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The OB stave construction of the Alice ITS Upgrade

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The Upgrade of the Inner Tracking System of the Alice Experiment consists of seven detector layers of Si Monolithic Active Pixel Sensors, each with a size of 30mm x15 mm.
The seven layers are organized in an Inner Barrel (IB) consisting of three layers and an Outer Barrel (OB) made of four layers. Each layer forms a cylindrical array of staves around the beam line, with a layout that depends on the radius of the layer. The IB staves (270mm x 15mm) are the assembly of nine pixel chips aligned and connected to a Flex Printed Circuit (FPC) and supported on a carbon plate that also provides cooling.
The OB stave consists of two Half Staves (HS), each made of four or seven Hybrid Integrated Circuits (HIC), aligned and glued on a Cold Plate, with a length of 900 mm or 1500 mm, which corresponds to the Middle Layer (ML) and Outer Layer (OL), respectively.
The Cold Plate is a thin carbon plate, 30mm wide and 300 μm thick, with integrated cooling pipes, which provides the support and the cooling to the chip sensors.
The HIC consists of fourteen pixel chips organized into two rows of seven chips each, glued and electrically connected by means of wire bonds to the FPC. The wire bonds are not encapsulated or protected, enhancing the difficulties of HIC manipulation.
The two HS are supported by a lightweight carbon fiber truss structure referred to as spaceframe.
Tight requirements in the stave construction come from the precision in the sensor alignment and in the very precise knowledge of their final position.
The construction of the IB staves is based at CERN, while five construction sites are in the process of building the OB staves, using identical procedures and mechanical tools to ensure final comparable product quality.
The aim of this work is to describe the procedure for the alignment, the assembly and the qualification of an Outer Barrel stave together with the most relevant mechanical tools designed, produced and used for the different phases.
The main steps of the stave assembly procedure can be summarized as follows:
- The Half-Stave assembly is performed by aligning and gluing four or seven HICs on the cold plate. This operation is performed with tools equipped with vacuum suction systems, which are used for the manipulation and positioning of the HICs in their nominal position by means of micrometric motion stages tuning.
The entire task is achieved on a stainless steel base plate, 1,6 m long, machined with a planarity of 50 μm, which supports and maintains the cold plates in position during the HIC alignment phase. The alignment step is fully controlled by a Coordinate Measuring Machine (CMM) equipped with a video camera. Custom made CMM programs guide the operators during the entire process. The Reference System used for the HICs nominal position is defined by special features machined on the stainless steel base.
- The Stave assembly consists of the alignment and gluing of each HS to the space frame and a carbon fiber bar, 1,6 m long, equipped with vacuum suction cups and reference planes machined with a planarity precision of 100 μm is used. The Reference System used during this step is defined by means of dedicated support structures, on which the experiment official support blocks are glued. The gluing procedure is performed using a master jig which is also used for the gluing of all the stave connectors.
- The metrological survey is the final step of the assembly. A dedicated Jig located under the CMM is used to support the stave during this phase. This step allows to verify the final sensor positions, in 3D volume, exploiting special reference markers placed on the chip surface.
A series of additional tools were developed for a number of operations related to the electrical interconnections. This presentation will focus on the most complex one, used for soldering and manipulating the flex aluminum cable, BUS, used to power the detectors.
Finally, the results of the metrological surveys on the staves produced so far at the different production sites will be presented.

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