Advances of the SPIRAL 2 project

Jean-Michel Lagniel (GANIL) for the SPIRAL 2 Team

Menu

1- SPIRAL 2 facility (Phase 1) status

2- Challenges induced by the safety rules

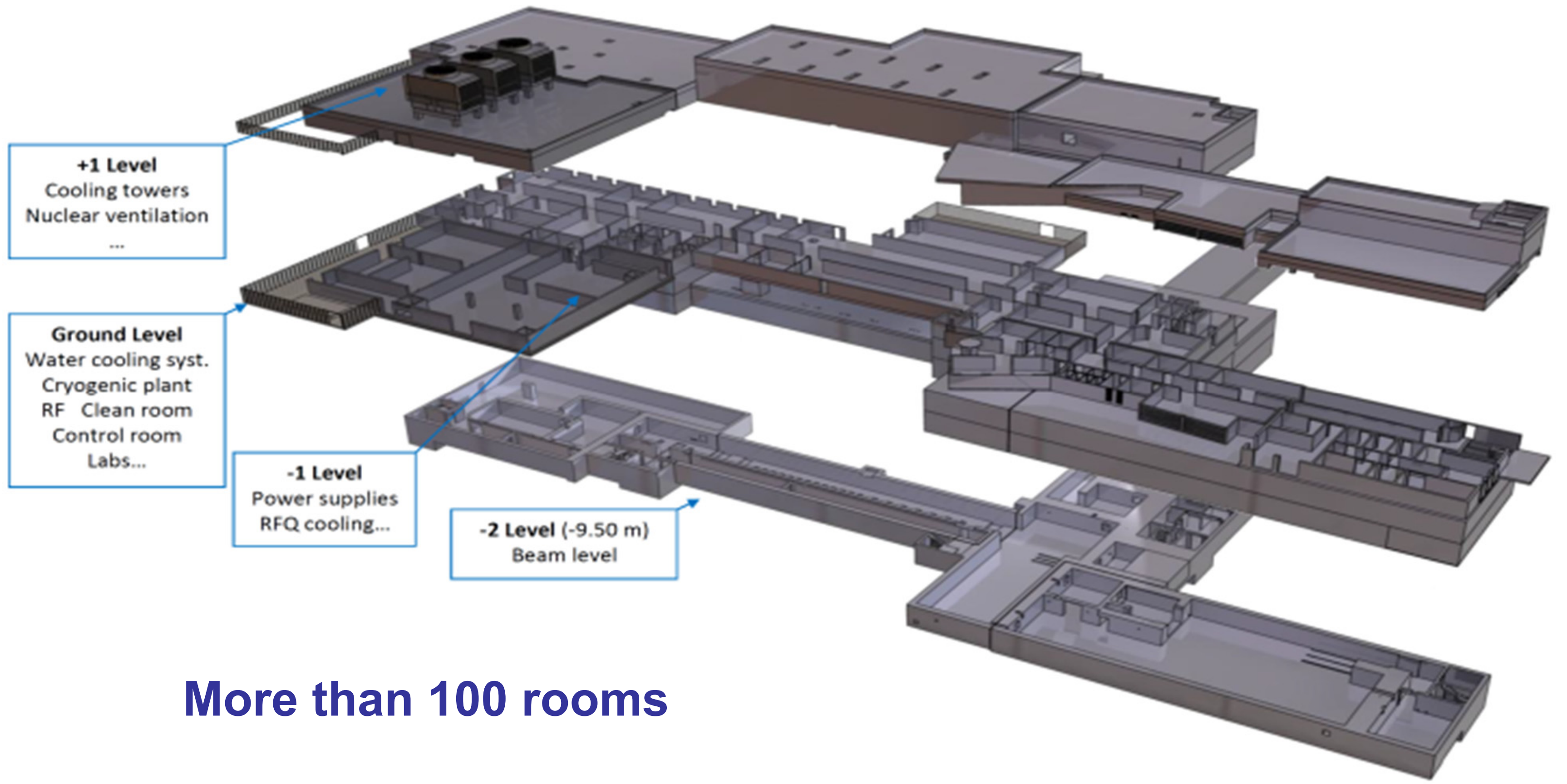
3- Plan for the commissioning

4- SPIRAL 2 future prospects

5- Summary

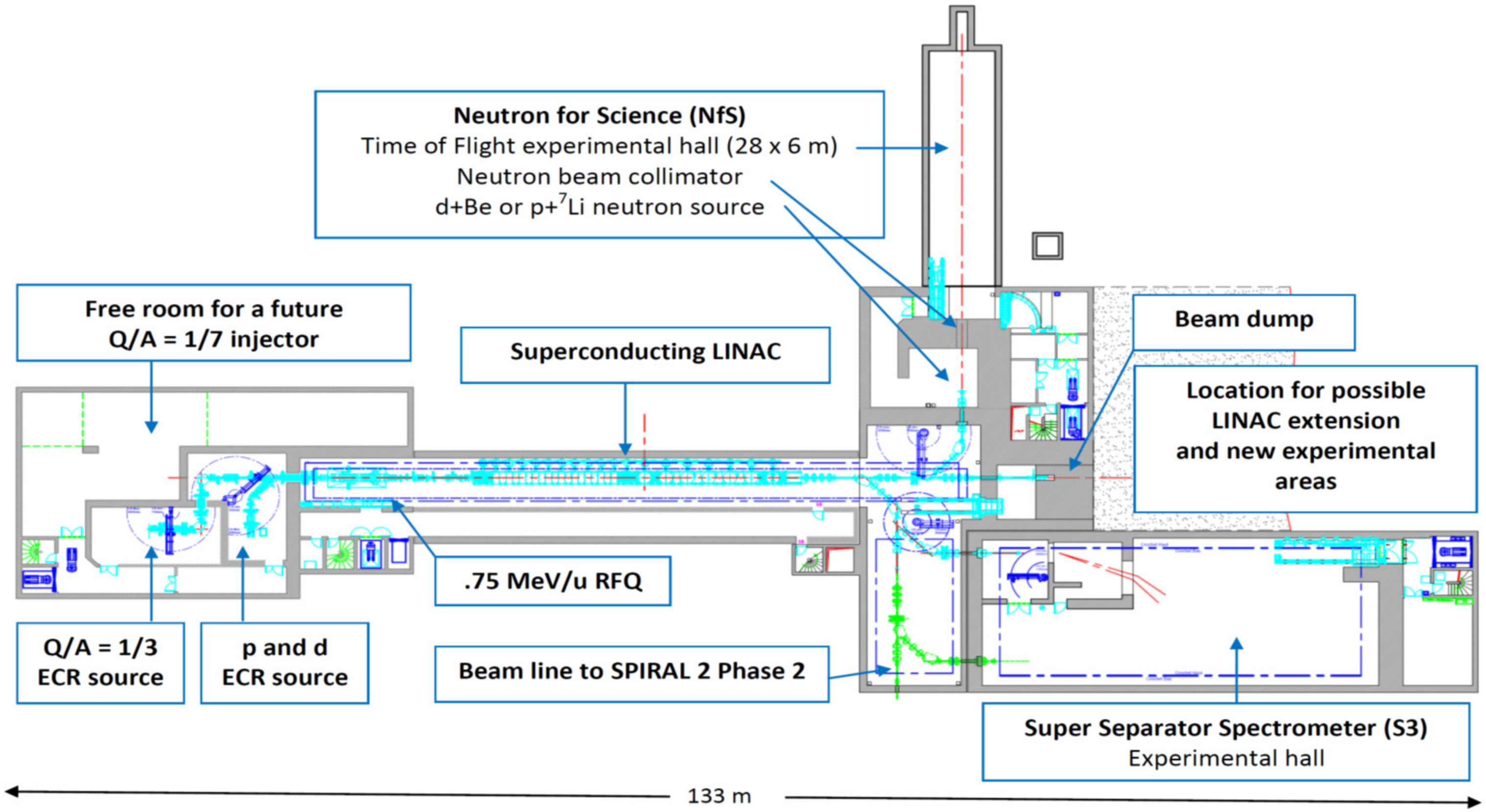
SPIRAL 2 integration of the accelerator processes,
building construction and process connections
Pascal ANGER (next talk)

-1- SPIRAL 2 Facility 7,200 m^2 4 levels



More than 100 rooms

-1- SPIRAL 2 Facility - 9.50 m (beam level)



