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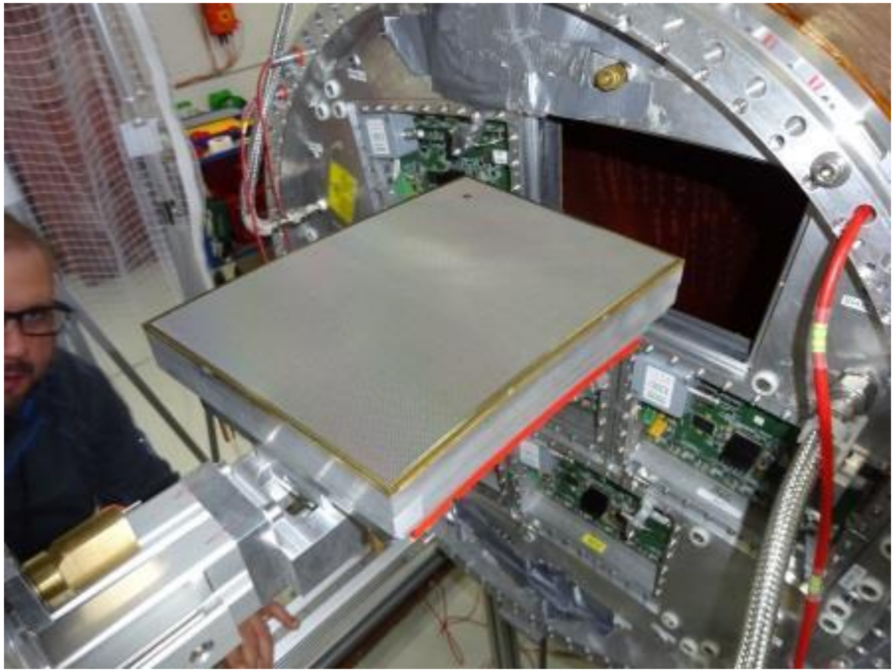
Micromegas module for ILC-TPC

A decade of R&D

Paul COLAS, CEA Saclay

Early tests
- Magnetic field
- charge spreading
- Ion Back Flow

Single-module tests
Micromegas development
Seven-module test
Integration issues :
electronics, cooling



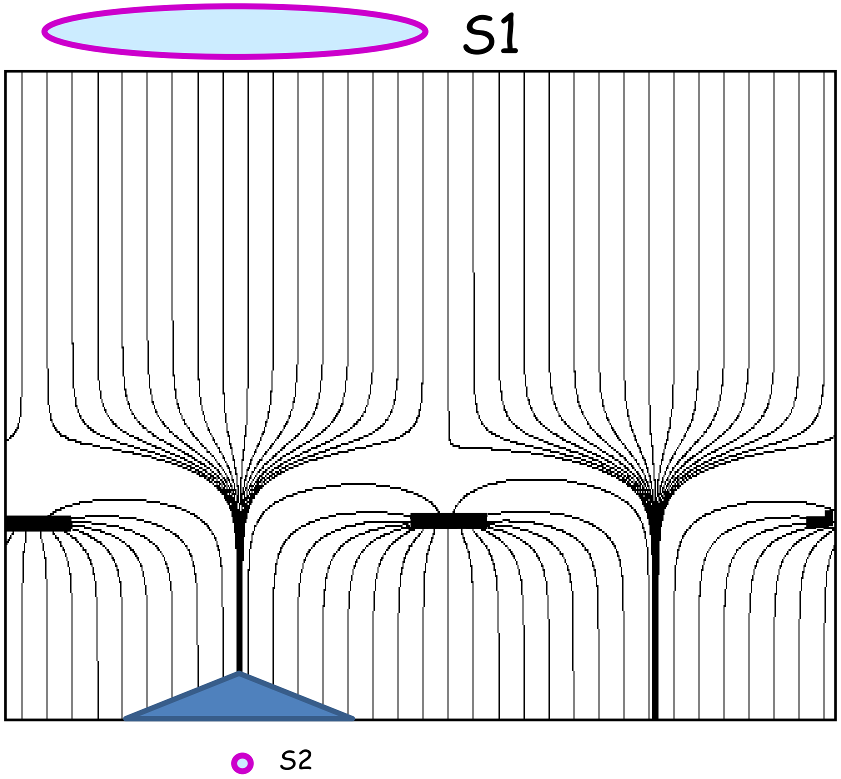
Introduction

- TPCs have good records in e+e- physics (ALEPH and DELPHI at LEP), and showed adaptability to dense high-rate environment (STAR, ALICE)
- MPGDs yield a promise for improvement : smaller structures lead to smaller ExB effects, ion feedback can be naturally suppressed, light construction of large area is possible.

Charged tracks cross a medium with a low (drift) field : 200 V/cm.
Ionization electrons drift to a mesh maintained ~100 µ above sensitive pads : the very high field (O(60kV/cm)) multiplies the electrons.

Very small gap : very fast detector

Funnel effect: avalanche spread by diffusion of electrons, ions follow back field lines, most of them closing on the mesh.

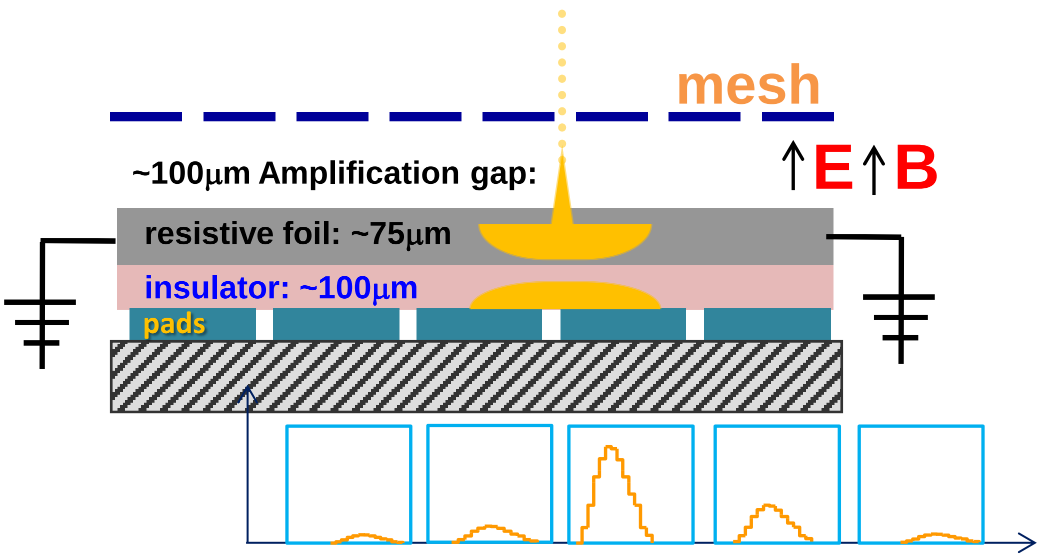


$S2/S1 = E_{drift}/E_{amplif} \sim 200/60000 = 1/300$

Micromegas

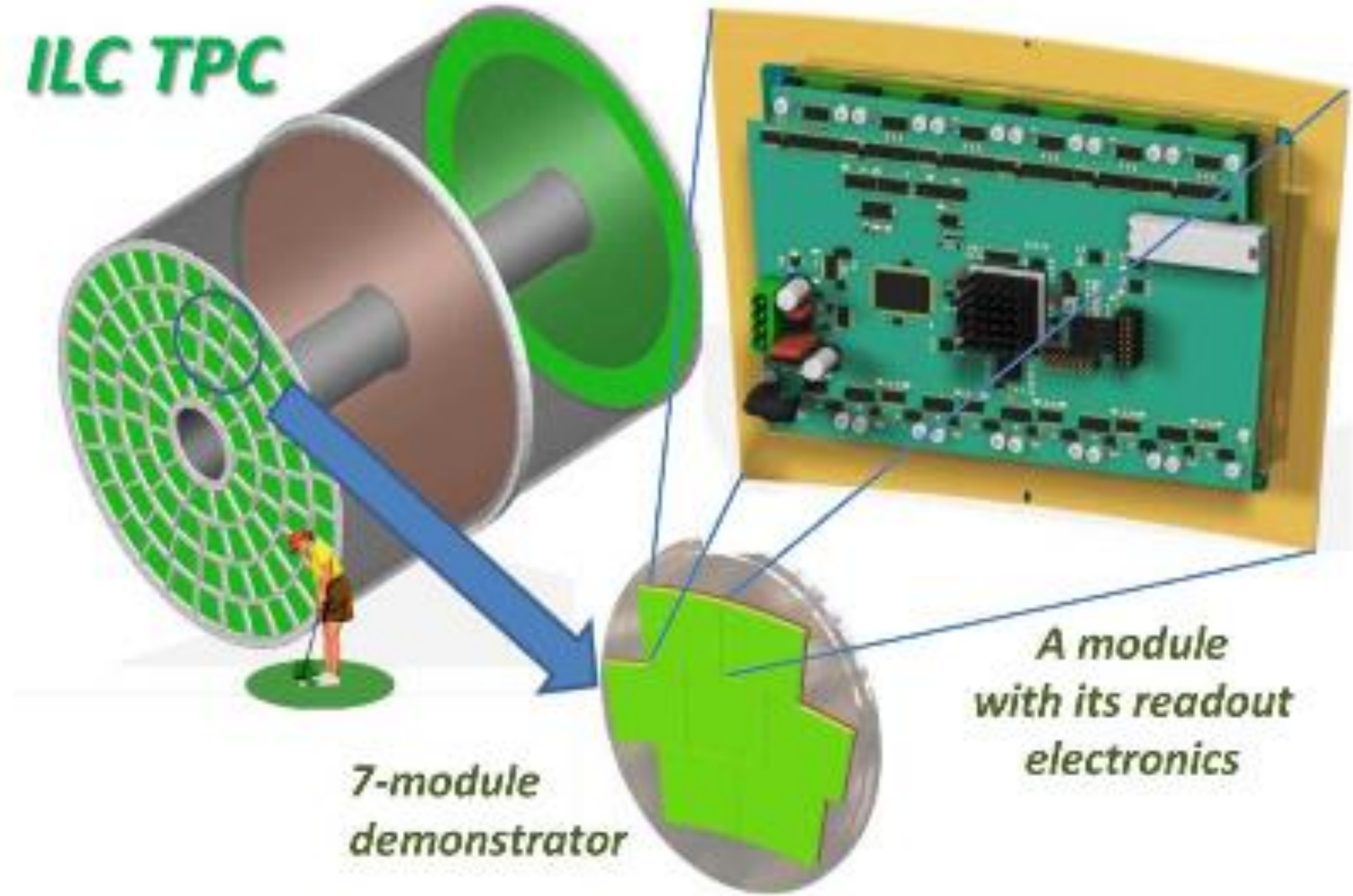
Charge spreading

- Continuous RC network spreading evenly the charge over several pads



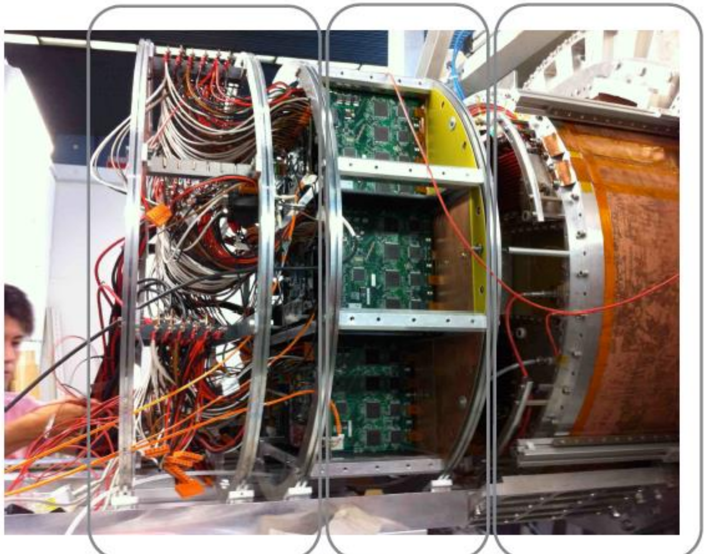
Early tests

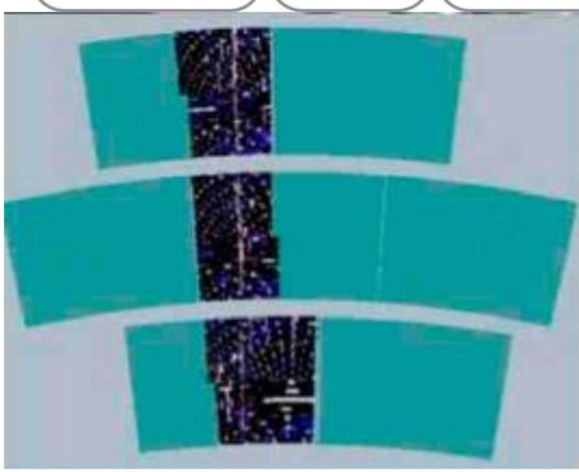
- 2001-2002 : Check that Micromegas works in a magnetic field. Requires non-magnetic mesh.
- Study the ion back flow natural suppression
- Select gas candidates
- 2000-2005 : development of the charge-spreading method (M. Dixit et al.). Tested in a 5T field: 30 μm resolution with 2mm pads


