



Swarm Parameters in HFO1234ze with a Pulsed Townsend Experiment

Eda A. Egüz, Christian M. Franck

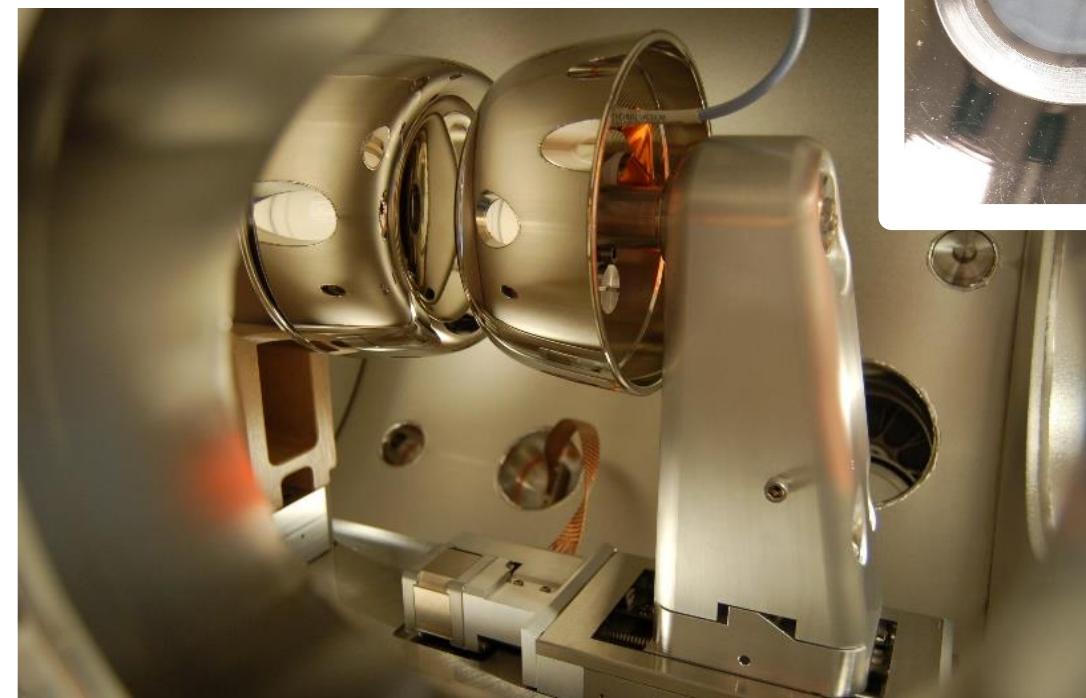
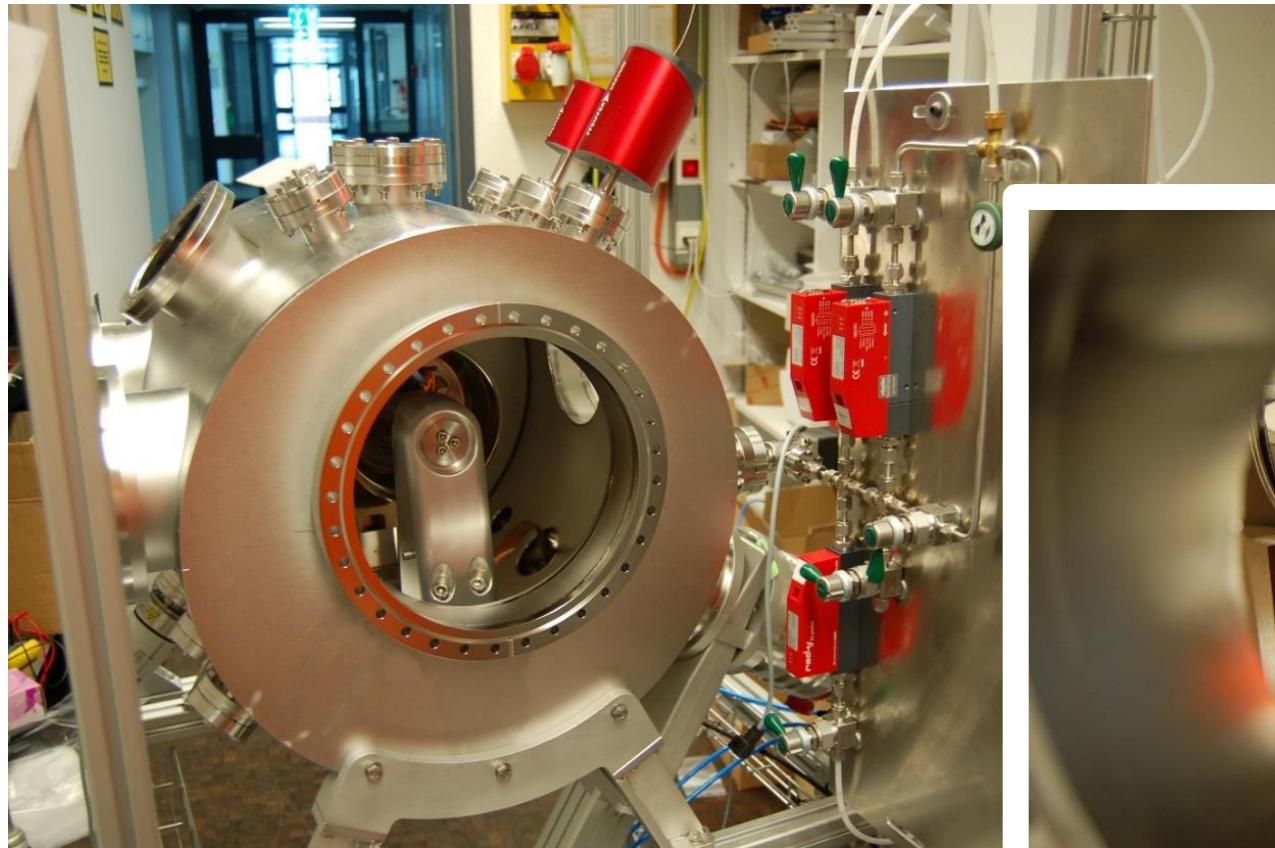
Institute for Power Systems & High Voltage Technology, ETH Zürich, Switzerland

Overview

- Pulsed Townsend experimental setup
- Data acquisition
- Data processing
- Swarm parameters in HFO1234ze

