

UCG Report on the TDR for the Upgrade of the ALICE Time Projection Chamber¹²

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Findings:

- The motivation of the upgrade is to provide efficient tracking and PID with similar performance as the current TPC but at interaction rates of up to 50kHz in Pb-Pb collisions. Key physics elements such as low-mass di-lepton studies, measurements of heavy-flavour suppression, and quarkonia production rely predominantly on the TPC's performance. The TPC is crucial to the success of all ALICE upgrades. The original TDR (CERN-LHCC-2013-020, March 3, 2014) has been updated with an Addendum (CERN-LHCC-2015-002, February, 2, 2015).
- Upgrade of the Time Projection Chamber (TPC) consists of the replacement of the present MWPC-based readout chambers by a completely new design, consisting of quadruple GEM planes allowing the continuous operation without active ion gating, and new pipelined read-out electronics. Prototypes of the new readout chambers were tested extensively during the past year and meet the experiment's requirements for ion backflow blocking and energy resolution, although with only modest contingency.
- The total project cost has increased to 11.52 MCHF from the 2014 TDR value of 9.14 MCHF. The major factors are (i) a revised evaluation of the required QA efforts for the GEM foils, (ii) additional engineering and readout partitioning of the FEEs, (iii) the installation cost that were not considered in the TDR, as well as (iv) an increase in cost of the OROC due to the need for multiple production sites.
- The costs contain 1 MCHF for event processing nodes (EPNs) as a contribution to the Online & Offline Upgrade (O2). The collaboration has decided to include this item in the TPC upgrade budget.
- The production of the GEM foils will take place in the PH-DT Micro-pattern Technologies workshop at CERN and includes 50% spares. 40 inner (IROC) and 40 outer read-out chambers (OROC) will be produced of which 2x36 will be installed respectively; 4+4 spare chambers are kept for fast exchange (1-2 days) should that become necessary during final installation before transport into the pit.
- The production and assembly of the OROC takes place in different sites in Germany and Romania, while the IROC is manufactured in several institutions in the US. Final test and integration takes place at CERN. Project risks are mitigated by a moderate rate of chamber production allowing detailed quality tests after every production step, and by the final chamber qualification test at CERN.

Comments:

- The UCG appreciated the thoughtful and complete answers the ALICE collaboration has provided to the UCG and the quality of the written documents. Project costs, manpower need, and risk factors were estimated in sufficient detail; the milestones are well defined.
- The QA of the GEM foils is done at two sites (Helsinki and Budapest). The UCG notes that the cost-effectiveness and risk mitigation for this option was not presented.
- The TPC Upgrade is a very challenging project with an aggressive time schedule. Construction, testing and assembly will require a substantial amount of expertise and proficient project management. Critical items are the timely delivery of the SAMPA chip and the development and testing of multi-channel cascaded HV power supplies for the GEM stacks.
- The available and needed manpower profile has been shown broken down into physicists, mechanical and electronics engineers and technicians. The overall profile looks adequate.
- Project management and all groups involved have good experience from past involvement in the TPC construction and operation and new groups bring fresh expertise to the project.
- **We are concerned that the funding profile peaks very late with the largest expenditure of 5.6 MCHF in 2018, exposing the project to schedule risk if the FEC's are delayed.**

Recommendations:

- The cost and manpower estimates are found to be reasonable and should receive LHCC approval.
- Given the vital importance of the TPC for the whole ALICE upgrade program, the collaboration should establish a rigorous quality assurance and testing program to ensure that the chambers meet the requirements.
- **ALICE and the RRB SG should give special attention to the progress of the FEC production.**

¹ [CERN-LHCC-2013-020; ALICE-TDR-016](#)

² Addendum [CERN-LHCC-2015-002; ALICE-TDR-016-ADD1](#)