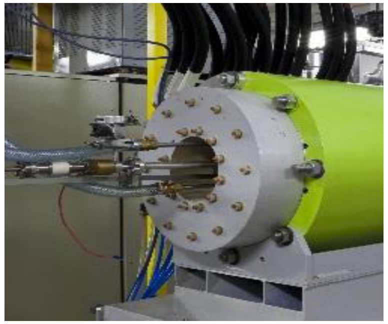
-1- SPIRAL 2 Status

SPIRAL 2 building site preparation December 2010 - January 2011

-1- SPIRAL 2 Status

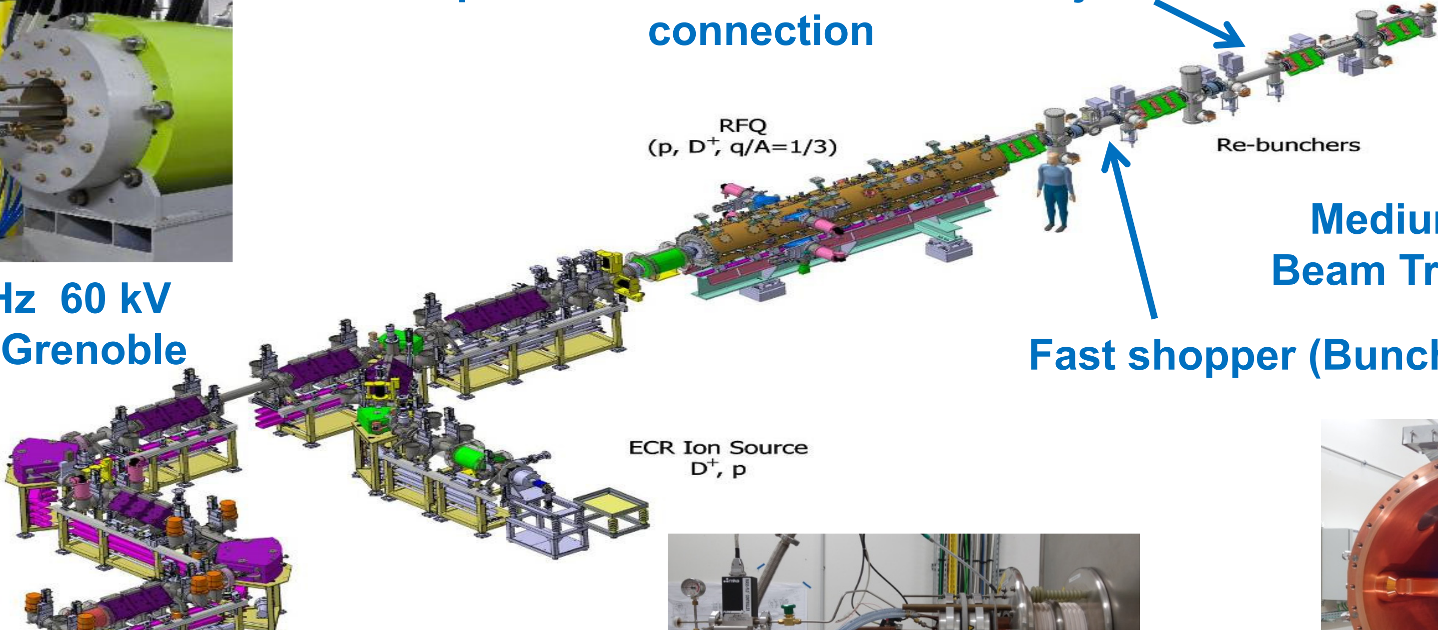
+3.5 years : September, 2014 (Pascal Anger talk)

-1- SPIRAL 2 Facility injector



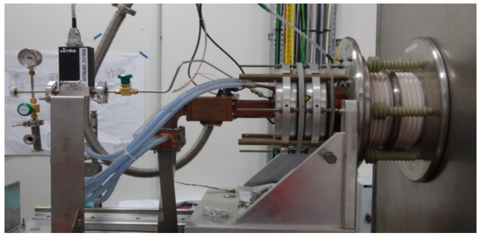
18 GHz 60 kV
LPSC Grenoble

Free space for the future Q/A = 1/7 injector connection

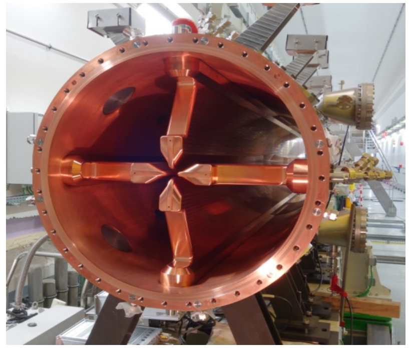


Medium Energy
Beam Transfer Line

Fast shopper (Bunch selector)



