Overview on Micromegas TPC R&D

Achievements and prospects

Collaboration Meeting

P. Colas

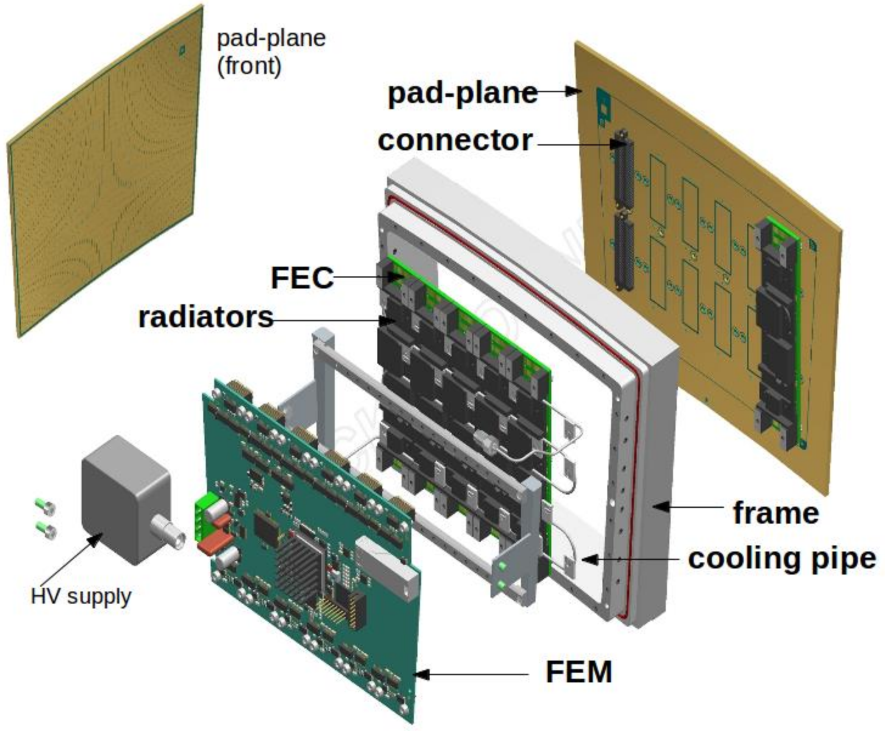
New scheme : encapsulated resistive anode

Tests at DESY in November 2018

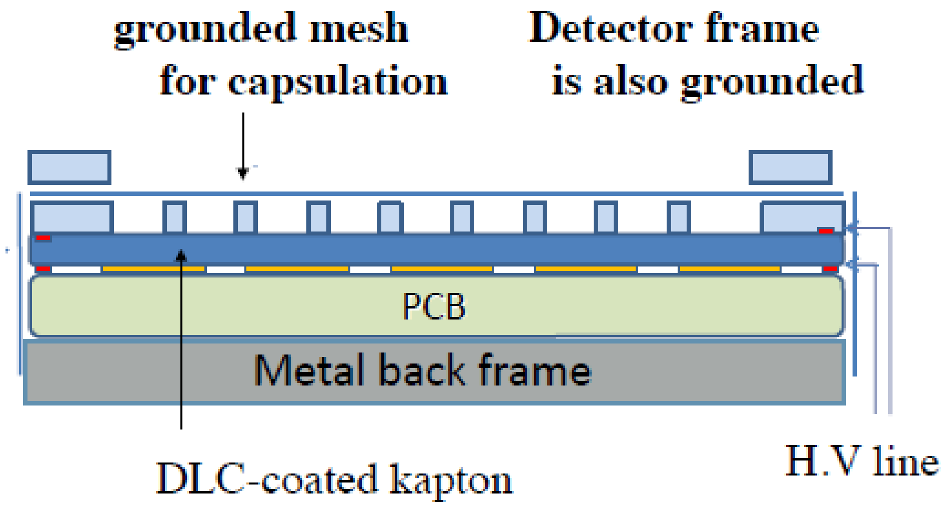
2PCO2 Cooling

Costing scheme (tomorrow)

