HINA Project

(Highly charged Ions for Nuclear physics and Astrophysics)

Journée des AP du Pôle Physique Nucléaire 12 juin 2024

Sarah Naimi

HINA et ses fidèles

Chercheurs


Serge Della Negra


Sarah Naimi


Vladimir Manea

David Lunney

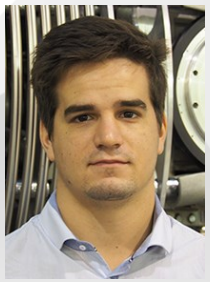

Maroua Benhatchi


Michele Sguazzin

Support technique


Isabelle Ribaud


Denis Reynet


François Daubisse


Alexandre Migayron


Bruno MERCIER


Hervé Lefort


Philippe GAURON

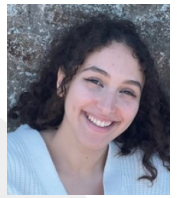
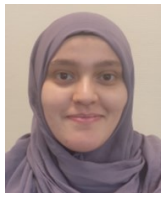
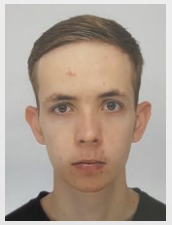
Collaborateurs externes (MPIK)


José Crespo


Klaus Blaum


Manfred Grieser

Stagiaires M1/L3

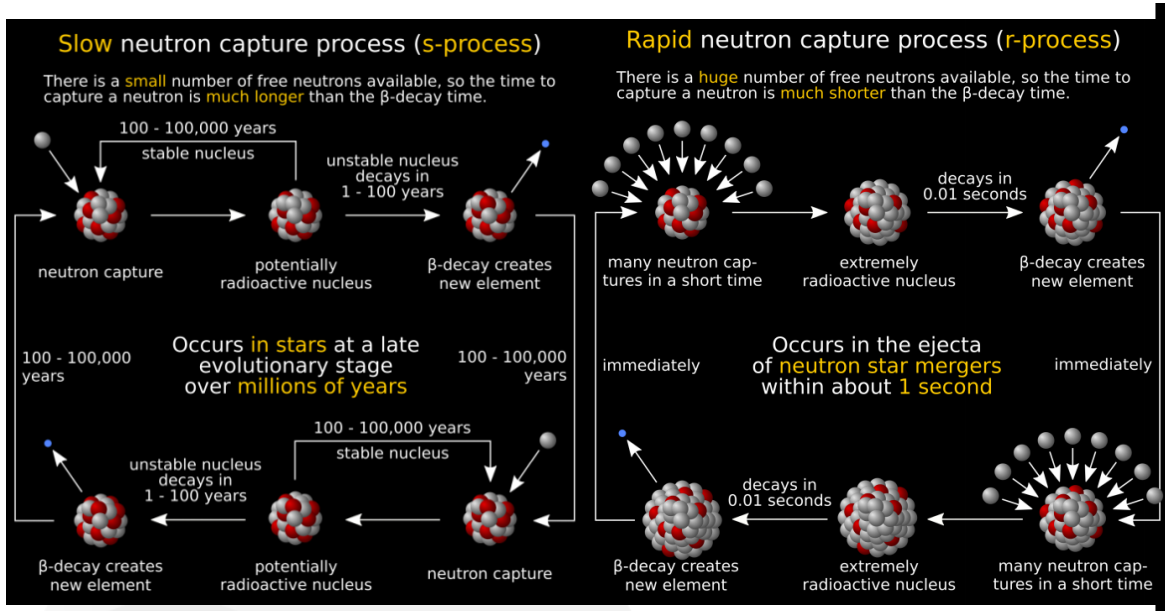
Sophie, Amelle, Sarah
Damien, Maxime

Quel lien avec l'astrophysique ?

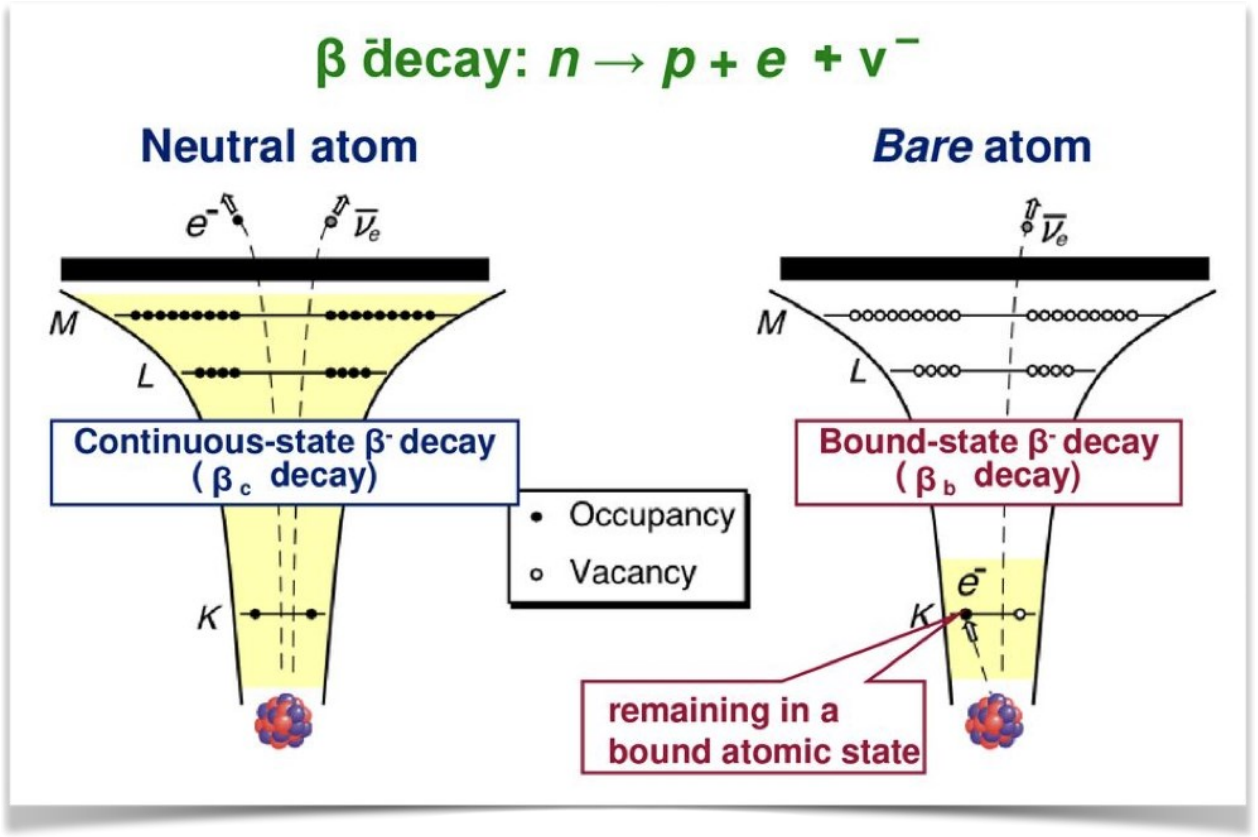
Dans le milieu stellaire les noyaux se trouve dans des ions fortement chargés, même totalement épluchés!

La majorité des noyaux sont instables et leur décroissance joue un rôle décisive dans la nucléosynthèse.

Peut être modifiée en fonction de l'état de charge.



Décroissance beta liée



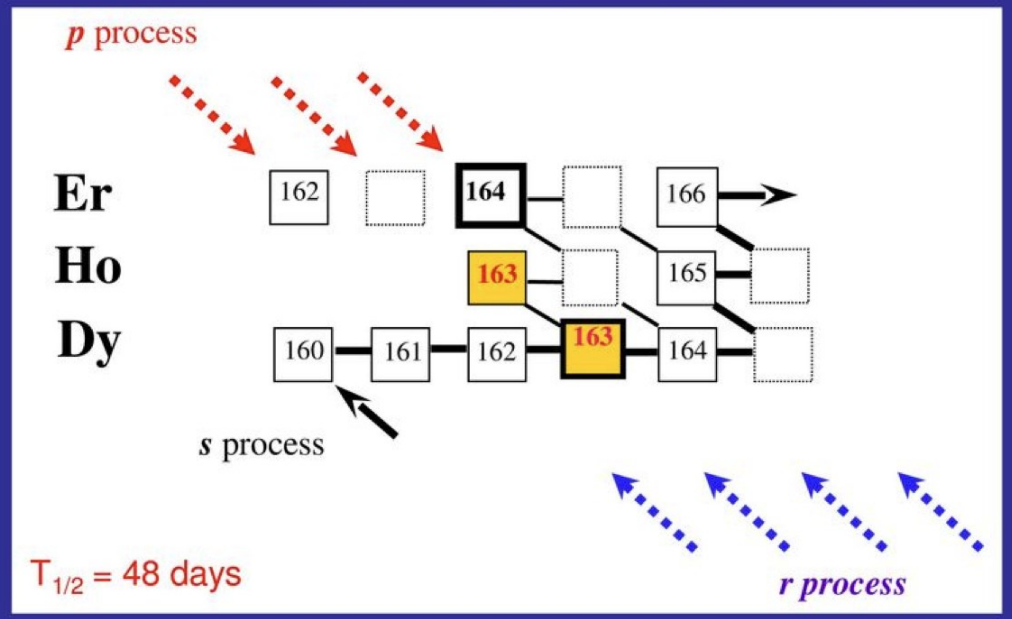
$$Q_{\beta_b}(\mathrm{K}, \mathrm{L}, \ldots) = Q_{\beta_c^-} - |\Delta B_{e^-}| + |B_{e^-}^{\mathrm{K,L\ldots}}|$$

