5 Global support structure, services and installation

Corrado (5) DRAFT V1 A description of the global support structures and the services for the ITS3 H-detector is provided in this section, together with an overview of the ITS3 installation and possible removal sequence. The mechanical structure that supports an H-detector and its services is illustrated in Sec.5.2, while Sec.5.3 describes the cooling system and the cable routing to the H-detectors. Section 5.4 is devoted to the description of the layout, installation, and bake-out of the beam pipe, which dictate the boundary conditions between ITS3 and LHC. The new ITS3 installation and removal, as well as the mechanics associated with it, is outlined in Sec.5.5. Finally, the strategy to survey and align the detector elements at different assembly and installation steps is presented in Sec.5.6.

5.1 General requirements

The layout of the new ITS3 support structures has been developed to interface and be compatible with the mechanical components of the ITS2 (Figure 5.1) and its global support structure, called Cage. At the same time, the ITS3 support structures must fulfil the following design criteria:

- Provide an accurate position of the detector with respect to the TPC and the beam pipe.
- Locate the first detection layer ($r = 18$ mm) at a minimum distance to the beam pipe wall.
- Installation alignment to be handle 3 m far away from the IP.
- Ensure structure thermo-mechanical stability in time;
- Facilitate accessibility for maintenance and inspection;

Similarly to the ITS2 vertex detector, the overall mechanical support structures of the new ITS3 have the shape of a barrel that extends over the whole length of the TPC. Each barrel is divided into two halves, top and bottom, which are mounted separately around the beam pipe. Each barrel is composed of a detector section and a service section. To minimise the material budget in the sensitive area, each ITS3 H-detector is conceived as a cantilever structure supported at one end and outside the ITS2 tracker acceptance by a service support structure (Figure 5.2). The half layers are connected via electrical signal connections (e-links) and power cables to the H-detector patch panel 1 (PP1). An additional patch panel (PP2) is located immediately outside of the TPC, and is accessible from the ALICE miniframe. The service barrel integrates the cable trays that support the e-links and power cables through their routes from the PP1 to the PP2.

5.2 Service support structure

The closest point of access to the TPC bore is at one side of the Experiment (A-side) at about $z = -3$ m. Therefore, the services attached to the detector barrel and extending out to $z = -3$ m must be inserted or retracted together with the detectors. All services, including cooling pipes, power, and signal cables, will be integrated into the service barrel, which is an extension of the H-detector.

