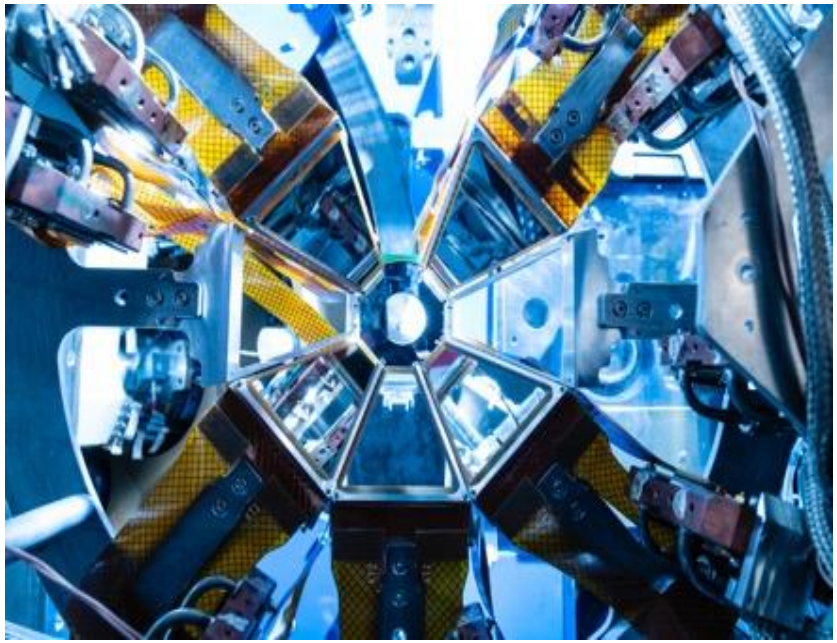
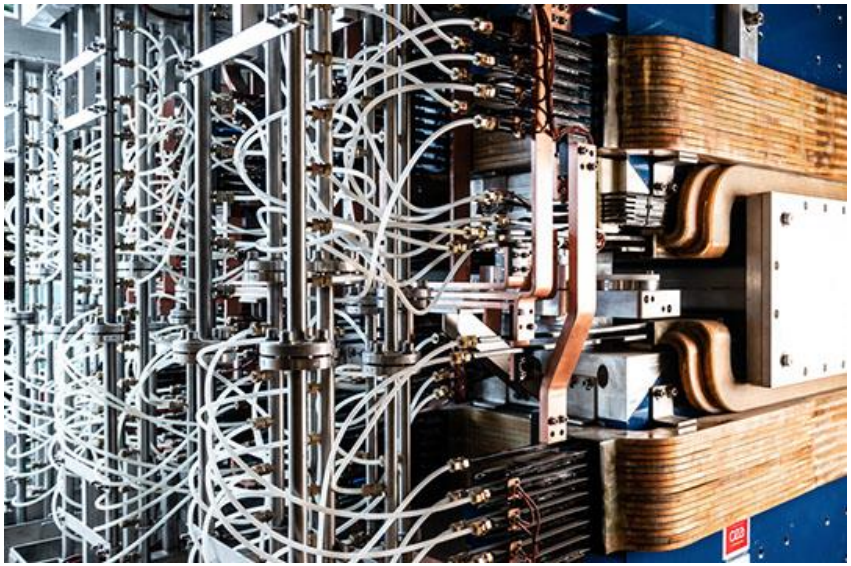


GANIL SPIRAL2

Highlights and future milestones

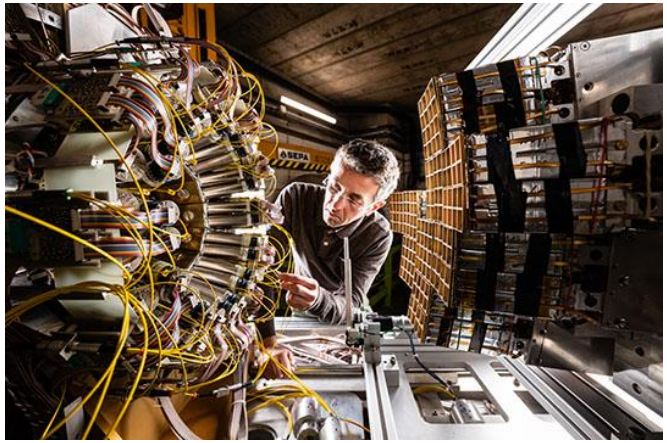


- 2018-2019 experimental campaigns
- Status of SPIRAL2
- Some evolutions
- GANIL short, medium and long range plan

Highlights

(non exhaustive)

Vibrant opportunities



- Start of the commissioning of SPIRAL2 – LINAC after getting the full authorization from the safety authority.
- Experimental campaigns with AGATA coupled to NEDA DIAMANT and to MUGAST+VAMOS
- New beams from the SPIRAL1 upgrade
- New detectors: NEDA, ACTAR TPC, FAZIA, MUGAST


thank you
danke
рахмат
謝謝
ngiyabonga
teşekkür ederim
Баярлалаа
спасибо
faafetai lava
mersi
kia ora
barka
welalin
tack
spas
dank je
misaotra
matondo
paldies
grazzi
mahalo
tapadh leat
vinaka
спасибі
blagodaram
gracias
хвала
asante
manana
kiitos
dankie
nanni
nandri
dhanyavad
mauruuru
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obrigada
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murakoze
bedankt
bayarlalaa
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shukriya
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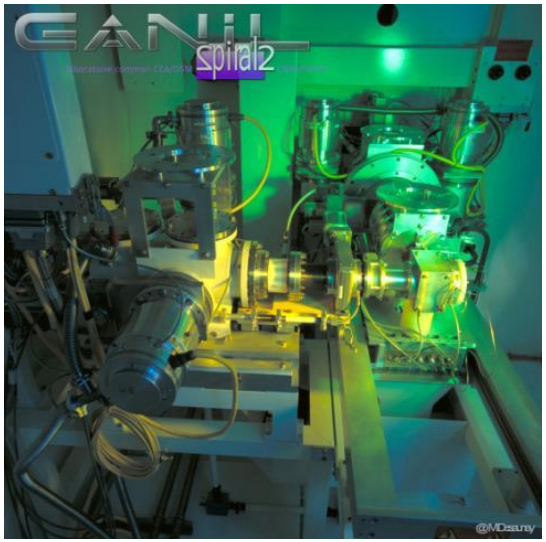
мерси
kam sah hamnida
rahmat
তোমাকে ধন্যবাদ
감사합니다
xièxie
merci

