Light Collection Module and Light Readout System. Technical Report

N.Anfimov, I. Butorov, D. Korablyev, K. Kuznetsova, A. Rybnikov, A. Selyunin, S. Sokolov, A. Sotnikov

November 12, 2019

Abstract

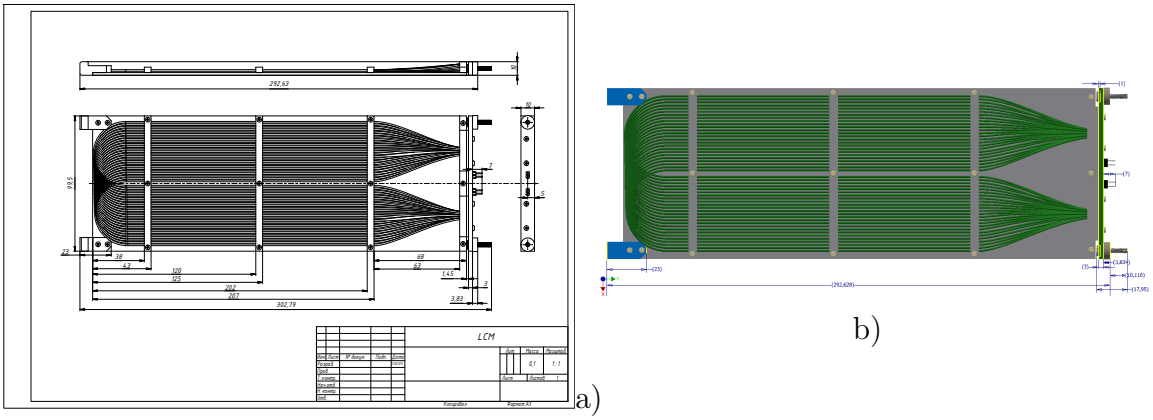
In this report we present most important technical details on Light Collection Module: LCM design, materials, components, power supply system and frond-end electronics (DAQ).

1 Introduction

We are preparing the light readout system for a singe TPC module prototype test which will be held at Bern University this end of fall - begin of winter. The module 60x60x120 is divided by two sections of 60x30x120 with cathode plane in the center. In total we need to cover 4 walls with the Light Readout System - LRS: LCM and ArCLight. The first scheme is to combine alternatively ArcLights and LCMs on each wall as 3 LCM - 1 ArcLight - 3 LCMs - 1 ArcLight. In total we require to produce - 24 LCMs and 8 ArcLights. Each module is readout by Silicon Photomultipliers which are located by pairs on each SiPM-PCB. One LCM is readout by a single SiPM-PCB, but one Arclight is readout by 3 SiPM-PCB boards. 3 SiPM-PCBs are grouped together by insertion to a single E-shape PCB - E-PCB. The E-PCB is intended to interface SiPMs signals to a long micro-coaxial (in future - flex) cable lines. To gain signal power each E-PCB is equipped with 6 preamplifiers. To interface all LRS in a single TPC-module the 16 E-PCBs are used.

2 LCM design

The Light collection module (LCM) is a frame cantilevered by PVC plate that holds WLS-fibers which are bent into two bundles readout with two SiPMs light sensors. Drawings of the LCM and general view are shown on fig. 1. PVC plate with WLS-fiber on it are coated with TPB that re-emit a VUV liquid argon light(128 nm) to the blue region(427 nm) which is shifted in fibers to the green light(510 nm) and then transported to the SiPMs.



a) b)

Figure 1: The LCM drawing and general view

2.1 LCM-dummy design

For the mechanical mockup tests we prepare a simplified LCM-dummy design for production in the US. Sketch is shown on fig. 2. 3-D model(.stp file) could be find in the uploaded files of the current document(see LCMdummy.stp) as well as .docx file(see LCMdummy.docx) with a list of materials for each component of the LCM-dummy module.

3 PCBs design

The PCB with mounted SiPMs is shown on fig. 3b. This PCB is attached to the LCM by means of polycarbonate screws. On the other side the PCB has two connectors with 2 Pins each to plug it to the E-PCB. The E-PCB drawing is shown on fig. 4.

We have two kind of the E-PCB - 8 are like on fig. 4b(bottom) and 8 are the same design but mirrored(fig. 4b(top)).

