Studies of interaction between Ion and atom/molecule at Fudan University

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EBIT Group


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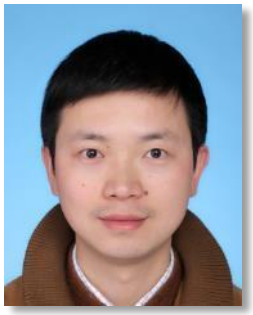
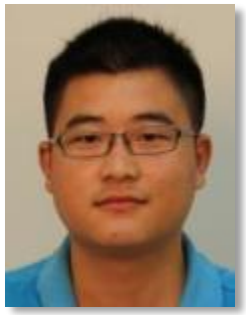

郑 川


黄良玉


屠秉晟


张 煜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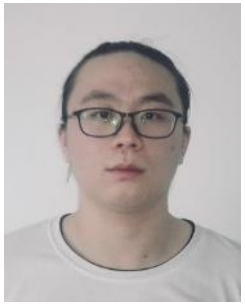
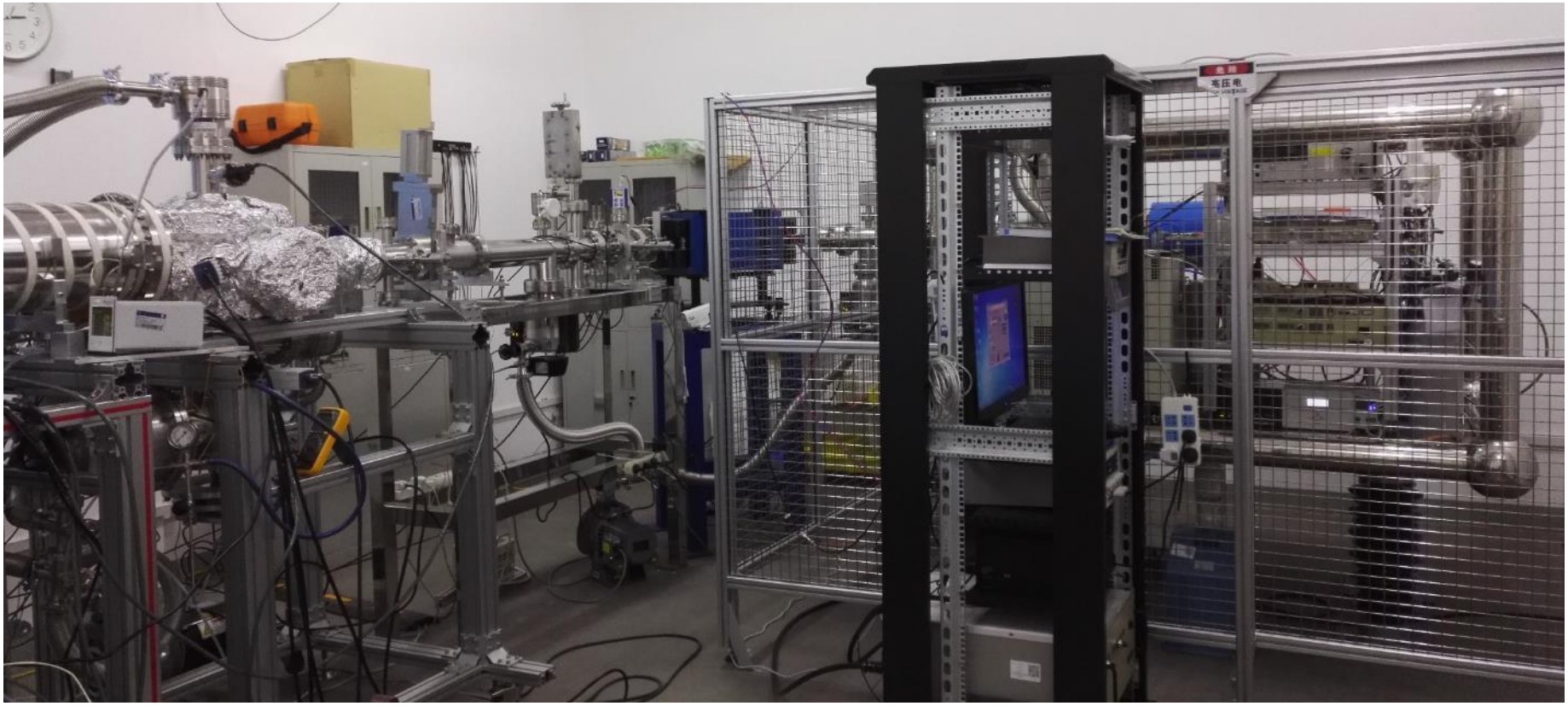
魏 龙


蒋天天

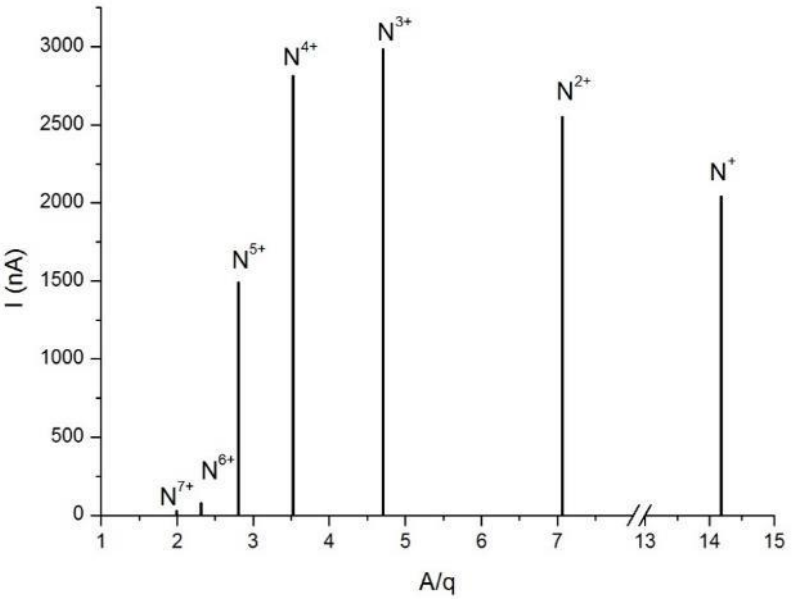
Outline

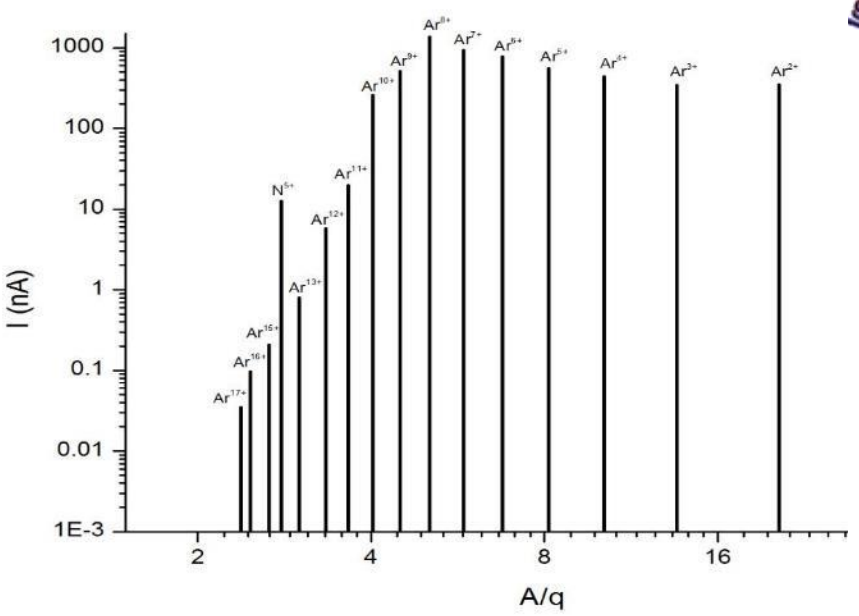
- Experimental setup at Fudan University
- Experiment result
- New Project: Cross section measurement

Experimental setup



Experimental setup

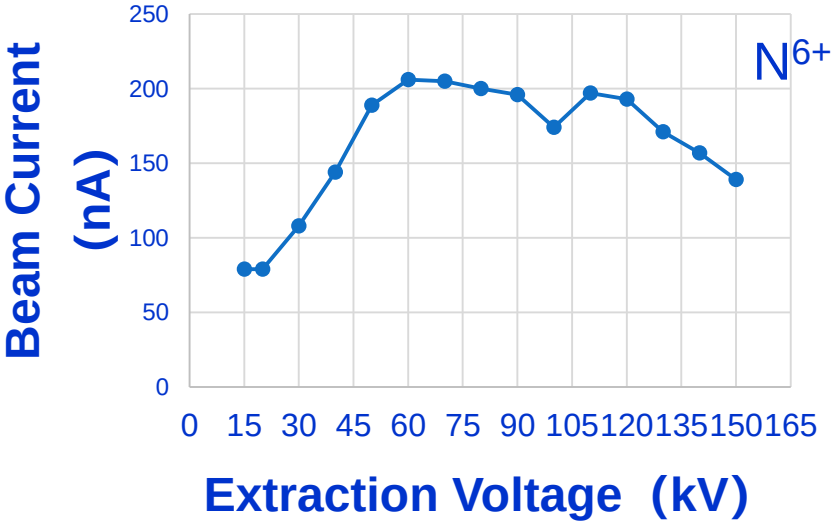




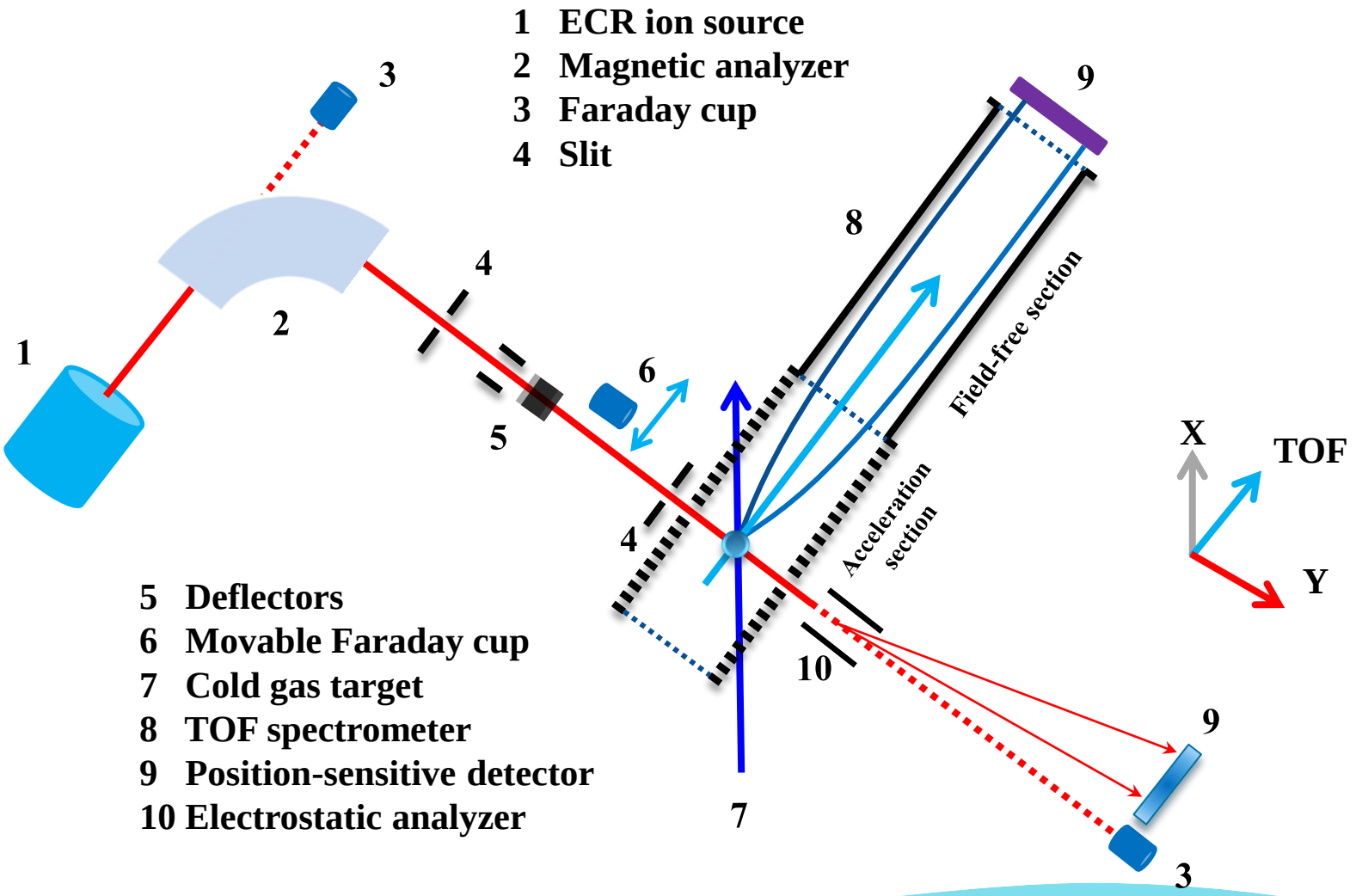
H, C, N, O and inert gas beams could be supplied.

