



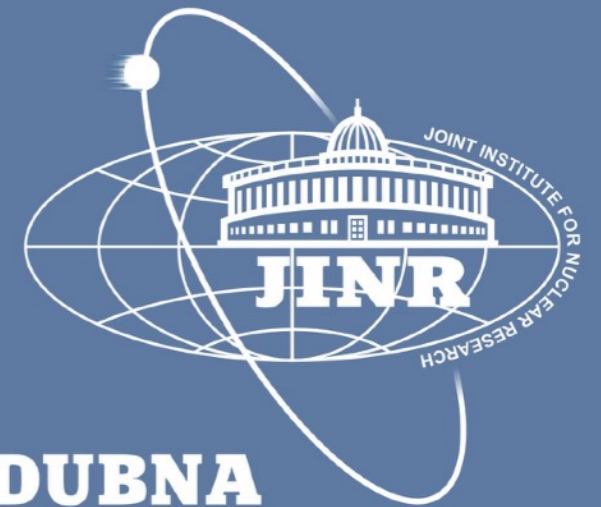
ArgonCube

АргонКубе

DUNE ND Workshop May 25-27, 2019, Fermilab

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UNIVERSITÄT  
BERN



DUBNA

ДУБНА

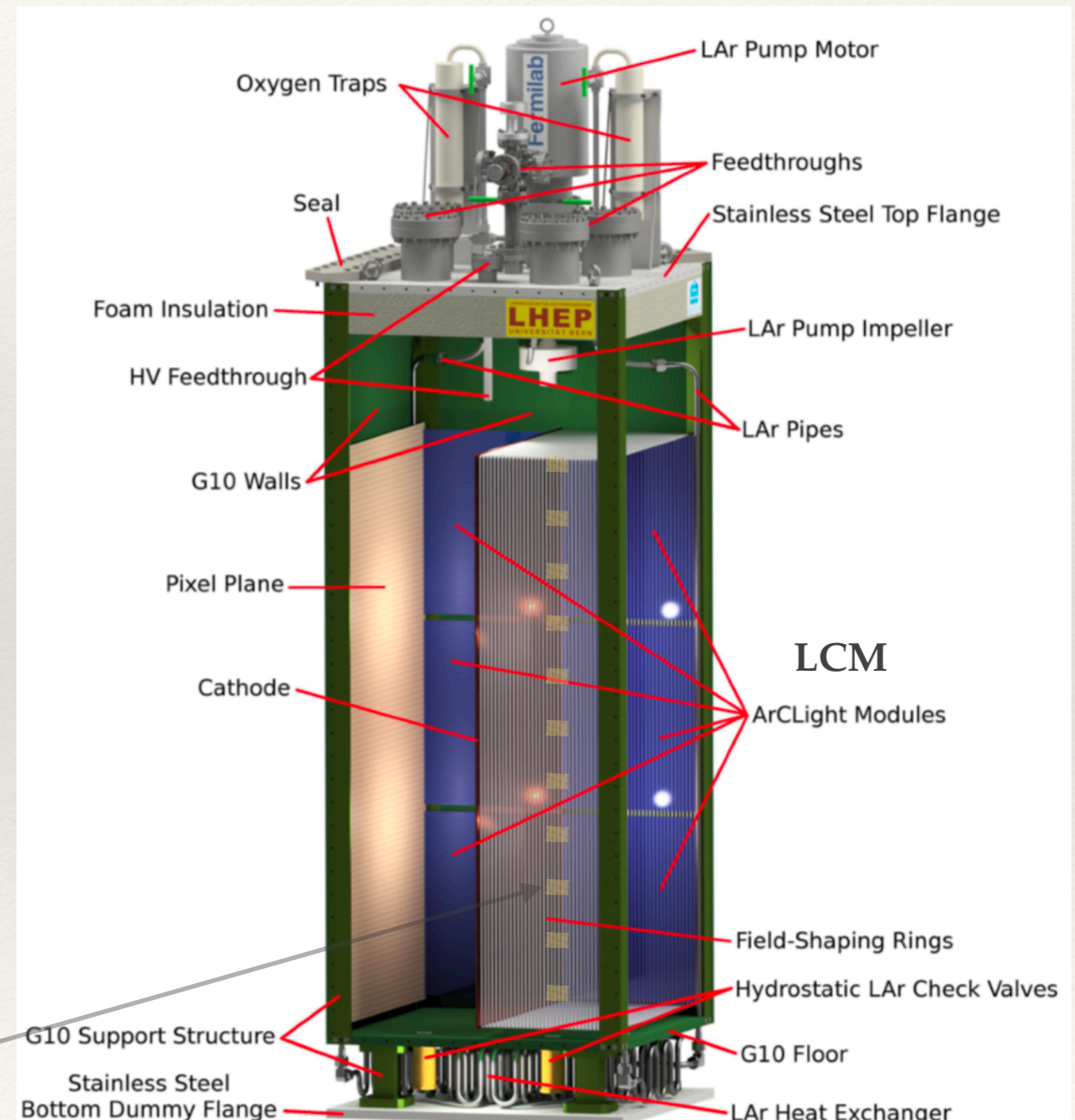
# Light Readout System for ArgonCube prototype

Nikolay Anfimov  
On behalf of JINR and UniBe  
groups



# ArgonCube Module Prototype

- ❖ Size - 670x670x1200 mm
- ❖ Cathode plane in the center
- ❖ LCM/ ArCLight ~  
30 cm x 120 cm - 4 planes
- ❖ Current solution  
LCM/ ArCLight = 50/50%.
- ❖ PCB with connectors as cables  
feedthrough.
- ❖ 48 SiPM for LCM and 48 ArcLight



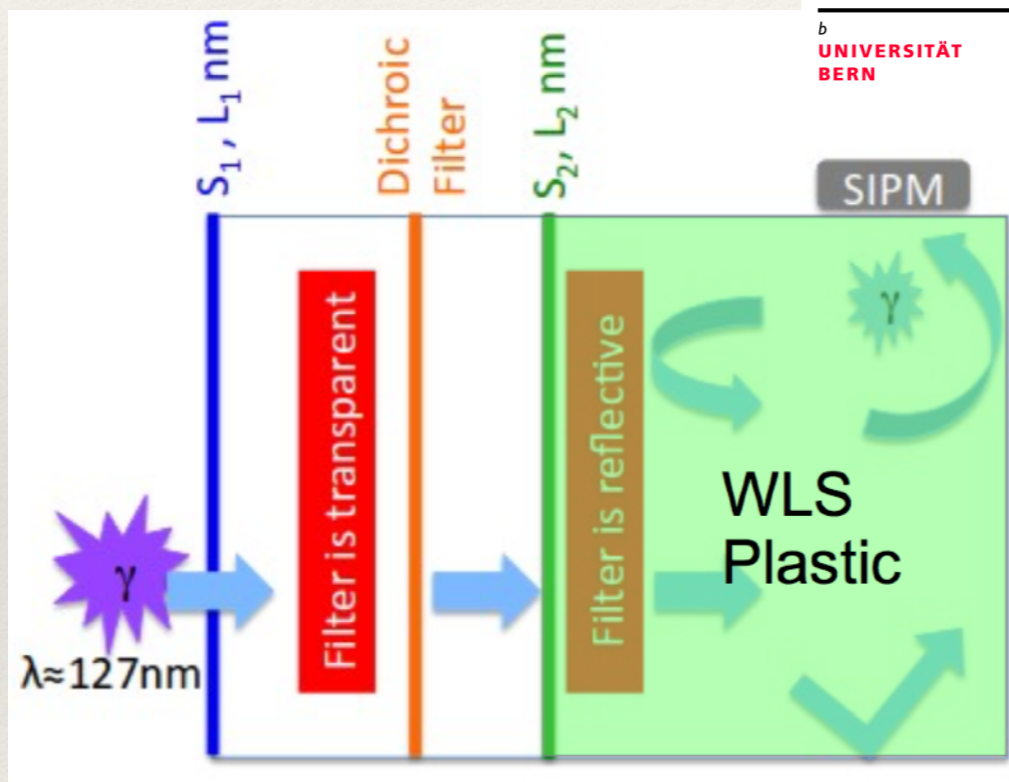
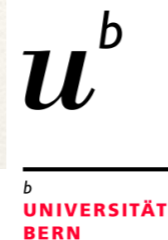
Clip fasteners for Light Modules  
(see Knut's talk)



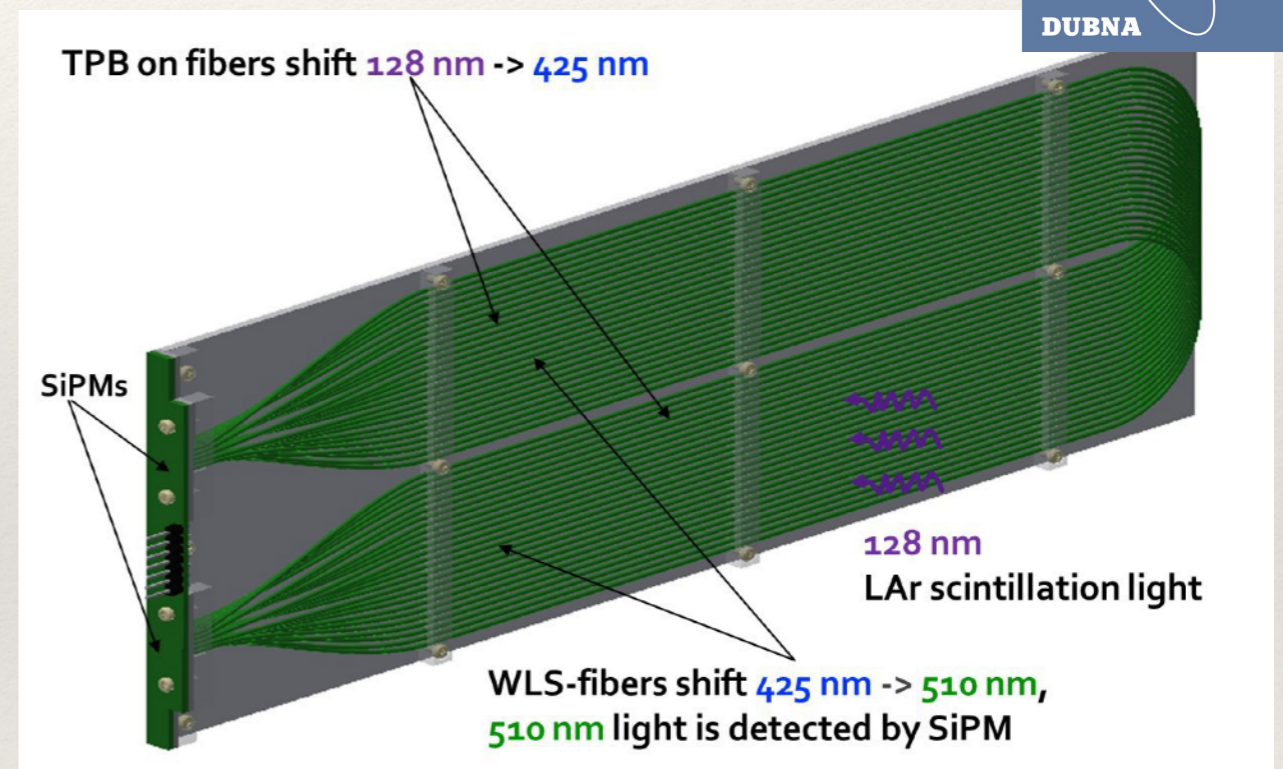
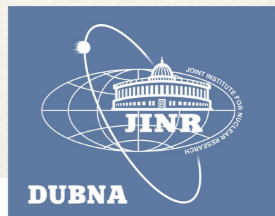
# Light readout. LCM vs ArCLight

