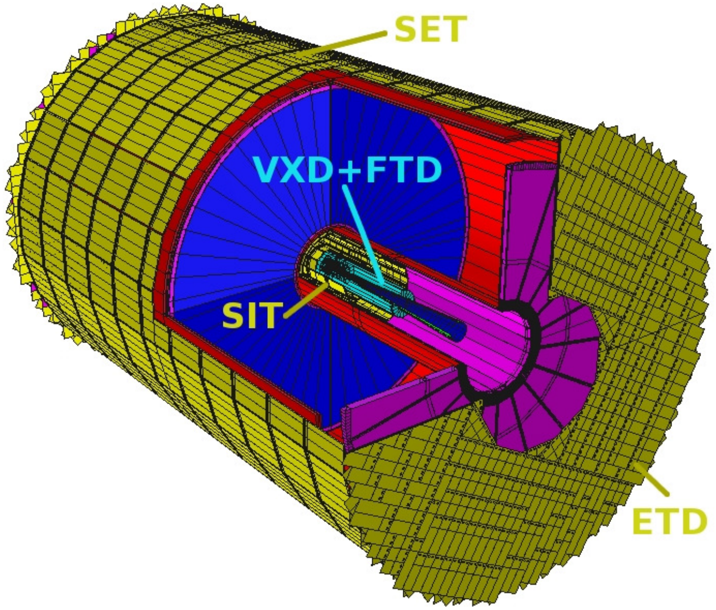
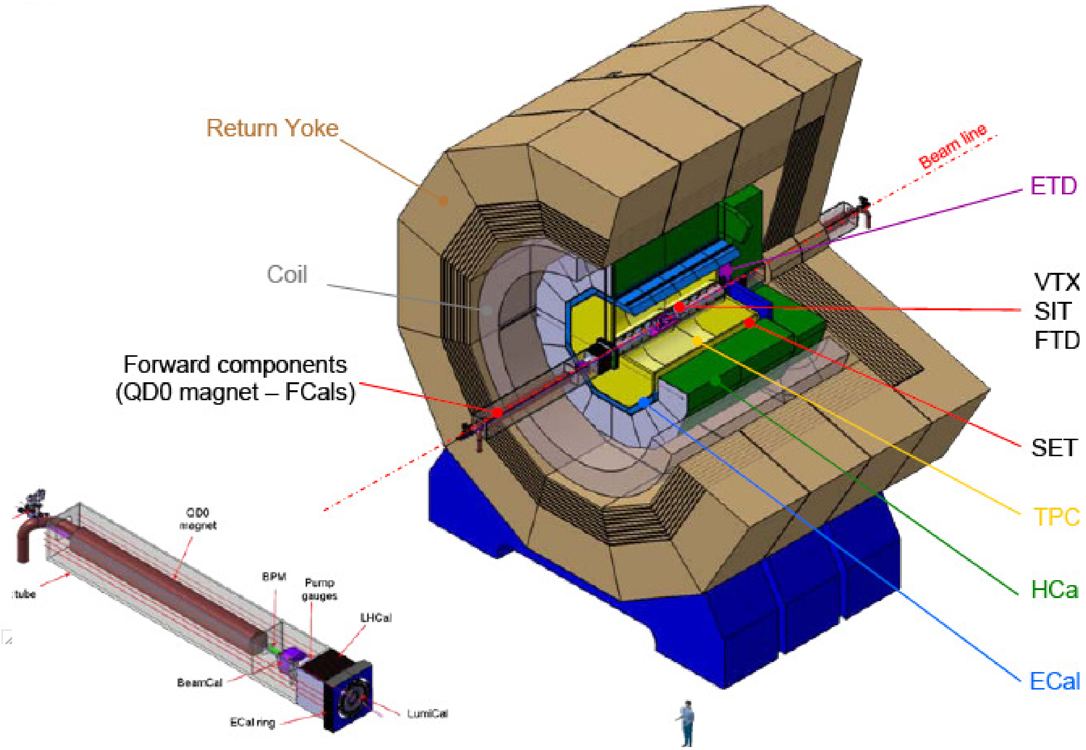
Integration SIT, SET and ETD



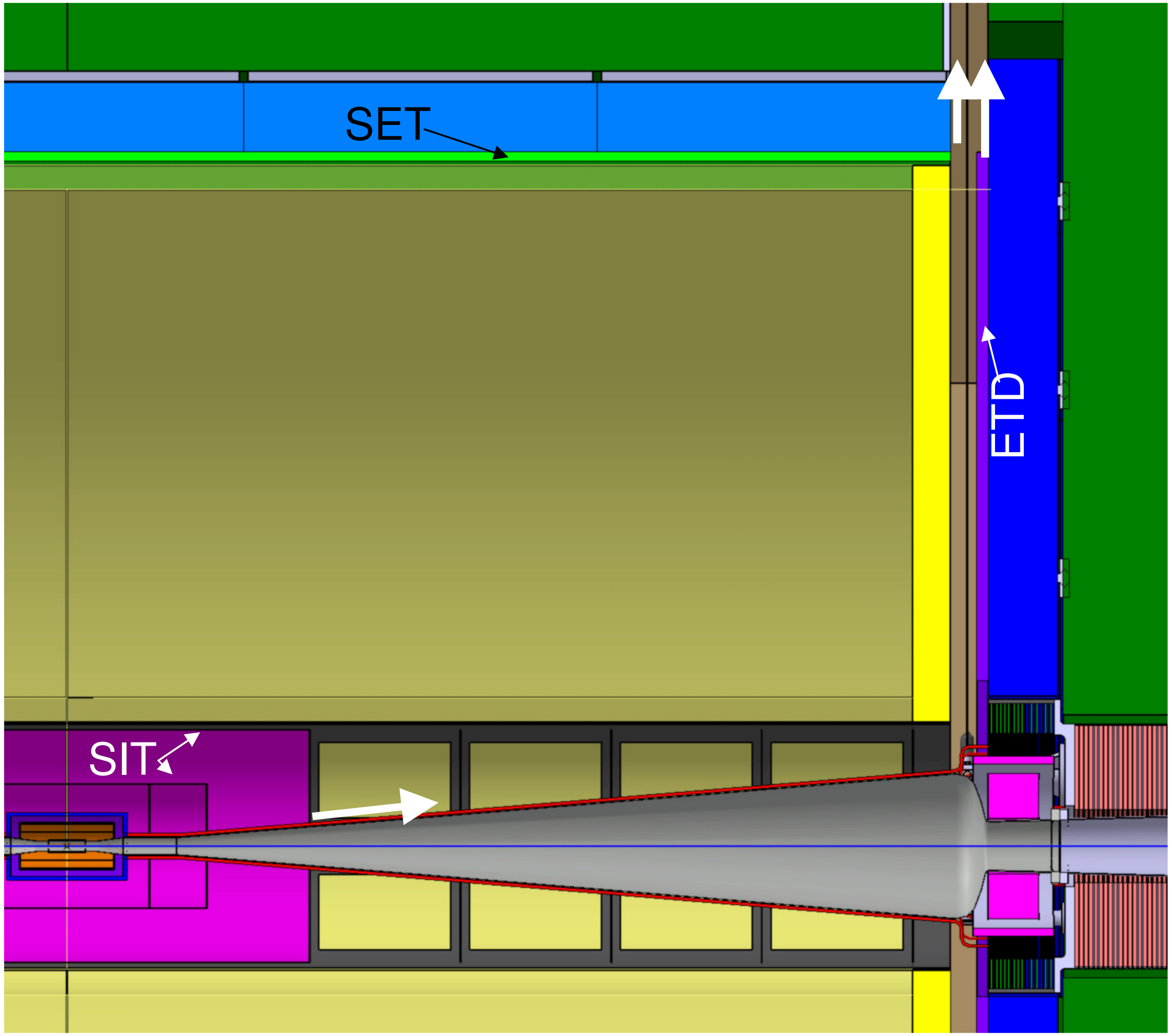


Aurore Savoy-Navarro, LPNHE, Universite Pierre et Marie Curie/CNRS-IN2P3

ILD SOFTWARE and INTEGRATION WORKSHOP,
July 6-8, 2010, DESY-Hamburg

Main features

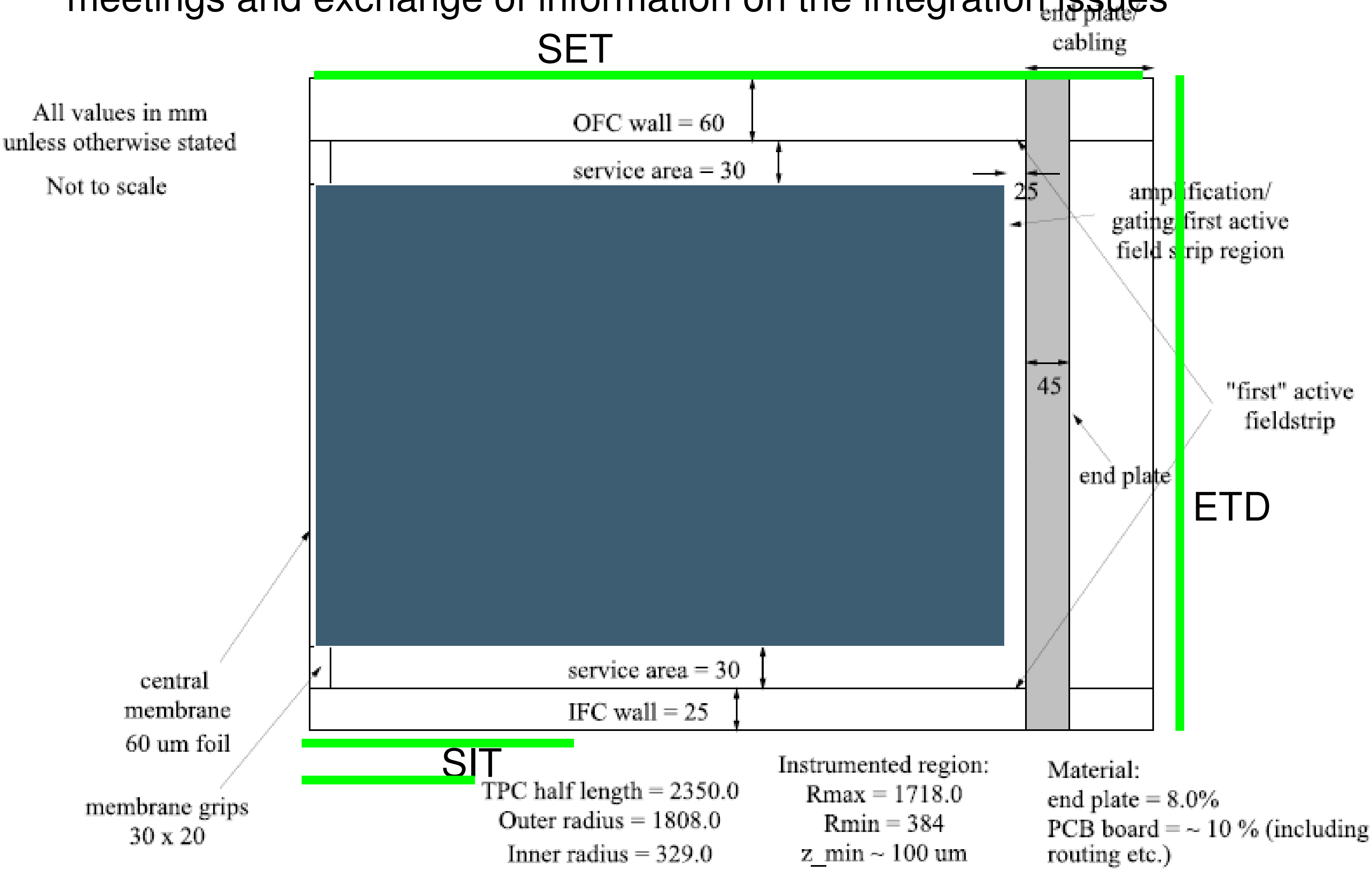
- Baseline sensors and elementary modules
- Baseline geometry
- Detailed Architecture & Integration of each component
- Opened questions concerning
    - the Silicon detectors
    - the other subdetectors



SIT, SET, ETD: challenging locations

(white arrows indicate the cable paths)

Collaborative efforts are developing with LCTPC, (re)started meetings and exchange of information on the integration issues



All values in mm
unless otherwise stated

Not to scale

TPC half length = 2350.0
Outer radius = 1808.0
Inner radius = 329.0

Instrumented region:
Rmax = 1718.0
Rmin = 384
z_min ~ 100 um
z_max = 2225

Material:
end plate = 8.0%
PCB board = ~ 10 % (including routing etc.)
OFC = 2.0 %
IFC = 1.0 %
membrane = 0.1%
gas = 1%

Baseline sensors & elementary modules

The main goals are: low material budget, robustness, precision and simplicity to build and mount, cheap.

To do so and based on experience with LHC Si trackers:

⇒ Unique sensor type for the 3 components
⇒ Common type of modules and support structure
⇒ FEE in DSM with full signal processing, high fault tolerance but low power dissipation
⇒ Direct connection FEE-ASIC and sensor
⇒ Well integrated alignment systems

Work is going on these issues within the SiLC R&D collaboration, also profiting from synergies with LHC upgrades, Belle II and now muon g-2/EDM proposed experiment.

Based on real life tests with prototypes: important to get a right idea of the problems to face and to ensure the proposed solutions are realistic.

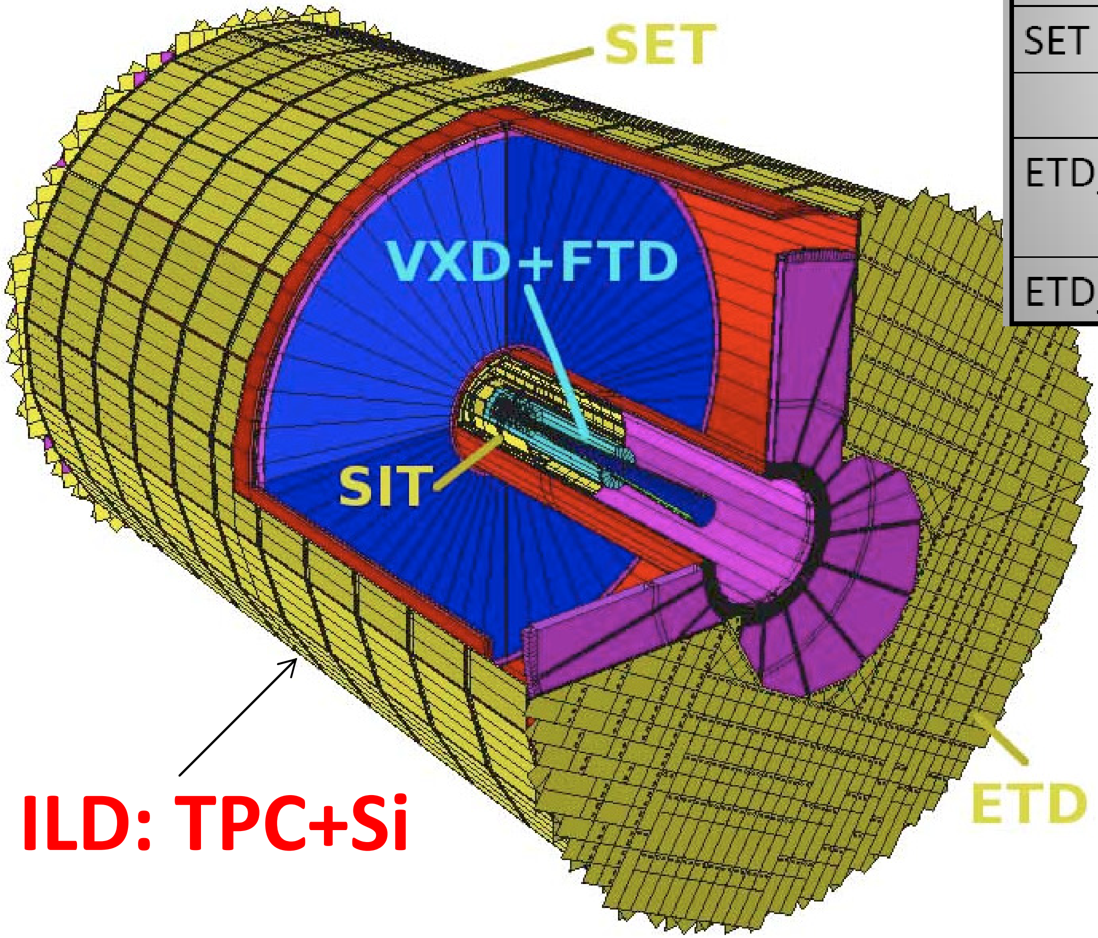
Asset: applications to shorter term experiments: BELLE II (SuperKEKB) and Muon g-2/EDM proposed experiment at JPARC-KEK
Synergy with LHC upgrades.

