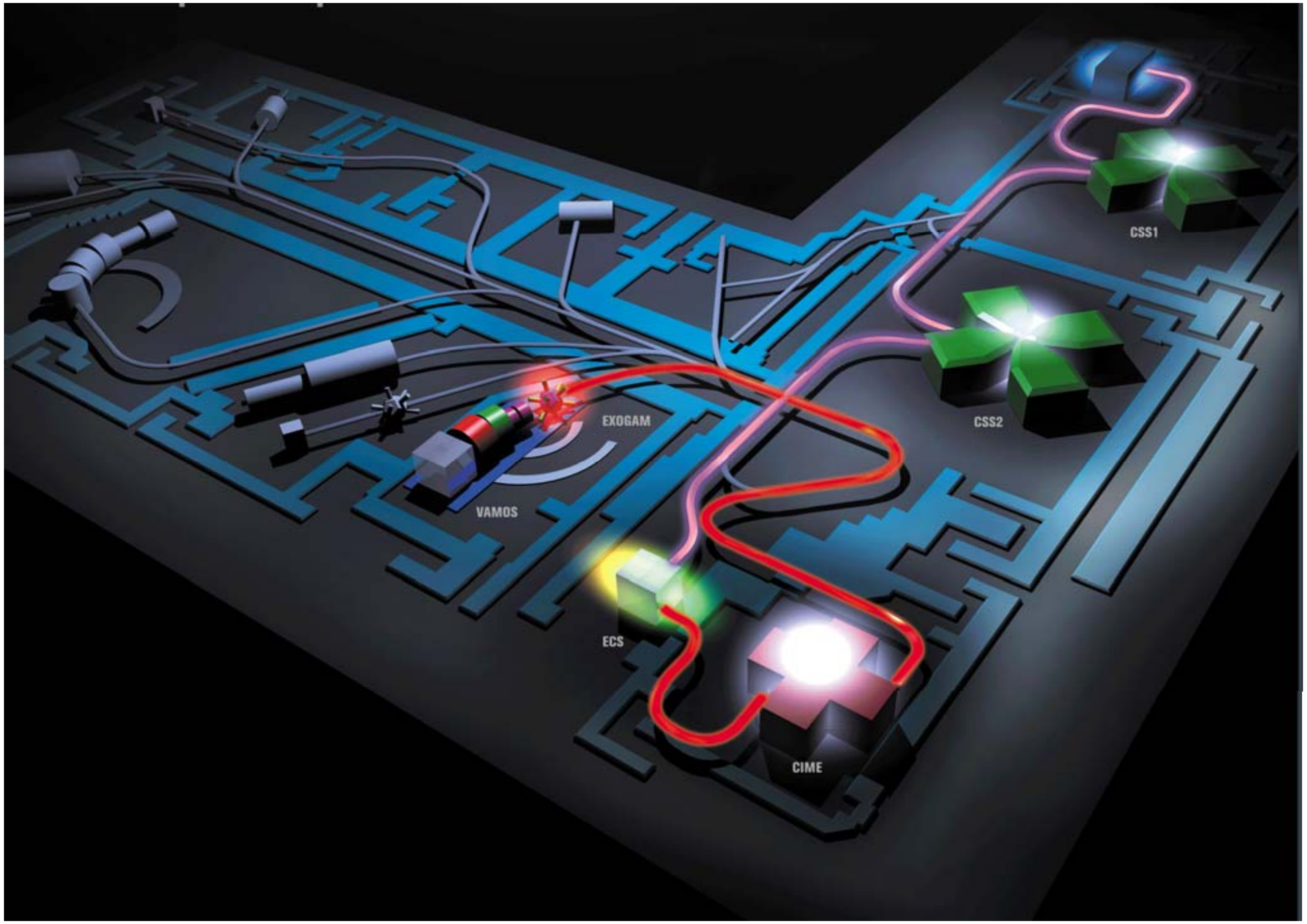
HIGH INTENSITY ION BEAMS AT GANIL

F. Chautard,

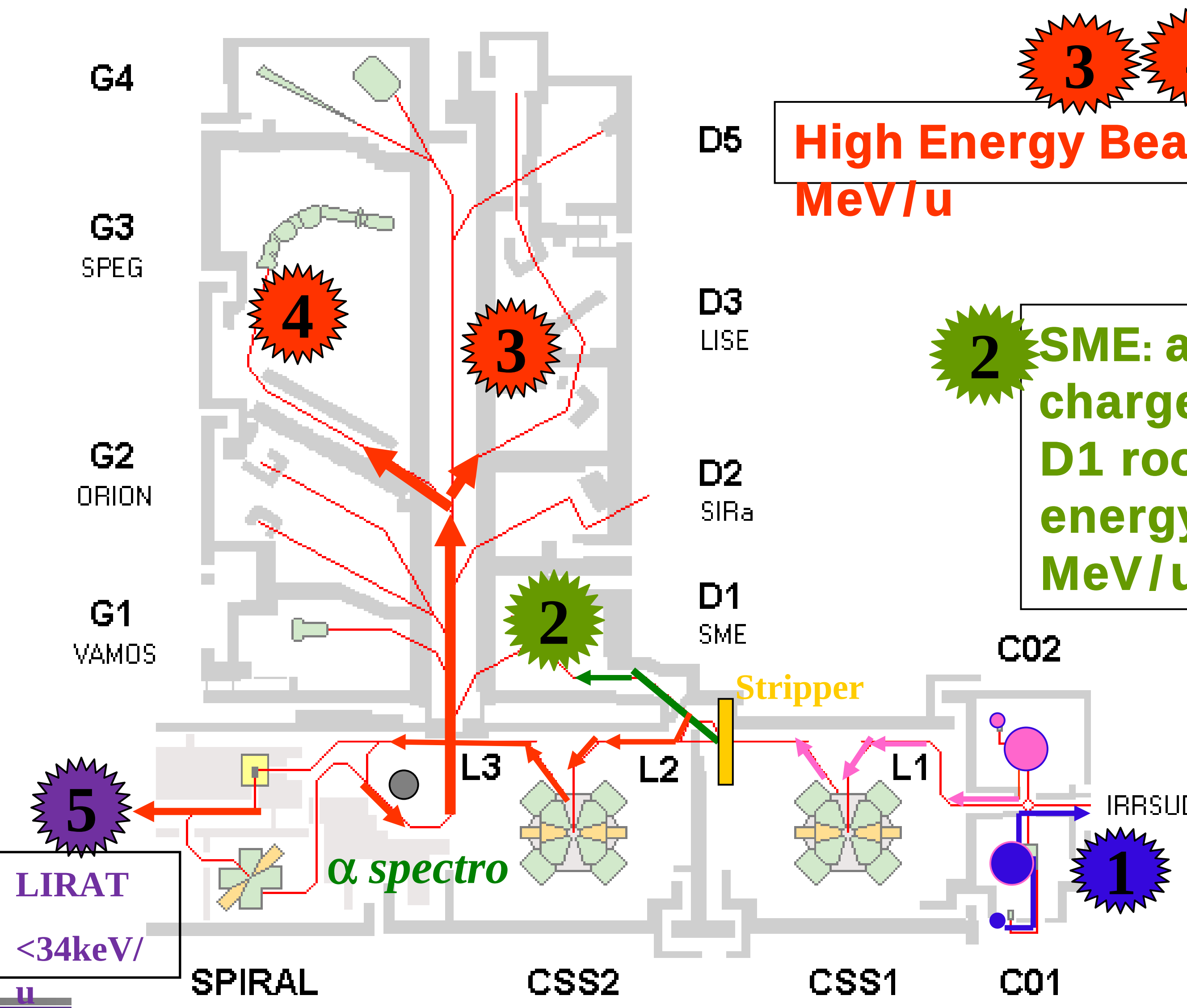
September 6th, 2010



OUTLINE

- ♦ **Operation modes at GANIL**
- ♦ **Statistics**
- ♦ **Stable beams**
- ♦ **Exotic beams**
  - ➢ ISOL
  - ➢ In Flight
- ♦ **Beam developments**
  - ➢ Stable beams
  - ➢ Exotic beams
- ♦ **Machine developments**
  - ➢ Diagnostics and purification
- ♦ **Foreseen operation with SPIRAL2**

Multi-Beam Operating Mode:
5 experiments in parallel with stable beams



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**

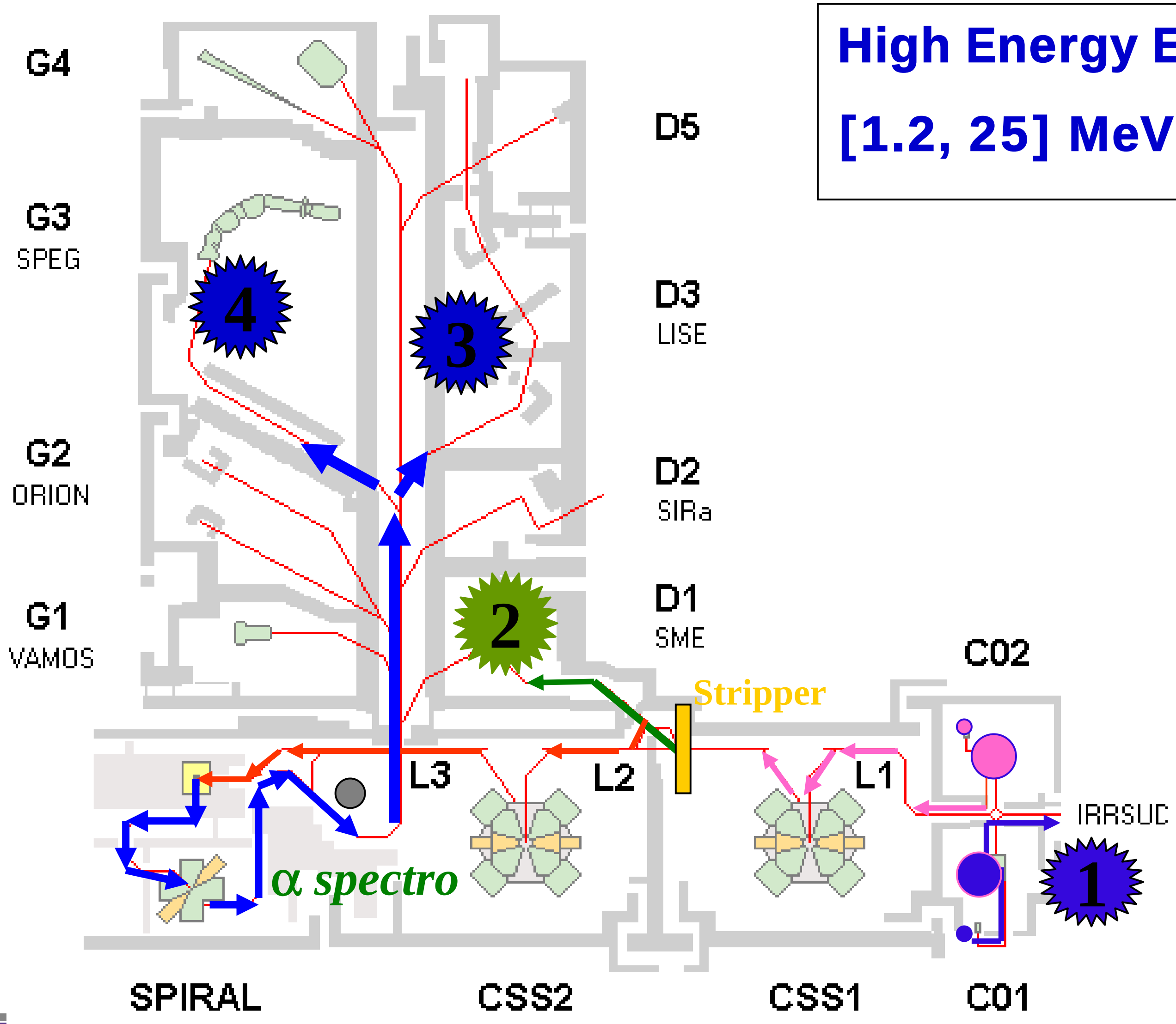
IRRSUD: low energy beam irradiation line 1

