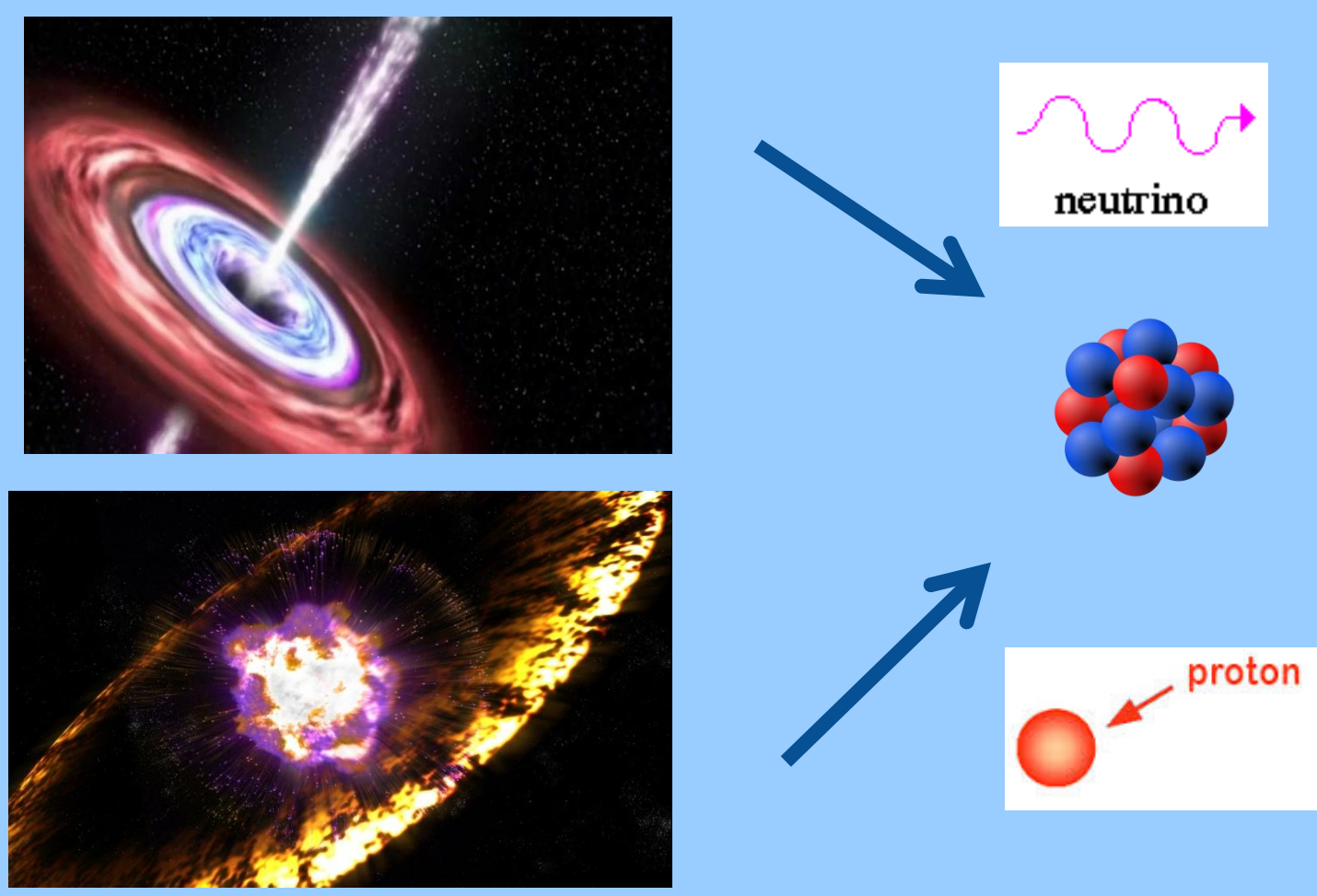


The SiRO Detector (Silicone Read Out) for cosmic muon flux-trajectory measurements

