SECONDARY EMISSION MECHANISMS INDUCED BY MEV GOLD NANOPARTICLES.

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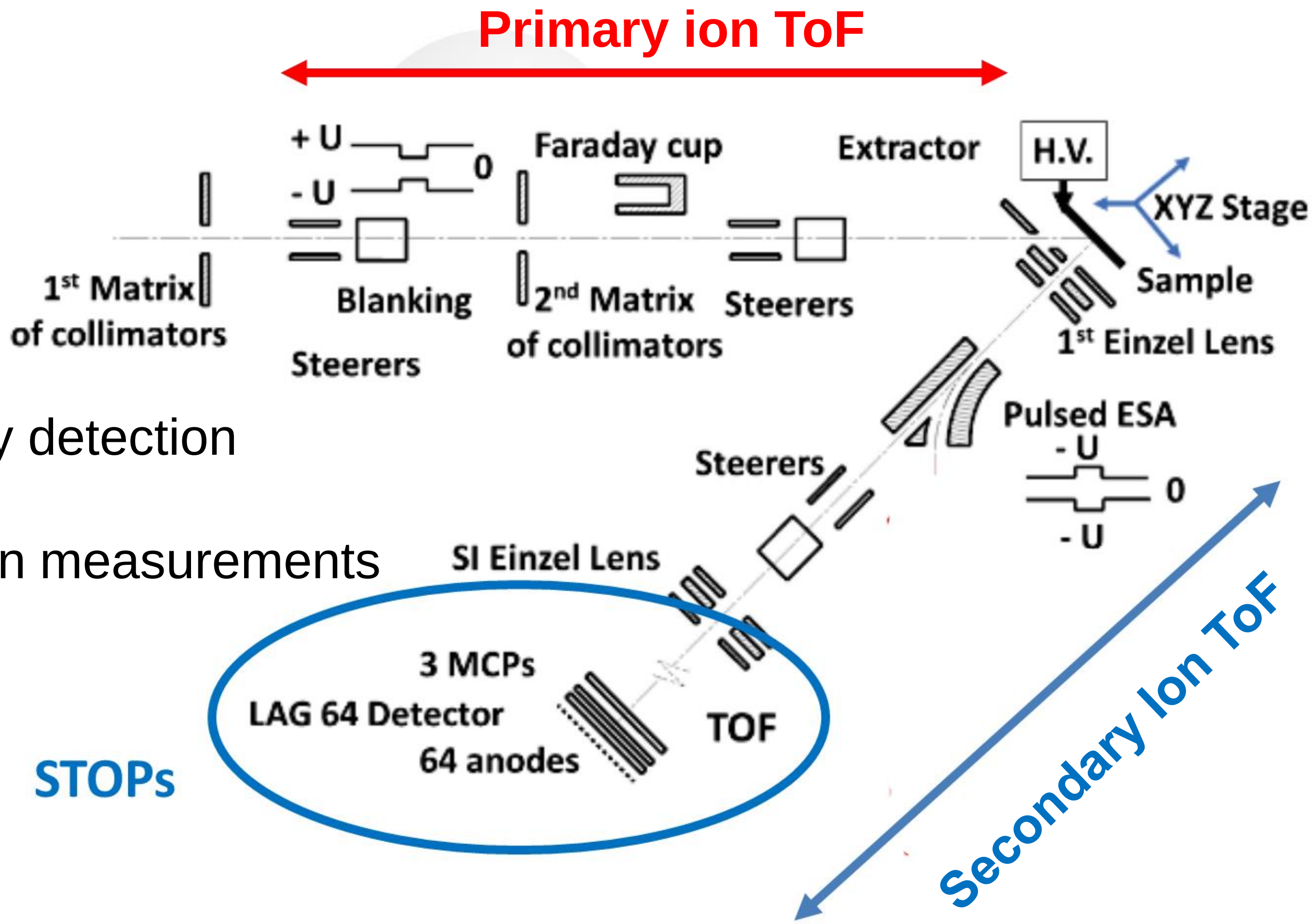
OUTLINE

Presentation of the EVE mass spectrometer
Secondary ion Yields (Recall)
Measurement of **angular distributions**
Negative and positive molecul... ...s
Influence of mol...
Heavy" m... ...daltons, positive-negative
Comparison ... emission from a gold substrate
Final state of ... **...crater shapes**
Concl...

Fundamental studies AND Instrumentation Detection/Focalisation
several hundreds secondary ions emitted per impact !



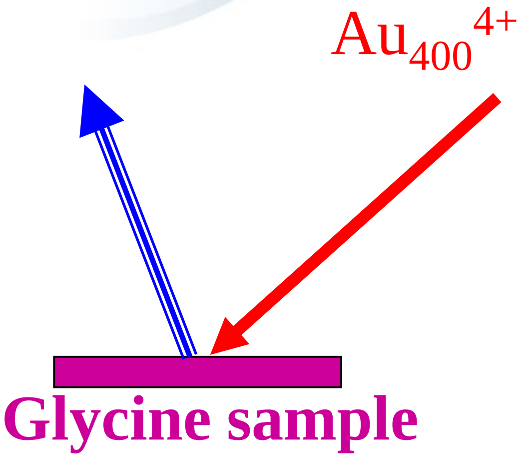
High ion Multiplicity detection

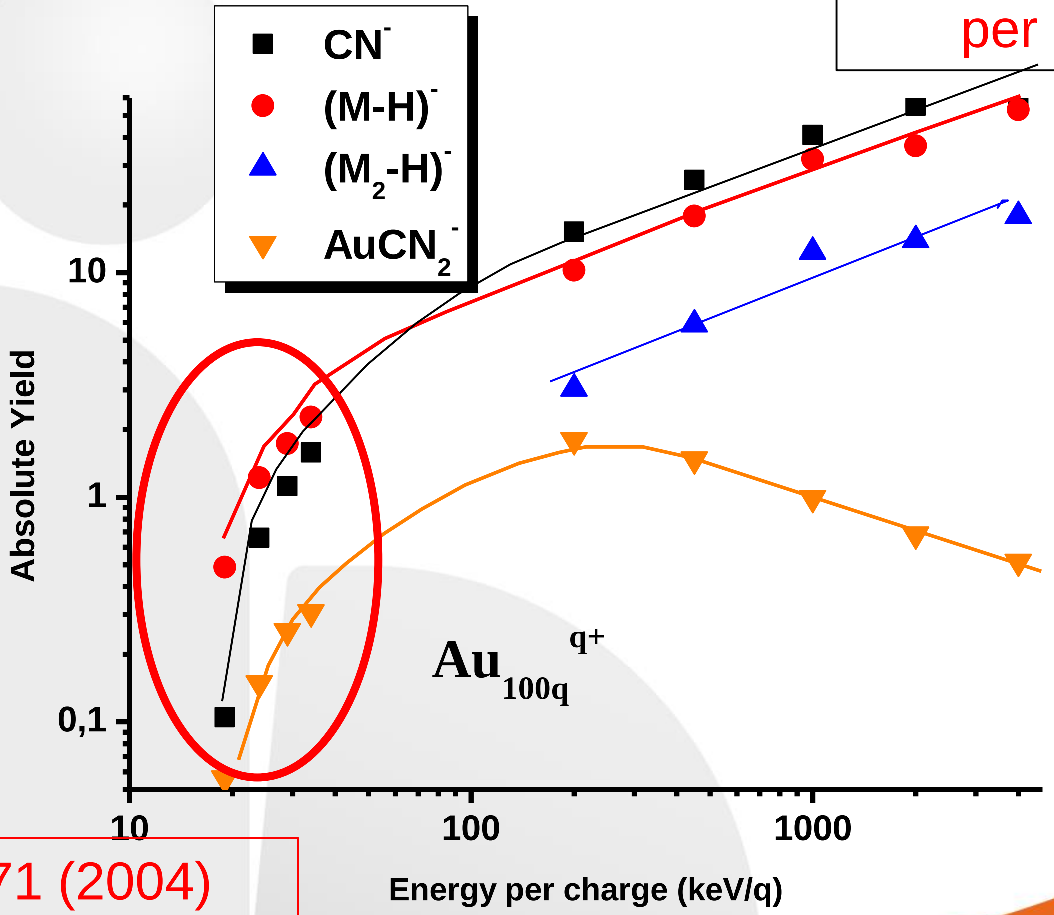
&

Angular Distribution measurements

Influence of the projectile energy (velocity)

