AIDAinnova (7.2)
MRPCs for fast timing at high incident flux of charged particles
Muon tomography: Low power, minimal gas use, excellent time resolution

	Name of the legal entity	Type	Country	Main contact person
EUROPEAN MEMBERS	INFN, Bologna	Institute	Italy	Gilda Scioli
	Picotech SAS	Company	France	Crispin Williams
	LIP-Coimbra	Institute	Portugal	Alberto Blanco
	University of Clermont Ferrand	University	France	Cristina Carloganu
EXTERNAL MEMBERS	Tsinghua University	University	China	Yi Wang
	Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	Institute	China	Zheng Liu
	Seoul National University Bundang Hospital	Institute	South Korea	Do-Won Kim
	Gangneung-Wonju National University	University	South Korea	Yongwook Baek
	Benemérita Universidad Autónoma de Puebla	University	Mexico	Cecilia Uribe Estrada

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AIDAinnova

Advancement and Innovation for Detectors at Accelerators

Horizon 2020 Research Infrastructures project AIDAINNOVA

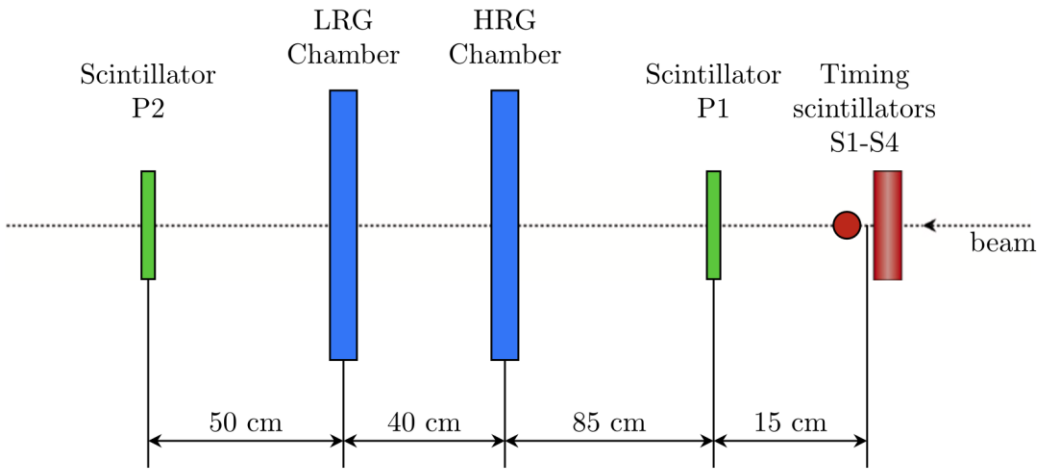
DELIVERABLE REPORT

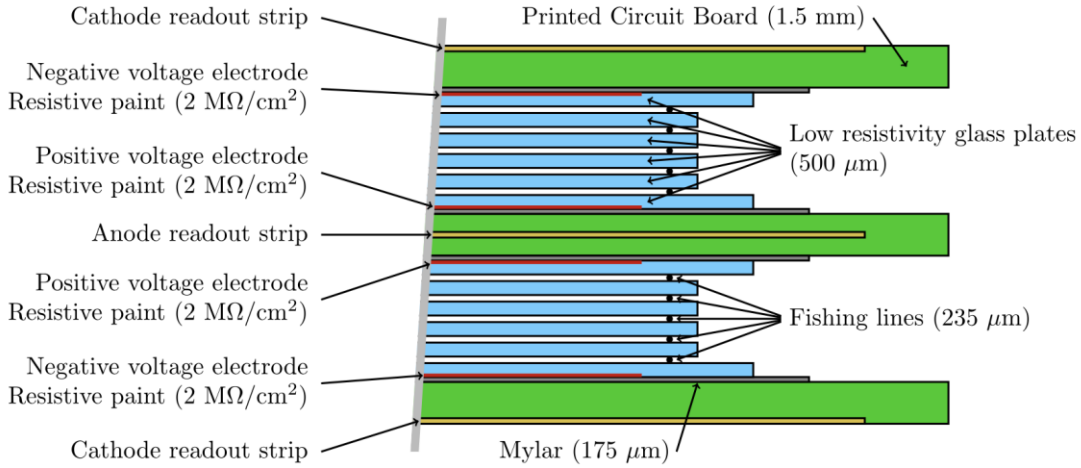
CHARACTERISATION OF SMALL SIZE MRPC PROTOTYPES FOR FAST TIMING AND HIGH RATES

DELIVERABLE: D7.2

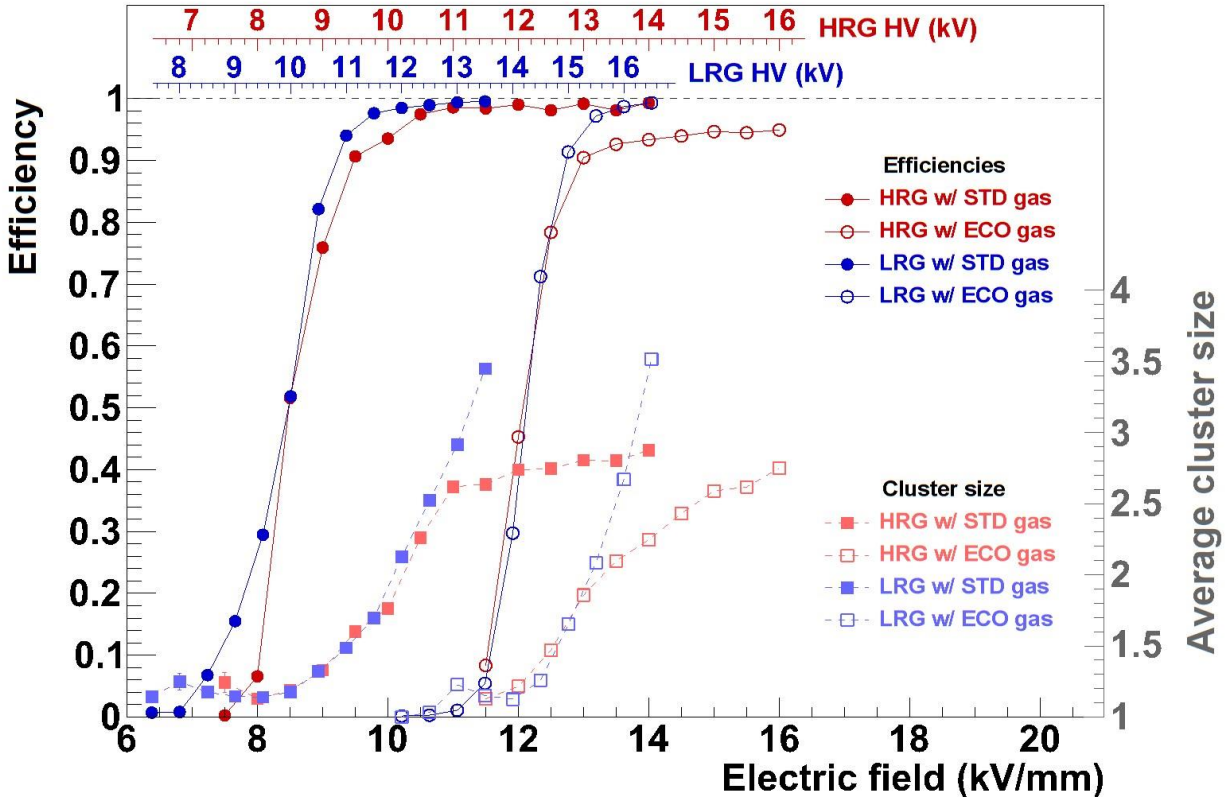
Many thanks to Yongwook Baek and Jinsook Kim for this report

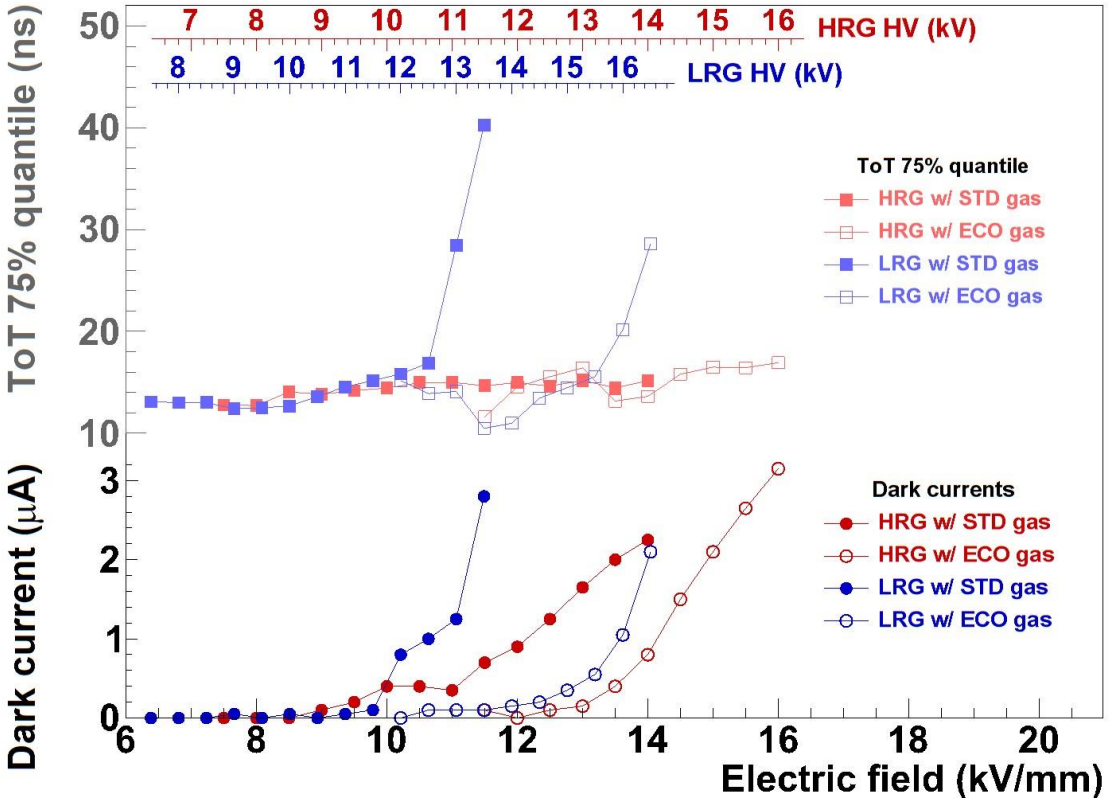
- Beam test :
  - T10 line at PS CERN
  - Two MRPC tested :
    - 8-gap (2 stacks of 4-gaps) chamber **(HRG)**
      - standard float glass, thickness 400µm
      - gap size 250 µm
      - nylon fishing lines as spacers
    - 10-gap (2 stacks of 5 gaps) chamber **(LRG)**
      - Low resistive glass (10^9 Ωcm), thickness 500µm
      - gap size 235 µm
      - ceramic coated fishing lines as spacers
  - Two mixtures of gas tested :
    - 98% $C_2F_4H_2$ and 2% SF_6
    - **100% HFO-1234ze**