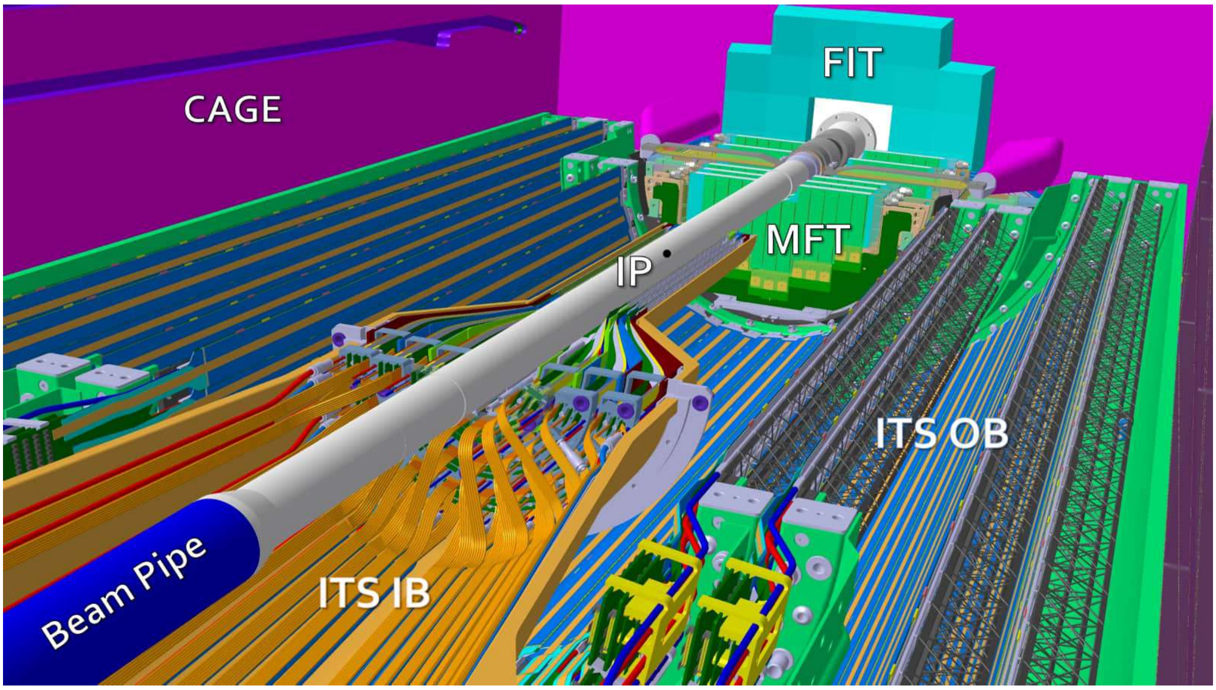

Figure 5.1: Overall interface with ITS2 mechanical layout.new pict.

PLACEHOLDER
IMAGE

Figure 5.2: Service support structure.

Inside the TPC, the service barrels will form a half-cone, jutting from the H-detectors to the TPC service support wheel. The service barrel copies the shape of the TPC cone in order to distribute the services outside the acceptance of the forward detectors.

The assembly composed of an H-detector barrel and H-service barrel is inserted or extracted from the TPC bore by means of two sets of lateral rollers fixed on the service barrels and sliding on their corresponding rails provided by the cage. The service barrel itself is a lightweight composite structure that has to provide both structural stiffness and dimensional stability to guarantee a precise installation of the ITS3 inside the TPC.

5.3 Services

Cooling and cabling services run for about 4 m from patch panel 1 (PP1) through the service barrels and out on the TPC service support wheel before they reach patch panel 2 (PP2), accessible from the miniframe (Figure XXX). The services have to cope with space limitations imposed by the feed-through on the TPC end-wheels. This space must be shared with the beam pipe and other services coming from the MFT and the ITS2 outer barrel. Cooling lines and cables will be equally distributed around the beam pipe in order to avoid material concentration.

Cooling: Polymer cooling pipes guarantee the correct amount of gas mass flow (baseline dry air flow) for H-detector cooling. Dimension of the pipes sets in accordance with the requirements of space encumbrance and minimization of the gas pressure drop induced by the pipe.

Cabling: Data, clock and slow control signals, together with power, are provided through the FPCs (Section XXX). The FPC tails extend outside the sensitive volume on the detector A-side where a connection to commercial high-speed cables is made at the Patch panel 1 level. Similar high-speed connector used for ITS2 is the baseline.

5.4 Beam pipe

The beam vacuum pipe represents the main interface between the experiment and the LHC machine. It fulfil a dual set of requirements:

- ALICE experimental requirements: maximum transparency to particles, limited beam-gas background, and conformity with the environmental and installation constraints.
- LHC machine requirements: safe operation of the machine, adequate beam aperture, and severe vacuum conditions compatible with ultimate LHC performance.

The ALICE beam pipes extend over 19 m on either side of the interaction point and consist of three sections: RB24-section, central section, RB26-section. The present central section of the beam pipe is 5.5 m long with about 0.8 m in beryllium inside the TPC [30]. One side is limited by the hadronic absorber, which penetrates inside the TPC, and on the opposite side by a large vacuum valve. The connection to the contiguous beam pipe sections is made via bellows to avoid induced displacements. With respect to the beam pipe currently installed in ALICE, the central section of the new beam pipe will have a smaller radius a smaller wall thickness of the central beryllium section and the the same length of 5.5 m but the gate valve on th A-side will be removed. This modification of the central section of the beam pipe is necessary to reduce the material in front of FOCAL. The RB26-section consists of three chambers of conical stainless steel tubes, which are up to 450 mm in diameter. The RB24-section uses standard LHC machine components and consists of copper tubes. The layout of the beam pipe central section affects the ITS performance and integration. The most critical parameters (radius, wall thickness, material, sag and bake-out procedure) are discussed below.

PLACEHOLDER IMAGE

Figure 5.3: Beam pipe.

