Ionization, excitation and fragmentation of the isolated nucleobases ***uracil*** and ***thymine*** by multiply charged ions

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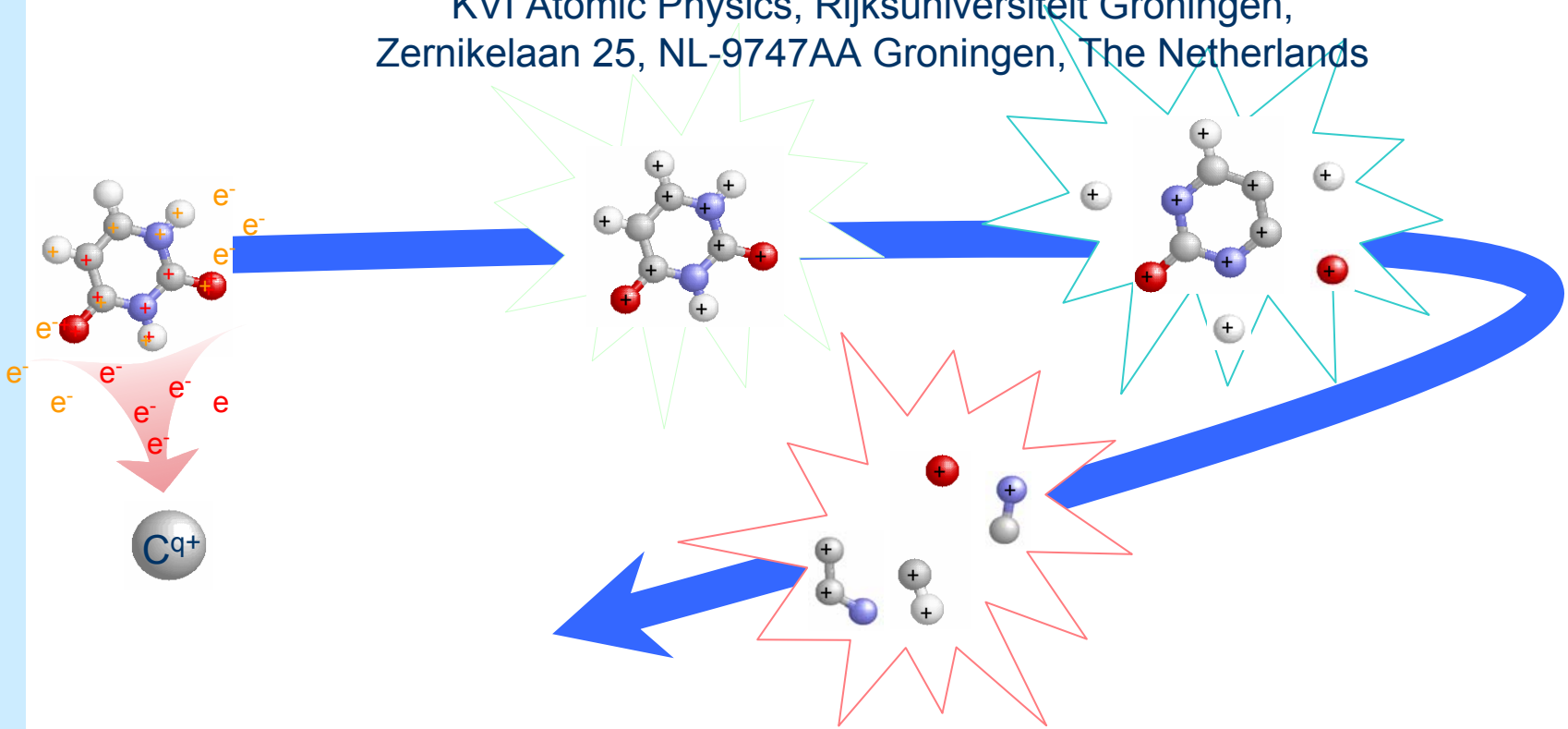


Overview

- What is the role of Multiply Charged Ions (MCI) in Radiation Damage research?
- How do we study MCI interaction with nucleobases?
- What is the fragment mass distribution?
- Are there projectile effects?
- Are there target effects?
- What can be learned from fragment kinetic energies?
- What can be extracted from coincidence plots?
- Is it possible to identify fragmentation channels?

