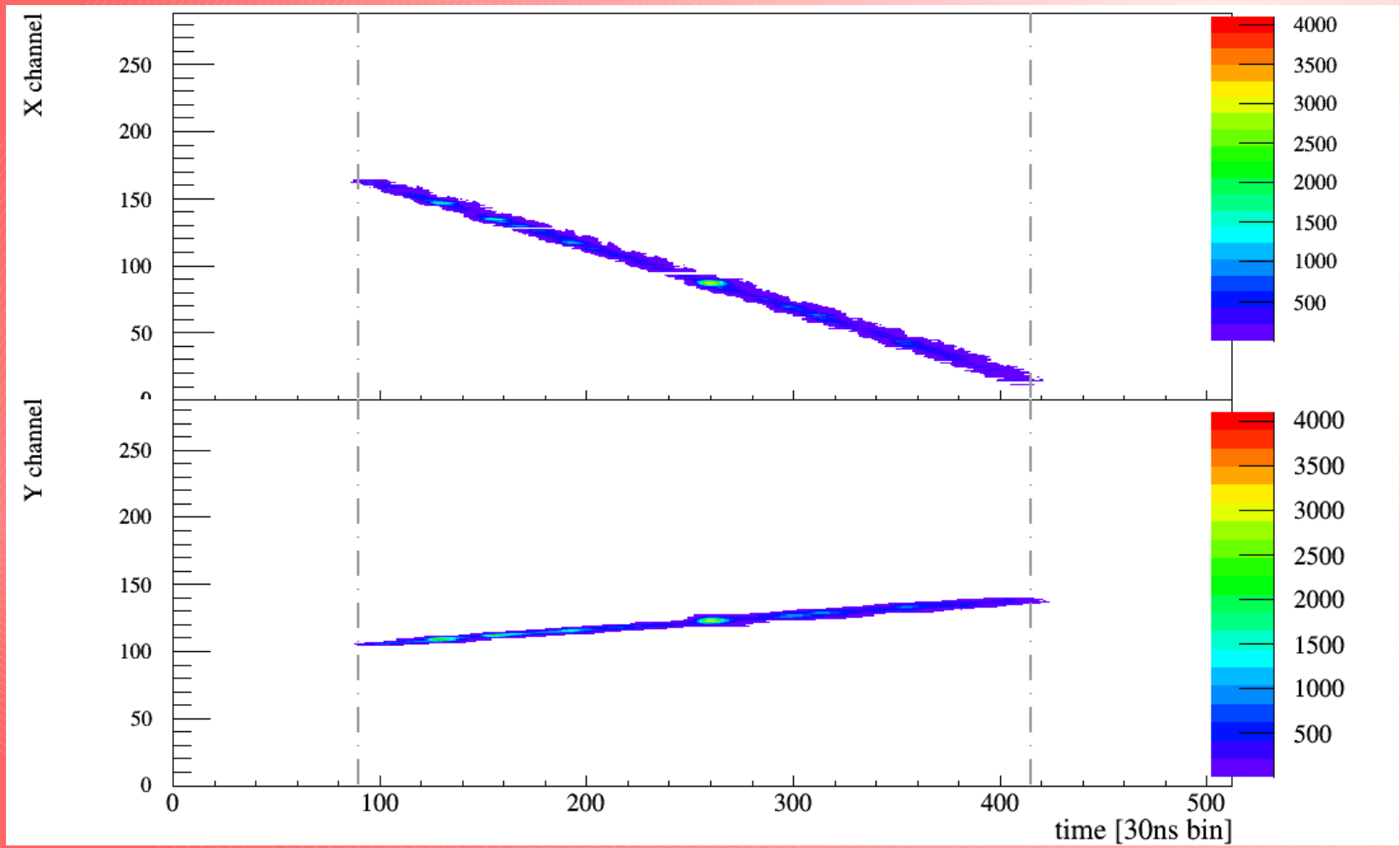
Gas circulation and purification in the sealed HARPO TPC

- Gas monitoring method with data
  - Cosmic ray data
  - Charge measurement
- Gas evolution
  - Gas degradation over 5 months
  - Purification system
  - gas analysis
- Conclusions

Cosmic ray configuration

- "vertical" position
  - muons arrive through the readout plane
- Simple trigger
  - coincidence of 2 scintillators