Both approaches are based on shifting UV light (128 nm) into visible (425 nm) by TPB

ArCLight Concept



LCM Concept

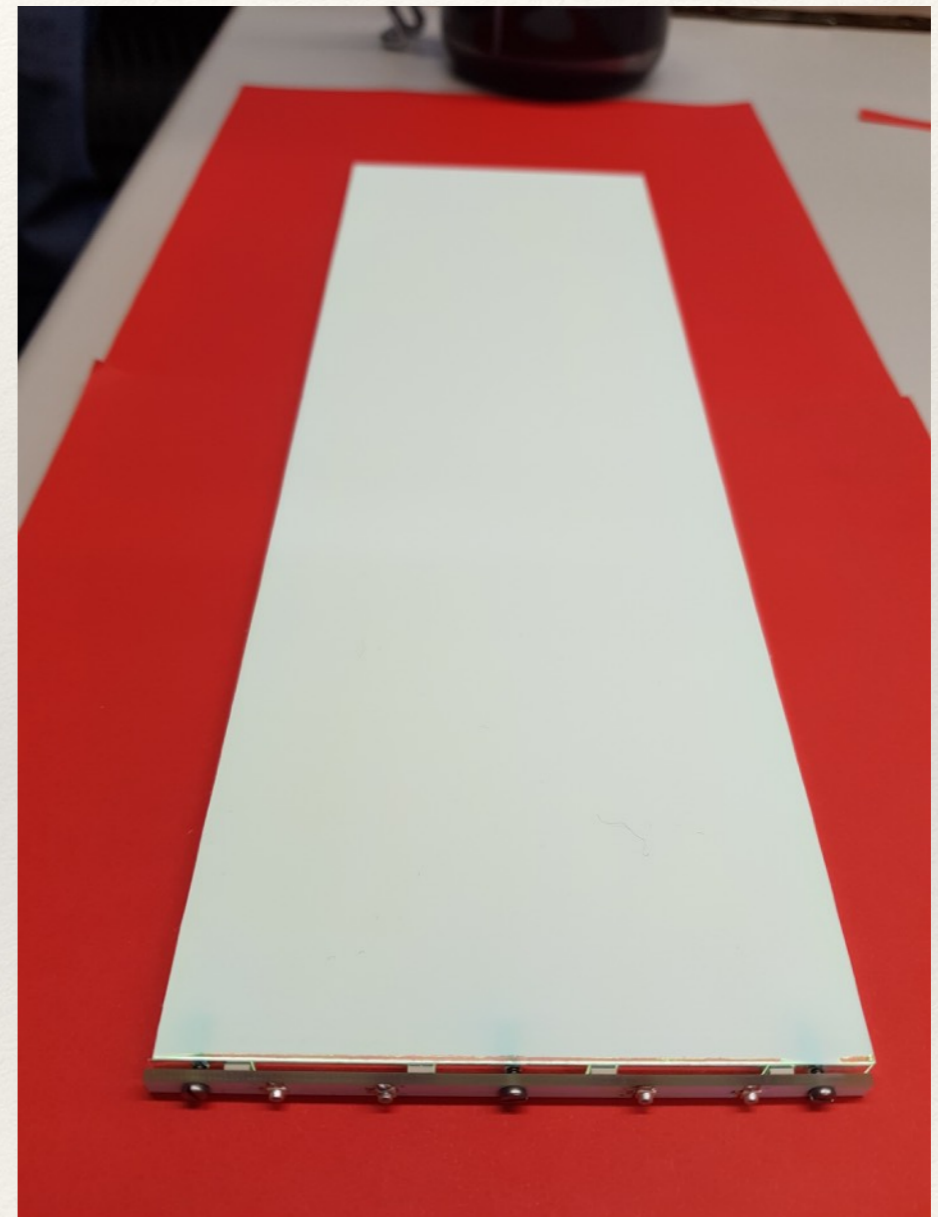
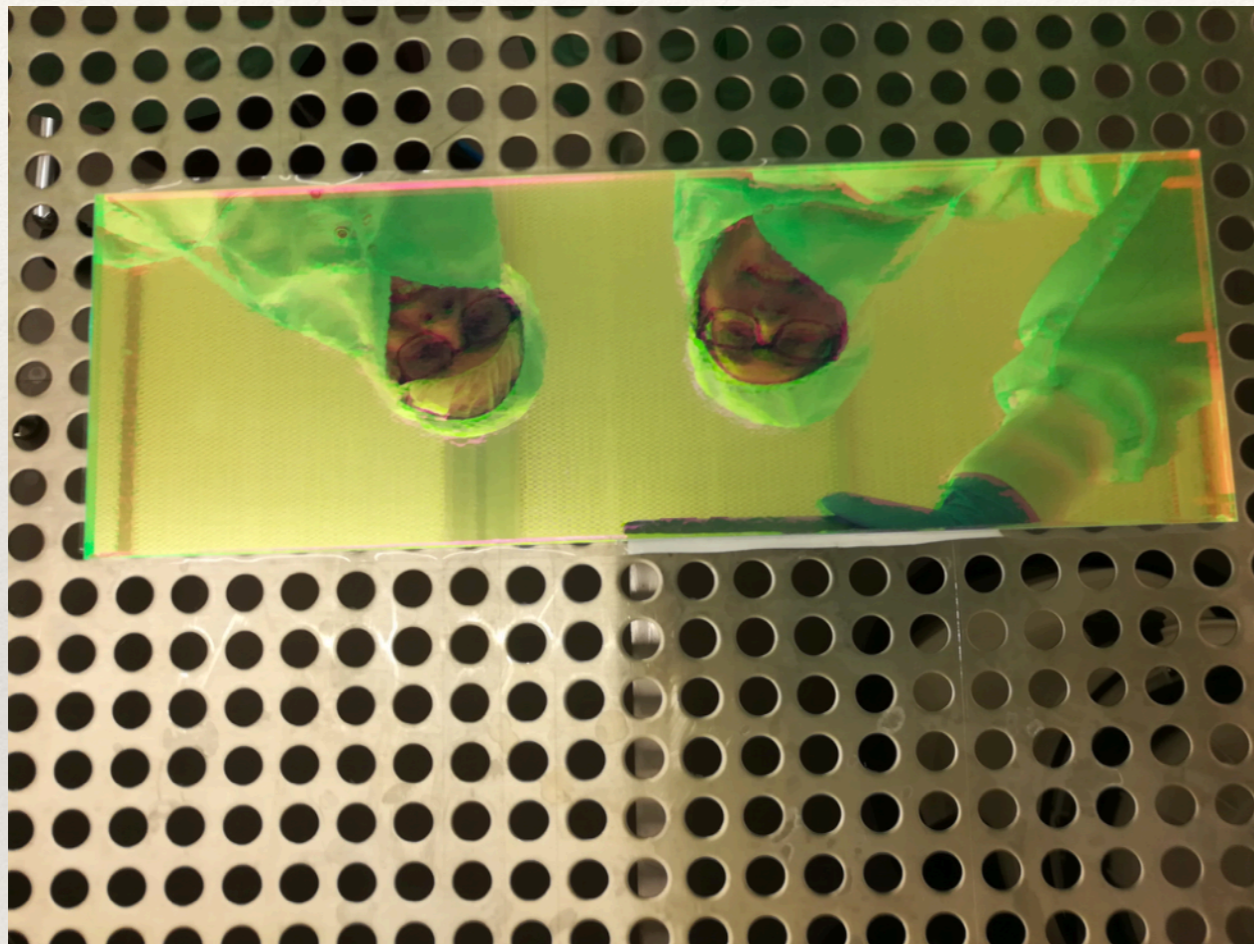


- + Provides more rigid construction
- + Better spatial resolution
- + Thickness 4 mm. (10 mm for prototype)
- loses PDE for scaling up. PDE ~ **0.1-0.4%**

- + Easy to scale -> Fibers have long attenuation
- + Doesn't lose efficiency (PDE) with scaling up. PDE ~ 1 - 2 %
- Thickness ~ 10 mm