[0.3, 1.0] MeV/u

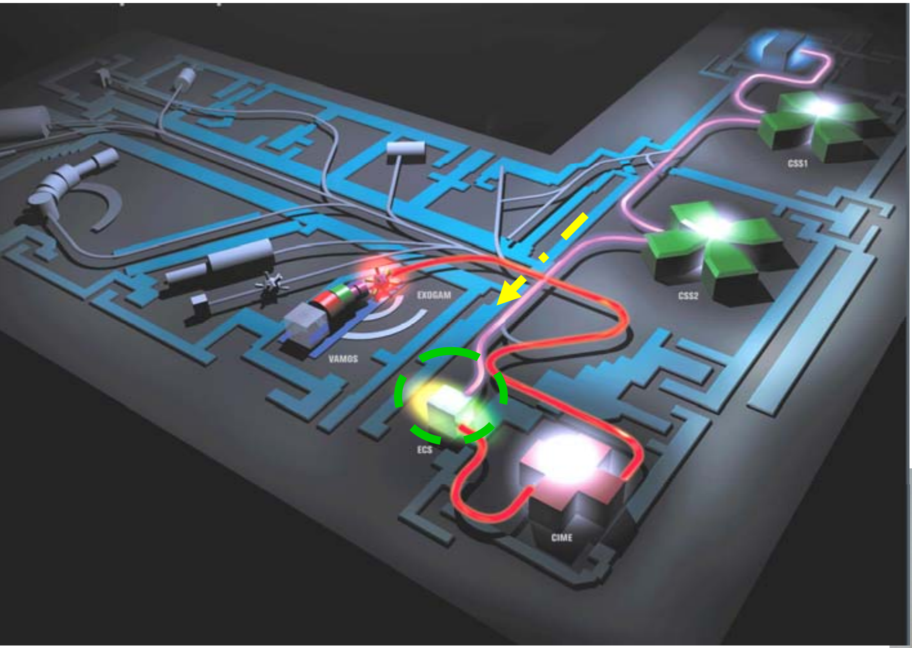
SPIRAL1 operating mode:
4 experiments in parallel

High Energy Exotic Beam

[1.2, 25] MeV /



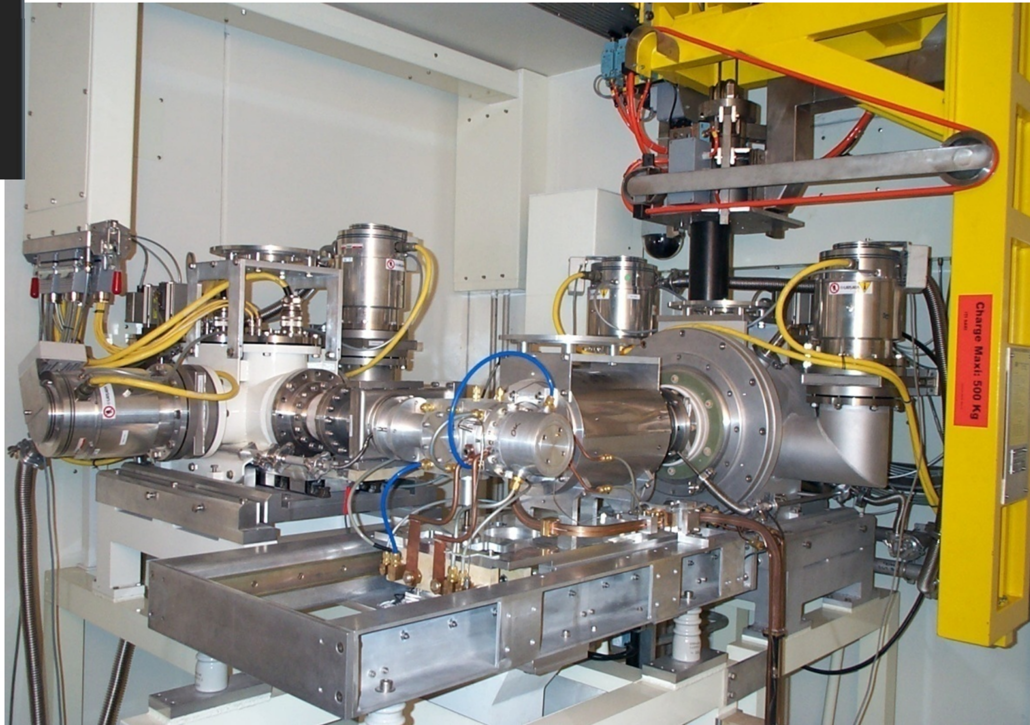
Radioactive ion beams with «ISOL» method since 2001 (W<25MeV/u)



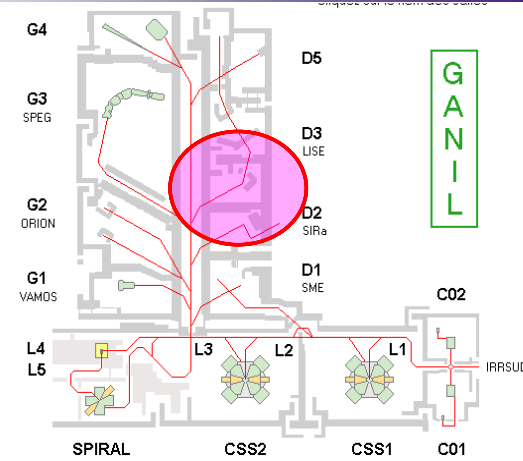
GANIL heavy ion beams up to 95 MeV/u onto a thick carbon target

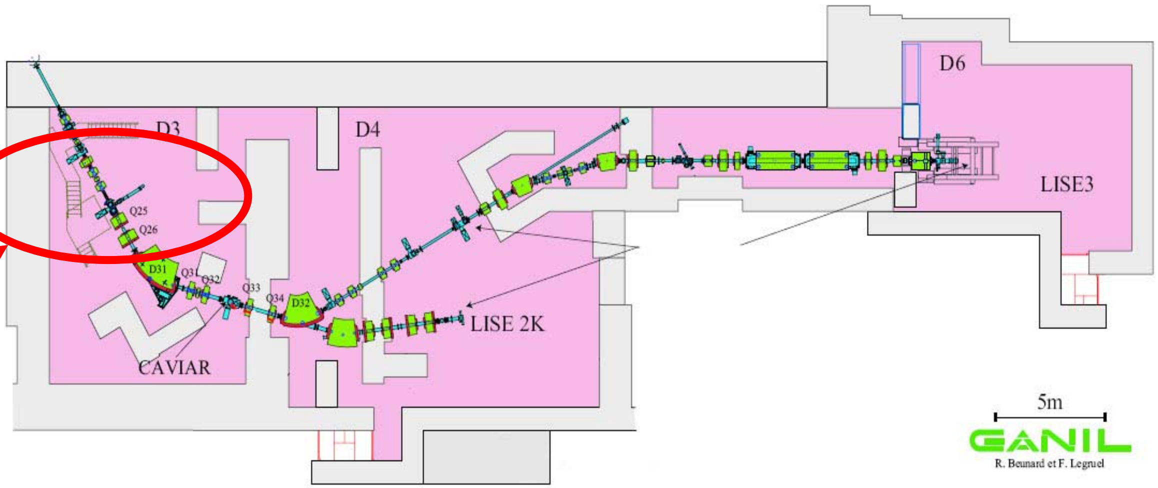
→ **radioactive atoms**

Acceleration and Purification in the compact cyclotron CIME



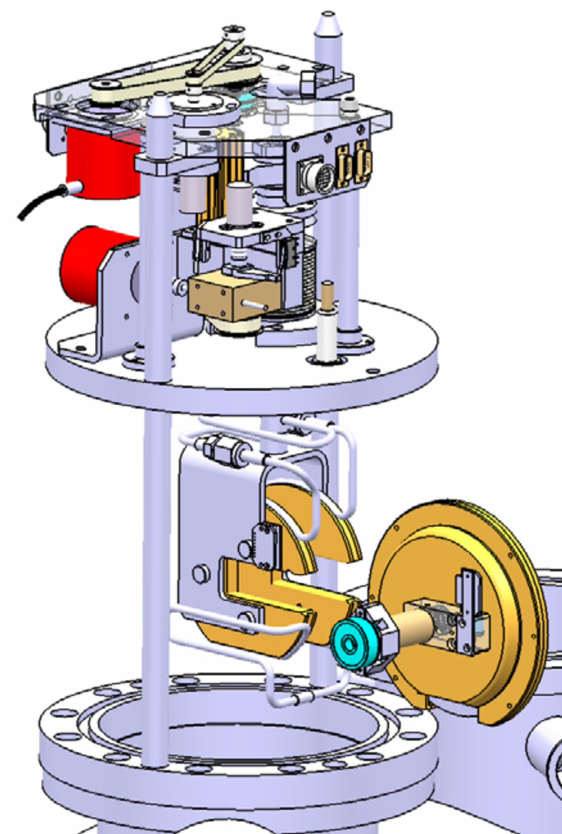
Radioactive ion beams with «In Flight» method (W<95 MeV/u)

