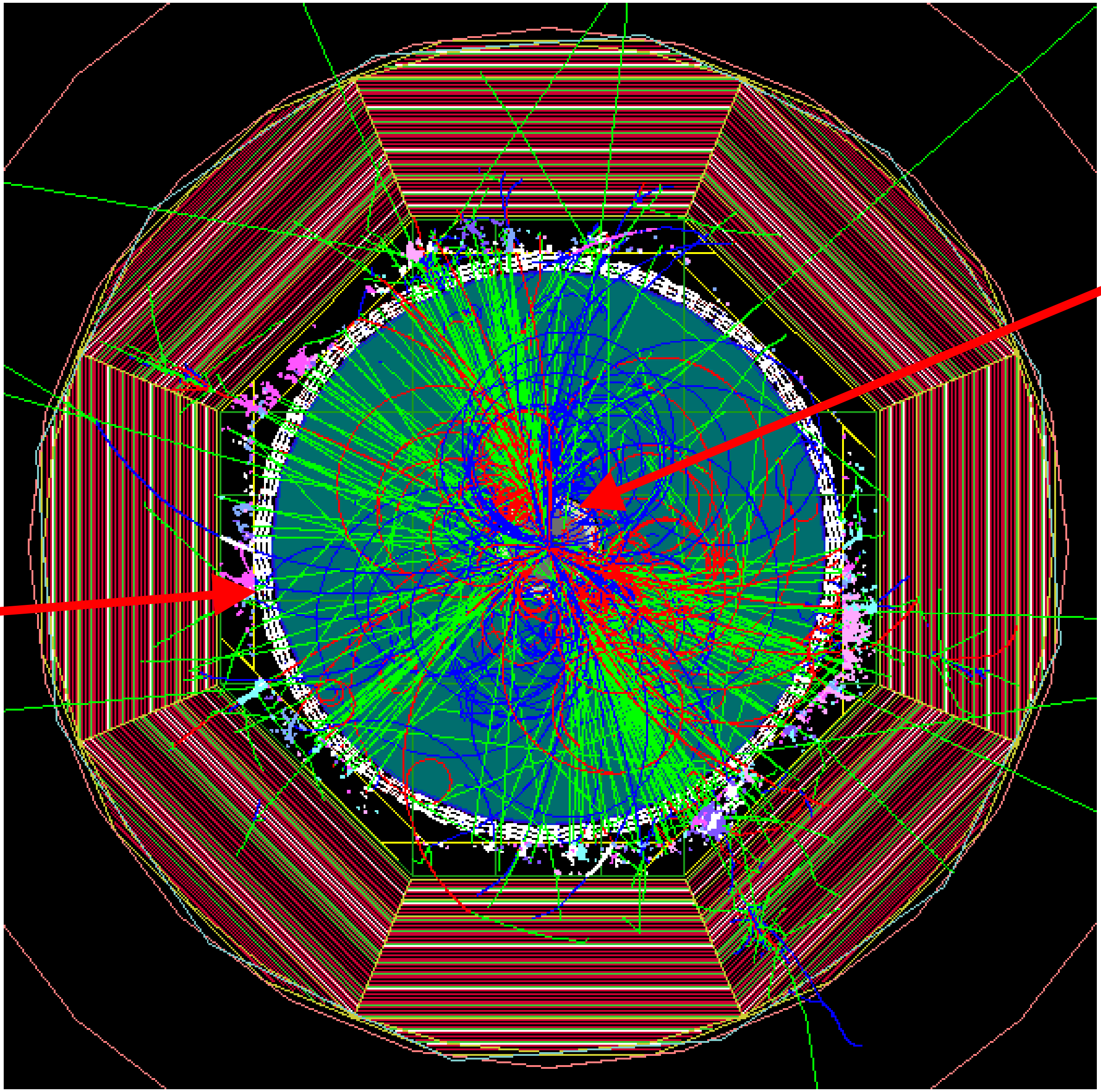


Occupancies are calculated with BRAHMS full simulation (Si-Envelope+TPC), Higgstrahlung HZ with bbbar and q qbar at Ecm=500 GeV
Values at most of order 1% to 2% for the hotest places in the detector!

Strips of length from 30cm to 60cm are appropriate.

