



МЕТОД ОЦЕНКИ РАБОТОСПОСОБНОСТИ ОПТИЧЕСКОГО И ЭЛЕКТРОННОГО ТРАКТА ДЛЯ ПОДСИСТЕМЫ BBC В ДЕТЕКТОРЕ SPD

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

*LXXV Международная конференция «ЯДРО-2025. Физика атомного ядра
и элементарных частиц. Ядерно-физические технологии»*

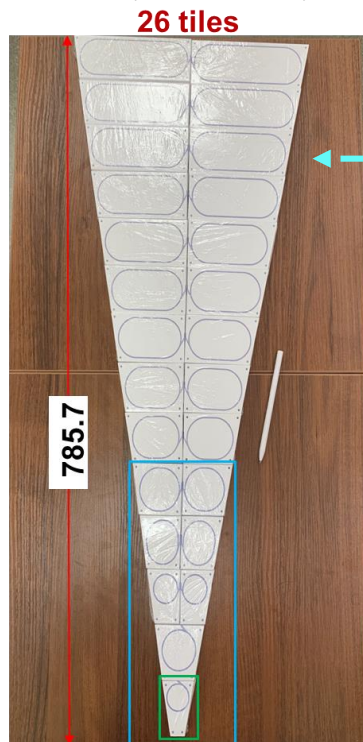
1 июля 2025, Санкт-Петербург

- ❑ Introduction for BBC subsystem
- ❑ R&D tests
 - hardware
 - method
 - the comparing of the attachment techniques
 - the scan by SGF length (comparing of SGF diameters)
 - the scan by SGF length (comparing of WLS)
 - test of full optical and electronic path
 - the method of assembled sector fast check
- ❑ Prospects
- ❑ Conclusion

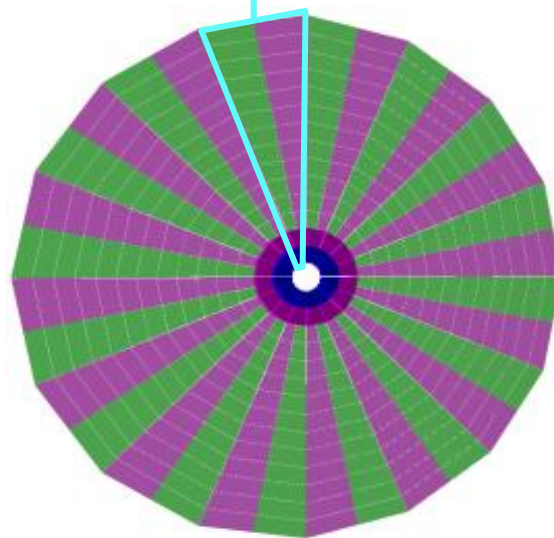
Introduction



BBC Sector (1/16 of wheel) design

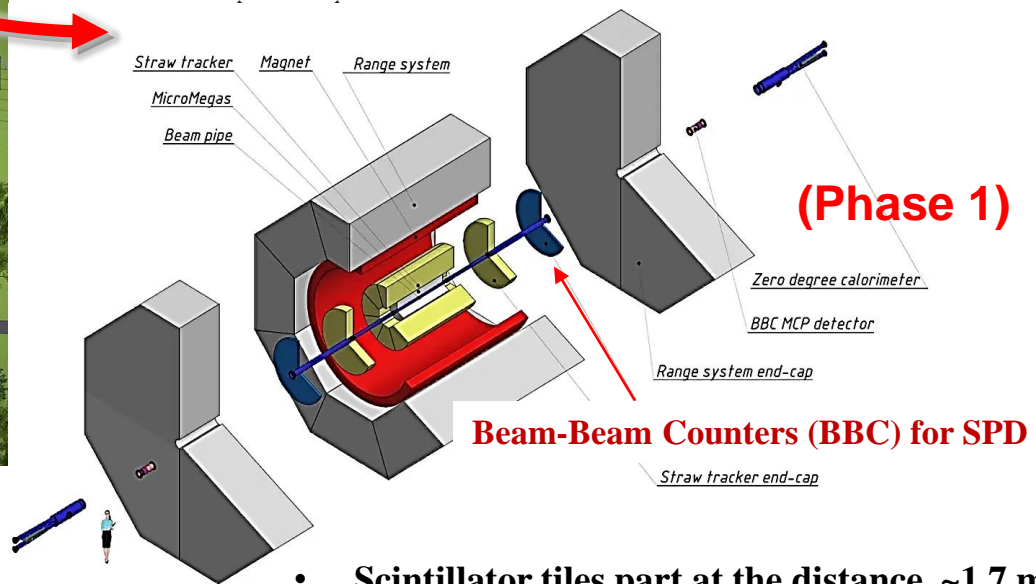


TDR 2023
2 wheels with
400 tiles each (416)



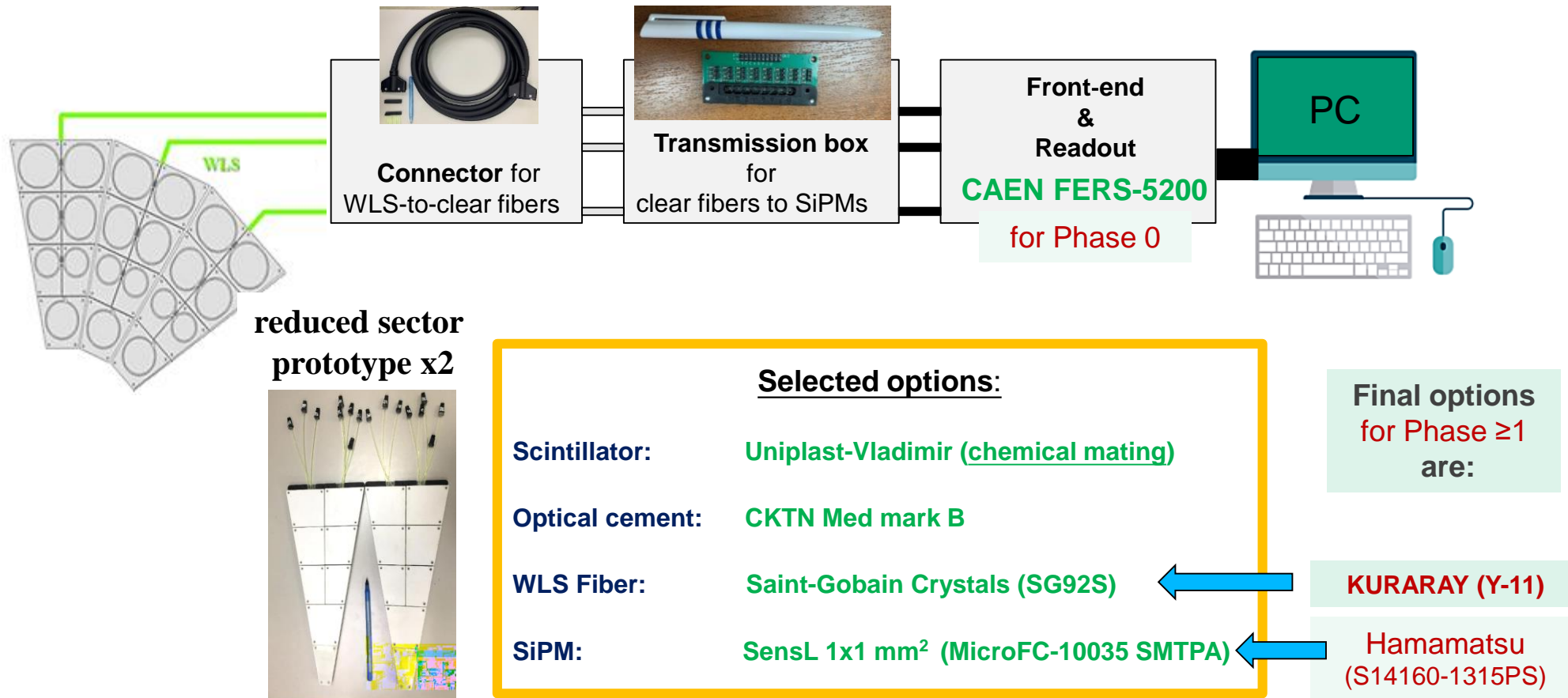
General

Spin Physics Detector



- Scintillator tiles part at the distance ~ 1.7 m

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



The verification in the mass production process

- check the uniformity of the tiles
see: A. Zakharov
- **method for estimating the efficiency of an optical and electronic path**

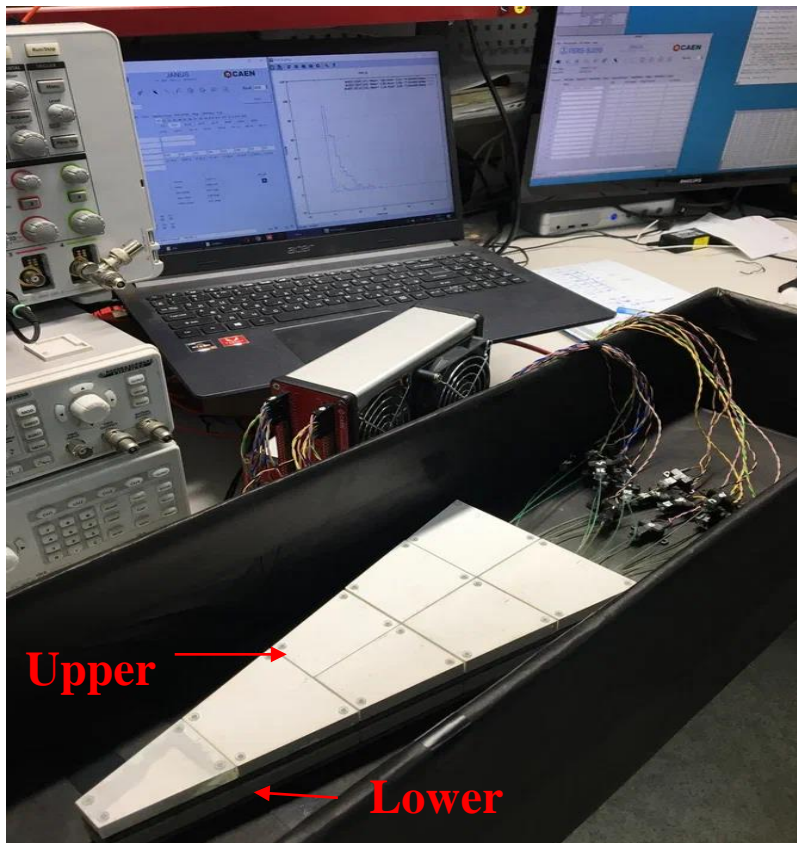
The method will allow us to check the path:

- immediately
- monitoring the change in the detector over time

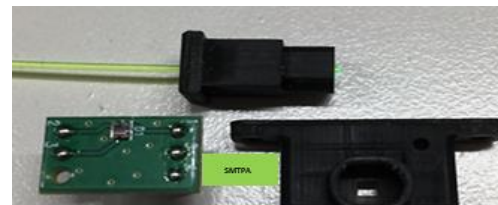
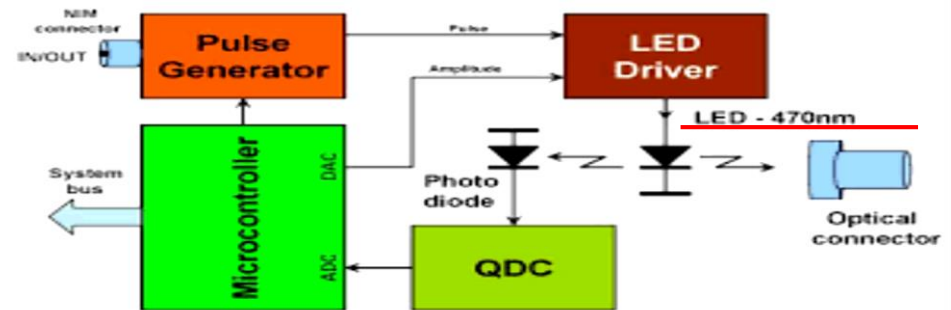
CAEN FERS 52XX is an extendable high speed front-end readout system

- DT5203 (picoTDC chip) **Hybrid mode**
- DT5215 (Concentrator) **(LG+ToT+ToA)**
- DT5202 (x2 Citiroc 1A chip)

Stand for BBC measurements



Schematic view of the LED

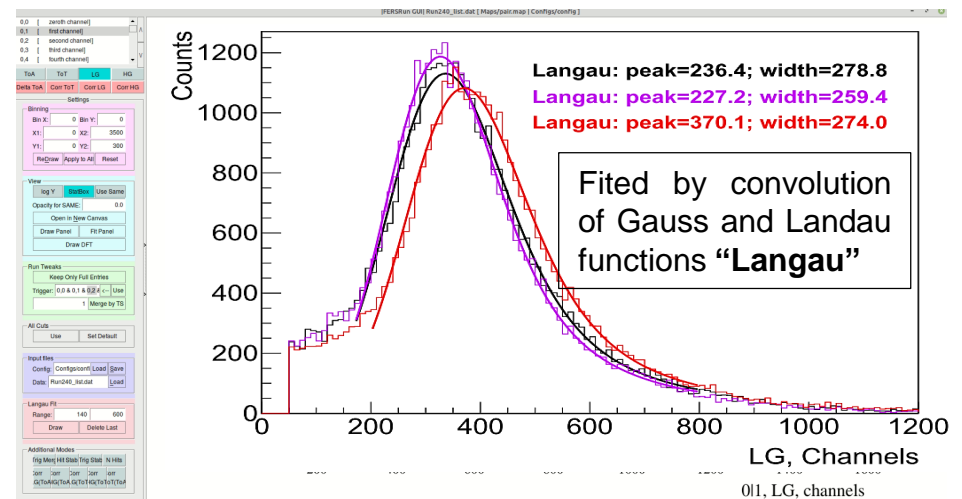


SiPM SensL 1x1 mm²
(MicroFC-10035 SMTPA)




Diameters of SGF

The “FersRun” framework has been designed.

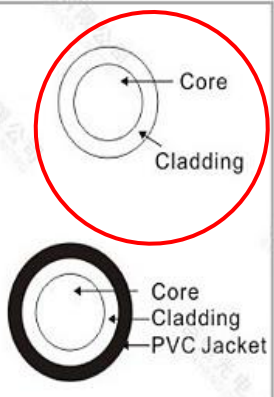


This method is based on side glow fiber (SGF). In principle: the LED light transmitted along the SGF. We attached the WLS to SGF, and then the optical signal passes through the optical path and detected by SiPM.

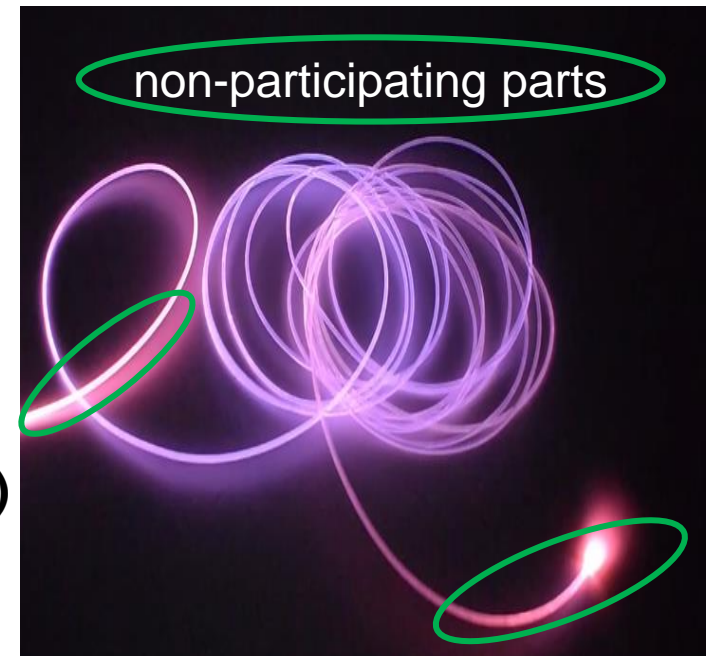
(WLS \leftrightarrow Clear Fiber \leftrightarrow SiPM \leftrightarrow DT5202 unit)



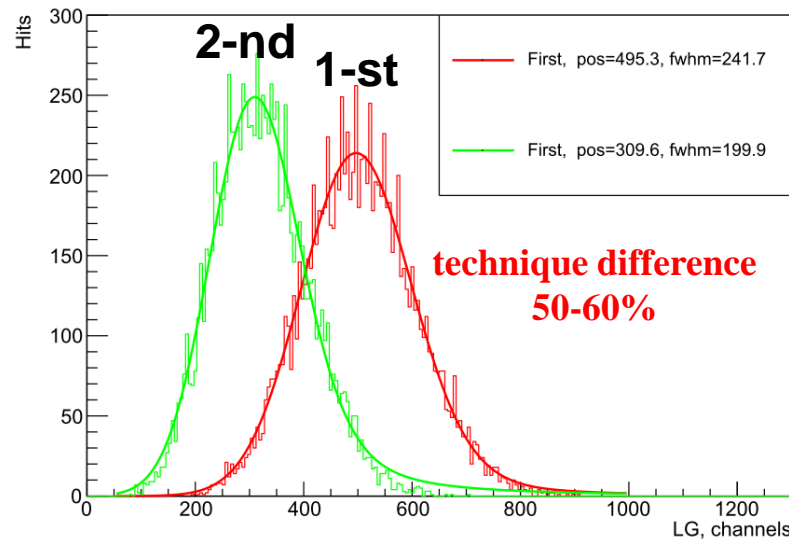
Item no.	Diam-1.5, 2, 2.5, 3, 3.5, 4, 5, 6, 8, 10, 12, 14, 16, 18mm
Item name	Solid core Side glow Optic fiber
Fiber core material	Methyl Methacrylate (MMA)
Cladding material	Polytetrafluoroethylene (PTFE) (Teflon)
Jacket material	N
Core refractive index	1.55
Cladding refractive index	1.50
Refractive index Profile	Step
Wavelength range	350 - 780nm
Max bending radius	5X diameter
Working temperature	-20 - 100°C
Storage temperature	10-50 °C



**Led
(light)**



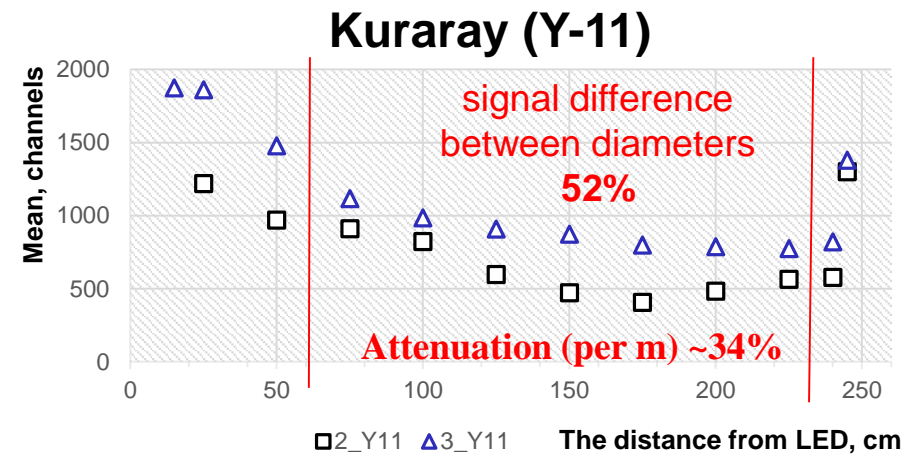
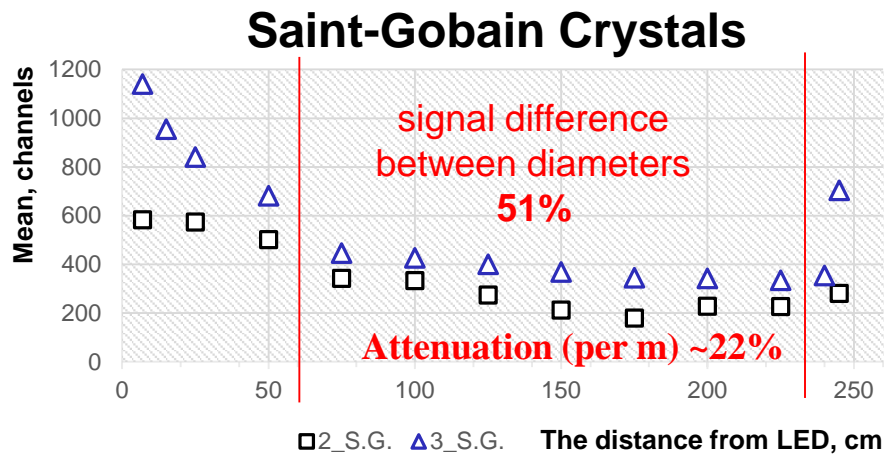
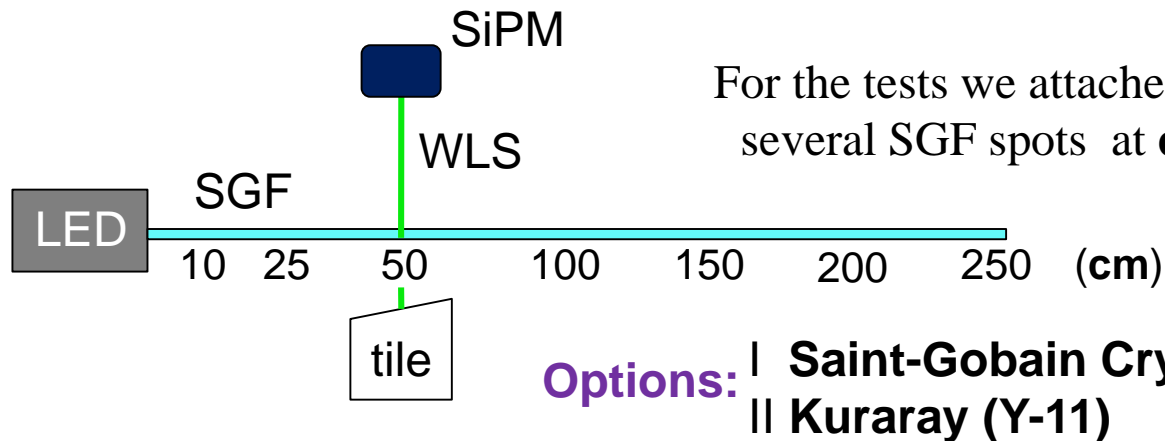
1-st attachment technique



- The difference between the attachment techniques is at the range of 50-60%.
- The 2-nd method is a priority, both from the point of view of simplicity of attachment, and potentially with multi-channel connection. But increase of the light output is required.

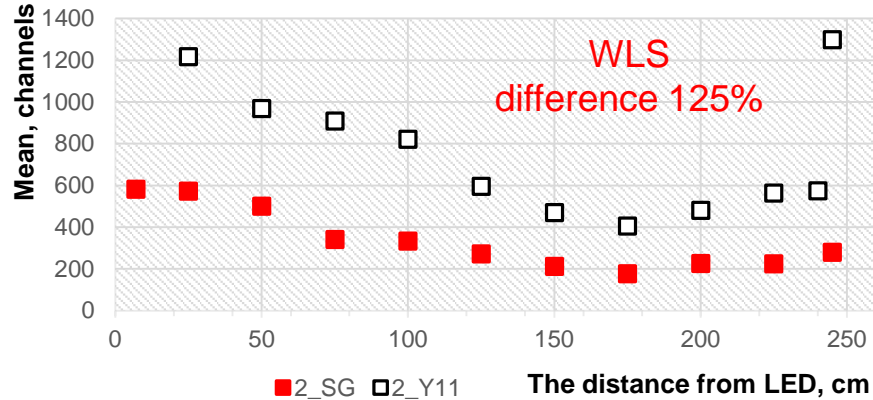
2-nd attachment technique



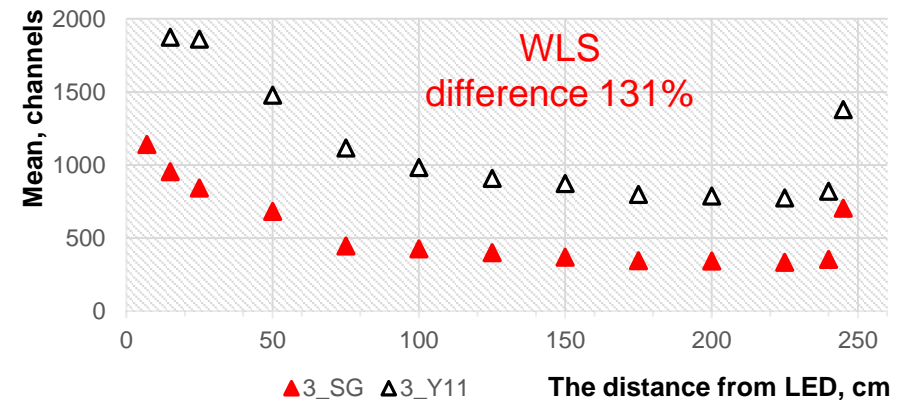


- There are edge effects. They are larger for 3mm fiber.
- Attenuation of light per meter for the SGF at the level of 30%.
- The signal difference between the 2mm and 3mm diameters is **about 50%**.

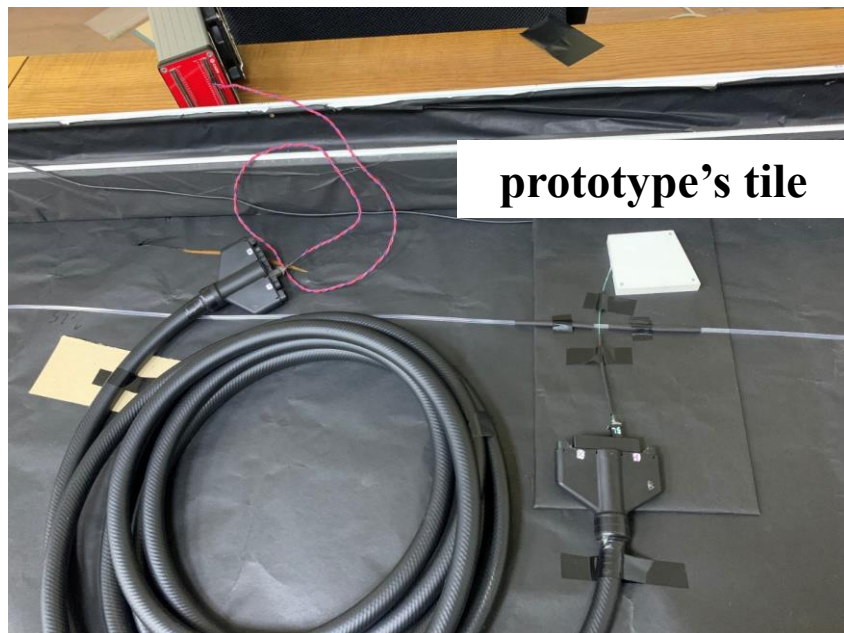
2mm diameters



3mm diameters



- WLS Kuraray (Y11) is approximately **130% effective**.



