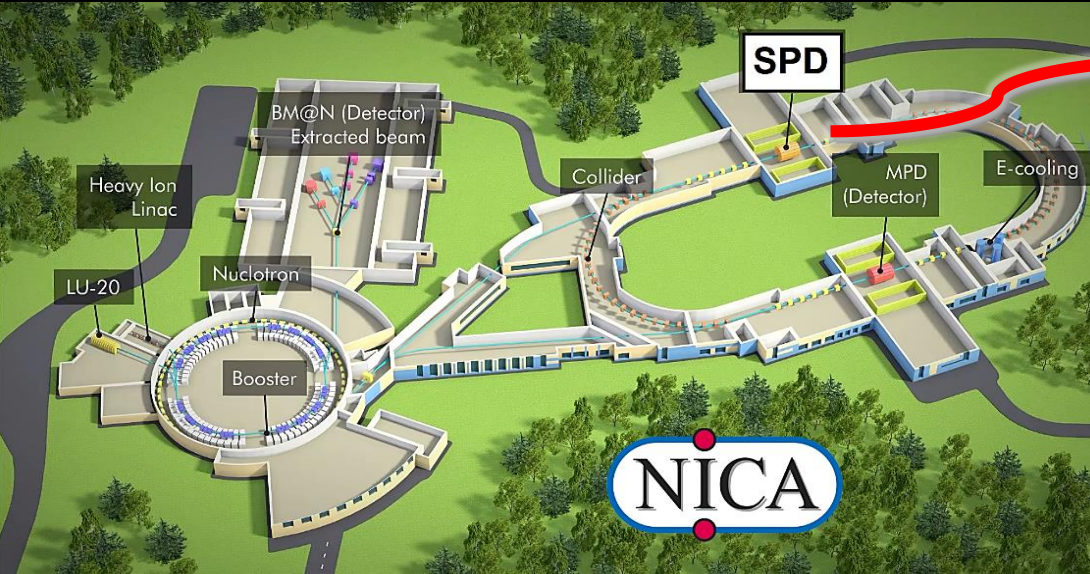
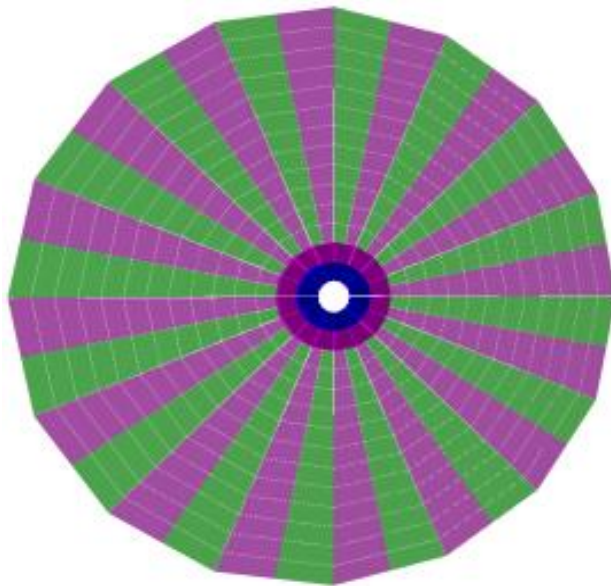


**The scintillation detector prototype of an extended version
of the SPD Beam-Beam Counter detector**

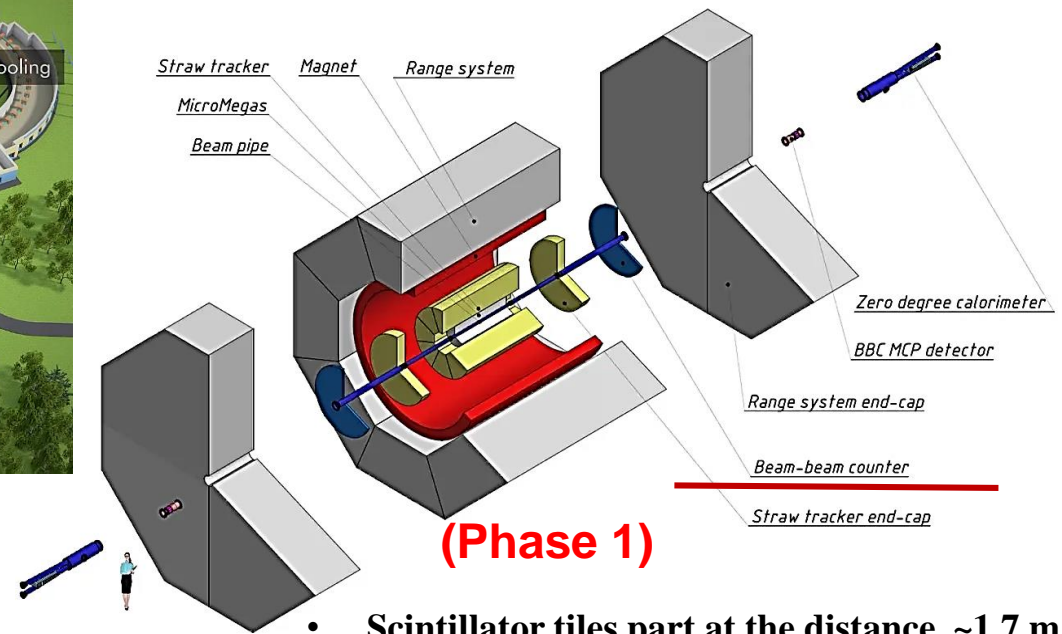
A.V.Tishevsky



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



The Spin Physics Detector (SPD)



(Phase 1)

- Scintillator tiles part at the distance ~ 1.7 m

The Beam-Beam Counters (BBC) for SPD

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

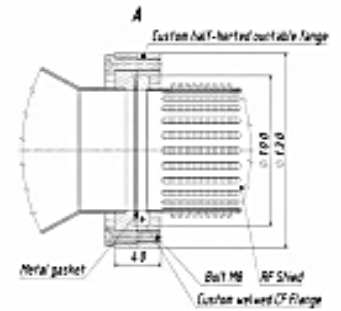
The main purpose of BBC is the permanent monitoring of the beam polarization using the azimuthal asymmetry of the inclusive charged particles yield.

Introduction

Extended design



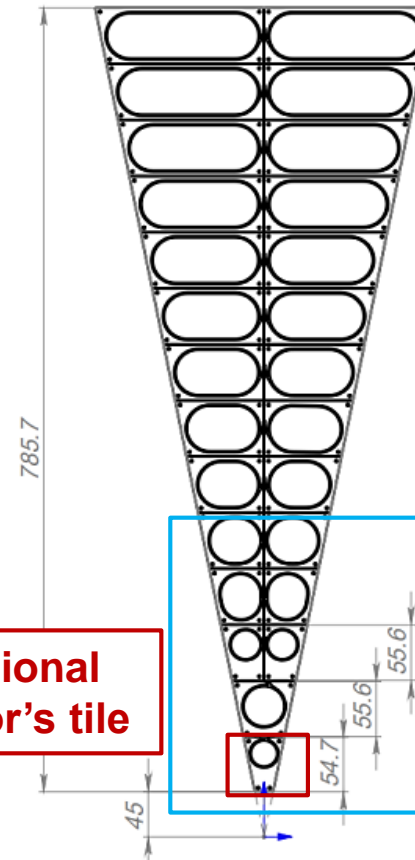
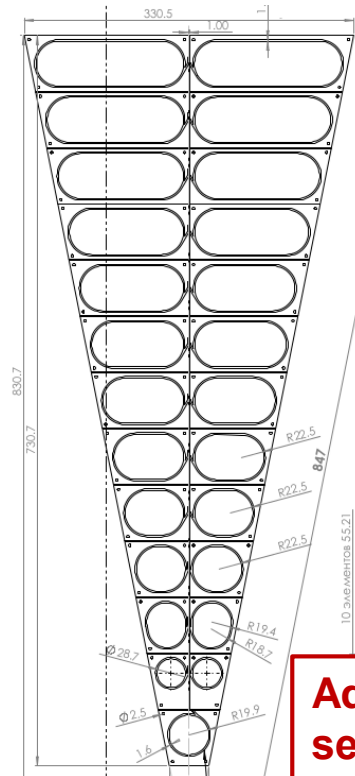
Now : 124 mm diameter
Need: 83 mm diameter



BBC Sector (Ring 1/16) design

25 tiles

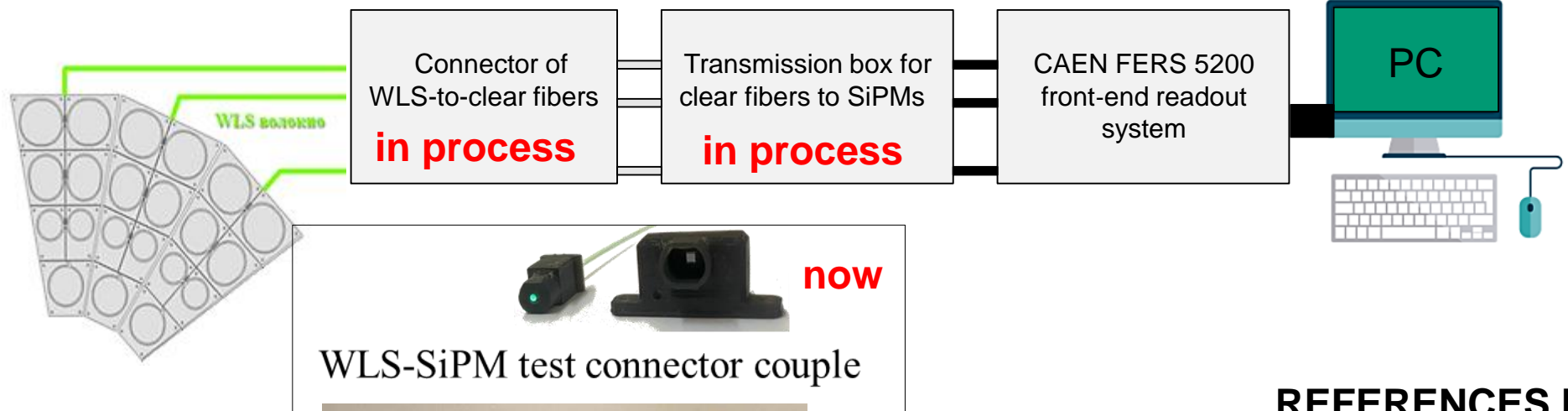
26 tiles



Additional sector's tile

8 channel prototype

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



REFERENCES [1-2]

