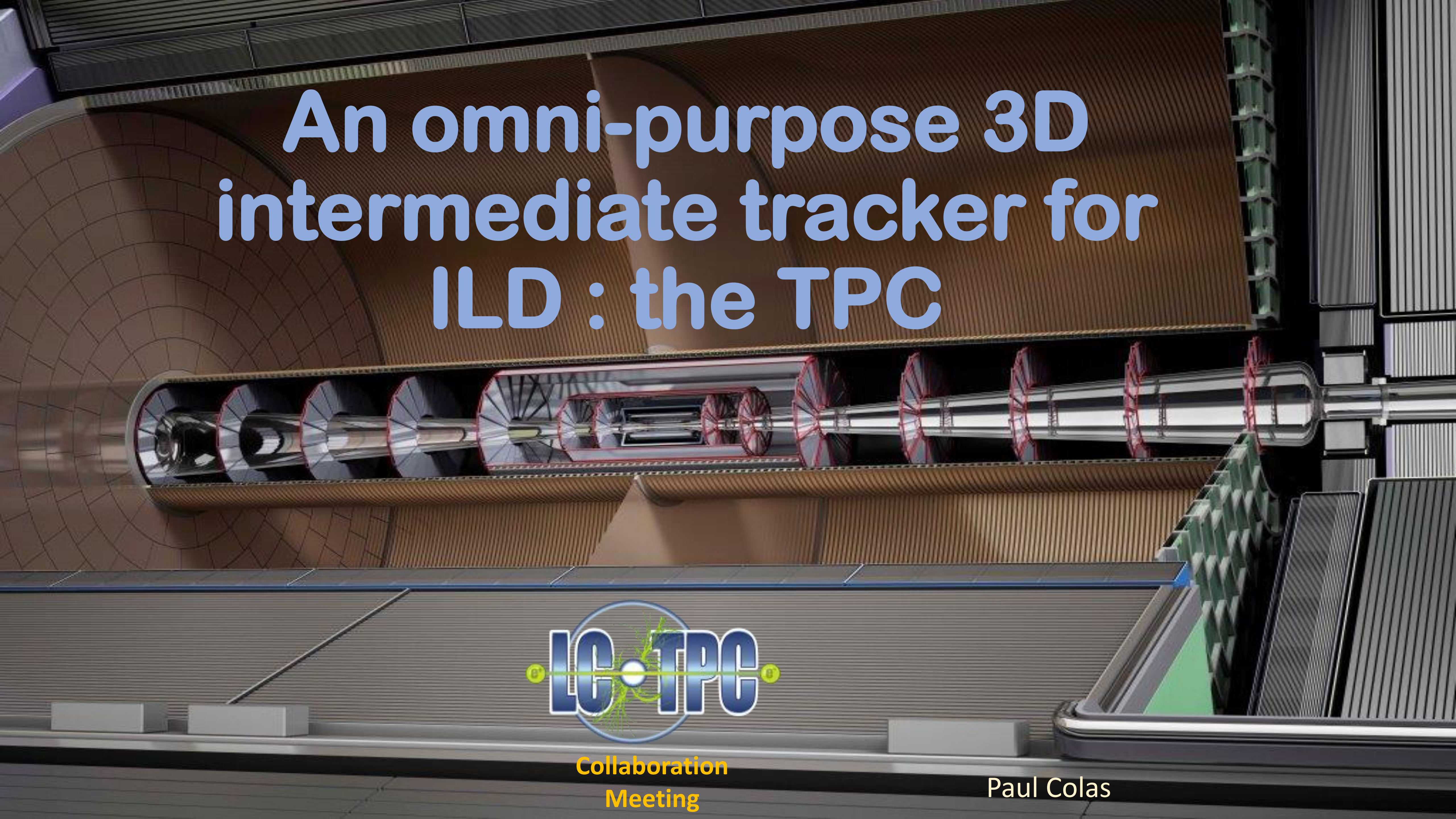
An omni-purpose 3D intermediate tracker for ILD : the TPC



Collaboration Meeting

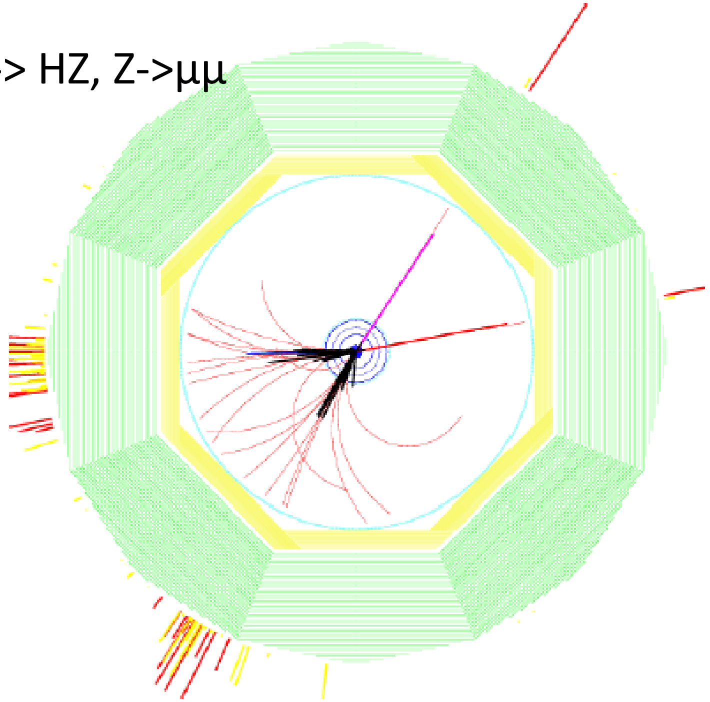
Paul Colas

Outline

- Motivation and adaptation to the ILC machine
- R&D
- Recent results
- Future developments
- Project aspects

Motivation

e+e- -> HZ, Z->μμ

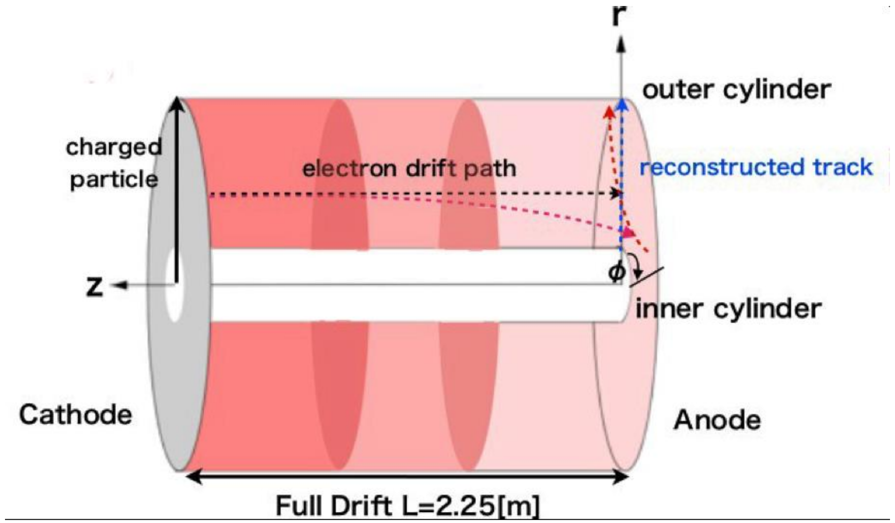


- Need to reconstruct complex multi-track events (jets) in a noisy environment : calls for high segmentation
- Also need to reconstruct very accurately high energy tracks from Z recoil to Higgs. This translates into O(10 μm) control of the systematics on sagitta