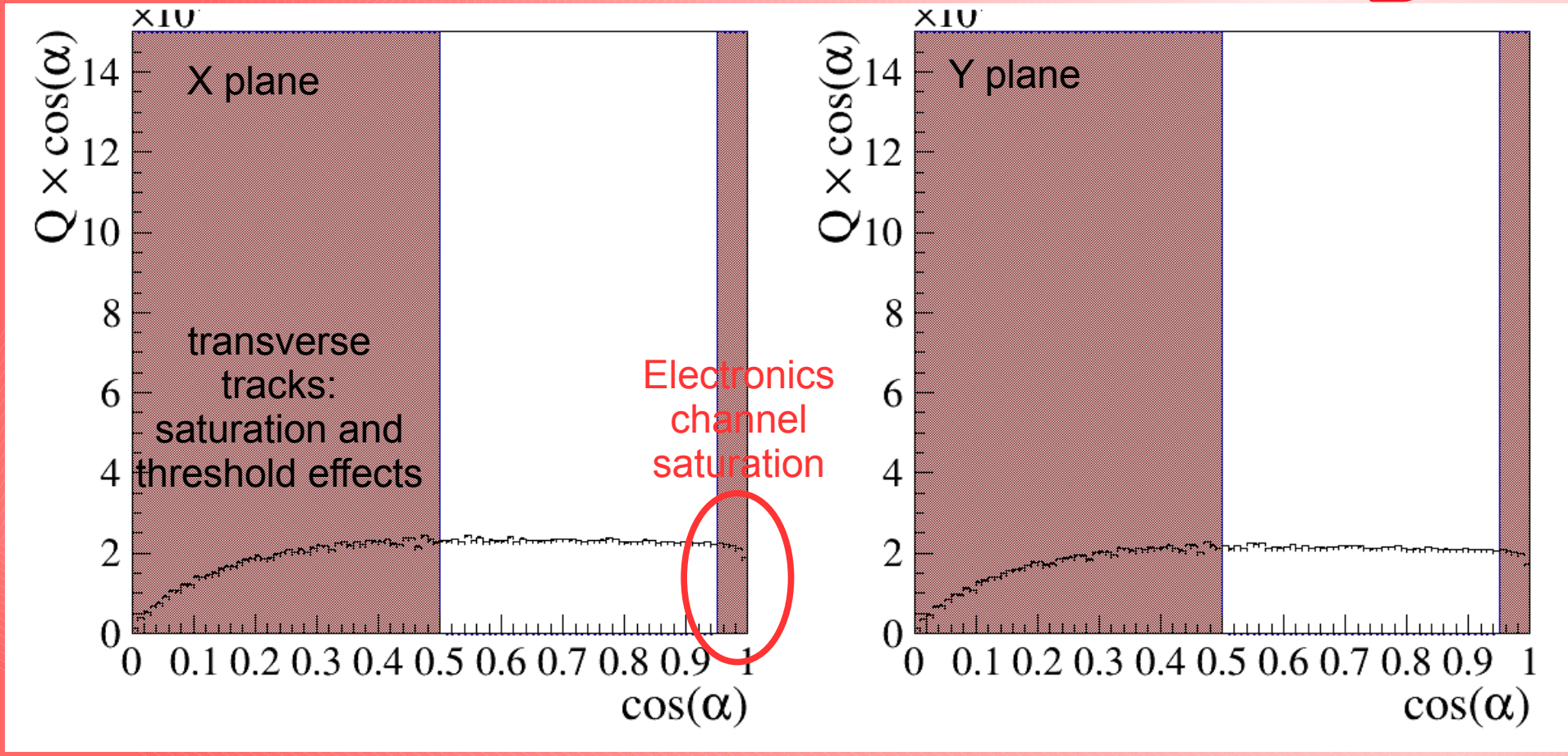
Typical cosmic ray event



Method

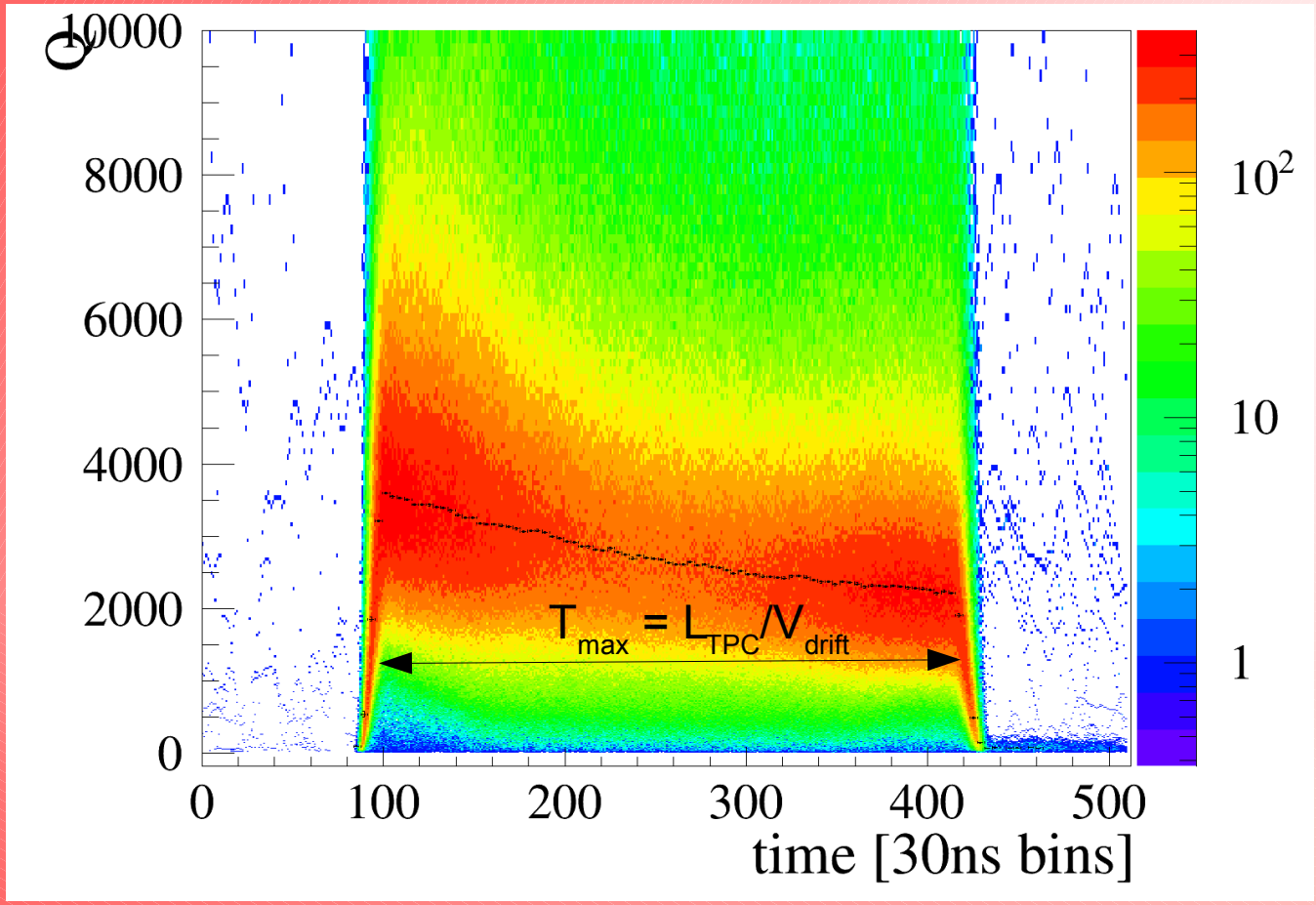
- Use high momentum tracks (cosmic muons)
  - <dE/dx> independent of event
  - Single track events for simplicity
- Use Q_{cl} vs Z_{drift}
  - Angular corrections (length of track sample)
- Get MPV for all drift distances
  - Landau fit

