EPFL

Development of a cosmic-ray detector (electromagnetic calorimeter)

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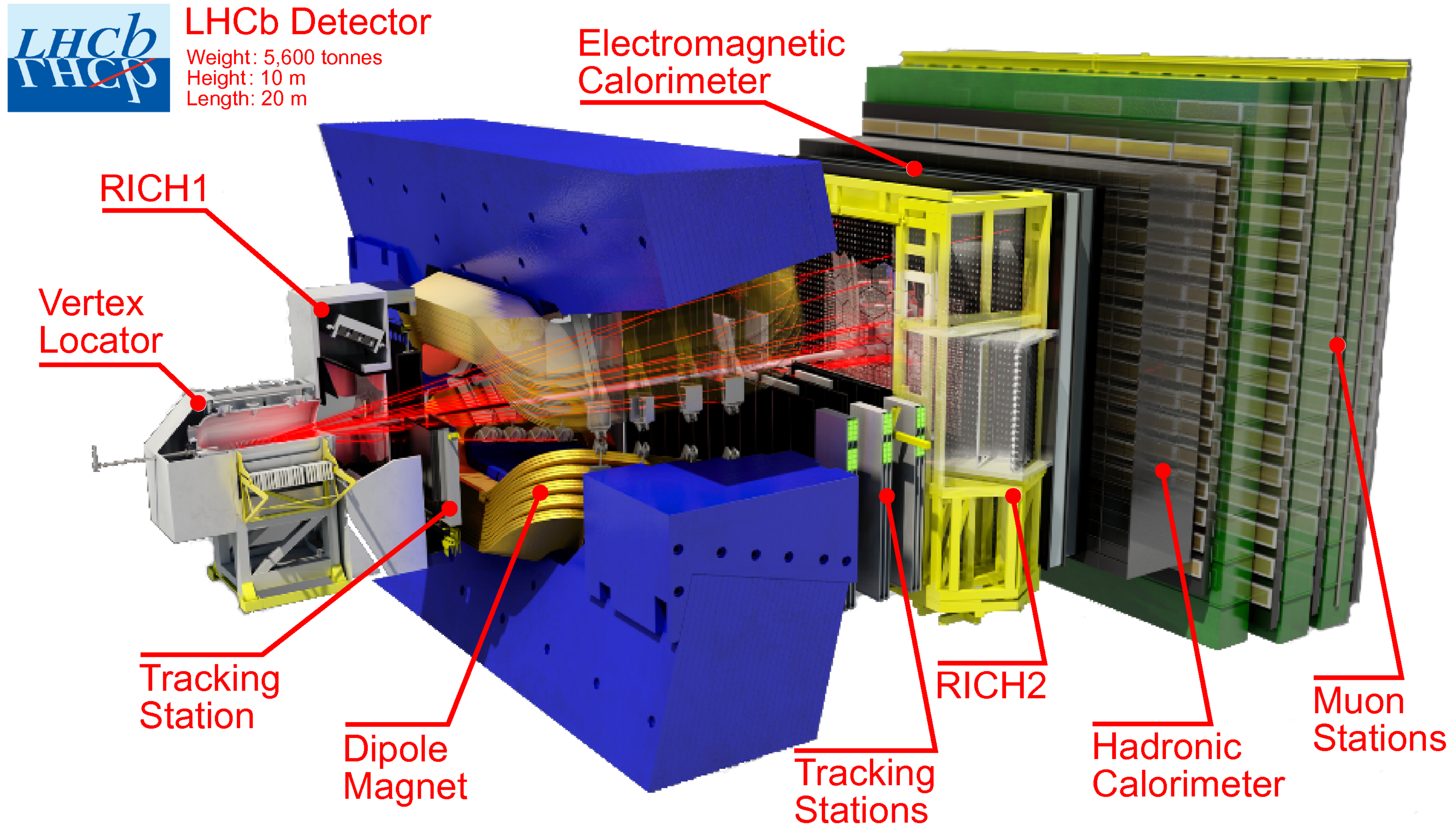
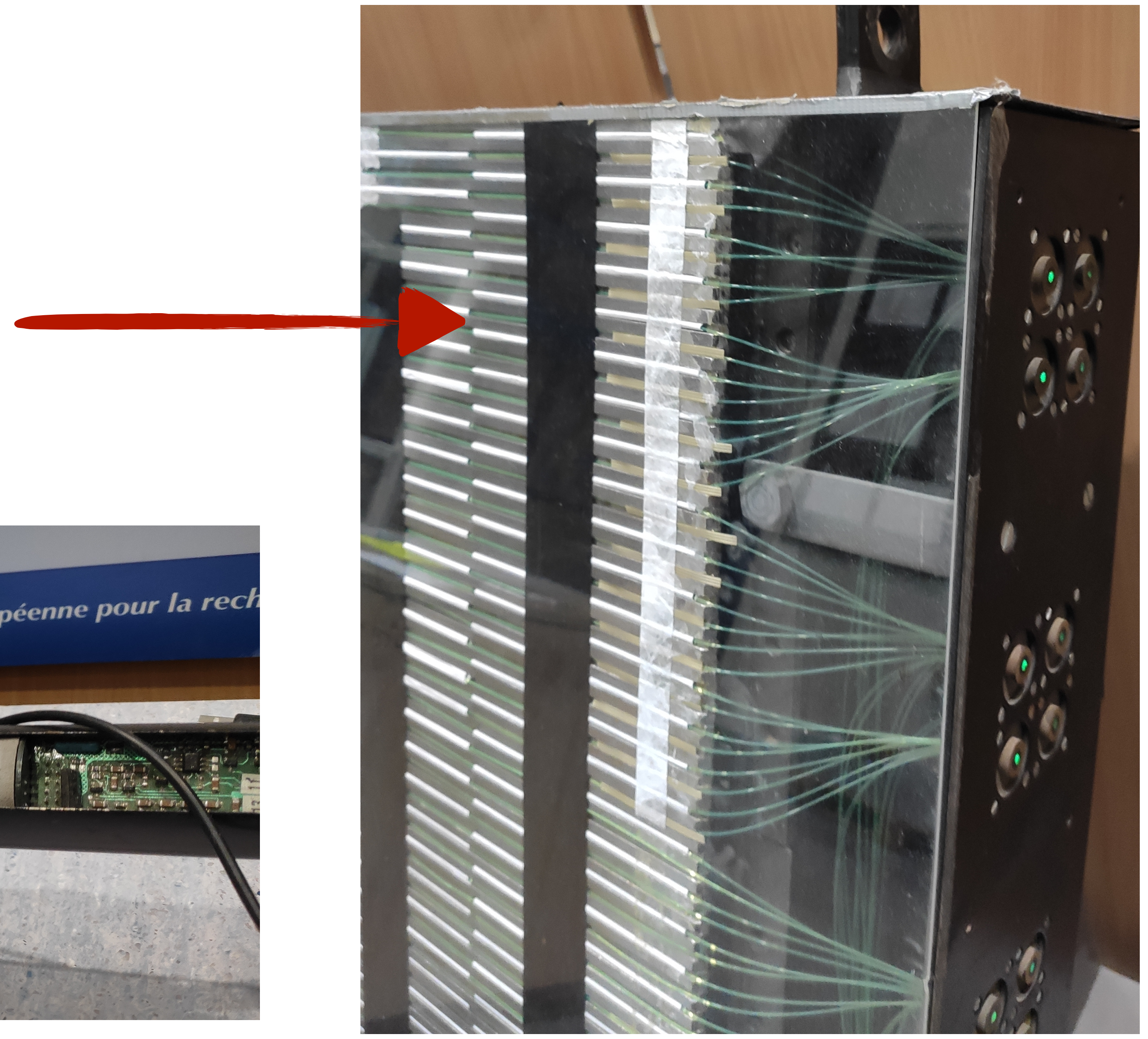
26/09/2022

