Commissioning of a Pair of Commercial GEMS for the Position Calibration of HVMAPS Using Cosmic-Ray Muons

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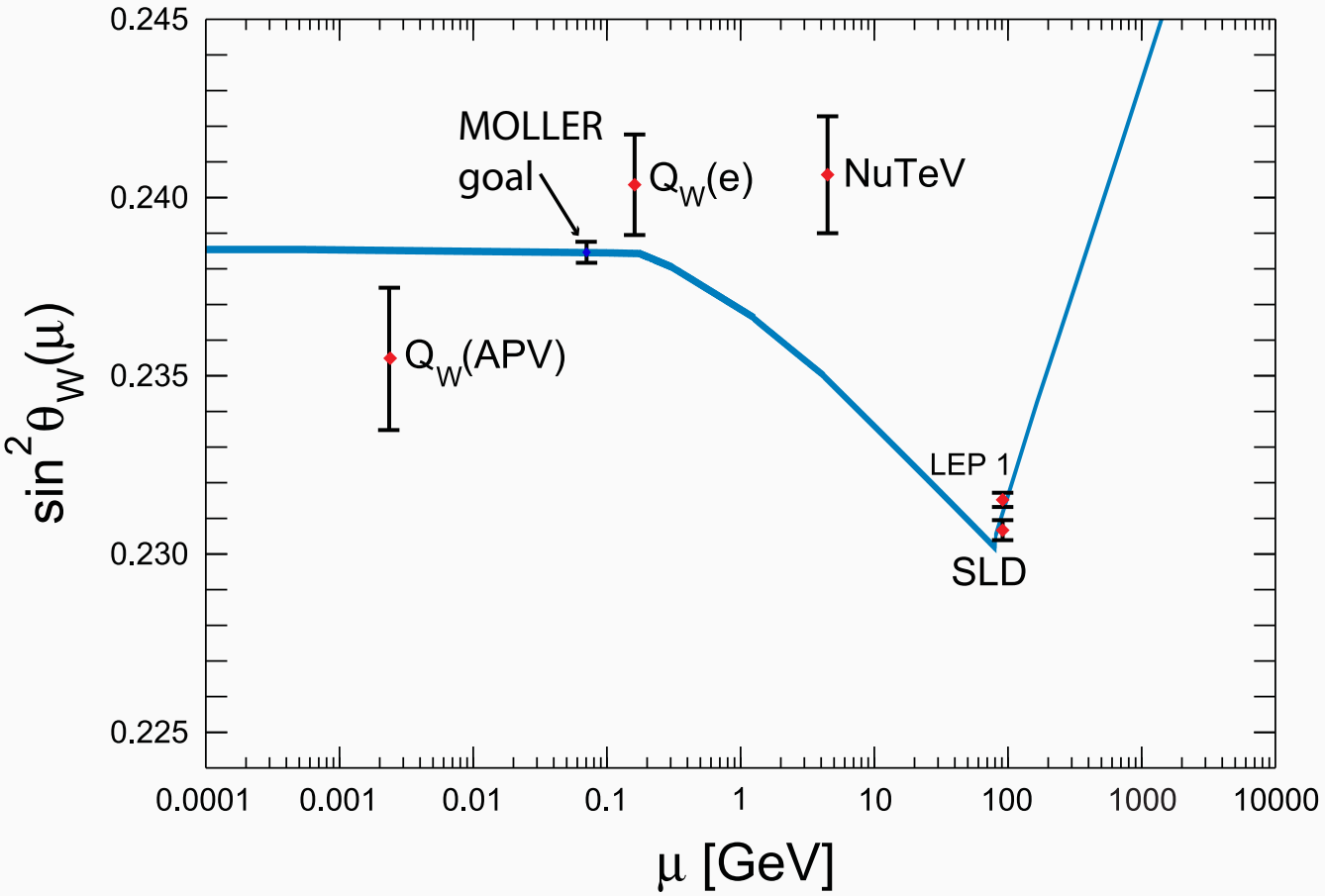
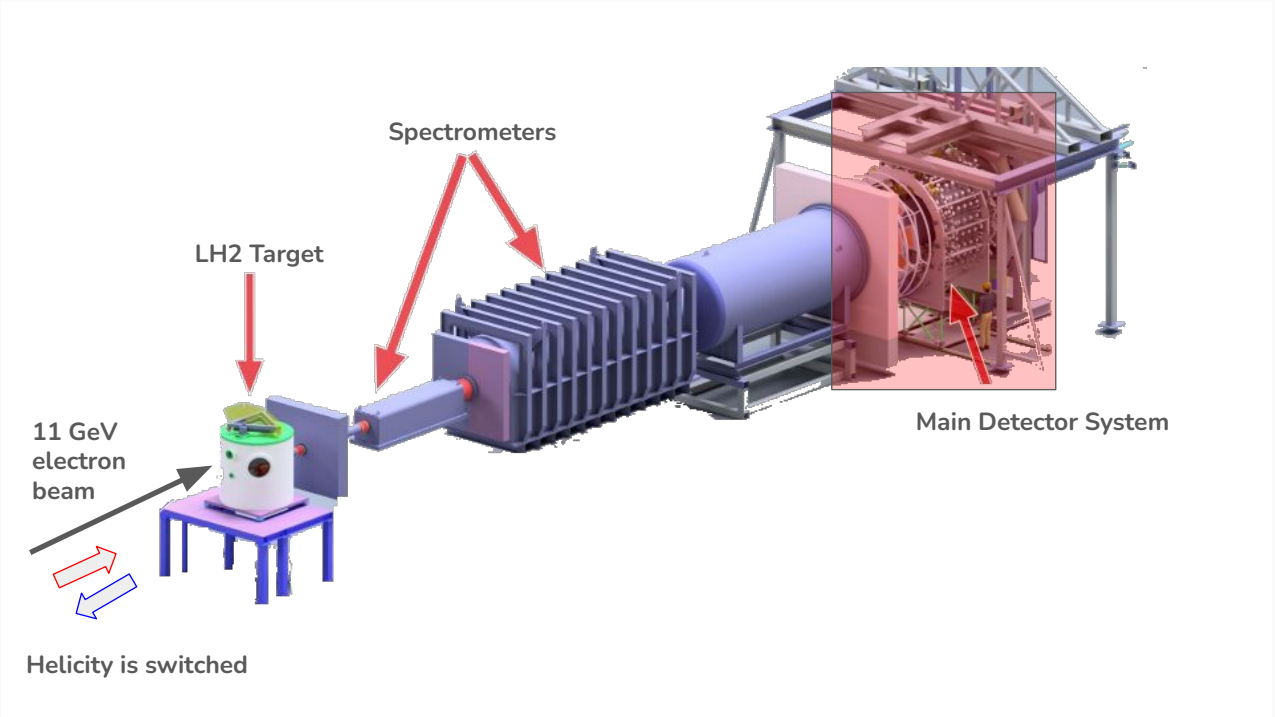
Physics Motivation

