E-JADE is a Marie Sklodowska-Curie Research and Innovation Staff Exchange (RISE) action, funded by the EU under Horizon2020

E-JADE

Report from ILD Software and Technical Meeting

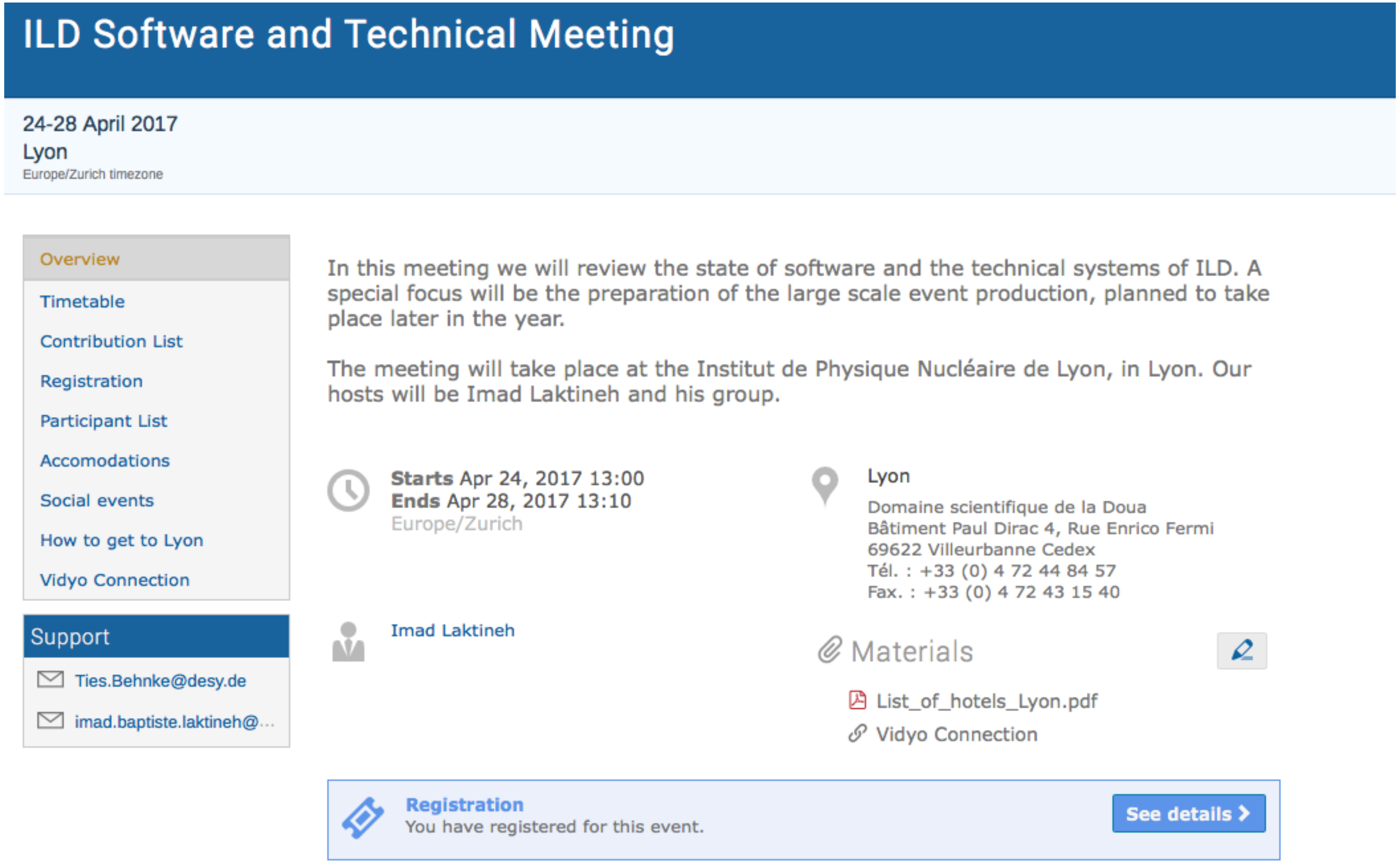
Karsten Buesser

Mini-Workshop on CFS and Infrastructure for Physics and Detectors

KEK
16.05.2017

ILD Software and Technical Meeting

- 24.-28.4. Lyon, F
- 45 participants
- Main topics:
  - Software: definition of the ILD software baseline for the next MC production
  - Technical:
    - Absorber structure of the HCAL
    - Anti-DID
- I will concentrate on topics with input on infrastructures



ILD Software Baseline Models

- Study two alternative ILD geometries
  - ILD-L: DBD-like
  - ILD-S: smaller radius of the tracking system (TPC)
- Trying to define two points in the detector optimisation phase space with full detector simulation
- All with new simulation software (DD4HEP)
- Comparable to DBD and CLIC

Have converged on two geometric ILD models (ILD-S and ILD-L) as "boundaries" for the optimization

Both models now are available in DDSIM

ILD-S

- Same length as ILD-L
- Size similar to CLIC for maximum synergies
- Concept same as ILD-L

A Reminder

	ILD_lx_v01	ILD_sx_v01
Detektor	DBD (ILD-L)	Small ILD (ILD-S)
B-Field	3.5 T	4 T
VTX inner radius	1.6 cm	1.6 cm
TPC inner radius	33 cm	33 cm
TPC outer radius	180 cm	146 cm
TPC length (z/2)	235cm	235 cm
Inner ECAL radius	184 cm	150 cm
Outer ECAL radius	202.5 cm	168.5 cm
Inner HCAL radius	206 cm	172 cm
Outer HCAL radius	335 cm	301 cm
Coil inner radius	344 cm	310 cm

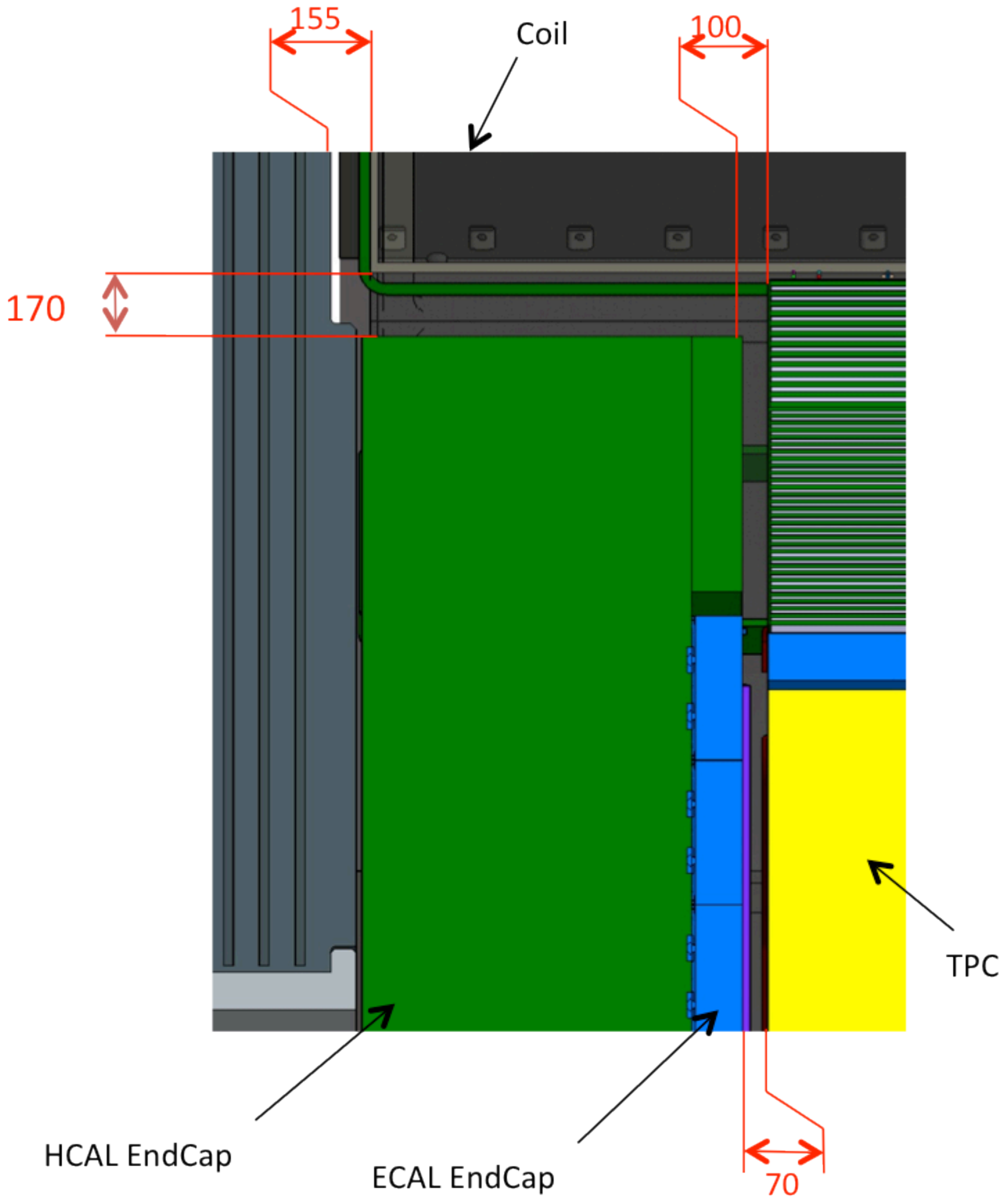
X=1,2,4

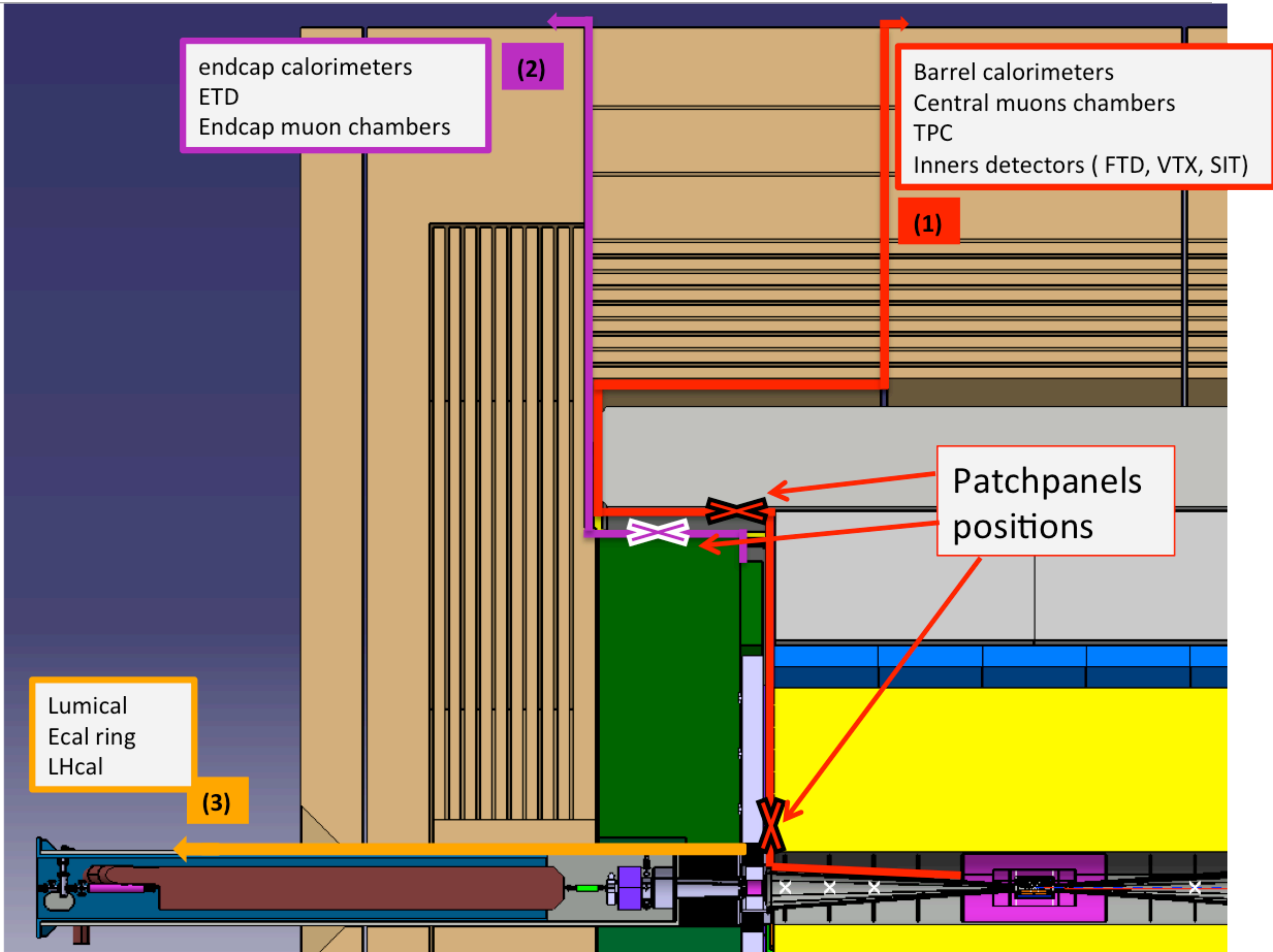
7/12/2016 12

ILD Cables and Services

Paths for Cables and Services

- DBD (2013)





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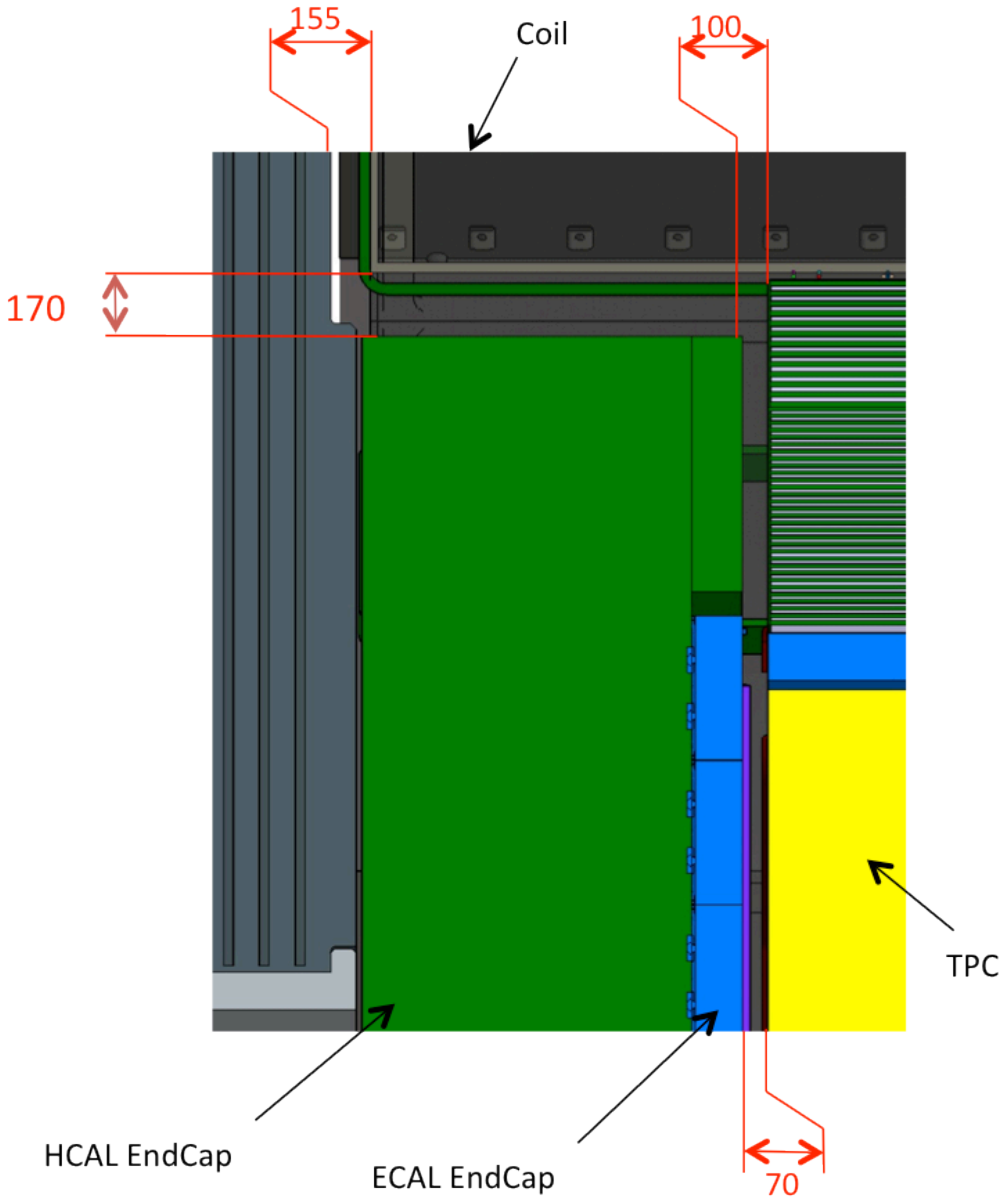

