GANIL OPERATION STATUS AND UPGRADE OF SPIRAL1

O. Kamalou, *F. Chautard, L. Maunoury, O. Bajeat, P. Delahaye, M. Dubois, P. Jardin.*
GANIL, FRANCE

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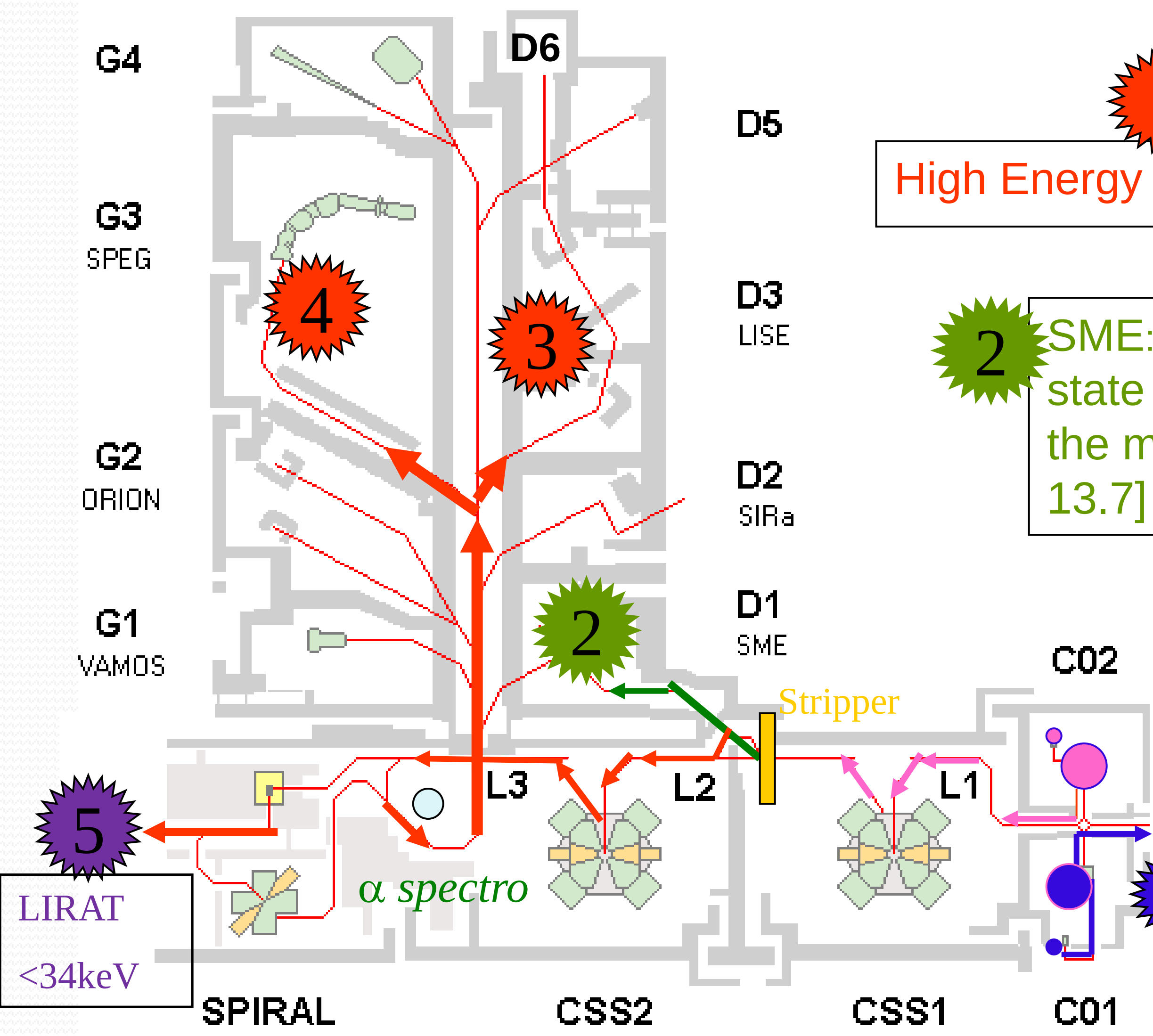
OUTLINE

- Operating modes at GANIL
- Running statistic
- Radioactive beam with <<ISOL>> Method
- SPIRAL 1 UPGRADE
  - ECR multi-ionization
  - 1+FEBIAD source
  - First tests
  - Charge breeder
- Schedule and organization

Operating Mode at GANIL



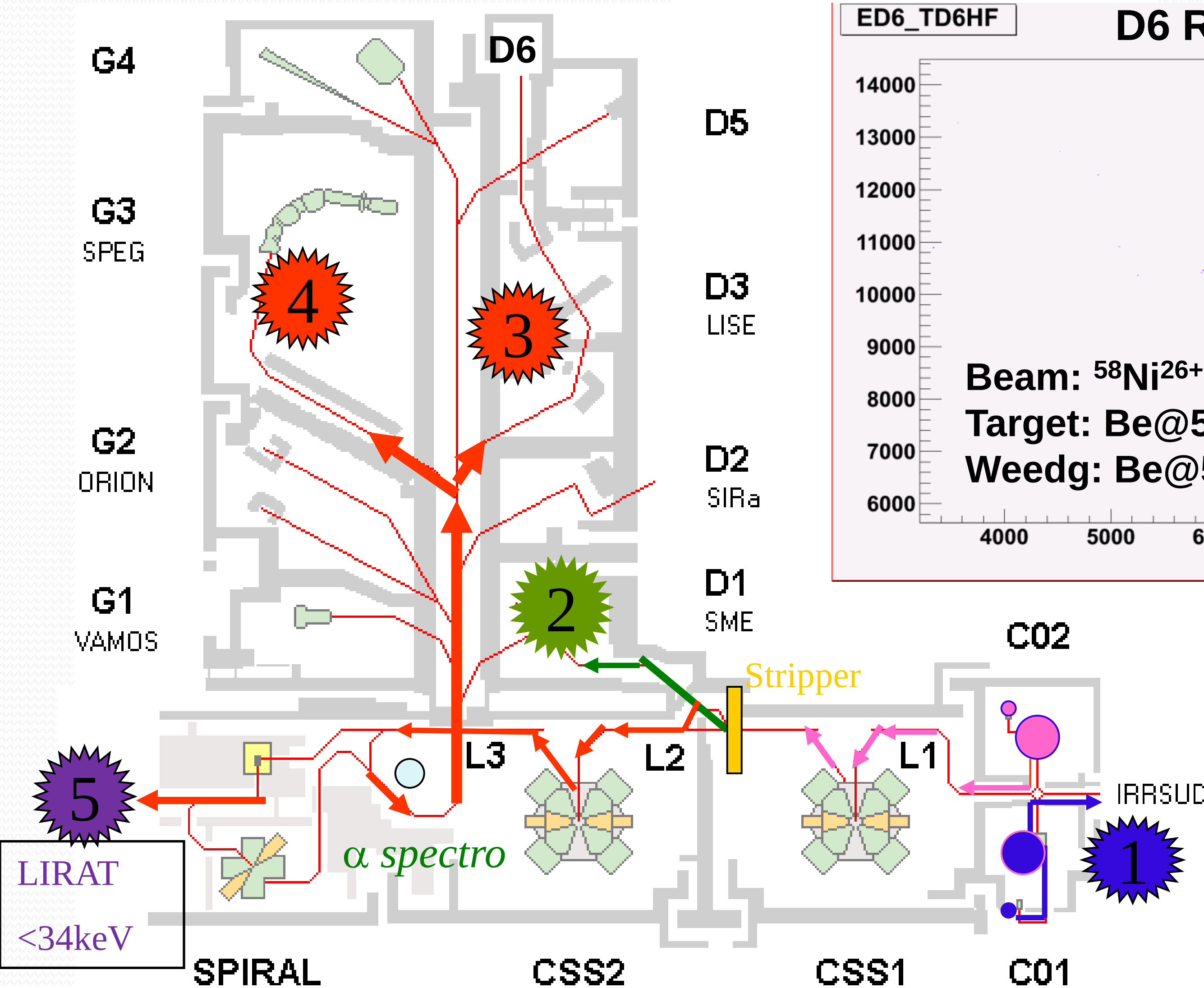
3 4
High Energy Beam GANIL [24, 95] MeV/u