Close collaboration/follow up between simulations (A. Charpy + K. Androsov) and mechanical design plus advances on all the crucial R&D objectives (sensors, FEE, DAQ) => evolutive studies

ILD Hybrid tracking: *The Silicon Envelope*

(in numbers as currently in the ILD LOI)

Component	Layer #	# modules	# sensors/ module	# channels	Total surface m2
SIT1	1st layer	33	3	66.000	0.9
	2nd layer	99	1	198.000	0.9
SIT2	1st layer	90	3	180.000	2.7
	2nd layer	270	1	540.000	2.7
SET	1st layer	1260	5	2.520.000	55.2
	2nd layer	1260	5	2.520.000	55.2
ETD_F	X or U or V	82/quad =328/layer =984/ETD	2 or 3 or possibly 4	2.000.000	30
ETD_B	idem	idem	idem	idem	30



ILD: TPC+Si

Total number of channels:
10^6 (SIT) + $5\mathrm{x}10^6$ (SET) + $4\mathrm{x}10^6$ (2 ETD)
= **$10\ \mathrm{x}10^6$ channels**

Total area:
7 (SIT)+110 (SET) +2x30(ETDs) = **180 m^2**

Total number of modules:
500 (SIT) + 2500 (SET) + 2000 (ETDs)=
5000 modules with unique sensor type
(but for FTD) but ***variable strip length***
(10-30 cm) depending module location.

GEANT4 simulation **(here)& mechanical design** (CATIA) in progress

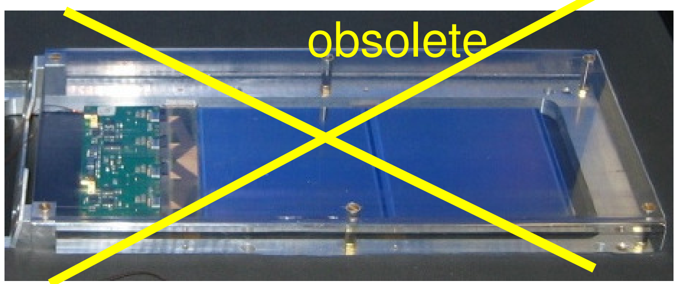
Baseline sensors & module design

Baseline sensors:

SSD 10x10 cm^2, 200 µm thickness, 50 µm pitch, AC coupled with A.F. option (high transmittance) and active edge=> planar architecture

(DSSD 6'' now available by HPK (BELLE II + SiLC))

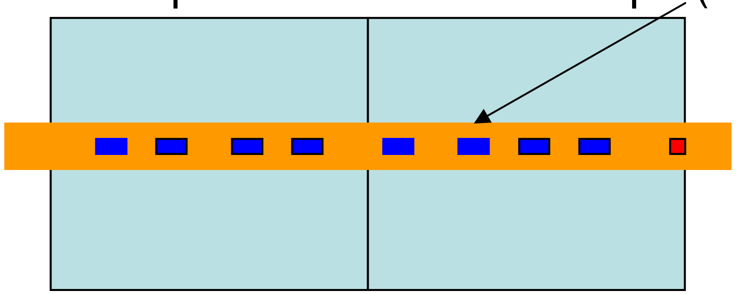
Work in progress on new sensors (cf. SiLC): CNM, IRST, VTT, ETRI, HPK



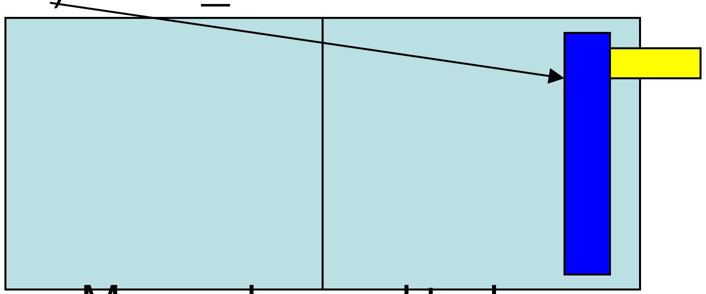
Elementary modules:

Work in progress on diminishing as much as possible X0% of the support structures and needed services (cabling, LV, cooling, alignment infrastructure…)

About 2000 channels per module thus 8 chips (256 ch): SiTR_130

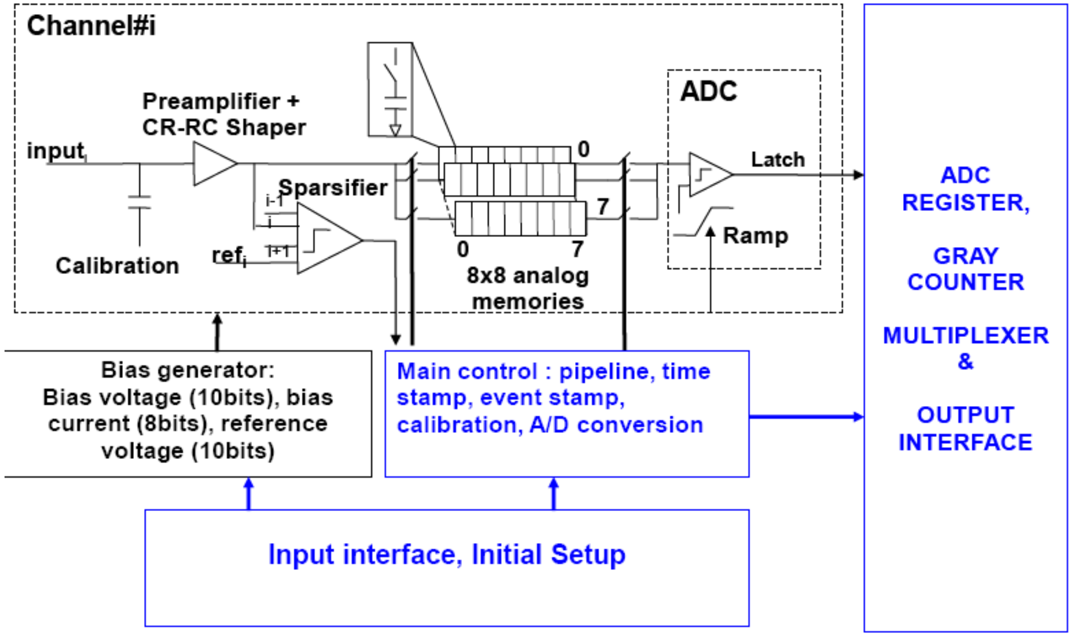


Techno already available: Tape Automated Bonding (TAB)
(see next slide)



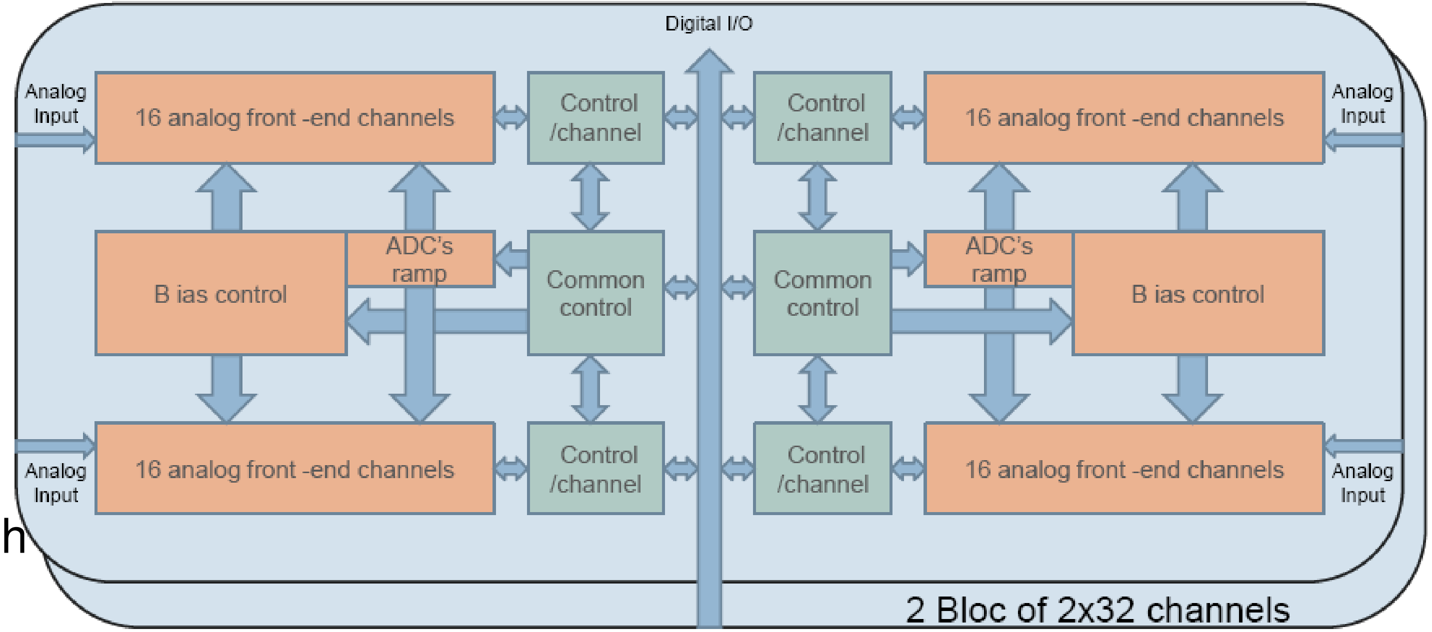
More advanced techno still to be proven

FEE readout ASIC



SiTR_130

128 channels in 0.5x1cm^2 => 256 channels in 1x1cm^2 should be feasible already in CMOS 130nm



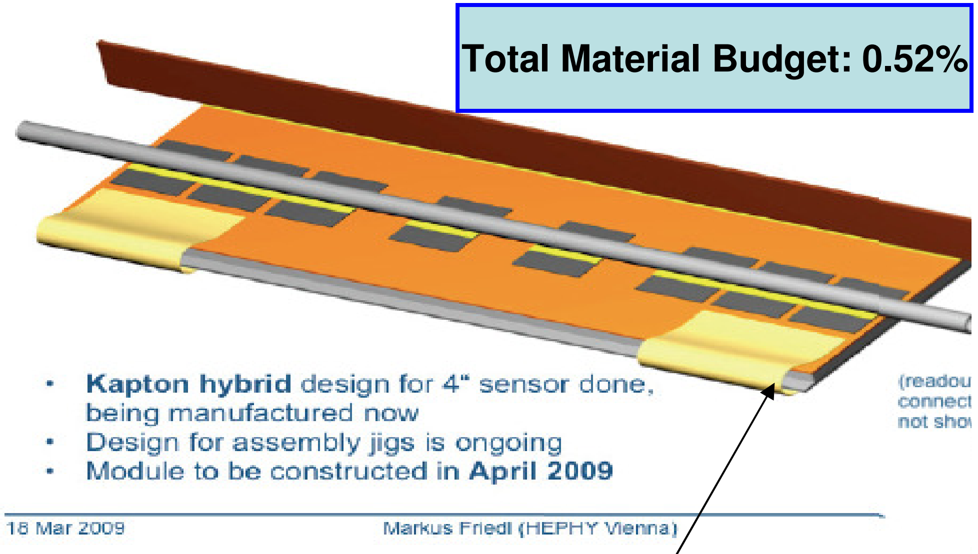
Goal: 1-1.5 mWatt/ch not including power cycling: presently achievable

Chip on sensor readout

A kapton flex circuit with several APV25 chips (thinned to 50 µm) will be mounted on a DSSD and both sides of strip signal will be readout. The opposite side strips are read with folded kapton tabs.

SiLC (LPNHE) will apply this connection to the new FEE (SiTR_130) presently under development for the modules that will be equipped with these new FE ASICs.

More advanced inline pitch adapter R&D, will be studied (LPNHE+HPK) with new ASIC (NdA+MTA).