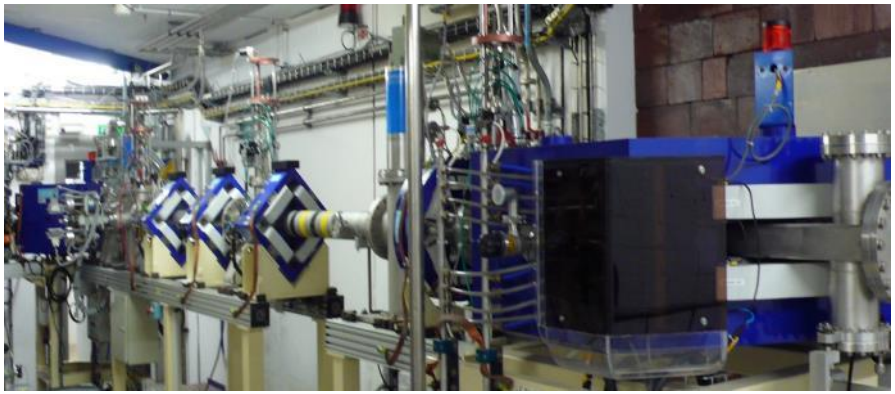
SPIRAL1 upgrade

SPIRAL1 before the upgrade

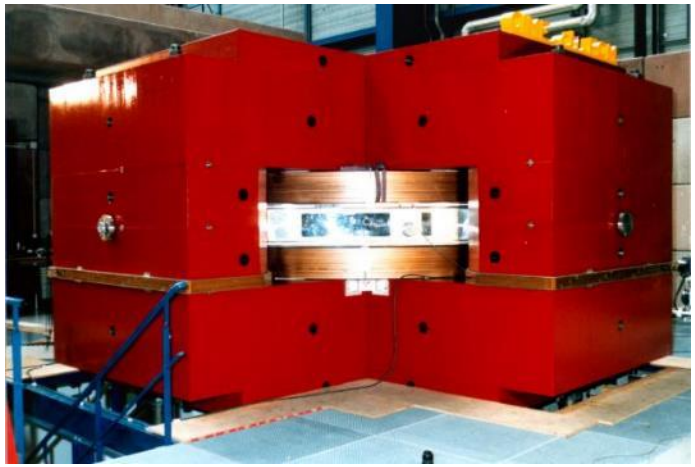
Target ion source system
NANOGANIII



Low energy transport, 34q.keV max



CIME up to 20 MeV/u



Targets

Reaccelerated beams

- 35 isotopes
- 7 chemical elements (He, Ne, Ar, Kr, N, O, F)
- $T_{1/2}$ min: 128ms (^{8}He)

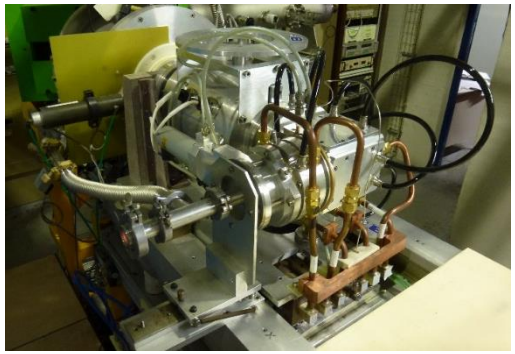
SPIRAL1 upgrade

Objectives of the upgrade: to enlarge the capabilities of radioactive ion beam production towards condensable elements

How ?

- ❑ Make use of the charge breeding technique with
  - → Phoenix booster as the ECR charge breeder
  - → FEBIAD ion source
- ❑ Extend the number of combinations of primary beams and target, to include target fragmentation and fusion evaporation reactions (new safety authorization)

- First successful test of the new system in 2017 with stable beams
- Tests and experiments with radioactive beams in 2018 and 2019

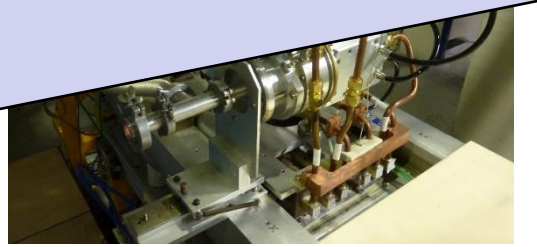


SPIRAL1 upgrade

- A lot of effort put by the team
- Primary goal is reaccelerated beams
- Need dedicated off-beam and in-beam tests
- 3 years needed for a new beam
- Objective :1 new beam every year

First results and perspectives with the SPIRAL1 new beams

Talk from P. Delahaye Tuesday 10th

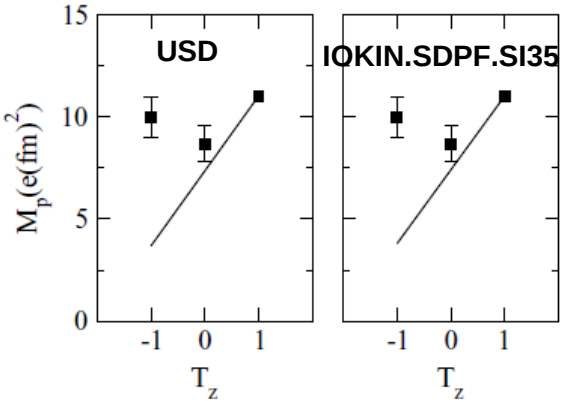


Direct measurement of the isospin mixture by Coulomb excitation of a ^{38}K beam produced by SPIRAL 1

E737 G. De France, A. Gadea et al

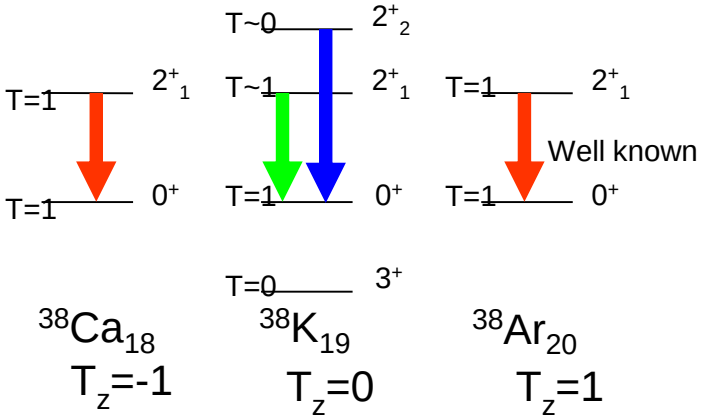
- ^{38m}K isomeric beam from SPIRAL1 (20% of isomer in the beam)
- use of EXOGAM with the full NUMEXO2 electronics

Large discrepancy between shell model calculations and experiment → isospin mixing ?



F.M. Prados Estévez *et al* PRC 75, 014309 (2007)

Calculation of isospin mixing using transitions



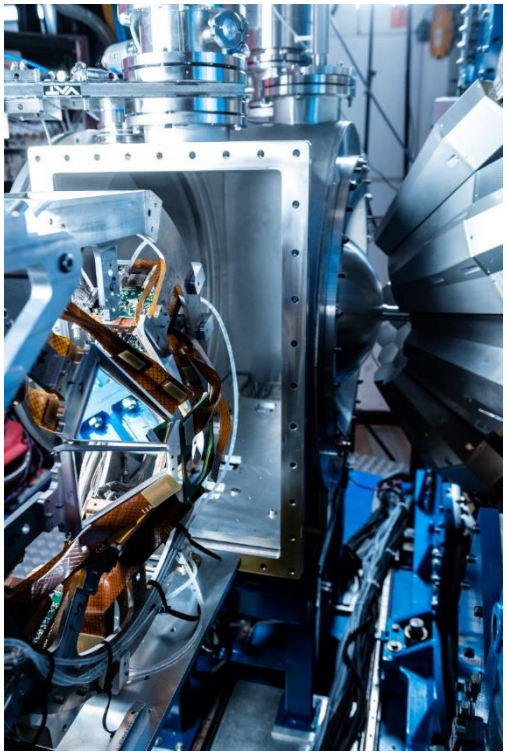
$$\Phi = \frac{M(0,1) - M}{M(0,2)}$$

- ❑ Beam produced with an intensity of 2.10^6 pps (demand of 1.10^6 pps)
- ❑ Data analysis under progress