Large common module, future electronics



Encapsulated Resistive Anode Micromegas



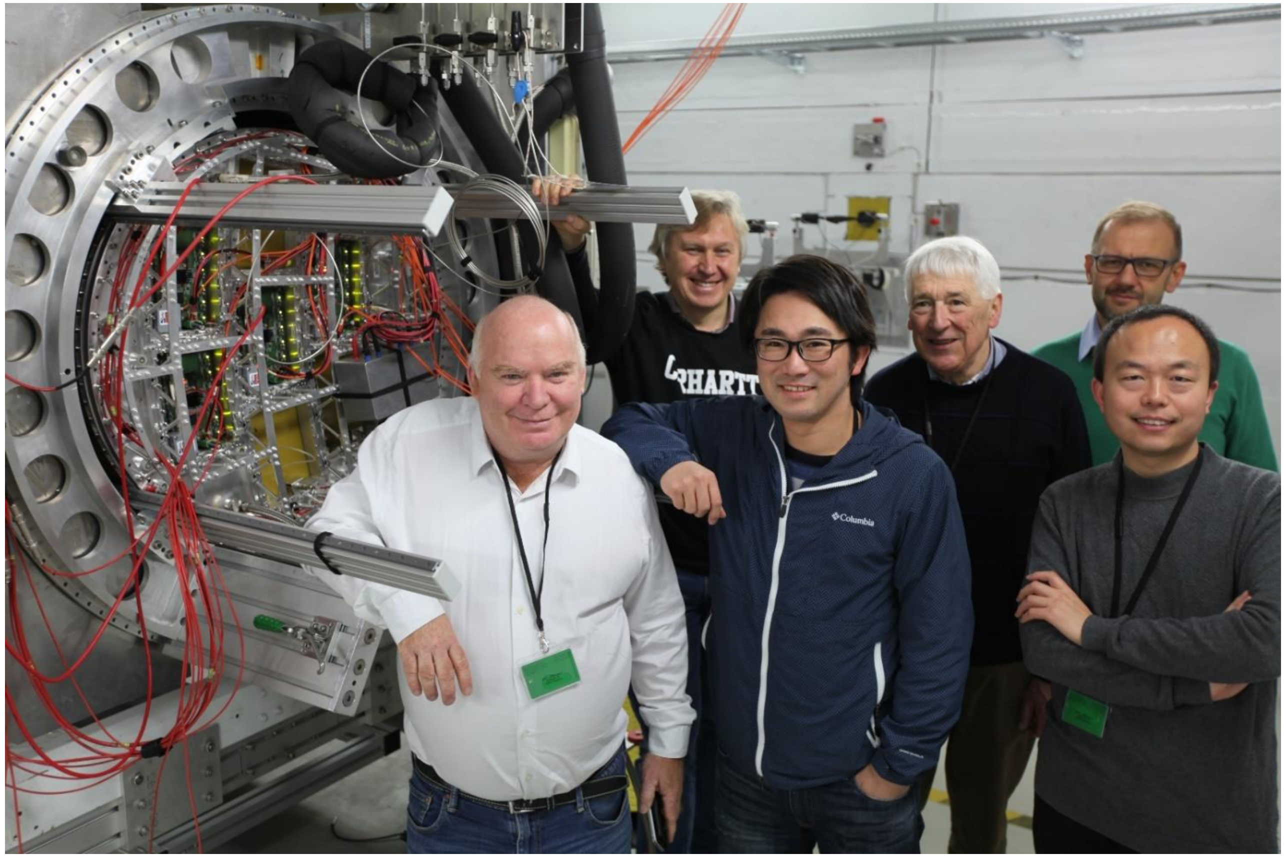
- New scheme, to **reduce distortions** at the edges of the modules : mesh at the same potential as the frame, and resistive anode at the +ve HV. Also encapsulation **reduces the EMI**. Another advantage: the amplification field can be tuned independently of the drift field, providing **flexibility**. The gains can be equalized while keeping the drift field very uniform.

Tests at DESY in November 2018

- Commissioning: D. Attié, P. Colas, S. Ganjour, T. Ogawa, M. Riallot
- Data taking: the same, plus: X. Coppolani, S. Emery, Huirong Qi, J. Timmermans, M. Titov
- Strong support from DESY: thanks to R. Diener, V. Prahl and O. Schäfer

Goals of the test :

- Use LP2 endplate
- Use 2PCO2, test 1-loop operation
- Test the new scheme (encapsulated resistive anode with grounded mesh). Proved to work already in a cosmic test at Saclay and in a T2K upgrade test at CERN.
- Use better mechanics for pad connection : 99.9% of good connections
- Make detailed studies to confirm the expected advantages of this scheme : less distortions (mesh at same voltage as frame), less noise, better flexibility. Analysis results will be shown by T. Ogawa tomorrow.