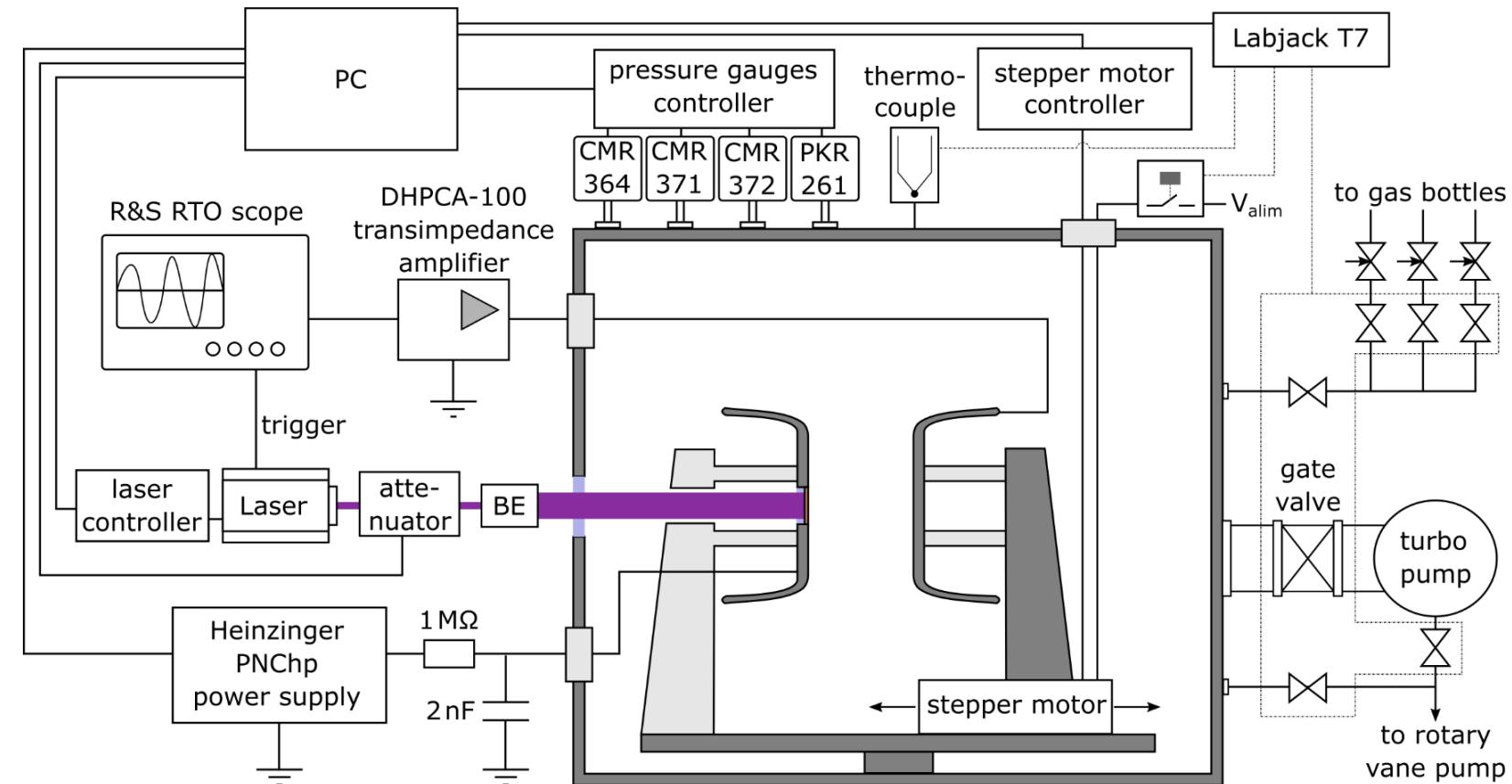
Pulsed Townsend experimental setup

New setup “PT2”



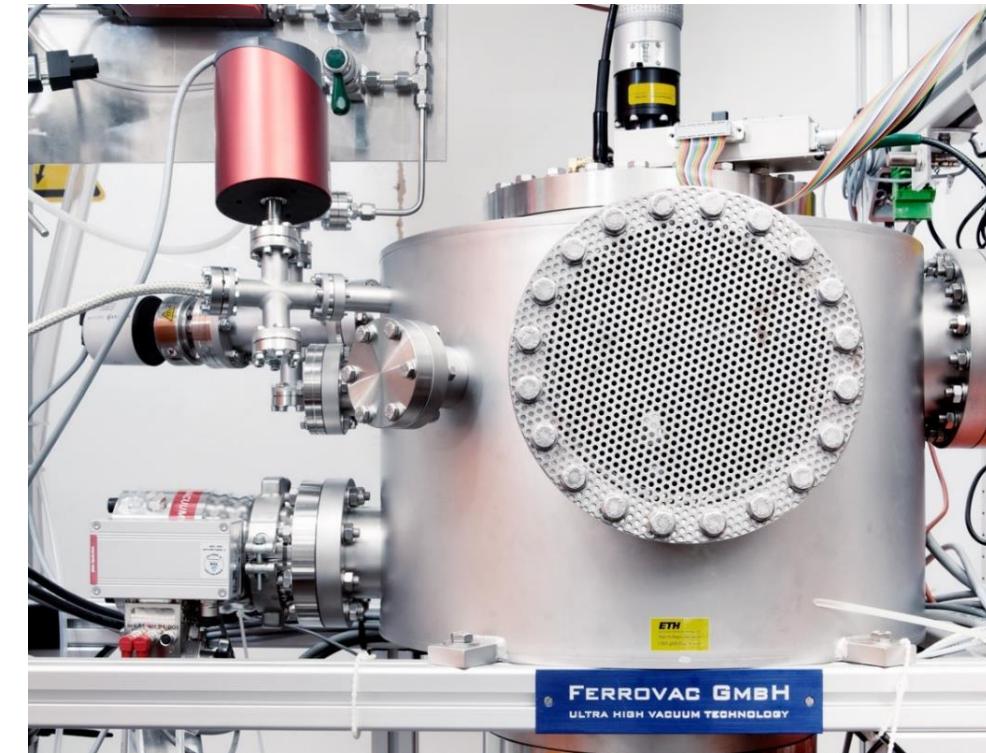
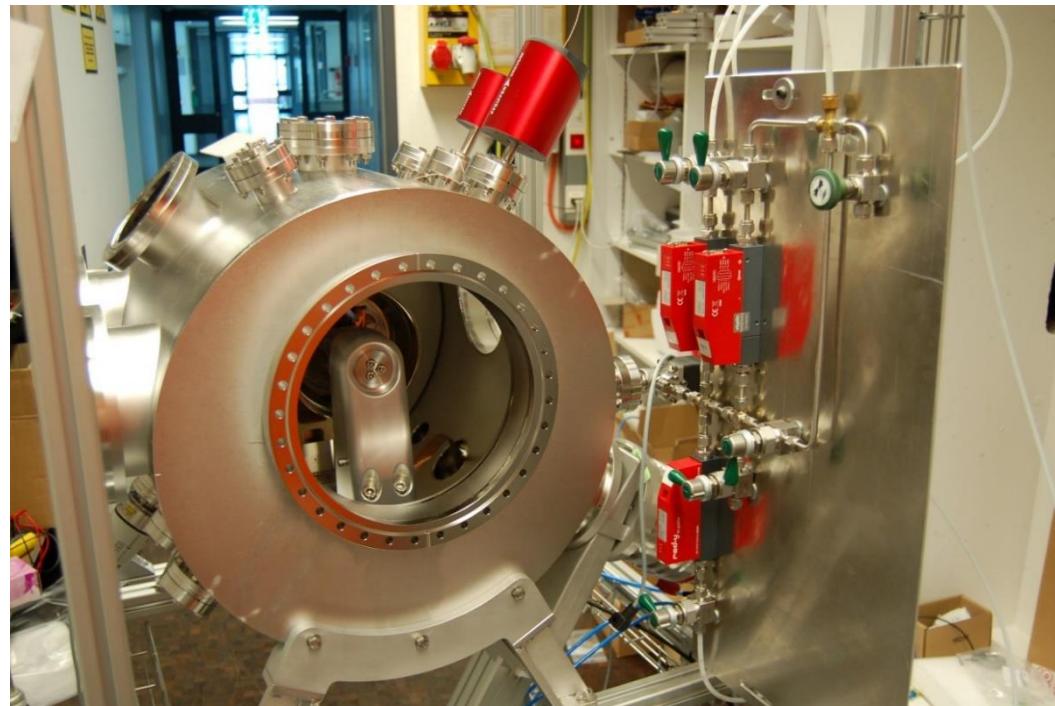
Pulsed Townsend experimental setup

PT2 schematics



Pulsed Townsend experimental setup

“PT2” & “PT1”

