Material description in the simulation

S. Elles, R. Lafaye, J. Levêque, S. Jezequel

P.Y. David, P. Delebecque, N. Geffroy, N. Massol, J.M Nappa, T. Rambure, A. Rummler, S. Vilalte, T. Yildizkaya

LAPP, Annecy-le-Vieux

LAPP ITk Pixels - December 2014

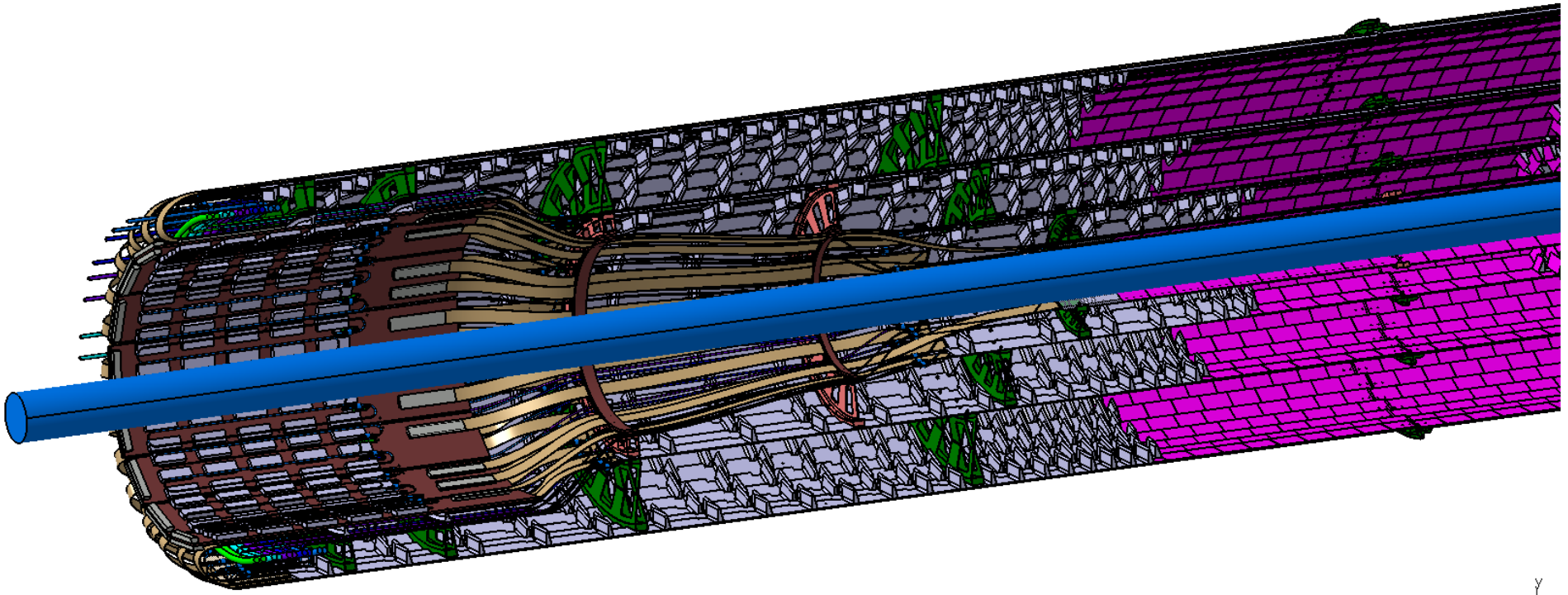
The Alpine stave project :

- the layout
- from CATIA to GeoModel (ATLAS geometry framework)
- the layer material plots

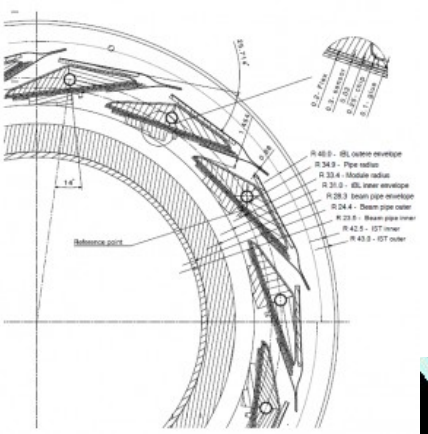
Alpine Stave layout

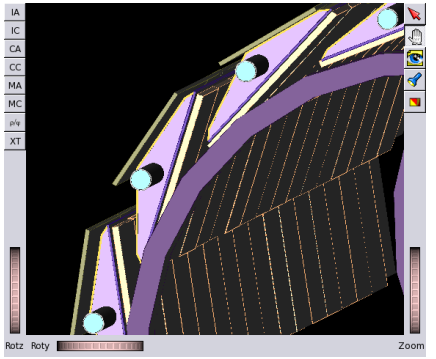
- Design available in CATIA
  the design is still evolving (optimisation, ring supports, ...)
- Electronic services
  the design is under development (depend on the data rate)
  a first prototype is already available

Alpine staves are IBL like ⇨ use the tools developed to implement the IBL geometry in GeoModel

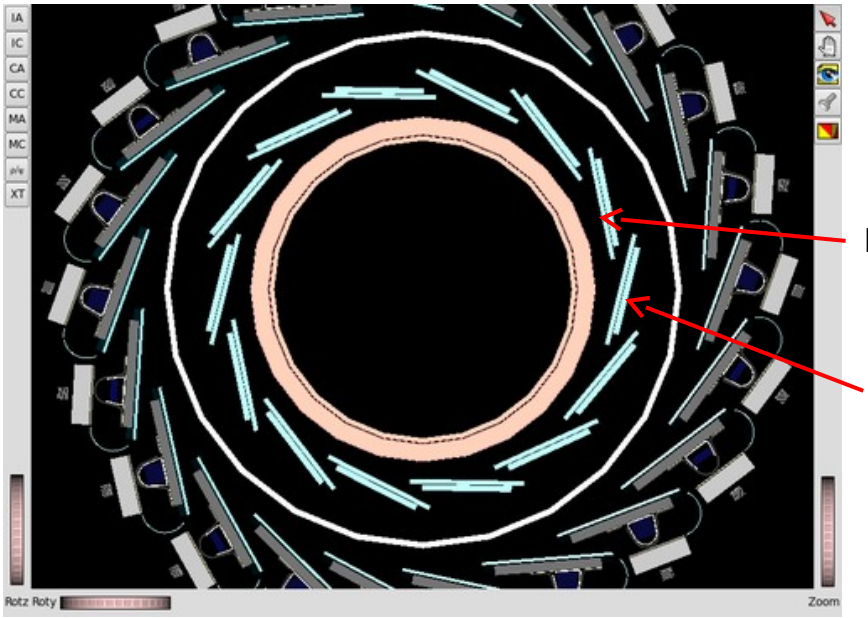


the IBL (Insertable B-Layer) layer : from CATIA to GeoModel





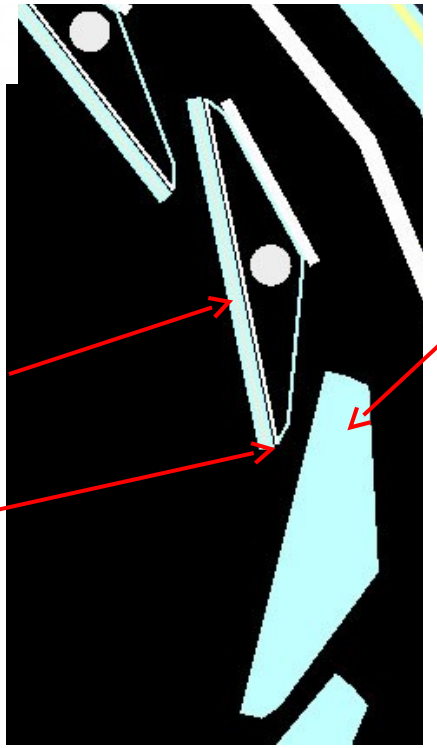
ATLAS GeoModel



Pixel module

Stave

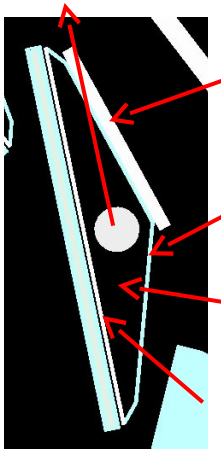
Initial design



Convex 3D envelop

Detailed model

Cooling pipe
(outer shape)



