



MuGrid: A scintillator detector towards cosmic muon absorption imaging¹

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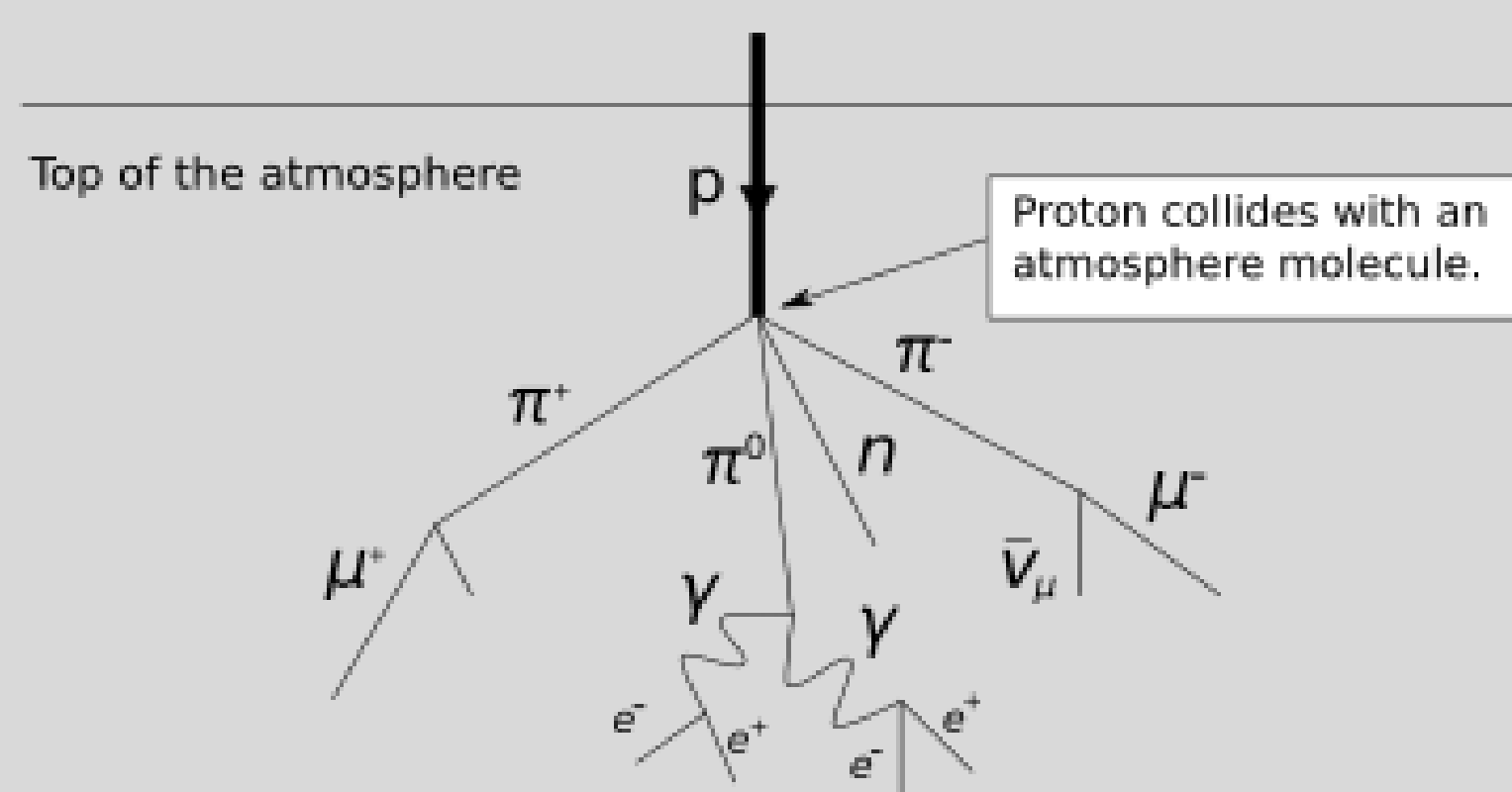
Muography is believed to have a wide range of applications especially in the cross-disciplinary area as it can probe the internal composition of objects in a non-destructive way. We designed a cosmic muon tracking detector MuGrid using plastic scintillators with a novel construction. Preliminary progress of the MuGrid detector are shown in this poster.

Muon absorption tomography

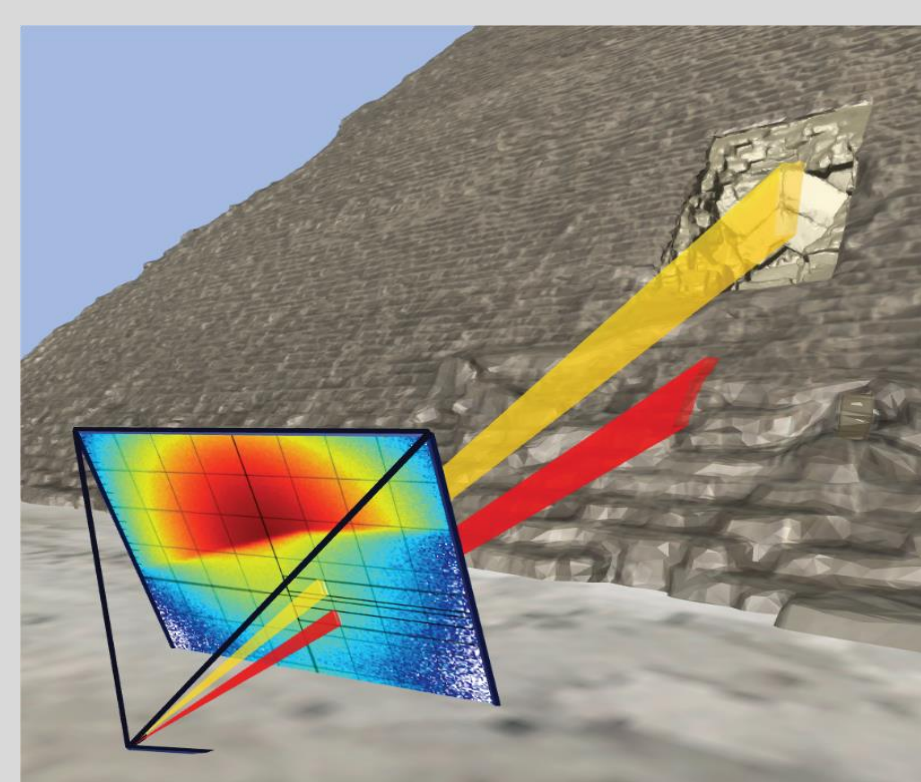
- * Muon is part of the air showers produced by the interactions of high energy cosmic rays with the atmosphere.
- * Cosmic muon interacts with matter primarily through ionization and its energy loss over the mass thickness dE/dx is described by Bethe-Bloch formula²

