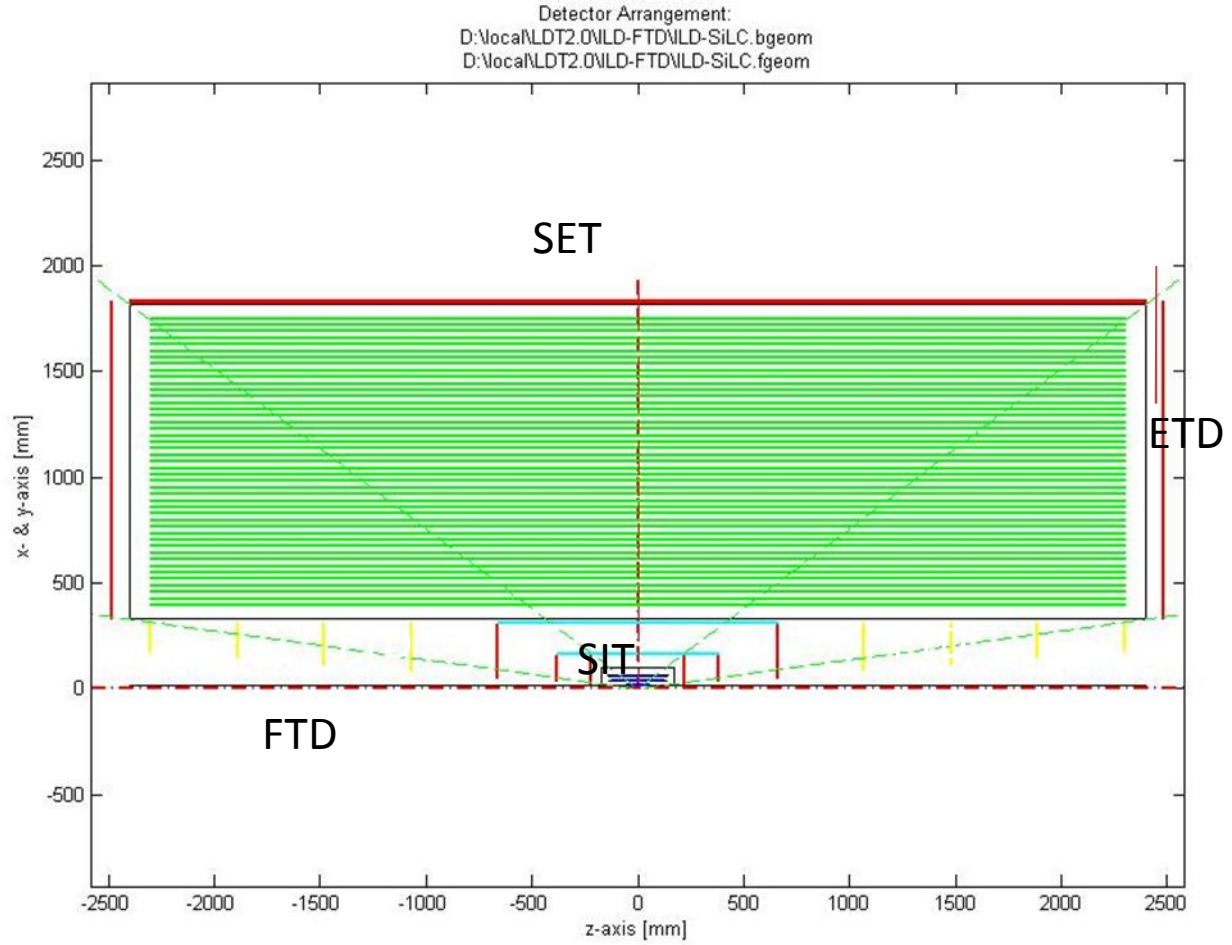
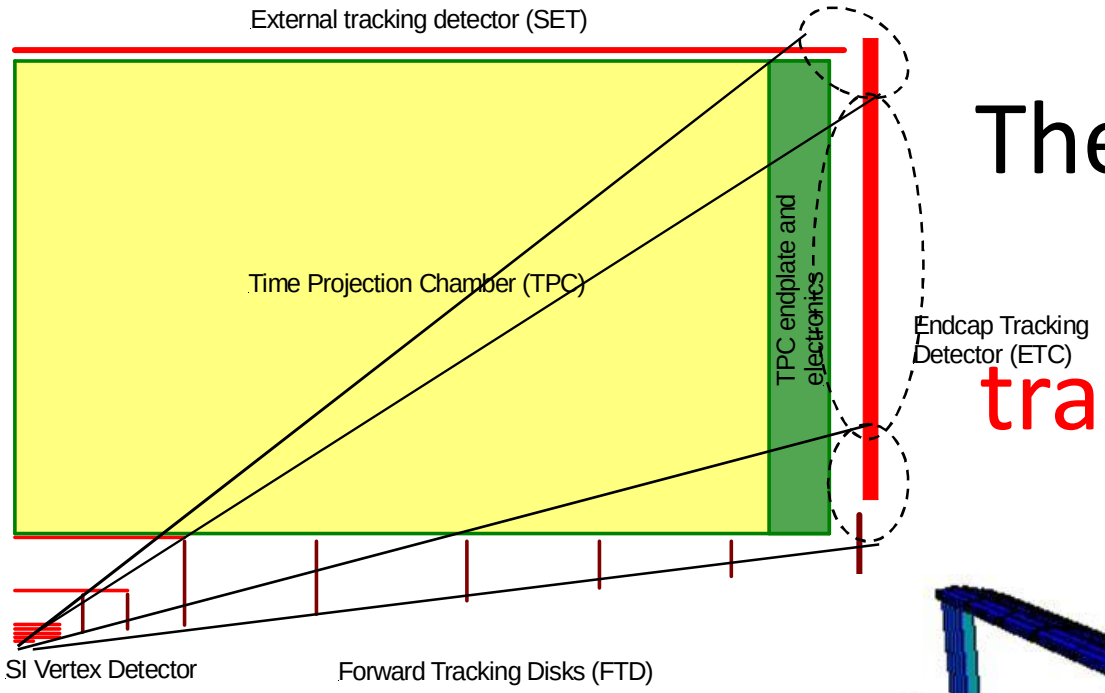
Silicon tracking system for ILD: integration

A. Savoy-Navarro, LPNHE/CNRS-IN2P3

The Silicon envelope (JE Augustin, M. Berggren, ASN)



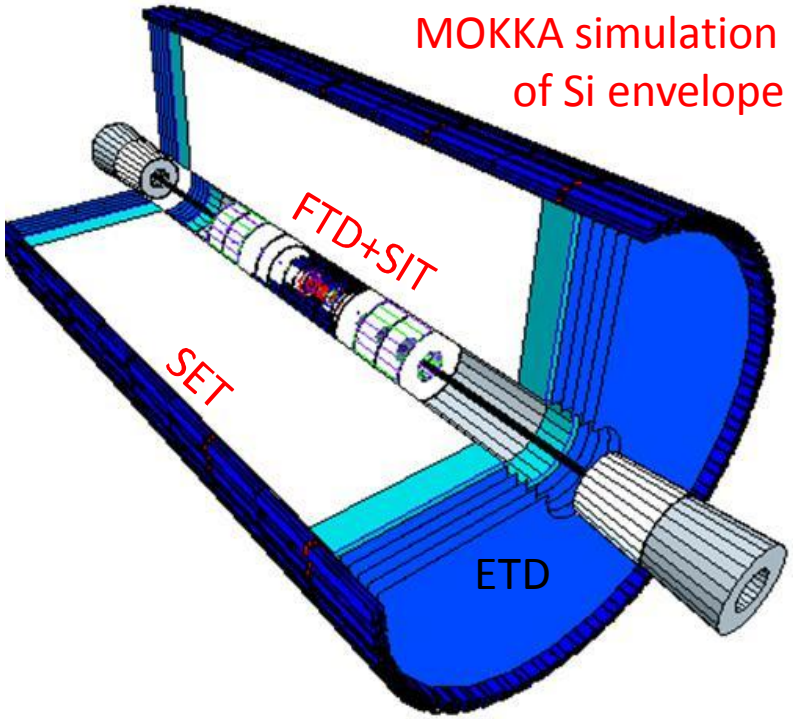
(by M. Valentan, LicToy)



