The SPIRAL2 Project

M. Lewitowicz
GANIL, CEA/DSM-CNRS/IN2P3, Caen, France

on behalf of the SPIRAL2 Project Group
&
Physics Collaborations

GANIL/SPIRAL1/SPIRAL2 facility

Caen, France

GANIL Beam time: 35 weeks/y (600 users)
SP2 Beam time: 44 weeks/y
ISOL RIB Beams: up to 53 weeks/y
Up to 50 % more users: 800-900
First experiments 2013

LINAC:
33MeV p
40 MeV d
14.5 AMeV HI

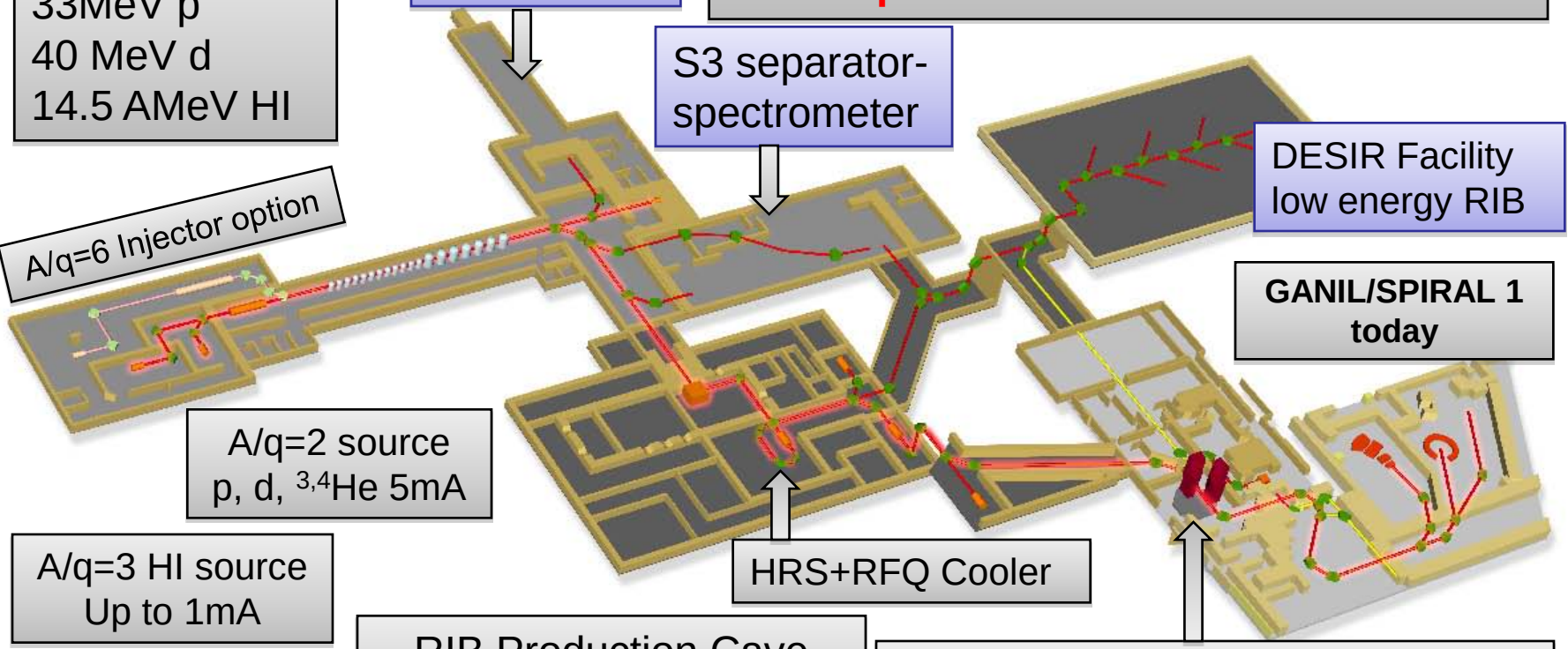
Neutrons For Science

S3 separator-spectrometer

DESIR Facility low energy RIB

A/q=6 Injector option

GANIL/SPIRAL 1 today



A/q=2 source
p, d, ^{3,4}He 5mA

A/q=3 HI source
Up to 1mA

HRS+RFQ Cooler

RIB Production Cave
Up to 10^{14} fiss./sec.

CIME cyclotron RIB at 1-20 AMeV
(up to 10 AMeV for fiss.fragments)

Cost: 200M€ Funded + 7M€ operation cost + 20 M€ detectors

2 RIB + 3 Stable-ion beams (ARIBE, IRRSUD, SME) **-> 5 experiments in parallel**

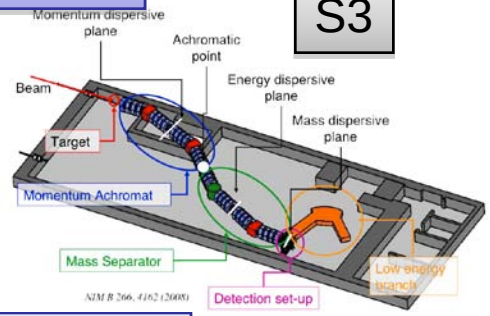
SPIRAL2 is one of the ESFRI list projects (45 most important EU research infrastructure projects)

Scientific case of GANIL/SPIRAL 2

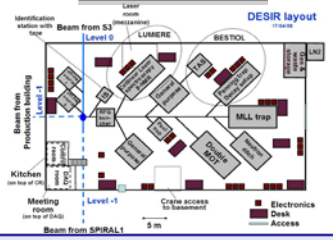
ISOSPIN DEGREES OF FREEDOM IN NUCLEAR FORCES

Heavy and Super Heavy Elements

S3



DESIR



Position of drip-line p, 2p, α decay

Equation of State
Role of Isospin

N=Z

Shell structure very far from stability

Astrophysics r-process path

PARIS
GASPARD
FAZIA
ACTAR

Astrophysics
s
rp-process

GANIL DETECTORS

Neutrons for science

AGATA

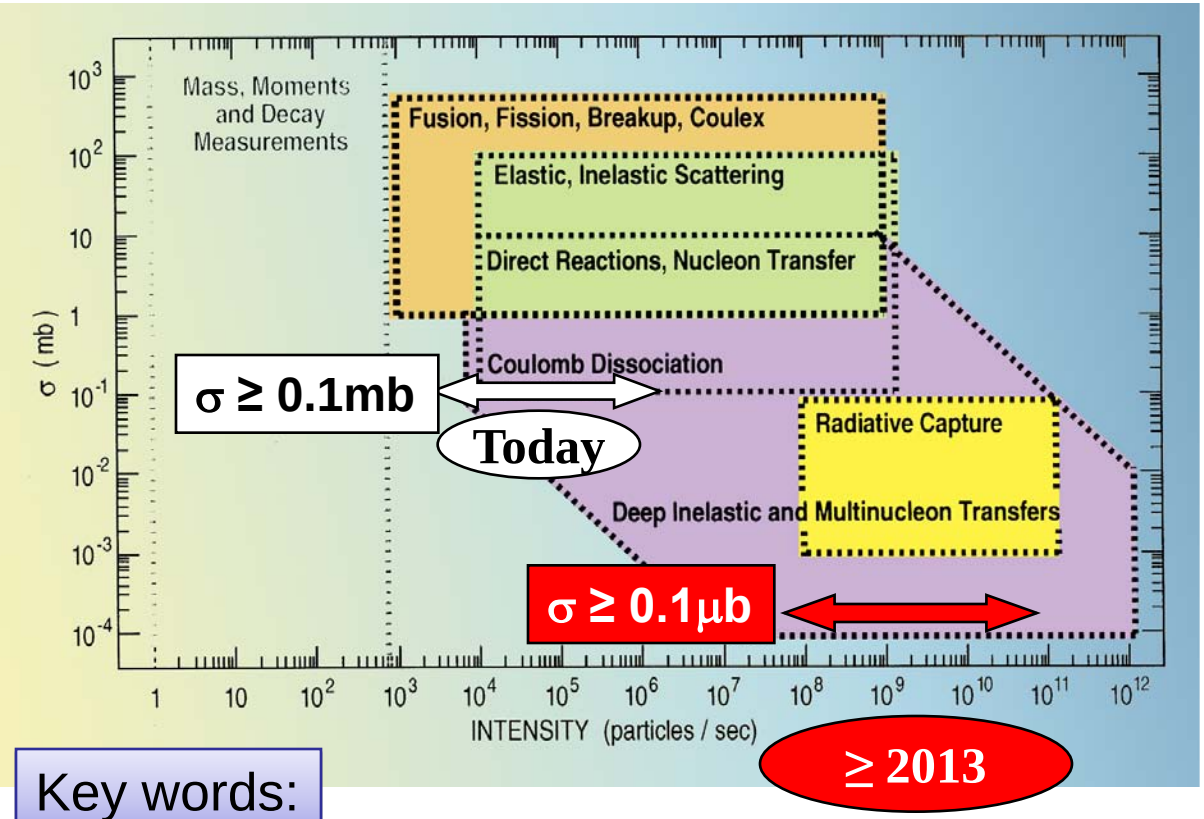
Spins & Shapes

Haloes & Structures in the Continuum

NFS

Atomic & solid state physics, Radiobiology & Isotope production

Physics with Radioactive & Stable-ion High-intensity Beams at 1-20 MeV/nucl.



Physics:

- single-particle structure
- nuclear pairing
- structure of very-heavy nuclei
- nuclear clustering and nuclear molecules
- isospin in reaction mechanisms
- applications to astrophysics

Reaction Types

- elastic & resonant el. (p,p) …
- inelastic (p,p'), (d,d')…
- transfer (d,p), (p,d), (p,t)…
- breakup
- fusion-evaporation
- deep-inelastic
- fission

+ "keV beam" physics !

Key words:

ISOL RIB beams:
- high intensity, optical quality & purity

Versatility:
- light & HI, high-intensity stable-ion & RIB

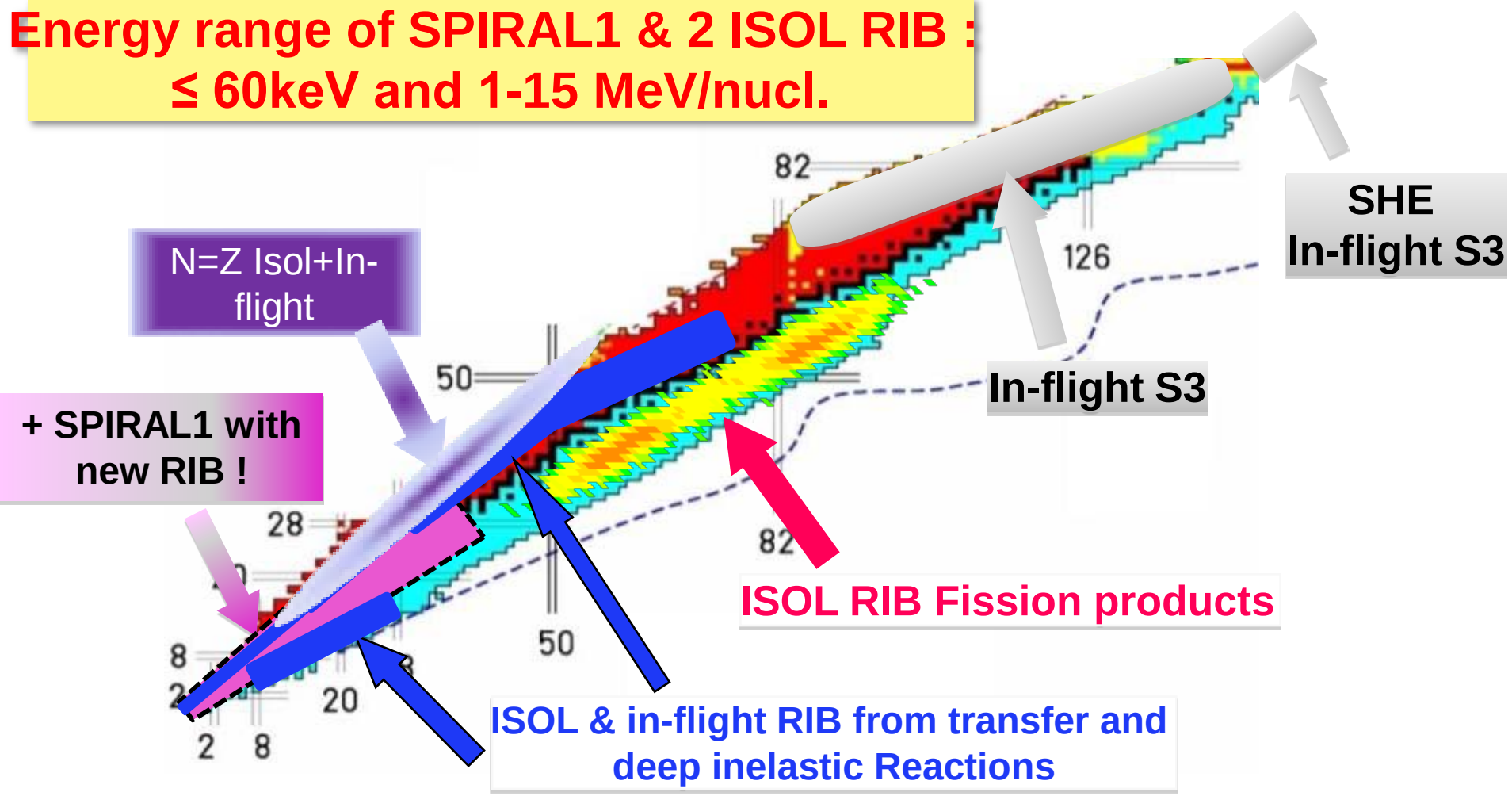
Multi-beam capabilities, months of beam-time

World-class arrays & detectors

RIB and nuclei far from stability

accessible with SPIRAL1 & SPIRAL2

Energy range of SPIRAL1 & 2 ISOL RIB :
≤ 60keV and 1-15 MeV/nucl.



