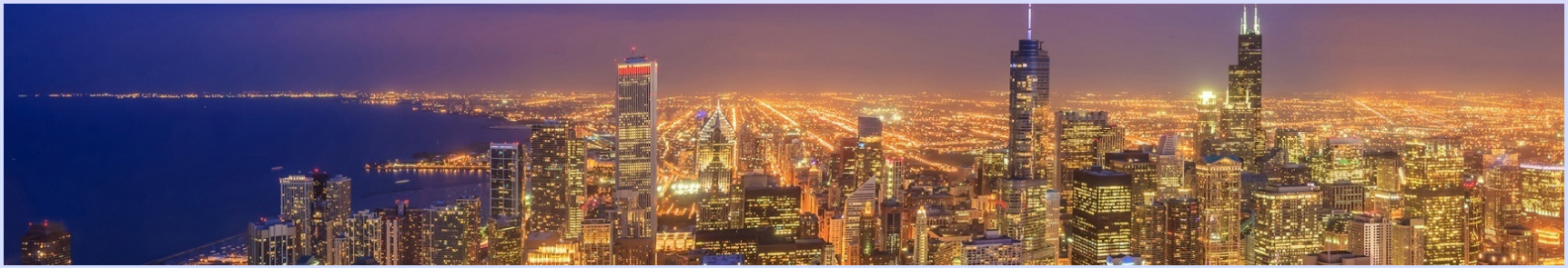
NAPAC2016

October 9 - 14, 2016
Chicago, IL U.S.A.



STATUS REPORT ON THE SPIRAL2 FACILITY AT GANIL

E. Petit, GANIL, Caen, France
on behalf of the SPIRAL2 collaboration

OUTLINE

- Description of the SPIRAL2 facility
- Progress of the accelerator part
  - building
  - equipment installation
- First results with beam
- Future plans
- Conclusions

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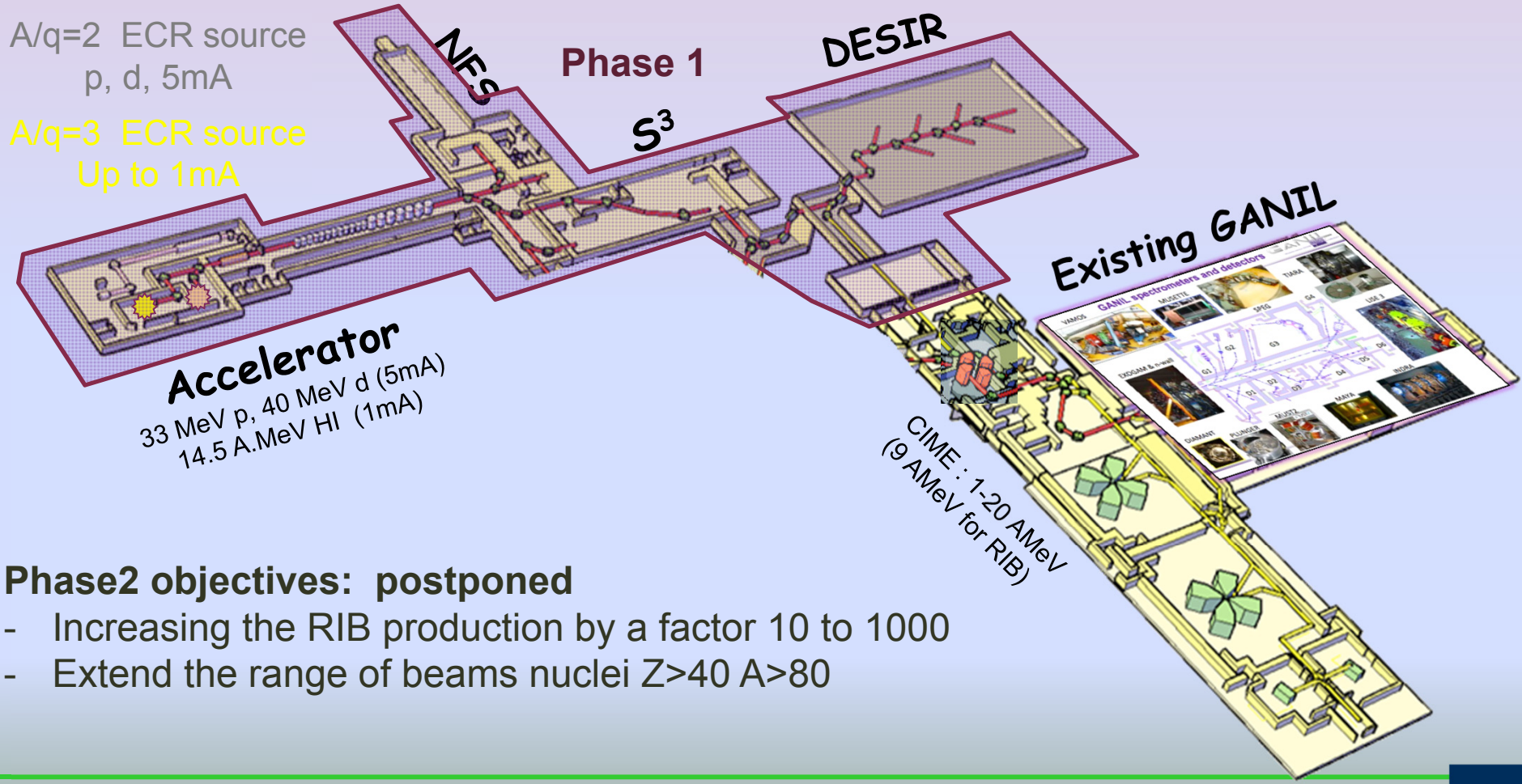
SPIRAL2 Facility

laboratoire commun CEA/DSM — spiral2 — CNRS/IN2P3

Phase1 objective:

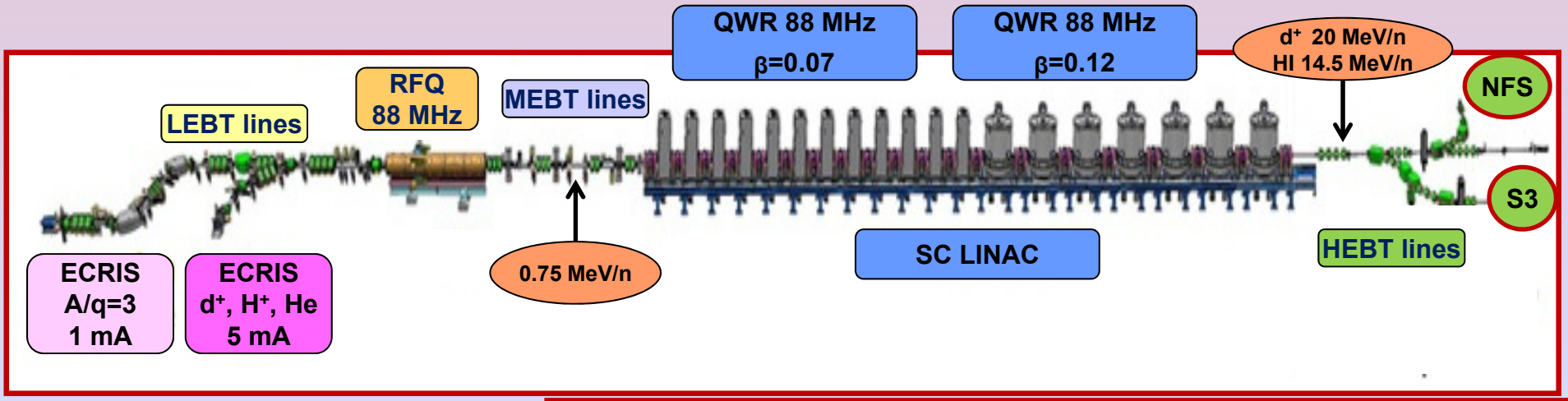
Increasing the stable beam power by a factor 10 to 100



Phase2 objectives: postponed

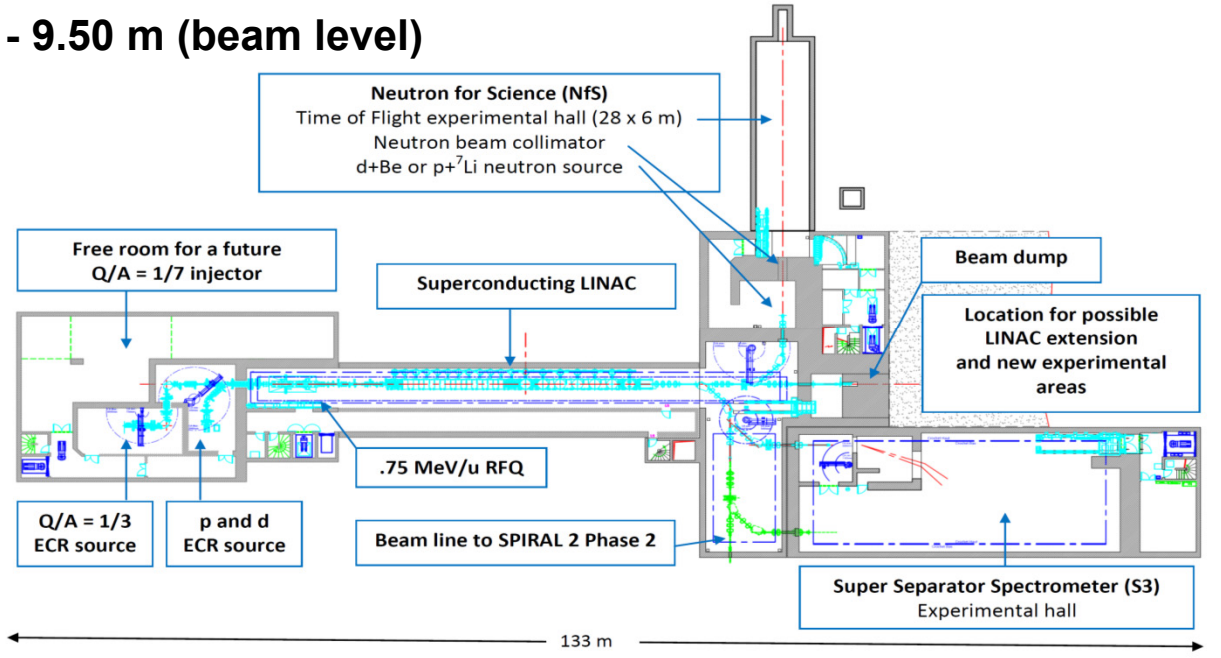
- Increasing the RIB production by a factor 10 to 1000
- Extend the range of beams nuclei Z>40 A>80

Accelerator configuration

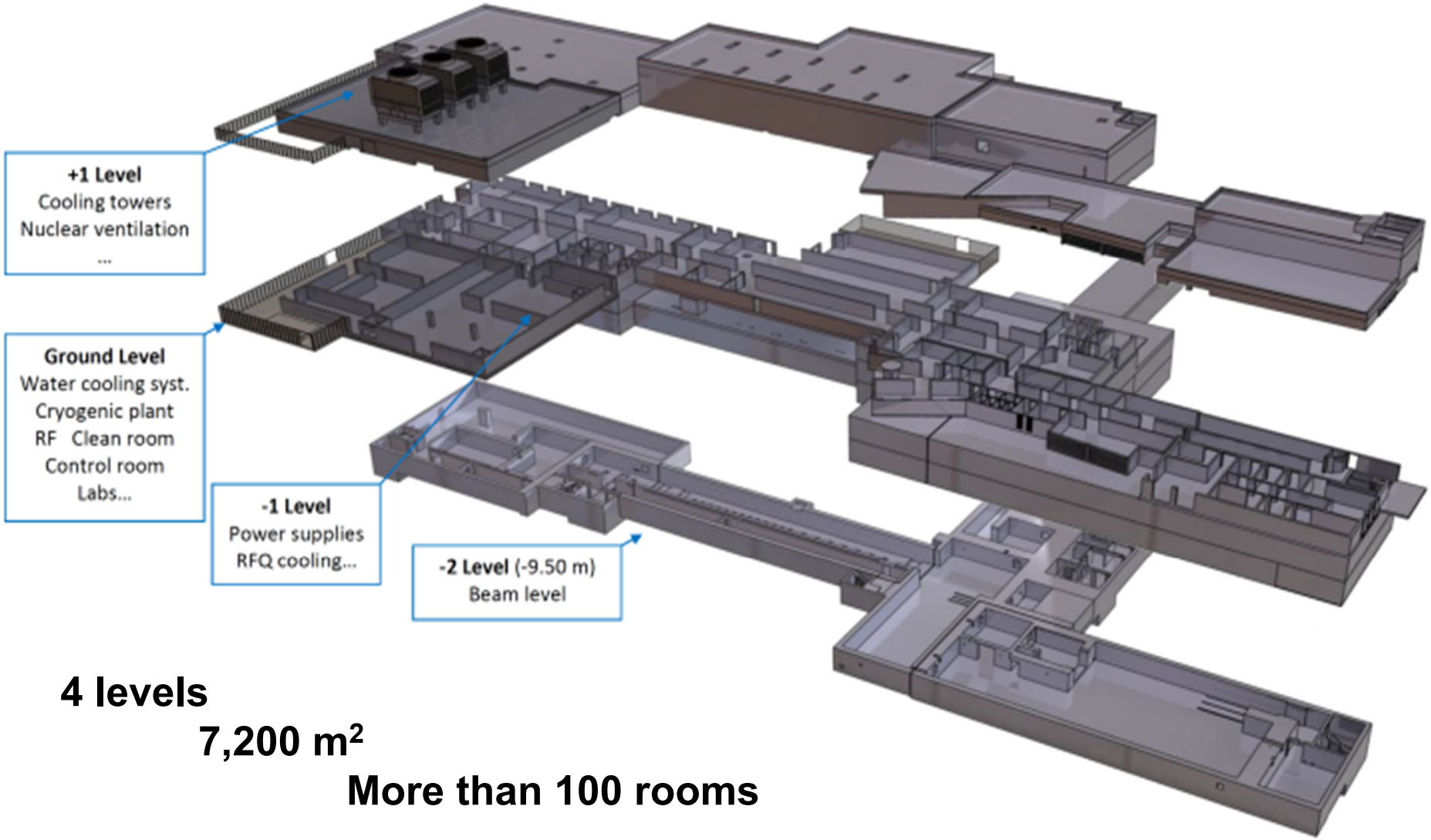


Beam characteristics

Particles	H^+	D^+	Ions	
Q/A	1	1/2	1/3	1/6
I (mA) max.	5	5	1	1
W_0 max. (MeV/A)	33	20	15	8.5
CW max. beam power (KW)	165	200	44	51



SPIRAL2 building



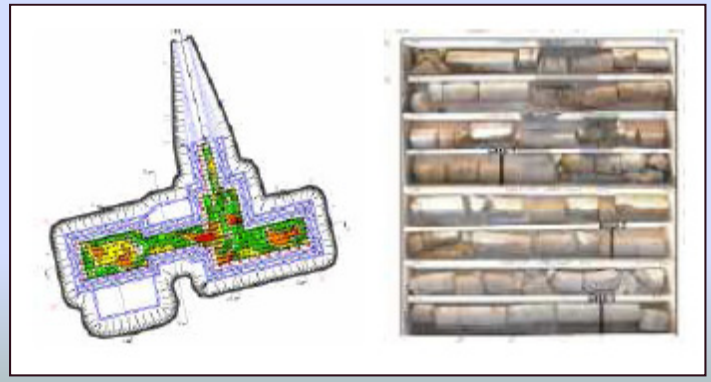
4 levels

7,200 m²

More than 100 rooms

SPIRAL2 building

End of excavation
May 2011



SPIRAL2 building

The first concrete poured in September 2011

The foundation stone laying ceremony in October 2011

SPIRAL2 building

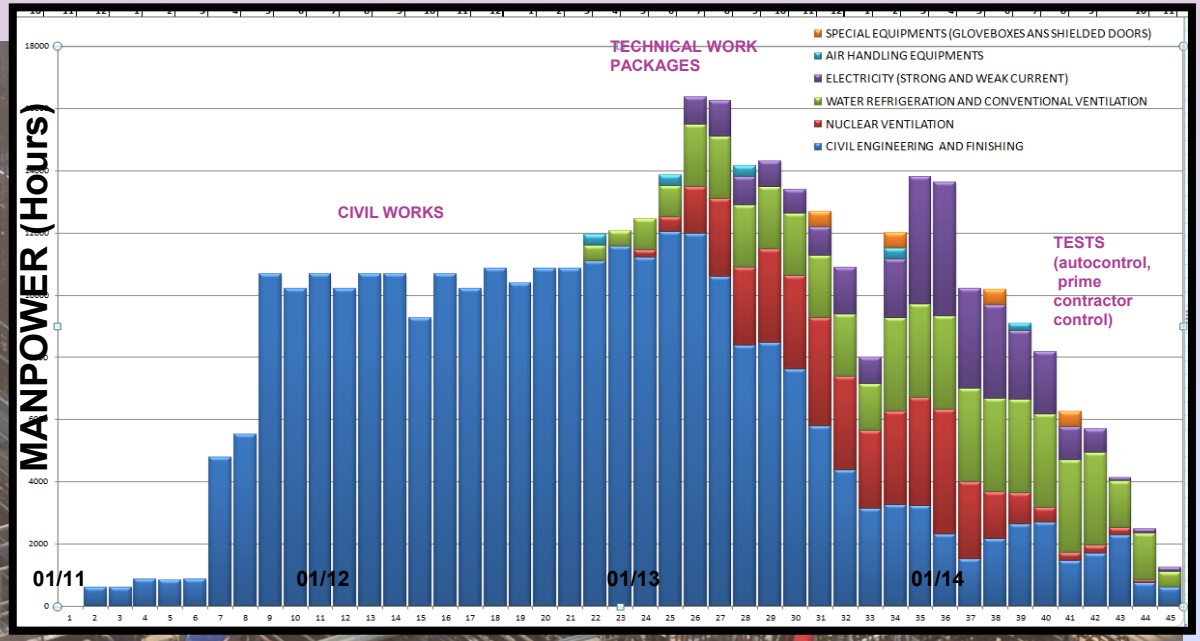
One day the crane is here

The day after the crane has disappeared !!

July 2013 :
End of Civil Engineering work

SPIRAL2 building

The Civil Engineering between June 2011 and July 2013



Key figures

14 000 m3 of concrete

2 200 T of reinforcement

450 000 hours worked

SPIRAL2 building

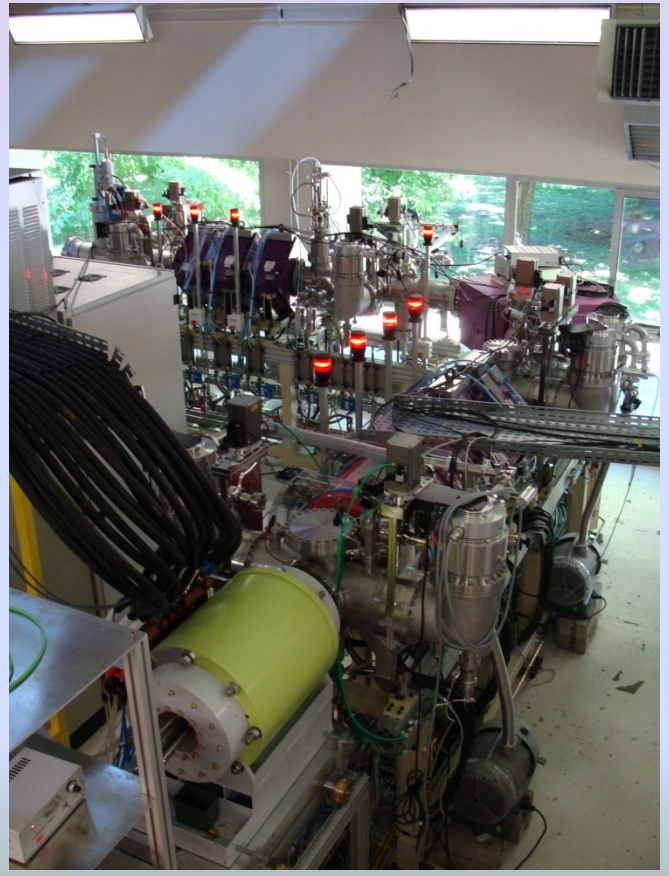
Building approval (all WP) end of the year 2014

Building and infrastructures Work Packages

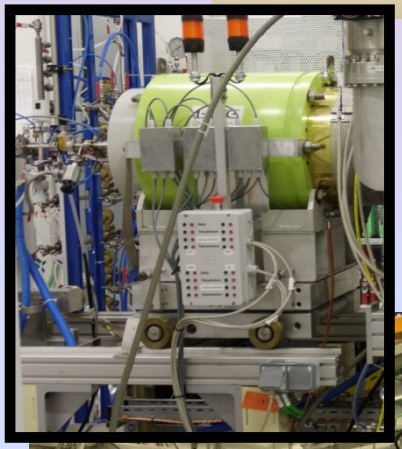
Excavation
Civil Engineering
Nuclear Ventilation
Electricity
Conventional Ventilation
Water cooling system
Handling equipments
and special equipments

Sources and LEBT

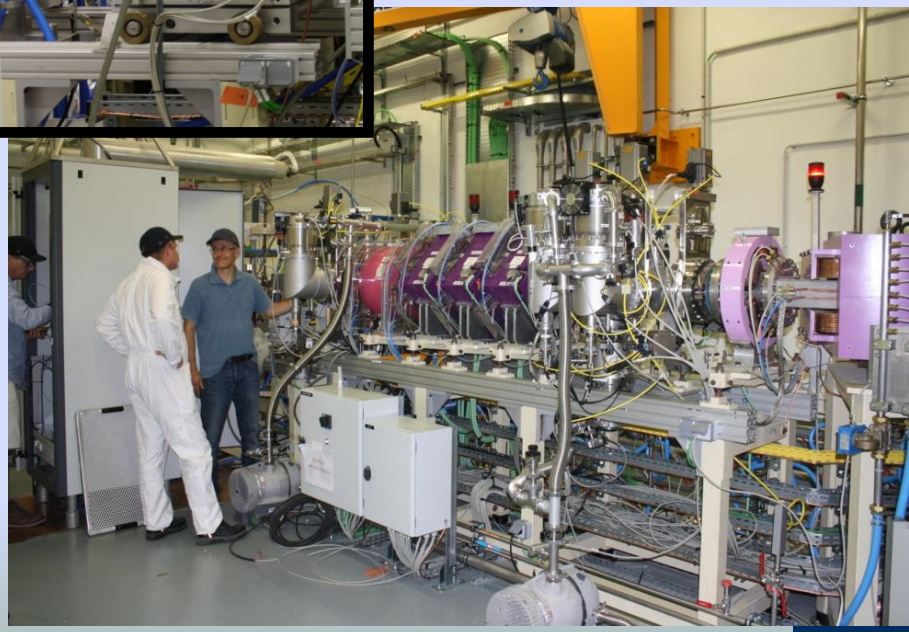
Phoenix-V2+LEBT1 beam tests (LPSC Grenoble)