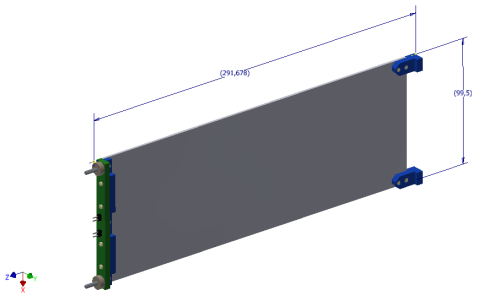


Figure 2: LCM-dummy sketch

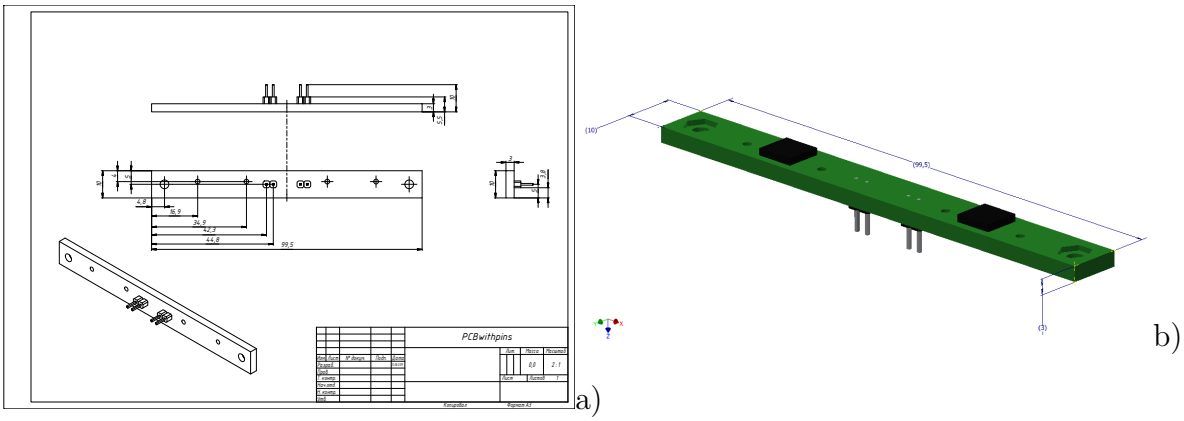


Figure 3: The PCB drawing and general view

4 Components, Cables, Connectors

To connect all 16 E-PCBs in a single TPC-module we are going to use 4 cables of 87 inches (2,2 m), 4 cables of 80 inches (2,0 m), 8 cables of 60 inches (1,5 m). Each cable is a cable assembly of 20 micro-coaxial cables FCF8-20-01-L-XX.XX-S type where XX.XX - is a length specified in inches. Cables are plugged into the E-PCB by means of FCS8-20-01-L-S-A-TR connector. On another side (at feed-through panel) cable is interfaced with adaptor board with the same FCS8-20-01-L-S-A-TR connector to the feed-through flex cable. Both cables and connectors are manufactured by Samtec company [1]. We placed order(fig. 5) with spare cables, connectors and for naked Alfawire micro-coaxial cable 9438 WH033 to provide spare mounting service.

To gain signal from the SiPM a LMH6624 preamplifier from Texas instruments will be used [2]. We already ordered 200 of the chips. six preamplifiers are located at a single E-shape board in order to provide readout of 6 SiPM (3 LCM or 1 ArcLight).

