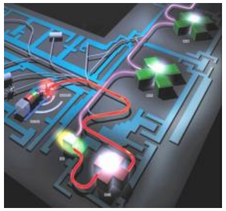
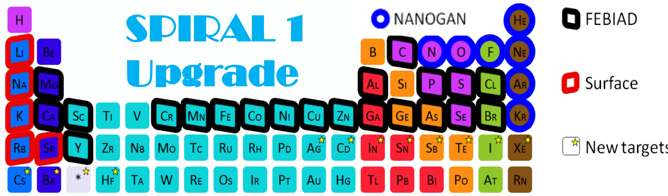
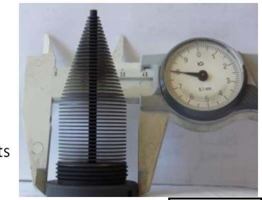






Radioactive ion beam R&D with SPIRAL 1

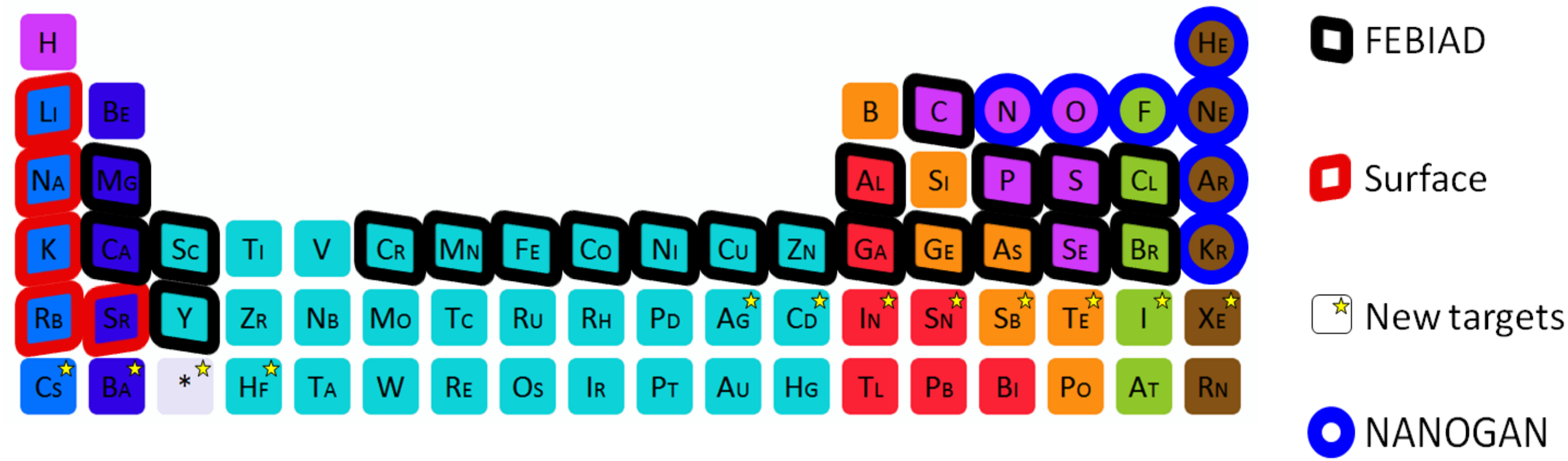
P. Delahaye for the SPIRAL 1 Upgrade team

