Status of Technical Description of ILD

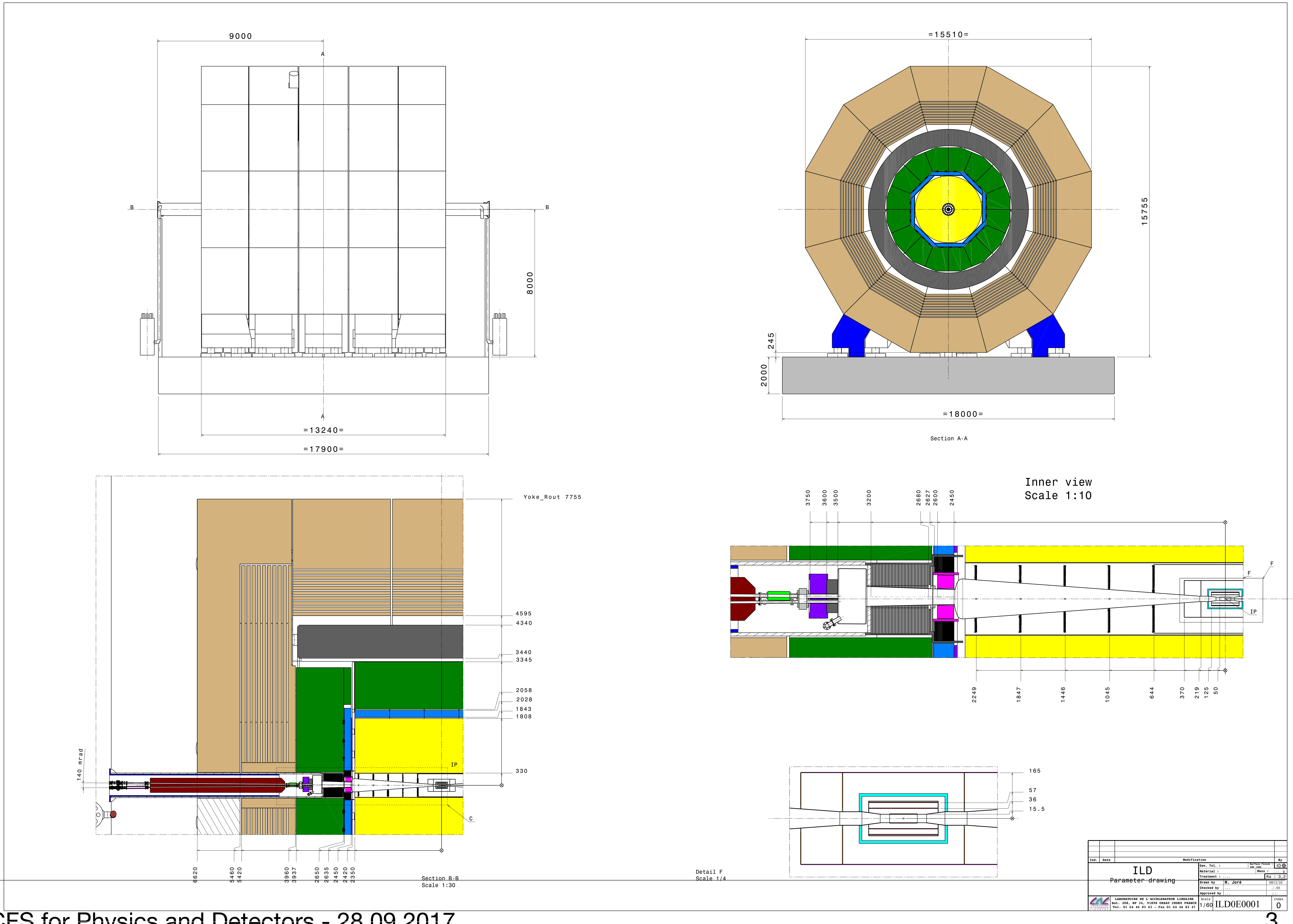
Karsten Buesser

Mini-Workshop on ILC Infrastructure and CFS for Physics and Detectors
28.09.2017

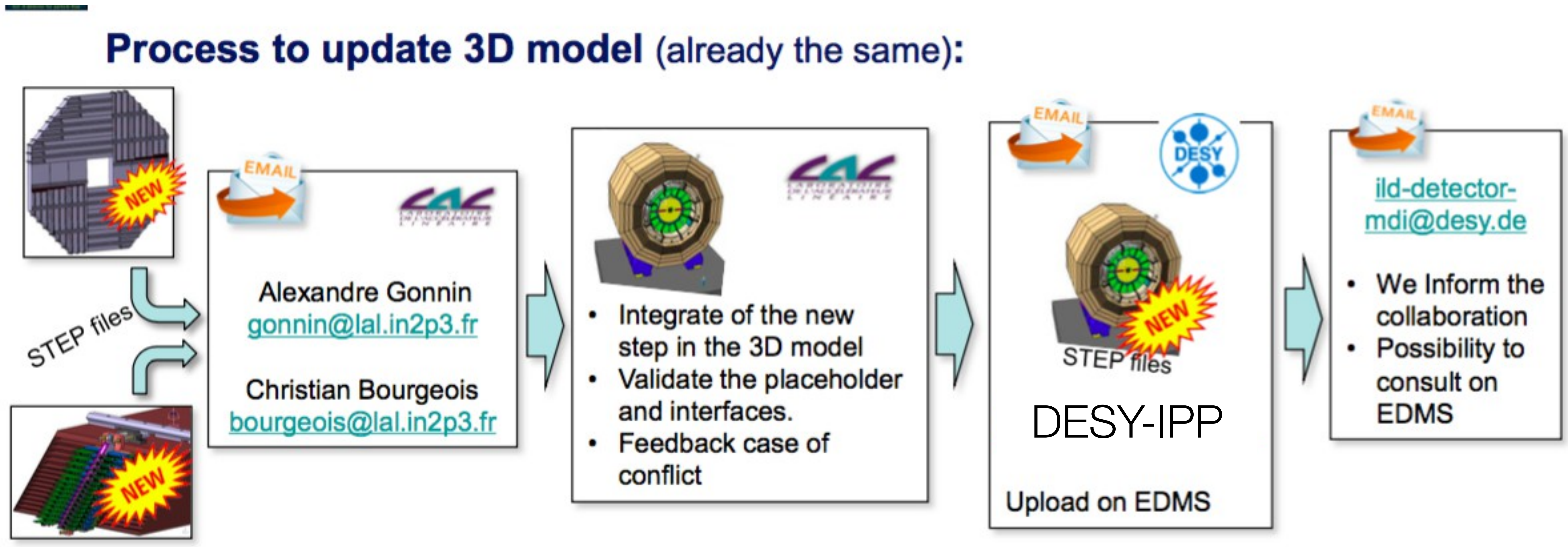
ILD CAD Model and Interface Control Documents

ILD CAD Model

- The ILD engineering model is kept in ILC-EDMS
- Manager of the model is Christian Bourgeois (LAL)
- Combination of different CAD sources to a unified model with help from DESY IPP
- Need to evolve model to keep up with design work in subdetector collaborations
- Have started an initiative to define the interfaces in a more formalised way



Engineering Model – Update process



R. Poeschl

- Updates of the engineering model have to be communicated to Christian Bourgeois and Alexandre Gonnin
  Otherwise they don't exist!!!!!

- Fill the interface control document

Interface control document

Proposal of an Interface Control Document (ICD):

Purpose of this document is:

- To know and record technical details of each subdetector
- To understand the consequences at the interfaces (gap, fixations, weight,)
- Follow up of different progress
-

One document by sub detector

Enter all technical details you know today (dimensions, weight, attachment points, center of gravity, positioning constraints, services, power consumption, thermal dissipation, integration specfications,)

Items may be missing (Please help actively to improve the document)

Each ICD will evolve during the phase of study.

They are not casted in stone yet

- ICD will become backbone of ILD Engineering Design study!!!
- Status will be monitored at ILD (Integration) meetings

R. Poeschl
H. Videau

Three documents

Document on ILD Conventions and rules

ilc international linear collider	ILD conventions and rules Template	Ref. : ????? Ed. : 0 Rev. : 3 Date: 21/10/16 Page : 1/8

ILD conventions and rules

ILD

Prepared by	Signature	Accepted by	Signature
Roman Pöschl			

Approved by	Function	Date	Signature

Summary	
Annexes	

Document Change Record

Edition	Revision	Date	Modified pages	Observations
0	1	21/10/16	all	Creation

Distribution	*See Distribution list at the end of this document*

Template V1.0

Obligatory document:
Author: Central Integration Group

Actual ICD

ilc international linear collider	Interface Control Document Template	Ref. : Ed. : 1 Rev. : 0 Date: Page : 1/9

Interface Control Document Template

XXXXXXXX (Sub detector name)

Prepared by	Signature	Accepted by	Signature

Approved by	Function	Date	Signature

Summary	
Annexes	

Document Change Record

Edition	Revision	Date	Modified pages	Observations
1	0			

Distribution	*See Distribution list at the end of this document*

Template V1.0

Obligatory document
Author: Subdetector group

Technical Design Document of subdetector

ilc international linear collider	Interface Control Document Template	Ref. : ????? Ed. : 0 Rev. : 3 Date: 22/8/16 Page : 1/34

Technical Design Document

SiEcal

Prepared by	Signature	Accepted by	Signature
Marc Anduze Henri Videau			

Approved by	Function	Date	Signature

Summary	
Annexes	

Document Change Record

Edition	Revision	Date	Modified pages	Observations
0	1	7/10/16	all	Creation

Distribution	*See Distribution list at the end of this document*

Template V1.0

Optional document
(Highly recommended)
Author: Subdetector group
-> See talks by Henri and Marc

R. Poeschl

Interface Control Documents - Status

Subdetector	
VTX	???
SIT/FTD/ETD	???
TPC	discussions have started
Si-ECAL	first draft available
Sc-ECAL	discussions have started
A-HCAL	discussions have started
SD-HCAL	discussions have started
FCAL	discussions have started
Yoke/Muon	???
ILD Conventions/Rules	first draft available

Conventions and Rules

- Central Design and Integration group: KB, R. Poeschl, T. Tauchi
- V0.1 on EDMS:

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ILD conventions and rules

ILD

Prepared by	*Signature*
Roman Pöschl	

Accepted by	*Signature*

Approved by	*Function*	*Date*	*Signature*

Summary	
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Template V1.0

ilc international linear collider	ILD conventions and rules Template	Ref. : ????? Ed. : 0 Rev. : 3 Date: 21/10/16 Page : 2/8

- Table of Contents -

1. LIST OF ACTIONS

EDMS Nr.: D00000001156315 Rev: A Ver: 1 Status: Released - Dat.: 12. Apr 2017

- Unit conventions
- Coordinate system
- Naming and numbering conventions
- Services
- Local regulations (T. Tauchi):
  - Electrical Appliance and Material Safety Law
  - Fire Service Act
  - High pressure gas safety law
  - Act on Prevention of Radiation Damage by Radioisotope
  - Building Standards Law
  - Corresponding rules at KEK…

3. GLOBAL CONVENTIONS OF ILD

This document constitutes a reference for every document concerning design, construction, assembly of any part of ILD.

3.1. Unit conventions

All the dimensions are given in mm.

3.2. Definition of the ILD reference frame

The origin of the frame is the centre of the interaction region.

We consider that at the interaction point the plane containing both beams is the horizontal plane. This is not trivial considering that the beams are at angle with the magnetic field and have traversed, before the detector, a compensation solenoid. This definition should be inherited from the accelerator. TO BE handled by MDI group

The normal to this plane (vertical) is O_y. Calling P_{e-} the mean momentum of the electrons and P_{e+} the mean momentum of the positrons, O_z is proportional to $P_{e-} - P_{e+}$. It is close to P_{e-} with an angle of 7mrad, the two momenta being equal in modulus and their angle being 14 mrad. O_x is deduced to make a right-handed frame.

The centre of the detector is the frame origin, its axis is O_z.

The global shape of ILD is cylindrical. The central part is called "barrel", the barrel is closed on each side by an end cap presenting disk shapes. The two end caps are called "end cap z>0" and "end cap z<0" with obvious definitions. This distinction is not valid for the inner detector part of the detector inside the TPC radius.

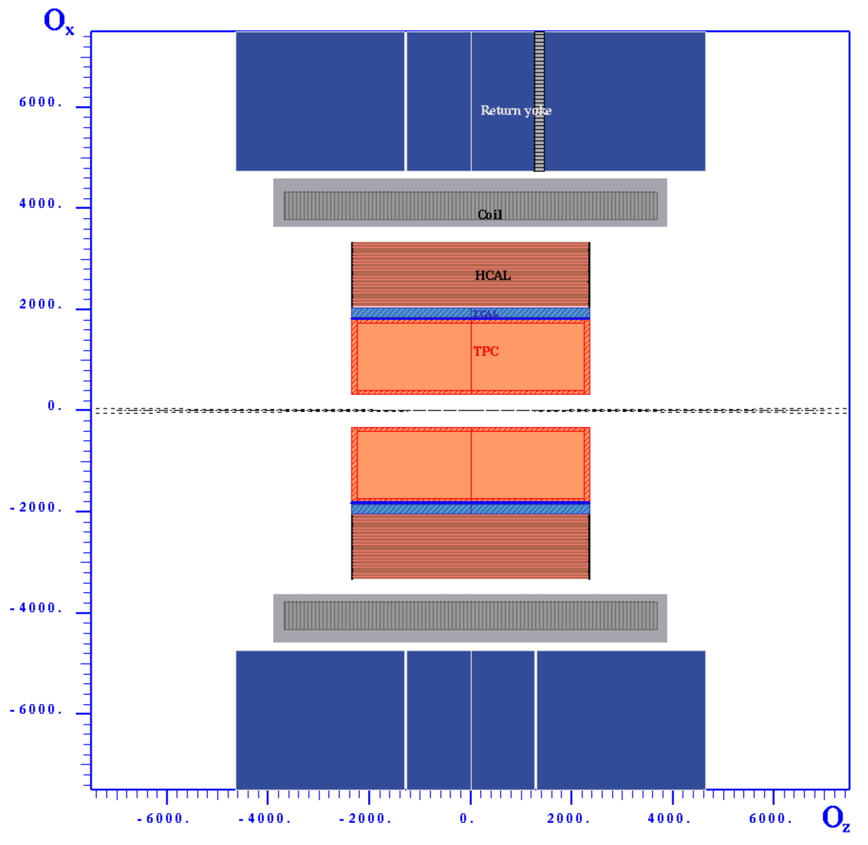


Figure 1. Schematic drawing of the detector barrel.

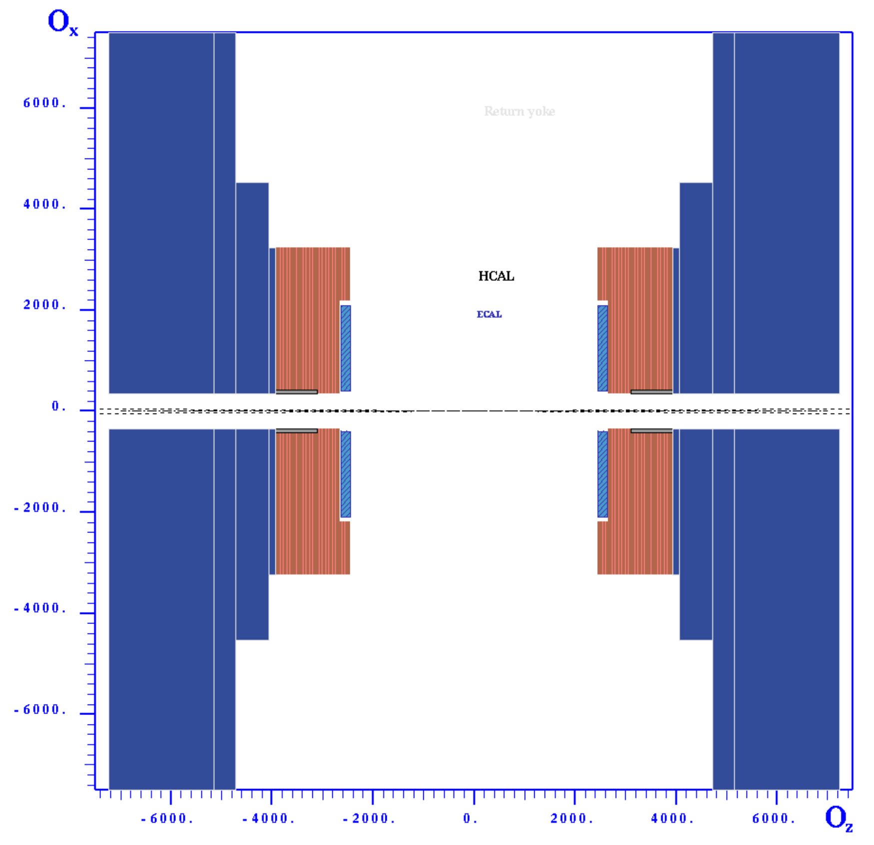


Figure 2. Schematic drawing exhibiting the two end caps of the detector

3.3. Naming and numbering conventions

Numbering definitions and scheme for ILD. The numbering of pieces goes with z for longitudinal structures, it goes with the azimuthal angle in the transverse dimensions. It starts at zero in such a way that multiplied by the angular span of the pieces one gets the angle of the pieces.

3.4. Cable and services path

from the Note on the integration of the ILD detector by C. Clerc and M. Joré

3.5. Detector cabling scheme

Principles

Two main constraints have driven our study:

- Allow maintenance with the minimum of cable disconnections.
- Minimise the number of cables and services in the way of particles

Thus, we propose the following cabling scheme (see figure 3.1.1.1):

- Inner and forward detectors cables/services along the beam
- Barrel detectors cables/services along the coil cryostat and between central and outer rings of barrel yoke. The cable might be distributed in chimneys. The cable might be distributed in chimneys. This is to be studied completely.
- Endcap detectors cables/services between barrel yoke and Endcap.

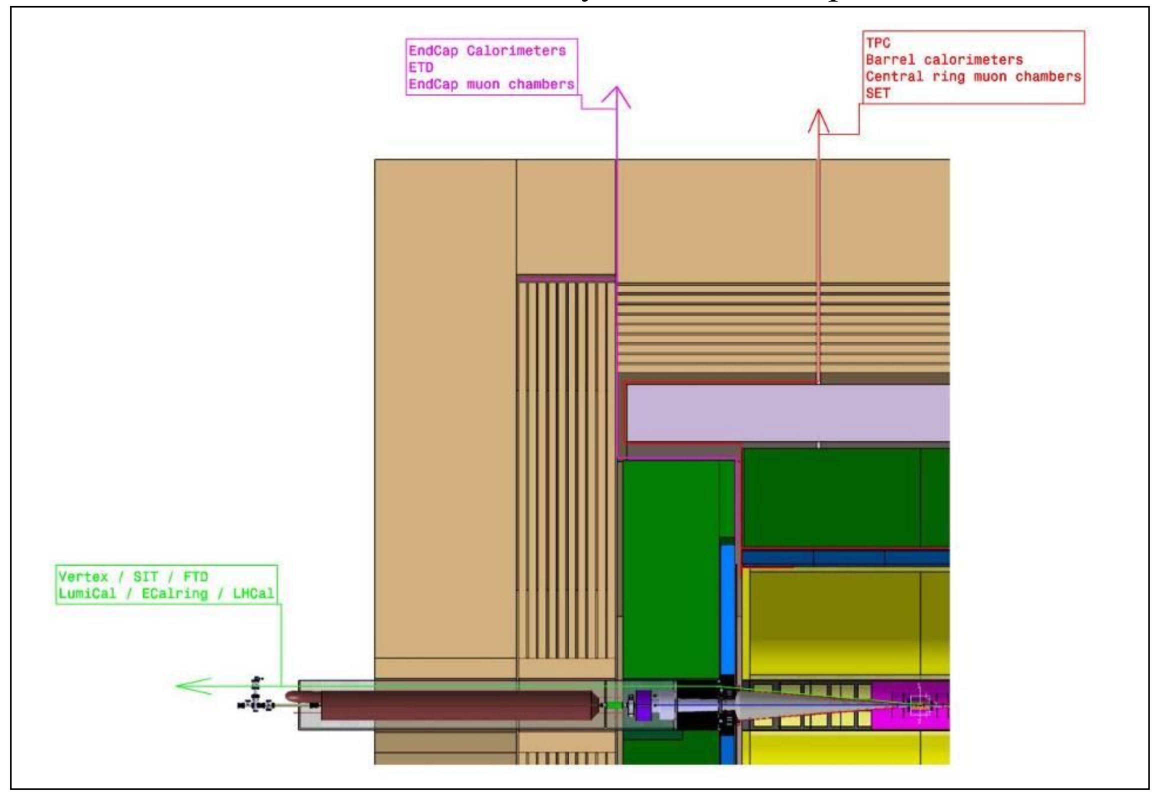


FIGURE 3.1.1.1 Cabling scheme

The inner and forward cables, in green in the figure above, will be routed along the pillar and after to the cable chains. The others cables will be routed to a patch panel connected to the cables chains.

The most delicate issue of this solution lies in the Lumical region. The cables coming from the inner part must find their way out along the Ecal ring, Lumical and support tube, but should not prevent the opening of the endcap. That last point implies a possibility of disconnection. Thus, a quick disconnection device, like a patch panel, is mandatory in this region. NOT TRIVIAL.