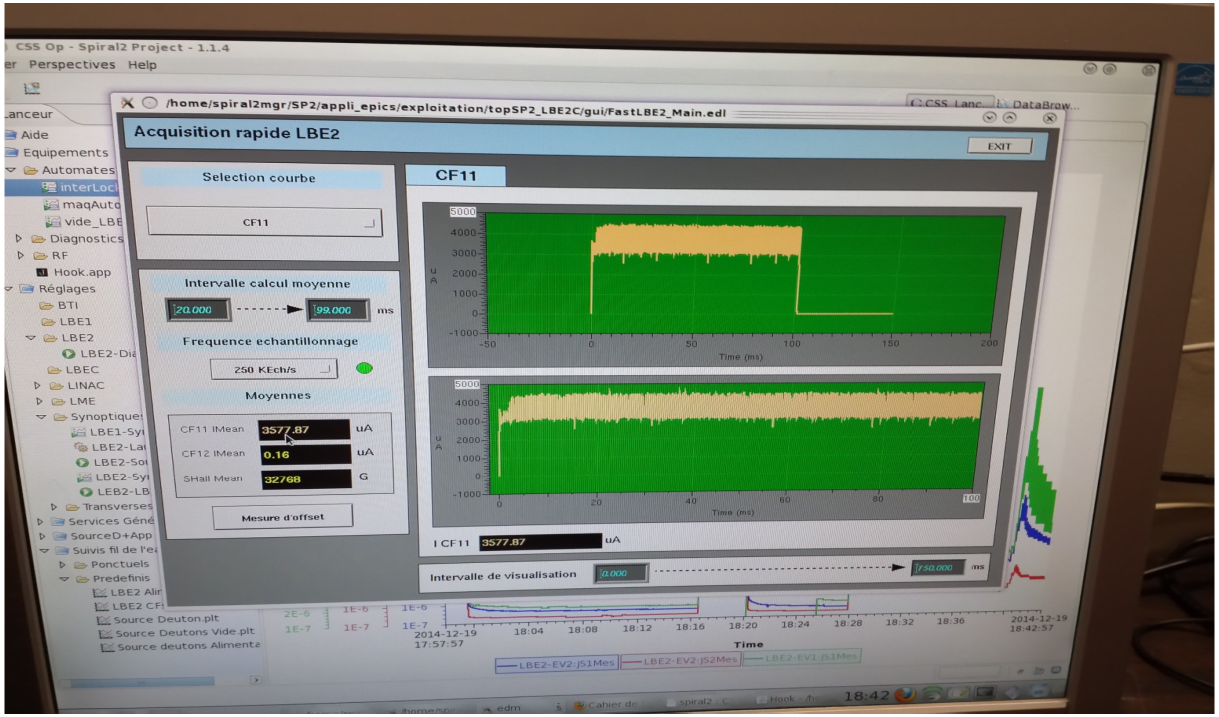
2.45 GHz 40 kV IRFU Saclay



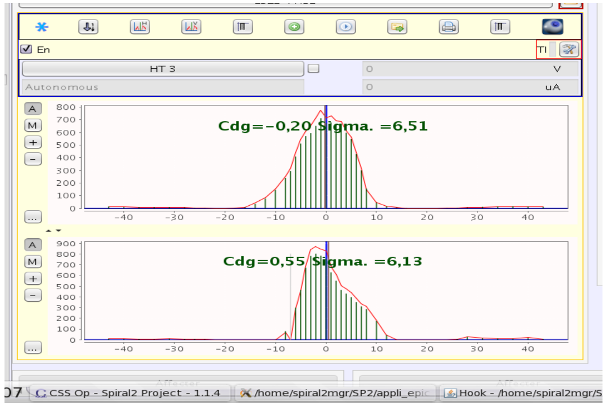
0.75 MeV/u RFQ

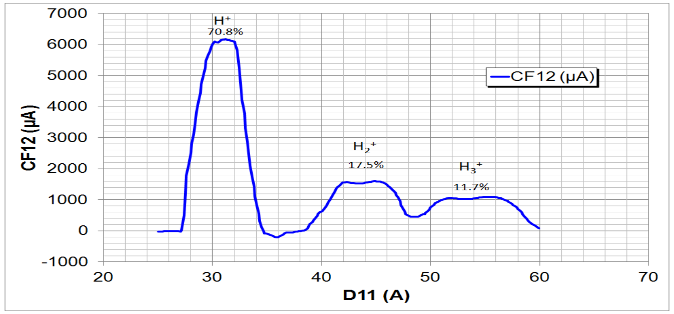
-1- SPIRAL 2 p/d Source Status

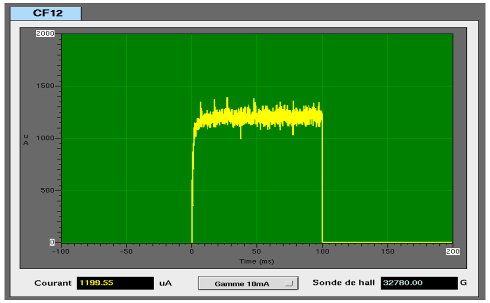
First beam December 19, 2014

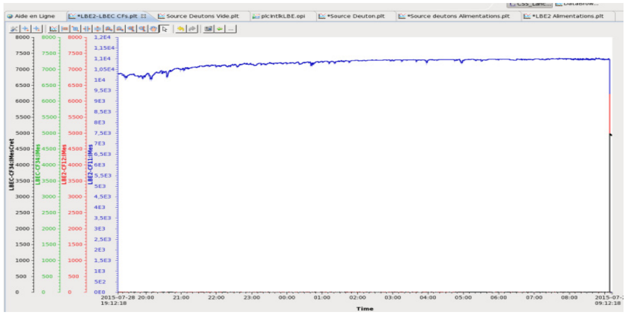


-1- SPIRAL 2 p/d Source Status

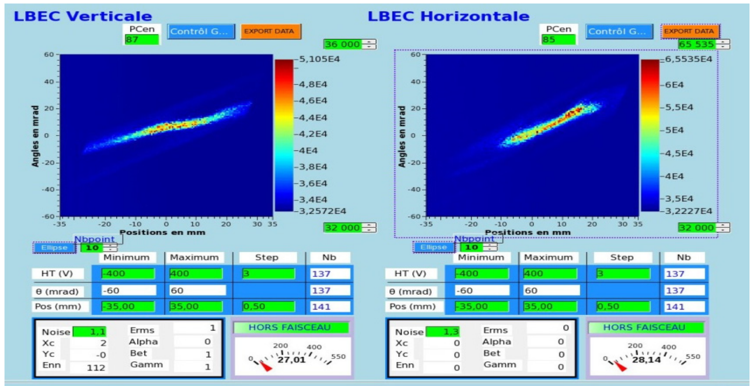








0.2 π mm mrd rms norm.



Long period stability (6 mA CW)

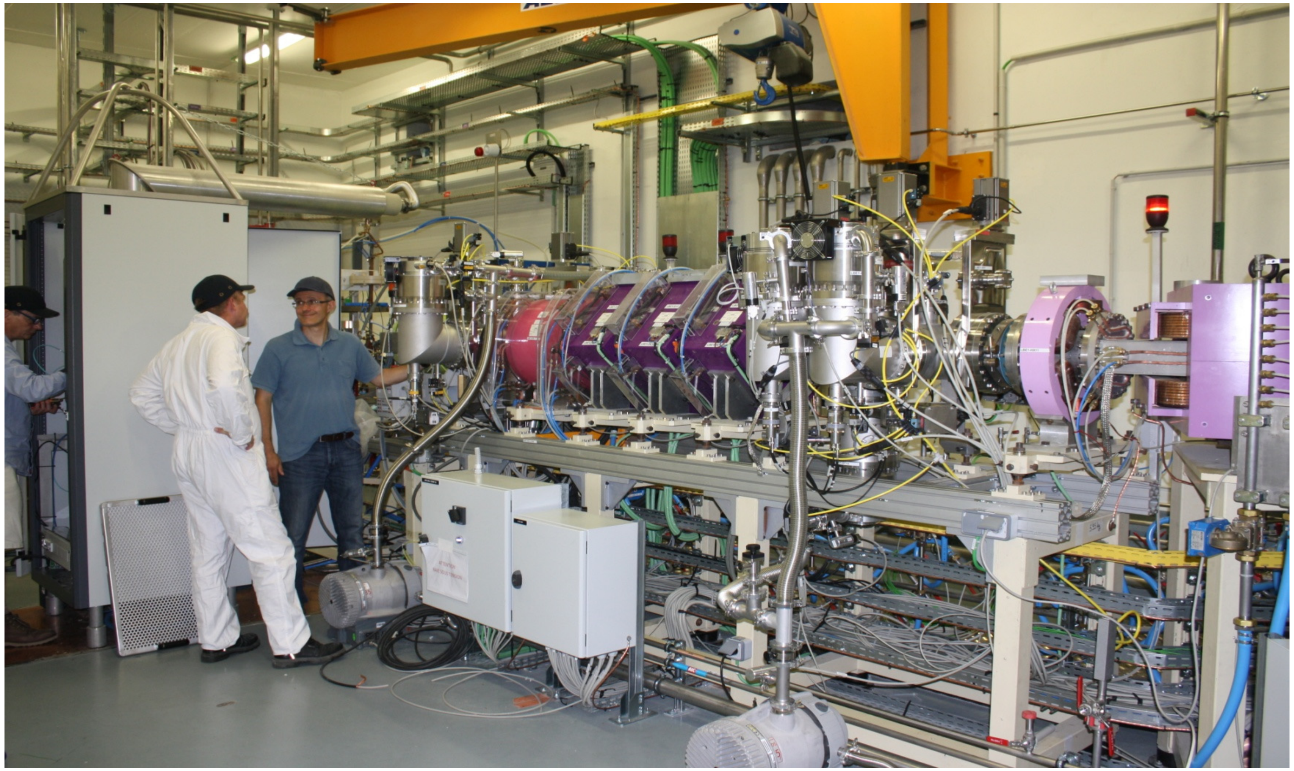
Emittance measurements f(I) July + August

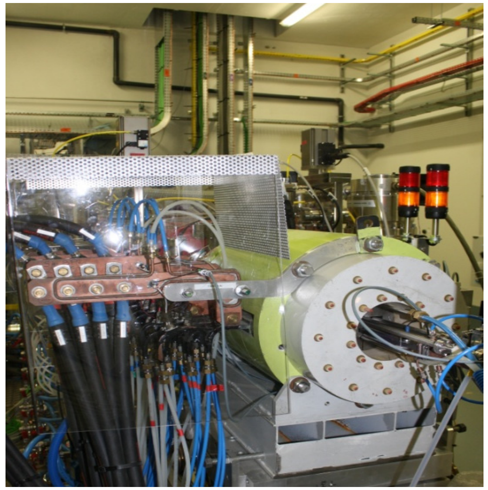
Ability to extract 11 mA CW from the source => 6 mA proton beam

Beam intensity and emittance control using 6 H and 6 V slit systems

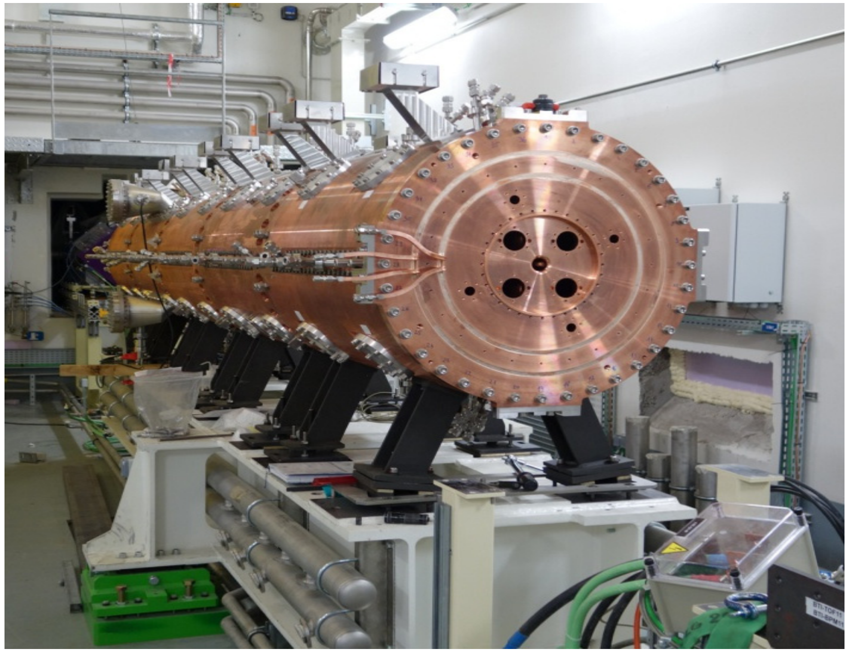
-1- SPIRAL 2   Heavy-Ion q/A = 1/3 Source Status