Weak mixing angle: Fundamental parameter of EW physics



The interference of photon and Z exchange leads to a running of the weak mixing angle. New physics can modify the running and thus $sin^2\theta_W$.

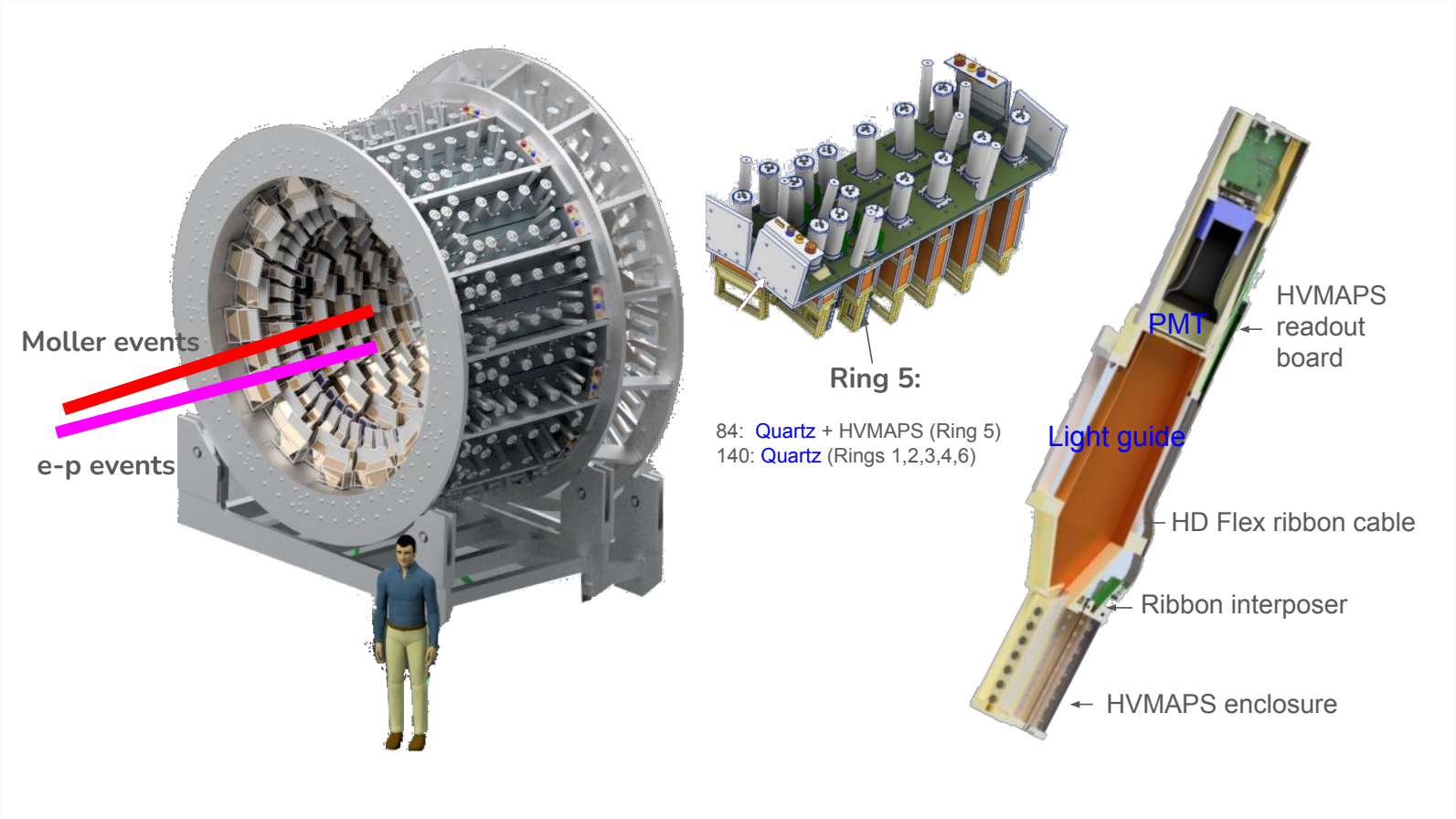
The MOLLER Experiment



Observable: A_{pv} Parity-violation asymmetry in electron-electron (Møller Scattering)

- Electron weak charge $Q_W^e \pm 2.3\% \implies sin^2\theta_W \pm 0.1\%$

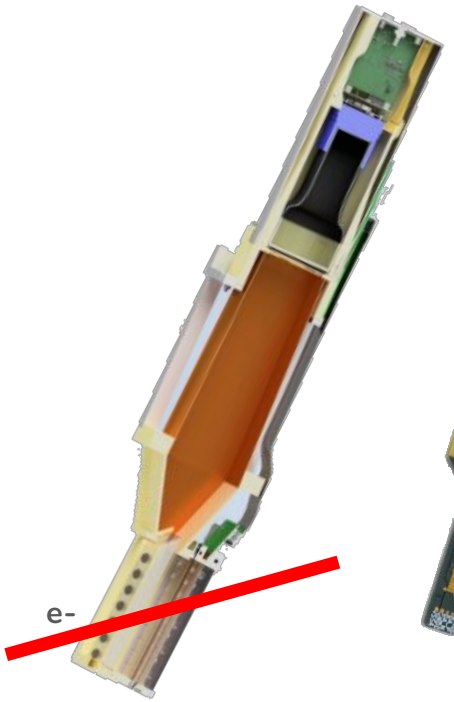
The Main Detector System at MOLLER



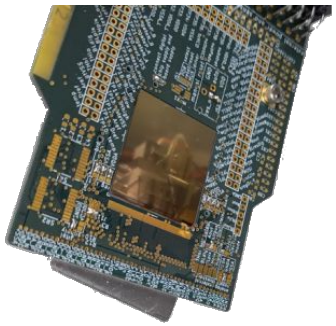
To measure A_{PV}, for each electron beam helicity the scattered electrons are counted/integrated with 224 detector modules.

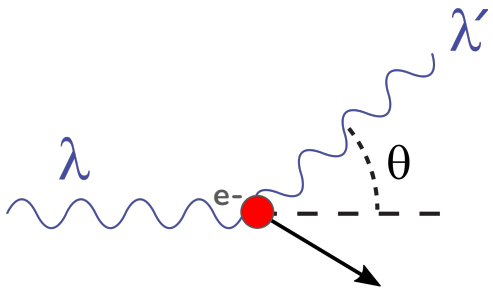
The detector modules are radially splited into six rings to a distance enough to separate e-e and e-p events.

High Voltage Monolithic Active Pixel Sensors (HVMAPS)