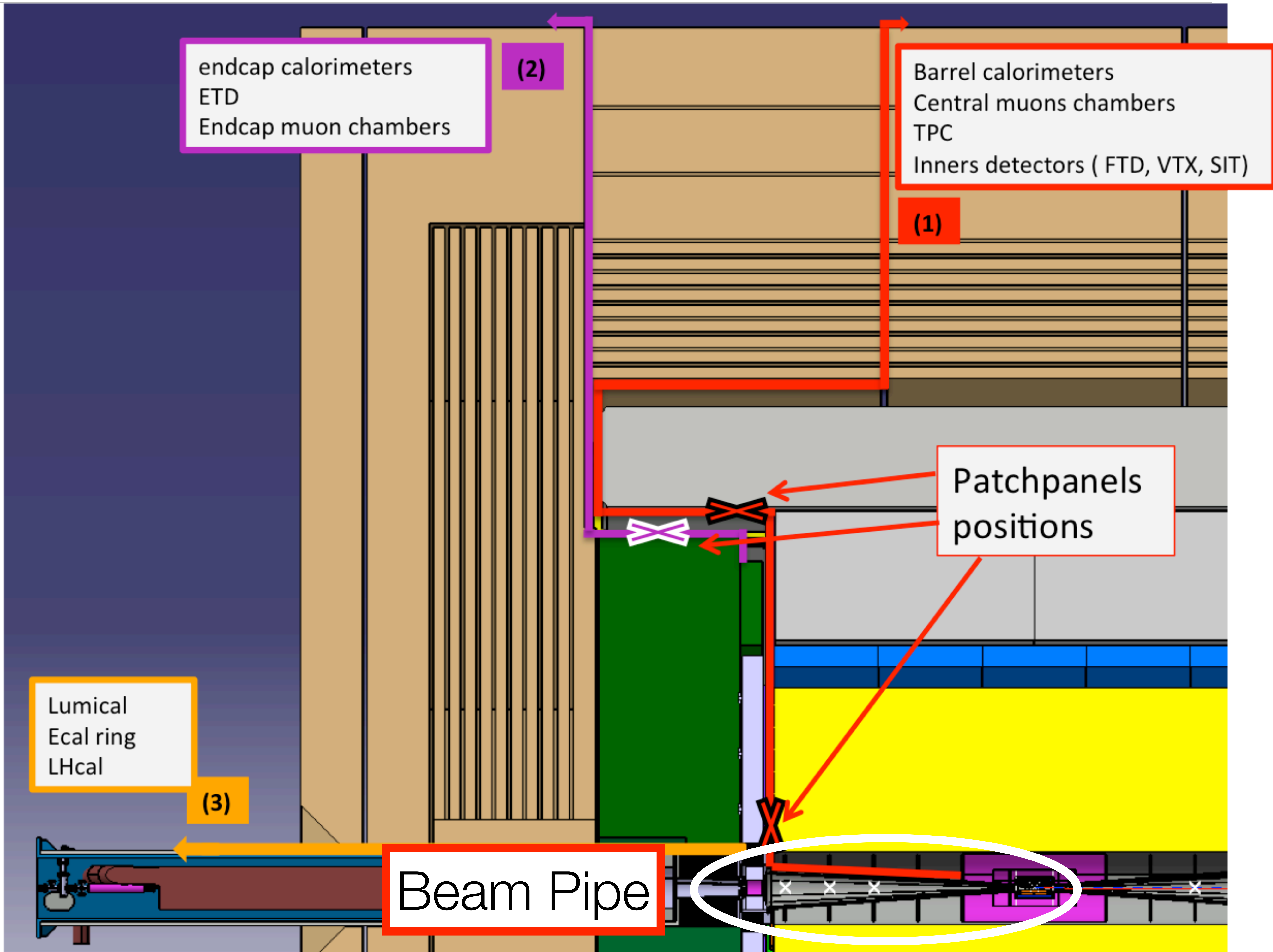

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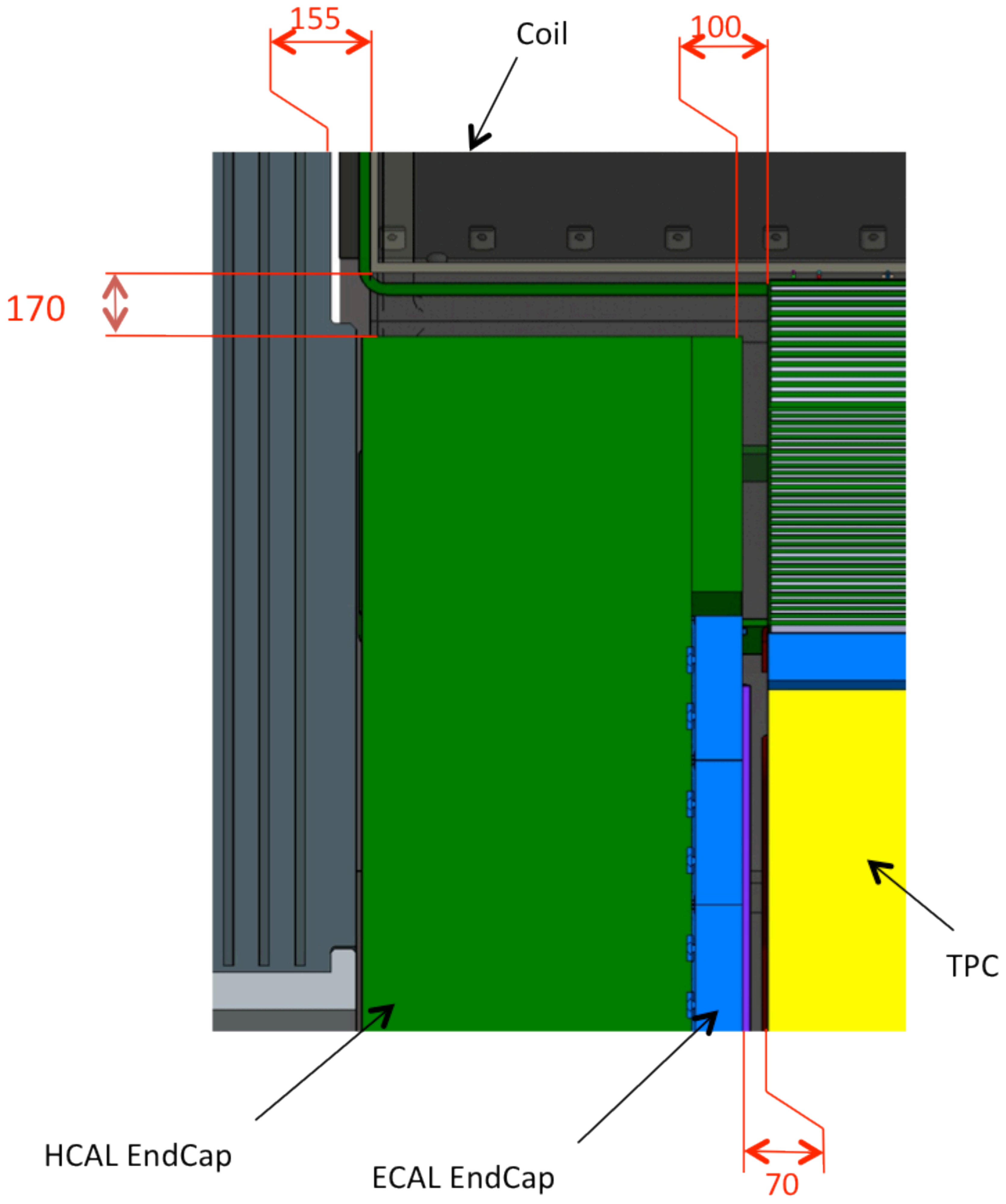
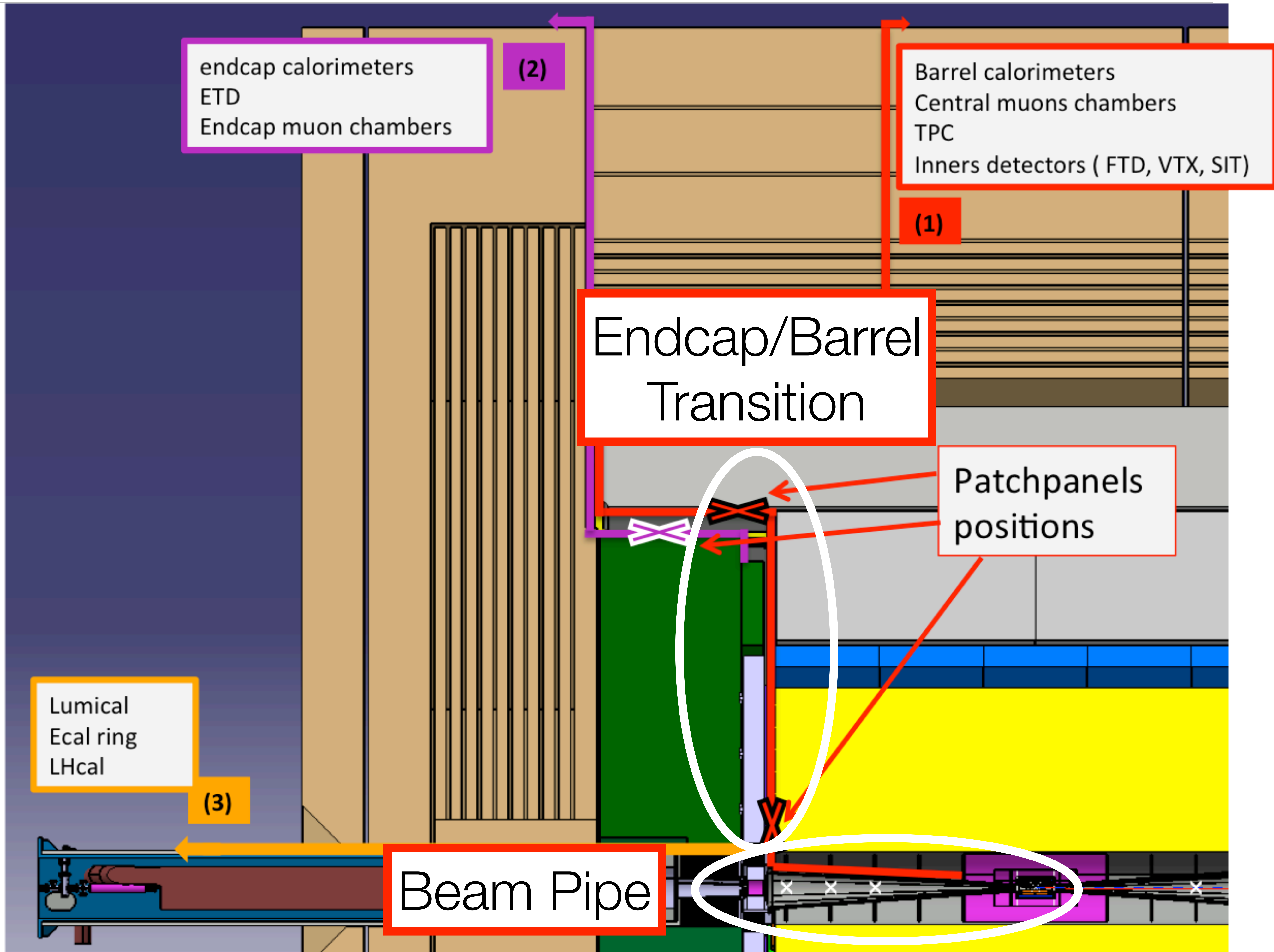
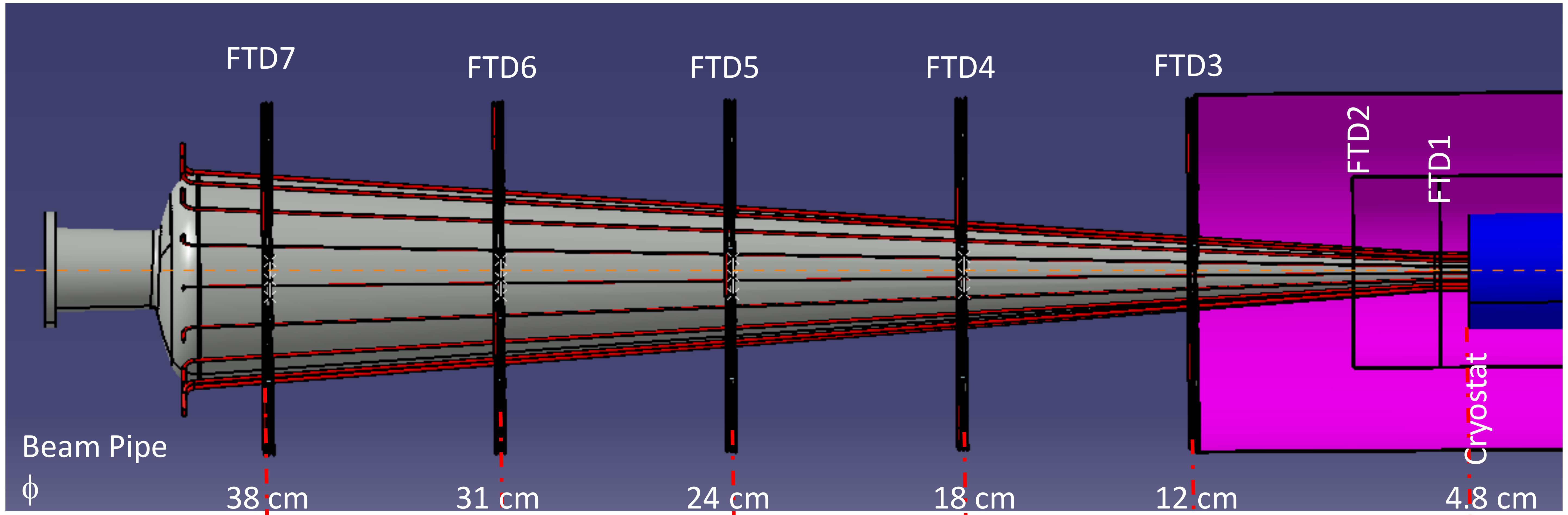




Cables Along Beam Pipe

Inner detectors (6) : X0 along the beam pipe

C. Clerc, M. Joré
2011



BP circumf	119 cm	97 cm	75 cm	56 cm	38 cm	15 cm
5 FTD + VXD	4 FTD + VXD	3 FTD + VXD	2FTD + VXD	1FTD + VXD		VTX : CMOS 85 mm² or FPCCD : 65mm²
875 mm² Cu eq to 0,73mm 5.1% X0	717 mm² Cu eq to 0,74 mm 5.2% X0	559 mm² Cu eq to 0,74 mm 5.2% X0	401 mm² Cu eq to 0,71mm 5.% X0	243 mm² Cu eq to 0,64mm Cu 4,5% X0		CMOS:4% X0 FPCCD:2.9% X0

So, with actual data : about 5% of X0 all along the beam pipe.

That means also

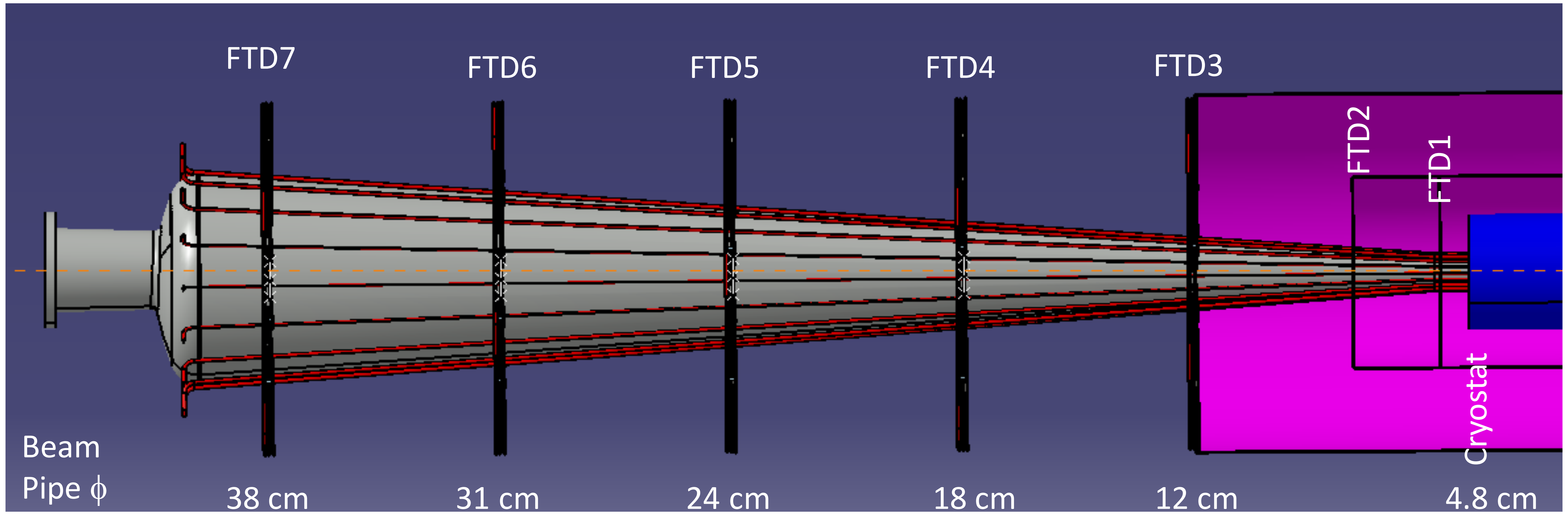
- *about 9 kg of material on each side*
- *a minimum gap between FTD supports and beam pipe of 2 cm for path of all the cables….*

And SIT/ FTD1&2 services not included…

Cables Along Beam Pipe (Status 2011)

Inner detectors (6) : X0 along the beam pipe

C. Clerc, M. Joré
2011



BUT (again):
SIT = 6,9 m² versus FTD (µstrips)= 4,8 m²
FTD 1&2 =0,67 m² per side versus VTX = 0,17 m² per side

We need to gain more than factor 2 !

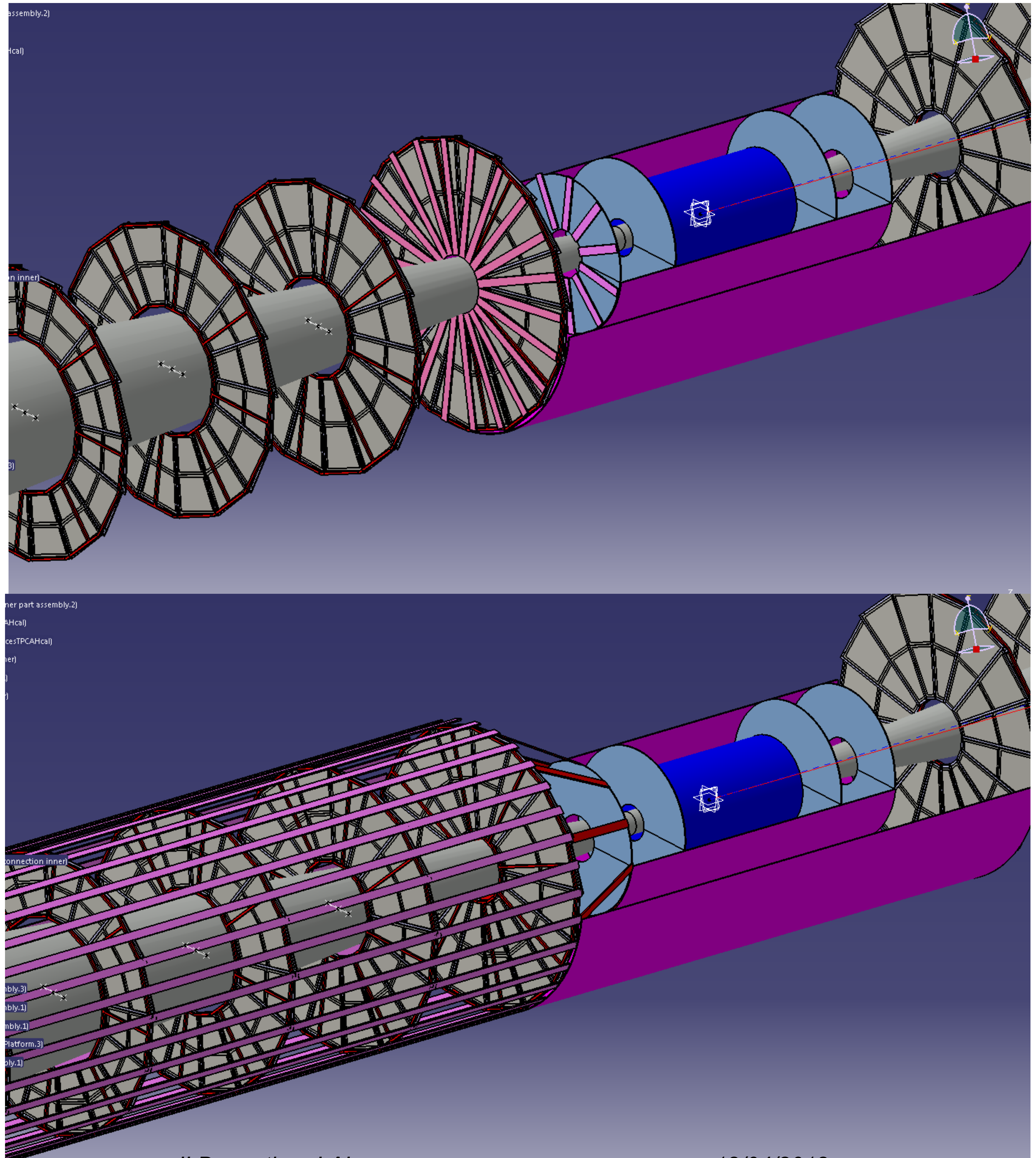
Conductor (Cu >>> Al ?)
+
Optimisation of the power distribution
Study of the heating of the beam pipe

SIT Cables

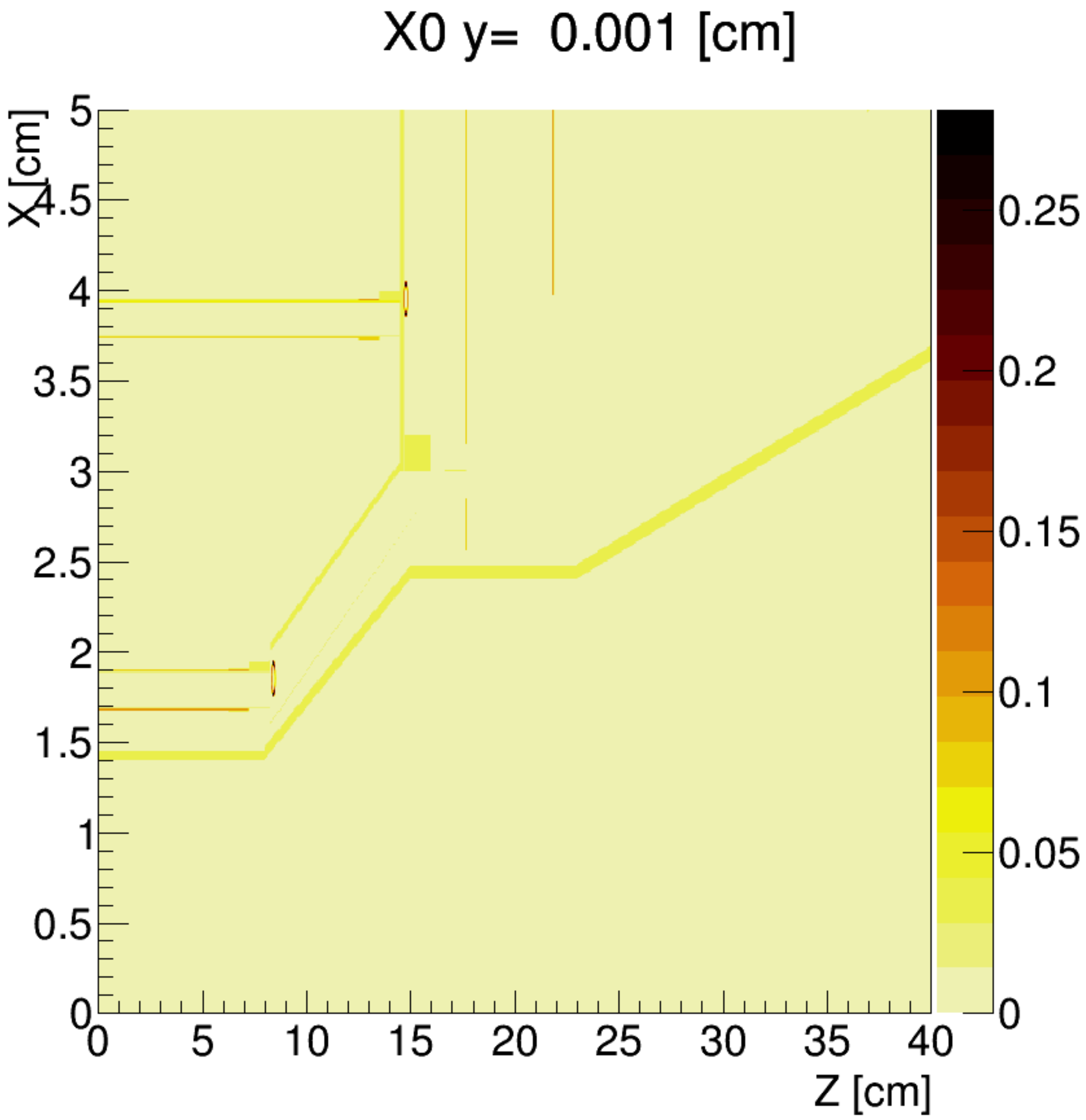
- Very preliminary studies done in 2012 (C. Clerc)
- Probably best routed along the inner field cage of the TPC
- No estimates about material yet
  - maybe extrapolate from FTD…

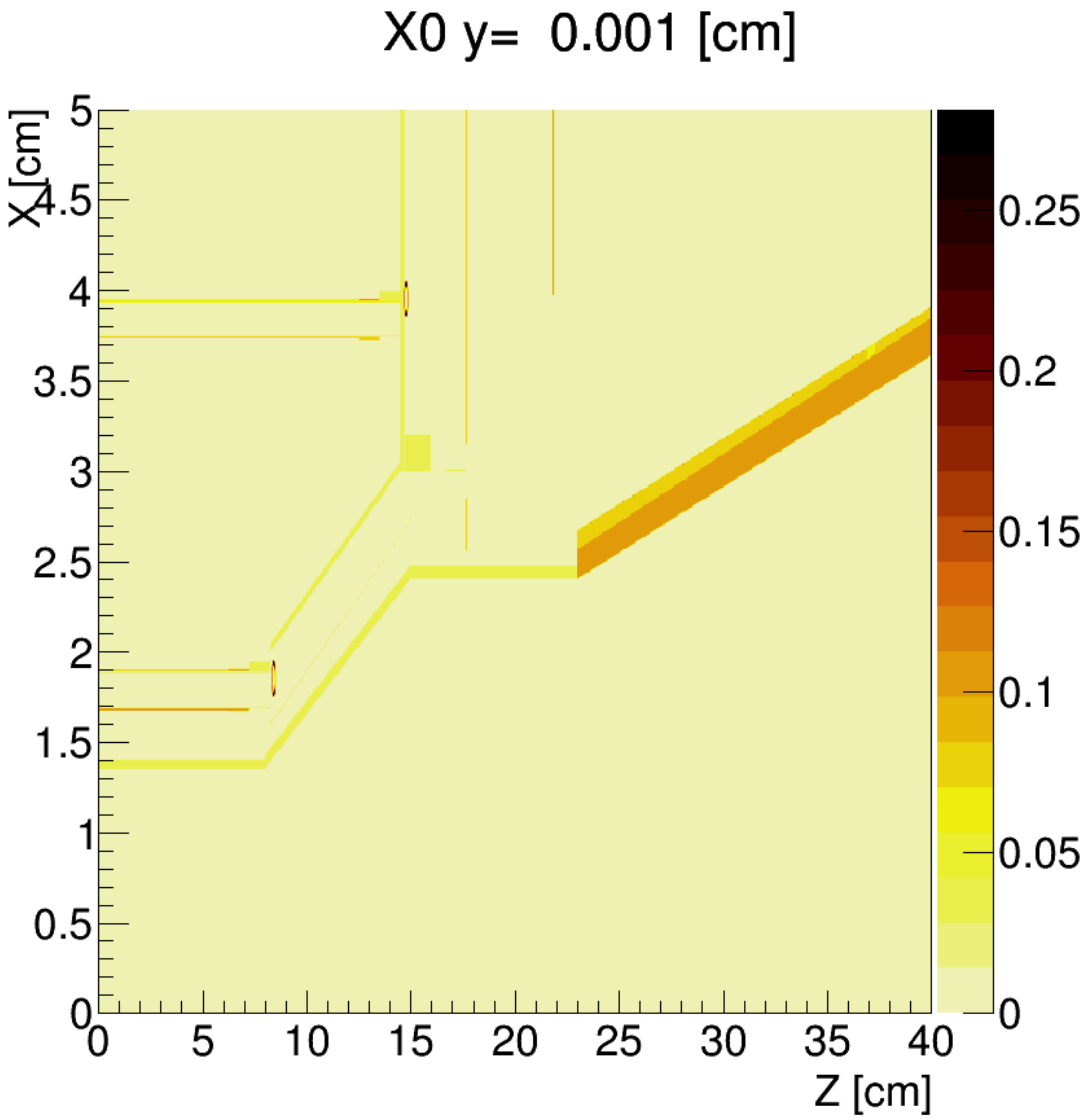
SIT, two solutions

1. Along the beampipe : they have to run on backside of FTD2 and 3 , then :
   - huge amount of material around BP
   - Material in front of the other FTD
2. Run along the inner radius of TPC



Old vs New (Daniel Jeans)





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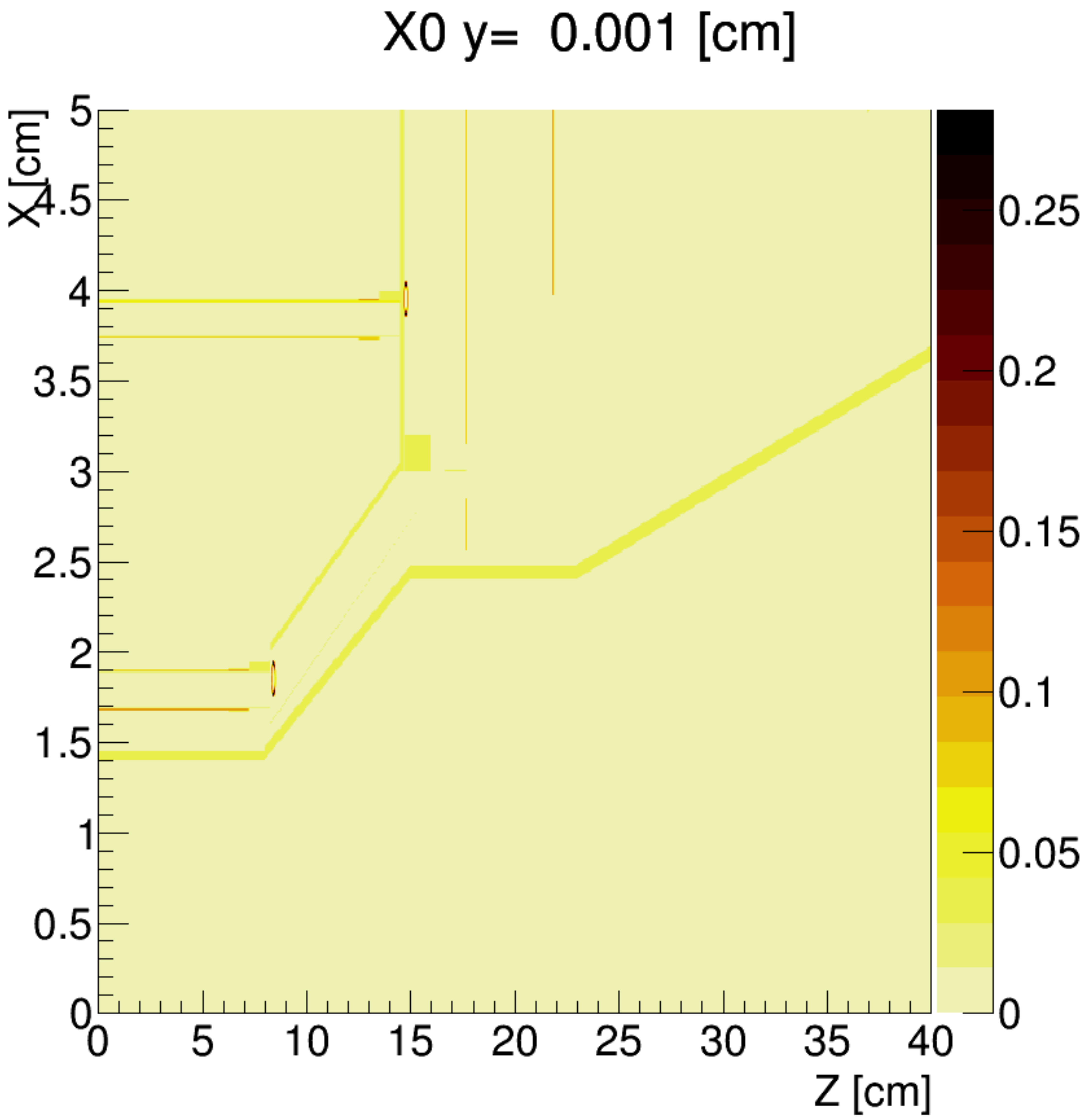

