Integration of inner detector region

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All components are assembled within one rigid structure, inserted in the TPC and suspended on both sides from the TPC endplates. The central tool for the integration of the inner region is the Inner Support Structure, which will be explained in detail in this section.

1.1 Composition of the inner region

A schematic view of the inner region is shown in Figure xxx. A brief reminder on the elements is given together with relevant technical details.

- **Beam pipe**: The design of the tube has been obtained to respond to the best luminosity. The weight of the Beam pipe is: 8 Kg**.**

- **VERTEX detector (VTX):** It is composed of 5 or 6 cylindrical layers. All these layers are equipped with 50 µm thin pixel sensors. The VTX will be clamped on the beam pipe and flushed by air. The weight of the Vertex detector : 300g supported by FTD3

- **Silicon Internal Tracker (SIT)**: The SIT is positioned between the vertex detector and the TPC. Its weight of about 5kg is supported by FTD3

- **FTD**: It is composed de 2 x 7 disks either on either side of the interaction point. The weight of the FTD is 500g / disks

- **Inner Support Structure (ISS):** It is a pipe made with 1mm of carbon fiber. The ISS is divided into two shells with access windows.

- **Cables and services**: The cables and services such as cooling will be mounted on to the beam pipe and on the ISS.

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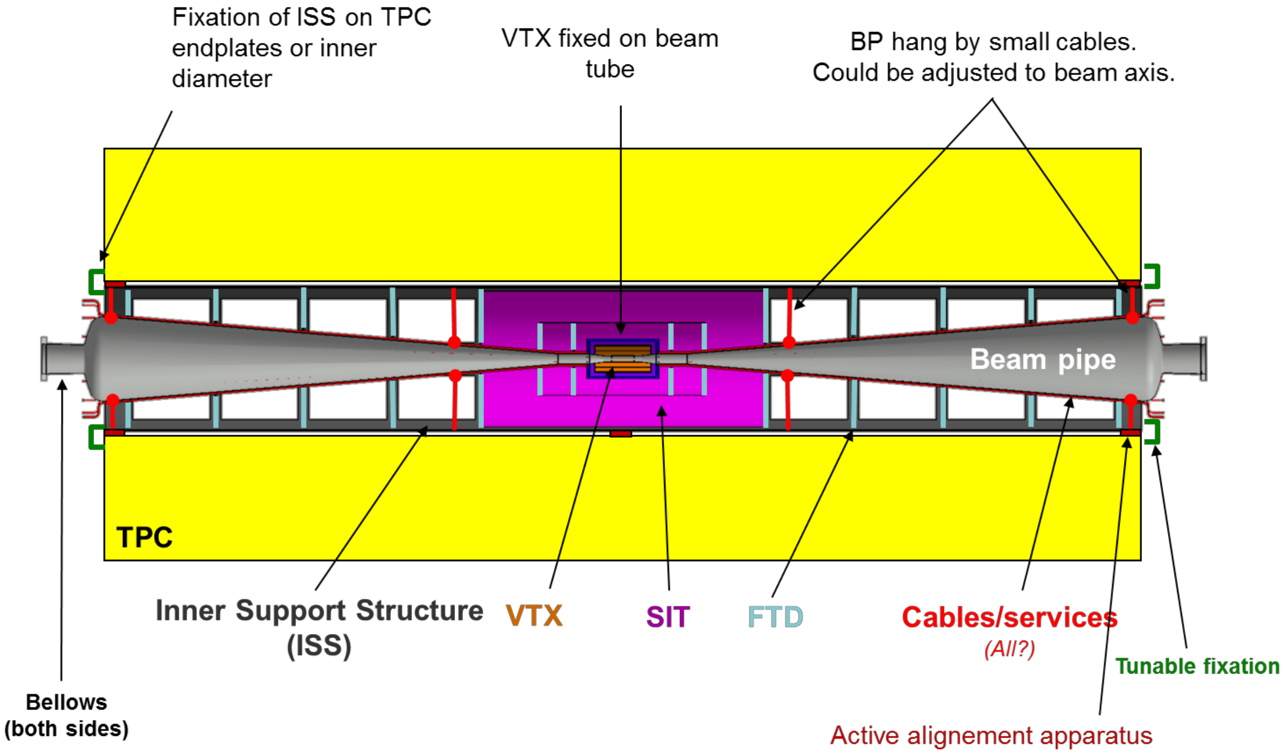
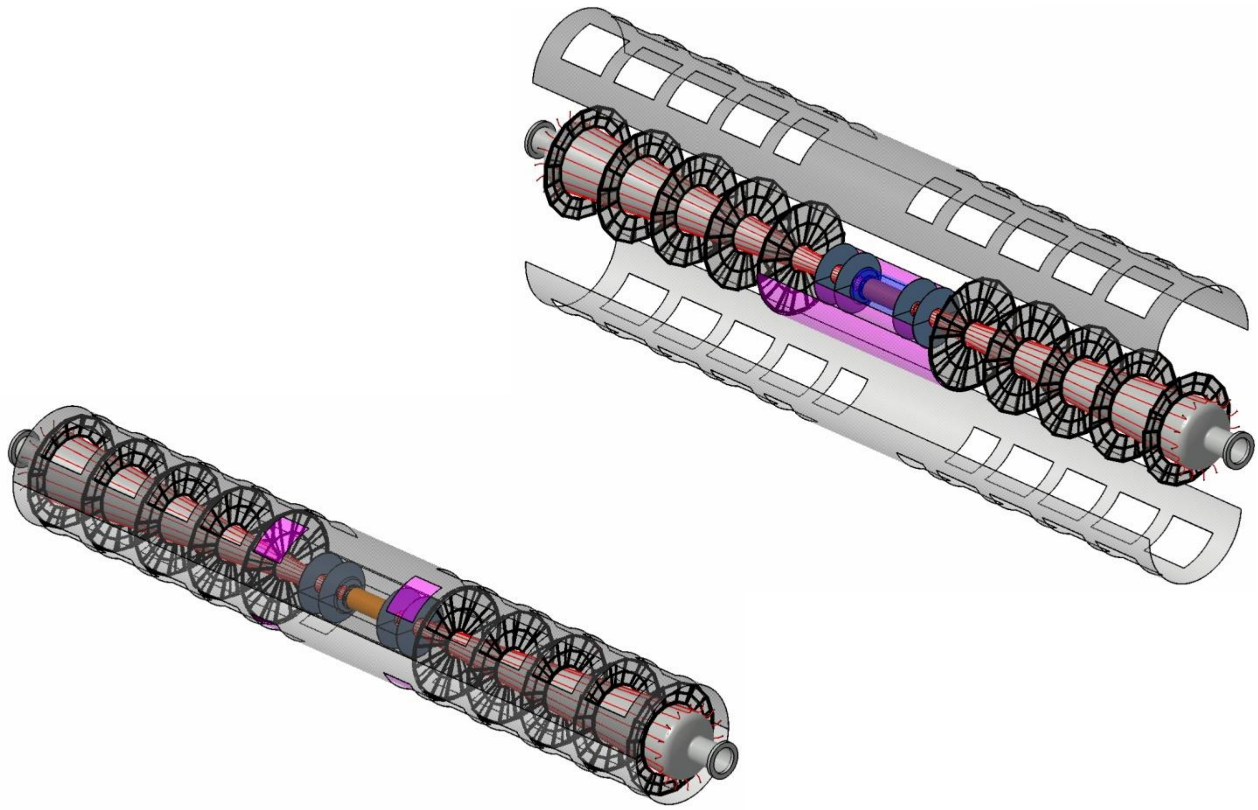
Detail of the Inner detector region



