

Radioactive ion beam production



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- What is existing now or under construction
- What we proposed since prospectives IN2P3 and within the call of the committee
- Summary table for ERL / e- ion scattering facility

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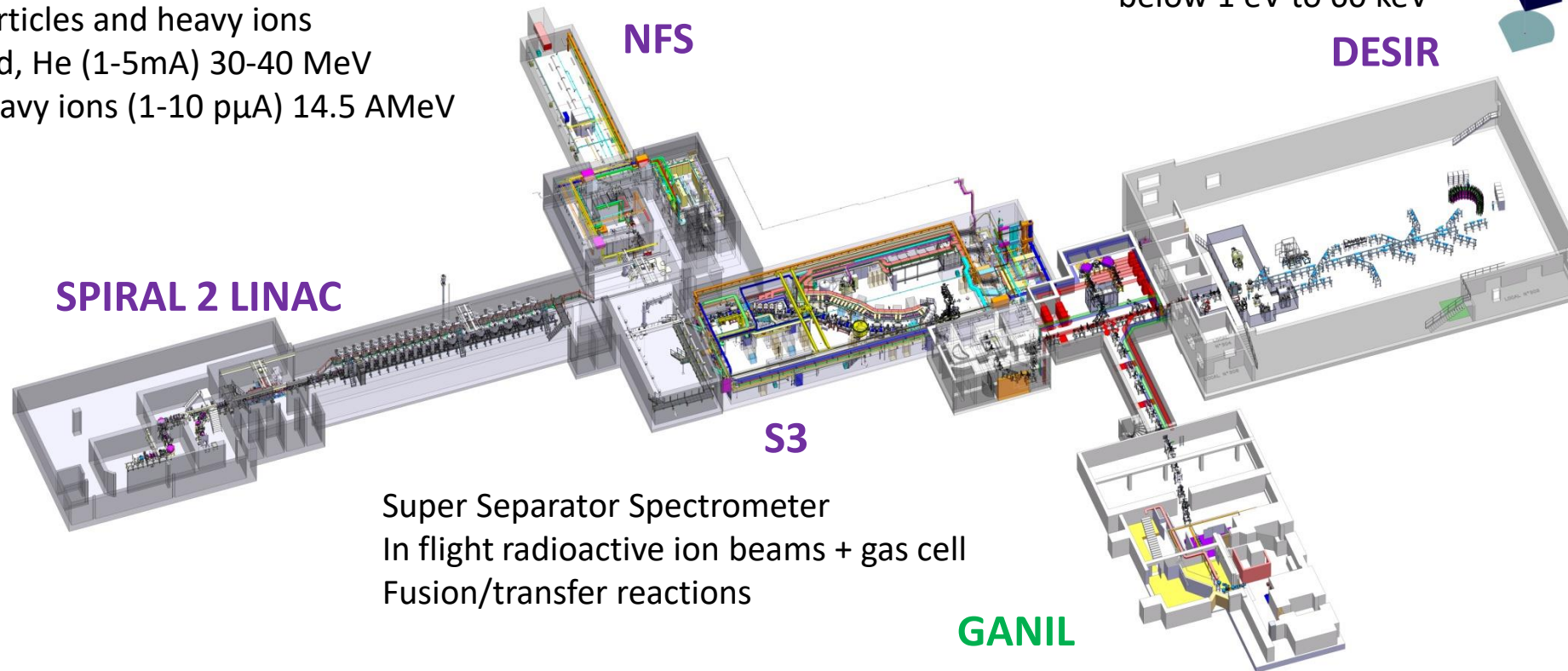
GANIL-SPIRAL 2 – Phase 1



High intensity beams of light particles and heavy ions
p, d, He (1-5mA) 30-40 MeV
Heavy ions (1-10 pμA) 14.5 AMeV

Neutron for Science
Neutrons up to 30 MeV

Experimental areas for very low energy beams:
below 1 eV to 60 keV



Super Separator Spectrometer
In flight radioactive ion beams + gas cell
Fusion/transfer reactions

Experimental areas and cyclotrons: heavy ions (pμA) up to 95AMeV
SPIRAL 1 facility: RIBs from fragmentation

Re-accelerated beams at SPIRAL 1

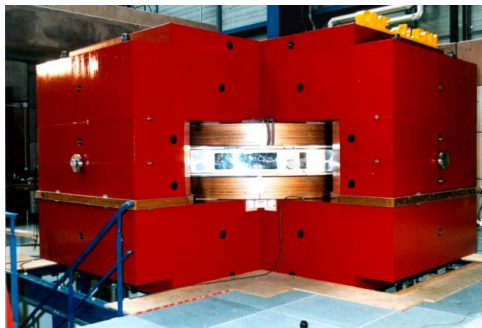
Isotope Separation On Line (ISOL) techniques in GANIL