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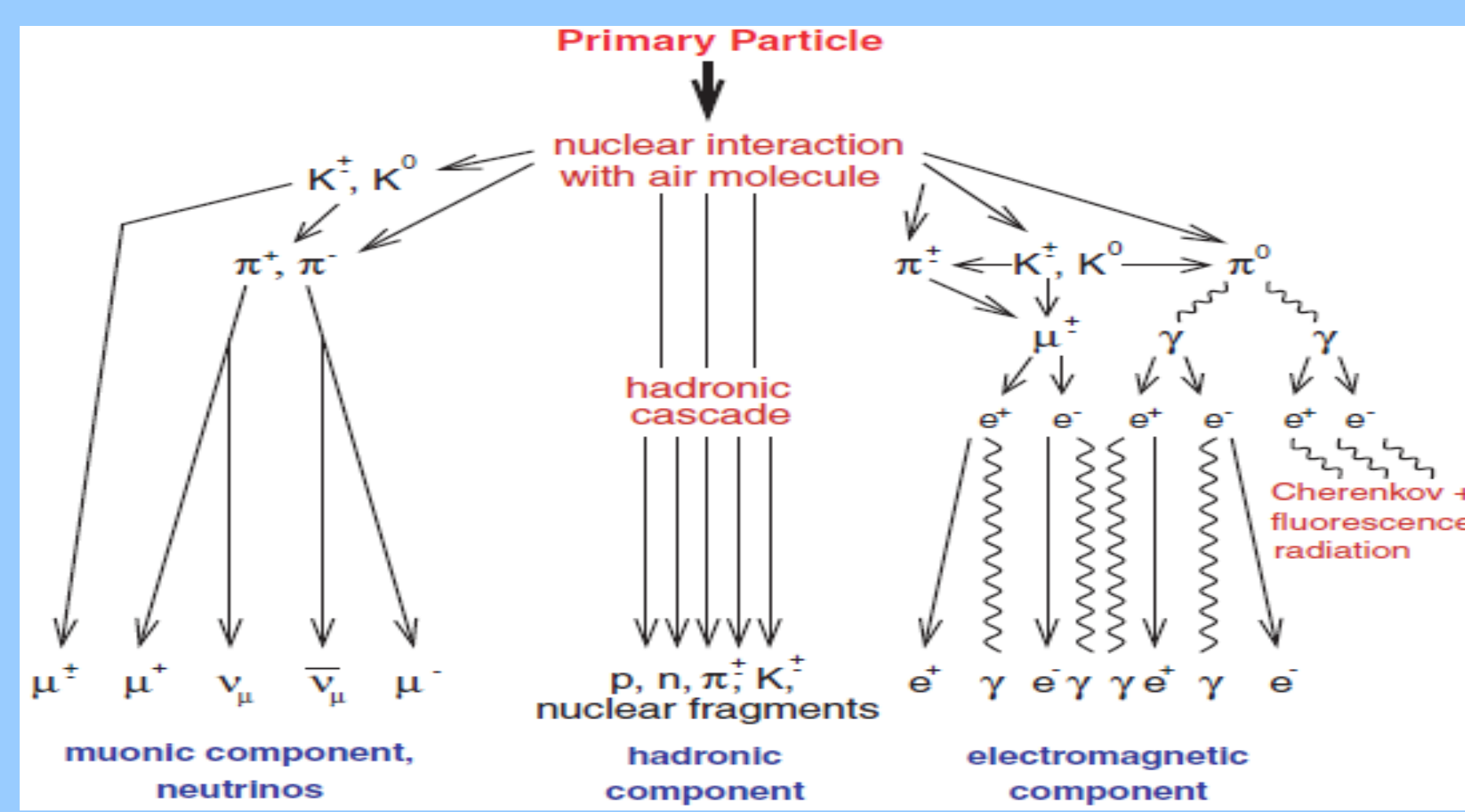
Cosmic Rays?



Ultra-high-energy cosmic rays (up to 10^{22} eV)



Extensive Air Shower

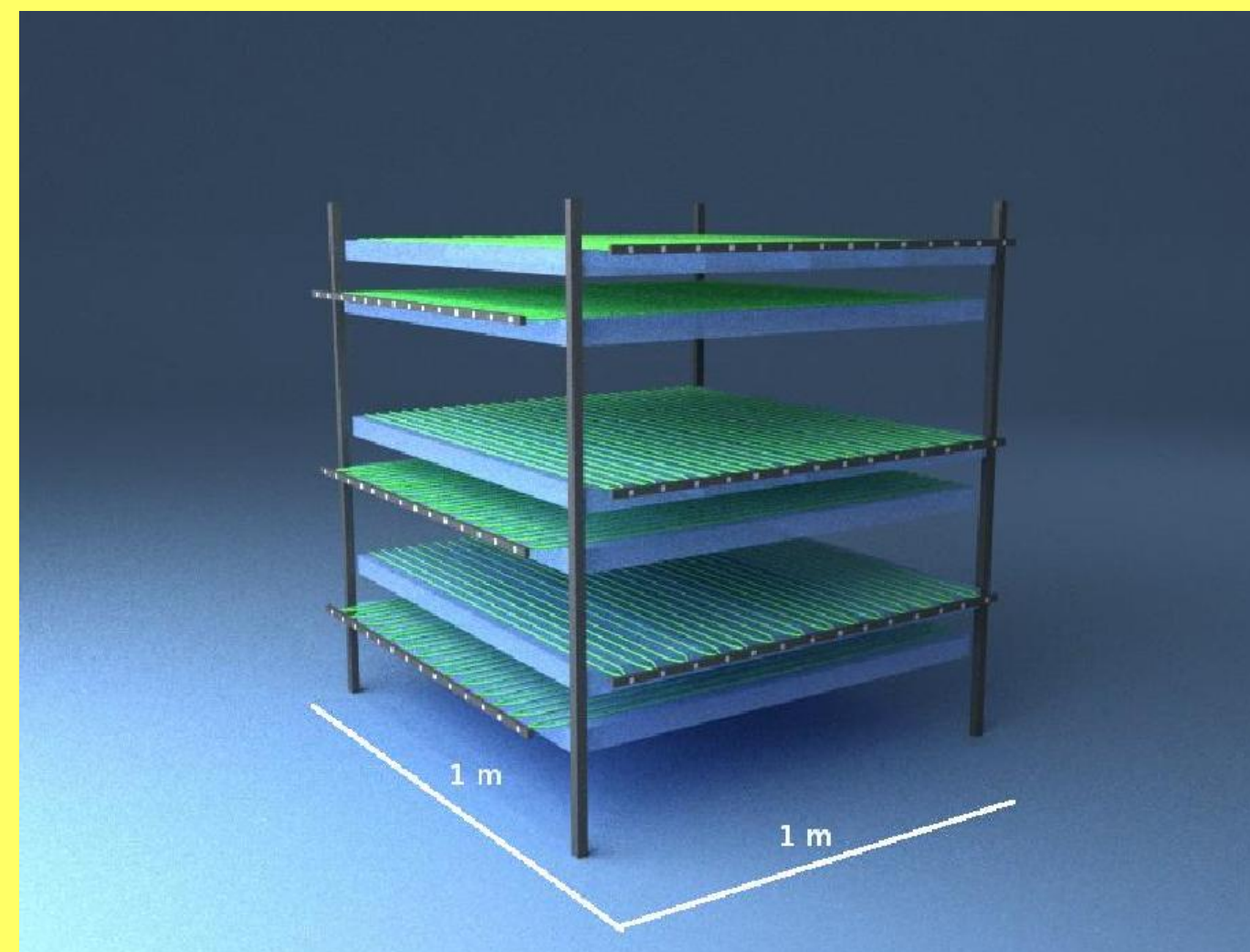


Muons? Why Muons?

