Report on DS Proto-0 run with mock-up MB

2019-10-16 Alexander Kish

The timeline of the integration and operation of the DS Proto-0 with mock-up MB is shown in Fig.1. After almost one month of assembly and preparation, the actual run with liquid argon in the vessel started on Oct. 11, and concluded on Oct. 16 at 16:00 CEST, when the open-mouth refills were terminated and the system left to warm-up.

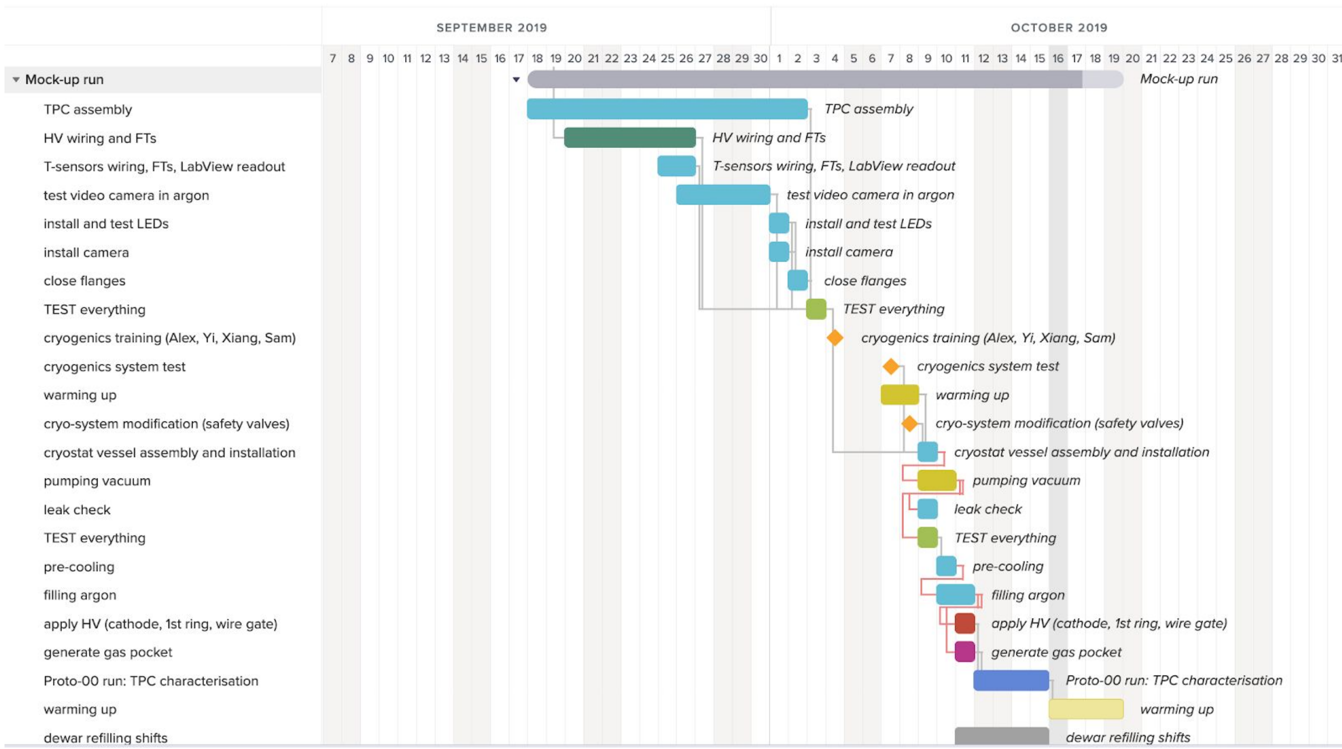

Fig.1: Timeline of the Proto-0 run with MB mechanical mock-up.

The assembled system (shown in Fig.2) was evacuated first with a roughing membrane pump, and then with a turbo-pump to the level of 1e-4 mbar. The initial pre-cooling started by filling open dewar with argon while TPC vessel is still under vacuum, and achieved slowly by radiation cooling. The subsequent cooling was performed by filling the inner vessel with liquid argon, resulting in cool-down rate of ~15 K/hour, limited by the rating required for the 5cm thick acrylic blocks which constitute the TPC.

In the assembly stage, the installation procedure for the mock-up MB has been established and documented by the PE group, as well as integration with further TPC components such as the anode, wire gate, field cage and the cathode.

In order to monitor and validate the gas pocket formation, in the absence of the photodetector planes in this mock-up run, a video camera was installed on the top flange, together with two LED strips illuminating the interior.