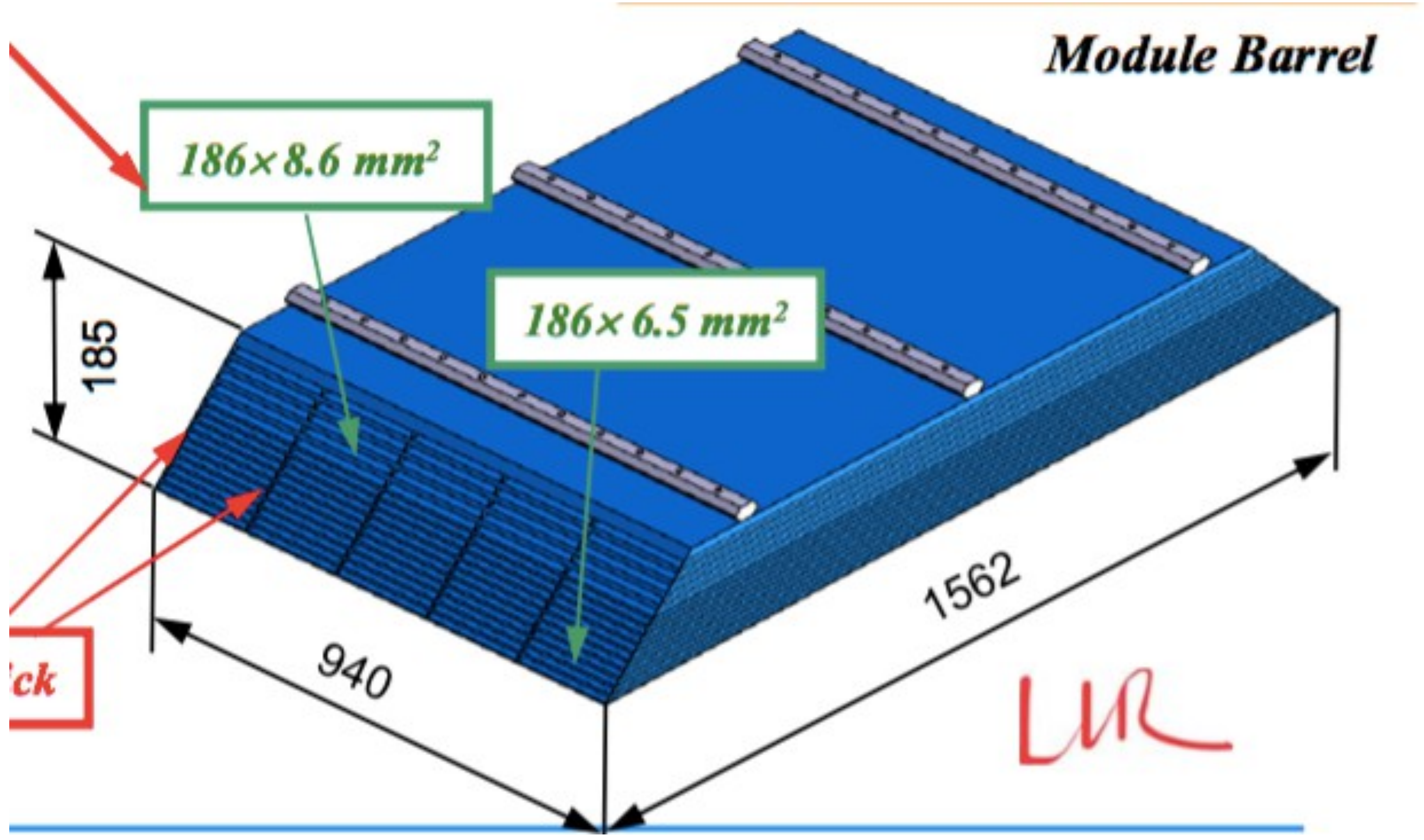
Reference for ICD

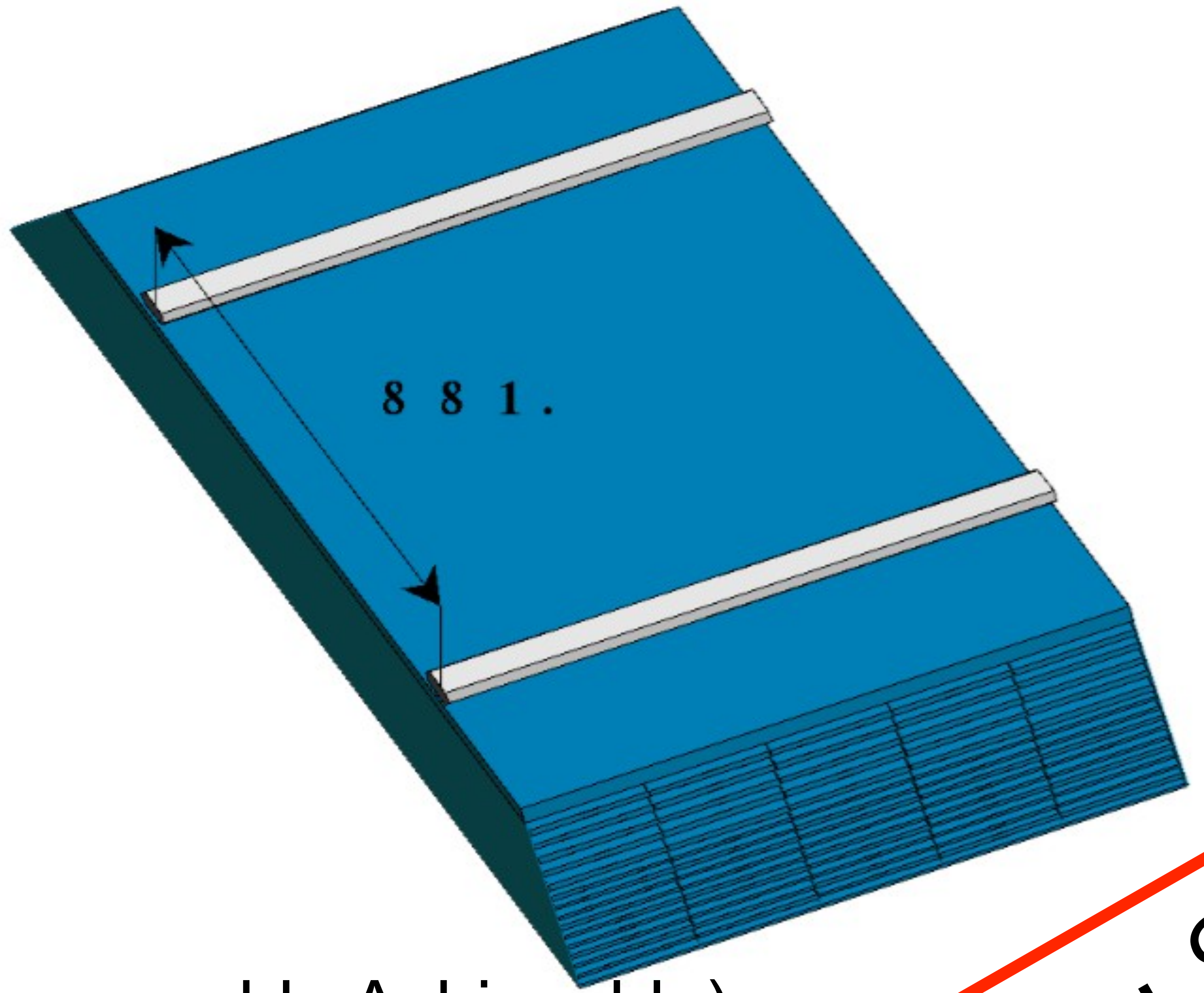
- **Until further notice reference for ICD is DBD**

- However, unavoidable changes can be taken into account
  e.g. SiECal Barrel Module

R. Poeschl
H. Videau

Module with 3 rails → Module with 2 rails





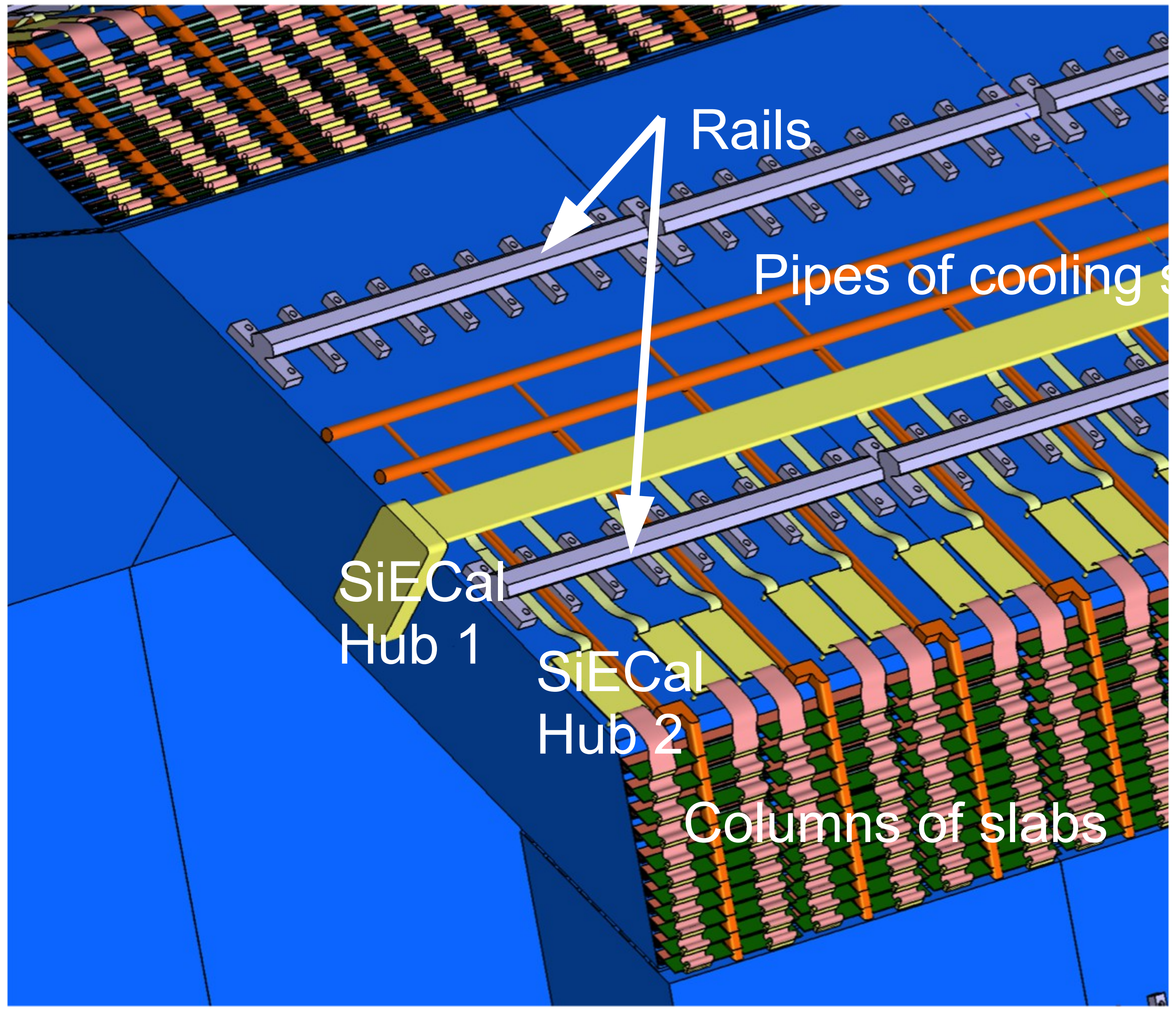
- Keep changes w.r.t. DBD ALARA (As Low As Reasonable Achievable)
  - Document them clearly

- How to deal with modified L*

Example: SiECAL

Drawings by M. Anduze

ICD SiECal – Example II



Disclaimer: Design subject to change

SiECal external components
i.e. Relevant for ICD

- SiEcal Hub 1
  (hub to external supplies and DAQ)
- Rails (connection to Hcal

SiECal internal components
i.e. Relevant for TDD

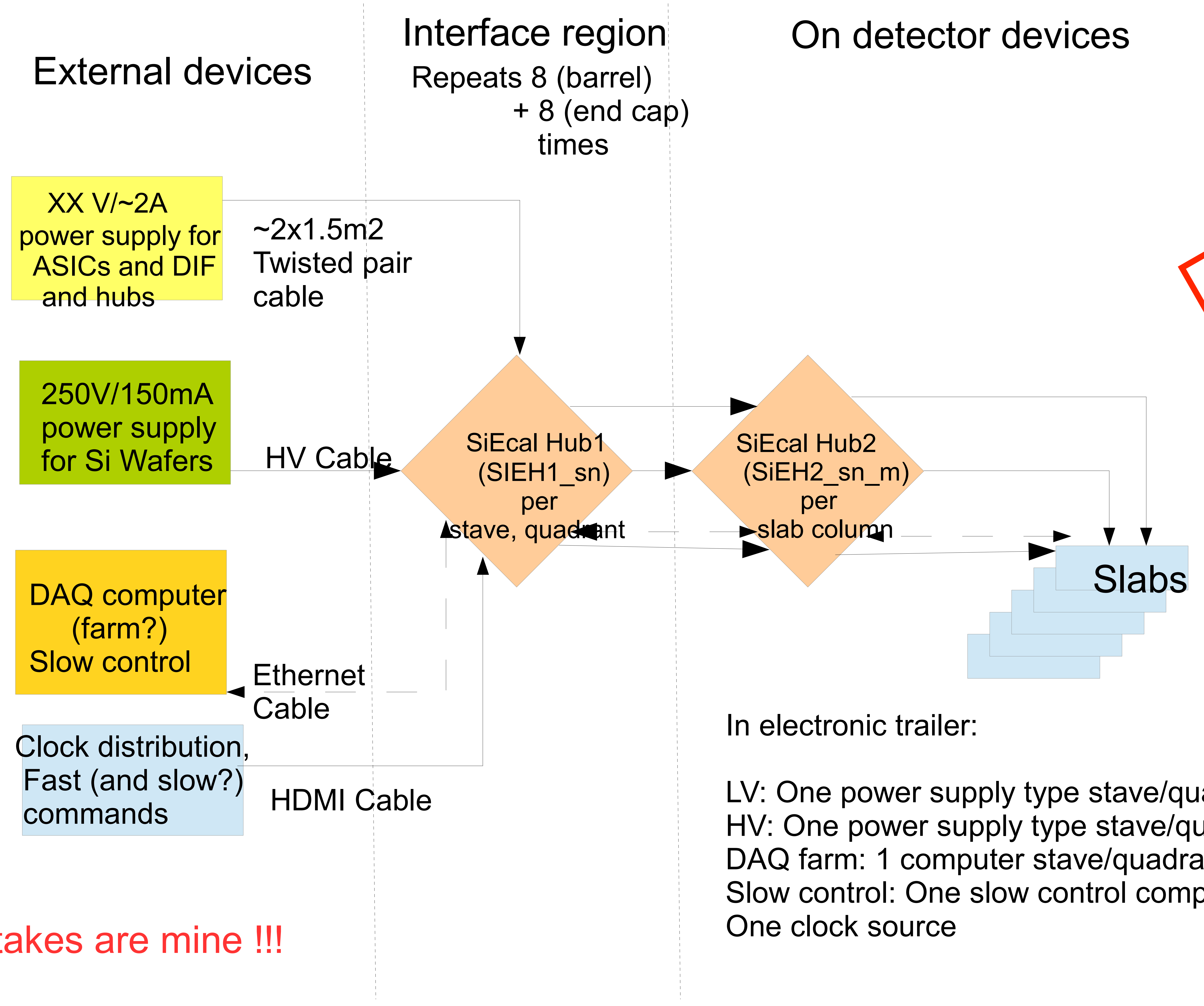
- Cooling pipes,
- SiEcal Hub2 (internal hub)
- Slab columns

... as long as they don't exceed the space between ECal and HCal or influence detectors in another way (heat, interspersed noise, etc.)

R. Poeschl
H. Videau

Example: SiECAL

Supplies – Naive block scheme



Example: SiECAL

R. Poeschl
H. Videau

In electronic trailer:

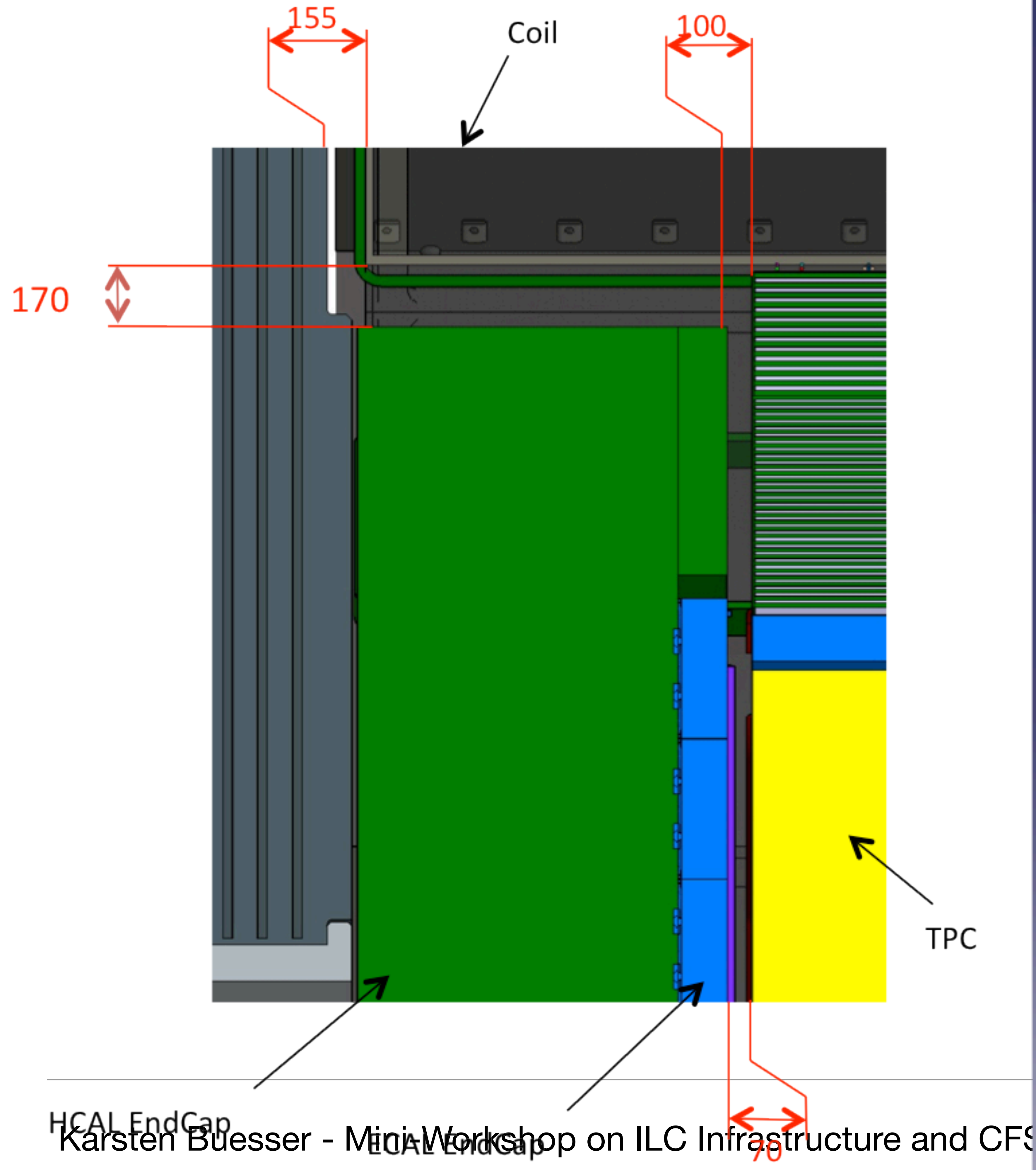
LV: One power supply type stave/quadrant
HV: One power supply type stave/quadrant
DAQ farm: 1 computer stave/quadrant for acquisition
Slow control: One slow control computer
One clock source

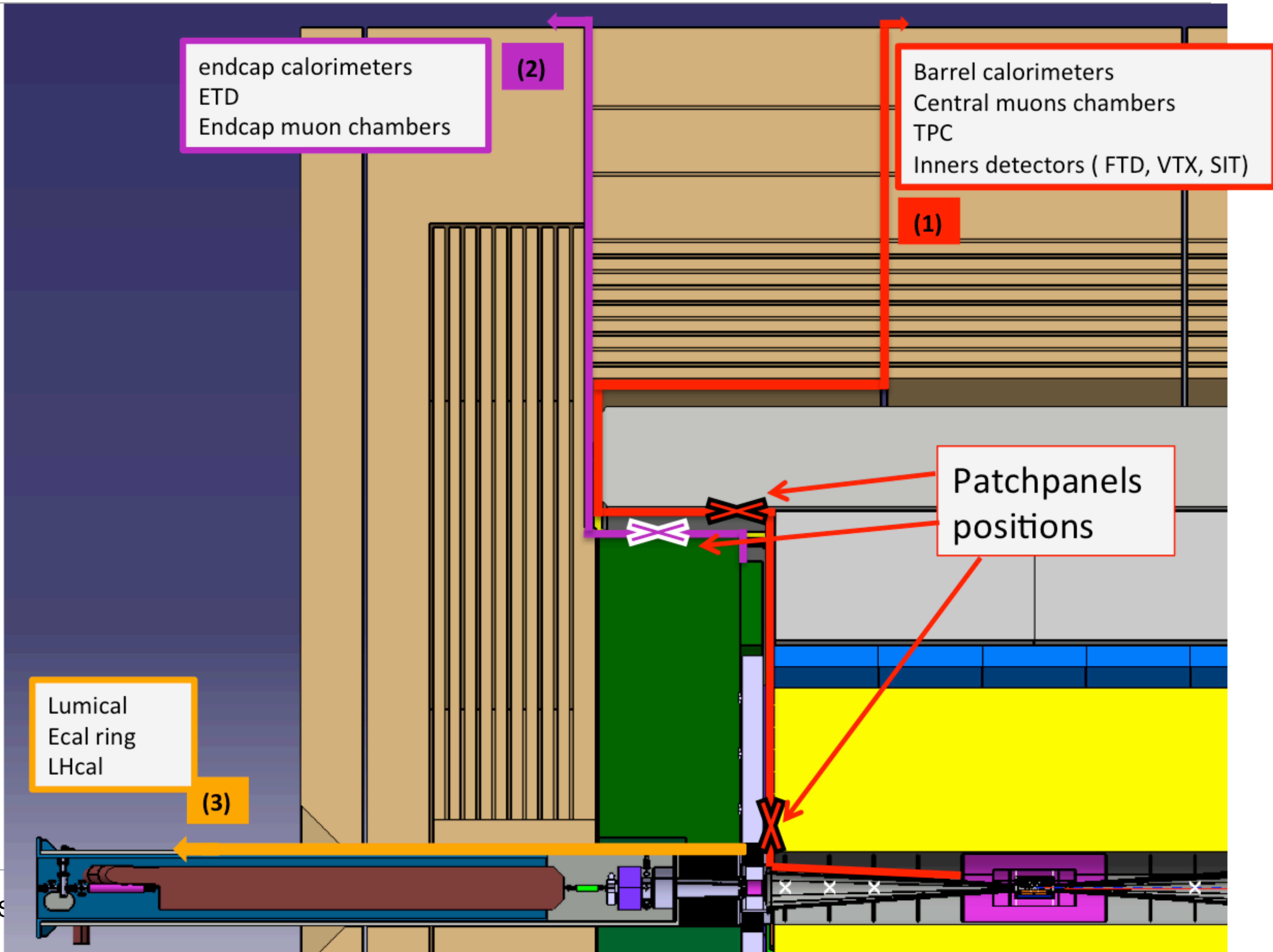
All mistakes are mine !!!