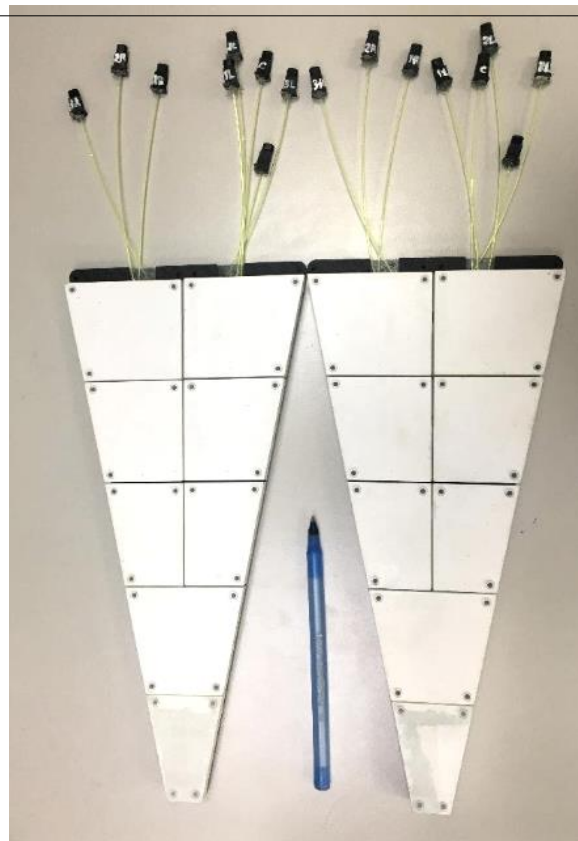
Selected options:

- Scintillator:** **Uniplast-Vladimir (chemical mating)**
- Optical cement:** **CKTN Med mark B**
- Fibers:** **Saint-Gobain Crystals (SG92S)**
- SiPMs:** **SensL 1x1 mm² (MicroFC-10035 SMTPA)**

Readout system: ✓ CAEN FERS-5200



Grooved carbon fiber backplate v1 prototype



2x reduced sector prototype

CAEN FERS 5200 is an extendable high speed front-end readout system

DT5203 (picoTDC chip)

DT5215 (Concentrator)

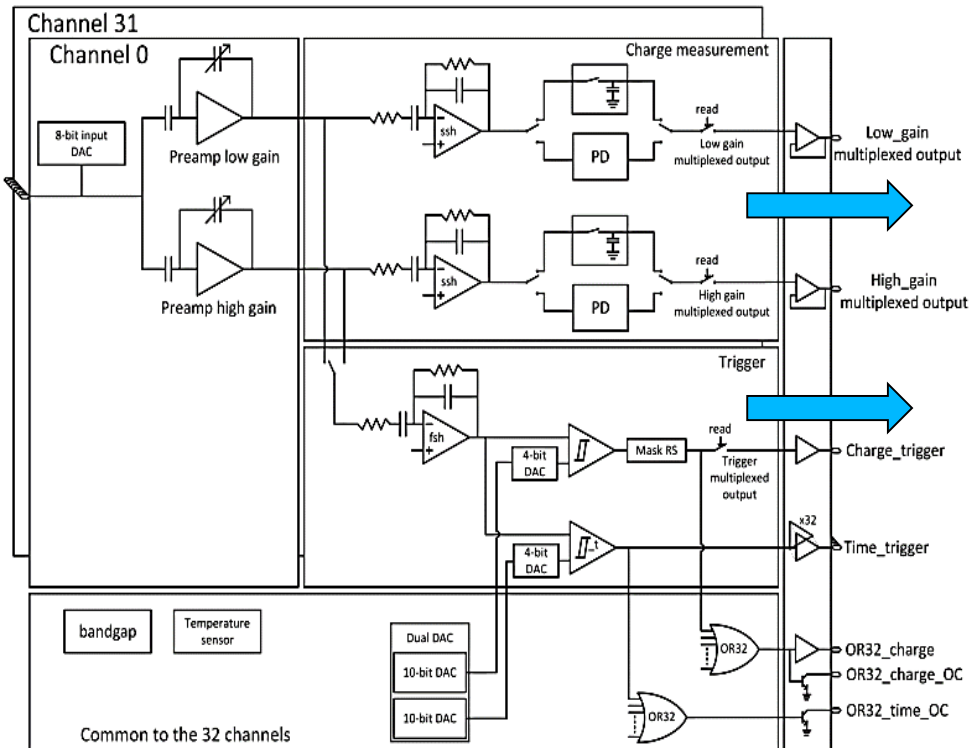
DT5202 (x2 Citiroc 1A chip)



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



Citiroc-1A block scheme



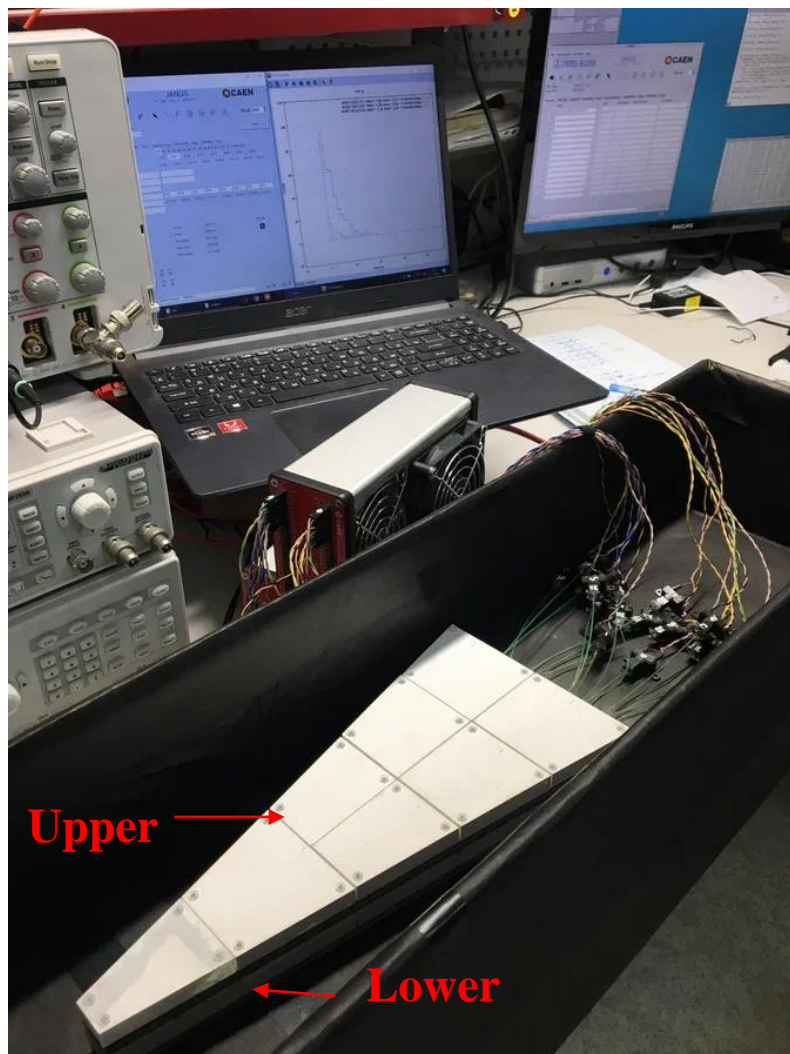
Main Acquisition Modes:

- SPECTROSCOPY → for collibration
- SPECT_TIMING (the Spectroscopy + Timing) → for tests
- **TIMING** → for testbeam & and Phase 1 tests

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

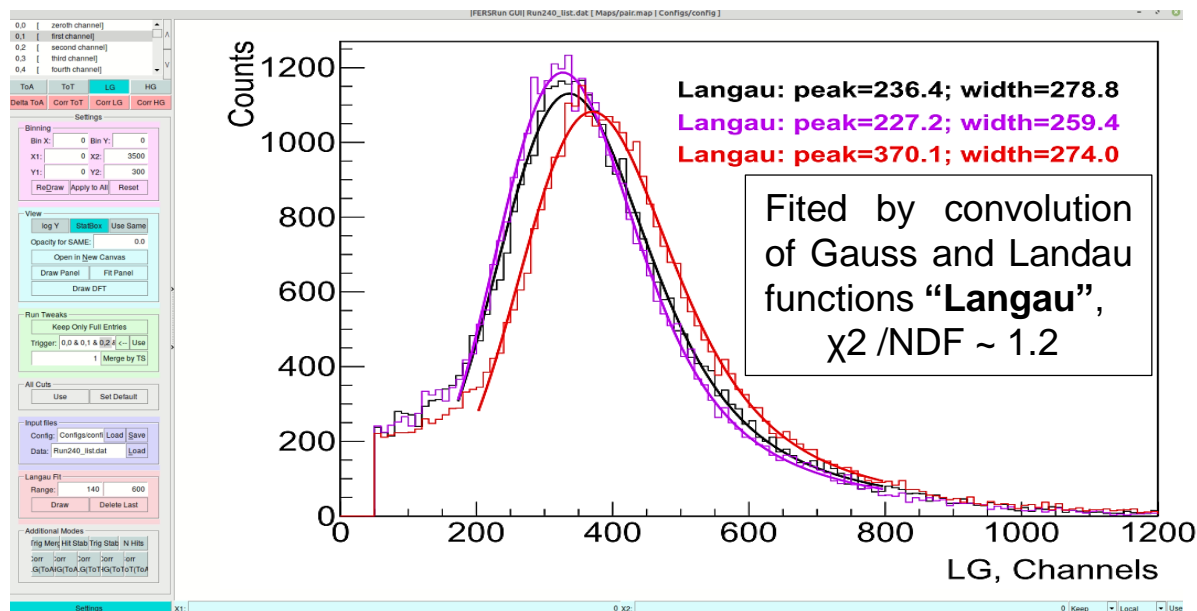
Time of Arrival (**ToA**) and Time over Threshold (**ToT**). **ToT** is giving a rough estimation of energy.