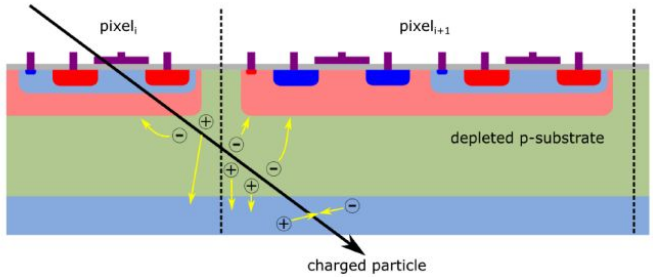


2 x 2 cm²
250 x 256 pixels
1 px ~ 80 x 80 μm²





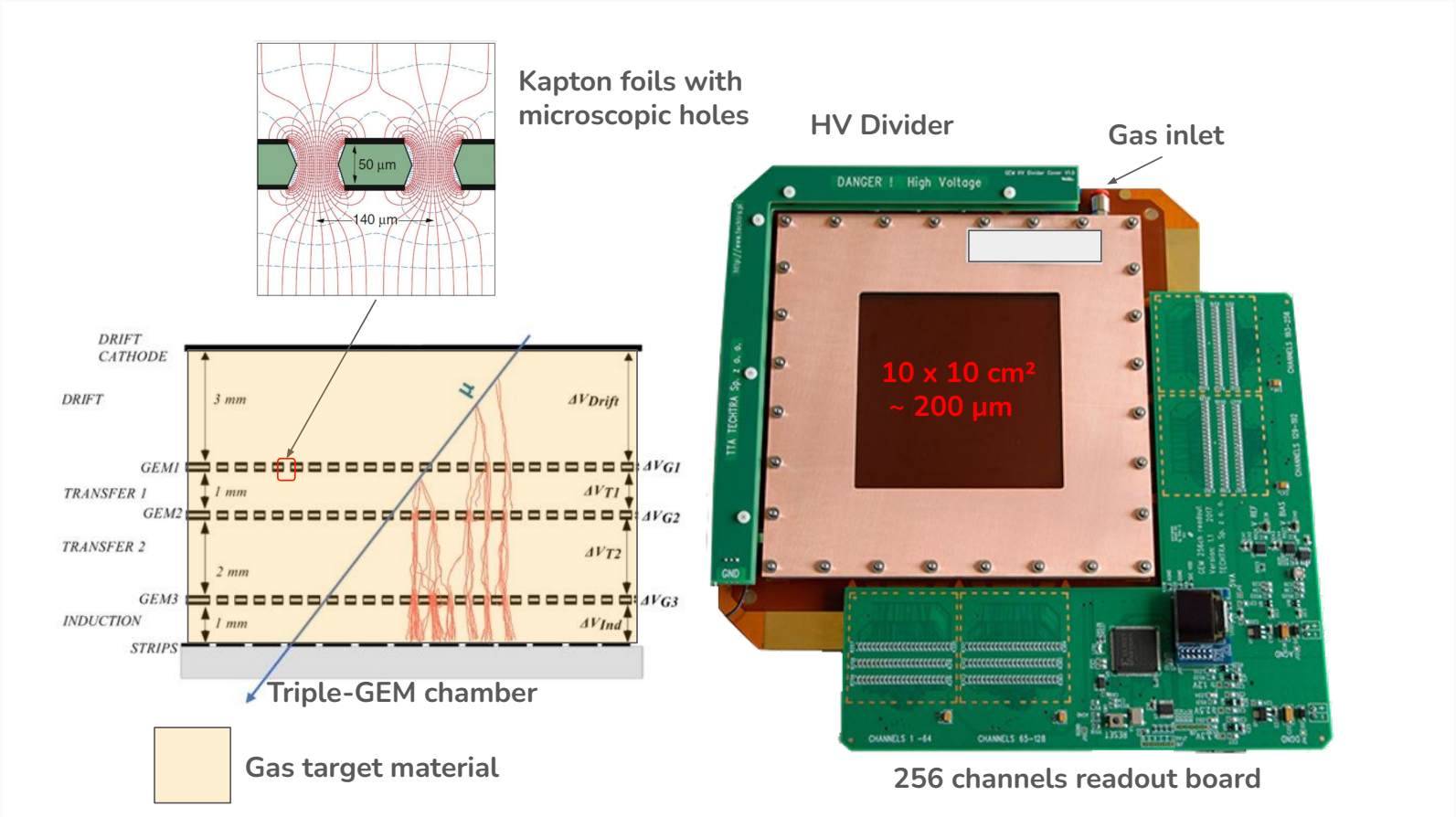
HVMAPs with high spatial resolution can measure accurately Compton-scattered electrons