Angular cut



- The charge is normalised with regard to the track angle => independent of angle
- We select mostly longitudinal tracks

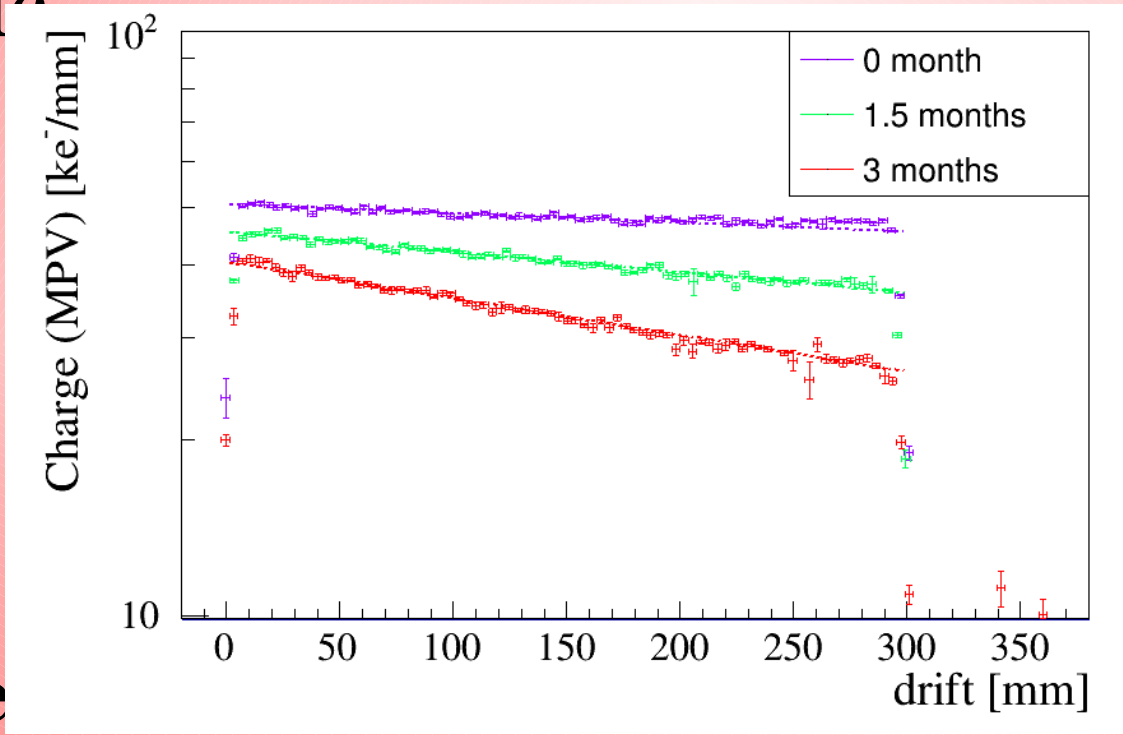
Q vs T_{drift}



- The charge is normalised with regard to the track angle
- The MPV is obtained from a Landau fit (of slices) (mean value affected by threshold/saturation effects)
- V_{drift} is also easily extracted from this plot

