20th Dubna Workshop on High Energy Spin Physics (DSPIN-2026)

Light Collection in Scintillator Tiles of the BBC Detector for the SPD Experiment

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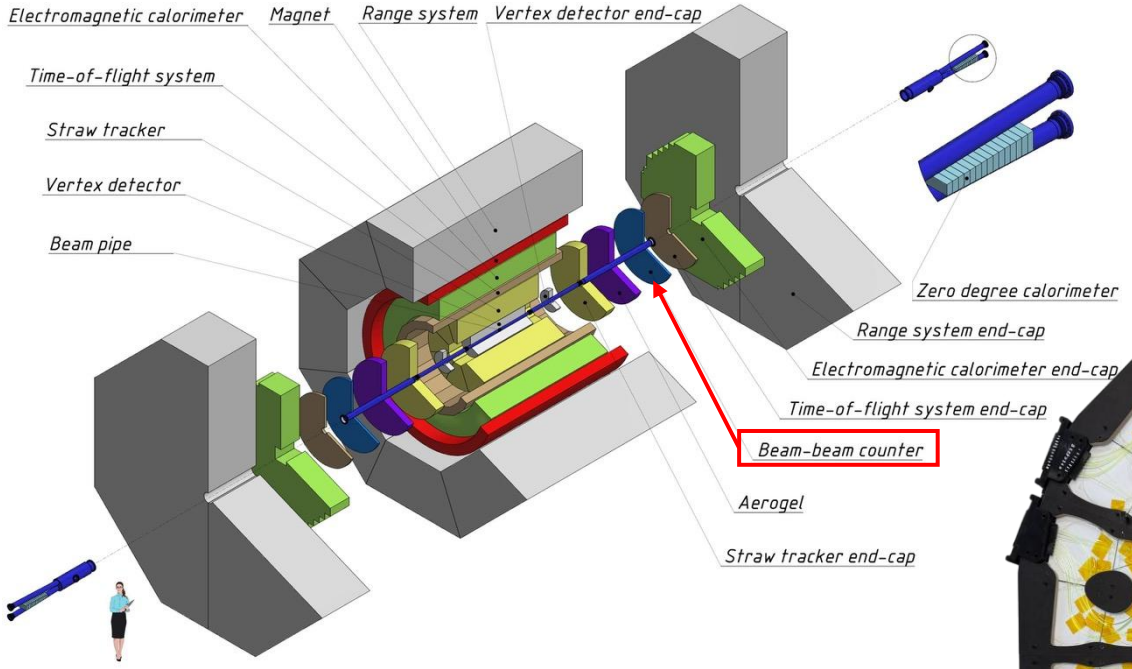
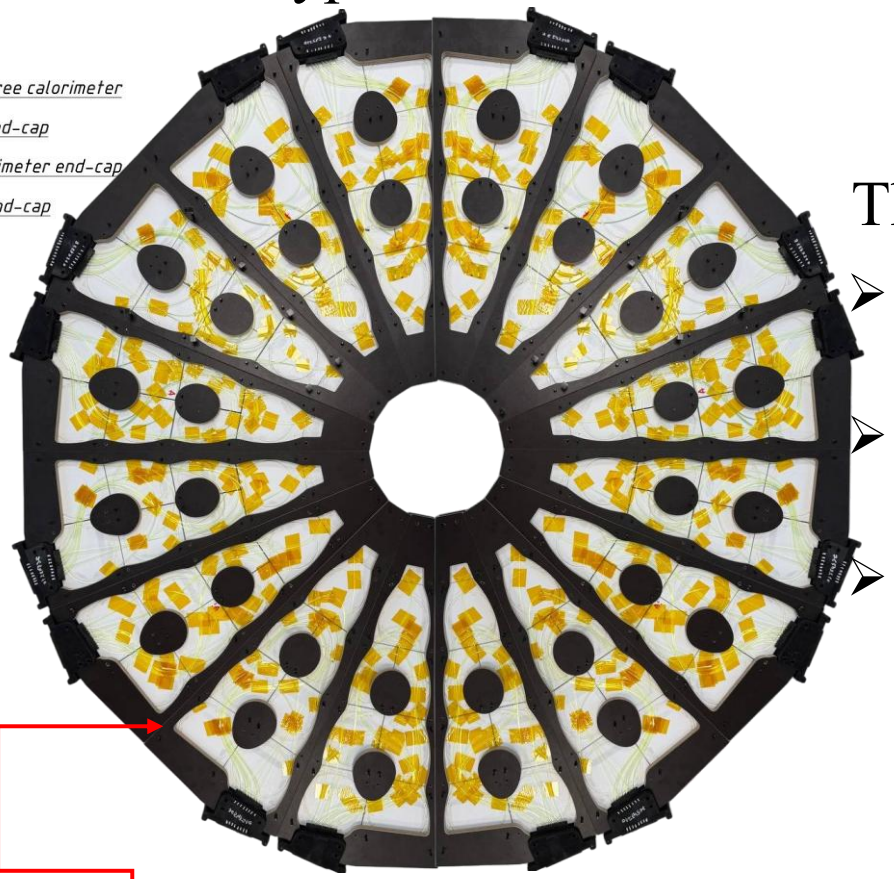
Dubna