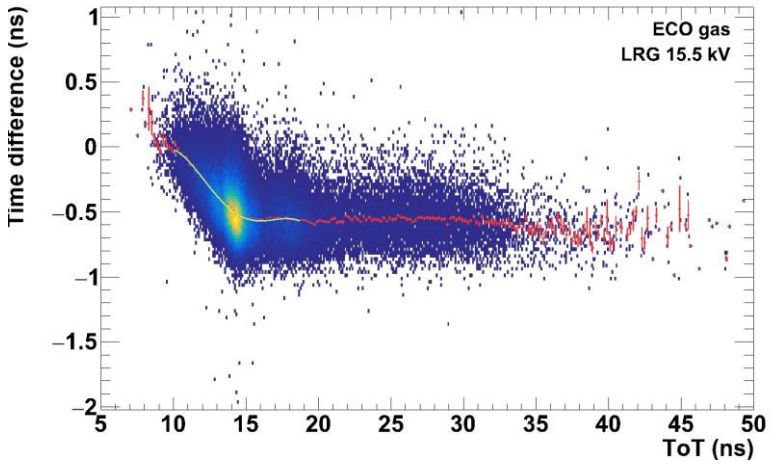
Efficiency/Multiplicity

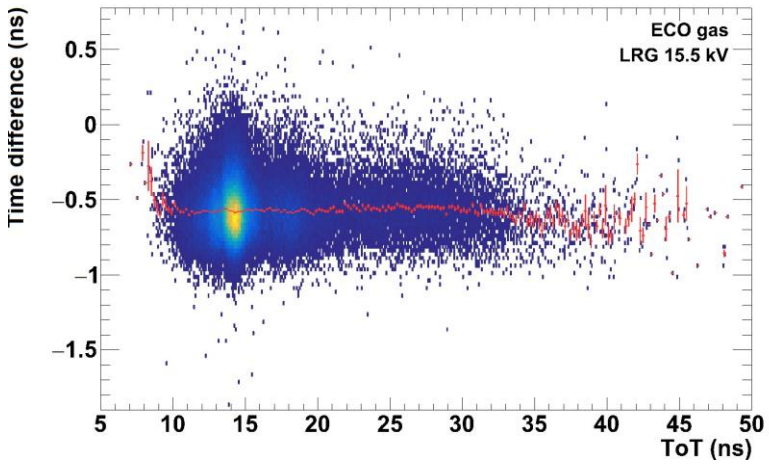




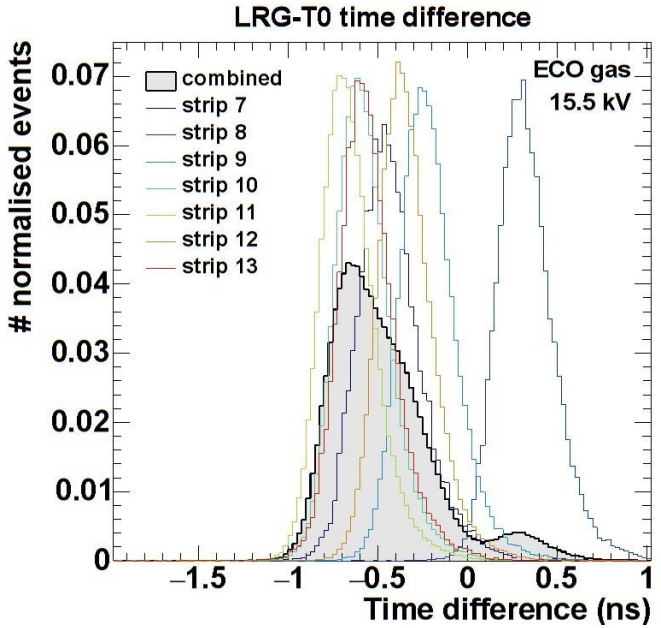
- In the case of ecological gas, the voltage needs to be increased by 4 kV to reach the efficiency plateau … also current starts to rise quicker when on efficiency plateau