Cables and Services

Paths for Cables and Services

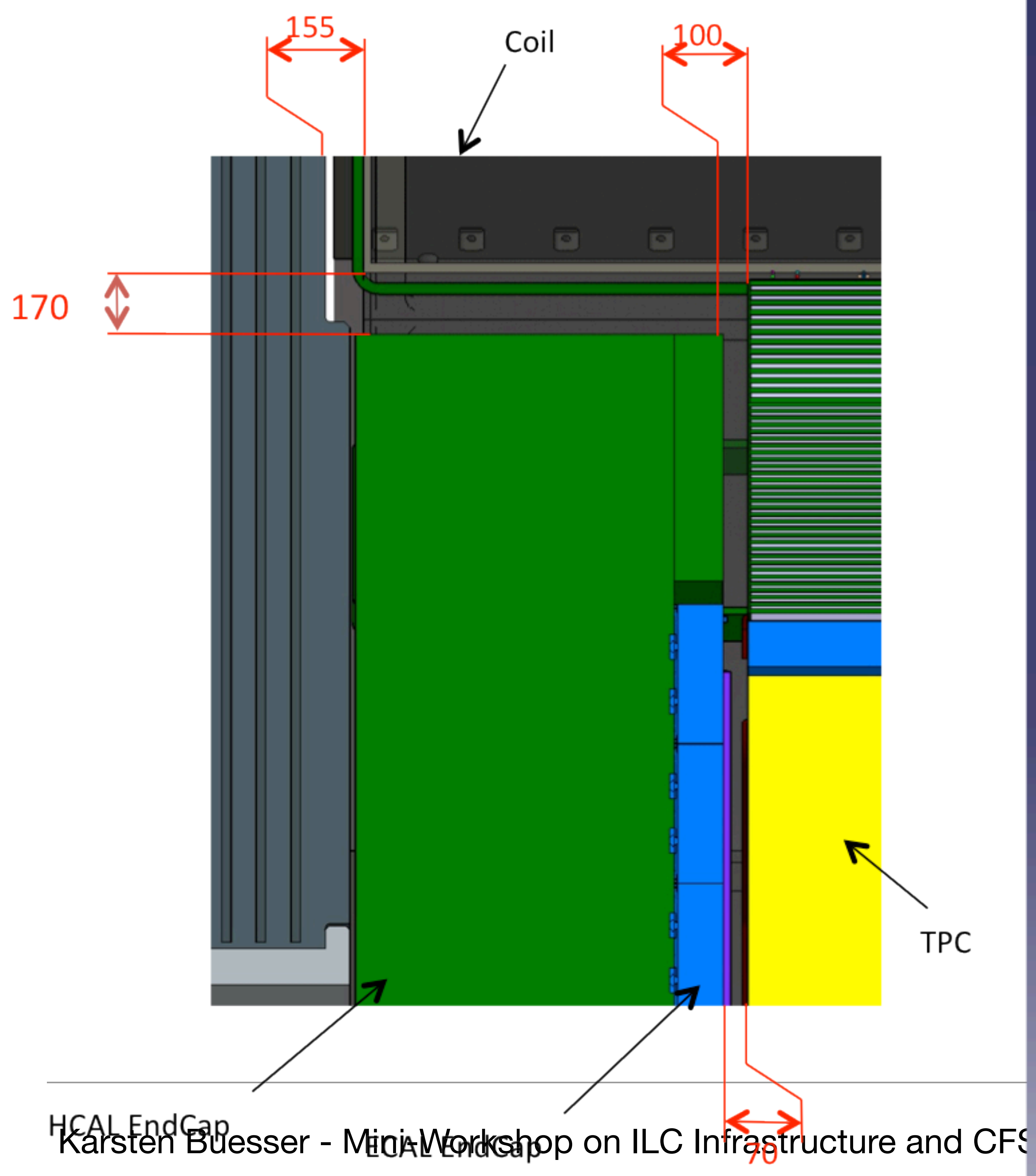
- DBD (2013)

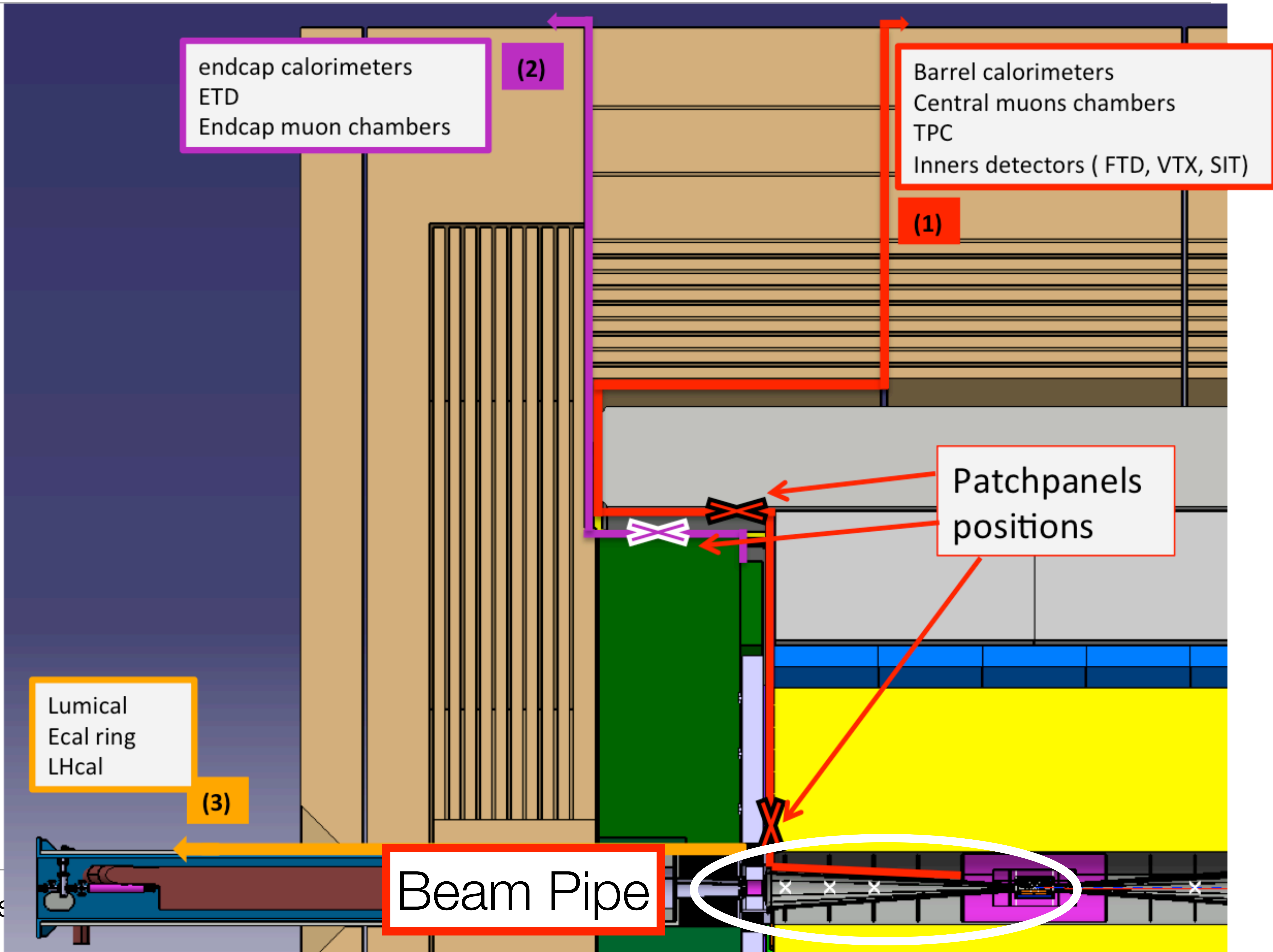




Paths for Cables and Services

• DBD (2013)





Paths for Cables and Services

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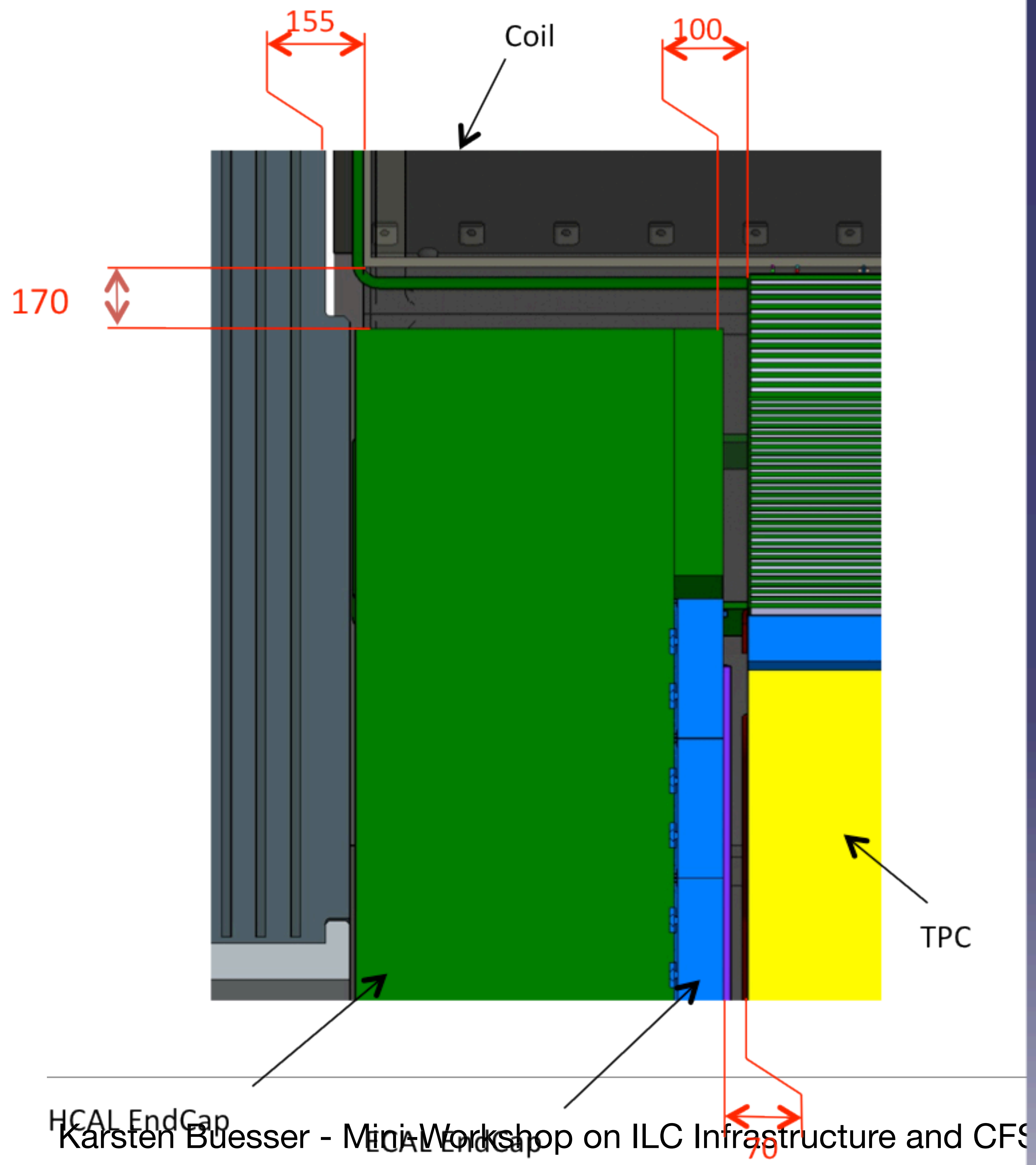
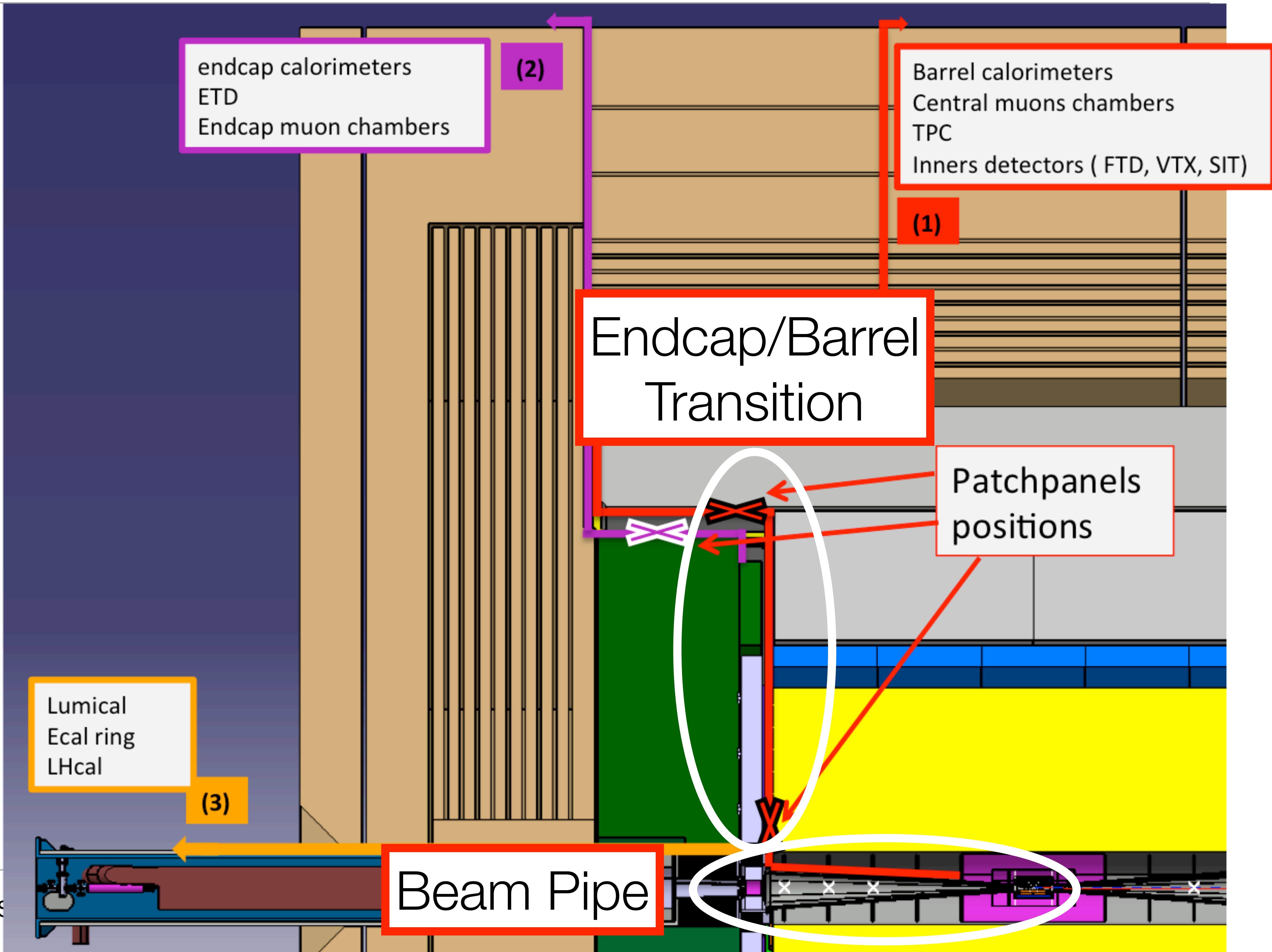
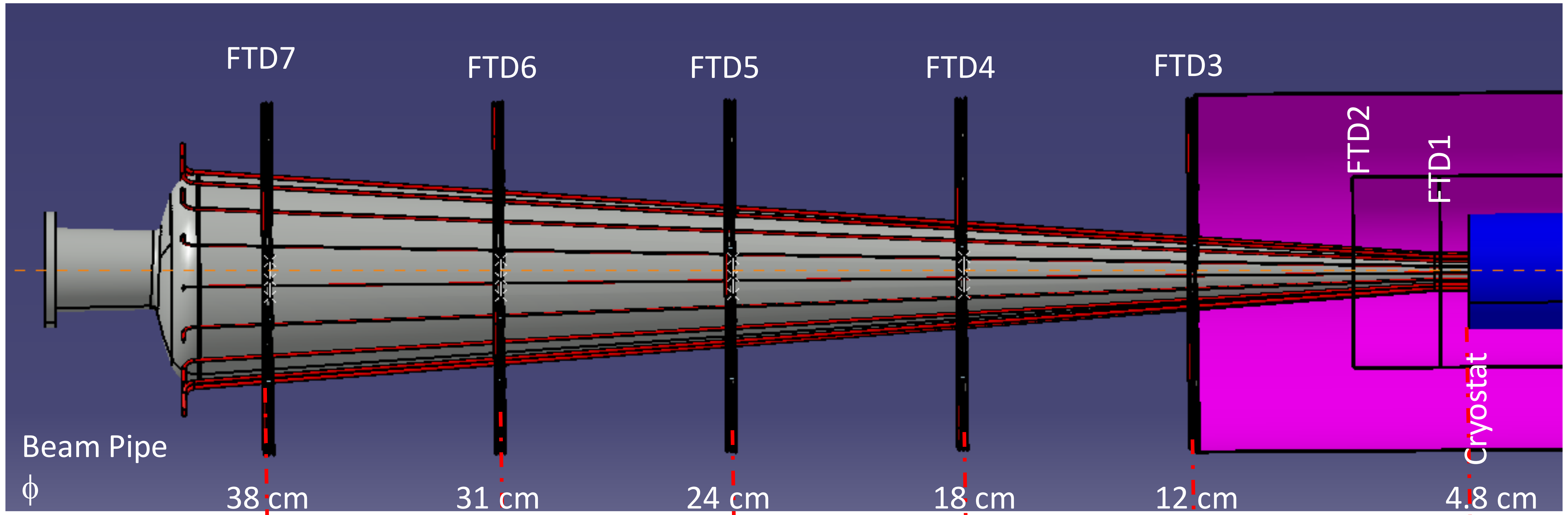




Cables Along Beam Pipe

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

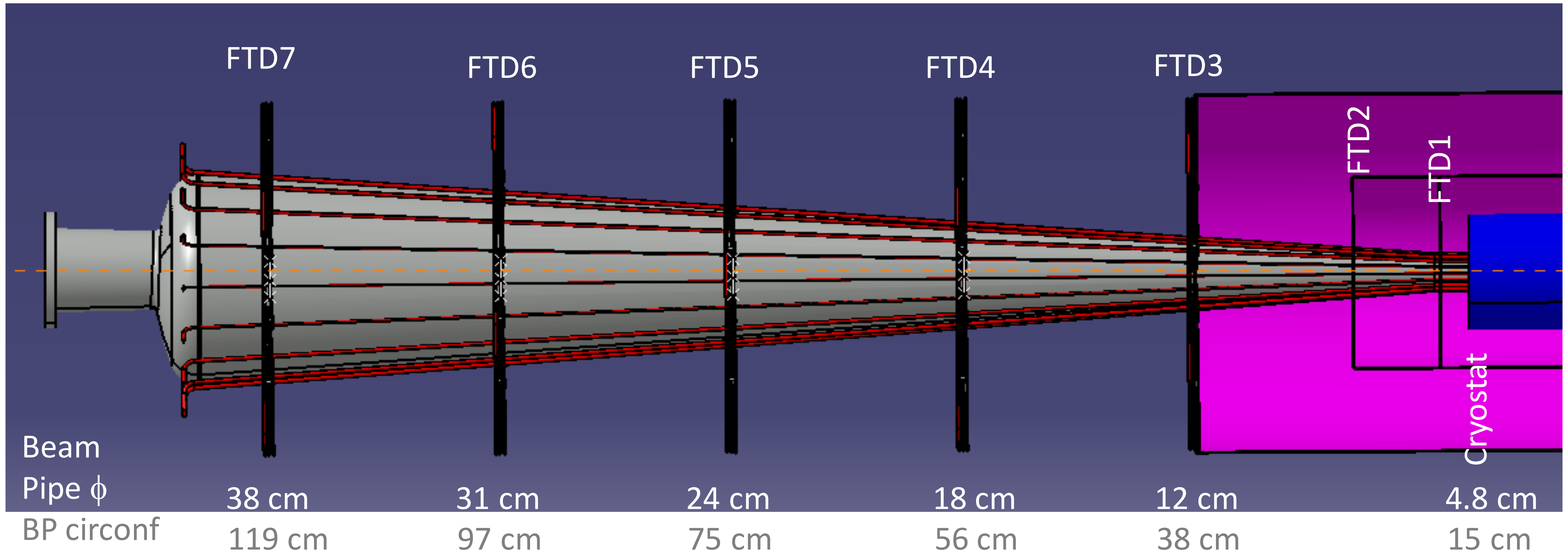
- *about 9 kg of material on each side*
- *a minimum gap between FTD supports and beam pipe of 2 cm for path of all the cables….*

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

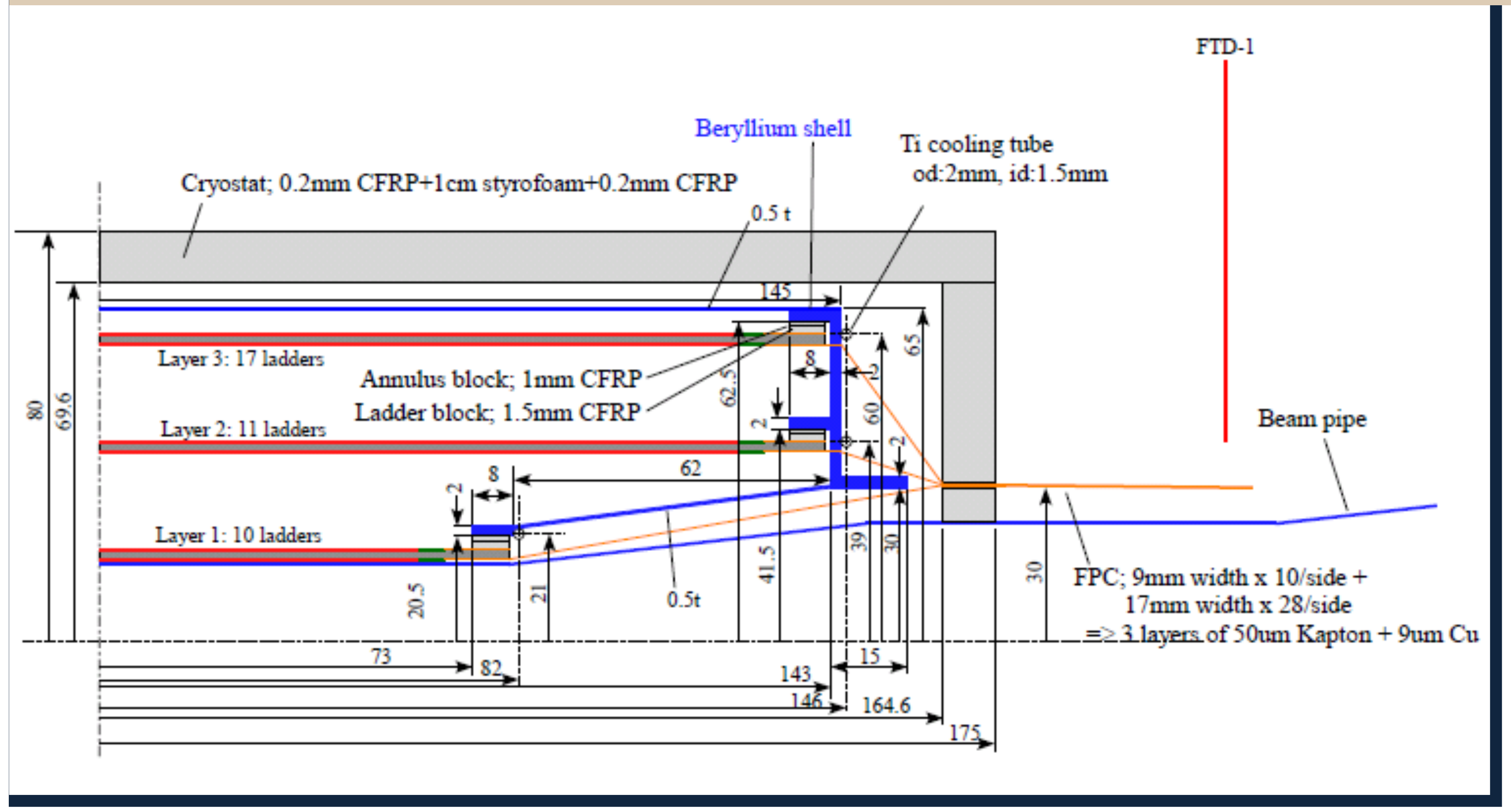
We need to gain more than factor 2 !

