



**Joint Institute for Nuclear Research**  
*Laboratory of High Energies Physics*

**Dubna State University**  
*Department of Physical and Technical Systems*



# Development of monitoring methods for MPD electromagnetic calorimeter modules

Speaker:

4<sup>th</sup> year student

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Supervisors:

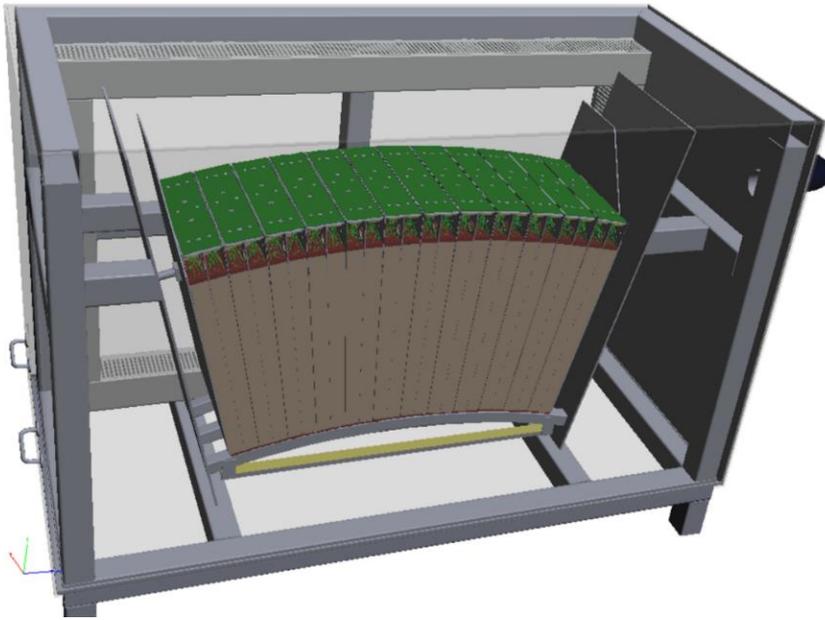
**Ustinov V.V. and Sukhov E.V.**

# Abstract

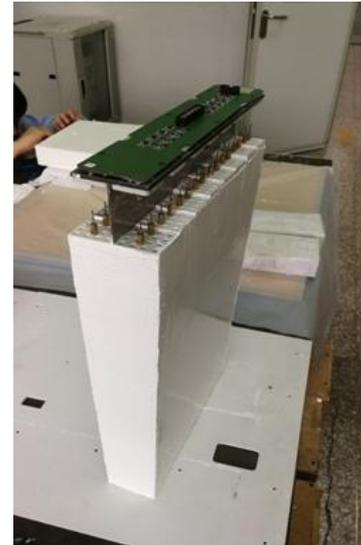
The development process of two scintillation monitoring systems for testing «Shashlyk» electromagnetic calorimeter modules (ECal) is considered.

One version of the system involves the use of small-area fast scintillation detectors in the trigger for testing Ecal using electron beams. In another version, it is proposed to use large-area scintillation detectors for testing modules on cosmic rays. Both implementations of such monitoring systems use SiPM technology to ensure high particle detection efficiency and possibility to work in high-intense magnetic fields.

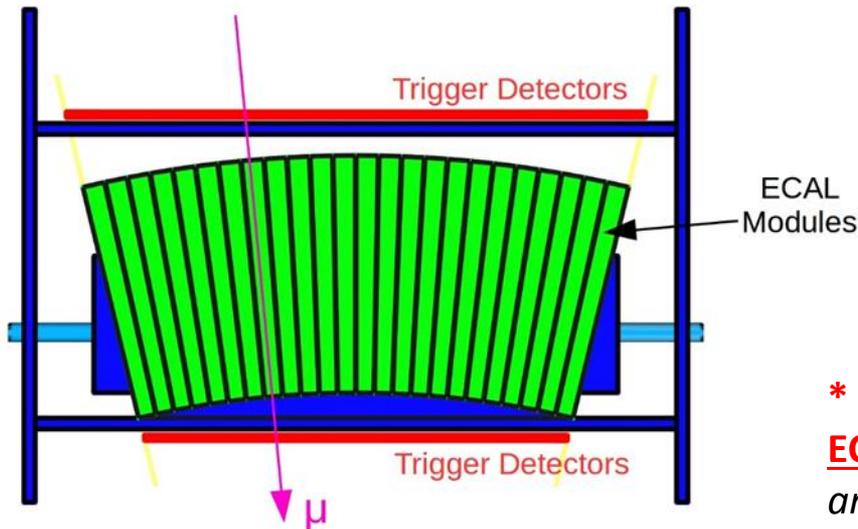
# The test bench for calibration of ECal modules



1 module  
16 towers (MPD)



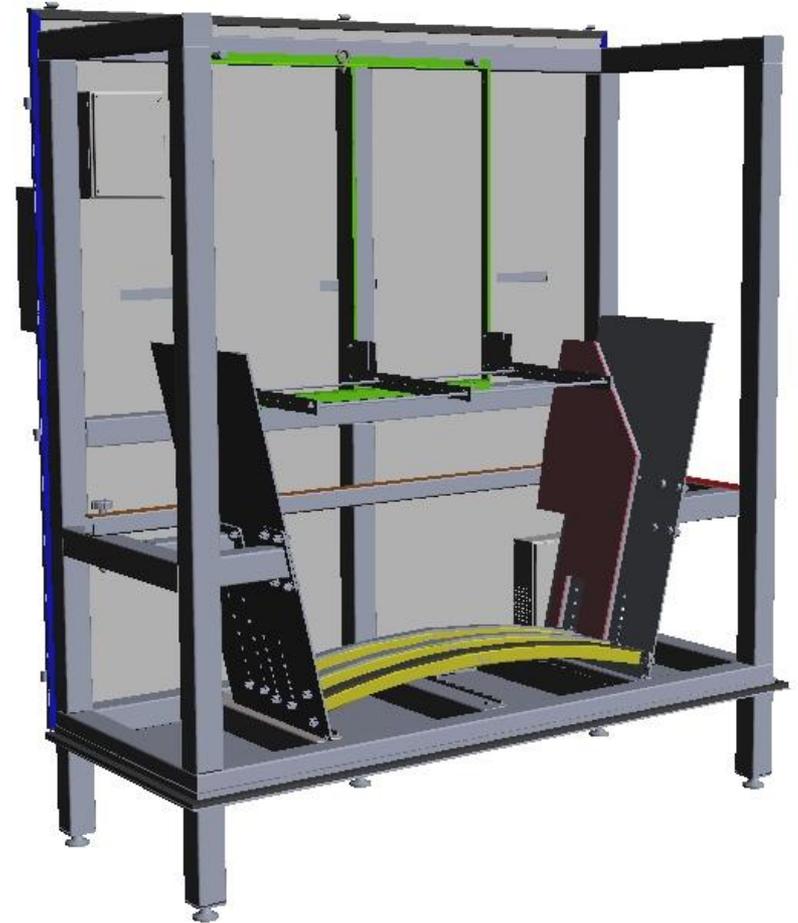
1 module  
9 towers (BM@N)