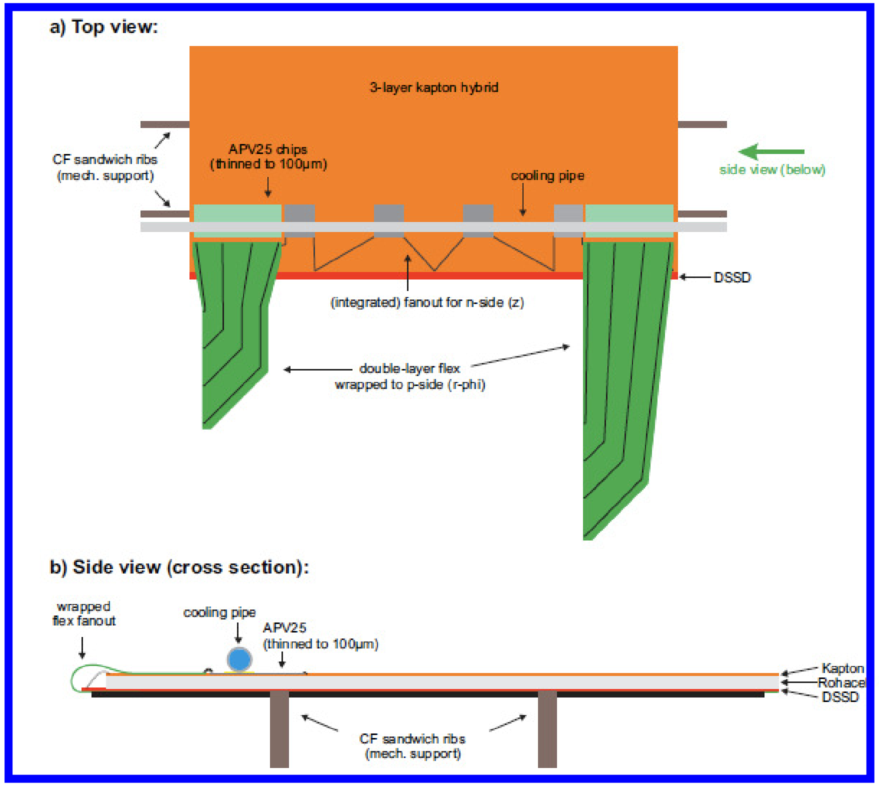
Total Material Budget: 0.52%

- **Kapton hybrid** design for 4" sensor done, being manufactured now
- Design for assembly jigs is ongoing
- Module to be constructed in **April 2009**

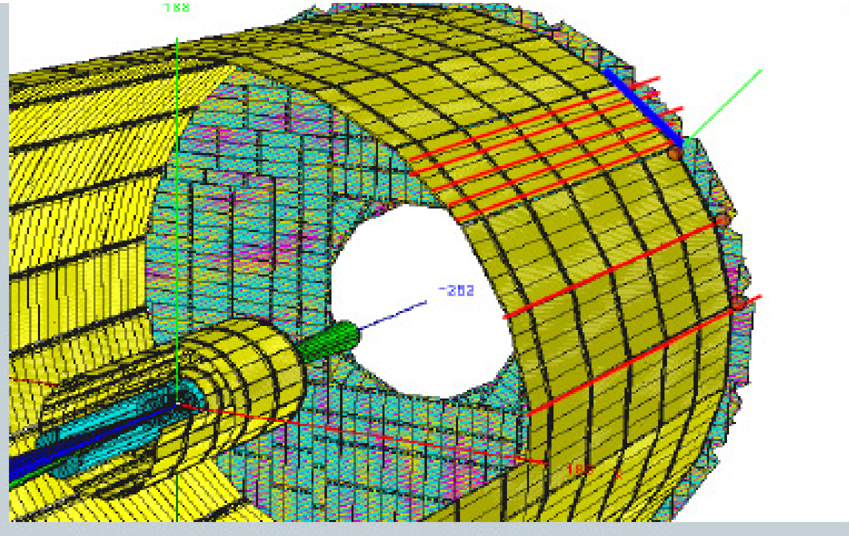
(readou
connect
not sho

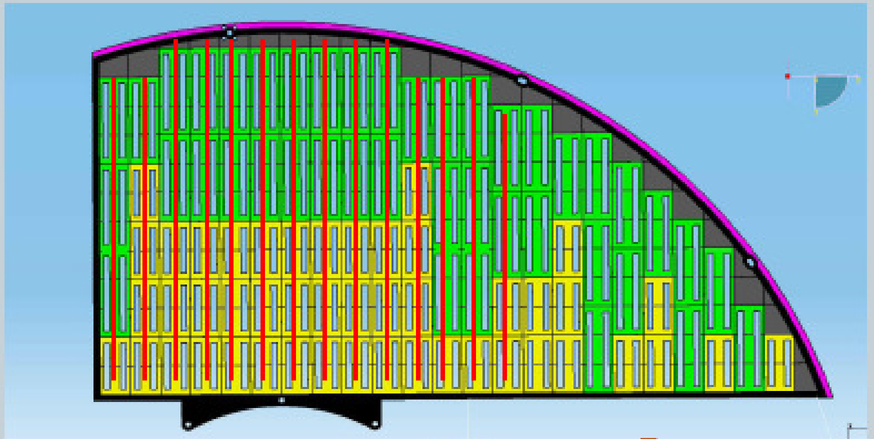
18 Mar 2009 Markus Friedl (HEPHY Vienna)

Prototype to be tested by HEPHY in SiLC Testbeam at SPS-CERN, Oct 2010.



Chaining the DAQ sub-elements





- On the "module":
  Chaining of 8 SiTR_130-256

- "Super Module":
  Chaining the adjacent ladders toward a level 1 concentrator

- Half cylinder ("Detector Element"):
  Level 1 concentrator (toward level 2 ?)

- Toward the global Silicon DAQ system by Optical fibers

- Send to Global DAQ system

Depending on the final requirements

Just starting to think about the topology design & how to build the DAQ chain:
***Just getting our nose out of the FEE chip*....LOT to DO: setting of a task force**

Rough estimate: 1 fiber per half panel => 24 per edge for the SET; 11 (SIT1) and 20 (SIT2) per edge. And 2 fibers per quadrant for the ETD => 24 fibers per ETD.

Detailed design and integration issues for each components: current status

- SET: Torino + Paris and collab with LCTPC
- SIT: Korea, Torino INFN and University, LPNHE plus contributions by HEPHY, KEK (based on work for BeLLE II)
- ETD: LPNHE and collab with LPSC+LAL+LLR

Work on the three components profit from the R&D work in SiLC on new sensor developments, new FEE, connection FEE and sensors, alignments and test beam activities. All these aspects greatly impact on the overall design of this detectors.

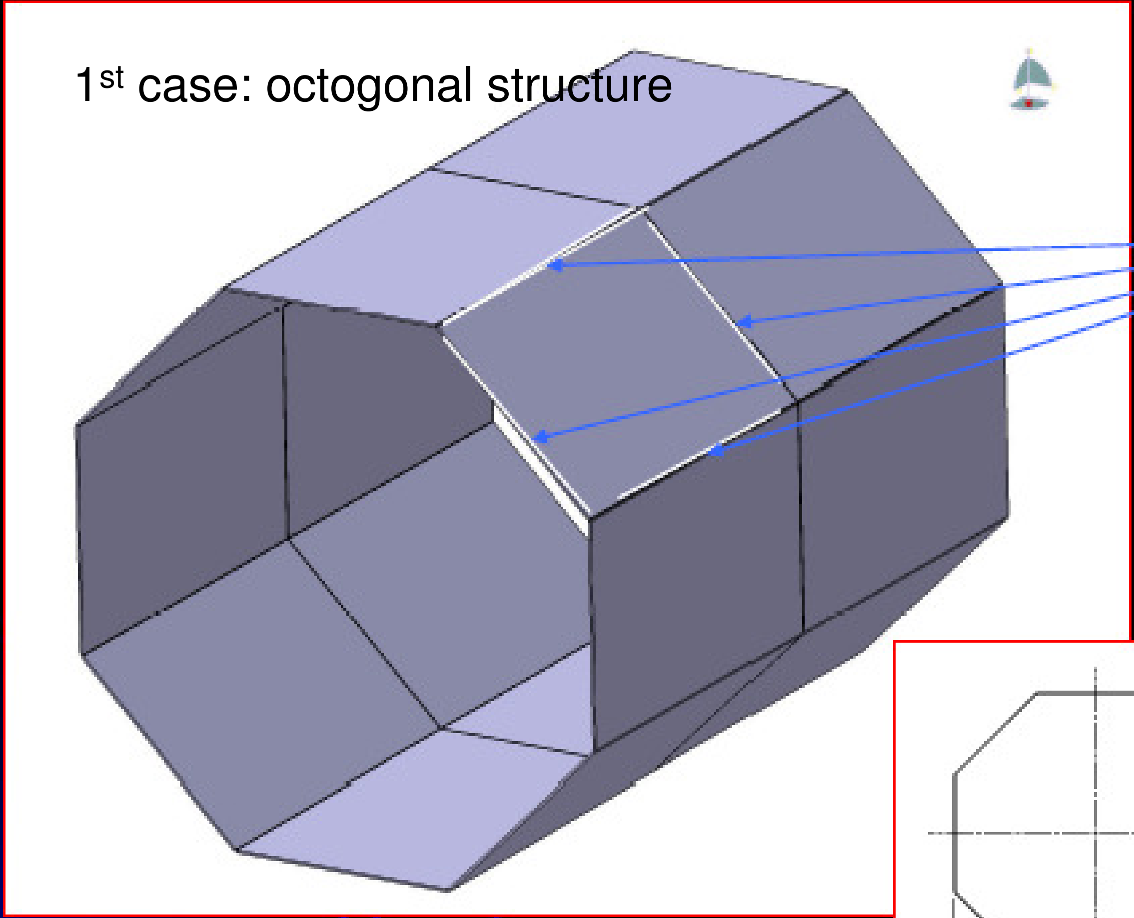
SET mechanical structure

- basic element geometrical & mechanical characterics;
- FEM analysis;
- integration scenario.

- VERY PRELIMINARY !

Study on the SET performed by Paolo MEREU
Discussions with Diego Gamba, Paolo Mereu,
Ron Settles, Didier Imbault, A. Savoy-Navarro.
New developments expected for September,
(Torino).

SET mechanical structure

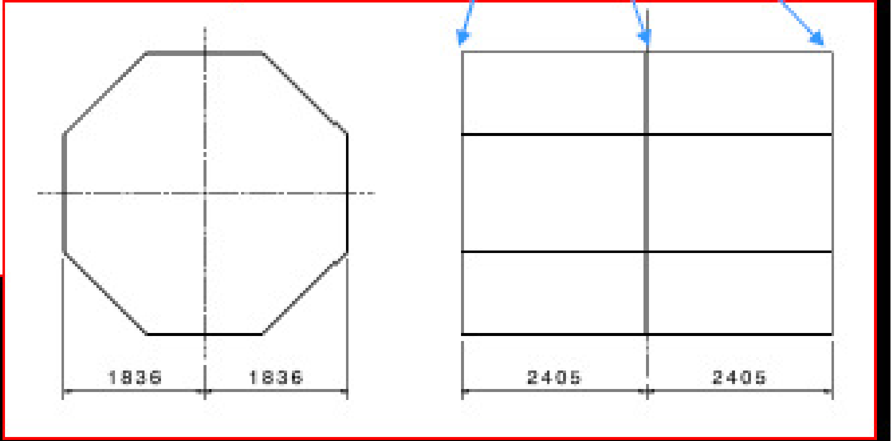


1st case: octogonal structure

Several cases studied

Each panel is constrained at 4 sides;

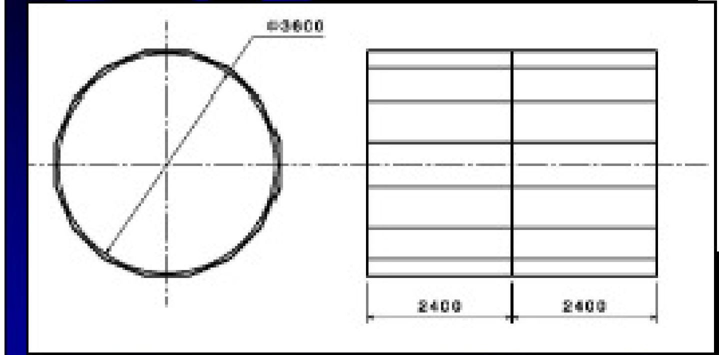
-> 3 support rings on TPC

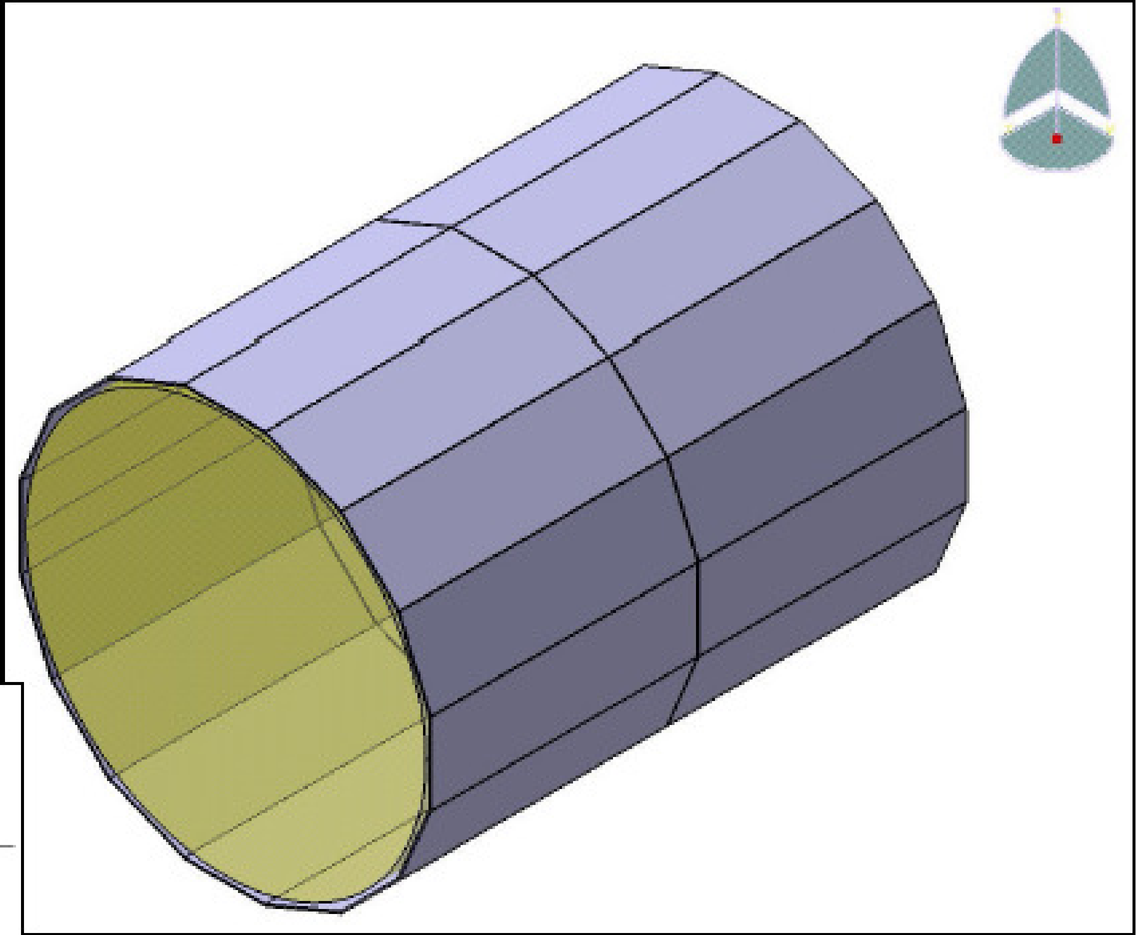


SET mechanical structure

16-panel-scenario

- 2x16 730x2400 mm panels;
- same constraint scheme;
- deformation t.b.c. (very likely to be similar...);
- number of longitudinal support doubled;
- simple and easy manufacturing and handling.





Paolo MEREU I.N.F.N. Torino mereu@to.infn.it

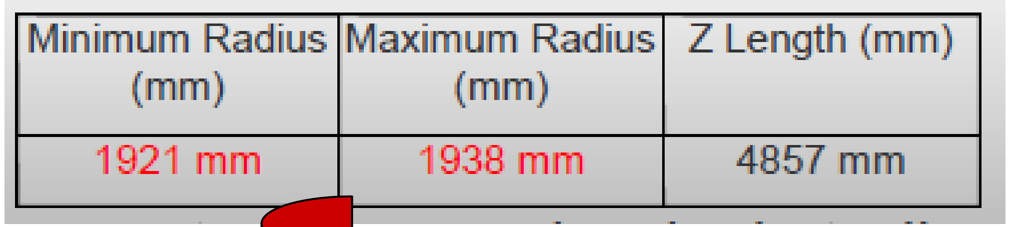
✓The Mechanical structure of the SET is made by 2 halves composed of ***24 panels*** 2,4x0,5m. Each panel is independently fixed.

✓Static deflection with a payload of 1kg/sqm is given in the following+1 slide.