Calorimetry

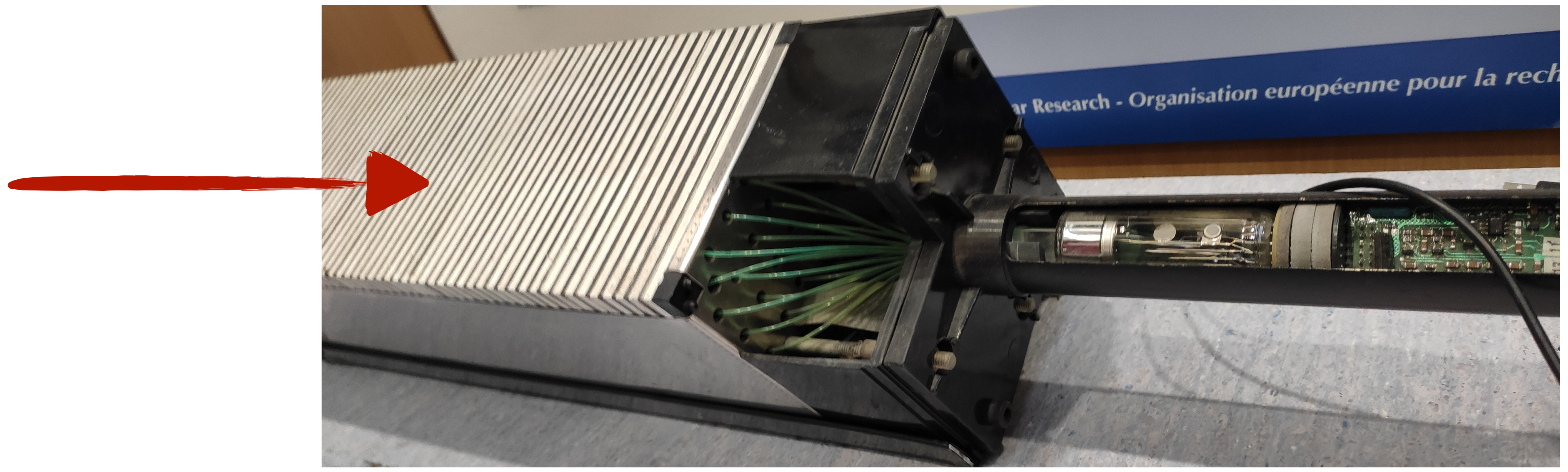
- Important and powerful detector techniques in experimental particle physics
- Two main categories:
  - Electromagnetic calorimeters (**ECAL**) for detection of $e^{\pm}$ and γ
  - Hadron calorimeter **(HCAL)** for detection of $\pi^{\pm}, p^{\pm}, K^{\pm}$, etc
- It measures:
  - Energy of incoming particles (by absorption)
  - Spatial location of the energy deposit
  - (Sometimes) direction of incoming particles



