FAIMS studies of non-covalent complexes of 3-methylxanthine

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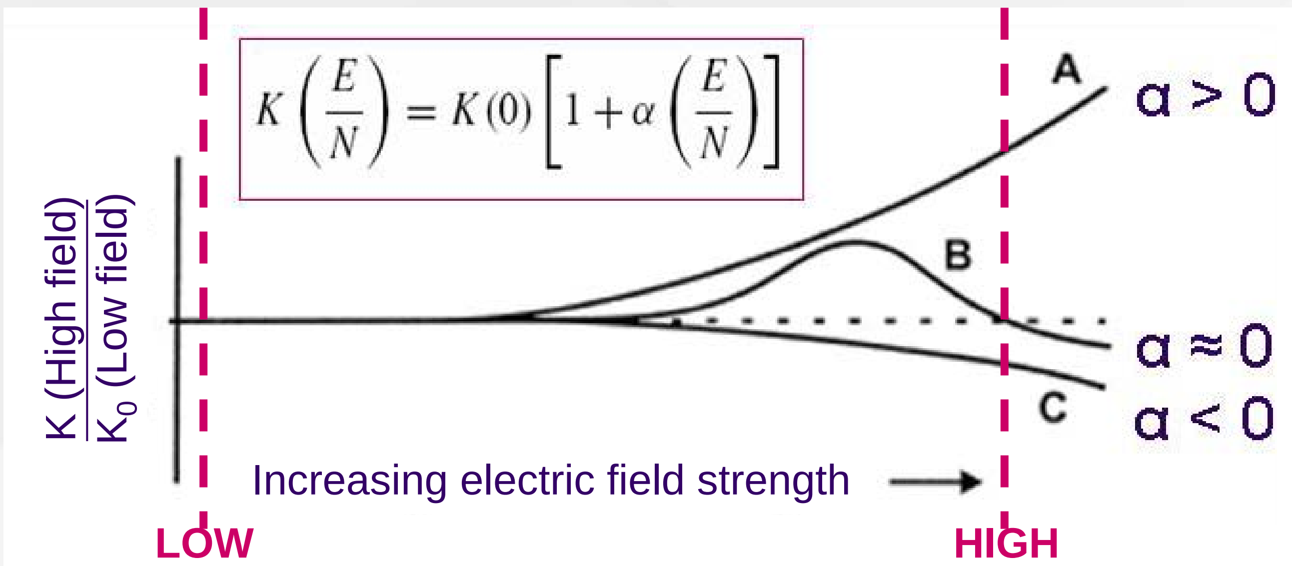
Introduction

- 3-methylxanthine (3-MX) is an example of a small molecule that can self-assemble to form supramolecular complexes
- Of interest in areas such as structural biology, supramolecular chemistry, nanotechnology, electrochemistry, …
- Going to evaluate how FAIMS-MS can be used to enhance the analysis of these complexes

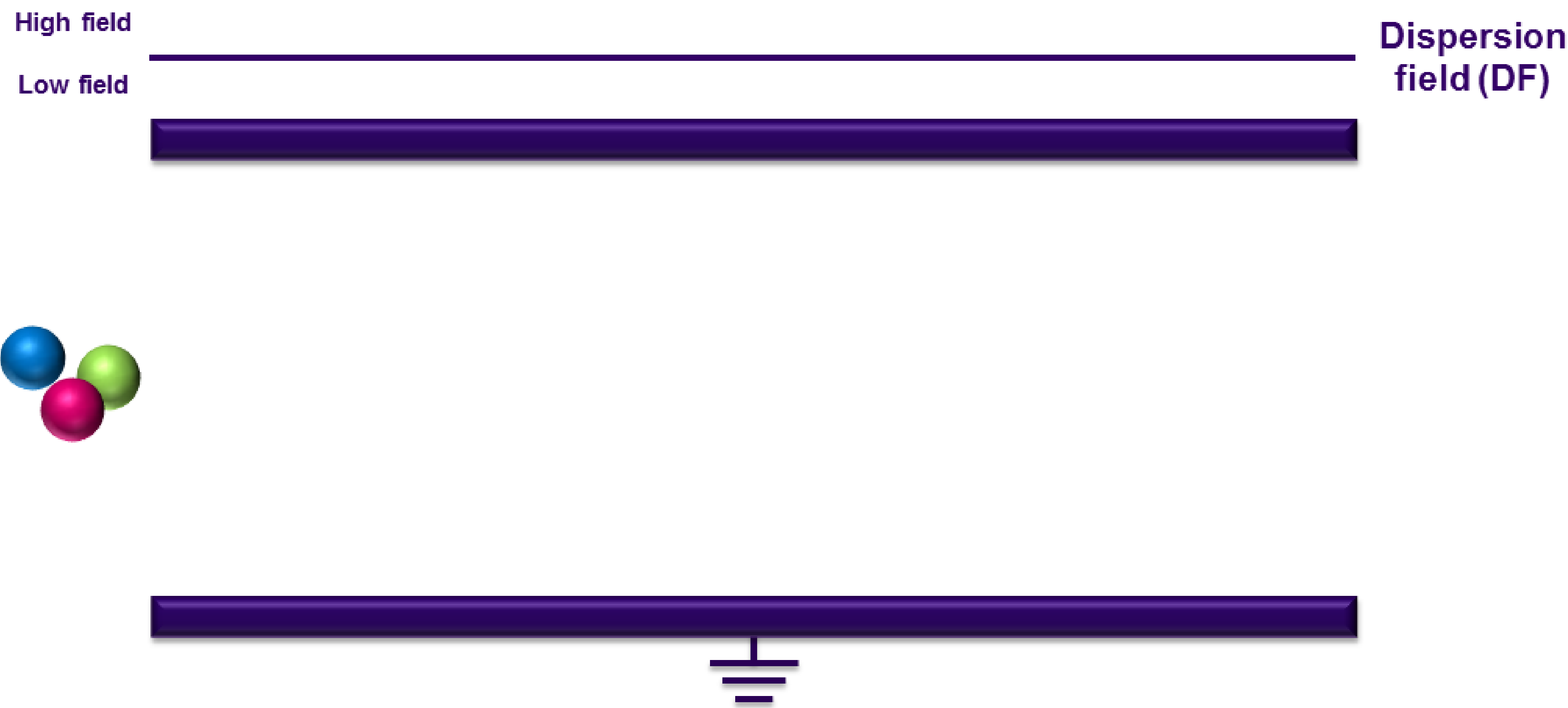
FAIMS

- Field asymmetric waveform ion mobility spectrometry
- Separation of ions based upon their non-linear relationship between mobility and increasing electric field strength
- **Ion separation based upon differential mobility**

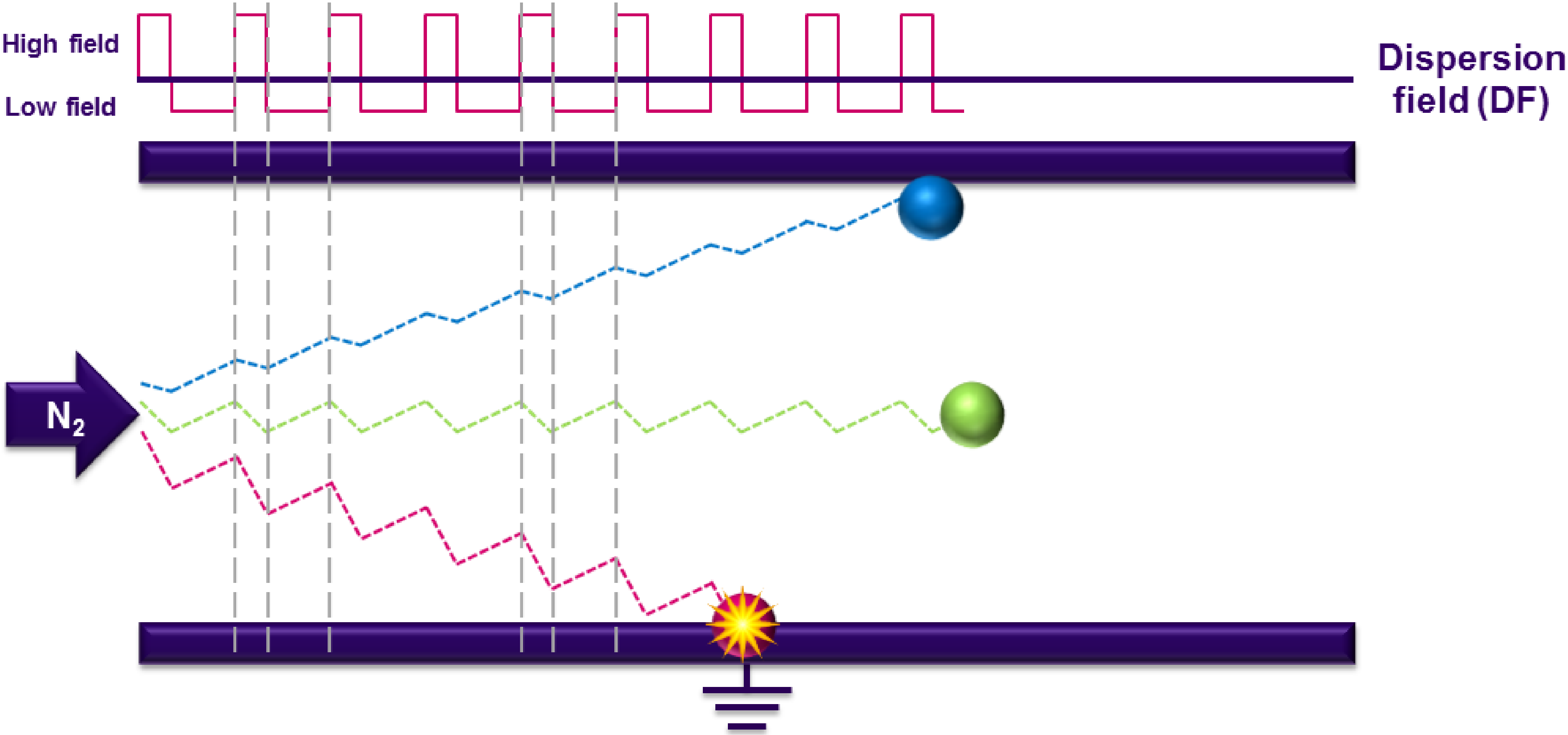


[Purves R W, Guevremont R, Anal. Chem. 1999, 71, 2346-2357]