✓Silicon detectors are fixed on the surface of each panel; details of this fixation are being studied (ETD model is the present foreseen solution))

✓Material budget:

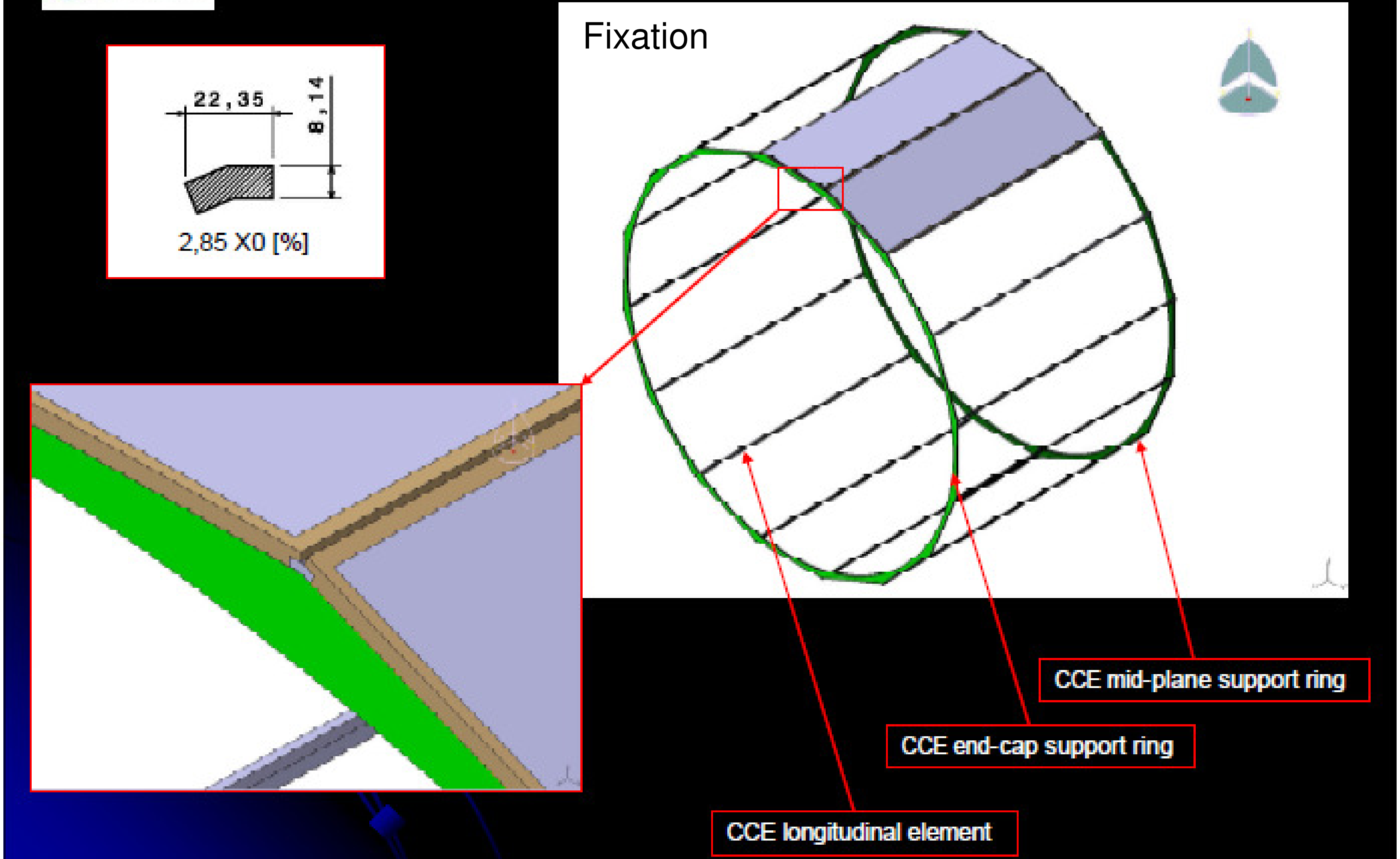
- 8 Unidirectional Carbon-Epoxy Prepreg 0,15mm each: 0,45 % X_0
- 15 mm-thick Rohacell31: 0,135 % X_0
- each panel has 0,585 % X_0



Minimum Radius (mm)	Maximum Radius (mm)	Z Length (mm)
1921 mm	1938 mm	4857 mm

17mm to locate the SET: looks VERY CRITICAL!

SET mechanical structure



2,85 X0 [%]

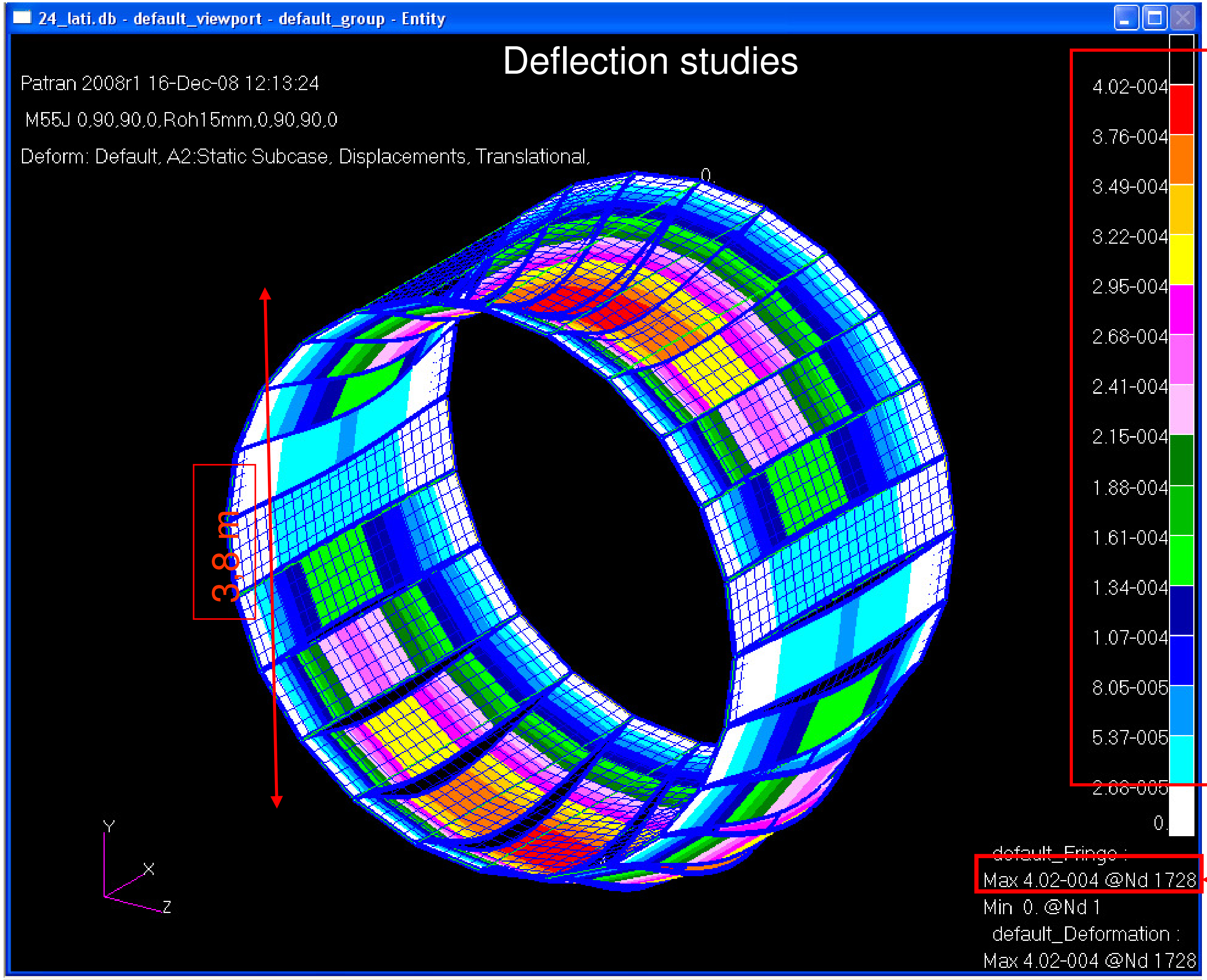
CCE mid-plane support ring

CCE end-cap support ring

CCE longitudinal element

Paolo MEREU I.N.F.N. Torino mereu@to.infn.it

24 panels (final scenario)



24_lati.db - default_viewport - default_group - Entity

Deflection studies

Patran 2008r1 16-Dec-08 12:13:24

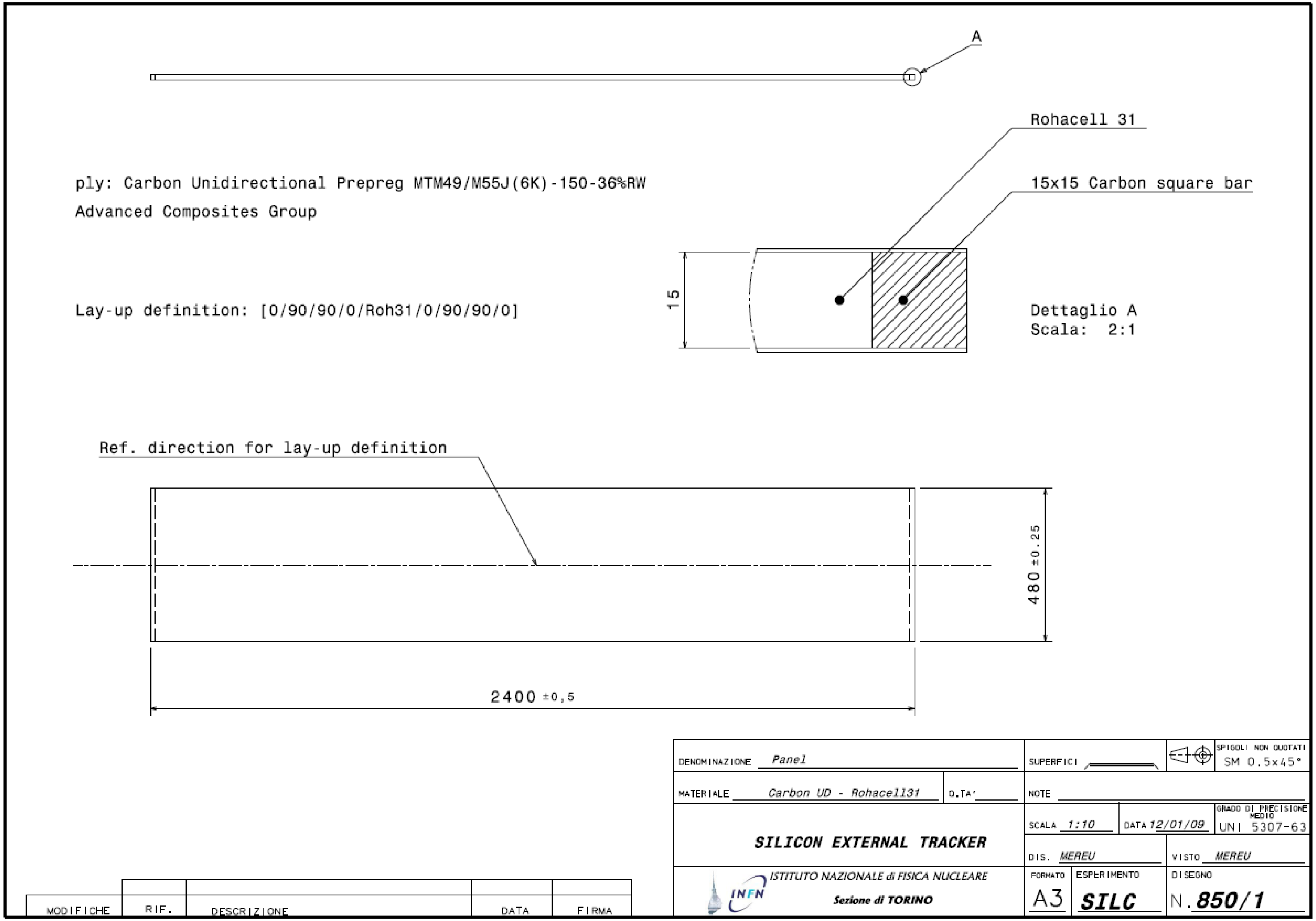
M55J 0,90,90,0,Roh15mm,0,90,90,0

Deform: Default, A2:Static Subcase, Displacements, Translational,

default_Fringe :
Max 4.02-004 @Nd 1728
Min 0. @Nd 1
default_Deformation :
Max 4.02-004 @Nd 1728

Scale in meters

SET Support material



ply: Carbon Unidirectional Prepreg MTM49/M55J(6K)-150-36%RW

Advanced Composites Group

Lay-up definition: [0/90/90/0/Roh31/0/90/90/0]

DENOMINAZIONE *Panel*

SUPERFICI

SPIGOLI NON QUOTATI SM 0.5x45°

MATERIALE *Carbon UD - Rohacell31*

Q.TA'

NOTE

SCALA *1:10*

DATA *12/01/09*

GRADO DI PRECISIONE MEDIO UNI 5307-63

SILICON EXTERNAL TRACKER

DIS. *MEREU*

VISTO *MEREU*

ISTITUTO NAZIONALE di FISICA NUCLEARE

Sezione di TORINO

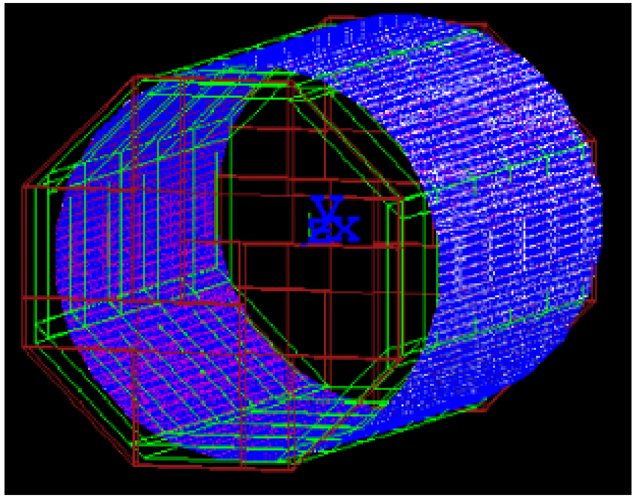
FORMATO A3

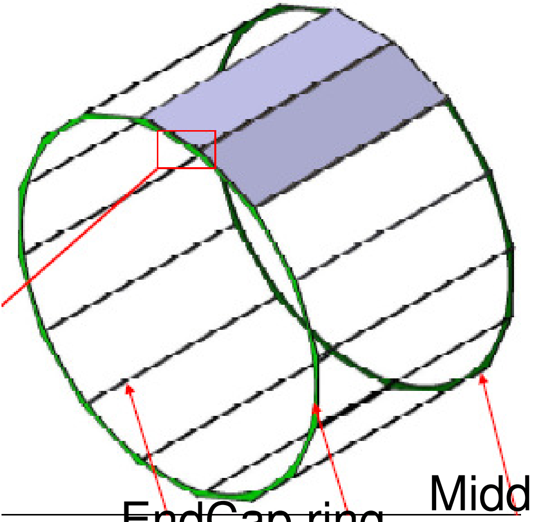
ESPERIMENTO **SILC**

DISEGNO N. **850/1**

Questions concerning the SET

- Space needed between TPC and em calorimeter: to be studied in details. Presently needed: ~ 2.5 cm.
- Alignment vs SIT & TPC (pixel+laser based system)
- Fixation of SET:
  - ❖ Need a fixation point in the middle of the TPC and
  - ❖ Fixation at theTPC end plate edge ? or
  - ❖ Bicycle wheel on both sides of the TPC, independent of the TPC, that could also serve for the SIT support structure (under study by Torino) & alignment system.

