Aachen Gas Laboratory

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DUNE-TUNE Meeting

07.07.20

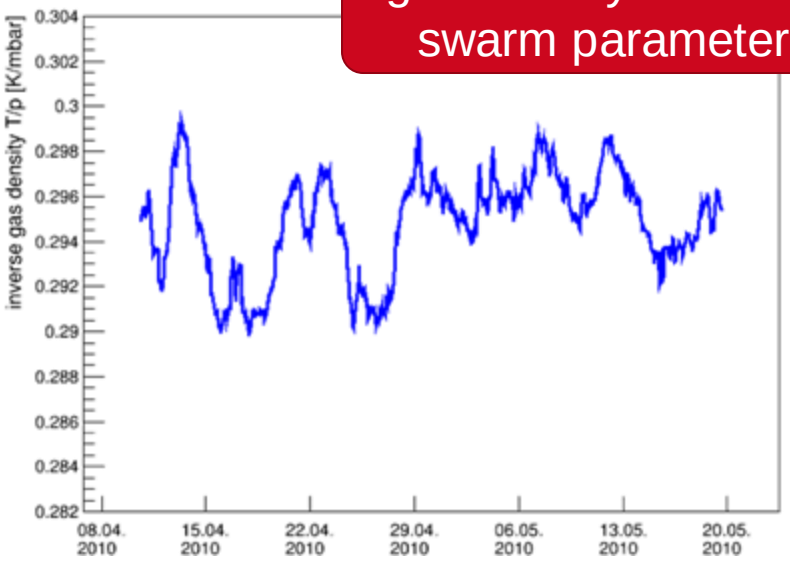
III. Physikalisches Institut B
RWTH AACHEN UNIVERSITY

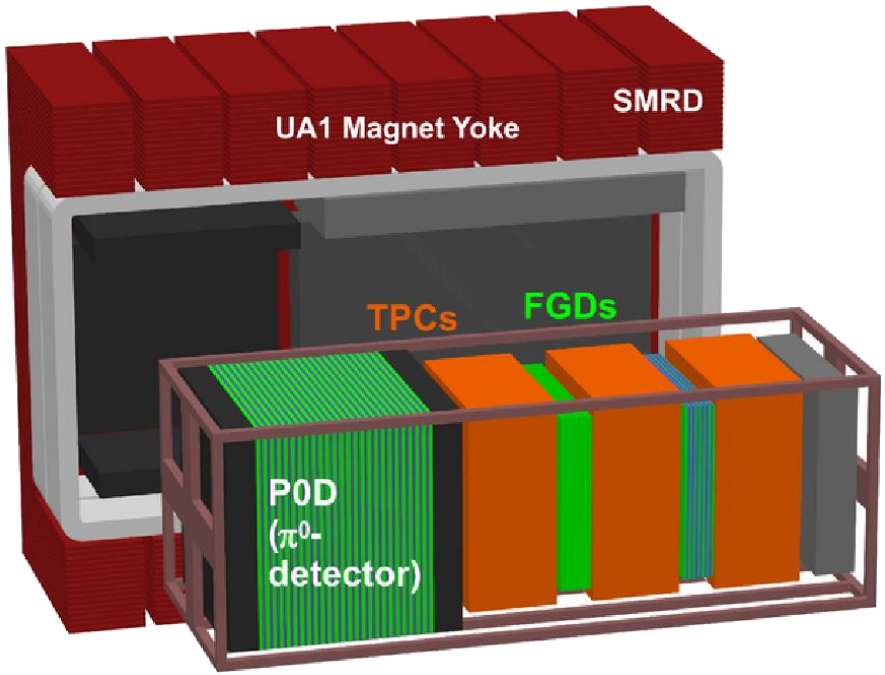
Calibration for TPC in T2K

Continuous gas calibration of (atmospheric) TPCs in ND280

- Near Detector ND280
- Among others: 3 atmospheric TPCs
  - Environmental pressure
  - Surrounding detector's temperature
  - Changing supply gas quality

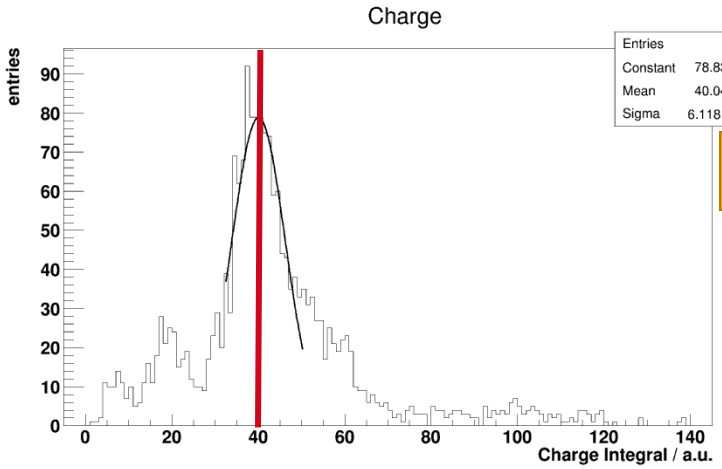
gas density affects all swarm parameters





