

GANIL: FROM THE BEGINNING 40 YEARS AGO TO RECENT RESULTS AND PROSPECTIVE

A. Savalle, C. Berthe, P. Chauveau, M. Dubois, B. Jacquot, O. Kamalou, G. Sénécal And the GANIL staff

A few days (and 40 years) ago : first beam from SSC2



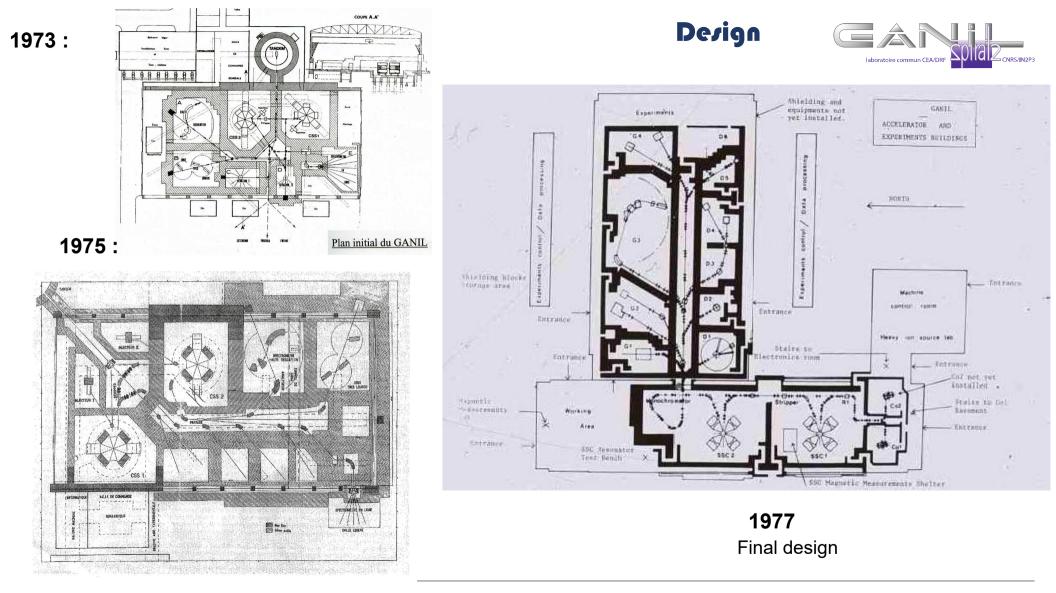
November 19th, 1982 : Output C02 : 2 μA 200 nA ejected from CSS1

Ar⁴⁺ stripped into Ar¹⁶⁺

4h : 150 nA entrance SSC2 7h15 : 15 nA accelerated 12h30 : 5 nA <u>ejected from CSS2</u>

3 novembre 1982	400	150 ma à l'entré de 1552
1982	1.000	150 ma à l'entré de CSS 2 Dujinction HF CSS 2
	4.40	Reglage In. CSSZ OK
		Réglage In. CSSZ OK 50 m sur le Tour d'éjection CSSZ
	5 415	Variation de las Pos Rot de la Source -
		Repuise des neglage (0, 155 Z, 1552
	7 4-15	15 m accideré dours 1552
	94 00	Réglage de l'injulion CSS2 faiscean injecte
	9" 25	Révelage de l'éjahan CSS2
	9440	phase par losidion - 130,8°
	11410	AC AC low vertice le champ dam ne6 C2.
	11" 25	Reprise righages d'ejection
	124 10	Rospiege deplacement de MSE3.
	12 30	EJECTION CSS 2 -> SWA SW LIPR
	Carl Carl	
		-www.
-1 -1 -1	the second	
	1	
		-minitospose and a second second
		and the second
	normality of the	
	in the second	Paiscean sur L3 PR11 20 NV /dru. 2019. + europs d'intégration 1 sec, 6.

Cvclotrons 2022



The building of the facility (1978 – 1982)









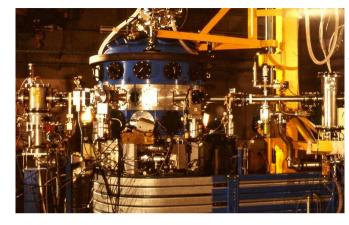






Beginning of operation

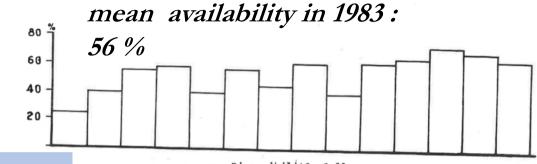






January 1983 : 1st experiment

> 1st beams : ¹⁶O @ 95 MeV/A ²⁰Ne @ 44 MeV/A ⁴⁰Ar @ 27, 44 and 60 MeV/A ⁸⁴Kr @ 35 MeV/A



Disponibilité réelle



1989: Opération Augmentation de l'Energie (OAE project)

The stripping efficiency was very bad at the beginning :

- Maximal energy 45 MeV/A for Kr, 25 for Xe (heavier beam accelerated)
- increase of the injection radius of SSC2 => increase of SSC1 energy
- New harmonics : SSC1 5 (previously : 7), SSC2 2