Since 2001

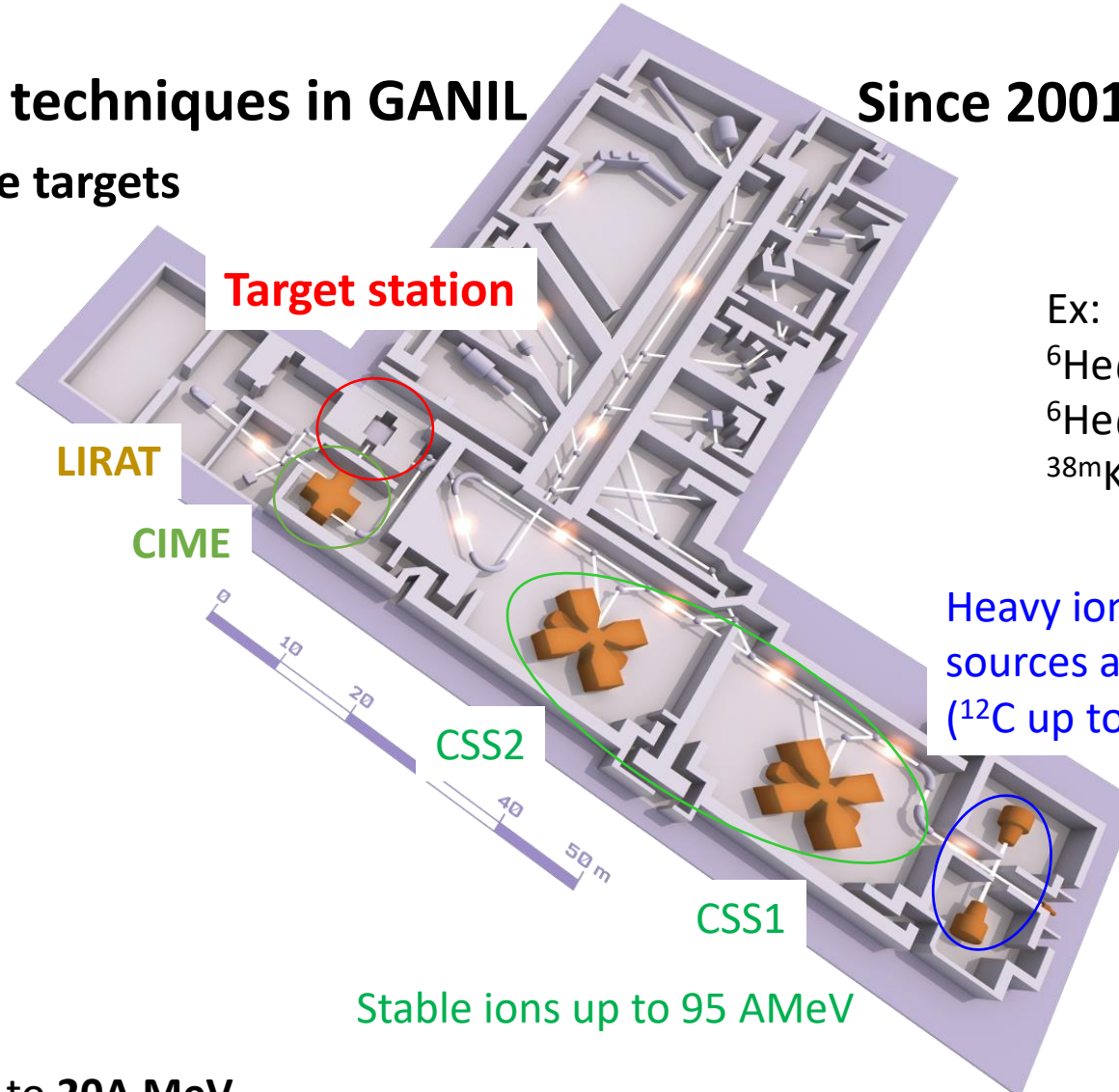
Heavy ion fragmentation on graphite targets



« Cyclotron d'ions de moyenne énergie »



Re-acceleration of radioactive ion beams up to **20A MeV**



Ex:

${}^6\text{He}@10\text{keV}$ $3 \cdot 10^8 \text{pps}$

${}^6\text{He}@20\text{AMeV}$: $5 \cdot 10^6 \text{pps}$

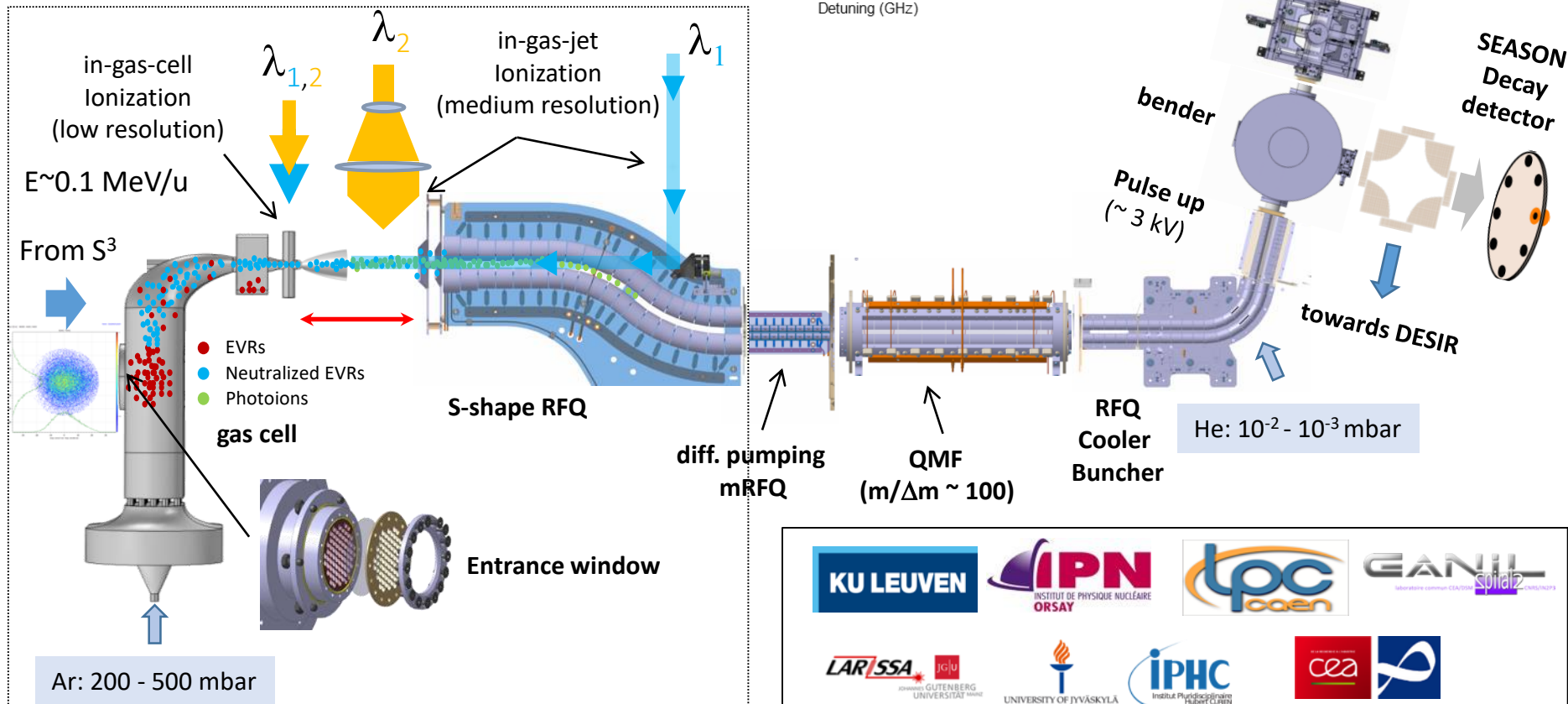
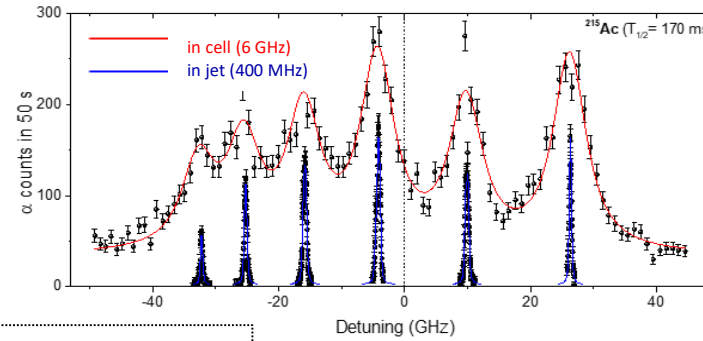
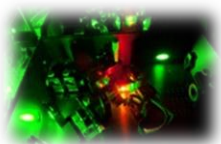
${}^{38}\text{mK}@9 \text{ A MeV}$: $7 \cdot 10^5 \text{pps}$