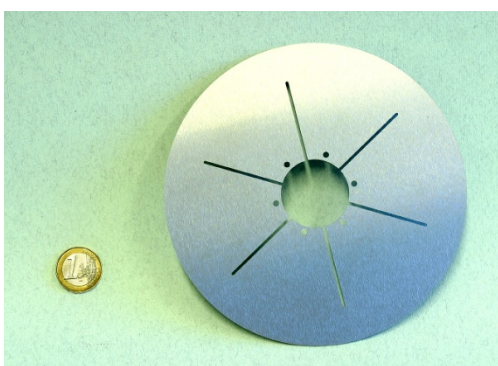


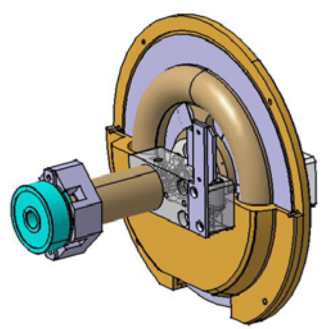


CLIM

- 2kW beam onto rotating target







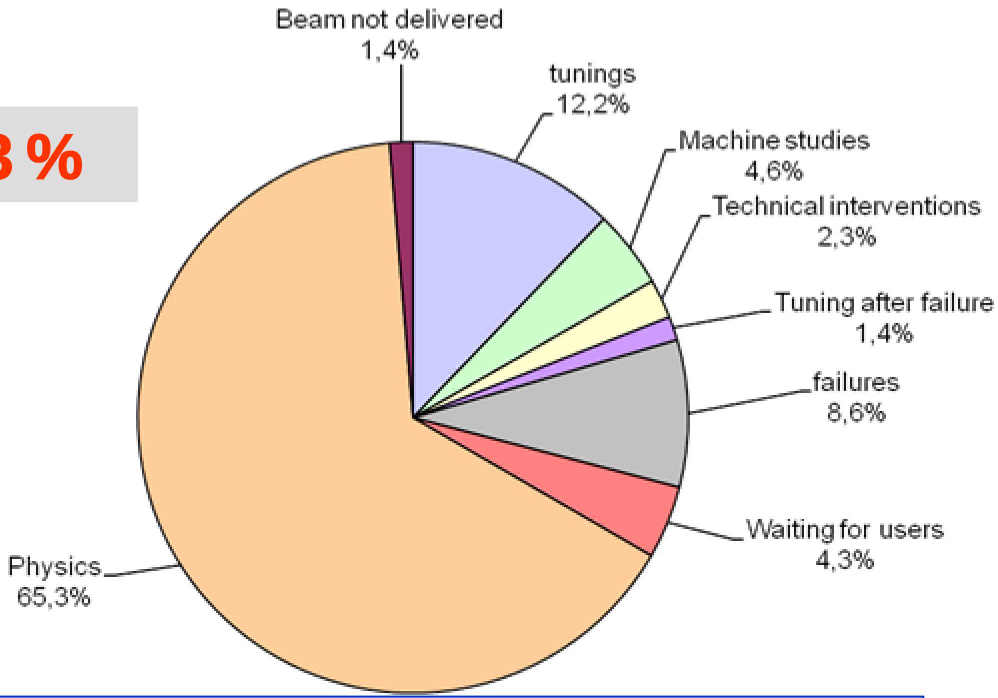
Multi-beam operating mode: Beam schedule

Date	hour	C01	C02	CSS1, CSS2	CIME	SME	Auxiliary beam
Saturday 25-Sep	6h00	Change of source chamber	36Ar 95 MeV/A	36Ar18+ 95 MeV/A			
	10h00						
	14h00						
	18h00			Test SPR D1			E587 S (I. Martel)
	22h00			P832 (Testard) D1 2 UT			
Sunday 26-Sep	2h00						
	6h00						
	10h00						
	14h00			P858 (Fourdrin) D1			
	18h00						
	22h00						
Monday 27-Sep	2h00	Outgassing	36Ar 95 MeV/A	P858 (Fourdrin) D1			E587 S (I. Martel)
	6h00						
	10h00	Tuning ECR 13C3+					
	14h00				16O2+ 2.02 MeV/A		
	18h00	Tuning C0 13C3+		BUFFER			
	22h00			Tuning Z	Tuning Z		
Tuesday 28-Sep	2h00	13C 75 MeV/A	Tuning ECR4 58Ni11+	13C6+ 75 MeV/A	E587 S (I. Martel) G21		
	6h00						
	10h00					SME	
	14h00						
	18h00			BEAM ON SPIRAL TARGET	8He1+ 2 MeV/A 2e5 pps		
	22h00						
Wednesday 29-Sep	2h00						
	6h00						
	10h00		Tuning C0 58Ni11+ 0.8 MeV/A		IBE		
	14h00						
	18h00		IRRSUD		E587 S (I. Martel) G21 9 UT		
	22h00						
Thursday 30-Sep	2h00						
	6h00						
	10h00						
	14h00						
	18h00						
	22h00						
Friday 1-Oct	2h00						
	6h00						
	10h00						
	14h00						
	18h00						
	22h00						

Running Statistics 2001-2009

Availability over 9 years: 83 %

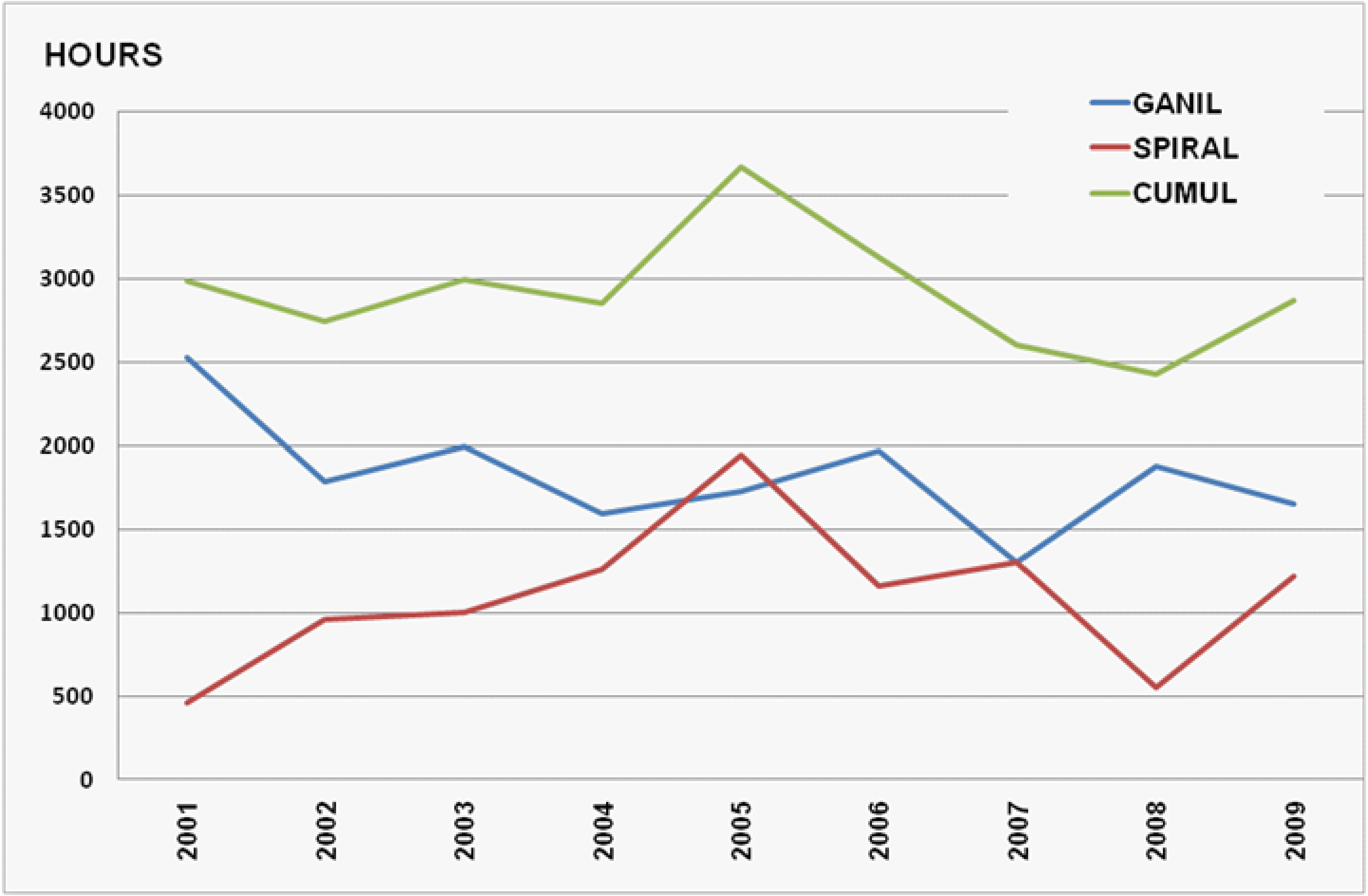
Availability in 2009 : 94 %



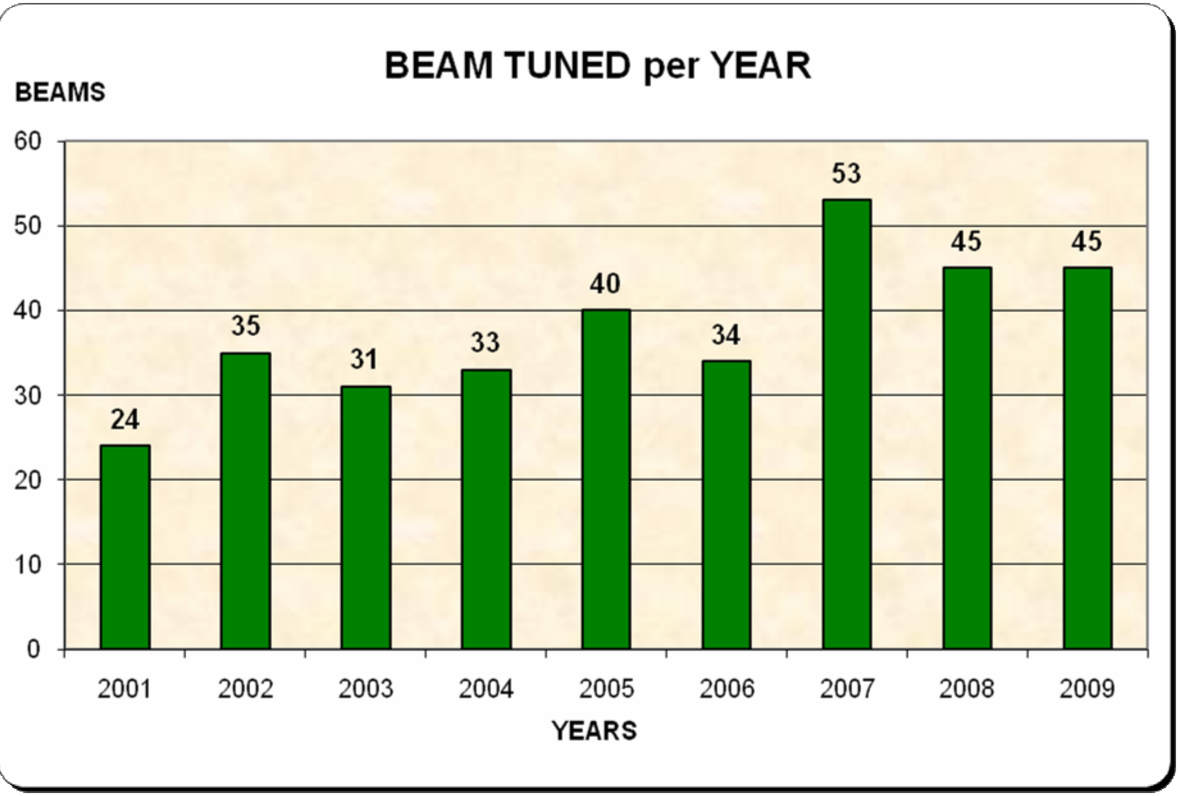
GANIL per year: 30 weeks / 4 periods: 5000h of operating time. Leading to 9000h of beam time for users (multi-beam effect)

