Latest improvements of the SPIRAL1 facility at GANIL

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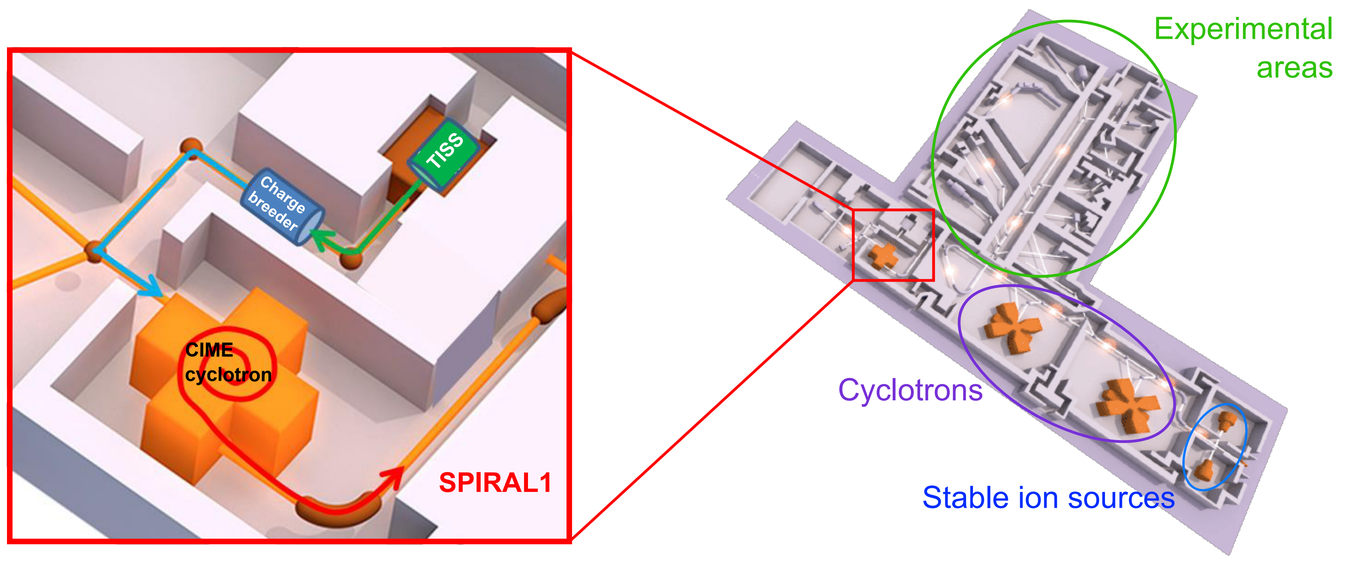
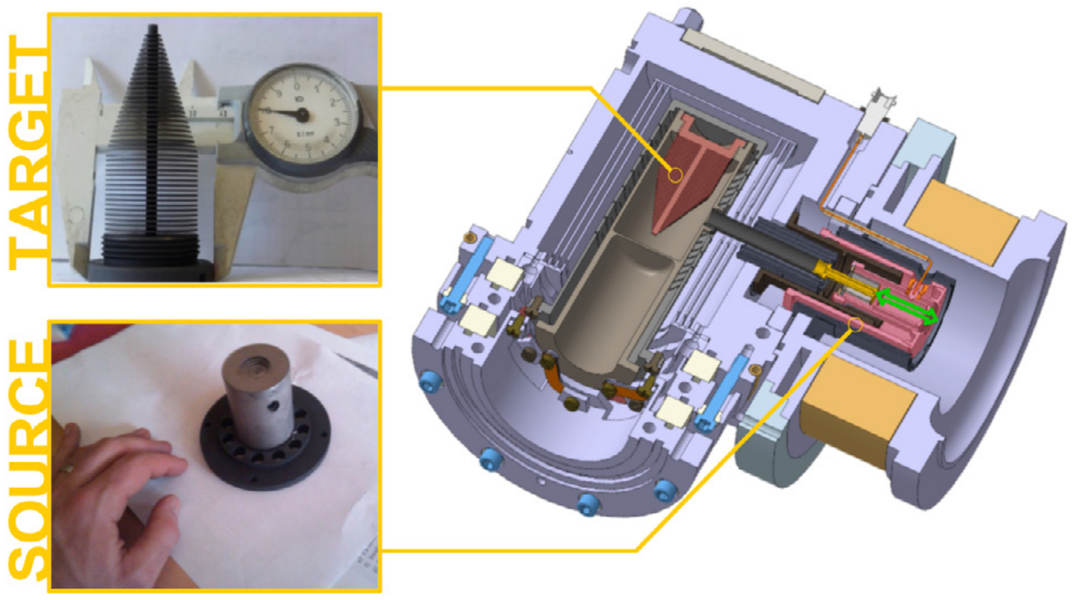
Context