$$-\frac{dE}{dx} = K z^2 \frac{Z}{A} \frac{1}{\beta^2} \left[\frac{1}{2} \ln \left(\frac{2m_e c^2 \beta^2 \gamma^2 W_{max}}{I^2} \right) - \beta^2 - \frac{\delta}{2} \right]$$

- * Based on this principle, muon can be used to probe the internal composition of overburden, similar to X-ray tomography.²
- * Using the natural particle source, Muography is considered to have broad application prospects in different fields like archaeology, geology.



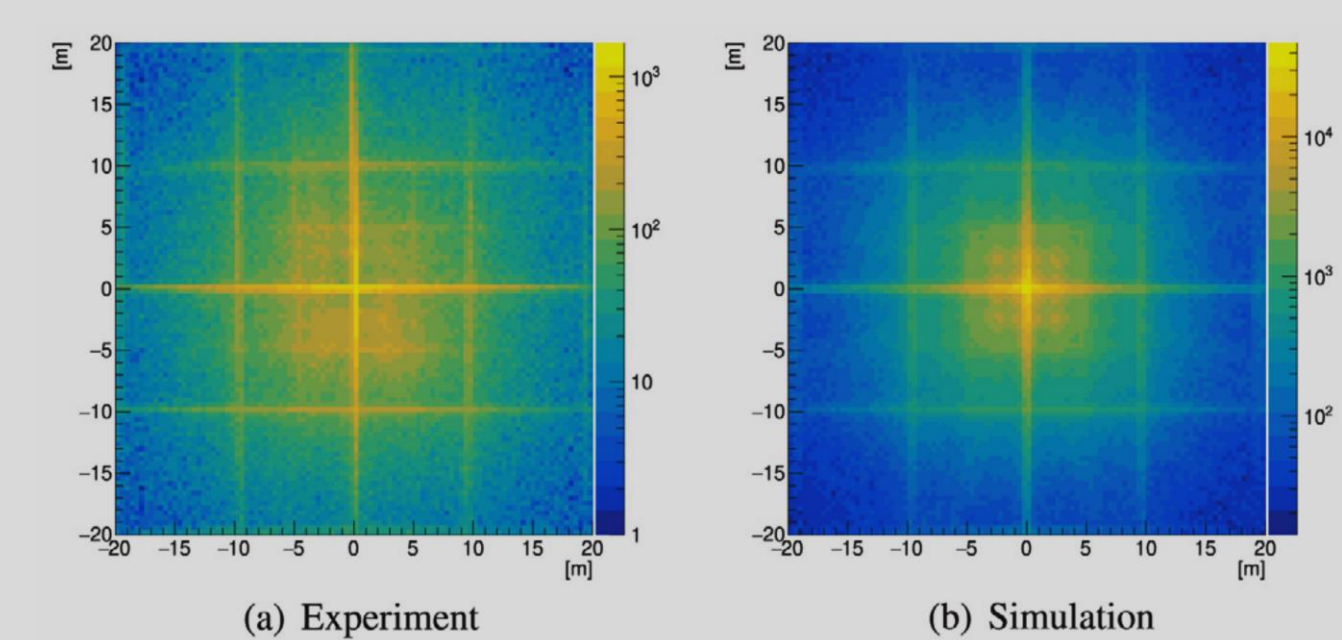
Air shower created by primary cosmic ray