AGATA campaigns

2018

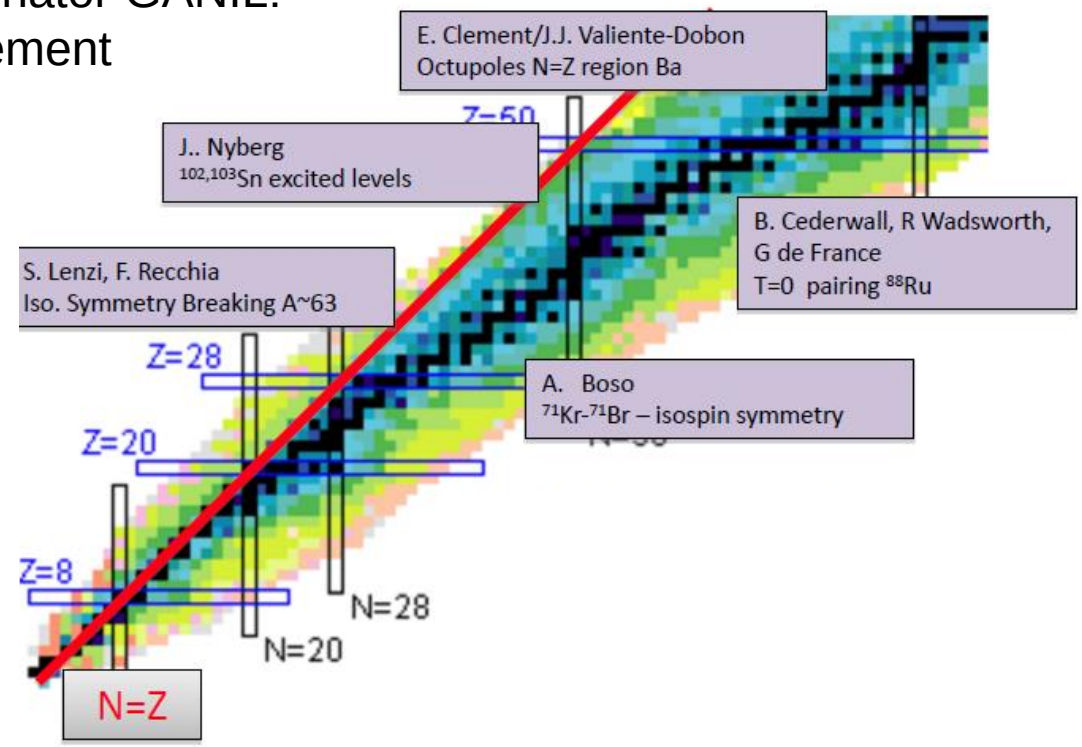
2019-2020



2018 AGATA-NEDA-N wall-DIAMANT campaign

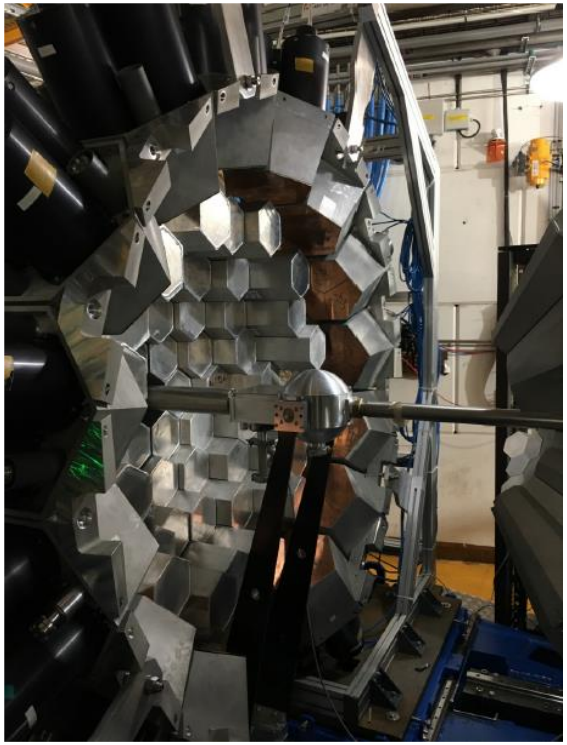
Physics program related to the study of N=Z nuclei

AGATA coordinator GANIL:
E. Clément



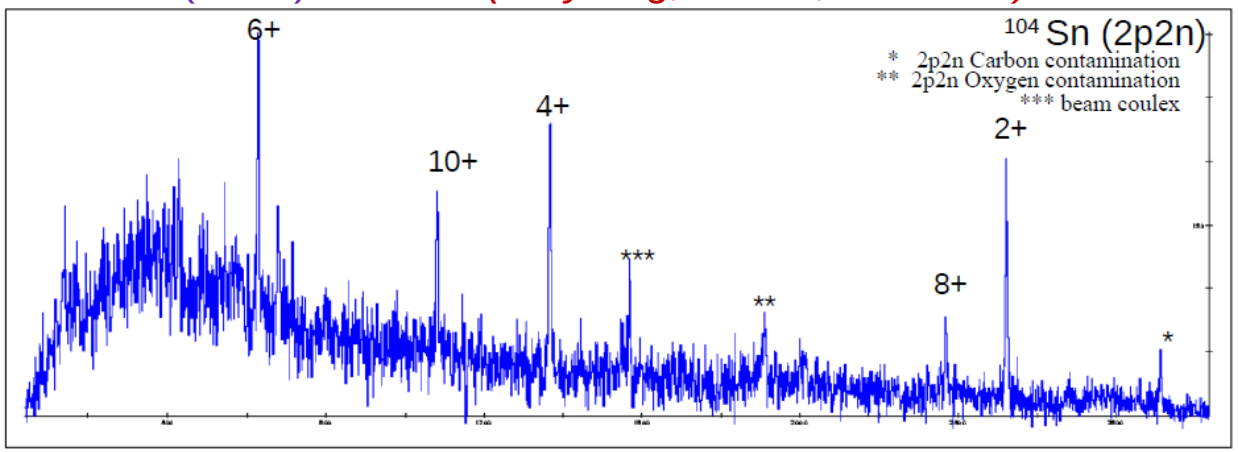
N Wall Campaign manager : G. de France

2018 AGATA-NEDA / N wall-DIAMANT campaign

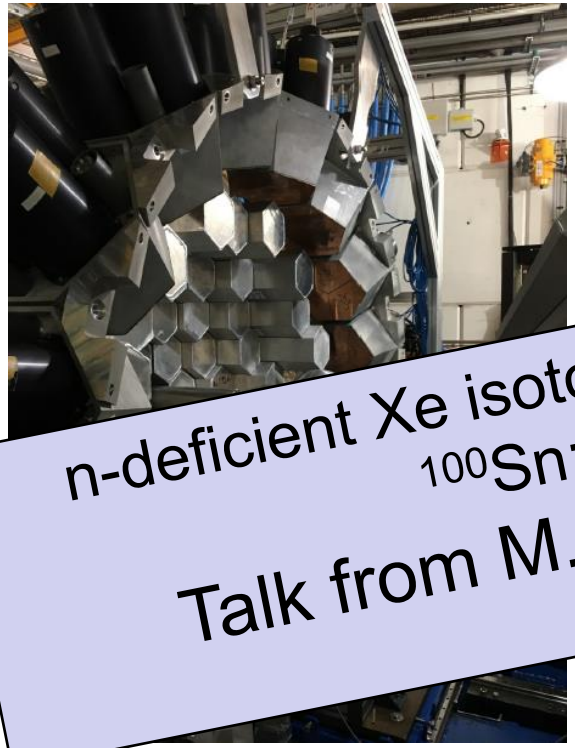


- New neutron detector NEDA
- Coupling of 3 high resolution detectors (AGATA, NEDA/Nwall, DIAMANT): high selectivity by tagging rare events on charge's particles and neutrons
- Use of the GTS system and the new EXOGAM2 trigger.