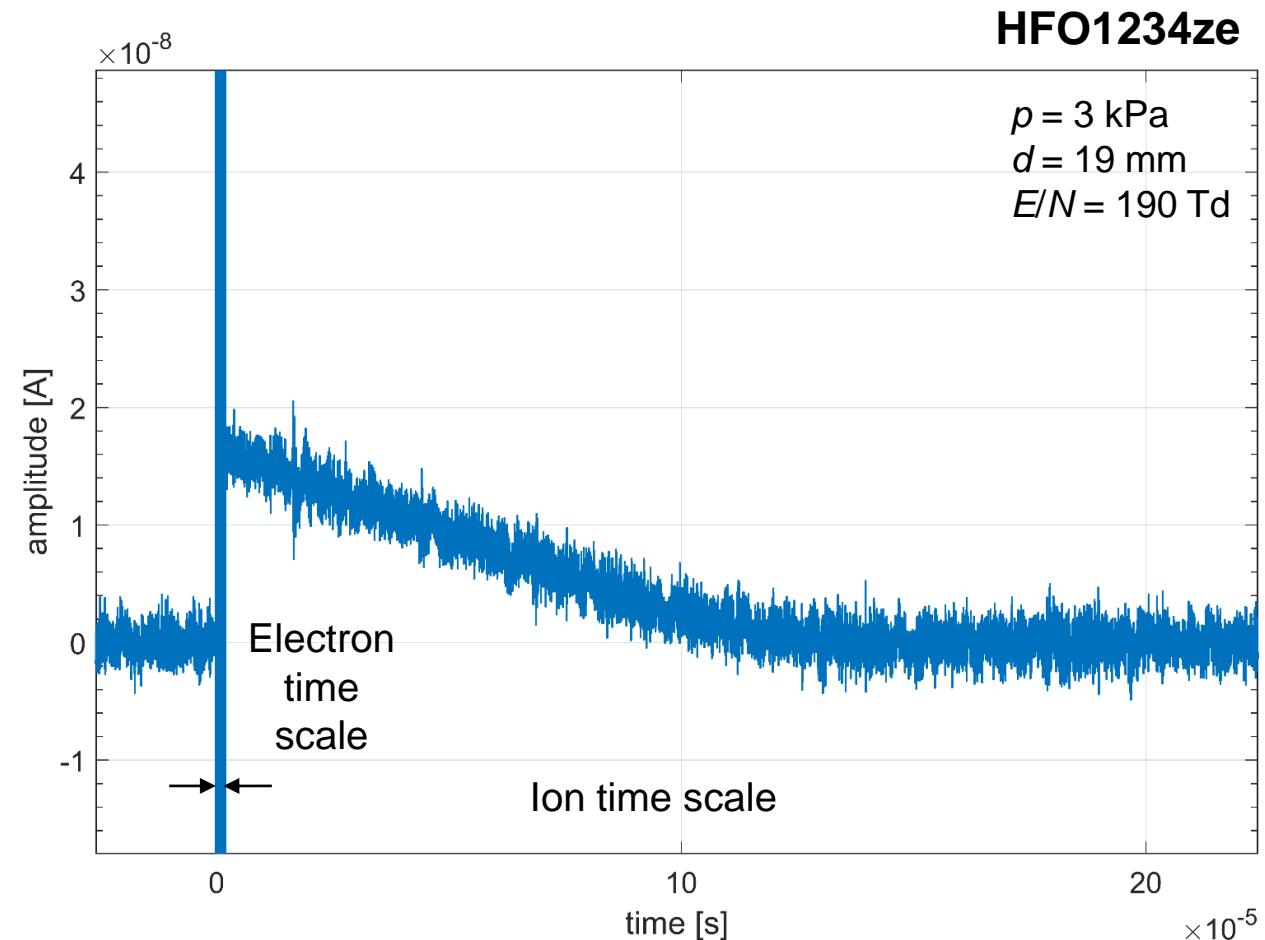


- E/N accuracy: $\pm 0.5\%$
- Lower system bandwidth

Data acquisition

Measured current signal

$$I_{\text{tot}}(t) = I_e(t) + I_{\text{ion}}(t)$$



Data processing

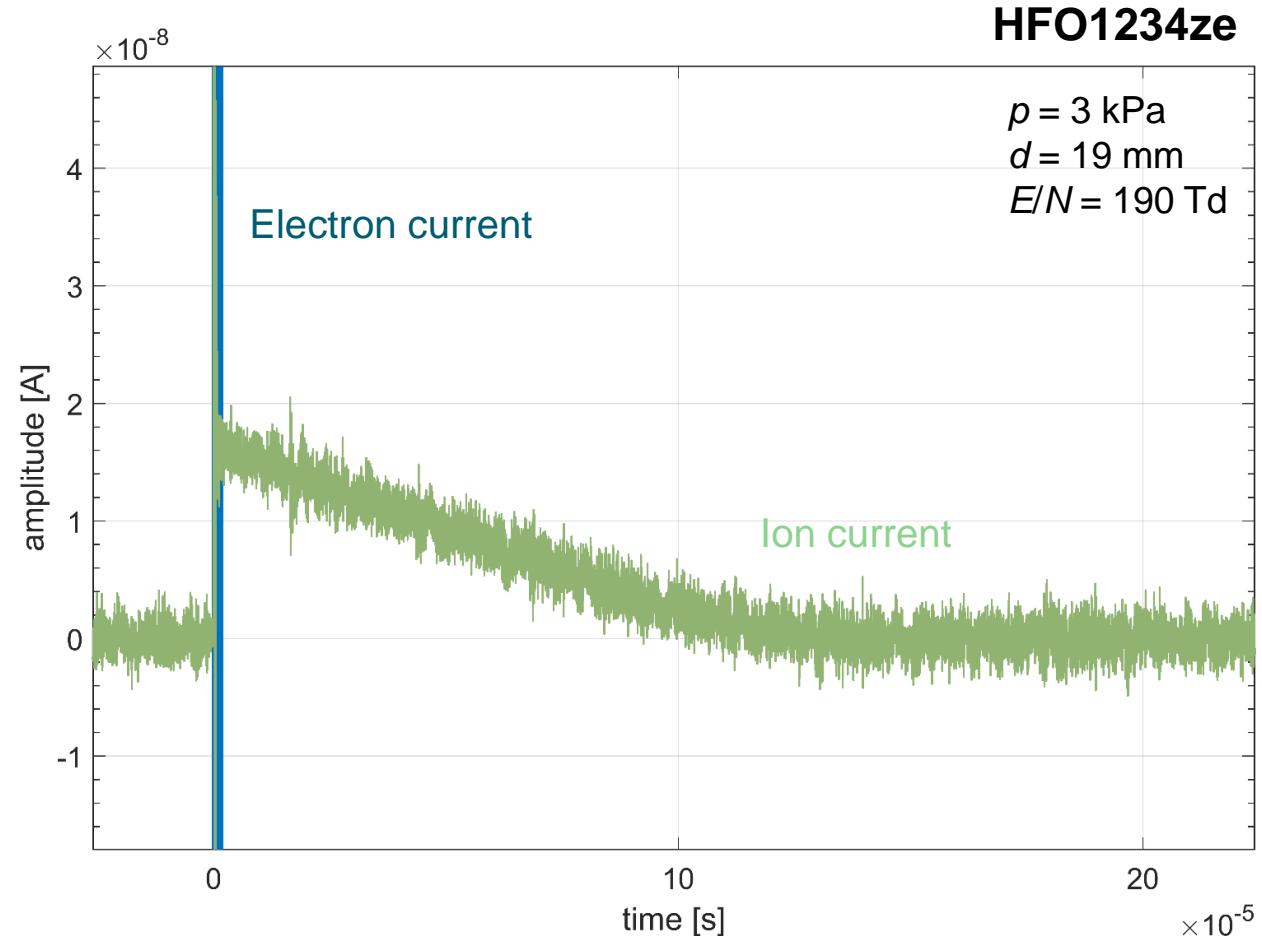
Separation of electron and ion currents

$$I_{\text{tot}}(t) = I_e(t) + I_{\text{ion}}(t)$$

$$= I_e(t) + \left(\nu_i \frac{w_p}{w_e} + \nu_a \frac{w_n}{w_e} \right) \int_0^t I_e(t') dt'$$

$$I_e^{(0)}(t) = I_{\text{tot}}(t)$$

$$I_e^{(j)}(t) = I_{\text{tot}}(t) - \left(\frac{I_{\text{tot}}(T)}{\int_0^T I_e^{(j-1)}(t') dt'} \right) \int_0^t I_e^{(j-1)}(t') dt'$$



Data processing

Swarm parameters

$$I_e(t) = \frac{N_e(0)q_0}{2T_e} \exp(\nu_{\text{eff}}t) \left(1 - \text{erf} \left(\frac{t - T_e}{\sqrt{2\tau_D t}} \right) \right)$$