Beam energy: 5~150 qkeV.

Beam current：nA ~ μA.

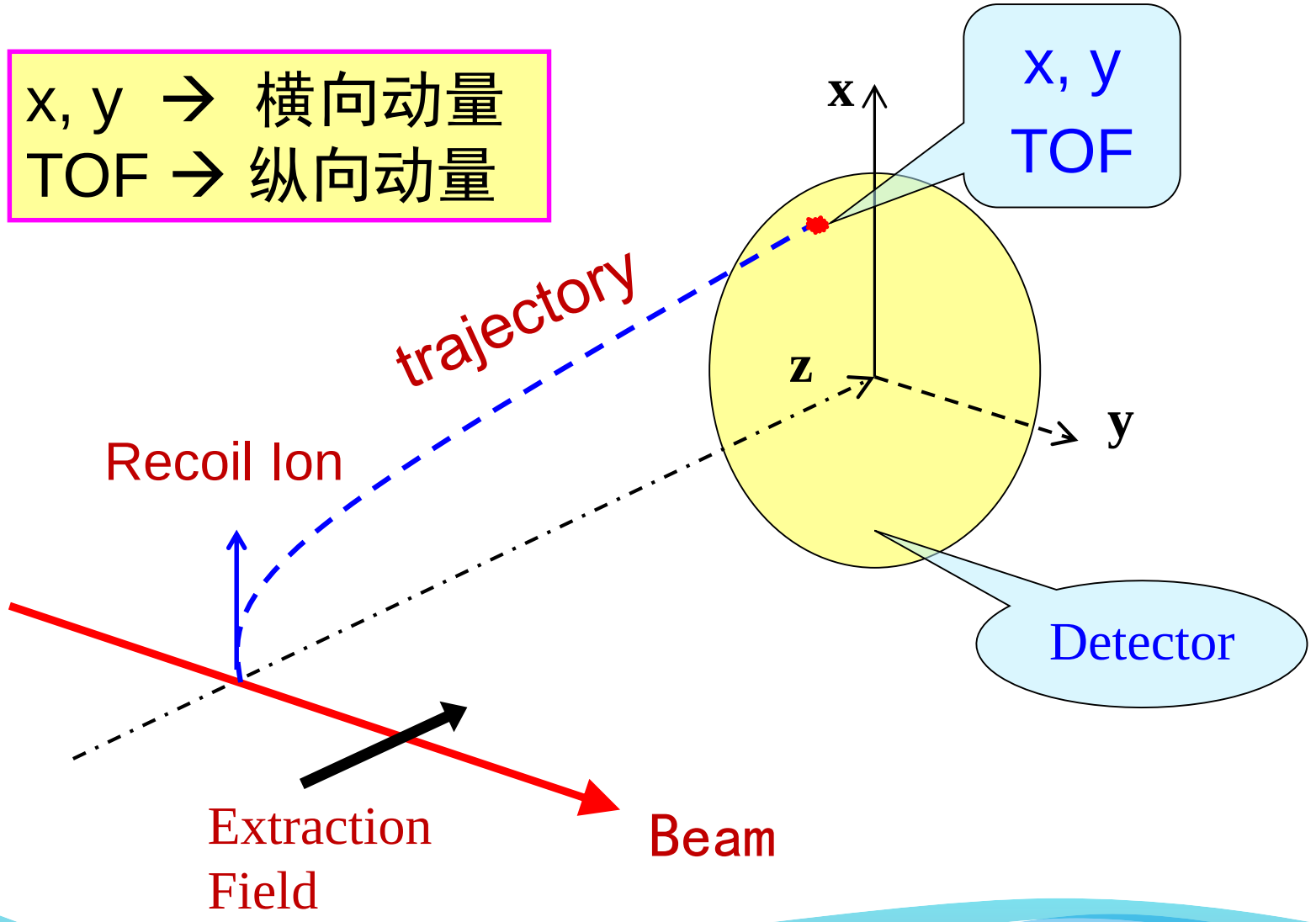


Experimental setup

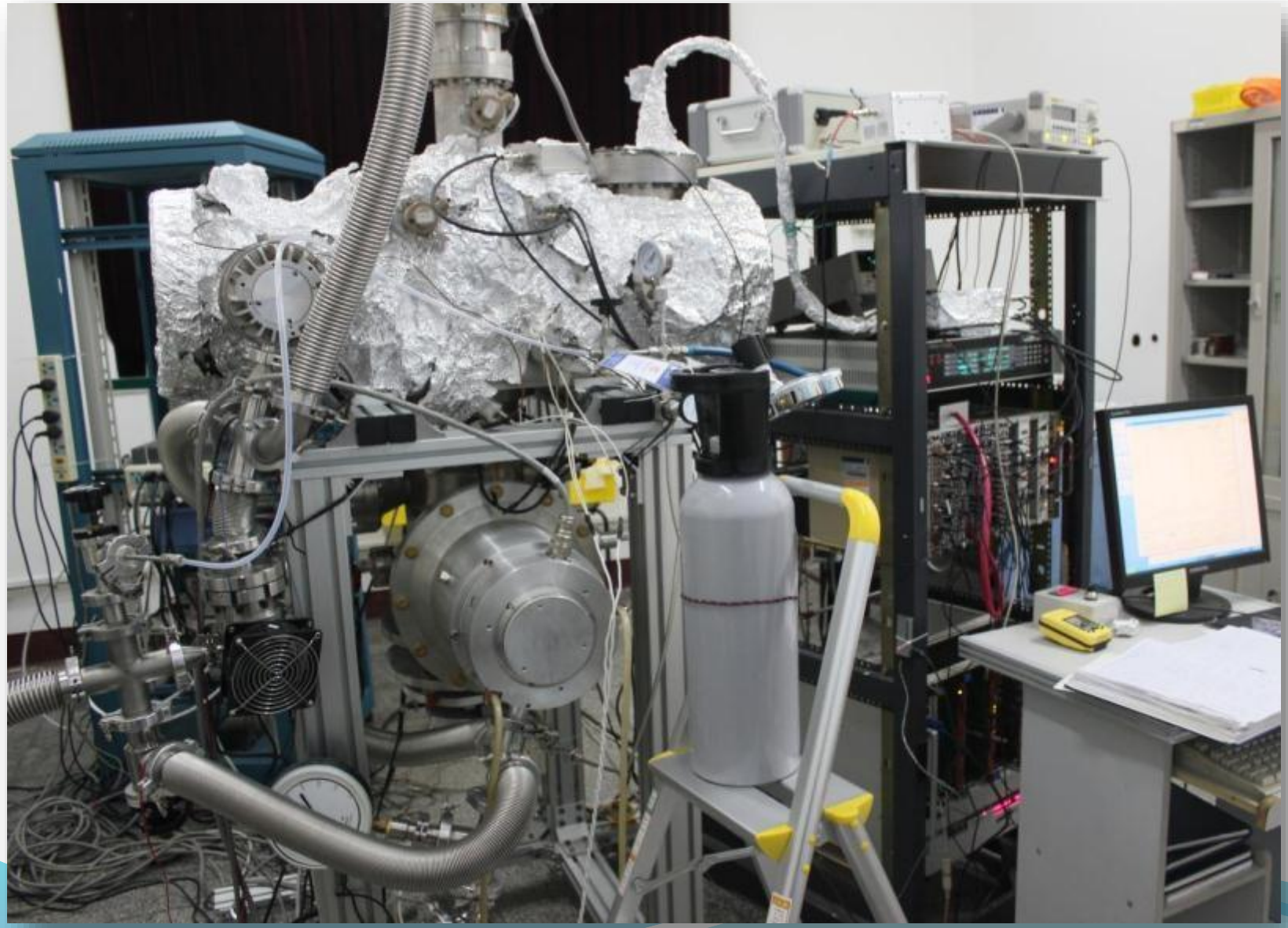


Experimental setup

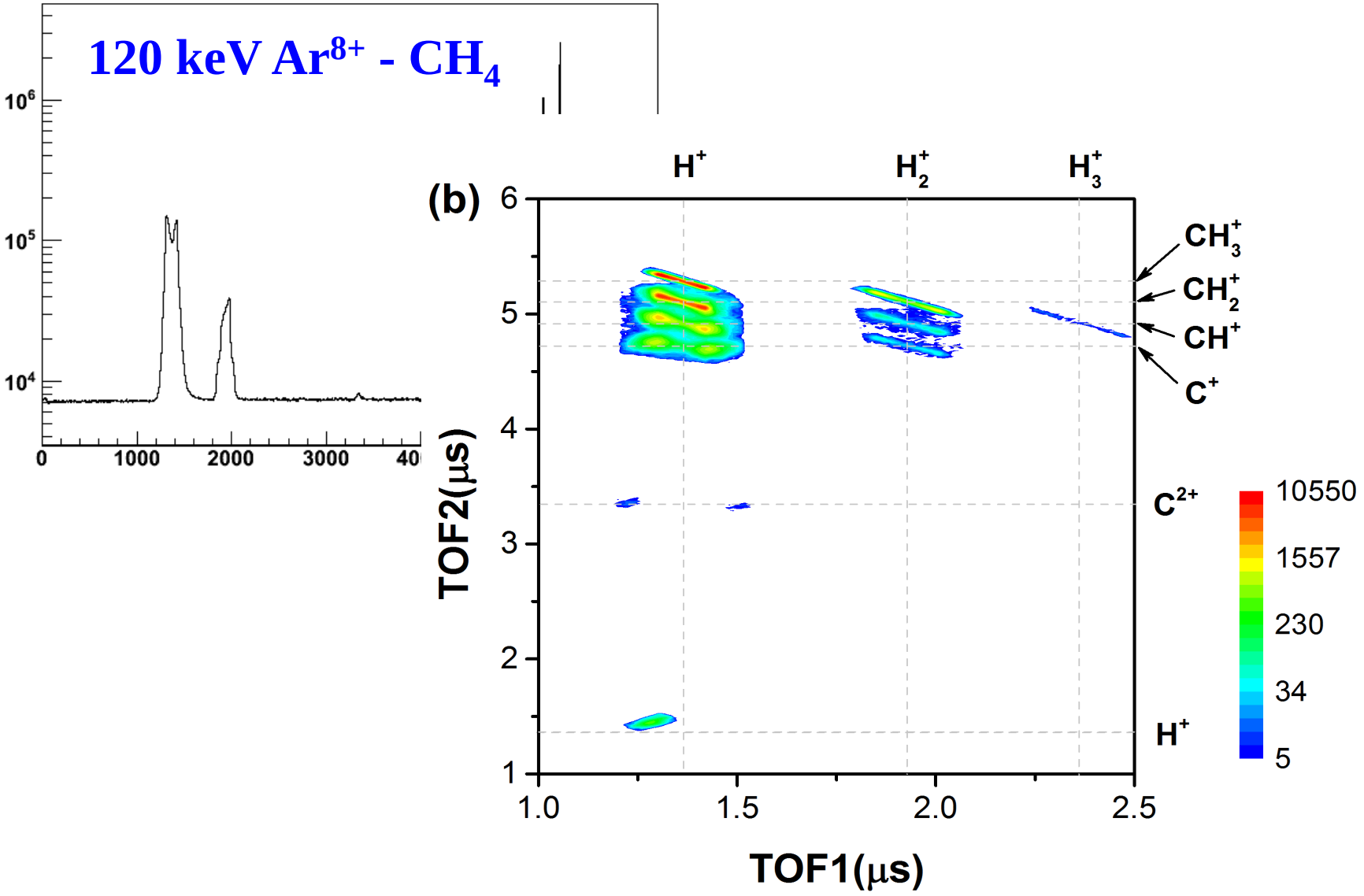
x, y → 横向动量
TOF → 纵向动量



Experimental setup



Experiment with HCI



Experiment with HCI

Synchronous concerted

$CH_4^{2+} \rightarrow CH_2^+ + H^+ + H$

$\rightarrow CH_3^{+*} + H^+ \rightarrow CH_2^+ + H^+ + H$

$\rightarrow CH_2^+ + H_2^{+*} \rightarrow CH_2^+ + H^+ + H$

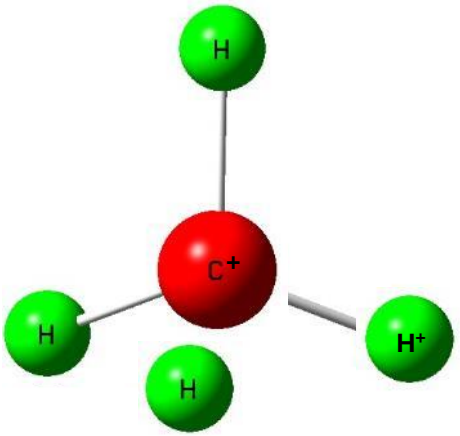
Two Step

No CH_3^{2+} in TOF Spectrum.