3D model of the Inner detector region



1.2 Assembly and integration of the inner part

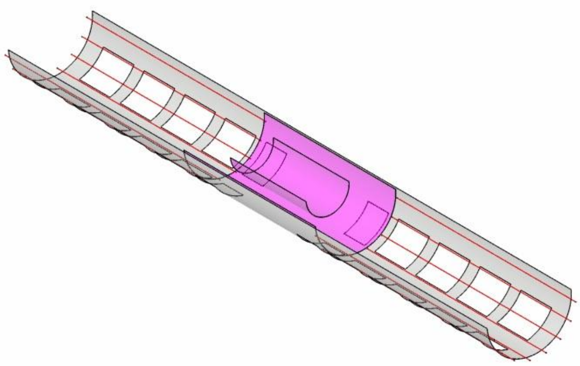
1.2.1 Assembly procedure

The various components will be assembled and aligned on an assembly tooling. This tool includes the same fixing points and support as the TPC.

In the following the steps of the assembly procedure are presented.

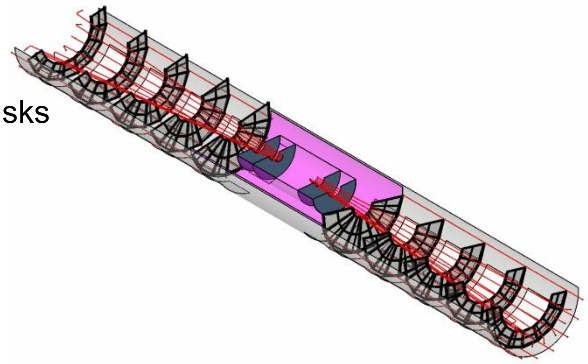
1st step:

- Mounting the half SID
- Cabling



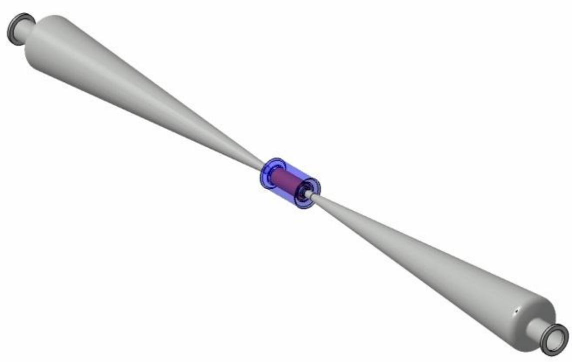
2nd step:

- Mounting the lower halfs of the FTD disks
- Cabling



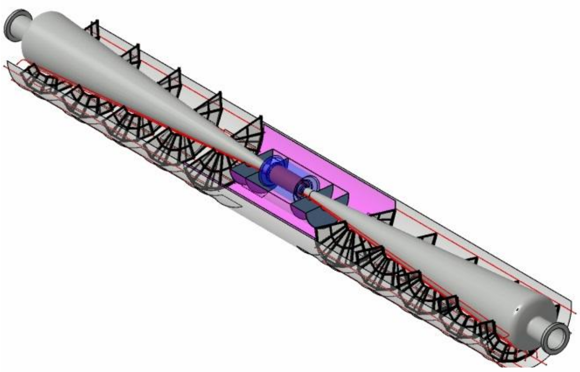
3rd step:

- Clamping the VERTEX on the beam pipe



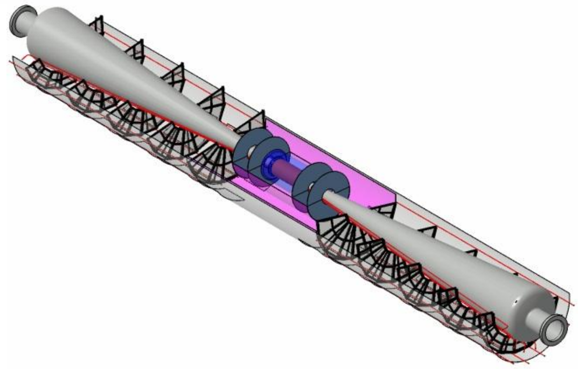
4th step:

- Integration of the beam pipe equipped with the Vertex detector
- Cabling



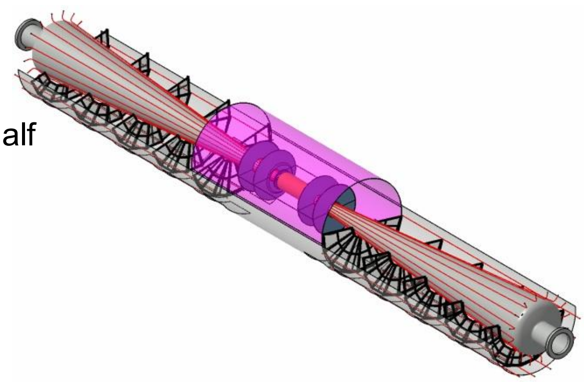
5th step:

- Mounting the half upper FTD 1 & 2
- Cabling



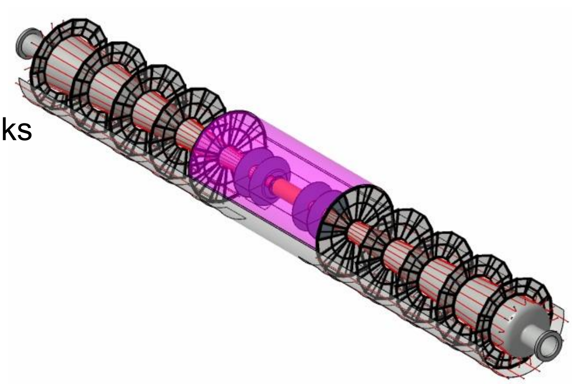
6th step:

- Mounting the parts of the upper SIT half
- Cabling



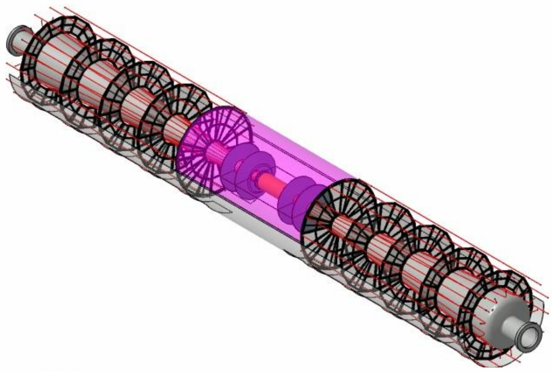
7th step:

- Mounting the uppe half of the FTD disks
- Cabling



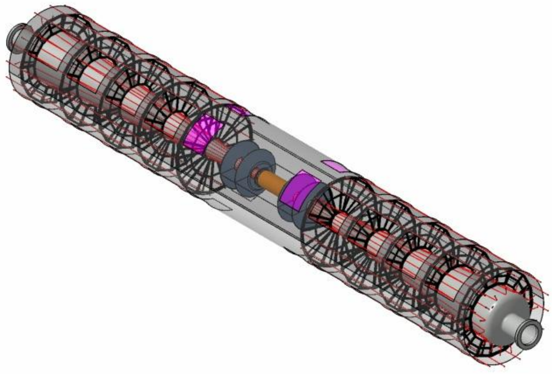
8th step:

- Finalizing the cabling



9th step:

- Mounting of the upper support structure
- Metrology and alignment
- Tests.



1.3 Integration of the Inner part into the TPC

The integration uses the same TPC insertion tool. For this purpose the tool is equipped with devices for the support and the insertion of the inner parts. It is guided by the TPC center and roll inside. During the insertion, the deformation, stress and alignment will be monitored. It will be fixed on TPC. The preliminary adjustment will be done with the TPC references. During the data taking, it will be measured and located with an active alignment device, which is fixed on the flange of the ISS. There is the option to add on the center, the same active device to limit the deformation of the inner part.

