MECHANICAL MODEL OF THE IR BEAM PIPE

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Many thanks for discussions and input to:
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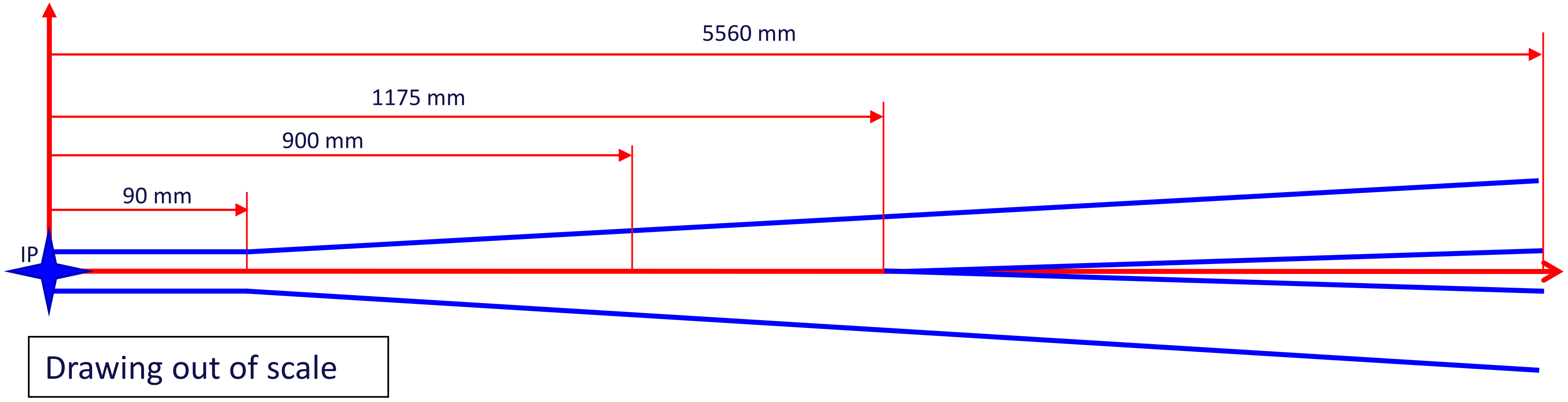
Outline

The presentation concerns:

- Definition of the parameters for the design of the beam pipe.
- Definition of the loads that we are using to do the FE analysis.
- Highlight over the position of the LumiCal.

Definition of the parameters for the design of the beam pipe

- Thickness of AlBeMet162= 0.35 mm
- Thickness of Copper= parametric design from 1 to 5 mm



90 mm from IP	End of the central part
900 mm from IP	End of AlBeMet and start of copper
1175 mm from IP	Division of the beam pipe
2500 mm from IP	Start of two circular pipes
5560 mm from IP	End of the model studied for now

Characteristic of AlBeMet162

DESCRIPTION

AlBeMet® is a family of **metal matrix composites** made up principally of beryllium and aluminum. The ratio of the two metals can be varied to alter the physical, thermal and mechanical properties.

AlBeMet162 contains **62 wt% commercially pure beryllium** and **38 wt% commercially pure aluminum**; it combines the **high modulus** and **low-density** characteristics of beryllium with the **fabrication and mechanical property** behavior of aluminum. These metal matrix composites are **weldable**, and can be **formed, machined**, and **brazed** like conventional aluminum metal matrix composites.

USED IN:

- IR of **DAFNE / KLOE** at LNF-INFN
- **LHCb** experiment at CERN

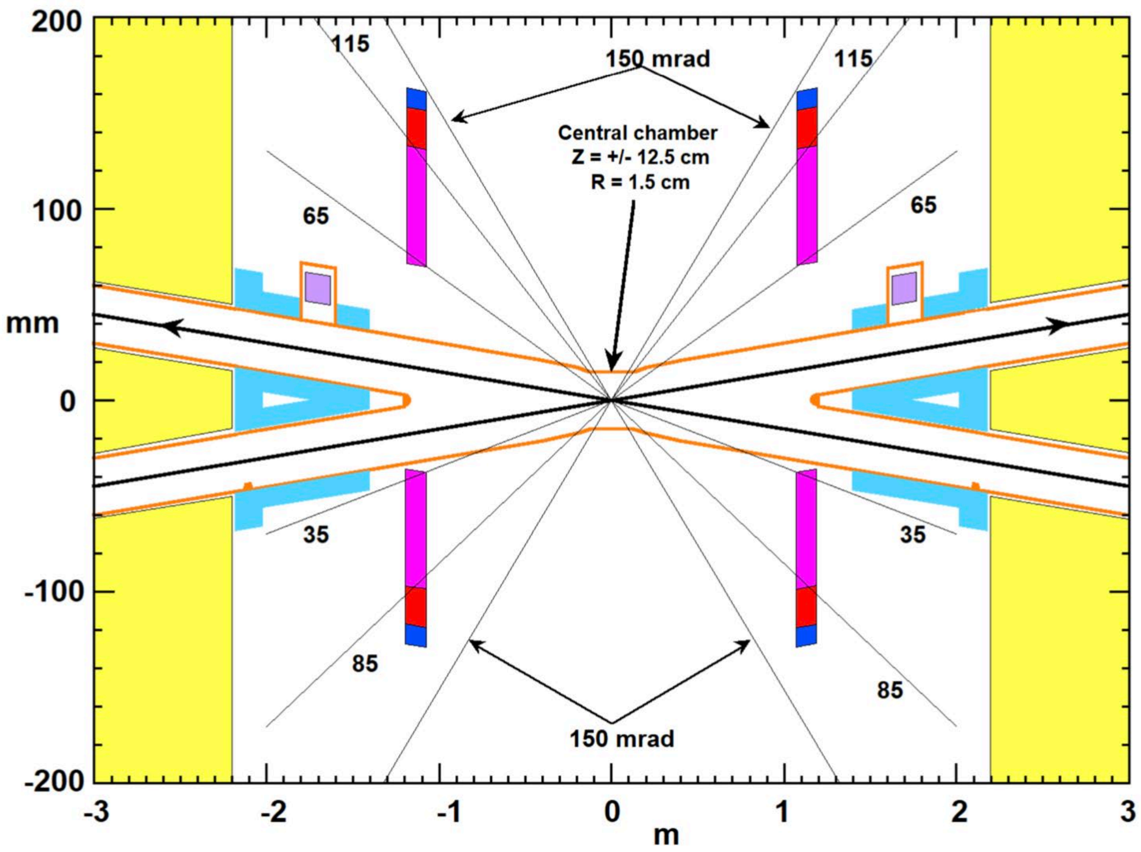
Density g/cm3 (Lbs/in3)	2.10 (0.076)
Modulus GPa (Msi)	193 (28)
Poisson's Ratio	0.17
Thermal Conductivity @ W/mºK (BTU/hr Ftº F)	210 (121)
Electrical Conductivity @ 20˚C, % IACS	49
Damping Capacity 25˚C, 500 HZ	1.5x10-3
Yield Strength MPa (Ksi)	276 (40)
Ultimate Strength MPa (Ksi)	386 (56)
Coefficient of Thermal Expansion at 25ºC ppm/˚C (ppm/ºF)	13.91 (7.73)

- It is necessary to be clear about the transition along the beam pipe in terms of material and geometry.
- The changes of material and geometry influence strongly every structural analysis.