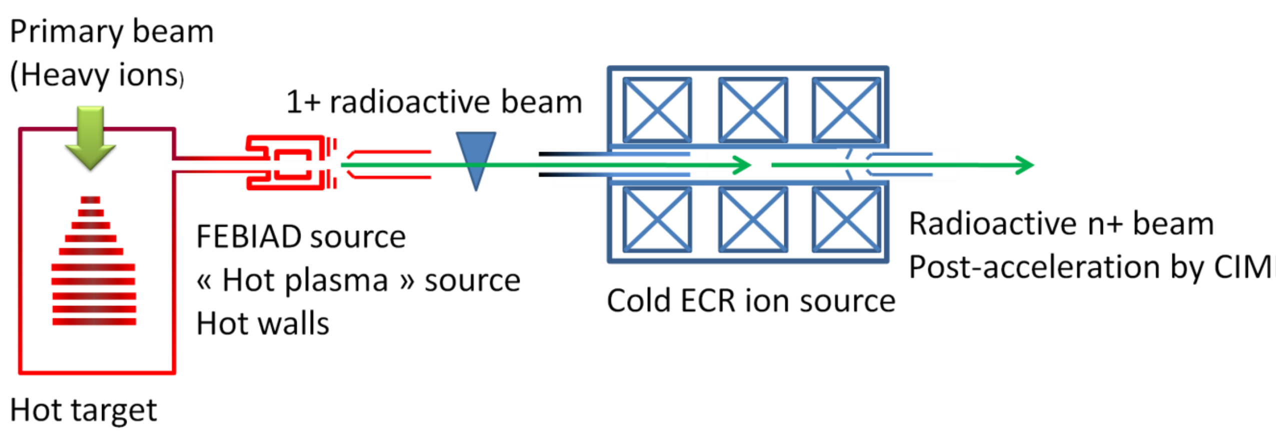
SGUI meeting, ISOLDE

3rd of May 2018

SPIRAL upgrade in a nutshell

Extending the number of elements produced by the ISOL method at SPIRAL





1+ ionisation: VADIS from ISOLDE

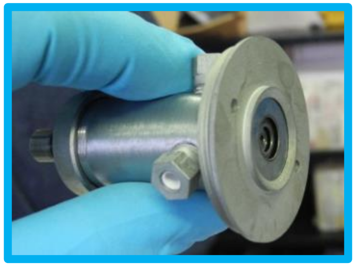
- 1+ beams from metallic elements with T_{fusion} <2000°C

Conversion from 1+ to n+: Phoenix booster

- Almost chemistry independant, charge breeding times from 10 to ~200ms

FEBIAD source

ISOLDE **VADIS**



1+ beams from metallic elements with T_{fusion} <2000°C

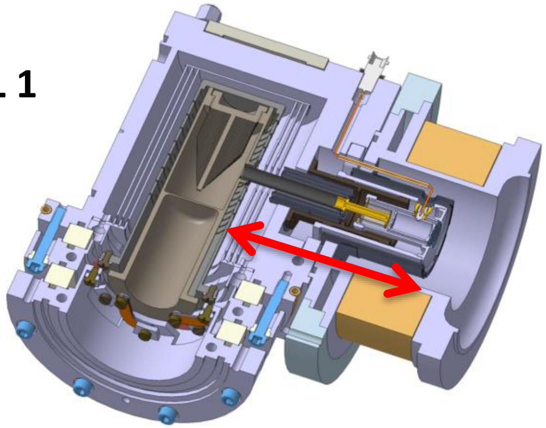
2011 -2013 - Different tests at SIRA and SPIRAL 1

Coupling of the SPIRAL 1 targets with the VADIS

Dilatation problems are fixed

- Ion source sliding against its axis
- oven attached to container

Record temperature of 2400°C attained

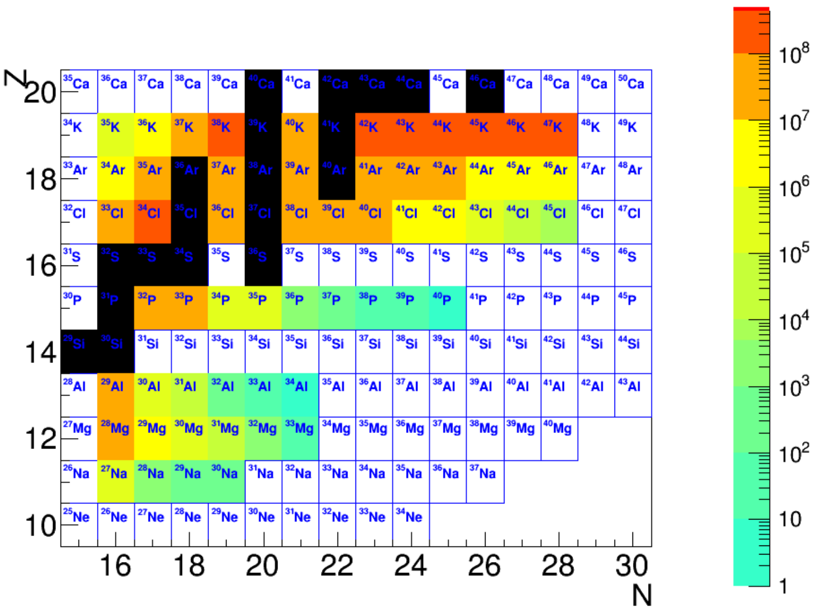


O. Bajeat et al, NIM B 317(2013)411

Dec. 2013: tests at nominal power at SPIRAL 1

P. Chauveau et al, NIM B 376(2016)35

1+ beam intensities (pps)



