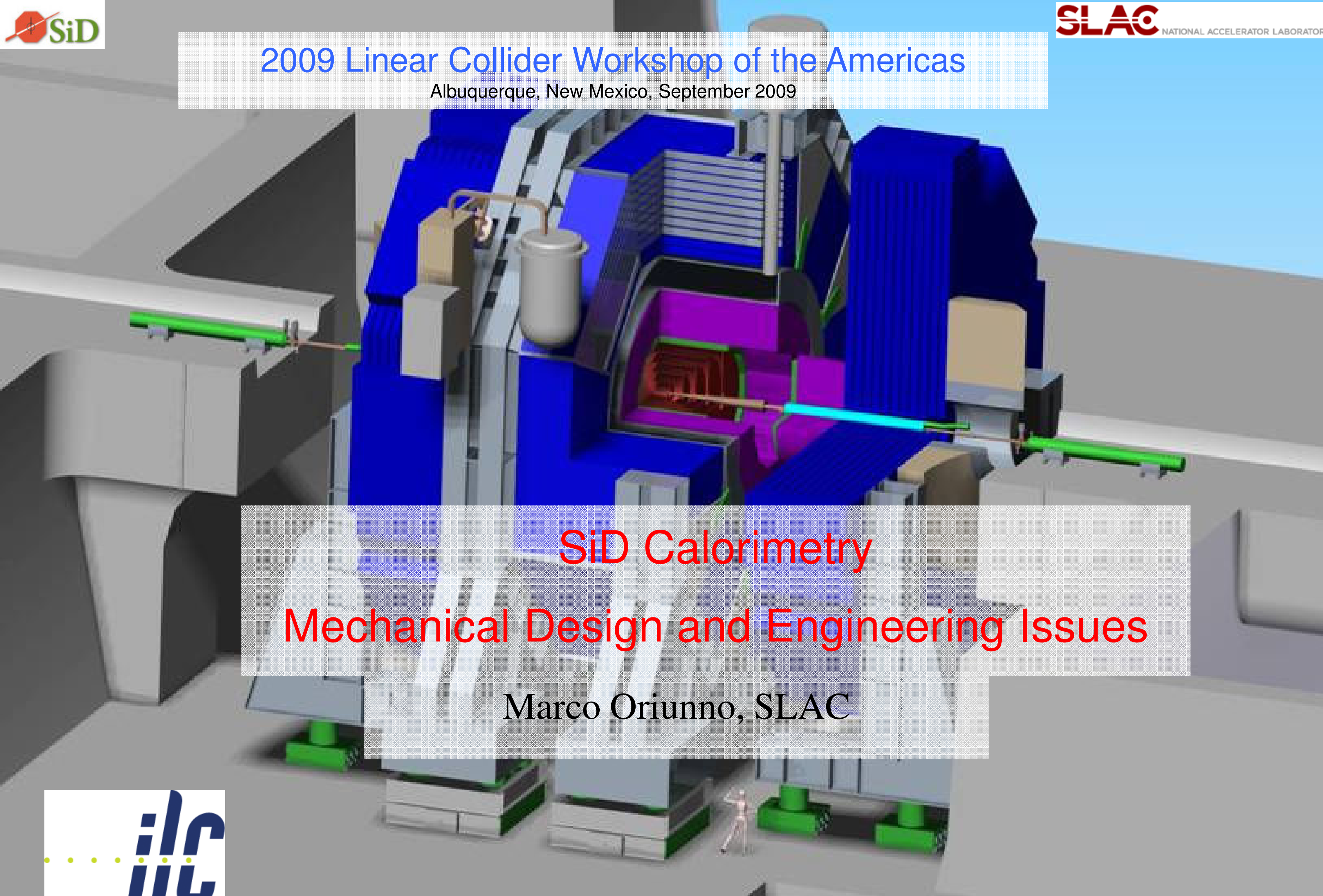


2009 Linear Collider Workshop of the Americas

Albuquerque, New Mexico, September 2009

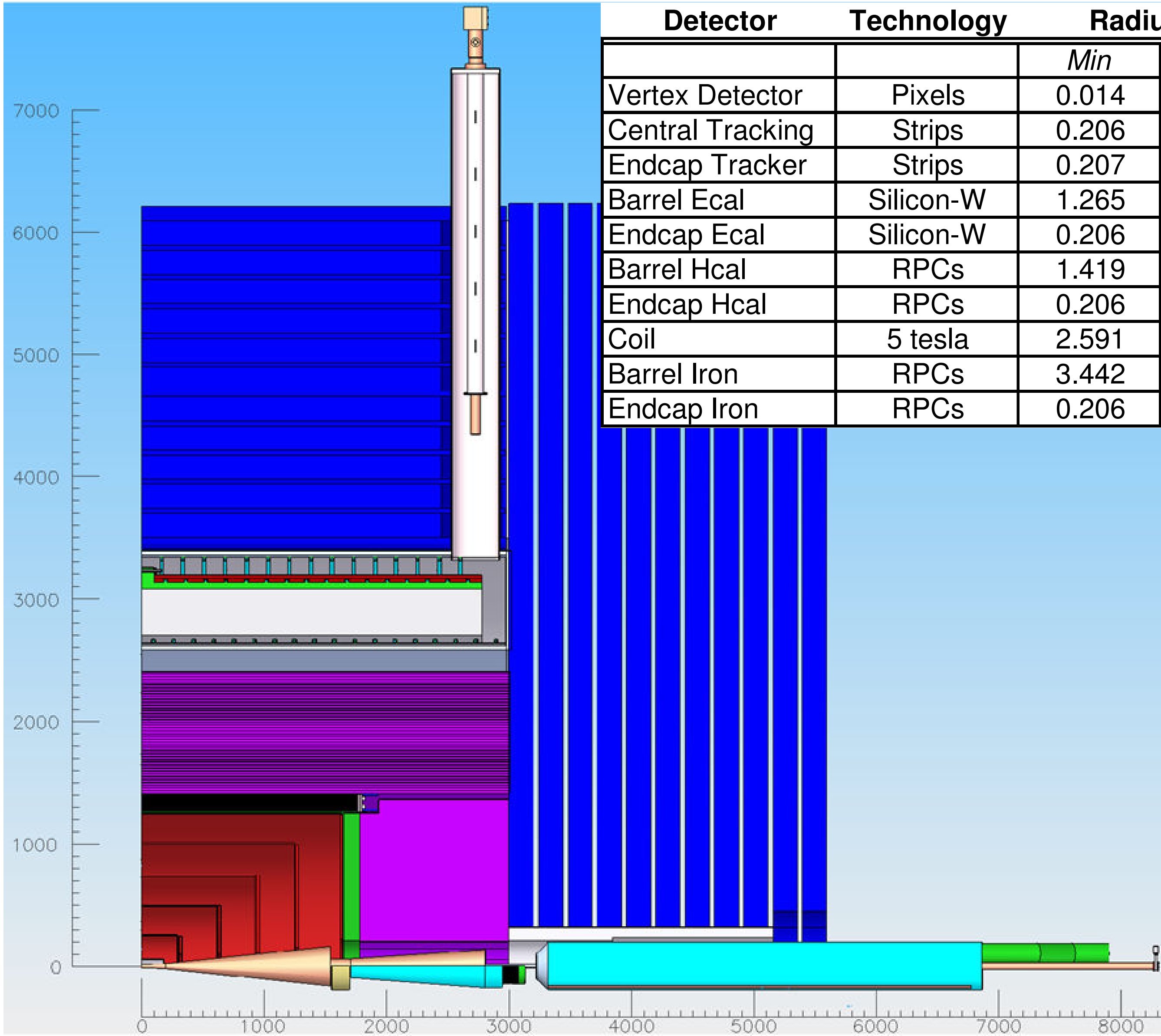
SiD Calorimetry

Mechanical Design and Engineering Issues

Marco Oriunno, SLAC

Engineering parameters

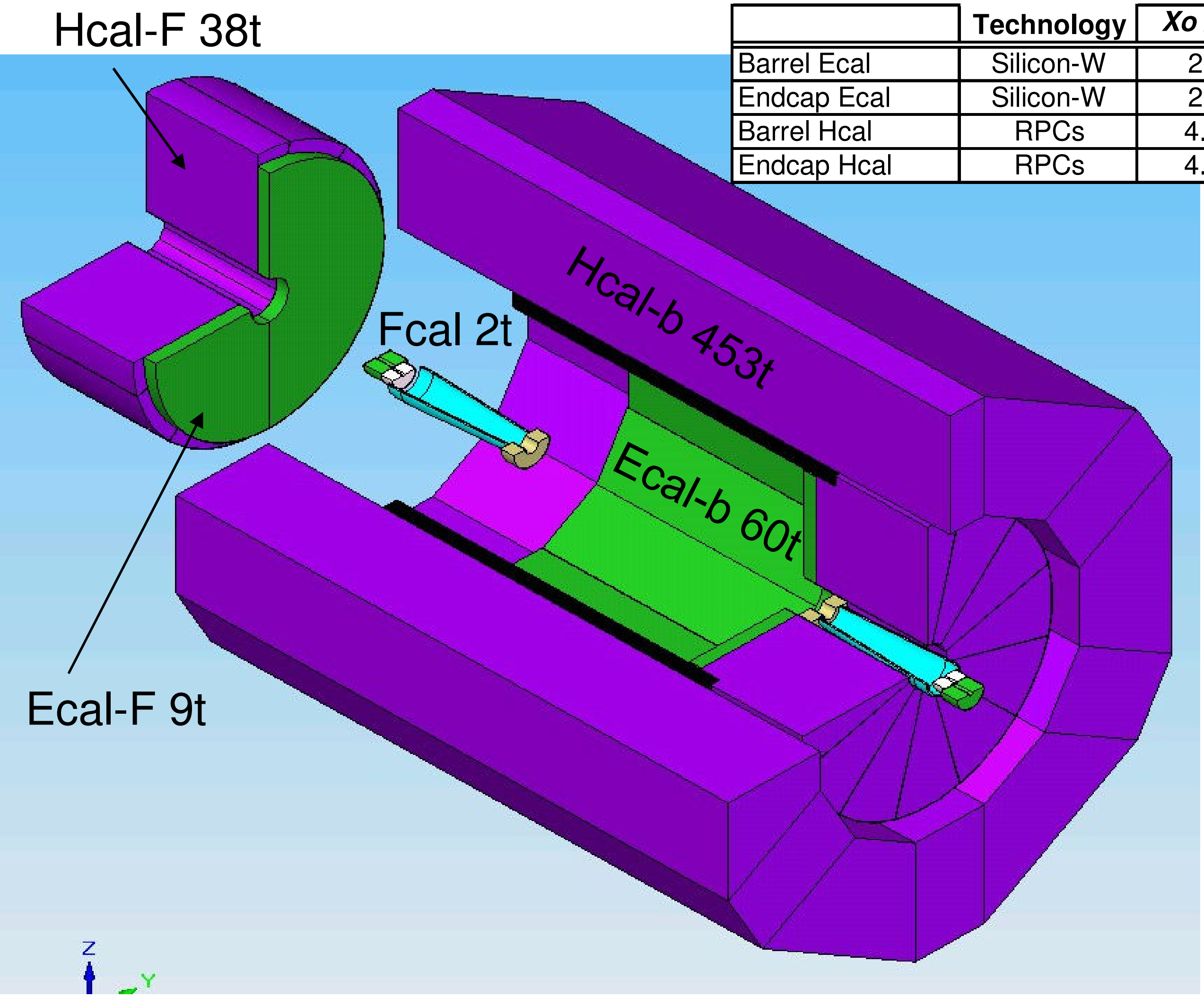
Detector	Technology	Radius (m)		Axial (z) (m)	
		Min	*Max*	*Min*	*Max*
Vertex Detector	Pixels	0.014	0.06		0.18
Central Tracking	Strips	0.206	1.25		1.607
Endcap Tracker	Strips	0.207	0.492	0.85	1.637
Barrel Ecal	Silicon-W	1.265	1.409		1.765
Endcap Ecal	Silicon-W	0.206	1.25	1.657	1.8
Barrel Hcal	RPCs	1.419	2.493		3.018
Endcap Hcal	RPCs	0.206	1.404	1.806	3.028
Coil	5 tesla	2.591	3.392		3.028
Barrel Iron	RPCs	3.442	6.082		3.033
Endcap Iron	RPCs	0.206	6.082	3.033	5.673