After OAE : Kr @ 60 MeV/A, Xe @ 50 MeV/A, U @ 24 MeV/A

New injection elements in SSC2



PROJECT "OAE" AT GANIL

a project for increasing the heavy ion energies

presented by J. Fermé

GANIL, BP 5027, 14021 CAEN CEDEX, FRANCE

11th int. Cyclotron conference

Jacques Fermé (left)



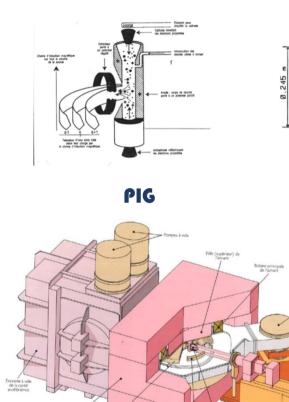


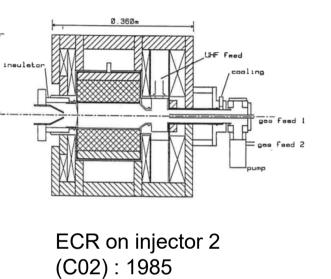
Cyclotrons 2022



Ion sources Evolutions

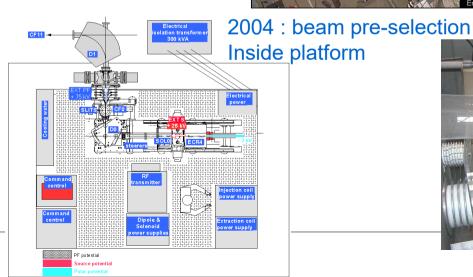
Bati support di la source d'ion





CEA CNRS

100 kV platform on injector 1 (C01) : 1992



Creater States

05/12/2022

Electrode d'accélératio

Schéma montrant les principaux éléments d'un injecteur Co

The first radioactive beams : SISSI



10

2

6

Ž

C Disp Hor, 4

Ligne L3 de la sortie de CSS2 au Pt objet Spectro Alpha

Emitance H= 5.0 V= 5.0 T/mm + mrd △W/W= 3.000 pm

Optique standard - SISSI alimenté

30

25

Env - Hor (mm) 21

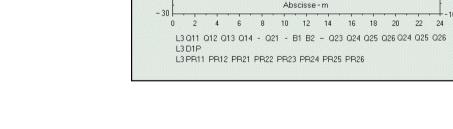
jū,

-Vert

È - 20 - 2F



Two superconducting solenoids

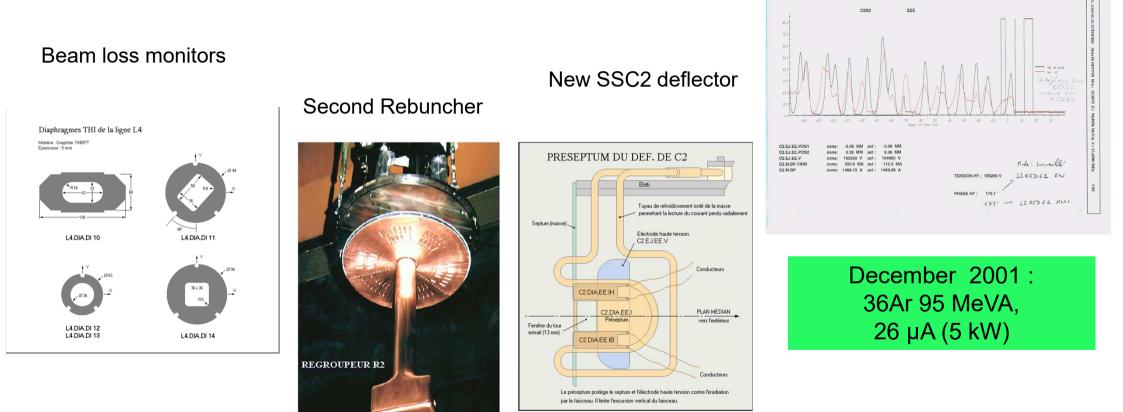


cooled, rotated target (1 KW deposited power)

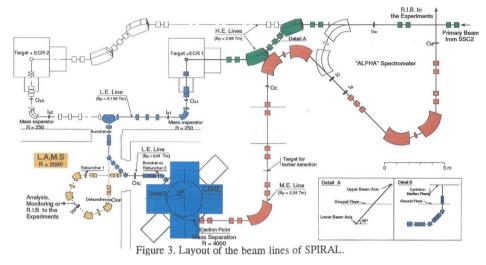
05/12/2022

To high intensity : the THI project : 6 kW





1995 - 1998 : SPIRAL 1









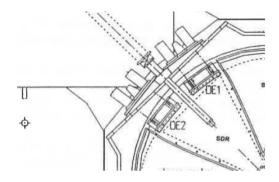




05/12/2022

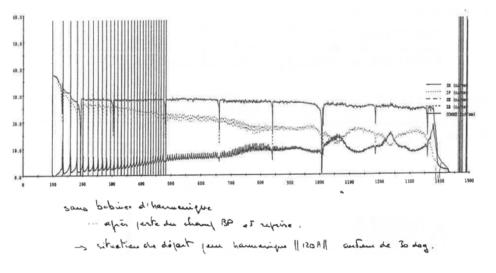
CNRS/IN2P3

1997 - 1998 : 1st beam tests in CIME



December 22th, 1997 : 1st beam accelerated Very low intensity measured on the radial probe between the two parts of the deflector