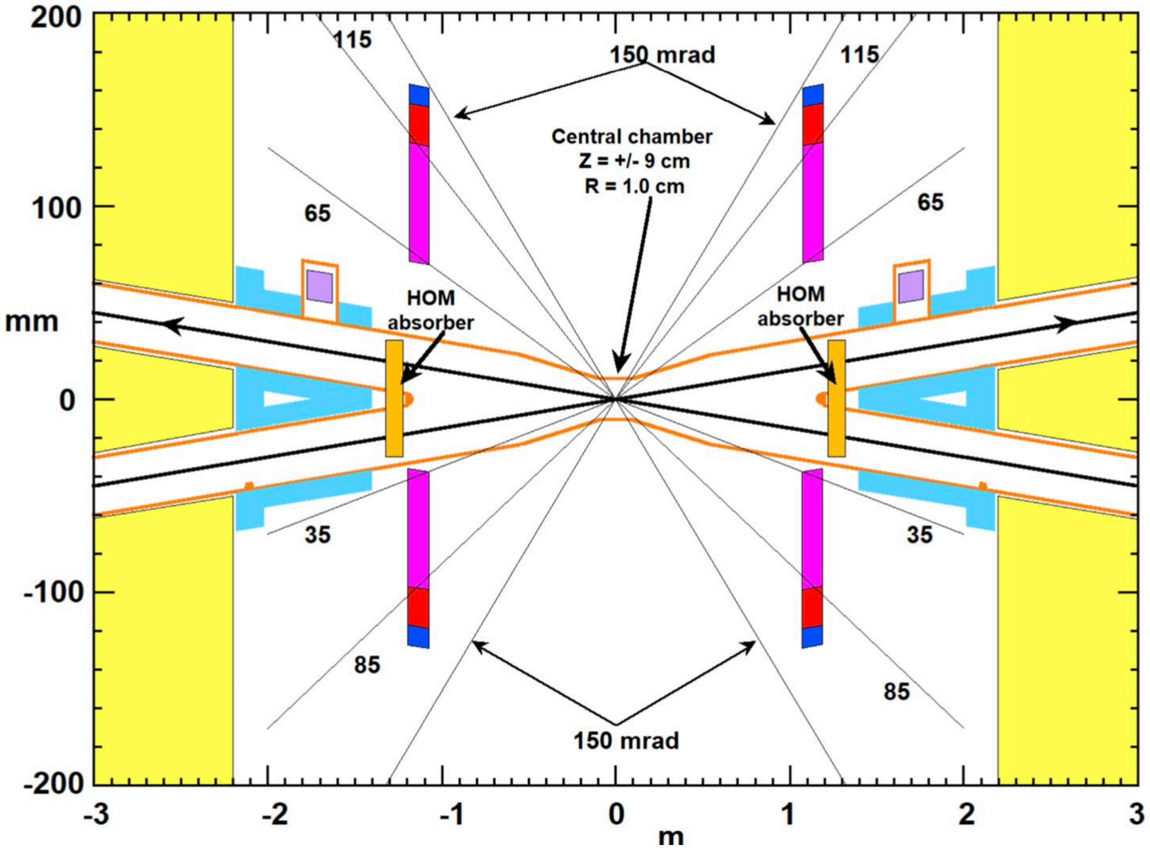
From (mm from IP)	To (mm from IP)	Internal dimension [mm]	Thickness	Material
0	90	circular chamber of 20	0.35 mm AlBeMet162 + 1 mm coolant + 0.35 mm AlBeMet162	AlBeMet162 (Be from CDR)
90	900 (2.5.1 CDR page 52)	Transition from a circular chamber of 20 to an ellipse 47.83x24.39	Studying range from 2 mm to 5 mm (AlBeMet162) + coolant (thickness in study) + studying range from 1 mm to 5 mm (AlBeMet162)	AlBeMet162 (Be from CDR)
900	1175	Transition from an ellipse of 47.83x24.39 to an ellipse of 57.28x25.88	Studying range from 1 mm to 5 mm (Cu) + coolant (thickness in study) + studying range from 1 mm to 5 mm (Cu)	Cu
1175	2500	Transition from an ellipse of 57.28x25.88 to two circular chamber of 30	Studying range from 1 mm to 5 mm (Cu)	Cu
2500	5560	two circular chamber of 30	Studying range from 1 mm to 5 mm (Cu)	Cu

Diameter and length of the central beam pipe

	CDR	**New values**
Internal diameter of the central pipe	30 mm	**20 mm**
Length of the central pipe	125 mm	**90 mm**