Heavy ion
sources and CO
(${}^{12}\text{C}$ up to ${}^{238}\text{U}$)

Stable ions up to 95 A MeV

Gas cell in S3 - LEB

REGLIS (Rare Element in Gas-jet Laser Ionisation and Spectroscopy)



Ex:
 $^{100}\text{Sn}@30\text{keV} \sim 10 \text{ pps}$

A few pps to 10^5 pps
N=Z beams and
superheavies

Commissioning in 2023

Nominal intensities
with $A/q=7$ injector
→ 2027



A/Q = 7 Injector: accepted NEWGAIN project

I. Stefan *Scientific Coordinator*

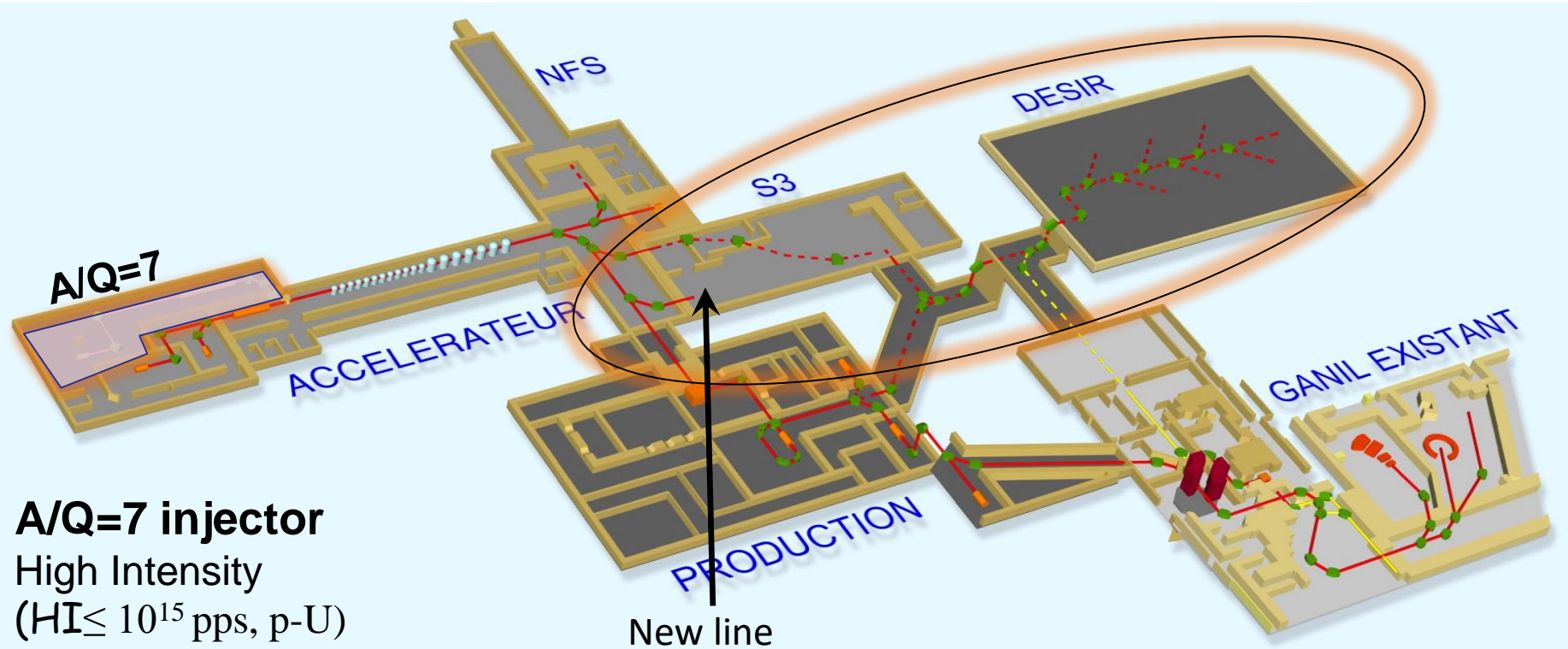
M. H. Moscatello *Technical Coordinator*

New injector for Linag presented in:
Spiral2 Physics Case, page 171 (2006)

A/Q=3 (existing): $E \leq 14.5$ MeV/A
A/Q=7 : $E \leq 7$ MeV/A

New beamline?