Then no reaction related CH_3^{2+}.

Experiment with HCI

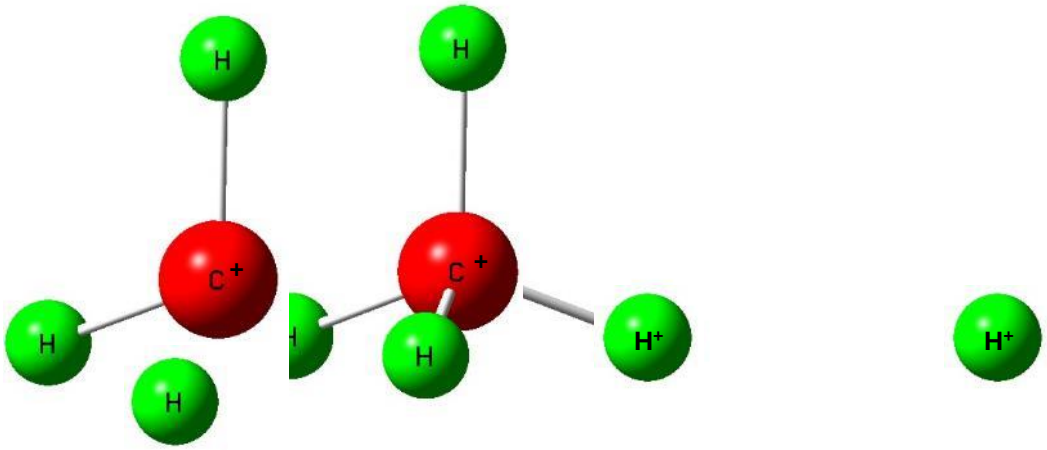
$$CH_4^{2+} \rightarrow CH_2^{+} + H^{+} + H$$



Experiment with HCI

$$CH_4^{2+} \rightarrow CH_3^{+*} + H^+$$

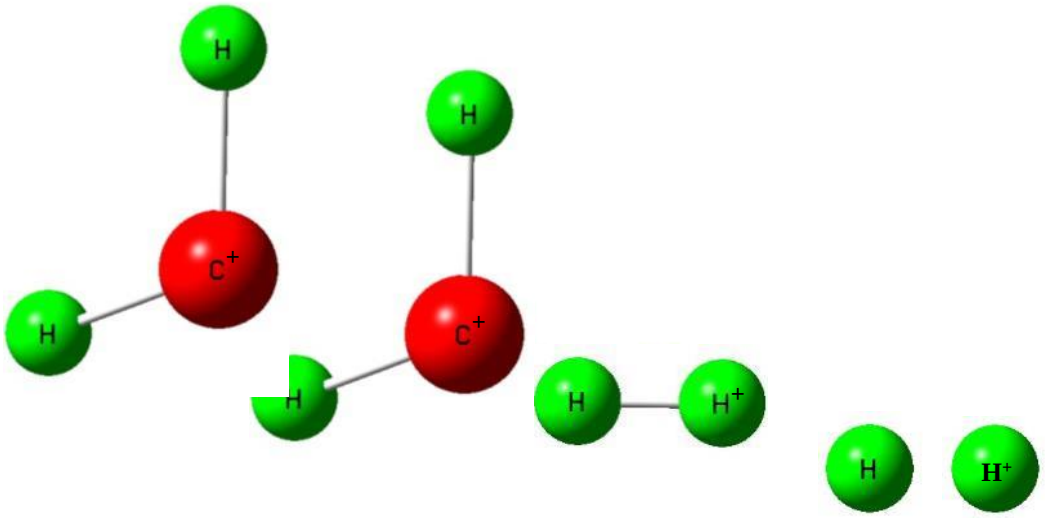
$$\rightarrow CH_2^{+} + H + H^+$$



Experiment with HCI

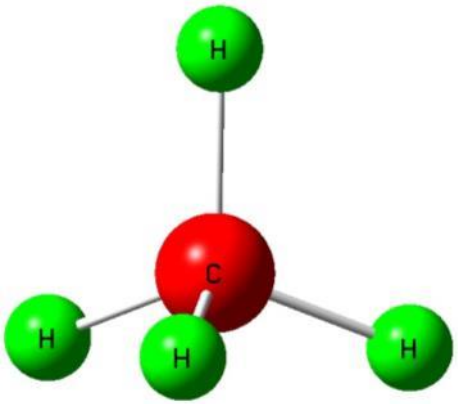
$$CH_4^{2+} \rightarrow CH_2^{+} + H_2^{+*}$$

$$\rightarrow CH_2^{+} + H^{+} + H$$



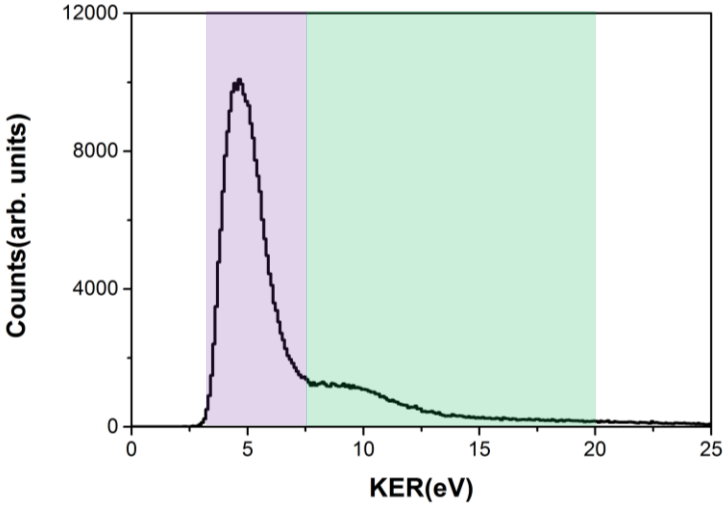
Experiment with HCI

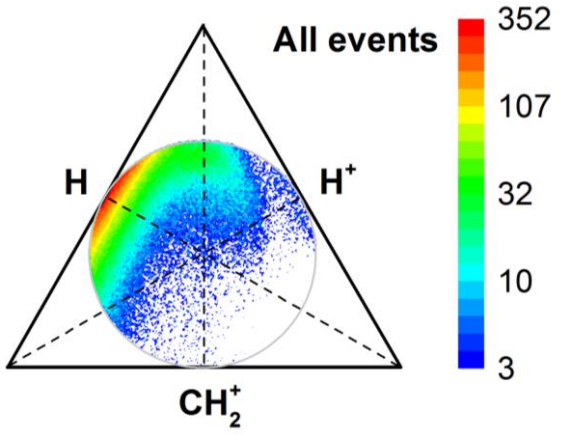
$$CH_4^{2+} \rightarrow CH_2^{+} + H^{+} + H$$

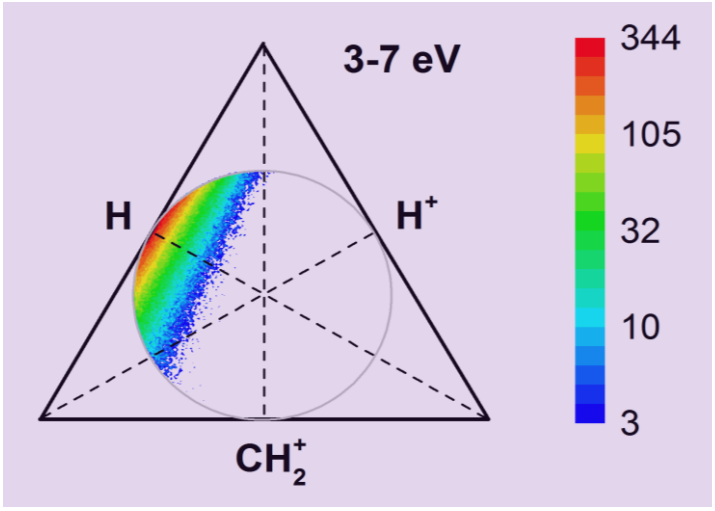


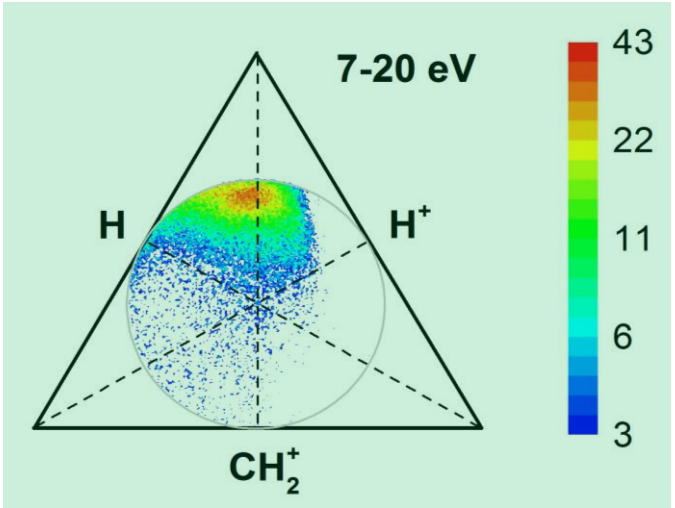
The momentum of H depends on the fragmentation mechanism.