Neutron and charged particle gating
(E703) ^{102,103}*Sn (J Nyberg, A Atac, M Palacz)*



2018 AGATA-NEDA / N wall-DIAMANT campaign



A première !

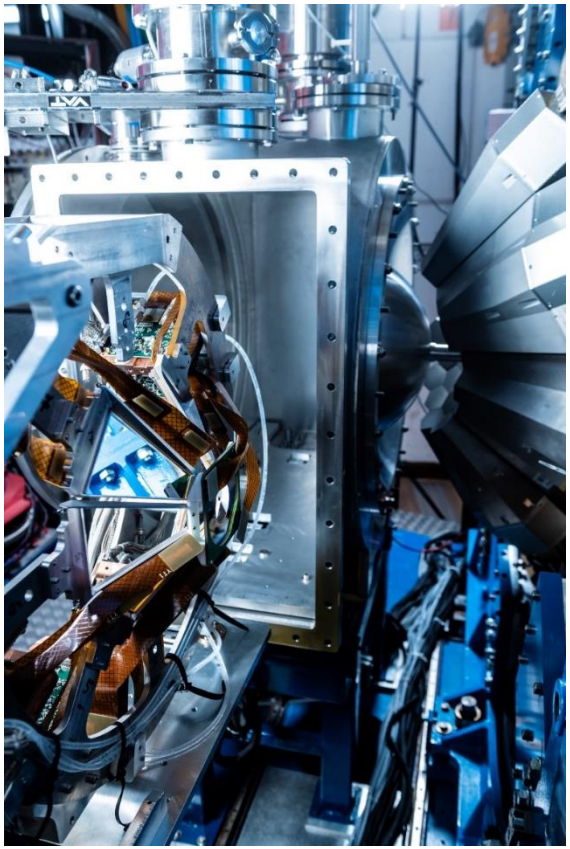
- Coupling of 3

n-deficient Xe isotopes and octupole correlations above ^{100}Sn: Status of the experiment

Talk from M. Jurado GOMEZ Tuesday 10th

2019 AGATA Vamos MUGAST Campaign

Campaign manager : M. Assié (IPNO)



• Above barrier narrow resonances in ^{15}F; *study of the coupling to the continuum*

I. Stefan et al.

•Proton in the sd shell along the N=28 chain : only spectators ? *Study of Potassium 47 (a neighbor of the doubly magic ^{48}Ca)*

A. Gottardo, M. Assié et al.

Cryogenic ^{3}He Target (IPNO)

• Determining the α+^{15}O radiative capture rate by measurement of the ^{6}Li(^{15}O,d)^{19}Ne reaction

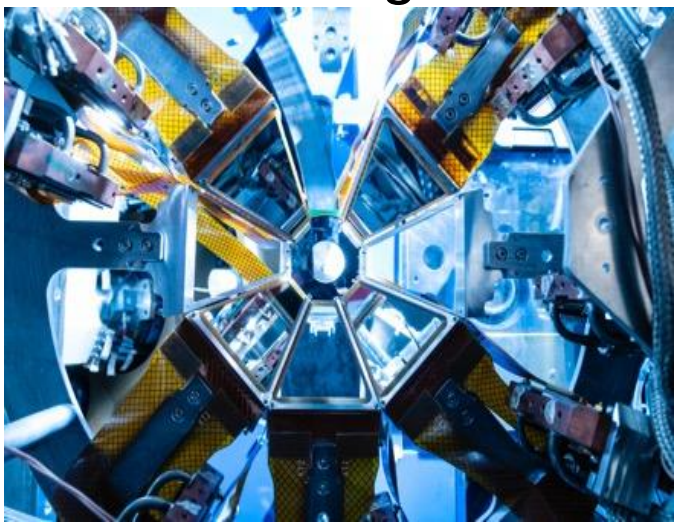
Ch. Diget, N. de Séréville et al.

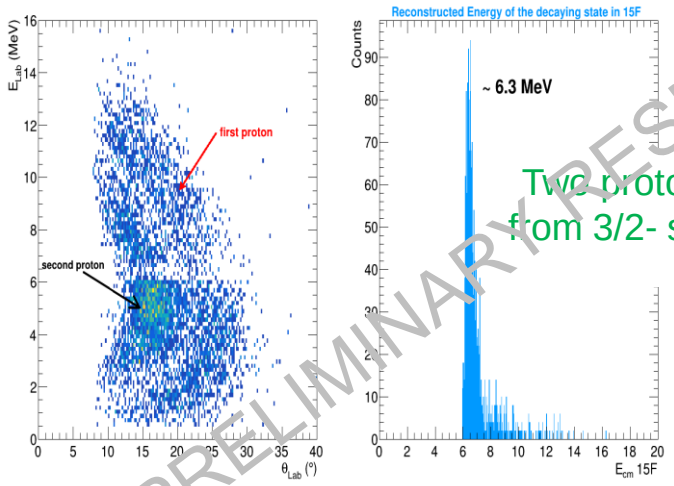
(Intensity of beam 1.5 10^{E}7 pps)

Campaign with MUGAST will continue in 2020

Nuclei at the limit of existence

decay by 2 protons emission
Search for gamma transitions between unbound states





Two protons!
from 3/2- state

Narrow resonance observed

^{14}O(p,2p) : beam intensity above expectation (>2 10^{E}5pps)

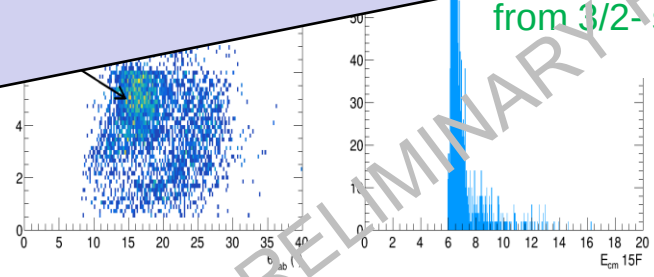
Spokespersons: I. Stefan (IPNO. France), J. Mrazek (Rez, Czech Republic)

Nuclei at the limit of existence

Resonant states in ^{15}F
And decay by 2 protons emission ?

Above barrier narrow resonnances in the unbound nucleus of fluorine 15

Talk from V. Girard-Alcindor Tuesday 10th

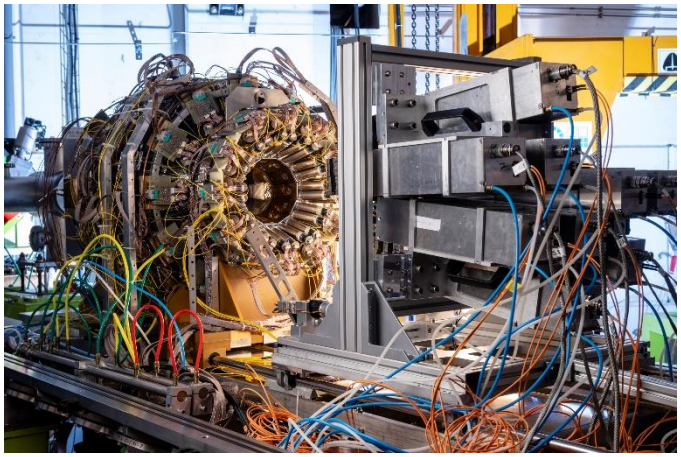


Spokespersons: I. Stefan (IPNO. France), J. Mrazek (Rez, Rep. Tchèque)