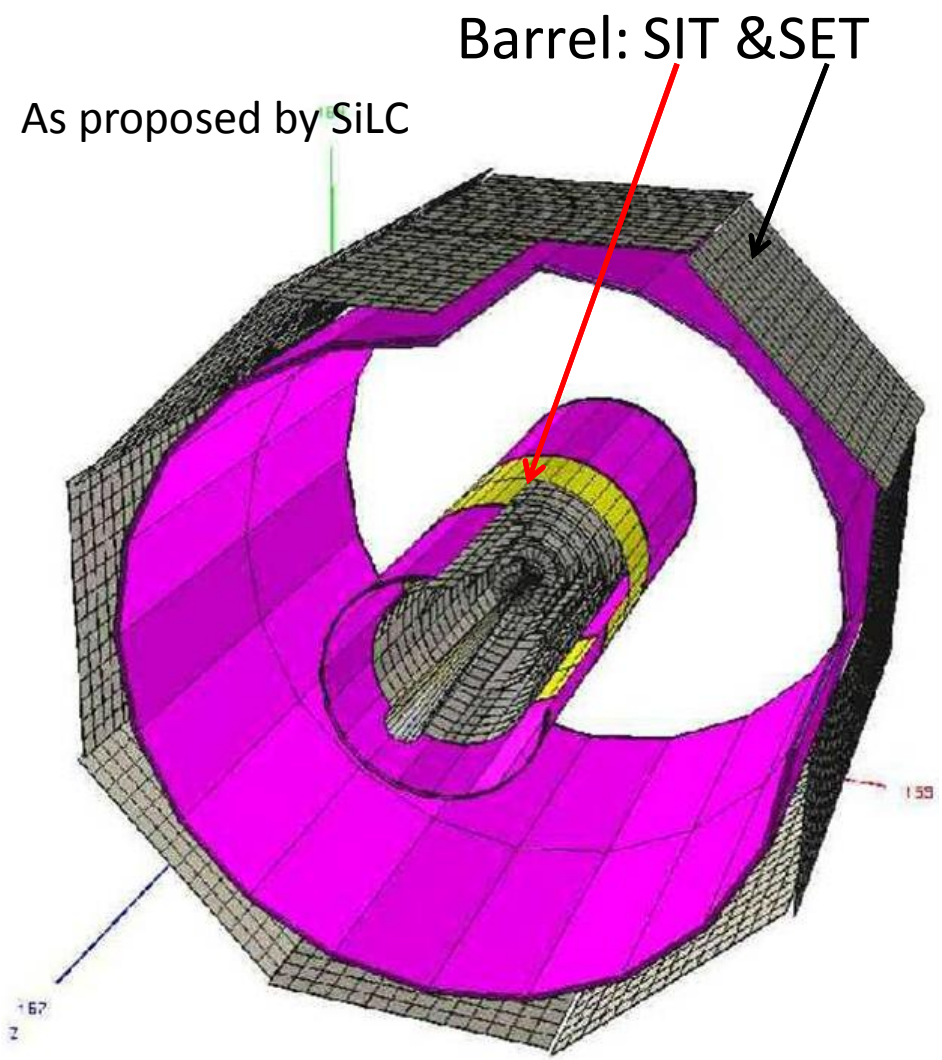
The silicon envelope or tracking hermeticity

The Full Silicon tracking system:
Barrel: SIT+SET (3 2D-layers total)
Forward: FTD+ETD
Is included in MOKKA framework by V. Saveliev

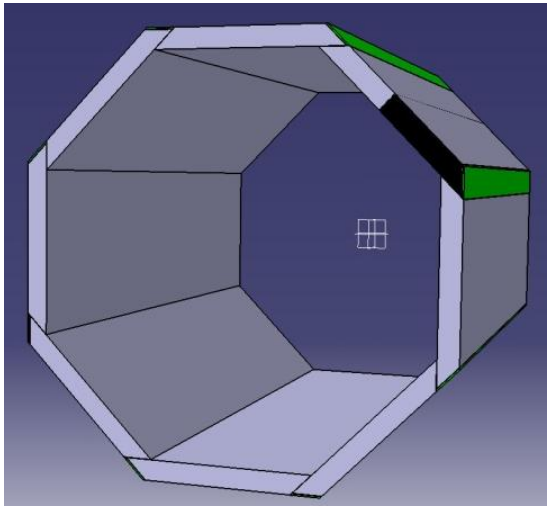
MOKKA simulation of Si envelope



ILD Silicon tracking: the barrel components

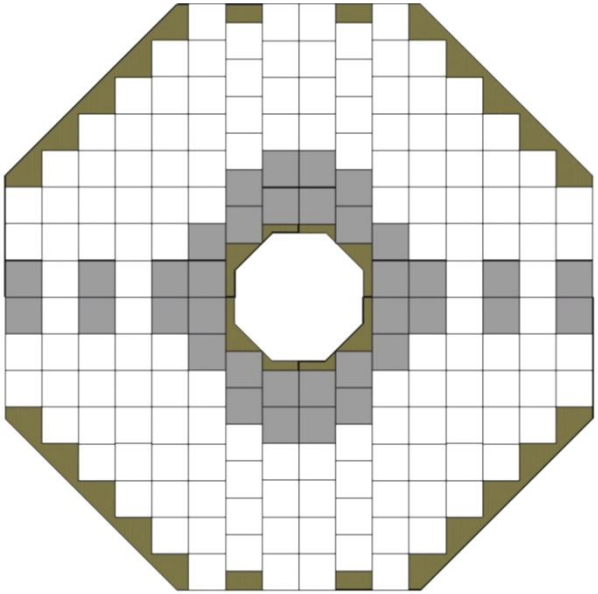


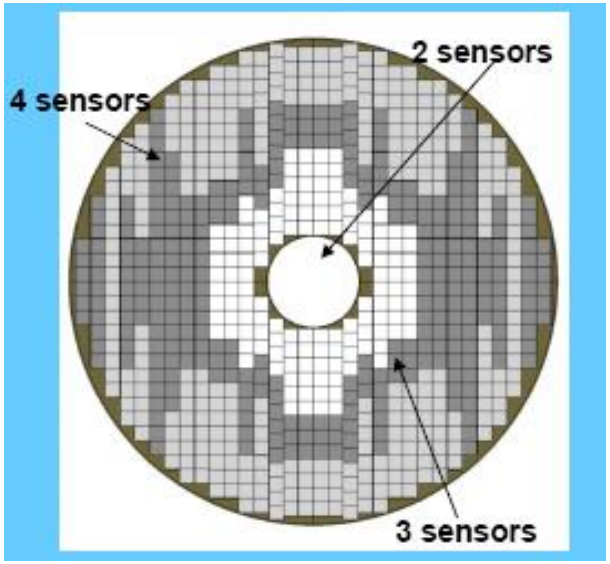
Simulation ILCRoot (A. Charpy)



Calorimeter shape

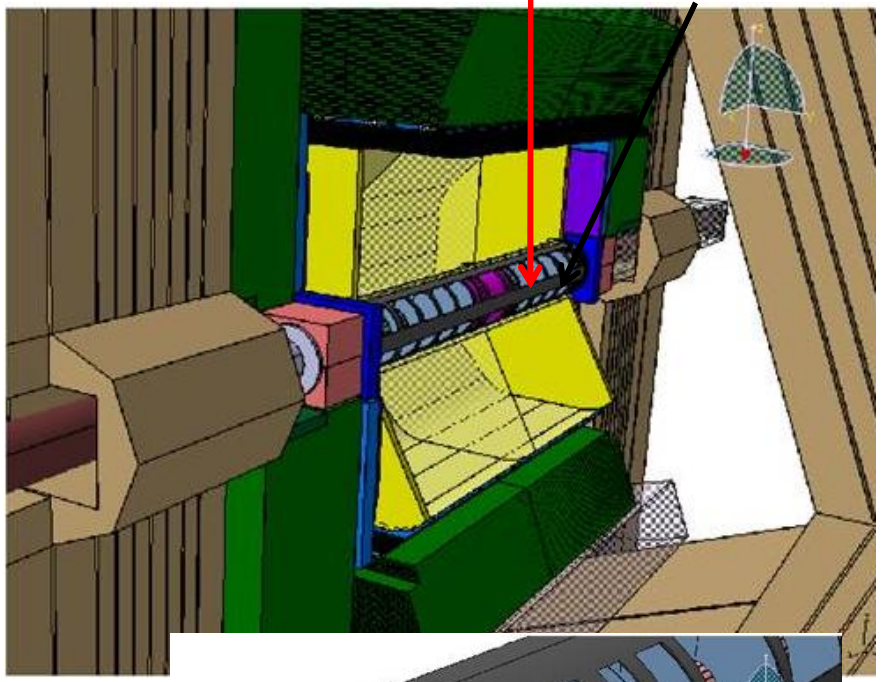
ILD Silicon tracking: the forward components

