Calibration of the Gas Gain Monitor

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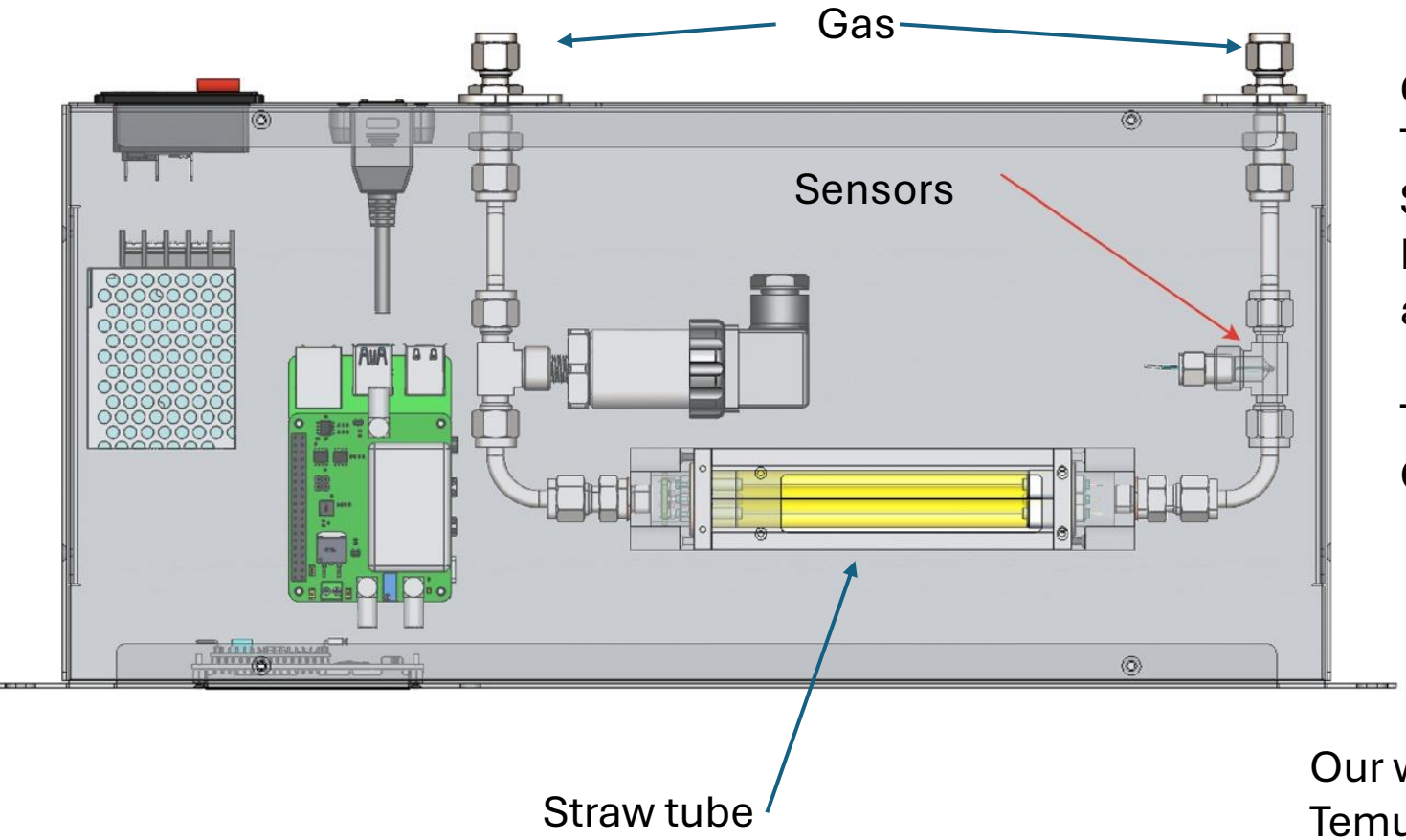
JINR

Gas Gain Monitor



Gas is passing through a short straw-tube.
This tube is irradiated by radioactive source ^{55}Fe.
Signal spectra are collected and stored in database.
Data from pressure and temperature sensors are also stored in database.

The device is now located in gas channel of CMS CSC on GIF++ facility at CERN.

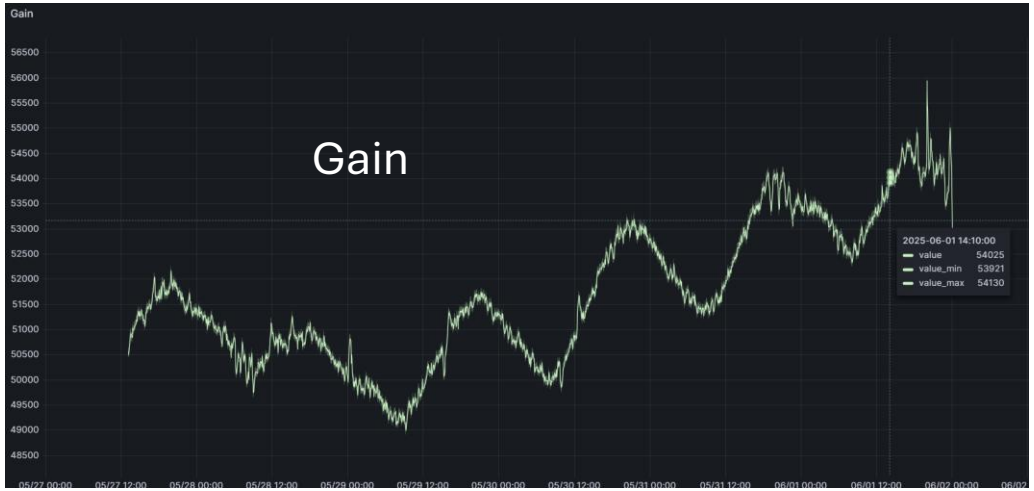
Our work group: Kirill Salamatin, Vitaly Bautin, Temur Enik, Ekaterina Kuznetsova, Viktor Perelygin, Alexey Kamenev, Vladimir Karjavine

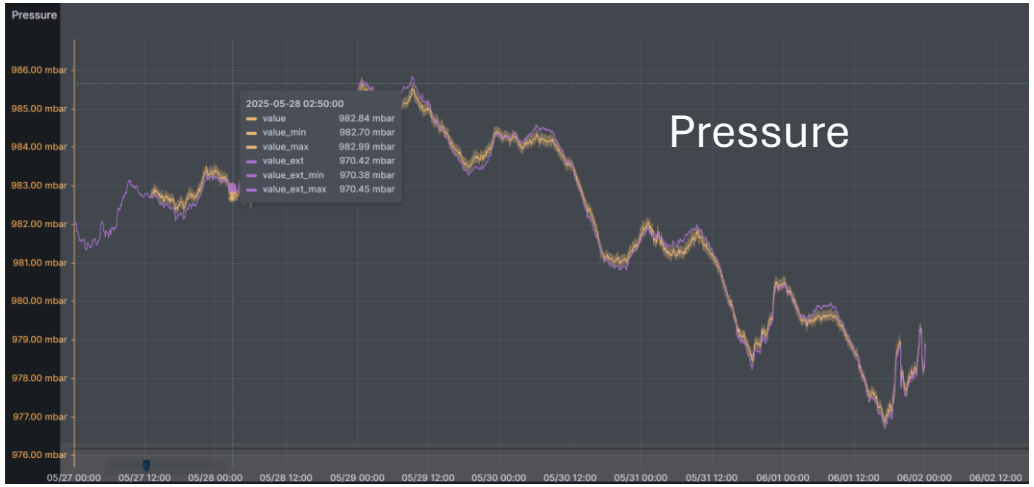
Database

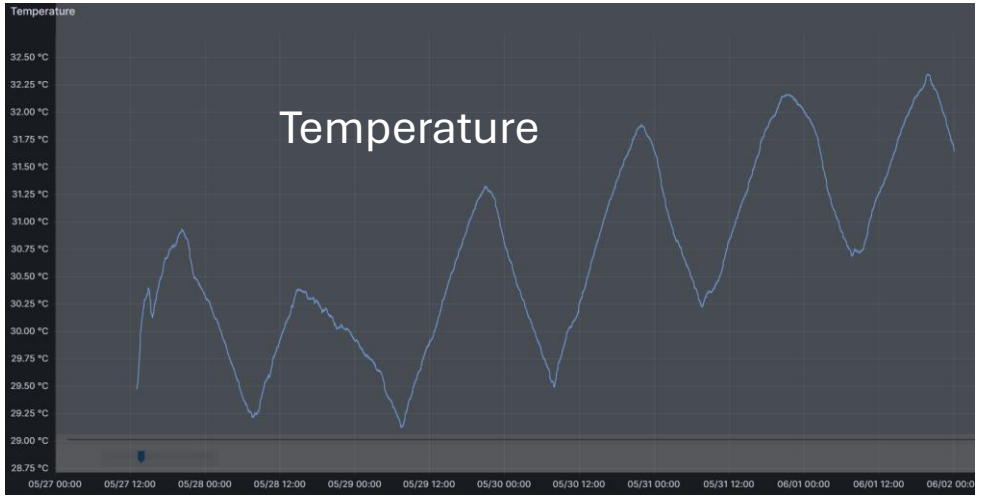
- Stored data:
  - Time stamp
  - Pressure and its error
  - Temperature and its error
  - Spectrum of signals collected over 3 minutes time
  - Signal readout rate
  - Once in 20 measurements (1 per hour) we make electronics test:

    HV is turned off and the test pulse is applied on straw tube wire.
    Spectrum of this test pulse is also stored in database

