FRAGMENTATION OF SMALL CARBON CLUSTERS.

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IV- Conclusion

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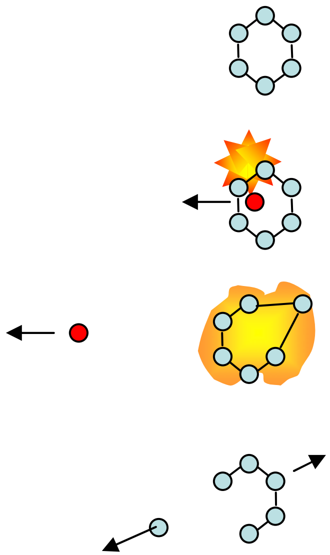
Physical situation and context.

High velocity (v>1 au) collision is used to prepare excited carbon clusters.



Time of collision ~ 10^{-16} s

Electronically excited clusters are created.
(Only electrons are concerned in high velocity collisions)

Coupling to ionic motion takes place in picosecond range.

Fragmentation is achieved after few ns.

- How electronically excited and (or) ionized carbon clusters fragment ?

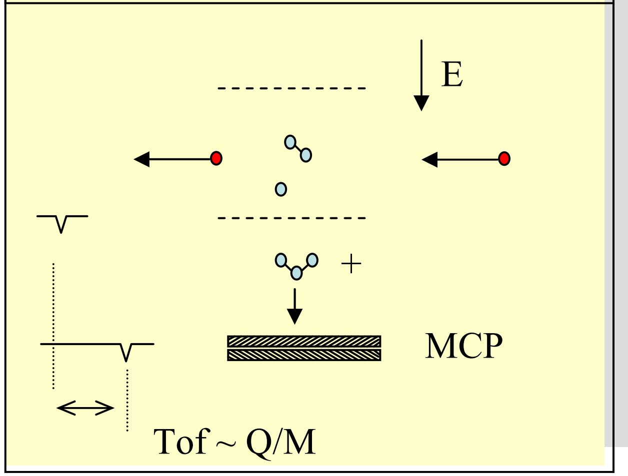
Interests:

- Quantum chemistry test.
- Thermodynamic of finite systems.
- Interstellar chemistry (CR and carbon Molecule).
- Combustion …

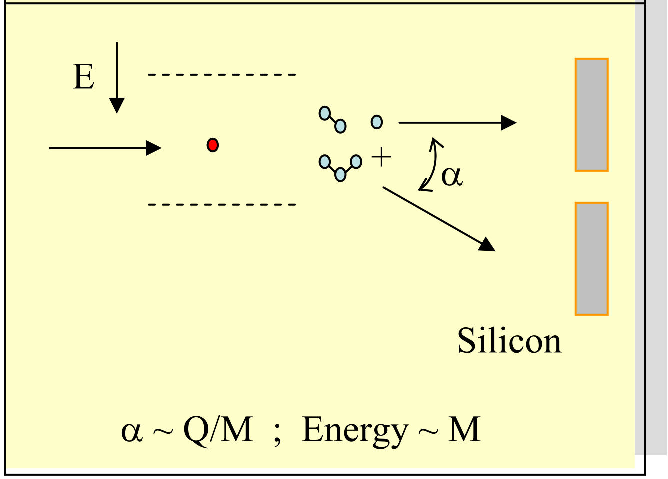
I- EXPERIMENT

Advantage of high velocity Inverse kinematics scheme.