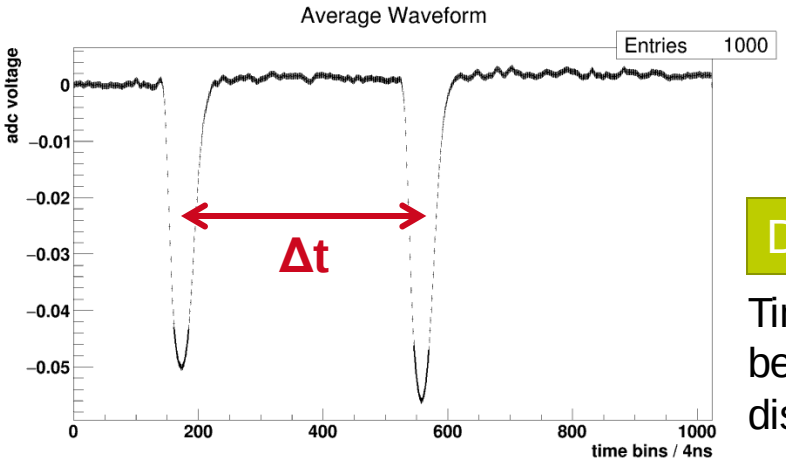
Gas Monitoring System: Gas Monitoring Chambers