Arrival on November 13th evening

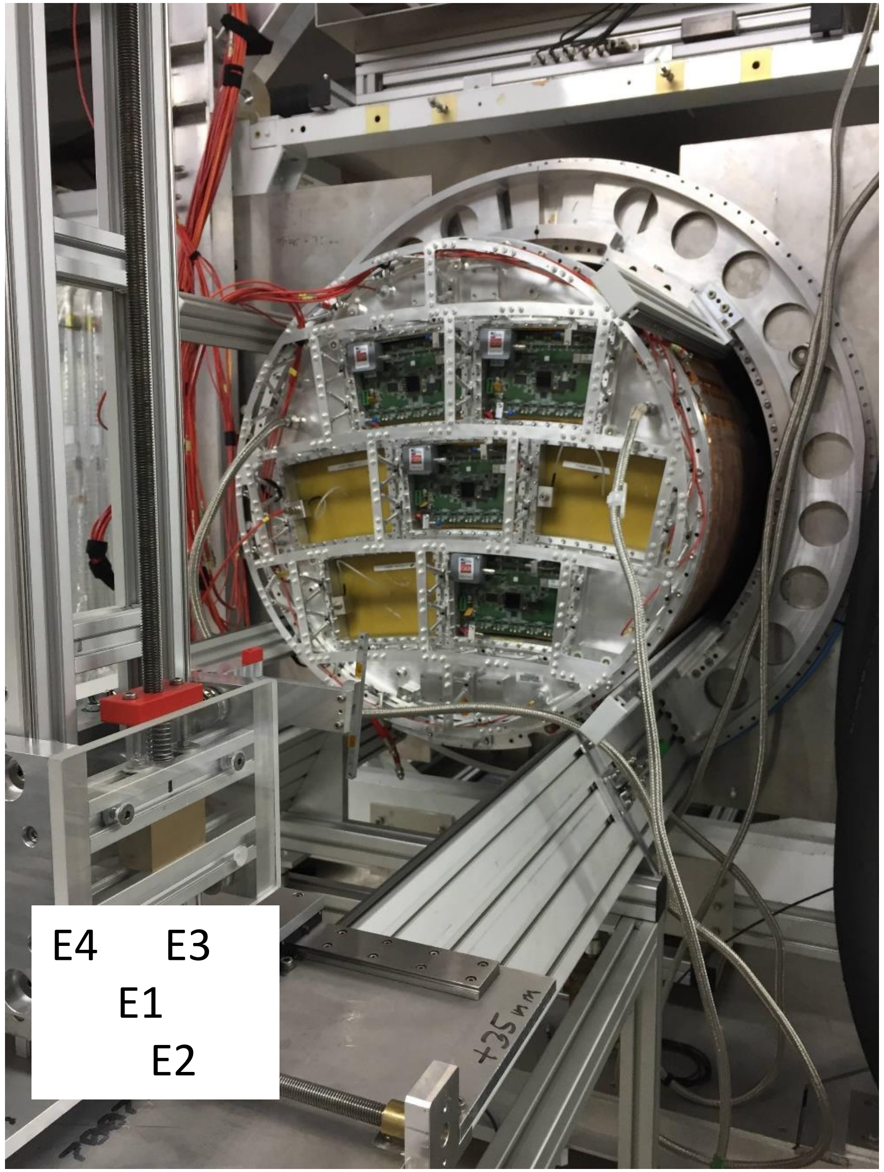
Re-test all modules on the table

Test Field cage HV on November 14

Mount 4 modules on November 14

Leak hunting on the new endplate

Install LV, fibers, etc…
Fill CO2 compressor for cooling
Took data until Nov. 28 morning : z scans, B=0 and 1T, x scan, phi scan, vary peaking time, vary central module HV



This test was the 11th of Micromegas modules at DESY in 10 years (it started in 2008)

Use of the Experiment Infrastructure

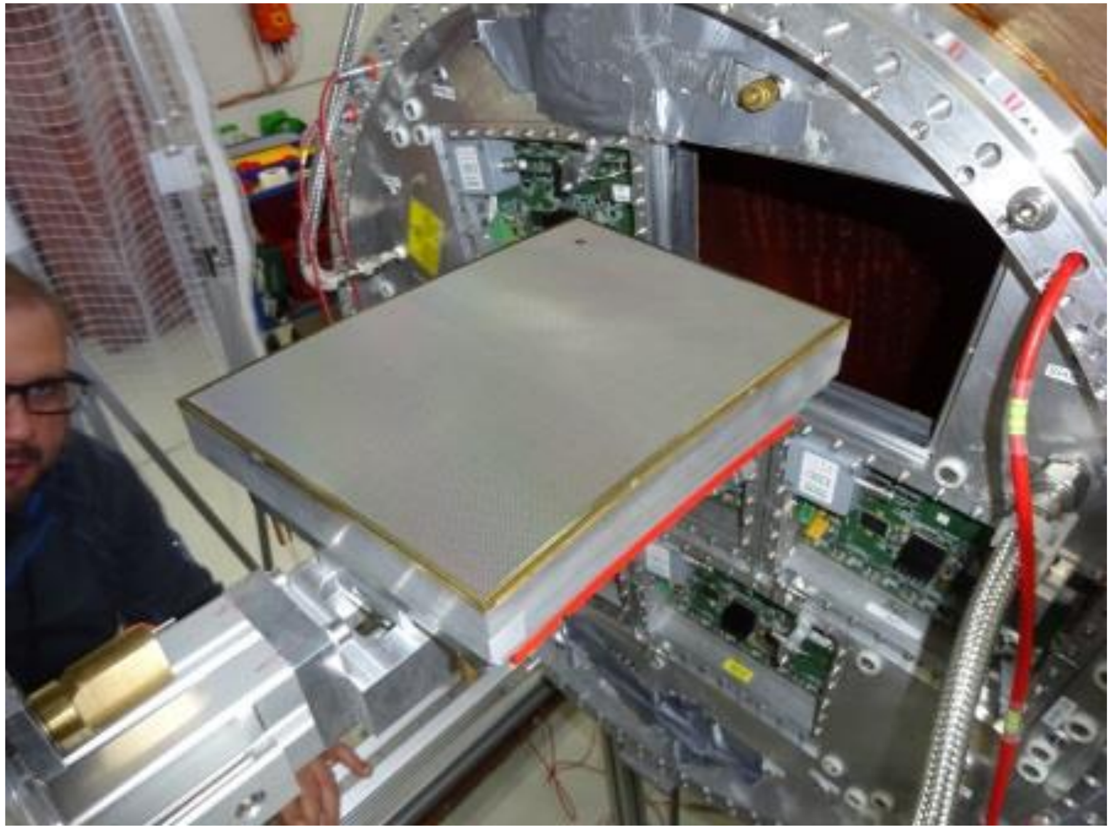
While in the first years the LCTPC collaboration was the main user of the setup, in the last years more and more groups from other experiments used the magnet and gas detector infrastructure.