Cable flex

Omega

Foam

Face plate

Alpine Stave layout : from CATIA to GeoModel

- layers (IBL design recipe - done mostly manually) :
  get the shape of a stave (foam/plate/...) from the CATIA design
  use the IBL GeoModel code to build the staves
  - ⇨ “real” geometry, no material smearing

- ring supports : implementation will depend on the complexity of their geometrical shape
  - ⇨ might not be implemented in details, but approximated by a simpler geometrical shape with correct material budget

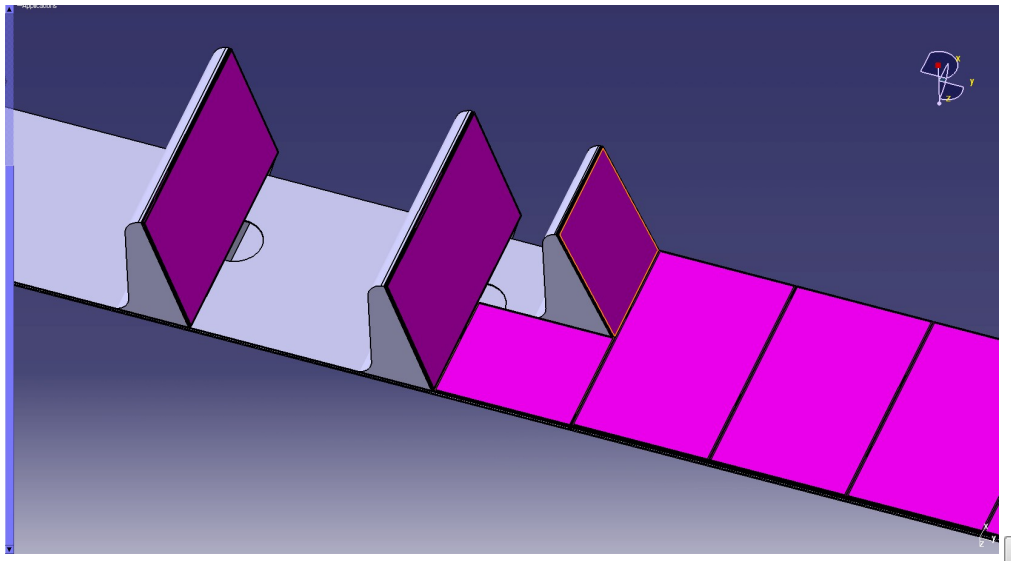
- electronic services not implemented yet
  design under development
  need to work with the electronic engineers
  - ⇨ might not be implemented in details, but approximated by a simpler geometrical shape with correct material budget

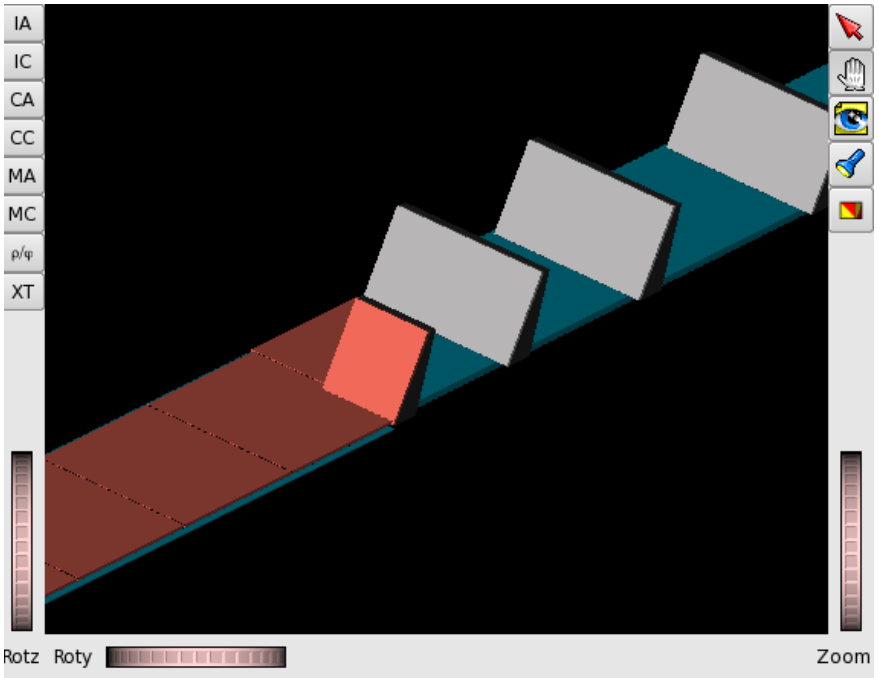
IBL design recipe to compute the service material budget

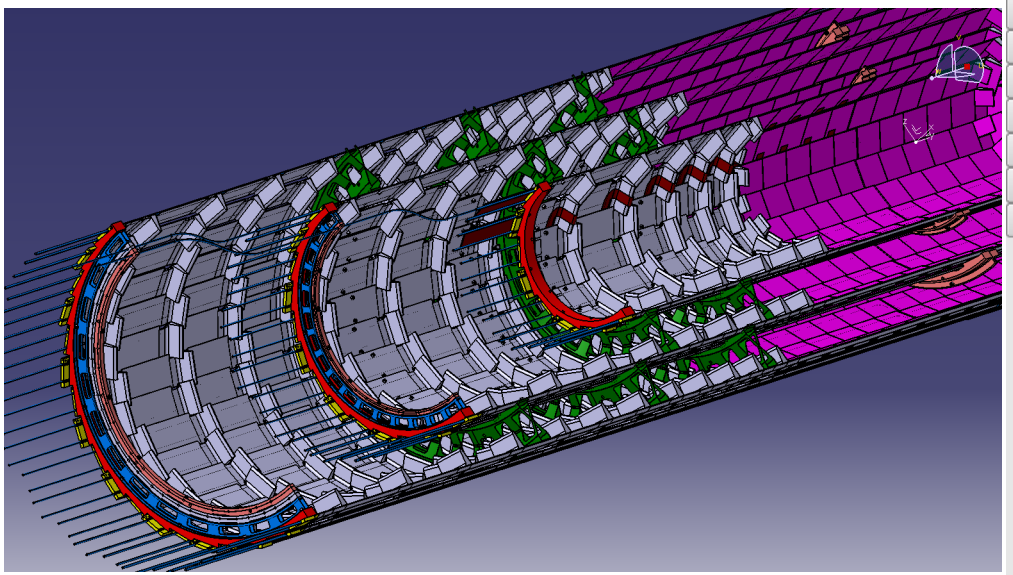
Alpine Stave layout : from CATIA to GeoModel