Phoenix-V2+LEBT1 installation at GANIL

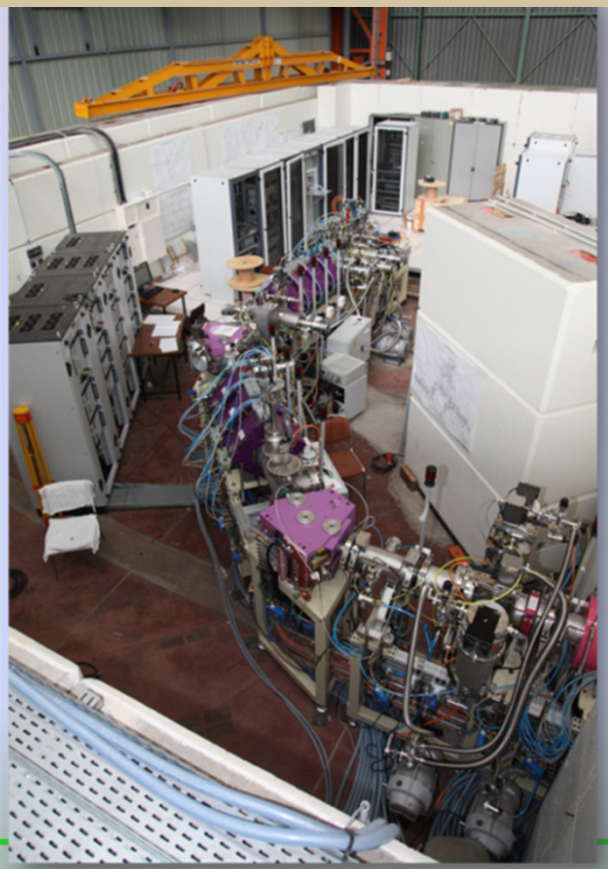


First beam produced In July 2015



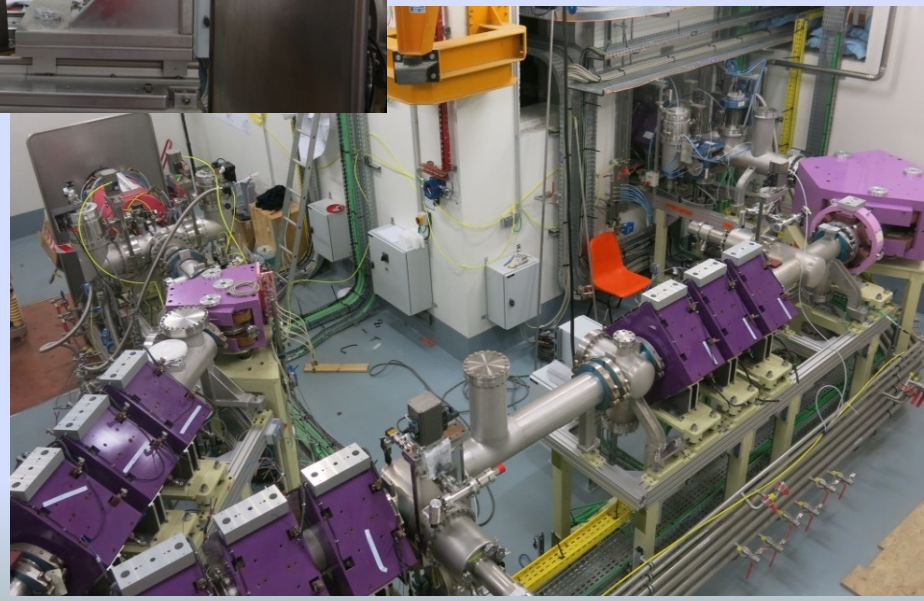
Sources and LEBT

Deuteron/Proton ECR + LBE2+LBEC beam tests at Saclay



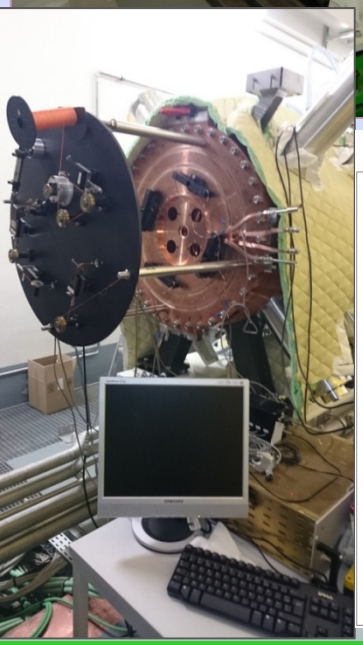
Deuteron/Proton ECR + LBE2+LBEC Installation at GANIL

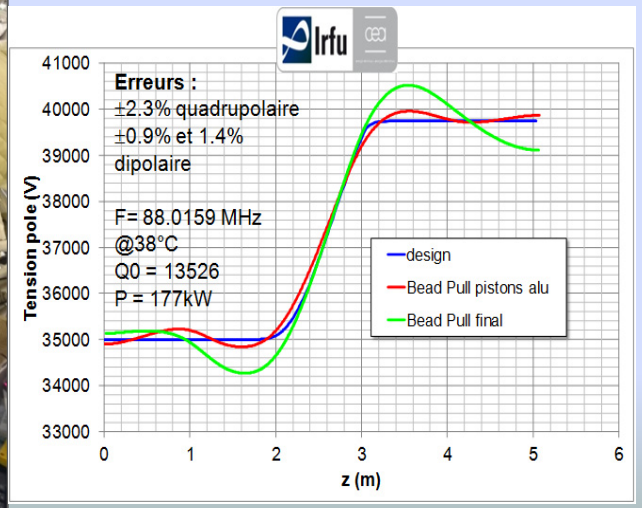
First proton beam produced in December 2014

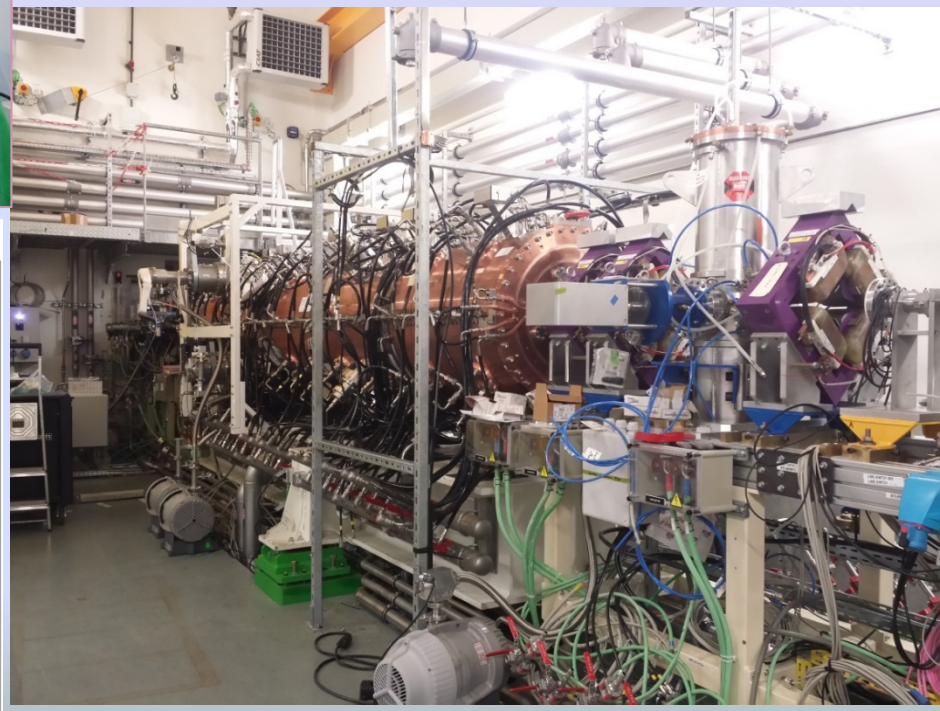


SPIRAL2 4-vanes RFQ

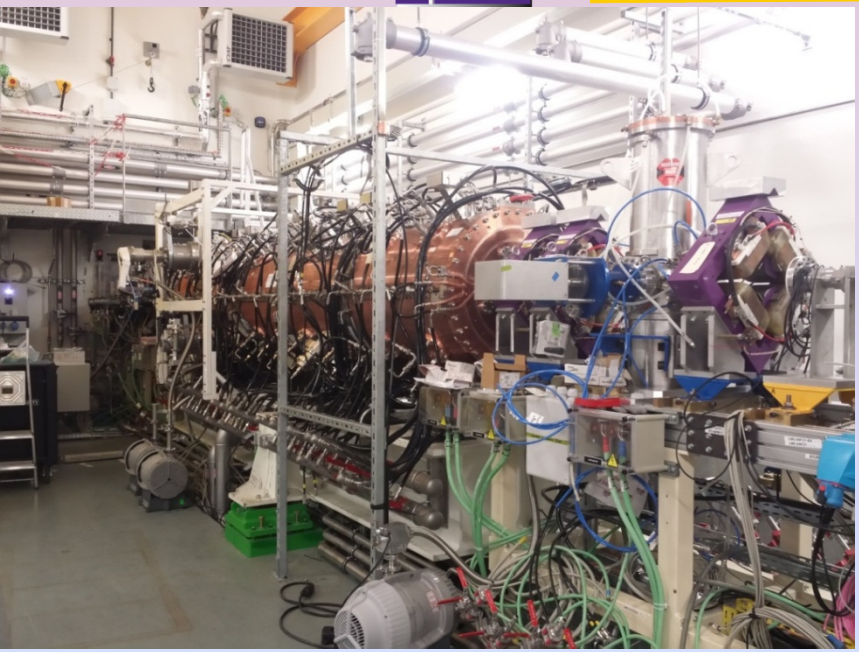
Assembly and bead pull measurements
from Sept 2014 to March 2015







SPIRAL2 4-vanes RFQ



The RF conditioning of the cavity started on November 2015:

- 85 kV CW reached with 3 out of 4 amplifiers
- 114 kV CW reached with the 4 amplifiers and 125 kV 5% dC

(115 kV required to accelerate A/q=3 ions)

First proton beam accelerated in December 2015

60kW RF amplifier

60kW RF circulator

Water cooling system

SPIRAL2 cryogenic system

Cryogenic system (1,300 W equivalent 4.5 K) installed, first liquid helium in July 2015

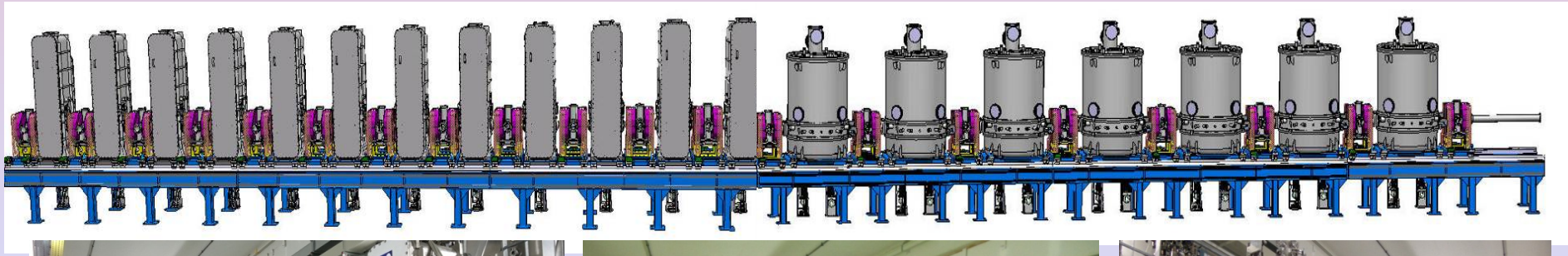
Approval of the cryogenic system, after tests on a thermal simulator, in November 2015

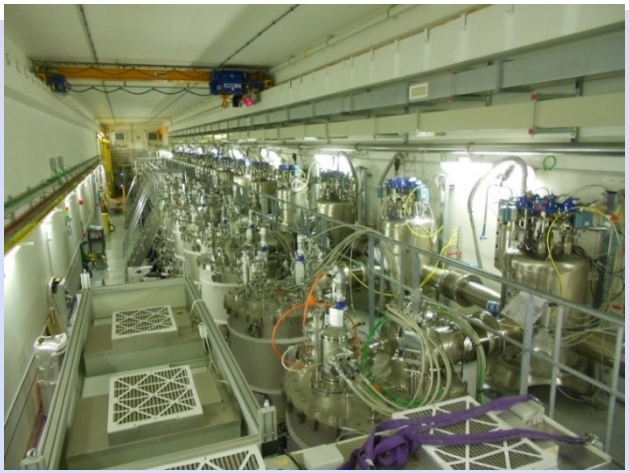
DSCN4912.JPG

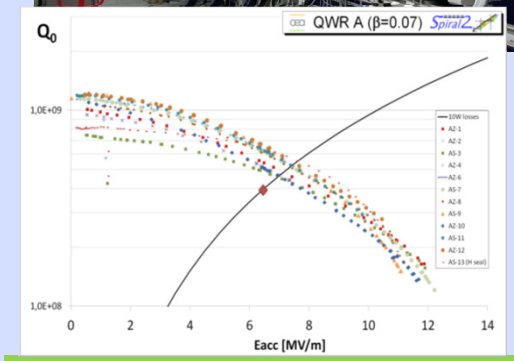
laboratoire commun CEA/DSM — spiral2 — CNRS/IN2P3