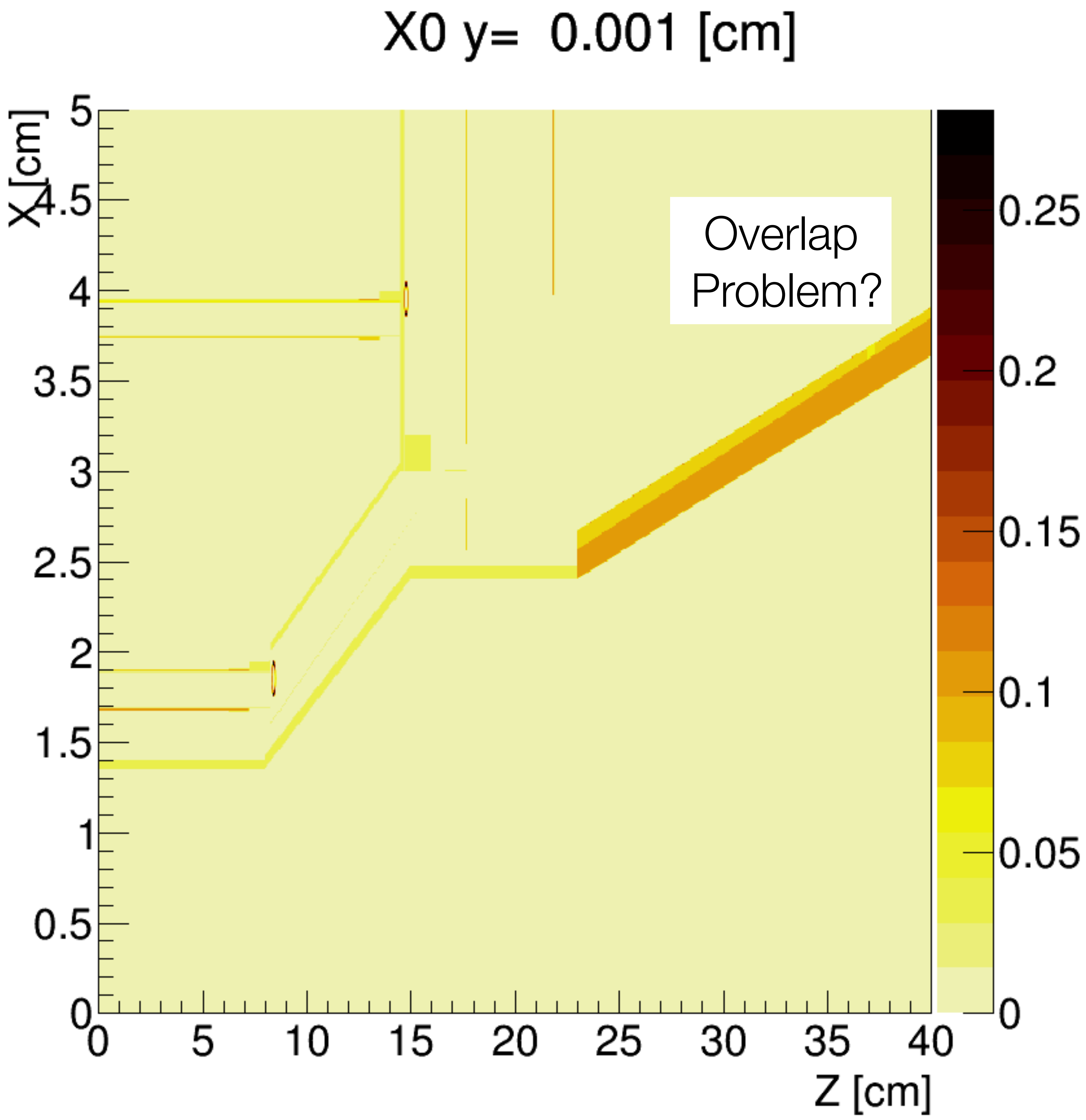

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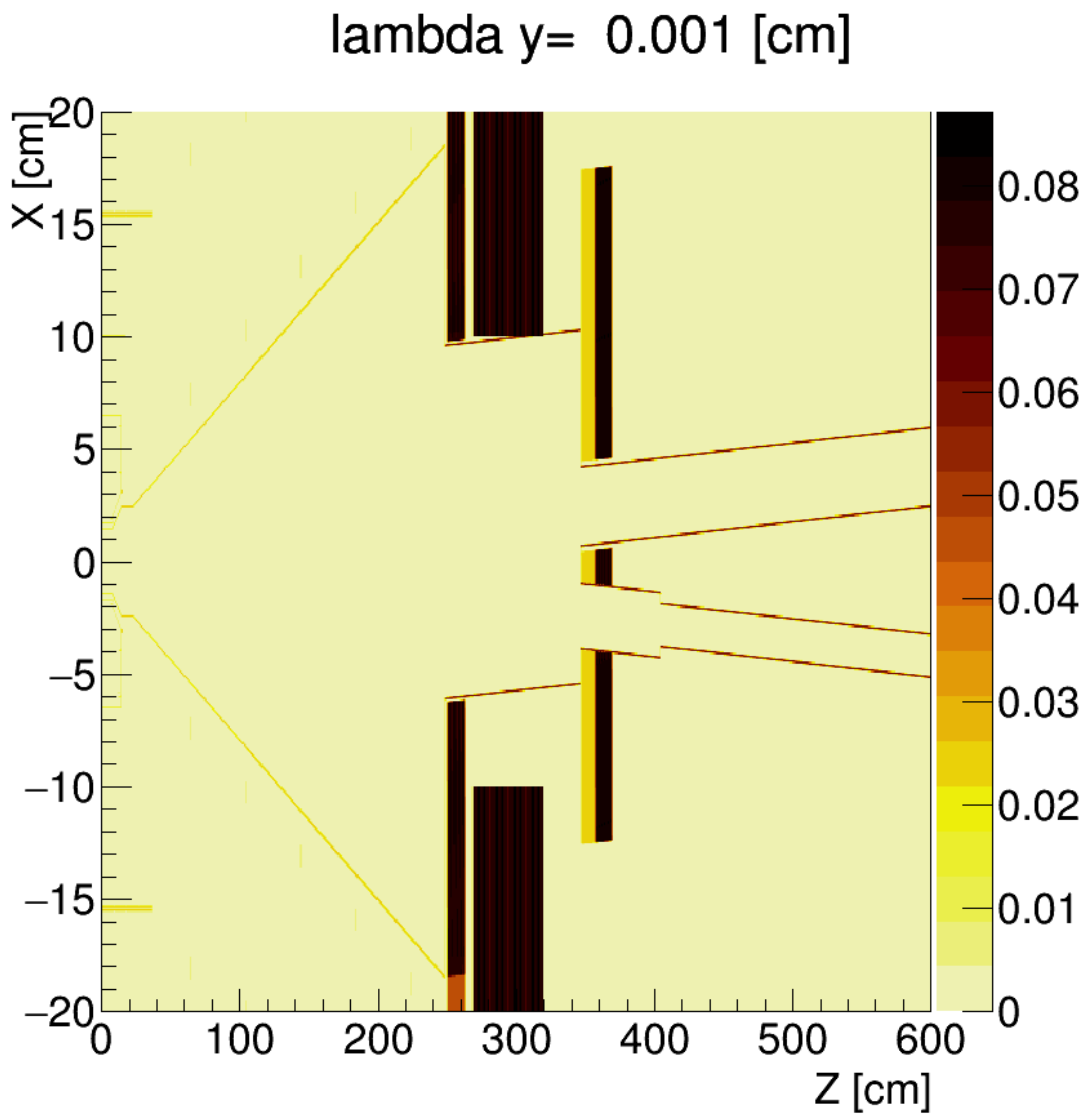
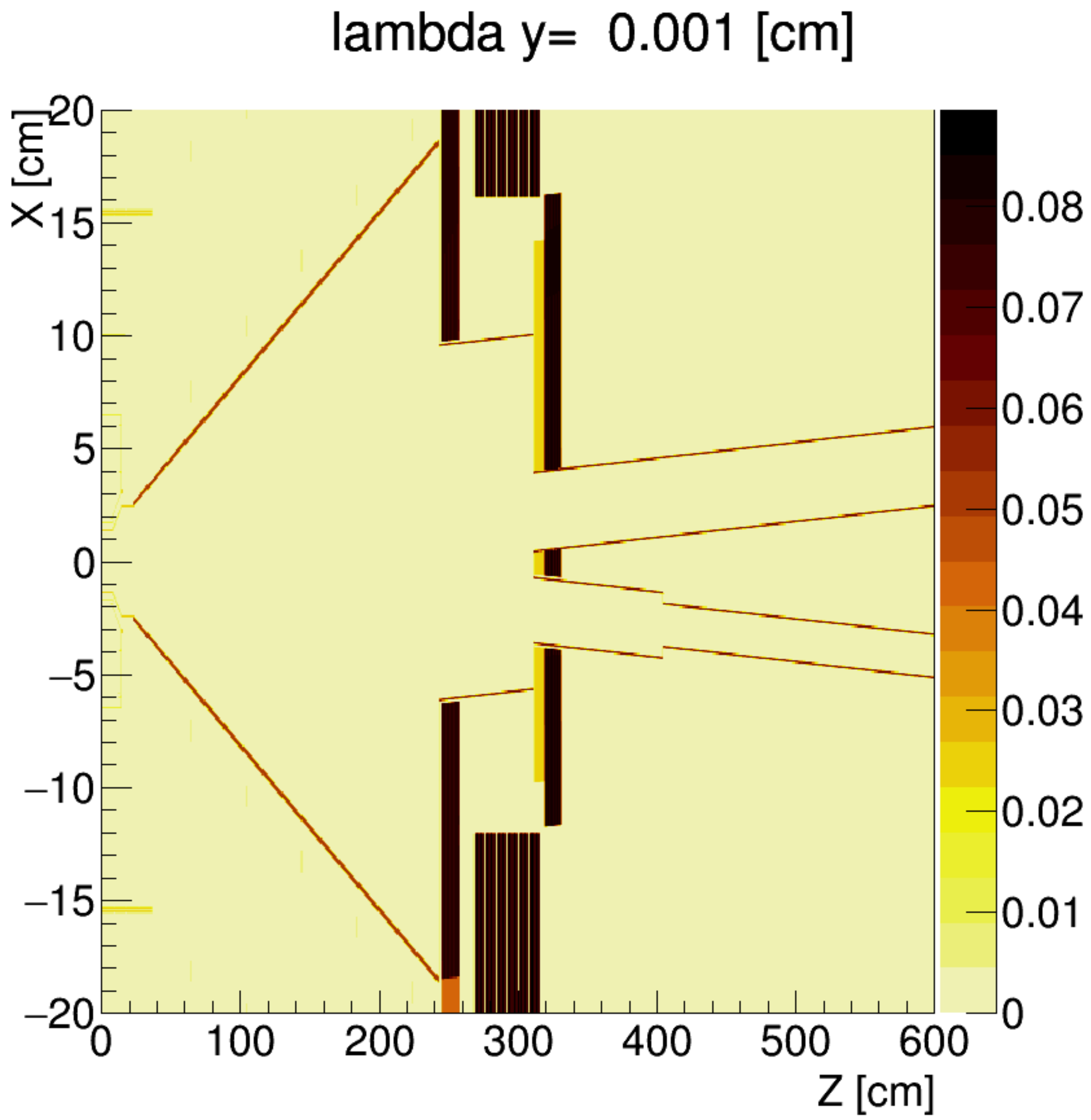


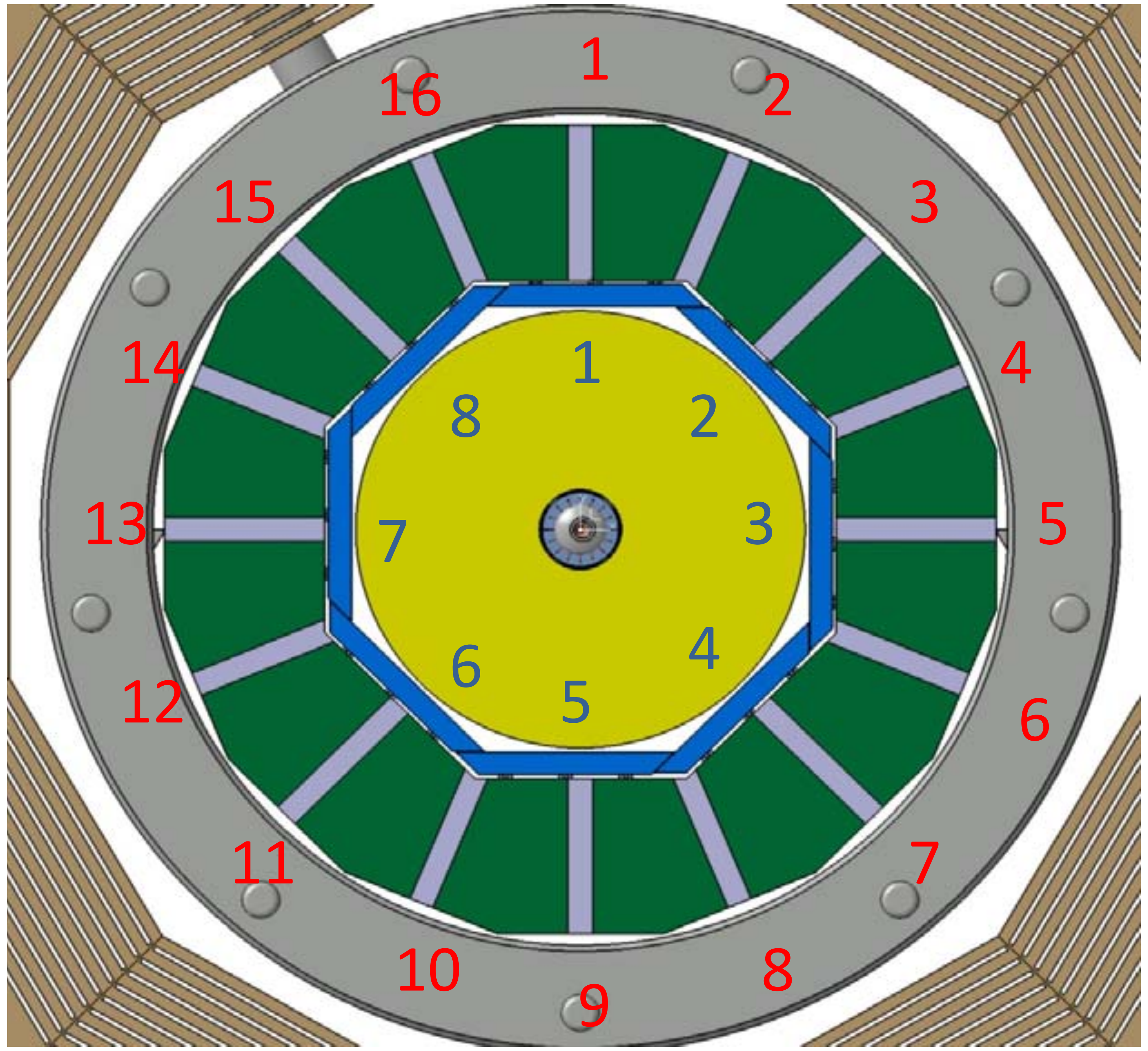


Barrel-Endcap Gap

- Services of
  - Inner Detector
  - TPC
  - ECAL
  - HCAL
- need to be routed out in gap between Barrel and Endcap Detector
- Study by C. Clerc
  - 2010

Services section vs way-out

Missing : TPC cooling
Liquid supply line = 5 mm ID; 7 OD
Vapor return = 8 mm ID; 10 OD



FACE Z-

	Cables				Ecal cooling		
Way in	Hcal	TPC	Ecal Barrel	Ecal Endcaps	Water Barrel Water Endcaps	Endcaps	Total cm²
1	100	0					100
2	0	10	30	7		0	47
3	100	0					100
4	0	10	30	7		0	47
5	100	0					100
6	0	10	30	7	42	14	103
7	100	0					100
8	0	10	30	7	28	14	89
9	100	0					100
10	0	10	30	7	14	14	75
11	100	0					100
12	0	10	30	7	28	14	89
13	100	0					100
14	0	10	30	7		0	47
15	100	0					100
16	0	10	30	7		0	47

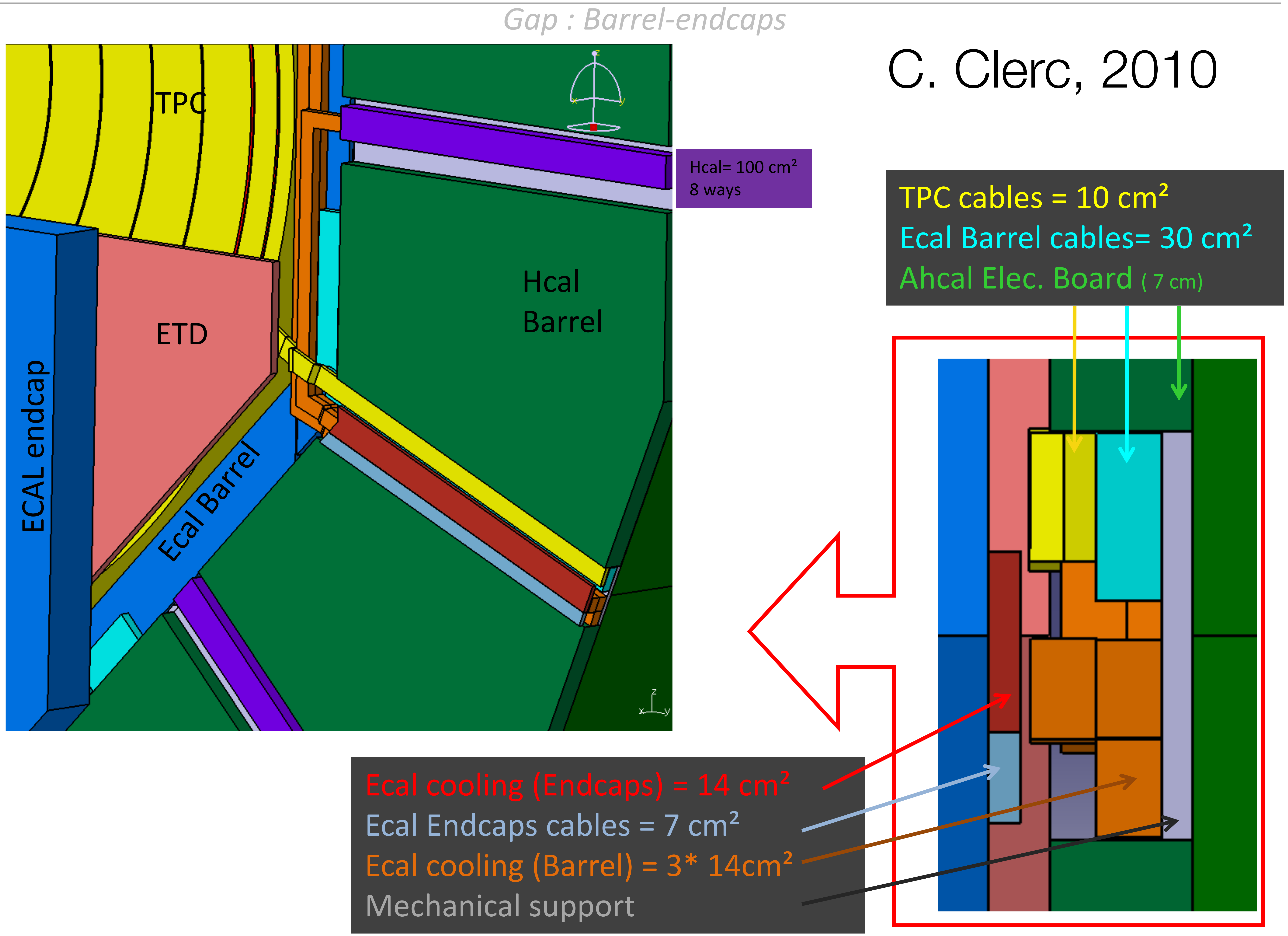
Worse case : path (6), 103 cm²

C. Clerc, 2010

Barrel-Endcap Gap

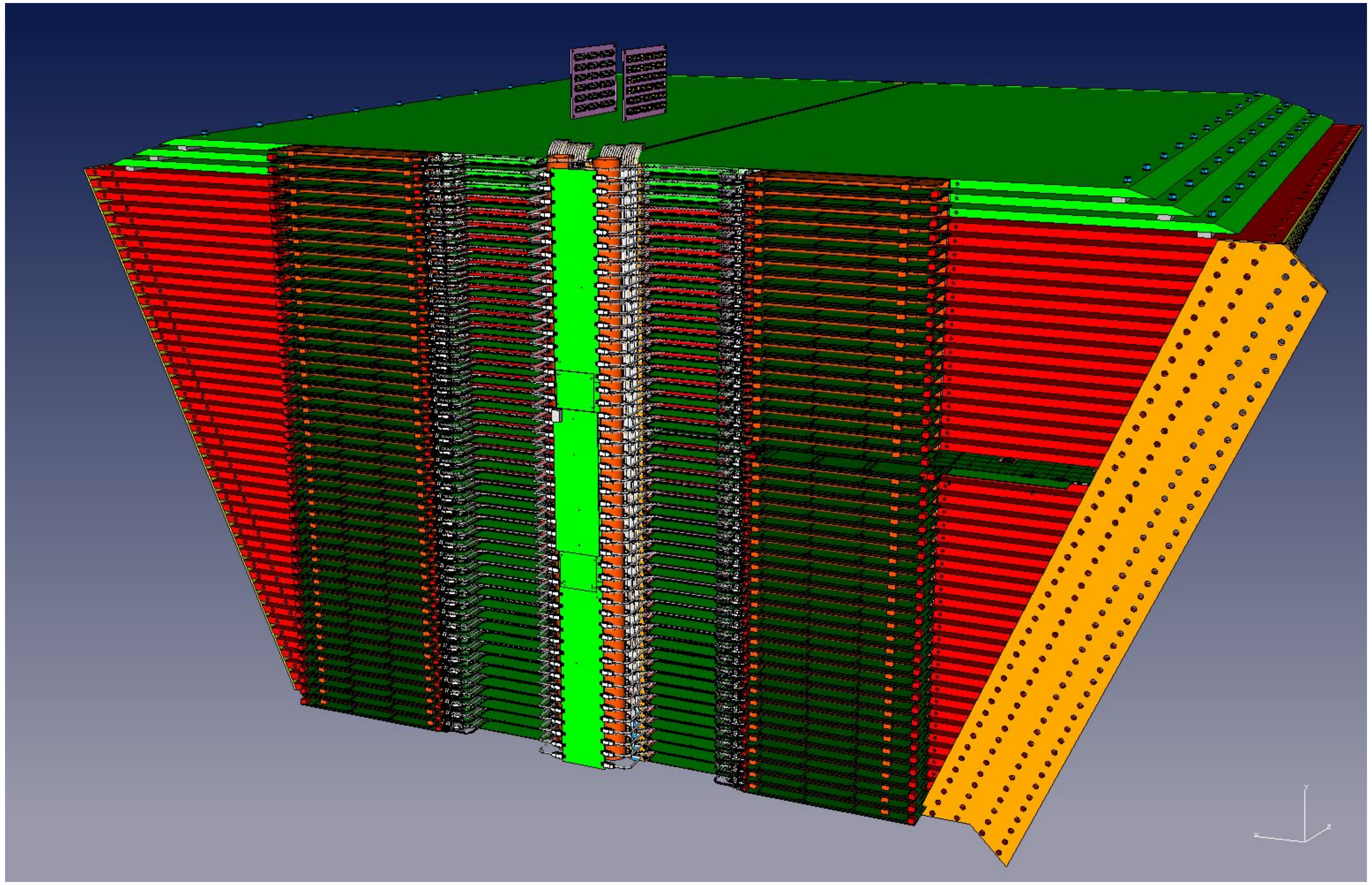
- „Trenches“ between AHCAL electronics
- Completely occupied by services (cables and cooling)
  - TPC
  - ECAL
  - AHCAL