- not part of this project
- good future opportunity
- independent of S3
- advantageous use of heavy beams (Pb,U)



7 years project: estimated cost ~12 MEuro

Starting year (2020!?)

Starting year+1
(2021!?)

Starting year+2
(2022!?)

Starting year+3
(2023!?)

Preliminary
Definition
Phase

Detailed Definition Phase

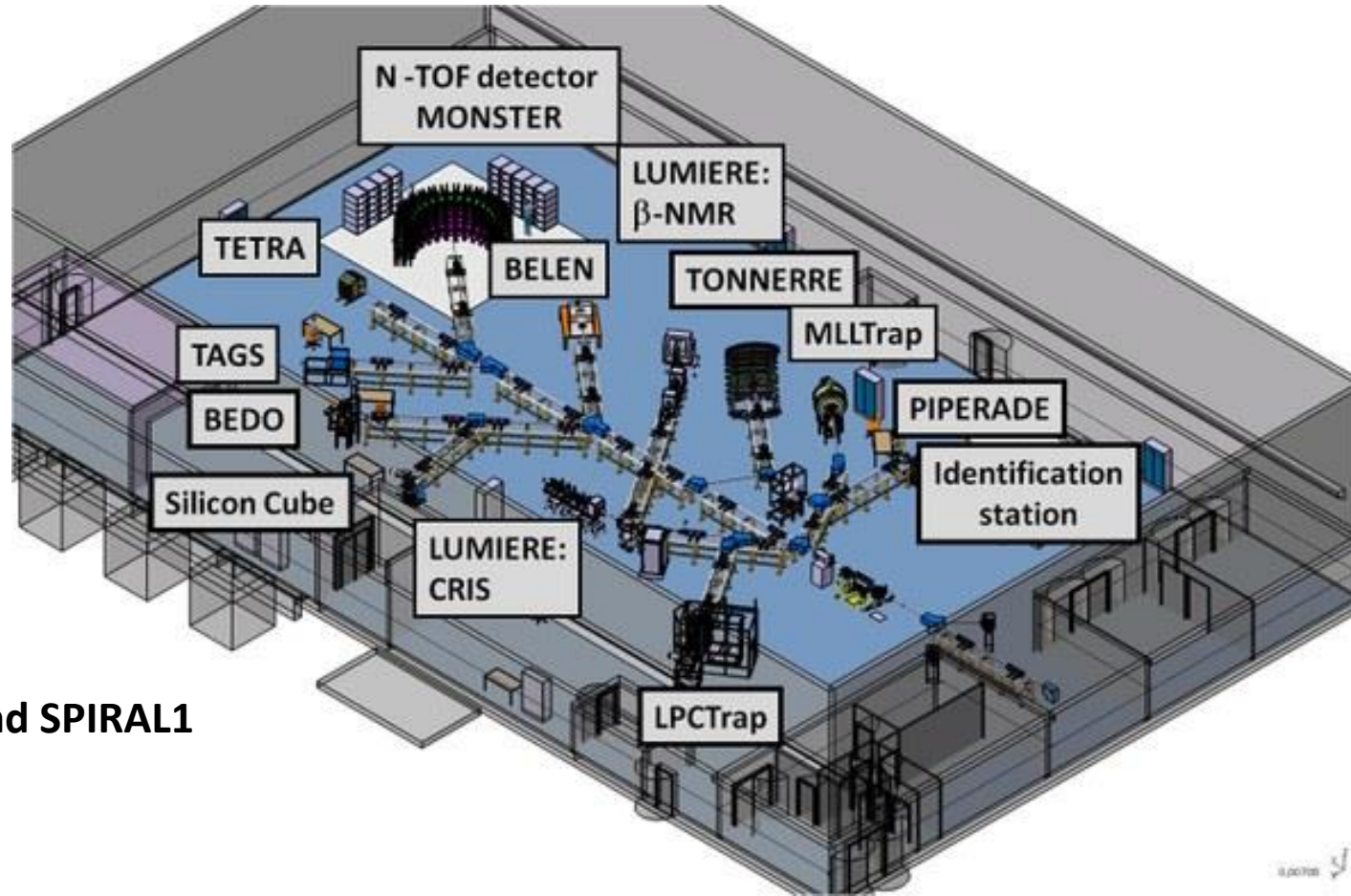
Construction -> End
starting year+7
(2027!?)

DESIR facility

2024-...

Very low energy beams:

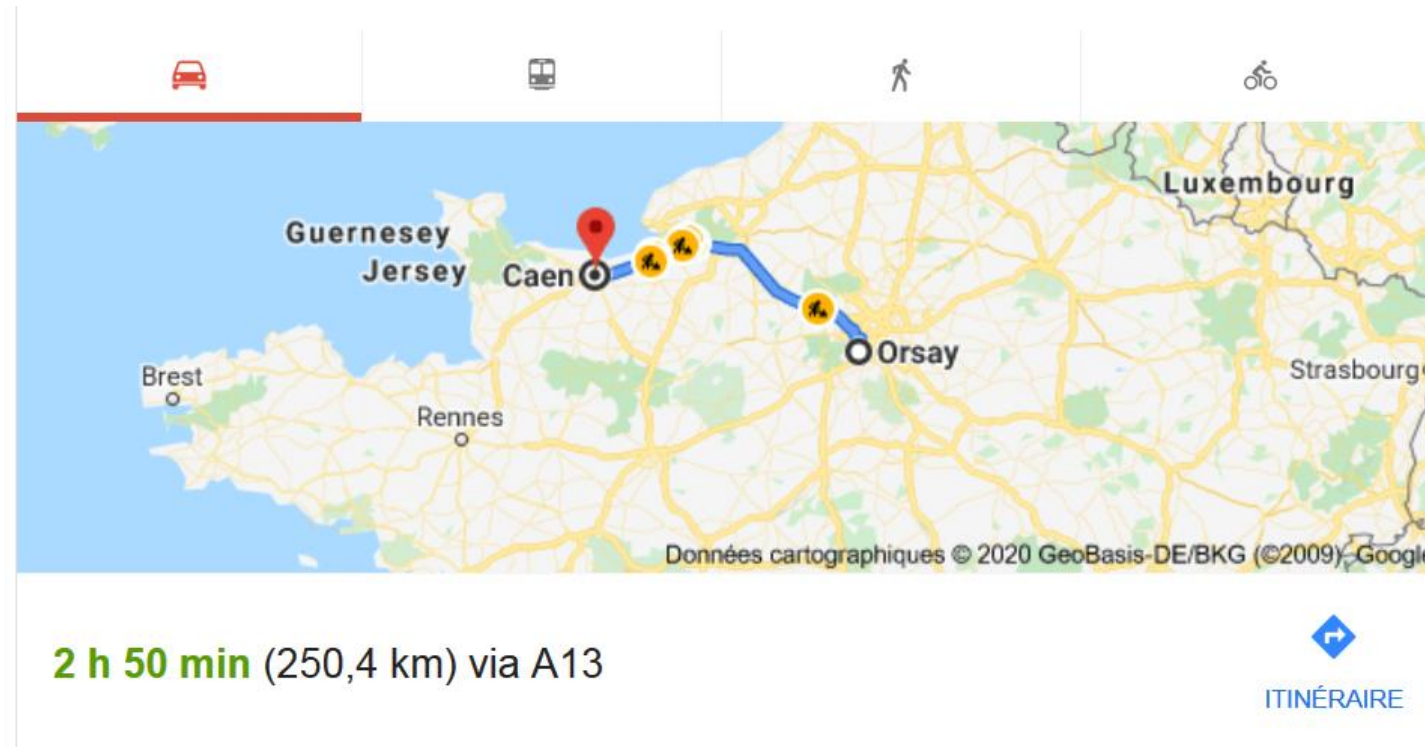
Spectroscopy of ground state properties of exotic nuclei produced at S3-LEB and SPIRAL 1
Traps, laser systems, and decay spectroscopy



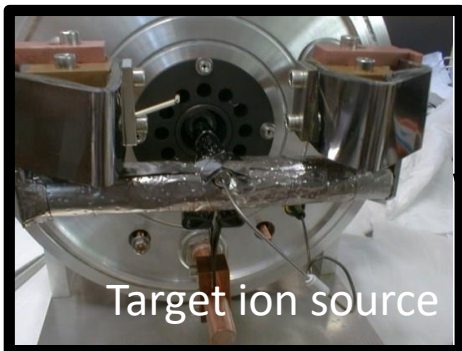
Beams from S3-LEB and SPIRAL1

Radioactive ion beam facilities in France

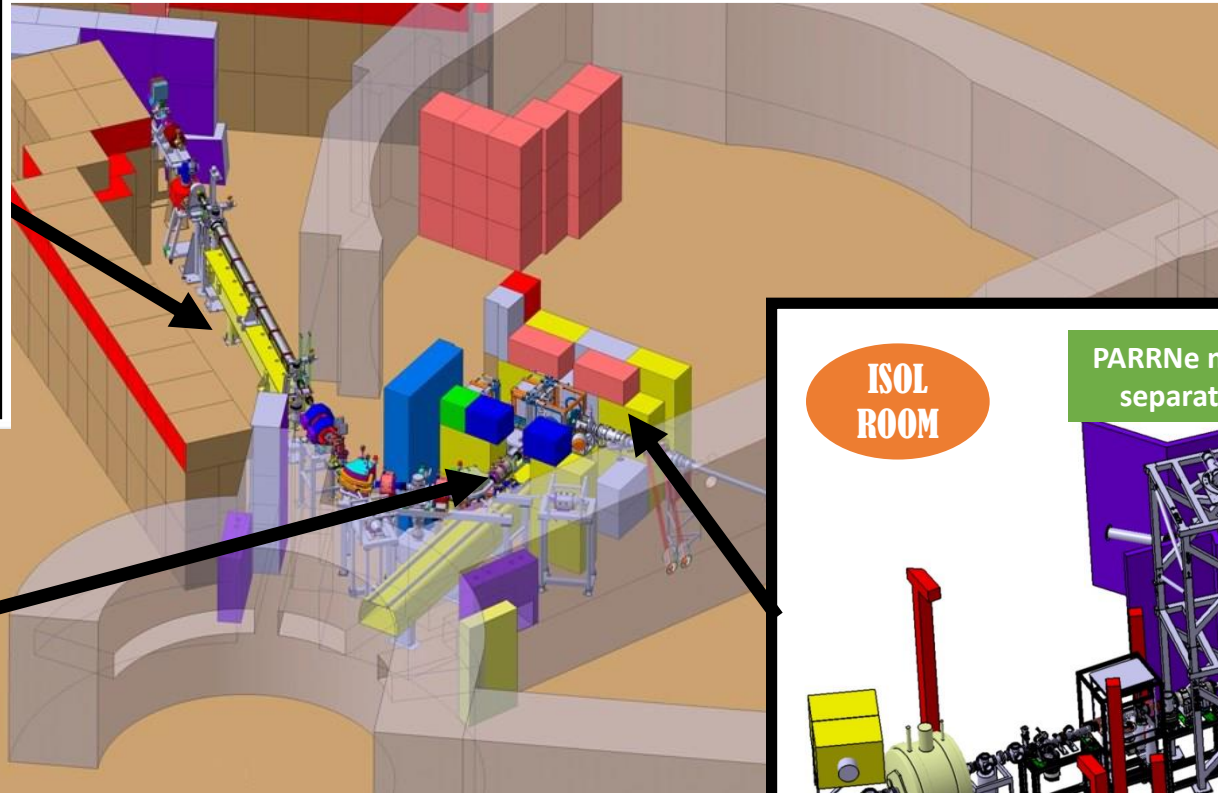
- 2 facilities: ALTO @IJCLab and GANIL-SPIRAL2



Photofission (installation pilote)