50 intact molecules
per Impact

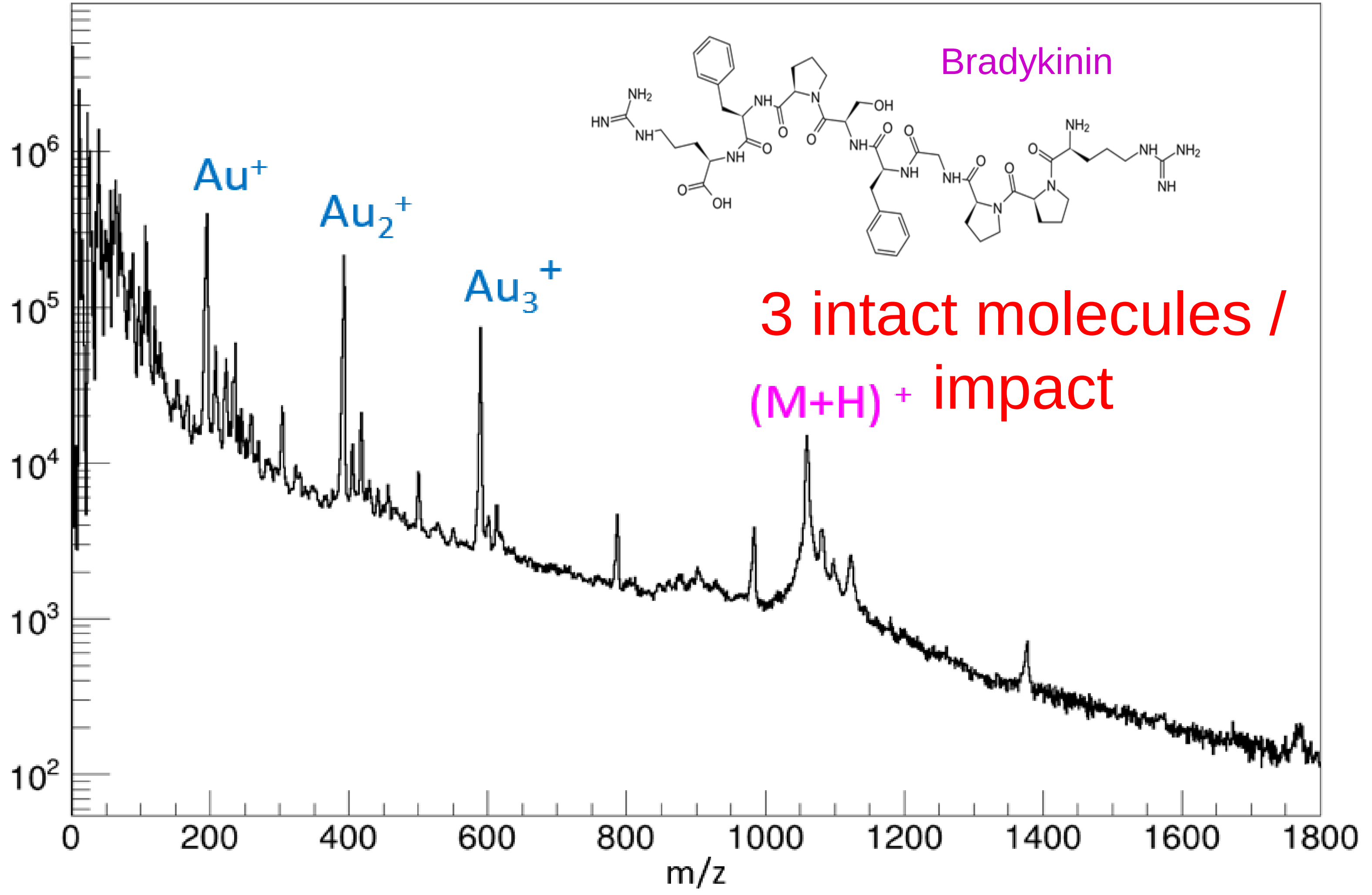




Increase of the S.I. Yield
Factor 50 /Au_3
The degree of fragmentation decreases

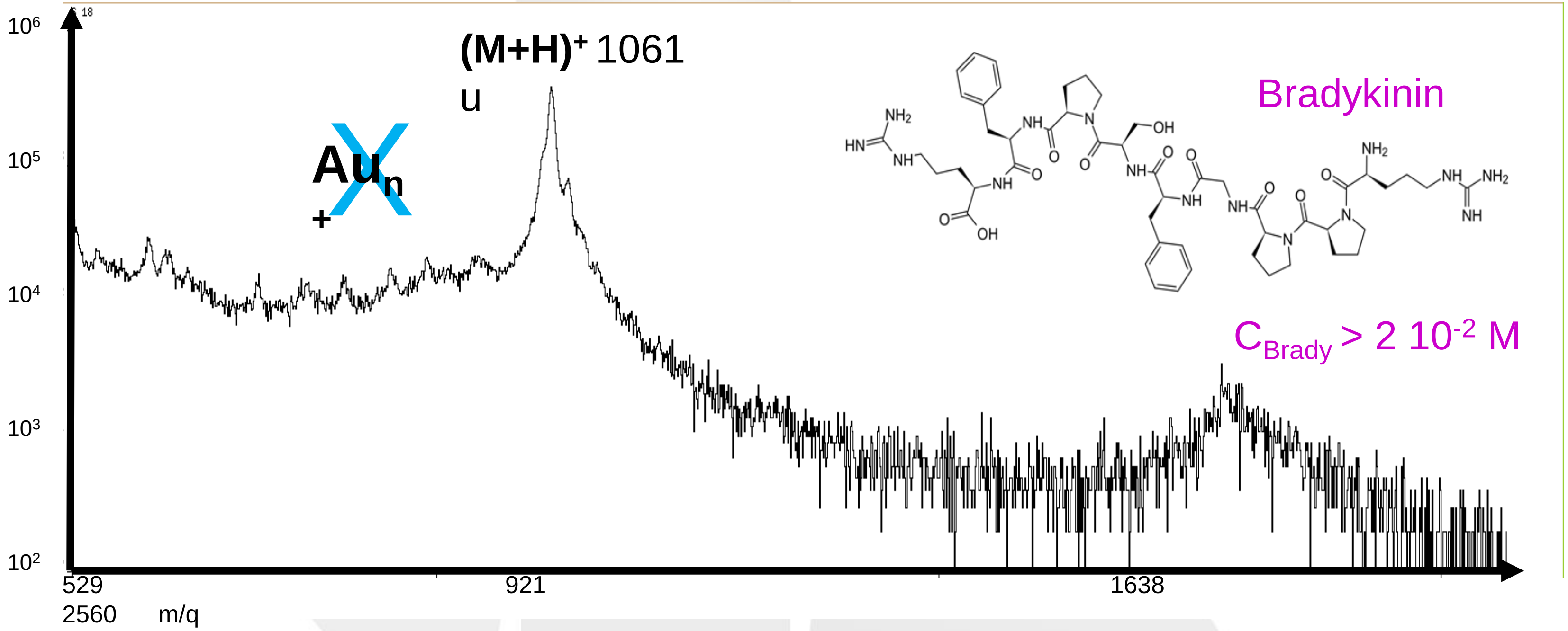
Rapid Comm. Mass Spectrom., 18, 371 (2004)

Secondary Ion yields



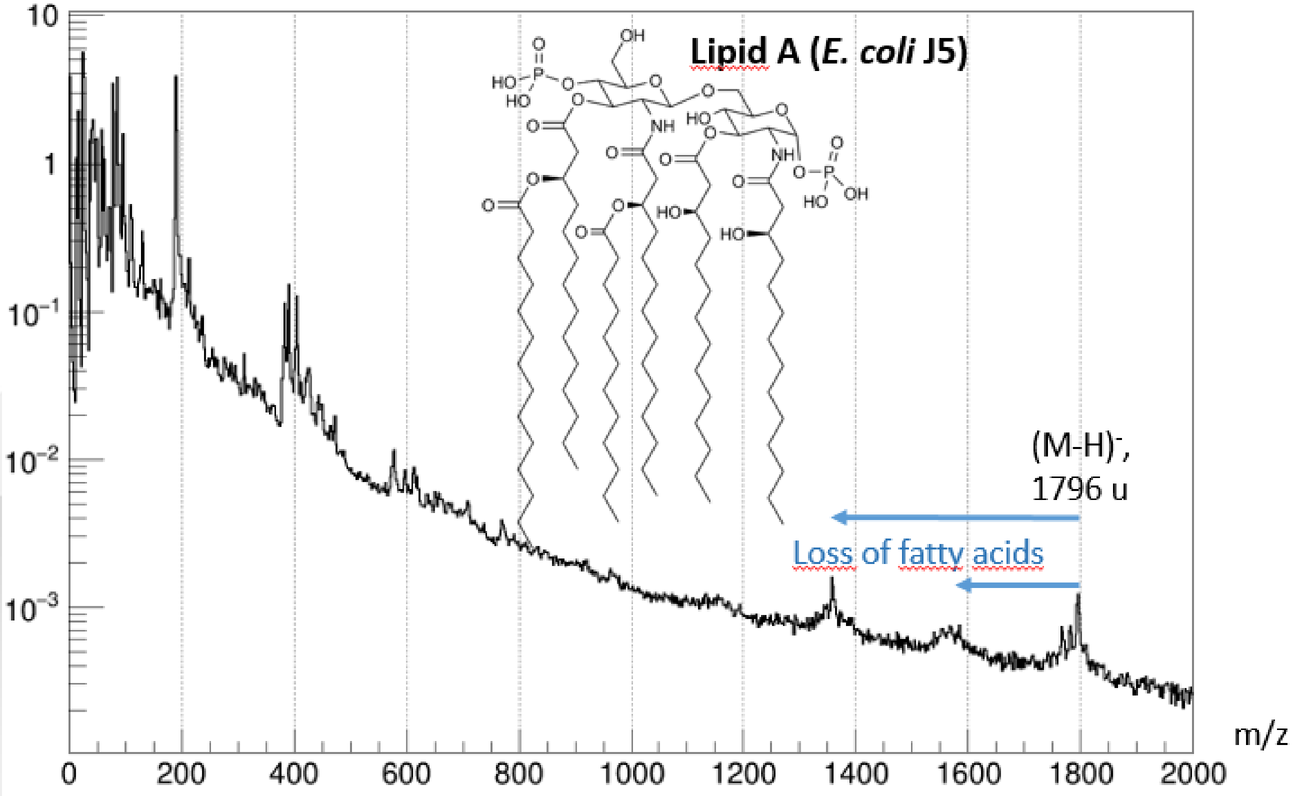
Thick deposit

5 intact molecules /impact



Au_{400}^{4+} 12 MeV : Emission efficiency 1000 times higher than commercial probes

