status BBC SPD @ JINR

A.V.Tishevsky on behalf of JINR BBC workgroup

Workgroups meeting, Moscow

October 2025

Introduction

BBC priorities

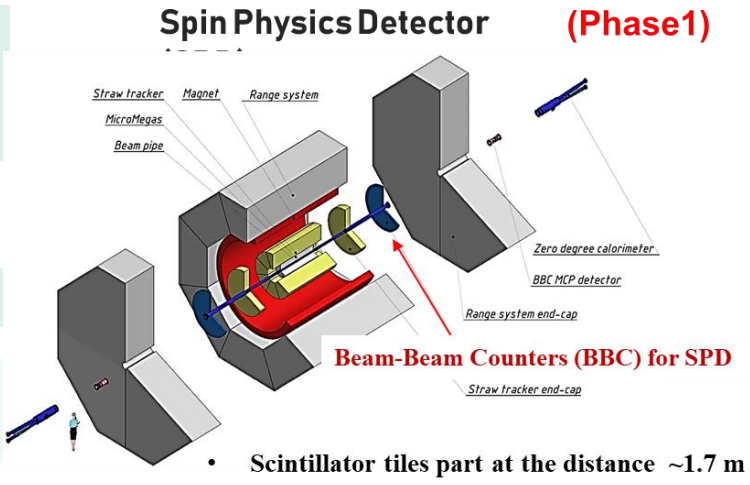
Selected options:

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)**

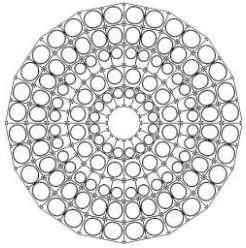
Final options for Phase ≥1 are:

KURARAY (Y-11)

Hamamatsu (S14160-1315PS)

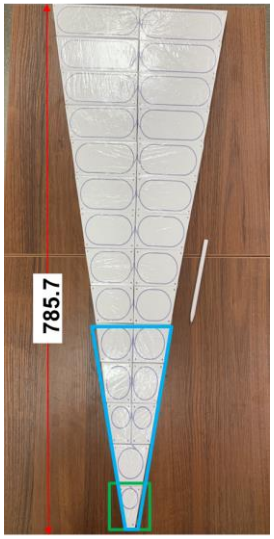


(Phase0)



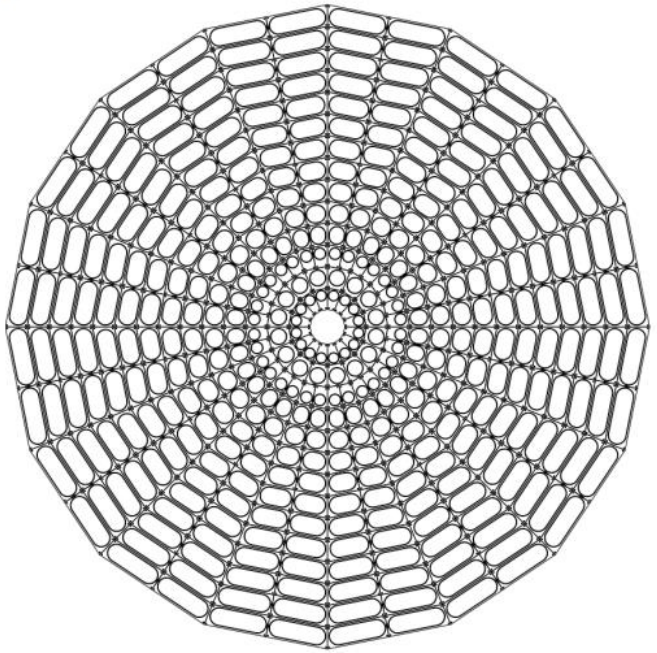
Step 1-st

BBC Sector (1/16 of wheel) design



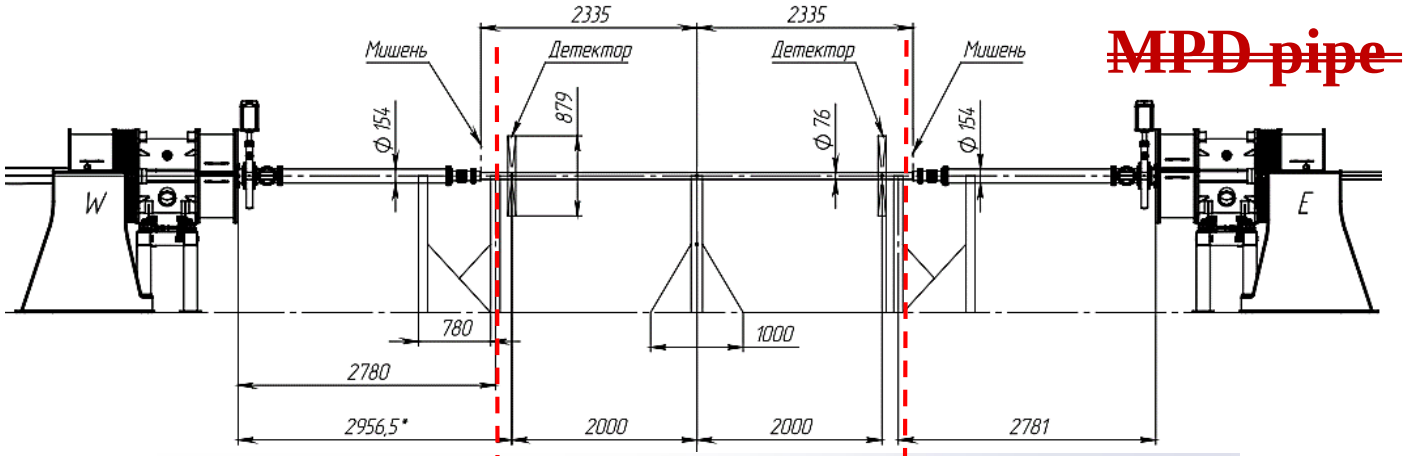
Intermediate step skill + changes (?)

(Phase1)



Step 2-nd

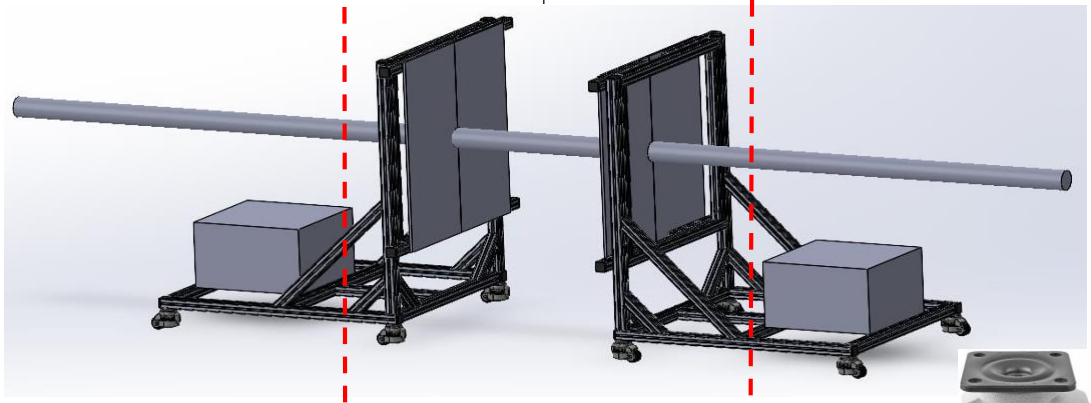
Xe124+ target collisions (FT mode)



~~MPD pipe~~

- **Pipe (Al or Fe)** (1.5 mm thick, 83 mm diameter)
- **targets (Au, Cu).**
- **distance** to collision point

talk by Volkov I.



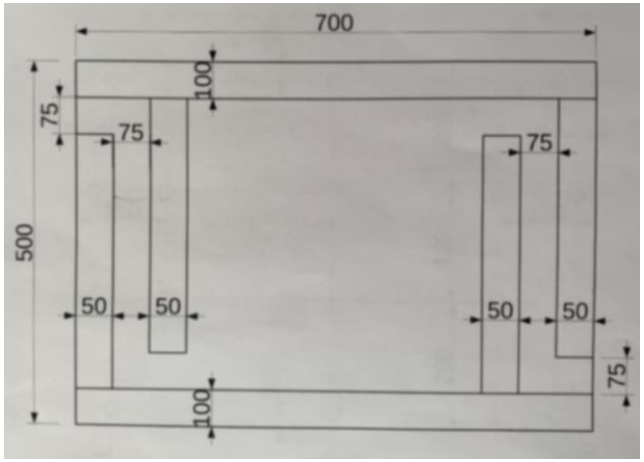
Needs:

2 Wheels 128 scintillator tiles each

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

In progress

DT5202 – yes
DT5215 – yes
Optical fiber – yes



thanks to V. Poliakov

30% boronated polyethylene plates (ПБ-30) for BBC/ZDC SPD

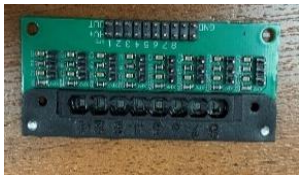
ООО «НПК Динамика»
(700x500x50 mm^3)

purchase is agreed

BBC assembling part

Proposal for reduced wheel prototype

8 ch

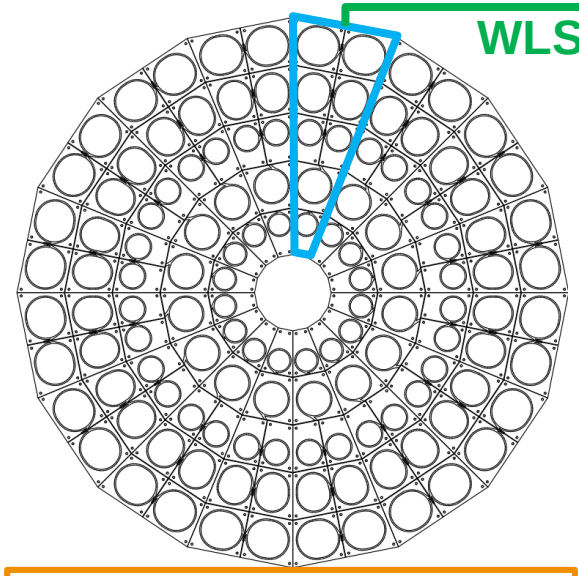


talk by Solonbekov M.

CAEN FERS-5200

for **Phase0**

128 tiles (8x16)



WLS

Connector for WLS-to-clear fibers

Transmission box for clear fibers to SiPMs

Front-end & Readout

12 ch

NEW ELECTRONICS for Phase ≥1 (needs)

talk by Dubinin F.

talk by Nekrasov P.

reduced prototype wheel (x2)
(the 1-st priority)

Mass production issues:

- **R&D tests (+ mechanisms of verification)**
- **Backplate**

Sandwich backplate for BBC

Honeycomb

(3-options with different thickness of carbon layers)

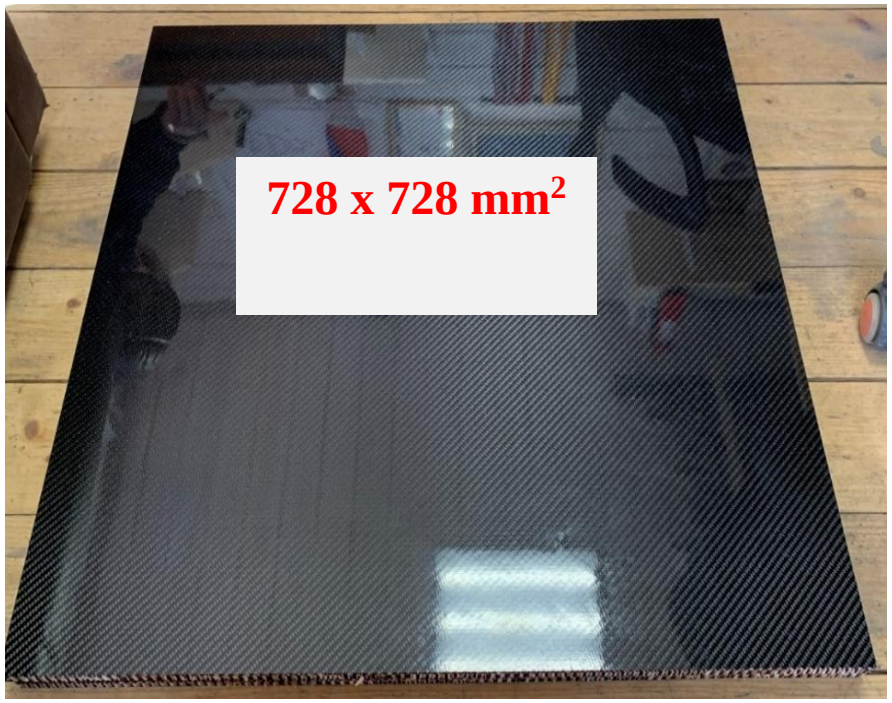
thickness of each ~ 20 mm

I. II. I. II. I. II.

Parts:

I. Infrastructure (grooved)

II. Detector support



The next steps are:

- **simulate the deformations** of the backplate,
- **select main option.**

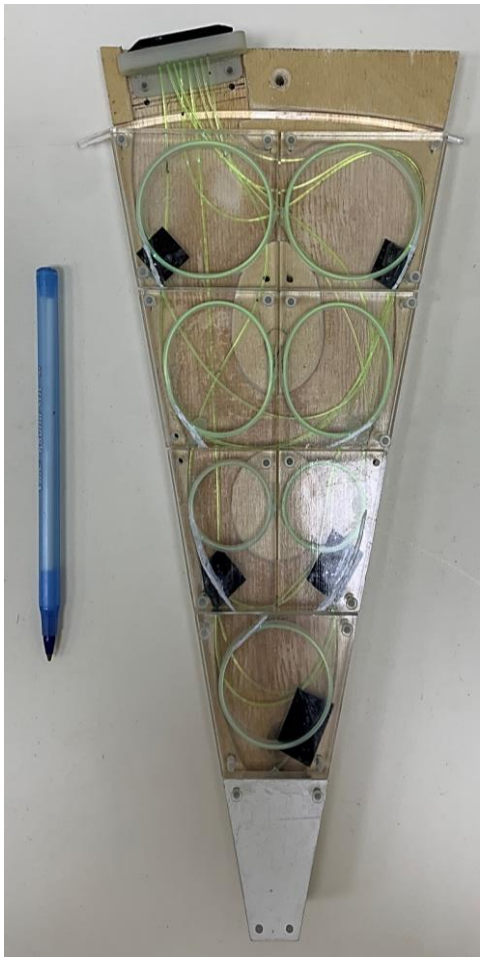
The grooving map has been done.