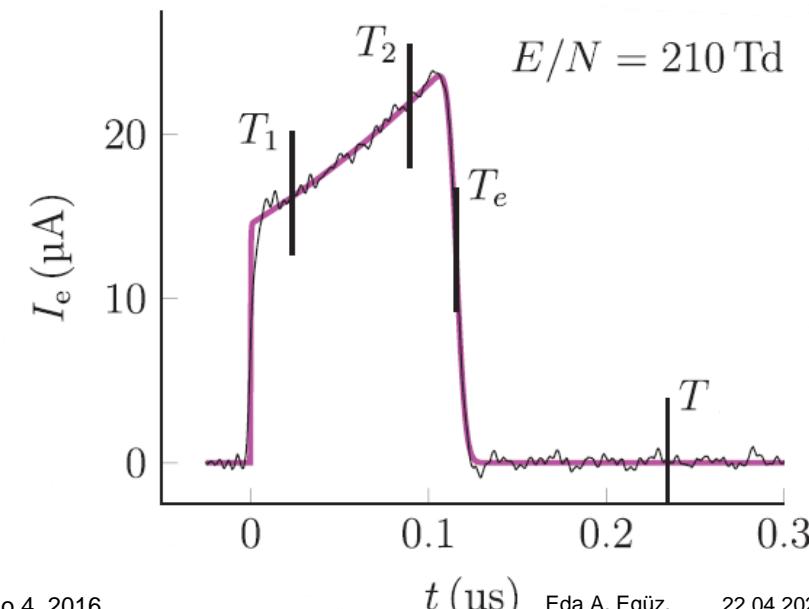
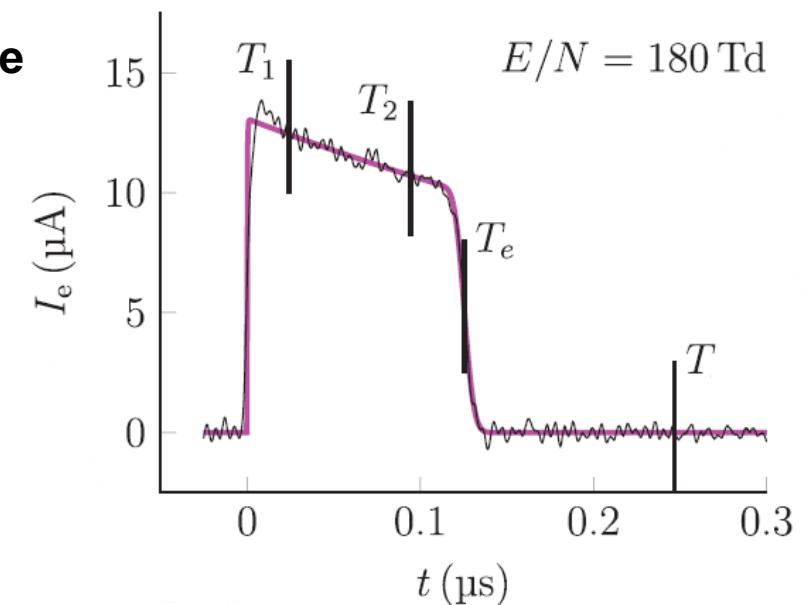
$$\nu_{\text{eff}} = \nu_i - \nu_a$$

$$T_e = d/w_e$$

$$\tau_D = 2D_L/w_e^2$$

HFO1234ze

$p = 3 \text{ kPa}$
 $d = 15 \text{ mm}$



Data processing

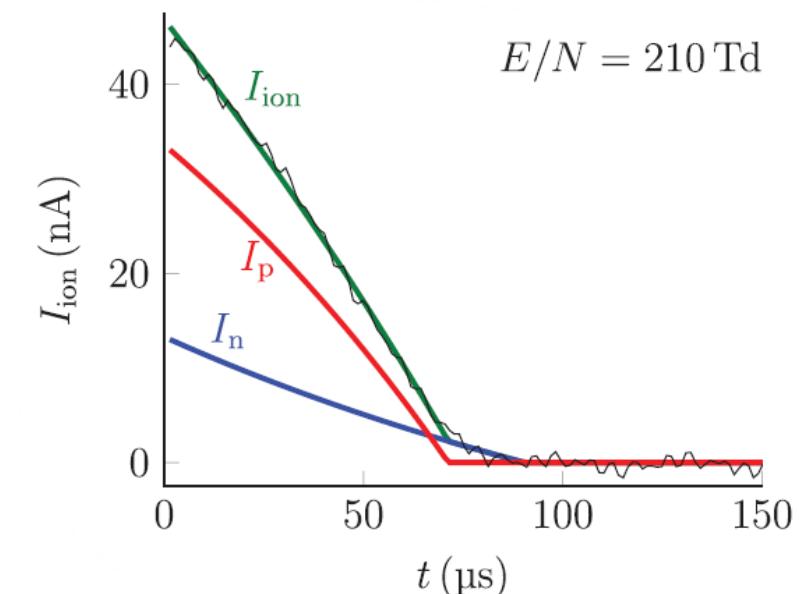
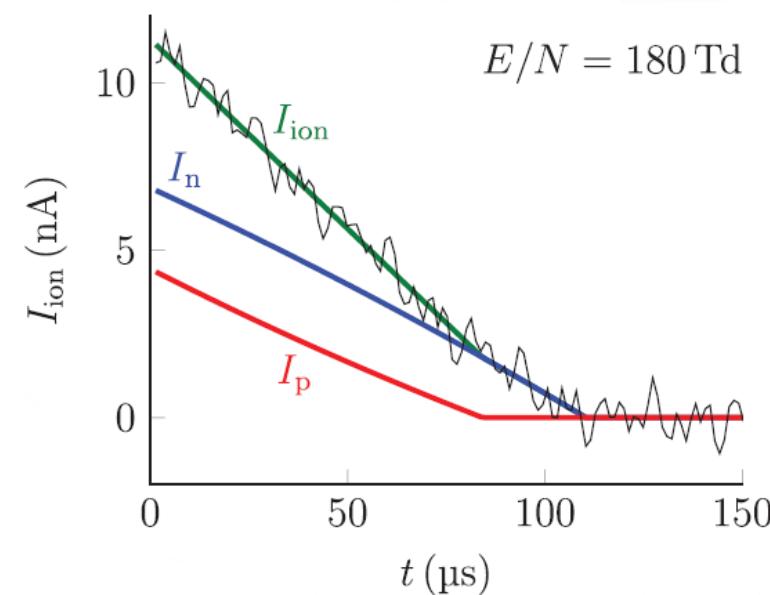
Ionization and attachment rate coefficients

$$t' = t - T_e: \quad I_p(t') = I_0 \frac{w_p}{w_e} \frac{\nu_i}{\nu_{\text{eff}}} \left(e^{\nu_{\text{eff}} T_e} - e^{\nu_{\text{eff}} \frac{T_e}{T_p} t'} \right)$$

$$I_n(t') = I_0 \frac{w_n}{w_e} \frac{\nu_a}{\nu_{\text{eff}}} \left(e^{\nu_{\text{eff}} T_e (1 - \frac{t'}{T_n})} - 1 \right)$$