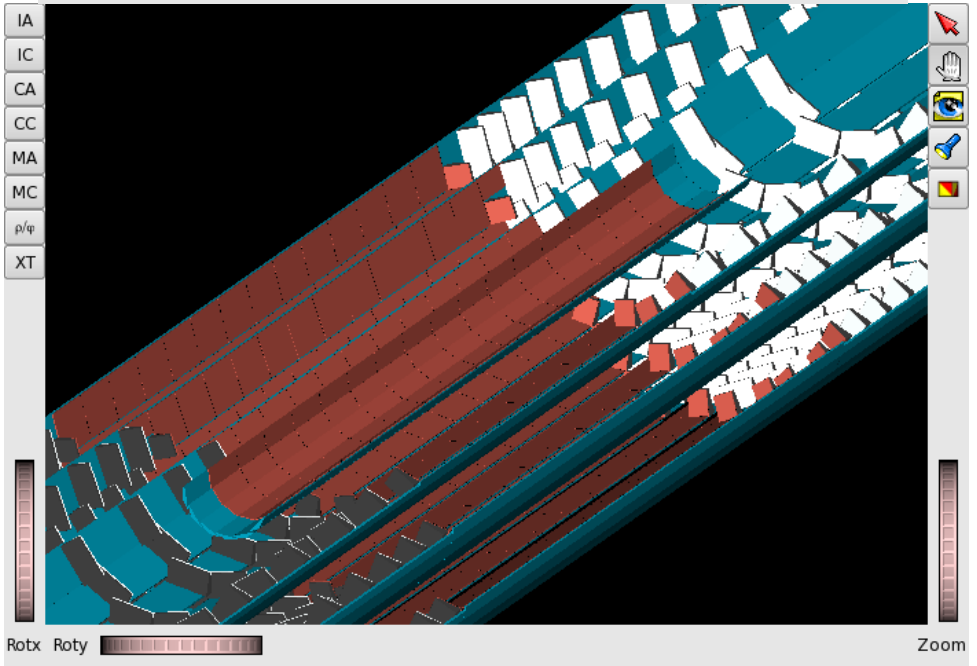
GeoModel

CATIA









The services

It is not possible to describe all the objects in details (memory and CPU consumption issues)

➡ need to identify which object has to be detailed, which can be smeared/approximated

depends on its position, its material, ...

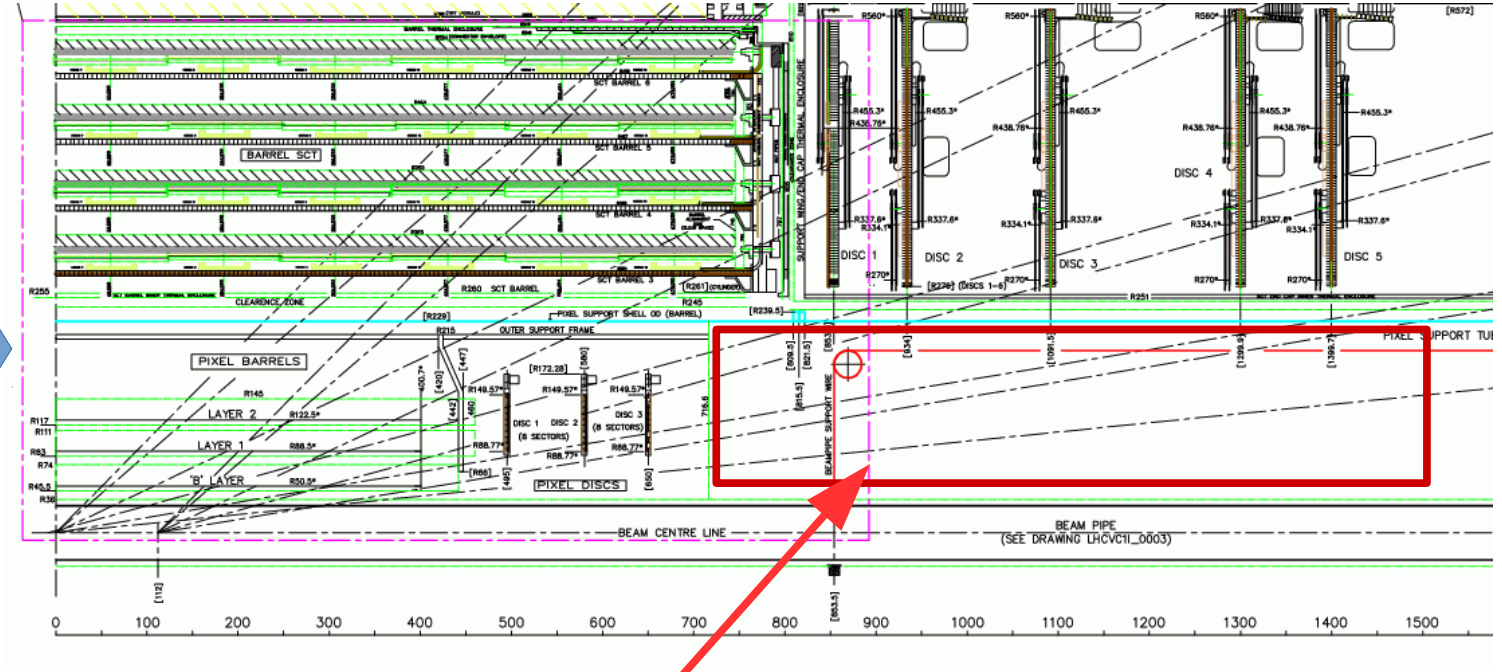
GeoModel :

- set of predefined shapes : tubes, boxes, cones, trapezoides, revolution volumes (around phi)
- dedicated C++ code / database tables if needed (IBL EOS services)

➡ several objects are often smeared into a same geometrical object the shape of an object is approximated by a simple shape (tube, box, ...)

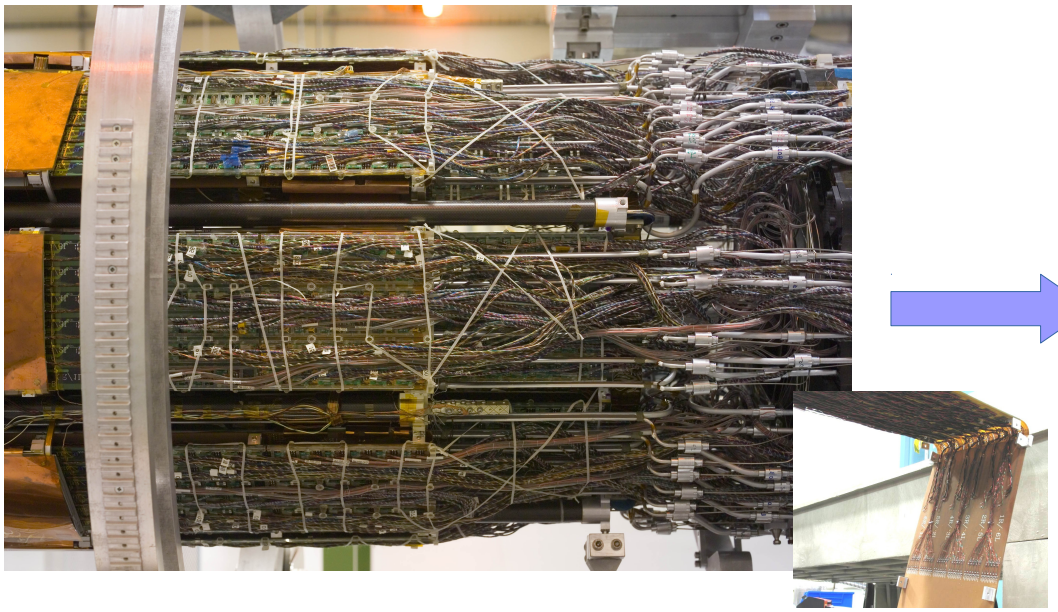
↳ in this case, the material assigned to the volume has to be computed precisely in order not to under/over estimate its quantity