Ex: $3 \cdot 10^7$ pps of ^{132}Sn



500W e⁻ sur cible UCx
Faisceaux ISOL de basse énergie
Décroissance, piégeage

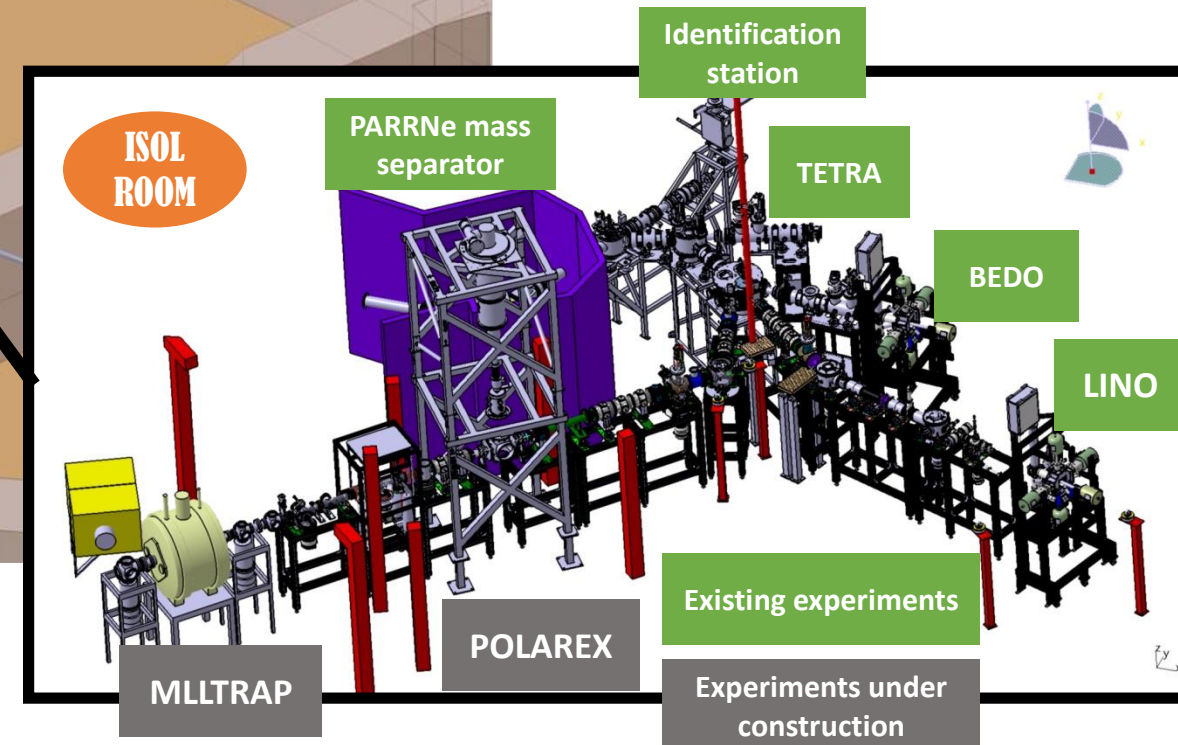
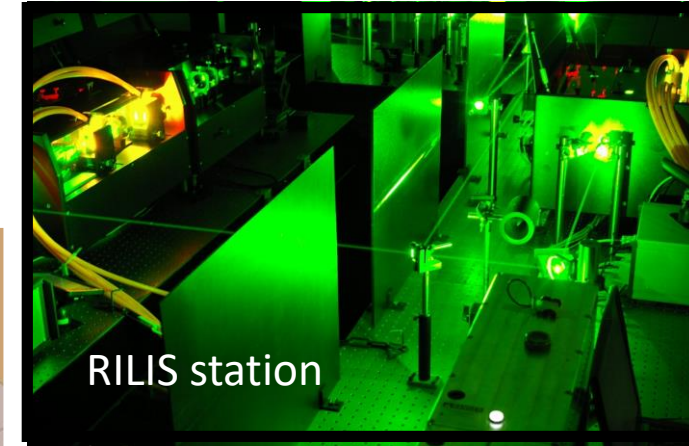
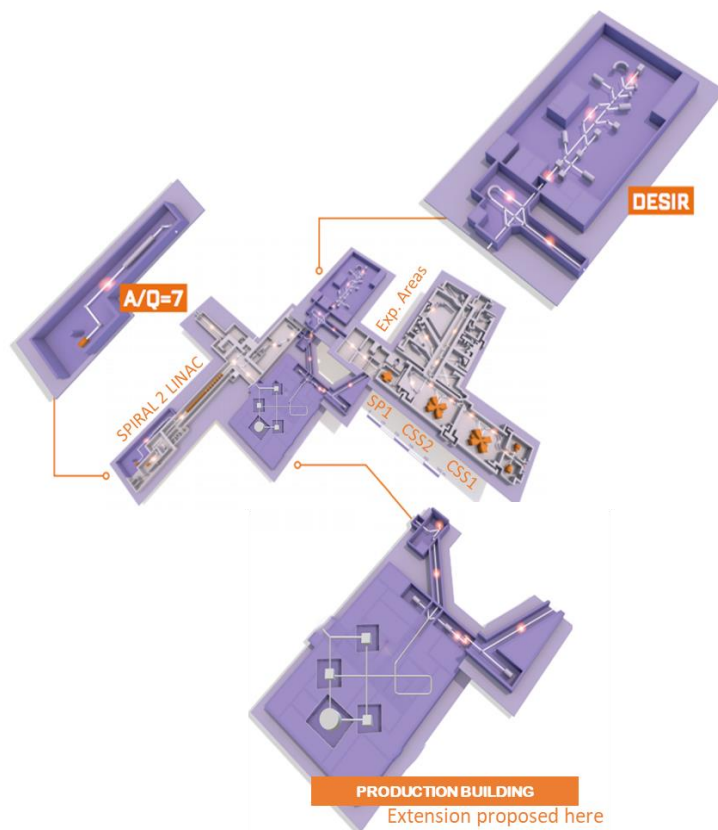


