

# MRPC with ecological gas

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- Motivation :
  - RPCs / MRPCs are usually operated using a mixture of  $C_2F_4H_2$  and  $SF_6$
  - Those gases have a very high Global Warming Potential (1430 for  $C_2F_4H_2$  and 23900 for  $SF_6$ )
    - will certainly be banned in the near future
  - Investigations to find an ecological alternative are ongoing :
    - The HFO-1234ze ( $C_3F_4H_2$ ) is found to be promising
    - It has a low GWP of 7

- Beam test :

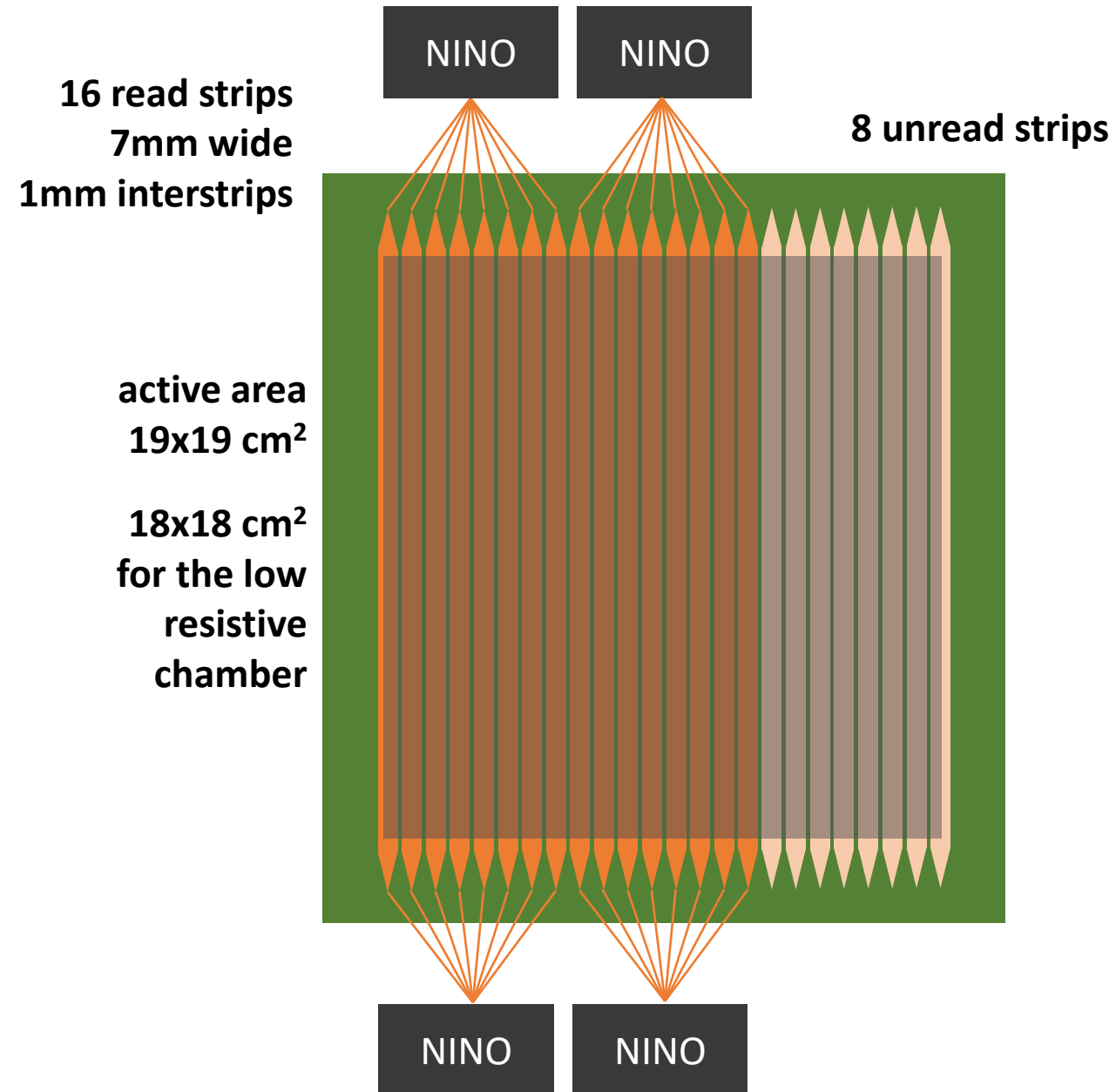
- T10 line at PS CERN
- April 2023

- Two MRPC tested :