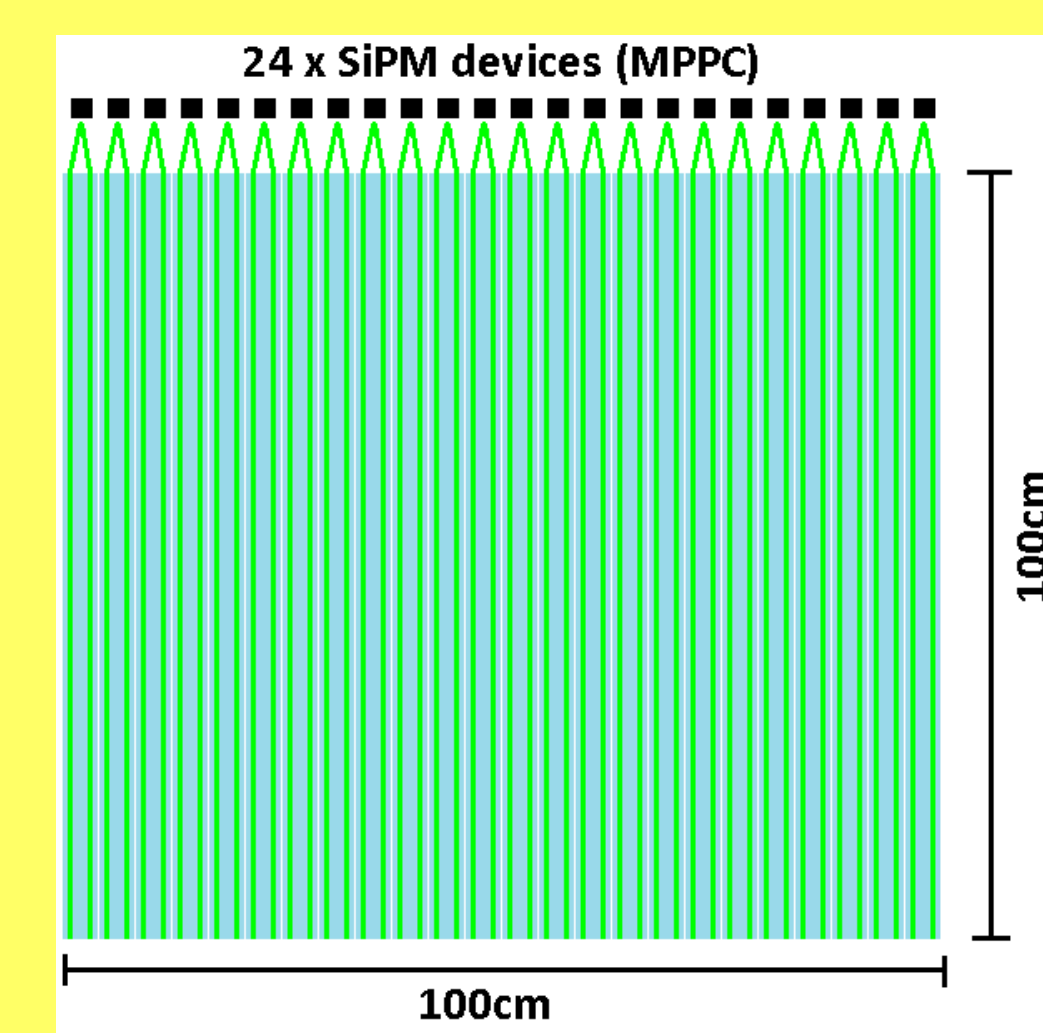
- * "Easy" to detect
- * They penetrate the atmosphere and soil (up to ~300m underground)