HVMAPS are used to measure beam polarization and Compton scattering. Can manage high radiation environments, integrate detector-signal-amplification-processing into the same sensor.

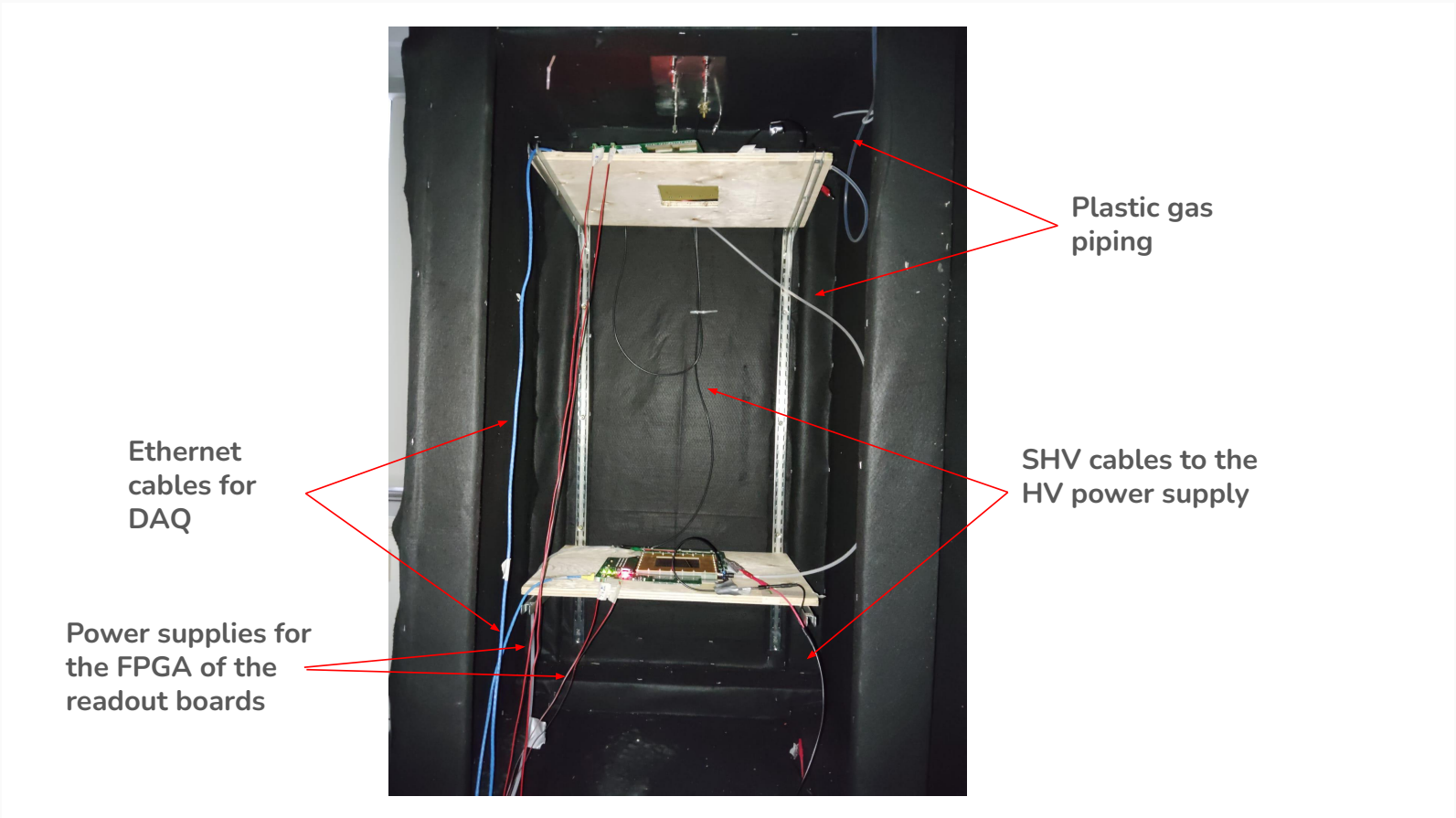
Commissioning of a Pair of Commercial GEMS