Grafana monitoring

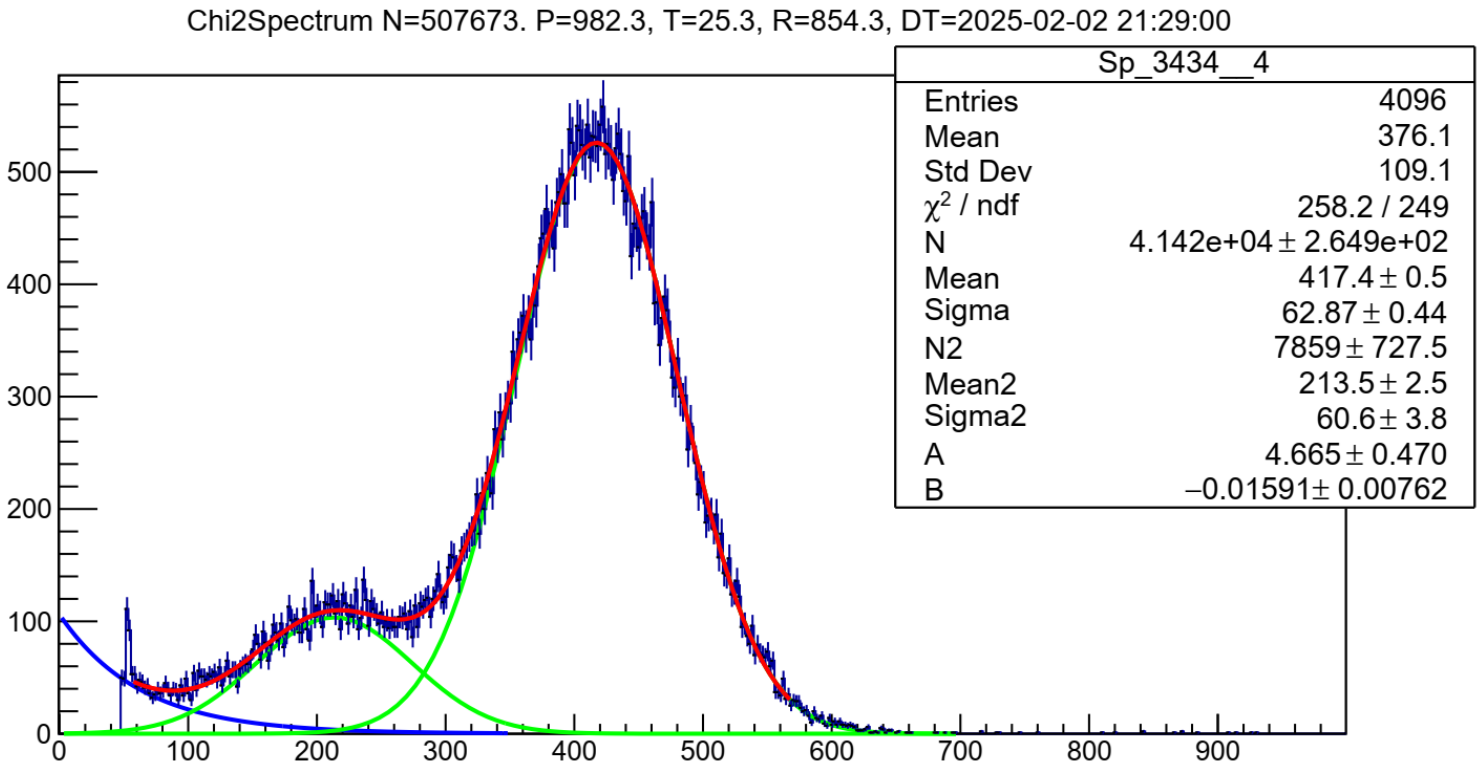






The database is connected to Grafana system for online monitoring

Signal spectrum and fitting



Escape peak Full absorption (FA) peak

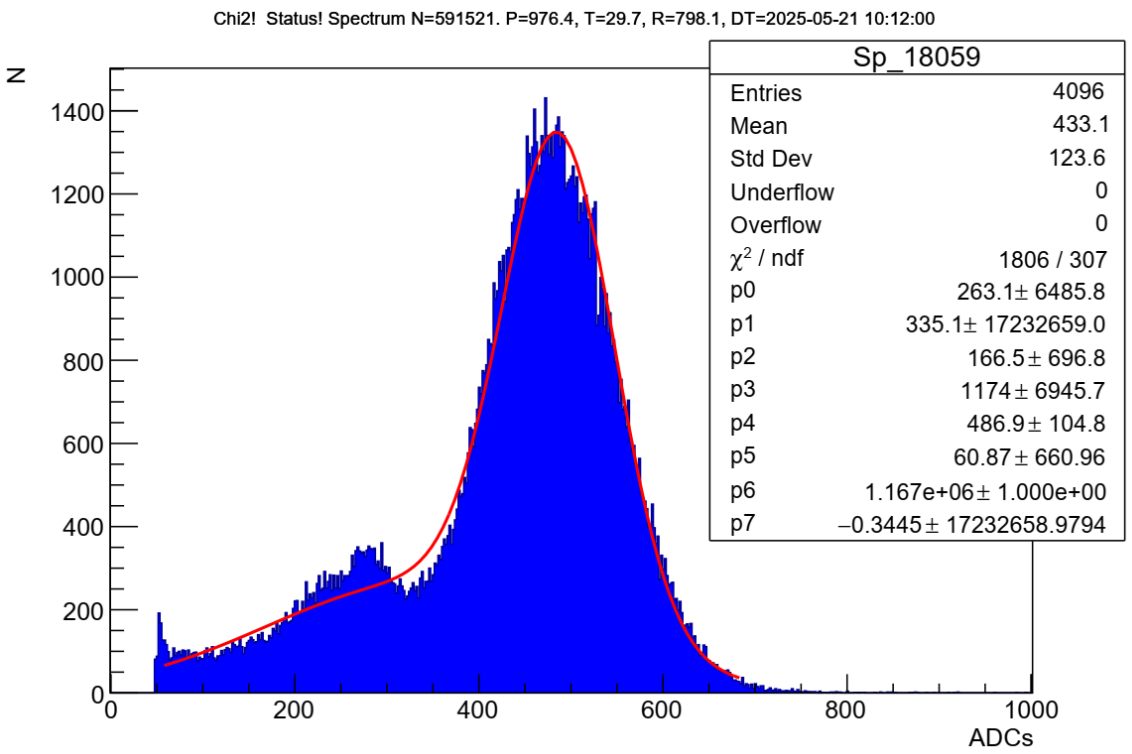
Spectrum has two peaks: escape peak and full absorption peak.

Spectrum is fitted with a convolution of two Gaus functions and an exponential function.

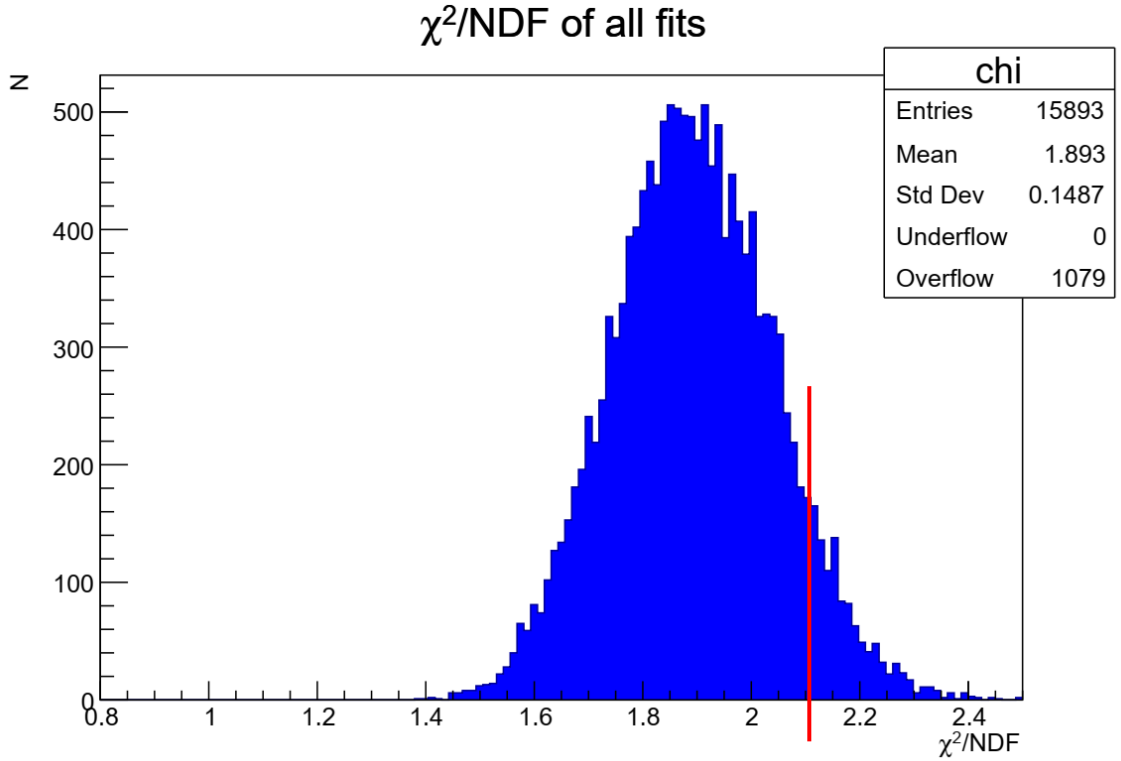
Calibration algorithm

- Fit all spectra
- Get full absorption peak position (the big one)
- Plot dependence of the peak position on pressure and temperature
- Fit this dependence to get a calibration function
- Check this calibration on a different set of data
- As a result, we can monitor the difference between new data and the calibration function.