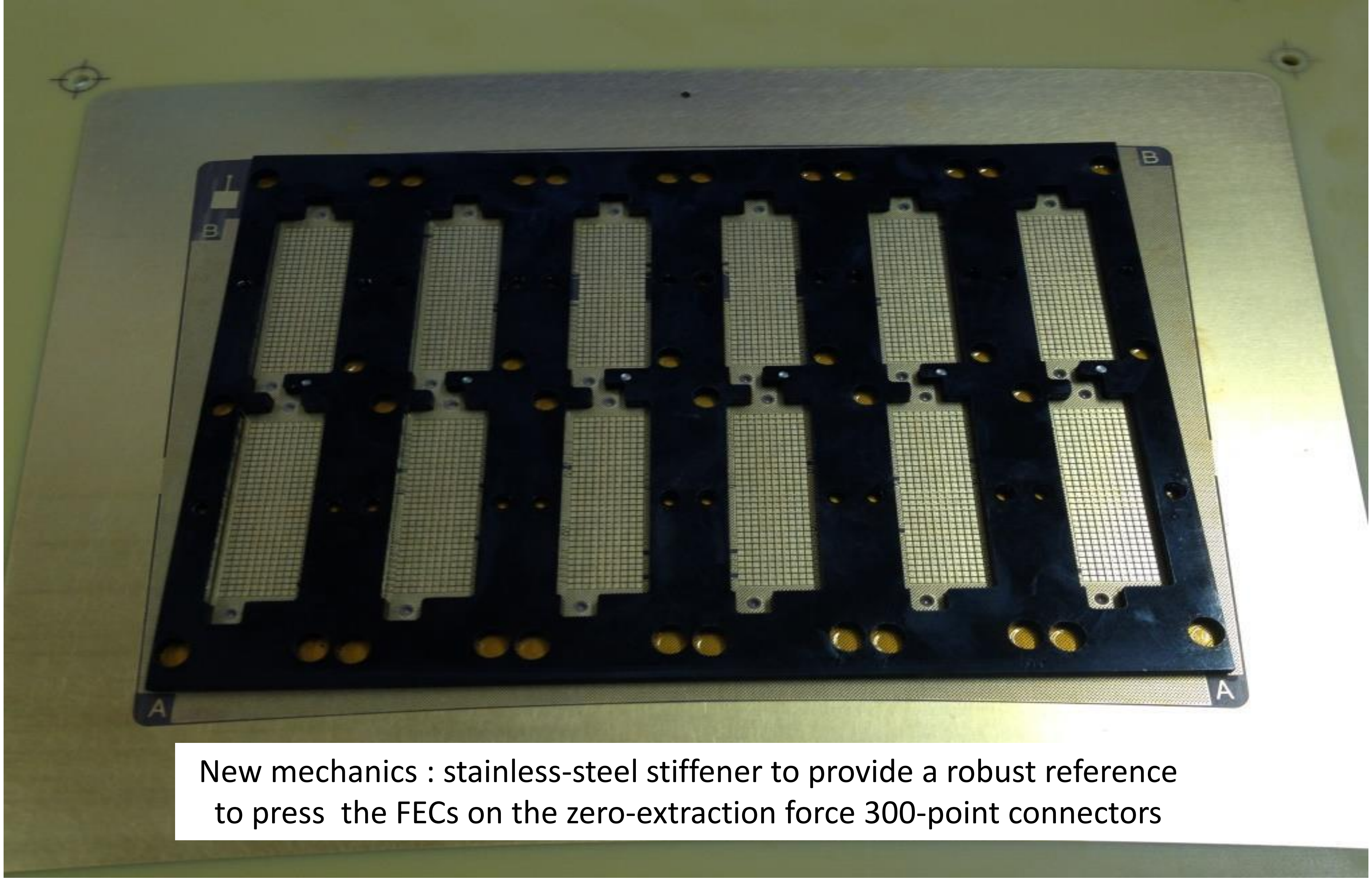
YEAR	MONTH	GROUP (main)	COLLABORATION EXPERIMENT	DESCRIPTION
2008	Nov-Dec	CEA Saclay	LCTPC	One Micromegas module with resistive anode
2009	Feb-Mar	KEK	LCTPC	3 Asian GEM modules, 3000 ALTRO channels
	Apr	U Rostock	LCTPC	TDC electronics with one Asian GEM module
	May-Jun	CEA Saclay	LCTPC	Micromegas modules with different resistive coatings; Laser photo-dot cathode calibratrion
	Jun	U Bonn	LCTPC	TimePix Octoboard with GEM amplification
	Jul	U Rostock	LCTPC	TDC and ALTRO electronics studies with one Asian GEM module
	Aug	Victoria U	LCTPC	Laser photo-dot cathode calibration using Micromegas module
	Sep	U Bonn	LCTPC	Small area GEM module, read out with ALTRO electronics
	Nov	CEA Saclay	LCTPC	Test of external Si-Tracker with Micromegas module
2010	Mar	CEA Saclay	LCTPC	Micromegas module using the movable stage of the PCMAG
	Mar	KEK	LCTPC	Three Asian GEM modules with ALTRO readout
	Sep	KEK	LCTPC	Three Asian GEM modules with ALTRO readout
	Dec	CEA Saclay / Ni	LCTPC	Ingrid Octopuce test
2011	Apr	DESY	LCTPC	First test of DESY GridGEM module (B=0T)
	May	CEA Saclay	LCTPC	Test of integrated electronics on a Micromegas module
	Jun-Jul	DESY	LCTPC	DESY GridGEM module
2012	Jul	CEA Saclay	LCTPC	Test with 6 Micromegas TPC modules with integrated electronics
	Sep	DESY	LCTPC	Test with 3 GridGEM TPC modules
	Nov-Dec	KEK, Saga U	LCTPC	Test of 3 SciEnergy GEM TPC modules
2013	Jan-Feb	CEA Saclay	LCTPC	Test with 7 Micromegas TPC modules with integrated electronics
	Feb	DESY	ATLAS	Measurement of Lorentz angle and charge collection efficiency of Si microstrip detectors
	Feb-Mar	DESY	LCTPC	Test with 3 GridGEM TPC modules
	Mar-Apr	U Bonn	LCTPC	Test with 2 TimePix TPC modules (GEM + Ingrid)
	Apr	DESY	ATLAS	Measurement of Lorentz angle and charge collection efficiency of Si microstrip detectors
	Apr	JLAB	SBS	GEM Tracker Chambers
	May	DESY	ATLAS	Measurement of Lorentz angle and charge collection efficiency of Si microstrip detectors
	Jun	Lund U	LCTPC	Micromegas TPC module with ALTRO readou electronics
	Jun	INFN	ATLAS	Micromegas chambers for ATLAS New Small Wheel (NSW)
	Aug	DESY	ATLAS	Measurement of Lorentz angle and charge collection efficiency of Si microstrip detectors
	Oct-Nov	DESY	ATLAS	Measurement of Lorentz angle and charge collection efficiency of Si microstrip detectors
	Nov	DESY	LCTPC	Laser calibration studies with GEM TPC modules
	Nov-Dec	DESY	BELLE II	Installation
2014	Jan	U Bonn	BELLE II	Pixel+strip sensor vertex detector integration test incl. DAQ, slow control and cooling
	Feb	DESY	ATLAS	Measurement of Lorentz angle and charge collection efficiency of Si microstrip detectors
	Feb	CEA Saclay	LCTPC	7 Micromegas modules with 2PCO2 cooling, laser calibration, run with 2 Ingrid modules
2015	Mar	CEA Saclay	LCTPC	7 Micromegas modules with 2PCO2 cooling
	Mar-Apr	U Bonn	LCTPC	3 Ingrid modules with 96 TimePix Chips
2016	Sep	DESY	LCTPC	3 Triple-GEM modules with guard ring field shaper
	Oct	KEK, Saga U	LCTPC	GEM module with highly transparent gating GEM
	Nov – Dec	DESY	LCTPC	3 Triple-GEM modules with guard ring field shaper
	Dec	U Bonn	BELLE II	Pixel+strip sensor vertex detector integration test incl. DAQ, slow control and cooling
2017	Jan	U Bonn	BELLE II	Pixel+strip sensor vertex detector integration test incl. DAQ, slow control and cooling