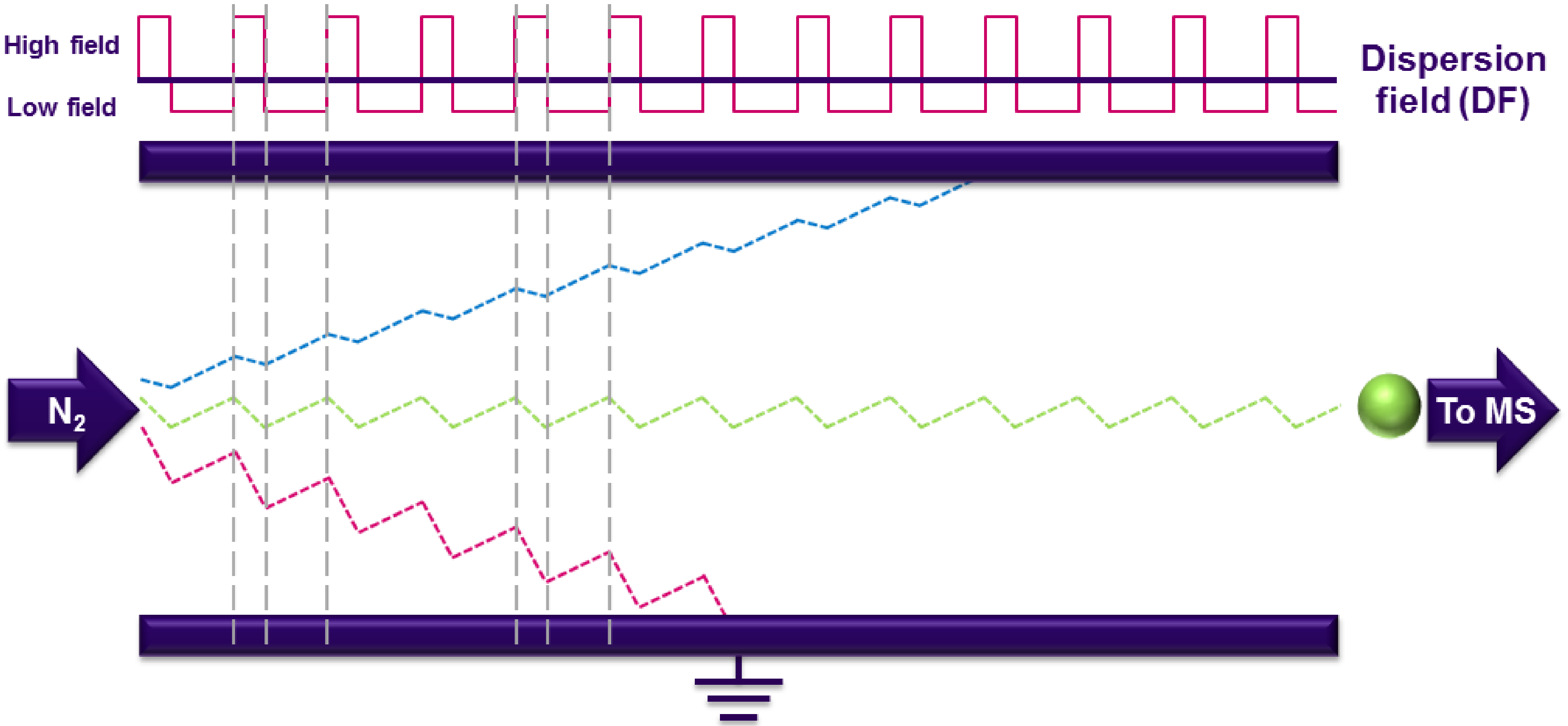
FAIMS



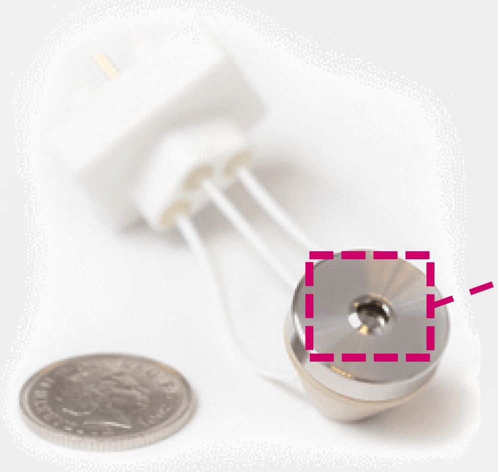
FAIMS



FAIMS



Owlstone chip-based FAIMS

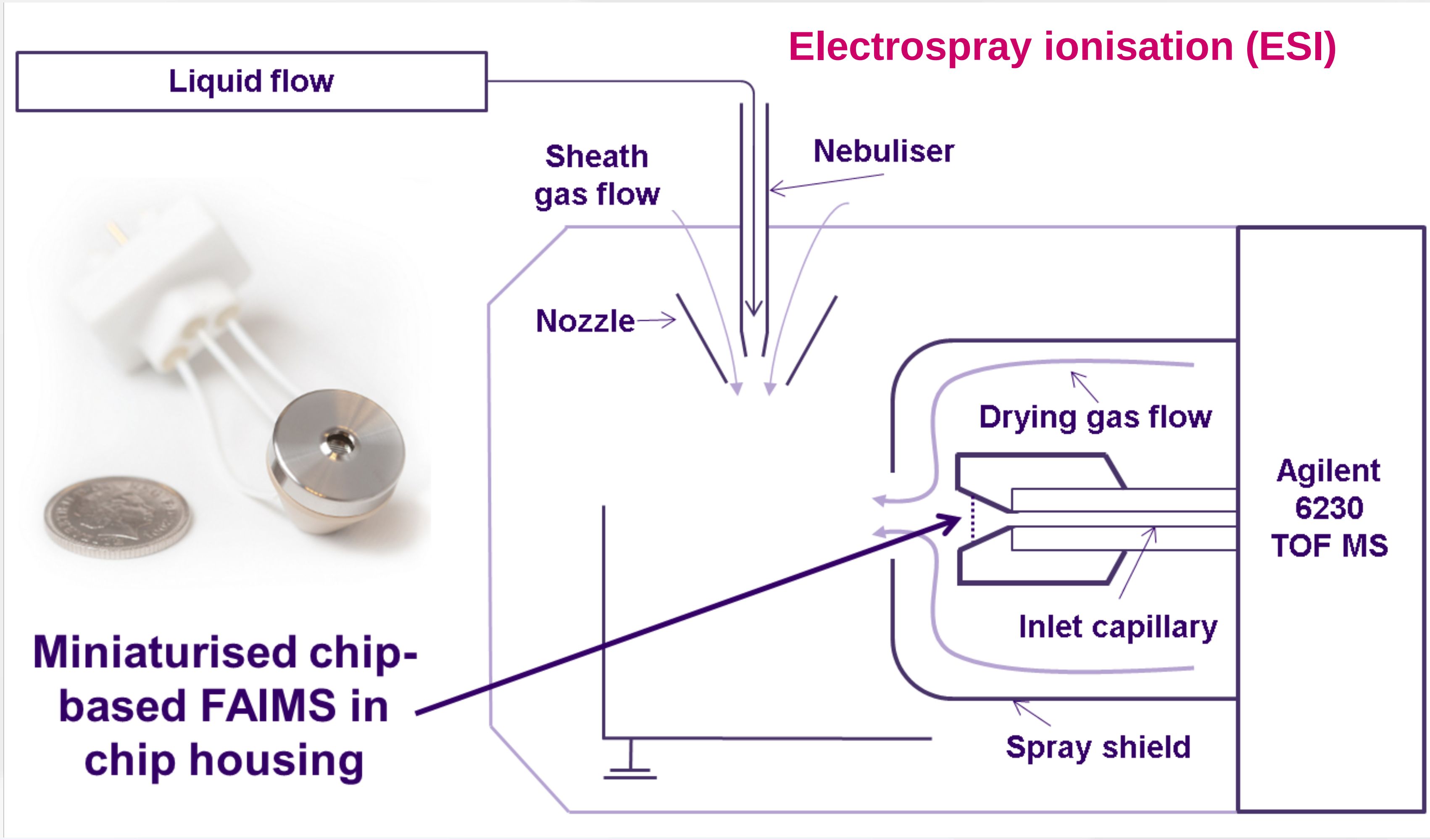


Miniaturised chip-based FAIMS in chip housing

Parallel pairs of electrodes

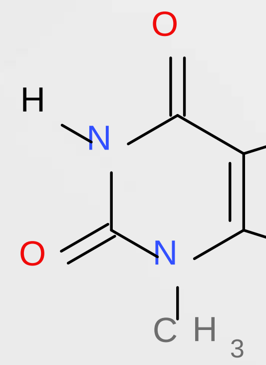
Side view of FAIMS chip

ESI-FAIMS-MS

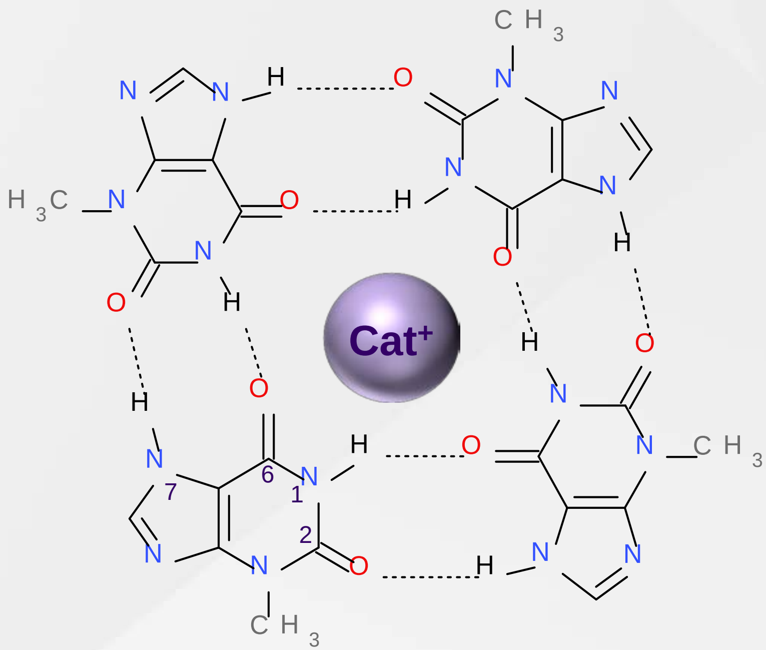


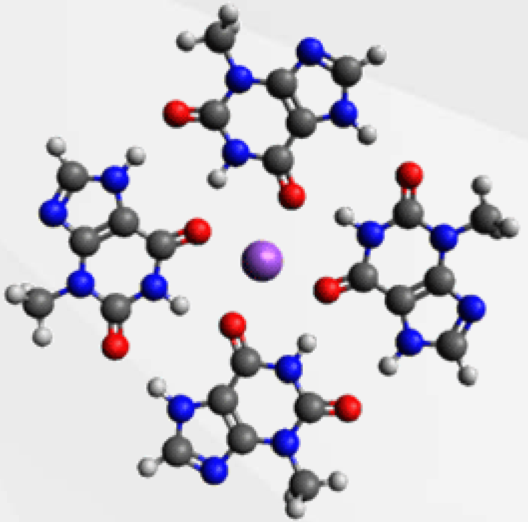
Electrospray ionisation (ESI)
Liquid flow
Sheath gas flow
Nebuliser
Nozzle
Drying gas flow
Agilent 6230 TOF MS
Inlet capillary
Spray shield
Miniaturised chip-based FAIMS in chip housing

3-MX Structure



Tetrameric species – $(3\text{-}MX)_4$





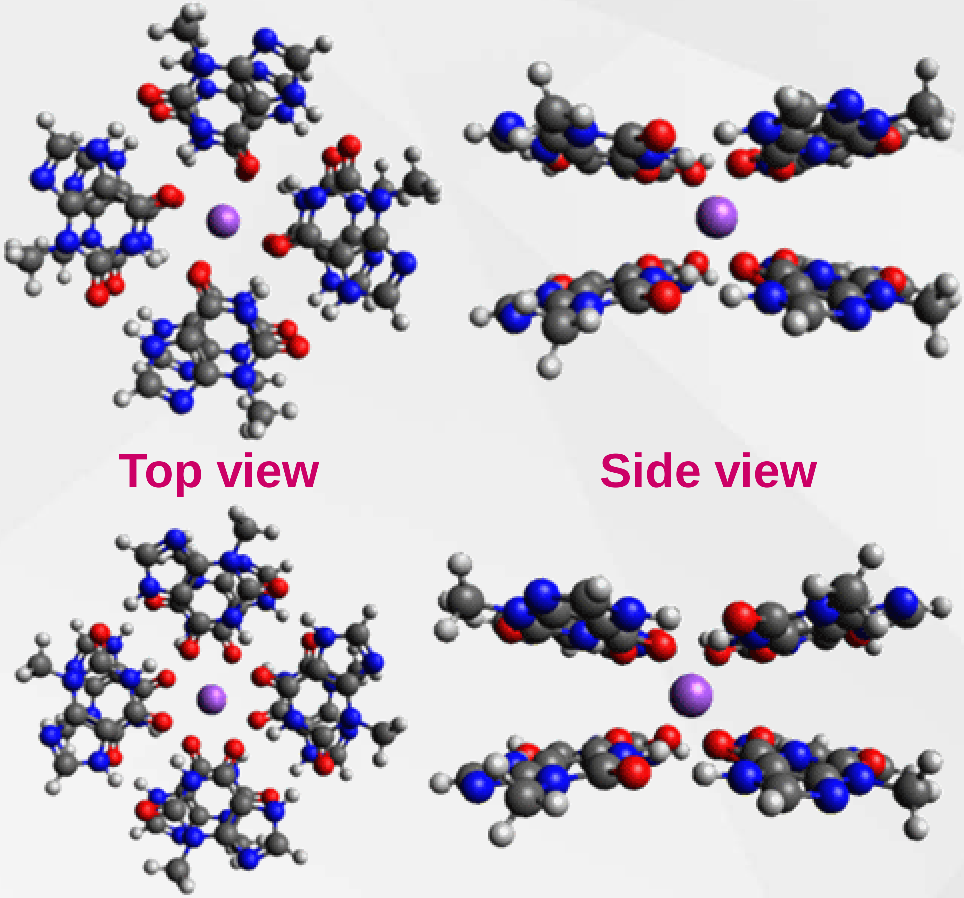
Top view

Side view

$Cat^+ = NH_4^+$, Na^+ or K^+

3-Methylxanthine (3-MX)