First beam (230 μA Argon 9+) July 10, 2015

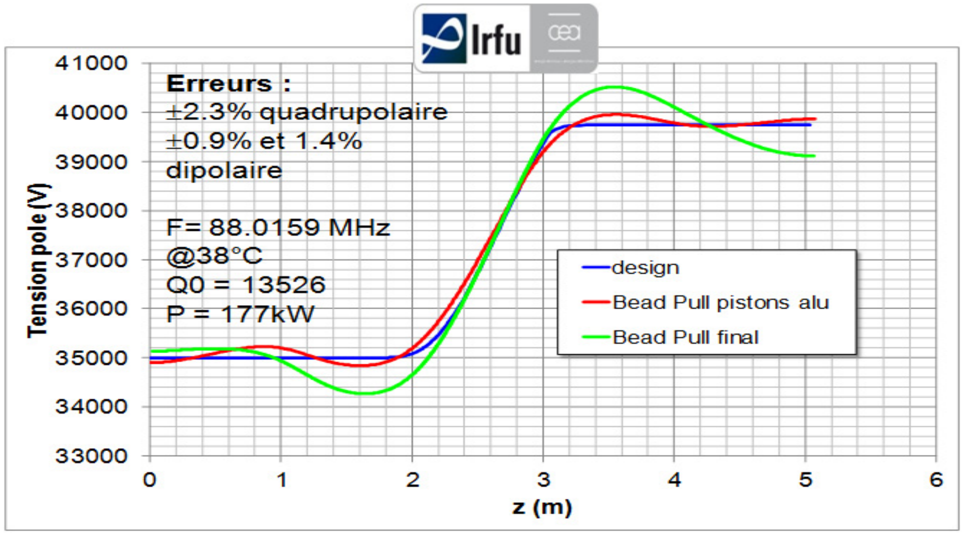




Ask
Thierry Lamy
for details !



Installation Nov. 2014 to Feb. 2015



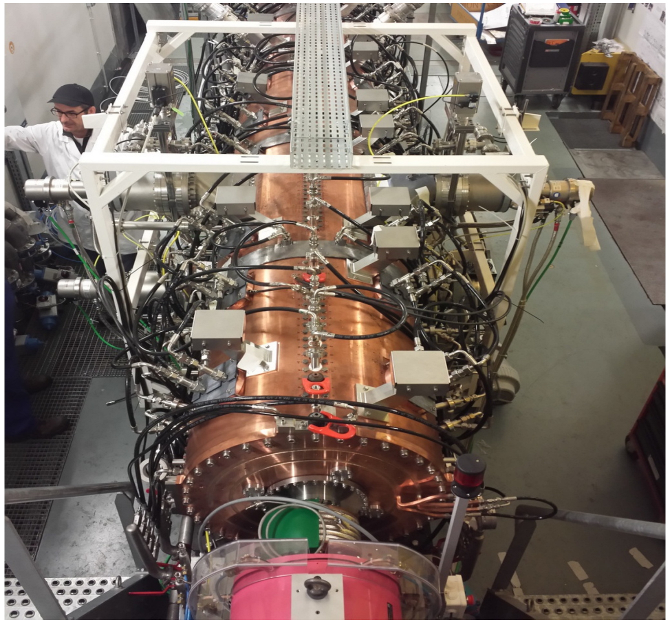
Voltage law (bead-pull) measurements + adjustments (40 plungers) OK March 2015

Max error = 2.3 % on the quadrupolar mode (+3 % longitudinal emittance increase)

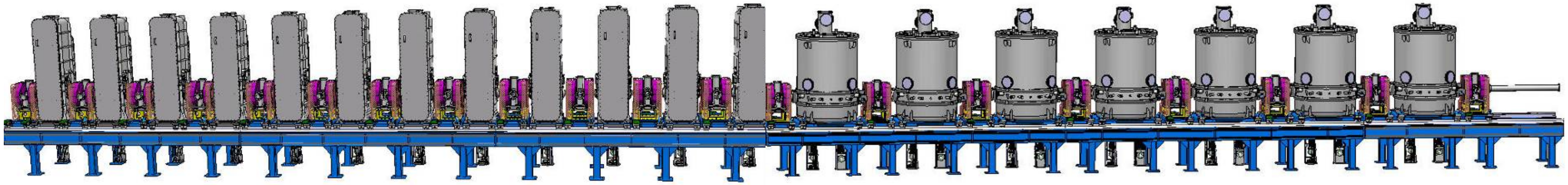
Expected transmission = 99.7 %

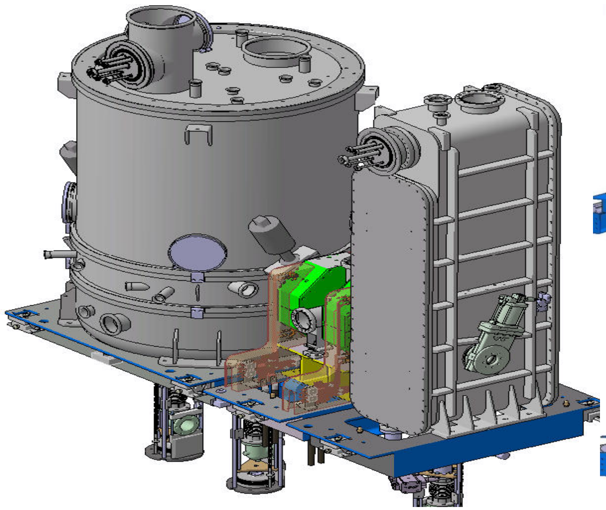
RF amplifiers installed, still in test
Cooling/tuning system commissioning ok

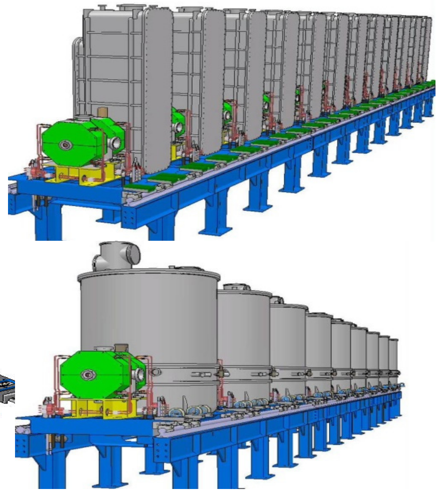
First RFQ beam expected October 2015



88 MHz QWR 12 x 1 = 12 $\beta = 0.07$ cavities 7 x 2 = 14 $\beta = 0.12$ cavities







	Q/A	I max (mA)	Energy (MeV/n)	CW max beam power (kW)
P	1/1	5	2 - 33	165
D	1/2	5	2 - 20	200
Ions	1/3	1	2 - 14.5	45
	1/7	*1*	*2 - 8*	*48*

Wide range of particles, intensities, energies, duty-cycles (CW up to single bunch)

-1- SPIRAL 2 LINAC Status

Cryogenic system (1,300 W equivalent 4.5 K) installed, first liquid helium in July

4 /12 CM-A + 3 /7 CM-B aligned and connected to their valve boxes

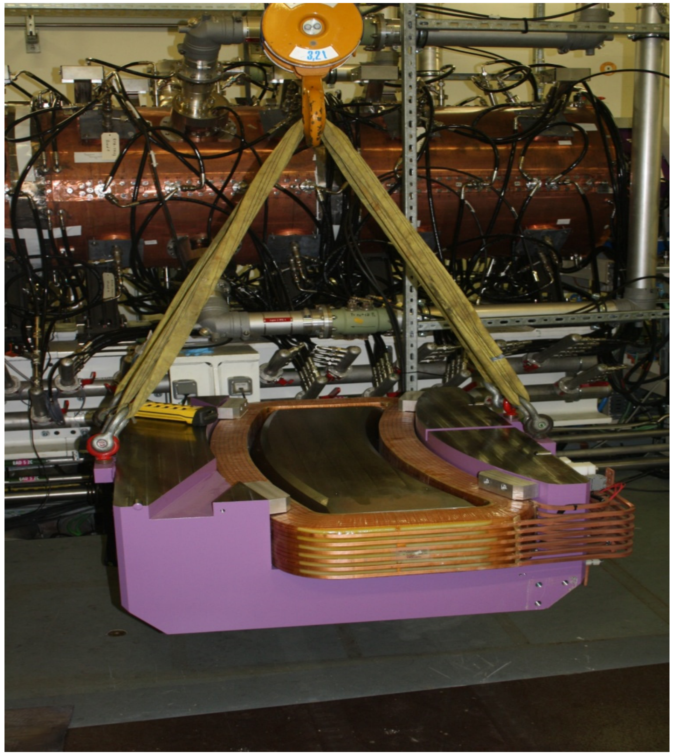
First connection to the hot sections this week