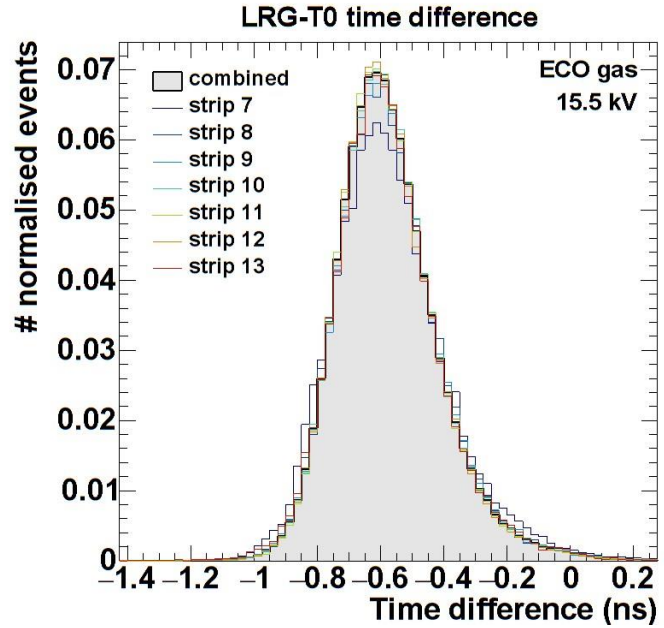
Calibration for channels





Time-slewing correction



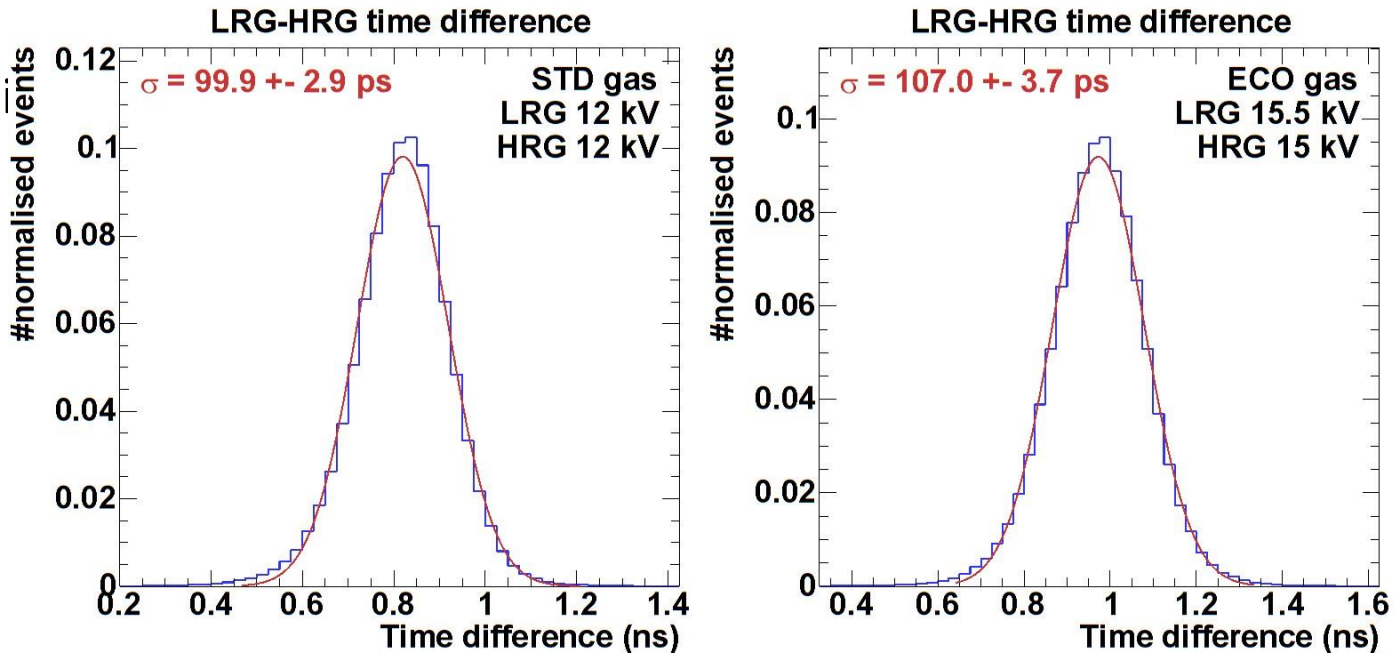


Time-off set correction

Timing

- Use the difference between the two chambers to estimate their timing resoluti (CFD was not operating properly)

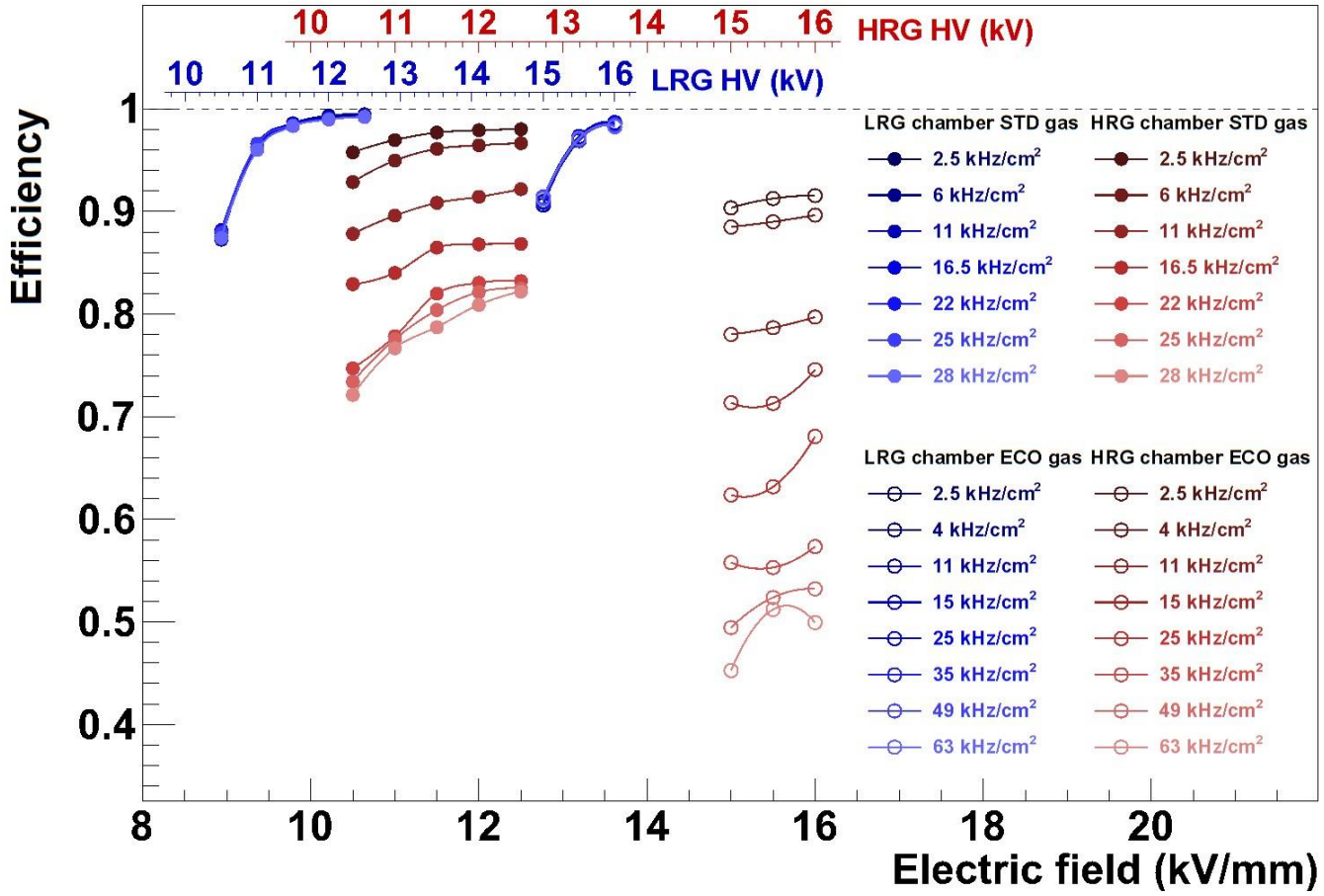
- Standard gas :
  - σ = 100 ps
    => 70 ps per chamber
- Eco gas :
  - σ = 107 ps
    => 76 ps per chamber