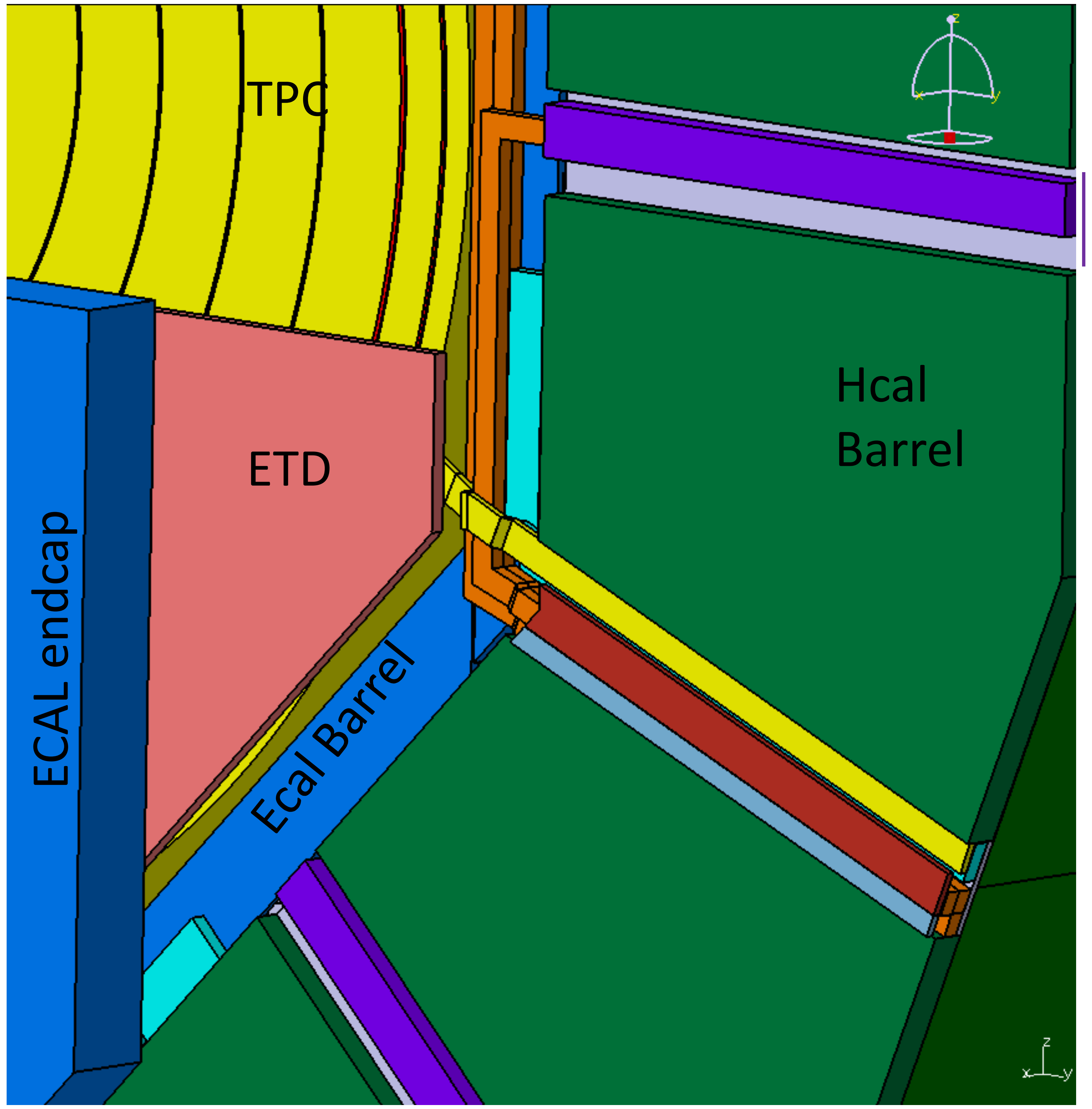
C. Clerc, 2010



AHCAL Services - Recent Updates

- Detailed design of the AHCAL services has just been done:





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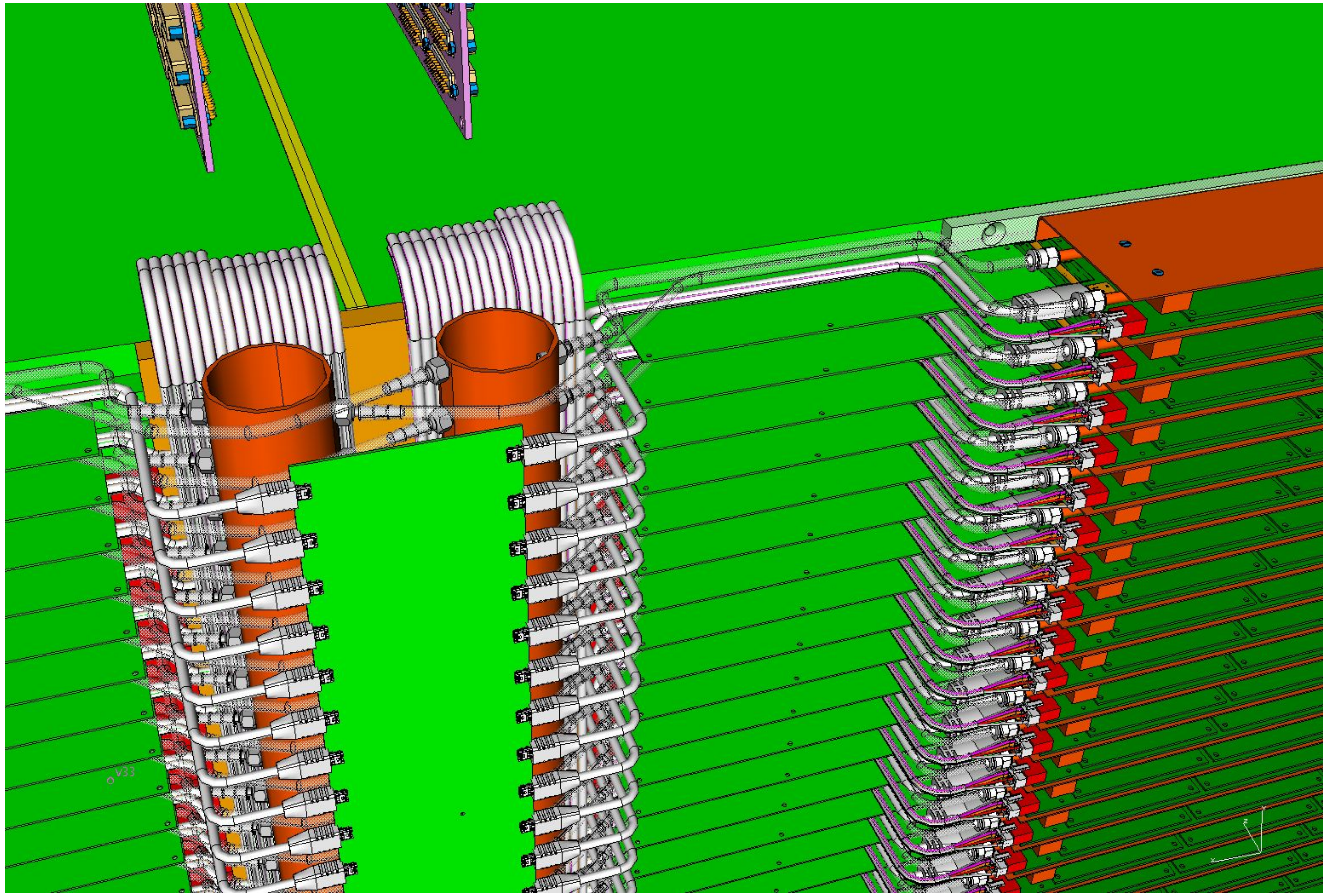
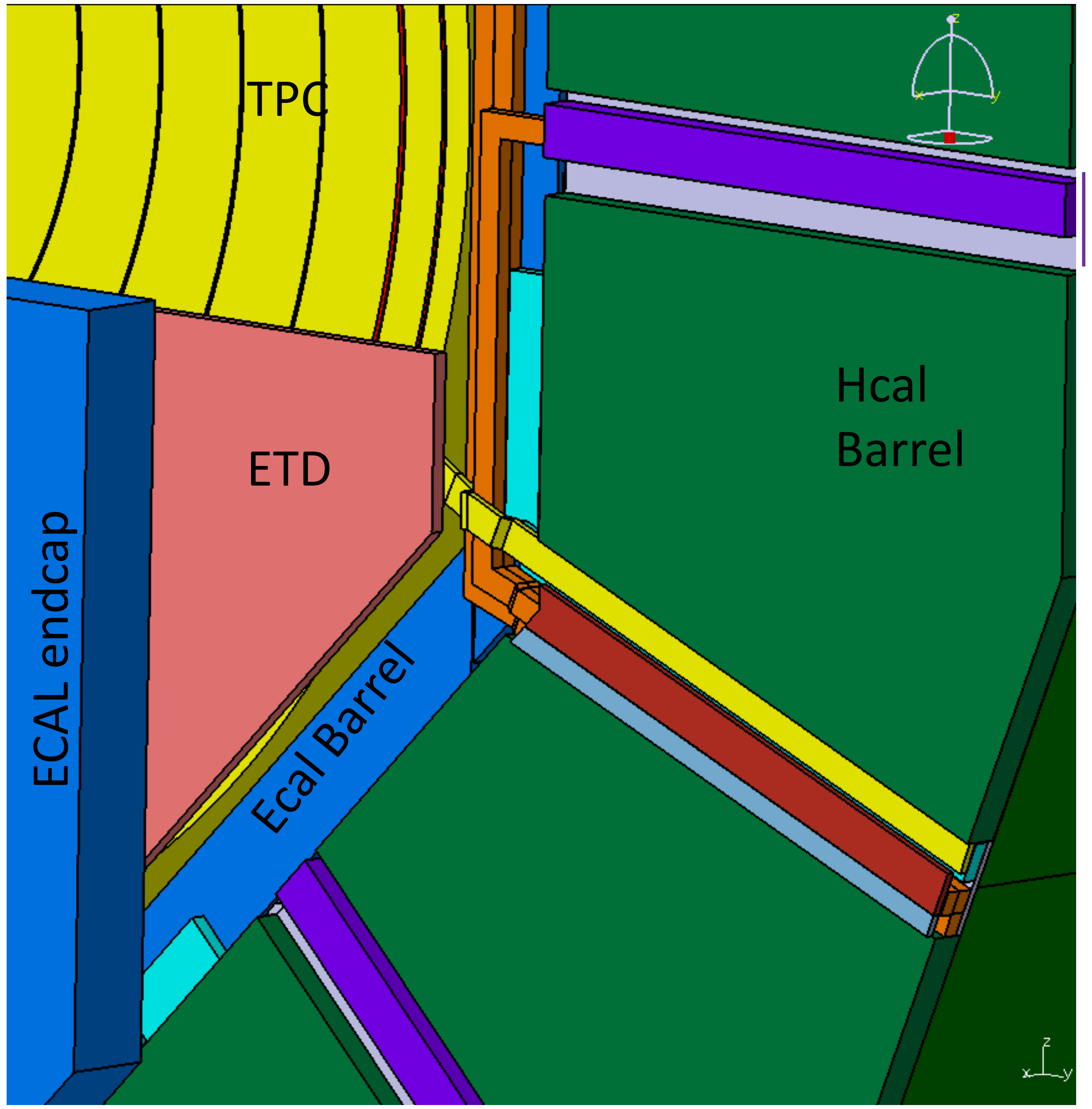


Gap : Barrel-



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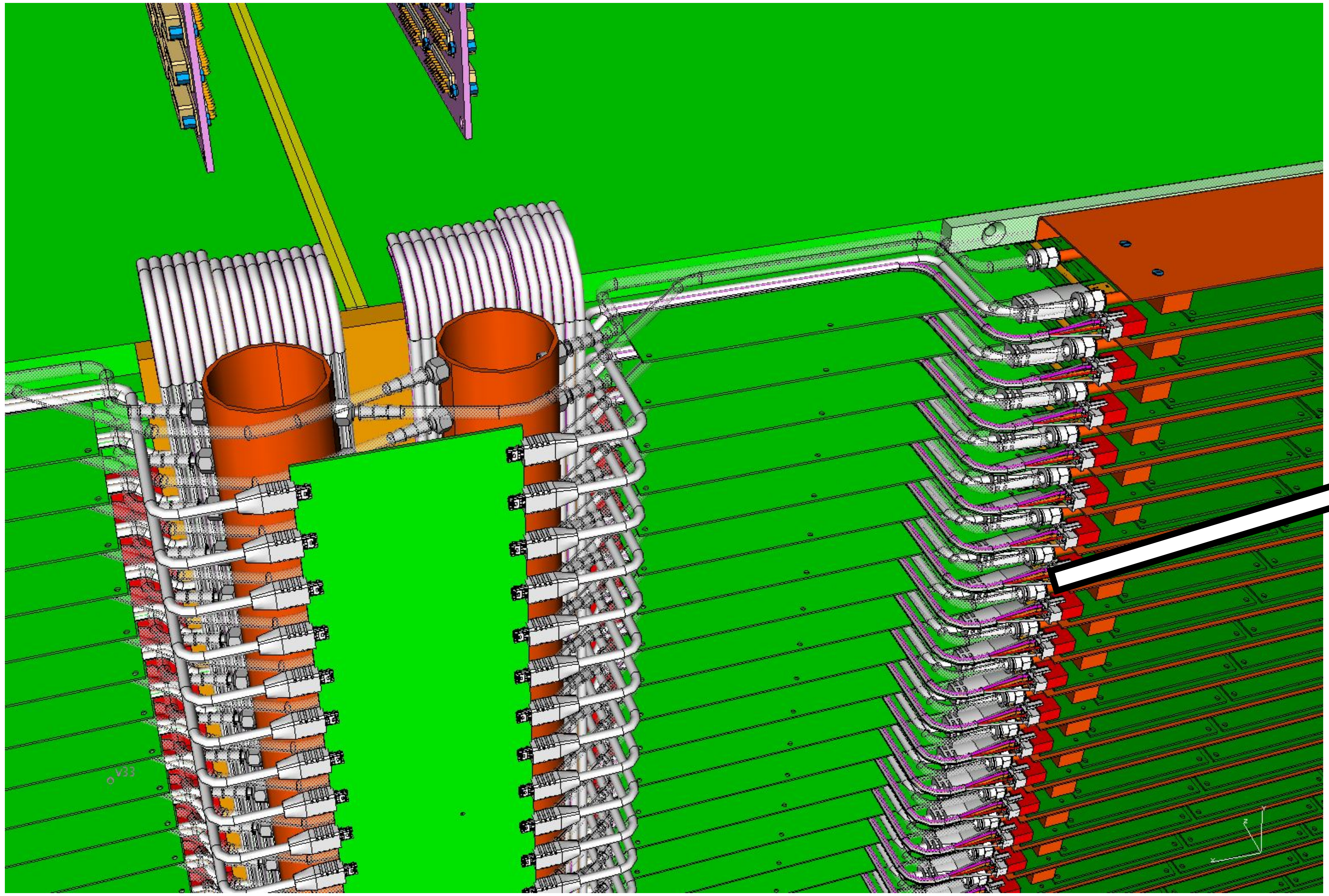
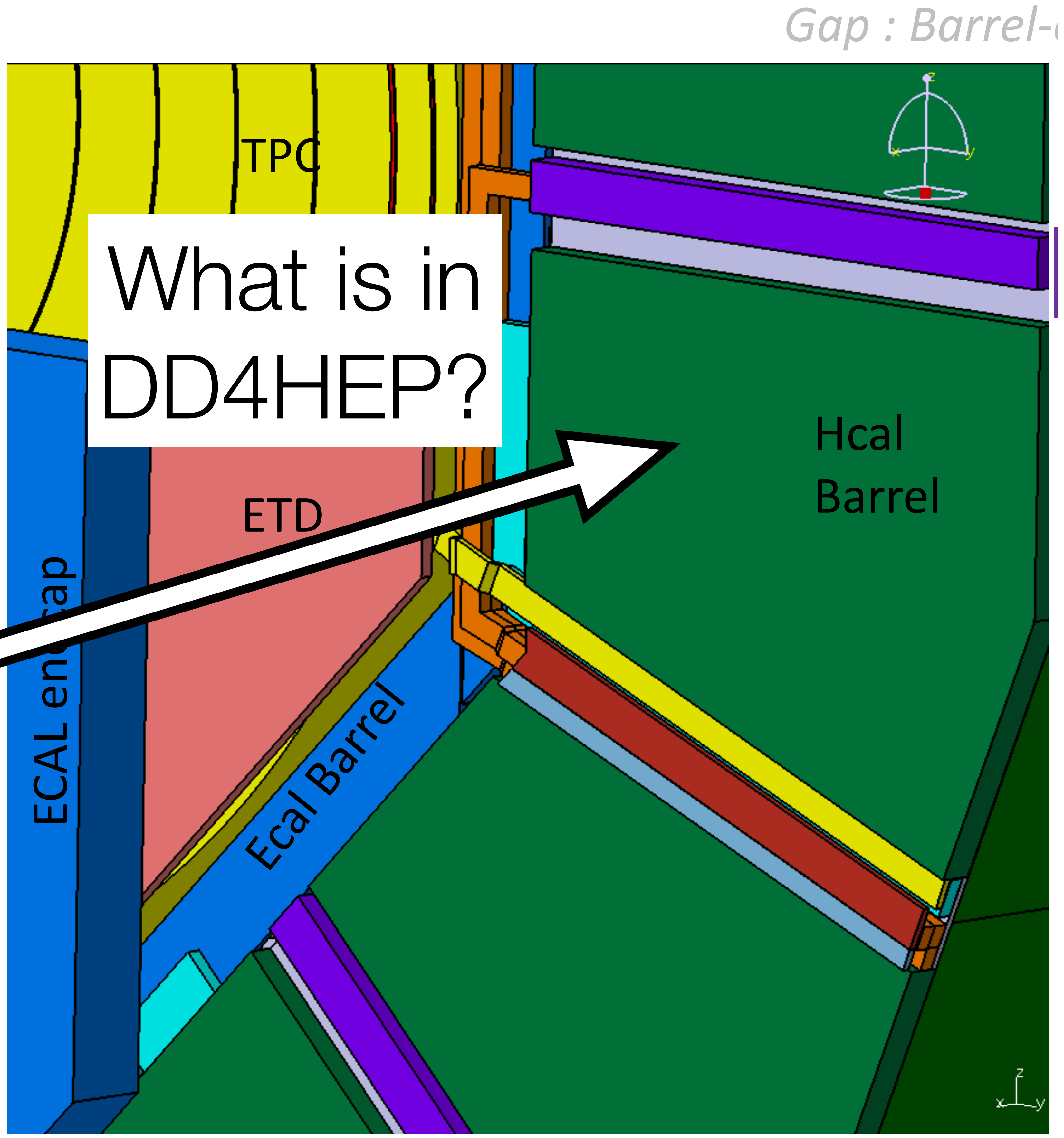
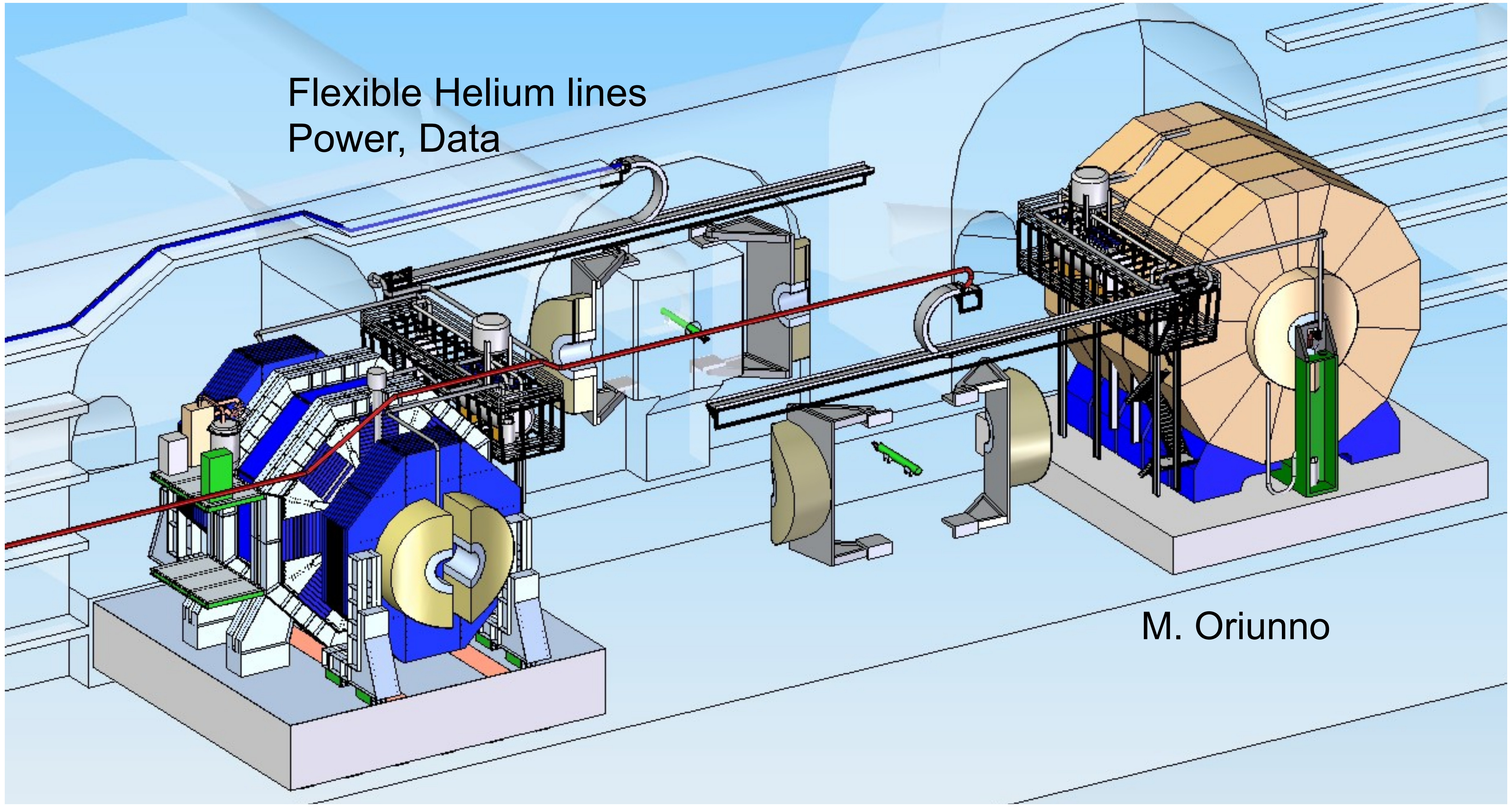




Push-pull System

- ILD lives on a moving platform
  - In symbiosis with SiD and the machine…
- Where to put the external services?
- First, we need the sub-detector requirements!
- Need to update plans on external integration:
  - cable chains
  - service spaces
  - etc
  - -> see talk this afternoon