$^{163}Dy^{0}$ **stable** → $^{163}Dy^{66+}$ **instable** **49keV** **-2,8keV** **13keV** **65keV**

Décroissance beta liée & Astrophysique

Bound-State β-decay of ^{163}Dy

s process: slow neutron capture and β- decay near valley of β stability at kT = 30 keV; → high atomic charge state → bound-state β decay

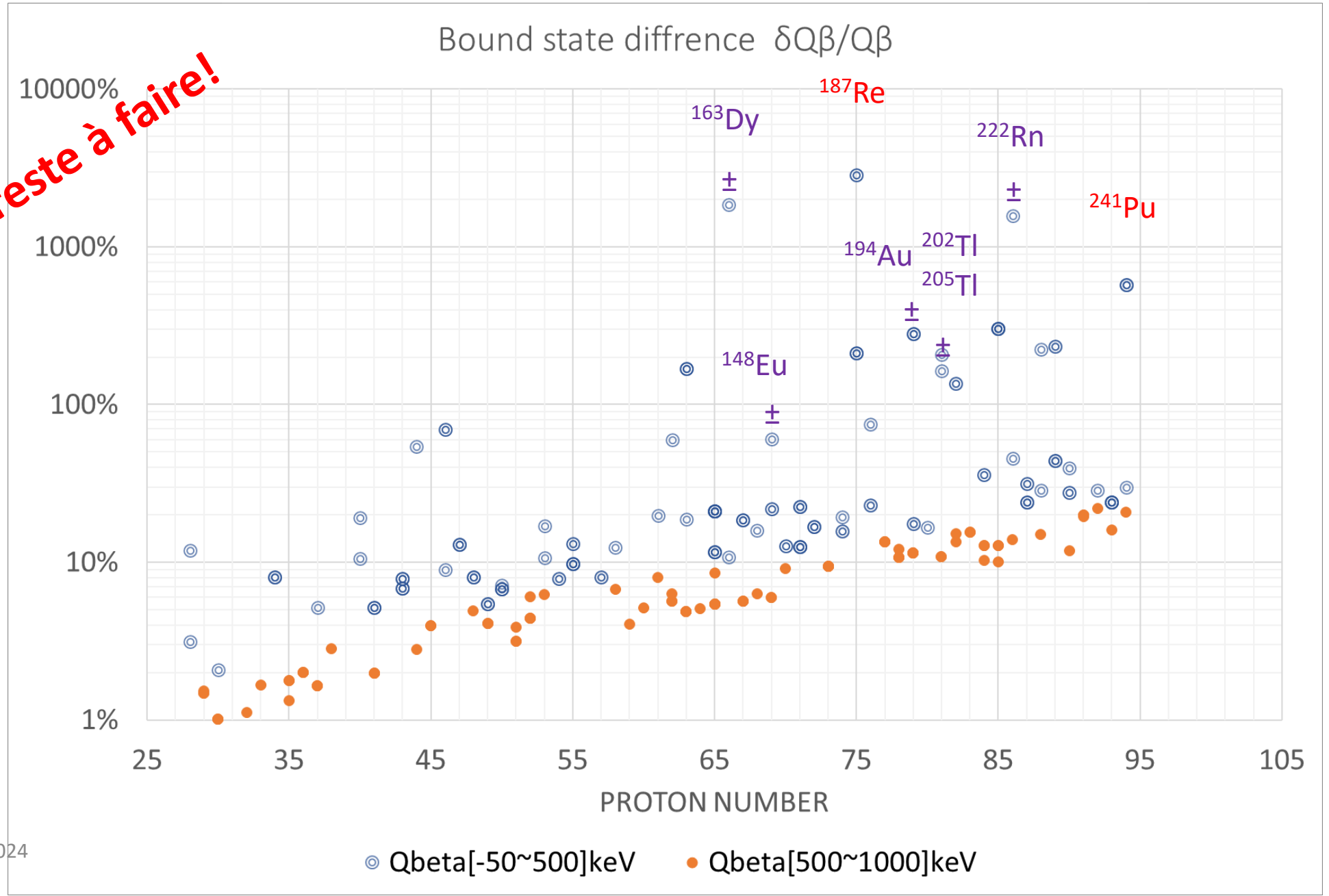


branchings caused by bound-state β decay

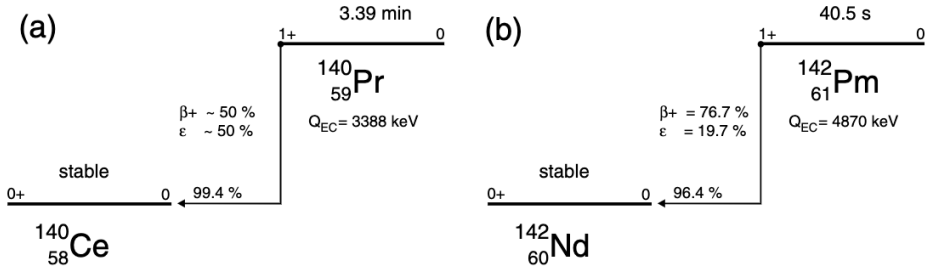
M. Jung et al., Phys. Rev. Lett. 69 (1992) 2164

$$Q_{\beta_b}(K, L, \ldots) = Q_{\beta_c^-} - |\Delta B_{e^-}| + |B_{e^-}^{K,L\ldots}|$$

Beaucoup reste à faire!



