Status report on the SPD Beam-Beam Counter (BBC) prototype for initial SPD runs at NICA

A.V.Tishevsky on behalf of JINR-MEPhI BBC

The 8th international conference on particle physics and astrophysics, Moscow

29 October 2026

❑ Introduction

- BBC priorities

❑ SPD Phase0

- SPD location (2026; FT mode)
- The stages configuration setup
- Sandwich backplate for BBC
- The prototype wheels assembling
- The optical cable issue
- Design of the BBC support system
- Design of the radiation shield box
- **The integration progress**
- The infrastructure issues

❑ Tests at Nuclotron: Run-2026 (spring)

❑ SPD Phase1

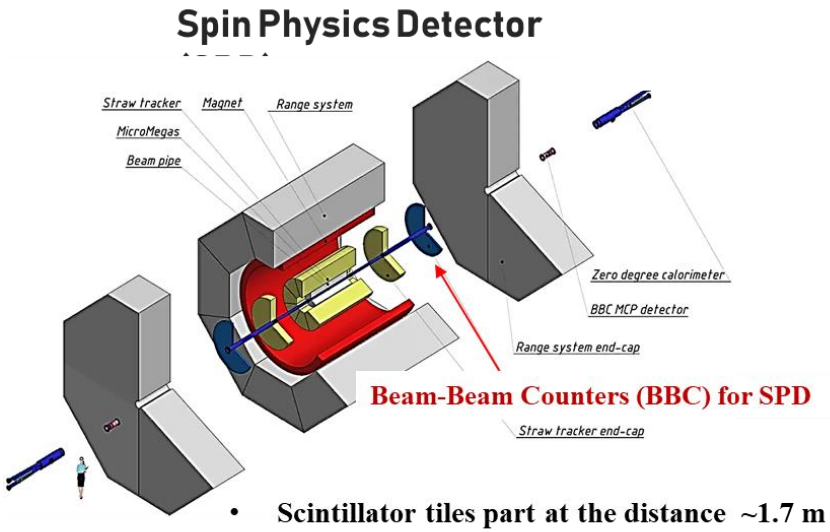
❑ Conclusion

BBC priorities

MAIN GOALS:

+ **local polarimetry**

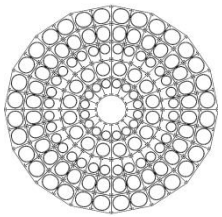
+ event plane detector for HI physics



- **Scintillator tiles part at the distance ~1.7 m**

Phase0

(2*128 tiles wheels)

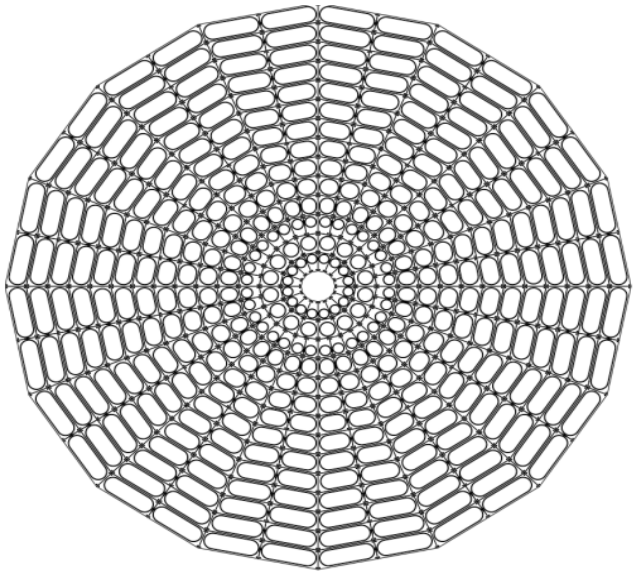


(Step 1-st)

2026-2030

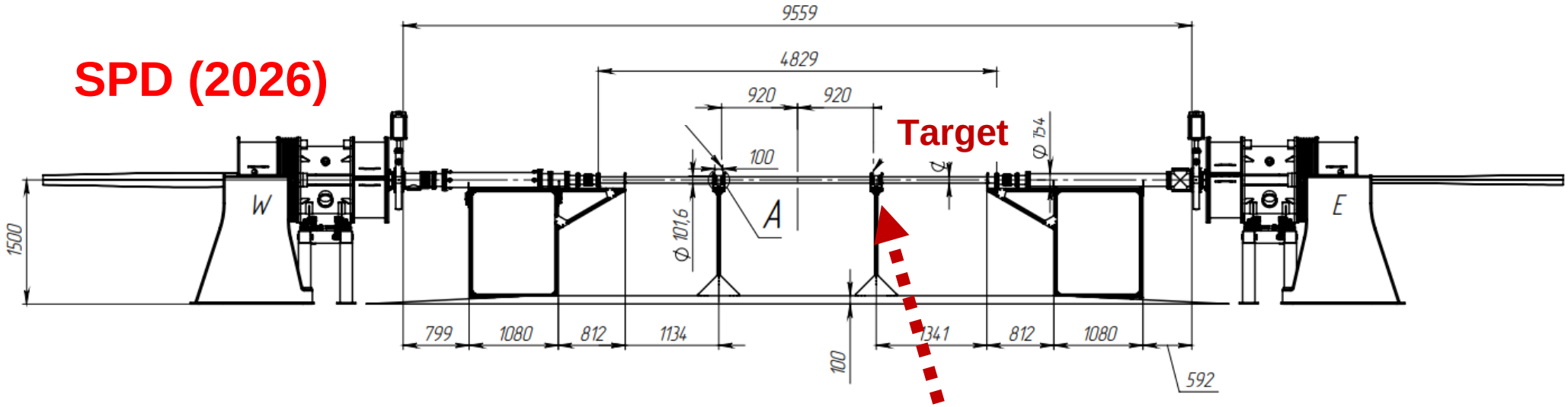
Phase1

(2*416 tiles wheels)



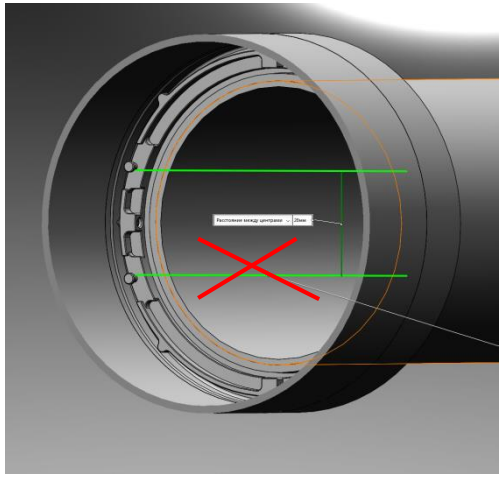
(Step 2-nd)

SPD (2026)



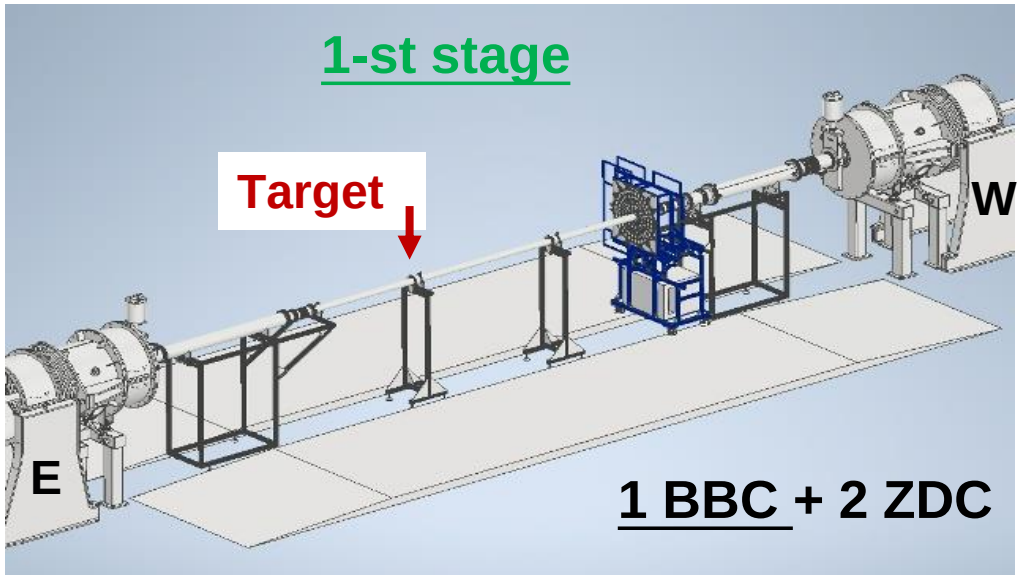
✓ **Titanium Pipe** (~83 mm diameter) **is mounted**

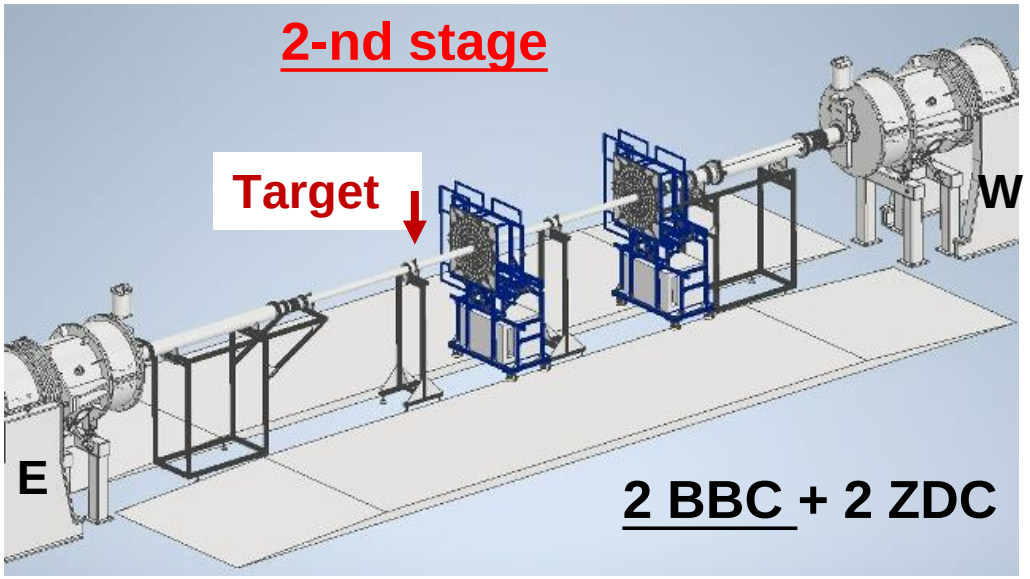




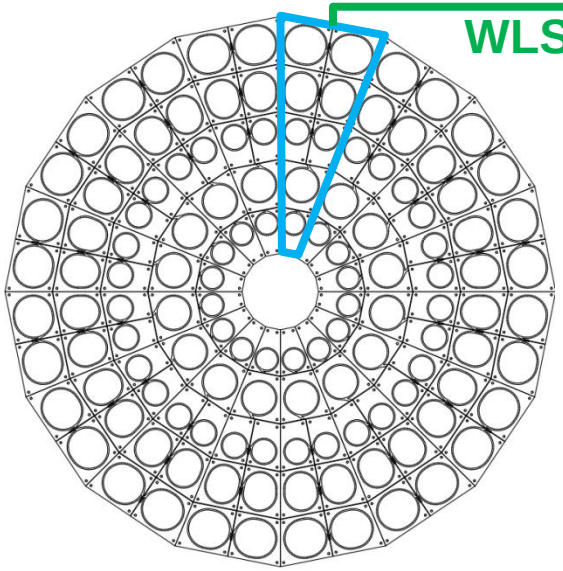
✓ **Target (Au) is mounted**

The stages configuration setup

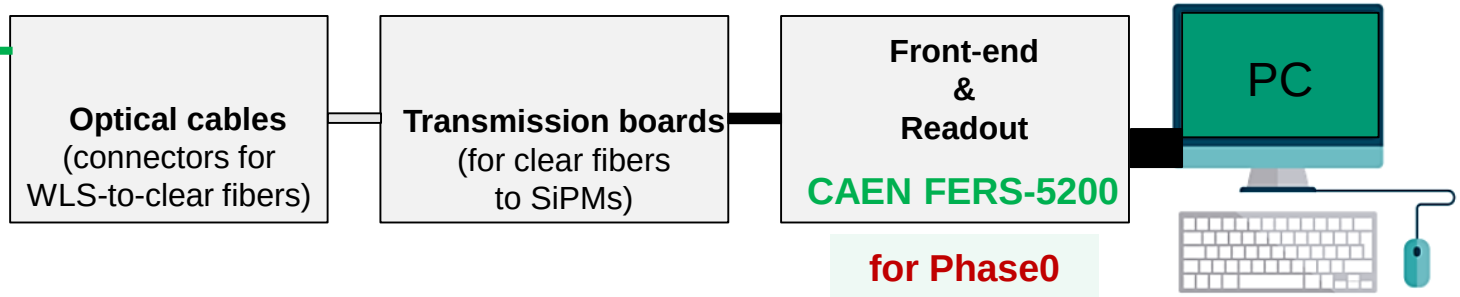




reduced prototype wheel (128 tiles)



It consists of 2 halves



for Phase0

DT5202
DT5215
Optical link



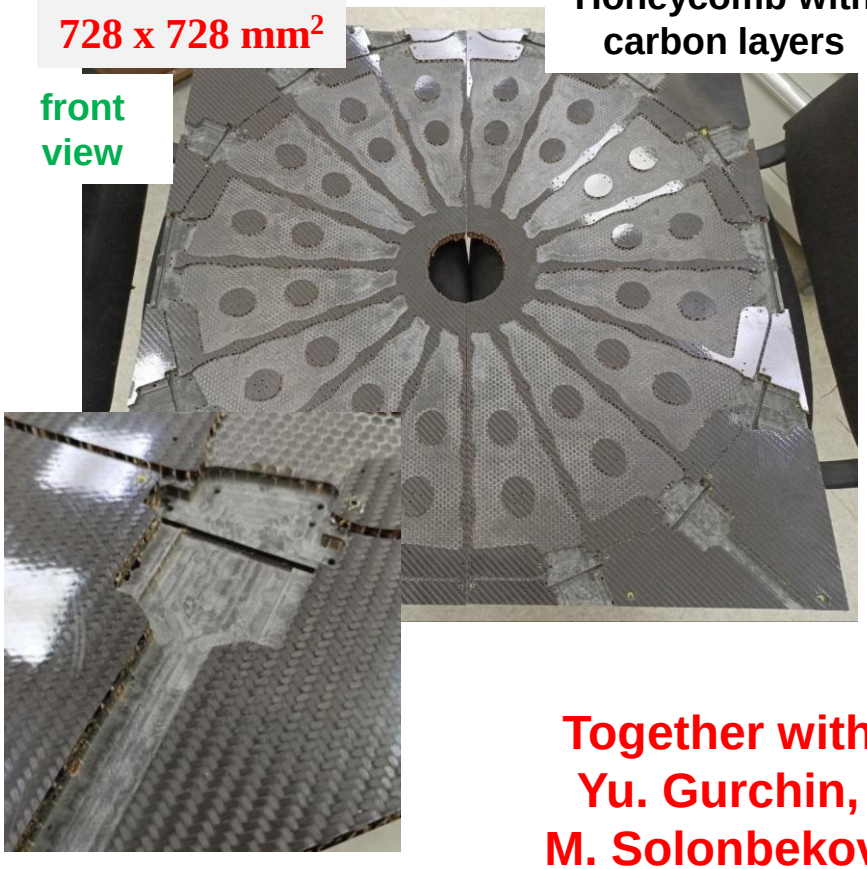
Sandwich backplate for BBC

Backplate for prototype

728 x 728 mm^2

Honeycomb with carbon layers

front view



side view



thickness ~ 15 mm

Parts:

I. Infrastructure (grooved)

II. Detector support

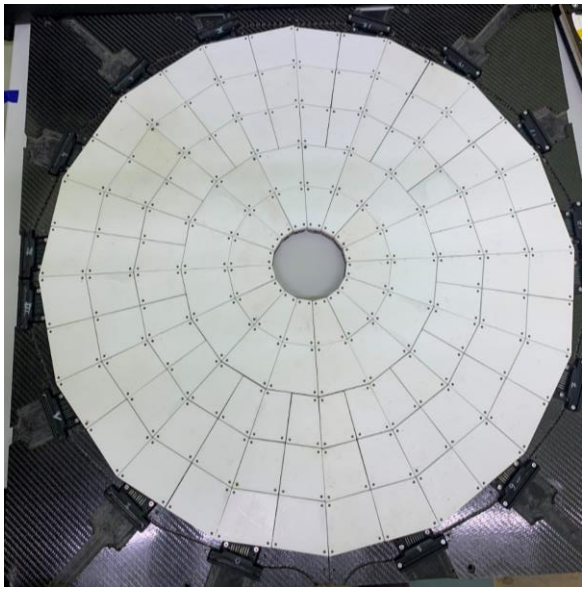


Together with Yu. Gurchin, M. Solonbekov, N. Fomichev

The prototype wheels assembling

1-st prototype wheel

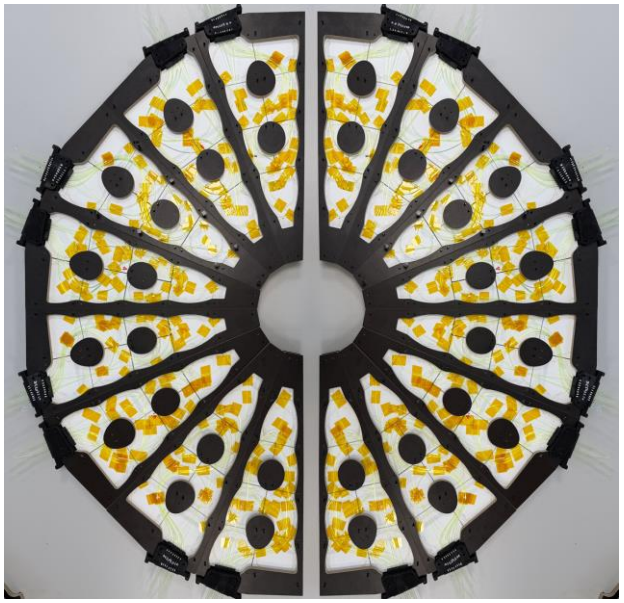
- ✓ backplate for prototype
- ✓ assembled
- ✓ quality test
- ✓ PCB 20 boards (SensL MicroFC-10035 SIPMs)



Light shielding is finished.

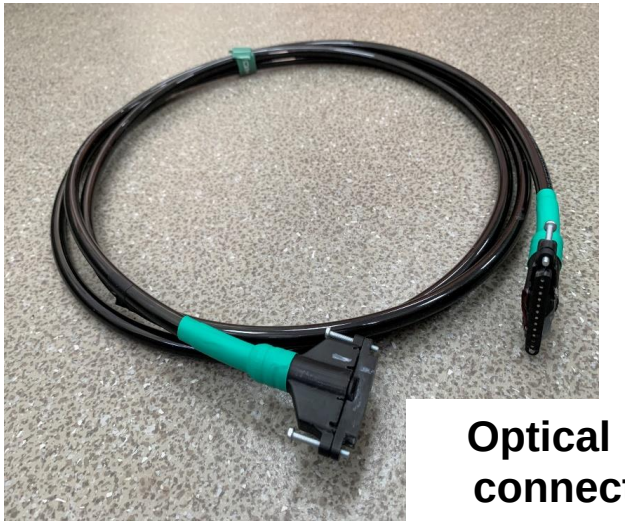
2-nd prototype wheel

- ✓ backplate for prototype
- ▪ assembling
- ▪ quality test
- ✓ PCB (20 boards)



16 sectors
delivered to JINR and tested

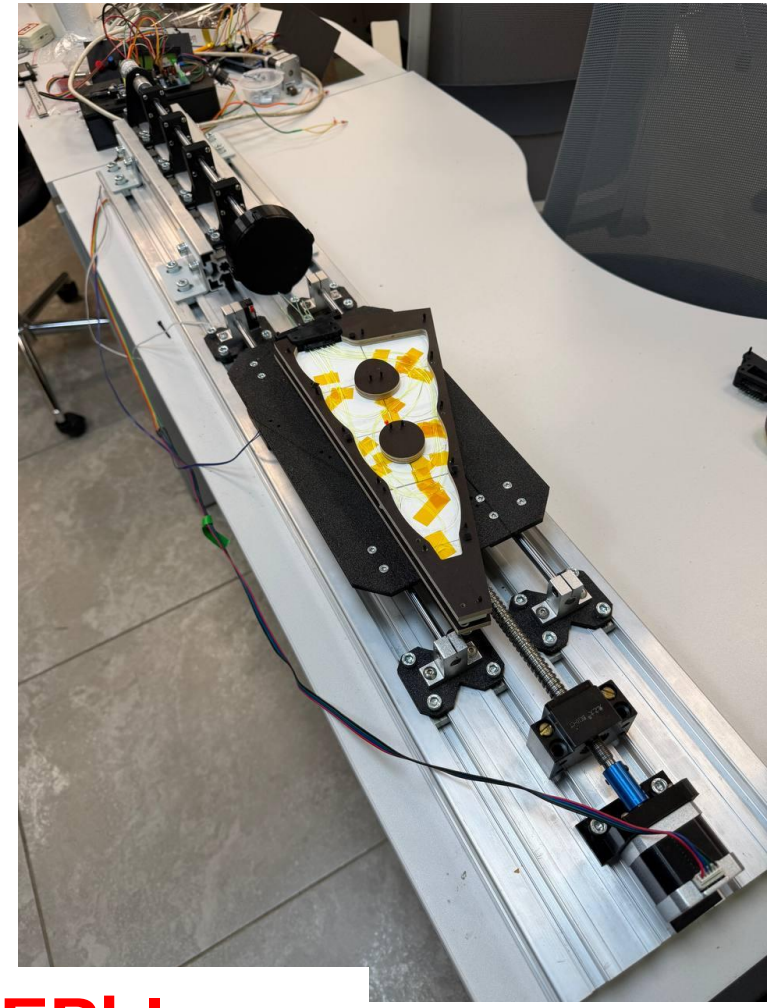
The optical cable issue



Optical cable connectors

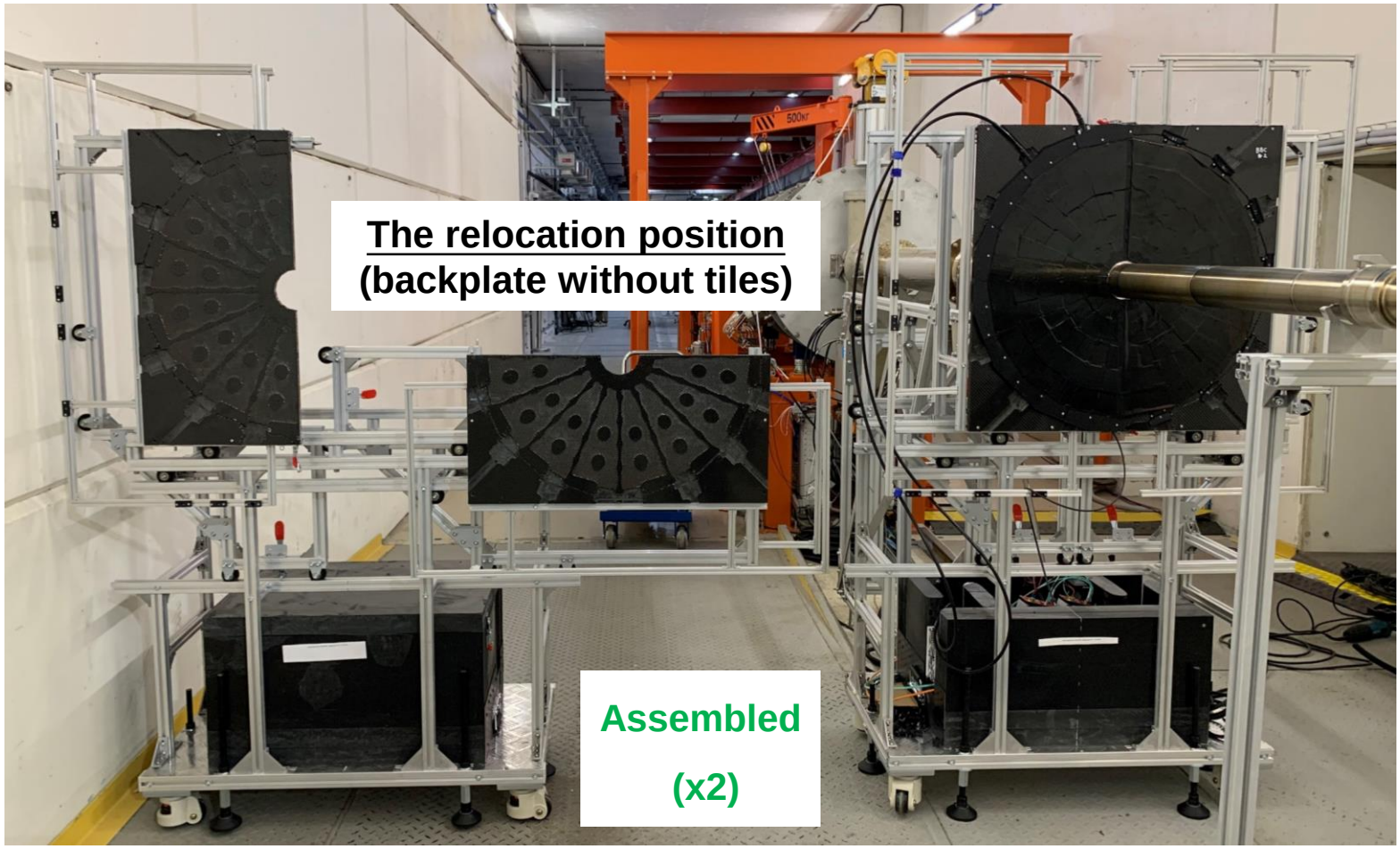
12 + 6 (broken) / **16 cables** (for 1-st wheel)

Connectors polishing stand



MEPhI responsibility

Design of the BBC support system

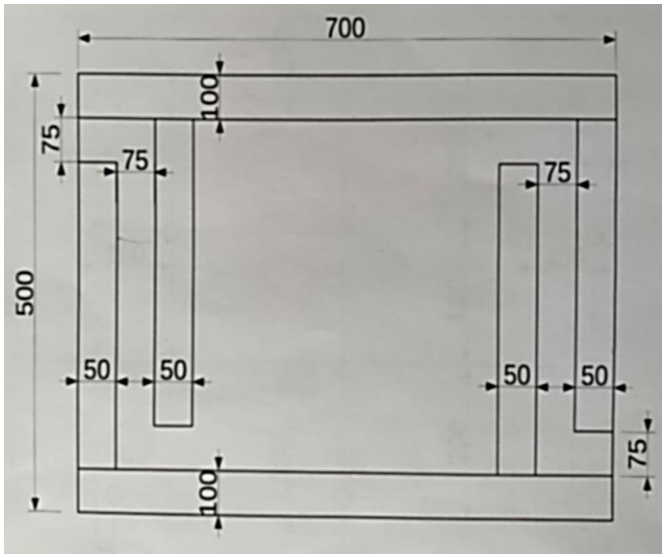


Main points:

- minimum staff time
- fast relocation
- easy disassembly of the detector half
- safety of the optical cable

Together with
A. Popov,
N. Fomichev

Design of the radiation shield box



30% boronated polyethylene plates (ПБ-30)

ООО «НПК Динамика»
(700x500x50 mm^3)

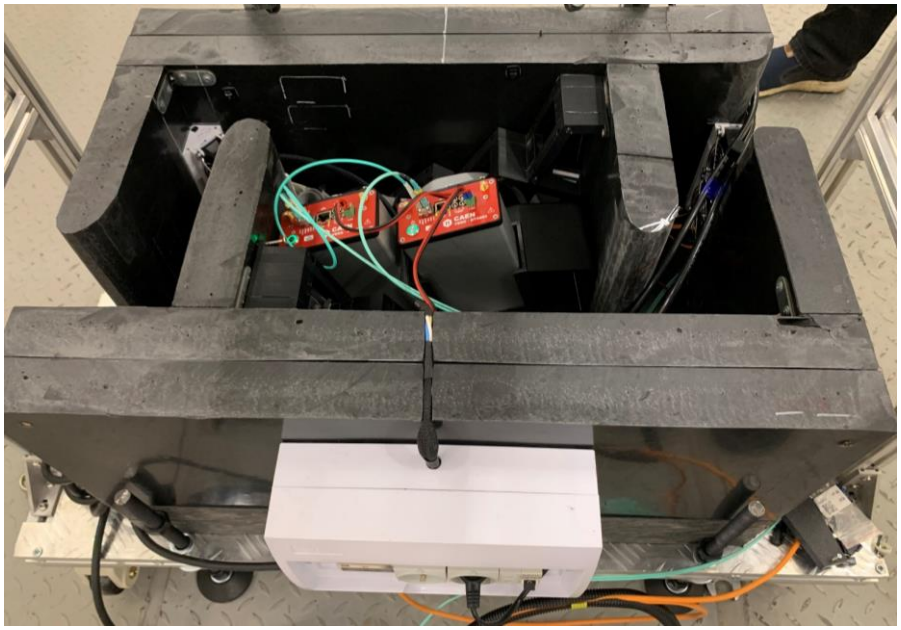
thanks to V. Poliakov



Produced:

2 for BBC

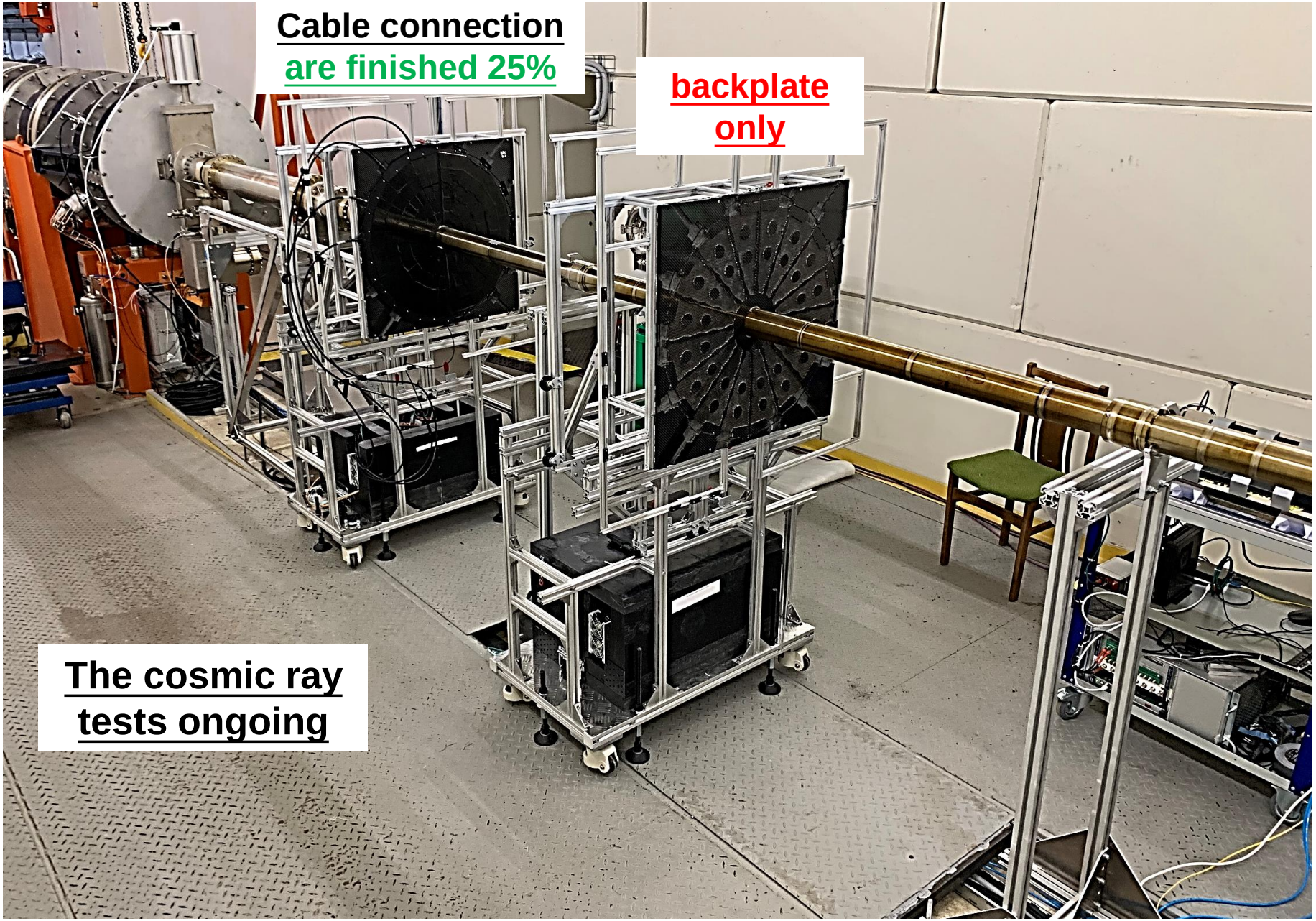
2 for ZDC



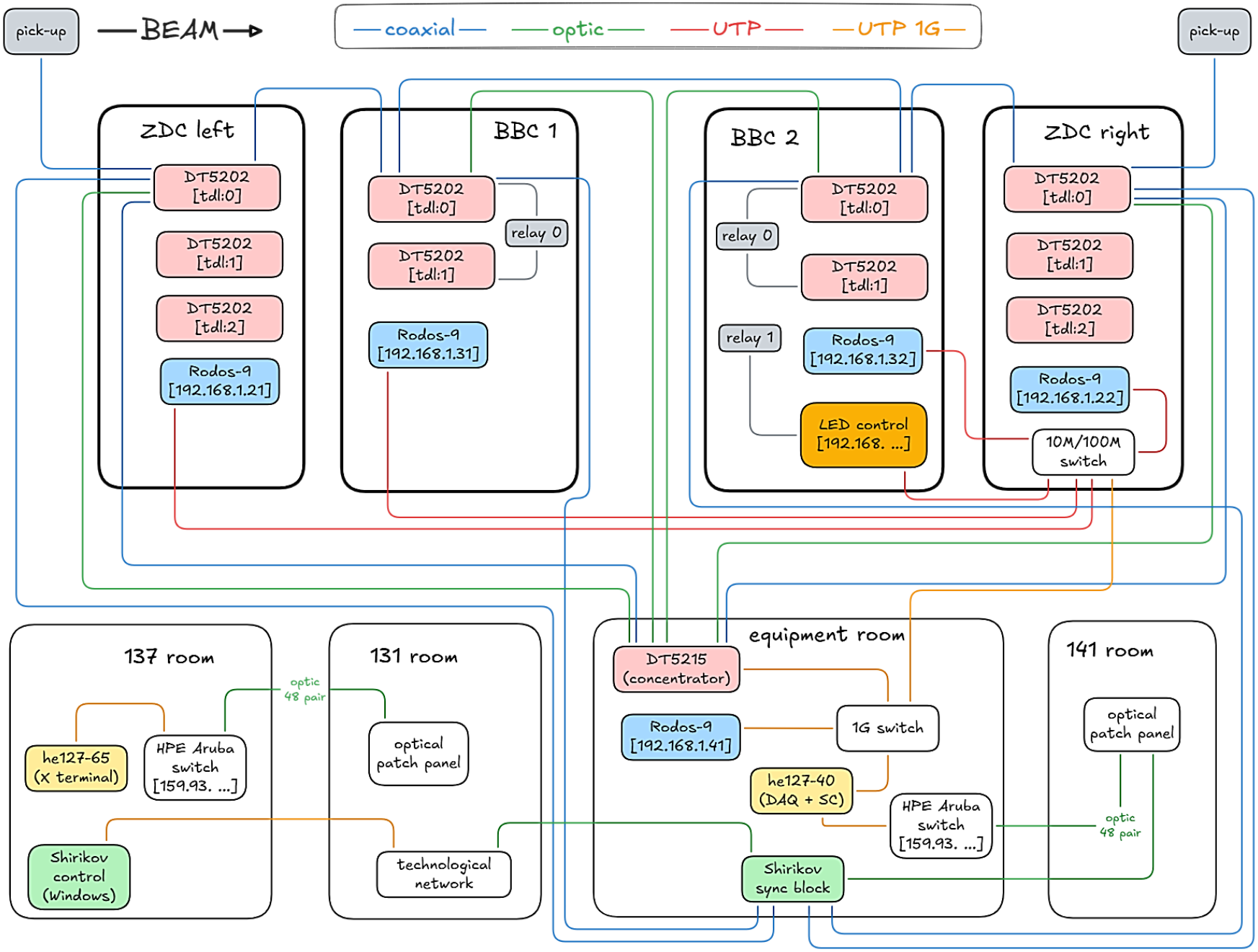
- ✓ **The fan blowing system**
- ✓ **PCB support** **are developed**
- ✓ **DT5202 support**
- ✓ **Switchboard**

(remote control of DT5202 power supply)

The integration progress



The infrastructure issues



Cables paths are finished

RF synchronization signal in progress

Selected options:

Scintillator:	**Uniplast-Vladimir (chemical mating)**
Optical cement:	**CKTN Med mark B**
WLS Fiber:	**Saint-Gobain Crystals (SG92S)**
SiPM:	**SensL 1x1 mm^2 (MicroFC-10035 SMTPA)**