Use Muography technology probe the inner structure of Khufu Pyramid³

Some preliminary results

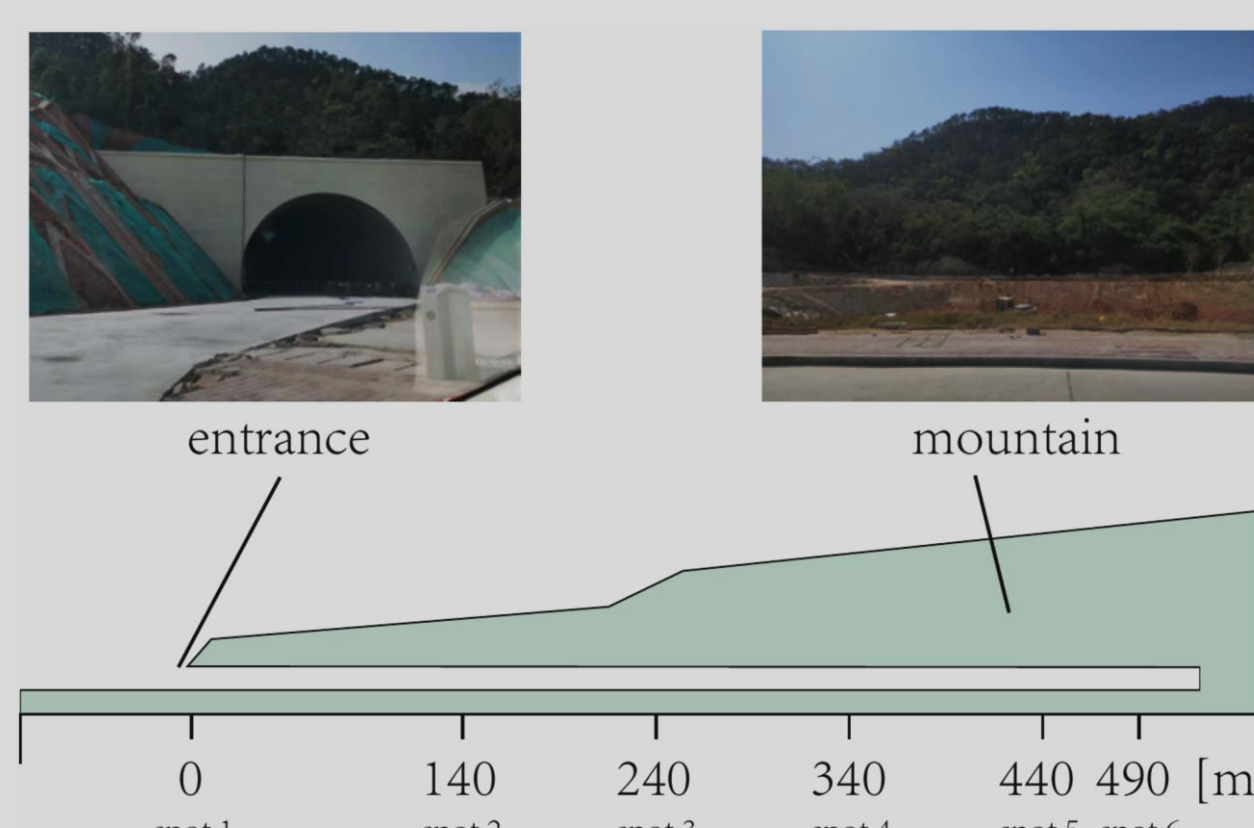
- * We collected some samples and compared them with simulations both in the lab and in the field.



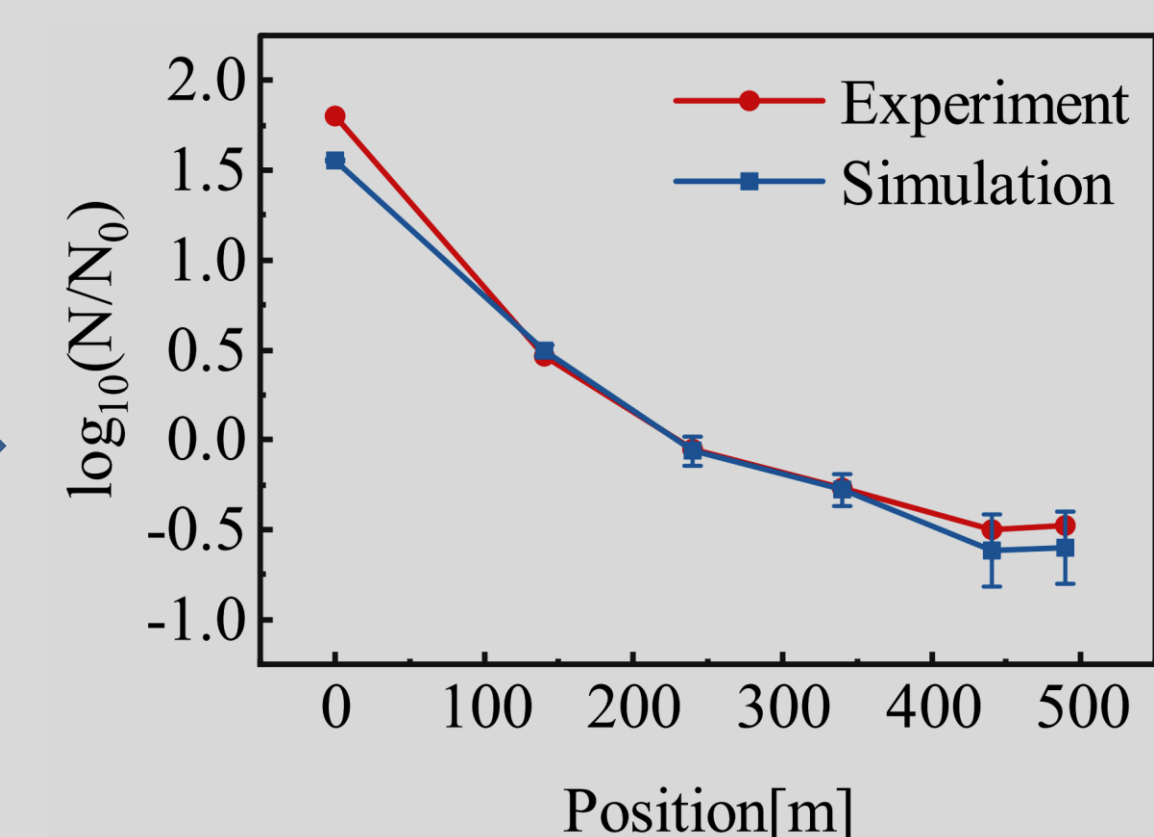
Back-projection image of experiment(a) and simulation(b). The projection plane is 10 m above the bottom of the detector.