We drop some spectra from calibration

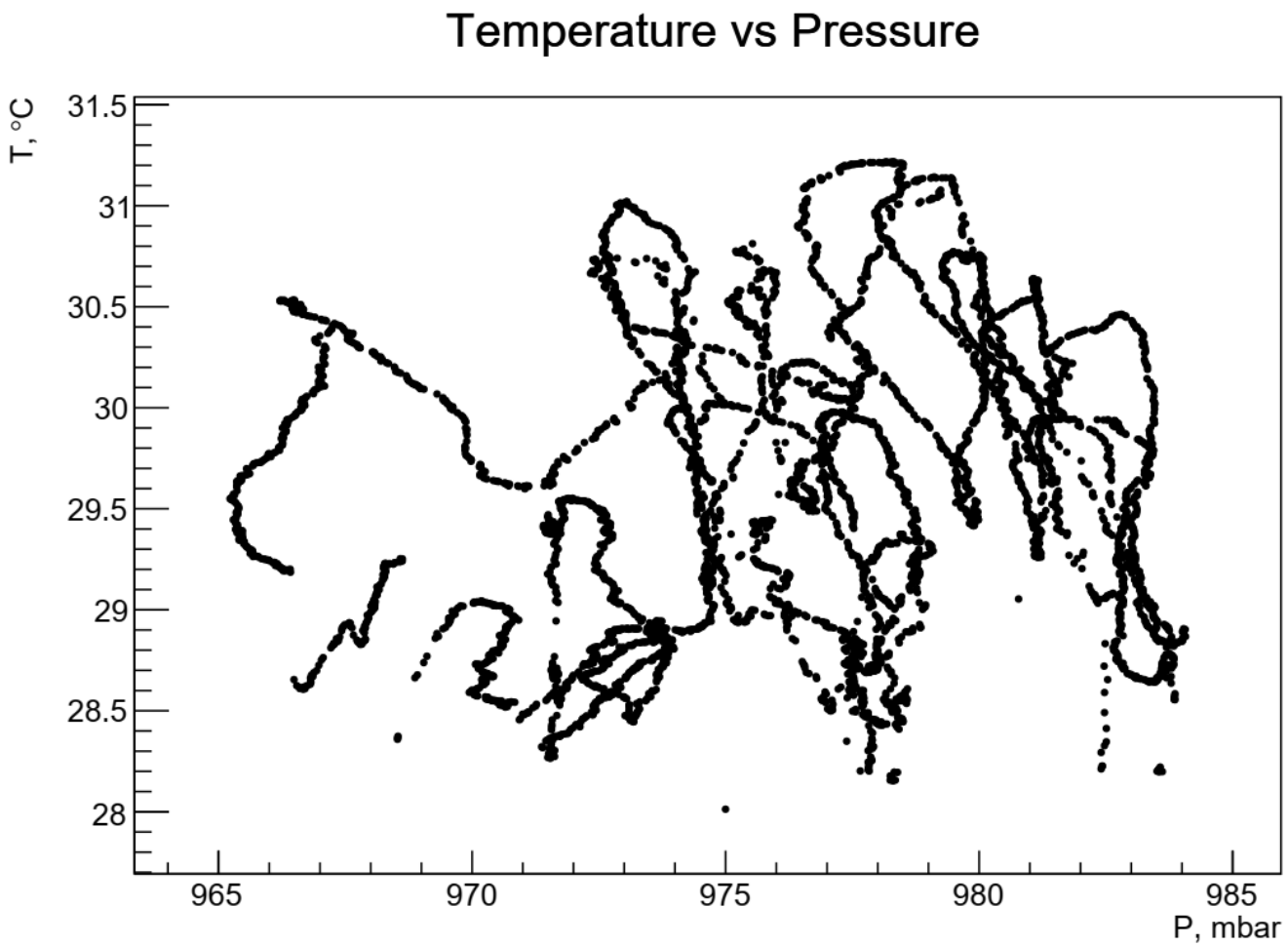


Some fits don’t converge



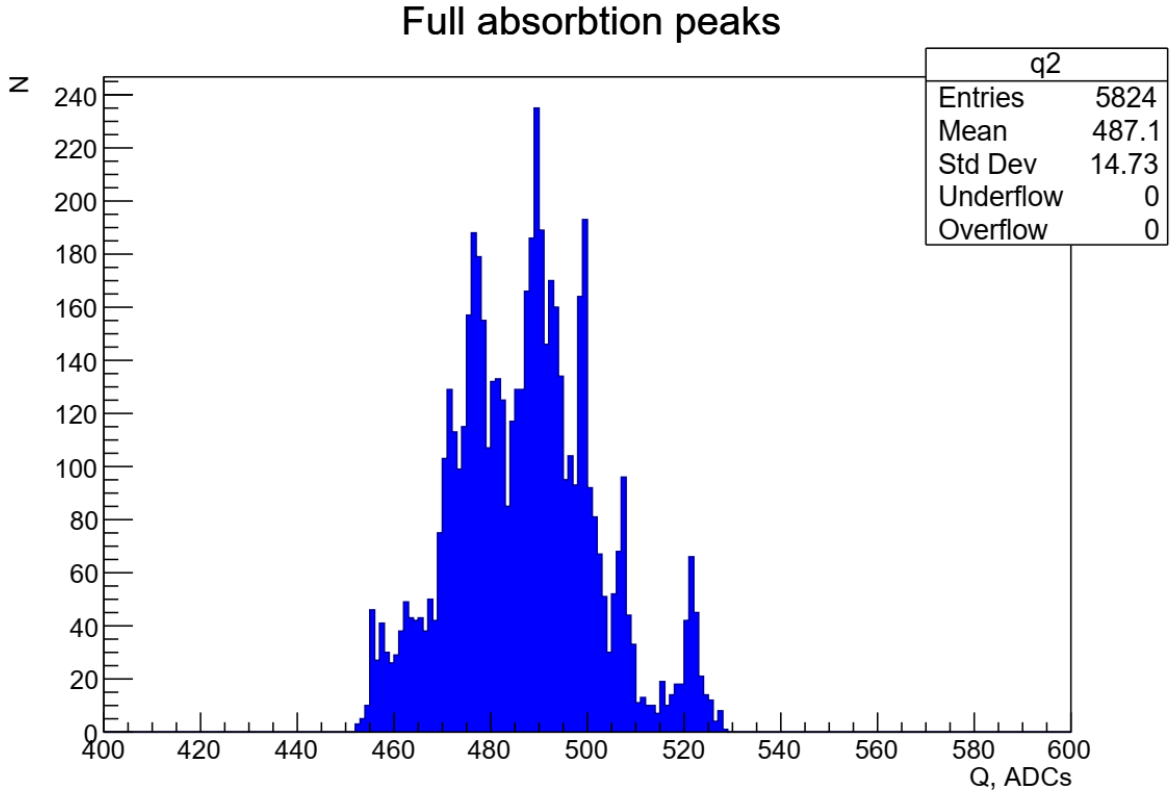
Bad χ^2. We set cut on fit quality.

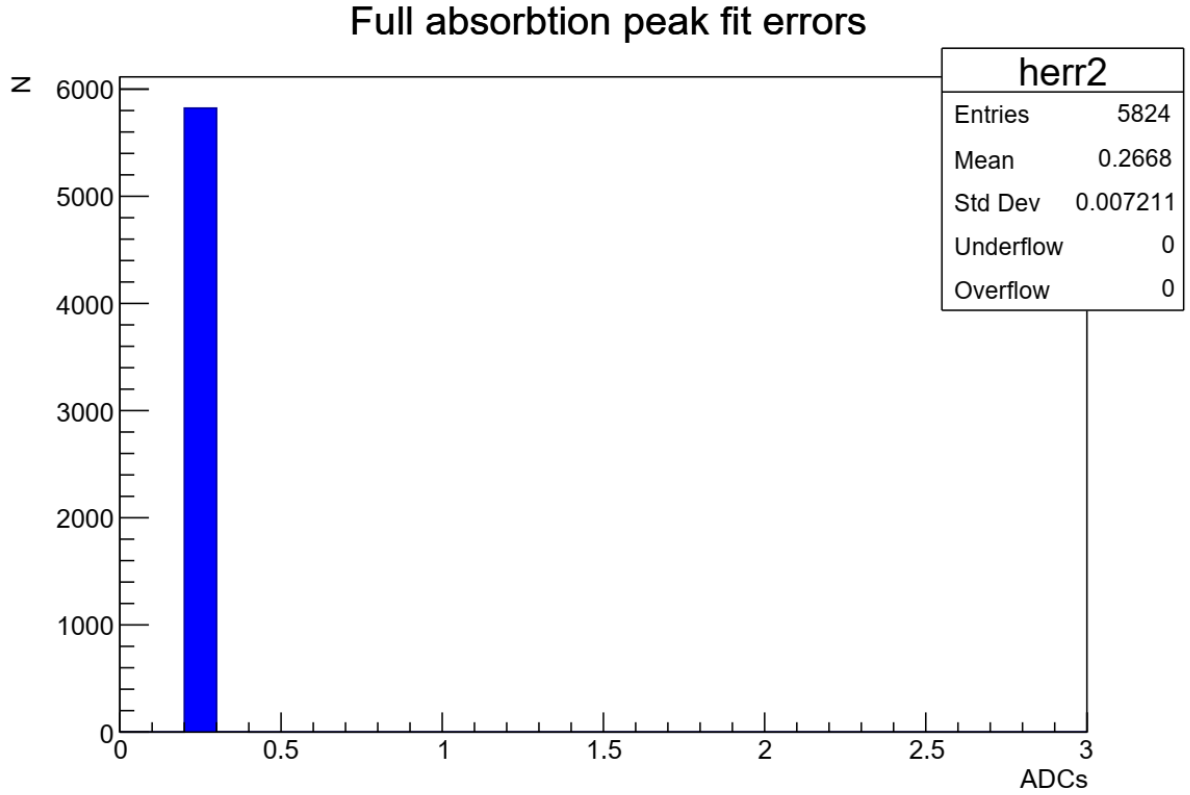
Pressure and temperature



May 2025 data. We only have a limited combinations of parameters.