Efficiency vs. Rate

- Beam: 7 GeV pions
- Beam profile : 1.3 cm FWHM

- Rates :
  - up to 28 kHz/cm2 for standard gas
  - up to 63 kHz/cm2 for eco gas

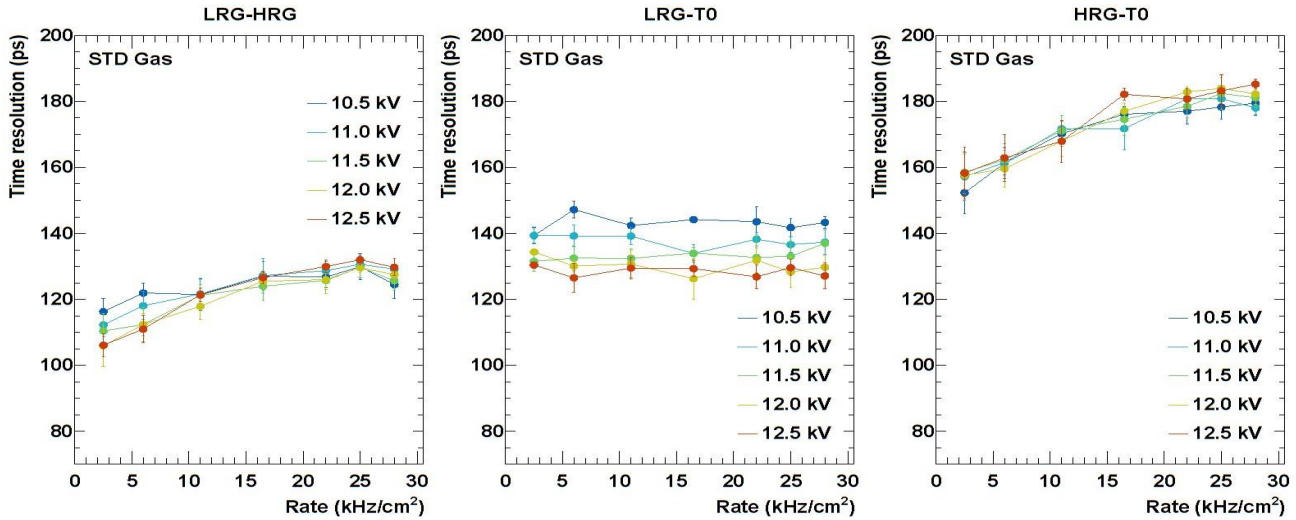


Rate has no effect on LRG chamber (as expected)

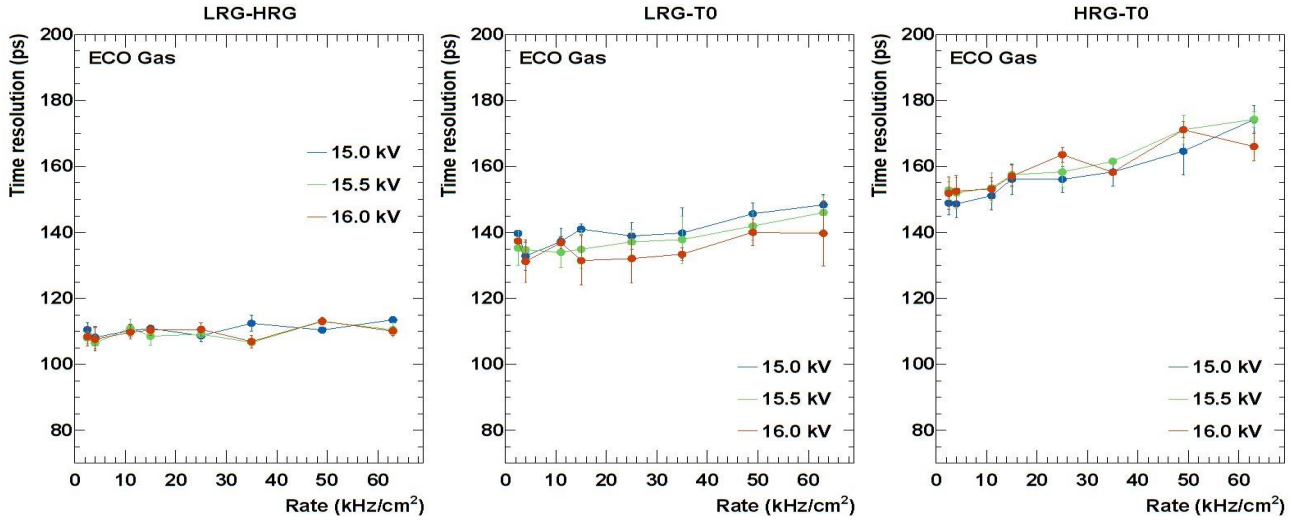
Time resolution vs. Rate

- Overall, similar results were obtained for both gases

STD gas



ECO gas



Conclusion

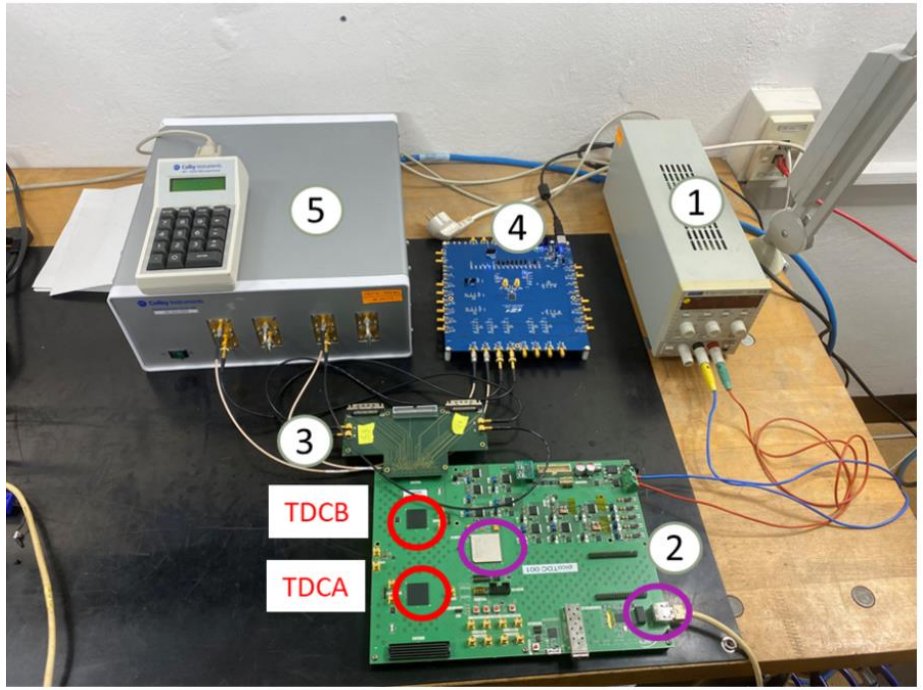
- HRG vs. LRG
  - A distinct difference in the rate capability at high rate flux
- Ecological gas vs. Standard gas
  - No conspicuous difference in efficiency and timing performance