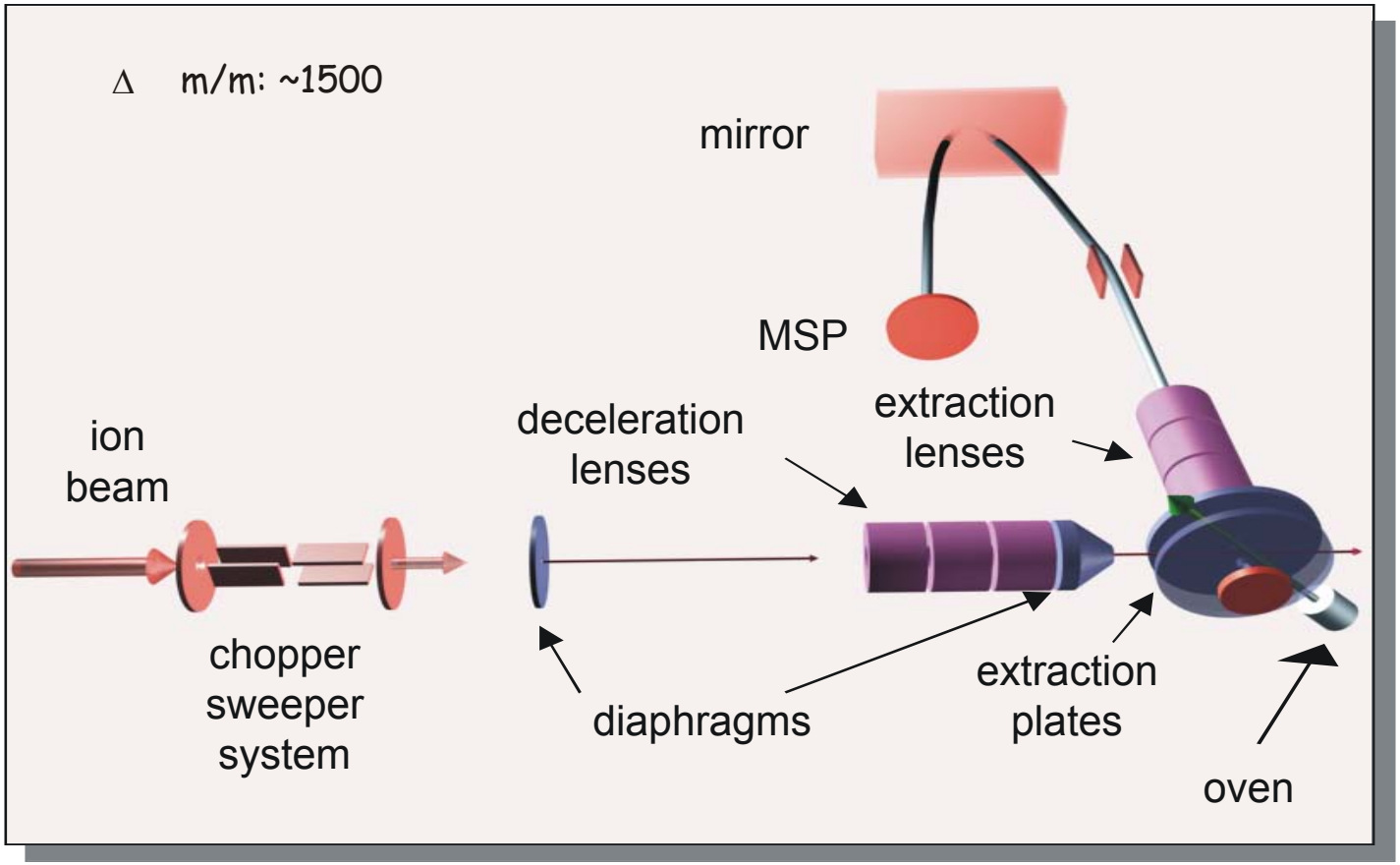
Multiply charged ions (MCI)

They are involved in primary or secondary radiation damage!!

Primary: Heavy ion therapy (C-ions), proton therapy and radiation exposure of biological tissue in space.

Secondary: They are formed within the track of primary radiation, together with low energy electrons and radicals.

