SoLID pre-R&D
Quarterly Progress Report

from May 1,2020 to July 31,2020

SoLID Collaboration

Contents

1 DAQ

1.1 Summary

This chapter summarizes the SoLID DAQ pre-R&D activities for the first quarter. The pre-R&D activities started at the beginning of 2020, while the full budget was approved on February 20, 2020.

The five main on-going tasks (A-E) for this pre-R&D are:

- A) GEM VMM3 readout high rate testing to determine trigger rate capability, behavior with pile-up and readout performance
- B) GEM APV25 readout high rate testing : show that 100 kHz trigger rate is achievable with existing readout hardware developed for SuperBigBite (SBS)
- C) FADC developments for fast readout and triggering
- D) Beam test of gas Cerenkov readout with analog sums and MAROC chip
- E) Time of flight using the Hawaii NALU sampling chip

There were four milestones by the end of the first quarter. Three (A1, D1 and E1) have been completed. For the fourth (C1), the work is on-going, while another milestone C2, which is scheduled to be completed by October 1, 2020, has been completed. Details are described in the next two sections. A digital trigger was developed and tested briefly with beam. GEM and FADC readout developments are making good progress with remote work albeit slowed down by lab closing. For the second quarter we expect a delay in the schedule due to the suspension of laboratory operations because of the COVID-19 pandemic.

1.2 Milestones

1.2.1 GEM testing milestones

A) VMM3 We will study the behavior of the VMM3 in high background and the maximum trigger rate that could be achieved.

Milestone	Objectives	Expected Completion Date	Status
A1	Finish development of VMM3 direct readout	A1 April 1, 2020	Complete
A2	High rate testing with detector	November 1, 2020	Started
A3	Optimized VMM3 setup for maximum data rate	March 1, 2021	Started

The VMM3 evaluation boards were ordered February and delivered April 5, 2020. We expect a few more weeks of testing to learn how to use the board. Ed Jastremzki (JLab fast electronics group) has powered the board and taken data with the provided software. Actual testing with a detector will be slowed down by the lab closure, so milestone A2 will be delayed.

B) APV25 To test the feasibility of reusing electronics from SBS to reduce electronics costs, we will determine if the existing electronics can reach a trigger rate of at least 100 kHz.

- Milestone B1, June 1, 2020 : while the intrinsic specs of the chip should allow 200 kHz trigger rate using one sample, some development is needed to determine if this is achievable with the existing electronics from SBS. The task involves enabling the APV25 buffering and optimizing the data transfer of the readout.

- Milestone B2, October 1, 2020 : Determine rate limits of the APV25 trigger and test in a high occupancy environment.

Milestone	Objectives	Expected Completion Date	Status
B1	Finish development of fast APV25 readout	June 1, 2020	Started
B2	Determine maximum rate achievable with APV25	October 1, 2020	Not started

A scheme to readout the APV25 using the INFN board MPD through the optical link has been designed and is being tested for up to 24 MPD modules using the SSP module, developed for Jefferson Lab pipelined electronics, at data rates up to 200 MB/s. The development of a faster readout using the VTP module has started, it consists primarily of designing an adapter board to route signals from the MPD module (which reads out the APV25 chips) to the VTP processor module. This allows parallel readout of the boards. Data from the VTP is transferred to a host computer on a 10 GigE link (1.25 GB/s). The milestones B1 and B2 are expected to have some delay due to the lab closure.

1.2.2 DAQ test stand and rate tests

C) DAQ

Milestone	Objectives	Expected Completion Date	Status
C1	Development FADC readout through VXS	April 1, 2020	On-going
C2	Testing PVDIS trigger functionalities and rate capability	October 1, 2020	On-going
C3	PVDIS trigger test with two sectors	February 1, 2021	Not started
C4	Test SIDIS trigger	March 15, 2021	Not Started

Milestone C1 was delayed to support Cerenkov test run. The fast FADC readout through VXS has started beginning of April and is expected to be first tested by the end of June depending when lab operation is resumed.

D) Cherenkov readout

Milestone	Objectives	Expected Completion Date	Status
D1	Setup FADC crate for Cerenkov sum testing	February 15, 2020	Complete
D2	Record beam data using sum and FADC	April 15, 2020	On-going
D3	Record beam data using MAROC readout	May 15, 2020	Started

Milestone D1 was achieved at beginning of March with the digital trigger implementation. Cosmic ray data and a few hours of beam data were collected before the suspension of operations at the lab. More details are in the Cerenkov section. The MAROC boards were built by our INFN colleagues and the board were shipped to Jefferson Lab. These will be tested when work resumes at the lab.