Identical Chambers for Supply and Return Flow



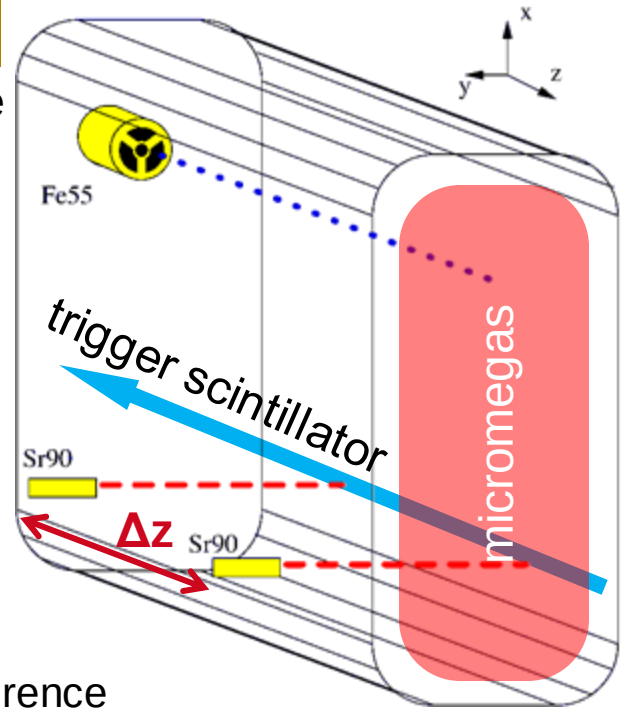
Gain Measurement

Collect amplified charge from defined primary deposition



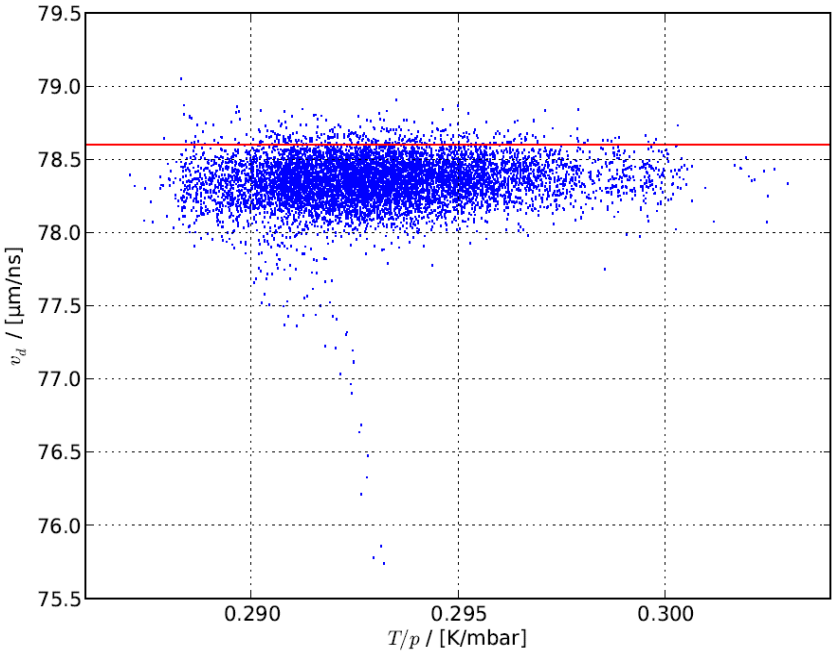
Drift Velocity

Time of arrival difference between tracks of defined distance

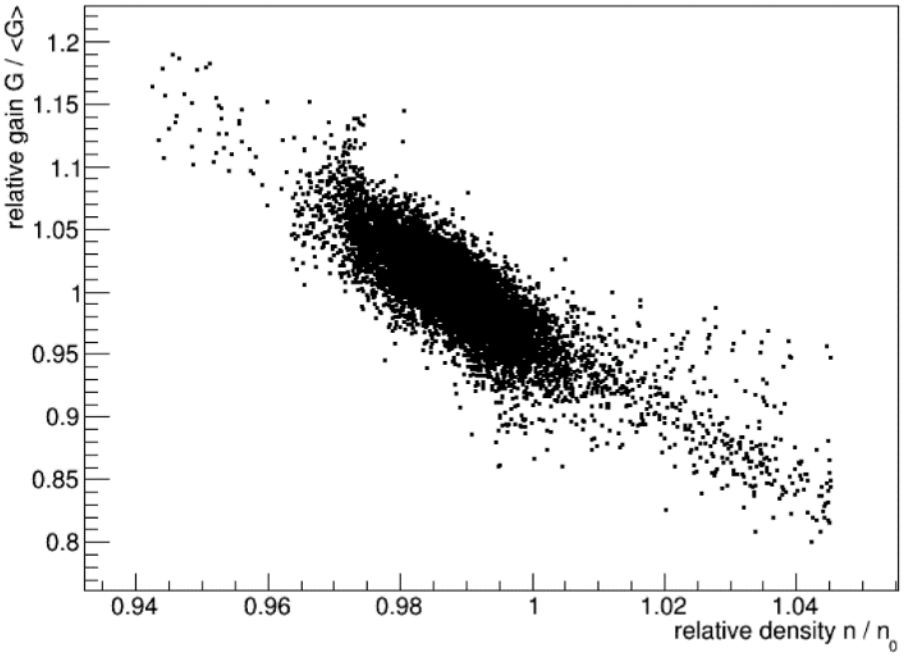


Raw T2K Calibration Data

- ^{90}Sr beta emitters for creating tracks
- Drift velocity and longitudinal diffusion



- ^{55}Fe x-ray source for point-like clouds
- Relative gas gain and transverse diffusion



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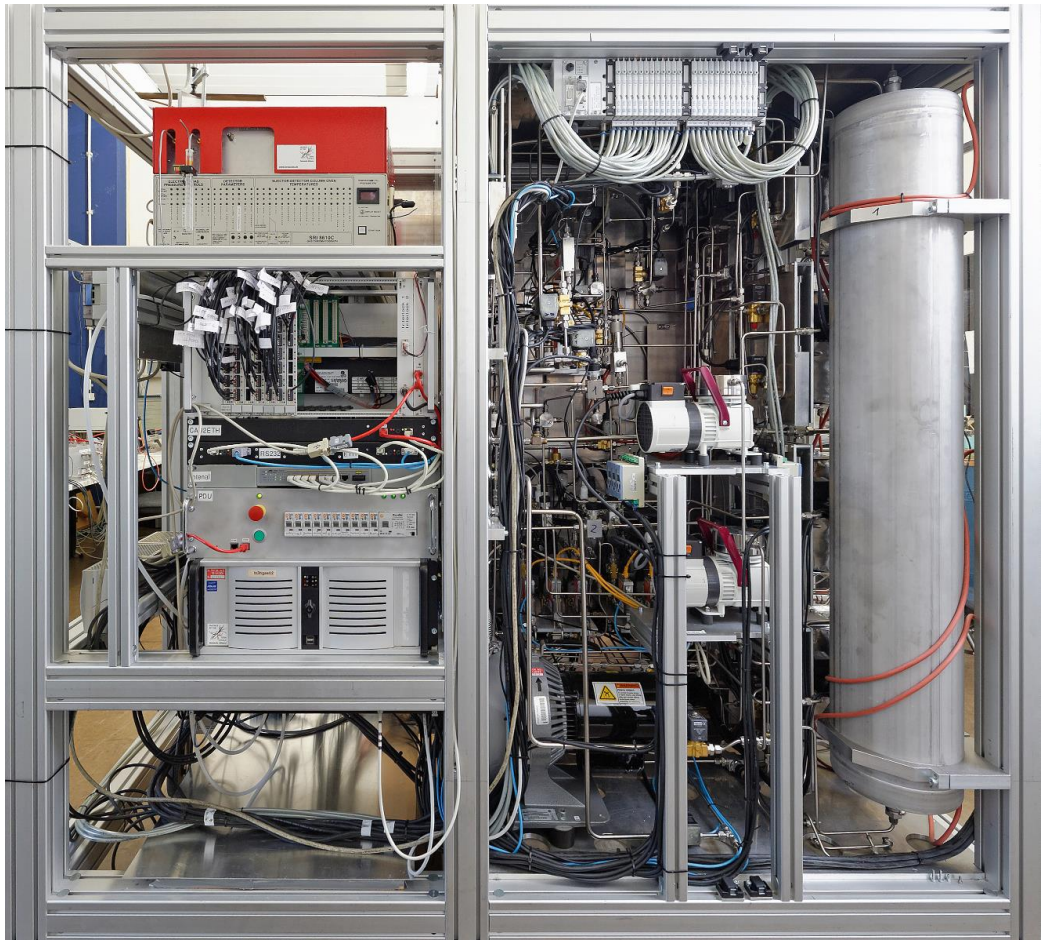
Universal Gas Mixing Apparatus