But it was not the beam ! (the radial probe moving through the electric field measures a current without beam)

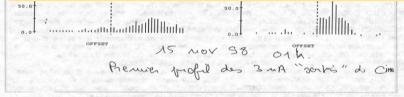




It was understood that the magnetic field was not equilibrated in the 4 sectors : Installation of magnetic coils to compensate this effect

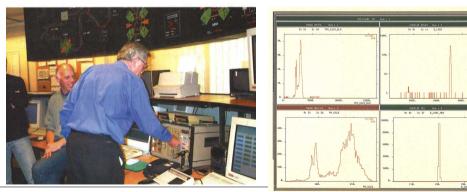
Dernière minute : le faisceau d'⁴⁰Ar⁹⁺ à 10 MeV/a a été accéléré et extrait dans la nuit du 14

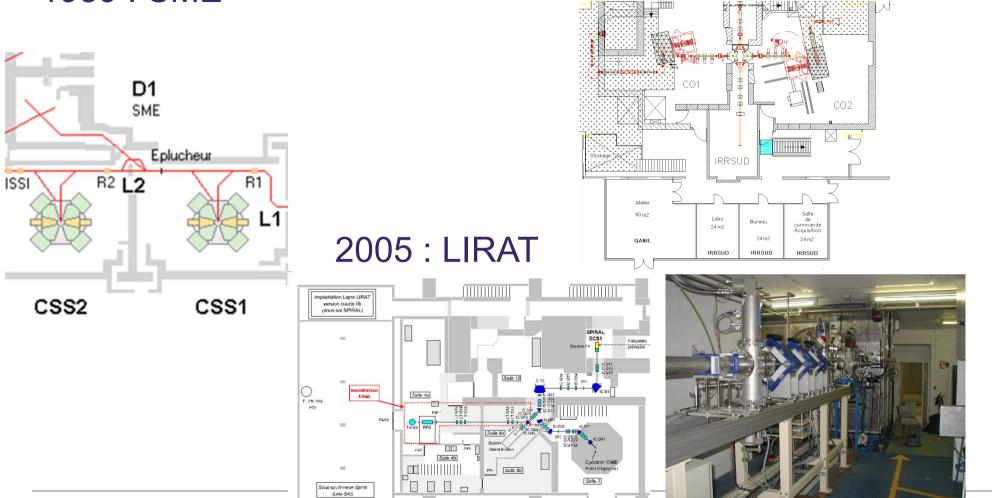
15 /11/ 1998 : 1st stable beam ejected



novembre, 5 jours seulement après la reprise des essais. La machine s'avère extrêmement stable et reproductible.

