Muon Spectrometer

The excellent overview and breakout presentations described the overall scope of the project, how it fits into the current detector and the motivation for the upgrades. Specifically, we were convinced that the upgrades covered by US NSF scope, were necessary as follows:

1) To cope with the high rates of HL-LHC, the readout electronics of the MDT system must be replaced
2) To reduce fakes and improve trigger efficiency, pT selectivity of tracks for the trigger needs to be improved by integrating the MDT info into L0 trigger
3) MDT chambers in the inner layer must be replaced with smaller MDT chambers (sMDT) to allow space to install RPC

A clear and consistent picture, show the flow of data from the MDT chambers to Mezzanine to CSM to L0MDT help the reviewers understand the big picture and made it clear that the project as a whole was well integrated and well motivated. Interfaces to other systems are well defined.

Comments:
A huge amount of material was presented, making it clear that this is a project operating at a world class level, both in terms of management and technical level. The presenters attempted to strike a balance between presenting information directly in the slides for both the L2 presentation and each of the L3 presentations and having pointers to other documents- making the presentation shorter and “crisper” but risking making the sheer volume of information more confusing and harder for the reviewers to navigate.

The charge to documentation map was very helpful in navigating to the documents.

1. Completion of design and development phase:
    a. The project has achieved the necessary level of technical preparation and readiness to begin construction.
        i. 6.1.1 sMDT tubes and chambers
            1. Findings:

            The MDT design is mature and has been frozen for some time. The only difference is the shorter length of the tubes. The project has been reviewed by international ATLAS and has been found to be ready to go into production (EDMS-2048104). This WBS is expecting to receive site certification for tube production and this will mark the readiness for MREFC.

            2. Comments:

            This WBS has a compelling story to tell. The proponents should make more direct connection between the physics goals and the technical specs such as the wire position and tube alignment specs.

            The WBS item is ready to proceed to FDR.

            3. Recommendation: None
        ii. 6.6.3 TDC

1. Findings:

The TDC is making good progress towards readiness for production but the v2 prototype is expected to be submitted in Sept and therefore the results will not be available in time for the FDR review- but should be available in time for the beginning of the MREFC period. The TDC does meet all specs but lacksTMR protection. TMR is being added to the V2 TDC prototype and if it is successful, the TDC will be ready to move forward to radiation testing and pre-production.

2. Comments:

TDC presentation lacked technical details regarding TMR implementation and testing.

The prototype v2 testing is a pre-MREFC critical path activity and closely coupled to the start of MREFC activity - “pre-production design start”. Hence any delays in the prototype v2 may be flagged in the FDR as issues that may delay readiness for MREFC

The WBS item is ready to proceed to FDR.

3. Recommendation:

The QA and QC plan should add details describing how the testing of TMR protected parts of the chip are to be handled.

iii. 6.6.4 CSM

1. Findings:

CSM has made significant progress since the PDR review. The CSM prototype vI testing which began in Jun 2018 has achieved many successes including demonstrating integration with the legacy Mezzanine cards. This WBS appears on track to complete v2 prototype in the fall of 2019 and to complete testing by the end of calendar 2019.

2. Comment:

There was not enough time to drill down into some of the technical details regarding the technical choices for the changes from v1 to v2. For example, the need for the lpGBT given the success achieved with the GBTx, the architecture of the lpGBT to GBT-SCA communications, the choice to use FEAST or bPOL (which one?) and so on.

There appears, on p11 of the CSM L3 presentation a diagram that shows a “Fanout ASIC” which does not appear elsewhere in the documentation. In the BOE, this appears to be an Artix FPGA. Is the diagram on p11 a typo or out of date? This may raise questions in the FDR review.

The WBS item is ready to proceed to FDR.

3. Recommendation:

Clarify the motivation for the differences between the successful v1 prototype and the v2 prototype currently being designed.

iv. 6.6.5 L0 MDT

1. Findings:

The L0 MDT Trigger Processor consists of a relatively small number (87 including spares) of board pairs based on the Apollo architecture. The pair consists of a service module and a command module. The command module carries the large FPGAs and all optical links. The service module handles external control and blade infrastructure. The WBS 6.6.5 scope includes the design and production of all the service modules, the production of about half of the command modules (design by MPI) and about 75% of all the firmware. This WBS appears to be making reasonable progress towards the MREFC milestone.

