

AXIS 1: NUCLEAR PHYSICS CENTER

Scientific Advisory Board: meeting n°1





UNIVERSITÉ
CAEN
NORMANDIE



RÉGION
NORMANDIE



Interdisciplinary research

Sylvain Maclot

November 6, 2024



CaeSAR

CAEN, STRATÉGIE
POUR L'ACCÉLÉRATION
EN RECHERCHE

Study case - Principal



Study case - Principal



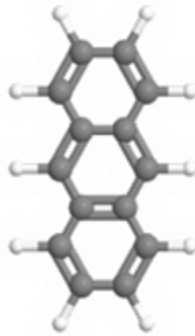
Isolated molecules
Covalent bonds

Study case - Principal

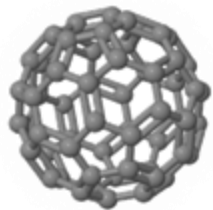
Isolated molecules
Covalent bonds



Biomolecules



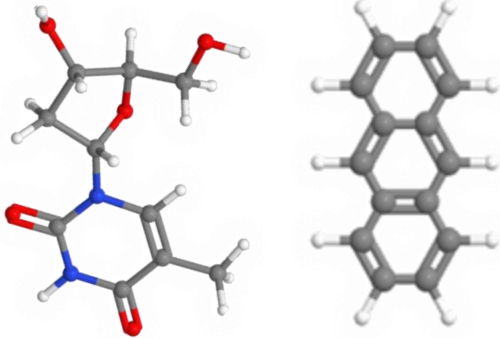
PAHs



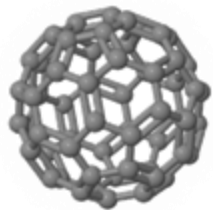
Fullerenes (C₆₀)

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Isolated molecules
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Biomolecules PAHs

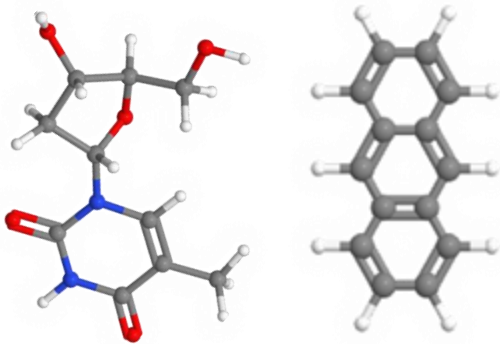


Fullerenes (C₆₀)

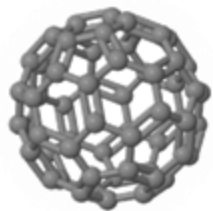
Molecular clusters
Non-covalent bonds

Study case - Principal

Isolated molecules Covalent bonds

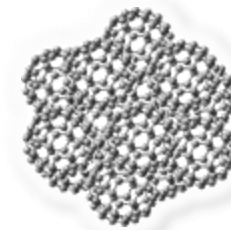


Biomolecules PAHs

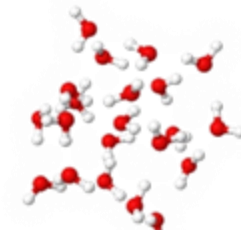


Fullerenes (C₆₀)

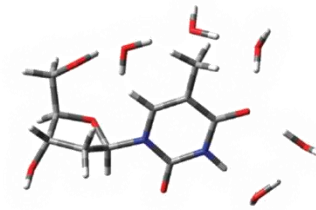
Molecular clusters Non-covalent bonds



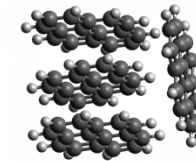
(C₆₀)_n



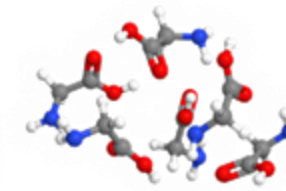
(H₂O)_n



Hydrated
Biomolecules



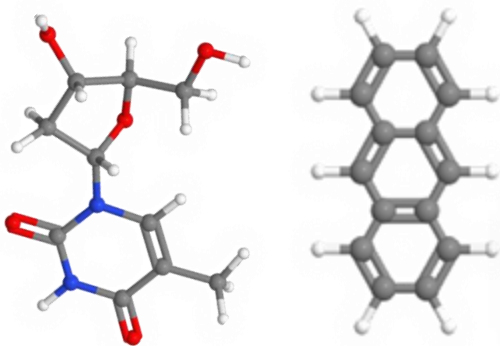
(PAH)_n



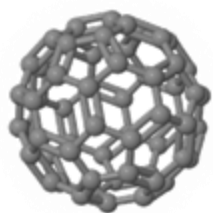
(Biomolecules)_n

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Isolated molecules
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Biomolecules PAHs



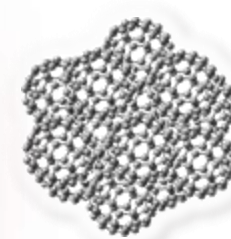
Fullerenes (C₆₀)

Ionizing
radiation

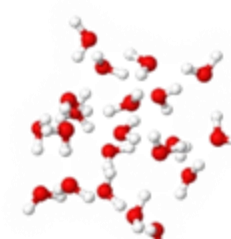


Multiply charged ions

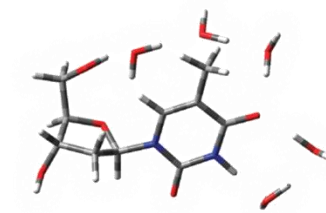
Molecular clusters
Non-covalent bonds



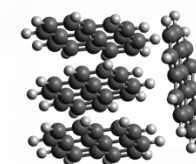
(C₆₀)_n



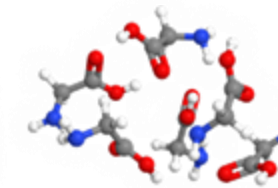
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Hydrated
Biomolecules



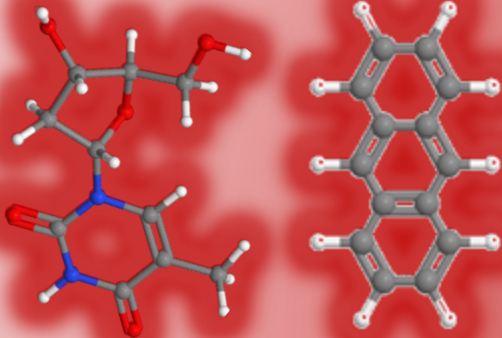
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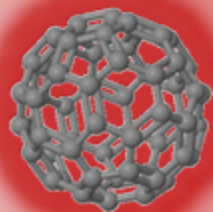
(Biomolecules)_n

Study case - Principal

Isolated molecules
Covalent bonds



Biomolecules PAHs



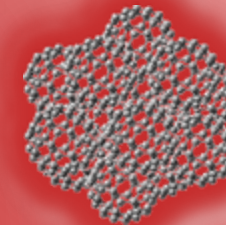
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Ionizing
radiation

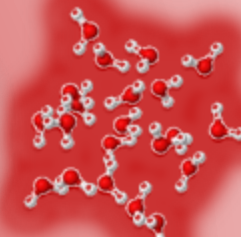


Multiply charged ions

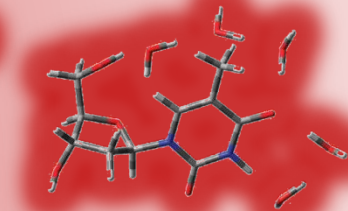
Molecular clusters
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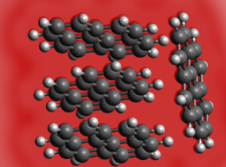
(C₆₀)_n



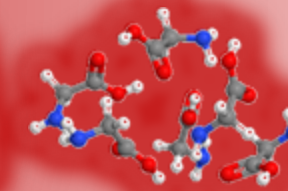
(H₂O)_n



Hydrated
Biomolecules



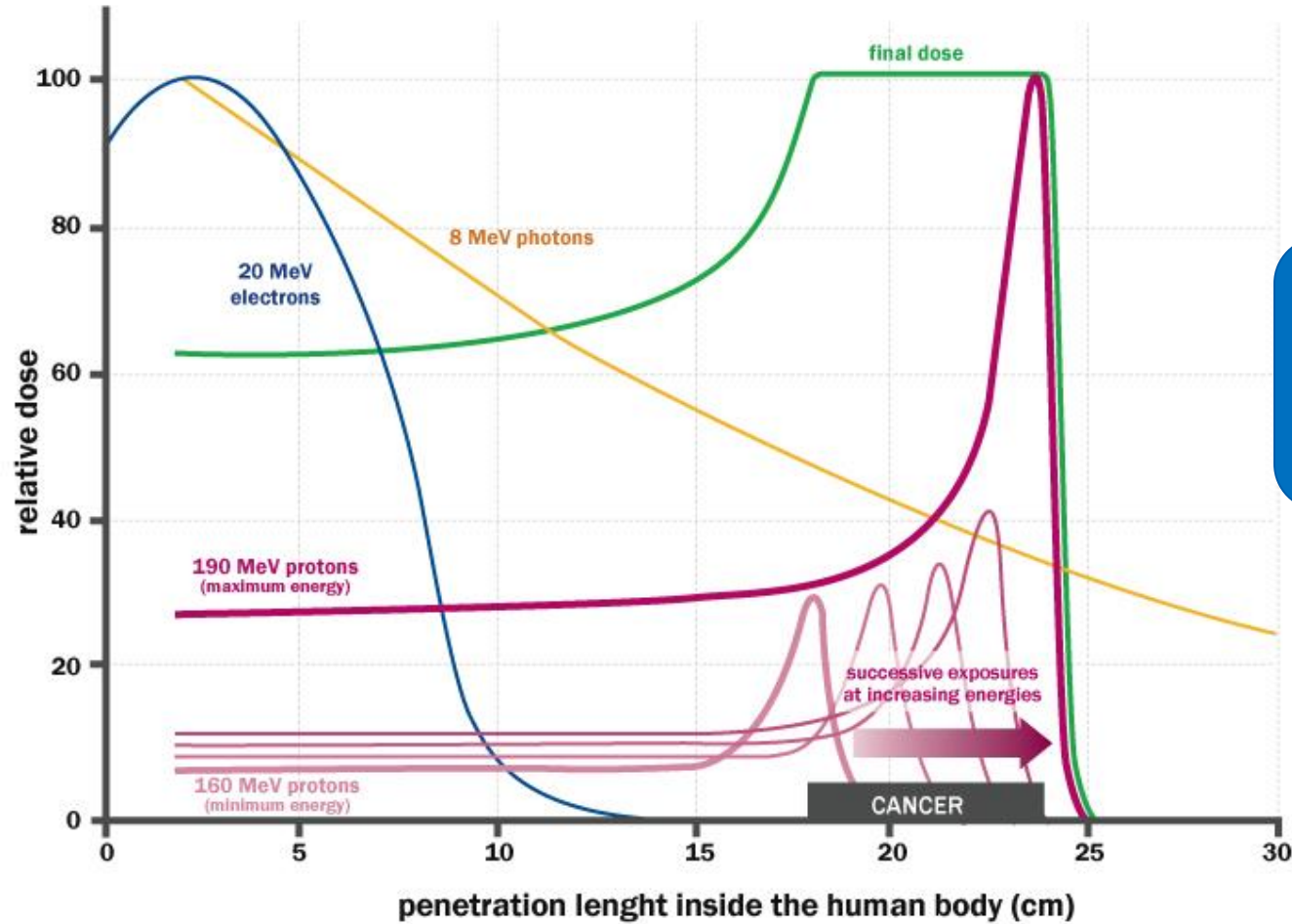
(PAH)_n



(Biomolecules)_n

Excitation/ionization ⇒ Relaxation/fragmentation

Hadrontherapy



Energy deposition:
Radiation damage

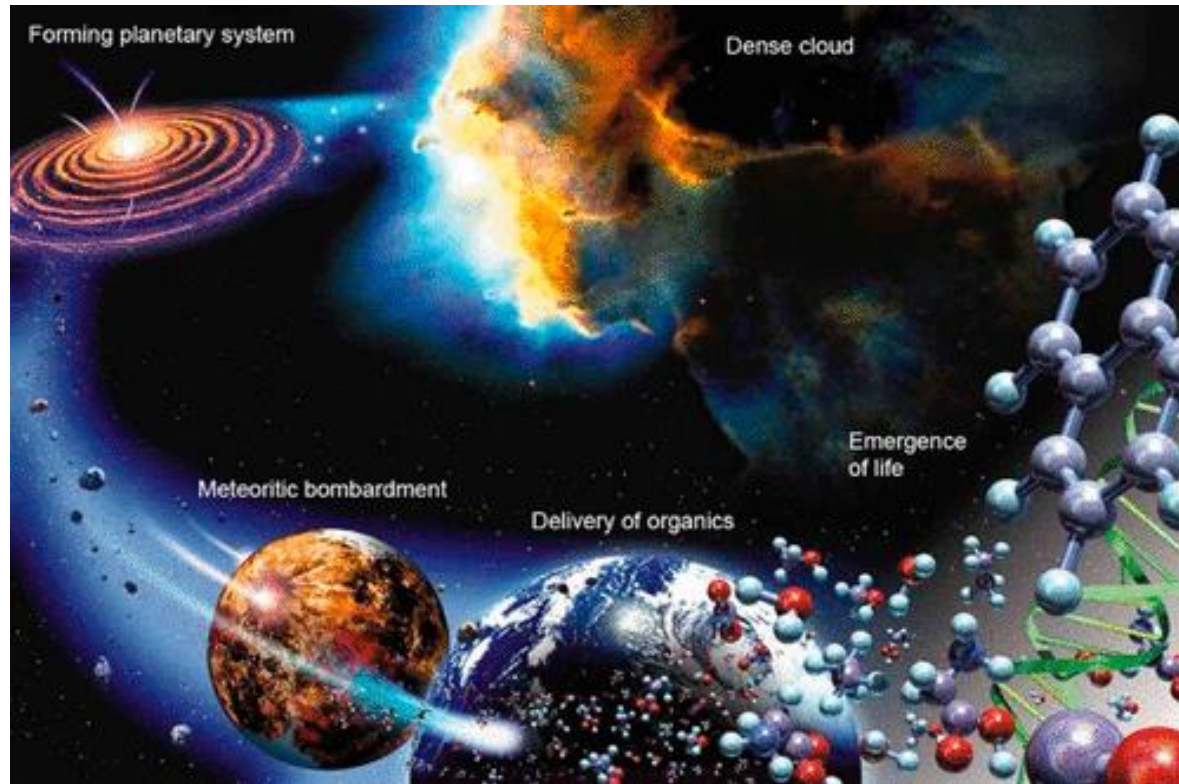
Thematics





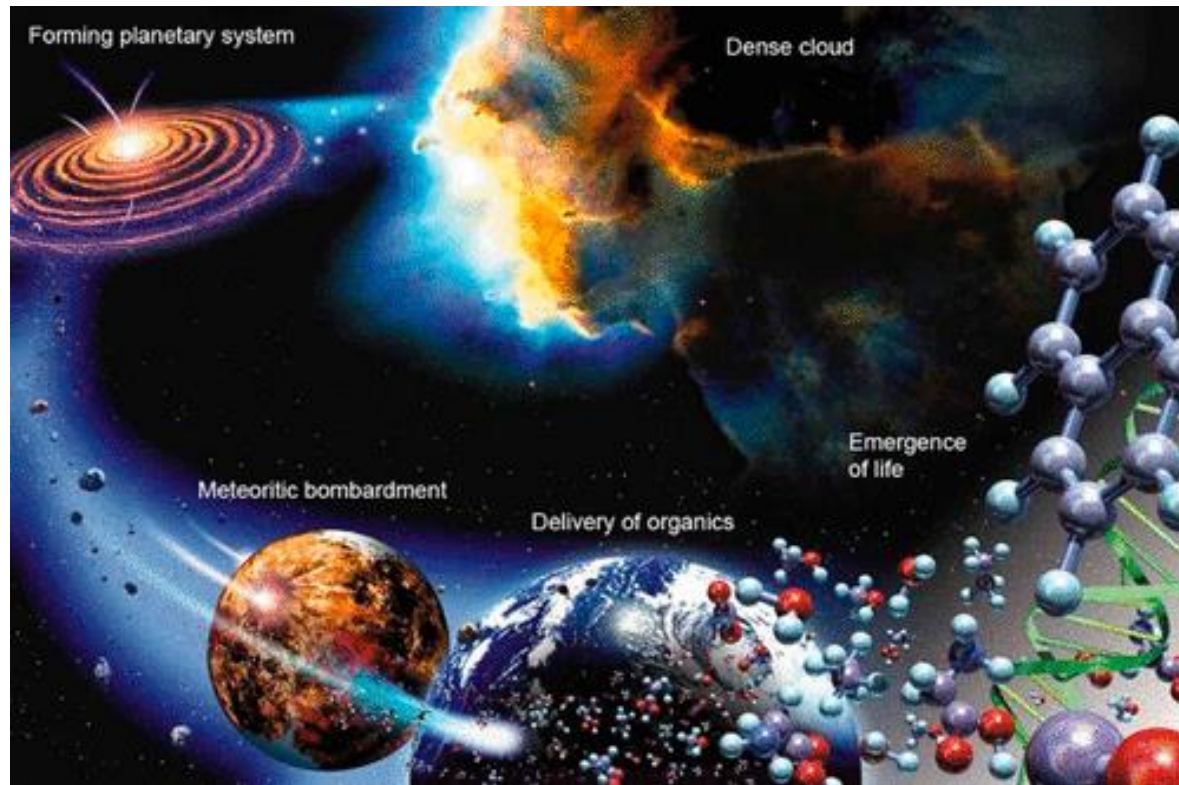
Formation of complex molecular systems ?

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Astro-chemistry/physics

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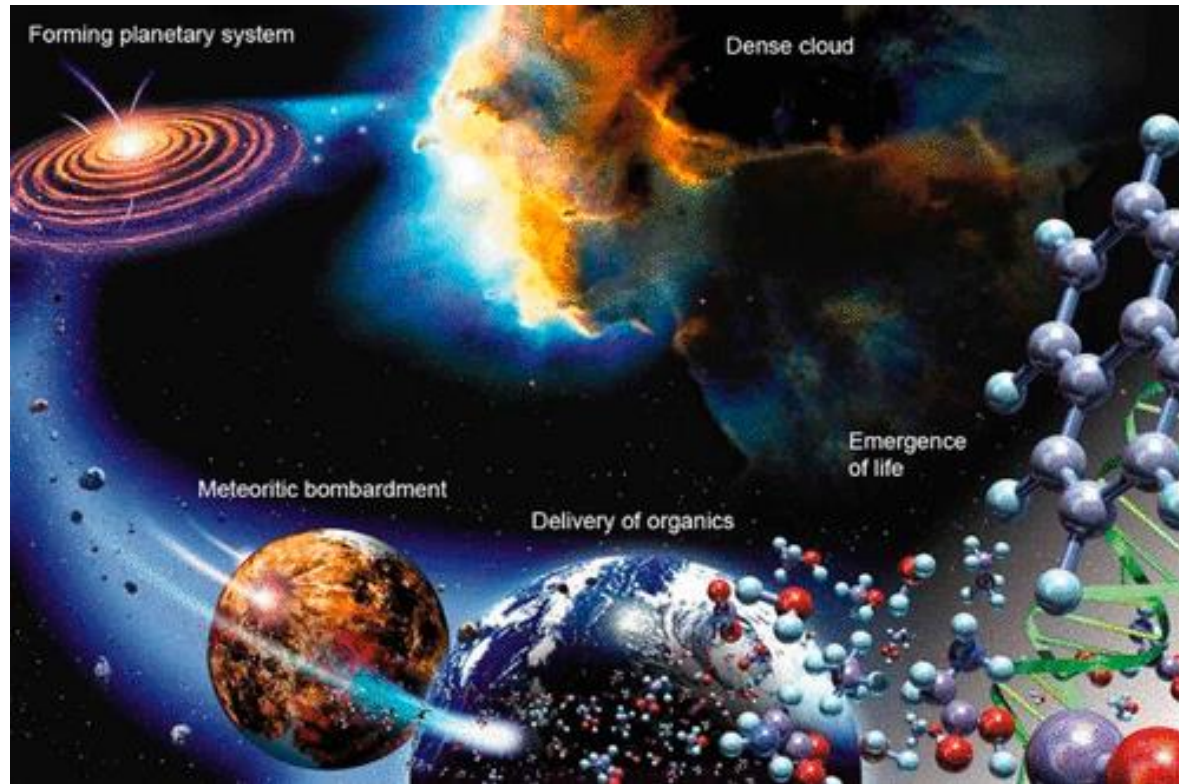


Ion-induced peptide bond formation in amino acid clusters



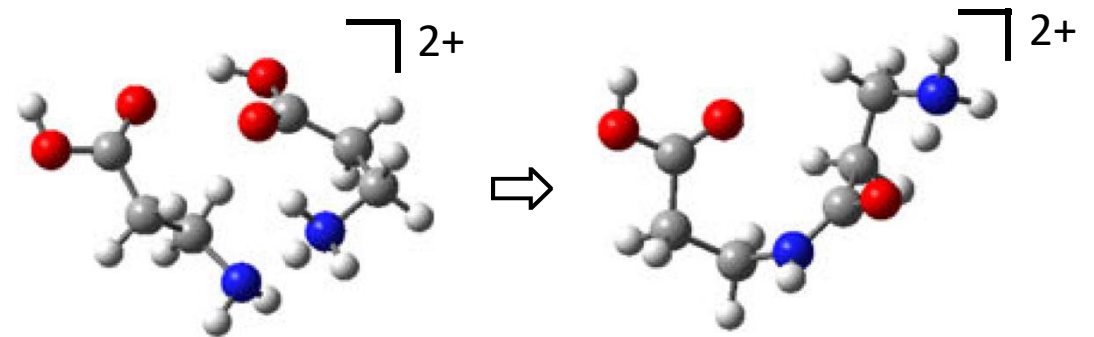
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P. Rousseau *et al.* Nat. comm. (2020)

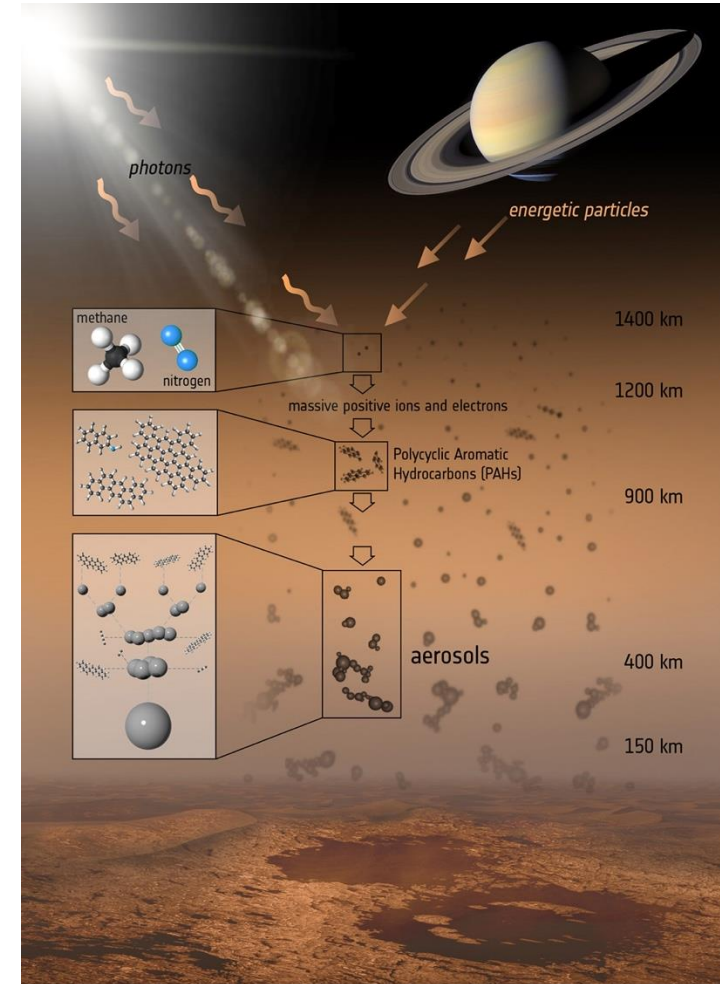


Formation and dynamics of aerosol precursors in planetary atmosphere

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Formation and dynamics of aerosol precursors in planetary atmosphere



