



## Status of BBC developments @JINR

A.V.Tishevsky on behalf of JINR BBC group

*VIII SPD Collaboration Meeting*

*5 November 2024*

## ▪ Outline of current talk

See talk:

Mechanics

- Construction basis
- Fiber laying and prototype assembly

Hardware

- CAEN FERS-52XX (Application of DT5215 concentrator)
- New electronics (TDC based on FPGA)

Volkov I.

Nekrasov P.

Tests  
@JINR-MEPHI

- Prototype tests
- Application of method for checking assembled sectors
- X-ray tests
- WLS- studies

Zakharov A.

Dubinin F.

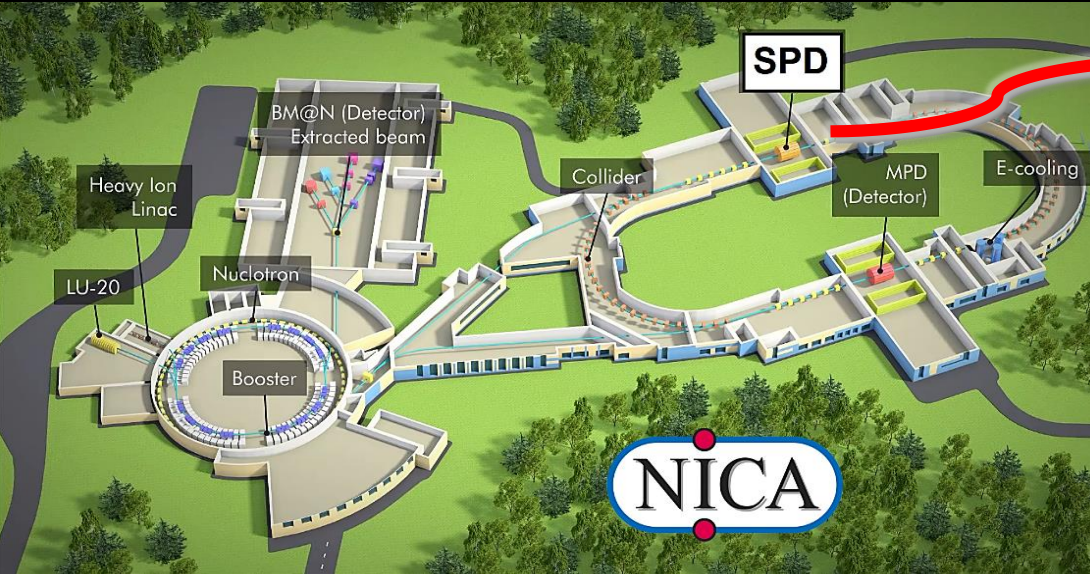
Simulation

- pp and dd interactions
- Xe124+W in fixed target mode

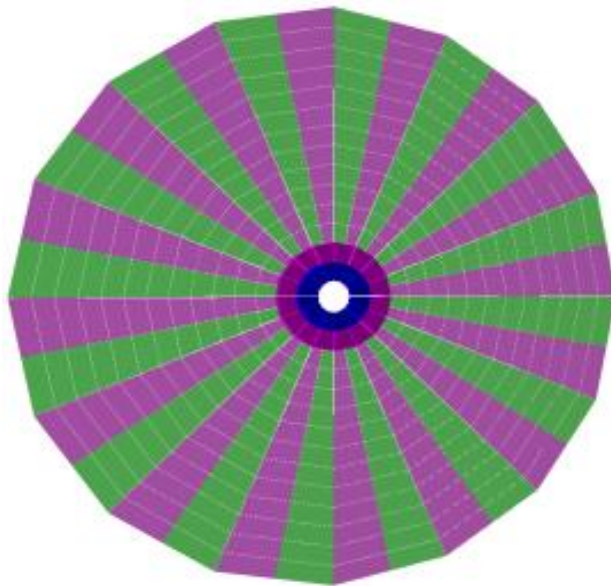
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Volkova K.

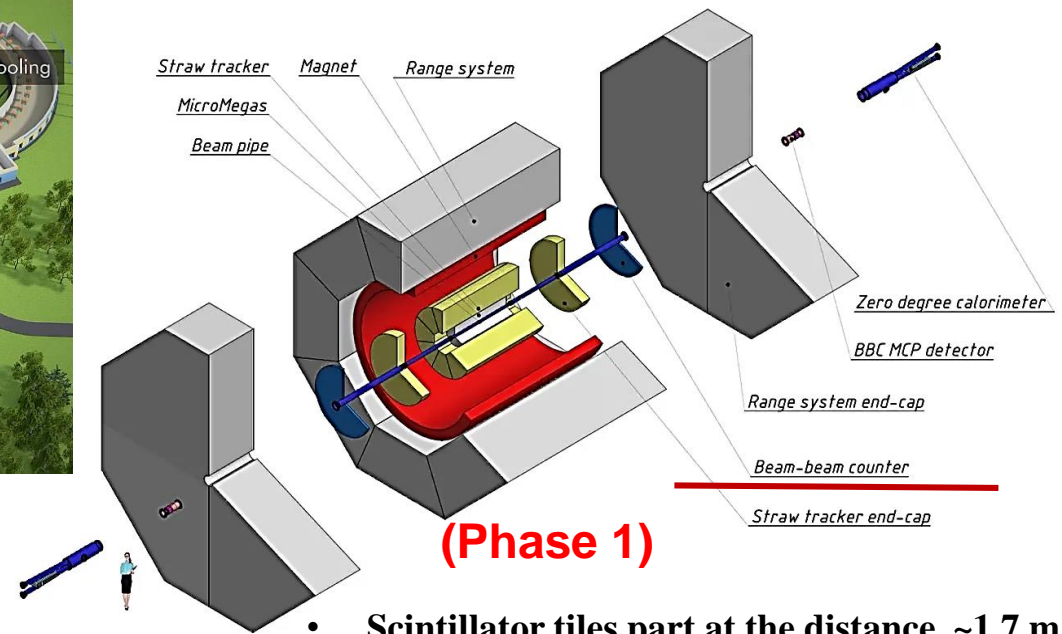
## ▪ Conclusion



TDR 2023  
 2 wheels with  
 400 tiles each (416?)



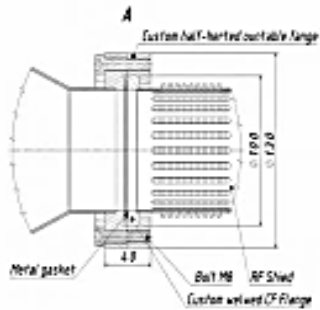
## The Spin Physics Detector (SPD)



## The Beam-Beam Counters (BBC) for SPD

- + event plane detector for HI physics
- + local polarimetry

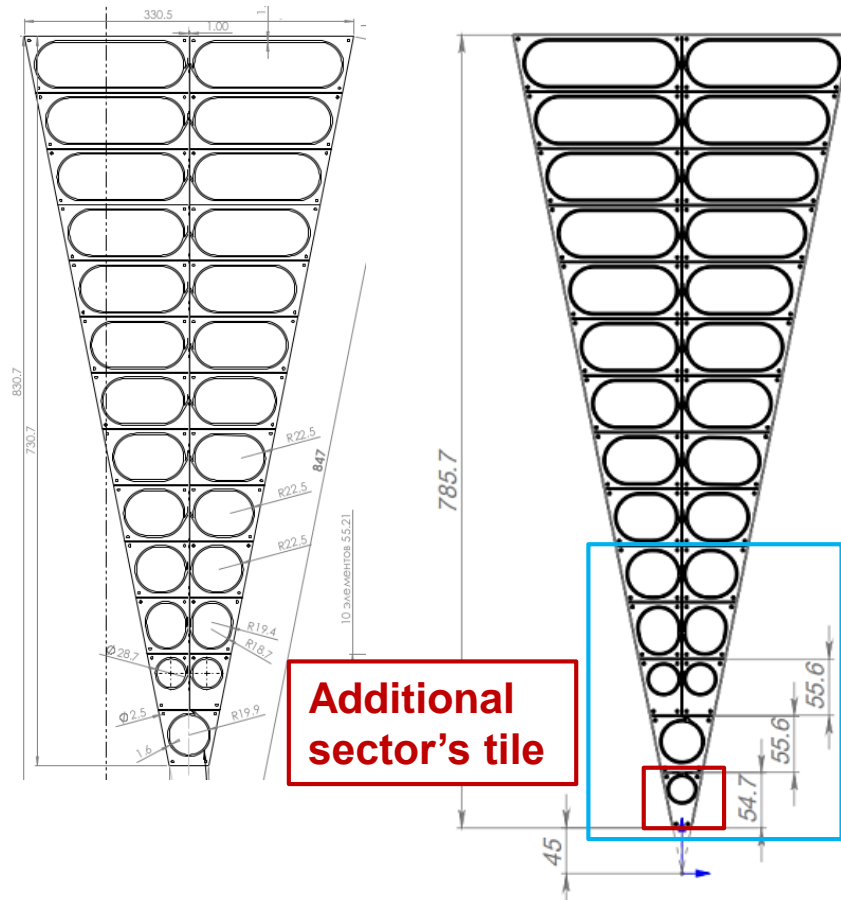
The main purpose of BBC is the permanent monitoring of the beam polarization using the azimuthal asymmetry of the inclusive charged particles yield.



BBC Sector (1/16 of wheel) design

25 tiles

26 tiles



Additional sector's tile

8 channel prototype

Now : 124 mm diameter  
Need: 83 mm diameter

We have the opportunity to use an additional tile due to the decreased diameter of the beam pipe.