Experiment with HCI





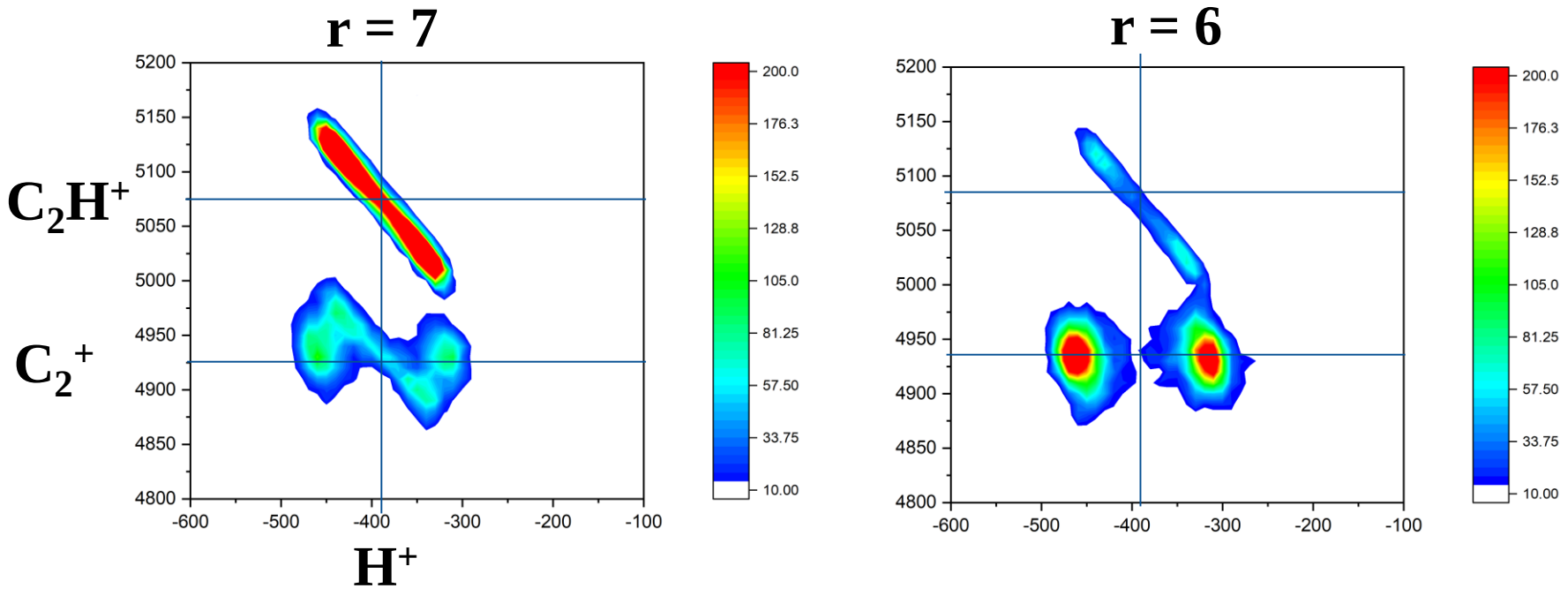




Y. Zhang, *et al*, Phys. Rev. A 97, 022703

Experiment with HCI

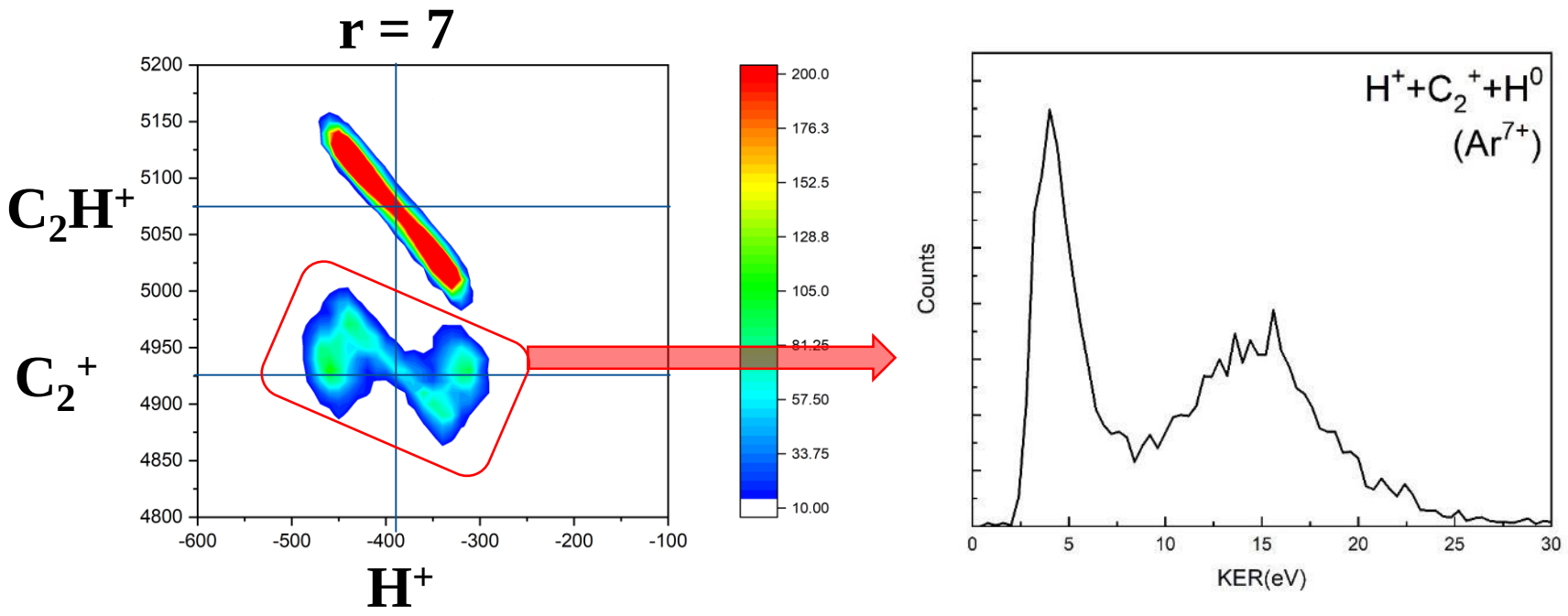
$$Ar^{8+} - C_2H_2 \rightarrow Ar^{r+} + C_2H_2^{2+}$$
$$\rightarrow C_2^{+} + H^{+} + H$$



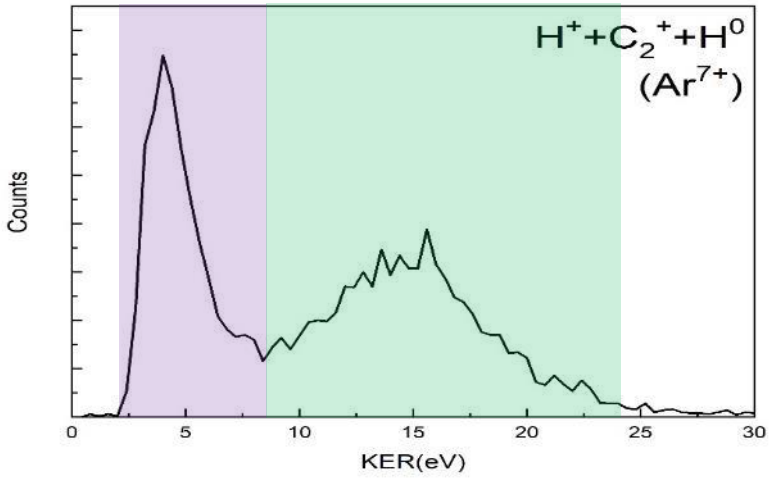
Experiment with HCI

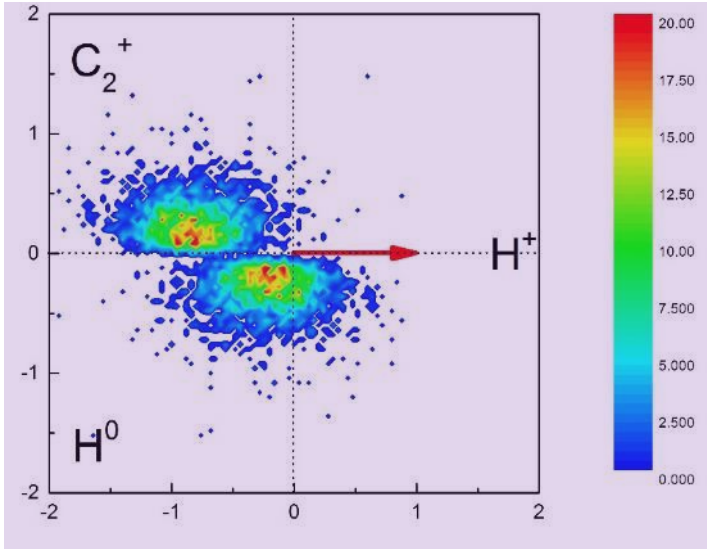
$$Ar^{8+} - C_2H_2 \rightarrow Ar^{r+} + C_2H_2^{2+}$$