1.3.1 Main Integration step

- Aligned of the insertion tool between TPC with respect to the inner diameter of the TPC,
- Inserting the inner part,
- Geometrical survey,
- Aligned inner part in TPC,
- Fixed on TPC the inner part,
- Calibrated and tested the active alignment apparatus,
- Close the Endcaps,
- Switch on the magnetic coil
- Measure the inner detector position and correct the position.

1.3.2 Fixing and roller design

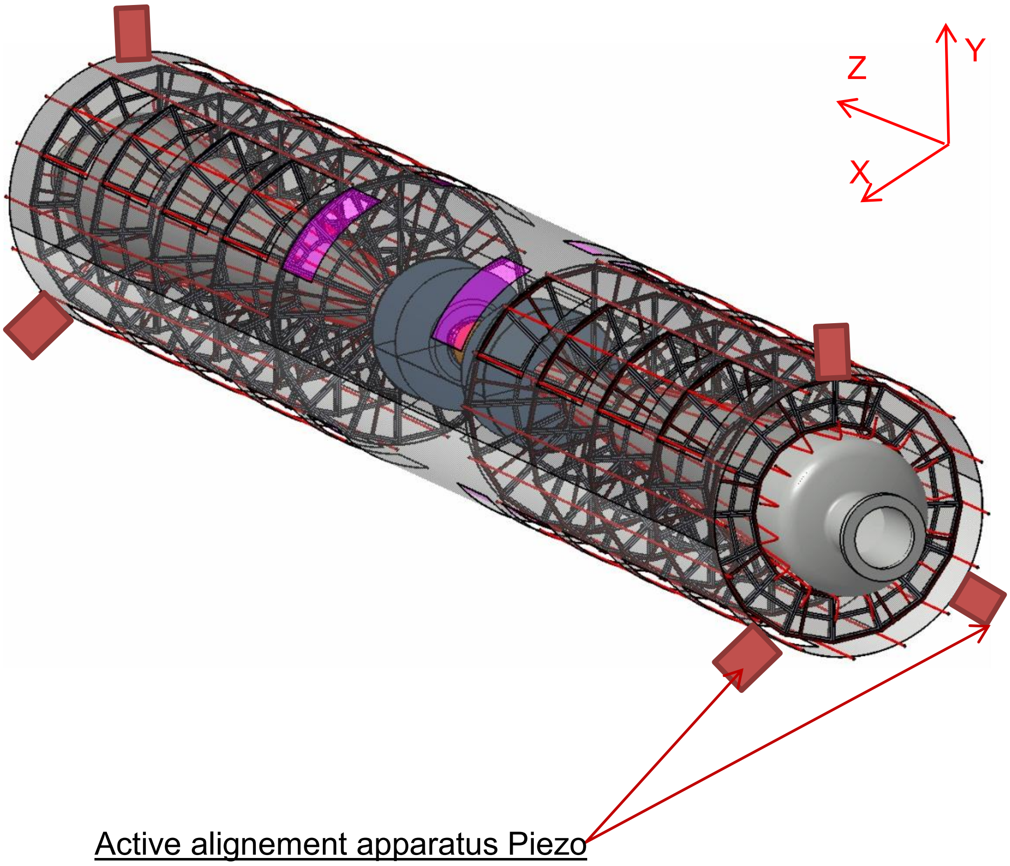
The ISS, which is made of carbon fiber, is equipped with flanges such that is can be fixed on inner diameter of the TPC. The Inner Support Structure (ISS) features a specific tool with rollers during the integration procedure. These rollers are guided by the inner TPC diameter and removed at the end.

The preliminary adjustment is expected to be better than 1mm. The positioning will be made with a geometrical survey (photogrammetry). The translation in Z direction will be limited by a stopper.