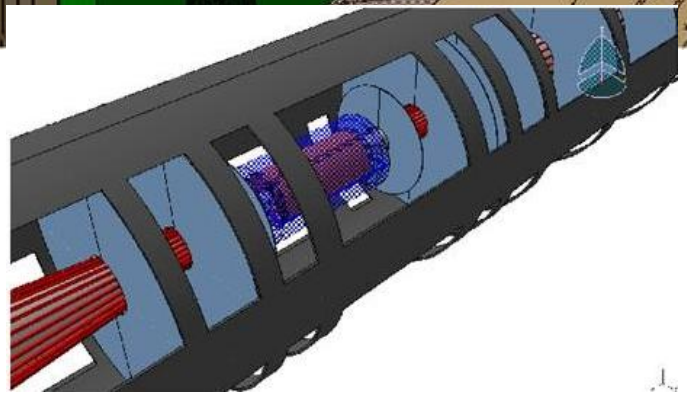




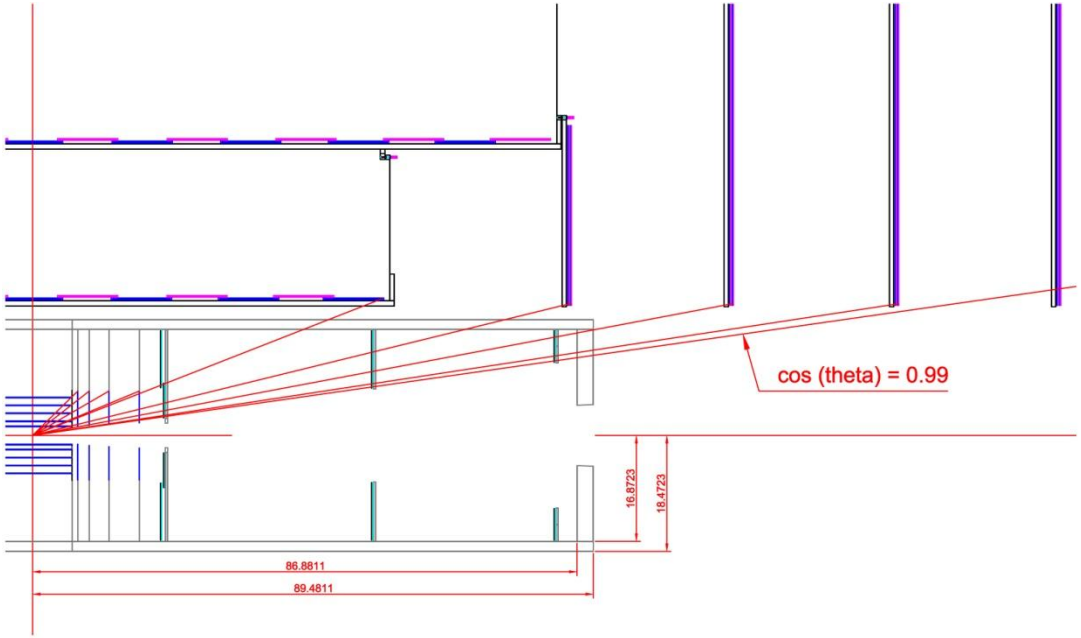
ETD: XUV design instead of projective (LPNHE)

Very preliminary mechanical design





Main integration challenge



All-Silicon tracking system:
fully integrated system =>
Much more easy to integrate.

Compared to an all Silicon tracking system (see SiD design for instance)
The ILD Silicon tracking system is much more challenging in terms of integration as it is an hybrid system: gaseous + Silicon and each component is in a LINK region between 2 (at least) sub-detectors.
Thus the SiLC collaboration which is working on this system has to address each case separatly this work is undergoing ad we are briefly summarizing here the present status.

Some important features:

- The FEE readout electronics prove to give:

  1mWatt per channel and is power cycled (factor: 70:1) => NO COOLING

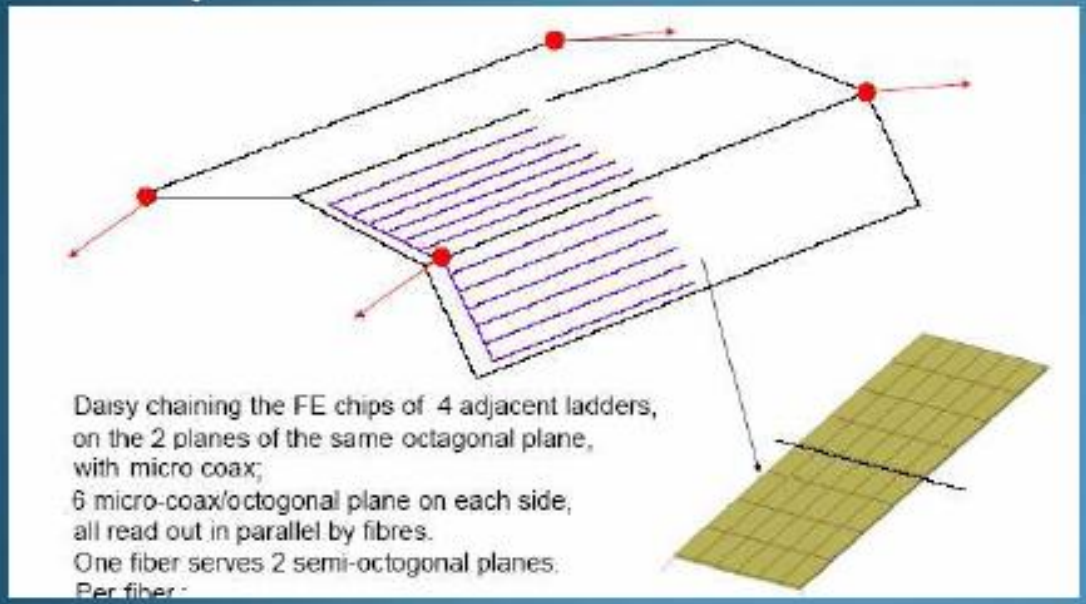
The strips sensors will be edgeless technology, thus a “flat structure”.

- The FEE readout will be on detector (bump bonding first then 3D vertical interconnect): high multiplexing in the FEE electronics architecture and NO FE-boards
- The processed data are daisy chained (microcoax) on the detector and the sent outside with digital fibers

  to the outside of the detector (CR)

Level 2: FE-on detector edges, interface detector with external world

Example



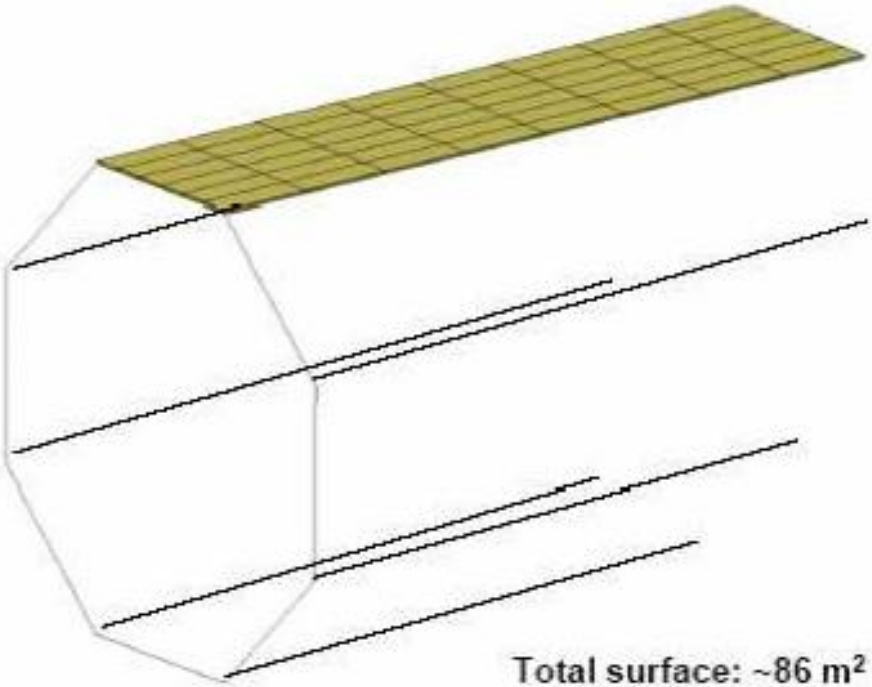
Daisy chaining the FE chips of 4 adjacent ladders,
on the 2 planes of the same octagonal plane,
with micro coax;
6 micro-coax/octogonal plane on each side,
all read out in parallel by fibres.
One fiber serves 2 semi-octogonal planes.
Per fiber :