LDC

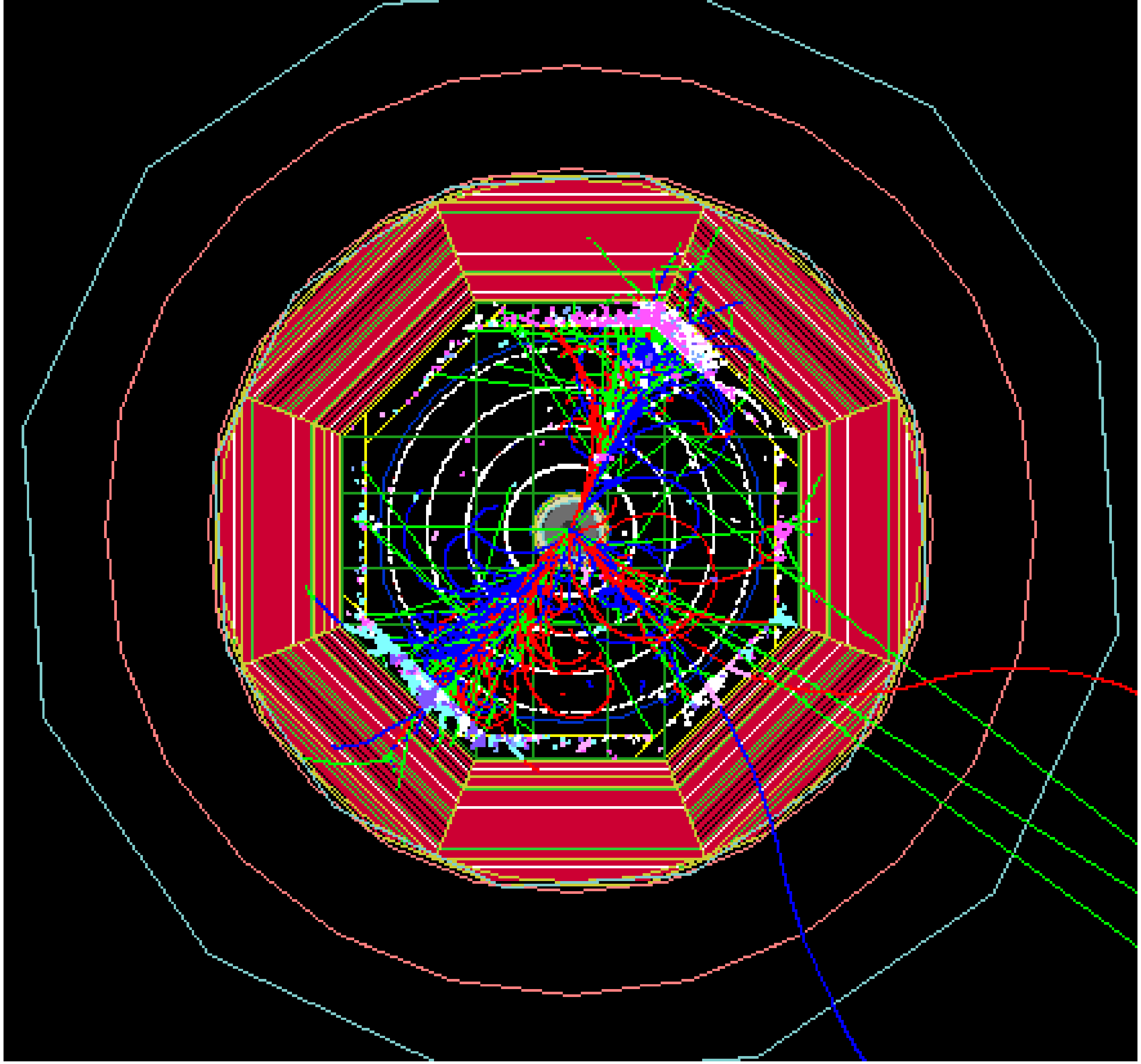
Silicon Internal barrel component



Silicon external barrel component

e+e- → H° → ttbar → 4q-jets + 2 b-jets, Ecm=750 GeV
Pythia +ISR+FSR+beamstrahlung+ full simulation (MOKKA: μvertex+SIT+TPC+SET +FTD+Si-FCH +em calo+hadron calo)

SiD



Geant4 simulation of Higgs event in SiD detector, using MOKKA framework including geometry DB for SiD concept

What we want to achieve (or at least where we intend to make significant progress on) during the Snowmass Workshop

- Study of the performances of the full tracking system (TPC + Si components) based on GEANT detailed MC simulations and various hypotheses (including reducing TPC volume or not, both in radius and/or length, more realistic estimate of material budget for Si components)
- Comparison between the two detector concepts especially in the Forward region (and possibly progress on XUV CAO design of Si FCH)

❖ Need of:

>>Informations from the various subdetectors

(μvertex, calorimeter, TPC) to properly address the related integration issues

>>Feedback from the 2 detector concepts

❖ Cooperation of all concerned parties is not only very welcome but strongly needed!