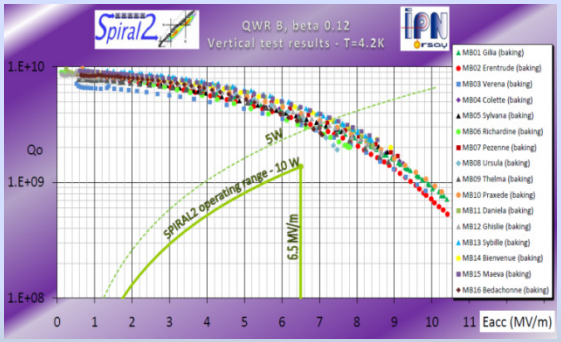
SPIRAL2 LINAC: SC cavities

88 MHz QWR 12 x 1 = 12 β = 0.07 cavities 7 x 2 = 14 β = 0.12 cavities









12 /12 CMA aligned and connected to their valve boxes

6 /7 CMB aligned and connected to their valve boxes

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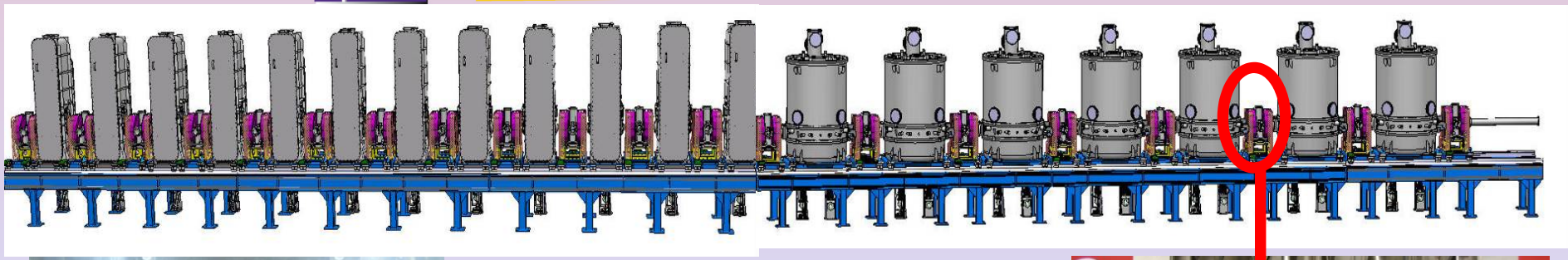
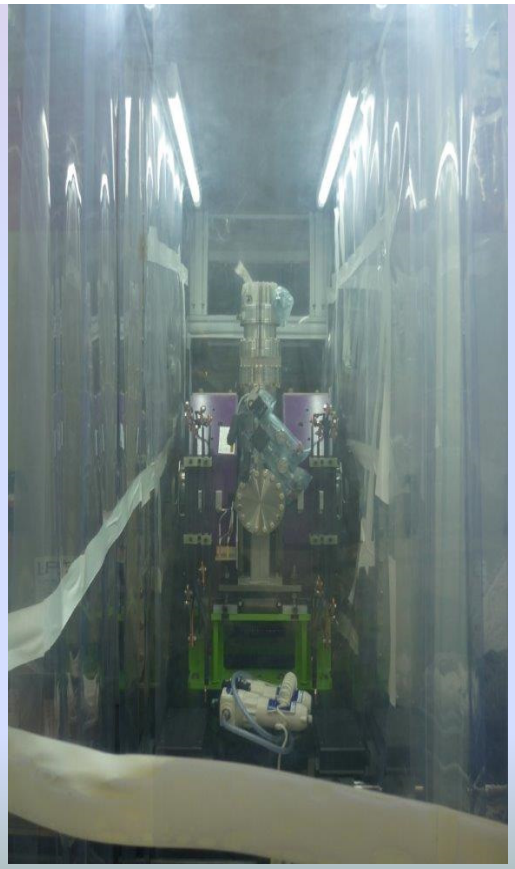
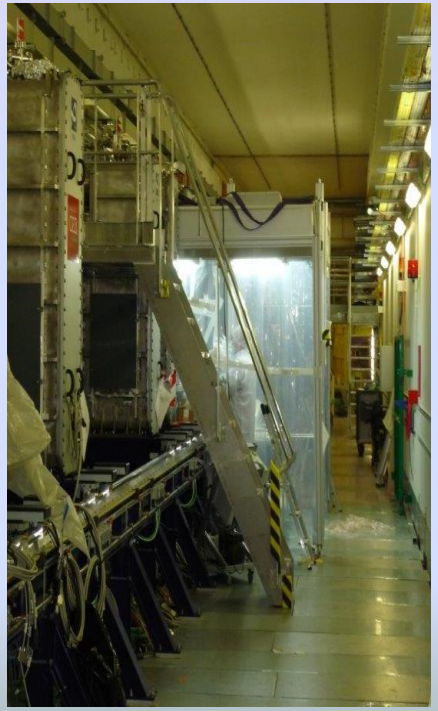
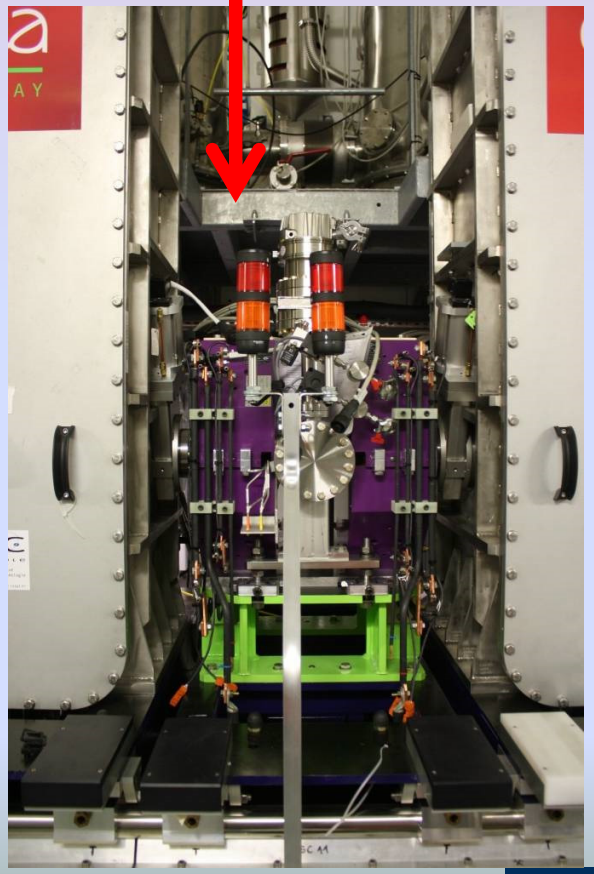
SPIRAL2 LINAC: warm sections





18 / 20 warm sections installed



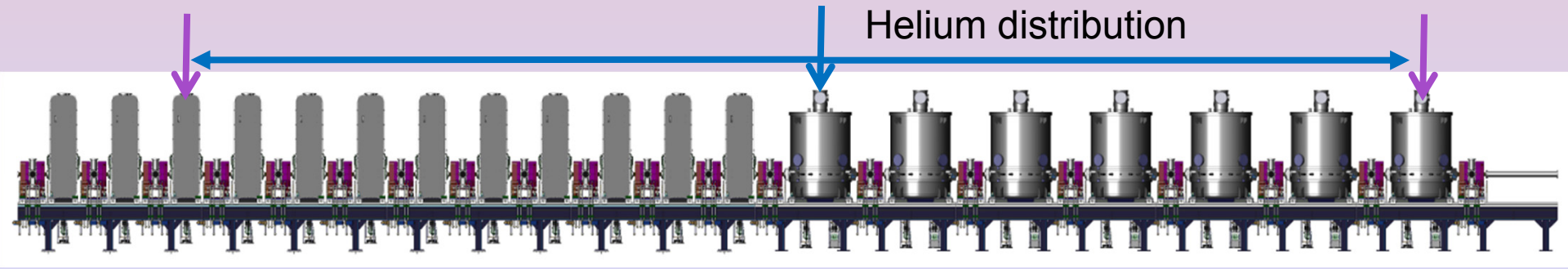


SPIRAL2 RF amplifiers

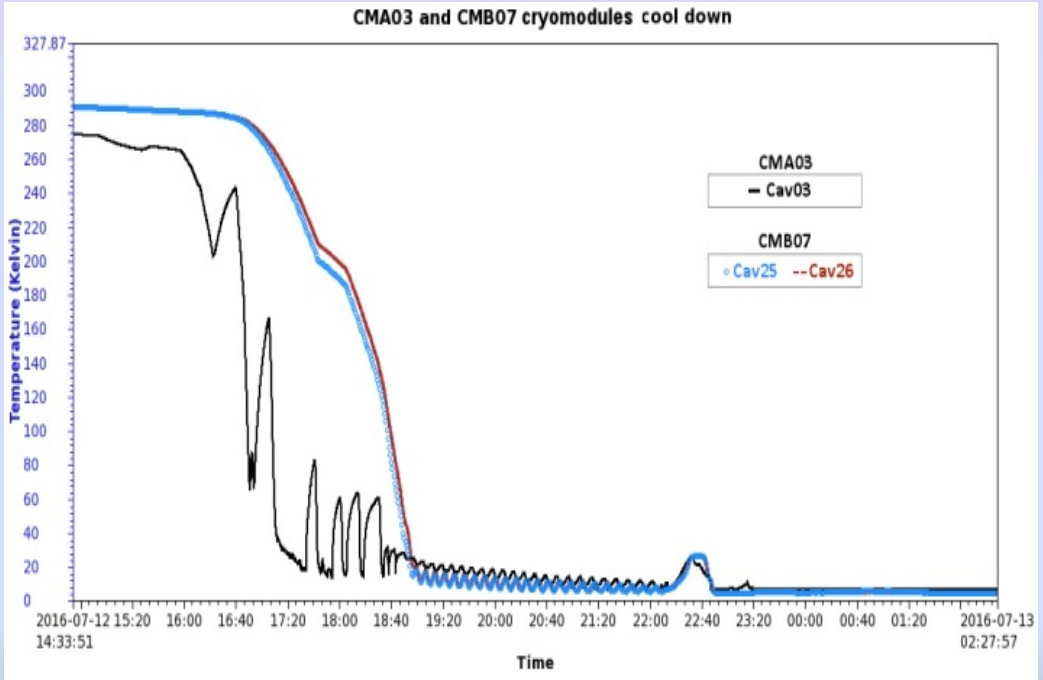
One solid state amplifier per cavity
Up to 20 kW

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

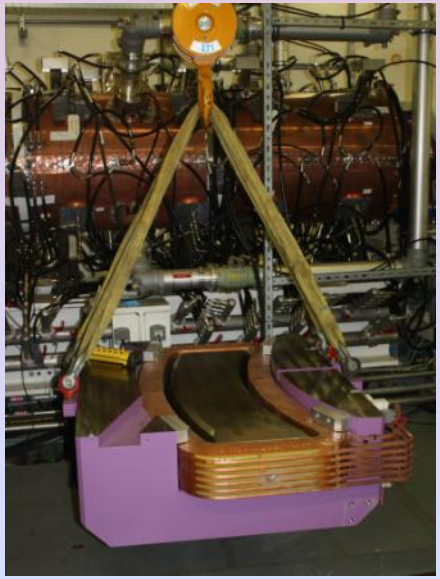
Linac first cool down

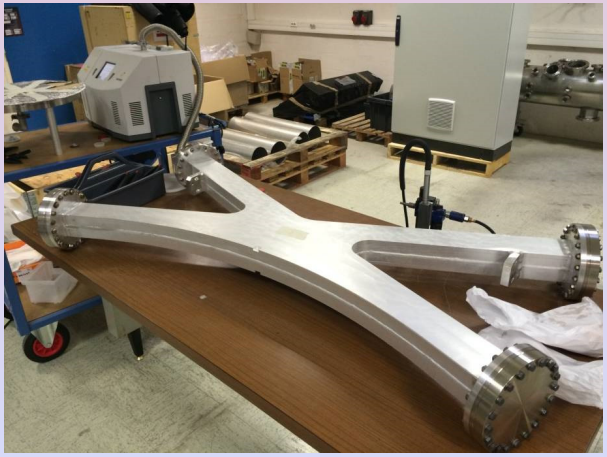


- First partial cool down on July 13, 2016
  - test a major part of the cryogenic installation
  - PLCs and C/C
- Both cryomodules were regulated at 4K after about 20 hours of cool-down