+concentrator

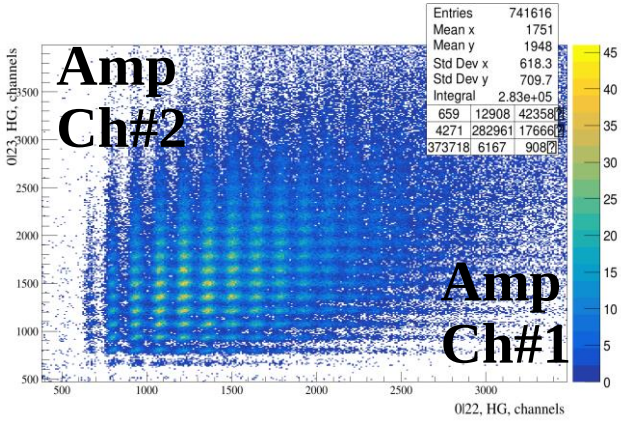


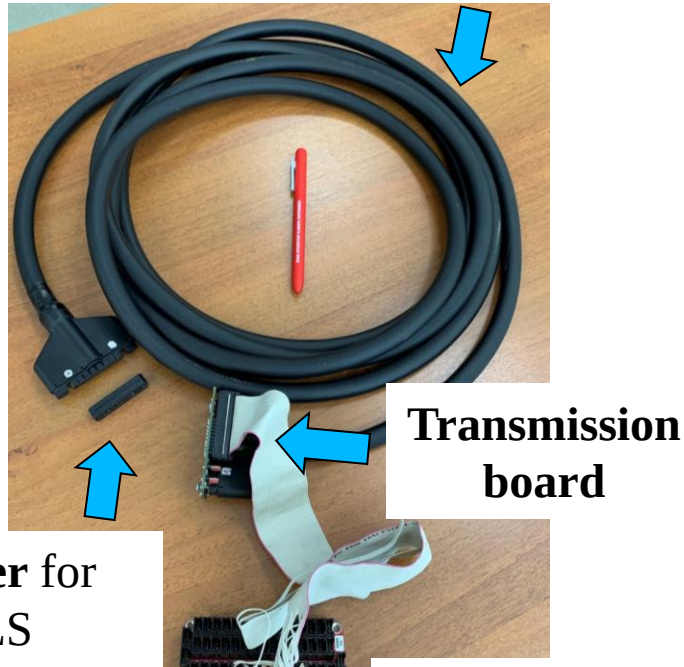
(A) The coaxial cable (3 meters) tests

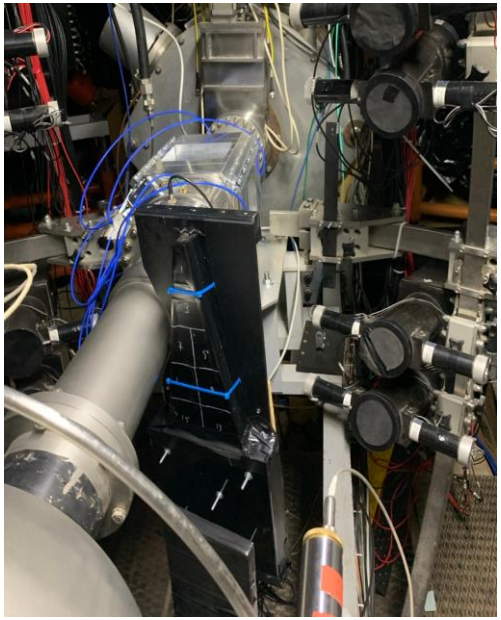
(B) The optical cable (5 meters) test

Kuraray (clear fiber) optical cable prototype with **8 channels connector**

Amplitude correlation

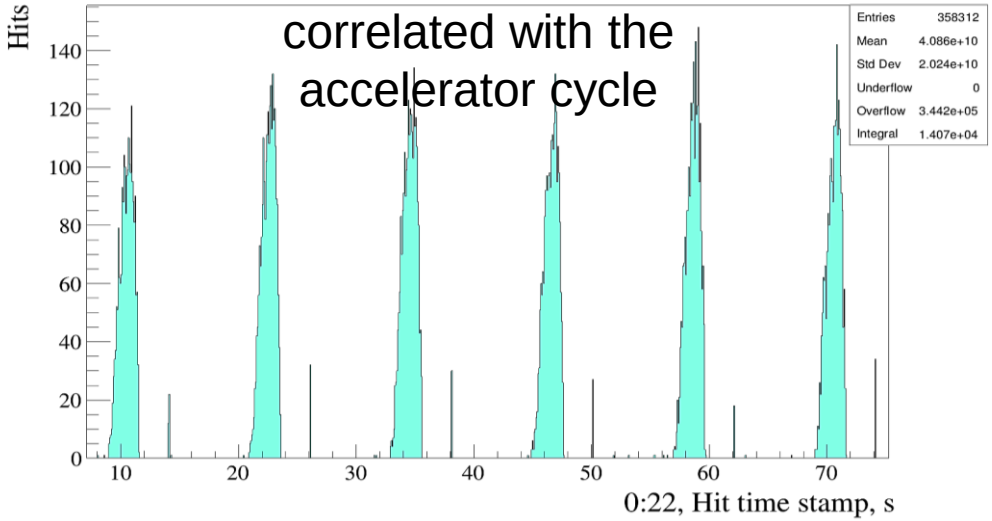




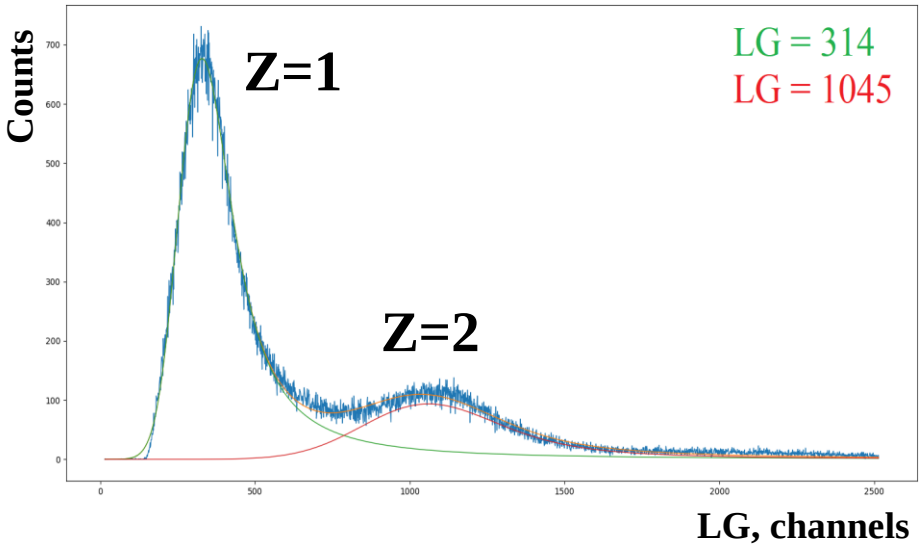


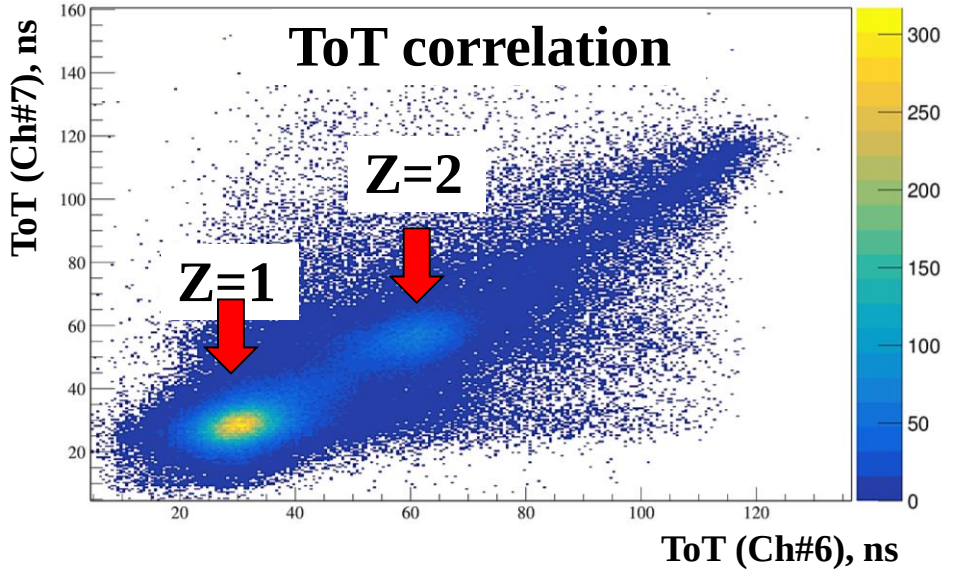
Hybrid (trigger) mode

Triggerless mode



The amplitude spectra





Together with
I. Volkov,
N. Fomichev,
M. Solonbekov

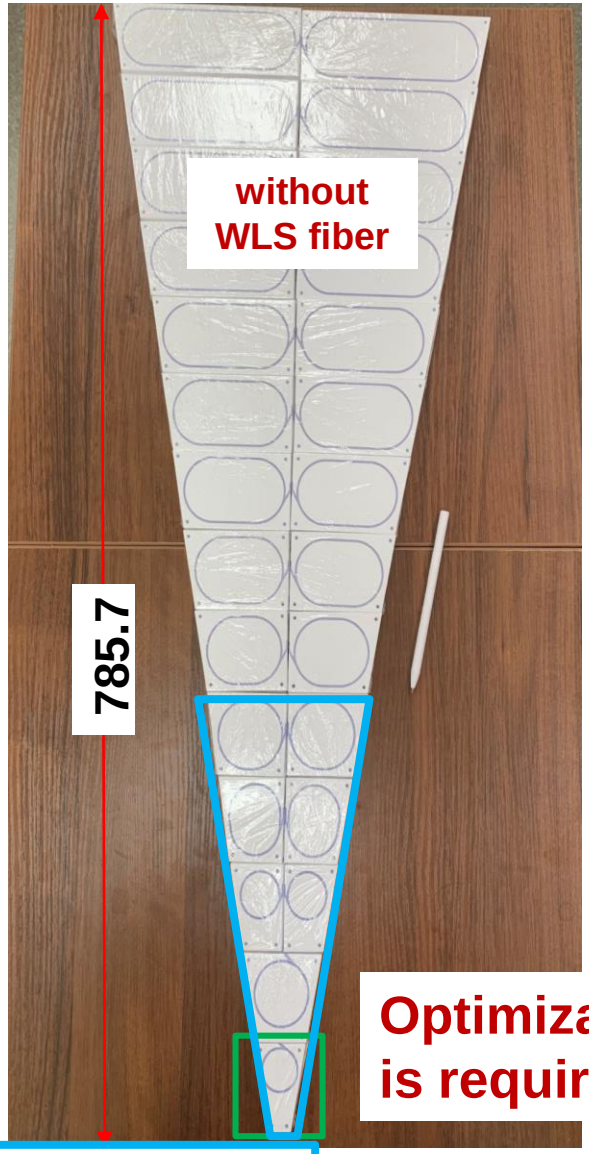
SPD results:

1/8 of SPD BBC detector has been tested using full DAQ chain for Phase0 both in triggered and triggerless modes.

Two full-size BBC sectors production

BBC Sector (1/16 of wheel) design

24 (26) - tiles



1/16 of reduced prototype wheel

Optimization is required

Boards based on **SensL** (**MicroFC-10035**) SIPMs



12 channels

Boards based on **Hamamatsu** (**S14160-1310PS**) SIPMs with the possibility of thermal sensor



The candidate for electronic



Together with (JINR) I. Volkov, S. Reznikov, A. Isupov (MEPhI) P. Nekrasov, A. Monakonov

The version of FEE that uses **KINTEX-7 FPGA based TDC** and new analog part

Updated firmware with 64 channels **is under tests.**

The main goal is to finalize the BBC technologies for the full size detector.

- ✓ The tests using full DAQ chain for Phase0 has been done. The triggered and triggerless modes have been used. The first testbeam results are promising.
- ✓ The details of BBC assembling part, as will as the availability of equipment have been described.
- ✓ The 1-st small BBC wheel integration has started.

To do list

- to complete integration of the 2-nd small BBC
- to start test of 2 small BBC wheels at the SPD
- to start full-size sector (x2) production

Problem

- optical cable

Thank you for the attention!

Backup

Proposal for reduced wheel prototype

20 boards (SensL MicroFC-10035 SIPMs)
with **electrical cables** (with 8 SiPM option)

performed



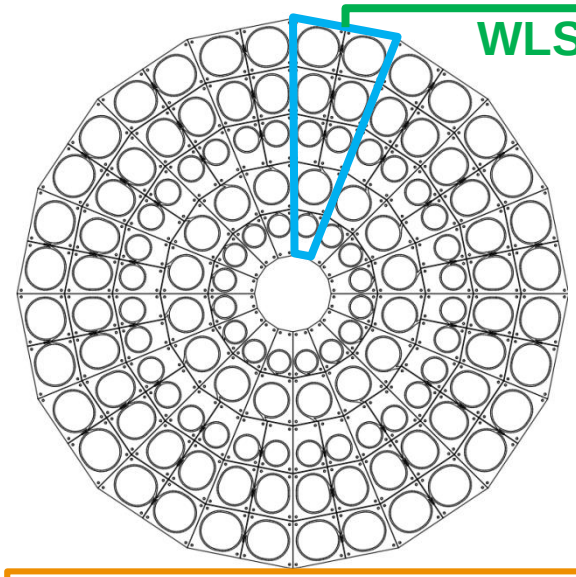


L = 500mm

NEW ELECTRONICS (needs)

for Phase ≥1

2 wheels with 128 tiles each



reduced prototype wheel (x2)

final version is required
Optical cables
(connectors for WLS-to-clear fibers)

Transmission boards
(for clear fibers to SiPMs)

Front-end & Readout
CAEN FERS-5200

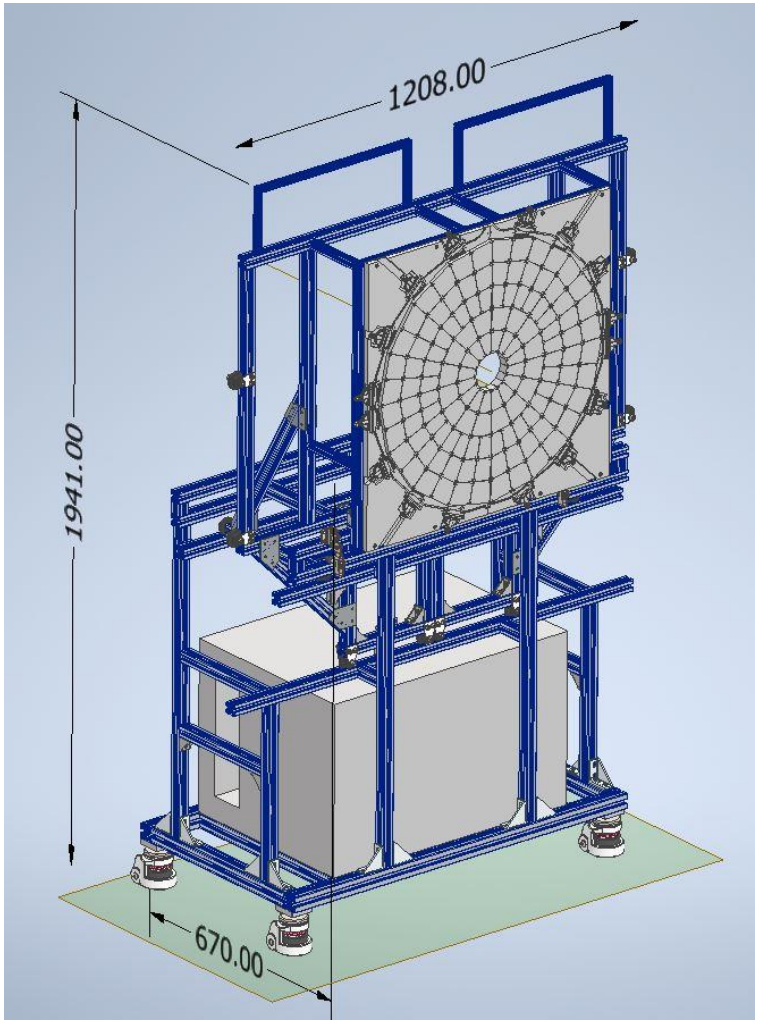
for Phase0

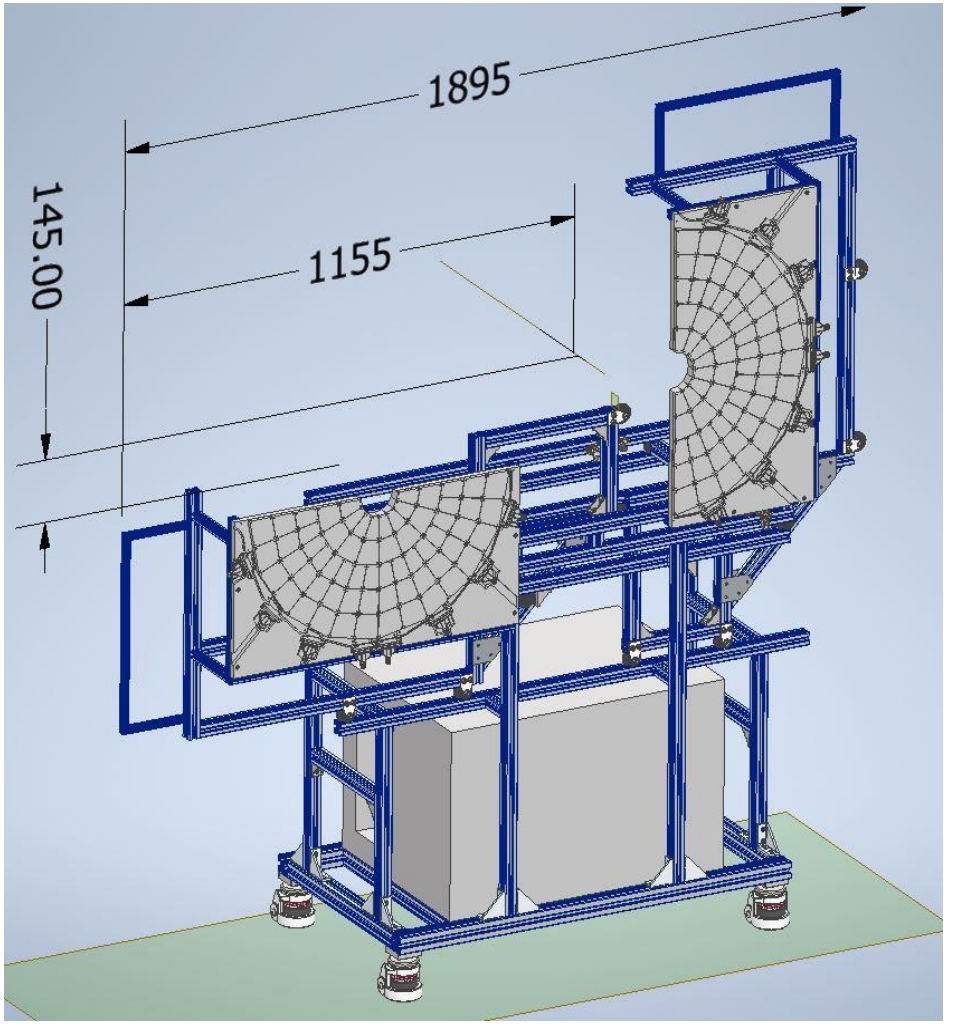


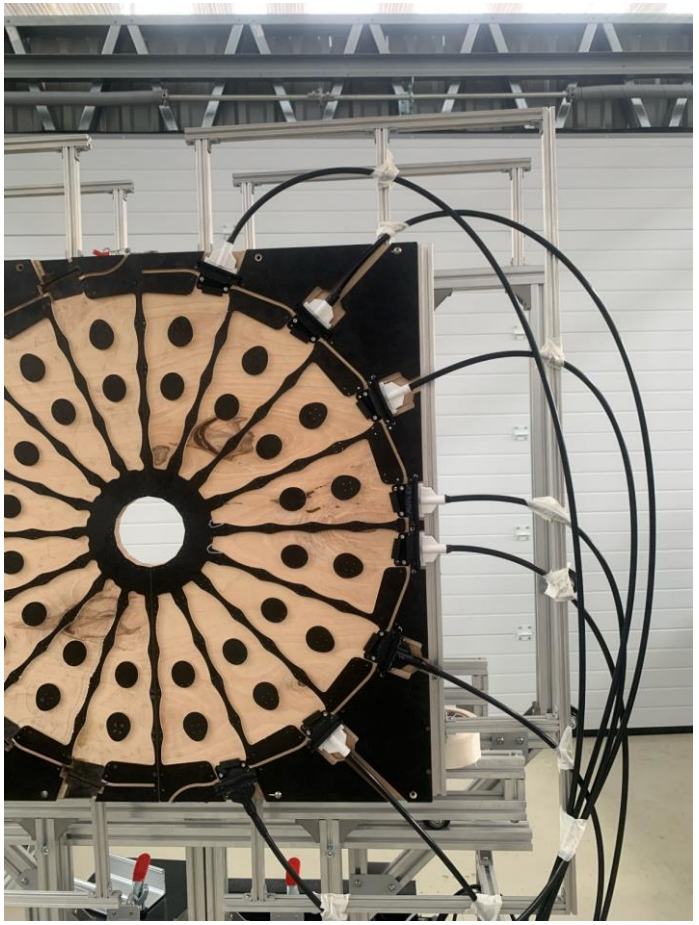
Needs:

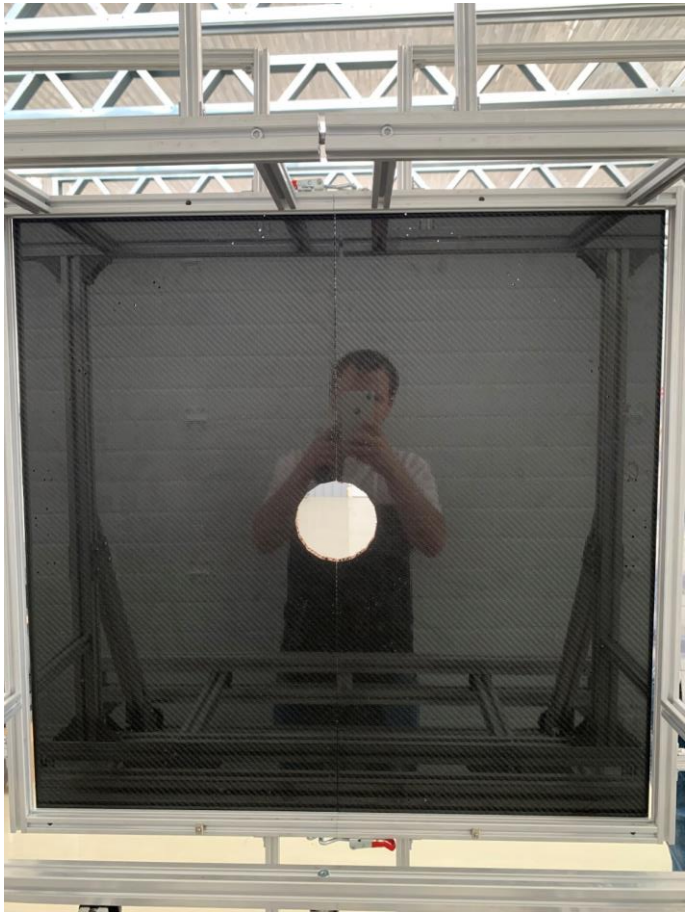
2 Wheels 128 scintillator tiles each

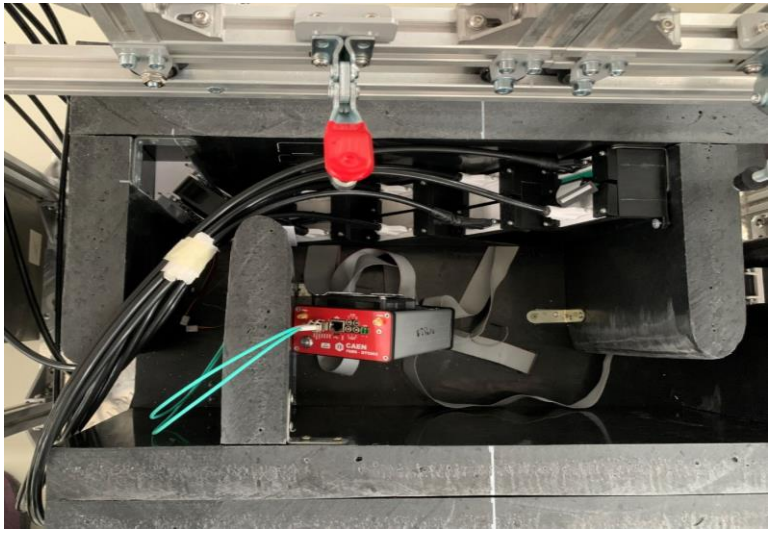
- **scintillator** – **yes**
- **WLS** – **yes**
- **SiPM** – **yes**


1208.00
1941.00
670.00


1895
145.00
1155





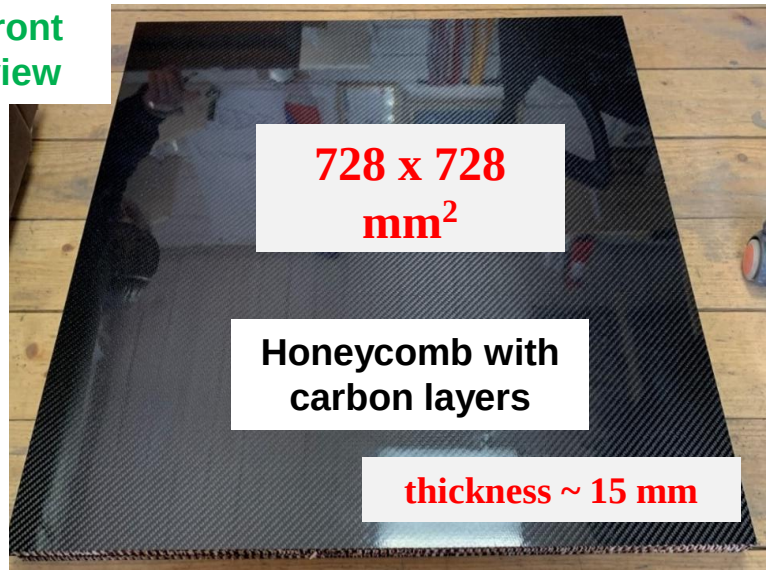



BASIC
C6

Sandwich backplate for BBC

Sheet for 2 prototype halves

front view



side view



Parts:

I. Infrastructure (grooved)

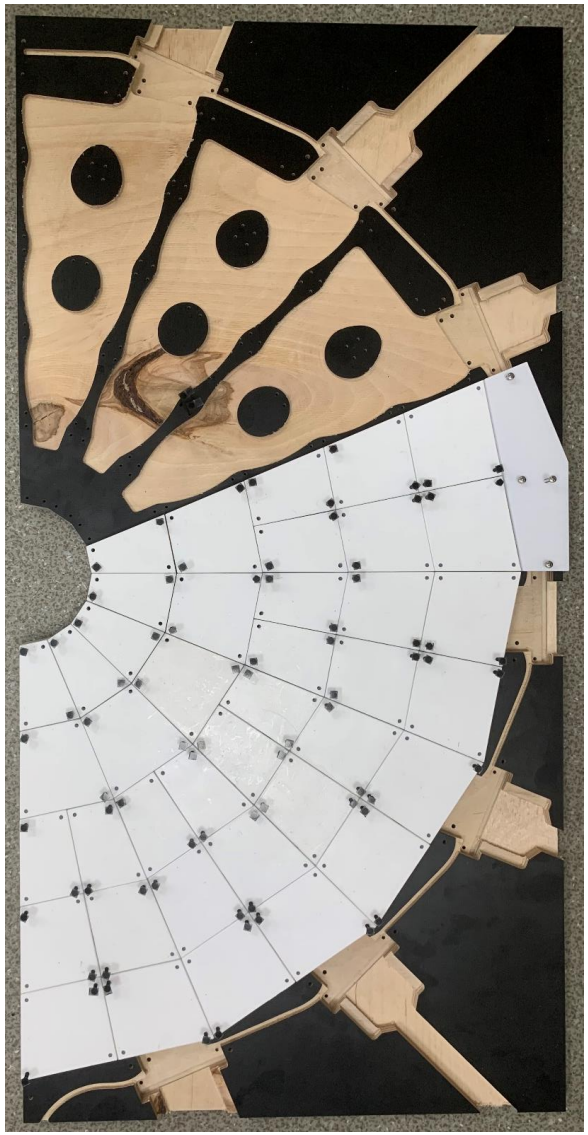
II. Detector support

Milling on plywood:

- part of common issues were resolved;
- selected pins (+ repair);
- finalized fasteners.

The grooving map has been done.

The plywood grooving map
½ of wheel



✓the fast checkup method implemented

✓light shielded

✓the connector mounting is reliable

Together with Yu. Gurchin, M. Solonbekov

Setup for calibrations

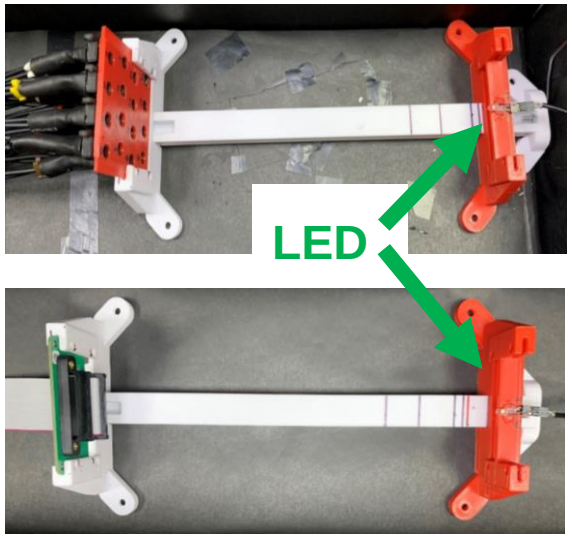
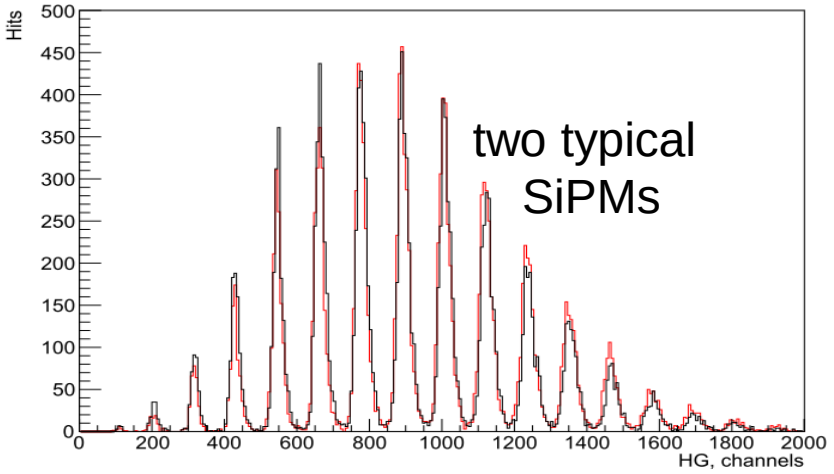
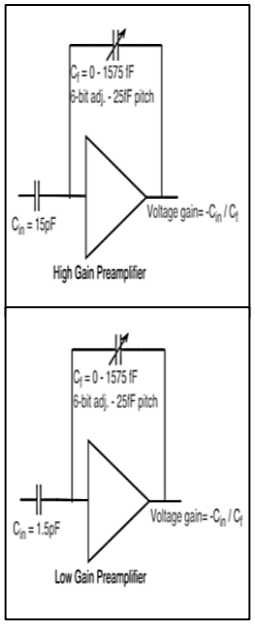