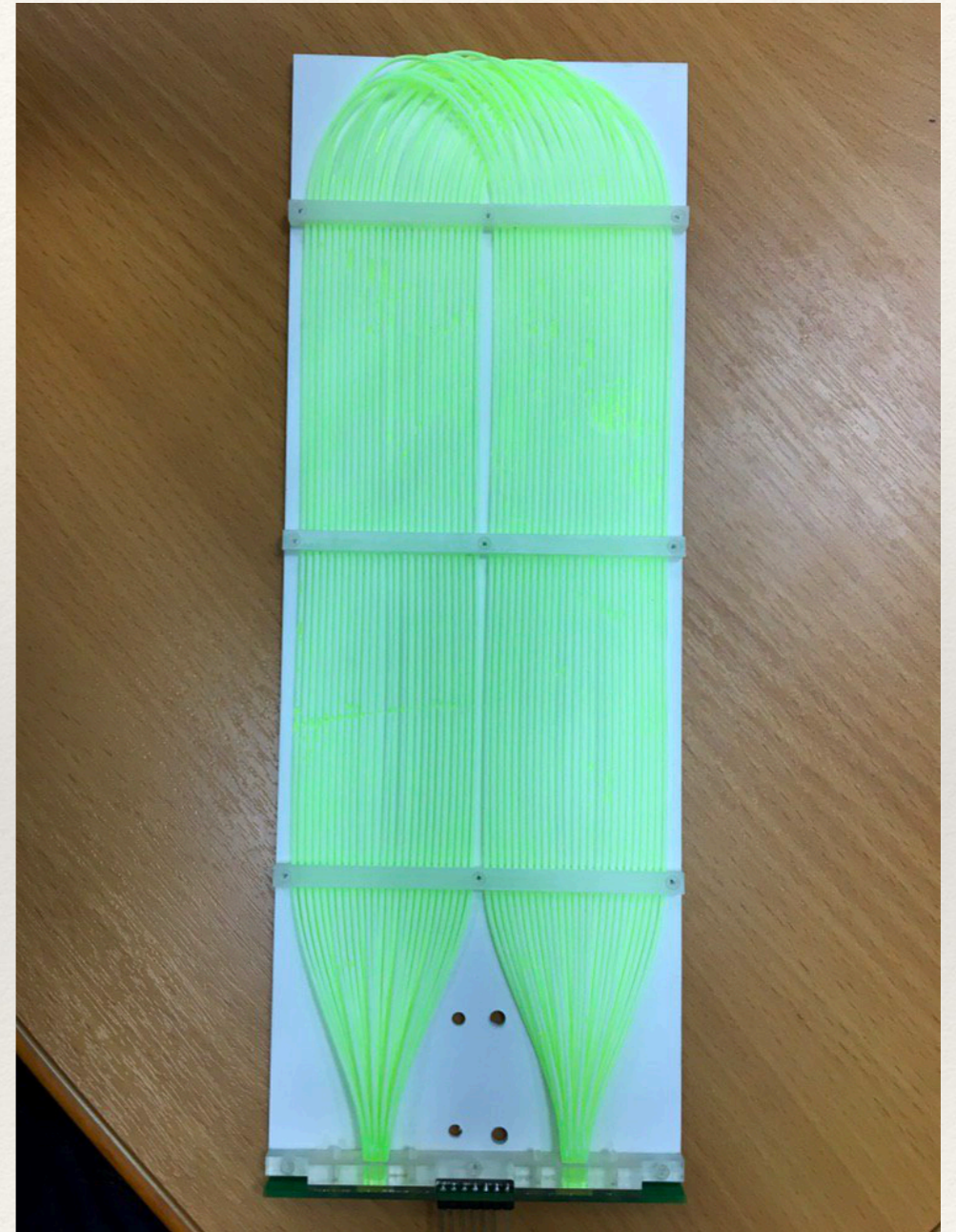
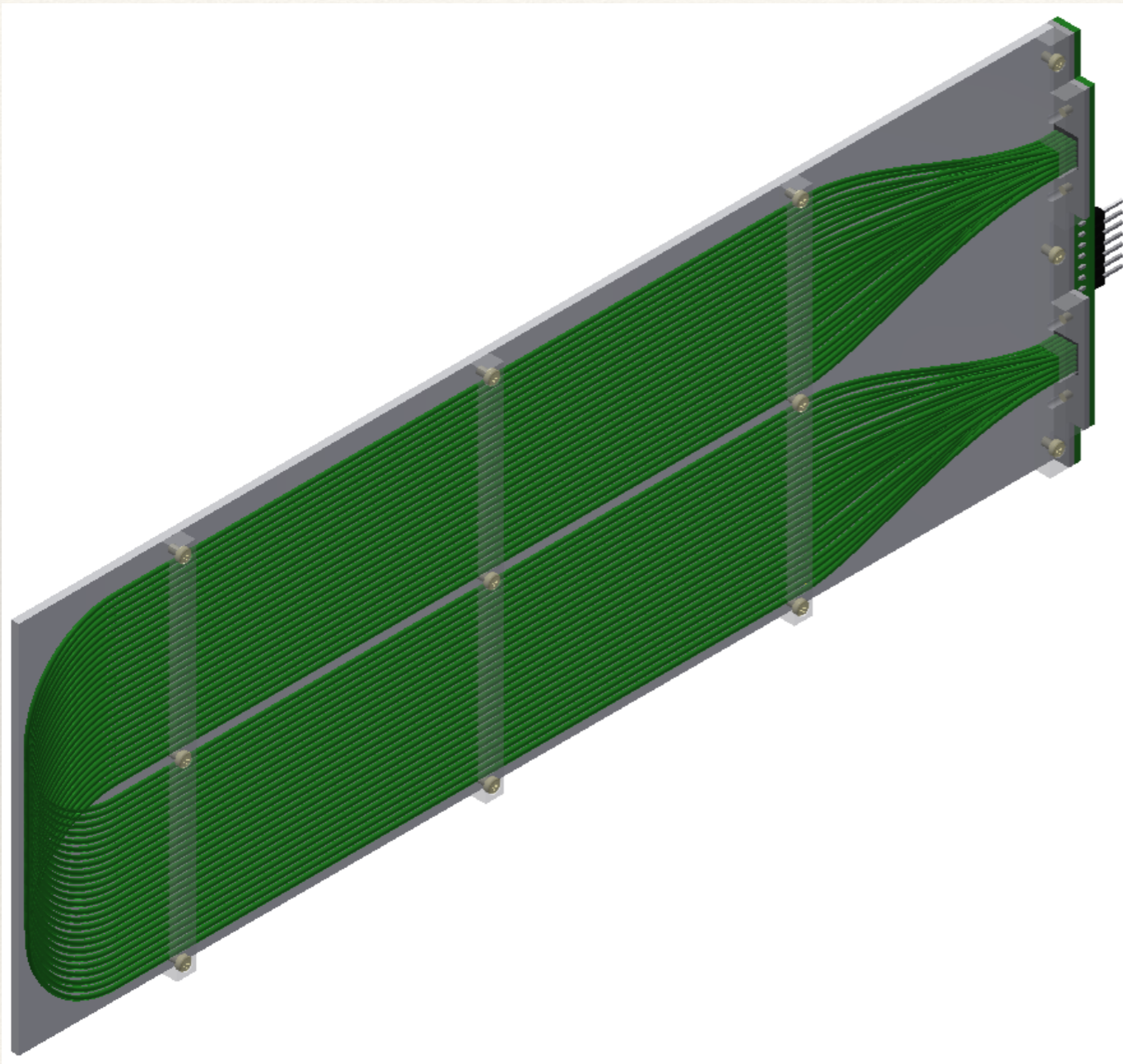
# ArCLight Module



Change thickness to **10** mm for prototype  
+ **6x6** SiPM => Increasing light yield