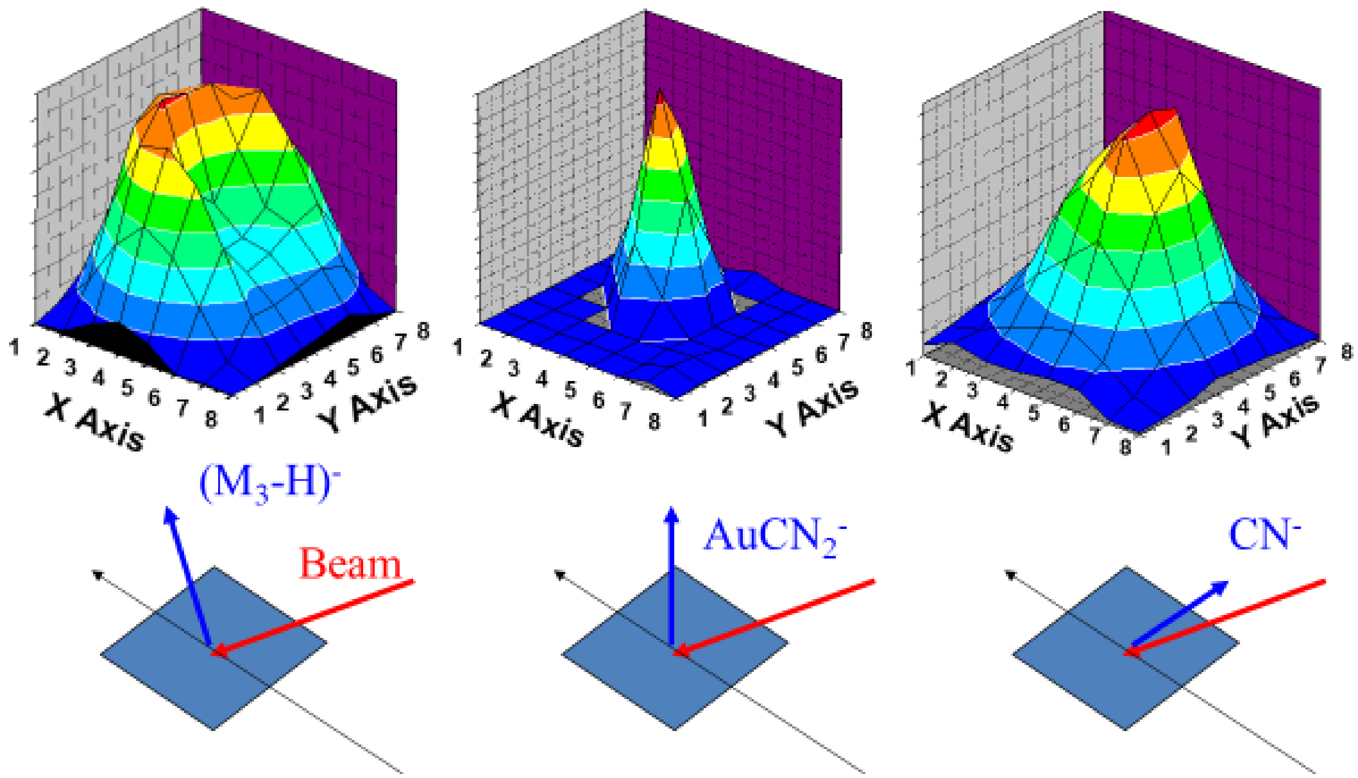
Feasibility study

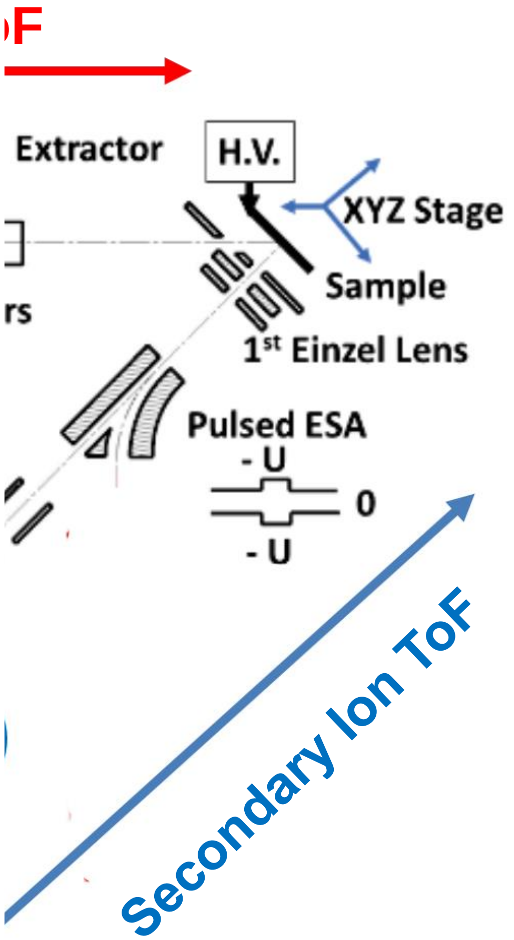


Equipe : Endotoxines, Structures et Réponses de l'hôte

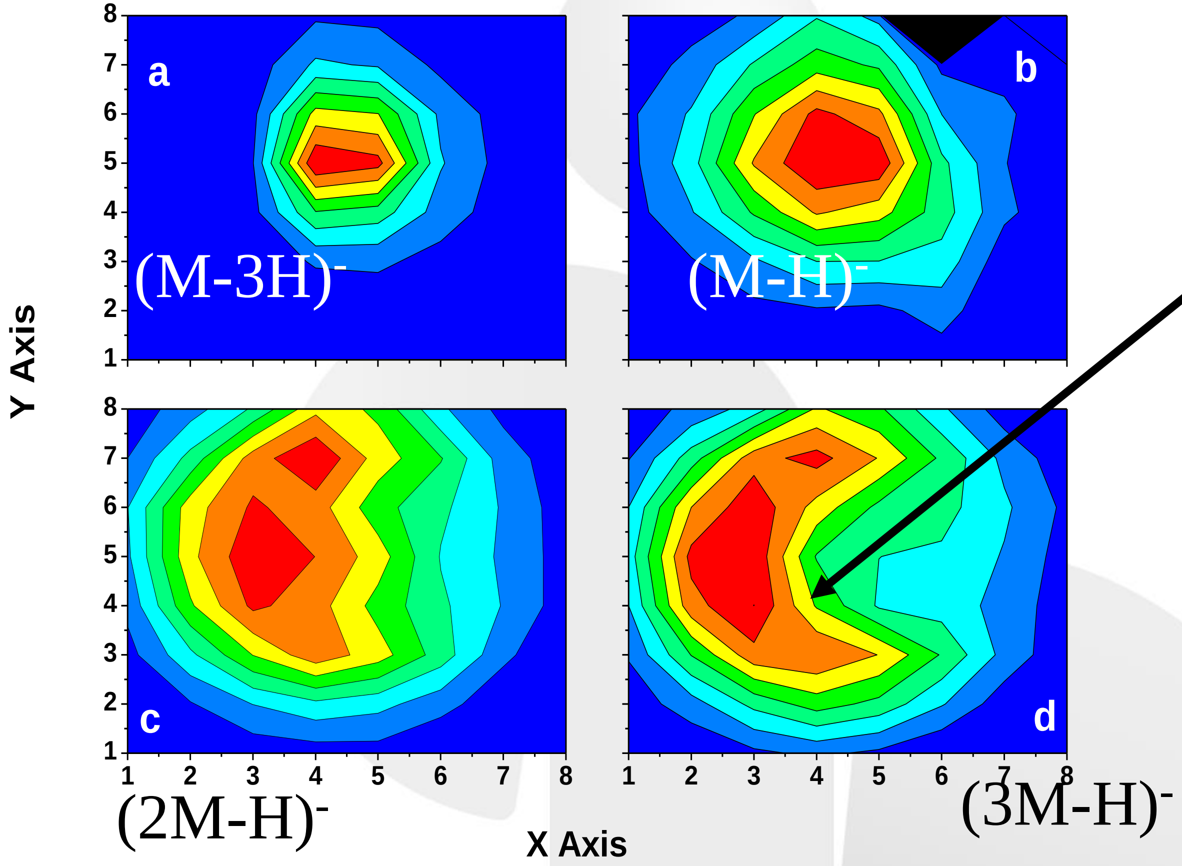
Emission yield : Y (lipid A) ~ 30%

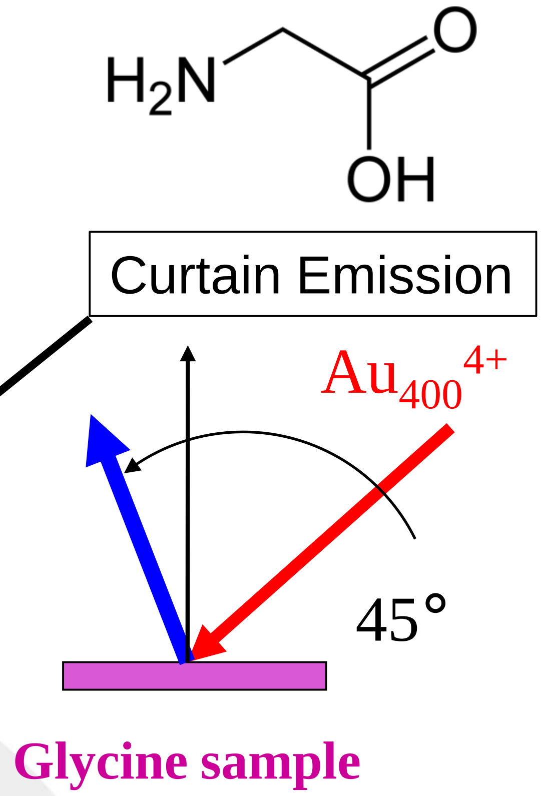
Glycine sample





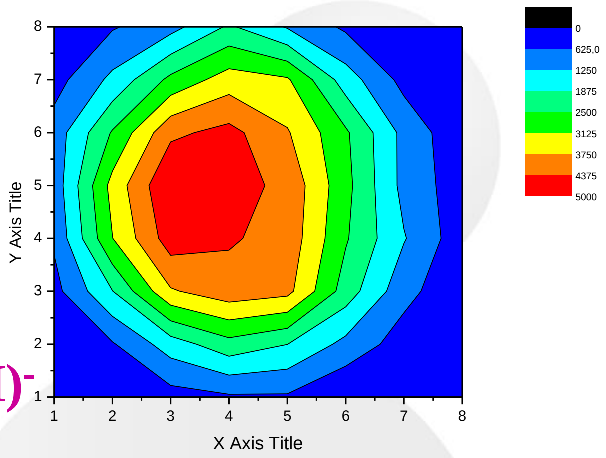
Negative molecular ions

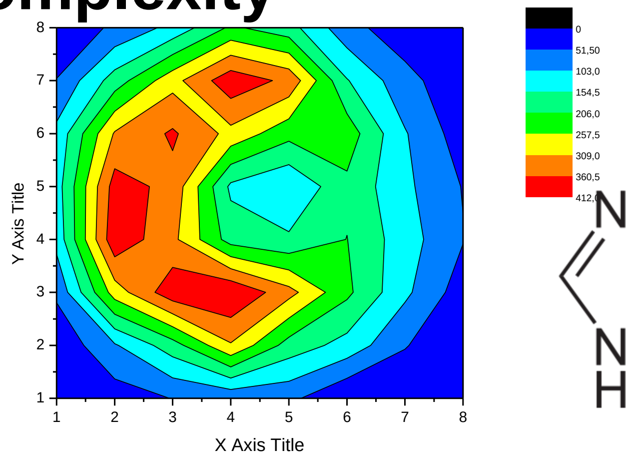


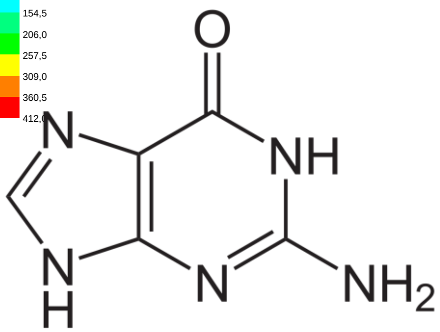


Influence of the complexity

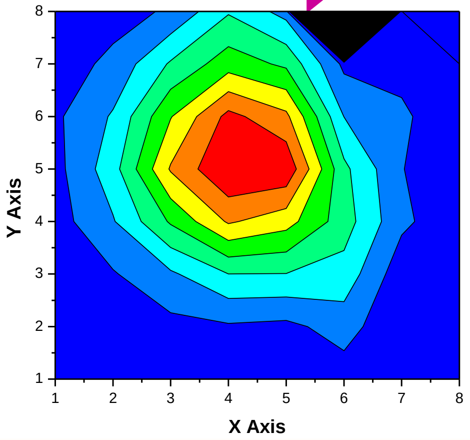
Guanine MW = 151 u
(M-H)$^-$ and (2M-H)$^-$