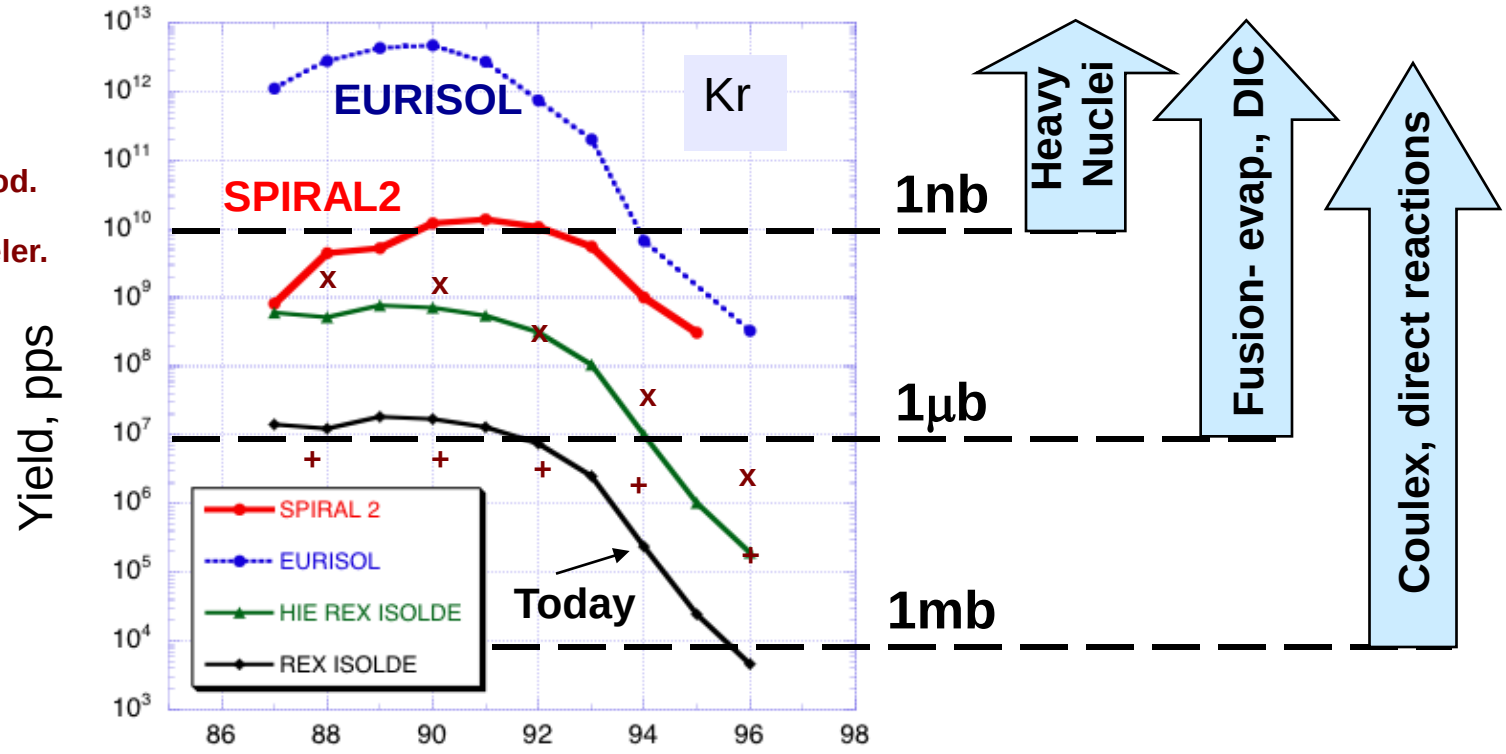
SPIRAL 2: Advanced ISOL RIB facility

SPIRAL 2: Experiments with RIB at low cross sections and very exotic nuclei at few MeV/nucleon

FRIB

\+ Direct prod.

x Post-acceler.



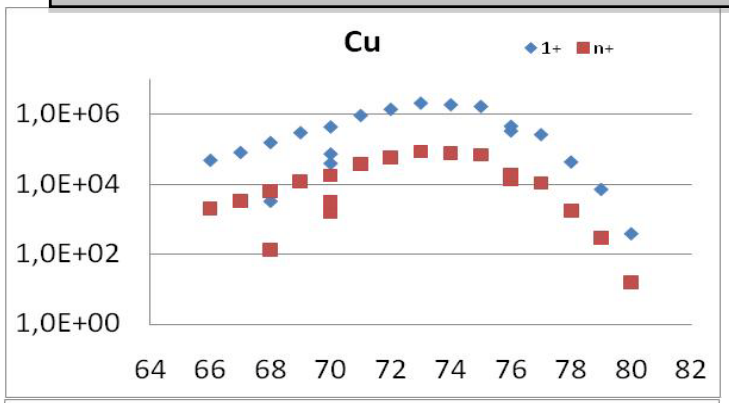
Ex.: At 1nb 1 nucl./day via fusion-evaporation

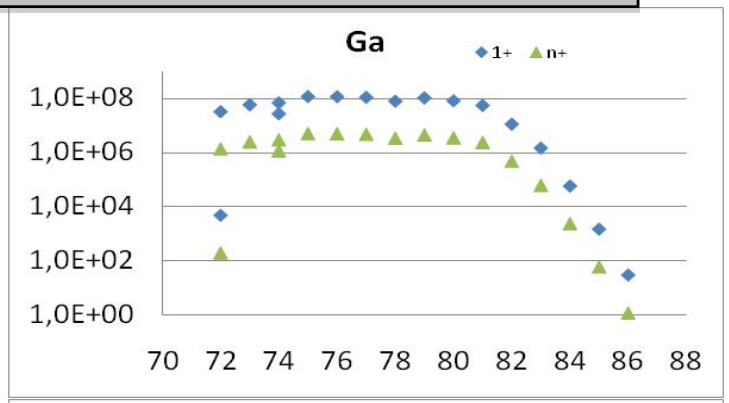
Post-Accelerated & DESIR RIB proposed for

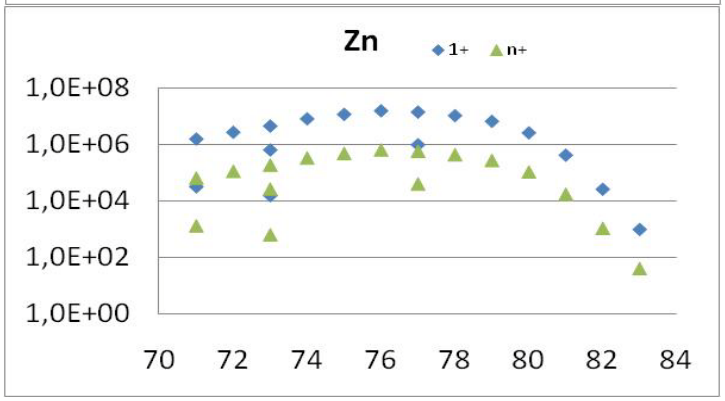
SPIRAL2 Phase 2 Day 1 experiments

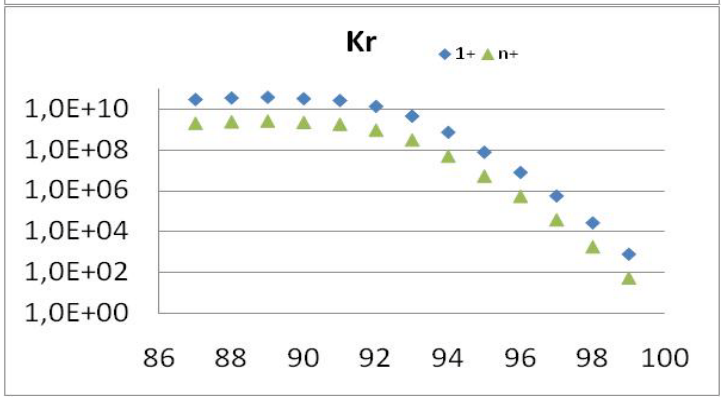
Restrictive assumption for the beginning of operation: 280g UCx target and 50kW deuteron beam power.

Examples of Day 1 beams of fission fragments (in pps):









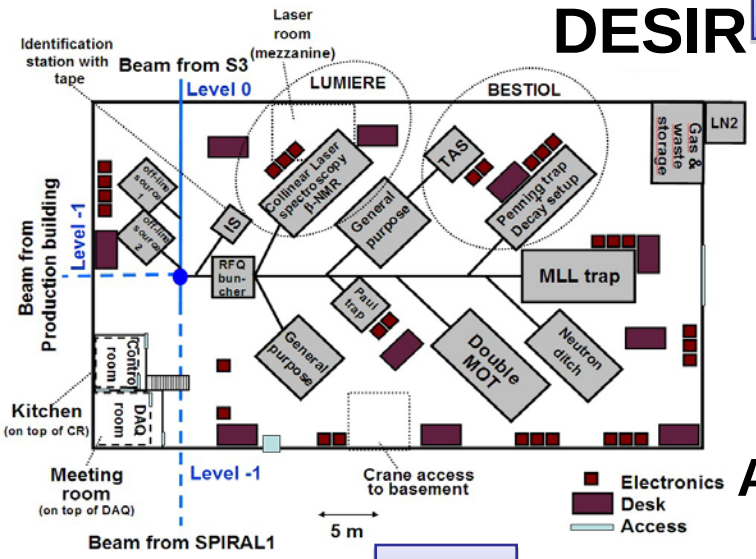
Nominal RIB intensities expected to be 15 times higher

> 600 different RIB of 25 elements produced in fission, fusion & transfer reactions

New detectors to be used at SPIRAL 2

DESIR

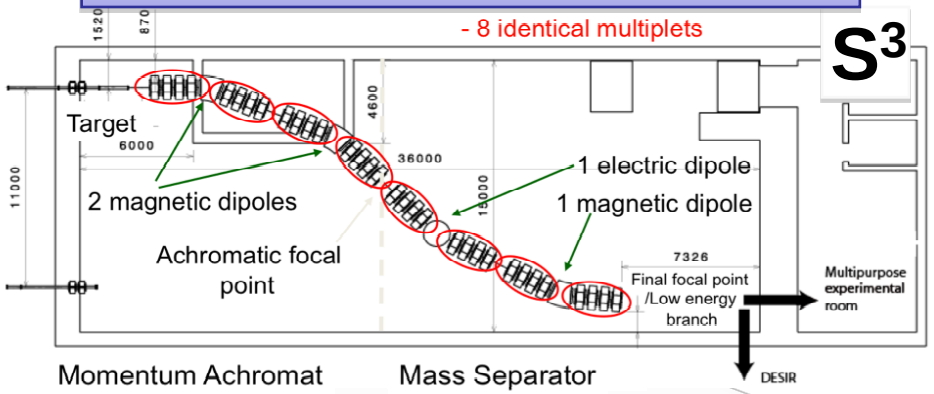
MoU



E. Farnea

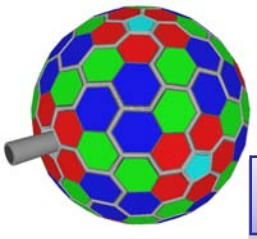
S³

Steering Committee formed->MoU



AGATA

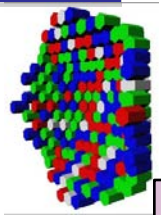
MoU



A. Maj

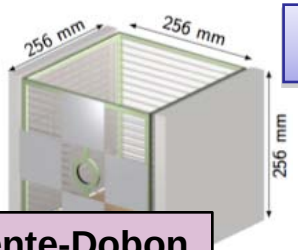
NEDA

MoU



J. J. Valiente-Dobon

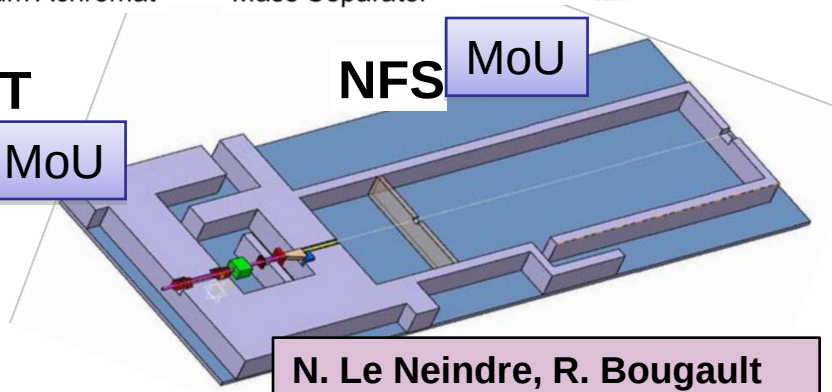
ACTAR & GET



MoU

NFS

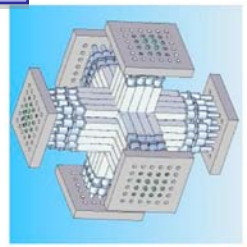
MoU



N. Le Neindre, R. Bougault

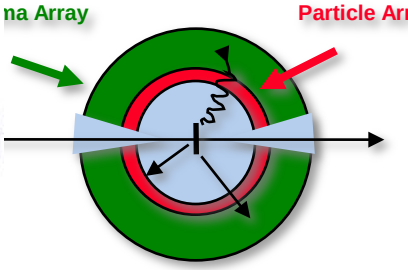
PARIS

MoU



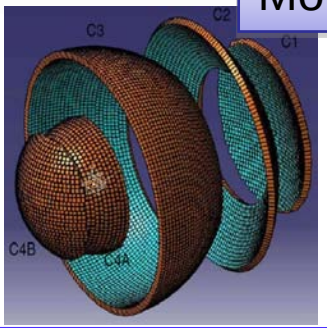
HELIOS

GASPARD

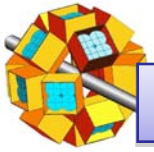


FAZIA

MoU



EXOGAM 2



MoU

Super Separator Spectrometer (S3)