ILC TPC
A module
with its readout
electronics
7-module
demonstrator

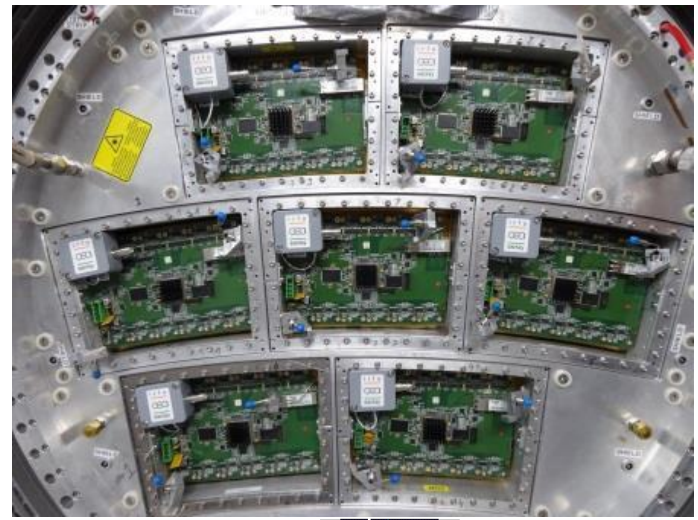
EUDET/AIDA Test facility at DESY

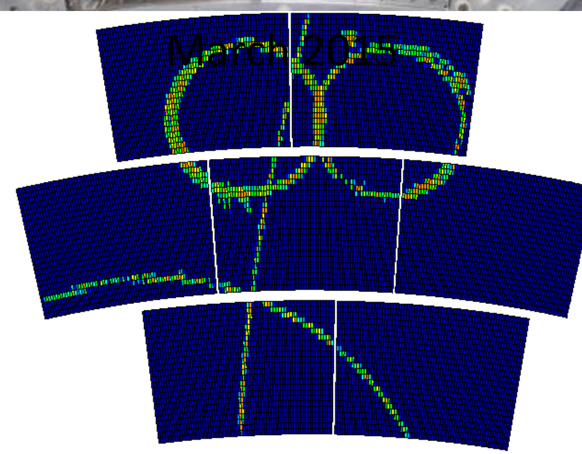
GEMs



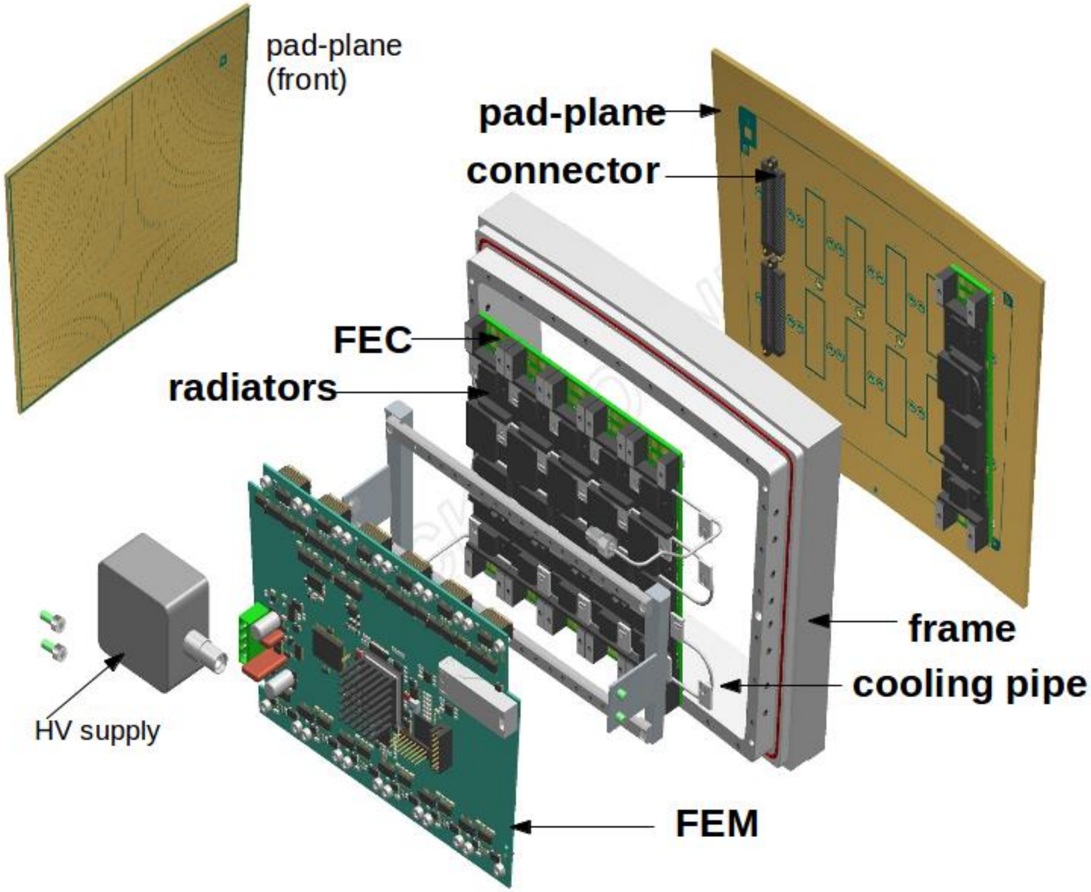


Micromegas

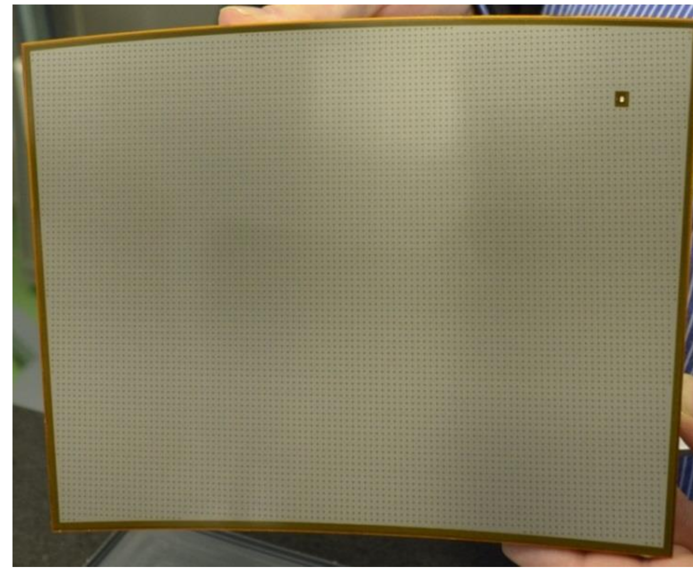




Micromegas module



Bulk process for MM manufacture
Carbon-loaded kapton or
Diamond-like carbon as resistive
coating