The sandwich backplate grooves for BBC

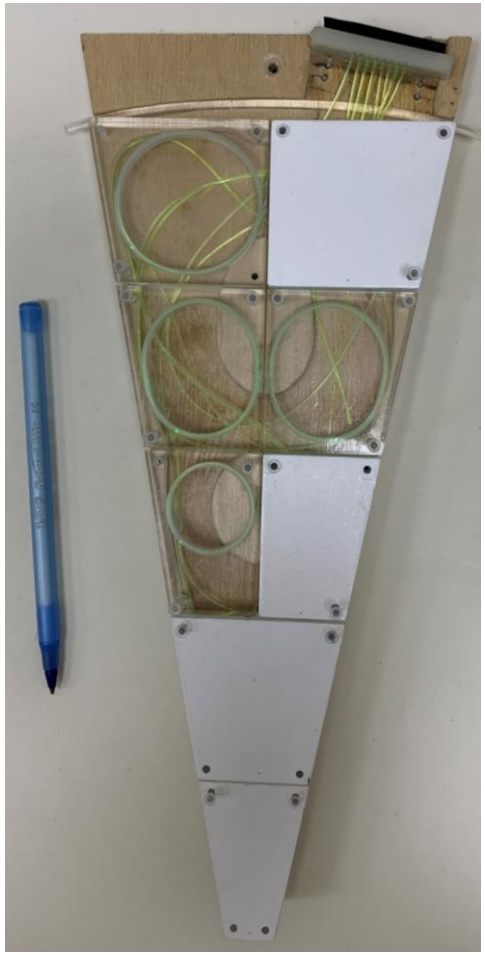
The grooving map
½ of wheel

Grooved wood backplate
V.4.3

left output



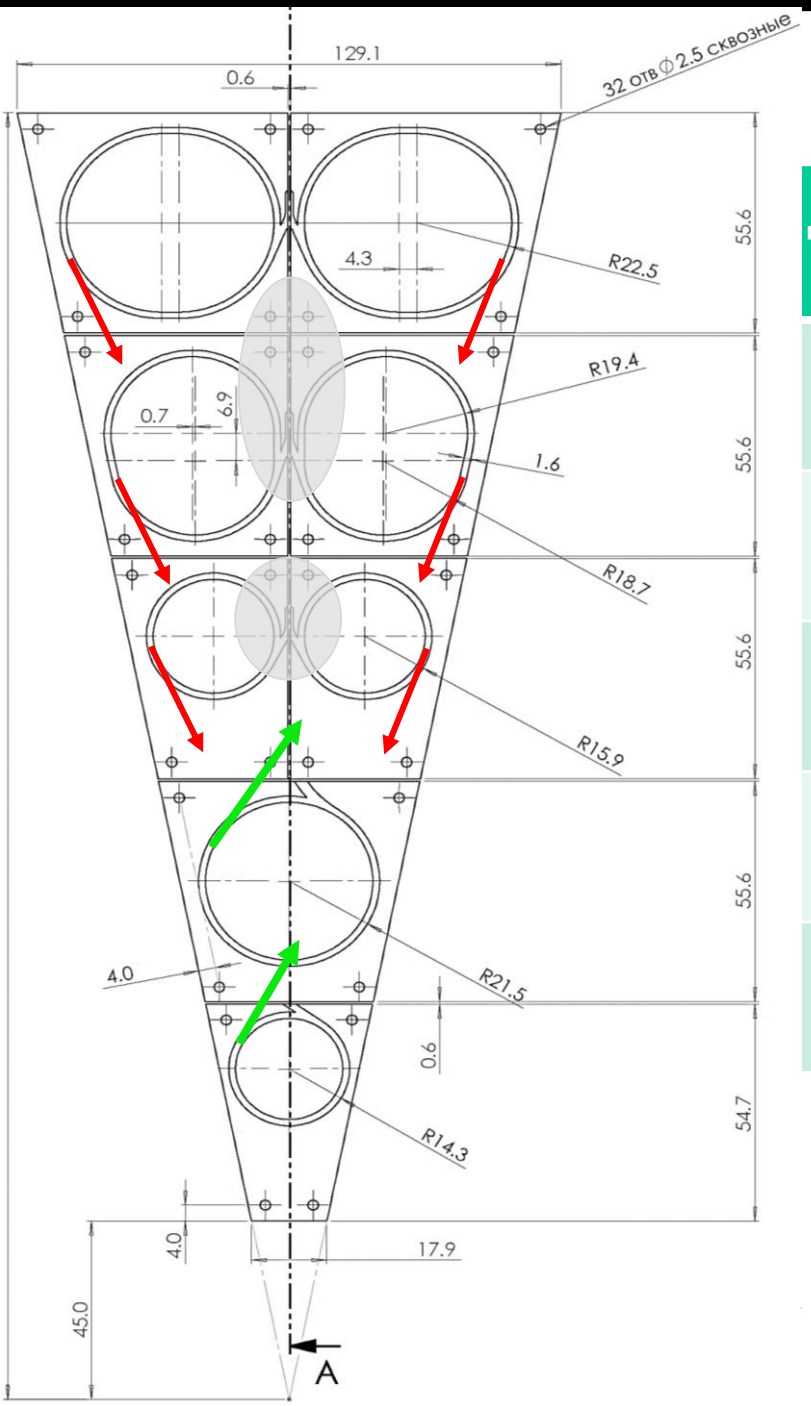
right output



- ✓ the verification method has been implemented
- ✓ the ability to quickly the connector substitution

BBC assembling part

The fiber laying



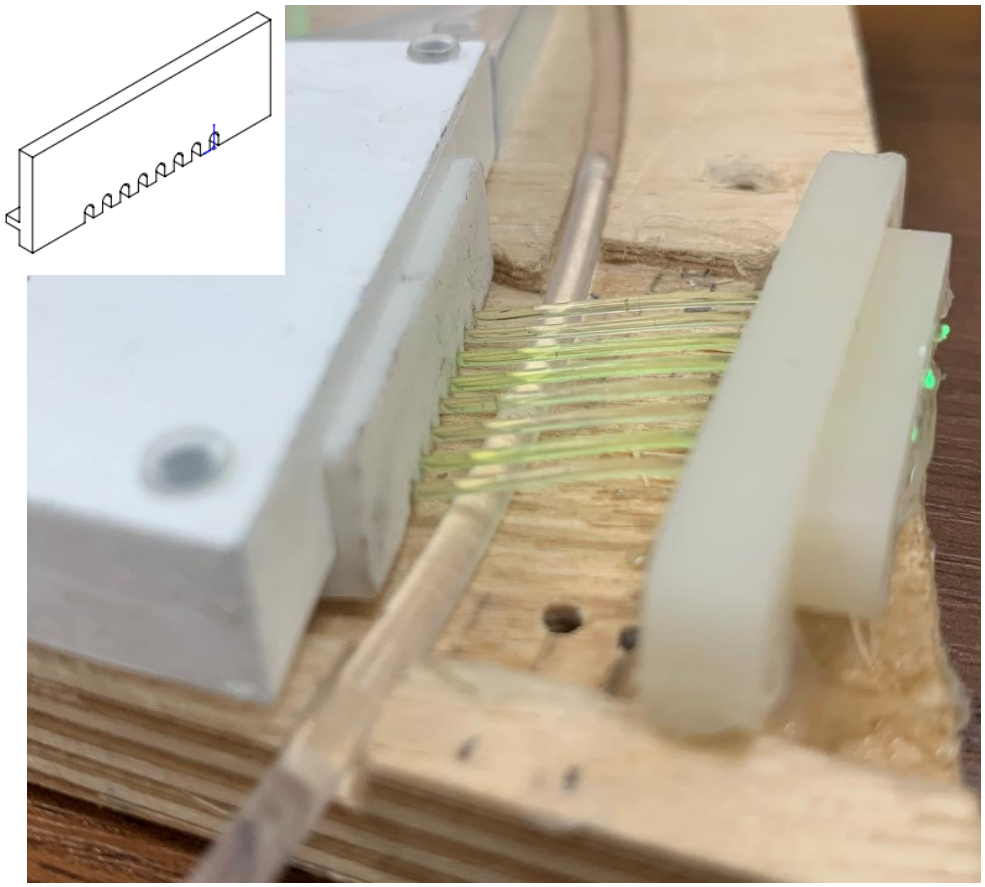
Длина, см	ряд	Длина, см
63	4	73.5
61.5	3	72.2
54.5	2	61.5
70	1	68
62	0	61

- ✓ Reserve (min. 40mm)
- ✓ Left/right output symmetry
- ✓ The minimum diameters are the same

❖ hard to transported

BBC assembling part

The sandwich backplate grooves for BBC

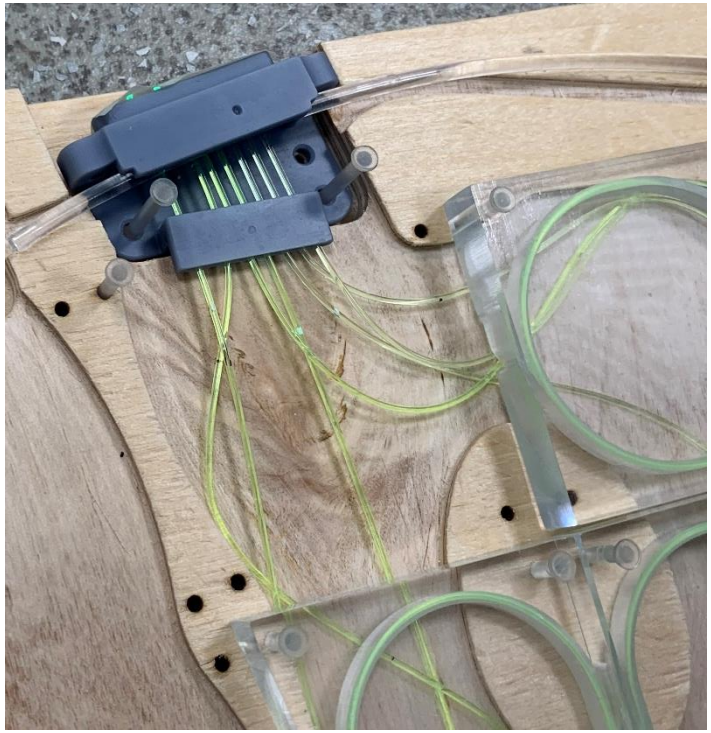


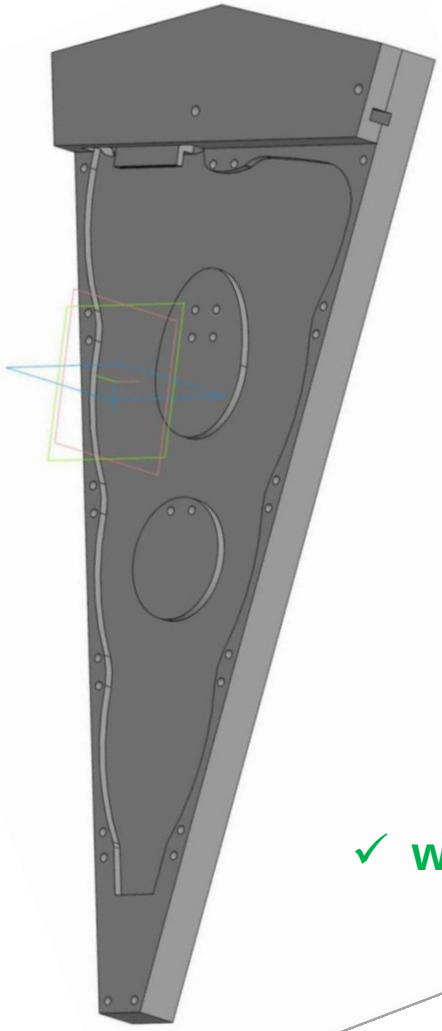
- the connector mounting is not reliable
- WLS tension
- not light shielded

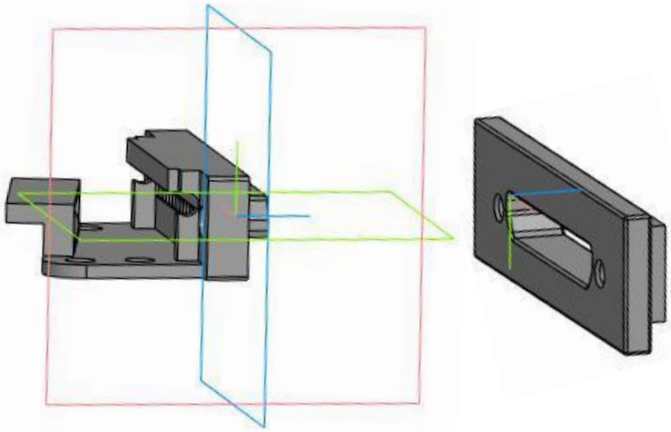
BBC assembling part

The sandwich backplate grooves for BBC

Grooved wood backplate
V.4.4 (final)