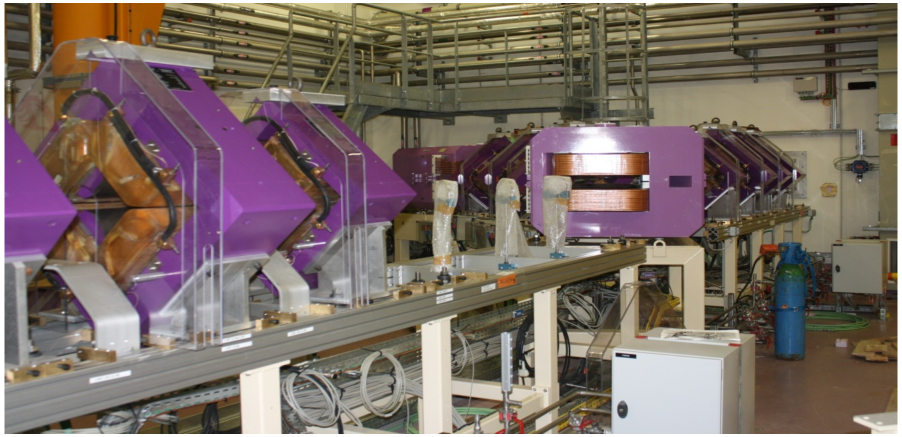
-1- SPIRAL 2 LINAC Status

One solid state
amplifier / cavity
Up to 20 kW

Amplifiers,
feeders, circulators,
LLRF and interlock
PLC have been tested
independently,
installed in the building
and interconnected

-1- SPIRAL 2 LINAC / LHE Status



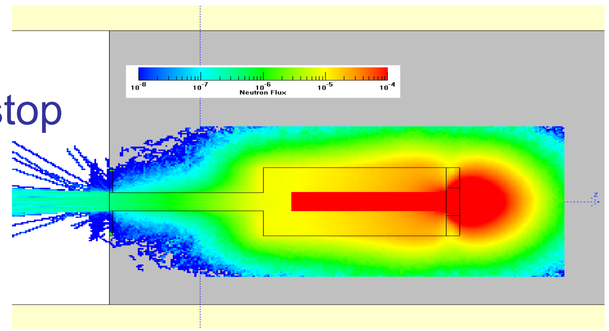


First LINAC beam September 2016

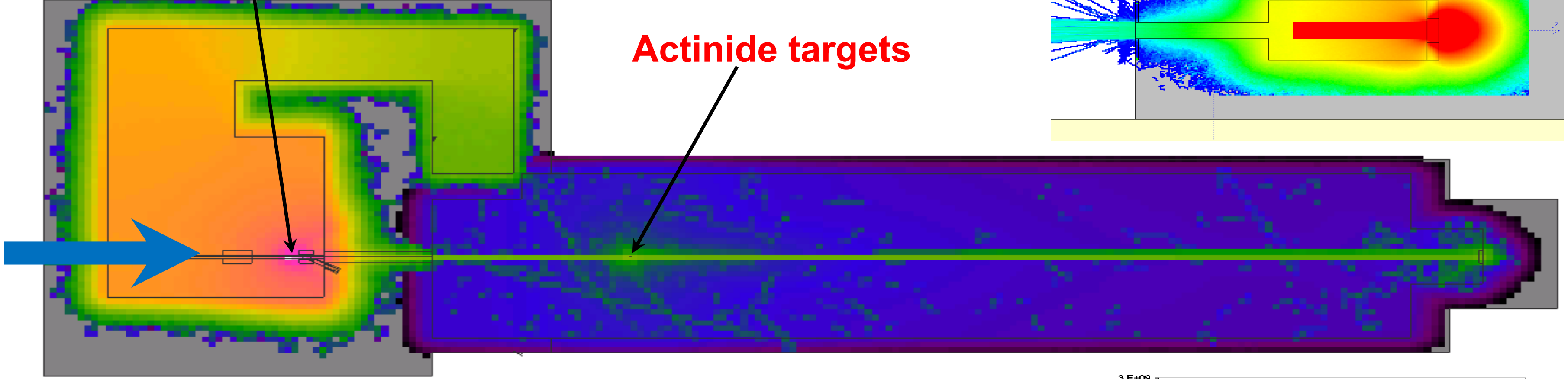
MCNPX calculations

d+ Be and p+^{7}Li N source

N beam stop

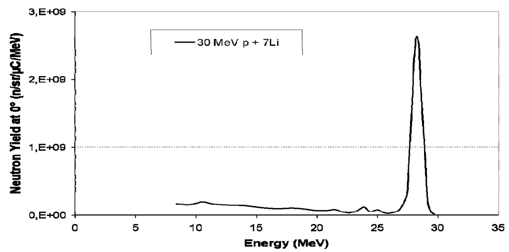


Actinide targets



28 m x 6 m ToF hall

T rf $_{LINAC}$ = 11 ns
Fast choper => 1 ns bunches

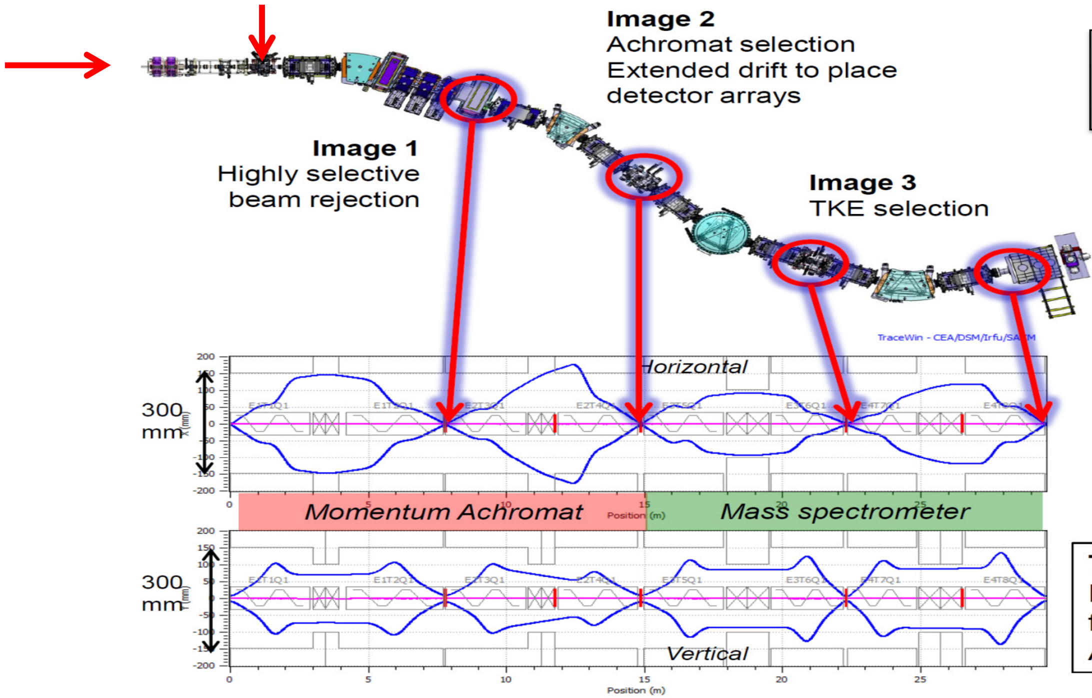


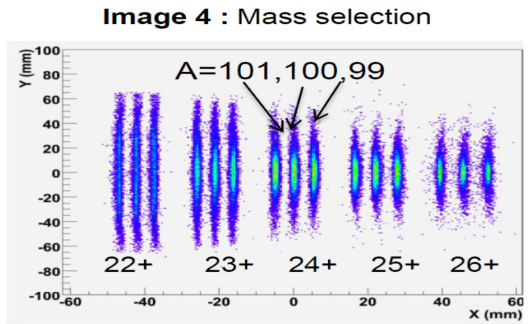
NfS ready for the first SPIRAL 2 experiment (September 2016)

High-power rotating targets
including actinides

Super Separator-Spectrometer

- Multistep separation
- Large acceptance
- Mass resolution (ΔM/M=460)





Tracewin simulation code (Irfu):
Full raytracing in the multipole 3D field maps
Automatic optimisation of **80 fields**

S3 ready beginning 2017

Which challenges for such facilities ?