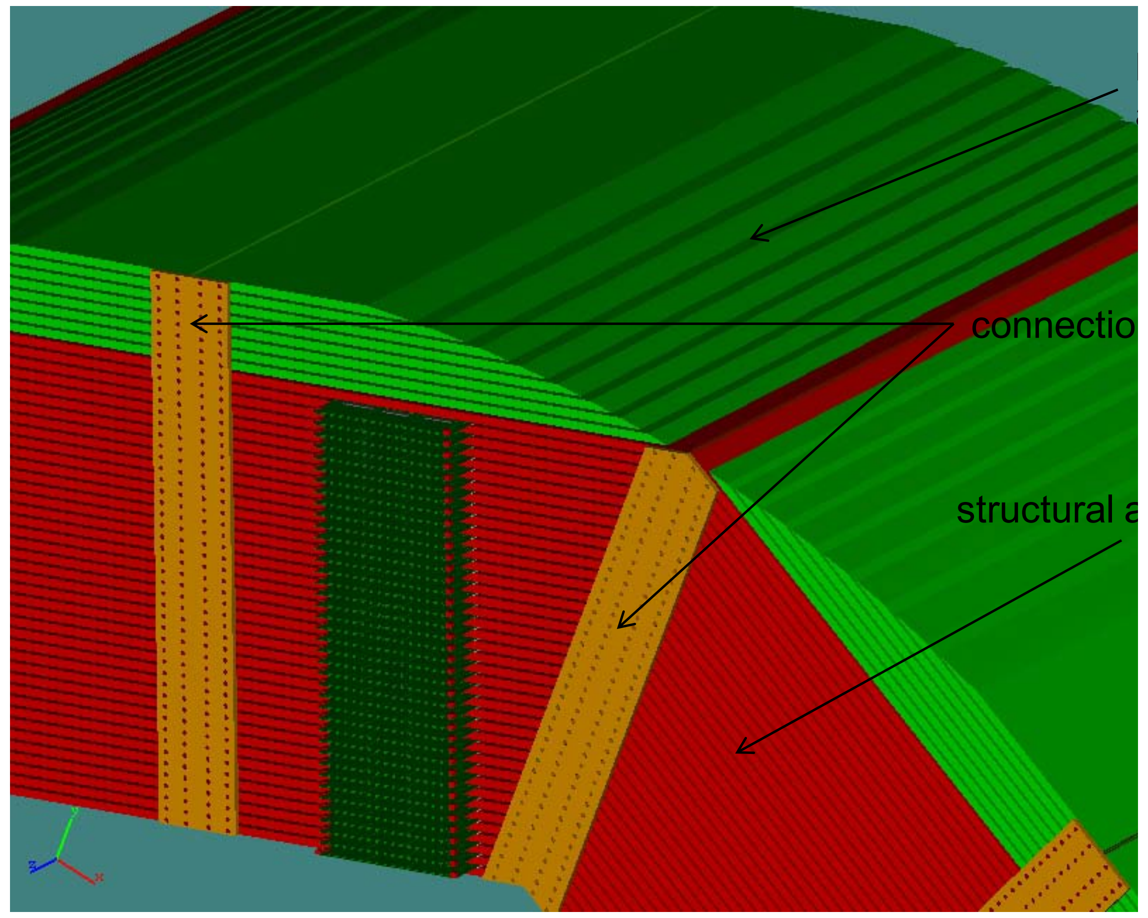


ILD HCAL Absorber Structure

AHCAL with „TESLA-Structure“

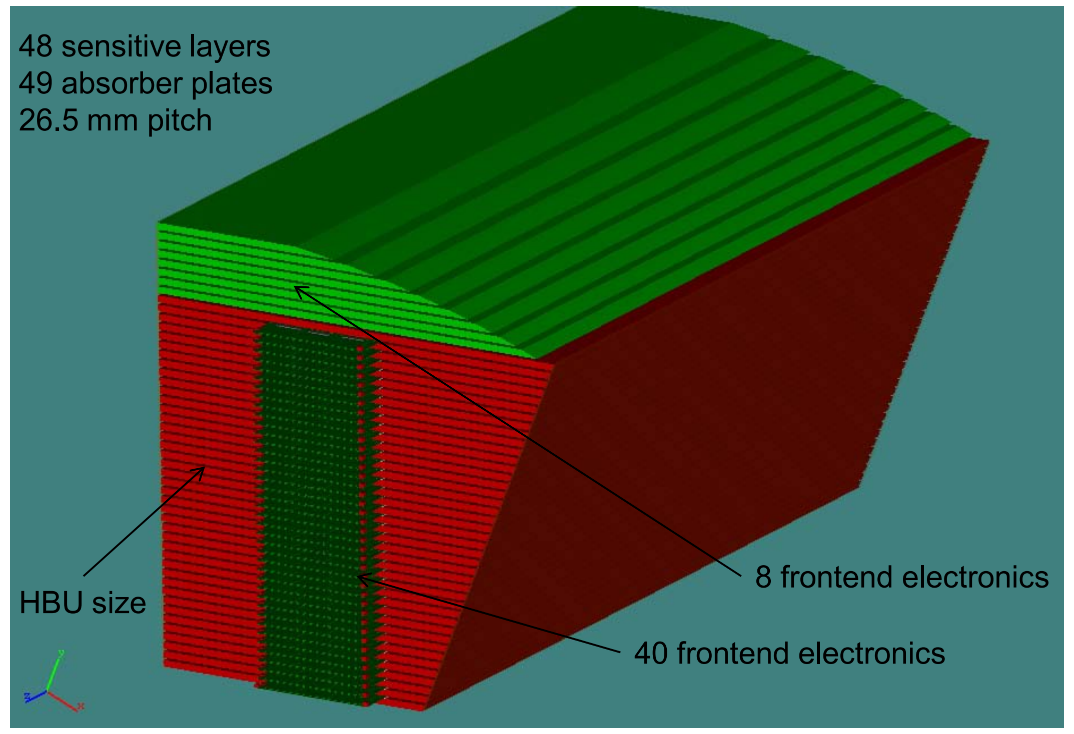
Design challenges

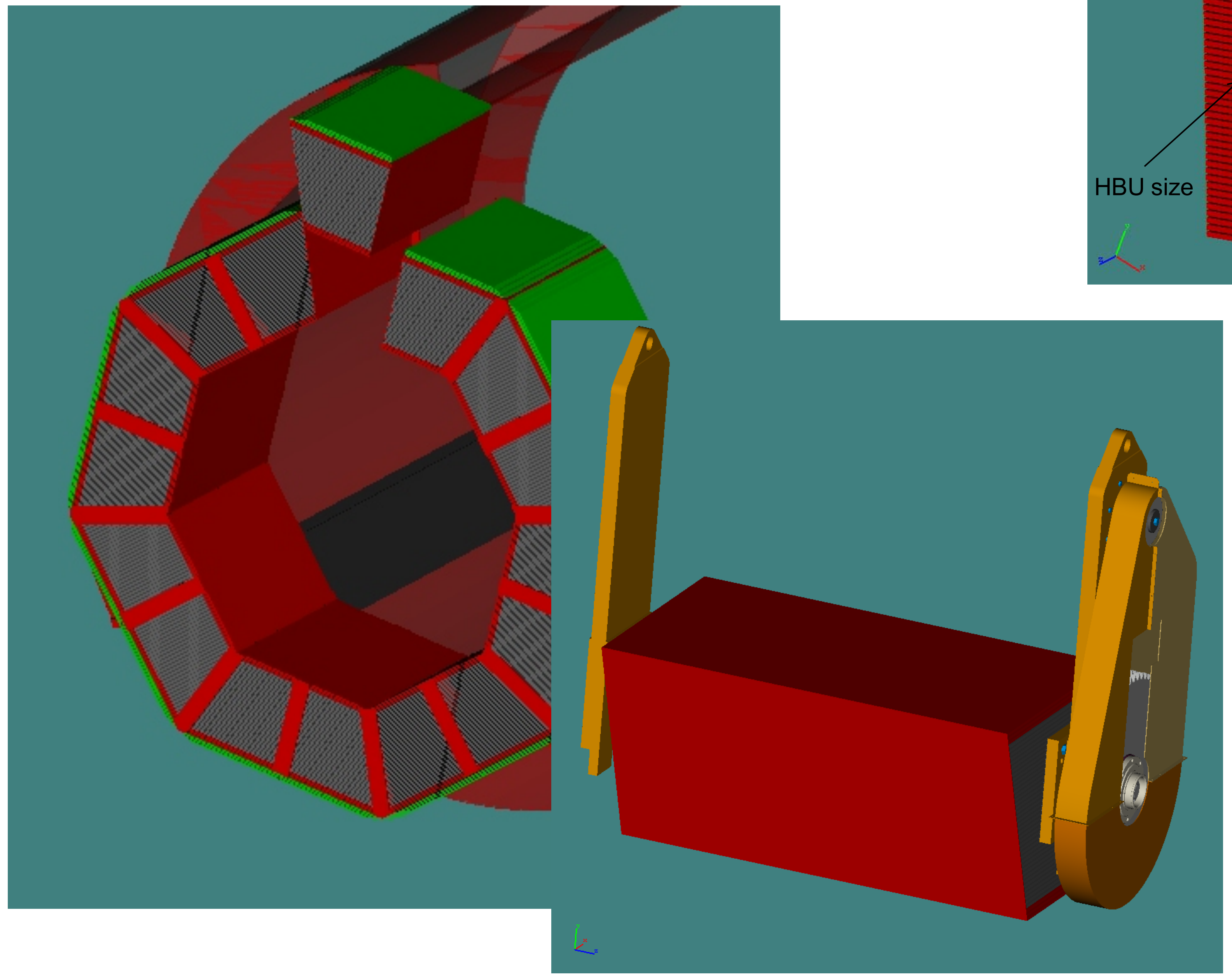
- Stainless steel
- Fine longitudinal sampling
  - 2cm plate thickness
- No cracks, minimal un-instrumented regions
- Inside coil radius:
  - compact design to maximise no. of hadronic interaction lengths
  - tight tolerances over large dimensions
- Accessible electronics
  - external: short access
  - internal: longer shutdown or upgrade
- Earth quake stability
  - computational challenge



Small modules

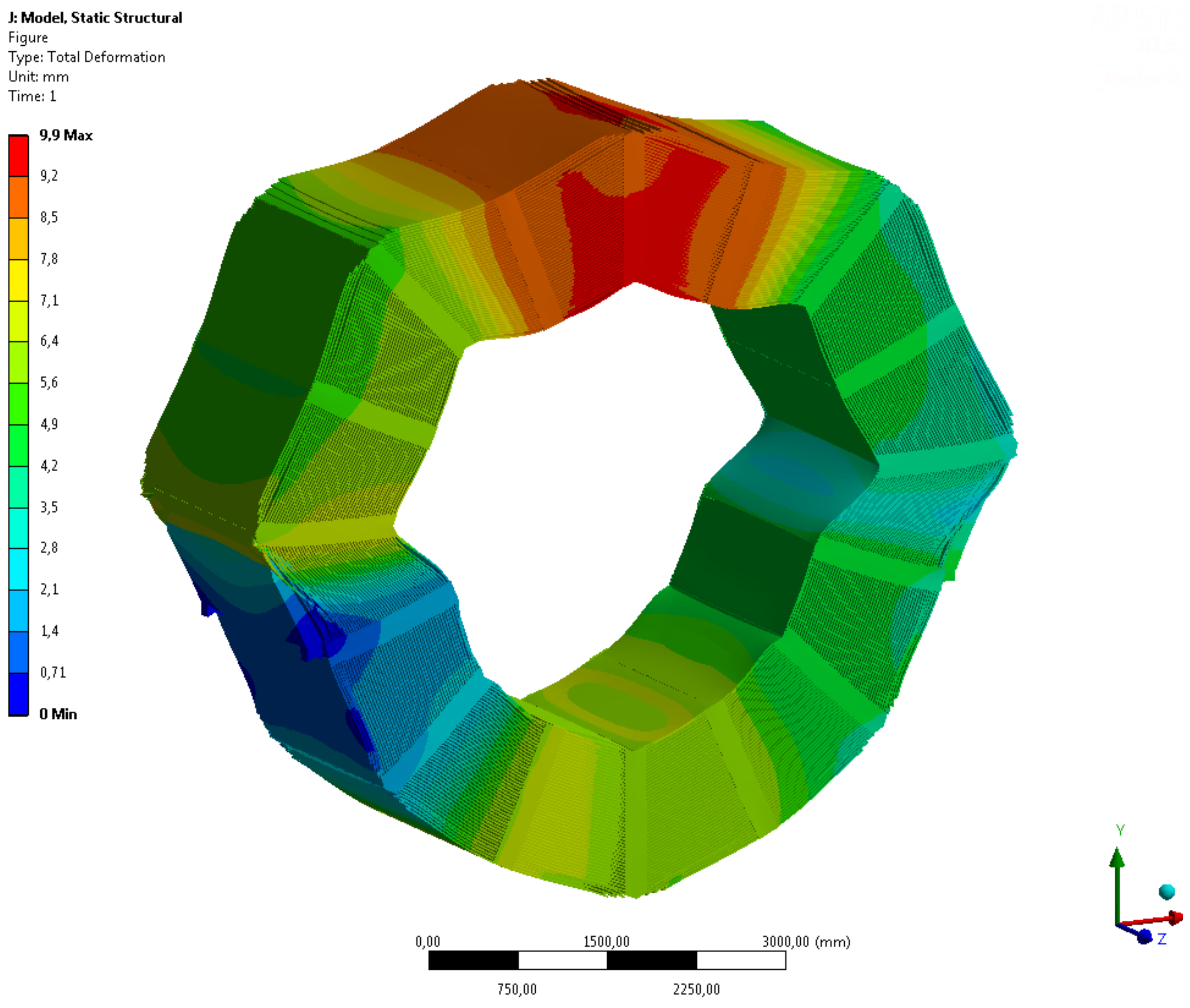
- Small sectors (<18t) for easy transport and assembly in situ





Static and Dynamic Simulations

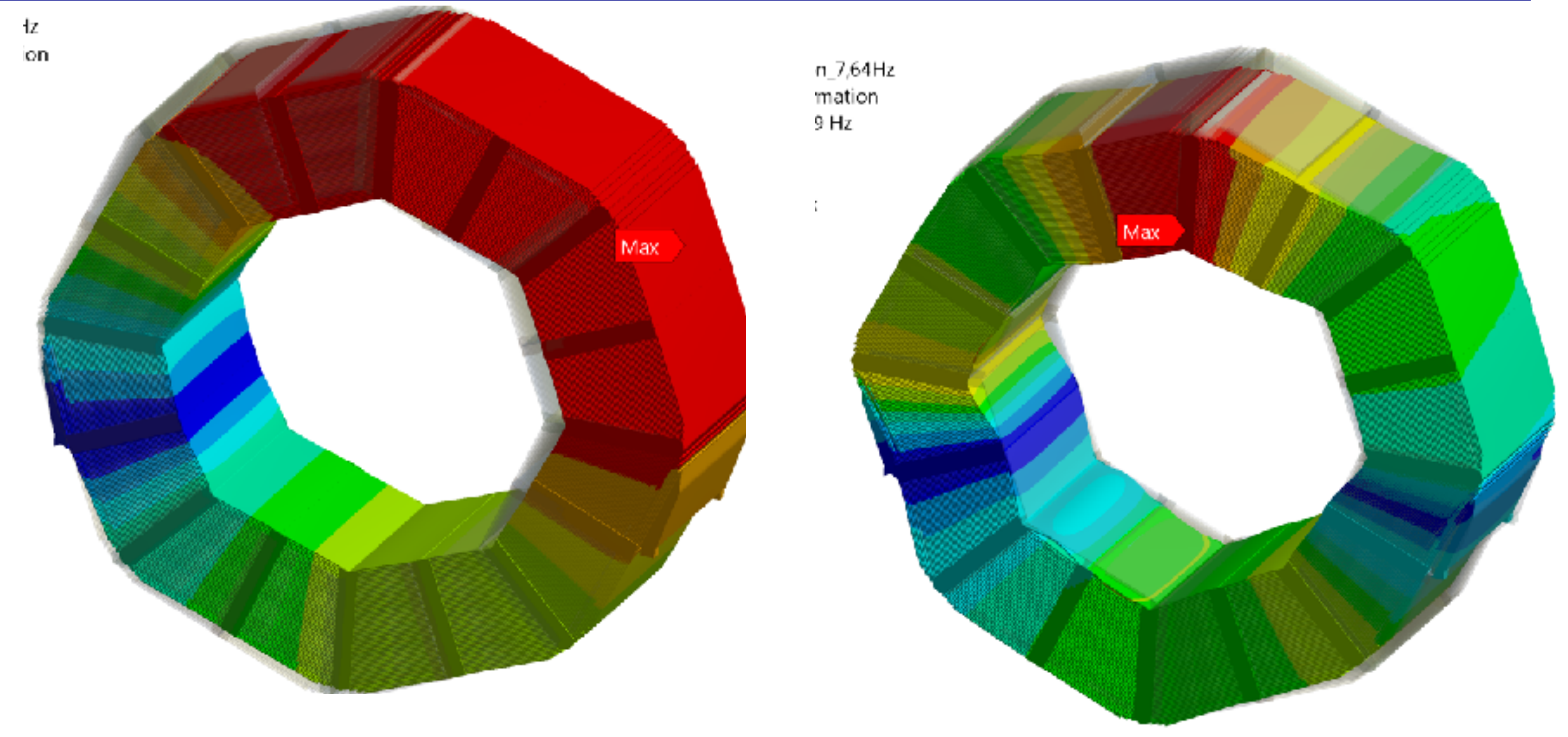
Ring deformation

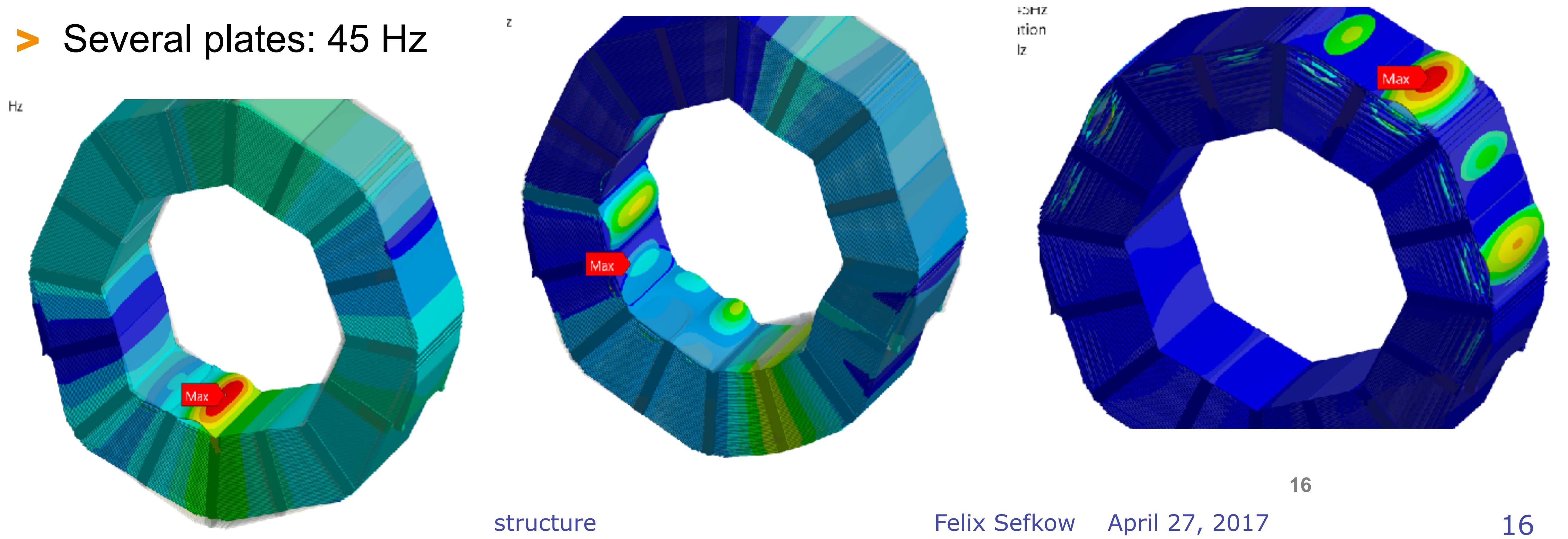


- max 10 mm

Eigen modes

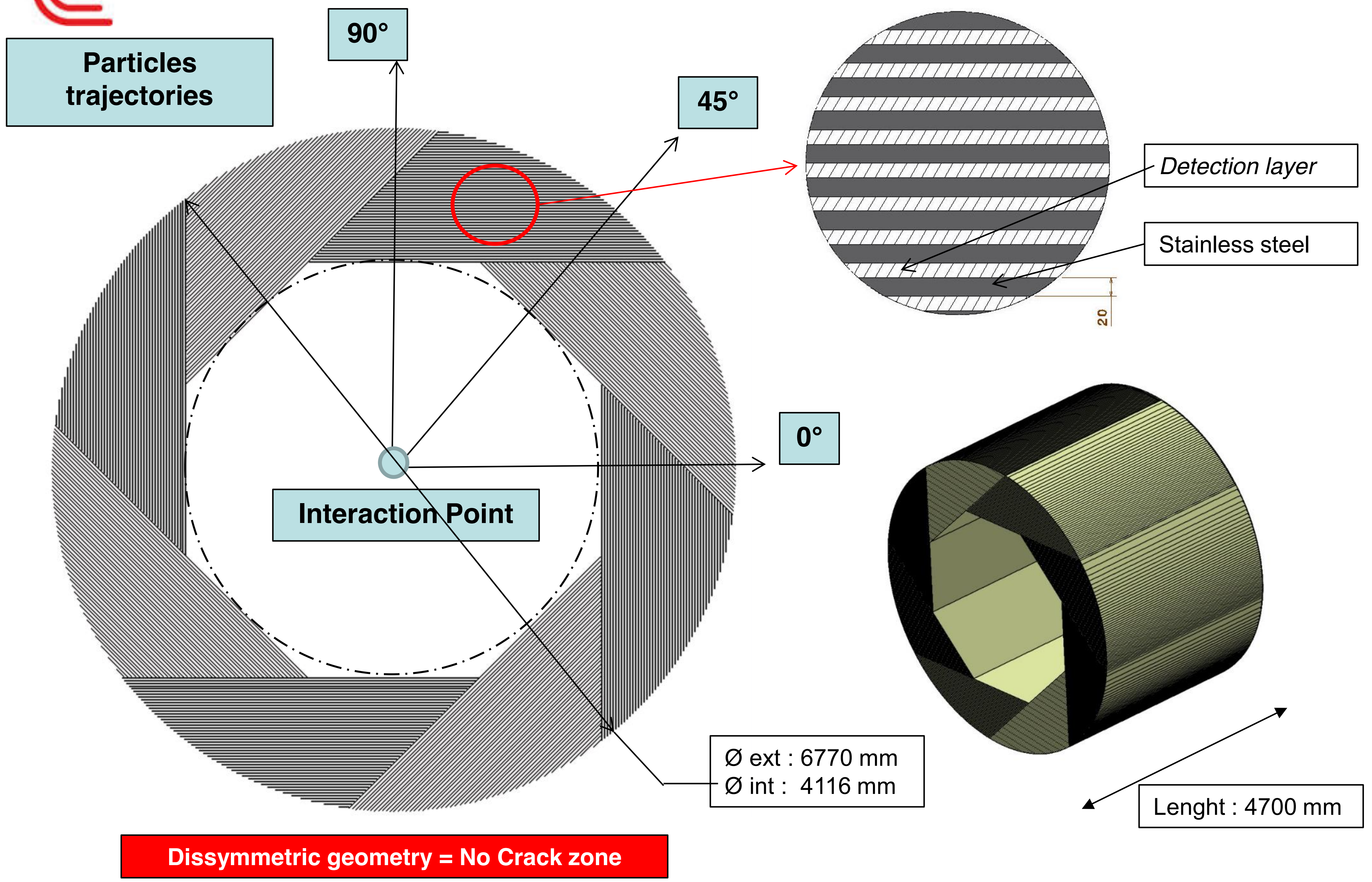
- Swinging barrel: 3Hz
- Swinging module: 8Hz
- Swinging plate: 6Hz
- Higher modes: 15 Hz
- Several plates: 45 Hz