" Direct " scheme experiment:



" Inverse " scheme experiment:



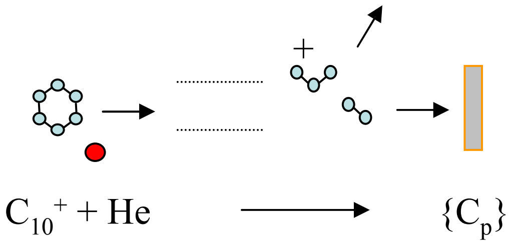
- Problems with multicharged fragments:

- No detection for neutral fragments

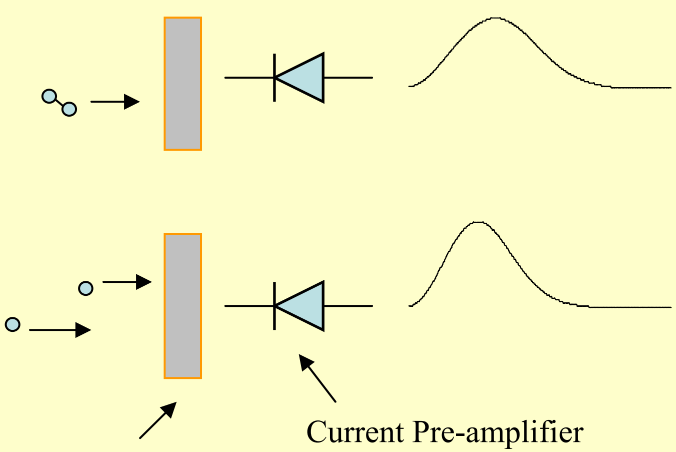
- identification in Charge and Mass.

- Neutral detection

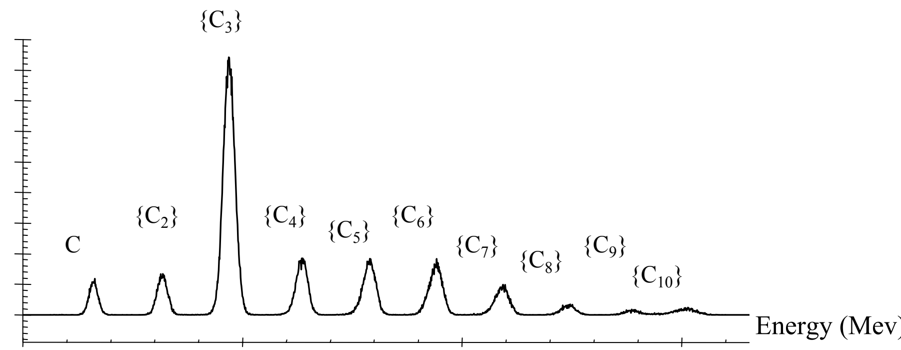
Detection with silicon.