EC decay of H- and He-like atoms

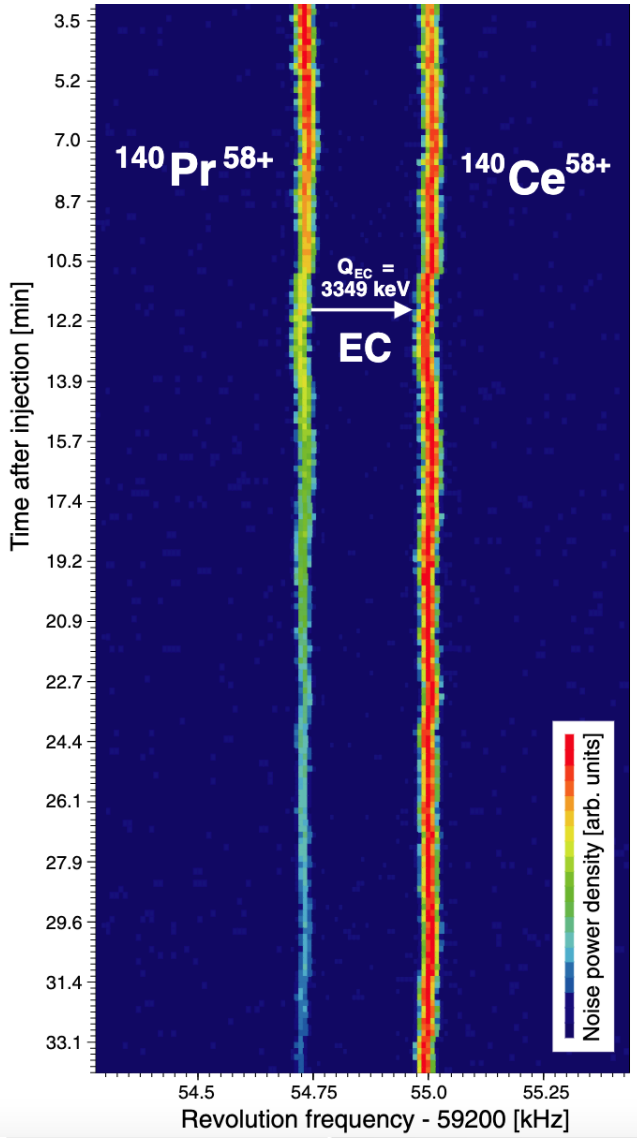


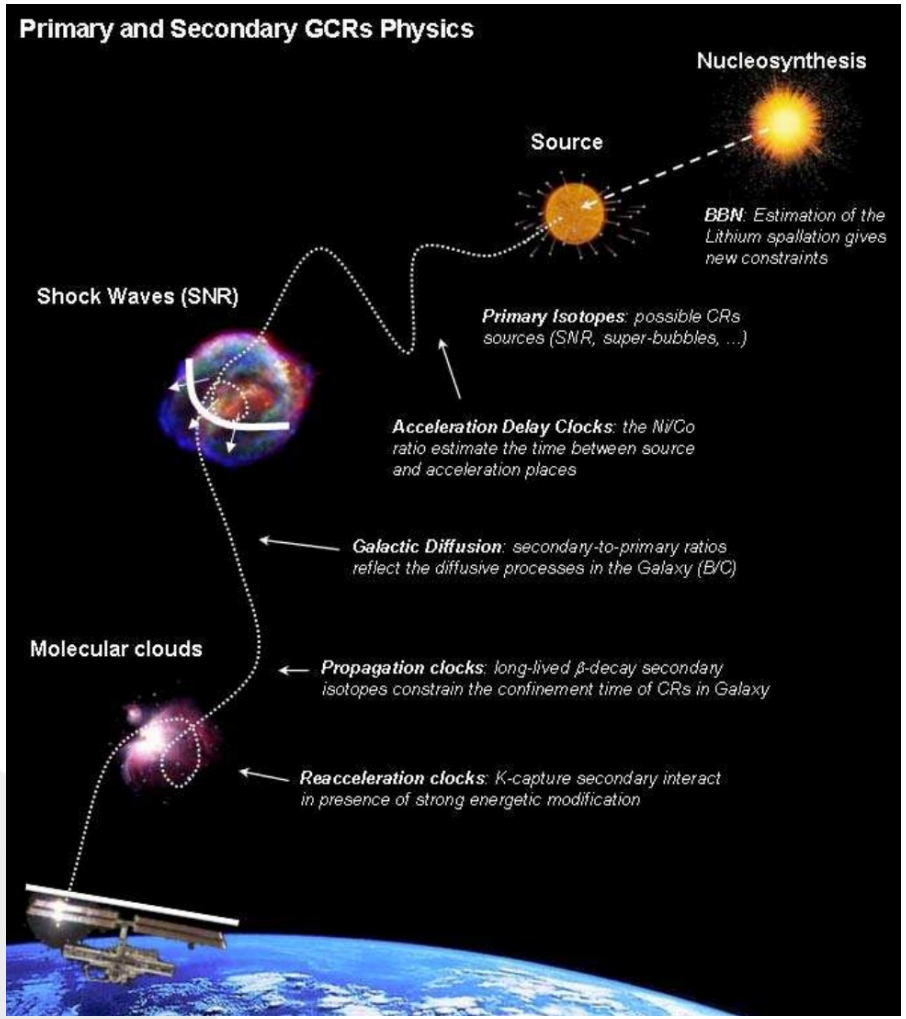
Measured @GSI

Ion	λ_{β^+} (s^{-1})	λ_{EC} (s^{-1})	$\frac{\lambda_{EC}}{(\lambda_{\beta^+}+\lambda_{EC})}$
$^{140}Pr^{58+}$	0.001 61(10)	0.002 19(6)	(57.6 ± 2.3)%
$^{140}Pr^{57+}$	0.001 54(11)	0.001 47(7)	(48.8 ± 3.1)%
$^{140}Pr^{0+}$	0.001 74(5)	0.001 65(5)	(48.7 ± 1.8)%
$^{142}Pm^{60+}$	0.012 6(3)	0.005 1(1)	(29.0 ± 1.3)%
$^{142}Pm^{59+}$	0.013 9(6)	0.003 6(1)	(20.2 ± 1.0)%
$^{142}Pm^{0+}$	0.013 2(5)	0.003 9(5)	(22.9 ± 2.7)%

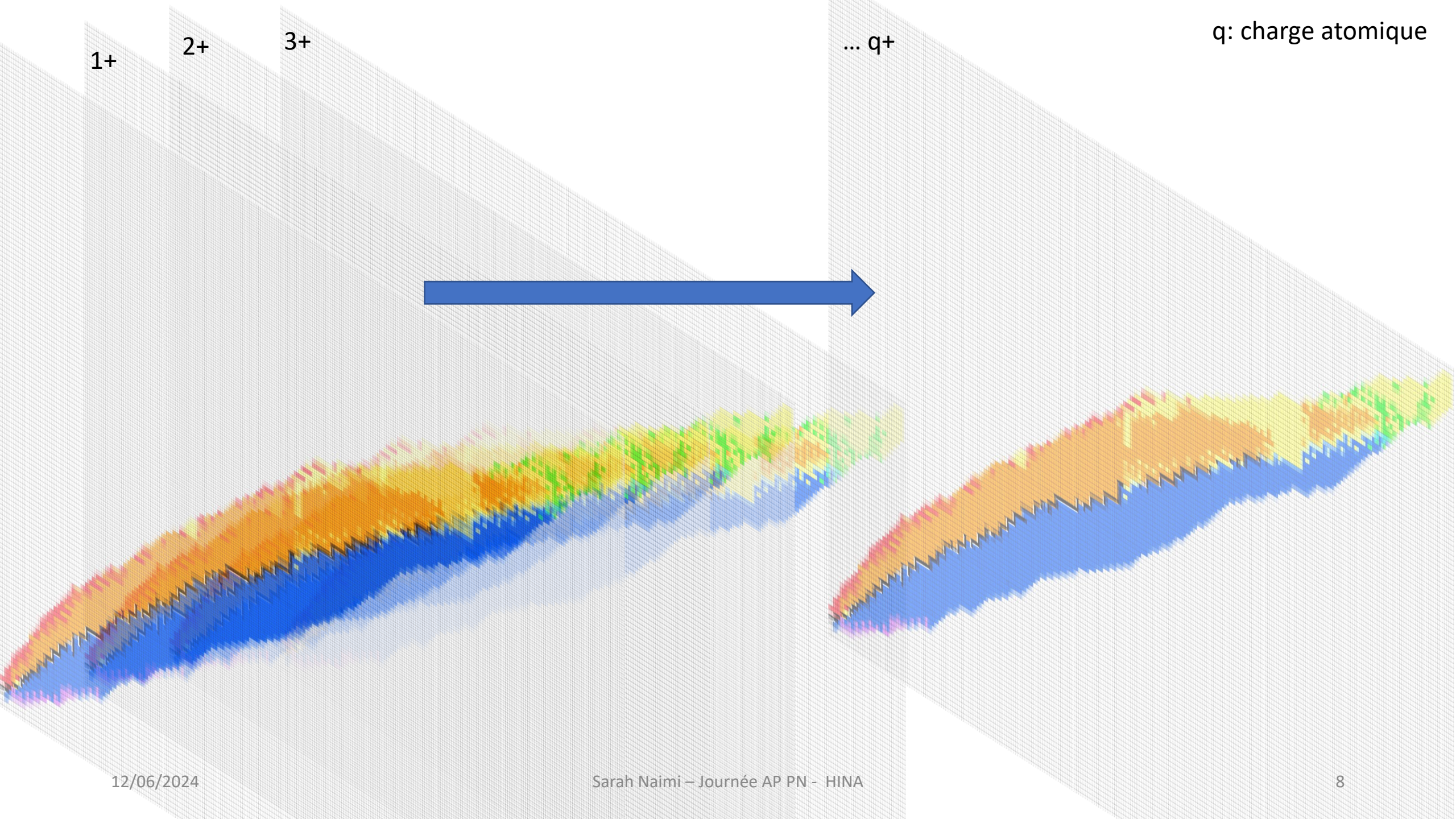
EC rate depends on the occupied electron shells