SiD calorimetry

ECAL and HCAL participating in the PFA

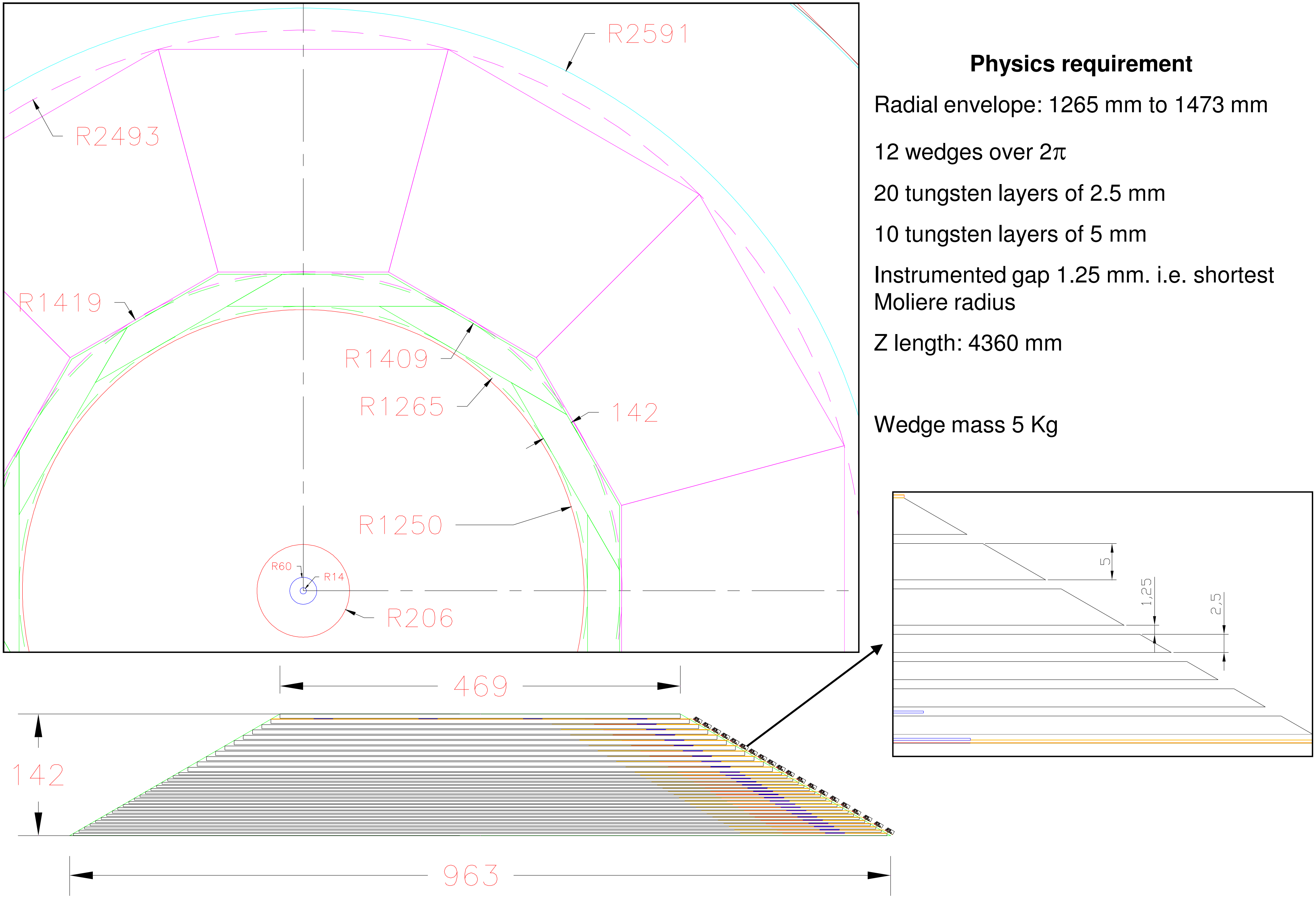
Forward calorimetry to enhance hermeticity and as Luminosity instrumentation



	Technology	Xo / λ	Absorbers	Weight (tons)	Area (m^2)
Barrel Ecal	Silicon-W	26	Tungsten	60	80
Endcap Ecal	Silicon-W	26	Tungsten	2 x 9	2 x 143
Barrel Hcal	RPCs	4.5	Stainless	453	3000
Endcap Hcal	RPCs	4.5	Stainless	2 x 38	2 x 247

