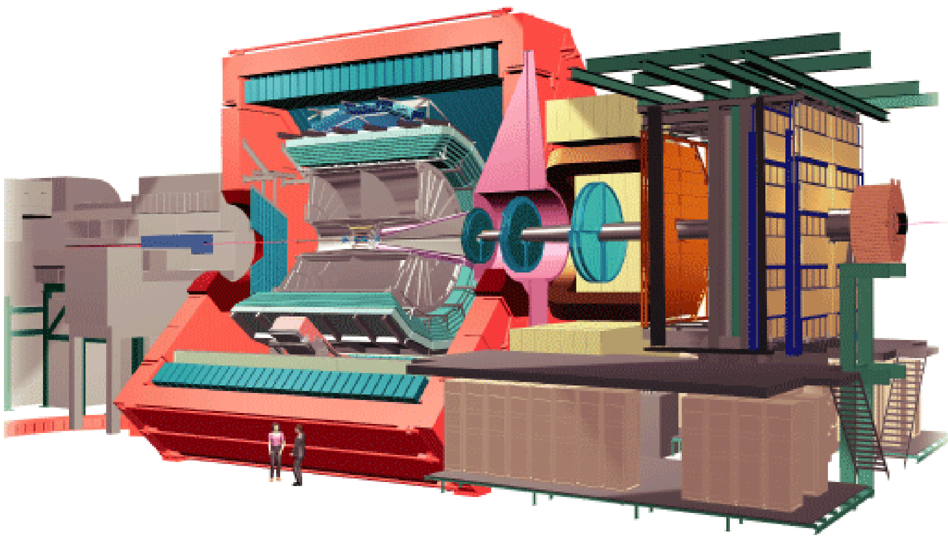
Close Cathode Chamber : MWPC With Reduced Material Budget and Reduced Requirements on Mechanical Precision

D.Varga[1], G.Kiss[1], G.Hamar[2]

[1] Eötvös Loránd University, Budapest
[2] MTA KFKI RMKI, Budapest

Outline

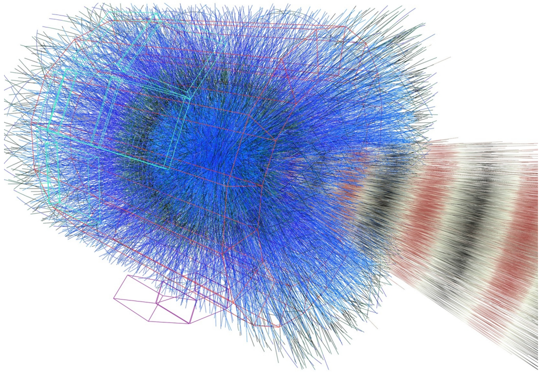
ALICE at LHC



ITS, TPC, TRD, TOF, Muon Arm, ZDC, V0, T0,

HMPID, EMCal, PHOS,

?+ Very High Momentum Particle Identification Detector (VHMPID) for π,K,p separation at 5 GeV < p_T < 25 GeV



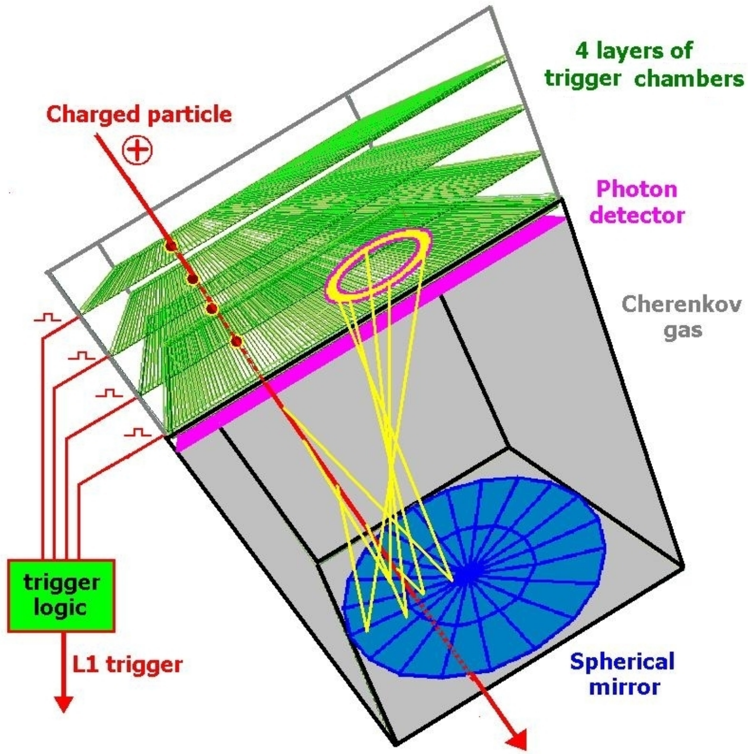
- Large Hadron Collider in CERN, pp @ 7 TeV, PbPb @ 3 ATeV
- A Large Ion Collider Experiment
- Quark gluon plasma
- Excellent particle identification up to 5 GeV/c
- High track density
- Not enough space for a hadronic calorimeter inside the magnet
- High momentum particles carry important information on QGP

VHMPID

(Very High Momentum Particle Identification Detector)

- **π, K, p yields at 5 GeV < p_T < 20 GeV**
  - Proton/pion anomaly (~ RHIC)
  - Particle production mechanisms (thermal,coalescence,pQCD)
  - Fragmentation function at the QGP
  - Jet energy loss, flavour dependence
  - High p_T D- and B-meson and Λ_c, Λ_b-baryon reconstruction