Kuraray (clear fiber) cable prototype with
8 channels connector

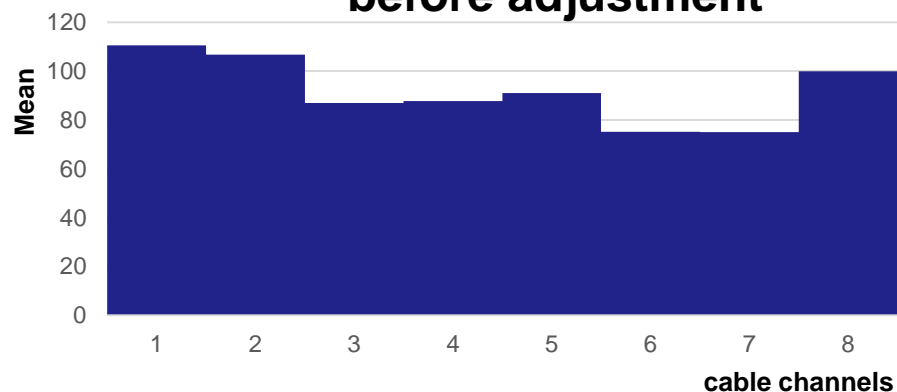
Channel-by-channel connector test



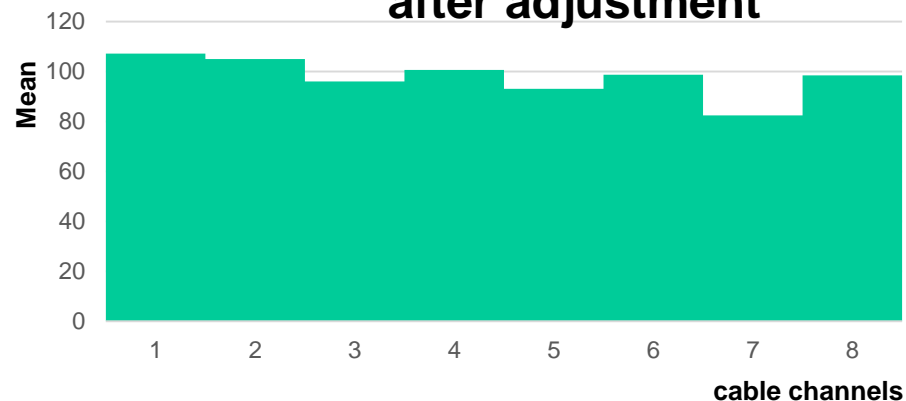
SensL 3x3 mm²
(MicroFC-30035)
to DT5202



before adjustment

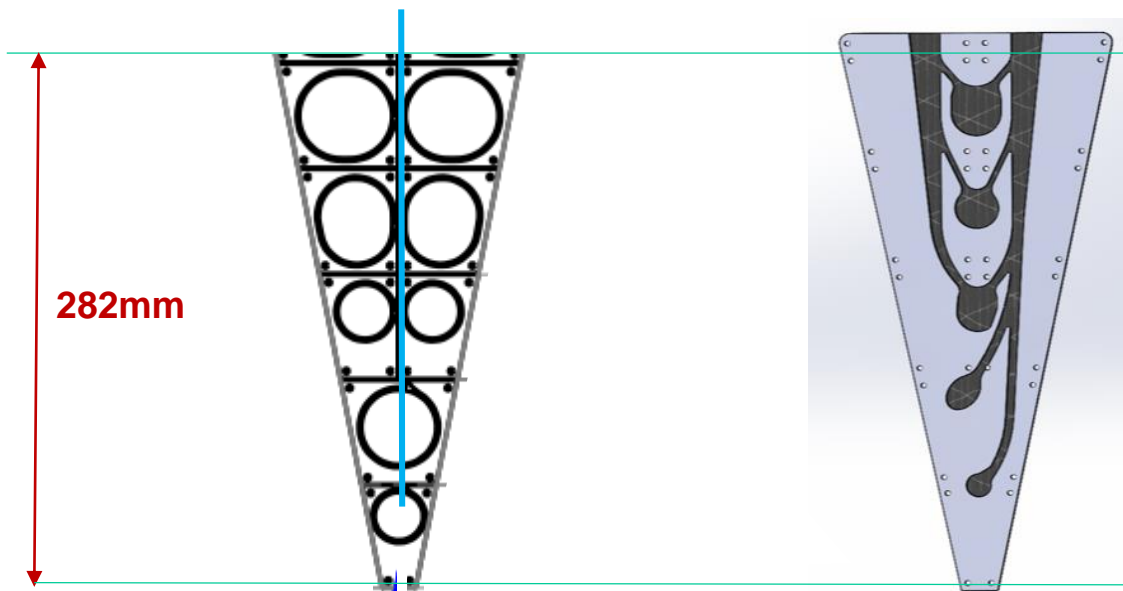


after adjustment

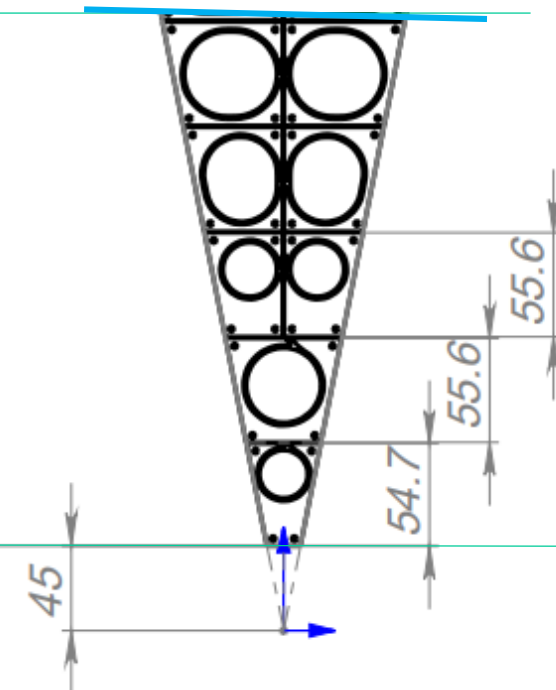


- the correction showed a **problem with polishing** and a **defect** for the transparent fiber
- **preparing to test** the main options

1-st attachment technique (parallel to WLS)

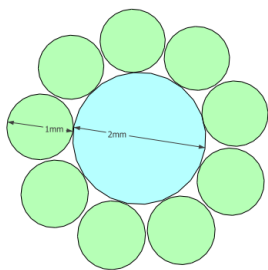


2-nd attachment technique (perpendicular to WLS)



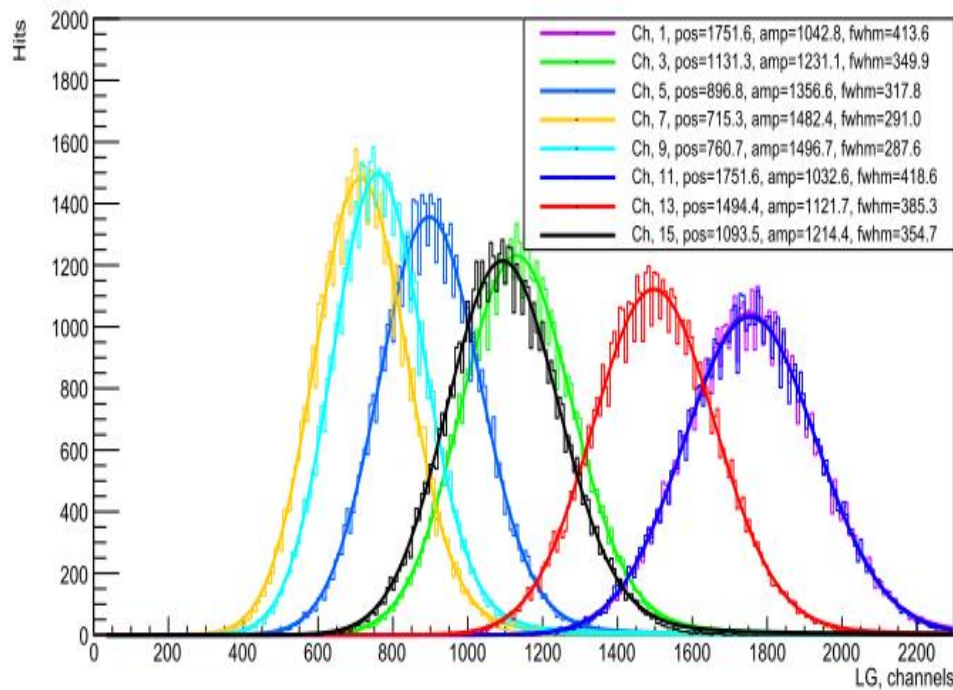
WLS single or group connection

WLS group connection



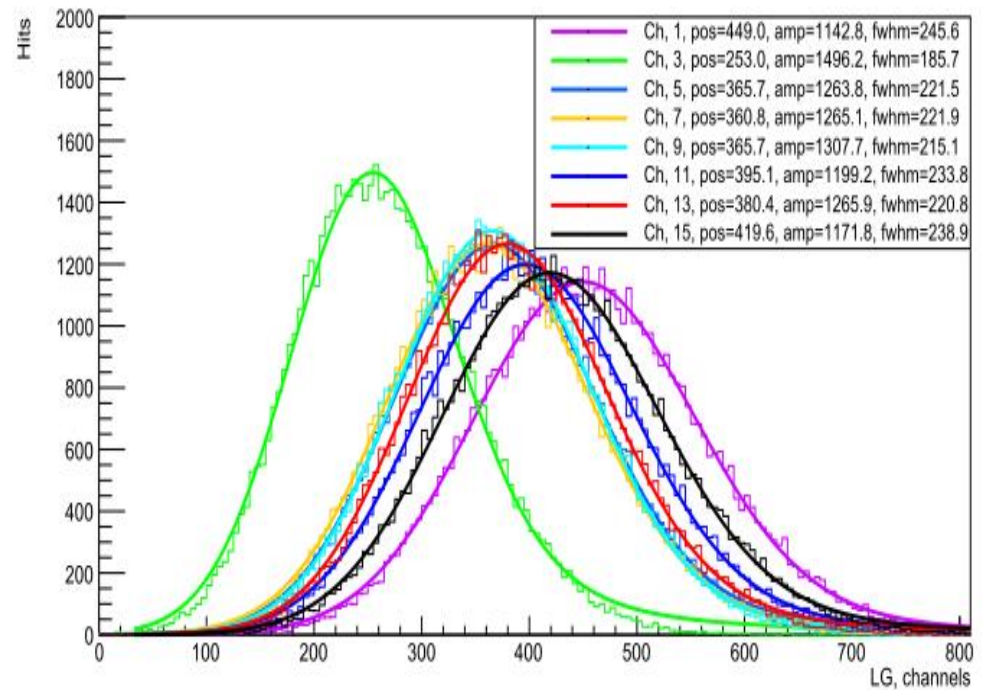
WLS
SGF

1-st attachment technique



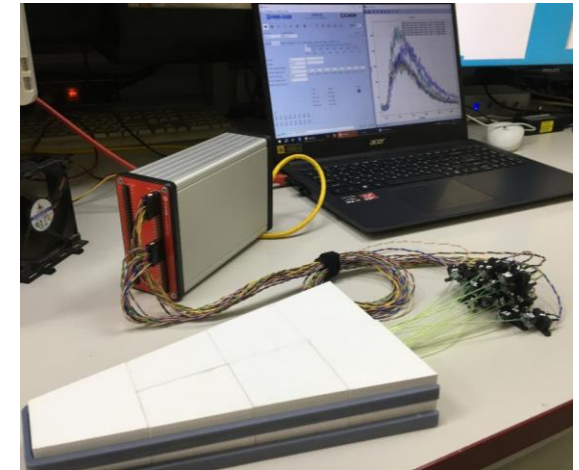
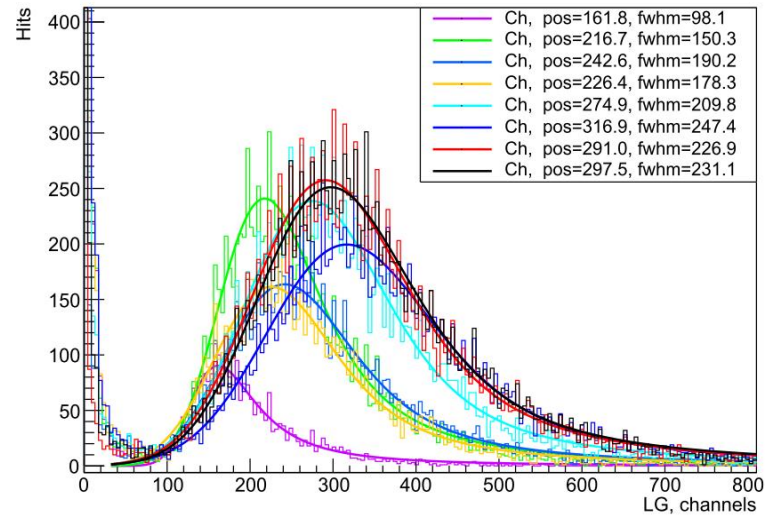
- random effect

2-nd attachment technique



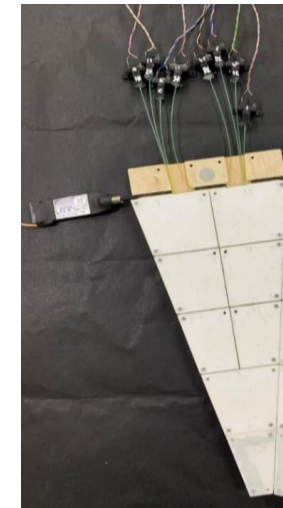
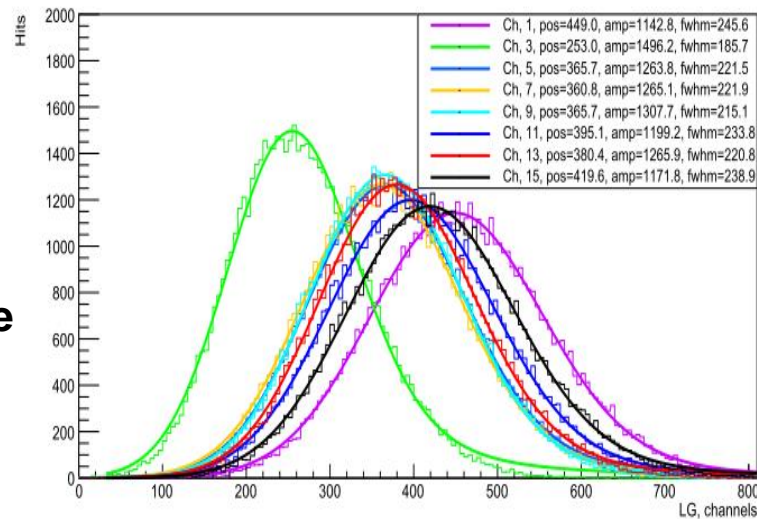
- the problem with the connector