Mixing from up to 3 gaseous components

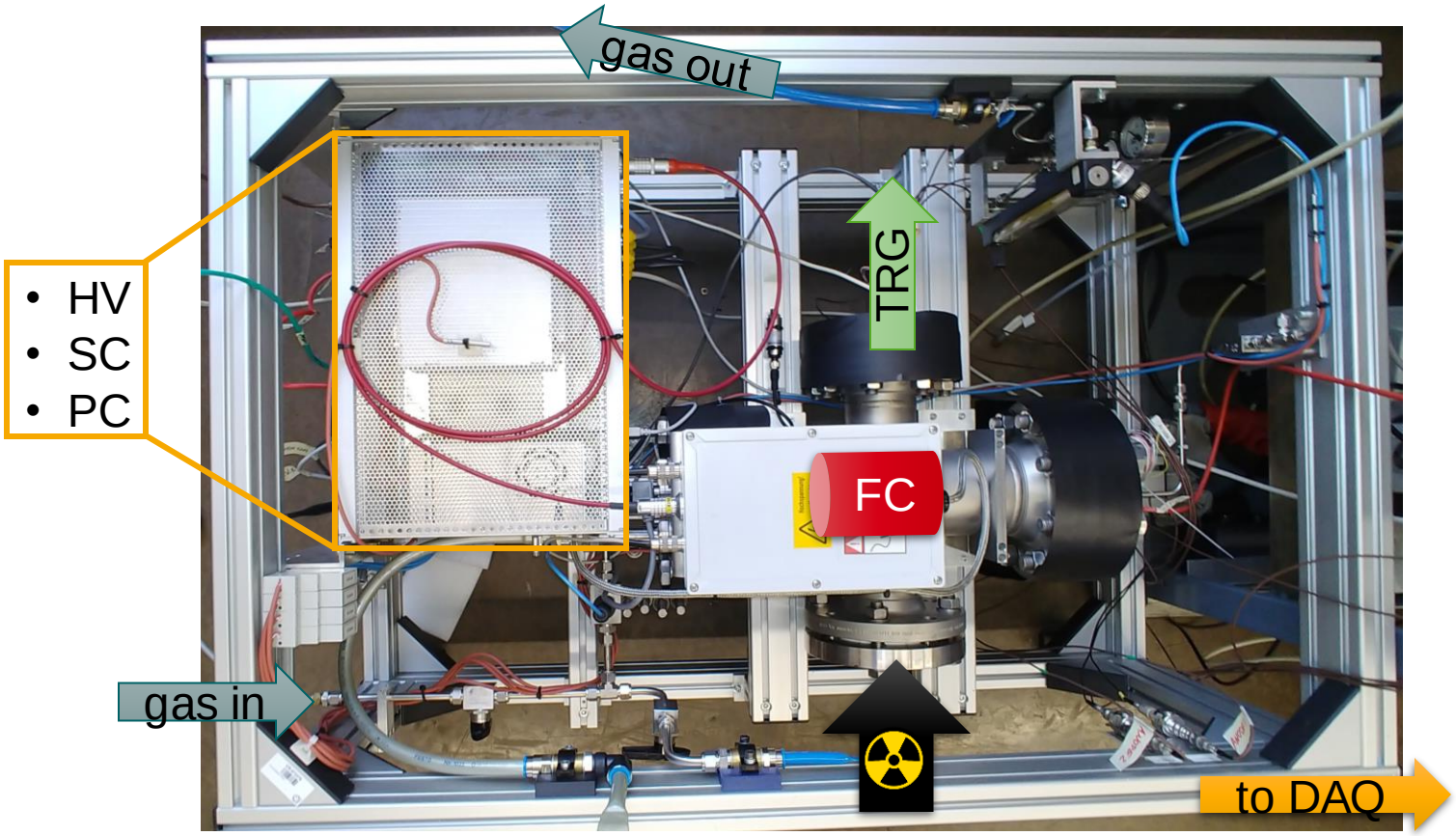
- Flow rate from <1 ln/h to ~200 ln/h
- Partial pressure or parallel flow mixing
- Closed and open loop possible
  - No recovery
  - Generally run in open mode
- Mixing uncertainty <0.1 vol%

Fully autonomous operation, weeks long – or until gas supply empty.



arXiv:2005.03636

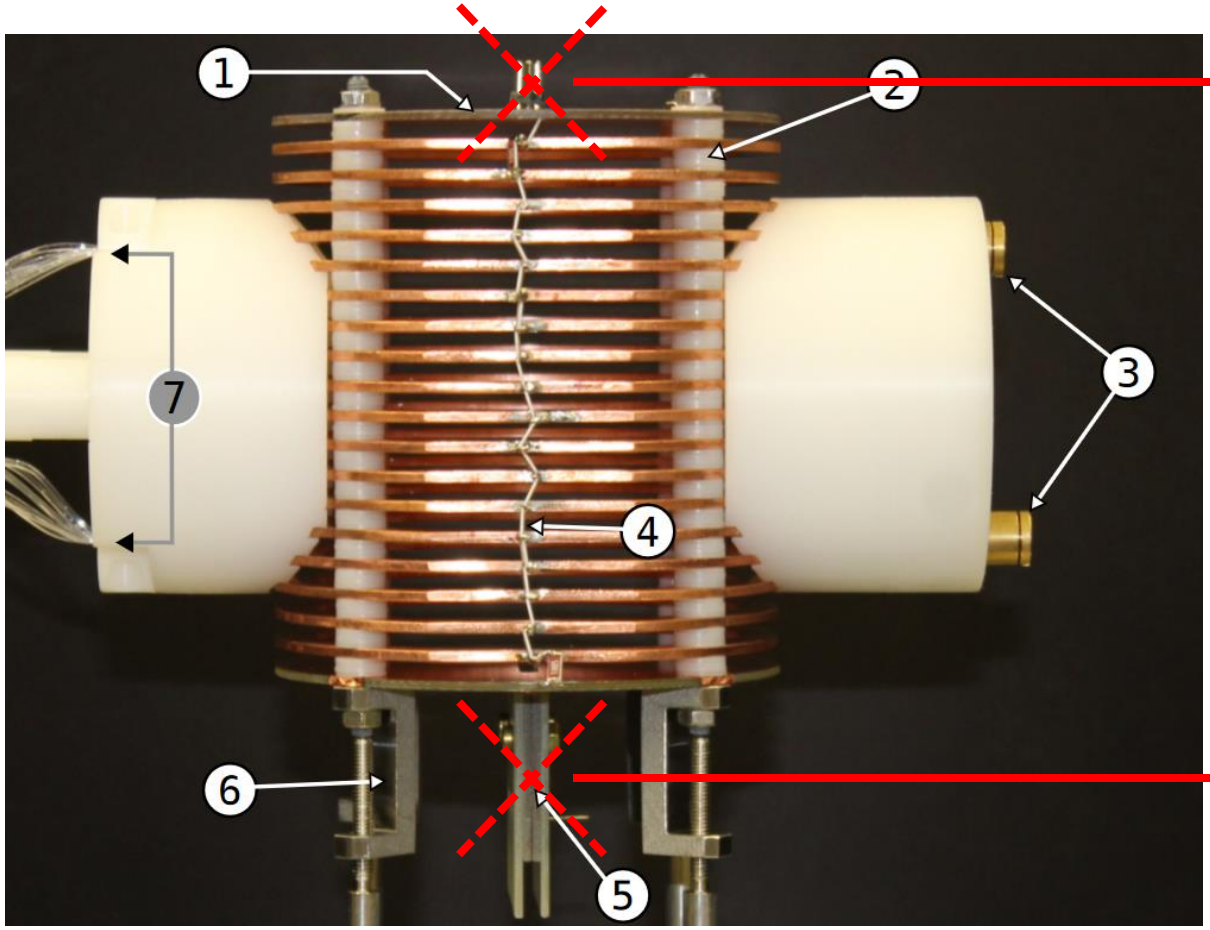
High Pressure Gas Monitoring Chamber (HPGMC)