The **Spin Physics Detector** at NICA

- Spin physics with polarized pp and dd collisions;
- Expected energies up to $\sqrt{s_{pp}} = 27$ GeV;
- Expected luminosity up to $L = 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$.

Prototype of BBC detector

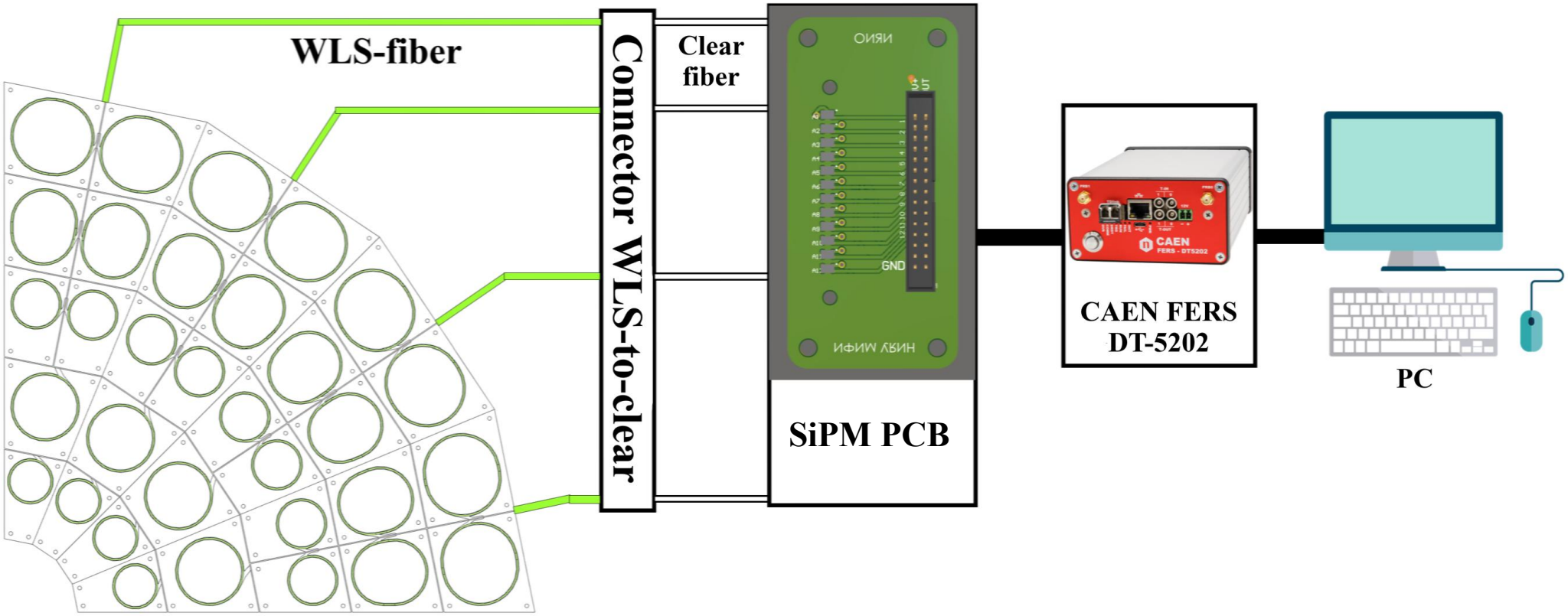


The **Beam-Beam Counter**

- Monitoring of local polarimetry;
- Luminosity/beam-collision monitoring;
- Timing and event-time determination.