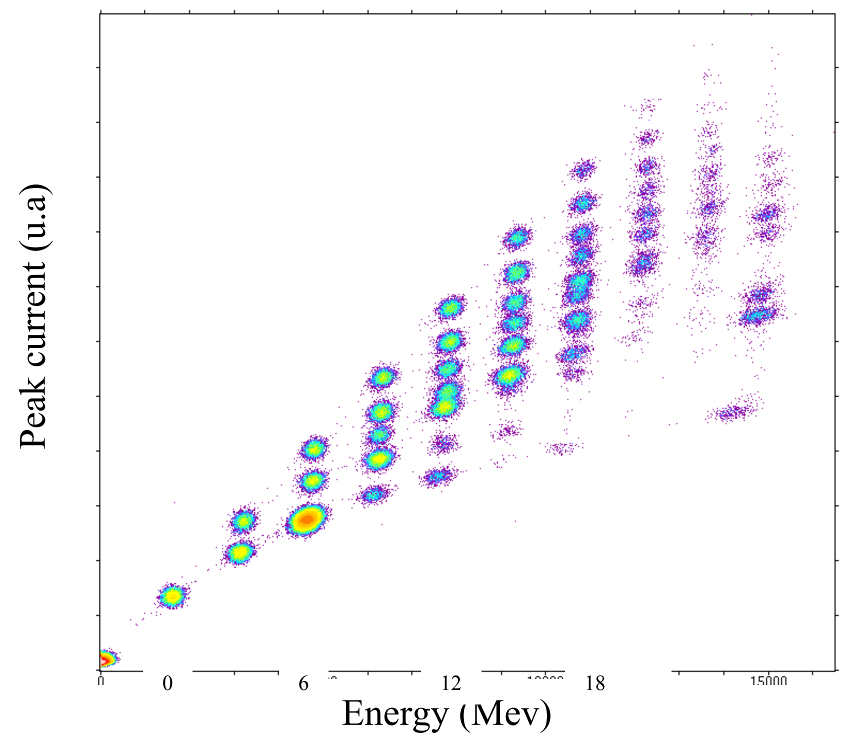


Shape analysis. *M.Chabot et al NIMB(2002)*

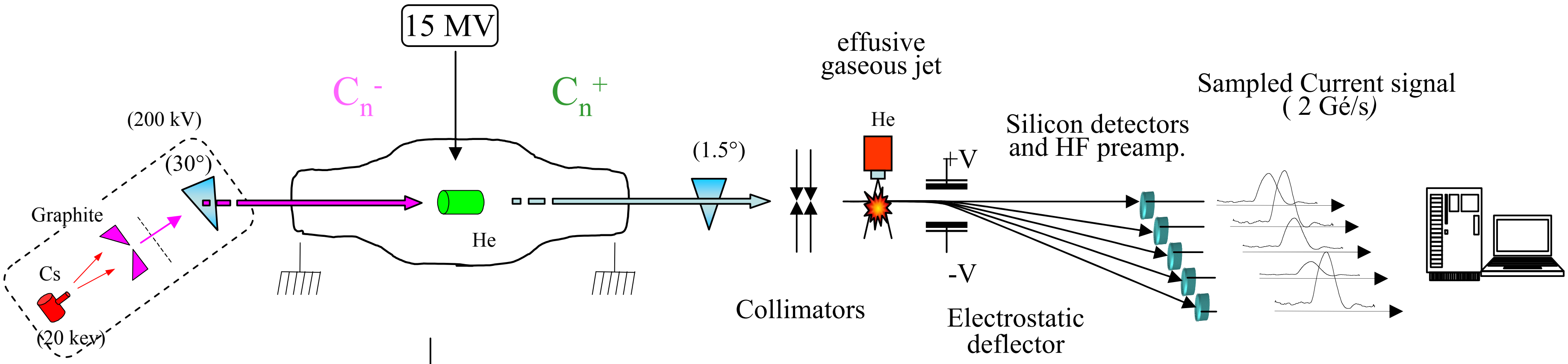


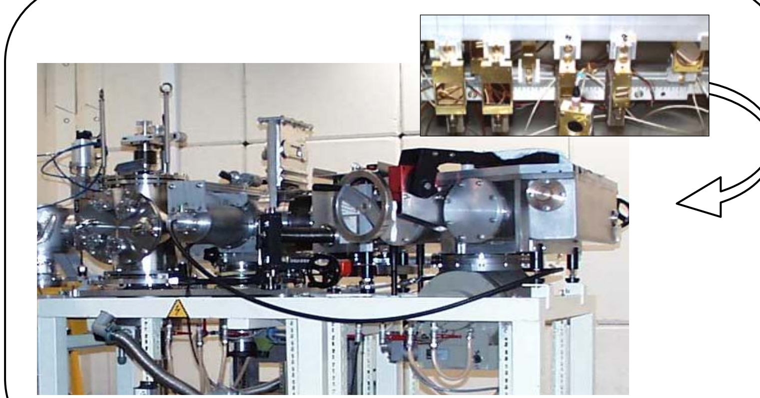
Epitaxial silicon (low defect)
High resistivity (low electric field)





AGAT@Tandem


15 MV
C_n^-
C_n^+
(200 kV)
(30°)
Graphite
Cs
(20 kev)
He
(1.5°)
effusive
gaseous jet
He
Collimators
+V
-V
Electrostatic
deflector
Silicon detectors
and HF preamp.
Sampled Current signal
(2 Gé/s)

