Summary of installation plans from LS2 to LS3

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Overview

Reminder: goals of the session

- For project X:
  - Detector geometry, 3D envelope requirements and constraints/conflicts
  - Impact of considered on integration, installation and schedule
  - Integration and installation plans
  - Present understanding of services, infrastructure and tooling requirements
  - Tasks which can/should be anticipated
  - Installation and integration timeline –vs- official schedule
  - Manpower: needs/training. Synergies with other projects
  - Priorities and main issues to be addressed

Contributions

- GE1/1 station (A. Marinov):
  https://indico.cern.ch/event/614702/contributions/2521030/attachments/1431659/2199434/GE11_Installation.pdf
- DT minicrate replacement (D. Fasanella):
  https://indico.cern.ch/event/614702/contributions/2521032/attachments/1431675/2199572/UpgradeWorkshop_DT.pdf
- Inner ring CSC electronics refurbishment (D. Morse):
  https://indico.cern.ch/event/614702/contributions/2521031/attachments/1431648/2199426/20170322_Morse_CSCMEx1_RefurbishmentAndPlans.pdf
- RE3/1 and RE4/1 rings (I. Crotty):
  https://indico.cern.ch/event/614702/contributions/2521033/attachments/1431670/2199726/IntegrationRE31412123March2017V3.pdf
- GE2/1 ring (A. Marinov):
  https://indico.cern.ch/event/614702/contributions/2521034/attachments/1431662/2199437/GE21_installation.pdf
- ME0 station (M. Bianco):
  https://indico.cern.ch/event/614702/contributions/2521035/attachments/1431610/2199562/MBianco_2017_03_22_RS.pdf

Detector geometry and open issues 1.

- CSC and DT projects are “modification of existing”. System geometry parameters remain, for most part, unchanged
  - DT considers 3 minicrate replacement options offering different pros/cons:
    A. Remove old and install new → requires full DT+RPC uncabling and complex integration (services)
    B. Install new inside old → less invasive (cabling and services)
    C. Install new on top of old → more like option 2 with in addition maintenance gain

  Tests ongoing, attempt to select best option by June CR, based on DT-RPC consensus

- GEM and RPC projects “add to the existing”
  - GE1/1 envelope well defined by present, and hopefully future (tbc), YE1 nose design
    - Demonstrator installation was the proof of principle: detector fits, even though some corrections on-the-fly were required. Suggest documentation/traveller

Detector geometry and open issues 2.

- RE3/1 and RE4/1 to cover up to η=2.4-2.5 need to be spaced off the disk to miss the radiation shielding
  - This brings to a reduction of the z-envelope and poses strict constraints on chamber design, including electronics
  - RE4/1 mounting requires “special frames” to be designed and tested
- GE2/1 has similar constraints in z-coord as REs
- Both RE and GE would interfere with present endcap h/w alignment laser system. The plan is to decommission the system – agreed by Muon

- ME0 ($2<\eta<2.8$) with 6 layers (on the back of HGC) would allow for ~9mm clearance (in z). This is too marginal considering the >15mm bending of the iron (towards IP) in this region when B is on

- Need to carefully address detector clearance issues. Real size mock-ups to be installed in LS2 would seem a viable risk prevention approach.

Installation and Integration

- GE1/1 demonstrator indicated that installation was far more complex and time consuming than originally anticipated.
- GE1/1 and GE2/1 require chamber installation tools for safe handling. Question is whether one universal fixture can be designed to serve both installations, perhaps using an “adapter frame”.
- A similar tool needs to be designed and built for RE31 and RE4/1. All lifting equipment must be approved by CERN safety!
- RE4/1 mounting frames should be installed
- RP must agree that CSC activation level is suitable for transportation to surface lab
- ME0 needs a dedicated study which must be done in close coordination with HGC project [Phase2 Engineering and Integration Forum]
- We seem to be lacking some dedicated engineering resources or need to find ways to share existing competences

Logistics in UXC

- The second crane (available from LS2) should bring considerable benefits to parallel work. Installation scheduled at LS2 startup
- Our effort should be to consider Muon installations in any shutdown **globally**, in the sense of:
  - Access to crane –vs- installation tooling. Lifting platforms (cherry pickers, scissor lifts)
  - Contribution from TC central teams (cabling), CMS contractors (cooling, gas services and tests) and CERN technical services (integration, gas, cooling infrastructures)
  - Optimize wheels/disks configurations, permanent scaffolding
  - Share expertise
  - Look at commonality between projects – do not reinvent the wheel
  - Merge installation teams when timeline of project X is very tight