Row

## Grooved carbon backplate of the prototype

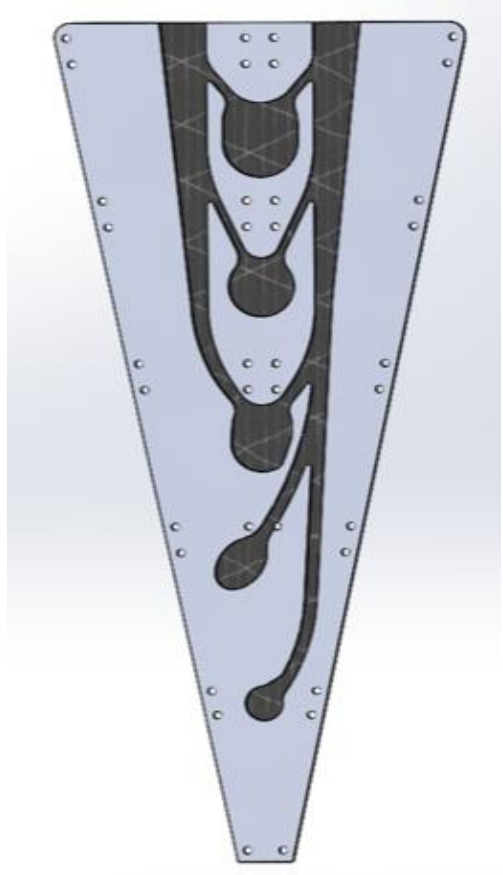
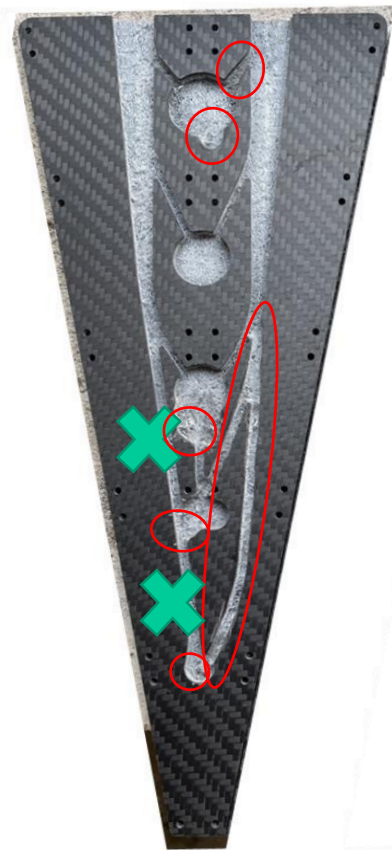
4

3

2

1

0

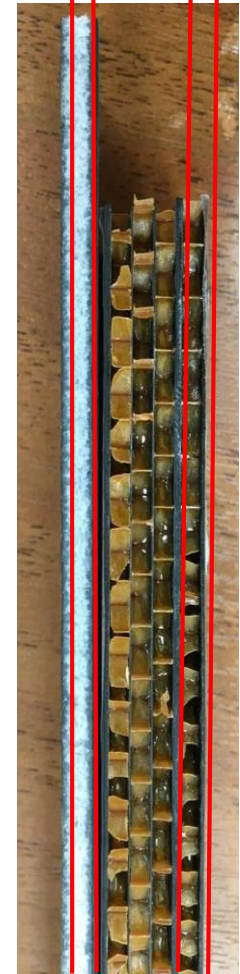


Start version (V0)

Modified version (V0)

Updated design (V1)

Infrastructure layers  
(grooved)

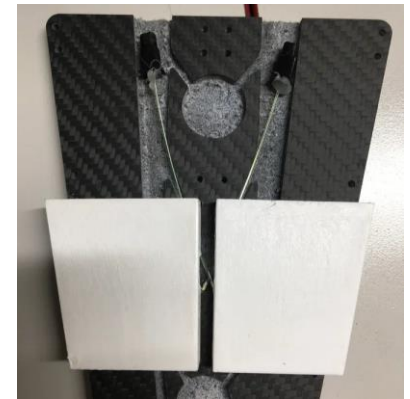
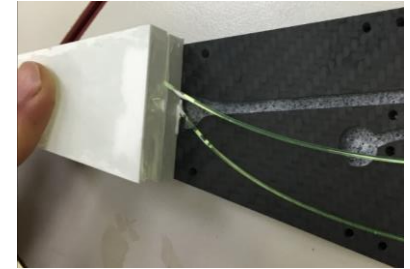


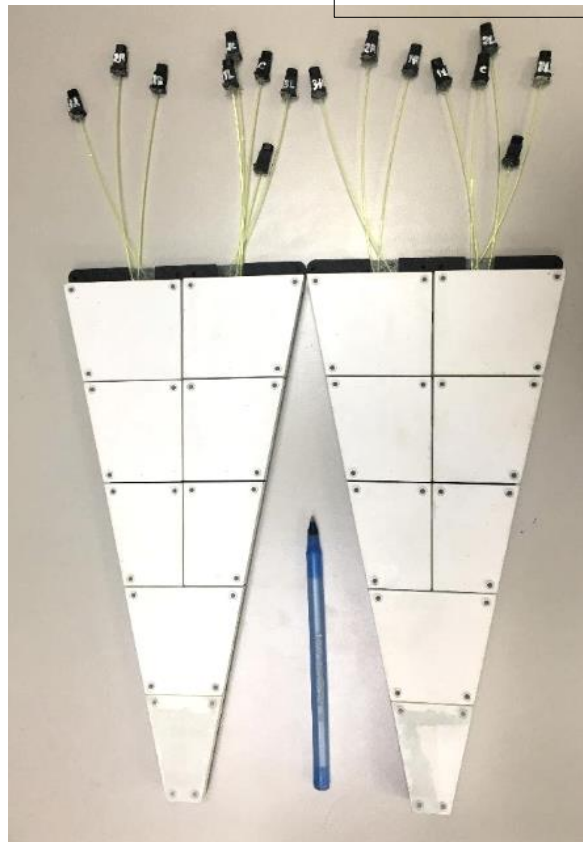
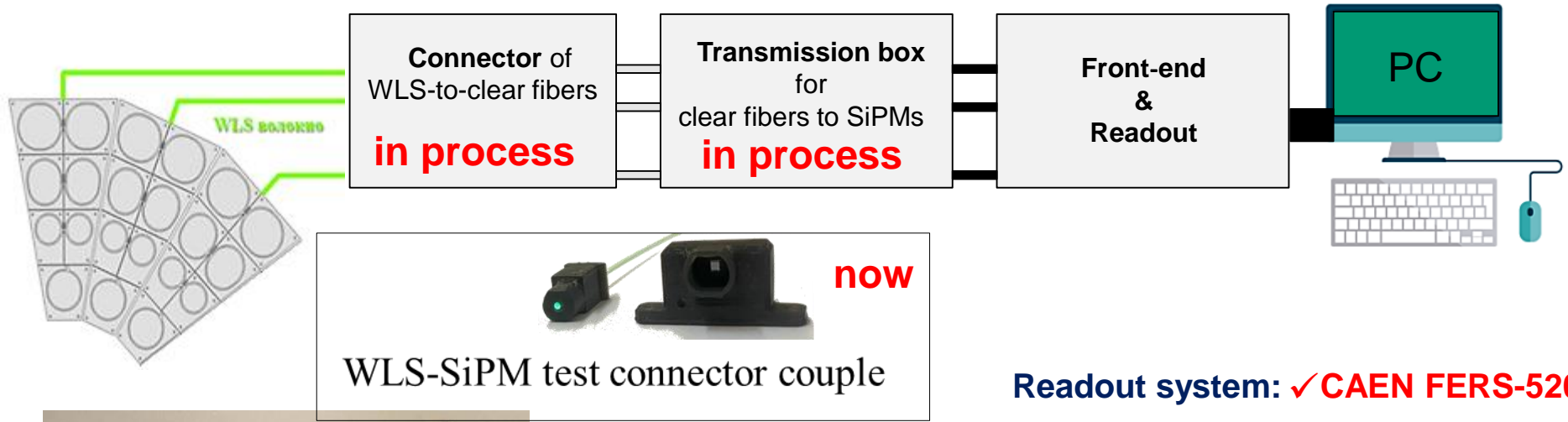
**Honeycomb sandwich base for BBC**  
**(under tests)**

As part of the next **approbation**, it is reasonable to perform milling in plywood or plexiglass.

## Comments for sectors mass production

1. It is necessary to ensure the uniformity of **WLS output** from tiles with a small degree of freedom.
2. The output of symmetrical tiles are located taking into account the intersection of fibers at the base of the tiles of each row.
3. In order to unify the assemblies, we assume that the WLS of the left tile is always located under the wls of the right tile.





reduced sector prototype x2

**REFERENCES [1-2]**

<u>Selected options:</u>	
Scintillator:	Uniplast-Vladimir (chemical mating)
Optical cement:	CKTN Med mark B
WLS Fiber:	Saint-Gobain Crystals (SG92S)
SiPM:	SensL 1x1 mm <sup>2</sup> (MicroFC-10035 SMTPA)

Final option is KURARAY (Y-11) for Phase 1 & 2

## CAEN FERS 52XX is an extendable high speed front-end readout system

DT5203 (picoTDC chip)

DT5215 (Concentrator)

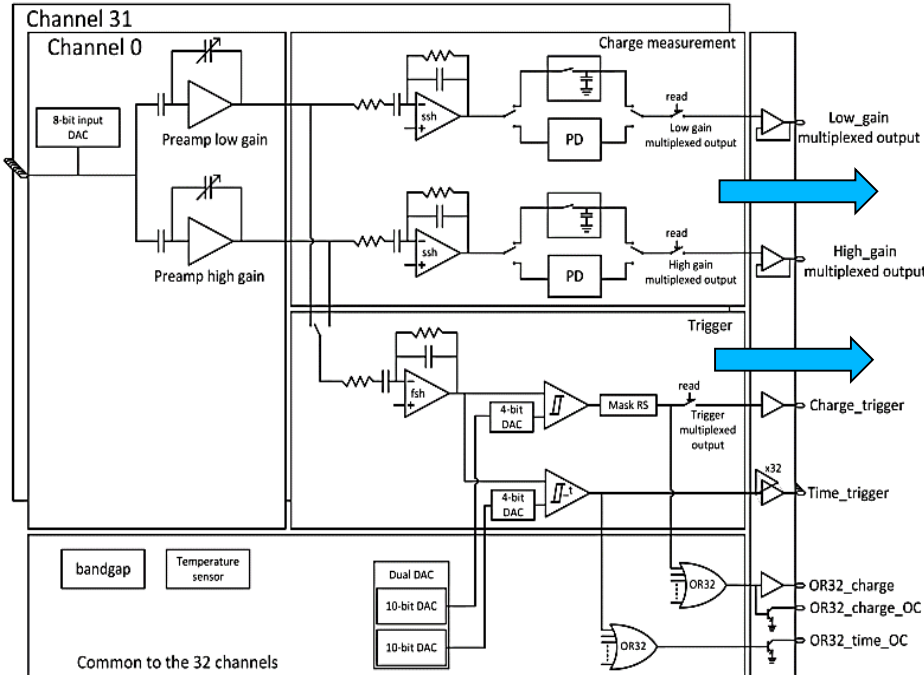
- **DT5202** (x2 Citiroc 1A chip)



- **DT5202** based on the 64-channel module **for SiPM**.