Beam pipe radius and wall thickness: Current studies indicate that it should be possible to reduce the inner radius of the beam pipe central section from the present value of 17.2 mm to 16.0 mm. Estimates for the linear sum of fabrication tolerance, survey precision and alignment uncertainties amount to 5.1 mm, resulting in a minimum clearance of XX.X mm radius with respect to the nominal beamline. The LHC aperture is quoted in terms of the so-called n1 parameter [31], which is a function of this mechanical clearance as well as the position along the beam line due to the varying beta function. The XX.X mm clearance corresponds to an aperture of n1 = XX.X at the ALICE interaction point for nominal injection optics. Beyond a distance of 2 m from the interaction point, the minimal aperture requirement of n1 ¿ 10 is violated and a larger beam pipe radius is foreseen. Therefore, in the current layout, we assume a conical beryllium beam pipe with increasing diameter beyond a distance of 290mm from the interaction point. The wall thickness of the central Beryllium beam pipe section, 500 mm long, is assumed to be 0.5 mm. Both radius and wall thickness is the minimum that would be ever achieved in an LHC experiment. Prototyping activities have been already launched to demonstrate feasibility (see Fig. 5.8).

Beam pipe supports: A study has been carried out in order to evaluate the minimum number of supports necessary to contain the sag, which has to be sufficiently small to allow the installation of the new ITS at 1.5 mm radial distance from the beam pipe wall. These studies show a large deflection if the beam pipe is supported only at the two extremities and suggests the use of additional intermediate support, which complicates the installation procedure. Since the ITS is inserted from one side, it has to pass through the intermediate support to reach its final position. New BP support A-side (conical region close)

Beampipe support points and installation sequence will be similar to ITS2 (see Sec. 5.5).

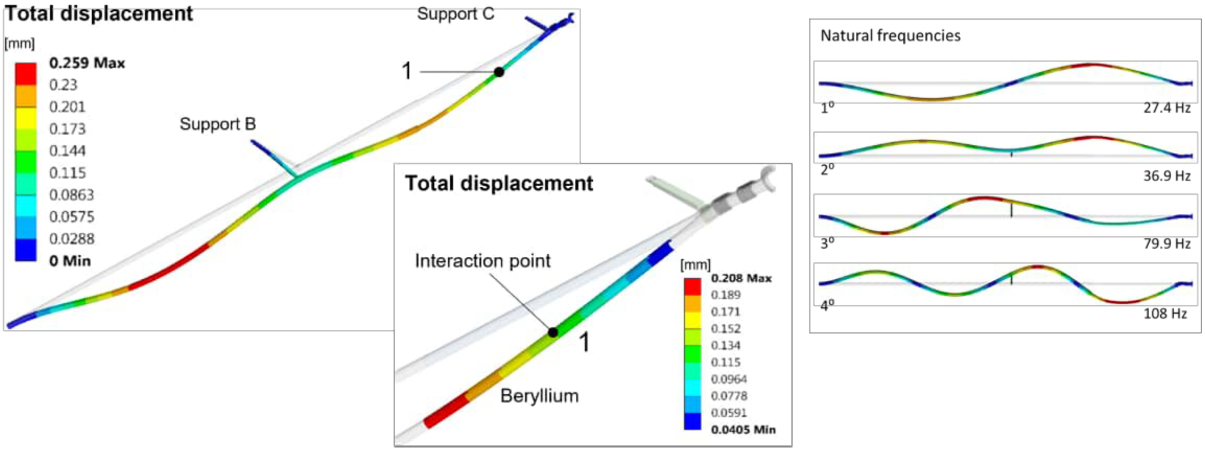

Figure 5.4: FEM of the beam pipe. new analysis

Beam pipe rings: Picture of the ring+BEAP with the targets.

Beam pipe bake-out: The beam pipe chamber is an Ultra High Vacuum (UHV) system pumped by a combination of lumped sputter-ion and distributed Non-Evaporable Getter (NEG) pumps. The NEG system is made up of a thin sputtered coating that runs over the whole internal surface of the vacuum chambers. The NEG film provides a high distributed pumping speed for most gases after activation by heating under vacuum to temperatures exceeding 200 C. Sputter-ion pumps remove gases that are not pushed by the NEG system. With the exception of the beam pipe central section, all vacuum chamber sections are permanently equipped with bake-out heaters for periodic re-activation of the NEG coating. If a bake-out of the beam pipe is required during detector installation, the ITS3 detector barrels must be extracted and the detachable oven positioned inside the TPC. The oven will employ the same rail system that was used to install the half-barrels for this insertion.