- **HCAL module**

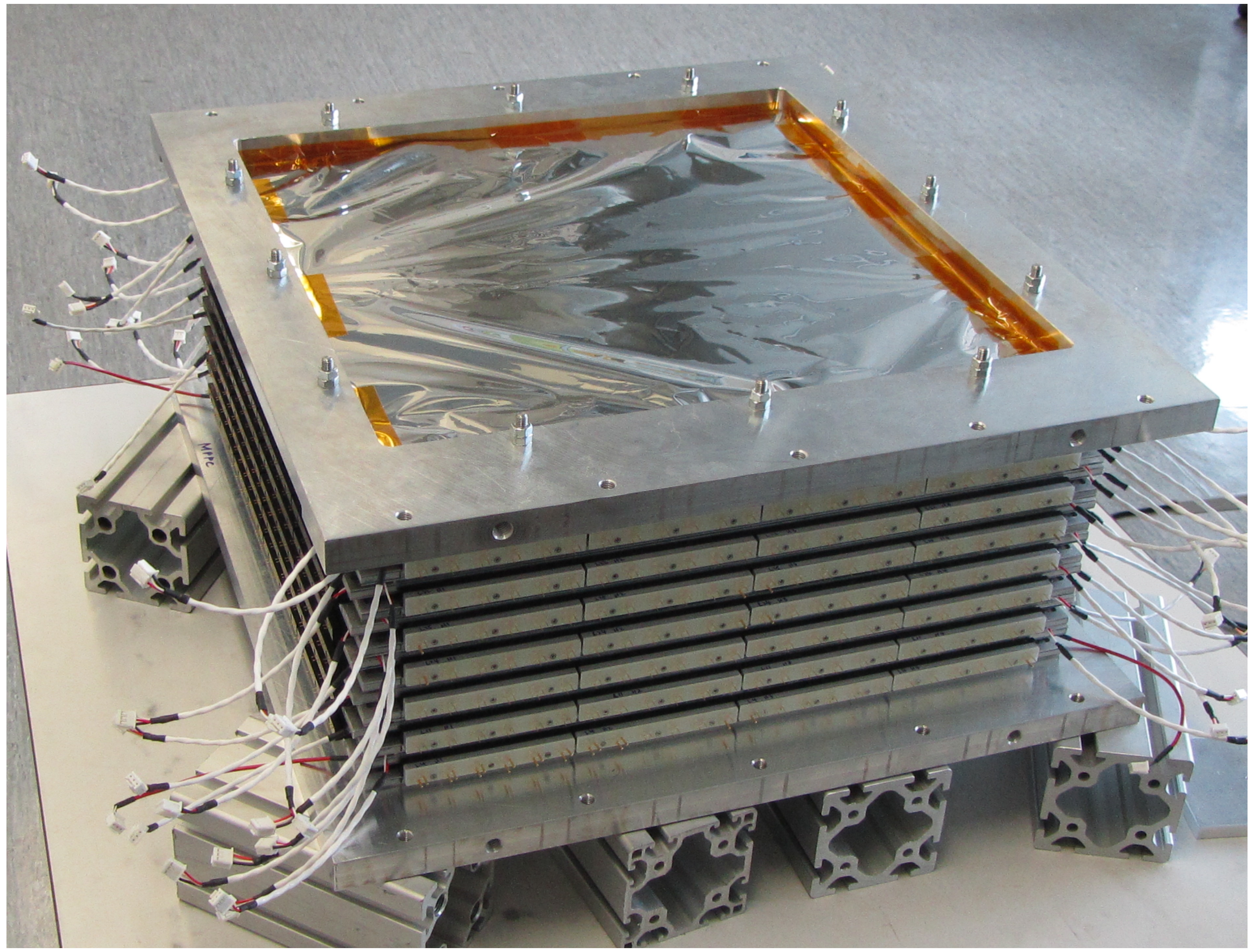


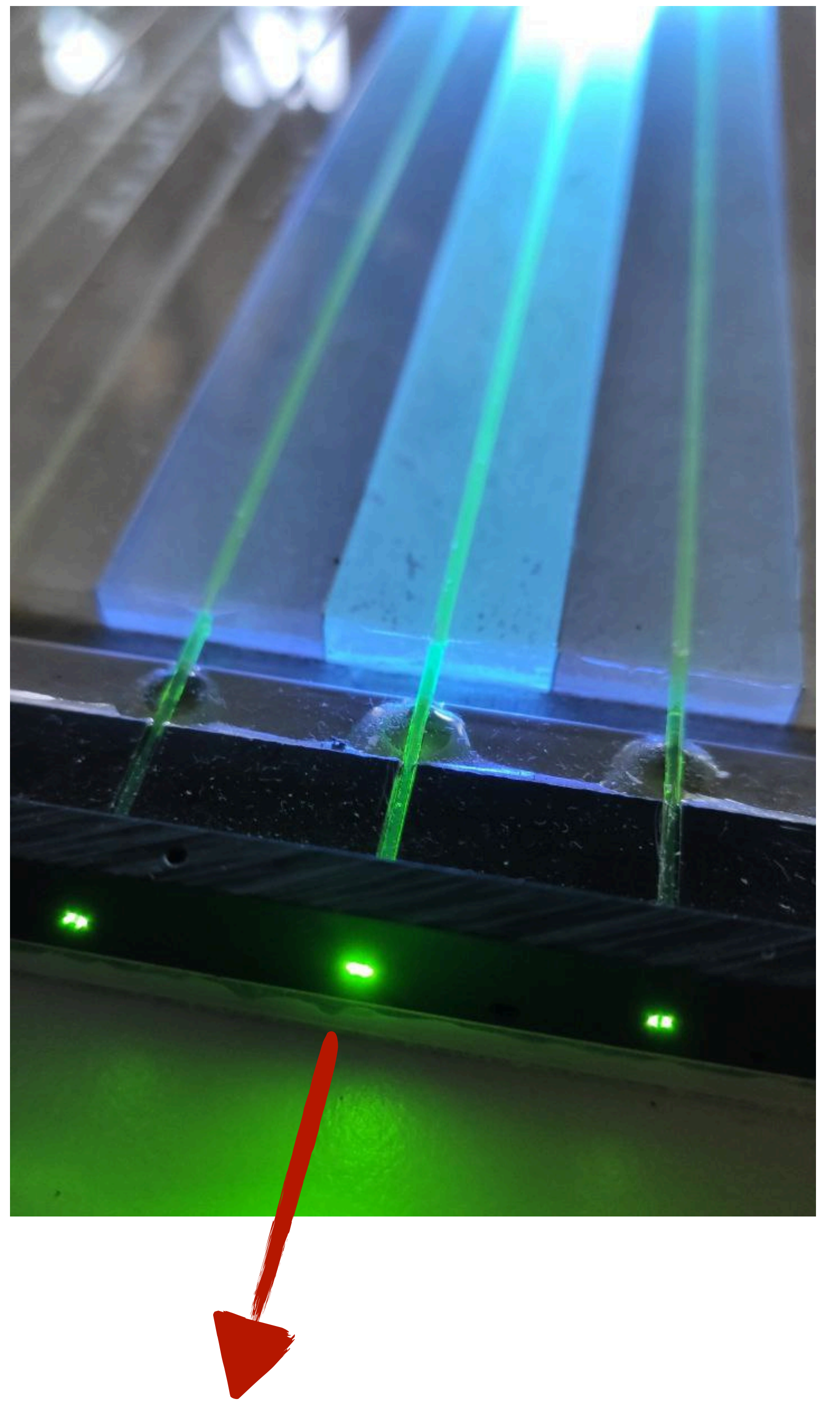
- **ECAL module**

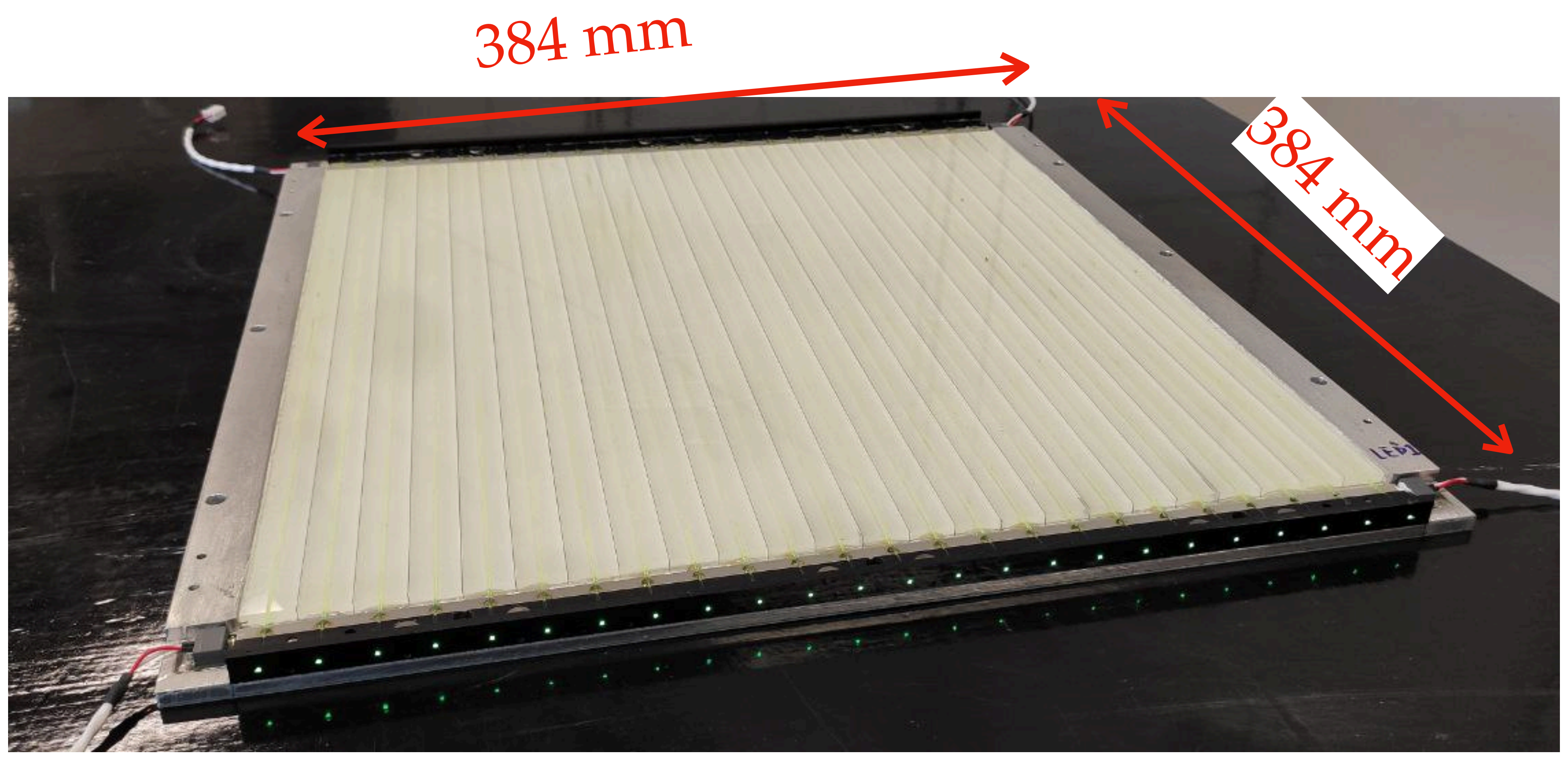


Our detector

- ECAL made of organic scintillator stripes forming active layers, that are interleaved with passive layers (absorbers)
- 16 layers in total in XY, corresponding to 0.75 radiation lengths (X_0) and about 0.035 nuclear interaction lengths (λ_0)
- Each sensitive layer has 24 scintillating bars with a wavelength shifting fibre
- Possibly to readout 24x16 = 384 channels