Cabling:
Level 1 to Level 2: microcoax
Level 2 to Level 3: digital fibers

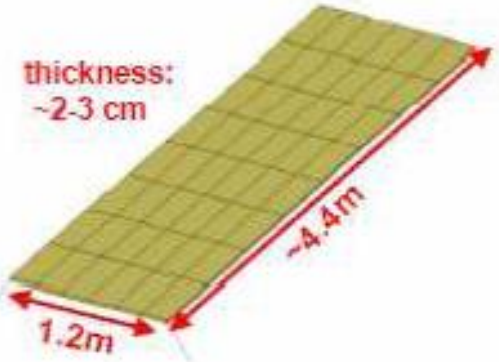
Number of issues related to cabling:
Follow industrial advances
High rates and high speed, reliability, fault tolerance, robustness
Common for all sub detectors

Each red points = buffer + pre-processing 2 (re-ordering & compressing data), transceiver (digital fiber to external world = Control Room)
Sends pre-digested data at CR and get slow control and distributes it on detector

Just an example



Total surface: ~86 m^2
Nb channels: 1,572864
Nb of fibres: 8 per side



# ladders/octagone	96
# sensors/octagone	288
# channels/octagone	196608
# µchips/octagone	192
# µcoax/octagone	192
# fibres/octagone	2
# µchips/fibre	96
# channels /fibre	98304

Outer Silicon tracking layer : false double sided sensors

The SET detector integratio

Preliminary Mechanical Structure of the SET Detector

- FEM studies of different lay-outs of SET mechanical structure;
- Production & Integration issues

- SET fixed on TPC

- Targets:
  - Good rigidity of the support structure;
  - Low X0 [%] for structural elements.

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Preliminary Mechanical Structure of the SET Detector

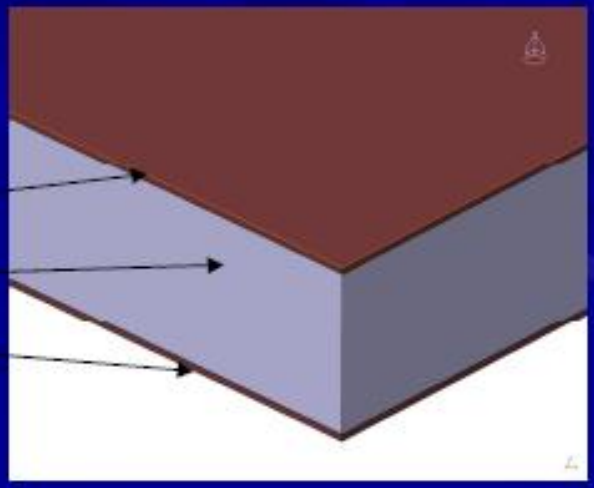
BASIC STRUCTURAL ELEMENT

- sandwich panel
  - 4 High Module UD Carbon-Epoxy 0,16 mm (0,64 mm) prepeg plies per side
  - 15 mm Rohacell 31 core (PMI) polymethacrylimide rigid foam;
  - approx. 2,5 kg/m^2

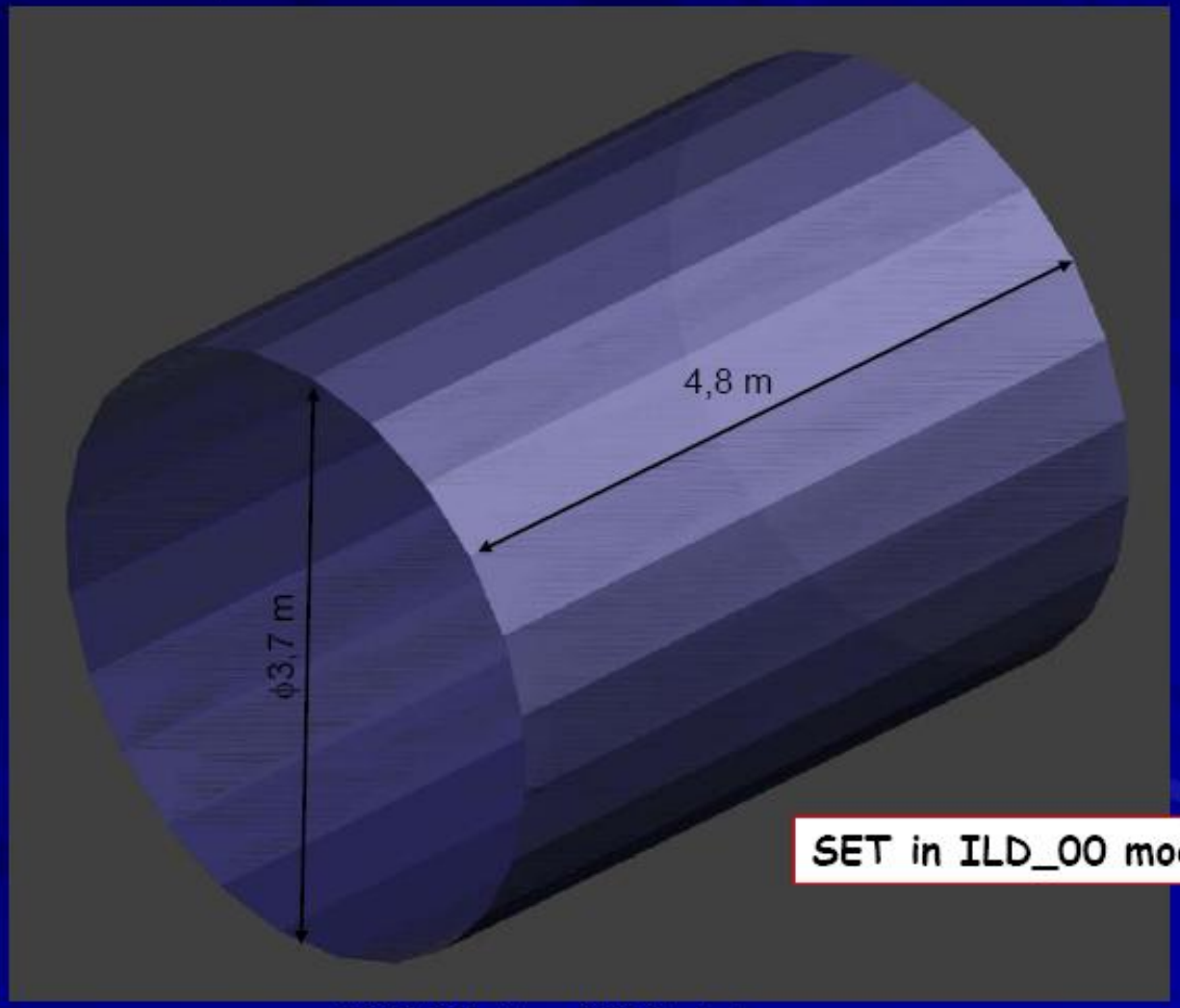
MATERIAL BUDGET

0,24 X0 [%] 4 UD *C* plies
O,135 X0 [%] 15 mm ROHACELL
0,24 X0 [%] 4 UD *C* plies

TOTAL 0,615 X0 [%]