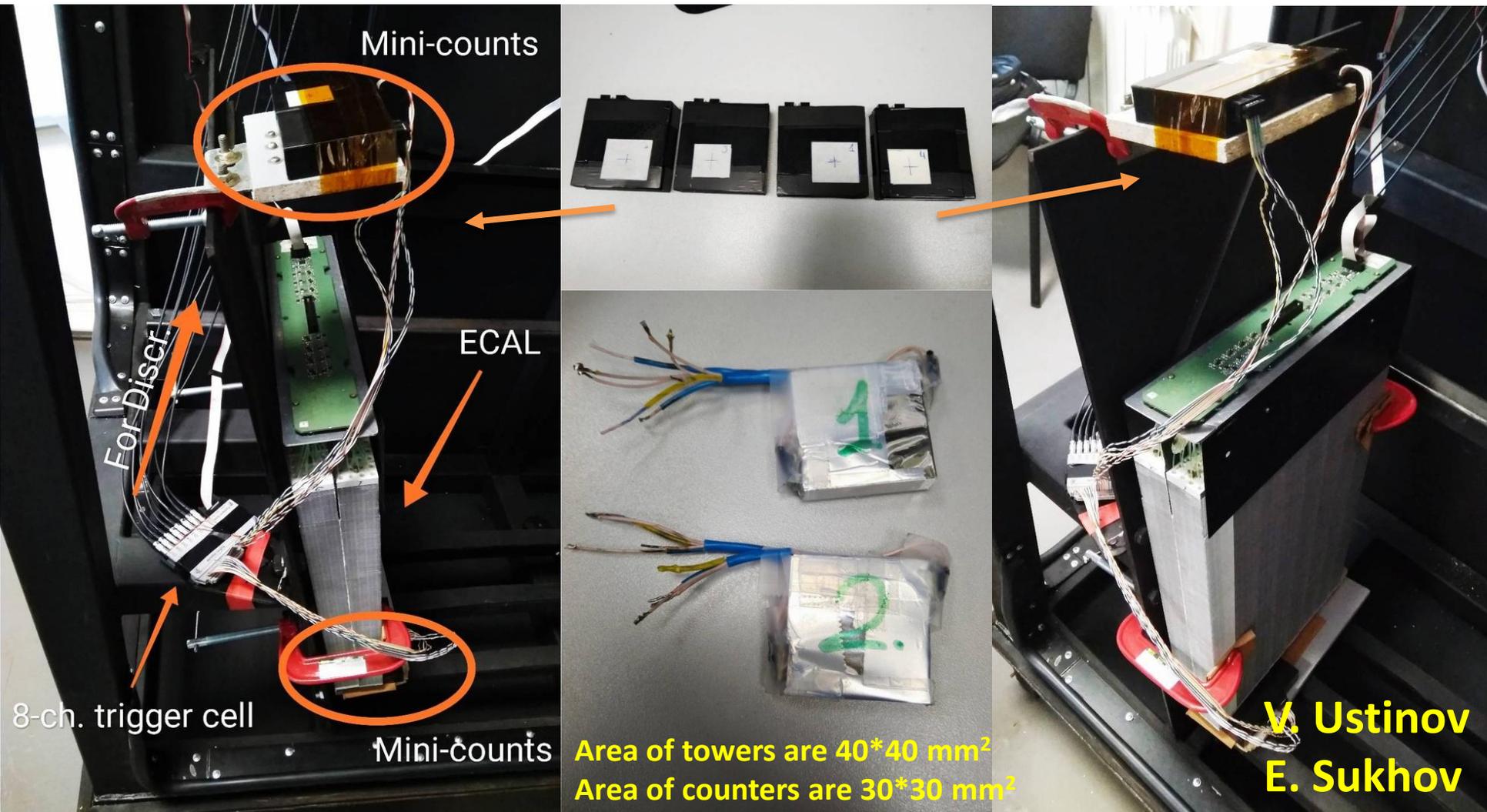
Cosmic rays is the only constant source of relativistic particles for the stand

\* More details in the [Yury Krechetov and MPD ECAL Group report](#), *Workshop on NICA/MPD, ECal and Software*, April 8-10 (2019), Beijing, China 3

# The test bench for calibration of ECal modules



# Individually calibrate of each tower using mini-trigger counters

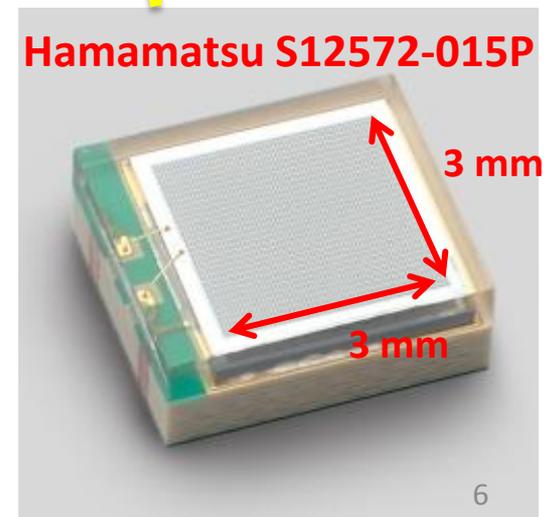
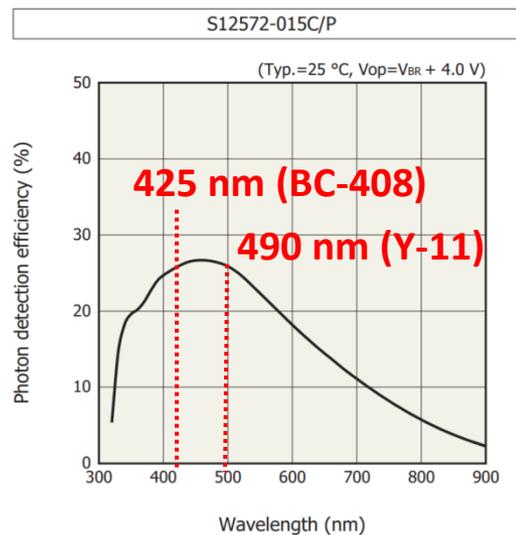
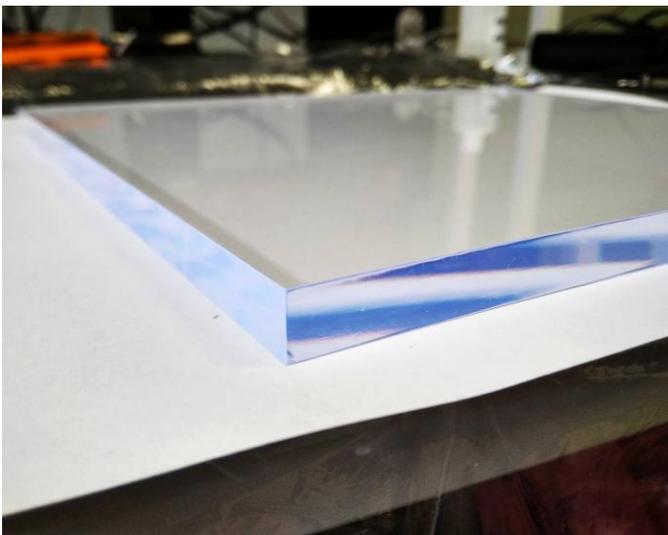
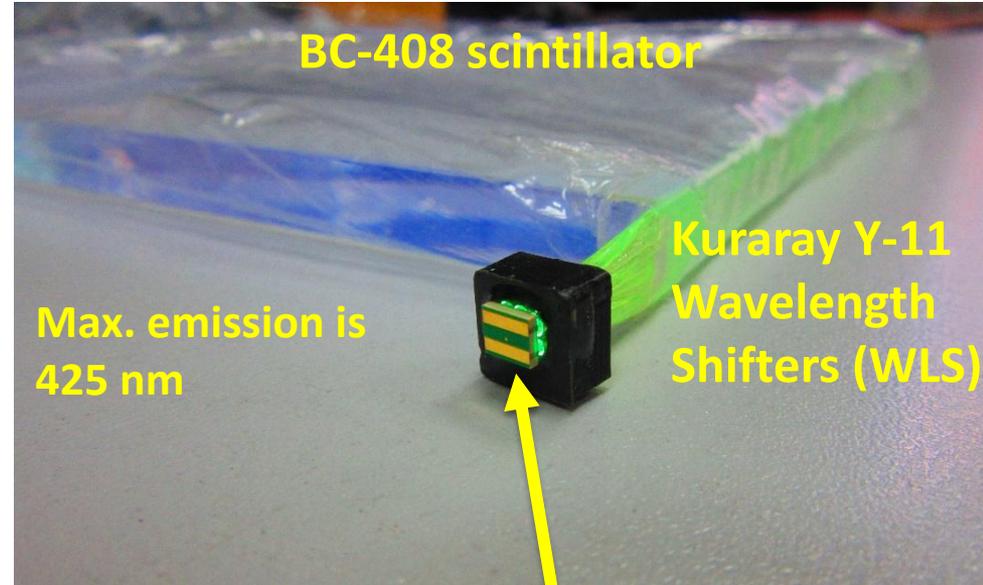
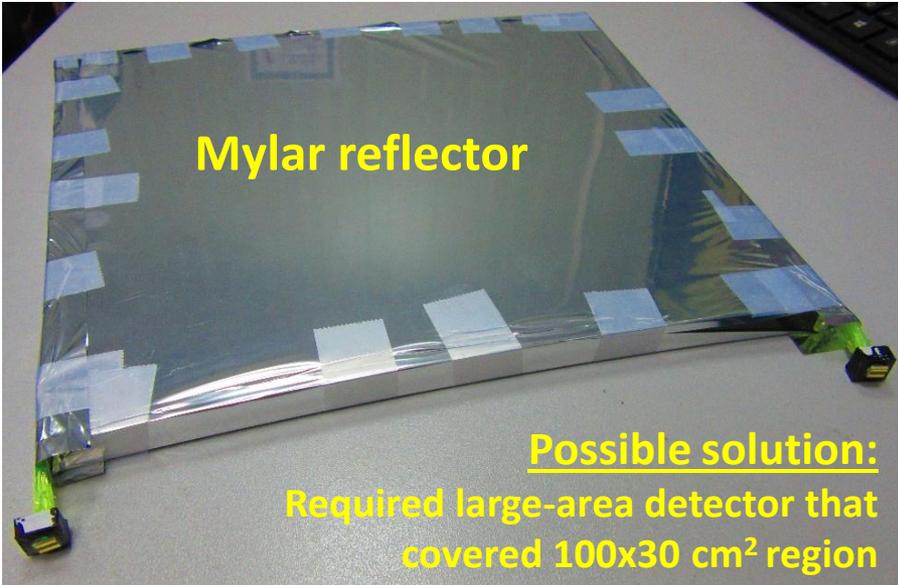