- **Near-side hadron-hadron correlations**
  - B-M (π-p) and B-aB (p-p) correlation (~ RHIC)
  - Di- and multihadron fragmentation functions
- **Cooperation with other special detectors at ALICE**
  - Near-side photon-hadron correlations : PHOS
  - Away-side jet-photon correalations : EMCAL
  - Away-side jet-jet correlations : HMPID



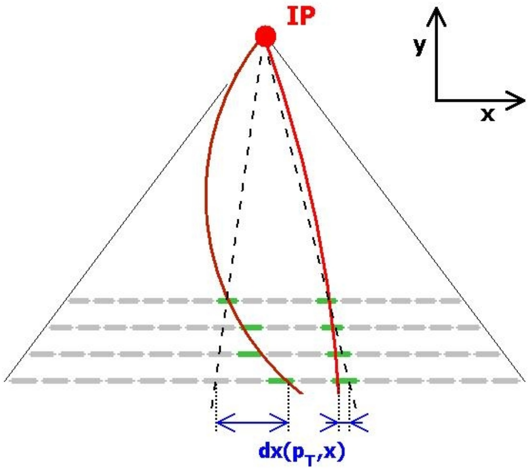
- Event by event PID in the region: 5 GeV/c < pT < 25 GeV/c
- Cherenkov radiation: only gas can be used: C_4F_{10} with Radiator length: ~ 80 cm
- Mirror generate circles
- Photon detection: CsI coated MWPC
- Need for triggering!
- Free space in ALICE: max 12% of TPC acceptance opposite side to HMPID

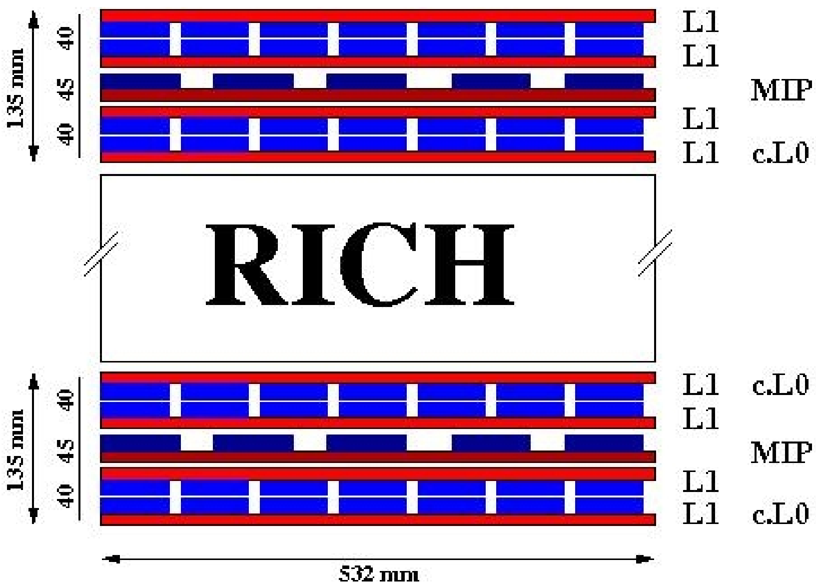
High P_T Trigger Detector

0.5 Tesla magnetic field inside ALICE

Track bending ↔ transverse momentum
↔ track inclination ↔ tracklet pattern

Set of patterns ↔ cut in transverse momentum

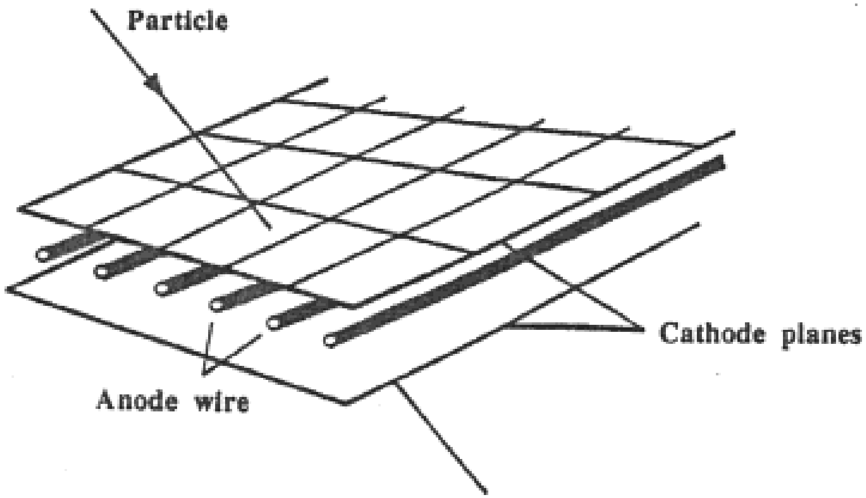




- **L1 trigger** for PbPb and pp collisions with p_T>10 GeV threshold
  gains a factor **40** at interesting data!
- **L0 trigger** at pp collisions with p_T>5 GeV
- **Tracking** before and behind the RICH module
- **Need for:**
  low material budget, good resolution, narrow pad response, digital readout, be fast for triggering, cheap!

MWPC

(Multi Wire Proportional Chamber)

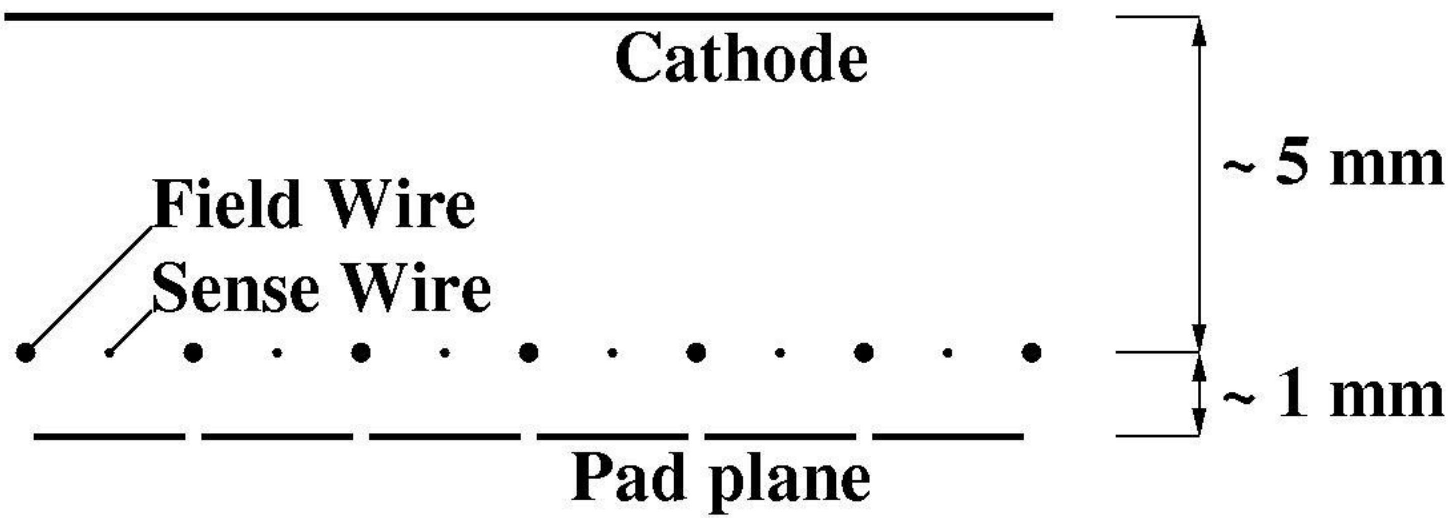


- Mechanical precision should be in order of 10 μm
- Large support frame increases the material budget
- Wide pad response function
  - ideal for ADC readout
  - bad for digital readout

- G.Charpak (1968)
- Charged particles / ionizing rays
- Gas filled chamber
  usually noble gas
  with some quencher
- Ionization ~ 100 e^- /cm
- Electrons drift towards the anode wires
- Avalanches near the thin wires
- Gas amplification gain ~ 10^3-10^6
- Cathode segmantation
  → 2 dim readout

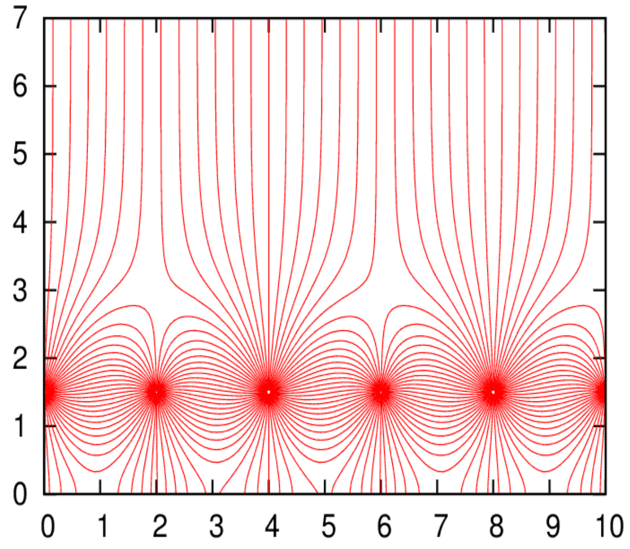
CCC conception

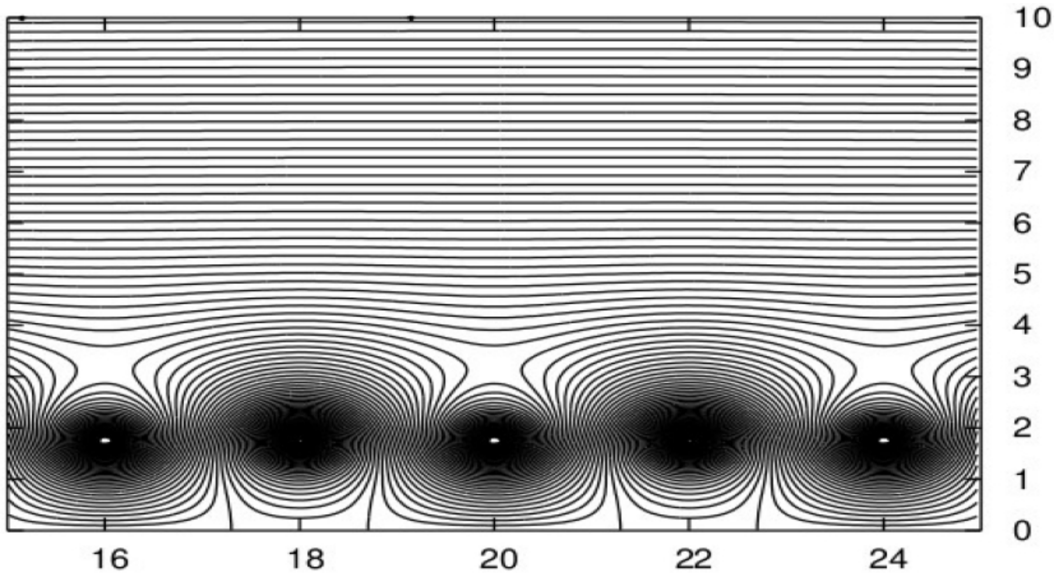
- Multi wire chamber with narrow pad response
  - Put the wires closer to the padplane
  - Asymmetric layout
- Mechanical tolerance ~10 μm → ~100 μm
  - Insert thick field wires with proper negative voltage to avoid strong dependecy on wire-pad distance



Simulations

- 2 dim electrostatic model
  (analytic formulae are known)
- Set chamber geometry (wires, cathodes)
- From charge information field could be calculated
  Or in the reversed way as well
- Gain depends only on the sense wire charge
  (electron avalanche is a local effect)
- Describe “voltage ↔ charge ↔ gain” dependencies
- Study gain variation with different wire voltages and positions

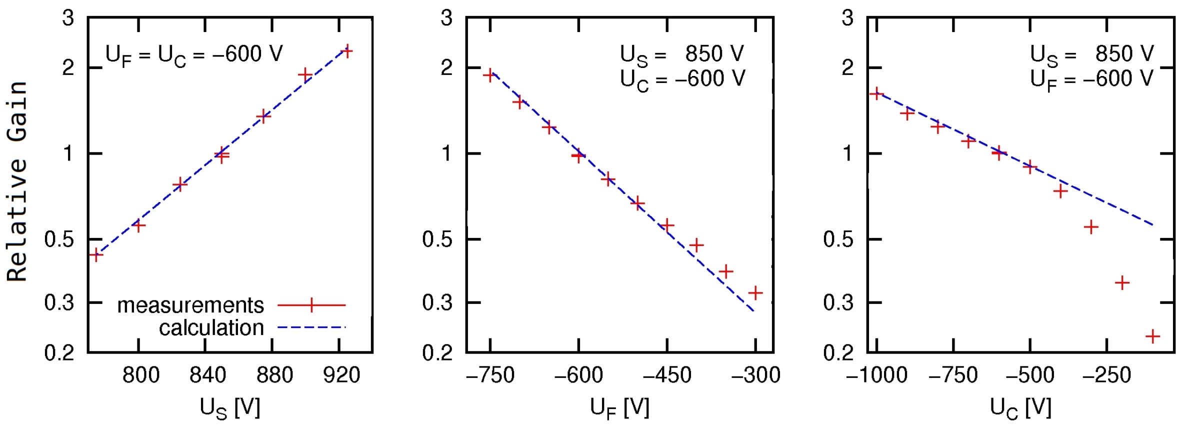




There exists a certain voltage configuration where sense wire charge and therefore gain does not depend on the padplane distance

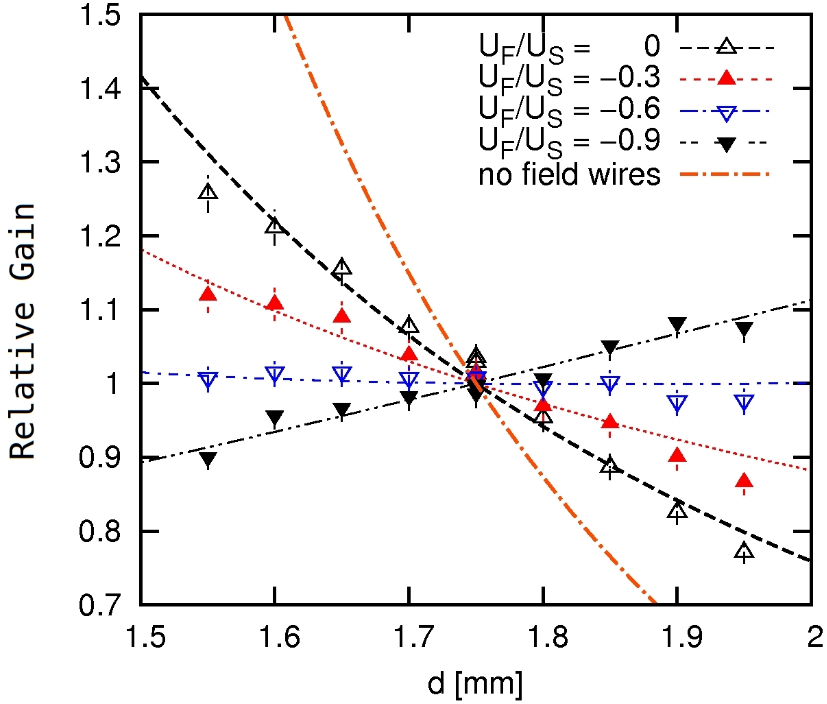
Electrostatic field configurations for this setup can be seen on the plots

Simulation results

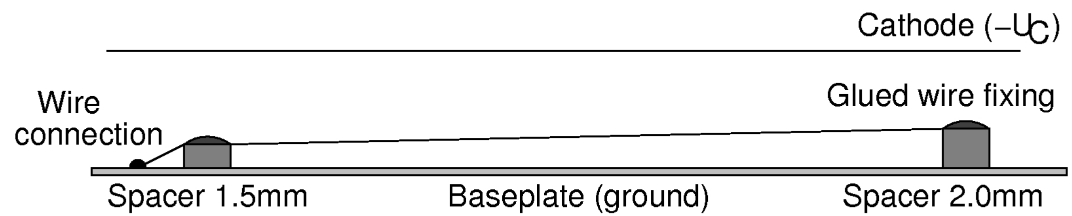


Gain vs sense wire voltage was measured as the only input parameter for the simulation (gain depends on the gaseous filling as well).