Citiroc-1A block scheme



### Main Acquisition Modes:

- SPECTROSCOPY → for calibration
- **TIMING** → for future tests
- SPECT\_TIMING → **for current tests**  
(Spectroscopy + Timing)

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

Time of Arrival (**ToA**) & Time over Threshold (**ToT**). **ToT** is giving a rough estimation of energy.

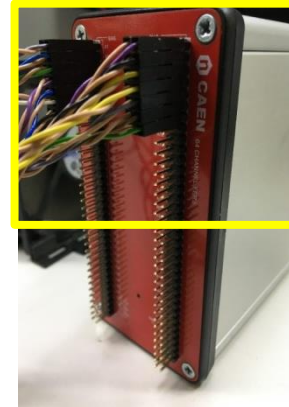
**The Timing mode** will be used for testbeam and Phase 1 (perhaps) tests, because only this mode has access to the CAEN FERS system **for free-streaming mode**.

Details by Volkov Ivan (see talk at this meeting)



The tests were performed for SPECT\_TIMING mode (Hybrid) with **self-triggering** opportunity. Main tasks of Hybrid mode are:

- test of the **self-triggering** option
- the signals analysis
- the **dependence** of the amplitude to the ToT

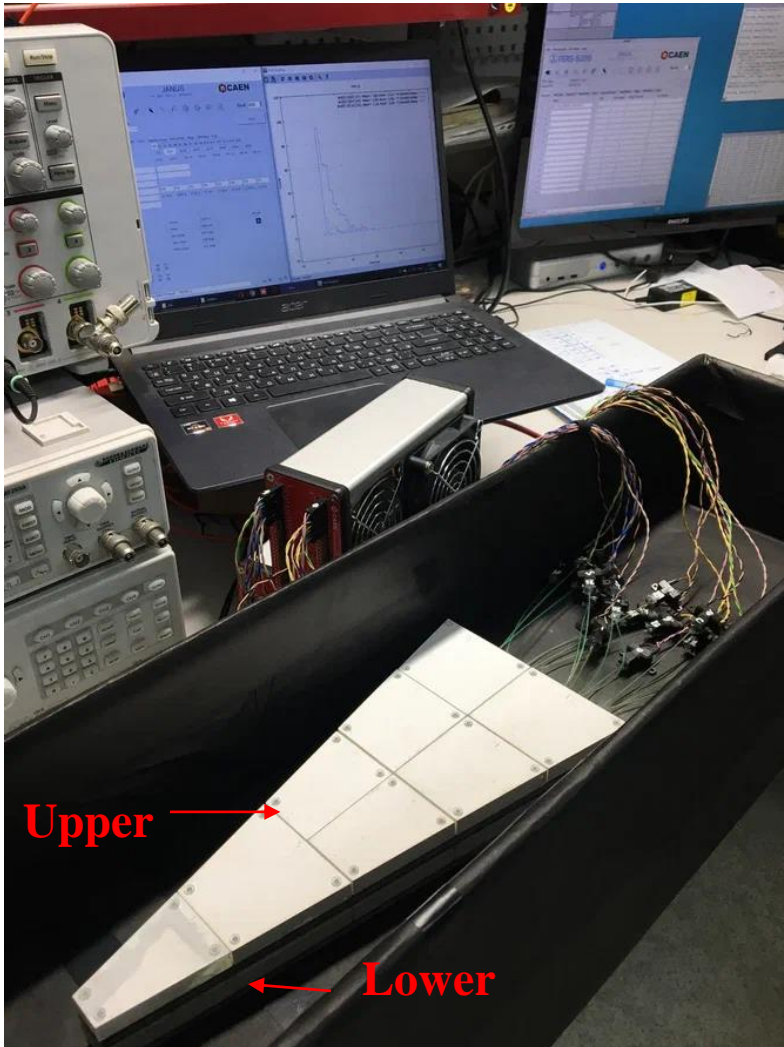
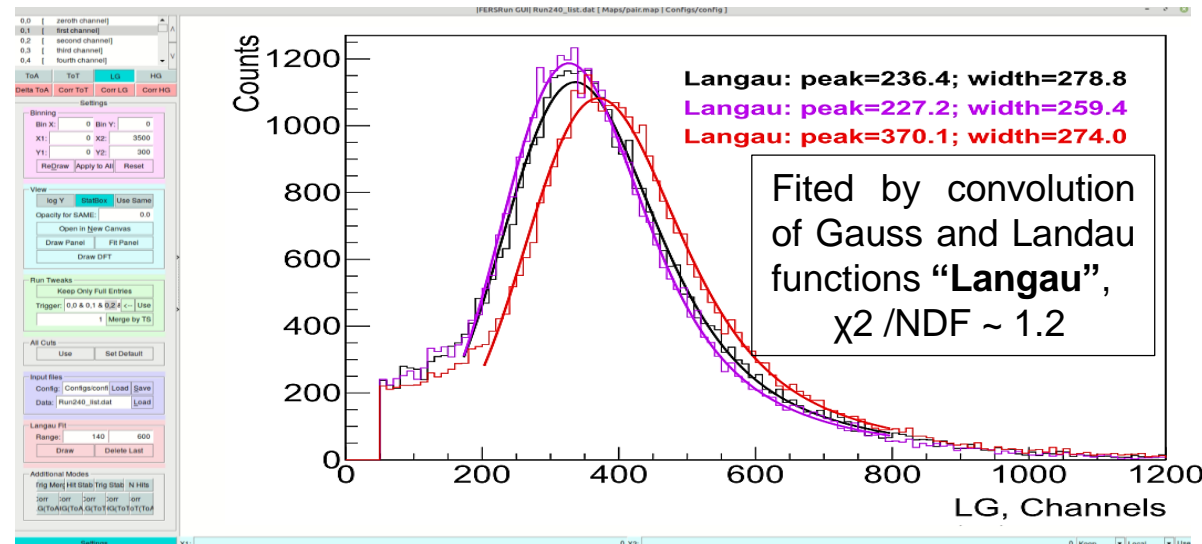


“AND2\_OR32”  
Trigger logic

Trigger logic for DAQ was “AND2\_OR32”

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

The “FersRun” framework have been designed.