First INDRA-FAZIA campaign

2019 INDRA-FAZIA campaign

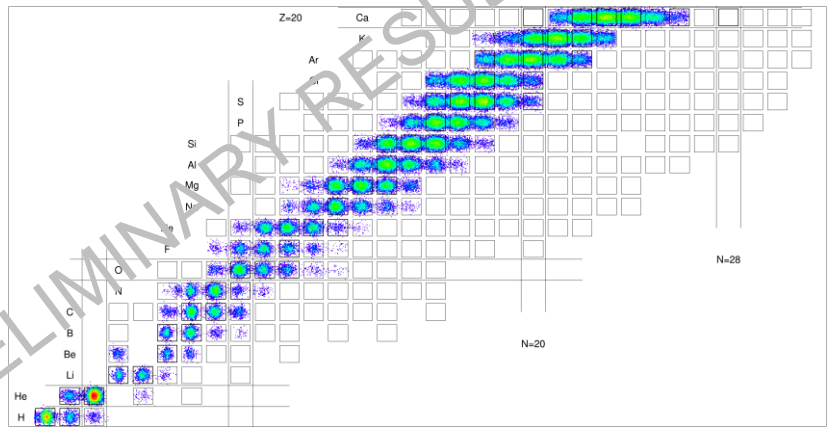
FAZIA was coupled for the first time with INDRA, replacing the forward part of this 4π multidetector for charged particles.



→ The combination of these detectors allowed for the first time a complete A and Z identification of multi-fragment reactions

→ It allows to better constraint the EOS for nuclear matter

INDRA FAZIA



Typical Z & A identification obtained with FAZIA during the experiment

Spokespersons: O. Lopez (LPC, France), S. Piantelli (INFN, Italy)

INDRA-FAZIA campaigns

A research program dedicated to the study of the nuclear dynamics at low densities and various temperatures

Mainly focused on:

- The study of the density dependence of the symmetry energy
- Radial flow measurement
- Study of the equation of state at very low density
- Clusterization

Talks in the reaction mechanism session
After the break today

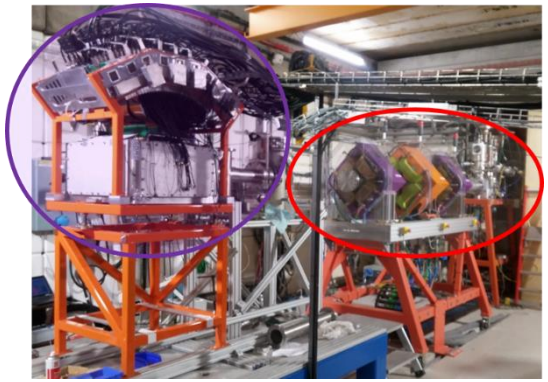
INDRA FAZIA

ACTAR-TPC

ACTAR TPC on the LISE spectrometer

ACTAR-TPC great achievements:

- 3D volume sampling with 2x2 mm² pads connected to digital electronics
- more accurate particle tracking (limited by the straggling of the ions in the gas)
- fully configurable side walls, possibly equipped with any kind of auxiliary detectors (Silicon detectors, gamma-ray detectors, ...)
- high detection dynamic range (> 1000)
- pixel-based trigger
- 2 experiments performed in 2019

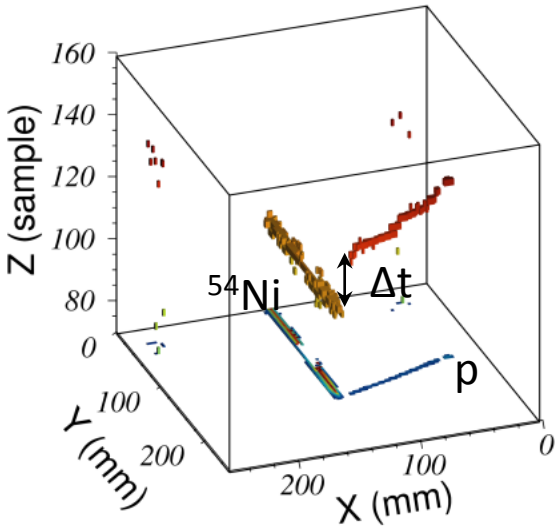


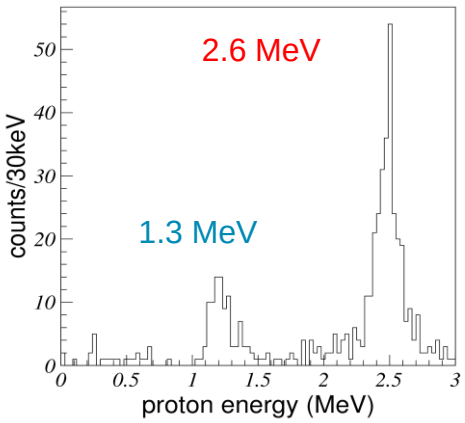
2019 Commissioning of new optical elements in the experiment room D6: "LISE QD6" project to improve the performance of the spectrometer completed

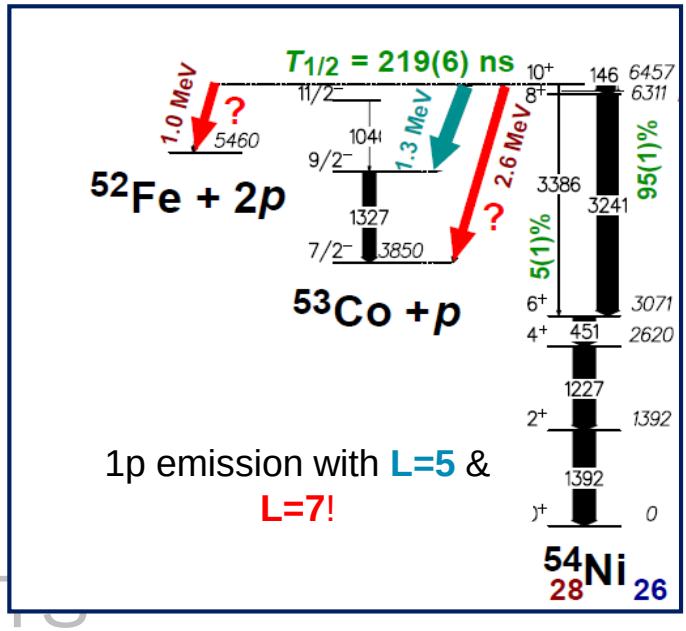
ACTAR-TPC in-beam commissioning in 2017 : ^{18}O beam at 3A MeV:
full reconstruction of the excitation function for (p,p) and (p,α) reactions

Experiments in 2019

1. Proton decay branches from the 10^+ isomer in ^{54}Ni *D. Rudolph, B. Blank et al.*







PRELIMINARY RESULTS

Experiments in 2019:

2. Study of giant monopole resonances in exotic Ni isotopes at LISE *S. Ceruti, R. Raabe*

Searching for isoscalar monopole resonnances in neutron rich ^{68}Ni with ACTAR TPC

Talk from A.A. Arokiaraj Wednesday 11th

Theory

PHYSICAL REVIEW C **100**, 014317 (2019)

Soft breathing modes in neutron-rich nuclei with the subtracted second random-phase approximation

D. Gambacurta,[1] M. Grasso,[2] and O. Sorlin[3]

[1]*Extreme Light Infrastructure-Nuclear Physics (ELI-NP), Horia Hulubei National Institute for Physics and Nuclear Engineerin, 30 Reactorului Street, RO-077125 Magurele, Jud. Ilfov, Romania*

