Institute of Electrical Engineering and Measurement Technology
Department of **Sensors + Measurement Technology**

SMT

Leibniz
Universität
Hannover

Ion mobility spectrometry

## How can new concepts pave the way into criminal investigations?

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# Principle of ion mobility spectrometry (IMS)

IMS is based on the characteristic motion of gas phase ions in an electric field **at ambient pressure**

$$\vec{E}$$

$$\vec{F}$$

$$+$$

$$\vec{F} = q\vec{E}$$

$$\vec{a} = \frac{\vec{F}}{m} = \frac{q\vec{E}}{m}$$

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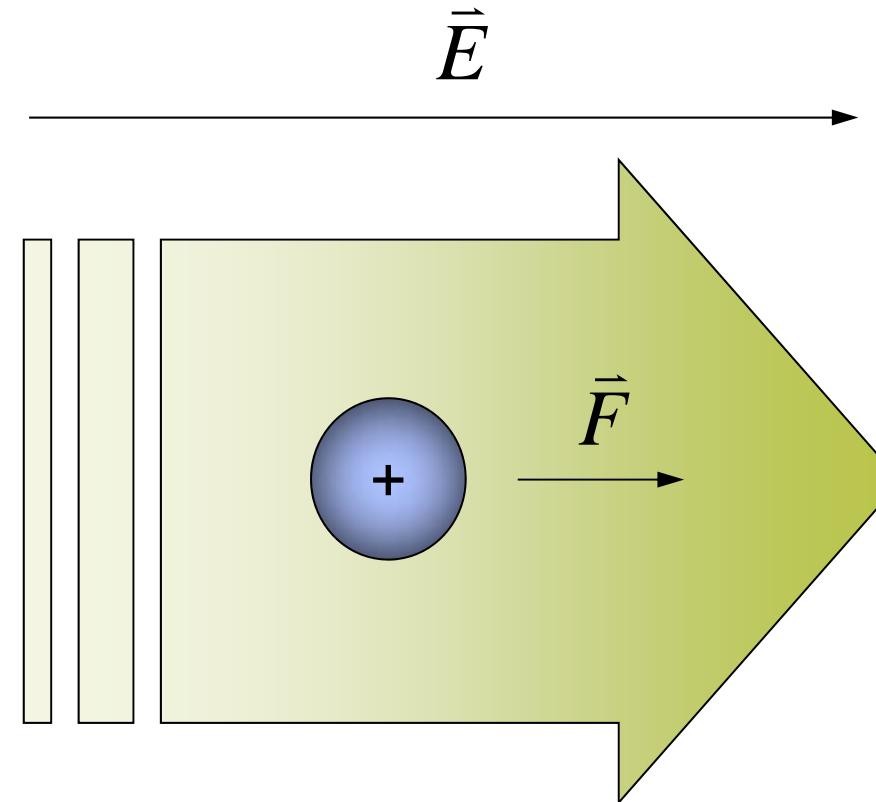
Ion movement at atmospheric pressure
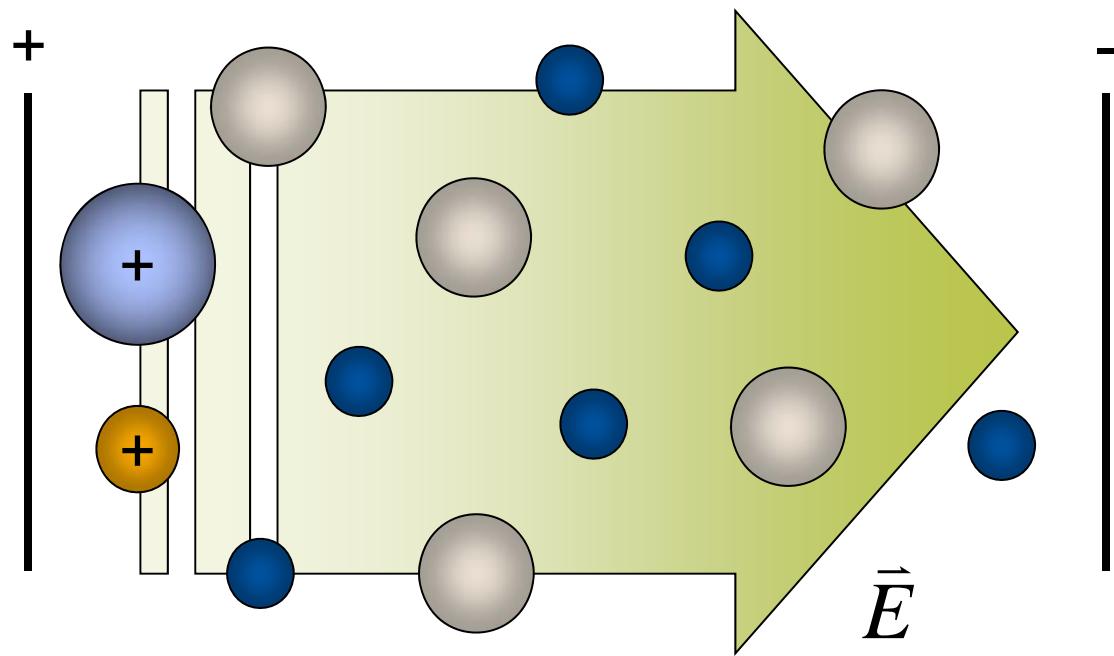
$$\vec{v} = K\,\vec{E}$$

$$t_d = \frac{s^2}{KU}$$

T = 300 K, P = 1013.15 mbar, mean free path ≈ 100 nm, 2.7*10^{19} molecules/cm^3

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Ion movement at atmospheric pressure

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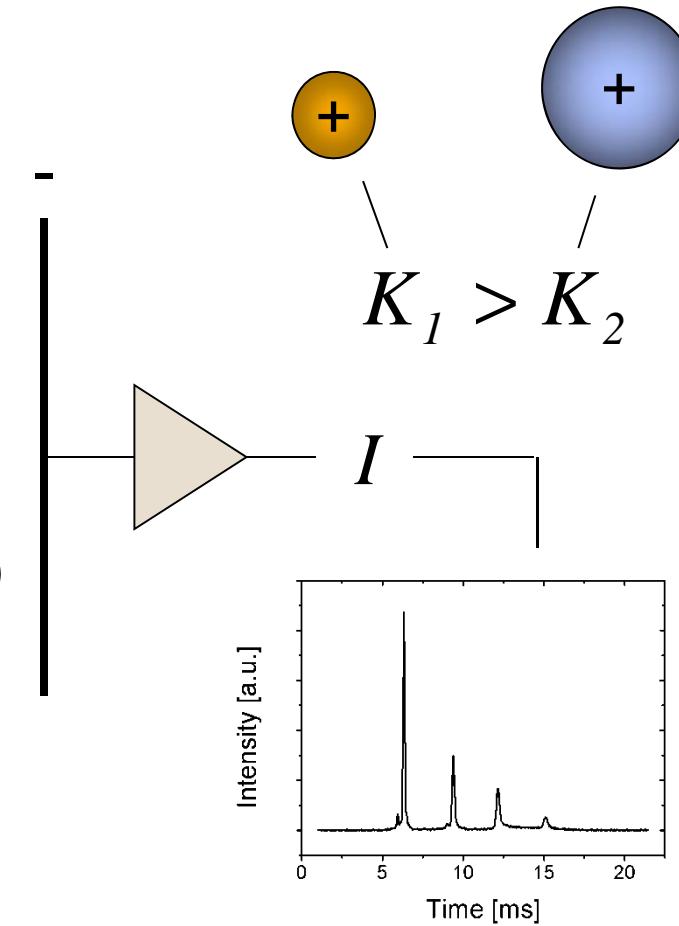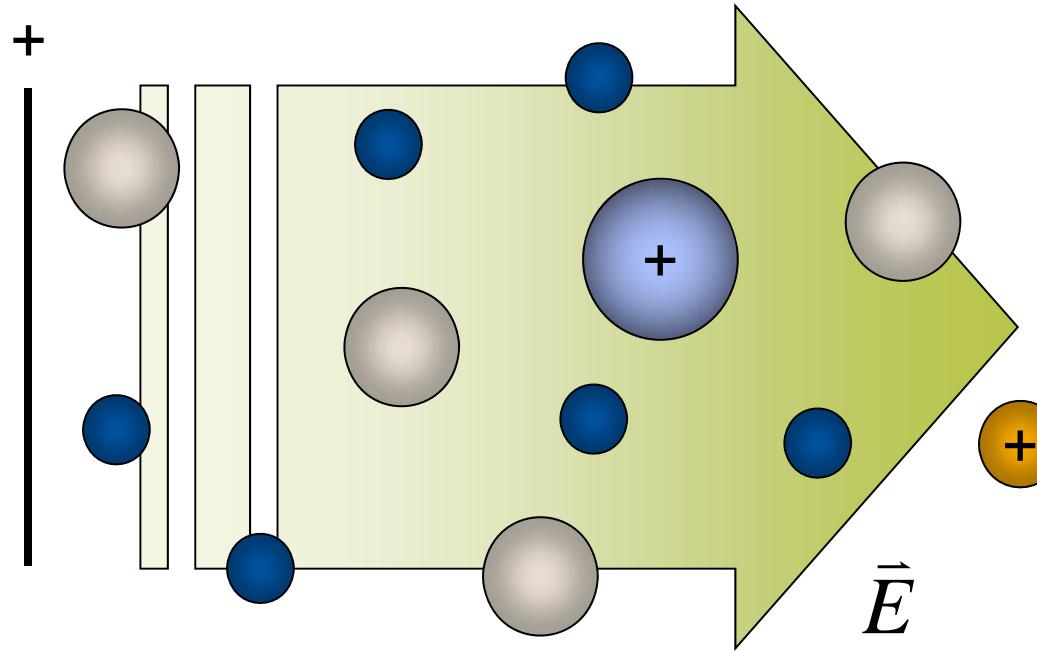
Drift tube ion mobility spectrometer

