# NEW CONNECTION CRYOSTAT TO INSERT FP420 PROTON TAGGING DETECTOR IN THE LHC RING

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*Abstract*

FP420 is a R&D project to assess the feasibility of installing proton tagging detectors in the region 420m from the interaction points at the LHC. They would function as new sub-detectors at ATLAS/CMS, allowing the measurement of the spatial position and arrival time of outgoing protons emerging intact from the collision. Forward proton tagging in this region is expected to open a new programme of electroweak, QCD and BSM physics.

At present the 420m region is enclosed in a 'connection cryostat' (maintained at 1.9K) that provides continuity for the LHC beam, cryogenic & vacuum services and electrical power circuits through superconducting bus bars. The requirement of near room temperature operation and critical position control close to the beam pipes has made inserting FP420 detectors in this region a very complex task. The currently favoured design calls for the replacement of the connection cryostats with a new ~14m long assembly that will have all the necessary features of the existing connections cryostat as well as the appropriate environment for the operation of the detectors. This paper mainly describes the cryogenic aspects of the new connection cryostat.

## INTRODUCTION

The FP420 R&D project [1] is an international collaboration with members from 29 institutes from 10 countries. The aim is to assess the feasibility of installing **F**orward **P**roton Tagging Detectors at **420m** from the interaction points (IP) of the ATLAS and / or CMS experiments at the LHC. The physics potential of forward proton tagging in the 420m region at the LHC has only been fully appreciated within the last few years. By detecting protons that have lost less than 1% of their longitudinal momentum, a rich QCD, electroweak, Higgs and BSM program becomes accessible, with the potential to make measurements which are unique at LHC, and difficult even at a future linear collider.

The drift spaces around 420m from the ATLAS and CMS interaction points are at present enclosed in a 14 m long interconnection cryostat [2] that connects the superconducting arcs and dispersion suppressor regions of the LHC. The cryostat provides continuity not only of the beam pipes held cold at 2K, but also of the isolation vacuum, electrical power, cryogenic circuits and thermal shielding. One of the key challenges for the FP420 experiment is to design a new 14 m section to replace the interconnection cryostat which will allow access to warm beam pipes. In this paper we describe the design concepts of the proposed new connection cryostat.

## EXPERIMENTAL REQUIREMENTS

The main requirements of the FP420 experiment are:

- The FP420 detector must be able to reconstruct the tracks of the outgoing protons a few mm away from the beam.
- Silicon pixel detectors [3] must be moved into a position as close to the beam as possible when stable beam conditions are reached.
- Geometry and the materials used for the modified beam pipe must not affect the normal running of the LHC.
- The new design of the cryostat with the detector assembly must ensure the continuity of the existing LHC services as well meet all the necessary criteria for cryogenic performance [4], alignment, transport and commissioning.
- The Si-detectors operate near room temperature whereas the beam pipes are maintained at 1.8K in the current design of the connection cryostat. **Providing a warm access to the beam pipe is a key challenge in designing a new cryostat.**
- The commissioning of the FP420 detectors is being planned during the LHC shutdown in January 2009. Transport, installation, decommissioning & commissioning of the cryostat including the integration of the complete FP420 detector with LHC during the beam shutdown period will be extremely critical.

## THE NEW CONNECTION CRYOSTAT

Figure 1 shows the cold mass in the present design of the connection cryostat. Figure 2 shows its cross section. The three bus bars M1, M2 and M3, the two beam pipes V1 and V2 and the heat exchanger line X are all enclosed in a cold mass maintained at 1.9K. Table 1 shows the configurations of the lines in the cryostat

Figure 1: Cold Mass inside the Connection Cryostat.