[2]*Institut de Physique Nucléaire, CNRS-IN2P3, Université Paris-Sud, Université Paris-Saclay, 91406 Orsay, France*

[3]*Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DSM-CNRS/IN2P3, BP 55027, F-14076, Caen Cedex 5, France*

- Study of low-lying isoscalar monopole excitation
- Comparison between RPA and 2nd RPA (SSRPA)
- Study of 40-48Ca and 60Ca, N=20 isotones from 40Ca to 36S, 34Si and 68Ni

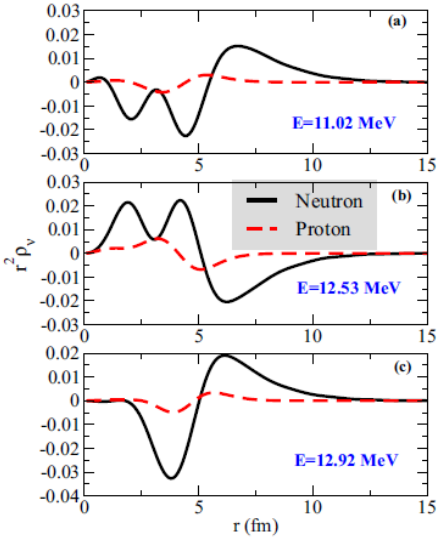


FIG. 11. Neutron and proton transition densities multiplied by r^2 (in units of fm^{-1}) associated with the peaks located at 11.2, 12.53, and 12.92 MeV in the monopole spectrum of ^{68}Ni.

- Prediction of soft monopole modes in n-rich nuclei driven by n excitation
- At variance with dipole pygmy modes, these excitations involve only neutrons over the entire volume of the nucleus

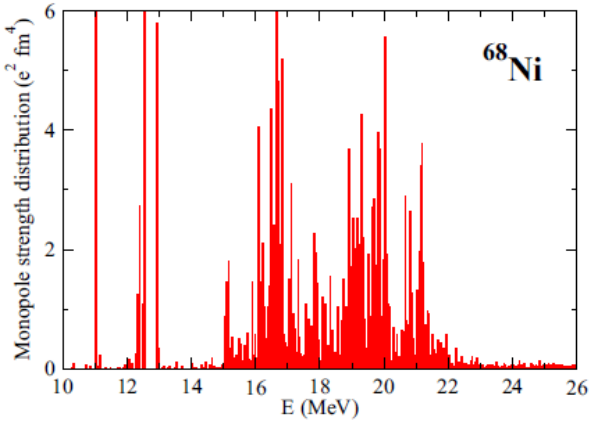


FIG. 10. Monopole isoscalar strength distribution for ^{68}Ni.

PHYSICAL REVIEW C 99, 044606 (2019)

Gamow shell model description of ^{4}He(d, d) elastic scattering reactions

A. Mercenne,[1] N. Michel,[2] and M. Płoszajczak[2]
[1]*Department of Physics and Astronomy, Louisiana State University, Baton Rouge, Louisiana 70803, USA*
[2]*Grand Accélérateur National d'Ions Lourds (GANIL), CEA/DSM-CNRS/IN2P3, BP 55027, F-14076 Caen Cedex, France*

Towards a comprehensive description of bound states, resonances and scattering many-body states within a single theoretical framework

- **GSM :** an open quantum system formulation of the shell model to describe bound and unbound many-body states and their decays
- **GSM in coupled channel**: applied for various observables involving one-nucleon reaction channels such as:
  - excitation function
  - p/n elastic/inelastic differential cross section
  - Low-energy p:n radiative capture reactions

This paper:

- extension of the GSM-CC approach to reactions with cluster reaction channels
- Application to ^{4}He(d,d) elastic scattering

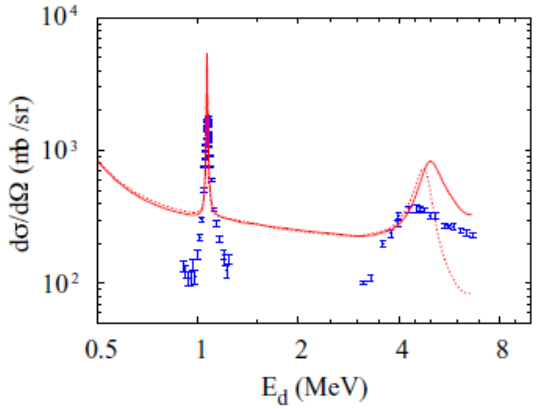


FIG. 4. Center-of-mass frame angular differential distributions for ^{4}He(d, d) elastic scattering reaction at deuteron backscattered angles 164.5 and 167 degrees, calculated with the FHT(E) (dotted

Interdisciplinary studies

Overview and prospects of interdisciplinary researches with GANIL ion beams

Talk from I. Monnet Monday 9th

Radiochemistry; irradiation of ices

Astrophysical ices are ubiquitous

→ Comets

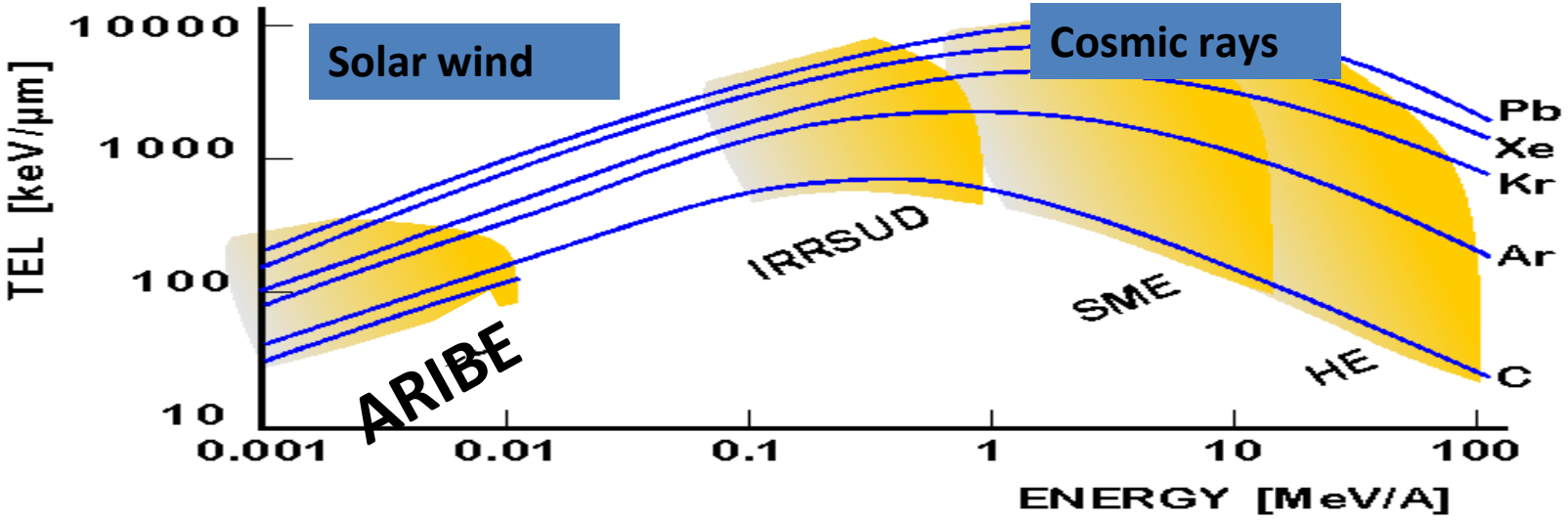
→ Giant Planet's Moons (Europa, …)

→ Dust grains

Ions to radiate these ices

- Cosmic rays
- The stellar wind (solar)
- Ions trapped in the magnetosphere of Jupiter.