Day 1 beams from FEBIAD TIS test results with ^{36}Ar@95AMeV at nominal power at SPIRAL 1

Already 7 new elements

Na, Mg, Al, P, Cl, Cu, Fe

+ many more to come

2014- 2015: reliability tests

- Failing BeO insulators exchanged
- High voltage discharges at extraction fixed

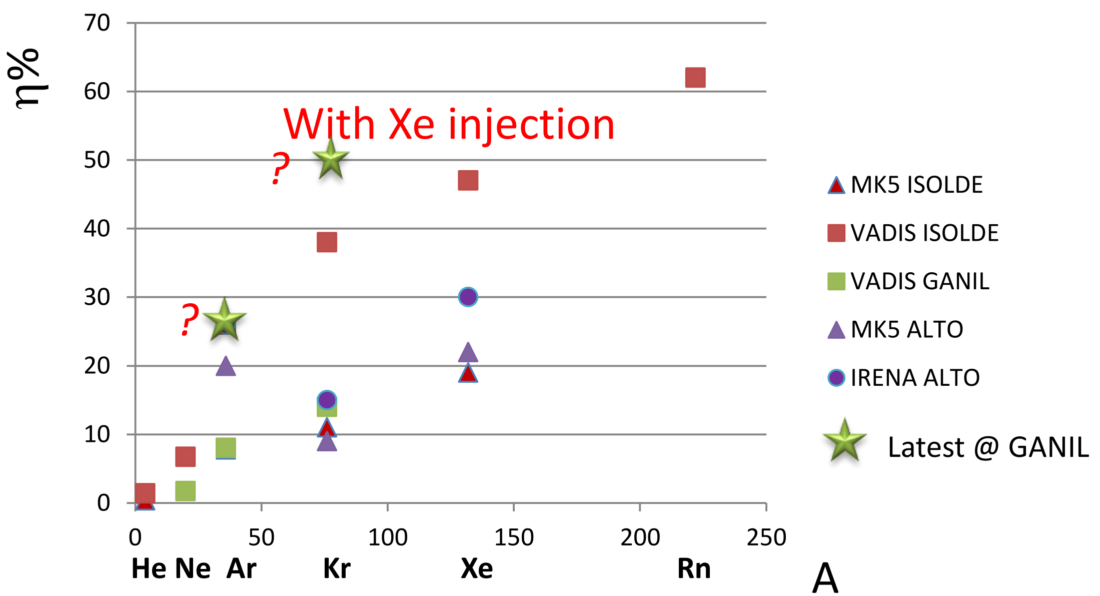
More than 3 weeks running with stable efficiencies

FEBIAD source - status - April

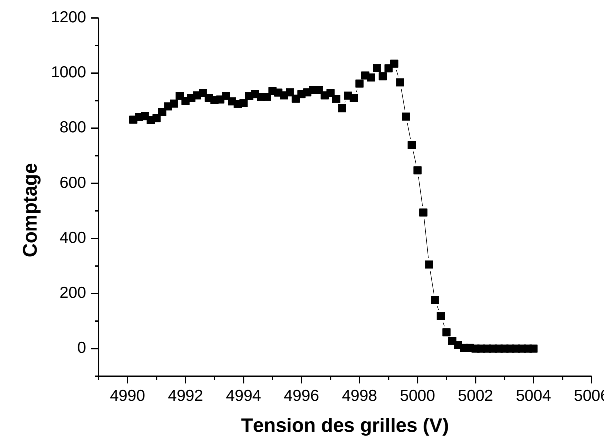
2 ion target ion sources

- 2 conditioned on the SPIRAL 1 test bench

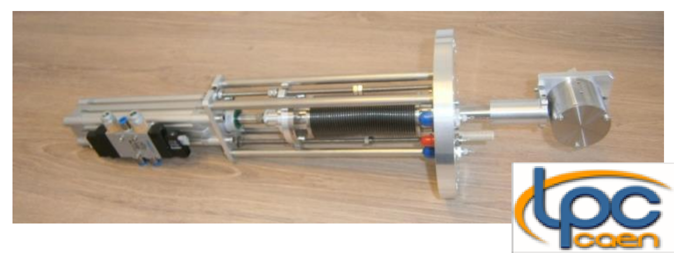
Ionisation efficiency measurements



Energy profile measurement



Simulations: M. Herbane, LPC Caen



Ref: L. Penescu et al, Rev. Sci. Instrum. 81, *P. Chauveau et al, NIM B 376*, S. Essabaa et al NIM A 317

