Design of ME1/1 service routing on the YE1 disk for the phase 2 upgrade of the CMS detector at the HL-LHC

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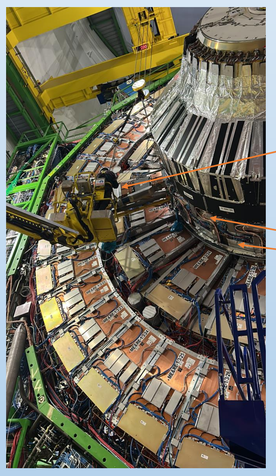
Abstract

The ME1/1 chambers are an essential component of the CMS muon detector consisting of cathode strip chambers installed on the CMS YE1 endcap. The routing of the services from the patch panel to the chambers is being redesigned as part of the phase 2 CMS detector upgrade to be performed during LS3. The development of piping and cabling routing for services like cooling, gas supply, optical fibres, control, high voltage, and low voltage cables is presented.

Introduction to the ME1/1 detector and the YE1 endcap disk

The YE1 endcaps are the first forward set of iron disks of the CMS endcap providing flux return for the CMS solenoid, instrumented with sets of muon chambers, calorimeters and services for them on both the IP facing and non-IP facing sides. The innermost ring of CSC muon detectors in the endcap muon system are the ME1/1 (Muon Endcap 1/1 detector) CSCs, positioned in the gap between the endcap HGCal and the YN1 support disk. The disk in each endcap is composed of 36 CSCs; 2 rings of 18 **IP (forward)** and **non-IP (backward)** chambers each.

The ME1/1 CSCs consist of arrays of positively-charged anode wires crossed with negatively-charged copper cathode strips within a gas volume. When muons pass through, they ionize the gas to cause electron avalanches which are collected by the anode, while ions induce charge on the strips. Fast timing information suitable for triggering and 2D position information, allows tracking and momentum measurement of the muons. Electronic signals are processed by front end electronics located on the ME1/1 chambers and data is transmitted to off chamber backend electronics for further processing.



The ME1/1 chambers and readout electronics require a network of services for both trigger and reconstruction data paths. The service routing is designed to avoid conflicts with other detectors and to ensure the smooth functioning of the detector chambers.

ME1/1 services

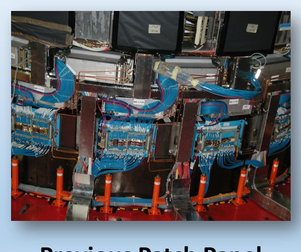
- **Cooling** services involve the supply of water at 22°C through copper pipes to dissipate heat generated by the detector. The cooling pipes are routed from a patch panel such that an IP and a non-IP chamber are connected in series with the water being circulated back to the same patch panel.
- **Gas** services involve the controlled delivery of an Argon-CO2-CF4 mixture which gets ionized and creates an electron avalanche when a muon passes through. Copper pipes circulate the gas through 4 chambers (2 IP and 2 non-IP) in series using 2 different patch panels for the input and output.
- **Optical fibre** services are crucial for data transmission between the detector and data acquisition systems.
- **Skew-clear** cables are used for on-chamber electronics control and data transmission.
- **High voltage** and **Low voltage** services provide the necessary electrical power for various detector components and electronics.

Service Type	Outer Diameter(mm)	Quantity per chamber
Cooling	10	2 (1 Cooling IN, 1 Cooling OUT)
Gas	8	2
Optical	10	1
HV	10.5	1
LV	15	1
Skew-clear	9	10

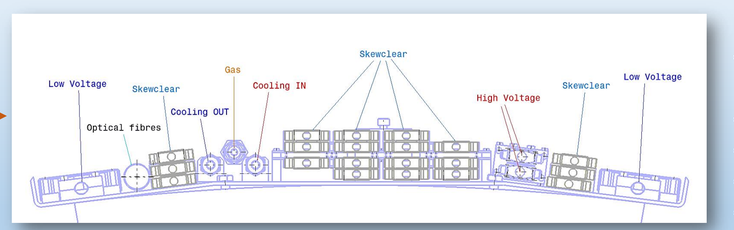
The ME1/1 services are supplied from the endcap periphery to the chambers through a patch panel which can which facilitate the installation and maintenance of these pipes and cables.

LS3 patch panel upgrades and routing baselines

- The ME1/1 patch panel for the LS3 occupies lesser area from the front view (420 cm2).
- It leaves a free area of 180 cm2 in the ME1/1 patch panel zone and an area of 120 cm2 above the zone till the envelope.
- The cooling and gas pipe connectors are now towards the middle of the patch panel, instead of being routed from the side.



Previous Patch Panel



New Patch Panel front view

The baselines for the routing design are:

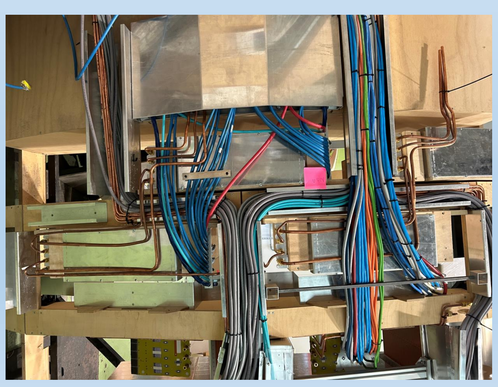
- Make the service requirements compatible with the space available for routing.
- Prioritizing and optimizing the space over the endcap.
- Thermal management of heat dissipated by cables.
- Minimization of service crossings.
- Compatibility with clamps for chamber extraction and in-situ repairs.

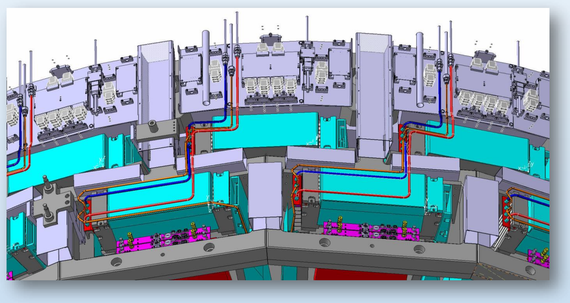
Piping design iteration 1 (Mock-up version)

The current routing design involves crossing pipes on top of the forward(IP) chamber to connect the IP and non-IP chambers in series.

Cooling IN : **Red**
Cooling OUT : Blue
Gas : Orange

ME1/1 services were implemented onto the YE1 endcap mock-up to assess feasibility on the overall layout.





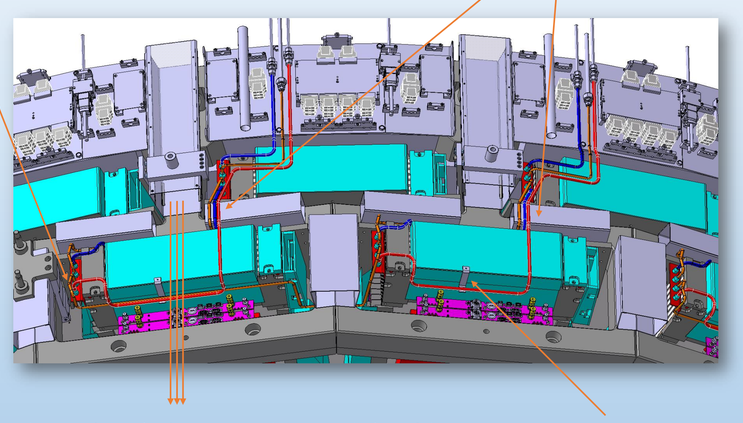
The lessons learned during this exercise were-

- The pipes passing on top of the IP chambers leaves no space for HGCal services that cross on top of the ME1/1 chambers.
- By forming a loop around the cooling pipe, the IP chamber gas pipes leave little space between the connectors and the brackets for the installation of service channel clamps.
- More space is needed in the crossing areas for ME1/1 cable services to pass through.

Piping design iteration 2

The gas pipe double angle is modified from 115° to 155° to add extra space between the connectors and brackets for the installation of the clamps.

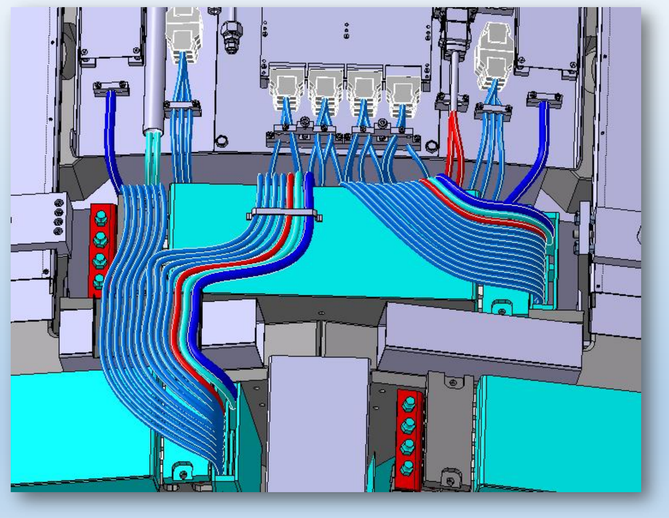
The pipes are shifted 30 mm towards the clamp to create enough space for the cable services to cross over onto the forward chamber.



The cooling and gas pipes being routed around the sides of the forward chamber allows for service channels of other YE1 detectors to pass over the top of the chambers without any interference, while respecting the envelope.

Double L shape clamps could be attached on top of the chambers to give support to the pipes being routed from the sides.

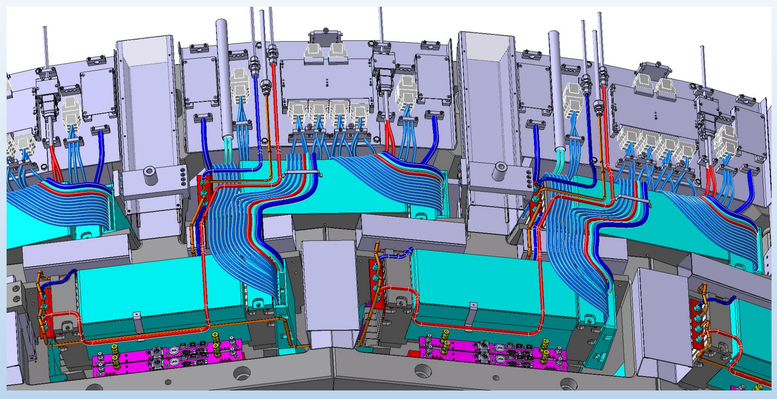
Cable routing design



The cable services are connected to the chambers through the patch panel cable support after going underneath the gap between the patch panel and the Non-IP chamber. This is done to accommodate the cable slack and re-route them in the order of the ME1/1 chamber connectors.

The forward chamber services are clamped together at the backward chamber to optimize the spacing and tension. They cross over a bridge on top of the service channels to accommodate the slack and cope with any relative displacements of the chambers.

Results and Next steps



The ME1/1 services for the LS3 are being routed in a manner that prioritizes compatibility and non-interference with other YE1 services while supplying the ME1/1 detector in the most efficient manner possible. The current routing design of all services from the patch panel to the ME1/1 detector is shown.

Future steps for the ME1/1 include-

- Bridge design for cable services crossing to the forward chamber
- Implementation on mock-up
- Design of service routing from endcap periphery to patch panel

References

1. YE1 services for phase 2 : YE1_services_v1_1_docx_cpdf.pdf (cern.ch)
2. ME1/1 Cathode strip chambers- CMS note : NOTE2008_026.pdf (cern.ch)

Acknowledgements

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