Scintillator tile with WLS fiber

- **16 sectors**, each containing **26 scintillator tiles** made of polystyrene and covered with a reflector;
- The scintillation light from each tile is collected by a **wavelength-shifting (WLS) fiber** and transmitted to a **silicon photomultiplier** (**SiPM**);
- The signal is processed by the **CAEN FERS-DT5202** multichannel data acquisition system.

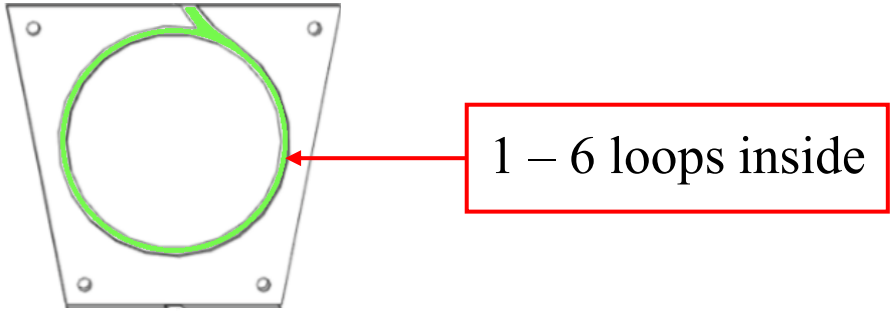


Motivation and goals

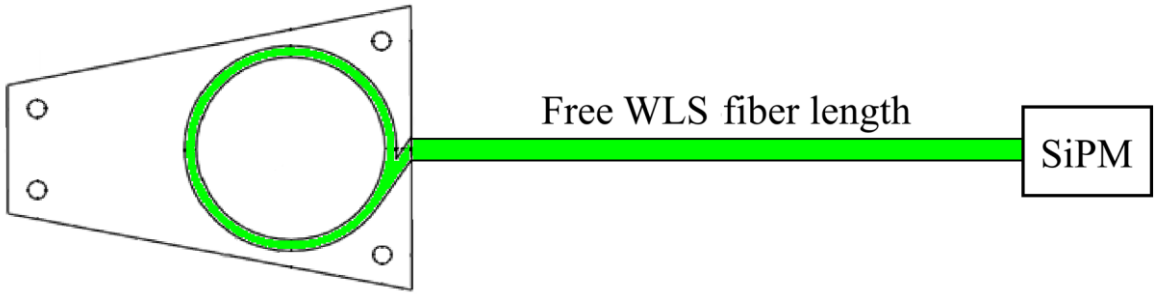
Goal: to determine the optimal parameters for a system consisting of a scintillator tile and a WLS fiber.

Investigated parameters:

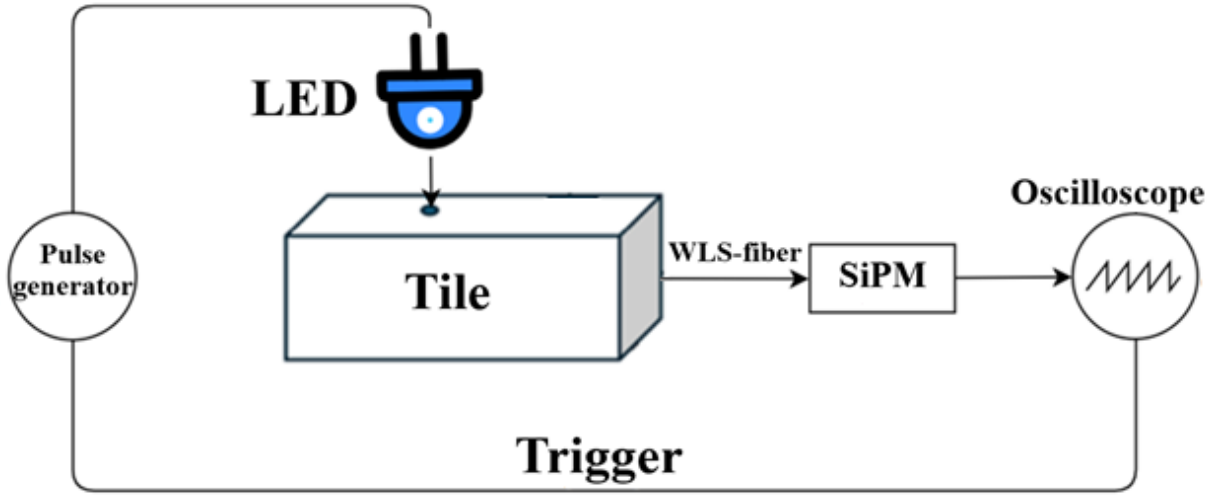
1. Number of WLS fiber loops inside the tile