the tracking area is described in details

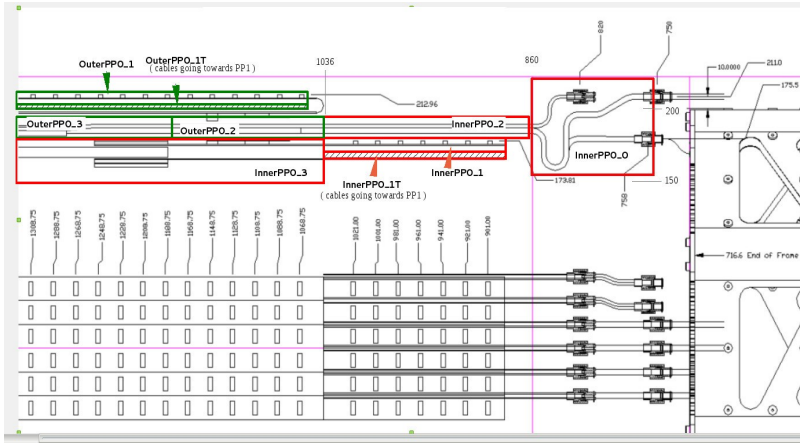


nSQP (smeared into boxes)

The complete geometrical description of the services was reviewed in 2013

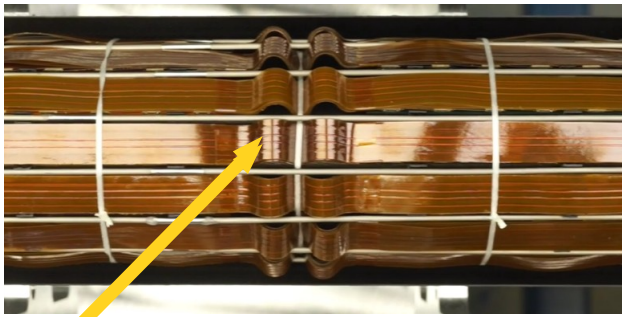


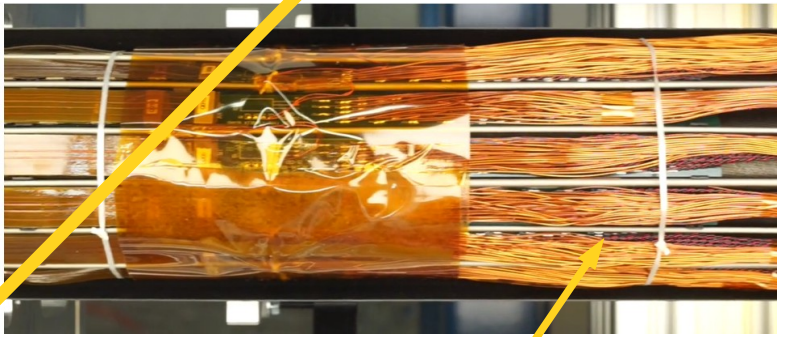
GeoModel mapping



The IBL flexes and cable

...





...

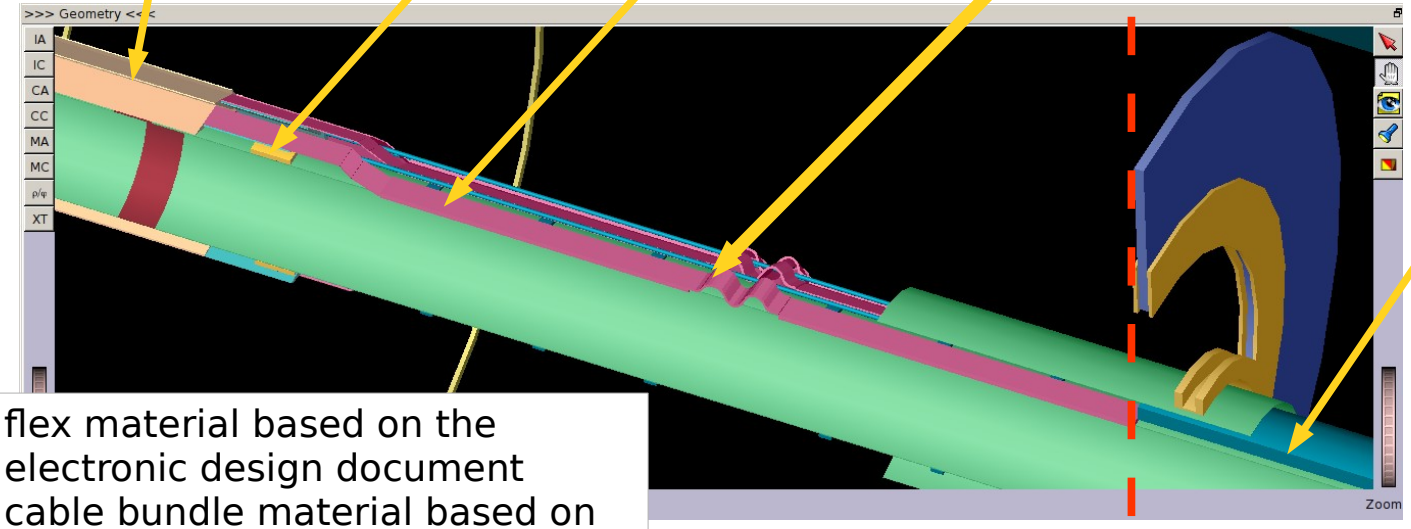
IBL staves

stave ring
(support structure)

flex

Iflex

type 1 cables



- flex material based on the electronic design document
- cable bundle material based on the bundle description