Radiochemistry; irradiation of ices



3 experiments performed at GANIL-IRRSUD in April 2019 (spok. A. Bacmann, G. Danger, E. Quirico)

Beam of $^{58}Ni^{9+}$ at 0.57 MeV/A
Study of the chemical changes induced by irradiation, production of new molecules.

Valorisation

Industrial applications

SCIENTIFIC / TECHNICAL GOALS

- Irradiation and hardening of electronic components, studies on the effect of charged particles: main application in the Space Industry Field – R&D on new components types and qualification of industrial series *(THALES ALENIA SPACE, AIRBUS, CNES , ESA…)*

- Microporous membranes: R&D for new applications and production of small series

RECENT ACHIEVEMENTS

• Irradiation of space components: new European company come to GANIL
• Production of 230 km of microporous polymeric film for a Chinese company
• R&D tests for a start-up developing new batteries based on nanoporous membranes
• Test of production of membrane with CIME Cyclotron

Film unwinder for membrane production

RXS safety reexamination

Safety Reexamination (RXS)

First safety reexamination:

- **103** actions
  - modification of the installation, studies and procedural modifications
  - It includes: 10 technical prescriptions and 70 commitments

- **91 actions** finished in may 2019

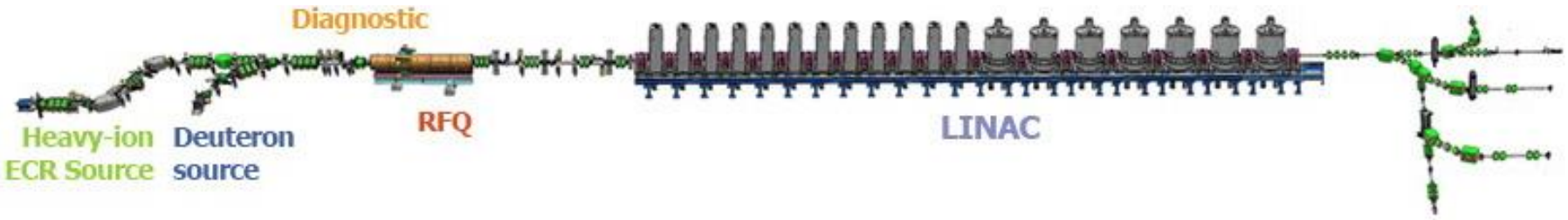
- In July 2017, a demand has been sent to ASN for postponing 6 deadlines of prescriptions. REEX 01, 03, 06, 08, 09 and 10 (article 26)

- **Progress as for schedule: end of the 1st RXS foreseen in 2022.**

- → **constraints on the available beam time in 2020 and 2021**

Second safety reexamination (2021-2031) : Dossier d'orientation (Identification of the main items) to be sent to ASN in oct. 2019

SPIRAL2 commissioning



SPIRAL2 LINAC

33 MeV p, 40 MeV d (5mA)

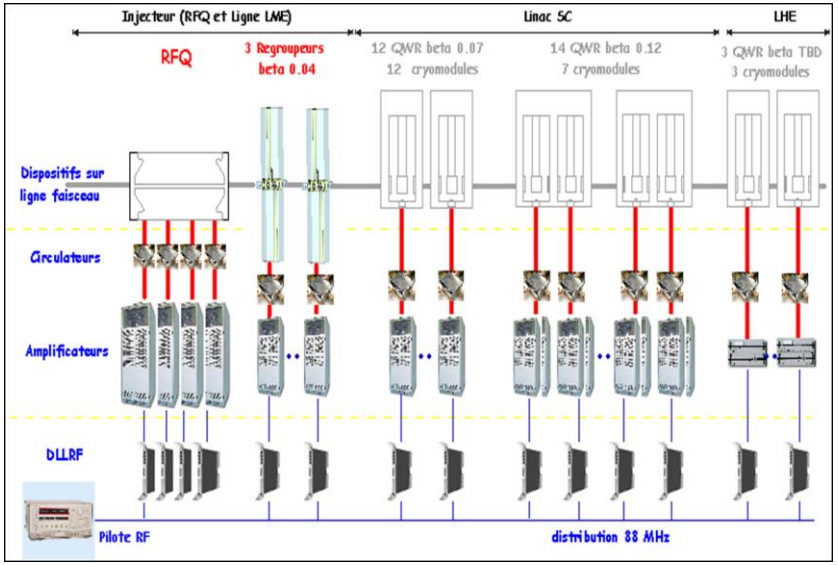
14.5 A.MeV HI (1mA)

July 8 : authorization from ASN for the commissioning of SPIRAL2 received by GANIL

Our FIRST and MAIN goal for 2019:

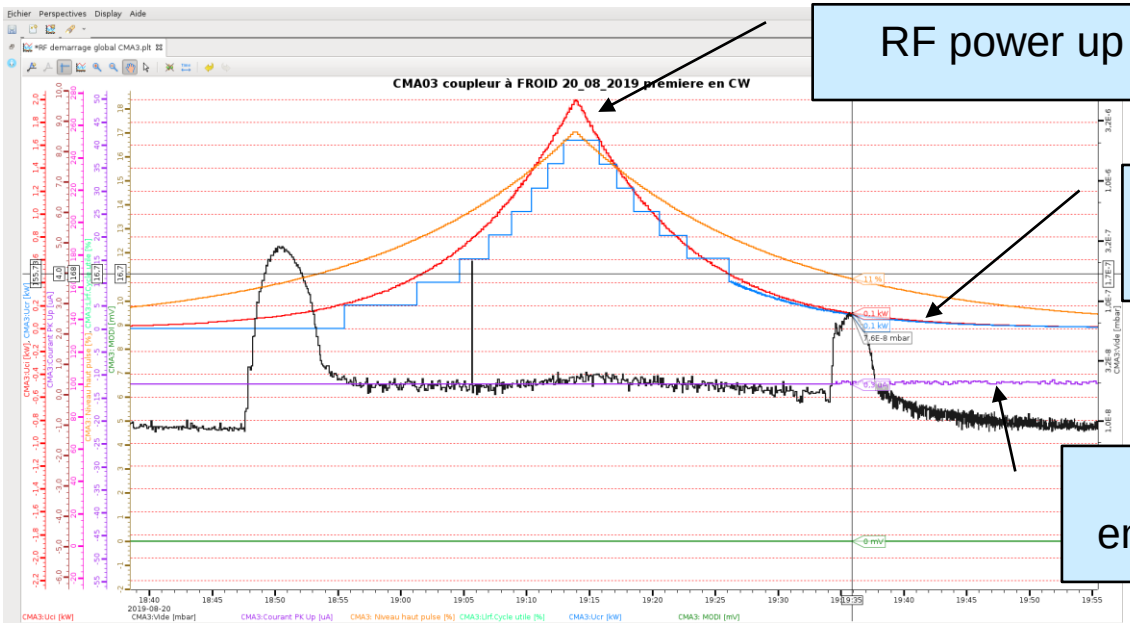
Qualification of the cryomodules performance of the LINAC

(accelerator field at nominal values and good cryogenics)