2. Comment:

- The L0 MDT Trigger Processor sits at the center of the MDT system and has bidirectional links to the SCM, Sector Logic and FELIX. This makes clear, agreed upon interface specifications critical. However, this seems to be in good shape with interfaces to the MDT CSM (EDMS2054329), Sector Logic (ATL-COM-DAQ-2019-101 & ATL-COM-DAQ-2019-103), TDAQ (EDMS 1563801), and even DCS (EDMS 1992002). However, the reviewers could not easily access the ATLAS internal notes listed above, though the presenters offered to make them available.
- The availability of tested and functional service module and command module demonstrators is a critical path item and defines the end of pre-MREFC activity and should be watched carefully, tracking the pre-MREFC milestones. Delays in meeting these milestones could lead to delay in MREFC start.
- The WBS item is ready to proceed to FDR.

3. Recommendation:

Make all documents referenced in the review available to the reviewers.

b. The project's scientific and technical contributors are credibly expected to accomplish the proposed work scope within the requested budget and schedule duration.

i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0MDT

1. Findings: The team members have decades of experience and experts in their respective areas. They will be able to deliver the project.
2. Comment: The BOEs seem well thought out and high quality. At this point in the project, the schedule seems reasonable though

some of the goals listed to be accomplished before MREFC seem aggressive (e.g. 6.6.4)
3. Recommendation: None.

c.

d. The project has finalized all necessary commitments and partnerships, including definition of project deliverables, performing organizations, and schedules.
   i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0 MDT
      1. Findings: Each of the subsystems presented a list of collaborators, both US institutions and international partners (mainly MPI). The project schedule and deliverables are also well defined.
      2. Comment: none
      3. Recommendation: none

e. The project has a defined acquisition strategy for purchased items. Designs, specifications and work scope comprising bid packages to industry are in advanced states of maturity and available for NSF review. Bid packages to be released in FY2020 are sufficiently clear and well defined as to be ready for bid.
   i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0 MDT
      1. Findings: Detailed quotes for M&S items have been obtained. Procurement plans were presented. Bid packages have not yet been developed.
      2. Comment:
      3. Recommendation: none

f.

g. Tools and technologies needed to construct the project are available. Industrialization of key technologies needed for construction is complete.
   i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0 MDT
      1. Findings: We find that the tools are well advanced and there are no new technologies required for construction.
      2. Comment:
      3. Recommendation: none

2. Project Scope
   a. Project documentation describes how the construction-ready design is derived from the flow-down of science goals to science requirements then on to technical performance specifications and requirements. The documentation is in a format that enables traceability, is clearly explained, and is aggregated into a dedicated section of the PEP.
      i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0 MDT
         1. Findings:
            a. The flow-down of science goals to science requirements are well motivated and they are documented in the respective subsystem TDRs, though not always in a

easy-to-trace format. The technical specifications are also developed and they are documented.

   b. The driving factors (and how they are connected to realizing the momentum resolution goal) which led to the technical specifications, for example the location precision, tube location precision on chamber and the alignment platform precision on chamber etc. are not easy to find. We reviewed the TDR, chapter 6 and were not able to find how these precisions were obtained http://cdsweb.cern.ch/record/2285580/files/ATLAS-TDR-026.pdf]. There is some info in section 2.2.1 of the TDR. The documentation is not in a format that enables EASY traceability.
   c. The Muon Trigger Requirements (in the current US ATLAS HL-LHC Science Flowdown document) state that "MDT chambers used in L0 trigger" is a requirement, but there is no upstream goal motivating that requirement within the same document. Such an upstream goal might be: "Increase the acceptance of some-physics-process". Which could then be followed by: "Increase the muon trigger efficiency in the barrel from 65% to 95%". Which then, finally, motivates the requirement in the current Science Flowdown document that states "MDT chambers used in L0 trigger".