ARIBE : Low-energy ion facility



Arife
GANIL

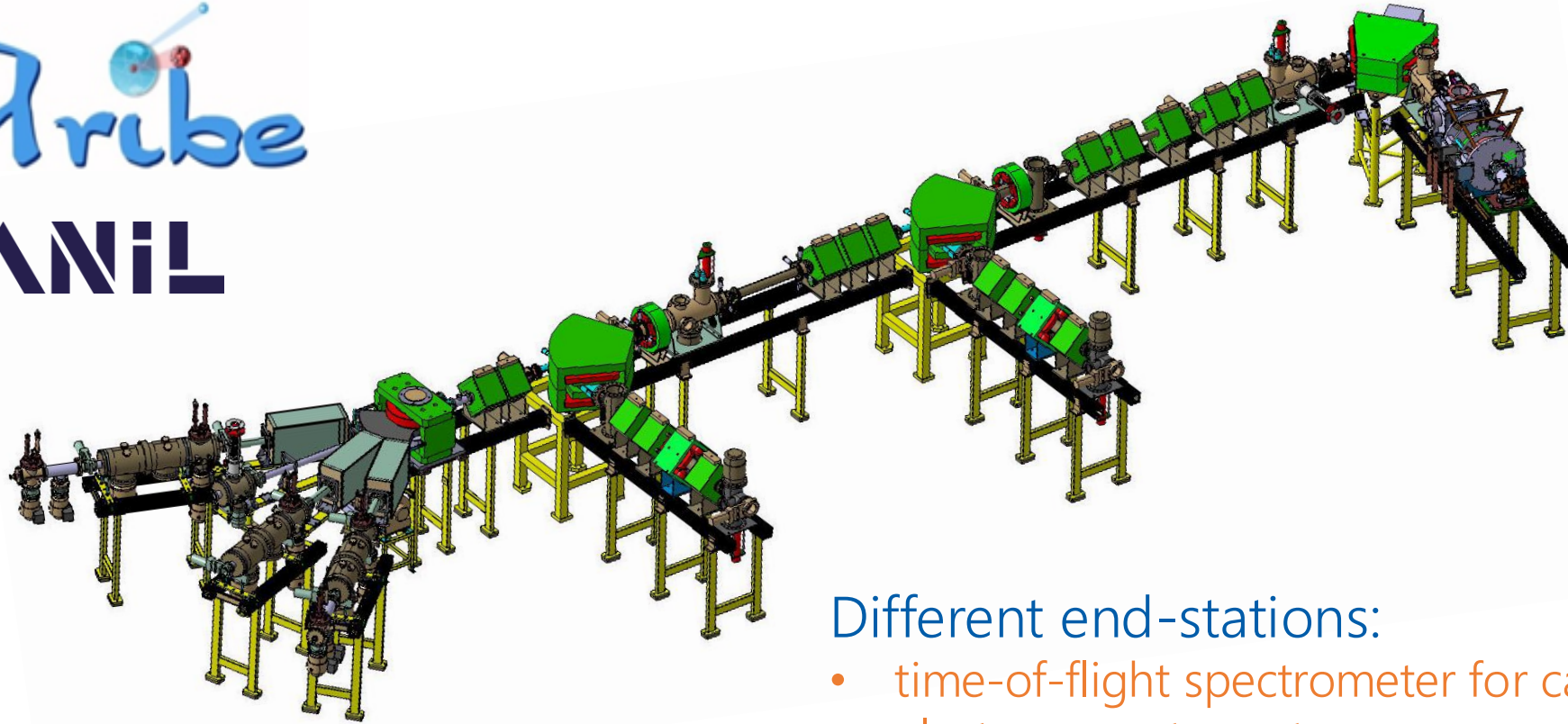


ECR ion source
From H^+ to Xe^{30+}
with a few kV/q

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Arife
GANIL

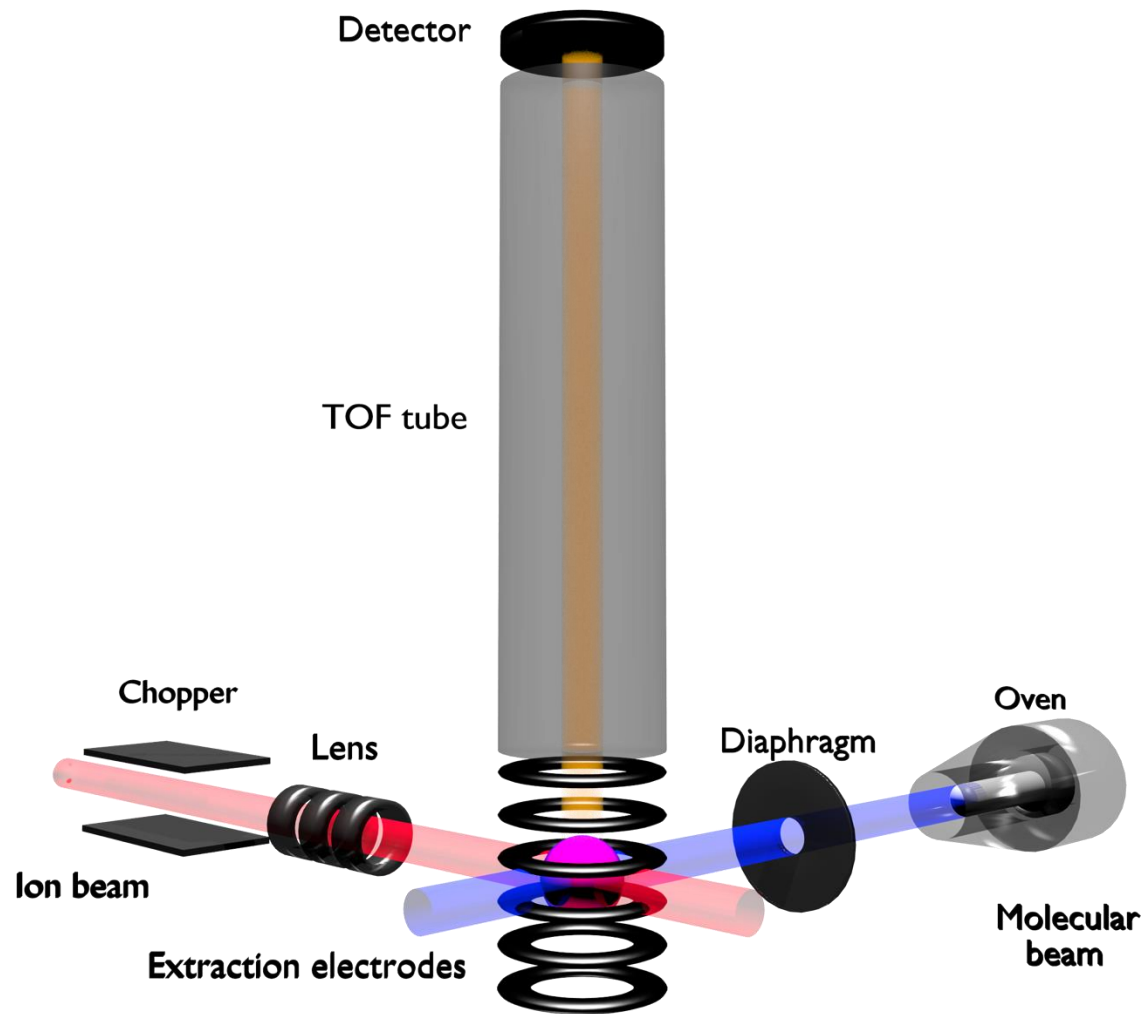


ECR ion source
From H^+ to Xe^{30+}
with a few kV/q

Different end-stations:

- time-of-flight spectrometer for cationic products
- electron spectrometers
- projectile spectrometers
- Astrophysical ices (condensed phase) – IR spectroscopy

Experimental setup COLIMACON



Ion-molecule collision



Ion-molecule collision



Low-energy multiply charged ions

Ion-molecule collision



Low-energy multiply charged ions

energy $\approx 10 \text{ keV/q}$

↳ velocity $< 1 \text{ u.a.}$

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Electronic capture is the dominating process.

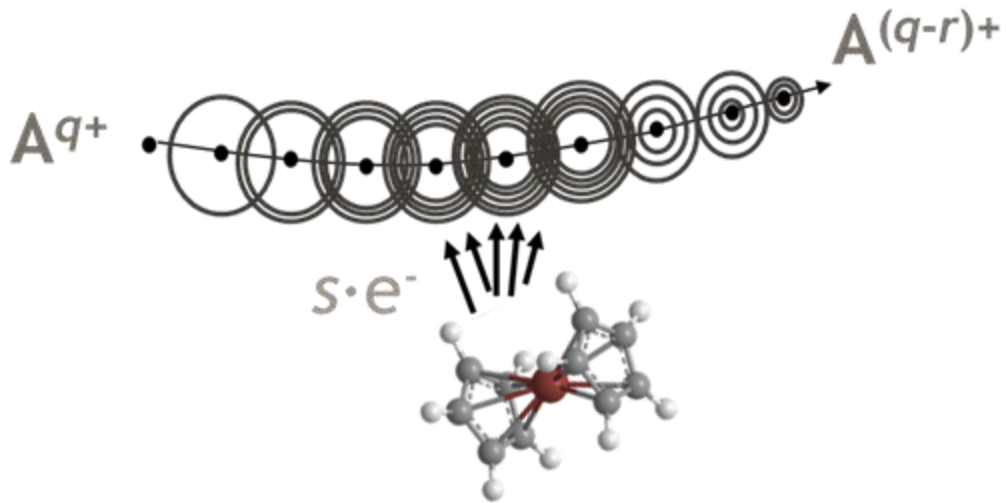
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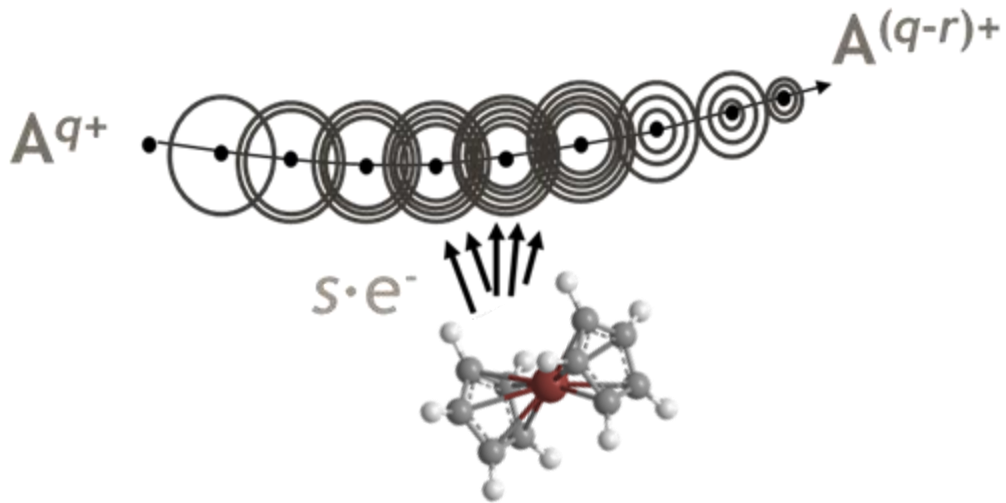
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Interaction time : a few femtoseconds