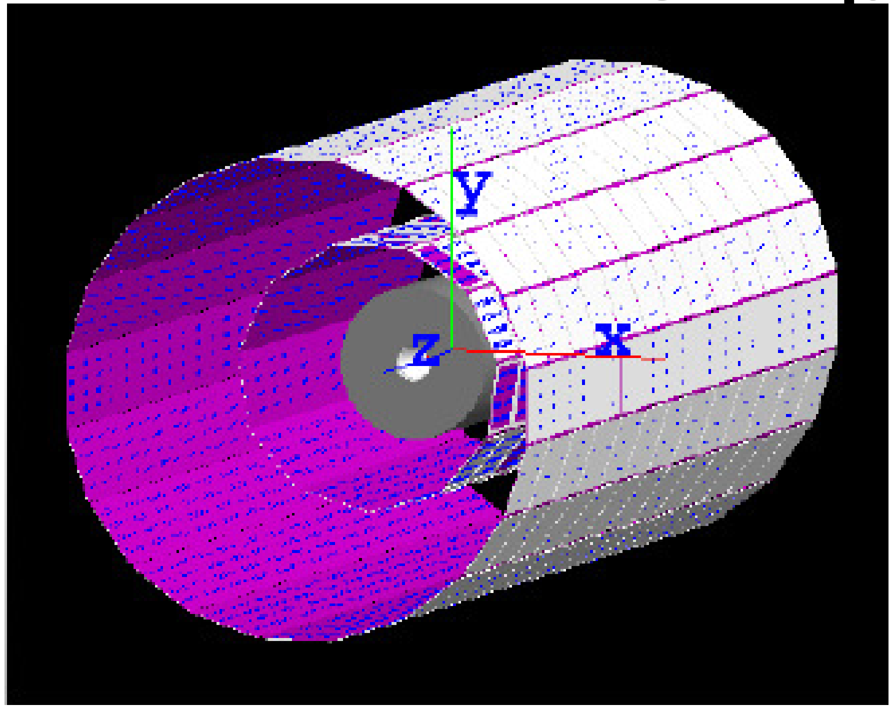




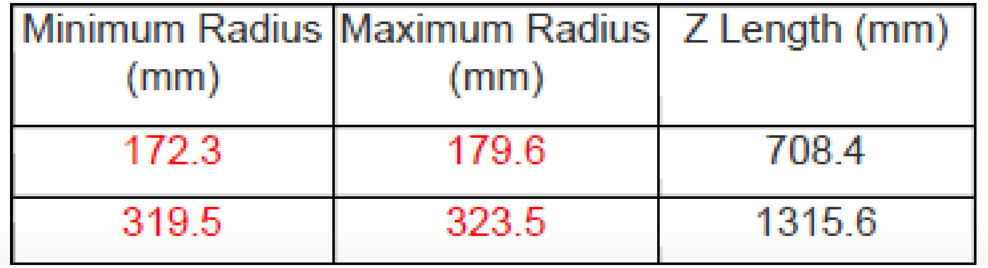
EndCap ring fixed on TPC edge

Middle Ring fixed on middle of the TPC

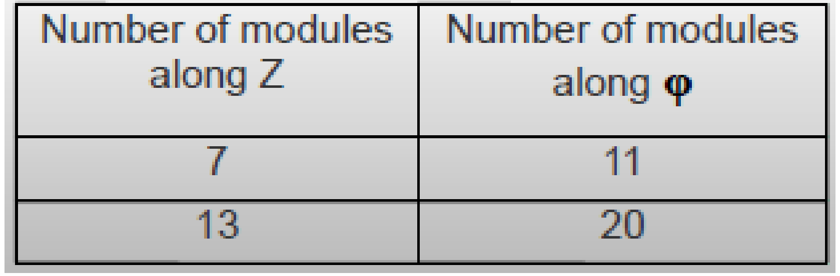
THE SIT present design



From simulation (A. Charpy+K. Androsov)



Minimum Radius (mm)	Maximum Radius (mm)	Z Length (mm)
172.3	179.6	708.4
319.5	323.5	1315.6



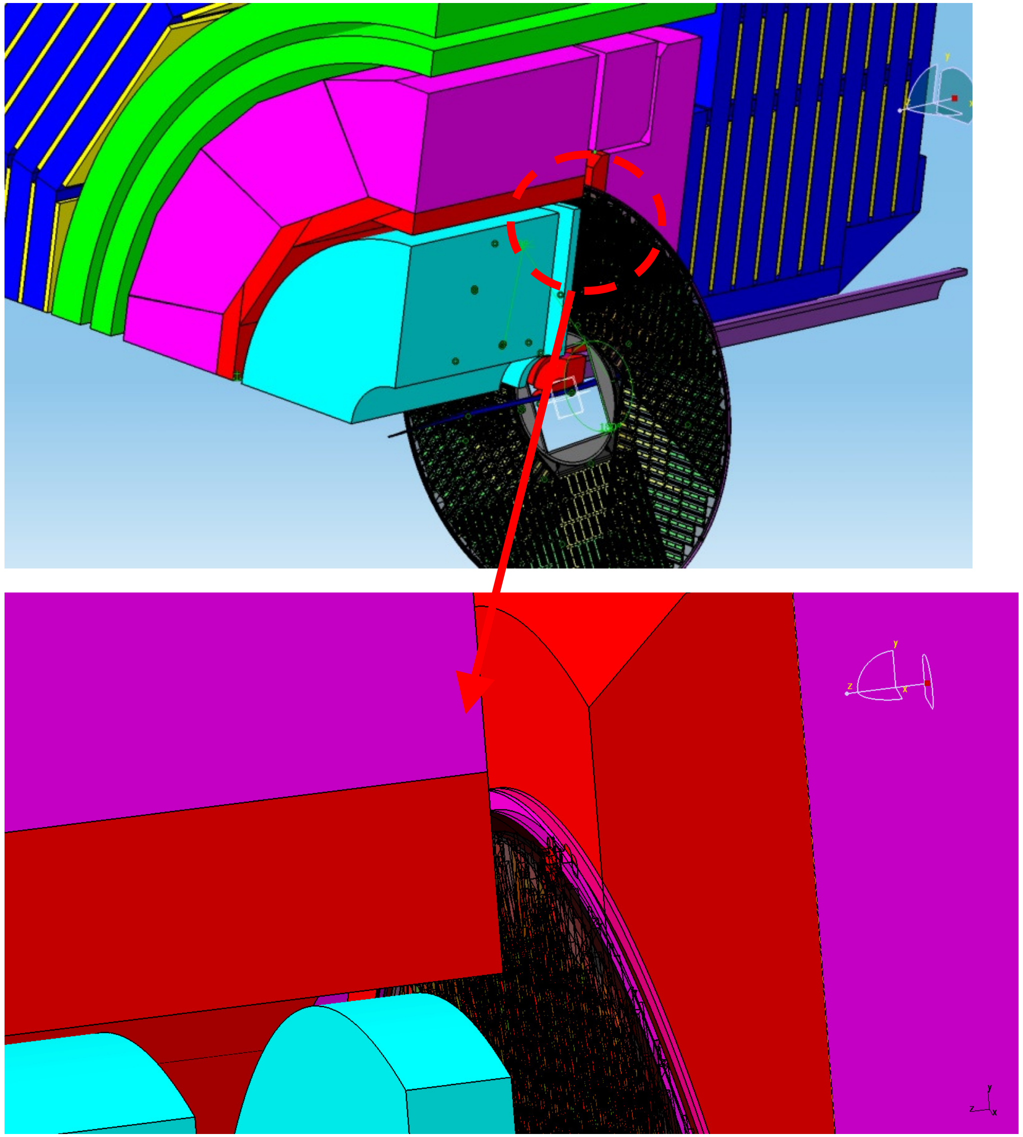
Number of modules along Z	Number of modules along φ
7	11
13	20

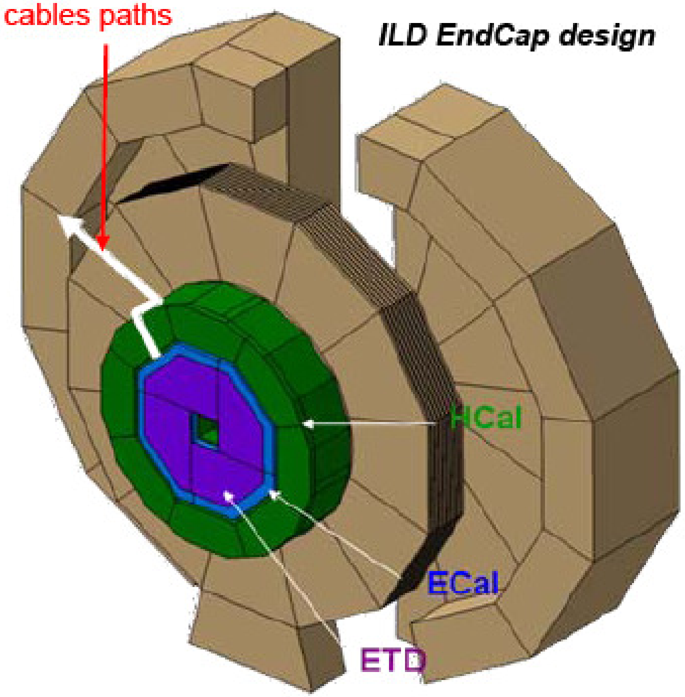
Current design: Two layers, each made of 2 SSD and stereo (6 degrees)
SSD strips sensors (10.12x10.12cm²), 200μm thick, 50 μm R.O.pitch, active edge.
SiTR based FE readout on chip
Support structure following the SET model, thinner and space frame

Questions:

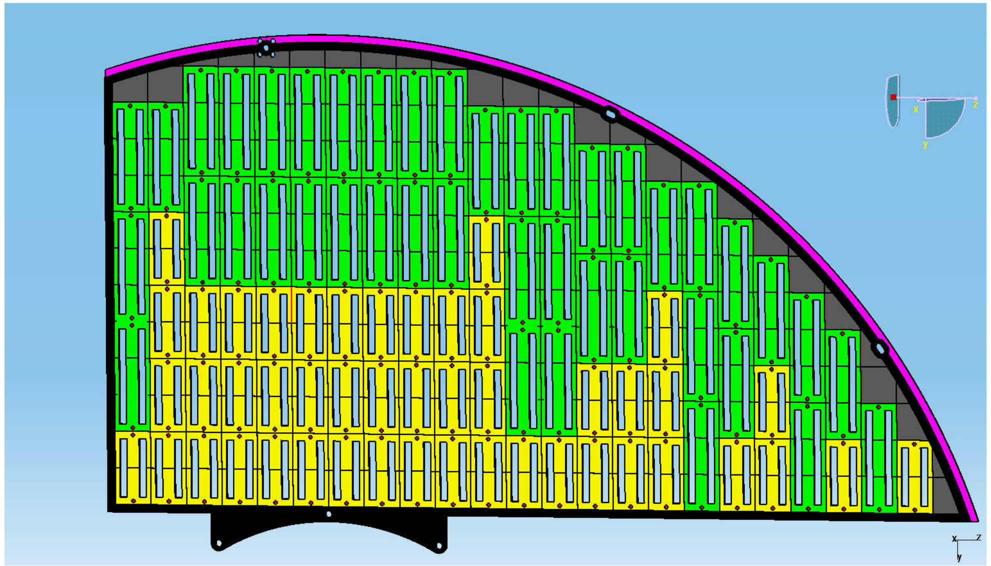
- Nb of layers: More than 2 layers (cf study by Korean team with 3 or 4 layers)
- time stamping (currently Si tracker -> bunch crossing stamping if more needed => additional layer (SIT?); dedicated FEE designed for CLIC
- including SIT into the vertex detector cryostat if any (see Snowmass 05 !)

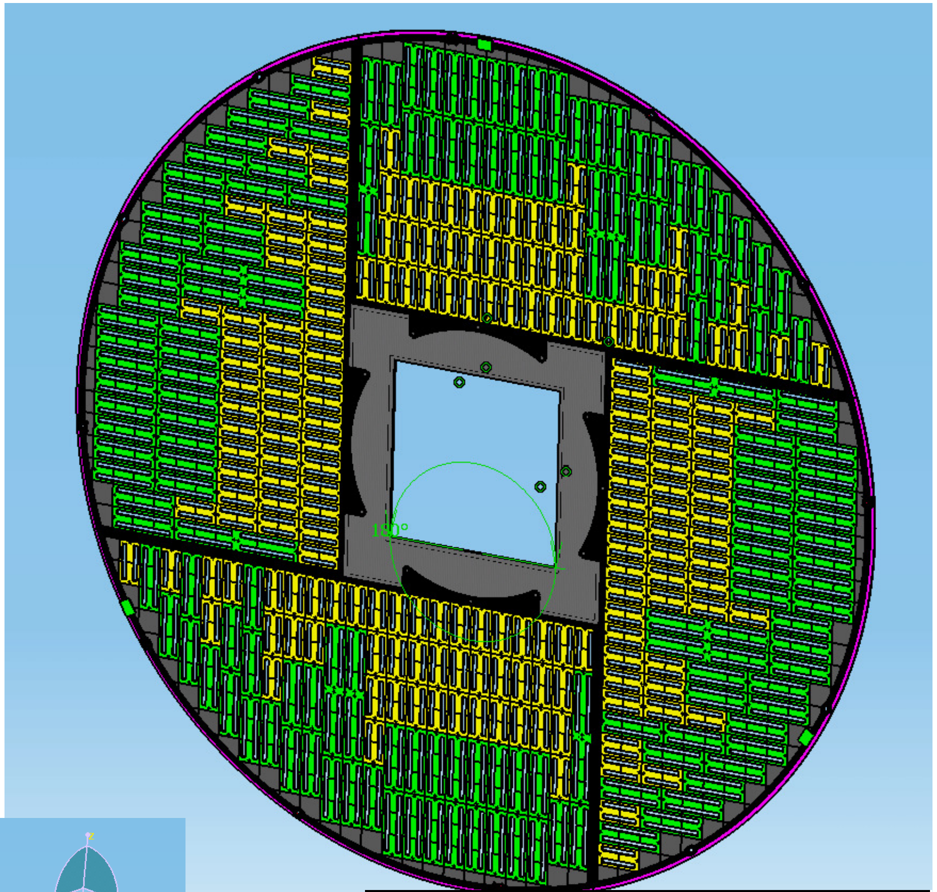
ETD: EnDCap Tracking Detector





Work in progress on the mechanical side at LPNHE by P. Ghislain & D. Imbault in collaboration with LPSC (D. Grondin), LAL (M. Jore), LLR (P. Anduze).