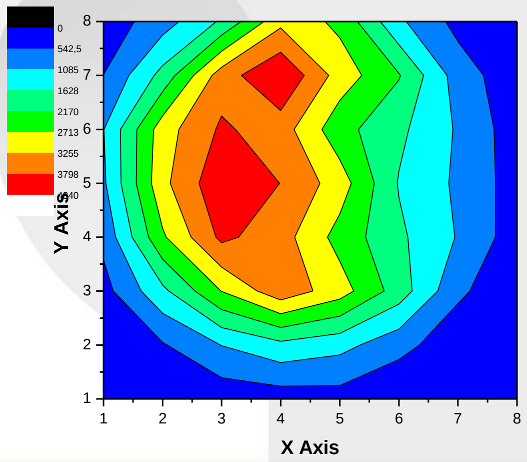


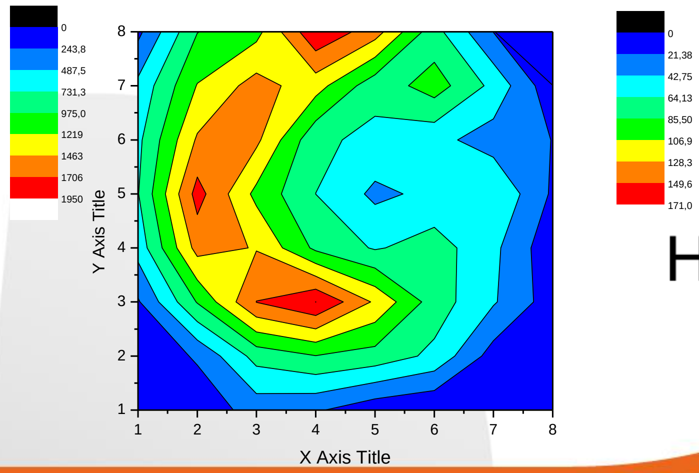


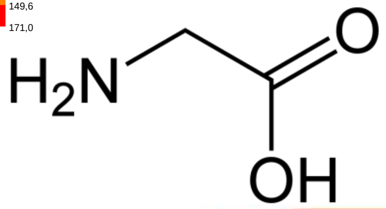


Glycine MW = 75 u
(M-H)$^-$, (2M-H)$^-$ & (4M-H)$^-$



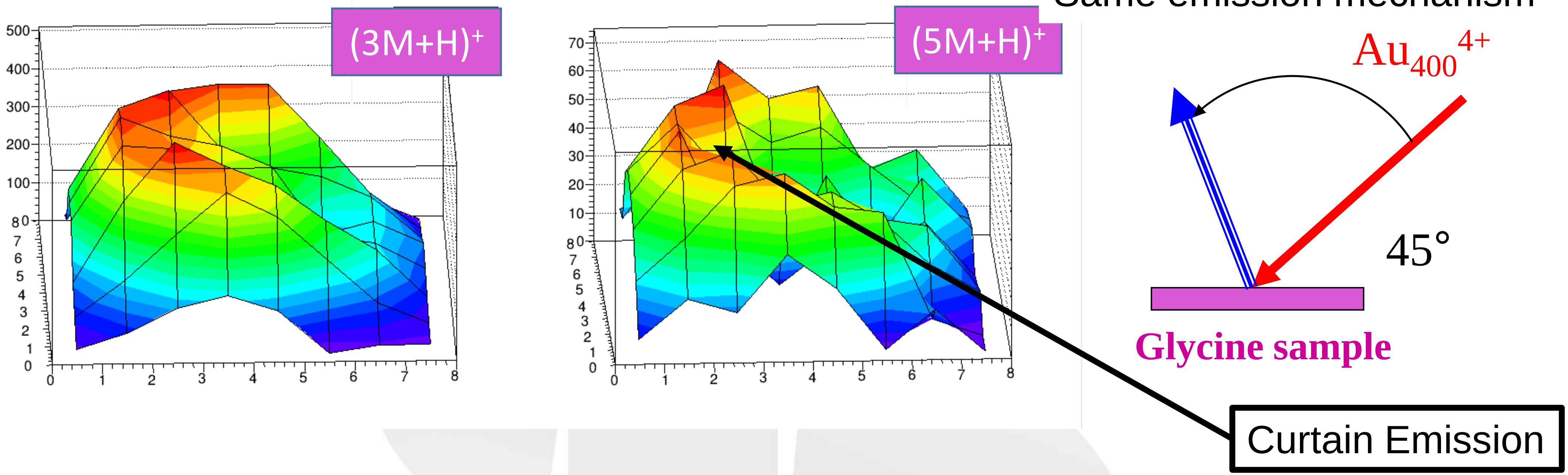




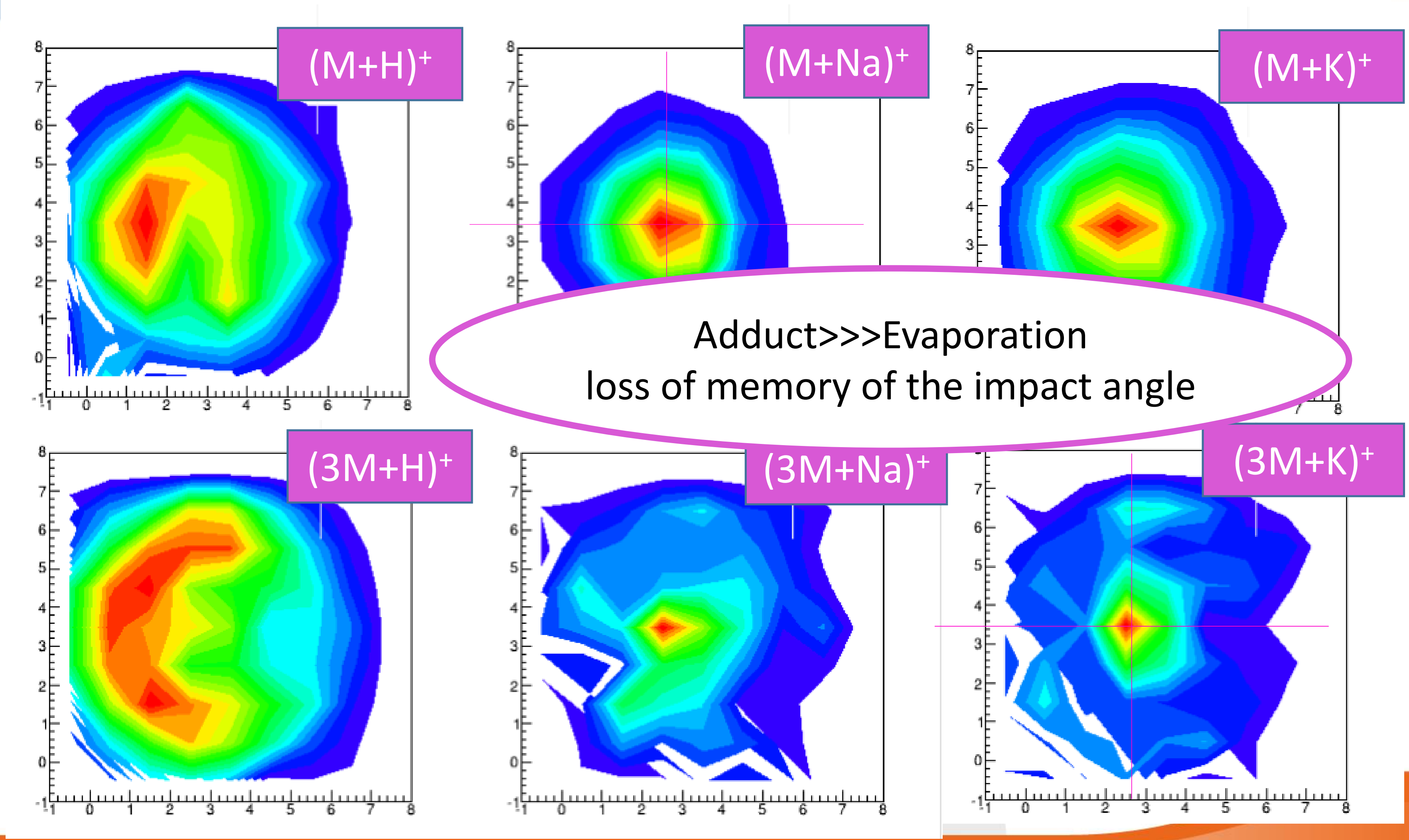