ECAL

Parameters Si/W ECAL barrel



Physics requirement

Radial envelope: 1265 mm to 1473 mm

12 wedges over 2π

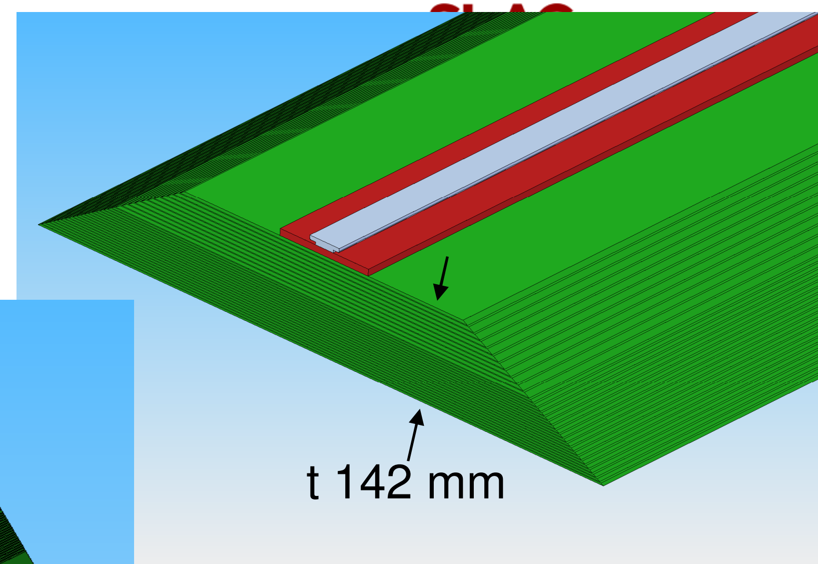
20 tungsten layers of 2.5 mm

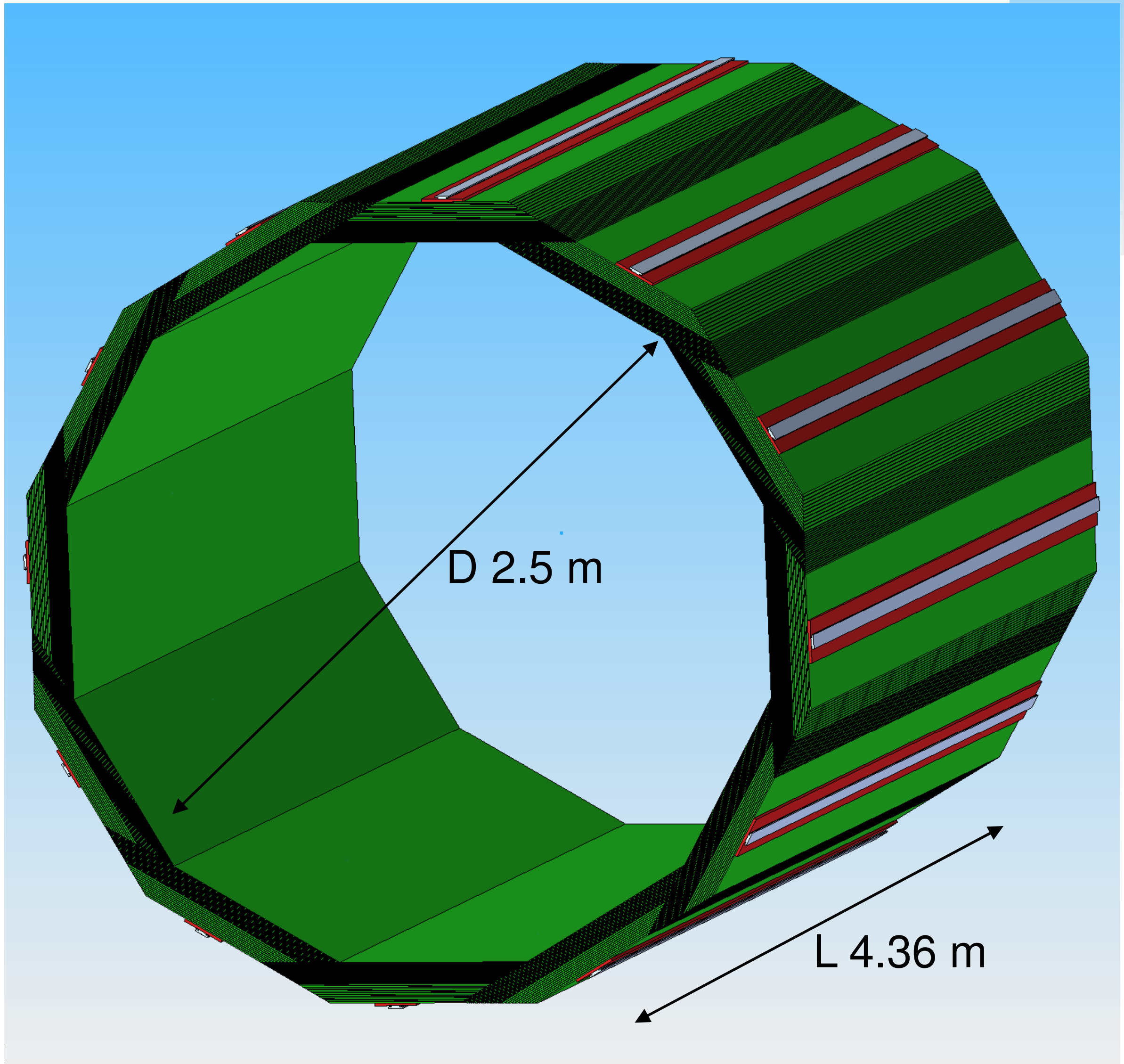
10 tungsten layers of 5 mm

Instrumented gap 1.25 mm. i.e. shortest Moliere radius

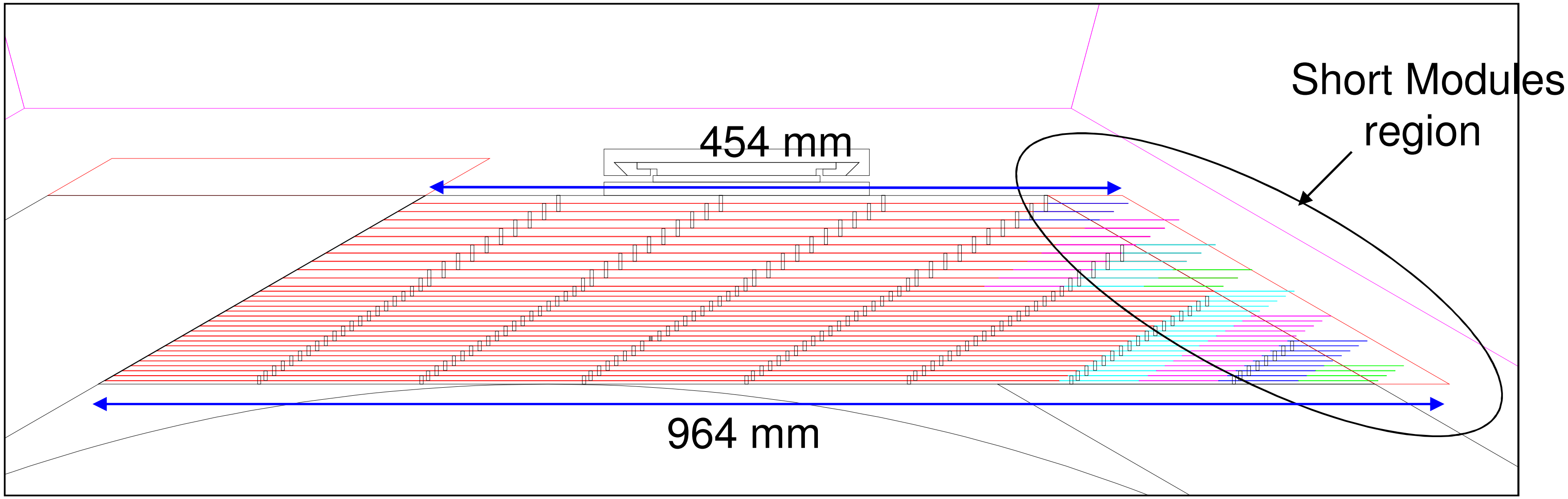
Z length: 4360 mm

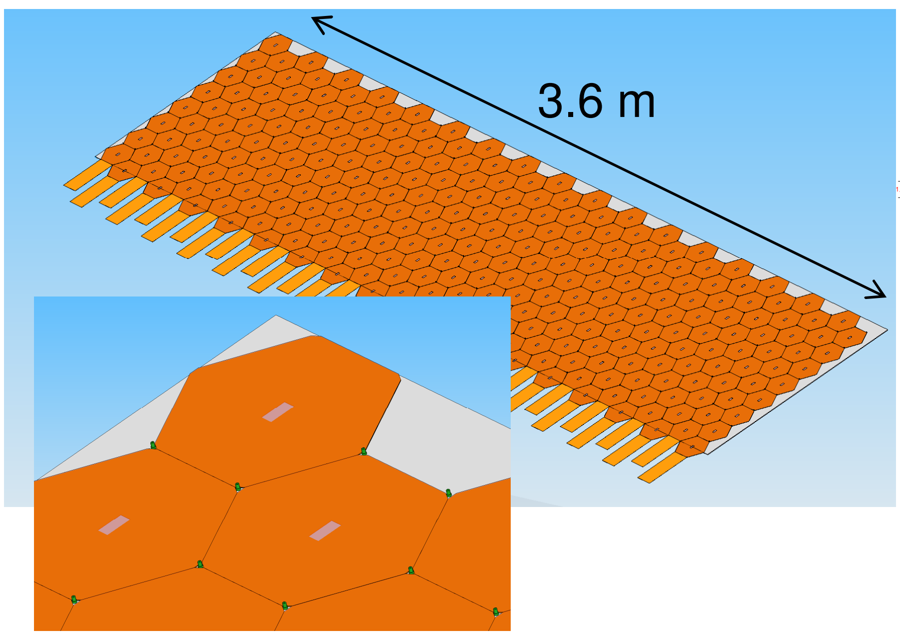
Wedge mass 5 Kg


t 142 mm


D 2.5 m
L 4.36 m

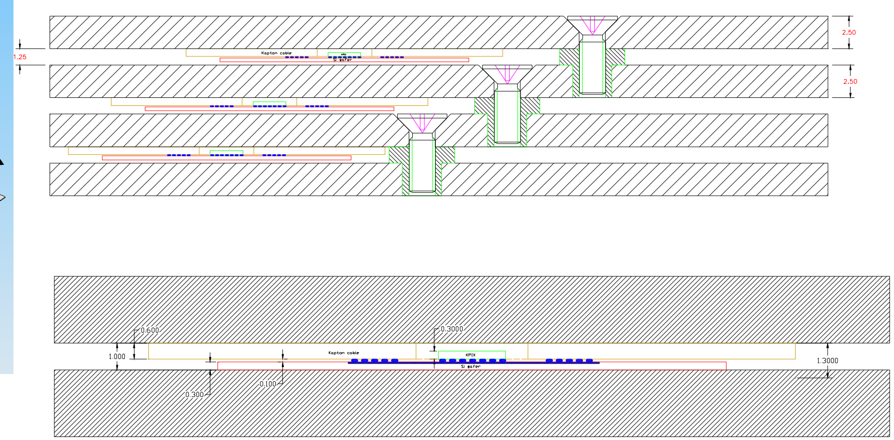
EMcal



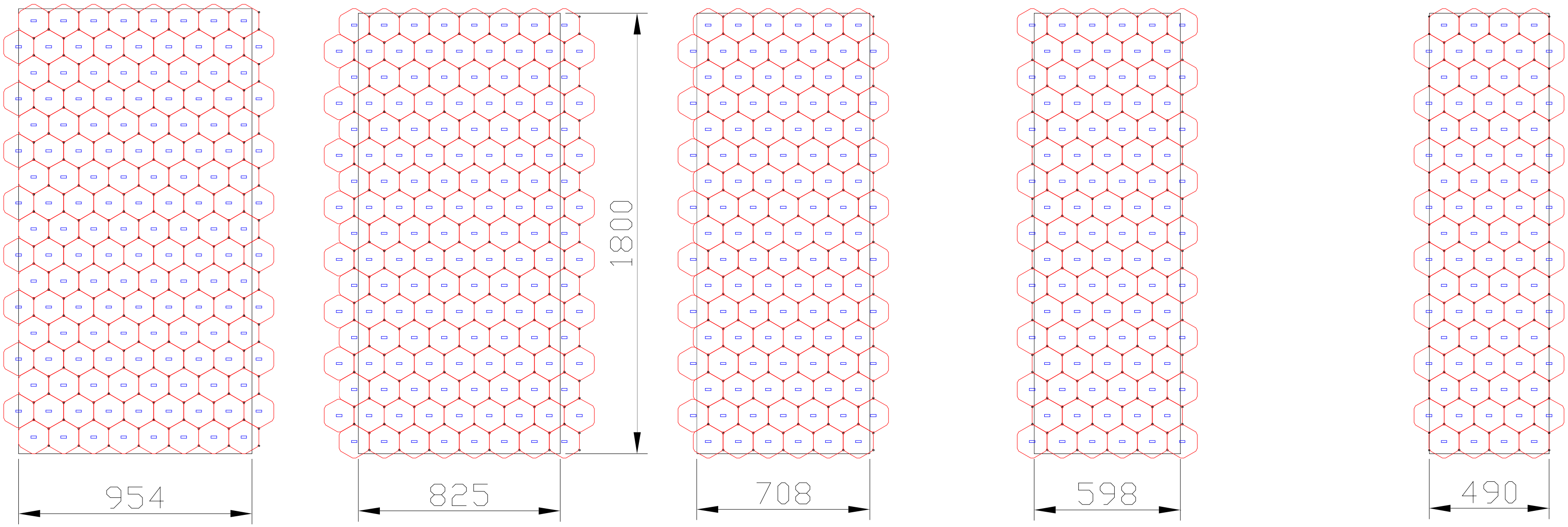


Staggered layout

Only 2 masks for the wafer and 8 for the kapton



Sensors shape

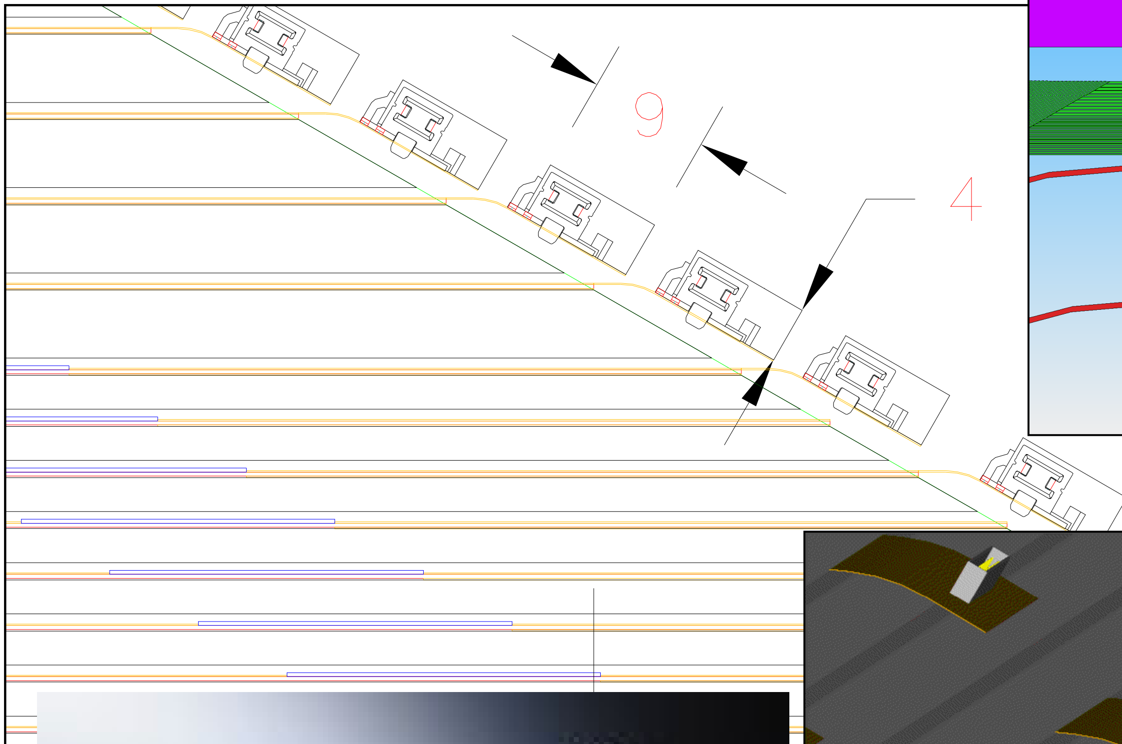


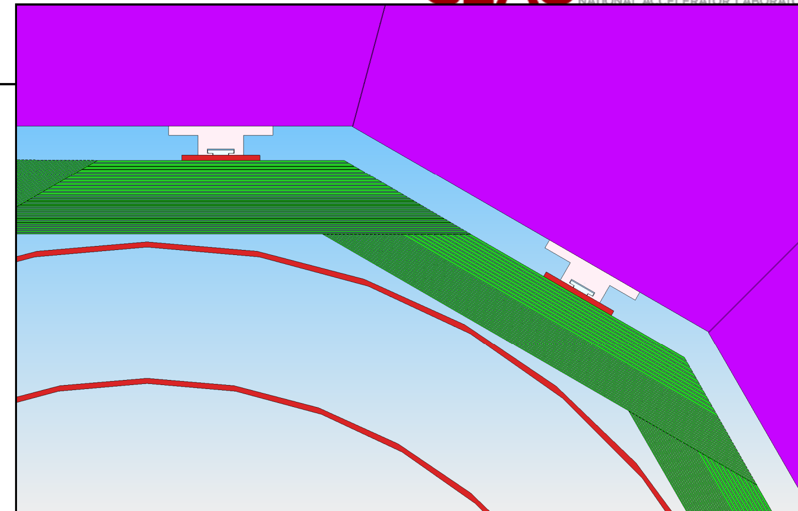
It is not possible to cover all the W plates dimension with the same silicon sensor size.

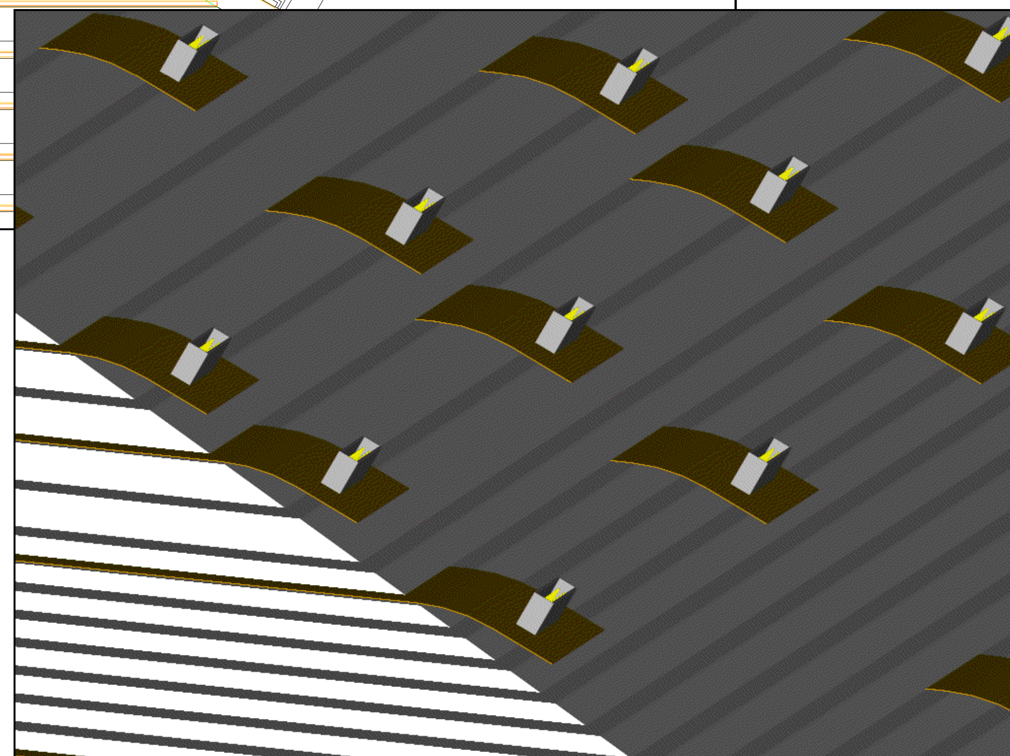
Increased number of masks for the edges

Hexagon geometry is an ideal tiling pattern, but doesn't make life easier : pins, overlap, cables