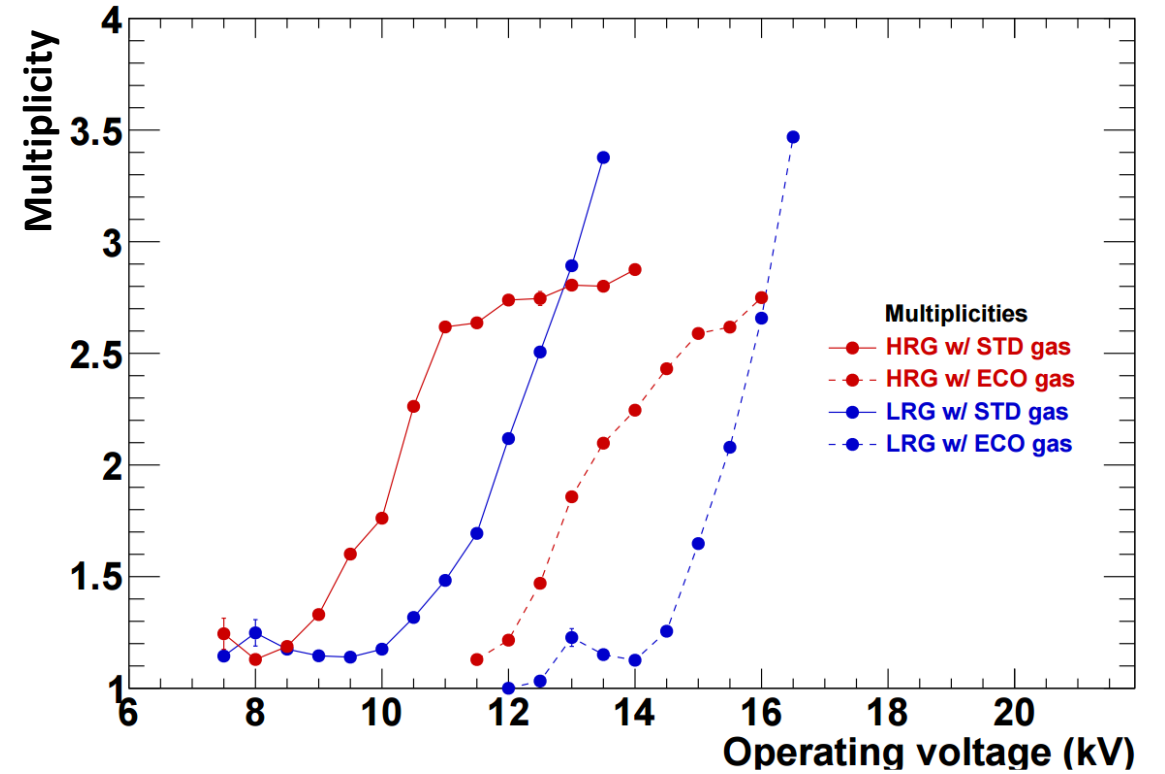
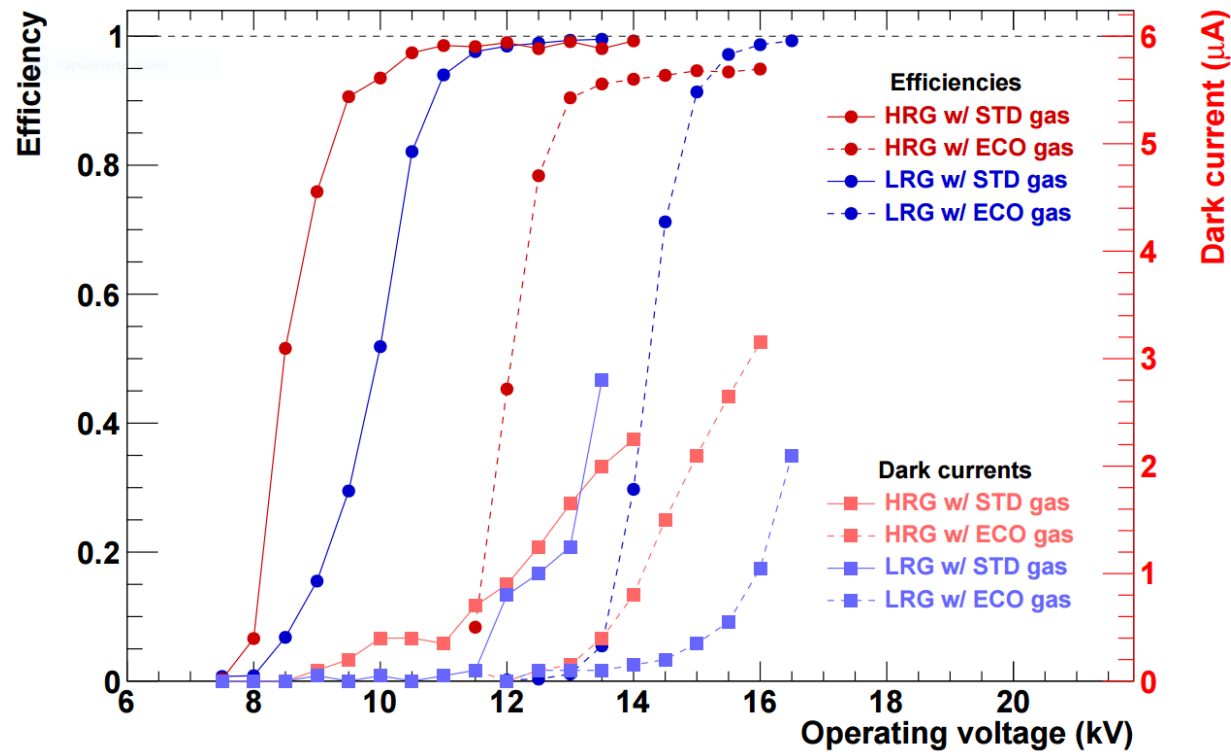
- 8-gap chamber **(HRG)**
  - standard float glass, thickness 400 $\mu$ m
  - gap size 250  $\mu$ m
  - nylon fishing lines as spacers
- 10-gap chamber **(LRG)**
  - Low resistive glass (10<sup>9</sup>  $\Omega$ cm), thickness 500 $\mu$ m
  - gap size 235  $\mu$ m
  - ceramic coated fishing lines as spacers