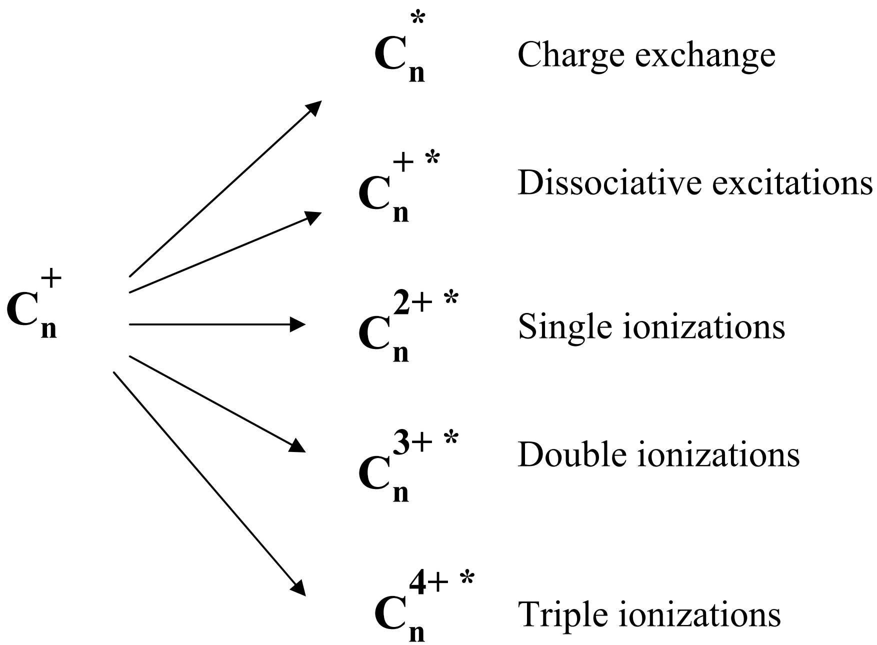


II- RESULTS

Results overview

C_n^+ @166kev/uma (n=1 to 10) + He

For a given process, leading to a fixed charge state, absolute production rates of all partitions of fragmentation are recorded.

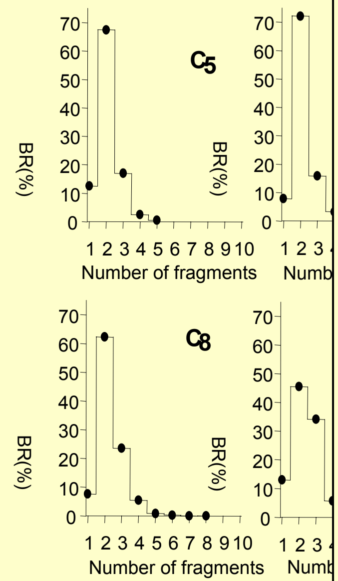


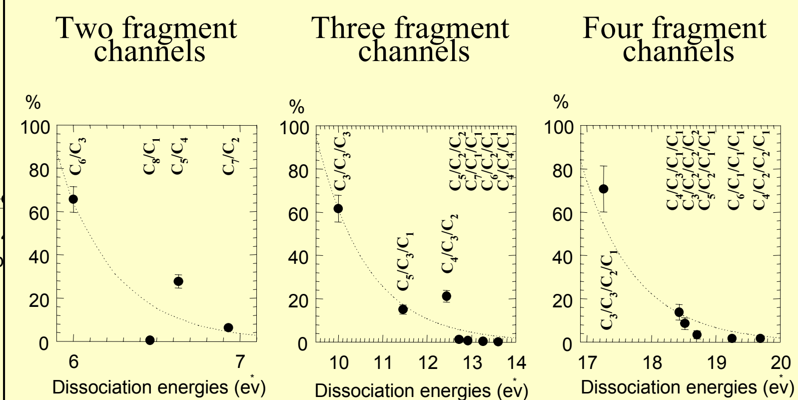
Specie	Number of partitions	Number of observed partitions (inside statistic)
C_{10}	42	31
C_{10}^{+}	96	90
C_{10}^{2+}	159	118
C_{10}^{3+}	169	117
C_{10}^{4+}	145	90

Fragmentation following Charge exchange

C$_9$ case.