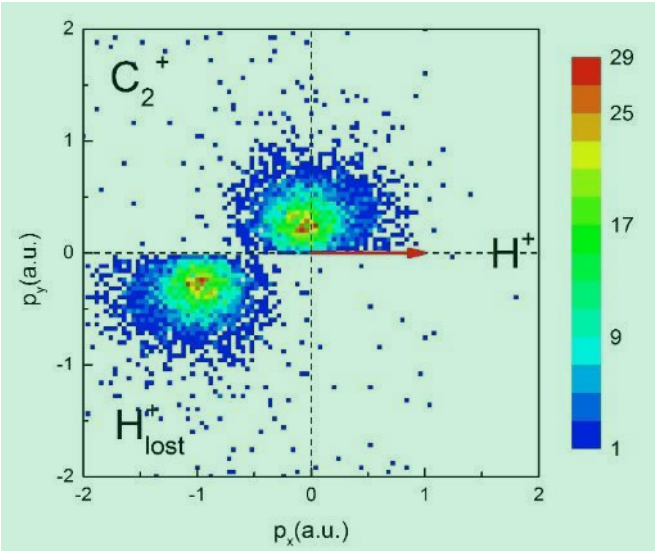
$$\rightarrow C_2^{+} + H^{+} + H$$



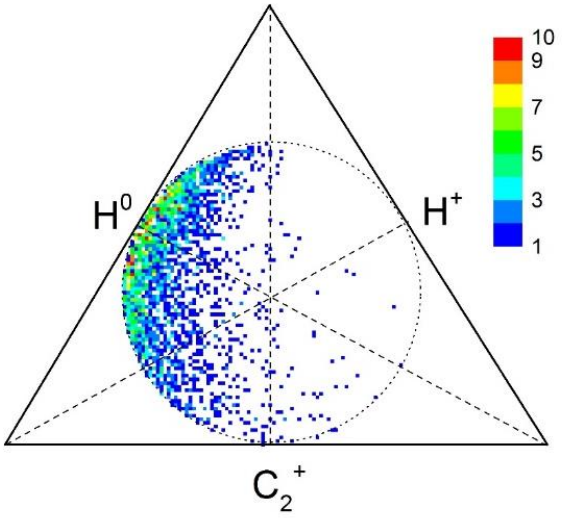
Experiment with HCI

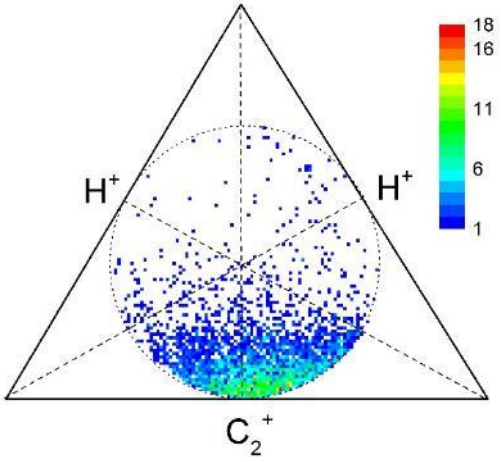


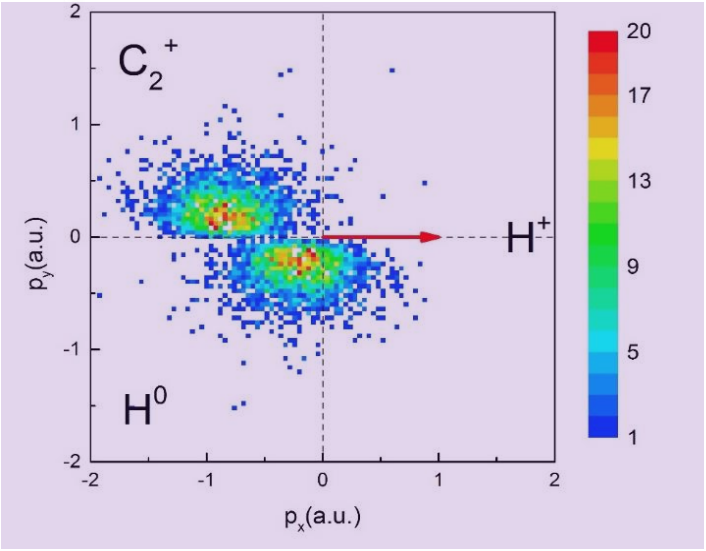


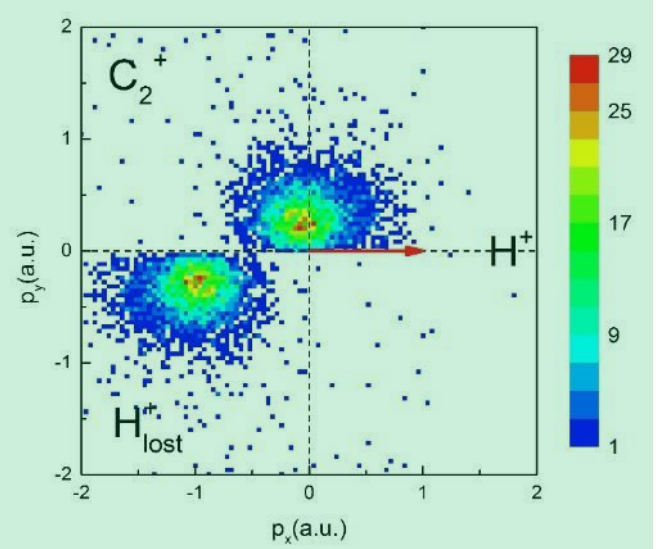


Experiment with HCI



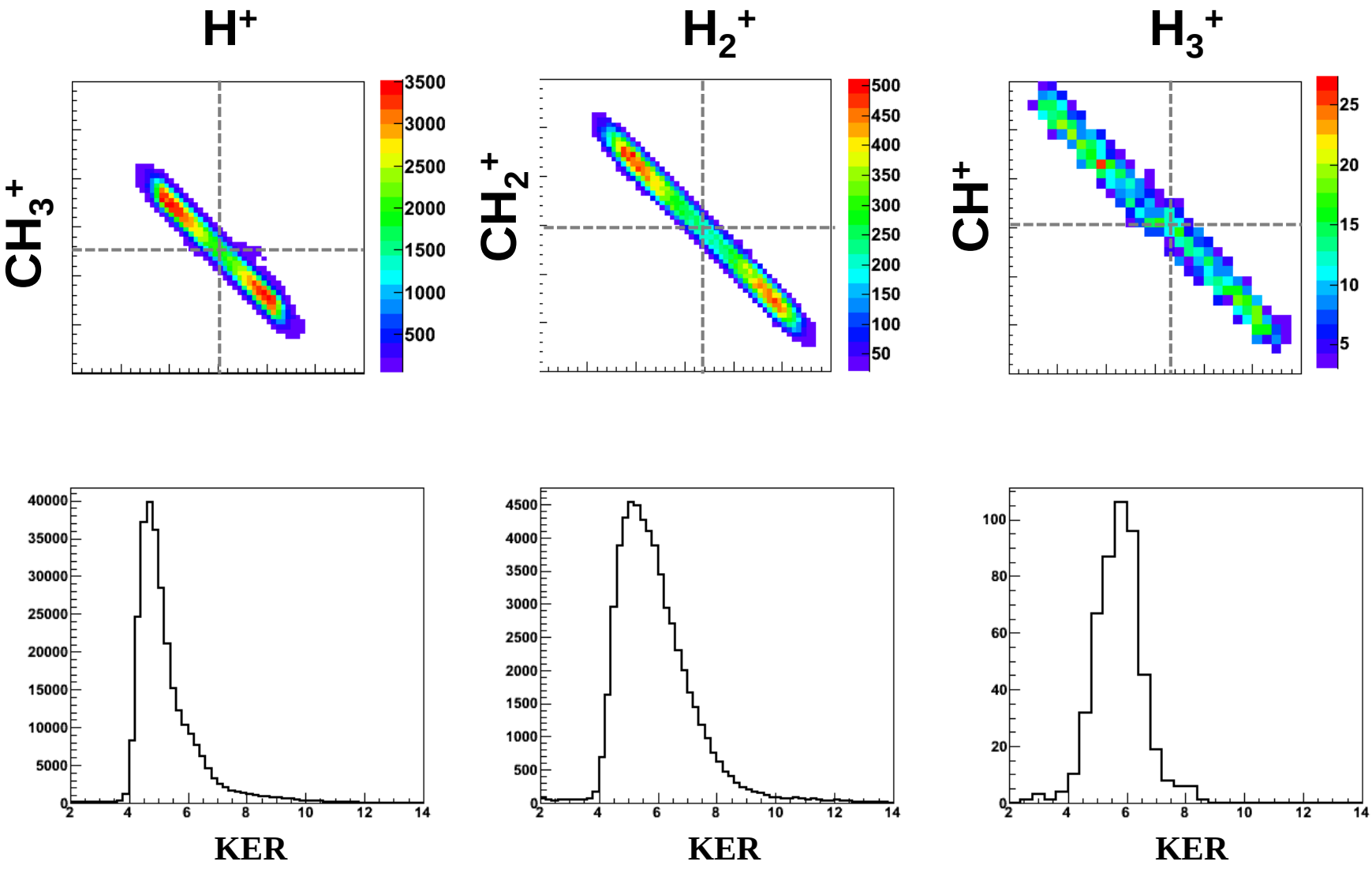






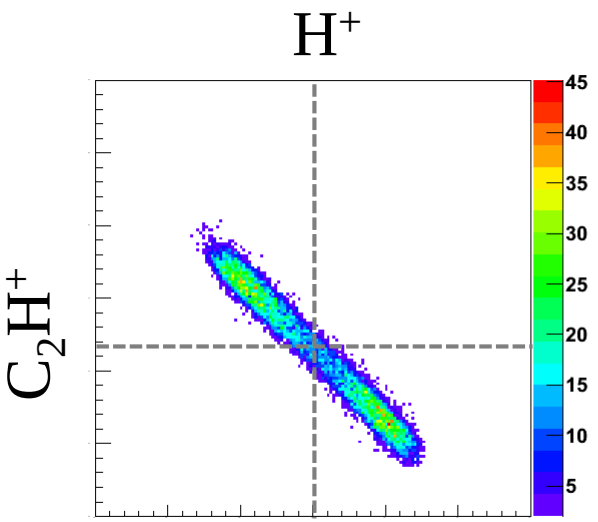
Experiment with HCI

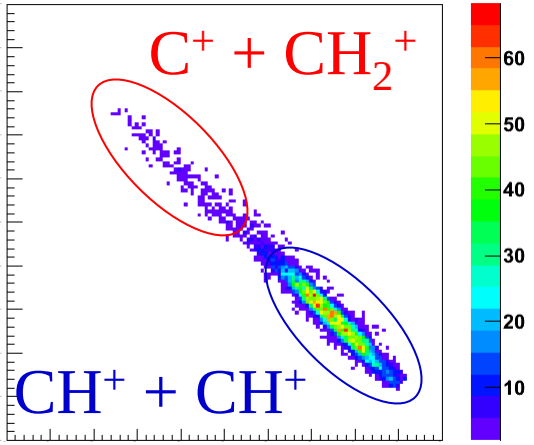
120 keV Ar^{8+} - CH_4

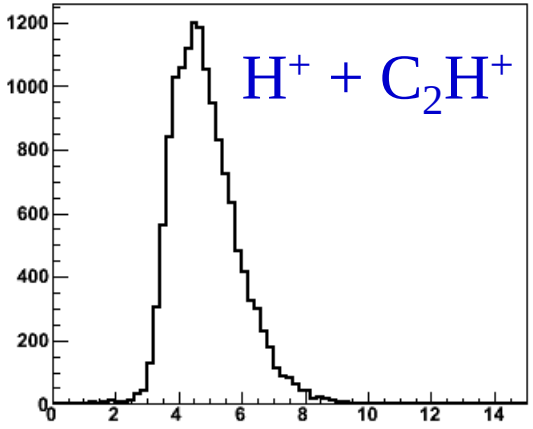


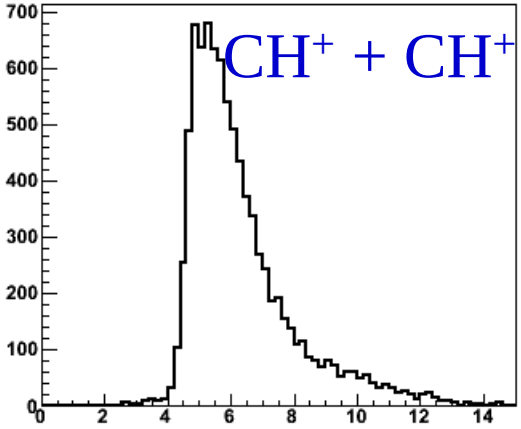
Experiment with HCI

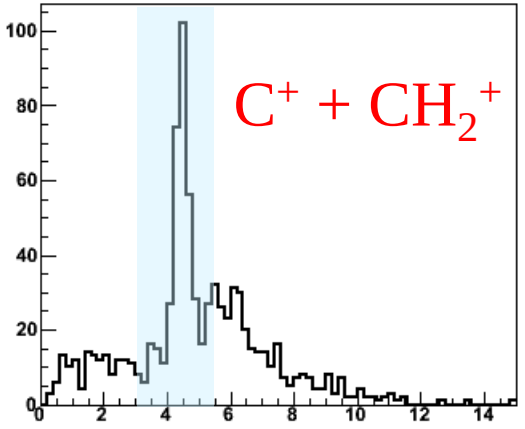
120 keV Ar^{8+} - C_2H_2



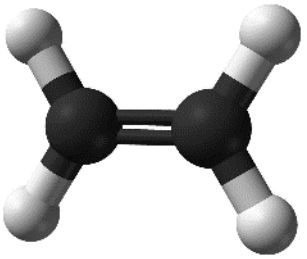




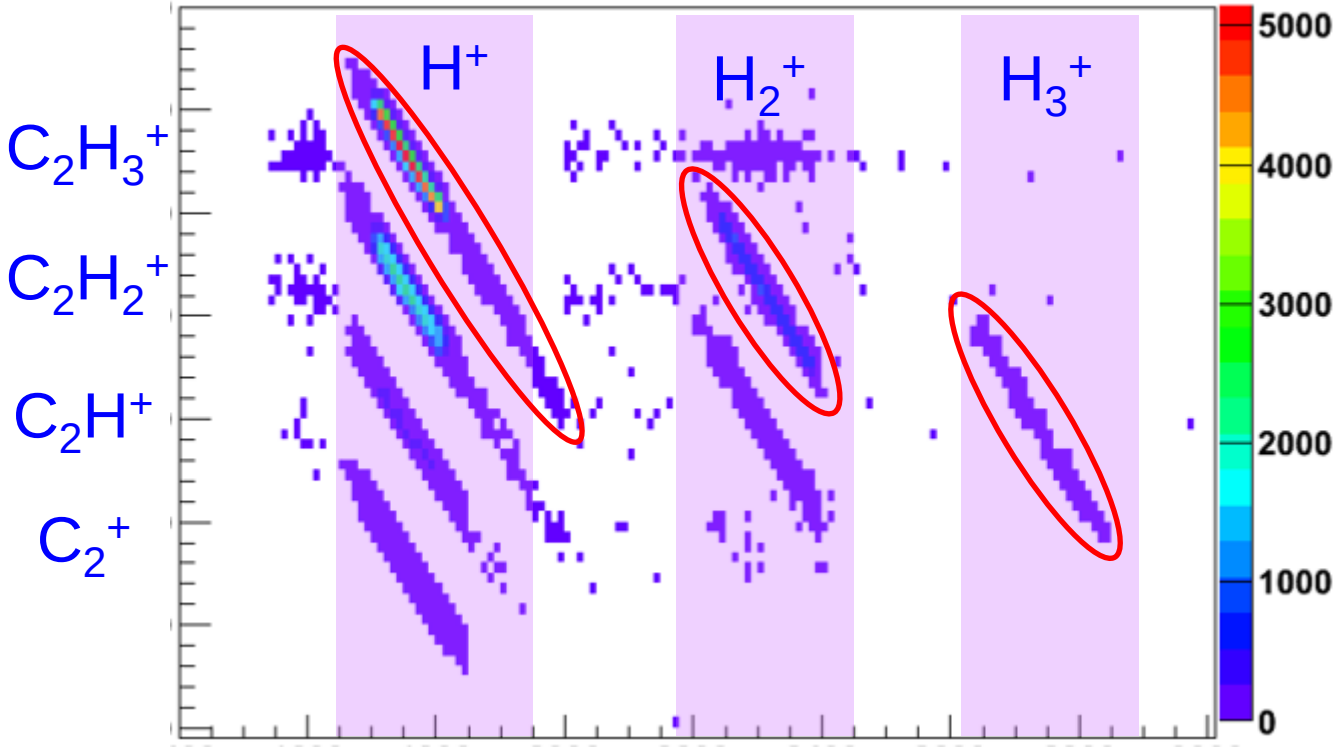




Experiment with e^-



100 eV e^- - C_2H_4



Proton migration

PRL **105,** 263002 (2010) PHYSICAL REVIEW LETTERS week ending 31 DECEMBER 2010

Ultrafast Extreme Ultraviolet Induced Isomerization of Acetylene Cations

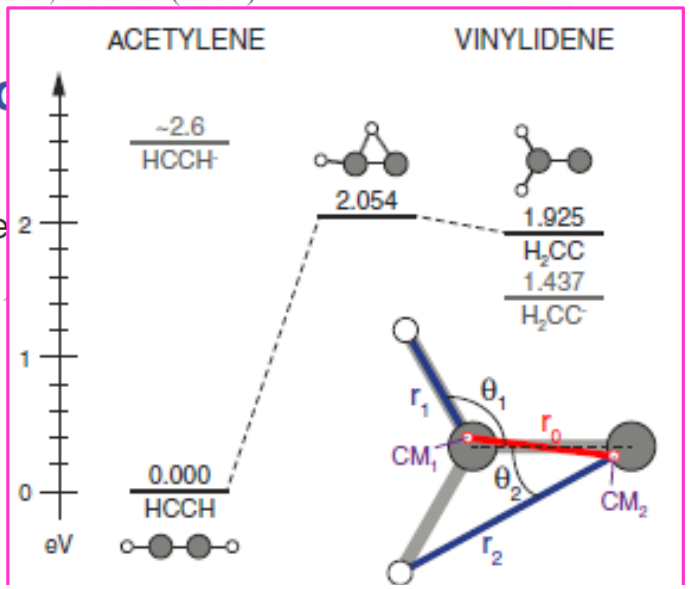
PRL **116,** 193001 (2016) PHYSICAL REVIEW LETTERS week ending 13 MAY 2016

Steering Proton Migration in Hydrocarbons Using Intense Few-Cycle Laser Fields

THE JOURNAL OF CHEMICAL PHYSICS **146**, 244305 (2017)

Ultrafast proton migration and Coulomb explo in intense laser fields

Pan Ma, Chuncheng Wang, Xiaokai Li, Xitao Yu, Xu Tian, We and Dajun Ding[a)]