**1 module = 16 towers**  
**1 test bench = 12 modules = 192 towers**  
**There are two counters for each tower = 384 piece**

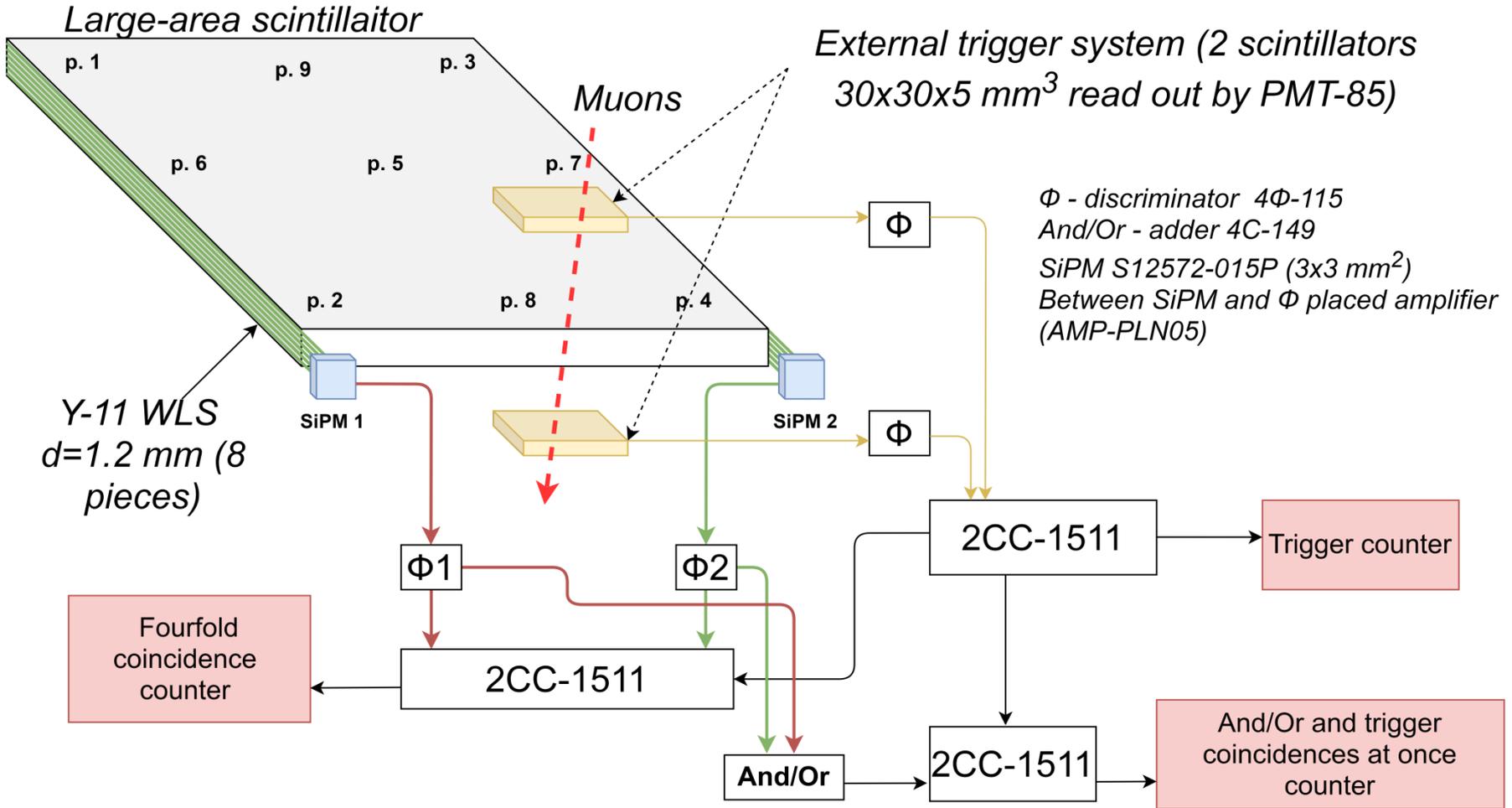


**This is too much electronics ->  
Unprofitable**

# Test of the monitoring counter large square



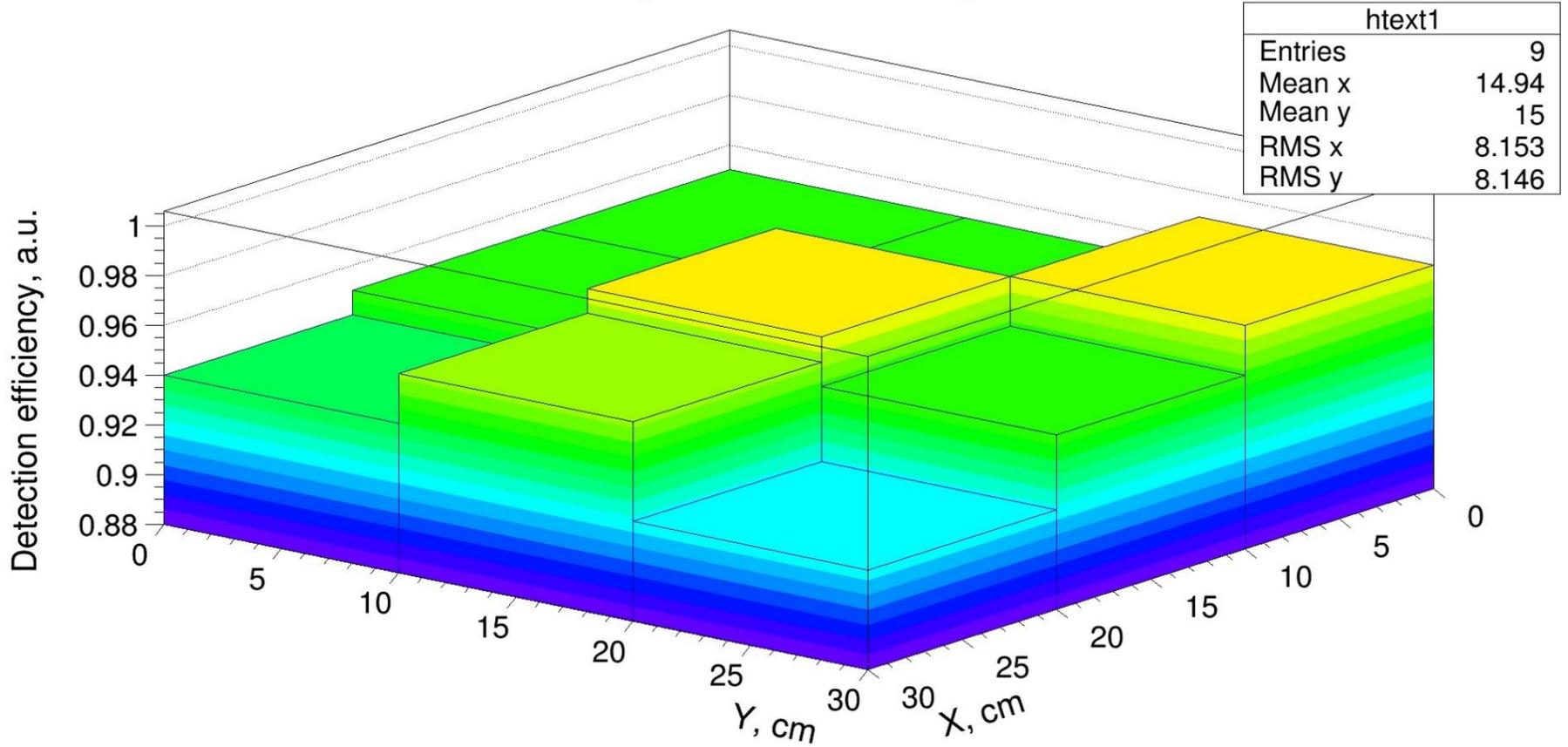
# Block-scheme of measurements



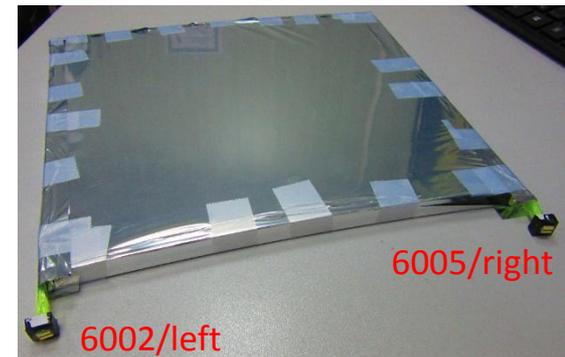