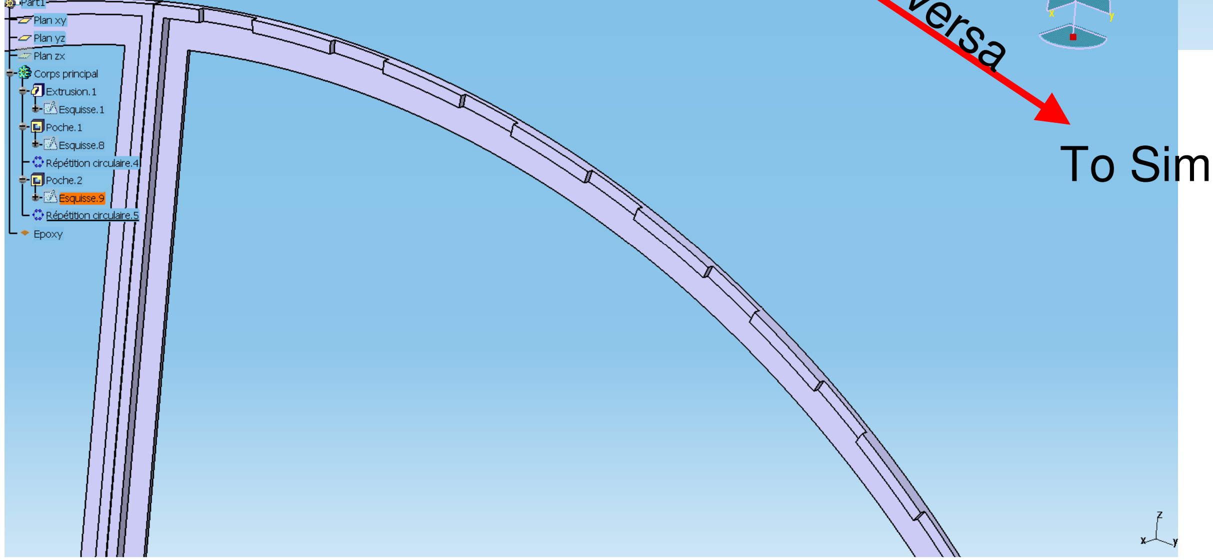


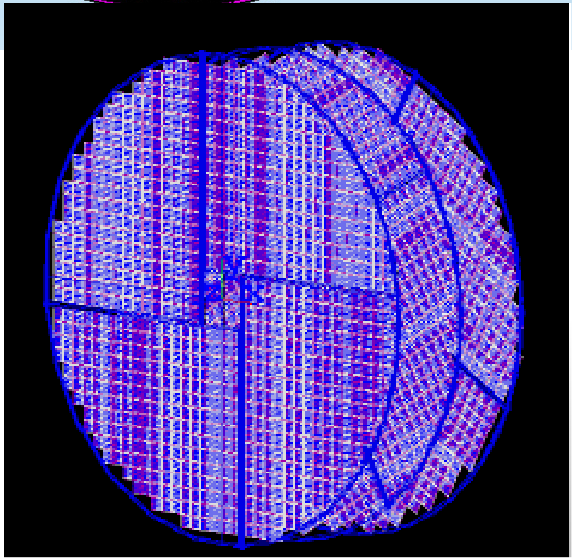
From CATIA

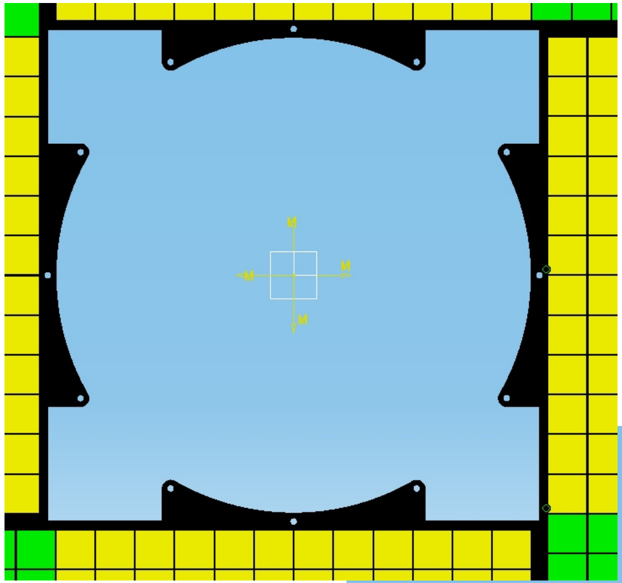
And vice & versa

To Simulation

Cabling + Laser fiber path

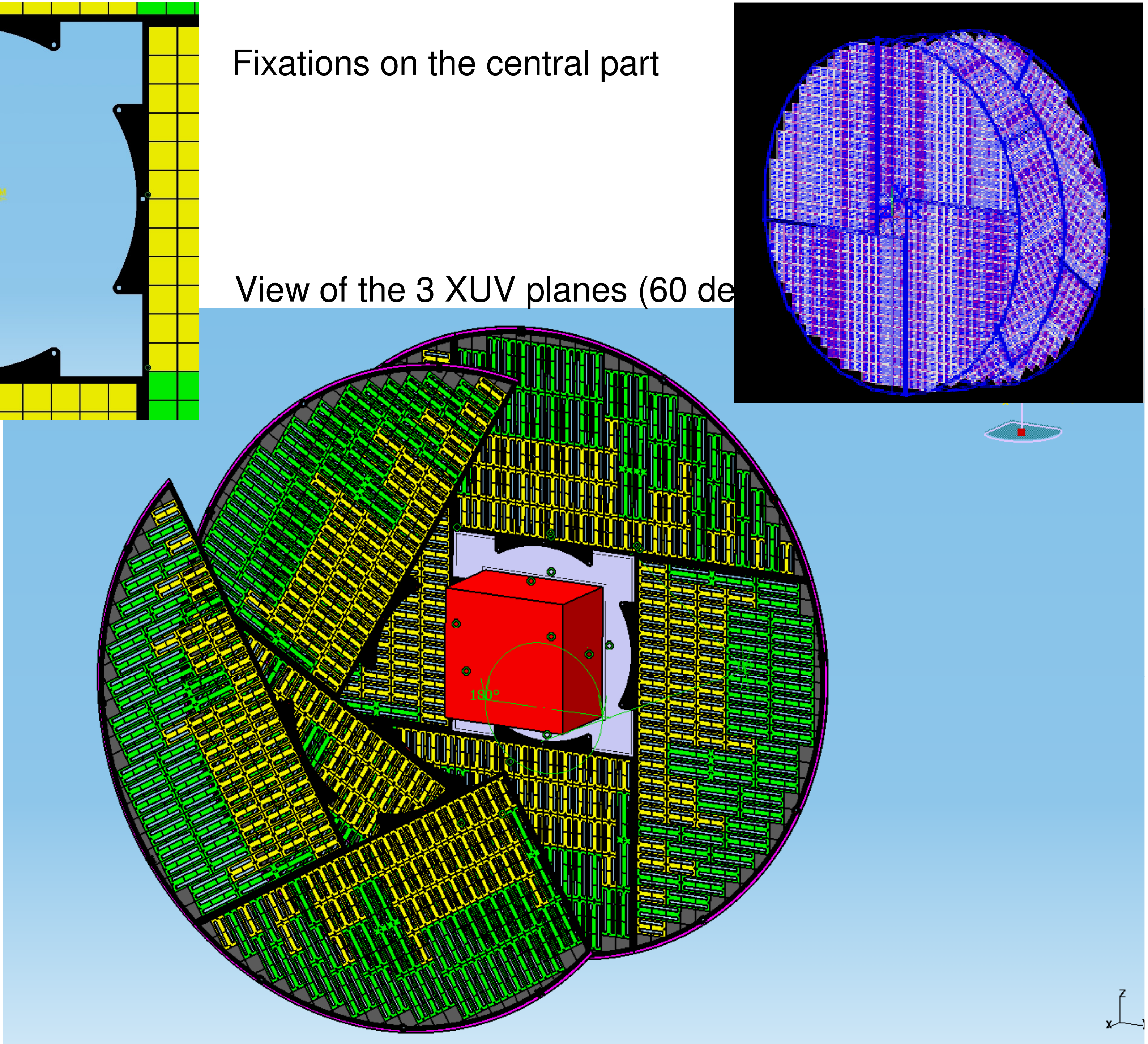




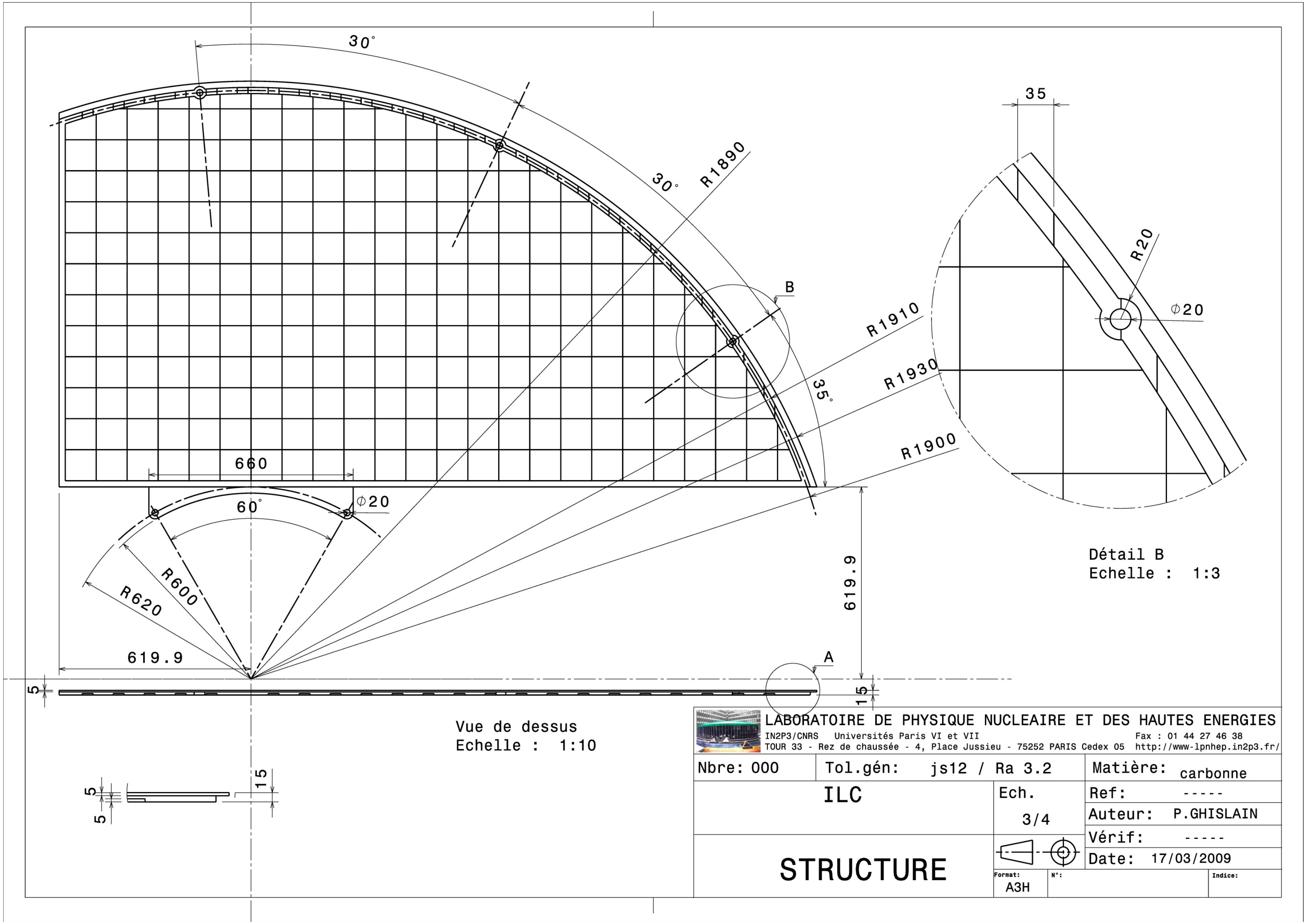


Fixations on the central part

View of the 3 XUV planes (60 de



Details of one ETD quadrant (2.40 cm x 1.20 cm)



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Ech. 3/4
Ref: -----
Auteur: P.GHISLAIN
Vérif: -----
Date: 17/03/2009
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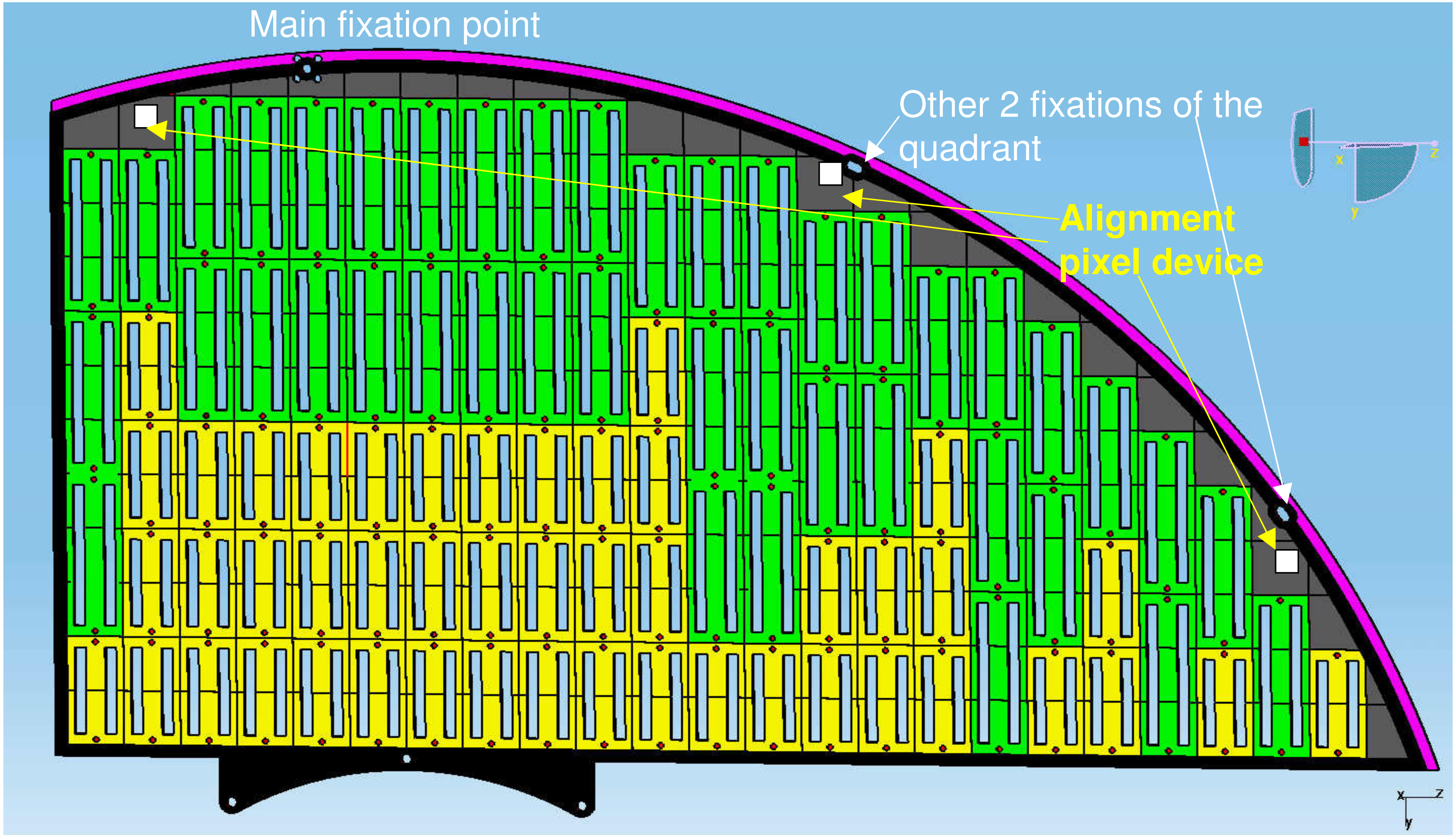
More on the quadrant