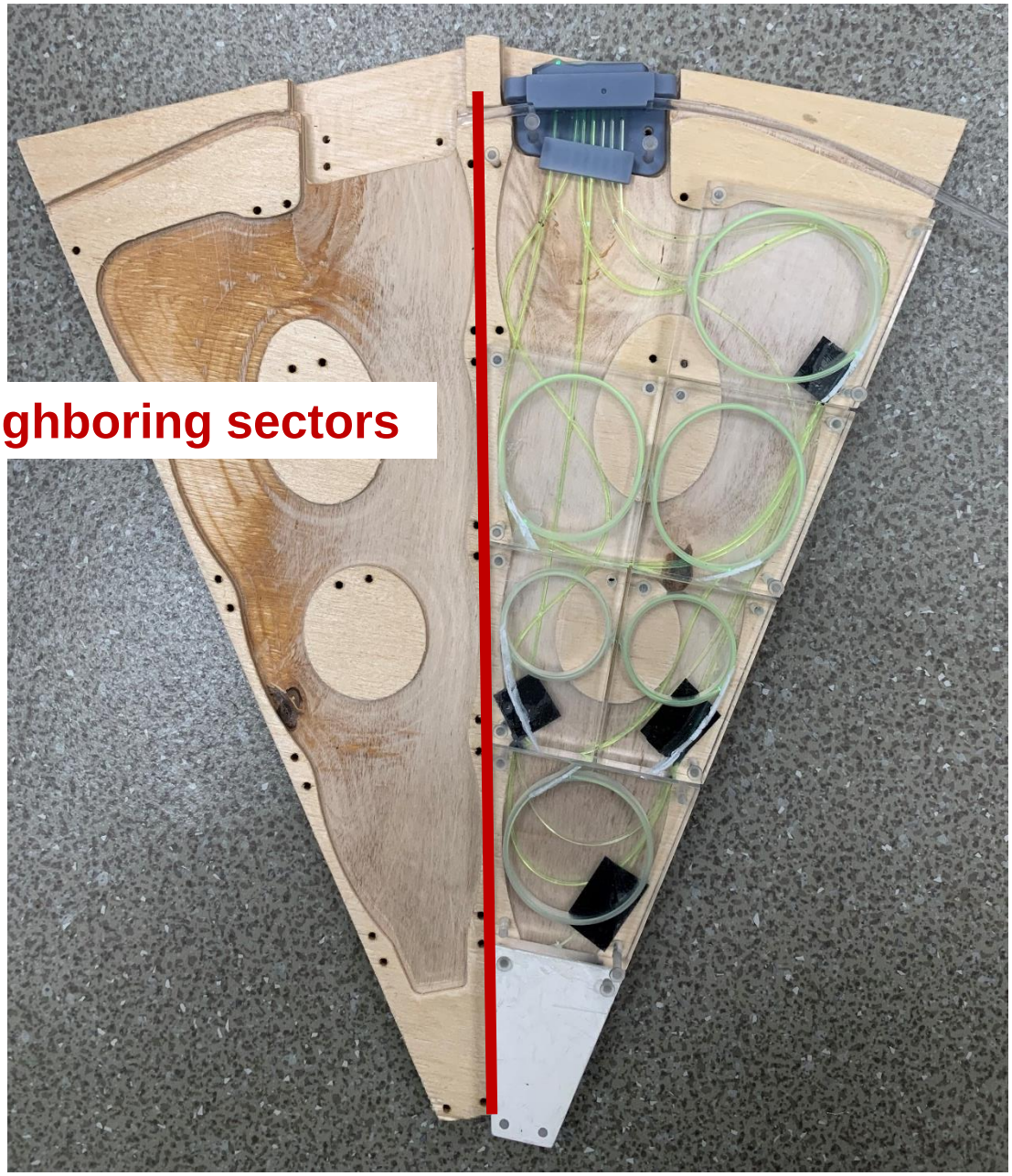




- ✓ **with uniform illumination (SGF)**
- ▪ **kind of light-shielding tape (?)**

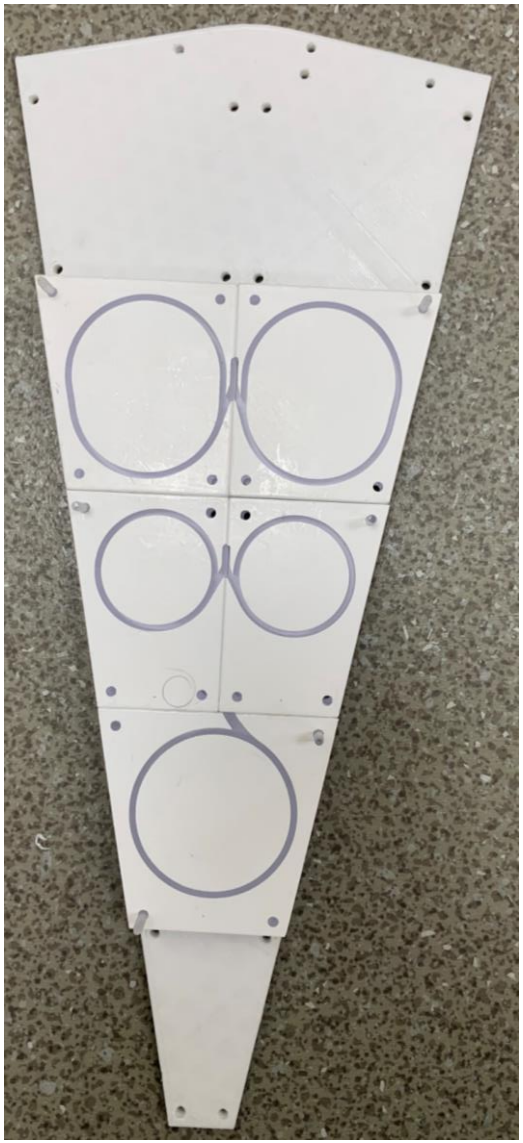
The sandwich backplate grooves for BBC

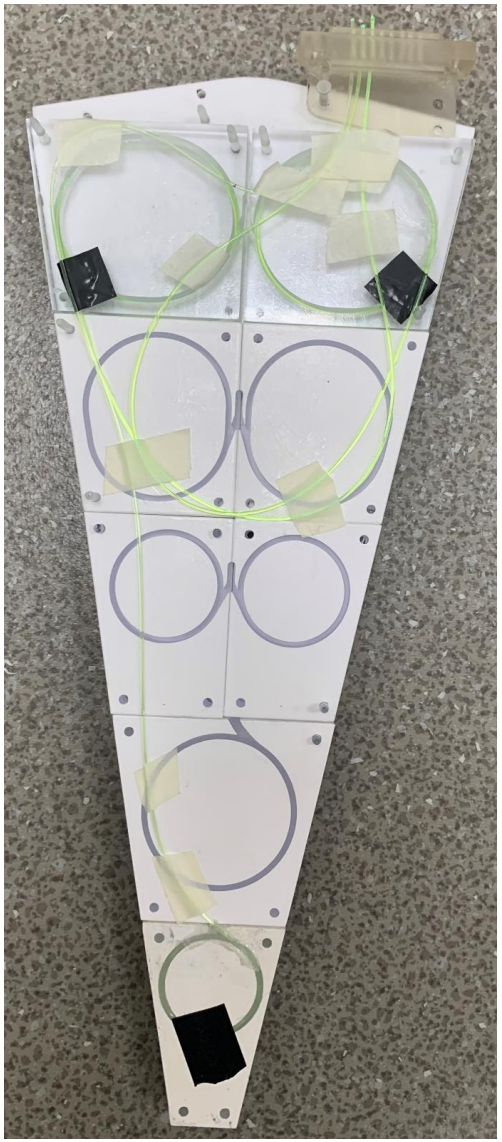
- problem with tiles of neighboring sectors



BBC assembling part

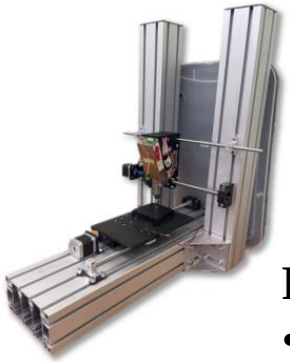
The mechanism of transported






https://1drv.ms/f/c/472043d3e6891bfc/ElejW62pvfVNpLCiogbmTfEBrmcCOR8yEwmVpFafLmUUkA?e=07G2Mb

shared models & etc.



Method. Full-map (scintillator homogeneity, **I**) or coarse-grid X-ray scans (**II**).

For definition of:

- **defects**
- **technological deviations (cement presence/quality, concentration; WLS turns)**

Cement concentration (CKTN-E): 2.5/100 vs 3.2/100 (datasheet-recommended) → 24.6 vs 29.2 μA (≈ 12%).

WLS turns (OK-72): 1 vs 3 → 14.5 vs 25.0 μA (≈ ×1.7).

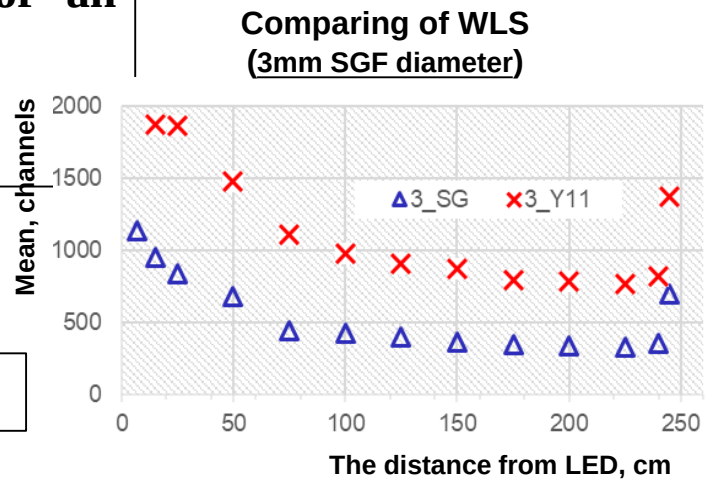
The verification for the mass production process

- **check the uniformity of the tiles**
- **method for estimating the efficiency of an optical and electronic path**

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

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

⌀3 mm is approved



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

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

✓ **WLS Kuraray (Y11)** is effective.

- ✓ The details of BBC assembling part have been described.
- ✓ The mechanism of transported have been proposed.
- ✓ The verification for the mass production process have been proposed. The methods are promising.

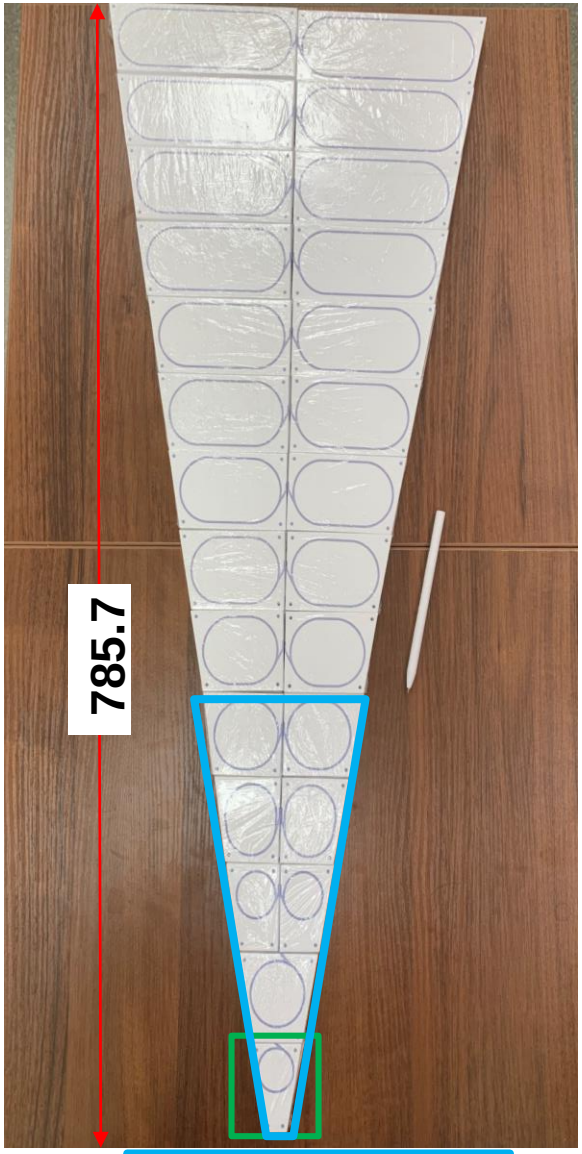
To do list

- modeling of the sandwich base hardness;
- detailing the mechanics
- finalizing the method of express sector check (NEW test samples + test of the upgraded optical cable and transmission box);
- start the mass production process

Two full-size BBC sectors production

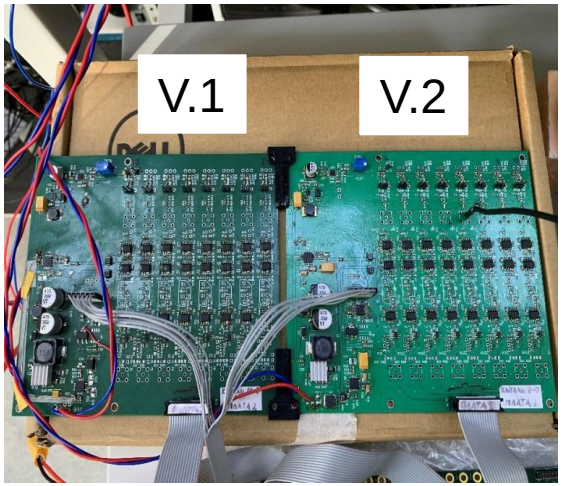
BBC Sector (1/16 of wheel) design

26 tiles

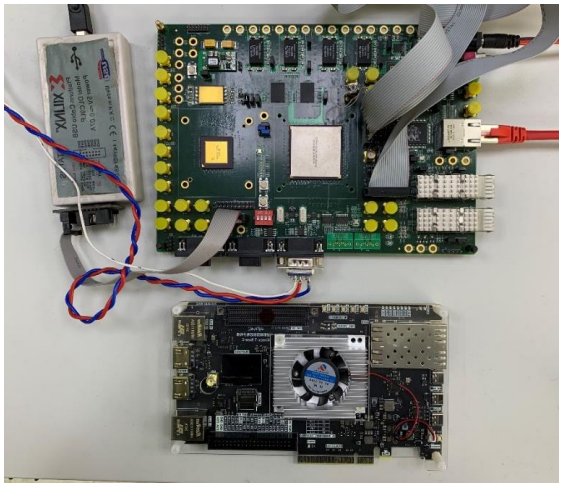


1/16 of reduced prototype wheel

Analog part versions



XILINX VIRTEX-5 FPGA (current)



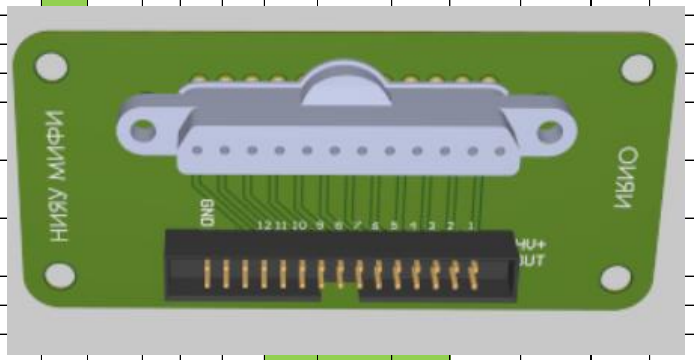
KINTEX-7 FPGA (new)

The version of FEE that uses **KINTEX-7 FPGA** and new analog part is under active development.