Challenges usually faced in any (accelerator based) **project**

Construction of an (efficient) multi-competency project team

National / international collaboration management   Real cost evaluation   Cost vs performance optimizations

Risk evaluation and risk management   Schedule constraints …

Plus new challenges for the new generation of high-power accelerators

High radio-active ion production and high neutron flux **+ Actinide target management**

Guaranty ALARA radioactive releases and worker / public exposition

☞ ***Challenges induced by the safety rules***

Beam loss control **+ Multi-ions / multi-energies / multi-duty-cycle / multi-intensities machine**

+ Safety constraints

☞ ***Challenges for the commissioning and operation***

SPIRAL 2 Safety main objectives :

Nominal operation

Workers : ALARA, goal < 2 mSv/y, max < 10 mSv/y

Public : ALARA, impact on the environment < 10 μSv/y

Accidental situation

Workers : ALARA, goal < 10 mSv/accident, max < 20 mSv/accident

Public : ALARA, goal < 10 μSv/accident, max < 100 μSv/accident, Total release < 1 mSv/accident

These values have severe impacts on

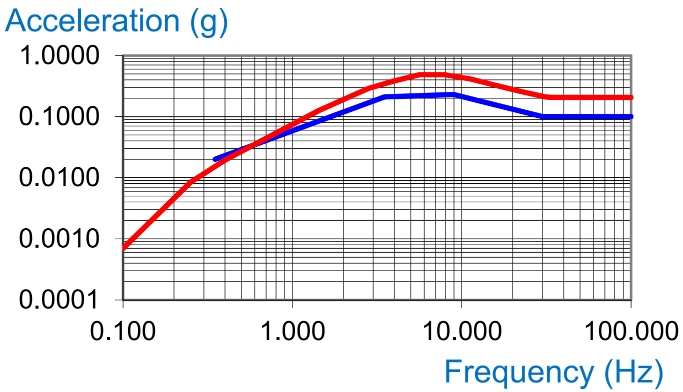
the schedule, cost, commissioning and operation of the facility

-2- Challenges induced by the safety rules

Construction done to “ Prevent – Monitor – Limit “

All the safety systems must “work” in case of accident
e.g. electricity failure, fire, earthquake, plane crash…

“Earthquake of reference” = Caen, December 30, 1775 (5.7 mag.)



15 000 m^3 of concrete

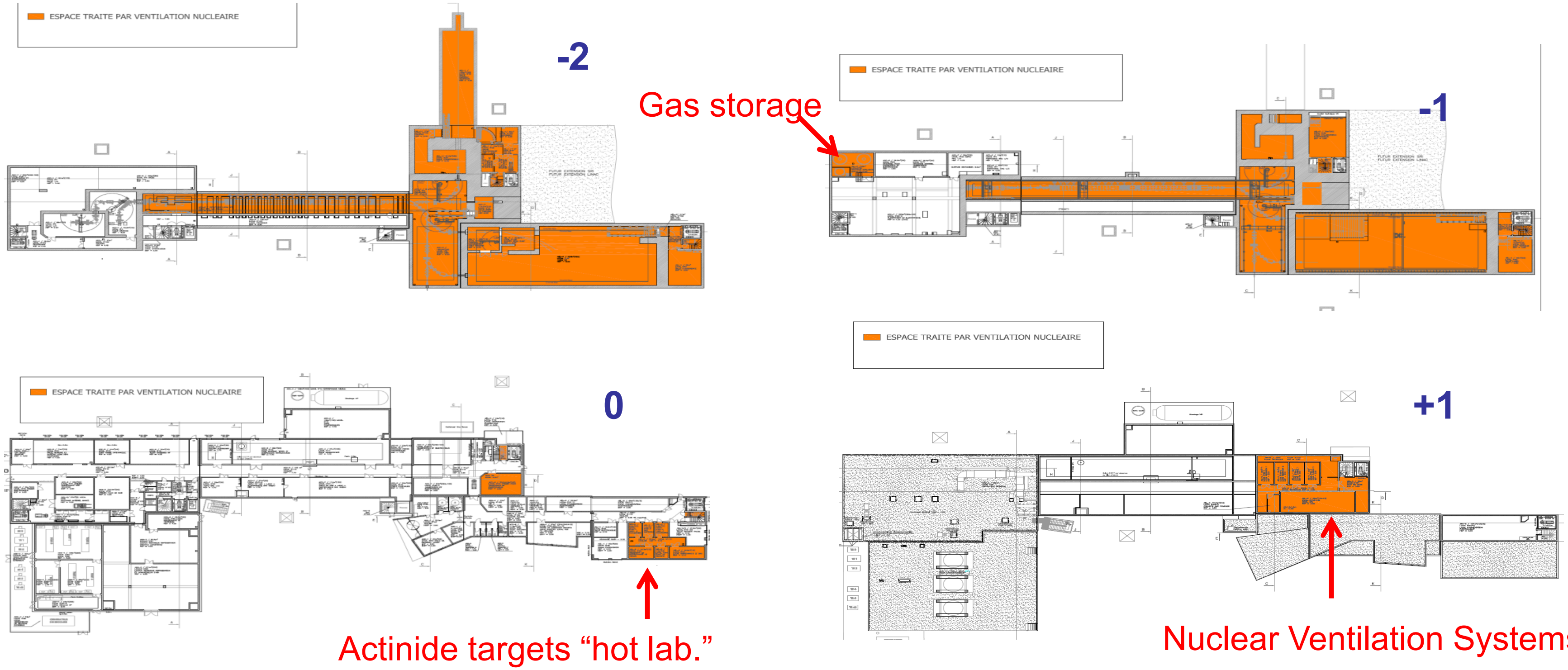
Ironing
total = 2 200 T up to 400 kg/m^3

The equipments (cryomodules, magnets, helium tanks, cranes…) **must not** damage the confinement barriers and shieldings

-2- Challenges induced by the safety rules

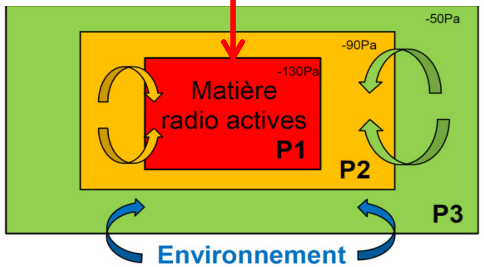
Confine and monitor @ a Nuclear Ventilation System

Linac and HEBT activated air, Beam dump, AEL, Actinide targets



-2- Challenges induced by the safety rules

Beam dump & actinide targets



Nuclear Ventilation System

→ Confinement dynamique
→ Confinement statique

P° atm > P3 > P2 > P1

Minimum air leaks ☞ Airtight doors +
Block up the cable and beam pipe wall traversals …

Vacuum pumps and glove box exhausts treated separately

Very-High-Efficiency filters

Air Treatment Facility (CTA)

-3- Commissioning and operation challenges

200 kW beam power vs 100 W enough to drill the vacuum chamber

200 kW beam power vs 1W/m beam losses for hands on maintenance

Although beam losses are unavoidable during commissioning and tunings !