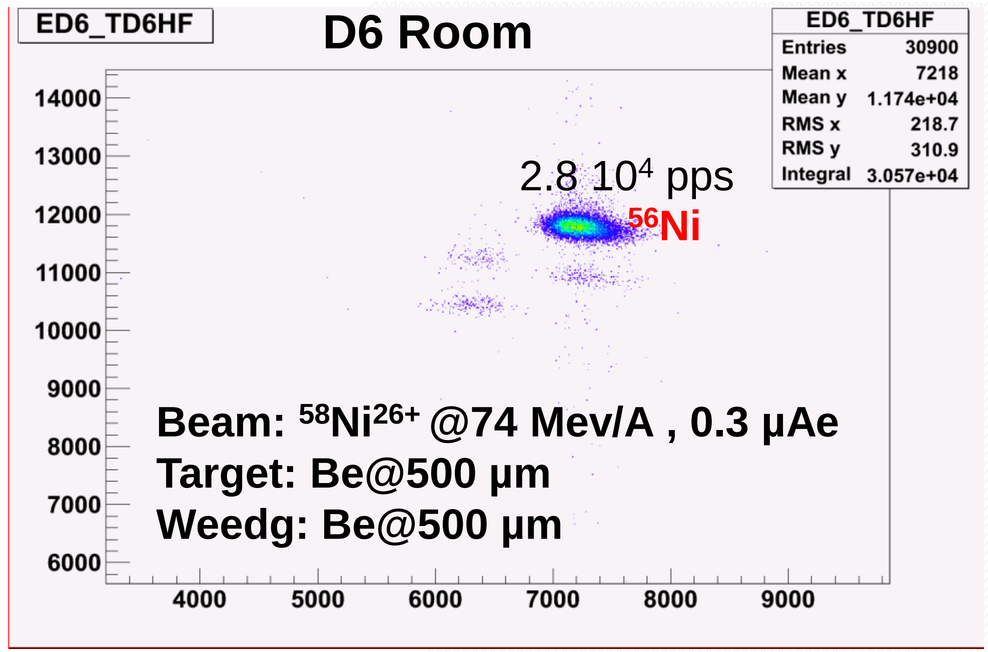
2
SME: after a stripper, one charge state is sent to the D1 room => the medium energy exit [3.7, 13.7] MeV/u