Cosmic rays



Tests with SGF

2-nd attachment technique



- the signal is comparable to the mip
- different acquisition time
- perfect alternative of cosmic rays

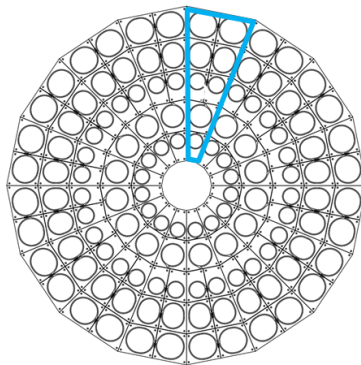
The techniques are sensitive to fibers contact areas

required

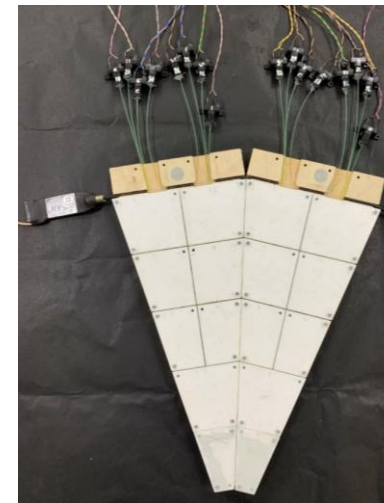
- the tool for uniform illumination
(combining all fibers into one connector)
- the scan by SGF length (>2,5 m)

2-nd attachment technique
(perpendicular to WLS)

reduced prototype wheel



Small prototype wheel ~ 2,1 m
Full size wheel ~ 5,0 m



The method can be useful for wheel prototype

- ✓ The method for estimating the efficiency of an optical and electronic path has been proposed.
- ✓ The possibility of increasing the light intensity was considered. The absorbed light of the Kuraray WLS is higher than Saint-Gobain Crystals WLS. The final solution is a matter of compromise between the diameter of the SGF.
- ✓ The possible method of express sector checking has been proposed. The signal is similar to minimum-ionizing particles (mips). The method is promising for evaluating the operability of the prototype and the BBC detector.

to do list:

- test of the main option of optical cable with transmission box;
- finalizing the method of express wheel check;

Thank you for the attention!

Backup

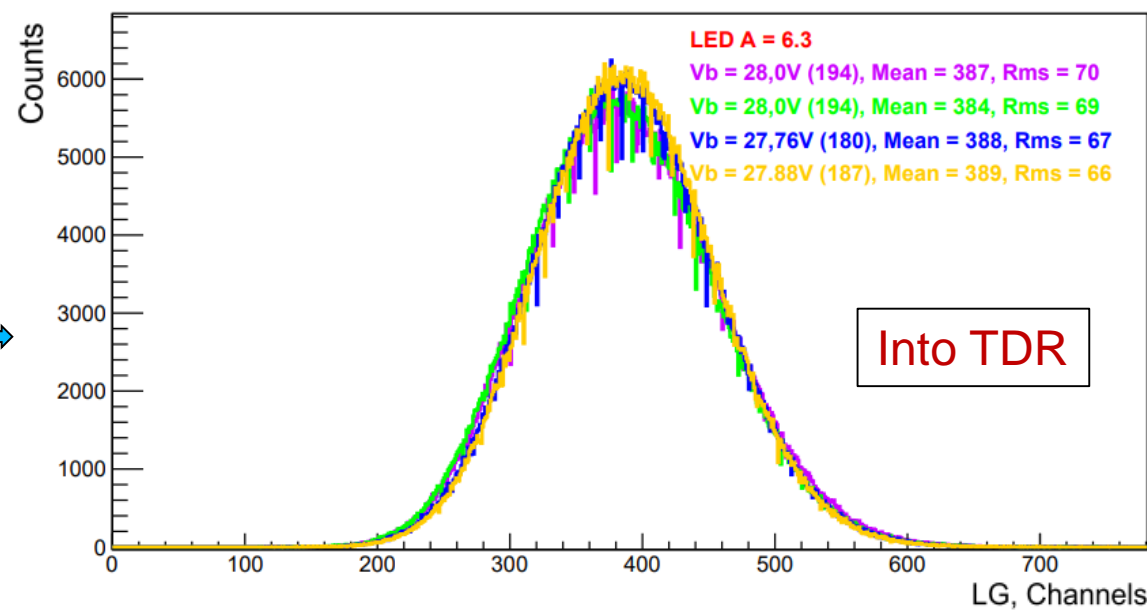
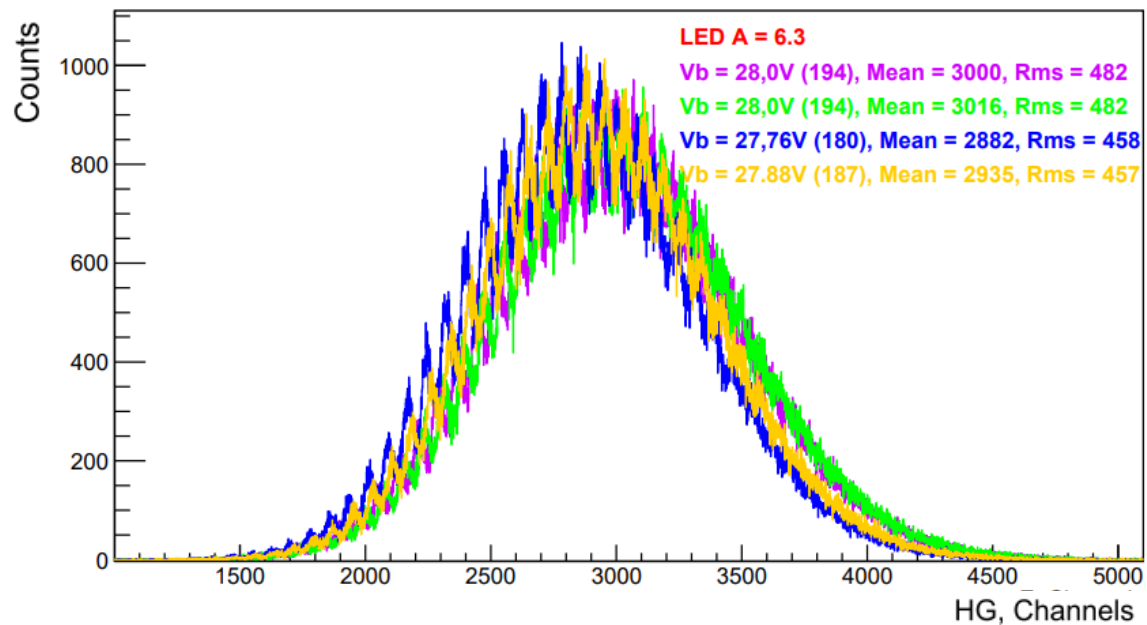
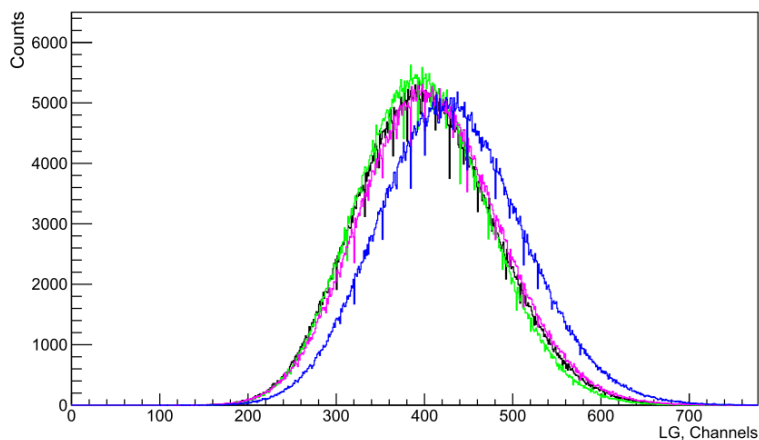
The hardware of BBC tests part

Calibration method (Led source)

DT5202 with CAEN LED Driver (SP5601)



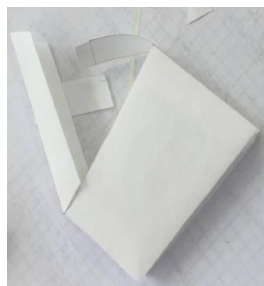
Not calibrated



Into TDR

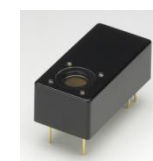
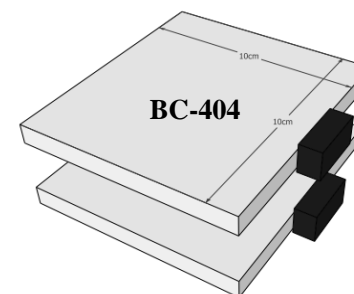
Materials selection test part

Scintillator cover



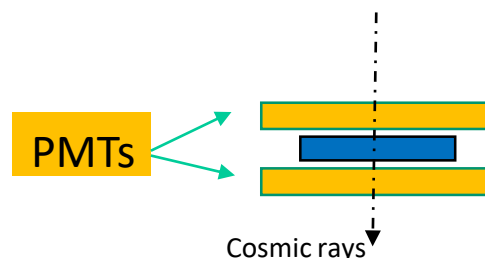
The amplitude spectra of the BBC prototype scintillation tile coated with **Mylar** or **Tyvek**, as well as covered with **Matted** options.