- * This pattern right side may result from the fact that the angular resolution is worse when triggered scintillators are on the same axis.

We conducted the first field experiment of MuGrid in a cave in ZhuHai.



A rough profile of the tunnel geometry. Thickness of the overburden generally increases with its distance from tunnel entrance.



Event rates at different spots in the tunnel. N_0 is the average count of 6 spots.

event rates drop dramatically as the thickness of the overburden arises conform to the simulation, which proves the stability and validity of MuGrid detector.

MuGrid demonstrator

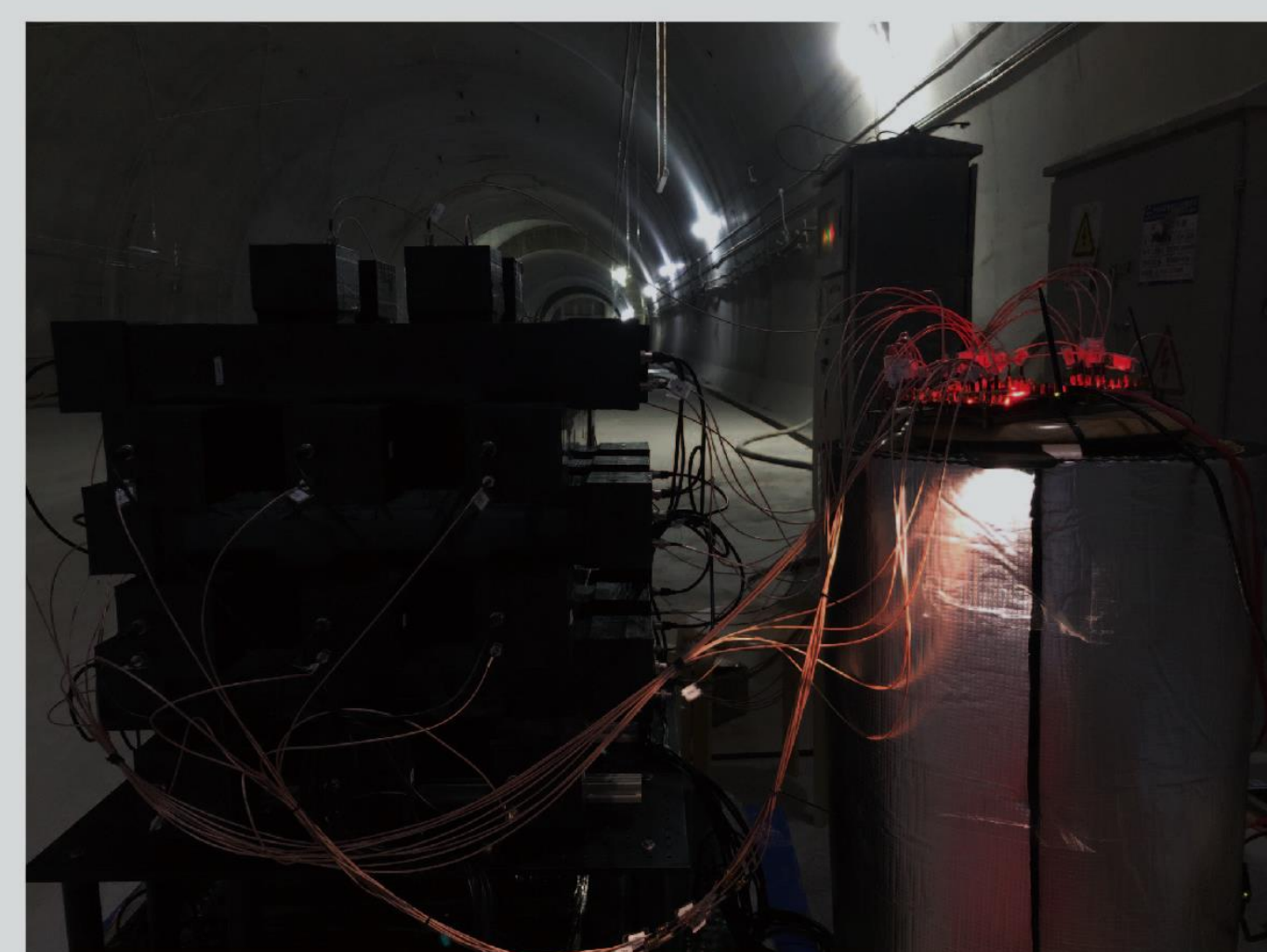
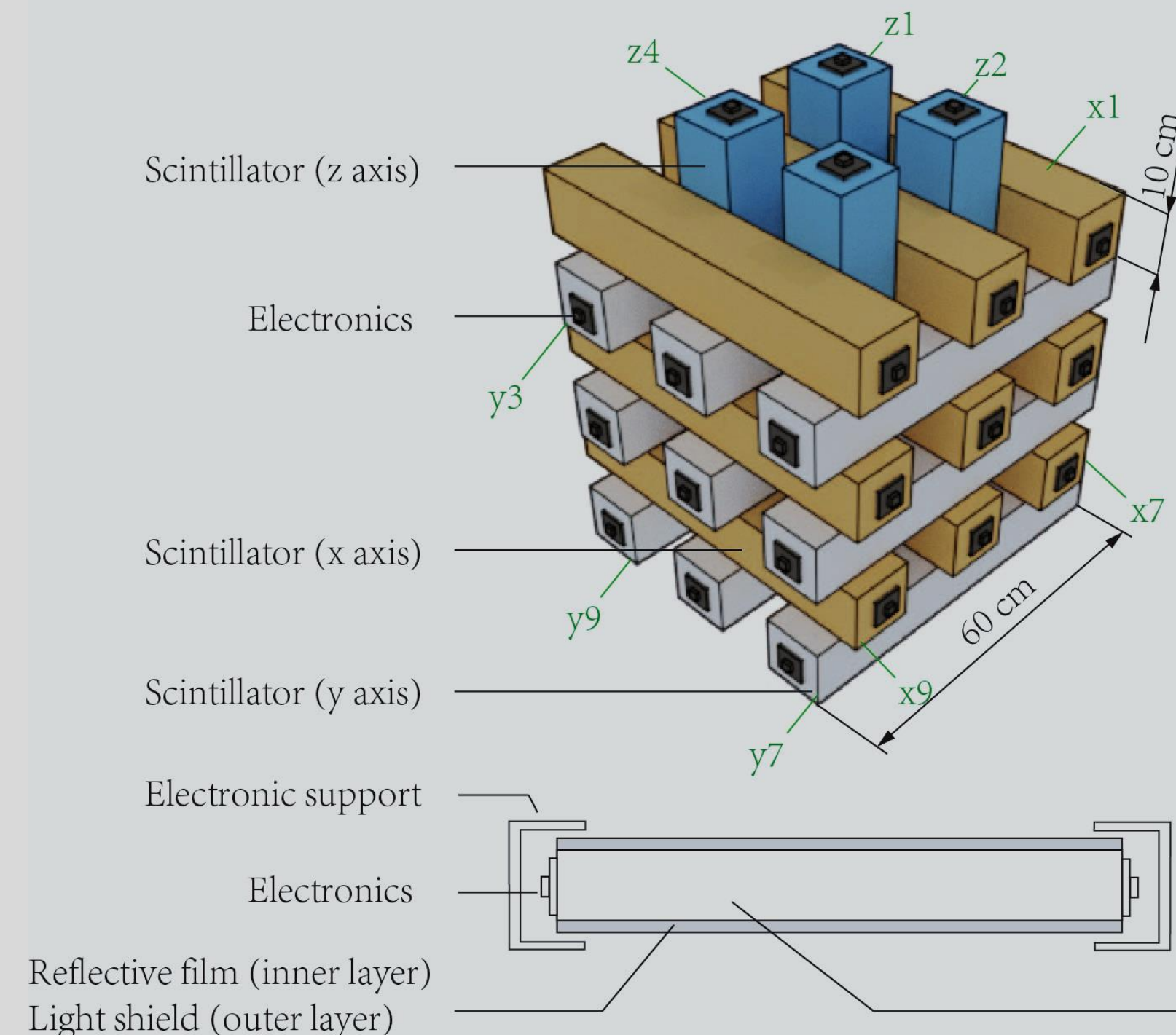
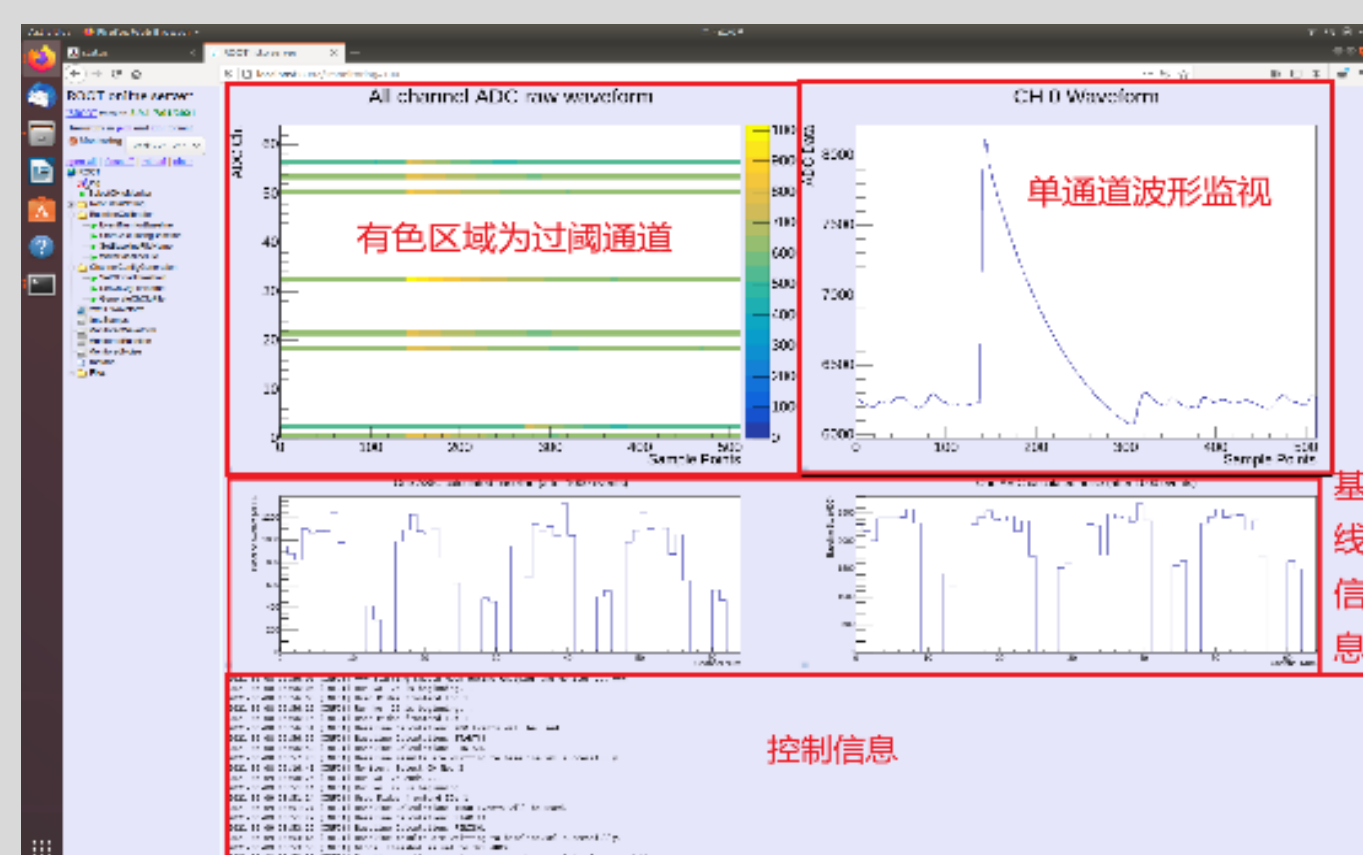
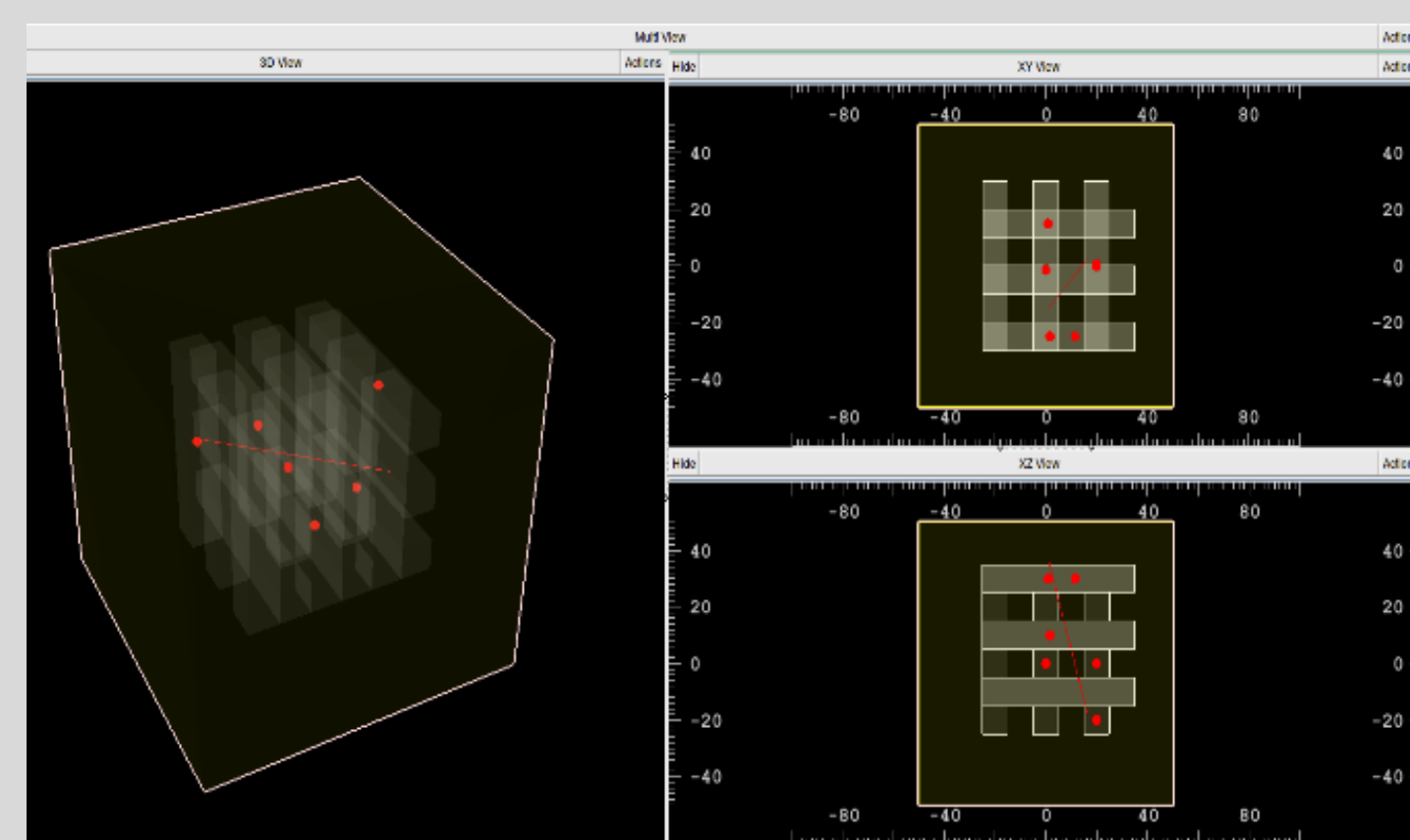