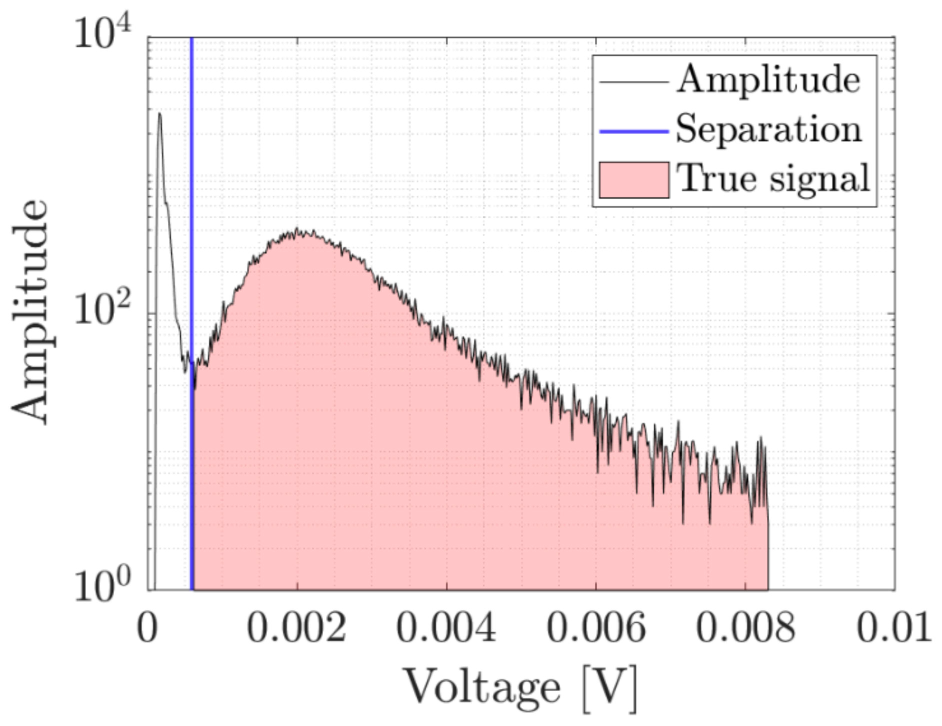




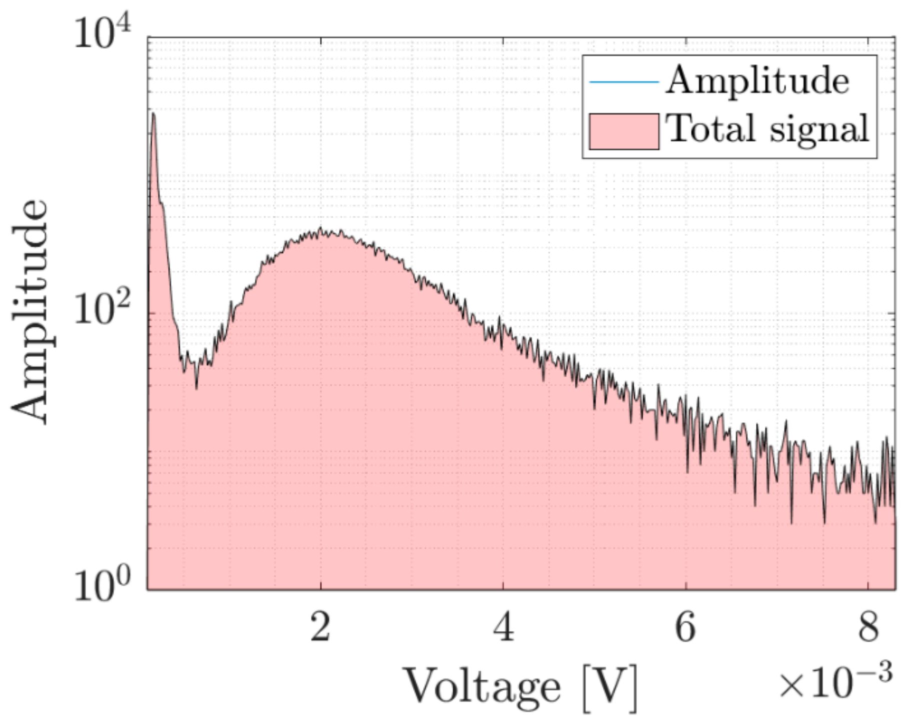


What can we detect?

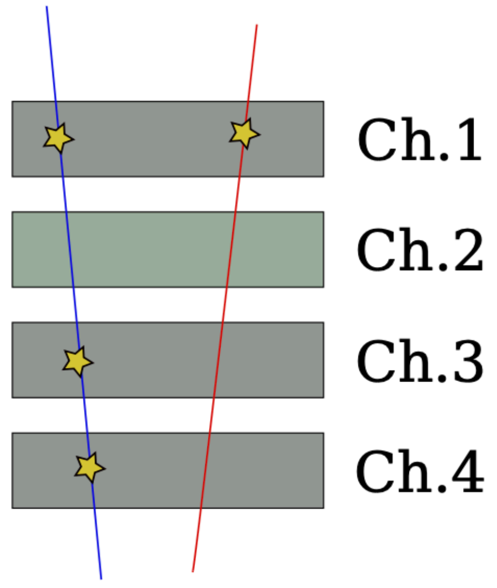
- Muons and electrons coming from cosmic rays, that are hitting atmosphere
- How do we know it was an electron? Muon?
- How can we measure its energy?
- Actually we really don't know —> you will be the ones doing it for the ~~first time!~~ second time :)
  - We had a first attempt of measuring cosmic muons with our detector in the previous semester