Module size: 22 cm × 17 cm

Readout: 1726 Pads

24 rows

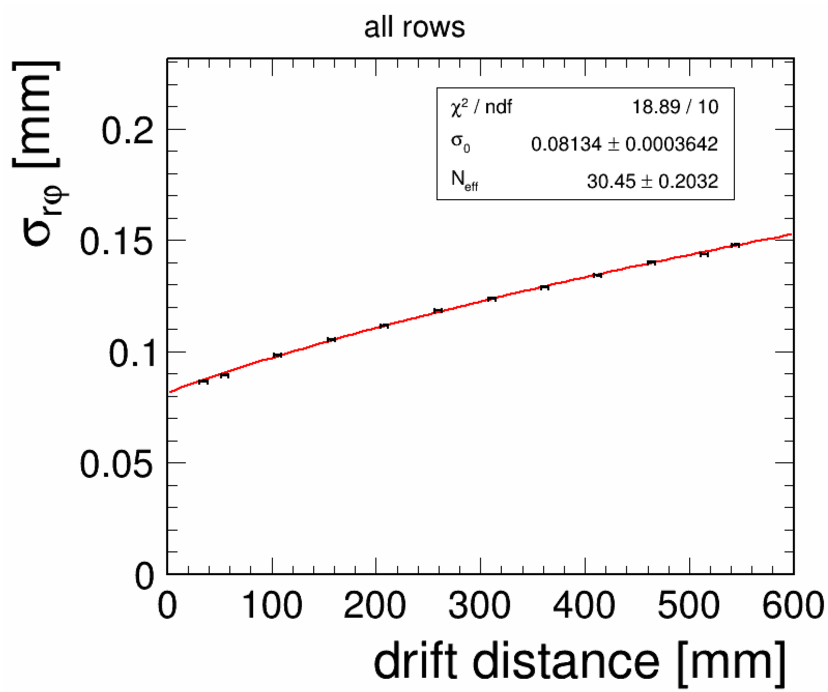
Pad size: ~ 3 mm × 7 mm

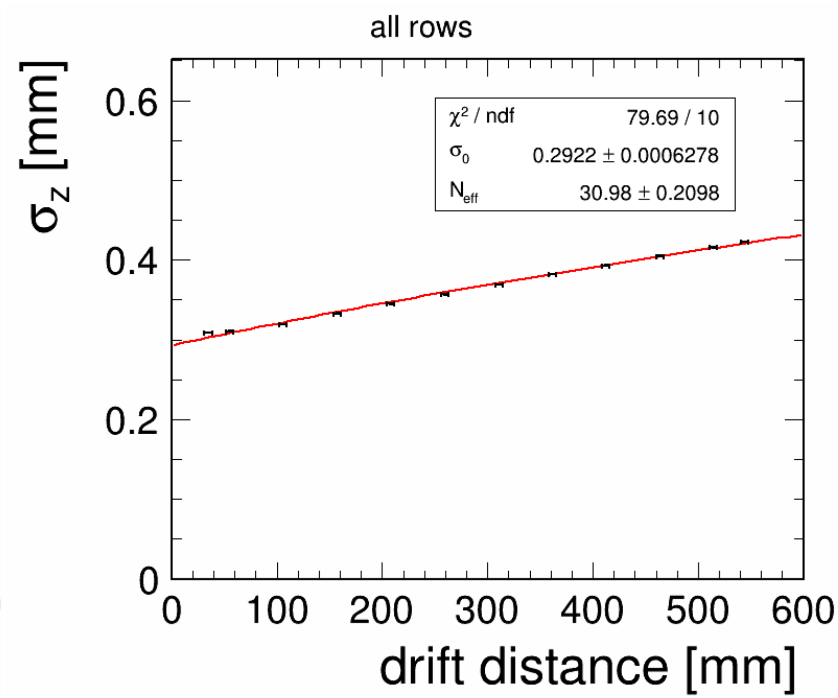
Chips on board (wire bonding) – The resistive foil suffices to protect against sparks – 0.25 X° thick

Gating

- Necessary to fully suppress the space charge produced by ion back flow from the amplification gap
- Practical solutions under study, e.g. gating GEM (see Akira Sugiyama’s talk)
- Not possible at CEPC (see Huirong’s talk)