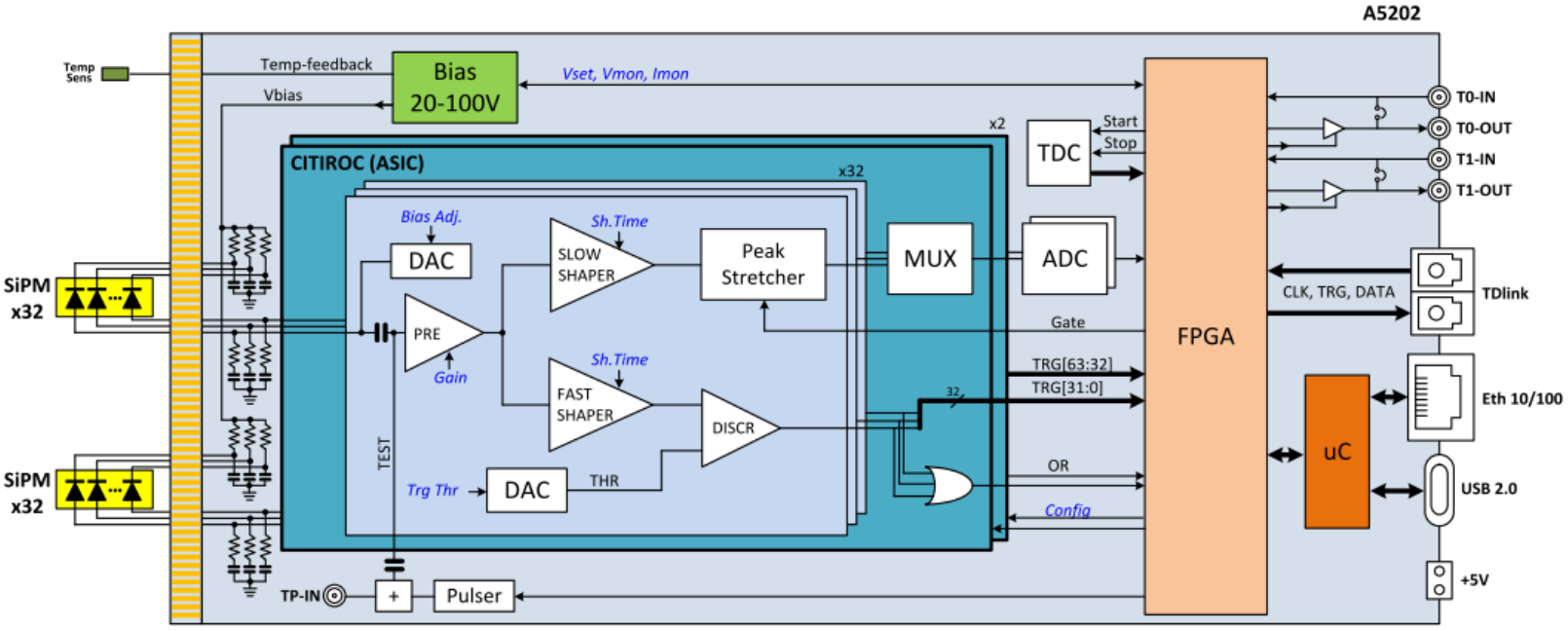
Plate calibration test with LED



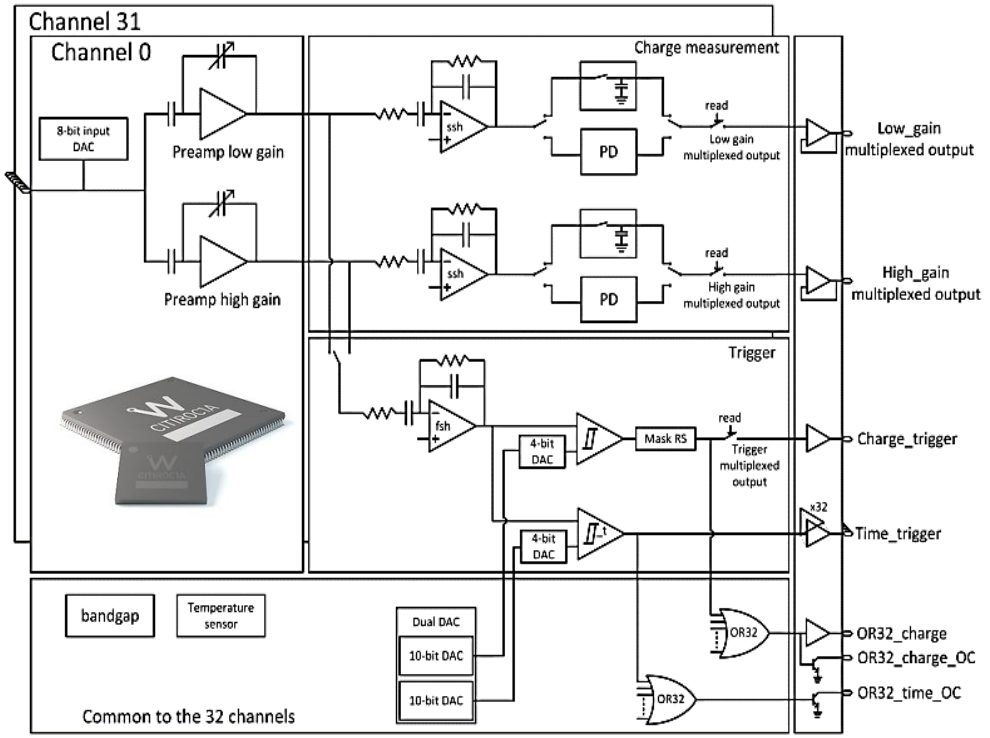
A **test stand** is developed to calibration of both current and future SiPM readout boards.

Simplified block diagram of the DT5202 FERS-5200 unit





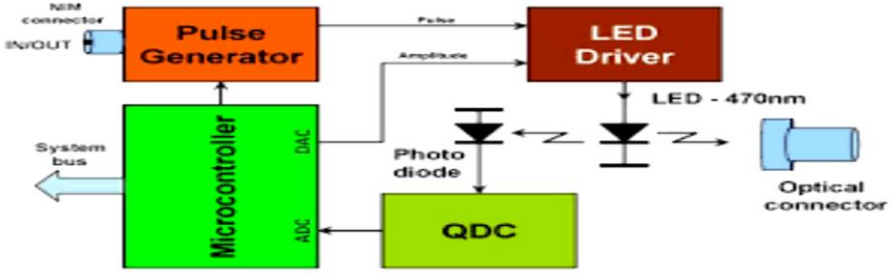
Citiroc-1A block scheme



Each channel has low **(LG)** and high **(HG)** gain preamplifiers providing a wide dynamic range.

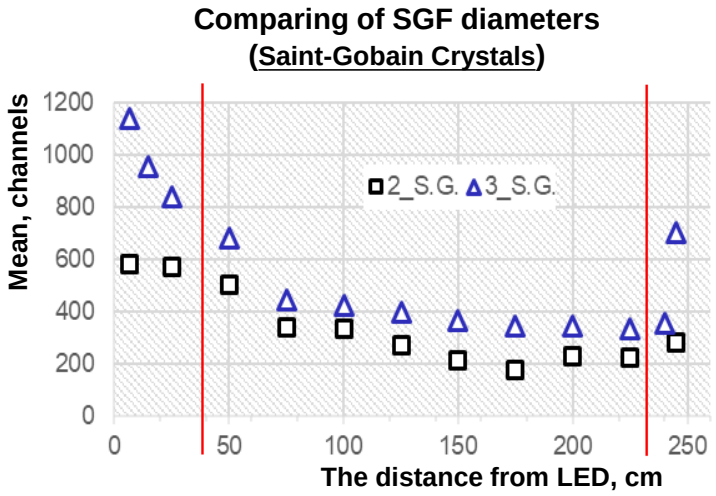
- Triggers of consecutive channels are sent to an AND logic operator (e.g. CH0&CH1, CH2&CH3, etc.). The 32 outputs are then sent to an OR logic operator.

Schematic view of the LED



The algorithm of verification for the mass production

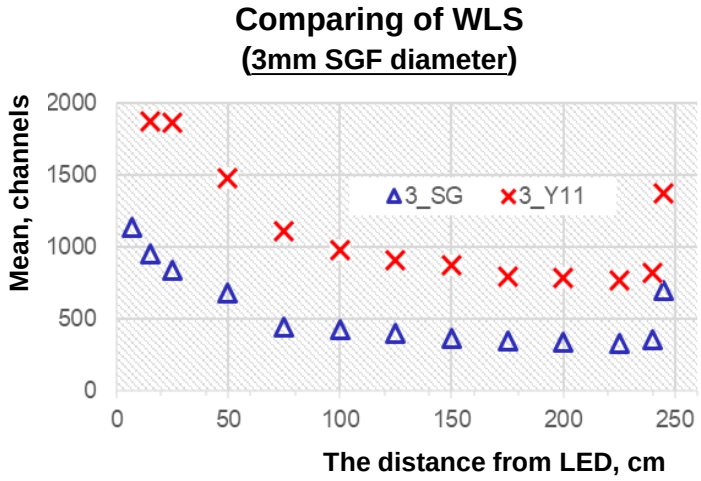
- **1-st part: check the uniformity of the tiles**
- **2-nd part: method for estimating the efficiency of an optical and electronic path**



The method based on **side glow fiber (SGF)**.

In principle: the LED light transmitted along the SGF. We attached the WLS to SGF, and then the optical signal passes through the optical path and detected by SiPM.

(WLS <-> Clear Fiber <-> SiPM <-> DT5202 unit)



- ✓ The average signal difference between the 2mm and **3mm** diameters is **about 50%.**
- There are edge effects. They are larger for 3mm fiber.

⌀3 mm is approved

✓ **WLS Kuraray (Y11)** is effective.

✓ **fast method (R&D + the changes over time)**

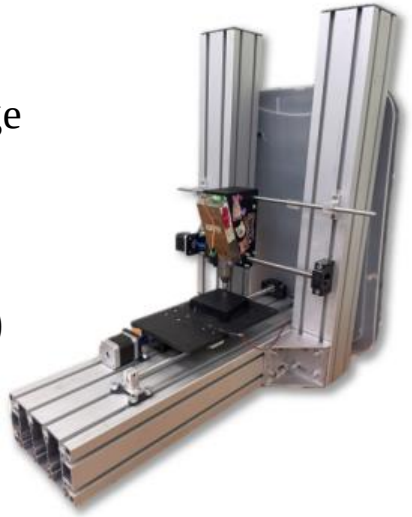
- **application for new backplate grooves design is required**

The reproducible QA of tile uniformity

Method. I Full-map scan (scintillator homogeneity)

II Coarse-grid X-ray scan.

Setup. AMPTEK Mini-X (Ag), Ø2 mm collimator, tube–tile gap ≈ 3.5 mm; motorized XY stage (mechanical resolution ≈ 20 μm); SiPM readout via **CAEN DT5202**.

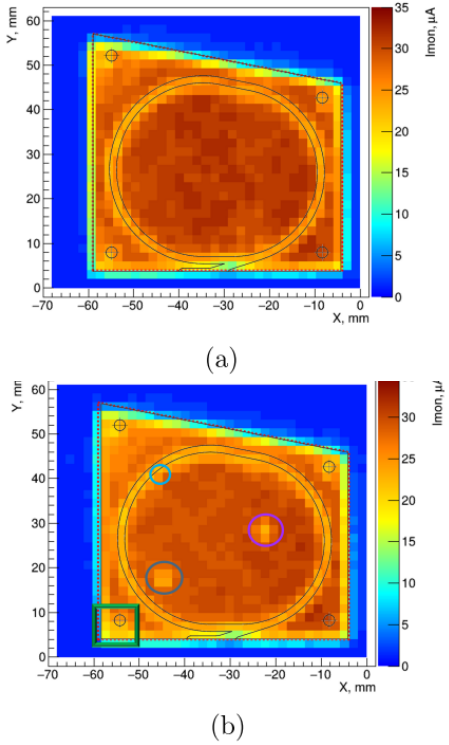


For definition of:

- **technological deviations (cement quality; WLS loops)**
- **defects**

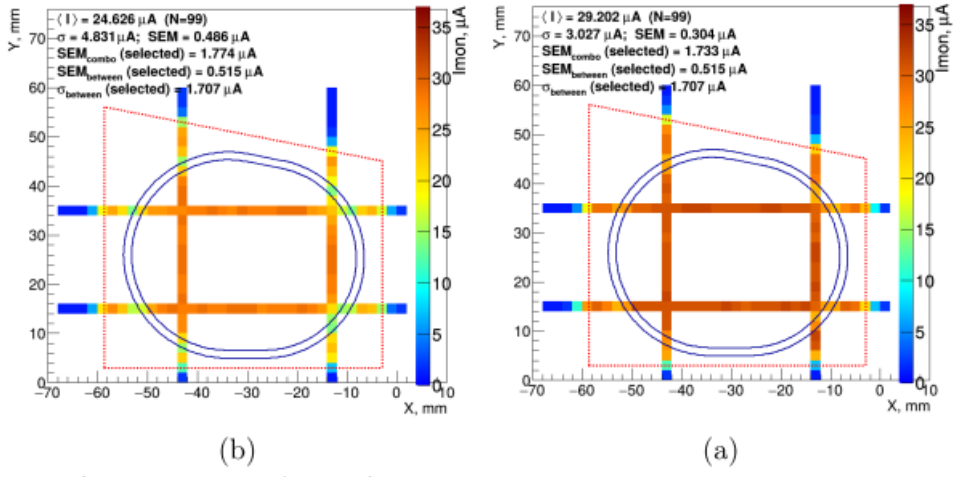
I

Scintillator scan heatmap before (a) and after (b) applying defects



II

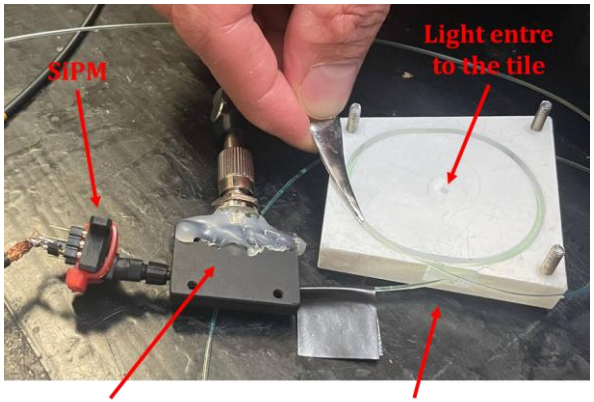
Scintillator scan heatmap comparison, a) CKTN E 3.2/100; b) CKTN E 2.5/100 A to B

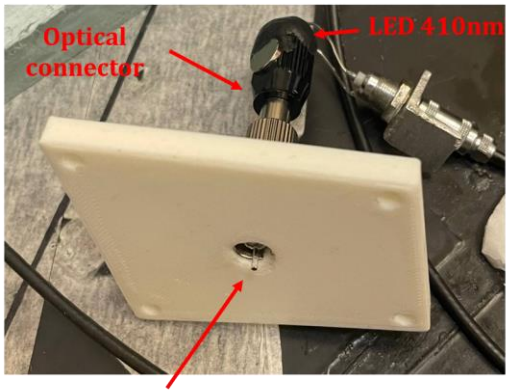


Cement concentration (CKTN-E):
2.5/100 vs 3.2/100 (datasheet-recommended)
→ 24.6 vs 29.2 μA (≈ 12%).
WLS loops (OK-72):
1 vs 3 → 14.5 vs 25.0 μA (≈ ×1.7).

The sensitivity of the method makes it possible to exclude an mistakes for the assembly stage.