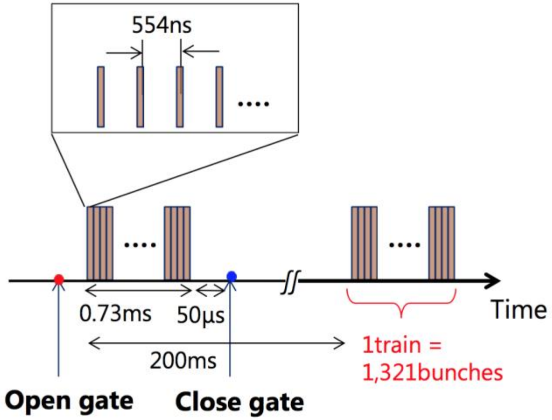
- Silicon detectors give point measurement accuracy, but also introduce multiple scattering, while a TPC provides a continuous 3D track reconstruction with minimal matter : useful for V0, kinks, connecting to vertex tracker, other silicon trackers, and to calorimeter.
- Also a TPC has dE/dx capability, for K/π separation

Need for gating

In TPCs, ions are produced and migrate very slowly (1 m/s) . They produce a charge density which can be one or two orders of magnitude above the primary ionization (IBF*Gain). The resulting electric field can be the origin of distortions.



At the ILC, the bunch trains last about 1ms every 200 ms, giving rise to ion disks slowly drifting to the cathode



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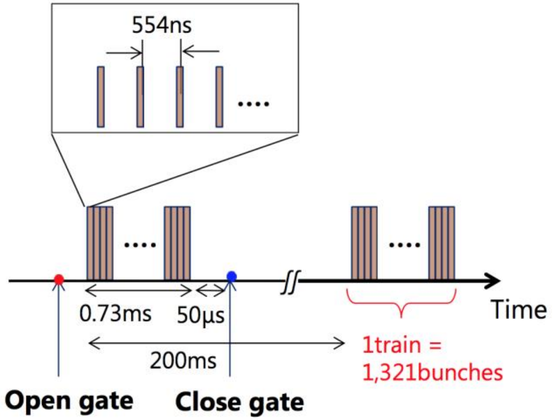
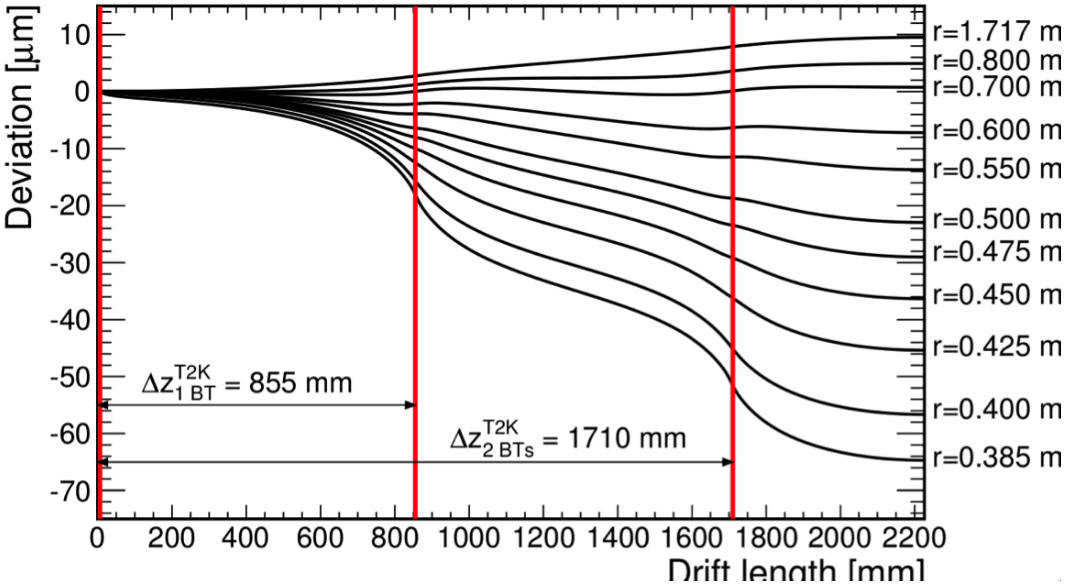
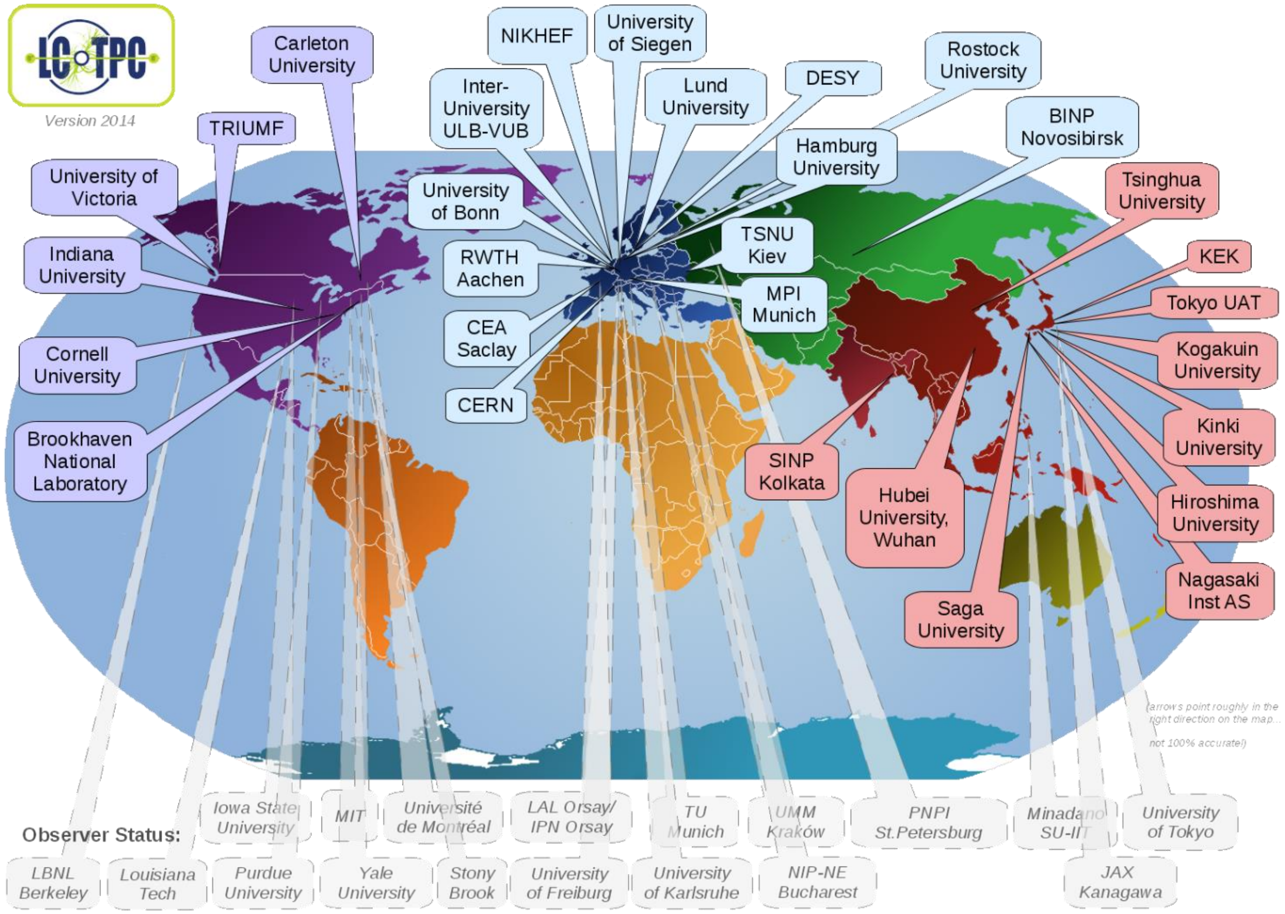