External trigger by coincidence of two scintillators with PMTs readout



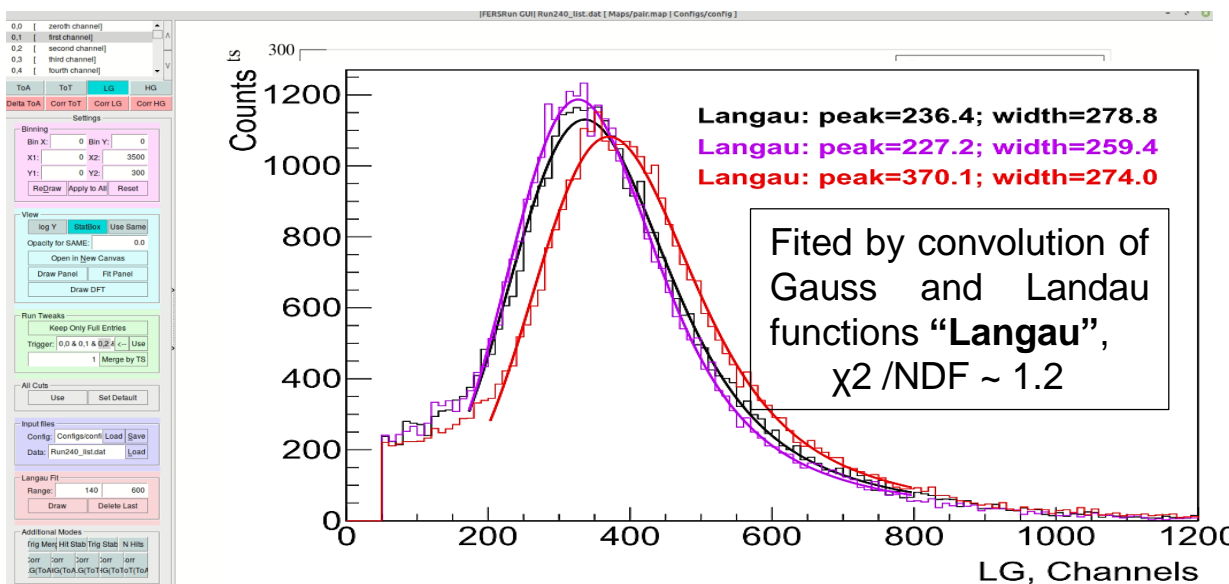
PMT
Hamamatsu
H10720-110

The “FersRun” framework has been designed.



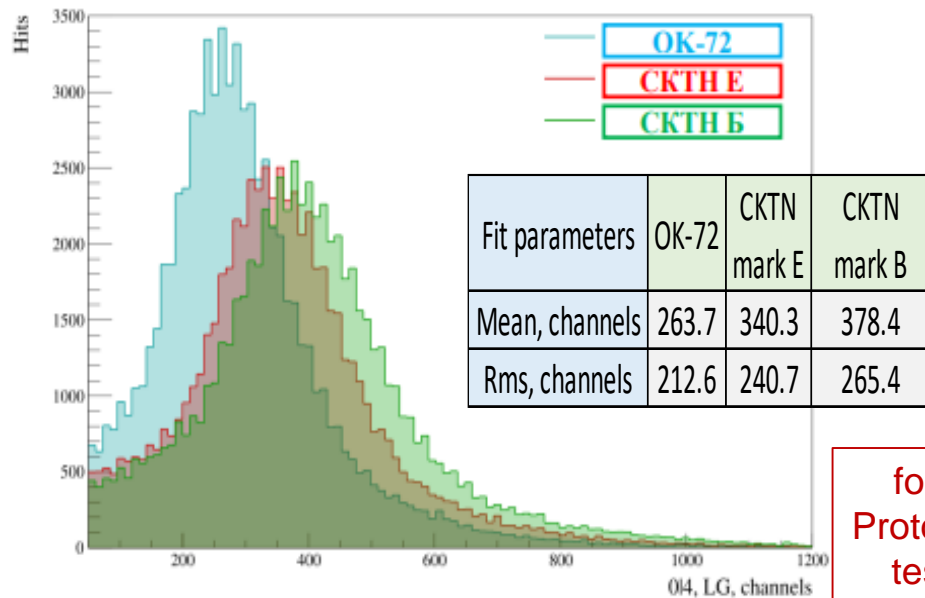
Matted
or
Mylar
or
Tyvek

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



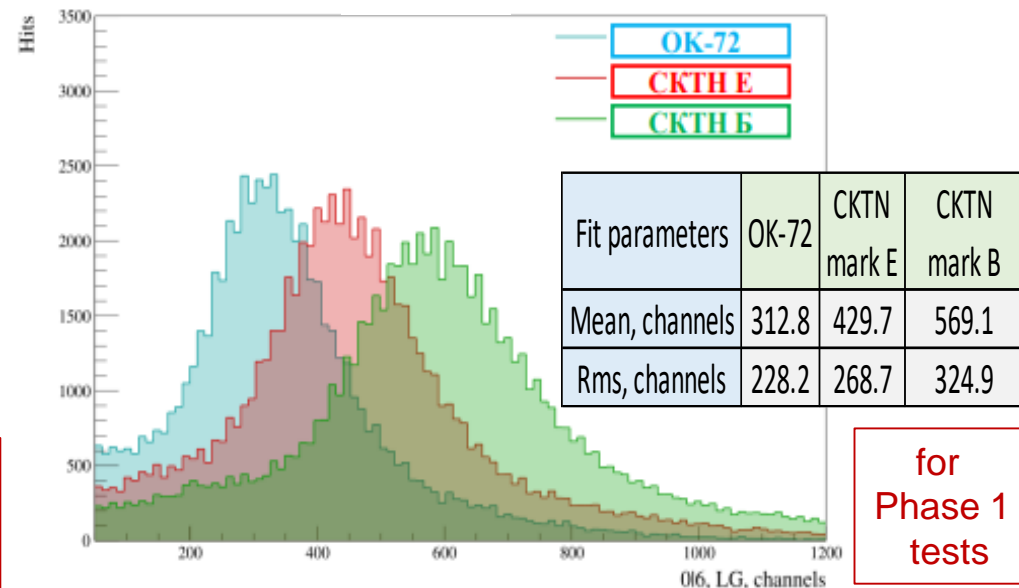
❑ The option with **matted tiles** is more priority for mass production.

SGC BCF92



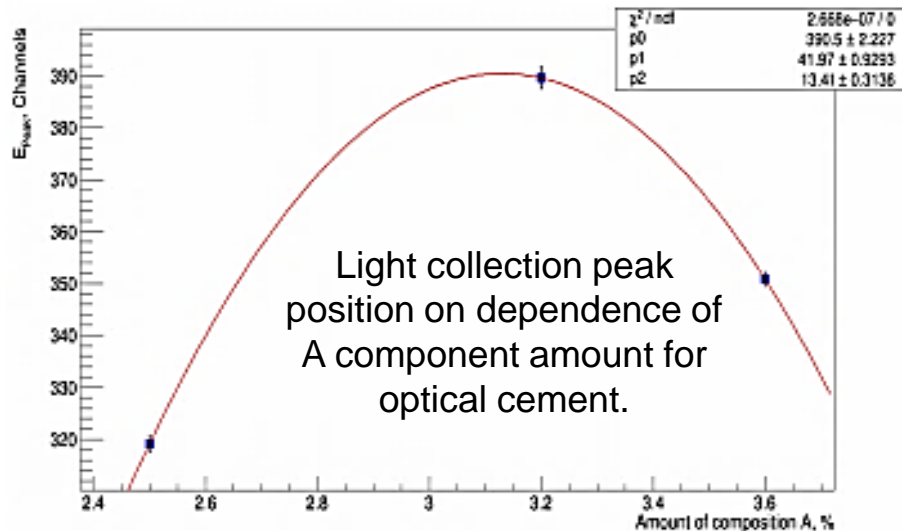
for
Prototype
tests

Kuraray Y-11



for
Phase 1
tests

CKTN



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

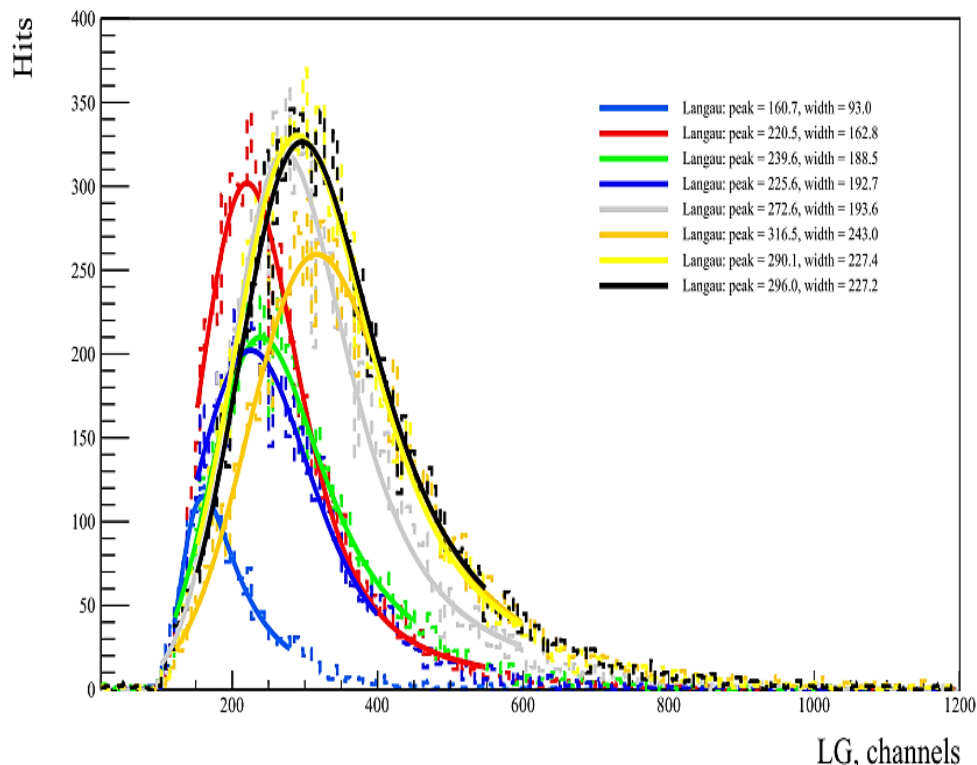
The results of tests of Kuraray WLS fiber and Saint-Gobain Crystals (SGC) WLS fiber with different types of cement are presented.