Using a calibrated leak with gas injection: $\eta = I1+/Igaz$

Intensity increase to be confirmed on long term

Yield estimates use conservative efficiencies

Charge breeding efficiency depends on δE

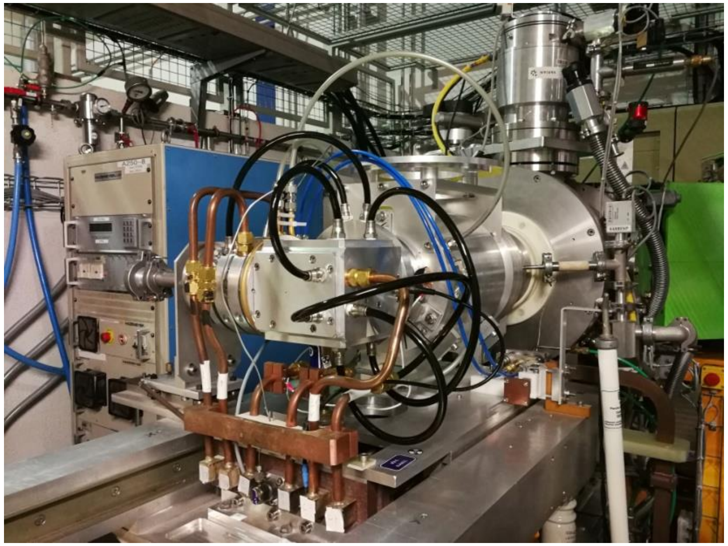
σ_E~1.5eV

FEBIAD source - status - May

2 ion target ion sources

- 1 failed during the beginning of the experiment!
  - Anode in shortcut, BN insulators were incriminated
- 1 broken on test bench, reconditionned and modified, now online
  - Rapid modifications to cool and protect new BeO insulators
  - First tests show that the ionisation is ok, but slow release probably due to a too low primary beam power on target

  - Next test beamtime with ^{36}Ar at nominal power on the 10th-11th of May

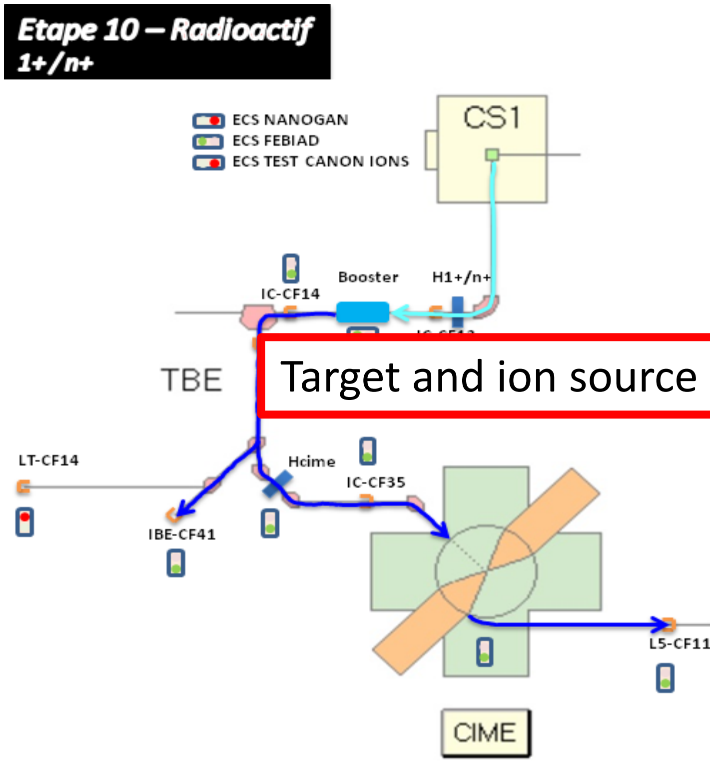


Goals:

- Reproducing the beam intensities obtained in 2013
- Preparing the MUGAST campaign: ^{28}Mg, ^{25}Al, ^{30}P
- First charge breeding of radioactive isotopes: $^{37}K^{+} \rightarrow {}^{37}K^{x+}$

Radioactive ion beam commissioning

2018 – run 1



Accepted experiments:

- ***Resonant proton elastic scattering on 17F and 2-proton emission from excited states in 18Ne*, G. F. Grinyer et al (E750)**

17F was observed as BeF molecule with dissociating BeO insulator
F atomic beams in principle well produced with FEBIAD sources

Target and ion source failure due to a shortcut of the anode

ragmentation using the FEBIAD, directly followed by the experiment

- ***Direct isospin mixing measurement in Coulomb excitation of an ^{38m}K isomeric beam from SPIRAL1*, G.De France et al (E737)**

^{38m}K from ^{58}Ni fragmentation ok but not from transfer reaction with ^{36}Ar
Population of the isomeric state depends on the reaction mechanism!