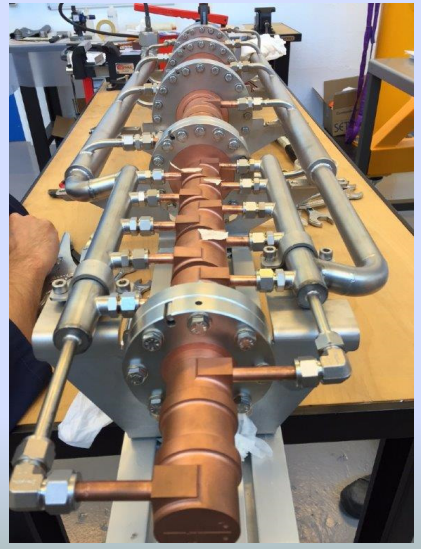


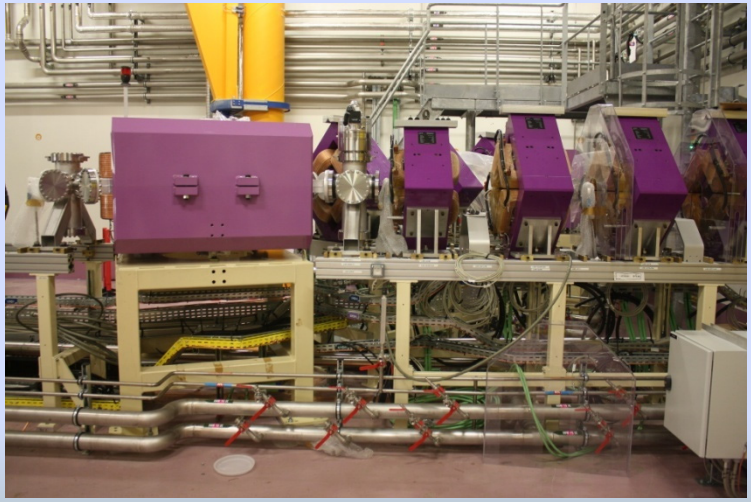
SPIRAL2 HEBT lines





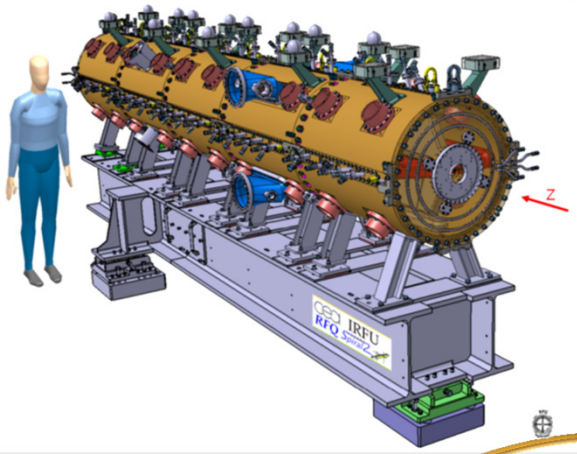
Under installation





HEBT lines will be fully equipped at the beginning of 2017

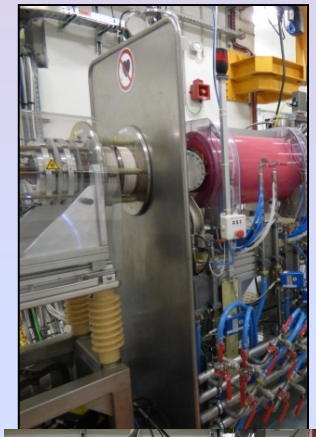
INJECTOR RESULTS WITH BEAM

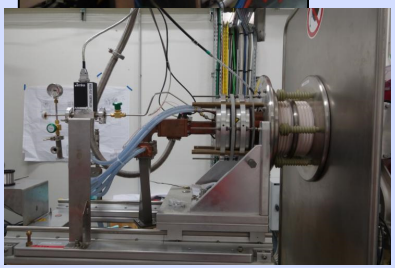


We got end of october 2014 the authorization from the French National Safety Authority to test the injector with beam (except deuterons)

Diagnostics Plate

Proton/deuteron source commissioning





First beam produced at GANIL on Dec 19, 2014 with 2 mA of protons.

Now:

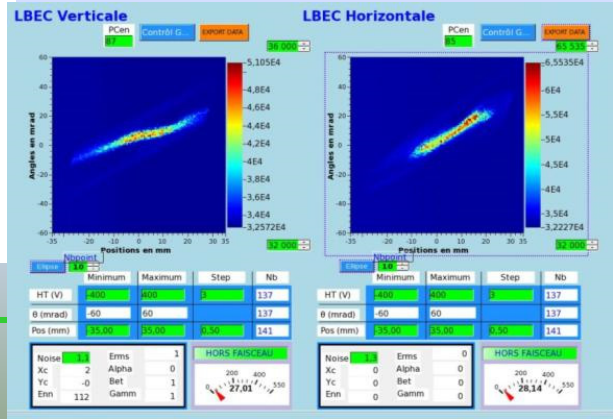
Ability to extract 11 mA CW from the source => 6 mA proton beam

Long period stability (6 mA CW)

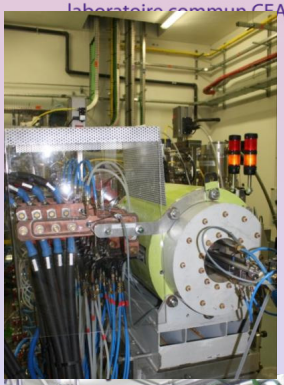
Routinely more than 5 mA at the end of LEBTc

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

0.2 π mm mrd rms norm.



Heavy-Ion A/Q = 3 source commissioning



First beam produced at GANIL on July 10, 2015 with 230 µA of Argon

Now:

- 50 µAe $^{40}Ar^{14+}$ (60 kV)
- 2 mAe $^{4}He^{2+}$
- 0,9 mAe $^{18}O^{6+}$

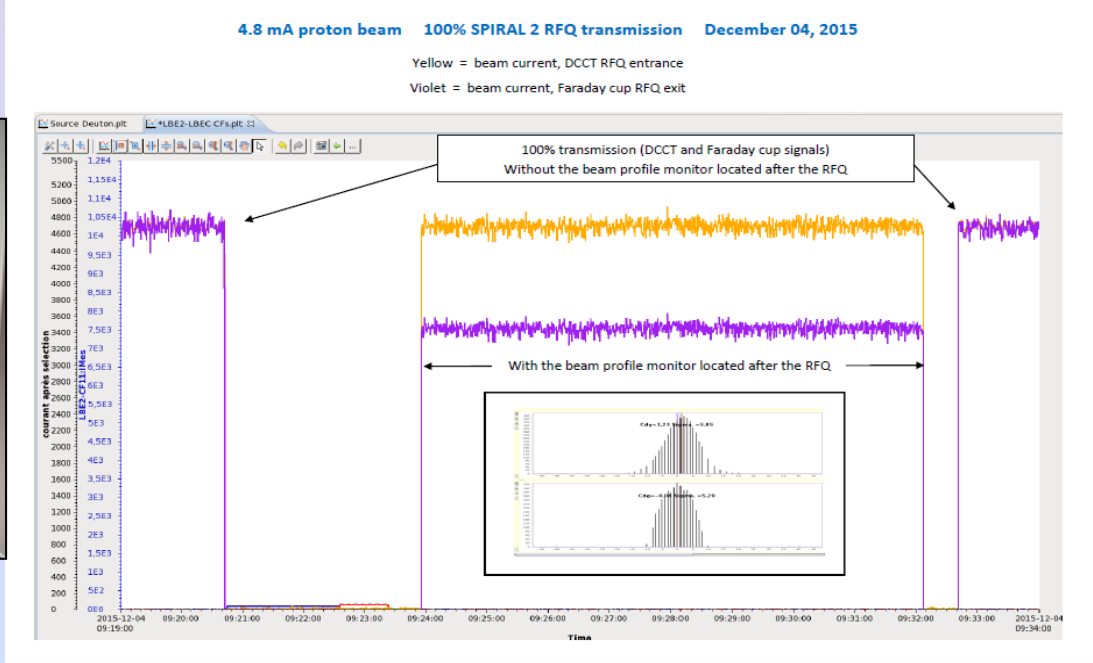
Emittance at the end of LEBTc

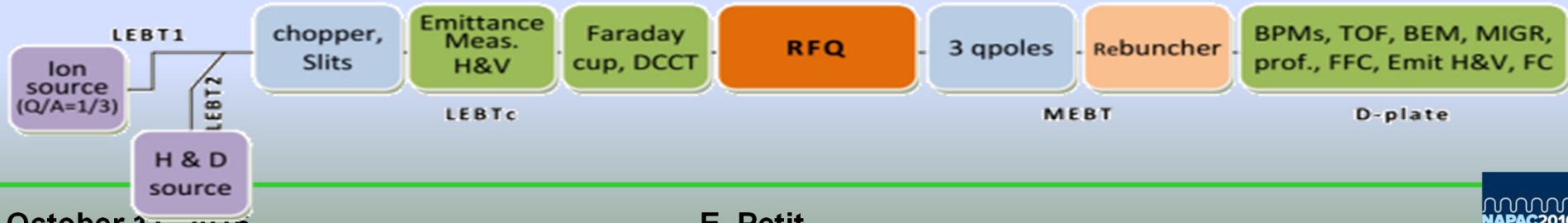
Particle	Beam current (mA)	Emit X (π.mm.mrad)	Emit Y (π.mm.mrad)
$^{4}He^{2+}$	1.35	0.54	0.43
$^{18}O^{6+}$	0.75	0.36	0.42

After tuning of the LEBT lines and optimization of the transverse emittances to get the highest beam current at the end of LEBTc

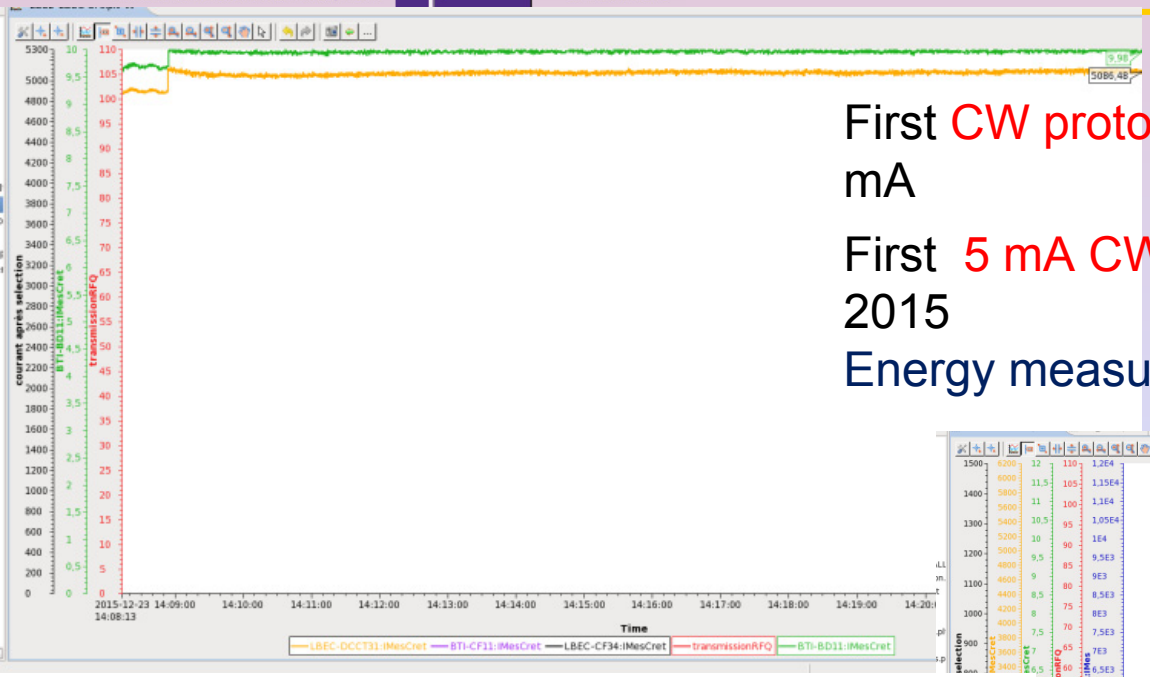
RFQ beam commissioning

- 2015, December 3rd, 9h26 : first RFQ beams (*Protons*)
- 4.8 mA (0.1% dC) with 100% transmission at the end of the same working day (SPIRAL 2 nominal beam current)