Full absorption peaks

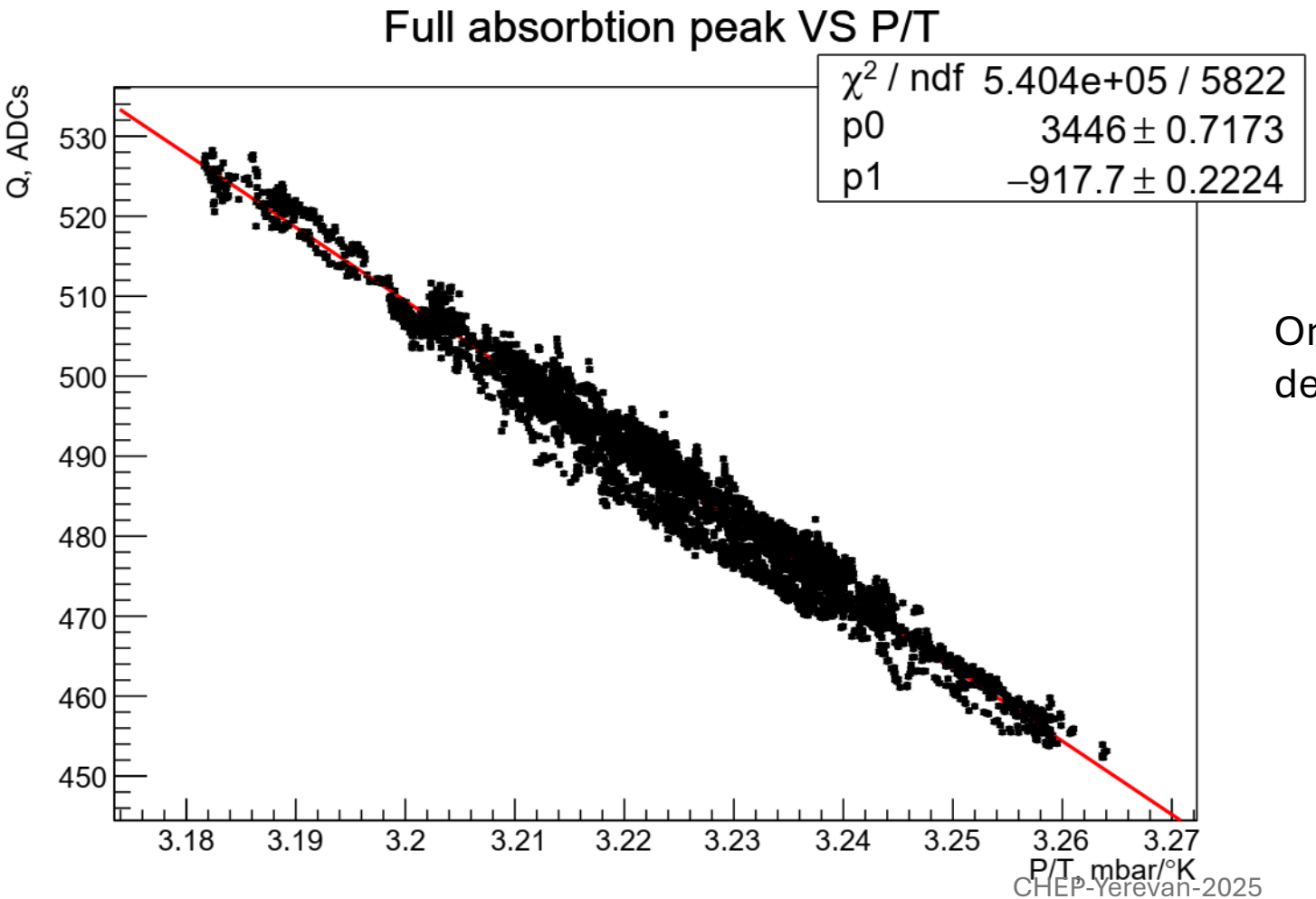




FA peak fit errors are less than 0.5 ADC

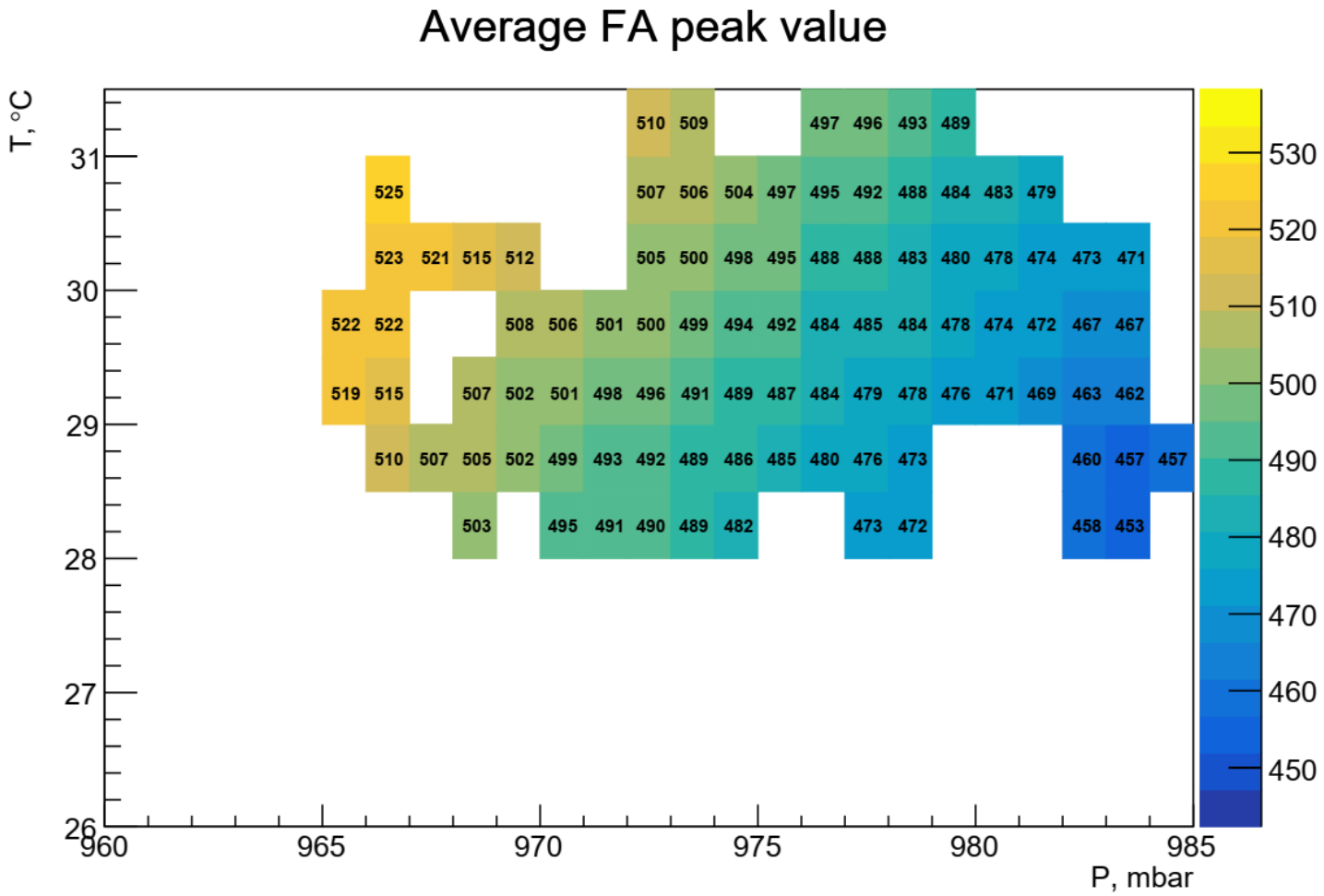
May 2025. Full absorption peaks.
All pressure and temperature combinations.

Full absorption peak VS (P/T)



One of the possible calibration functions is the dependence on ratio P/T.

Dependence of FA peak on P and T (2D)