Schedule of works

№	Наименование	2024 year										2025 year												2026 year					
		1-st quarter		2-nd quarter			3-rd quarter			4-th quarter		1-st quarter			2-nd quarter			3-rd quarter			4-th quarter			1-st quarter			2-nd quarter		
		March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June	July	August	September	October	November	December	January	February	March	April	May	June
1	Estimation of light loss on fiber bending																												
2	Manufacturing and testing of samples with various optical cement options																												
3	Selection of final assembly components																												
4	Production of a three-layer base for a prototype																												
5	Assessment of the strength of the base																												
6	**Development of 2 sector prototypes [2*7 tiles]**																												
6.1	Astimation tests																												
6.2	Calibration of the energy scale of DT5202																												
6.3	Determining the optimal thresholds for DT5202																												
6.4	Determination of temperature dependence and its consideration in tests																												
6.5	Prototype testing									1	2																		
6.6	Data processing and interpretation of results																												
7	Tests with Hamamatsu SiPM (1.3x1.3 mm^2)																												
8	Development of the inner part of the detector (the space between the tube and the proposed BBC concept)																												
9	Development of mapping_a for the BBC subsystem																												
10	**Development of 2 detector prototype wheels [2*(8*16) =256 tiles]**																												
10.1	Production of the prototype frame																												
10.2	Production of a five-layer base for a prototype																												
10.3	Implementation of composite sleeves for fixings, and milling																												
10.4	Installing the base into the frame																												
10.5	Development and manufacture of optical connector modules (WLS <-> transparent fiber)																												
10.6	Development and manufacture of connectors (transparent fiber <-> SiPM)																												
10.7	Development and manufacture of a printed circuit board (PCB) for SiPM																												
10.8	Checking the performance of connectors and PCB																												
10.9	Prototype testing (test beam)																												
10.10	Data processing and interpretation of results																												
11	Coordinating the output of detector cables to the BBC control room																												
12	**Assembly of 2 full-size BBC sectors**																												
12.1	Manufacturing of the frame (2 parts)																												
12.2	Manufacturing of a five-layer base for the detector																												
12.3	Implementation of composite sleeves for fixings, and milling																												
12.4	Installing the base into the frame																												
12.5	Full camera testing																												
12.6	Data processing and interpretation of results																												
13	Dismounting of detectors																												
14	Transferring detectors to SPD																												
15	Installation of detectors																												
16	Cross check and tests																												

~ 5-7 months delay



★ Not JINR

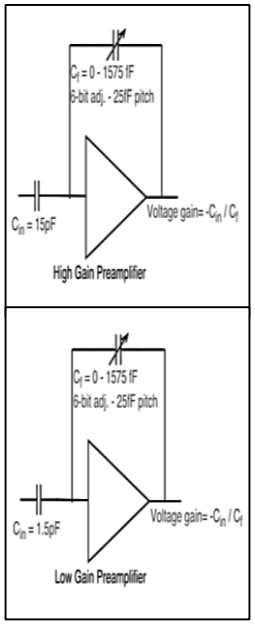
Thank you for the attention!

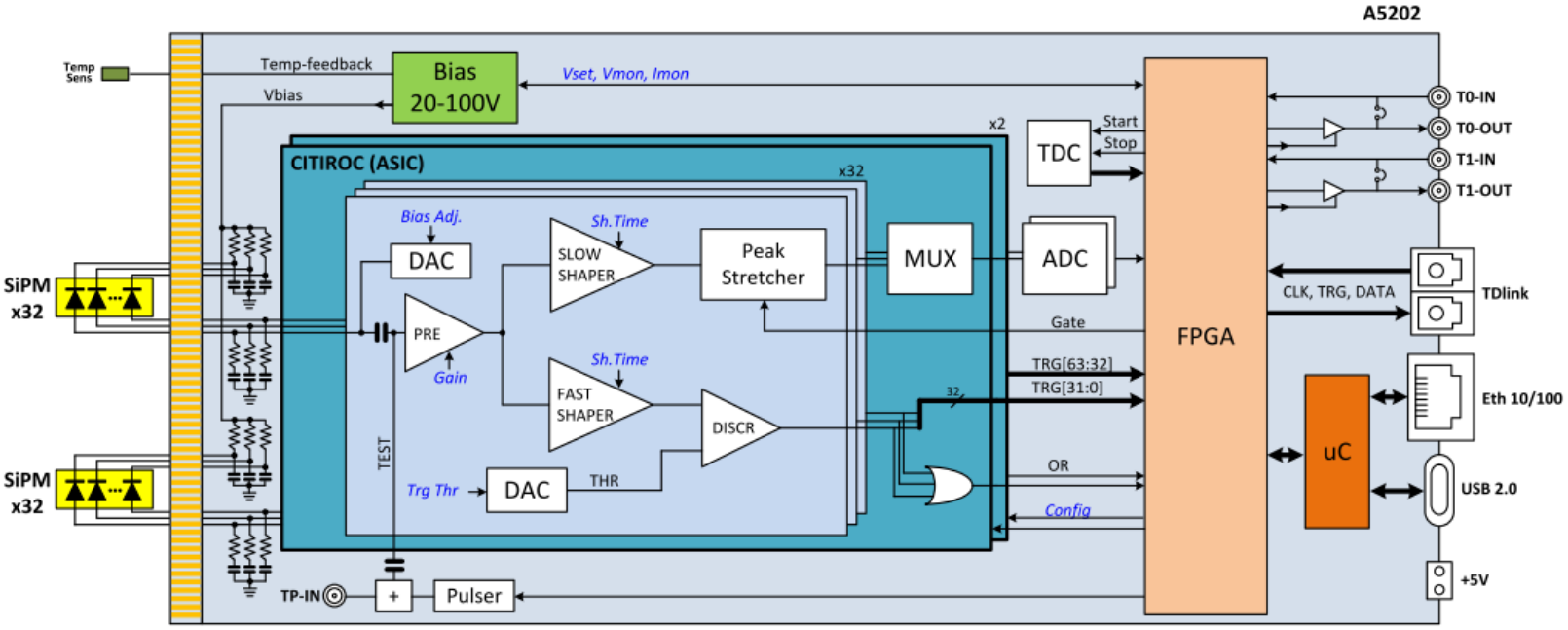
Backup

Outline

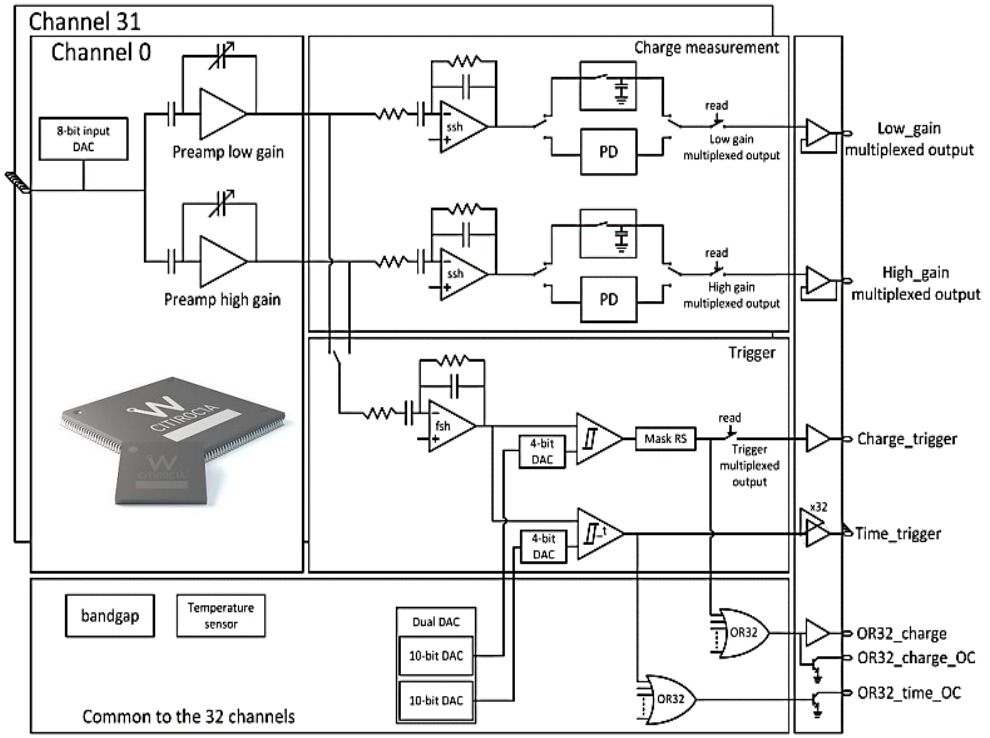
- Introduction
- BBC assembling part
- Hardware
- R&D tests
- Results (current status)
- SPD Phase0 plans
  - Simulation (Phase0)
- SPD Phase1 plans

Simplified block diagram of the DT5202 FERS-5200 unit





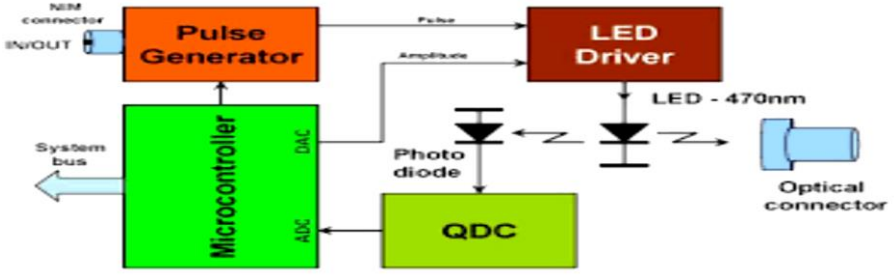
Citiroc-1A block scheme



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.

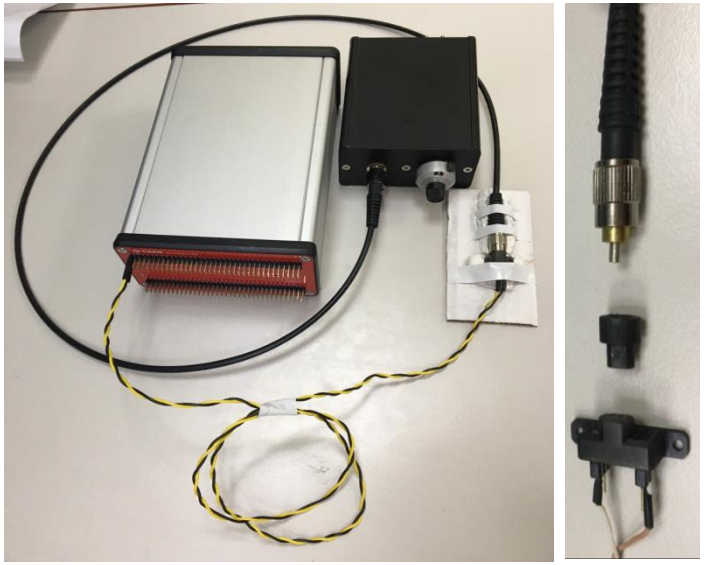
Schematic view of the LED



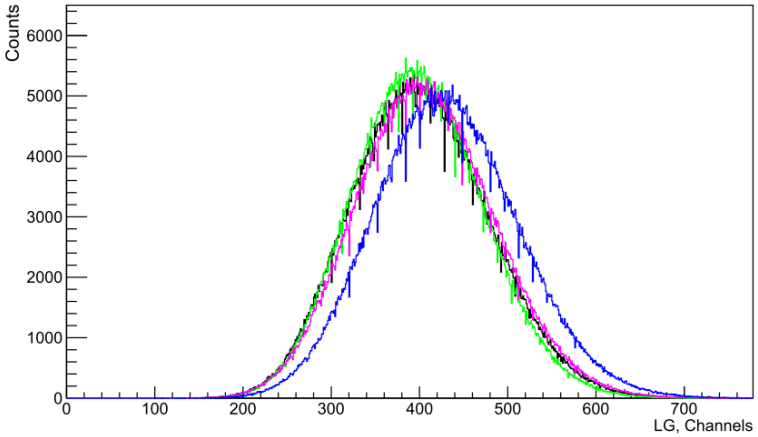
The hardware of BBC tests part

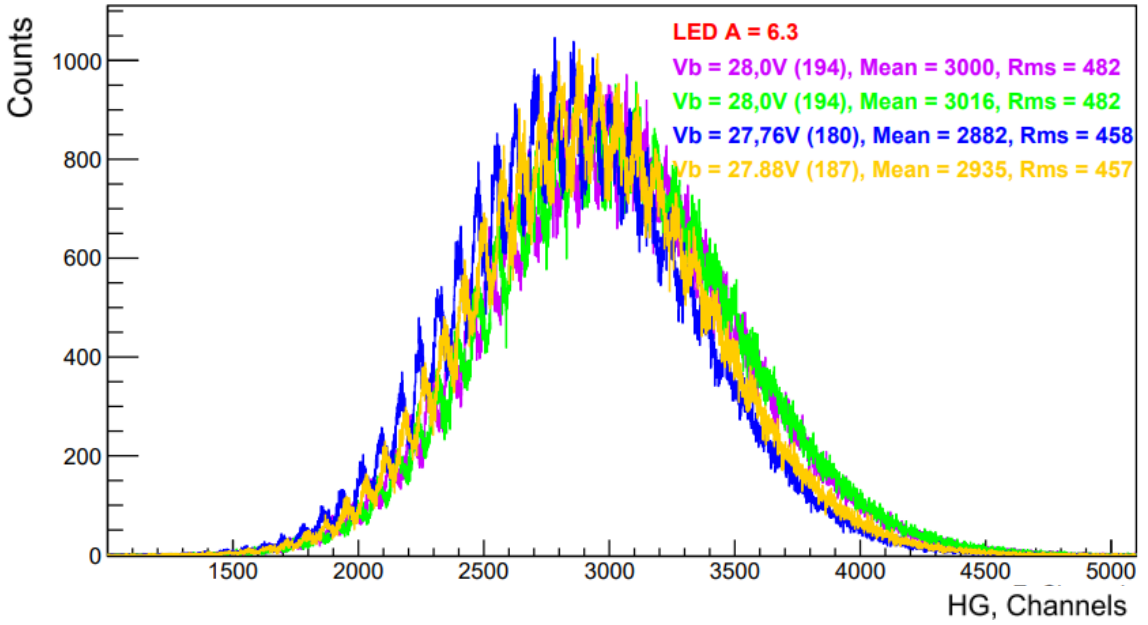
Calibration method (Led source)