Ion-molecule collision

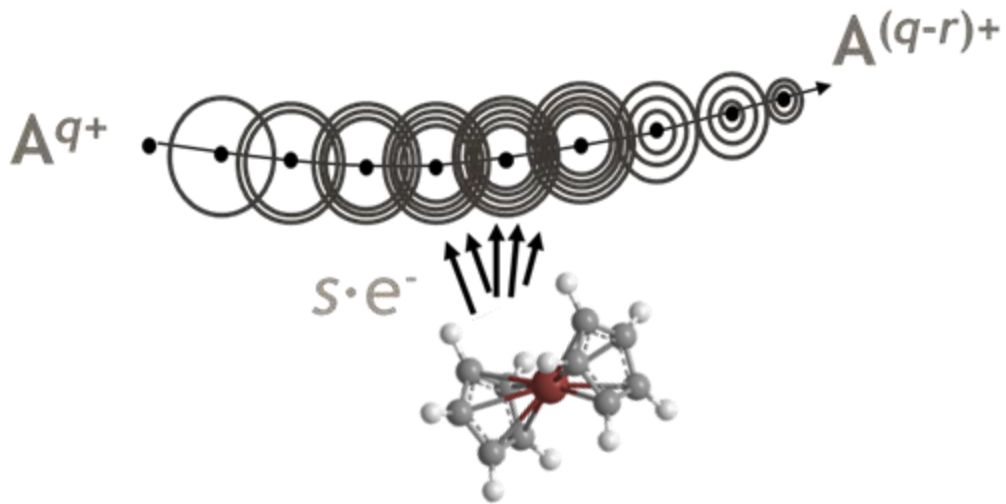
Isolated molecule

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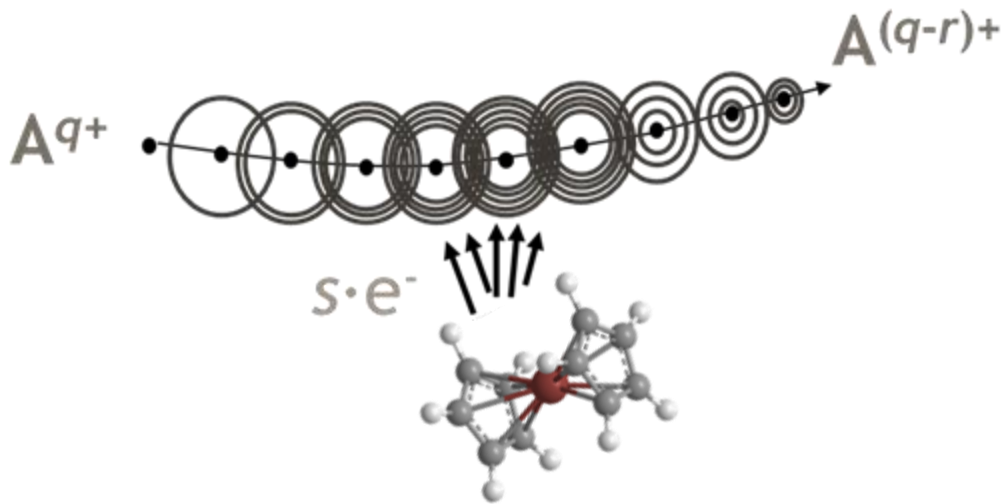
Ion-molecule collision

Low-energy multiply charged ions

energy ≈ 10 keV/q

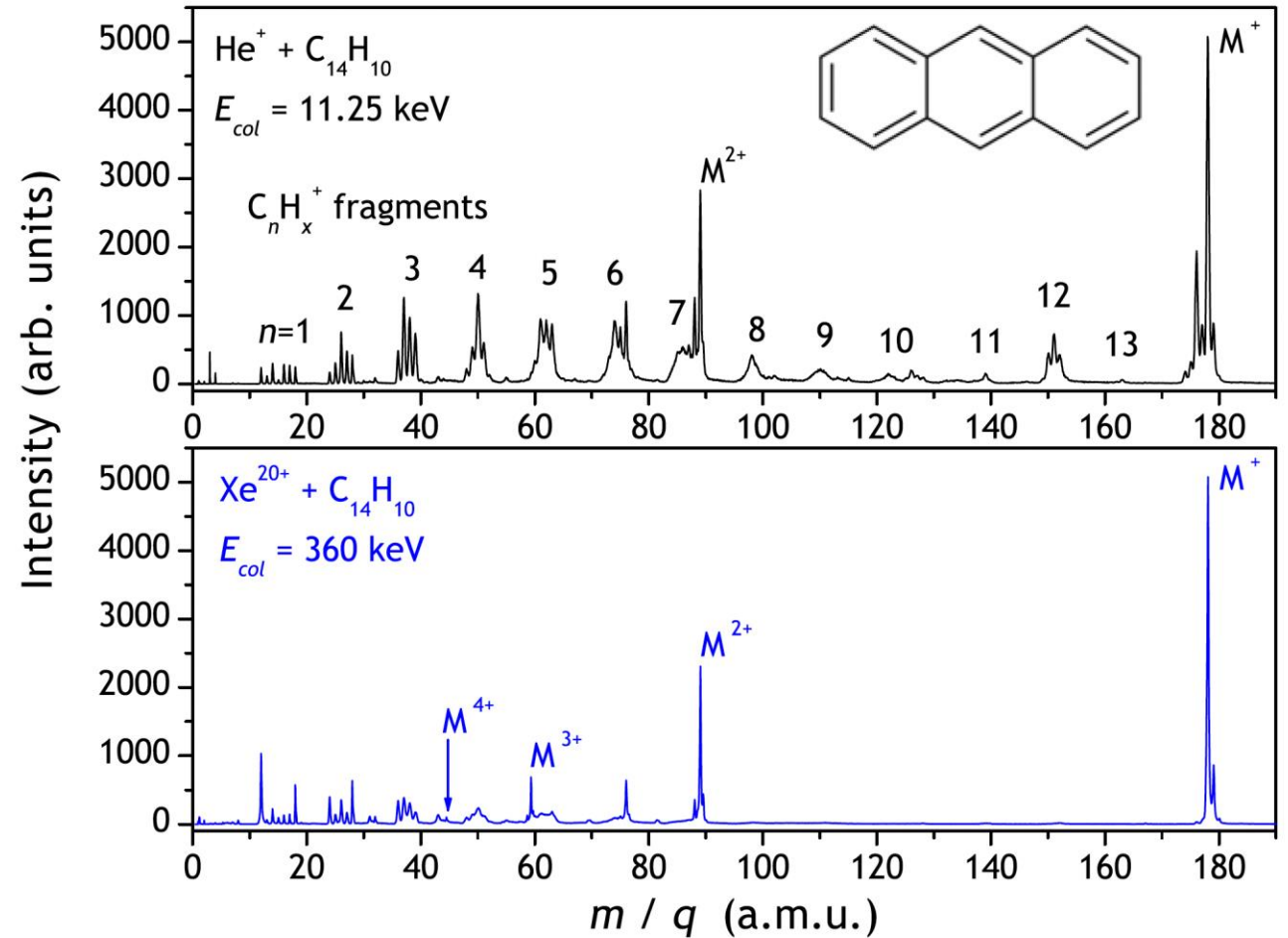
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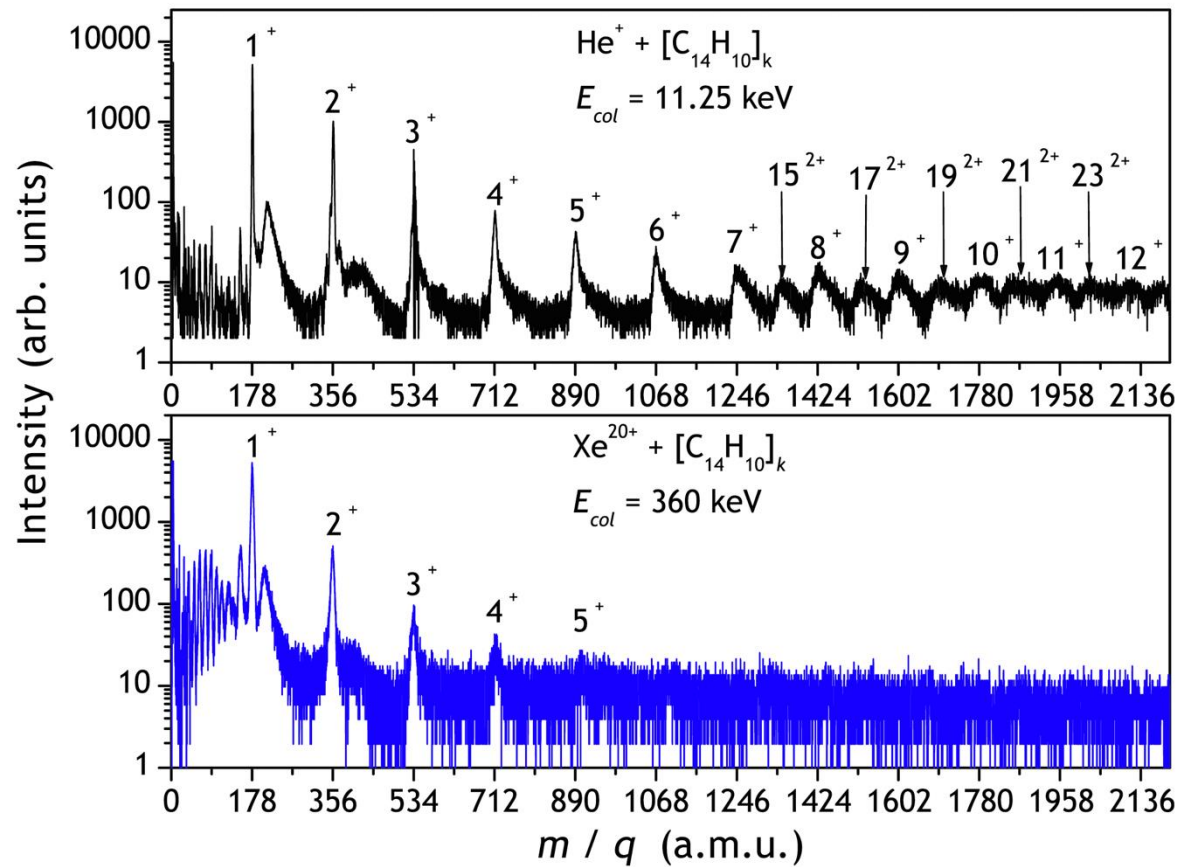