SiRO Detector

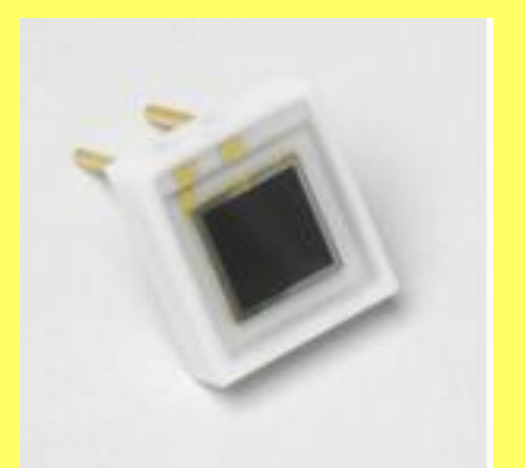
The schematic view of the SiRO Detector



The schematic view of one module and inside view from under construction phase

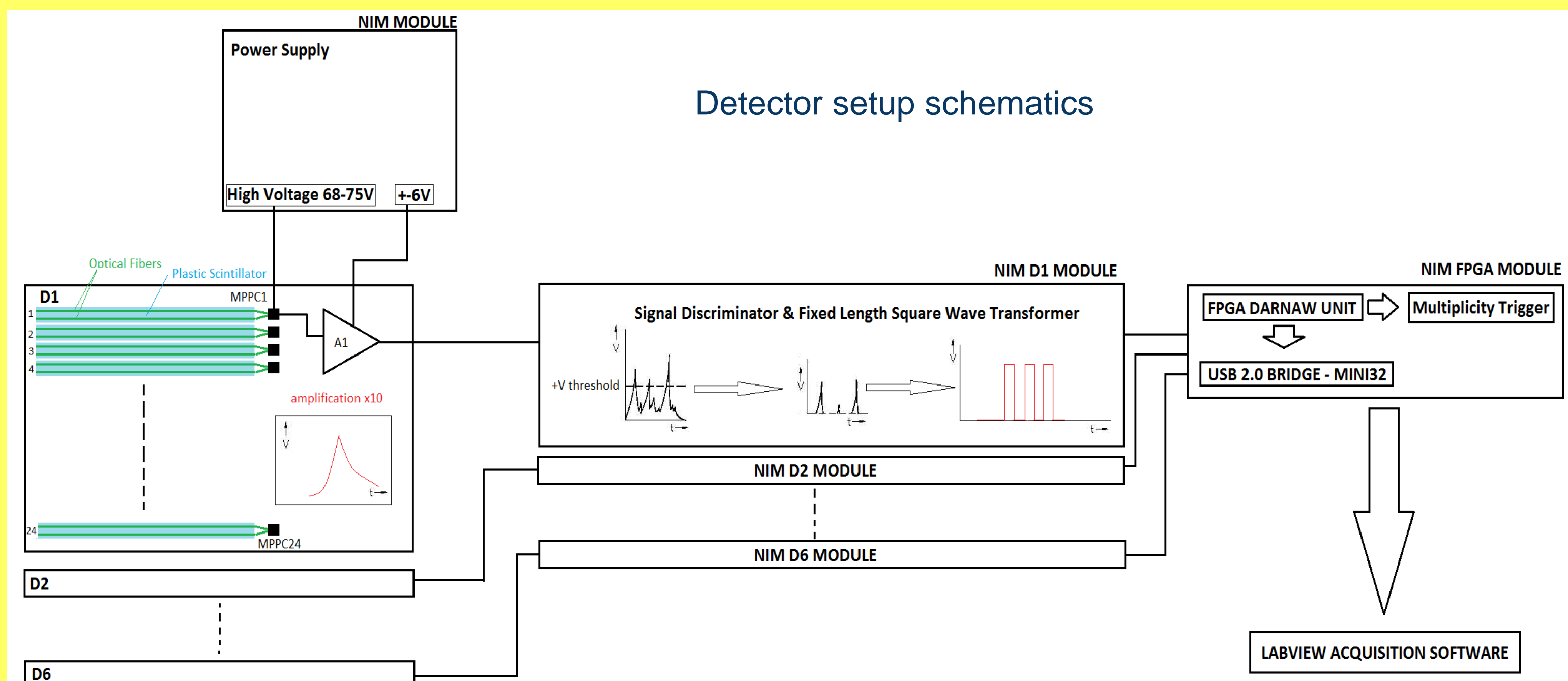
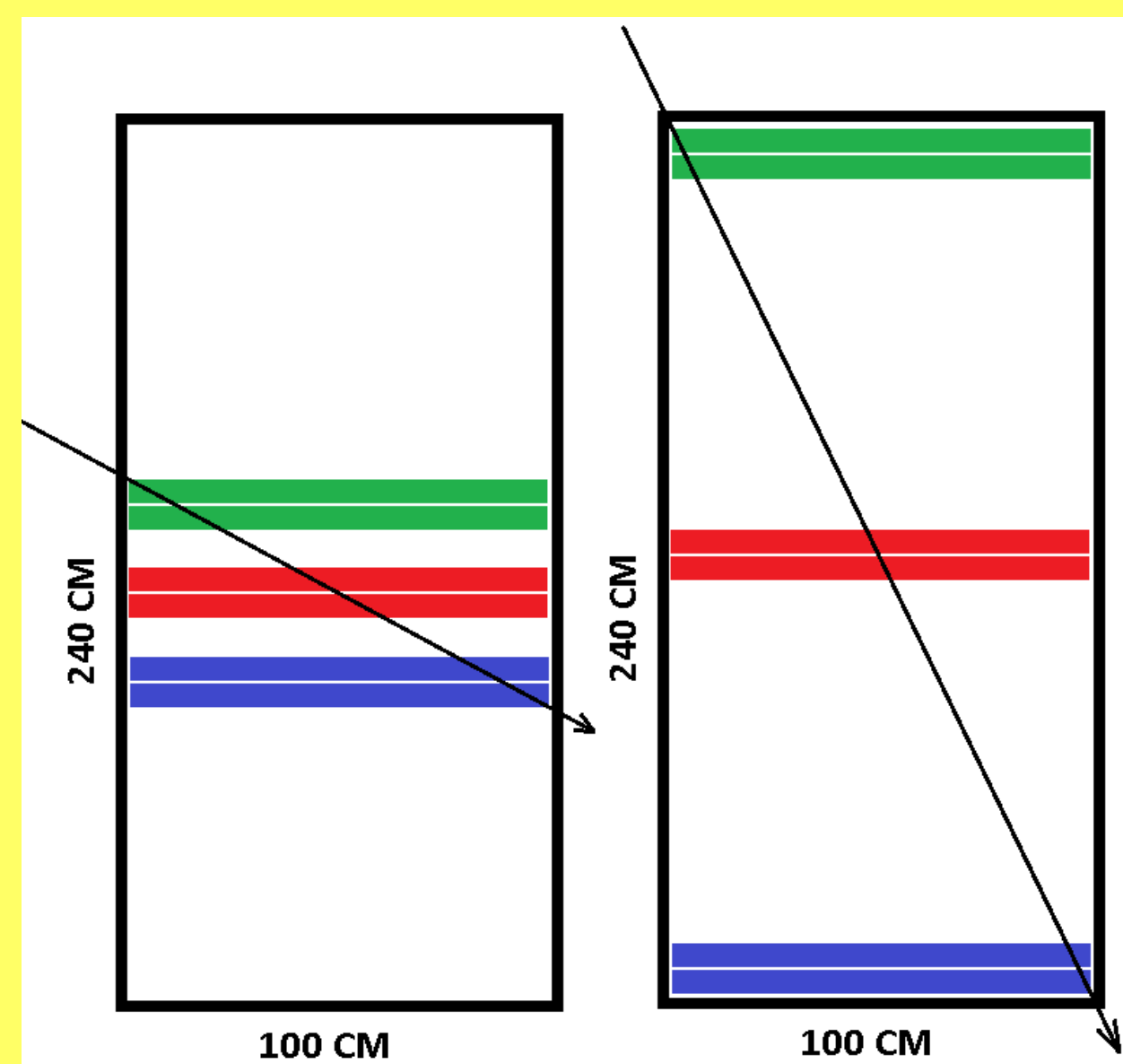