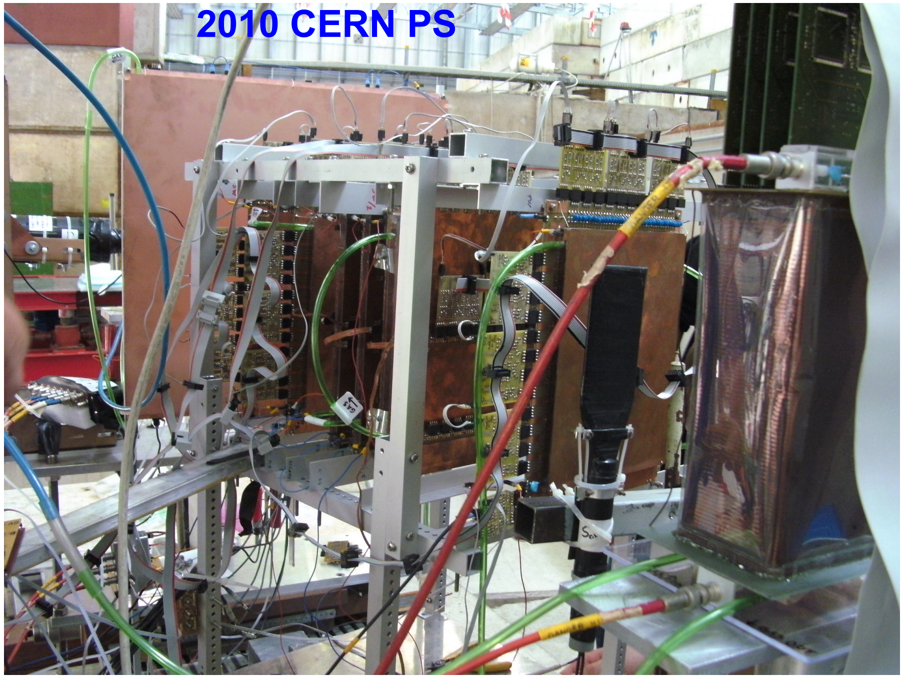
Other voltage dependencies could be calculated.
Good agreement with measured data.



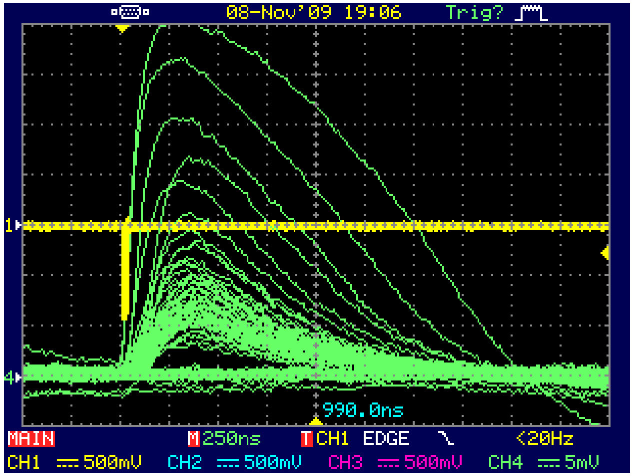
- Chamber with inclided wire plane have been constructed
- Wire plane distance dependencies could be measured with different voltage configurations

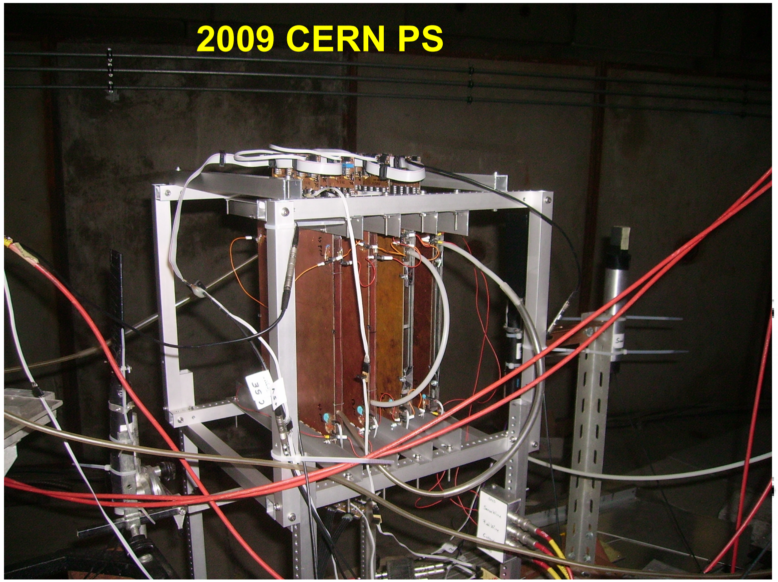


Beam tests



- Tests with beta source and cosmic rays
- Several beam tests was done at CERN PS T10 with 5 GeV/c pions
- About ten 20x20 cm^2 CCChambers and a 50x50 cm^2 one was tested successfully