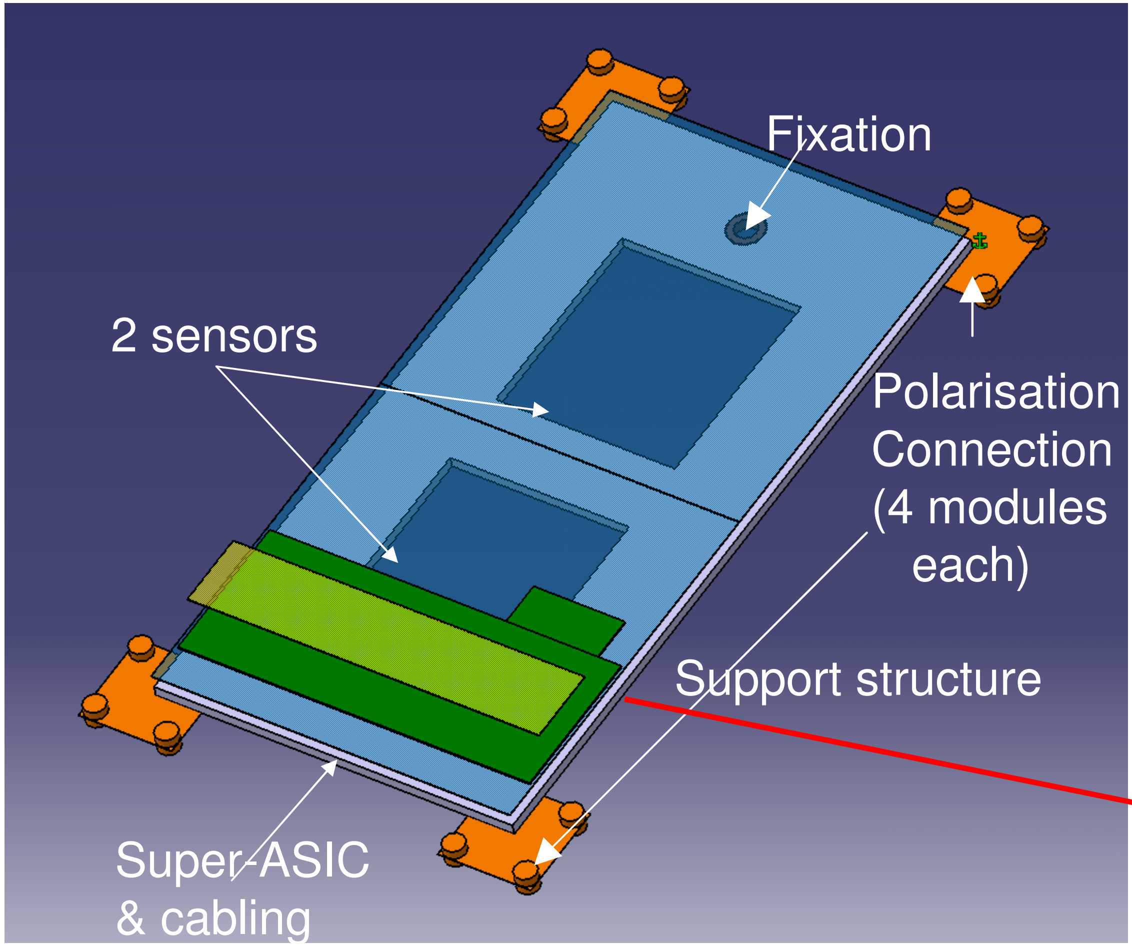


Main fixation point

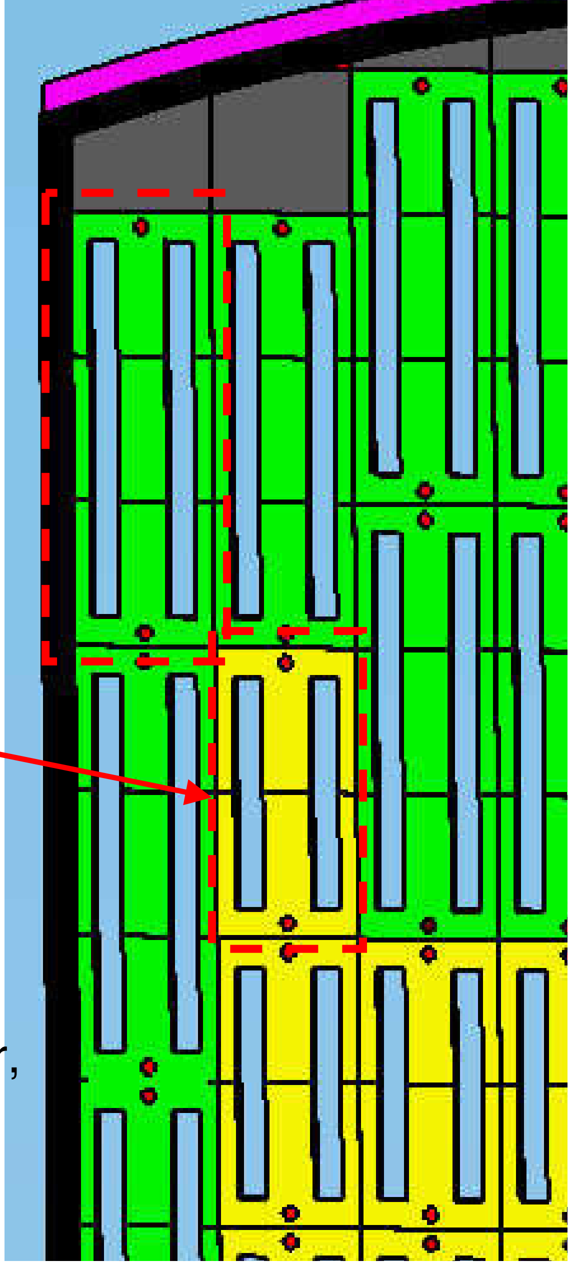
Other 2 fixations of the quadrant

Alignment pixel device

More details on ETD

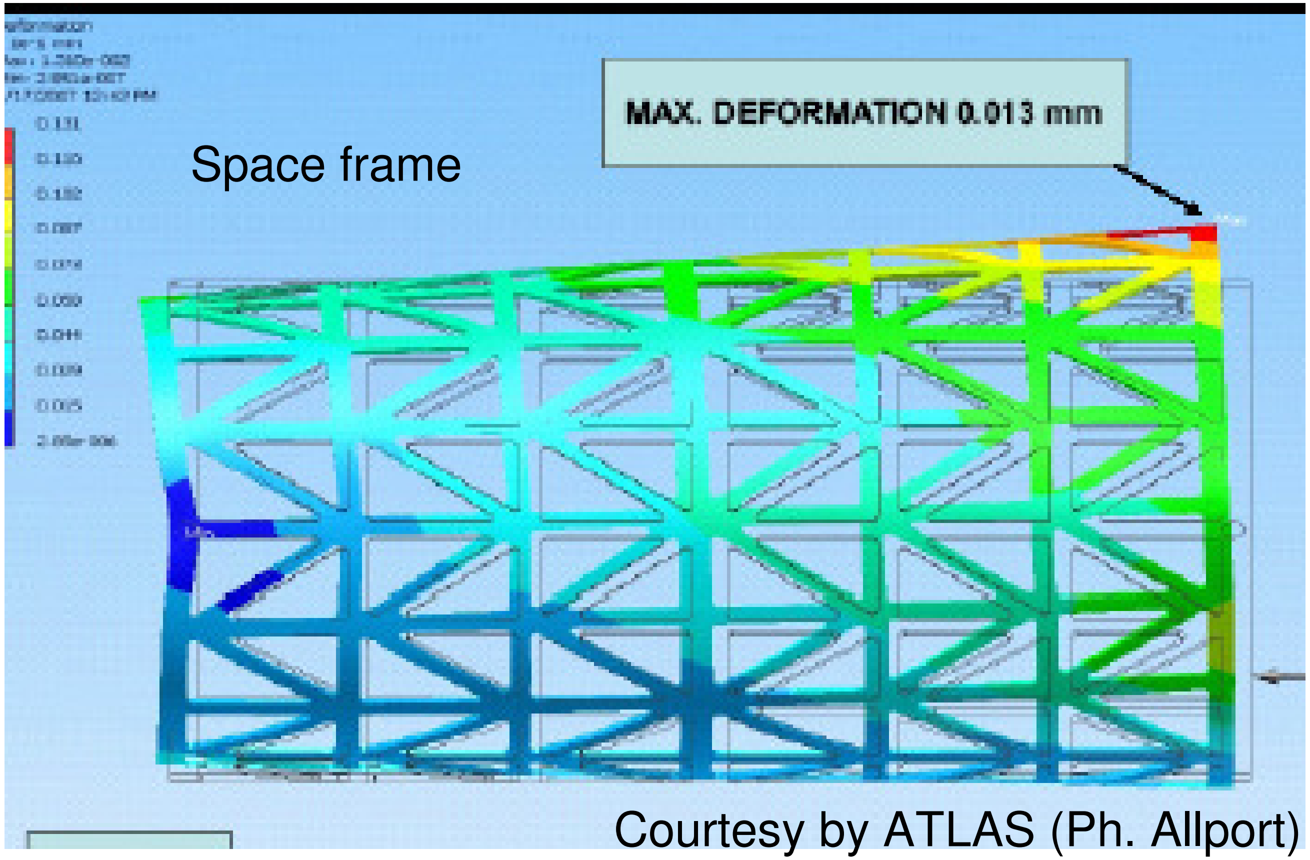


ETD is now based on modules made of 2 (yellow) or 3 (green) sensors.



N.B. Alternative solution: the fixation pin includes polarisation .
The distribution of LV is achieved by the network made by the aligned conducting fibers of the C support structure .
Both modules and support structures are getting lighter: thinner, space frame, new materials.

Working on lighter support structures



Space frame

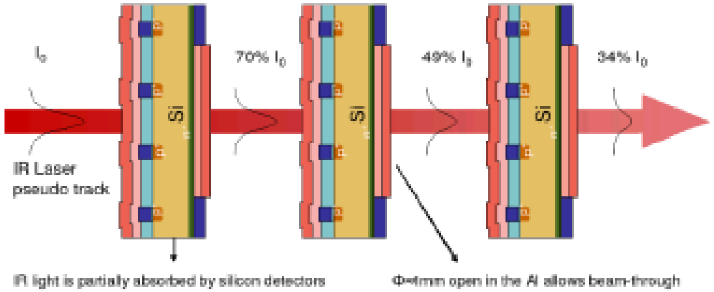
Courtesy by ATLAS (Ph. Allport)

Question:

Make a mechanical prototype of the ETD quadrant to study all the various issues related to such a large support structure: making it a frame structure, assembly mounting & fixation procedure of the modules, achievable precision, alignment.

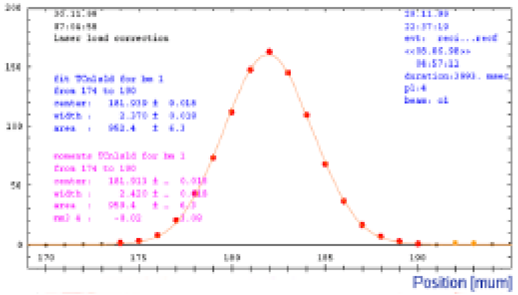
Alignment: *laser based alignment system*

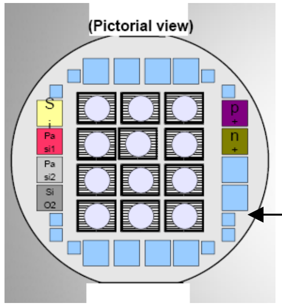
1) ***IR laser*** produces signal on the sensors. Fully integrated to detector FEE/DAQ



Based on R&D performed by CNM-IMB and IFCA. Transfer to Industrial Firm foreseen end of 2011. Only applies to SIT (several layers as the FTD)

Precision: σ=2.3 μm





R&D on new A.F.sensor for T~70% (CNM+IFCA)

2) ***Another laser system*** *(proposed by LPNHE)* to shine on dedicated gratings connected to detector elements: position of different sub-detectors relative to each other and variation on alignment of each detectors. This system can be used *during or outside data taking*: independent DAQ.

Ongoing R&D related to/impacting on the alignment:

- New module manufacturing based on new strip sensors (edgeless), new FEE (DSM), direct FE chip connexion onto strip sensors => impact overall alignment
- Novel sensors for the LAS alignment system for higher transmittance
- Tools to manufacture with high required precision modules & supermodules

Both alignment systems to be adapted/used by BeLLE II, g-2/EDM and LC

LPNHE
Laboratoire de physique nucléaire et des hautes énergies

Alignment monitoring system between different subdetectors/components

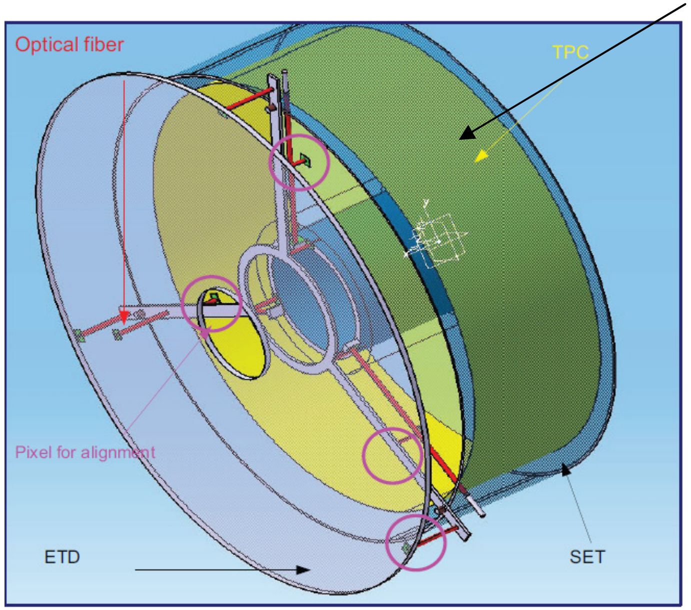
HAMAMATSU

Purpose: Monitoring the relative displacements of sub-components (push pull, environmental vibrations, etc..)