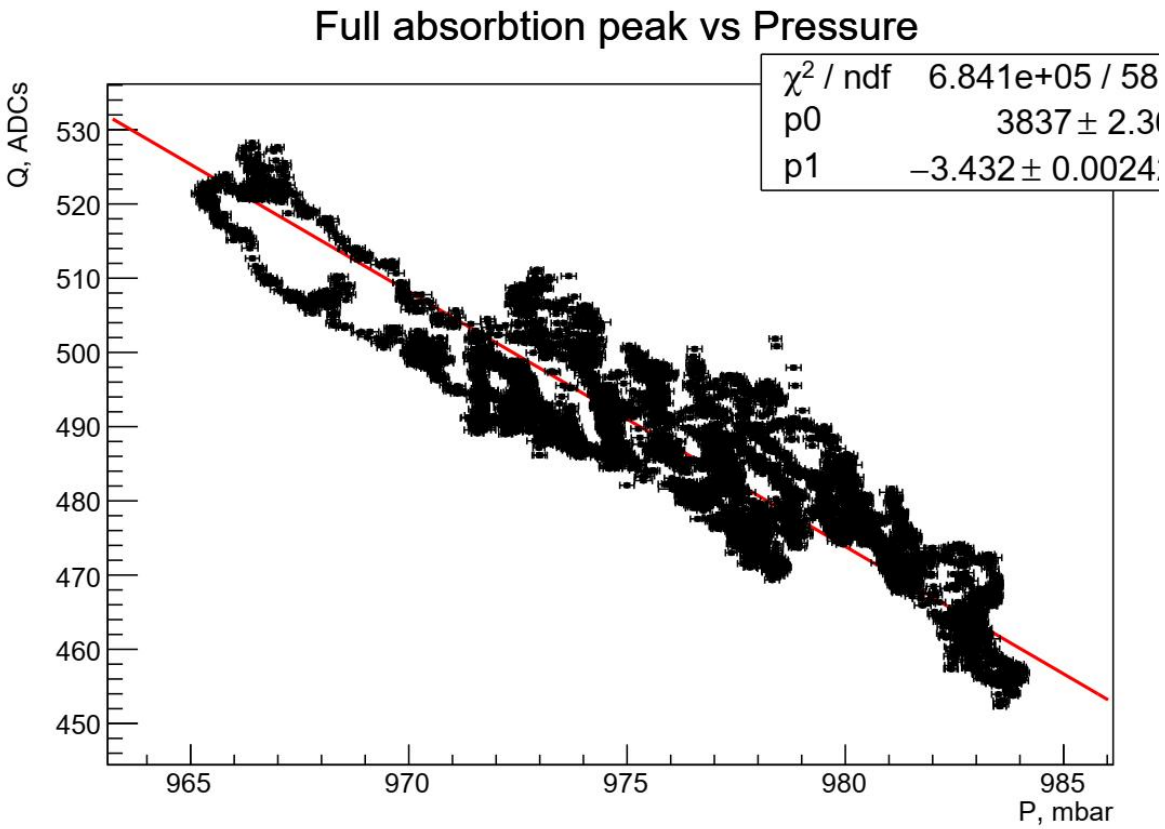


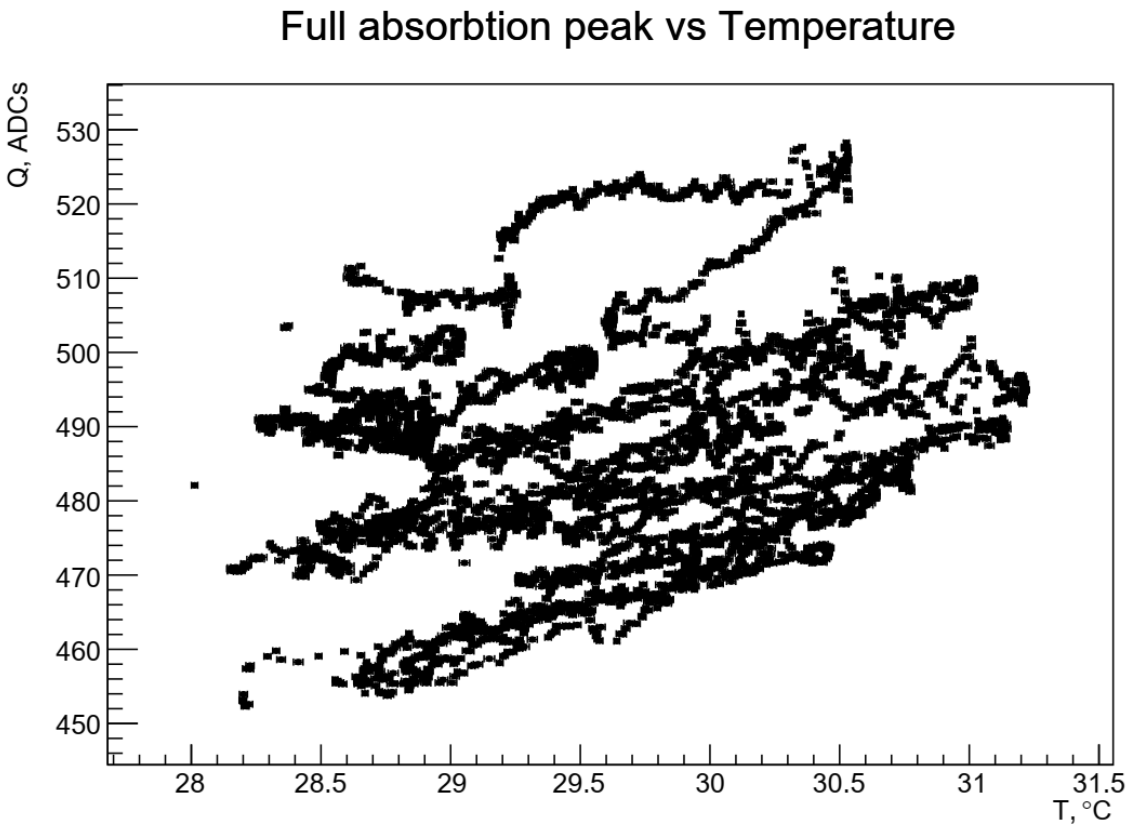
Average FA peak in bins 1mbar X 0.5°C.

Gas gain grows with temperature rise and drops with pressure increase.

We fit this plot with a plane:
a*P+b*T+C

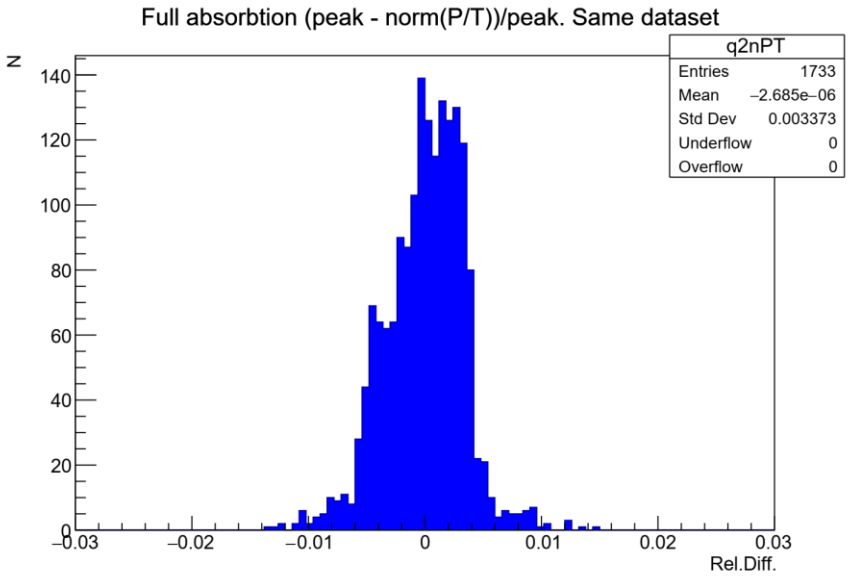
Separate FA peak dependence on P and T



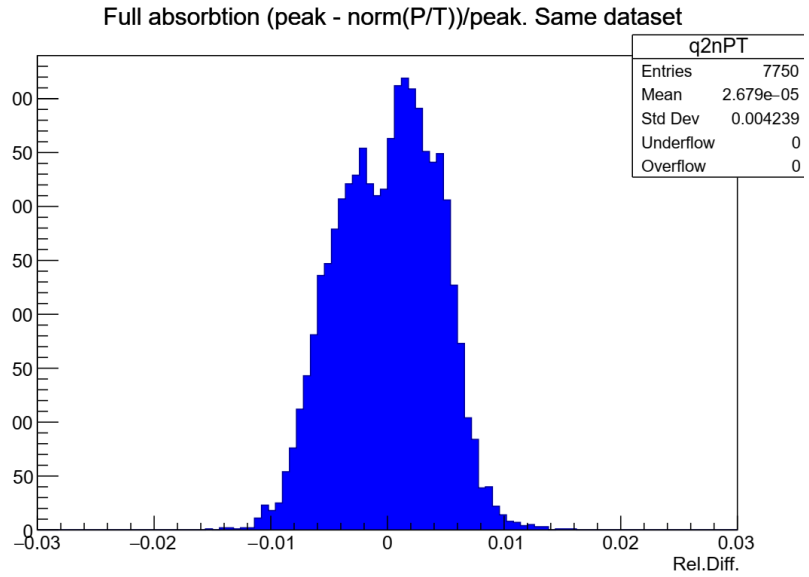


Dependence on separate parameters doesn’t work

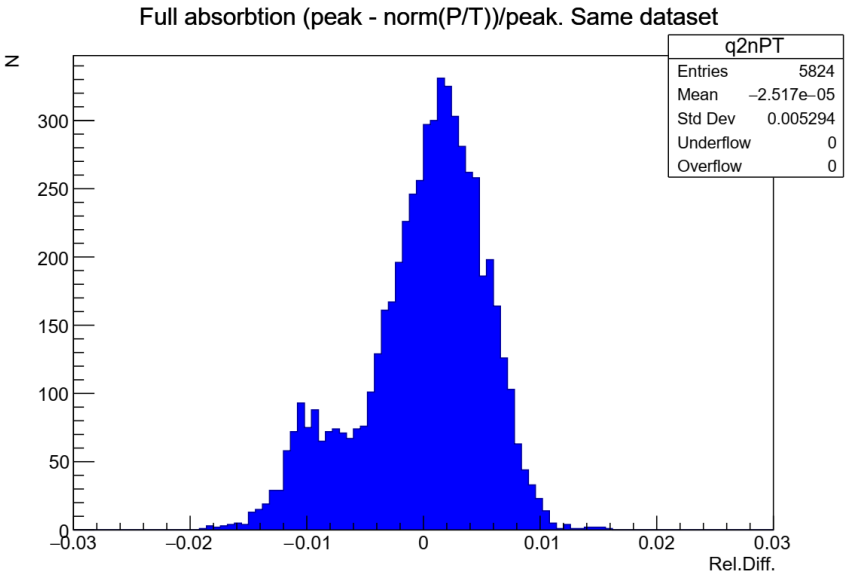
Relative difference between calibration and the measurement for (P/T) function



March 2025



April 2025

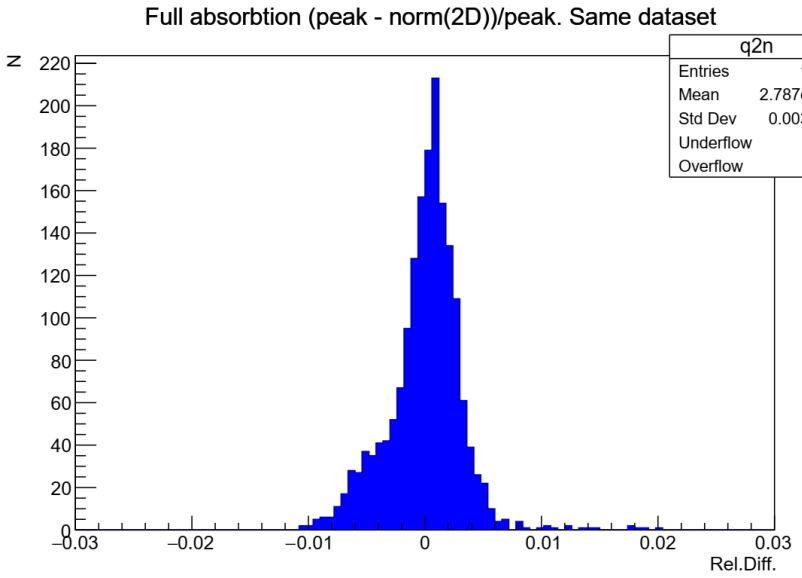


May 2025

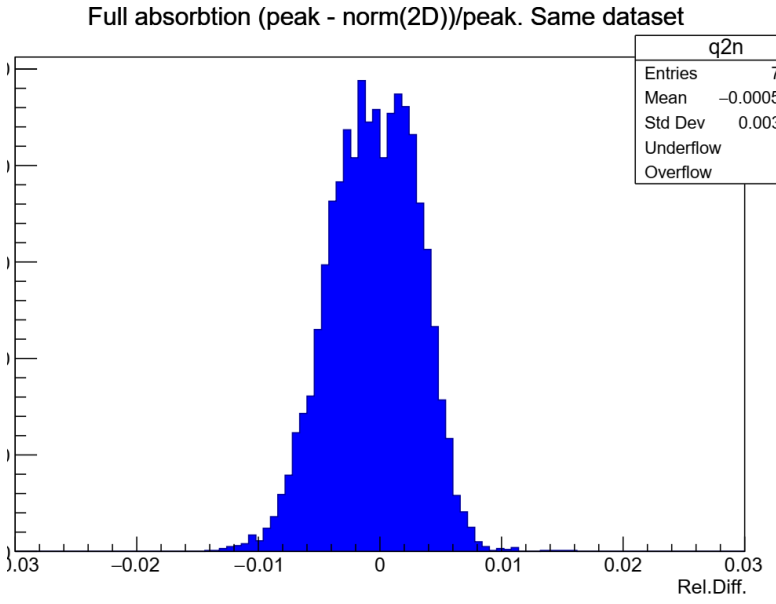
Relative difference. (FA-calibration)/FA. Most of the differences are less than 1%.

We have 3 sets of data. Here we see how data is arranged around its own calibration.