IRRSUD: low energy beam irradiation line

[0.3, 1.0] MeV/u
1

Operating Mode at GANIL





IRRSUD: low energy beam irradiation line

[0.3, 1.0] MeV/u

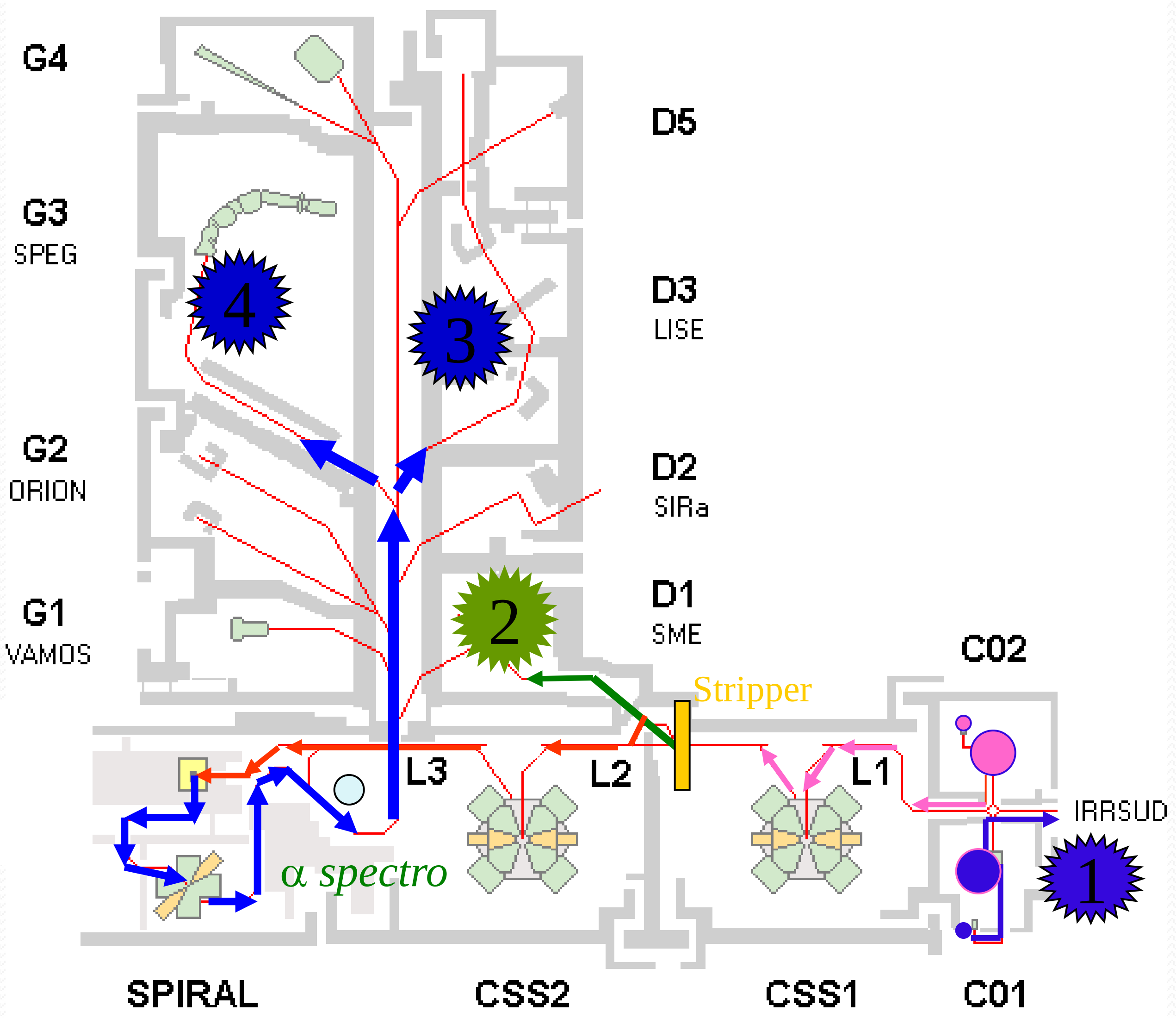
Intense Primary beams

2.10[13] pps Safety limitation reached

Possible improvement

Beam	Imax [µAe]	[pps] <2 10^{13}	Emax [MeV/A]	Pmax [W] <6kW	Used with Spiral
$^{12}C^{6+}$	18	1.9 10^{13}	95	3 200	
$^{13}C^{6+}$	18	2. 10^{13}	80	3 000	X
$^{14}N^{7+}$	15	1.4 10^{13}	95	3 000	
$^{16}O^{8+}$	16	10^{13}	95	3 000	X
$^{18}O^{8+}$	17	10^{13}	76	3 000	X
$^{20}Ne^{10+}$	17	10^{13}	95	3 000	X
$^{22}Ne^{10+}$	17	10^{13}	79	3 000	
$^{26}Mg^{12+}$	20	10^{13}	82	3 600	X
$^{36}S^{16+}$	11	5 10^{12}	77.5	1100	X
$^{36}Ar^{18+}$	16	5.5 10^{12}	95	3 000	X
$^{40}Ar^{18+}$	17	6. 10^{12}	77	3 000	
$^{48}Ca^{19+}$	4-5	1.3 10^{12}	60	600-700	X
$^{58}Ni^{26+}$	5	1.2 10^{12}	77	860	
$^{76}Ge^{30+}$	5	1.2 10^{12}	60	760	
$^{78-86}Kr^{34+}$	7.5	1.4 10^{12}	70	1200	X
$^{124}Xe^{46+}$	2	2.7 10^{11}	53	300	