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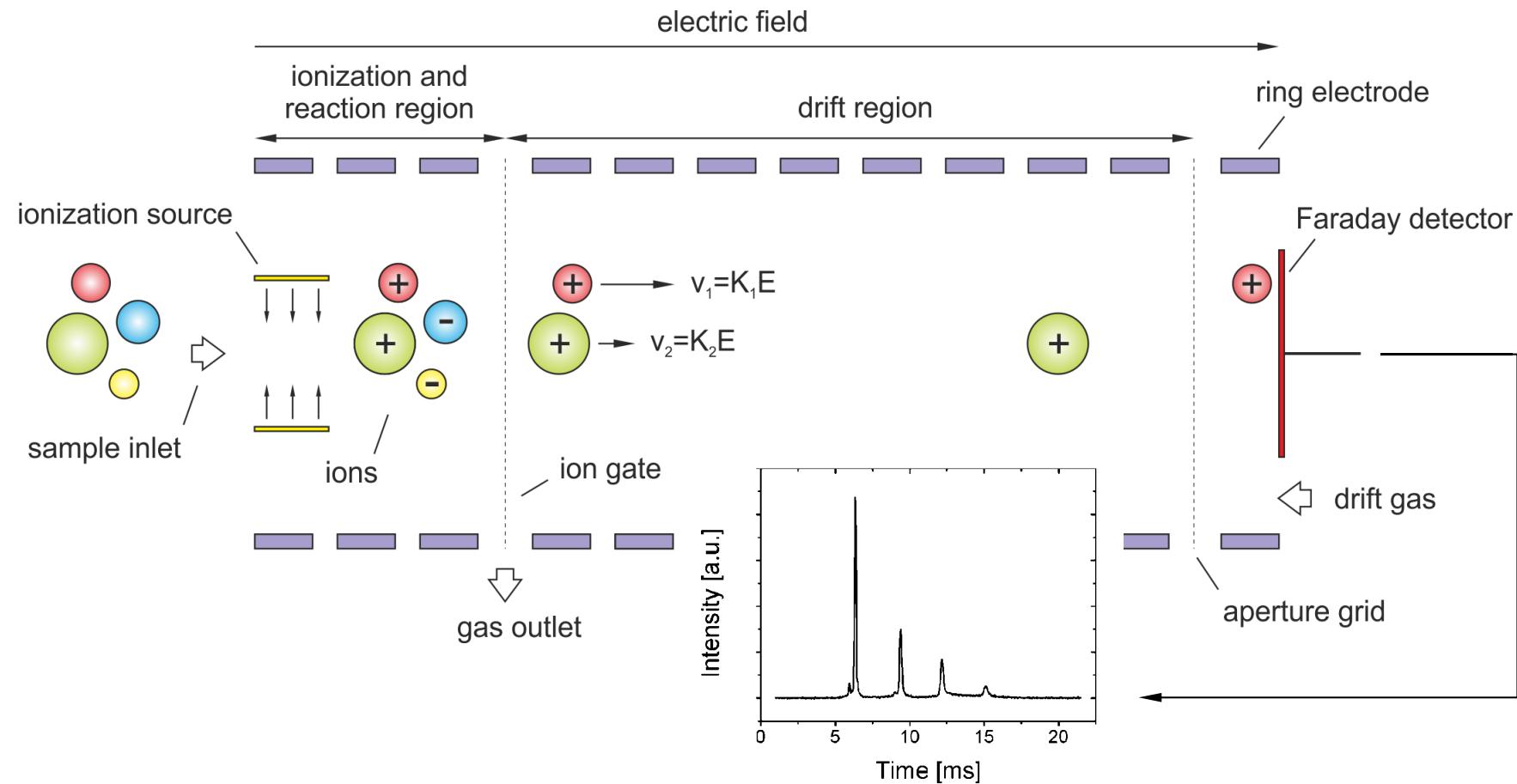
Critical components

- **Ion source** (non-radioactive, e.g. CD, UV, ESI, DBD, x-Ray, electron gun)

- **Ion gate** (BN, TP, FS, Tristate)

- **Drift tube** (inner diameter, length, electrode design)

- **Ion detector** (aperture grid, detector geometry, capacity)

- **Amplifier** (bandwidth, gain, noise)

- **Gas flows** (drift gas, sample gas)

- **Voltages** (reaction region, drift region, aperture, ion gate)

- **Ground potential** (detector vs. inlet)
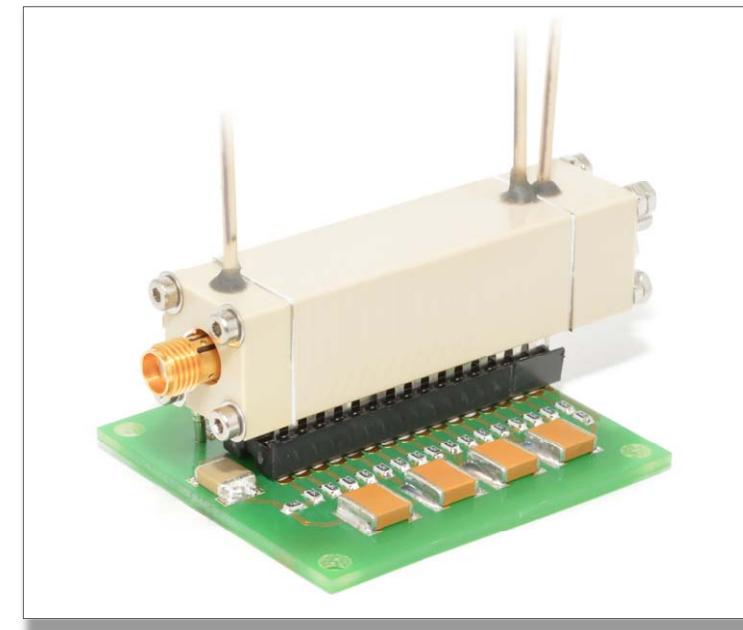
Considering basic design rules even **mini-IMS** can reach outstanding performance

- Drift length: **40 mm**

- Resolving power: **65**

- Detection limits: **low ppt** (in one second)

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mini-IMS with closed gas-loop and GC option

For complex samples or backgrounds, **GC helps reducing chemical cross sensitivities** and **adds an orthogonal separation** dimension but increases response time from seconds to several minutes and decreases sensitivity due to dilution effects.
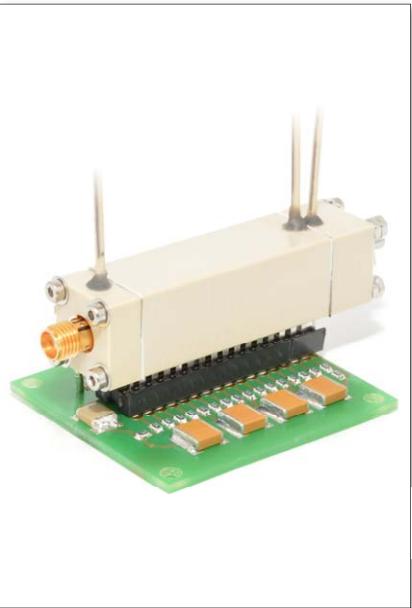

mini-IMS

Closed gas loop GC-IMS (not size optimized)

IMS mounted to a drone

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TATP dissolved in Methanol (GC-IMS)

35 ppb$_V$ TATP

Methanol and acetone

TATP fragment

RIP

Ammonia

Inverse reduced mobility in Vs/cm^2

Retention time in s

Detection limit: 1 ppb$_V$

× Measurement
— Linear regression

Amplitude in V

TATP concentration in ppb$_V$

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TATP headspace by (GC-IMS)