Cabling

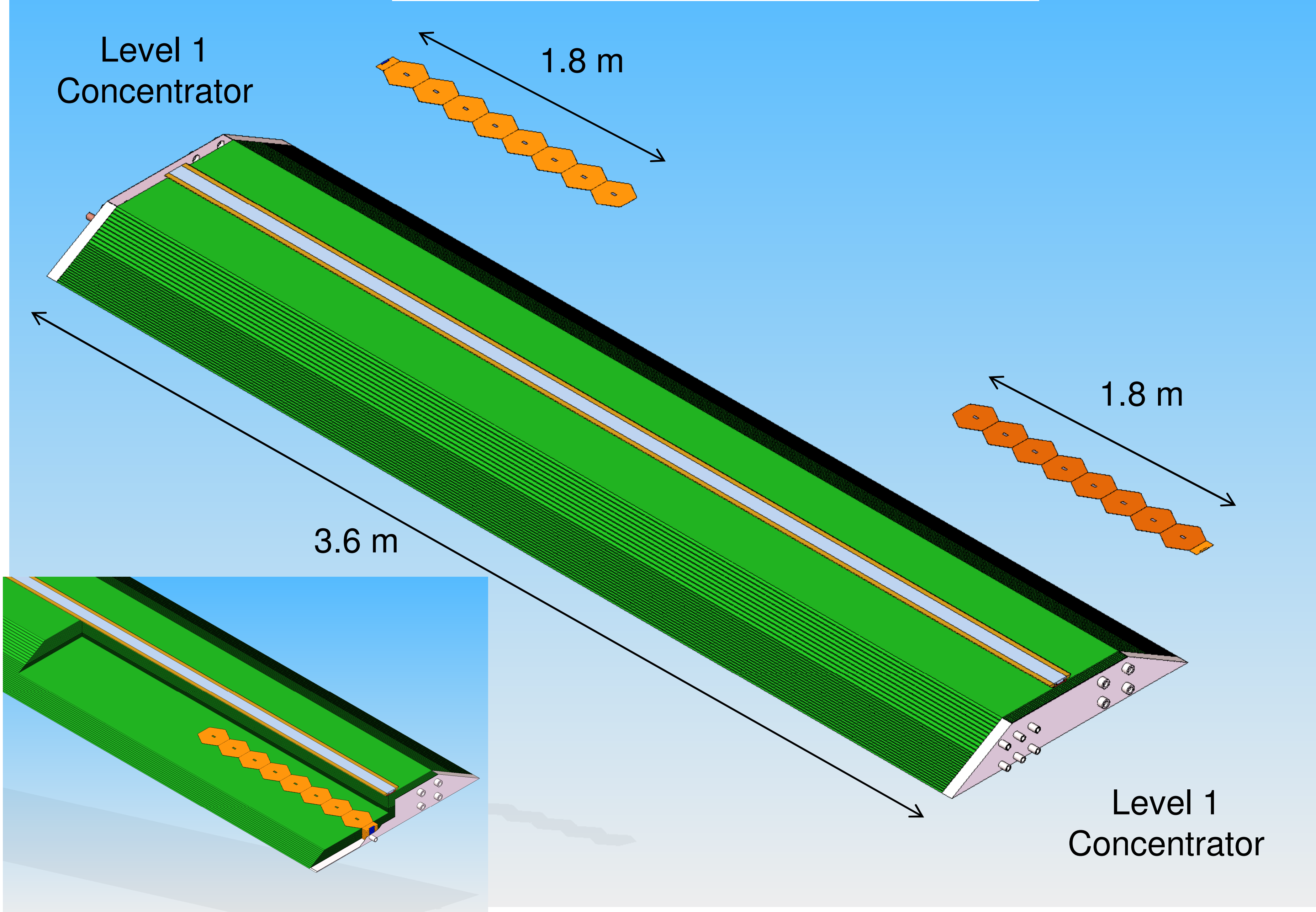




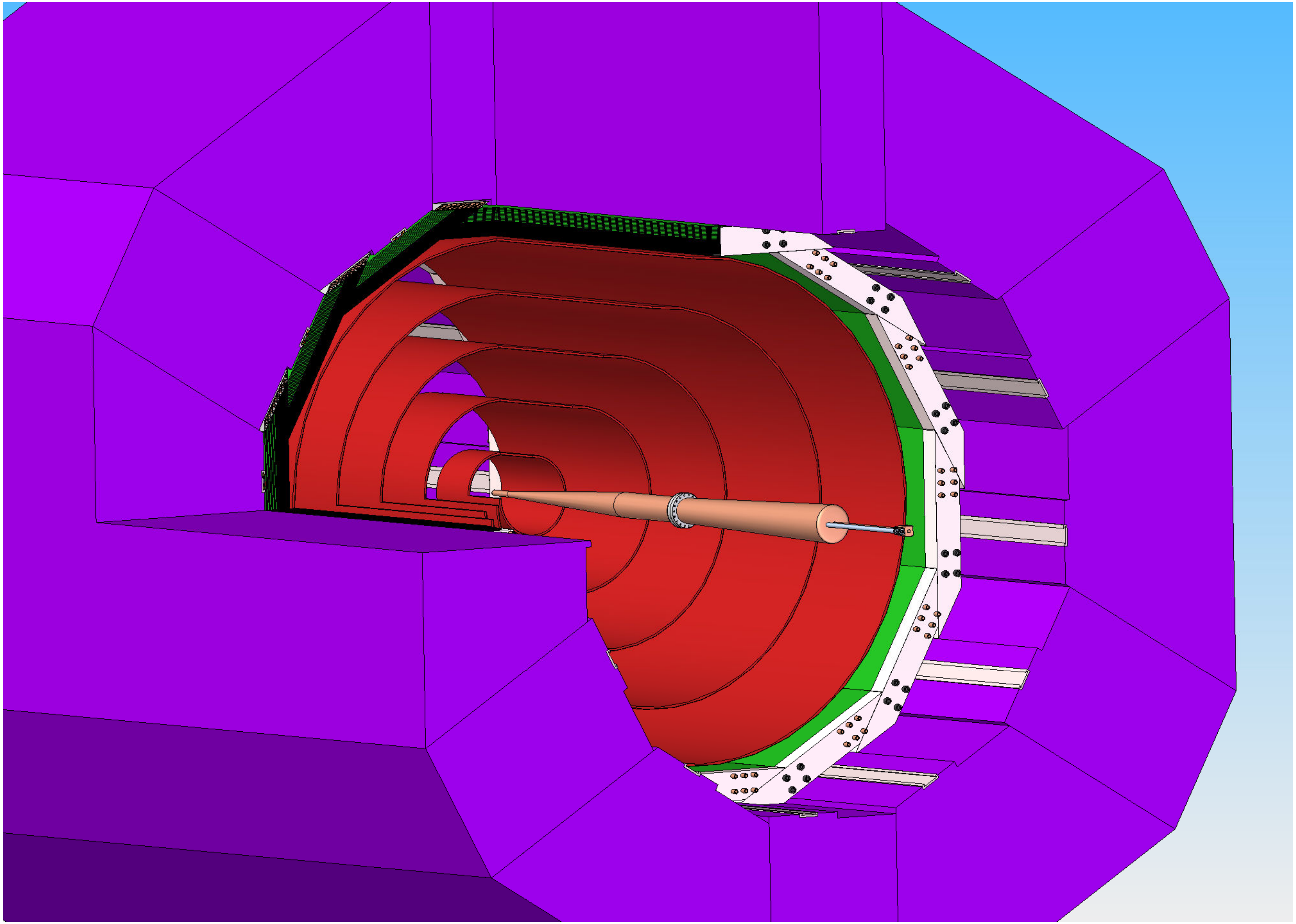


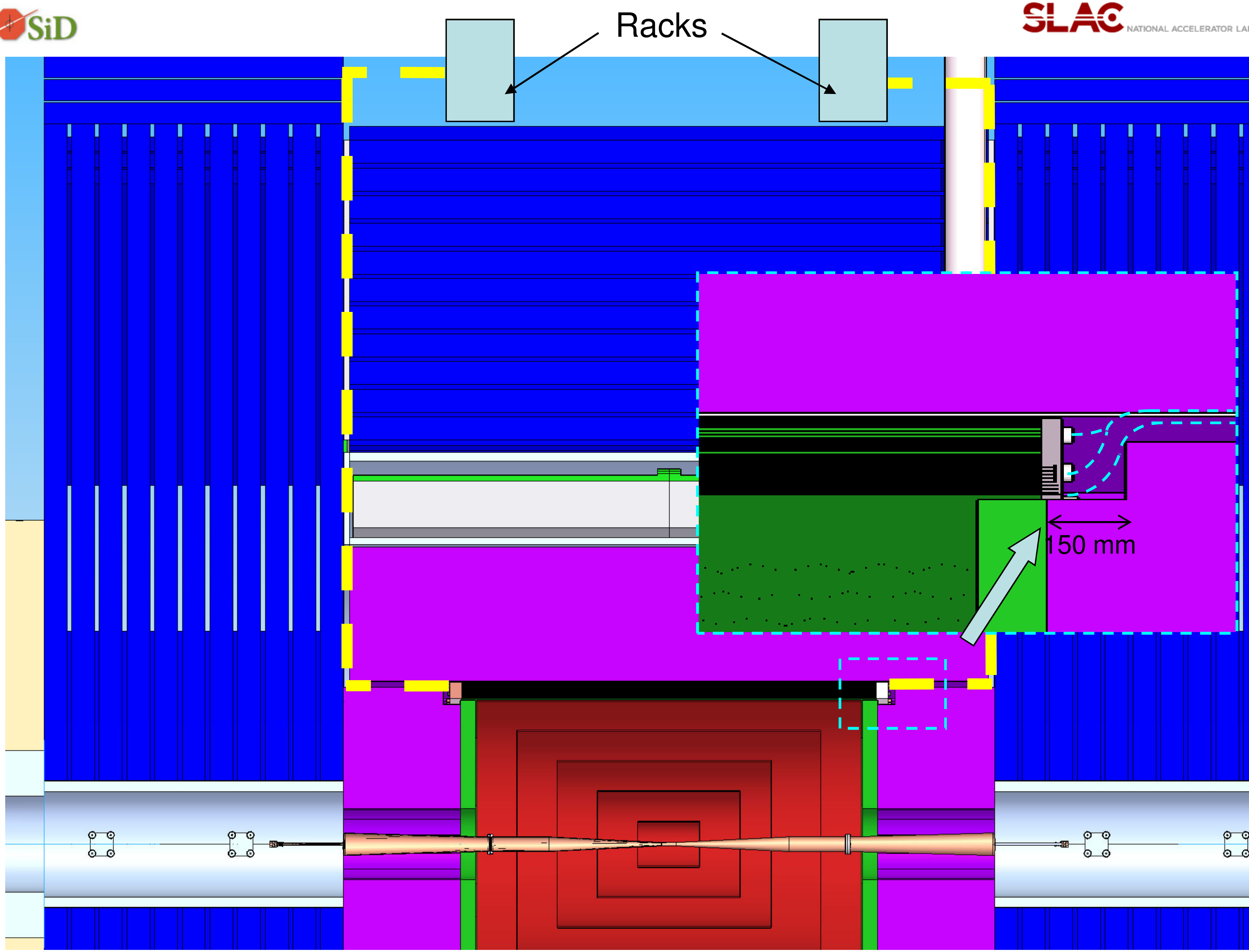
ERNI microstac 0.8 pitch, 50 pins

Flex circuit along Zee



Barrel-Endcap interface




Racks
150 mm

Cooling

Electronic operated in pulsed mode -> 20mW per chip

Total heat load per wedge module 115 Watt

Active cooling required (each sub detector must remove the heat produced)

Cold plate with water pipes routed laterally of the wedge

Total heat load 115 Watt per Wedge

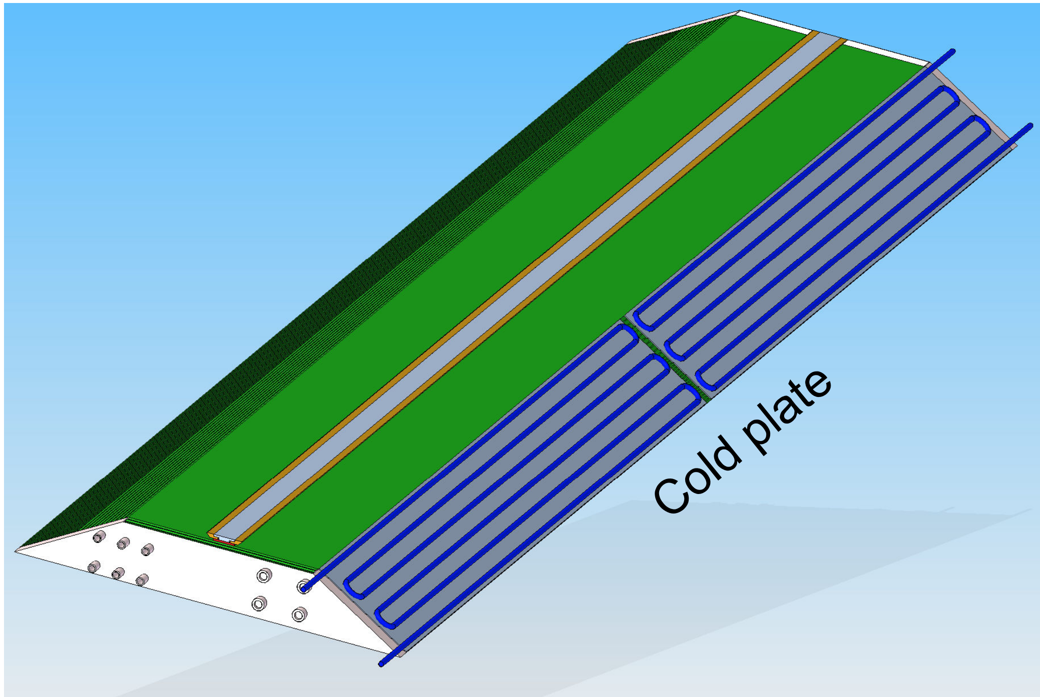
Cooling with demineralized water, Cp = 4.183 J/g.K