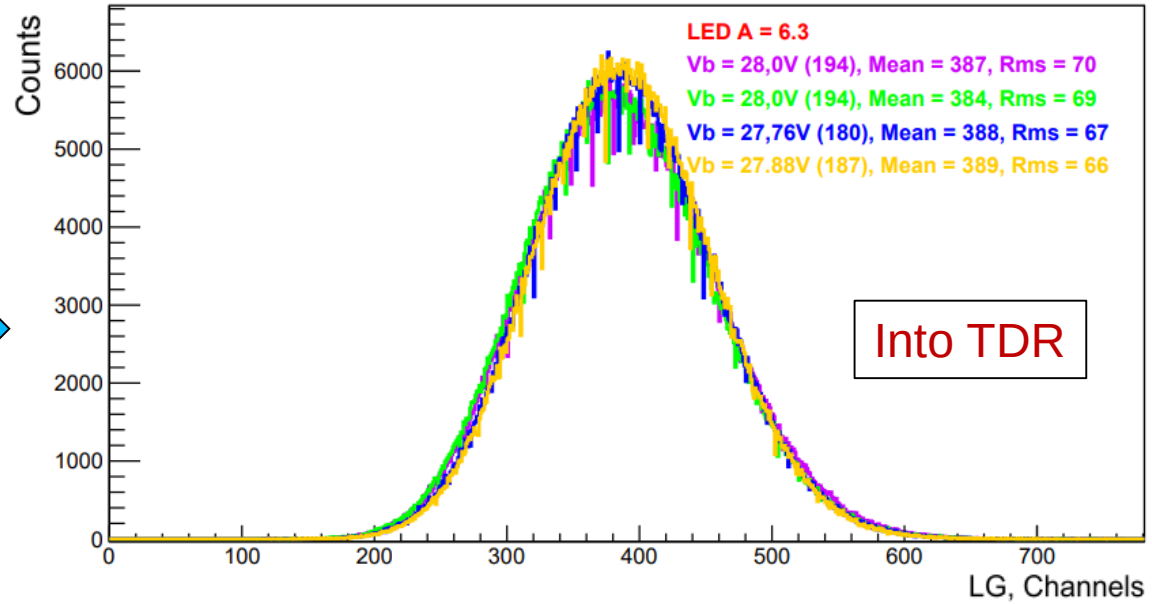
DT5202 with CAEN LED Driver (SP5601)



Not calibrated

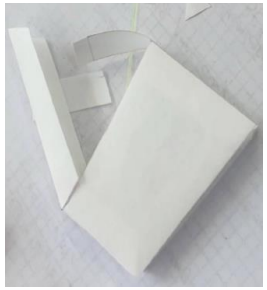






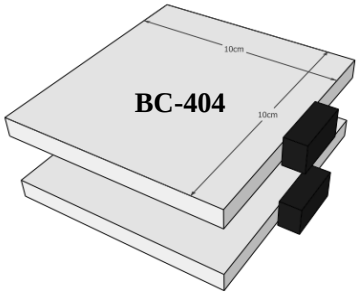
Materials selection test part

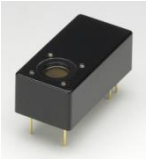
Scintillator cover



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

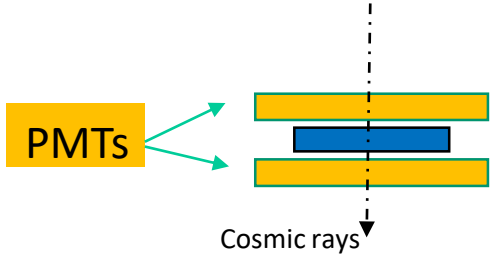
External trigger by coincidence of two scintillators with PMTs readout





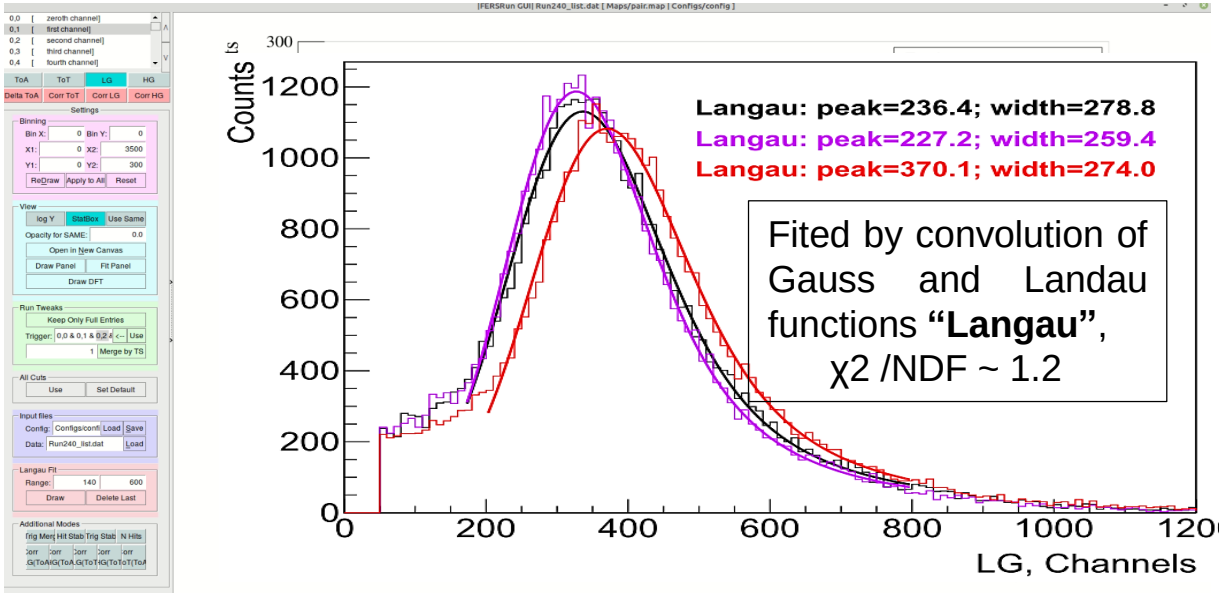
PMT Hamamatsu H10720-110

The "FersRun" framework has been designed.



Matted or Mylar or Tyvek

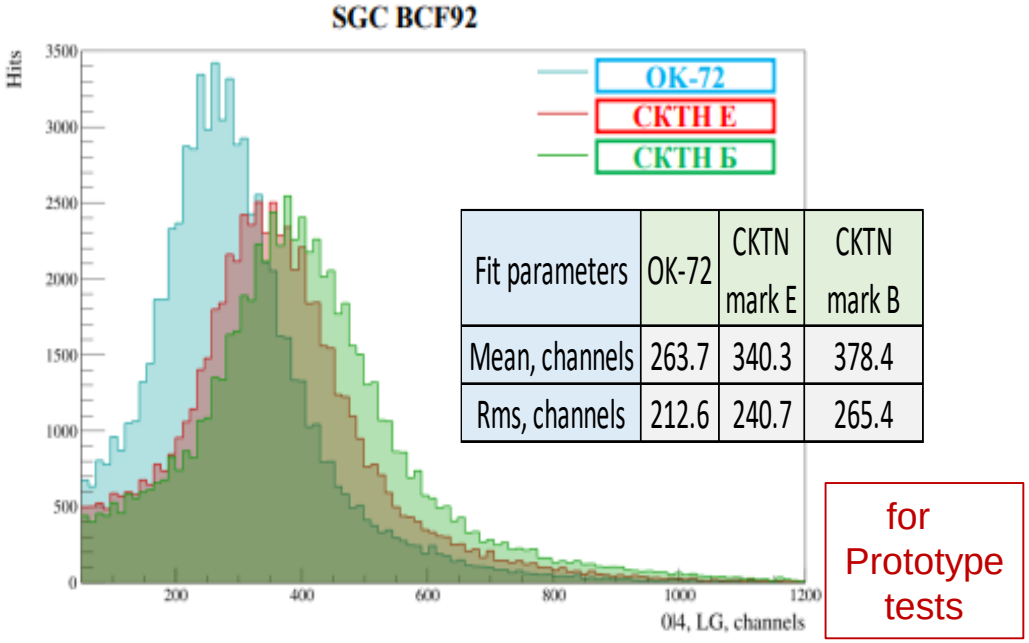
SensL SiPM (27.34 V.)
S.G. (WLS)
CKTN (opt. cement)



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

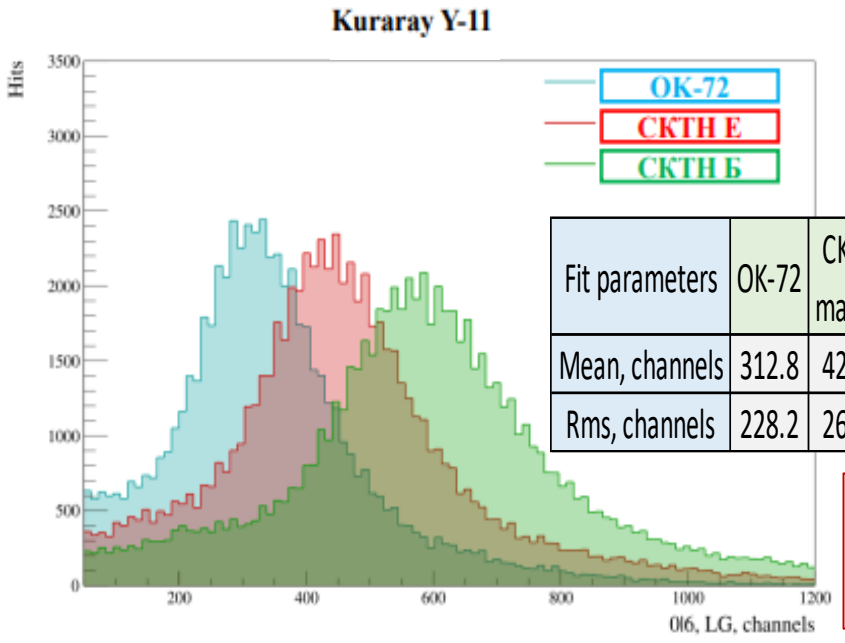
Materials selection test part

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

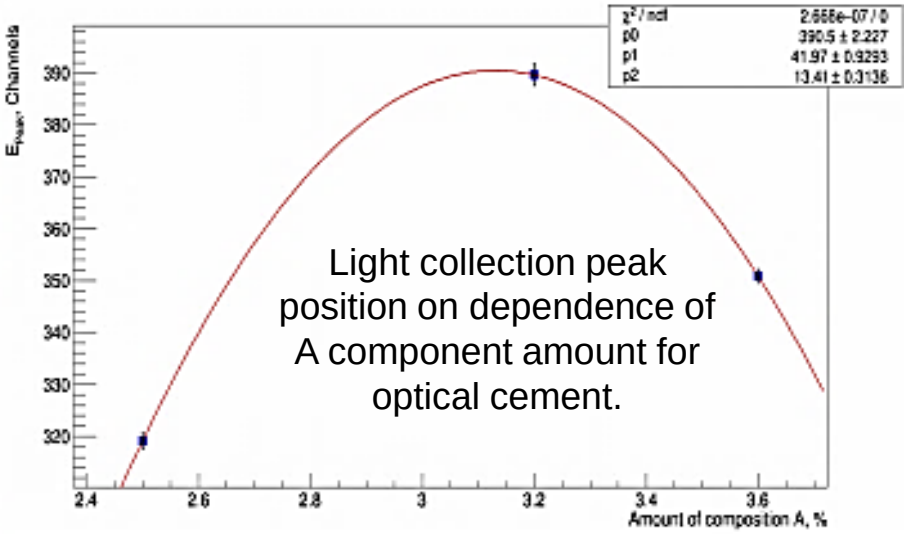
for Prototype tests



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.

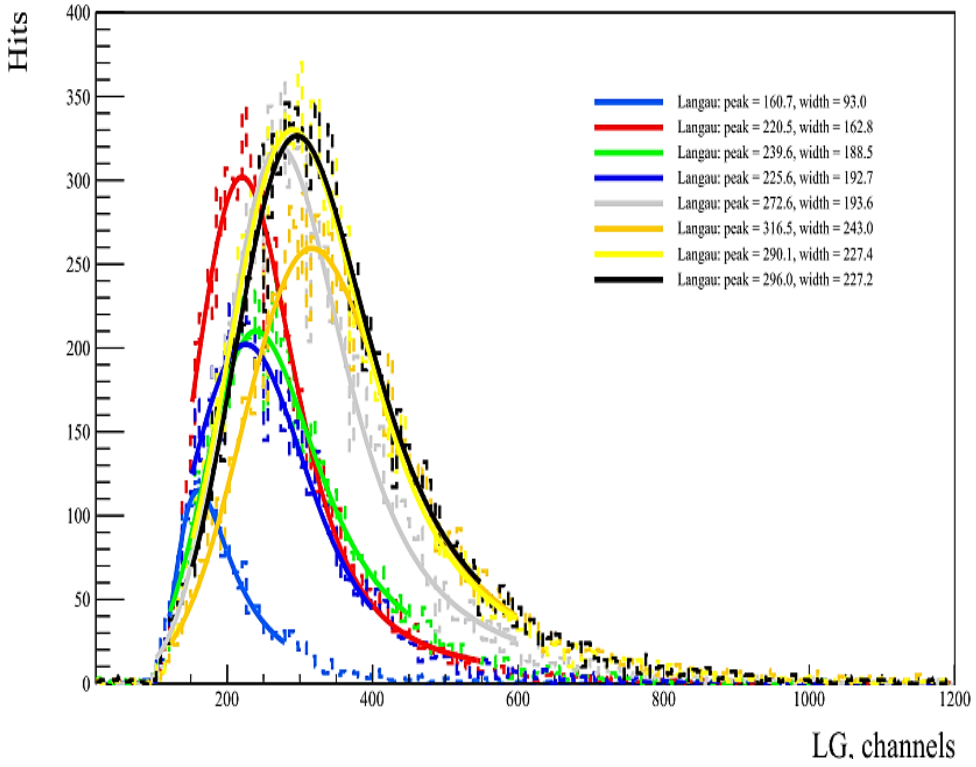
The results of tests of Kuraray WLS fiber and Saint-Gobain Crystals (SGC) WLS fiber with different types of cement are presented.