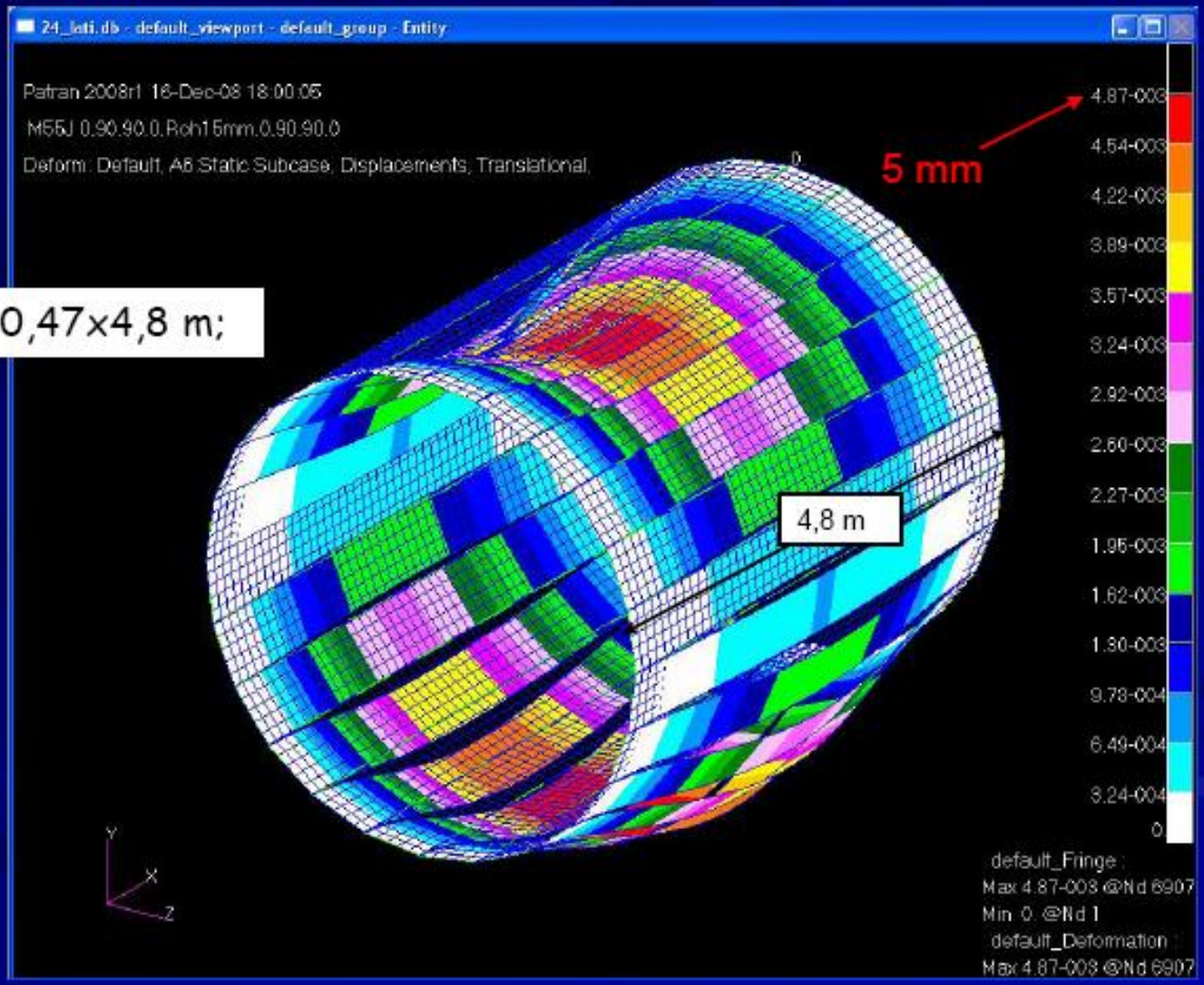


Preliminary Mechanical Structure of the SET Detector

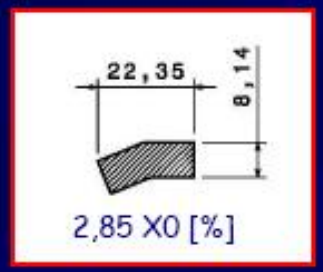


Preliminary Mechanical Structure of the SET Detector

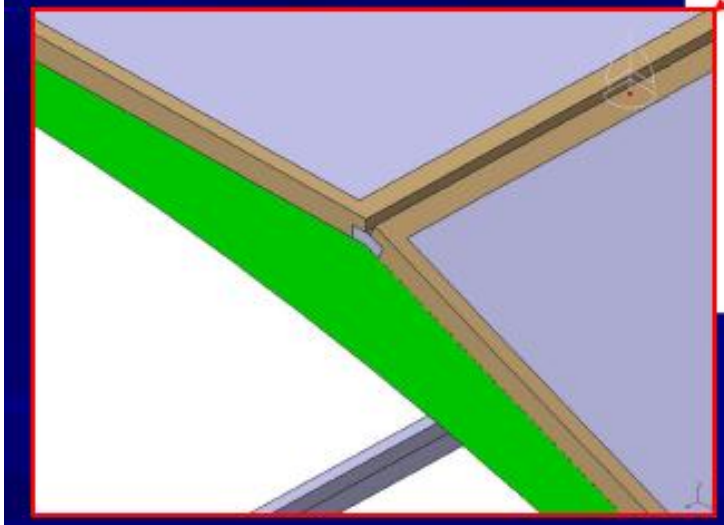
24 panels 0,47x4,8 m;

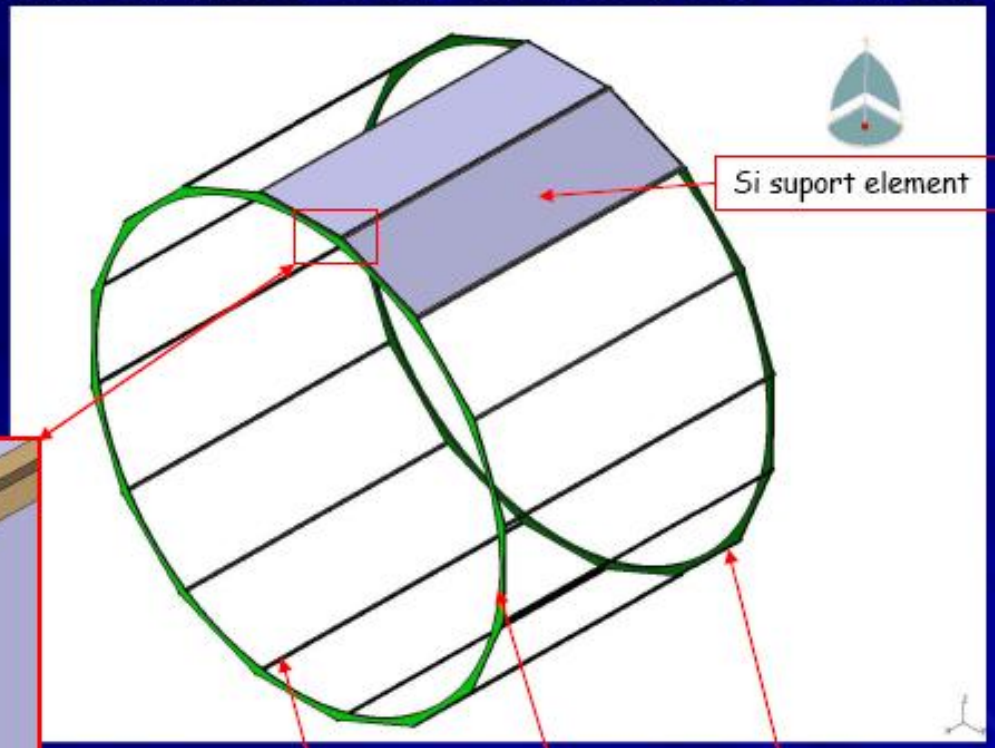


Preliminary Mechanical Structure of the SET Detector



2,85 X0 [%]





CFRE: Carbon Fiber Reinforced Epoxy

Preliminary Mechanical Structure of the SET Detector

Flat panel solution

- min deformation 0,4 mm;
- 2,4 meter-long sandwich panels;
- modularity: very good for production, Si positioning, assembly and maintenance;
- three fixation discs on TPC needed;
- more panels, better solution...