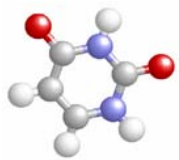
Our Experimental Setup



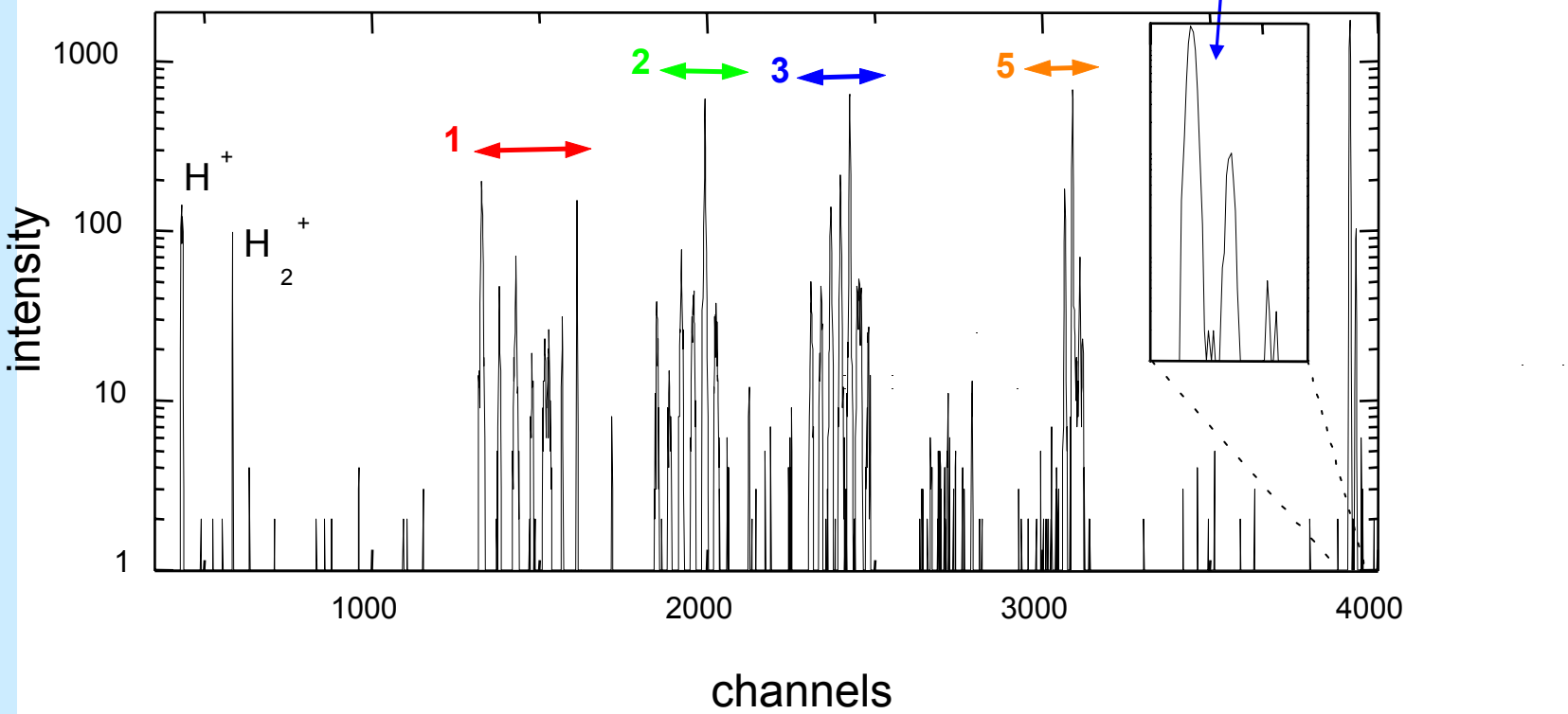
-fragment ion detection in event by event mode
(FAST P7888 TDC, 1 ns resolution)
-chopper ion coincidences
-electron-ion coincidences
-electron-ion-ion coincidences

J de Vries et al., J. Phys. B. ***35****, 4373 (2002)*

Uracil TOF spectrum

48 keV C^{5+} 

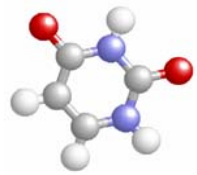
isotope structure of parent resolved

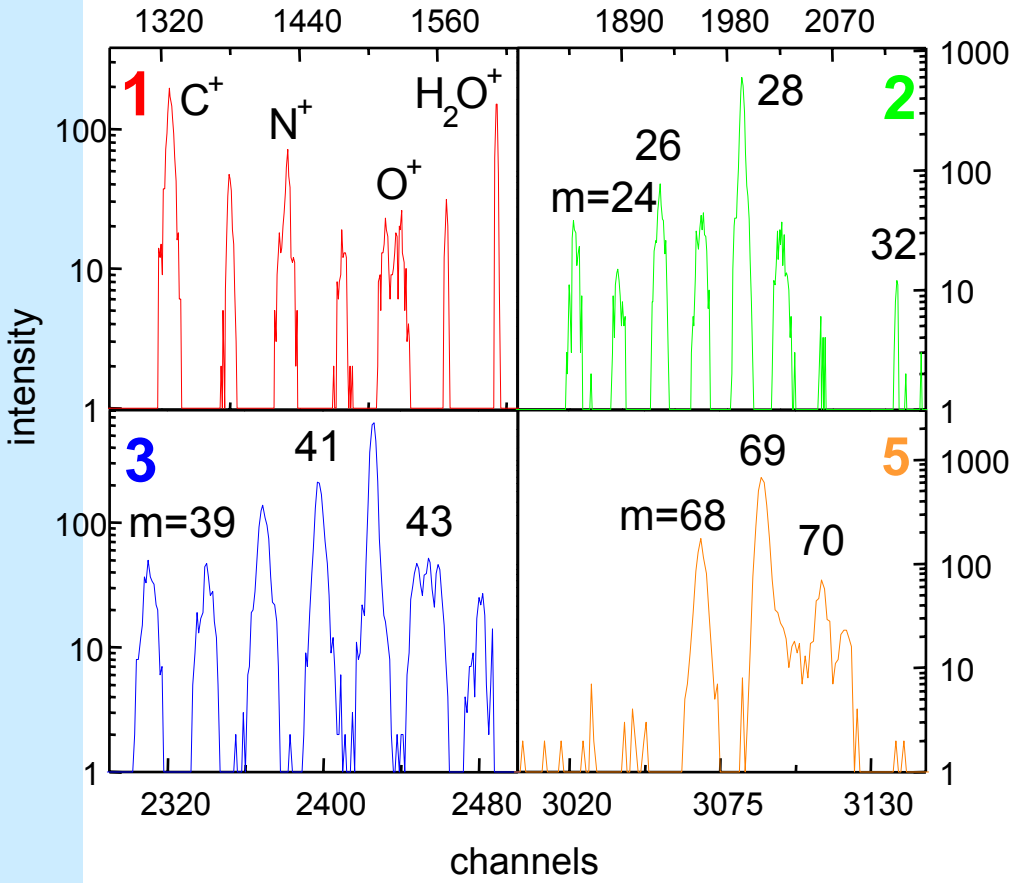


It is difficult to extract information only from the fragment's groups because they are the same for most organic molecules