- Two mixtures of gas tested :

- 98% C<sub>2</sub>F<sub>4</sub>H<sub>2</sub> and 2% SF<sub>6</sub>
- **100% HFO-1234ze**



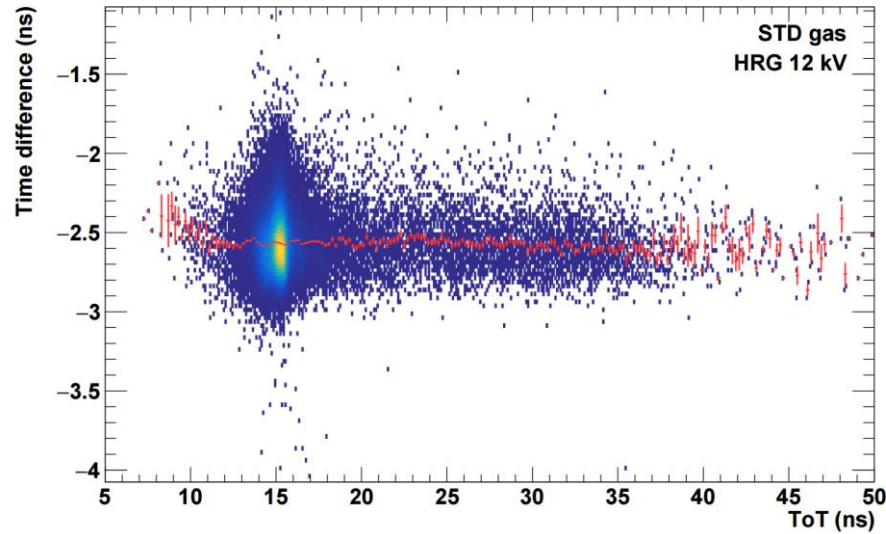
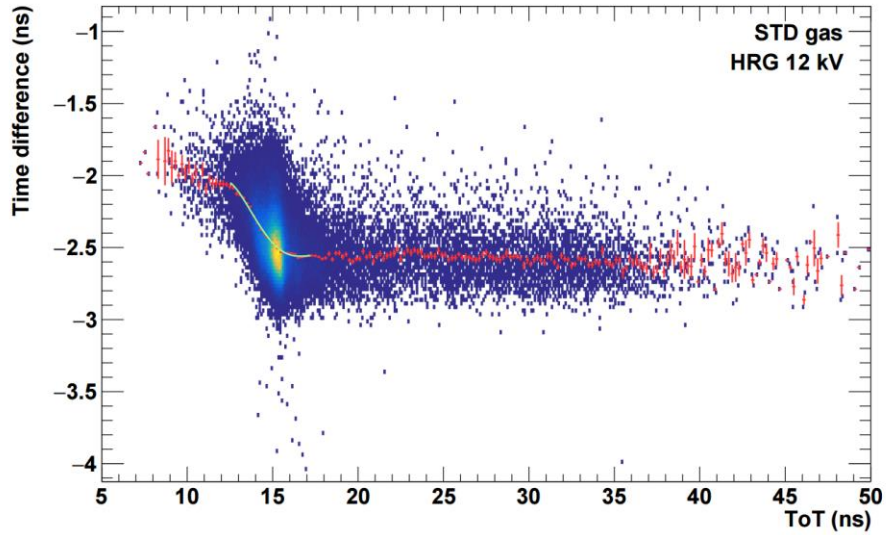
- Efficiency / Multiplicity