Photo of MuGrid demonstrator

- * MuGrid consists of 22 pieces of scintillators attached with SiPMs on both sides.
- * Each scintillator is modular, and you can assemble them into any shape you want.
- * 4 vertical scintillator is fixed in the center so that we can identify the horizontal muons.
- * Electronics readout system with MIDAS containing 64 channels allow us to increase more detector modules. Event display program makes the presentation convenient.
- * Total power consumption of the system is lower than 20W.



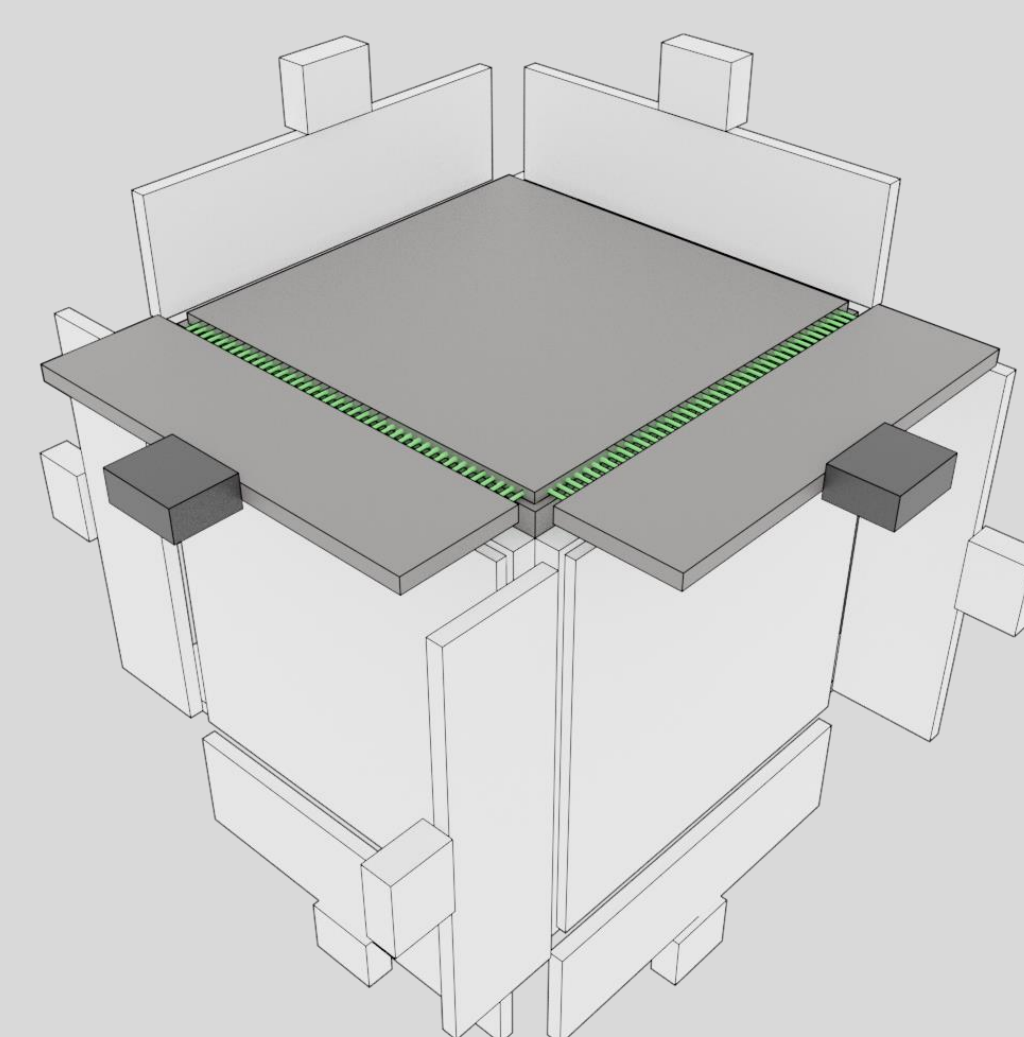
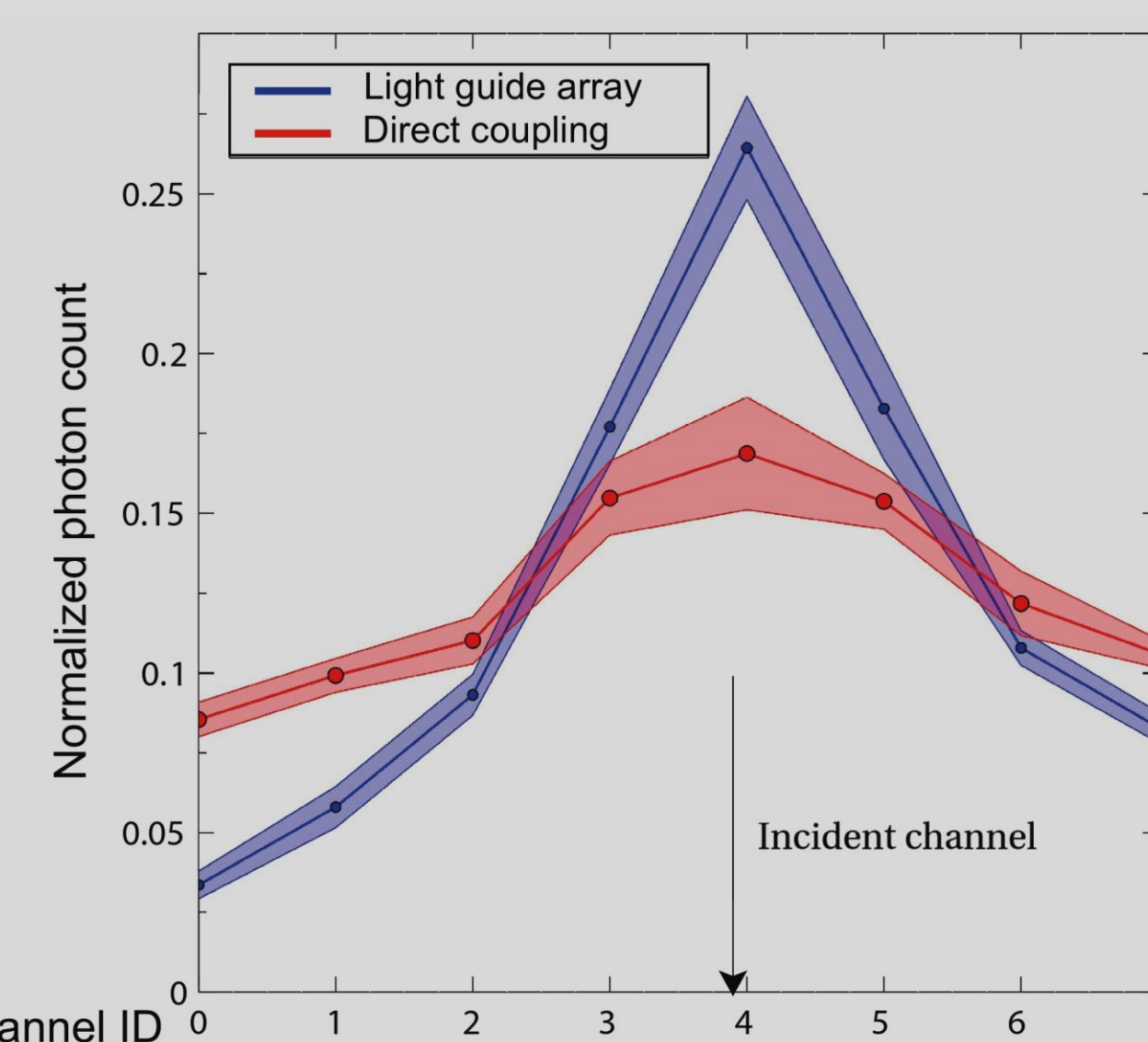
Real-time monitoring interface of MuGrid