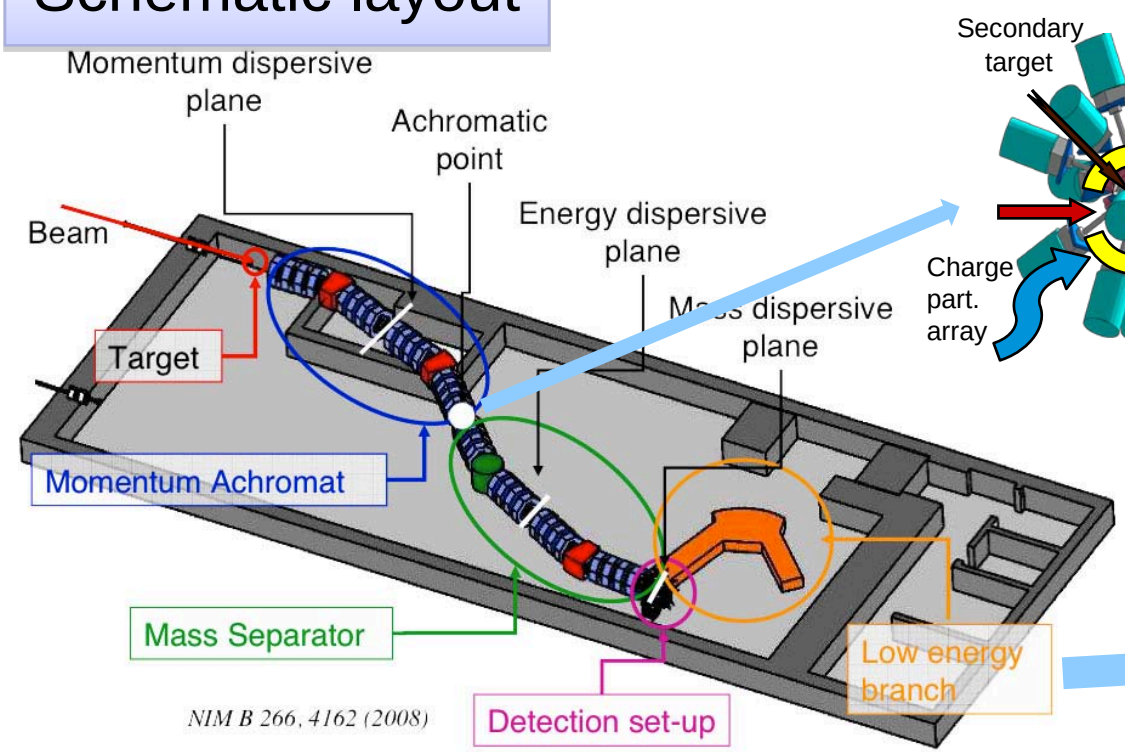
Collaboration

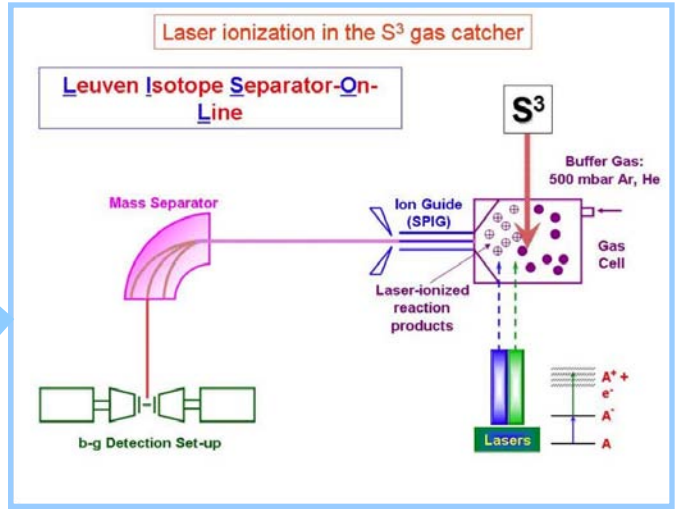
104 physicists, 30 institutions, 12 countries

Management Board

Hervé SAVAJOLS – GANIL, France (Project leader)
Antoine DROUART – Irfu/SPhN (CEA), France (Spokesperson)
Jerry A. NOLEN – Argonne National Laboratory, USA (Spokesperson)
Martial Authier – Irfu/CEA, France (Technical Coord.)

Schematic layout





- **Technically the project will be ready in 2011 to start the construction phase**
- **First experiment plan in 2013-2014**

S3 LoI Physics objectives

Proton Dripline & N=Z nuclei

LoI_Day1_6, LoI_Day1_8, LoI_Day1_9
LoI_Day1_11, LoI_Day1_17

- Tests of Shell Model
- Single-Particle structure
- Development of Collectivity
- Shape coexistence

LoI_Day1_3, LoI_Day1_4,
LoI_Day1_18

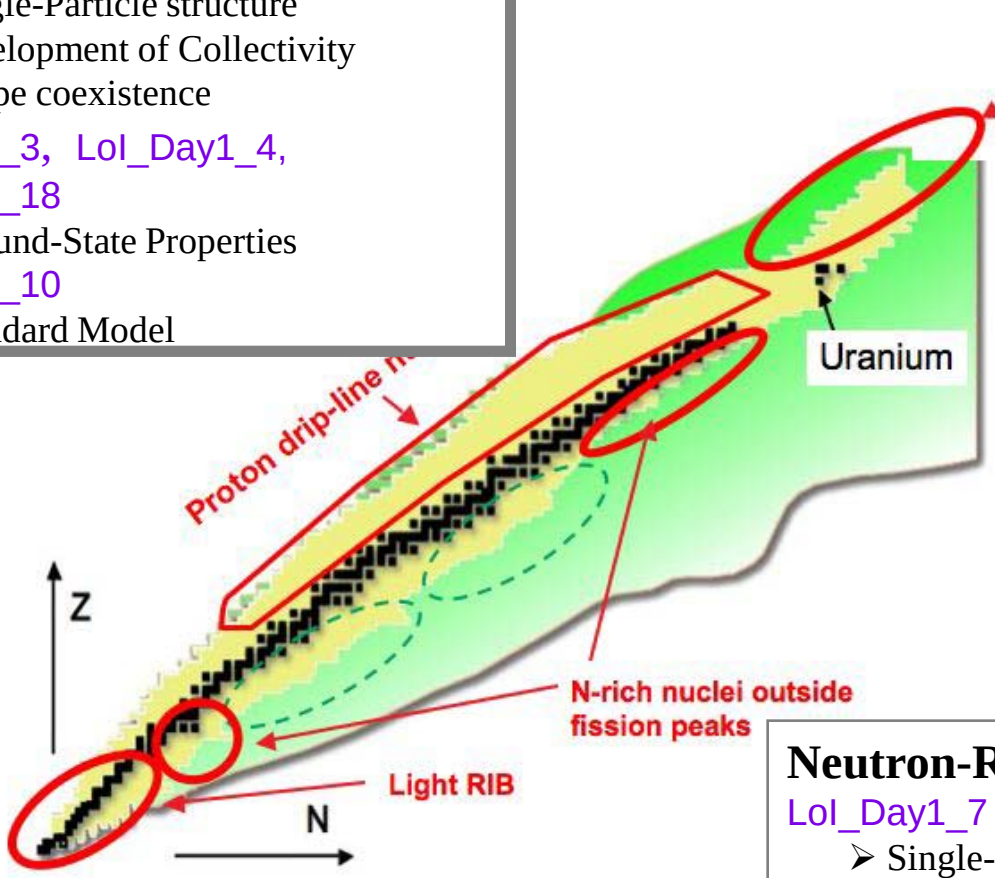
- Ground-State Properties

LoI_Day1_10

- Standard Model

FISIC project

LoI_Day1_1



Heavy and Superheavy Elements

LoI_Day1_2

- Synthesis
- Spectroscopy and Structure

LoI_Day1_5

- Ground-State Properties

Neutron-Rich Nuclei

LoI_Day1_7

- Single-Particle structure
- Quenching of Shell Gaps

- 15 LoIs submitted
- LoIs signed by 170 physicists
- Requested beam time : 380 days !!!

Neutrons For Science (NFS)

Collaboration

50 physicists, 18 institutions, 8 countries

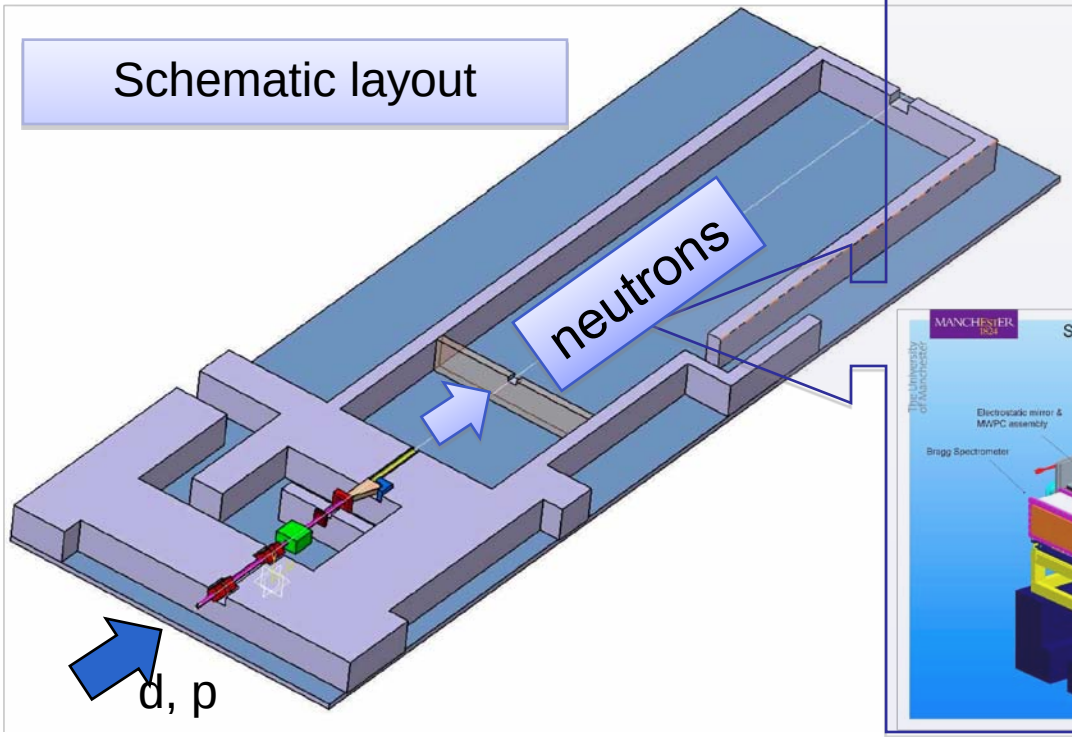
Spokespersons:

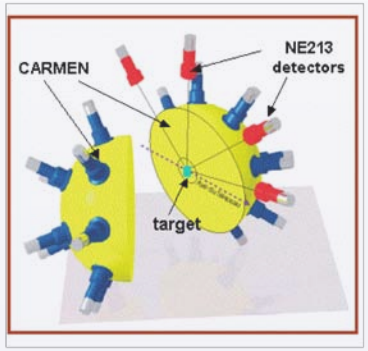
Xavier Ledoux, CEA/DIF/DPTA/SPN, France

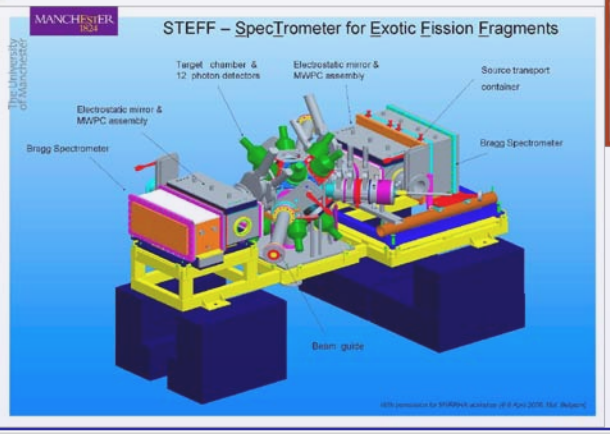
Stanislav Simakov, FZK, Germany

GANIL contact person: Fanny Rejmund

Schematic layout







Full cost including 10% overheads: 0,4 M€

DESIR Facility

Collaboration

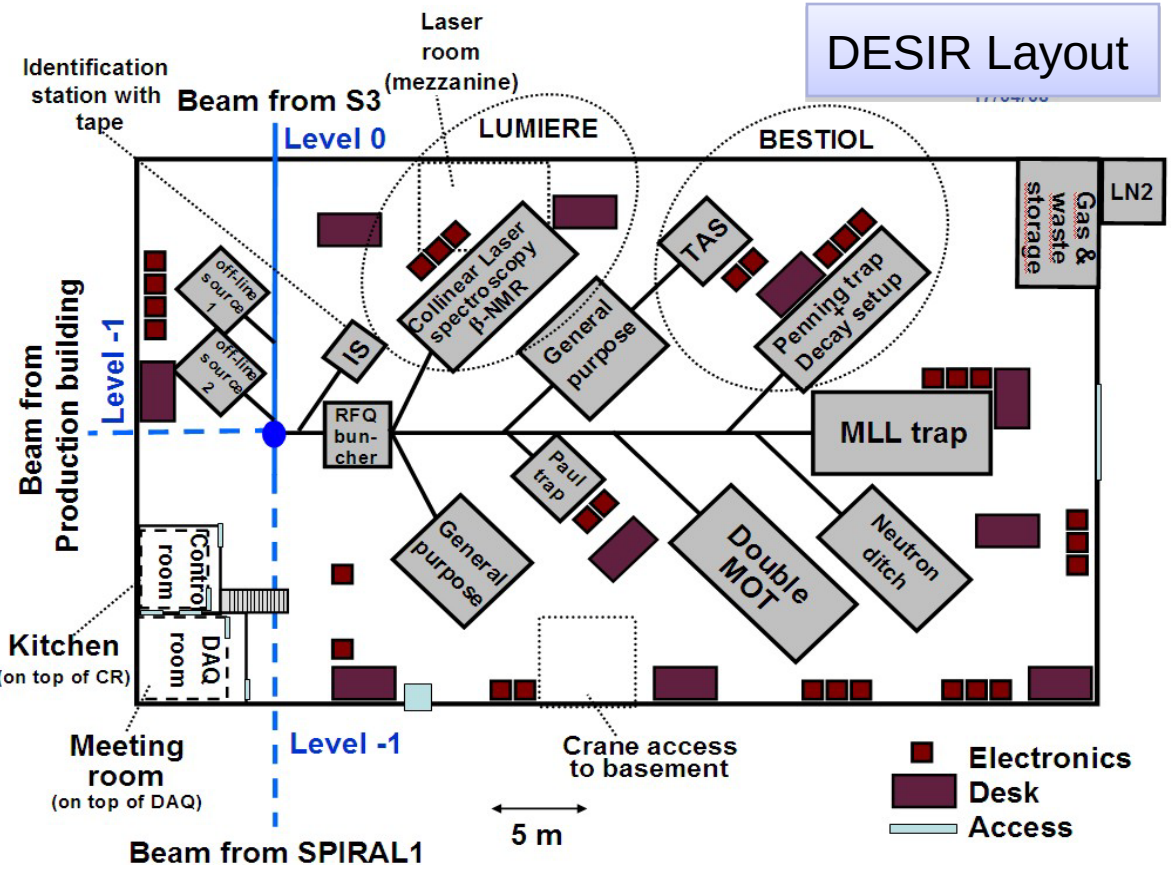
106 physicists, 34 institutions, 16 countries

Spokesperson:

Bertram Blank, CENBG, France

GANIL liaison: Jean-Charles Thomas

DESIR Layout



Topics:

- **nuclear fine structure**
- **charge radii & moments**
- **masses, ion-purification**
- **weak interaction studies**

Tools:

- **keV RI Beams**
- **decay spectroscopy**
- **laser spectroscopy**
- **ion / atom trapping**

DESIR time-line

- **design: 2007 - 2010**
- **construction: 2012-13**
- **commissioning: 2014-15**

ACTAR

Collaboration

40 physicists, 16 institutions, 6 countries

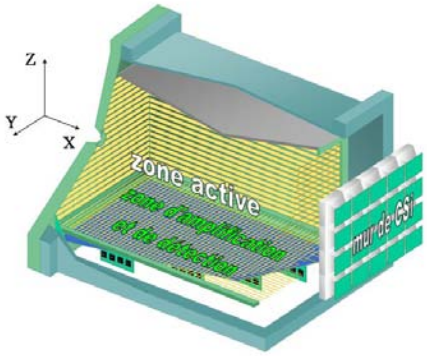
Spokespersons:

M. Chartier, Univ. of Liverpool, UK

D. Cortina, USC, Spain

P. Roussel-Chomaz, GANIL, France -> Geoff Grinyer

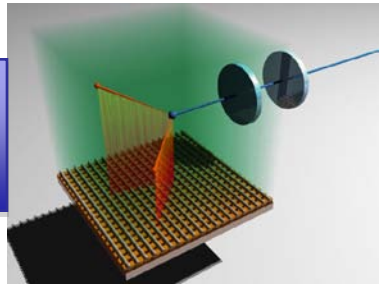
Today's SPIRAL 1 setups



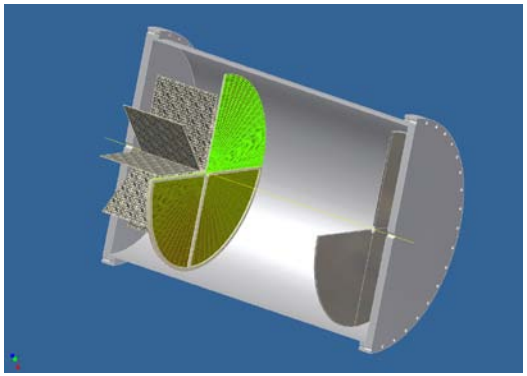
MAYA

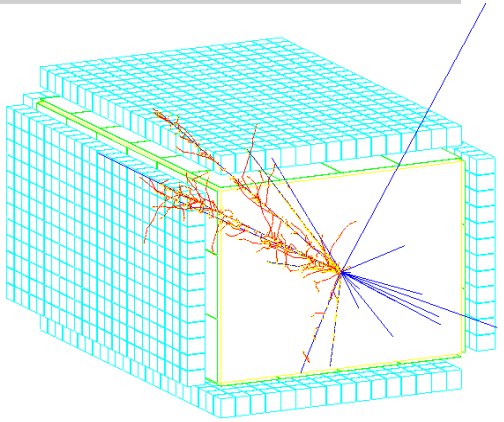
TPC

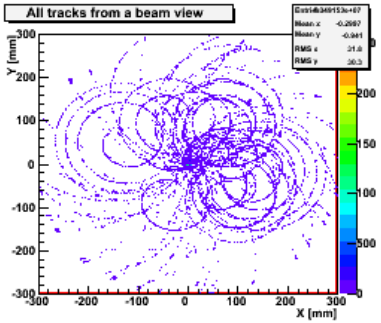
(2p radioactivity)

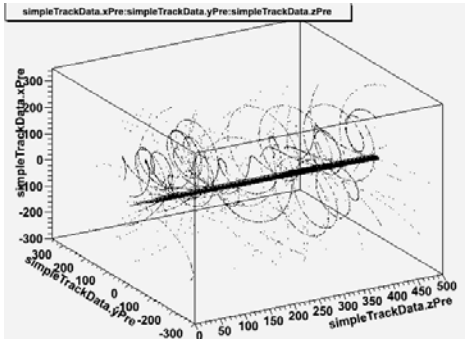


ACTAR (+GET electronics): Future setups









Scientific Community of SPIRAL 2

Organisation

Steering Committee → **SPIRAL 2 Scientific Advisory Committee**

Project management
- Project Leader
- Scientific Coordinator

GROUPE PHYSICIENS		
Resp.scientifique	**M.Lewitowicz**	**GANIL**
Adjoint au resp. scientifique	F.De Oliveira	GANIL
Adjoint au resp. scientifique	N. Alahari	GANIL
Correspondants Scientifiques		
Correspondant IRFU	N.Alamanos	IRFU
Correspondant CENBG	B.Blank	CENBG
Correspondant LPSC	G.Simpson	LPSC
Correspondant IPNL	N.Redon	IPNL
Correspondant IPNO	F.Ibrahim	IPNO
Correspondant IPHC	M.Rousseau	IPHC
Correspondant LPC	N.Orr	LPCCaen
Correspondants des collaborations Détecteurs SPIRAL2		
Correspondant GANIL AGATA	G. de France	GANIL
Co-porte-parole collaboration ACTAR	P.Roussel-Chomaz	GANIL
Porte-parole collaboration DESIR	B. Blank	CENBG
Co-porte- parole EXOGAM 2	G.de France	GANIL
Co-porte- parole FAZIA	R.Bougault	LPCCaen
Co-porte- parole GASPARD	D.Beaumel	IPNO
Co-porte- parole NFS	X.Ledoux	DAM/CEA
Co-porte- parole PARIS	A.Maj	IPN Cracovie
Co-porte- parole S3	H.Savajols	GANIL
Co-porte- parole SRI	JP.Grandin	CIMAP
Coordinateur SPIRAL2PP	**M.Lewitowicz**	**GANIL**
European Project Manager	K.Turzo	GANIL
Assistante administrative	S.Dubromel	GANIL

FP7 SPIRAL 2 Preparatory Phase

3,9 M€

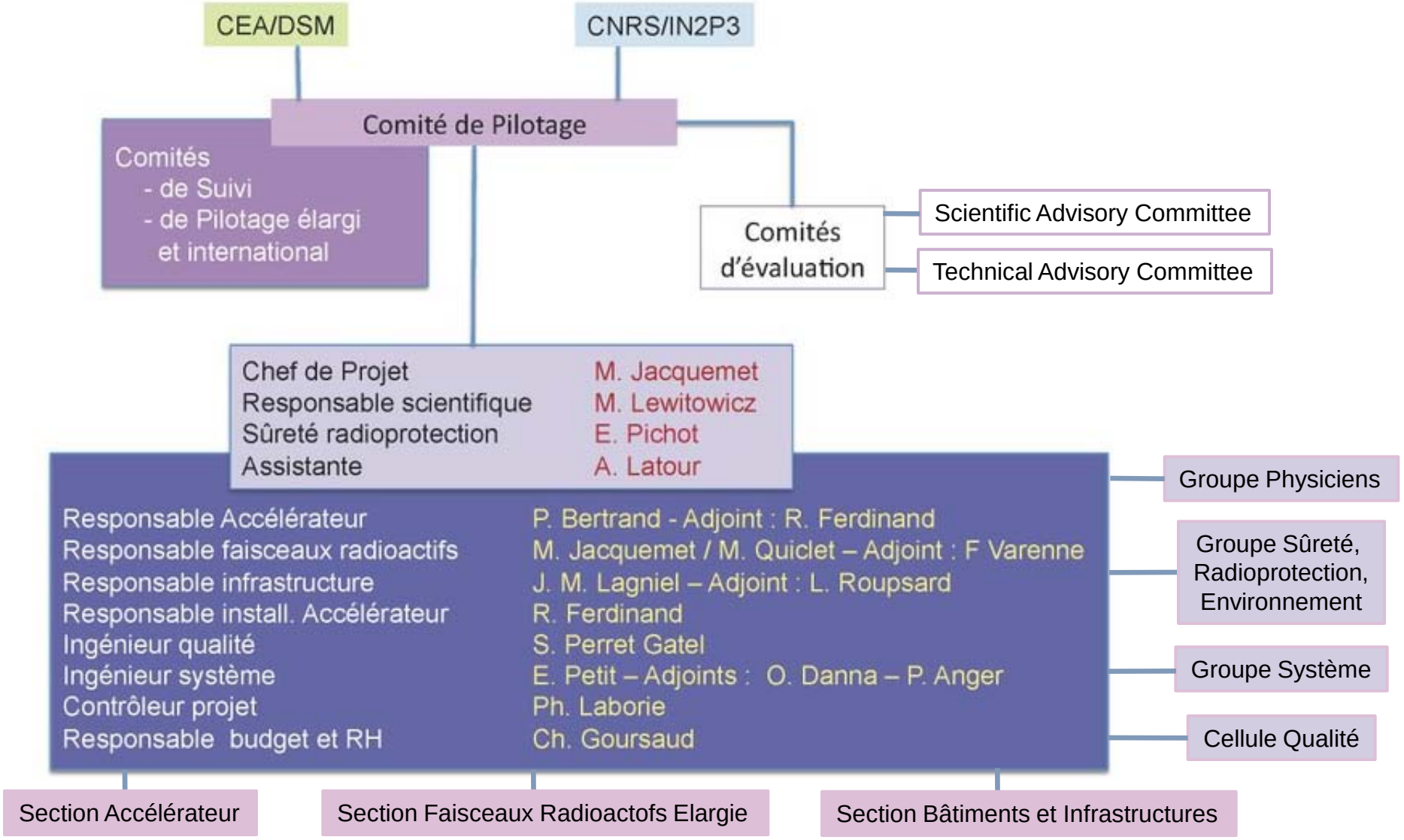
Instrumentation Coordination Committee

WGs
-Electr. & DAQ

International Collaborations:
- ✓ **Active targets**
- ✓ **DESIR**
- ✓ **FAZIA**
- ✓ **GASPARD**
- ✓ **HR Gamma-ray spectroscopy (AGATA, EXOGAM 2)**
- ✓ **NFS**
- ✓ **PARIS**
- ✓ **S3**
- ✓ **HELIOS**
- ✓ **ACTAR**
- ✓ **NEDA**