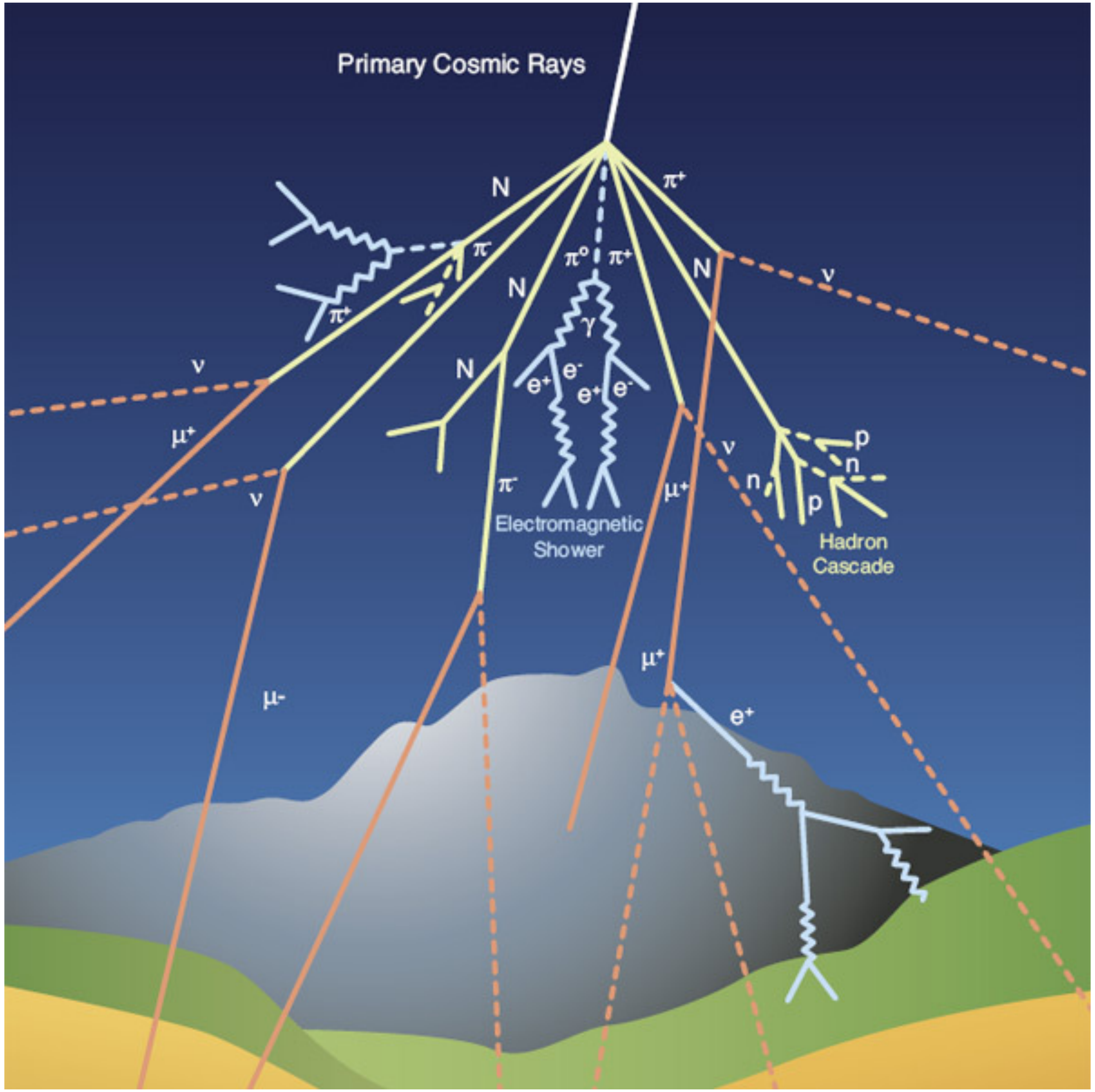
(a) Amplitude for the detected events



(b) Amplitude for all events

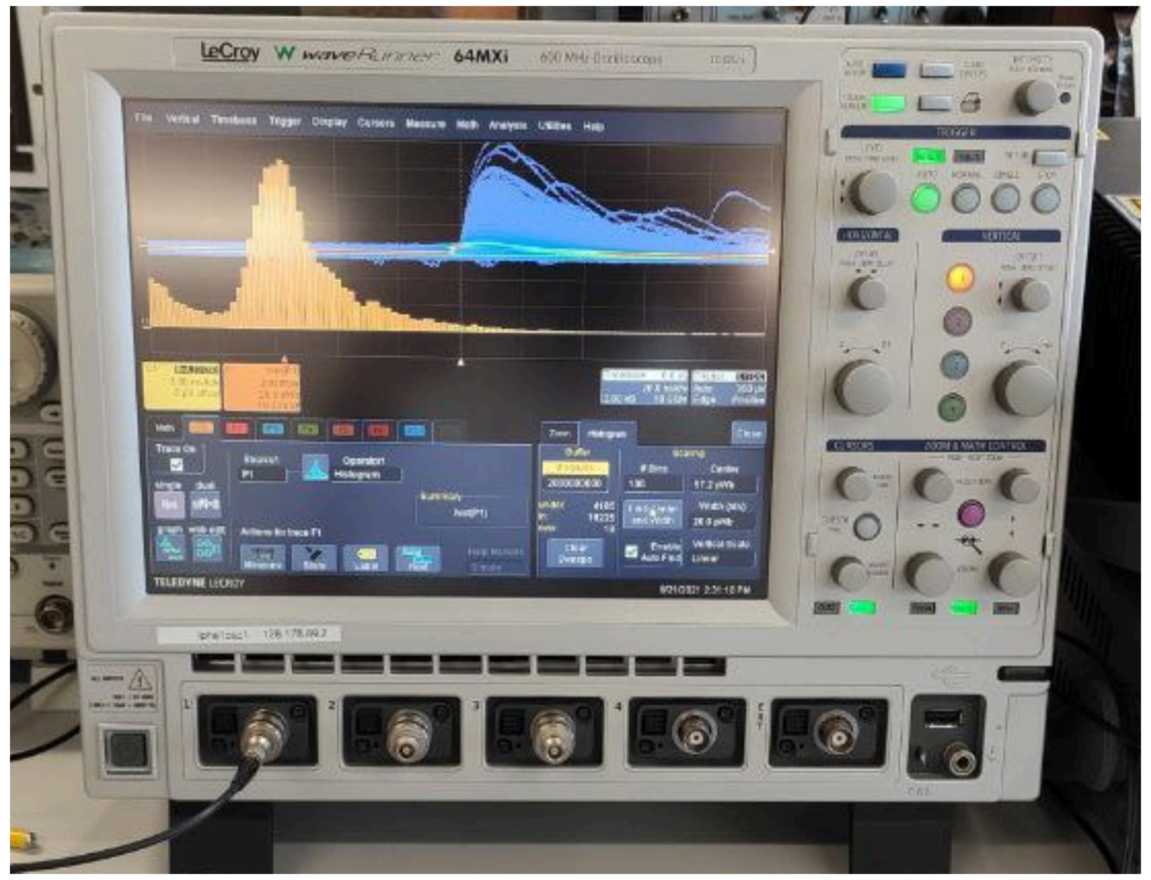


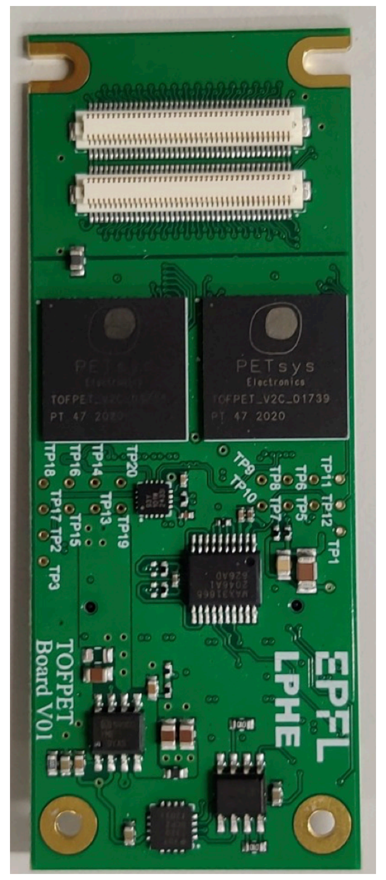
Measurement by C. Polivka, L. Niggli, T. Monnard