5.5 Installation and removal

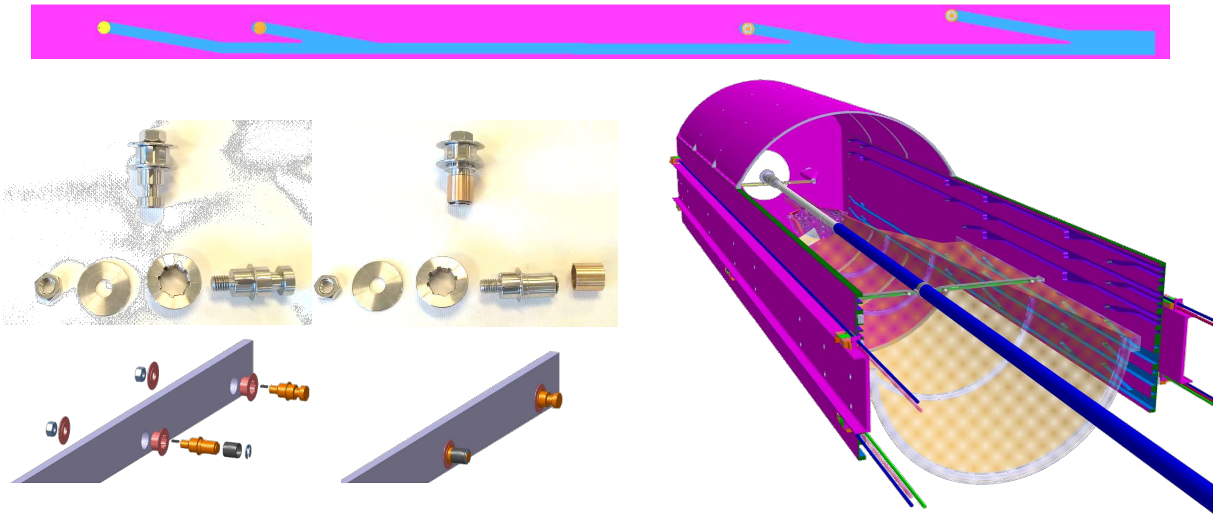

Figure 5.5: Cage interface.