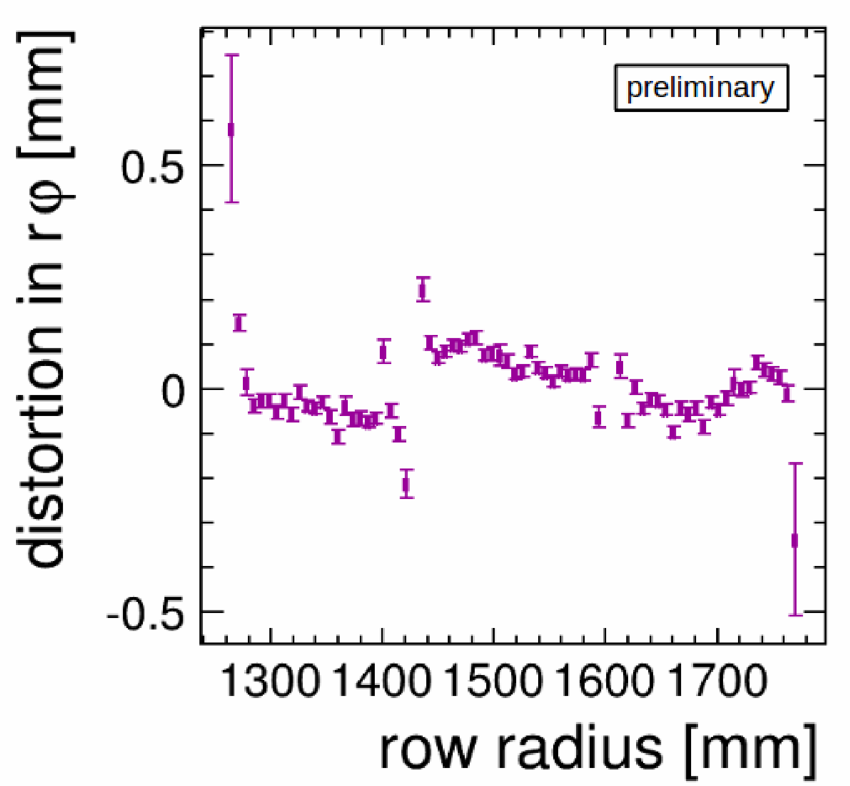
Perfomance : resolution

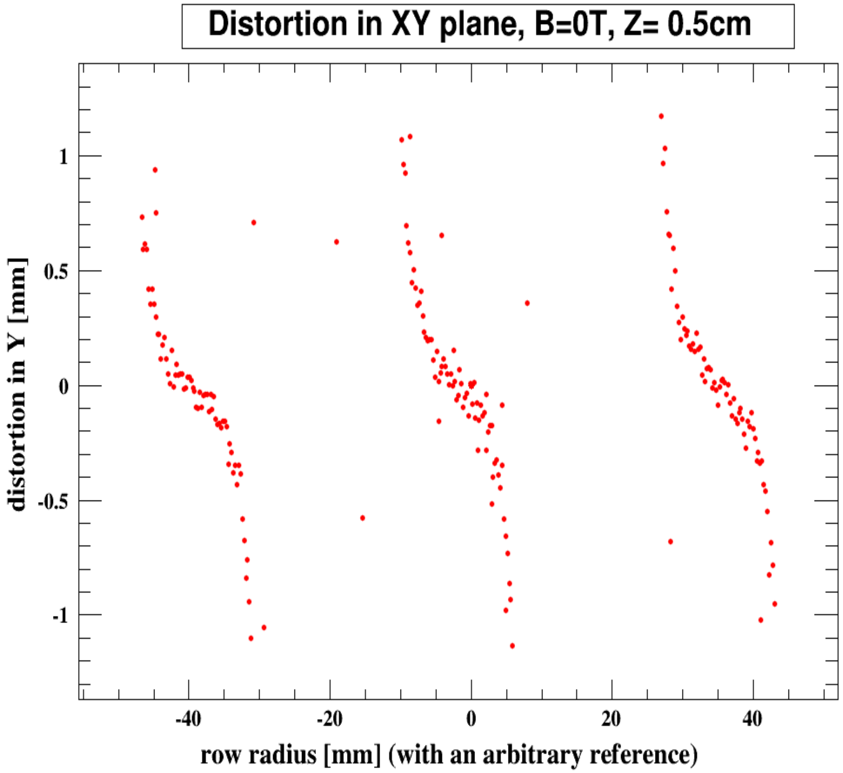




Resolution 70 µm in rϕ and 200 µm in z at zero drift distance for 3mm-wide pads
Drift dependence follows expectation from diffusion

Comparison of distortion between experiment and simulation