*J de Vries et al., J. Phys. B. **35**, 4373 (2002)*

Zoom into Uracil TOF



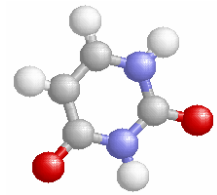


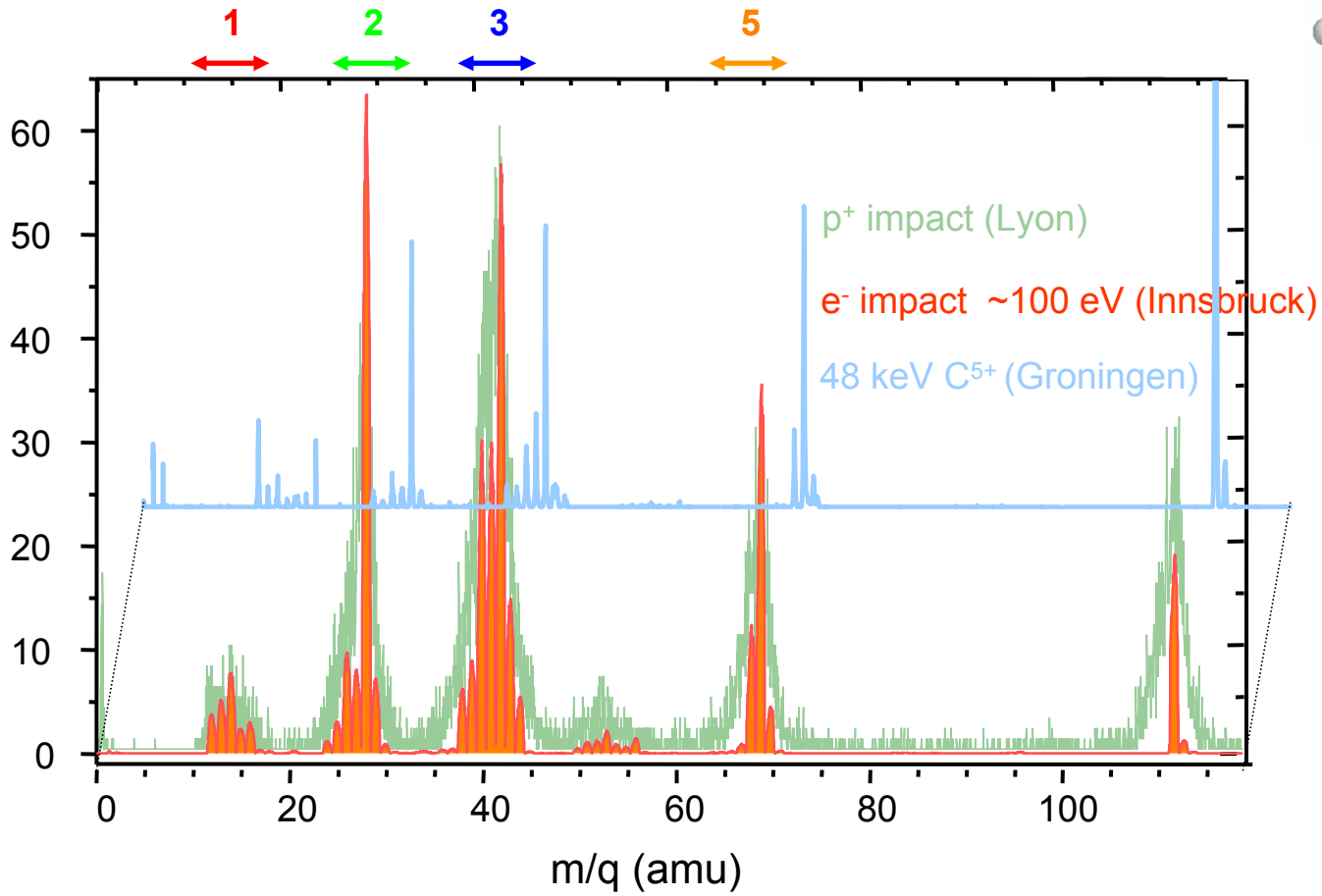
- H_2O^+, OH^+ and O_2^+ are very narrow, they are from the residual gas
- most other peaks of comparable width
- specific fragmentation channels: O^+, $CHNO^+$ and m=70