sept 27th, 2001 : 1st radioactive beam





5 m

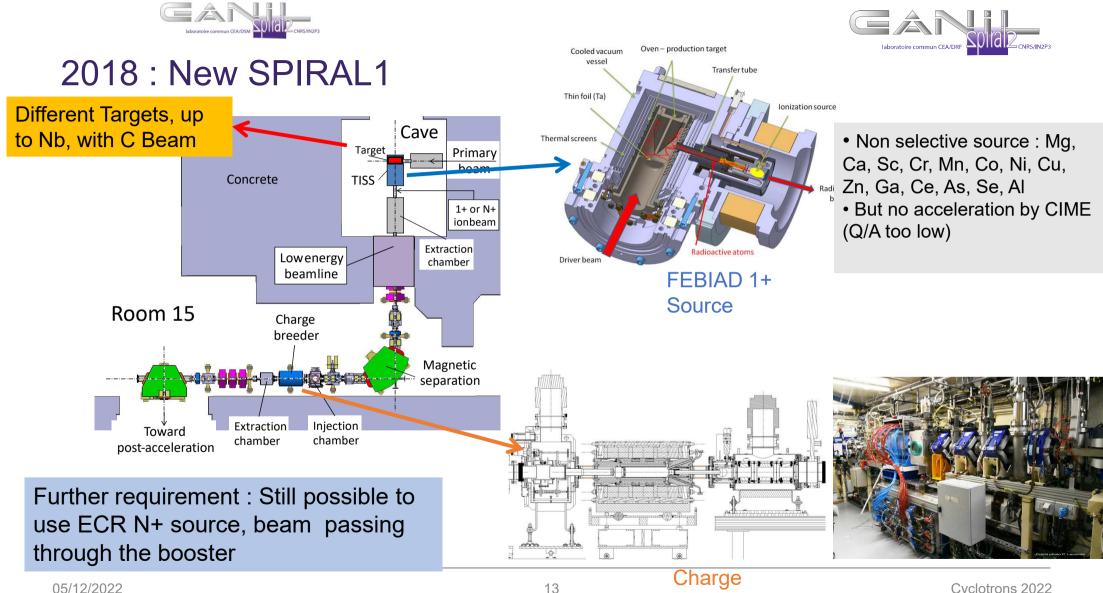
2002 : IRRSUD

1989 : SME

05/12/2022

Cyclotrons 2022





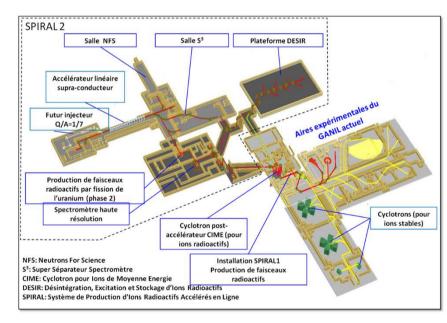
05/12/2022

breeder

Cyclotrons 2022

SPIRAL2 Project

2005 : Project launched



Original project, including postacceleration of fission products in CIME

2011 : excavation









2015: 1st beam in RFQ





October 28th, 2019 : 1st beam in the LINAC

05/12/2022

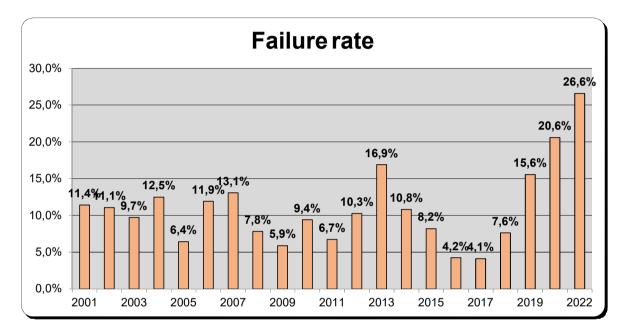
heures 3000 -Operation time (hours) Physics time (hours) Ω Cyclotrons + LINAC (hours) Physics time (hours) LINAC + CYCLOTRONS 2019 - 2021

OPERATION 1983 – 2022 (cyclotrons)

05/12/2022



<u>Failures</u> (cyclotrons)





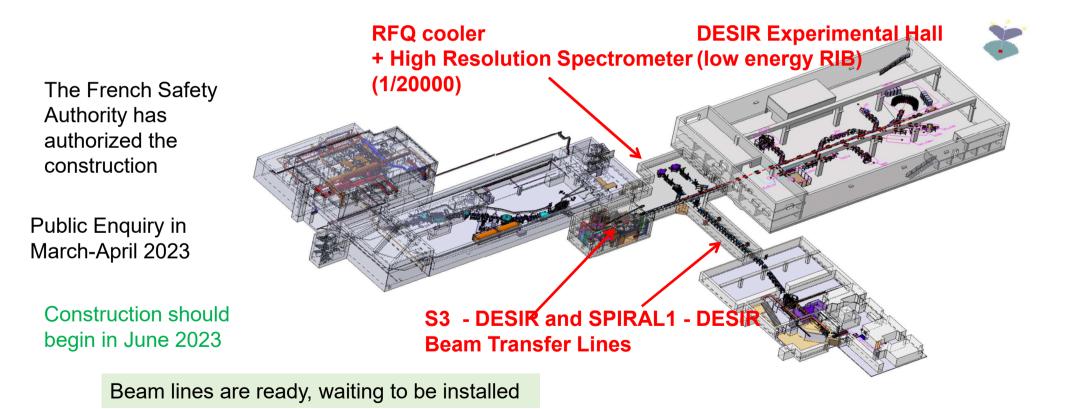


Mainly due to Water leak Inside the machine (cavity, injection elements, beam line – slits, diagnostics, ...)

And for the future ?



DESIR (Decay, Excitation, Storage of Radioactive Ions) Facility





And for the future ?

- Next years : Still more demand than time available for cyclotrons
- LISE spectrometer with SSC2 beams
- Post-accelerated SPIRAL1 new beams
- Fusion reactions (SSC1 beams)
- Industrial applications
- Tomorrow : DESIR with SPIRAL1 (²¹Na, ²³Mg, ³³Cl, ³⁷K, ³⁹Ca, ⁴¹Sc ...)
- => Cyclotrons to be still operated in 15 20 years

Developments of secondary beams 1 : FEBIAD 1+ source

			▶]
Phase	Objectives Project	2019 ^{38m} K ⁹⁺ 9MeV/A	2021 ⁴⁷ K ¹⁰⁺ 7MeV/A
1+ ionization	10%	> 5%	>15%
1+ to N+ transport	80%	>80%	>80%

84Kr@67MeV/A 10W beam -> 12C target

FEBIAD has been used in line in alkali mode : post accelerated beams : ^{38m}K (2019), ⁴⁷K (2021) It has been fiabilized (cooling of the insulators) and many tests have been made

≈80 radioactive isotopes/isomers seen, including 50+ at post-accelerable intensities (>10⁵pps).