- ❑ **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**.

Prototype assembling test

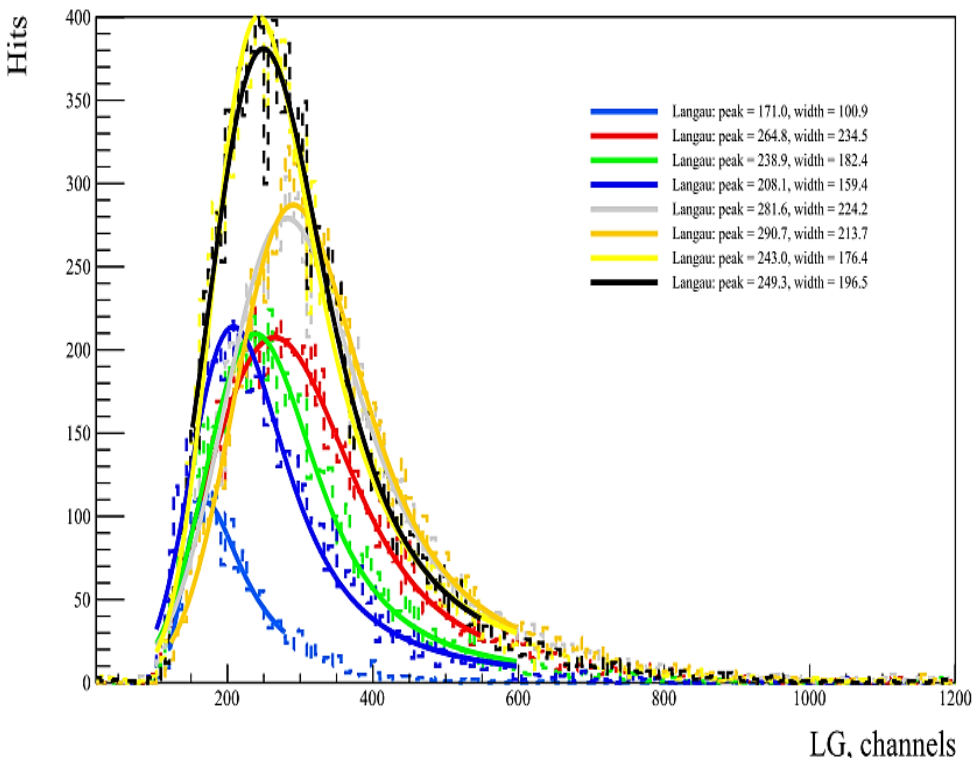
Amplitude spectra of two sectors

1-st sector prototype



There are 2 specific channels, but the debugging process of mass production continues.

2-nd sector prototype

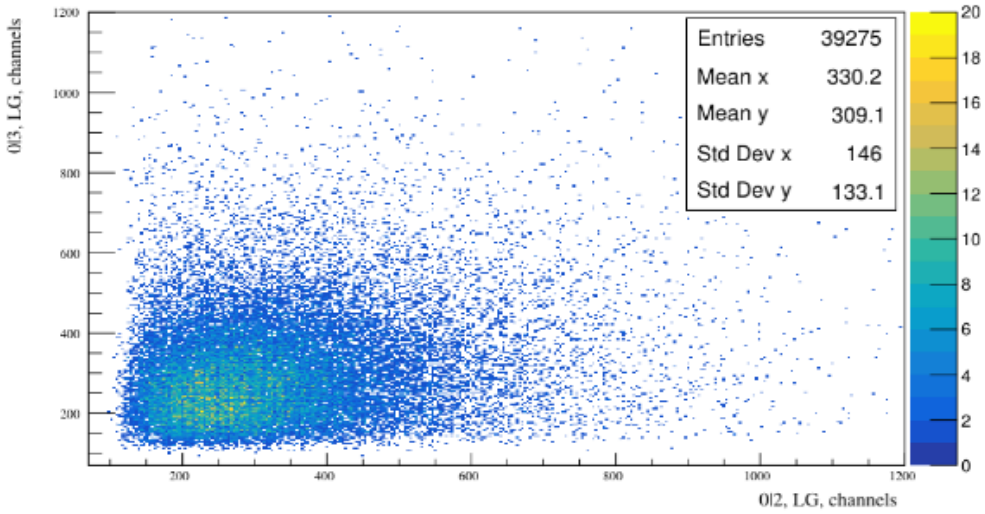


The stable tiles were taken for following tests

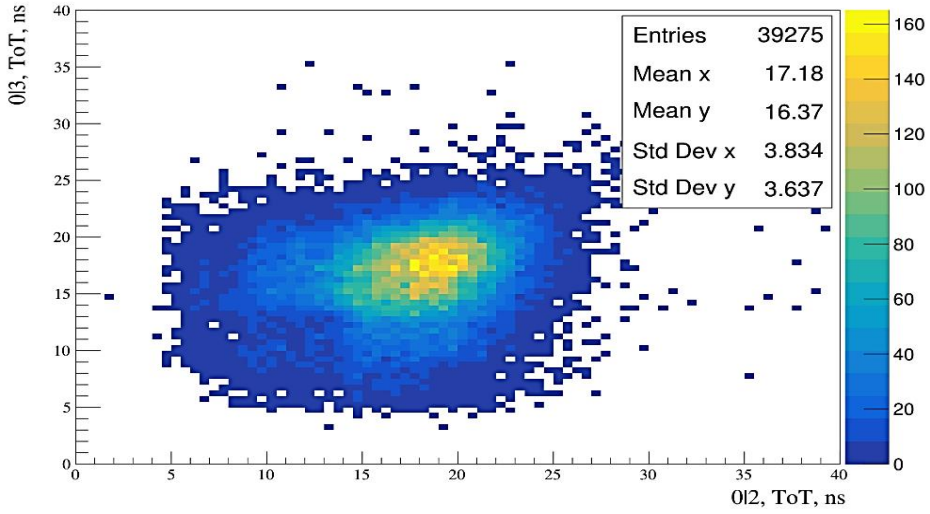
Prototype assembling test

The 1-st step for working with the timing mode

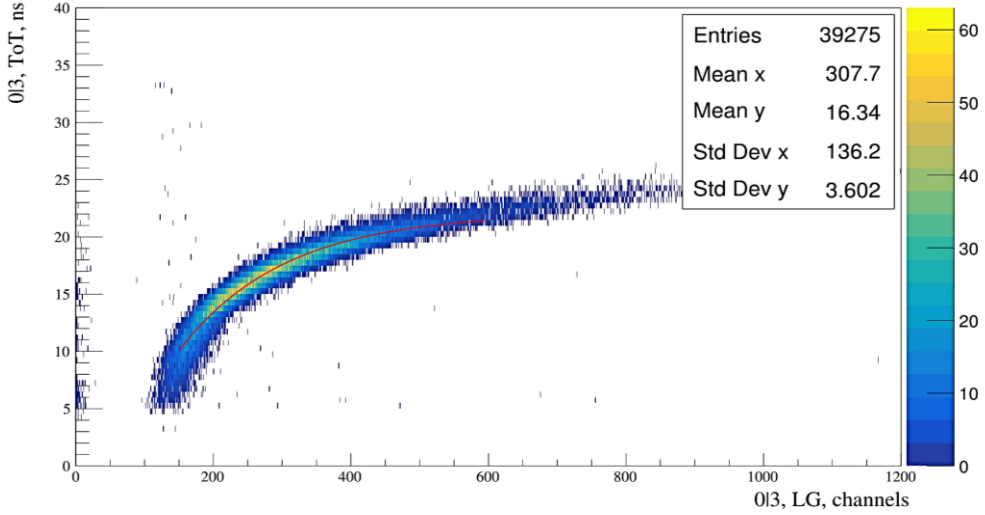
LG correlations

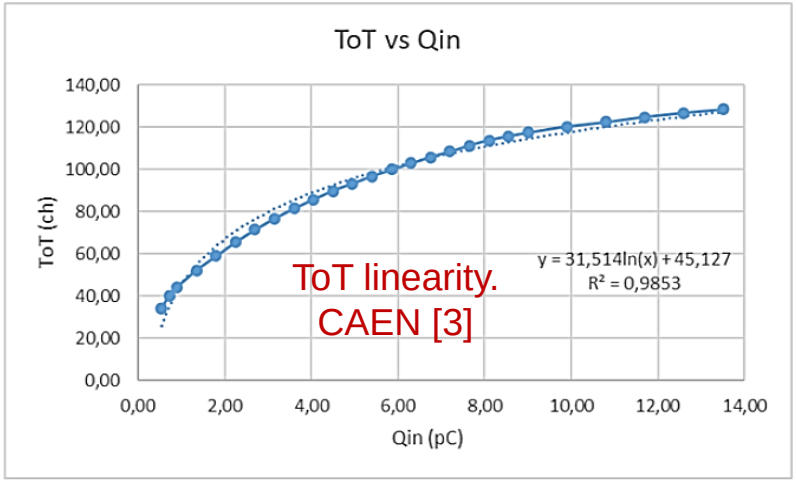


ToT correlations



LG vs ToT (channel №3)





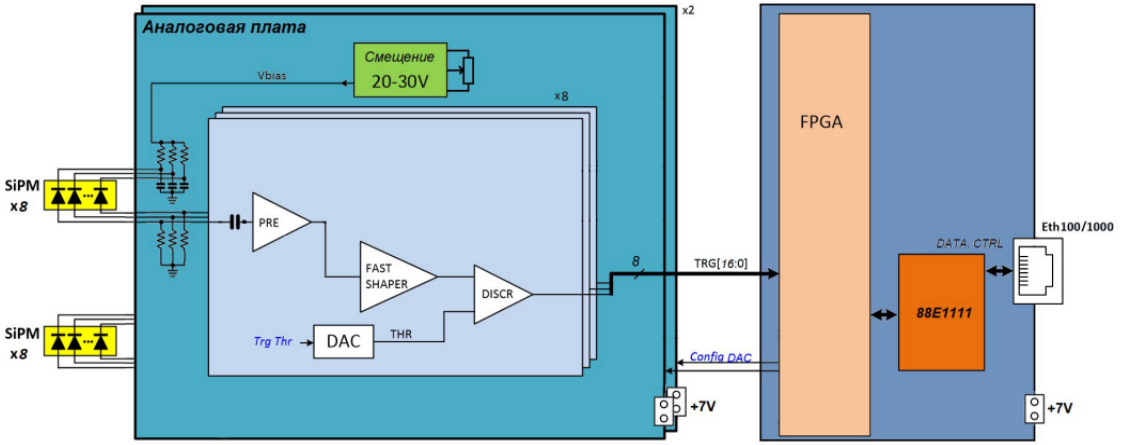
Correlation of energy deposition for 2 channels, as well as the time information for these channels.

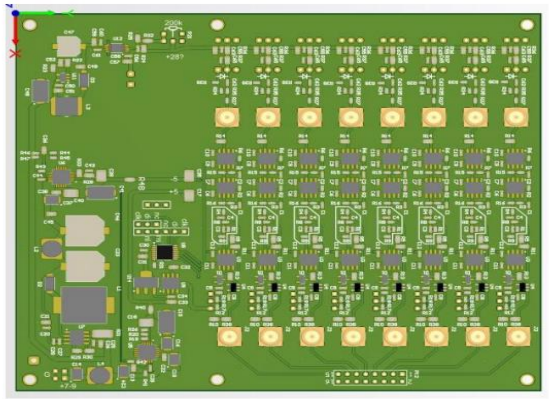
- The calibration of the charge scale is required

Prototype FEE specifications

Number of channels	16
Signal polarity	positive
Time resolution	18 ps
Discriminator threshold	12 bit programmable, for each channel
Power source	20-30 V
Working mode	streaming
Frequency	til 2 kHit/s
Shaping time	fixed, 20 ns
Time tagging	48 bit counter, 3 ns step
Interface	Ethernet 100/1000

Simplified block diagram



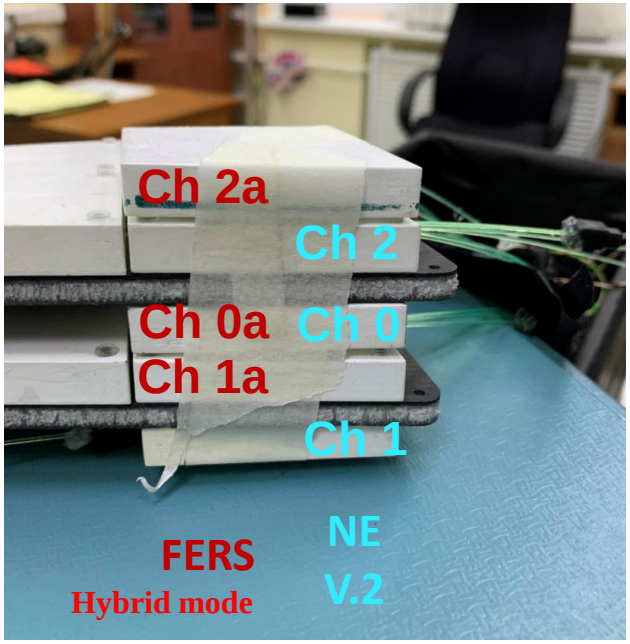


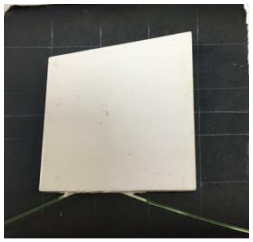
Front-end units
(SiPM supply, signal reading)

TDC based on FPGA
(XILINX VIRTEX-5)