- ❑ **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

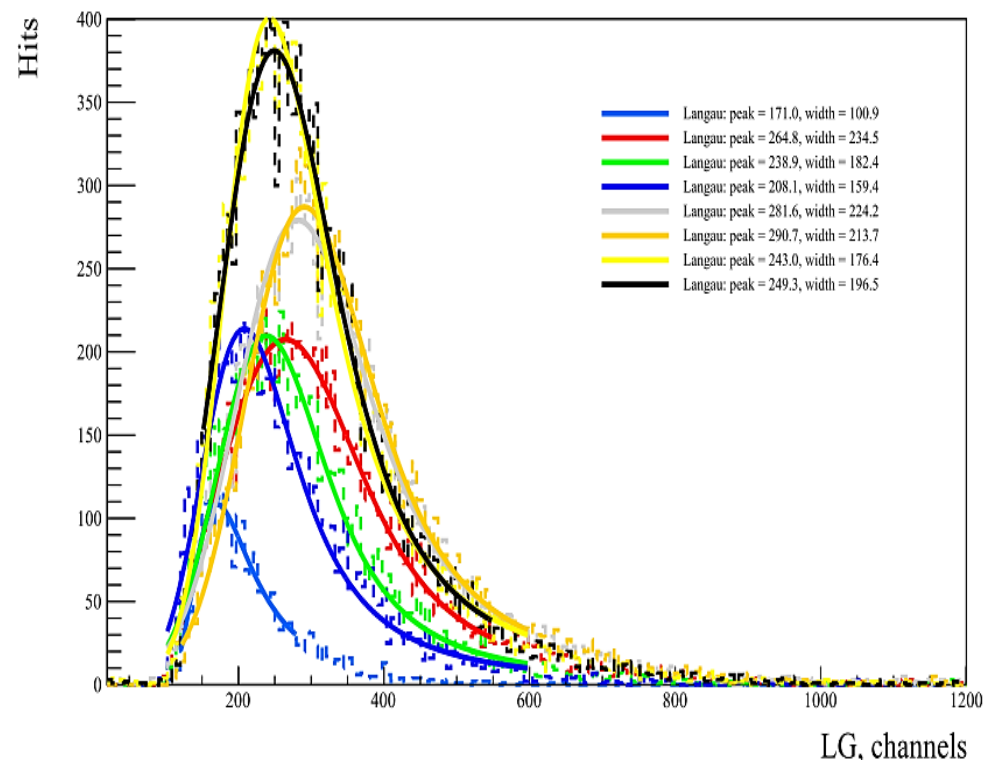
Amplitude spectra of two sectors

1-st sector prototype



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

2-nd sector prototype

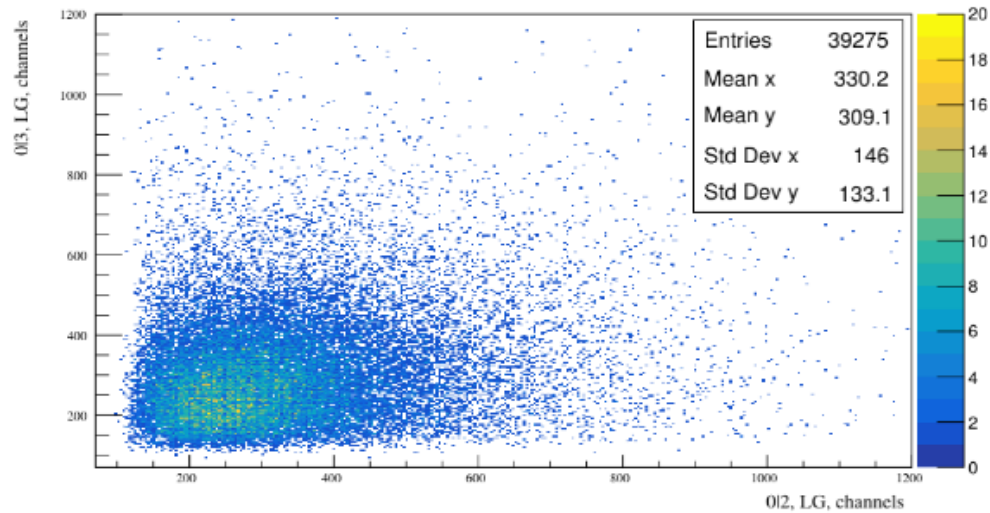


The stable tiles were taken
for following tests

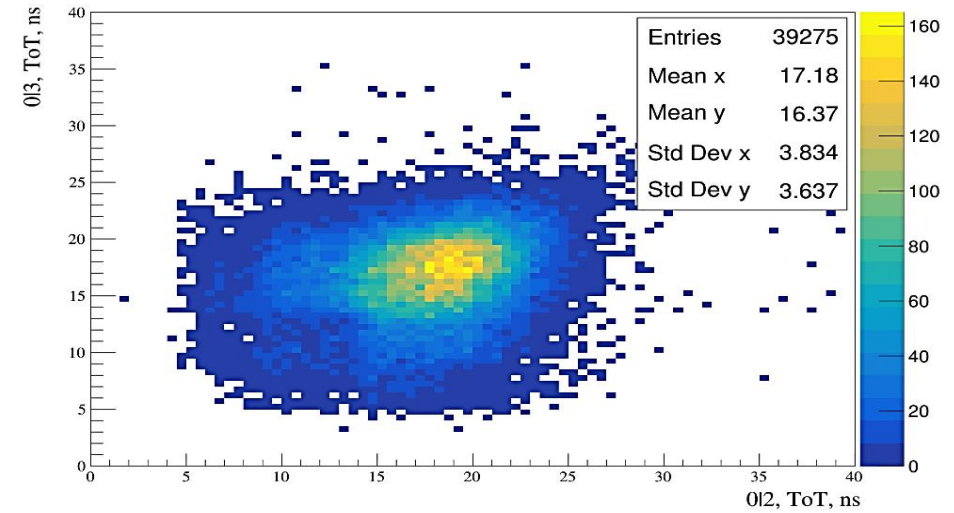
Prototype assembling test

The 1-st step for working with the timing mode

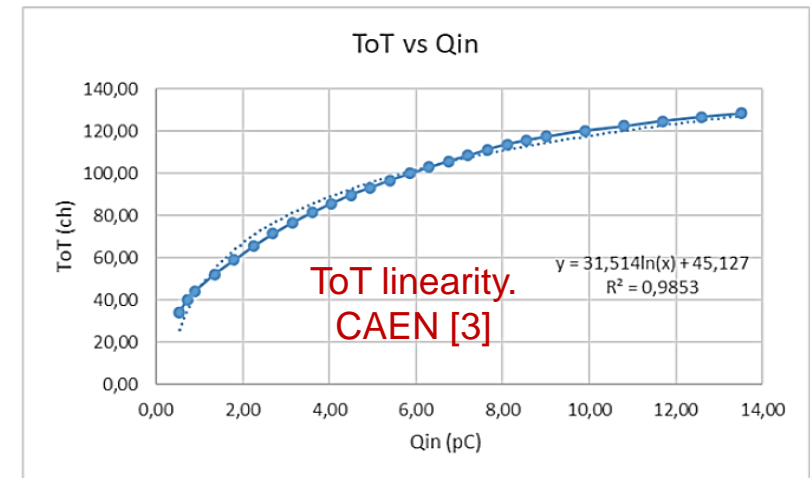
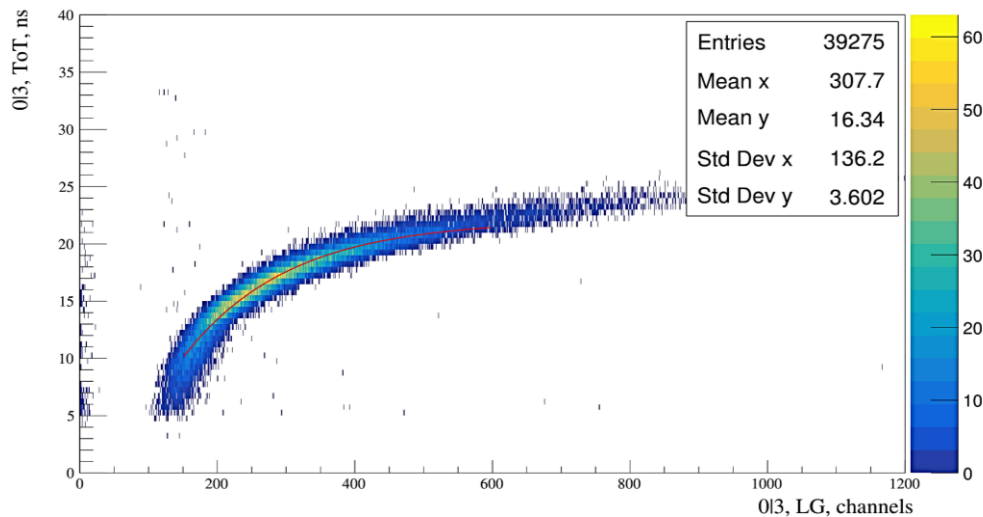
LG correlations



ToT correlations

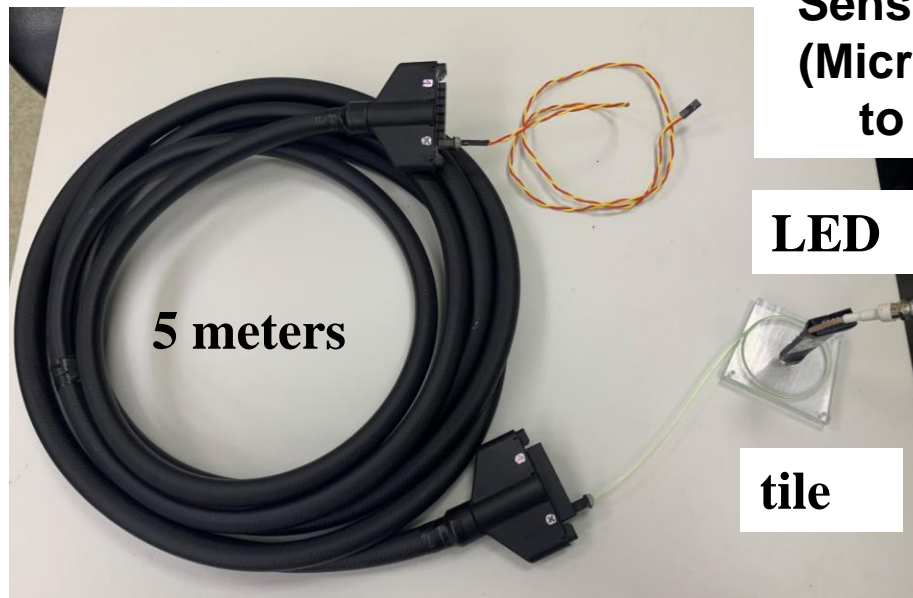


LG vs ToT (channel №3)