Infrastructures and services

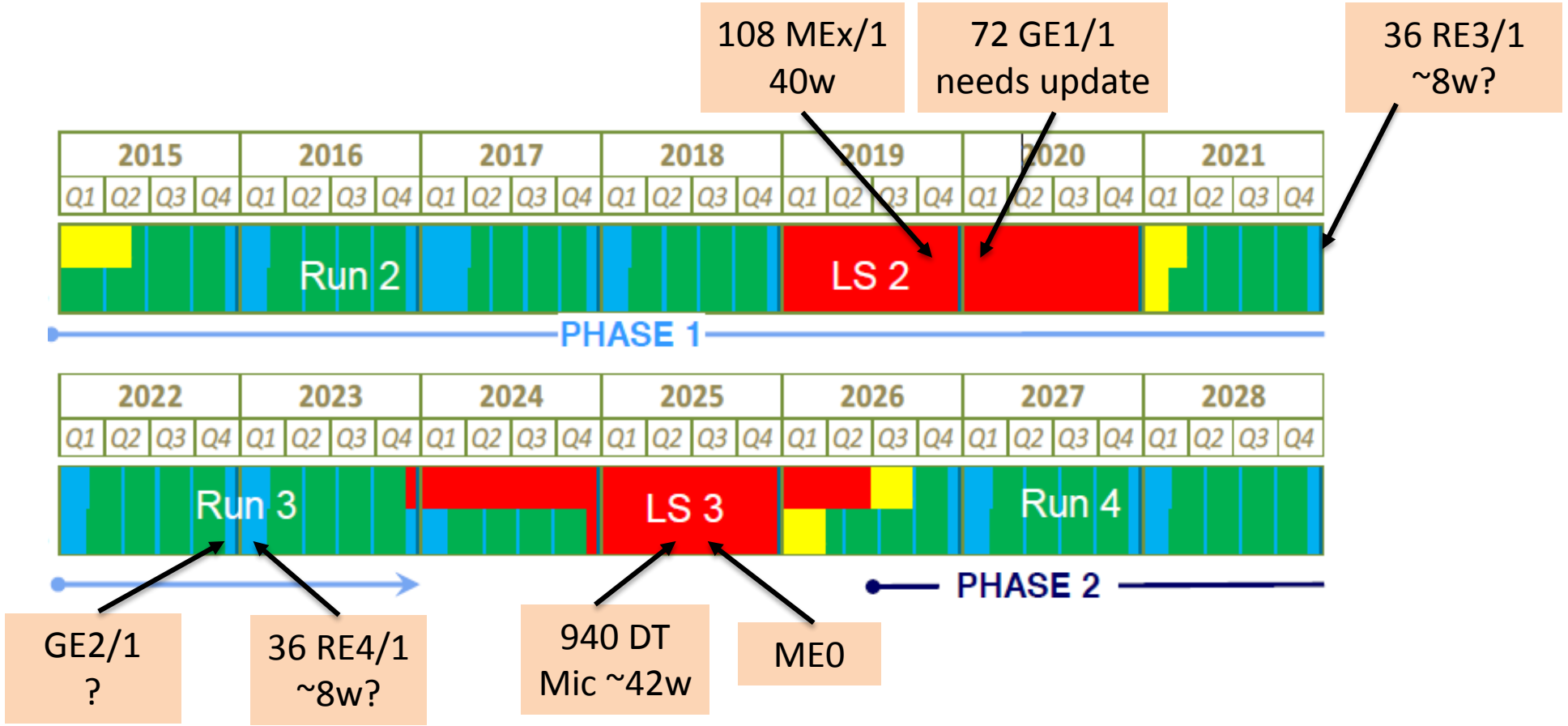
- Cabling is a serious concern, particularly for projects planning installations during YETS
  - DT (LS3): new minicrates require extra cabling space
    - A practice test in LS2 is planned using one of options of slide 4
  - GE1/1 on-disk cable routing does not need –to some extent- to be final in LS2 since in LS3 will need to be undone completely for nose rebuilding
  - Cabling in main-chains (GE, RE) and mini-chains (GE2/1, RE) requires careful planning
    - Present mini-chains have reached packing factor limit – going beyond (if at all feasible) is at risk of structural integrity and disk opening safety. We need to insist with TC for designing additional mini-chains
- Pre-empt what can be anticipated
  - USC to UXC cabling. Installation on towers and balconies
  - Detector services (gas and cooling pipes) cannot be installed prior detector installation, AFAIK. Commissioning is a time consuming task (e.g. leak testing). Such activities have large impact on schedules – compared to detector installation