Table 1: List of test beam campaigns using the PCMAG solenoid in T24/1

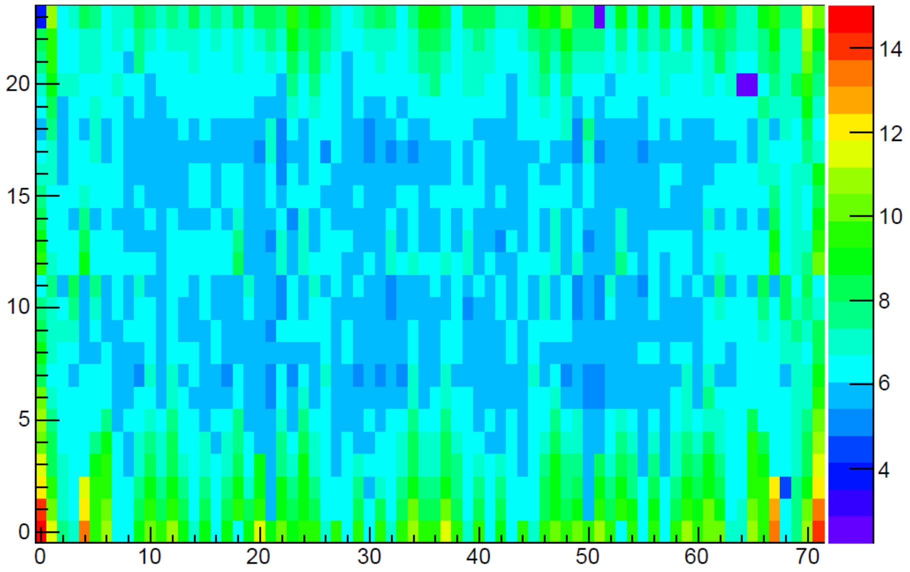
In 2018, with the LP2 space-frame endplate