Heart of SiRO Detector: MPPC (Multi Pixel Photon Counter) S10362-33-100C Device from HAMMAMATSU



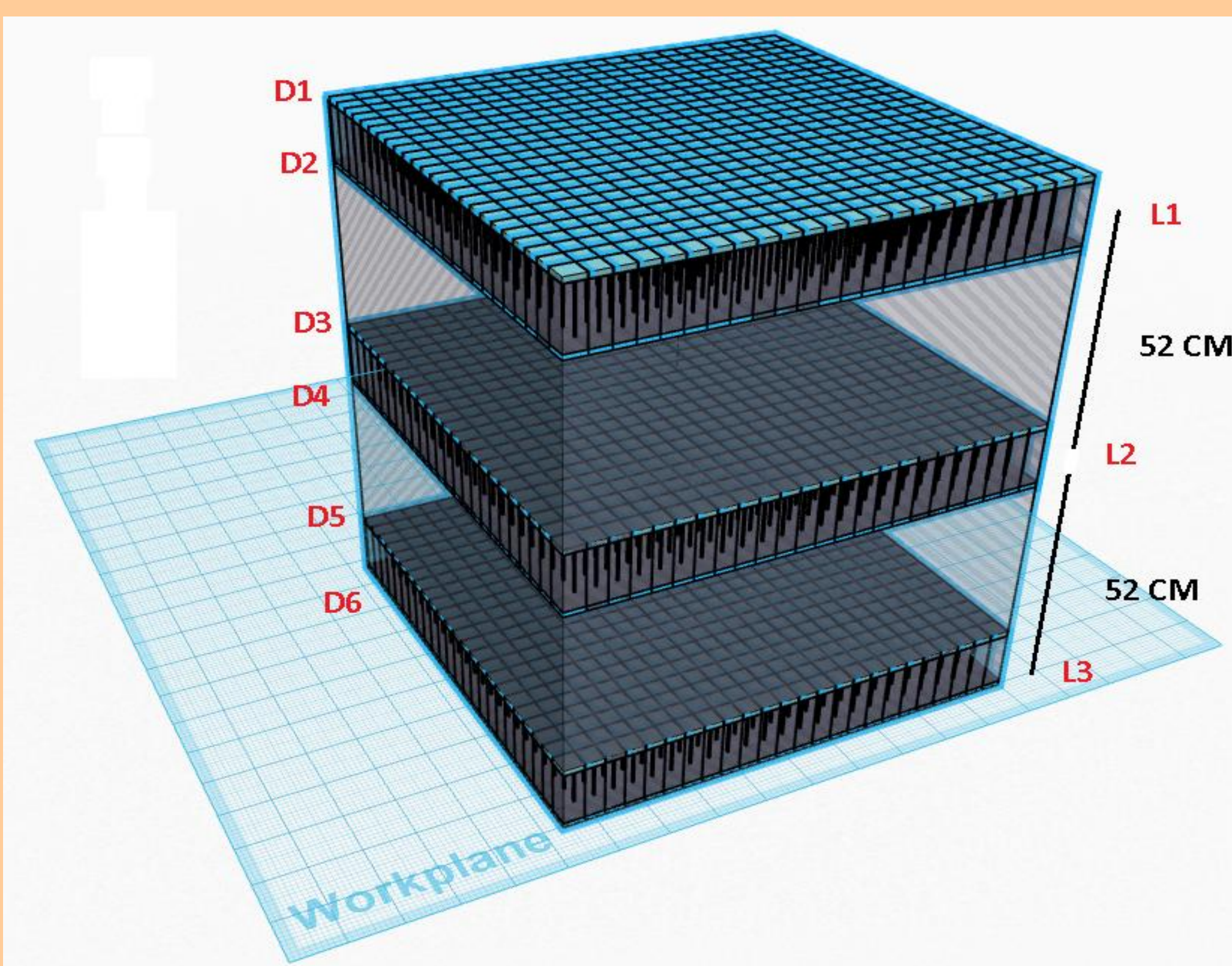
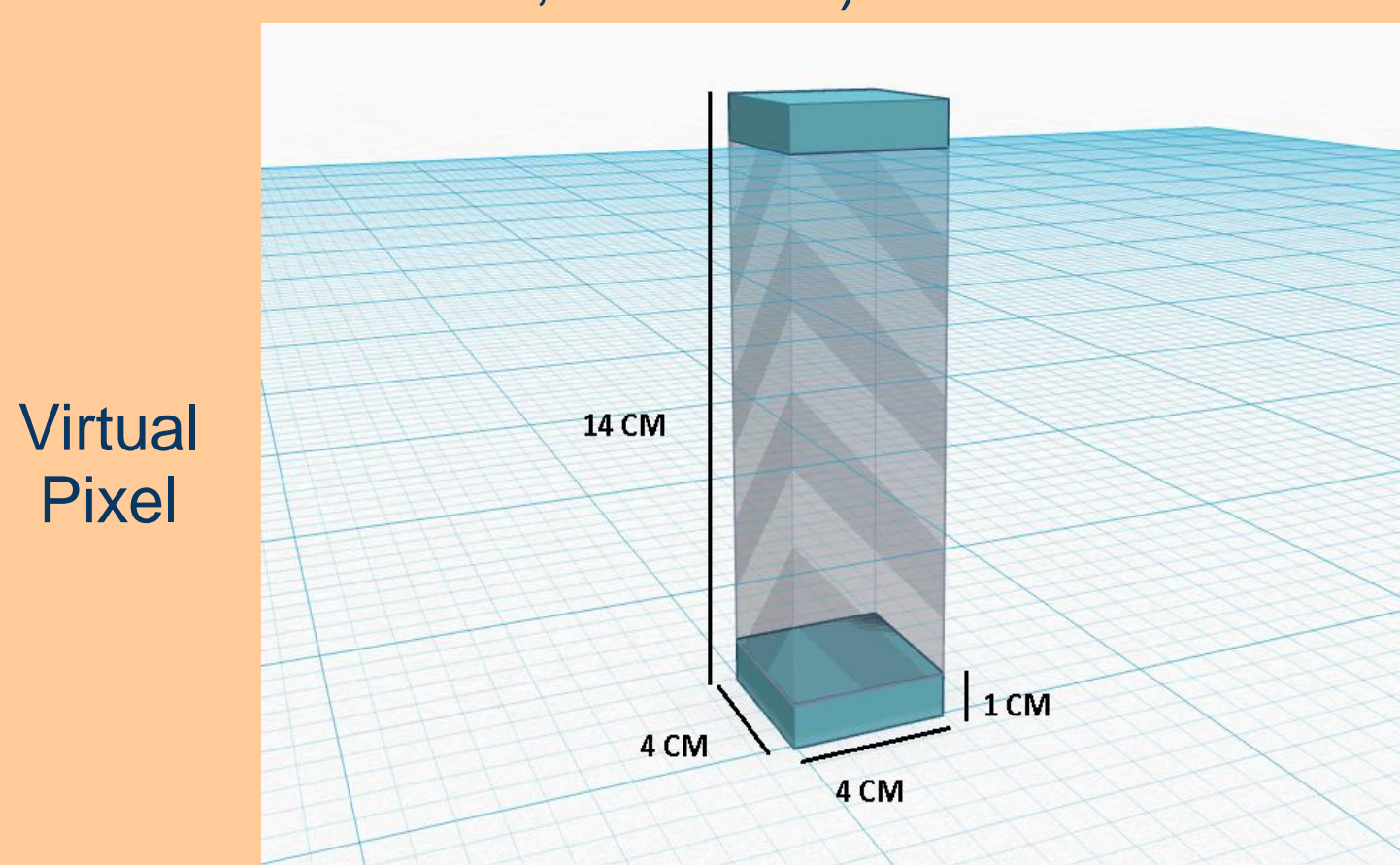
The SiRO detector is designed to perform cosmic muons flux measurements and can reconstruct each event incident trajectory. The detector is based on plastic scintillators, optical fibers (wavelength shifters) and readout by SiPM(MPPC-Multi Pixel Photon counter) devices.