Group + 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 addition (1) 100 110 100 110 100 110 100 110 100 110 100 110 100 110 100 110 100 110 100																										@67IVIEV/A I		120 target				
Group +1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 8 U 100-66 7 7 7 8 9 10 11 12 13 14 15 16 17 18 8 U 100-66 7 7 7 8 9 10 11 12 13 14 15 16 17 18 8 U 0.447 138-07 7																						<u> </u>		· .					48Ca@	260MeV/A 20	JOW beam ·	> 12C target
Group + 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 8 100-05 7 <td></td> <td>Masse</td> <td>Isotope(s)</td> <td></td> <td></td> <td>80</td> <td></td> <td></td> <td></td> <td>Masse</td> <td>s Isotope(s)</td> <td>T1/2 (s)</td> <td>ate@700W</td>																					Masse	Isotope(s)			80				Masse	s Isotope(s)	T1/2 (s)	ate@700W
Period 2 20% 0.04% 0.4%7 138-06 0 138-07 0 147C1 34.4 308-05 30.4 308-05 30.4 308-07 20 138-07	Grou	ıp → 1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	8		0.84									-
1 1	Peri	bd																			20	20Na	0.4479		79				37			
1 H Helder 11 3 get-or actionactive isotope 4 get-	+		_																		21	21Na	22.49	1.13E+07	10							
2 11 2 24 27 7 8 9 100 8 7 7 8 9 100 11 3068 386-07 4 460-07 434/2 33 686-07 3 11 11/2 <td< td=""><td>1</td><td> 1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>2</td><td>21</td><td>1H20F</td><td>11</td><td>3.90E+04</td><td></td><td></td><td></td><td></td><td>42</td><td>42CI</td><td></td><td></td></td<>	1	1																		2	21	1H20F	11	3.90E+04					42	42CI		
2 11 2 24 27 7 8 9 100 8 7 7 8 9 100 11 3068 386-07 4 460-07 434/2 33 686-07 3 11 11/2 <td< td=""><td></td><td>Η.</td><td></td><td></td><td></td><td>_</td><td></td><td></td><td>_</td><td></td><td></td><td>_</td><td></td><td>_</td><td></td><td></td><td></td><td></td><td></td><td>He</td><td>22</td><td>23Ne</td><td>37.25</td><td>1.43E+06</td><td></td><td></td><td></td><td></td><td></td><td>42K</td><td>44496</td><td>6.24E+08</td></td<>		Η.				_			_			_		_						He	22	23Ne	37.25	1.43E+06						42K	44496	6.24E+08
2 3 4 6 7 8 9 100 24/e 2028 218-r60 77Kb 28.8 5.208-r00 77Kb 28.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8 78.8				_		F	lem	ents	for	whic	h we	e ob	ser	ved							23	23Mg	11.3046	4.27E+06	78				40	43CI	3.3	6.84E+04
2 Li Be radioactive isotope B C N O F Ne 24 24Ma 30802 9.287+05 77% 228.8 202+06 77% 228.8 202+06 77% 77% 228.8 202+06 77% 77% 228.8 202+06 77% 77% 77% 228.8 202+06 77% <td>2</td> <td>3</td> <td>4</td> <td></td> <td>5</td> <td>6</td> <td>7</td> <td>8</td> <td>9</td> <td>10</td> <td></td> <td>24Ne</td> <td>202.8</td> <td>2.18E+05</td> <td></td> <td></td> <td></td> <td></td> <td>43</td> <td>43Ar</td> <td>322.2</td> <td>3 92E+07</td>	2	3	4												5	6	7	8	9	10		24Ne	202.8	2.18E+05					43	43Ar	322.2	3 92E+07
3 111 112 224Ma_m 0.0000 2874400 77 7778 22.0147 43 45K 1038 4.96E-08 4 19 200 21 21 22<	2	L.	B			r	adios	activ	ie ie	oton	P				Ř	ĬČI	Ń	ŏ			04	24Na	53989.2	9.29E+07								
3 111 120 244 2033 4/47E+02 77 78 78		-		C		19	auto	aouv	0 13	otop	C				D					INC	24	24Na m	0.0202	2.87E+05			4275	2.81E+07	45			
Al SI F SI CL Al SI	-	11	11-	2											12	11	15	16	17	10		24AI	2.053	9.47E+02	77							
Al SI F SI CL Al SI	- 3		04	2																		25AI	7.183	3.80E+04					47	47K	17.5	2.67E+08
4 19 200 21 227 23 24 25 26 27 28 29 30 31 32 33 34 35 36 25 26Na 1007 500 600 600 600 600 600 600 600 600 600 600 600 600 600 600 600 70 76kb 5320 600 600 600 600 600 70 76kb 5320 600 600 600 600 600 600 600 600 600 600 600 600 70 75kr 220 78kr 92 78kr 92 78kr 92 92 93 94 94 94 75 630 77 78kr 78kr 98 92 92 94 944 148 <td></td> <td>INA</td> <td></td> <td>g</td> <td></td> <td>AI</td> <td>21</td> <td>Р</td> <td>2</td> <td>C</td> <td>Ar</td> <td></td> <td>25Na</td> <td>59.1</td> <td>8.67E+06</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>		INA		g											AI	21	Р	2	C	Ar		25Na	59.1	8.67E+06								