Testing **^{38m}K from ^{40}Ca fragmentation**

R&D for future beams - *Beamlab activities*:

- **Priorities from GANISOL review 2016/7/4**
- **Preparing the MUGAST campaign – 2019/2020**

- From **^{40}Ca fragmentation**: test of of production of **^{25}Al and ^{30}P** (LoI De Séréville et al)

- Te

Recovering with tests: yields from ^{40}Ca and ^{36}Ar fragmentation

- Stripping to get rid of ^{56}Co and ^{56}Fe

Organisation of the target and ion source R&D

Different developments

- Testing production with new primary beam on C target
- New Target or … new ion source

	Delay (Month)	Number of TISS	GPI HR (supply, assembling, test) MM
Already exists	12	1	4
To be tested	18	1	6
To be improved and tested	24	1 to 2	12
To be designed and tested	36	1 to >2	12 + 36 (PhD student)
Difficult			

Ressources for 1 TISS	
Cost	25->50k€
Design	4 MM
Quotation	1 MM
Safety evaluation	1 MM

Evaluation in **GANISOL** ISOL beams for GANIL reviews after each PAC meeting

Direction + TISS developpers + 4 external physicists (T. Stora, M. Assié, B. Blank, N. Orr)

List of priorities - from Review 2016/07

Test of new beams with C targets

1) ^{30}P and ^{25}Al from ^{36}Ar fragmentation - 2018

2) ^{56}Ni, ^{48}Cr from fragmentation of ^{58}Ni. For ^{56}Ni: ^{56}Co contamination to evaluate. – 2019 ?

3) Beams (^{79}Se, ^{60}Fe, ^{67}As) from ^{86}Kr fragmentation. – 2019 / 2020?

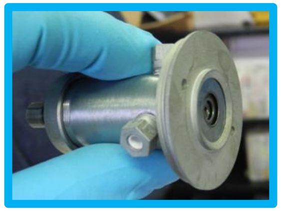
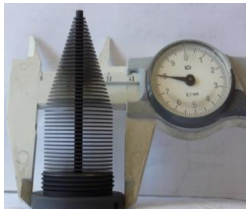
Development of new targets *All science driven (LoIs)*

1) Nb for production of high intensities for beams with 30<Z<40

1) ex aequo Fusion evaporation targets (N=Z nuclei)

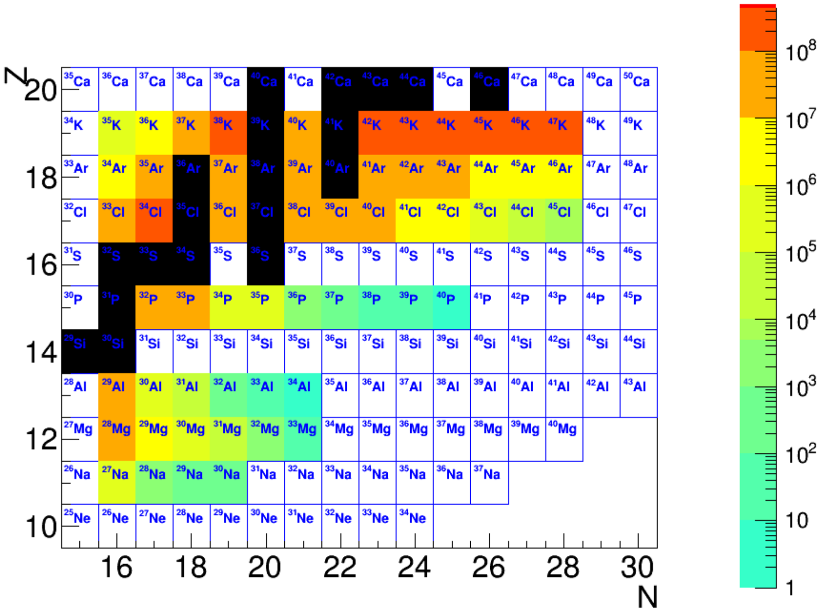
Beyond commissioning…

From day 1 beams…

ISOLDE FEBIAD + Graphite targets

1+ beam intensities (pps)