Octameric species – $(3\text{-MX})_8$



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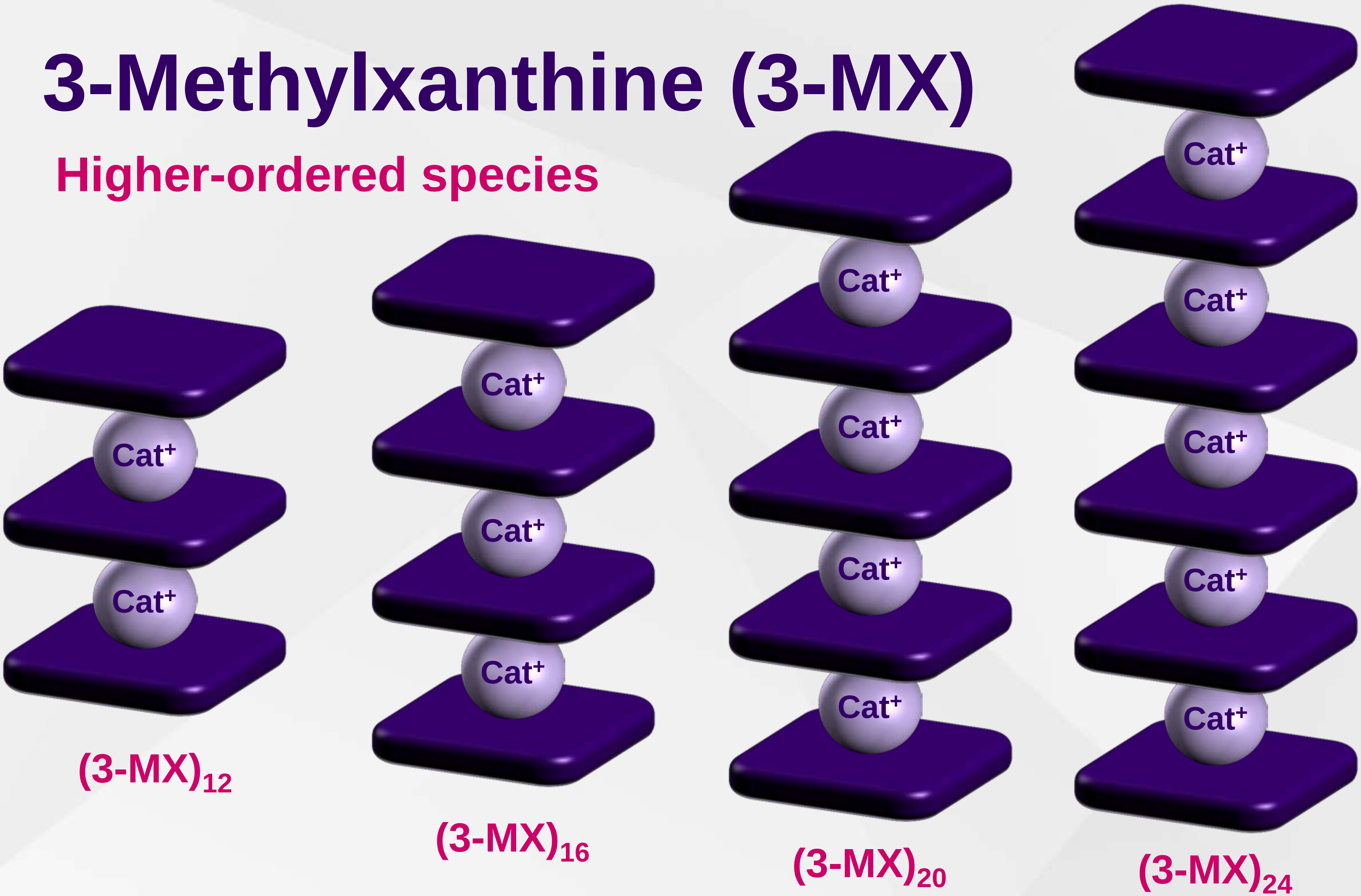
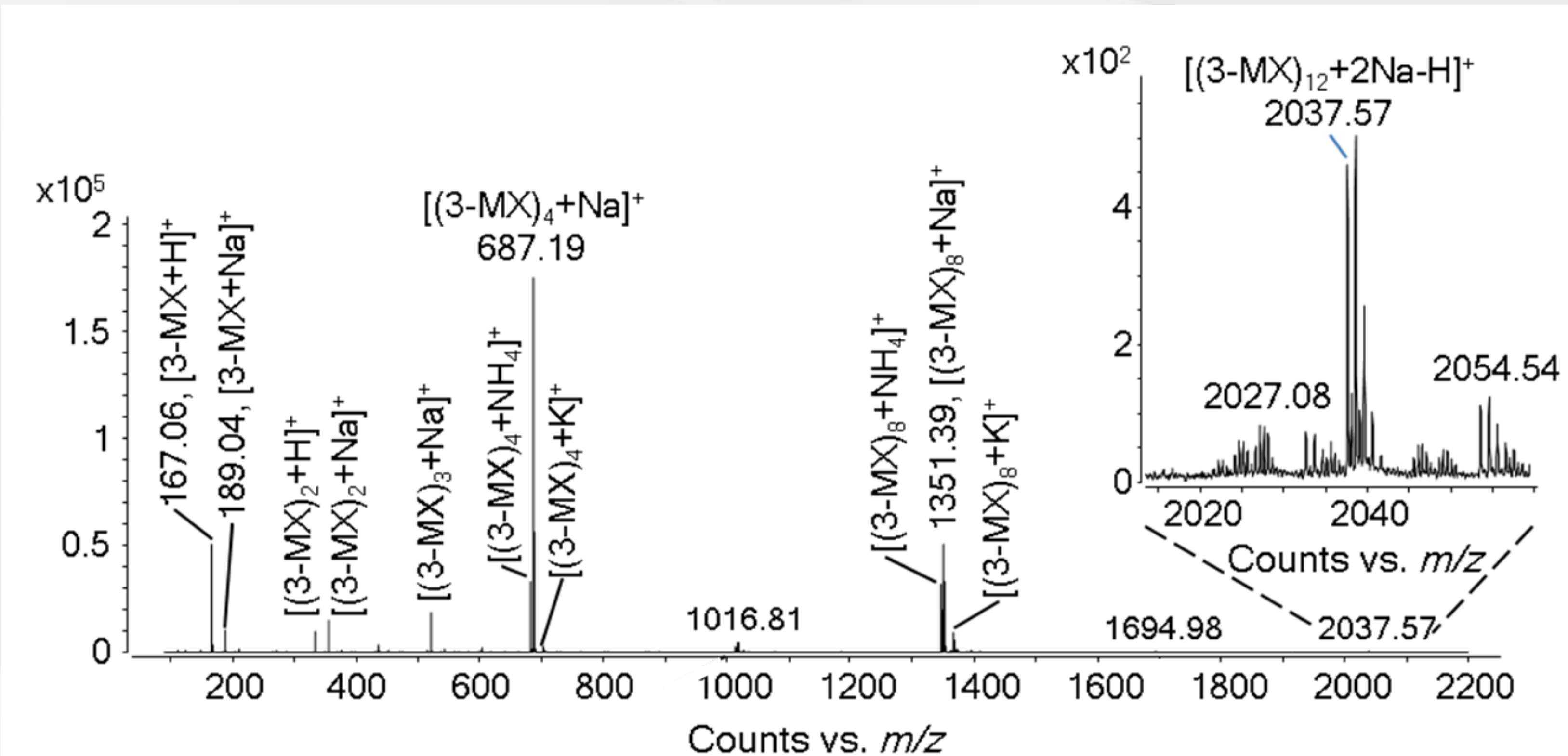
3-Methylxanthine (3-MX)

Higher-ordered species



ESI-MS of 3-MX

- Transmission of clustered complexes leads to complex mass spectra



ESI-MS of 3-MX

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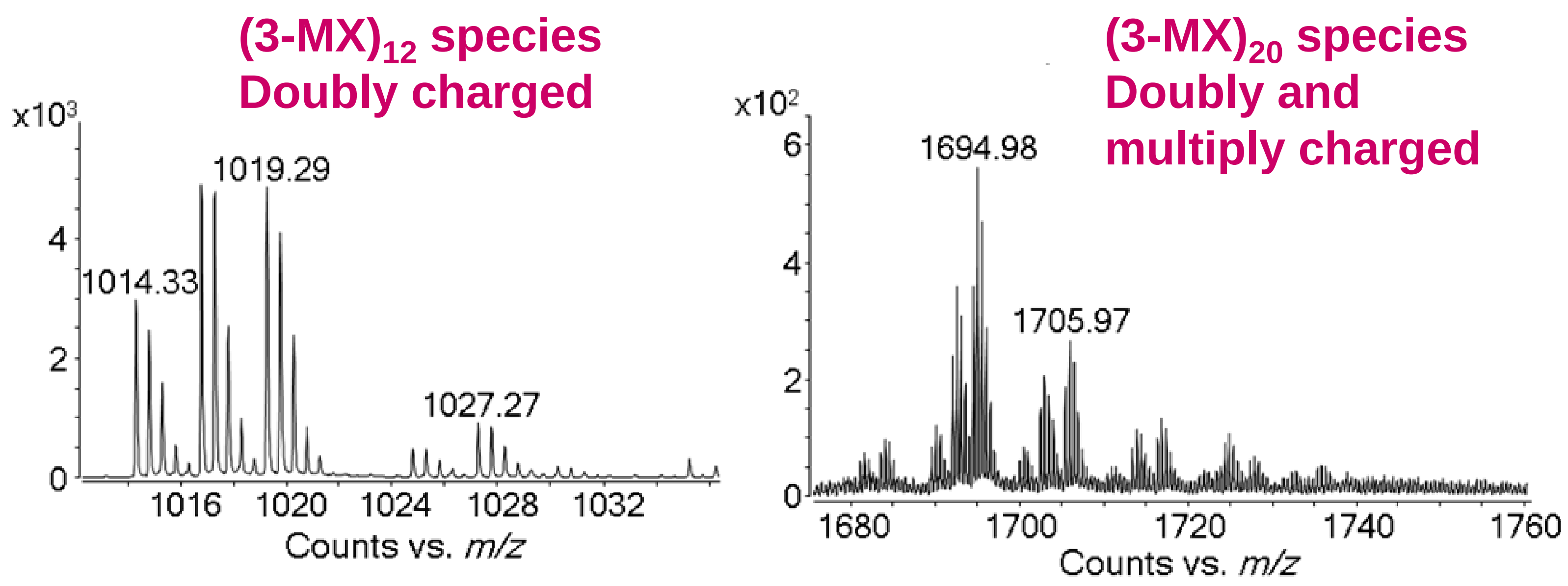