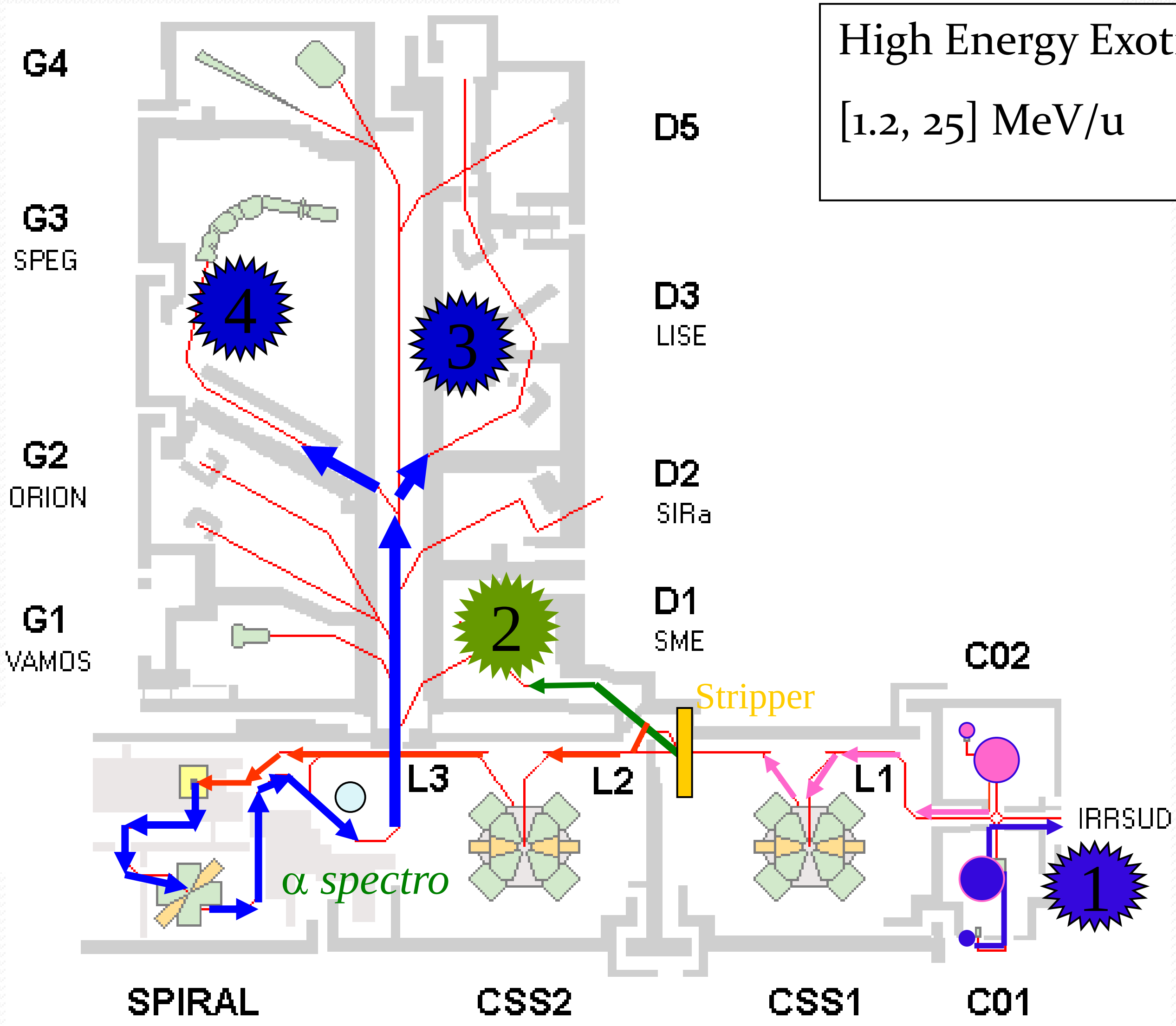
SPIRAL 1 Operating Mode



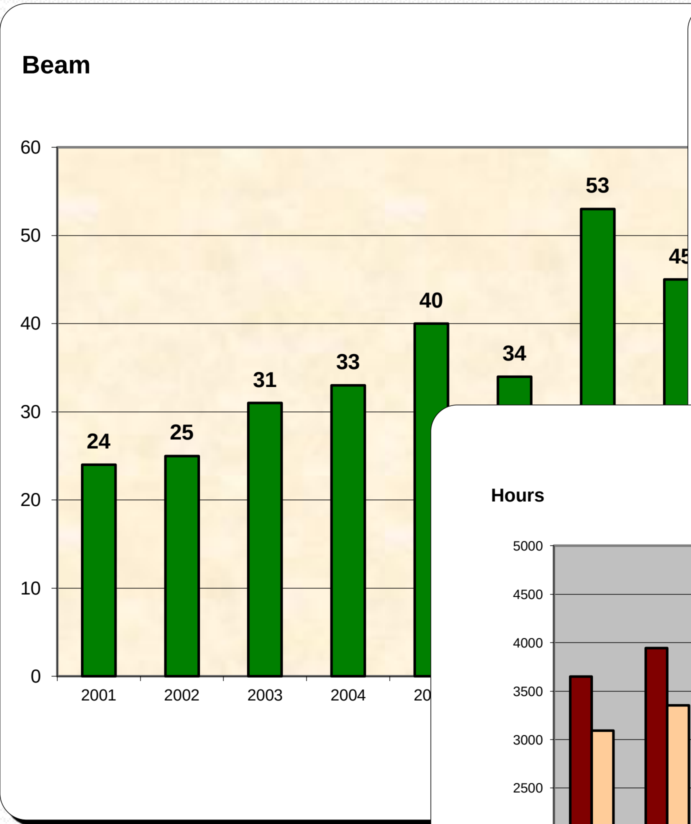
SPIRAL 1 Operating Mode

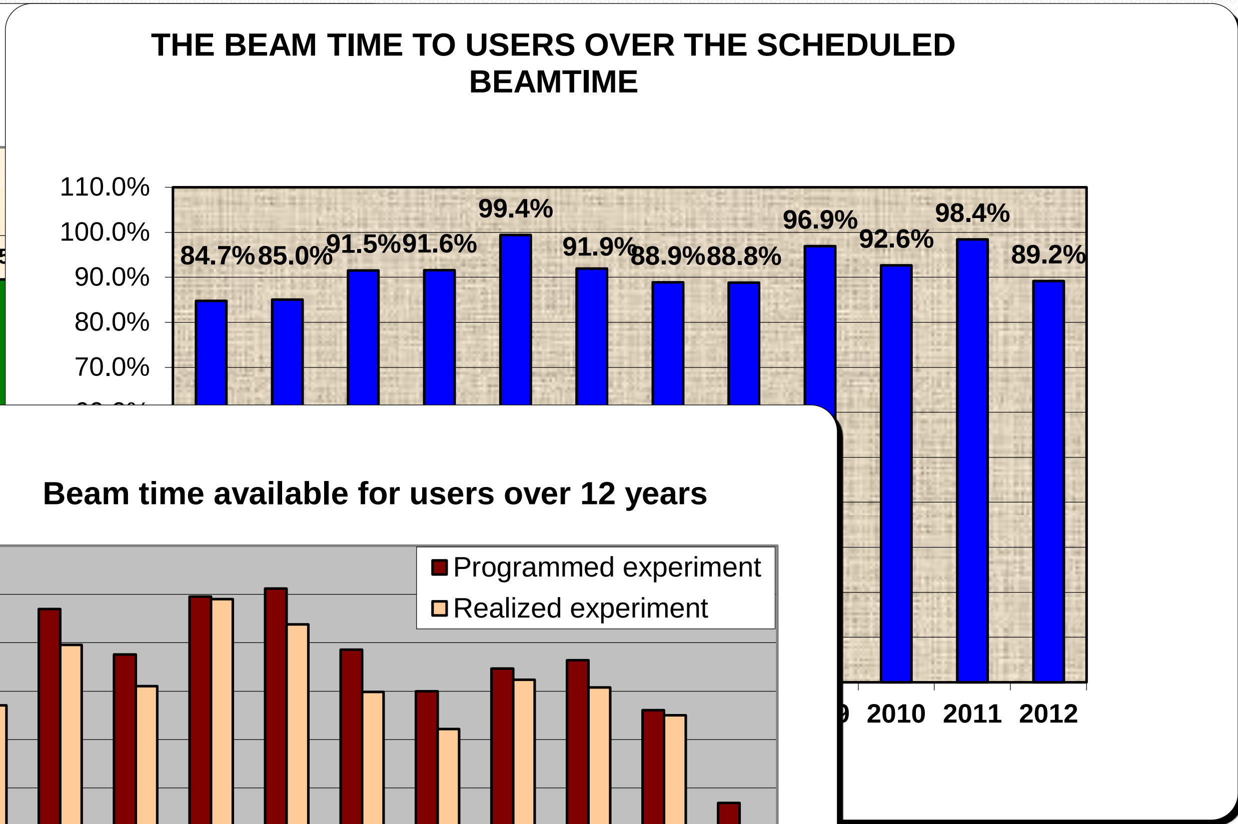
High Energy Exotic Beam

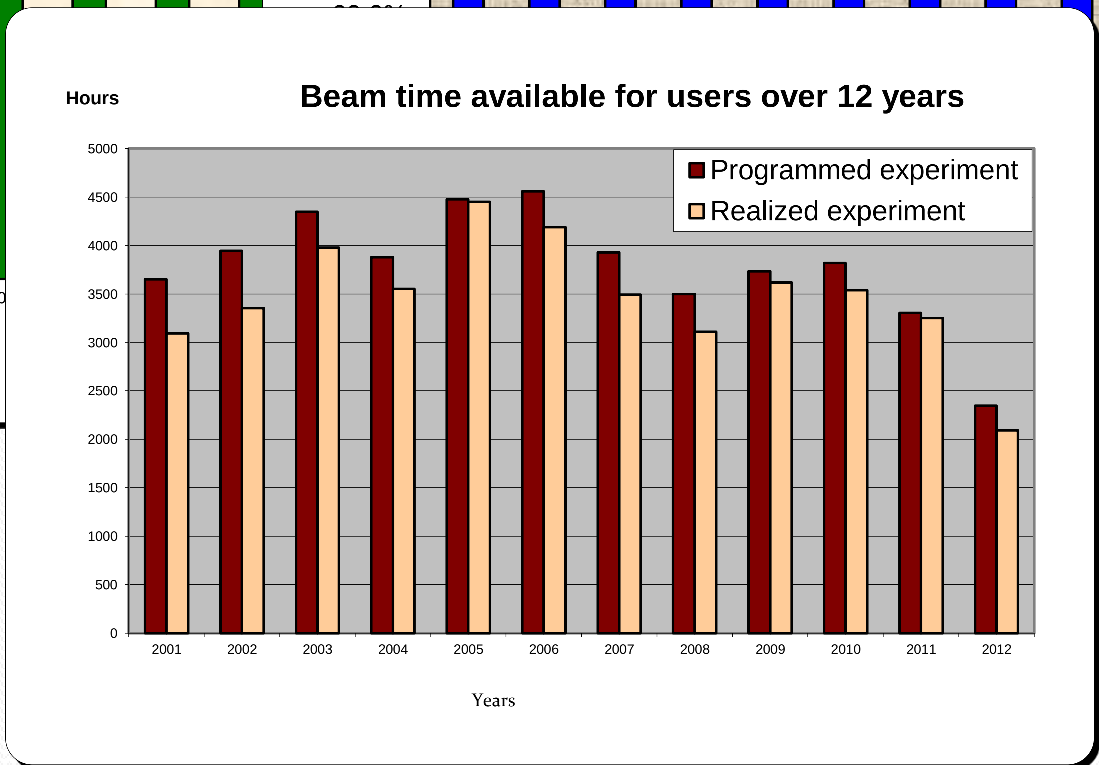
[1.2, 25] MeV/u 3 4



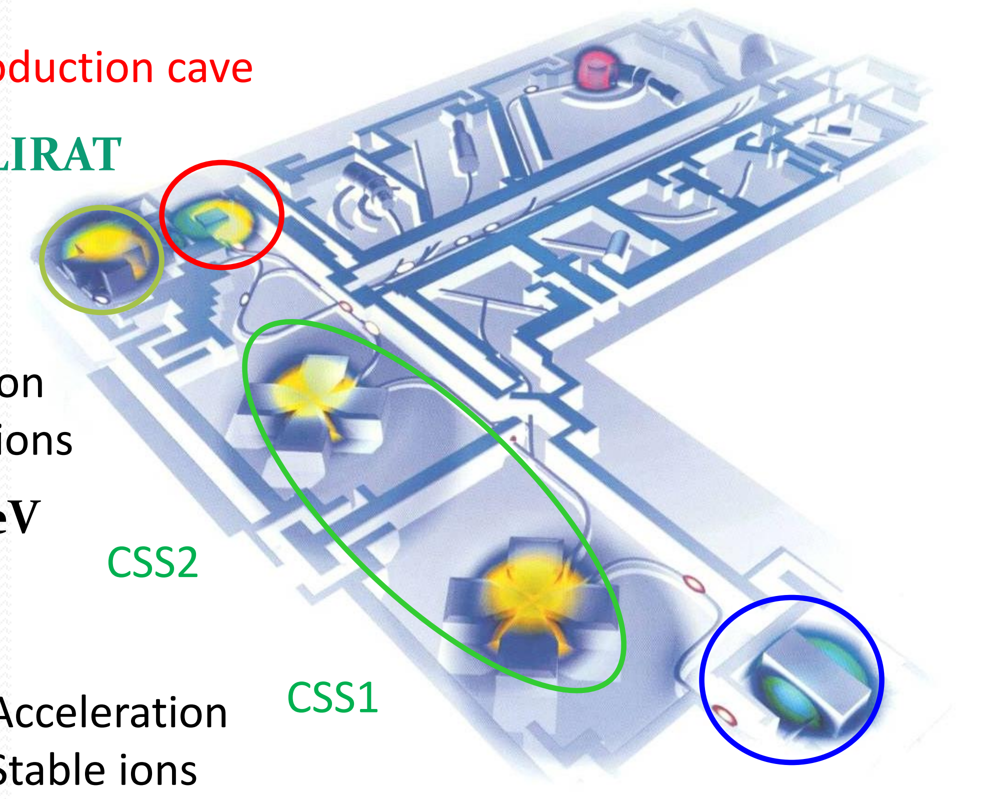
Running statistic From 2001 to 2012







Radioactive ion beams with «ISOL» Method



Post-acceleration
Of radioactive ions

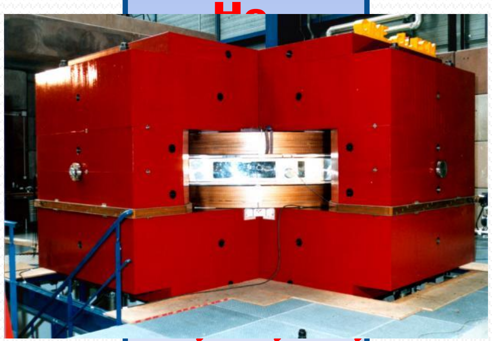
Up to 25 AMeV

Acceleration
Stable ions

CIME:
« Cyclotron d'ions de moyenne énergie »

Targets

3 kW



N, O, F

Heavy ion fragmentation on graphite targets

^{12}C to ^{78}Kr up to 95AMeV

Exotic beams production

ions	W [MeV/u]	[pps]	ion	W [MeV/u]	[pps]
6He	3.8	$2.8\ 10^{7}$	20F	3	$1.5\ 10^{4}$
6He	2.5	$3.7\ 10^{7}$	17Ne	4	4.10^{4}