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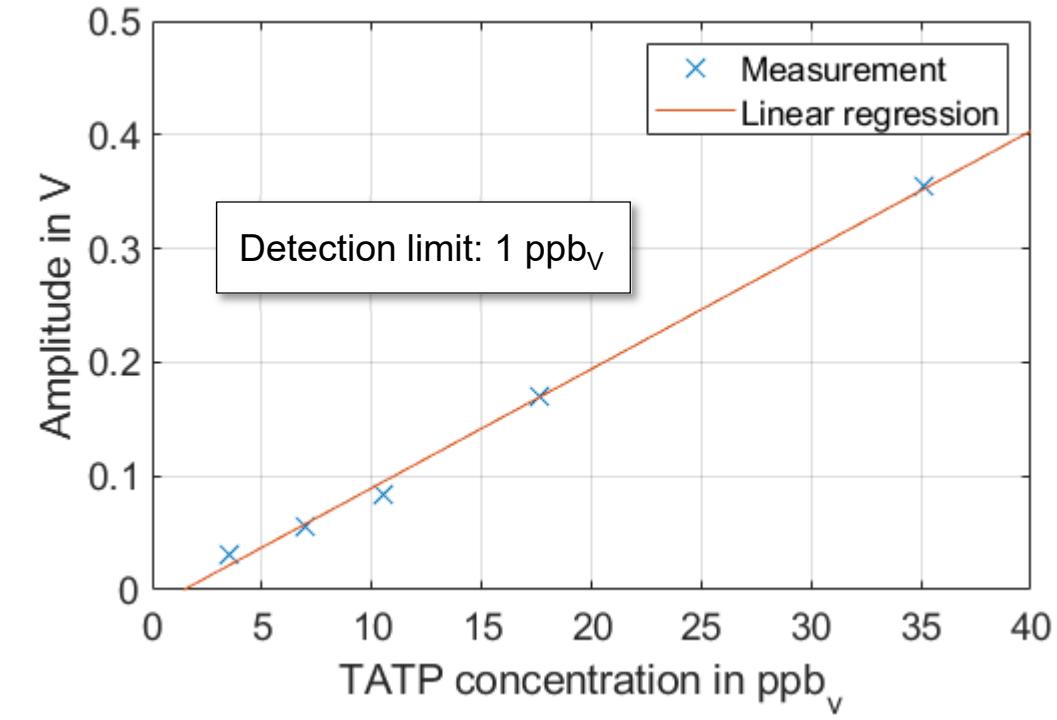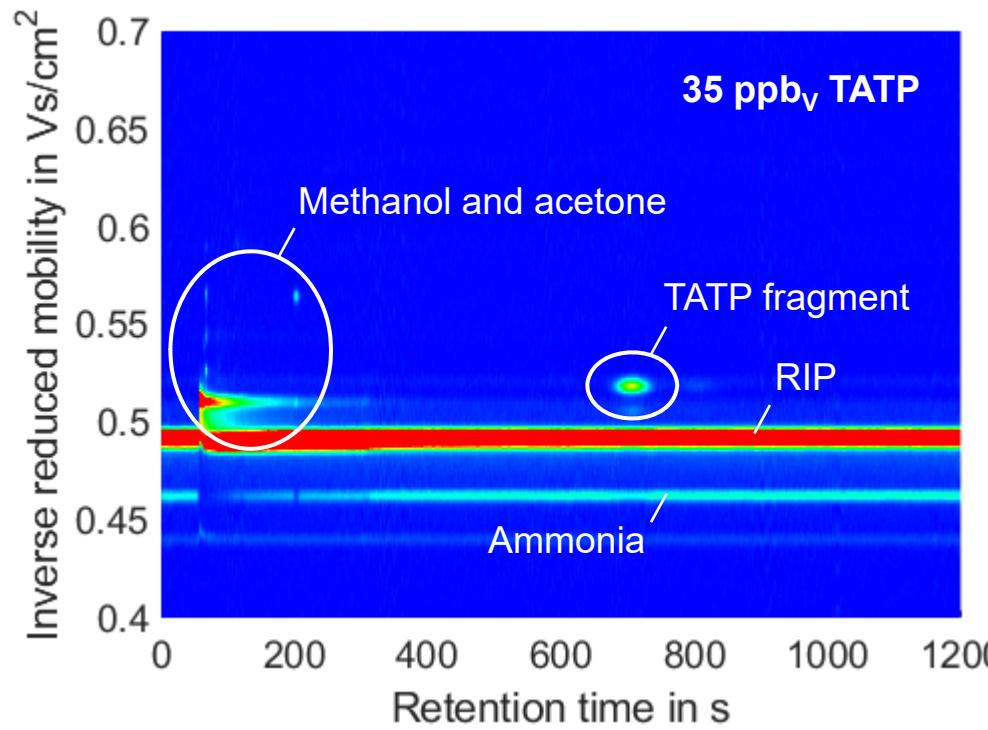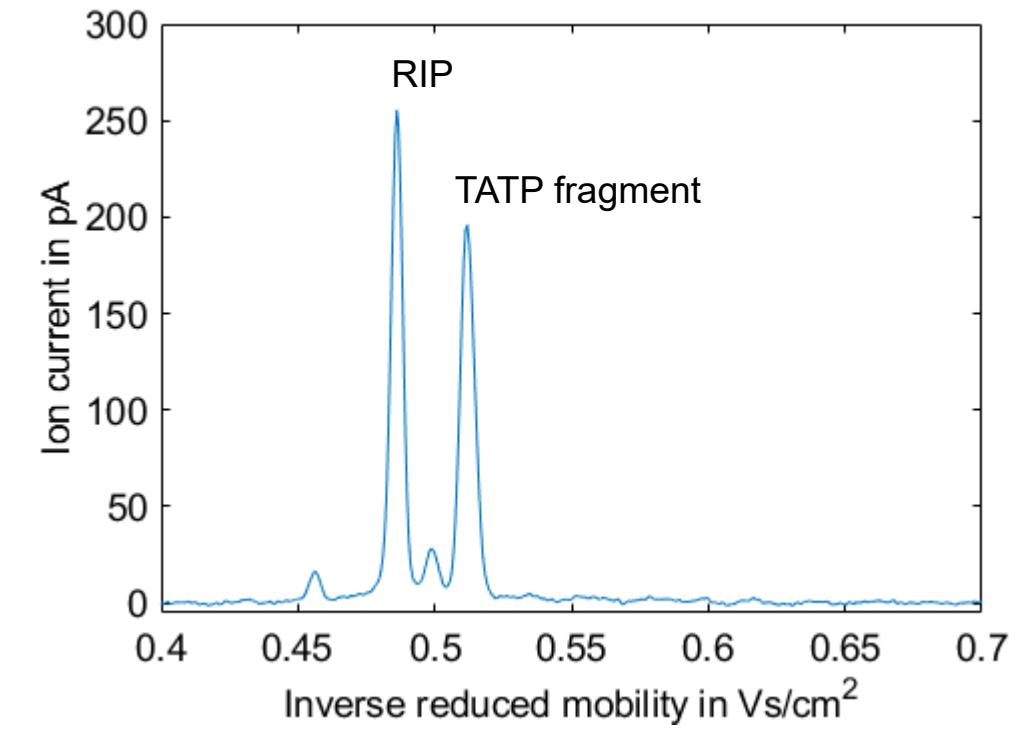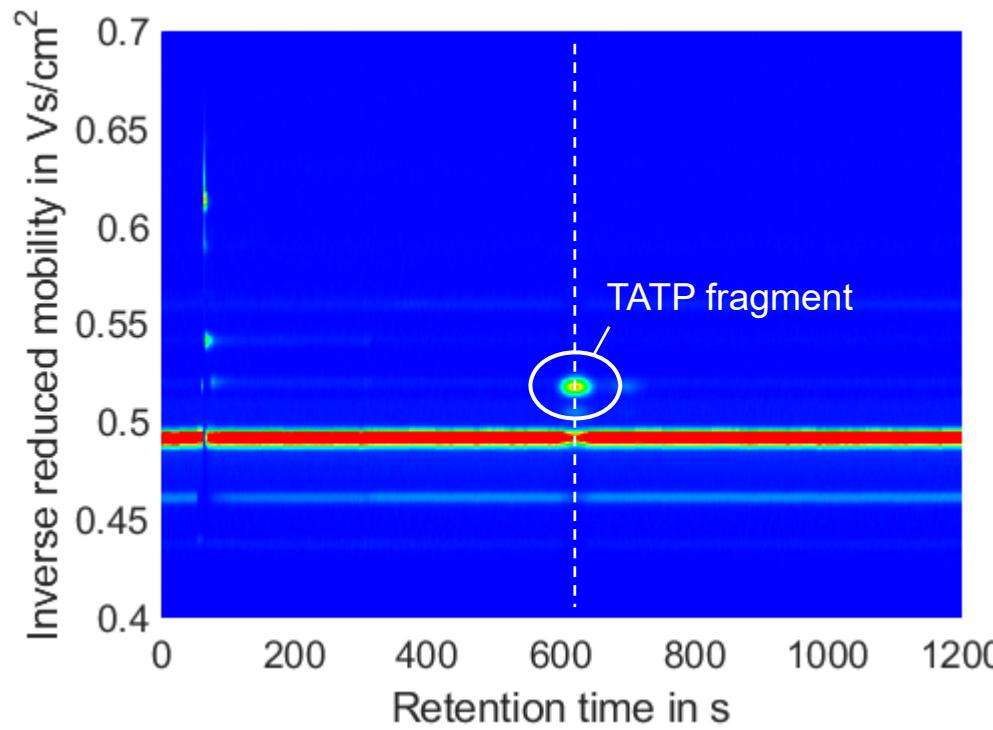
BMK for synthesis of methamphetamine (GC-IMS)