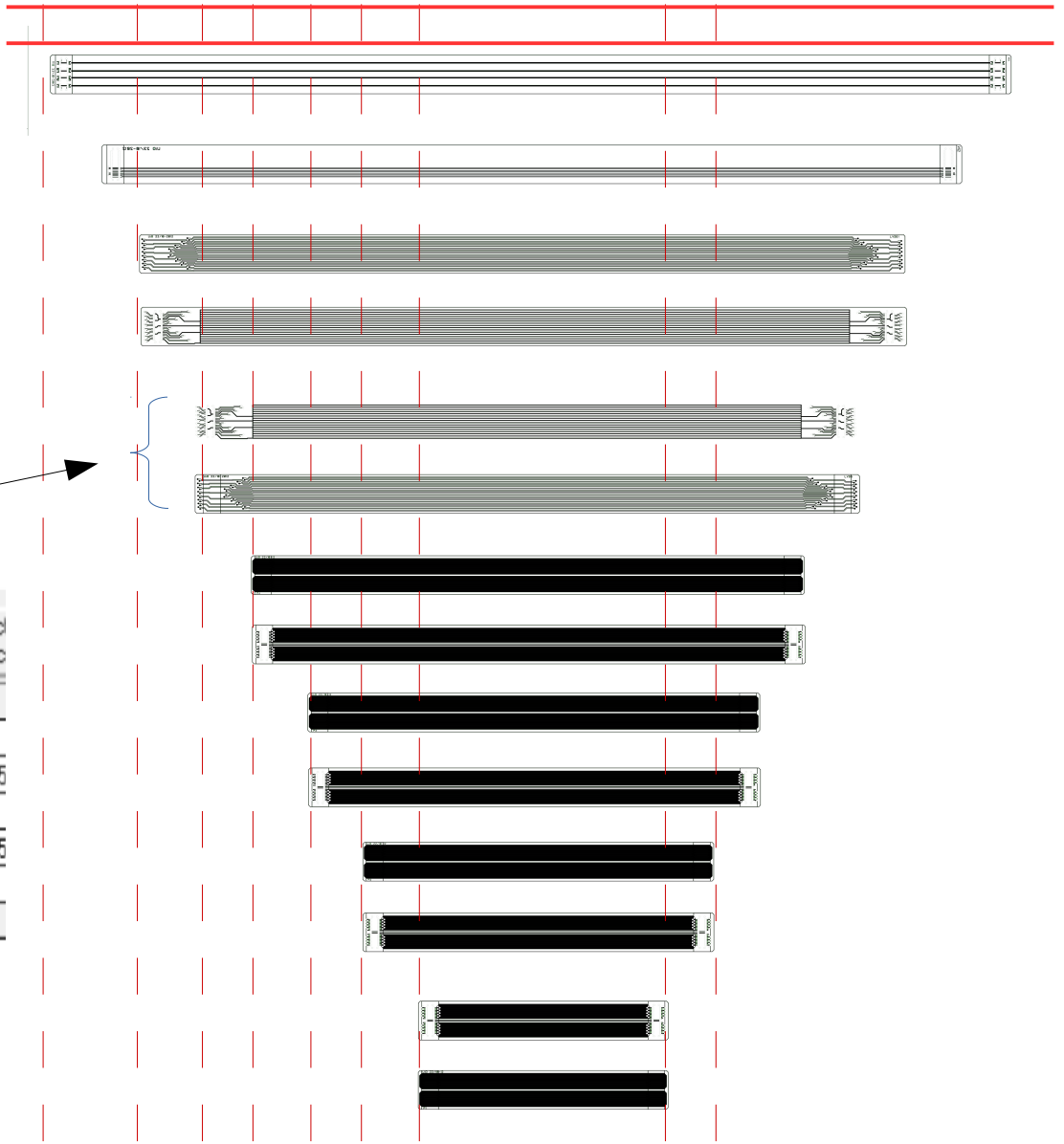
detailed description - cables smeared into a cylinder

The IBL flexes (IFlex)

Copper layers for the 8 flexes

Description of the one of the flex layers

	Subclass Name	Type	Material	Thickness (MIL)	Conduct (mho/c
1		SURFACE	AIR		
2		DIELECTRIC	POLYIMIDE	0.68	
3	TOP	CONDUCTOR	COPPER	1.37	5
4		DIELECTRIC	POLYIMIDE	1	
5	BOTTOM	CONDUCTOR	COPPER	1.37	5
6		DIELECTRIC	POLYIMIDE	0.68	
7		SURFACE	AIR		

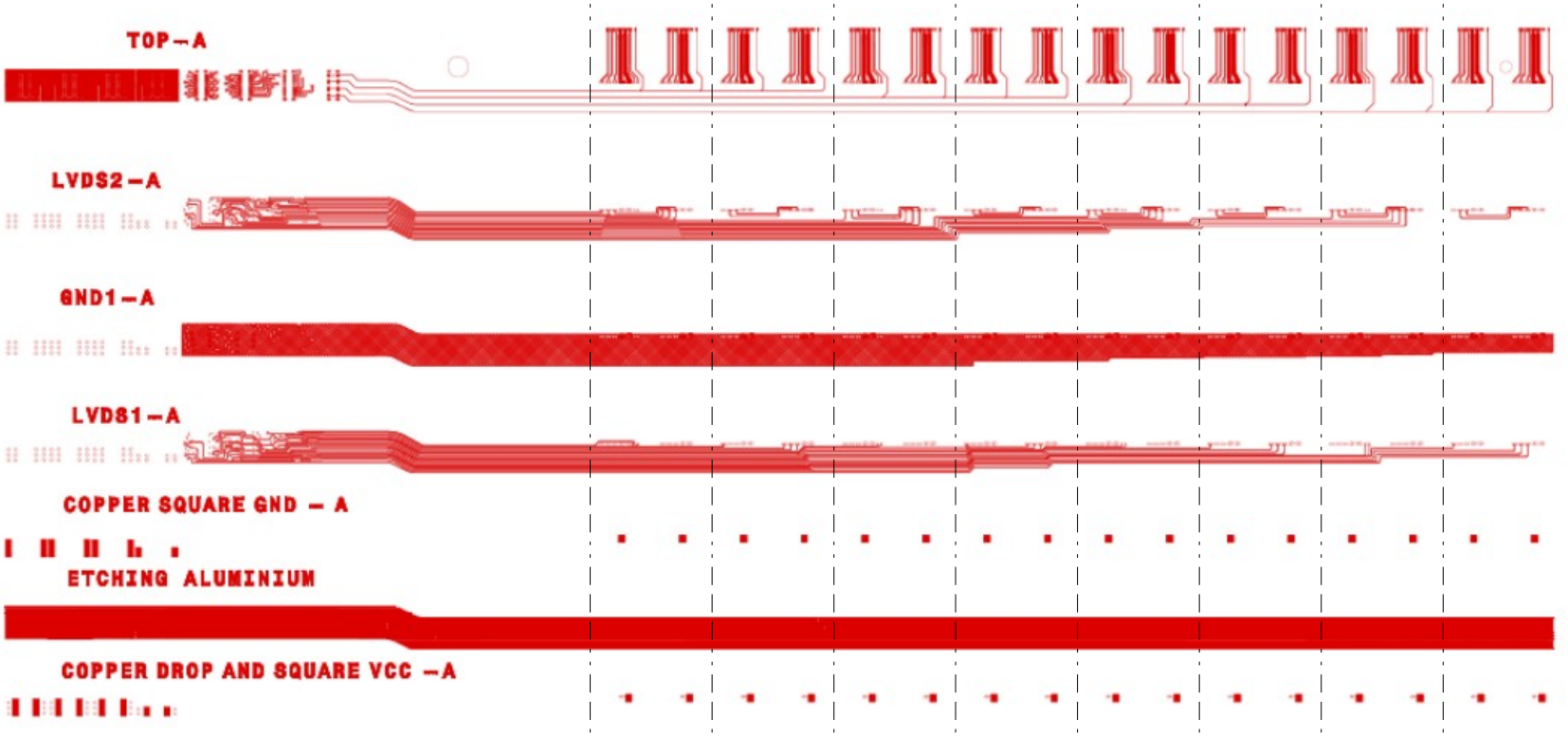


Dump of the design of the different flexes (with high resolution) ⇨ amount of material estimated by counting the black pixels (+ smeared for each region)