ESI-MS of 3-MX

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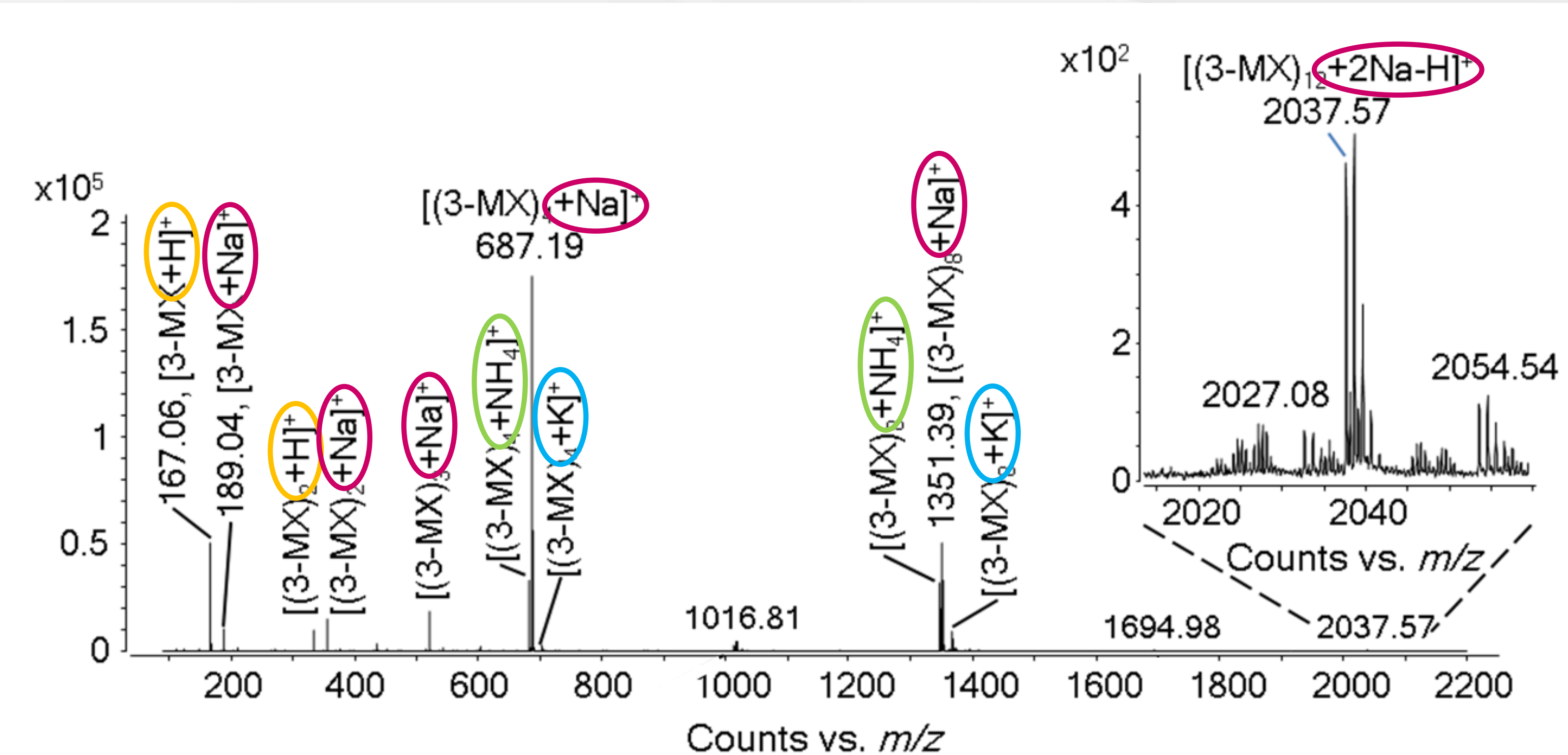
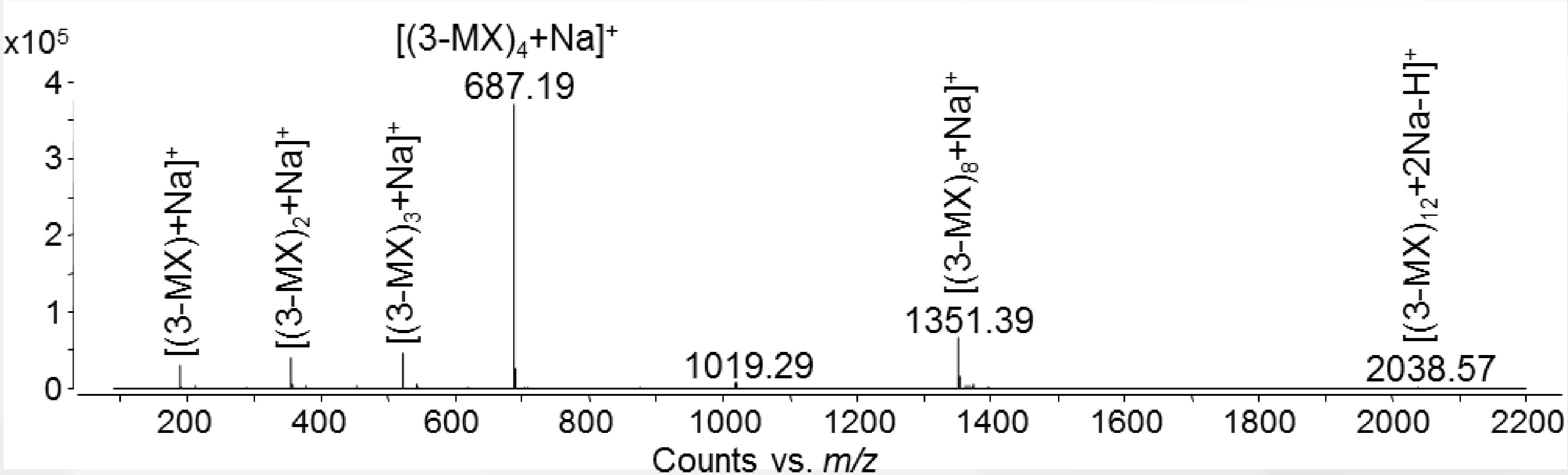
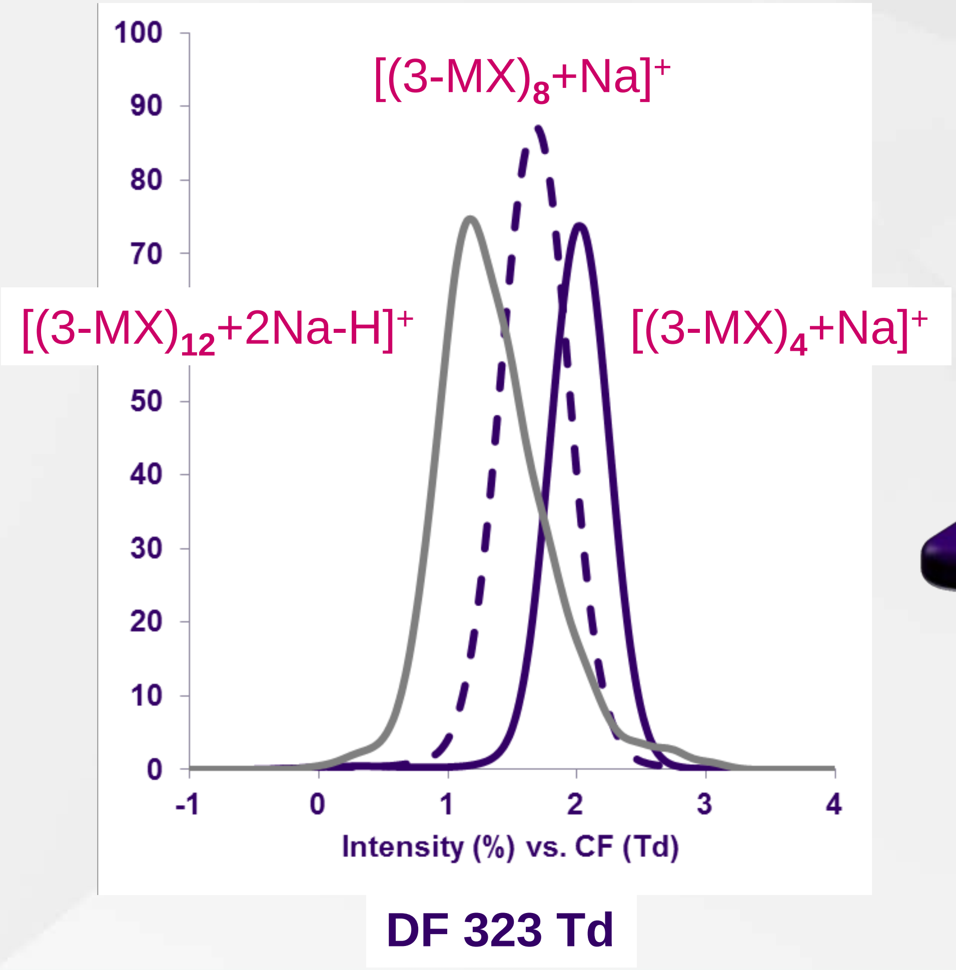


ESI-FAIMS-MS of 3-MX + Na^+

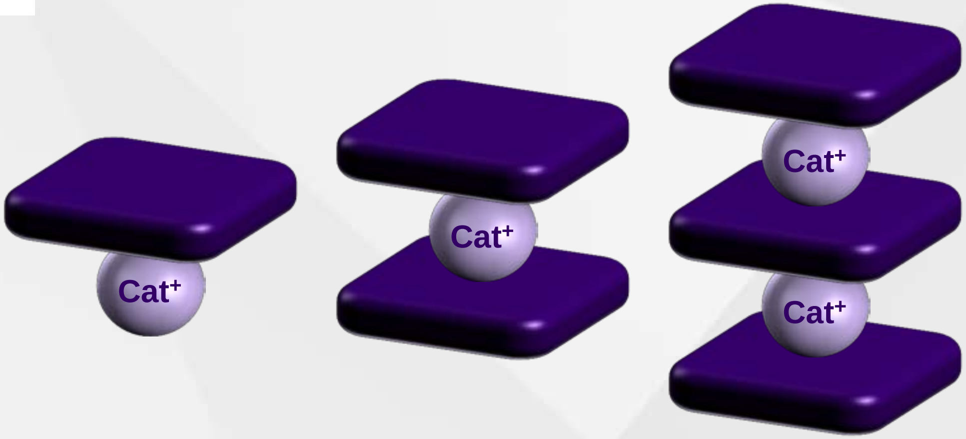
- Focus on Na^+ complexes in order to simplify mass spectrum and FAIMS spectra