SPIRAL1 since 2001: 9755h of exotic beams. More than 30 exotic beams

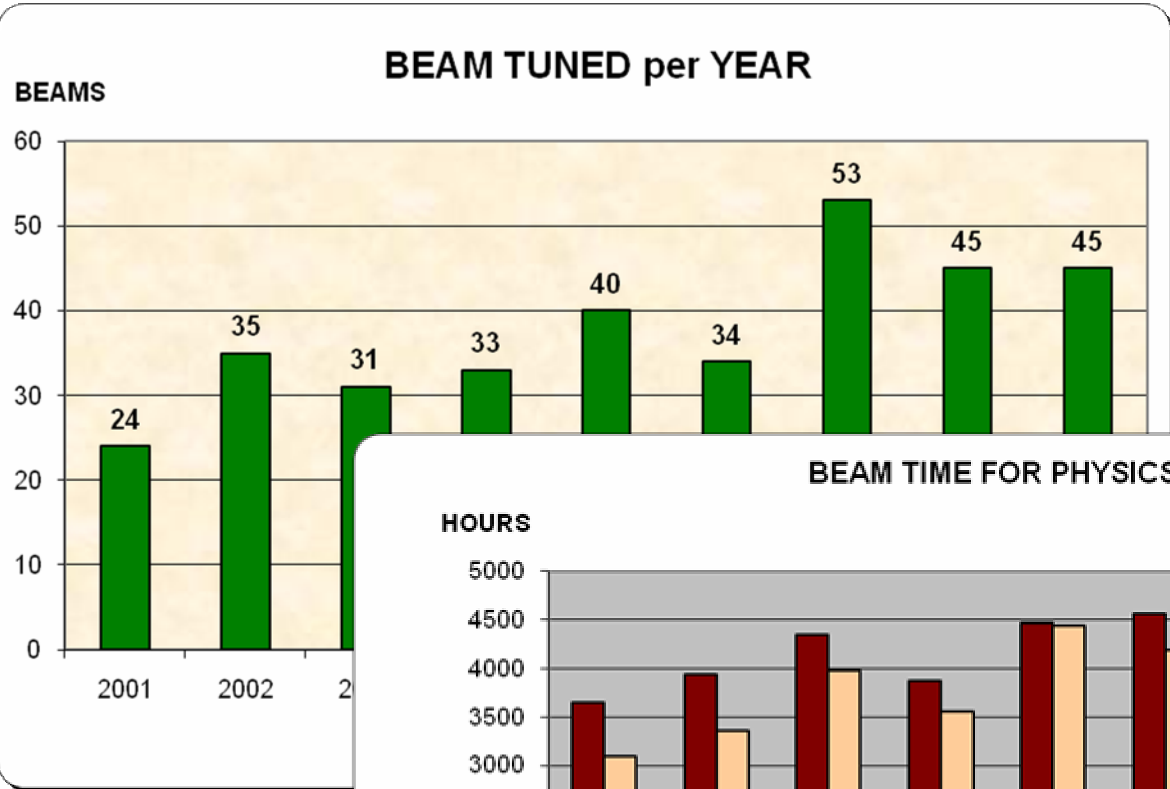
Repartition beam time between GANIL and SPIRAL1

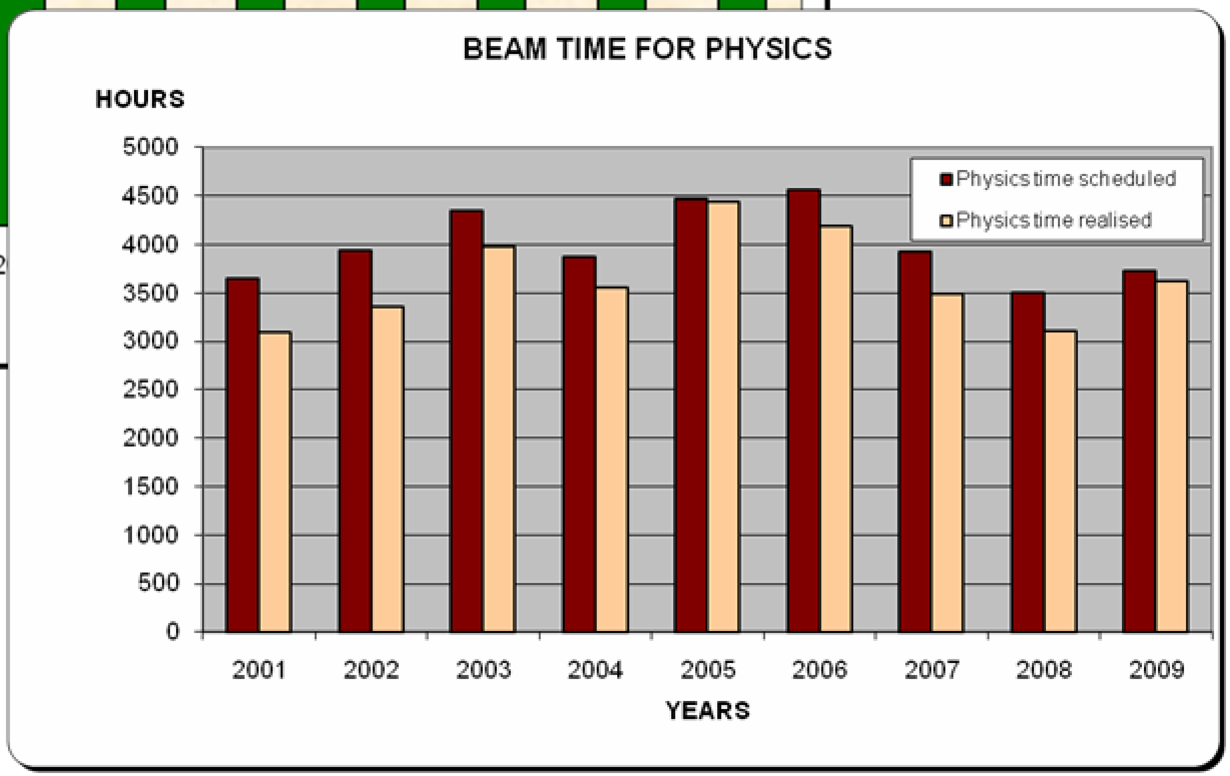


From 2001 to 2009

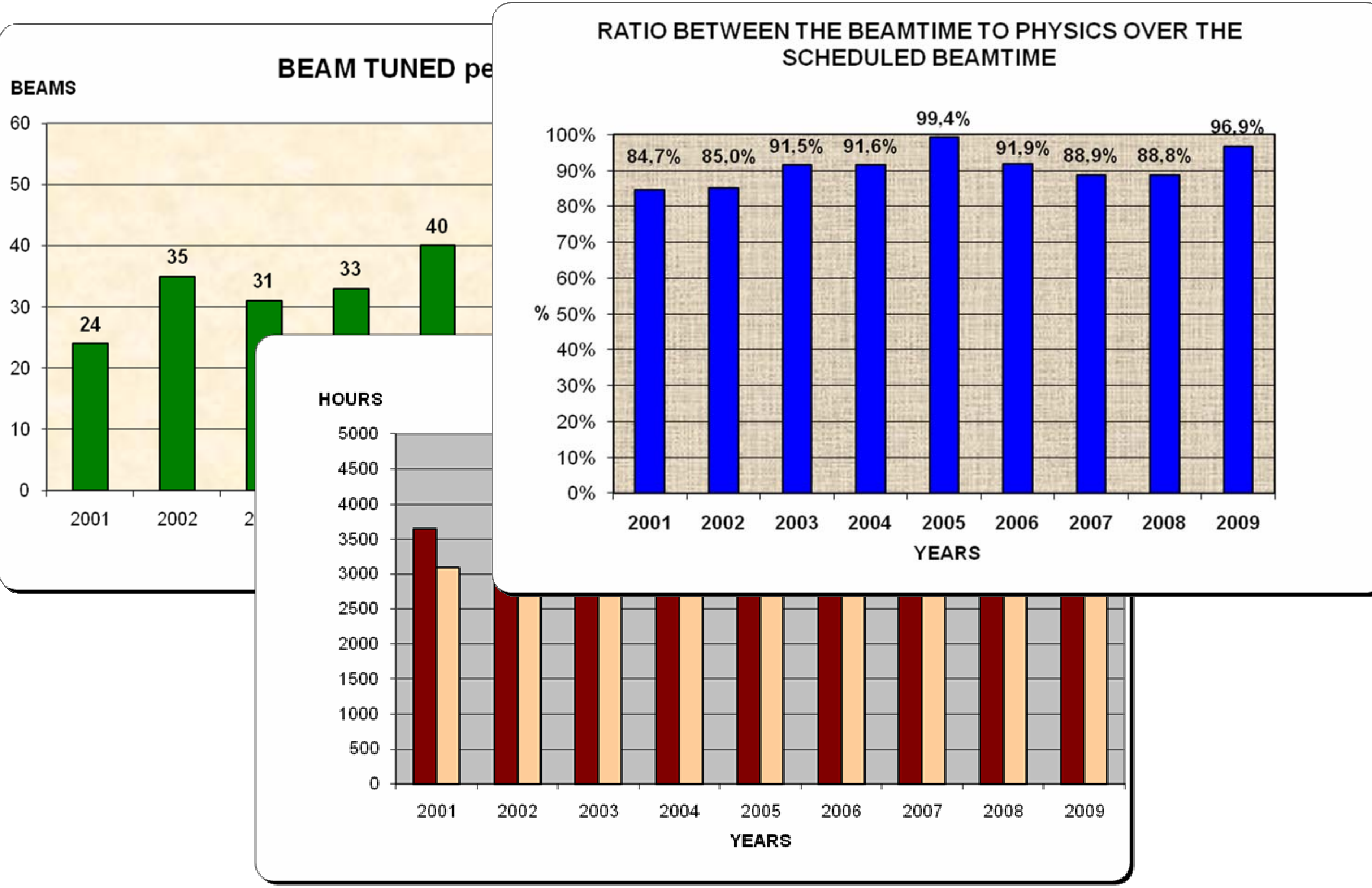


From 2001 to 2009





From 2001 to 2009



Intense Primary beams

http://pro.ganil-spiral2.eu/users-guide/accelerators/available-stable-ion-beams-at-ganil/view

In 1995, a High Intensity Transport safety system (THI) was studied and validated in 1998 in order to send a several kilowatt beam to the experimental rooms.