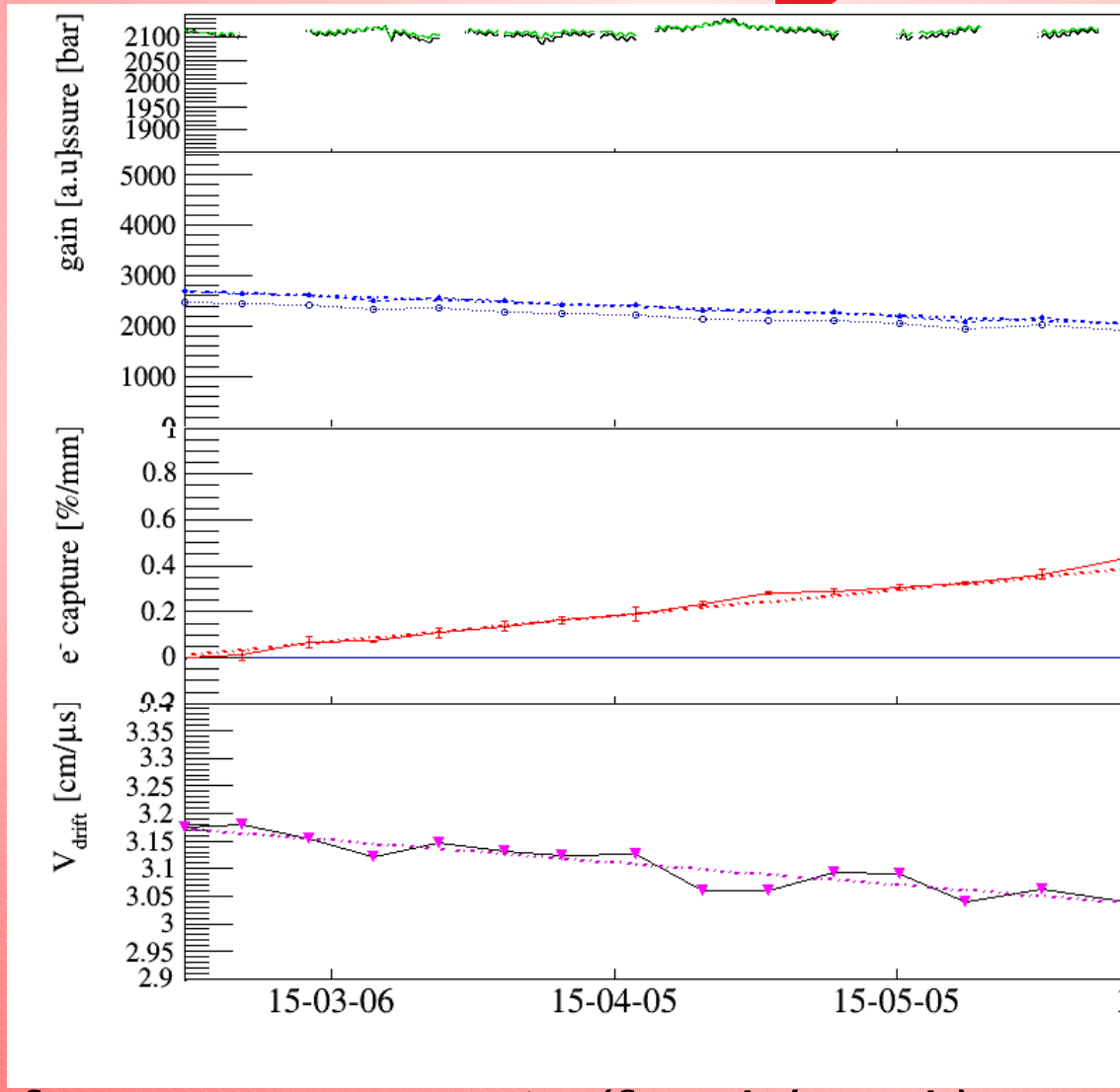
Cosmic runs LLR

- Remaining systematic effects
  - angular distribution
  - threshold
- Relative measurements
  - First run as reference (“clean gas”)
- Weekly data taking of ~1.5h, for 6 months
- Clear degradation of



Time evolution over 4 months (June)