CDR



M. Sullivan. slide 7 FCC WEEK 2020

Progress with FEA since FCC week 2021

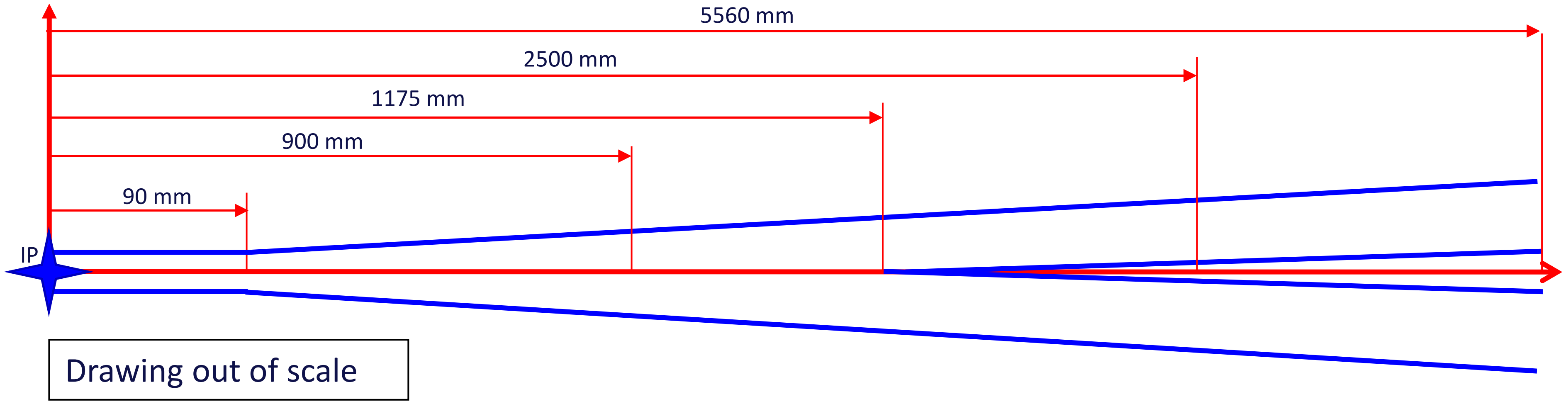
This table shows the progress made and the new characteristics of the beam pipe, now included in the FEA.

	FCC week 2021	Now
Geometry	One body with one thickness	**Different body** with **different thickness**
Pressure	Atmosferic pressure	Atmosferic pressure
Standard earth gravity	✗	✓
Heat load	✗	✓
Constraint	One type	Four different situations
Cooling	✗	✓

Heat load

- 0 to 90 mm from IR → 150 W/m (Alexander Novokhatski)
- 90 mm to 5560 From IR → 97 W/m (Alexander Novokhatski)

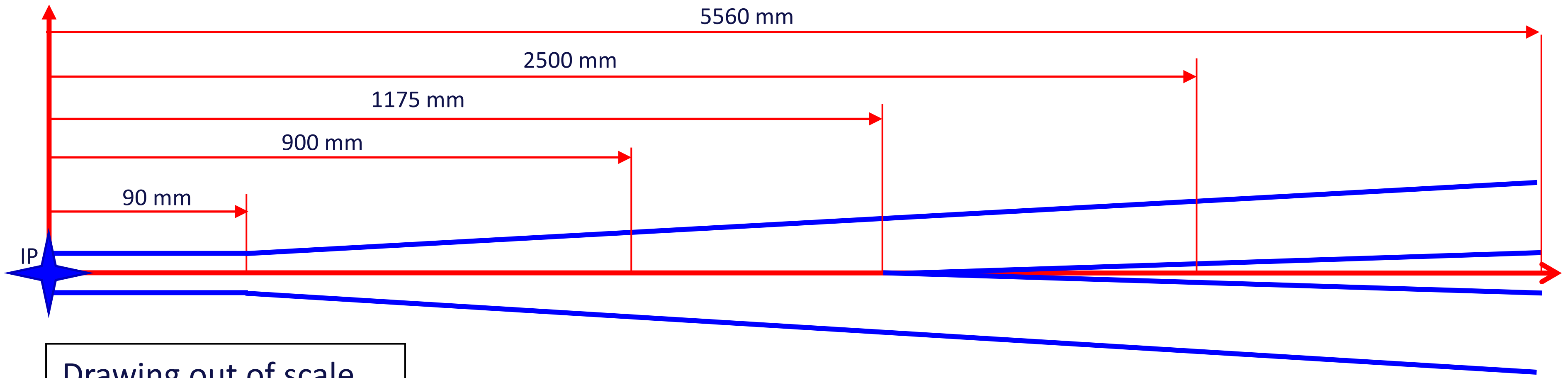
These heat loads are from resistive wake calculation so it is necessary to understand which other heat loads we have to consider.