Existing International Collaborations
- *NUSTAR*
- EURONS/ENSAR
- EURISOL
- LIA RIKEN, LIA India, LEA Poland, LEA Italy

SPIRAL2 Project organisation



A large National & International Collaboration

French Partners

CEN de Bordeaux-Gradignan

Centre de Spectro. Nucléaire et Spectro. de Masse Orsay

Institut de Physique Nucléaire Orsay

Institut de Physique Nucléaire Lyon

Institut Pluridisciplinaire Hubert Curien Strasbourg

Laboratoire Accélérateur Linéaire Orsay

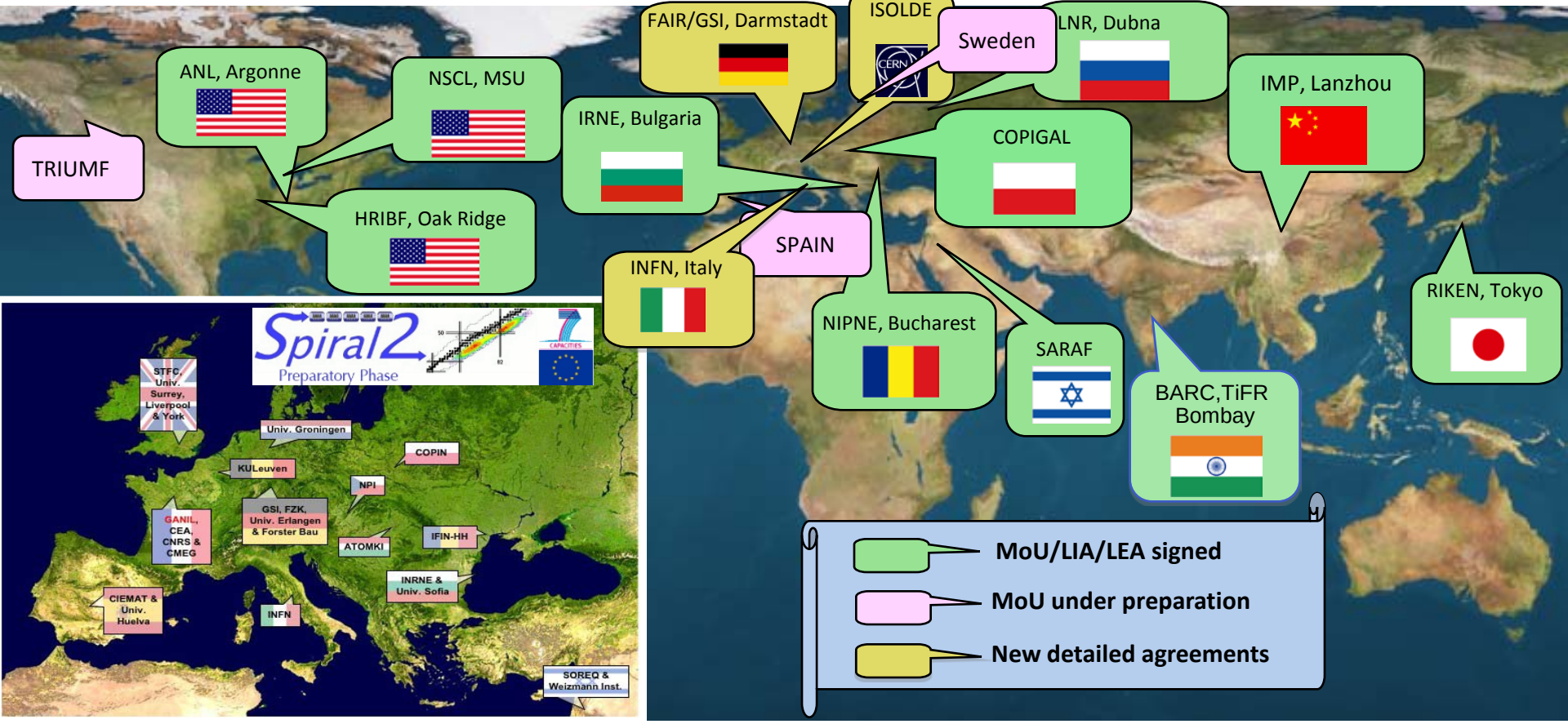
Laboratoire de Physique Corpusculaire de Caen

Laboratoire de Physique Nucléaire et de Htes Energies Paris

Laboratoire de Physique Subatomatomique et de Cosmologie Grenoble

DSM		Irfu/SPhN
		Irfu/SACM
DSM		Irfu/SIS
DSM		Irfu/SENAC
DSM		Irfu/SEDI
DSM – Saclay		Expertise
DAM	DPTA	DASE et DP2I
DEN		Expertise
DPSN		Expertise

Collaborations



15 signed (LEA*, LIA**, MoU***) agreements
3 agreements under preparation:
- MoU with GSI (FAIR)
- MoU with Bilbao (RIB production module)
- MoU with Sweden (MEDLEY detector for NFS)

21-22/09/10 LIA Workshop with India
22/09/10 Meeting with Sweden
8-9/11/10 Workshop with Dubna
15-19/11/10 LEA Workshop with SPES

SPIRAL 2 timeline

2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

Construction Phase 1 LINAC, NFS, S3

Commis-sioning Phase 1

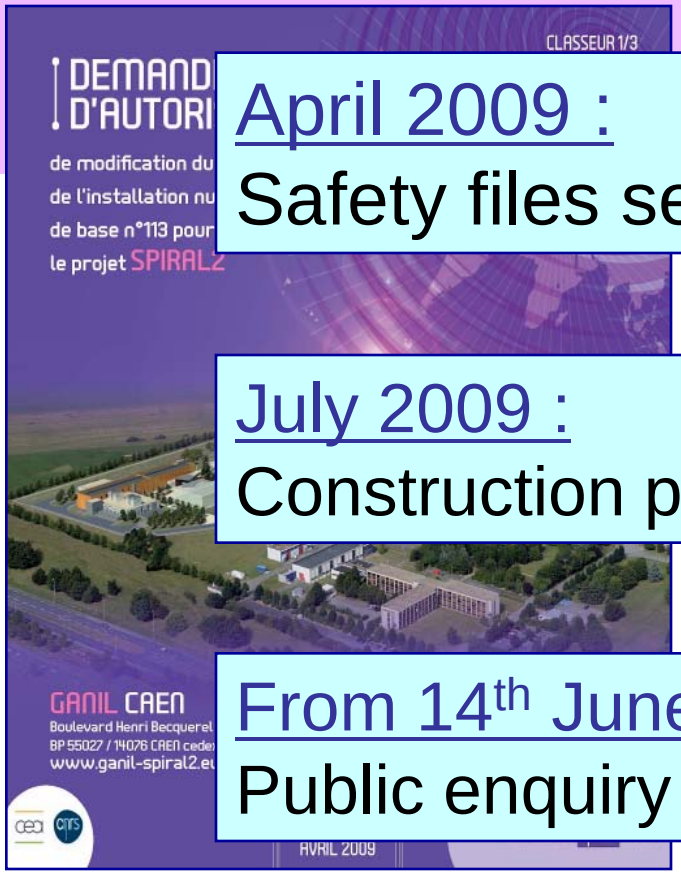
Stable ion beams from LINAC

Construction Phase 2 RIB, DESIR

Commis-sioning Phase 2

RIB

Safety Aspects Construction



April 2009 :

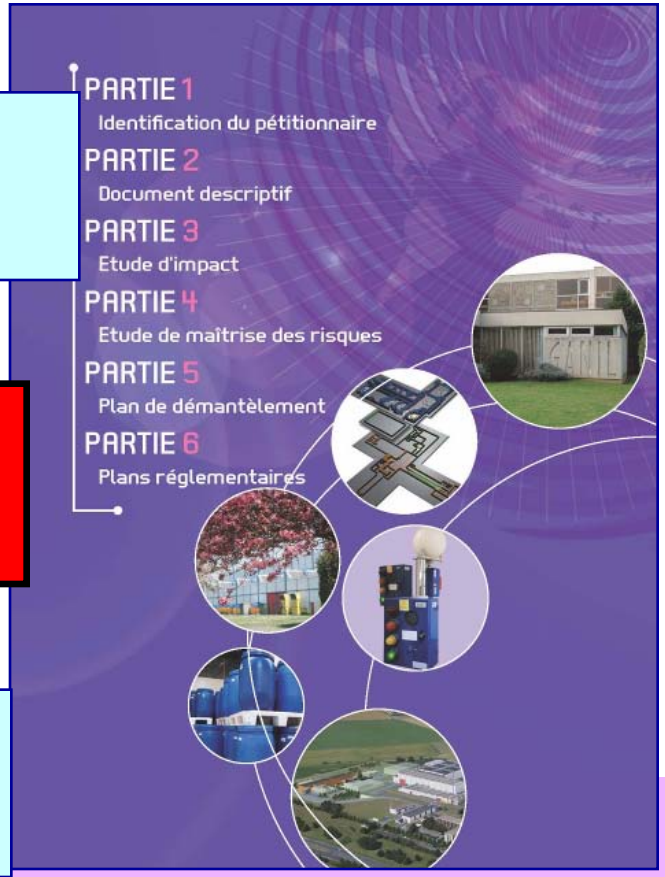
Safety files send

July 2009 :