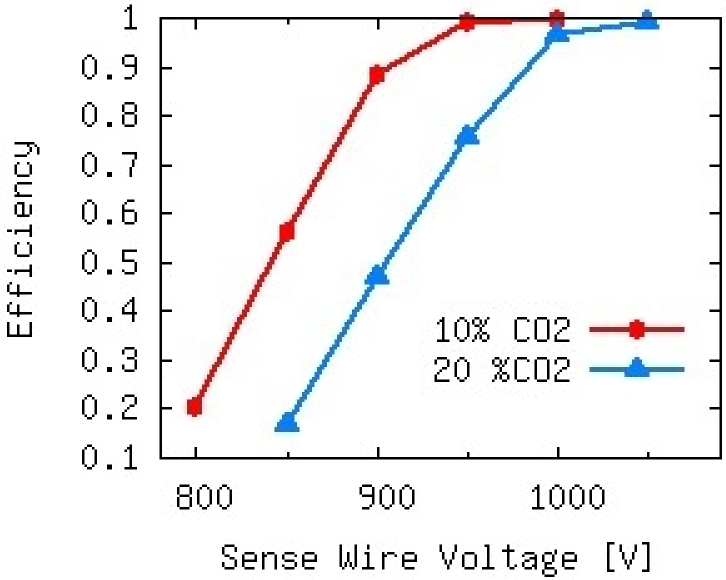


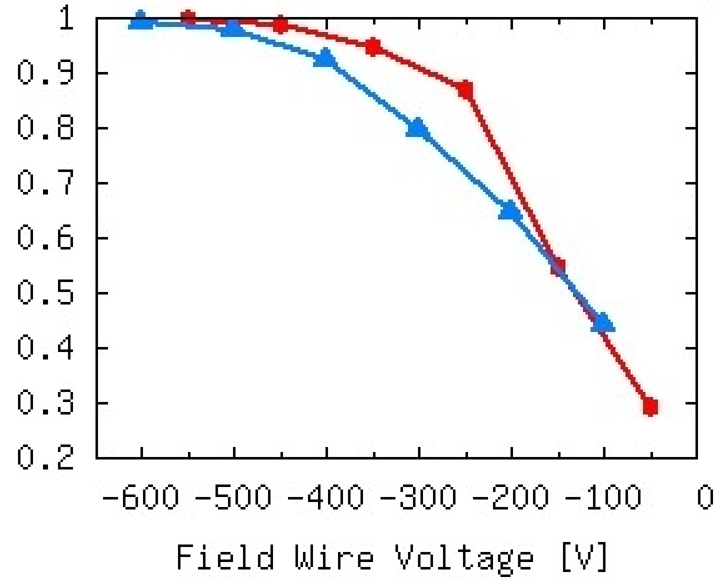


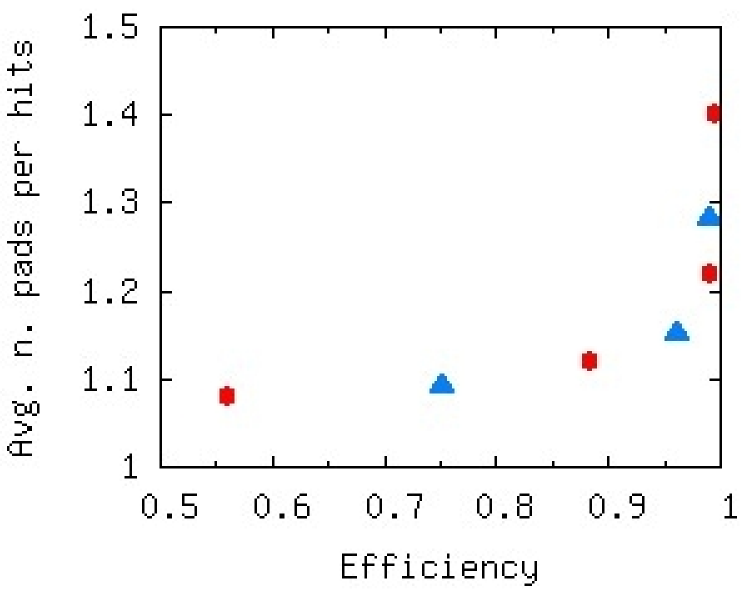

```
....X...........................
.......XX.......................
..........X.....................
.............XX............... -

.......XX.......................
..........XX....................
..............X.................
.................XX........... -
```