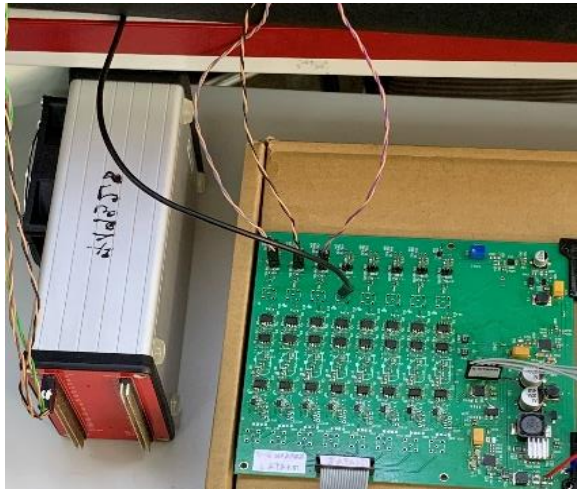
The hardware tests

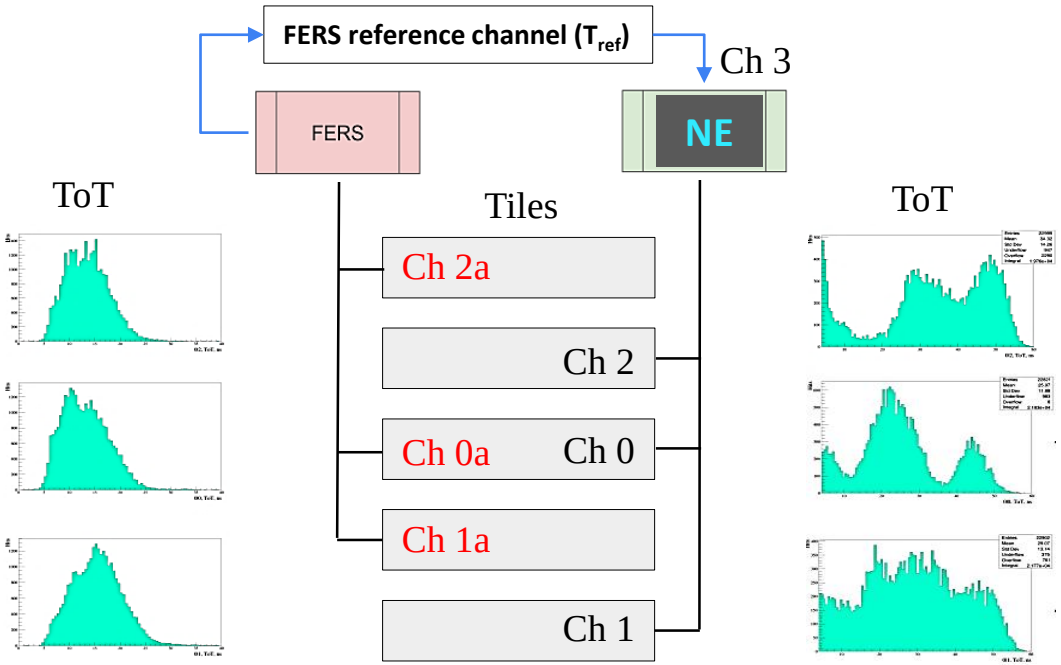
The electronics test

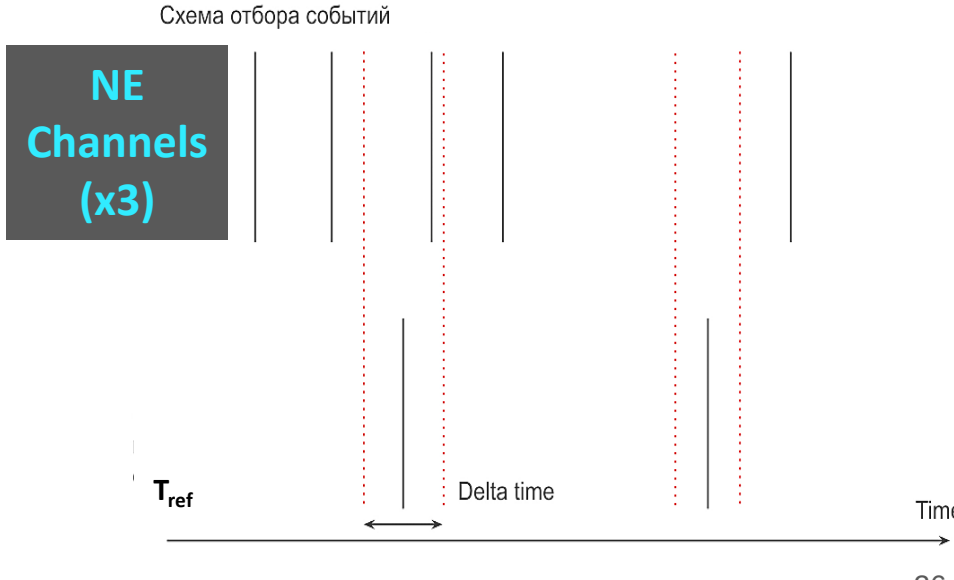




“Majority (3ch) ”
Trigger logic



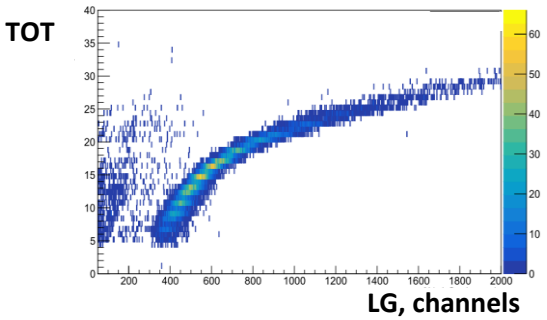


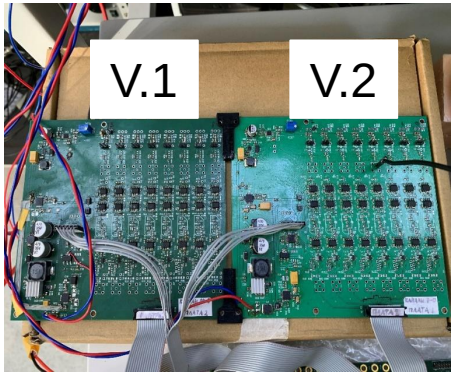


The hardware tests

Results

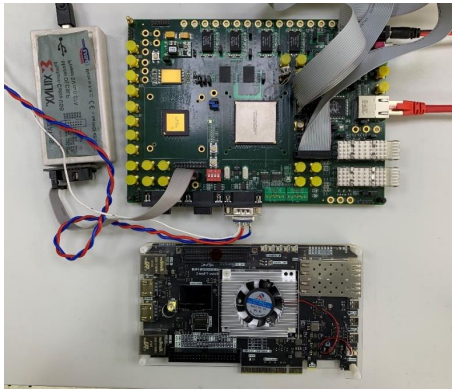
LG vs ToT (channel 1)



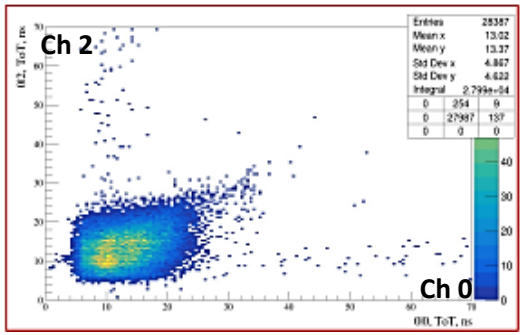


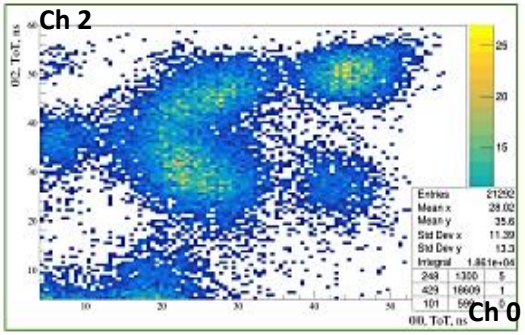
Analog part versions
(next V.3)

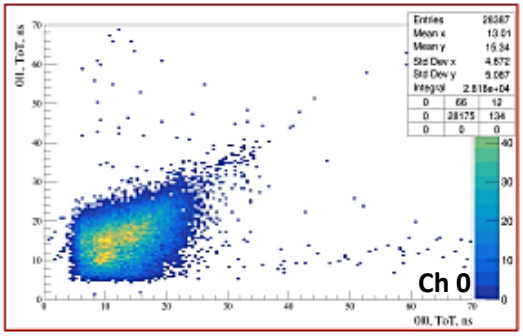
FPGA XILINX VIRTEX-5

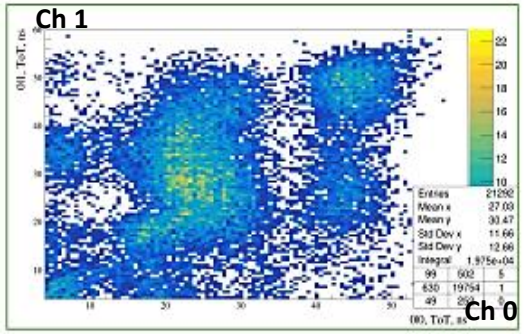


FPGA KINTEX-7





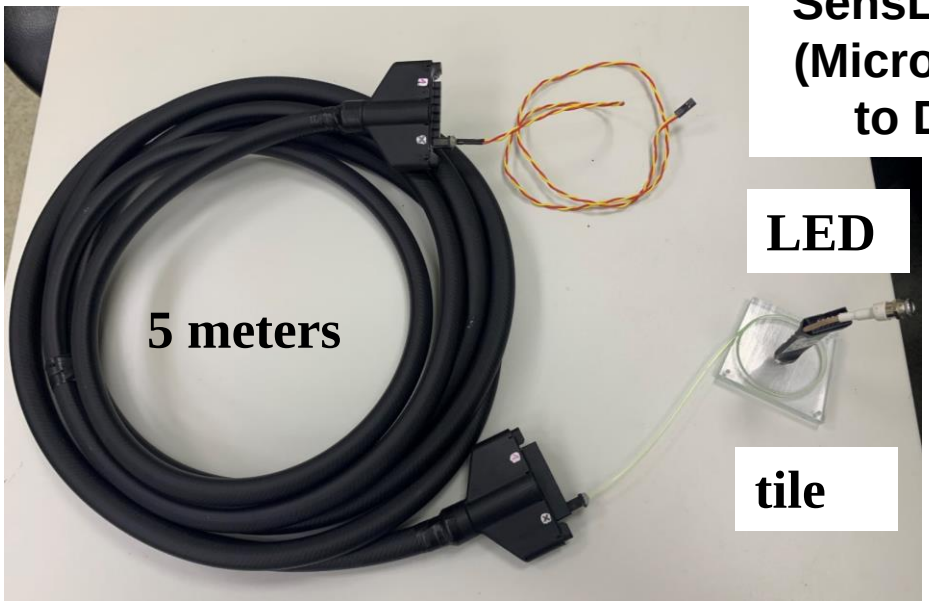




- Improvement the "FersRun" framework for the correlations between different electronic channels
- Further research
- NE improvements

are required

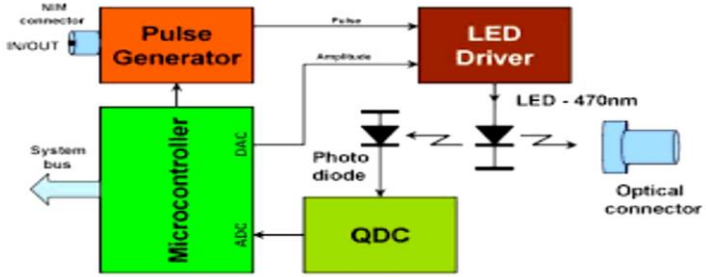
The optical cable prototype (clear fiber)

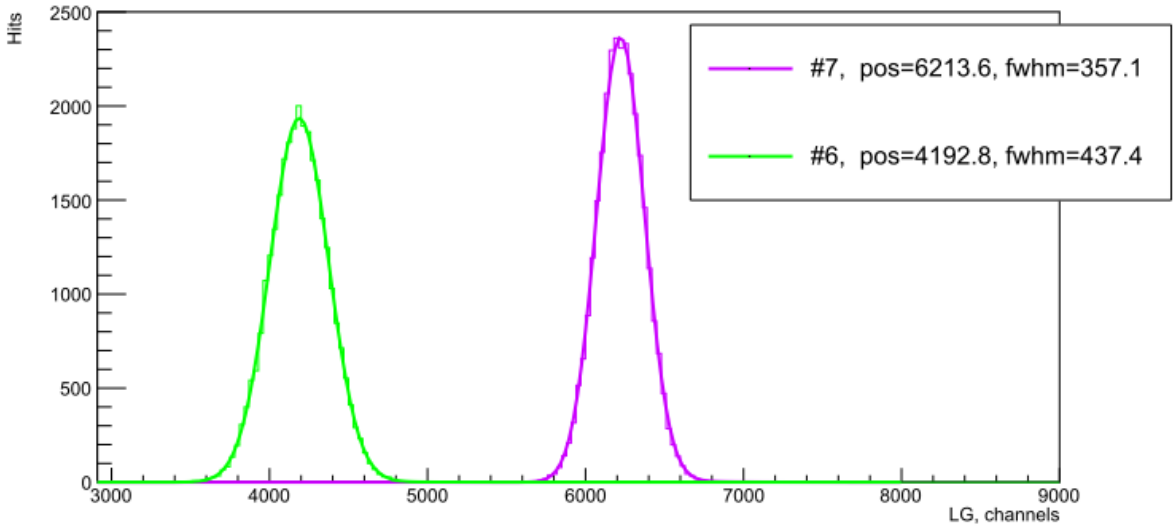


SensL 3x3 mm² (MicroFC-30035) to DT5202

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

Schematic view of the LED

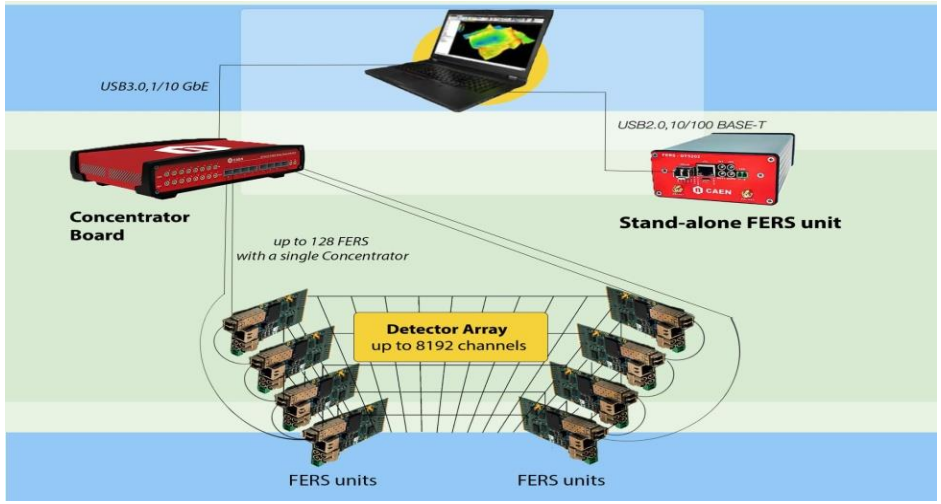




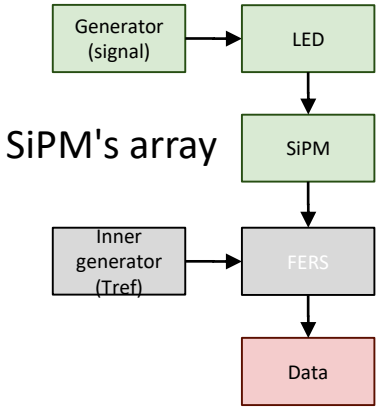
Light loss at 1 meter **~7%**

Application of DT5215 concentrator

- **SPD** is planned to operate without **T0** (start) so we need to work with **free-streaming mode.** **(first step - Hybrid mode for DT5202)**