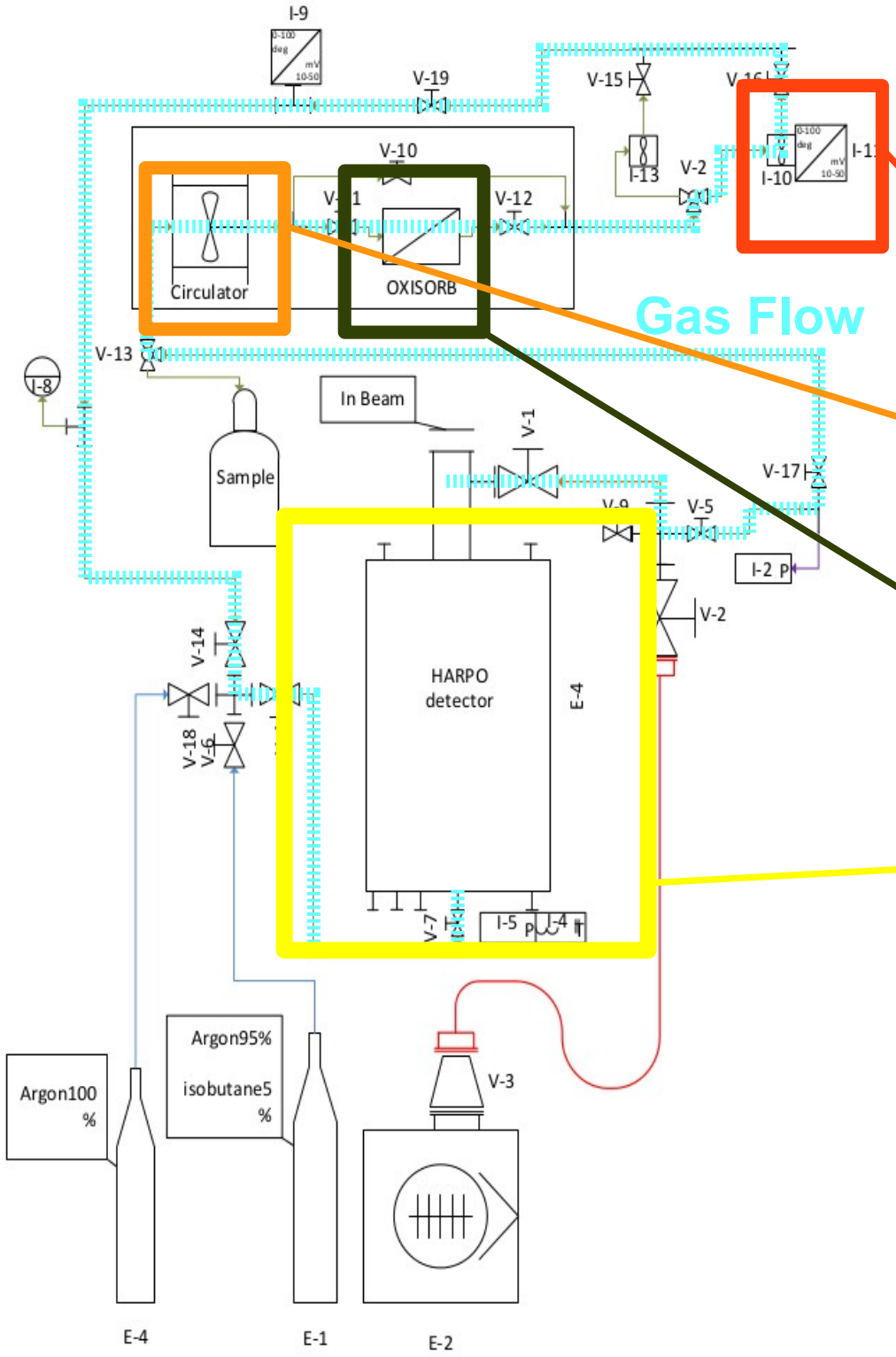
- Stable density
  - no measurable leak
- Gain loss
- Increasing e- capture
- Decreasing drift velocity

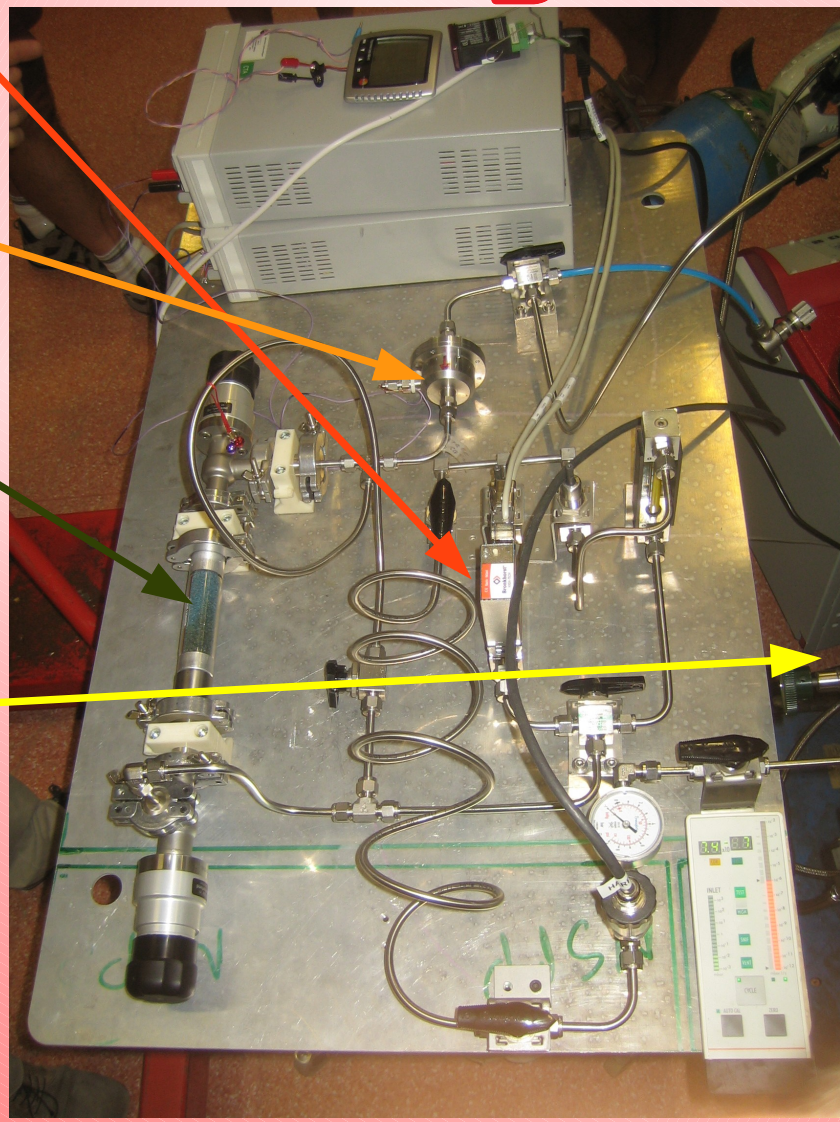


Detector under HV only for measurements (few h/week)