To obtain extra information, kinetic energies can be calculated

J de Vries et al., J. Phys. B. ***35****, 4373 (2002)*

Proton vs. electron vs. ion impact

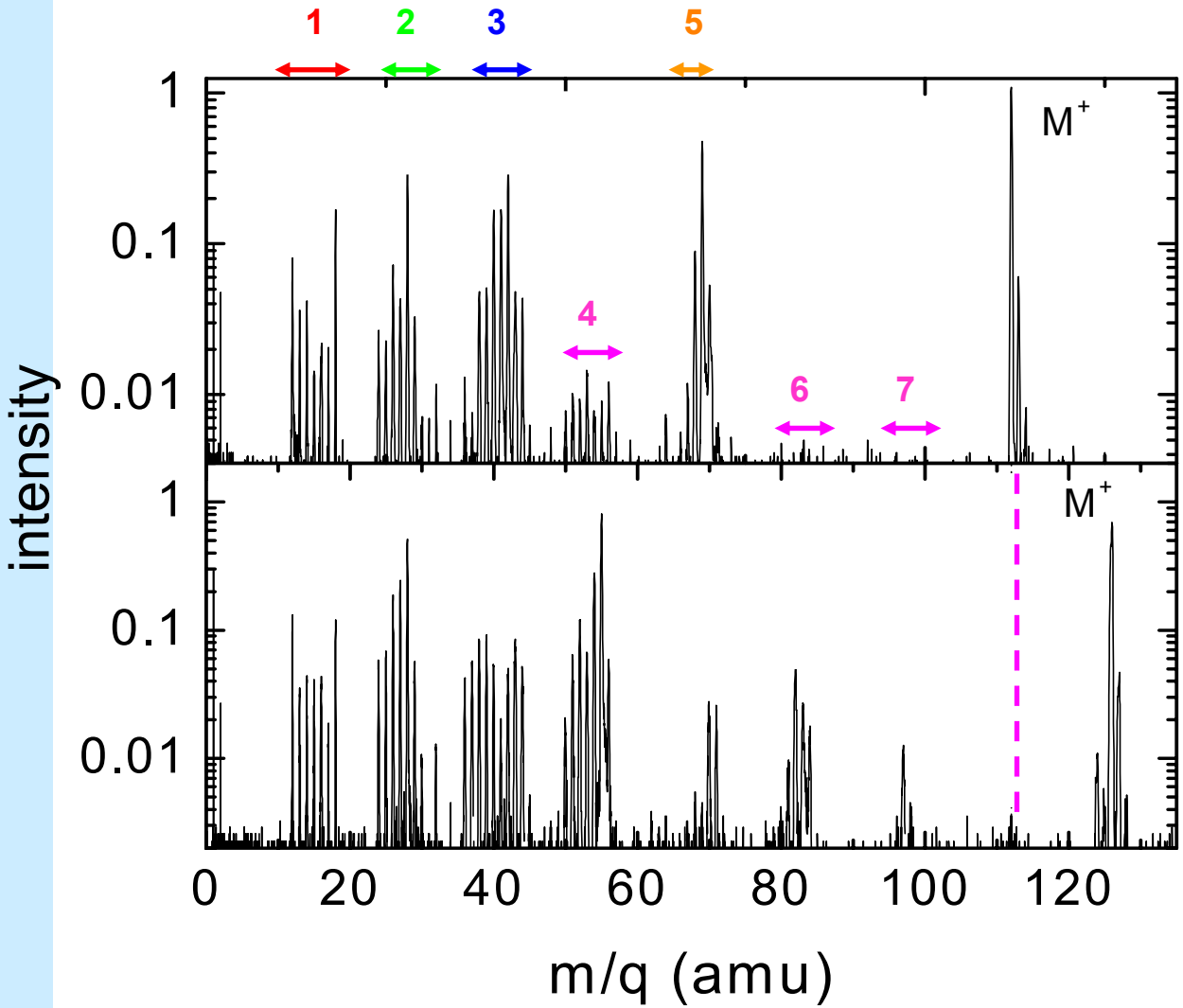


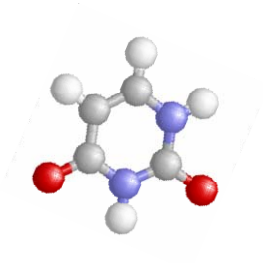


⇨ Similar fragmentation pattern!
Different fragmentation yield!

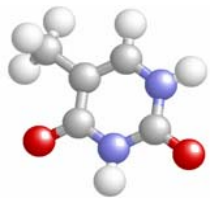
B. Coupier et al., Eur. Phys. J D, 20 (2002) 459
J. de Vries et al, JPB 35 (2002) 4373