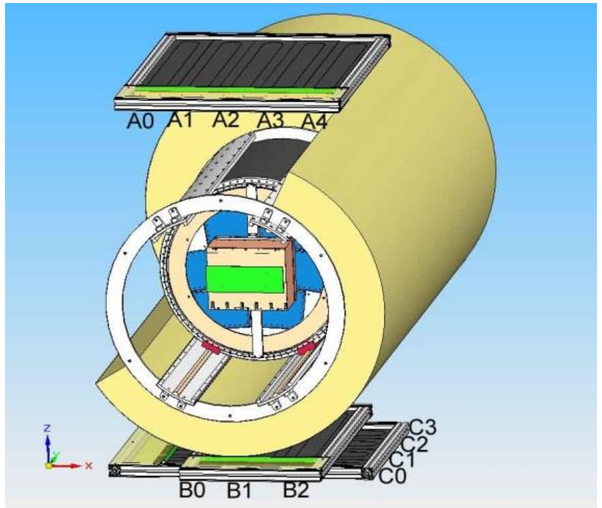
After 2 disks, the electrons receive a kick of up to 60 μm, too much wrt the systematics

The LCTPC collaboration and the DESY test setup

All the **TPC R&D** is gathered.
www.lctpc.org



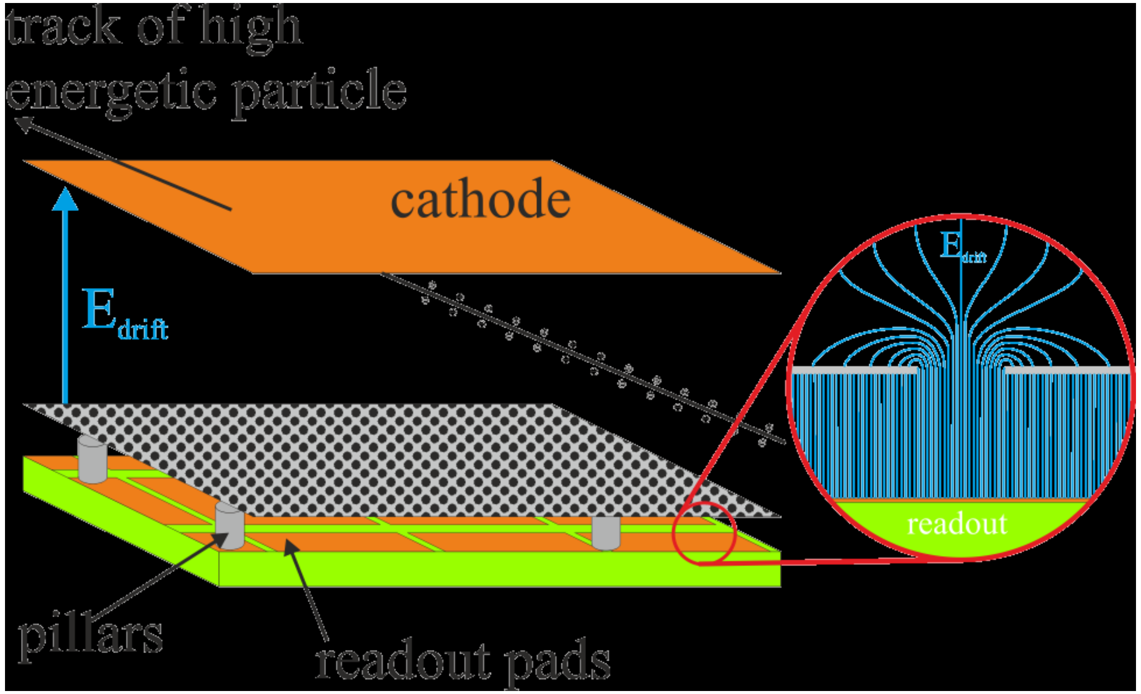
The collaboration shares a test facility at the DESY T24 test beam (Field cage, magnet, endplate, cosmic-ray trigger, ancillaries)