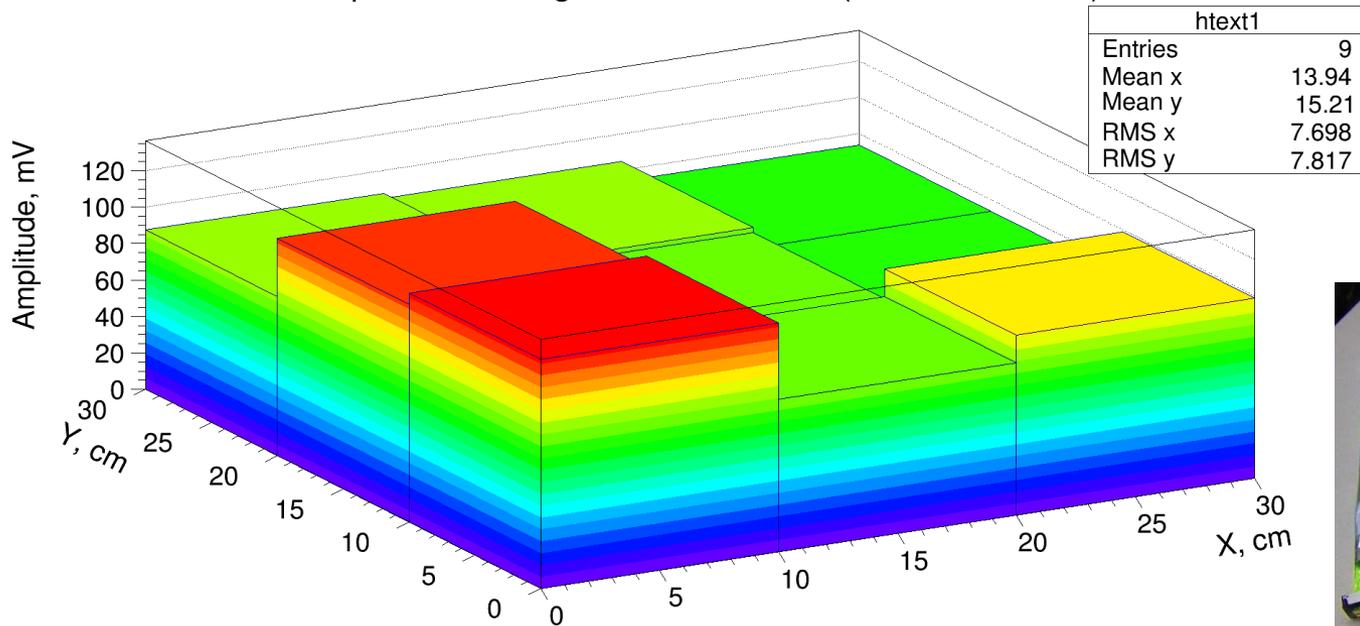
$$\epsilon_{\text{пер}} = \frac{N_{\text{зарег}}}{N_{\text{прошедших}}}$$

$N_{\text{прошедших}}$  - total number of particles that passed through external trigger system

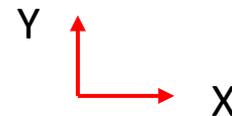
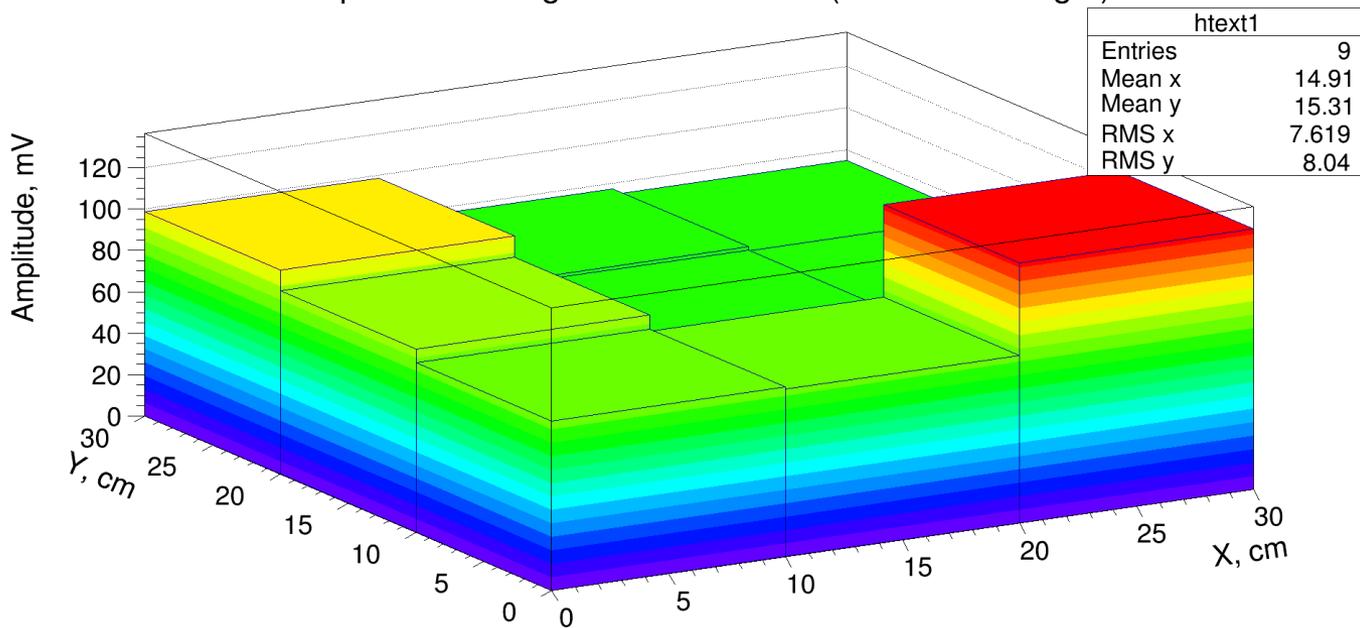
# Detection efficiency distribution of large-area scintillator