4 19 20 21 27 23 24 25 26 25 36 32 24 35 34 35		10			24				05	26					- 24					0.0	25					76Rb	36.5					
5 38 39 40 41 42 44 45 46 47 48 49 50 51 54 52 53 54 52 53 54 76 77 78 79 76 77 78 79 87 74 75 76 77 78 79 80 81 82 83 84 85 86 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 80 1.3 2274/3 334 1.14E+06 75 756e 1.30E+06 75 75 75 75 75 75 75 75 75 756 1.32E+04 75 756e 1.30E+05 75 226+07 75 226+07 75 226+07 714 2.32E+04 714 2.32E+04 714 2.32E+04 714 2.32E+04 71 714 2.32E+04 714 1.96E+04 714 1.96E+04 714 1.96E+04 714 1.9	4	19	20	0	21	22	23	24	25	26	2/	28	29	<u> 3</u> 0	31	32			35	36					76	76Kr						
5 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 27 27Mg 66 525 56 * 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 328+00 756 128+04 7 87 88 * 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 324+ 0.081 1.08E+05 71k 23808 * 103 104 105 106 107 108 109 101 117 118 116 117 118 33 324+ 0.098 1.16E+03 322h 0.098 1.16E+03 33 324+ 0.098 1.16E+03 33 334+ 0.173 9.8E+04 71k 238060 1.02E+04 <t< td=""><td></td><td>K</td><td>Ca</td><td>a</td><td>Sc </td><td> Ti </td><td> V </td><td>Cr </td><td>Mn</td><td>Fe </td><td>Co </td><td>Ni</td><td>Cu</td><td> Zn </td><td>Ga </td><td>Ge</td><td>As</td><td>Se</td><td> Br </td><td>Kr </td><td></td><td></td><td></td><td></td><td>10</td><td>76Br</td><td>58320</td><td></td><td></td><td></td><td></td><td></td></t<>		K	Ca	a	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr					10	76Br	58320					
5 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 27 27Mg 567.5 262E+06 75Kr 262E+06 6 55 56 * 71 77 78 79 78 79 80 81 82 83 84 85 86 86 9294/ 394 1.14E+06 756 766 128E+06 7 78 79 76 76 760 77 78 79 80 81 82 83 84 85 86 80 304 322E+06 756 766 766 98 99 90 91 100 101 110 111 110 111 110 111 110 111 110 111 110 111 110 111 110 111 110 111 110 111 110 111 110 111 110 111 110 111 110 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>26</td><td></td><td></td><td></td><td></td><td>76mBr</td><td>1.31</td><td>1.53E+06</td><td></td><td></td><td></td><td></td></t<>																					26					76mBr	1.31	1.53E+06				
6 55 56 * 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 75Ge 44 2282H04 7 87 88 * 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 30A 30A 32A 30A 32B 30A 32B 130E+03 71 87 88 * 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 108 32 32Ar 0.098 1.16E+03 32 32Ar 0.098 1.16E+03 33 33Ar 0.173 981E+04 99 90 1.92E+03 98 912 1.39E+07 98 90 90 60 612.62 623 64 655 66 67 68 69 70E 33 33Ar 0.173	5	37	38	8	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	27					75Kr	276	8.03E+05				
6 55 56 * 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 75Ge 44 2282H04 7 87 88 * 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 30A 30A 32A 30A 32B 30A 32B 130E+03 71 87 88 * 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 108 32 32Ar 0.098 1.16E+03 32 32Ar 0.098 1.16E+03 33 33Ar 0.173 981E+04 99 90 1.92E+03 98 912 1.39E+07 98 90 90 60 612.62 623 64 655 66 67 68 69 70E 33 33Ar 0.173	J	Rb	S	r	Ϋ́Ι	Żr	Ńbl	Mo	Ťc	Ru	Ŕĥ	Pd	Aa		In	Ŝn	Ŝb	Te	Ť	Xe					75	75Br	5802	4.26E+07				
6 55 56 * 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 30 30.1 3.62 1.30E+03 71.6 71.8 238.6+04 7 87 88 * 103 104 105 106 107 108 109 110 111 112 113.8 114 115.6 117.5 108 33.47 0.098 1.10E+03 32.27E+03 71.7 78.8 23.8E+04 7 87 88 * 103 104 105 106 107 108 109 110 111 112 113.8 114 115.7 118 09 32.27 0.098 8.52E+04 694.8 912 1.86E+05 696.9 675.9 676.9 677.9 688.9 699.9 702.1 33.33A' 0.173.9 921.6 0.28E+07 696.4 <td< td=""><td></td><td></td><td></td><td></td><td>•</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td><i>.</i>.9</td><td></td><td></td><td>0.1</td><td>0.0</td><td></td><td>-</td><td>7.0</td><td></td><td></td><td></td><td></td><td>15</td><td>75Ga</td><td>126</td><td>1.22E+04</td><td></td><td></td><td></td><td></td></td<>					•								<i>.</i> .9			0.1	0.0		-	7.0					15	75Ga	126	1.22E+04				