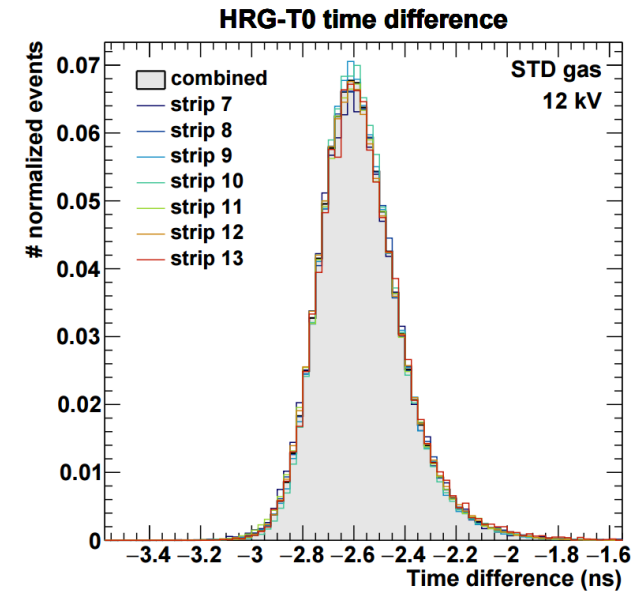
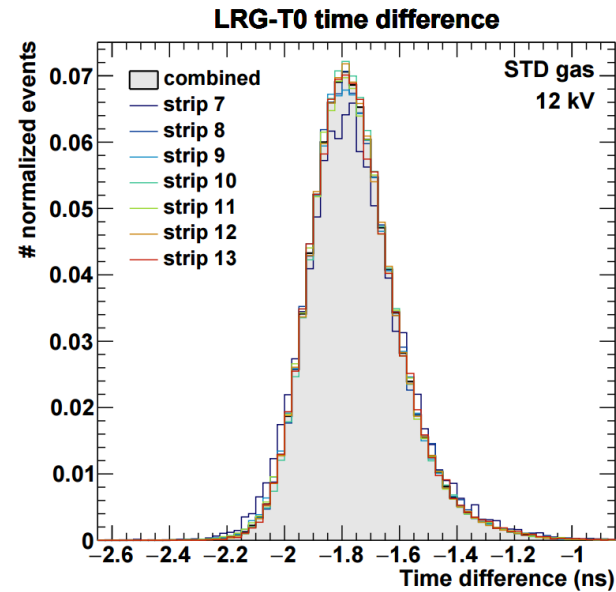
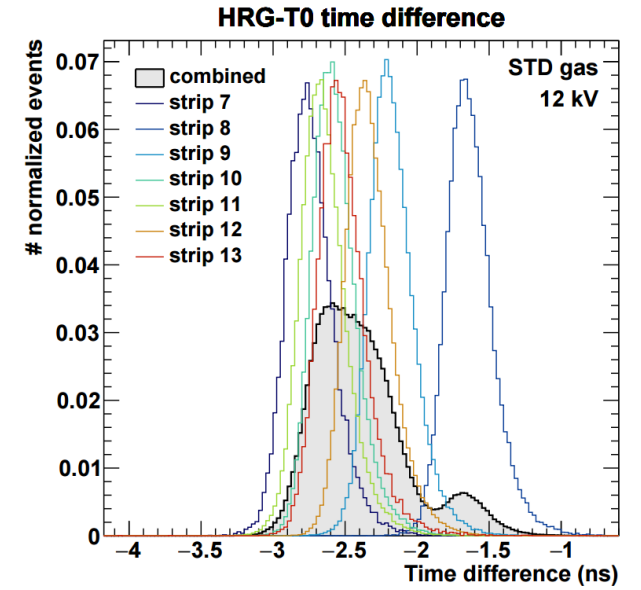
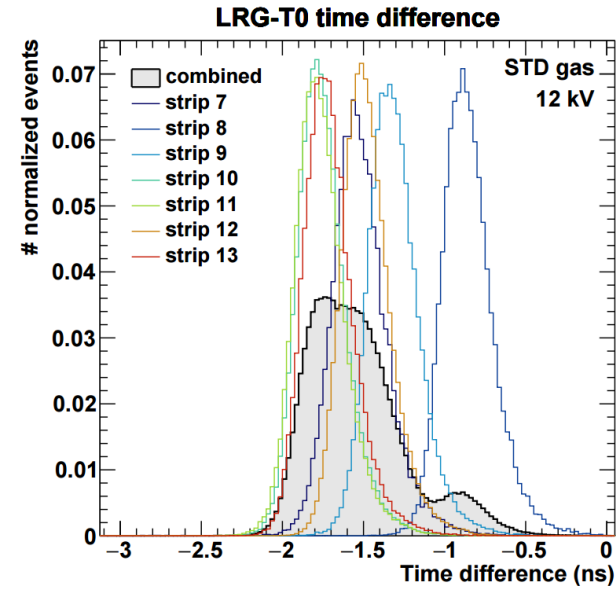
- In case of ecological gas, the voltage needs to be increased by 4 kV to reach the efficiency plateau