- A realistic test on the rate capability needs to be carried out in the further test by irradiating the larger detector area instead of a focused beam on a small spot.

Some words on the picoTDC development

- INFN Bologna

Update on picoTDC card (128 channels)

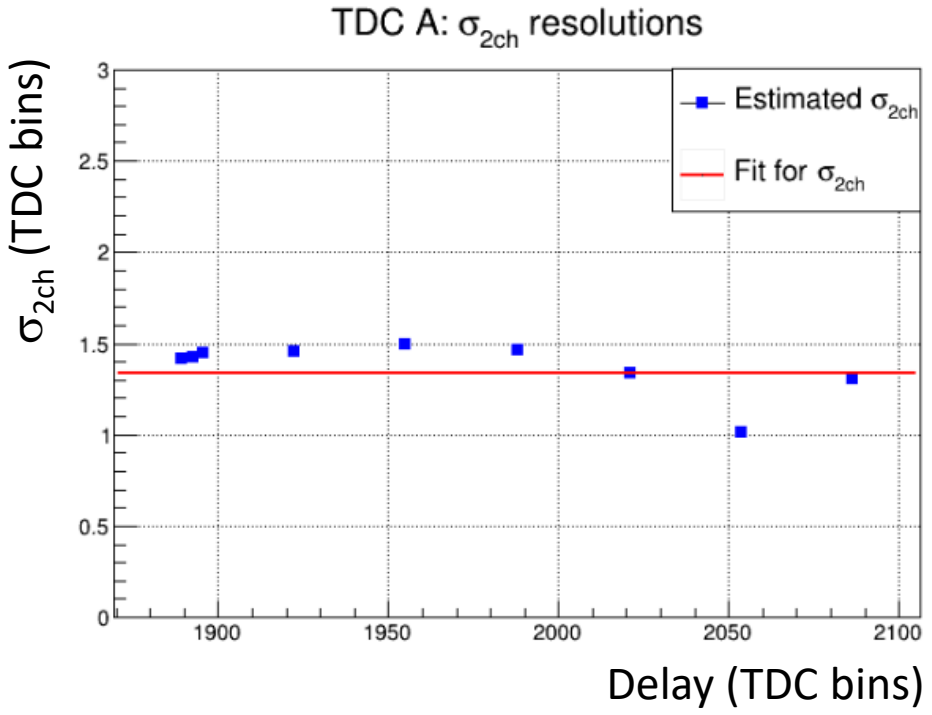


1. power supply (12 V)
2. picoTDC board with 2 picoTDC
3. FMC adapter card (includes VHDCI connectors getting inputs from ALICE TOF FEA cards)
4. SiLab low-jitter clock (used to pulse at 30 KHz)
5. Electromagnetic trombone (Colby XT-200)

- Firmware suite fully developed for PolarFire FPGA
- I2C programming of picoTDC
- Data acquisition via Ethernet (IPBUS)

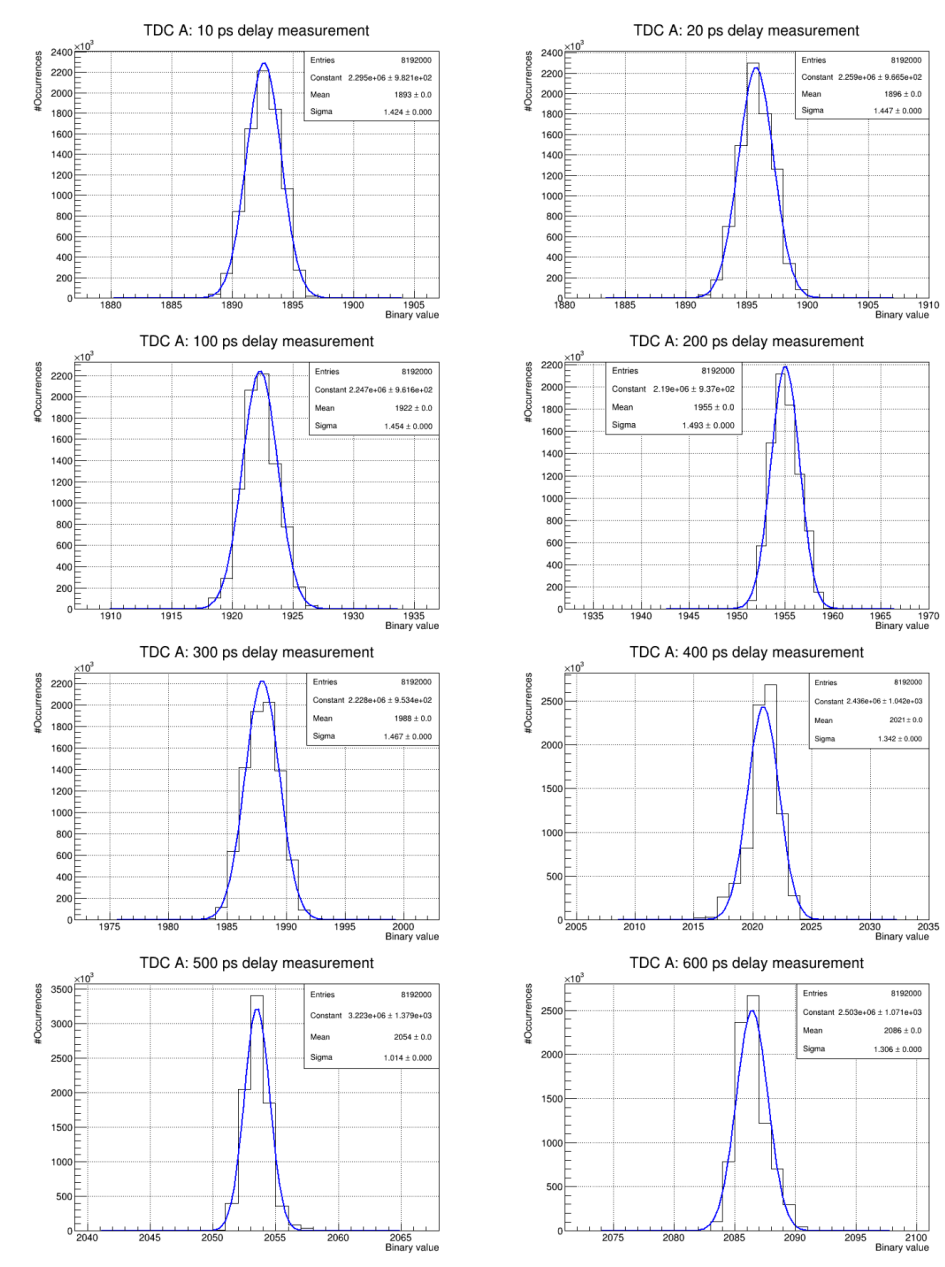
Resolution tests using calibrated delayed line (EM) (0 – 600 ps)

