Innovative Gaseous Particle Detector R&D

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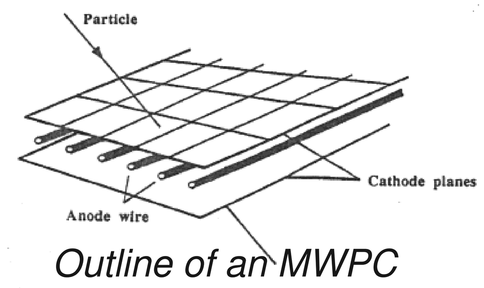
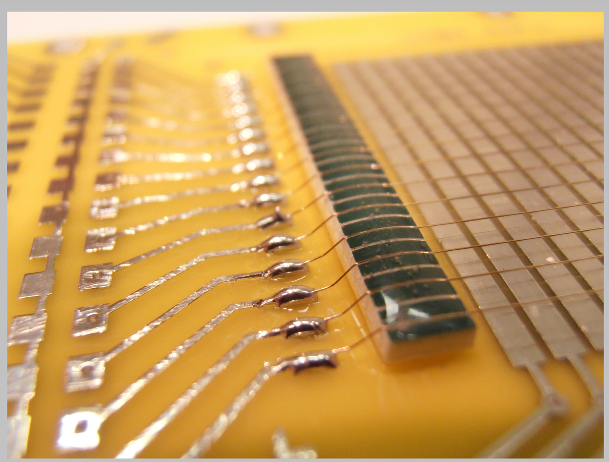
Gaseous particle detectors are key components of high energy physics experiments. They are used most often for the challenging task of particle tracking. The REGARD group at the Wigner RCP contributes to the world-wide R&D efforts for such technologies.

Gaseous Detectors

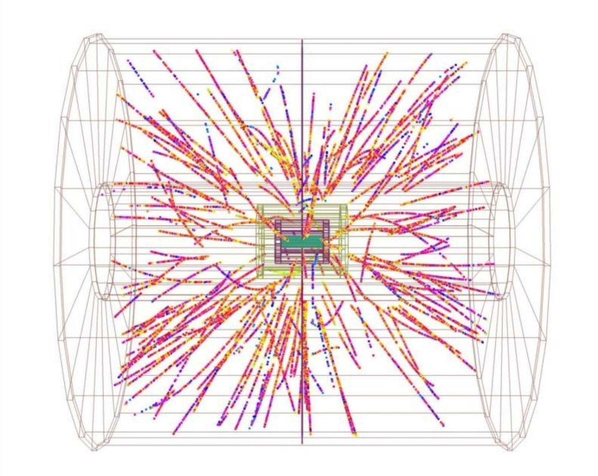


Outline of an MWPC

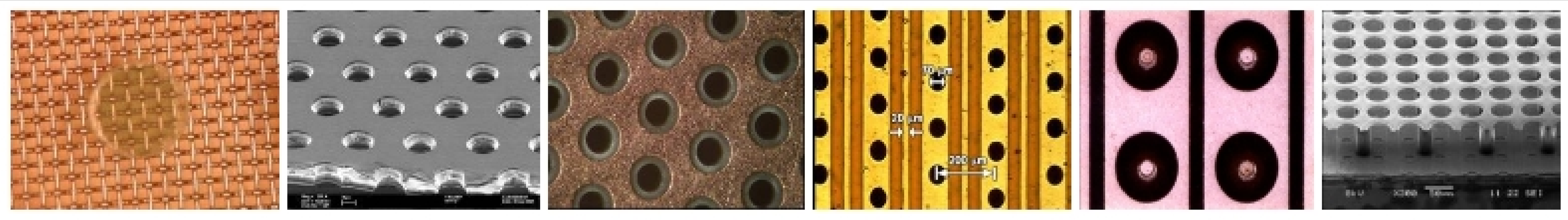
The operation of gaseous detectors is based on the ionization process initiated by charged particles. Electrons are produced and guided towards a region with a very high electric field where an avalanche multiplication process takes place, which allows for electronic readout.