It consists of a stack of 6 detection modules, grouped in 3 layers for determining the muon trajectories through 3 planes. One module has 24 plastic scintillator strips with 2 fiber mounted on each strip, read by 24 MPPC devices. Active surface is 1m x 1m. The modules can be placed in any configuration, thus tracking incident trajectories angle can vary from a maximum of 59° to 25.4°.

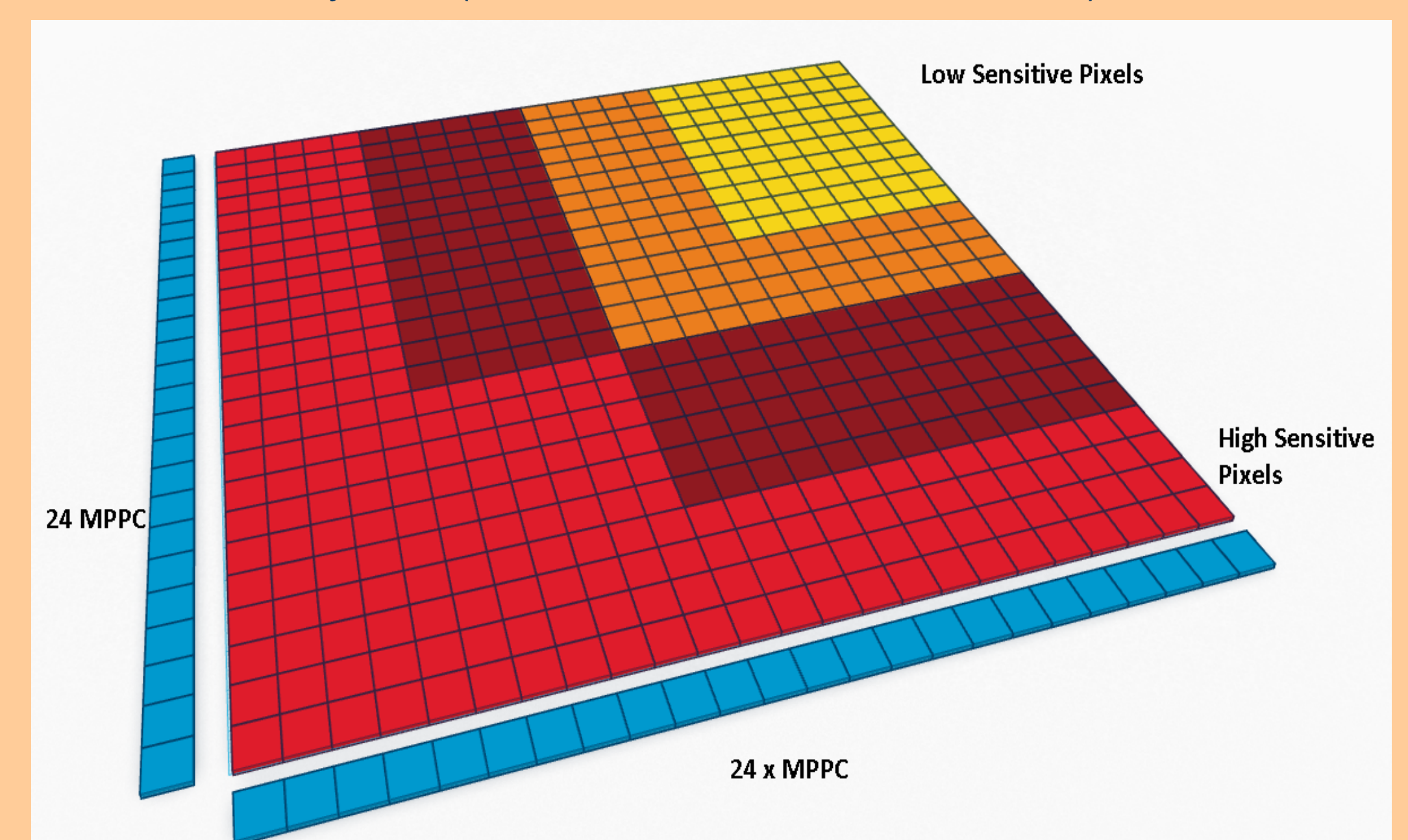