Gas Electron Multipliers (GEMS)



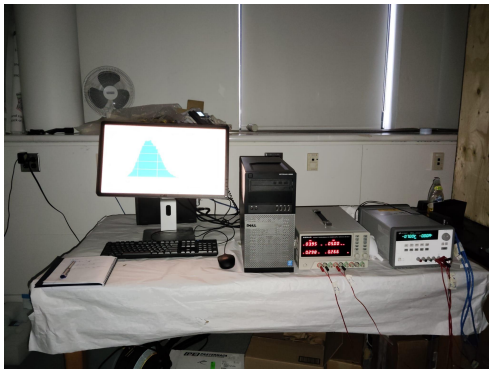
Unlike traditional gas detectors with an anode wire, the gas amplification in GEMS occurs inside narrow holes in a special foil

Commissioning of the pair of GEMs

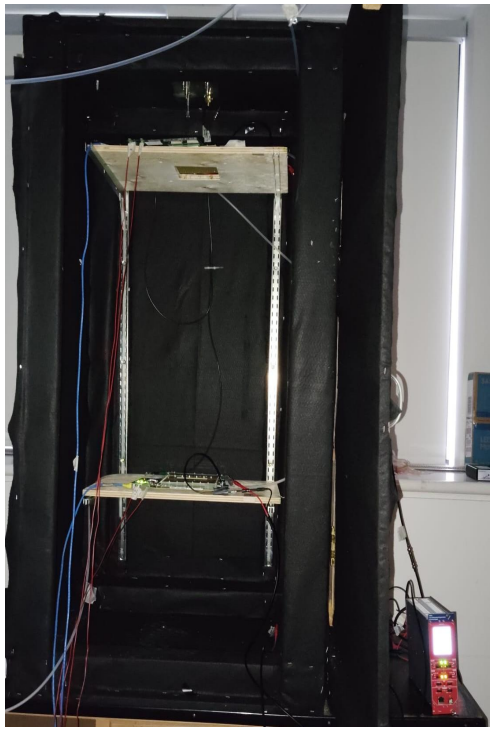


A pair of GEMs bought to CERN were assembled, tested and configured at the University of Manitoba