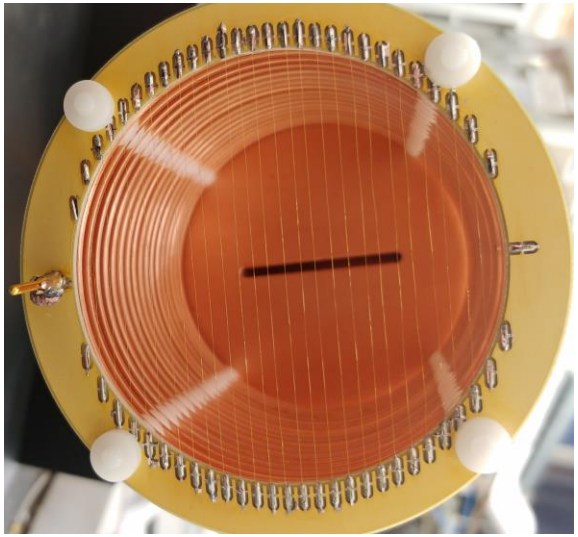


- Maximum operation pressure 10 bar
- *Basket* contains most electronics
- Pressure and temperature monitored
- Supply from pre-mixed bottle gas
- External DAQ crate

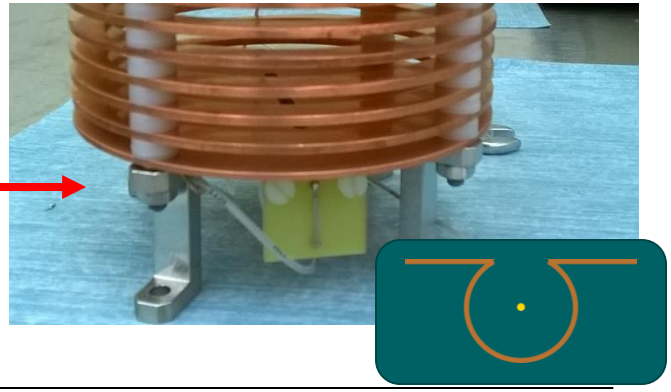
Components Inside Pressure Vessel

Fieldcage as Reference for ^{90}Sr and Trigger





- transparent cathode
- single wire anode

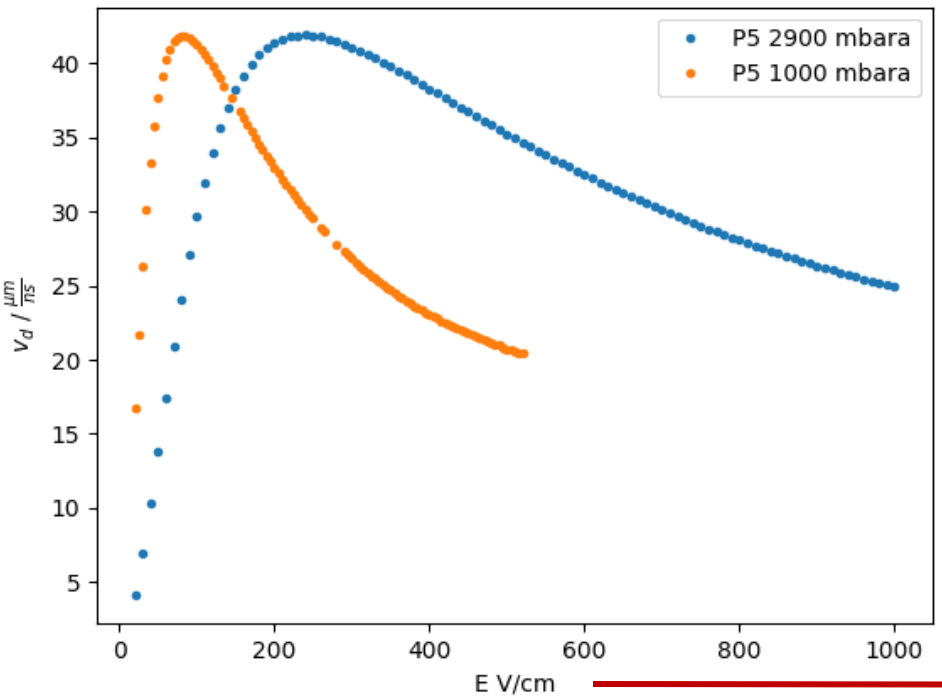


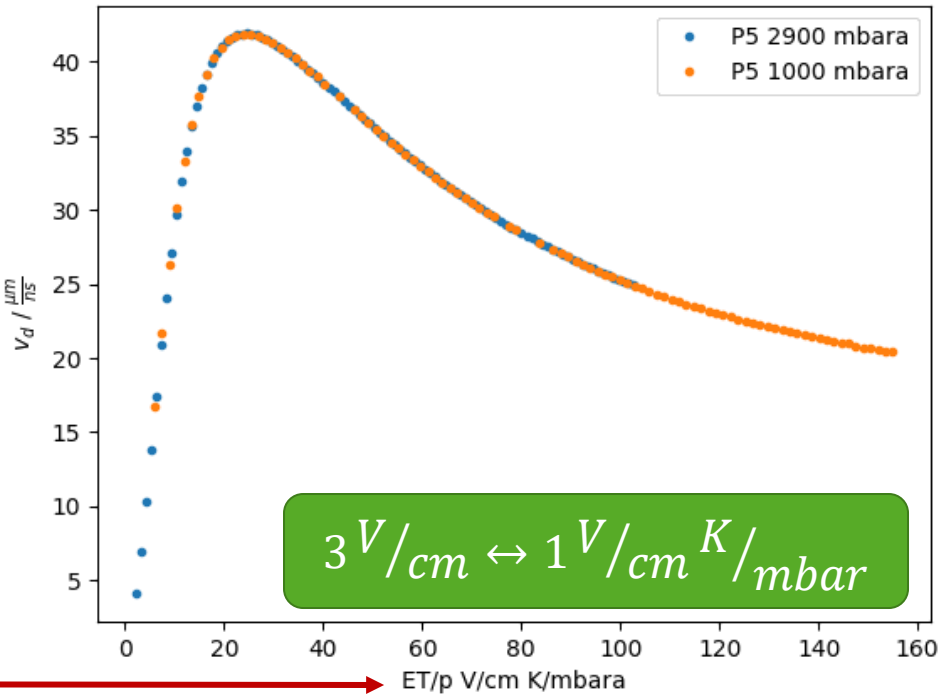
Pressure Scaling

- Gas density affects electron propagation