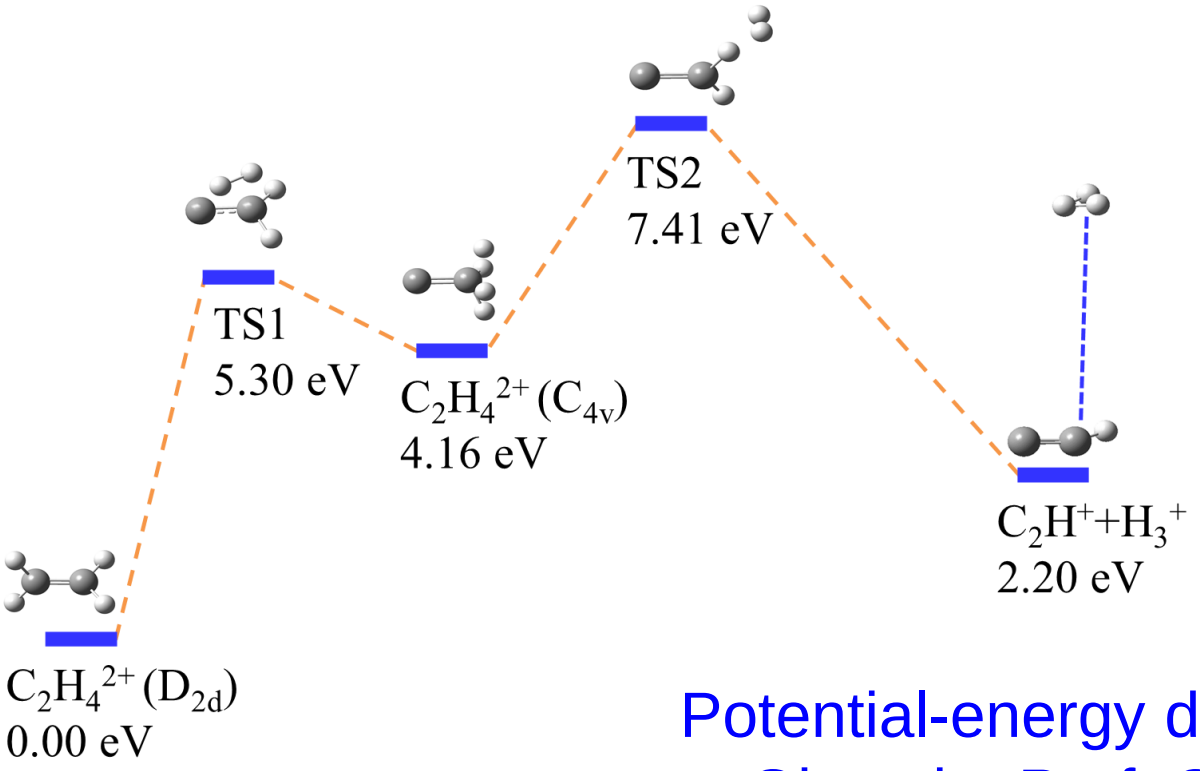
DeVine et al., Science 358, 336–339 (2017)

Proton migration

Two-step mechanism

I. A long-lived neutral moiety of H_2 is formed.

II. The H_2 moiety abstracts a proton to form H_3^+.



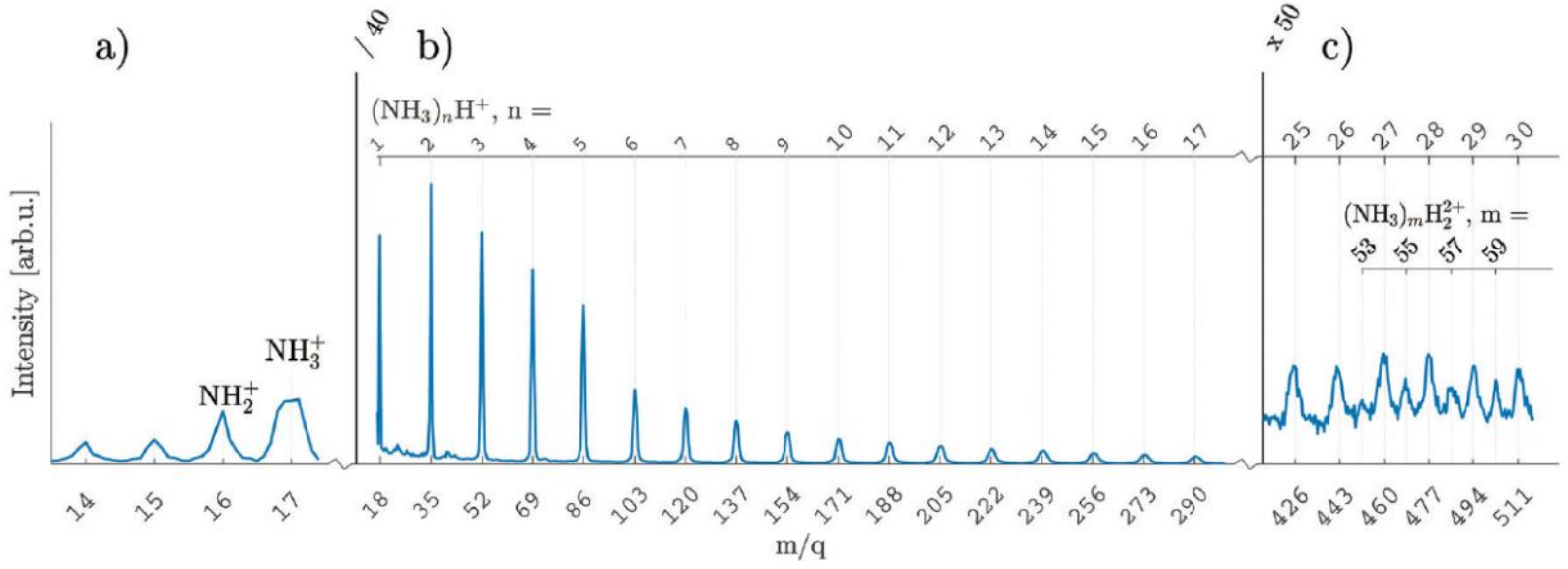
Potential-energy diagram
Given by Prof. C. Yang

Experiment with e$^-$

Cite this: *Phys. Chem. Chem. Phys.*, 2018, 20, 932

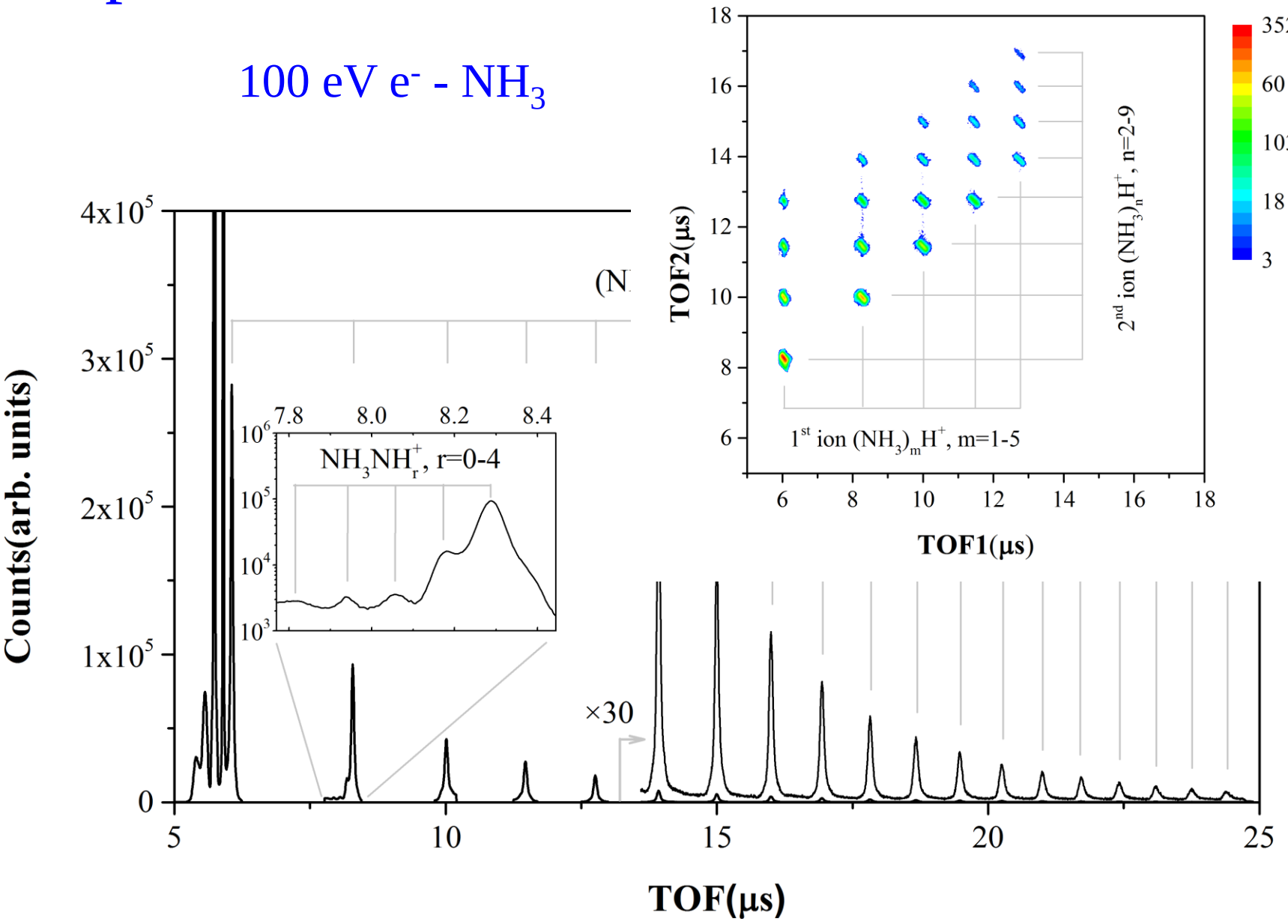
The role of charge and proton transfer in fragmentation of hydrogen-bonded nanosystems: the breakup of ammonia clusters upon single photon multi-ionization

Bart Oostenrijk, [a] Noelle Walsh, [b] Joakim Laksman, [c] Erik P. Månsson, [d] Christian Grunewald, [e] Stacey L. Sorensen [a] and Mathieu Gisselbrecht [a]

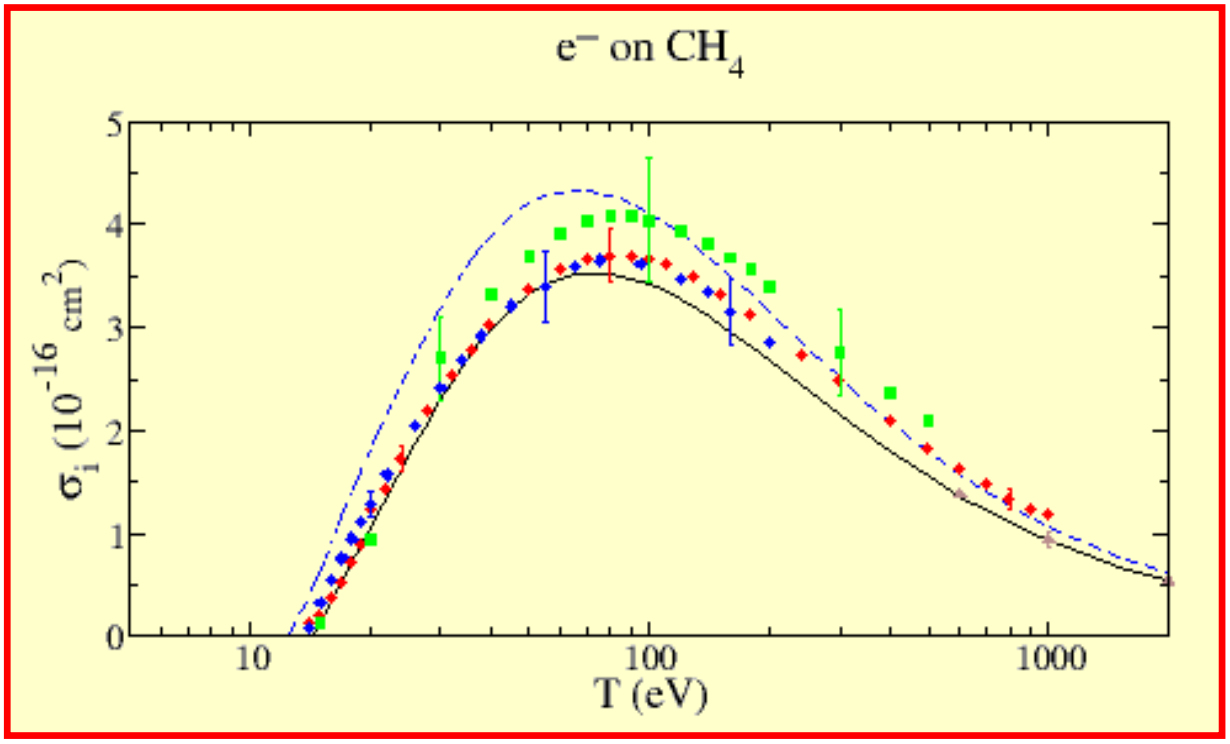


Experiment with e^-

100 eV e^- - NH_3



Cross section



Cross section

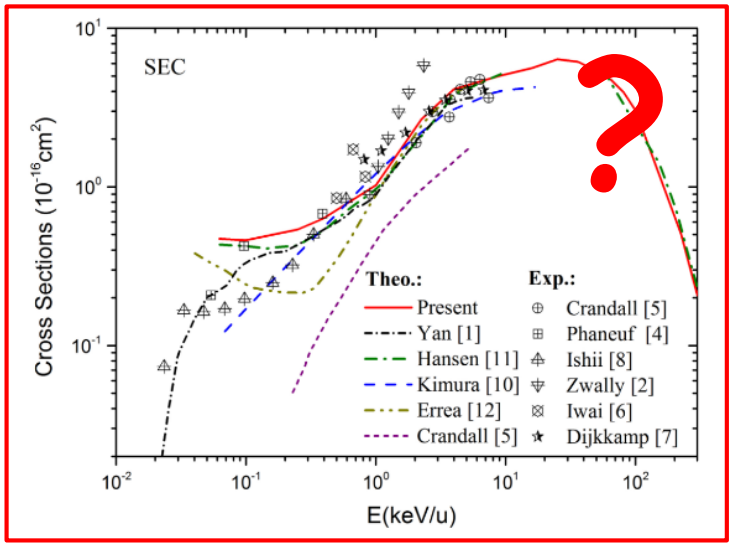
THE ASTROPHYSICAL JOURNAL SUPPLEMENT SERIES, 234:14 (4pp), 2018 January https://doi.org/10.3847/1538-4365/aaa02c