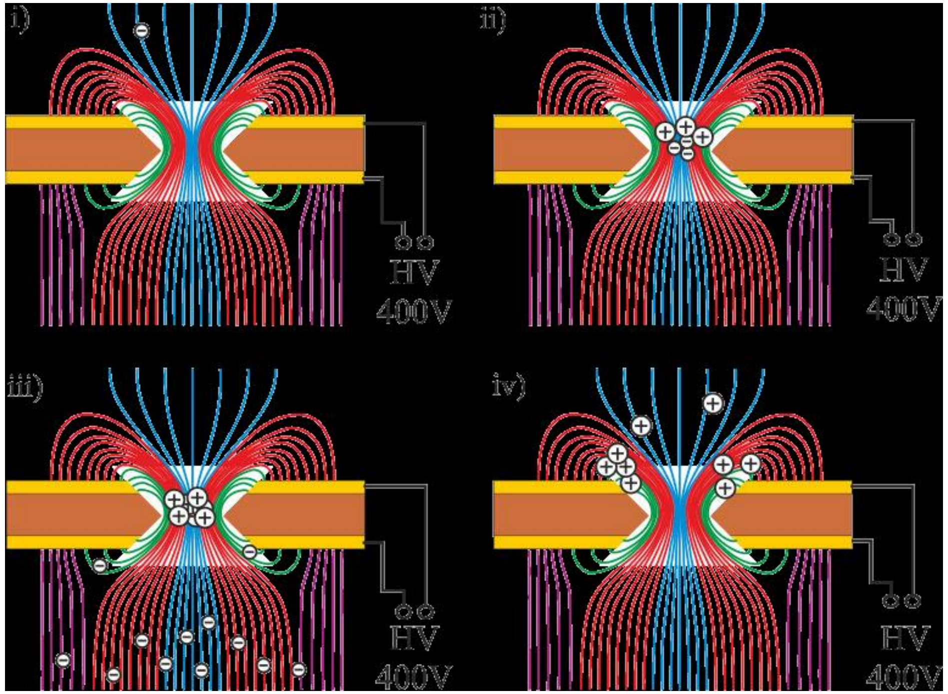
Allows testing/comparing several technologies/ideas with cost-awareness

Technologies

Micromegas : Micromesh gaseous chamber



GEM : Gas Electron Multiplier



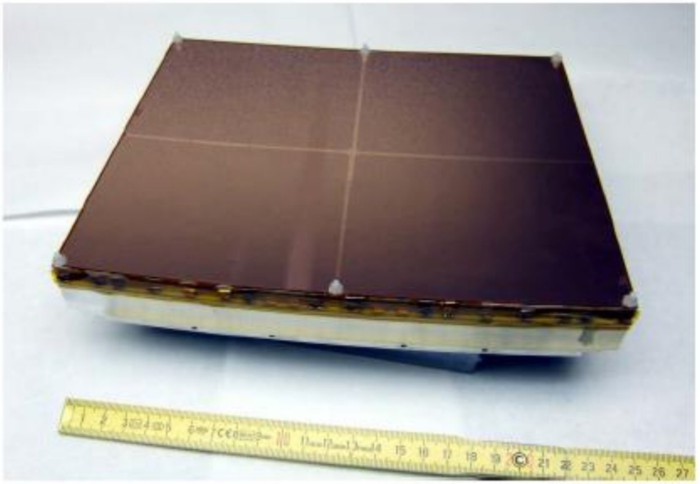
The DESY GridGEM Module

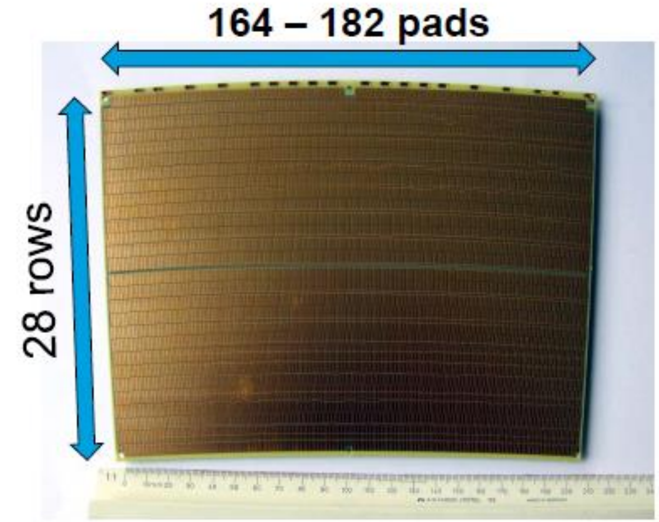
Design Goals

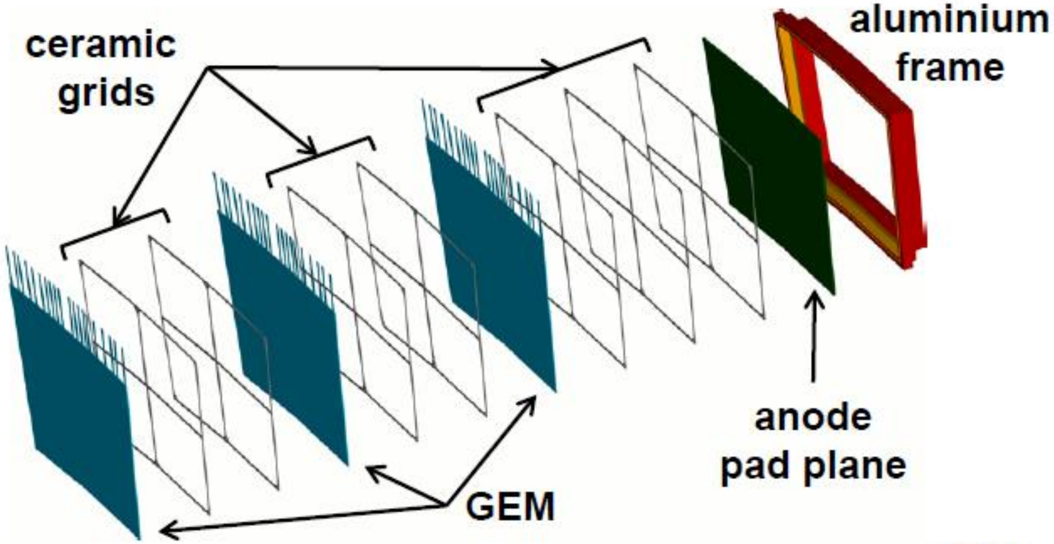
- Maximum sensitive area
- Minimal gaps
- Minimal material

Design Choices

- Integrated, self supporting GEM amplification structure
  - 3 GEM stack supported by thin ceramic grids
- Segmented readout anode:
  - ~5000 pads ($1.26 \times 5.85\ mm^2$) in 28 rows
  - ~95% sensitive area
- Size and shape as planned for ILD TPC ($\sim 17 \times 23\ cm^2$)
- Custom ALTRO system as readout electronics