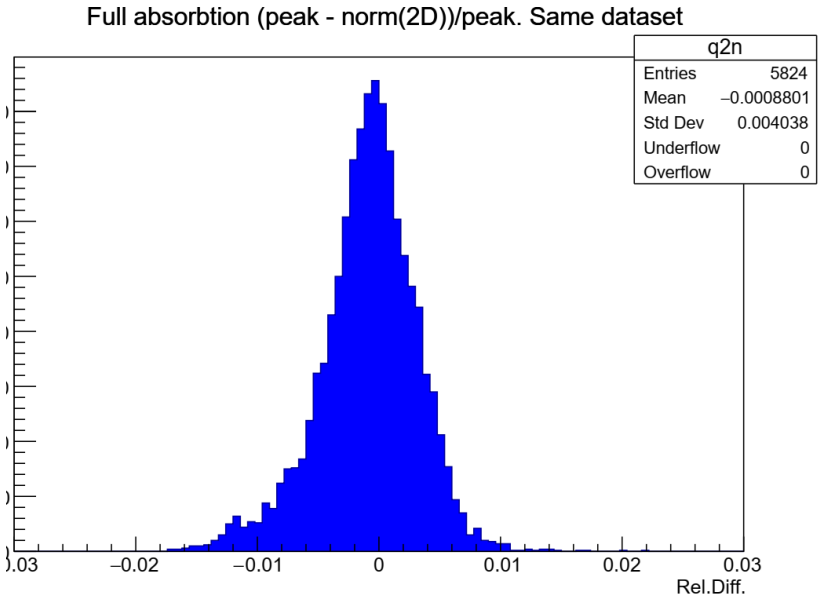
Relative difference between calibration and the measurement for 2D function



March 2025



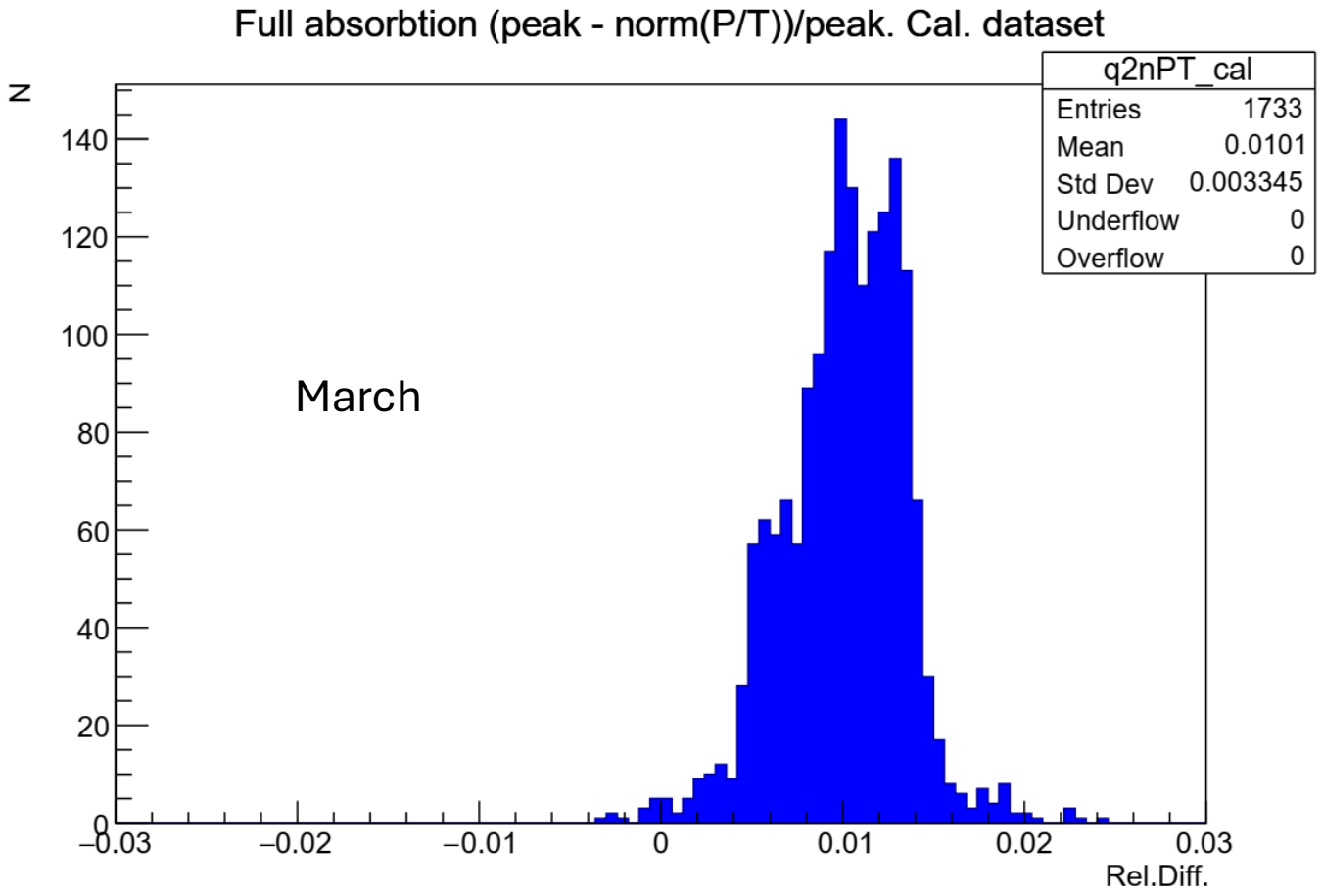
April 2025

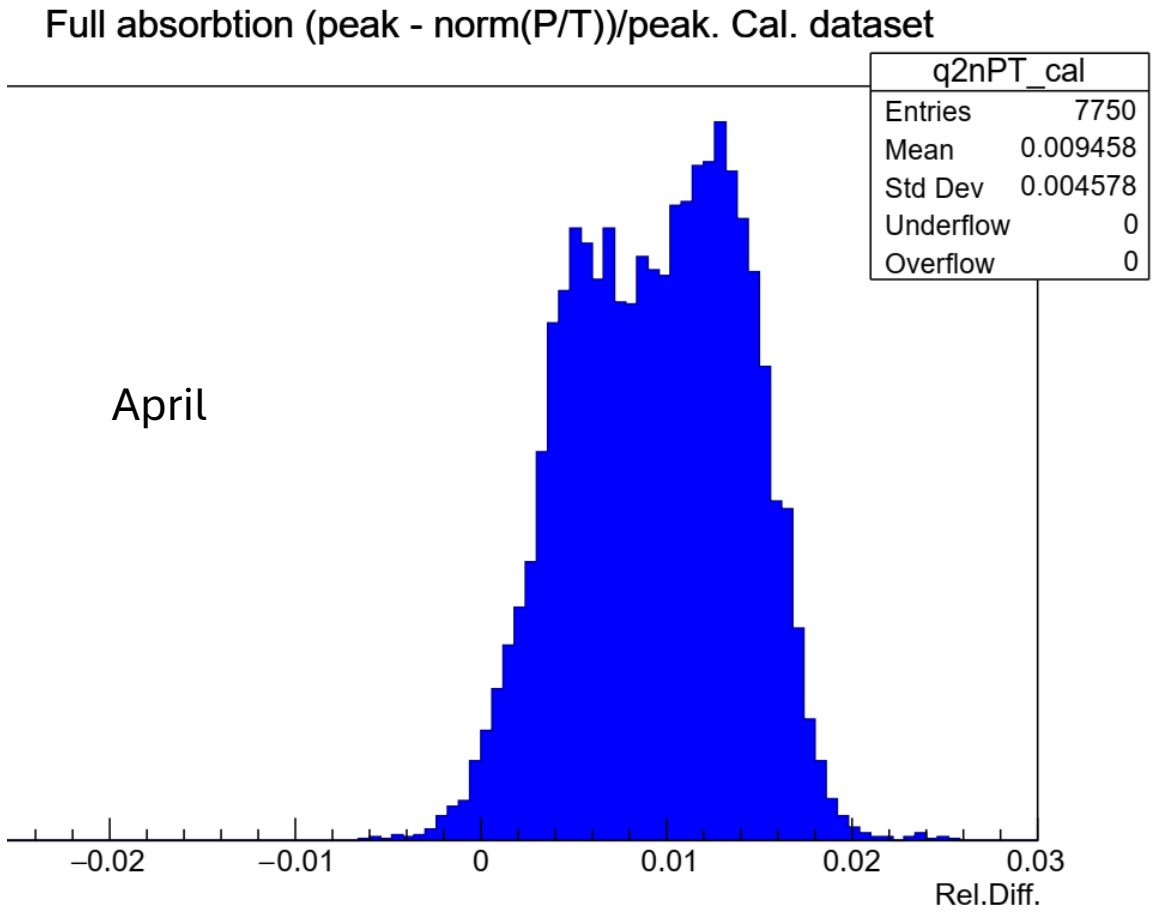


May 2025

Relative difference. (FA-calibration)/FA. Most of the differences are less than 1%.