Commissioning of the pair of GEMs



DAQ Station + FPGA
readout boards voltage

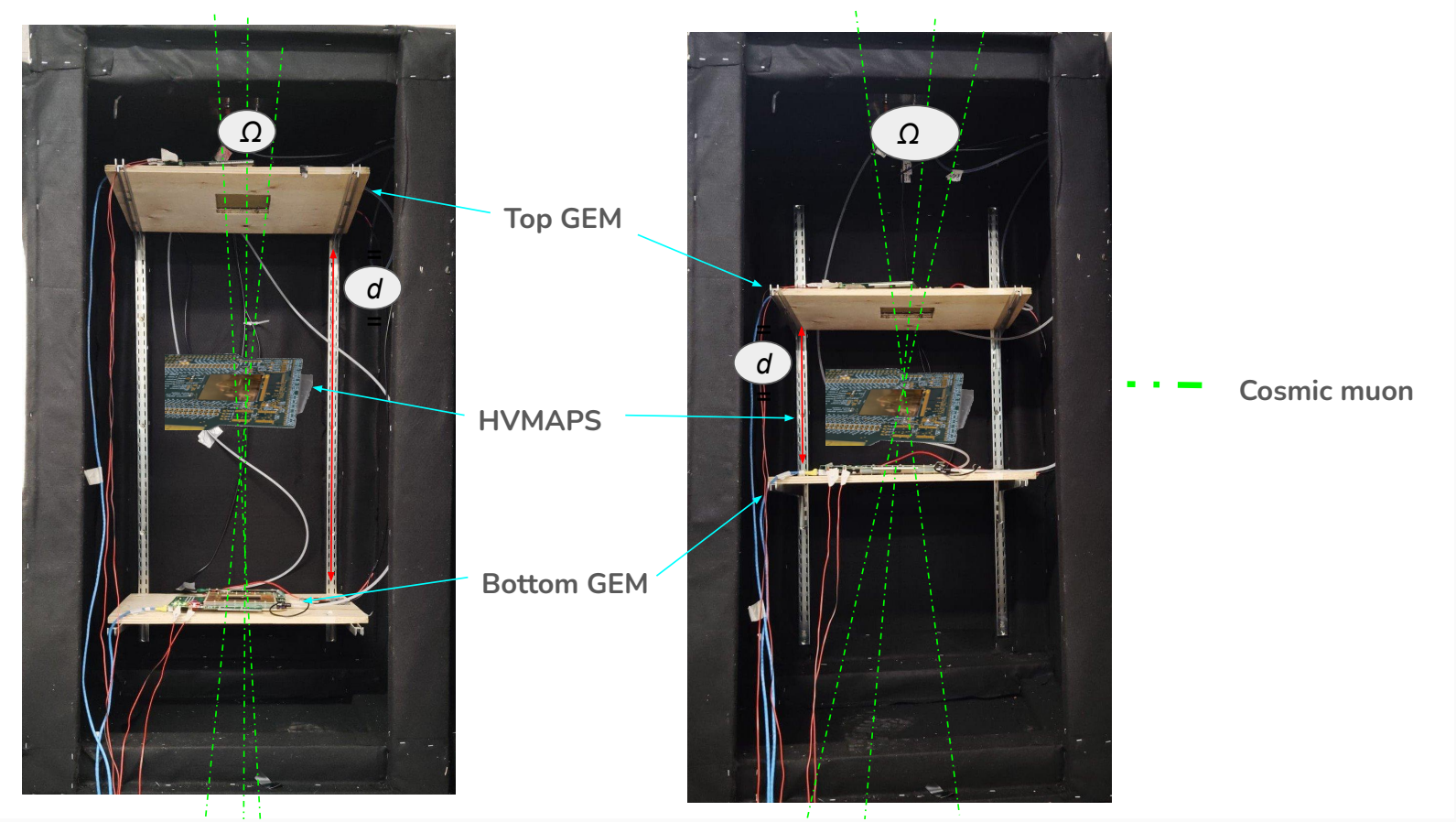


Detector Assembly

CO2:Ar Gas Chart

Additional subsystems were built and troubleshot with input of the MOLLER local group (electronics, gas piping and HV electronics)

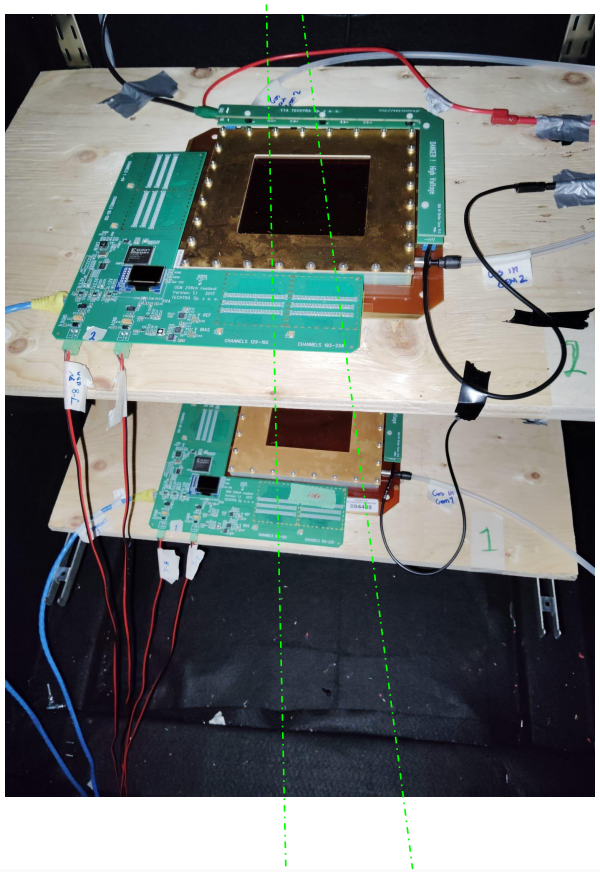
Setup for spatial resolution of (HVMAPS) using the pair of GEMS