ESI-FAIMS-MS of 3-MX + Na^+

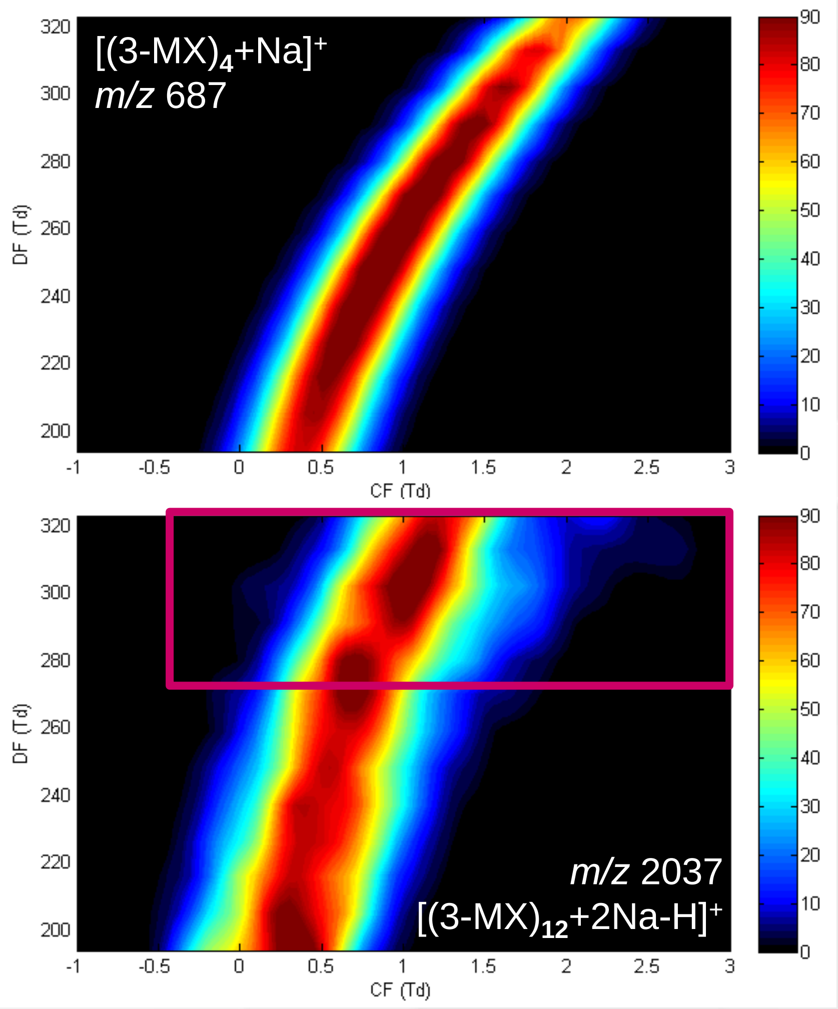


- FAIMS CF spectrum at a particular DF

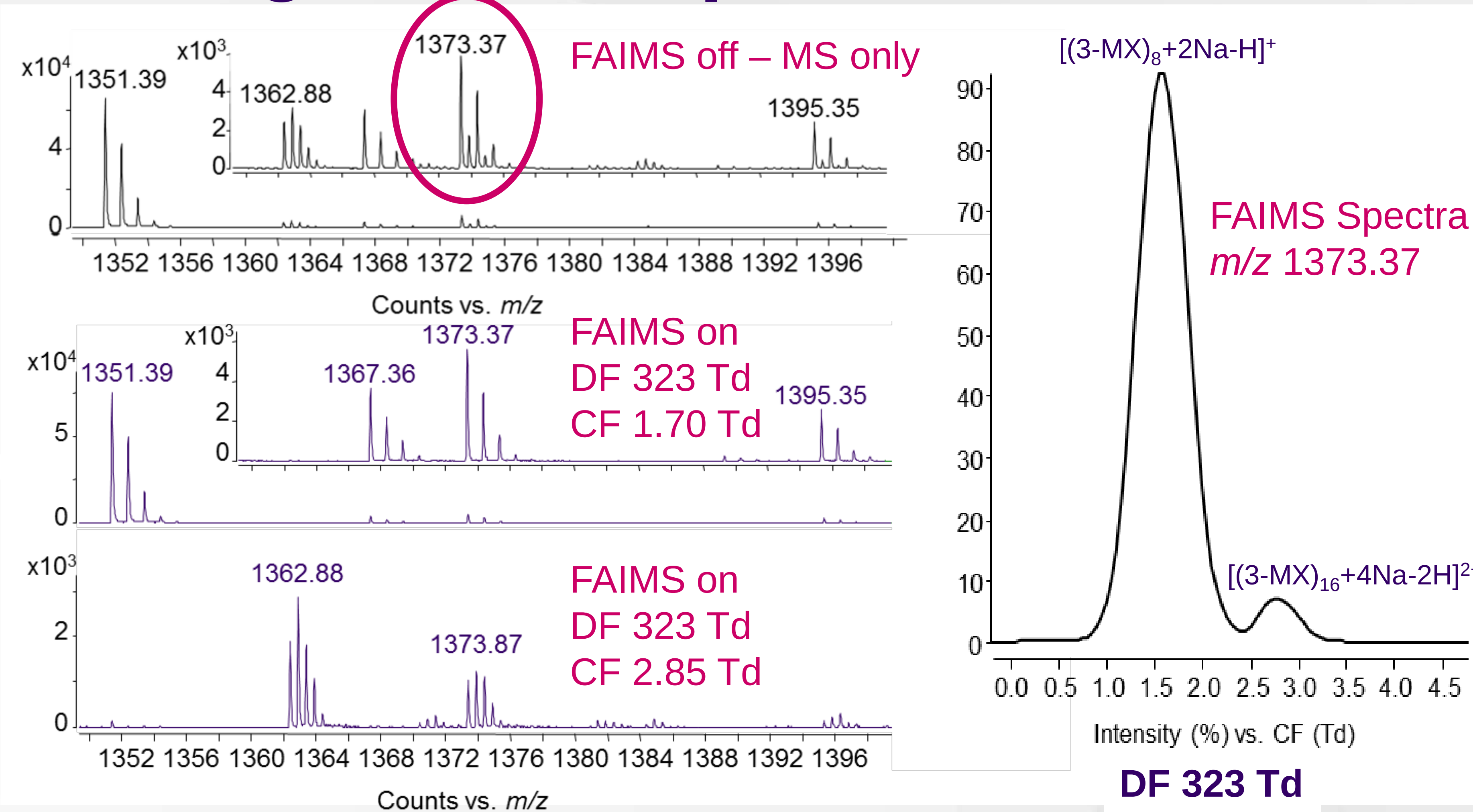


ESI-FAIMS-MS of 3-MX + Na^+

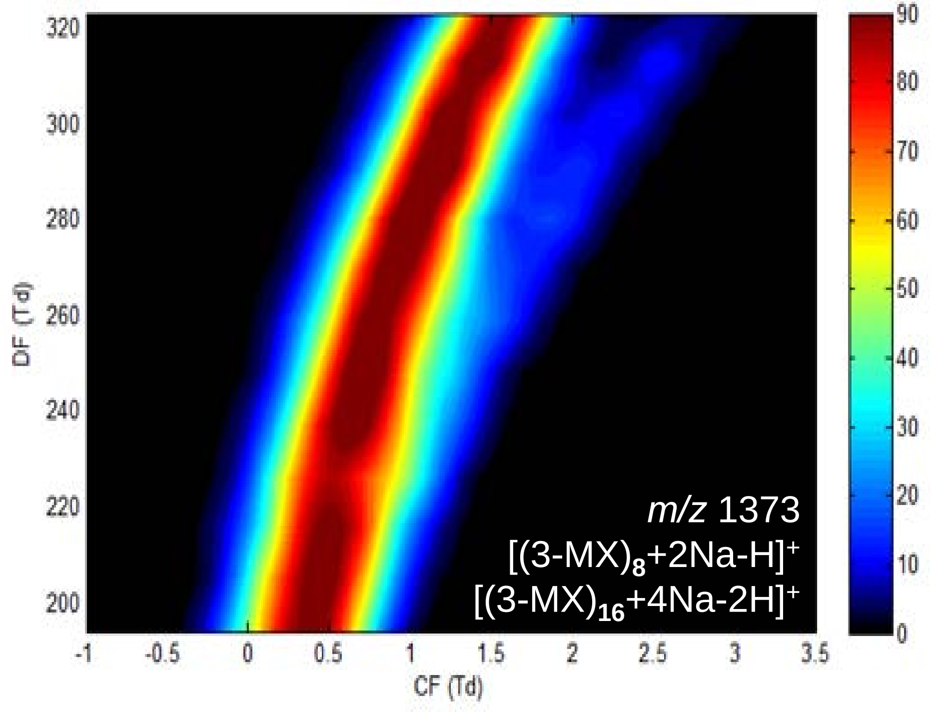
- DF vs CF heat map for a particular *m/z* value (with relative intensity on the colour scale)

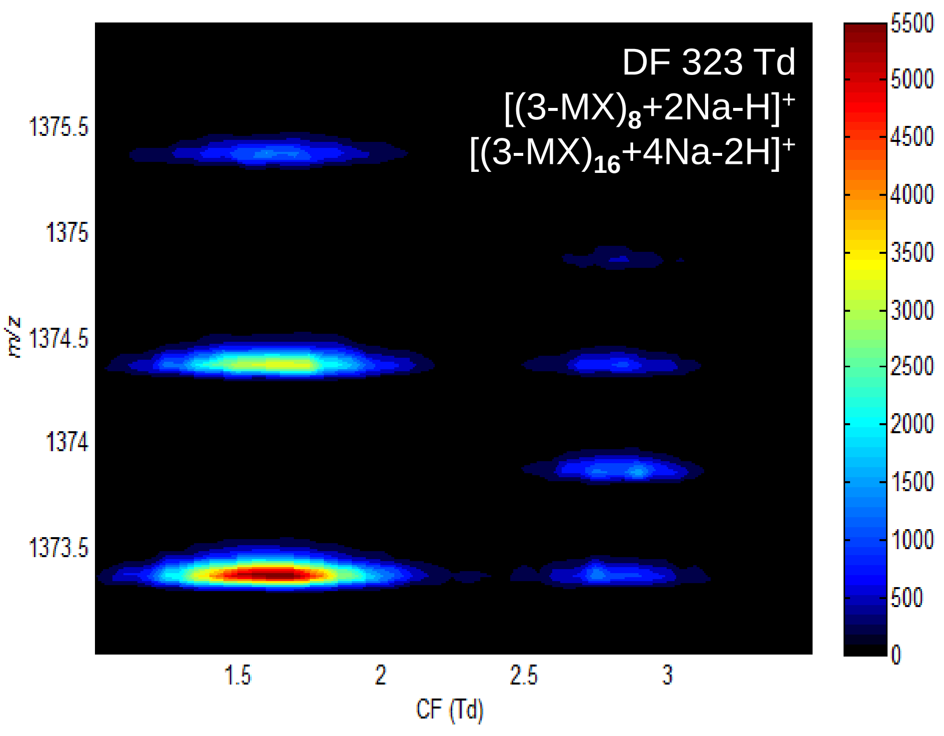


Charge state separation



Charge state separation



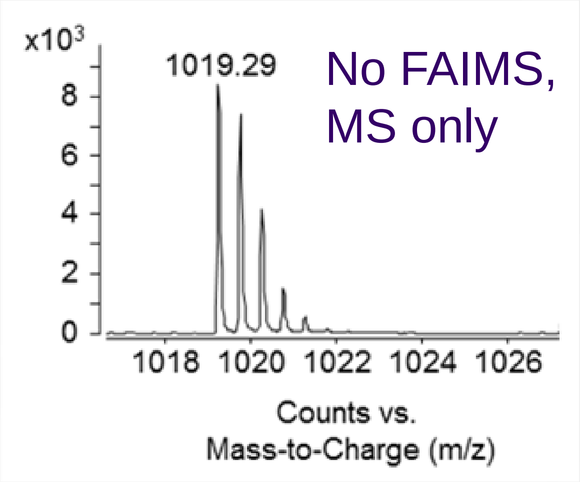


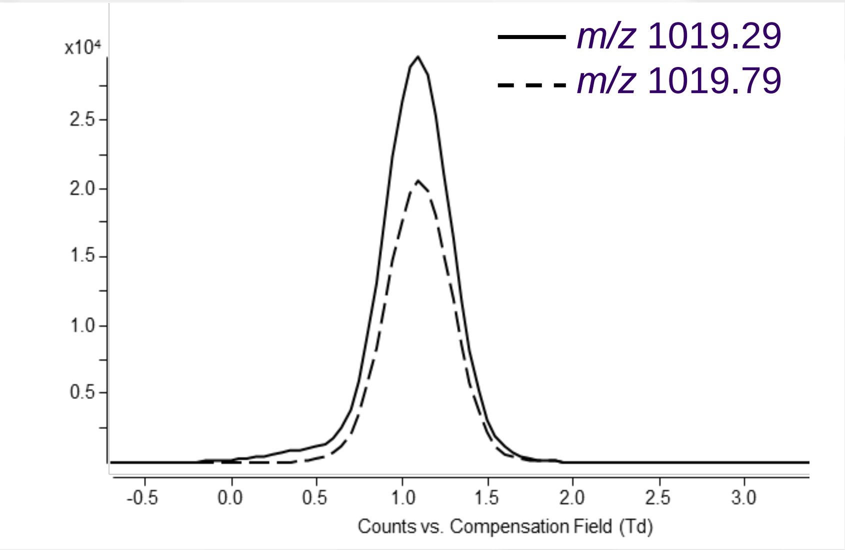
DF (Td) vs CF (Td)

***m/z* vs CF (Td)**

FAIMS parameter selection

- Careful selection of FAIMS parameters can transmit ions that could not be seen with MS alone