$\sigma_{2ch} \cong 1.34$ LSB → $\sigma_{1ch} \cong 0.95$ LSB

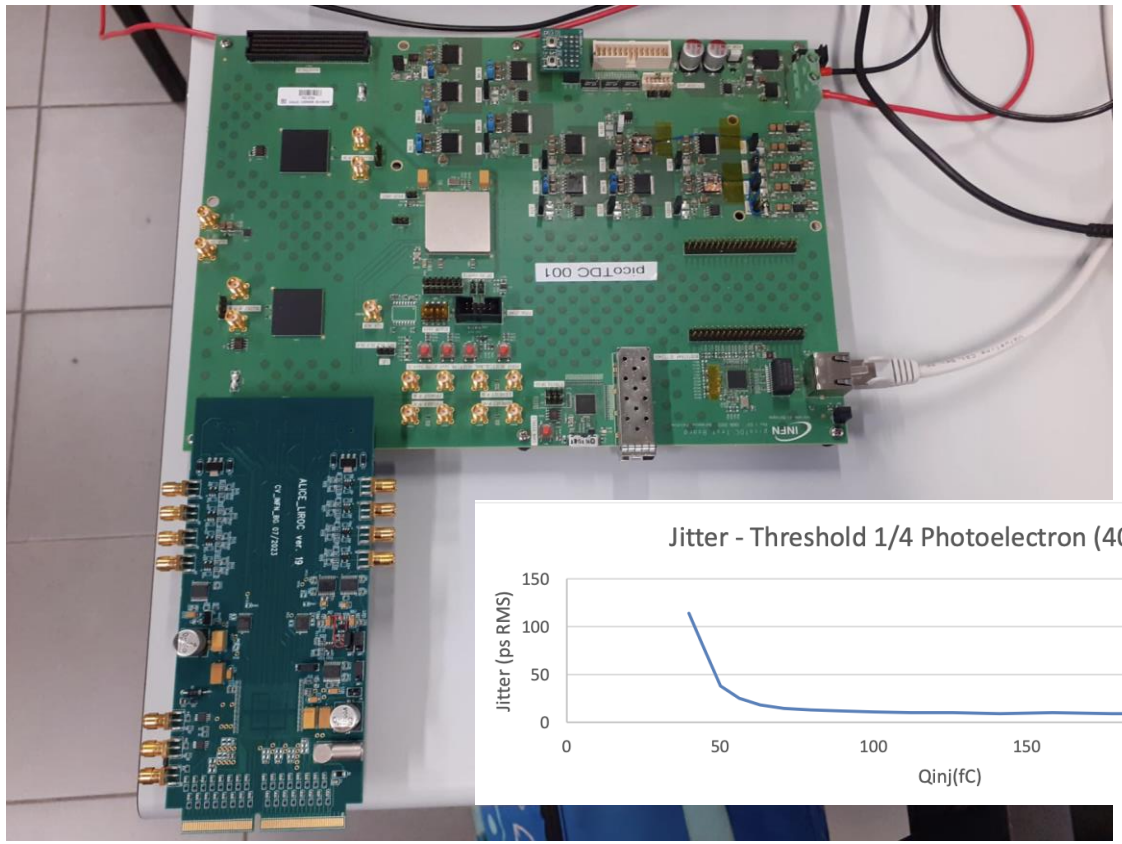


Note :
LSB is 3 ps

Delay line measurements with picoTDC Board



Additional custom card: FMC adapter for Weeroc LIROC



- LIROC is an ASIC (preamp+disc) optimized for SiPM
- 64 channels naturally “coupled” with picoTDC
- 8 discriminated output available on ext. connectors
- I2C programming of LIROC via picoTDC Board

