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Abstract

The existing Compact Muon Solenoid (CMS) Endcap Hadron Calorimeters (HE) have been in operation for several years and contributed substantially to the success of the CMS Physics Program. The High Luminosity Large Hadron Collider (HL-LHC) performance criteria, however, require a re-examination of the ability of the detector active material and electronics to meet the requirements of 3000 fb$^{-1}$ [1, 2]. Based on these studies, CMS proposes the replacement of the Endcap Calorimeters, which cover the region of pseudorapidity $1.5 < |\eta| < 3.0$, with a new High-Granularity sampling Calorimeter (HGC). The current HE calorimeters are proposed to be converted to the Backing Hadron Calorimeter (BH). For the BH, the base line mechanical design, scintillator design and segmentation, and optical readout scheme must be defined by the end of 2016. Also upgraded Endcap design must provide the accessibility of BH and easy scintillators (megatiles) replacement [3]. This can be achieved by the adding of a new element “Trays Skirt”. A possible design of this element is presented.

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The existing Compact Muon Solenoid (CMS) Endcap Hadron Calorimeters (HE) have been in operation for several years and contributed substantially to the success of the CMS Physics Program. The High Luminosity Large Hadron Collider (HL-LHC) performance criteria, however, require a re-examination of the ability of the detector active material and electronics to meet the requirements of 3000 fb⁻¹ [1, 2]. Based on these studies, CMS proposes the replacement of the Endcap Calorimeters, which cover the region of pseudorapidity 1.5<|η|<3.0, with a new High-Granularity sampling Calorimeter (HGC). The current HE calorimeters are proposed to be converted to the Backing Hadron Calorimeter (BH). For the BH, the base line mechanical design, scintillator design and segmentation, and optical readout scheme must be defined by the end of 2016. Also upgraded Endcap design must provide the accessibility of BH and easy scintillators (megatiles) replacement [3]. This can be achieved by the adding of a new element – Trays Skirt. A possible design of this element is presented.

Introduction
As a part of a modernization of the CMS detector for the HL-LHC during Long Shutdown 3 (LS3) it is planned to carry out a wide range of works on Endcap calorimeters design upgrade. The HE will be converted to the BH, and the EE will be replaced by the HGC.

It is supposed that the upgrade of the Endcap design will also allow to greatly simplify the processes of the maintenance during long shutdowns and will provide in particular:
– quick replacement of the BH megatiles;
– separate maintenance of the BH and HGC.

Numerous pipes and cables coming from HGC will complicate the access to the BH megatiles. Therefore it is proposed to add to the Endcap design a new element – Trays Skirt, that will allow to dismantle the HGC services not each taken separately but as a single unit.

The Trays Skirt design overview
The Trays Skirt is made of 18 sectors, that are connected to each other by bolted connections. Each sector has a channel for the laying of the pipes and cables coming to the HGC (Fig. 1). After the laying the services are closed by the covers.
One of the possible materials for the Trays Skirt sectors manufacturing is a non-magnetic stainless steel. The blanks are the ~50 mm thick plates. Production from the aluminum alloy or carbon fiber is also possible. The final choice of the material will be done after the carrying out of the strength calculations.

The present geometric dimensions of the HE absorber do not allow to allocate the Trays Skirt. It is necessary to reduce the absorber dimensions both at the conic and cylindrical parts.

![Fig. 1. Trays Skirt Assembly](image)

The Trays Skirt fastens by bolted connections to an Interface Flange, on which the HGC was mounted. After that the laying of the HGC services into the Trays Skirt channels is performed. This order of assembly allows to carry out the independent tests of the HGC with its systems and to detect leaks and faulty sealings before the stage of mounting at the BH Absorber (Fig. 2).

The Interface Flange with the installed Trays Skirt and HGC connects to the BH Absorber as a single unit.
Fig. 2. Possibility of the independent HGC & Systems testing

**Maintenance of the Endcap during long shutdowns**

In the present Endcap design the replacement of the megatiles require considerable time costs because it means the need of demounting and the following mounting of:

– trays covers;
– cables and pipes (both copper and steel) coming to the EE and the Preshower Detector (ES);
– copper pipes of the trays cooling;
– trays themselves;
– HE Absorber services.

The Trays Skirt adding to the Endcap design allows to perform the undertime replacement of the megatiles. This is ensured by the fact that the HGC pipes and cables are located in the Trays Skirt channels and can be demounted with the Trays Skirt and HGC as a single whole. All services from the BH Absorber are placed under Trays Skirt (Fig. 3).

To sum up, while using the Trays Skirt it will be necessary to perform the following operations to get the access to the megatiles:

– disconnection of the HGC services in the region of Trays Skirt end face;
– demounting of the Trays Skirt and HGC with services as a single unit;
– demounting of the BH Absorber services.

The process of the Endcap assembling with the Trays Skirt and HGC is carried out in reverse sequence.
It is also possible to perform the necessary maintenance works on the disconnected module «Trays Skirt with HGC» while the BH megatiles are replacing.
Conclusions

A new additional part of the Endcap calorimeter design, Trays Skirt, provides:
– combining trays into the single unit that is connected to HGC and can be easily moved from BH;
– separating HGC services and BH services (BH services are placed under Trays Skirt and HGC services are fixed on the Trays Skirt);
– easy replacement of the BH megatiles during shutdowns and possibility of separate maintenance of the BH and HGC.

References: