

GEM TC Status Report

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GEM TC

Outline

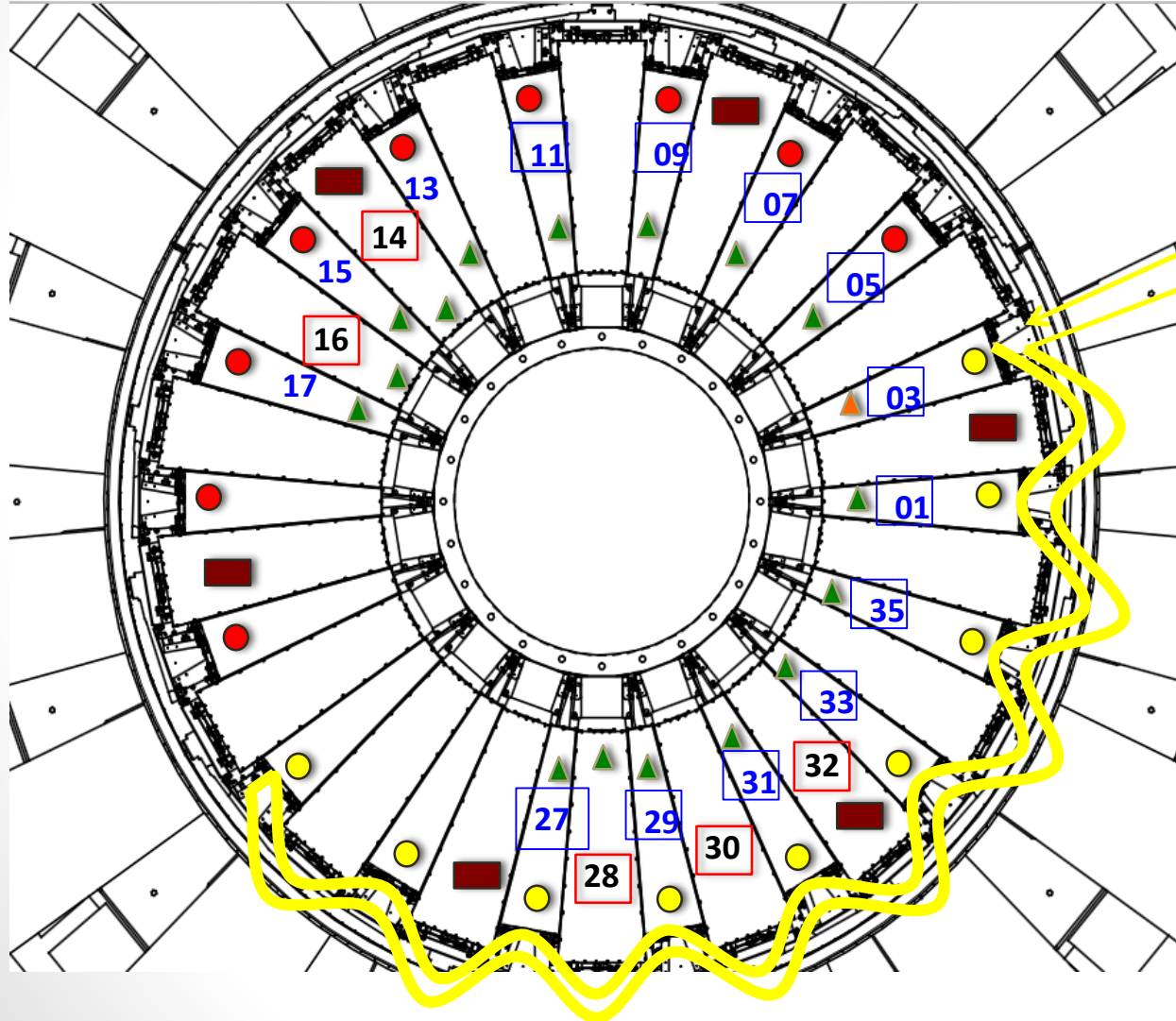
- GE1/1
 - Super Chamber Installation Progress
 - Installation Schedules
 - Services Preparation
 - Toward Commissioning (what we can do) : When & How
- GE2/1
 - Services Preparation
 - Status of Chamber Design
 - Outcome (Main) from GE2/1 EDR
 - Integration Progress
 - Tooling/Setup
- MEO
 - Prototype Preparation
 - Modules / Stack design
- Manpower
- Summary

Super Chamber Installation Progress

- 17 SC (14 Short / 3 Long) installed up to Friday 27th September
- 4 SC Long ready for installation in P5 (2 ongoing today, 2 foreseen for tomorrow)
- 1 SCS installed in position #03 currently has GEM 2 on short (3 sectors), flushing with CO2 since Friday lunch time, trial for cleaning tomorrow, if will not be successfully will be extracted on Wednesday morning and moved back to 904
- 15 (or 16) SC to be installed between 14th and 25th Sept
- First trolley have to be shipped to P5 by Friday 11th lunch time, it **HAVE TO** contain 6 SC Long (2 with Radmon sensors) and 2 SC Short (at least one yellow line)
- Second trolley with last 7 (or 8) SCs in P5 by Friday 18th morning

Super Chamber Installation Progress

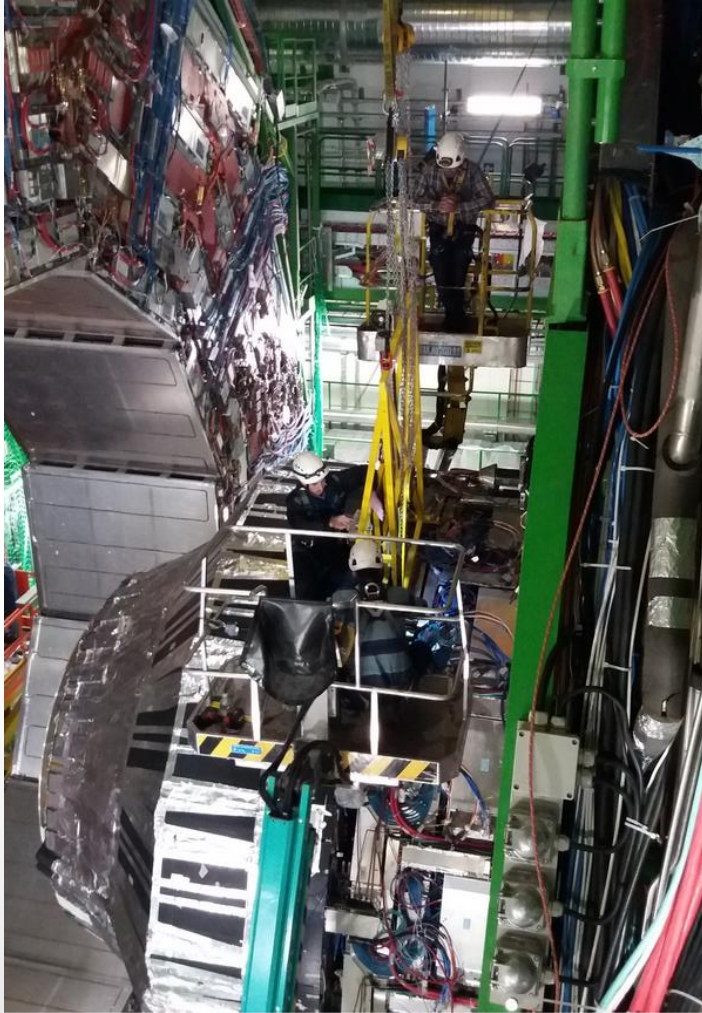
FAR Negative Endcap NEAR



Legend:

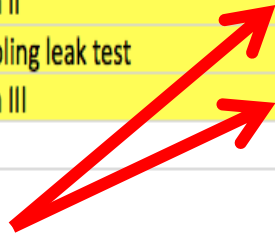
- SC short yellow chain
- SC short red chain
- SC long with Radmon
- ▲ SC installed
- ▲ SC (may to be removed)

Super Chamber Installation Progress



Schedule (GE1/1 SC Installation)

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Names	% Complet	Sub System
247	GE-1/1 HV US-UX cable installation	15 days	Tue 17/09/19	Mon 07/10/19		RTech5	0%	GEM
248	GEM gas system SGX to UGX cable installation	3 days	Fri 20/09/19	Tue 24/09/19	246	RTech3	0%	GEM
249	GE-1/1 chamber installation II	11 days	Tue 17/09/19	Tue 01/10/19		Crane -	0%	GEM
251	Install 3-way-valve PP & cooling leak test	8 days	Wed 02/10/19	Fri 11/10/19		ZEC	0%	GEM
253	GE-1/1 chamber installation III	2 wks	Mon 14/10/19	Fri 25/10/19	251	Crane -	0%	GEM
254	GE-1/1 commissioning	7 wks	Mon 28/10/19	Fri 13/12/19	247,253		0%	GEM



- GE1/1 SC installation planned in two separated windows (actually three considering the early installation) 17th Sept -1st Oct and 14th Oct-25th Oct (21 w.d. in total) to allow, in the middle to ZEC to install the cooling PP with the 3-way valve and connect the houses to the spigots
- 34 SC have still have to be installed (2 in place since 25th July), at rate o 2 SC/day we have up to 4 days of contingency
- Installation II postponed to 18th Sept afternoon, due to additional delay introduced by the Open Days
- No chamber installed on 18th due to the rupture of Pivot Pins during SC installation
- One SC may need to be removed and replaced (One GEM foil found on short after the installation), currently only one day of contingency in the installation plan

Services Preparation (Negative EndCap)

GE1/1

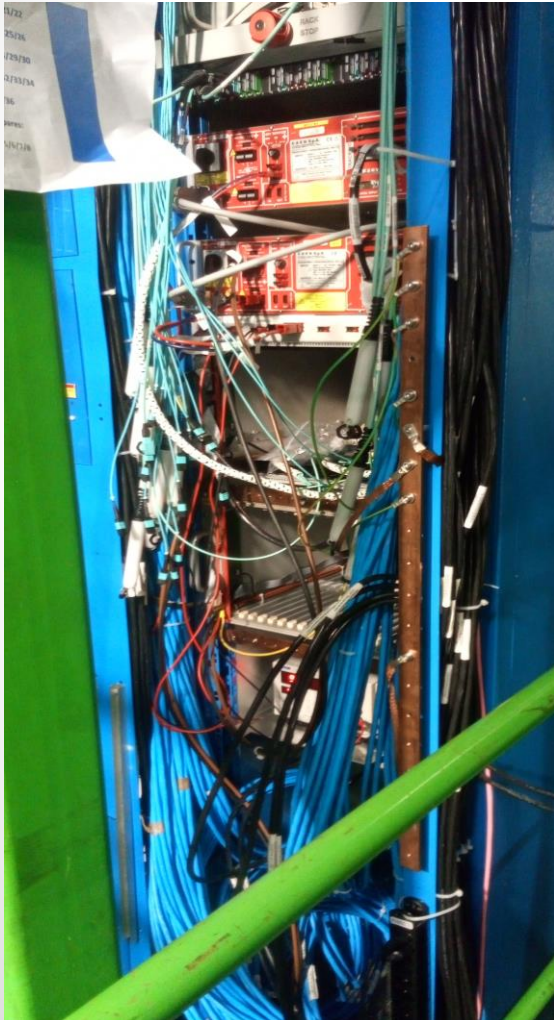
Services On Disk

- Routing of LV cables completed, connectorization Rack Side started on 25th Sept 2019
- Routing of HV cables completed, connectorization Rack Side (on balcony) completed, *allow to power the all SCs with flying connection from UXC balcony*
- RO Fibers routing completed, *allow to RO all SCs with proper connection till counting room in USC, CTP7 to RO the whole Neg EndCap can be moved soon in P5 for commissioning*
- Fibers for Temperature Sensors to be routed 1st week on Nov.
- Routing of cables for Radmon sensors completed, connectorization Rack side (UXC) from 30th Sept (Sofia group at CERN this month)
- Gas system finalized and commissioned
- Cooling flexible houses installed, connectorization and connection to control valves and water supply manifold will start on 2nd Oct

Services Preparation (Negative EndCap)

LV Rack in preparation (UXC)

HV Rack in preparation (UXC)



Services Preparation (Negative EndCap)

GE1/1

Services USC-UXC

- Routing of LV cables completed, Patch Panel for connection with On Disk services still missing, to be provided by CMS TC (Sergei Lusin) expected in two weeks, **no possibility to operate LV power system without this patch panel**
- HV cables installation has been delayed due to unexpected interferences with existing cable and space reserved for LS3 installation. **New cable trays will be installation in progress, additional stop due Smoke Pipes in UL55X which have to be modified HV cables not in place before 20 Oct, (Risk to be ready only from 10/15th November) than need to be connectorized**
- RO Fibers routing completed
- Radmon cables routing completed, to be connectorized UXC side
- Gas system finalized

Schedule (GE1/1 services)

133	GE-1/1 service installation	16 days	Fri 21/06/19	Fri 12/07/19			100%	
134	GE-1/1 cooling installation	3 days	Fri 21/06/19	Tue 25/06/19	117,122FS+3	ZEC 3p	100%	GEM
135	Service power cabling US-UX	2 days	Wed 03/07/19	Thu 04/07/19		RTech	100%	GEM
136	GE-1/1 cooling installation	3 days	Mon 08/07/19	Wed 10/07/19	218	ZEC 3p	100%	GEM
137	GE-1/1 gas leak test (1st day access to the nose to check f	2 days	Thu 11/07/19	Fri 12/07/19	136	ZEC 2p	100%	GEM
138	Gas leak test on new muon US-UX pipes	2 days	Wed 26/06/19	Thu 27/06/19	134	ZEC 3p	100%	RPC,GE
232	GE-1/1 installation and commissioning	106 days	Mon 15/07/19	Fri 13/12/19			19%	GEM
233	GE-1/1 Chamber Plate Installation	2 days	Mon 15/07/19	Tue 16/07/19	136,137	Setphine	100%	GEM
234	GE-1/1 OF PP on X2 & X5	2 days	Wed 17/07/19	Thu 18/07/19	233	Michele,M	100%	GEM
235	GE-1/1 LV cable installation	4 days	Fri 19/07/19	Wed 24/07/19	234	RTech4	100%	GEM
236	GE-1/1 chamber instllation I	2 days	Thu 25/07/19	Fri 26/07/19	235		100%	GEM
237	GE-1/1 LV cable installation	1 day	Mon 29/07/19	Mon 29/07/19	236	RTech4	100%	GEM
238	GE-1/1 OF installation	7.5 days	Mon 29/07/19	Wed 07/08/19	236	RTech2	100%	GEM
239	GE-1/1 Gas pipe cutting	1 day	Wed 21/08/19	Wed 21/08/19			100%	GEM
240	GE-1/1 HV cable installation Near	5.5 days	Fri 16/08/19	Fri 23/08/19	109FS+3.5 day	RTech4	100%	GEM
241	GE-1/1 HV cable installation Far	7 days	Mon 26/08/19	Tue 03/09/19	240	RTech4	0%	GEM
242	GE-1/1 cabling work in X4 Near rack	1 day	Fri 30/08/19	Fri 30/08/19		RTech4	0%	GEM
243	GE-1/1 Radmon cable installation	2 days	Wed 04/09/19	Fri 06/09/19	241	RTech2	0%	GEM
244	GE-1/1 48DCV Service Power & Communication US-UX Ins	4 days	Wed 28/08/19	Mon 02/09/19	241SS+2 days	RTech4	0%	GEM
245	GE-1/1 OF & Radmon US-UX installation	3 days	Tue 03/09/19	Fri 06/09/19	244	RTech4	0%	GEM
246	GE-1/1 OF & Radmon US-UX installation	3 days	Tue 17/09/19	Thu 19/09/19		RTech4	0%	GEM

Task completed

Toward Commissioning #1

- Currently no cooling is available at all (temporary cooling used to supply two SCs installed in July and used for August test dismantled to allow installation of new SCs)
- Final cooling expected in place by 11th Oct, if not unexpected problem will come, from 14th Oct 12 SCs could be supplied with final cooling (#13-14-15 and 28-to-36)
- Connectorization of LV power system in progress, but PP to connect USC to UXC not yet delivered, expected in two weeks, than one week for connectorization
- RO system (fibers) fully in place, On Disk/UXC PP/UXC-USC fibers; Fibers on PP to be plugged.
- HV cables finalized till balcony, HV system till USC will require at least two months

Toward Commissioning #2

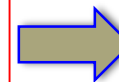
- What can be done next weeks:
- Quick tests, up to 3-4 minutes of LV Power ON, can be done almost any moment on all SCs installed (RO fibers in place), need only to plug RO fibers on SCs and ground on back flanges, few hours of work to to connect all SCs installed
- Long tests (like August) possible from 14th Oct on 12 SCs, but maybe only two SC at the time if LV PP not in place, eventually bench Power System and special LV cables adapter have to be used.
- No stable HV system available before end of Nov, this means no possibility of HV training for GEM foils possible before -> no ArCO₂ mixture in the SC before end of 2019
- MWGR of November 2019 could include the DAQ system and SCs without HV
- Cosmic data possible not before beginning / mid December 2019

Current schedule for Positive EndCap

371	GE+1/1 installation and commissioning	110 days	Mon 02/03/20	Mon 10/08/20			0%	GEM
372	GE+1/1 gas service installation	13 days	Mon 02/03/20	Wed 18/03/20			0%	GEM
373	GE+1/1 gas system installation	10 days	Mon 02/03/20	Fri 13/03/20	313	ZEC	0%	GEM
374	GE+1/1 gas leak test	3 days	Mon 16/03/20	Wed 18/03/20	373	ZEC	0%	GEM
375	GE+1/1 cooling service installation	12 days	Thu 19/03/20	Fri 03/04/20			0%	
376	GE+1/1 cooling installation Manif2PP	3 days	Thu 19/03/20	Mon 23/03/20	374	ZEC	0%	GEM
377	GE+1/1 cooling installation PP2CH	3 days	Tue 24/03/20	Thu 26/03/20	376	ZEC	0%	GEM
378	GE+1/1 3-way-valve installation & cooling leak test	6 days	Fri 27/03/20	Fri 03/04/20	377	ZEC	0%	GEM
379	GE+1/1 chamber installation	4 wks	Mon 06/04/20	Thu 07/05/20	378	Crane+	0%	GEM
380	GE+1/1 cable installation	30 days	Fri 08/05/20	Mon 22/06/20	379	RTech	0%	GEM
381	GE+1/1 commissioning	7 wks	Tue 23/06/20	Mon 10/08/20	380		0%	GEM

- GE1/1 + SCs Installation scheduled from 6th April (4 working weeks)
- GE1/1 + cables routing scheduled after the SC installation

Commissioning (no possibility to switch ON any SC) cannot start before July 2019 (including time for cable connectorization)



MuTCO for schedule modification required

GE2/1 services (Negative EndCap)

Services On Disk

- Routing of LV cables completed
- Routing of HV cables completed

Connectorization Rack Side both LV and HV will be performed only after completion of GE1/1 connectorization, **due to lack of manpower this task is treated as best effort, this could cause possible conflict in future with GE2/1 installation and commissioning**

- Gas system finalized and commissioned
- Cooling flexible houses installed, connectorization and connection will start on 2nd Oct
- **After the definition of the RO System (GBTx) would be fundamental to start soon the procurement of the GE2/1 RO fibers, may would be possible to proceed with their installation still in LS2**

GE2/1 Services Preparation Schedule (Positive EndCap) to be modified

306	YE+2 Activities	21 days	Mon 20/01/20	Mon 17/02/20			0%	
307	GE+2/1 service installation	21 days	Mon 20/01/20	Mon 17/02/20			0%	GEM
308	GE+2/1 gas system installation	18 days	Mon 20/01/20	Wed 12/02/20	305	ZEC	0%	GEM
309	GE+2/1 gas leak test	3 days	Thu 13/02/20	Mon 17/02/20	308	ZEC	0%	GEM

GE2/1 +EndCap services are scheduled to take place in two separated windows in 2020

- January/February: Gas System Installation and commissioning
- June/July: Cables and cooling

408	YE+2 Activities	30 days	Fri 29/05/20	Fri 10/07/20			0%	
409	GE+2/1 cable installation	25 days	Fri 29/05/20	Fri 03/07/20	407	RTech	0%	GEM
410	GE+2/1 cooling system installation	5 days	Mon 06/07/20	Fri 10/07/20	409	ZEC	0%	GEM

GE2/1 Modules Design

- Design mostly completed but still several point to be clarified and finalized
- **To be clarified:**
 - Copper layer on RO boards: is needed or not?
 - Grounding pads on RO boards (in case of copper layer) needed?
Slots on GEB already introduced
- **To be finalized:**
 - M4 / M8 HV pins position, imply limited modification of Drift/Internal Frames/ GEM foils
 - Gerber of ROB (modified for GEBs fixation points) and Technical Production specs for PCBs manufacturing

GE2/1 EDR Outcome

(General Comments)

- ***The priority of the GEM teams within the muon project should unequivocally be given to the completion, installation, commissioning and operation of GE1/1, whose successful operation as a triggering detector at P5 is a vital milestone for the whole GEM community.***
- *GE2/1 and ME0 designs (chamber technologies, electronics and readout) should be identical as much as possible*

GE2/1 EDR Outcome

(Comments on foils)

- *Double-mask technique used by Mecaro carries higher risk than the current CERN-single-mask technique, at least for large GEMs.*
- *The quoted yield of 70% at Mecaro, the re-cleaning requirements of 7-8% at CERN, plus some initial issues with Mecaro foils all point to the importance of cleanliness (and homogenous cleaning procedures) at all points of the production.*
- *Understanding the capability of the Korean teams to react to production problems, to avoid relying excessively on CERN QC feedback. Prompt QA/QC should be in place both at the supplier and at CERN for the first production foil deliveries of each type and each batch (picking up rapidly issues such as the initial M7's showing lower gain than expected, due to etching time anomalies).*

GE2/1 EDR Outcome

(Mechanics, Installation & commissioning)

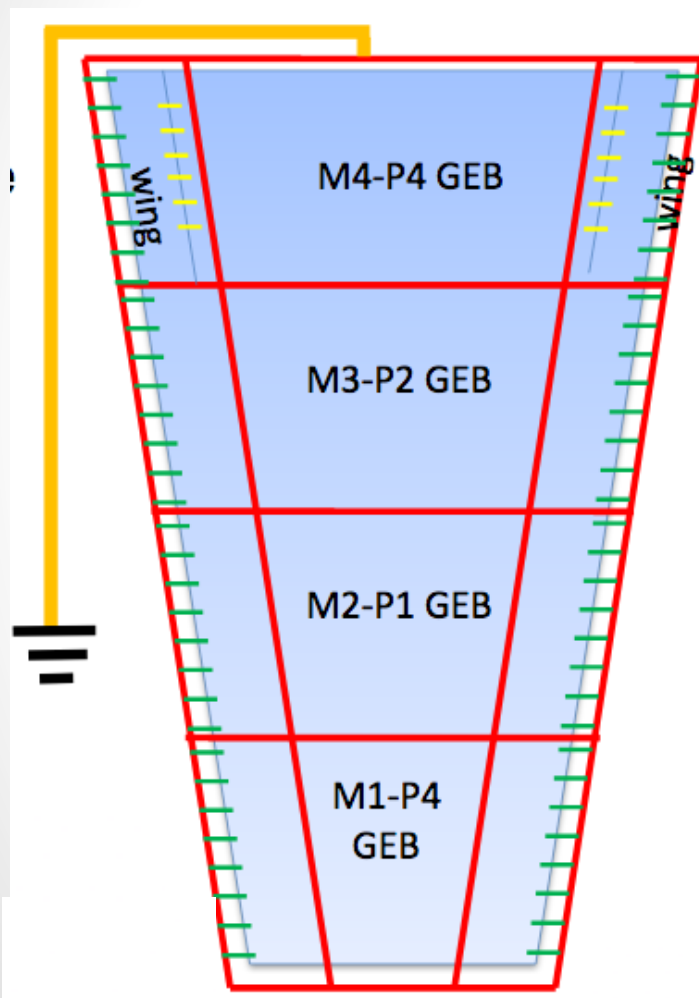
- *Analysing, before production starts, the grounding and shielding concept (in consultation with Sergei Lusin from Technical Coordination), along with galvanic contact/isolation between neighbouring conducting surfaces.*
- ***Conduct a trial installation with the final mounting structures before the end of LS2.***
 - ***Currently design and prototyping is stuck, people (A.Conde / S. Brachet) working on installation of GE1/1, finalization of GE2/1 Modules/GEBs design and ME0 integration in the new Nose***
- *Re-designing the installation beam, with moveable counter-weight anchored on a sliding mechanism on the beam, and adjustment via a hand-cranked worm gear, and making a second installation beam to allow for the possibility of installing at both ends simultaneously*

GE2/1 EDR Outcome

(Chamber QA/QC)

- *Anticipated move of assembly and QA/QC central control away from CERN group responsibility needs to be handled carefully to maintain the appropriate match of responsibility and authority.*
- *Since chamber assembly is scheduled to start in March 2021, a **conflict may arise**, for certain skill-sets, **with GE1/1 commissioning with beam, which, as mentioned above, must take priority in the GEM group over GE2/1 and ME0.***
- *Choosing high quality, radiation-tolerant, verified components, with generous safety margins, for all on-detector systems. In particular, the risk of capacitor failure or current leakage should be assessed carefully. Amongst many failure instances recorded, the recent observation of shorts of 5kV SMD HV supply filter capacitors operating at approximately 4 kV in LHCb triple GEMS is particularly notable. Radiation damage is the suspected cause.*

Chamber integration



- Frame
- Copper braid
- GEB grounding
- Frame grounding
- Wing-GEB connection



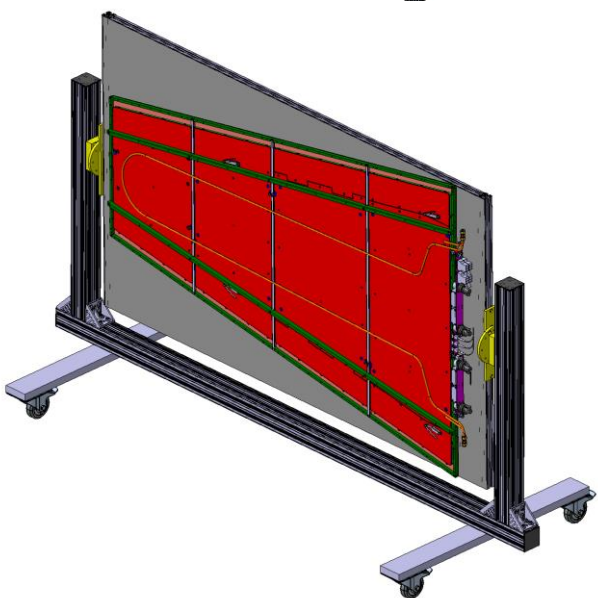
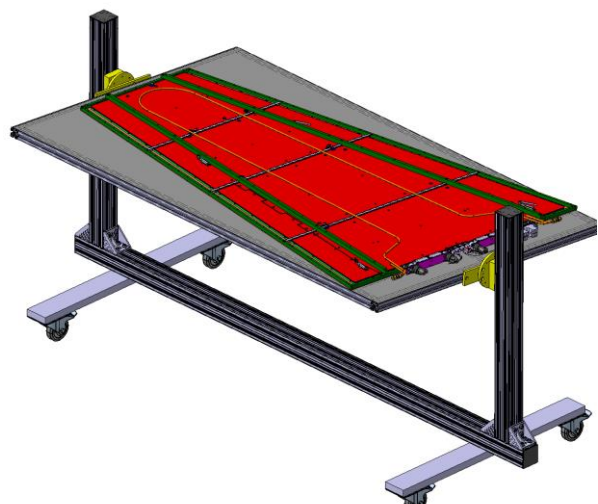
Electronic/Mechanics integration proceeding fine in 904

Prototype of GE2/1 cooling circuit now expected at CERN for 4th November

Integration tests will take ~ 3 days, this will require interruption of electronic studies for about a week