In number | Inside a given number of fragment:



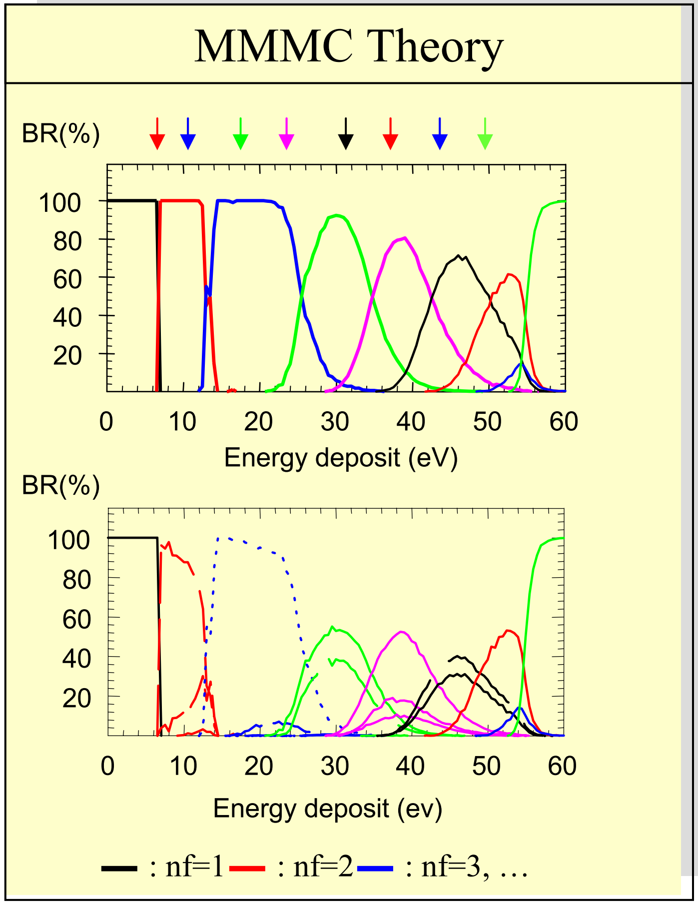


- Line are to guide eye

*(CCSD) S.Tendero et al ??? 2005

- No strong evolution of the number of fragments distribution with the cluster mass.
- Strong correlation with energy formation.
- Odd-even fluctuation.
- C_3 energetically favoured.

Statistical description of carbon cluster fragmentation.



- At fixed energy, the population of an observable is proportional to the size of the phase space. This phase space is defined by all the accessible microscopic states.

-Entropy is responsible of the shape of breakdown curves

- Branching Ratio writes:

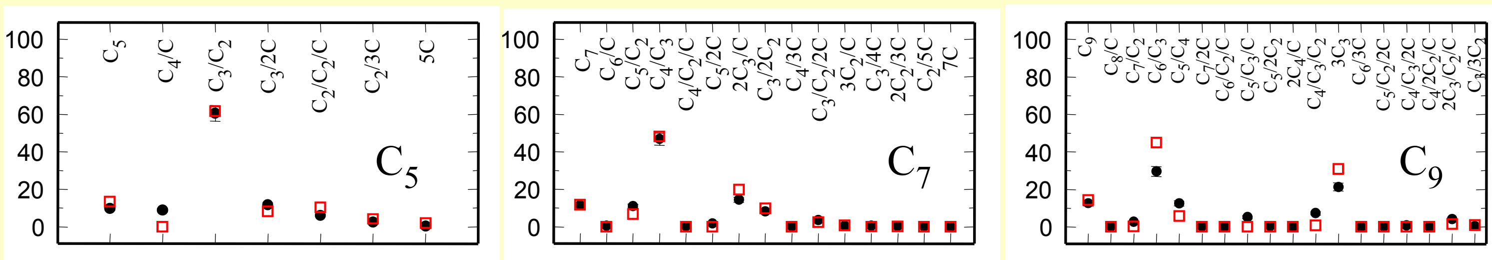
$$BR_{obs.} = \int P_{obs.}^{MMMC}(E) \times D(E)dE$$