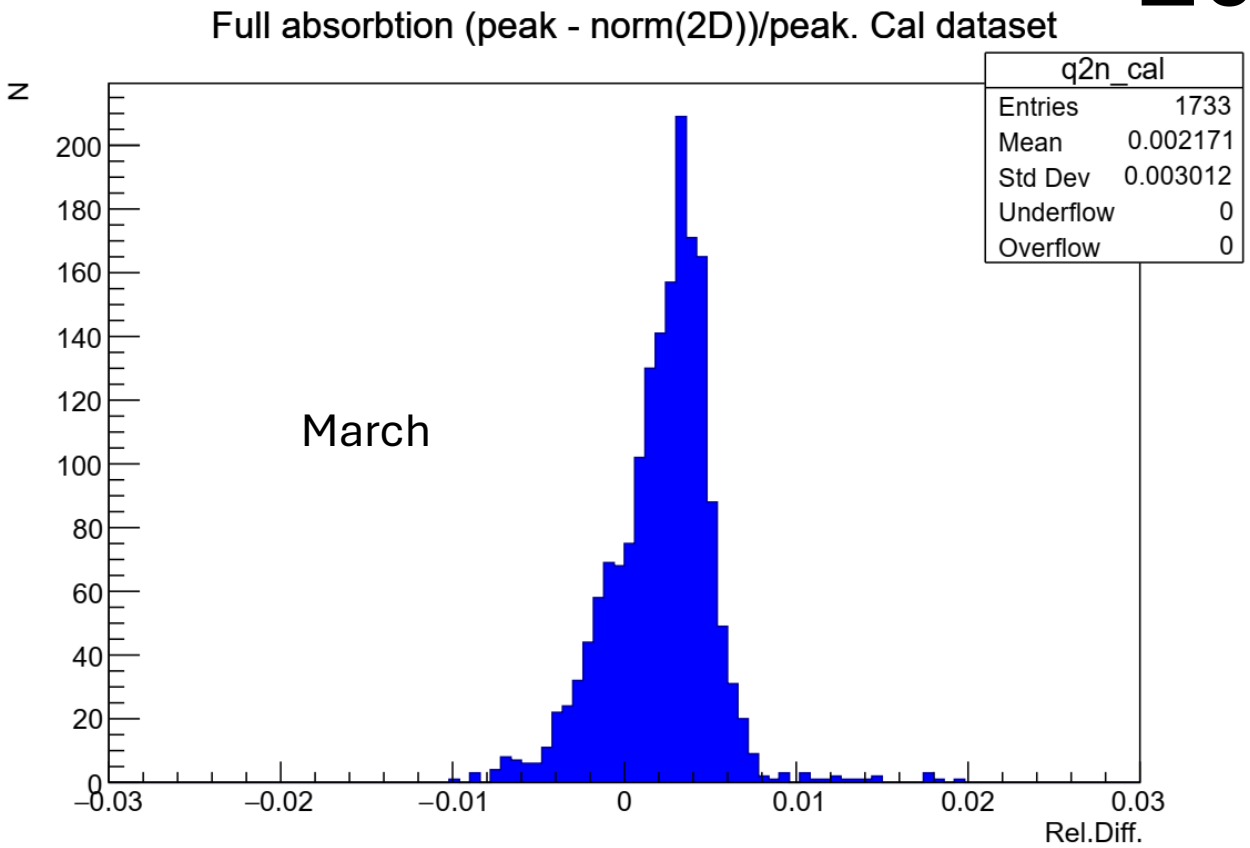
Datasets comparison (P/T). Reference is May 2025