2. Free WLS fiber length between the tile and the SiPM



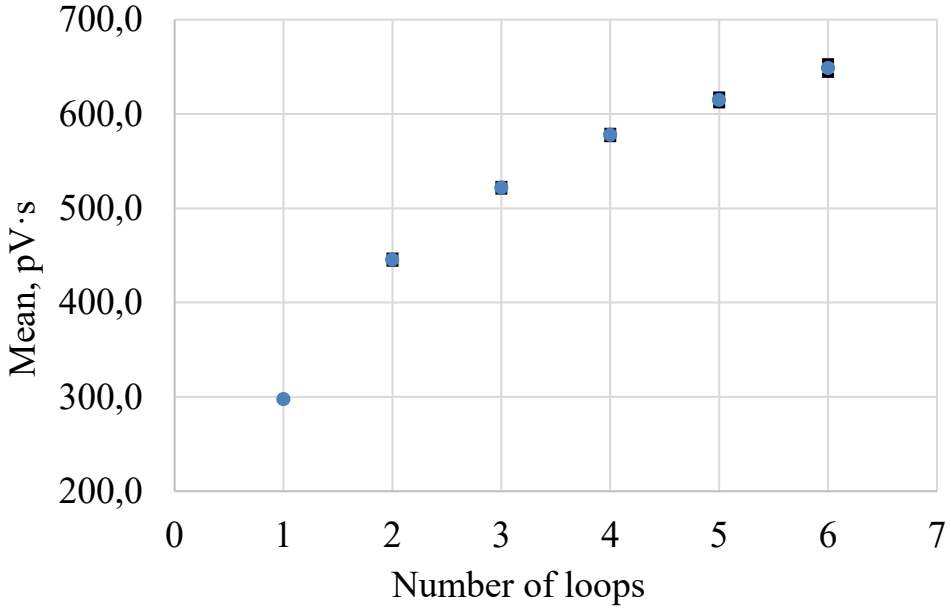
Purpose: to investigate the effect of the number of WLS fiber loops on light collection.

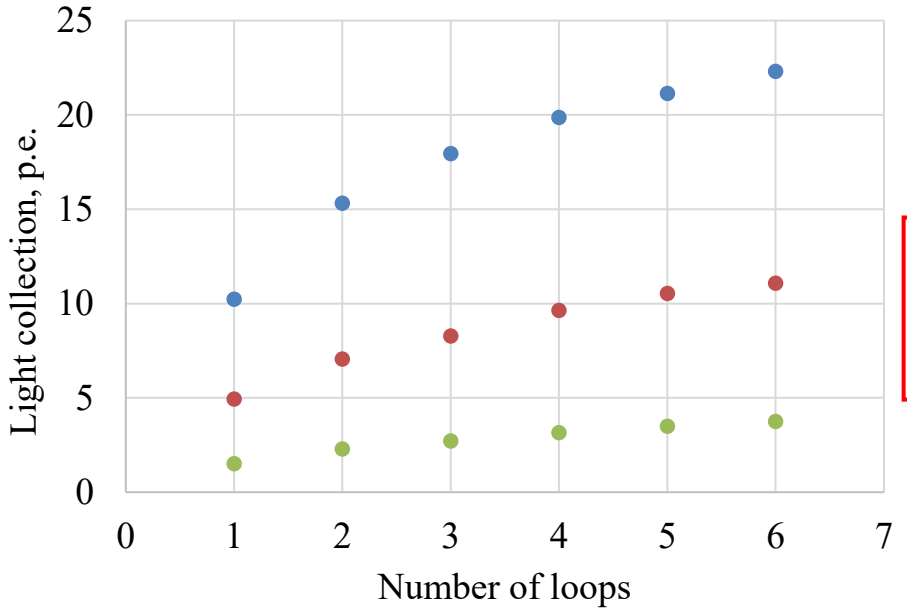


Experimental setup:

- A hole is drilled in the tile to accommodate the optical fiber;
- An LED is connected to the fiber using a connector and driven by rectangular pulses;
- The setup allows the number of WLS fiber loops inside the tile and the fiber length to the SiPM to be varied.

Result №1: Number of loops



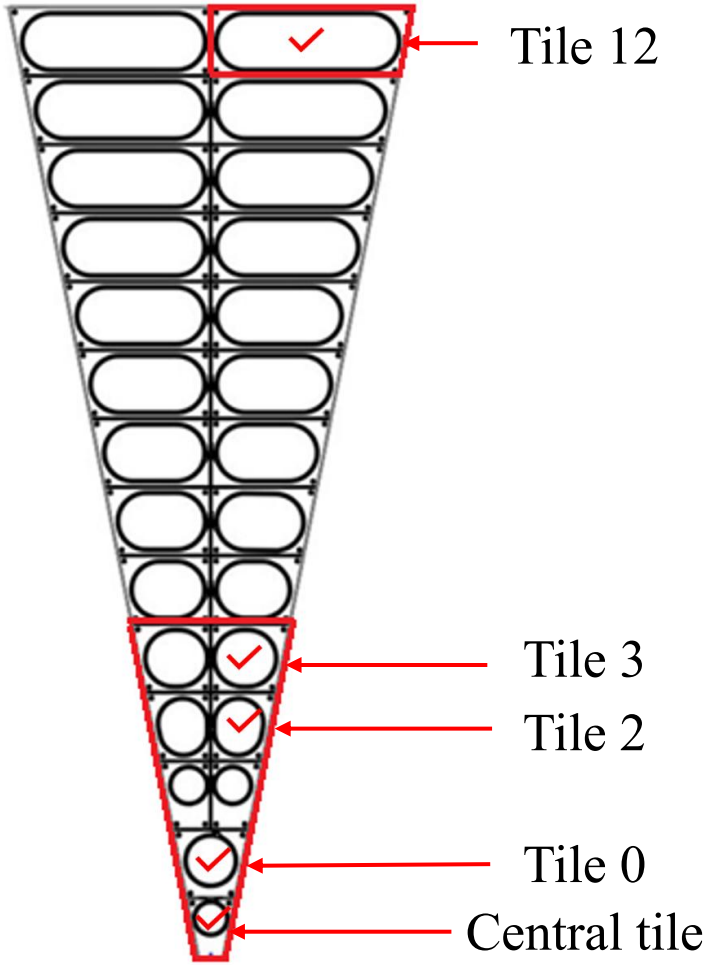


- Increasing the number of WLS fiber loops from **1 – 2** loops **to 3 – 4** loops results in a **20 – 90% increase** in the light response;
- A further increase from **3 – 4** loops **to 5 – 6** loops provides only an additional **10 – 20% increase** in the signal;
- Thus, the benefit of adding more loops becomes less pronounced, while the longer optical path introduces additional light losses.