Uracil and Thymine





24 keV C^+



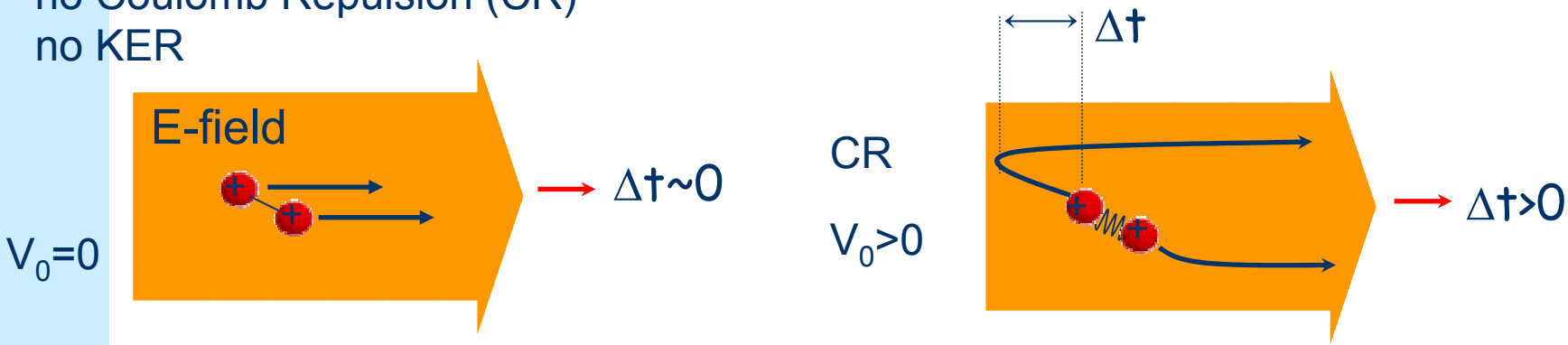
Fragmentation changes dramatically!!

J de Vries et al., Physica Scripta. (in press, 2004)

Kinetic Energy Release (KER)