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

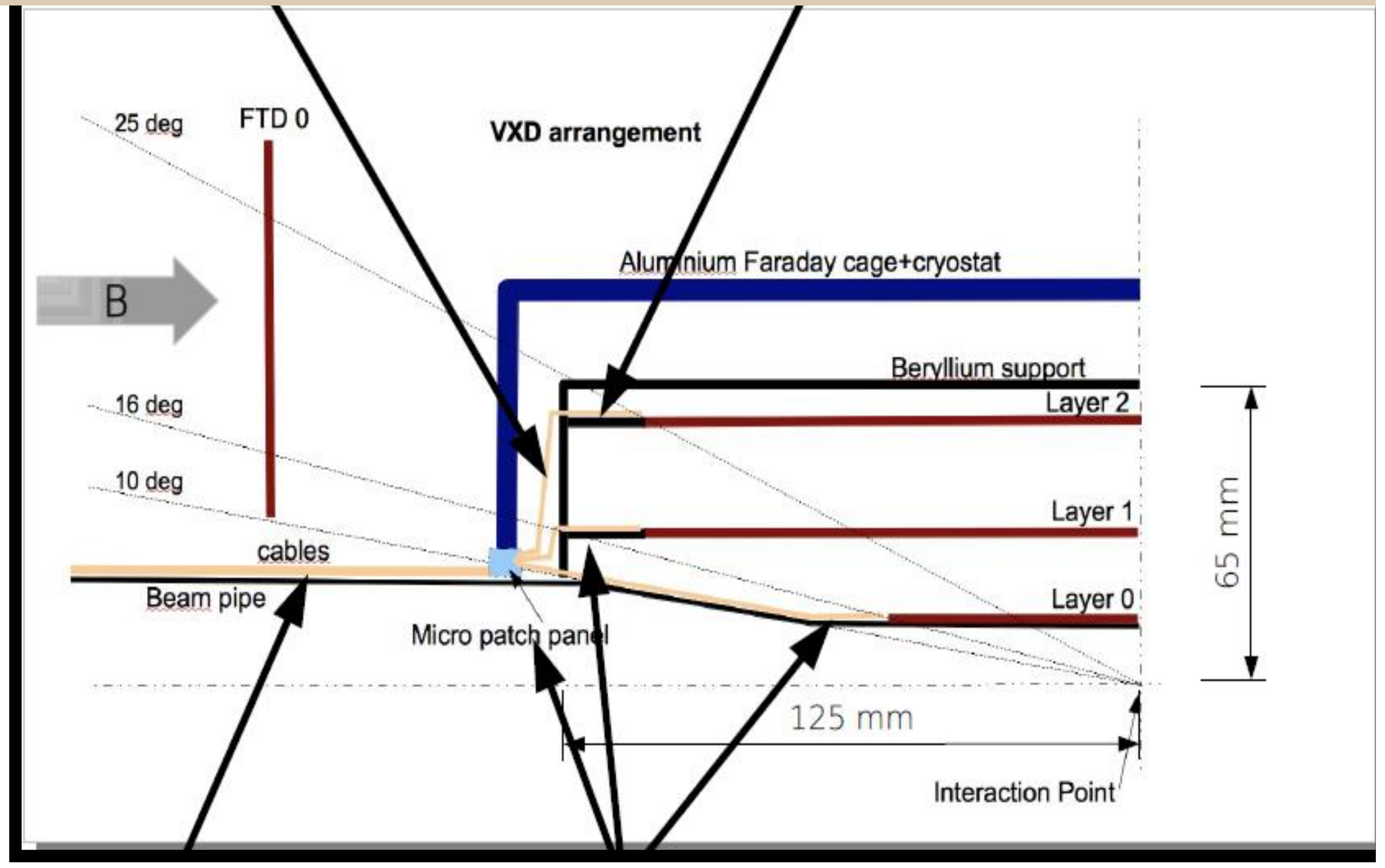
Vertex Detector

Inner detectors (4) : vertex

C. Clerc, M. Joré
2011



FCPPD (from Y.Sugimoto)

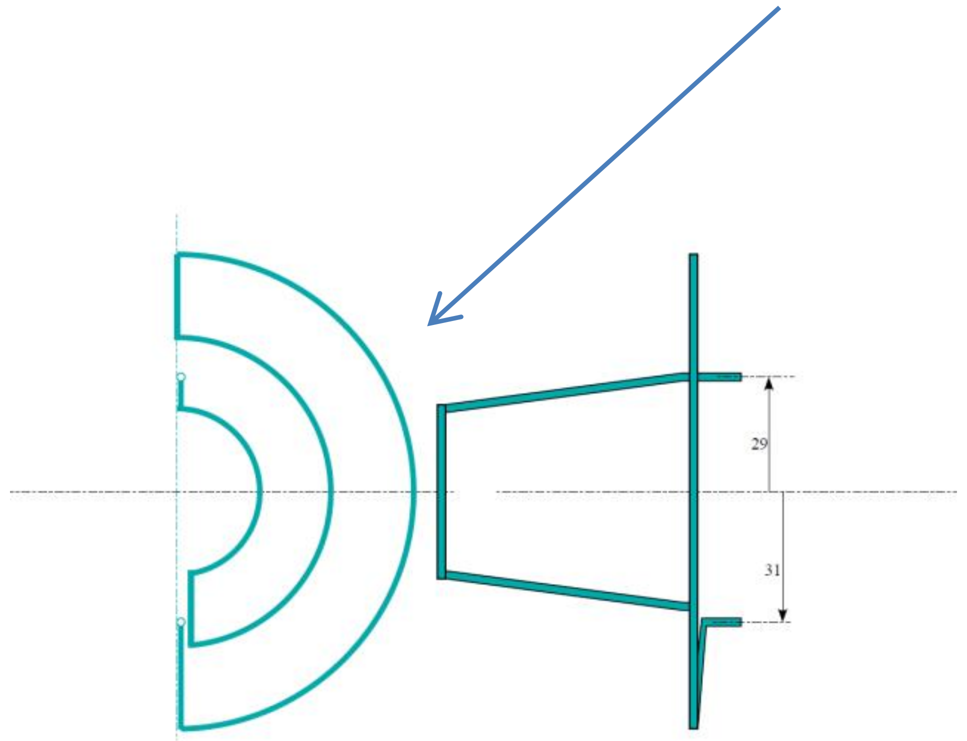


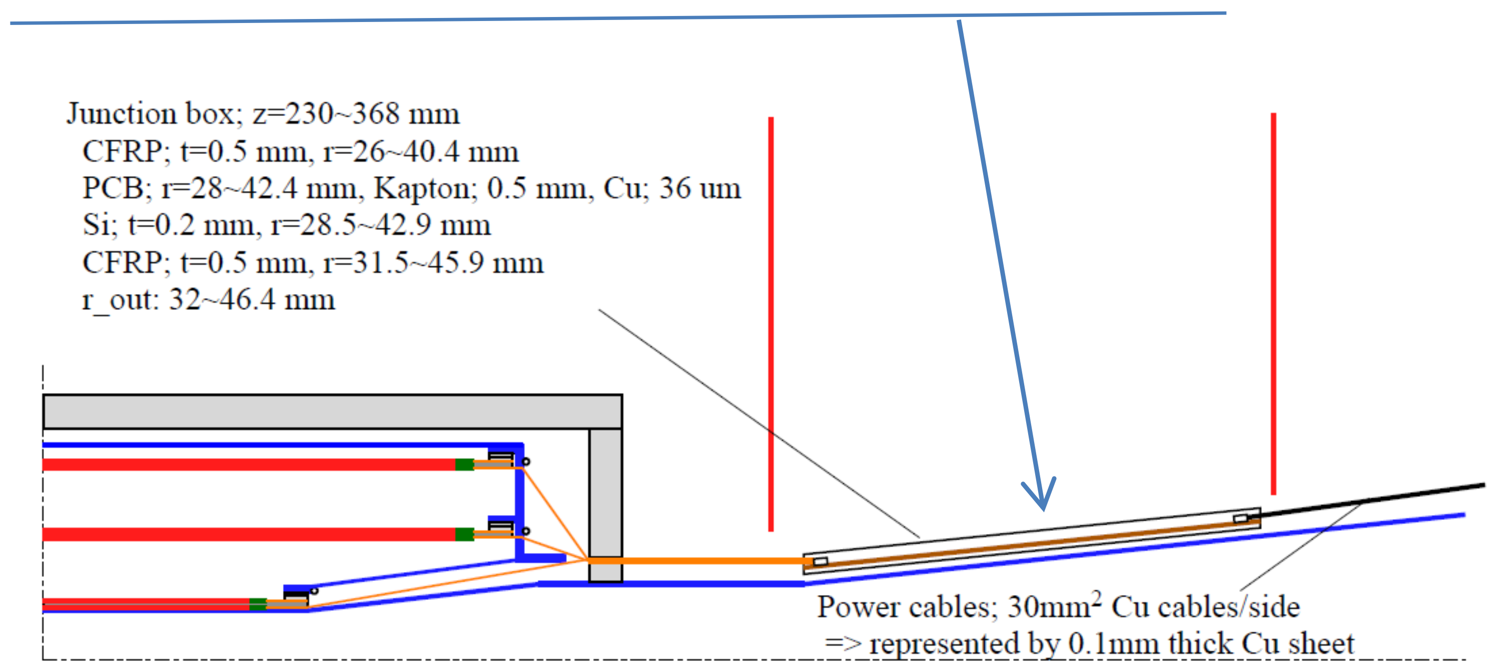
CMOS(from J.Baudot)

The 2 designs are considered to be compatible for simulation in the inner part of the cryostat,
But as **FPCCD** not pulse :

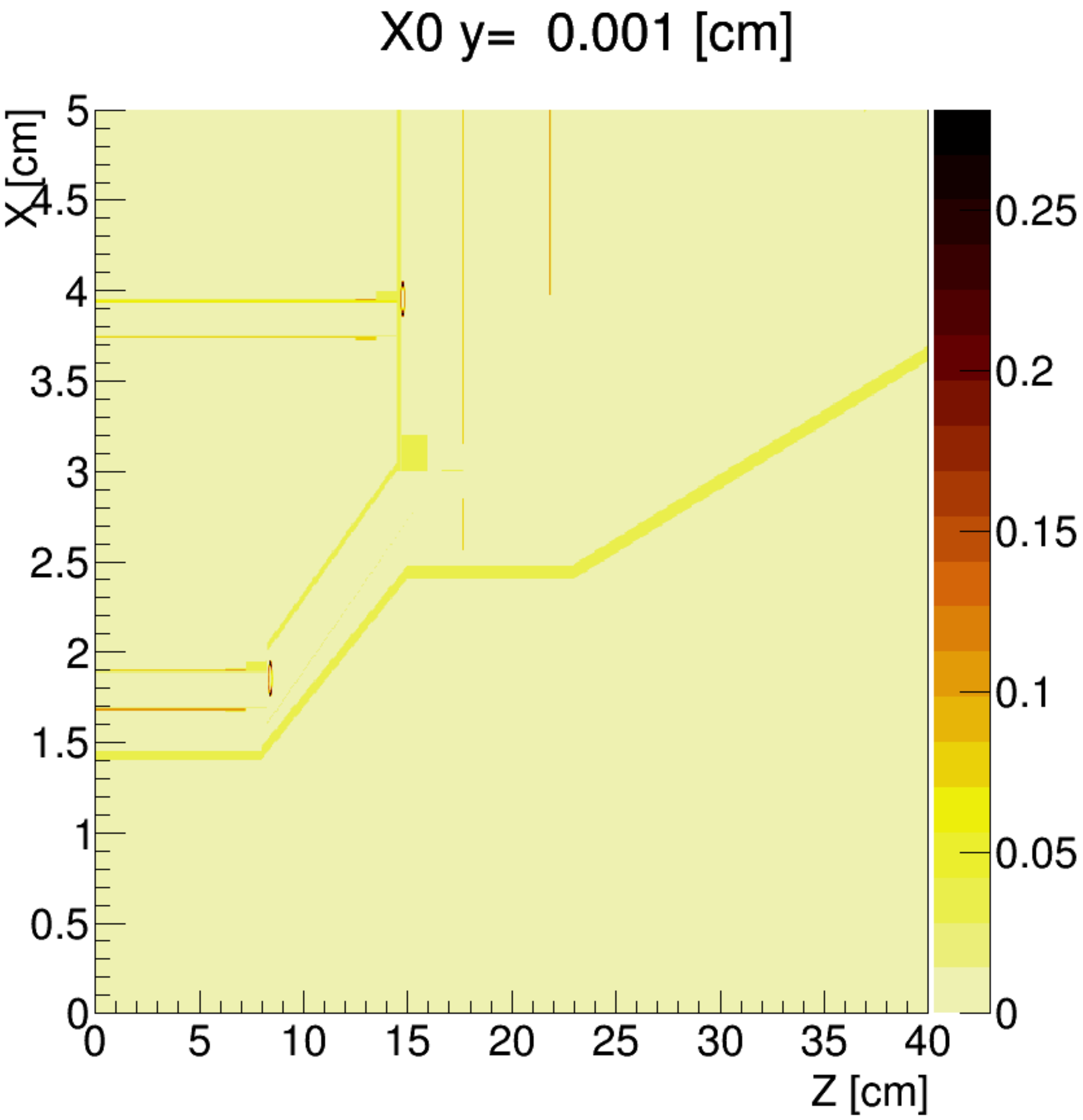
CO2 cooling foreseen , Titanium tube 2mm o.d. and 1.5mm i.d

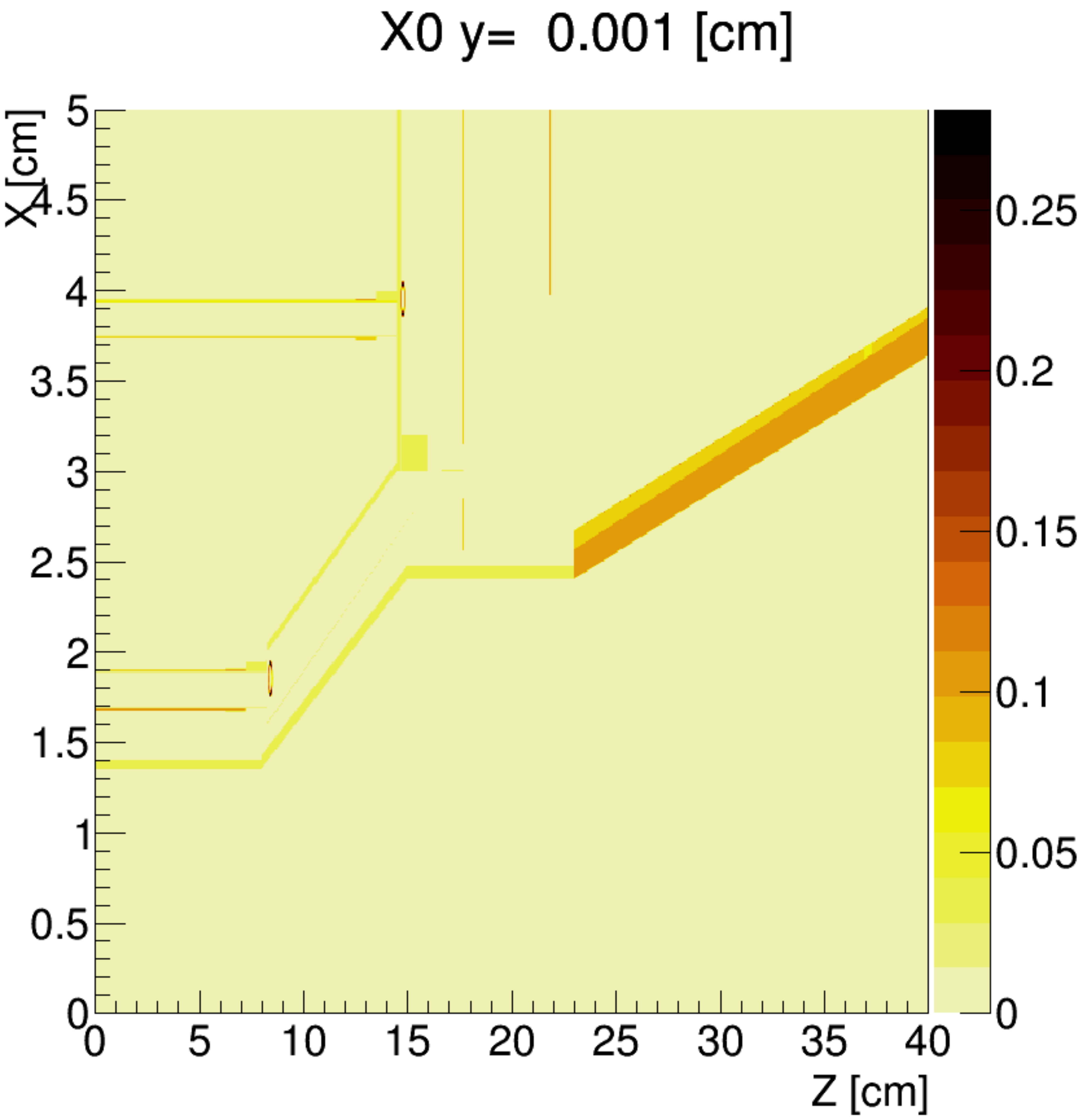
\+ **junction box** between the 2 first FTD





Old vs New (Daniel Jeans)





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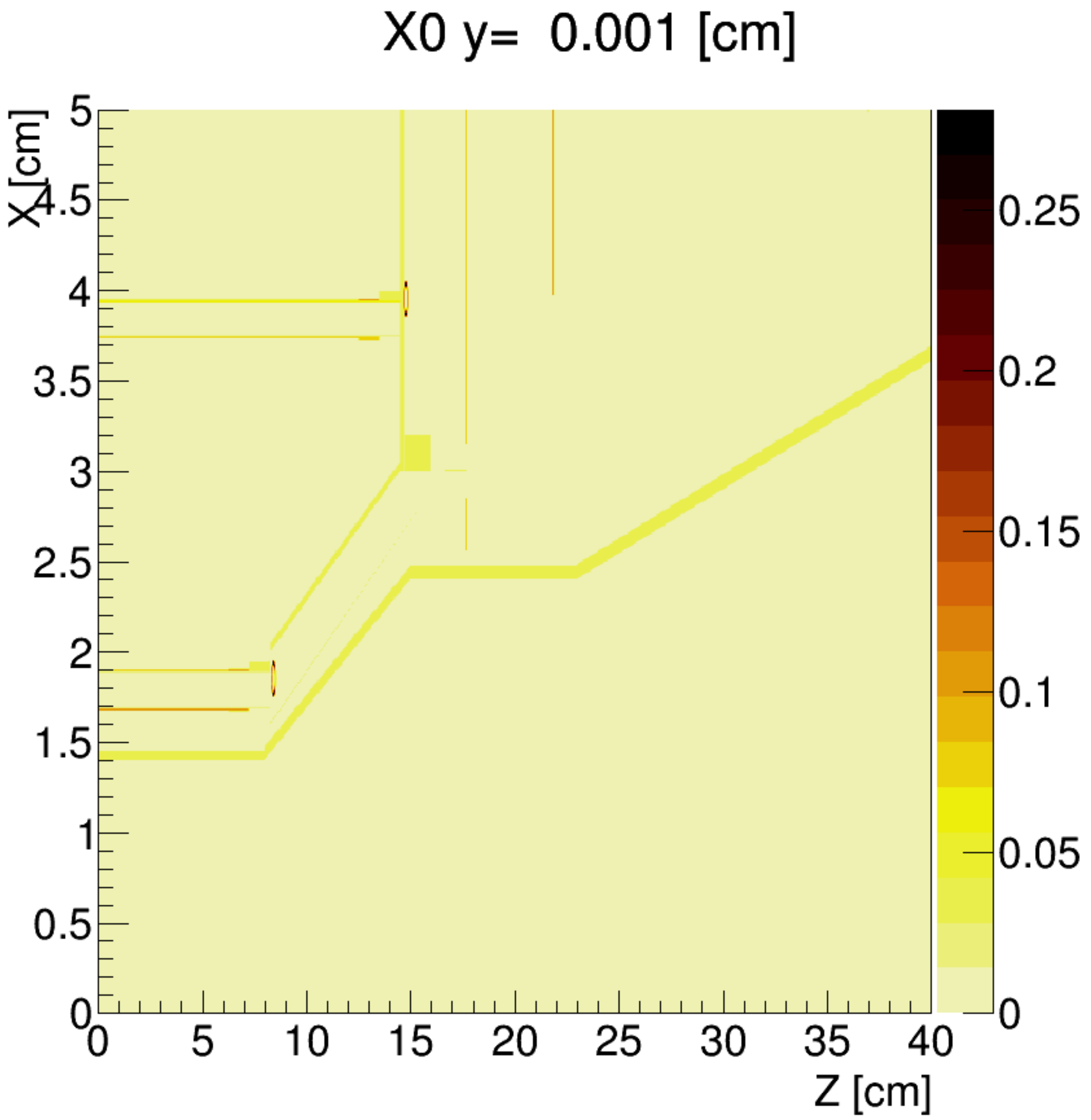