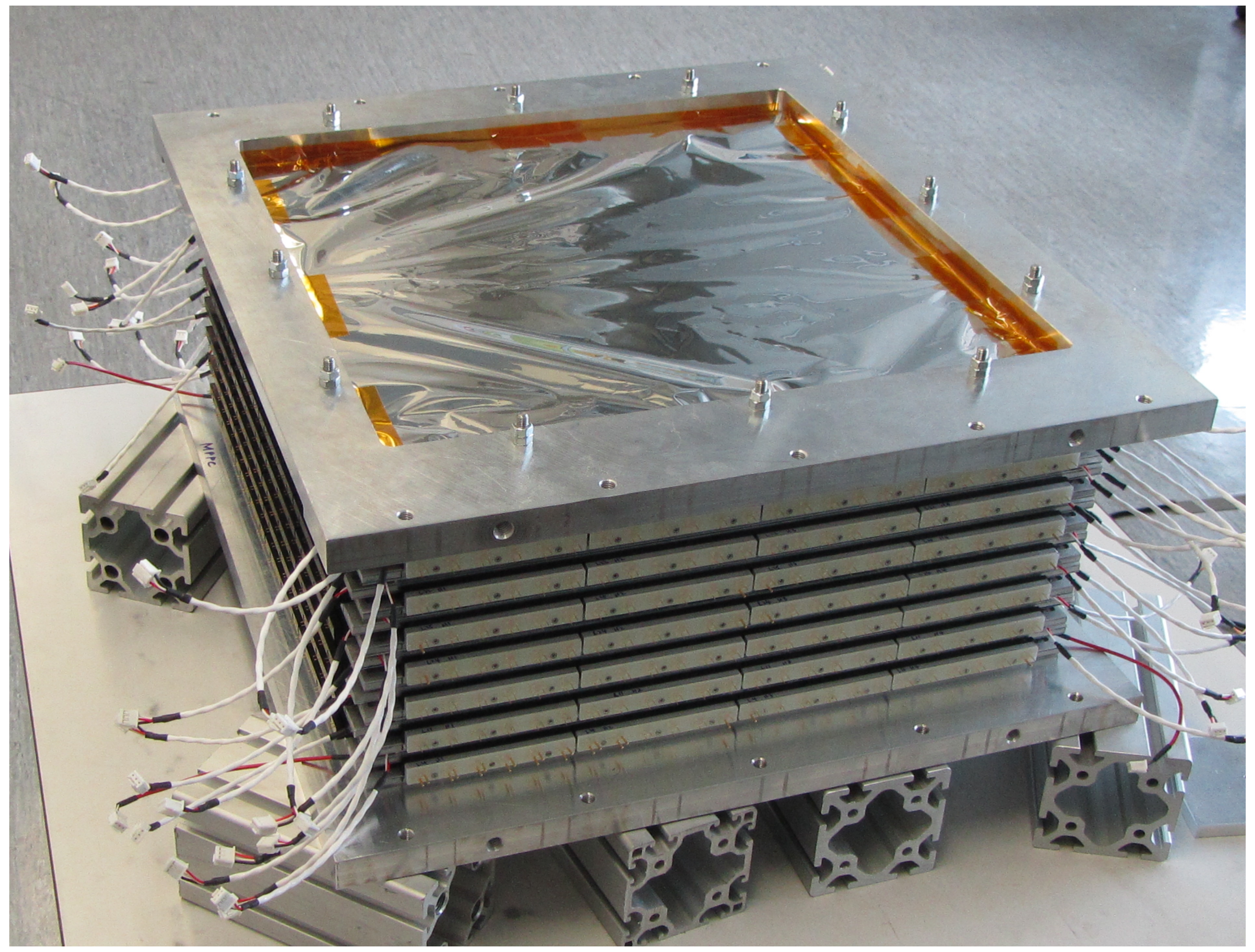


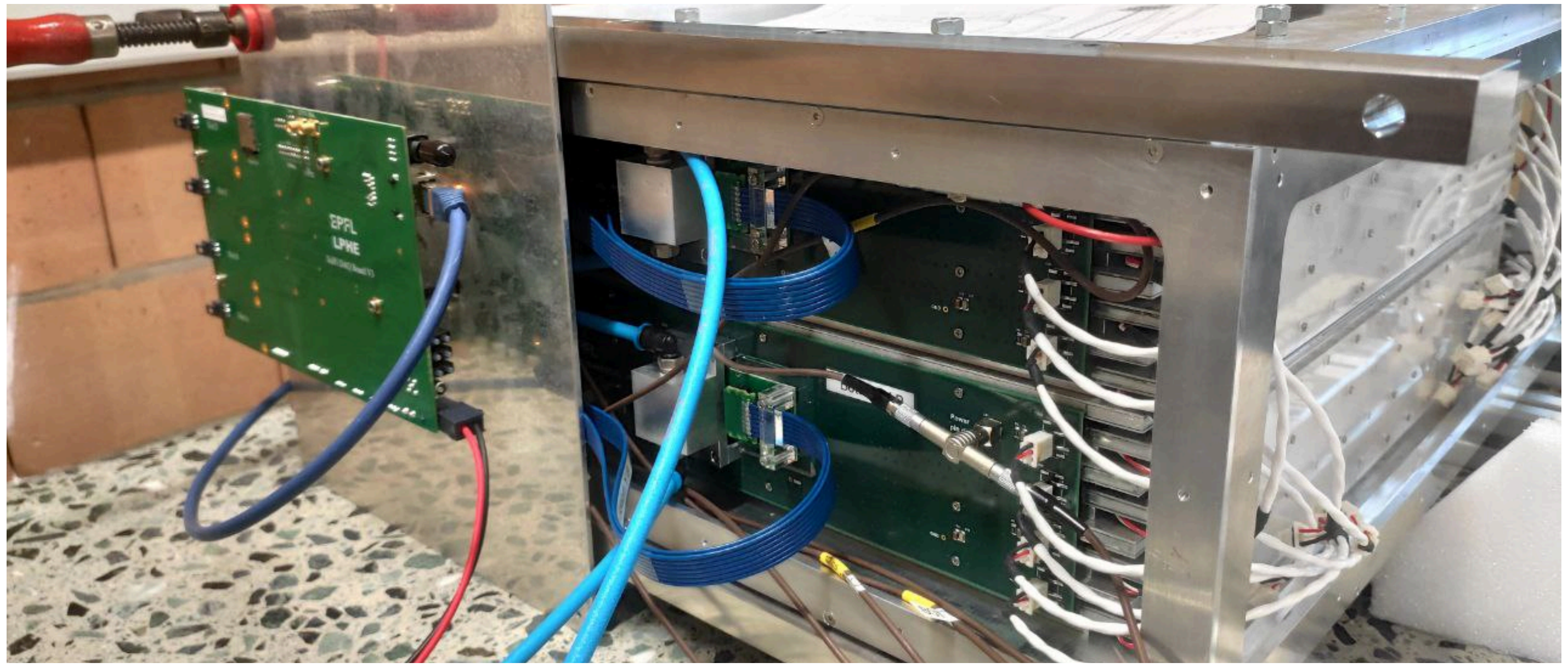
Already done:

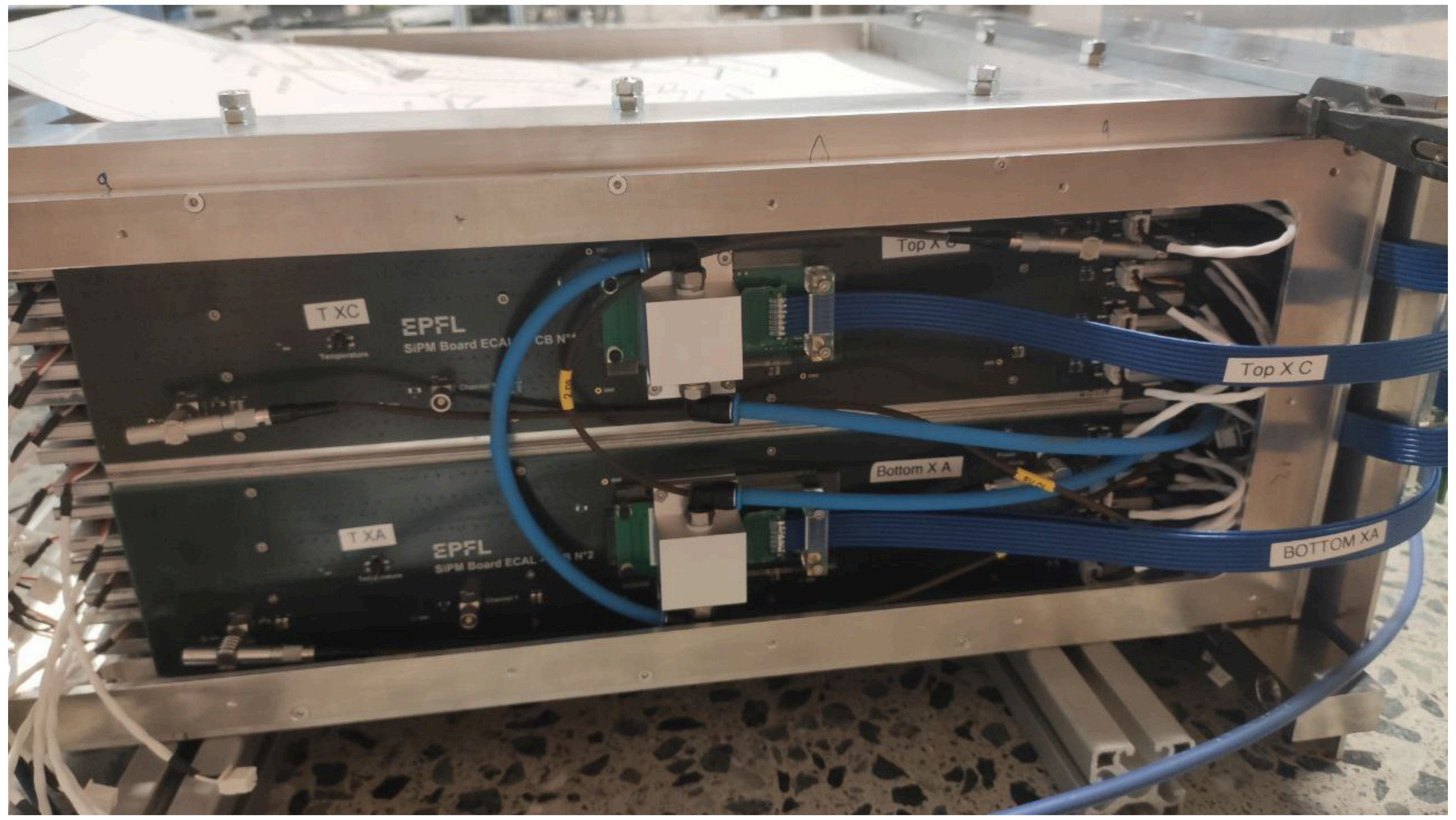
- the full readout using application-specific integrated circuit (ASICS)