  - reduces gain at constant voltage
  - shifts drift velocity curve
  - shifts and scales diffusion and amplification
  - e.g. Ar, N_2, CH_4, CF_4, CO_2, …

Drift field and gas parameters	Density correction
Electric field strength	$^{ET}/_{P}$
Drift velocity	v_d
Diffusion coefficients	$\sigma_{\mathrm{L,T}} \cdot \sqrt{^{P}/_{T}}$
First Townsend coefficient	$\alpha \cdot {}^{T}/_{P}$

arXiv:2005:05252





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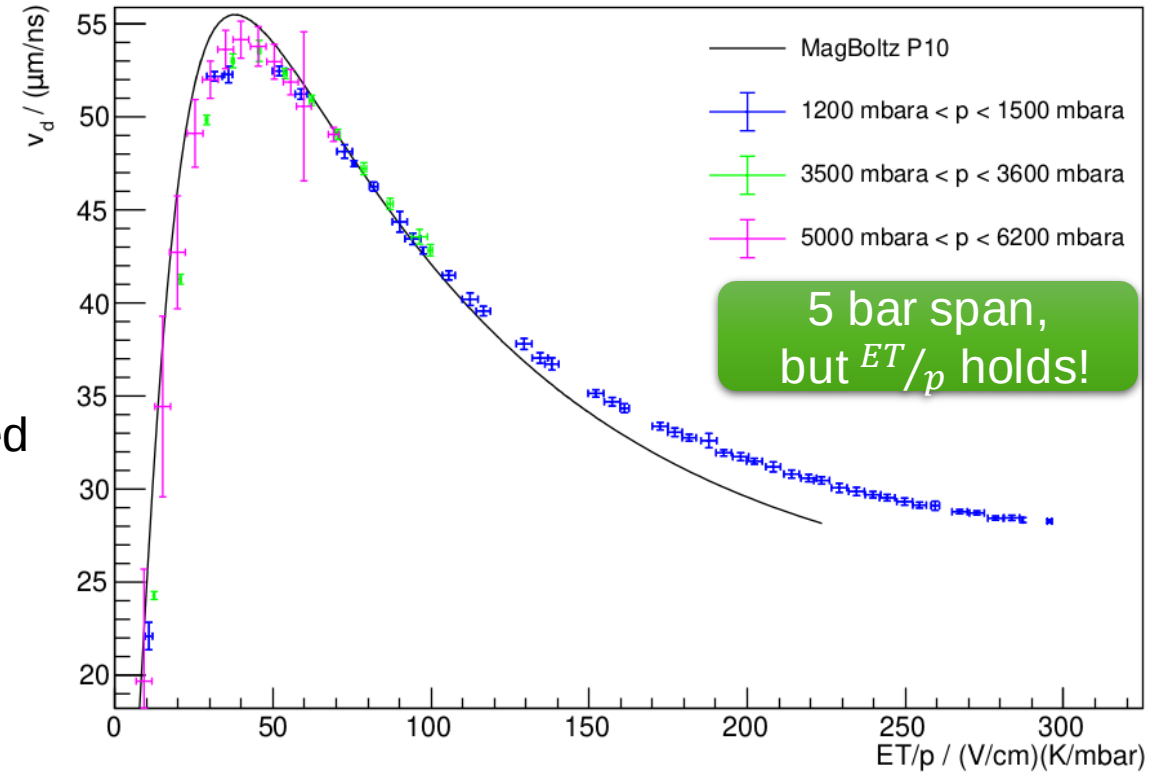
Drift Velocity Measurement with P10