Construction permit Phase 1 requested

From 14th June to 15th July 2010

Public enquiry



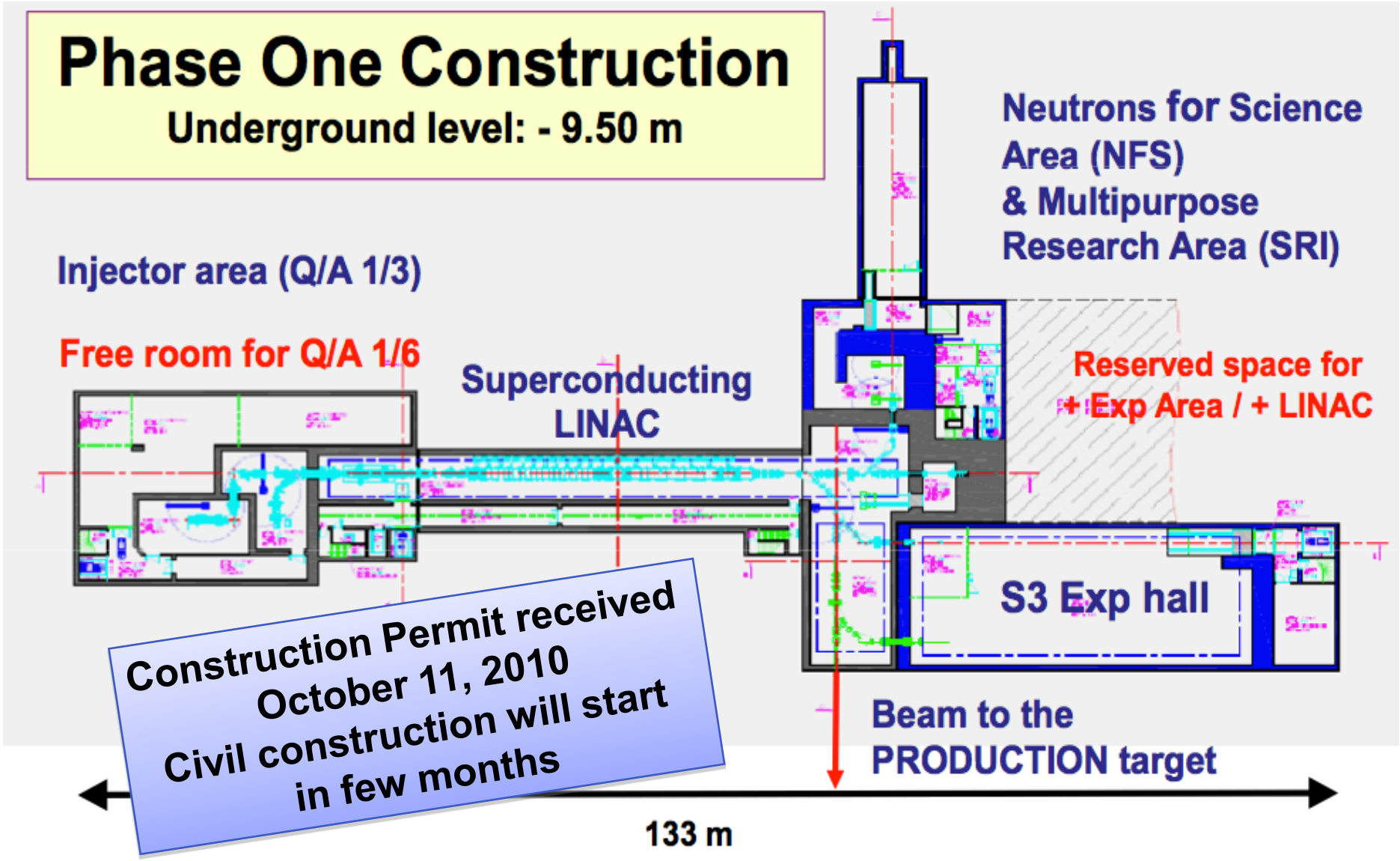
11th October 2010

Permit of construction delivered

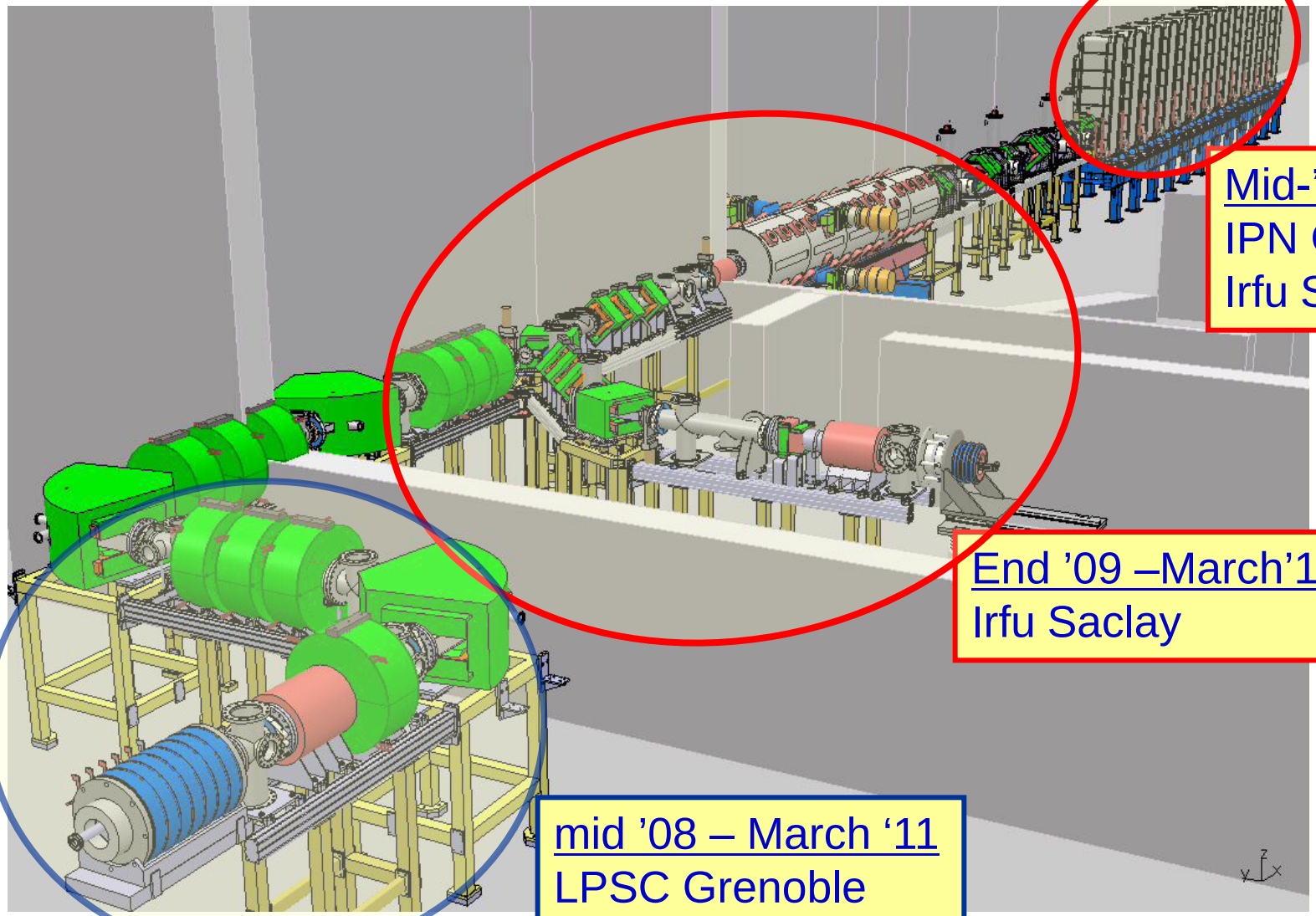
Beginning of 2011

Site preparation – Ground breaking

Layout of SPIRAL2 Phase 1



Accelerator



Mid-’08 – End-’10
IPN Orsay
Irfu Saclay

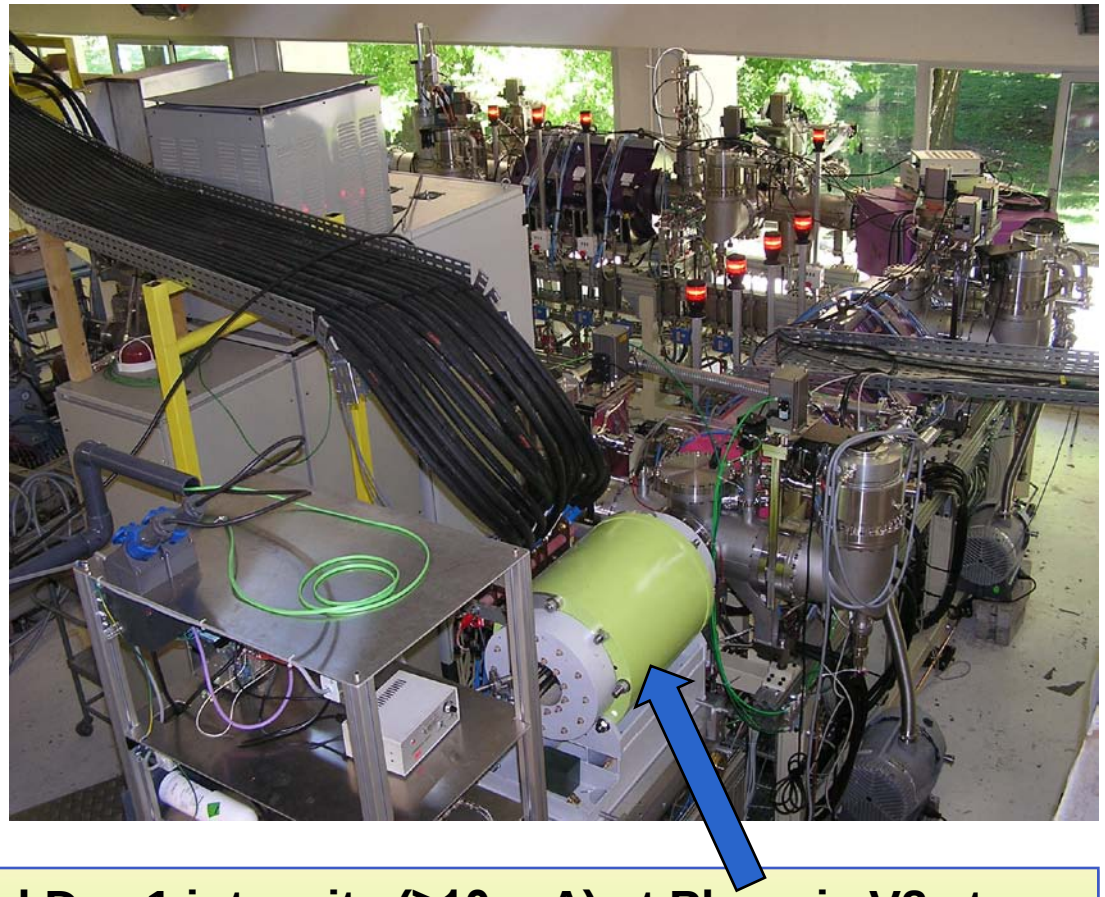
End ’09 –March’11
Irfu Saclay

mid ’08 – March ‘11
LPSC Grenoble

Heavy-ion injector of LINAC

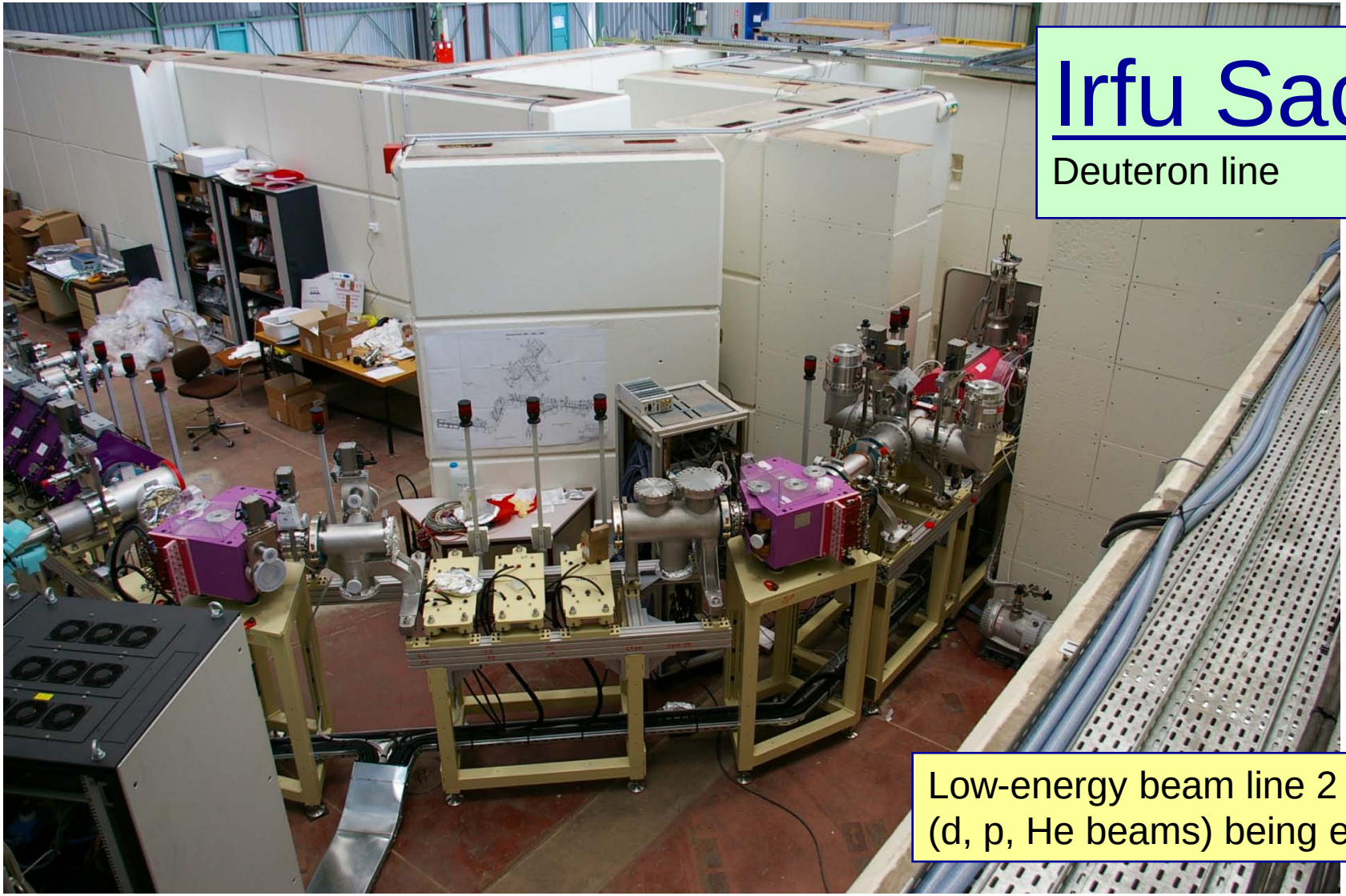
LPSC, IRFU
GANIL, IPNL

Tests in Grenoble



- **$^{18}O^{6+}$ and $^{36}Ar^{12+}$ beams reached Day 1 intensity (≥10pμA) at Phoenix V2 at LPSC Grenoble**
- **Tests of metallic beams (Ca, S, Si, Ni) will start in few weeks**
- **Tests of the new generation SC ECR A-Phoenix source in the coming months**