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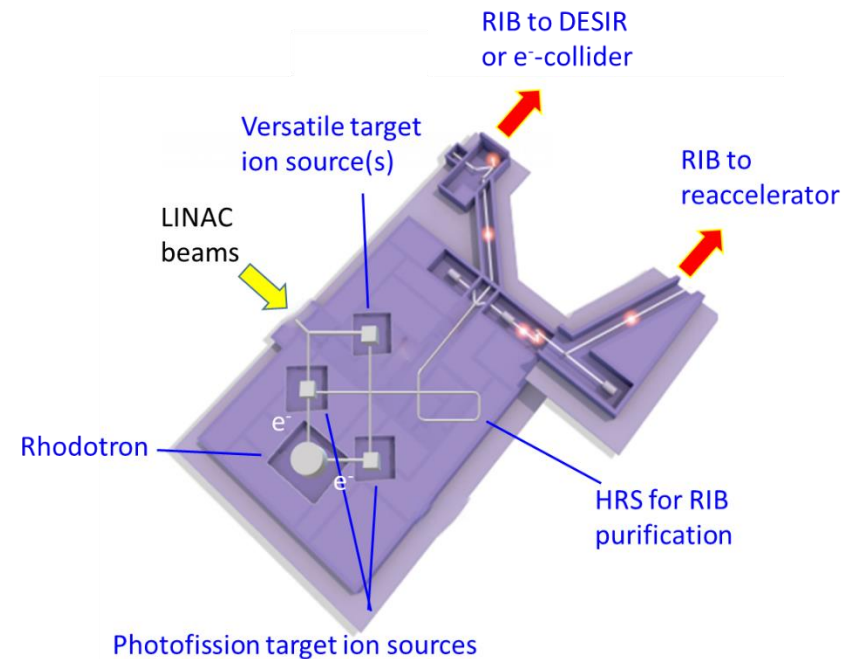
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Production building close to the LINAC

ISOL consolidated production capabilities with a multi-user facility
LINAC and Rhodotron beams

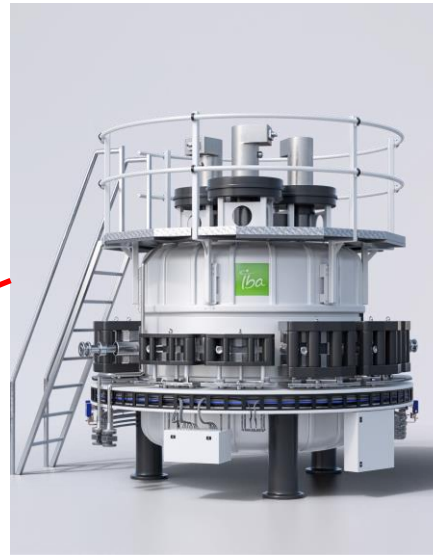
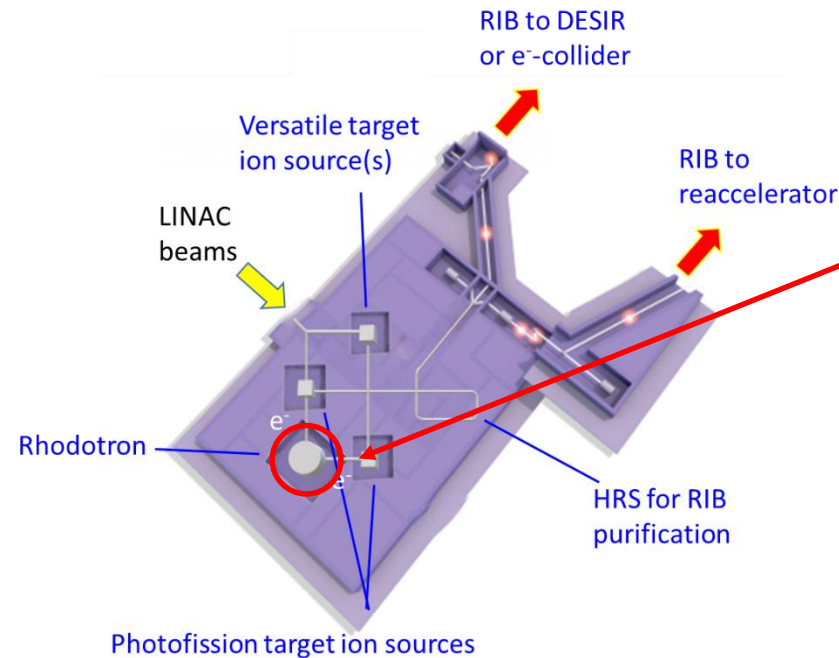


Production building



GANIL-SPIRAL2 as a Multifaceted Radioactive Ion Beam Facility, P. Delahaye et al.,
<https://indico.in2p3.fr/event/20534/contributions/81850/>

Production building: « detailed » view

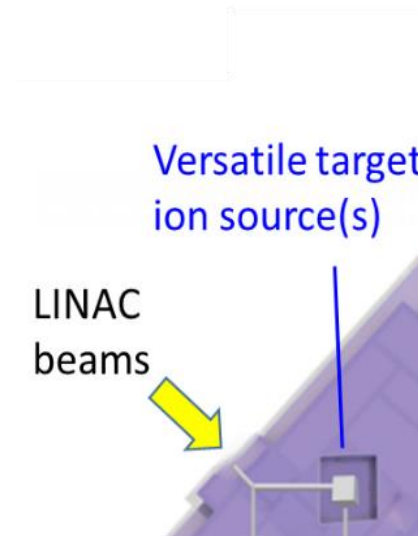


Rhodotron® TT300-HE
High Energy Electron Generator

~7M€ according to IBA inc.
Beam line and diagnostics

Rhodotron: an independant « on-off » driver

- Less competition for beam time with the LINAC
- Grants DESIR ambitious program with fission fragments