The IBL stave flexes

Material is computed for each module (double chip module)

Layer Name	Type	Material	Thickness (um)
Coverlay	Dielectric	KAPTON GLUE	12.5 12.5
TOP (HV)	Conductor	Copper	19
	Dielectric	Pyralux 25 µm	25
LVDS2	Conductor	Copper	18
GLUE	Dielectric	GLUE	25
GLUE	Dielectric	GLUE	25
GND1	Conductor	Copper	5
	Dielectric	Pyralux 75 µm	75
LVDS1	Conductor	Copper	19
GLUE	Dielectric	GLUE	25
	Dielectric	Kapton 25 µm	25
GLUE	Dielectric	GLUE	25
Aluminium	Plane	Aluminium	50
GLUE			
	Dielectric	Kapton 12.5 µm	from 40 to 60
GLUE			
Aluminium	Plane	Aluminium	50
Coverlay	Dielectric	GLUE KAPTON	12.5 12.5
			496



The material study - X/X_0 study

high energy electrons loose energy predominantly by bremsstrahlung

radiation length X_0: mean distance over which electron looses all but 1/e of its energy by bremsstrahlung

also characteristic length for pair production: survival probability for photon is 1/e over a length $7X_0/9$

thickness of detector often expressed in 'fraction-of-radiation-length' X/X_0

examples

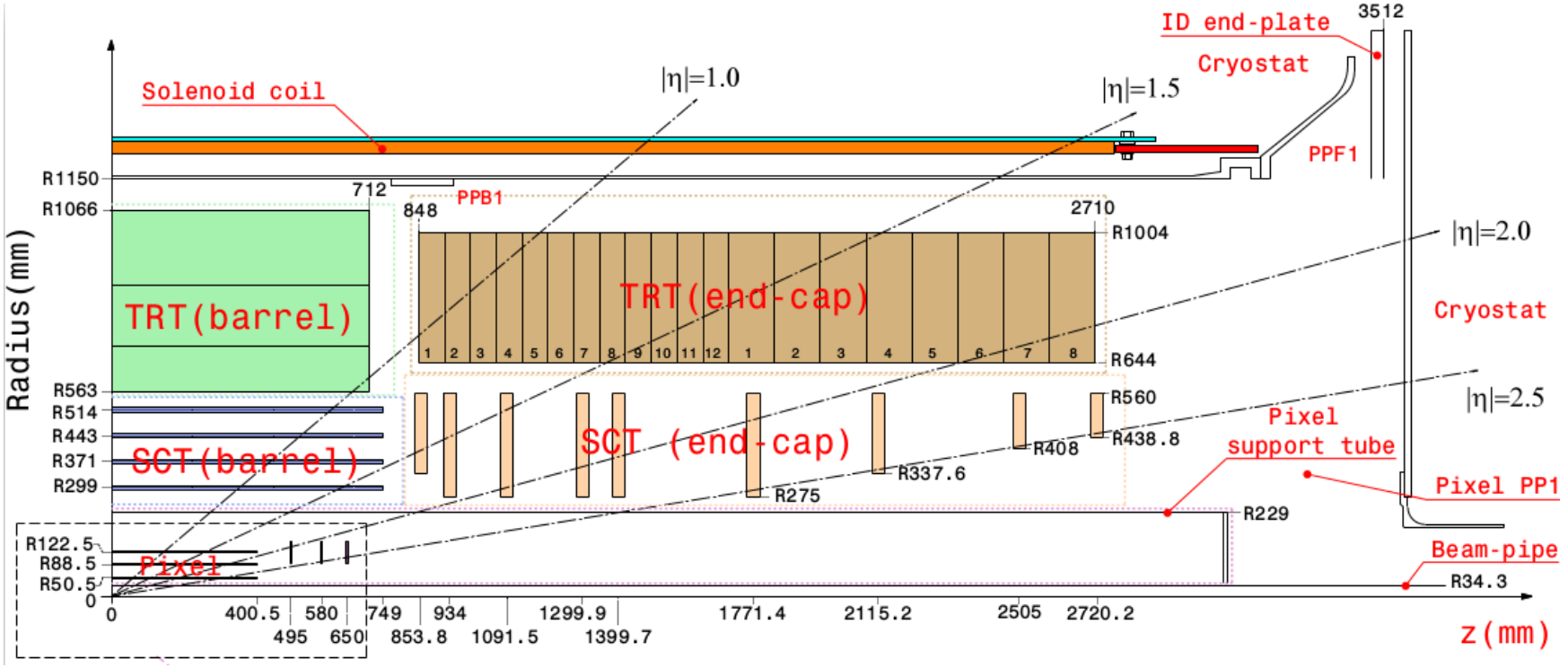
1 meter air:	$x/X_0 = 0.003$
300 micron silicon:	$x/X_0 = 0.003$
1 mm iron:	$x/X_0 = 0.06$

(copy/paste from a CERN talk)