Thin wires, fixed by soldering, above a segmented cathode

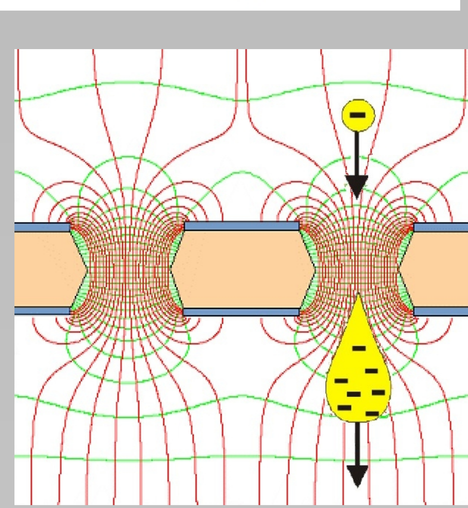
The Multi Wire Proportional Chamber (MWPC) is a well established technology, in which the avalanche is created close to a set of thin wires at positive potential. The Nobel Prize in Physics in 1992 was awarded to G. Charpak, the inventor of the MWPC, in recognition of its impact on fundamental science.


Tracks from an event in ALICE TPC

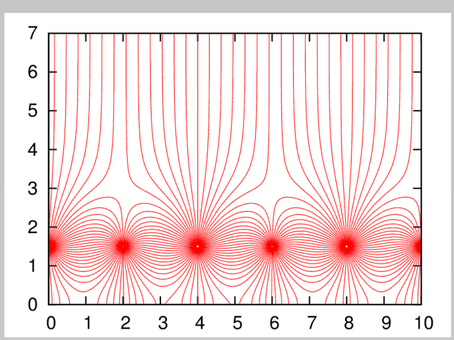
Micropattern Detectors


MicroMegas GEM THGEM MHSP microPIC Ingrid

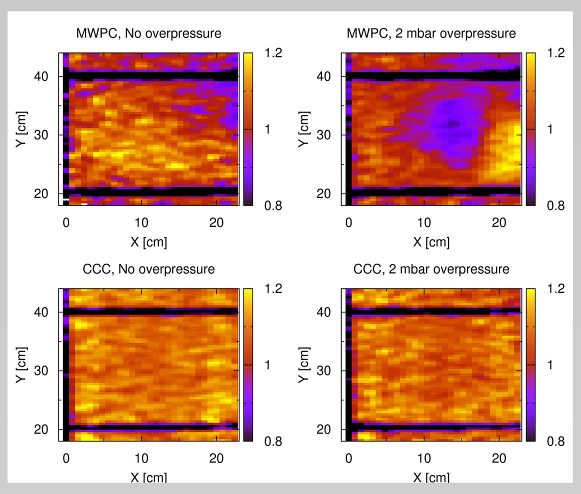
Technological advances have made it possible to produce innovative structures which are well-suited to create avalanche multiplication. Instead of wires, one can use pins, holes or mesh layers. The GEM is a popular realization of this idea: the small holes in a copper-covered kapton foil act as an electron amplifier. Commercially available printed circuit technology has also reached the sufficient quality for microstructure detector construction.


Electric field lines in a GEM, indicating avalanche creation

Close Cathode Chambers


Electric field lines in a CCC chamber

The Close Cathode Chamber (CCC) is an MWPC that was developed by the REGARD group in which the electric field shape is optimized to reduce the sensitivity for the mechanical deformations in the detector structure.

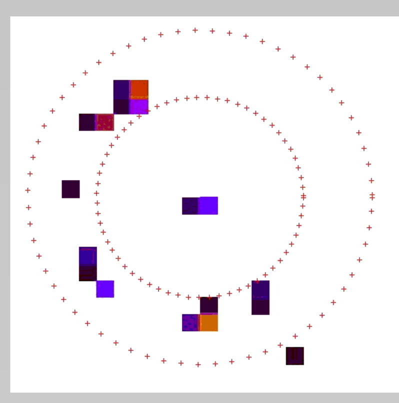


MWPC amplification is sensitive to pressure variations (upper figures), whereas CCCs are uniform

One of the issues that has been solved is the sensitivity to bulging: inner overpressure bends the detector walls. For the CCCs the pressure effect is drastically reduced, and therefore thin, small material budget detectors may be constructed.