Radioactive ion beams (RIBs) offer opportunities for physicists to explore the properties of nuclear matter in ever more exotic nuclei. The SPIRAL1 facility at GANIL (Caen, France) is a RIB factory using the ISOL method. It has been providing post-accelerated RIBs to experimental areas since 2001. Over the last decade, SPIRAL1 has been upgraded [1] to provide beams of condensable elements, by combining a FEBIAD-type ion source [2] (producing 1+ ions) and a PHOENIX ECR charge breeder (to increase the charge state for post-acceleration). Significant progress has been made in the past 3 years on the FEBIAD source and the charge breeder.



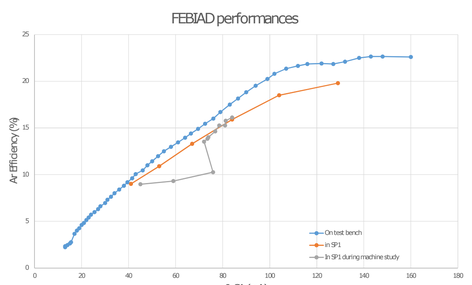
The FEBIAD ion source

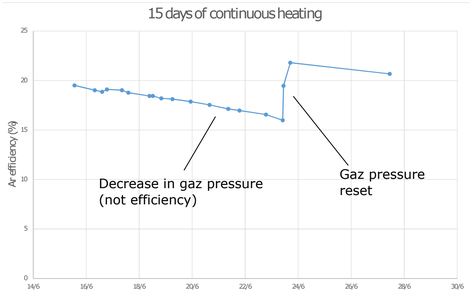
Spiral1 was initially limited to gaseous elements with a Nanogan ECR source, but was then upgraded to be compatible with other types of source. In particular the FEBIAD ion source, capable of producing 1+ ions of condensable elements, is intended to be the work horse of the SPIRAL1 facility in the coming decade.



After several years of test and many design improvements [3-5] our FEBIAD ion source is now showing excellent performances :

- **Efficient** : ^{40}Ar efficiency up to 25%
- **Resilient** : TISS (Target-Ion Source System) #55 has been irradiated 36 hours was kept at Eff_{Ar}=20% for 15 days without loss of performance.
- **Stable over time** : same performances 3 months appart.
- **Reliable** : same results on test bench and Spiral, and between 2 TISS.





Latest online results

Most recent FEBIAD post-accelerated beams:

Isotope	Post-accelerated rate (pps)	Energy (MeV/A)
38mK	8.00E+05	9
47K	6.00E+05	7.7

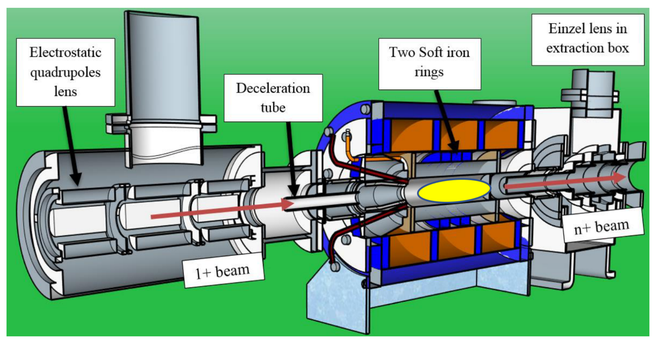
Low energy rates.
/100 for post-accelerated beams.