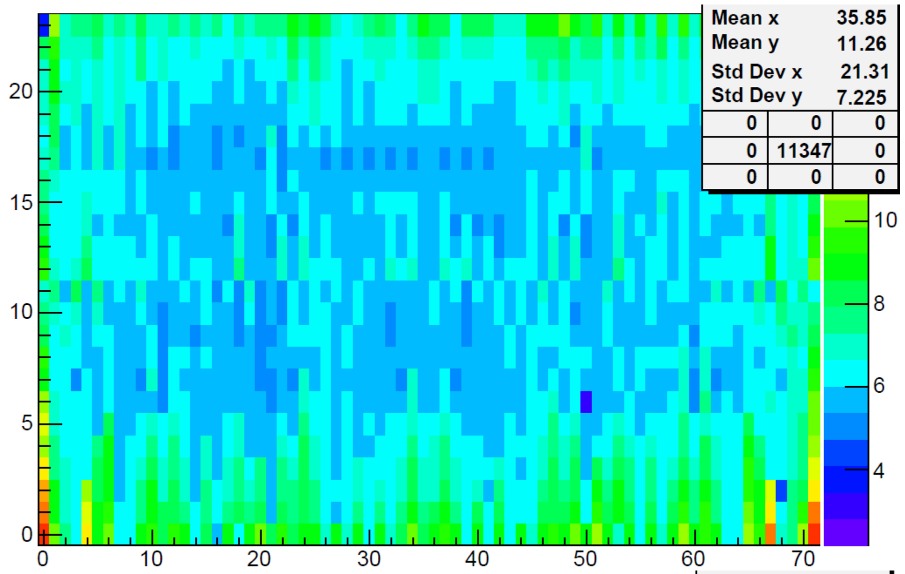
In 2015 with LP1 endplate

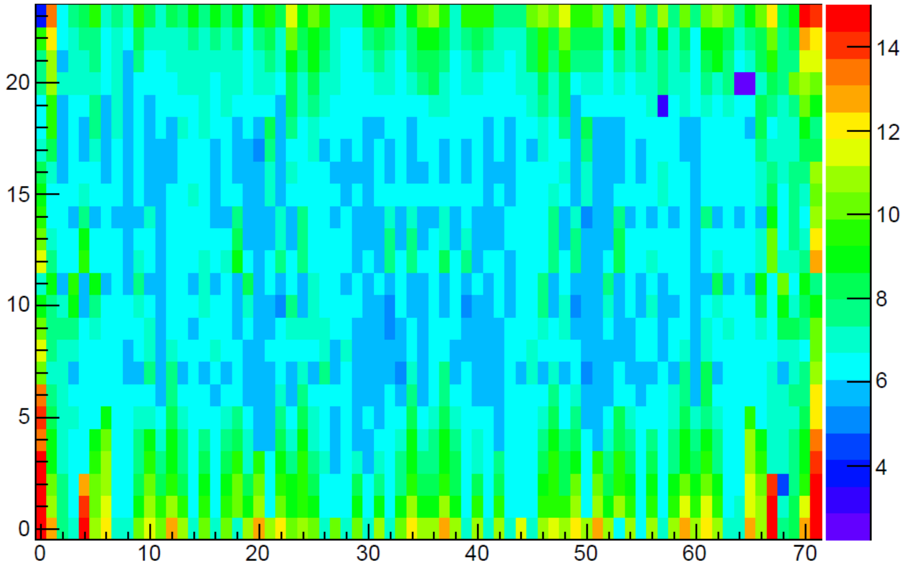


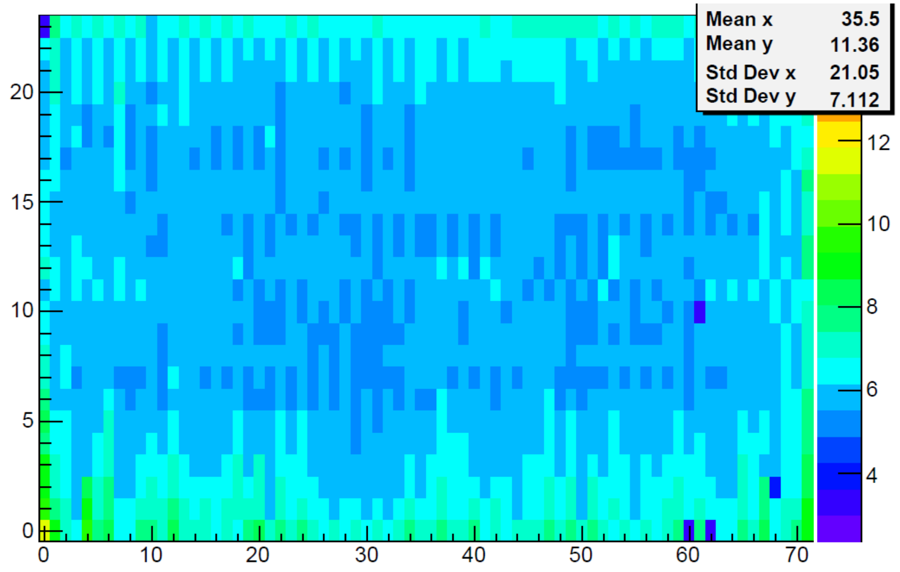


New mechanics : stainless-steel stiffener to provide a robust reference to press the FECs on the zero-extraction force 300-point connectors




Mean x 35.85
Mean y 11.26
Std Dev x 21.31
Std Dev y 7.225
0 0 0
0 11347 0
0 0 0




Mean x 35.5
Mean y 11.36
Std Dev x 21.05
Std Dev y 7.112

The DLC (2.5 Mohm/sq, same at T2K August 2018 test) was not perfect. Base material obtained by etching the copper from a GEM base material.