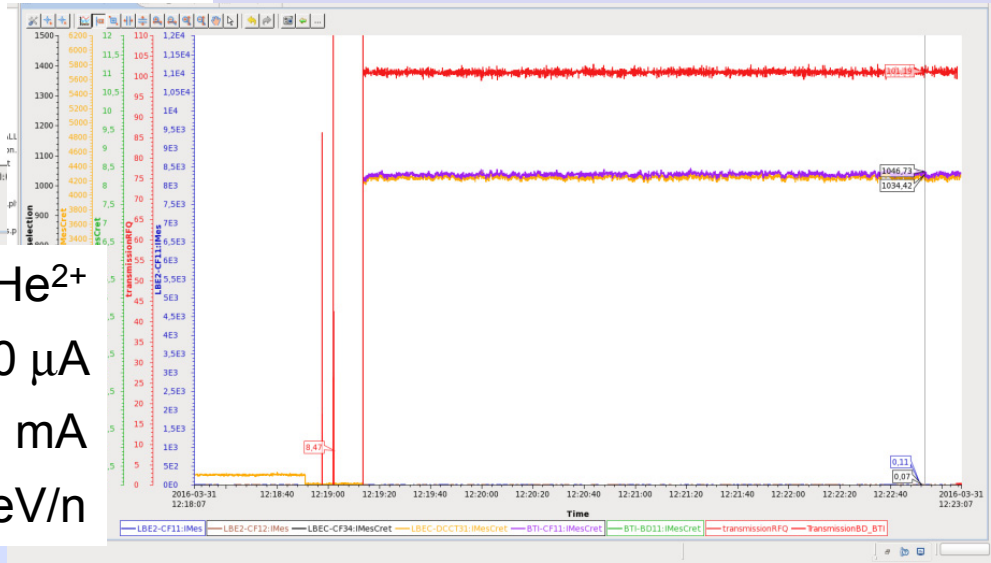
RFQ beam commissioning



First CW proton beam : December 18 with 2.3 mA

First 5 mA CW proton beam : December 23, 2015

Energy measured: 0.730 MeV



A/Q = 2 beam $^4He^{2+}$

February 25, 2016 : First pulsed beam, 250 µA

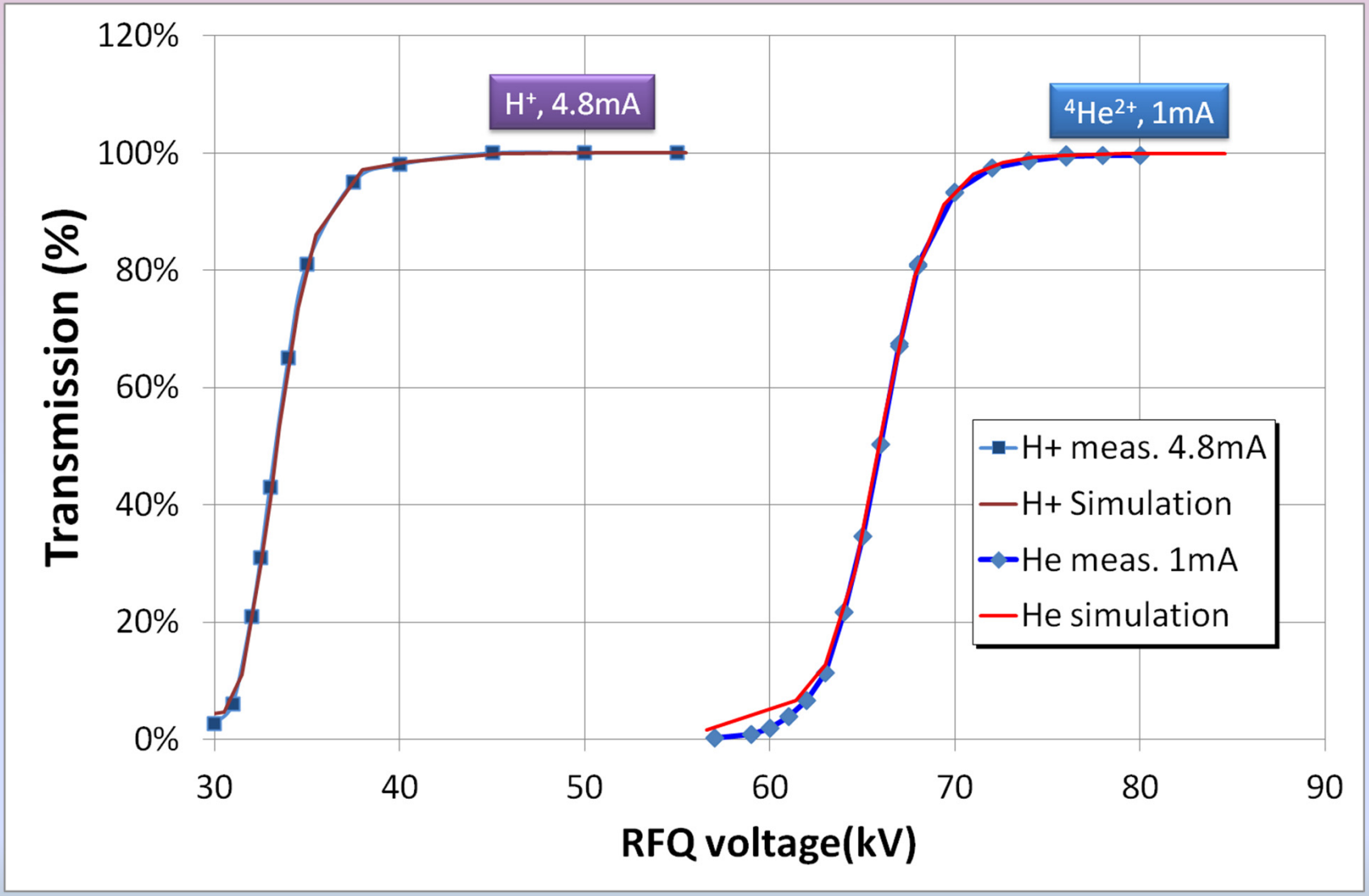
First CW beam : June 04, 2016 ~ 1 mA

Energy measured: 0.727 MeV/n

Proton & A/Q = 2 => good transmission (100%) with the expected beam energy

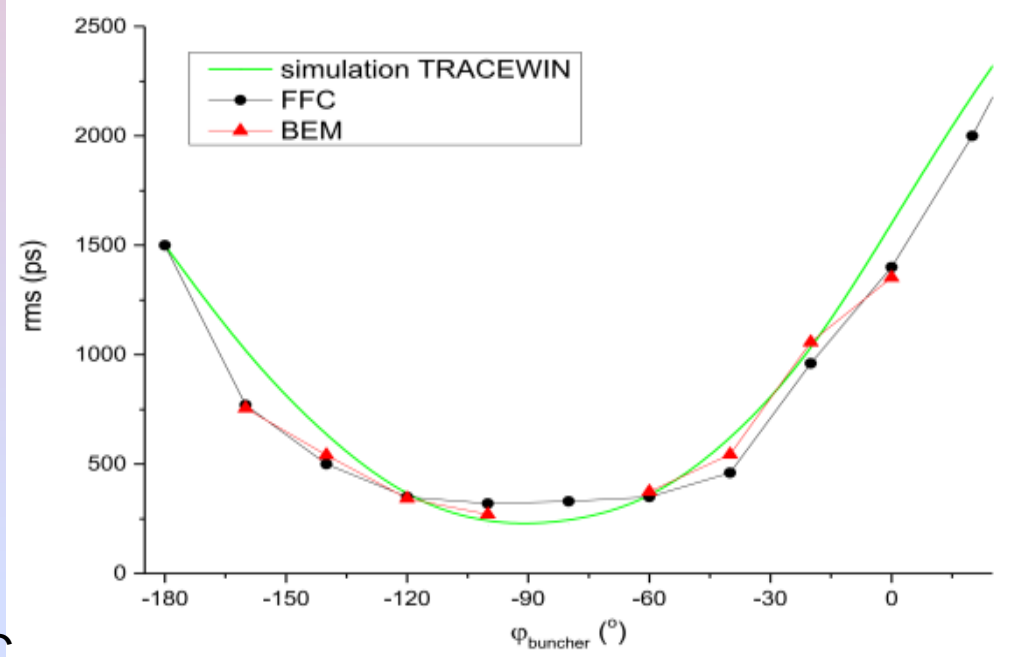
RF operation stable and reliable, with 3/4 amps, up to 80 kV