Reconstruction of incident trajectories

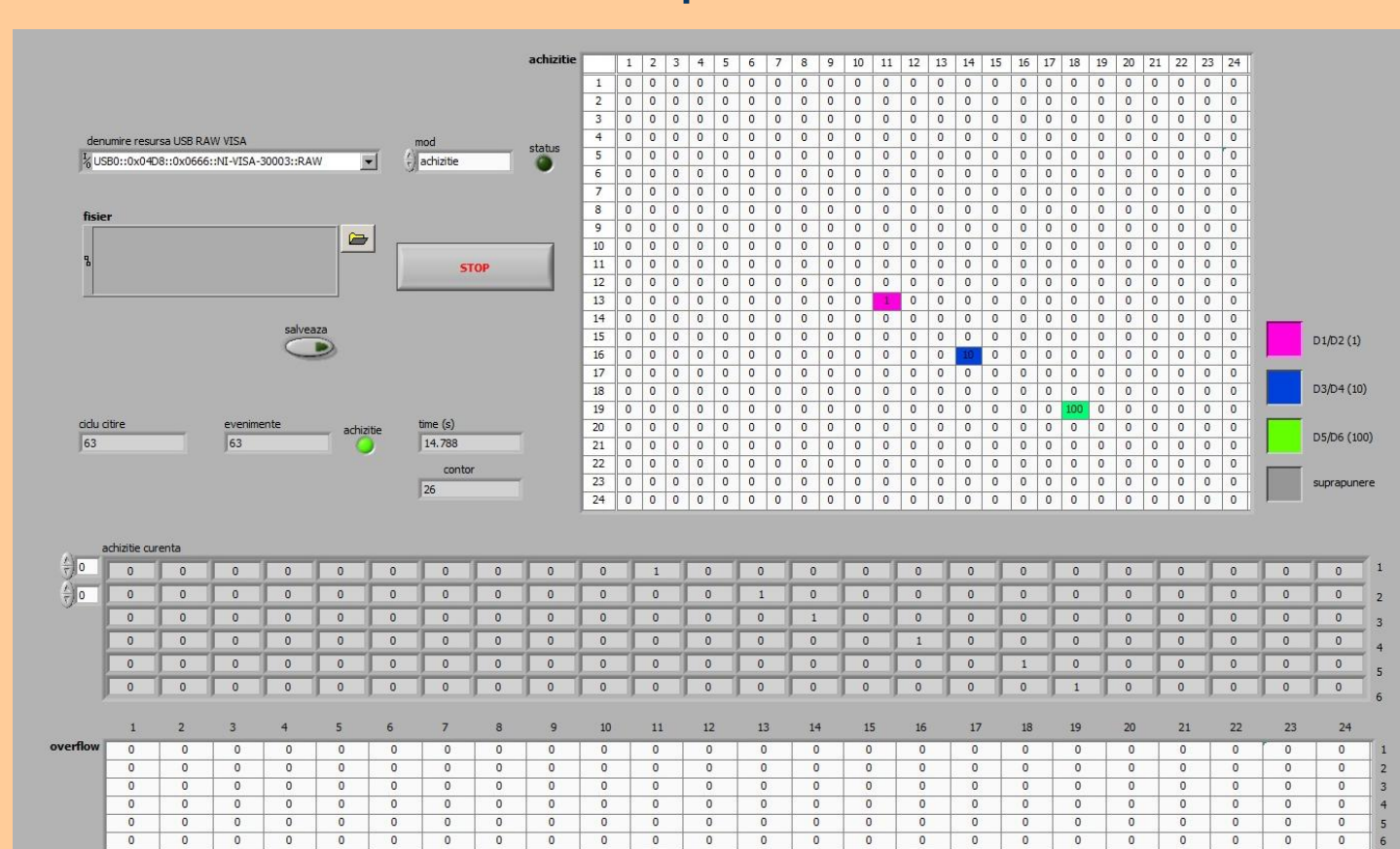
For trajectory reconstruction and event validation the software analysis will virtually split one detection surface (from 2 modules) in 576 of virtual pixels. The software will analyse event by event and will determine what pixels are positive and will search mathematically in 3D any valid trajectories from a set of 3 pixels (from L1, L2 and L3).



