Micropattern Gaseous Detectors with Charge and Optical Readout for Charged Particle and Photon Detection

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We are proposing and developing novel micropattern gaseous detectors (MPGD) for registration of charged particles and photons, produced with highly intense, pulsed laser beams. Focus is put on lowest material budget, high detection efficiency and robustness with respect to aging and electro-magnetic disturbance (EMP), stemming from the laser-plasma-interaction.

The detectors exploit the ionization of a suitable detector gas (such as Ne:CF_4 80:20 vol.%) by the traversing particles and photons in a few millimeters wide gap. Ionization charge is then either directly registered by a custom high-gain gated integrator electronics, or amplified in high electric fields by gas amplification by up to 5×10^4. For the detection of this amplified charge, we pursue two disjunct concepts: First, the collection and registration of the charge on conductive readout electrodes, highly segmented into strips or pixels; second, the registration of visible gas fluorescence light, parasitically produced in the gas amplification processes, with an electron-multiplying charge coupled device (emCCD), outside the beam path.

We are able to produce highly segmented readout structures with conventional copper or low-material budget aluminum electrodes inhouse. We have built and characterized strip and unsegmented ionization chambers with 40nm aluminum electrodes, carried by 2µm Mylar or 10µm Polyimide foils. If the energy spectrum of a particle bunch is known, e.g. from previous measurement or by filtering magnetically, an accurate determination of the particle number in the bunch is possible. For monoenergetic 22MeV protons, produced by the MLL tandem accelerator, Garching, a current resolution below 2% (one sigma) has been observed for 1.5×10^6 p/frame and above [1]. We have recently observed that the custom gated-integrator-electronics can be immunized against the EMP efficiently, by integration into the IC gas volume. For efficient single particle detection, we have developed Micromegas readout structures with a material budget as low as 10^{-3} X_0 and successfully tested them in 22MeV proton beams at the MLL tandem at rates of order 10^7/cm^2 s and above.

Also at the tandem accelerator, an optically read out Micromegas detector with a conductive glass anode was recently successfully tested for beam monitoring of 22MeV proton beams. The device is able to also register minimum ionizing single particles, as seen with radioactive sources. A concept will be presented for a considerable reduction of the material budget, rendering the detector suitable for monitoring of laser accelerated particle beams in transmission.

We will highlight and discuss the inhouse MPGD production capabilities with a special focus on applicability for laser accelerated particle detection. Results from different recently developed and tested MPGDs will be presented and we will introduce the concept of beam characterization with an optically read out Micromegas.

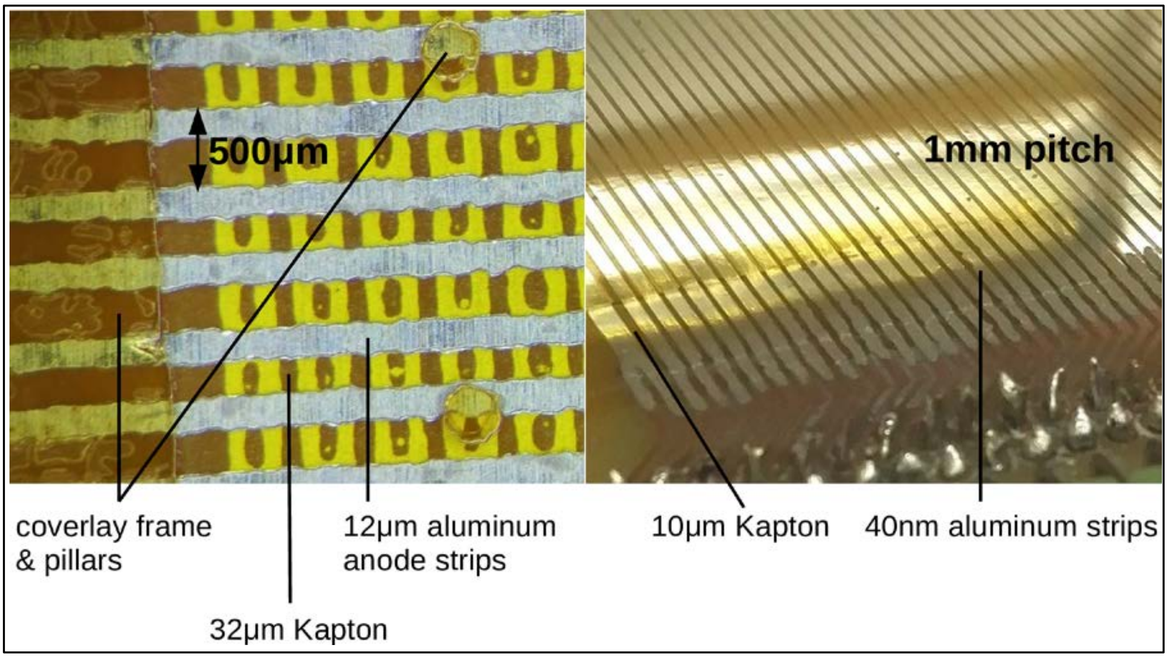

Figure 1: Close-up of an aluminum floating strip Micromegas structure (left), developed for a pre-clinical proton transmission tomography system [3]. Cathode strip structure (right) of an ionization chamber with 40nm aluminum strips on 10µm Polyimide.

[1] P. Lämmer, Studies on a Time Projection Chamber and an Ionization Chamber for Ion Transmission Imaging and Beam Monitoring, Master's thesis, Ludwig-Maximilians-Universität Munich (2019)

[2] J. Bortfeldt, *et al.*, Entwicklung und Herstellung mikrostrukturierter Gasdetektoren für ein präklinisches Protonenbestrahlungssystem, presented at the DGMP 2019 conference Stuttgart, https://doi.org/10.5282/ubm/epub.70699

[3] K. Parodi, … , J. Bortfeldt, … , P. Lämmer, … , J. Schreiber, *et al.*, Towards a novel small animal proton irradiation platform: the SIRMIO project, Acta Oncologica, (2019), 58, 1470-1475, https://epub.ub.uni-muenchen.de/70659/