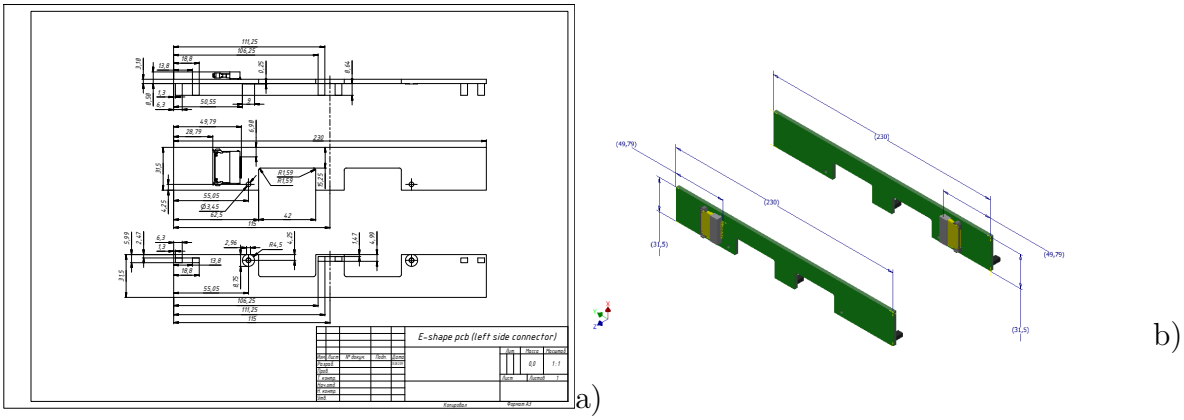


Figure 4: The E-PCB drawing and general view

Счет № ПРЗК-19-00102Д от 05.08.2019

№	Наименование	Ед. изм	Кол-во	Цена	Сумма	НДС%	Сумма НДС	Всего с НДС
1	Разъем FCF8-20-01-L-80.00-S	шт	5	9 083,33	45 416,67	20	9 083,33	54 500,00
2	Разъем FCS8-20-01-L-S-A-TR	шт	50	280,00	14 000,00	20	2 800,00	16 800,00
3	Кабель 9438 WH033	шт	2	24 083,34	48 166,67	20	9 633,33	57 800,00
4	Разъем FCF8-20-01-L-87.00-S	шт	5	11 375,00	56 875,00	20	11 375,00	68 250,00
5	Разъем FCF8-20-01-L-60.00-S	шт	10	6 770,83	67 708,33	20	13 541,67	81 250,00
	Итого:		72		232 166,67		46 433,33	278 600,00

Figure 5: Invoice for cables and connectors (Russian, rubles). 1 USD ≈ 65 RUB.

Each preamplifier dissipates around 30-40 mW in a range of 1 V and BW of ∼30 MHZ (∼10 ns rise time).

5 SiPM Power supply system

SiPM Power supply system - SiPM-PSS is based on common bias provided by Keythley 6487E and multichannel DAC. We tested that system with LTC2668 12-bit 16 channel DAC provided voltage in a range of -10 V to 10 V. For the prototype we are going to use 6 DAC81416 16-channel 16-bit (0 V to 40 V) from Texas Instruments

and common bias of 20 V. In this case a failure of DAC channel ramp down SiPM voltage to 20V. As a spare solution we purchased two DAC60096EVM 96-Channel 12-Bit DAC Evaluation board (±10.5 V) from Texas Instruments and two CAEN WA7040ANXAA4 - A7040AN - SYx527 H.V. channels -100V/1mA - DB37 Conn. common floating (each of 48 ch). We require a Mainframe from CAEN SY4527LC or SY5527LC. The plan is to rent it from CERN pool for BERN tests.

6 Front-End

On the warm side of the cryostat we place a metal box which is a block of driver amplifiers AD8139 that interfaces unipolar signal from coax cable to differential para-phase signal on screened ribbon twisted pair cable. We also going to put Six 6 DAC81416 16-channel 16-bit boards and Thinker board microPC to control SiPM power via SPI interface. 16 microcoax cable assemblies are plug at the warm side of the feedtrough flange to the standard FCS8-20-01-L-S-A-TR connector. In the metal box we spit assembly and solder it to the six 40 pins connectors. Three are for signals and another three for SiPM power supply. From the metal box 3 bundles of ribbon twisted pair cables are going to the rack with ADCs. In the rack upstream to ADCs a 19" unit with VGAs (Variable Gain Amplifiers) - LMH6521-type is placed to adjust dynamic range from Single photoelectrons (SiPM calibration) to high amplitude MIP signals. To digitized analogue signals from SiPM we are going to use two ADC64 100 MHz 10-bit 64-channel (differential signals, full range ± 1.25 V) ADC produced by JINR [3]. This ADC stream UDP/TCP data packets via M-link MStream protocol that provides 10 Gbps optical link. To readout ADCs we purchase network PCI-E card with two SFP+ transceivers, so we need a PC with fast PCI-E bus and fast disk drive. We also purchased 14 SFP+ ports 10 Gbps fast D-Link Switch to scale up to 14 ADCs boards (896 channels). The ADCs could be synchronized via White Rabbit protocol with 1 ns timestamp. For the prototype test we synchronized them by means of splitting sync-signal using one channel in each of two ADCs.

7 Data Analisys

8 Things to be borrowed from the CERN pool/ UniBe

The list of equipment:

1. Mainframe CAEN SY4527LC or SY5527LC - 1 pcs
2. Keythley 64874/E - 1 pcs
3. VME 64 MiniCrate for ADCs, Logic Units. - 1 pcs
4. PC with PCI-E bus, SSD+HDD disk.

References

[1] http://suddendocs.samtec.com/catalog_english/fcf8.pdf.

[2] http://www.ti.com/lit/ds/symlink/lmh6626.pdf.

[3] https://afi.jinr.ru/ADC