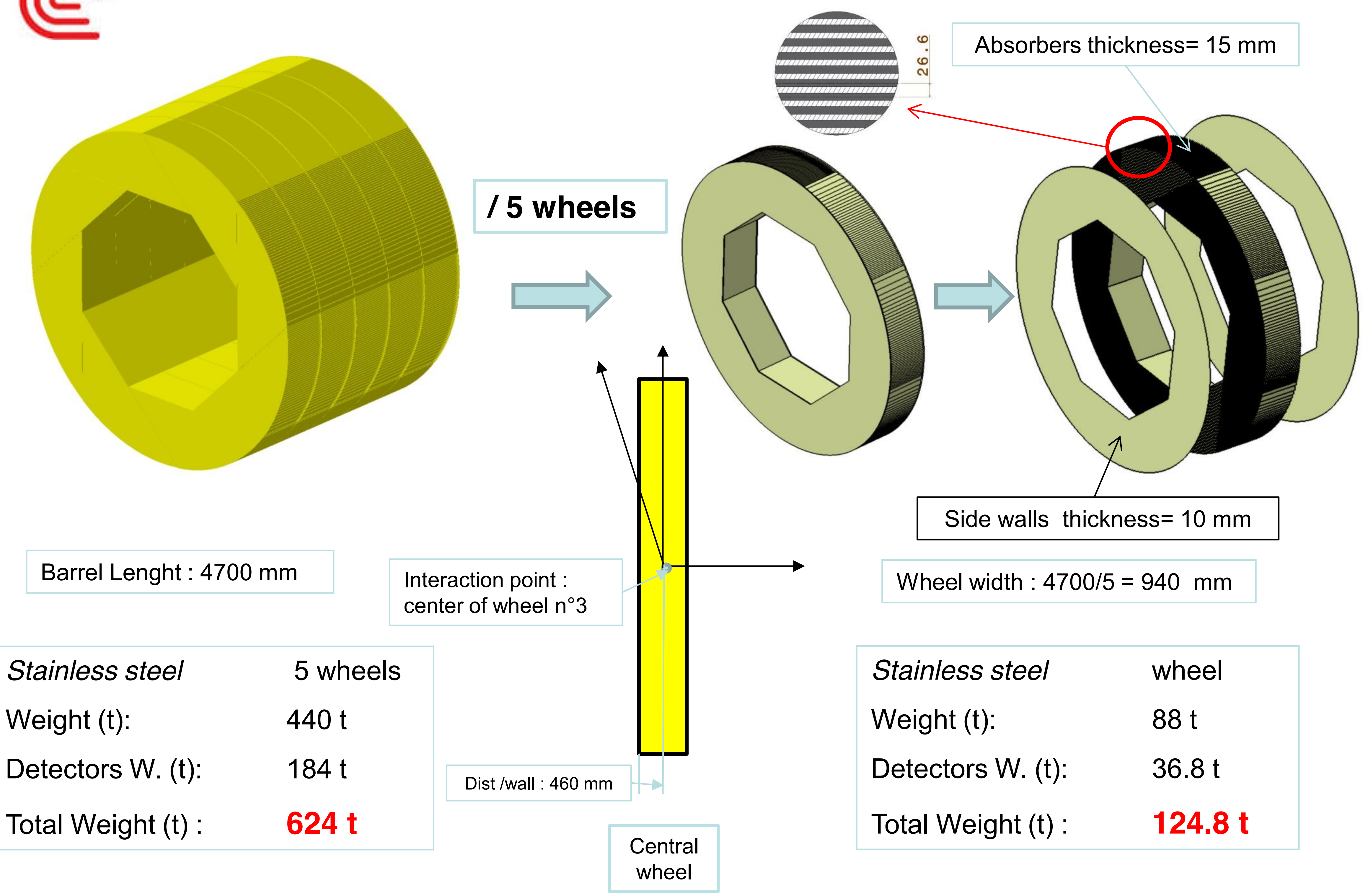
„Videau-Structure“

Barrel Integration : "Videau" design for physic



IPN Lyon ILD Integration Page 2

Barrel integration : : "Videau" design 5 wheels



Stainless steel	5 wheels
Weight (t):	440 t
Detectors W. (t):	184 t
Total Weight (t) :	**624 t**

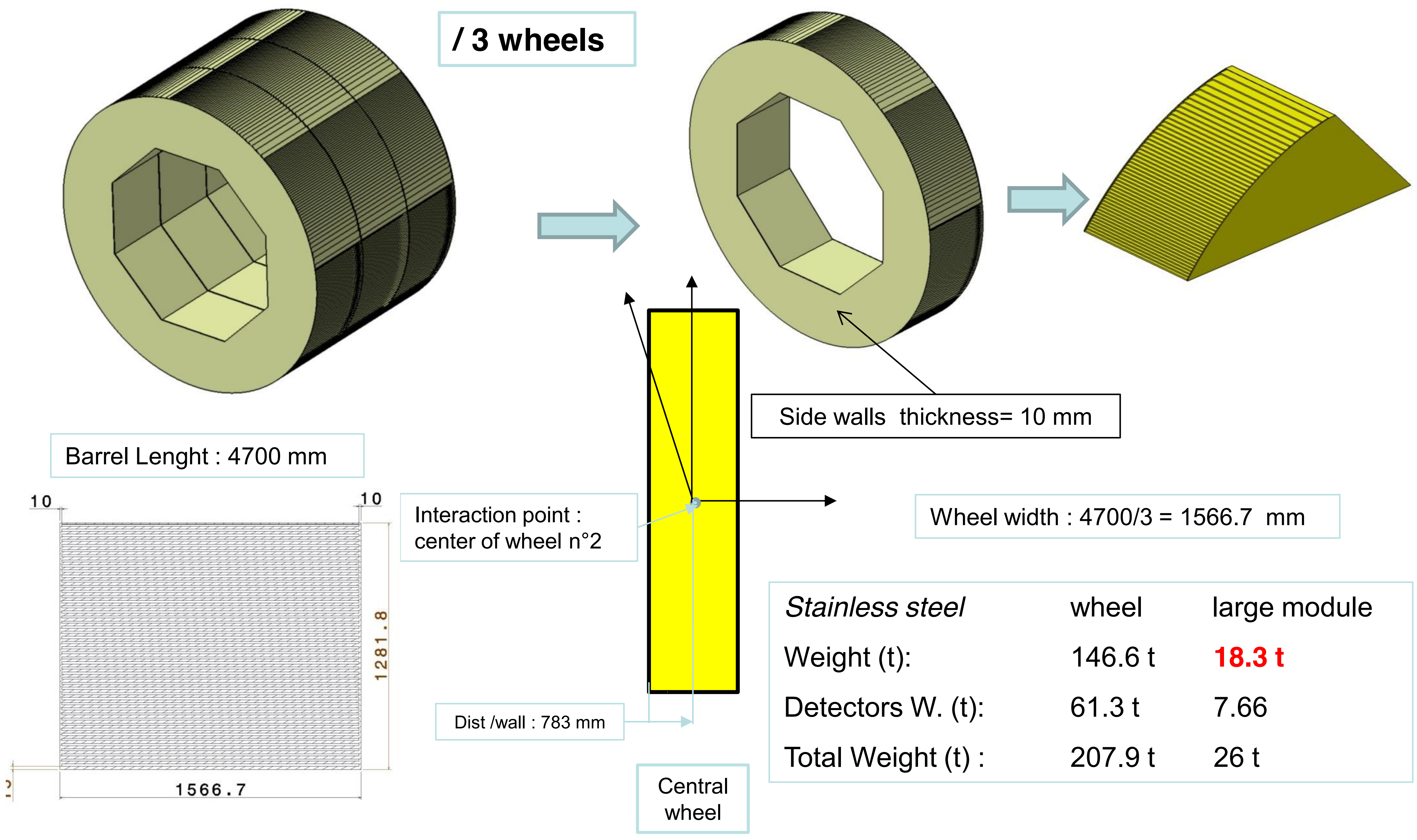
Stainless steel	wheel
Weight (t):	88 t
Detectors W. (t):	36.8 t
Total Weight (t) :	**124.8 t**

IPN Lyon ILD Integration Page 4

„Videau“ with 5 or 3 Rings?

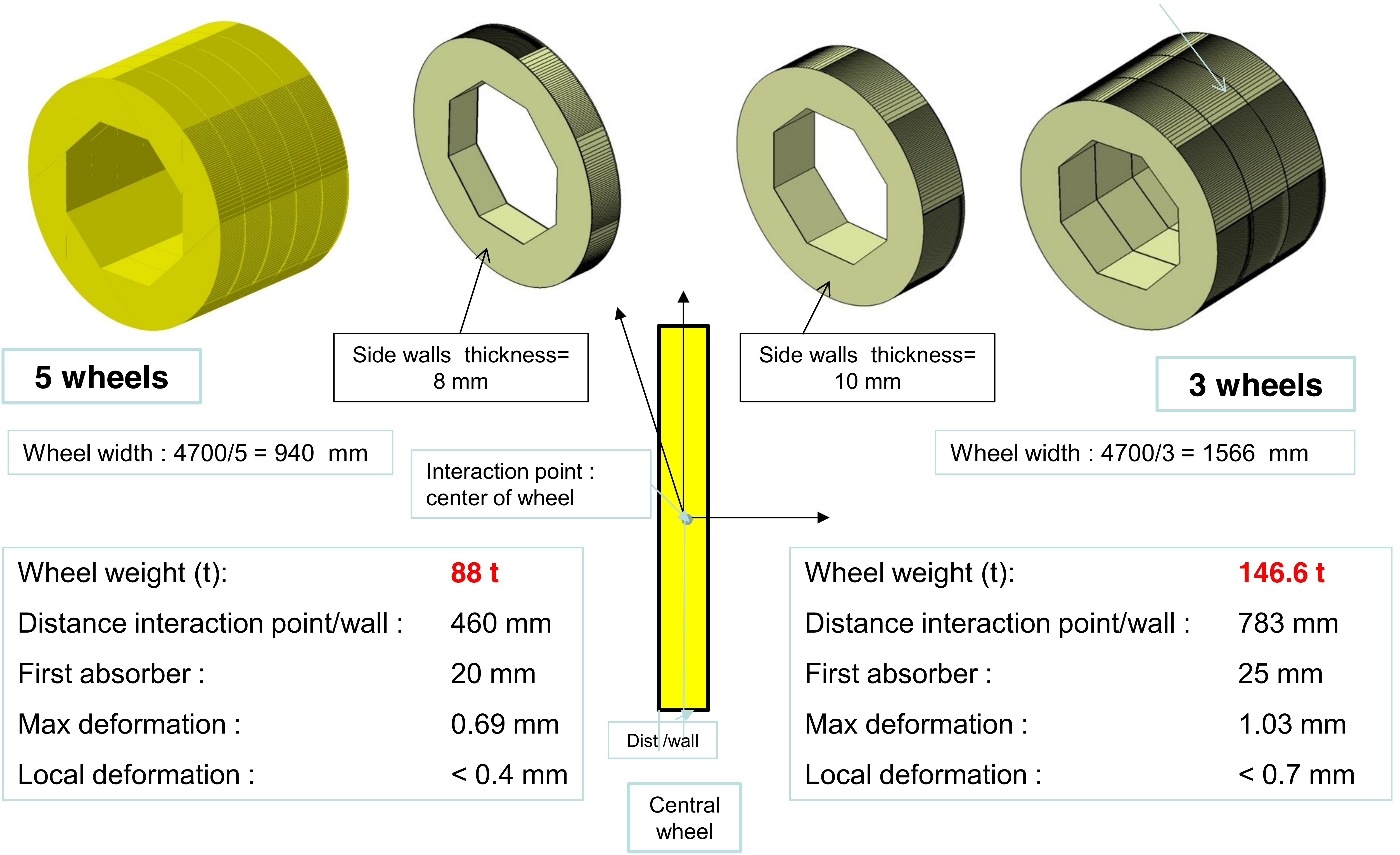
- 3-ring version has less dead zones, but single wheel gets very heavy

Barrel integration : : "Videau" design 3 wheels



Stainless steel	wheel	large module
Weight (t):	146.6 t	18.3 t
Detectors W. (t):	61.3 t	7.66
Total Weight (t) :	207.9 t	26 t

Barrel integration : : "Videau" design synthesis



Wheel weight (t):	88 t
Distance interaction point/wall :	460 mm
First absorber :	20 mm
Max deformation :	0.69 mm
Local deformation :	< 0.4 mm

Wheel weight (t):	146.6 t
Distance interaction point/wall :	783 mm
First absorber :	25 mm
Max deformation :	1.03 mm
Local deformation :	< 0.7 mm

„Videau“: Assembly on Location

Barrel integration : wheel assembly

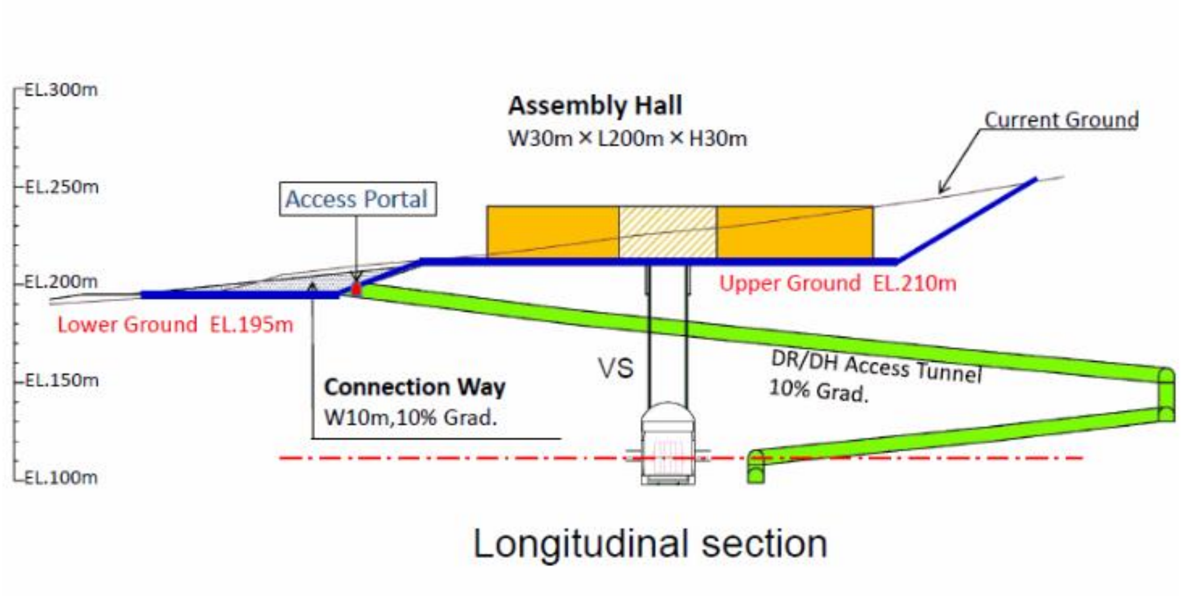
- Wheel Building in assembly hall : 8 modules => 5 wheels

Building Method

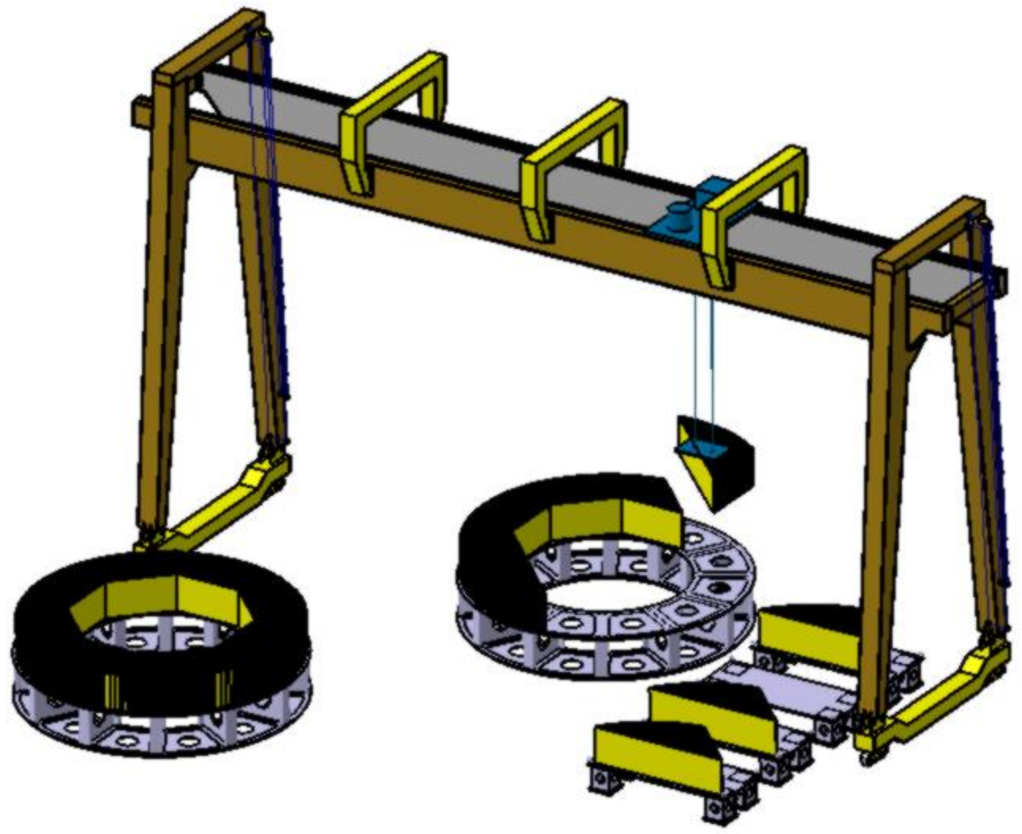
•Step 1 : Modules assembly to wheel

- 8 modules in position on specific tool
- welding operations

• **Step 2 :** Wheel on specific tool ready to receiving detection layers



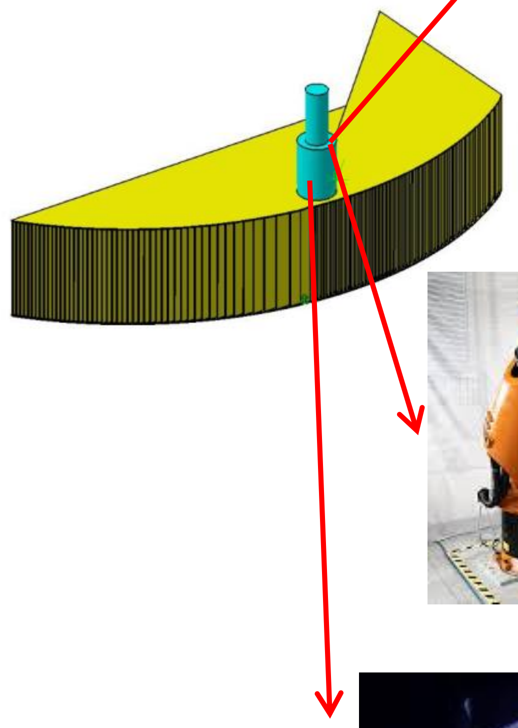
Longitudinal section



Wheel weight = 88 t

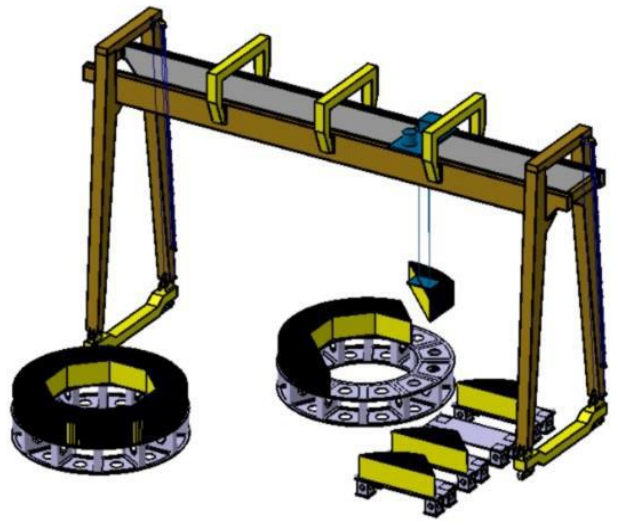
Barrel integration : wheel assembly

- Wheel building in assembly hall : welding details



***Mobile electron beam gun** :*

- *Welding along an axis*
- *Mobile local vacuum with sliding joint*

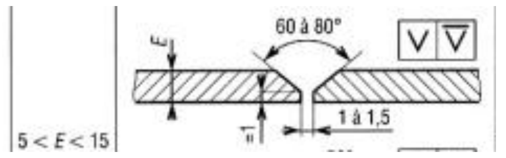


***Friction welding robot** :*

- *Welding along an axis*
- *Rotation to friction welding heat*

***Manual MIG-TIG welding** :*

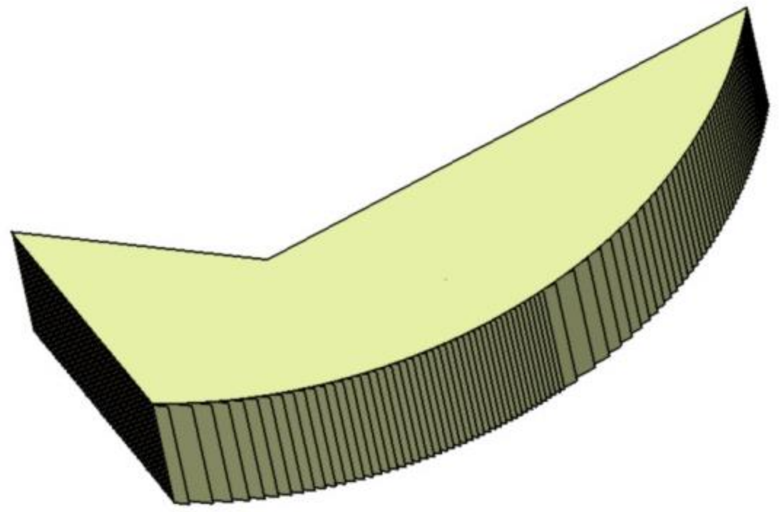
- *Traditionnal welding along an axis*
- *TiG & MIG multipass , low deformation on a rigid structure (absorbers act like tighteners)*



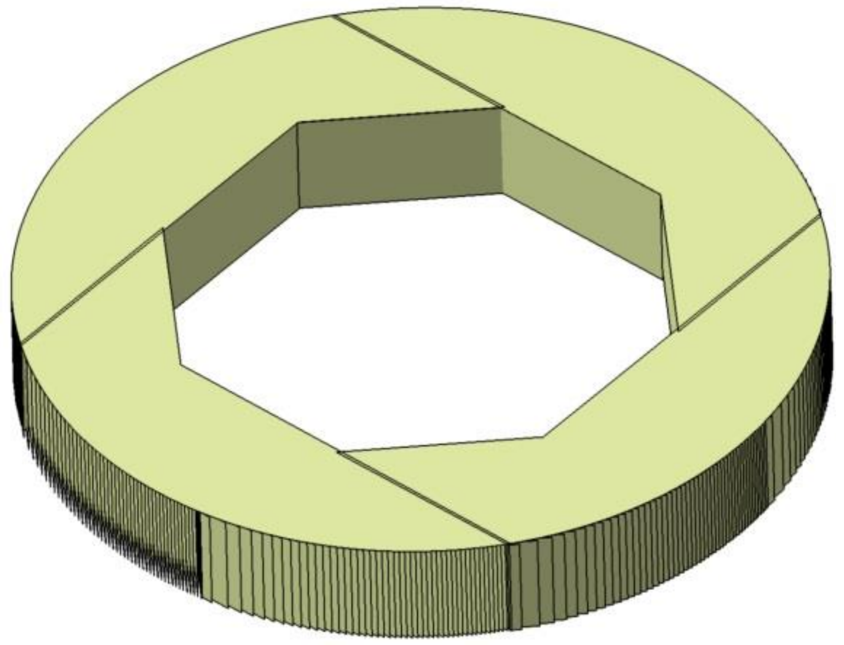
„Videau“ with Super-Modules

Barrel integration : wheel with super-modules

- Wheel building : 4 super-modules



x4



Supermodules = module x 2 = ¼ wheel

Weight 22 t *- size : 4742x2500x940 mm* ^{3}

Wheel made in Assembly Hall by :

Mobile EBW , friction welding, TIG-MIG

Only four zones to weld on site

Super-modules built by Electron beam welding in very big vacuum chamber

Tribute to SCHIAKY

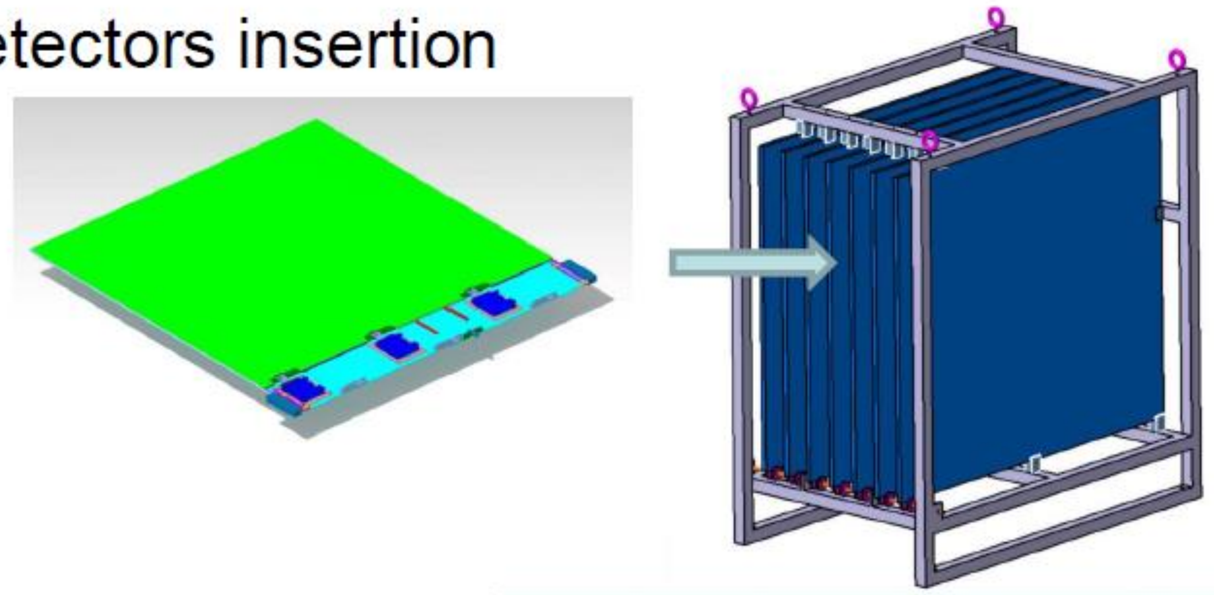
total weight	trailer/ track	our package	daytime	night	Xpwy	paper work
25 ton	~10 ton	~15 ton	YES	YES	YES	0
44 ton	~20 ton	~24 ton	YES†/ NO	YES	NO	1
80 ton	~30 ton	~50 ton	NO	YES	NO	10

† Probably "YES", if our package fits into a standard container (W=2,438mm).