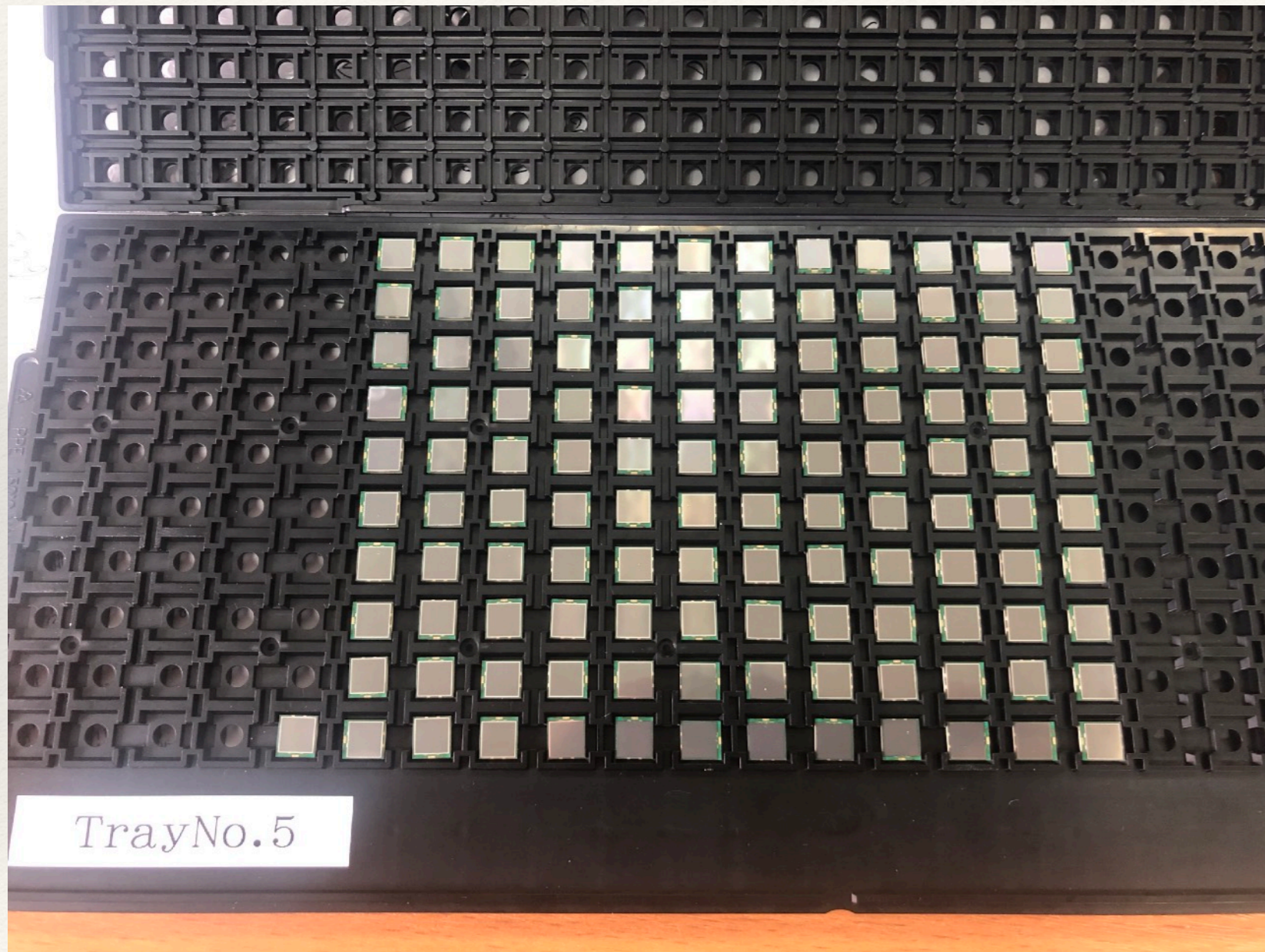
# Light Collection Module



Current LCM's dimensions 100x300x10 mm, SiPM = 6x6 mm<sup>2</sup>



# SiPMs preparation



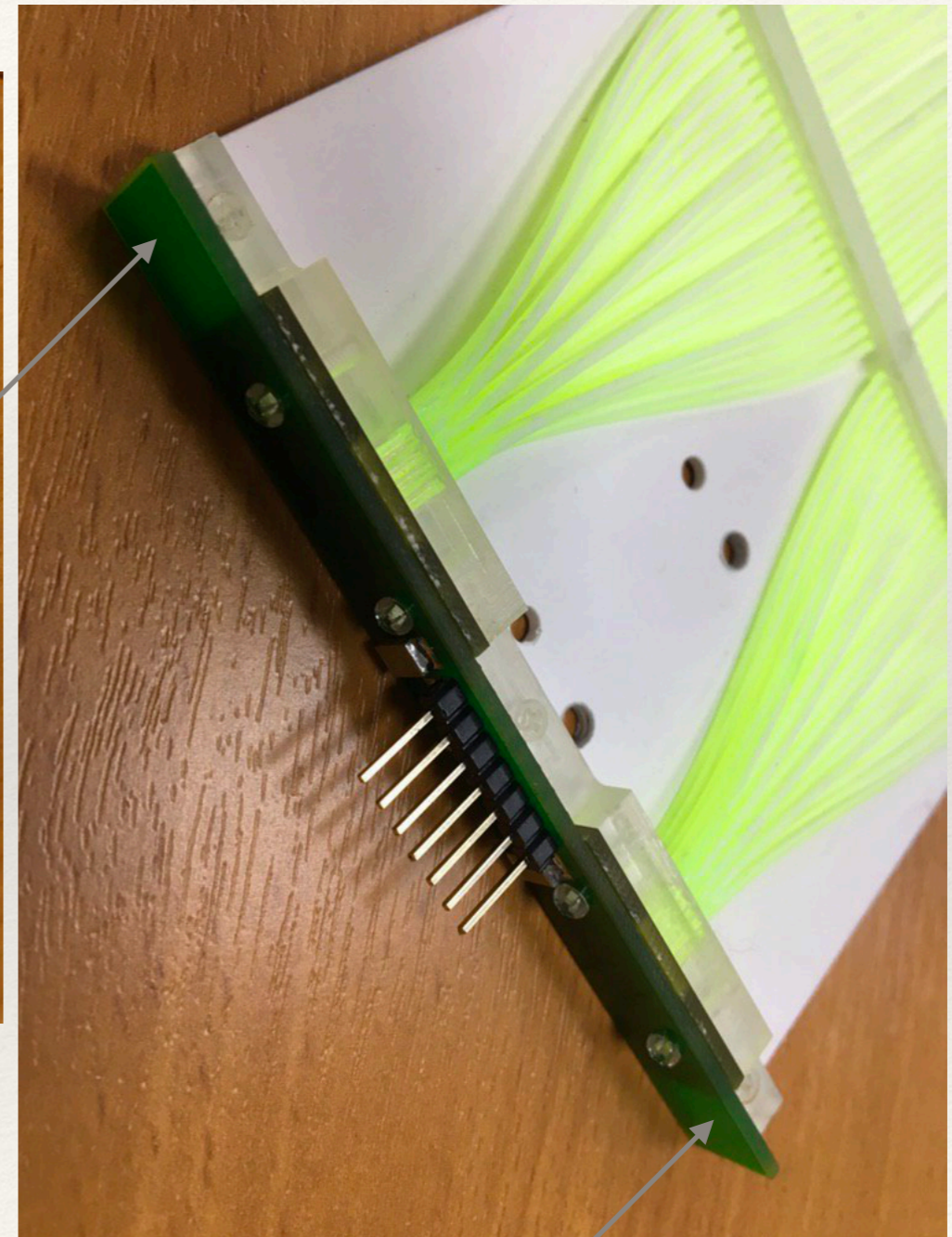
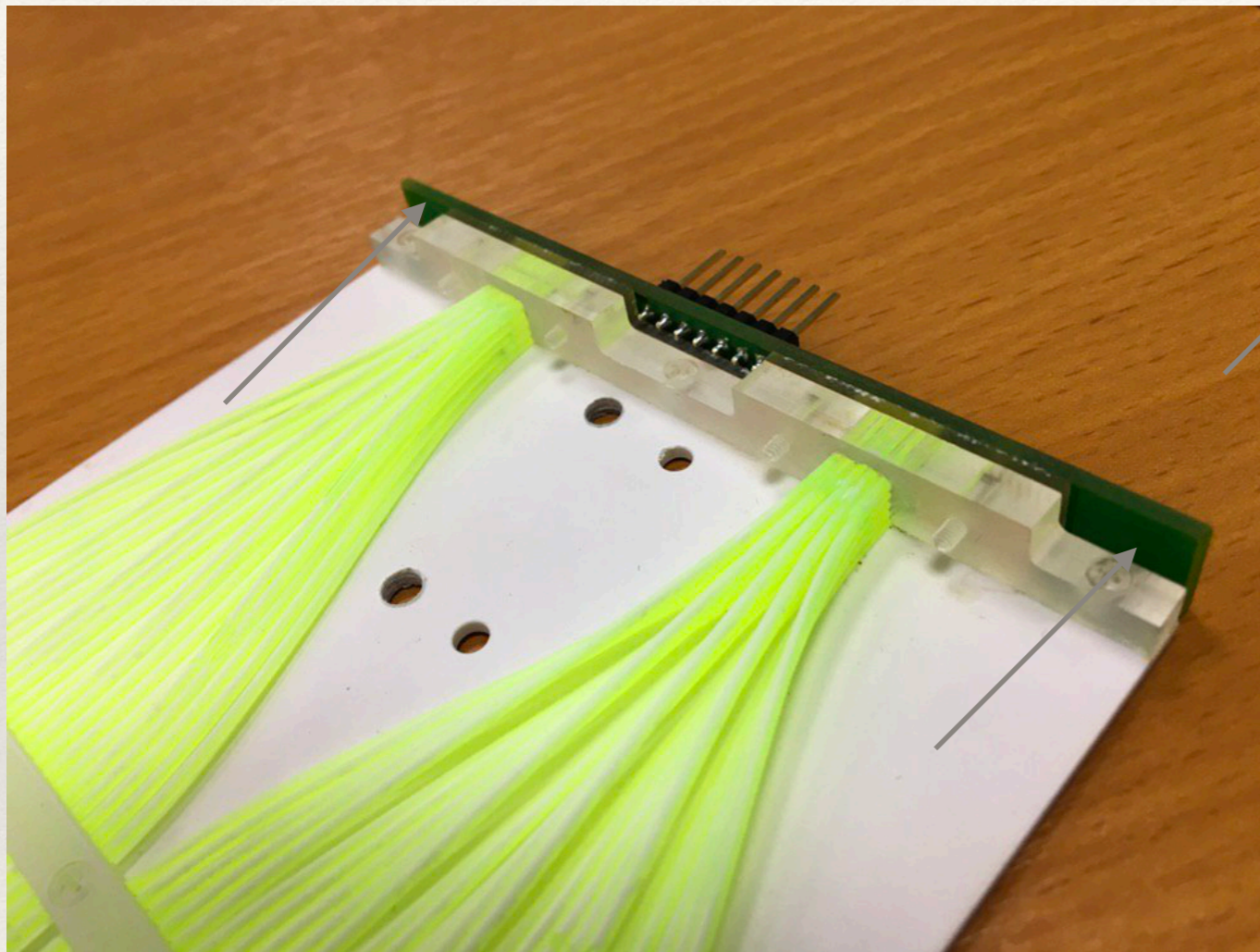
We have 121 Hamamatsu SiPMs  
S13360-6025PE (PDE=20%)  
for prototype

We placed order for 120 SiPMs  
S13360-6050PE (PDE = 35%)

It would be great to try both SiPMs  
and compare performance



# Light Collection Module

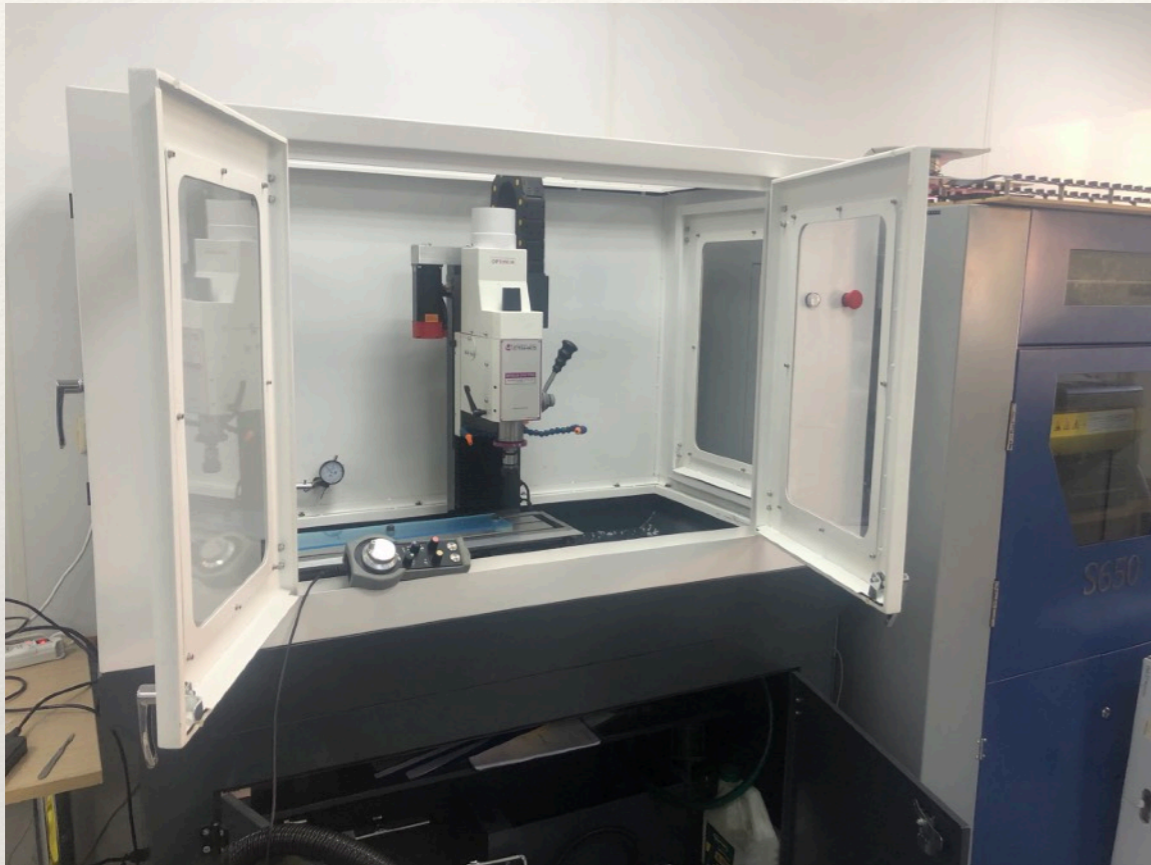


We can make any pins type and arrangement

Arrows point to  
the attaching holes (not drilled)