6He	5	3.10^{7}	24Ne	4.7	2.10^{5}
6He	LIRAT (<34 keV/u)	2.10^{8}	24Ne	7.9	$1.4\ 10^{5}$
6He	20	5.10^{6}	24Ne	10	$2\ 10^{5}$
8He	3.5	1.10^{5}	26Ne	10	3.10^{3}
8He	15.5	1.10^{4}	31Ar	1.45	1.5
8He	15.4	$2.5\ 10^{4}$	33Ar	6.5	3.10^{3}
8He	3.5	6.10^{5}	35Ar	0.43	4.10^{7}
8He	3.9	8.10^{4}	44Ar	10.8	2.10^{5}
14O	18	4.10^{4}	44Ar	3.8	3.10^{5}
15O	1.2	$1.7\ 10^{7}$	46Ar	10.3	2.10^{4}
19O	3	2.10^{5}	74Kr	4.6	$1.5\ 10^{4}$
20O	3	4.10^{4}	74Kr	2.6	$1.5.10^{4}$
20O	4	4.10^{4}	75Kr	5.5	2.10^{5}
18Ne	7	1.10^{6}	76Kr	4.4	4.10^{6}
18F	2.4	$2\ 10^{4}$			

SPIRAL 1 upgrade

One of the main recommendations of scientific advisor comity for existing facility is to extend the radioactive ion beam variety available from the SPIRAL1 facility.

SPIRAL achievements: highlights

Existence of unbound ^{7}H using the active target MAYA [1].