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



Stand for BBC measurements

The “FersRun” framework have been designed.



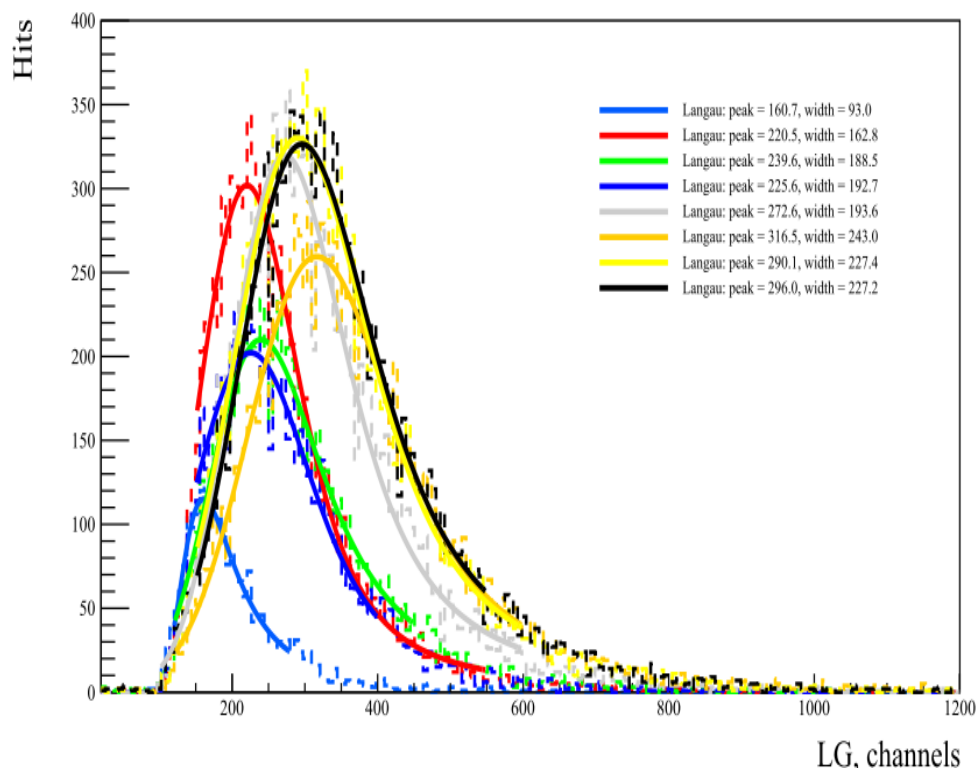
The tests were performed for Hybrid mode with **self-triggering** opportunity. Trigger logic option for DAQ:



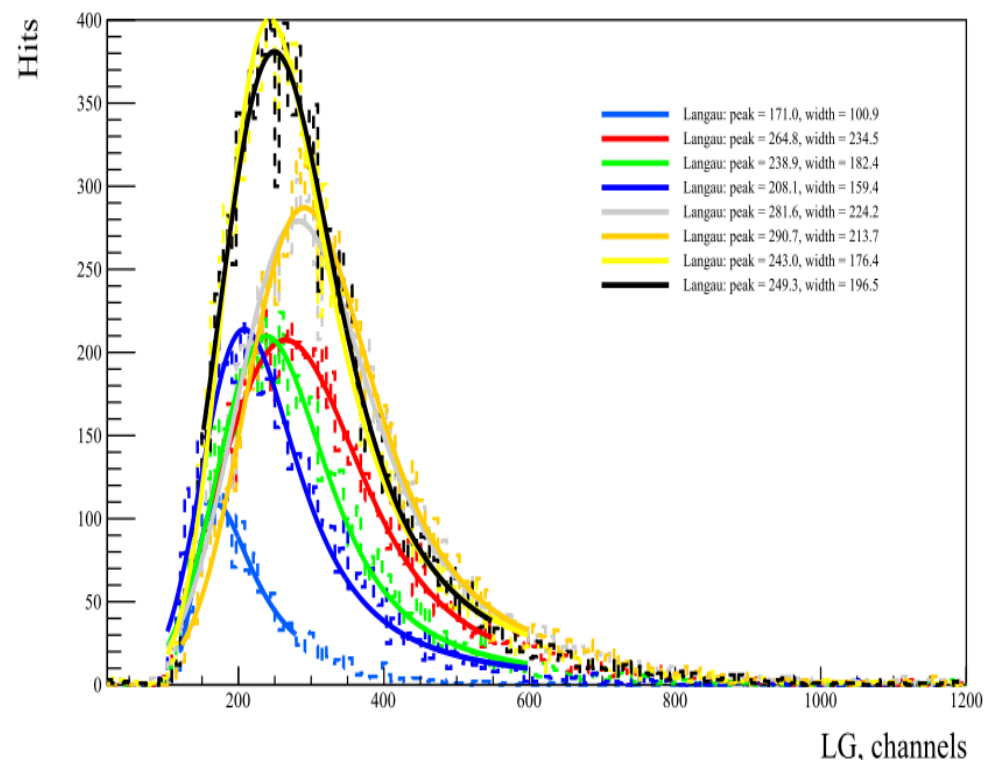
AND2_OR32
Parameter

- 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.

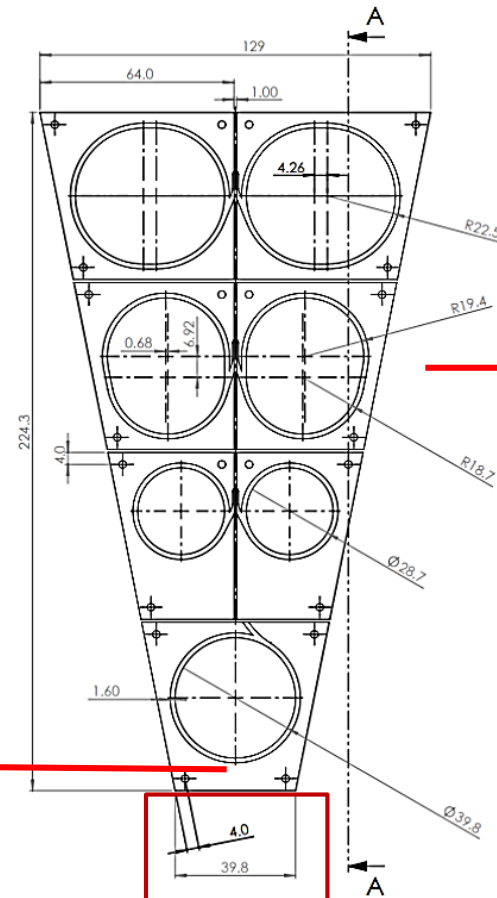
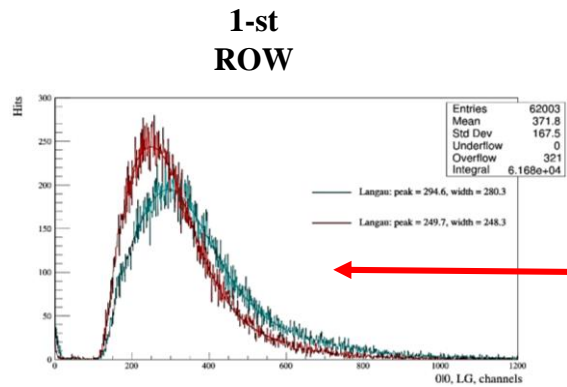
1-st sector prototype