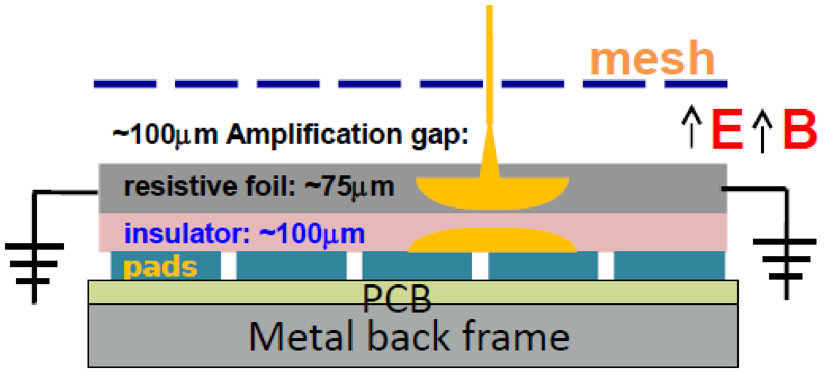




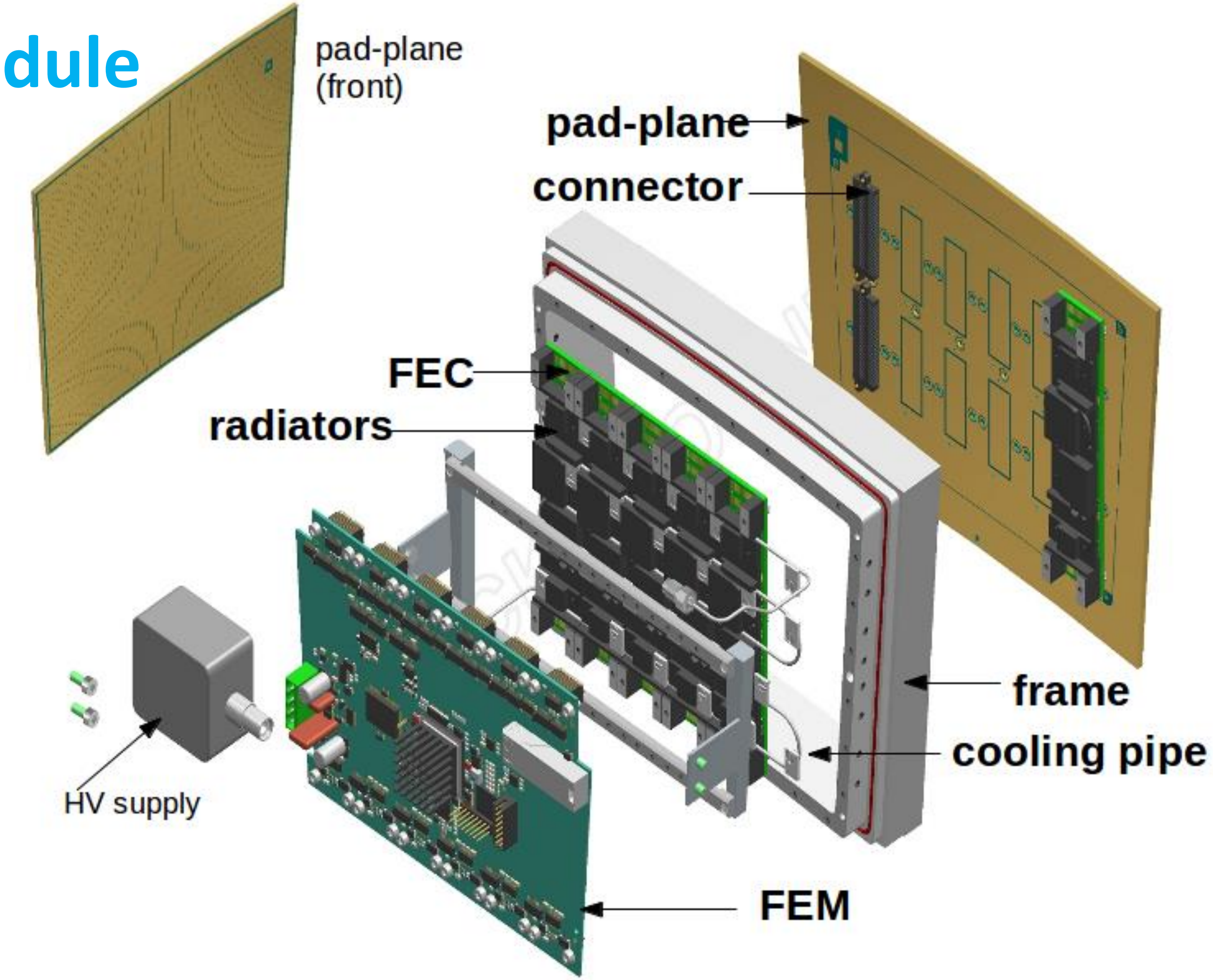


The Saclay Micromegas Module

Fully integrated electronics and cooling

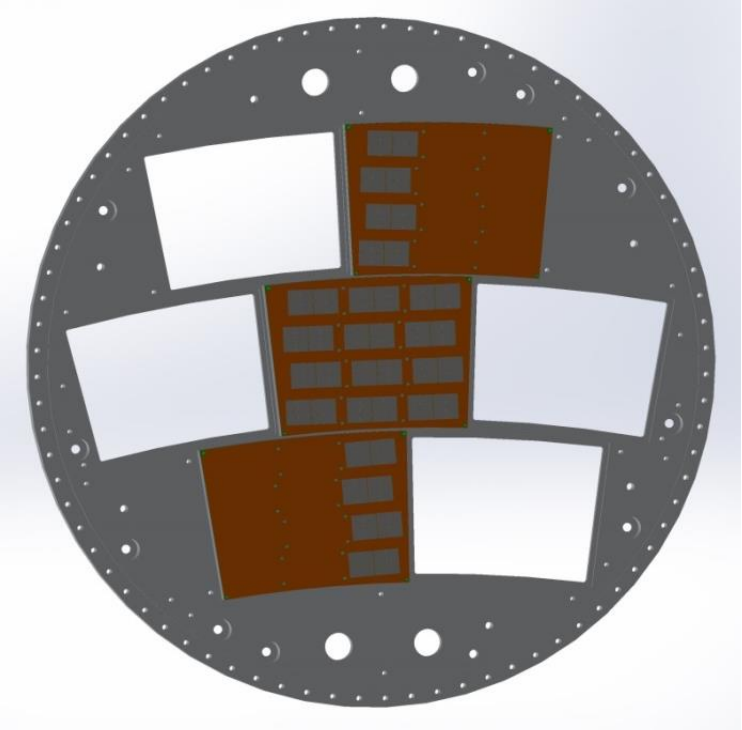


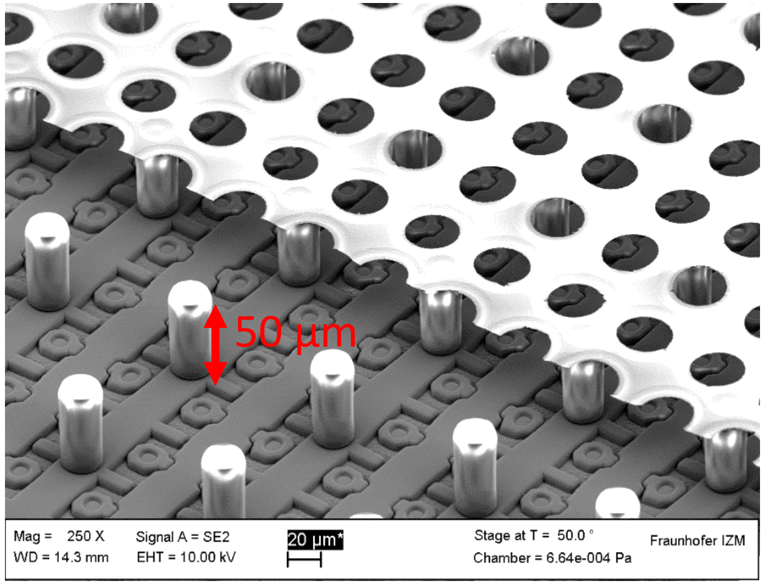
PCB equipped with a RC continuous circuit covering the pads (insulator + resisitve foil), to spread the charge, so that several pads are hit and a barycenter can be used to improve the resolution

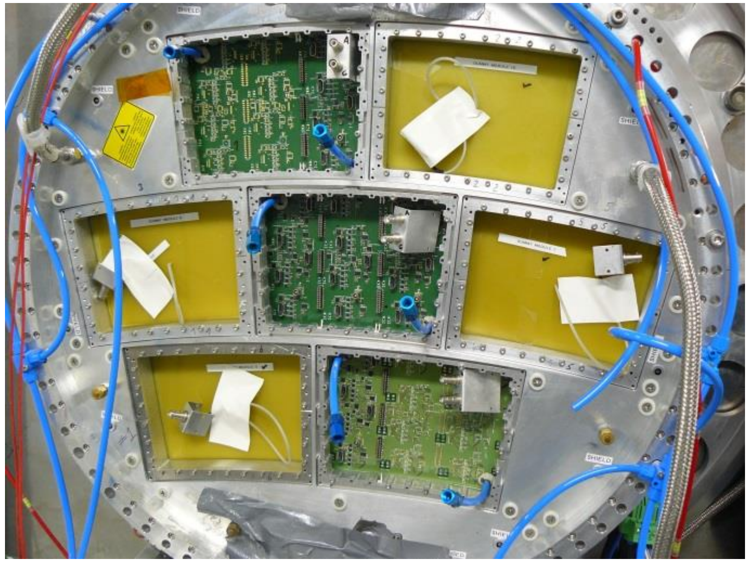


Gridpix : ‘digital TPC’

Reconstruct every ionization electron with a high efficiency.