Cooling

- 0 to 90 mm from IR → Cooling with paraffin
- 90 to 1230 mm from IR → Cooling with water/paraffin
- 1230 to 5560 mm from IR→ not cooled (?)

Fluid	h [W/m²K]
Paraffin	900
Water	500
Air	2



Drawing out of scale

LOAD: atmospheric pressure over the vacuum chamber, gravity, thermal load.

CONSTRAINT: different configurations of constraint are being taken into account.

Constraint case	Constraint A	Constraint B	Constraint C
1	Fixed	dispY=0	dispY=0
2	Fixed	Fixed	Fixed
3	Fixed		
4	Fixed		dispY=0

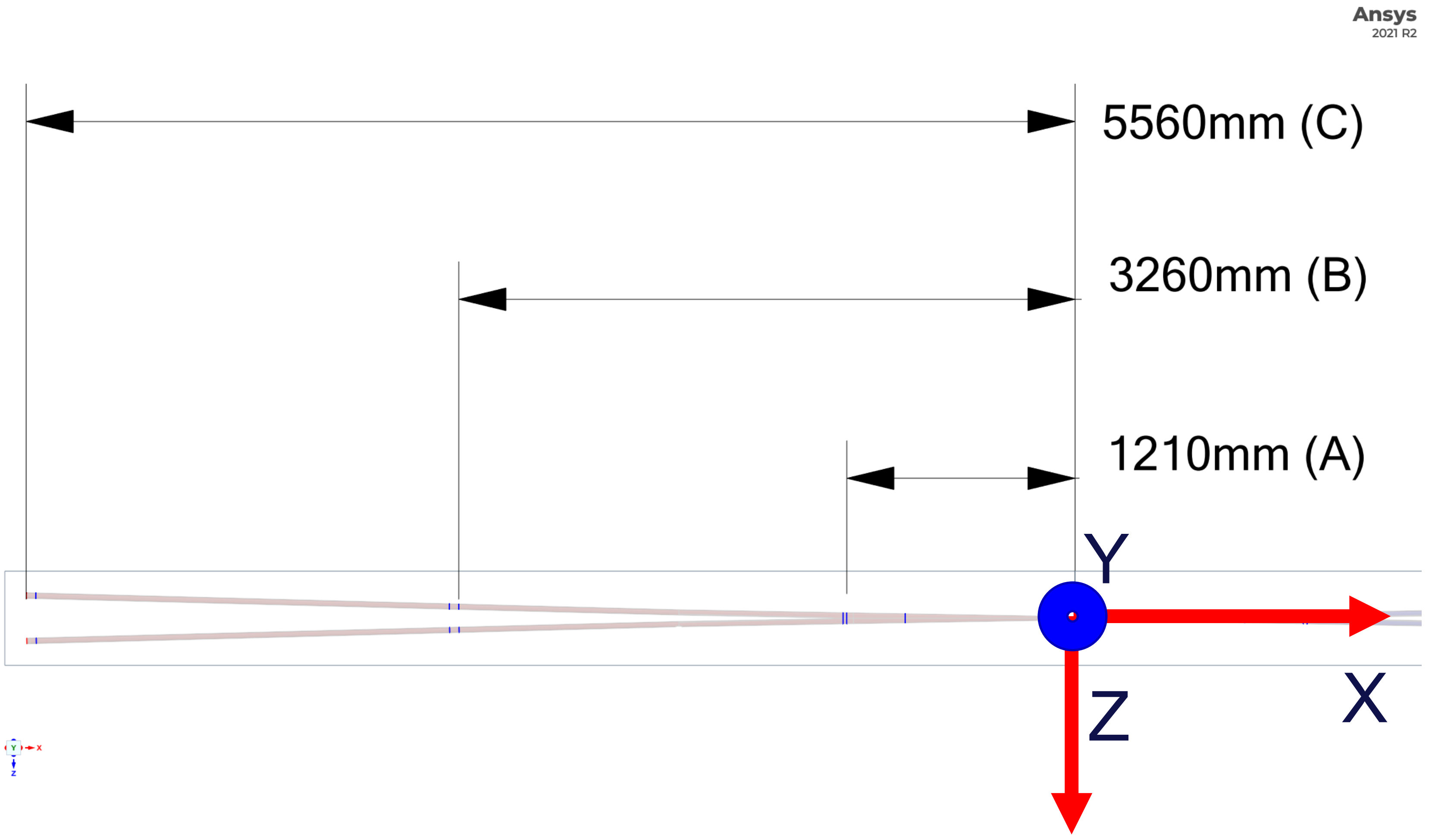


Table with the results of different analysis with different thickness and constraint configuration

Constraint case	Central part thickness [mm]	Other tickness [mm]	Maximum stress (Von Mises) [Pa]		Maximum strain (Von Mises)	Displacement X [m]	Displacement Y [m]	Displacement Z [m]	First linear buckling multiplyer
			central part	lateral part					
1	0,35	1	6,34E+06	6,55E+07	0,00067	3,01E-05	0,0004	8,97E-05	28
2	0,35	1	6,34E+06	6,55E+07	0,00067	2,25E-05	0,00037	8,97E-05	28
3	0,35	1	5,51E+06	1,60E+08	0,0013	0,022	0,32	0,015	5