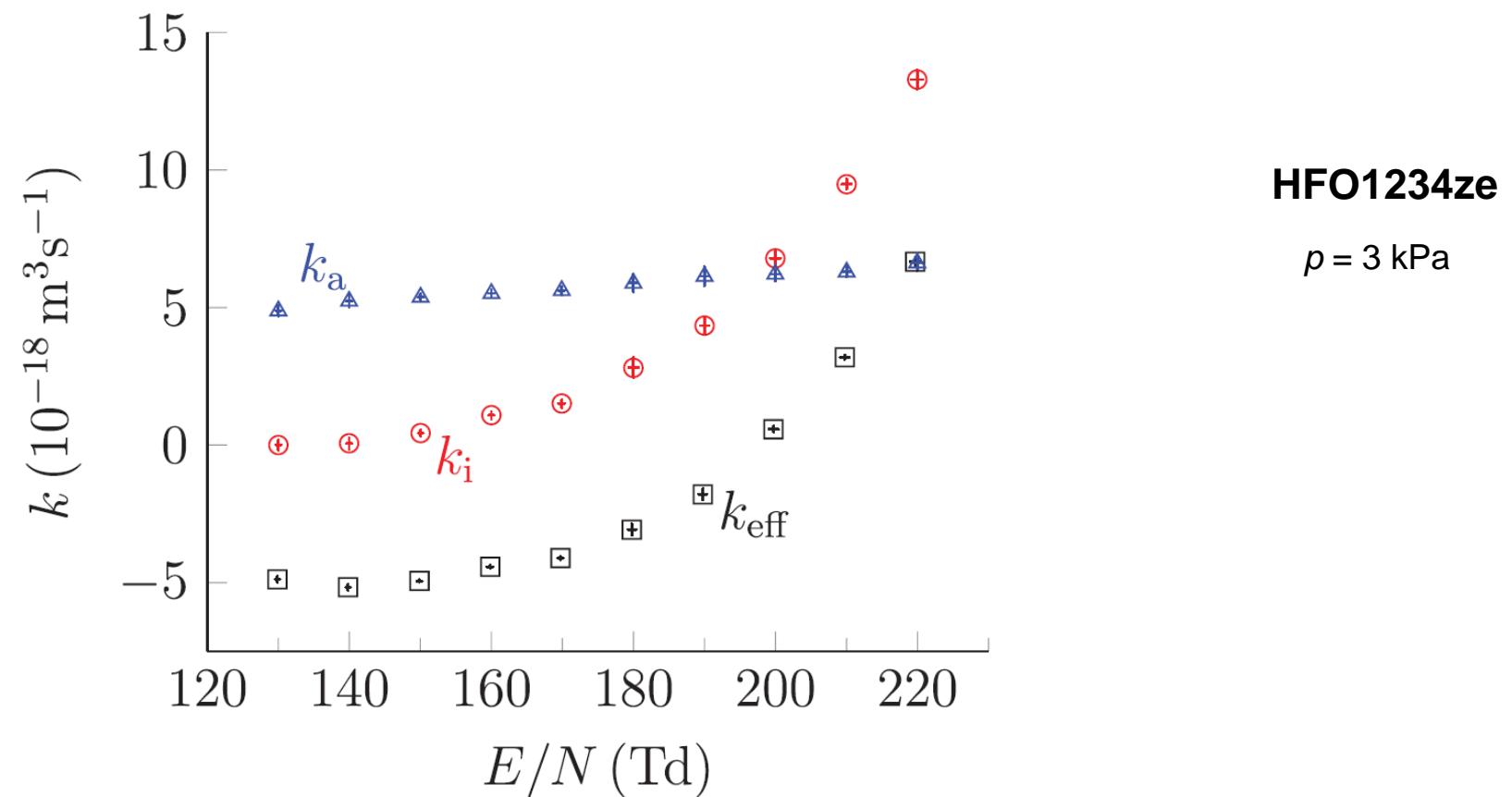
HFO1234ze

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 $d = 15 \text{ mm}$



Data processing

Ionization and attachment rate coefficients $k_i = v_i/N$ and $k_a = v_a/N$



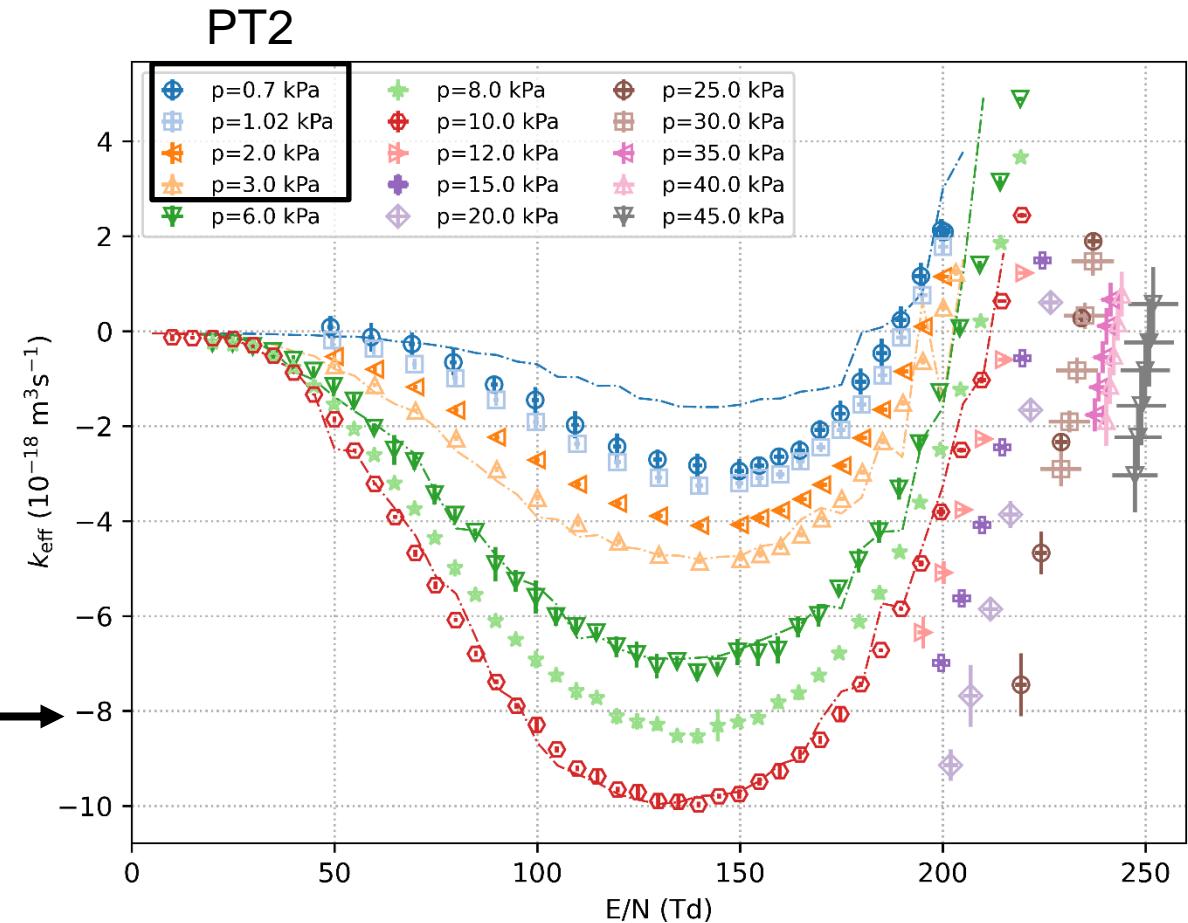
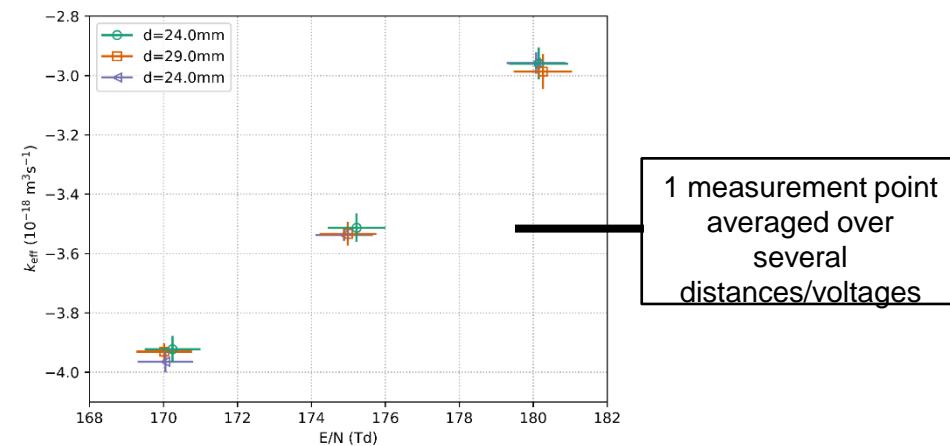
Swarm parameters in HFO1234ze