Measure dE/dx by cluster counting







Now uses Timepix 3 and chip protection against sparks has been improved.

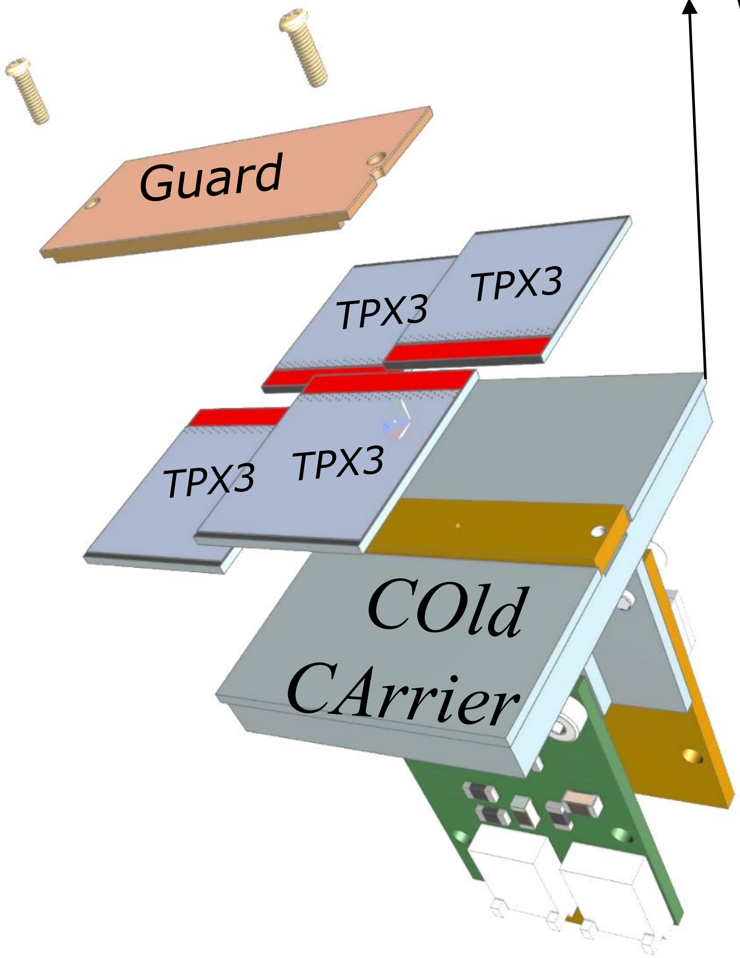
THE NIKHEF-BONN PIXEL MODULE

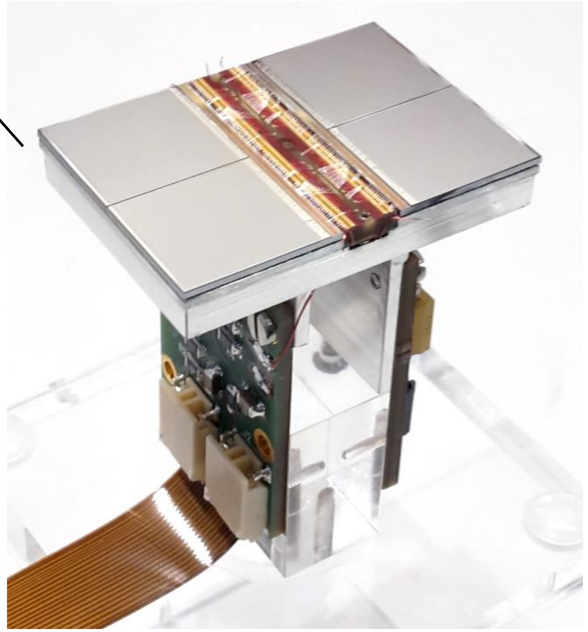
QUAD design and realization

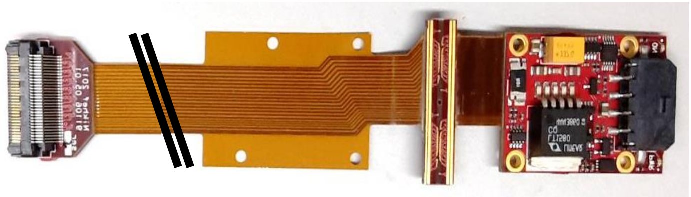
- Four-TimePix3 chips
- All services (signal IO, LV power) are located under the detection surface
- The area for connections was squeezed to the minimum
- Very high precision 10 µm mounting of the chips and guard
- QUAD has an sensitive area of 68.9%
- DAQ by SPIDR
- Tested in a beam in Bonn