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Benzyl cyanide for synthesis of BMK (GC–IMS)

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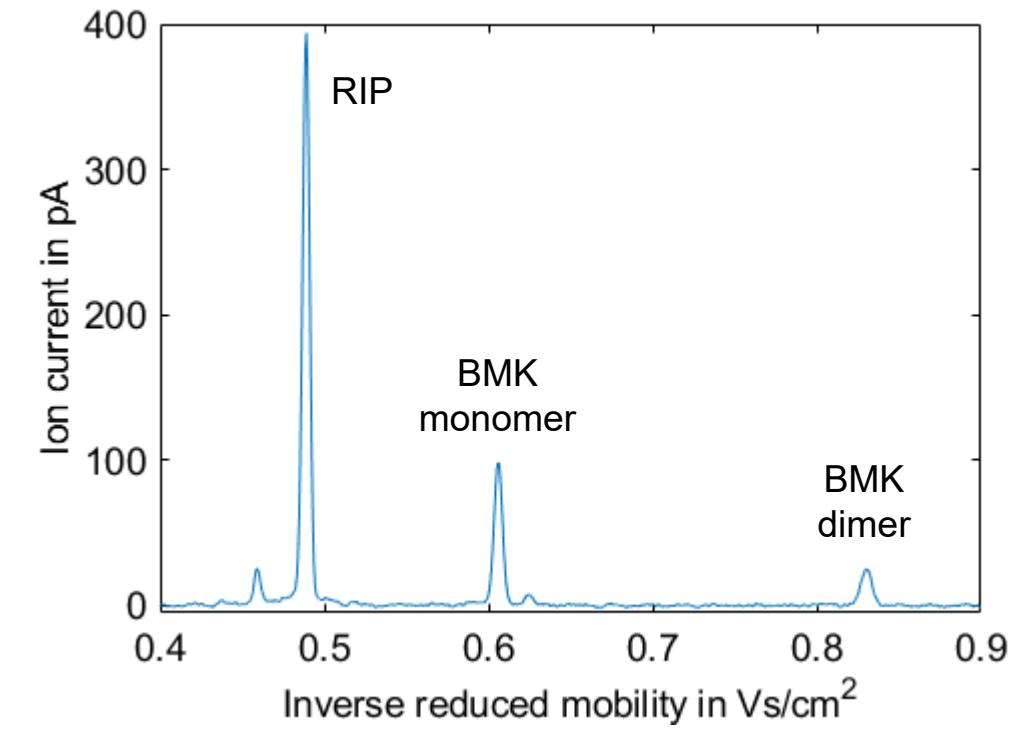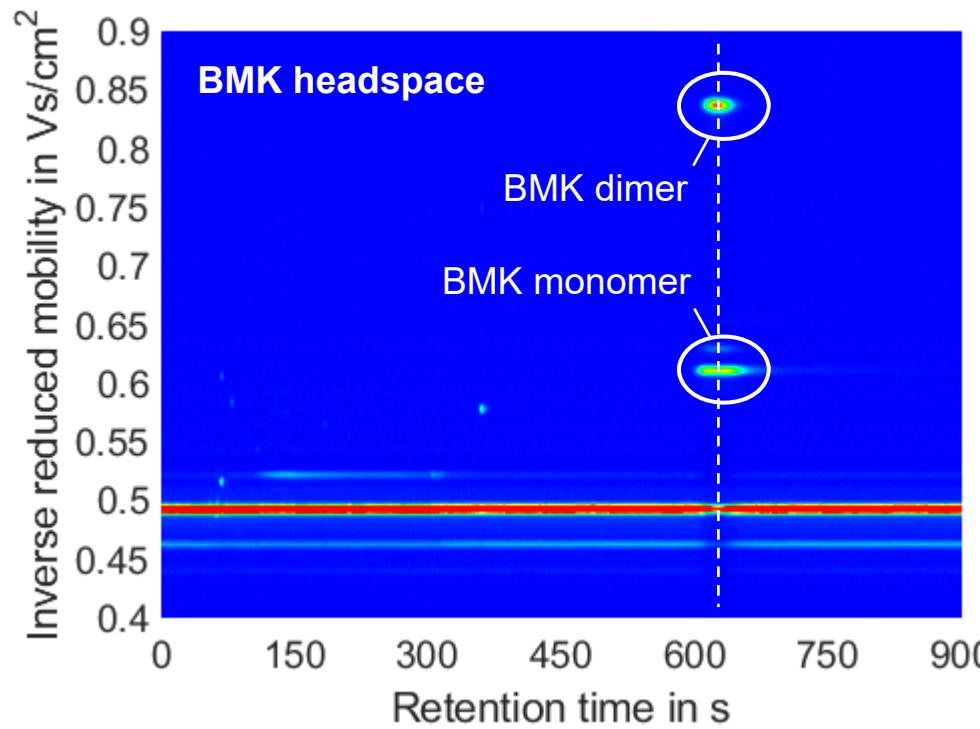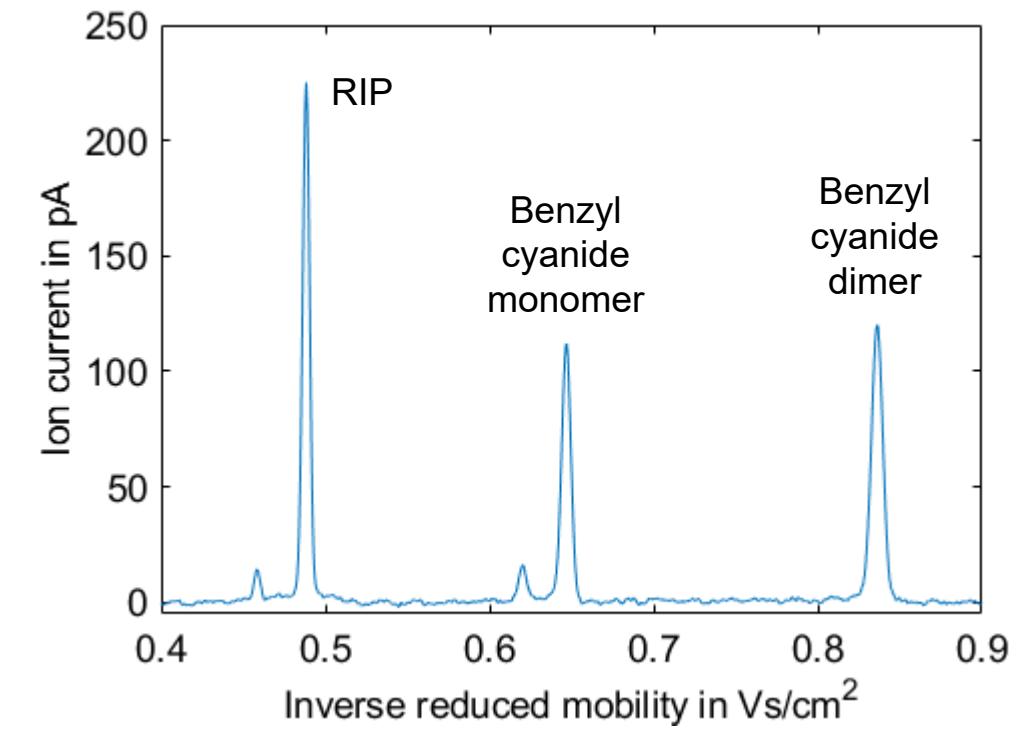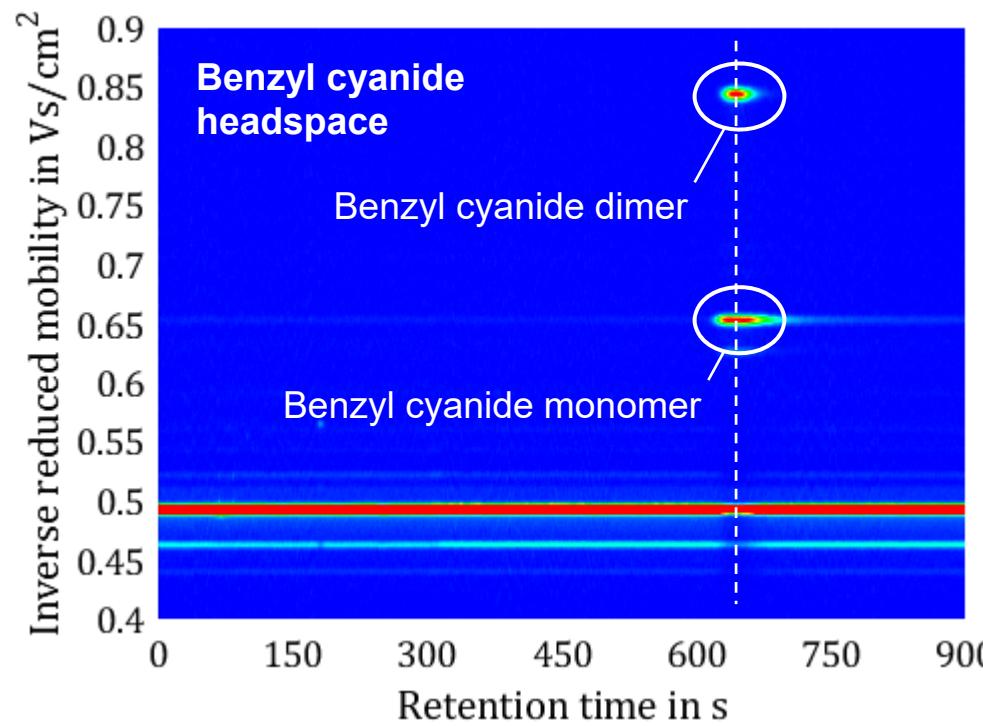
High Kinetic Energy IMS (HiKE-IMS)