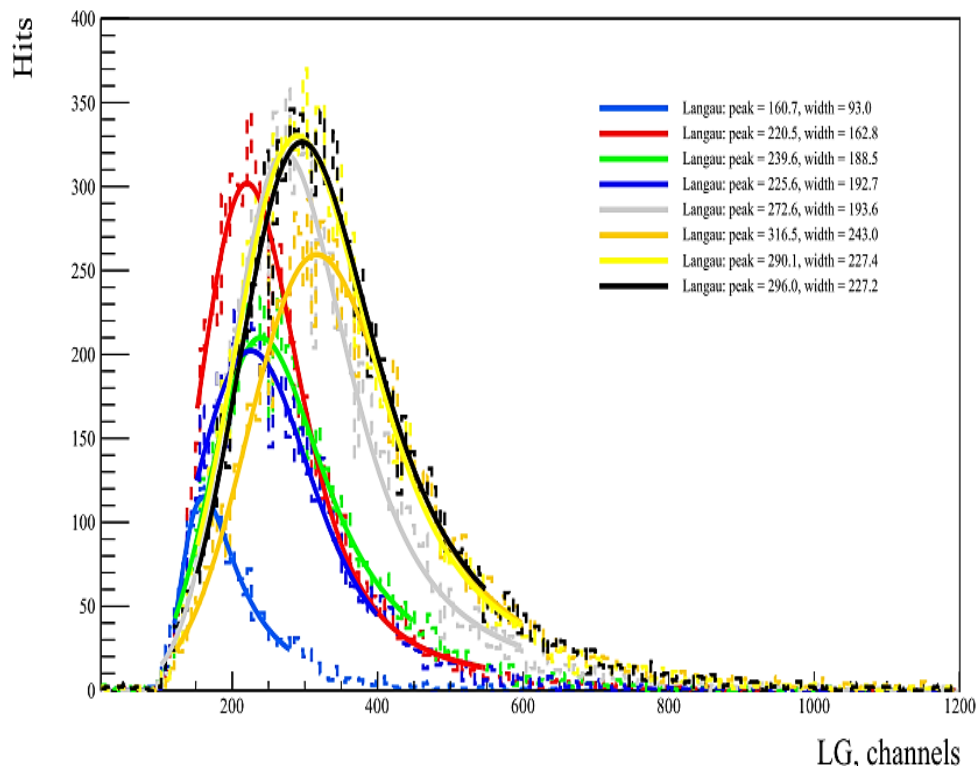


Upper

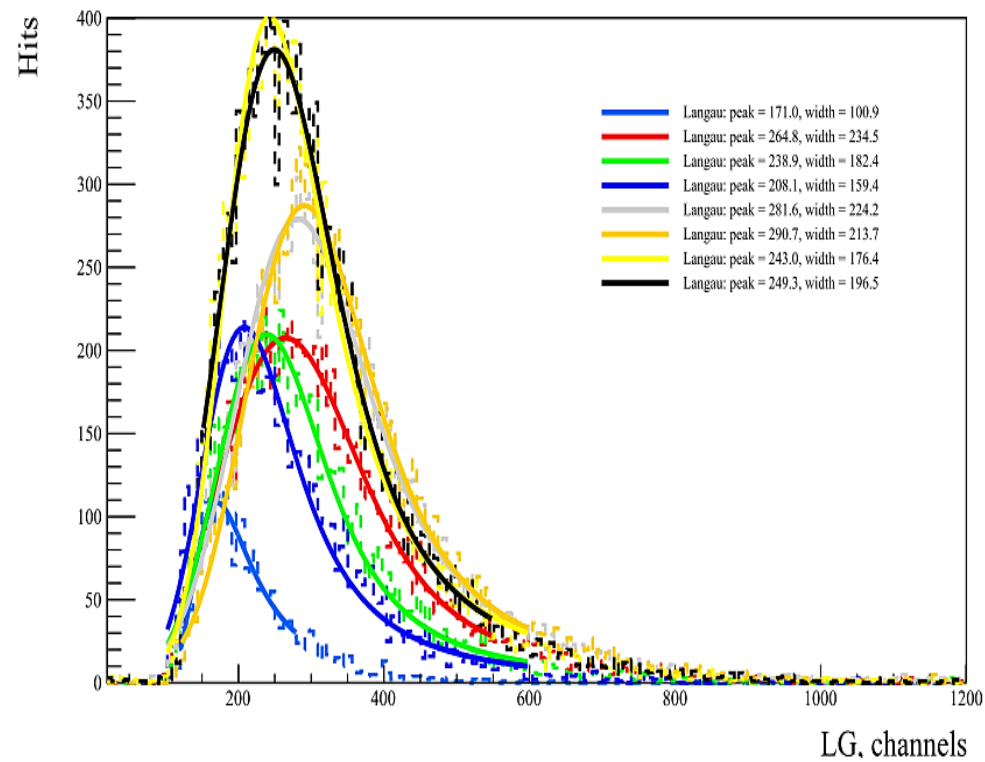
Lower

Stand for BBC measurements

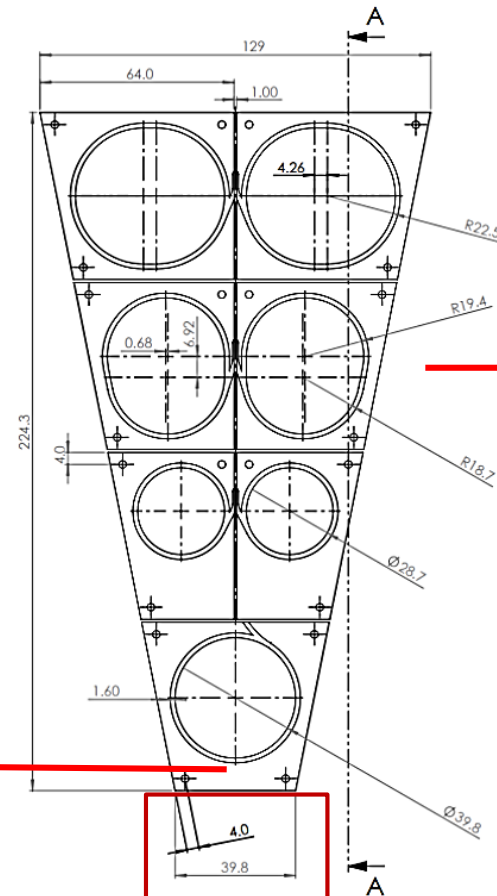
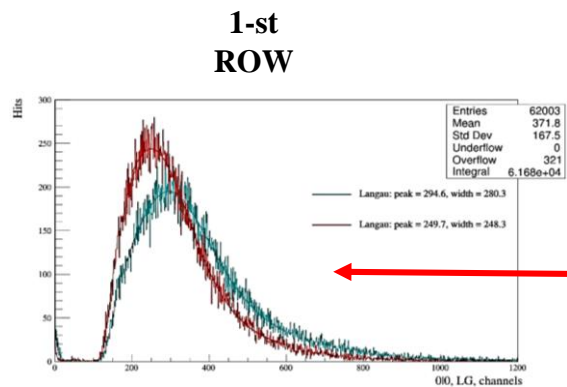
## 1-st sector prototype



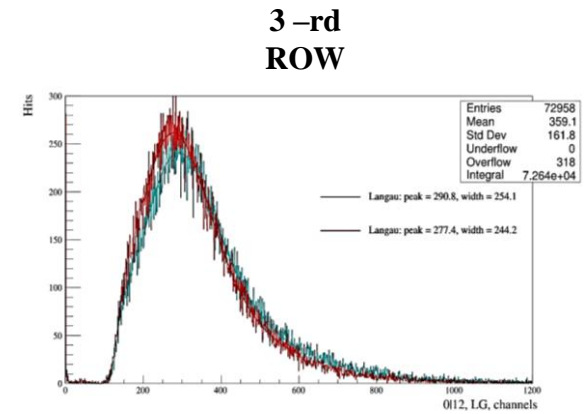
## 2-nd sector prototype



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

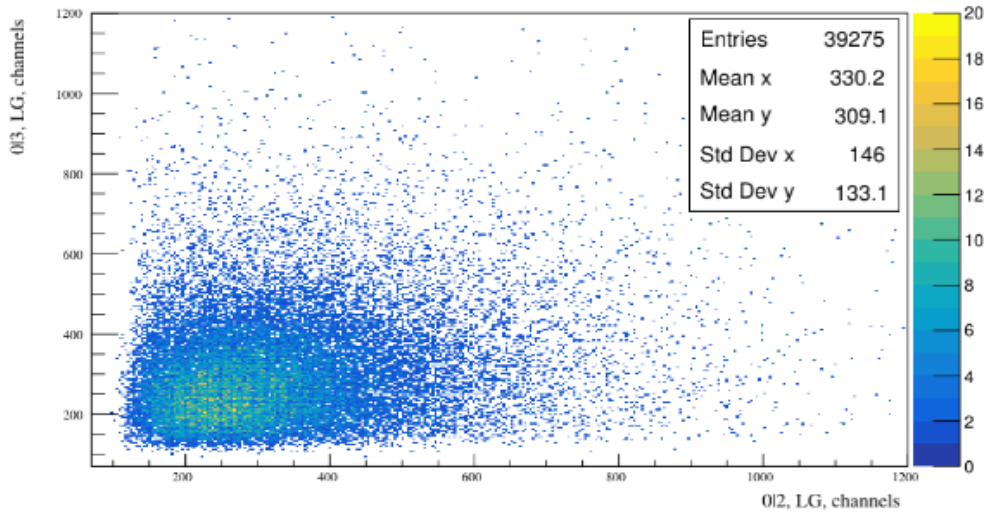


**Additional sector's tile**

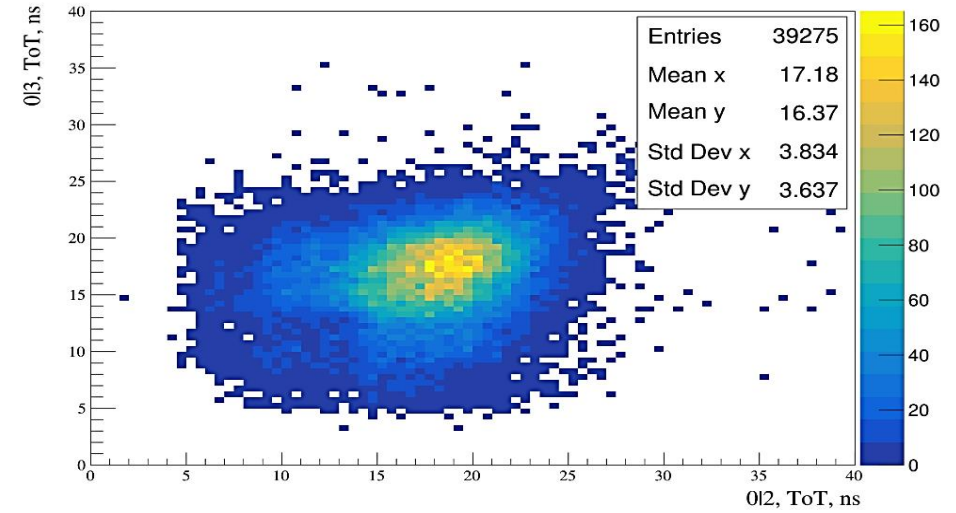


These stable tiles were taken for following tests

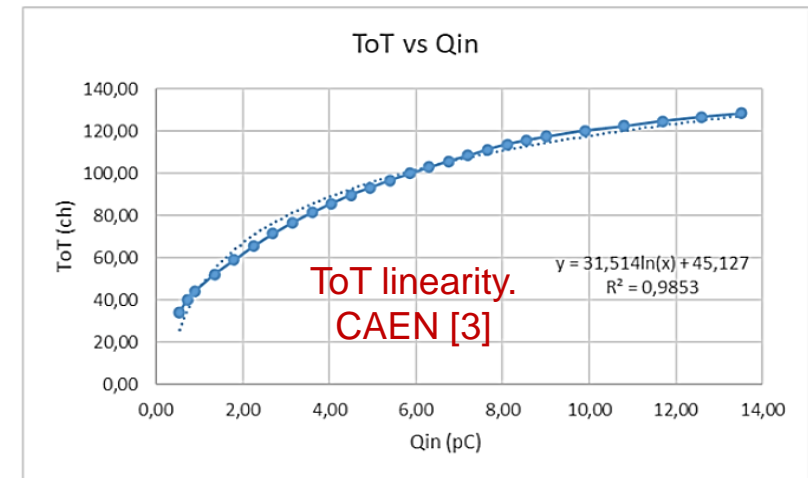
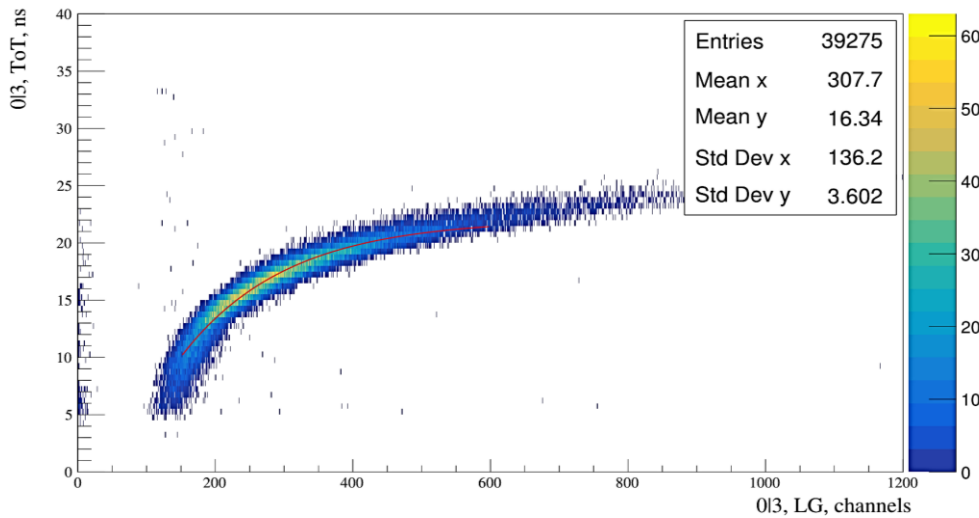
### LG correlations