To longer term: 2018-…

New targets:

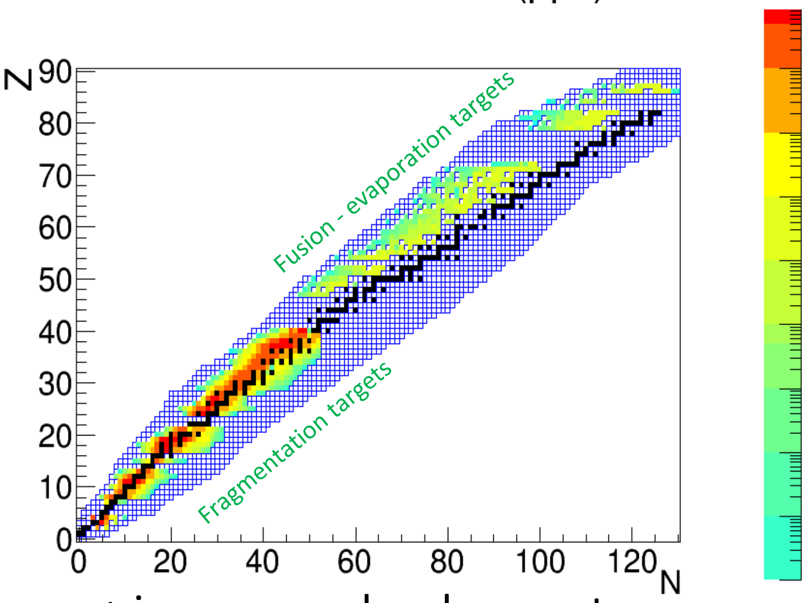
Fragmentation targets

- **Nb** target design is ongoing
- Others under study (**SiC, Al2O3, CaO**…)

Fusion evaporation targets

- thin **Ni** target (PhD thesis V. Kuchi)

1+ beam intensities (pps)



+ ion source developments

Collaborations within EURISOL/Beamlab within ENSAR2

Fusion evaporation targets

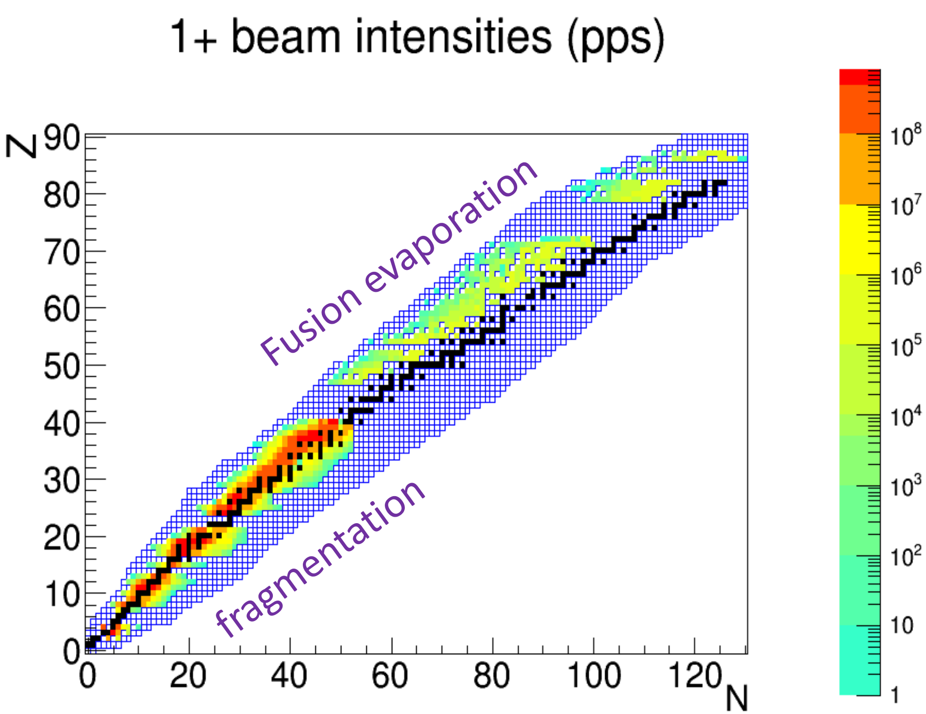
List of priorities from the GANISOL review 2016, July 4th