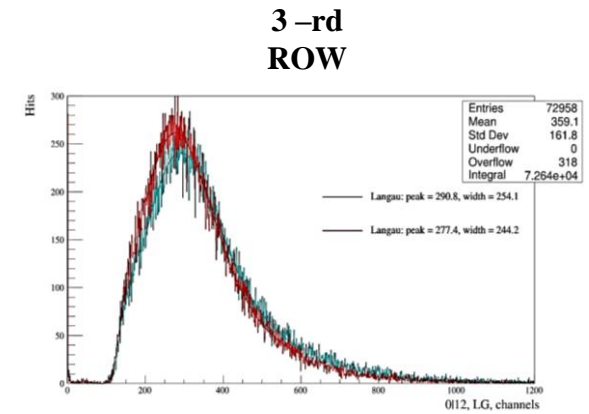
2-nd sector prototype



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

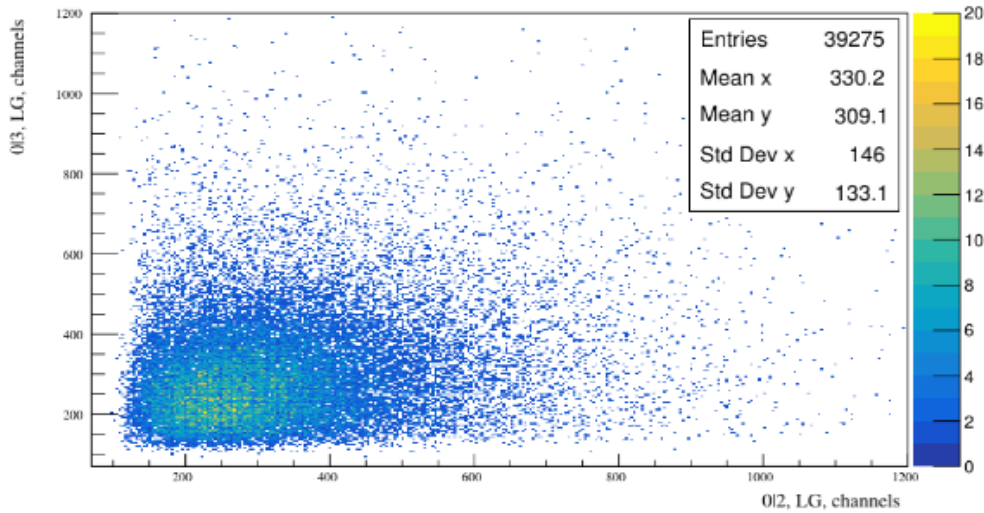


Additional sector's tile

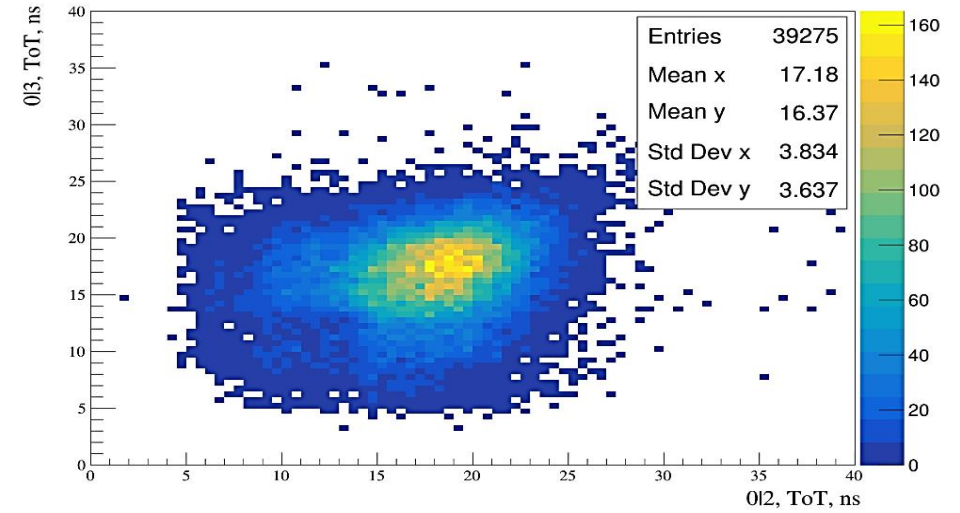


These stable tiles were taken for follow tests

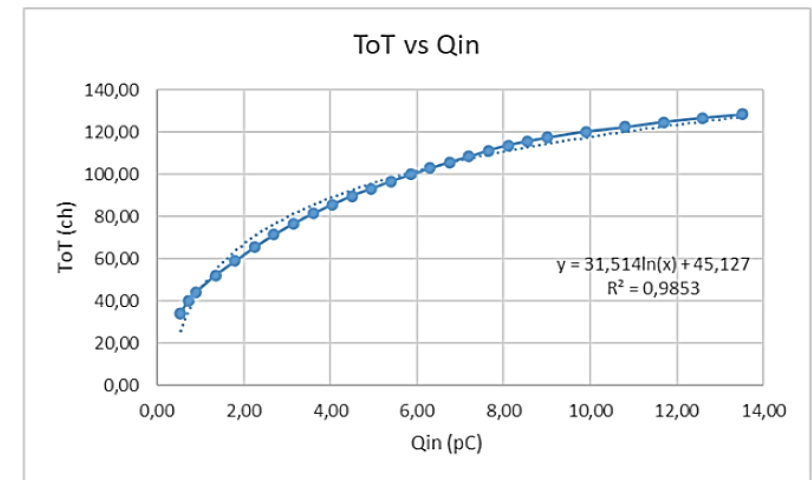
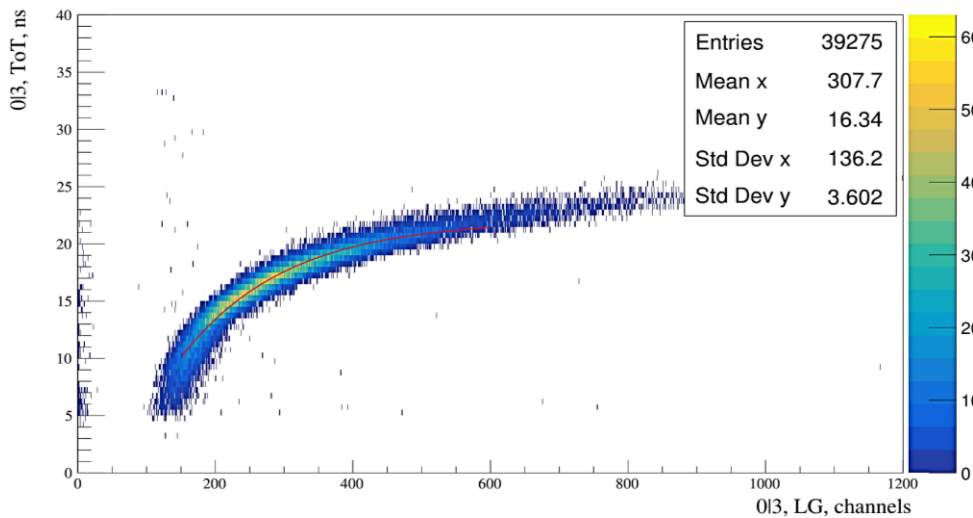
LG correlations



ToT correlations



LG vs ToT (channel №3)



UM6377 – A7585/DT5485 User Manual
www.caen.it/support-services/documentation-area

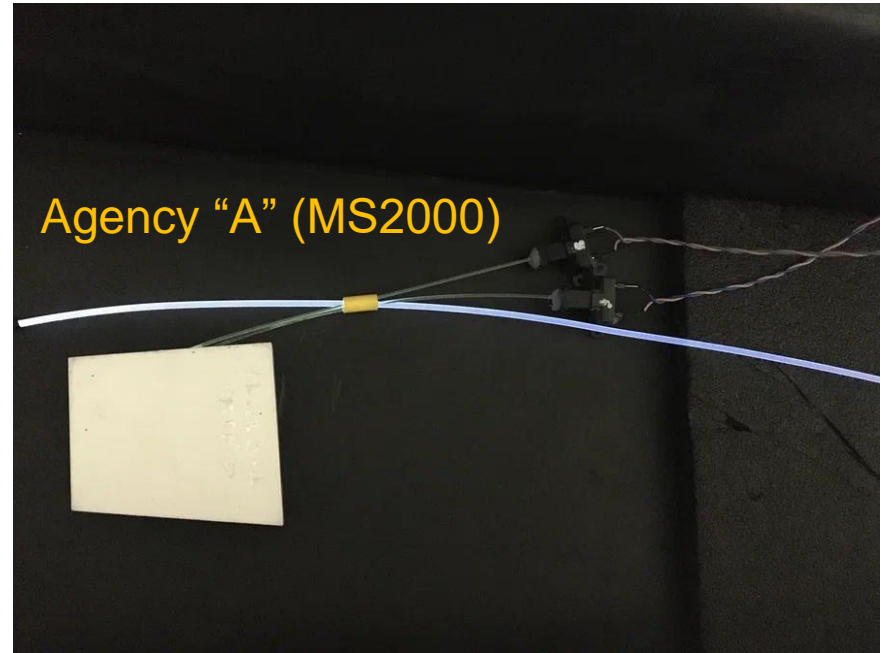
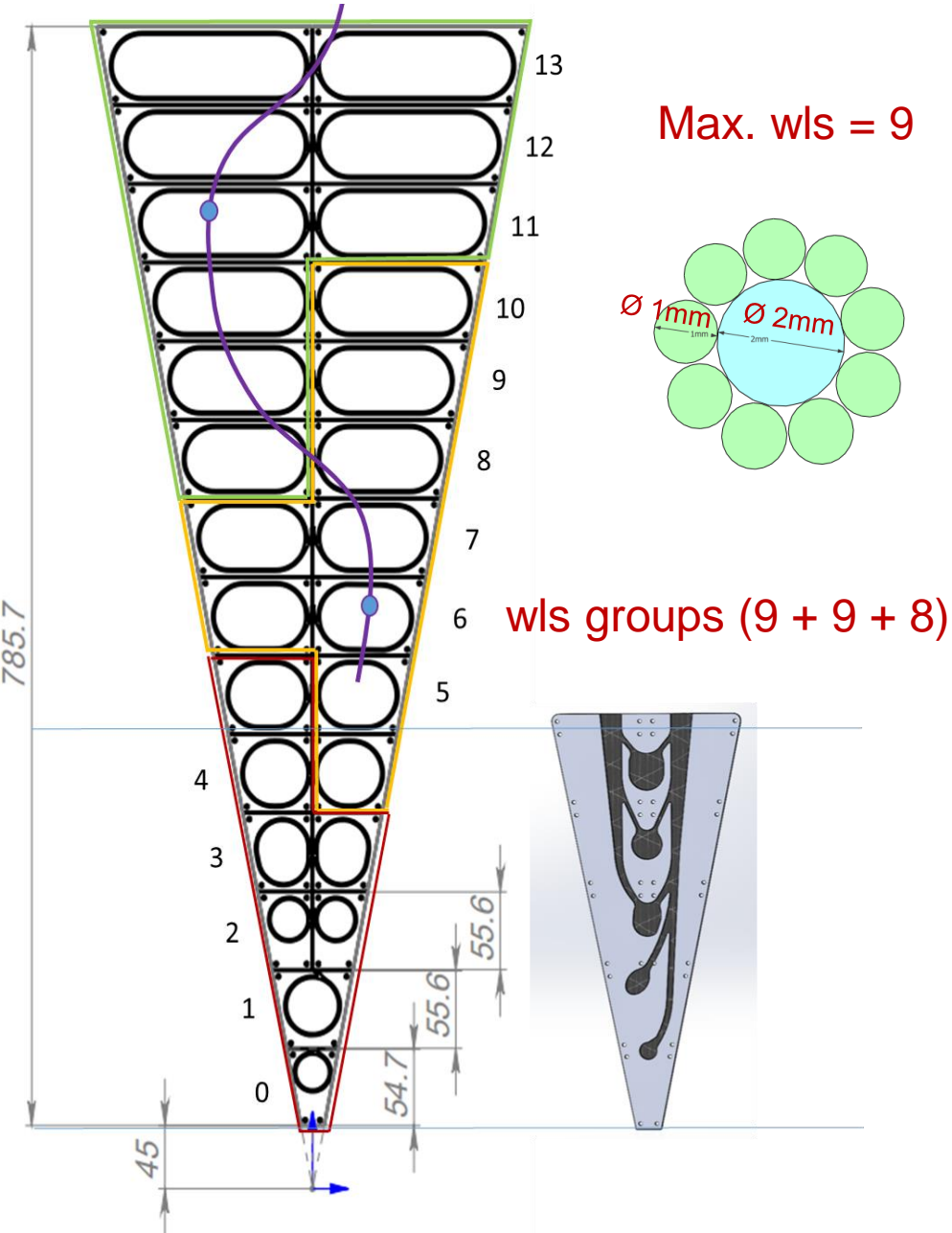
Correlation of energy deposition for 2 channels, as well as the time information for these channels.