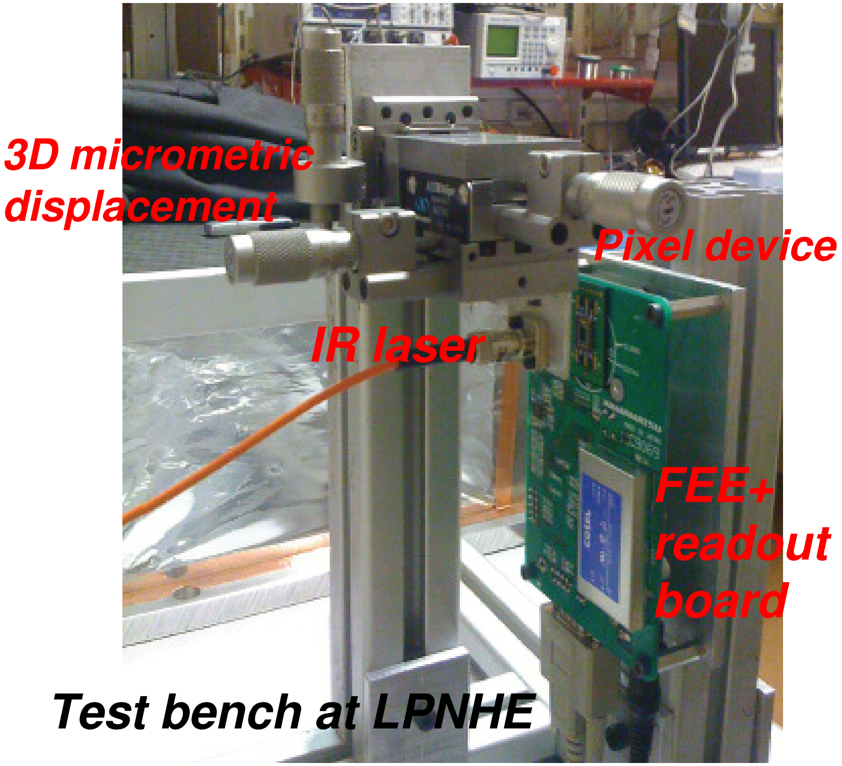
Especially crucial in the case of an hybrid system (Silicon+TPC)

Under study and development a system Laser and pixel detector based available on the market at LPNHE Lab test bench.

The pixel detectors are placed on strategic positions on the support structure (ex ETD)



Schema of this system in ILD case: TPC plus various Silicon components

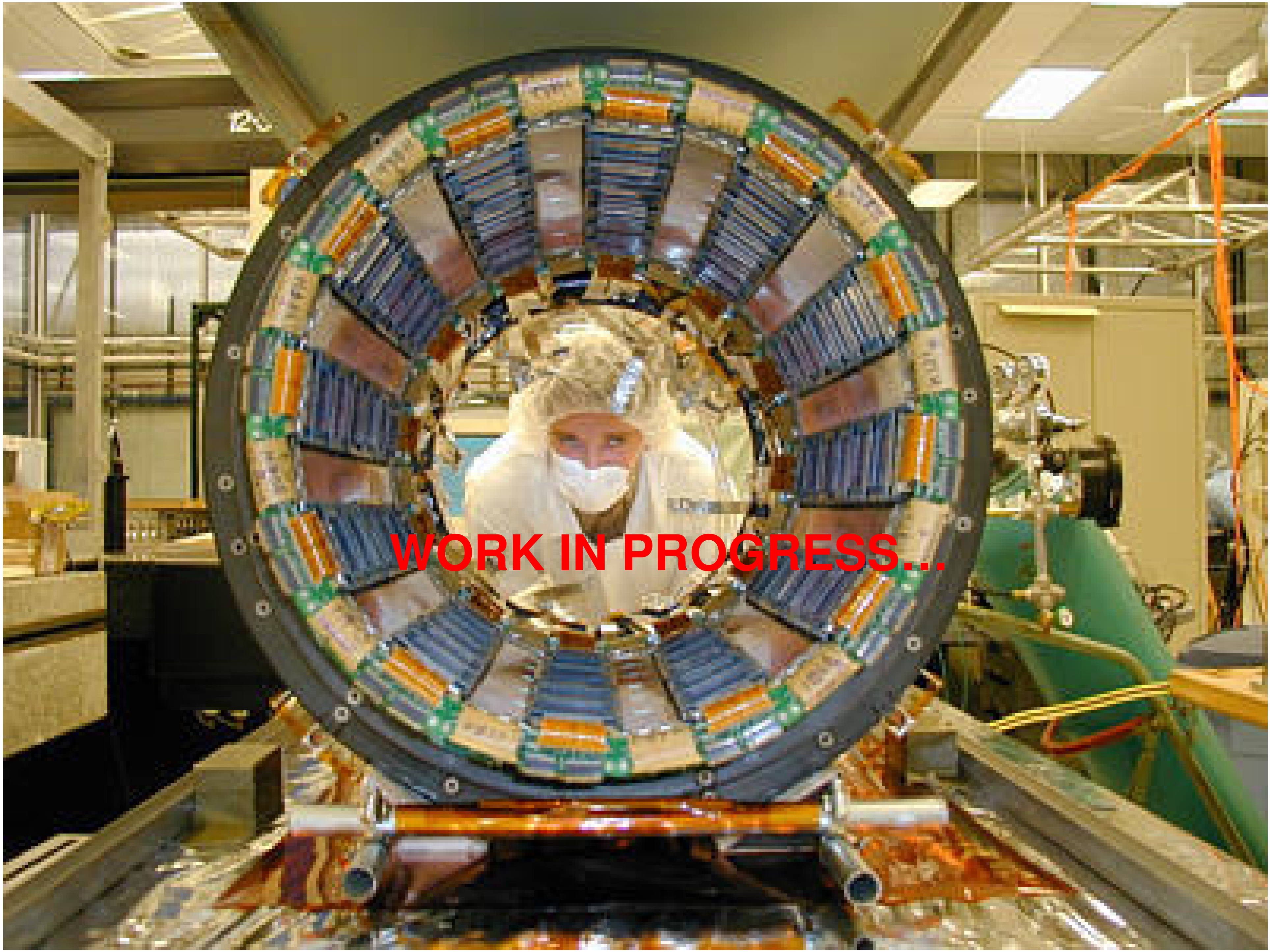


Test bench at LPNHE

COOLING

Global issue:

- what is needed by each subdetector?
- Is there a common solution foreseen?
- Need for a dedicated meeting on this issue



WORK IN PROGRESS…

Backup slides

Integration of a Silicon system into the ILD concept: remarks

The construction and the integration of a Silicon tracking system, part of an hybrid tracking ensemble (CDF, ATLAS) is much more challenging than an all-Silicon fully integrated system (CMS, SiD and futur s-ATLAS). Among the main challenging issues:

- **THE SPACE ALLOCATED**:

An all-Silicon system has all the tracking space for it alone (1.2m radius or so)
Hybrid: only 2cm for the SET, 4cm for the ETD, 20-25cm for SIT+FTD

- **THE FIXATION and SUPPORT STRUCTURE**:

All Si can build the support structure as desired as well as its own fixing system.
Hybrid: the Si device fully depends on the restricted space and the surroundings.

- **THE ROLE**:

All Silicon system must primarily fulfill the role of a highly performing tracker i.e. in momentum and spatial resolution measurements.
Hybrid case: the Si component must provide additional functions: alignment, time stamping, handling of distortions of the gaseous detector etc….

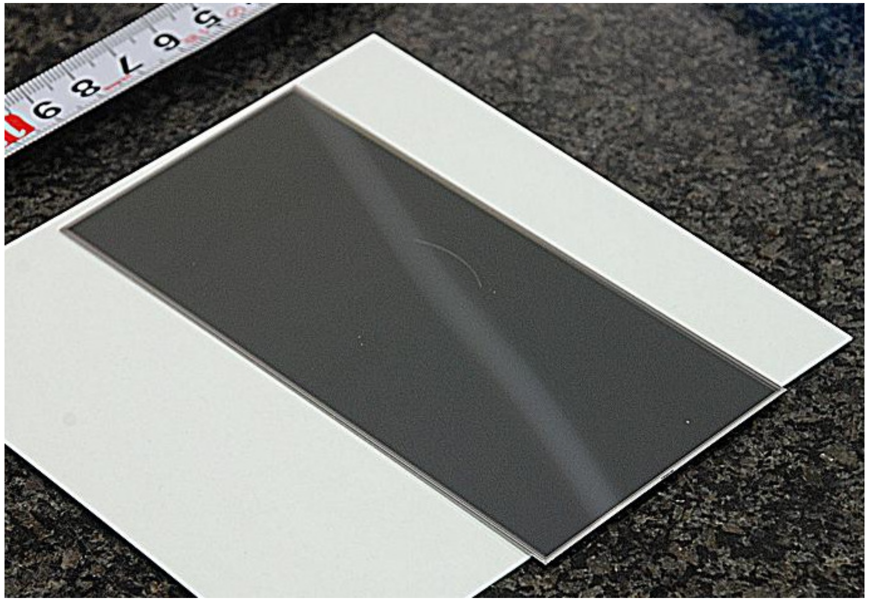
- **ALIGNMENT: “global”** in the all Si case**, “mixed-mode”** in the hybrid case.
- **COOLING**: here also much more constraining in the hybrid case (much more dependant on the neighbors)

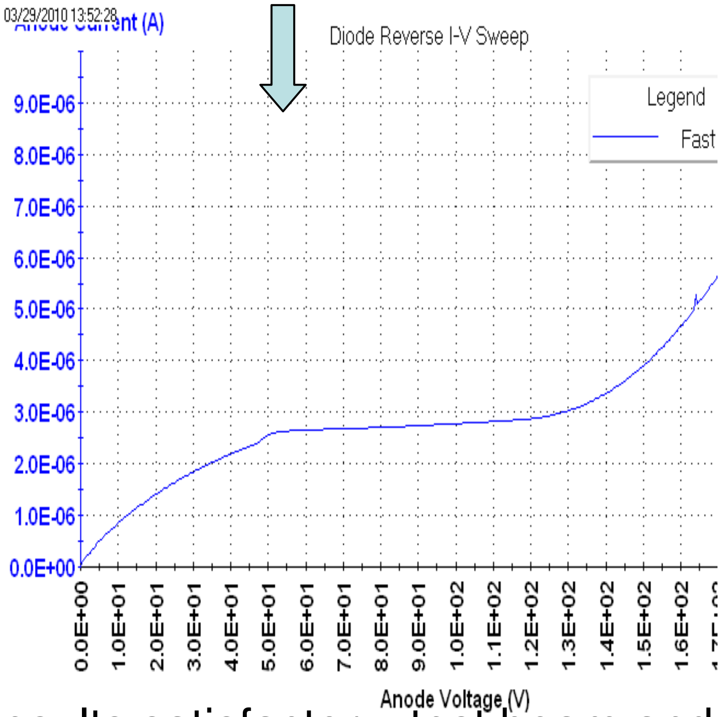
New sensors: DSSD

After 2 years of intense search for 6’’DSSD => 2009/8: HPK starts 6” DSSD production line.

- 2009/9: 6” design submitted to HPK
- 2010/3: Prototype sensors from pilot batch delivered to KEK
- Evaluation in progress

	p side (r-ϕ)	n side (z)
Sensor Area	124.88x59.60 mm	
Active Area	122.90x57.72 mm	
Wafer	6” diameter 320 μm thick	
Full depletion Volt.	100 V	
Strip pitch (μm)	75	120
Readout pitch (μm)	75	240
Readout channels	768	512

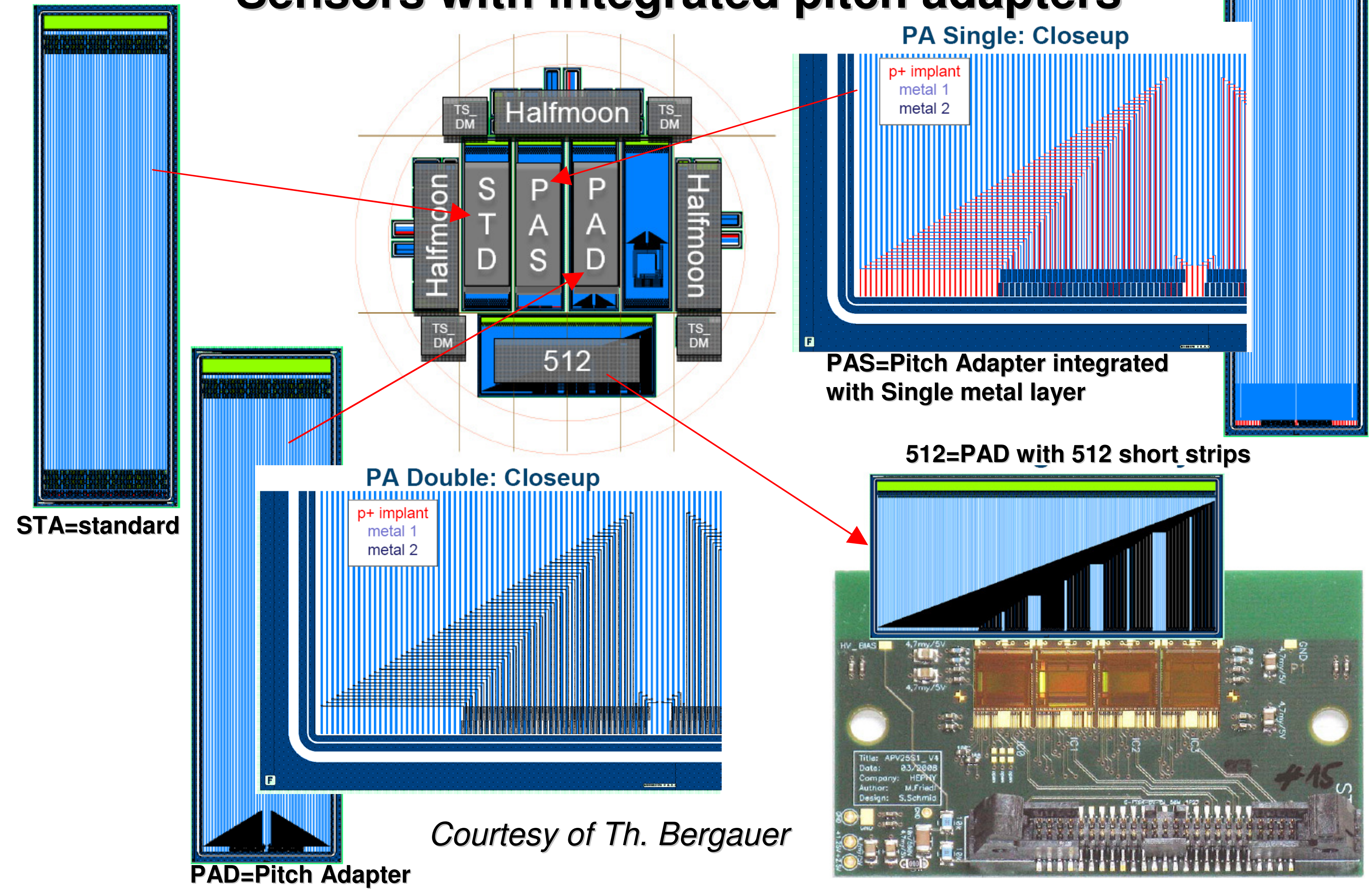




Results satisfactory; test beam and new batch within fiscal year

+ ITE (Poland)

Sensors with integrated pitch adapters



PA Single: Closeup

PAS=Pitch Adapter integrated with Single metal layer

512=PAD with 512 short strips

PA Double: Closeup

STA=standard

PAD=Pitch Adapter integrated with Double metal layer

Courtesy of Th. Bergauer