~5% deviation near maximum also seen by e.g. arXiv:1910.06983

- Standard P10 measurement
- Testing of density scaling laws
- Maximum reachable $^{ET}/_{p}$ limited by cathode voltage (*30kV*)

- Same gas source
- Data agrees remarkably well



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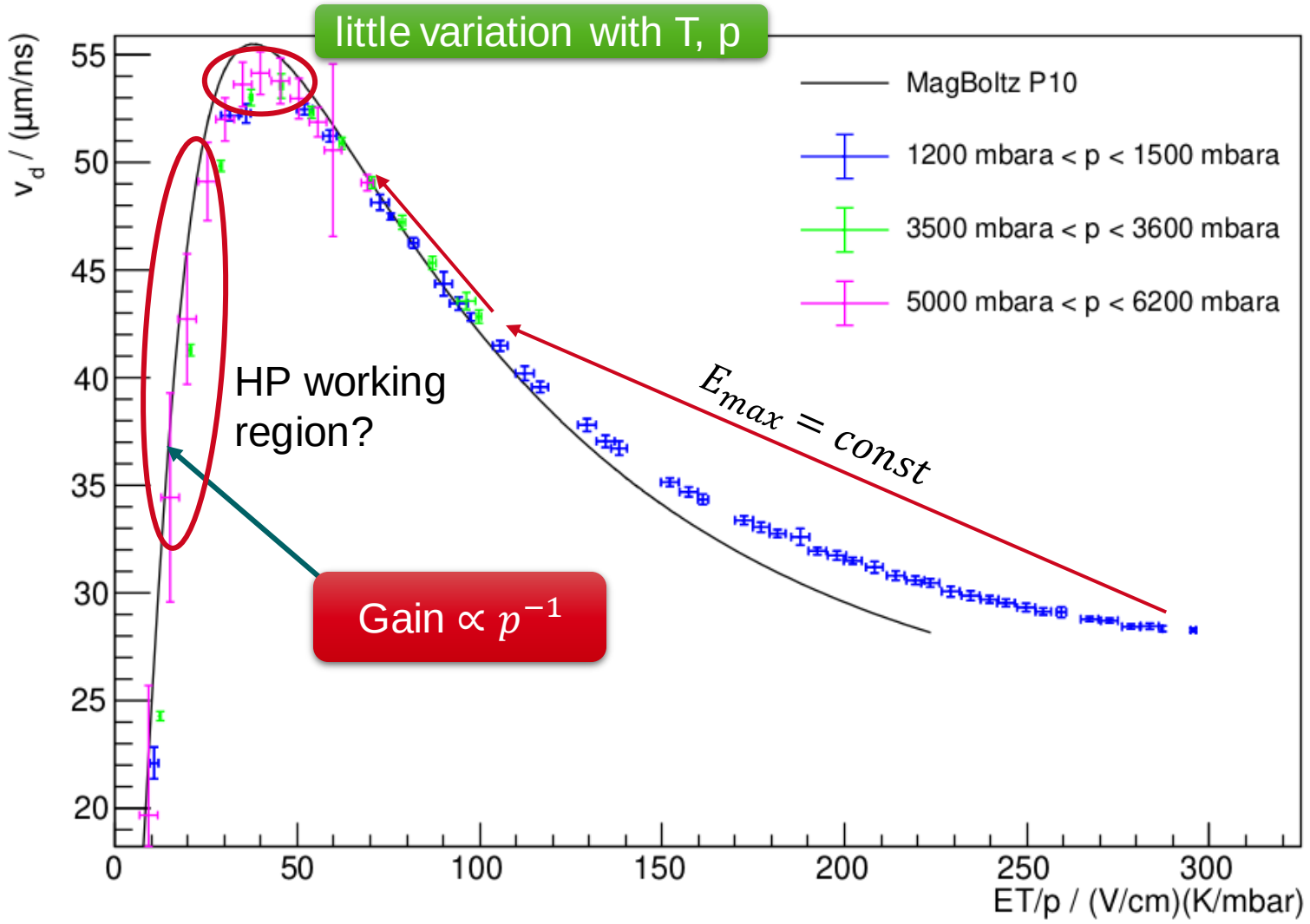


Summary and Outlook

- Lab historically focused on atmospheric pressure gas studies
- Calibration of TPCs

- Online mixing of 3 gas components

- HPGMC as the high-pressure continuation of low-pressure work
  - Any TPC gas up to 10 bar
  - Drift fields tp to 3000 V/cm
  - Currently upgrading to a segmented anode

- Interested in gas studies of Ar:CpHq

Thank you!