- The calibration of the charge scale is required

Prototype assembling test part

The method of fast check of the assembled sector

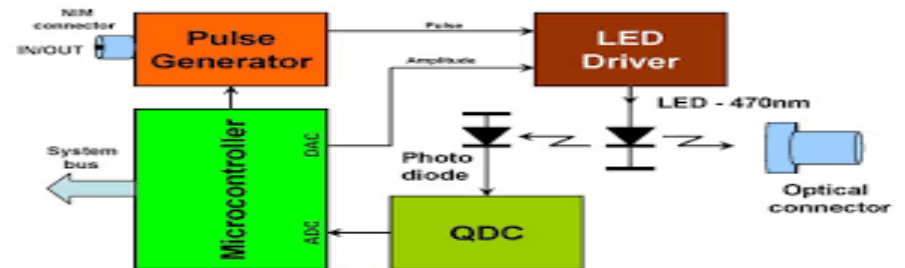
Optical connector (26 + 1)
wls <-> clear + fiber

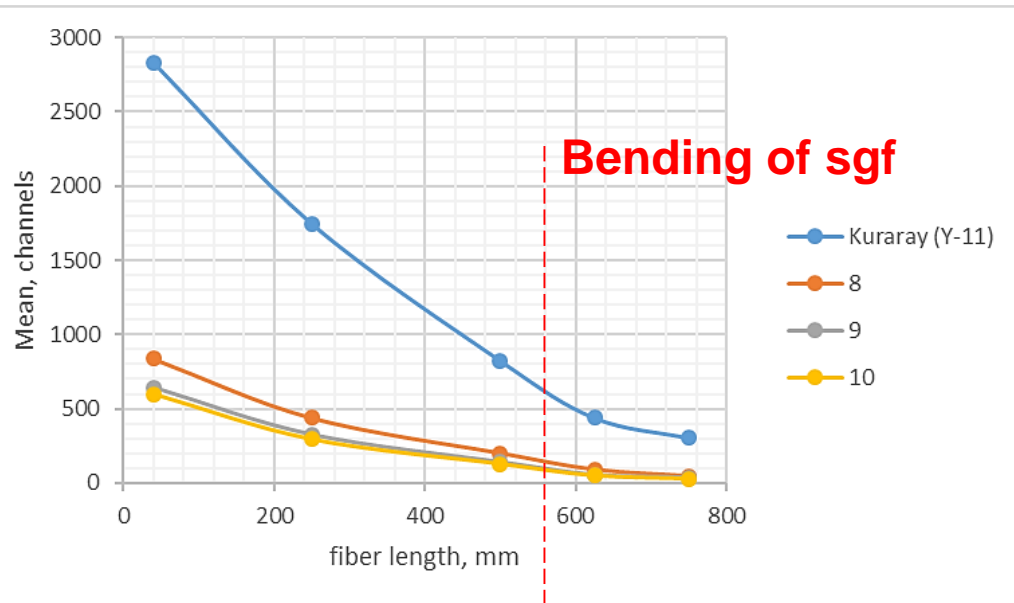
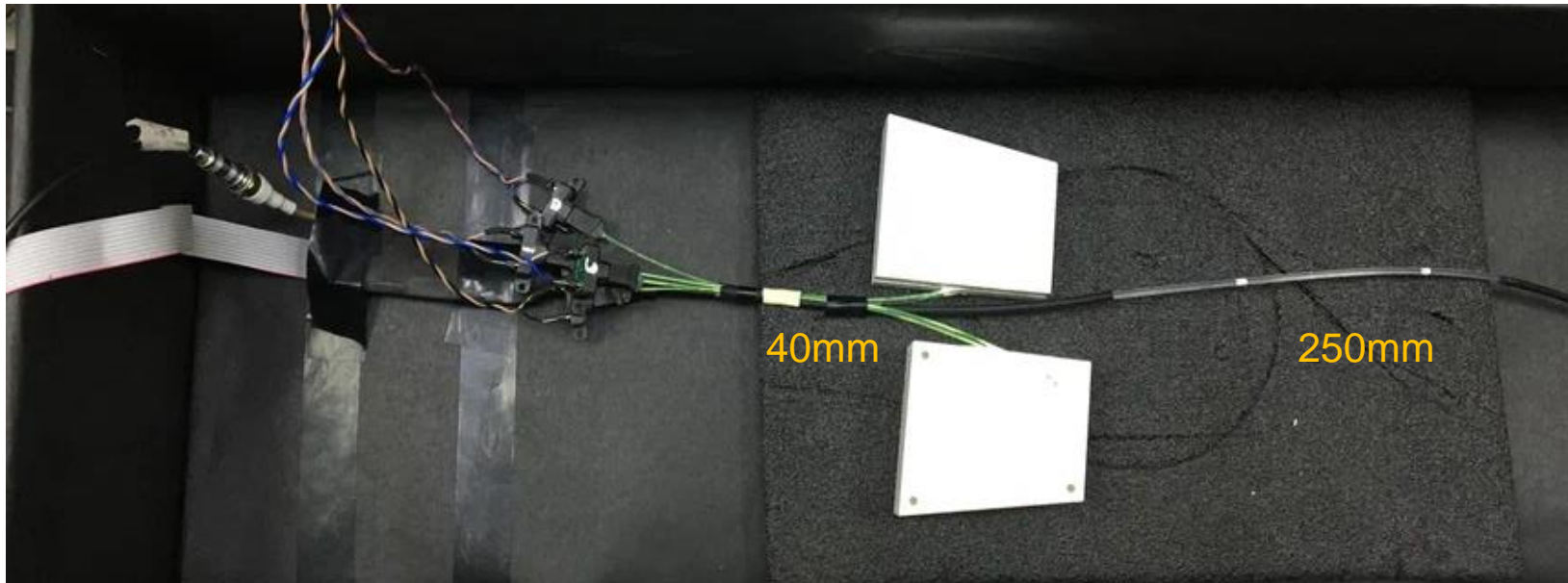


The side glow fiber (sgf) is one of the option



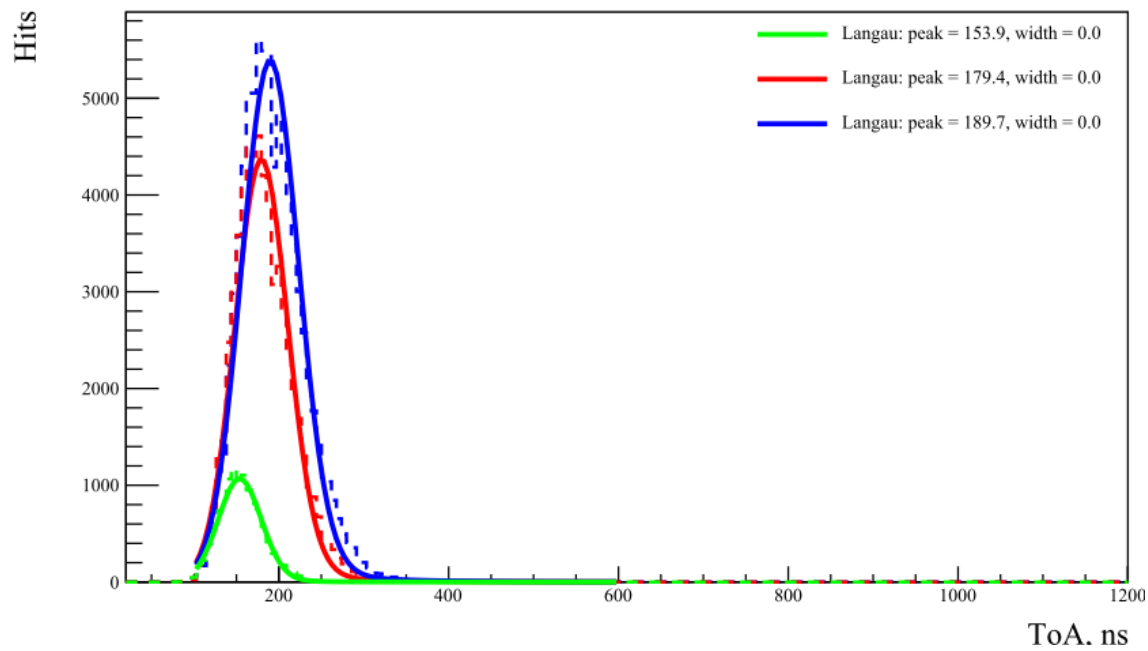
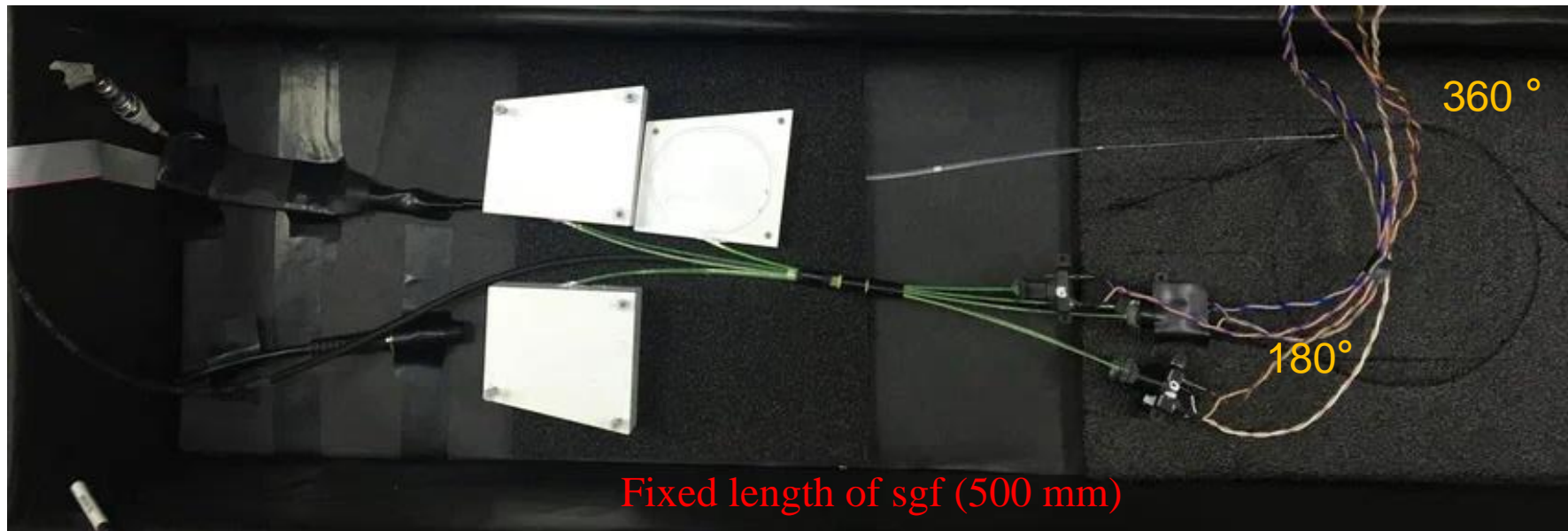
Schematic view of the LED





mm\channel	0	8	9	10
40	2831	840	643	600
250	1747	438	325	295
500	826	200	140	128
625	441	90	55	50
750	305	45	36	28