Beams	Imax [mAe]	10^{13} [pps]	Emax [MeV/u]	Pmax [W]	Used with Spiral
$^{12}C^{6+}$	19	2	95	3 600	Planned
$^{13}C^{6+}$	18	2	75	2 900	X
$^{14}N^{7+}$	15	1.6	95	3 400	Planned
$^{16}O^{8+}$	16	1	95	3 000	X
$^{18}O^{8+}$	2.3	0.18	75	400	
$^{20}Ne^{10+}$	15.7	1	95	2 400	X
$^{22}Ne^{10+}$	15	1	80	2 600	Planned
$^{24}Mg^{12+}$	20	1	95	3 800	Planned
$^{36}S^{16+}$	11	0.43	77.5	1 900	X
$^{36}Ar^{18+}$	24	0.8	95	4 600	Planned
$^{48}Ca^{19+}$	4.5	0.15	60	700	X
$^{58}Ni^{26+}$	4	0.1	75	700	
$^{76}Ge^{30+}$	3.5	0.07	61	500	
$^{78}Kr^{34+}$	7	0.13	70	1 200	X
$^{124}Xe^{44+}$	2	0.03	50	300	

Intense Primary beams

2.10¹³pps 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	
$^{36}S^{16+}$	6.4	2.5 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	

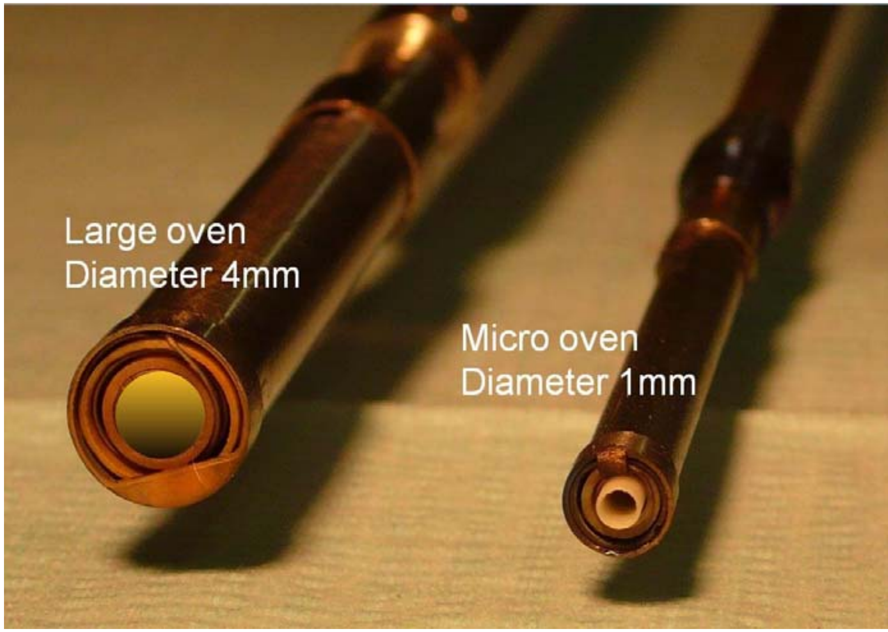
R&D: Intense Primary beams

It goes with an improvement of the oven for the metallic ion production.

• First, a modified version of the existing micro-oven at high temperature (1700° C max) to a higher capacity oven but at a lower average temperature (1100° C max).

• Second, build a large capacity and high temperature oven.

• Above the 1700° C temperature limit, development with induction oven is foreseen.



• Those developments are coherent with the beam needs expressed by the SPIRAL2 project for the production of $48Ca^{16+}$ and $58Ni^{19+}$.

R&D: Intense Primary beams

Beams	Imax [μAe]	10^{13} [pps]	Emax [MeV/u]	Pmax [W]	Used with Spiral
$^{64}Zn^{28+}$	1.2	0.03	74	-	-
$^{127}I^{45+}$	0.23	0.03	49.5	-	-
$^{133}Cs^{47+}$	0.08	0.01	49.3	-	-
$^{238}U^{34+}$	0.04	0.01	7.8	-	-

The developments are driven by physics experiments foreseen by the GANIL Physics Advisory Committee

Exotic Beam Production : ISOL (SPIRAL1)

http://pro.ganil-spiral2.eu/users-guide/accelerators/spiral-beams

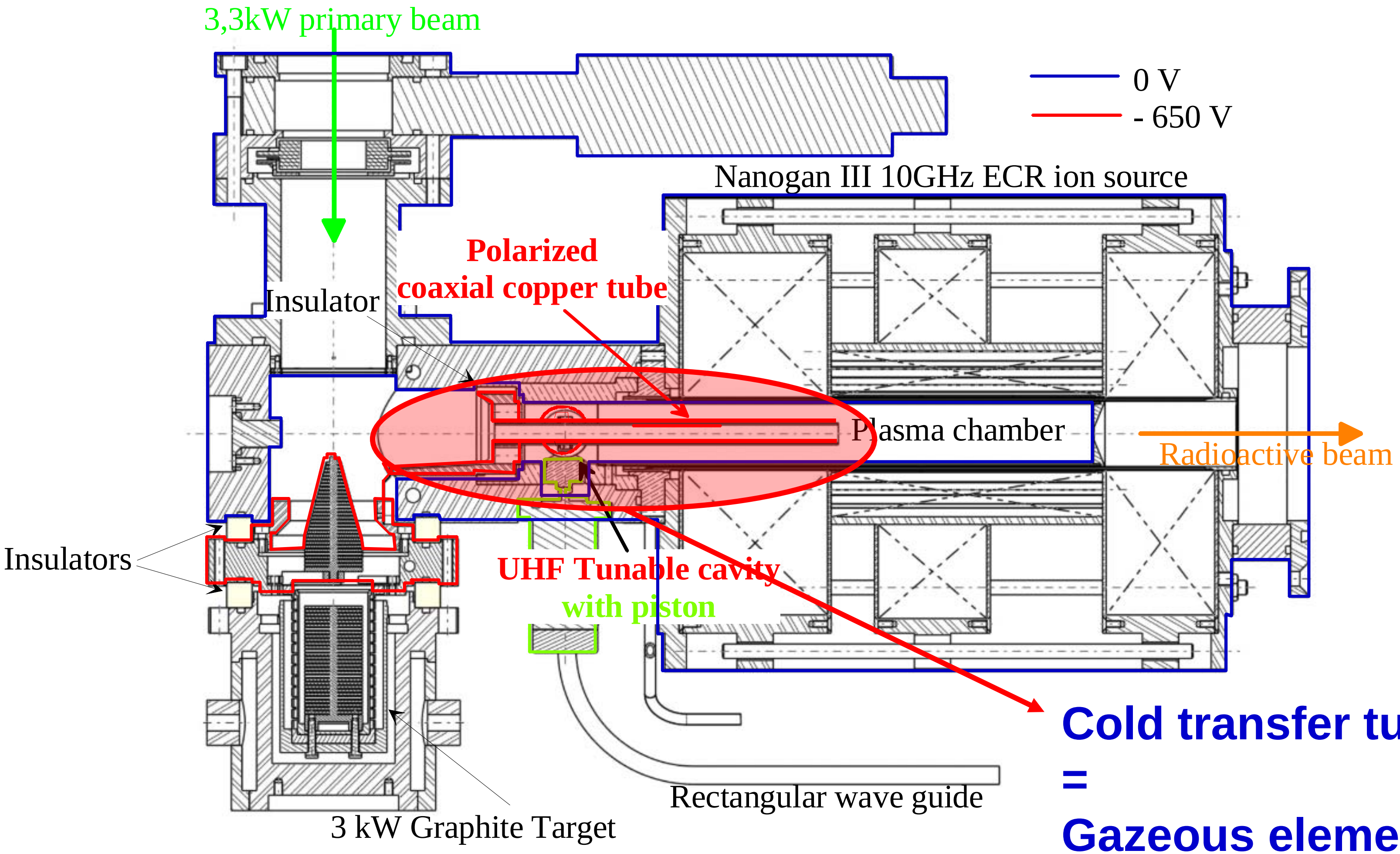
ions	W [MeV/u]	[pps]	ion	W [MeV/u]	[pps]
6He	3.8	2.8 10^7	20F	3	1.5 10^4
6He	2.5	3.7 10^7	17Ne	4	4.10^4
6He	5	3.10^7	24Ne	4.7	2.10^5
6He	LIRAT (<34 keV/u)	2.10^8	24Ne	7.9	1.4 10^5
6He	20	5.10^6	24Ne	10	2 105
8He	3.5	1.10^5	26Ne	10	3.10^3
8He	15.5	1.10^4	31Ar	1.45	1.5
8He	15.4	2.5 10^4	33Ar	6.5	3.10^3
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	2 104			

Foreseen Machine Developments

- **A GANIL 2015 committee** was created to identify the strength and weakness of the present facility in the close future range.