Effective ionization rate coefficient $k_{\text{eff}} = v_{\text{eff}}/N$

- PyMETHES: Python Monte-Carlo ETH Electron Swarm

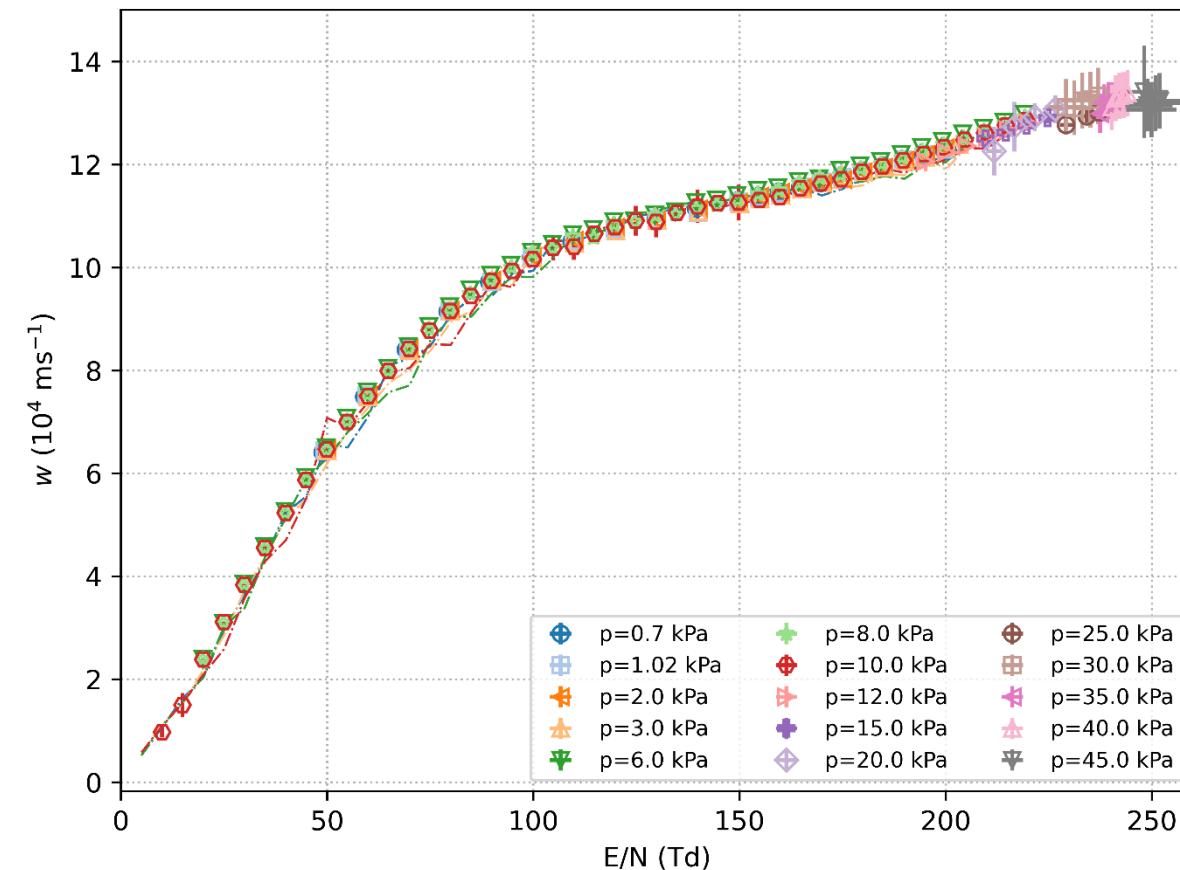
https://gitlab.com/ethz_hvl/pymethes

- PyMETHES simulations with set of cross section by Petrovic *et al.*^[3] (dash-dot lines)



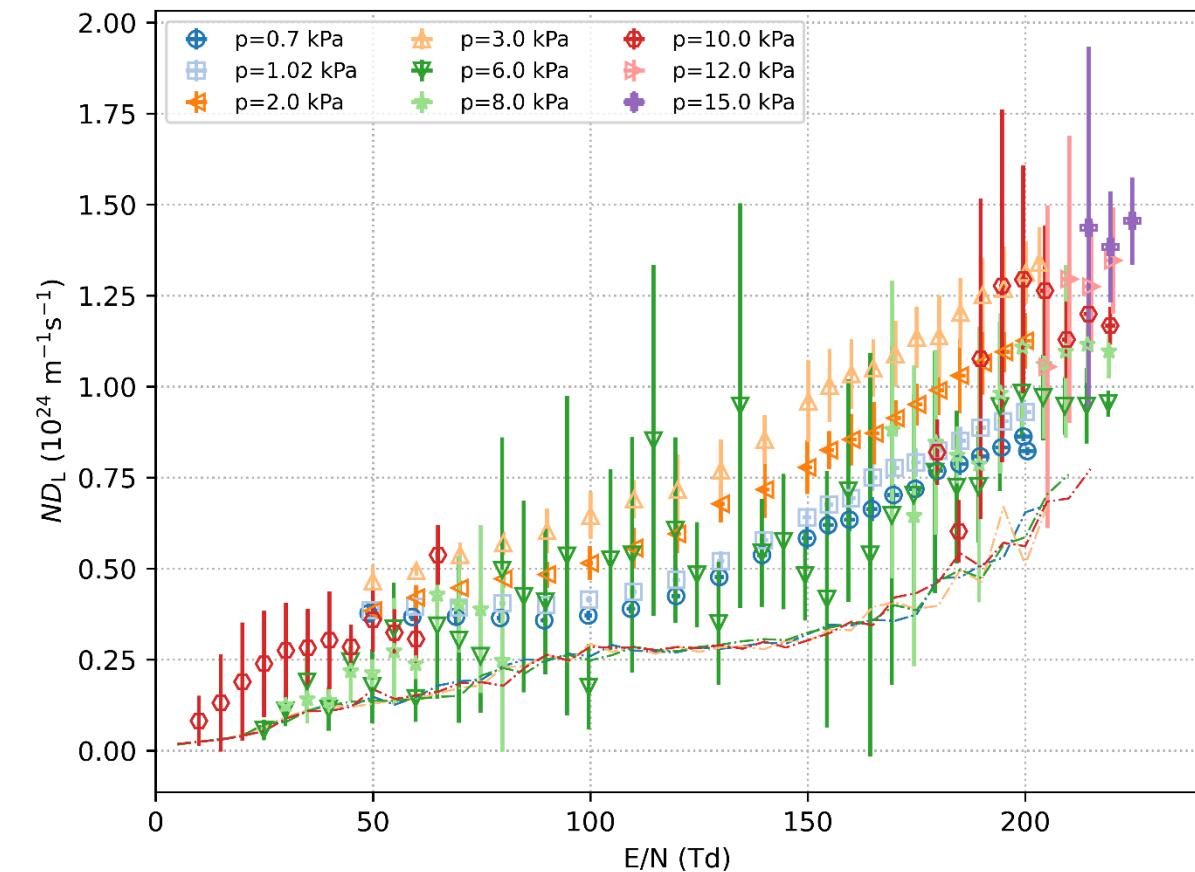
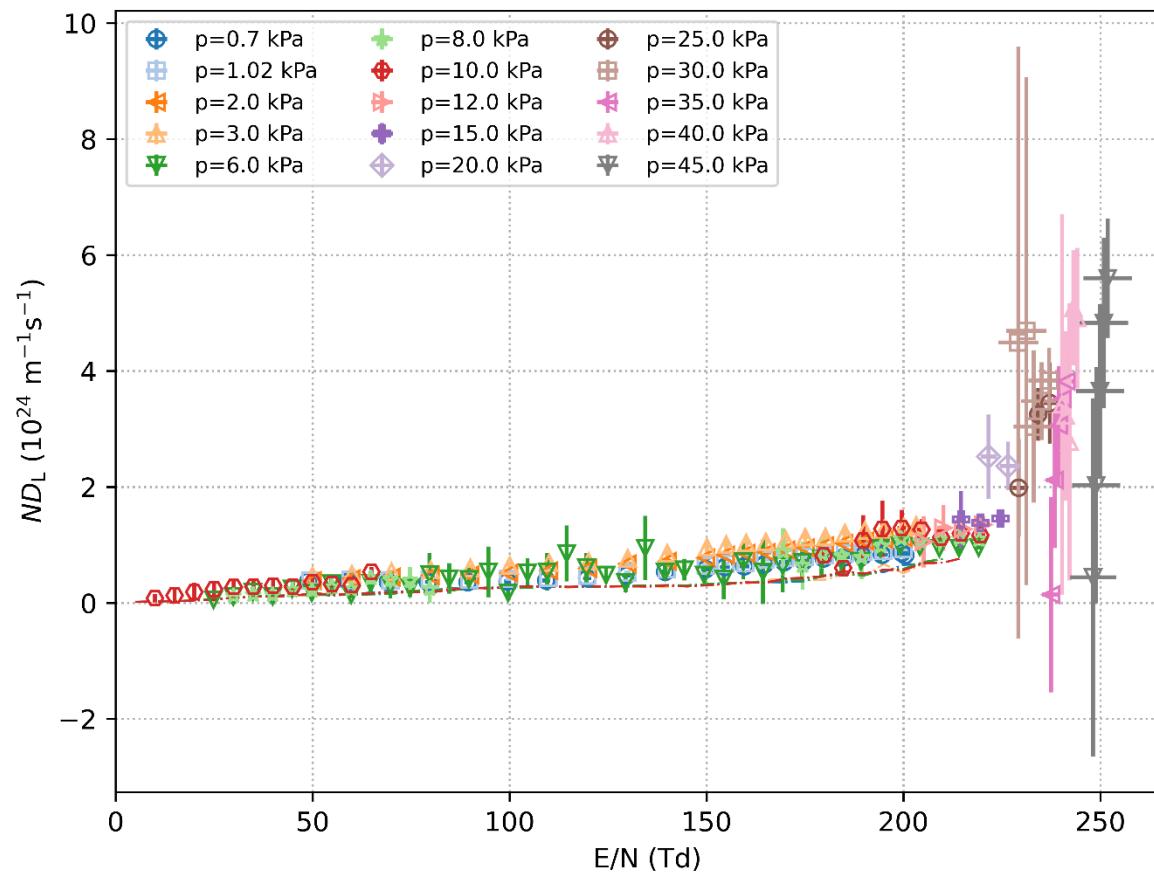
Swarm parameters in HFO1234ze