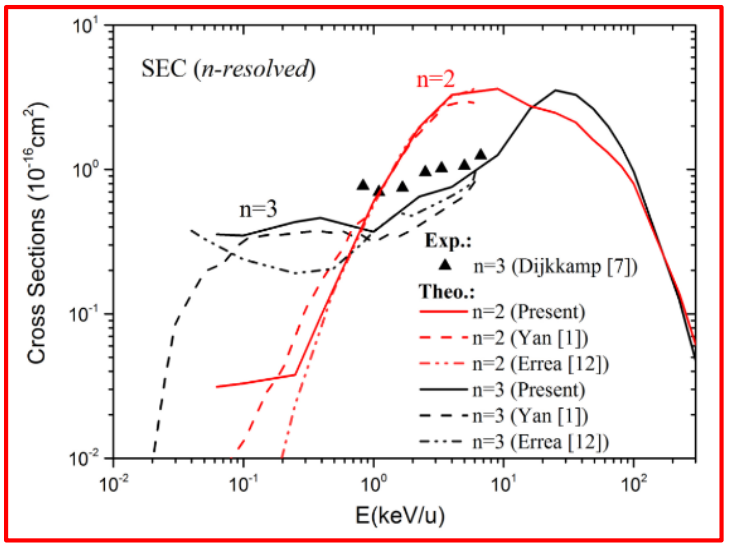
Measurement of Absolute Single and Double Charge Exchange Cross Sections for $Si^{(7-10)+}$ at 0.88–2.50 KeV/u Impacting He and H_2

PHYSICAL REVIEW A **96**, 052703 (2017)

Single- and double-electron transfer in low- and intermediate-energy C^{4+} + He collisions