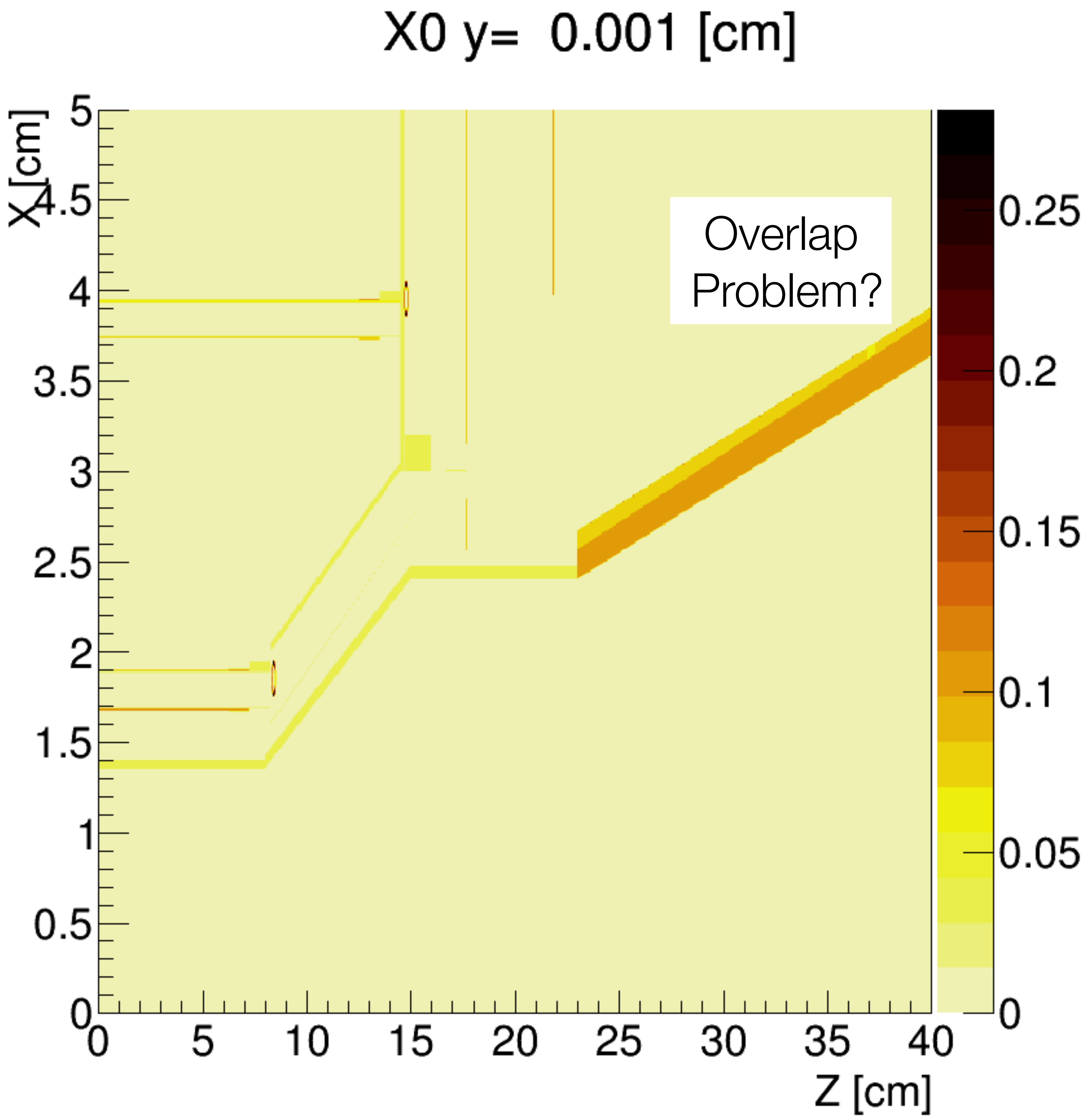

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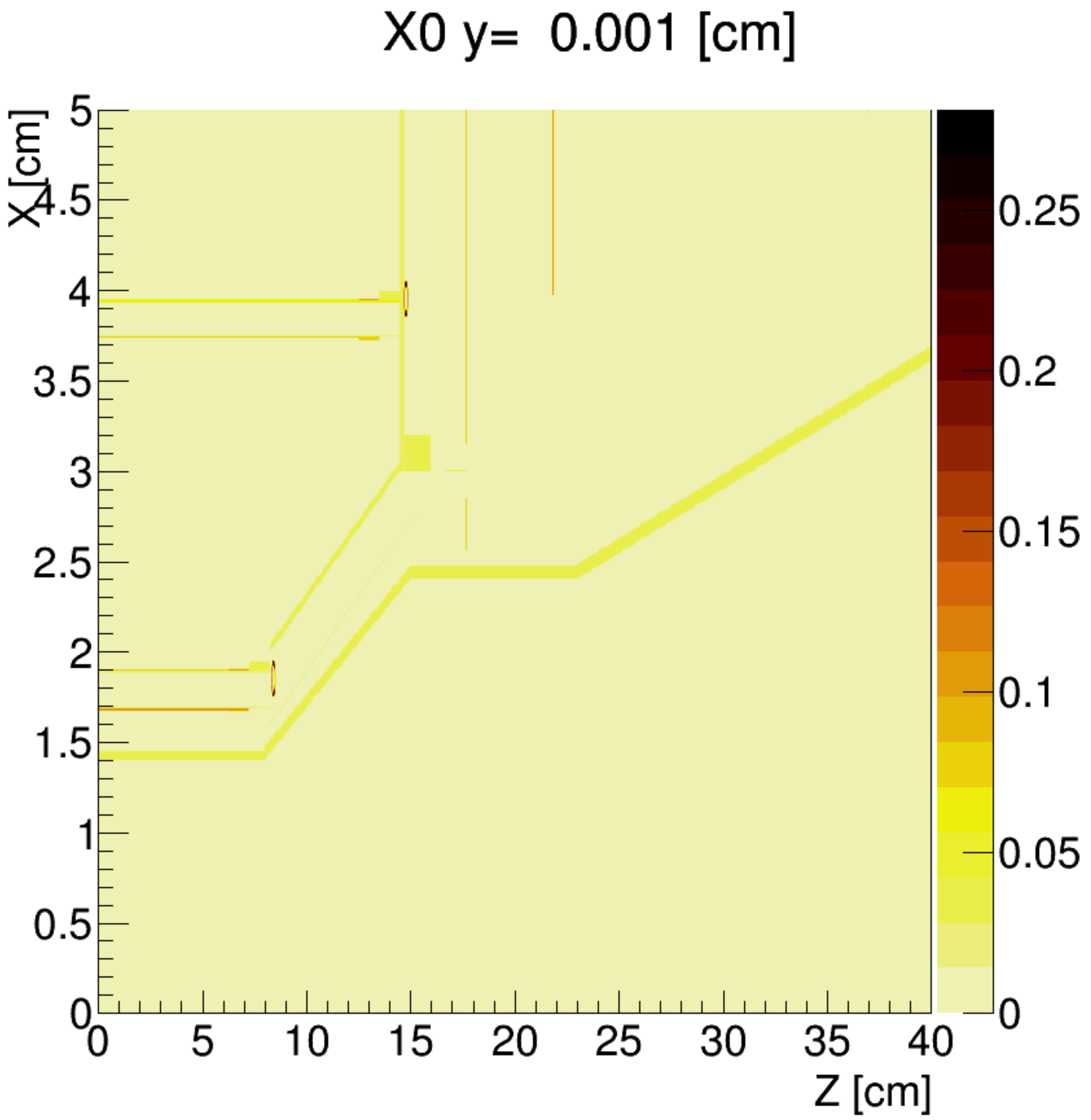
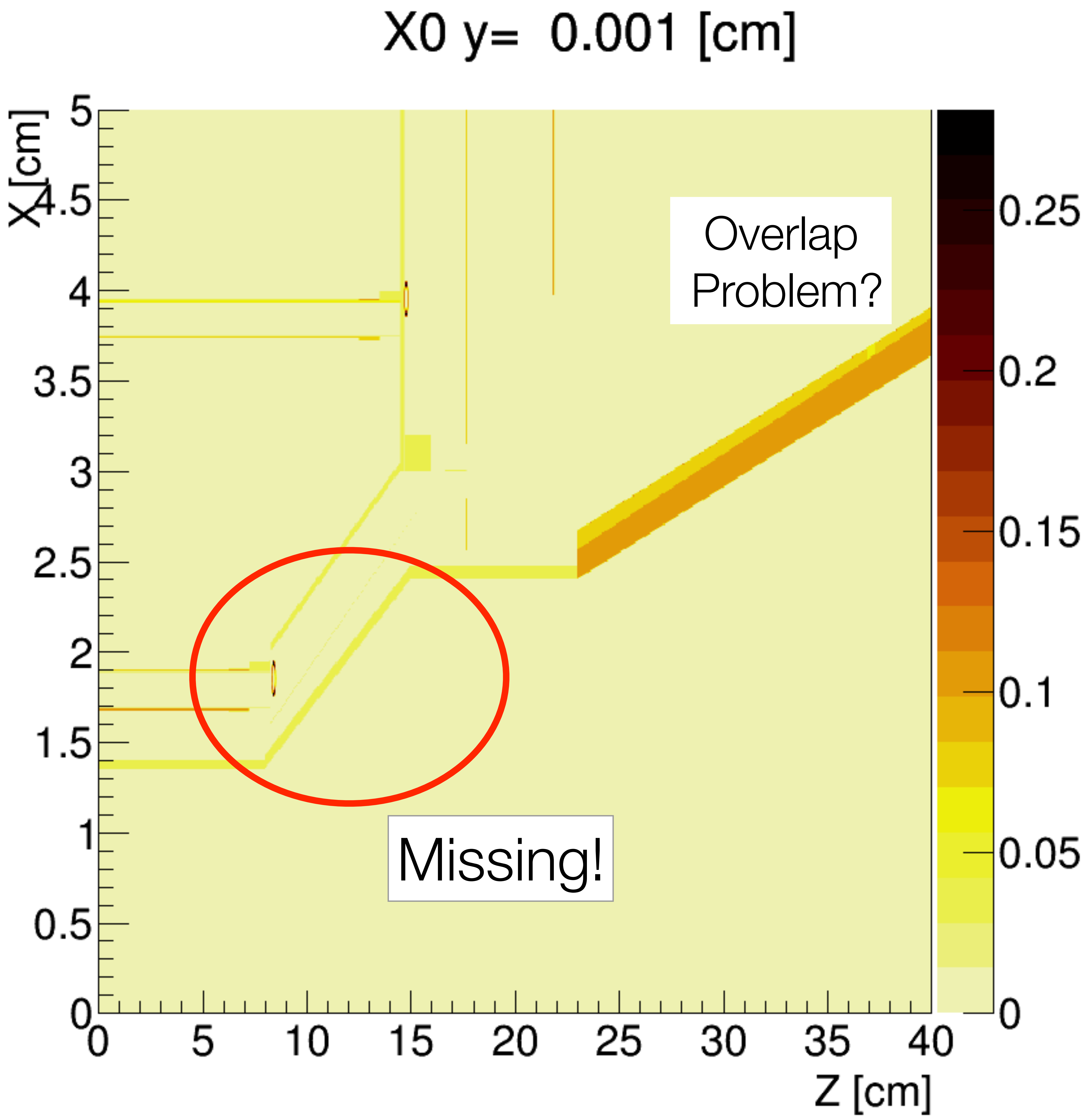
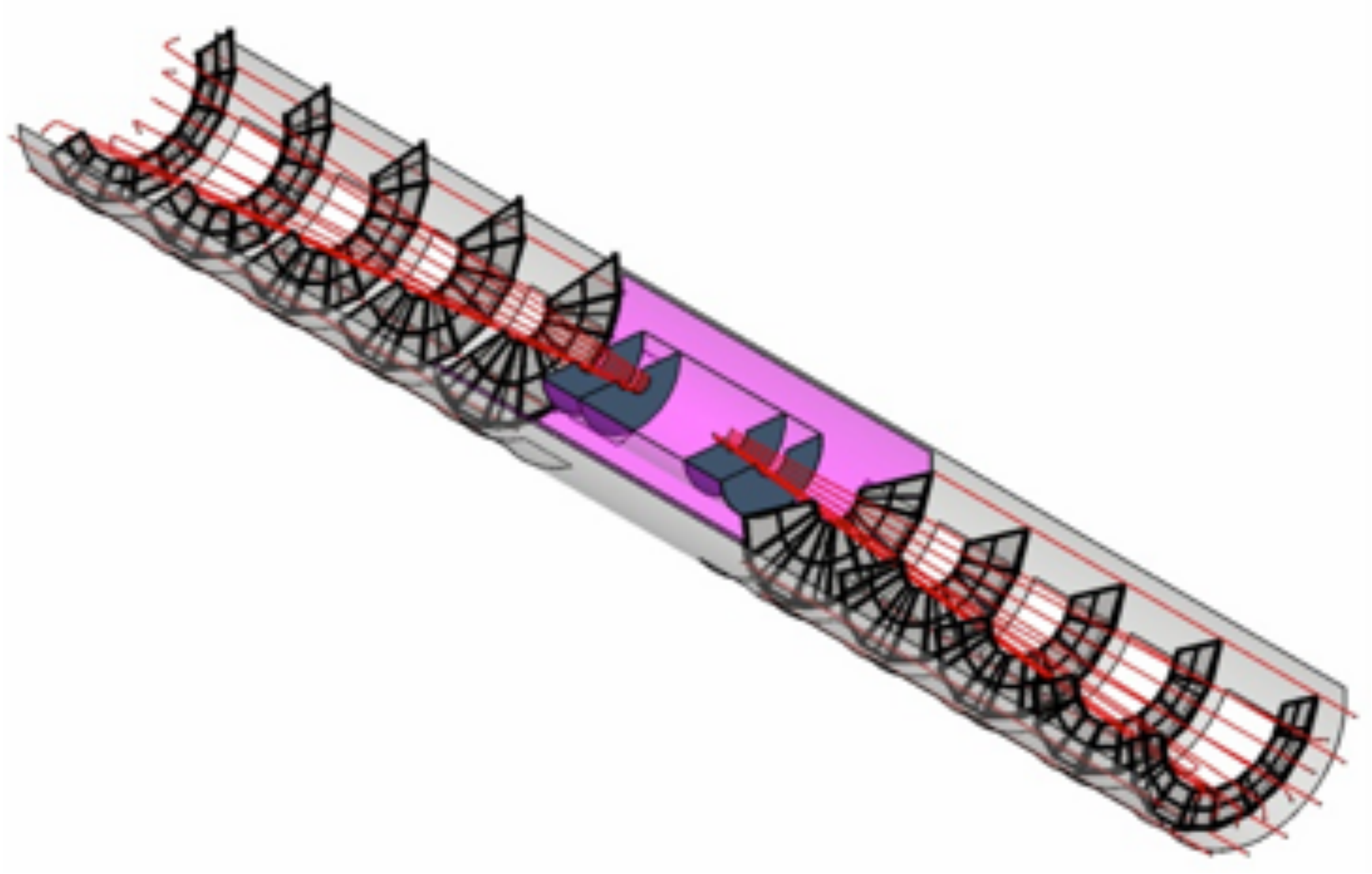
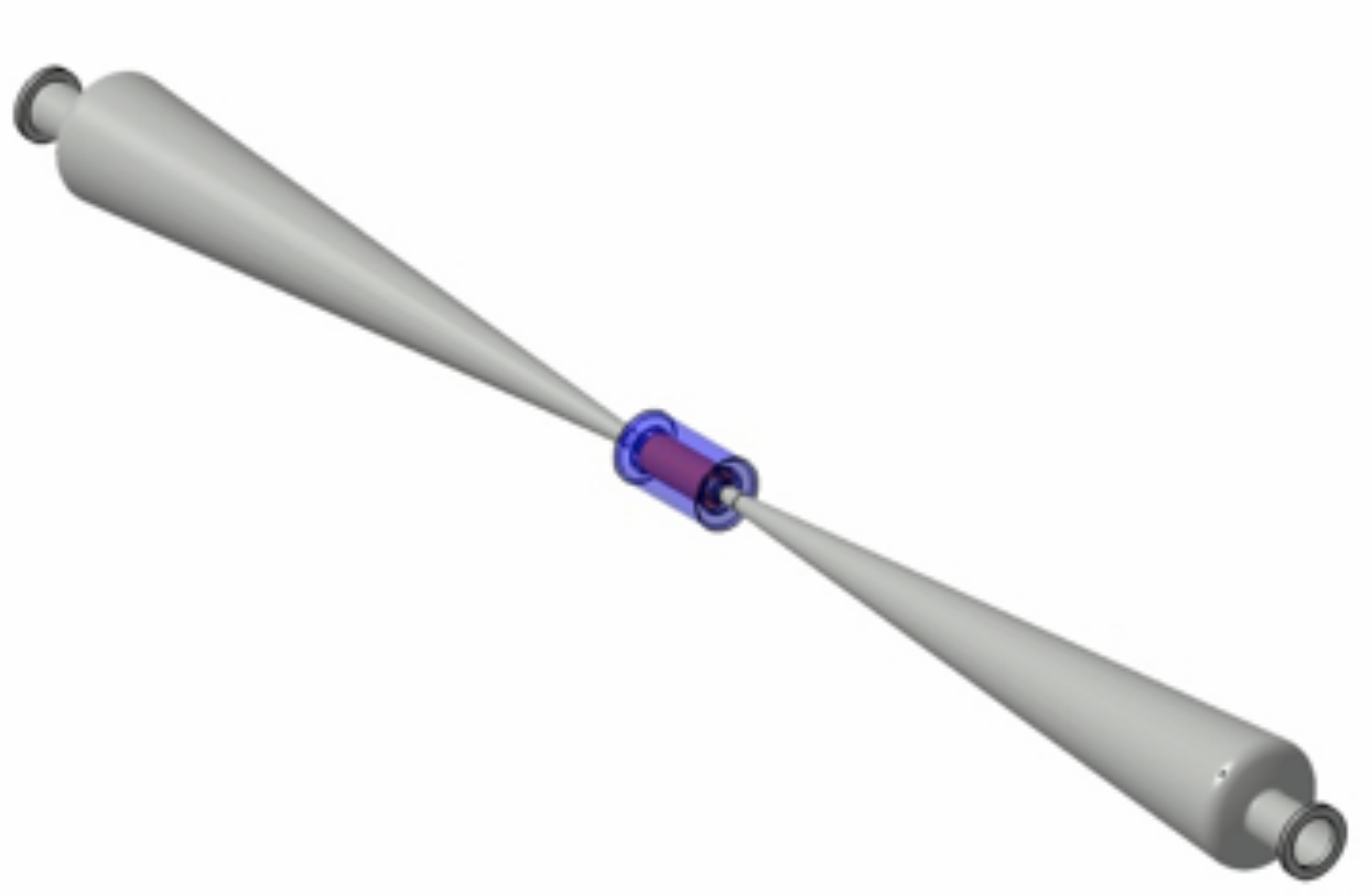


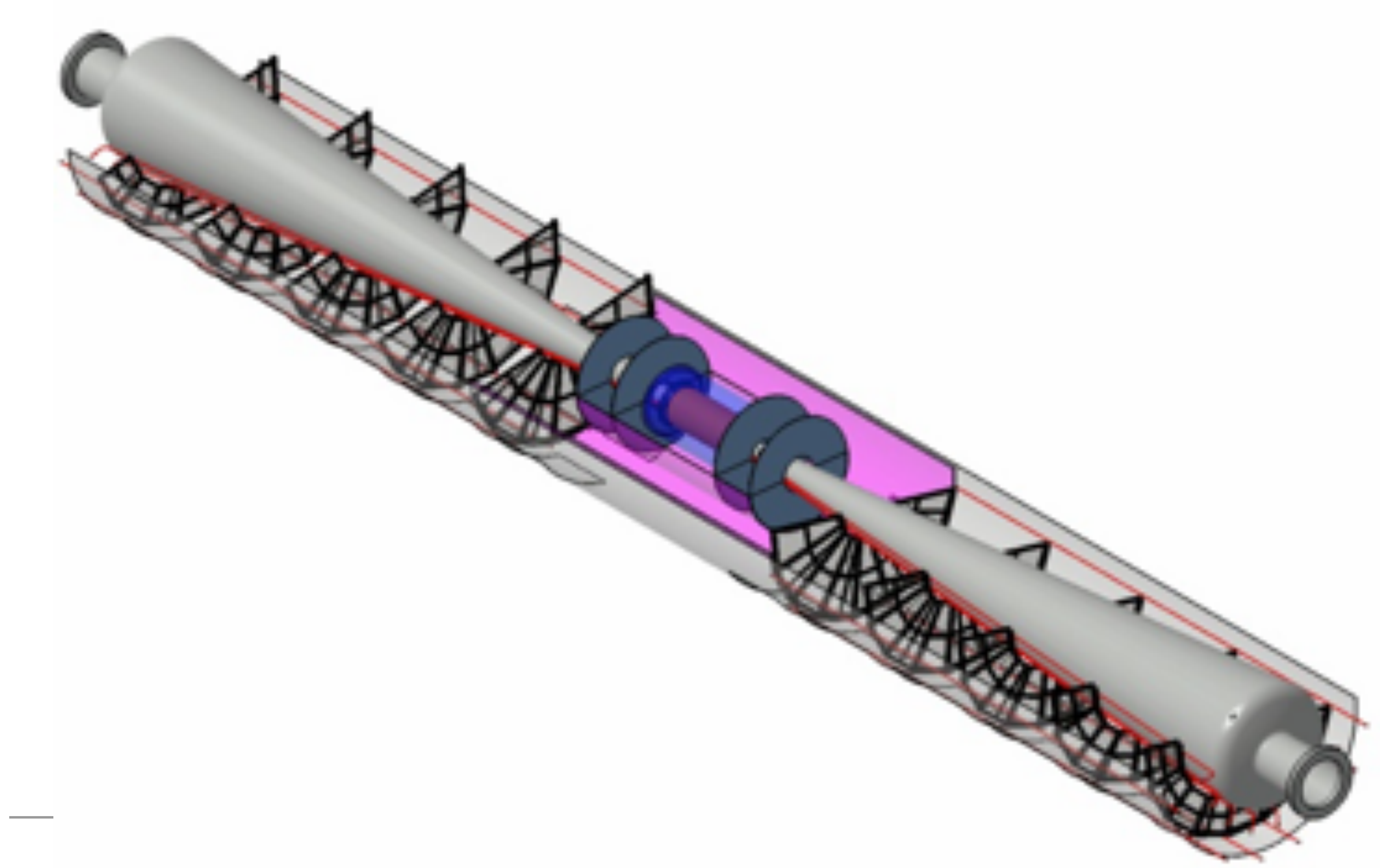


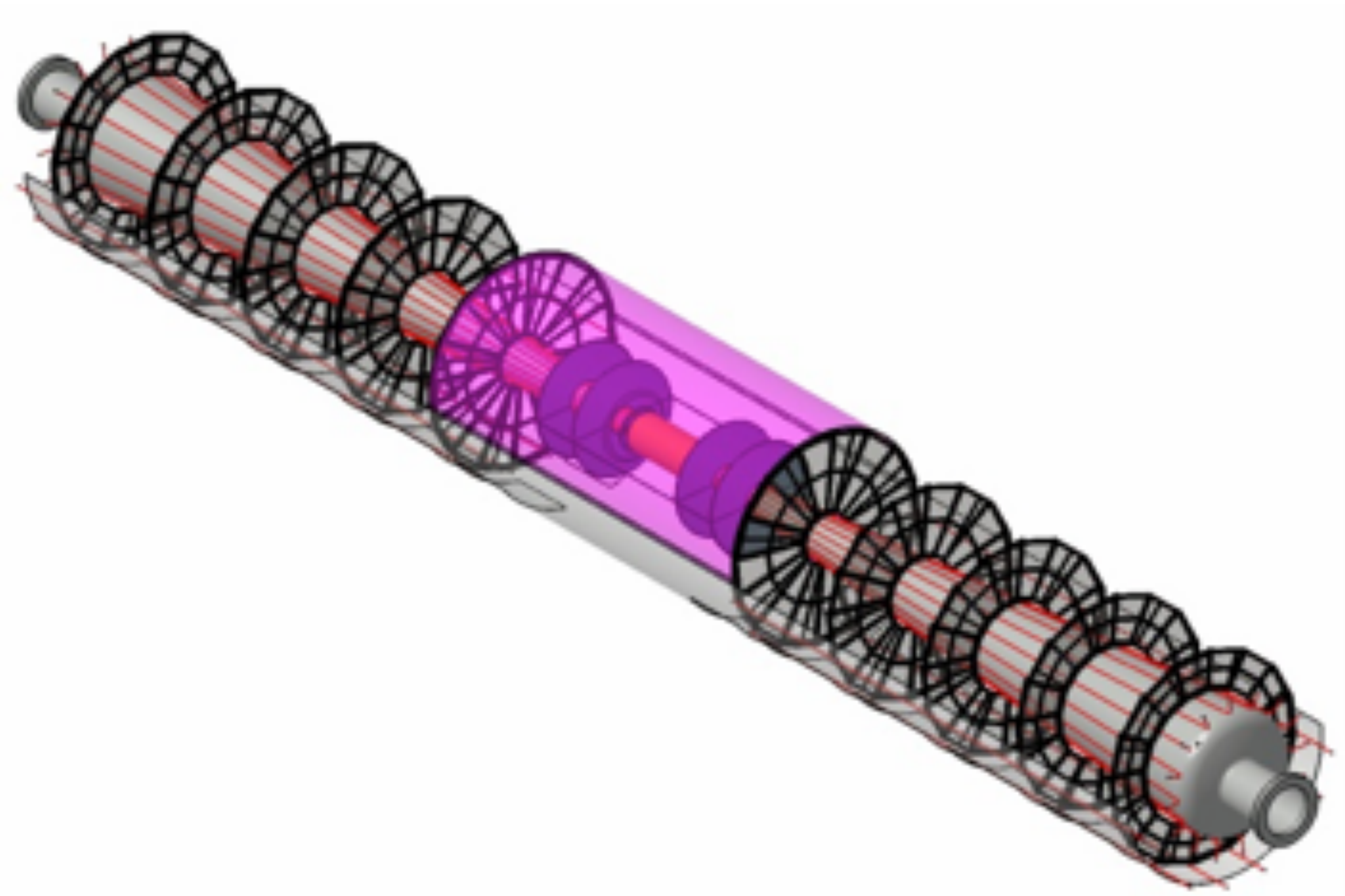
Inner Detector Integration (DBD)