For the Micromegas modules on the **LPTPC endplate.**

B=0T

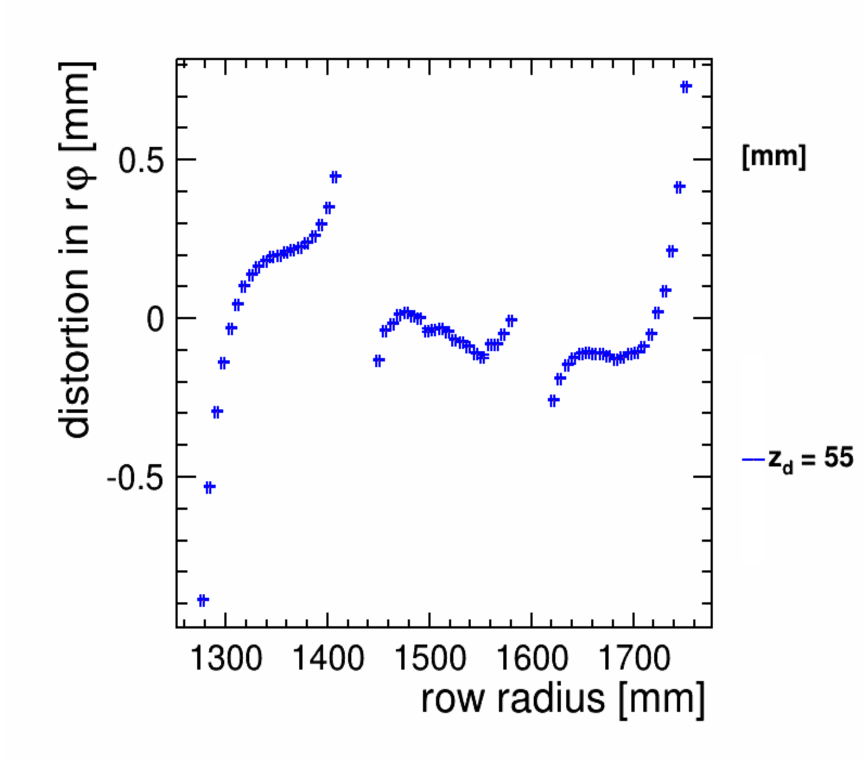
Distribution of the residuals as obtained in **Experiment** *after* alignment correction.

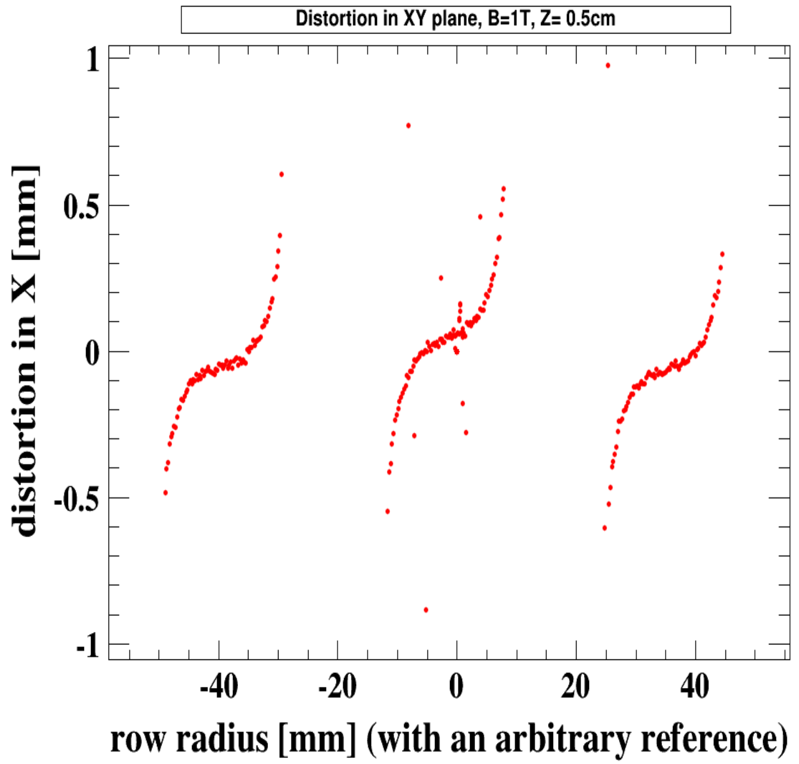
For the **simulated** Micromegas modules