500 mm ~ 75% lost



bending loses
180° ~ 6%
360° ~ 19 %

- I. The 8-channel prototype with 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 radius of the WLS.
- II. The work of the **ToT function** has been shown, the study of the dependence on the charge **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

Connector development

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

To do list

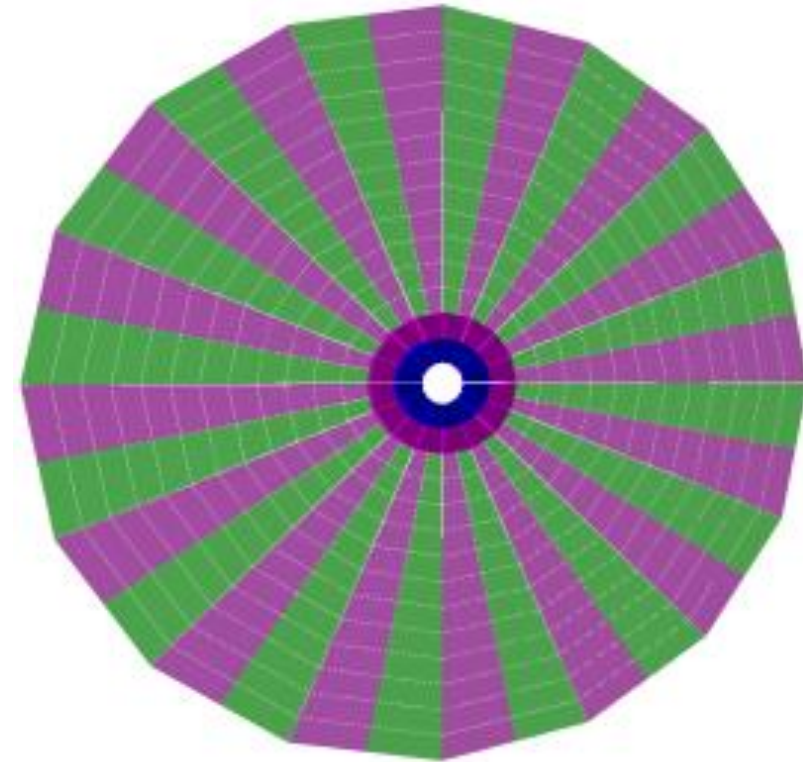
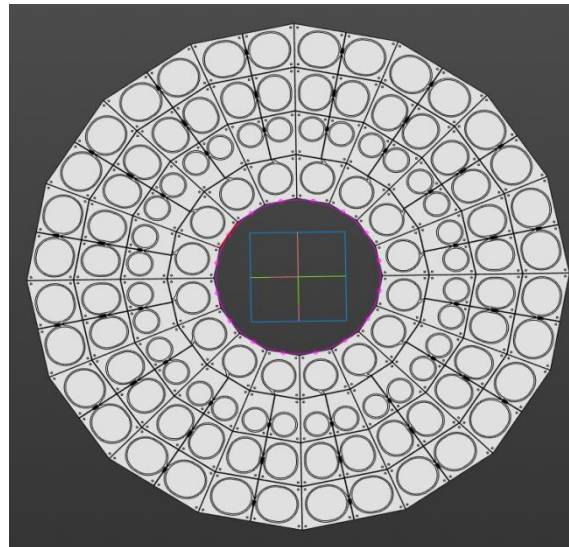
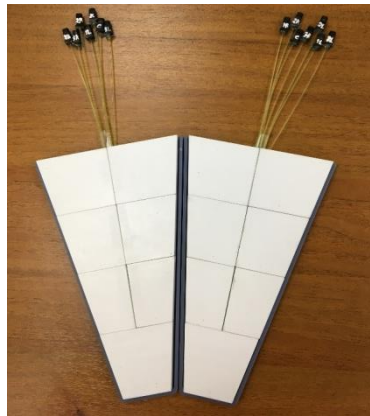
Thank you for the attention!

REFERENCES (A.V. Tishevsky et al.)

1. Physics of Atomic Nuclei, 2024, Vol. 87, No. 4, pp. 450–457.
2. Phys.Part.Nucl. 55 (2024) 4, 1091-1098

Backup

M
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1-st Stage
14 tiles (16?)

2-nd Stage
2 wheels with 112 tiles each (128?)

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

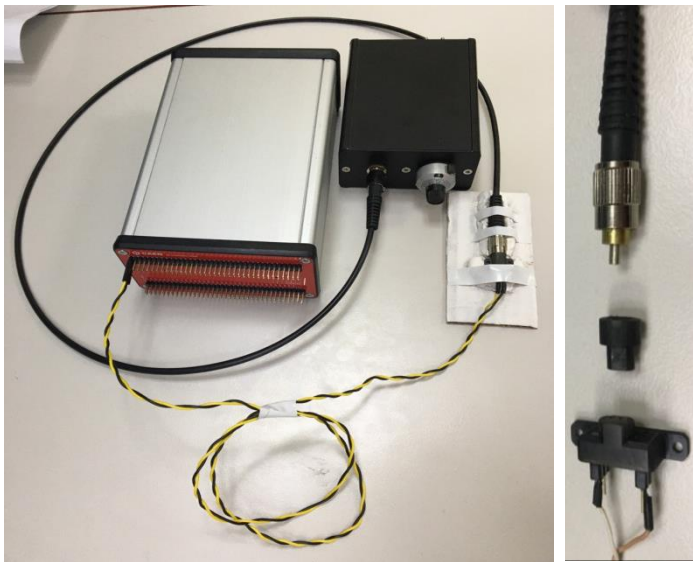
Phase 0

Phases: 1-st & 2-nd

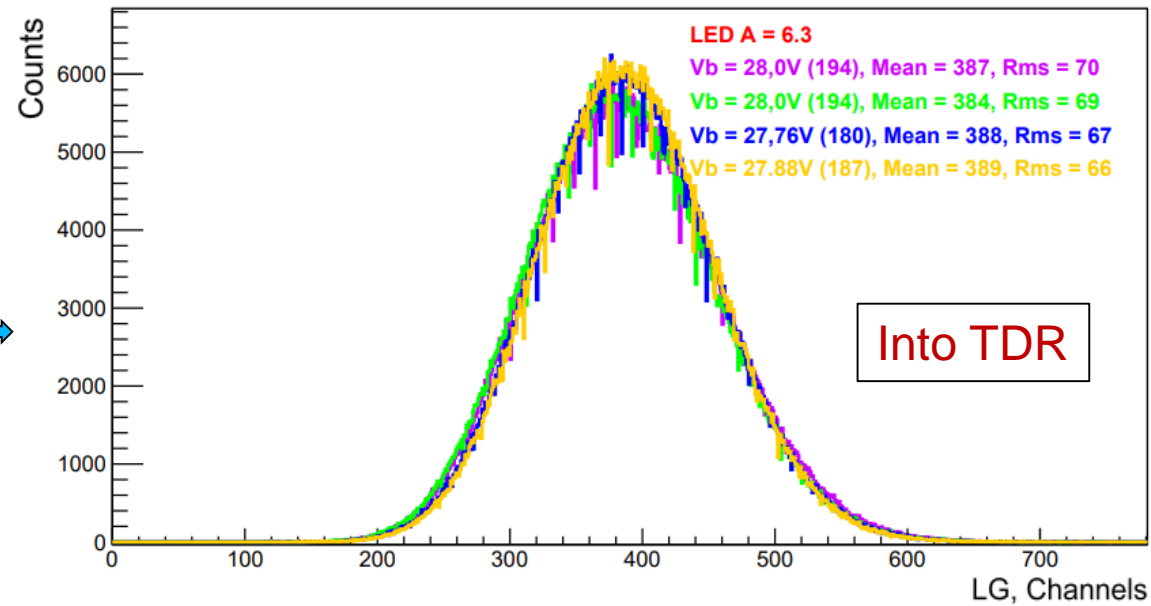
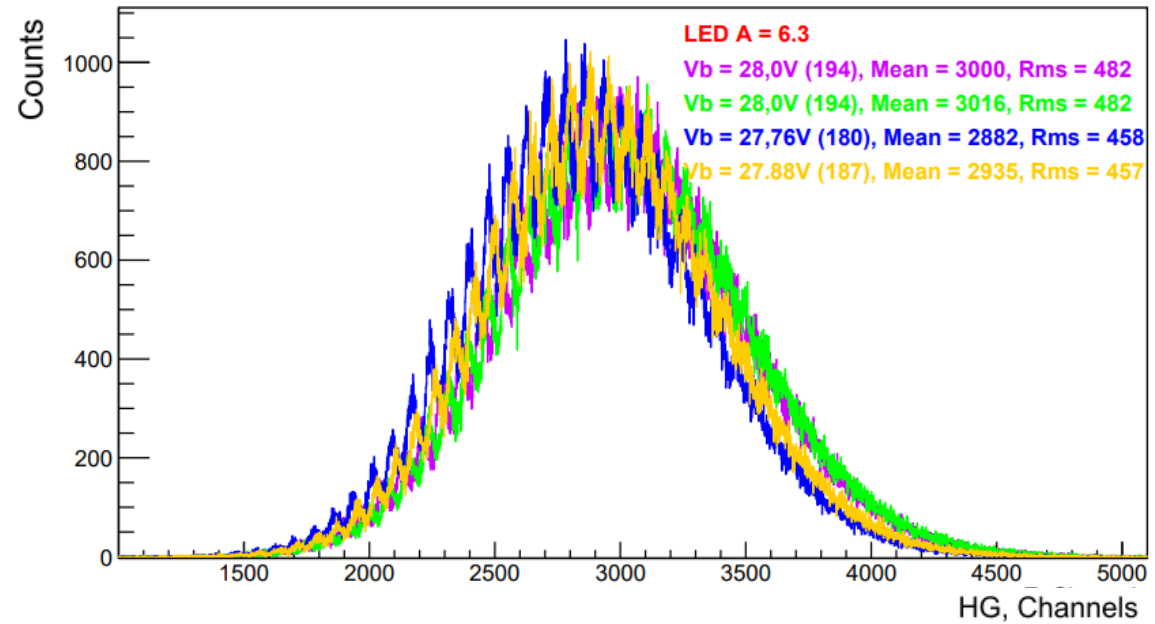
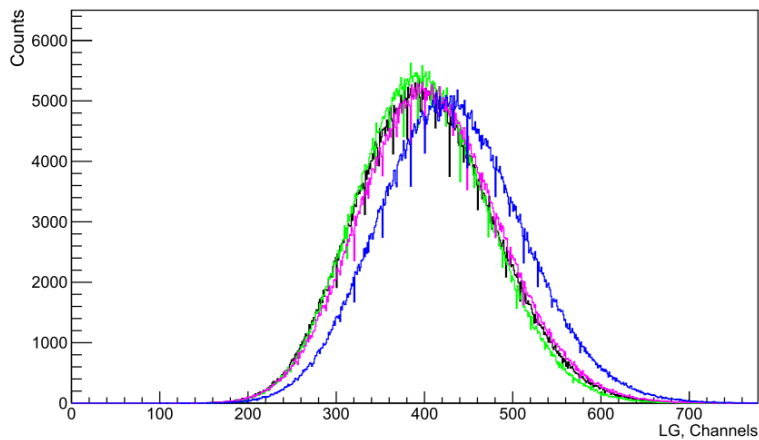
The hardware of BBC tests part