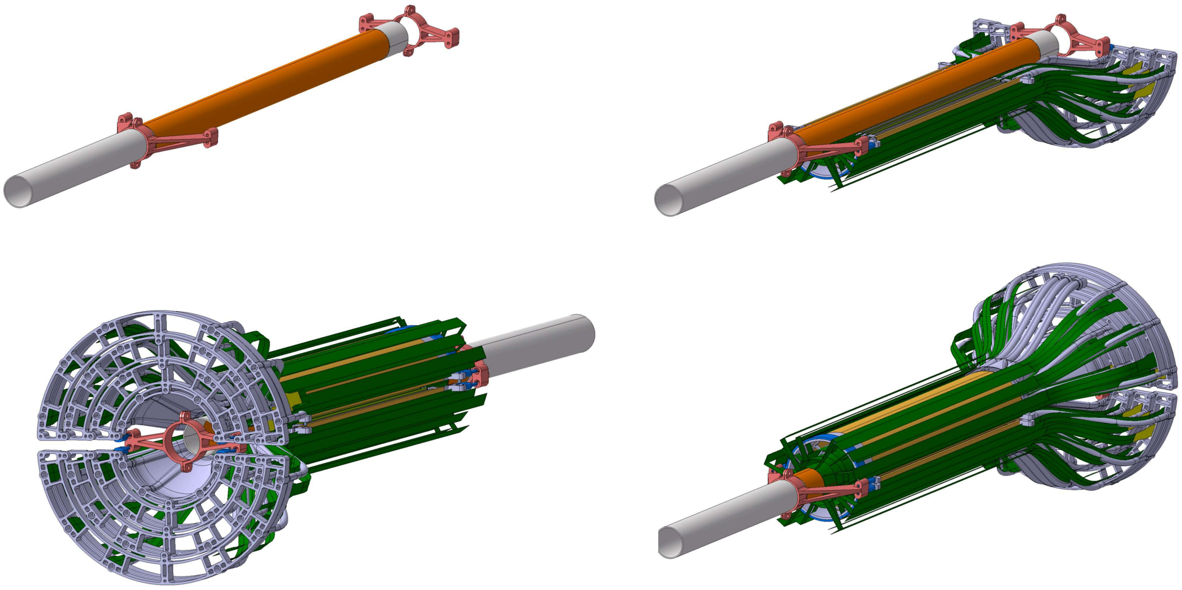

Figure 5.6: Beam pipe interface.

The ITS installation scheme is driven by the requirement of rapid access to the ITS barrels during the yearly LHC winter shutdown lasting 3-4 months. This requirement excludes the possibility of displacing or dismounting the surrounding detectors. or this reason a new installation concept has been developed for the ITS2 and it will preserved for ITS3. The minimum gap between the two half detector of 1mm and between the two halves and the beampipe of XX pose an additional challenge. A safe matching with such tight gap suggest the use of positioning rings on the beampipe that provide the correct references among the matching parts and avoid collision. This design option , schematically represented in fig if form one side provide a solution to the safe closure of the ITS3 around the beampipe, form the other side open a a new challenge in the decoupling of the detector barrel section from the Service barrel section in order to avoid the transfer of load on the beampipe.

5.5.1 Sequence

5.6 Survey and mechanical alignment

The survey and alignment requirements for the different detector elements are separated into two different categories:

- First, the different ITS elements must be placed at the nominal position within a specified tolerance, typically of the order of few tenths of millimetres, to permit adequate positioning of sensors in terms of overlapping and to preserve proper clearance for smooth installation and maintenance.
- Second, the position of the silicon sensors and their stability in time during operation have to be known with a tight accuracy, of the order of few microns for the IB and few tens of microns for the OB.

Although the mechanical structure of the ITS is designed to provide precision and stability with the required level of accuracy, several factors influence the uncertainty of the position of the detectors:

- the manufacturing accuracy of all components;
- the tolerance after assembly of the components in the barrel;
- the deformation of the components under load;
- the global positioning uncertainties related to the installation procedure;
- possible vibrations of the mechanical support structure;
- thermal expansion of the components;
- other long-term effects such as the settling of different parts of the ITS structure
- and surrounding ALICE interfaces.

The required precision of the final position of the ITS detectors can only be ensured if the position of the components relative to each other is measured during each step of the assembly process. Once the layers are assembled in a half-barrel an Xray sacn will provide the obtained layout for the sensors shape and their realtive position. The scanned configuraytion will be related to common reference targets on the detector barrels, which will be visible to an external survey system and that will be used for the determination of the half barrel final position inside the Experiment. Indeed, following insertion of the half-barrels, their position will be surveyed by a tracking system, through line of sight along the beam pipe from the A-side. By using targets on the barrels, the ITS3 local coordinate system will be related to the ALICE global system, i.e. to the beam axis. As the quite small angle of view of the inserted ITS from A-side degrades the quality of a photogrammetric measurement, a laser tracking system is preferred. The precision of the measured position of the detectors in the global ALICE coordinate system is determined by the accumulation of the measurement errors in each of the steps described above. To ensure that the detector position does not change in time, active monitoring of some elements of the ITS will be required during its operation. The construction of the ITS and its location within ALICE limits the choice of the monitoring techniques that can be used. On the C-side, where access is prevented by the hadronic absorber, a fixed measuring device will provide the measurement of the position of the targets on the detectors barrels. The relative position of the ITS and the TPC will be monitored by an optical system. These metrology and survey data serve as starting points for the final alignment, based on the reconstruction of tracks. The continuous tracking of the barrel position can be used to crosscheck the possible relative displacement of sensors made evident by the tracks re- construction, caused by displacement or deformation due to external factors e.g. vibration, thermoelastic movement and settling of different parts. The alignment process must there- fore be repeated periodically.