Safety constraints ☞ Limited amount of radio activated material

☞ Limited use of the beam dump : 400 W /24h → 3 min 200 kW /24h

Superconducting LINAC ☞ Non (weak) interceptive diagnostics @ pollution

☞ Limited amount of diagnostics

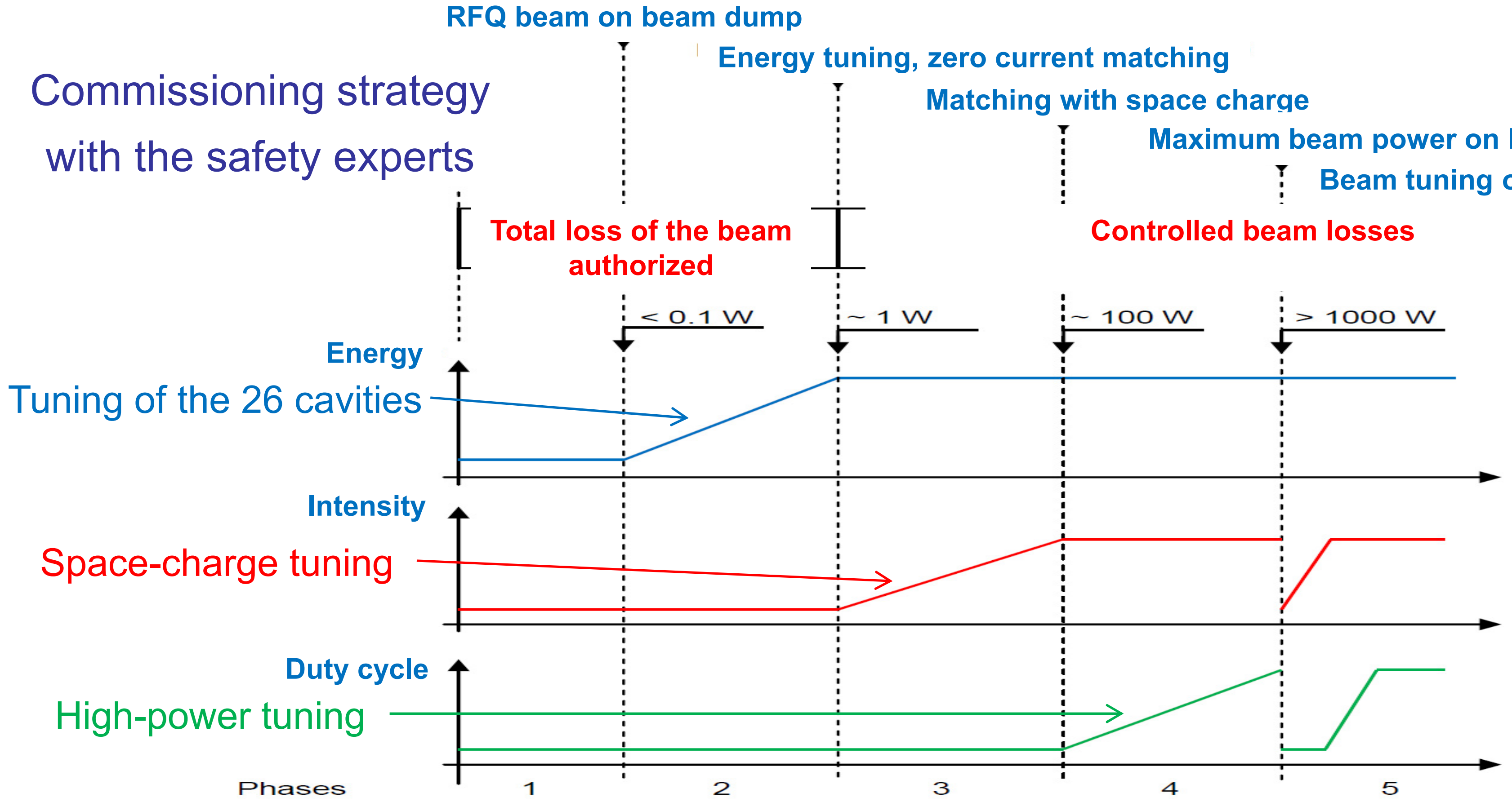
Low frequency single gap cavities ☞ Long radial and longitudinal focusing periods

☞ High space charge (nonlinear) effects 5 mA > 50 mA (SNS / ESS)

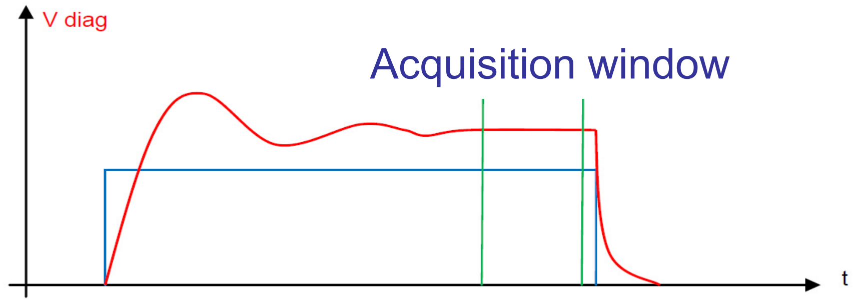
Low energy accelerator ☞ **Weak efficiency of the Beam Loss Monitors**

Commissioning strategy

with the safety experts

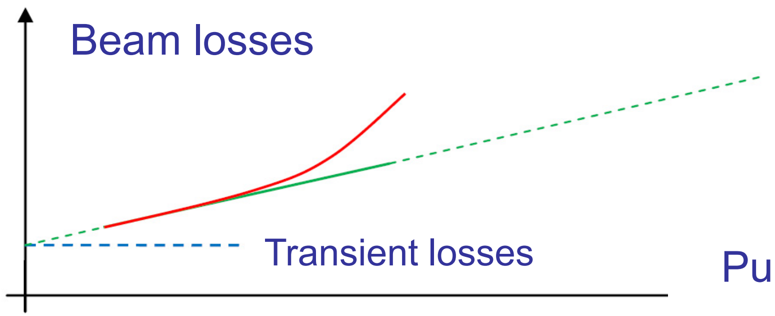


-3- Commissioning and operation plan



Tuning constraints

- ☞ Current ok for the diagnostics (>150 μA for the BPMs)
- ☞ Pulse duration ok for stable beam and diagnostic acquisition
- ☞ Rep rate for fast tuning 2 Hz / 1 Hz min



Pulse duration

Beam loss recording system

to understand and predict

the beam loss level

at full power

Choices of beam current, rep. rate and pulse duration for the tunings at very low power (Phases 1 and 2)

Full beam loss during tunings

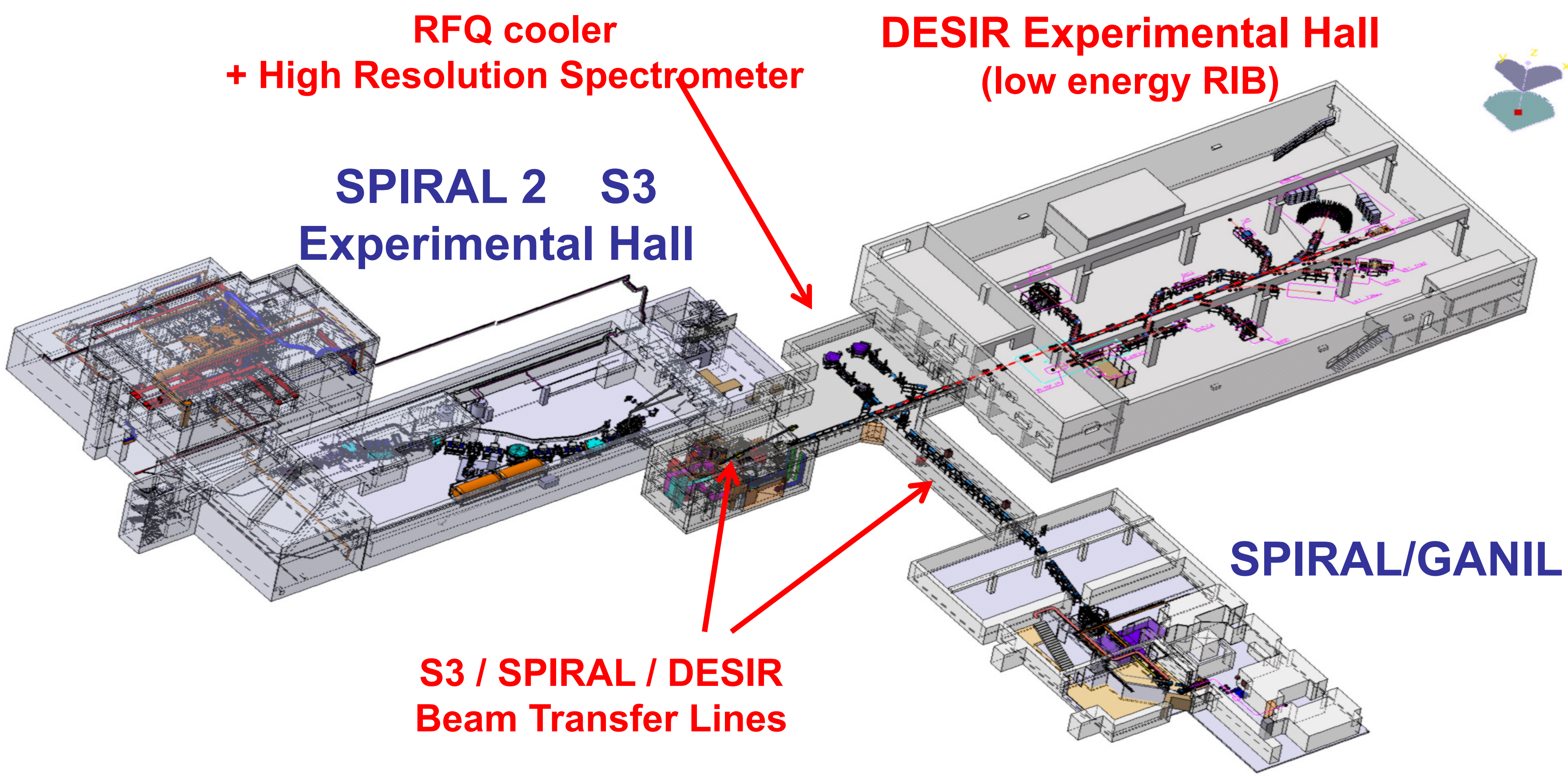
2 hypotheses : <Pf> = 1W and 10W

BPM degraded performances at 50 µA

Mean power	Pick intensity	Duty cycle	Pulse length / rep. rate
1 W	25 nA	CW	
	50 µA	$5.0\ 10^{-4}$	500 µs / 1s
	150 µA	$1.7\ 10^{-4}$	170 µs / 1 s 660 µs / 4 s
	5 mA	$5.0\ 10^{-6}$	5 µs / 1 s 500 µs / 100 s
10 W	250 nA	CW	
	50 µA	$5.0\ 10^{-3}$	5 ms / 1 s
	150 µA	$1.7\ 10^{-3}$	1.7 ms / 1s
	5 mA	$5.0\ 10^{-5}$	50 µs / 1 s 500 µs / 10 s