„Videau“ Installation

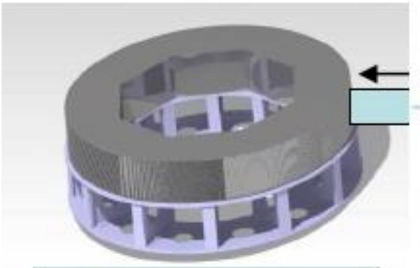
Barrel integration : detectors integration

- Barrel Building & GRPC Detectors insertion

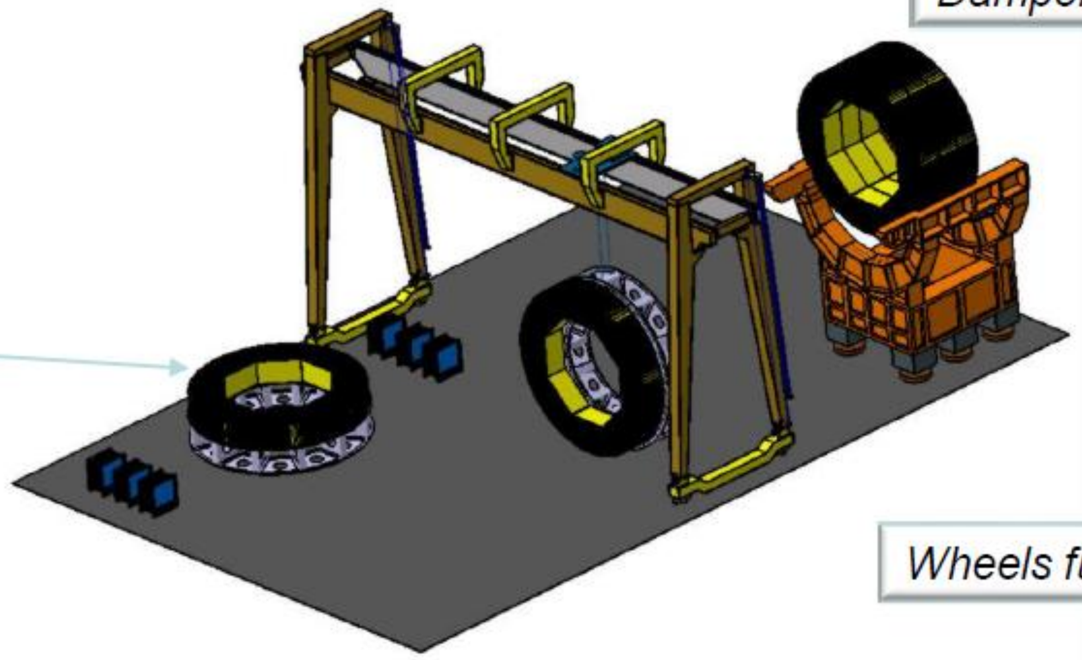


Damper transport structure for GRPC

- 5 x Wheels built in Assemby hall
- **368** GRPC insertion for **1 wheel**
- stock **1840 GRPC** for all the barrel



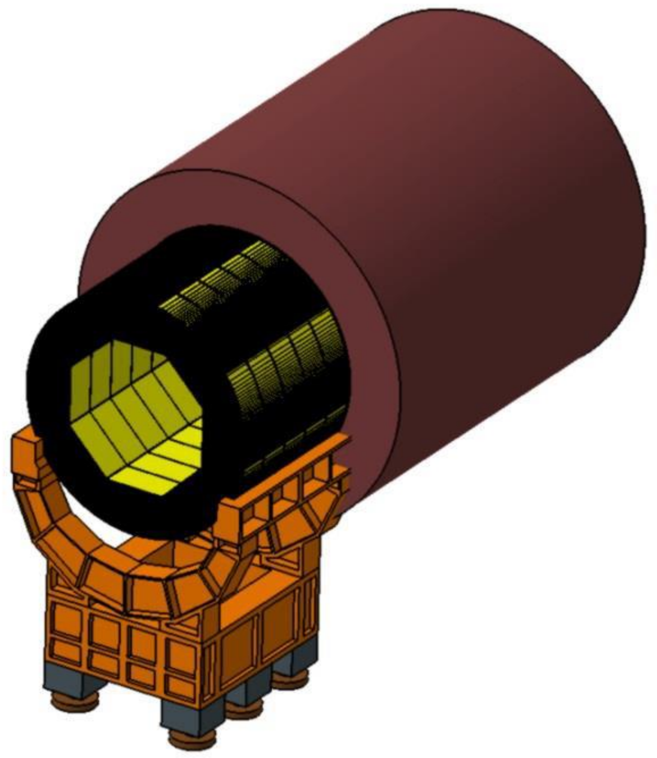
GRPC insertion with specific tool



Wheels full of GRPC put on structure

Barrel integration : insertion

- Barrel insertion & services connecting



Barrel insertion

- Wheels put on the structure one by one
- Barrel with 5 linked wheels on same sub-structure as ECAL (similar to CMS)
- Rails inside the cryostat
- Insertion by « push-pull »
- Fixation inside the cryostat on both sides

CMS « enfourneur » with ECAL insertion system

HCAL Installation Issues

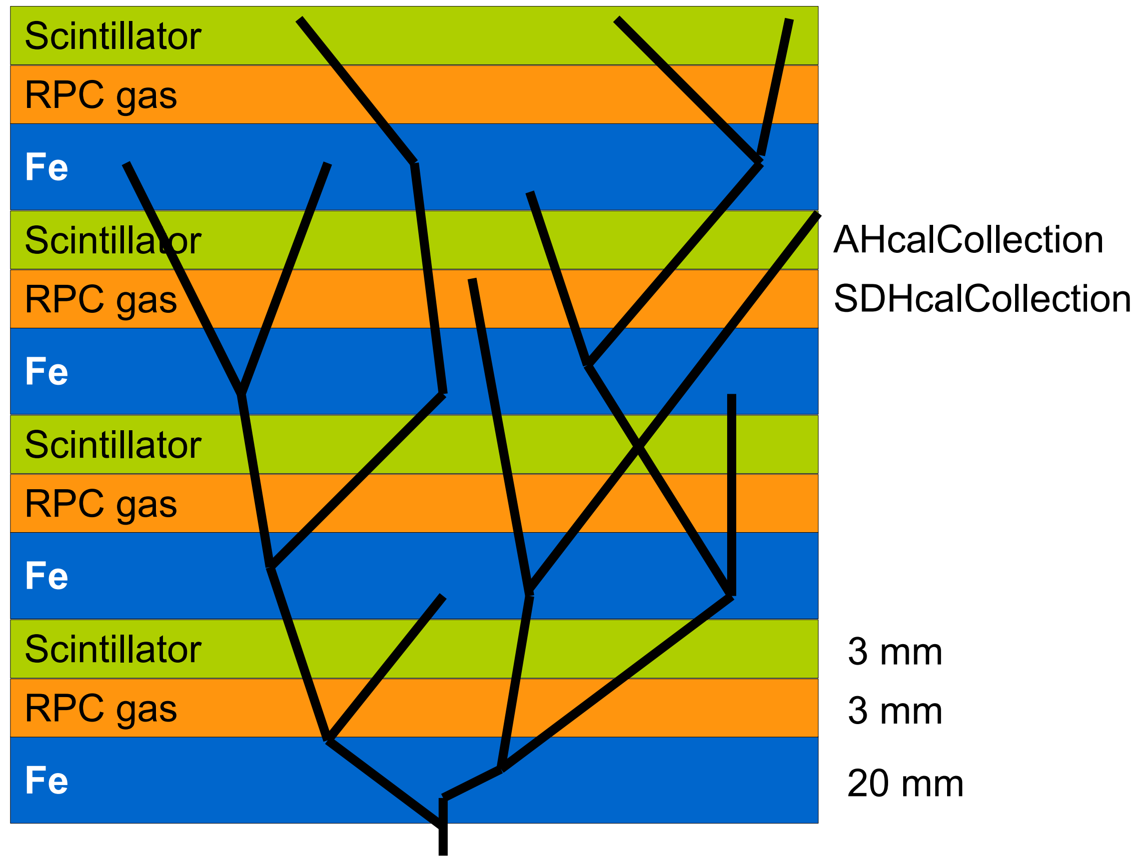
- We assume that calorimeters will be installed in the cryostat in the surface assembly hall
- Heavy tools are required to do this (especially for „Videau“ structure)
- The complete central yoke ring with cryostat and calorimeters will be lowered into the hall
  - gantry crane
- The access to the sensitive elements, cables, cooling in the „Videau“ case requires removal of the complete barrel from the cryostat
  - „TESLA“ structure allows access to sensitive layers by just opening the detector endocarps
- In case something breaks seriously in the „Videau“ case, it will be a lengthy operation to remove the barrel in the underground hall
  - space is sufficient, but not abundant
  - crane capacity is only 80t (or 250t if over the IP access shaft)
  - heavy tools (cradle) need to be installed

ILD: „TESLA“ or „Videau“?

- Factorise the problem!
- Hybrid simulation for Scintillator and RPC readout
- Make large sample simulation independent on the technology choice
  - still do a choice (for the simulation only!) on the absorber structure

Introduction

- calorimeter shower development basically defined by absorber structure
- idea to create HCal (Ecal) model with two sensitive materials
- could use in large scale MC production with little overhead in disk space
- would provide possibility to **compare technologies** on full physics analysis using the **same events**

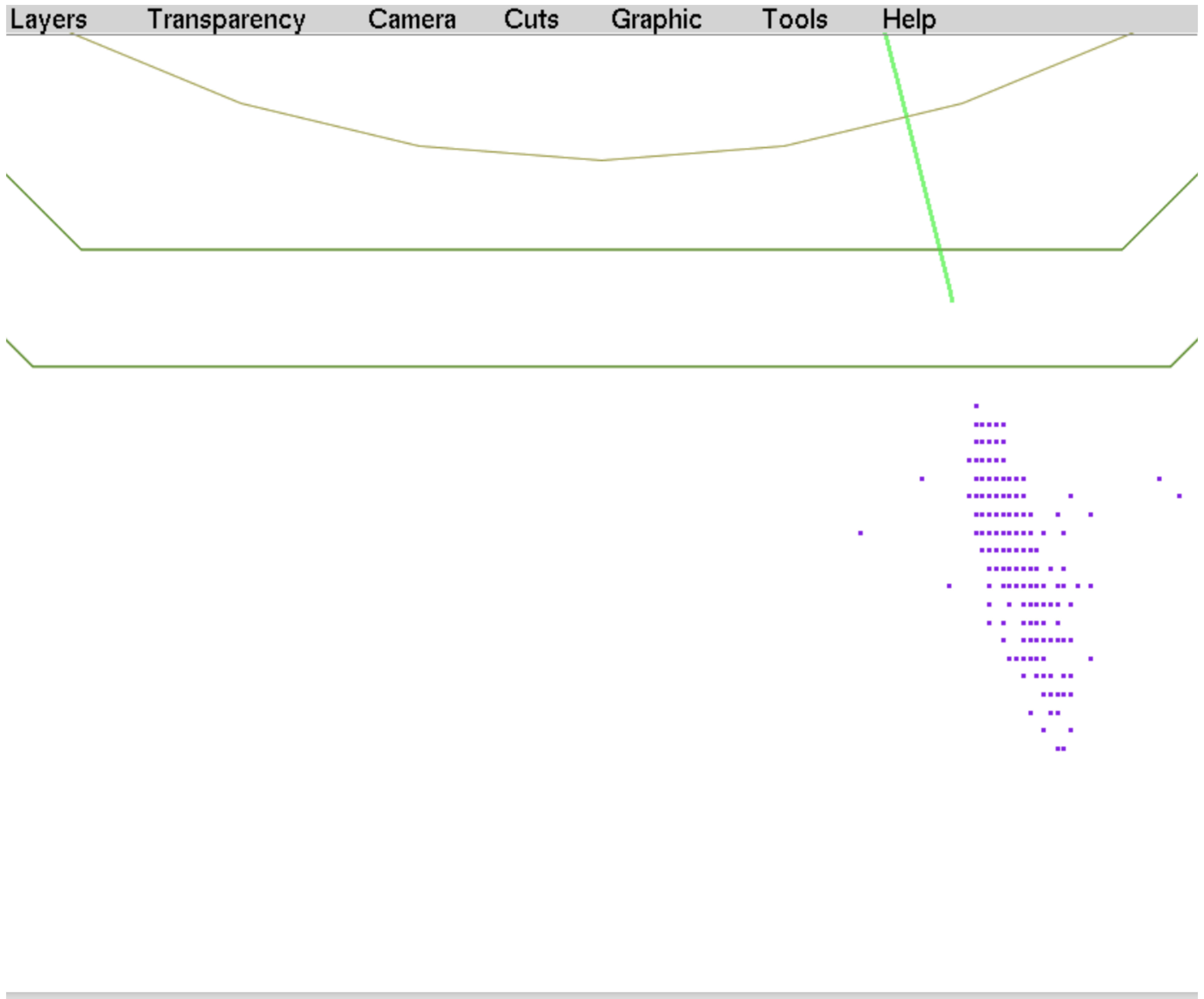


- what is needed for this to work ?

Hybrid Simulation: RPC

example: e^- shower in hybrid prototype

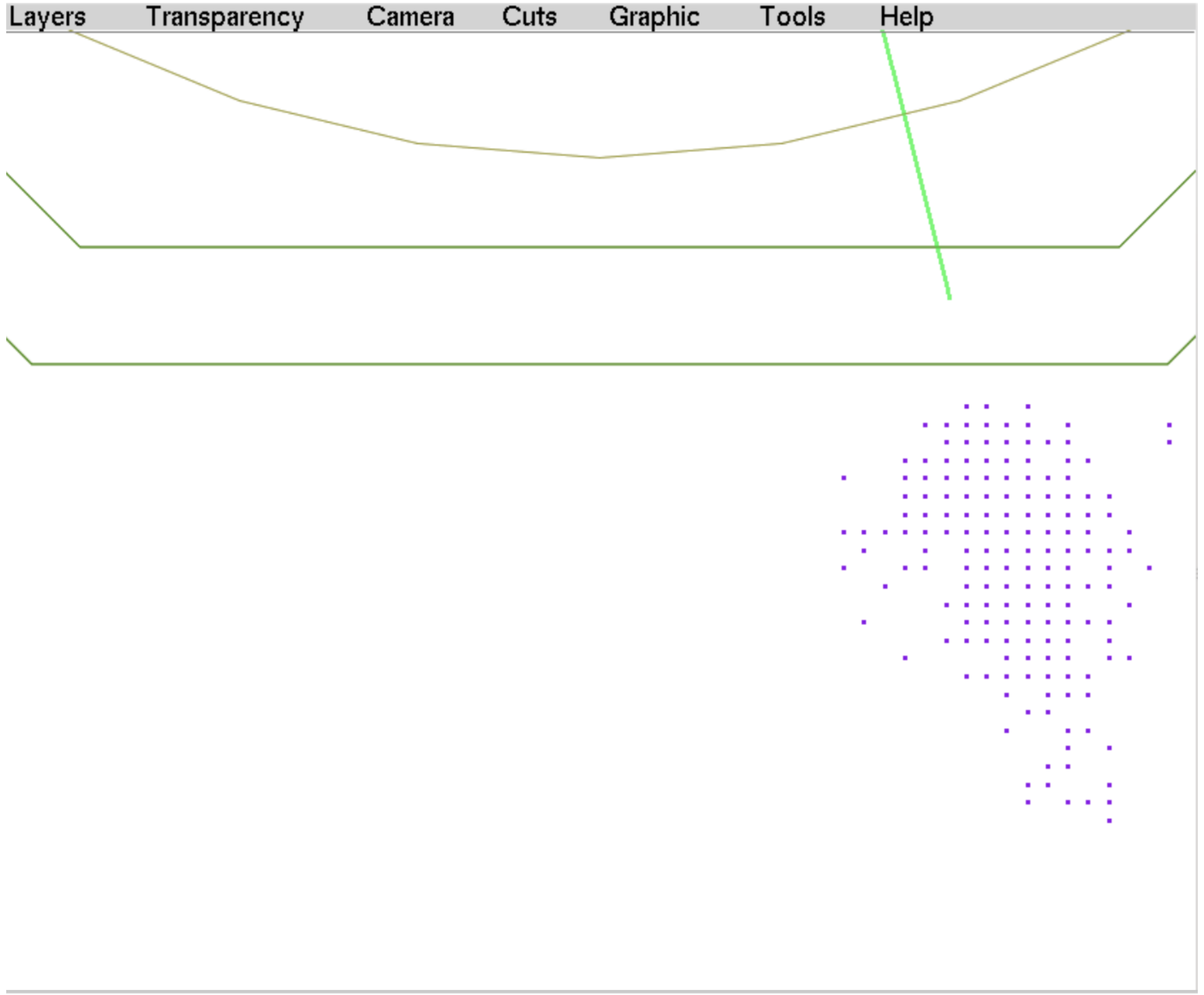
- HcalBarrelRPCCollection



Hybrid Simulation: Scintillator

example: e^- shower in hybrid prototype

- HcalBarrelSciCollection

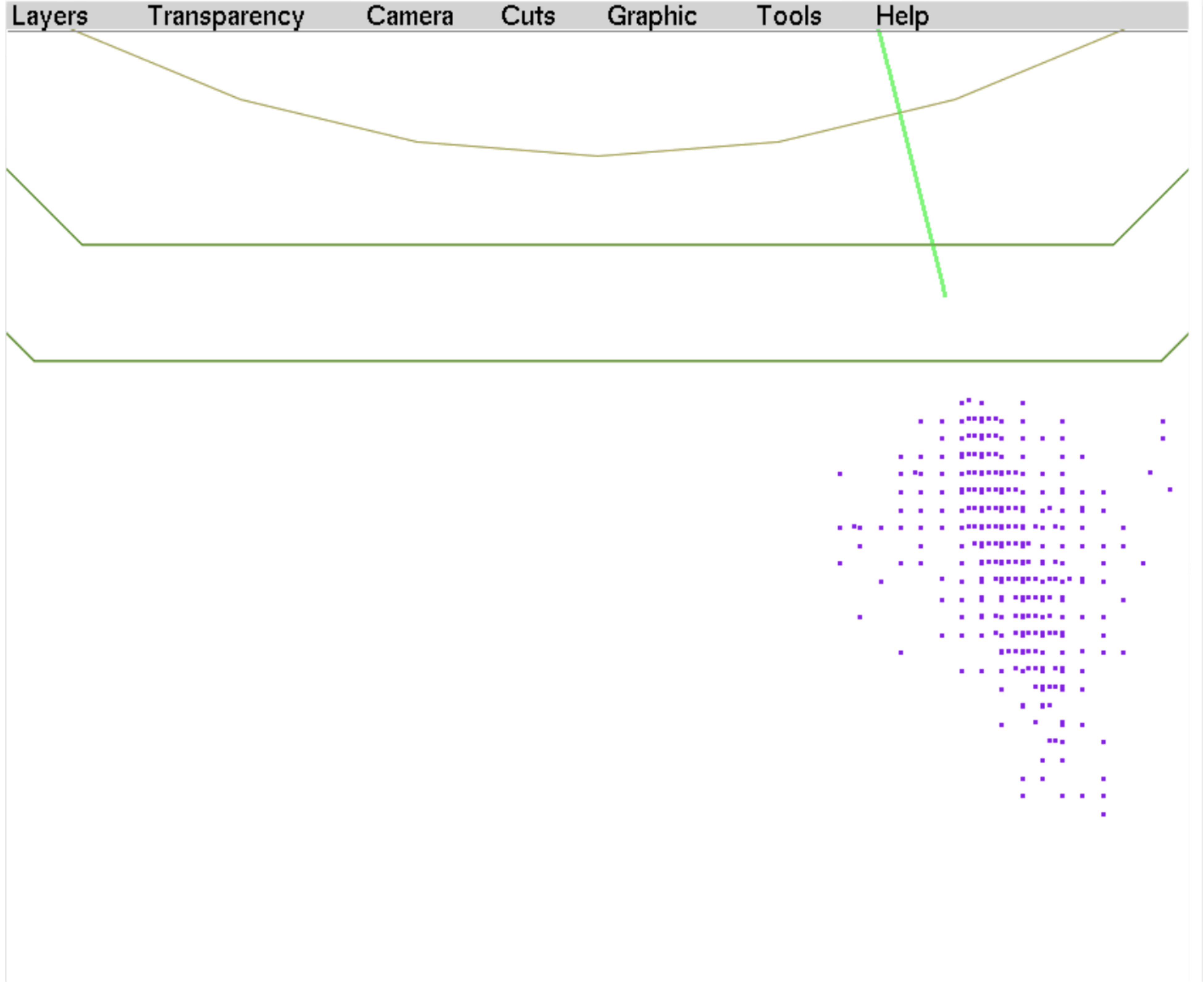


Hybrid Simulation: Both

example: e^- shower in hybrid prototype

- HcalBarrelRPCCollection
- HcalBarrelSciCollection

- clearly see the different segmentations and the different *slices* used
- question: why do the RPC showers have so much less hits ?
  - possibly *energy cut-off* too high . . .