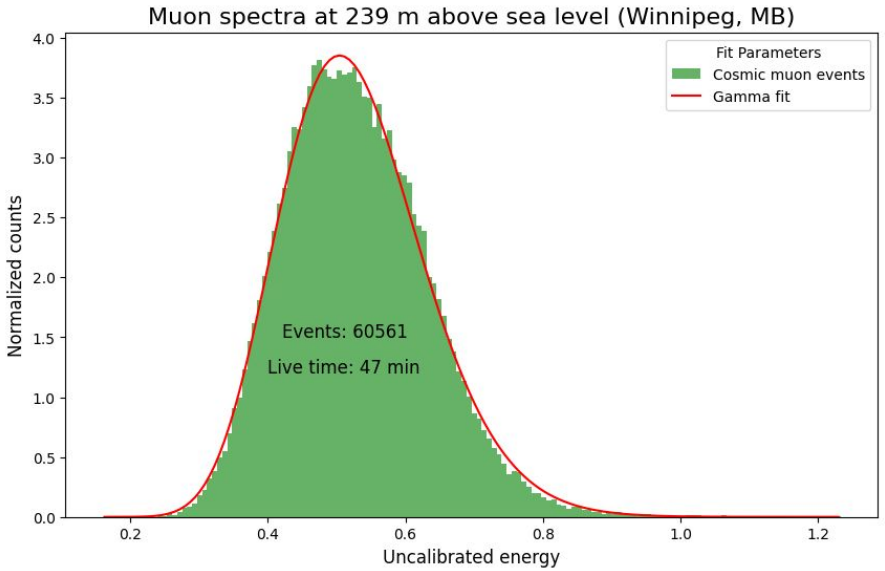


Changes in *d* allows for studies of the Ω of cosmic muons detected.
Thus, the spatial and angle reolution of the HVMAPS can be resolved.

Preliminary results from GEM testings alone

Top GEM energy dispersion of Muon Tracks

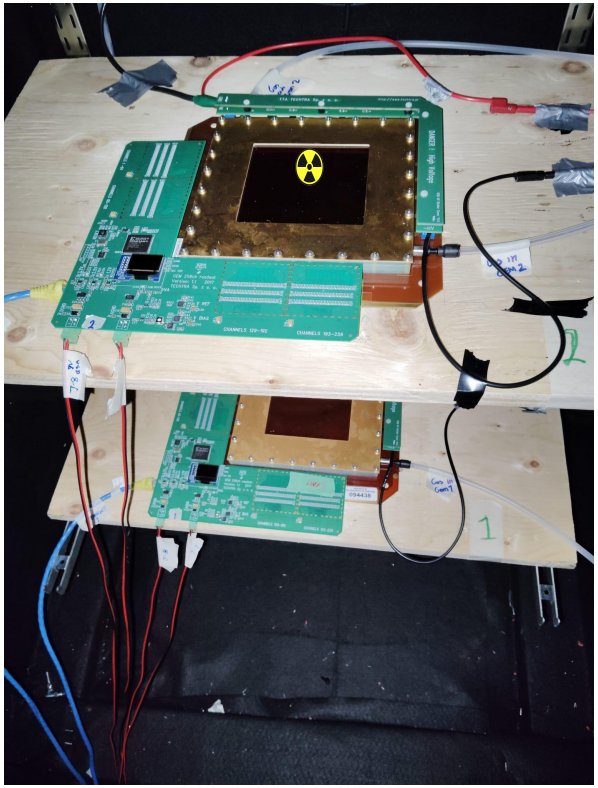


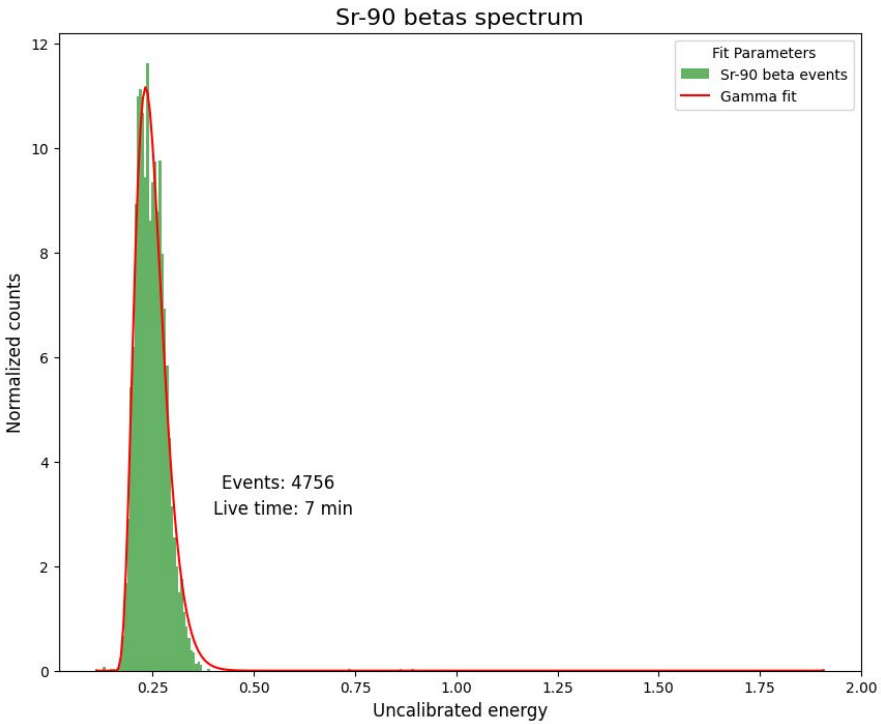


Top GEM: Muon tracks can be resolved to high statistics

Bottom GEM: Shows poor performance (gas line? HV?)