4	0,35	1	5,51E+06	4,18E+08	0,0035	0,02	0,0058	0,015	5
1	0,35	2	9,08E+06	1,78E+07	0,00019	1,72E-05	0,00043	1,26E-05	29
2	0,35	2	9,08E+06	1,78E+07	0,00019	8,08E-06	0,0004	1,26E-05	29
3	0,35	2	4,39E+06	1,59E+08	0,0013	0,021	0,3	0,0066	9
4	0,35	2	4,39E+06	6,93E+08	0,0065	0,019	0,0058	0,0067	8
1	0,35	3	1,12E+07	1,05E+07	8,79E-05	1,29E-05	0,00036	6,31E-06	29
2	0,35	3	1,12E+07	1,02E+07	8,80E-05	6,65E-06	0,00032	4,01E-06	29
3	0,35	3	6,48E+06	1,57E+08	0,0013	2,00E-02	0,27	3,80E-03	13
4	0,35	3	6,48E+06	5,18E+08	0,0043	1,90E-02	0,0052	3,90E-03	9
1	0,35	4	1,26E+07	8,49E+06	6,74E-05	1,10E-05	0,00034	4,30E-06	29
2	0,35	4	1,26E+07	8,21E+06	6,60E-05	6,43E-06	0,00031	1,79E-06	29
3	0,35	4	1,05E+07	1,54E+08	1,20E-03	1,90E-02	0,26	0,0025	16
4	0,35	4	1,05E+07	5,31E+08	0,0044	0,018	0,0049	0,0026	7
1	0,35	5	1,35E+07	7,33E+06	7,06E-05	9,74E-06	0,00032	3,16E-06	29
2	0,35	5	1,35E+07	7,10E+06	7,06E-05	6,80E-06	0,00029	9,78E-07	29
3	0,35	5	1,48E+07	1,49E+08	1,20E-03	1,90E-02	0,24	0,0017	19
4	0,35	5	1,48E+07	5,38E+08	0,0045	0,017	0,0046	0,0018	6