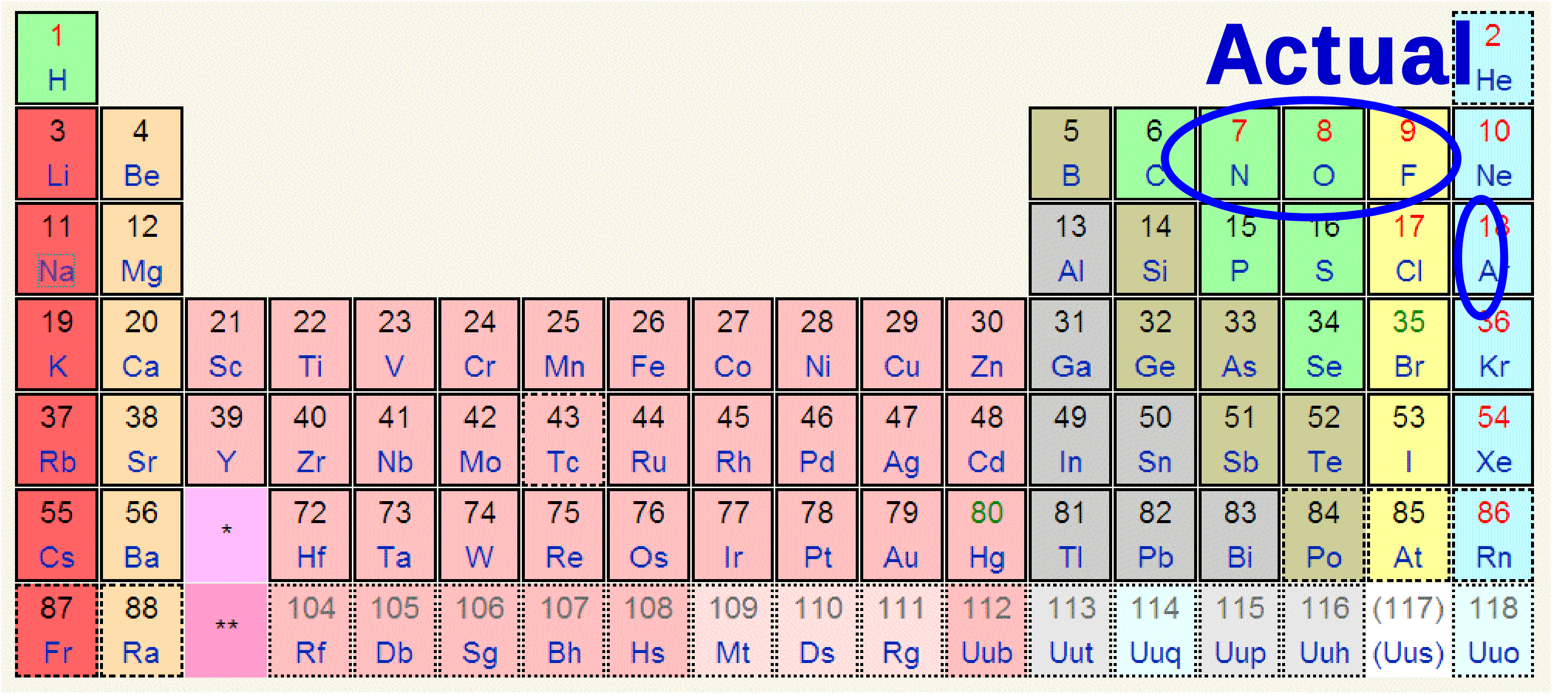
- One of the main recommendations is to **extend the radioactive ion beam variety** available from the **SPIRAL1** facility.

ISOL Production Limitation with the actual Nanogan 3 source



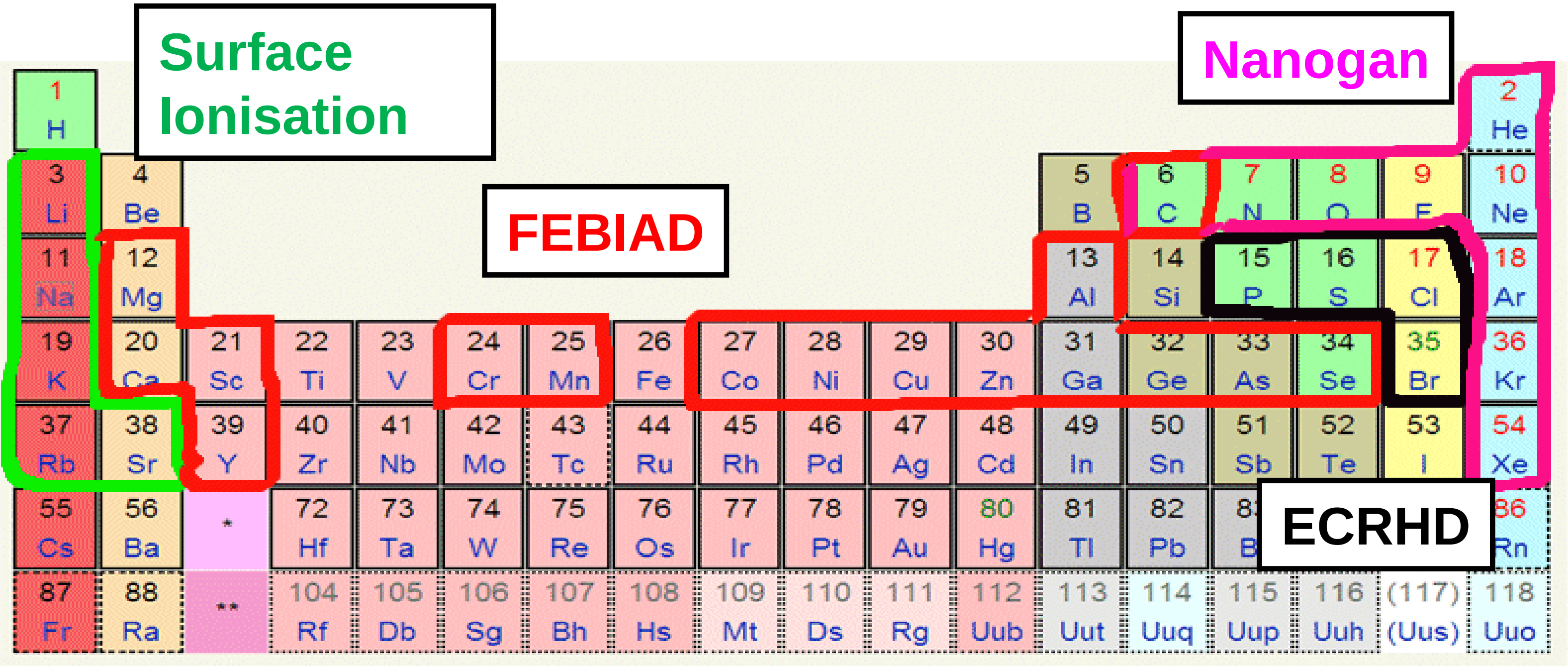
Cold transfer tube
=
Gazeous elements

ISOL Production Limitation with the actual Nanogan 3 source



- GANIL group project constituted
- **Overview of source developments for SPIRAL1: done**

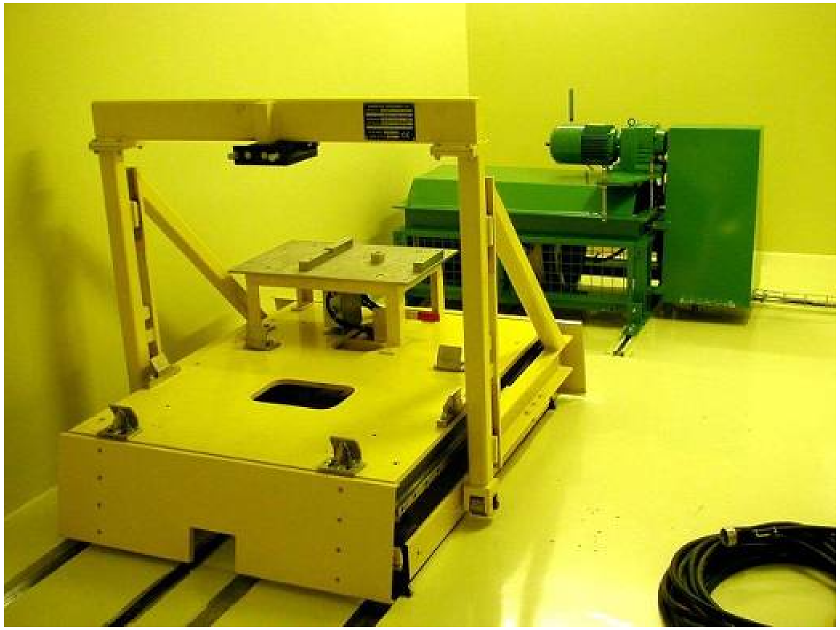
Possible New Beams from graphite targets with SPIRAL1 design compatible sources



Mass limited to <~90 for various technical reasons, can be extended in the future.

The developments should be driven by physics cases (LoI)

Constraints for development of radioactive ion sources



Limited volume for new ECR

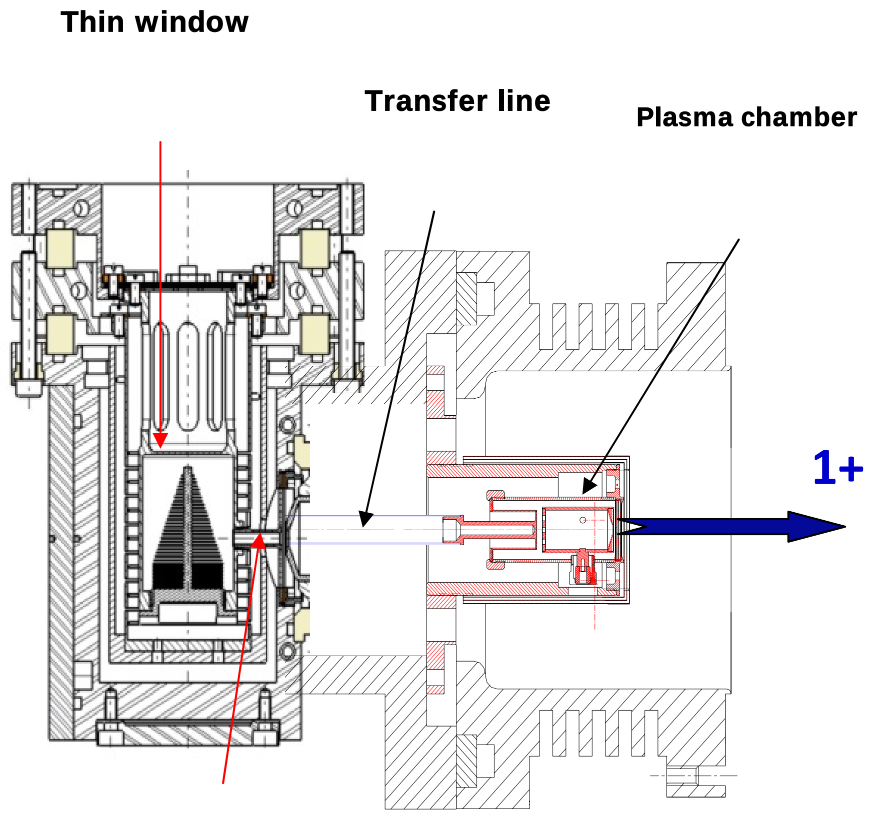
R&D strategy

Ongoing projects priority :

1. 1+ compact source type FEBIAD
2. Charge breeder in CIME injection line
3. 1+/N+ compact sources : ECRHD (collaboration with PANTECHNIK)

1+ FEBIAD source (type VADIS ISOLDE)