### ToT correlations



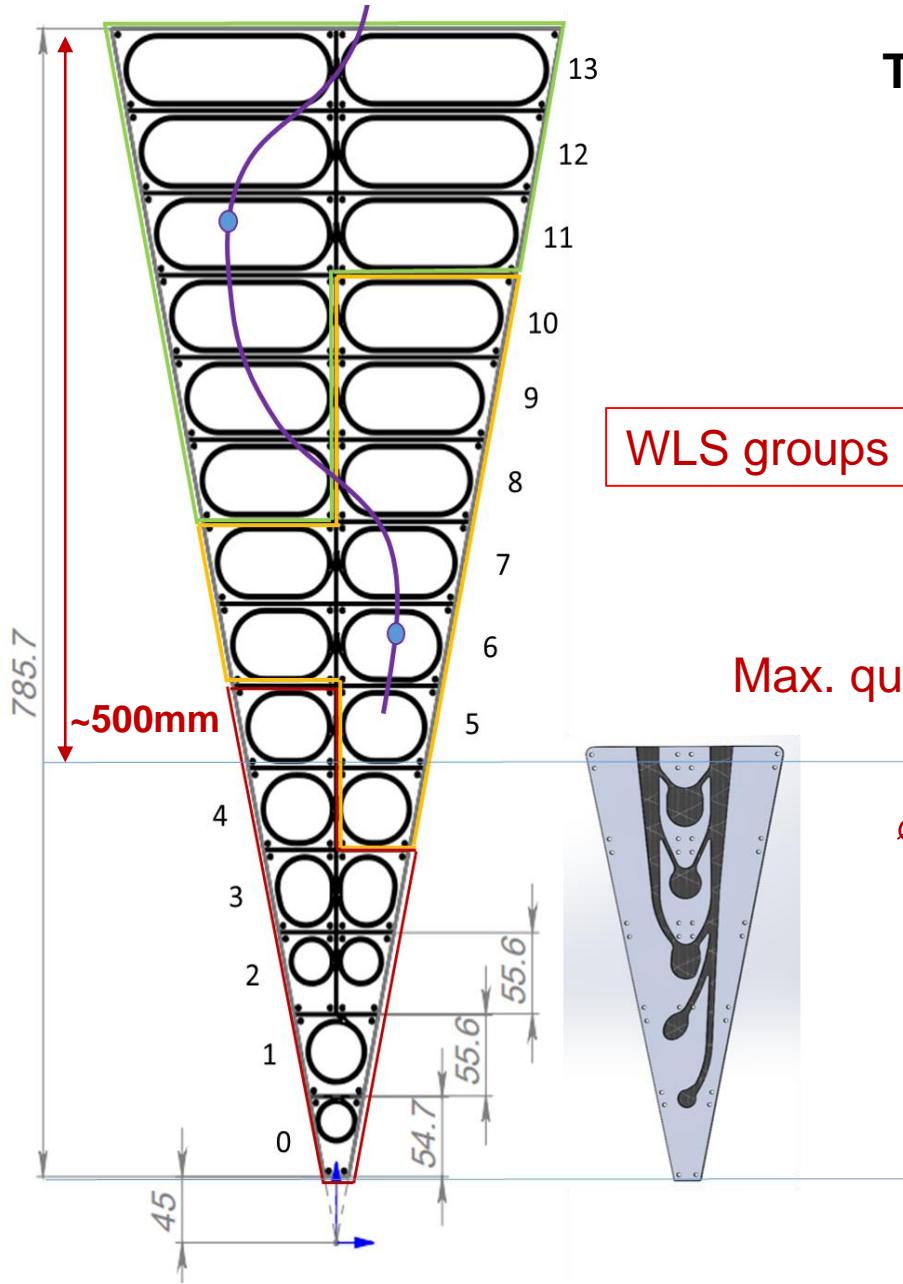
### LG vs ToT (channel №3)



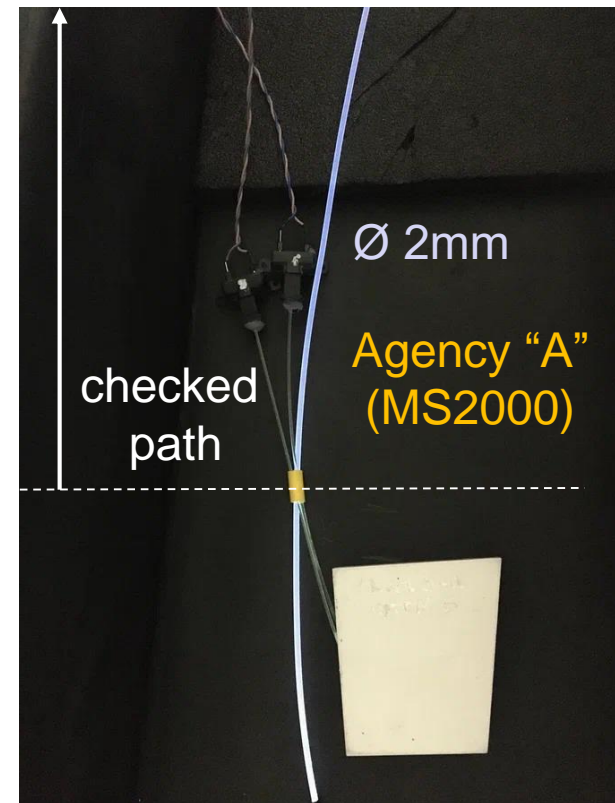
Correlation of energy deposition for 2 channels, as well as the time information for these channels.

- The calibration of the charge scale is required

Optical connector (26 + 1)  
WLS <-> Clear Fiber + SGF

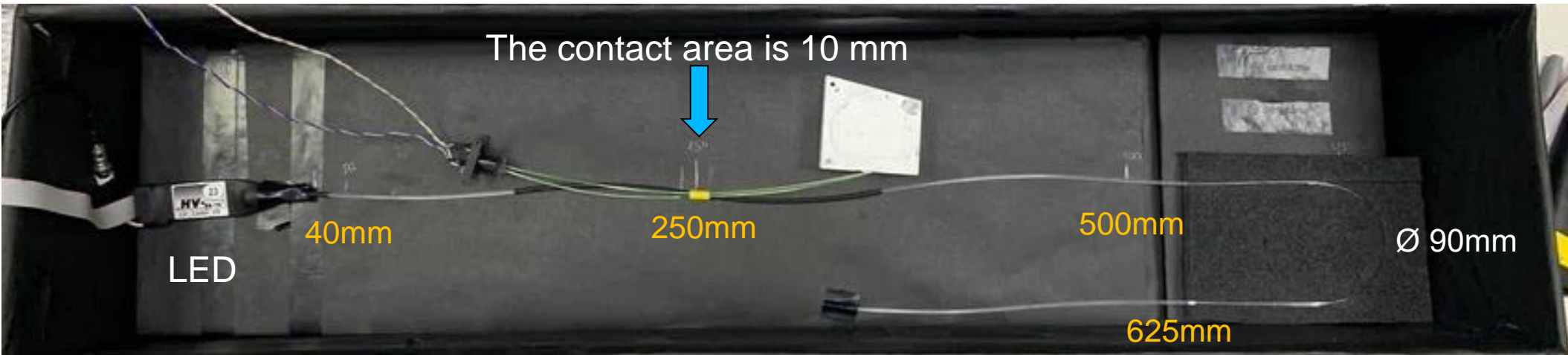


The side glow fiber (SGF) is one of the option for the fast check of a larger part of the signal path (WLS <-> Clear Fiber <-> SiPM <-> DT5202 unit)

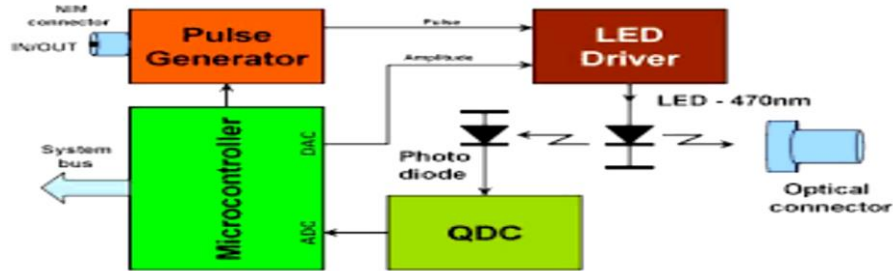


# Prototype tiles test

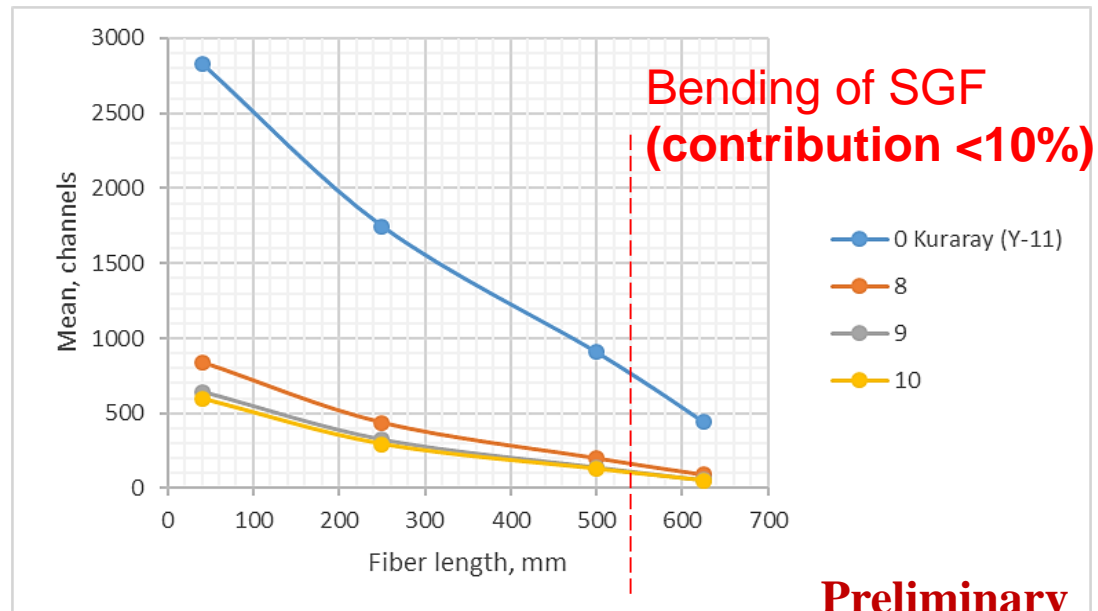
# The scan by SGF length



## Schematic view of the LED



	Kuraray (Y-11)	Saint-Gobain Crystals (SG92S)		
mm\channel	0	8	9	10
40	2831	840	643	600
250	1747	438	325	295
500	906	200	140	128
625	441	90	55	50



from 40mm to 500 mm ~ 75% lost

- I. The 8-channel prototype has been assembled, the **self-triggering option** of CAEN FERS-5200 system has been tested. The radial dependences of the tiles **are correspond** with the study of the bending losses of the WLS.
- II. The work of the **ToT function** has been shown, the calibration of the charge scale for estimate of ToT linearity **is required**.
- III. One of the **possible methods** of express sector checking has been **proposed**.
- IV. A side glow fiber has been tested. The loss of light at possible bends does not exceed over 10%, but the **loss of light** at a length of 0.5 m is **about 75%**. Several fiber manufacturers needs to be considered.