Efficiency, PRF



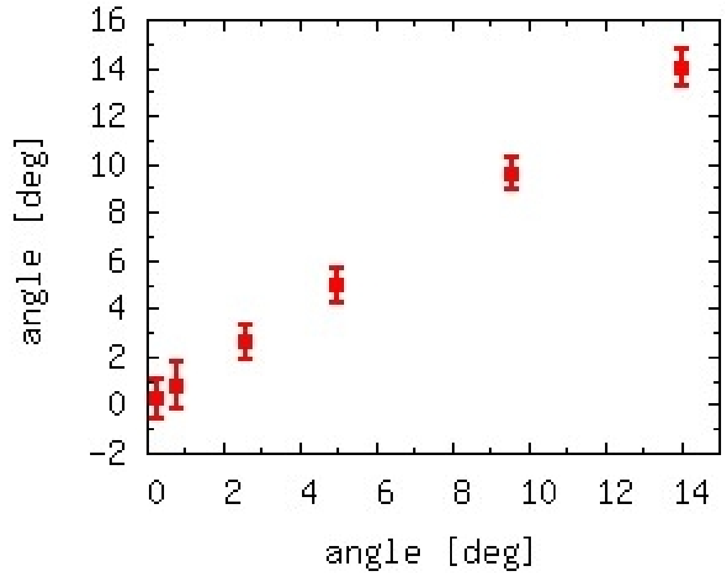


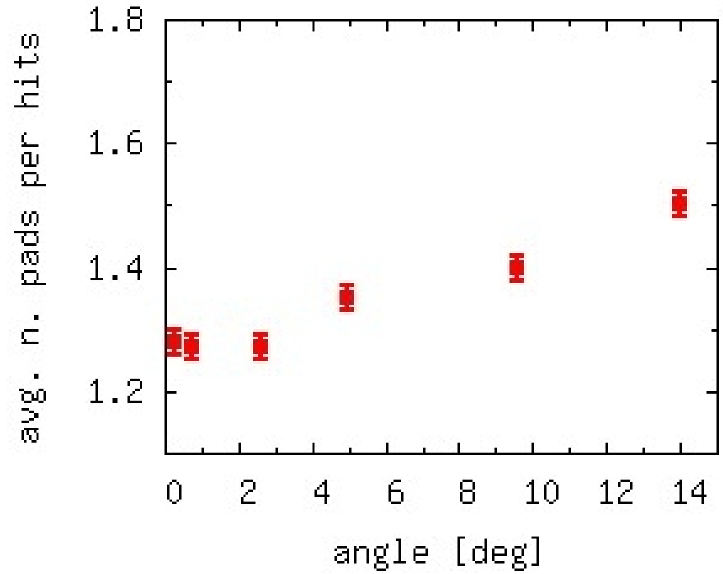


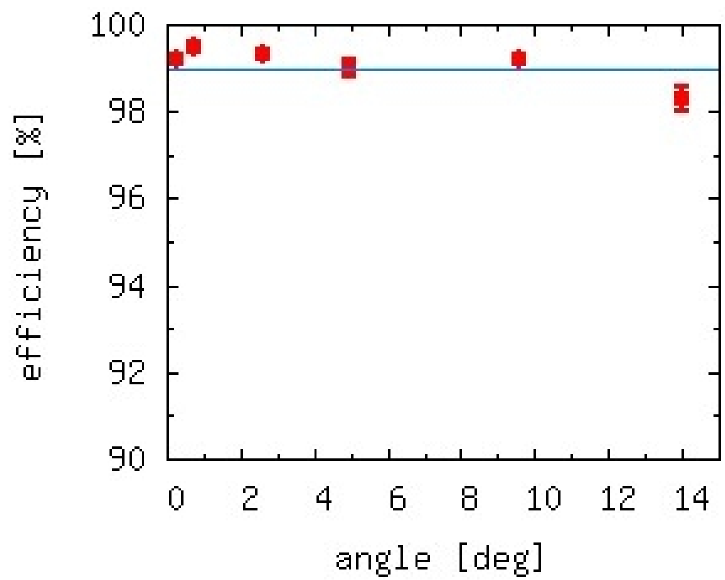
- 99.8 % efficiency
- 1.3 pads/hit in average
- Gas dependencies were studied
  no significant difference in
  the important parameters

  (Ar + 10% ill 20% CO_2)