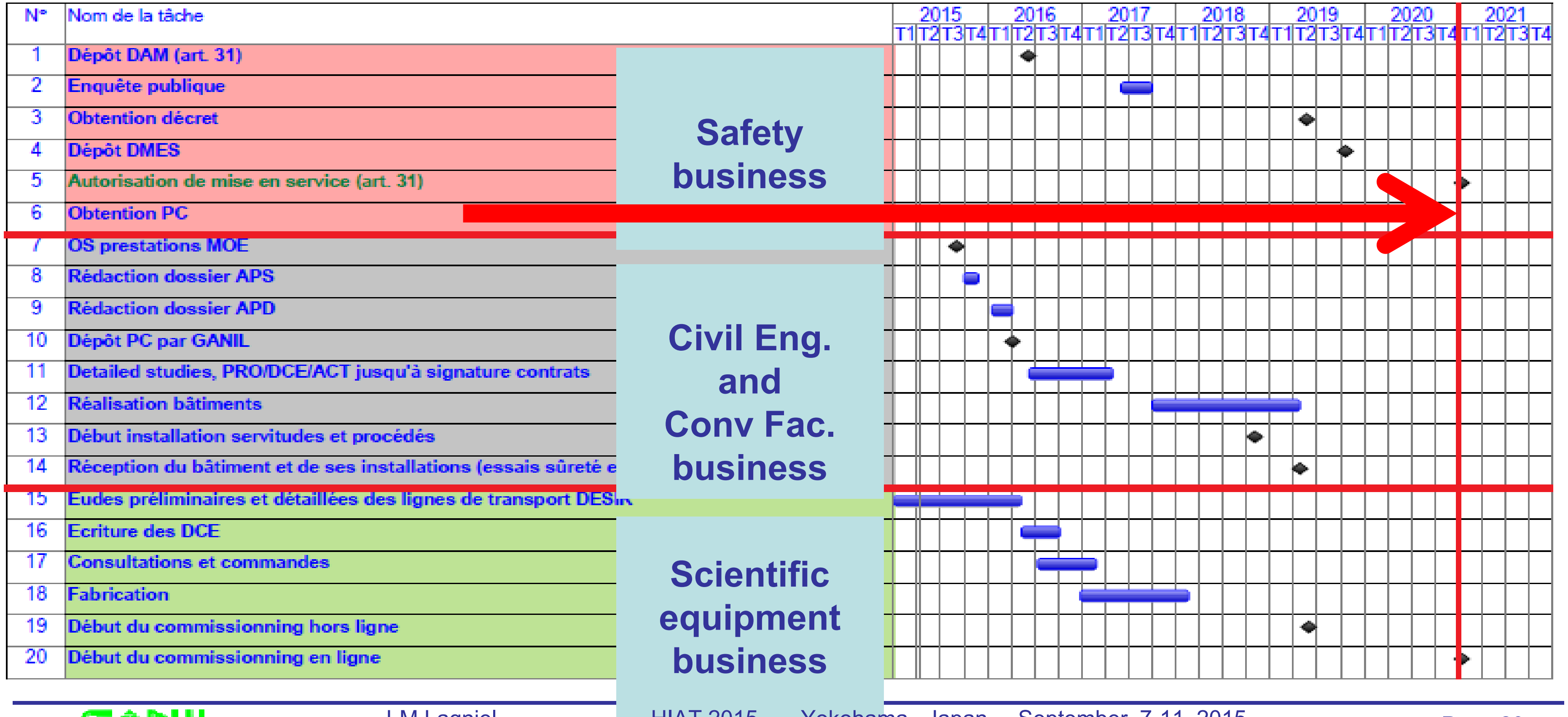
The success will depend on the diagnostic quality !

-4- SPIRAL 2 1+ Phase future prospect

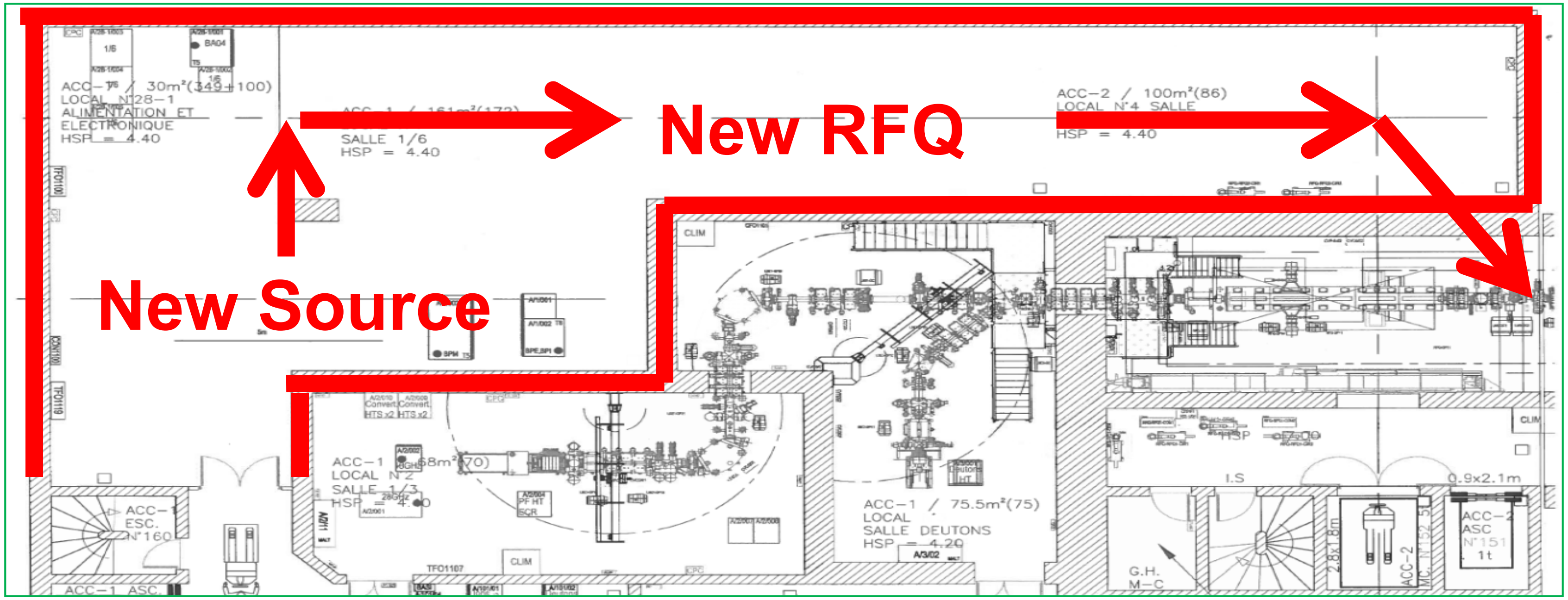


-4- SPIRAL 2 1+ Phase future prospect

100% financed Possible schedule



4- SPIRAL 2 Q/A = 1/7 injector future prospect



Grenoble + Saclay + GANIL Working Group
First step = Source choice

60 GHz ECR ? Thierry Lamy, Thursday morning

-5- Summary

Good advances of the SPIRAL 2 project since HIAT'12 Chicago

- Accelerator and conventional facility installations in great progress (Pascal Anger talk)

- The light and heavy ion sources are working very well

- RFQ RF voltage law tuning and cooling control ok, first beam expected next month

- Cryogenic plant, RFQ and linac RF amplifiers installed

- Superconducting linac installation in // with the RFQ commissioning

- The installation progresses are limited by the availability of the GANIL team (Operation of the GANIL "cyclotron facility" in //)

- First linac beam in September 2016

- The safety constraints have been and still are a concern