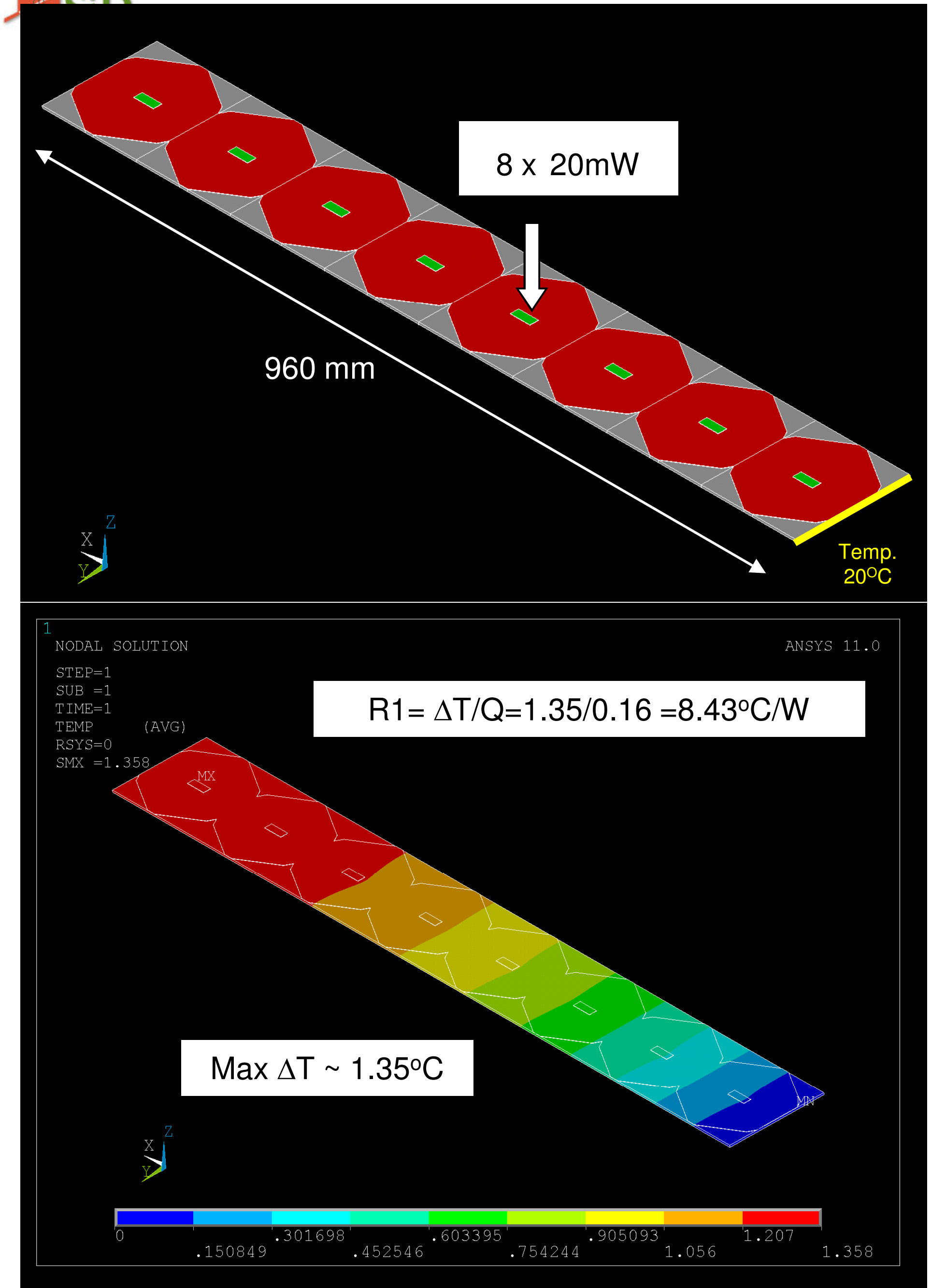
T input 20^{o}C, Max DT = 2^{o}C -> mflow = 0.82 l/min

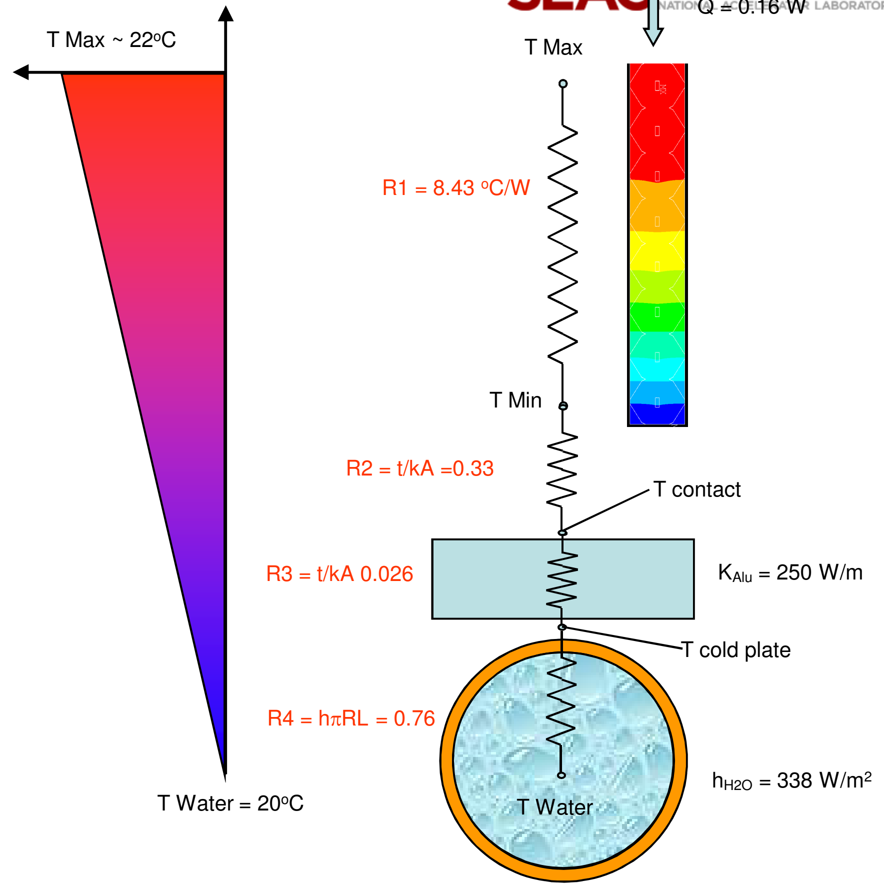
Assuming ➢12/14 mm inox pipes,

Reynolds = 1272 < ~ 2000 i.e. laminar flow

Pressure Drop over the full length ~ very low







$\Delta T = Q*(R1+R2+R3+R4) = Q*(8.43+0.33+0.026+0.76)$

$DT = Q*R = 0.16*9.55 = 1.52\ ^{o}C$

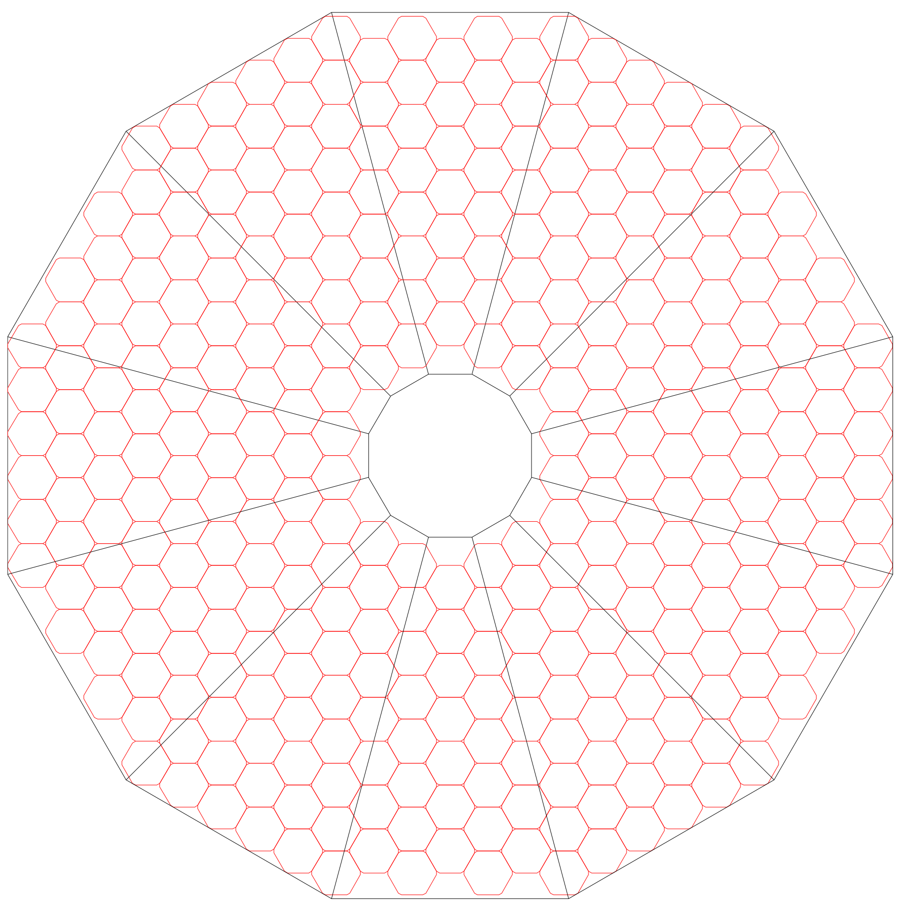
Ecal Frwd -> Petals

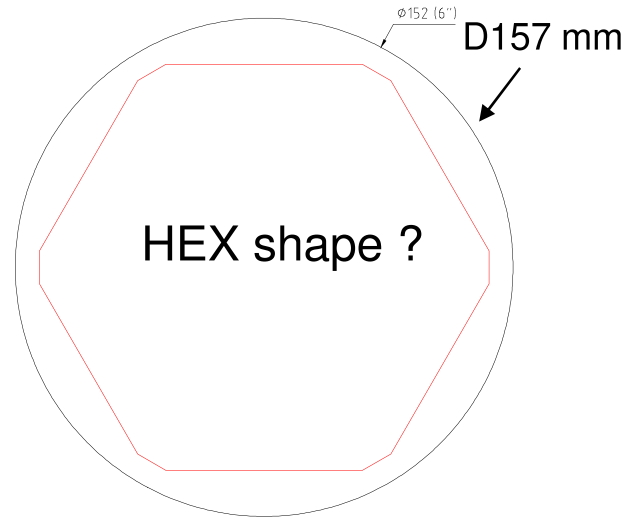
Natural subdivision of the dodecagon

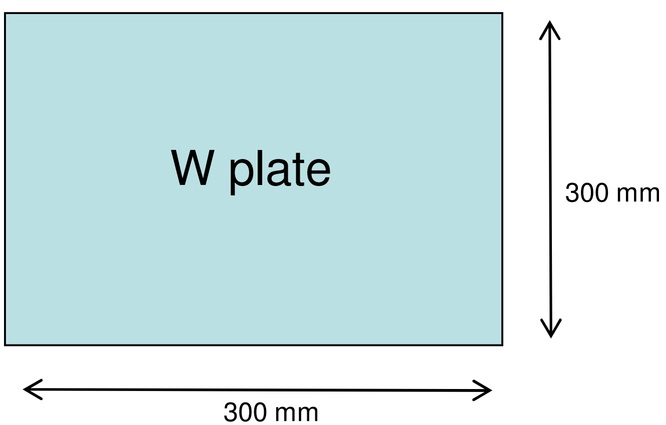
Small sub assembly ~ same size the barrel wedges