DF 216 Td

FAIMS parameter selection

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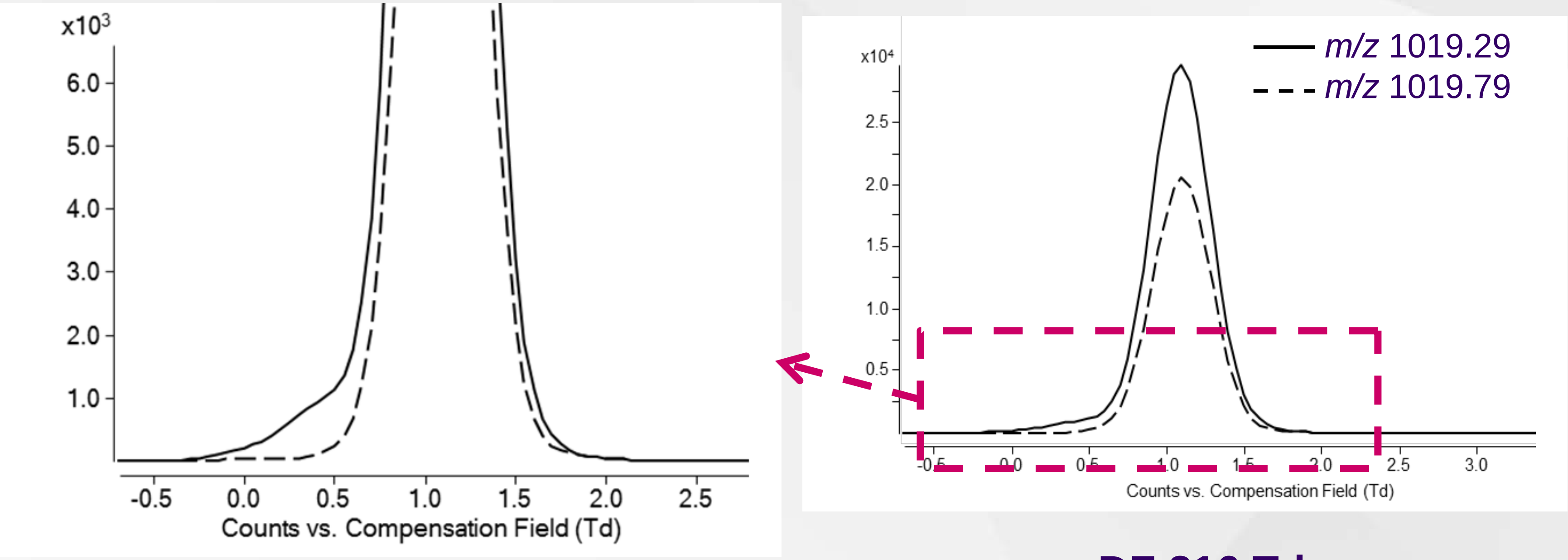

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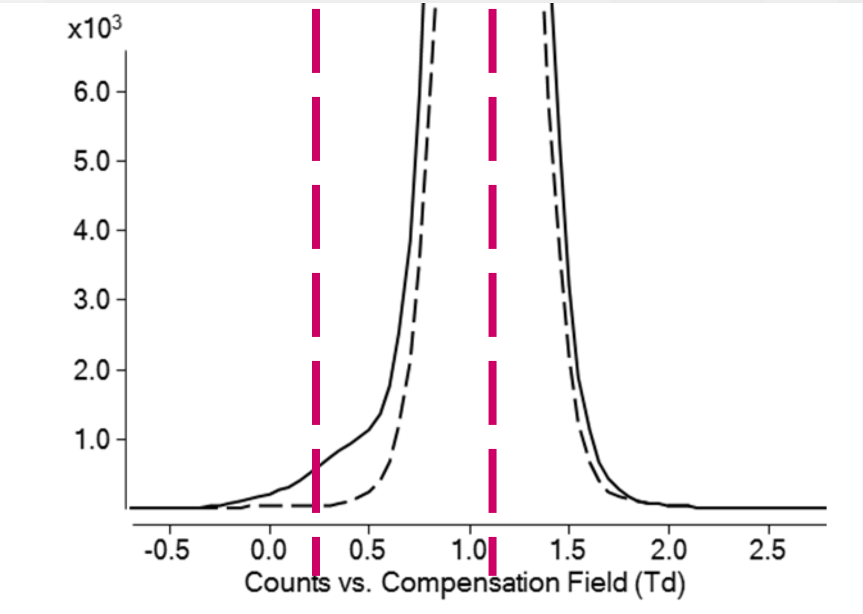
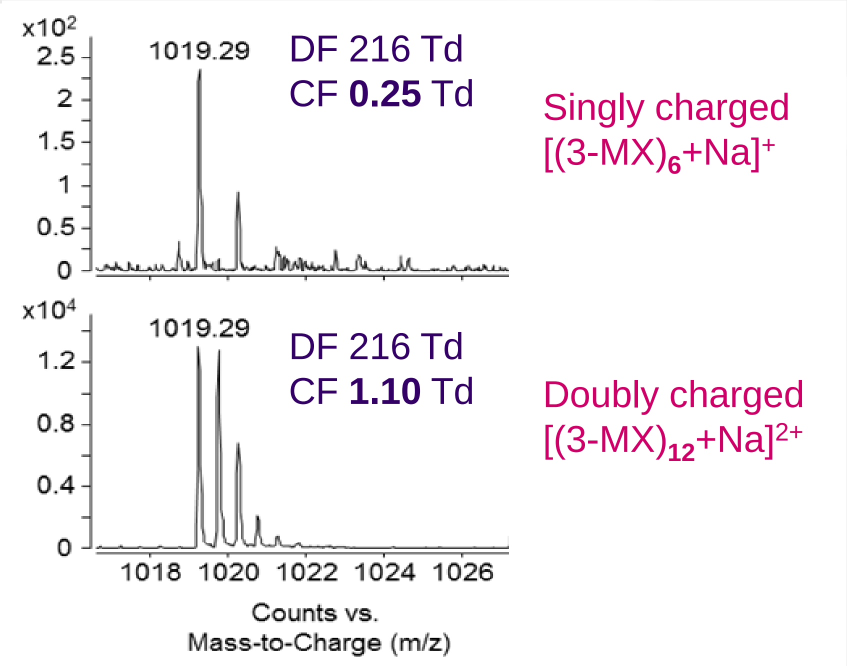
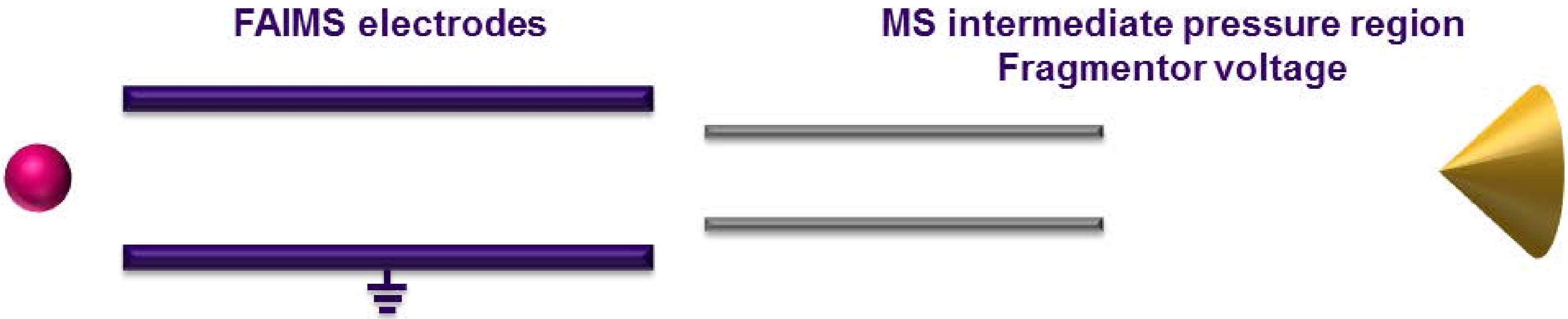




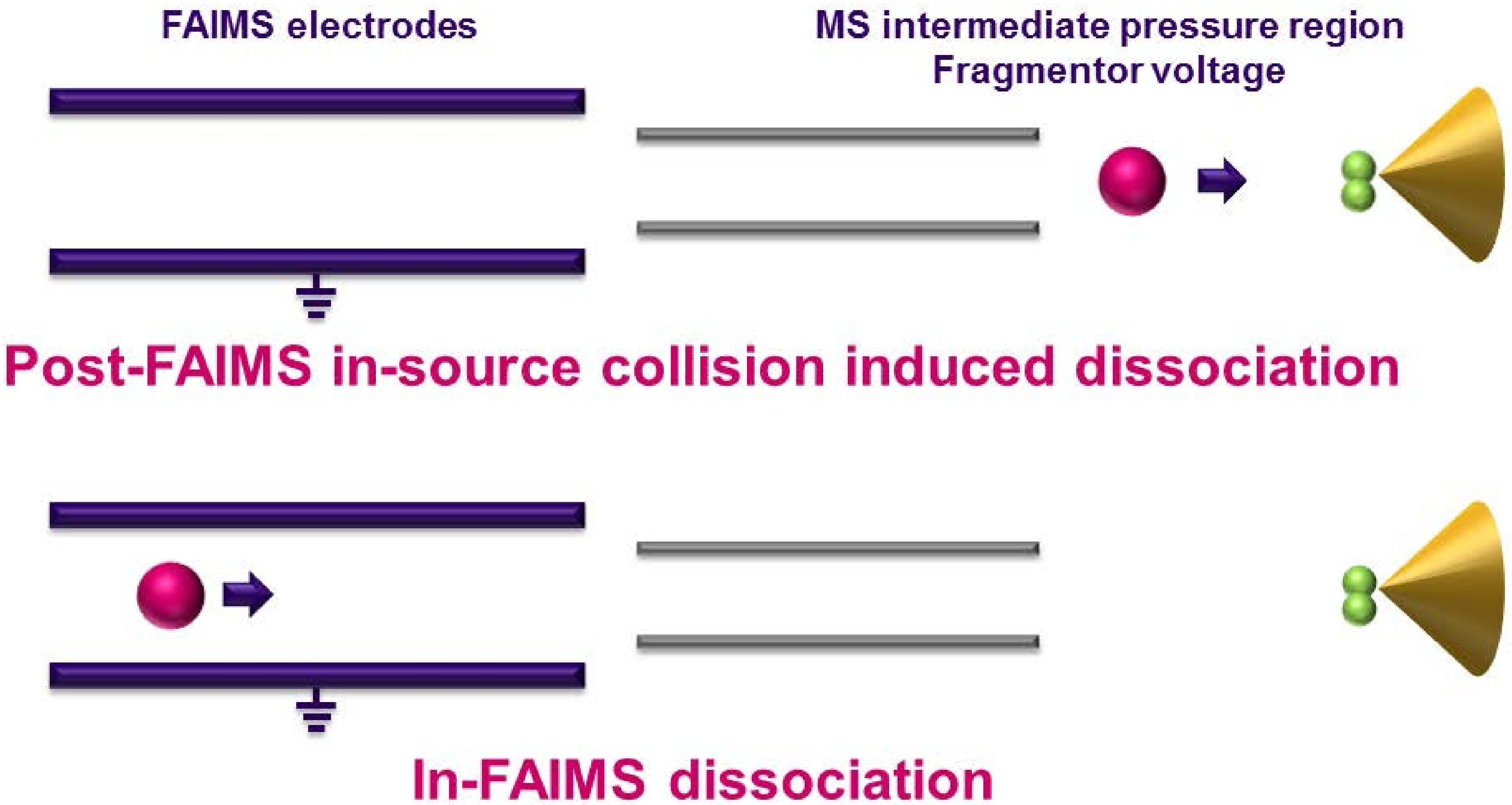
Dissociation in FAIMS-MS



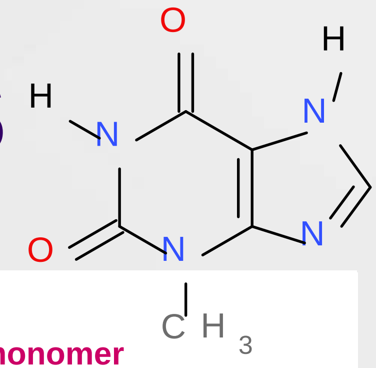
Post-FAIMS in-source collision induced dissociation