The calibration of the charge scale

### To do list

Test of clear fiber (Saint-Gobain Crystals and Kuraray manufacturers) attenuation

Test with new connector and transmission box

The assembly of 2 small BBC wheels (128 tiles each) for SPD Phase 0

# Thank you for the attention!

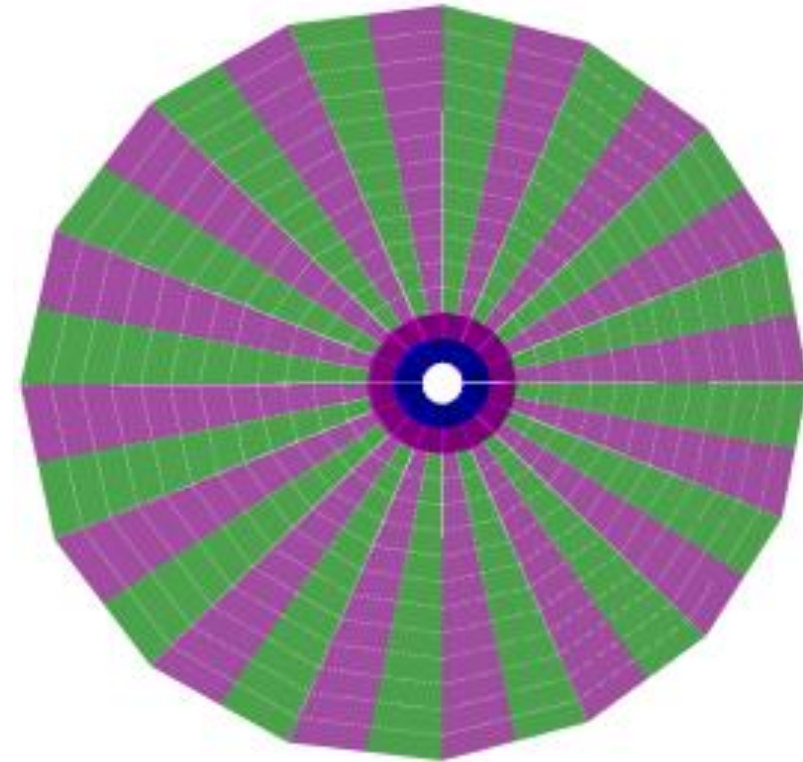
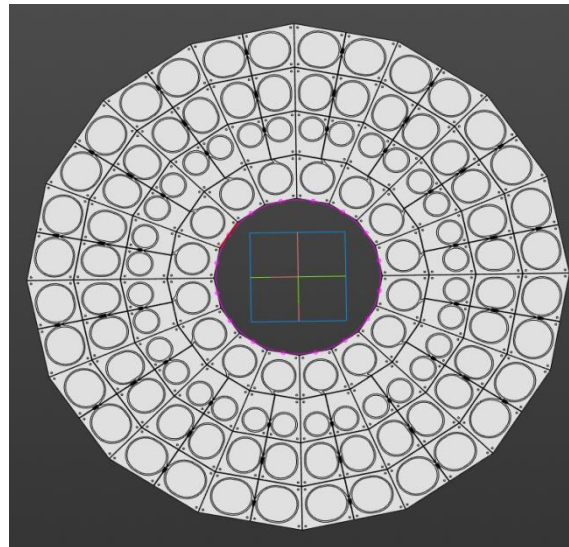
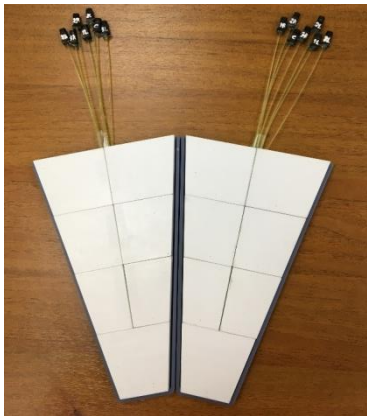
## REFERENCES

1. Physics of Atomic Nuclei, 2024, Vol. 87, No. 4, pp. 450–457.
2. Phys.Part.Nucl. 55 (2024) 4, 1091-1098
3. [www.caen.it/support-services/documentation-area/](http://www.caen.it/support-services/documentation-area/) (A5202/DT5202 User Manual)



**Backup**

M  
a  
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s



1-st Stage  
16 tiles

2-nd Stage  
2 wheels with 128 tiles each

3-rd Stage (final)  
2 wheels with 400 tiles each (416?)

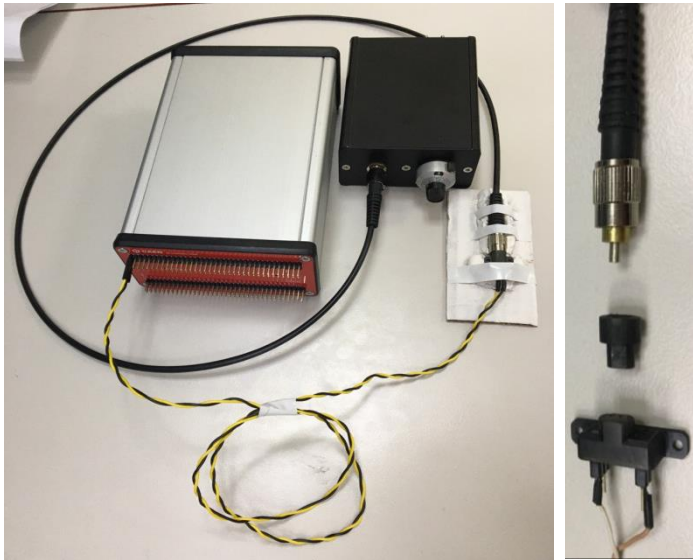
Phase 0

Phases: 1-st & 2-nd

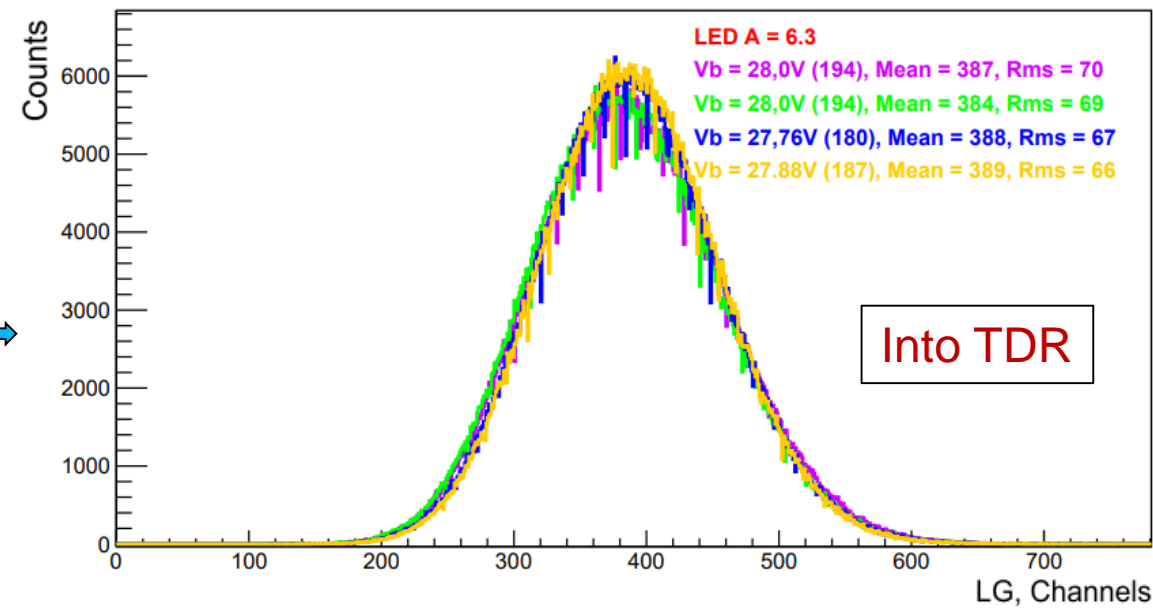
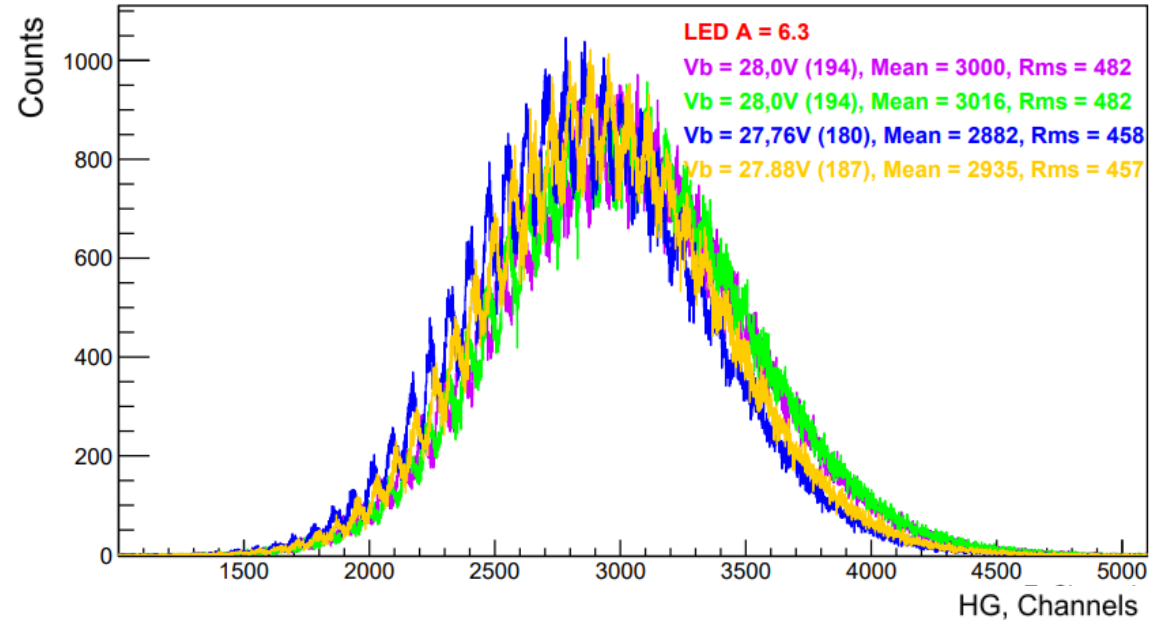
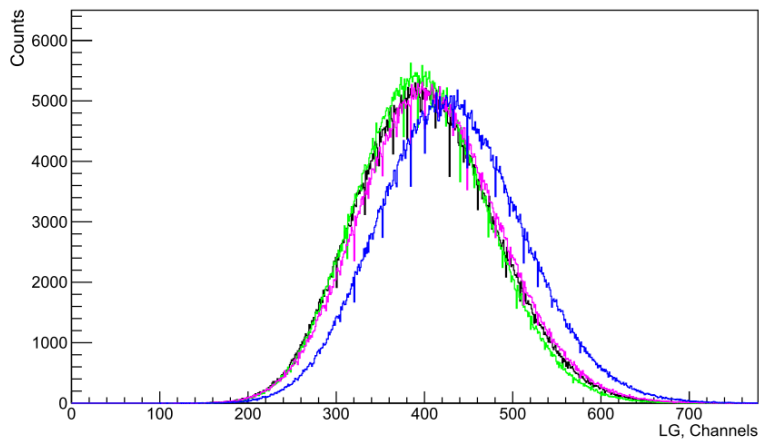
# The hardware of BBC tests part