2. Comments:
   a. It would be helpful to provide a mechanism that facilitates quick and easy drill-downs on the Science Flowdown during a review. Currently, the ability to find specific science goals and the corresponding science and engineering requirements are sometimes hidden deep within large, complex, external technical documents that are difficult to navigate and digest by reviewers. When providing references to external documents for particular scientific or technical requirements, the proponents might consider including fully specified pointers (for example, the page number) that enables easy traceability to the particular requirement in question.
   b. Please double check and ensure that the US ATLAS HL-LHC Science Flowdown document reflects the most recent requirements (the current document dates back to 2017).
3. Recommendation:

a. Develop documentation, clearly showing the connection between the science requirements and technical specification, to convince a review committee that the specifications are science-driven. Additionally, in the Science Flowdown document, please ensure that all downstream requirements can be self-consistently traced to at least one upstream requirement within the same document.

b. All detector functions and requirements are reflected in the Performance Measurement Baseline.
   i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0 MDT
      1. Findings: The technical specifications were provided for all subsystems. In many cases these are EDMS documents and in many cases the subsystems have gone through international ATLAS reviews. As a result there is very good and thorough description of the detector functions and there are milestones to track the progress of the development required to meet these.
      2. Comment:

      It might be helpful to the reviewers for the L3 presentations to highlight the milestones that will allow management to measure the progress of development on all the detector functions and requirements, especially for those WBS items that may not have fully completed development before Apr 2020

      3. Recommendation:

      None

   ii.

c.

d.

e.

f. Specialized technologies enabling the scope fabrication are sufficiently mature to begin construction.
   i. 6.6.1 sMDT
      1. Findings: tube and chamber construction does not use any specialized technologies
      2. Comment:
      3. Recommendation:
   ii. 6.6.3 TDC
      1. Findings: The first prototype of the TDC ASIC has been designed, fabricated and tested, no design problems found so far. A second prototype with TMR will be submitted for fabrication soon.
      2. Comment: The project is on track for start of pre-production design in April 2020, and has production scheduled for May 2021.
      3. Recommendation:

iii. 6.6.4 CSM
   1. Findings: The proposed technologies are off-the-shelf; there are no specialized technologies to consider.
   2. Comment:
   3. Recommendation:

iv. 6.6.5 L0 MDT
   1. Findings: The proposed technologies are off-the-shelf; there are no specialized technologies to consider.
   2. Comment:
   3. Recommendation:

g. Technical scope elements of the performance baseline remain consistent with what was approved for advancement to Final Design stage following PDR.

i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0 MDT
   1. Findings: No technical scope has changed since PDR for sMDT, TDC, CSM. There has been a change to the strategy for the L0MDT. These changes have undergone reviews within ATLAS and are a simplification that leverages the Apollo platform and simplifies technical development.
   2. Comment:

   We feel the new approach is simpler and safer

   3. Recommendation:

3.

4.

5. Project management and the Project Execution Plan, including governance of the project, working with interagency and international partners, and subaward management.

a.

b.

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h.

i.

j. Performance verification and acceptance test policies for all deliverables are defined and complete. Documentation describes how acceptance tests will verify that deliverables meet design performance specifications and safety requirements.

i. QA plans and activities are integrated into the RLS.

ii. QA and radiation exposure policies are applied consistently across the project.

6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0MDT

1. Findings: yes. QA/QC procedures are documented and integrated in RLS.
2. Comment: The description of the QA/QC procedures are, for the most part presented in a very compact format and where appropriate, they should link to a more detailed document. There is no section for QA for the sMDT, since those tasks are complete- however, it would be helpful to link there relevant documentation.
3. Recommendation: none

k. There is a vetted safety plan and appropriate safety experts are available to the project to implement and oversee the safety plan.
   i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0MDT
      1. Findings: All subsystems have an ES&H plan and the relevant risks have been considered. Contacts responsible for ES&H at each institute have been identified.
      2. Comments: none
      3. Recommendation: none

l. Plans and justifications for fabrication of spares within the construction program are defined and well justified.
   i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0MDT
      1. Findings: yes, the fabrication of spares is defined
      2. Comment: in some cases, the justification can be strengthened, for example by specifying the assumed yield as is done in the TDC case (L0MDT, CSM)
      3. Recommendation: none

m. Plans and schedules for shipment of deliverables to CERN are credible and appropriately integrated into the RLS.
   i. 6.6.1 sMDT, 6.6.3 TDC, 6.6.4 CSM, 6.6.5 L0MDT
      1. Findings: yes, the plan is available where applicable.
      2. Comment:
      3. Recommendation: none