S.Tendero et al PRA 2005

Energy deposit by Charge exchange

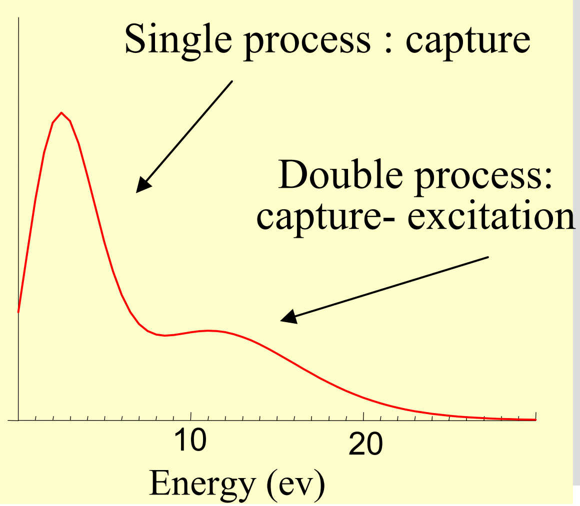
MMMC Theory Test.

G. Martinet et al PRL 2004



- MMMC is close to the experiment. (still some work on minority channel has to be done).

Energy deposit by charge exchange.

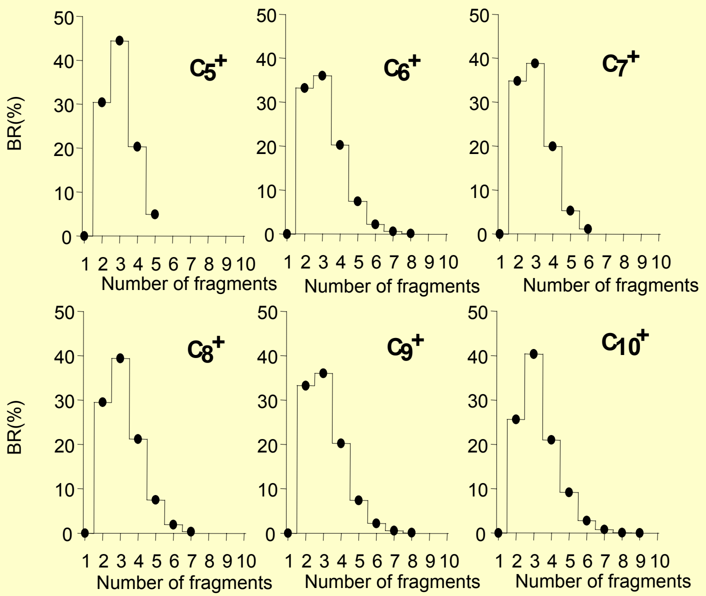


- A single Energy distribution is able to reproduce all experimental BR for the three cluster sizes.

- The second component of the “experimental” energy distribution matches calculation of Capture – Excitation (IAE model).

Fragmentation following Excitation.

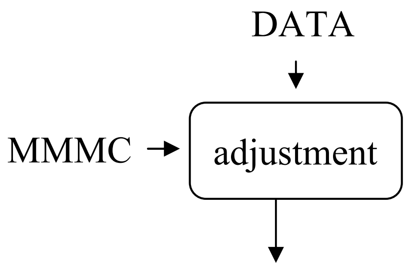
In number of fragment:



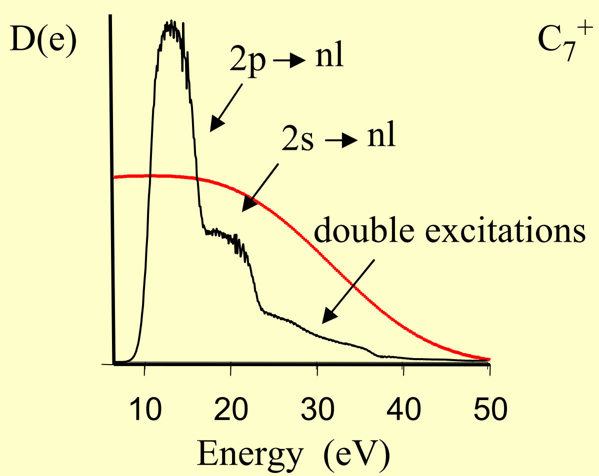
- Only dissociative excitation is measured.