Circulation and purification system

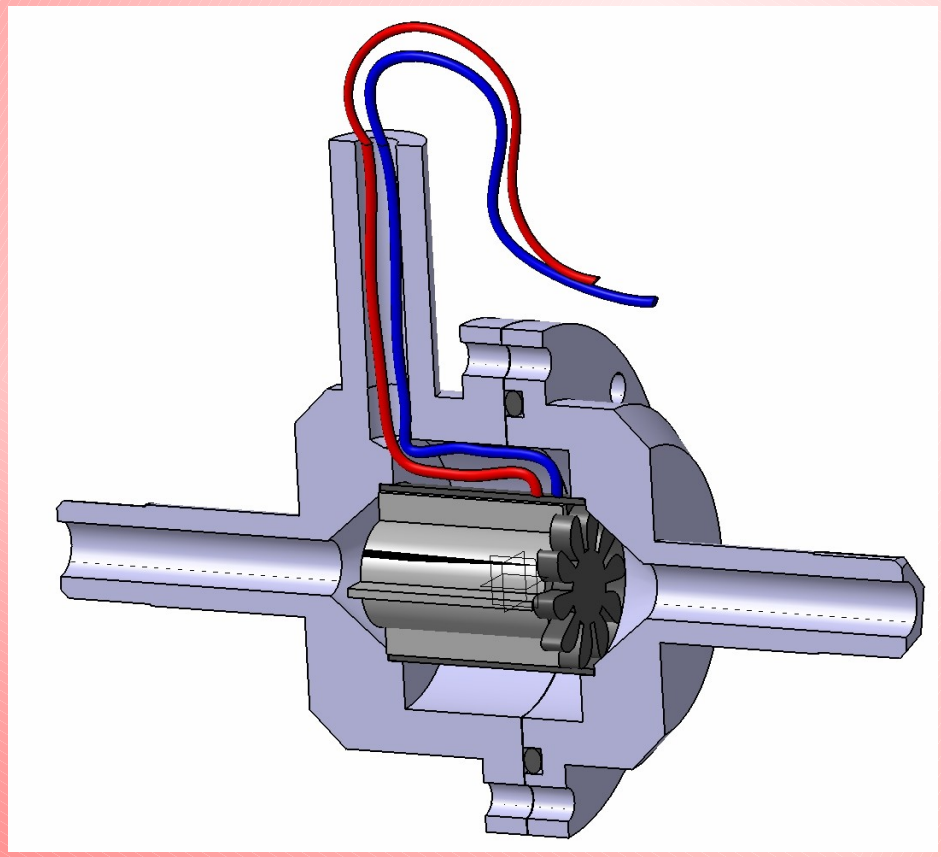
- Lightweight circulation system
- Closed circuit
  - 2 bar
  - tested for leak in vacuum and pressure
- Small turbine for gas flow
  - ~1L/h flow
- Oxisorb for cleaning O2 and H2O


I-9
V-19
V-15
V-10
V-12
I-13
V-2
I-10
Circulator
OXISORB
Gas Flow
V-13
I-8
In Beam
Sample
V-1
V-17
V-5
I-2 p
V-2
V-14
V-18
V-6
HARPO
detector
E-4
V-7
I-5 p
I-4
V-3
Argon100
%
Argon95%
isobutane5
%
E-4
E-1
E-2