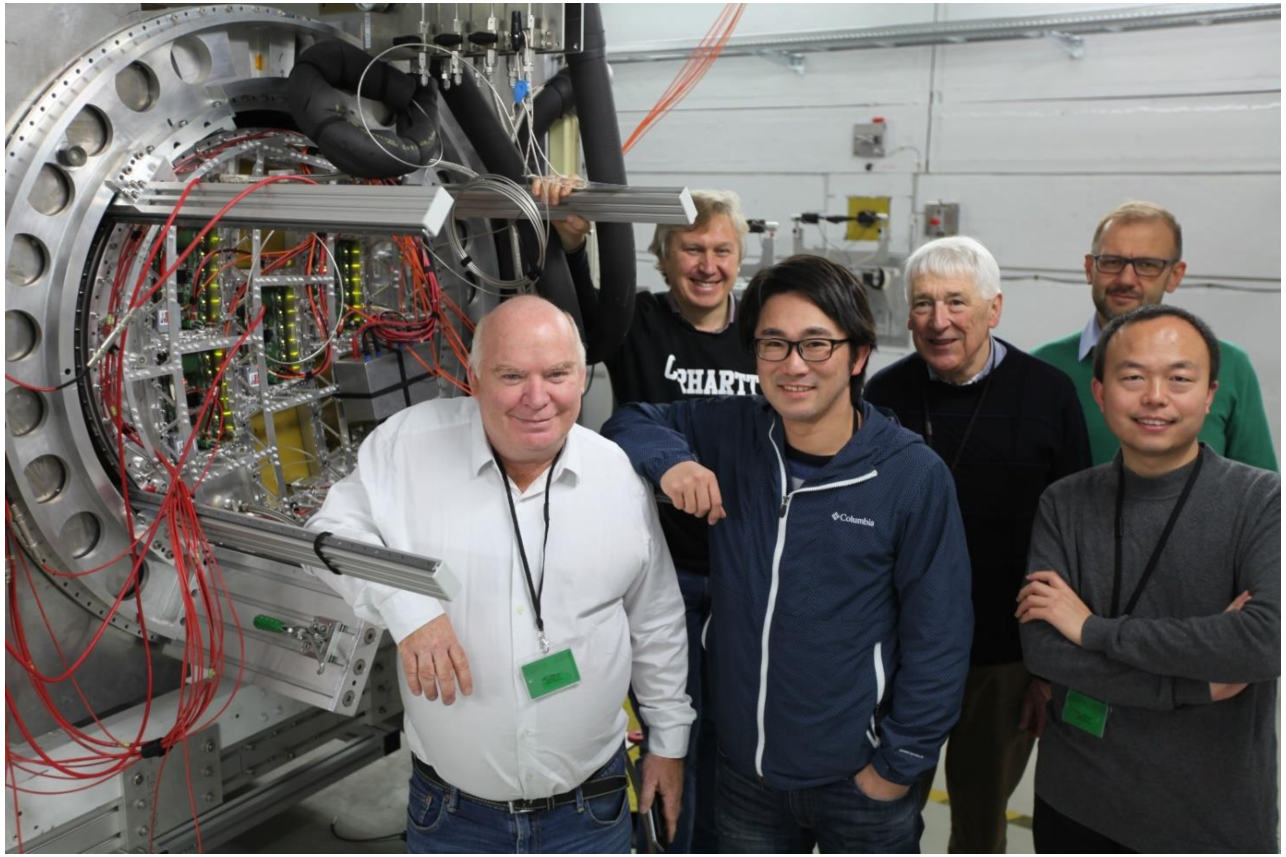
series of QUADs

39.6 x 28.38 mm

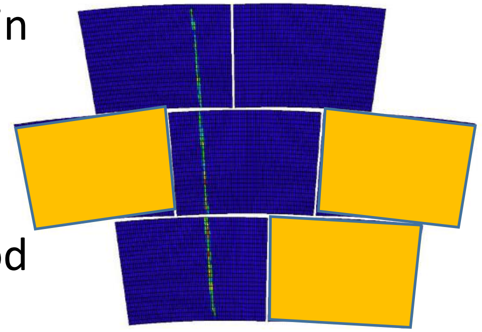


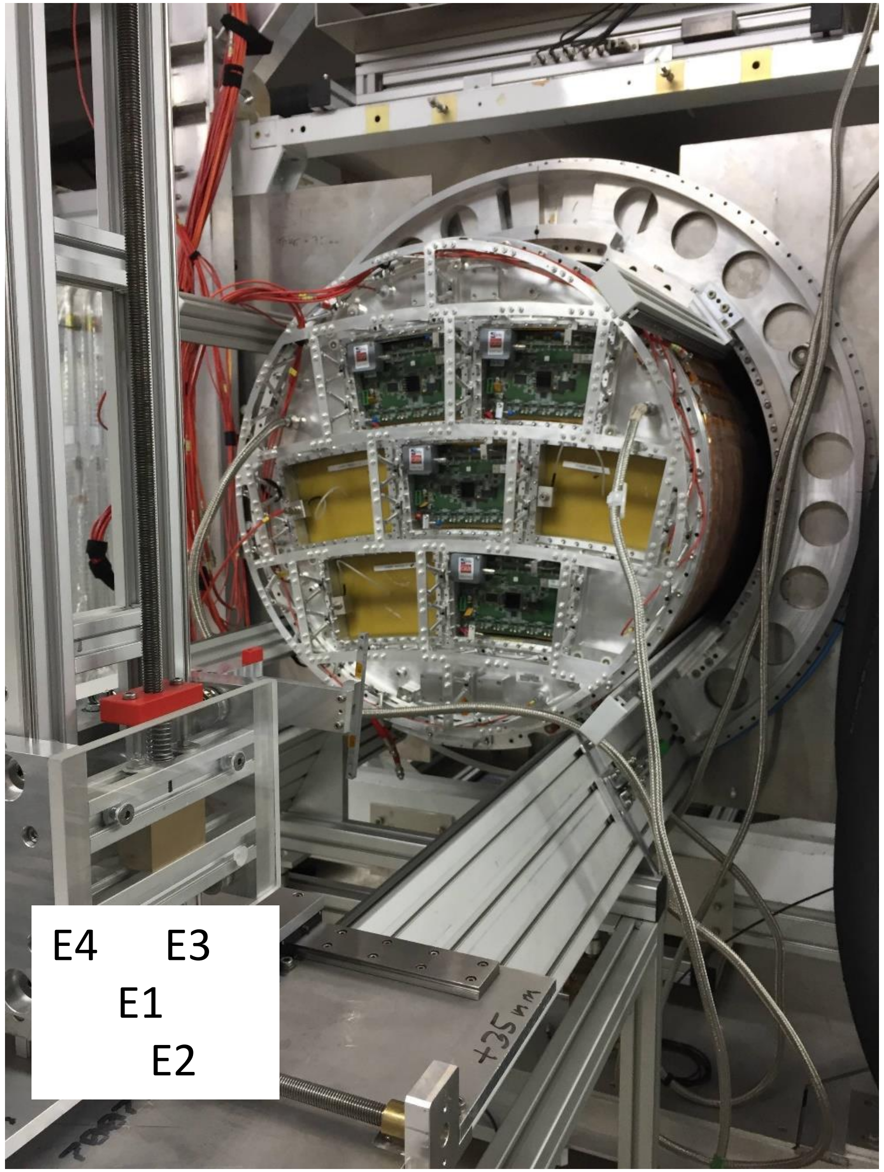




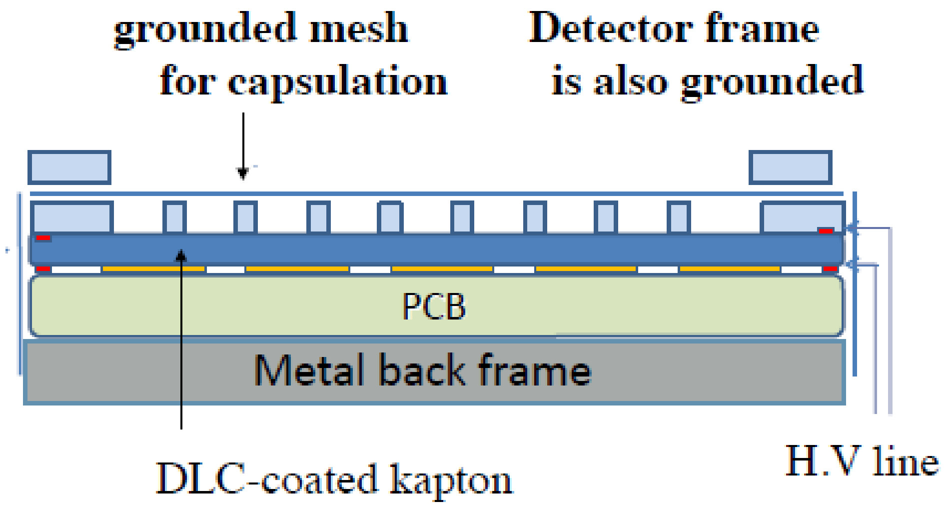


4 new Micromegas modules tested in November 2018 at DESY, with
- New ‘spaceframe’ endplate
- 1-loop 2-Phase CO_2 cooling
- Improved mechanics : 99.9% good connections
- New scheme : encapsulated resistive anode





Encapsulated Resistive Anode Micromegas



New scheme, to **reduce distortions** at the edges of the modules : mesh at ground (same potential as the frame), and resistive anode at the +ve HV.

Also encapsulation **reduces the EMI**.

Another advantage: the amplification field can be tuned independently of the drift field, providing **flexibility**.

The gains can be equalized while keeping the drift field very uniform.

Track distortions B= 1 T

No alignment done

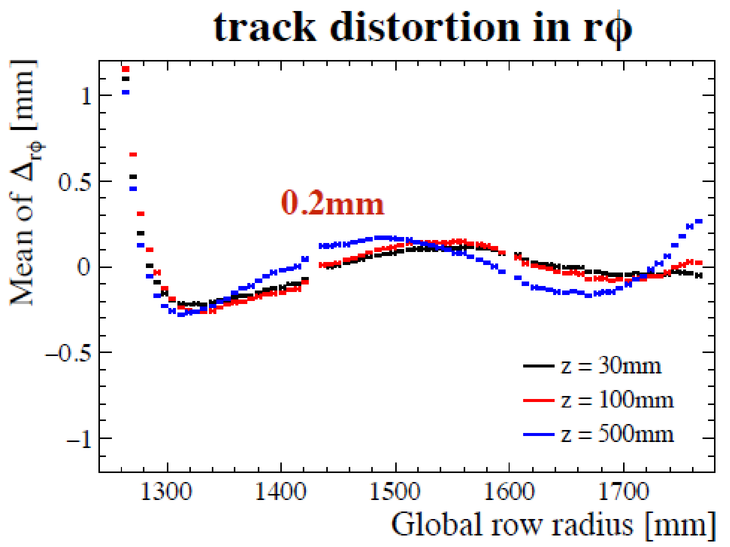