RFQ beam commissioning

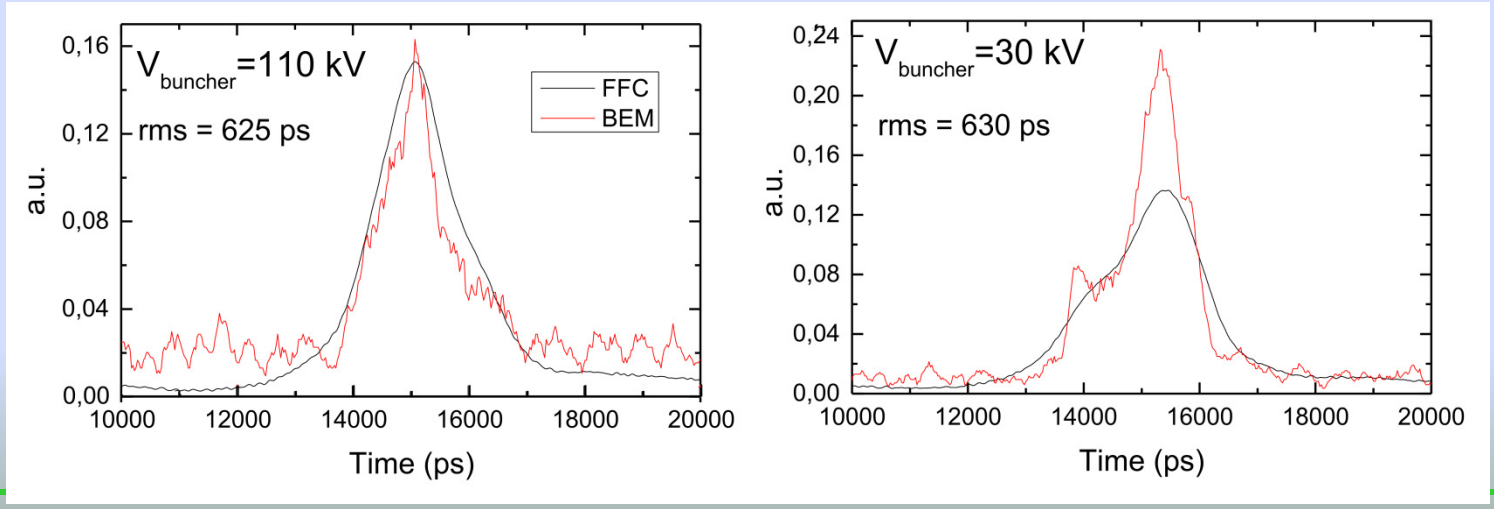


Bunch length measurement comparison

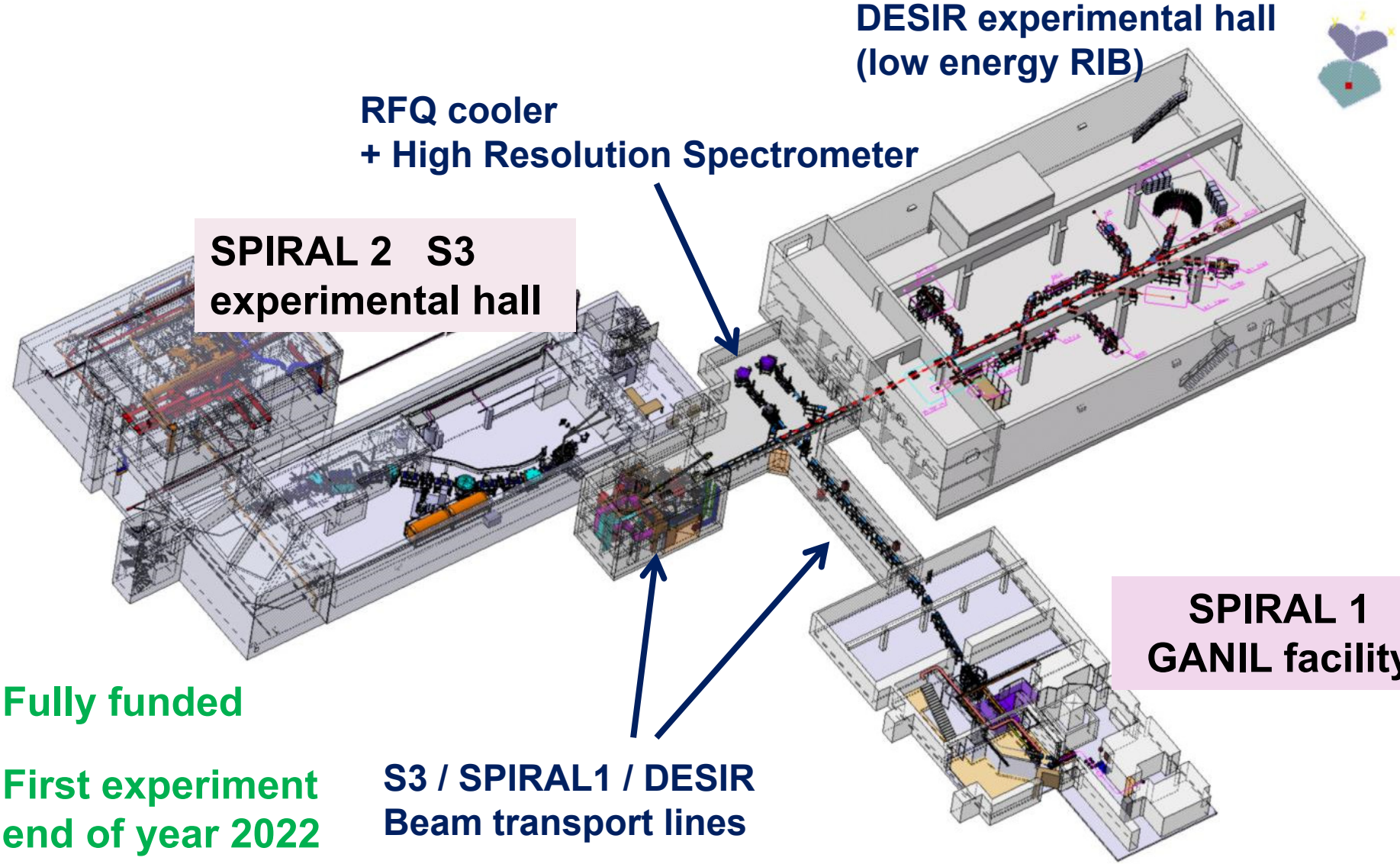
- good agreement between the two measurements and the TraceWin simulations
- Buncher variation in phase or voltage



Comparison FFC with BEM, 0.6mA, 1%dC



Perspectives: DESIR facility

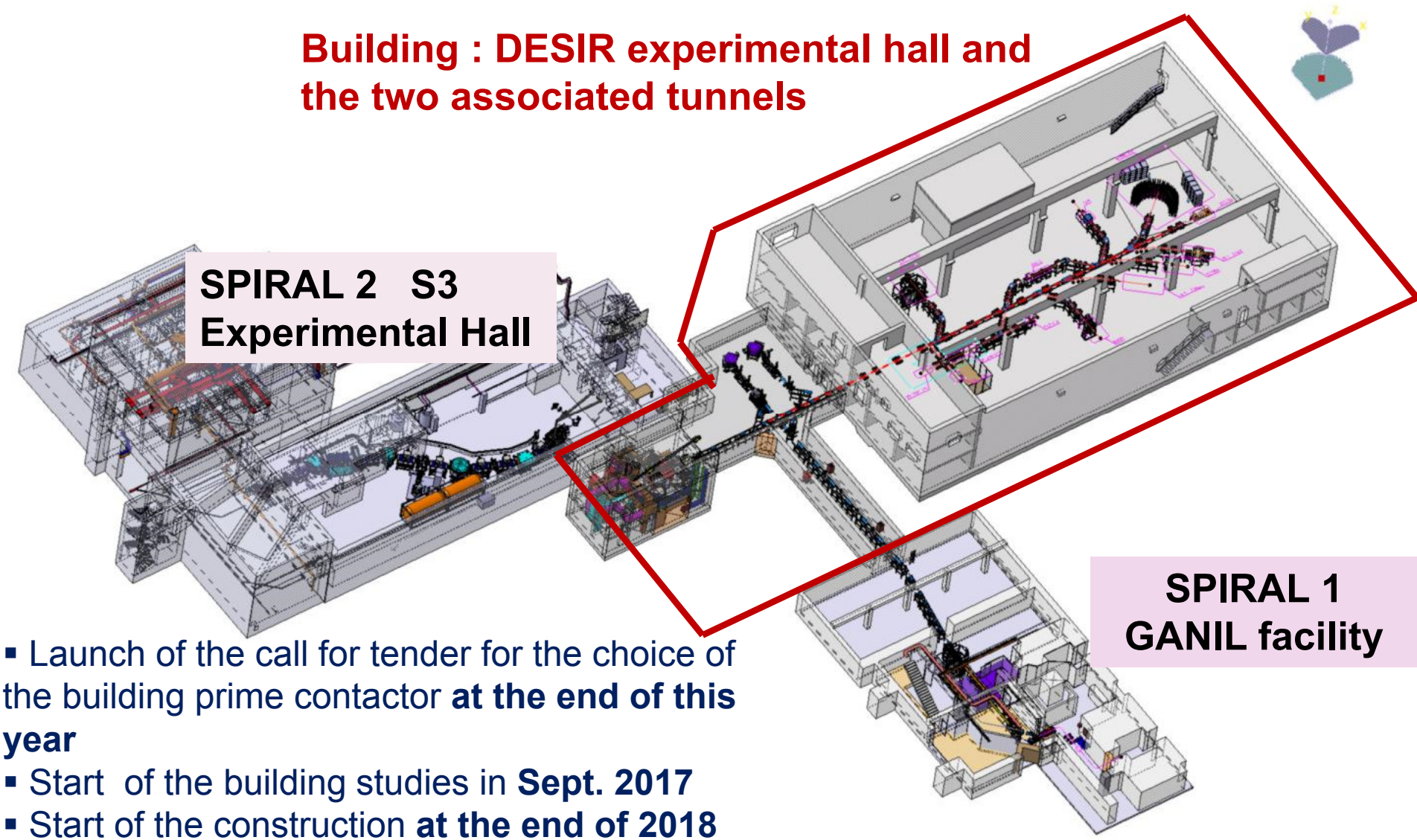


Fully funded

First experiment end of year 2022

DESIR facility: building

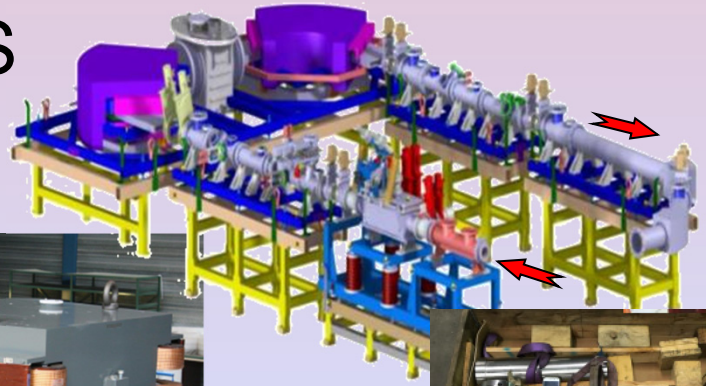
Building : DESIR experimental hall and the two associated tunnels

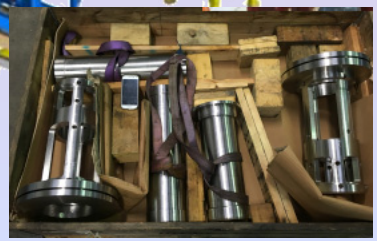


- Launch of the call for tender for the choice of the building prime contactor **at the end of this year**
- Start of the building studies in **Sept. 2017**
- Start of the construction **at the end of 2018**

DESIR facility: HRS + RFQ Cooler

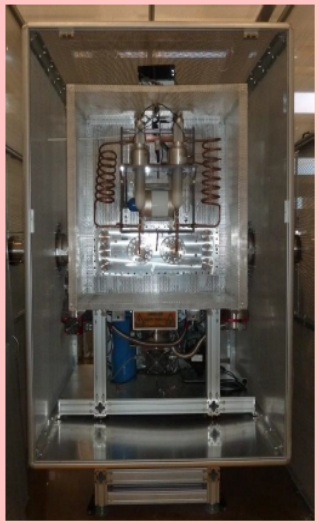
HRS



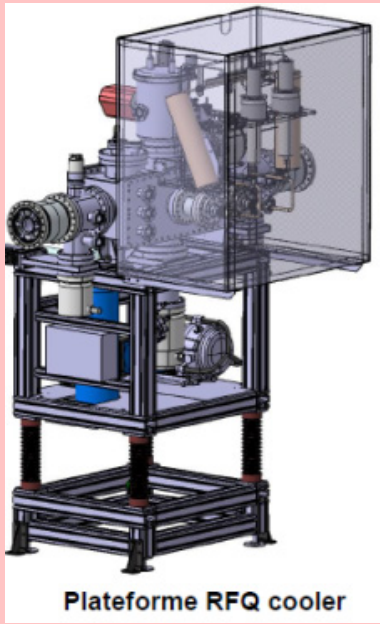


- The mechanical components are completely manufactured or under manufacturing
- The mechanical installation just started in CENBG lab (Bordeaux)
- Commissionning of the HRS with stable beams from 2017 to 2019

RFQ Cooler



RFQ cooler

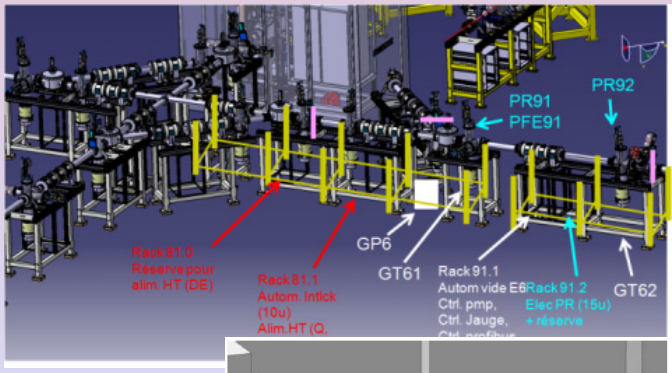


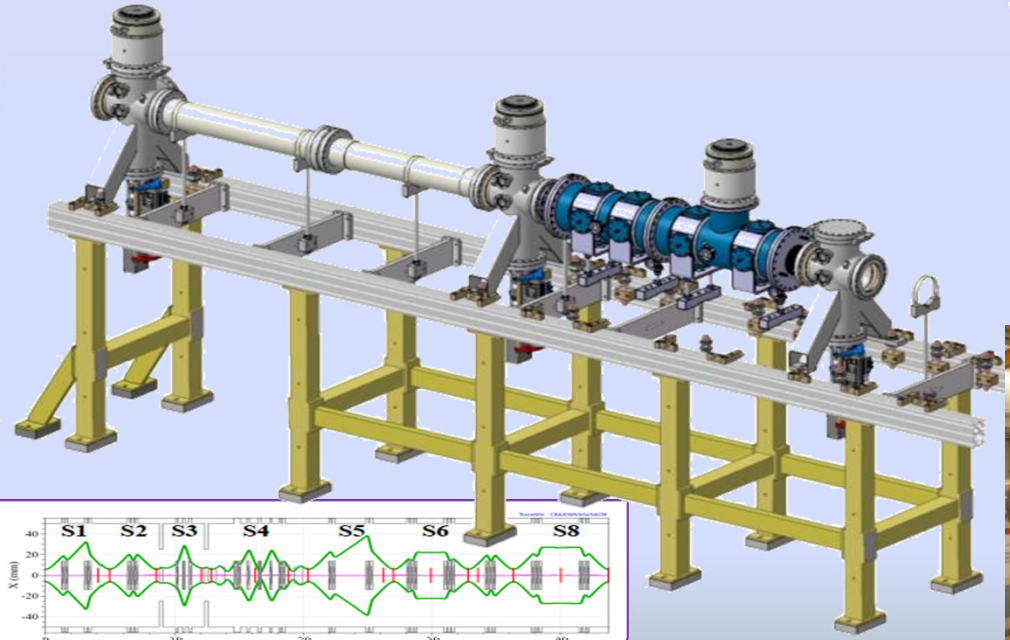
Plateforme RFQ cooler

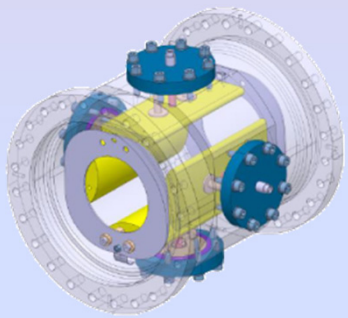
- A version exits and is tested, originally scheduled for SPIRAL2 Production facility
- This version must be mechanically adapted to the DESIR beam lines