Bulk drift velocity w



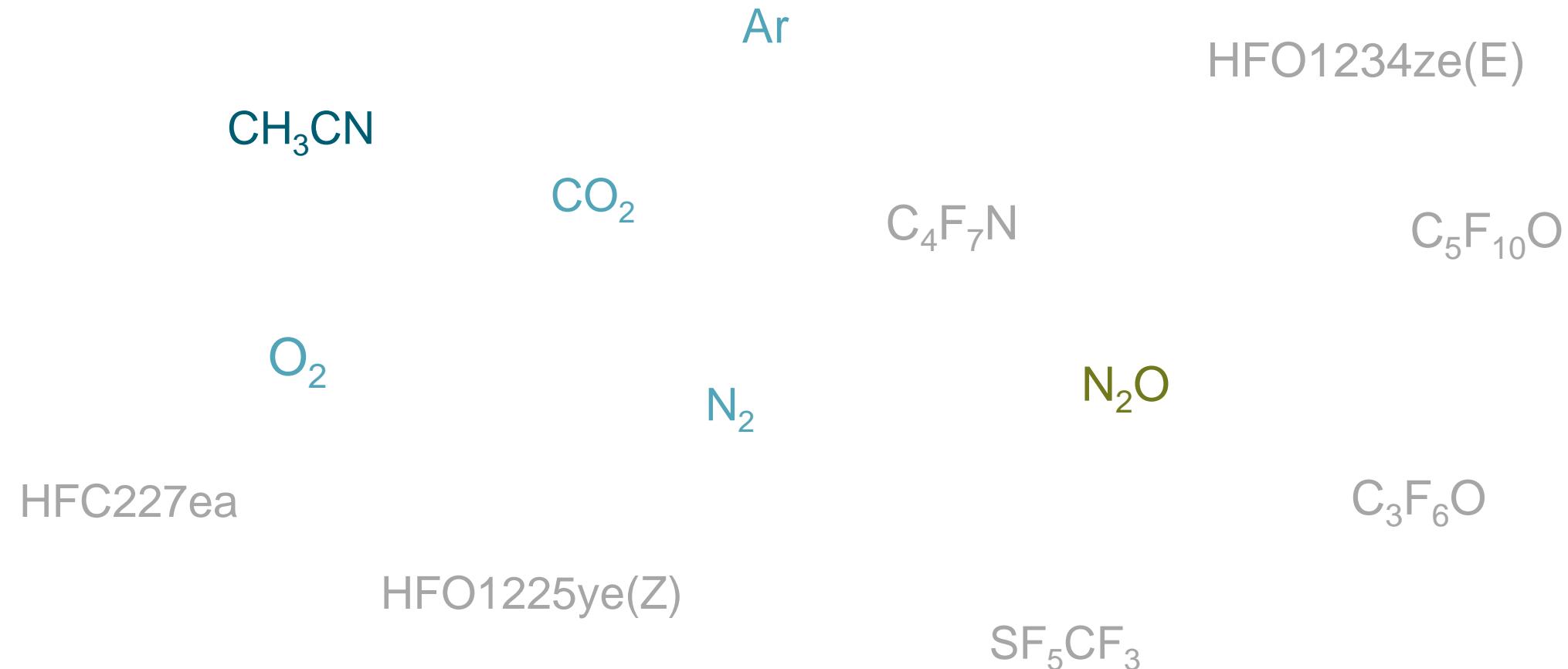
Swarm parameters in HFO1234ze

Longitudinal diffusion coefficient ND_L



ETHZ data available on LXCat

Pure gases



ETHZ data available on LXCat

Mixtures

Gas

...in mixtures with:

HFO1234ze(E)	CO ₂ , Ar, N ₂ , SF ₆
HFO1225ye(Z)	N ₂ , CO ₂
C ₄ F ₇ N	CO ₂ , N ₂ , CO ₂ & O ₂
C ₅ F ₁₀ O	CO ₂ , N ₂ , CO ₂ & O ₂ , N ₂ & O ₂
SF ₅ CF ₃	N ₂ , CO ₂
c-C ₄ F ₈ O	Ar, CO ₂ , N ₂
2-C ₄ F ₈	Ar, CO ₂ , N ₂
HFC227ea	CO ₂ , N ₂
HFPO	CO ₂ , N ₂
N ₂	CO ₂ , O ₂
CO ₂	O ₂

ETHZ data available on LXCat soon...