Z. Patyk et al. PRC77, 2008

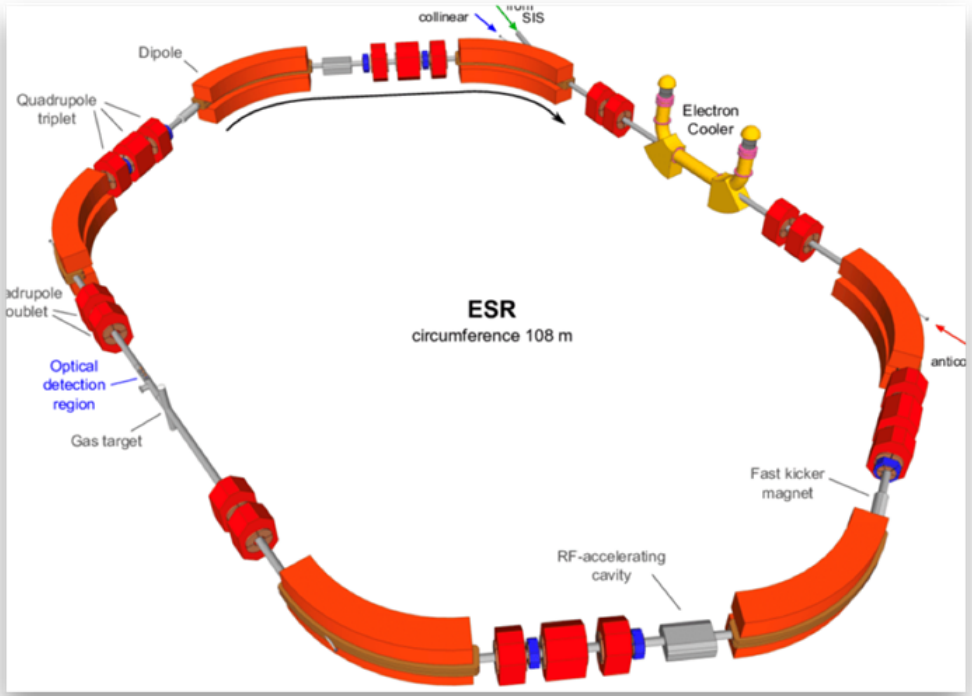




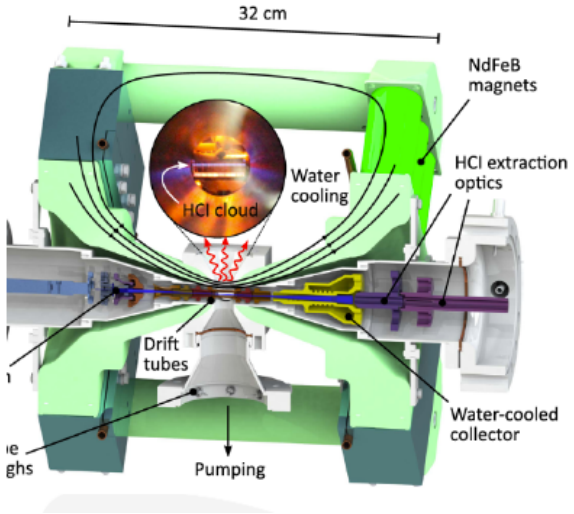
q: charge atomique

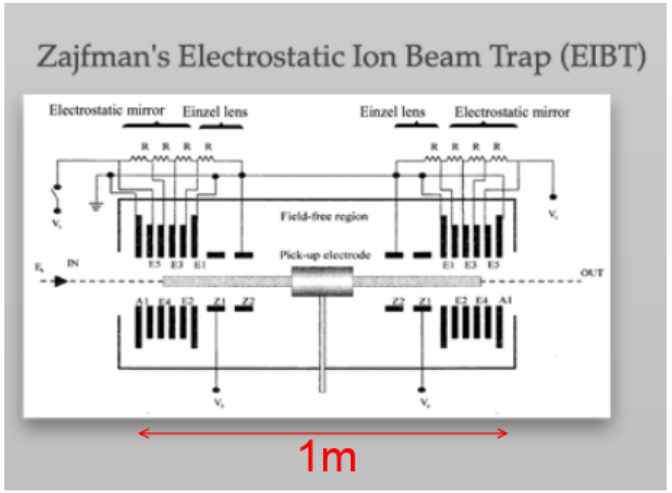


Développer des outils alternatifs



Instrument alternative: Pièges à ions plus petit, moins cher, plus performant





Avantages:

Eco / coût

opération offline possible

confinement en espace

—> détection de la radiation

Inconvénients :

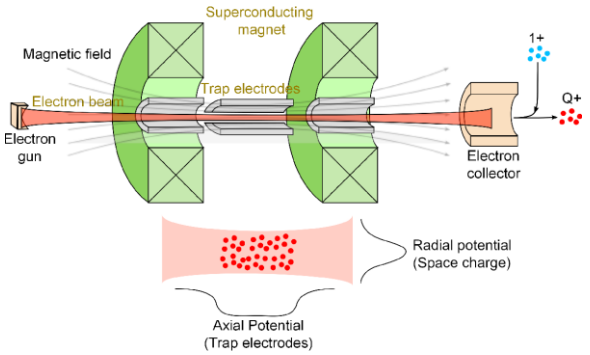
confinement en espace

—> effets charge d'espace

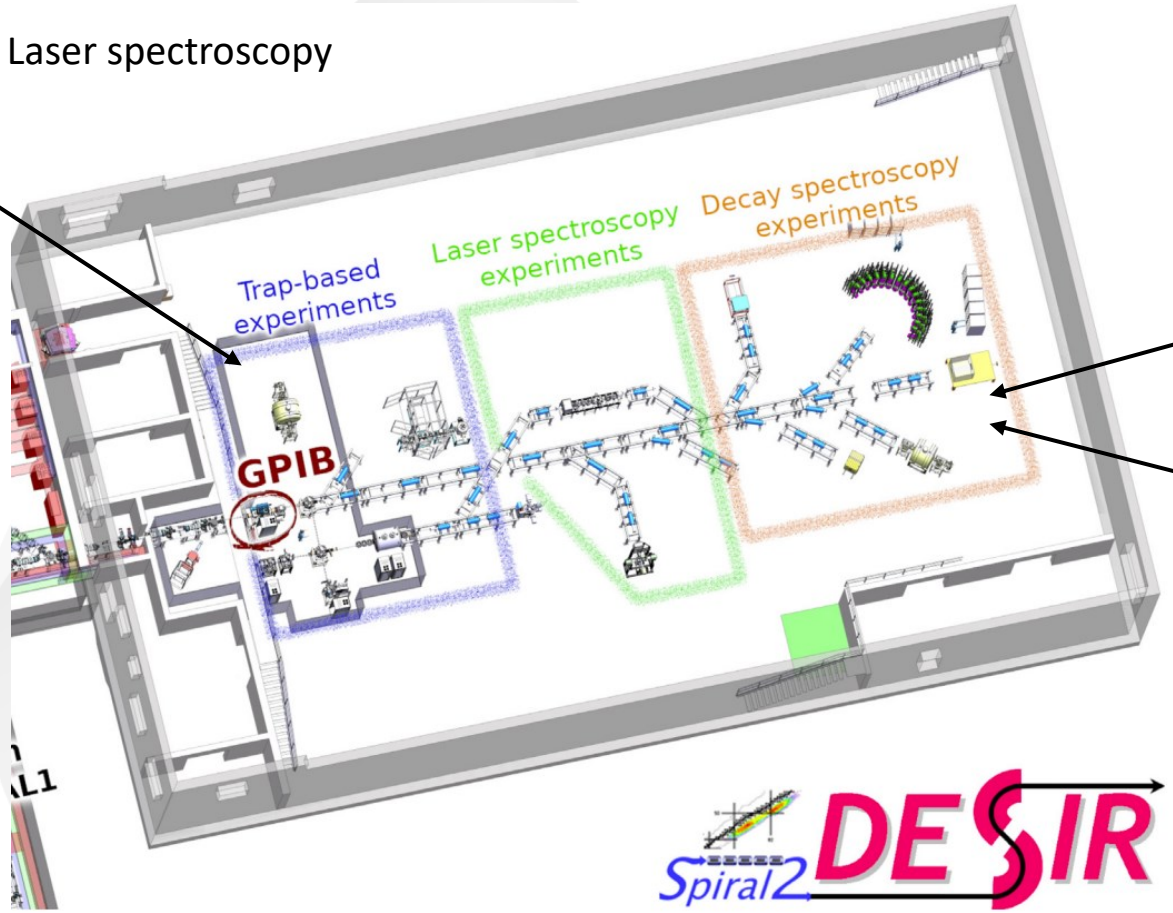
HINA project (Highly charged Ions for Nuclear physics and Astrophysics)

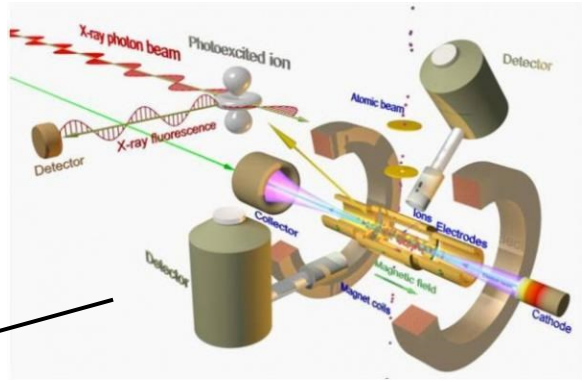
High precision mass measurements & Laser spectroscopy

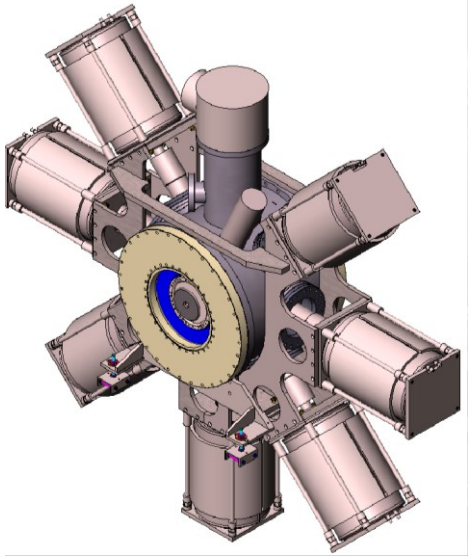
$$\frac{m}{\Delta m} \propto \frac{q \cdot B}{m} \cdot T_{RF}\sqrt{N}$$



