



Study of the characteristics of the BBC detector prototype

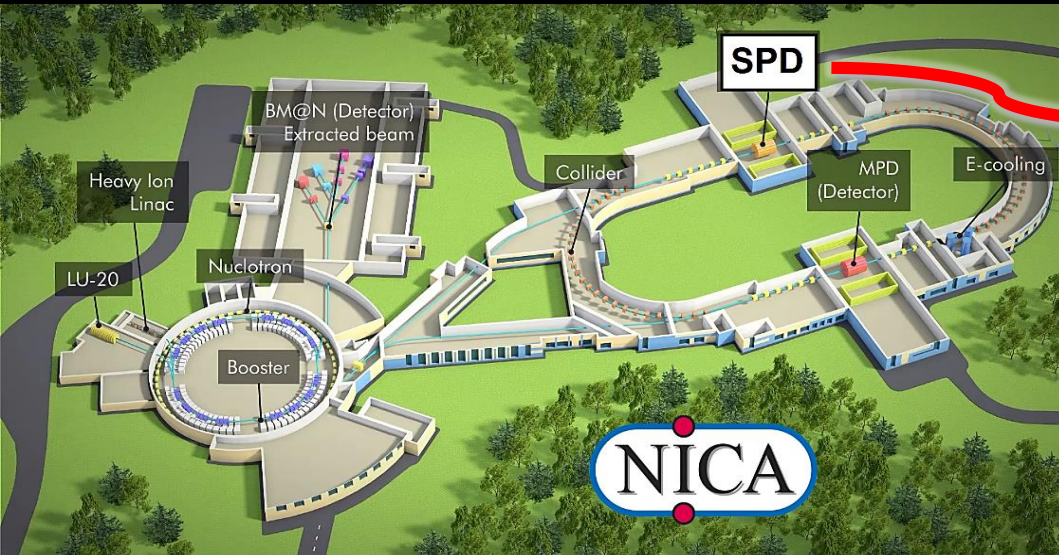
A.V.Tishevsky on behalf of JINR-MEPHI BBC

*29th International Scientific Conference of Young Scientists and Specialists
(AYSS-2025)*

27 October 2025, Dubna

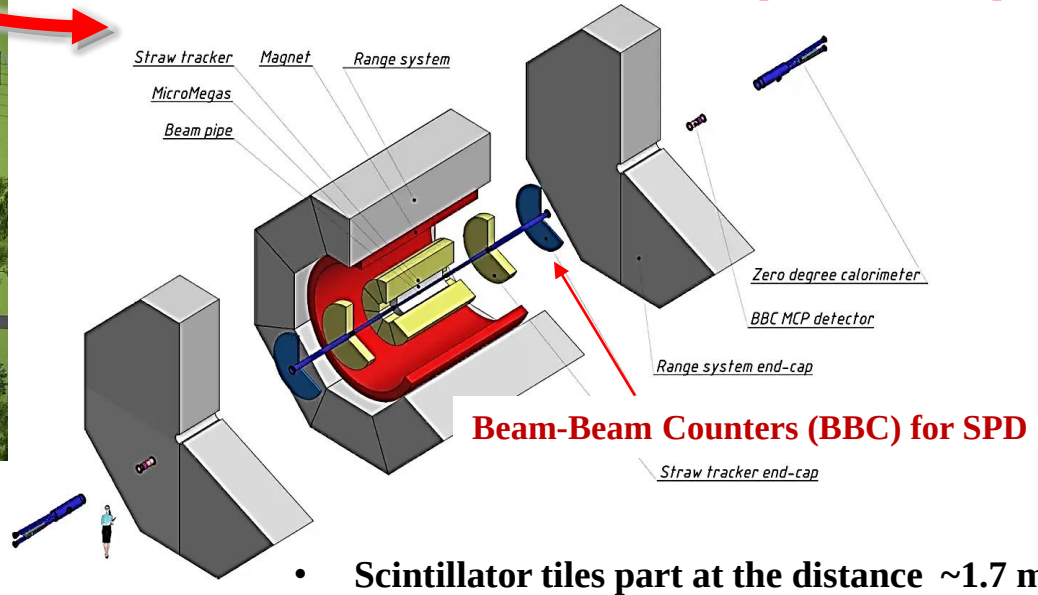
- ❑ Introduction for BBC subsystem
- ❑ R&D tests
 - method
 - the comparing of the attachment techniques
 - the scan by SGF length
 - test of full optical and electronic path
 - the method of assembled sector fast check
- ❑ Prospects
- ❑ Conclusion

Introduction

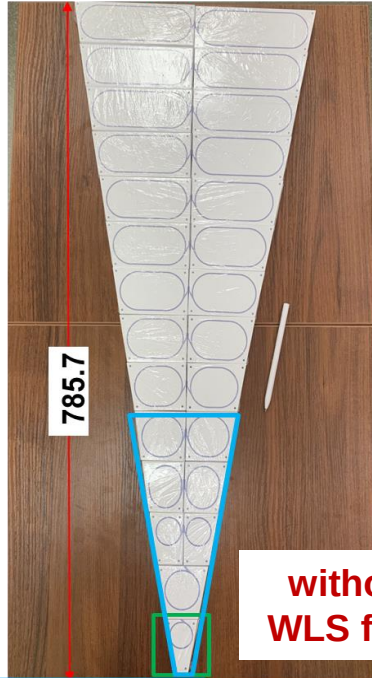


General

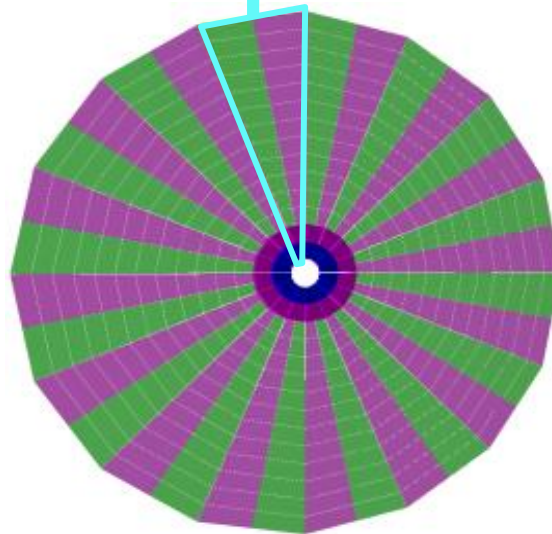
Spin Physics Detector (Phase1)



BBC Sector (1/16 of wheel) design
24 (26) - tiles



TDR 2023
2 wheels with
400 tiles each (416)



+ local polarimetry
+ event plane detector for HI physics

Selected options:

Scintillator: **Uniplast-Vladimir (chemical mating)**

Optical cement: **CKTN Med mark B**

WLS Fiber: **Saint-Gobain Crystals (SG92S)**

SiPM: **SensL 1x1 mm² (MicroFC-10035 SMTPA)**

Final options
for Phase ≥1
are:

KURARAY (Y-11)

**Hamamatsu
(S14160-1315PS)**

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)

**2 wheels with
128 tiles each**

WLS



Connector for
WLS-to-clear fibers

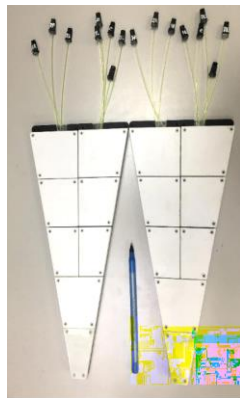


Transmission
boards for
clear fibers to SiPMs

Front-end
&
Readout
CAEN FERS-5200
for Phase0



**reduced sector
prototype x2**



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

Phase0

NEW ELECTRONICS (needs) for Phase ≥1

The optimization issues:

- backplate;
- R&D tests;
- mass production verification;

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

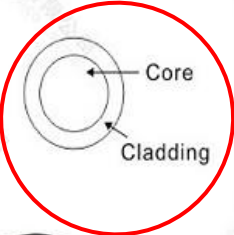
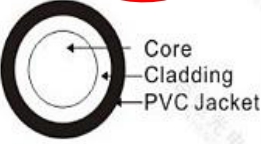
The method based on side glow fiber (SGF).

In principle: the LED light transmitted along the SGF.

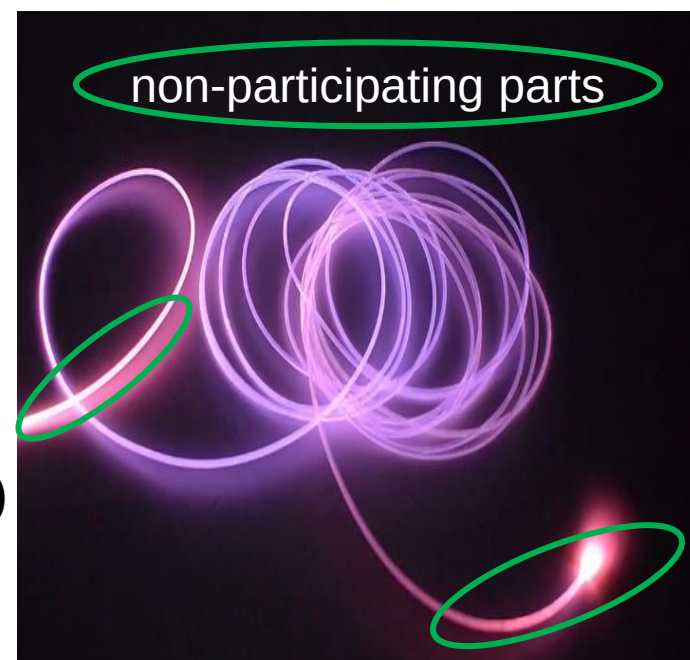
We attached the WLS to SGF, and then the optical signal passes through the optical path and detected by SiPM.

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



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)(Telfon)	
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)

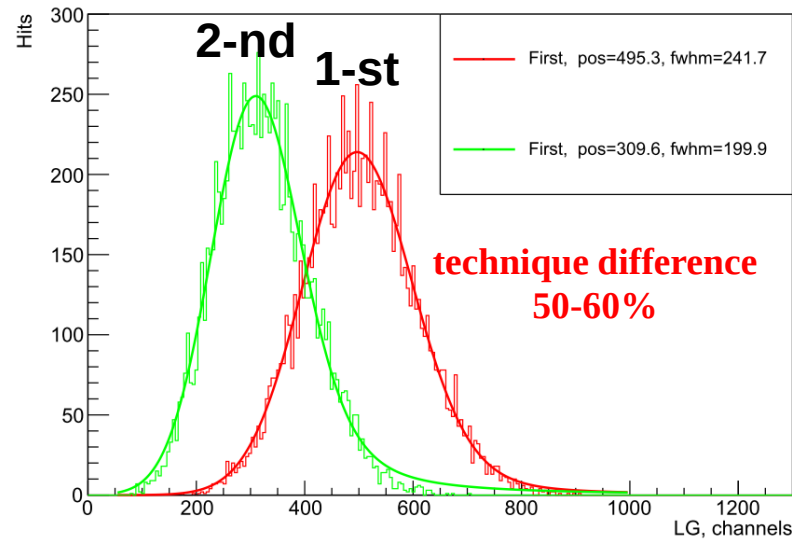


non-participating parts

1-st attachment technique



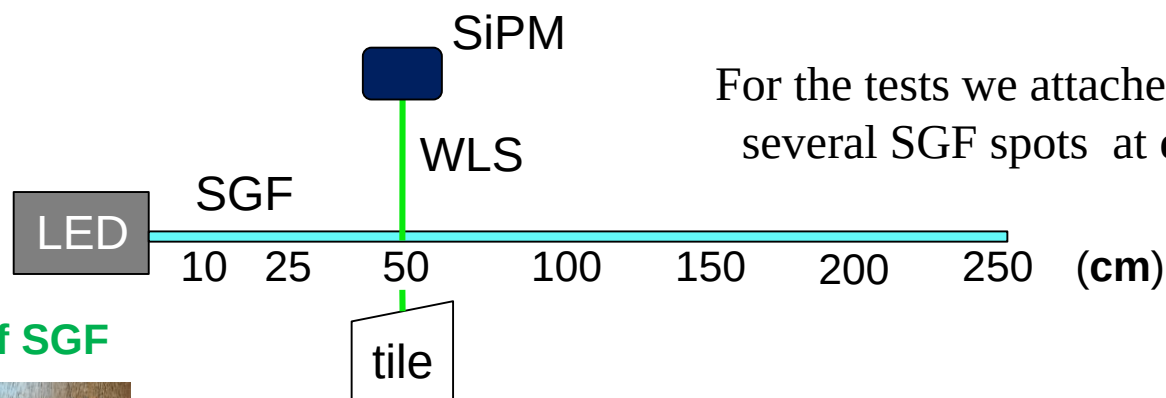
SGF diameter = 2mm



- 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





For the tests we attached WLS fiber output in several SGF spots at **distance from LED**.

Diameters of SGF

new

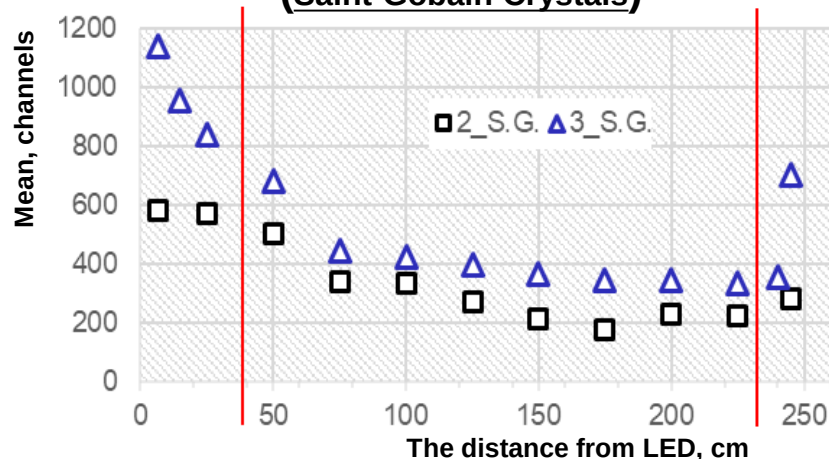
3mm

2mm

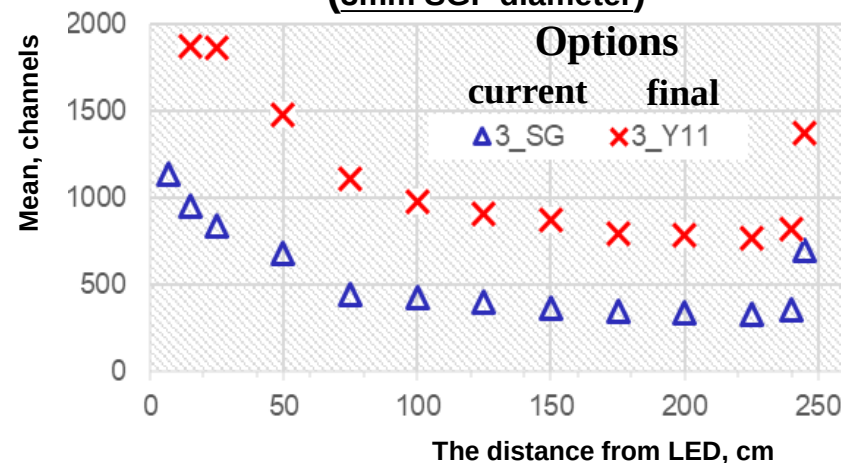


Options: I Saint-Gobain Crystals (SG)
II Kuraray (Y-11)

Comparing of SGF diameters (Saint-Gobain Crystals)



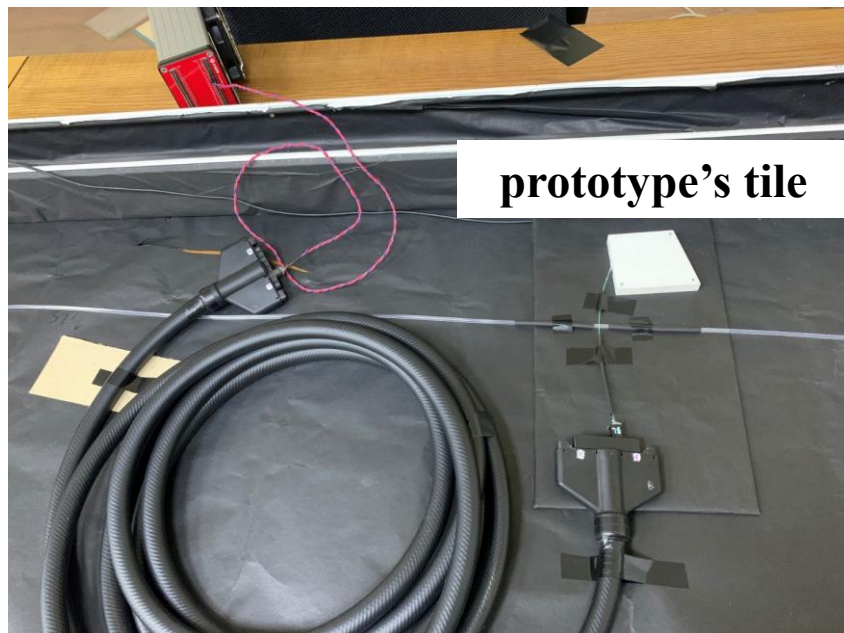
Comparing of WLS (3mm SGF diameter)



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

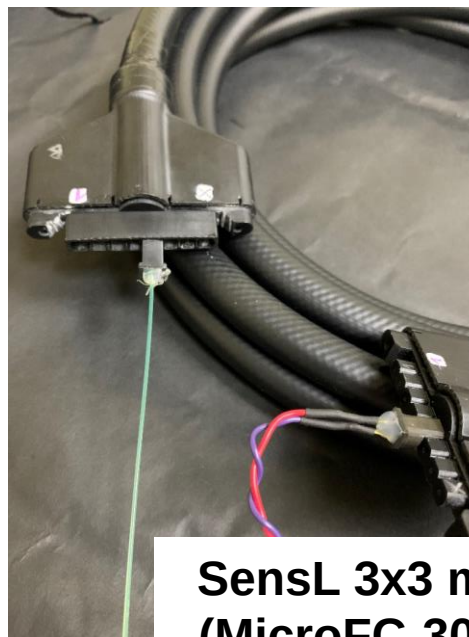
ø3 mm
is accepted

✓ WLS Kuraray (Y11) is **more efficient**.

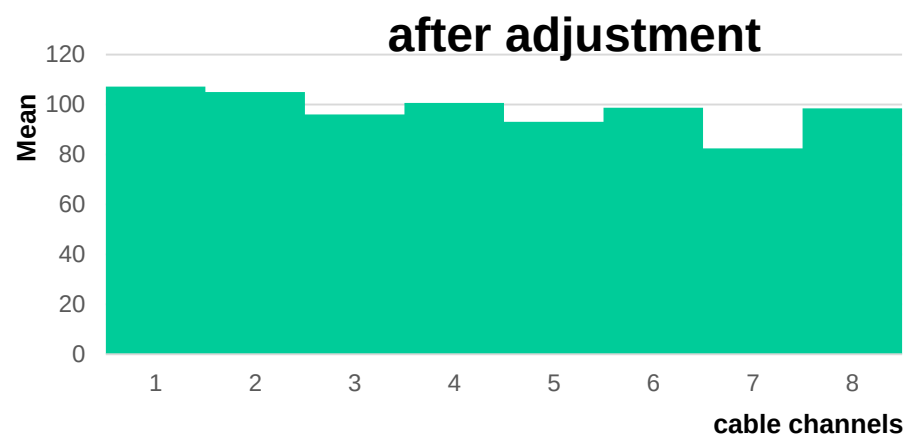
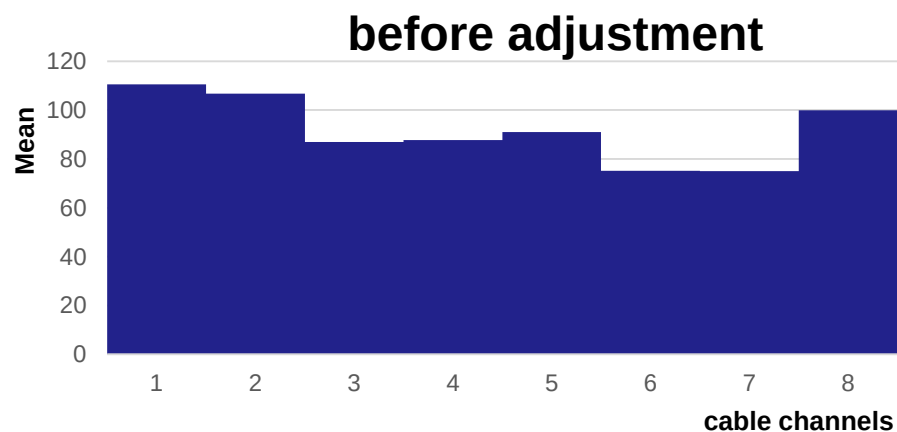


Kuraray (clear fiber) cable prototype with
8 channels connector

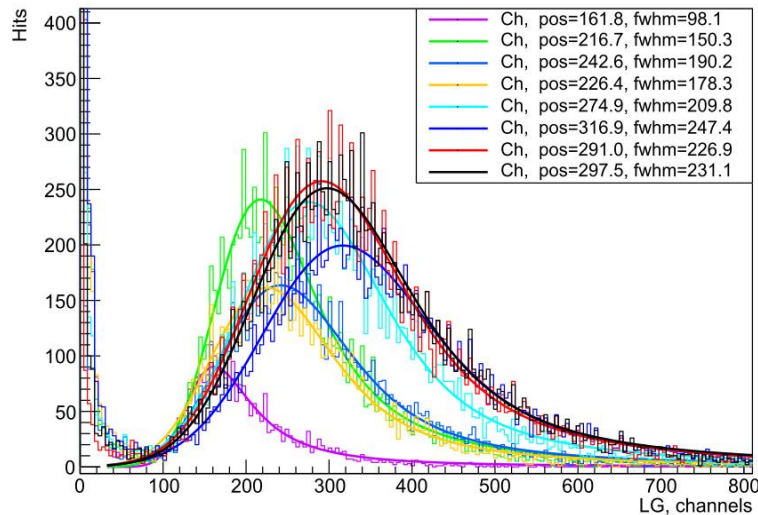
Channel-by-channel connector test



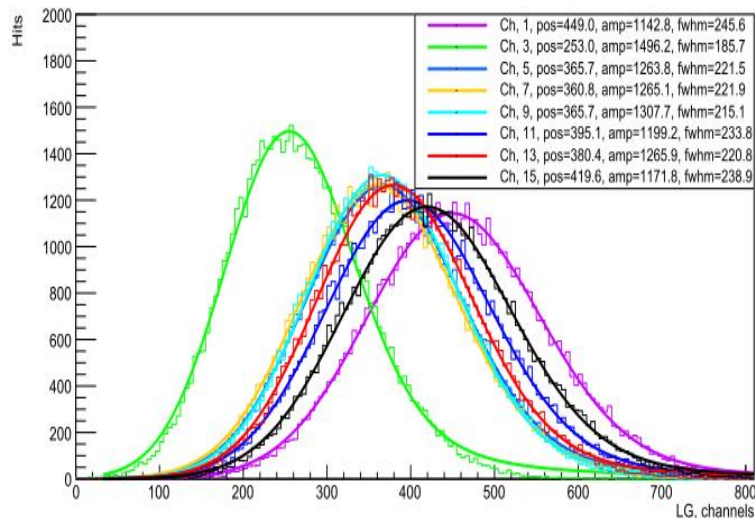
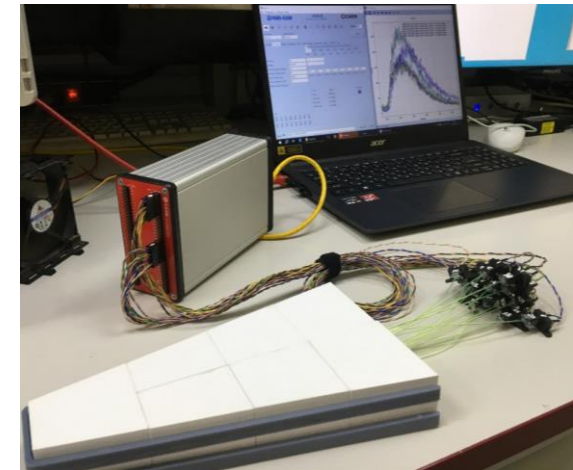
SensL 3x3 mm²
(MicroFC-30035)
to DT5202



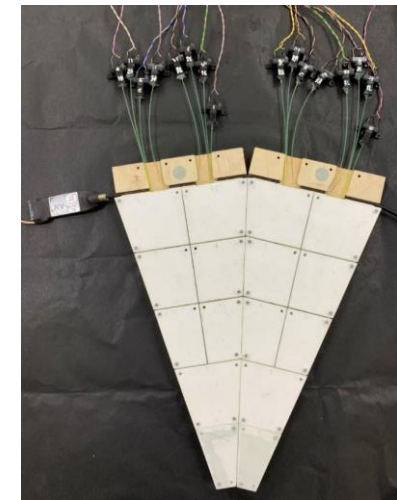
- the correction showed a **problem with polishing** and a **defect** for the clear fiber
- preparing to test of the **optical cable and the transmission boards** main options



Cosmic rays



Tests with SGF

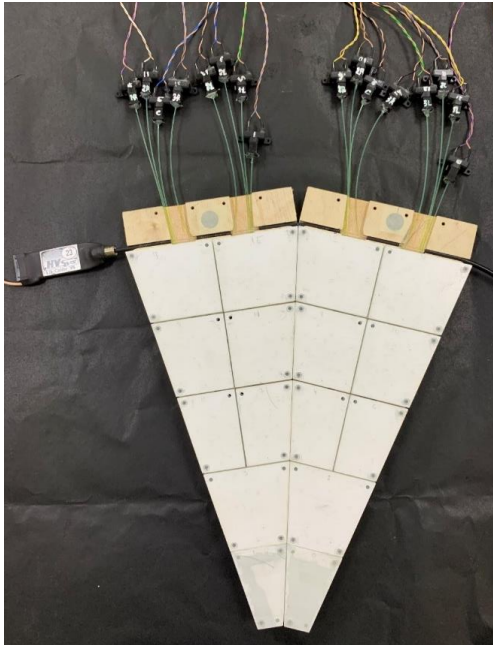


- ✓ the problem with the connector
- ✓ perfect alternative of cosmic rays
- ✓ less acquisition time

- explain the disparity for prototype channels
- application for current backplate design

are required

Previos backplate design

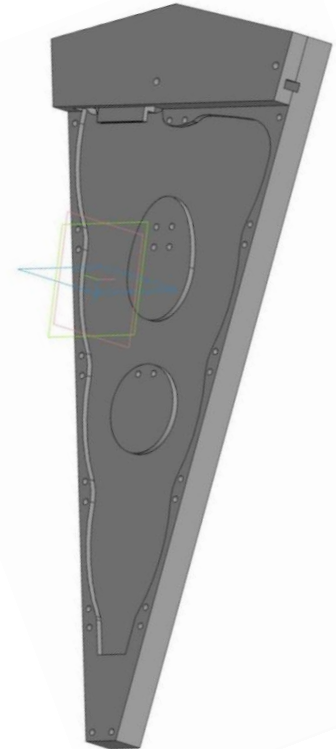
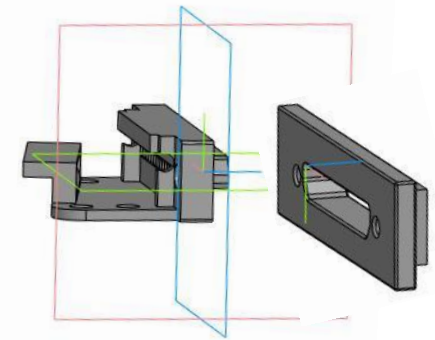


Current backplate design

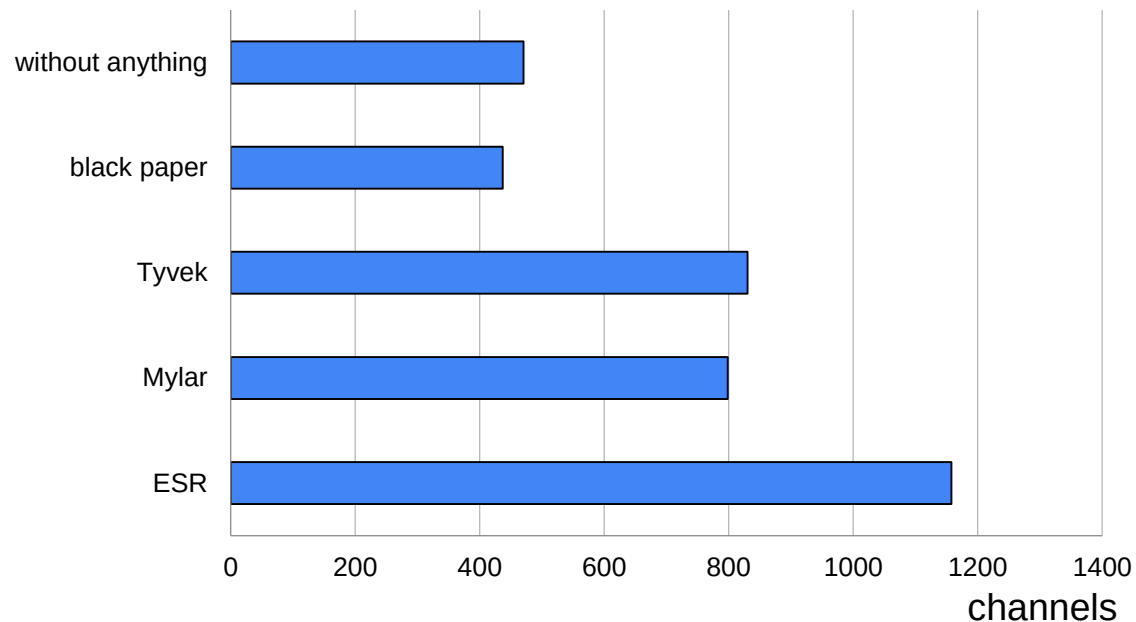


✓ the verification method by SGF has been implemented

- ✓ fast method (immediately + the changes over time)
- ✓ useful for small prototype wheel



Comparison of the reflective materials



3M™ Enhanced Specular Reflector Films (**ESR**) maximize the recycling efficiency of liquid crystal display backlights. 3M ESR is >98% reflective across the visible spectrum and contains no metal.

Preliminary

- ✓ Tyvek and Mylar are similar.
- ✓ **ESR** is approximately 40% more efficient.

- ✓ 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 for the **SGF diameter** is **3mm.**
- ✓ The possible method of express sector checking has been proposed. The signal is similar to MIPs. The method is promising for the BBC detector prototype.

to do list:

- finalizing of the QA/QC method;
- test of optical cable and transmission boards main options;

Thank you for the attention!

Backup

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)

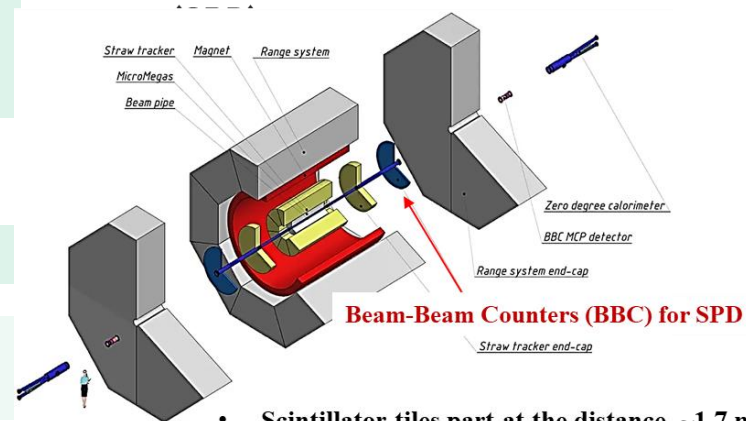
Final options
for Phase ≥1
are:



KURARAY (Y-11)

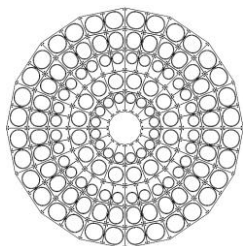
Hamamatsu
(S14160-1315PS)

Spin Physics Detector (Phase1)



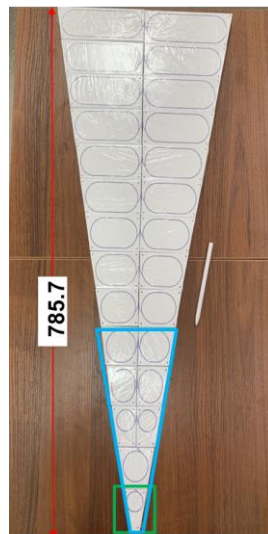
Phase0

(2*128 tiles wheels)



(Step 1-st)

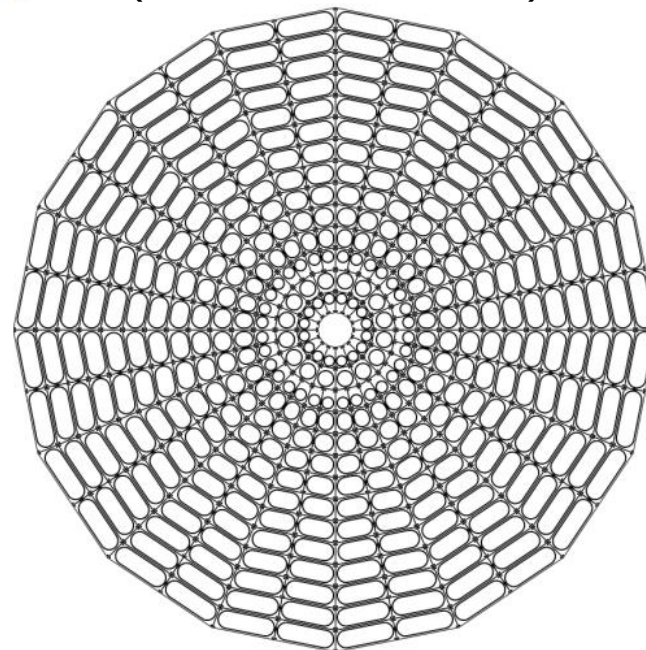
BBC Sector (1/16 of wheel) design



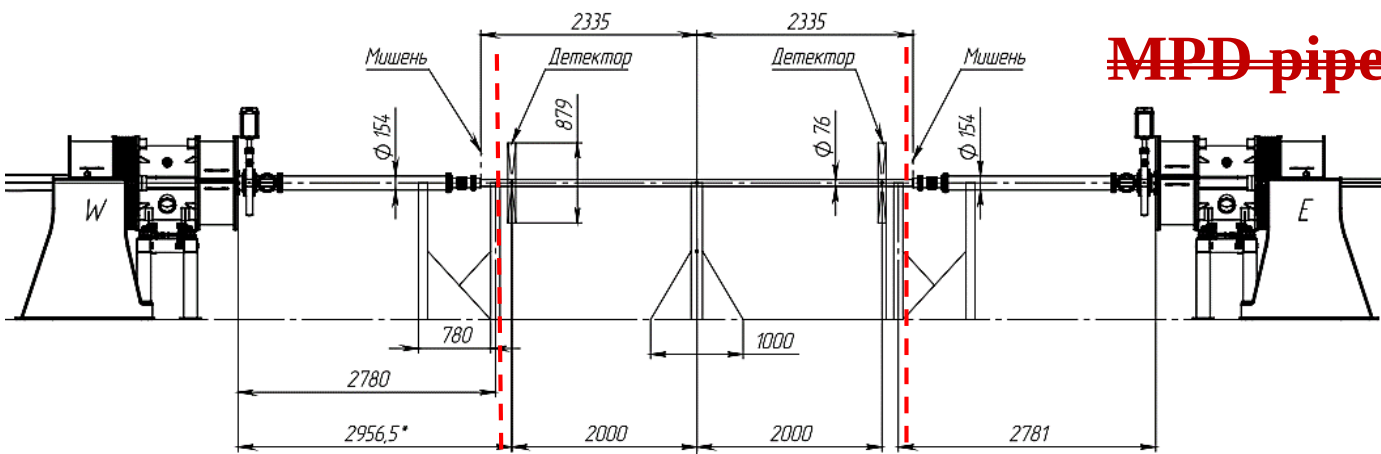
Intermediate step (two sectors)
skill + changes (?)

Phase1

(2*416 tiles wheels)



(Step 2-nd)



~~MPD pipe~~

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

Needs:

2 Wheels 128 scintillator tiles each

-scintillator -yes

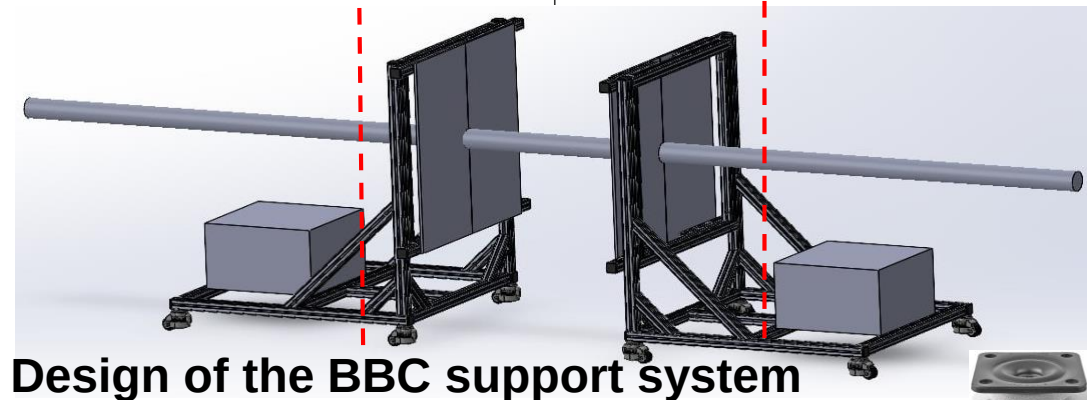
-WLS – yes

- SiPM – yes

DT5202 – yes

DT5215 – yes

Optical fiber – yes



Design of the BBC support system

In progress



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

ООО «НПК Динамика»
(700x500x50 mm³)

purchase is agreed

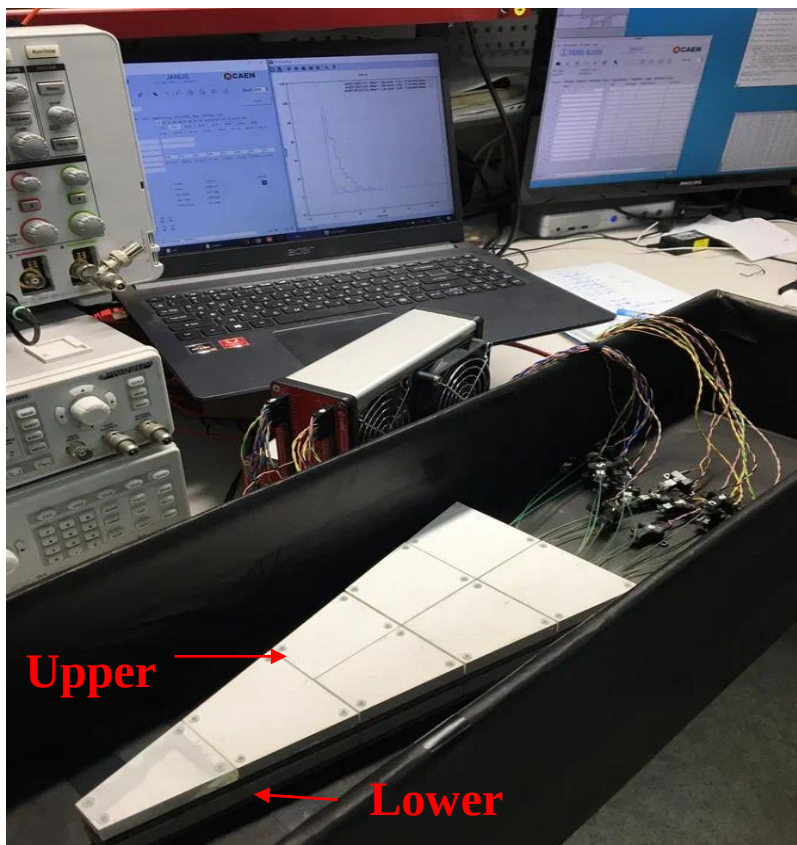


thanks to V. Poliakov

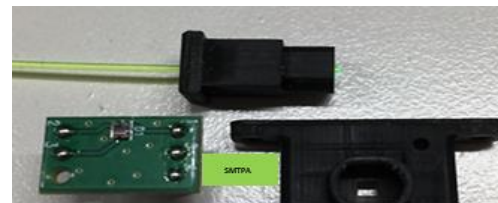
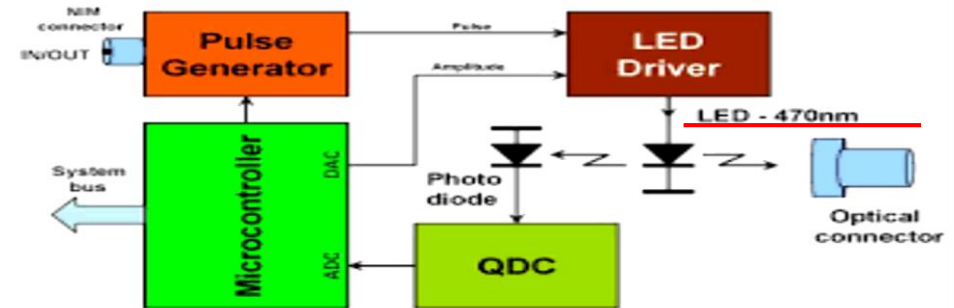
CAEN FERS 52XX is an extendable high speed front-end readout system

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

Stand for BBC measurements



Schematic view of the LED

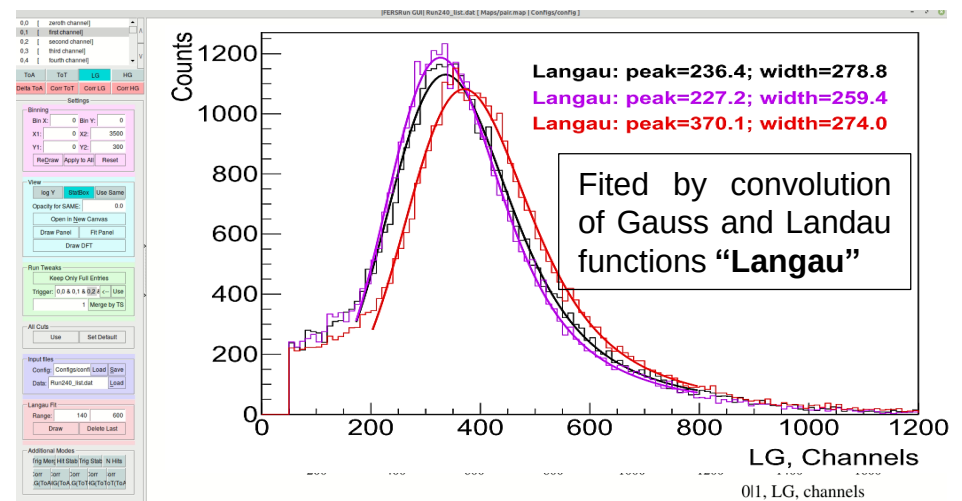


SiPM SensL 1x1 mm²
(MicroFC-10035 SMTPA)



Diameters of SGF

The “FersRun” framework has been designed.



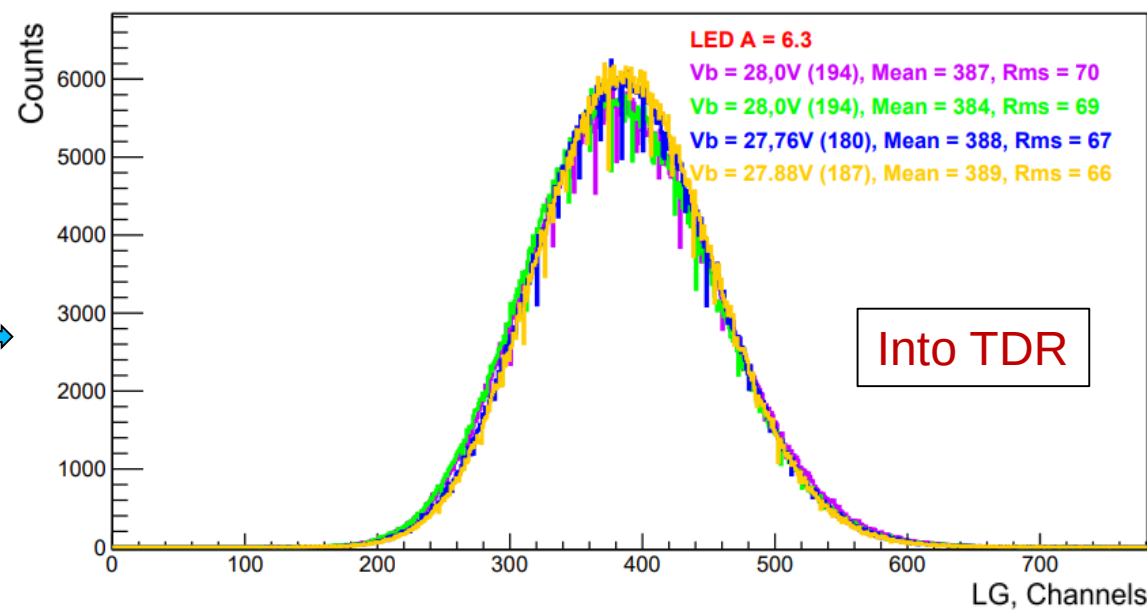
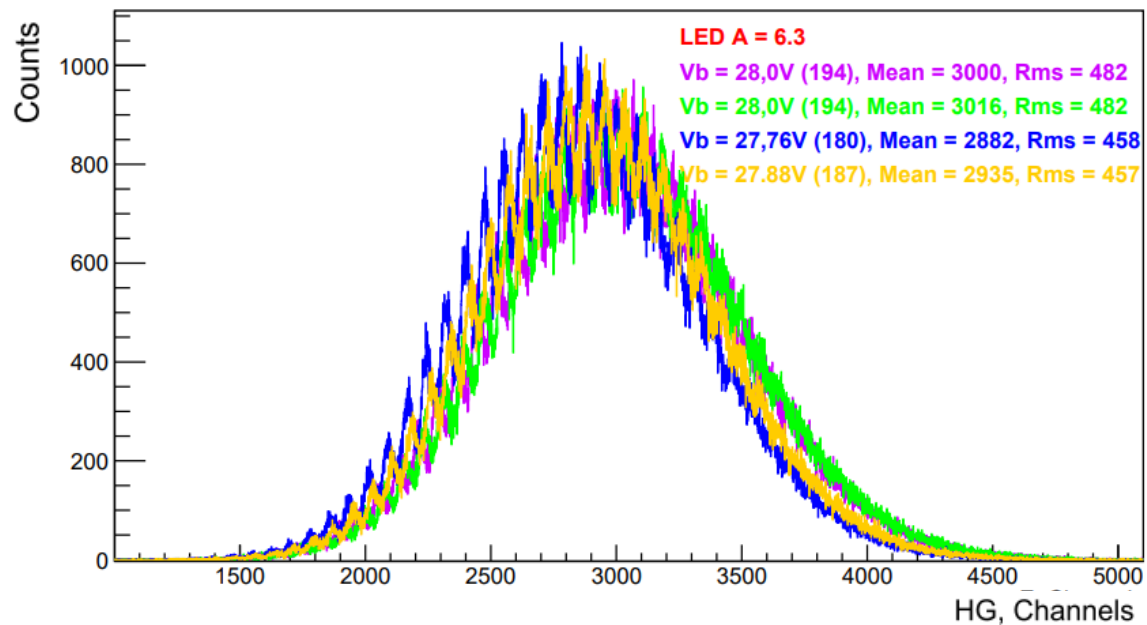
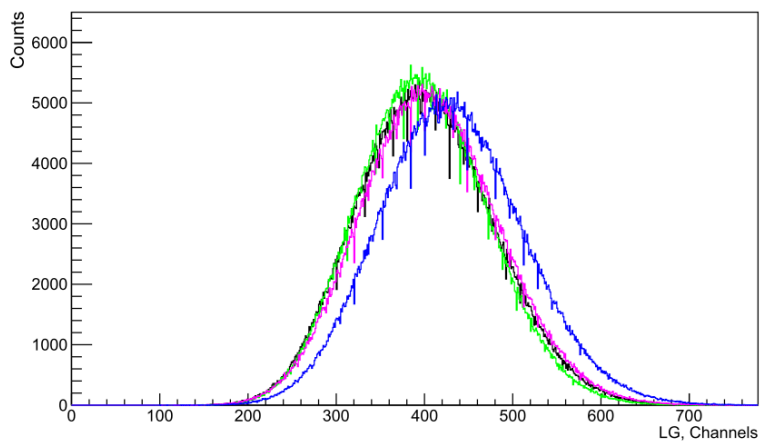
The hardware of BBC tests part

Calibration method (Led source)

DT5202 with CAEN LED Driver (SP5601)

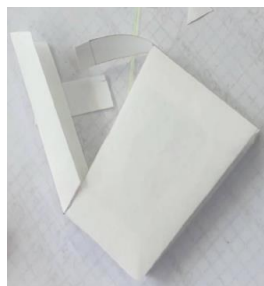


Not calibrated



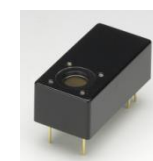
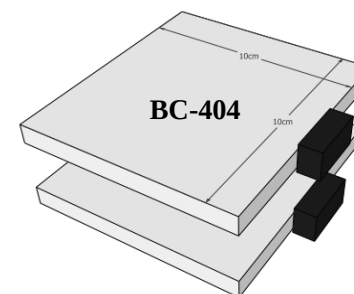
Materials selection test part

Scintillator cover



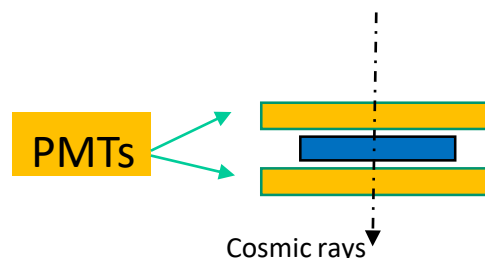
The amplitude spectra of the BBC prototype scintillation tile coated with **Mylar** or **Tyvek**, as well as covered with **Matted** options.

External trigger by coincidence of two scintillators with PMTs readout



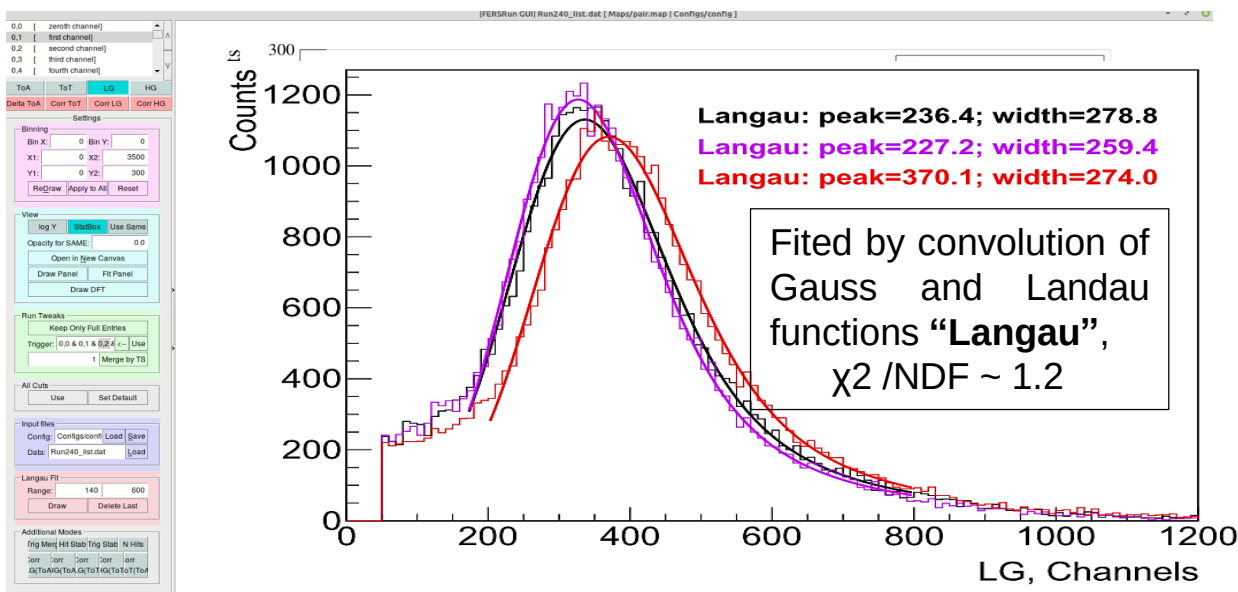
PMT
Hamamatsu
H10720-110

The “FersRun” framework has been designed.



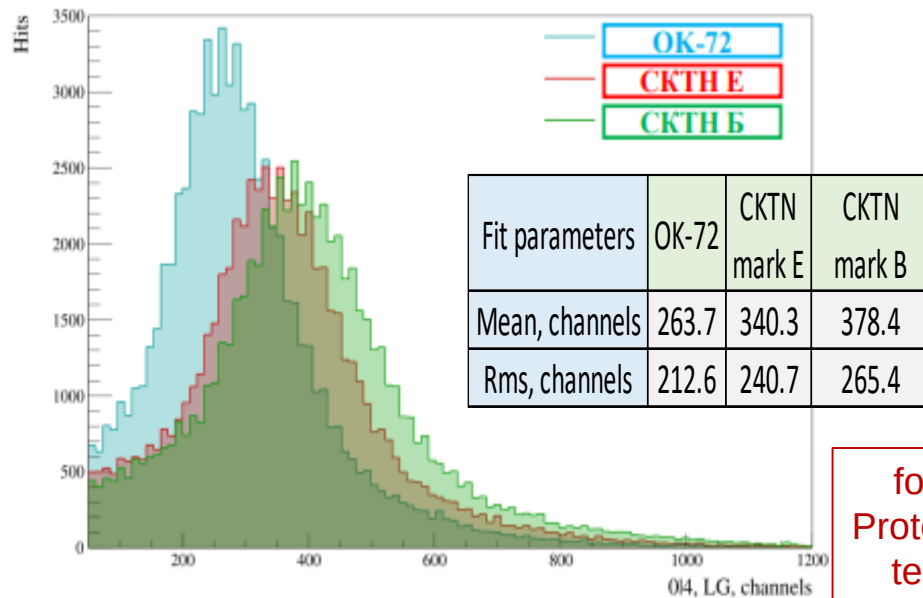
Matted
or
Mylar
or
Tyvek

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



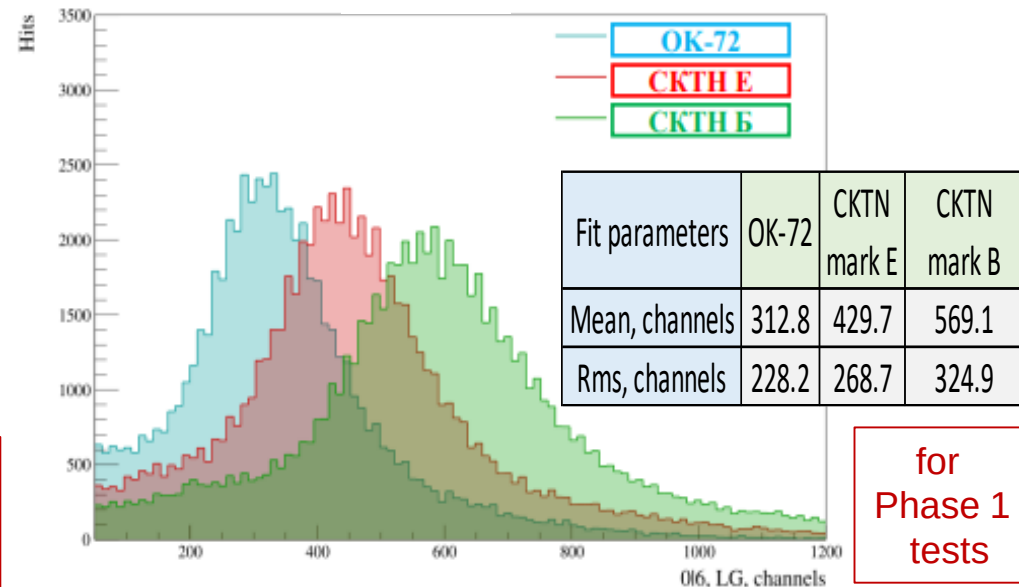
❑ The option with **matted tiles** is more priority for mass production.

SGC BCF92



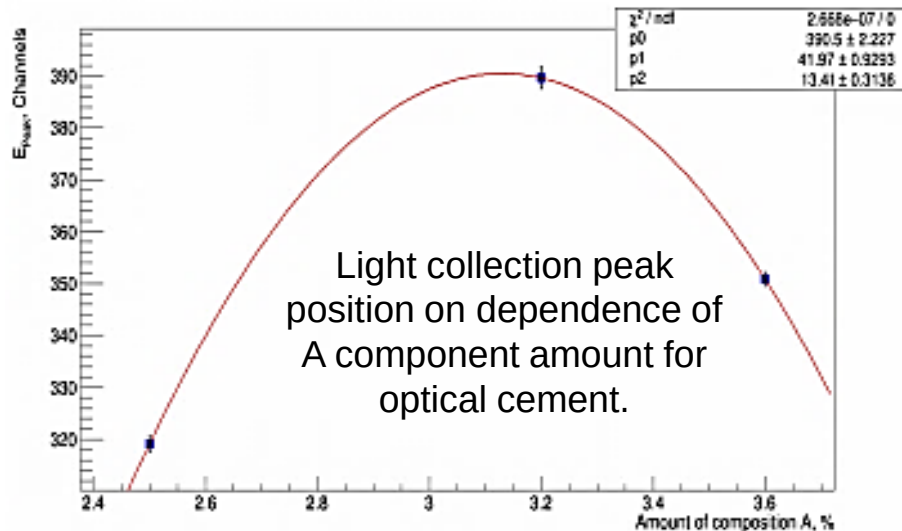
for
Prototype
tests

Kuraray Y-11



for
Phase 1
tests

CKTN

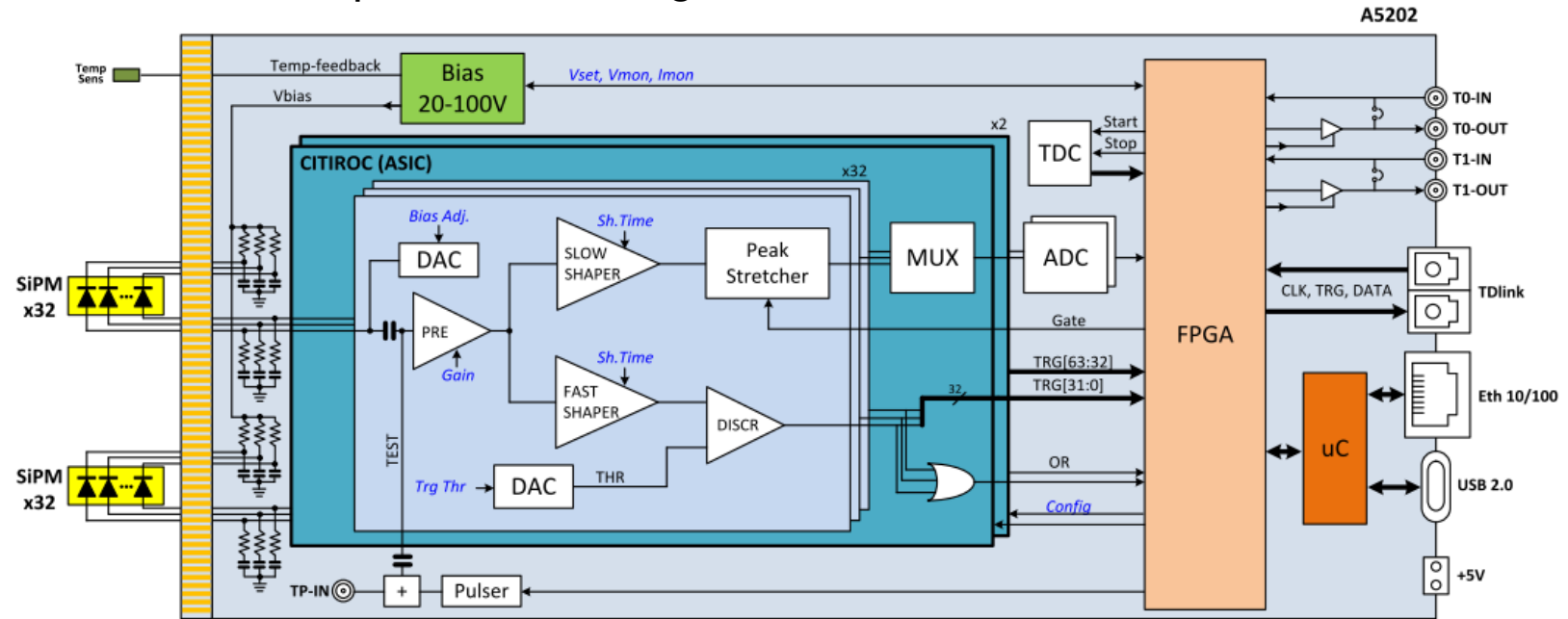
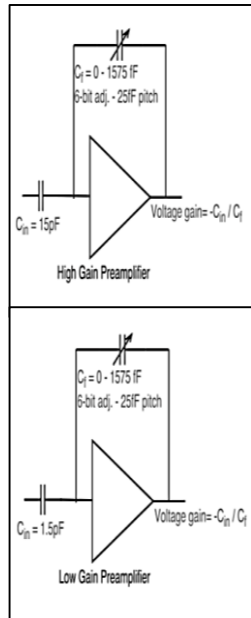


- ❑ Datasheet ratio will be used and closely monitored for mass production.

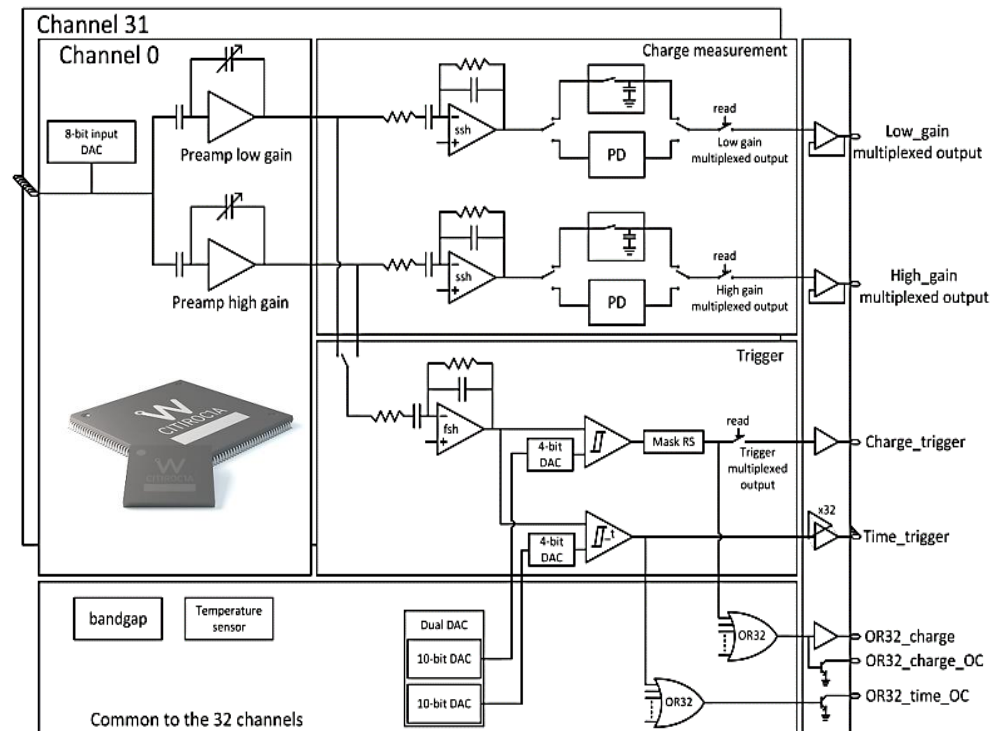
The results of tests of Kuraray WLS fiber and Saint-Gobain Crystals (SGC) WLS fiber with different types of cement are presented.

- ❑ **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**.

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.