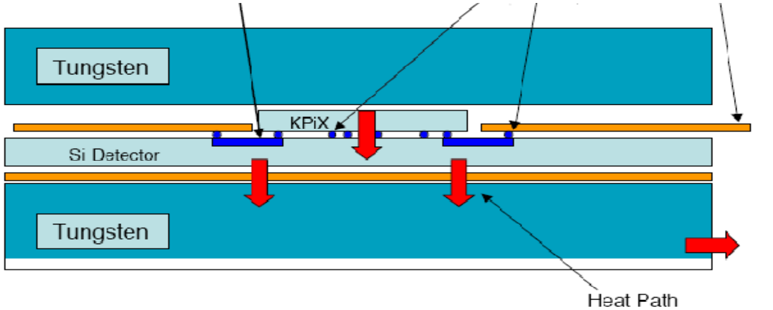
Mechanically independent

Fixed on the from of the Hcal Forward

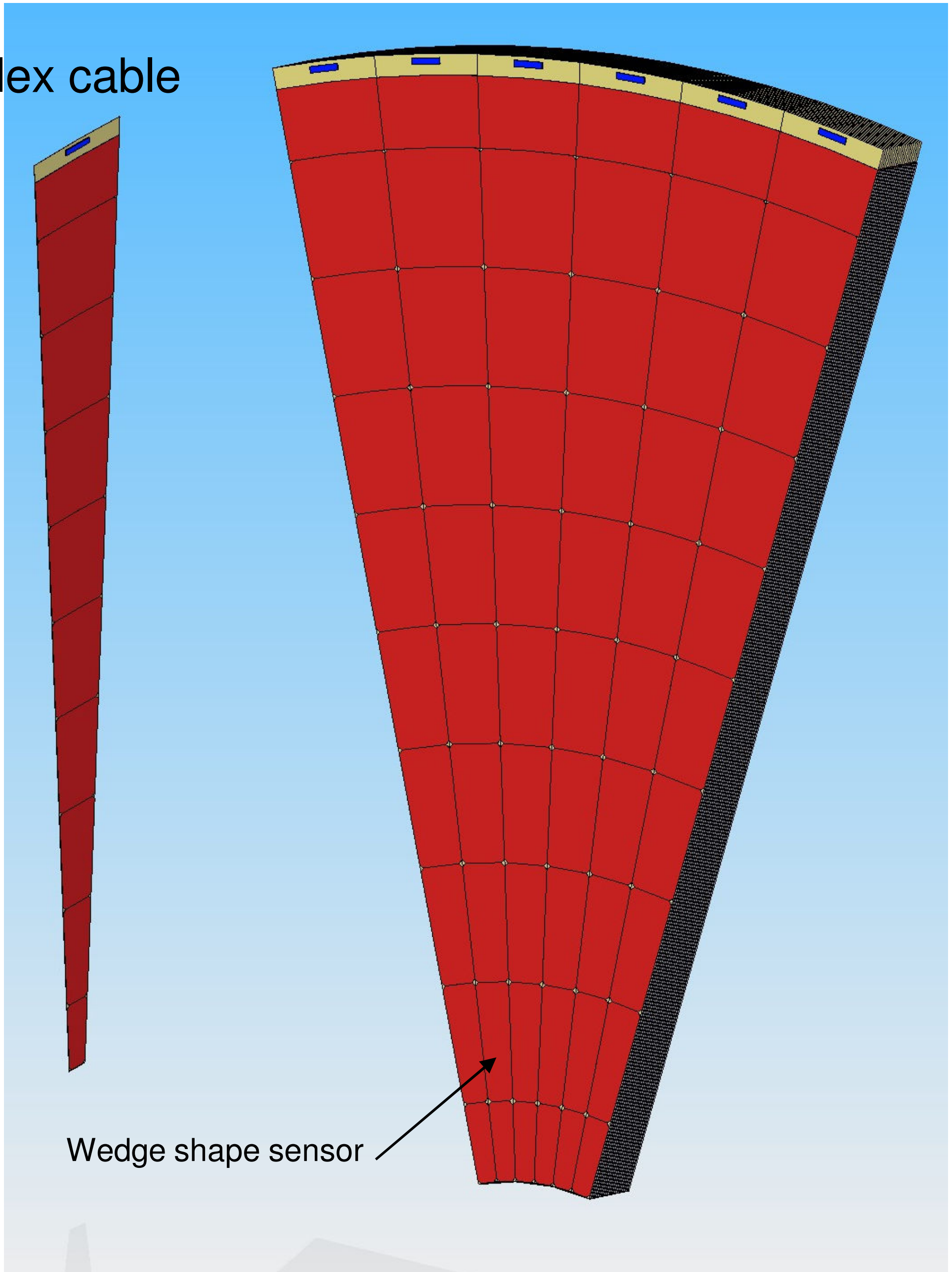








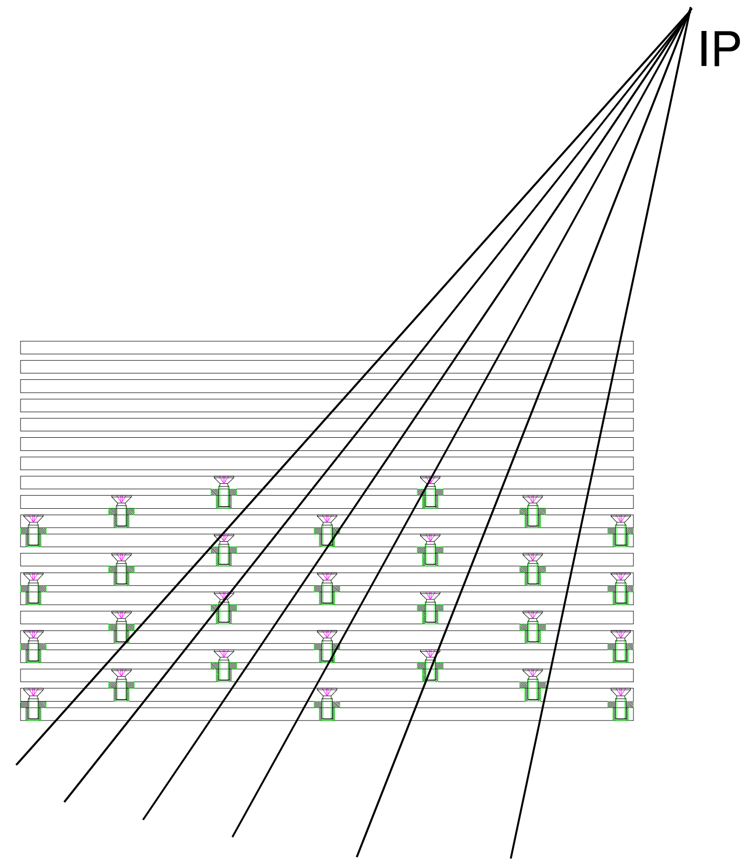
A petal assembled



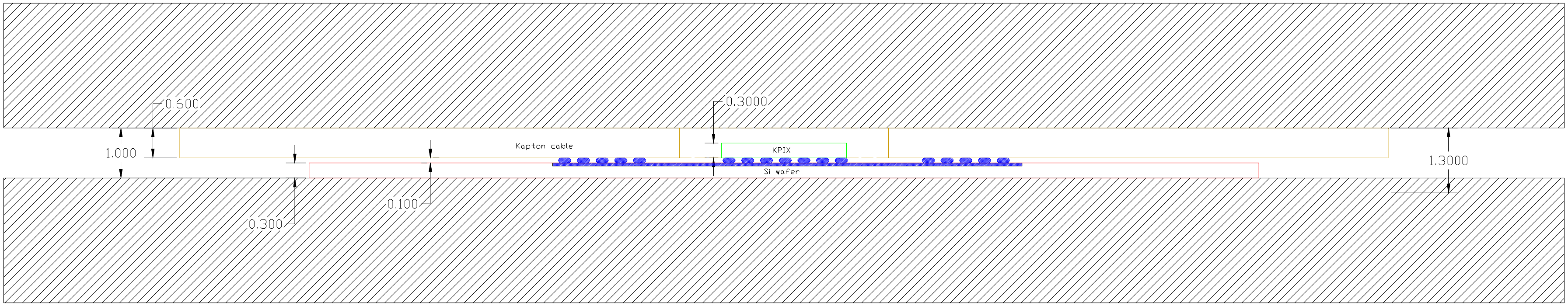
Mechanical connections between W plates as in the barrel wedges

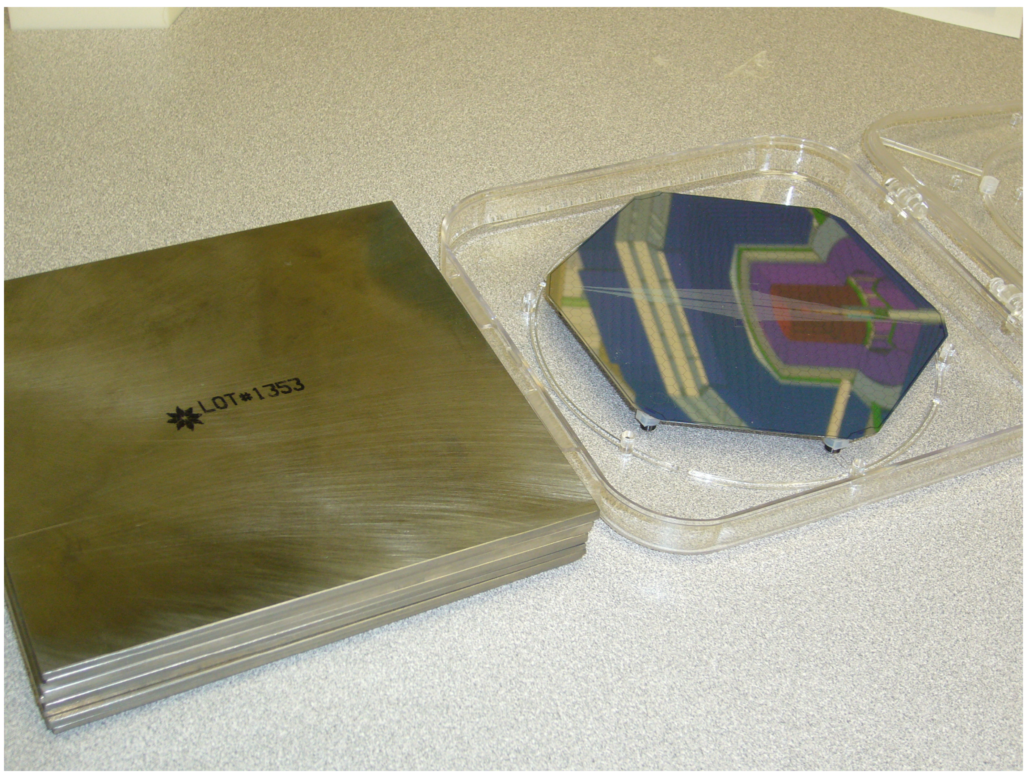
Not all the screws in the name planes need to be used

Some projectivity on the dead space, mitigated by the coiling due to B and the offset of the IP



Small Ecal assembly for beam test





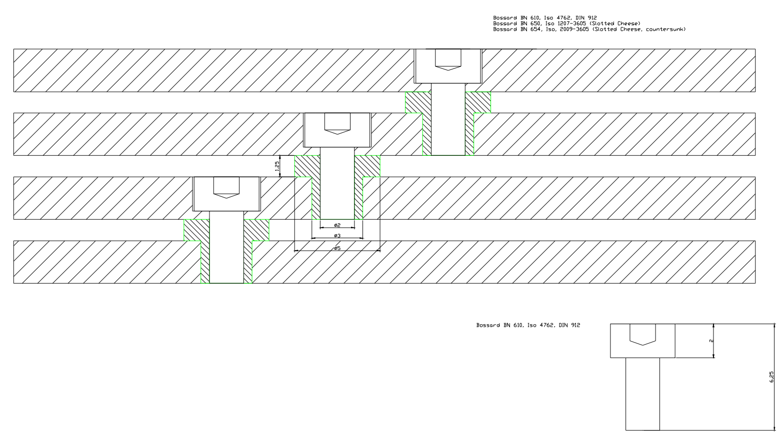
Available at SLAC :

20 plates 6" x 6" x 2.5 mm

10 plates 6" x 6" x 5 mm

Good planarity (visual inspection)

Thickness tolerance < 1 mil



ECAL Mechanical prototype

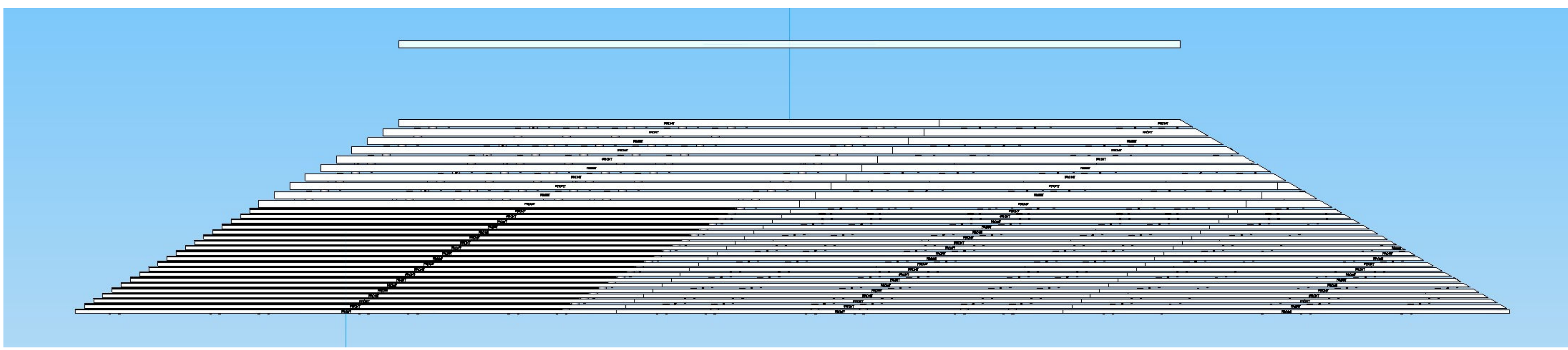
Plan to make a full scale prototype, full width, full thcikness, short zee lenght

Stainless steel in place of Tungsten

We have been delivered with 30 plates SS304L, 36”x48”

Perfect Test bed for

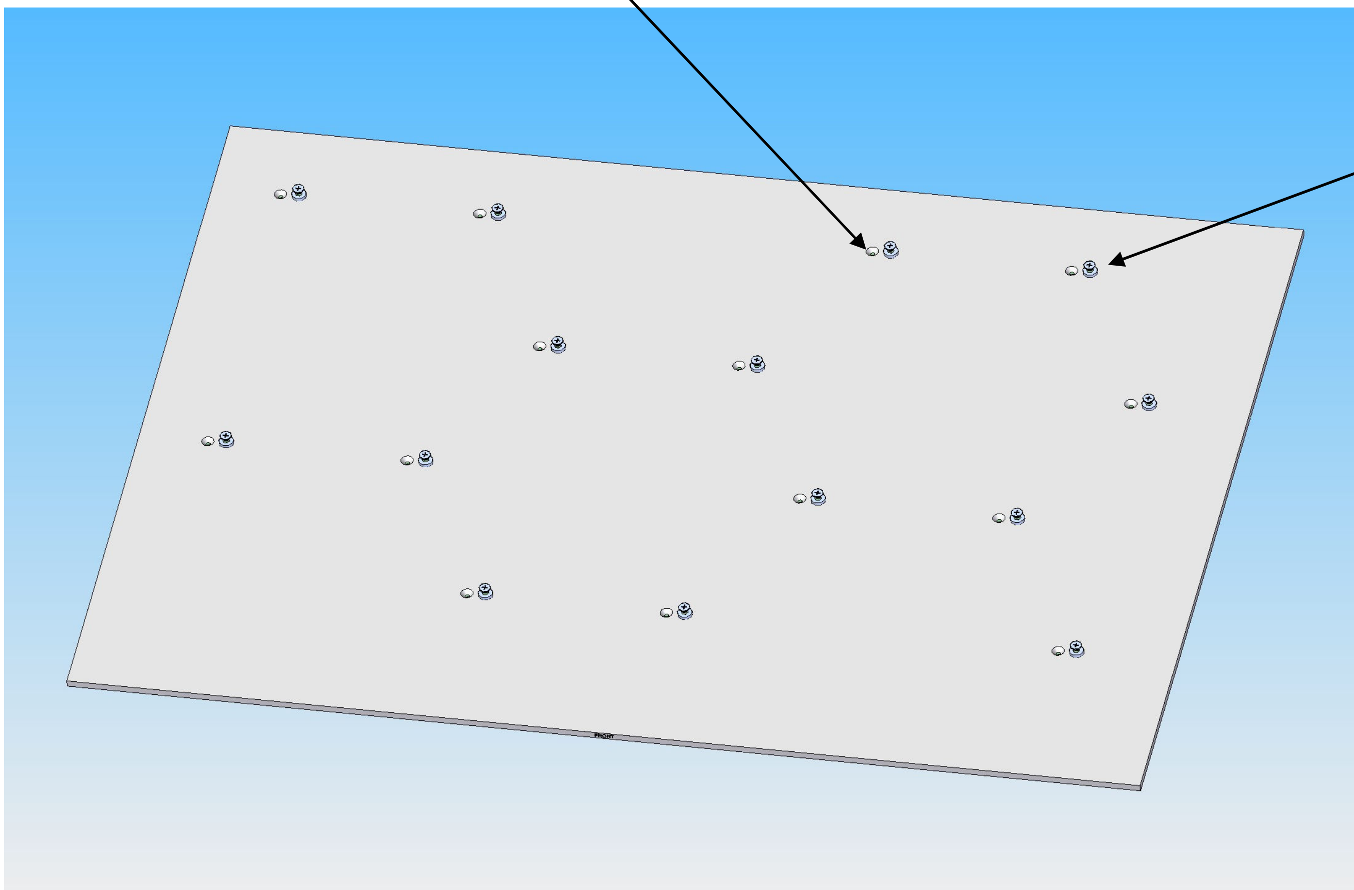
- the small screws design
- The integration of the electrical interconnections
- the cooling cold plates