5 cm
1 m
6 m

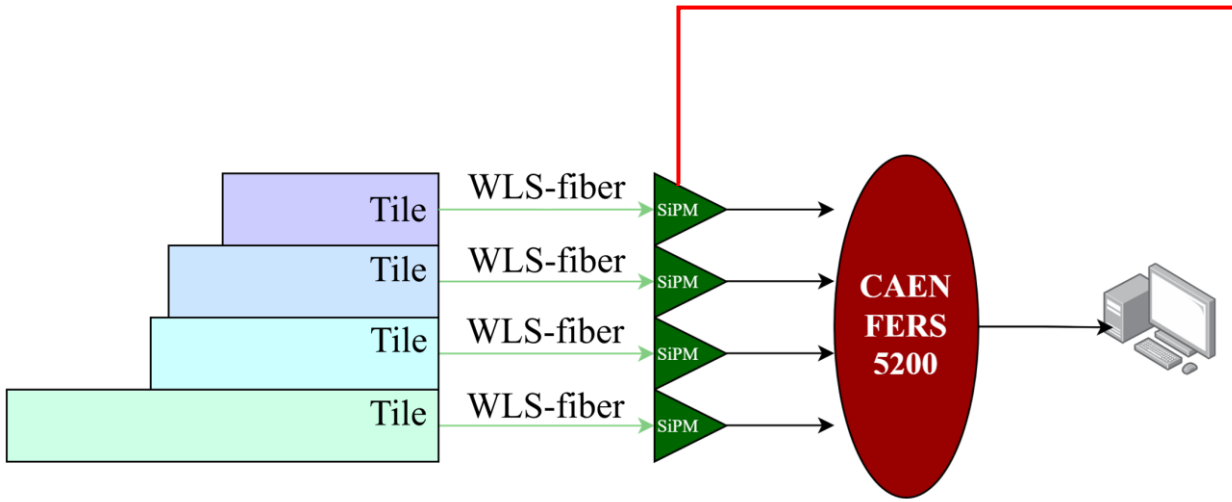
length of WLS fiber between a tile and a SiPM

Purpose: to investigate the influence of the free WLS fiber length on the tile response.

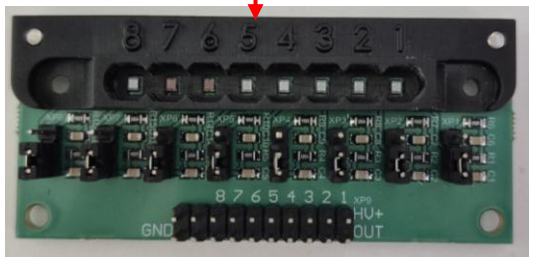


The measurements were divided into two series:

- **Series 1**: **tiles 0, 2, 3, and 12** with a free WLS fiber length of **4 cm**;
- **Series 2**: **central tile, tiles 3 and 12** with a free WLS fiber length of **132 cm**.

