Close Cathode Chamber
a New Variant of MWPCs

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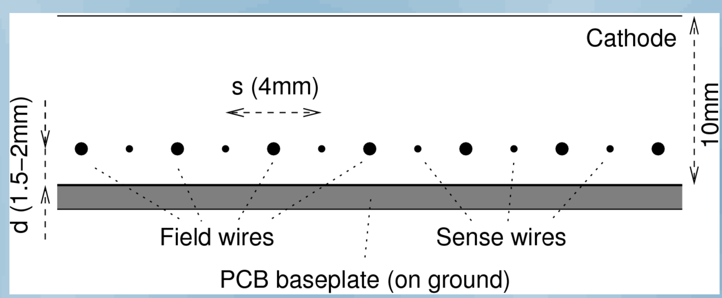
1. Motivation

MWPCs have served as baseline detectors for tracking in HEP applications for several decades. The main drawback of MWPCs is the need for massive frames and high precision mechanics and its limit in rate capability. These problems are partially solved with new micropattern technologies (MPGD), which are attractive R&D and upgrade choices for several experiments.

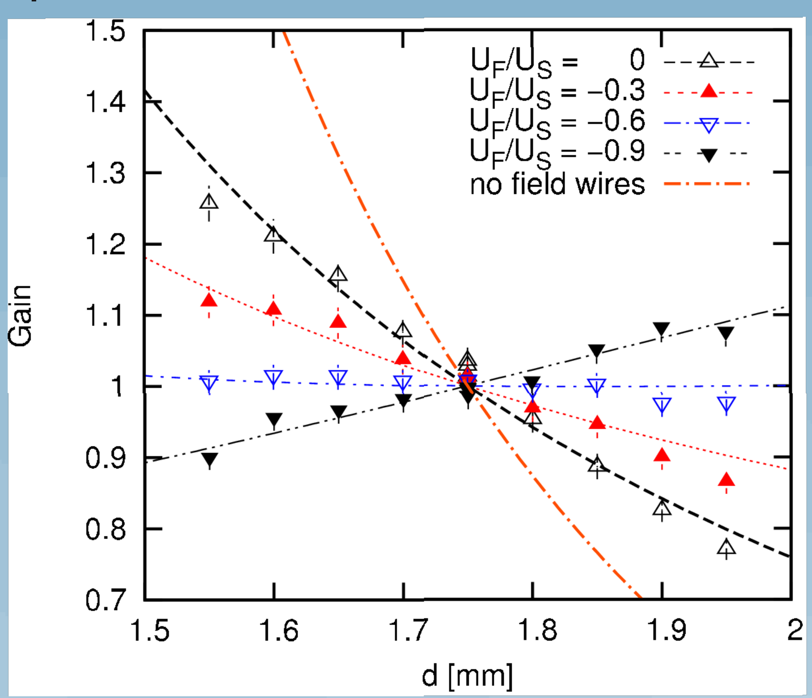
Our aim was to develop a lightweight MWPC version where the mechanical precision does not play a critical role even in large sizes, and its pad response function is small to let us operate with simple digital readout with low occupancies.



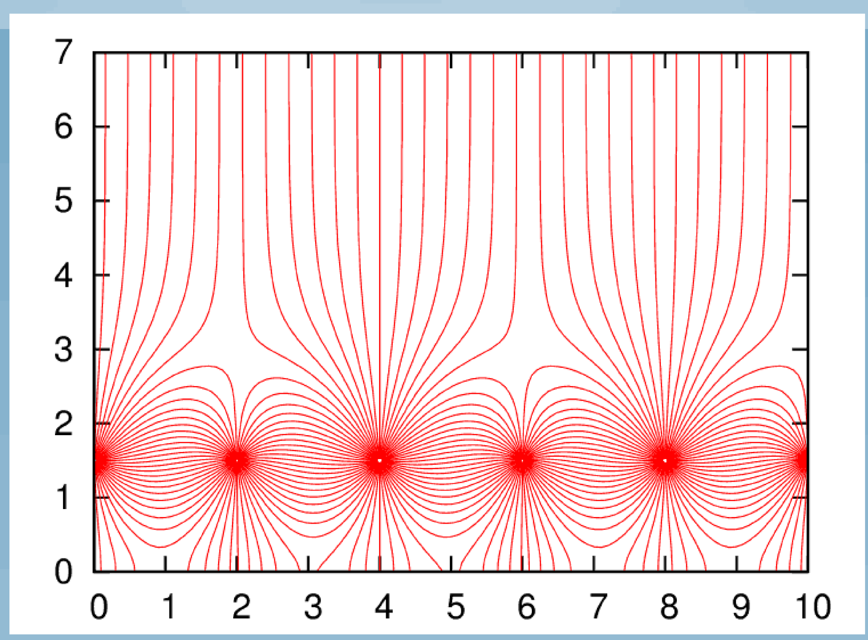
Basic outline of the Close Cathode Chamber

2. Concept

The Close Cathode Chamber is an asymmetric wire chamber with alternating sense and field wires. Field wires have negative voltage thus concentrating electric field lines between the wires. It has been demonstrated that there exists a proper ratio of sense- and field wire voltages, where the gas gain does not depend on the distance of the wire plane and the closer cathode. This reduces the requirement for precision flatness.