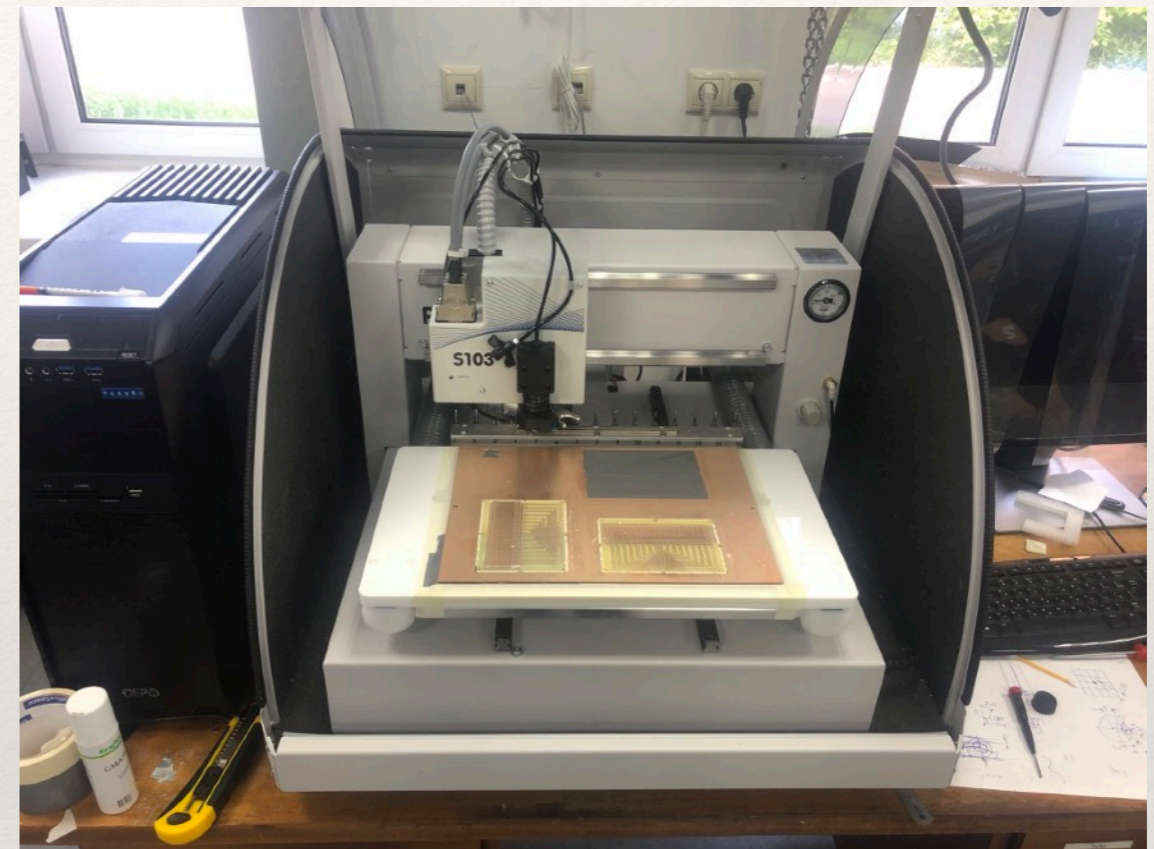


# CNC Machinery @ JINR



CNC - Milling machine  
to produce components for LCM

We are going to produce all  
mechanical components in our lab



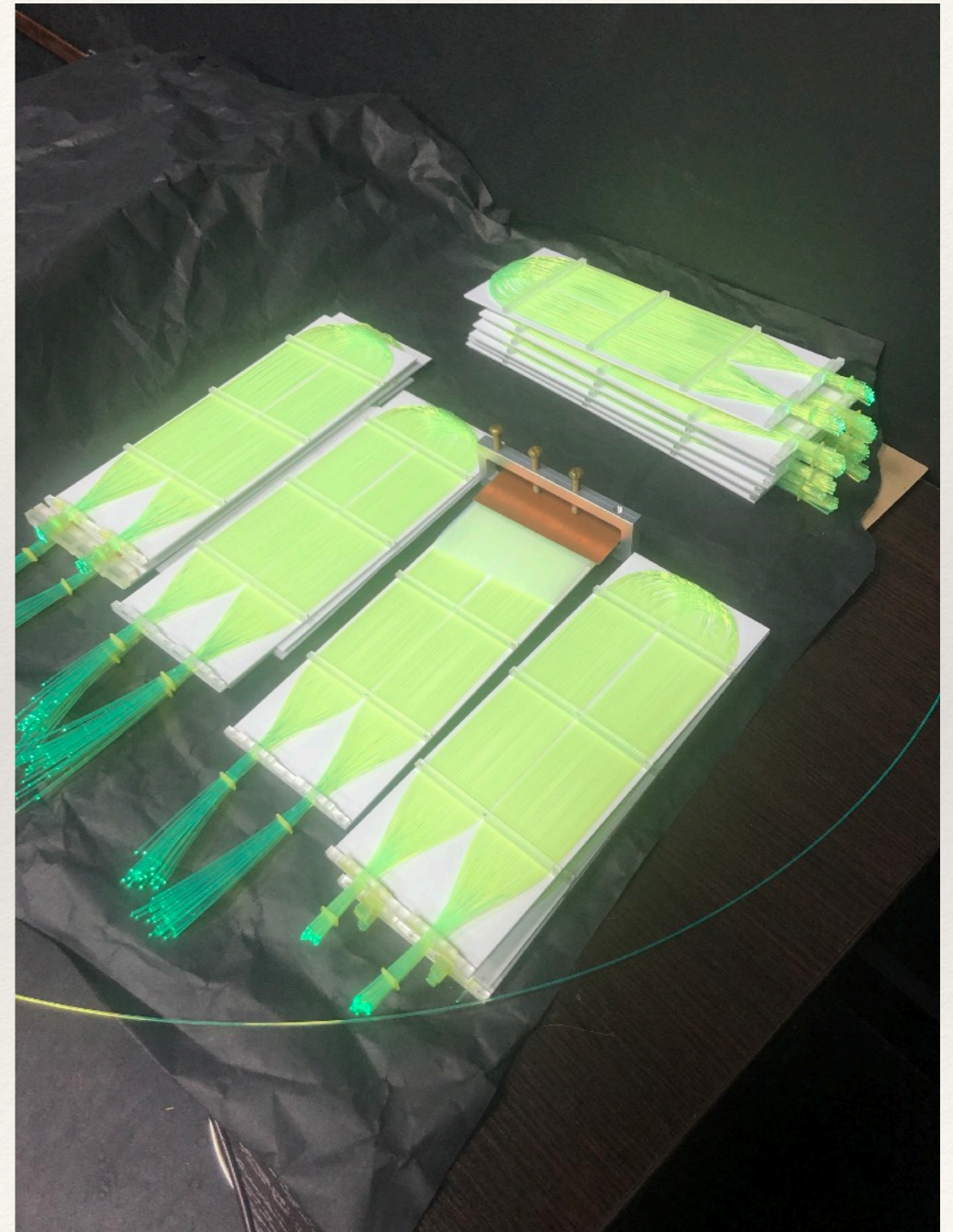
Fully automatic CNC-Milling  
For PCB prototyping and precise components

PCB will be printed, SiPM SMD-mounted  
at JINR electronics facility or  
on Outside company