## Calibration method (Led source)

### DT5202 with CAEN LED Driver (SP5601)

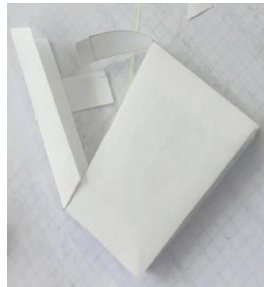


Not calibrated



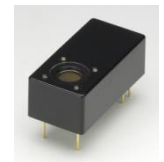
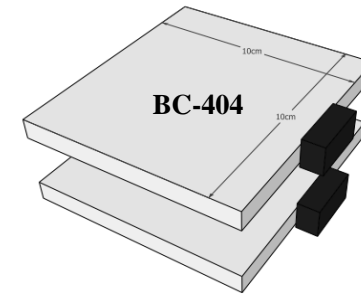
# Materials selection test part

# Scintillator cover



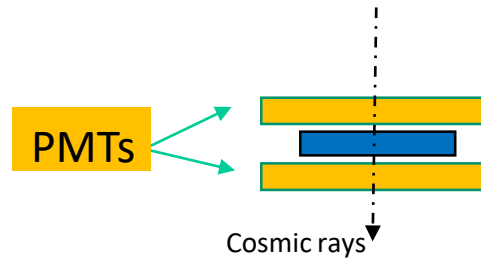
The amplitude spectra of the BBC prototype scintillation tile coated with **Mylar** or **Tyvek**, as well as covered with **Matted** options.

External trigger by coincidence of two scintillators with PMTs readout



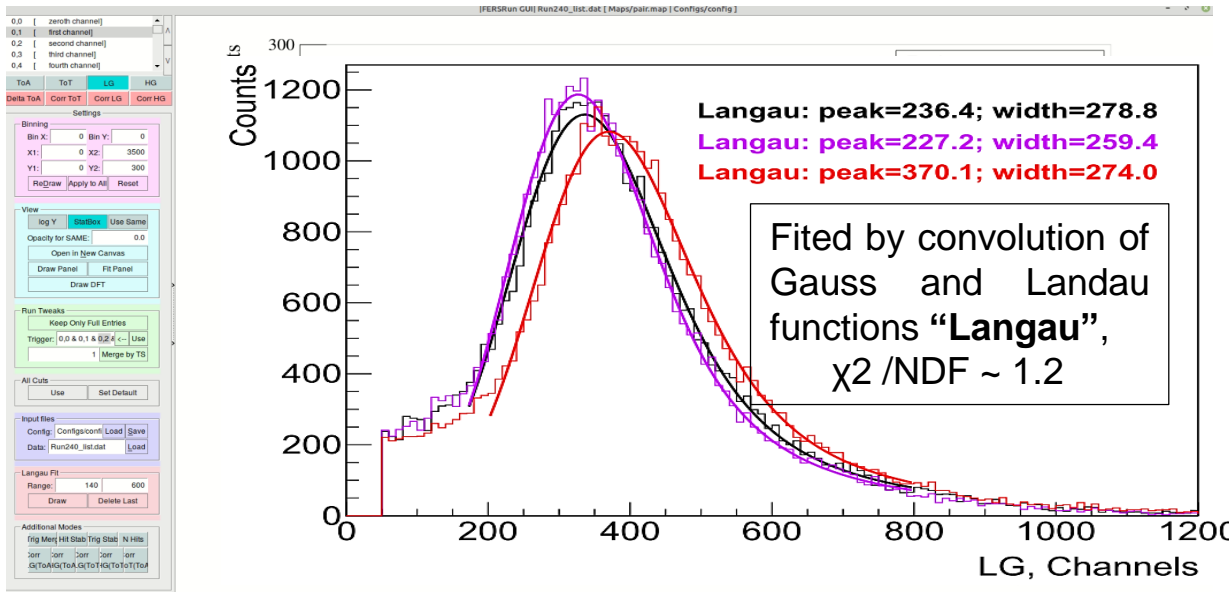
PMT  
Hamamatsu  
H10720-110

The “FersRun” framework has been designed.



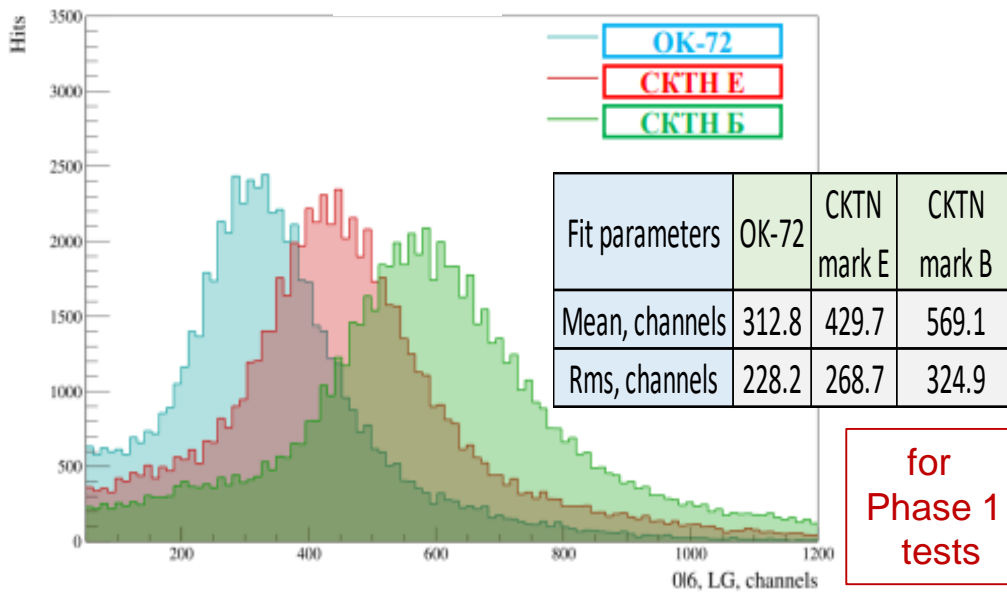
**Matted**  
or  
**Mylar**  
or  
**Tyvek**

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



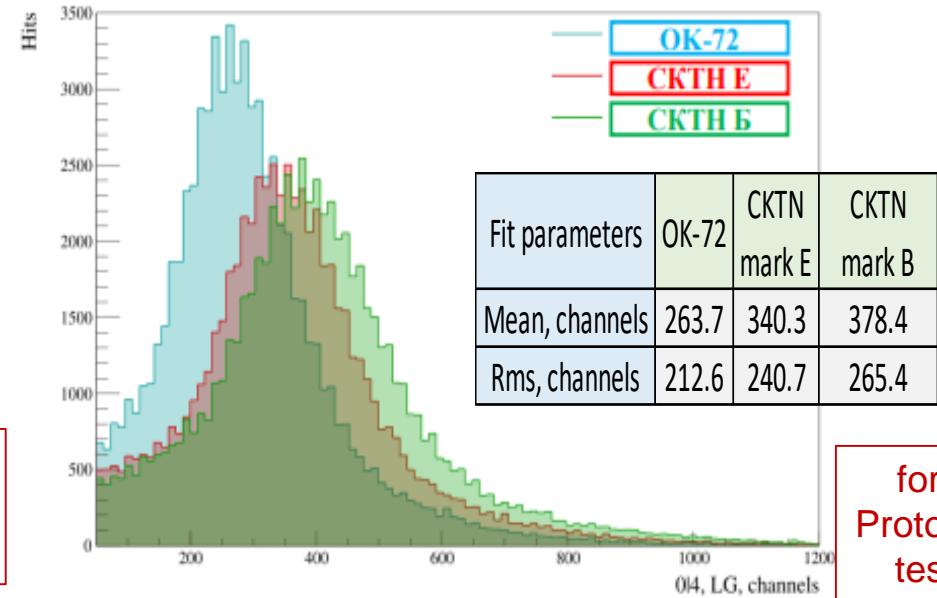
☐ The option with **matted tiles** is more priority for mass production.