Measured and calculated gain dependence on the wire plane distance at different sense- and field wire potential ratios.

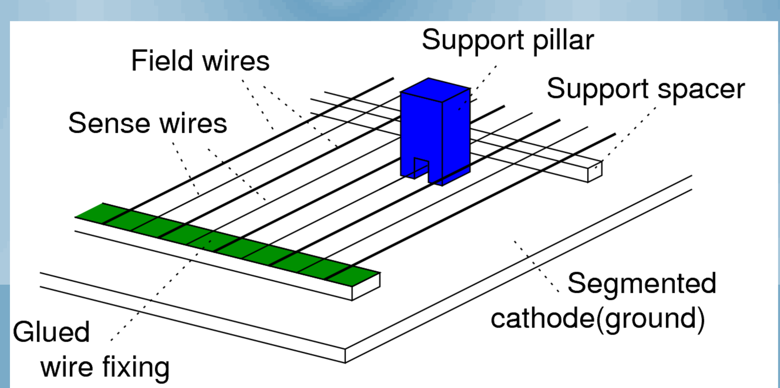


Field line structure of the CCC, sense wires are located at 0,4, and 8 mm.

This concept was proven with electrostatic calculations, simulations and direct measurements as well. The measurements were performed on a wire chamber with inclined wire plane, thus letting us test different distances with exactly the same conditions at a time.

3. Construction

Horizontal placement of wires is kept precise with laser engraved wire support bars. To reduce the effective wire length, spacers are holding the wire plane in every 20-30cm along the chamber. Both structures are fixed with glueing, as well as the wires on them. This way the applied moderate tension can be held by the baseplate of the closer cathode (pad plane).



Schematics of the support structures inside the large area Close Cathode Chambers

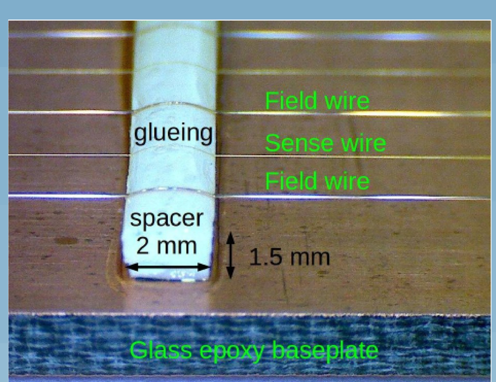


Photo of a slice of a CCC with the wires glued onto a spacer inside the chamber

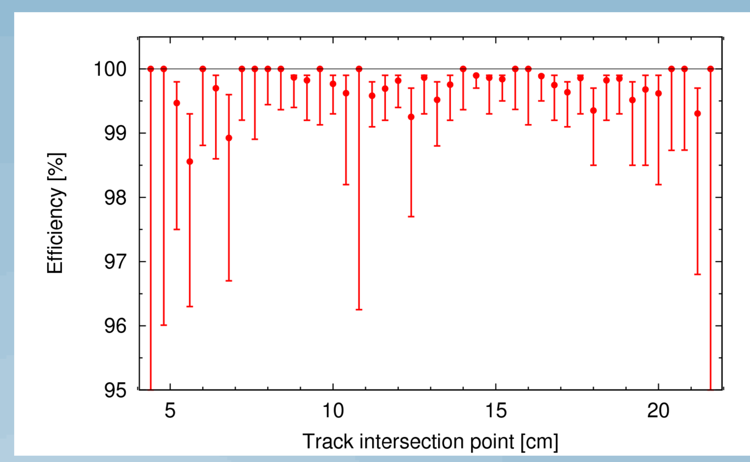
Small overpressure inside the chamber would mean significant force on large surfaces of the cathodes. Small pillars were glued several places between the baseplate and the cathode. The pillars were placed near the spacer to reduce the dead areas.

Using 1mm thick printed cicruit board (PCB) as baseplate and 0.5mm thick PCB as a cathode, the total material budget becomes 1.5% radiation lengths. Chambers of 1mx0.5m were constructed (with 1m long wires), with weight of 2kg. The structure is self supporting. The total weight including protective aluminum sidebars is still moderate, 3 kg.