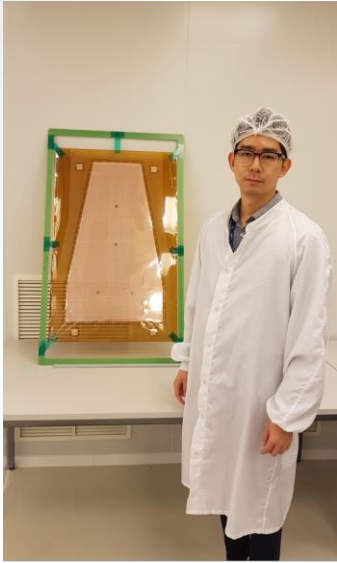
Camp for electronic studies, focusing on sparks protection currently scheduled second half of November

GE2/1 Tooling & Tech Support

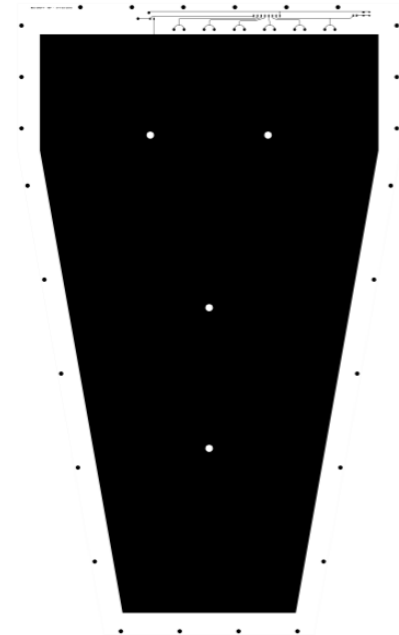
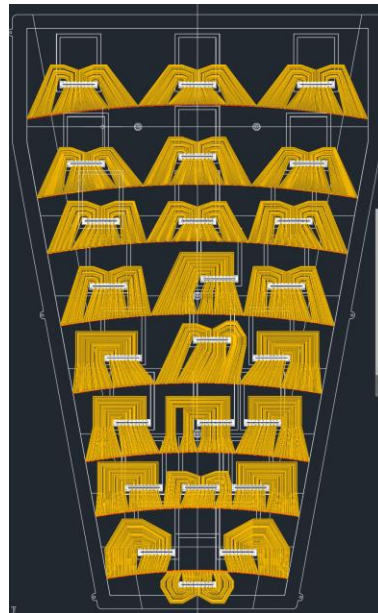
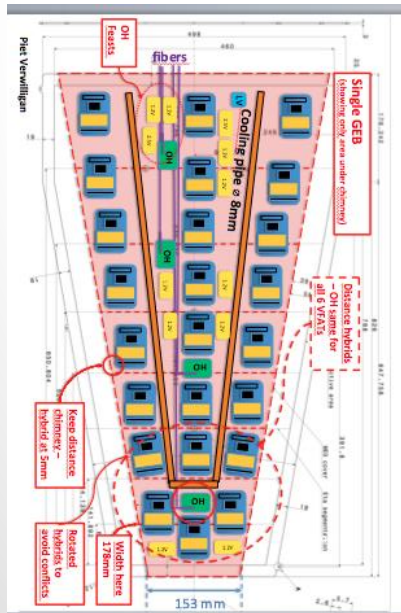


- Several tools are needed to proceed with GE2/1 integration tests: Cooling Infrastructure, Rotating Table (for common tests with CSC), Cosmic Trigger System, Discharge Tests,
- No dedicated manpower for technical design & mechanical GE2/1 activities
- From spring/summer 2020, even the limited support provided by CERN will be reduced due to reduced CERN crew
- ***GEM community need to plan for almost continuous technical support for GE2/1 integration activities at CERN, may shared with the activities of material acceptance (QA/QC) for modules mass production***

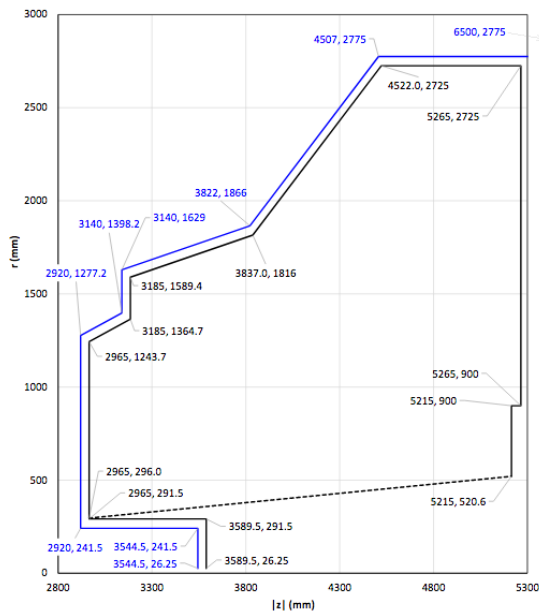
ME0 Module Design & Prototype Construction