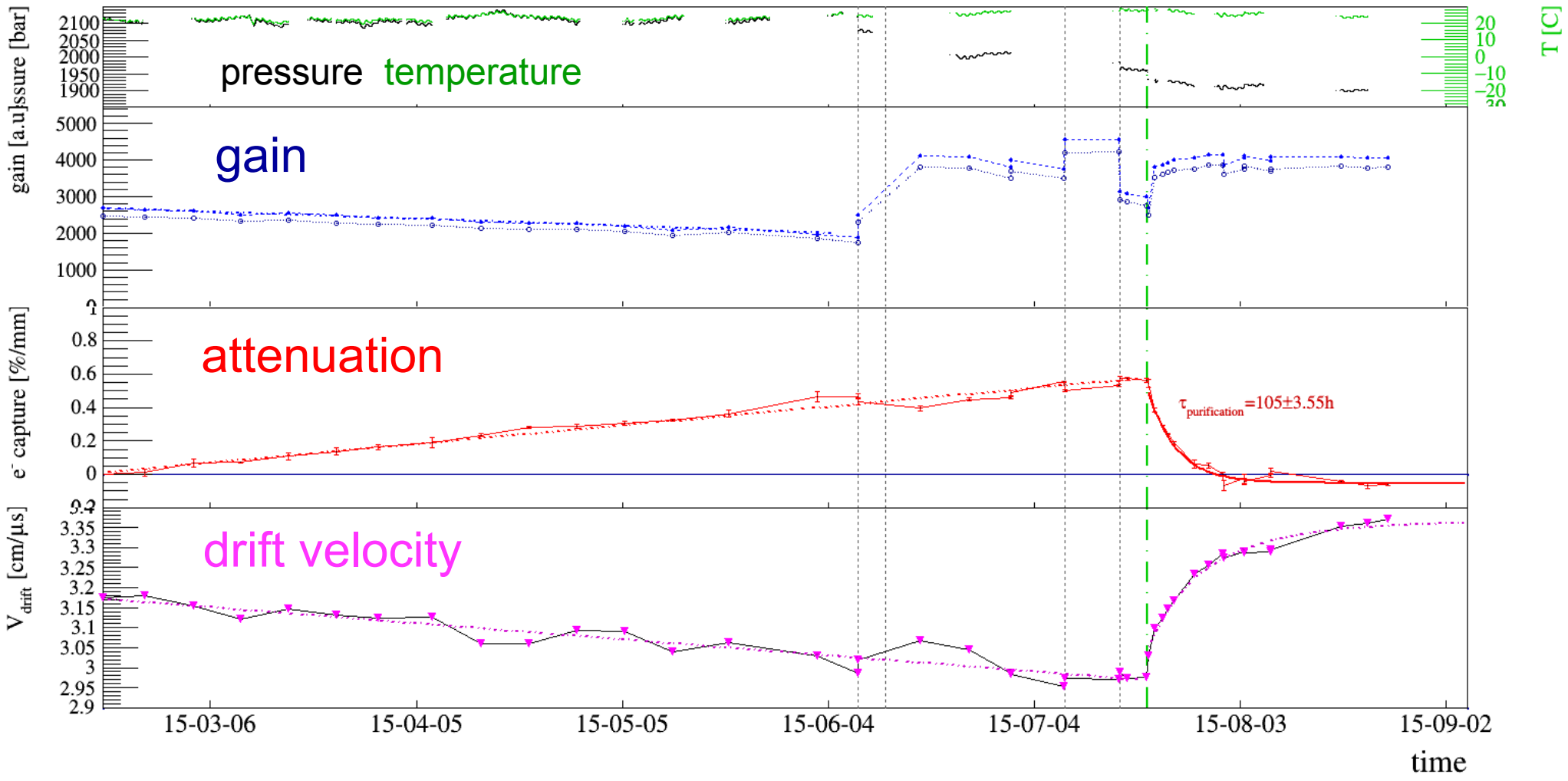


Circulator

- Light and sealed turbine for circulation
  - qualified from 10^{-5}mbar to 10bar
  - up to 15V
  - up to ~1L/h for Argon at 2 bar
- *Patent FR 15 50987 (2015/02/09)*