Modules numbered by decreasing quality order from E1 to E4

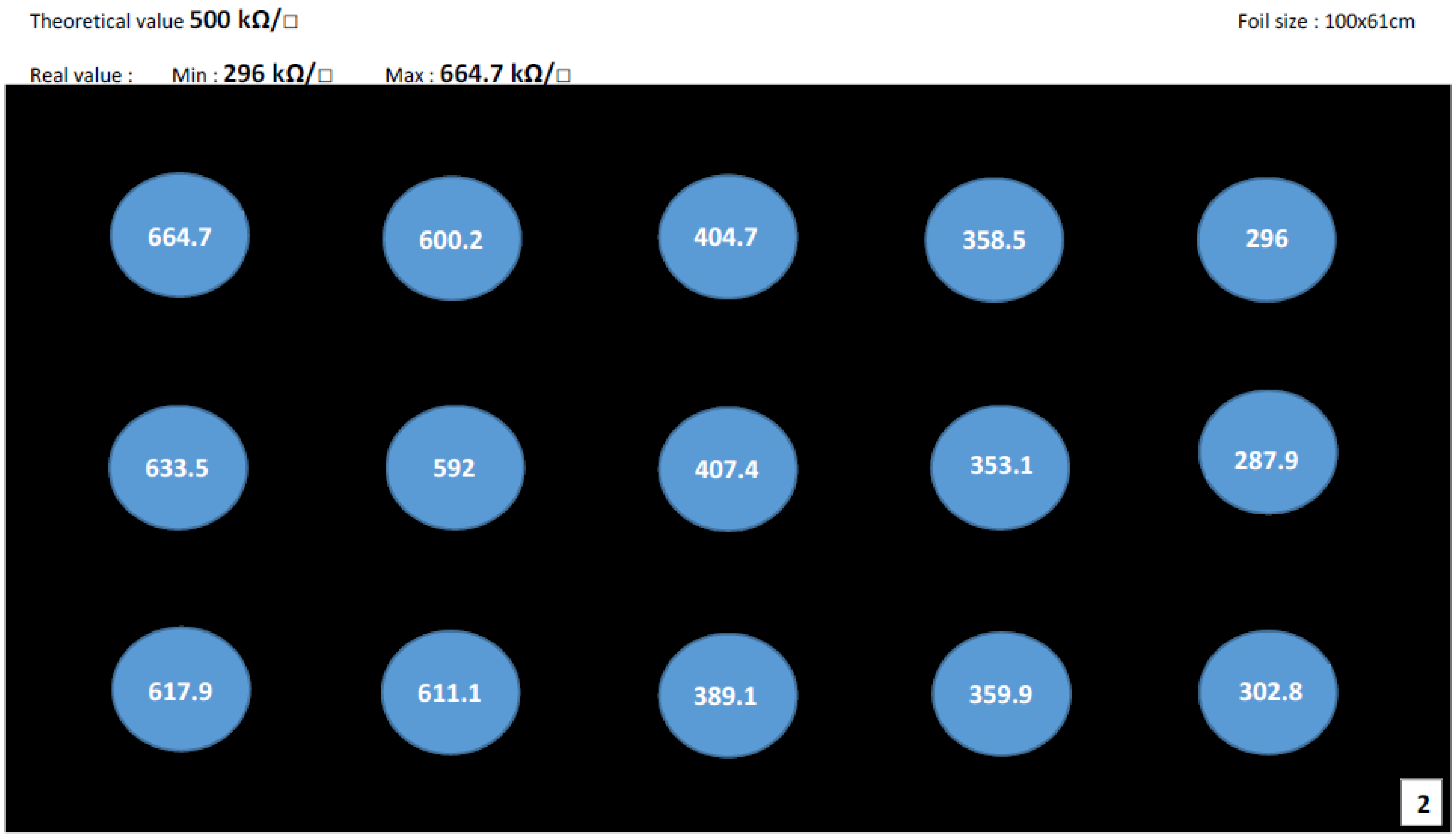
The Oxygen and Water contents were not optimal, but sufficiently low (60 ppm and 120 ppm)

A module in a 50 cm drift TPC is constantly monitored with cosmic rays in Saclay since more than 2 years. (B. Tuchming, R. Aleksan)

Since December, a new module is installed

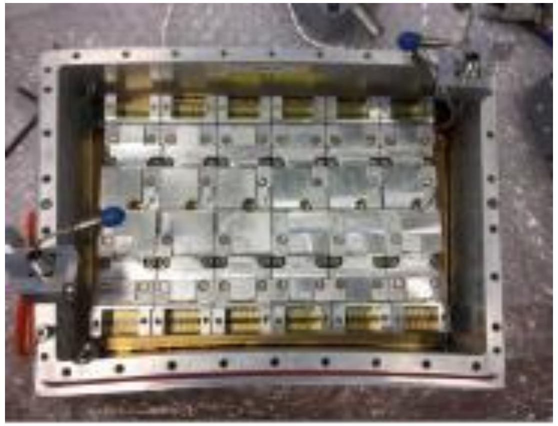
Diamond-Like Carbon coated resistive sheet for T2K.