1.3.3 Active alignment device:

During the data taking the inner part will be adjusted continuously. According to a first study a precision of better than 0.01 mm can be obtained with a piezo technology.

This apparatus is composed by 2 x 3 (or 3 x 3) lower points for the alignment in X and Y direction. And 2 x 1 points upper points to limit the translation in z- in X and Y direction. And 2 x 1 points upper points to limit the translation in z-direction. The latter constitutes a protection against serious shocks as e.g. provoked by an earthquake.



1.4 Inner Support Structure (ISS)

1.4.1 Dimensions of the tube:

Outer Diameter = 650 mm
Length = 4700 mm

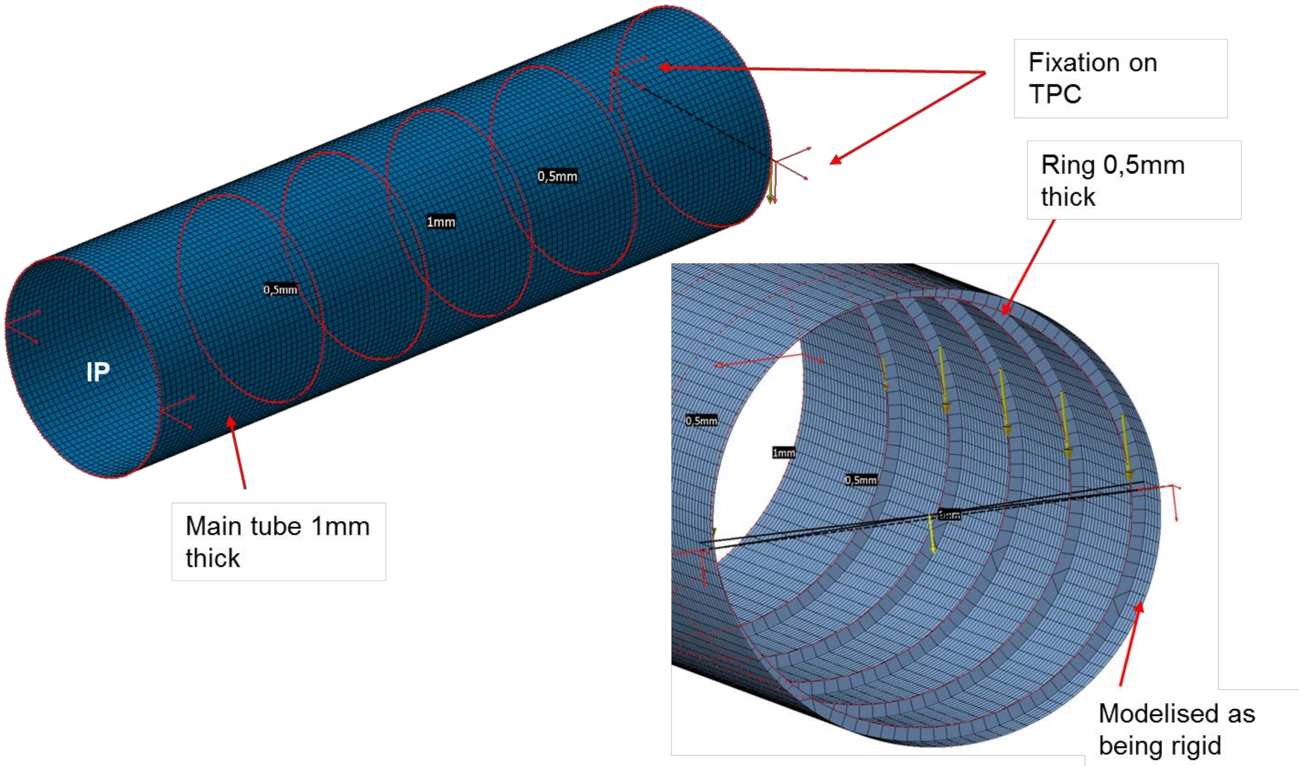
Reminder TPC Inner Diameter = 660 mm.