7 elements

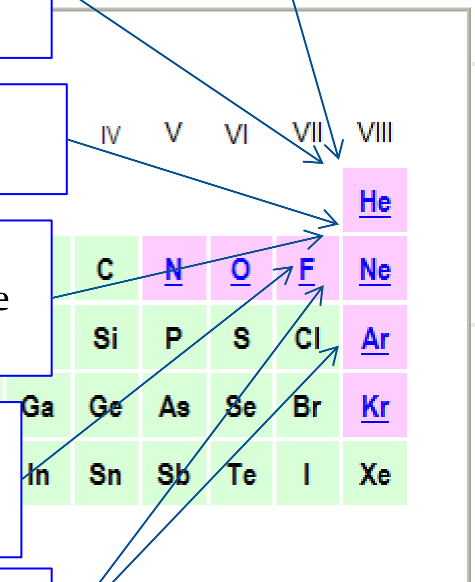
Searching for signatures of physics beyond Standard Model by measuring the β–ν angular correlation parameter in the decay of ^{6}He at LPCtrap[2].

Probing the neutron distributions in borromean nuclei from charge radii measurement using a laser trap [3] and transfer reactions [4].

Study of quantum tunneling at the femtometer scale – probing the interplay between intrinsic structure and the reaction dynamics of the colliding nuclei around the Coulomb barrier using beams of $^{6,8}He$ [5].

Resonant elastic scattering for probing the role of unbound nuclei in explosive combustion of hydrogen - see for instance [6].

Evolution of N=20 and 28 shell closures far from stability and the emergence of new shell gap at N=16, using neutron rich beams of Ne [7] and Ar[8].

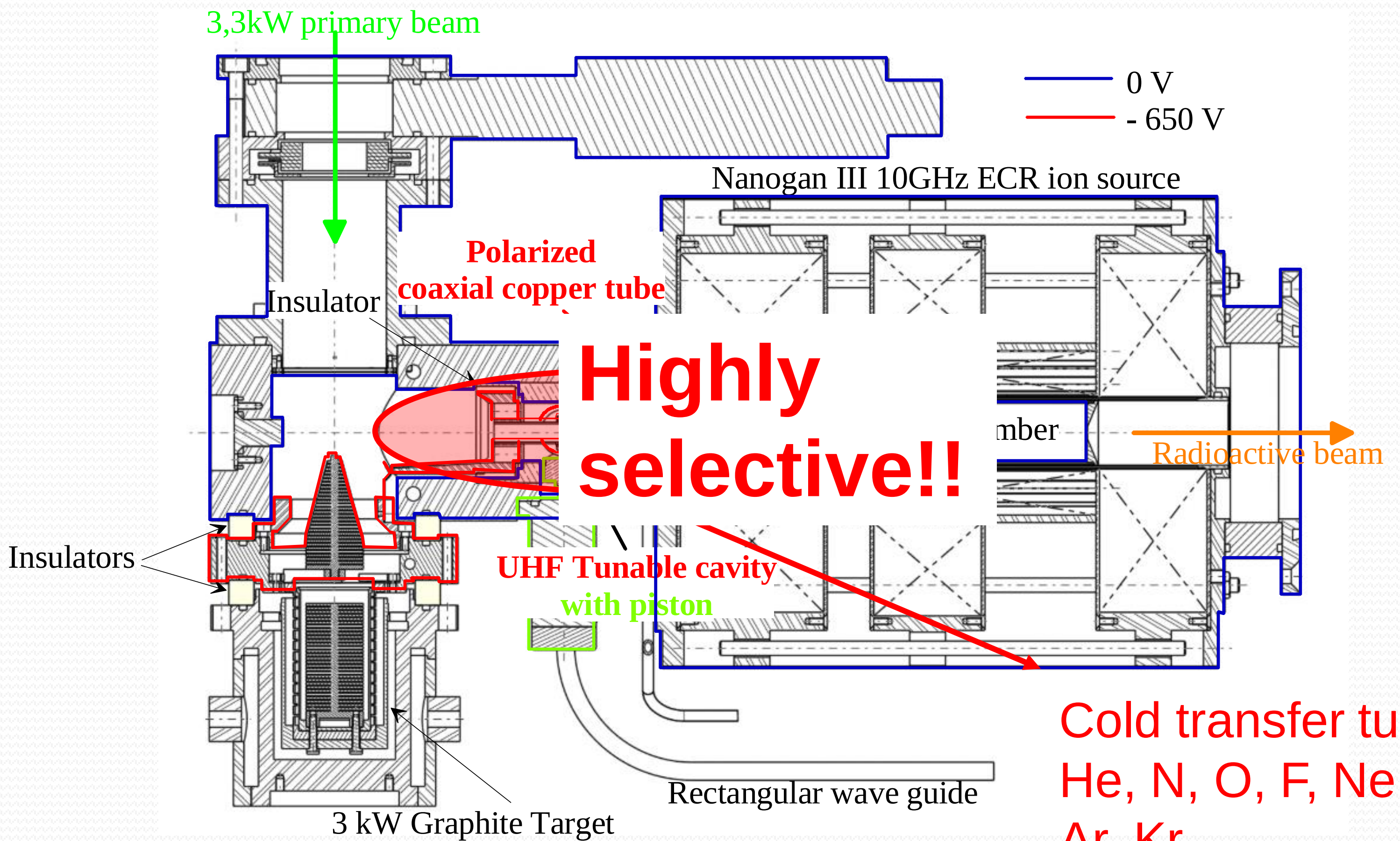


2001 – 2008:
70 physics articles
12 PhD Thesis
53 technical articles
7 PhD thesis

[1]: M. Caamaño et al, Phys. Rev. Lett. 99 (2007) 062502.
[2]: X. Flechard et al., Phys. Rev. Lett. 101 (2008) 212504.
[3]: P. Mueller et al., Phys. Rev. Lett. 99(2007)252501.
[4]: A. Chatterjee et al., Phys. Rev. Lett. 101(2008)032701.
[5]: A. Lemasson et al., Phys. Rev. Lett. 103 (2009) 232701.
[6]: W.N. Catford et al., Phys. Rev. Lett. 104(2010)192501.
[7]: L. Gaudefroy et al., Phys. Rev. Lett. 97(2006) 092501 and Phys. Rev. Lett. 99, 099202 (2007).
[8]: F. De Oliveira Santos et al., Eur. Phys. Jour. A 24 (2005) 237-247.

ECR multi-ionization in Nanogan 3

- Highest ionisation efficiencies for gases!