Roadmap

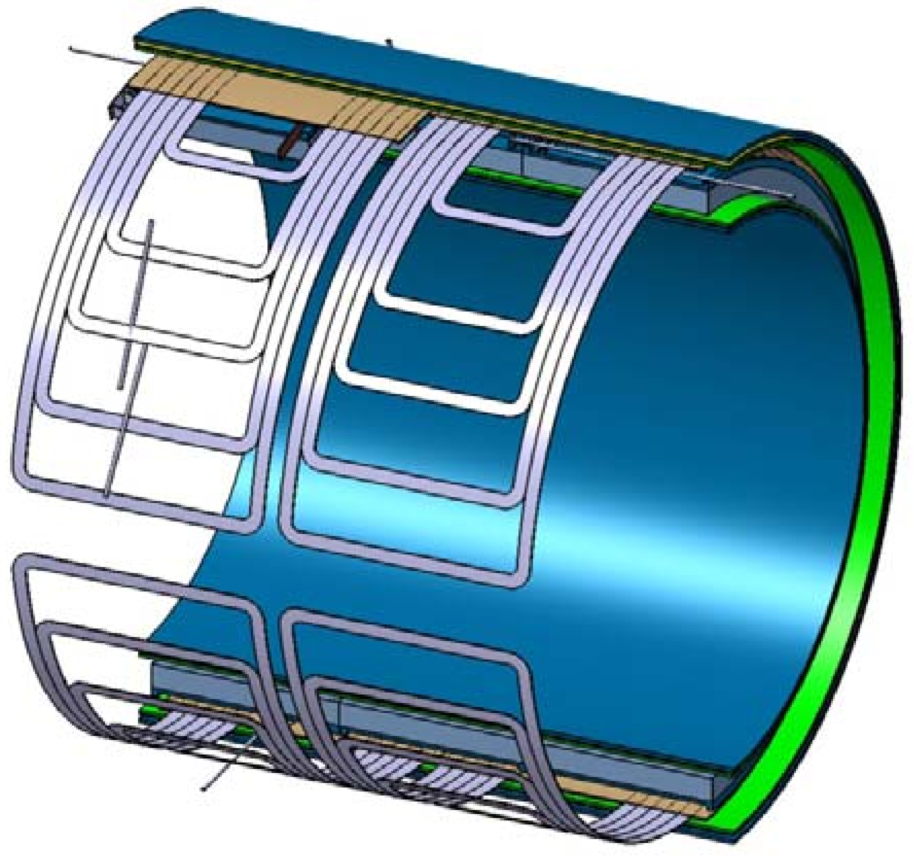
A POSSIBLE ROADMAP

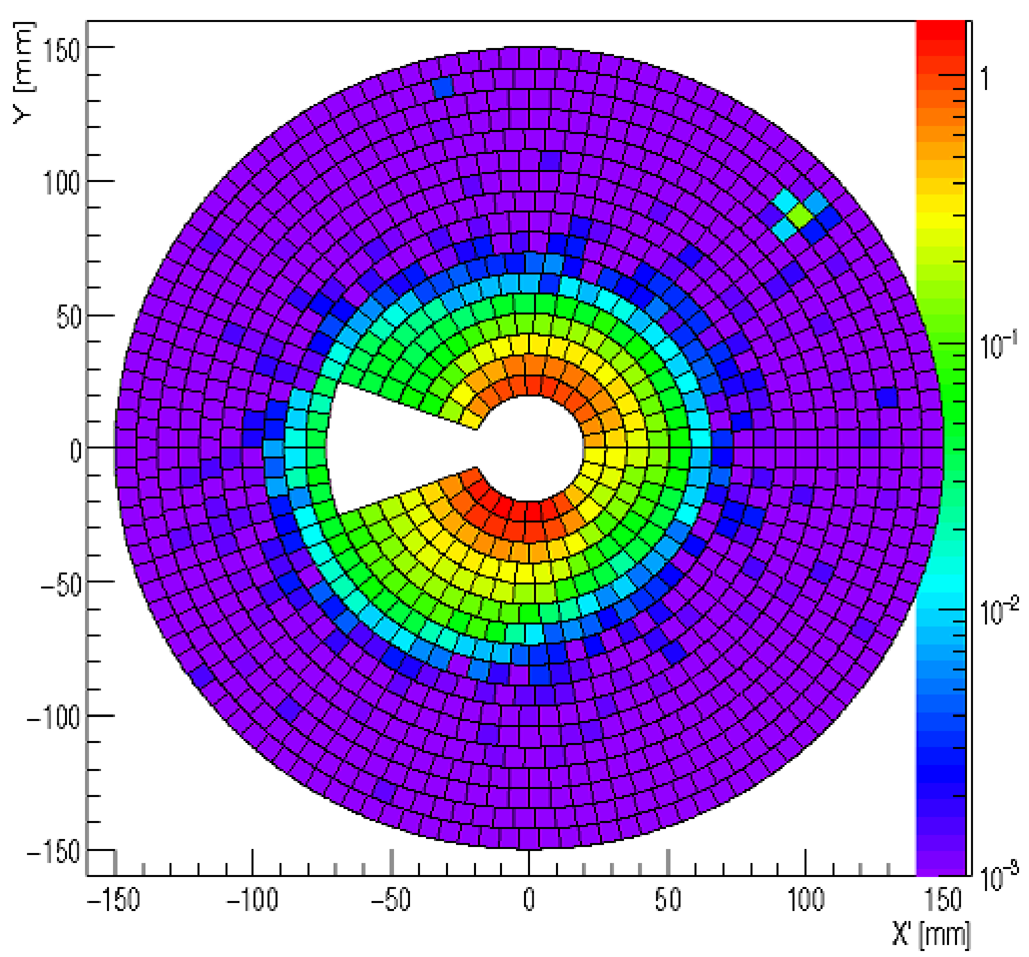
	ACTIONS	COMMENTS
SHORT TERM benchmark simulations	1. Validate hybrid SDHCAL/AHCAL simulation 2. Simulate physics benchmark samples with: Uniform B field, Tesla geometry, hybrid HCAL response 3. Add beam-beam BG patterns to physics events to study anti-DID field configurations	• Assumes that field Inhomogeneities will not affect significantly tracking performance • O(%) imprecisions of hybrid sim superseded by the large gain in the physics samples information content • Keeps DBD geometry as reference for comparison • Avoids unexpected software problems related to big geometry change. • Geometry choice not critical to optimize global parameters like size and B field value
LONG TERM final detector	1. Pursue detailed mechanical simulations of both options including optimization of #wheels, absorber plates thickness, #layers for both HCAL and ECAL 2. Optimize experimental hall and integration aspects for detector access 3. Get external expertise from LHC about access frequencies, electronics reliability, etc…	**NB:** ***The real final detector will have to take into account many more factors than were considered up to now in the detector design.***

Anti-DID or not?
(just short, talk by Uwe)

Anti-DID

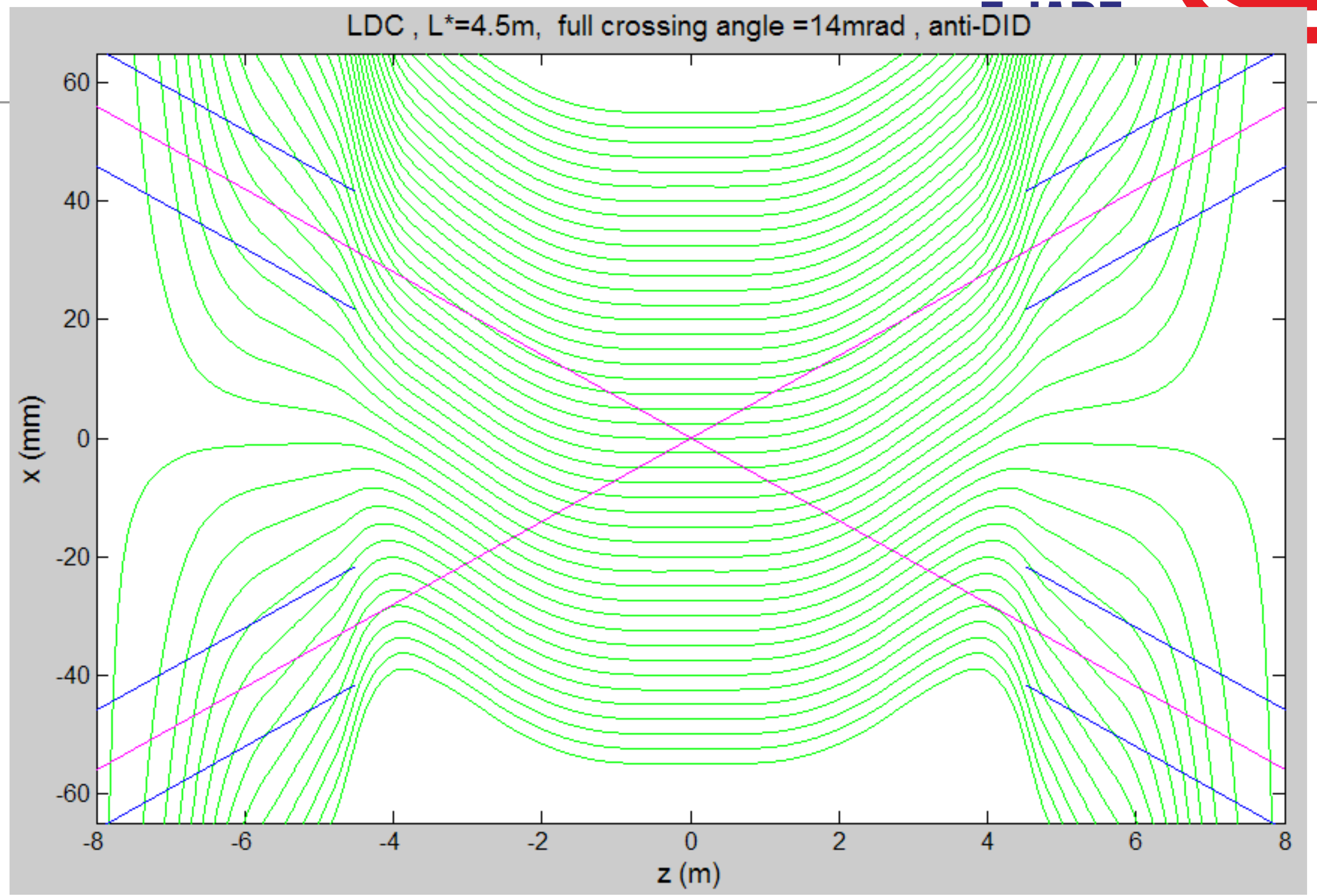
- Detector Integrated Dipole field was invented by Andrei Seryi and Brett Parker to make the net magnetic field parallel to incoming beams
  - polarisation tuning, reduce emittance growth due to synchrotron radiation
- Turned out that these problems were not as bad and could be corrected without DID
- Then proposed Anti-DID: make net magnetic field parallel to outgoing beam
  - reduce background on BeamCal as low energetic charged background particles are guided to exit hole



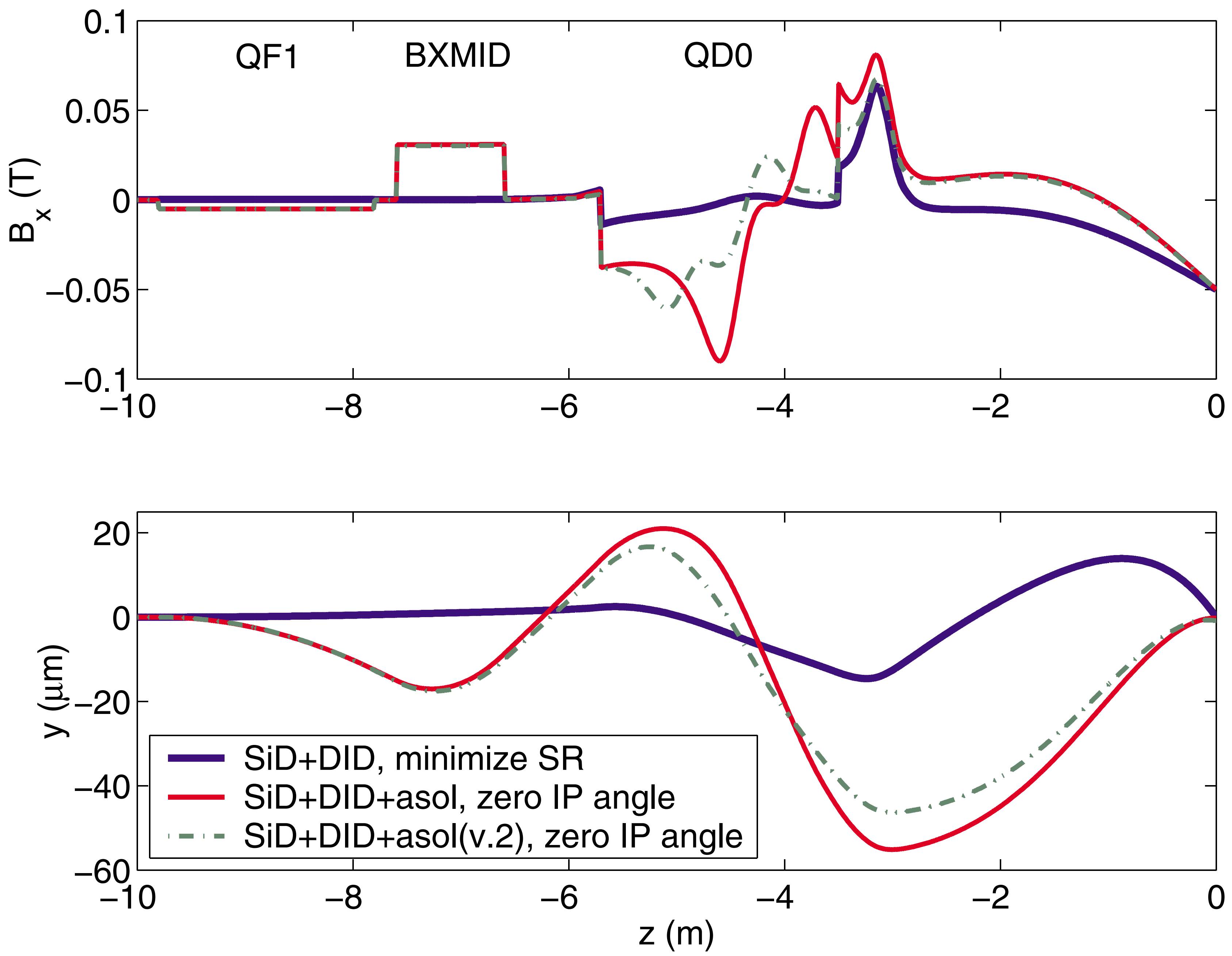


Forward Region Magnetic Fields

Seryi et al. SLAC-PUB-11662



- The magnetic fields that determine the background distribution in the forward regions are complicated overlays:
  - Detector solenoid (fringe) fields
  - QD0 quadrupole (fringe) fields
  - Anti-solenoid (fringe) fields
  - Anti-DID (fringe) fields
- A detailed 3D model of all fields would be needed to do proper background simulations.
- This needs to be done anyhow for the new L* geometries
  - collaboration with machine experts required
  - probably hard to get in view of resources at machine groups…



Parker, Seryi, PR STAB 8.041001

Anti-DID: Small Coil

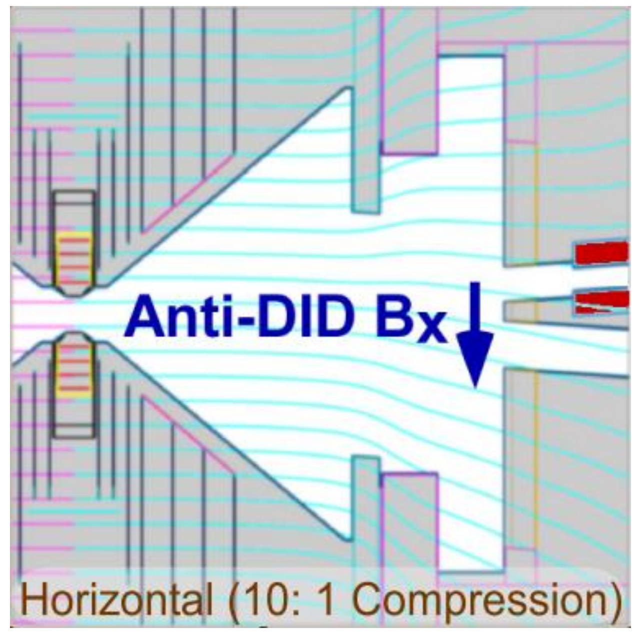
- Small coil at the beam pipe

Anti DID First Specification

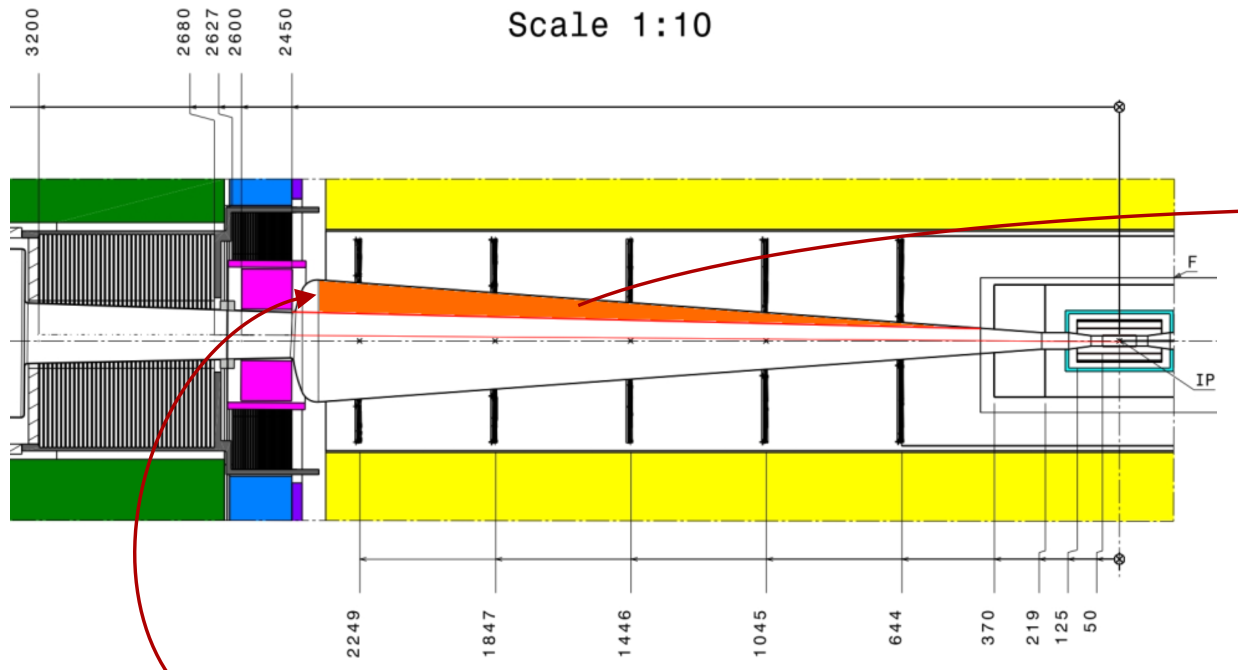
Berriaud

First specification:

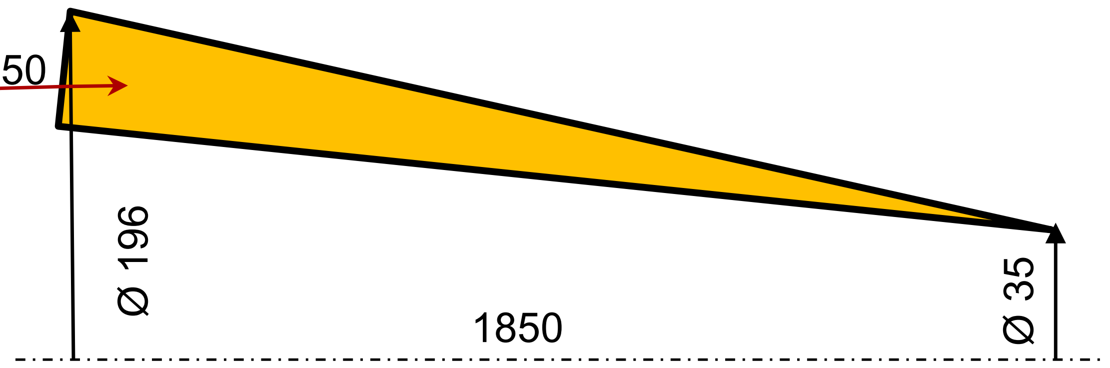
- $\int B d\ell$ = 0.1T.m;
- No stray filed constraint;
- Fixed on beam tube;
- No radiation issues;
- Feeding access will be study later;
- No request on uniform field along the axis;
- No harmonic constraints
- Geometry data are below:



Brett Parker



Maximum available space for the dipole

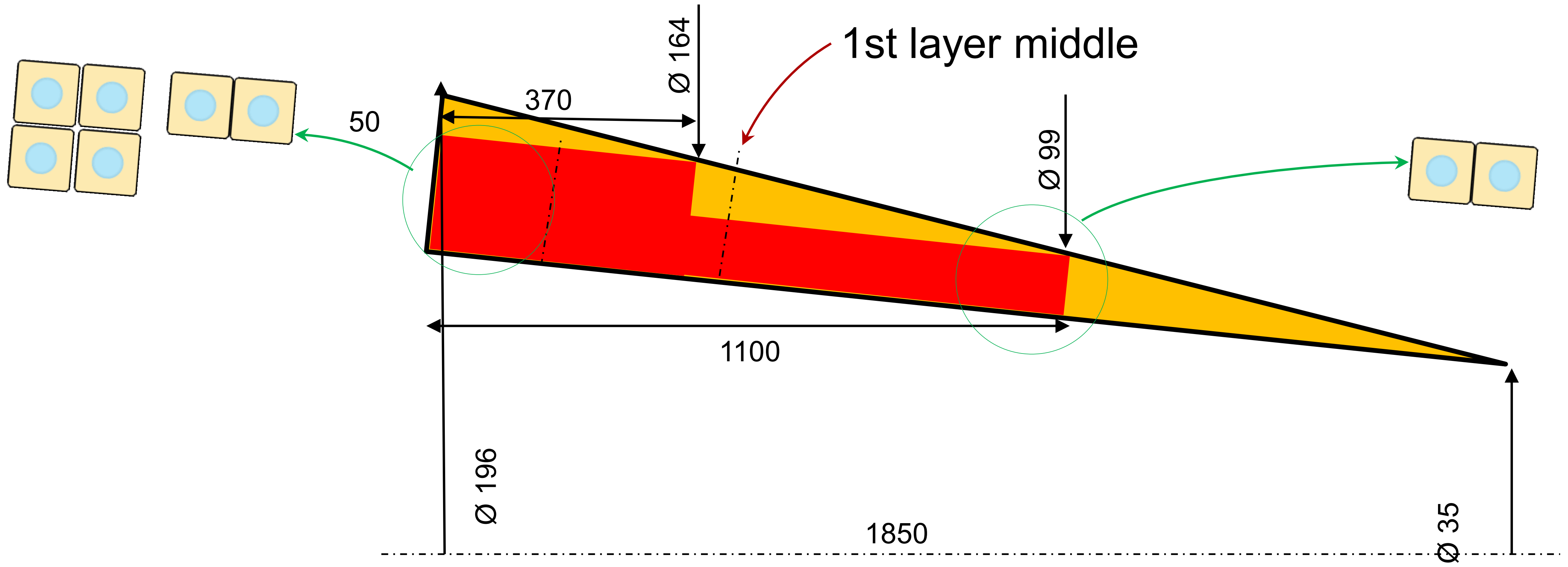


Geometry data

2

Winding location

Berriaud



Useful length of the first layer:

- 1100-(196+99)/2 ~ 960 mm

Useful length of the second layer:

- 370-(196+164)/2 ~ 190 mm

Middle	l [mm]	$Ø_e$ [mm]	$Ø_i$ [mm]
First layer	550	148	78
Second layer	185	180	90

4

- Too much material in the detector, large forces
  - will not be followed up

Summary

- ILD is preparing a large simulation run with full detector simulation
  - ILD-L (DBD-like) vs ILD-S (smaller)
- Topics to decide before simulation can be started:
  - Include Anti-DID or not?
    - Tendency: not for production run, but have available for dedicated studies, e.g. on backgrounds
  - Which HCAL absorber structure, „TESLA“ or „Videau“?
    - Factorise steel structure and technology with hybrid simulation
    - Tendency: do production with „TESLA“ as only there full particle flow reconstruction is available
      - work on PFA for „Videau“ and prepare simulation model for selected benchmark reactions
- Some of these topics have an impact on CFS and infrastructures
  - cables, services
  - HCAL structures: assembly, transport, services
  - Anti-DID: coil production