J. W. Gao,[1,2,*] Y. Wu,[1] N. Sisourat,[2] J. G. Wang,[1] and A. Dubois[2]

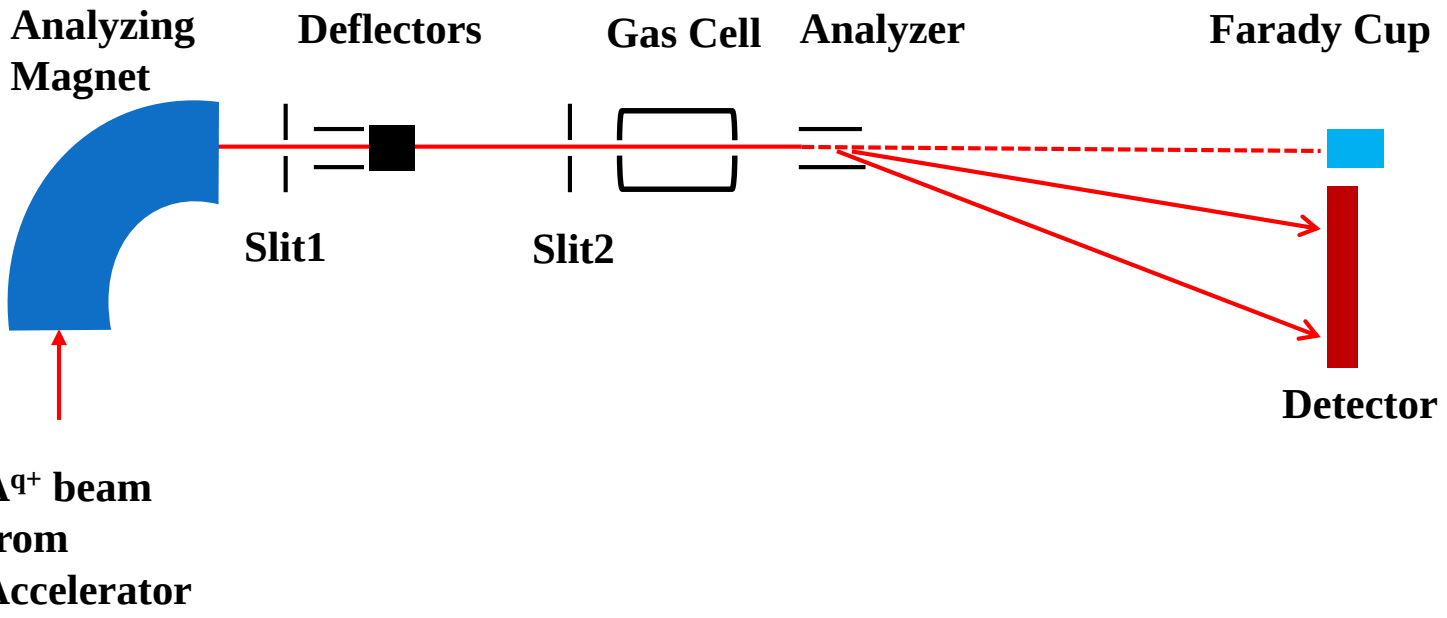




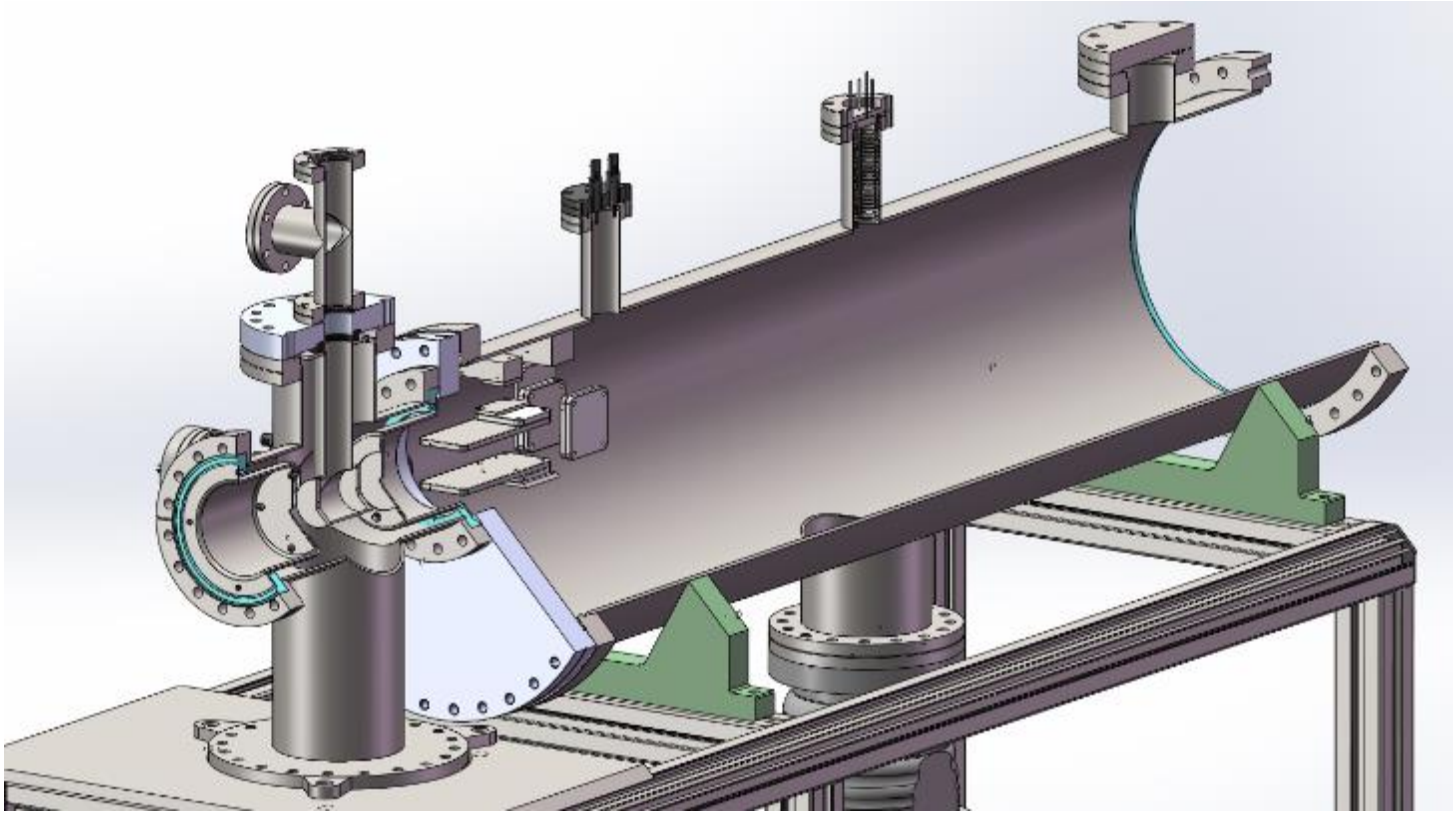
Cross section

- Absolute single and double electron capture cross section

$$\sigma_{q,q-j} = \frac{kT}{PL}\frac{qI_{q-j}}{(q-j)I_q}$$



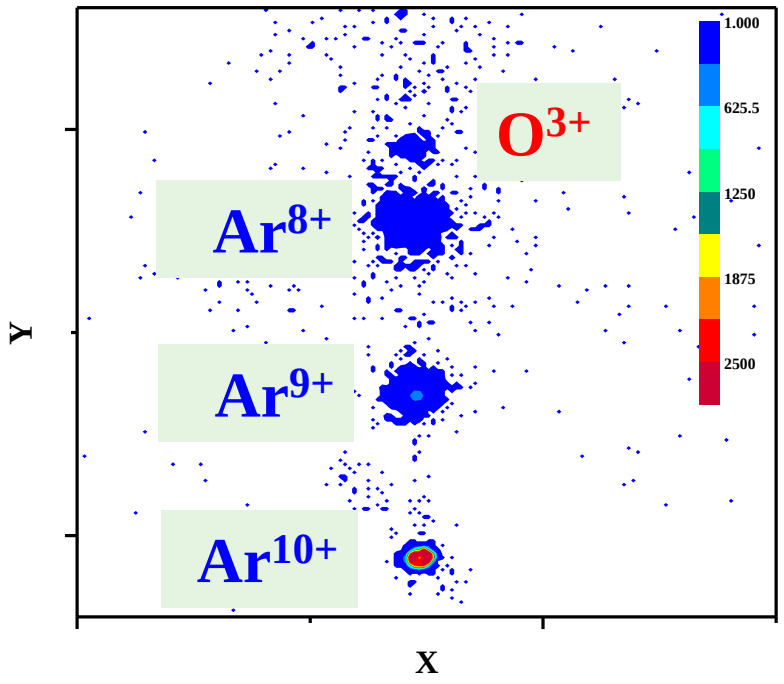
Cross section



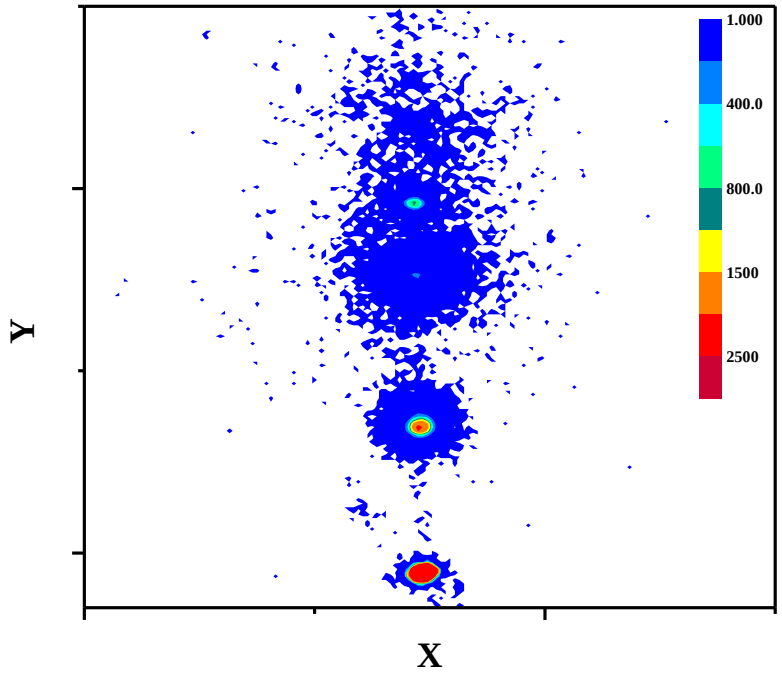
Cross section

150 keV Ar^{10+} — Ar

0.02 mTorr

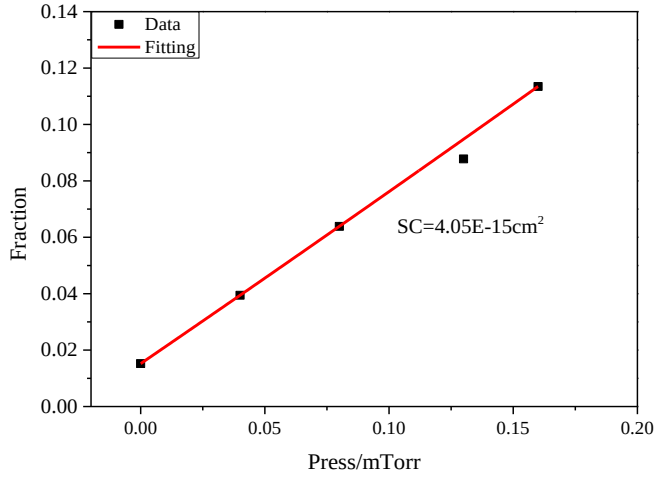


0.1 mTorr

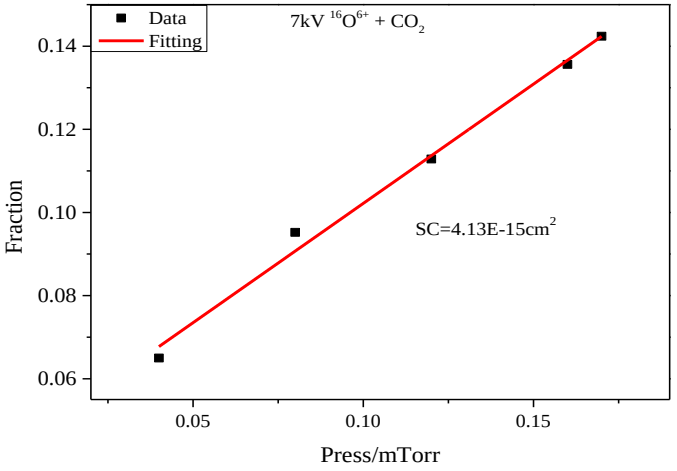


Cross section

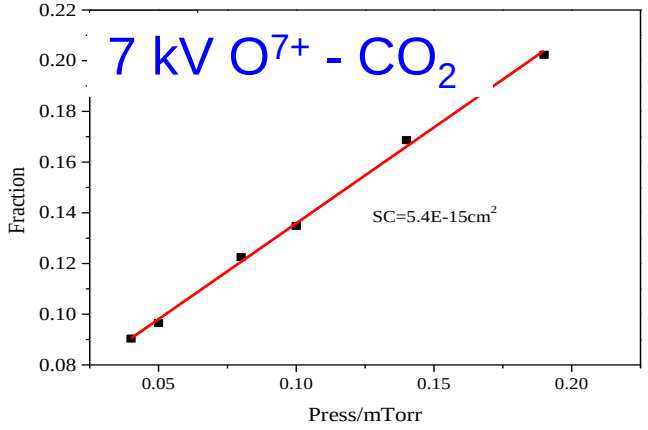
7 kV O^{5+} - CO_2

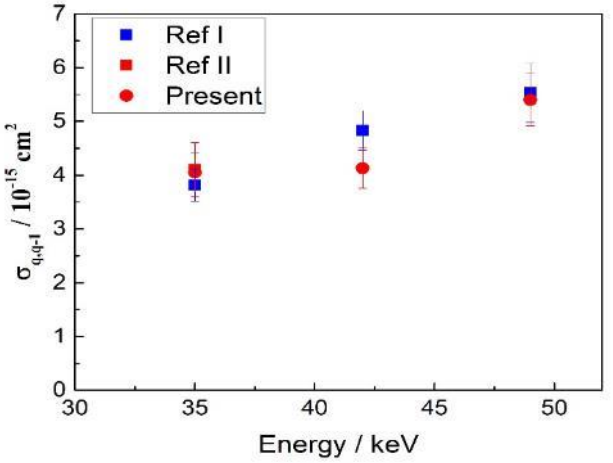


7 kV O^{6+} - CO_2



7 kV O^{7+} - CO_2



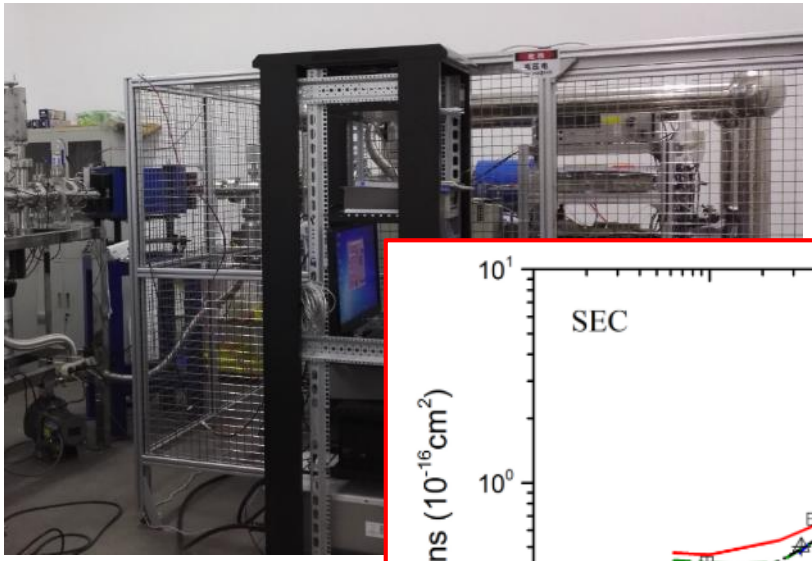


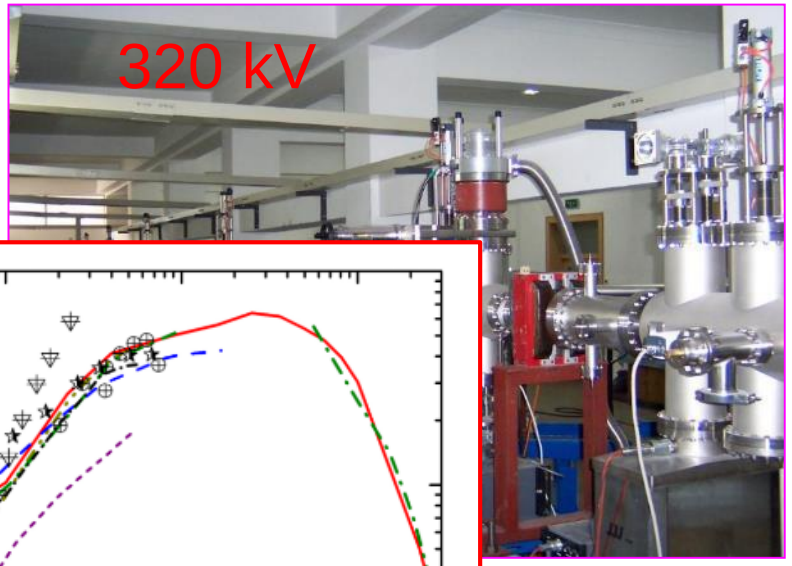
Ref I, PRA-75-032704, Ref II, PRA-63-062707

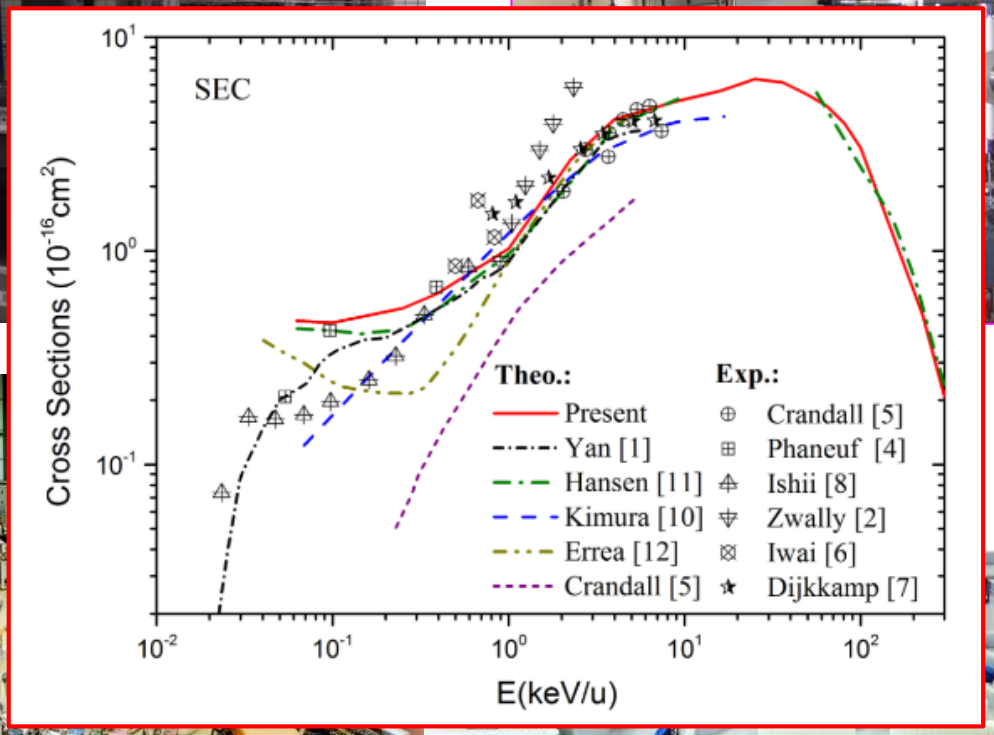
Cross section: Experimental uncertainties

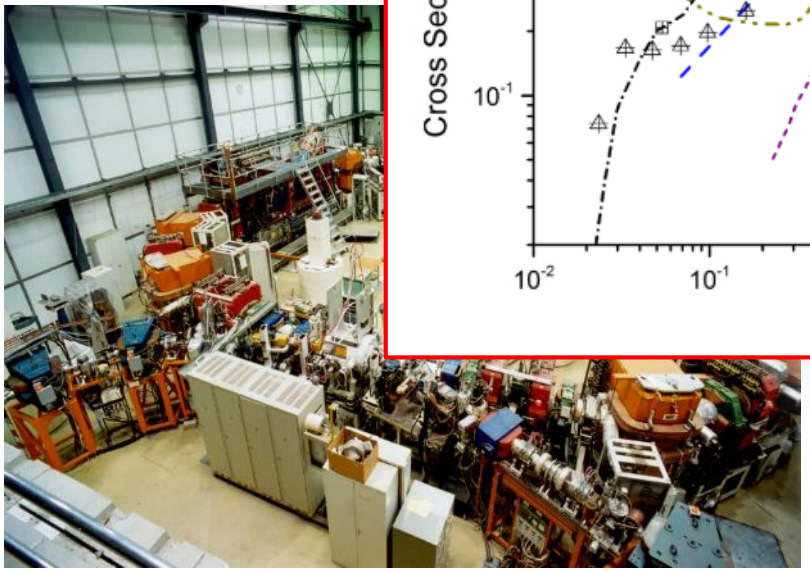
T	Cell temperature change	0.10%
P	Temperature different about guage and cell center	1%
	Accuracy of Capacitive manometer (MKS 627D) reading	0.25%
	Pressure attenuation causes systematic correction errors	2%
	Pressure fluctuation	3%
L	The efficient length of gas cell	3%
	Background particle (10^{-5}torr——10^{-7}torr)	2%
	Relative Detection efficiency of different Position	6%
n	Statistical errors	2%
	Total errors	9%

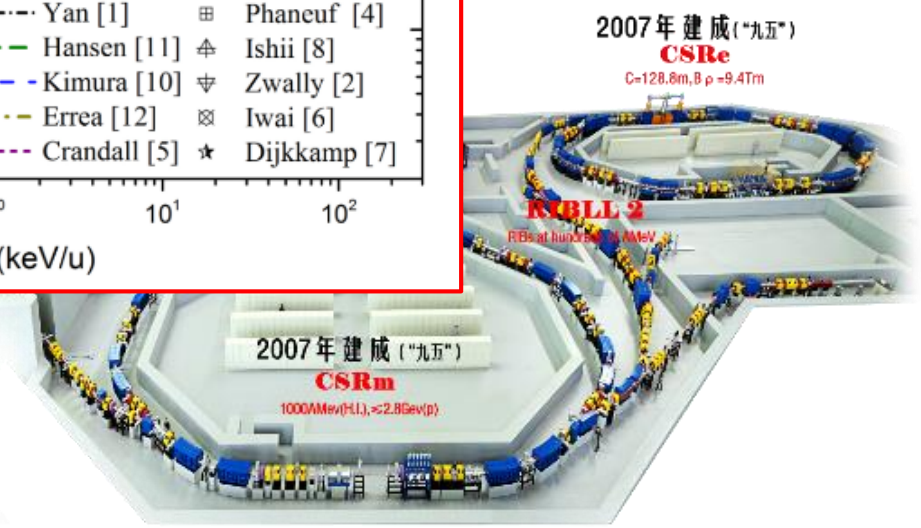
Cross section











Cross section

The absolute charge exchange cross section for HCI interaction with atom and molecule will be measured in an international collaboration.

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Thanks for your attention !