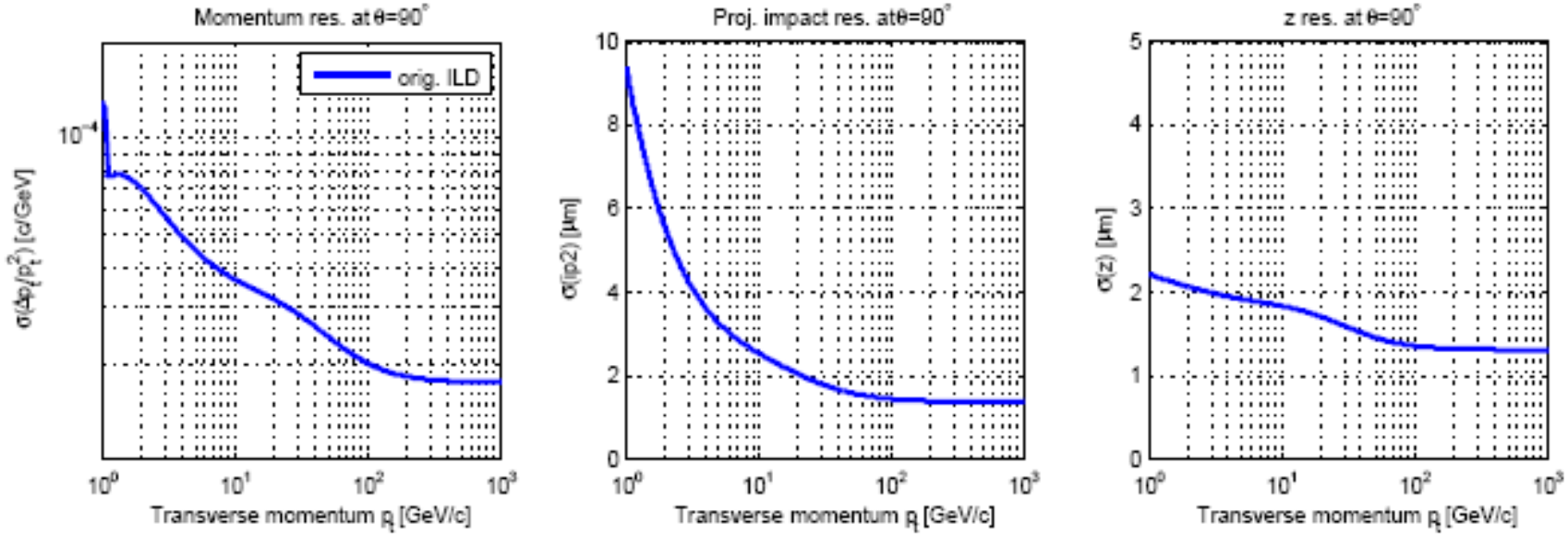
ILD's tracking performance (in the barrel region)

and the effect of the silicon enevelope

Tracking performance in the barrel region of the present ILD setup, in terms of

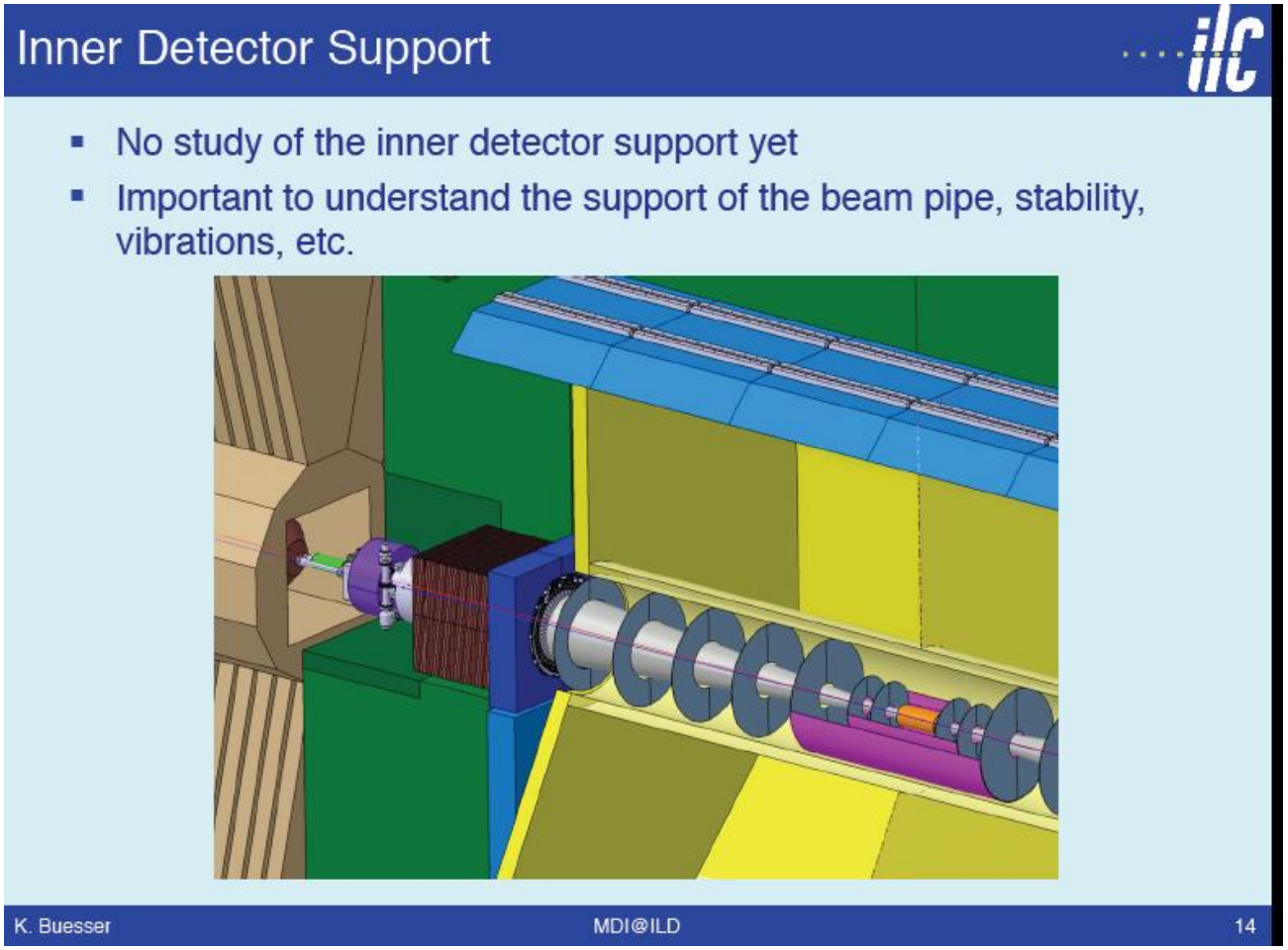
- Momentum resolution $\sigma\left(\frac{\Delta p_{\mathrm{T}}}{p_{\mathrm{T}}^2}\right)$
- Projected impact parameter resolution $\sigma(ip2)$
- z resolution $\sigma(z)$
- evaluated at the inner side of the beamtube
- with LiC Detector Toy 2.0

Tracking performance as function of p_T, at $\vartheta = 90°$



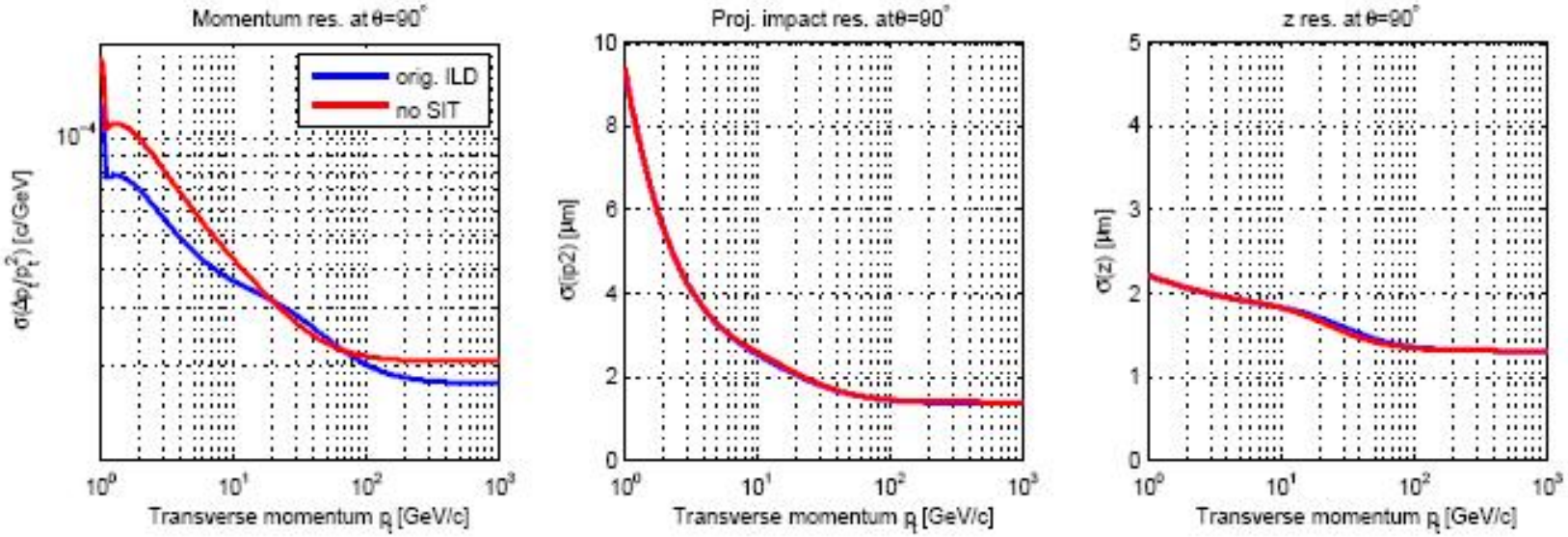
(Evaluation at the inner side of the beamtube)