- Time calibration

time slewing correction



strip offset correction

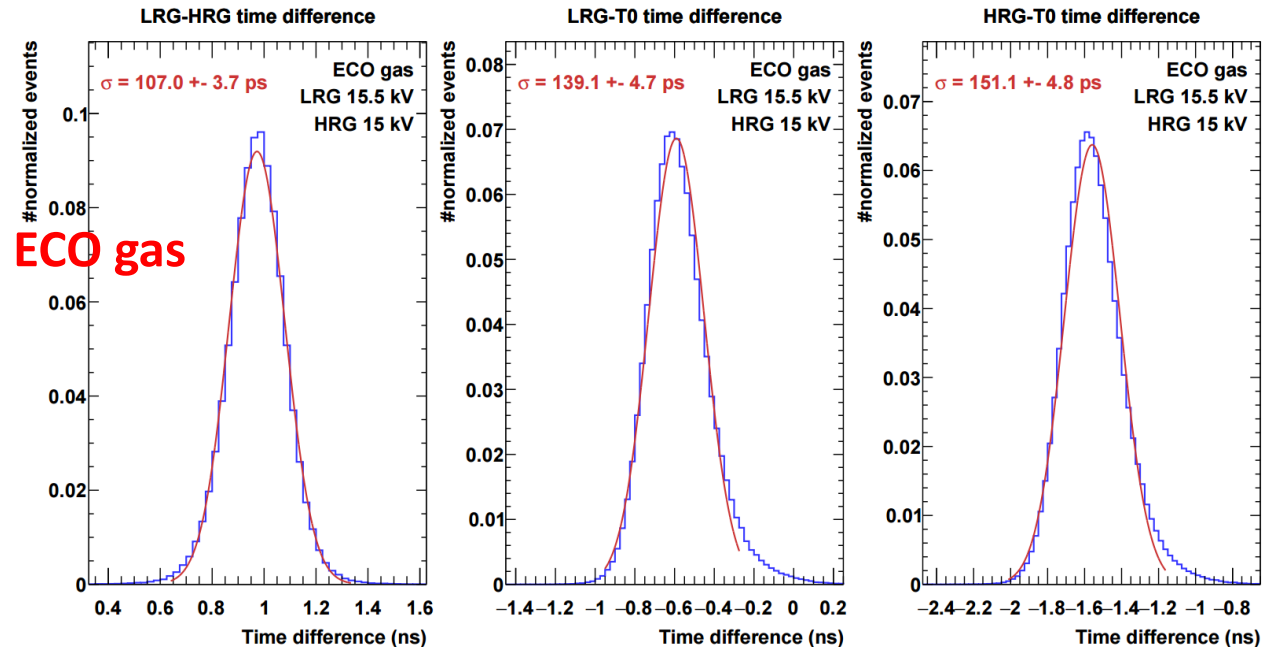
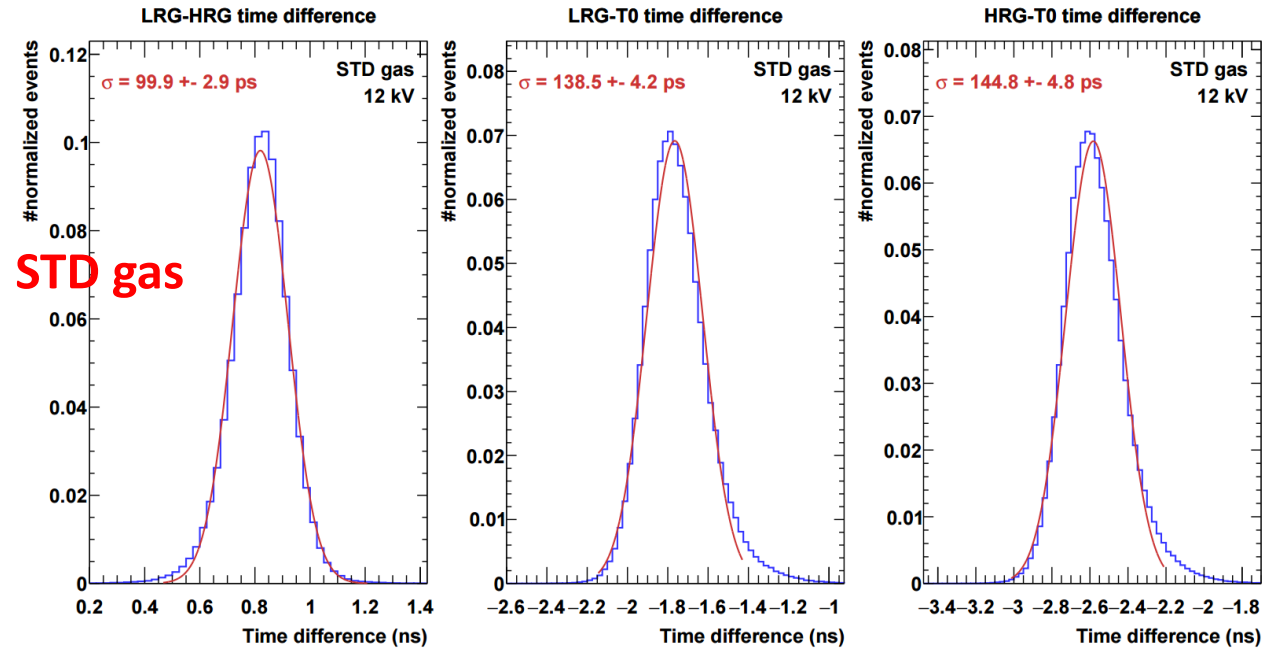