Positive molecular ions

$(nM+H)^+$ and $(nM-H)^-$
Same emission mechanism

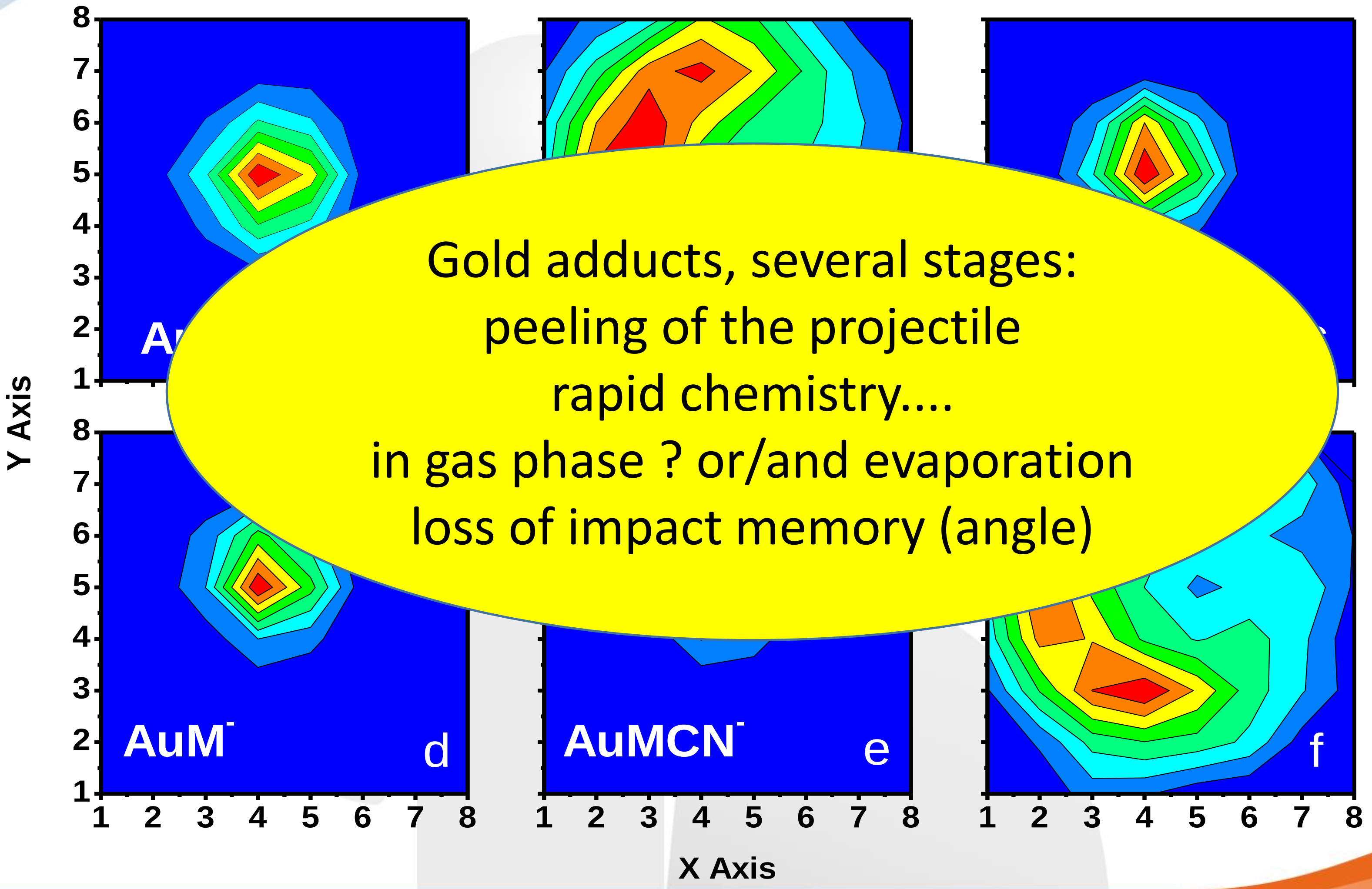


Adducts

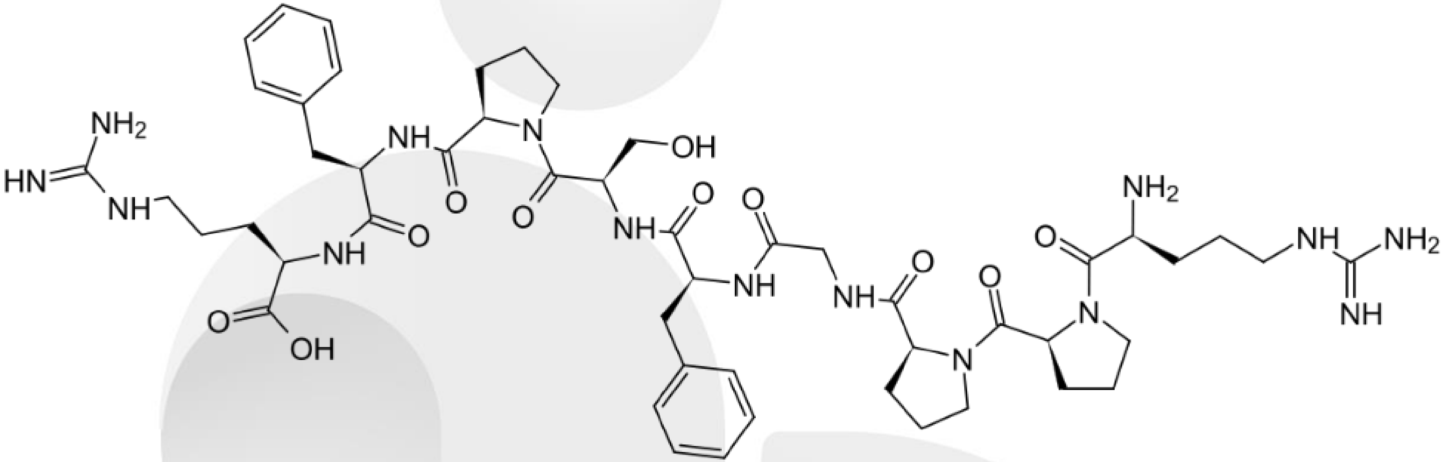


(M+H)⁺
(M+Na)⁺
(M+K)⁺
(3M+H)⁺
(3M+Na)⁺
(3M+K)⁺
Adduct>>>Evaporation
loss of memory of the impact angle