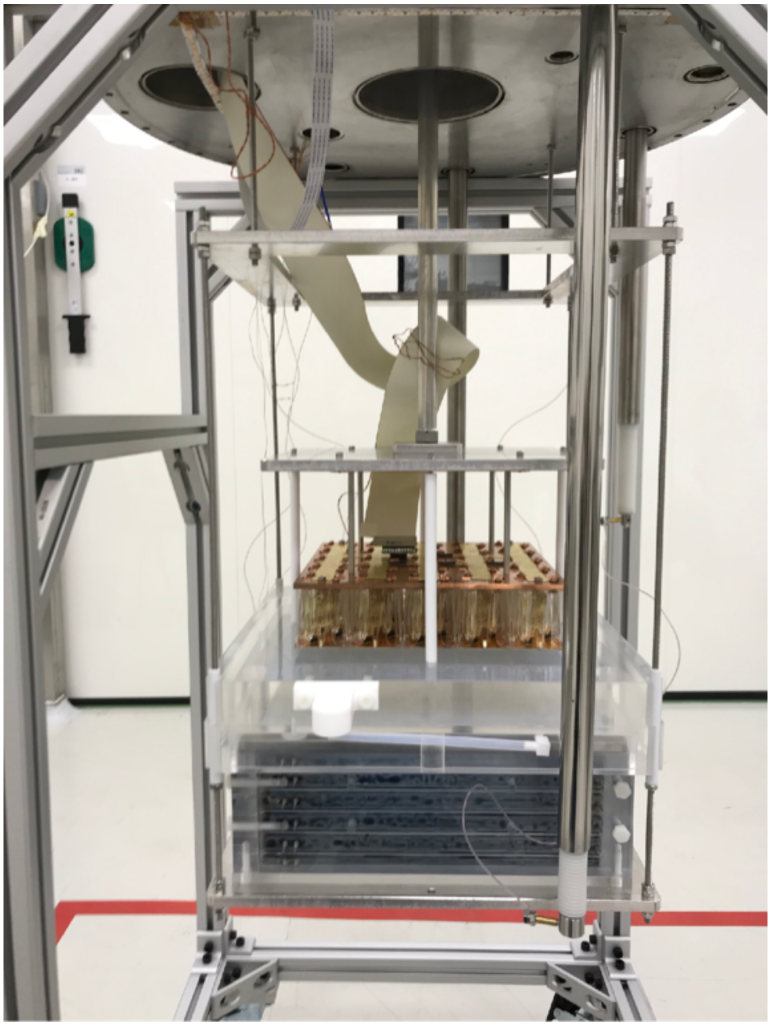

Fig.2: The DS Proto-0 TPC assembled with the mock-up MB on the top. A video camera is installed on the top flange in order to monitor and validate the TPC performance (i.e. gas pocket formation and stability).

Fig.3: An example of the video camera view field, where the TPC gas outlet can be seen (flexible PTFE pipe connected to the motion feedthrough with a threaded rod).

The sequence of operations on the Proto-0, presented in the timeline chart in Fig.1, can be chronologically summarized as follows:
1. Mechanical mock-up installation on the support structure
2. Assembly of the anode
3. Assembly of the field cage
4. Wiring the connections
5. Installation of the assembled TPC in to the vessel and transportation by the overhead crane to the experimental site
6. Evacuation of the system with a turbo-pump and a leak check with helium
7. Pre-cooling (filling the outer bath while the inner vessel was under vacuum, and injecting a small amount of argon gas into the inner vessel)
8. Cooldown and argon filling
9. TPC operation (applying HV to the electrodes, current through Pt-1000 resistors, varying P)
10. Warm-up

As part of photoelectronics tests, the wire bonds have been scanned after each intervention on the detector, including several steps of assembly and regularly during cool-down and argon filling, operation (including when varying pressure and HV), and final warm-up. The log file can be found at the following link.
During operation (7) it was found that channel 106 increased its resistance from 1.75kOhm to 2.15kOhm. The detailed cooling log is at the following link, together with the results of the scan during this period. The initial fluctuation (recovery after 10 min) on this channel was observed, when filling the open dewar was started to pre-cool the system (mostly by radiative cooling; inner vessel filled with a small amount of argon gas), and the temperature close to the mock-up MB was ~230K. After cooling overnight, and at the start of argon filling, the resistor stabilized at a higher value.
It is difficult to reach a definite conclusion on the exact cause of failure, mainly due to the absence of the pull tests and cool-down tests on the mechanical mock-up, and possibly worse quality of the copper substrate with respect to Arlon used for the actual motherboard. However, a visual inspection with a microscope after the mock-up MB is dismounted from the vessel might reveal some detail.
In general the wire bondings undergo quality control tests, such as immersion of the tiles into LN2 bath, as well as destructive tests on a large sample of bondings, consisting of measuring the force needed to lift the bonding foot or to splice the aluminium wire.
In particular, the pull test performed on 650 wire bondings on Arlon tile substrate (without SiPMs) showed that the force needed to destroy a single wire bind is consistently ~10g, for which 5g are sufficient to lift the wire.

The following studies have been performed **for the TPC** during operation (9), aimed at the optimization and finalizing of the TPC geometry:

1. Gas pocket creation with a bubbler (heat) and required power to maintain the gas pocket of about 10 square meters in area.

* This study has to be confirmed on larger scale at the planned depth with reasonable area in order to scale the power needed in real situation (~2m depth from the LAr surface).

2. Confirmation of Clevios conductive polymer: applied HV and tested the polymer-coated anode and field cage.
3. Confirmation of the proposed resistor link concept and the actual installation and functioning of the resistor link.