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

- The calibration of the charge scale is required

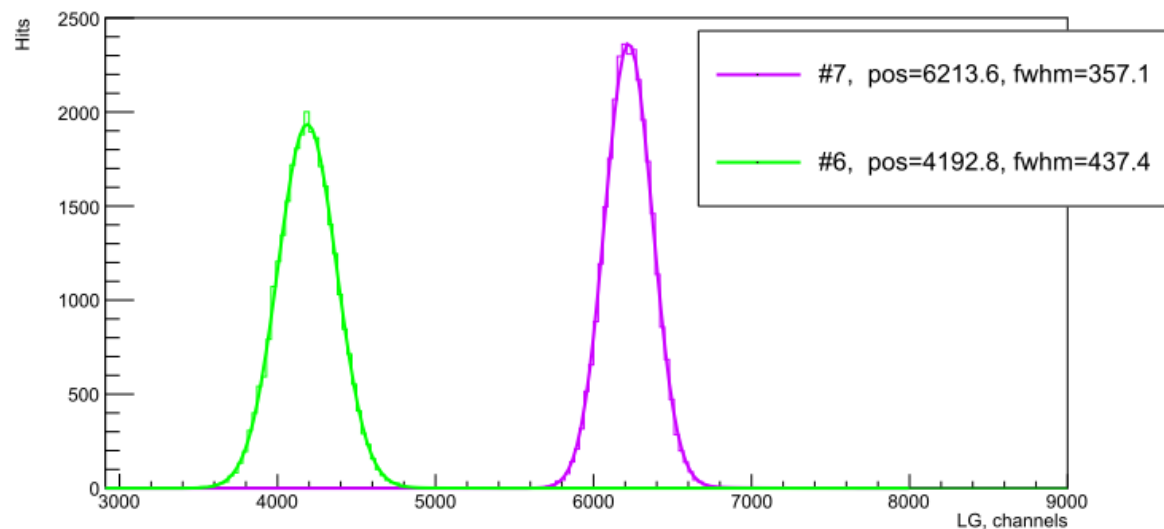


SensL 3x3 mm²
(MicroFC-30035)
to DT5202

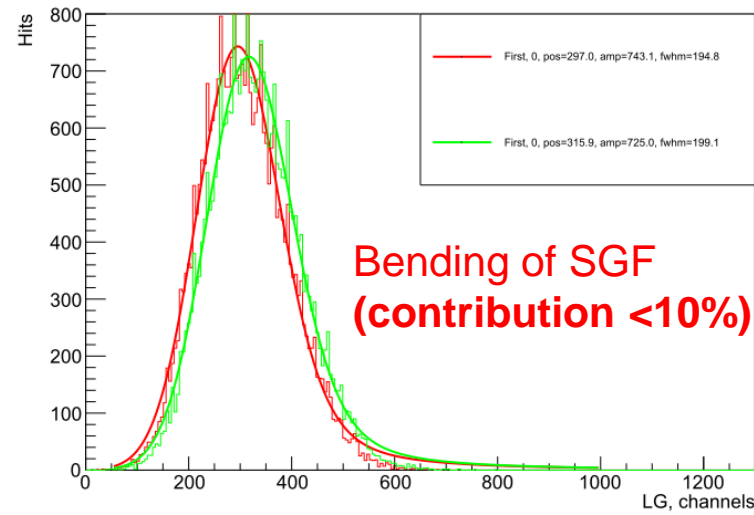
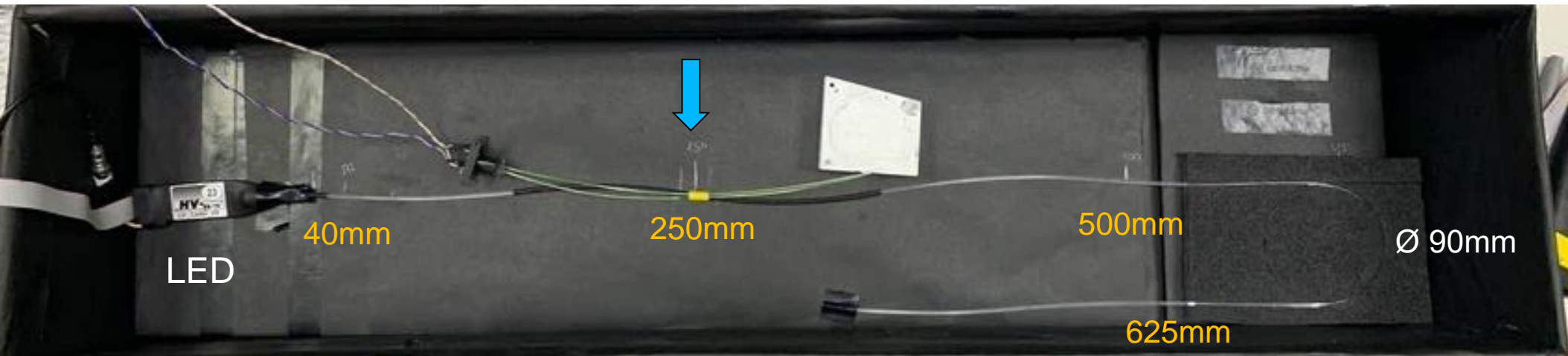
LED

tile

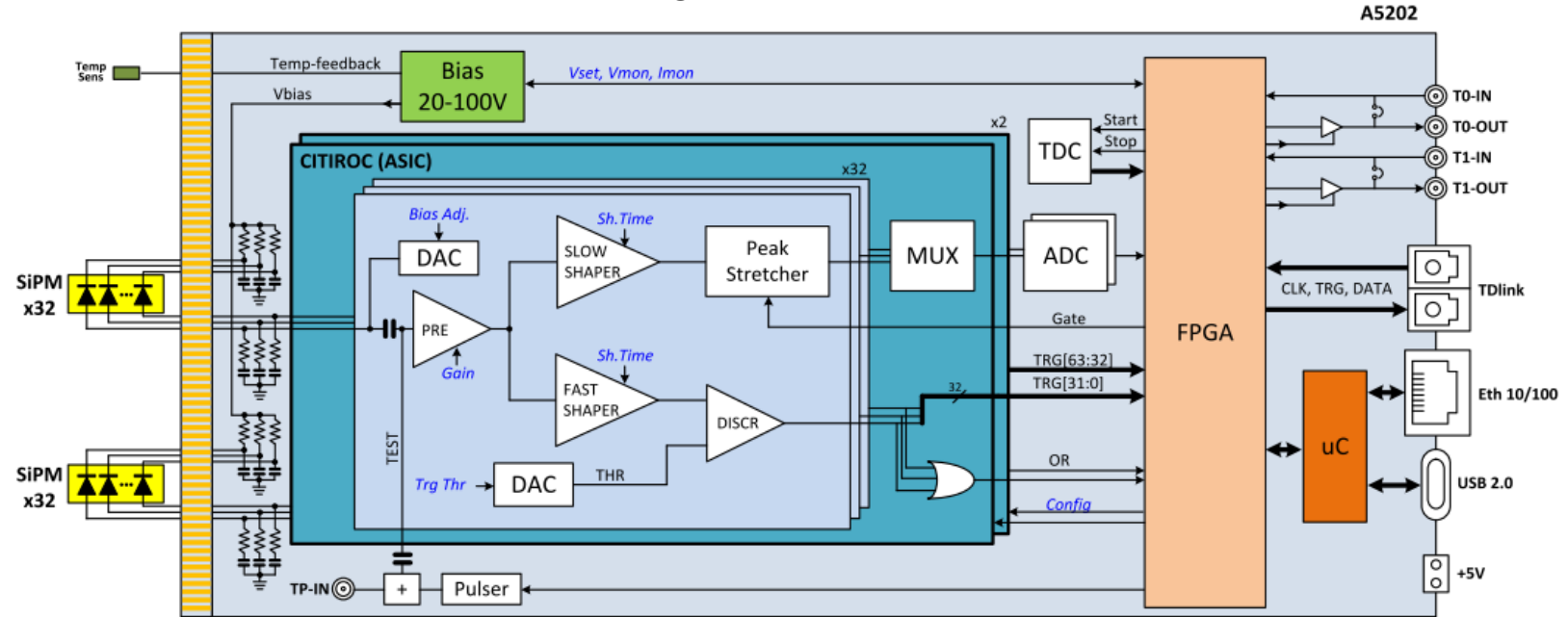
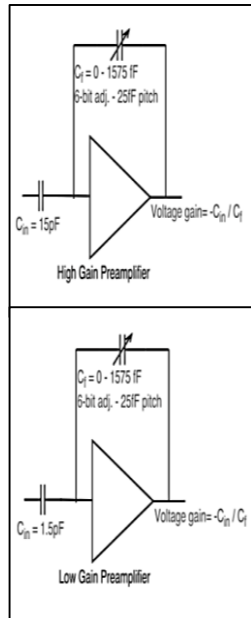
Kuraray (clear fiber) cable prototype with **8 channels connector**



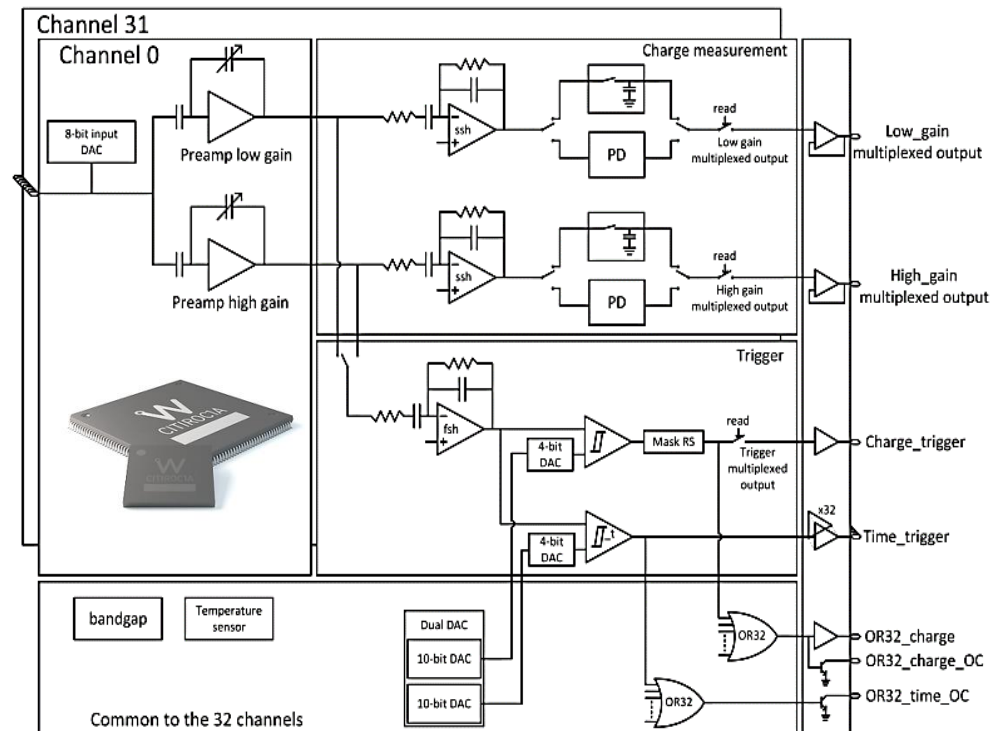
Light loss at 1 meter ~**7%**



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.