Gold Adducts

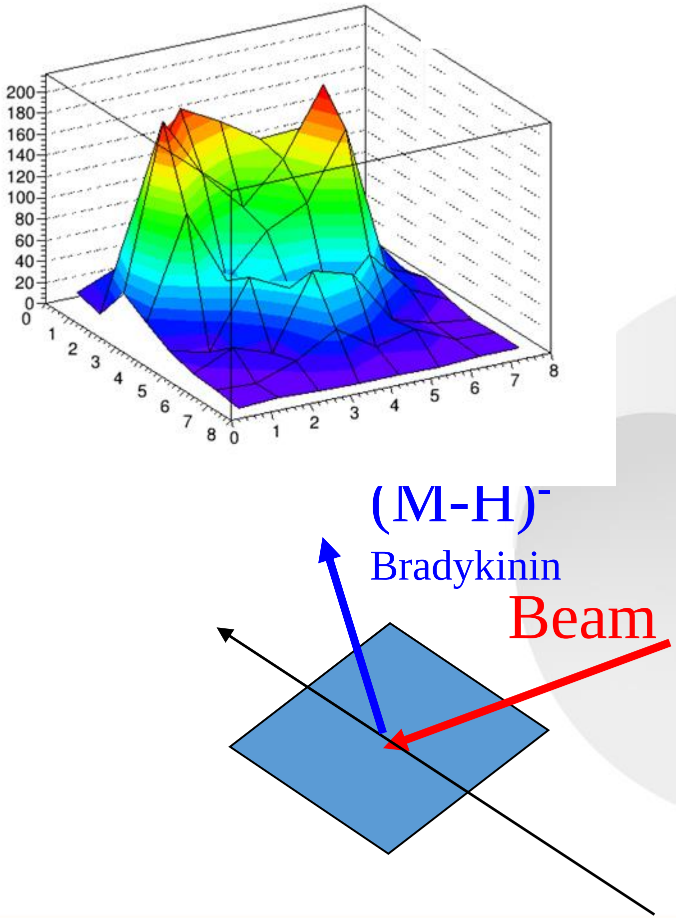


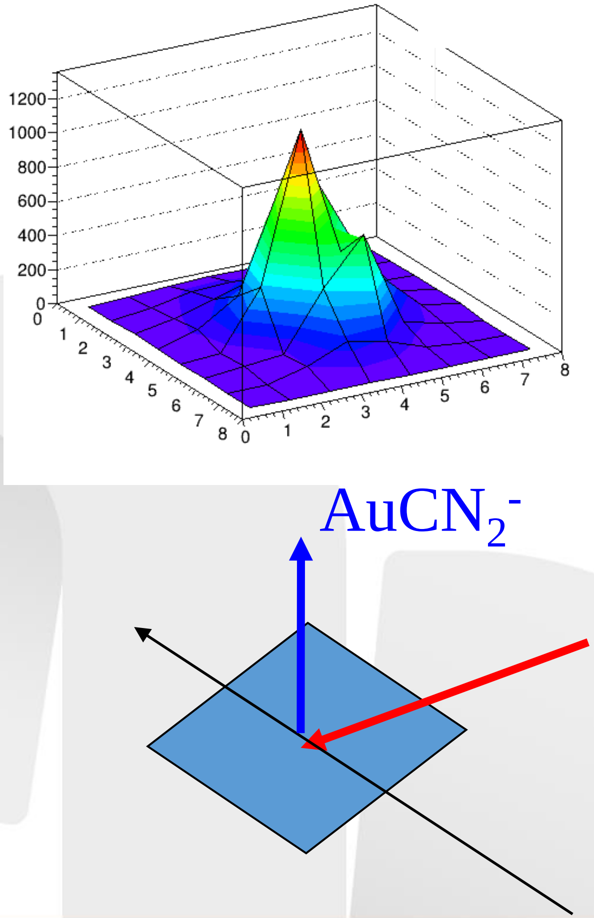
Influence of the molecular weight (complexity)

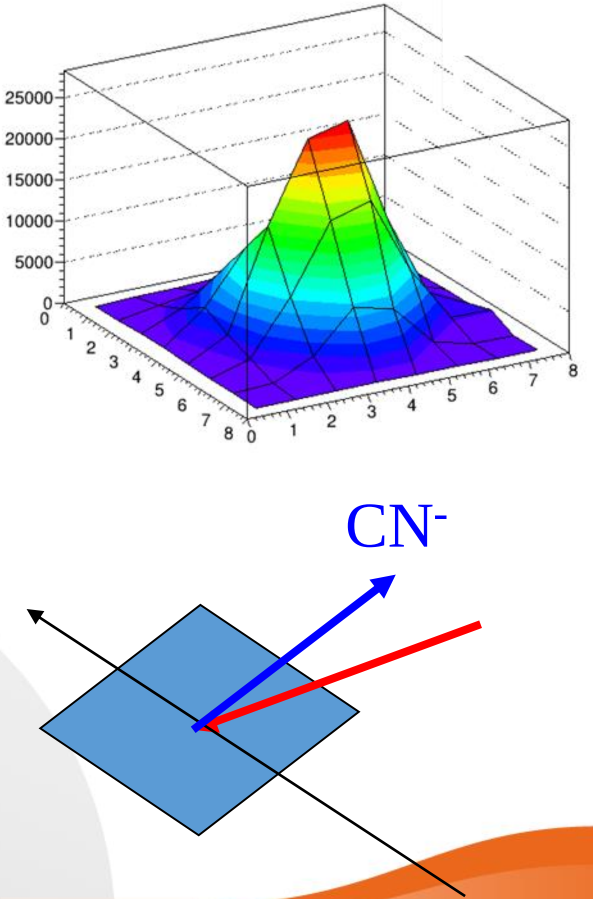


Bradykinin, MW = 1061 Daltons

Influence of the molecular weight (complexity)



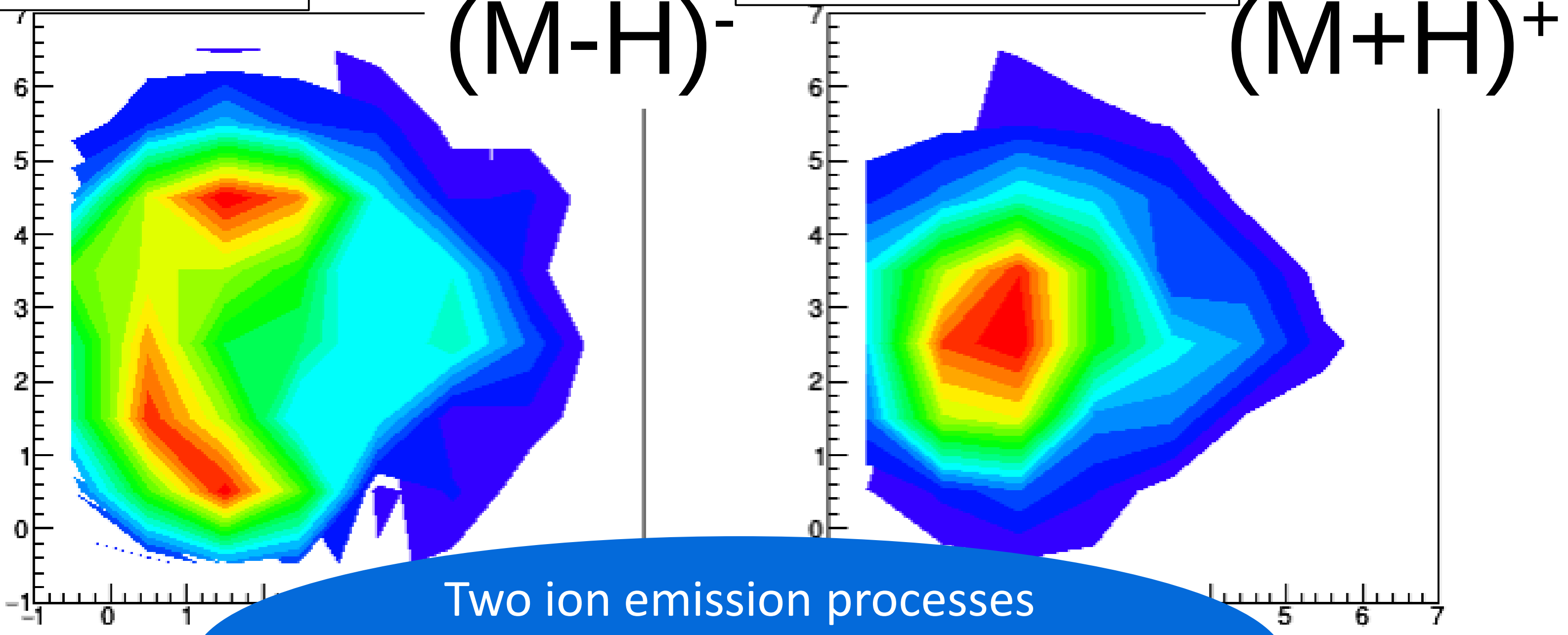




Influence of the molecular weight (complexity) And ionisation processes

Curtain emission

Emission lobe



Two ion emission processes

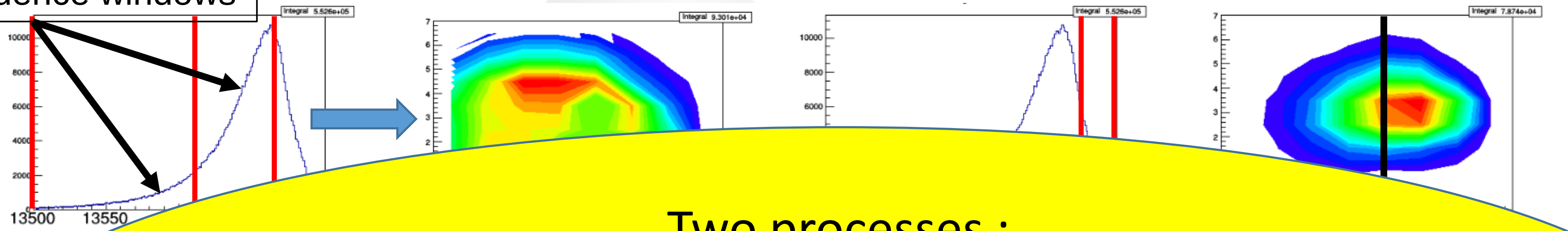
$(M-H)^- \neq (M+H)^+$

Ionisation or stability ?