1.4.2 Material: Carbon fiber / epoxy composite:

Young modulus = 50 GPa
Density = 1750 Kg/m^3
Radiation length X_0 = 25 cm

Tube design with reinforcement rings. Possibility to attach all elements.

Half tube:



- Preliminary estimation :
  (Calculations was done without windows and split design)
  - Max displacement ≈ 0,1mm
  - First resonant frequency at 90Hz
  - Thickness of tube could be 1mm

However, we can correct the deformation in case of an active apparatus in the center.

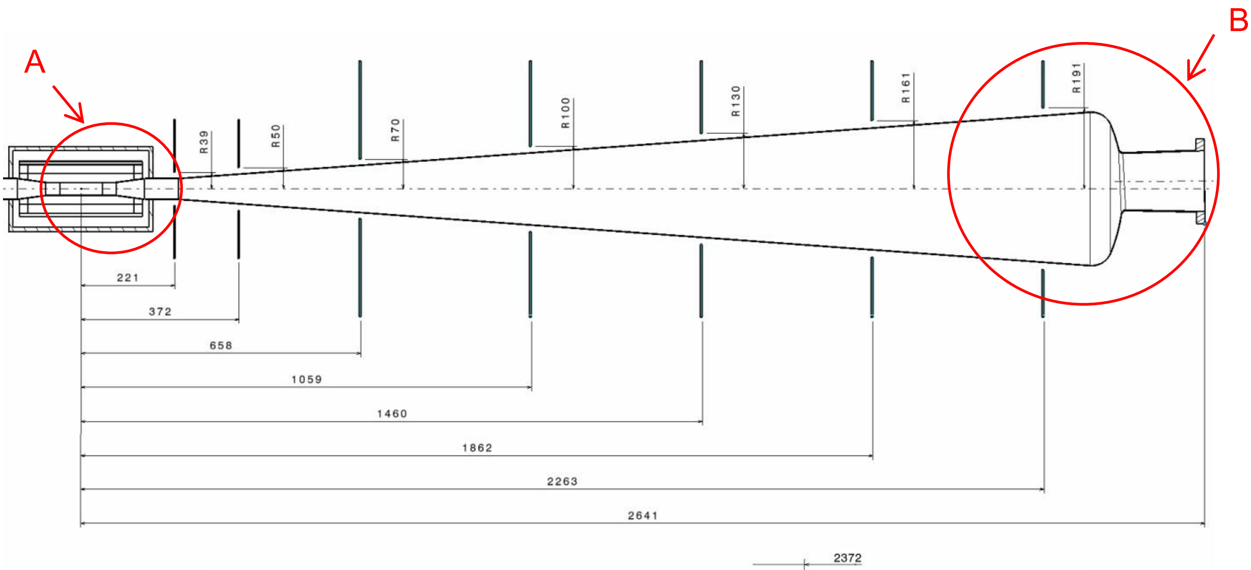
1.5 BEAM pipe :

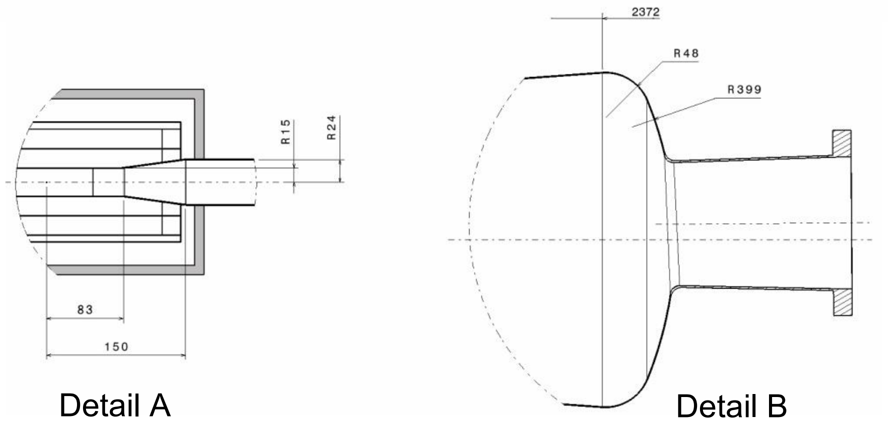
1.5.1 The design

In the picture below, the beam pipe is represented in its environment with the forward structures and the tracking disks.