Under development @IJCLab



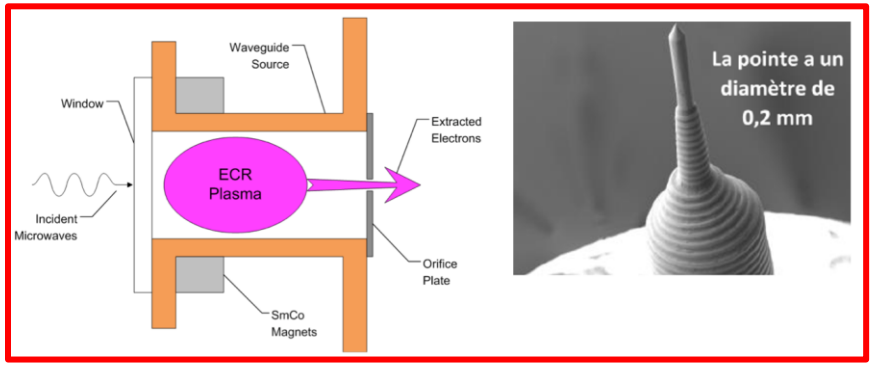


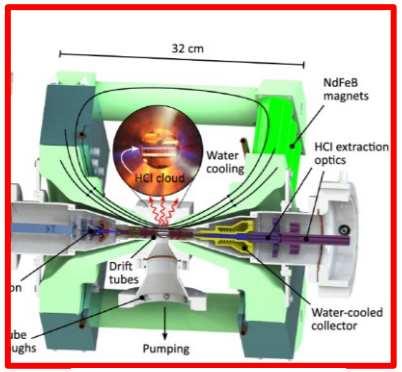


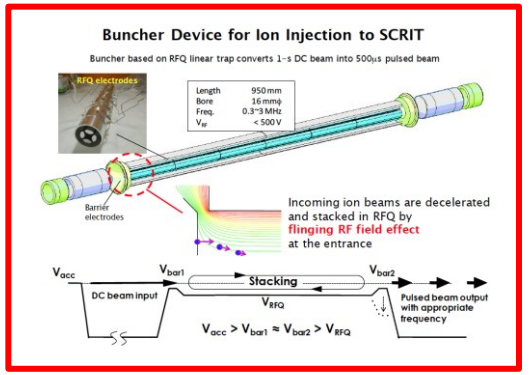
Les outils à développer à IJCLab

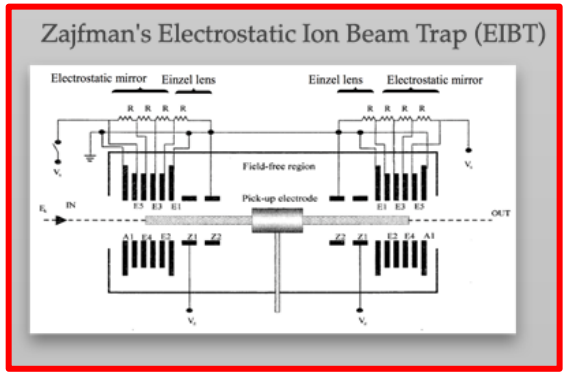
mosaic

Production (ECR/LMIS) → Charge breeding → Accumulate Cool → Trapping Observation

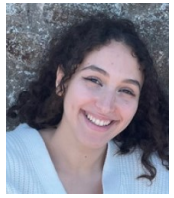


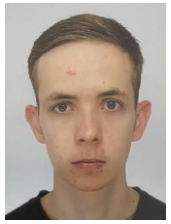







Serge Della Negra


Amelle Khamkham (M1)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Michele Sguazzin (postdoc in2p3)

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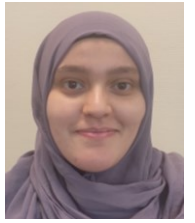
Maroua Benhatchi PhD (IJCLab)


Sarah Hussein (M1)


Maxime Duval (L3)

Production d'ions multichargés à Tancrède

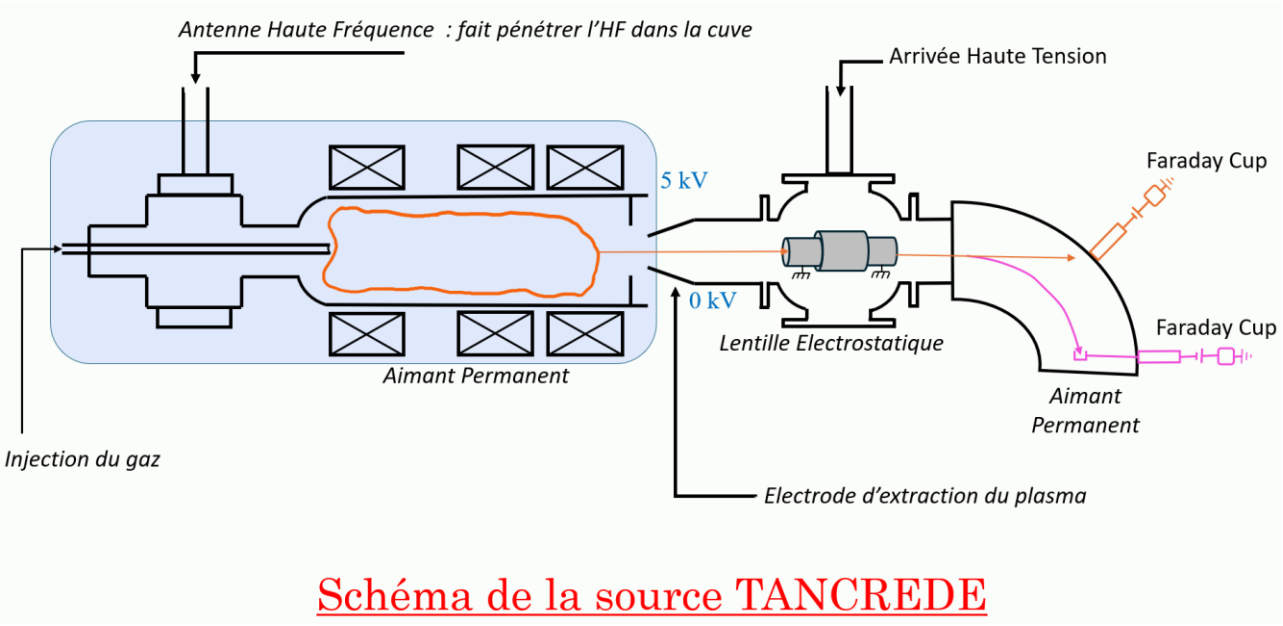
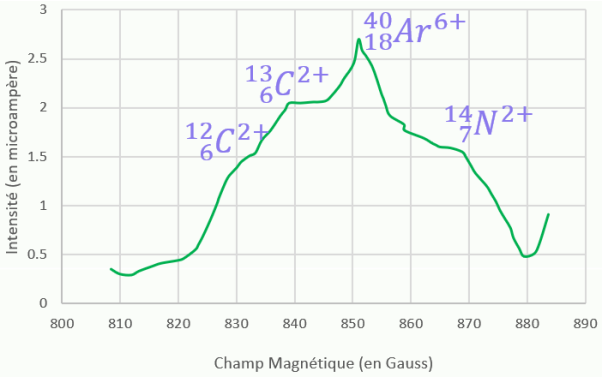
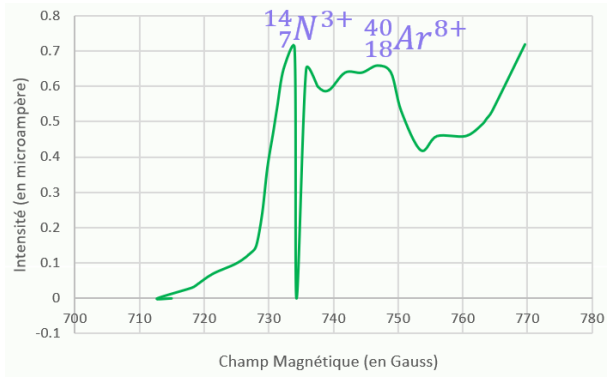
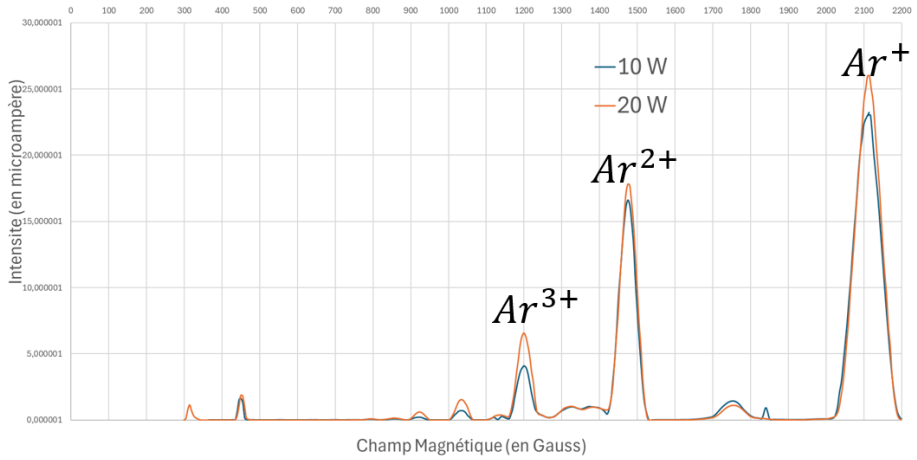


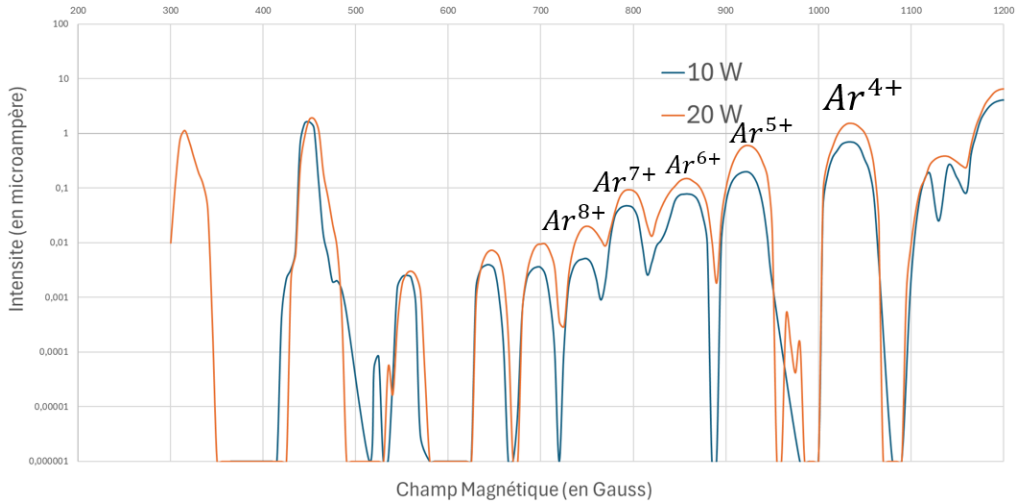
Schéma de la source TANCREDE







Spectre Argon multi-chargé (courant en fonction du champ magnétique)
Comparataison entre 10 W et 20 W de puissance, à 10 kV

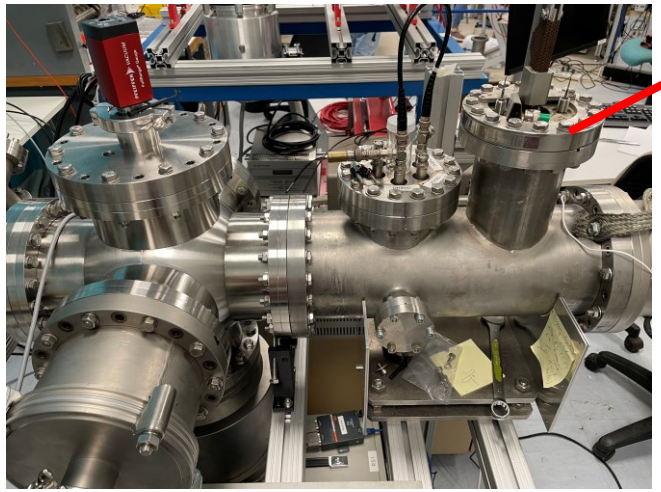


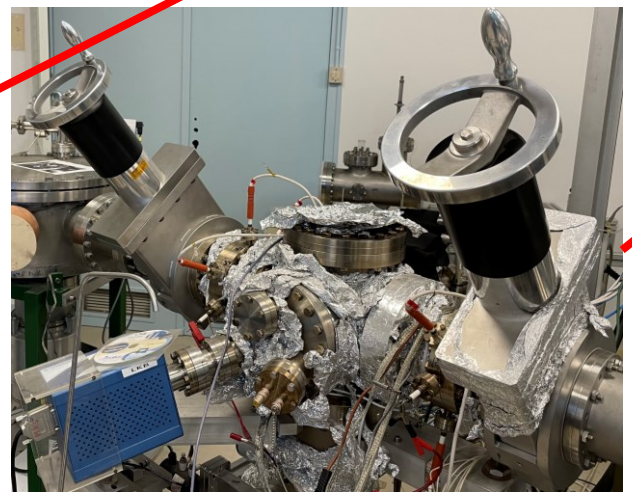
Amelle Khamkham (M1)

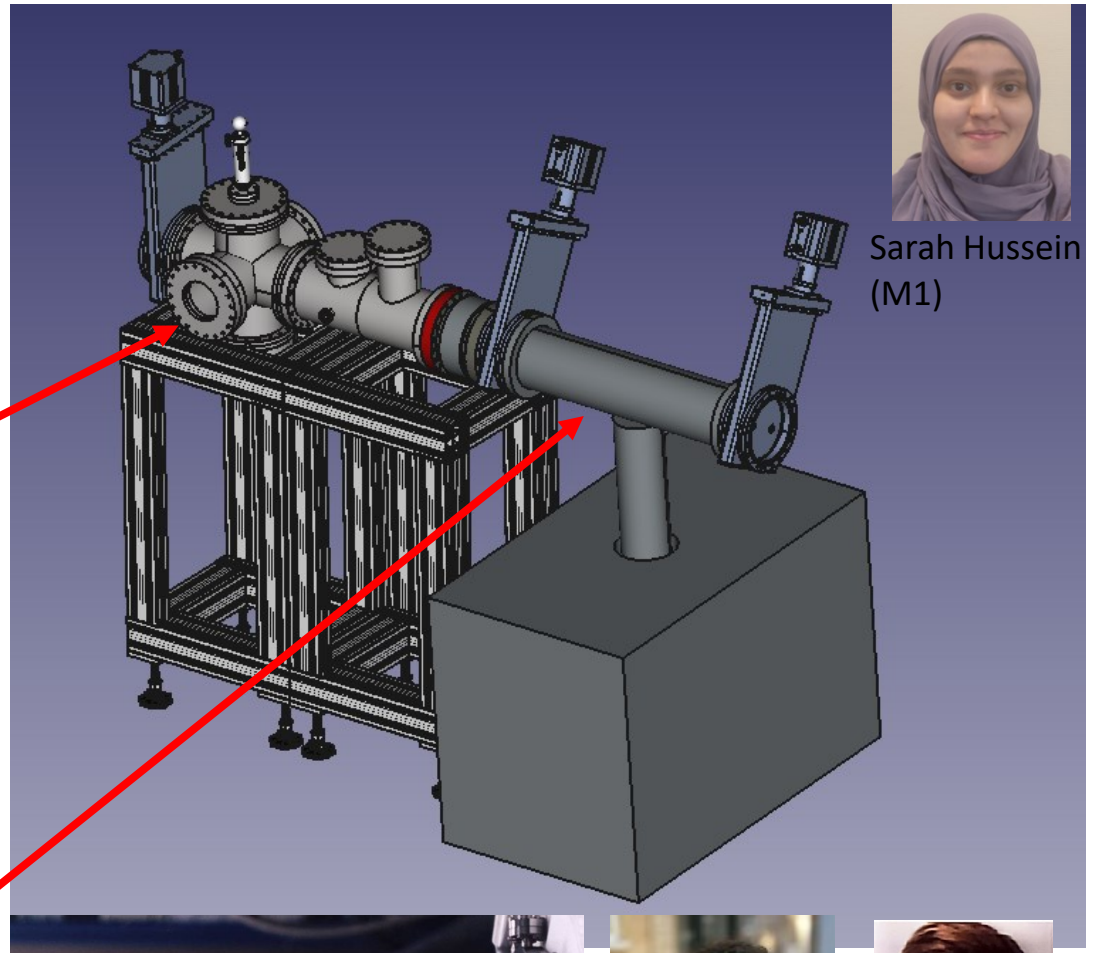
Michele Sguazzin (postdoc in2p3)

Installation à Tancrède (en cours)

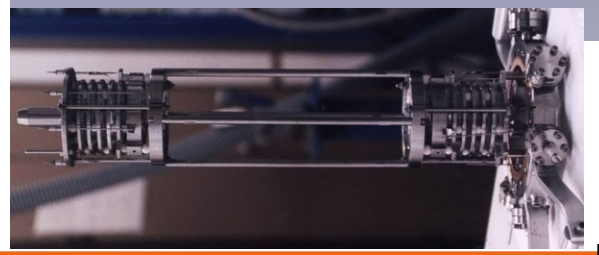
mosaic







Sarah Hussein (M1)

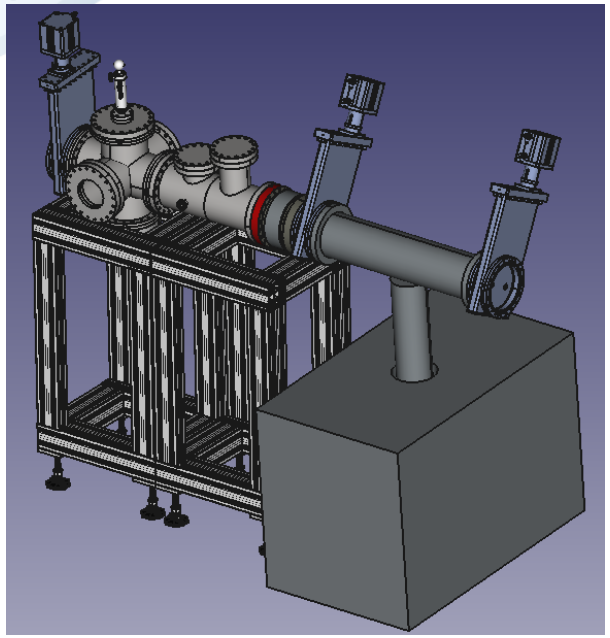


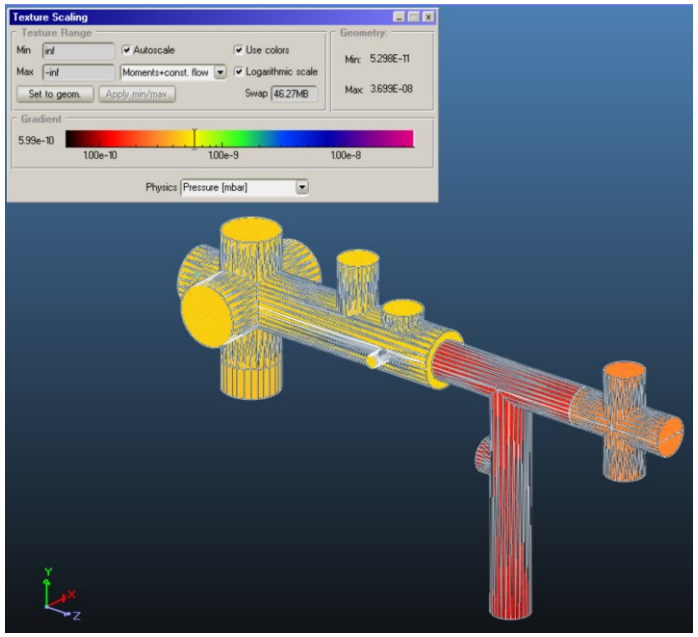
Maroua Benhatchi (PhD)

Maxime Duval (L3)

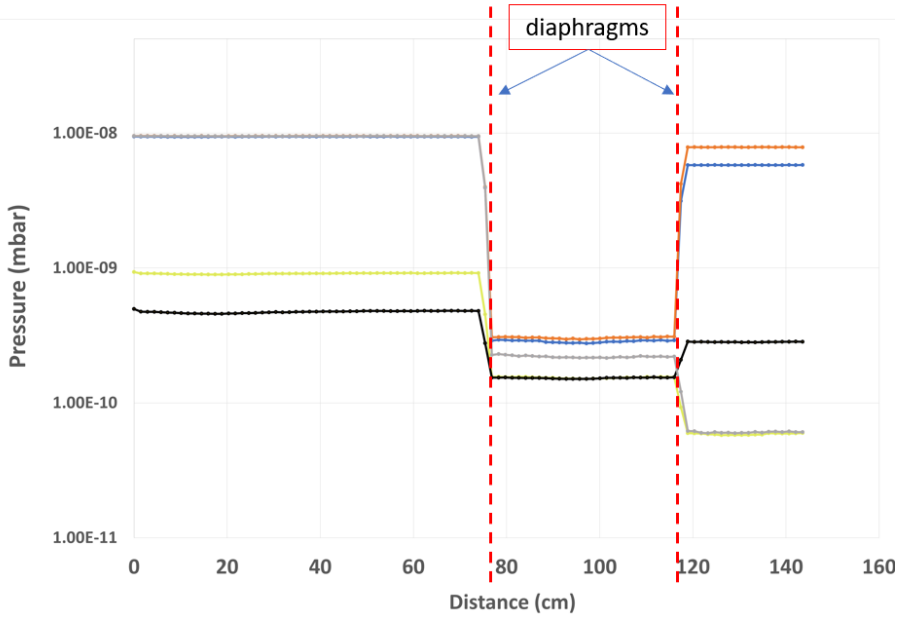
Simulation for vacuum (Molflow)

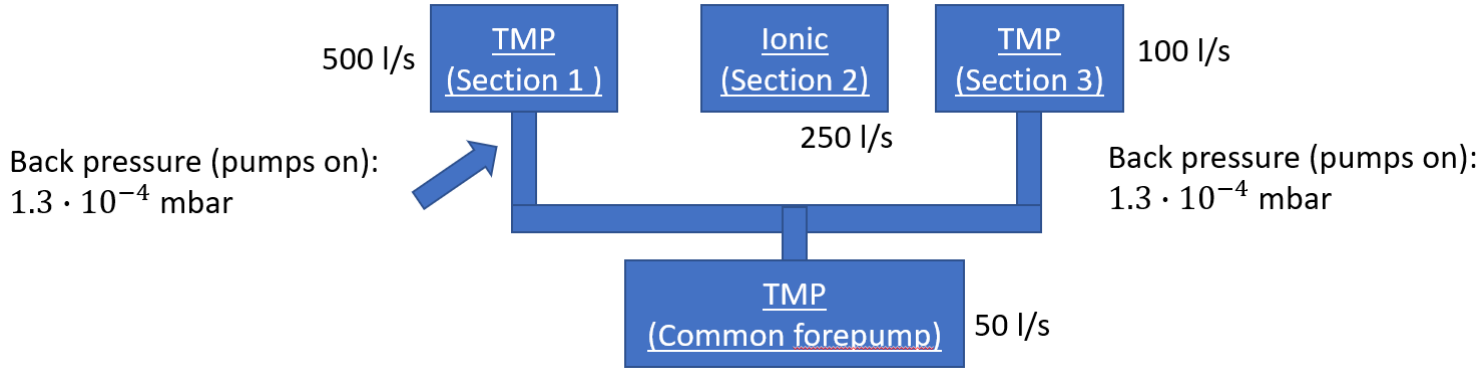
Michele Sguazzin (postdoc in2p3)





Partial pressure of H_2



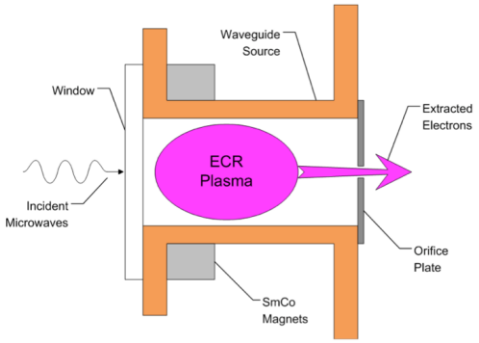


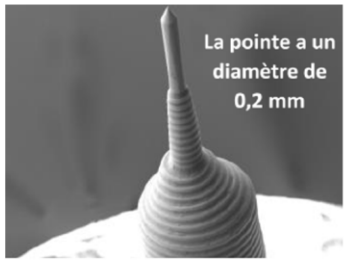
A Valider!

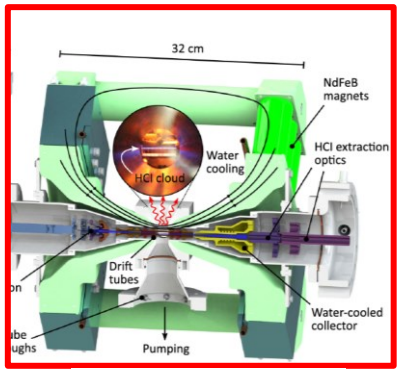
Les outils à développer à IJCLab

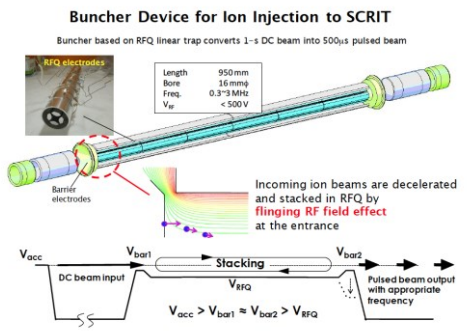
mosaic

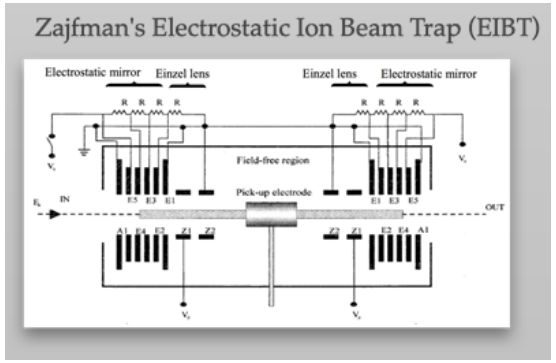
Production (ECR/LMIS) → Charge breeding → Accumulate Cool → Trapping Observation



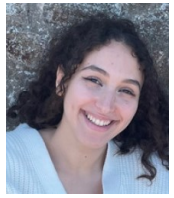




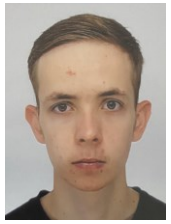




Serge Della Negra



Amelle Khamkham (M1)

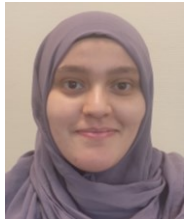


Damien Jacquemin (L3)

Michele Sguazzin (postdoc in2p3)

David Lunney

Maroua Benhatchi PhD (IJCLab)

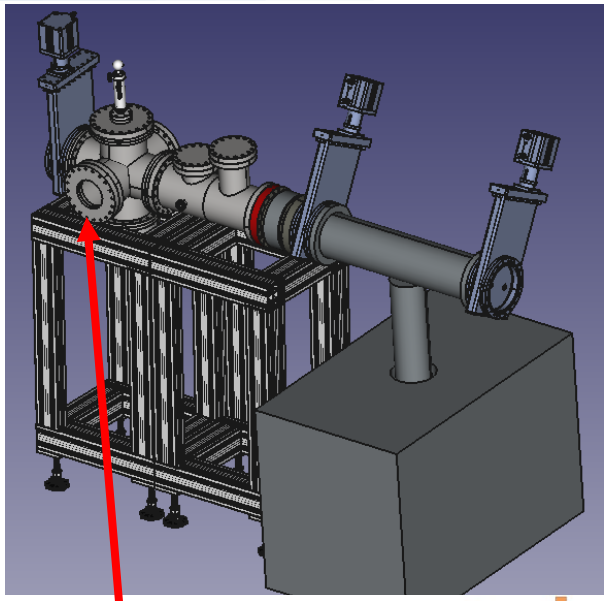


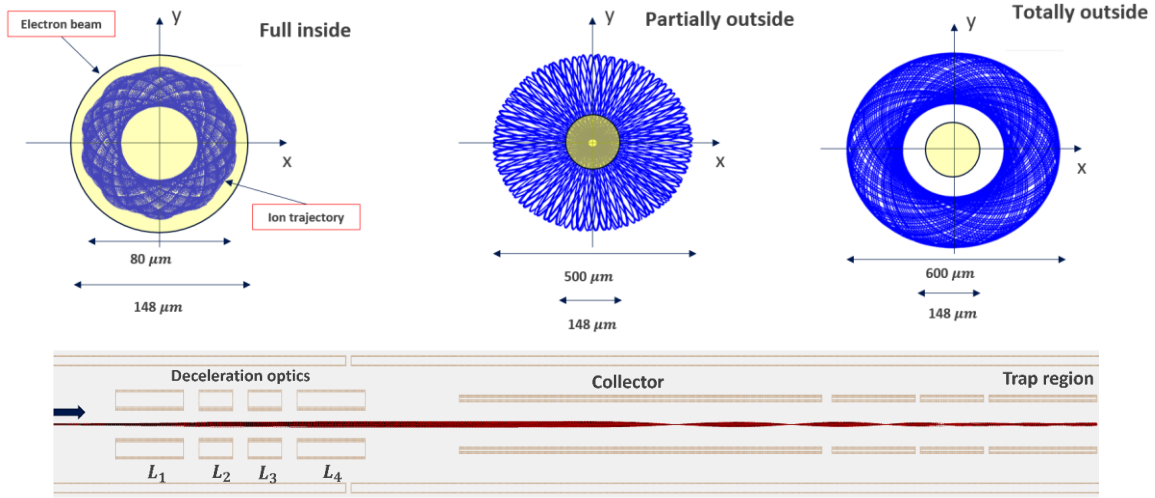
Sarah Hussein (M1)

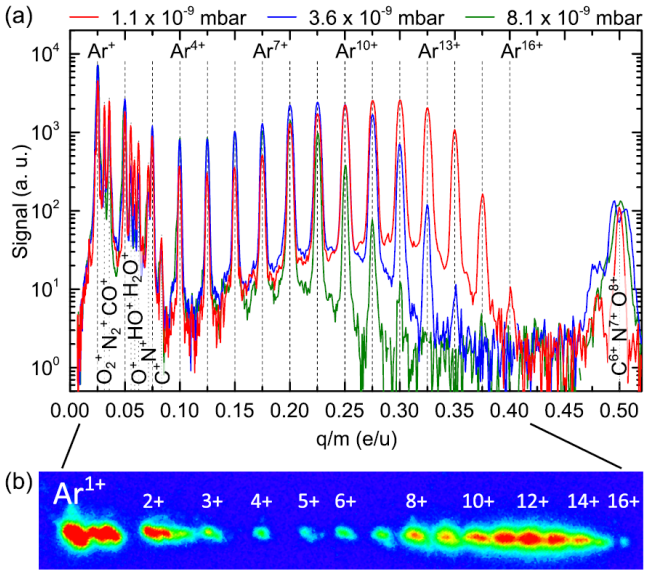
Maxime Duval (L3)

Charge breeder EBIT : simulation study

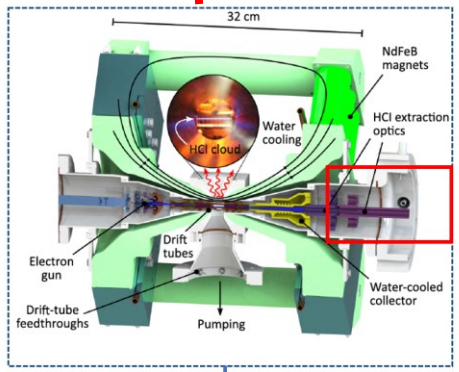
Michele Sguazzin
(postdoc in2p3)

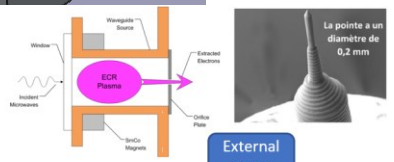






Micke et al, Rev. Sci. Instrum. 89, 063109 (2018):
e- gun: 4mA, 2.8keV
Electron gun operation up to 80mA and 10keV



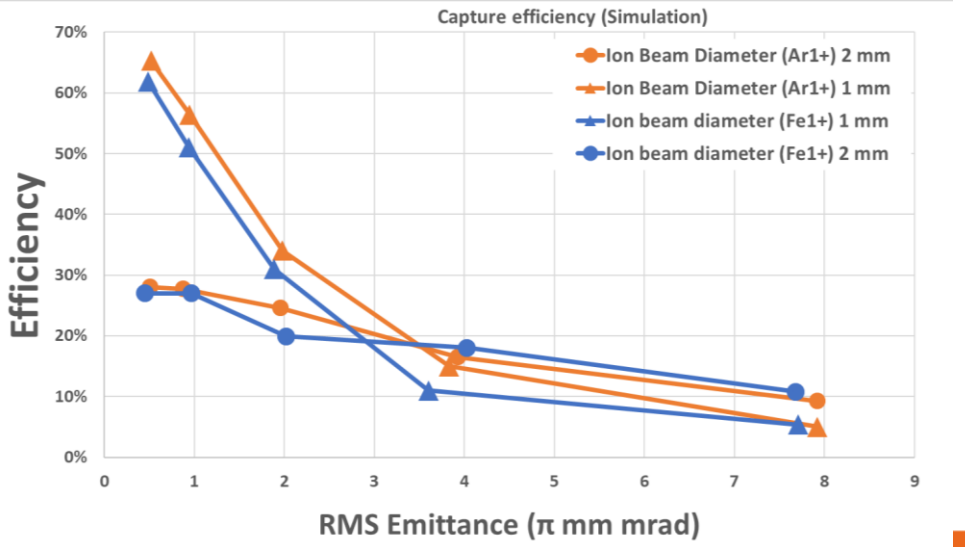


External source

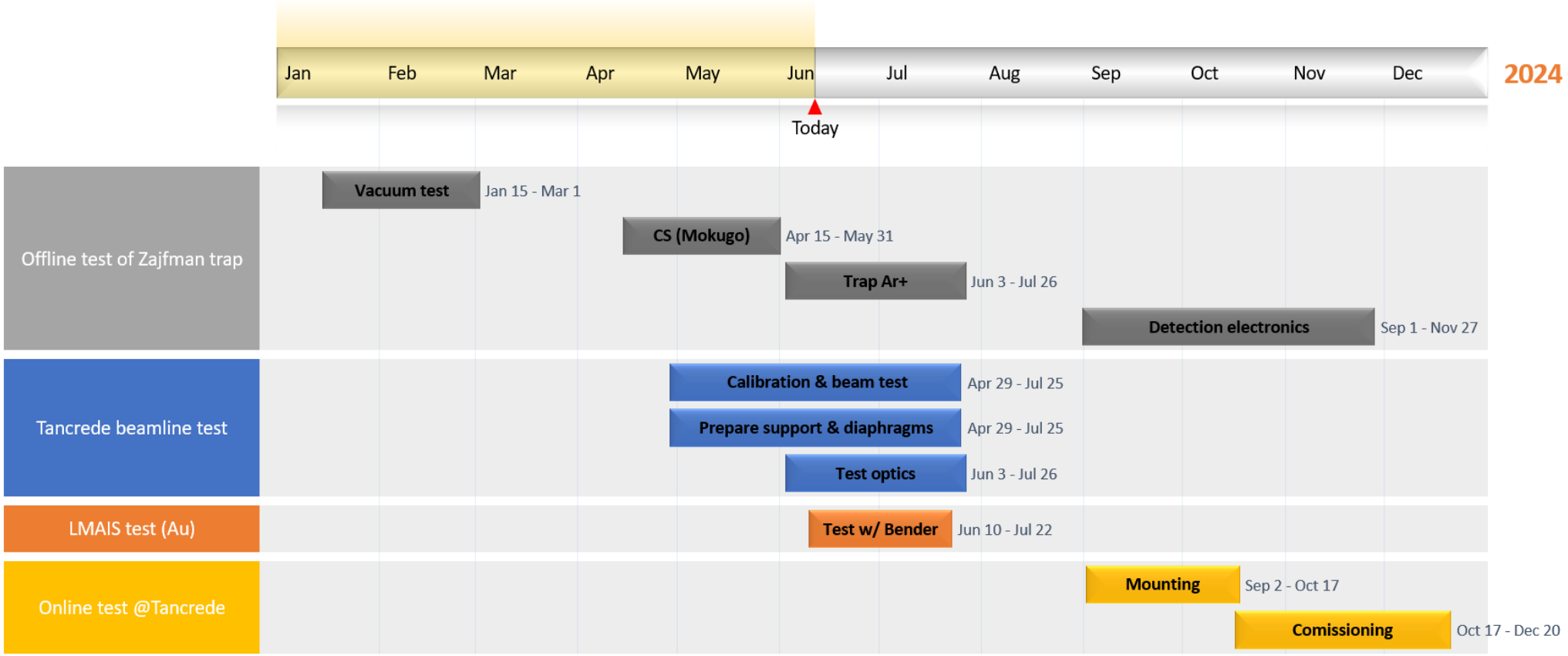
1+/Low q+
at tens of keV

High q+

HV platform



Planning 2024 & Demande 2025



Financements:

IJCLab (2023)

ERM (2024)

ANR (en cours)

R&T in2p3? (140k€)

Demande 2025:

- Ouverture ligne budgétaire HINA
- 3,5 kEUR **Missions** MPIK pour M. Sguazzin, M. Benhatchi, A. Migayron, D. Reynet et S. Naimi
- 3 kEUR **Fonctionnement** (Recharge source + Gaz Argon)