Kuraray Y-11



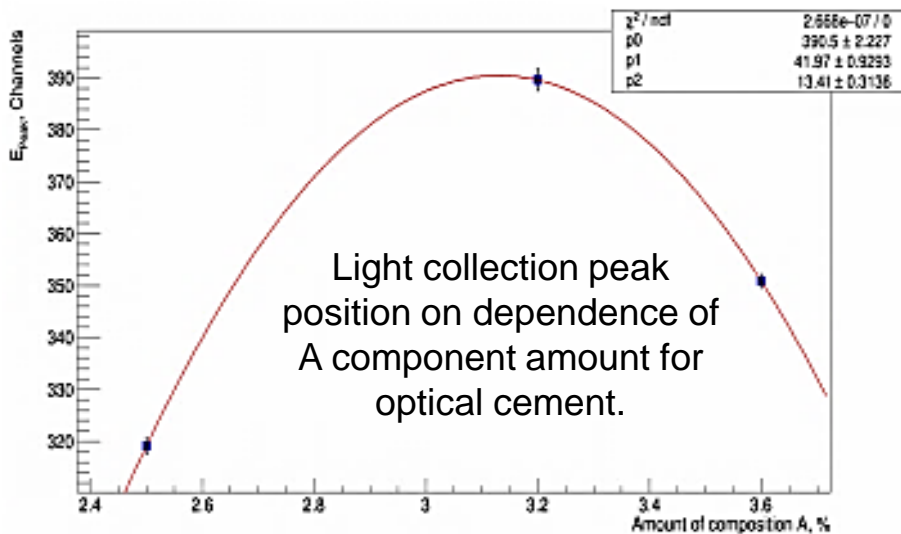
for Phase 1 tests

SGC BCF92



for Prototype tests

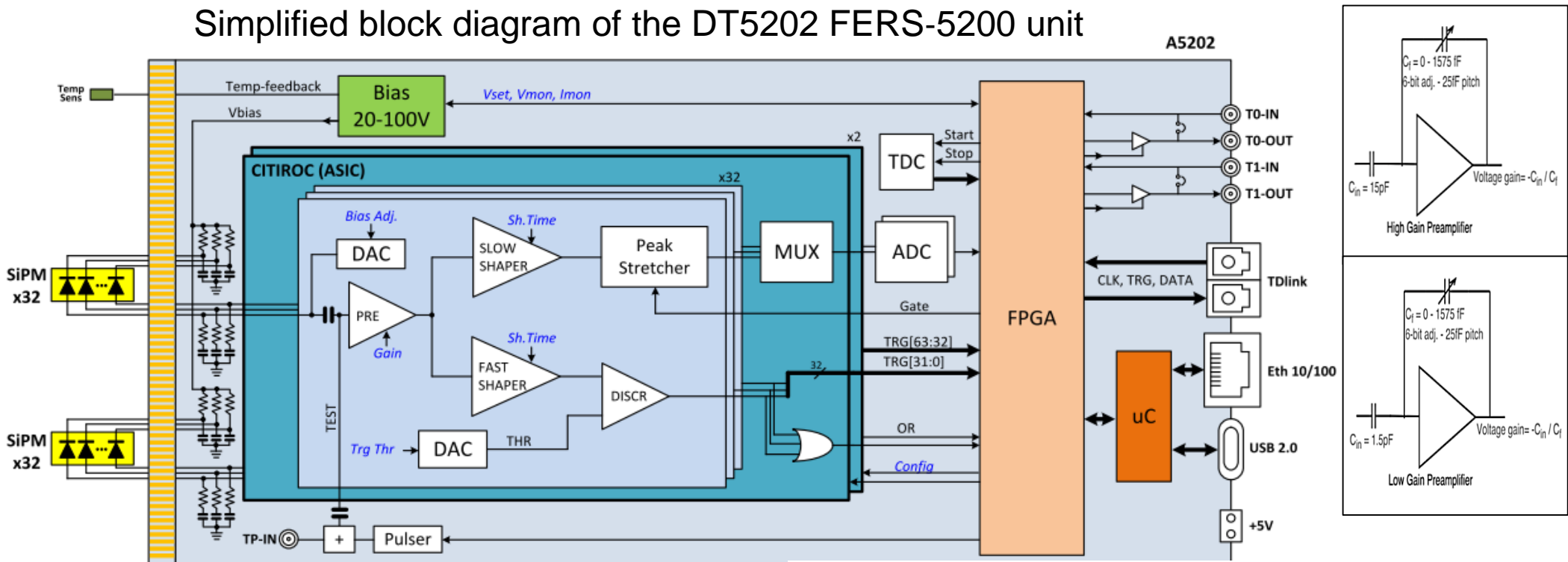
CKTN



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

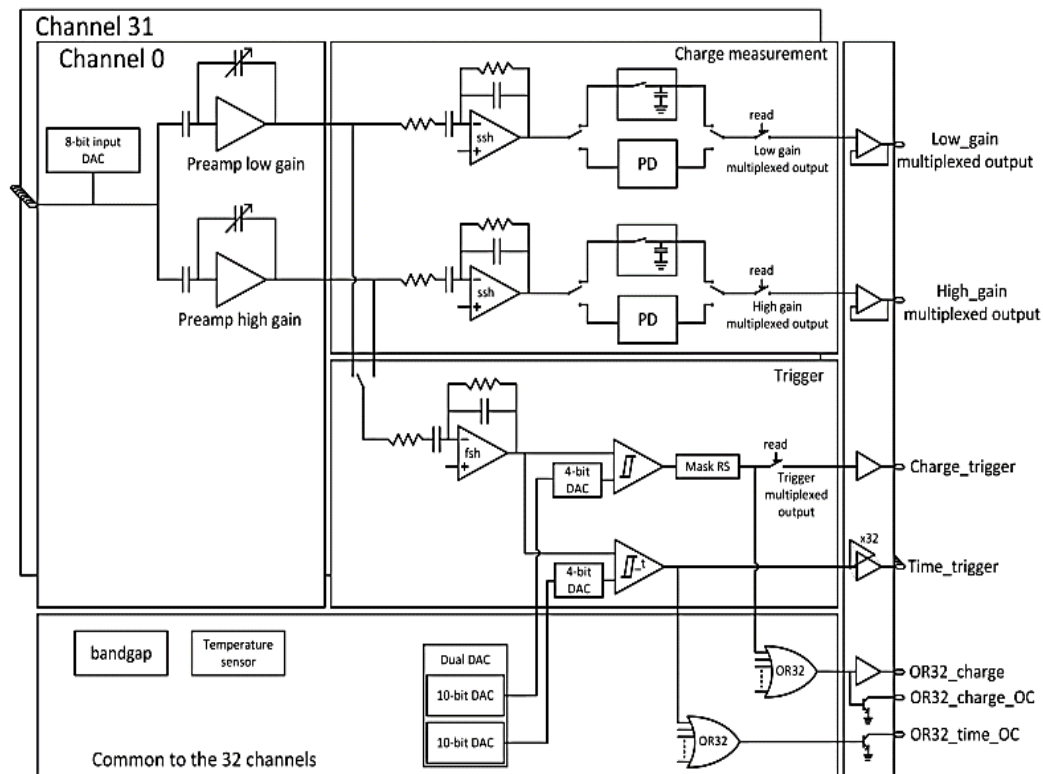
- ❑ **CKTN mark B** paired with Kuraray WLS fiber are the most appropriate candidates for future testbeam.
- ❑ **CKTN mark B** paired with SGC WLS fiber are the most appropriate candidates **for prototype** assembly tests.
- ❑ Datasheet ratio will be used and closely monitored for mass production.

# Simplified block diagram of the DT5202 FERS-5200 unit



❑ 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.

❑ OR32\_AND2: Triggers of each Citiroc-1A (32 channels each) are sent to an OR logic operator. The 2 output signals (one for each Citiroc-1A) are then sent to a logic AND operator.



# FEE studies results

# Saint-Gobain Crystals vs KURARAY fibers difference. (CKTN optical cement)

## Saint-Gobain Crystals fibers

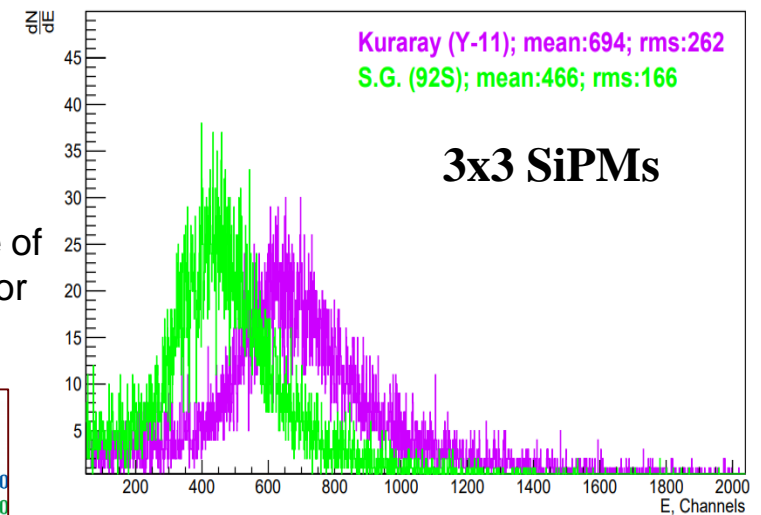
Specific Properties of Standard Formulations				
Fiber	Emission Color	Emission Peak, nm	Decay Time, ns	# of Photons per MeV**
BCF-10	blue	432	2.7	-8000
BCF-12	blue	435	3.2	-8000
BCF-20	green	492	2.7	-8000
BCF-60	green	530	7	-7100
BCF-91A	green	494	12	n/a
BCF-92	green	492	2.7	n/a
BCF-98	n/a	n/a	n/a	n/a

\*\* For Minimum Ionizing Particle (MIP), corrected for PMT sensitivity

## KURARAY fibers

Description	Emission			Absorption Peak[nm]	Att.Leng. <sup>2)</sup> [m]	Characteristics
	Color	Spectra	Peak[nm]			
Y-7(100)	green	See the following figure	490	439	>2.8	Blue to Green Shifter
Y-8(100)	green		511	455	>3.0	Blue to Green Shifter
Y-11(200)	green		476	430	>3.5	Blue to Green Shifter (K-27 formulation) Long Attenuation Length and High Light Yield
B-2(200)	blue		437	375	>3.5	UV to Blue shifter
B-3(200)	blue		450	351	>4.0	UV to Blue shifter

Kuraray Y-11 fiber collects more photons



Light collection peak position on dependence of A component amount for optical cement.

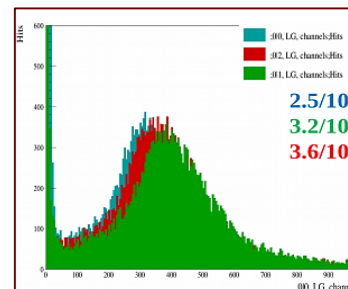


Table 1. Optical cements and their parameters

Brand	Viscosity, cPs	Operating temperature range	Spectral characteristics	Refractive index
EJ-500	800	From -65 to +105 °C	60-95% at 300-350 nm 95-100% at 350-600 nm	1.574
CKTN MED Mark E	15 · 10 <sup>3</sup>	—	92-96% at 500 nm	1.606
OK-72	—	From -60 to +60 °C	99% at 400-2700 nm	1.587