# Essential Materials

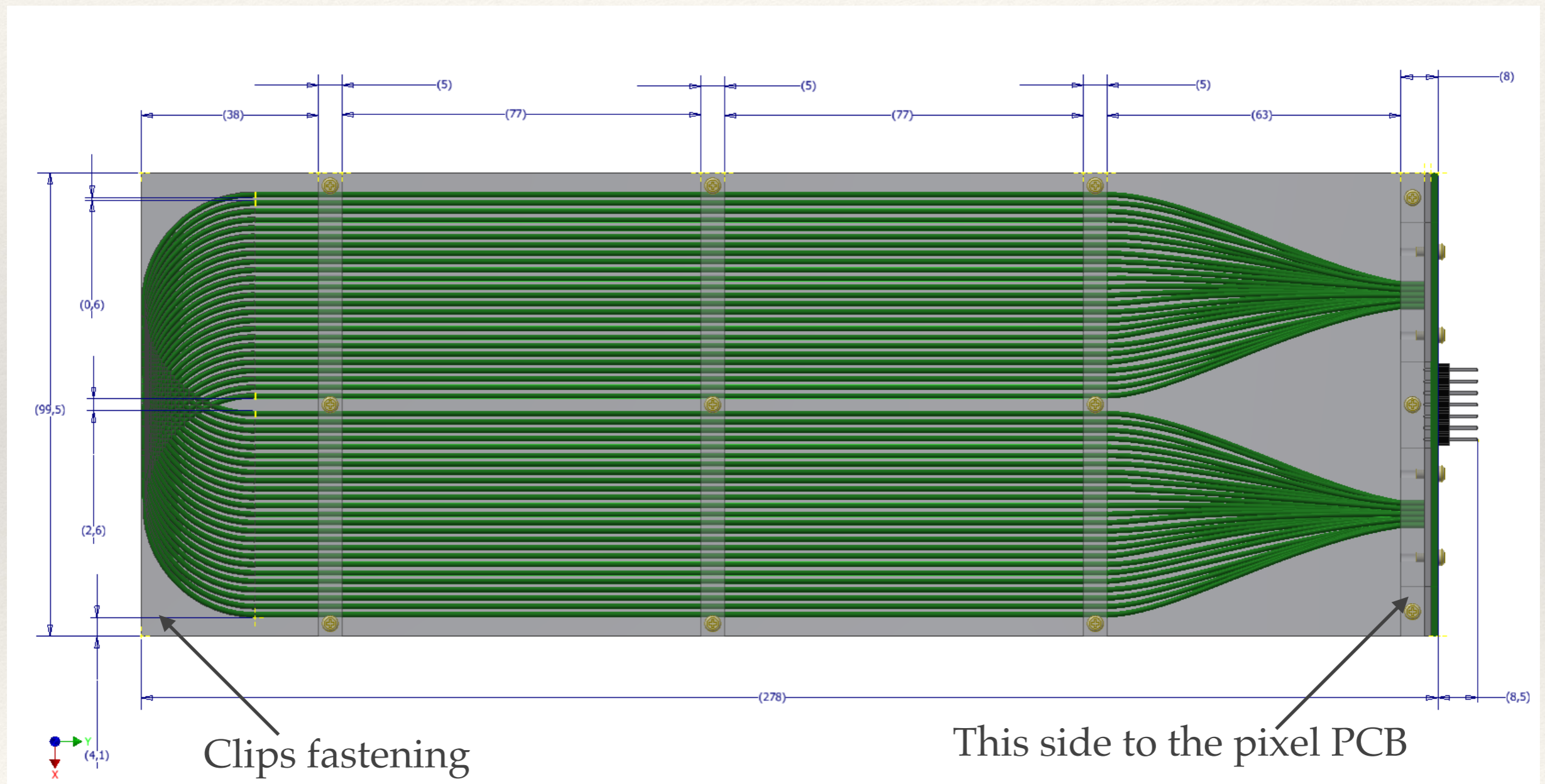
- ❖ BERN already purchase 4 mm WLS-plastic bulk and mirror&dichroic films.
- ❖ Now BERN is arranging 10 mm WLS-plastic order.
- ❖ JINR has prepared 12 LCM already.
- ❖ JINR placed order to Kurraray for 2 km of WLS fiber.
- ❖ TPB and Bis-MSB already in Dubna.





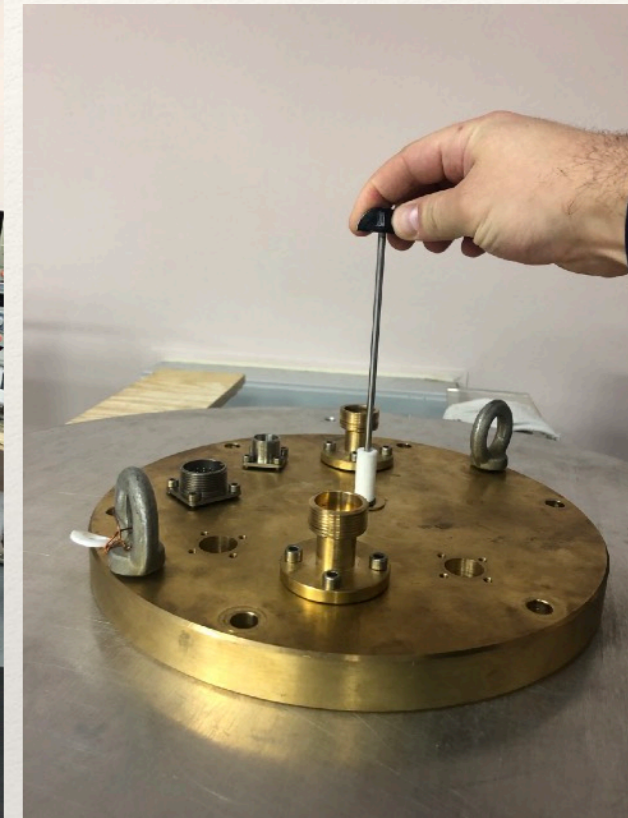
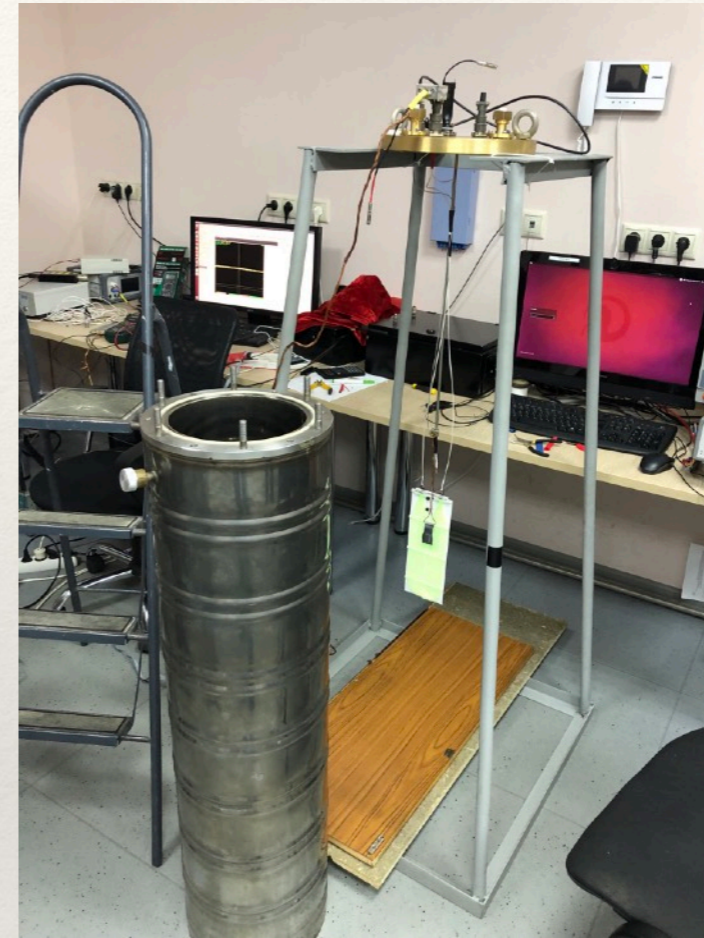
# Fastening LCM

Main concern - bending by the temperature deformations





# Cryogenic stand at JINR



Purchase LAr from Kurchatov's Institute

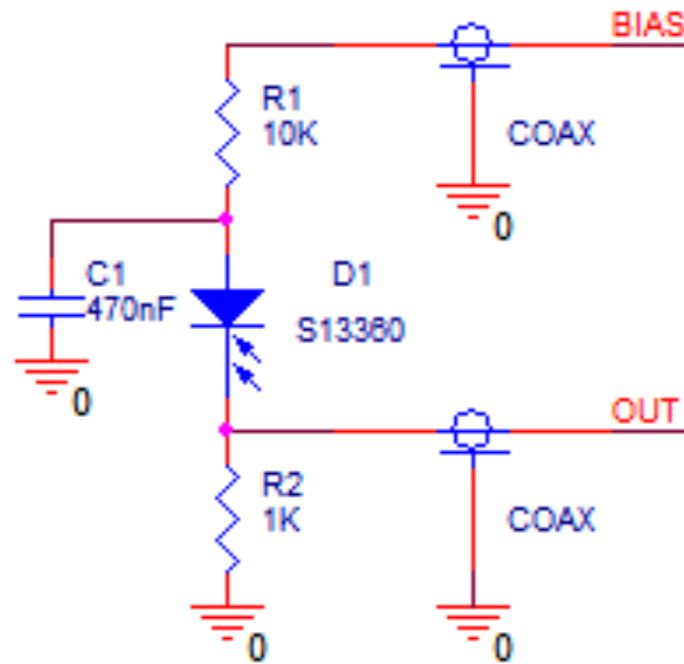
We use open  $^{231}\text{Am}$   $\alpha$ -source

Purity of LAr at level  $10^{-5}$  -  $10^{-6}$ , but we can perform relative measurements  
**For LCM and ArCLight both**

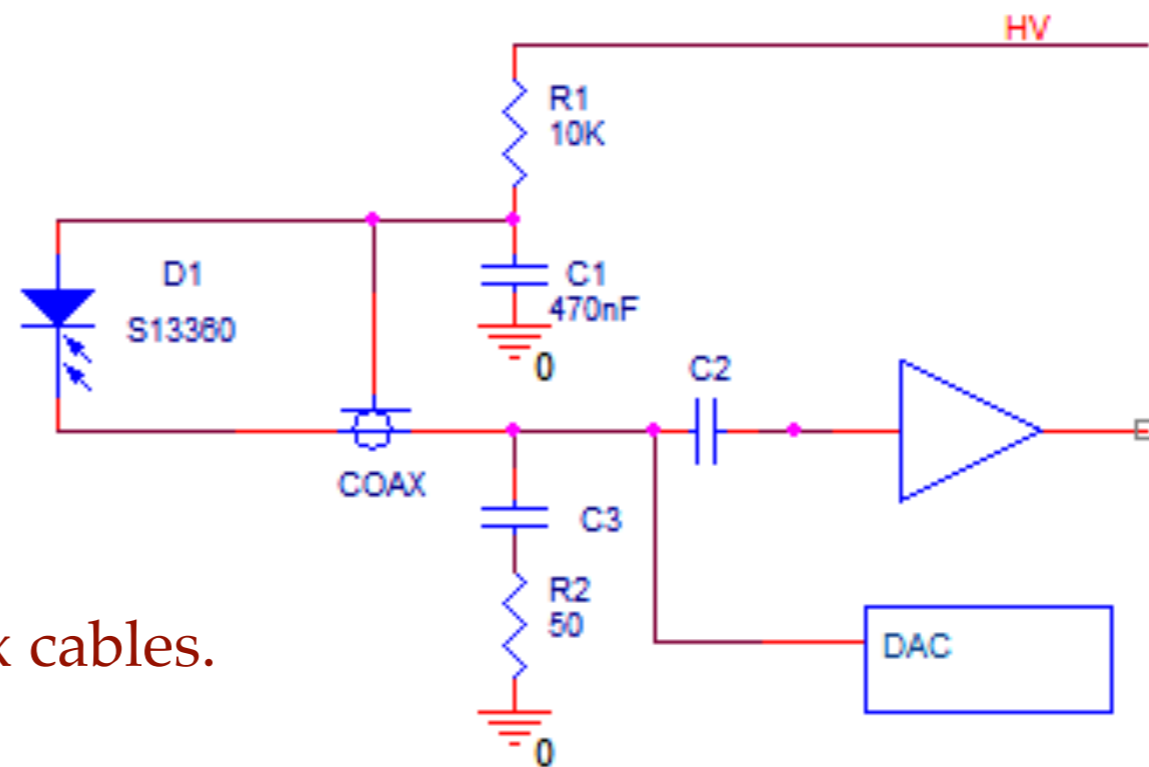
We can also use Gaseous Argon - easy to handle the tests



# SiPM Biasing and Readout



One side biasing ( multi-ch PS)



Flex cables.