B=0T

Distribution of the residuals as obtained in **Simulation**

Comparison of distortion between experiment and simulation





For the Micromegas modules on the **LPTPC endplate.**

B=1T

Distribution of the residuals as obtained in **Experiment** *without* alignment correction.

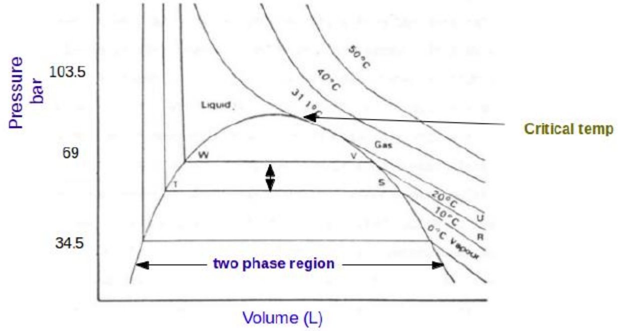
For the **simulated** Micromegas modules

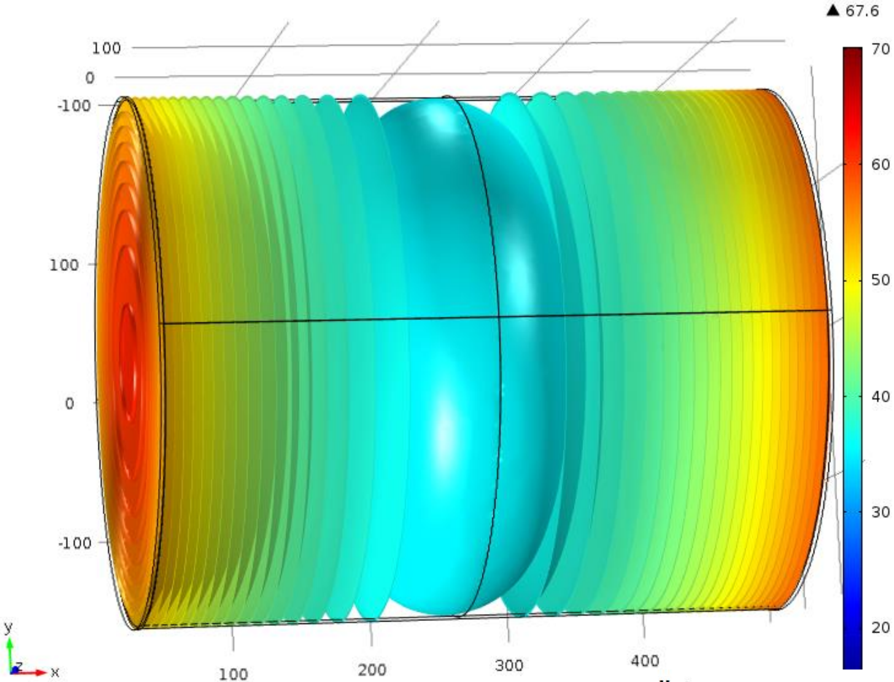
B=1T

Distribution of the residuals as obtained in **Simulation**

2-phase CO_2 cooling

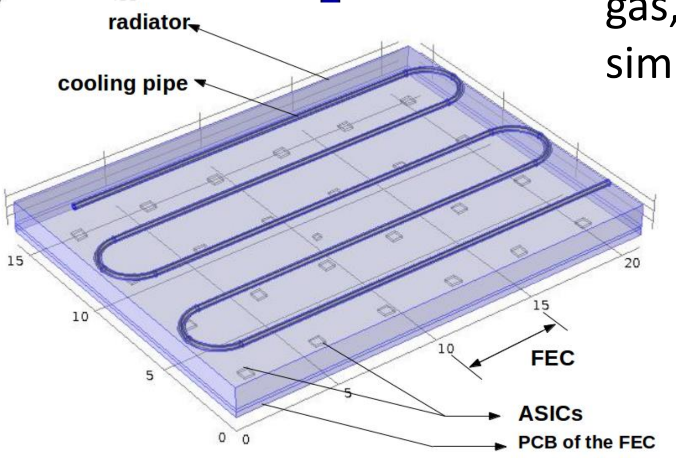
- Can operate at room temperature (requires high pressure, no problem in O(1mm) pipes. Allows more uniform gas temperature and no worry with dripping condensed water.
- No consequence of leaks : CO_2 vaporizes
- Excellent heat removal (high heat capacity and high latent heat)
- Very little matter budget