In-FAIMS dissociation

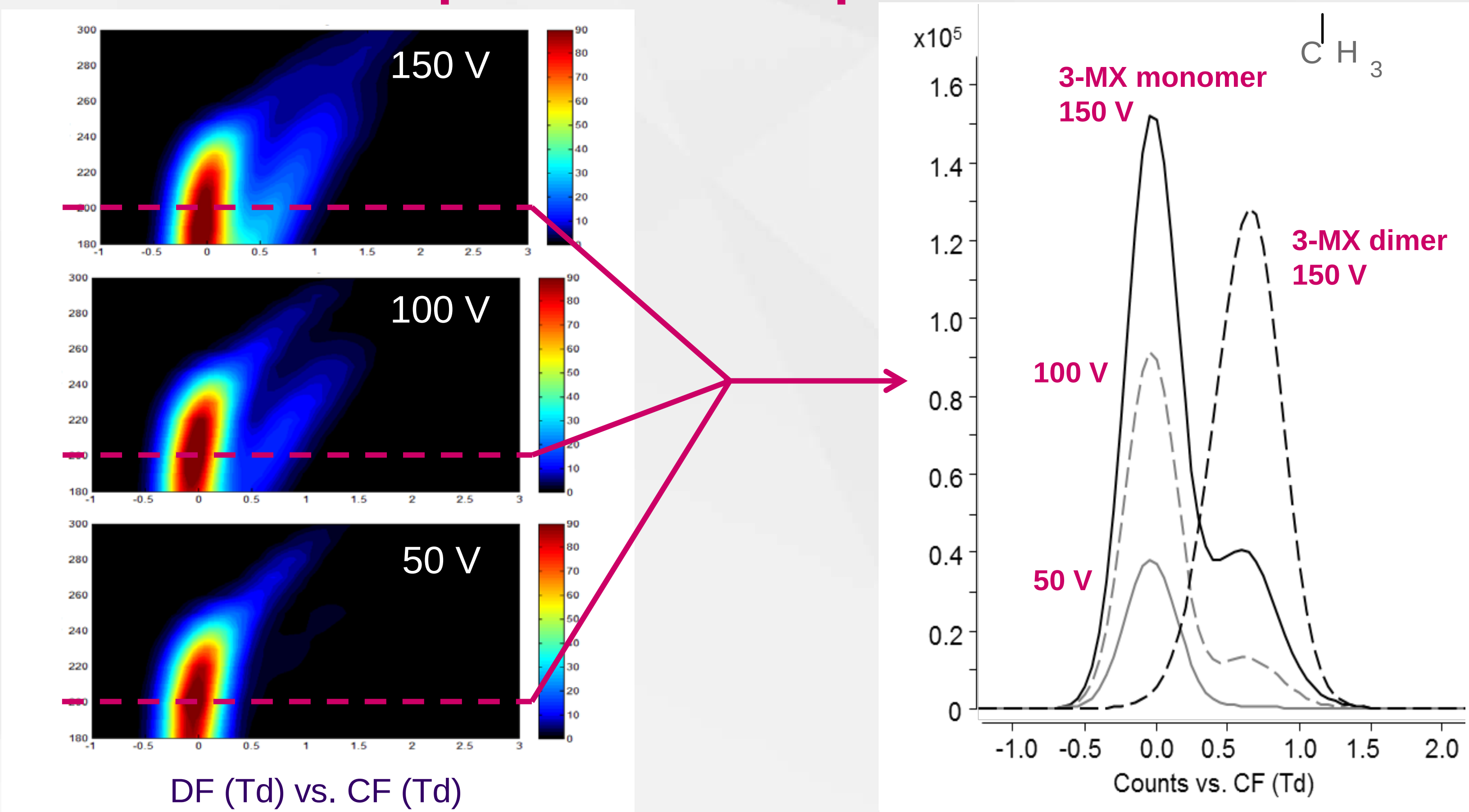
Dissociation in FAIMS-MS



Dissociation in FAIMS-MS

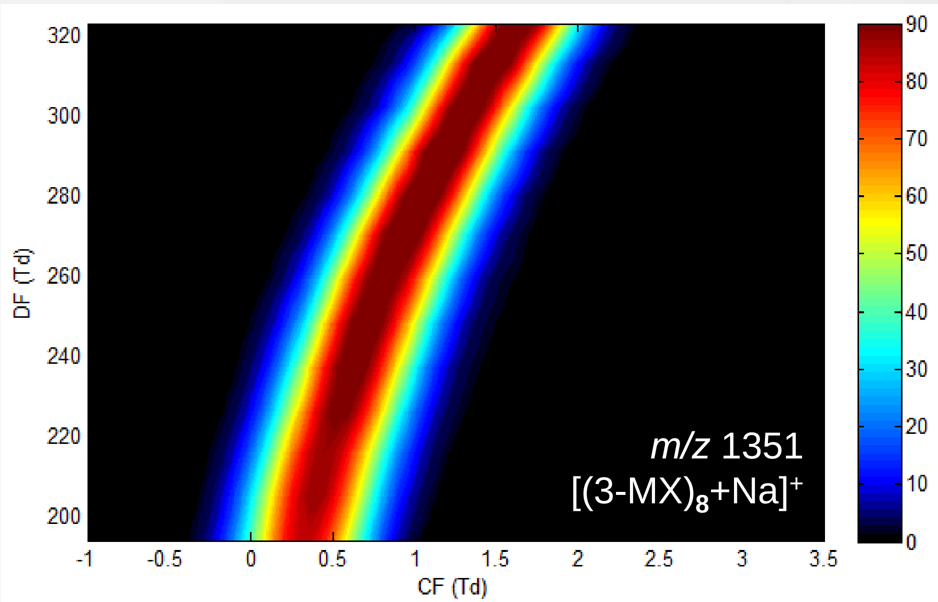


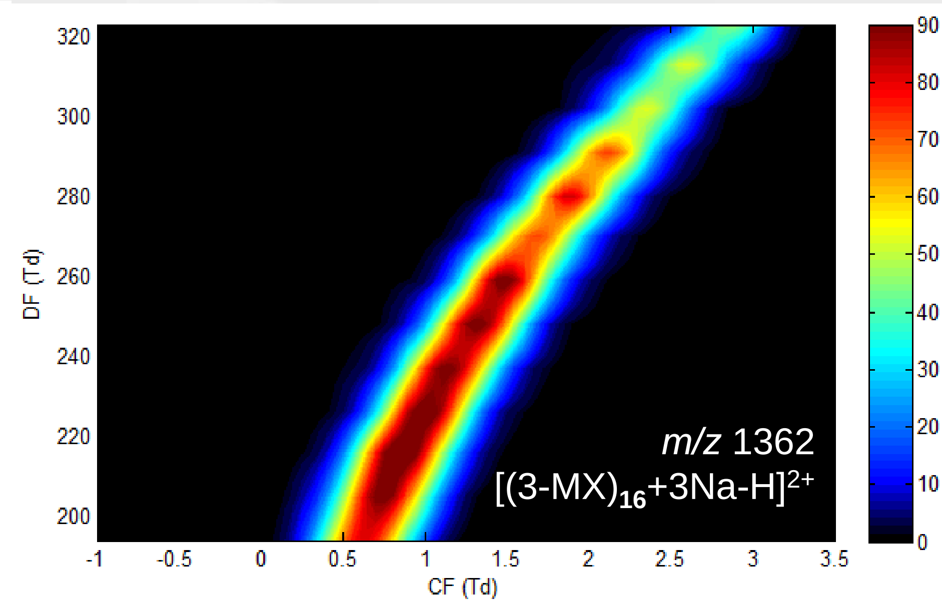
In-source CID – post-FAIMS separation



Dissociation in FAIMS-MS

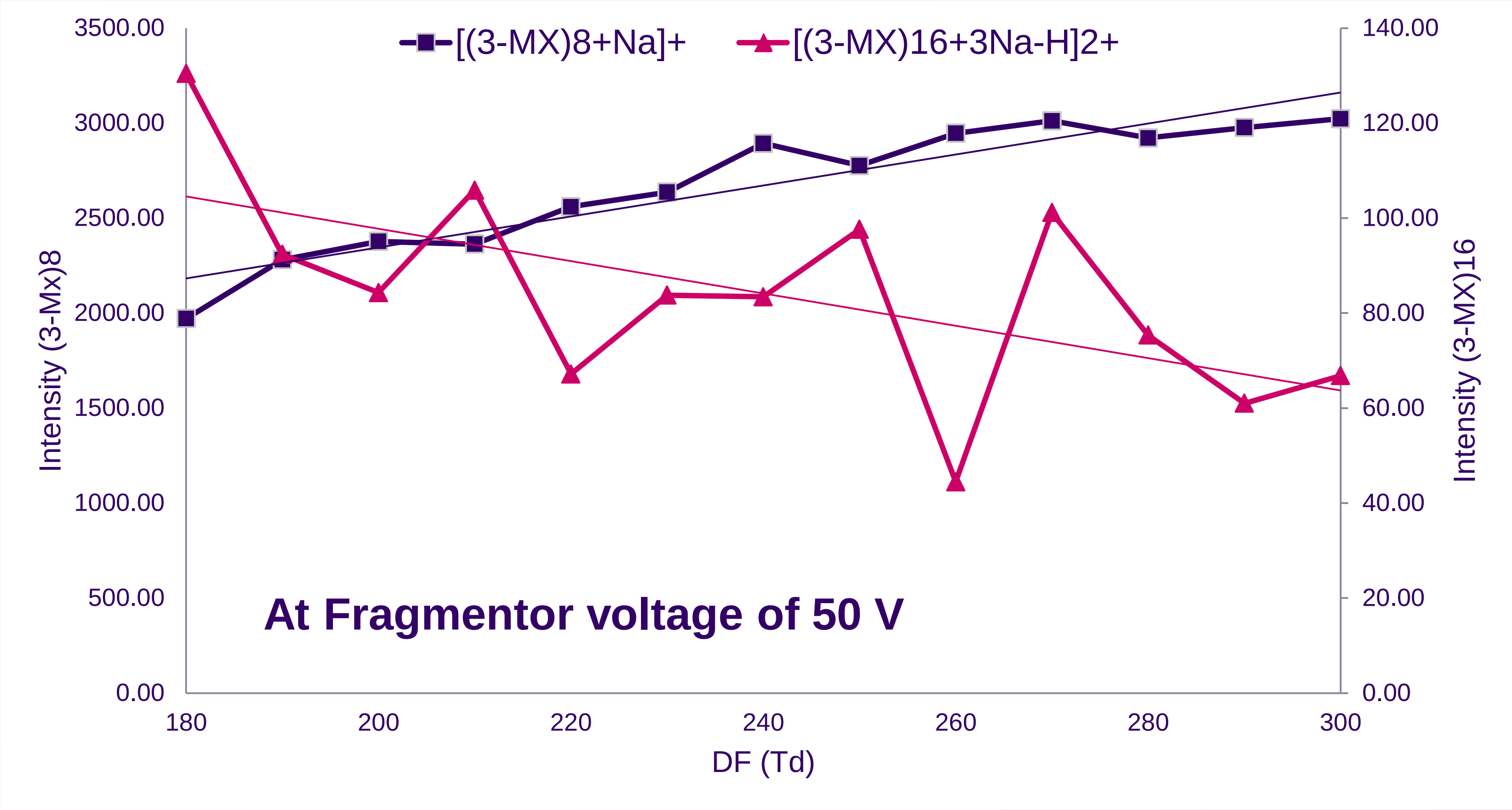
In-FAIMS dissociation



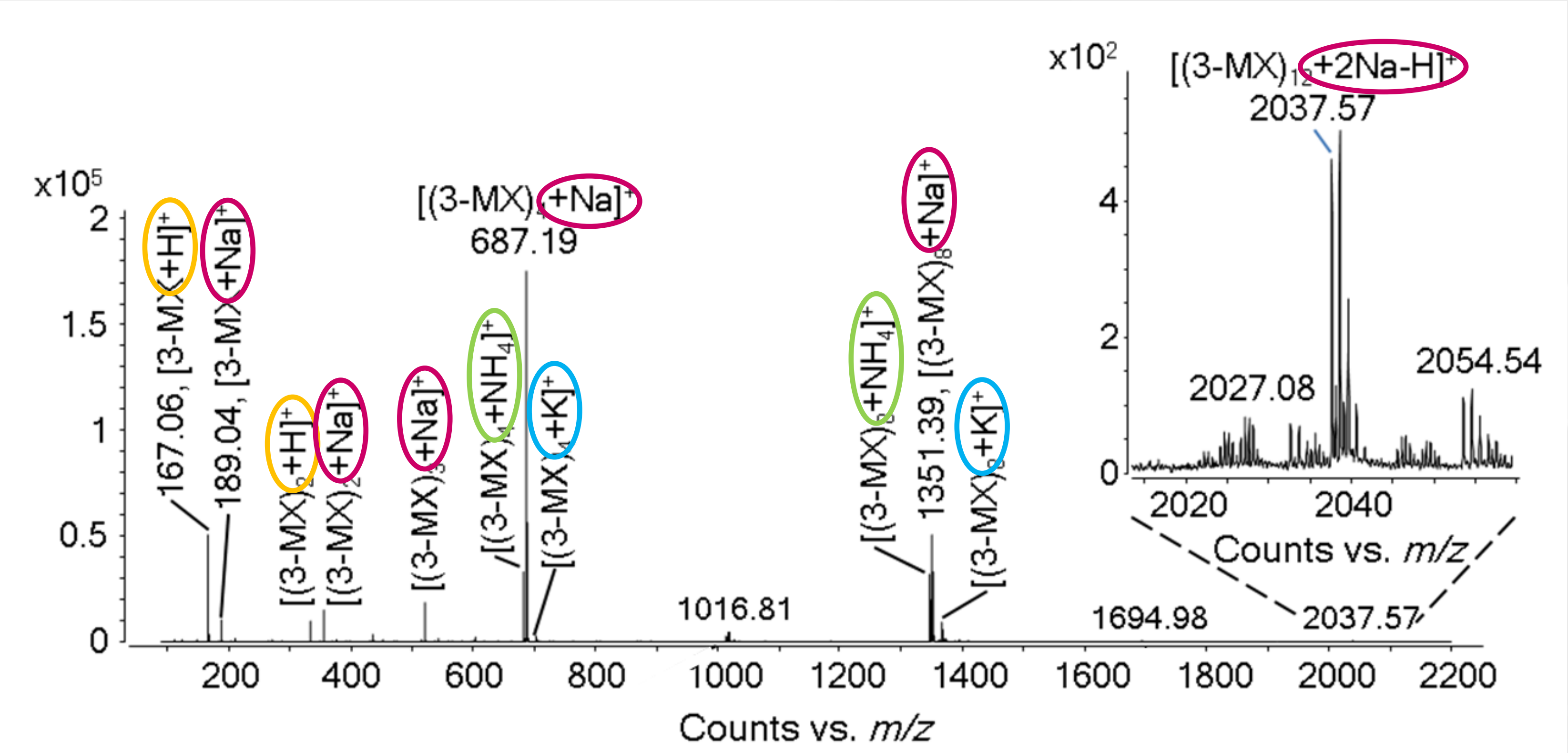


Dissociation in FAIMS-MS

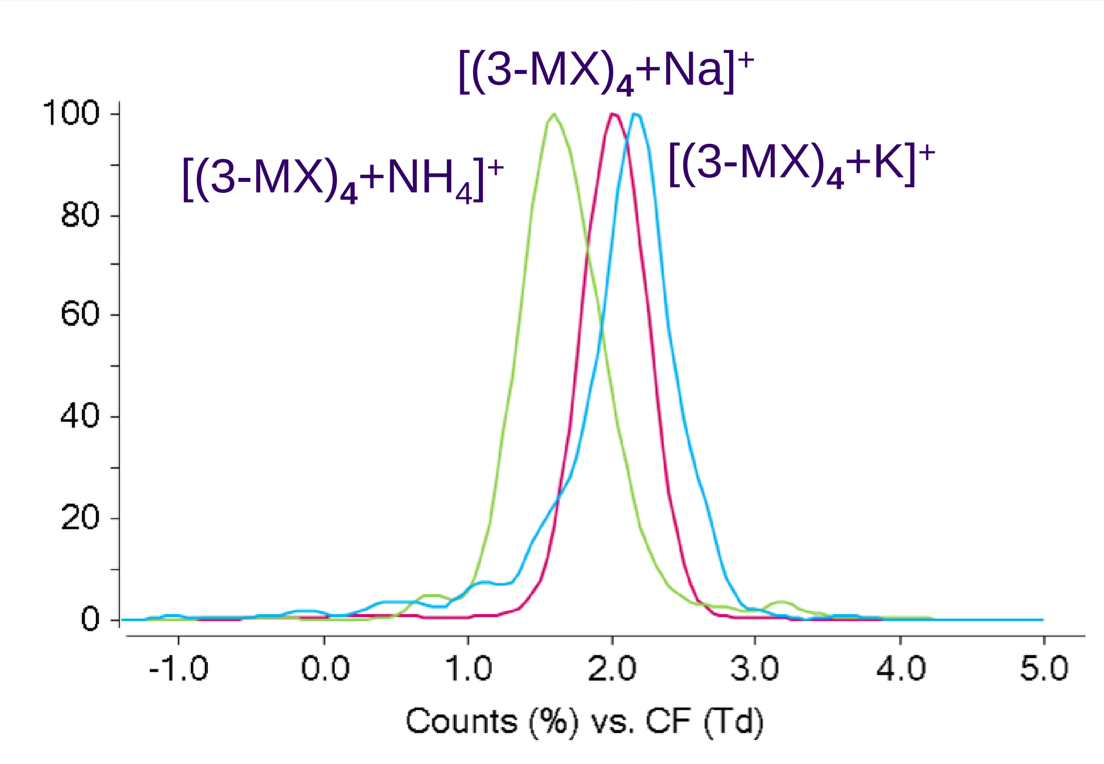
In-FAIMS dissociation



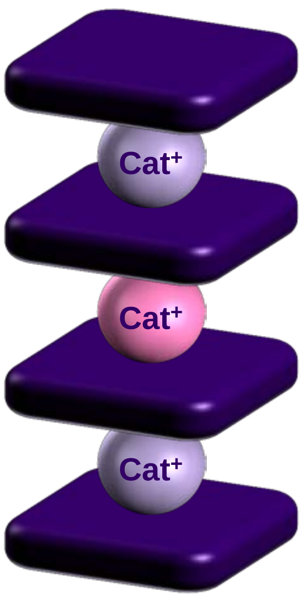
ESI-FAIMS-MS of 3-MX + Cat$^+$

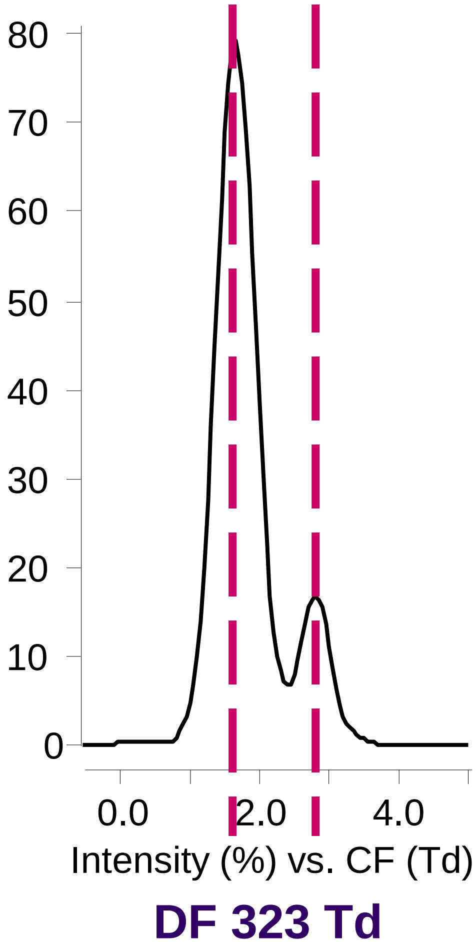


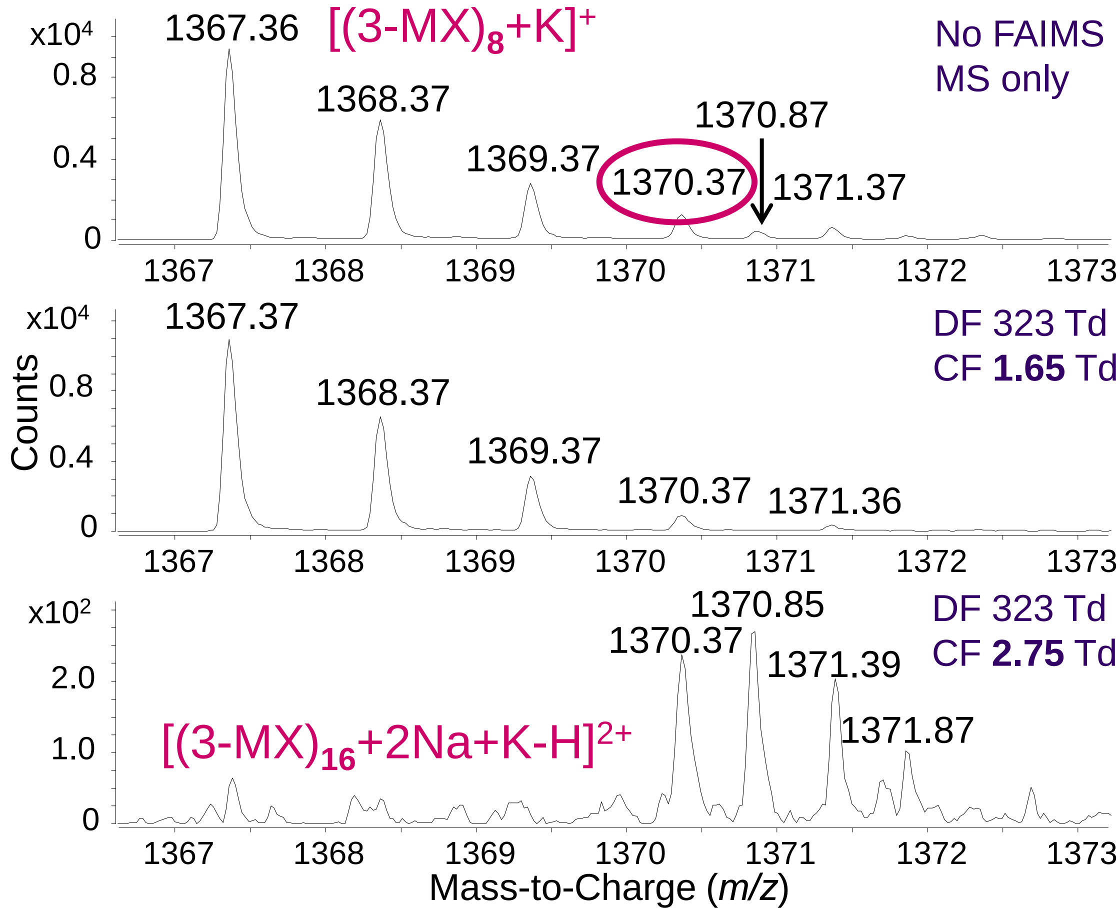
ESI-FAIMS-MS of 3-MX + Cat^+



FAIMS-MS of Heterocationic species







What has FAIMS done for me?

- Non-covalently bound complexes of a small molecules have successfully traversed the FAIMS-MS interface for FAIMS analysis and MS detection
- FAIMS analysis of tetrameric structures has shown a decreasing CF for transmission with increasing complex size
- FAIMS selection prior to mass analysis has allowed:
  - Charge state separation
  - Identification of non-tetrameric based structures previously undetectable with MS alone

What has FAIMS done for me?

- Two types of dissociation within FAIMS-MS has been observed:
  - Post-FAIMS in-source CID in the TOF MS interface
  - In-FAIMS dissociation of ions before mass detection
- Varying FAIMS parameters based upon which stabilising cations present – demonstrates alternative options for FAIMS separation

Acknowledgments

- Loughborough University:
  - **Colin Creaser**
  - **James Reynolds**
- New Mexico State University:
  - **Gary Eiceman**
- Staff and researchers at the Centre for Analytical Science

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