Membrane pump:
**10 cm x 10 cm x 5 cm**
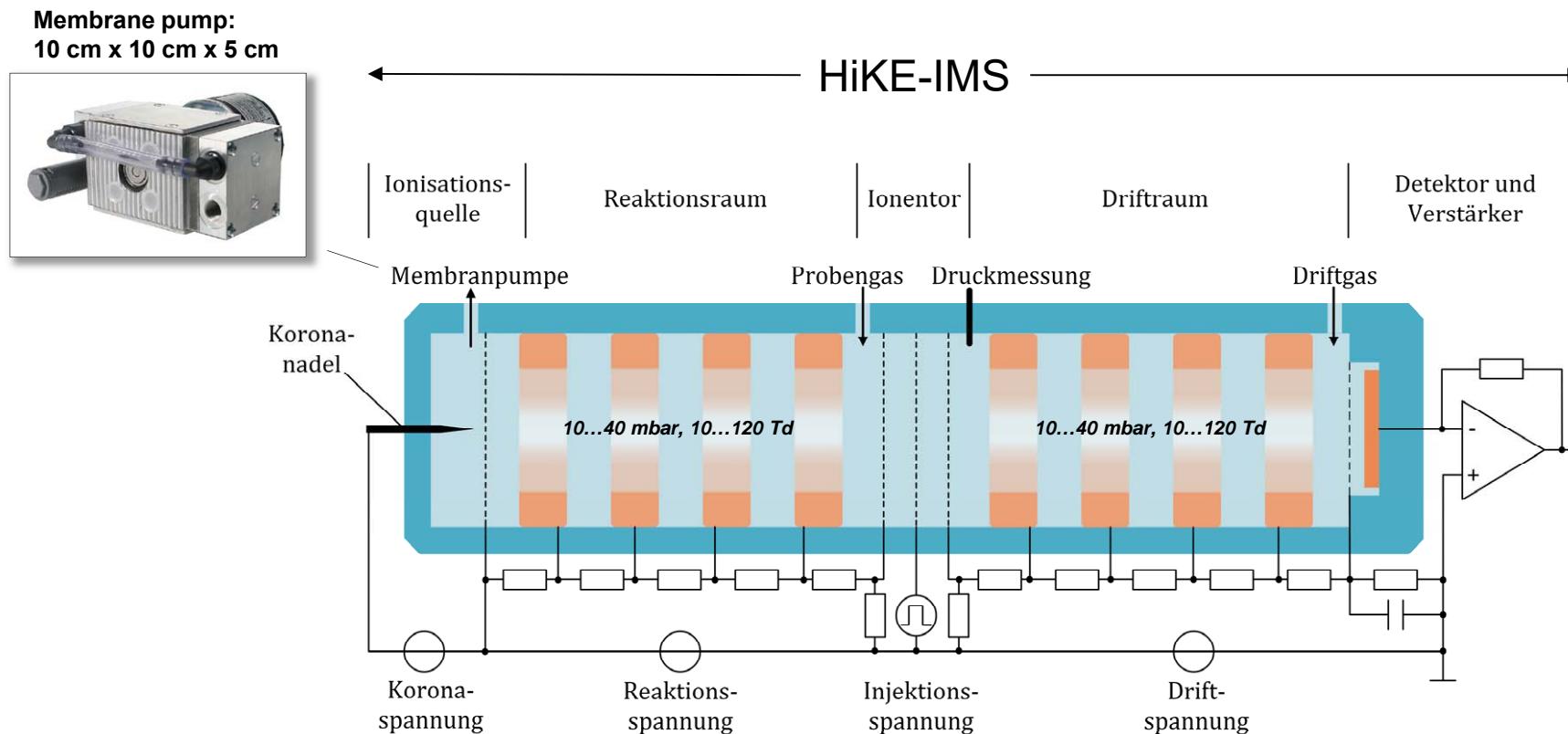
- Less chemical cross-sensitivities, less water dependence, larger spectrum of detectable compounds, improved compound identification (alpha-functions and collision induced fragmentation

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TATP headspace (HiKE–IMS)

Acetone fragment, m/z = 43
O_2^+, m/z = 32
Acetone, m/z = 59
m/z = 75
m/z = 91
Specific TATP-Fragments

Inverse reduced mobility in Vs/cm^2
Reduced drift field strength in Td

E/N_{RR} = 100 Td, E/N_{DR} = 100 Td
Specific TATP-Fragments
Ion current in nA
Inverse reduced mobility in Vs/cm^2
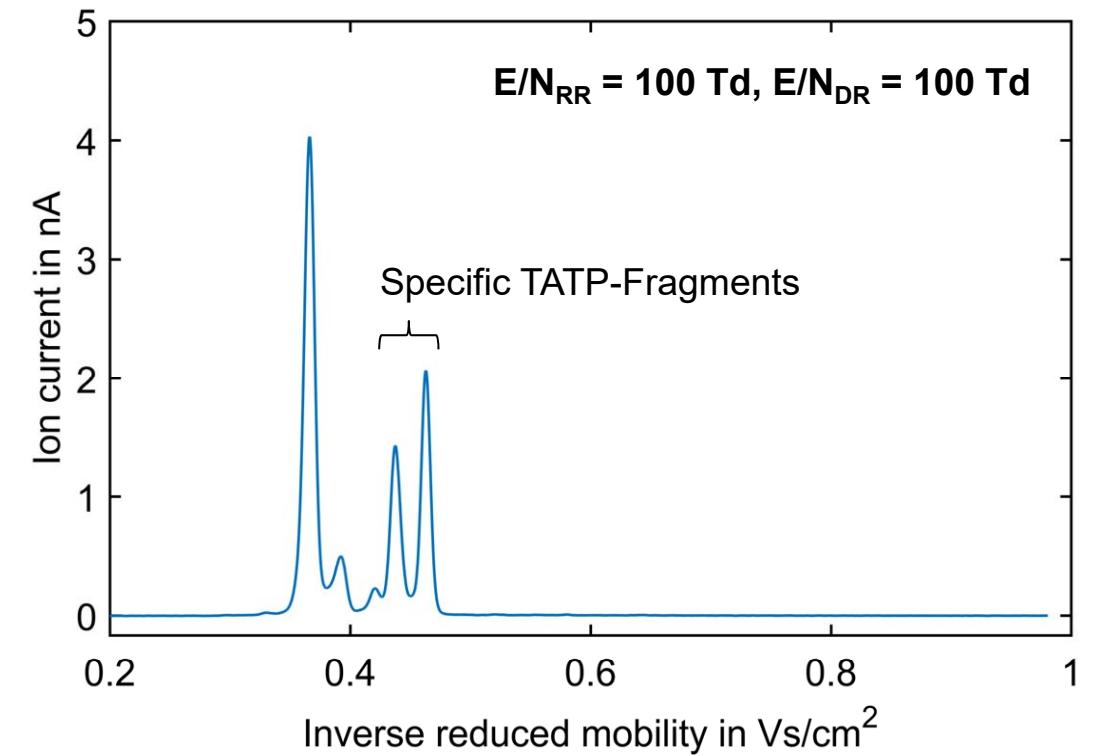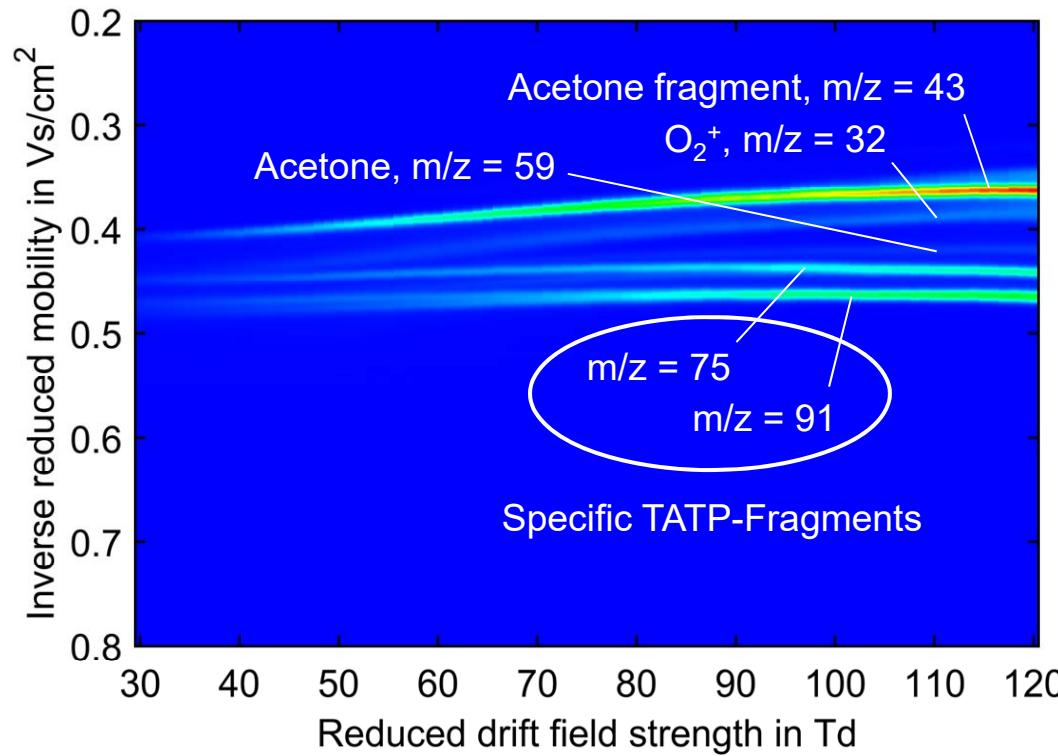
TATP headspace (HiKE-IMS doped with ammonia)