- ✓ *Reduced space under the chamber cover make challenging the organization of the electronics and cooling on the Readout Board; finalized in May 2019*
- ✓ *Rest ME0 Module design already completed and used to lunch prototype production*
- ✓ *Foils with double face segmented layout have been chosen*
- ✓ *9 Prototype modules in preparation at CERN to be used both for R&D, Mechanical Integration tests and Electronics Integration tests*
- ✓ *Two modules kits will be shipped in FIT for local/integration test, two (or more) will be assembled and qualified in Bari, other modules, for first stack integration, assembled and qualified at CERN*



ME0 stack design



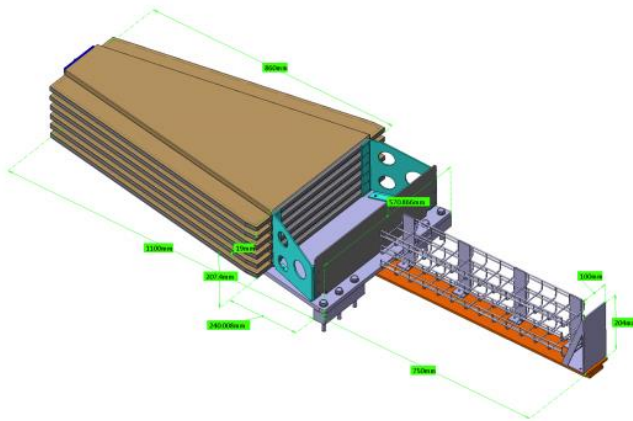
■ Mechanical Design

- HGCAL Envelop have been defined, space for ME0 stack insertion confirmed but continuously under attach form HGCAL-mechanical-group, we have to be ready to provide strong argument against space reduction which will downgrade ME0 to 5 layers stack
- HGCAL fixation point to HE back flange not yet finalized, this could require the design of two special Stacks per EndCap at 3 and 9 o'clock, discussion and studies ongoing in the integration group

- **Technician/Engineer with experience with CATIA is needed to support the ME0 design, as suggested by A. Conde, someone with permanent position able to follow for long time (till LS3) the evolution of ME0 design spending 20/30% of his time on this task is needed, visits at CERN to align the work with A.Conde and Integration Office will be also necessary**

■ Electronics Design

- CMS-internally discussing a FPGA-less solution completed, Change Control done.



Manpower

- Manpower for GE2/1 technical support and ME0 design discussed above.
- Expert in detector mechanics to work with integration team and TC (triad) is needed to be identified asap
- For Activities in P5:
 - GE1/1 Chamber installation and services finalization (by the end of 2019) are almost secured with the expected manpower contribution promised up to now
 - About three additional months of technicians with electronics skills and possibility to work in the cavern have been requested during last IB, only one have been covered by Bari group
 - **HV/LV connectorization cannot be demanded to Phd student, simply not possible!!!**
 - As for GE1/1 Negative endcap, also for the Positive endcap SCs installation, cables preparation/installation/connectorization will require about 16/18 months of technicians at CERN, detailed schedule with topic period will be circulated soon
 - Additional 8 months have to be considered for GE2/1 (including what not done on Negative Endcap in 2019)

Summary

- Despite several concurrent problems, GE1/1 installation is almost on track
- Delay on HV cables installation (USC-UXC) will not allow to have HV power before beginning/mid Dec 2019
- Late arrival of LV USC-UXC PP, will prevent complete LV powering before end of October
- Schedule for P5 GEM activities in 2020 need to be revised, currently several critical points both on GE1/1 and GE2/1
- Full list of presences for technicians at CERN for activities in the cavern (2020) will be circulated as soon as the schedule will be clarified/fixed
- Almost absent technical manpower for GE2/1 integration support in 904, this will start to impact more and more in the next months on ongoing integration tests
- ME0 integration proceeding very slowly, in shadow of GE1/1 and GE2/1, but Integration Office requiring more feedback for common space/services definition, Technicians/Engineer with experience with CATIA is required
- Full week workshop, should be avoided during critical production/installation period, people already overstretched with regular tasks

Backup

GE2/1 EDR Outcome

(Schedule)

- Scheduling GE2/1 installation simultaneously with other GEM assembly and testing is acceptable, given the short time window involved and the overall planning constraints
- The project should consider how to prepare for various alternative scheduling options, in particular a fall-back baseline where there is a pilot installation of some fully working GE2/1 detectors in one endcap in YETS 21-22, followed by full installation at both ends simultaneously in the EYETS 22-23 (although it was noted that a present RE3/1 or 4/1 installation is already on the menu for these YETS).
- CMS management should be informed about delayed funding issues and should act appropriately, as resources allow, to help resolve them.
- The project contributes actively to studying the balance of risk between delay mitigation within the current schedule, versus the options for schedule evolution (eg extended YETS in 2022-23 and corresponding delays to LS3 start), that could form part of an overall CMS position assuming that modifications to the CERN planning are considered later in 2019.