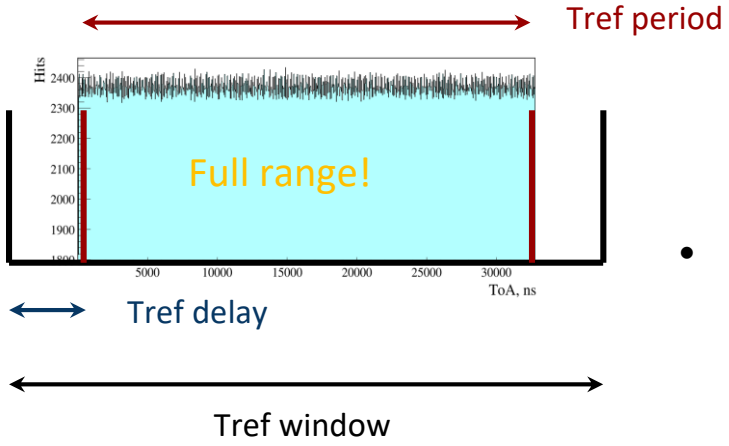


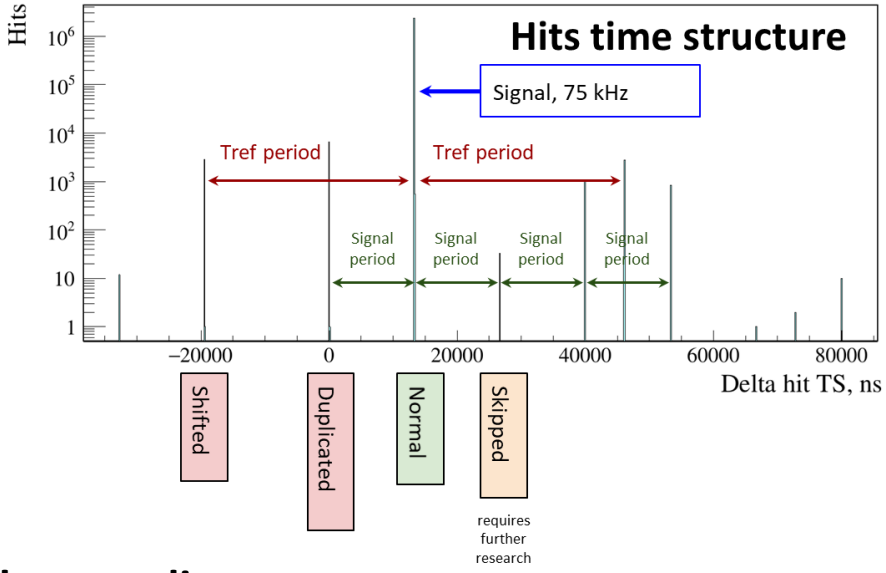
Tests with SiPM's array



Hits acquisition ranges

Tref may be provided by
- outer generator (T0)
- inner generator (PTRG)





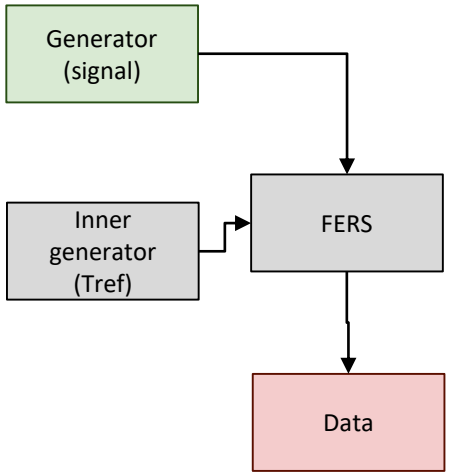
- **Continuous data reading** can be made only with **fine-tuning** of board parameters.

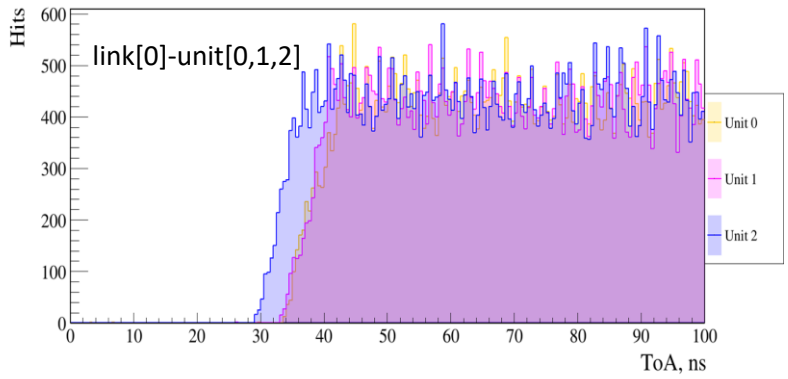
upgrade f/w and tests are required

Application of DT5215 concentrator

Tests with different unit-concentrator links configurations

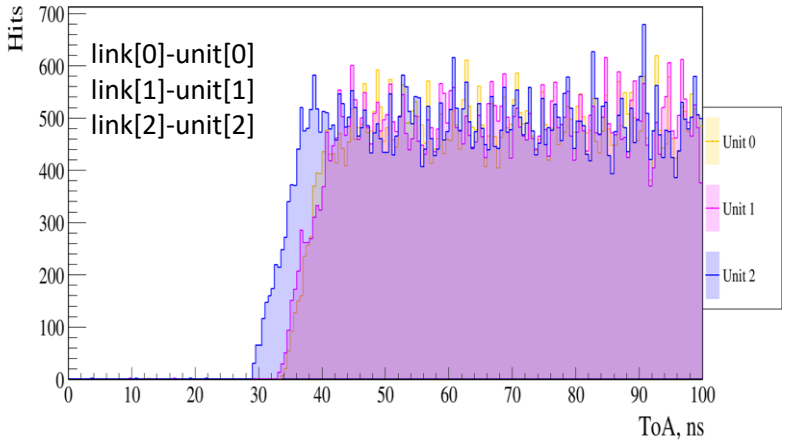
DT5215 (FW v. 6.0)

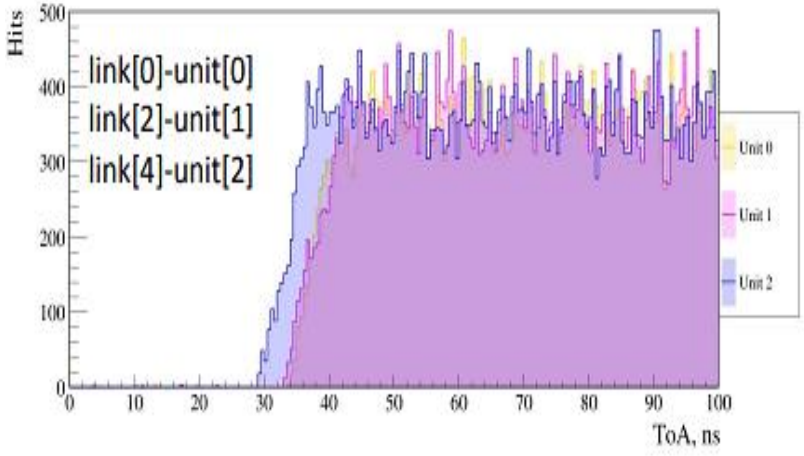




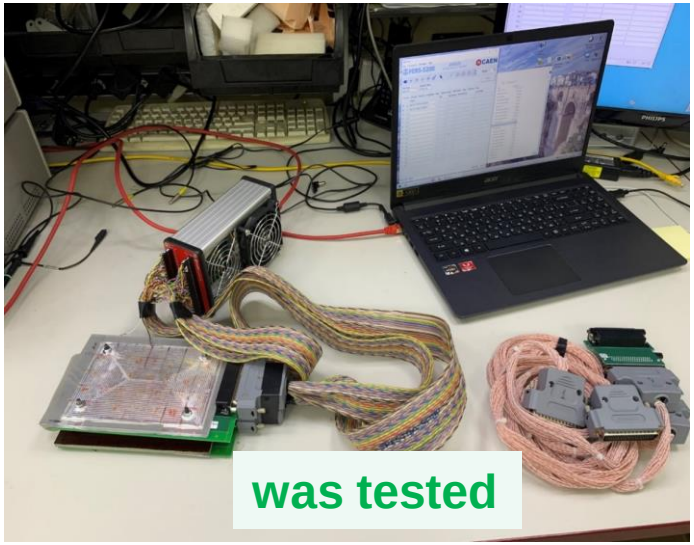
LINKS (1 & 0)

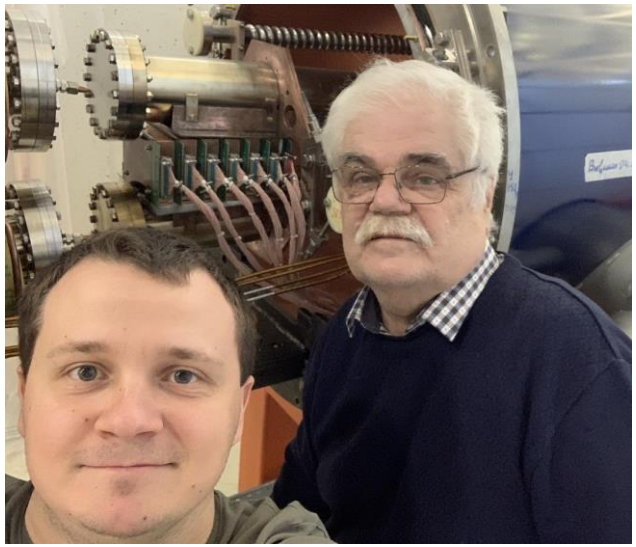
Concentrator to boards opto-fiber connection



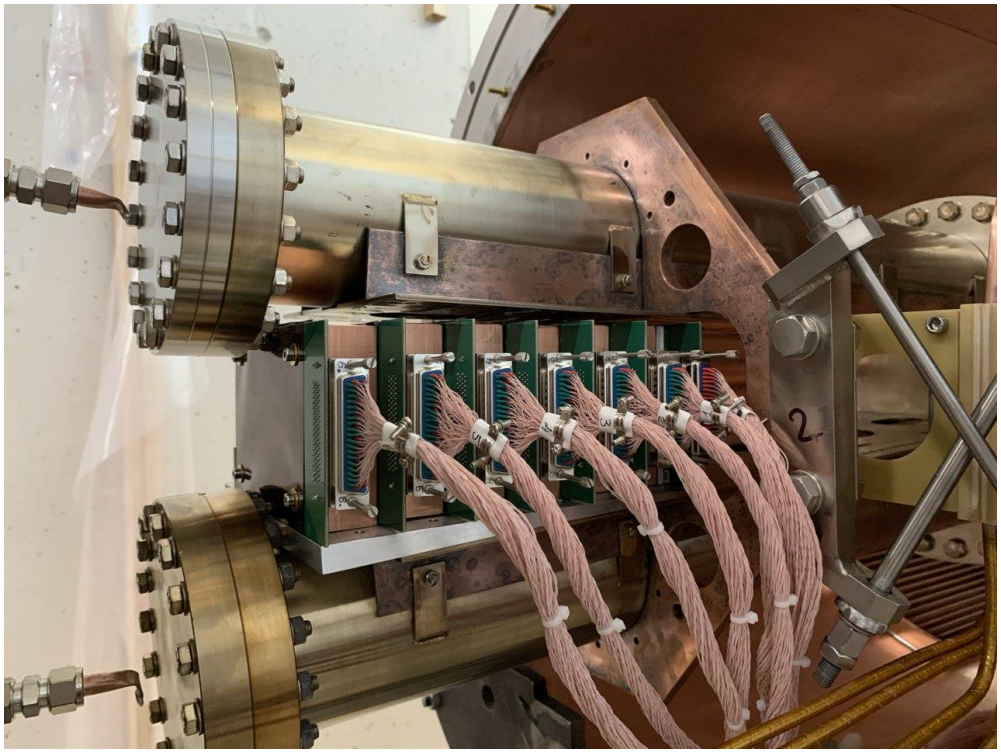


DT5202 with 2X31 SiPM PLATES





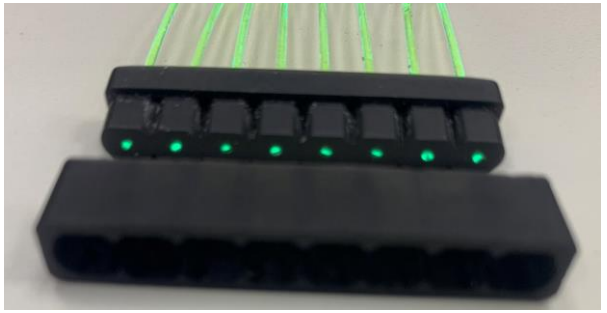
The first stage of ZDC is – 6 planes + 1 veto with trapezoid geometry



Working on the beam BBC & ZDC (?)

- **“FersRun” framework**
- **DT5215 concentrator**

- ✓ Preparation of infrastructure for mass production (obtaining equipment, equipping rooms, etc.)
- Development of methods of mass production (tools + algorithm)



Tiles and sectors: gluing frames

- The algorithm for polishing the connector has been proposed. The further developments are required:

mechanism	working group BBC@MEPhI
tool	working group BBC@JINR