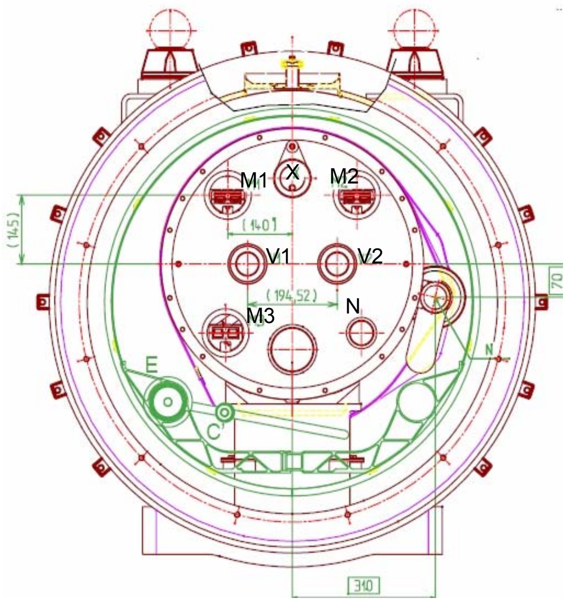


Figure 2: Cross section of the existing connection Cryostat

Table 1: Service in the Cold Mass

| Line | T(K) | Dia (mm) |
|---|---|---|
| M1, M2,M3<br>Bus Bars | 1.9 | 80-84 |
| N<br>Aux bus Bars | 1.8 | 50-53 |
| X<br>Heat exchanger | 1.8 | 54-58 |
| E<br>Thermal Shield | 50-65 | 79-86 |
| C<br>Support posts and beam screens | 4.6 | 15-17.2 |
| V1, V2<br>Helium jackets around beam pipes | 1.9 | 50-53<br>66-70 |

The main difficulty in designing a new cryostat is to introduce the 3D Silicon detectors which work near ambient temperature close to the beam pipes which at present are maintained at 1.9K. After several design iterations it was found convenient to split the existing cold mass into two independent cold sections. The upper section contains the heat exchanger (line X) and the lower section contains the rest of the cold services like bus bars in the lines M1, M2, M3 and N. The beam pipes V1 and V2 in the middle are accessible at ambient temperature. Figure 3 shows a 3D sketch of the new proposed cryostat. Figure 4 shows the cross sectional views at the points A, B and C in the figure 3 respectively. Line X assembly is shifted in the horizontal plane to create sufficient space around beam pipes for mounting the silicon detectors. The new beam pipes will be modified to accommodate thin windows with very close proximity to the circulating beam.

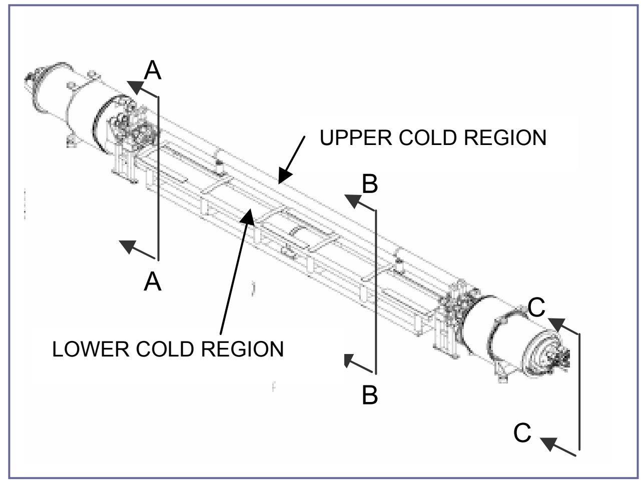


Figure 3: New Connection Cryostat

In order to maintain the compatibility with the connections at the interface between the cryostat and the LHC superconducting magnet it is necessary that the cross section of the new cryostat is identical to that of the existing cryostat. Such a transition (from Figure 4b to 4c) has been achieved inside the shuffling modules at both ends of the cryostat by adapting the design concepts from the ATM modules (Figure 5) [5, 6]. The design of individual components in the transition region is extremely complex but due to the adaptation of the existing designs significant amounts of engineering and design efforts have been saved.