Because of the modules design and the positioning of MPPC devices on one end of the optical fibers, the pixels in matrix closer to the sides with the MPPC manifest a lower level of needed excitation for triggering the acquisition system (the differences are less than 5%)



LABVIEW Acquisition Software



The Acquisition Software is capable of tracking and showing muon trajectories in real time. In the 24x24 matrix is shown which pixel is triggered in all of the 3 layers of the detector for all the events

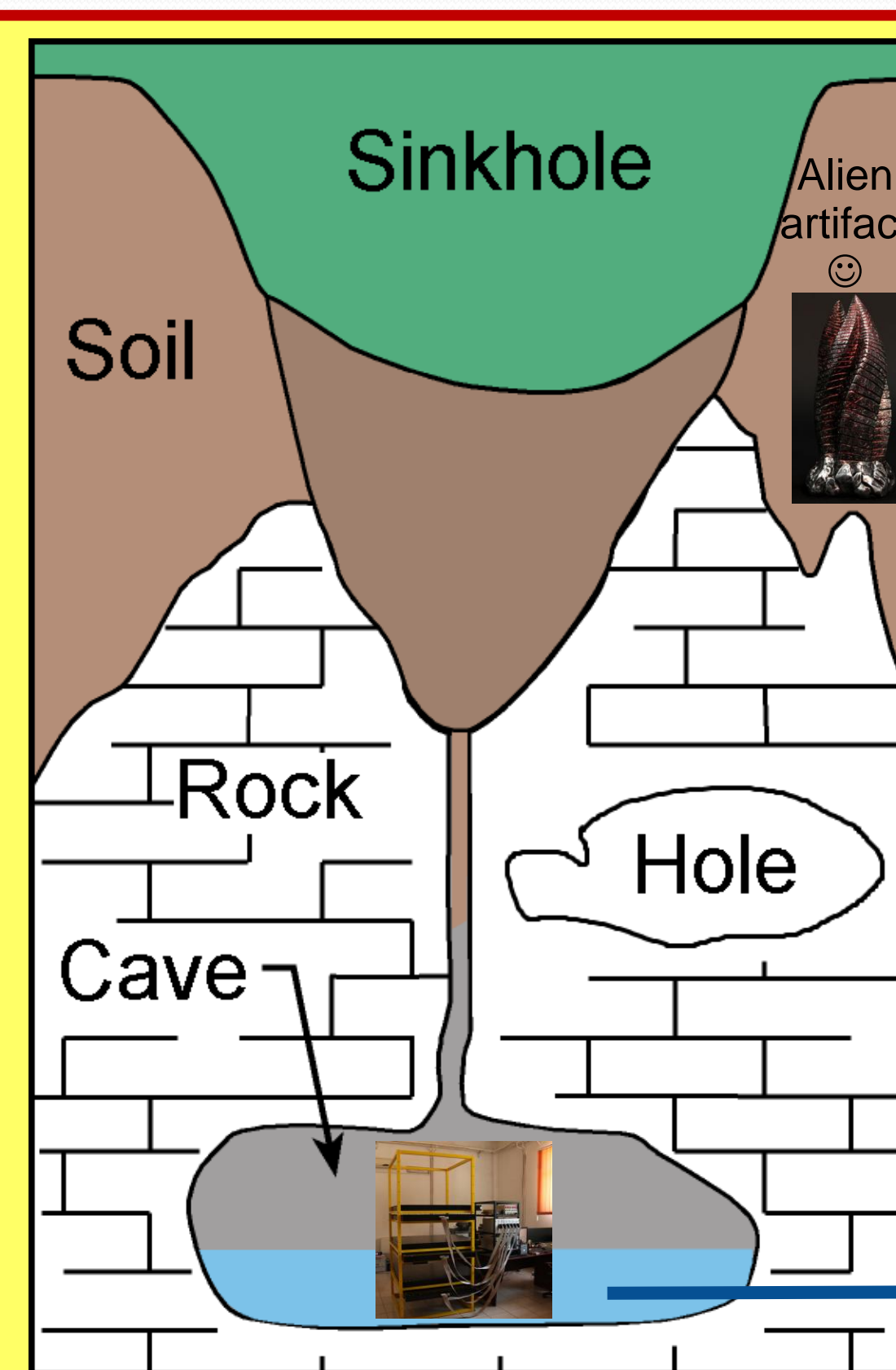
Efficiency analysis from open space ground level flux measurements

Coincidence	Single valid trajectory events	Multiple valid trajectory events	Invalid trajectory events	Total efficiency
L1 si L2	94.2 %	5.8 %	-	-
L1 si L2 si L3	86 %	5.7 %	8.3 %	91.7 %

What it is used for?

The detector can be used for precise measurements of the directional variation of the muon flux at ground level, under water or in the underground (low radiation background). Those measurements are used for detecting unknown cavities in old mining sites or to explore variations in the rock density and composition above the observation level for non-invasive geological studies.

The unique design implies a considerable practical flexibility of using the procedure of measuring muon flux differences for various aspects



Simulations
Physical Interpretations
Acquired data analysis

3D ground mapping with precision up to 1m

Moving and rotating detector in open spaces & acquiring data