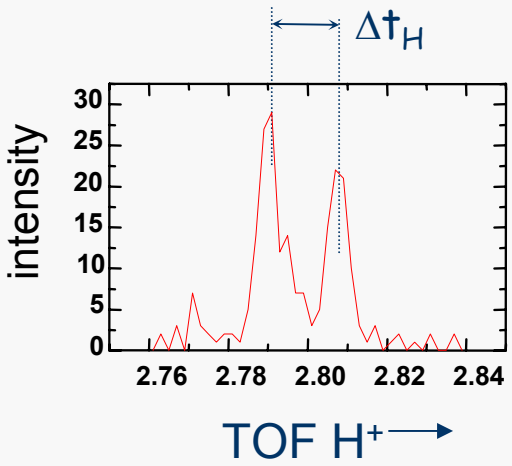
Simple case – two bodies

no Coulomb Repulsion (CR)
no KER

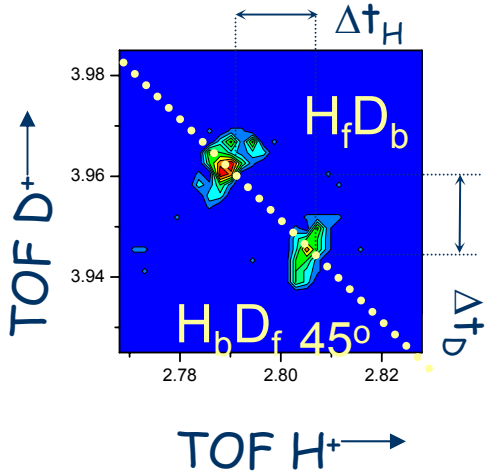


HD^{++} fragmentation

e^--ion coincidences



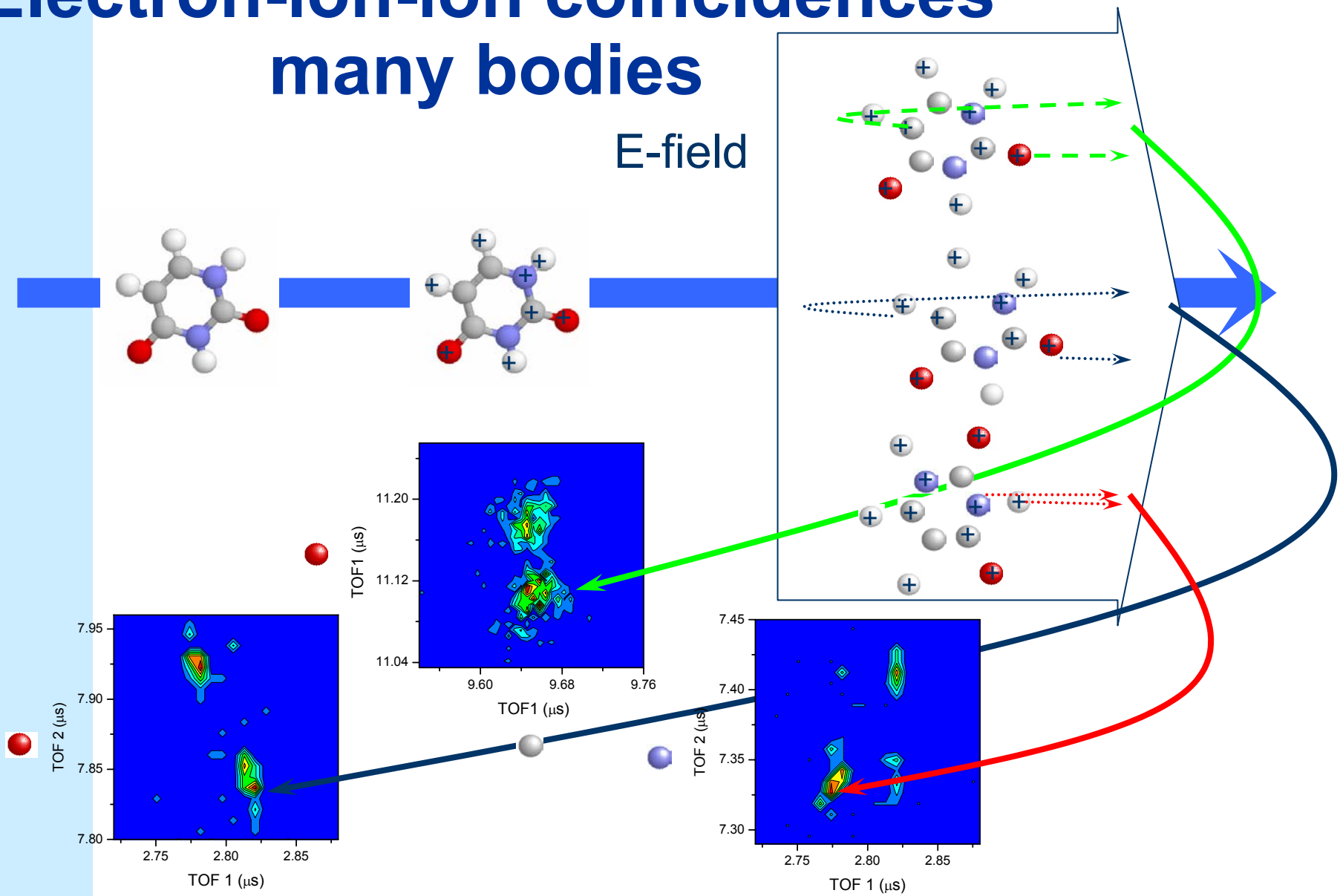
e^-- ion-ion coincidences



KER~19 eV

H forward/D backward
or
H backward/D forward

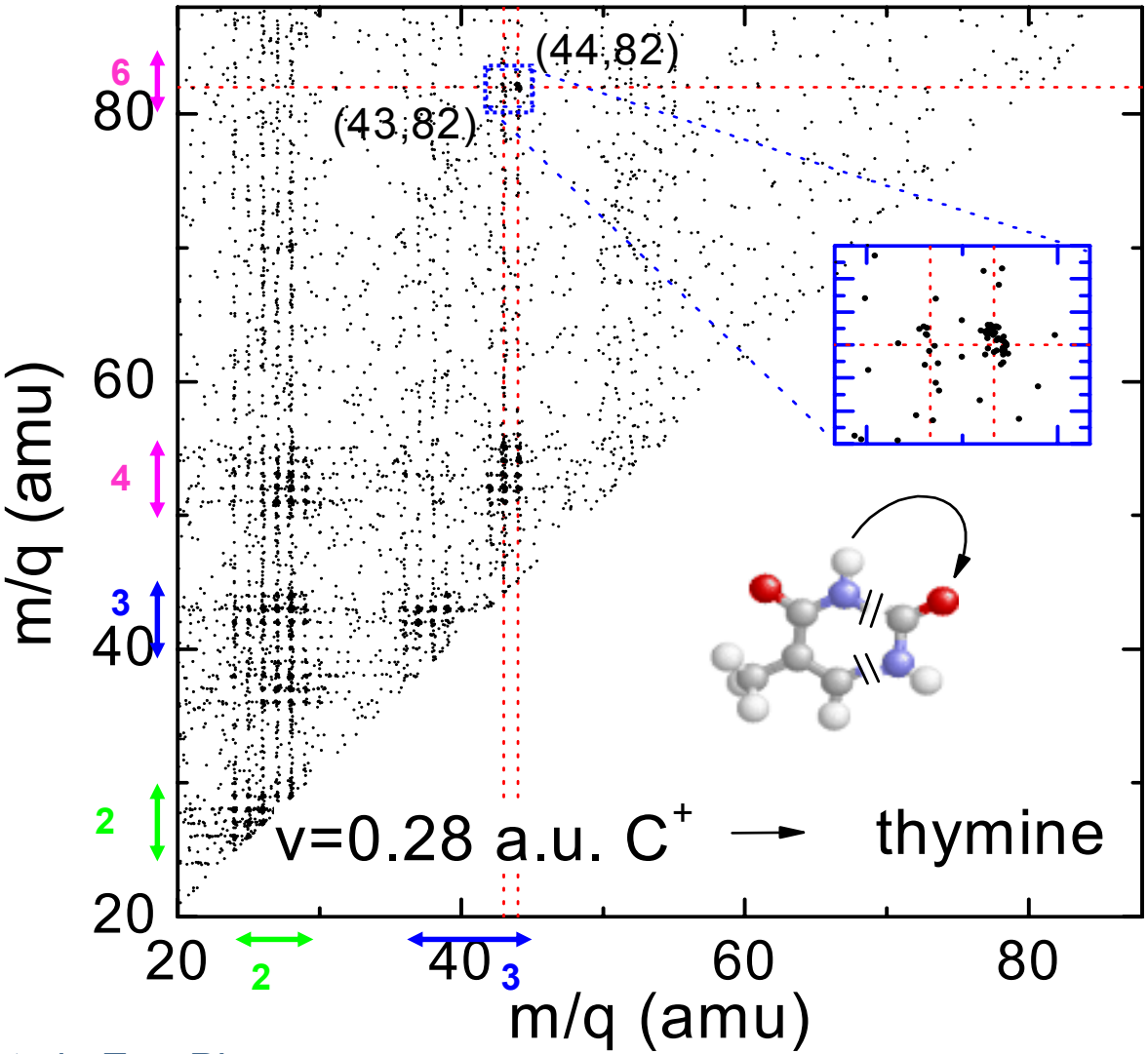
Electron-ion-ion coincidences many bodies