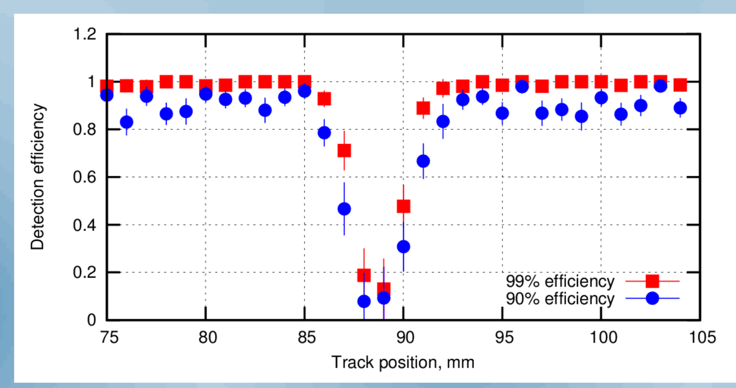
The lightweight large area CCC (1mx0.5m) was only 2kg

4. Performance

Efficiency and uniformity were measured with cosmic and beam particles as well, such that the chamber under study was sandwiched by tracking layers. High and uniform efficiency was easily achieved in Ar:CO2 (80:20) with sense wire voltage of 1050V.



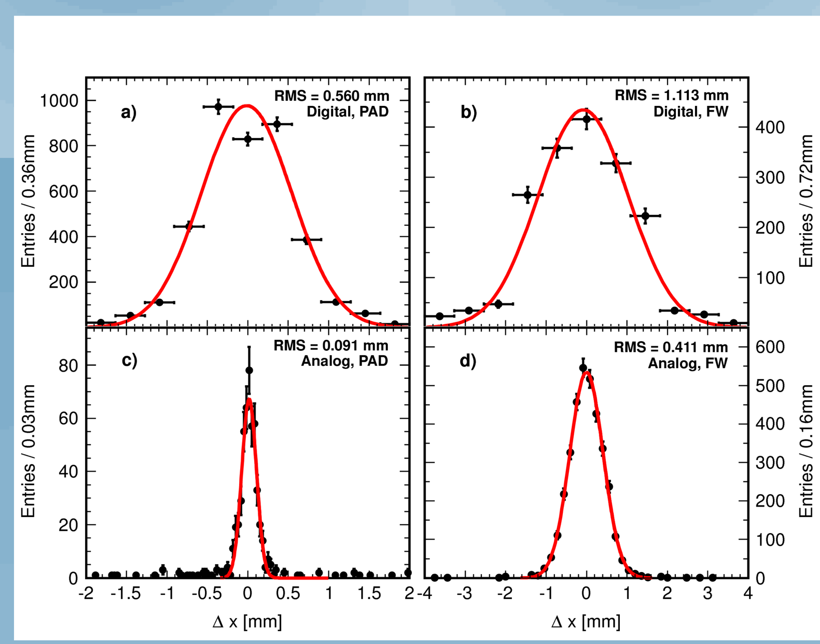
Efficiency of a CCC in Ar/CO_2



Drop of efficiency around a spacer makes 4mm effective blind area

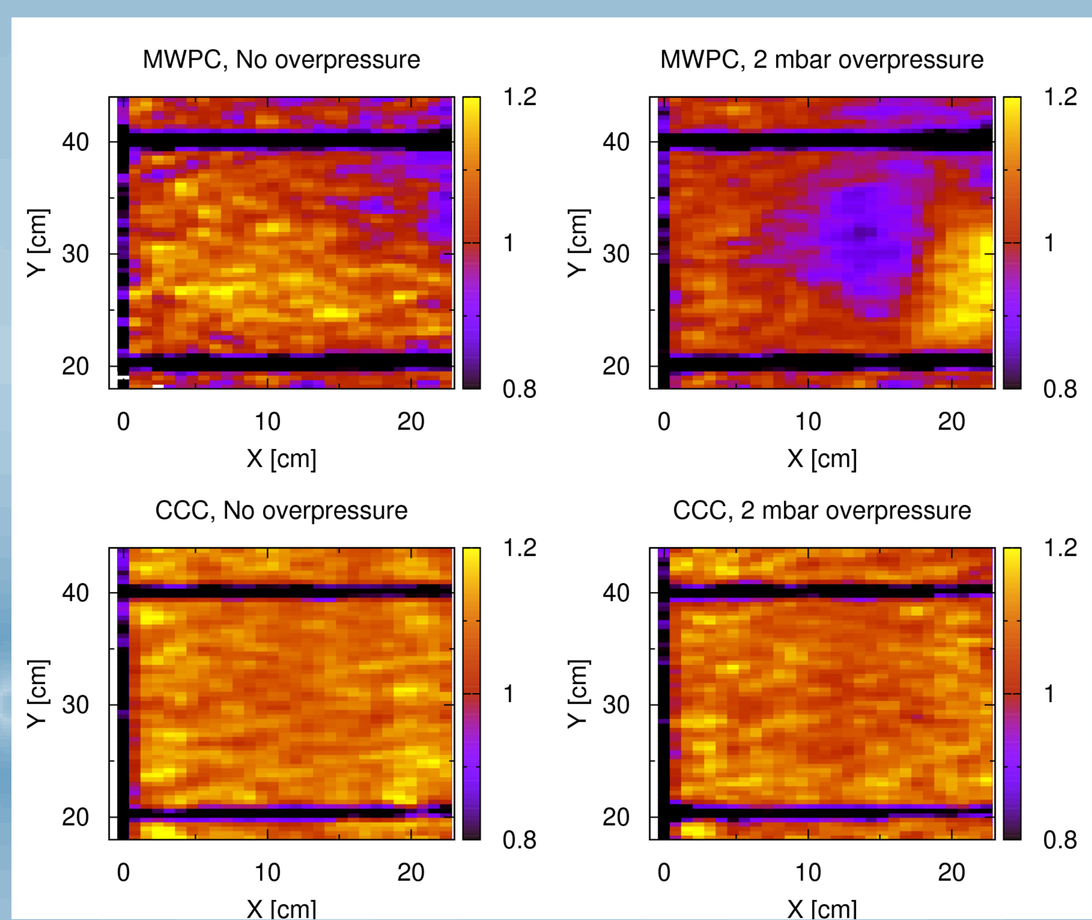
Drop of efficiency around the spacers were measured with high precision, resulting 4mm of effective thickness of the used 2mm wide spacers. This is smaller than that for usual MWPCs. The effect of pillars lies in the same range. The overall loss of effective surface thus became 2% (4mm/20cm).