7 87 88 * 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 108 230a 22.0E+07 7 Fr Rf Db 106 107 108 109 110 111 112 113 114 115 116 0.19 8.05E+02 71 712n 712n 712n 712n 712n 147 1.90E+04 7 712n 147 1.92E+03 32 32Ar 0.098 1.16E+03 69A 912 1.80E+05 69A 912 1.80E+05 66A 67 68 69 70 33 33Ar 0.173 9.81E+04 69 696 69	6	55	56	5 *	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	29					75Ge	4966.8	1.98E+05				
7 87 88 * 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 108 230a 22.0E+07 7 Fr Rf Db 106 107 108 109 110 111 112 113 114 115 116 0.19 8.05E+02 71 712n 712n 712n 712n 712n 147 1.90E+04 7 712n 147 1.92E+03 32 32Ar 0.098 1.16E+03 69A 912 1.80E+05 69A 912 1.80E+05 66A 67 68 69 70 33 33Ar 0.173 9.81E+04 69 696 69	6				111	íf	$ _{T_2}$				I'r			Цйа	I TI I	Dh	Bi			D n	30					71Se	284.4					
7 87 88 * 103 104 105 106 107 108 109 110 117 113 114 115 116 117 188 33 C190 26.91 1.92E+03 712n 1447 1.96E+046 * 57 58 59 60 61 65 66 67 68 69 70 70 33 33Ar 0.013 9.81E+04 6946 1.92E+03 6946 1.92E+03 6946 1.92E+03 6946 1.92E+03 712n 14256 1.67E+05 6948 1.92E+03 712n 14256 1.67E+05 6966 1.67E+05 6966 1.67E+05 697 68 667 68 667 68 667 68 667 68 67 712n 14256 1.67E+05 6960L 149 1.92E+01 </td <td></td> <td>CS</td> <td></td> <td>a</td> <td>Lu</td> <td></td> <td>Та</td> <td>vv</td> <td>Re</td> <td>03</td> <td>11</td> <td>ΤU</td> <td>Au</td> <td>ng</td> <td></td> <td></td> <td></td> <td>10</td> <td></td> <td>IXII</td> <td></td> <td></td> <td></td> <td></td> <td>71</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>		CS		a	Lu		Та	vv	Re	03	11	ΤU	Au	ng				10		IXII					71							
Fr Ra Lr Rf Db Sg Bh Hs Mt Ds Rg Cn Nh FI Mc Lv Ts Og 32 32Ar 0.098 1.16E+03 696 696 1.10E+03 32 32Ar 0.098 1.16E+03 696 697 0228 8.52E+04 696 696 1.40580 1.39E+07 697 033 33Ar 0.173 9.81E+04 696 697 492 1.86E+05 696 697 03 33Ar 0.173 9.81E+04 696 697 492 1.86E+05 696 697 03 33Ar 0.173 9.81E+04 69 696 697 696 697 70	_	07	0	2 1	102	104	10E	106	107	100	100	110	111	112	112	111	115	116	117	110	31											
Image: Normal and the second secon	- 7	우/			105	104										14																
* 57 12 58 59 10		Fr	Ra	a 🔨	Lr	RI	מט	sg	ы	ПS	IVIL	DS	Rg	Ch	IND	FI	IVIC	LV	IS	Ug	32											
* 57 La Ce Pr 60 * 89 * Ac Ph 91 Pa 92 P1 Pa 92 P1 Pa 92 P1 Pa 92 P3 P4 Pa Pa P5 P6 Pr 60 Pr 60 Pr 61 Pa 92 P3 P4 Pa P5 P6 P6 P7 P8 P6 P7 P8																									69							
* 89 * Ac Th Pa U 91 92 93 94 95 96 97 06 Pr Bk Cf Ps Cf Ps Pr Md No Pr Bk Cf Ps Pr Md No Pr Bk Cf Ps Pr Md No Pr				. 1	F7				64	60	62	64		CC	C 7	60	60				33				00		49521.6					
* 89 * Ac Th Pa U 91 92 93 94 95 96 97 98 99 100 101 102 35 35Ar 1.7756 1.54E+08 68Ga 4062.6 1.42E+07 34mCl 1919.4 7.90E+07 67 67Ga 281810.8 4.42E+07 35 35Ar 1.7756 1.54E+08 65Ga 281810.88 4.42E+07 1919.4 1.89E+07 65 65Ga 912 6.92E+06				*	5/				61	62	63					68		01								69Cu	171	4.22E+04				
* 89 * Ac Ph Pa P2 P3 P4 Pu P5 P6 Pm Pa P2 P3 P6 Pm Pa Pb Pa Pb Pa Pb Pa Pb Pa Pb					La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Ib	Dy	Ho	Er	Im	Yb			34				68							
* 89 90 91 92 93 94 95 96 97 98 99 100 101 102 * Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No 35 35Ar 1.7756 1.54E+08 67 67Ga 281810.88 4.42E+07 #35 65Ga 912 6.92E+06																					54				00	68Ga		1.42E+07				
http://www.action.com/action/acti				*	89	90	91	92	93	94	95	96	97	98	99	100	101	102							67							
http://www.action.com/action/acti				*	Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No			35				07							
65Ni 9061.884 4.53E+04																						n 34m Cl	1919.4	1.09E+07	65	65Ga	912	6.92E+06				
																									00	65Ni	9061.884	4.53E+04				