The lower part of the figure shows a zoom into the endpoints labeled A+B

Material: Beryllium**,** weight: **8 kg (Be density: 1850 Kg/m^3)**





Detail A Detail B

The global shape is the following:

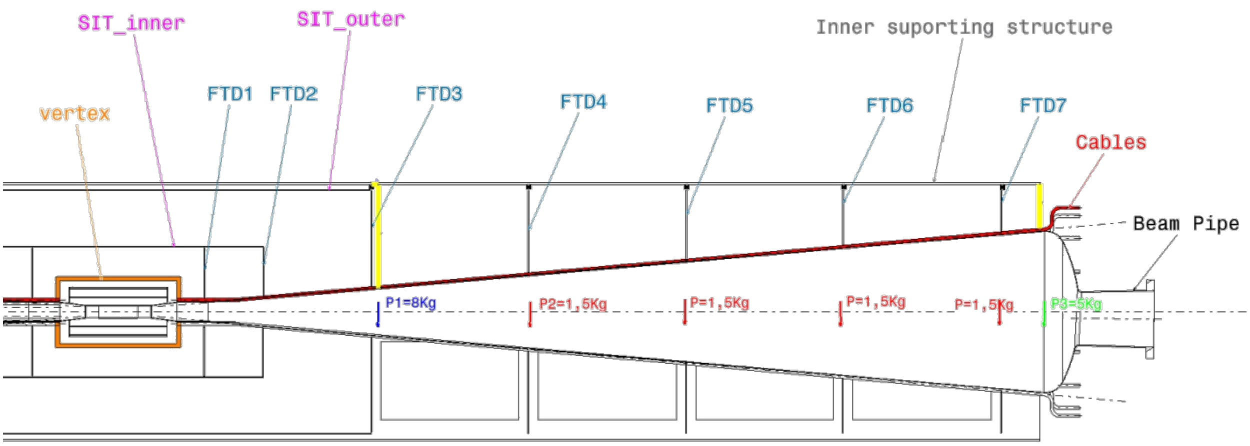
- a cylindrical part with a small radius,
- a first cone opening the tube to avoid the pair background,
- a second cylinder to join to the large cone,
- the large cone pointing slightly beyond the interaction point,
- a cupola closing the tube in front of the luminosity monitor,
- a conical tube passing through the monitor centered on the outgoing beam,
- a flange to connect to the rest of the beam tube.

Dimensions:

In the following the inner dimensions are given; the outer dimensions can be derived according from the thickness at the different places.

	Radius (mm)	Length (mm)
Central cylinder	15	83
First cone	24	67
Second cylinder	24	80
Large cone	180	2142
Spherical cupola center	2050	399
Fillet	48	

The cone under the Lumical is centered on the outgoing beam, it starts at 2450 mm and has for radius 76 mm.



1.5.2 Result of the Preliminary calculation:

Central region: the inner cylinder has a radius of 15mm with a Be thickness of 0.5 mm. Both, the first cone and second cylinder have a thickness of 1 mm. The delicate part is the big cone which has a strong tendency to buckle. Without reinforcements a thickness of at least 2 mm is required (3mm in case of aluminum).

- maximum displacement of 30 µm
- maximum constraint of 41 Mpa

Certainly one can reduce the thickness but to go beyond this first approach would need a close cooperation with manufacturers because the employed technology becomes very important.

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