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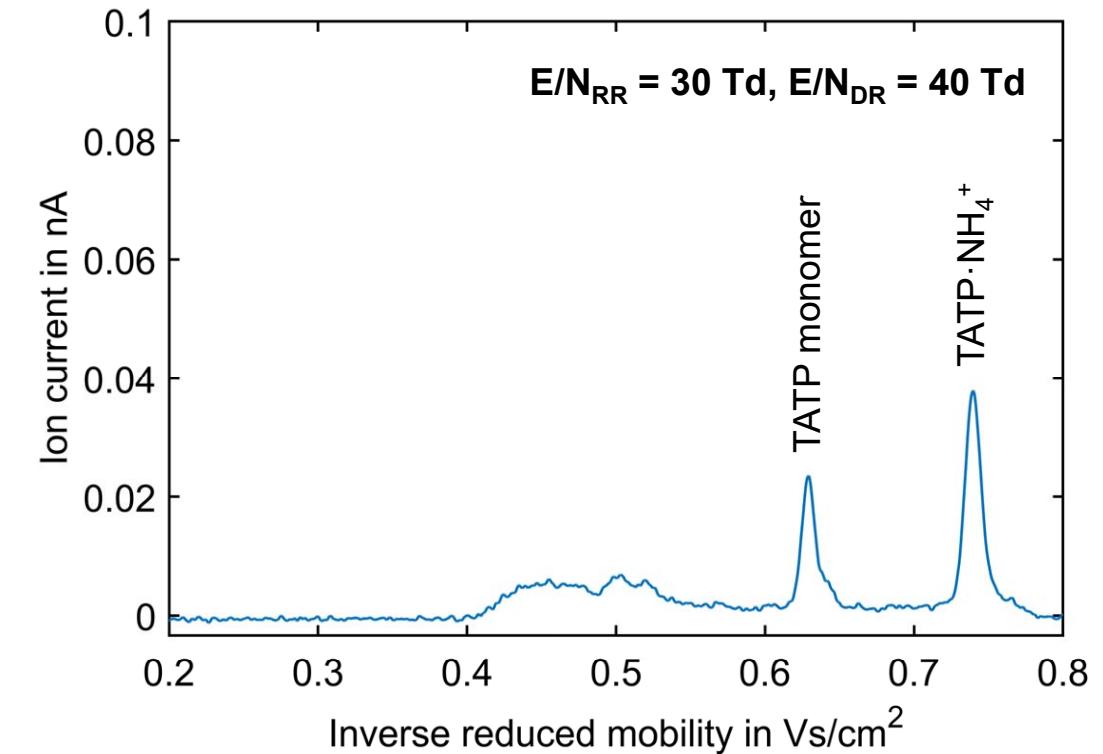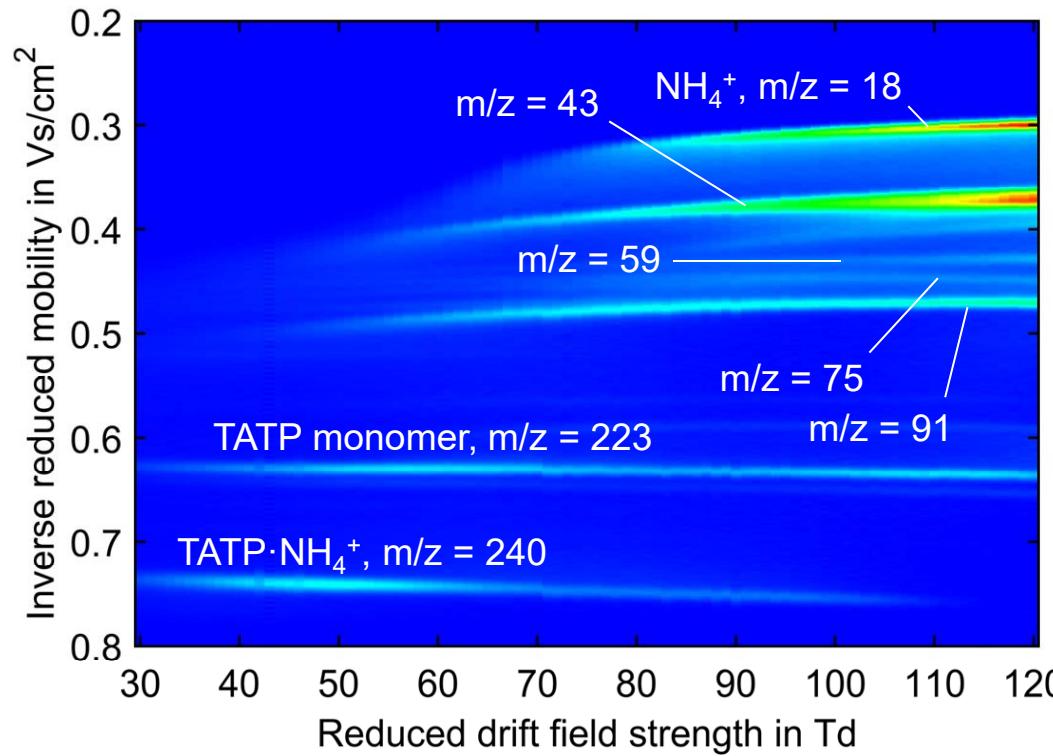
BMK for synthesis of amphetamine and methamphetamine (HiKE-IMS)