Services: cooling

- New detectors need to check their on/off detector total heat dissipation, establish their cooling needs and prove compliance with existing system capacities
  - DT minicrate integration options lead to different cooling design/requirements
  - Cooling needs of new RE electronics higher than standard electronics? Does FE electronics placed between chamber and disk increase requirements?
- For ME0 we need to design the cooling supply infrastructure from scratch
- YE1 endcap cooling circuit capacity is at limit. There are no more cooling branches available. Pickup from exiting pipes, via T-connectors, is not the obvious solution – flow considerations. I am not sure it will reliably perform with new HE, GE1/1, GE2/1, ME0. This is serious
- YE3 needs study as well
- Barrel cooling system seems to be ok

Projects timeline and schedule

- **All projects rely on very aggressive plans, particularly those scheduled for YETS, obviously since YETS is >~15 weeks**



Scheduled

- Refurbish 108 ME234/1 on-chamber electronics
- Install 72 GE1/1

Additional

- DT Minicrate slice test installation – perhaps removal?
- Dismount 36+36 RE4s - to allow dismounting of ME4/1 – and bring to storage
- Trail installation of GE2/1, RE3/1 and RE4/1 mock-ups?
- Install RE4/1 mounting frames (after ME4/1 electronics refurbishment)?
- Install additional mini-cable chain in UXC balconies? Then, perform RE3/1, RE4/1, GE2/1 USC-to-UXC cabling?
- Install power units and integrate new crates inside tower racks?
- Maintenance

YETS 21-22 and (E?)YETS 22-23

Scheduled

- Install 36 RE3/1 and 36 RE4/1
- Install 72 GE1/1

Additional

- Maintenance

Scheduled

- Replace 940 DT minicrates
- Install 36 ME0 as part of the new YE1 nose

Additional

- Remove 72 GE1/1, 216 ME and 144 RE detectors from YE1s and bring to storage
- Strip off all cables, fibers, pipes from YE noses and YE1 radial cable trays
  - Many components will be broken and will need to be replaced → expect M&O cost inflation
- YE1 reinstallation and re-commissioning is equivalent to a “new project”, requiring same level of participation and coordination
  - Extra load on GEM group (new ME0, old GE1/1)
  - Very heavy on RPC (barrel + YE1)
  - Heavy on CSC
  - Many large teams to work simultaneously
- Maintenance

Labs & Storage

Labs

- B904, TIF: detector production, assembly, testing (GEM, RE?)
- SX5: detector refurbishment (MEx/1 before and during LS2)

Storage @P5

- LS2
  - 72 RE4 in a clean, climate controlled space requires ~200m^2 floor space
- LS3
  - 432 muon chambers (GE, RE, ME) requires ~1000m^2 floor space, equipped with:
    - HVAC
    - Gas for 3 systems
    - Power, racks
    - Testing and re-commissioning stands
- CMS TC is aware of our needs and is actively searching for optimal solutions

Conclusion and Outlook

- We all appreciate the considerable effort by all projects to address general installation and integration issues.
- Considered individually all plans appear to be reasonably thought out, and the issues are given appropriate attention. In general:
  - we know how to do things. In some cases we haven't yet figure out the best approach.
  - However, assuming Chf is not an issue, the two open questions are: **timeline and person-power**
- Reality is by far more complex, and we still fail to look at the Muon upgrade as a global effort.
- We should expect maintenance to become more demanding in future
- If we think of the Muon group in the future (LS2, YETS, LS3 and beyond) as a better integrated entity than it is now, we cannot continue to plan P5 work at those times as a bare sum of independent efforts, sometime even conflicting with each other. Our community cannot sustain a "duplication model" (teams, engineers, experts, etc.) forever.