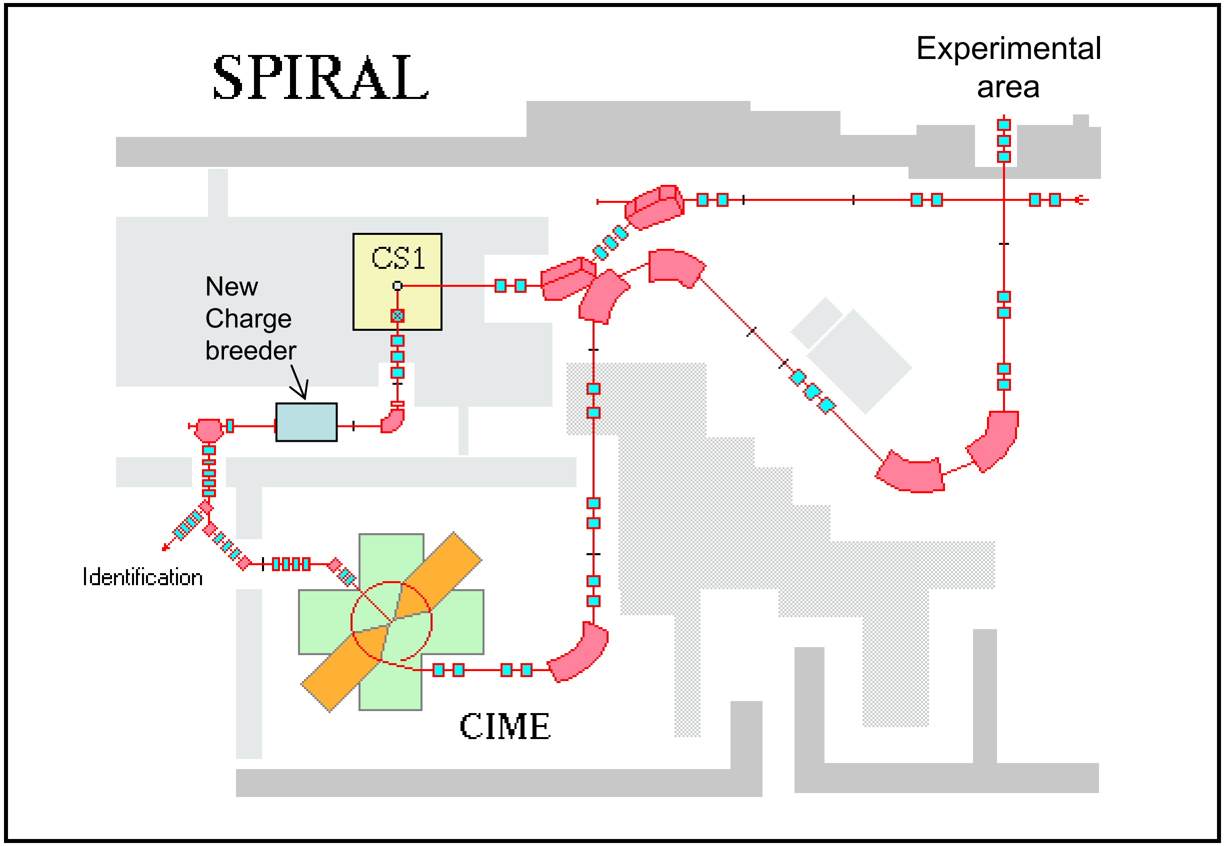
(Forced Electron Beam Induced Arc Discharge)

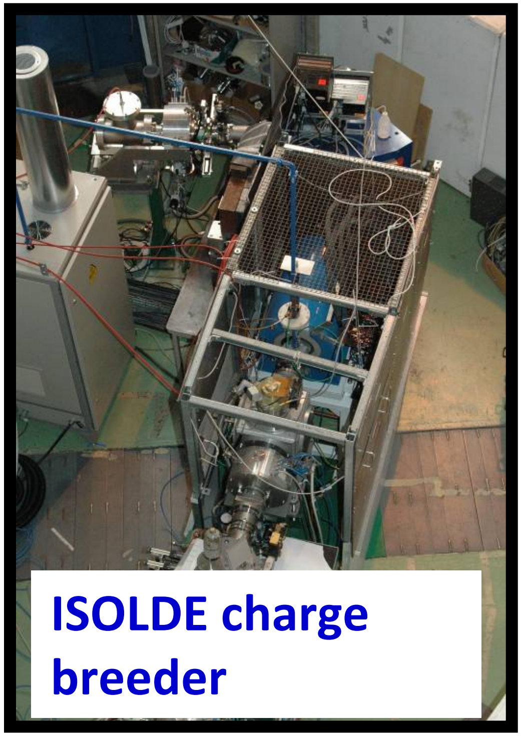


- First mechanical design – ok
- Thermal calculations ongoing
- Extraction optics ongoing

- 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)

Coupling a charge breeder to a 1+ source

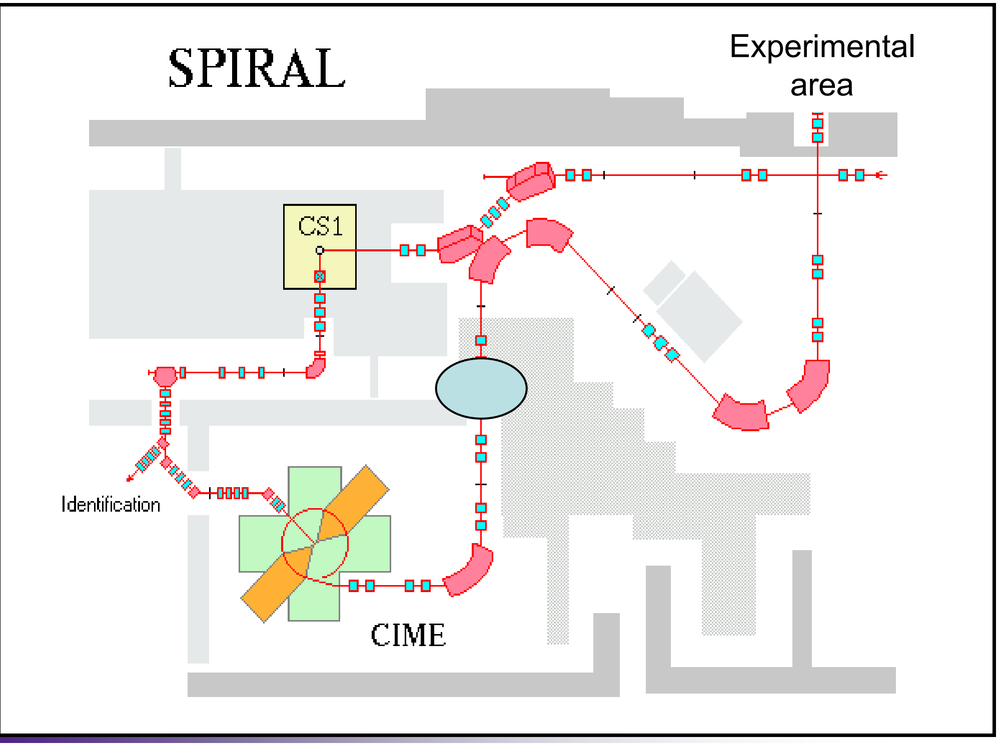


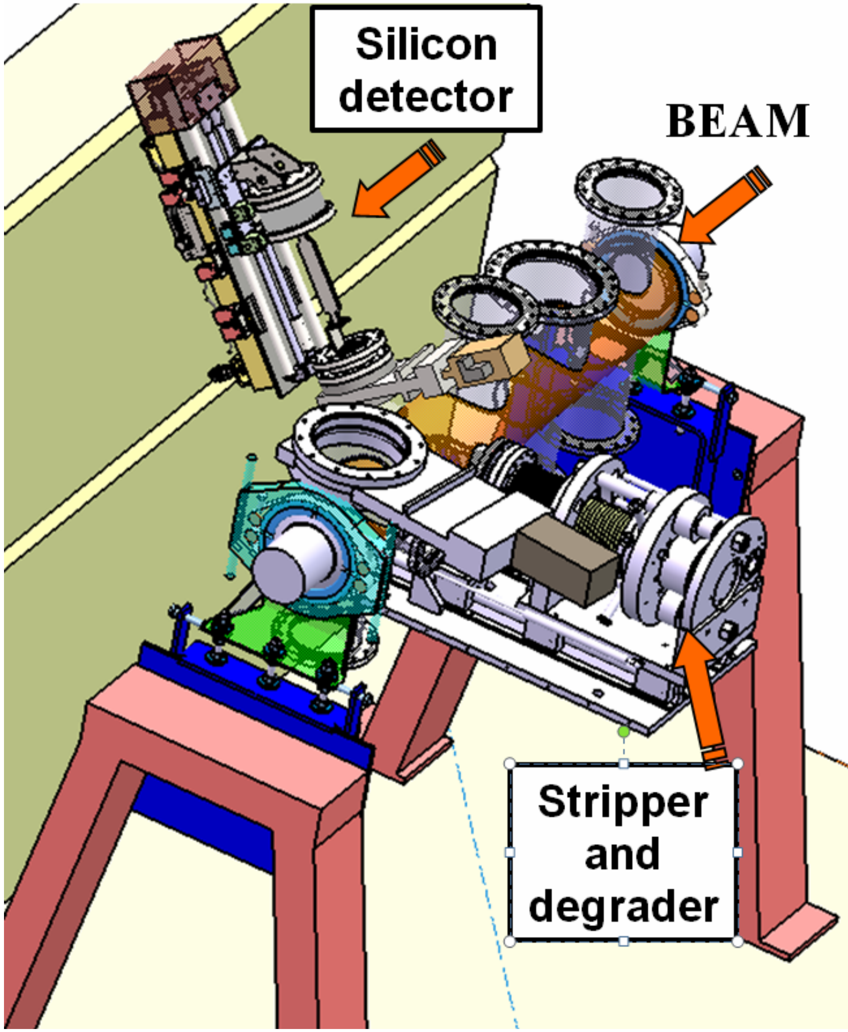


- 1+ source = compact to fit in the cave
- Breeder outside cave = accelerate beams in CIME

SPIRAL1 Beam Purity Improvement

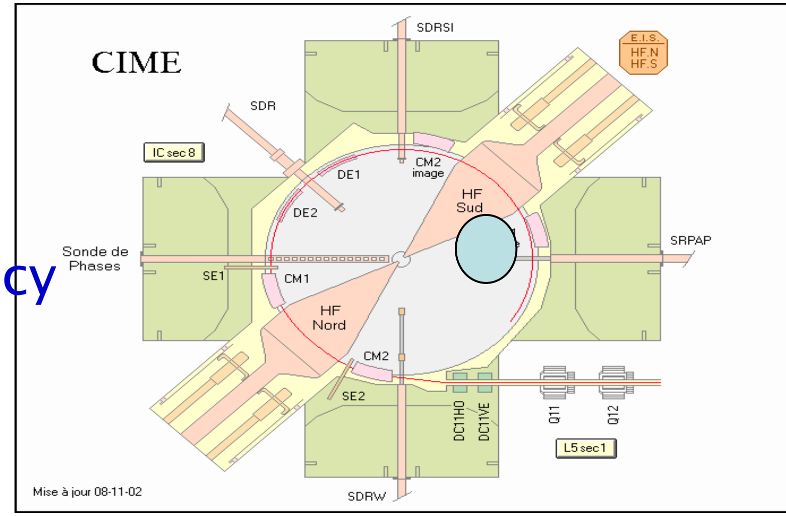
- Even with a selective source, the exotic beam might be polluted (18F, 14O …)
- Purification SPIRAL choices:
  - **Stripping**
  - **Energy loss in degrader**
  - Vertical deflector