Gold nanoparticles on gold surface

Two coincidence windows

Au^-



Au_3^-

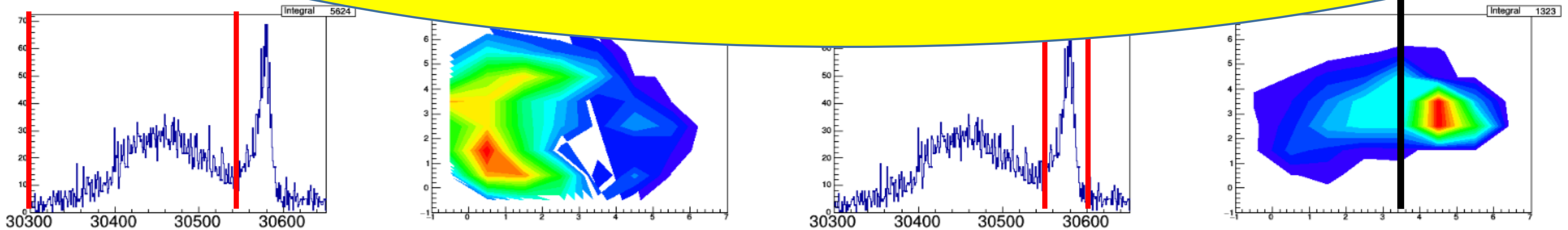
23500

Two processes :

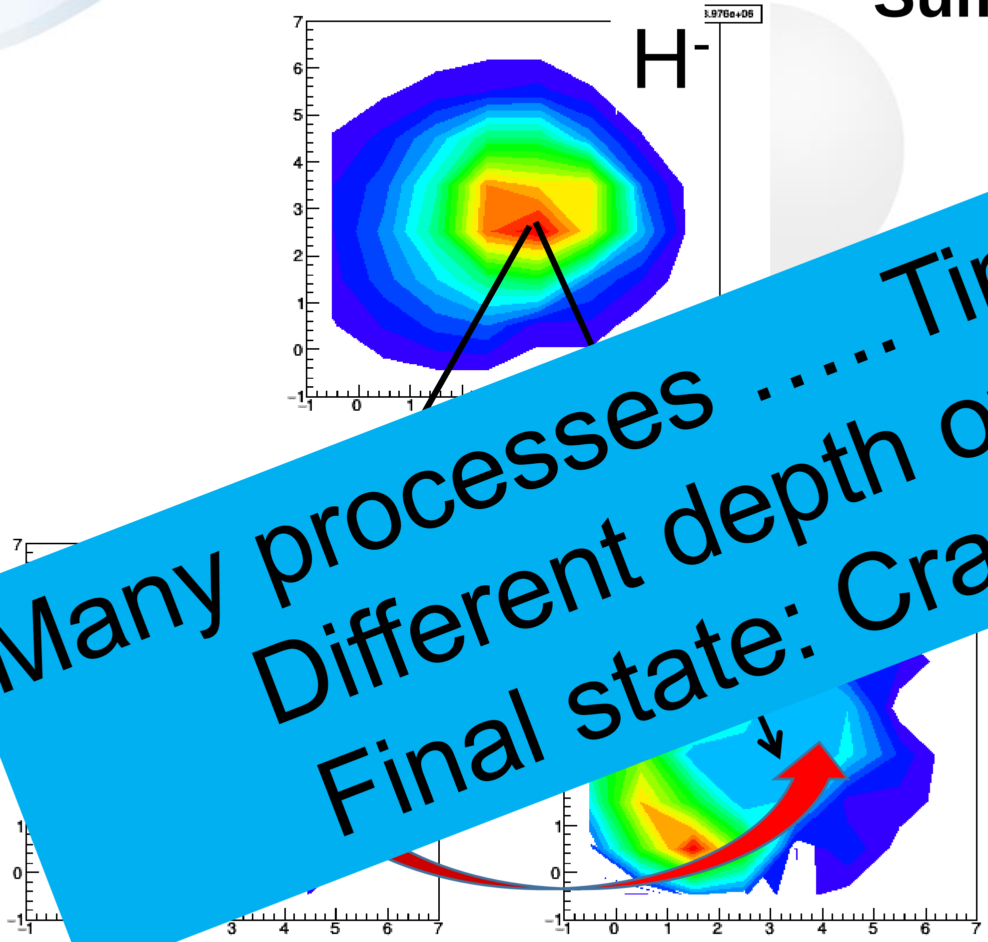
1- Curtain emission with high axial velocity but
Similar radial velocity ? Sound velocity Shockwave ?

2- rebound in the projectile direction

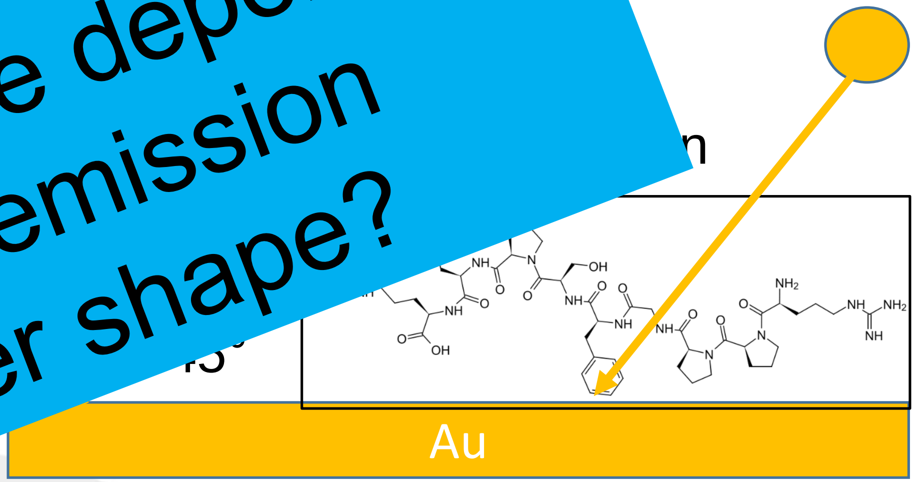
Au_5^-



Summary



Many processes …..Time dependent
Different depth of emission
Final state: Crater shape?

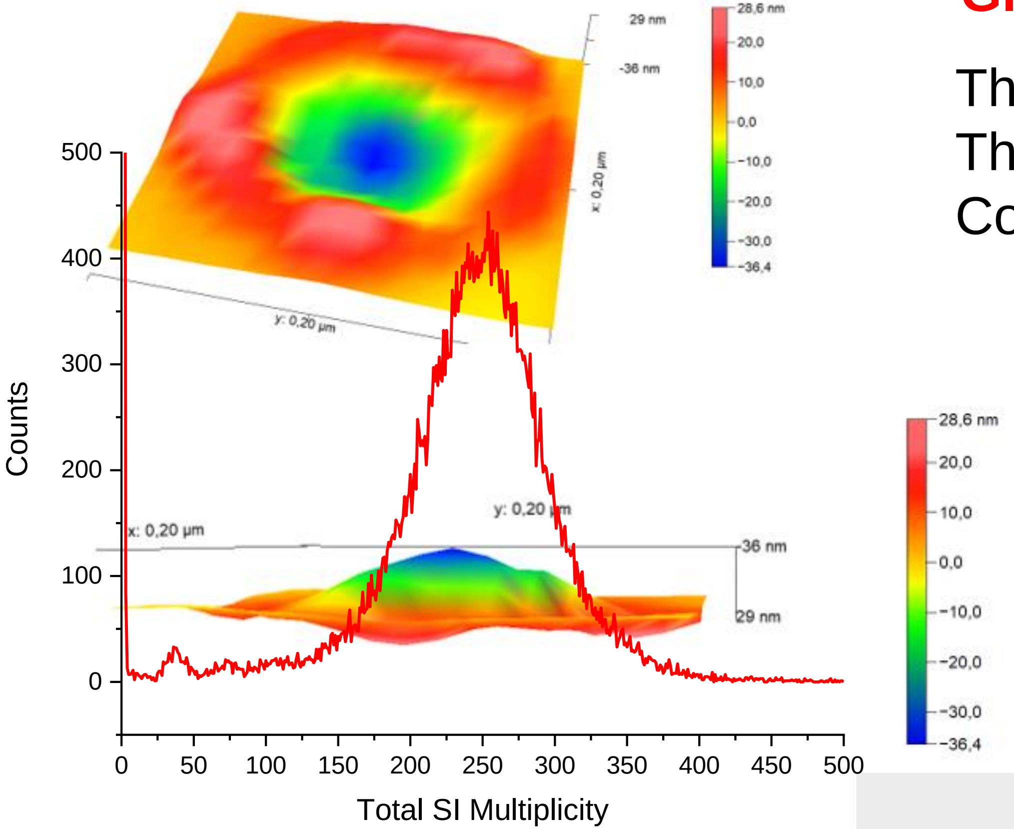


Beam direction;
45 °

Gold Nanoparticle beams

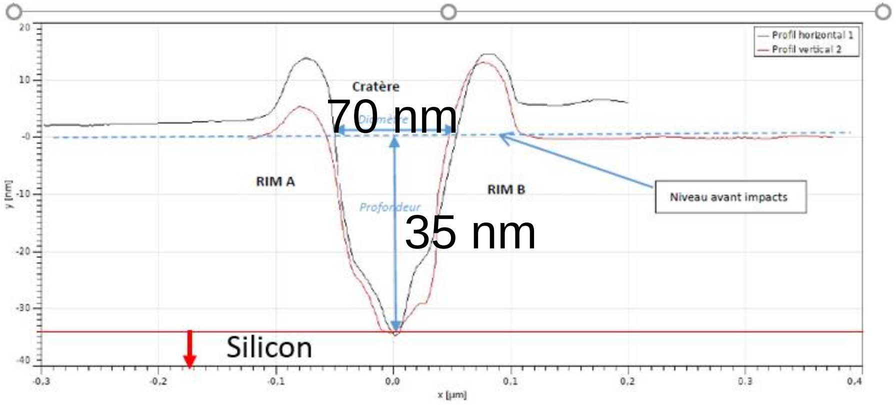
12 MeV Au_{400}^{4+}

Polymer film (35 nm/Si)



Giant Volume correlated to HUGE Ion Emission

The memory of the incident angle is lost !
The depth is larger than the range of Au at 30 keV
Coherent motion effect ?