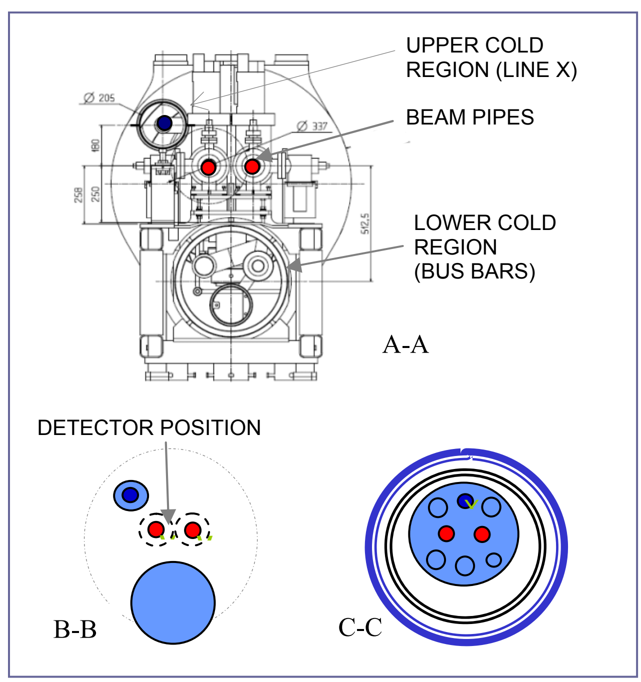


Figure 4: Cross sectional views of the cryostat

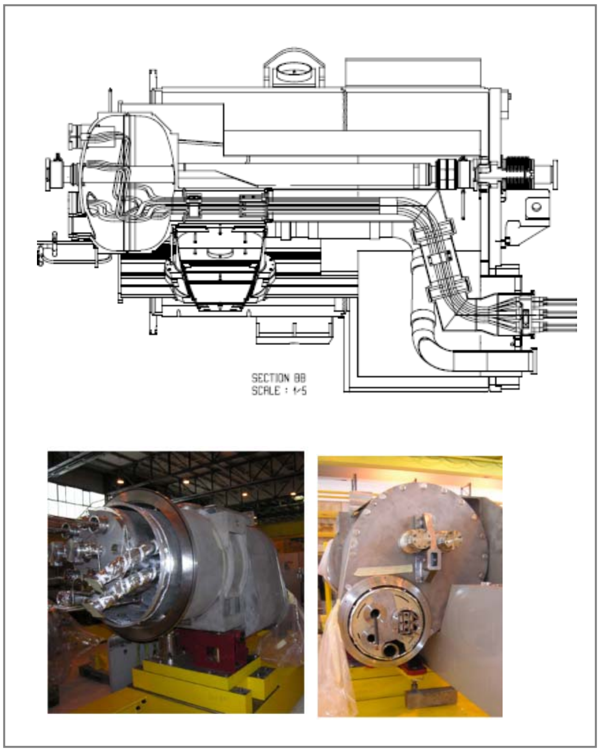


Figure 5: ATM Modules

## INTEGRATION WITH THE LHC

The new design now ensures 1:1 replacement with the existing cryostat as well as maintains the continuity of all the services mentioned earlier. A 7.5m long region is available for inserting the Si-detectors in an overall length of 14m. Initial estimates indicate that the overall heat load budget for the new design is lower than those specified for the existing connection cryostat. Detailed calculations will be performed once all the details about the dimensions, tube sizes, material etc. are defined. Due to the limited time available during the beam shutdown period of 3 months the assembly, transport, alignment, commissioning and decommissioning of the cryostats will be extremely critical. Work is in progress [7] to evaluate the necessary sequence of operations for this task.

## SUMMARY

FP420 is a R&D project to assess the feasibility of installing proton tagging detectors in the region 420m from the interaction points at the LHC. Key requirement is to create warm access to the beam pipe to insert the silicon pixel detectors as close as possible to the beam. In the proposed design the existing cold mass has been split into two cold regions, upper and lower, with the beam pipes in the middle exposed to ambient temperature. Continuity of all the necessary services and compatibility at the interface between the cryostat and the LHC magnet has been achieved by adapting the design concepts from the ATM module.

The FP420 collaboration expects to have a detailed feasibility and design study to present to the ATLAS and CMS collaborations during 2007, with a possibility of installation and commissioning during the beam shut down in January 2009.

## REFERENCES

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