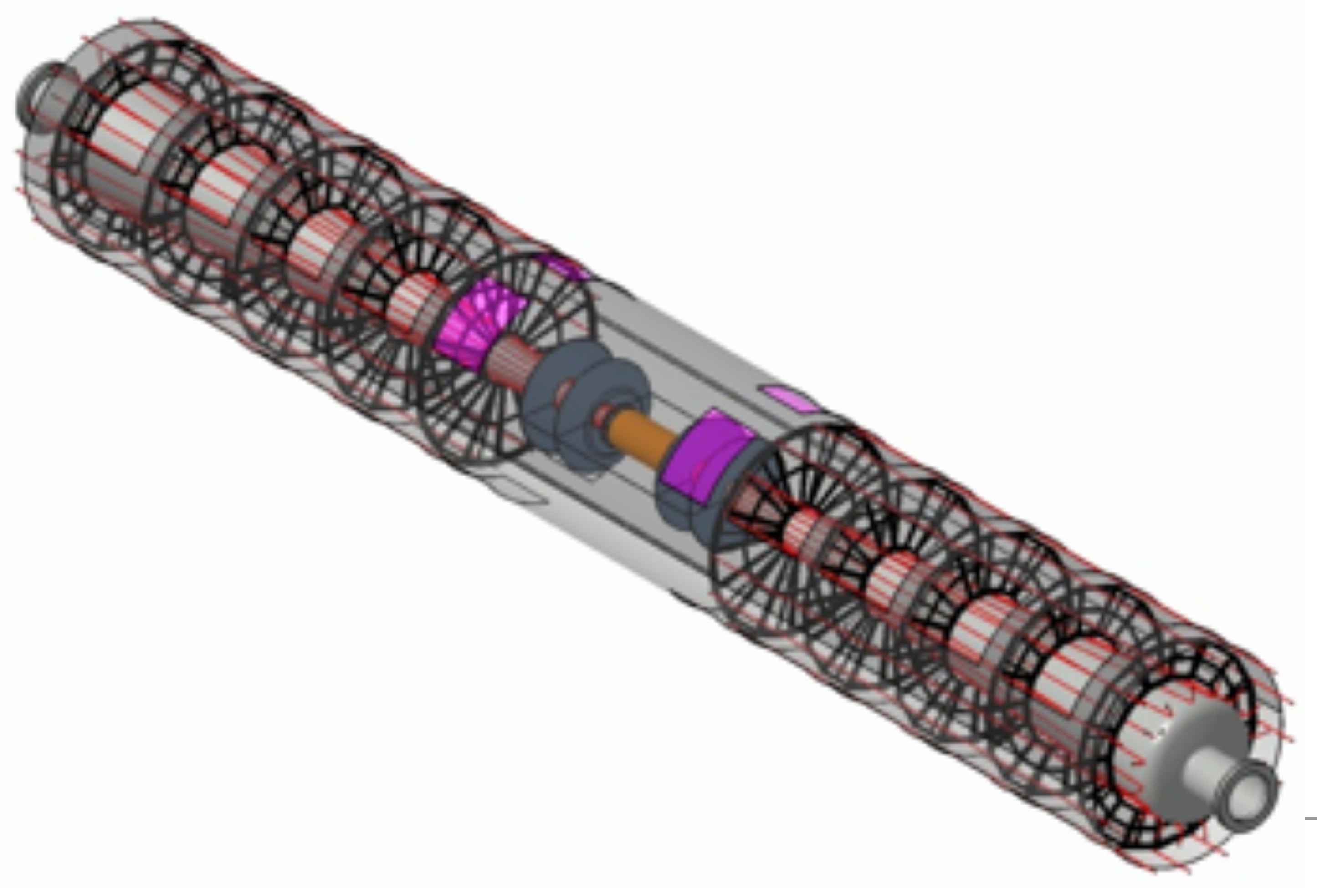
- Might need to re-visit assembly procedure with new cabling scheme for VTX







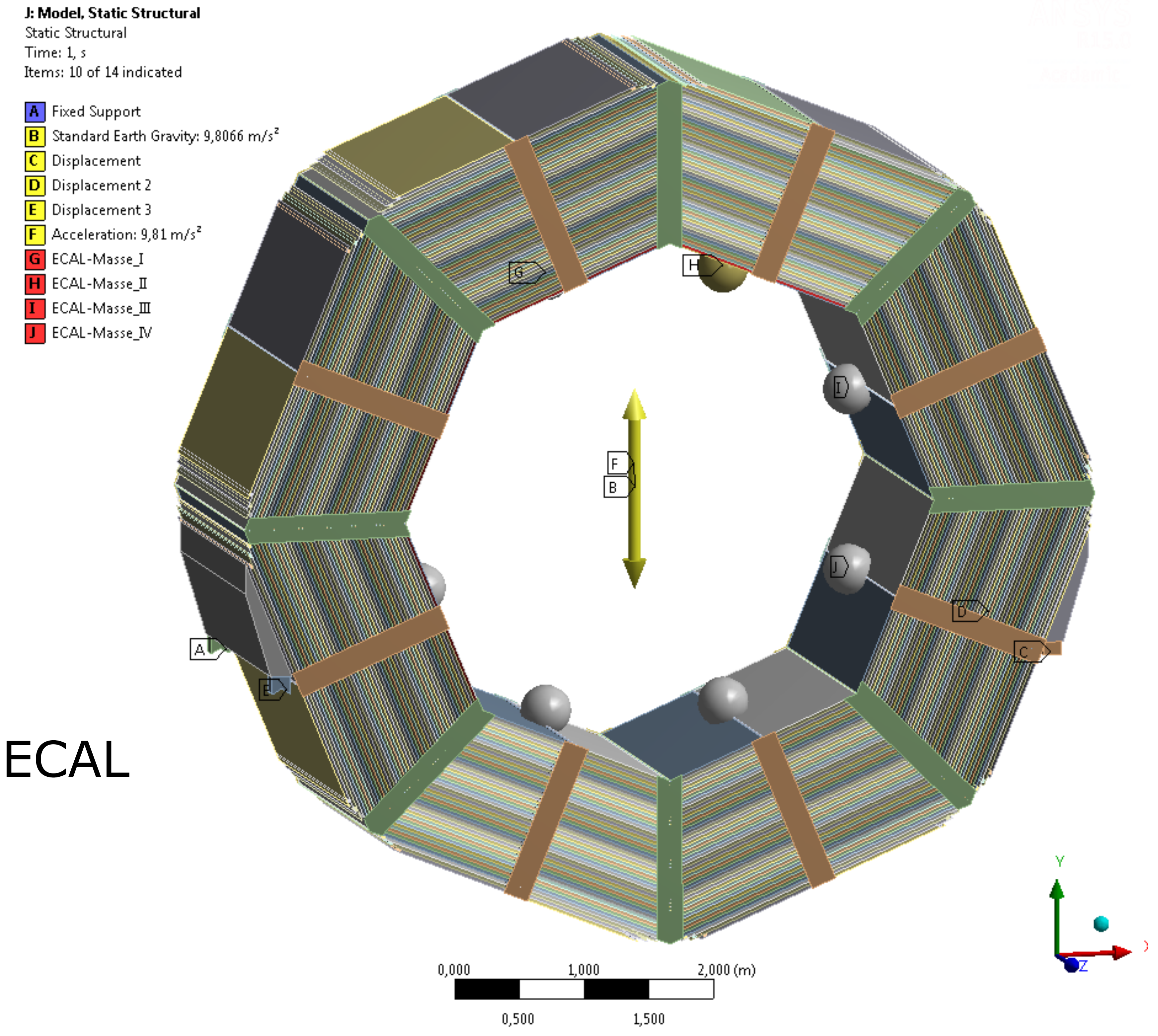




ILD and Earthquakes

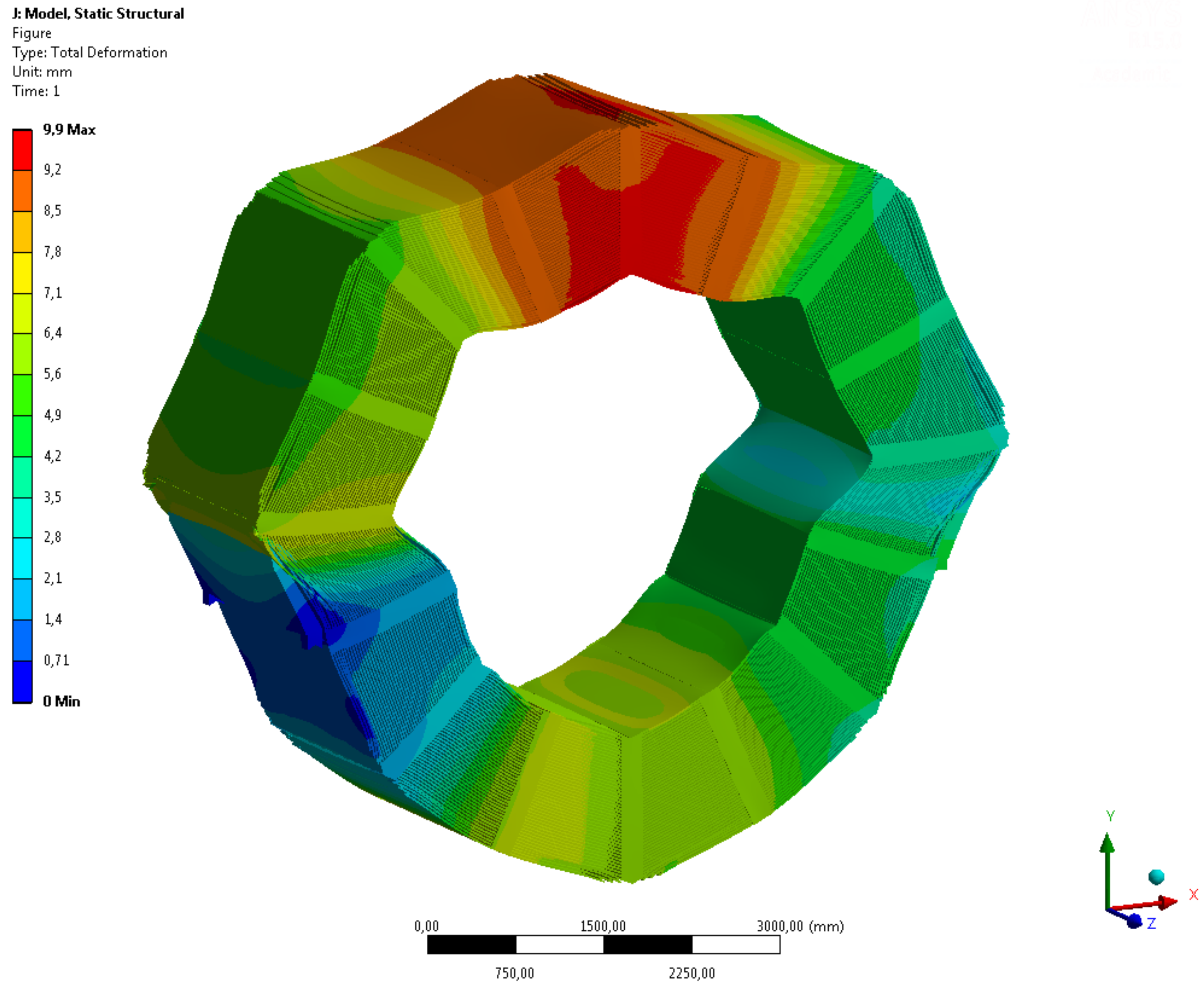
ILD AHCAL Static Analysis

Ring structure



- model includes ECAL masses

Ring deformation



- max 10 mm

Slides from F. Sefkow

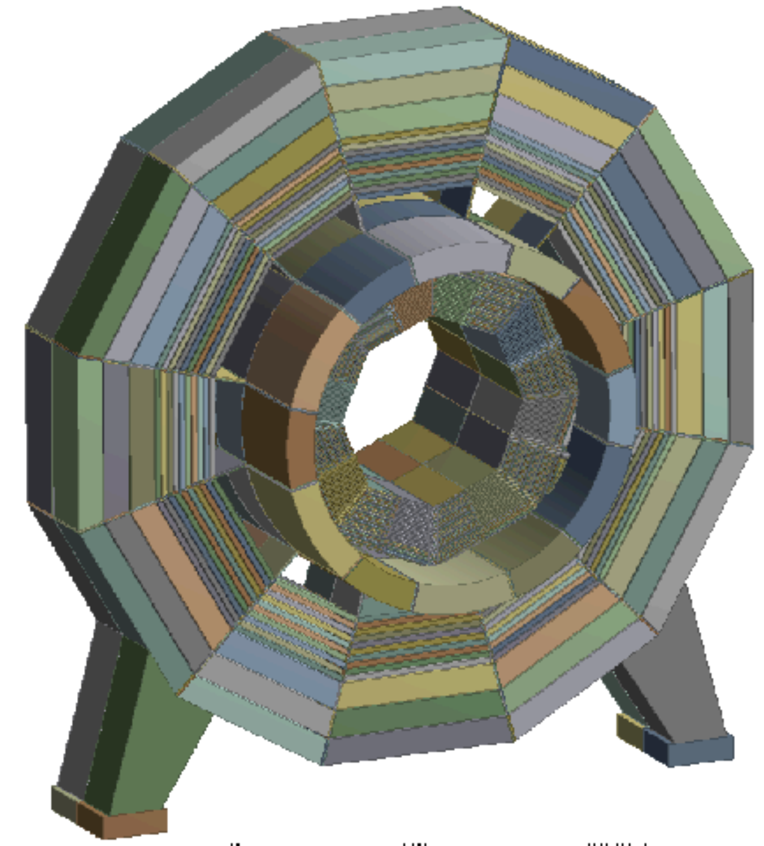
Dynamical stability

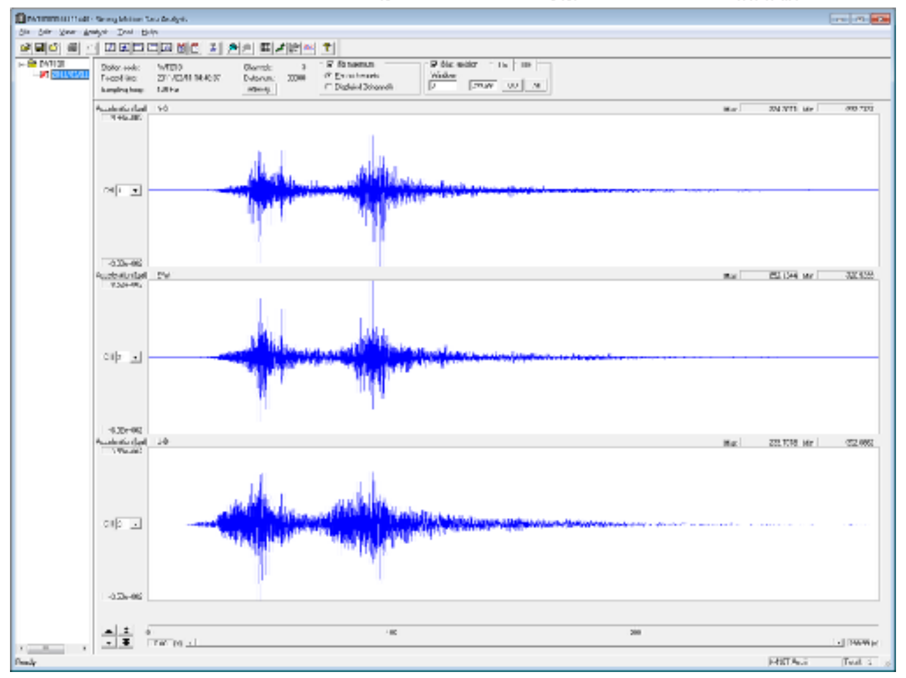
Slide from F. Sefkow

Dynamic Analysis

Dynamic analysis

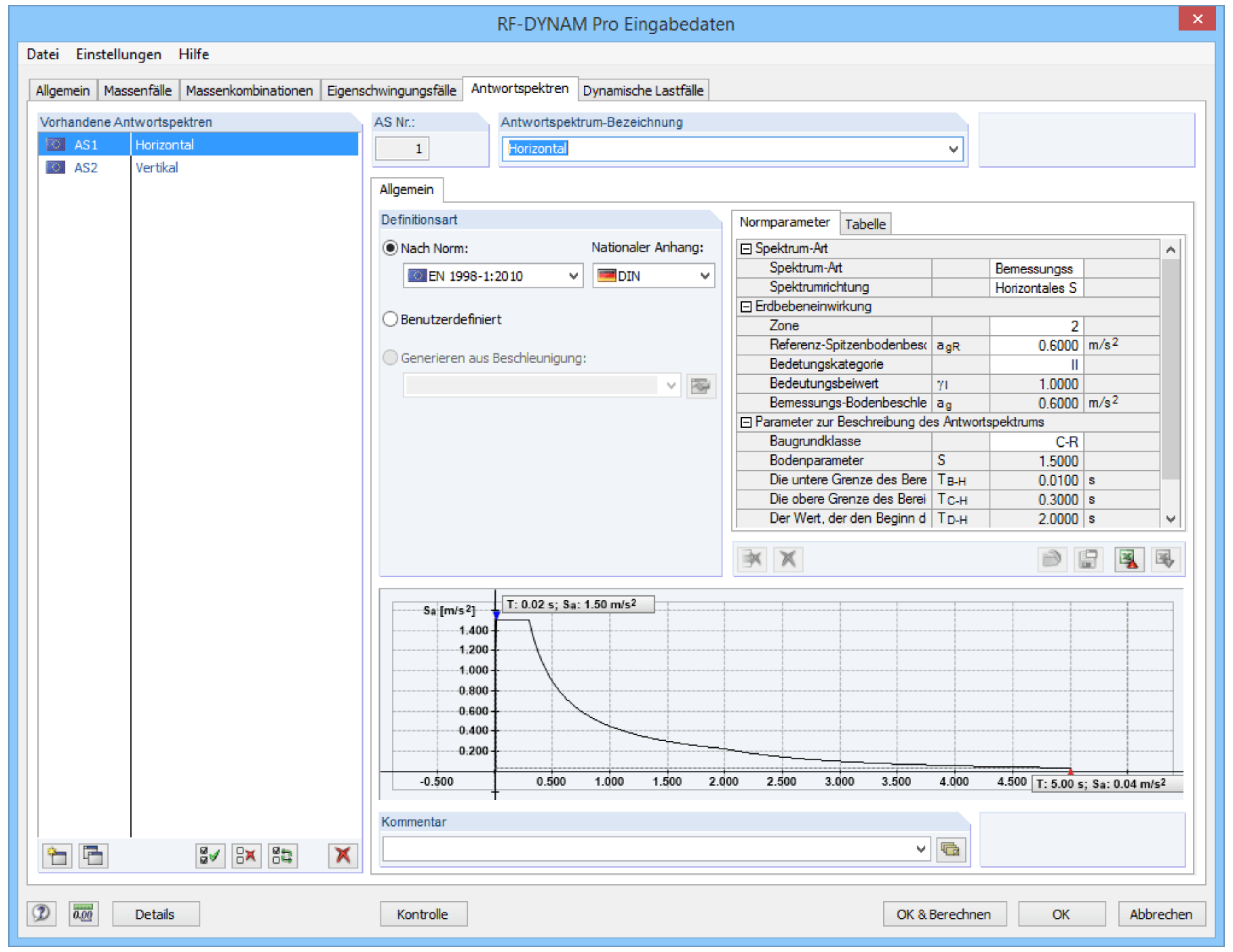
- In principe one needs to study the entire system of yoke, cryostat and HCAL
- Not enough details known: assume rigid transmission of excitation forces to HCAL and study HCAL alone
- Steps:
  - eigen mode analysis
  - response spectrum (with damping)
  - excitation with real earth quake wave form
    - East-West 0,36 g
    - North-South: 1,02 g
    - Vertical: 0,36 g