Information about molecular geometry

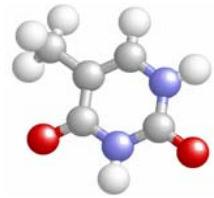
*J de Vries et al., PRL. **91**, 053401 (2003)*

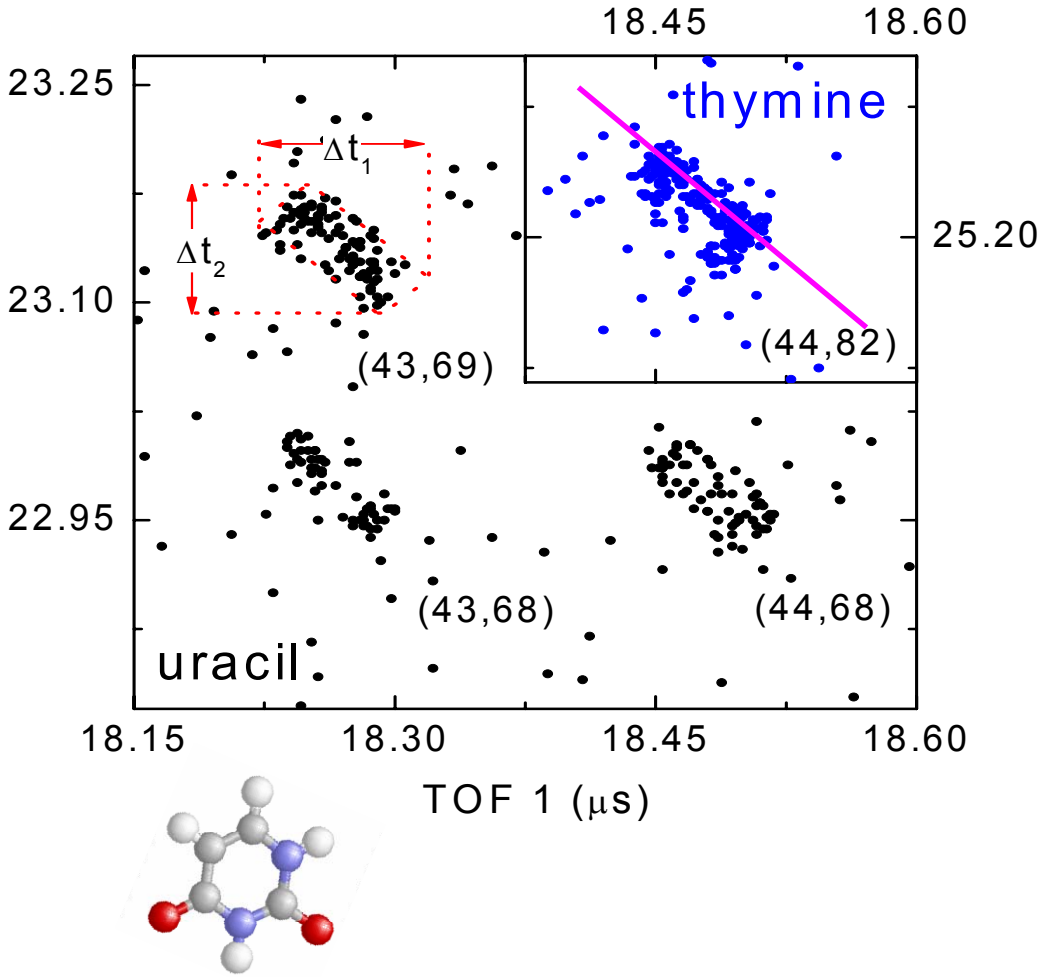
Coincidence plot for thymine



J de Vries et al., Eur. Phys. J. D. ***24****, 161-164 (2003)*

Two body breakup similarities





$$\Delta t_i = \frac{2 m_i v_0}{U}$$

$$\Rightarrow E \approx 5.2\ \text{eV}$$

repulsion of two charges

↓

0.28 nm apart (ring diameter)

Summary

- Fragment mass distribution for uracil and thymine can be obtained but contains little information
- Different projectiles → different fragmentation yields
- In spite that thymine and uracil have similar structure → fragmentation changes dramatically
- Studies of fragment kinetic energies can give us information about the reaction dynamics and the molecular geometry
- Coincidence plots are useful to identify the fragmentation channels, for instance two body breakup

Thanks

Reinhard Morgenstern

Ronnie Hoekstra

Jur de Vries

Thomas Schlathölter

KVI
RuG

funding:

FOM

Koninklijke
Nederlandse
Akademie van
Wetenschappen