Consideration about FEA

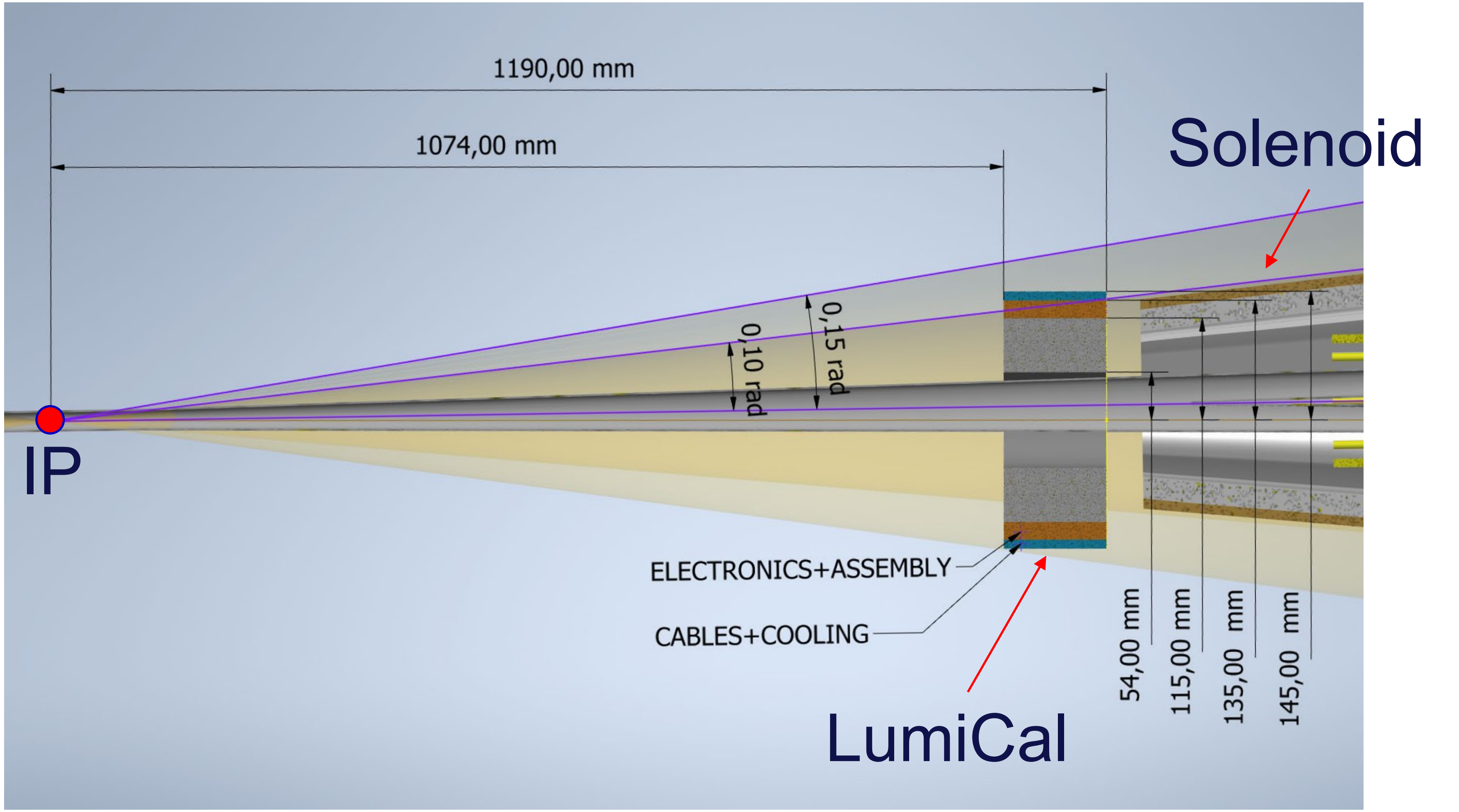
- These FEAs give an idea about the deformation and stress at different thickness.

- The constraint configuration is very important to extimate stress and strain, so it is necessary to know where the chamber could be constrained, according to the space constraint.

- The cooling is very important to mantaine the chamber temperature low and to avoid big thermal deformation.

Highlight over the position of the LumiCal

- In the figure are shown the two cones of reference of the LumiCal, 100mrad and 150 mrad.
- According to the dimension given by Mogens Dam, the Lumical, with its cabling, cooling and electronics, is contained in 150mrad cone but not in the 100mrad cone.



Future steps

- **Progress with structural analysis:** division of the chamber including the position for the supports according to possible position.
- Create a new model for Alexander Novokhatski, with separated parts corresponding to different materials, to do more accurate calculations of the heat load due to wake fields.
- Input the components' weight to design the **supports** and start the structural studies.
- Introduce mechanical details in the chamber design (flanges, bellows, AlBemet/copper joints).

THANK YOU FOR YOUR ATTENTION

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