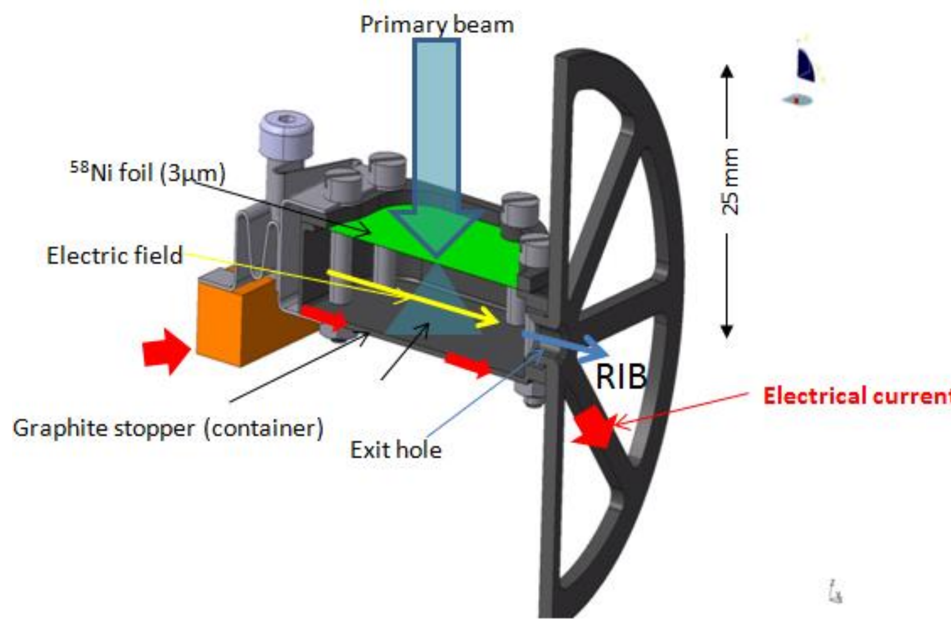
Ongoing developments
To be tested at SPIRAL at the earliest in 2020

Fusion evaporation target ion source development

- neutron deficient isotopes such as ^{74}Rb, ^{114}Cs, N=Z for DESIR

Offline test 2017-2018
Ionisation efficiency and rapidity measurement
Online test at ALTO earliest 2019
Online test at SPIRAL earliest 2020





ECS fusion evaporation V. Kuchi, P. Jardin

Interest to test SnS formation at ALTO within Beamlab

Collaboration with IPN Orsay – first test possible in 2019 with the Tandem

Fusion evaporation targets

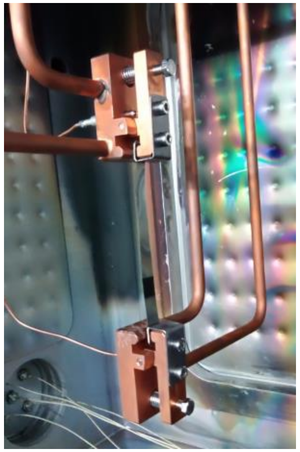
List of priorities from the GANISOL review 2016, July 4th

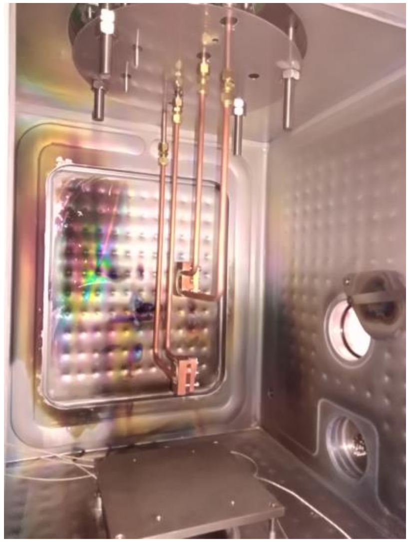
Ongoing developments
To be tested at SPIRAL at the earliest in 2020
Fusion evaporation target ion source development

- neutron deficient isotopes such as ^{74}Rb, ^{114}Cs, N=Z for DESIR

Offline test 2017-2018
Ionisation efficiency and rapidity measurement
Online test at ALTO earliest 2019
Online test at SPIRAL earliest 2020

- **Ongoing measurement of emissivity of target foils**





Test setup
Measurement of emissivity with a 2 wavelength pyrometer

- **ANR ‘TULIP’ (Target Ion Source for Short-Lived Ion Production) has been submitted**