The FTD integration case



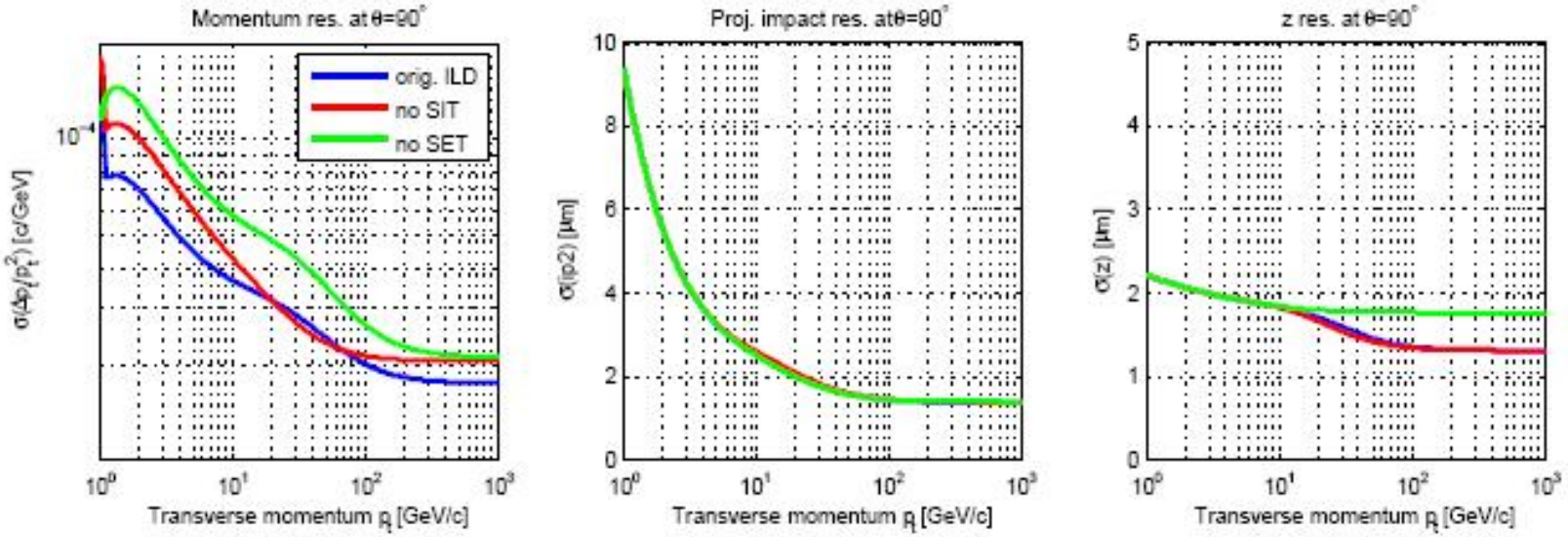
Preliminary idea: the FTD small disks 7x2 and the 2 DS SIT layers will be included in a single envelope made of rohacel l foam included into 2 foils of C-fiber

Tracking performance as function of p_T, at $\vartheta = 90^\circ$



(Evaluation at the inner side of the beamtube)

Tracking performance as function of p_T, at $\vartheta = 90^\circ$



(Evaluation at the inner side of the beamtube)

The SET provides a precise *z* measurement at large lever arm!

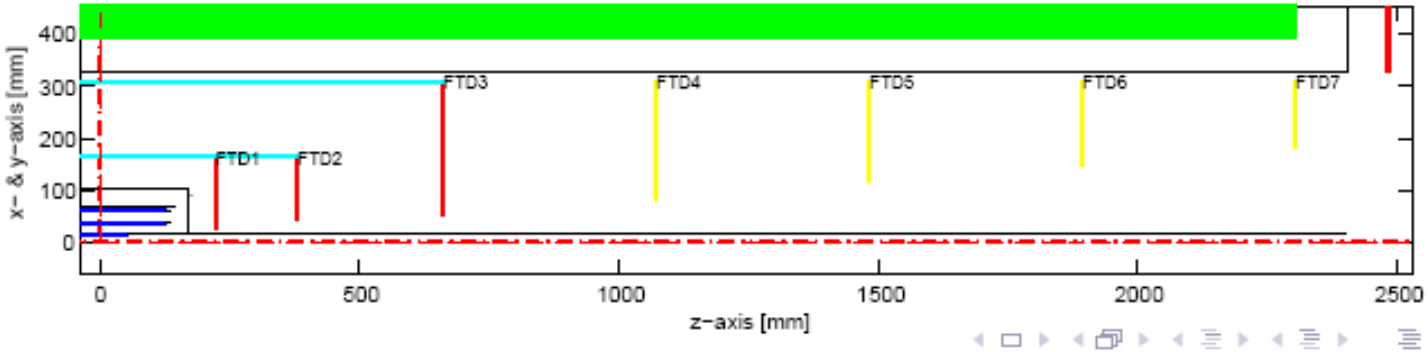
Optimization of ILD's forward tracker

Up to now:

- 3 pixel disks *FTD*1-*FTD*3 near the vertex detector
- 4 microstrip disks *FTD*4-*FTD*7 with equal resolution in R and $R\Phi$ (stereo angle $\alpha = 90°$)

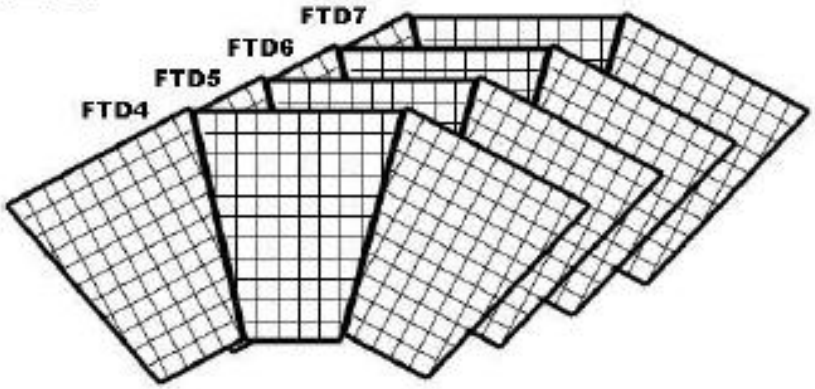
Optimized setup:

- Pixel disks untouched
- use sensors with stereo angle $\alpha = 6°$ (like in CMS)
  - *FTD*4, *FTD*5, *FTD*7: one radial strip direction, the other one inclined by 6° (measures $R\Phi$ very precisely)
  - *FTD*6: module rotated by 90°, measures *R* very precisely



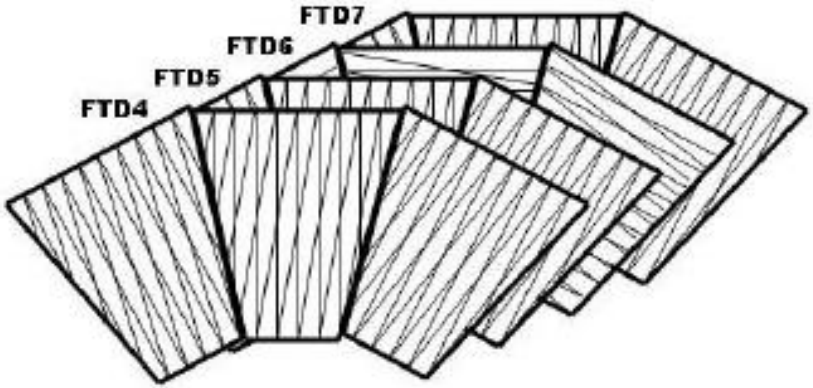
Optimization of ILD's forward tracker

ILD:



$\alpha_{4,5,6,7} = 90^\circ$ ("+ + + +")

Optimized setup:

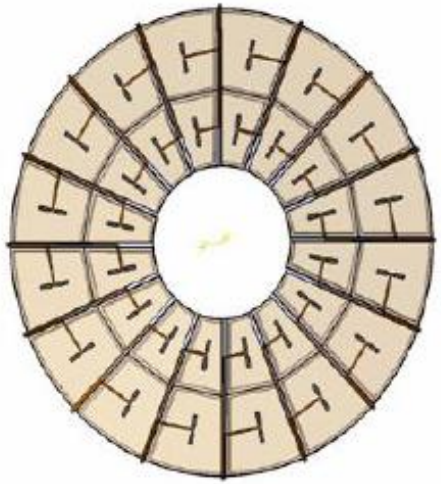


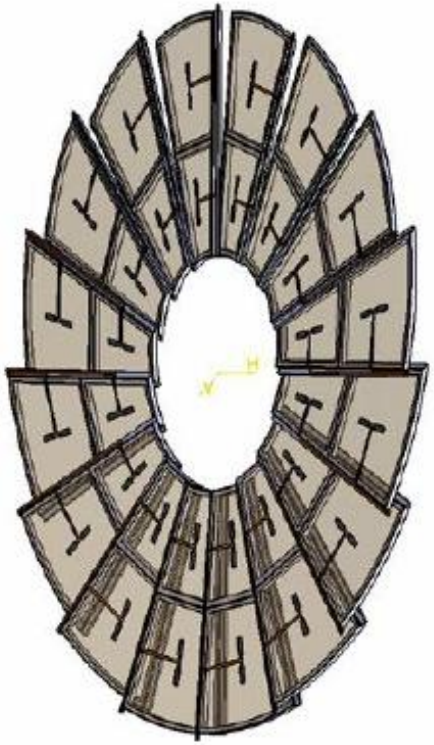
$\alpha_6 = 6^\circ$, rotated by 90°,
$\alpha_{4,5,7} = 6^\circ$ ("|| || = ||")

FTD disks

4th FTD DESIGN

- Applying the design to all the petals of the FTD
- In the right picture we can see the rotation of the petal respect to the bean pipe axis
- In the bottom picture we can see the 4th FTD perpendicular projection to the beam pipe.

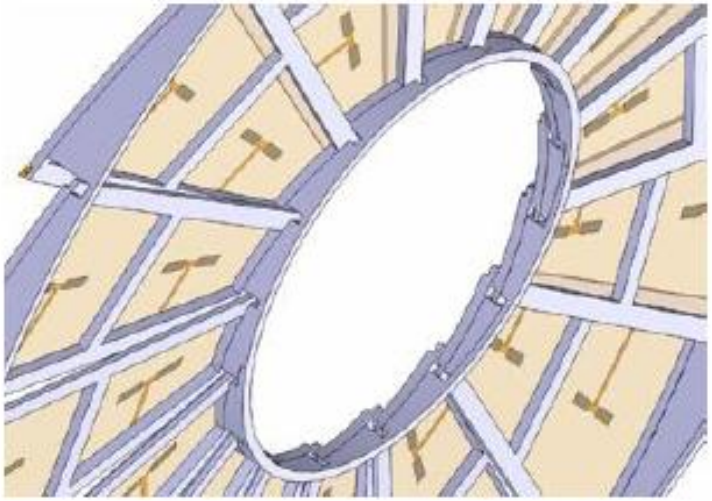




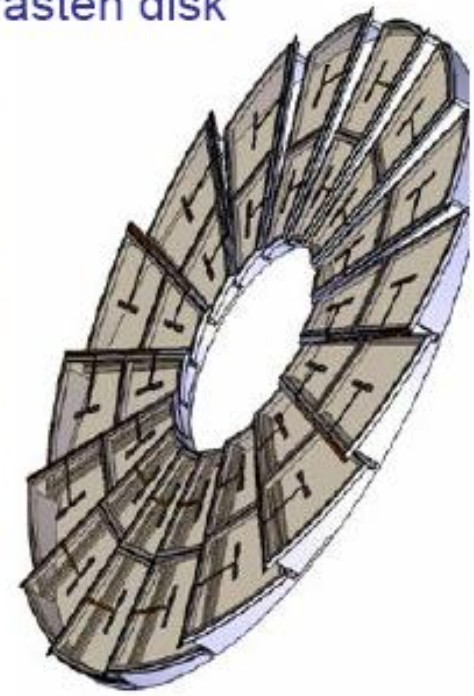
FTD 4 FASTEN DISK

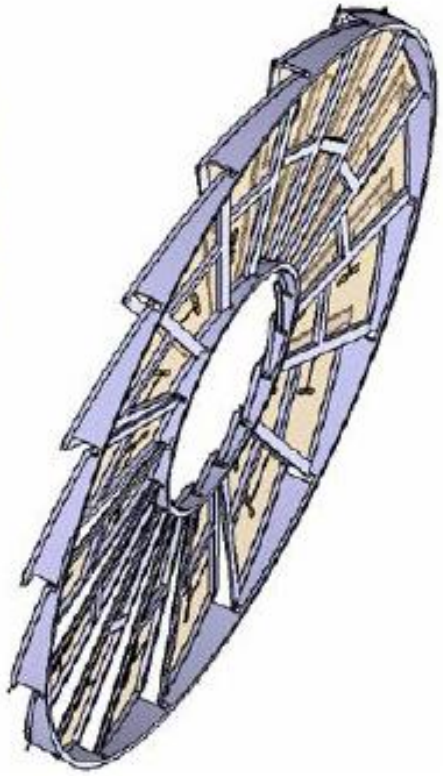
- Possible fasten of the petals using 2 disks

Inner fasten disk



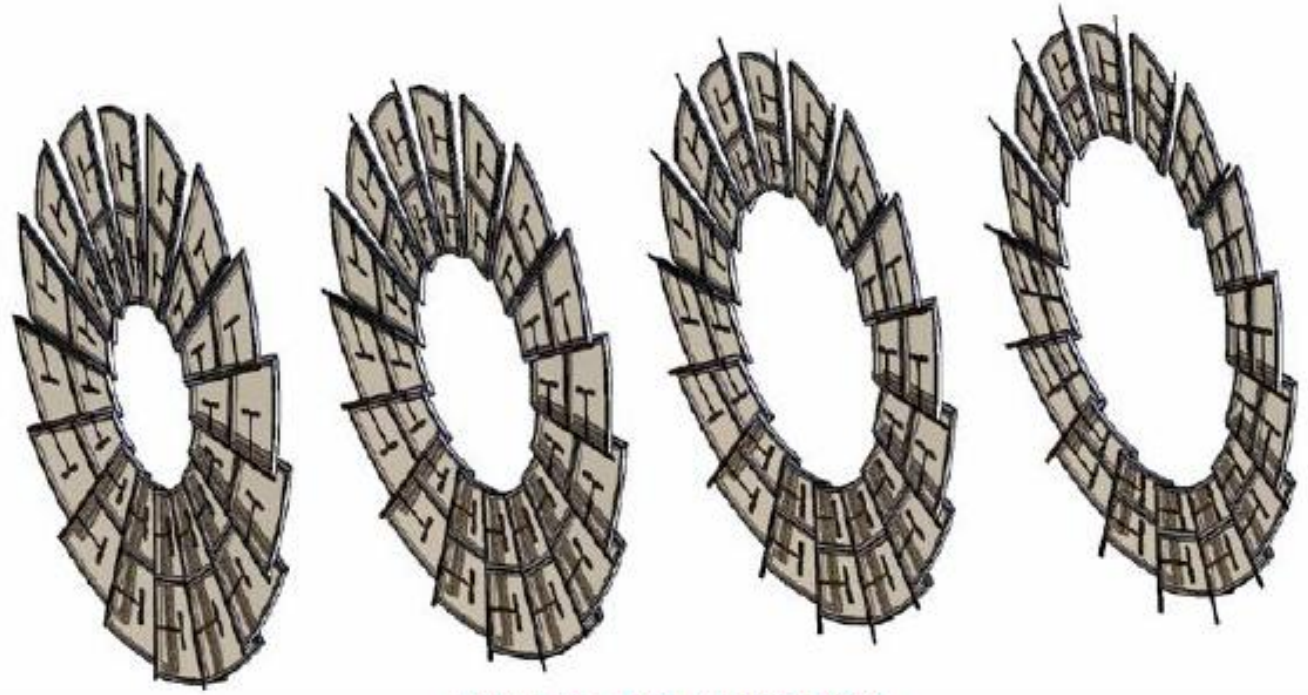
out fasten disk





DISK 5,6,and 7 DESING

- Once the FTD 4 geometry and design is defined, we apply this to the 5,6 and 7 forward tracking disk.



Alignment is going to be worked out
by the IFCA team especially (more soon)

Concluding remarks

- Works on integration of the Si components is udertaken by SiLC collaboration
- No show-stoppers
- But need to have collaborative effort with other subdetectors and MDI team to achieve a first reliable integration schema for all the components.