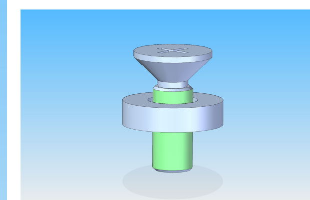


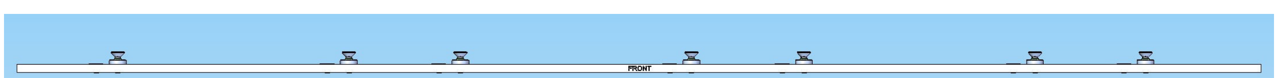
ECAL Mechanical prototype

M2 tapped hole

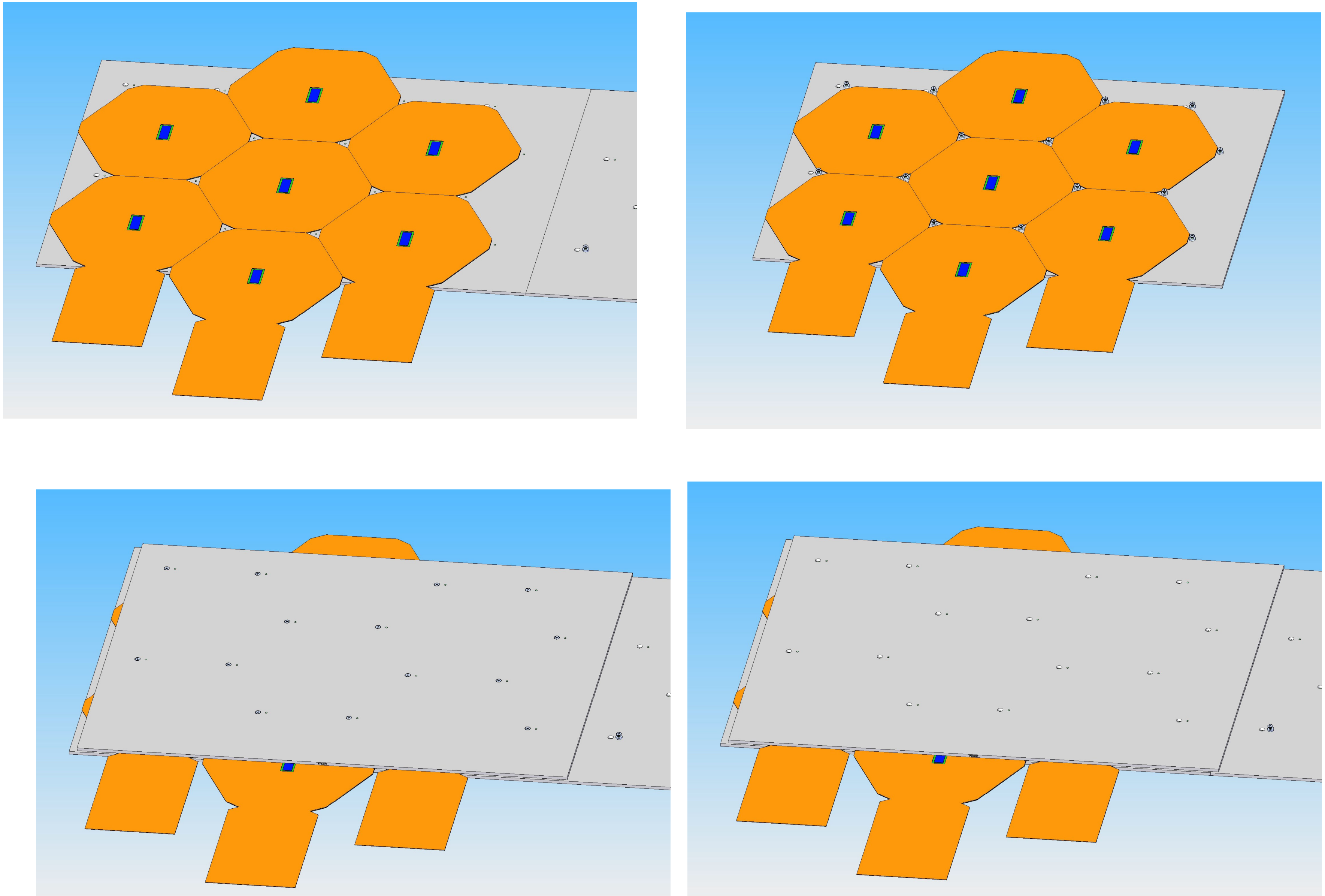
M2x6 screw + spacer







ECAL Mechanical prototype



Tungsten

We had several meeting with Tungsten vendors over the last 12 months

- Plansee (we visited their production facility in France (ex Cime-Bocuze)
- H.C. Starck
- Mi-Tech Metals
- ATI-Allegheny

All Extremely interested in the project

We've got a lot of feedback on technical issues

They have different skills and size, useful along the development of the project

Not all of them would be able to process the full amount of Tungsten required for SiD (~80 tons)

Many of them already involved in the field of accelerator industry (DESY, XFEL) with Ni-Ti alloys and other refractory materials (W, Mo, Ta, etc)

Possibility to invest in infrastructures (large ovens) in case of a large contract

They are looking for projects to challenge their R&D centers

Rolled plates size availability

PLANSEE

Material	Thickness (mm)	Width (mm)	Length (mm)	Flatness (mm)
W 99%	2.5 ± 0.3	600 ± 3	950 +5,0	Surface as rolled, < 1.5
W 99%	2.5 ± 0.025	590 ± 0.5	700 ± 0.5	Ground surface
W 99%	5 ± 0.3	500 ± 0.5	550 +5,0	Surface as rolled, < 1.5
W 99%	5 ± 0.025	490 ± 0.5	515 ± 0.5	Ground surface
W 99%	2.5 ÷ 5	680 ÷ 750	1300	In Development
IT180*	2.5 ± 0.2	170 ± 0.5	500 ± 0.5	
IT180*	5 ± 0.2	170 ± 0.5	500 ± 0.5	

*IT180 is a Tungsten alloy, W 95%, Ni, Fe; density 18 g/cm3

H.C. STARK

Material	Thickness (mm)	Width (mm)	Length (mm)	Flatness (mm)
W 99%	2.5	250	300	
W 99%	5	150	200	
W 99%	7	150	200	

ATI Firth Sterling

Material	Thickness (in)	Width (in)	Length (in)	Flatness (mm)
Dens23*	0.098 ± 0.002	12 ± 0.005	24 ± 0.005	
Dens23*	0.196 ± 0.002	12 ± 0.005	24 ± 0.005	

*Dens23 is a Tungsten alloy, W 92.5%, Ni, Fe; density 18 g/cm3

Powder Metallurgy Cycle fully in house :

Equipped with an R&D department, for new process and products with customers

- High Control of the microstructure property W-Fe-Ni or W-Cu
- Spark Plasma Sintering, new technology 12 minutes instead of 8 hours
- Goal of 98% W for amagnetic W-Cu
- 3-4 months for the calibration of the new alloy process parameters

Production focused on two alloys with a predefined W range

- W-Cu (Inermet© and Sparkal©) amagnetic with W% range: 90% and 92%
- W-Fe-Ni (Densimet©) paramagnetic with W% range: 90%-98.5%

Rolled Plated 2.5mm - 5mm thickness ± 25 microns

- Max size 250-300mm width x 600mm length

Size may be increased if larger oven are available (no technical but financial constraints)

Final Thickness achieved by calibration after sintering

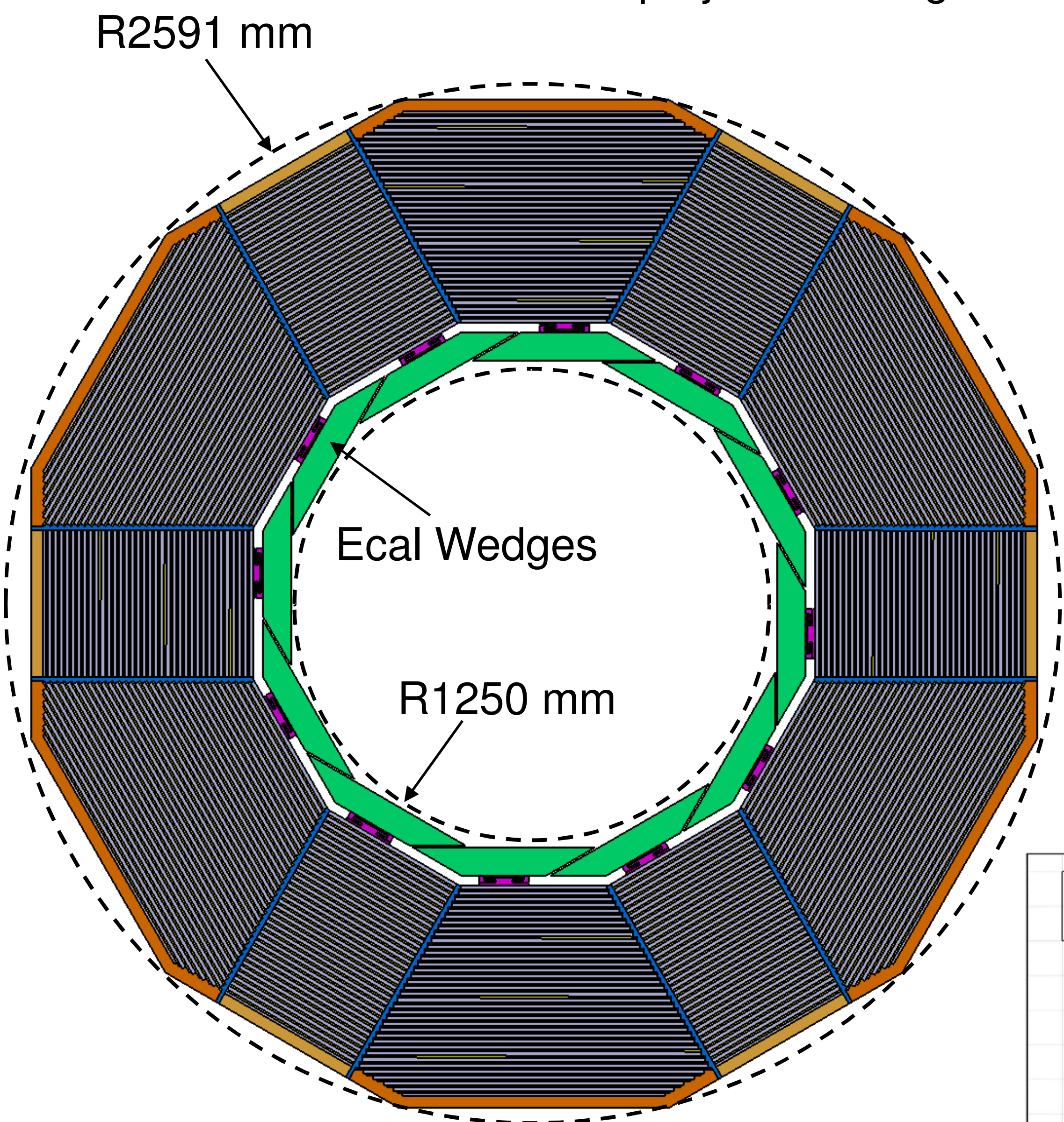
Joining techniques :

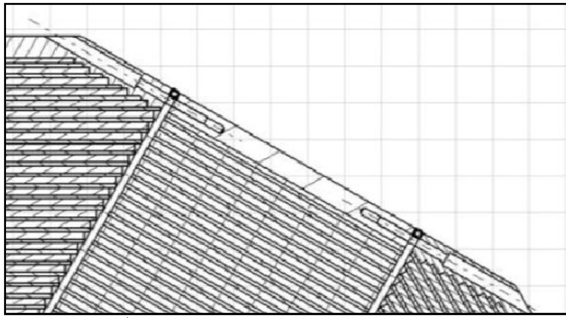
- Braze, needs a different joining material and large autoclave (large autoclave available from industrial partner) – The same applies for Electrobeam welding
- TIG welding, risk of microstructure pollution