Effect of WLS number of loops







Oscilloscope input impedance: 50 Ohm
Driving pulse for LED:

- Amplitude: 5V
- Width: 15ns

SiPM – tile distance (WLS tale width): 5cm

Test setup

Power supply: Keithley 2400

Pulse generator: Rigol DG4102

Pulse analyzer: Lecroy 620Zi

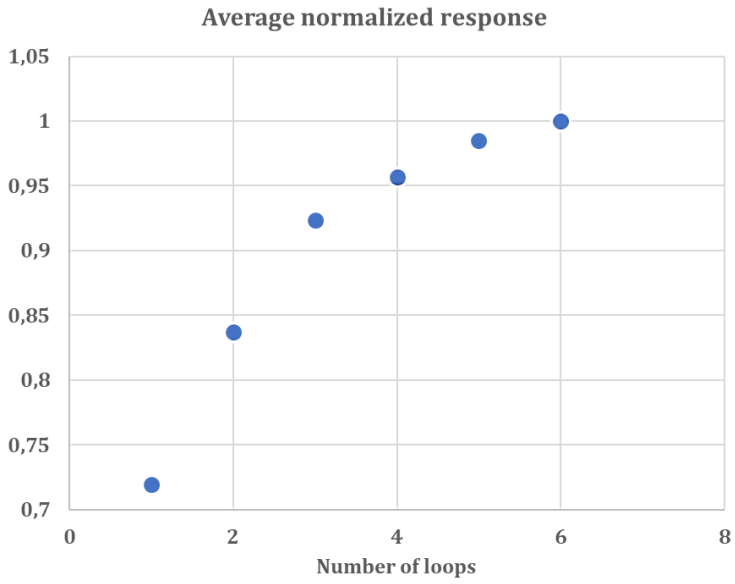
Measured values:

SiPM charge response

Charge RMS

Trigger to SiPM pulse delay RMS

SiPM pulse width

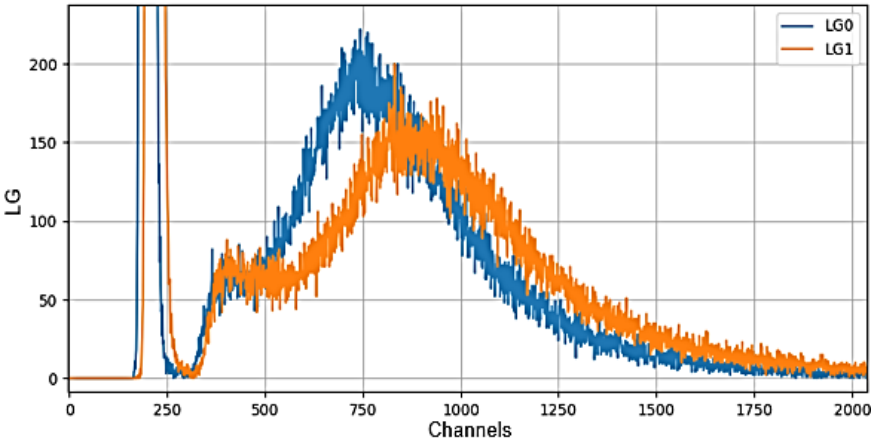


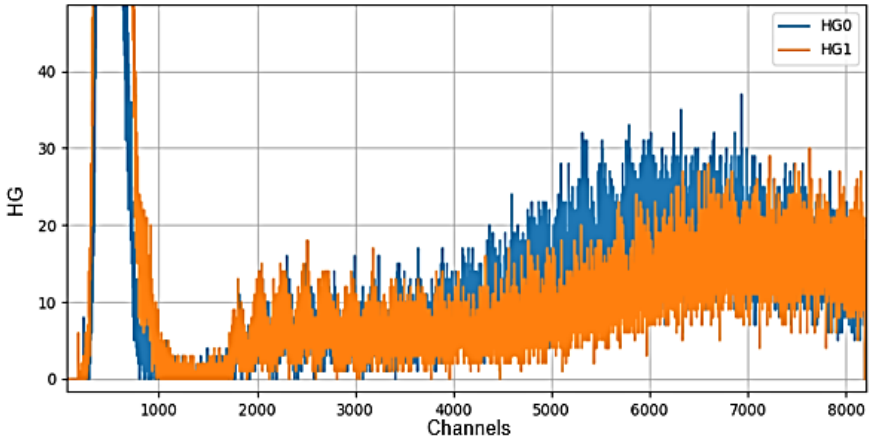
Signal charge increase with the number of loops. **The compromise solution is 3 loops.**



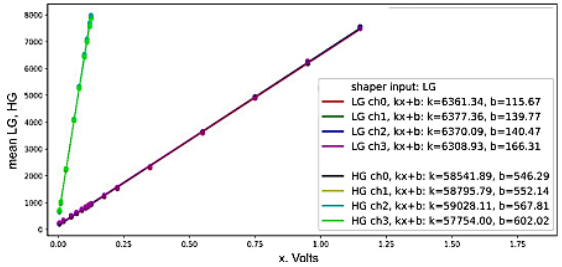
DT5202 Parameters:

Bunch Trigger Source: TLOGIC
Trigger Logic: AND2_OR32
Fast Shaper Input: HG-PA





conversion graphs



$k_{LG} = 6354.4$, $k_{HG} = 58529.9$, $b_{LG} = 140.5$, $b_{HG} = 567.0$ - average approximation coefficients

$C_{max0} = 750$, $C_{max1} = 875$ - position of the maximum of channels 0 and 1 in LG

$P_{HG0} = 1812$, $P_{HG1} = 1819$ - position of the first pixels for HG

$$P_{LG} = \frac{k_{LG}}{k_{HG}}(P_{HG} - b_{HG}) + b_{LG}$$

$P_{LG0} = 275.7$, $P_{LG1} = 276.4$ - position of the first pixels for HG

$T_{HG0} = 227$, $T_{HG1} = 231$ - periods for HG 0 and 1 channel.

$$\Delta T_{LG} = \frac{k_{LG}}{k_{HG}} \Delta T_{HG}$$

$T_{LG0} \approx 24.6$, $T_{LG1} \approx 25.0$

$$M = \frac{(C_{max} - P_{LG})}{T_{LG}}$$

$M_0 \approx 20$, $M_1 \approx 23$

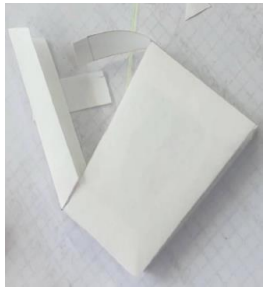
The number of photons at MIPS was determined to be 20 and 23 for tile 0 and 1, respectively

To be cross-checked…

Materials selection test part

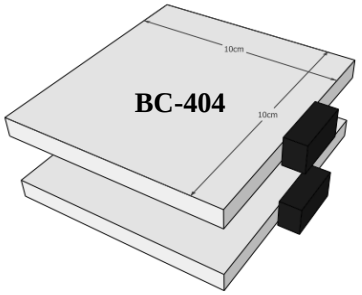
Scintillator cover

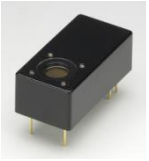




The amplitude spectra of the BBC prototype scintillation tile coated with **Mylar** or **Tyvek**, as well as covered with **Matted** options.

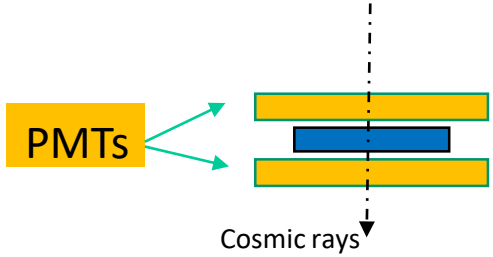
External trigger by coincidence of two scintillators with PMTs readout





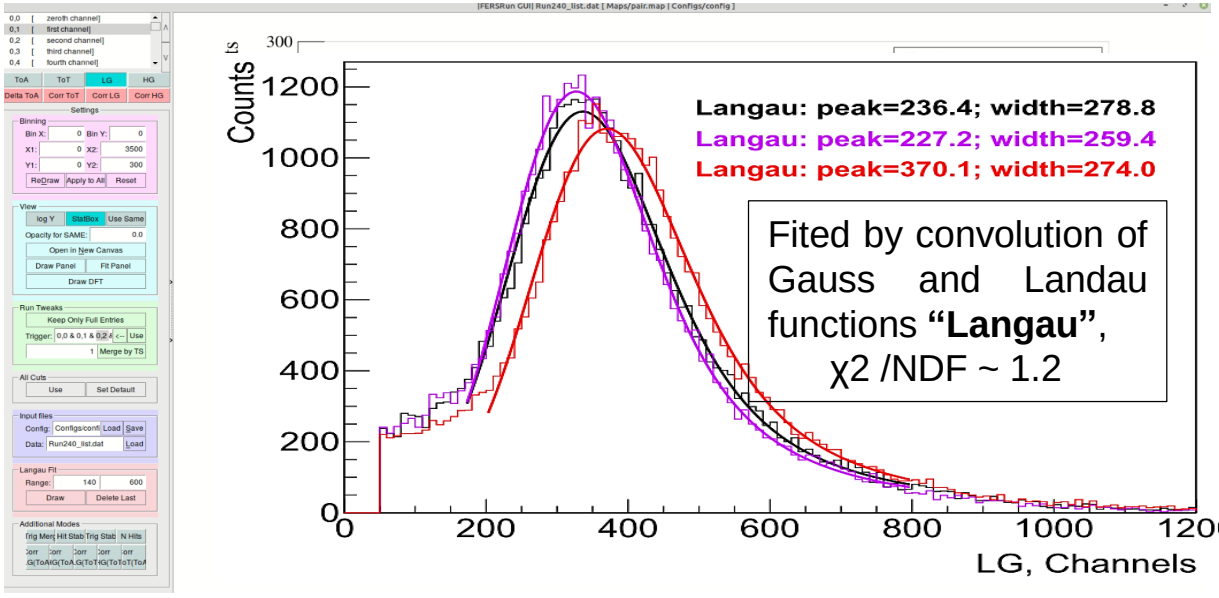
PMT Hamamatsu H10720-110

The "FersRun" framework has been designed.



Matted or Mylar or Tyvek

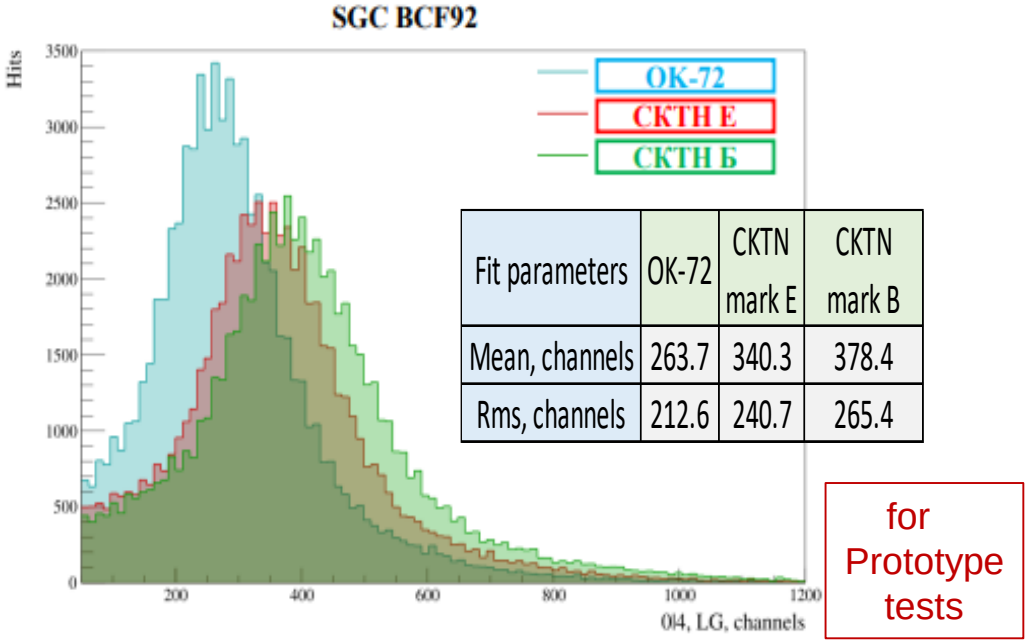
SensL SiPM (27.34 V.)
S.G. (WLS)
CKTN (opt. cement)



- The option with **matted tiles** is more priority for mass production.

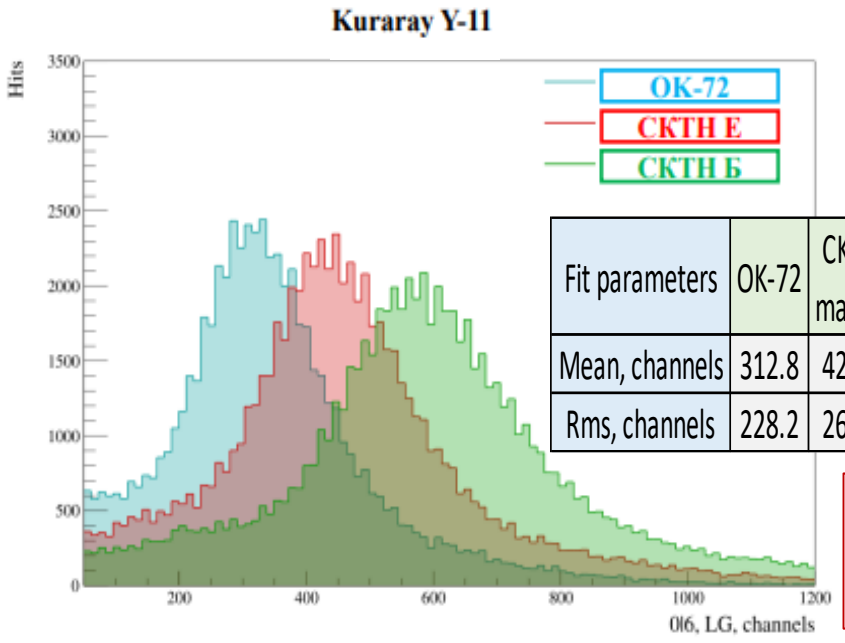
Materials selection test part

Optical cement and WLS



Fit parameters	OK-72	CKTN mark E	CKTN mark B
Mean, channels	263.7	340.3	378.4
Rms, channels	212.6	240.7	265.4

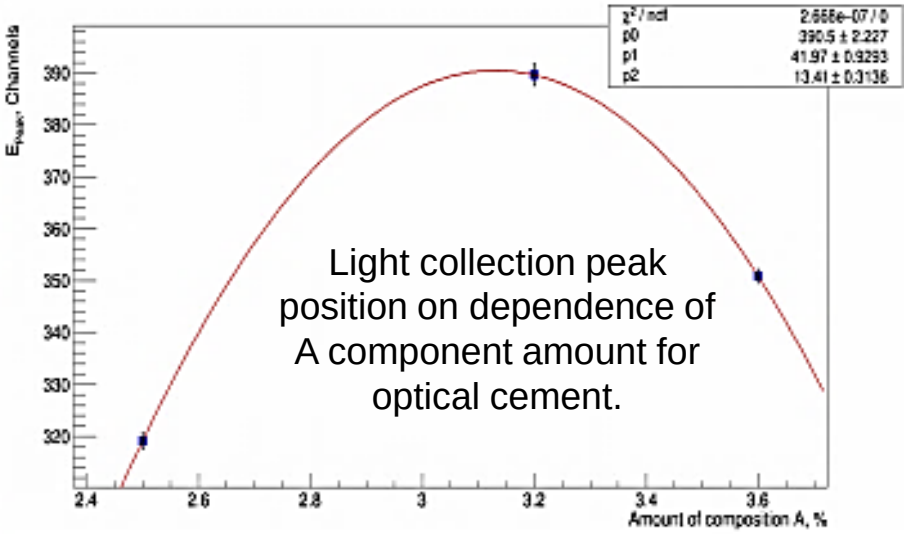
for Prototype tests



Fit parameters	OK-72	CKTN mark E	CKTN mark B
Mean, channels	312.8	429.7	569.1
Rms, channels	228.2	268.7	324.9

for Phase 1 tests

CKTN



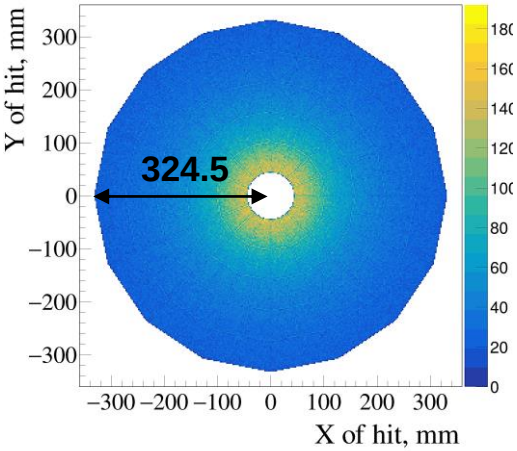
- ❑ Datasheet ratio will be used and closely monitored for mass production.