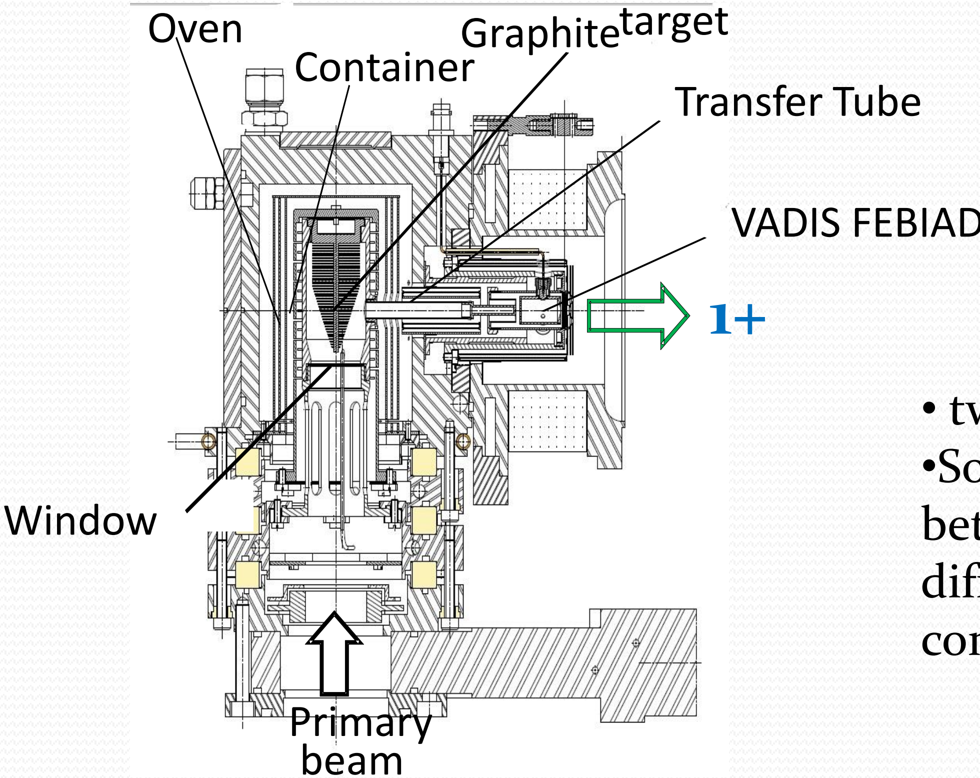


Cold transfer tube
He, N, O, F, Ne, Ar, Kr

A. C. Villari et al., Nuclear Physics A 787 (2007) 126c–133c

To the cost of universality

1+ FEBIAD source (type VADIS ISOLDE)



- two online testes with measured yields
- Some technical issues: the coupling between the source and the target is difficult because of thermo-dynamical constraints on the transfer tube

- Non selective source : Mg, Ca, Sc, Cr, Mn, Co, Ni, Cu, Zn, Ga, Ce, As, Se, Al
- On line beam tests: fall of 2010
- But no acceleration by CIME (Q/A too low)

FEBIAD: Forced Electron Beam Induced Arc Discharge

Deduced 1+ intensities 1st test

PRELIMINARY

^{58}**Ni@75AMeV**

From Gamma line intensities at saturation

ISOTOPE	Half-life (s)	Power (W)	Measured 1+ intensity	1+ intensity (750W)	Efficiency /EPAX (%)
38K	456	4	3.8E+04	**7.3E+06**	2.08E+01
38mK	0.923	4	-	**-**	
53Fe	510.6	34	6.6E+04	**1.4E+06**	1.07E+00
53mFe	154.8	34	1.4E+04	**3.0E+05**	2.24E-01
58Mn	3	37	5.7E+04	**1.2E+06**	
58Cu	3.204	37	4.3E+03	**9.0E+04**	
59Cu	81.5	38	7.3E+04	**1.5E+06**	
60Cu	1422	35	2.5E+03	**5.E+04**	

Mostly >10^5 pps!

Contains:
Release efficiency
(diffusion + effusion delays)
Ionisation efficiency

Despite the reliability and temperatures issues, the target ion source exhibits performances as good as one could wish!

Deduced 1+ intensities 2nd test

PRELIMINARY

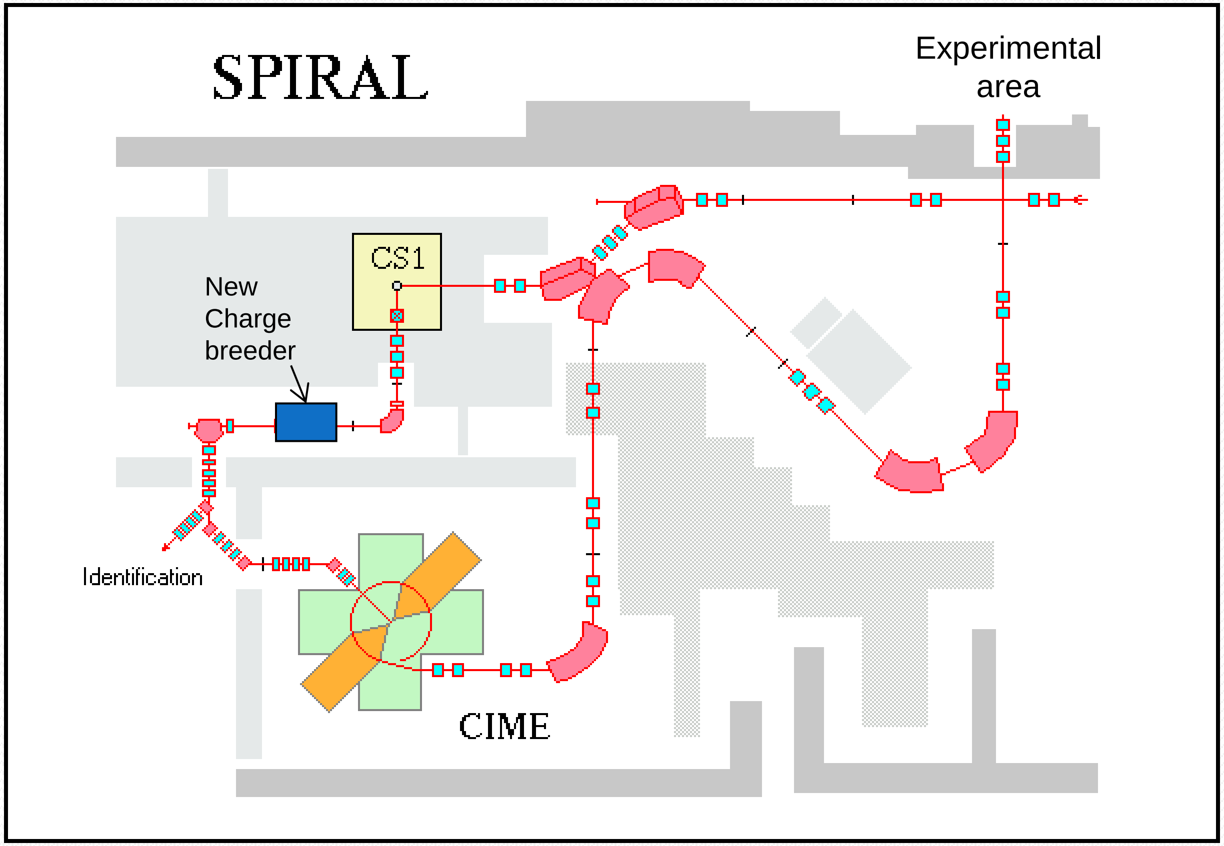
From Gamma line intensities at saturation taken on line ^{36}Ar@95AMeV