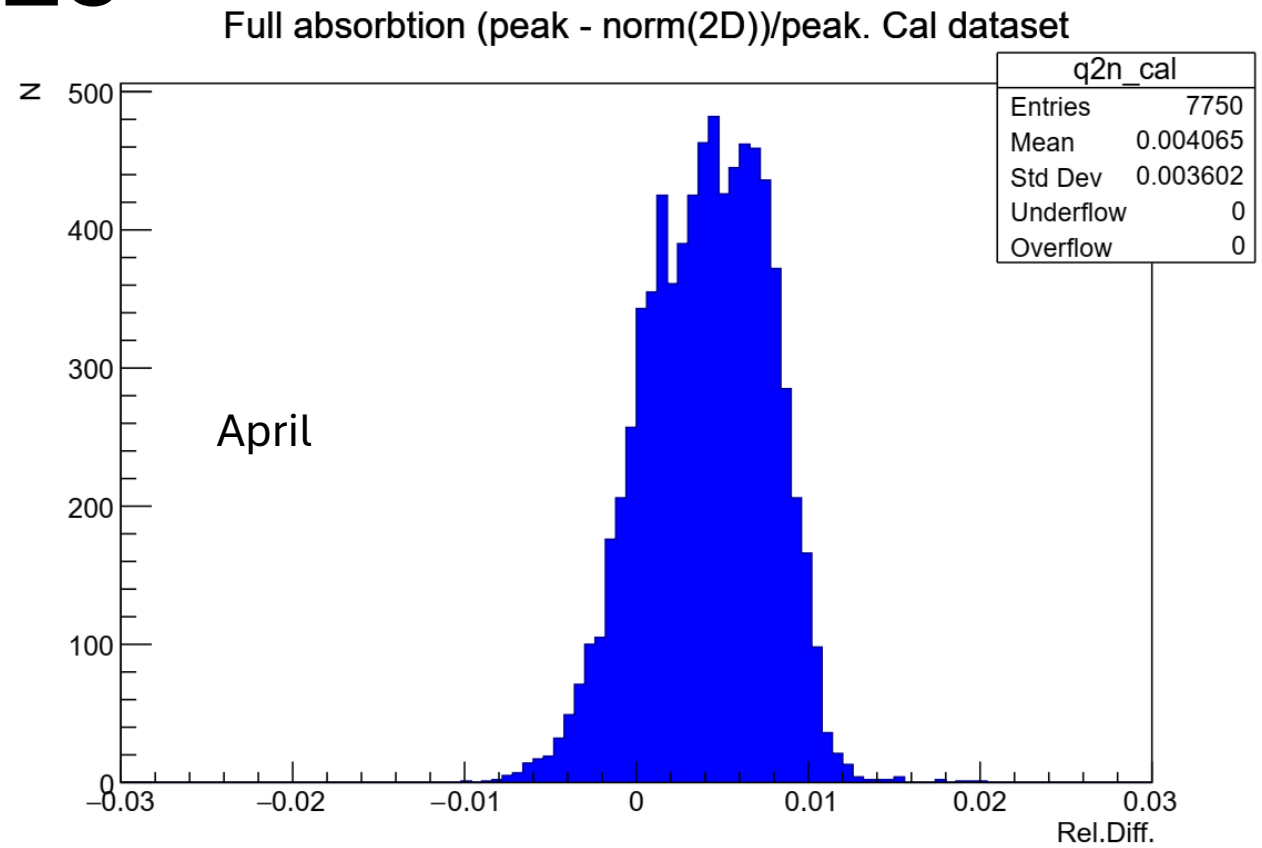




Relative difference distribution around May calibration 1D function

Datasets comparison 2D. Reference is May 2025

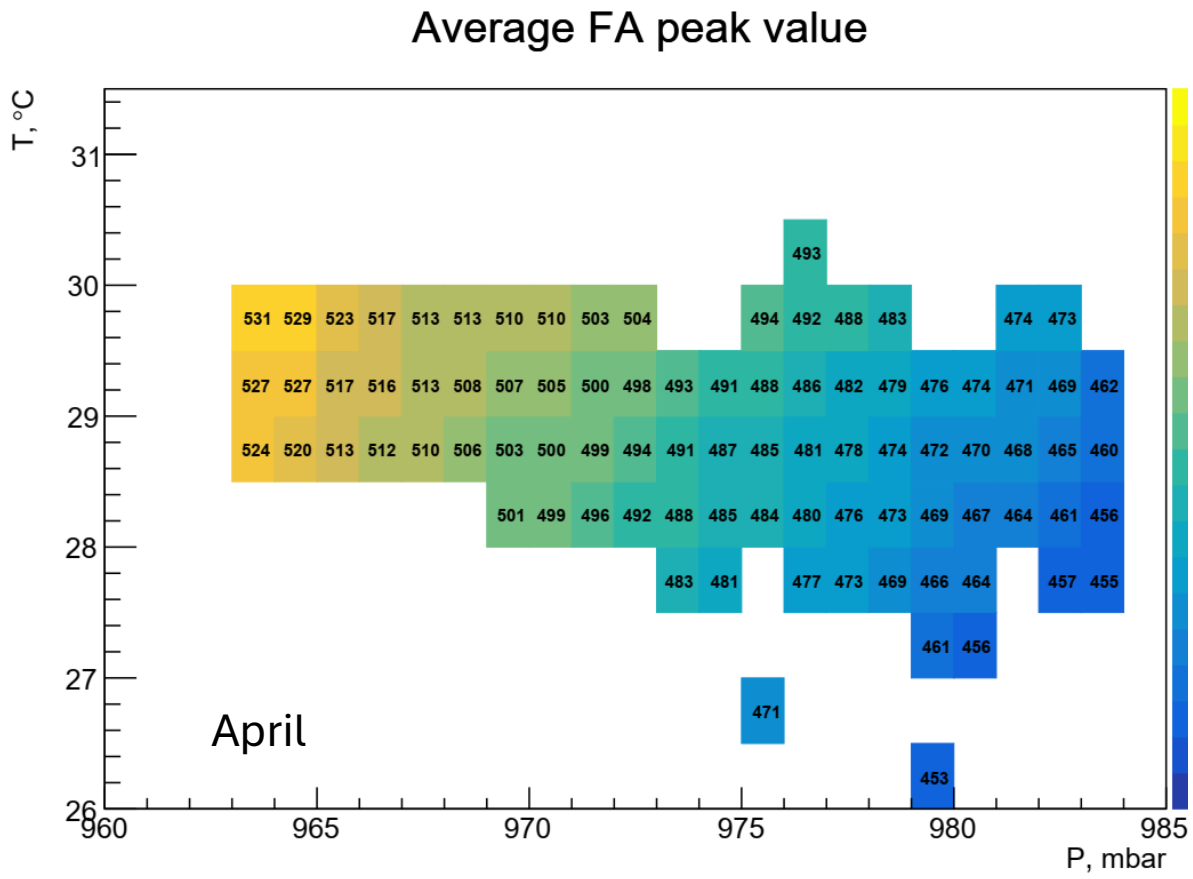


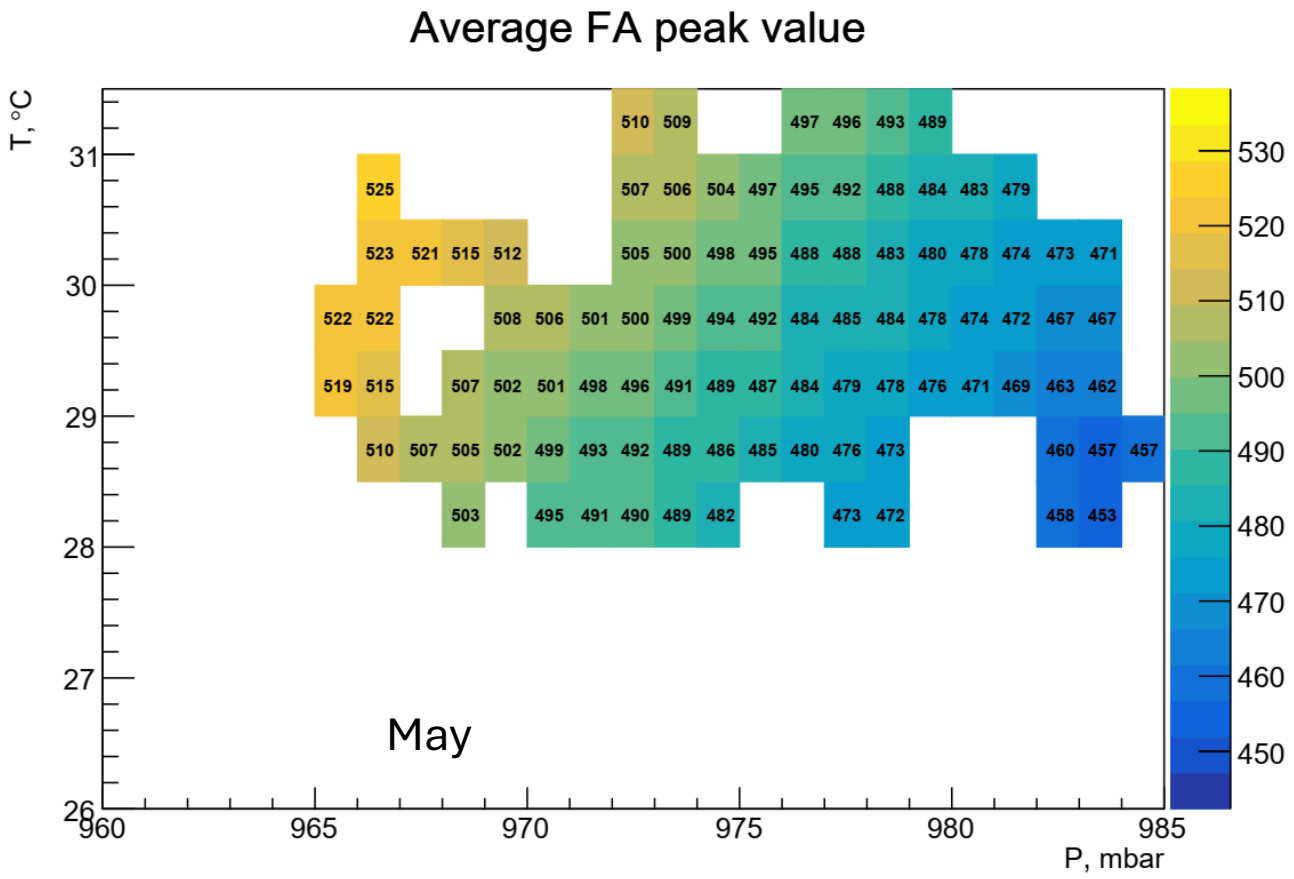


Relative difference distribution around May calibration 2D function

Shift of the mean value is less than for P/T calibration

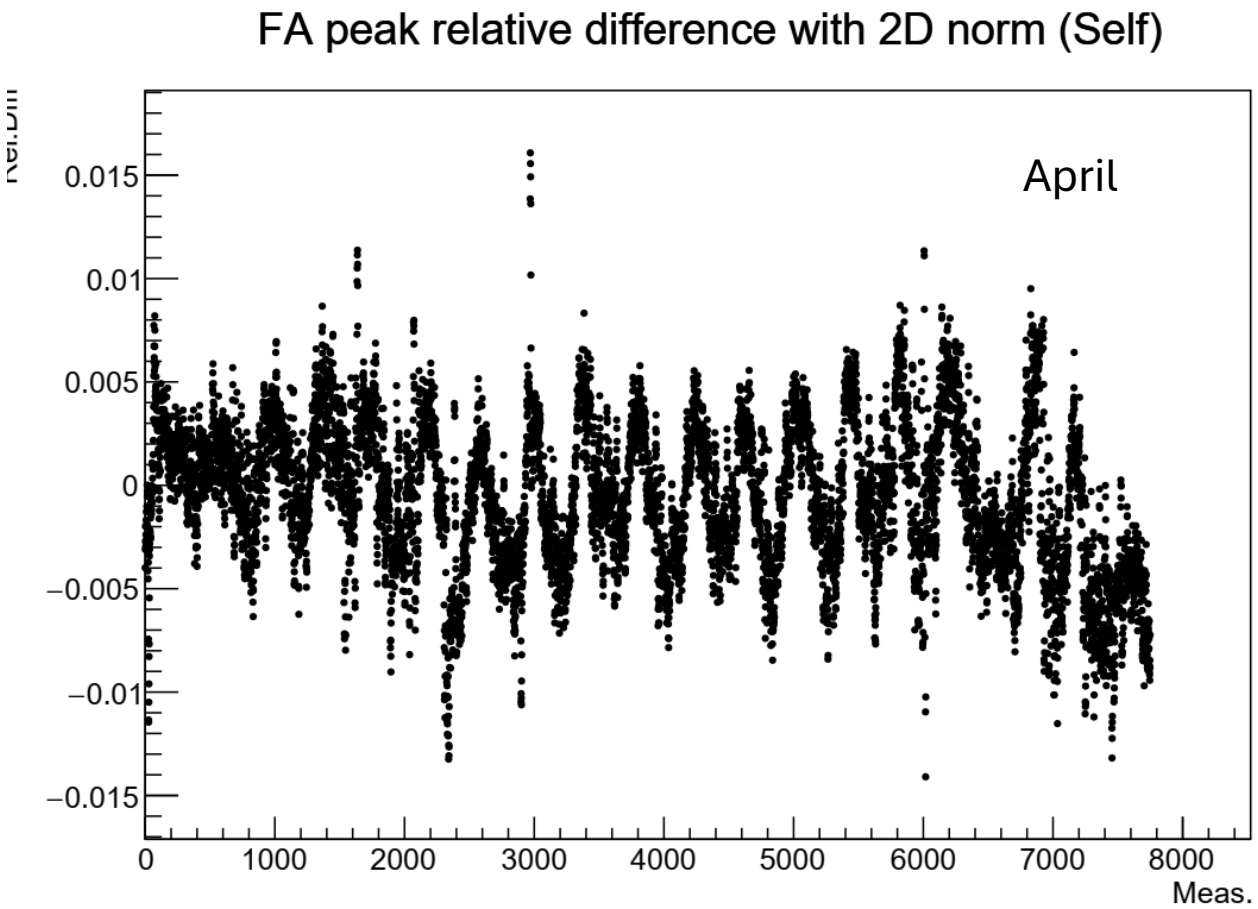
Difference of datasets





Mean values on the previous plots are not zero because conditions were slightly different.

Relative difference VS time

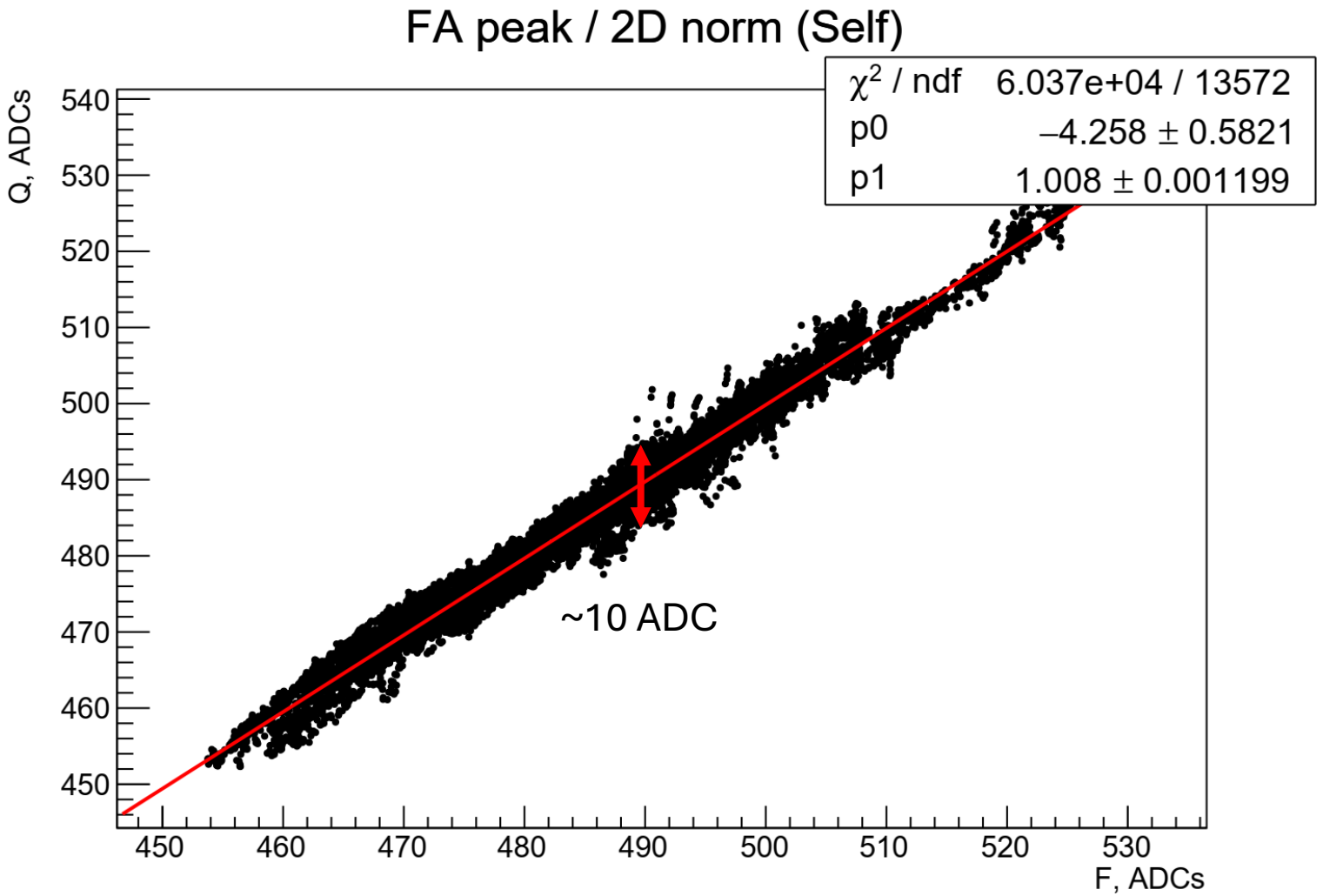


(FA peak – calibration)/(FA peak) dependence on time. X-axis is a measurement number, as we have some periods of lost data.

Distribution is within ±1%

We can see regular variations over time. This is correlated with daily temperature variations. Probably this is the influence of temperature on readout electronics.

FA peak – Calibration correlation



Slope is almost 1. Width is ±1%.

Conclusion

- We propose an algorithm for the calibration of gas gain monitor
- Variations of the data around calibration function is about ±1%
- Plans:
  - Investigate daily variations in gas gain due to temperature
  - Implement comparison of the calibration with new data into online monitoring
  - We are building a new version of the device