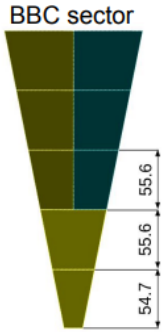
The results of tests of Kuraray WLS fiber and Saint-Gobain Crystals (SGC) WLS fiber with different types of cement are presented.

- ❑ **CKTN mark B** paired with SGC WLS fiber are the most appropriate candidates **for prototype** assembly tests.
- ❑ **CKTN mark B** paired with Kuraray WLS fiber are the most appropriate candidates for future **testbeam**.

Heavy-Ion Collisions for Phase0 (by Volkov I.)

Condition of the simulation with Geant4





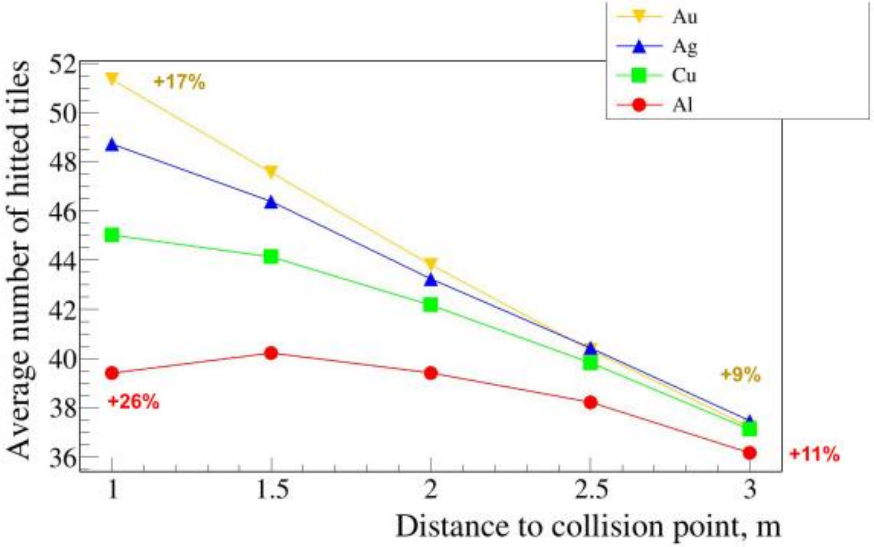
^{124}**Xe** beam with energy **3 GeV/n** collides with the the various fixed **targets (**Al**, Cu,** Ag**, Au).**

The detector is a wheel with an inner radius of **45 mm** and an outer radius of **324.5 mm**, which is divided into **16 sectors** and **5 rows**. A total of **128 scintillators**, the gap between scintillators is **0.6 mm**, thickness is **10 mm.**

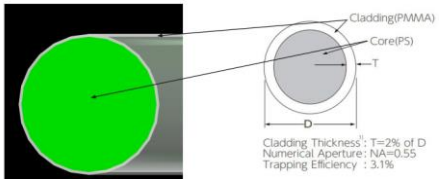
New in advanced model:

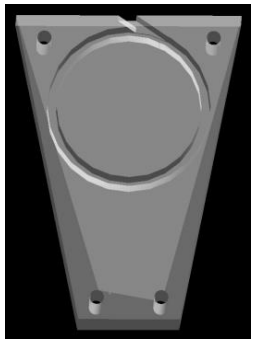
- **Pipe (Al or Fe)** (1.5 mm thick, 86 mm diameter), **vacuum inside.**
- Environment is **air.**
- Plastic **backplate** (10 mm thick).

Advanced model



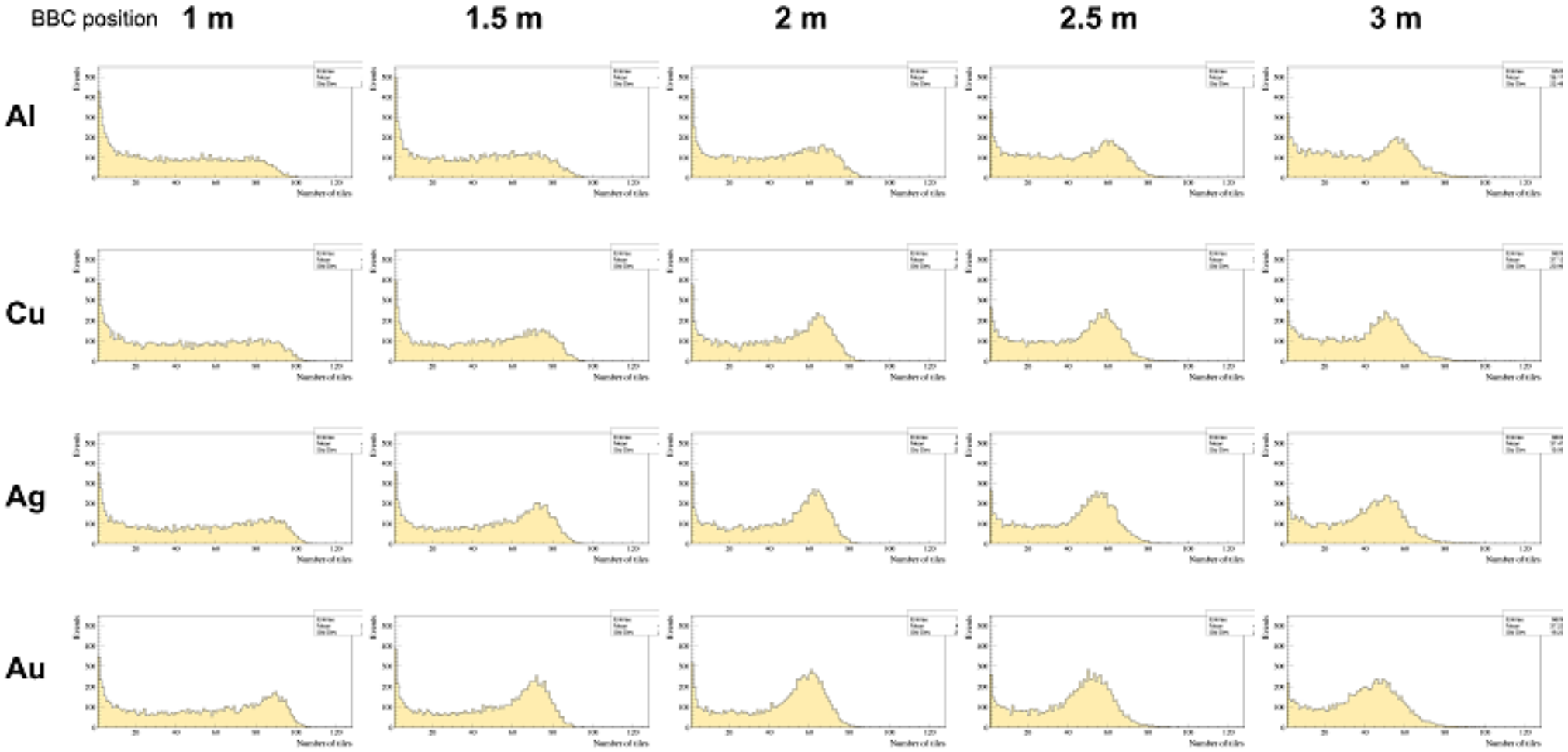
Activity related to the implementation of the **tile and WLS fiber** real model has been started.





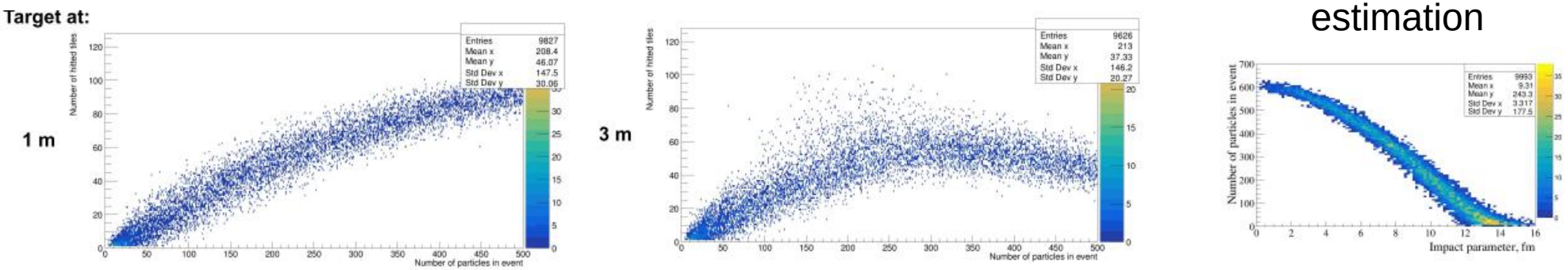
(by MEPhI group)

Number of hitted tiles

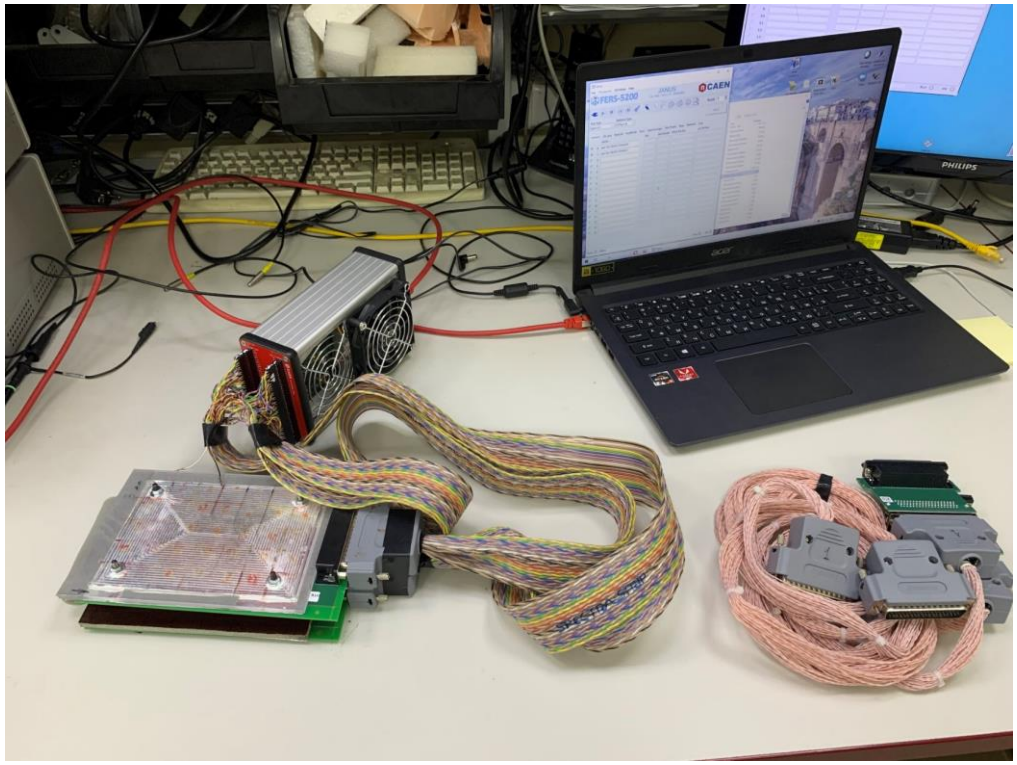


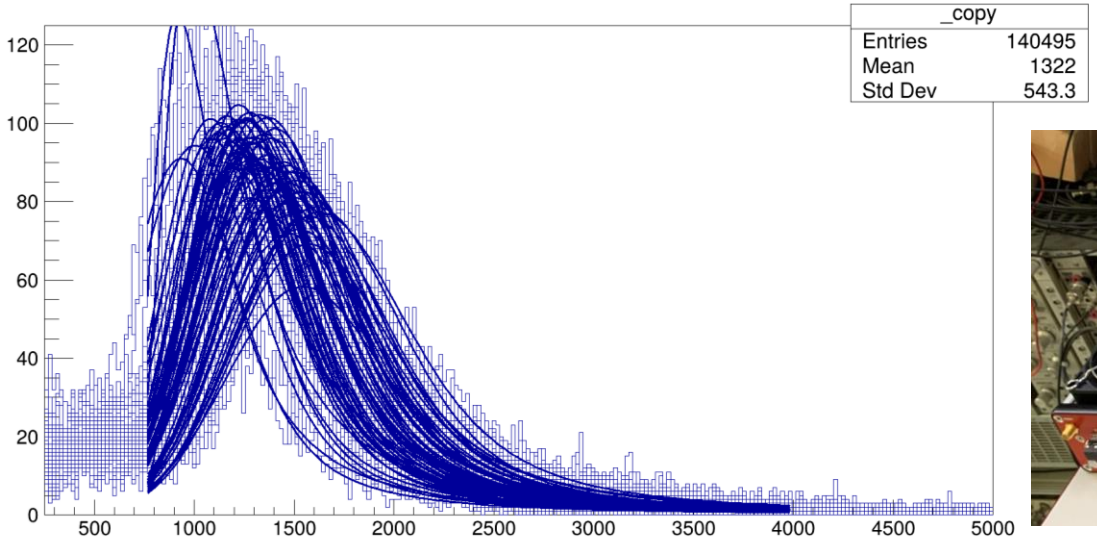
XeAu collision. Multiplicity correlation

impact parameter estimation



SPD Phase0





ZDC