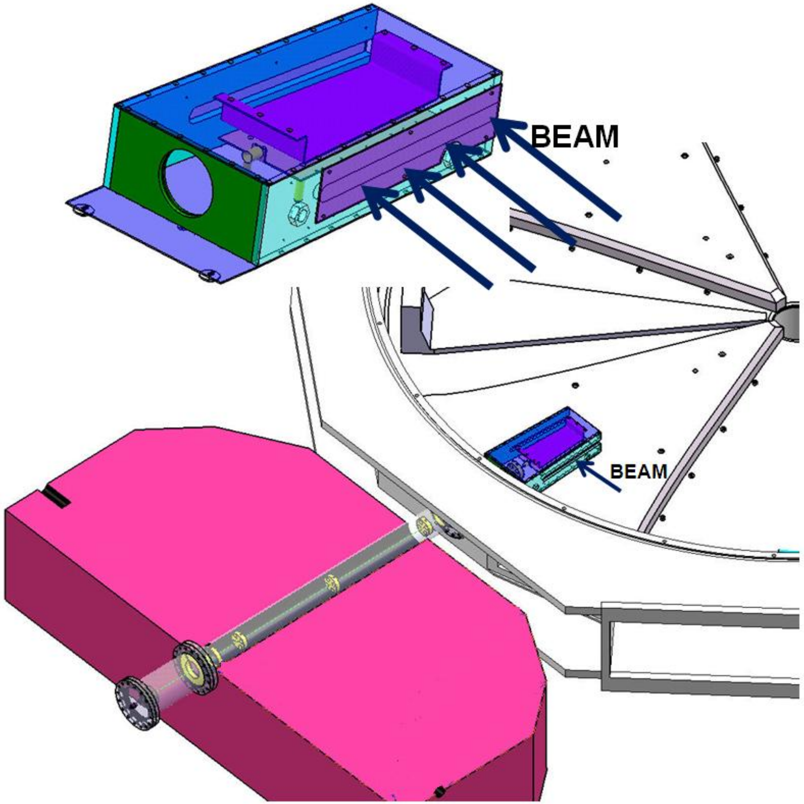




SPIRAL1 Beam Purity Improvement
(Presentation P. Bertrand and A. Savalle : THM1CIO01)

- Even with a selective source, the exotic beam might be polluted (18F, 14O …)
- Purification SPIRAL choices:
  - Stripping
  - Energy loss in degrader
  - Vertical deflector for variable frequency





GANIL: HISTORY

- The first beam of GANIL was sent to an experimental room in 1983.
- Since then, the variety and intensity of the ion beams available always increased.
- Progress in the source domain make possible to potentially transport of kW beams.
- The cyclotrons and the beamlines had to be upgraded to handle such a new constraint.

SPIRAL: HISTORY

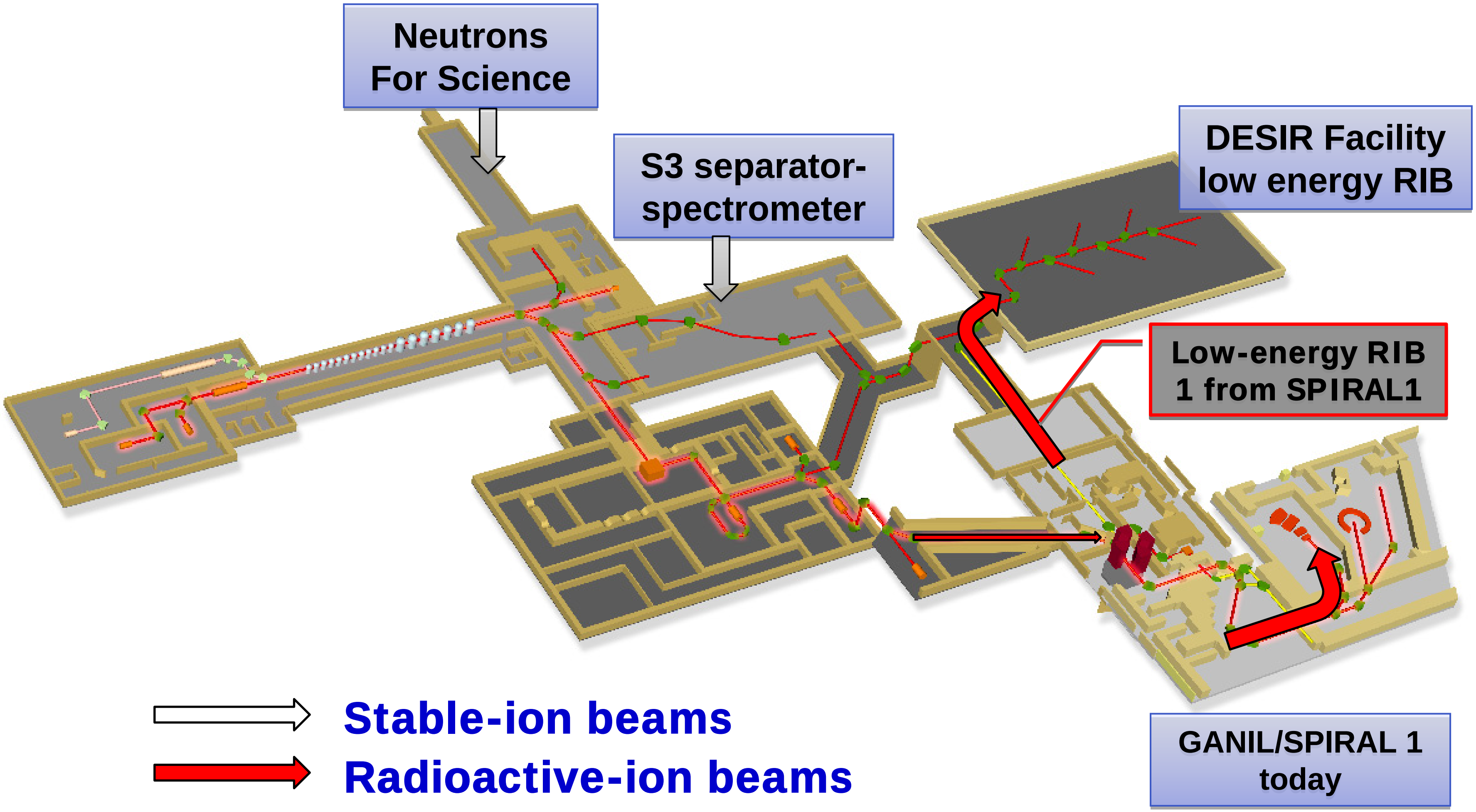
- In 2001, the first exotic beam of SPIRAL1 was produced with the existing cyclotron used as a driver.
- The exotic ion production was then depending on the target power resistance and the increase of the primary beam power.
- This leading to the developments of 3 kW target of SPIRAL1 and meanwhile increase the primary beam power within the safety rules (<6kW).

GANIL-SPIRAL: Looking towards the Future

- The variety of the ion species is now the main concern at GANIL. The present selective ECR ion source should be replaced by an alternative one in order to reach metallic beams.

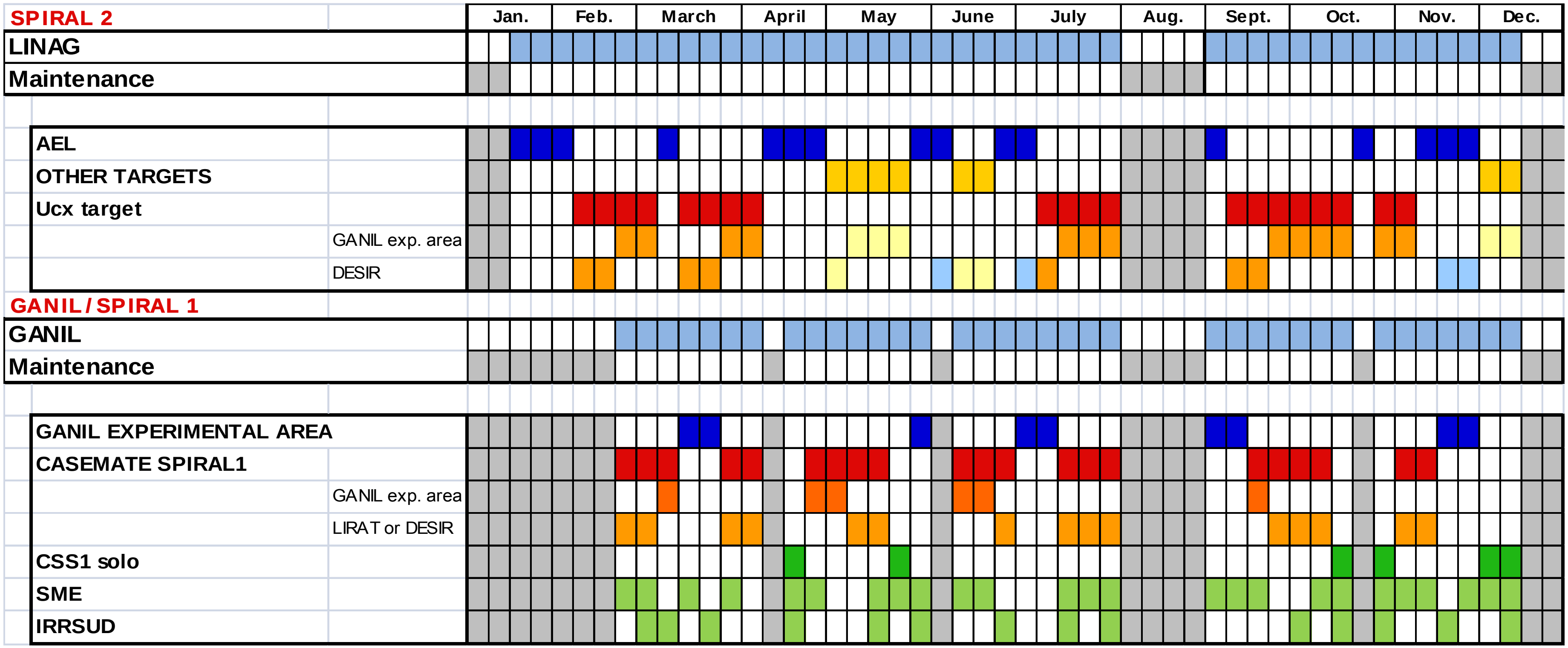
- The great care given to the maintenance of the 27 year old machine allows us to still expect to increase its performances and be competitive until the SPIRAL2 arrival.

GANIL/SPIRAL1/SPIRAL2 facility



GANIL potentiality

44 weeks for SPIRAL2 and 36 weeks for GANIL a year are foreseen



Thank you for your attention