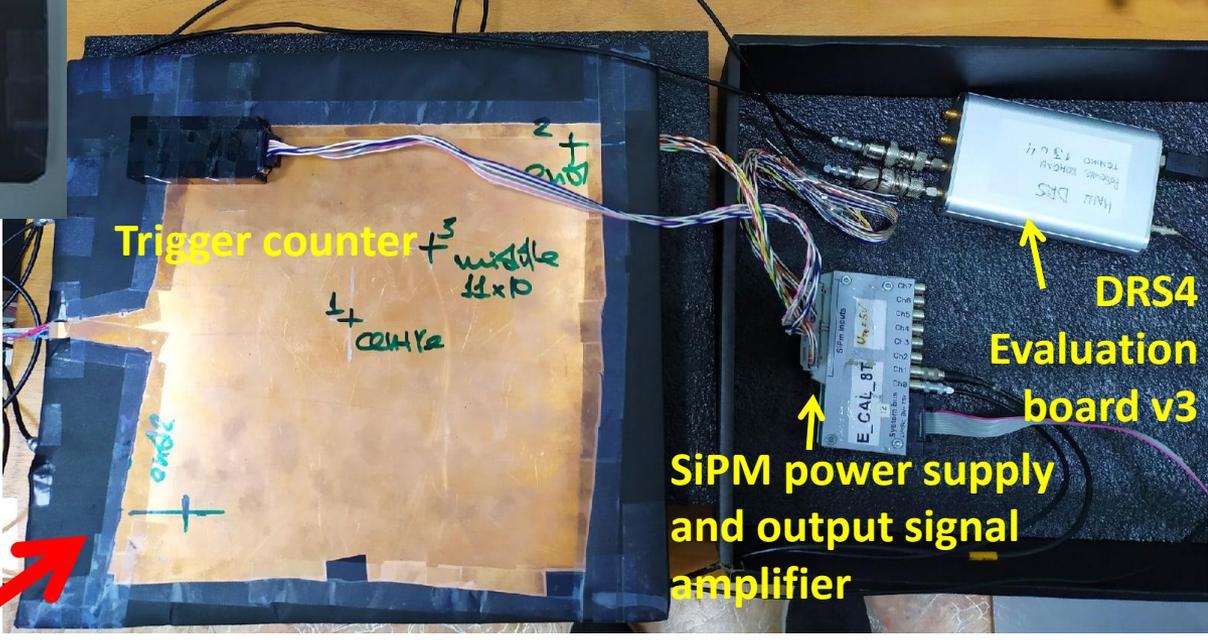
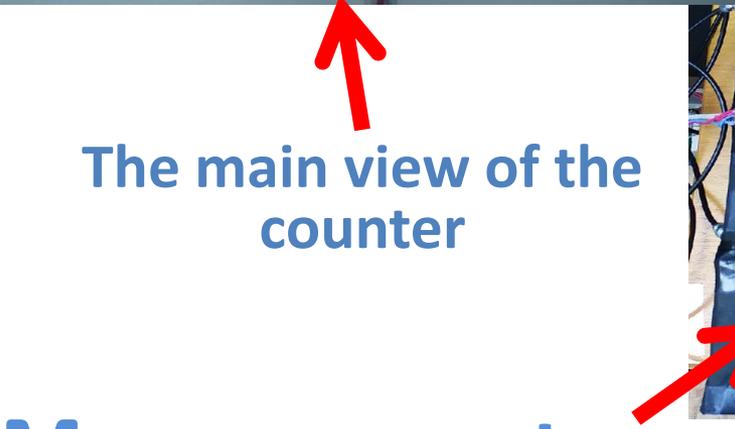
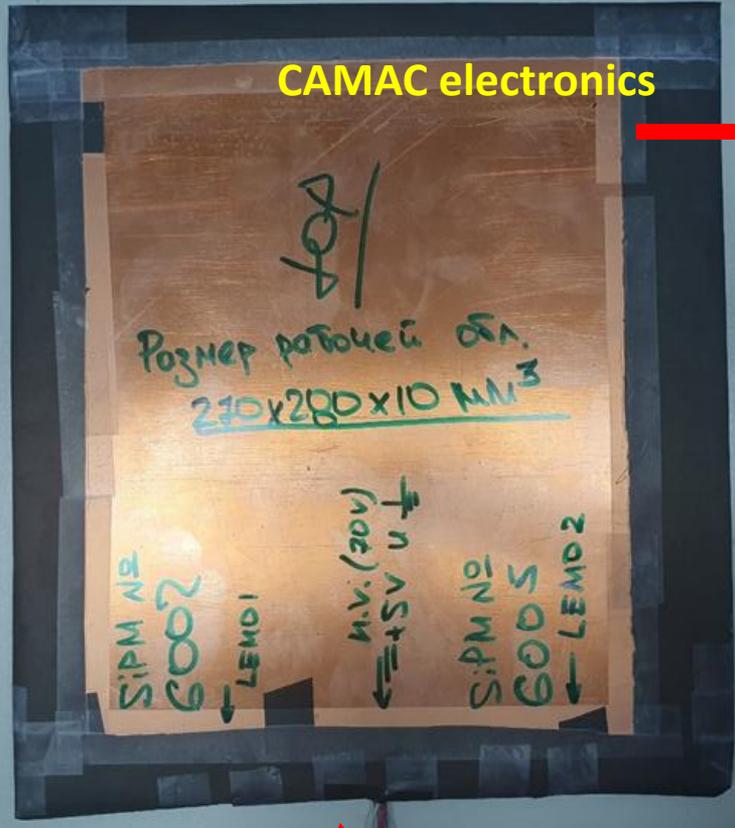


Amplitudes of large-area scintillator (SiPM #6002/left)