Both side biasing (1 ch PS + DAC)

- + Less components - higher MTTF
- + DC coupling / direct grounding
- Expensive (CAEN A7040AN - 100 €/ch)

- + Easy to manage adjustment
- Complex schematics - less MTTF
- AC coupling / decoupled ground (**load rate/ background?**)



# SiPM Biasing and Readout



## CAEN A7040AN:

- 48 independently controllable High Voltage channels
- Common floating return shared by all channels
- DB37 connector
- Available with positive or negative polarity
- 0 ÷ 100V output voltage
- 1mA maximum output current
- 0.2mV voltage monitor resolution
- 2 nA current monitor resolution
- Low Ripple
- Independently programmable for each channel
- **Needs VME controller**

**4900 Euro/each -> 100 Euro/ch**

JINR is purchasing  
2 modules for prototype -> 96 ch



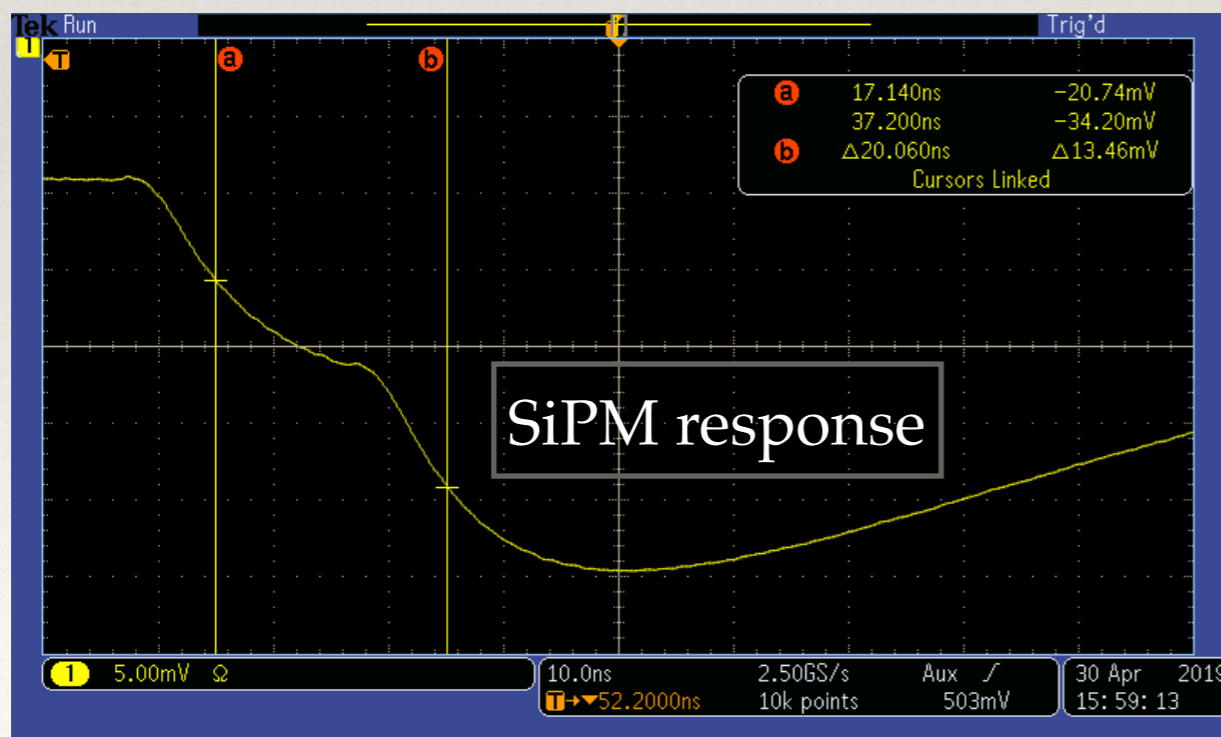
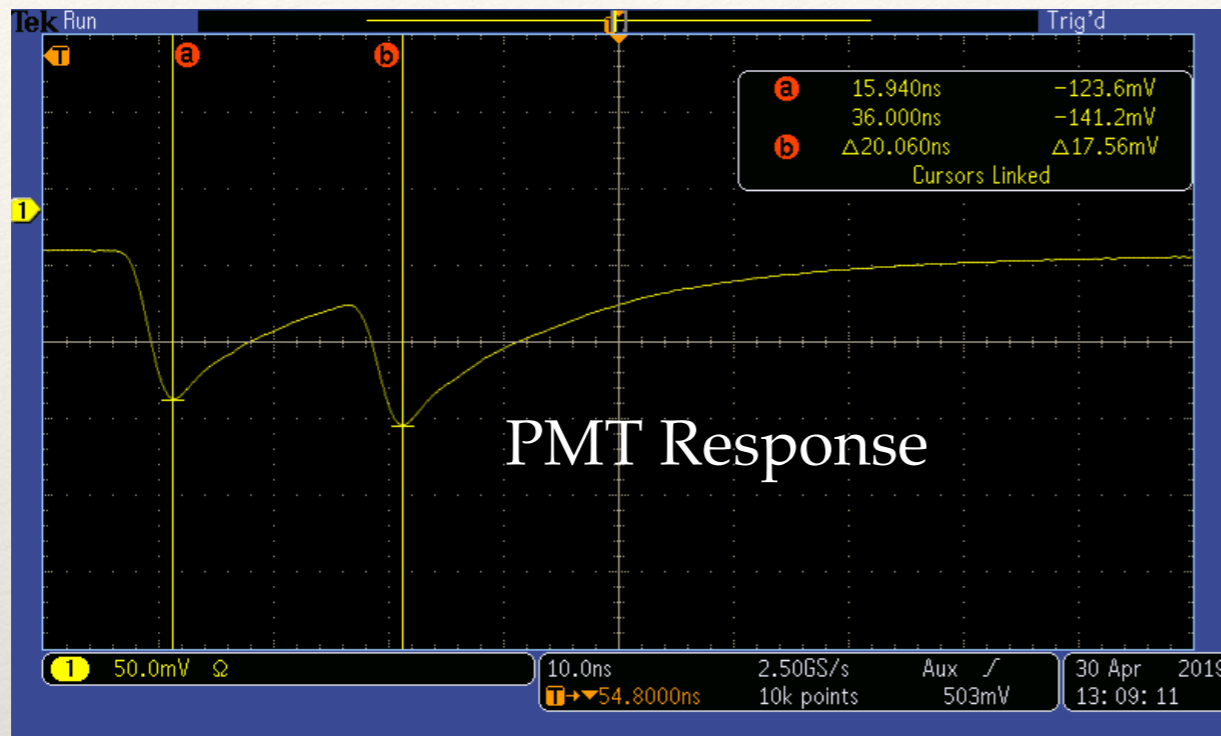
ASUS Thinker Board (RaspPi-like) +  
6 SPI 16ch DAC Boards DC2025:

- LTC2668 12-bit DAC range +/-10V (2.5 mV step)
- 10 ppm/°C -> 0.1 mV/°C @ 10V
- Custom made 50V - 1 ch PS (100 USD)
- Custom made software -> good for Slow Control

16 ch unit = 150 USD (chip ~ 40 USD) ->  
10 USD / ch (3 USD / ch)



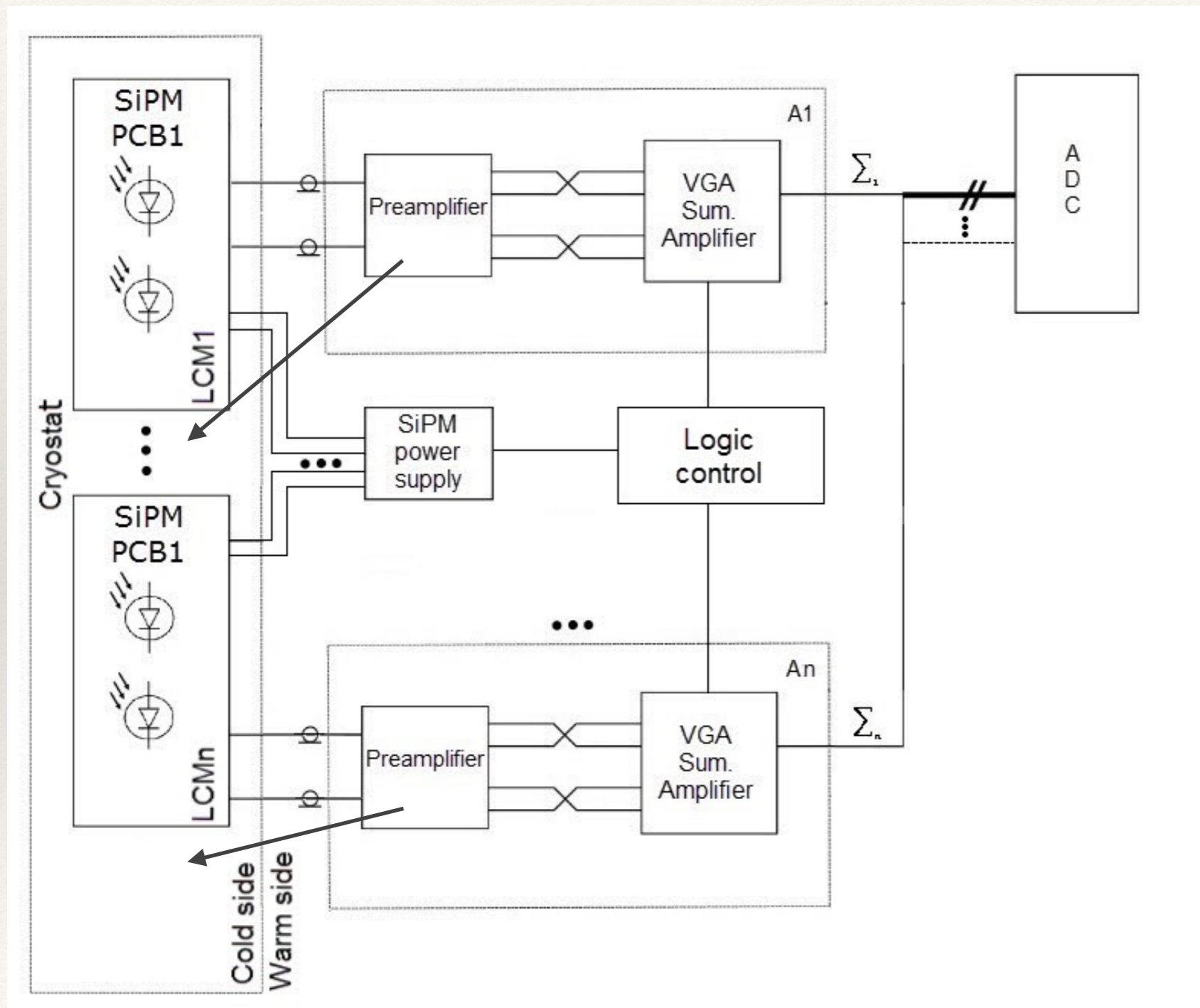
# LED double long pulses (dT=20 ns)