Collaboration with IPN Orsay – first test possible in 2019 with the Tandem

GANISOL
ISOL beams for GANIL

SPIRAL upgrade team

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C. Couratin *(now IKS leuven)*
M. Dubois (chef de projet)
P. Delahaye (resp. scientifique)
M. Fadil
R. Frigot
S. Hormigos
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P. Lecomte
N. Lecesne
L. Maunoury
B. Osmond
V. Toivanen (postdoc)
E. Traykov *(now IPHC)*
J. C. Thomas
…

T. Stora
C. Seiffert
F. Wenander
L. Penescu

E. Lienard
G. Ban
X. Fléchard
D. Durand

J. Angot
T. Lamy

R. Vondrasek

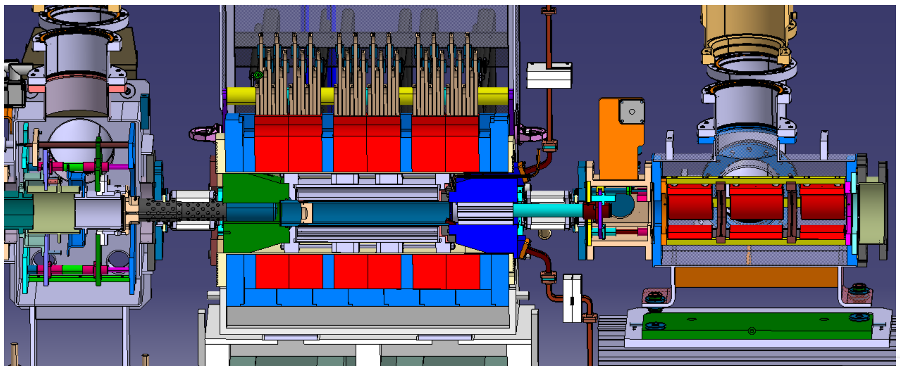
Acknowledgements to


TEAM UP GRADE SPIRAL1
patCréat 2017

Phoenix ECR charge breeder

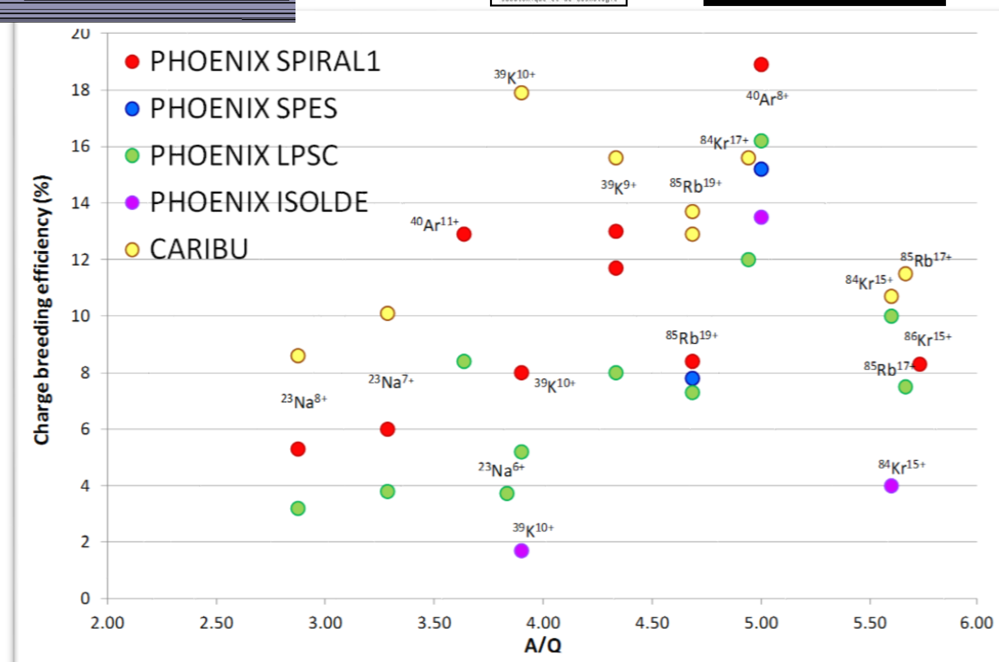
Former ISOLDE ECR charge breeder

➢ Upgraded with new Al plasma chamber, UHV vacuum,2 RF ports and gas injection, injection triplet, mobile injection and puller electrodes



With contributions from

➢Tested at LPSC in summer 2015



High efficiencies with stable beams

Rare gases and alkalis

L. Maunoury et al, Rev Sci Instrum. 87(2016)02B508