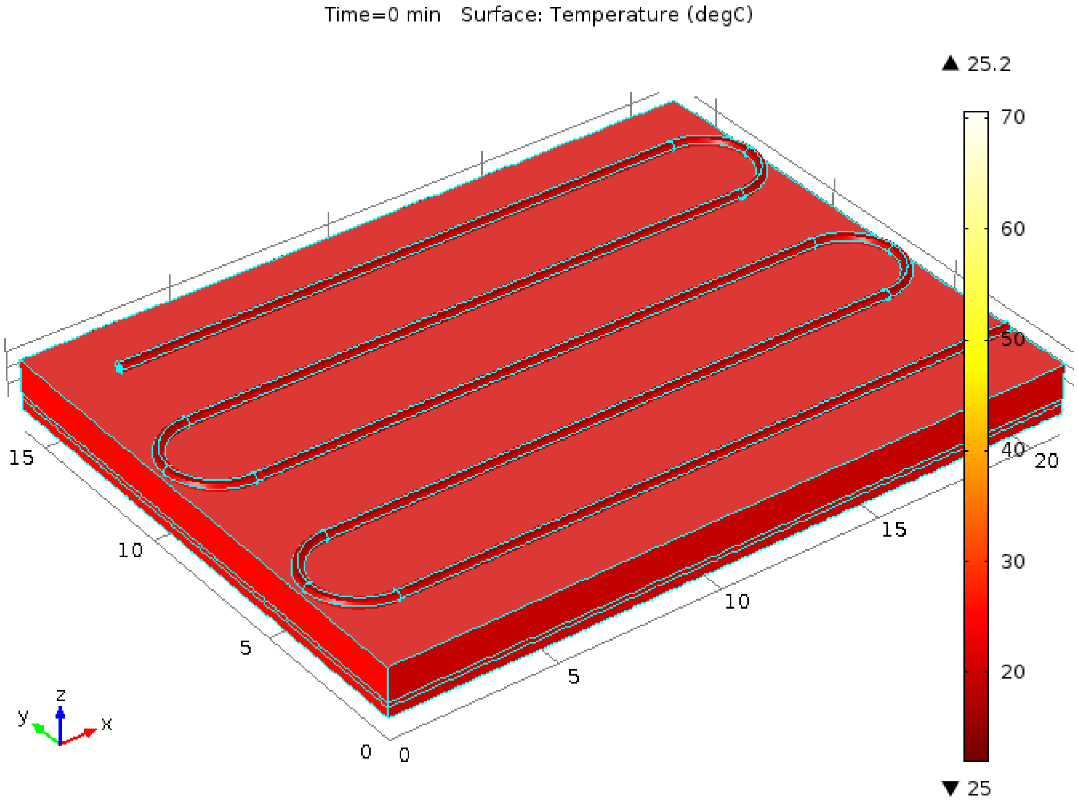


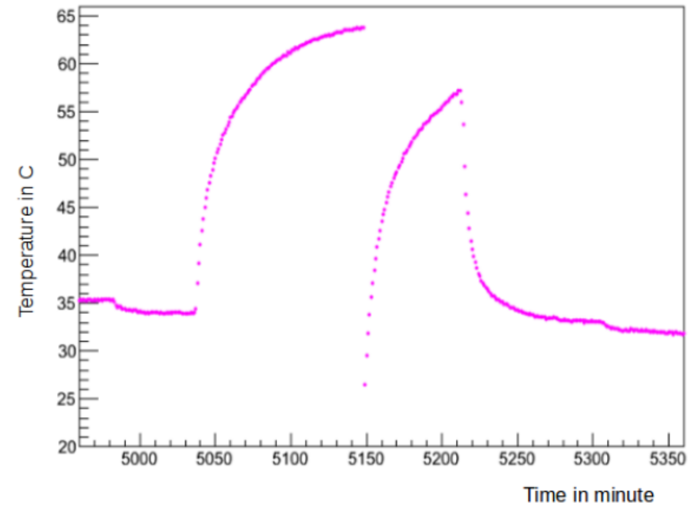
D.S. Bhattacharya

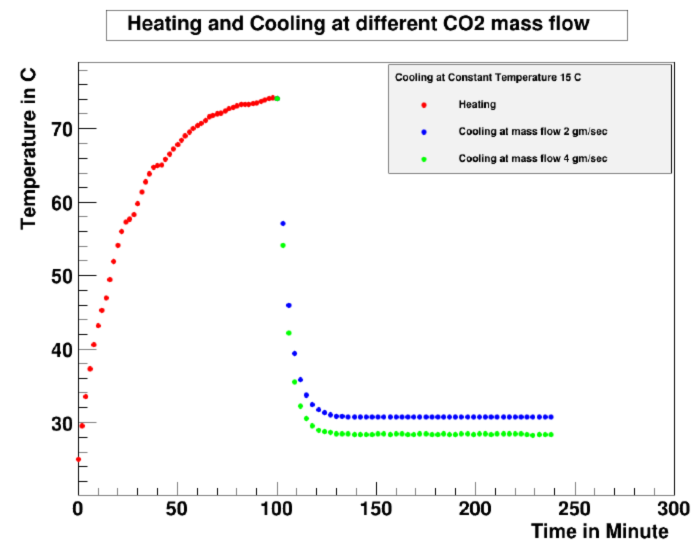
Thermal inhomogeneities cause changes in drift properties in the gas, hence distortions. Needs simulations.



Thermal simulation of the gas volume and of the endplate modules







Warming up and cooling down of a module. Good agreement with data

Summary

- Basic demonstration that a TPC can operate at ILC with required performance is made
- More work needed to demonstrate that it can work at a CC (time structure, ion back flow)
- A lot of progress was made in a decade towards an engineered detector