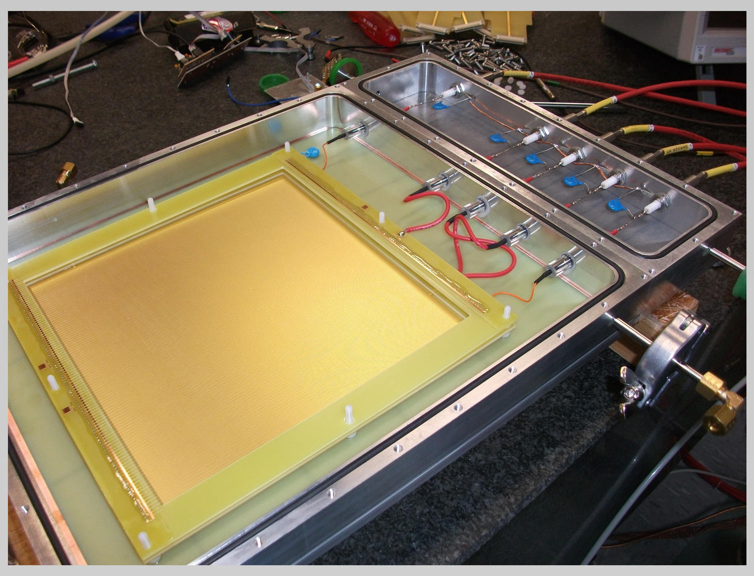

This 0.5m by 1m CCC detector weighs only 2 kg

Single UV Photon Detection

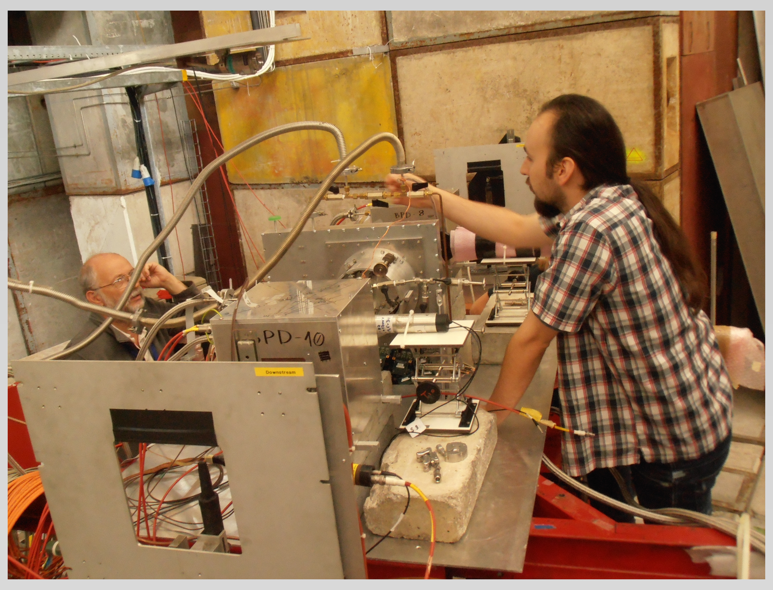

A Cherenkov ring of 7 photons observed by the TCPD

Gaseous detectors with proper surface treatment are able to detect UV light with a high quantum efficiency which is comparable to PM tubes. In this case, a single electron initiates the avalanche to be detected.

The photon sensitivity can be exploited for the observation of Cherenkov light, which enables measurement of the velocity of fast particles. The number of detected Cherenkov photons is usually low; in the order of 5–30. The group has developed an MPGD+CCC hybrid, called TCPD, with advantages of both technologies.

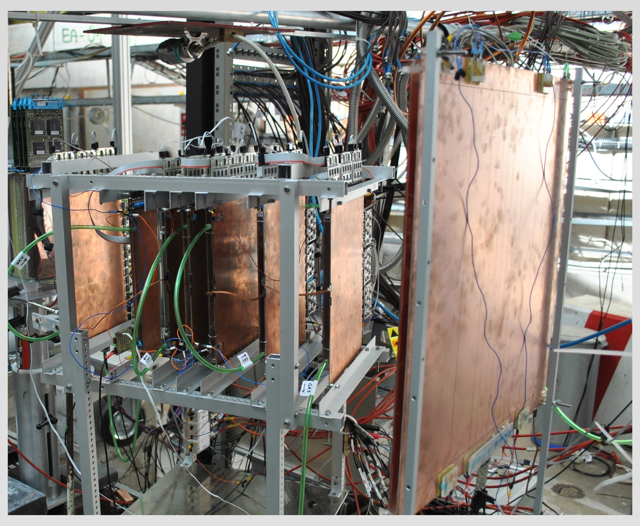

Microstructure UV photon detector, developed by the REGaRD group, during assembly