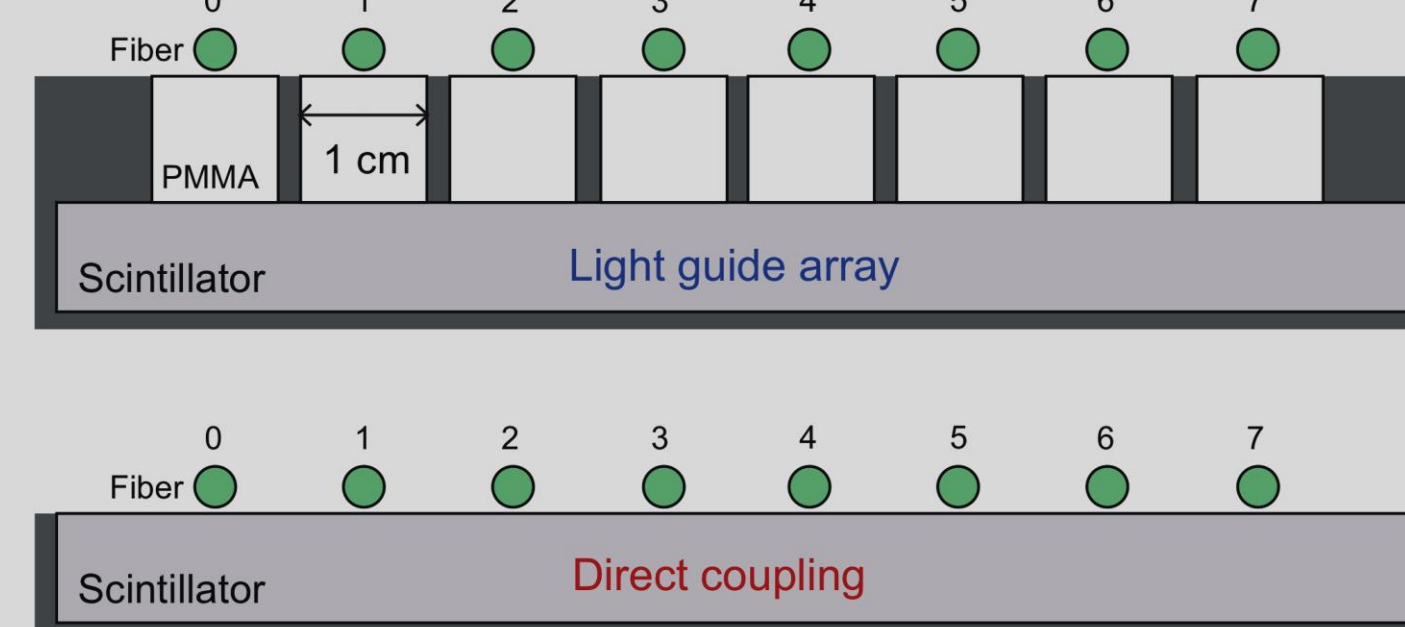
Event display program can reconstruct the tracks from root files easily.

Future upgrade plans

- * A new detector structure have been proposed by us aimed to improve the resolution of muon detector to the order of centimeters.
- * Use WLS fiber and light guide PMMA to discriminate the hit position of muons. It also help reduce the huge cost of the scintillators.
- * Preserve the good acceptable angular aperture (4π) and symmetry of the detector.



Schematic diagram of MuGrid version2



Comparison between the proposed structure and direct coupling structure. The photon count of each channel is normalized by the total count of the 8 channels. The new structure is able to reduce the crosstalk so that we just need a whole blocks of scintillator.

A Special edition of MuGrid for education

- * We have updated a special edition of MuGrid which is small, exquisite and much easier to encapsulate and assemble.
- * This new edition detector is now used in undergraduate experimental classes in which students will be taught how to package it and utilize it to measure muon flux.



MuGrid special edition: more delicate and suitable for experimental teaching.

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Team