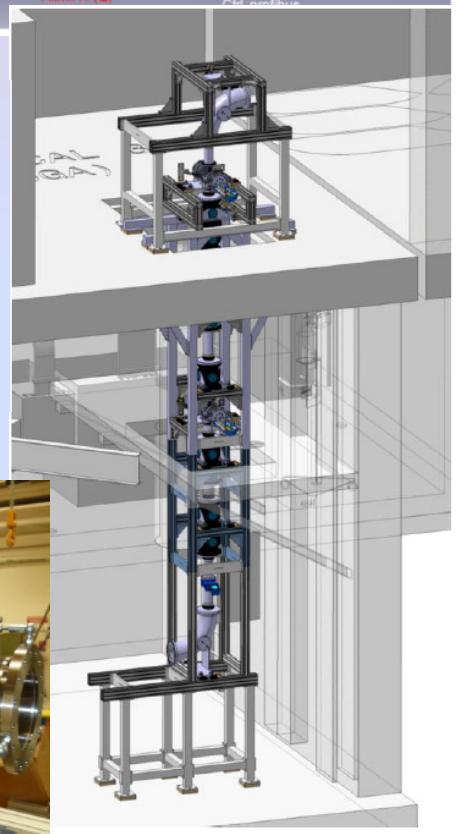
DESIR facility: beam lines

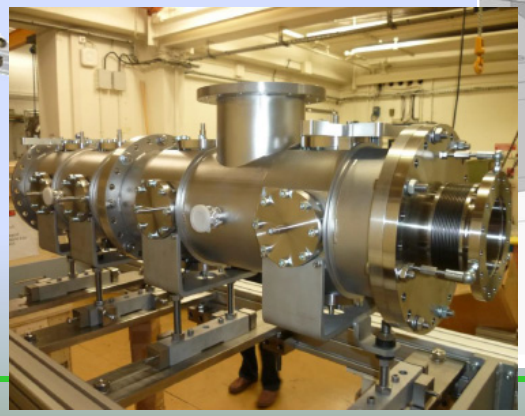
- Optical and mechanical design reviewed and validated
- Detailed studies are underway on major equipment
- Start of the manufacturing of mechanical components of the beam lines in 2017

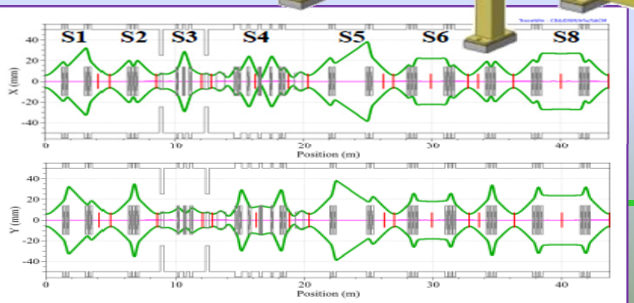








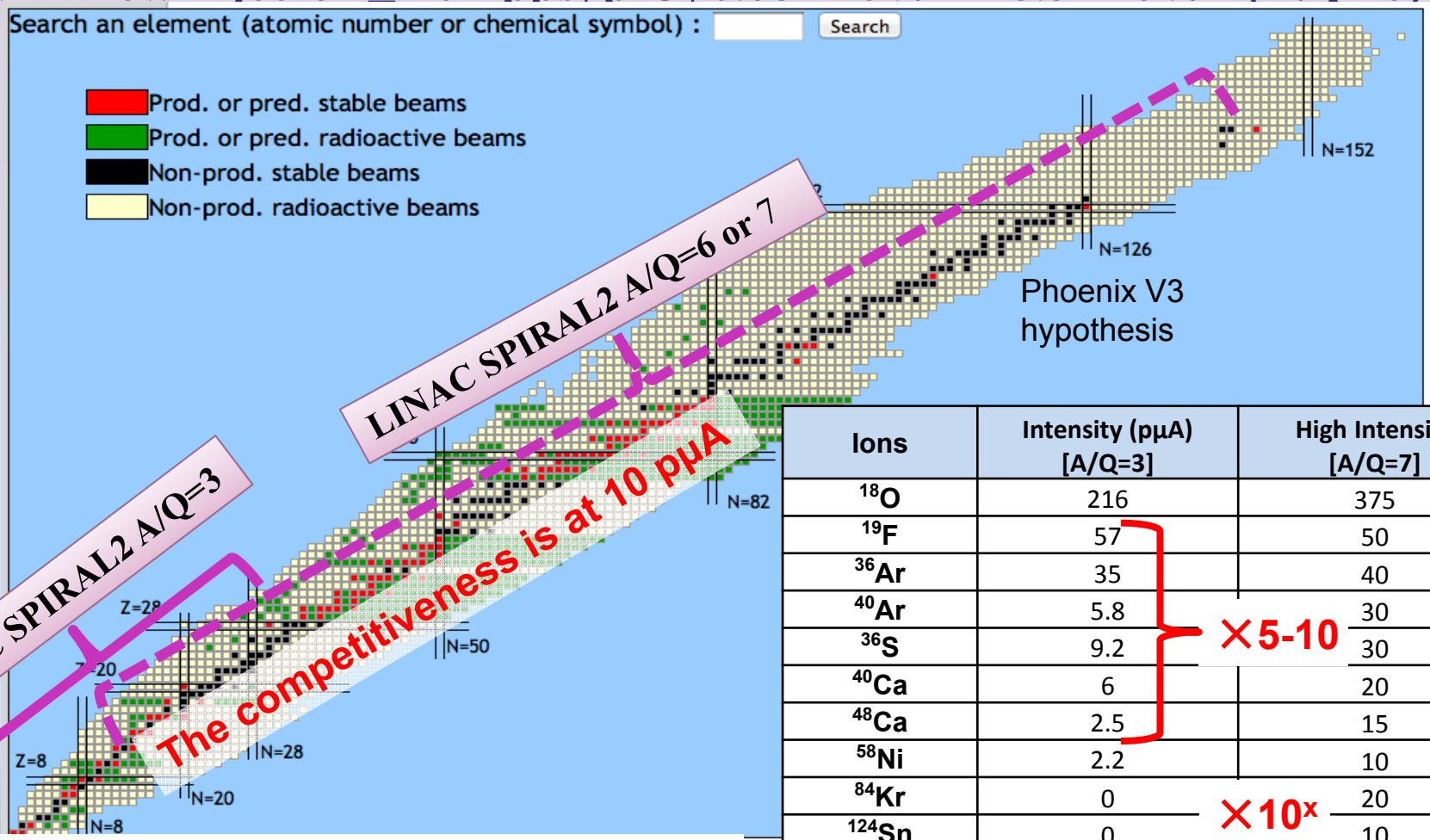




Perspectives: Injector A/q= 6 or 7

Stable beams @ SPIRAL2

- Reference project ≤ 10^{15} pps, p-Ni, 0.75 MeV/n – 14.5 MeV/n
- With new injector ≤ 10^{15} pps, p-U, 0.75 MeV/n – 8.5 MeV/n (A/Q=6)



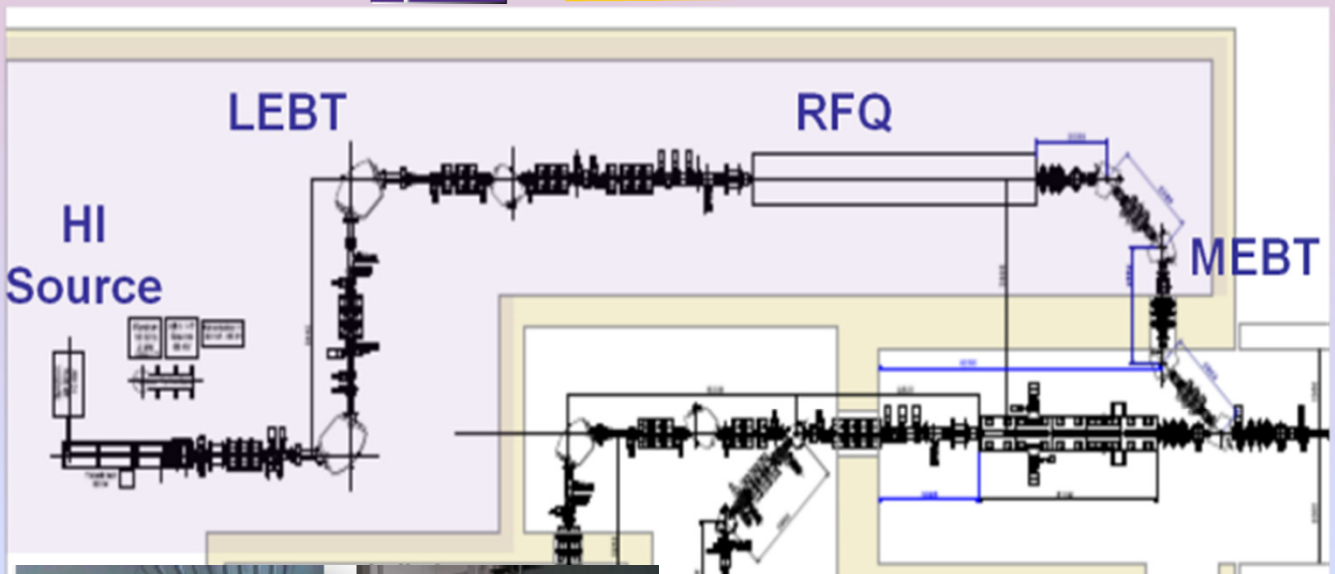
Ions	Intensity (pμA) [A/Q=3]	High Intensity [A/Q=7]
^{18}O	216	375
^{19}F	57	50
^{36}Ar	35	40
^{40}Ar	5.8	30
^{36}S	9.2	30
^{40}Ca	6	20
^{48}Ca	2.5	15
^{58}Ni	2.2	10
^{84}Kr	0	20
^{124}Sn	0	10
^{139}Xe	0	10
^{238}U	0	2.5

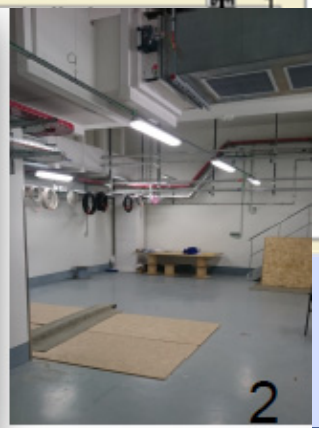
×5-10

×10^{x}

- Strengthen the DESIR scientific program
- Open new perspectives (Pb,U heavy beams)

Perspectives: Injector A/q= 6 or 7





Space and utilities required for the implementation of this new injector have been taken into account since the construction time of the SPIRAL2 facility

Discussion started with partner labs with the objectives:

- **To start the studies at the beginning of next year**
- **To start the constuction at the end of the year 2018 IF FULLY FUNDED**

Conclusions

- **Good advances of the SPIRAL2 project**
  - Both light and heavy ion sources working very well
  - RFQ working well with protons and A/Q = 2 ions (He) with about 100% transmission
- **RFQ preliminary conditioned up to maximum voltage (114 kV, CW) => A/Q = 3 ions soon**
- **Superconducting linac : Successful first partial cooling down => new cooling down in November**

- **RF in cryomodule : beginning of next year**
- **First linac beam : mid of 2017**

- **The future extensions (DESIR and the new injector) will increase the competitiveness of SPIRAL2 GANIL facility and will open new perspectives for the scientific program at GANIL**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Thank you
for your attention