Applications at CERN and in HEP

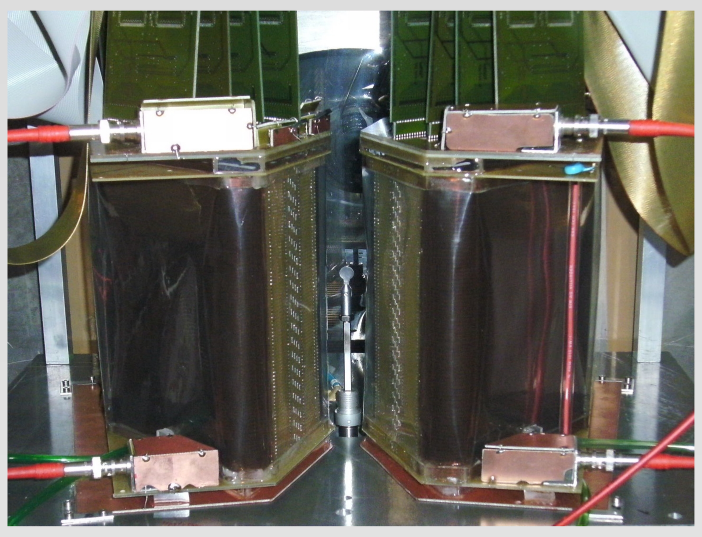

Installation of a Cherenkov detector for test beam measurements at the CERN PS

Most of the detector components built by the group are intended to be part of larger CERN experiments. The purpose of the VHMPID project was to develop Cherenkov-based particle identification at the ALICE Experiment. This detector required a reliable tracking unit, with CCC technology as the most reasonable candidate.


A CCC tracking chamber


Multiple layers of CCC chambers during a CERN test beam

The Low Momentum Particle Detector at the CERN NA61/SHINE Experiment has been developed and built by the REGaRD group. It is a small tracking device designed to efficiently tag particles emitted from a small target at high angles.


LMPD detector at the CERN NA61 Experiment

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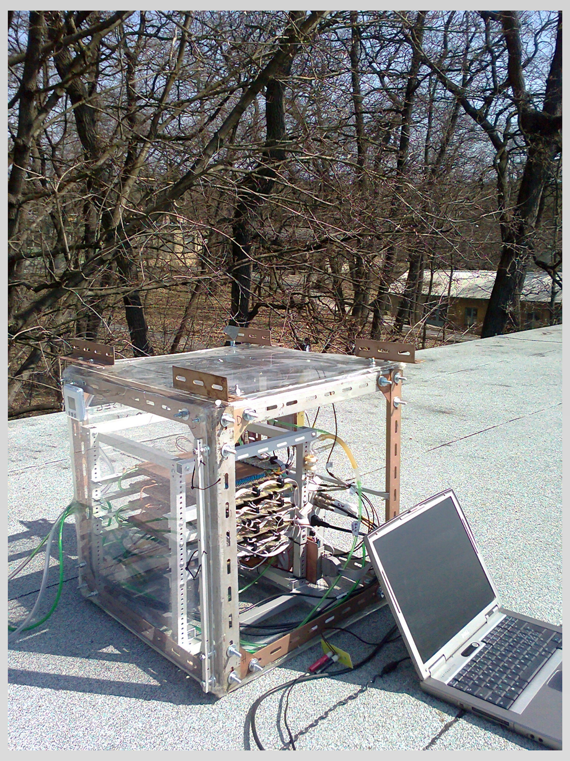
Applications in Industry and Physics

High energy physics instrumentation has potential applications outside fundamental science, once innovations allow cost-efficient production.


Muon tracking detector at the Wigner RCP campus

A tracking detector has been developed for underground cosmic muon flux measurements. Since the number of muons decreases with depth, the detector is able to map the soil density above the measurement point.


The Muon Tomograph in the Pilis Mountains, inside the Ajándék Cave

The method was applied in a search for unexplored underground caverns in recently discovered natural caves.

References:
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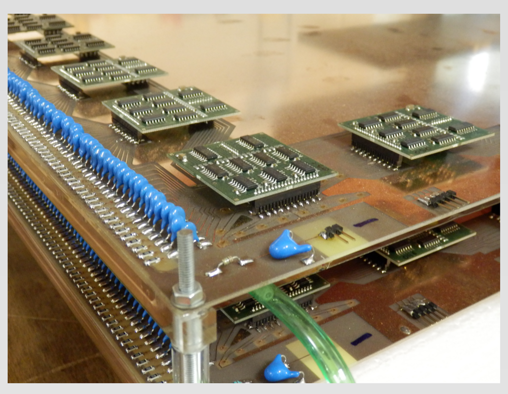
Tracking chambers with readout electronics