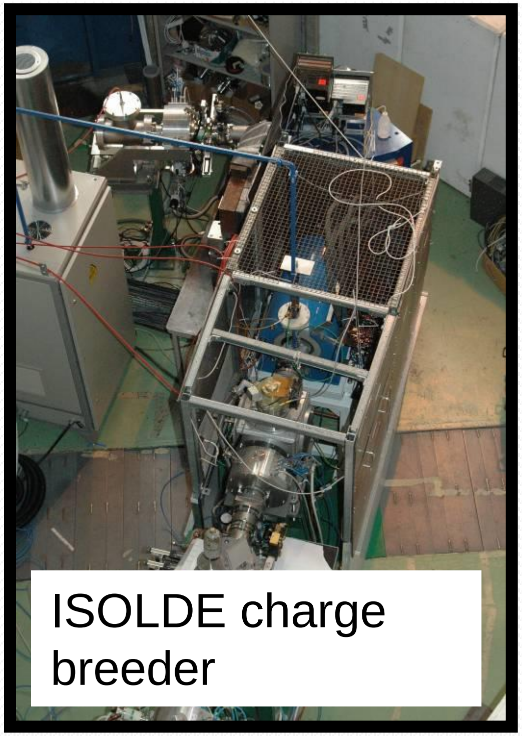
ISOTOPE	Half-life (s)	Power (W)	Measured 1+ intensity	1+ intensity (1.5kW) and nominal ionisation efficiency
23Mg	11.3s	~13	1.73E+03	**2.00E+06**
25Al	7.18s	~13	2.60E+02	**3.00E+05**
33Cl	2.5s	~13	6.93E+03	**8.00E+06**
35Ar	1.775s	~13	8.67E+03	**1.00E+07**
37K	1.226s	~13	1.10E+04	**1.27E+07**
38K	6.3min	~13	1.30E+04	**1.50E+07**
38mK	923ms	~13	1.30E+04	**1.50E+07**

Ionisation efficiency ~10% of the nominal
- lack of conditioning time
- misbehaving extraction optics

Monitored with ^{20}Ne and verified with ^{35}Ar (radioactive)

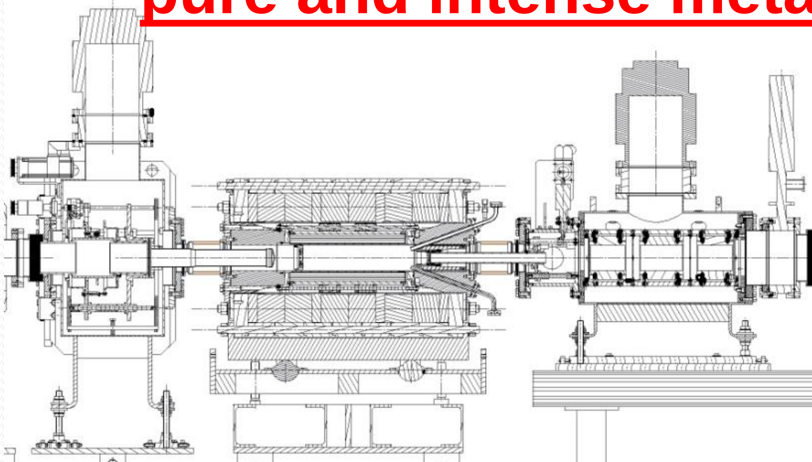
Coupling a charge breeder to a 1+ source





- 1+ source = compact to fit in the cave
- Breeder outside cave = accelerate beams in CIME

Phoenix charge breeder upgrade for the production of pure and intense metallic radioactive ion beams



Improving on ***beam purity***

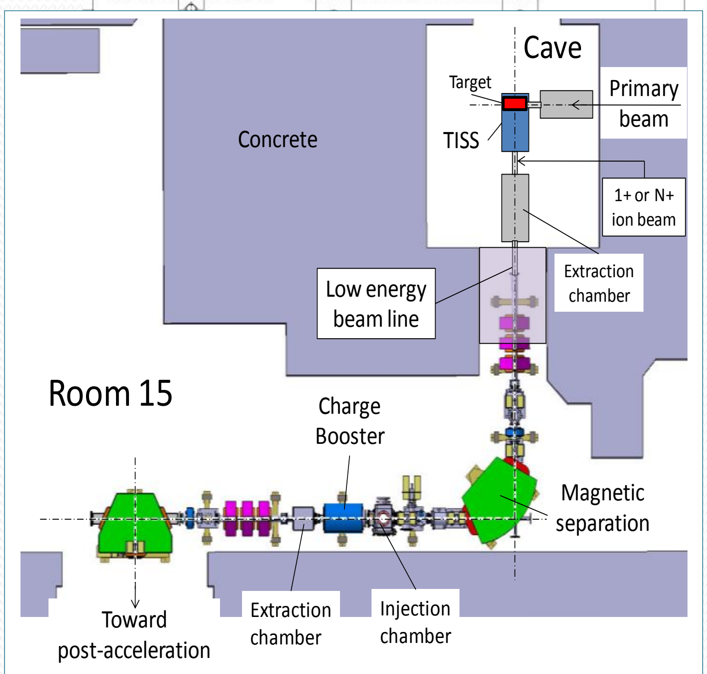
•Al plasma chamber and UHV design

•Optimized extraction optics

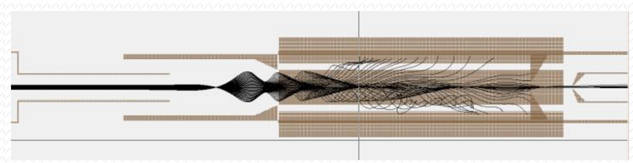
Improving on ***capture efficiencies***

•Remote controlled injection tube

•Modified HF injection for 2 RF heating



Optimization towards light masses



SIMION ® calculations ongoing

Design of the upgraded charge breeder

P. Delahaye, L. Maunoury and R. Vondrasek, NIMA 2012

Latest tests at ANL: up to 9.6% Na^{8+} and 17.7% for K^{10+}

R. Vondrasek et al, RSI 2012

Schedule and organization

• Production cave: already modified
• Installation of a nuclear ventilation in room 15
2013 Instruction by MOE and ASN done
2014 first semester: installation
• FEBIAD:
Second quarter of 2013: stable beam tests
Last run 2013: tests on SPIRAL
• Charge breeder
Off-line assembly → fall of 2013
Installation: Second semester of 2014
Commissioning and tests: 2015

Beginning of 2016: upgraded facility is available

Thank you for your attention