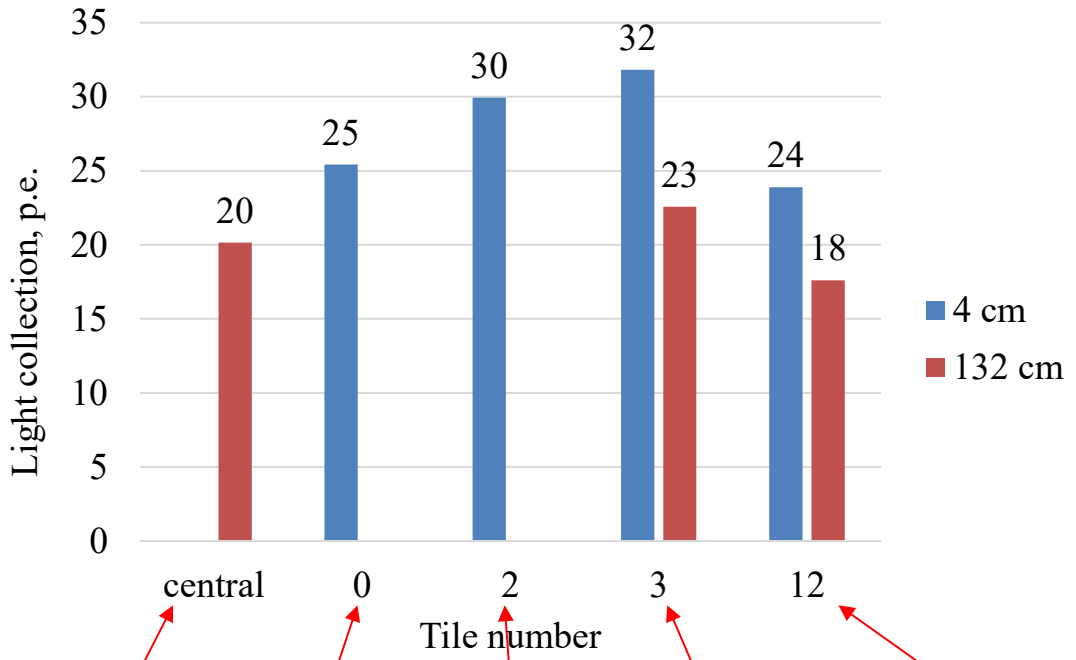


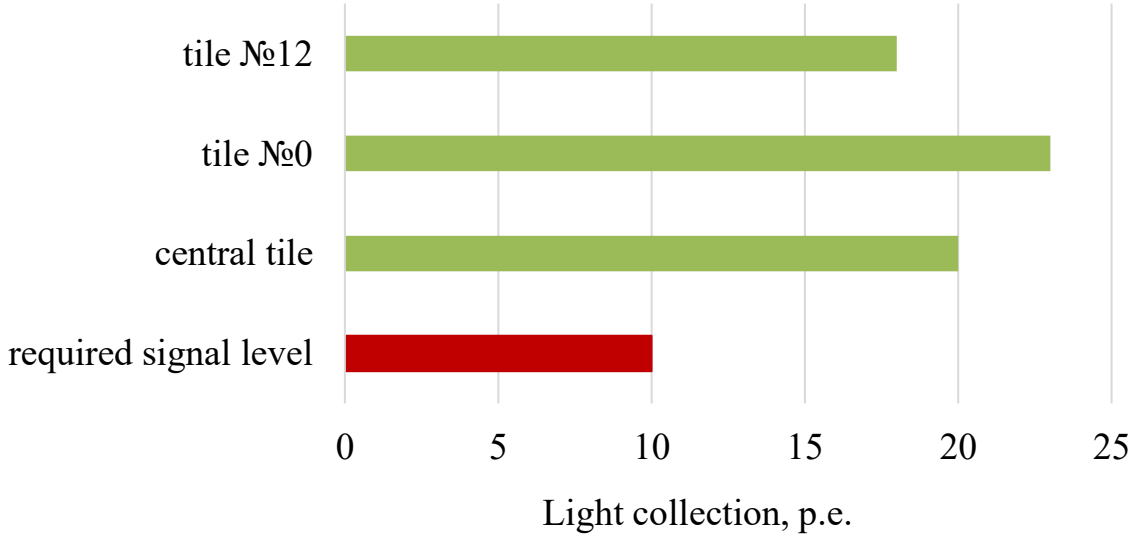
Muon telescope coincidence scheme

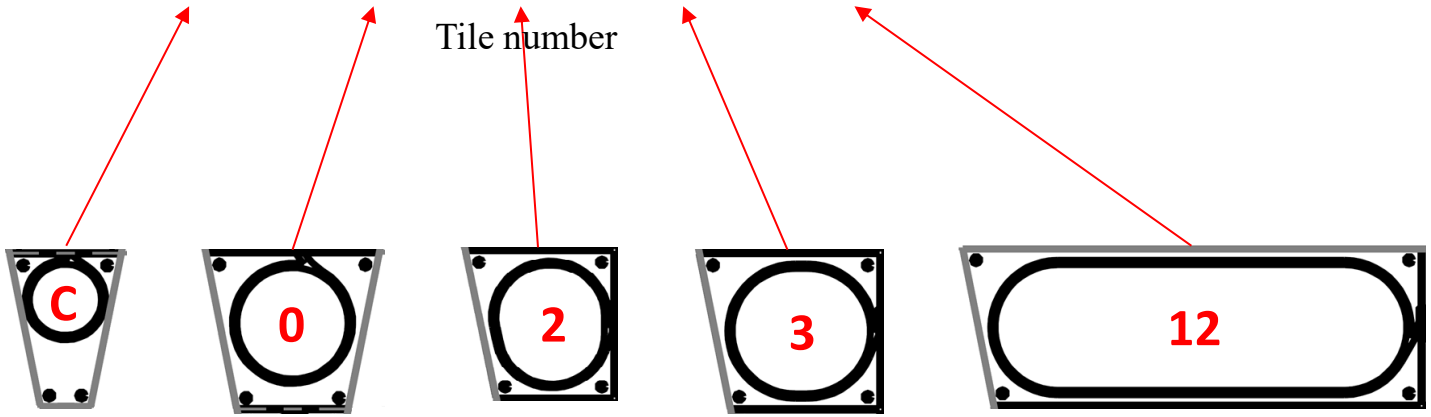


8-SiPM PCB
(Onsemi fc10035)