Ion-cluster collision



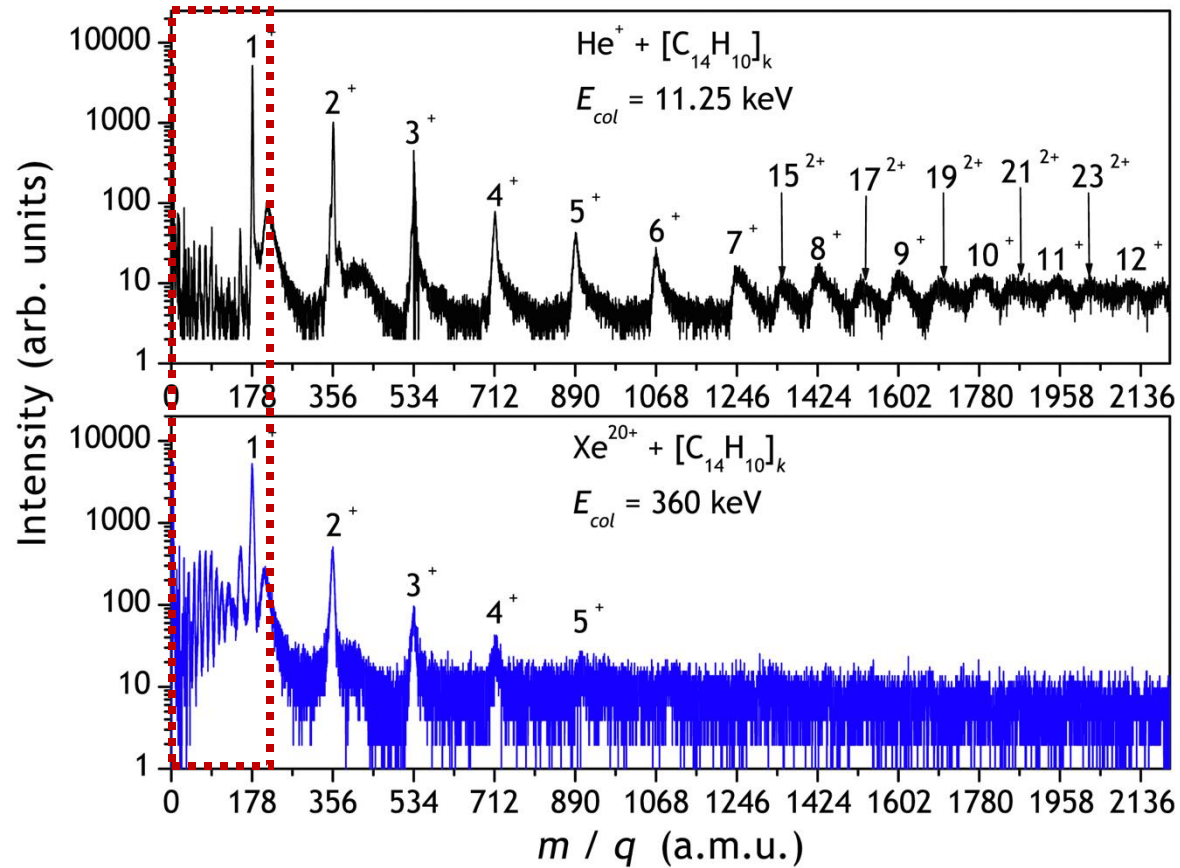
Ion-cluster collision

Molecular cluster



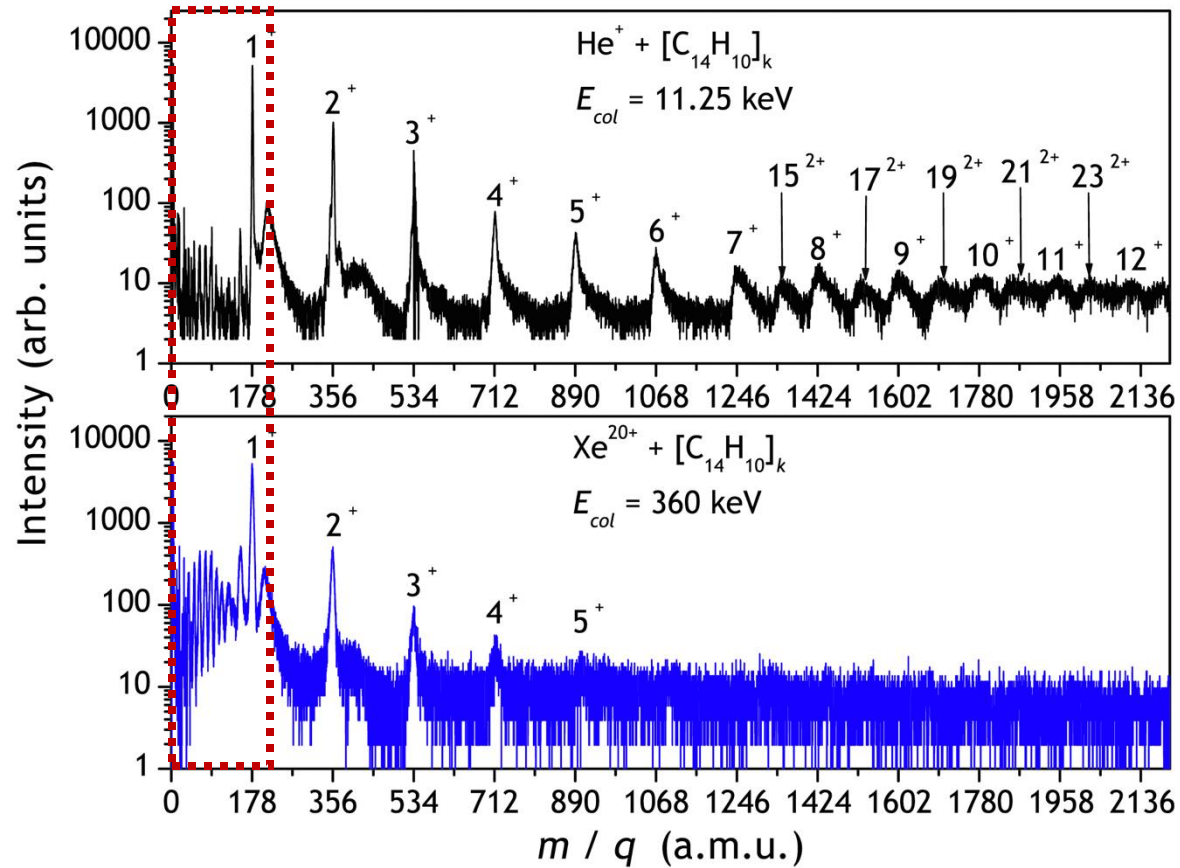
Ion-cluster collision

Molecular cluster

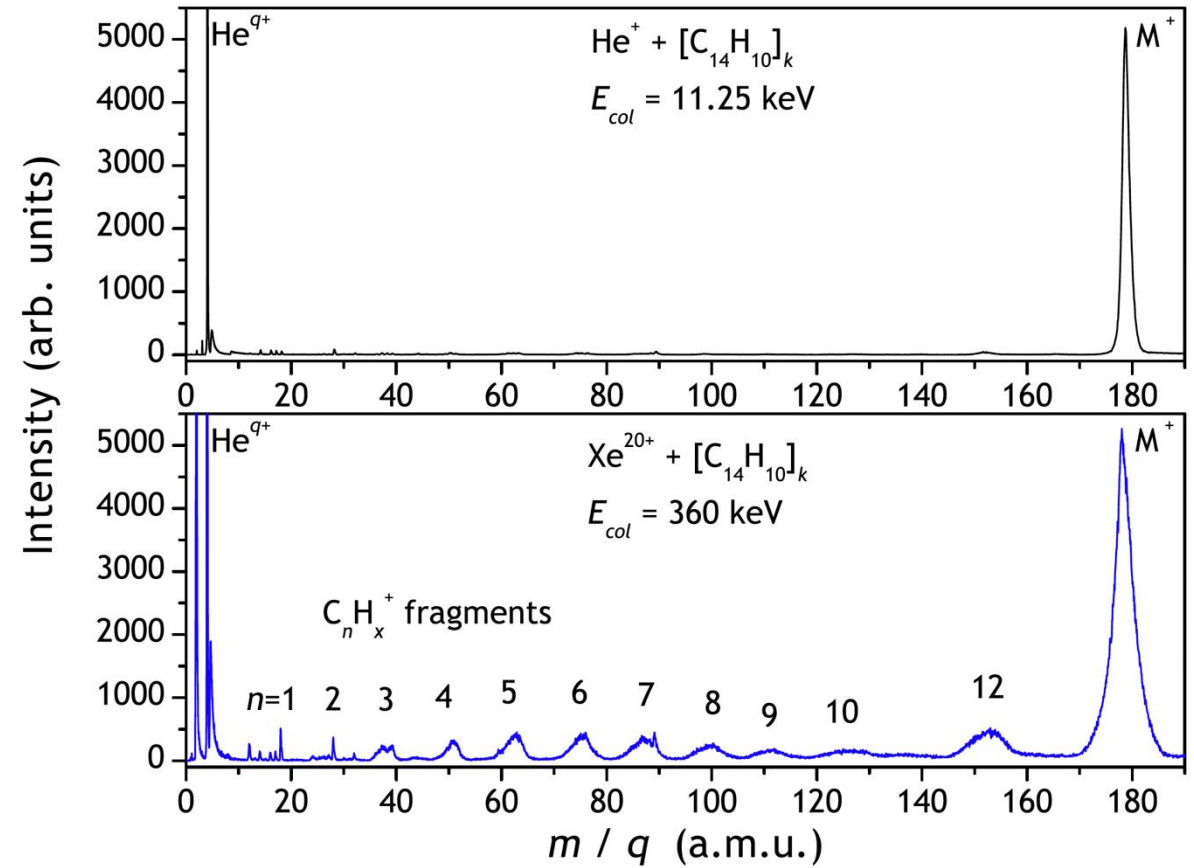


Ion-cluster collision

Molecular cluster



Fragmentation

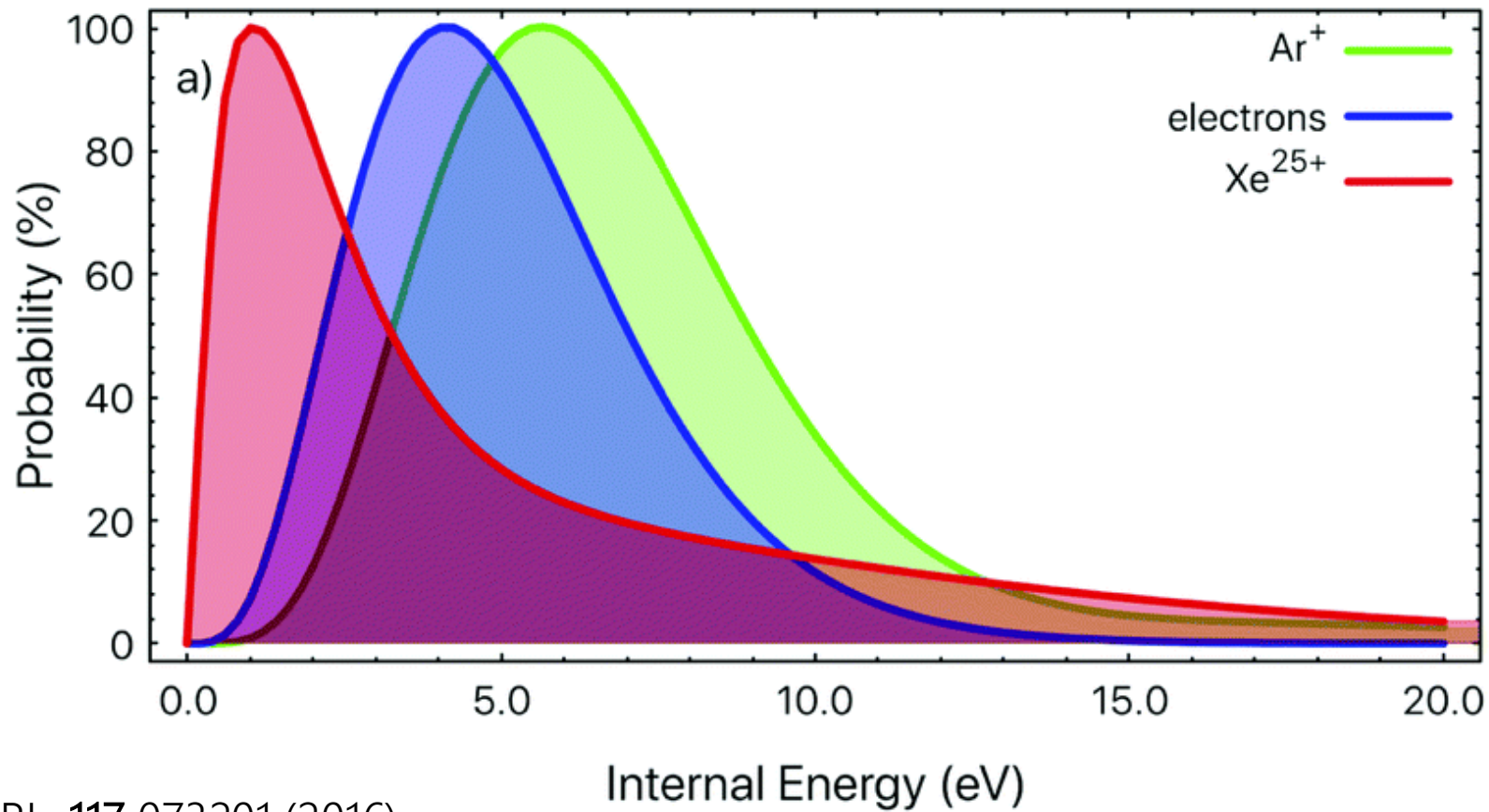


Energy transfer in ion-molecule collisions



Energy transfer in ion-molecule collisions

Distribution of internal energy



S. Maclot *et al.* PRL, **117** 073201 (2016)
E. Erdmann *et al.* PCCP, **23** 1859 (2021)

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EN RECHERCHE

ERC Booster :