Reason why we calibrate: Gas Density

- Most gas related corrections depend on the density of the gas

$$p\,V = N\,R\,T = const$$
$$\frac{p}{T} = \frac{NR}{V} = const$$

  - by using corrections in p/T we can correct for density changes

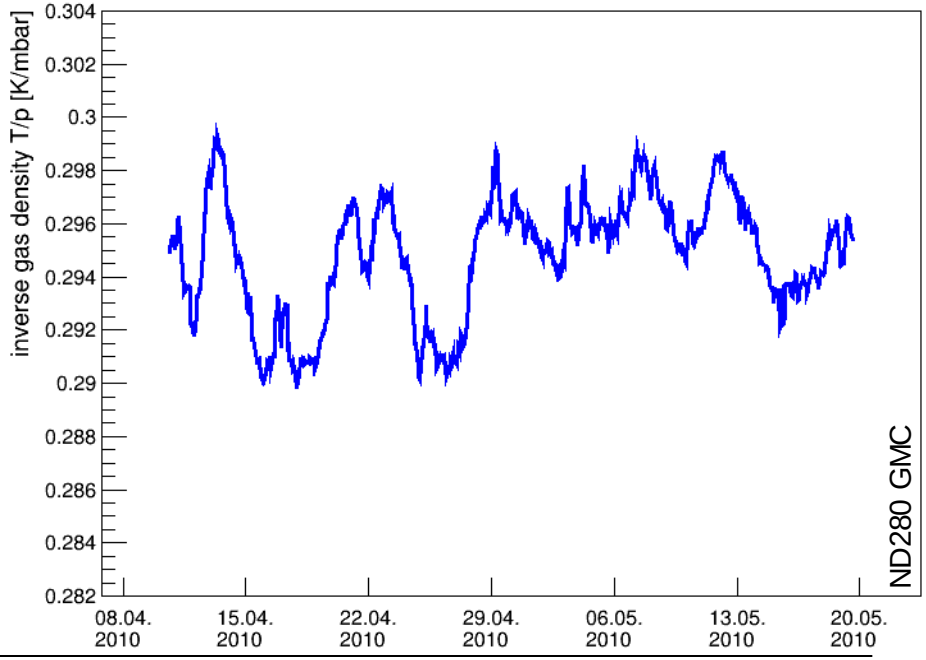
Multiplicative corrections:

$$\frac{p}{T} \cdot \frac{T_0}{p_0}$$

Typically detectors are not controlled in:

- Temperature
- absolute Pressure

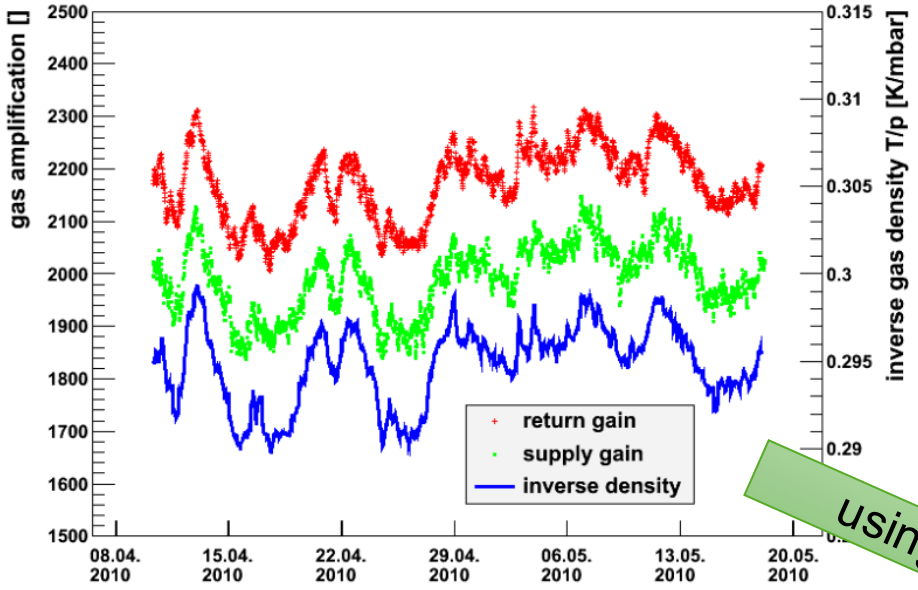
Time depended density changes



Gas Amplification

Density effects

- When looking at the gas amplification over time one observes large changes
- Caused by fluctuations in (inverse) gas density



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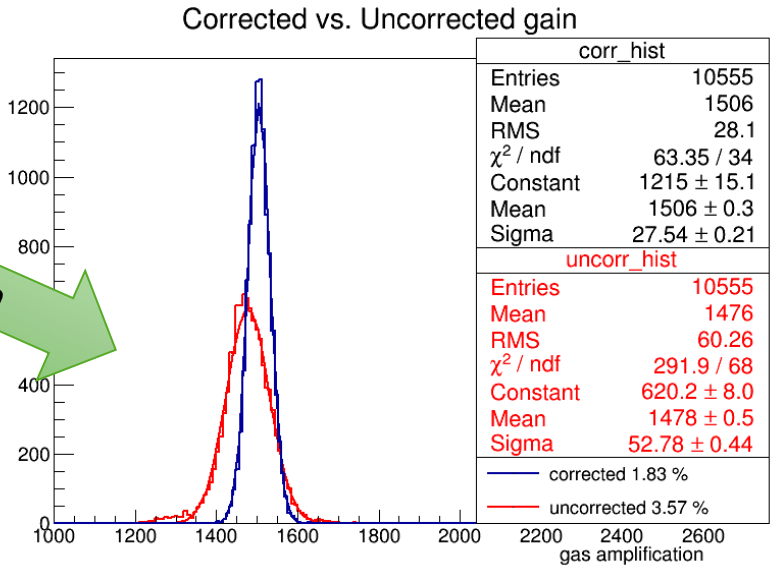

arXiv:1012.0865