36Ar@74MeV/A 850W beam ->12C target			
Mass	Isotope(s)	T1/2 (s)	rate@1200W
20	8Li	0.84	1.00E+05
21	20Na	0.4479	1.38E+06
	21Na	22.49	1.13E+07
23	1H20F	11	3.90E+04
	23Ne	37.25	1.43E+06
24	23Mg	11.3046	4.27E+06
	24Ne	202.8	2.18E+05
	24Na	53989.2	9.29E+07
	24Na_m	0.0202	2.87E+05
25	24Al	2.053	9.47E+02
	25Al	7.183	3.80E+04
	25Na	59.1	8.67E+06
	25Ne	0.602	6.52E+03
26	25Na 100V	59.1	8.00E+06
	26Na	1.07128	2.21E+05
27	26Al_m	6.346	9.22E+04
28	27Mg	567.5	2.62E+06
29	28Al	134.7	3.27E+06
	29Al	394	1.14E+06
30	29Mg	1.3	2.27E+03
31	30Al	3.62	1.30E+03
	31Cl	0.19	8.05E+02
32	C19O	26.91	1.92E+03
	32Ar	0.098	1.16E+03
33	32Cl	0.298	8.52E+04
	33Ar	0.173	9.81E+04
34	33Cl	2.511	2.21E+06
	34Ar	0.8438	7.02E+06
	34Cl	1.5266	2.39E+07
35	34mCl	1919.4	7.90E+07
	H34mCl	1919.4	1.89E+07