18 months postdoc + 100 k€

Project leader: Sylvain Maclot

MCF since 2024

Postdoc: Sumit Srivastav

Started October 2024



Project INTEND: INTernal ENergy Distribution



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ERC Booster:

18 months postdoc

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Project INTEND: INTernal ENergy Distribution



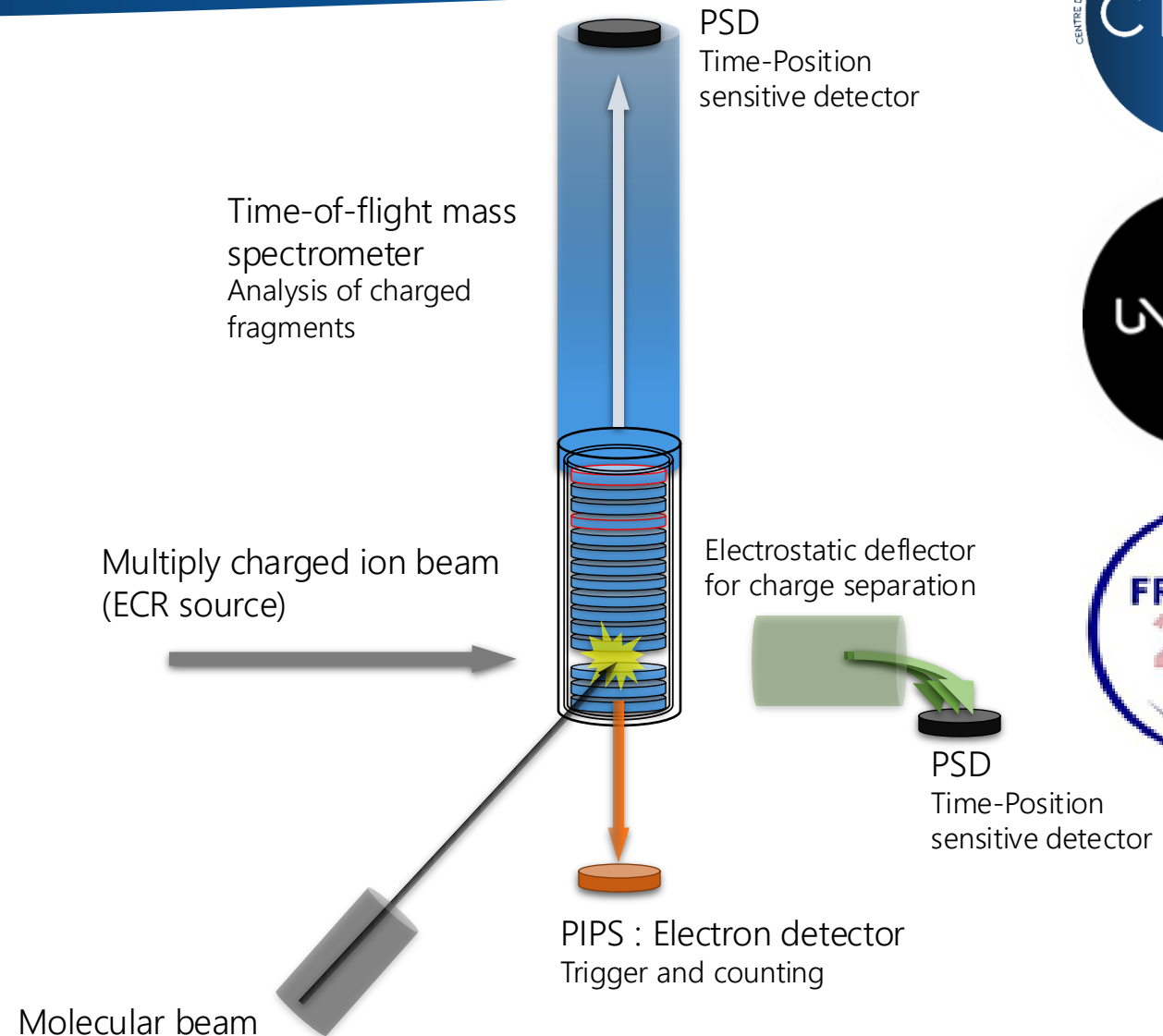
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Objective:

Detection of projectile ions and interaction products in coincidence for better determination of charges and transferred energy.



Chair permanent

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EN RECHERCHE



Chair permanent



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CAEN, STRATÉGIE
POUR L'ACCÉLÉRATION
EN RECHERCHE

Chair permanent:

36 months PhD (Région)

+ 18 months postdoc

+ 50 k€ (Travel)

Project leader: Patrick Rousseau

MCF since 2011

Project start: 2025



Project SMILEI: Stored Molecular Ions in Linear Electrostatic Ion trap



Project SMILE: Stored Molecular Ions in Linear Electrostatic Ion trap



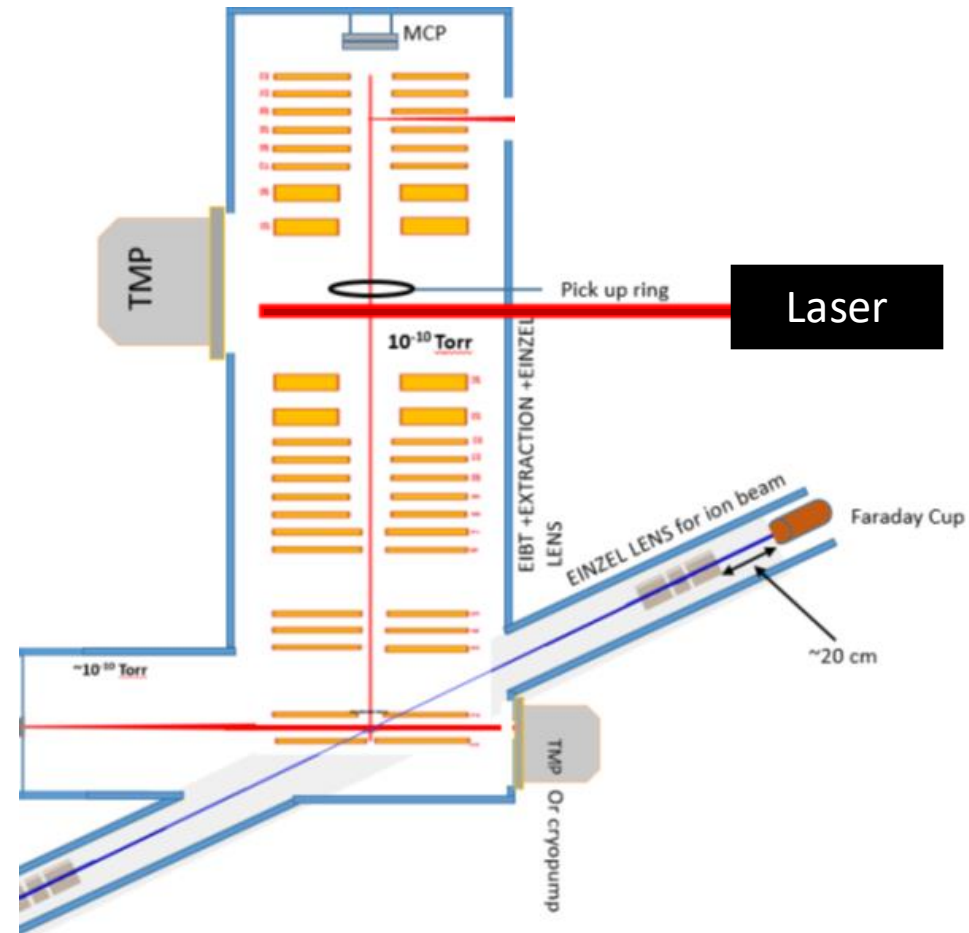
RÉGION
NORMANDIE

Objective:

Preparation of (cold) ions and will open the possibility of spectroscopy of well prepared species with application foreseen in molecular physics and in nuclear physics.

The “open” design of the Weizmann Institute trap allows for the implementation of laser beam and spectrometer in the field free region between the two ion mirrors.

Blaum *et al.*, Phys. Scr. T152 (2013)



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WEIZMANN INSTITUTE OF SCIENCE



THANK YOU