Accelerator

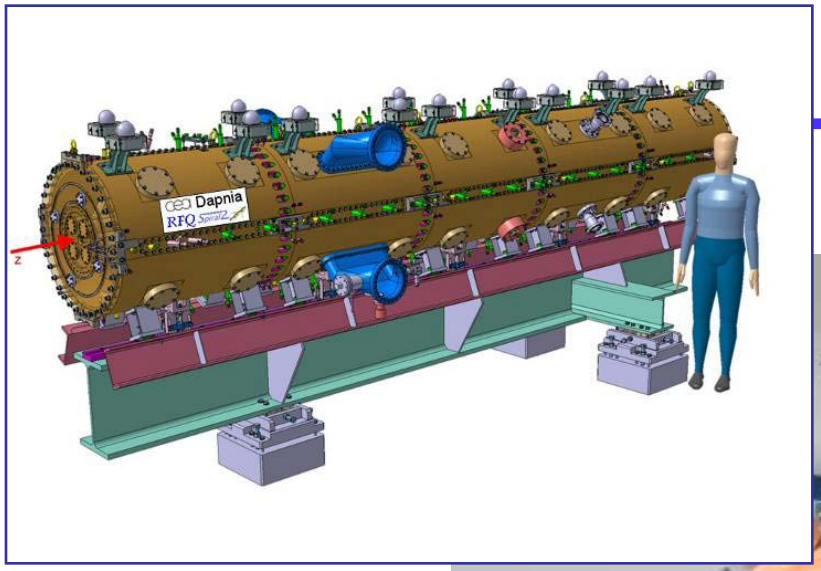


Irfu Saclay

Deuteron line

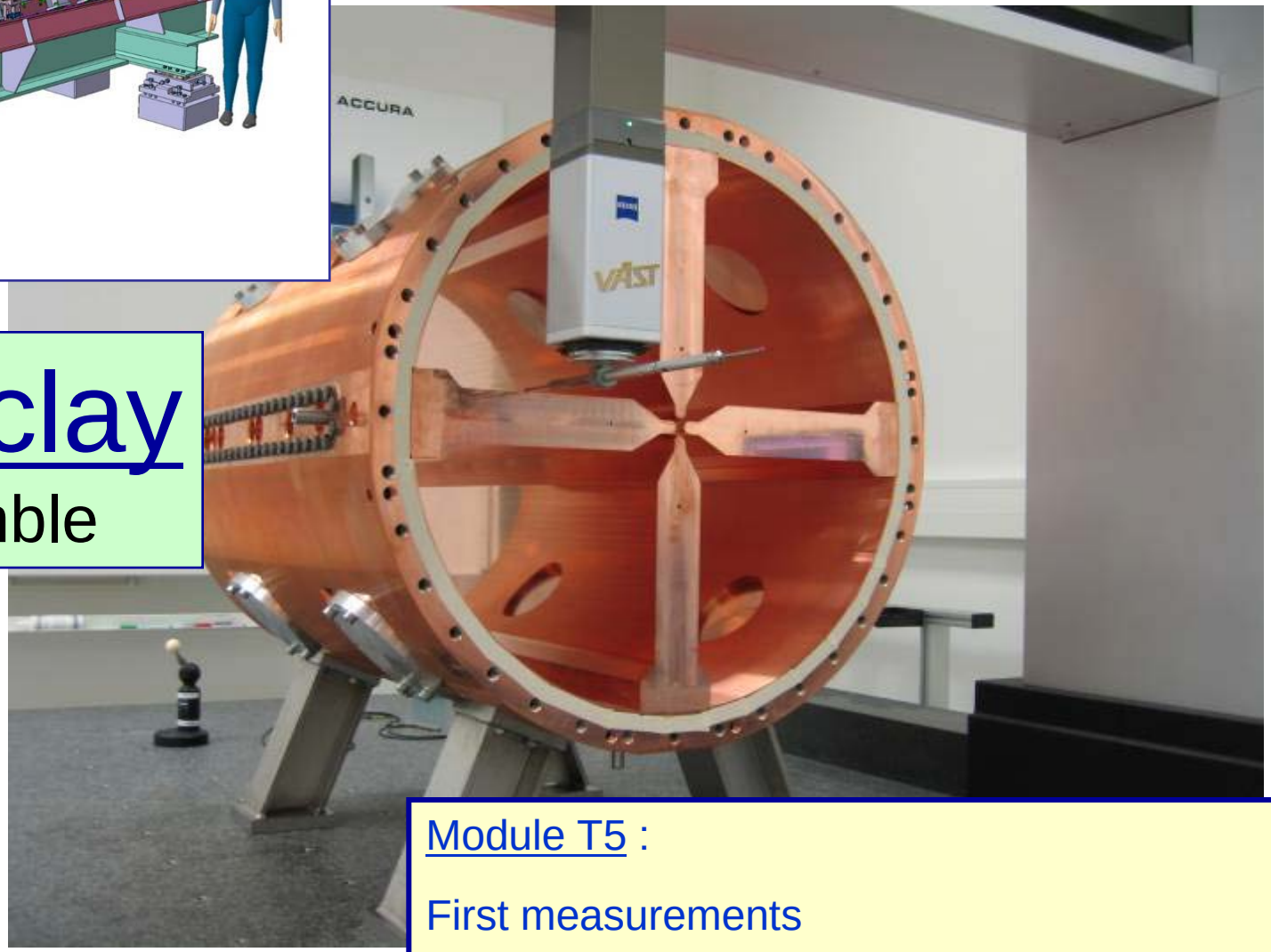
Low-energy beam line 2
(d, p, He beams) being equipped

Accelerator



Irfu Saclay

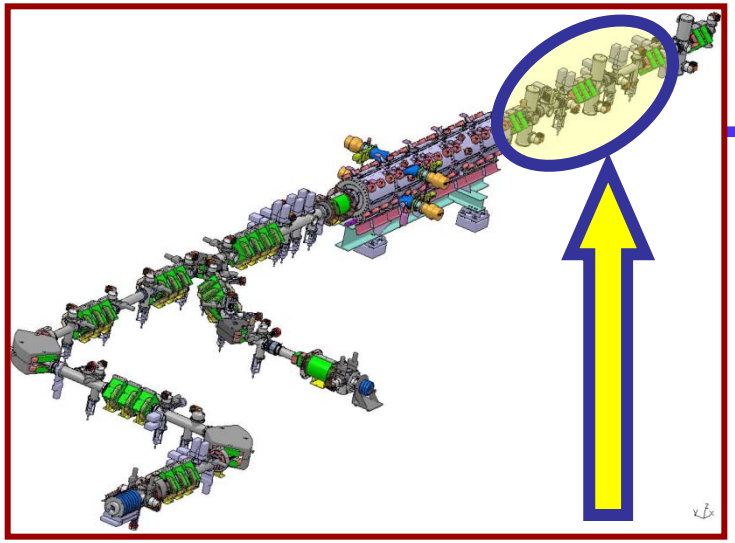
RFQ Ensemble



Module T5 :

First measurements

Accelerator



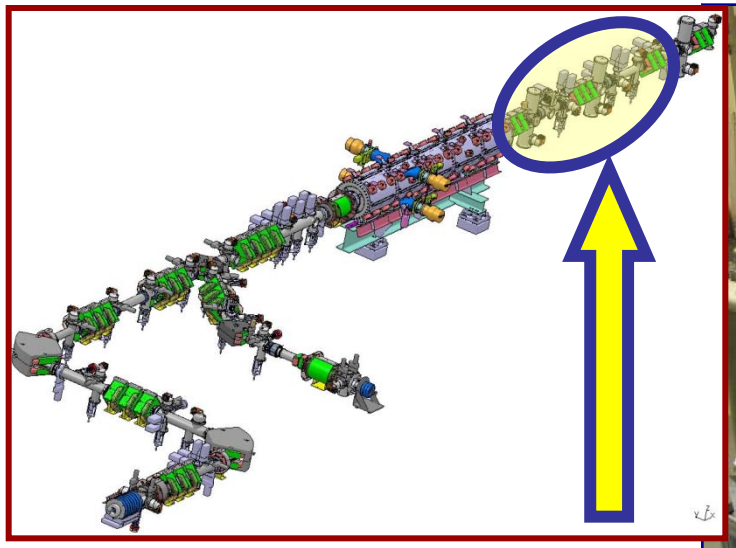
Ganil

Linac

Magnetic measurements

Series realization by Tesla (UK)

Accelerator



IPN Orsay

SC Cavities Type B

Status:

All cavities delivered and tested:

1st Cryomodule delivered in December

Accelerator

IPN Orsay

Cavities type B

QWR beta 0.12

tical test results - T=4.2

Qo

1.E+09

1.E+08

SPIRAL2 operating range - 10 W

6.5 MV/m

All cavities successfully tested

Eacc (MV/m)

0 1 2 3 4 5 6 7 8 9 10 11 12 13

- MB01 Gilia
- MB02 Erentrude
- MB03 Verena (baking)
- MB04 Colette
- MB05 Sylvana
- MB06 Richardine (baking)
- MB07 Pezenne
- MB09 Thelma
- MB10 Praxede (baking)
- MB11 Daniela (baking)
- MB12 Ghislie (baking)
- MB13 Sybille (baking)
- MB14 Bienvenue (baking)