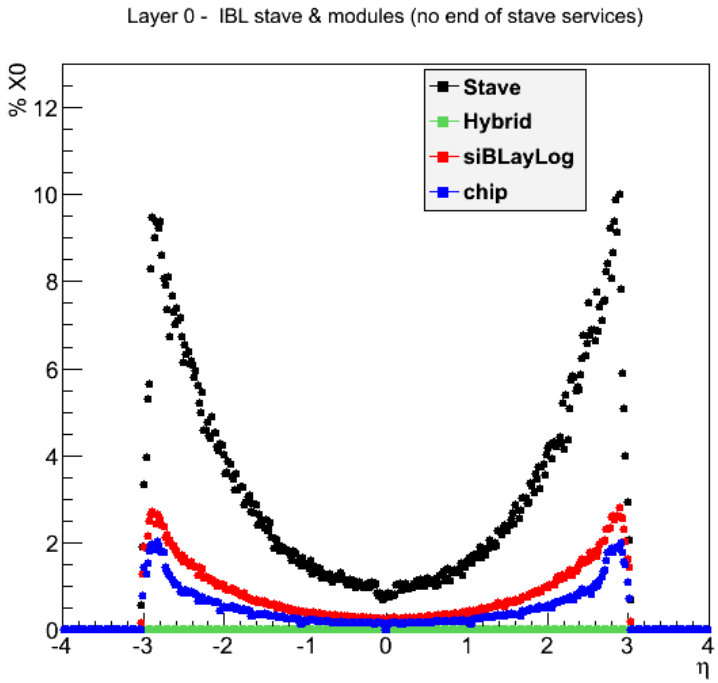
The material study - X/X_0 study

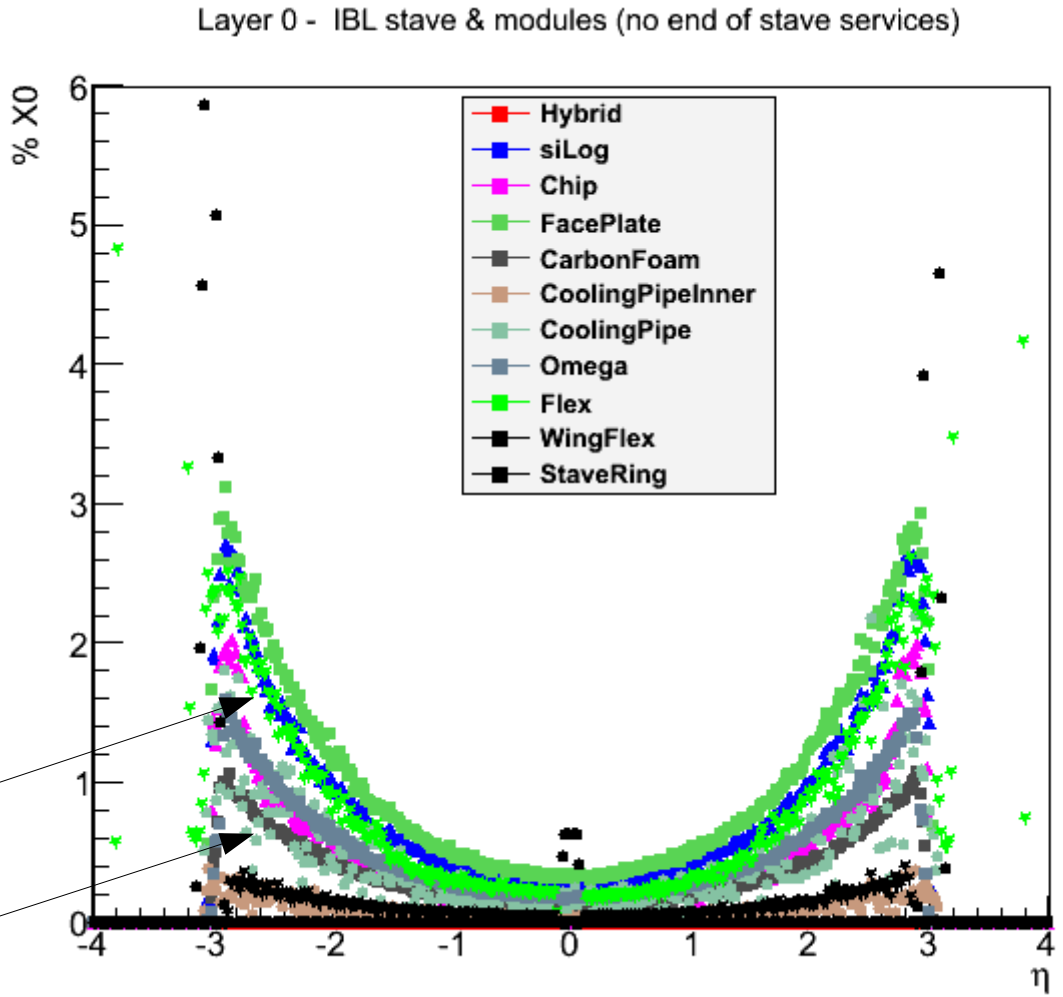
The X/X0 are computed for each crossed volume along a line (fixed η value)

(Note : for a volume defined uniformly along the Z axis, the thickness of material grows with eta)



The IBL stave material study



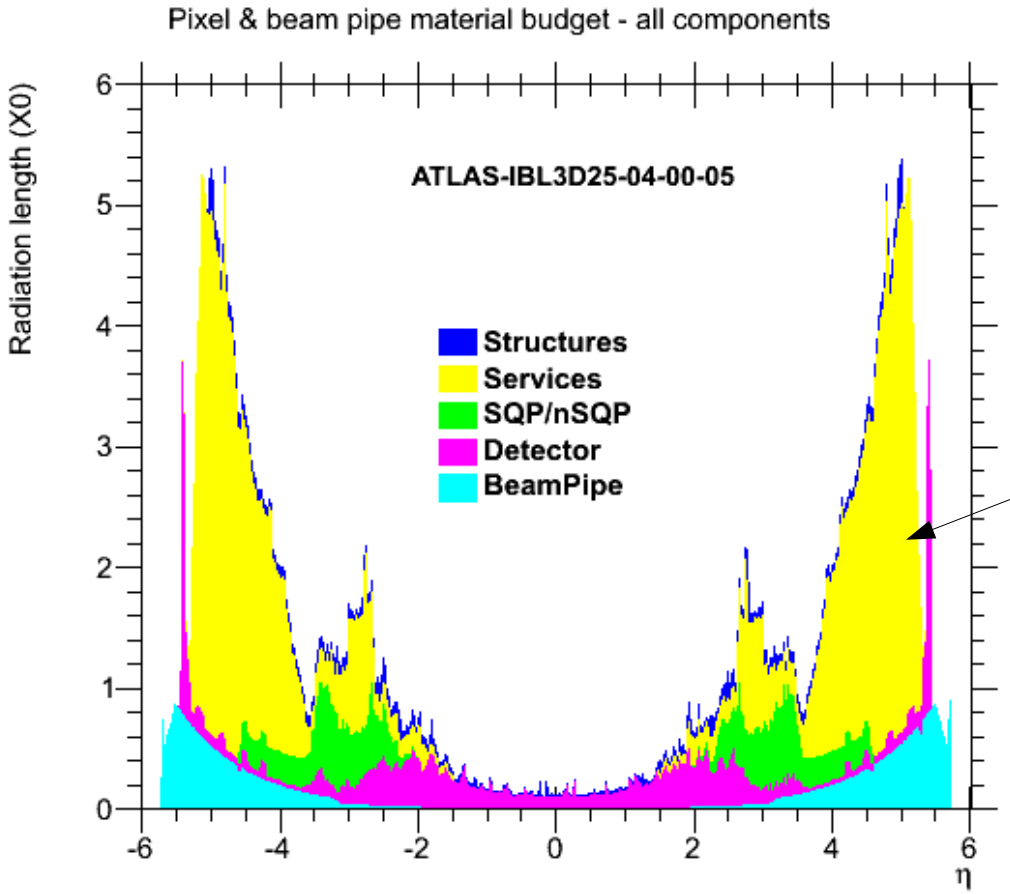


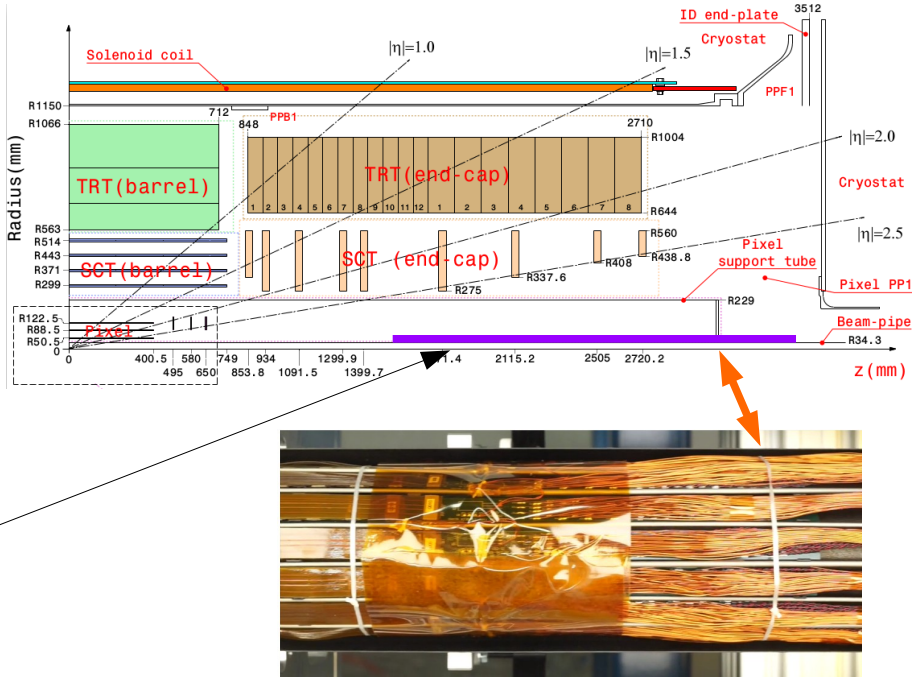
IBL flexes (light green)