- Distributions peak around 3 fragments dissociation. (it was two for charge exchange).

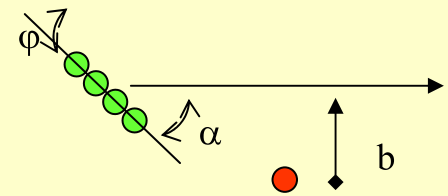
Energy deposit by Excitation.



De



Model of Independent Atom and Electron :
(give good results on absolute cross sections)



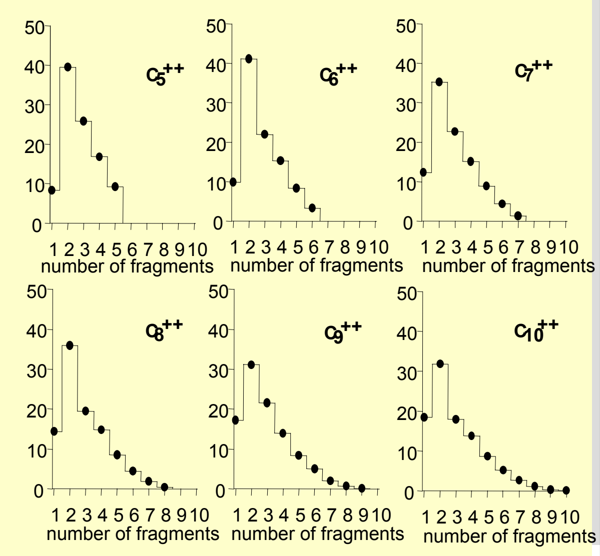
Classical P (E,b) for Carbon Atom (CTMC)

- As much as 40 eV can be deposited by excitation.

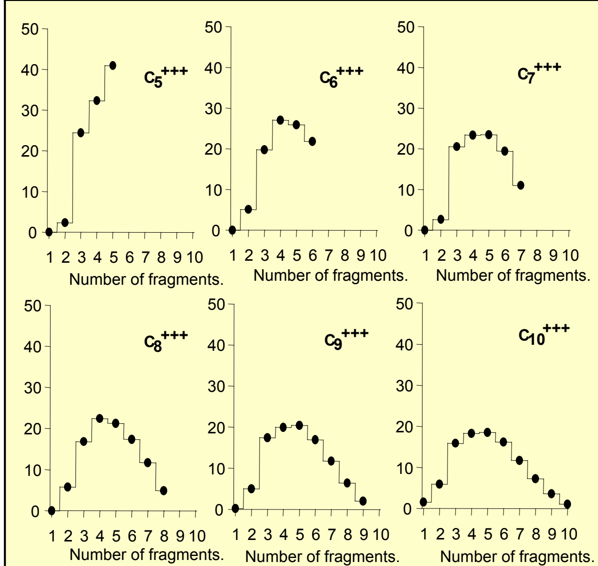
- Band widths of excited states in C_7^+ are reflected in the energy deposit.