Angular dependencies

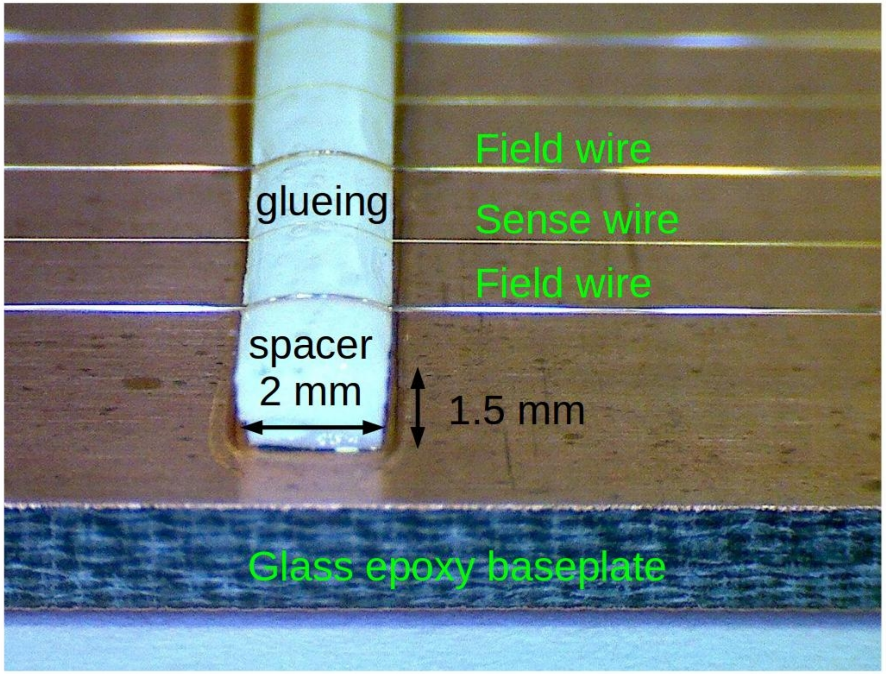




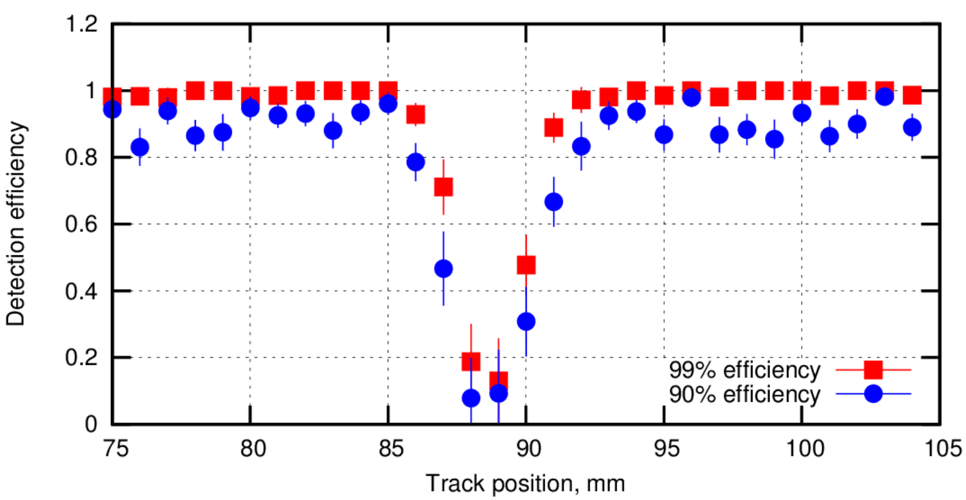


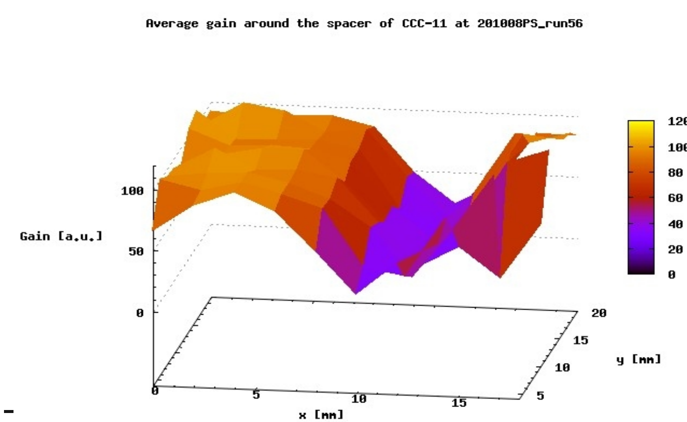
- Angular resolution: ~1.4 degrees
  same until 15 degrees of incidence
- Efficiencies above 99% (up to 10 deg)
- Average pads/hit slightly increases with the angle of incidence from 1.3 to 1.5 (feature of the CCCs)

Large chambers

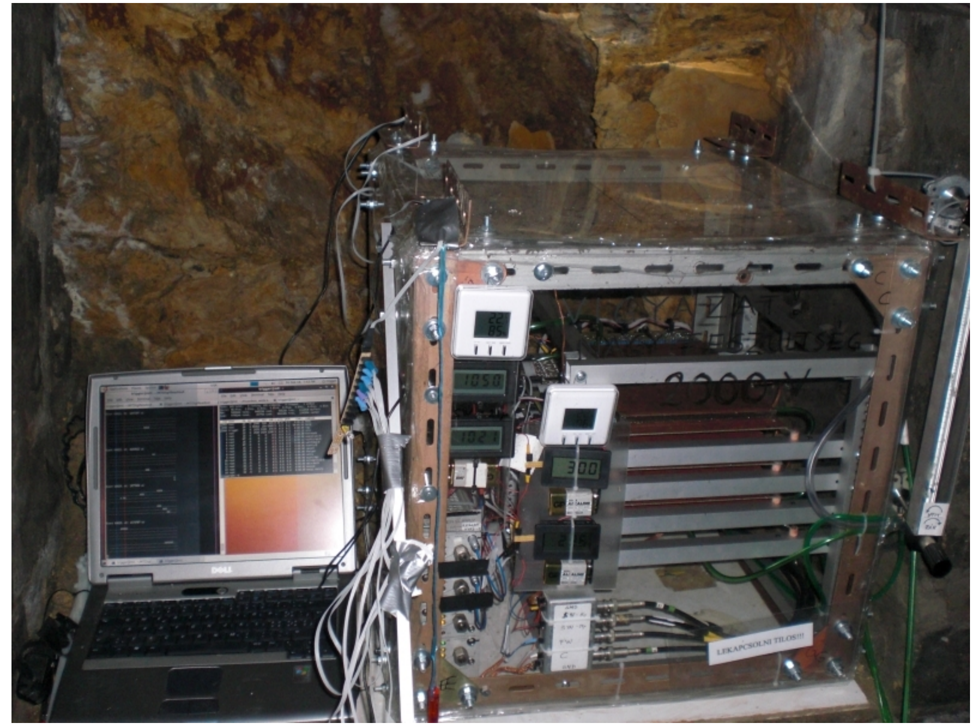


- Long wires
  - Sagging, electrostatic forces
  - **Spacers** have been inserted
  - Keeps wire postions in both directions
  - No wire tension on it
  - 2mm spacer → 4 mm loss of efficiency ~ 4mm / 200mm = 2% of the chamber
- Large surface
  - Small overpressure → large force
  - **Pillars** have been inserted
  - $3*3mm^2$ / $200*200$ mm^2

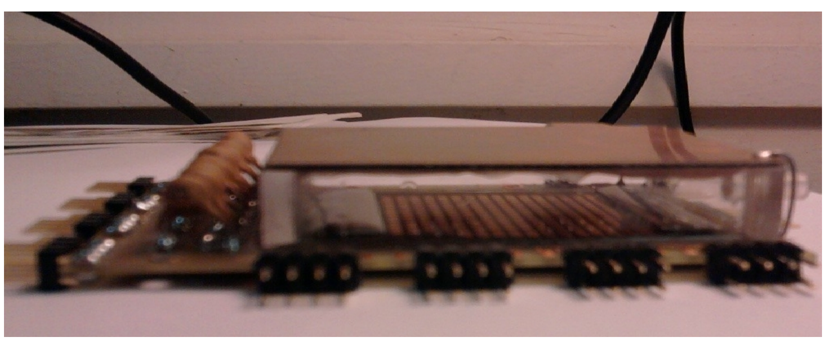




Current projects with CCChambers



- **HPTD** (shown before)
- **Muon tomography** for caves
  - With the track reconstruction of the cosmic muons, from muon flux discrepancies unexplored caves can be found
  - Portable detector, lightweight, cheap digital readout



- **Beam Position Detectors** (still under study)
  - Wire-pad distance in less than 1 mm
  - Good resolution, easy construction and readout

Summary

- QGP and jet studies in ALICE needs high momentum hadron identification (VHMPID) and triggering (HPTD)
- HPTD – several gaseous chambers need for : good granularity, narrow pad response for digital readout, low material budget, cheap construction
- **Close Cathode Chamber**
  - Asymmetric layout, 1-2 mm between wires and padplane
  - Field wires with proper voltage, tolerates flatness inconsistencies
  - Narrow pad response, average 1-2 pads/hit
  - Easy construction, mechanical tolerance, no robust support frame
- Simulations conforms the conception of CCC's operation
- Several chambers are in use for years with successful lab, cosmic and beam tests.
- Technique is expandable to large surfaces
  - Spacers decrease effective area by only 2%

Thank You for your attention !