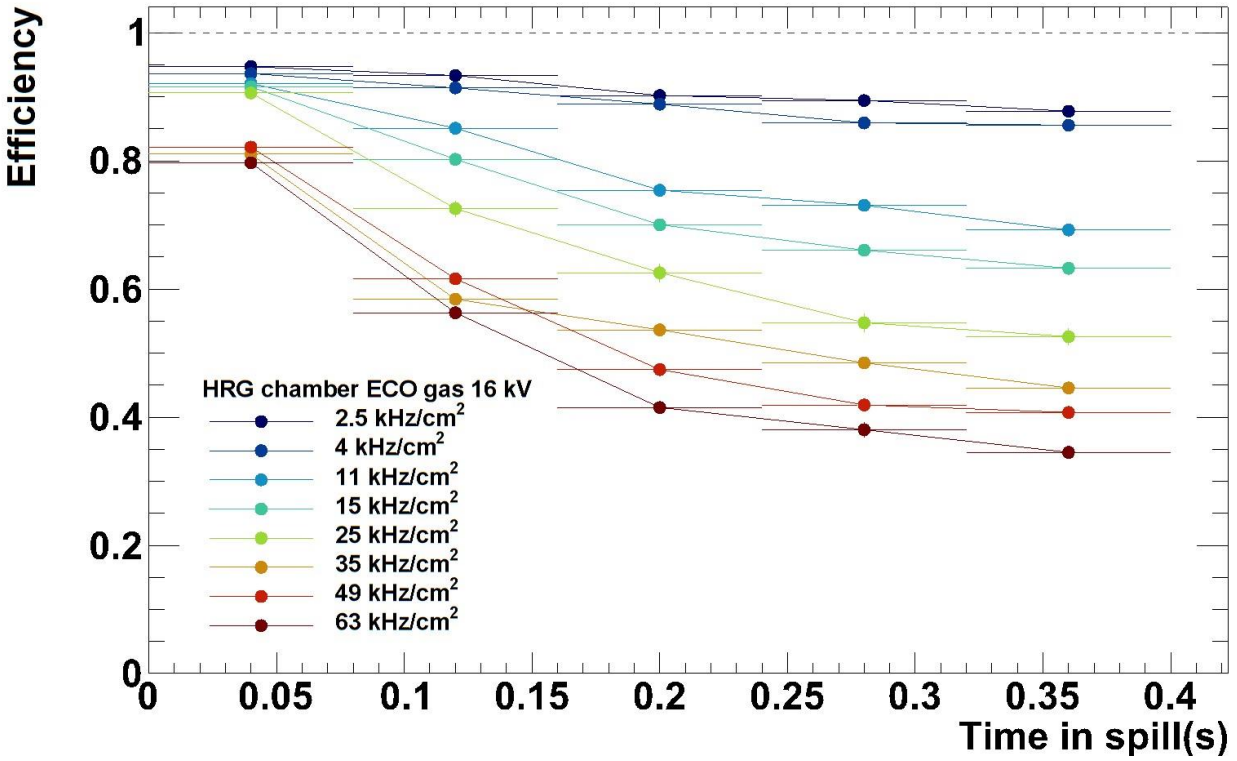
The cards will be used for test beams at CERN both on MRPC (from NINO FEA) and SiPM (from LIROC)

Thank you for your attention

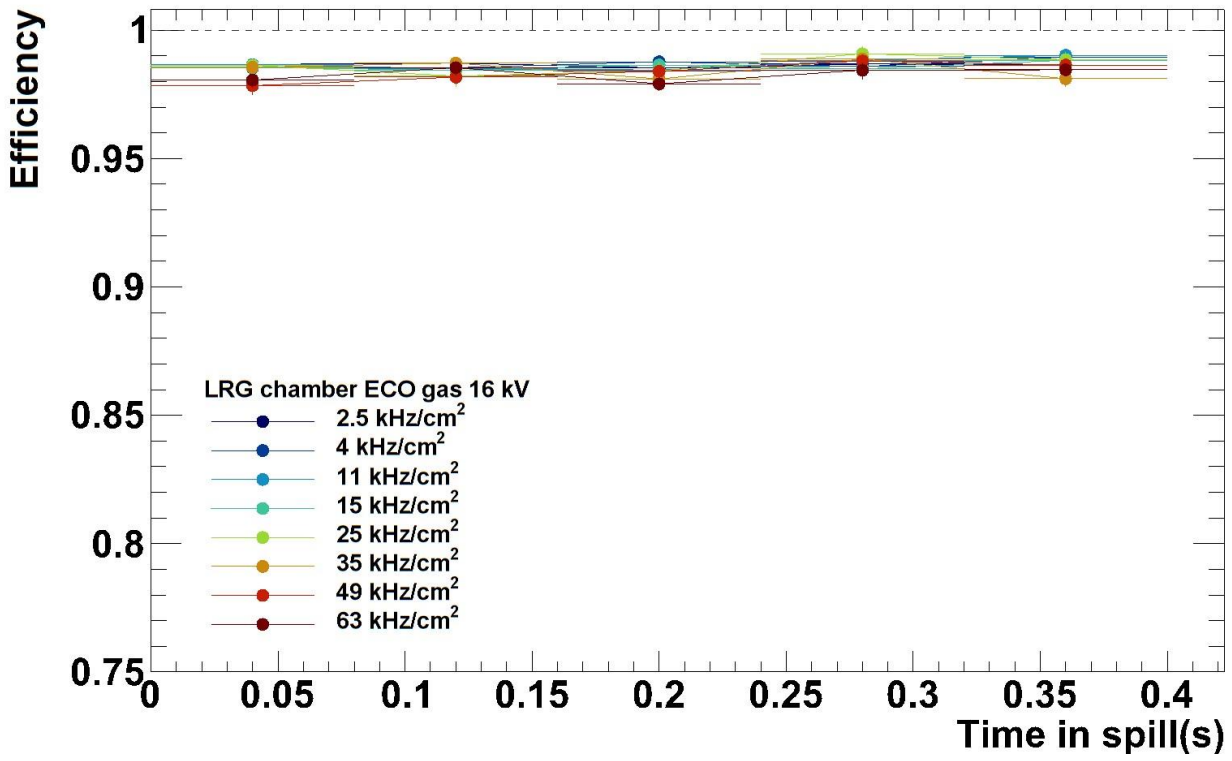
Backup

Efficiency in a beam spill

HRG



LRG



ToT distribution