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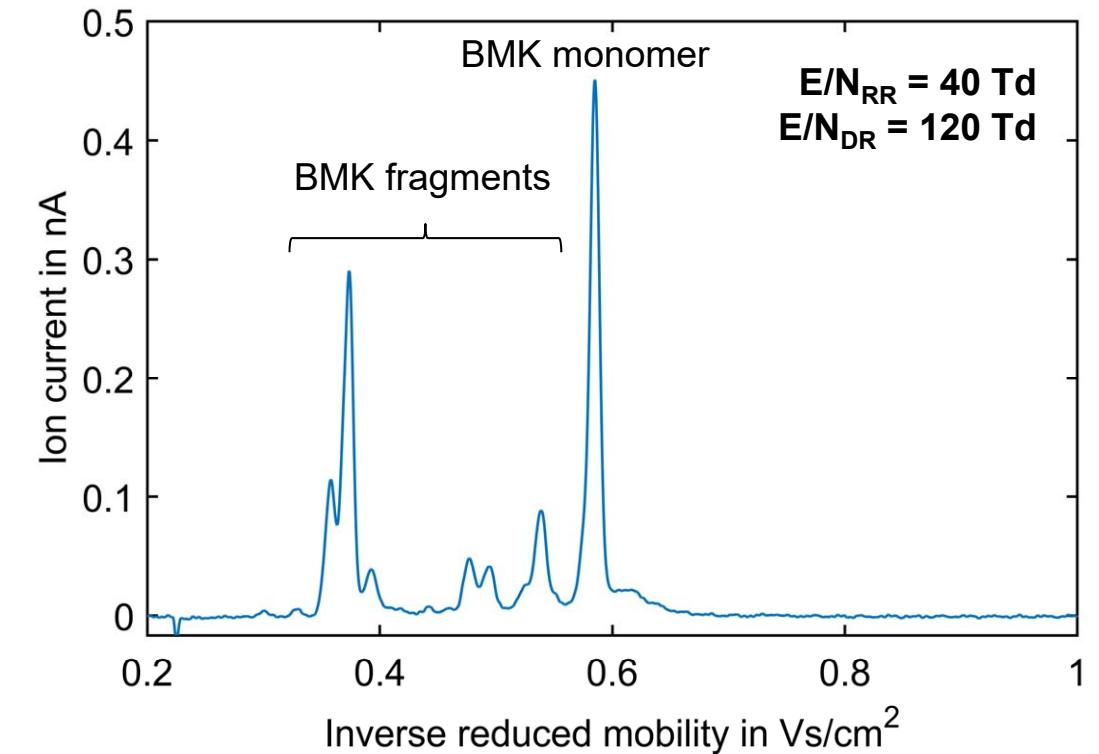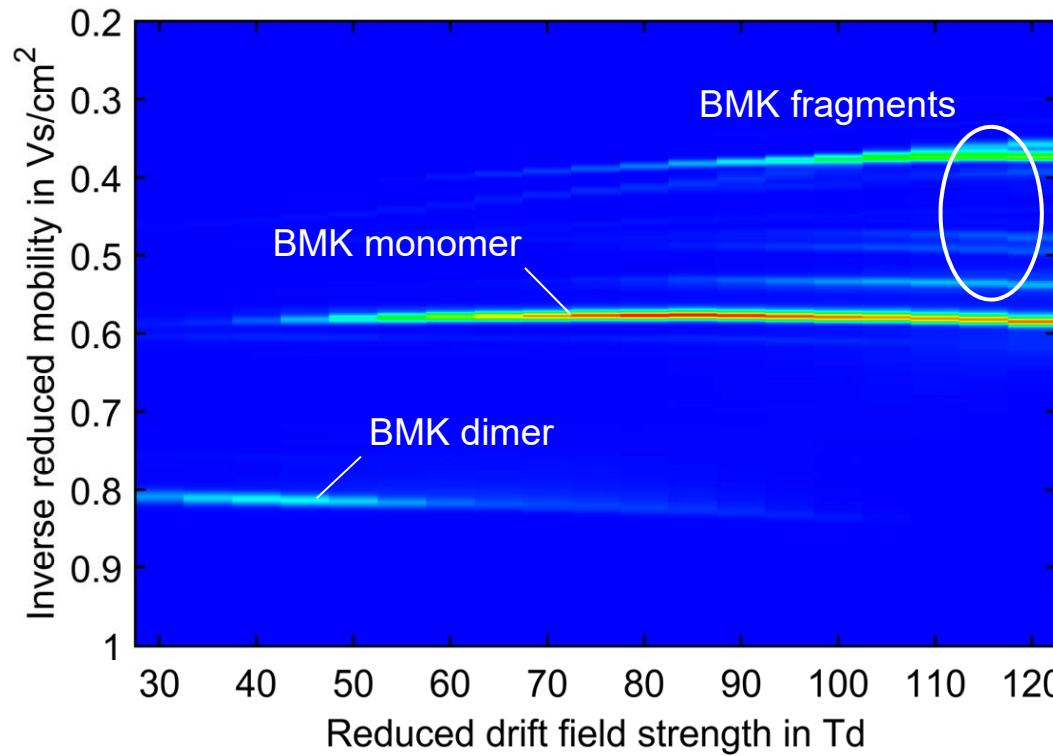
Benzyl cyanide for synthesis of BMK (HiKE-IMS)

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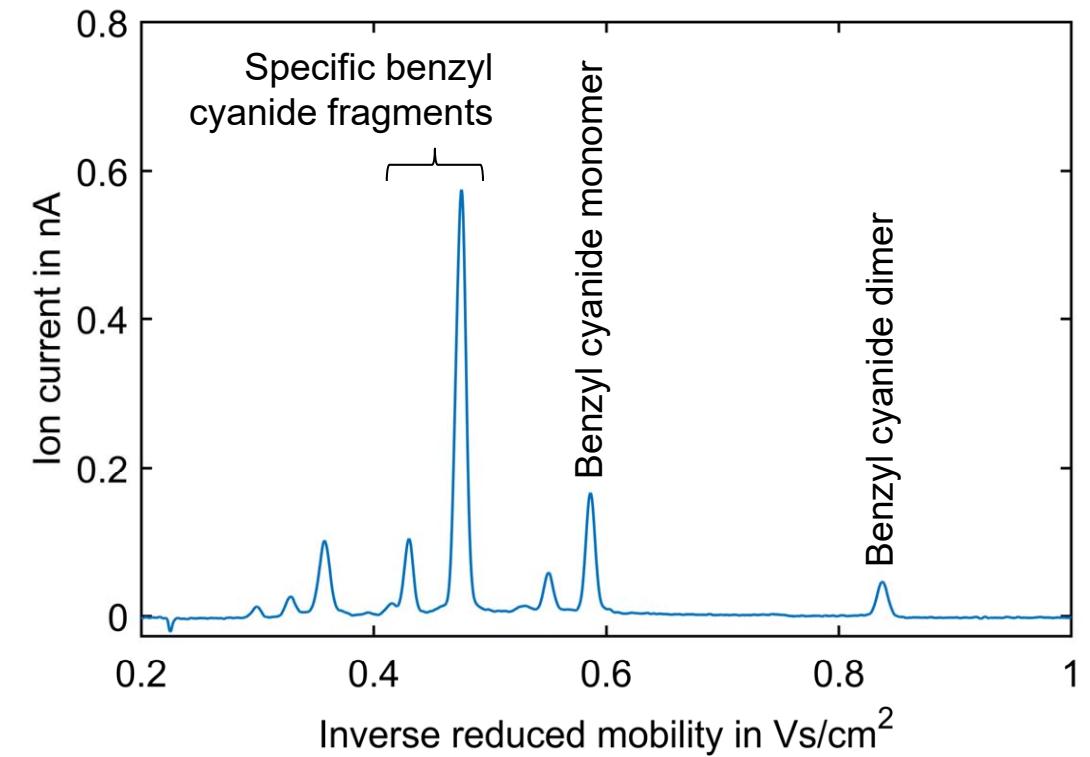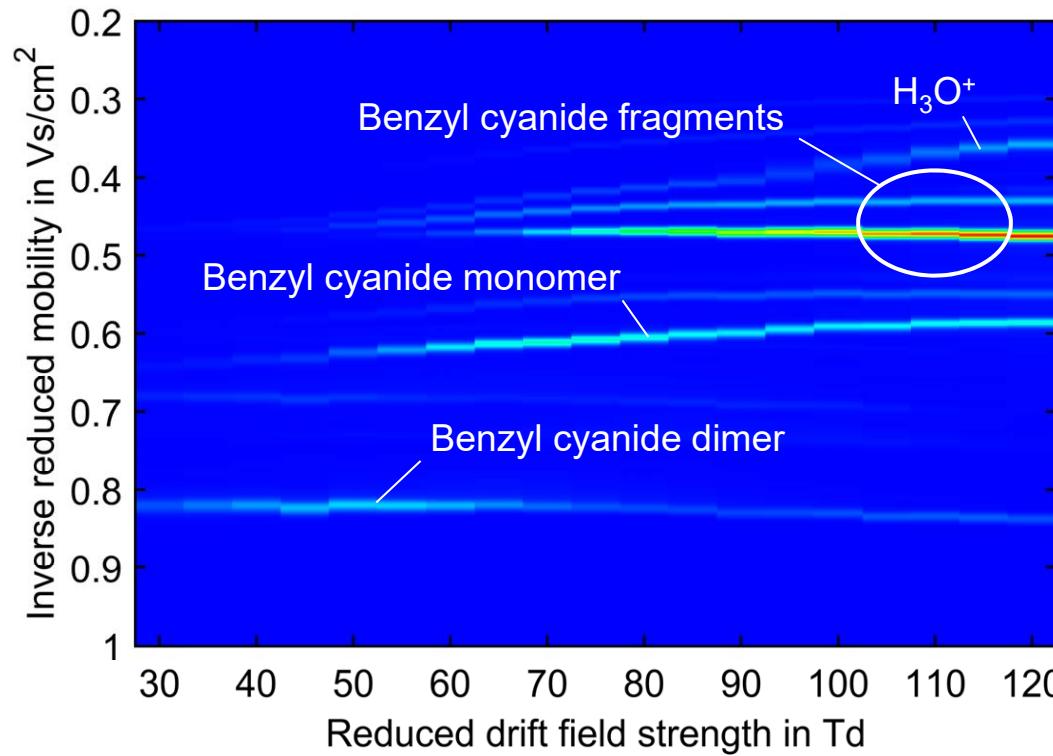
Methylamine for synthesis of methamphetamine (HiKE-IMS)

