REQUIREMENT DOCUMENT

CMS Endcap Cooling Upgrade requirements for Muon detectors

This document describes the changes in power dissipation towards the Endcap cooling circuit from the different Muon detectors of CMS foreseen for the period 2019-2026. It includes references to the present Endcap cooling circuit measured performances and an estimate of their changes due to the new heat load.

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| Prepared by:P. Tropea | Checked by:A. DimitrovA. LanaroPetr LevchecnkoIan CrottySalvatore Buontempo,Michele Bianco | To be approved by:A. Colaleo [CMS Muons Project Manager]A. Ball [CMS Technical Coordinator] |
|  |
| Distribution List:cms-tig-extended@cern.ch |

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# Scope of the document

This document describes the changes in power dissipation towards the Endcap cooling circuit from the different Muon detectors of CMS foreseen for the period 2019-2026. In includes references to the present Endcap cooling circuit measured performances and an estimate of their changes due to the new heat load.

With this document, the Muon detector experts validate their additional power dissipation requirements for the Endcap region with respect to the present situation and the changes in the detector thermal gradients that are expected with these new loads.

# The Endcap Muon system upgrade

## Endcap muon systems changes in LS2 and 2021-22 YETS

The Endcap Muon system will undergo several changes in the period between LS2 and the YETS 2021-22:

* On YE+1 and YE-1: the GE1/1 system will be installed, requiring 2.9 kW per each endcap (80 W per Super Chamber for a total of 36 Super Chambers). On the Endcap circuit, this represents an increase of **5.8 kW**
* On YE+2 and YE-2: the CSC electronics of ME2/1, ME3/1 will be replaced and the power dissipation of the chambers will double with respect to the present 4.7 kW per endcap (260 W per chamber for a total of 36 chambers instead of 130 W per chamber). On the Endcap circuit, this represents an increase of **9.4 kW**
* On YE+3 and YE-3: the CSC electronics of ME4/1 will be replaced and the power dissipation of the chambers will almost double with respect to the present 2.2 kW per endcap (260 W per chamber for a total of 18 chambers instead of 123 W per chamber). On the Endcap circuit, this represents an increase of **4.7 kW**

The total increase in power dissipation for LS2 is 5.8+9.4+4.7 kW = **19.9** kW

## Endcap muon systems RUN3

During EYTS 2021-22 and 2022-23, GEM based muon stations will be added on the YE1 Endcaps, and additional RPC stations will be added to the YE3 disk, all to be cooled by the Endcap cooling circuit:

* On YE+1 and YE-1: the GE2/1 require 5.8 kW per each endcap (160 W per chamber for a total of 36 chambers). On the Endcap circuit, this represents an increase of **11.6** kW
* RE3/1 chambers will be connected in series to the existing RE3 cooling circuits, adding 1 chamber per circuit (20 W each for a total of 18 chambers). On the Endcap circuit, this represents an increase **0.72** kW.
* RE4/1 chambers will be connected in parallel to the existing RE4 cooling circuits, adding 2 chamber in series on 9 of the 18 circuits (20 W per chamber for a total of 18 chambers). On the Endcap circuit, this represents an increase **0.72** kW.

The total increase in power dissipation for Run3 is 11.6+0.72+0.72 kW = **13.04** kW

## Endcap muon systems LS3

During LS3, additional muon stations will be added on the Endcaps, to be cooled by the present cooling circuit:

* On YE+1 and YE-1: ME0 systems will be installed, 18 ME0 stacks per Endcap. ME0 require 6.5 kW (60 W per module, each ME0 stack will be realized by 6 module for a total of 108 module endcap). On the Endcap circuit, this represents an increase of about **13 kW**

At the end of LS3, the Endcap circuit will be loaded with about 45 kW more than present measured load, which has been measured by EN-CV to be at maximum 137 kW during the Run2.

In LS3, some of the flow presently dedicated to cooling HE cables will be available to be re-distributed to the muon systems.

In between LS2 and LS3, maintaining the present flow rate available for the muon stations, the calculated temperature rise of the circuit would be about 2 degrees in Run4, against the 1.7 of design, and the 1.5 measured during Run 2 ([https://edms.cern.ch/file/2027036/1/Annex\_[3]\_Bilan\_puissance\_ED\_USC\_55\_2017.xlsx](https://edms.cern.ch/file/2027036/1/Annex_%5B3%5D_Bilan_puissance_ED_USC_55_2017.xlsx)).

In order to cope with this, CMS has requested to EN-CV to reduce the operation inlet temperature of the circuit, going from 17 C to 16 C.

This is a compromise value which is acceptable for the operation of the Muon detectors. Locally, all circuits will temporarily