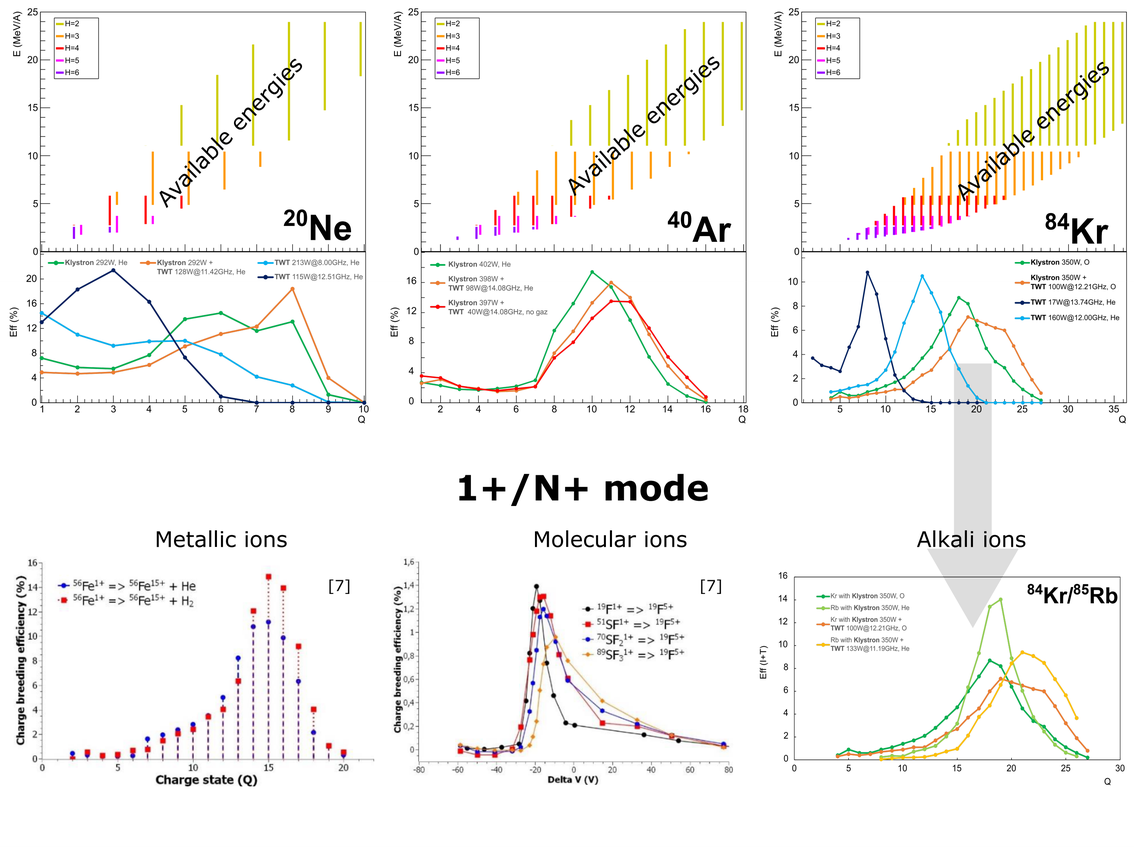
84Kr@67MeV/A 10W beam ->12C target			
Mass	Isotope(s)	T1/2 (s)	rate@500W
80	80Rb	34	7.13E+07
79	79mKr	50	3.28E+07
	79Kr	126144	6.39E+07
	79Rb	1374	1.14E+07
	79mBr	4.85	8.17E+06
	78mRb	344.4	1.98E+06
78	78Rb	1059.6	3.89E+05
	78Br	387	4.69E+07
77	77Rb	226.8	5.20E+05
	77Kr	4275	2.81E+07
	77mBr	256.8	5.29E+07
	77Br	205344	7.59E+07
	77mSe	17.36	3.08E+04
76	76Rb	36.5	2.37E+04
	76Kr	53280	7.21E+06
	76Br	58320	6.00E+07
	76mBr	1.31	1.53E+06
75	75Kr	276	8.03E+05
	75Br	5802	4.26E+07
	75Ga	126	1.22E+04
	75Ge	4966.8	1.98E+05
71	71Se	284.4	2.63E+04
	71As	235080	2.26E+07
	71Zn	147	1.96E+04
	71mZn	14256	1.67E+05
69	69As	912	1.86E+05
	69Ge	140580	1.39E+07
	69mZn	49521.6	2.66E+06
	69Cu	171	4.22E+04
68	68mCu	225	7.03E+04
	68Ga	4062.6	1.42E+07
67	67Ge	1134	1.74E+05
	67Ga	281810.88	4.42E+07
65	65Ga	912	6.92E+06
	65Ni	9061.884	4.53E+04

The Charge Breeder

The charge breeder (CB) [6] is used to increase the charge state of the 1+ beams from the FEBIAD source for post-acceleration. It can also be used directly as a gaseous ion source in parallel of the FEBIAD beams.



The CB has been recently equiped with a TWT-type amplifier, in addition to the existing Klystron. This enables variable single frequency heating and double frequency heating, allowing some control over the charge state distribution and improved plasma stability. These new modes have been tested both with gaz and 1+ beams, with promising results.



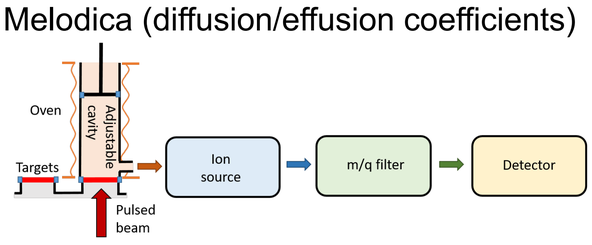
Perspectives

Fully operational FEBIAD source and charge breeder ⟶ Spiral1 could be the place for your experiment. **Please tell us what you need !**

New are beams of interest are being developped (^{8}Li, ^{85}Kr, ^{48}Cr)

Ongoing R&D :

- Tulip (new TISS for production n-deficient RIBs)
- Melodica (diffusion/effusion coefficients)



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