To achieve space resolution, the baseplate was segmented to pads. Narrow pad response function was achieved with pads parallel to the wires, average cluster size of 1.2 at efficiency 99%.
With pads perpendicular to the wires, the field wires were read out as well, and both signals were measured once with analog (Gassiplex based ADC) and later with digital readout. Spatial resolution with 4mm wire spacing and 2mm wide pads spatial resolution of 0.090mm analog and 0.560mm digital were measured.



Spatial resolution on pads and field wires with analog and digital readout

5. Uniformity

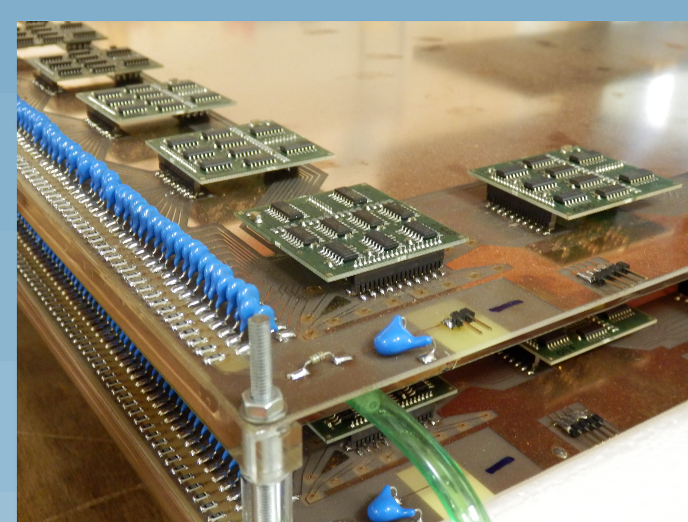


Gain map with and without overpressure, same conditions in MWPC and CCC mode

Due to even a small overpressure, large area chambers suffer from the bending of the chathodes. The gain uniformity of the same chamber was measured in semiclassical (field wire at zero voltage) and CCC mode with cosmic particles with tracking layers around (like in the former section). While the effect in semiclassical MWPC mode was 30%, in CCC mode with same conditions it was less than 2%. This is a direct demonstration that more than 200 micron bending of the cathode does not infere a gain variation in the CCC.

5. Applications

Owing to its low material budget and excellent uniformity the Close Cathode Chambers were the baseline option for the trigger and tracking chambers for the ALICE VHMPID upgrade project. The lightweight and reduced need for precision makes CCCs ideal for outside-laboratory applications as well. Portable cosmic tracking system was assembled from several layers of CCCs, where the connected sense wires provided the trigger signal, while the field wires and pads were read out for position information.



Picture from two layers of a 50cm x 50cm MuonTomograph made of CCCs with digital electronics and field wires and pads

5. Summary

Close Cathode Chambers are asymmetric multiwire chambers where the precision of cathode flatness is highly relaxed, therefore small material budget can be reached. It is shown that this feature involves excellent uniformity even with large area detectors. Chamber construction is simple and unexpensive, dead areas caused by the introduced spacers and pillars are on the 2% level. Few tens of CCC chambers have been made and operated so far, and applied in high energy physics and environmental physics as well.

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