- Timing

- Our triggering system was not working properly (unable to use the CFD), so its timing performance was not sufficient enough (~130ps)

- We can only use the difference between the two chambers to estimate their timing resolution

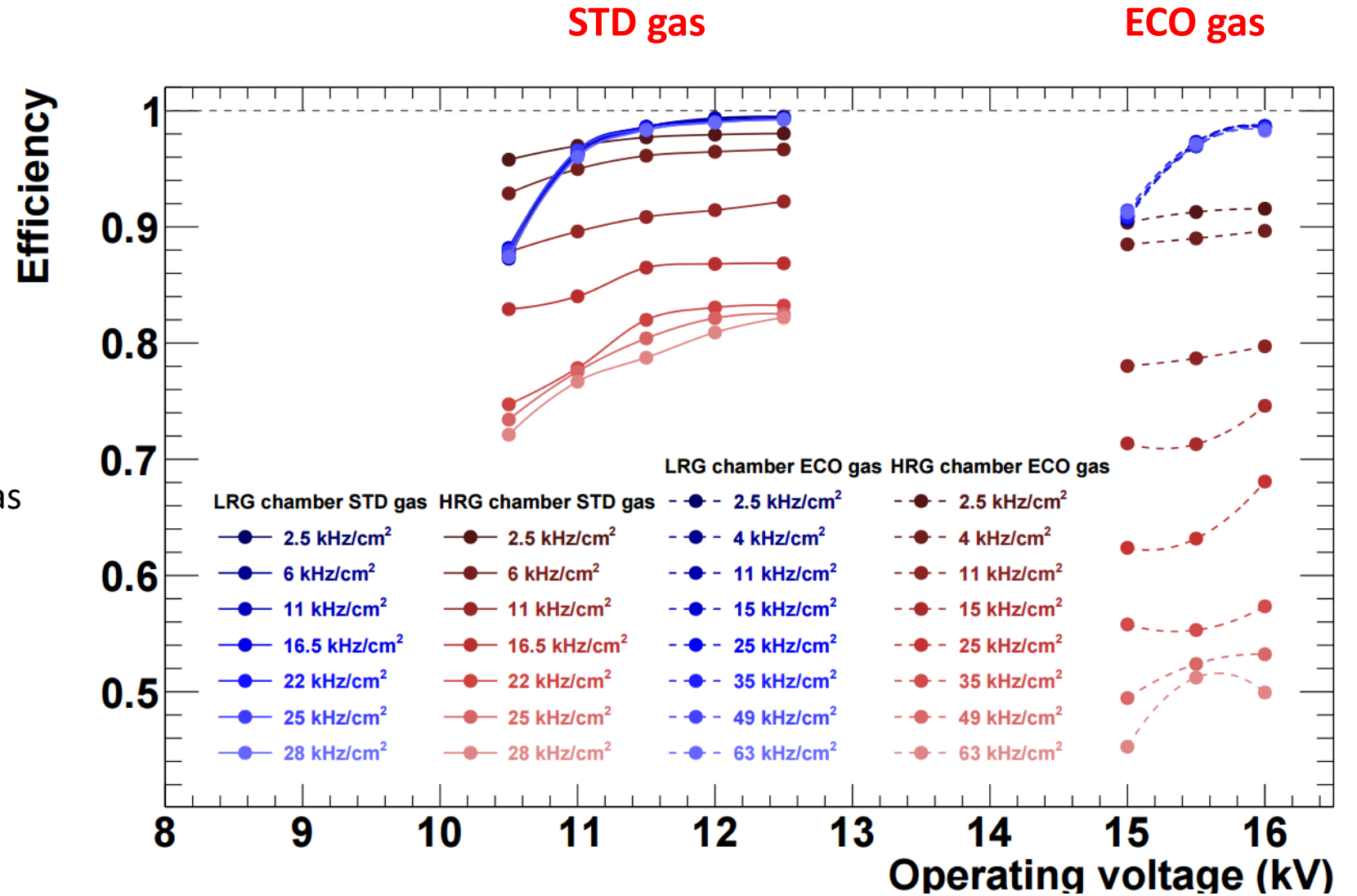
- Standard gas :
  - $\sigma = 100$  ps
    - => 70 ps per chamber
- Eco gas :
  - $\sigma = 107$  ps
    - => 76 ps per chamber