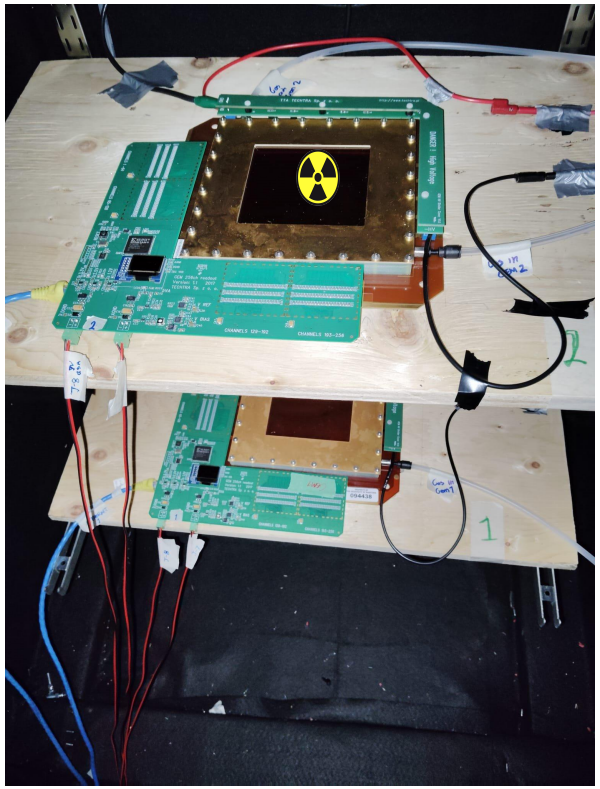
Top GEM energy dispersion for Sr-90 betas

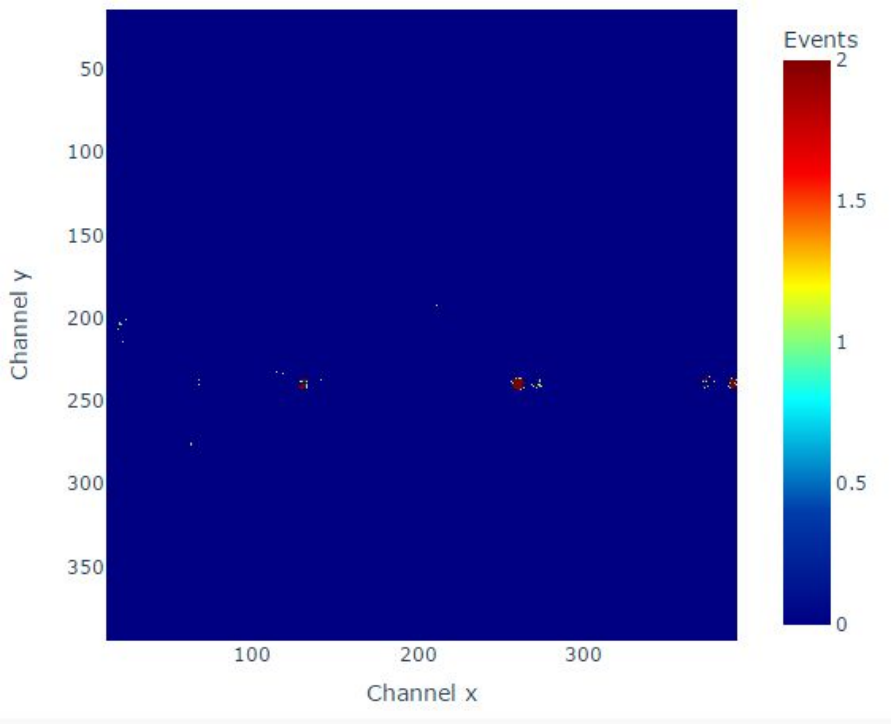




The betas from a 1 MBq Sr-90 source sitting at the windows of the top GEM, can resolve the spectrum of the Sr-90, except for low energies.

Top GEM reconstruction of Muon Tracks





Preliminary results of the GEM spatial resolution are promising for eventually operate both of them in coincidence (software or hardware approach).

Conclusion

- The MOLLER experiment will measure the electron weak electron weak charge $Q_w^e \pm 2.3\% \implies sin^2\theta_W \pm 0.1\%$
- To reach the physics goals of the MOLLER experiment, an accurate knowledge of the HVMAPS position resolution is required.
- A pair of GEMS has been set up to fully characterize the HVMAPS position resolution and angle dependence pixel by pixel.

Acknowledgments

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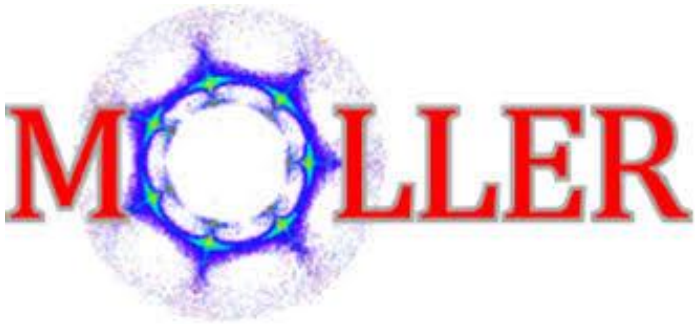
Institut canadien de physique nucléaire



Questions?