Calibration method (Led source)

DT5202 with CAEN LED Driver (SP5601)

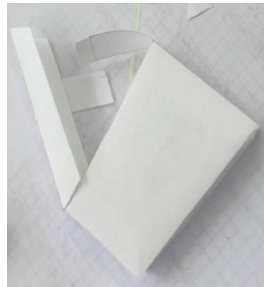


Not calibrated



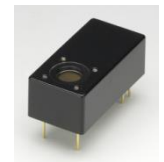
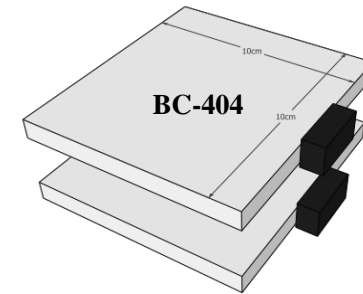
Materials selection test part

Scintillator cover



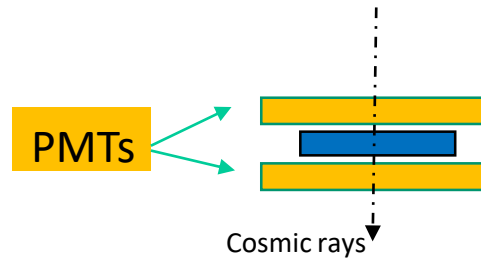
The amplitude spectra of the BBC prototype scintillation tile coated with **Mylar** or **Tyvek**, as well as covered with **Matted** options.

External trigger by coincidence of two scintillators with PMTs readout



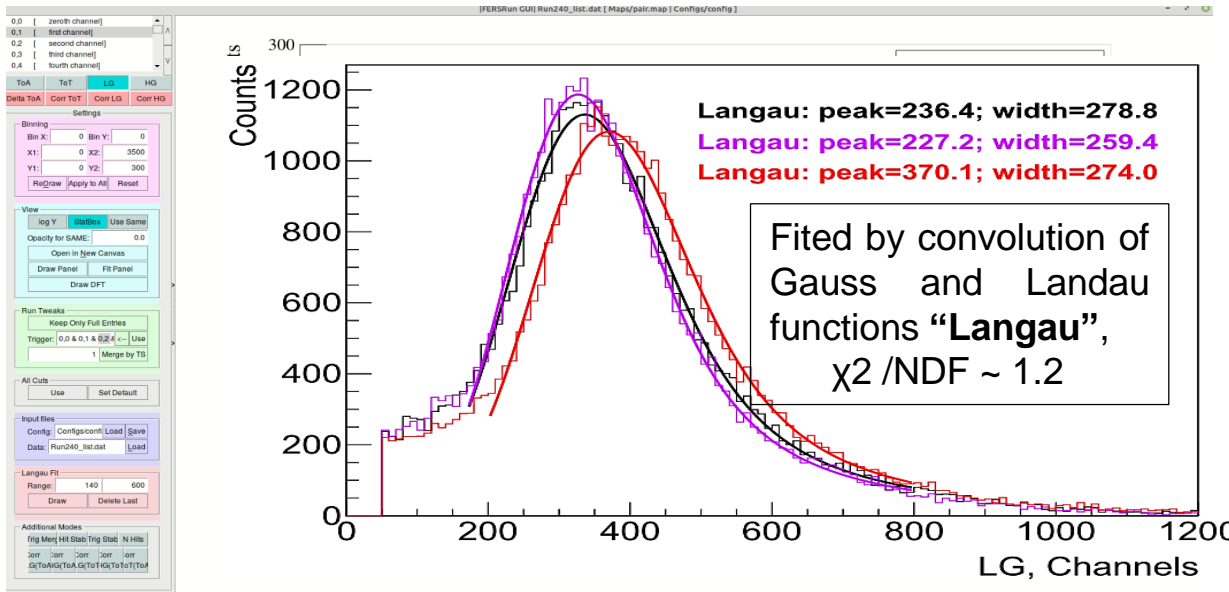
PMT
Hamamatsu
H10720-110

The “FersRun” framework has been designed.



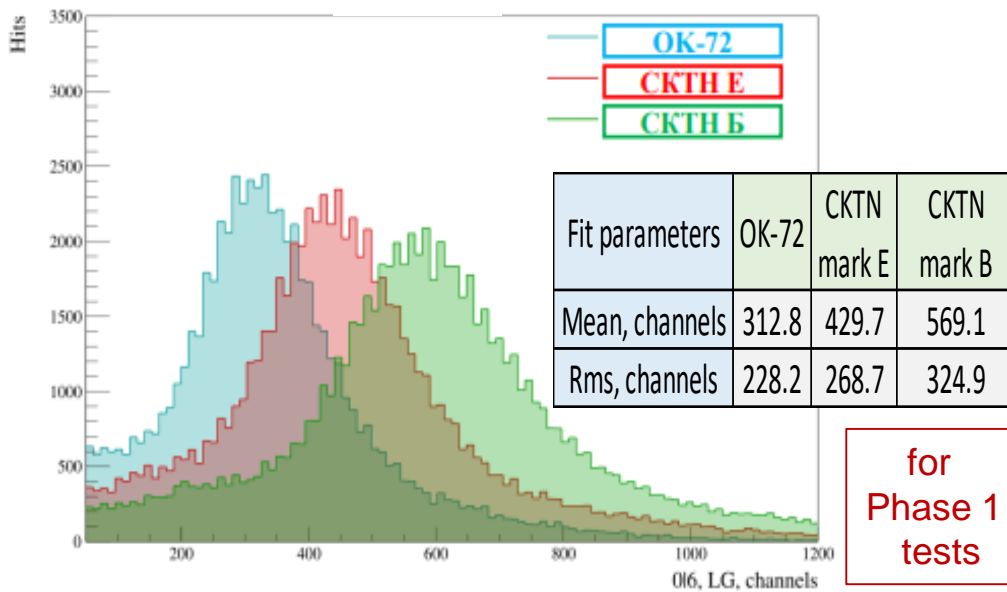
Matted
or
Mylar
or
Tyvek

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



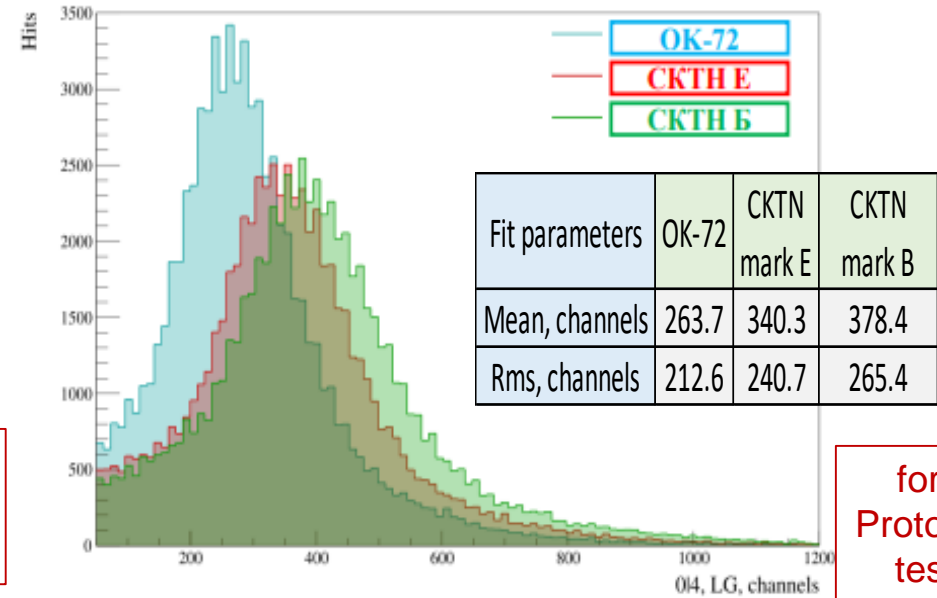
☐ The option with **matted tiles** is more priority for mass production.