Developments of secondary beams 2: SPIRAL1 Charge breeder

Phase	Objectives Project	2019 ^{38m} K ⁹⁺ 9MeV/A	2021 ⁴⁷ K ¹⁰⁺ 7MeV/A
Charge Breeding	5-10%	1.5%	8%
Extraction N+	50%	80%	80%

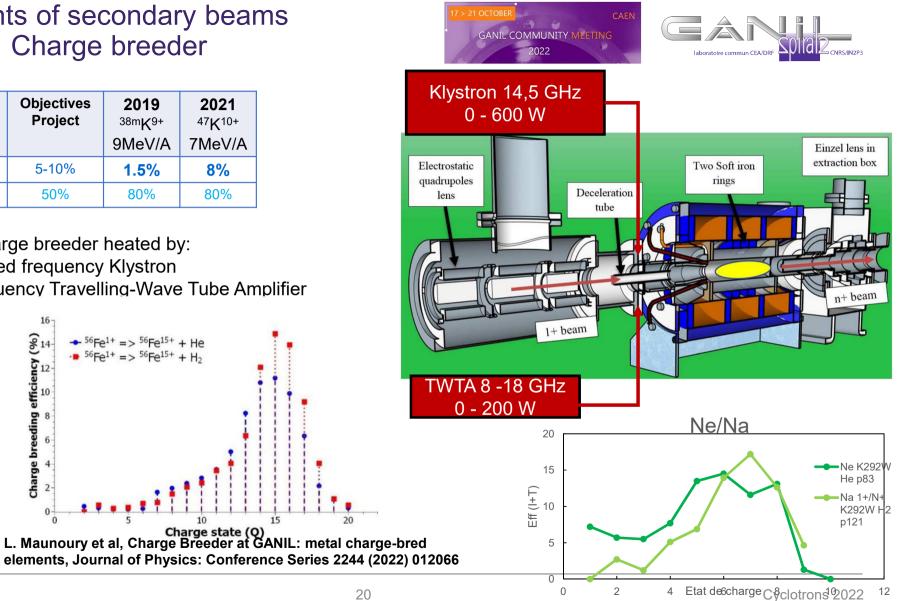
Plasma in the Charge breeder heated by:

(%) filtering (%) filtering (%)

Charge br

- The historic fixed frequency Klystron
- A variable frequency Travelling-Wave Tube Amplifier ٠

 $Fe^{1+} = 56Fe^{15+} + He$



Renovation program

CY_{clotrons}**REN**_{ovation}



> Objectives of the project

to keep the facility in operational conditions for at least 20 years

Cyclotrons and experimental caves									
Power Supplies and Magnets									
RF cavities and systems									
Remote control									
PLCs									
Vacuum systems									
Diagnostics									
Production targets									
lons Sources									

Pre project

Infrastructures and utilities

Electricity Distribution Cooling systems

HVAC

Buildings

Various networks (water, air, gas)

Computer Infrastructures



Radioprotection devices (radiation detectors, active dosimeters, gamma spectrometers, ...)

> Access Management System Fire Safety System

WHAT IS TO BE DONE ?

THE MAIN TOPIC : RF CAVITIES



Risk : cooling circuit leak, unreachable for repairing

→ At least, manufacturing of a new cavity and keeping an old one as a spare : Reference scenario

→ Replace the 4 SSC RF cavities : HIGH scenario

Issues to be assessed

> Sourcing

- ✓ At least one company able to manufacture a SSC RF cavity
- ✓ Evaluated cost : 5,7 M€ first cavity, 4 M€ each other
- ✓ Manufacturing delay : 2 years first cavity then 1 cavity per year
- > *RF characterization* of the new cavity
 - ✓ 8 months
 - ✓ No test stand available => qualification in a SSC cave
- Storage conditions of the spare cavity
- Handling issue : How to take a cavity out of a cyclotron cave and out of the building



40 years ago

assembly area



totation the second sec

New 2200 m² storage building (not only for spare cavity)

OTHER MAJOR TOPICS

Power Supplies

REF scenario

~4 M€ 11,5 FTE

360 PS over 30 years old to

refurbish or replace



Cooling Systems

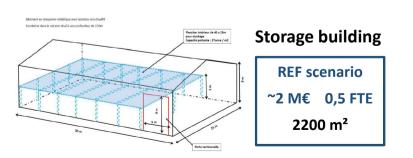








Remote control





~1,5 M€ 5 FTE Code refactoring VME crates virtualisation Software engineering contract

REF scenario

HIGH scenario

Not evaluated yet



Conclusion

After 40 years, GANIL cyclotrons are still demanded and it should be true for 20 years more

SPIRAL1 development is still active after the upgrade

DESIR : start of building construction in 2023

A large renovation plan is to be launched

In addition to the LINAC part (SPIRAL2) of the facility : operation, new experimental room, new injector to come

Thank you for your attention