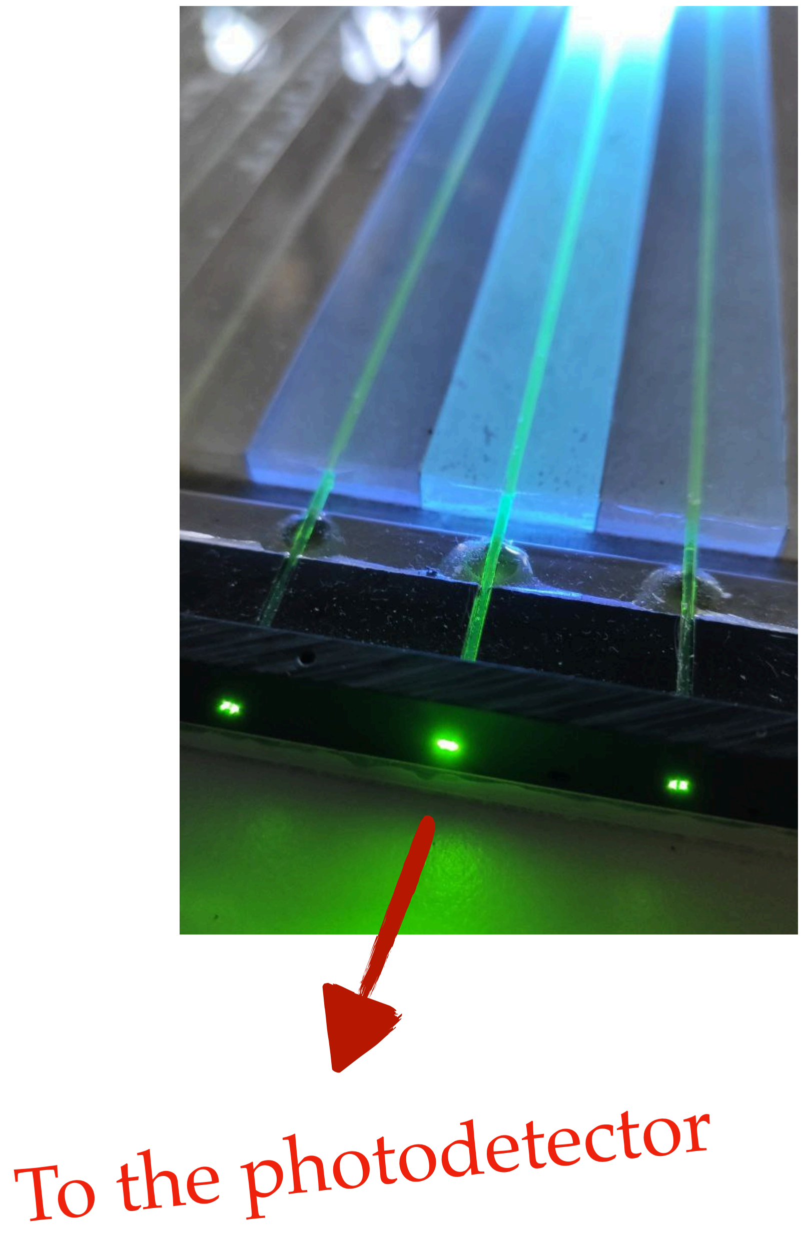


Already done:

- Geometry mapping (readout channels to physical cells)
- Basic track reconstruction algorithm

You will be doing:

- Improving track (+ showers) reconstruction algorithm
- Time alignment of the readout channels
- Detecting muon decays inside of ECAL (developing data analysis algorithm based on the track reconstruction)