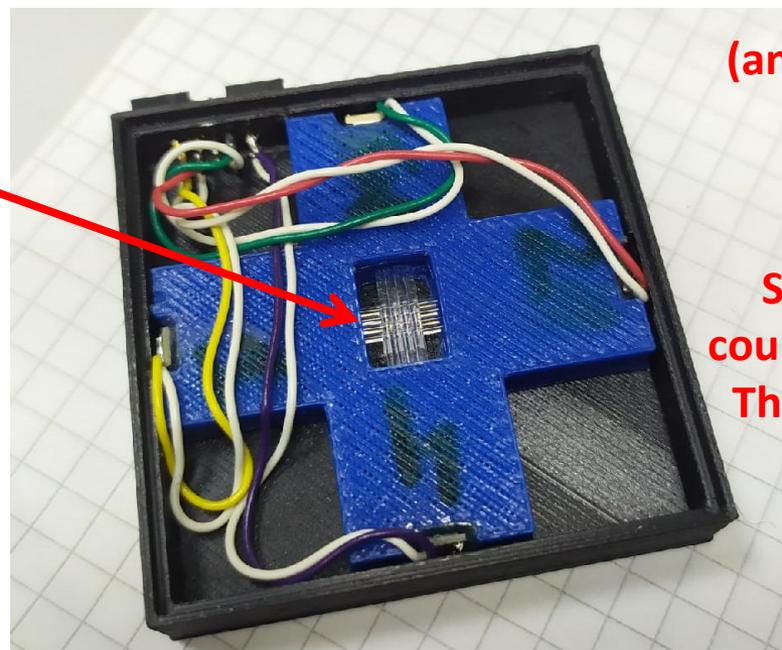
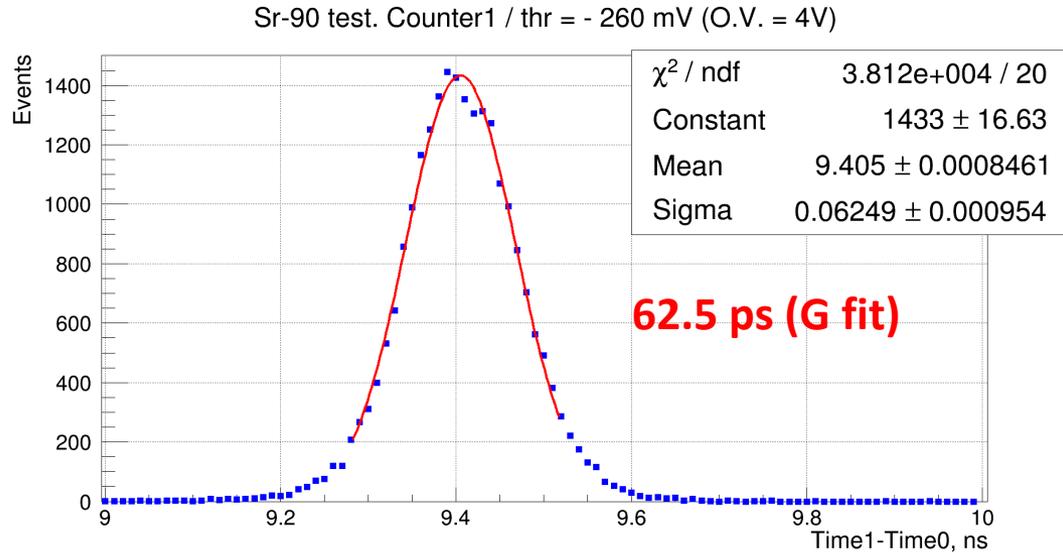
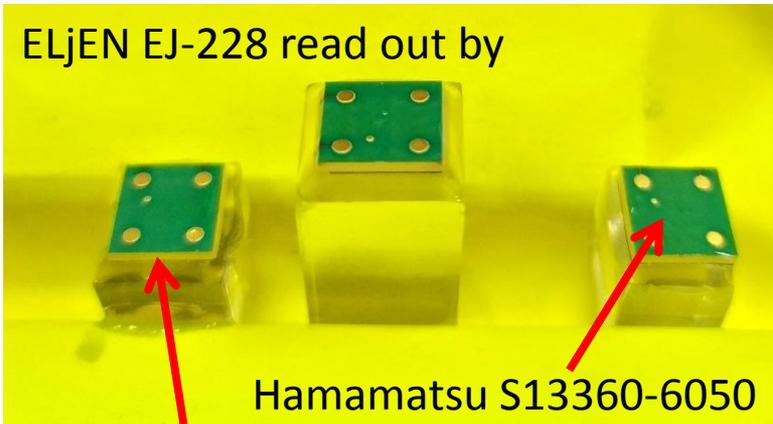
Amplitudes of large-area scintillator (SiPM #6005/right)





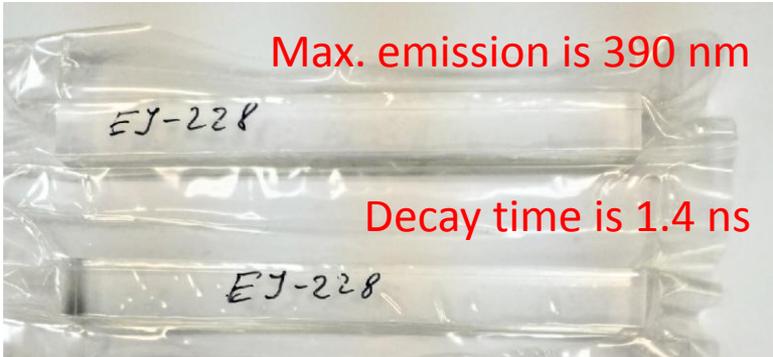
# Measurements

# Development of the fast beam counters



**Bicron BCF-10  
(analogue BC-408)  
read out by  
S12572-015P**

**Sensitive area of  
counter is 4x4 mm<sup>2</sup>  
Thickness is 2 mm**



# Summary

1. A large-area prototype of trigger counter has been development and tested. The counter is based on Bicron BC-408 plastic scintillator; light extraction was carried out by an Y-11 WLS, that ensures high uniformity of the output signal.
2. Developed 6 fast mini-counters based on Eljen UV scintillators for beam tests. The counters have a high temporal resolution from 60 up to 80 ps.
3. A special beam counter based on Bicron BCF-10 scintillating fibers with a working area of  $4 \times 4 \text{ mm}^2$  (thickness is 2 mm) has been developed.
4. The efficiency of minimally ionizing particles registration of all counters is close to 100%.

**Thank you for attention!**

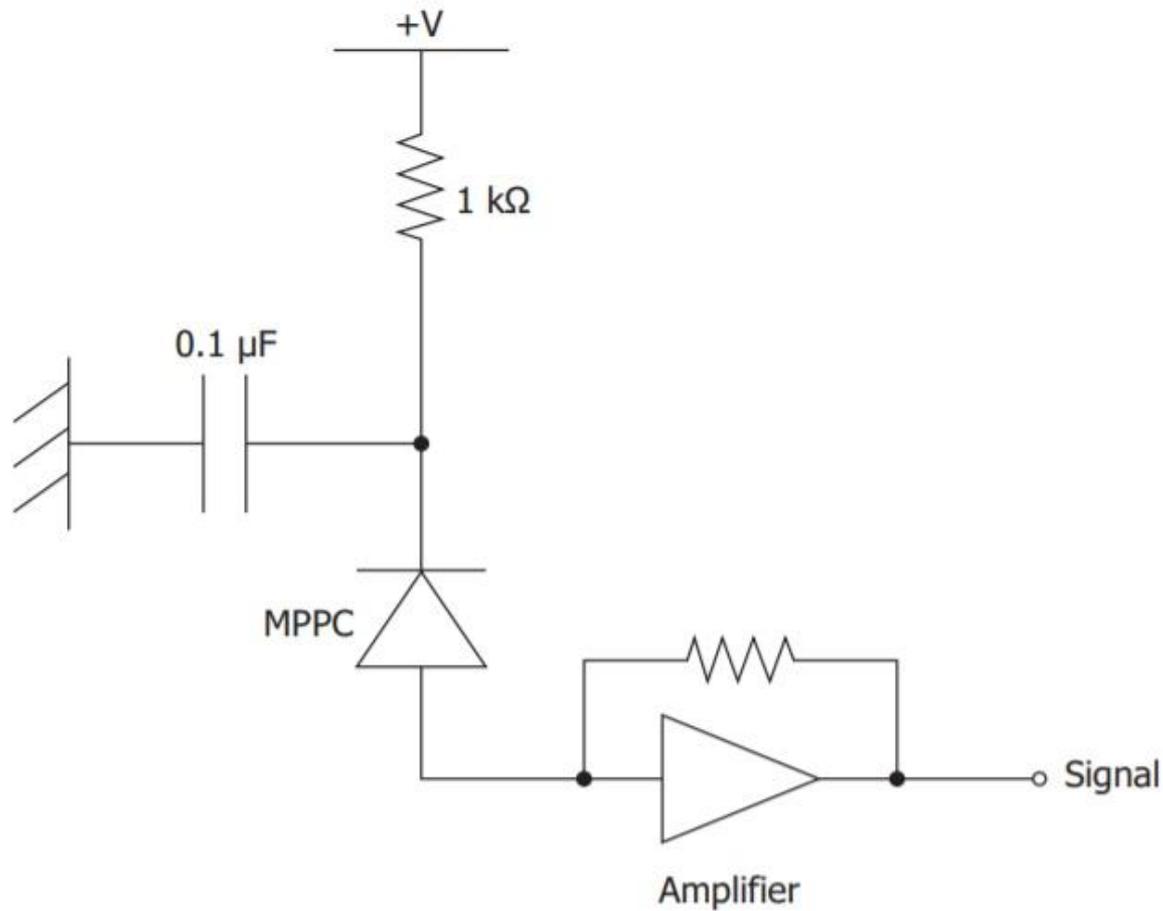
# References:

- V. Ustinov and S. Afanasiev

«A system of ECAL/BM@N monitoring with wavelength shifting fibers readout for operation in a magnetic field»

Memories of the Faculty of Physics, Lomonosov Moscow State University, issue № 3, 1830204 (2018)

## Connection example



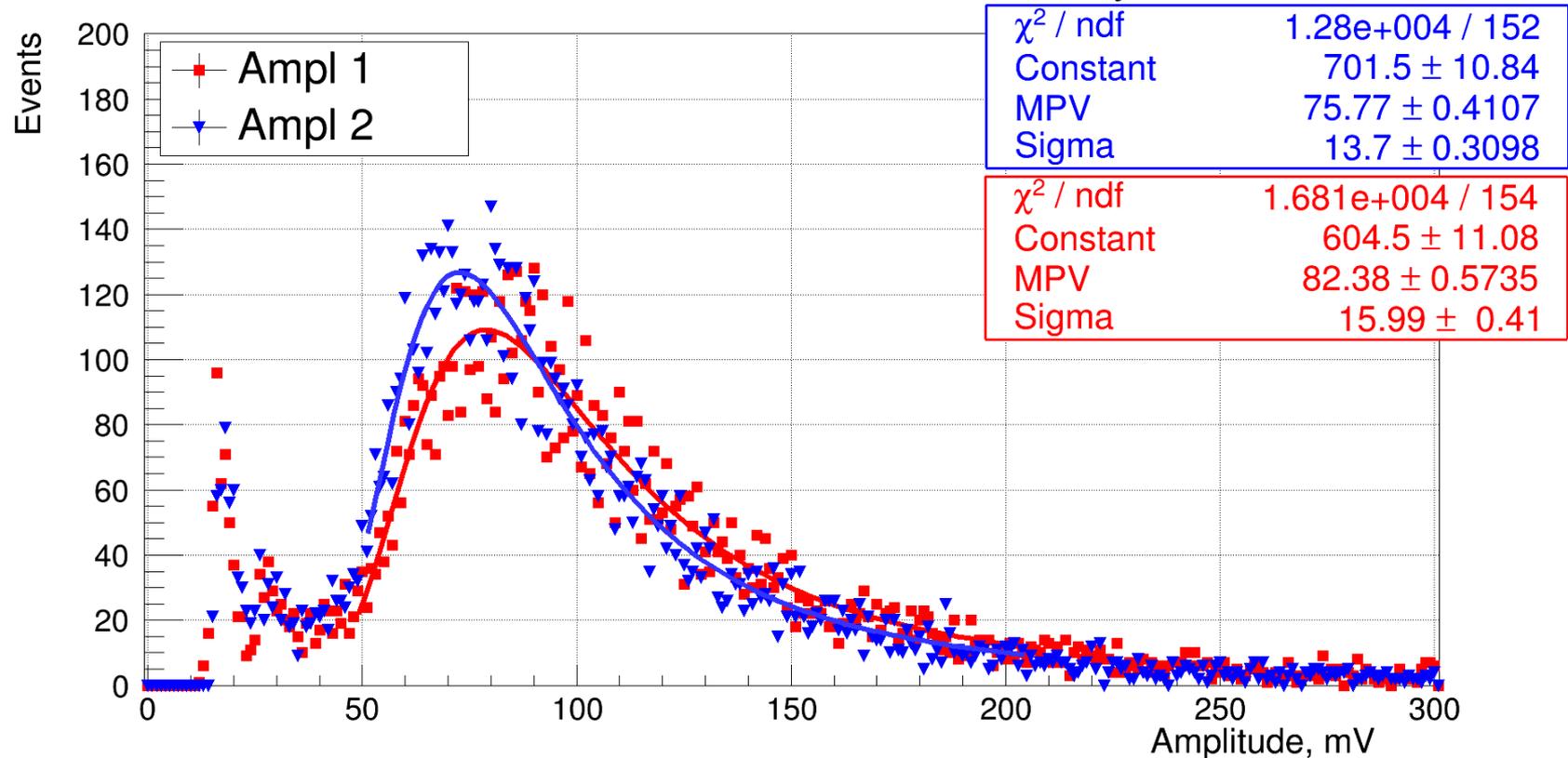
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**HAMAMATSU**