Fragmentation following ionizations

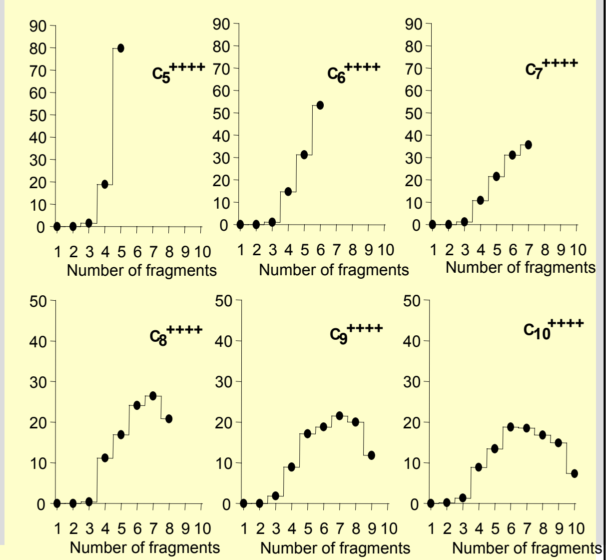
Single ionization (C_n^{2+})



Double ionization (C_n^{3+})



Triple ionization (C_n^{4+})



- Shapes of distributions are independent of the cluster size.

- Number of intact cluster increases with the cluster size.

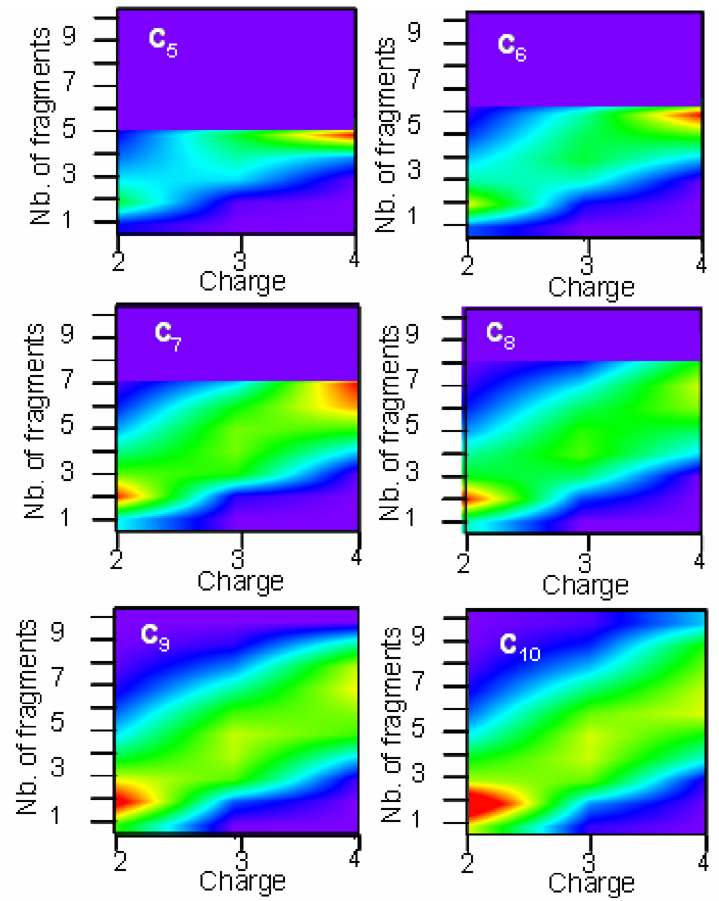
- Shapes of distribution are identical only for big clusters.

- For small clusters vaporization is the main output channel.

- Intact triply charged clusters are observed (C_{10}).

fragmentation following ionizations

Number of fragments as a function of the cluster charge state



False color : probability

- For 1 charge added 3 fragments are produced.

- $C_n^{q+} \rightarrow C_m^{(q-1)+} + C_p^{+}$: 1 fragment by charge state.

- Ionizations can occurs on π or σ electrons: Ionized clusters are thus electronically excited and extra fragmentation with respect to coulomb repulsion is observed.

Conclusions

- High energy Inverse scheme experiments .

- New technique of shape analysis of current signals from silicon detectors.

- Measurement of all partitions of fragmentation.

- Fragmentation looks statistics.

- MMMC theory is OK for neutral and singly charged clusters.

- For some minor channels MMMC fails.

- The fragmentation of multicharged clusters is qualitatively understood.

- Experiments on C_xH_y fragmentation in connection with astronomic observations are in progress.