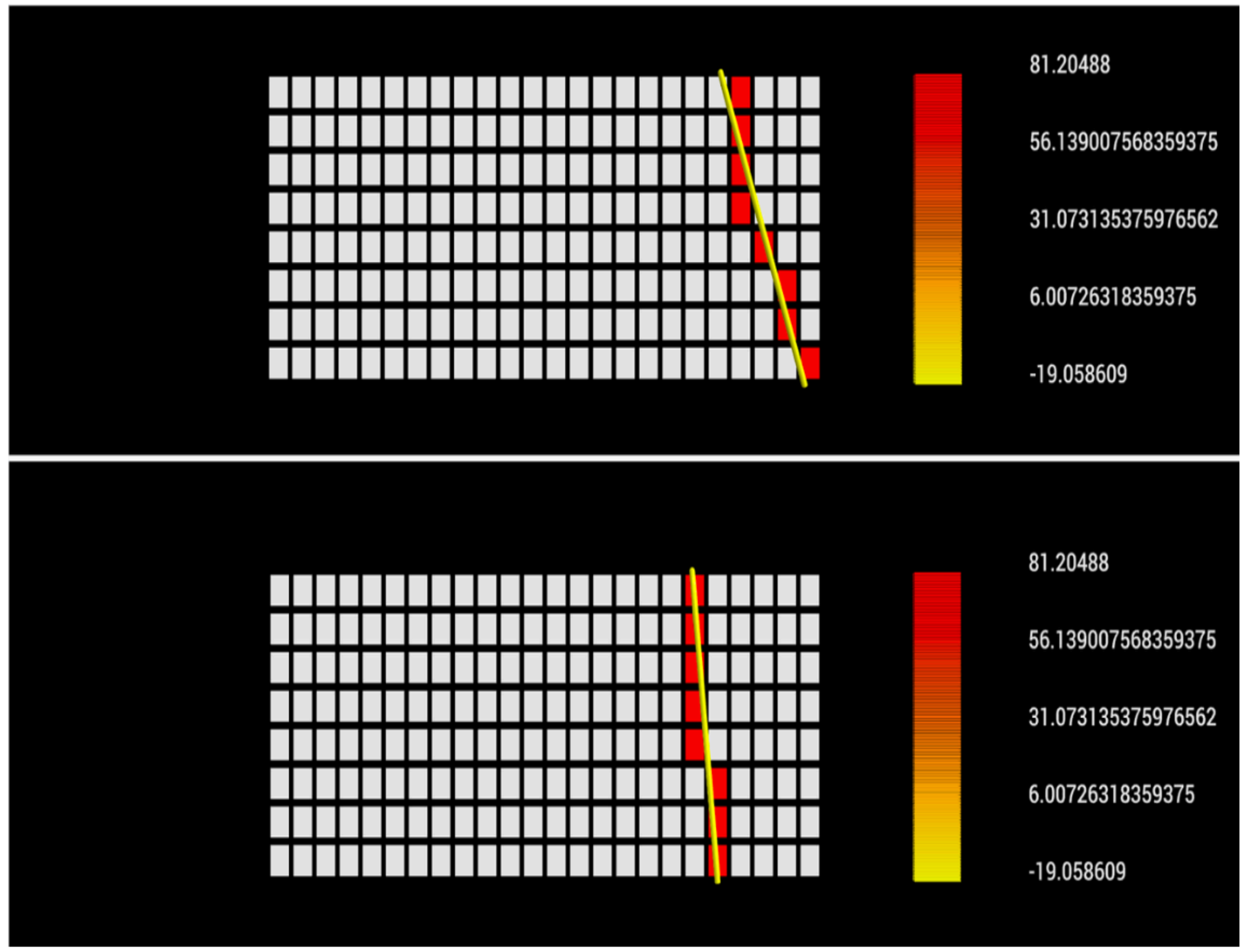


FIGURE 4
Example of Track reconstruction

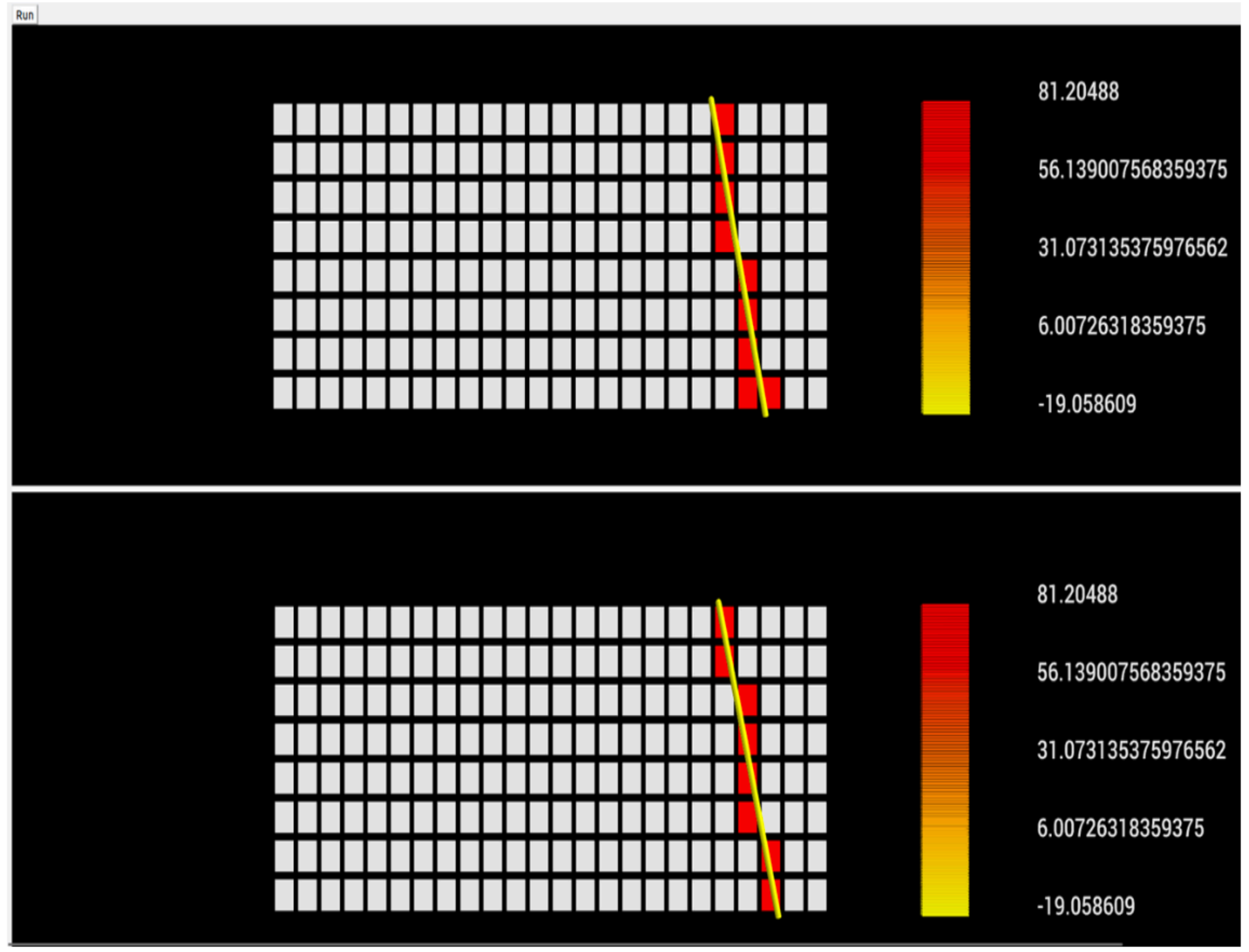


FIGURE 5
Example of Track reconstruction

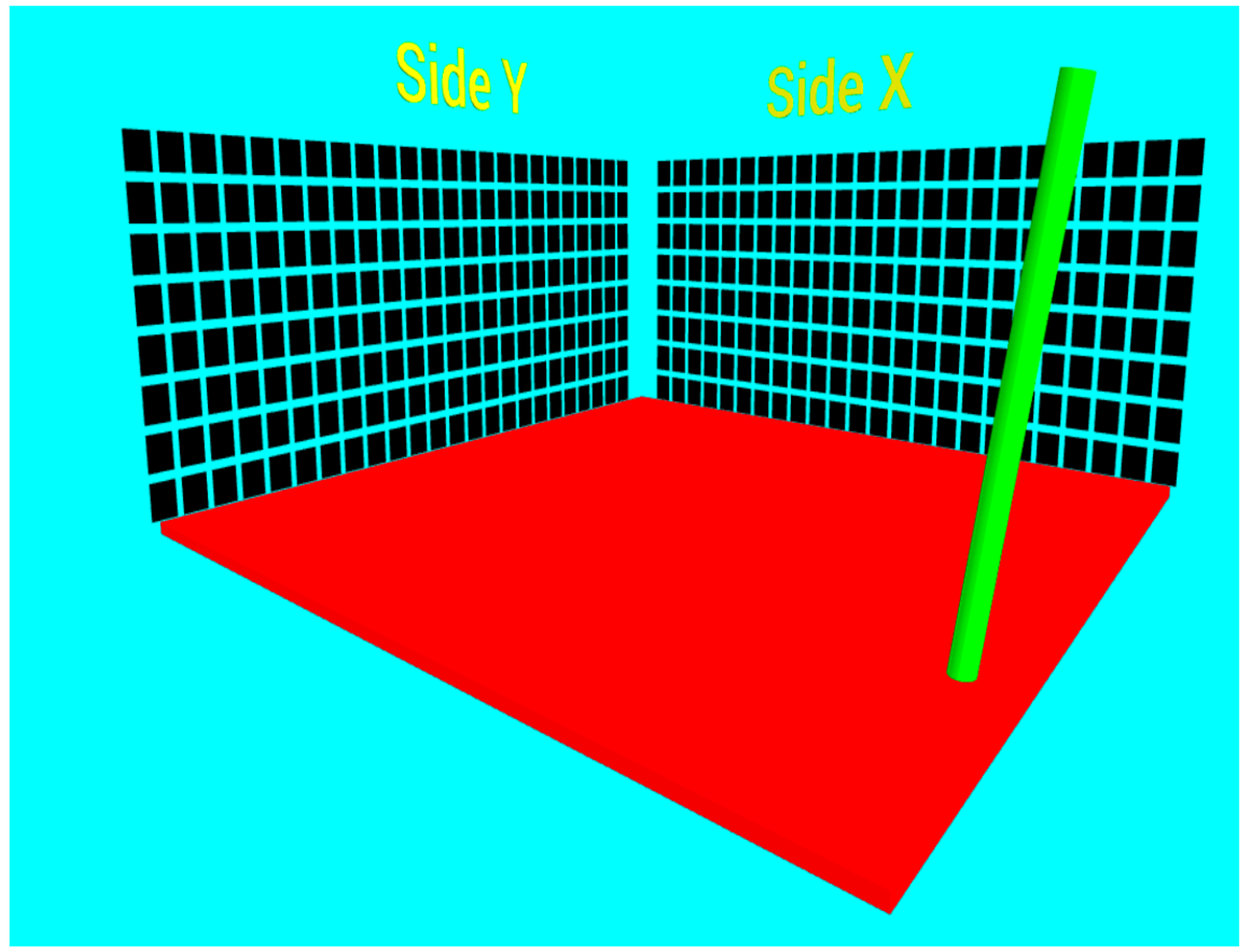


FIGURE 6
Example of 3D track reconstruction

Thank you!

Code editors and some useful tips:

- Visual Studio Code (VSC) - allows you to write your code directly on your machine and port it to the cluster/remote via ssh tunnel (https://code.visualstudio.com/docs/remote/ssh)
- Sublime text - same functionality except the remote writing
- Old-schoolers use VIM / emacs! No need to install anything, just to learn couple dozens of short cuts ;)

- To copy data from and to the remote machine **scp** is fine but I do recommend **rsynk**
- For the most curious, there is a possibility to "mount" a remote machine as local disc to your PC (https://askubuntu.com/questions/412477/mount-remote-directory-using-ssh)

Starting tutorials + project documentation:

- Tbd