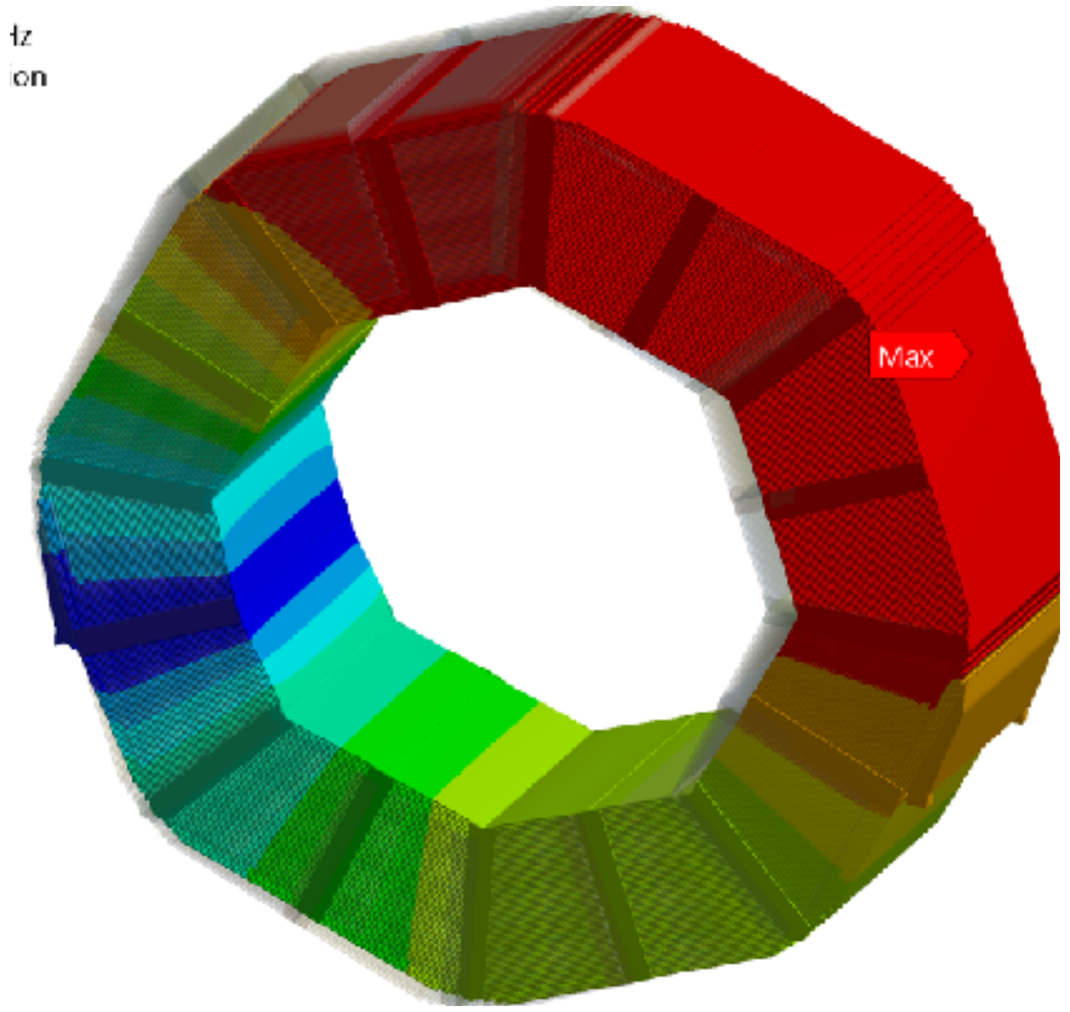
EQ data processing

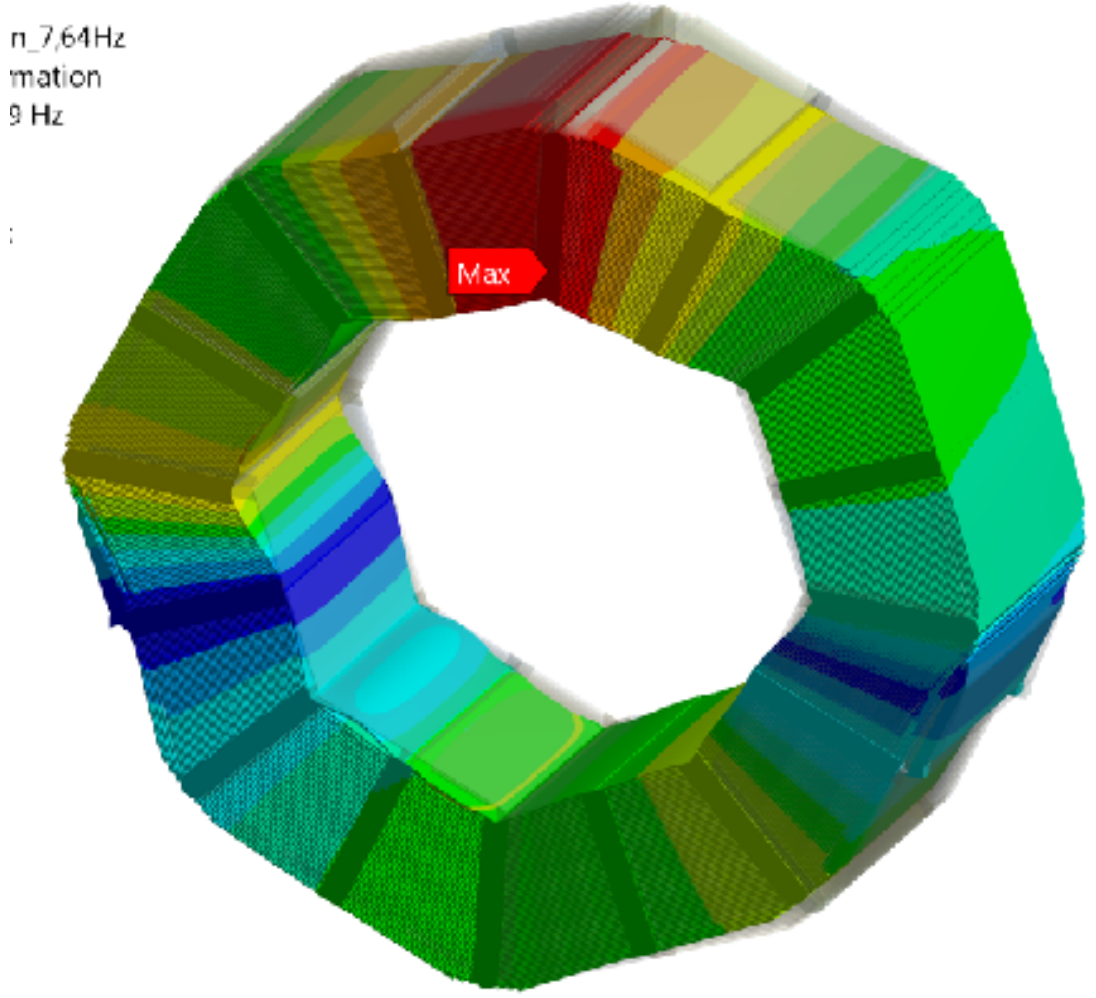
- Earthquake data from NIED (Japan) can be processed using commercial software „RSTAB“ from DLUBAL (link: https://www.dlubal.com)
- Input: measured accelerations
- Output: tabular wave form to be directly used as acceleration boundary conditions in ANSYS
- Greatly simplifies work

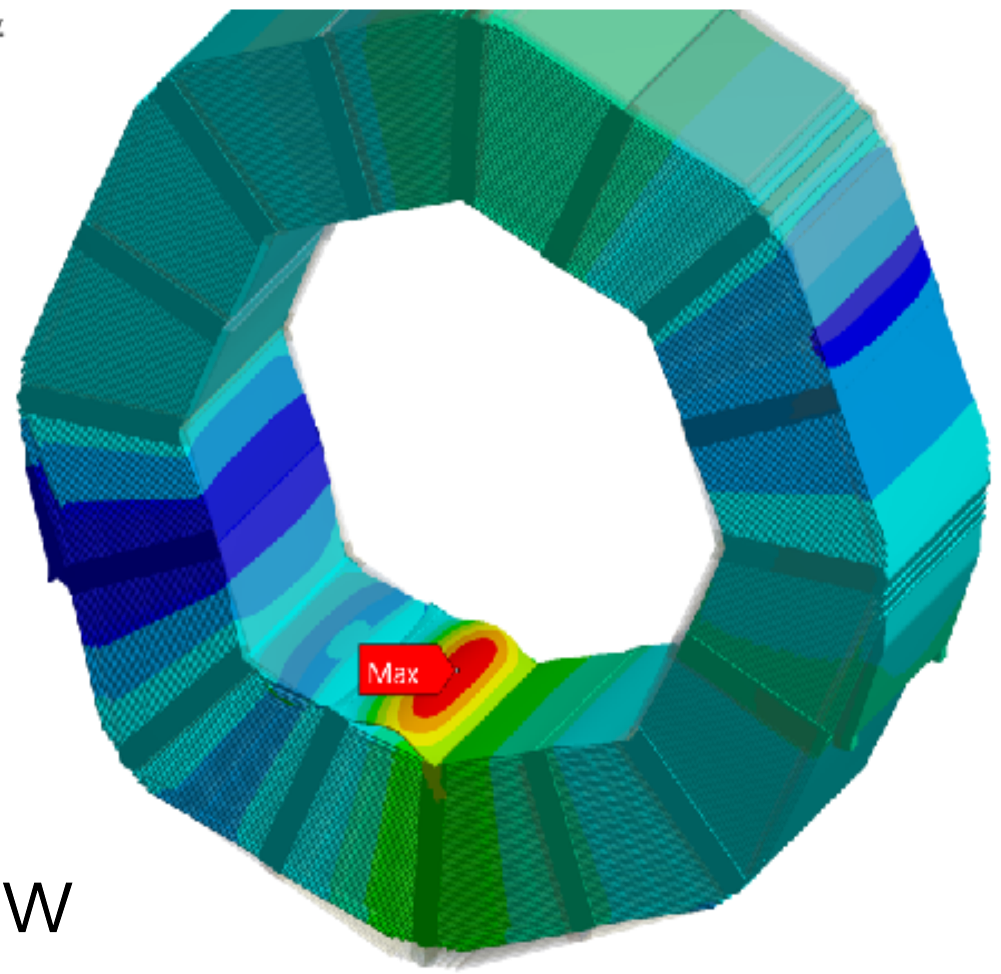


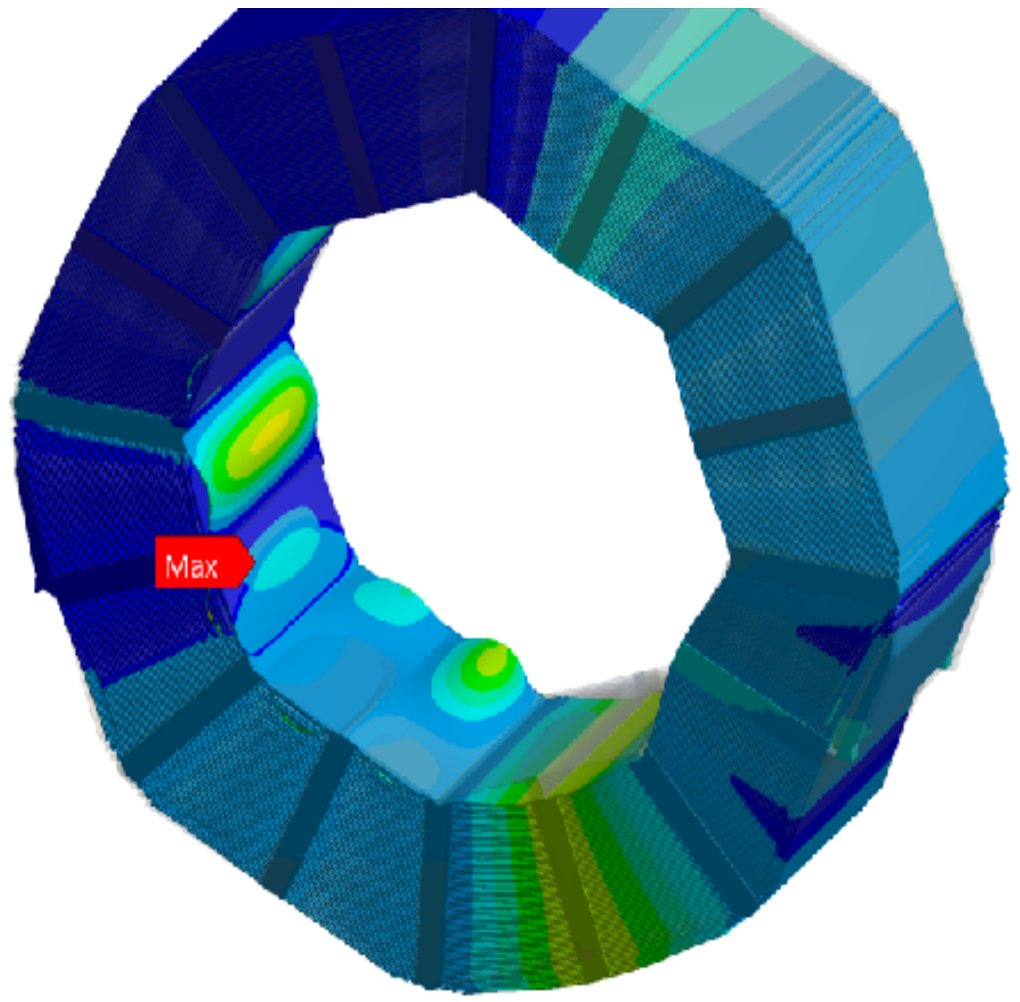
Eigen mode analysis

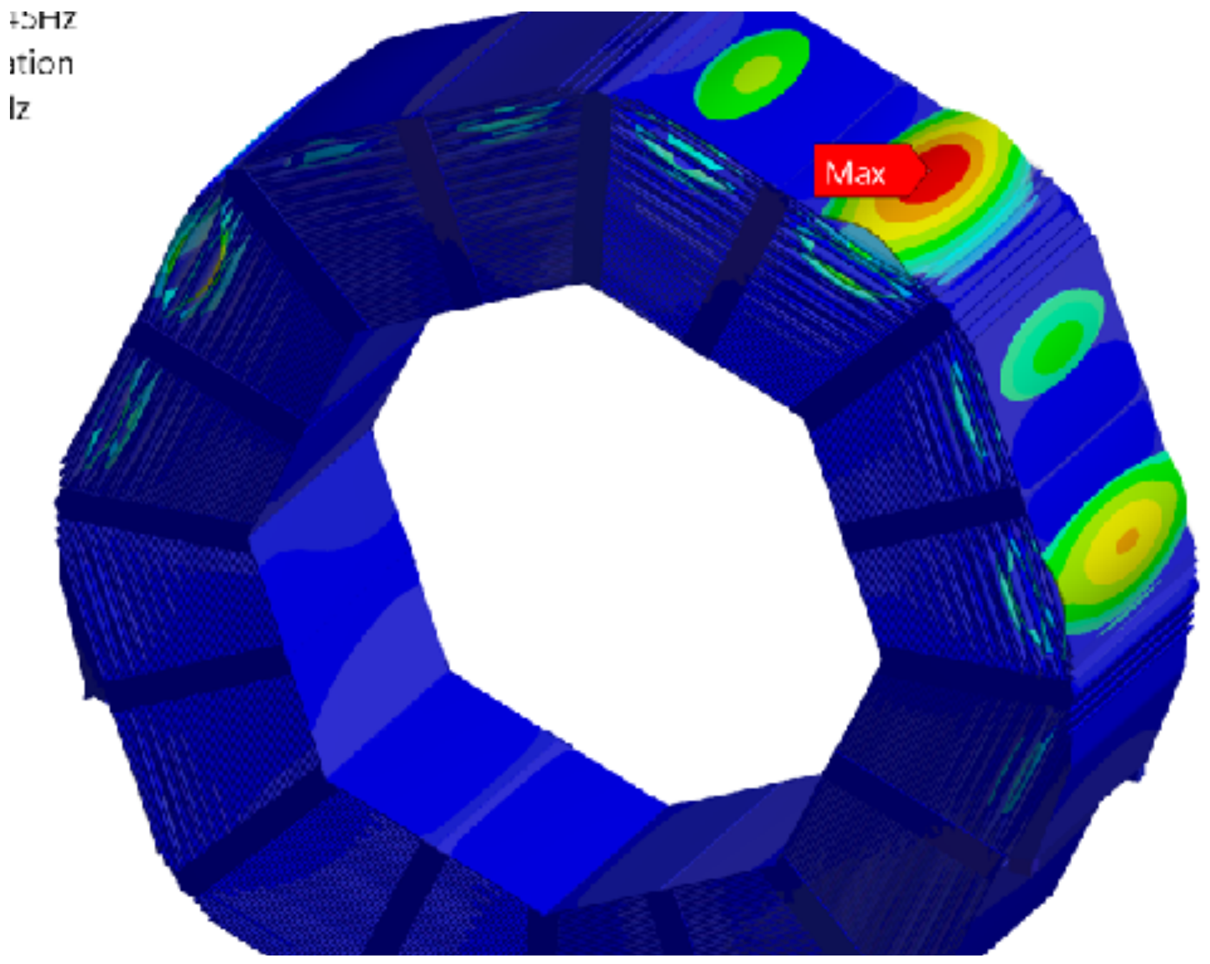
- Swinging barrel: 3Hz
- Swinging module: 8Hz
- Swinging plate: 6Hz
- Higher modes: 15 Hz
- Several plates: 45 Hz











Slide from F. Sefkow

Conclusion

- Challenging project, new difficulties encountered at every step
- Circumventing computing power limitations requires brain power

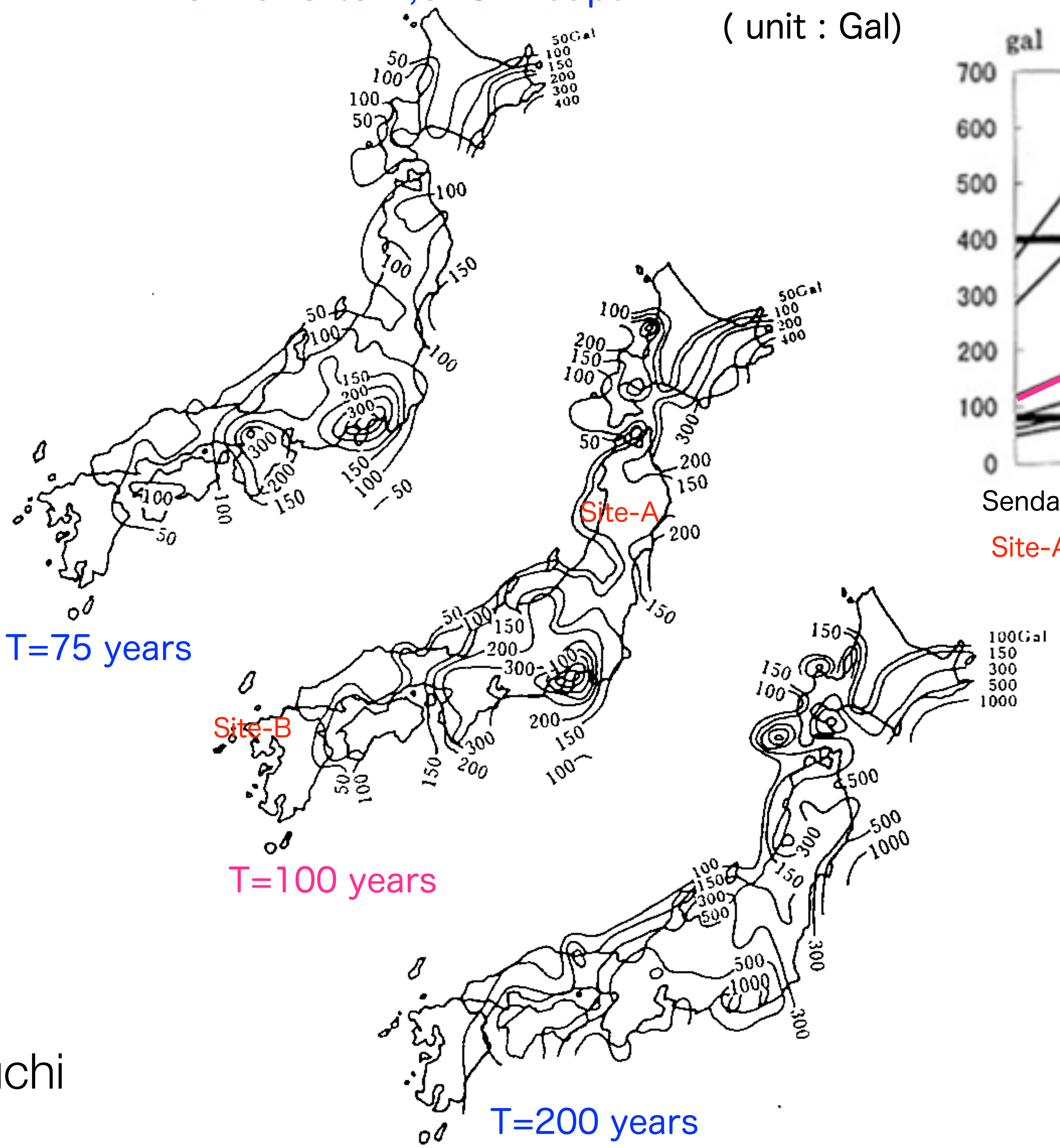
- Next steps:
- Complete analysis
- Outlook:
- Validation
- use existing structures
- on a shaker

Slide from F. Sefkow

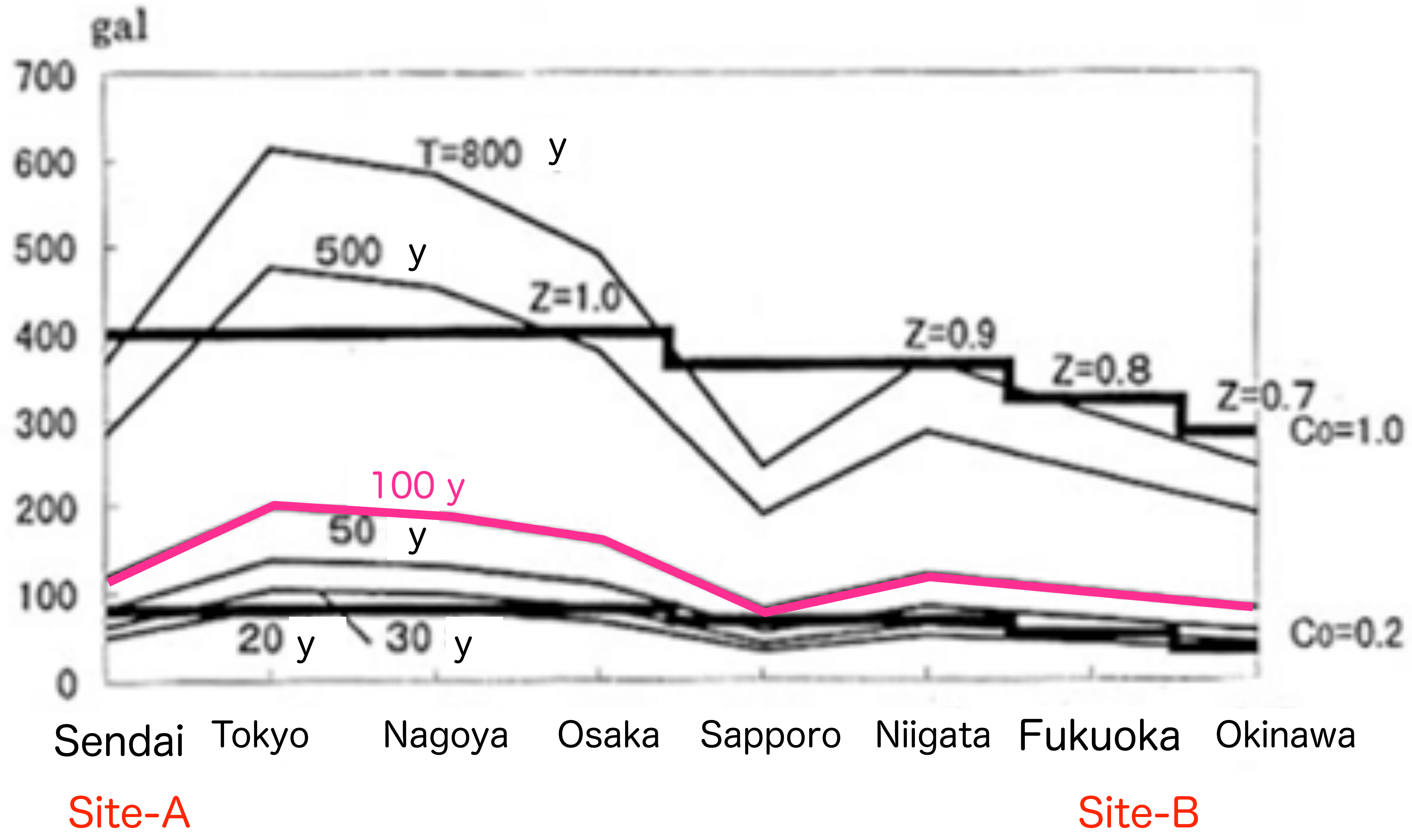
Seismic Hazard Map in Japan : Maximum acceleration (gal) in recurrence intervals (T) of earthquake