Result №2: Free WLS fiber length



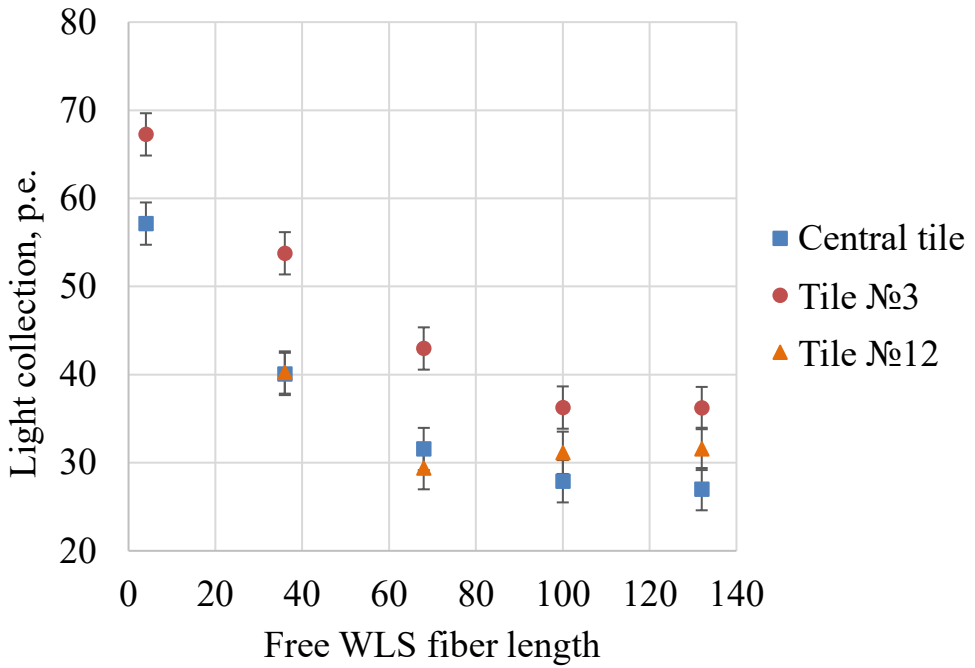




Increasing the free WLS fiber length **from 4 cm to 132 cm** results in a **30% decrease** in light collection for **tile 3** and a **25% decrease** for **tile 12**.

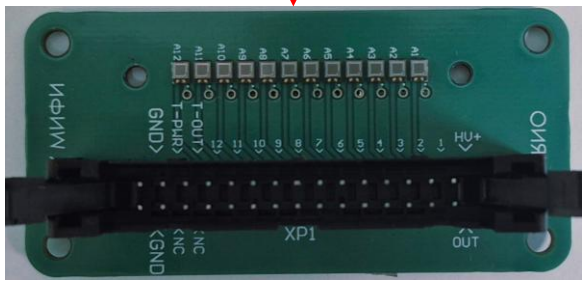
In both cases the response remains above the required detection threshold of approximately 10 photoelectrons.

Light attenuation along the WLS fiber



- The free WLS fiber length was reduced **from 132 cm to 4 cm in steps of 32 cm**;
- For each length, amplitude spectra of energy losses from atmospheric muons were measured;
- The 4 cm point for tile 12 is missing due to damage to the WLS fiber.

The best response is achieved in the configuration with the minimum WLS fiber length: the response of **central tile increases by 53%**, the response of **tile 3 increases by 46%**, and the response of **tile 12 increases by 7%**.



12-SiPM PCB
(Hamamatsu SiPM S14160-1315 PS)

Conclusions

- Increasing the number of WLS fiber loops from 1 – 2 loops to 3 – 4 loops results in a 20 – 90% increase in the light response. Further increasing the number of loops provides only a slight increase in the signal;
- Increasing the free WLS fiber length from 4 to 132 cm reduces the light collection by approximately 28% on average;
- The response remains above the required level even for the longest investigated fiber length;

The optimal configuration for the BBC detector consists of 3 – 4 loops of the WLS fiber within the scintillator and the shortest possible free WLS fiber length between the tile and the SiPM.

Thank you for your attention!