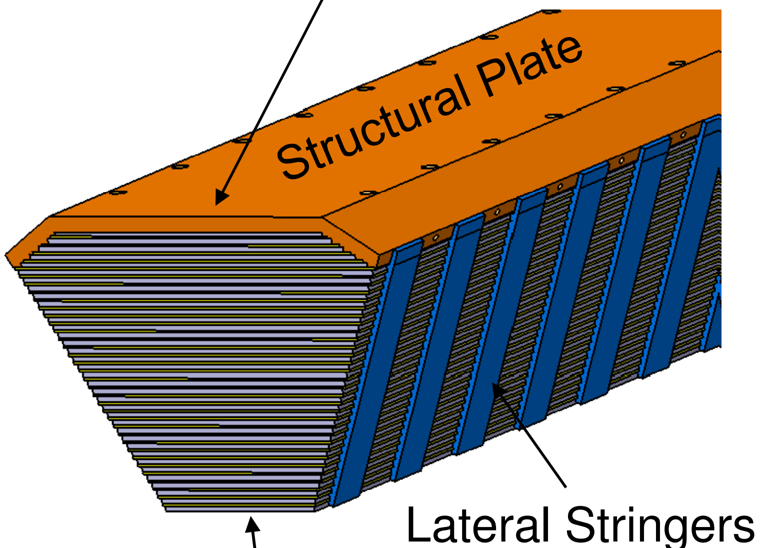
HCAL

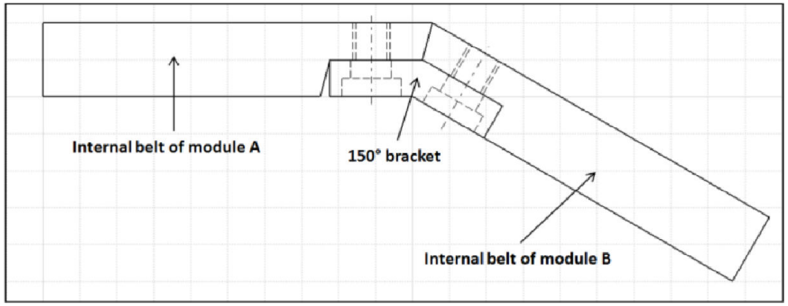
Hcal geometry

6 + 6 non projective wedge units

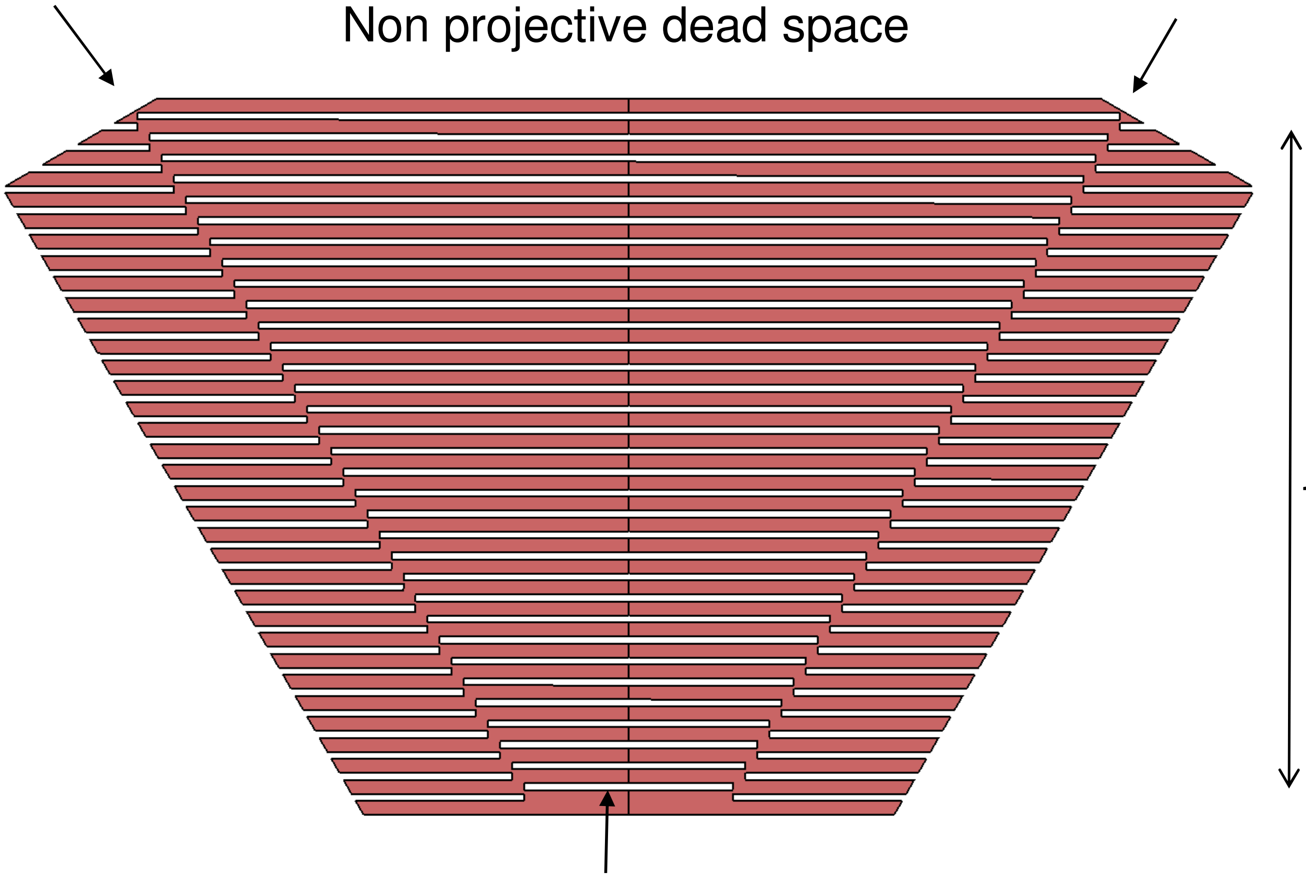








Non projective dead space



40 plate SSteel

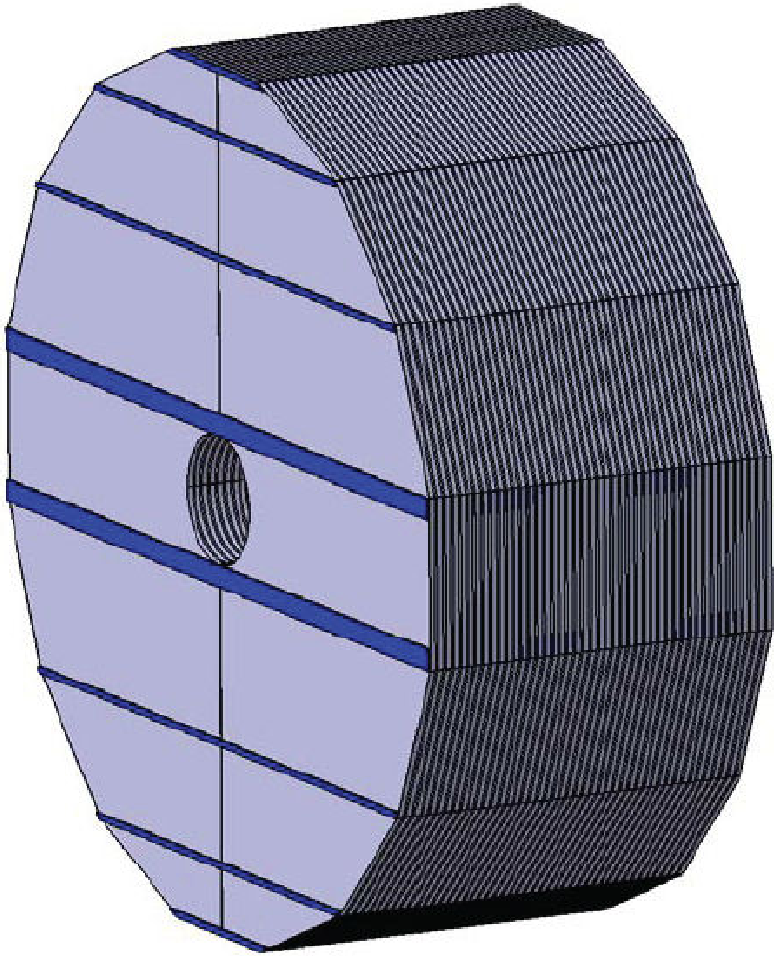
19 mm thickness

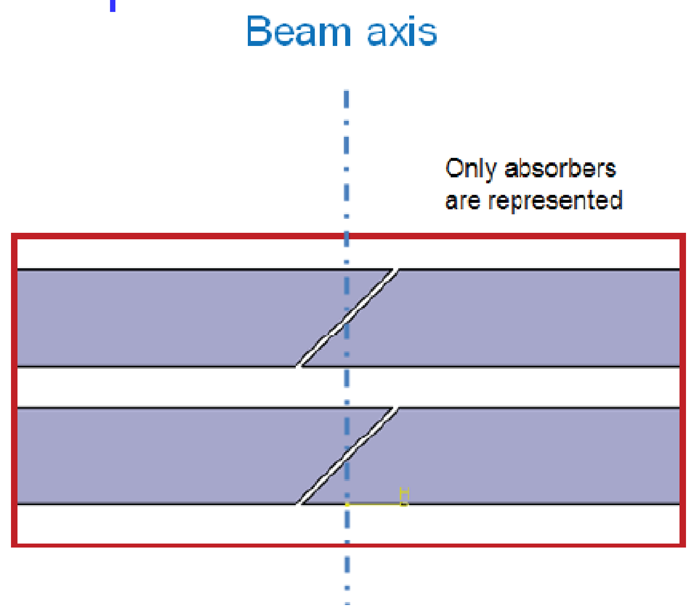
4.5 λ

1080 mm

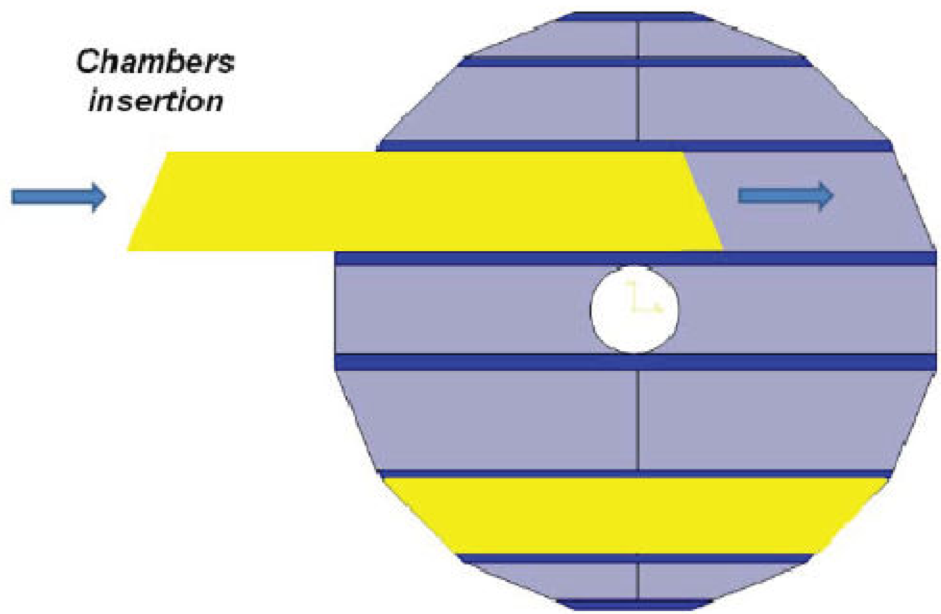
8 mm nominal gap for detector

HCAL Endcap





Beam axis
Only absorbers
are represented

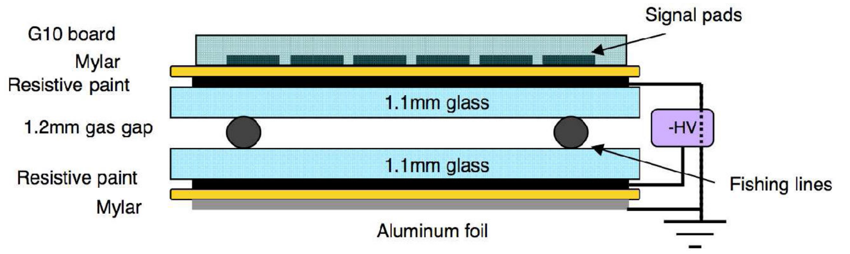


Chambers
insertion

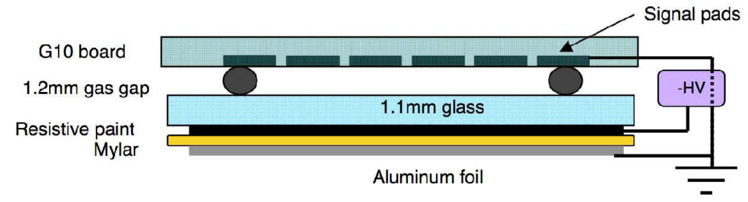
Detectors

Resistive Plate Chambers are the baseline HCAL technology in the LoI

Minimal thickness ~ 3.3 mm



Minimal thickness ~ 2.4 mm



HCAL Mechanical design has been carried out with 8 mm gap between absorber

Available for the detector ~5÷6 mm total thickness

Need to understand the integration requirement of the chambers (Gas, Cooling, Power)

Other technoly option : GEM, Micromegas, Scintillator