

Status of FRIENDS3 project

Elodie Morin

May 29th, 2024



- 1 Developments for S³-LEB gas cell improvement
- 2 Experimental tests

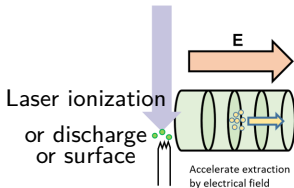
- 1 Developments for S³-LEB gas cell improvement
- 2 Experimental tests



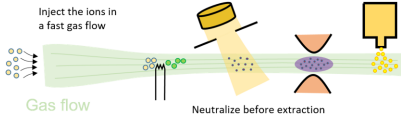
Fast Radioactive Ion Extraction and Neutralization Device for S³

- Improvement on neutralization efficiency
- Improvement on extraction time

Ion production



Neutralization



Laser re-ionization



Current gas cell extraction time : 500-600 ms

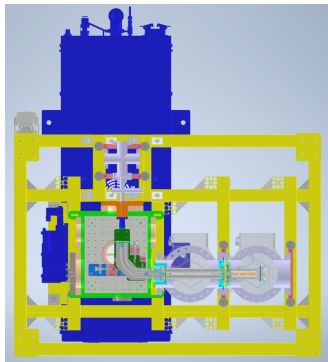
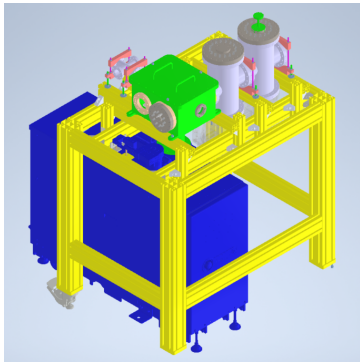
Our tools :

- Simulations (COMSOL and SIMION)
- Design of a test bench



Fast Radioactive Ion Extraction and Neutralization Device for S³

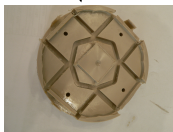
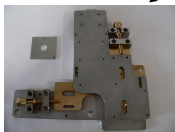
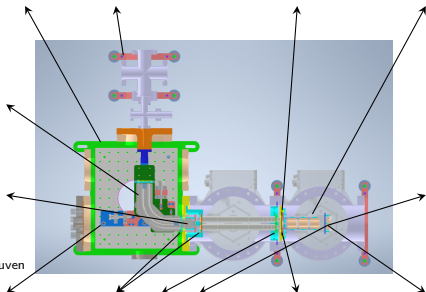
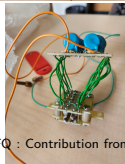
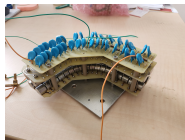
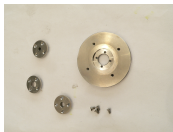
- Improvement on neutralization efficiency
- Improvement on extraction time



Phase 1



Manufacturing

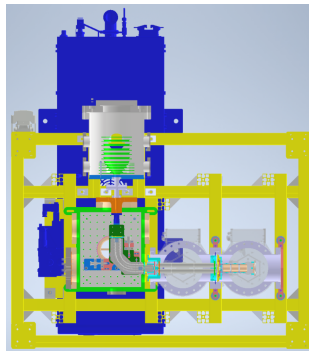
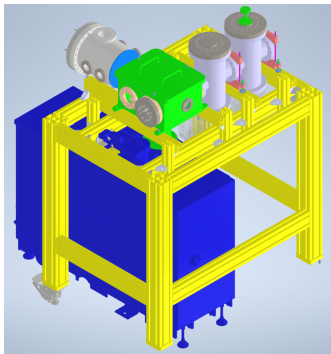


bRFQ, mRFQ : Contribution from KU Leuven



Fast Radioactive Ion Extraction and Neutralization Device for S³

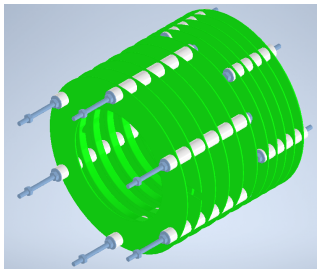
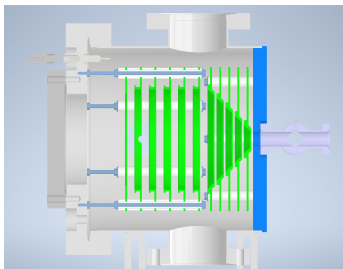
- Improvement on neutralization efficiency
- Improvement on extraction time -> **Electrical Gas Cell**



Phase 2

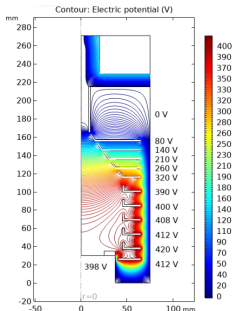


Electrical Gas Cell

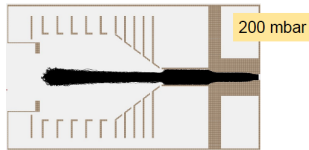
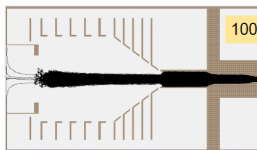


Design from
JETRIS gas-cell
model

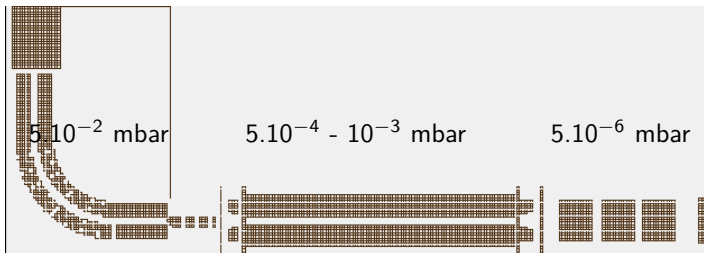
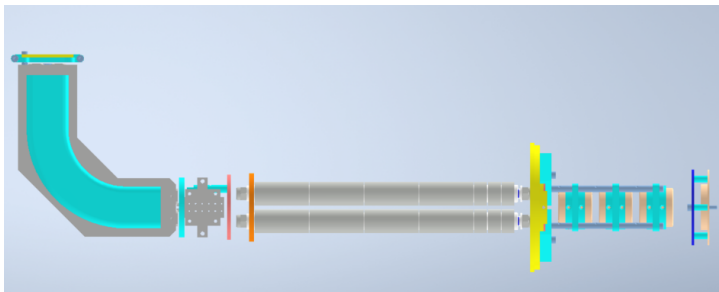
S. Raeder et al.,
NIM B 463, 272-276 (2020)



/	100 mbar	150 mbar	200 mbar
Transmission	17.3 %	30.7 %	43.1 %
Average ToF (ms)	97.3	115.3	130.6



Courtesy to W. Dong

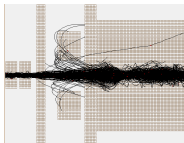




Test with 1 MHz radiofrequency in all RFQs

- **Transfert mode :**

- Transmission up to : 83 % at 1 MHz
- Main losses in the ion guide area (reflections at entrance, conductance at exit)



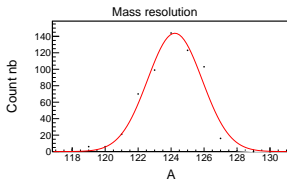
- **Buncher mode :**

- Transmission about : 31 % at 1 MHz
- Time resolving power : $t/2\Delta t(1 \text{ MHz}) = 24$

- **Mass filter mode :**

- **Ion guide :**

- ★ 14 % transmission at 1 MHz with $a = 0.23$,
 $m/\Delta m(1 \text{ MHz}) = 31$



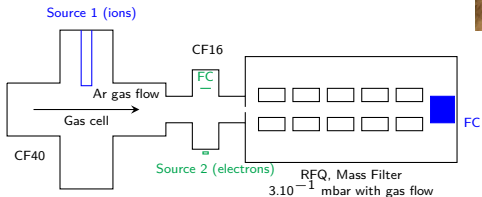
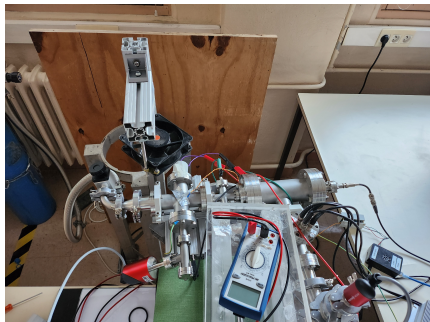
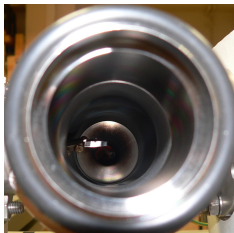
- **mRFQ :**

- ★ 5 % transmission at 1 MHz with $a = 0.23$,
 $m/\Delta m(1 \text{ MHz}) = 37$

- 1 Developments for S³-LEB gas cell improvement
- 2 Experimental tests

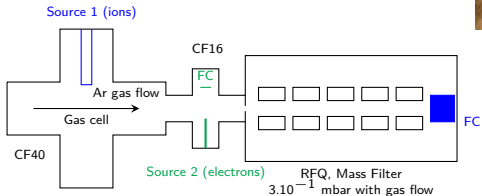
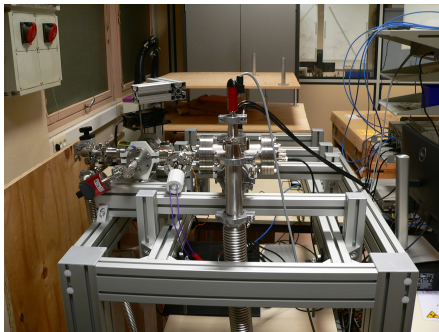
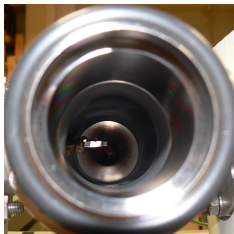


Reduced test bench



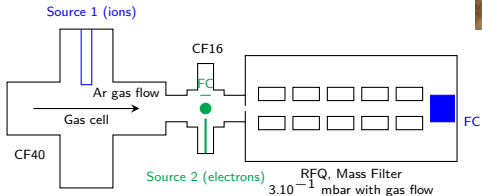
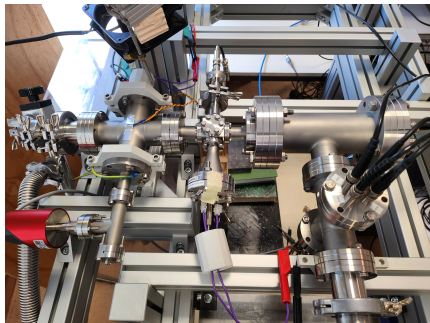
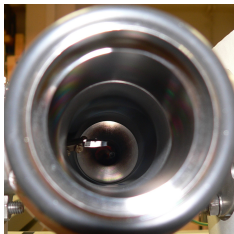


Reduced test bench



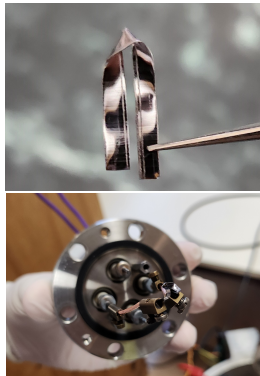


Reduced test bench





Ta foil (with or without Cs deposit)



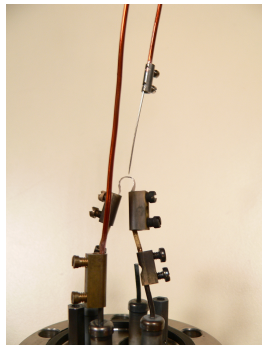
Max current obtained :
about 8 pA

Alkali pellet



Max current obtained :
● 0.8 pA in source 1 position

Discharge



Max current obtained :
about 30 pA, needle at
20-30 V

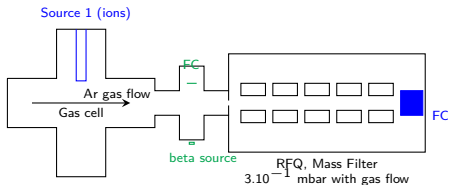


Neutralization tests

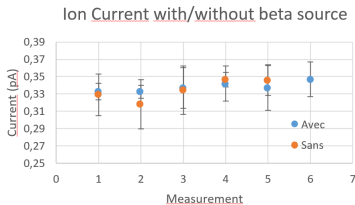
Electrons produced with 2 methods

- Beta source : no additional electromagnetic field
 - No major impact on ion current measured on the end FC
 - Measurement of electron current : only background drift observed

Effect not visible or not existing !



Cs pellet as ion source, $P_{Ar} = 100$ mbar



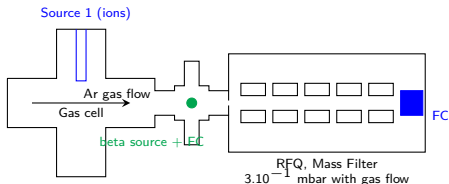


Neutralization tests

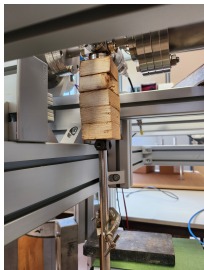
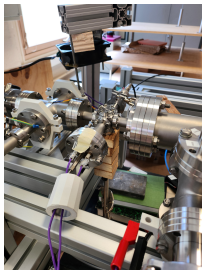
Electrons produced with 2 methods

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Effect not visible or not existing !



Perspective : Bring source closer to interaction point

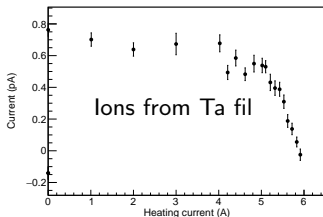
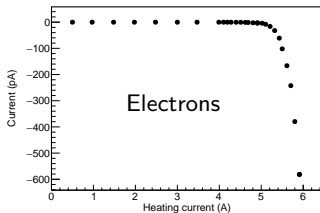
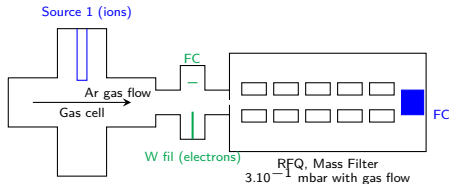




Neutralization tests

Electrons produced with 2 methods

- W filament
 - No major impact of filament potential on ion beam
 - W filament ions captured with bias

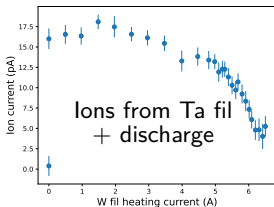
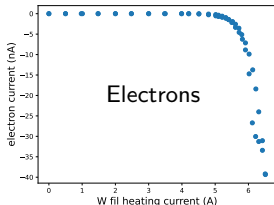
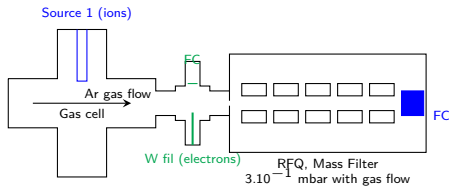




Neutralization tests

Electrons produced with 2 methods

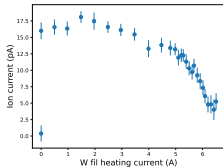
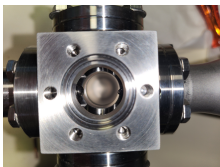
- W filament
 - No major impact of filament potential on ion beam
 - W filament ions captured with bias





Conclusion

- Test bench developed and manufactured, soon constructed
- Neutralization tests performed with W filament electrons, soon with a beta source close to interaction point



By the end of the year

- Moving to GANIL, first tests with lasers
- Manufacturing of the electrical gas cell



Acknowledgements

FRIENDS3 team @ IJCLab

Wenling Dong, SSerge Franchoo, Thierry Hourat, David Lunney, Vladimir Manea, Enrique Minaya Ramirez, and Samuel Roset

S³-LEB team

JETRIS (HIM, JGU Mainz, GSI) 



ANR-21-CE31-0001

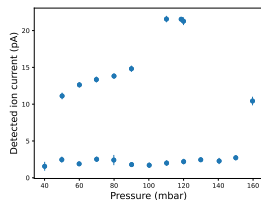
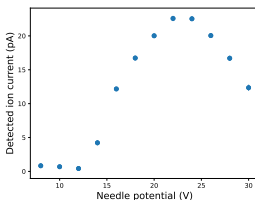
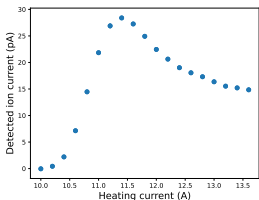
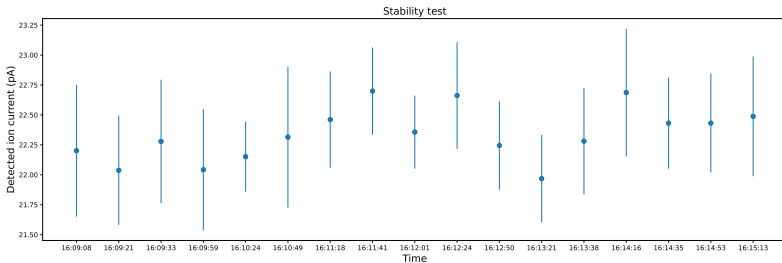


Thank you for your attention !

Backup

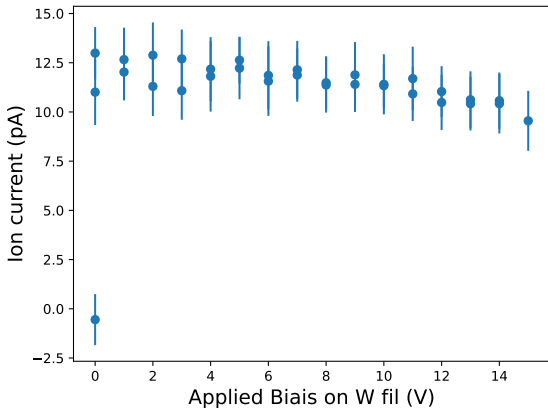


Discharge ion source characterization





Influence of bias on W filament

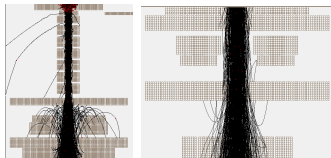




Test with 500 kHz radiofrequency in all RFQs

- Transfert mode :

- Transmission up to : 41 % at 500 kHz
- Main losses in the ion guide area (reflections at entrance, conductance at exit)



- Buncher mode :

- Transmission about : 11-15 % at 500 kHz
- Time resolving power : $t/2\Delta t(500 \text{ kHz}) = 12$

- Mass filter mode :

- Ion guide :

- ★ 6 % transmission at 500 kHz with $a = 0.23$,
 $m/\Delta m(500 \text{ kHz}) = 25$

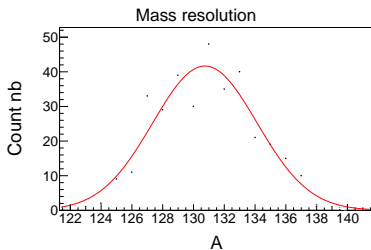
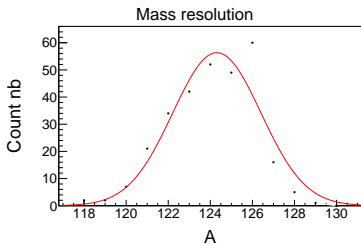
- mRFQ :

- ★ 4 % transmission at 500 kHz with $a = 0.22$,
 $m/\Delta m(500 \text{ kHz}) = 16$

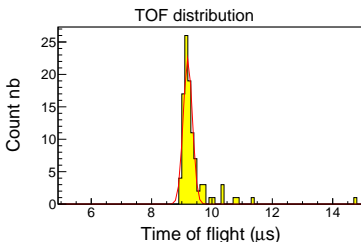


Simulations - 500 kHz

- 500 kHz (runs with 1000 ions)



Ion guide $a = 0.23$, resolving power = 25 mRFQ $a = 0.22$, resolving power = 16

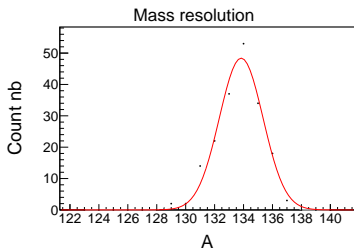
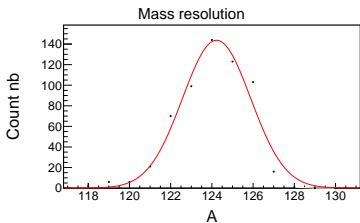


Buncher 5ms trapping time, resolving power = 12



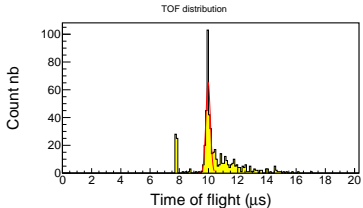
Simulations - 1 MHz

- 1 MHz (runs with 1000 ions)



Ion guide $a = 0.23$, resolving power = 31

mRFQ $a = 0.23$, resolving power = 37



Buncher 5ms trapping time, resolving power = 24



- 1 MHz : up to 83 % transmission
 - After bRFQ : > 97 %
 - After mRFQ : 97 %
 - After ion guide : 88 %
 - After detection area conductance : 85 %
- 500 kHz : up to 41 % transmission
 - After bRFQ : 75 %
 - After mRFQ : 55 %
 - After ion uide 47 %
 - After detection area conductance : 44 %