- Liquid Argon: RiseTime  $\sim 5$  ns, FallTime  $\sim \mu s$ ) - long pulse!
- SiPM has huge capacitance  $\sim 1$  nF - integrates long pulses
- We cannot resolve two long light pulses within 20 ns!
- Fast neutrons delay  $\sim 5$  ns - **No way to resolve in the same cell!**
- Don't need fast sampling electronics.
- Resolving two neutrino vertices overlap  $\sim \mu sec$  - No problem!



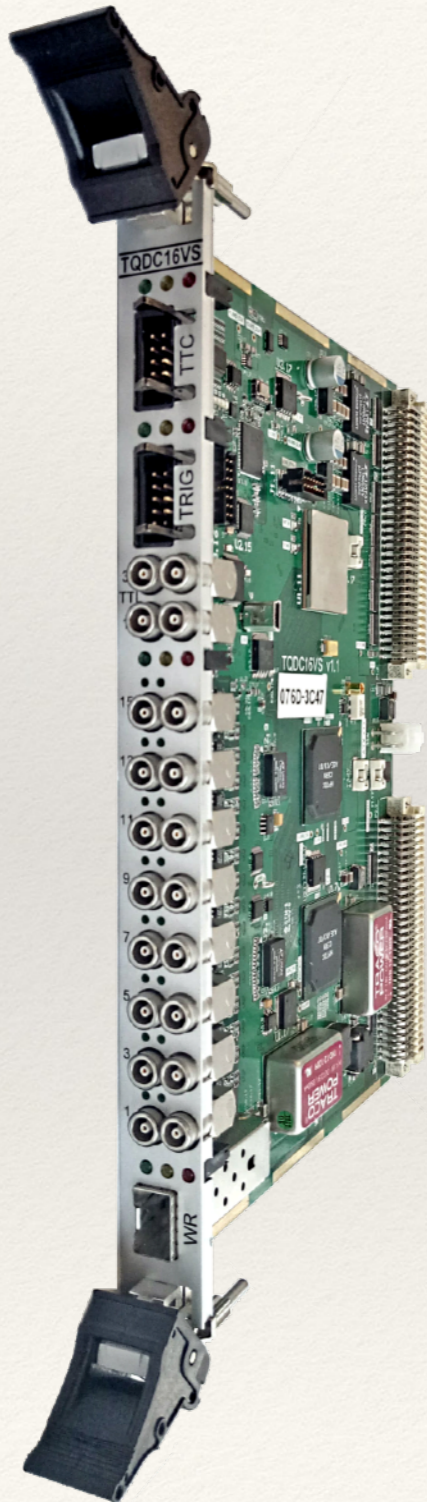
# SiPM readout and Trigger



- Spill = 10  $\mu\text{sec}$
- Light pulse  $\sim$  few  $\mu\text{sec}$
- Preferable ADC window  $\sim$  16  $\mu\text{sec}$



# Front-End electronics (Flash+TDC)



## JINR TQDC

- 14-bit @ 125 MS/s (8ns) Buffer of 2048 kSamples  
= 16  $\mu$ sec
- HPTDC provides 25 ps time resolution
- Analog inputs on Lemo coaxial connectors
- 16 channels, 1-unit wide 6U VME64 module
- VME64 and Ethernet (up to 10 Gbits)
- Embedded trigger logic - fast comparators (250 ps)

Price ~ 150 USD / ch



# Front-End electronics (Flash+TDC)



We obtained 2 boards, writing DAQ software, then perform tests with LCM

We are planning to purchase 8 pcs (2 spare)

**For prototype run we require 9 ports VME crate! (6 ADC, 2 CAEN + 1 Controller)**



# Front-End electronics (Flash ADC)

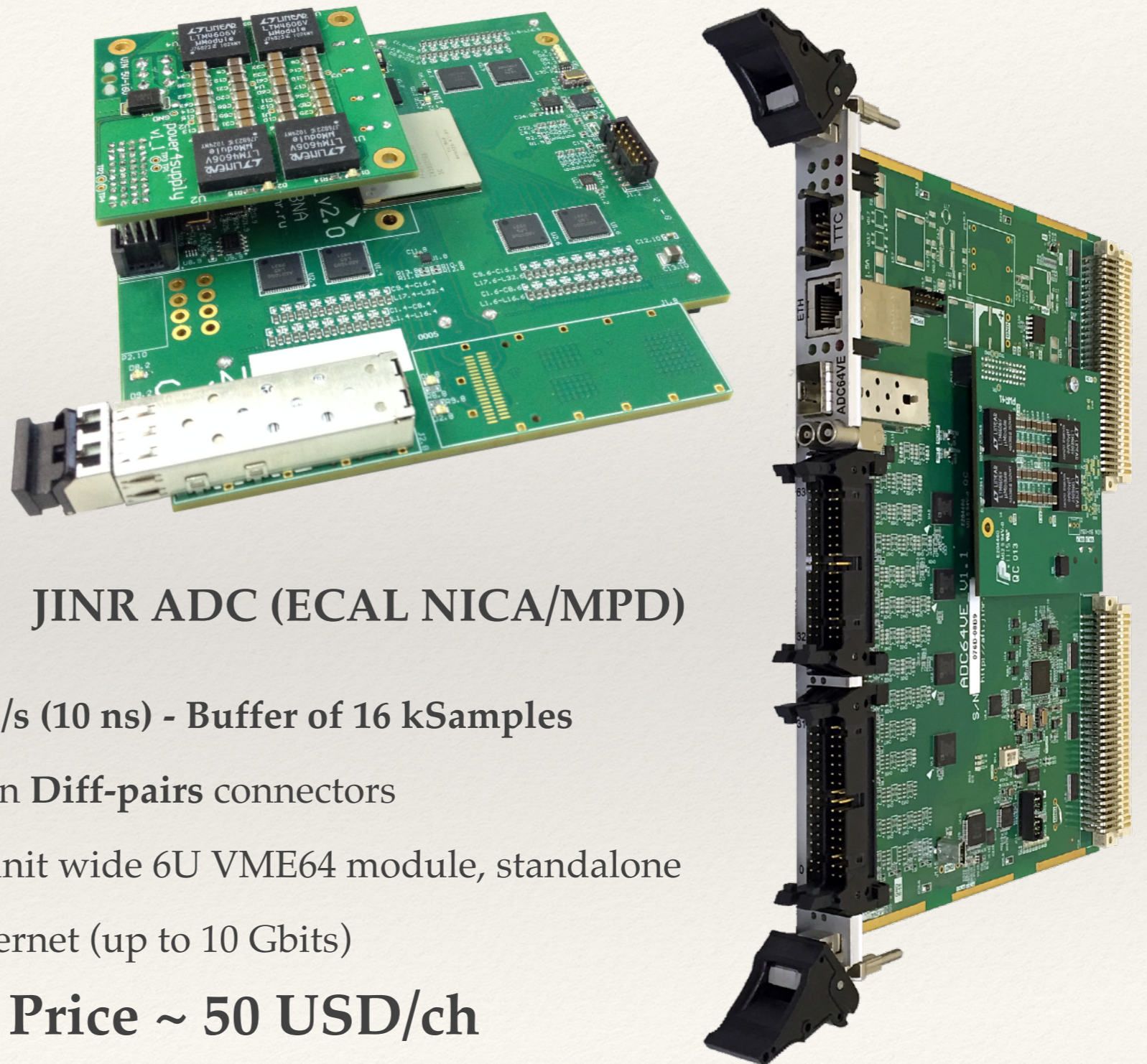
## Great solution for 2x2 and NearDetector

We need simulate operation processing Data from the Prototype Run with JINR TQDC:

- Apply software bandwidth filter
- Reduce sampling rate
- Reduce Resolution to 10-bits

- 10-bit @ 100 MS/s (10 ns) - Buffer of 16 kSamples
- Analog inputs on Diff-pairs connectors
- 64 channels, 1-unit wide 6U VME64 module, standalone
- VME64 and Ethernet (up to 10 Gbits)

Price ~ 50 USD/ch





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# Summary for the prototype

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- ❖ LCM/ ArCLight mixed layout - 24/24 modules
- ❖ Individual SiPM biasing (CAEN PS and Custom PS+DAC)
- ❖ Front End = Sampling 125 MHz ADC + TDC (optional)
- ❖ **Everything is arranged (prepared) for the prototype**  
**RUN: SiPM, essential materials, PS, FE-electronics.**
- ❖ After the RUN we will decide for Light Readout layout,  
Power supply, FE-Electronics, SiPM-type to prepare 2x2  
Module's RUN @ Fermilab.