SPIRAL 2 timeline

2007 2008 2009 2010 2011 2012 2013 2014 2015 2016

Construction Phase 1 LINAC, NFS, S3

Commis-sioning Phase 1

Stable ion beams from LINAC

Construction Phase 2 RIB, DESIR

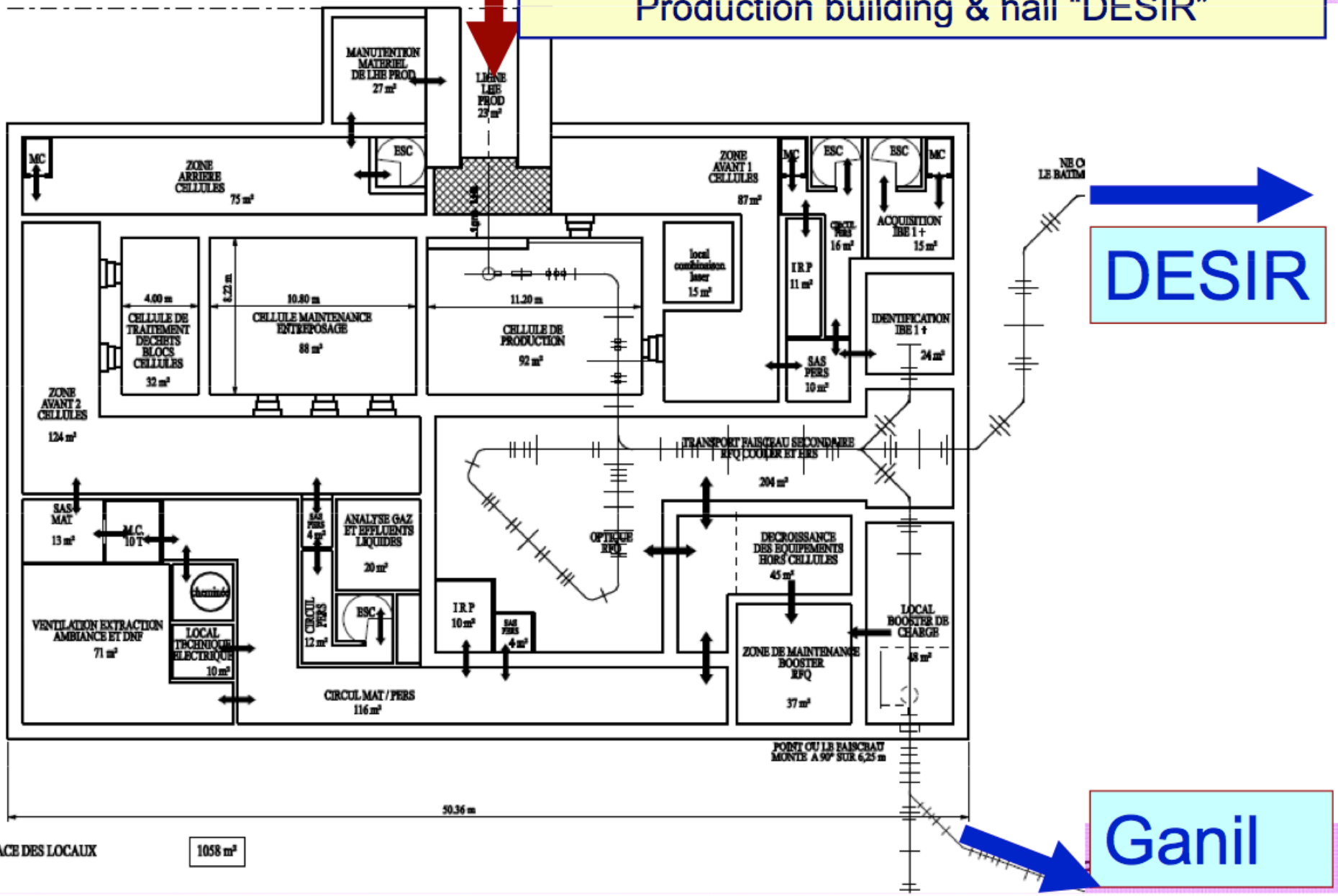
Commis-sioning Phase 2

RIB

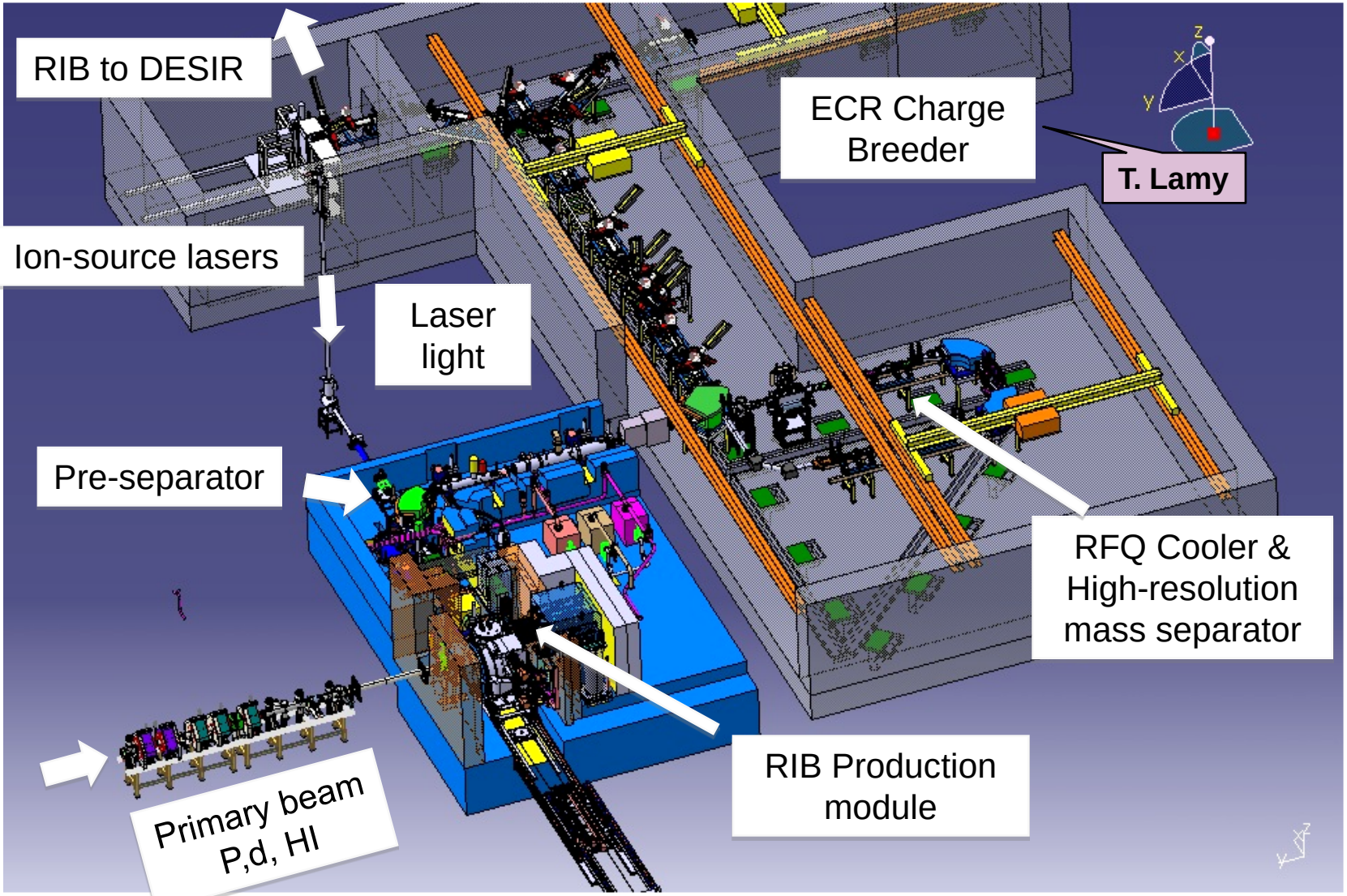
Beam from LINAC

Infrastructures Phase 2

Production building & hall "DESIR"

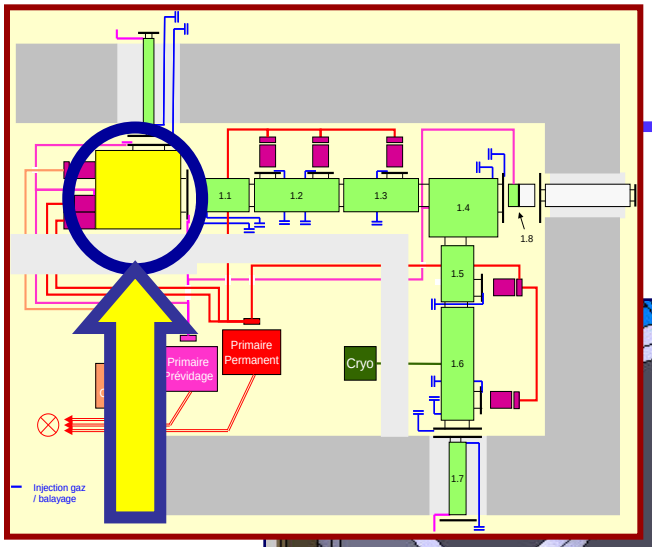


Detailed design of the RIB building



Radioactive Beams

Production Module



Extraction

ECR

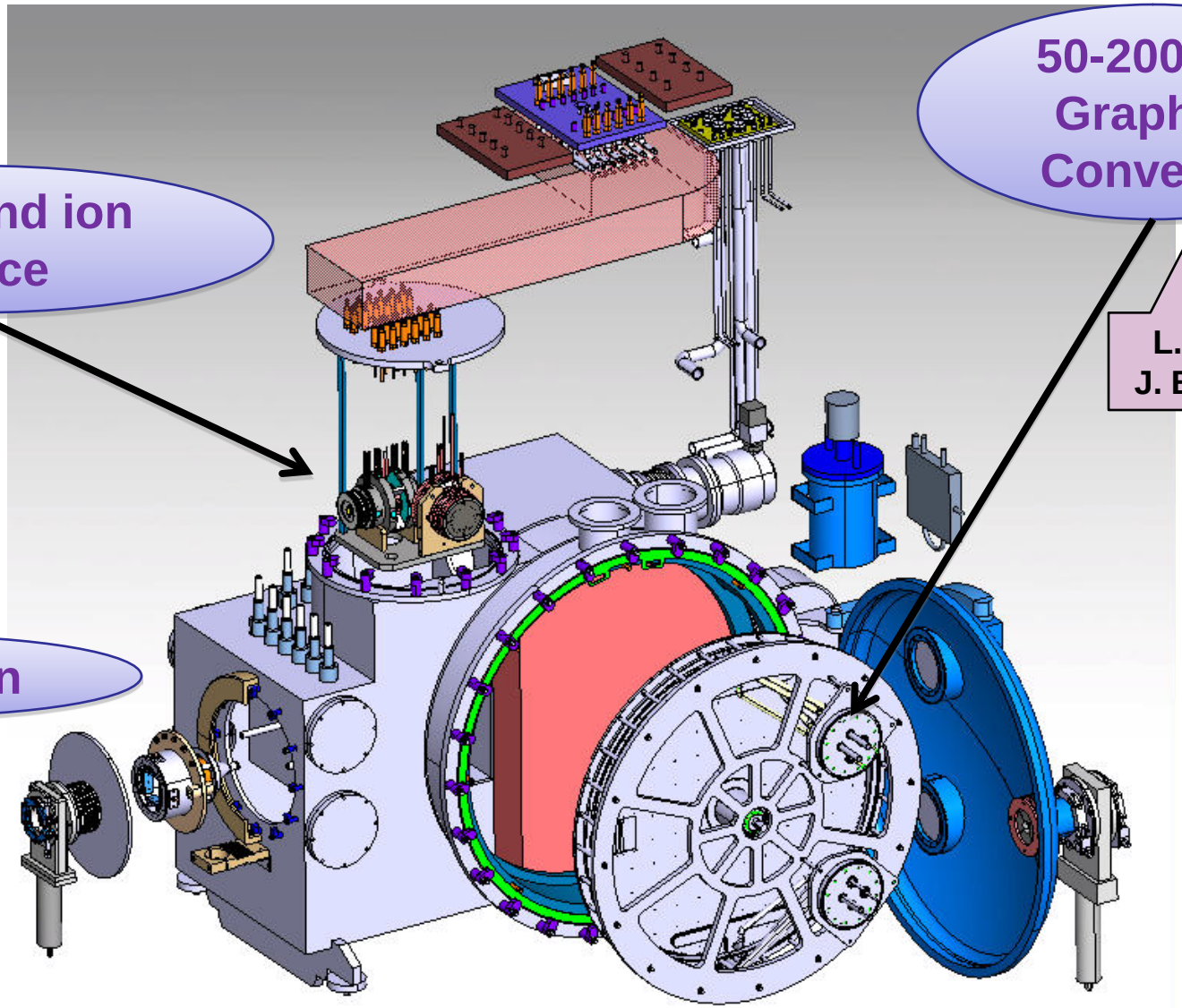
Converter

Einzel Lens

HT Insulator

Target + oven

RIB production module



Conclusions

- Civil construction of Phase 1 (LINAC, NFS and S3 experimental halls) will begin in the coming few months; Commissioning of LINAC: end of 2012; first experiments by 2013

- New detectors for SPIRAL2: R&D work and signatures of MoU entering in a final phase

- International collaboration network around SPIRAL2 (SPIRAL2PP and bilateral collaborations with more than 20 countries)

✓ 22 Letters of Intent for Day 1 experiments with high-intensity stable-ion beams with NFS and S3 facilities submitted and evaluated

- **Very important involvement of Italian physicists in above actions (via LEA COLLIGA, FP7 SPIRAL2PP and other bilateral collaborations)**

SPIRAL2 Physics: forthcoming actions

- Call for Letters of Intent for Day One experiments at SPIRAL2 with RIB launched now (dead-line December 17, 2010)

- FUSTIPEN (Theory US-France collaboration) starts officially on January 18, 2011

- *SPIRAL2 Week 2011* 24-27/01/2011 (400 participants in 2010)

Multi-beam capabilities
GANIL/SPIRAL1/SPIRAL2 facility

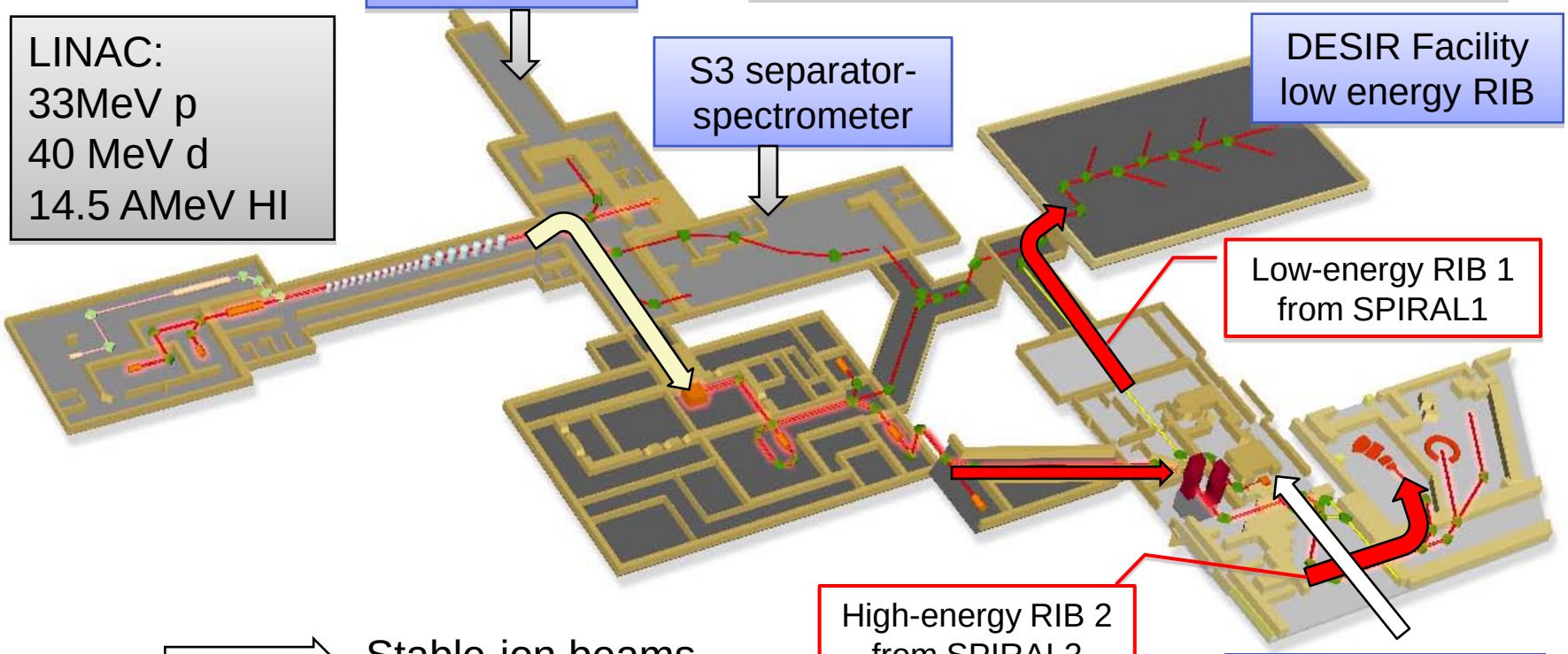
SP2 Beam time: 44 weeks/y
GANIL Beam time: 35 weeks/y
ISOL RIB Beams: up to 53 weeks/y

Neutrons For Science

LINAC:
33MeV p
40 MeV d
14.5 AMeV HI

S3 separator-spectrometer

DESIR Facility low energy RIB



Low-energy RIB 1 from SPIRAL1

High-energy RIB 2 from SPIRAL2

GANIL/SPIRAL 1 today

Stable-ion beams

Radioactive-ion beams

2 RIB + 3 Stable-ion beams (ARIBE, IRRSUD, SME) **-> 5 experiments in parallel**