A/q=7 beams:
NEWGAIN
EQUIPEX
accepted

Gas cell for reactions
with A/q=7 beams

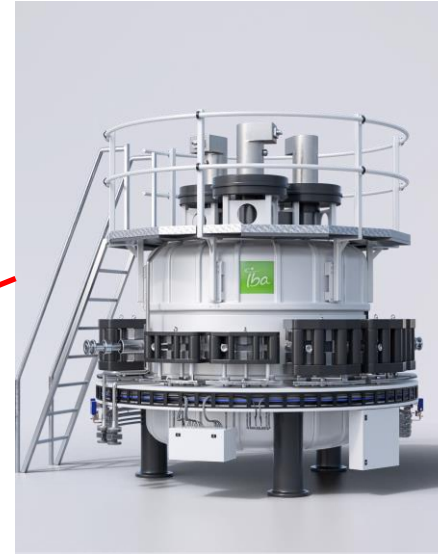
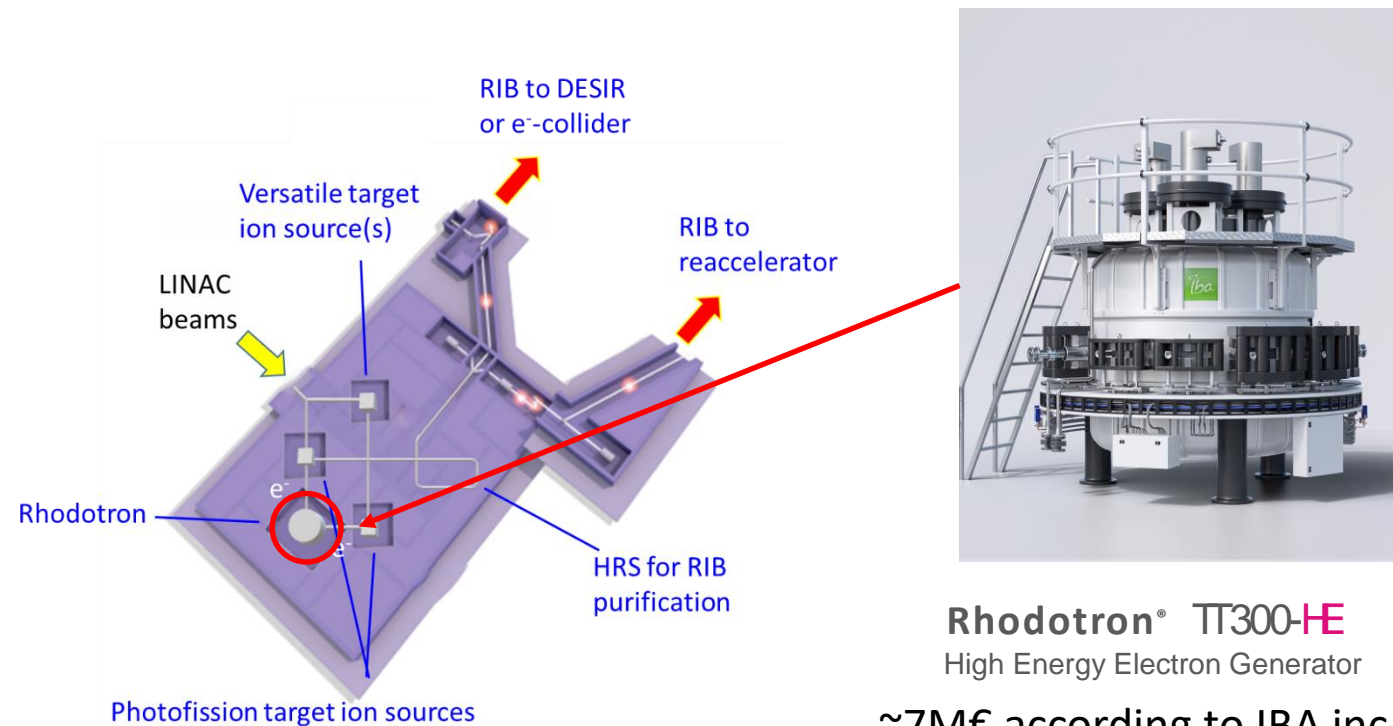
Making full use of A/q=7 beams

- Trans-lead and Actinide production
- Light ($A \lesssim 50$) neutron rich beams from MNT

RFQ injector A/Q = 7 for the production of exotic nuclei using fusion-evaporation and multinucleon transfer reactions, C. Theisen et al., <https://indico.in2p3.fr/event/20534/contributions/81871/>

Production building: « detailed » view

All of this would a priori fit in the original cave foreseen for SPIRAL 2 phase 2

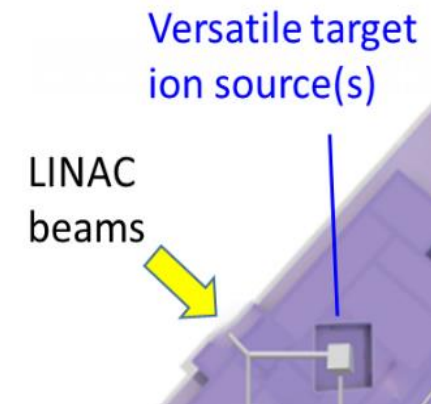


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Summary table: production for e- ion scattering facility

Facility	Beams	Reaction mechanism	When	Comments
SPIRAL 1	A<80, intensities up to $\sim 10^9$ pps	Fragmentation	Many are ready, some to develop	Fusion evaporation possible (TULIP)
S3-LEB	Mid-heavy to heavy neutron deficient beams A >40 \rightarrow ~ 270 Intensities up to 10^6 pps	Fusion evaporation	Starting on-line development as of 2023	
Gas cell/ production cave with A/q=7	Light to heavy (N=126) neutron rich beams, with intensities up to 10^5 ?pps	Multinucleon transfer	* After A/q is ready > 2027 * ideally in the production building ~ 2030 ?	See contribution of C. Theisen
Fission fragments from LINAC	70<A<150 with intensities up to $\sim 10^9$ pps	Fusion reactions Light particle induced fission (p,d,3He,4He)	Production building, ~ 2030 ?	See contribution of Delahaye et al.
Fission fragments from Rhodotron	70<A<150 with intensities up to $\sim 10^9$ pps	Photofission à la ALTO	Production building, ~ 2030 ?	

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Requires a production building

Full picture