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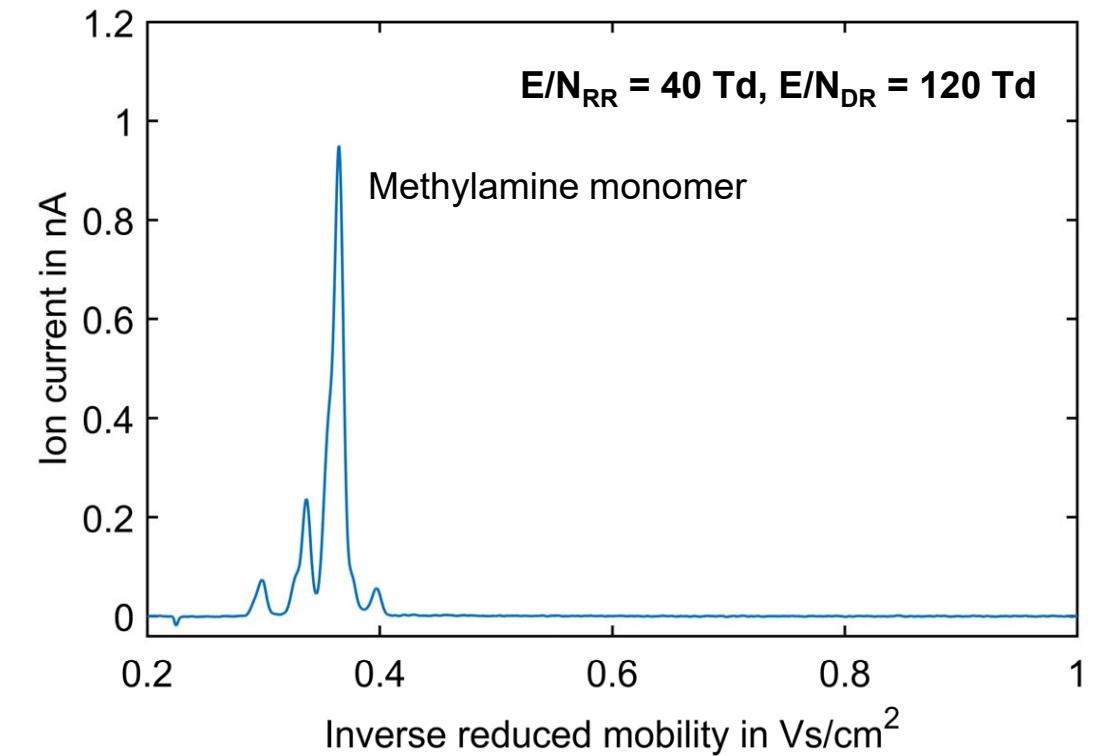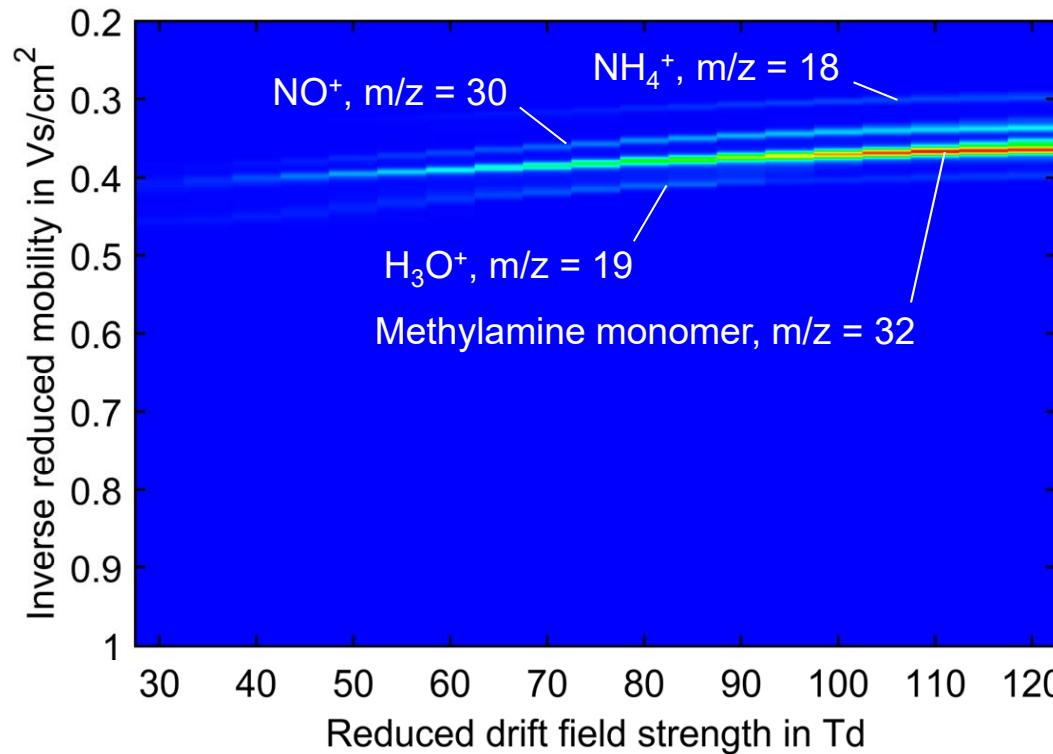
Seized home-made BMK (HiKE-IMS)

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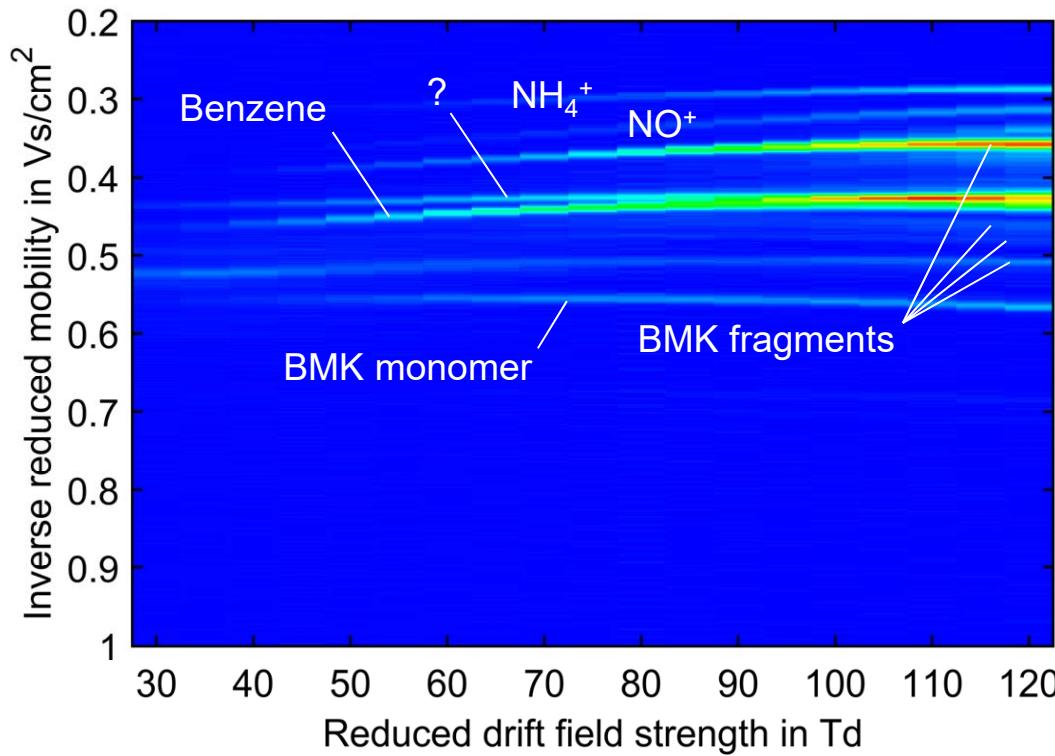
Thank you for your attention

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