Cooling pipe (light gray)

- Stycast glue included in face plate, cooling pipe and omega materials -
(charged glue)

The IBL material study





Alpine Stave layout - layer material plots

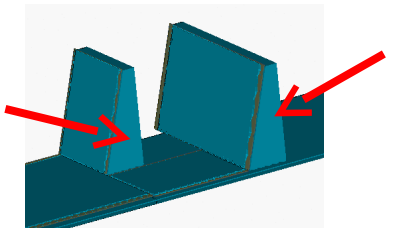
- computed with the same script than the one used for the IBL/pixel geometry
- only possible once the GeoModel is built ☹

Stave geometry :

current model do not include flex

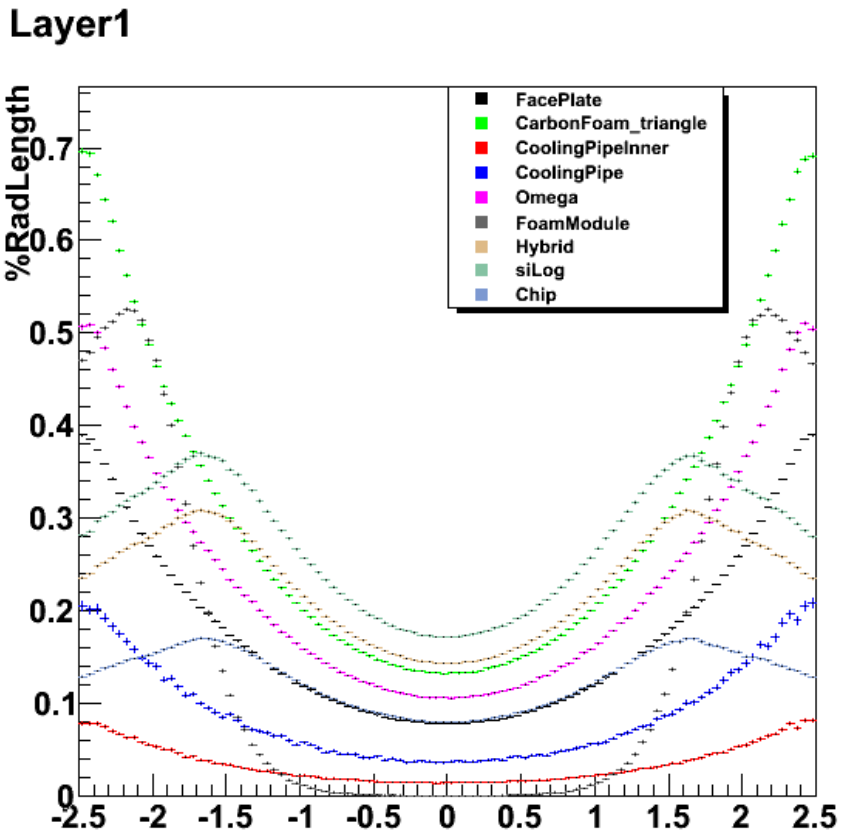
materials :

"CarbonFoam_triangle"stands for stave support carbon foam component
Cooling pipe diameter 2.2 mm
"FoamModule" stands for endcap module supports



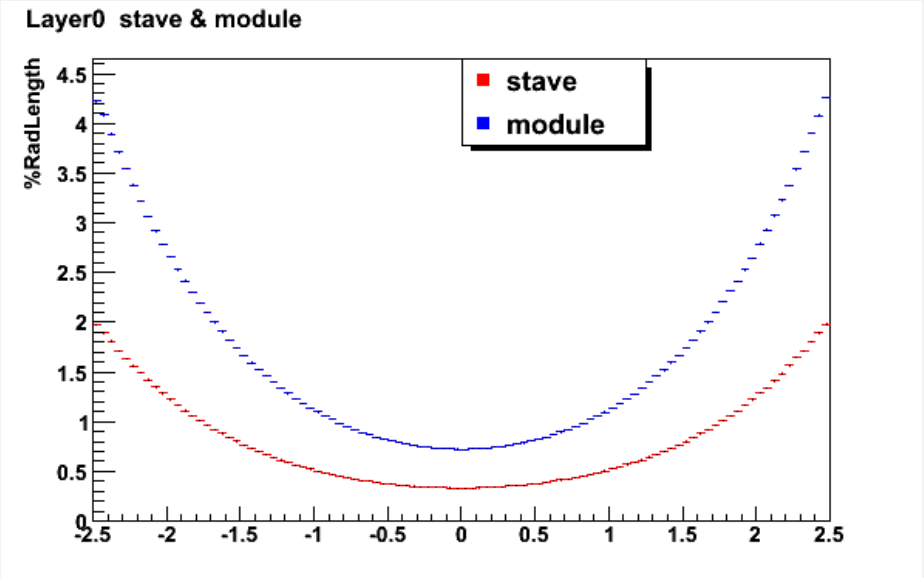
Module geometry :

Hybrid thickness : 0.15 mm
Board thickness : 0.15 mm
Chip thickness : 0,15 mm



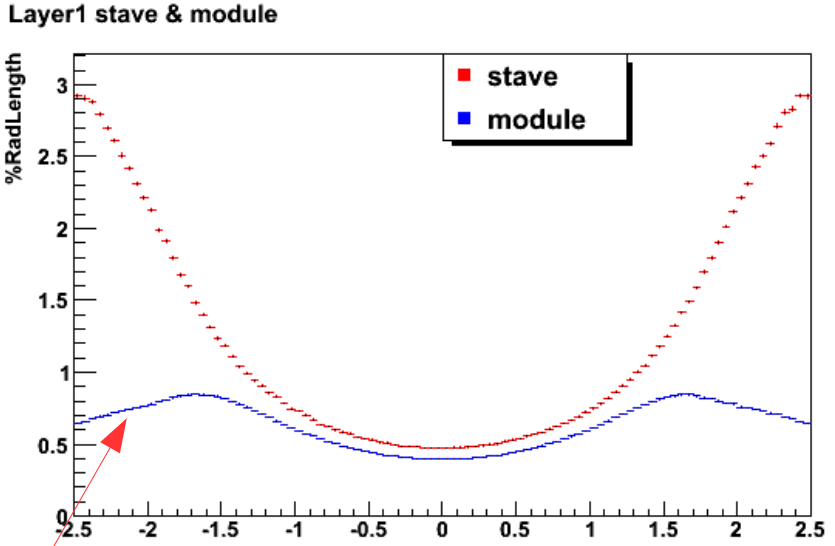
Old GeoModel implementation
- to be updated -

Alpine Stave layout - stave material vs modules



Standard planar module layer

(board 0.25 / hybrid 0.2 / chip 0.25)



Alpine stave modules

(board 0.15 / hybrid 0.15 / chip 0.15)

Old GeoModel implementation
- to be updated -

Alpine endcap modules are bent

(less material crossed at high eta)

Questions ...