- **Including ExB**

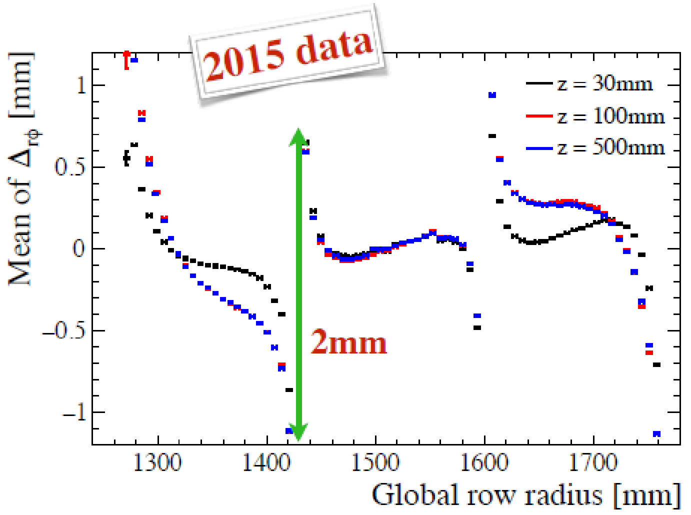
Ed= 230V/cm
Data selection :
#of tracks=1,
No saturated pulse

Δ = Hit - track

In 2015, z=100 mm has already big distortions.

Huge improvement (10 times) between the module boundary





ExB effect between modules is fully suppressed in the new scheme.

Other highlights of 2018

- Resumed analysis meetings : dE/dx studies in 4 technologies, z resolution and 2-track separation, distortion studies.
- Gas studies to optimize the gating: study ion mobilities (A. Cortez)
- Re-started work on TPC Mechanics : static deformations under weight and pressure, new solution for TPC fastening
- Continued ILD integration studies, scheme to assemble and test the detector in Kitakami. Revision of the costing.
- Evaluation of the resources necessary in Kitakami: space and power.

HOPE FOR A GREEN LIGHT VERY SOON!

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