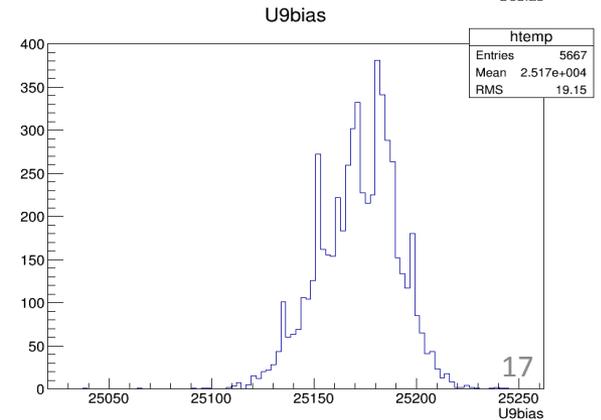
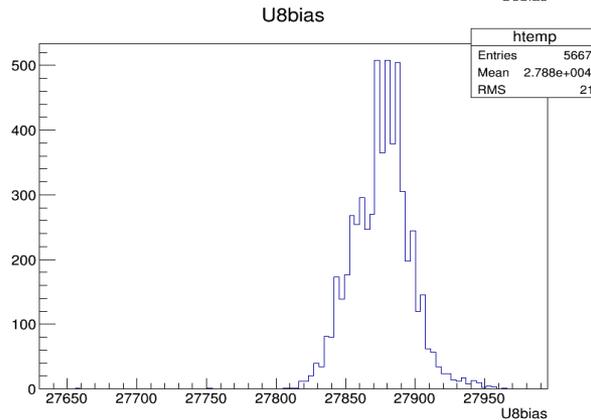
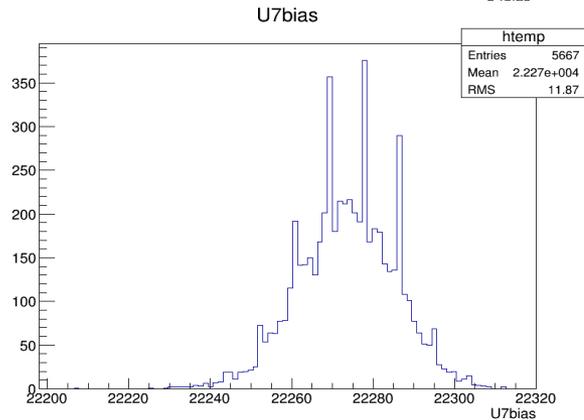
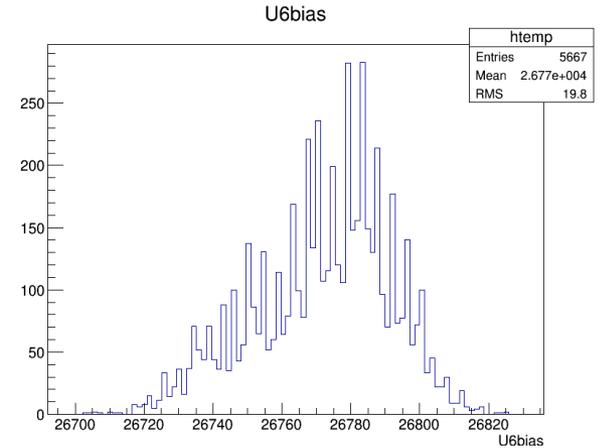
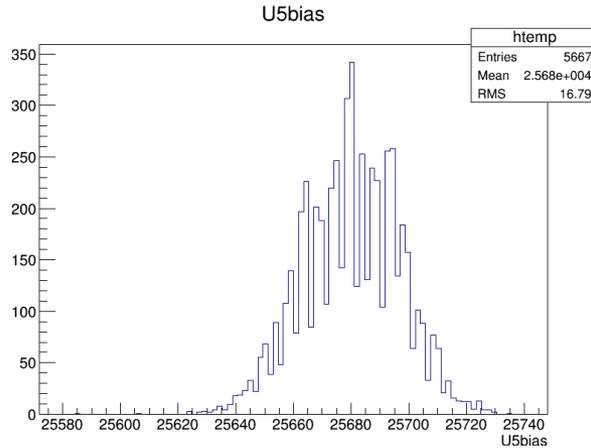
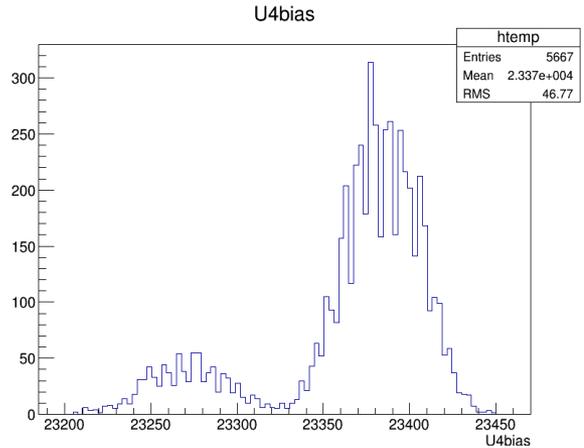
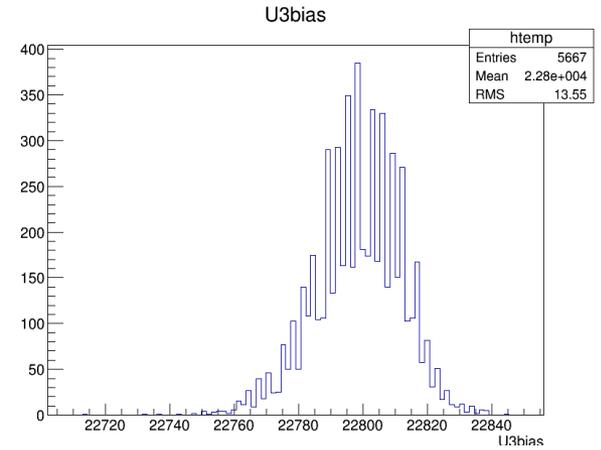
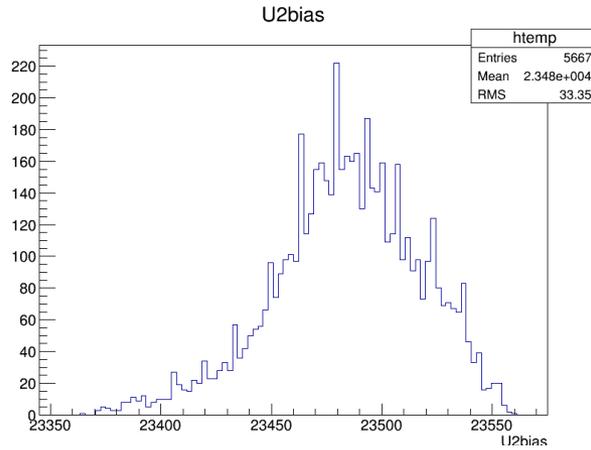
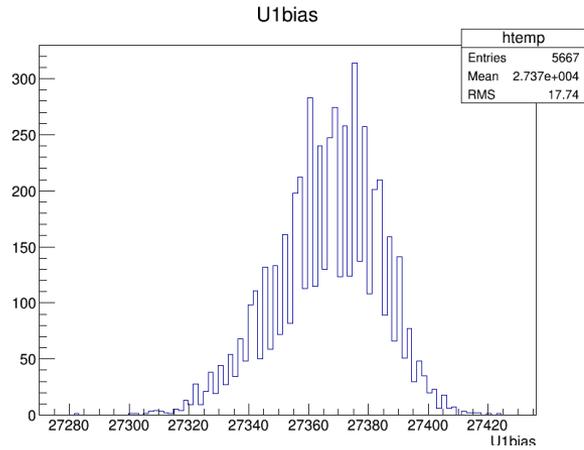
PHOTON IS OUR BUSINESS

# Example of detected amplitudes (centre of counter)

Test scintillator detector on cosmic rays



# Amplitudes of signals when muon passing



# Signals from calorimeters selected by the trigger system

The screenshot displays a software interface for configuring and monitoring an ADC64. The main window, titled "ADC64 | Program index: test\_eal\_42 | Configuration name: default", shows various configuration options:

- Trigger:** Lemo(TTL) is checked.
- Readout Window:** Size is 60, Latency is -5.
- Zero suppression:** Software ZSS is checked.
- DSP:** MAF is checked, MAF selector is 8, BLC thr is 100.
- Tail Cancellation:** None.

Below the configuration, the status bar shows "ADC64WR 076D-3E83 ADC:51 WR Invas 1.0.25763 Online Adc lock Ok". The "Start" button is highlighted, and "Write file..." and "Channels setup..." options are visible.

The plot area shows a signal trace for 16 channels (ch1 to ch16). The y-axis ranges from -700 to 100. A prominent signal is visible in channel 4, showing a sharp negative-going pulse reaching approximately -650 units around event 18. Other channels show minimal activity.

On the left side, there are two panels for bias voltage configuration:

**Top Panel (T(C)=27.20):**

Ch.	Negative Bias(V)	Output (V)
0	1.131	1.131
1	1.443	1.443
2	1.470	1.470
3	1.330	1.330
4	1.490	1.490
5	1.246	1.246
6	1.267	1.267
7	1.396	1.396
8	1.307	1.307
9	1.408	1.408
10	1.955	1.955
11	1.453	1.453
12	1.509	1.509
13	1.217	1.217
14	1.335	1.335
15	1.666	1.666
VDD	64.822	64.822

**Bottom Panel (T(C)=-11.80):**

Ch.	Negative Bias(V)	Output (V)
0	1.000	1.000
1	1.252	1.252
2	1.000	1.000
3	1.650	1.650
4	1.300	1.300
5	1.100	1.100
6	0.650	0.650
7	1.900	1.900
VDC	65.001	65.001

In the center, a "Lookup table" for "0A7A-6E07" is shown, listing thresholds and counts:

thr, V	count
1 0.000	426454
2 0.000	448287
3 0.000	534467
4 0.000	505882
5 0.000	370756
6 0.000	347102
7 0.000	306548
8 0.000	338331
9 0.000	0
10 0.000	0
11 0.000	0
12 0.000	0
13 0.000	0
14 0.000	0
15 0.000	0
16 0.000	0

# Calculation results

Studies have shown that the efficiency of light registration is equally high over the entire area of the counter and does not depend on the passage of minimally ionizing particles.

№ точки измерения	Кол-во триггеров	Кол-во совпадений	Кол-во И/ИЛИ	Эффективность 4х-кратных совпадений	Эффективность И/ИЛИ
1	387	368	-	0.95	-
2	2074	1953	2028	0.94	0.98
3	6862	6669	-	0.97	-
4	200	184	188	0.92	0.94
5	2057	2000	-	0.97	-
6	276	261	269	0.95	0.97
7	267	256	260	0.96	0.97