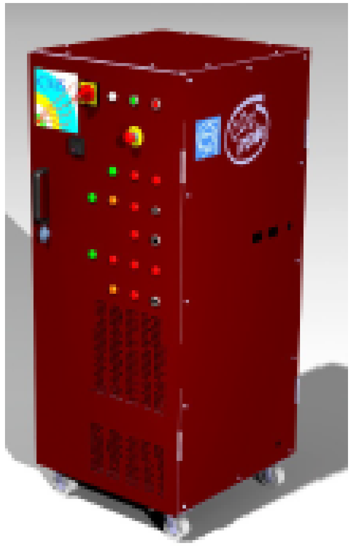
Resistivity measurement with a square probe



Homogeneity of the resistivity could be improved

2-phase CO_2 cooling





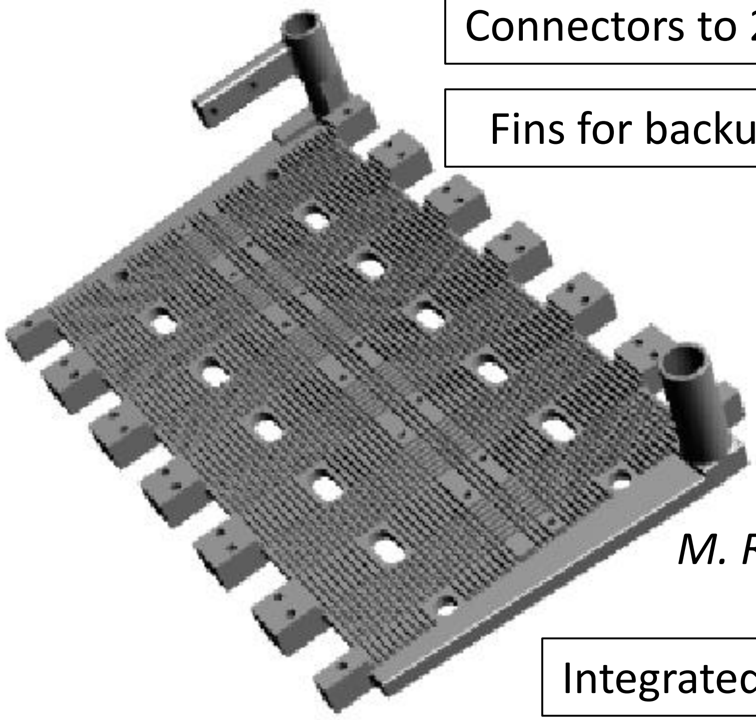
- Pioneered at Nikhef and CERN, studied at KEK.
- KEK bought a compressor (« TRACI ») for ILC and Belle II, installed at DESY Test Beam T24.
- Tested in 2014 and 2015 with 7 independent modules with a distribution by a manifold (« clarinette »). 0.8 mm inner diameter pipe
- This time (2018) tested with 4 modules in one loop. Very stable operation at 50 bar. 28-31°C on the FECS: continuous operation during 11 days without any incident.

Gating

- The displacement and evolution of the ion disk depends on the behaviour of the various species involved
- Ion mobility study by André Cortez et al. : they studied various mixtures of Ar with Isobutane and/or CF4, and measured the ion mobilities.
- This allows the gating gap to be dimensionned : large enough to contain the whole thickness of the disk, but as small as possible to ease mechanical construction. Prelim. result : 5 mm.
- Still caveats: there might be much slower ions (molecular clusters) moving very slowly, and the measurements were done at low pressure. More work in progress.

FUTURE

- Cooling plate in 3D printing



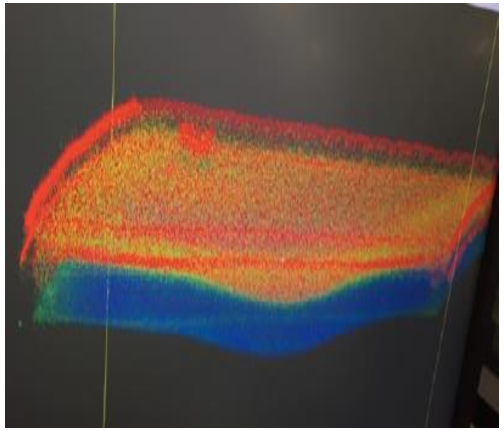
Connectors to 2P CO2 loop

Fins for backup air-cooling

Integrated serpentine

M. Riallot, Y. Jan

- Module planeity studies (in progress)



M. Mur

- Large module

~40x40 cm

6000-8000 pads

FUTURE

- Electronics for ILD TPC

Need development (probably in 65nm technology).

Broad outlines (still to be studied):

- 25-40 MHz sampling
- 9 bit low-consumption ADC
- ~200 ns peaking time shaper
- Power pulsing

Before this

Electronics for tests :

A new generation of the AFTER family: DREAM, AGET, ASTRE, etc…

Self-triggered time-stamped chip

Conclusion

- Saclay is actively involved in the TPC R&D, in collaboration with all other labs
- There is also a natural synergy with T2K, ALICE TPC and RD51 collaborations
- The new scheme of encapsulated resistive anode Micromegas gives very satisfactory results (stable operation, suppressed distortions)