Effect on the data



- Clear improvement, back to original properties

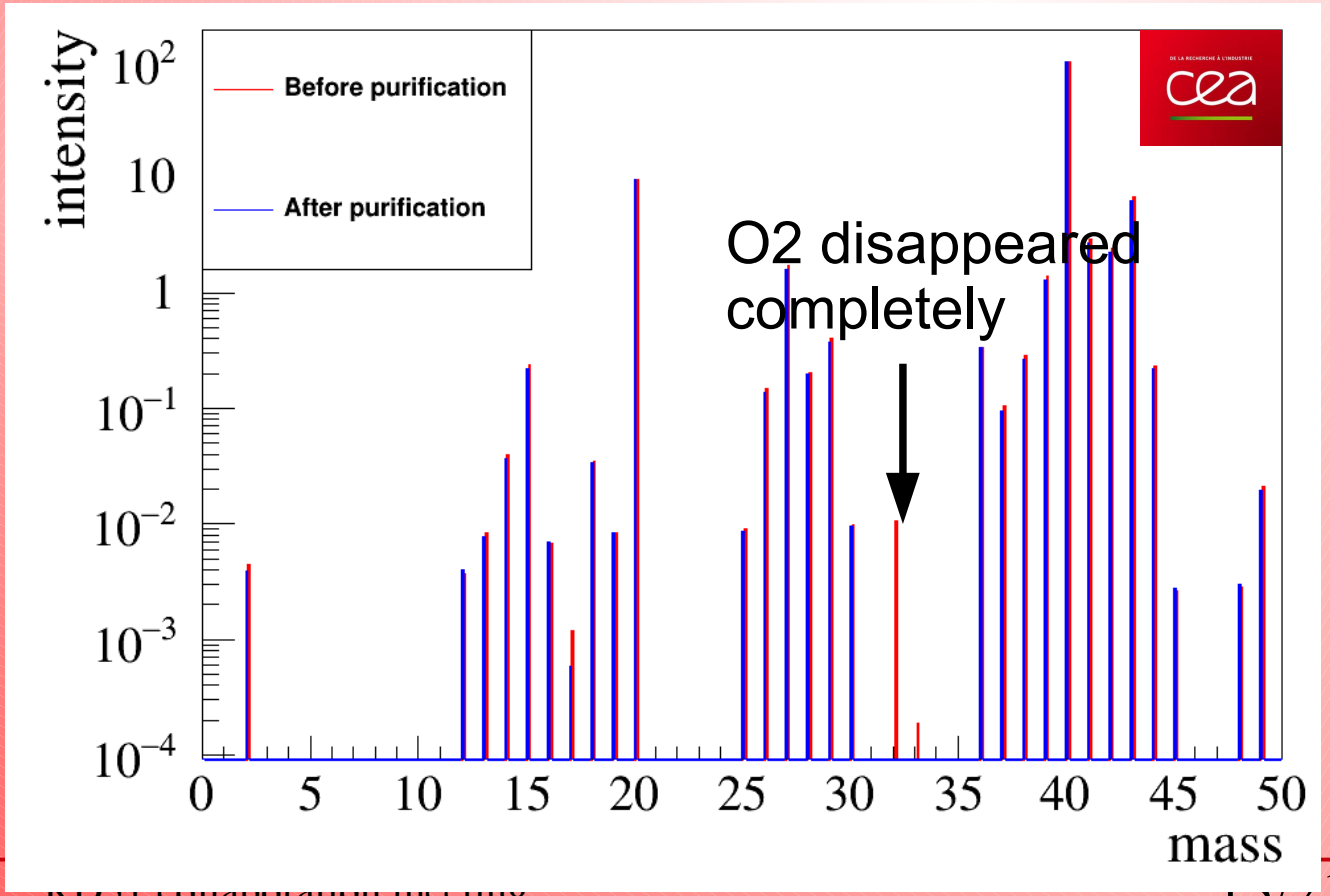
Gas analysis

Mass spectrometer

Mass spectrometry

- O_2 completely disappeared
- No other change in spectrum

Spectrometry measure
by LRMO,
CEA Saclay



Interpretation

- Multiple sources of gas degradation
- Air leaks
  - electron capture by O_2
- Outgassing
  - decreased drift velocity with H_2O
- Other?
  - effect of HV?
  - disappearing isobutane?

Conclusions

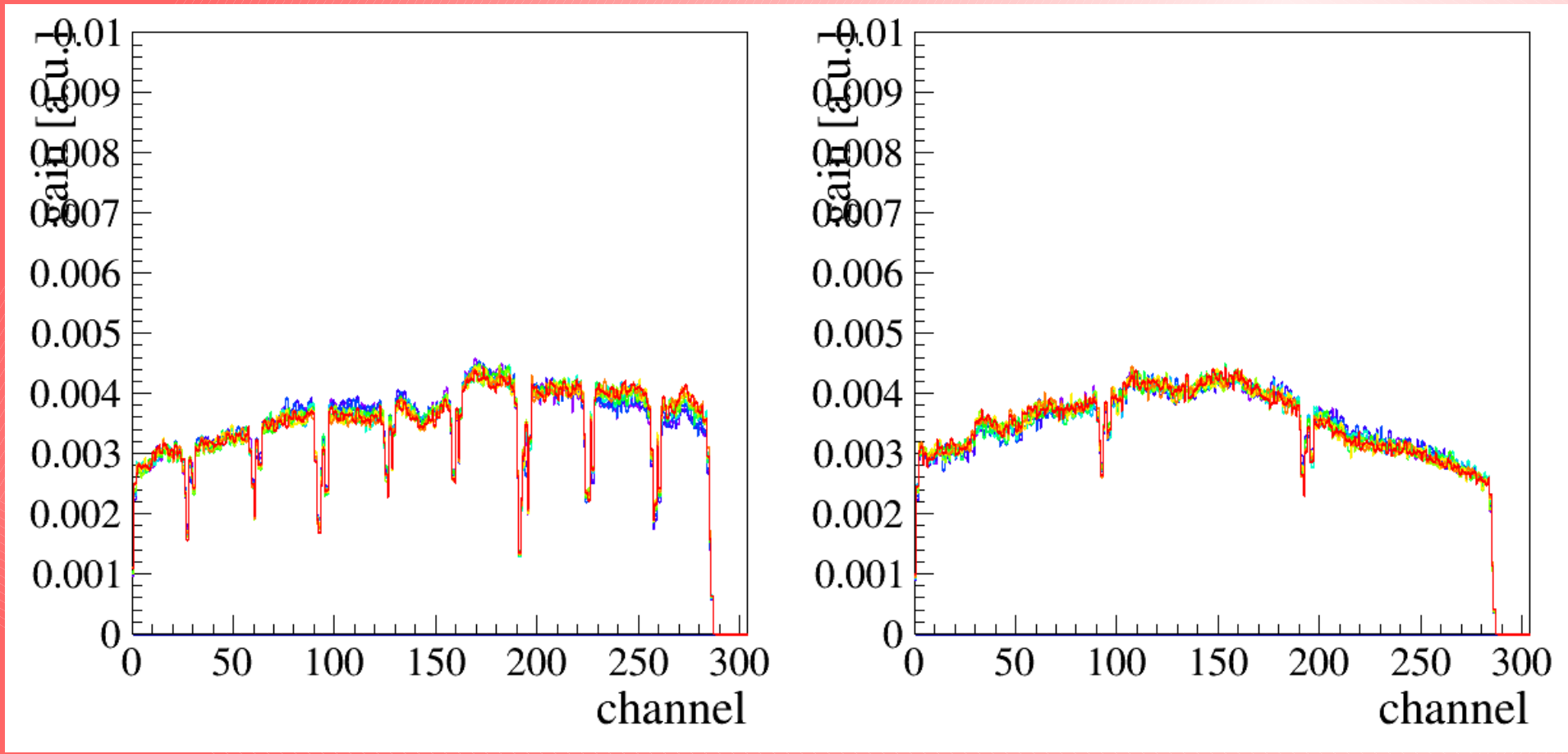
- HARPO offers a simple way to monitor the gas quality using cosmic rays
- 5 months with same gas in sealed mode
  - degradation, from leaks and outgassing
  - detector performance decreased, but not fatal
- Successful purification
  - adding circulator and filter without affecting detector
  - performance recovered after a few weeks
- *Good prospects for long term TPC use in sealed mode (e.g. in space)*

backup

Gain calculation

- Conversion ADC to electrons
  - 1ADC ~ 20 electrons
- Full calculation not possible
  - theory: <dE/dx>, reality: MPV (depends on correlations => simulation?)

Space dependence



Cosmic ray geometry