E) Time of flight

Milestone	Objectives	Expected Completion Date	Status
E1	Acquire and setup AARDVARC evaluation board	February 1, 2020	Complete
E2	Acquire data of scintillator with beam	May 15, 2020	On-going
E3	Complete analysis and determine achieved timing resolution with AARDVARC and compare to FADC resolution	February 15, 2021	Started

AARDVARC evaluation board is available but can only accommodate a short timing window of 12 ns at the moment which will not be suitable for the time-of-flight scintillators used for the test, so we decided to loan an ASOC board for the test. FPGA boards were ordered to drive the ASOC board. The board and software were operated successfully meeting milestone E1 but testing with detector could not be done because of the laboratory shutdown. E2 will most likely not be achieved due to the lab closure and will be replaced by testing with a high rate radioactive source, which will be carried out once laboratory resumes operations.

1.3 Budget / spending summary / procurement

System	Cost ($)	Number	Total	Spent
VXS crate for DAQ modules	15,000	2	30,000	30,000
VTP - Module for triggering and data movement	10,000	2	20,000	0
SSP	6,500	1	6,500	0
TI - Trigger Interface	3,000	2	6,000	0
SD - Signal Distribution card	2,500	2	5,000	0
FADC trigger distribution card	2,000	2	4,000	4000
VME CPU	4,500	2	9,000	11,000
Trigger Supervisor	3,500	1	3,500	0
Hardware components for VMM readout test stand	25,000	1	25,000	4,000
APV25 GEM system	23,000	1	23,000	0
Cables/patch	400	160	64,000	8,000
Optical fibers	100	20	2,000	2,000
MAROC eval board	23,000	1	23,000	0
AARDVARC eval board	10,000	1	10,000	1000
Optical transceivers	50	32	1600	1600
Total M/S direct			210,600	61,600
Overhead			16,700	4,860
Total request M/S			227,300	66,460
Workforce 2020	$130,000$	1.25	162,500	90,000
Workforce 2021	$133,900	1	133,900	0
Contract DG electronics	78,250	1	78,250	0

Table 1: Budget summary

VXS crates are in shortage at the lab since they are being used by all the running experiments, so 2 VXS crates were ordered at the beginning of project since those are long lead items. Most of the other boards are on hold waiting for larger orders to drive the cost down and waiting for manufacturing companies to reopen. NALU agreed to loan the TOF readout boards so we save 4.5 K$. Part of the cables, optical fibers and transceivers were ordered right away since those are standard off the shelf items and will be needed for GEM testing. Others items will be ordered later when testing the full trigger setup in next quarter. VME CPU came out slightly more expensive than expected at 11 K$ instead of 9 K$ but the extra cost will be absorbed with the saving from NALU loan.

	Budget ($)	Obligated ($)
Material	227,300	65,480
Personel	372,700	79,291
Total	600,000	144,771

Table 2: Budgeted and obligated funds summary (includes overhead)

To date funds have been used to purchase 2 VXS crates, a trigger distribution card, a VME CPU, hardware for the VMM readout test stand, cables to be used in GEM tests and an AARDVARC evaluation board. Labor funds have been used to contract postdoc support from a collaborating university. NALU has agreed to loan Time-Of-Flight readout boards.

2 High Rate Test of MaPMT Array and LAPPD Using a Telescopic Cherenkov Device

2.1 Summary

A DOE review of the project was conducted with favorable comments and constructive suggestions from the independent review panel. The Telescopic Cherenkov Device (TCD) was installed at low angle, and high-rate data was collected using 16 WLS coated MaPMTs and our electronic simple-summing board. The TCD has now been returned to the low-rate configuration with LAPPDs, and will soon begin collecting more data. We are optimistic that we will collect data for the LAPPD with CO2 gas, and possibly collect data with C4F8 gas, if parasitic opportunity allows.

2.2 Project Milestones

Milestone	Objectives	Expected Completion Date	Status
1	Construction and delivery of Cherenkov tank to Jefferson Lab.	Early January 2020	Complete (Q1)
2	Cosmic testing and installation into experimental hall.	Mid February 2020	Complete (Q1)
3	Collection and analysis of low and high rate data with electronic summing-board.	End of Year 2020 (+2 Month Contingency)	Collection complete (Q2), Analysis ongoing
4	Collection and analysis of high rate data with MAROC electronics.	End of Year 2020 (+4 Month Contingency)	Not Started

2.3 Budget / spending summary / procurement

To date funds have been used to purchase all the materials to construct the Cherenkov prototype tank with pressure controls, all connectors and cables for reading out signals of 64 channels from MaPMTs or LAPPD, mirror, 16 MaPMTs, wavelength shifter coating, radiator gas, MAROC readout boards and their cabling. Funds have been used for the mechanical engineering design and machining as well as electrical engineering support, travel and transport of the prototype from Temple to Jefferson Lab.

	Budget ($)	Obligated ($)
Material	210.0	124,736
Personel	240.0	31,376
Total	450,000	156,112

Table 3: Budgeted and obligated funds summary from both Temple and Duke for the Cherenkov prototype (includes overhead)

2.4 DOE Review

2.5 High Rate Installation and Data Collection

2.6 Low Rate LAPPD Installation

2.7 Analysis and Simulation Progress

2.8 Summary