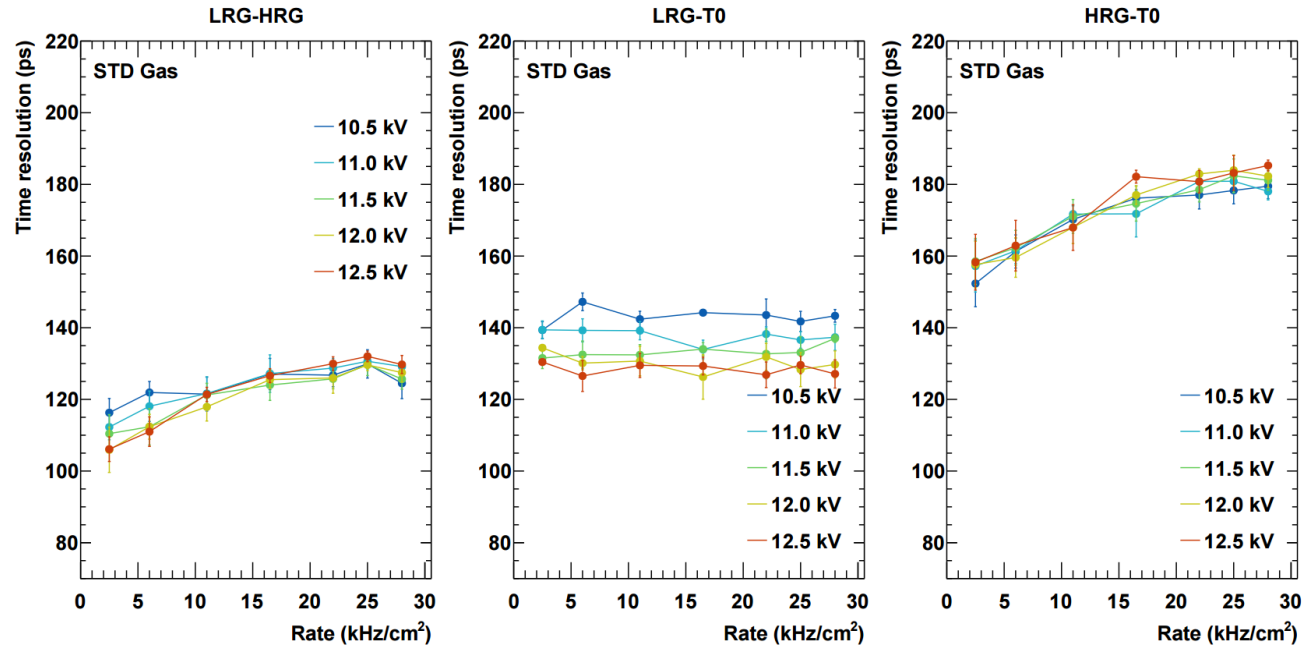
- Rate capabilities

- Efficiency

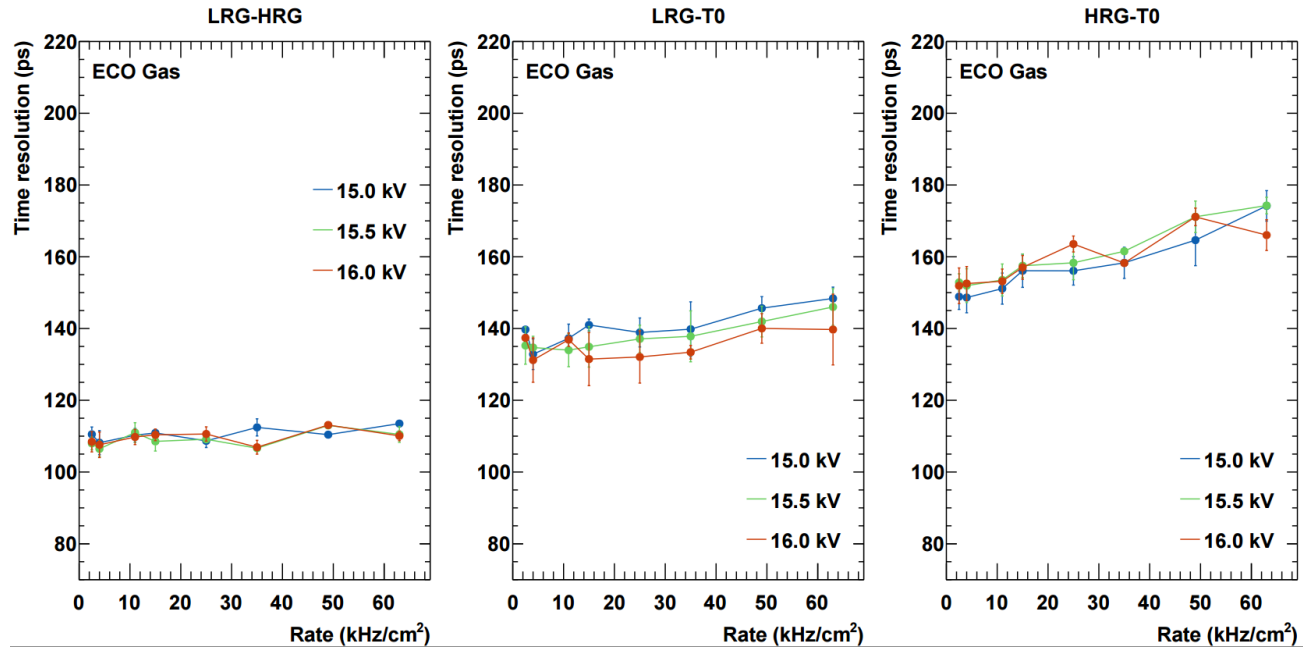
- 7 GeV pions
- beam profile : 1.3 cm FWHM
- Rates :
  - up to 28 kHz/cm<sup>2</sup> for standard gas
  - up to 63 kHz/cm<sup>2</sup> for eco gas



- Rate capabilities
  - Time resolution



**STD gas**

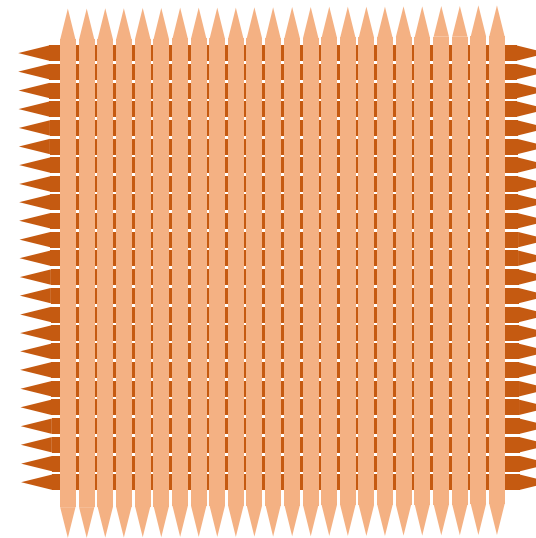


**ECO gas**



- Conclusion :
- Ecological gas was tested and looks promising :
  - No minimal drop of performances for efficiency and time resolution
  - Looks also suitable for high rate environments but this needs to be further investigated by irradiating the whole chamber instead of a focused beam

- Future :
  - An other beam test at T10 was performed in end of August
    - The triggering system was fixed this time
    - Ecological gas was again used
    - Data waiting to be analysed
  - A beam test is planned for end of October
    - More focused on tracking than high rate capabilities
    - New design of chambers will be tested :
      - perpendicular strips on both sides of the chamber
    - Readout will still be done with NINOs but the plan is to use LIROC+ picoTDC for the future



# Backup

# ToT distribution