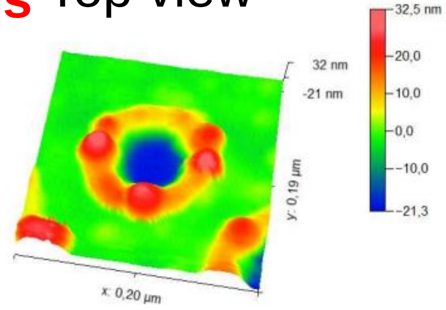
Gold Nanoparticle beams

12 MeV Au_{400}^{4+}

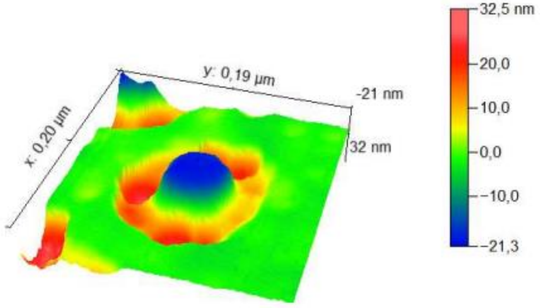
Gold surface (40 nm/Si)*

Giant Volume correlated to HUGE Ion Emission
With several hundreds of secondary Ions
Emitted per impact

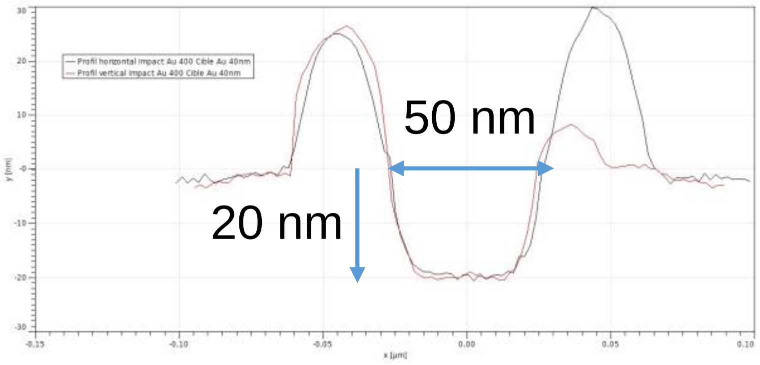
Top view



Bottom view



Profil en croix au centre de la trace

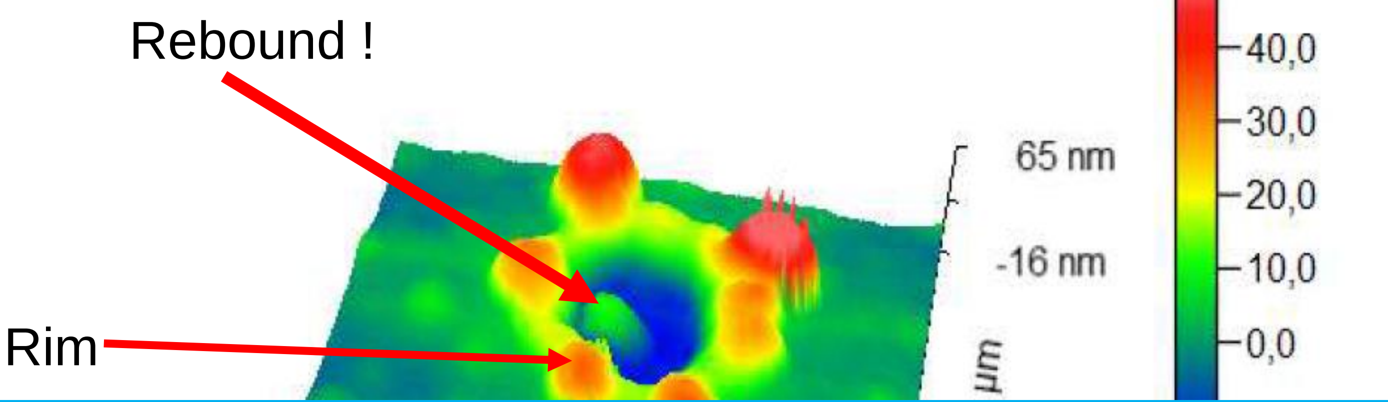


Crater profil

AGAIN FOR GOLD SAMPLE:
The memory of the incident angle is lost !
The depth is larger than the range of Au at 30 keV
Coherent motion effect ?

* Samples provided by IRB(Croatia)

Au_{700}^{5+}, 3 MV/ Au40 nm



There is not specific direction for these structures corresponding to the final frozen state of the solid. There is a variety of rim structures and « rebound »shapes.

BUT: the distribution of diameters and depths are monodisperse.

Signature of given pressure and temperature ?

Question: relationship between crater volume, amount of matter set in motion and ejected matter (ions and neutrals) ?

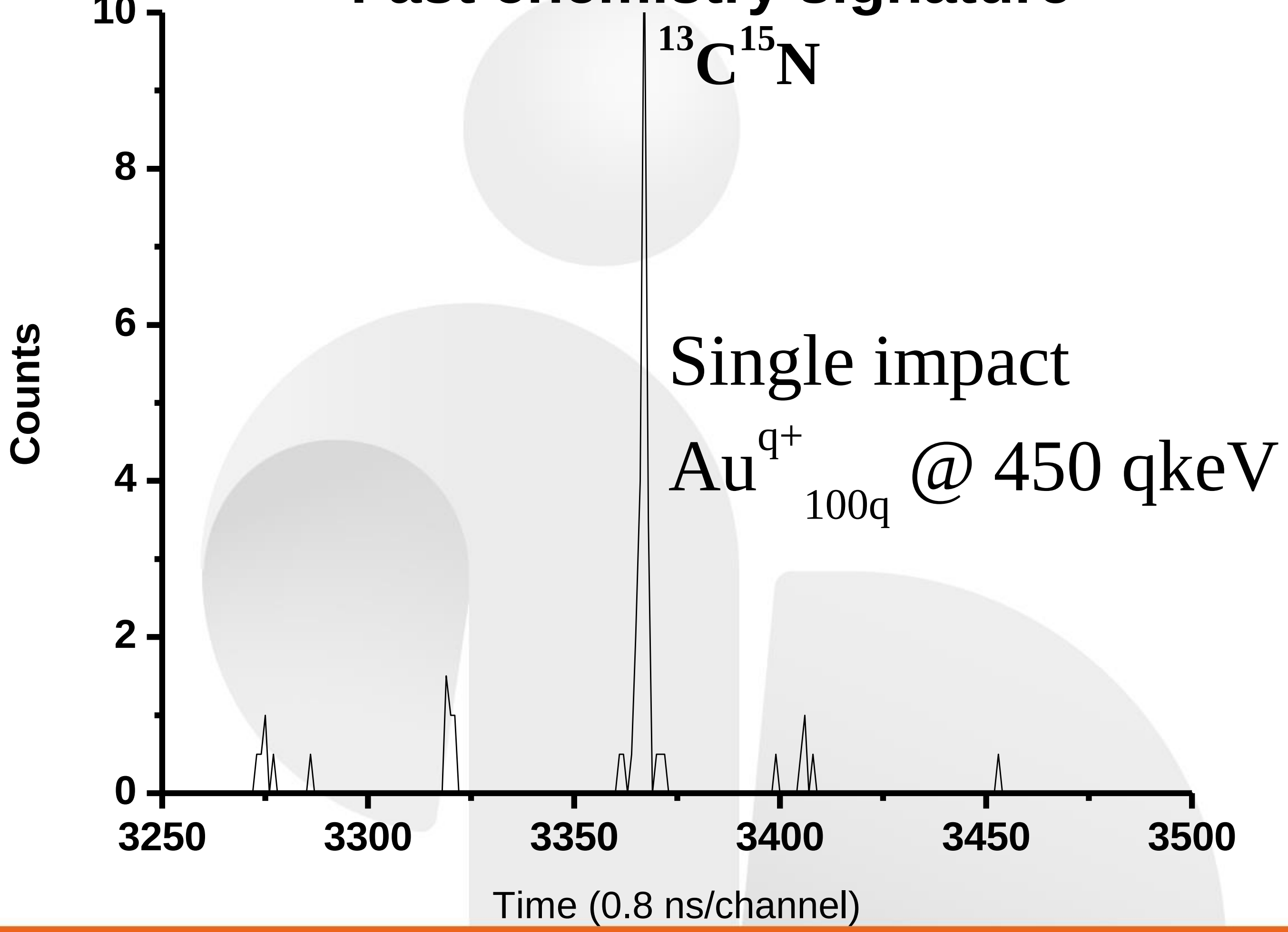
Conclusions

1. Knowledge of the angular distribution is essential for the detection of all ions with adapted focusing conditions.

2. The use of such massive clusters associated with multi-anode detectors, allowing the simultaneous detection of several ions of a given mass, permits correlation studies between the emitted ions within a single impact, shedding additional light on the chemical composition and structure of the analysed sample for various samples from metallic surfaces to biologic molecules deposits.

Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis

Fast chemistry signature



Influence of the projectile energy (velocity)