Kawasumi map : based on earthquakes from 679 to 1,948 in Japan

(unit : Gal)



Max. acceleration in cities, Japan



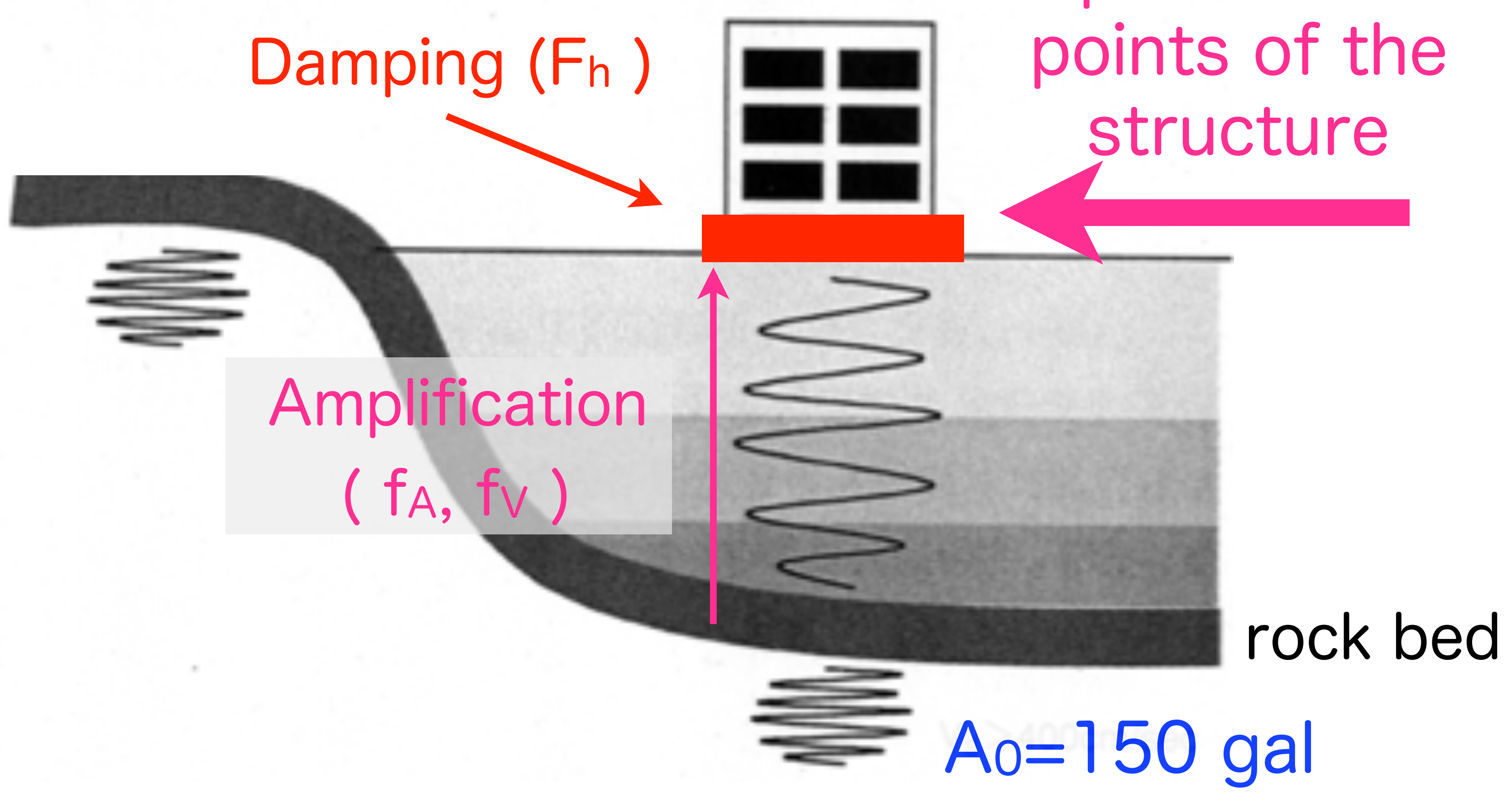
Slide from T. Tauchi

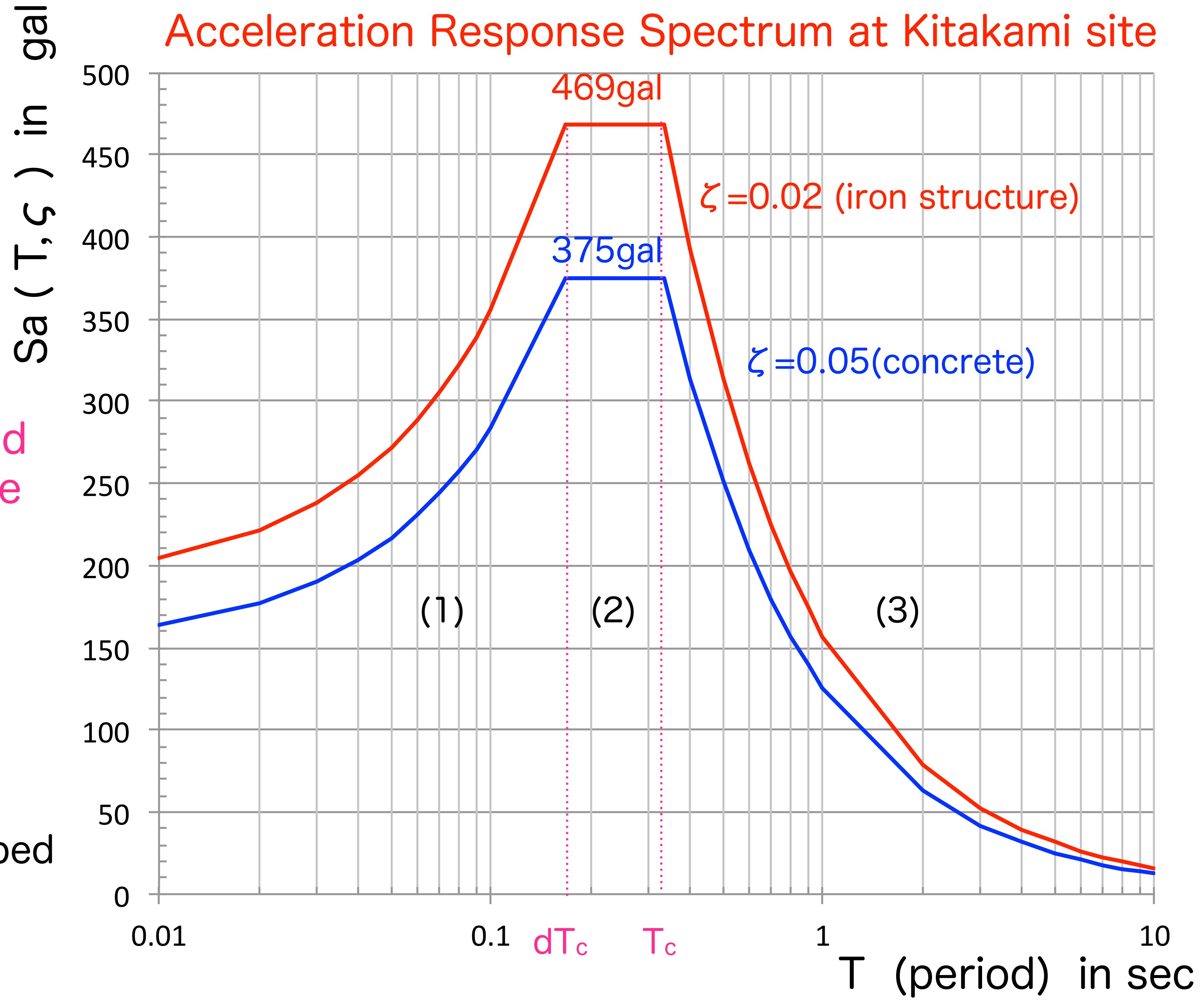
Seismic Analysis with the class-1 geology (hard soil)

following the guideline of construction loads by Architectural Institute of Japan, also ISO3010

Kitakami is a site with hard soil.

Slide from T. Tauchi





$$(1)\ 0 \le T \le dT_c \quad : \quad S_a = \left(1 + \frac{f_A - 1}{d}\frac{T}{T_c}\right) F_h G_A R_A A_0$$

$$(2)\ dT_c \le T \le T_c \quad : \quad S_a = f_A F_h G_A R_A A_0$$

$$(3)\ T_c \le T \quad : \quad S_a = \frac{2\pi f_V F_h G_V R_V V_0}{T}$$

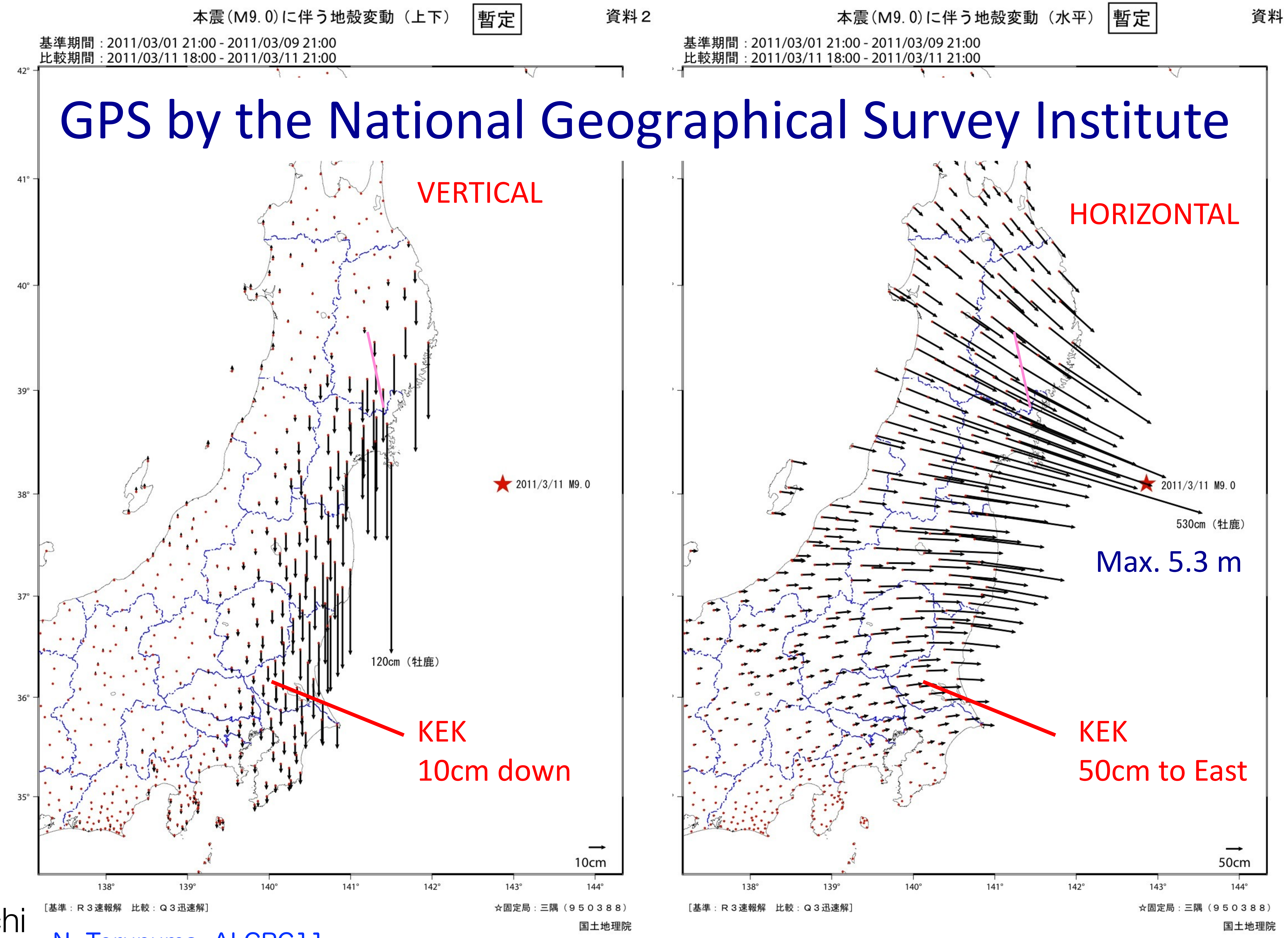
(constant velocity spectrum)

$$T_c = \frac{2\pi f_V G_V R_V V_0}{f_A G_A R_A A_0} = 0.33\text{sec}$$

$$dT_c = 0.17\text{sec for } d = 0.5$$

$$\text{Frequency:} f = \frac{1}{T} \quad \text{Displacement:} x(f, \zeta) = \frac{S_a(T, \zeta)}{(2\pi f)^2}$$

GPS by the National Geographical Survey Institute



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N. Terunuma, ALCPG11

Acceleration/Velocity/Displacement Response Spectrum

2011.3.11 M9.0 24 km in depth

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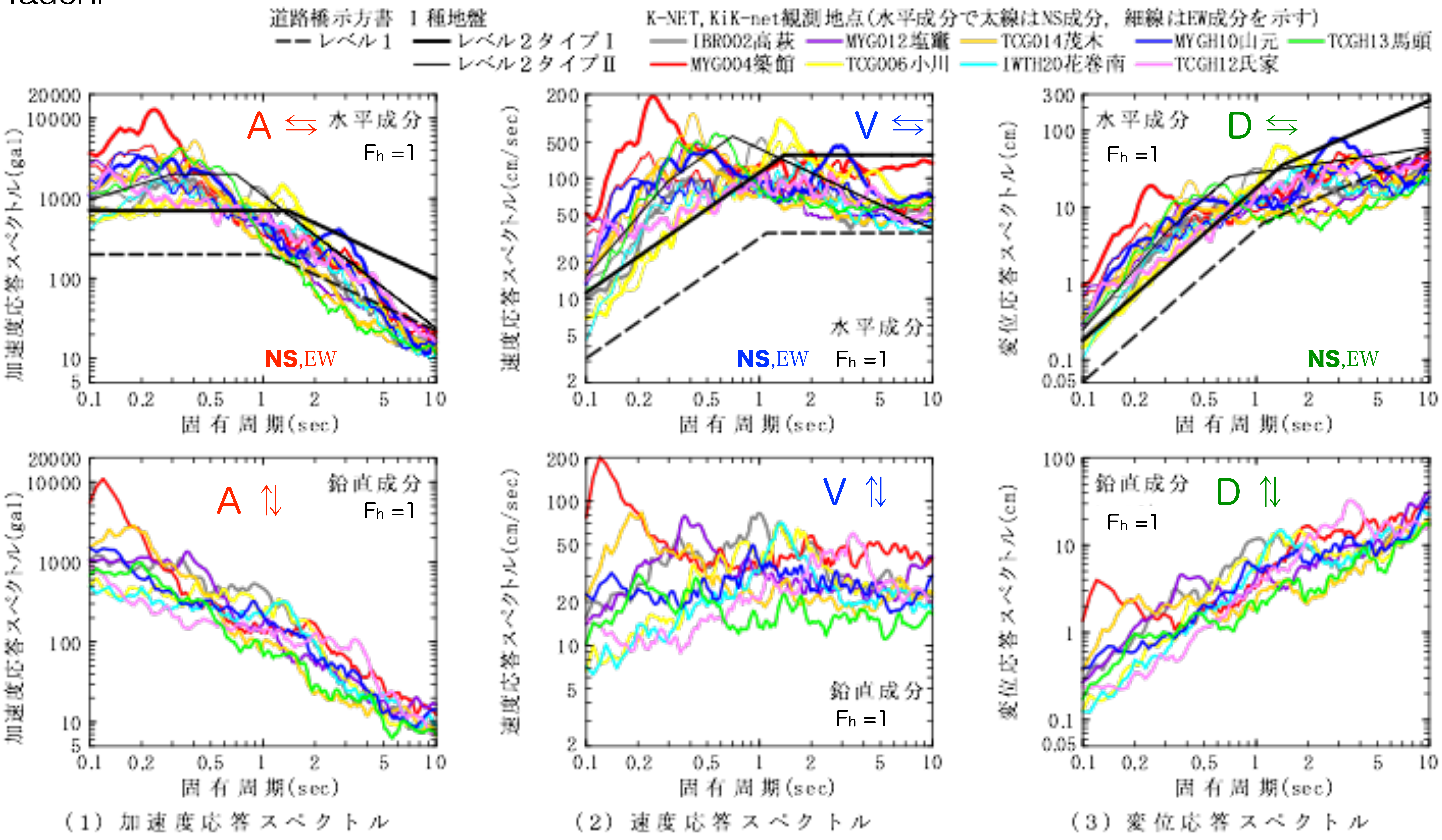
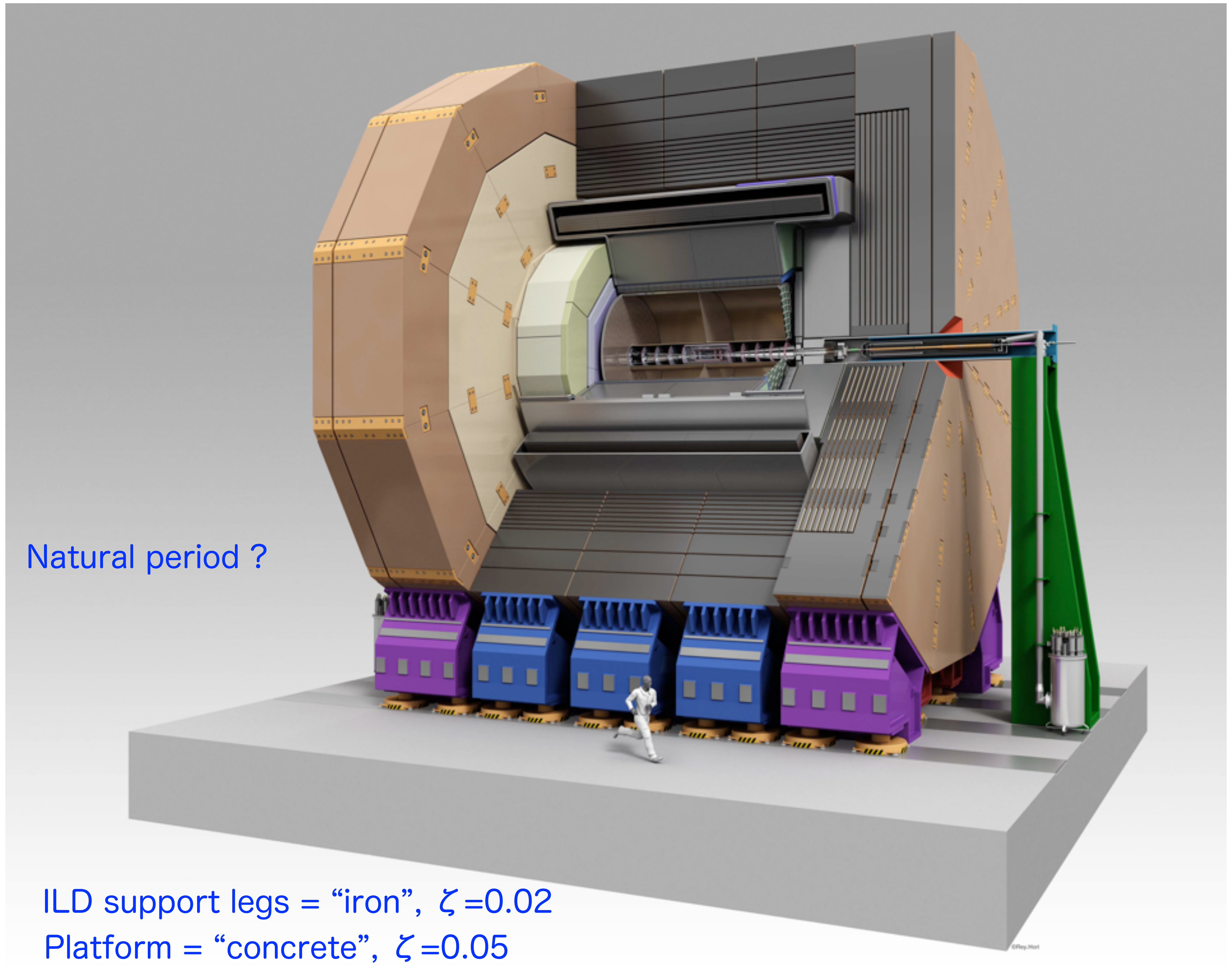


Acceleration : shear force

Velocity : kinetic energy

Displacement : strain



Material Strength and Allowable stress

	Material		Steel	Aluminum	Stainless
			SS400	AC4C−T5	SUS304
Material strength	Tensile (σu)	N/mm2 (=MPa)	400	137	520
	Yeild (σy)	N/mm2	205	108	205
	F-1	F-1=σy	205	108	205
	F-2	F-2=0.7*σu	280	96	364
	F	Smaller value	205	108	205
Material Allowable Stress		Allowable stress(MPa)			
	Tension	ft=F/1.5	137	72	137
	Shearing	fs=F/(1.5√3)	79	42	79
	Bending	fb=F/1.3	158	83	158
	Hertz stress	fp=F/1.1	186	98	186
	Bolt(Tension)	ft=F/2	103	54	103
	Bolt(Shear)	fs=F/(1.5√3)	79	42	79
	Bolt(Hertz)	fp=1.25F	256	135	256
	Roller	fp=1.9F	390	205	390
	Welding(PT)	fs=F/(1.5√3)	79	42	79
	Welding(No PT)	fs=0.45F/(1.5√3)	36	19	36
	Earthquake	(Above)x1.5	237@Bend (=158x1.5)		

H. Yamaoka, “Magnet seismic analysis”, 10 July, 2007, KEK

Slides from T. Tauchi

Summary/recommendation on seismic studies for the Kitakami site

1. Earthquake protection should follow AIJ and ISO3010;

   uses analysis with the response spectrum

2. Earthquake model at Kitakami site :

   150 gal (100 years) as the earthquake representative A_0
   , where flat period between 0.17 to 0.34sec (dT_c - T_c)
   , using the damping coefficient ζ=0.05 (0.02) for concrete (iron) base structure

3. For ILD earthquake protection

   - Natural periods of the structure and each sub-detectors
   - Nothing should exceed the material allowable stress
   - Minimum gaps should be enough for the natural vibrations
   - Isolation must be carefully designed on the platform

Summary

- The technical description of ILD consists of:
  - A combined CAD model of all sub-detectors, supports, services
  - A set of technical documents:
    - General conventions and rules
    - Interface Control Documents: one per sub-detector!
    - Technical Design Descriptions: one per sub-detector (strongly recommended)
  - Going through the process of creating the documents is tedious but extremely useful!
    - Especially for the corresponding sub-detectors!
  - Cables and service paths need to be re-viewed
  - The response of the ILD detector to seismic events needs to be understood better
    - There are clear guidelines and procedures, but it is difficult work: the devil is in the details…
    - A-HCAL is leading the way!