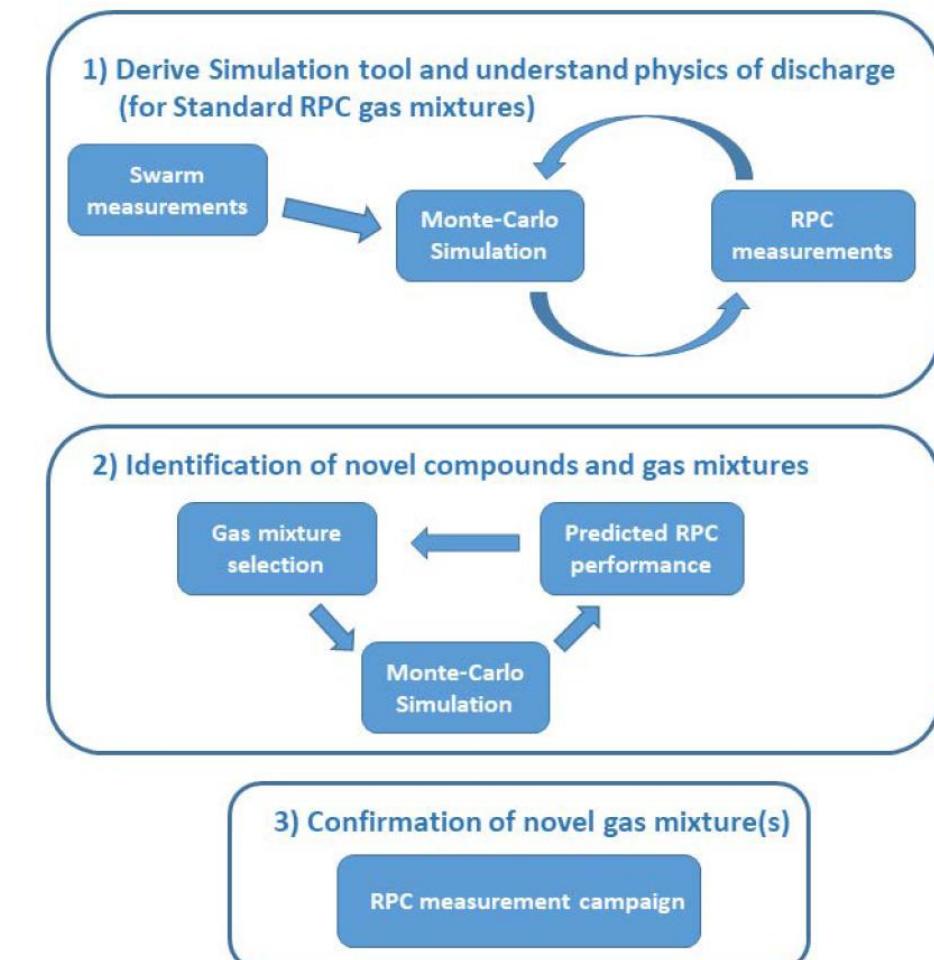
Pure gases & mixtures

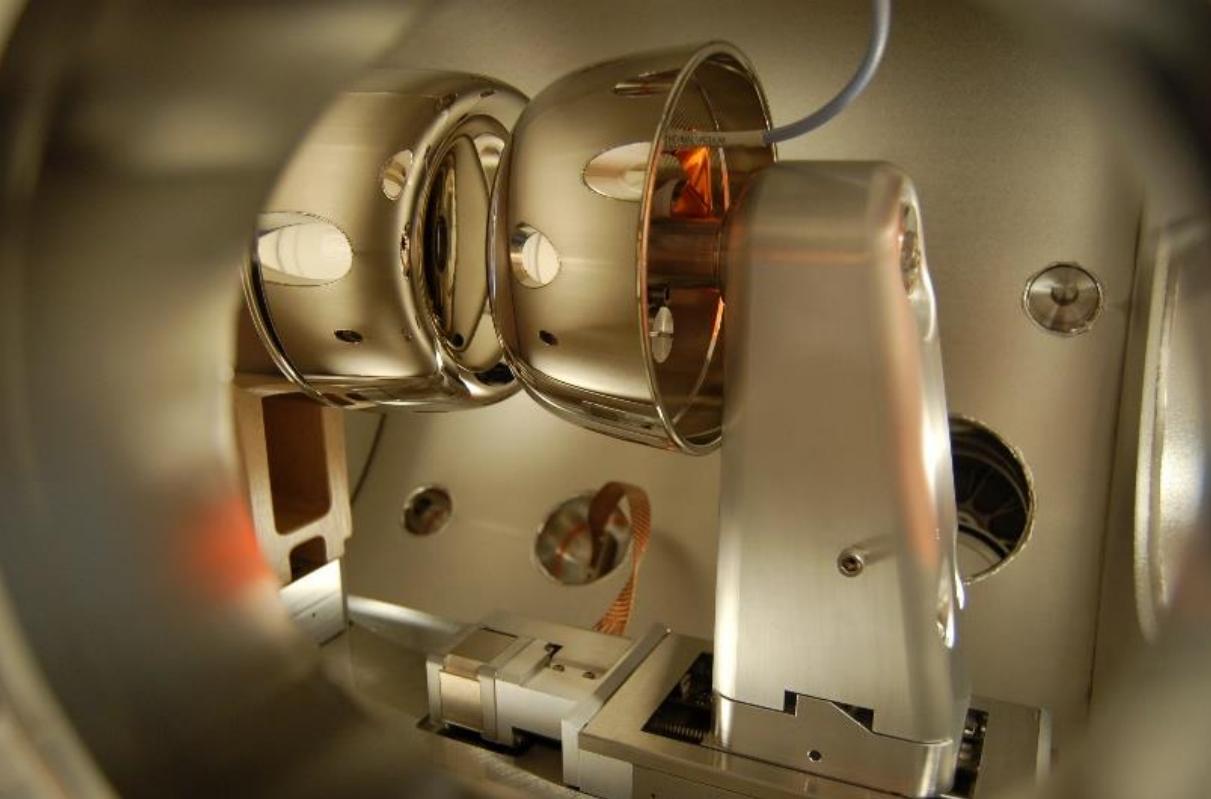
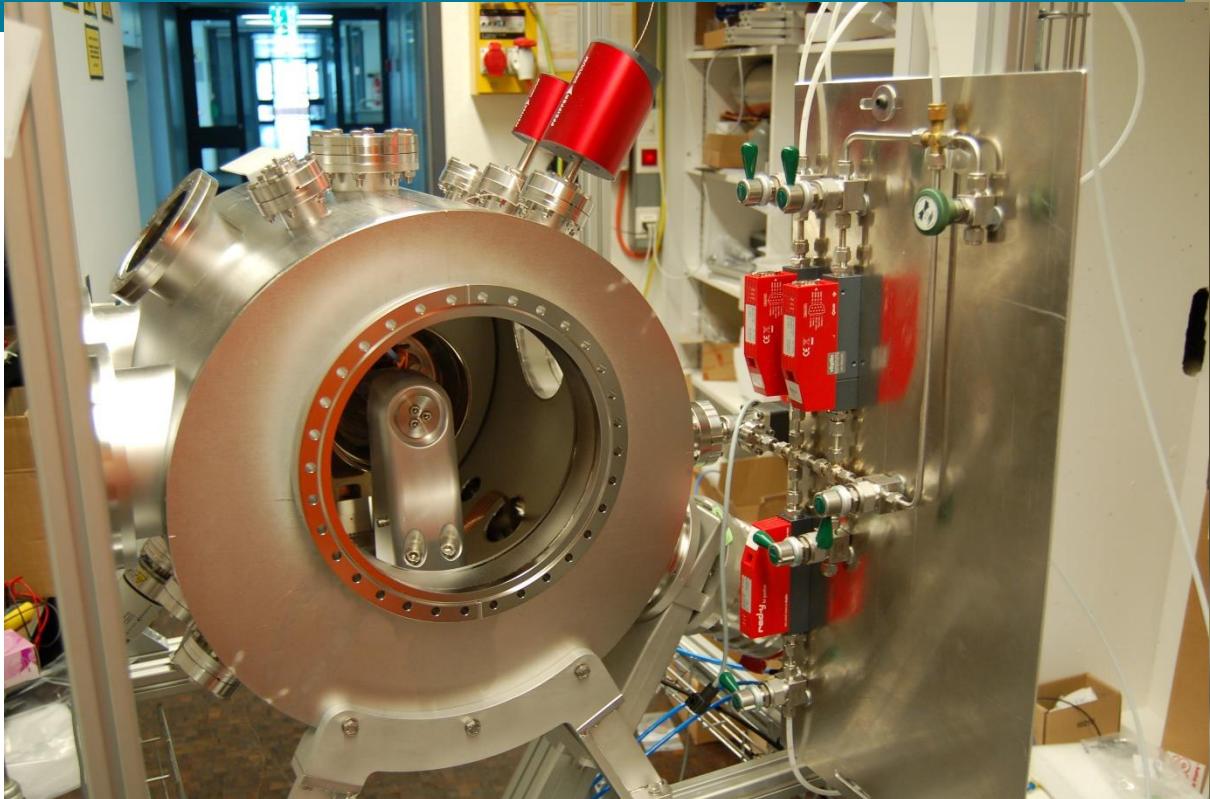
Similar molecular structure	Gas	...and in mixtures with:
	HFO1234ze(E)	C ₅ F ₁₀ O, C ₄ F ₇ N
	HFO1225ye(Z)	C ₅ F ₁₀ O, SF ₆
	HFO1225ye(E)	SF ₆
	HFO1234yf	SF ₆
	C ₃ H ₆	SF ₆
	C ₃ H ₄ F ₂	SF ₆
R1233zd		

Outlook

Swiss National Science Foundation proposal: Environmental friendly gas mixtures for RPC detectors

- Submitted project proposal to SNSF in 2019 together with:
 - CERN (Mandelli and Guida)
 - I.N.F.N. Rome "Tor Vergata" (Liberti)
 - Università di Torino (Ferretti, Gagliardi)
- Project aims to make use of our measurement and simulation experience with application in the field of RPC
- Proposal very positively rated but rejected by a narrow margin...
- ... Still very interested in the project and looking for project collaborators for resubmission !





Thank you for your attention !