Kuraray Y-11



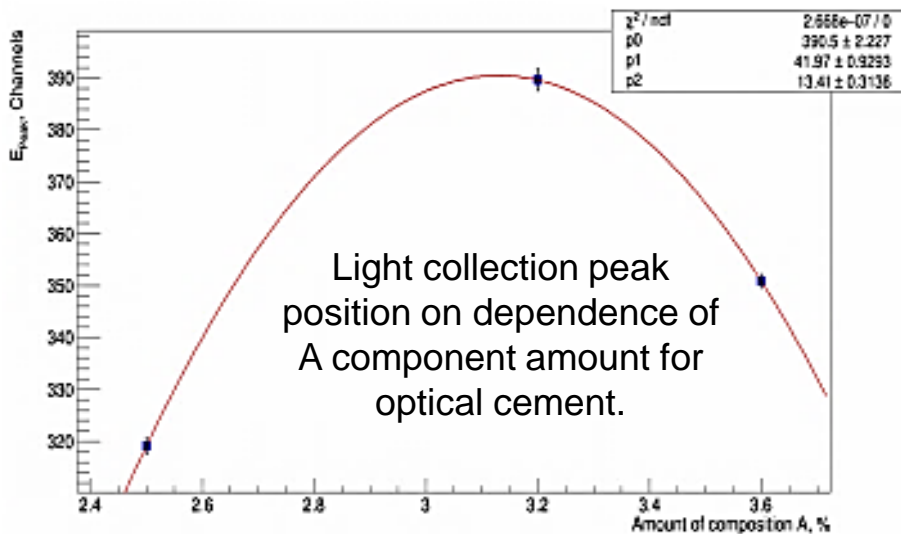
for Phase 1 tests

SGC BCF92



for Prototype tests

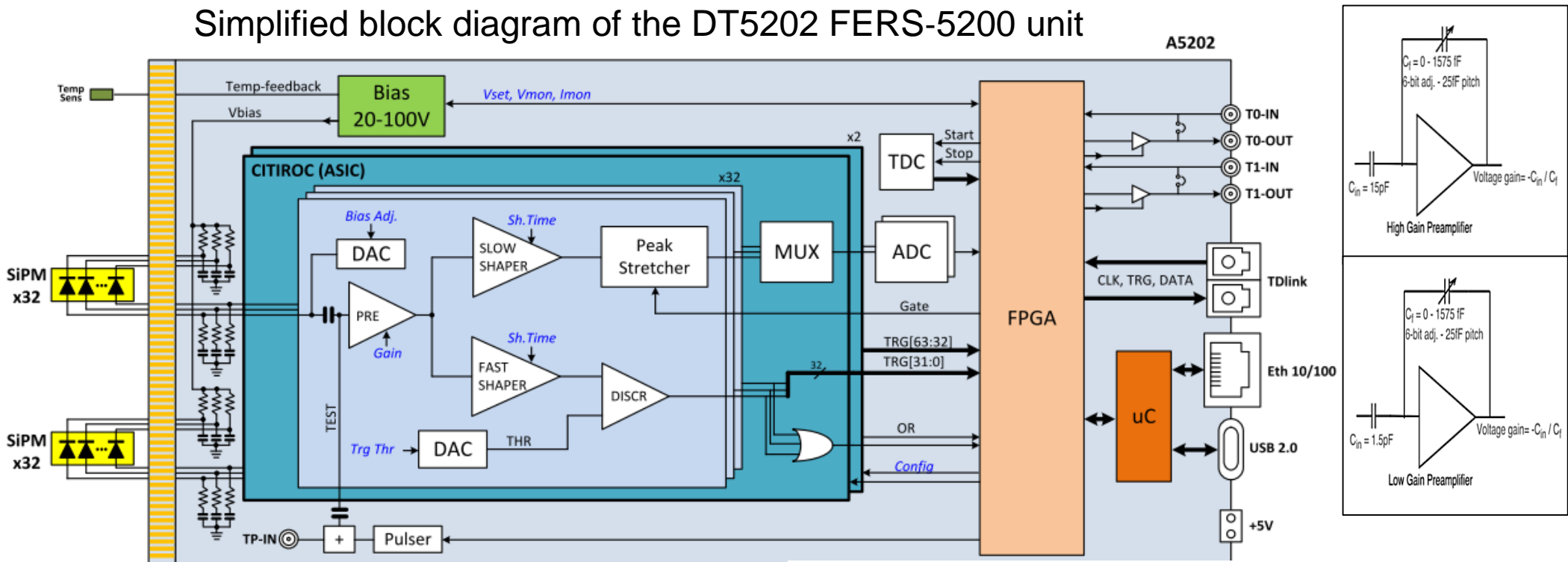
CKTN



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

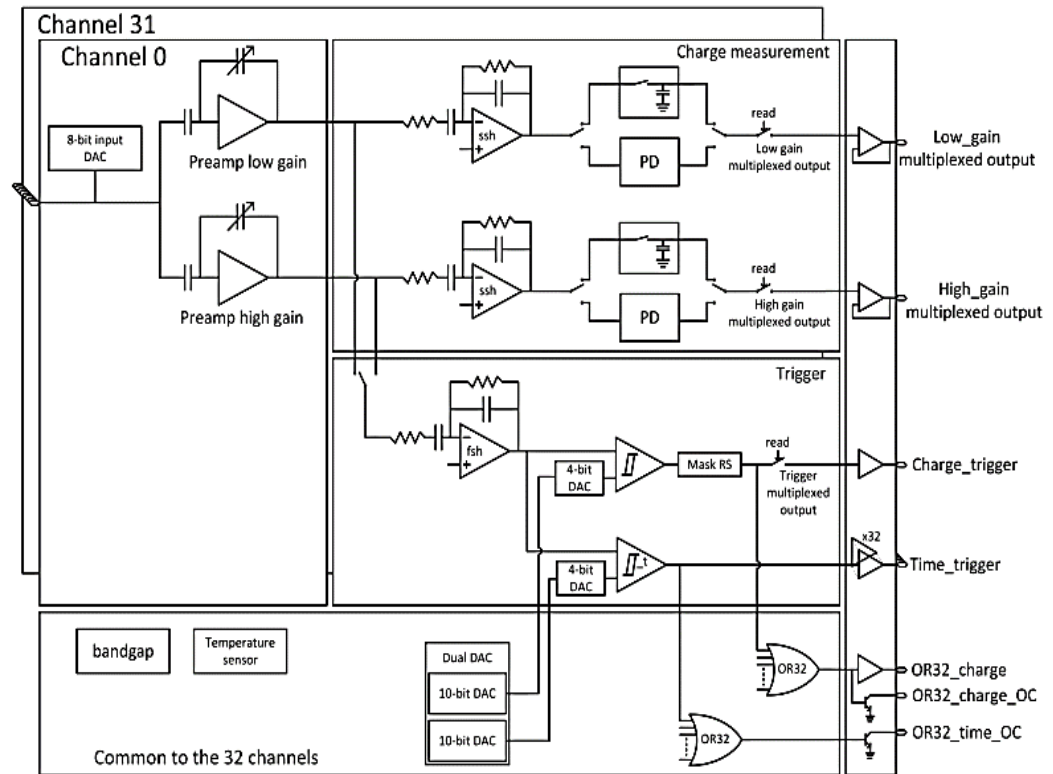
- ❑ **CKTN mark B** paired with Kuraray WLS fiber are the most appropriate candidates for future testbeam.
- ❑ **CKTN mark B** paired with SGC WLS fiber are the most appropriate candidates **for prototype** assembly tests.
- ❑ Datasheet ratio will be used and closely monitored for mass production.

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

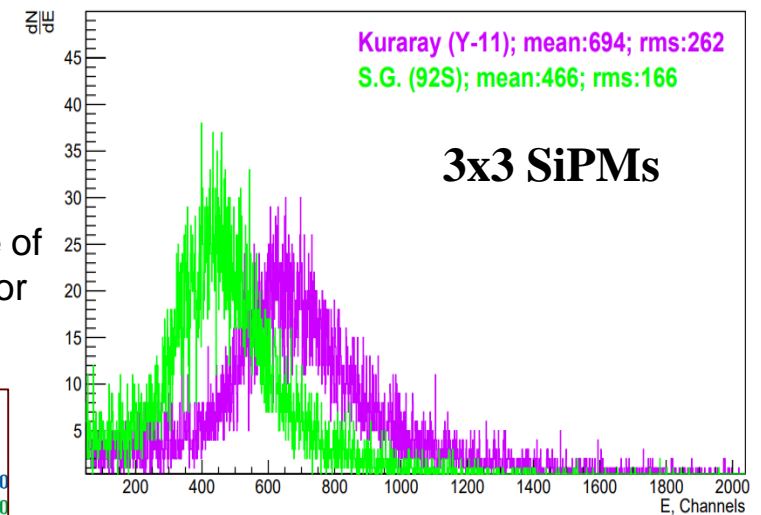
Specific Properties of Standard Formulations				
Fiber	Emission Color	Emission Peak, nm	Decay Time, ns	# of Photons per MeV**
BCF-10	blue	432	2.7	-8000
BCF-12	blue	435	3.2	-8000
BCF-20	green	492	2.7	-8000
BCF-60	green	530	7	-7100
BCF-91A	green	494	12	n/a
BCF-92	green	492	2.7	n/a
BCF-98	n/a	n/a	n/a	n/a

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

KURARAY fibers

Description	Emission			Absorption Peak[nm]	Att.Leng. ²⁾ [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.

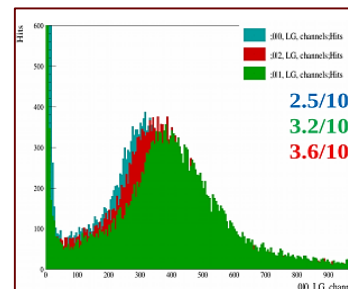


Table 1. Optical cements and their parameters

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 ³	—	92-96% at 500 nm	1.606
OK-72	—	From -60 to +60 °C	99% at 400-2700 nm	1.587