Qualification of the RF supra cavities

1. **Conditioning of the RF power couplers** at room temperature and at 4K



RF power up to 16 kW

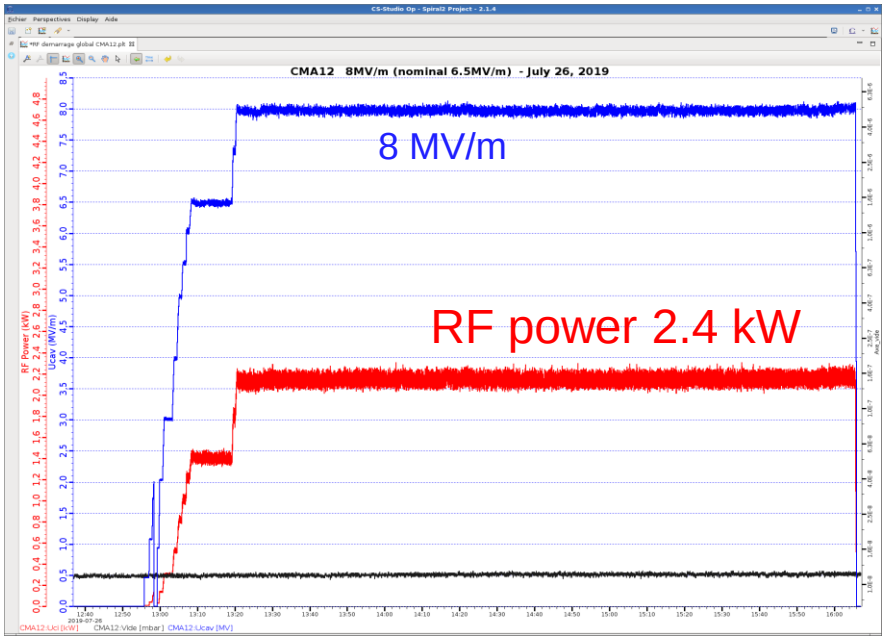
Vacuum level (less than 6 10-7 mb)

Pick up (coupler field emission less than 80 µA)

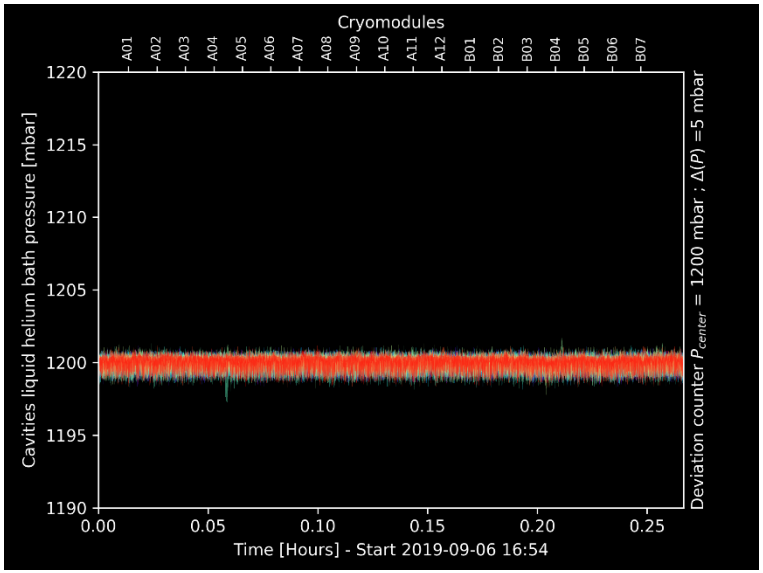
On the 27th of August : All RF coupler conditioning done in the final configuration

Qualification of the RF supra cavities

2. LINAC cavities qualification and conditioning: Ramp-up of the accelerator fields of the cavities (nominal value 6,5 MV/m)

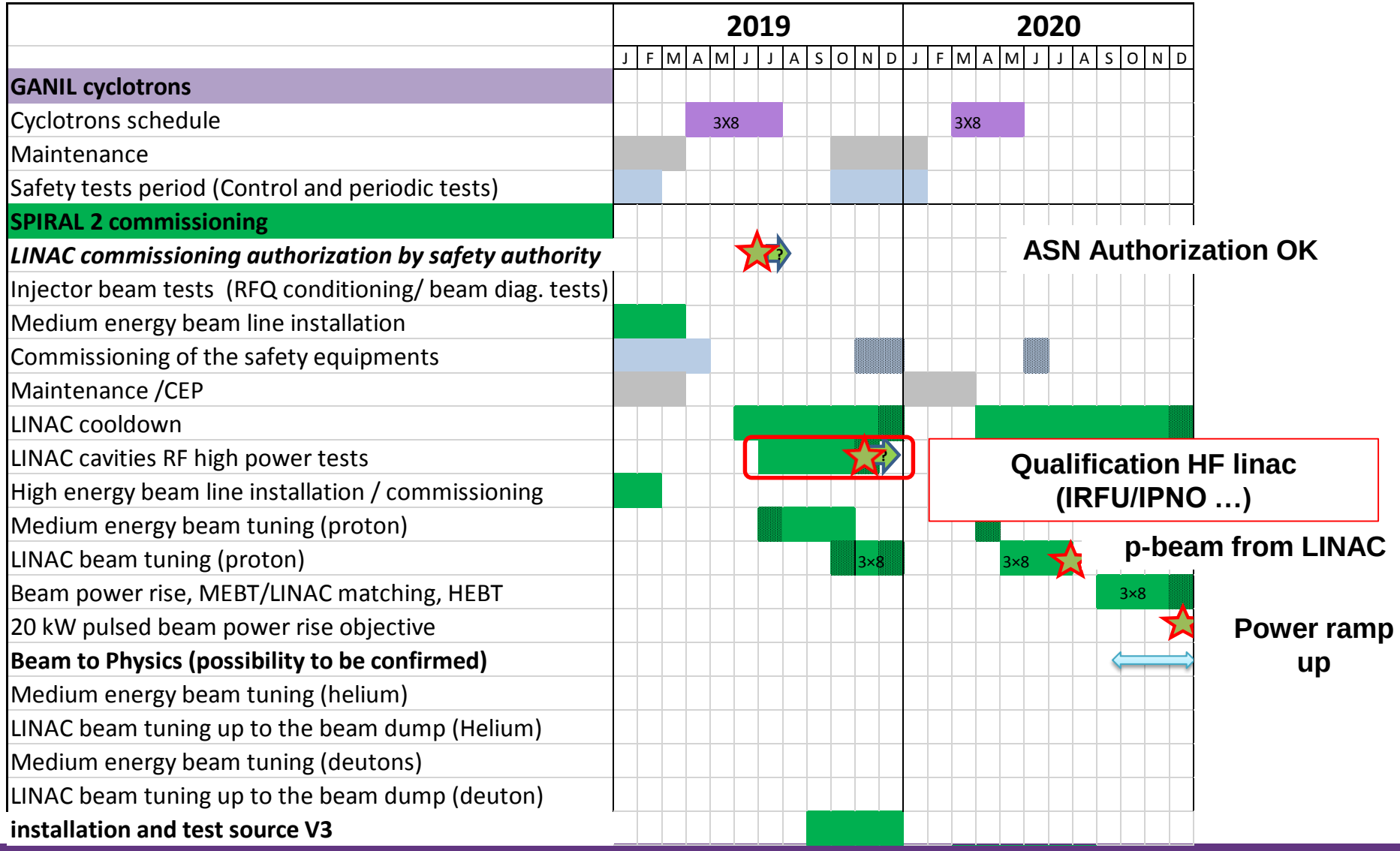


September 6
All the 12 CMA have reached designed values with a good cryo regulation



3. Frequency regulation of the cavities (frequency tuning system) and **regulation systems** (phase and amplitude)

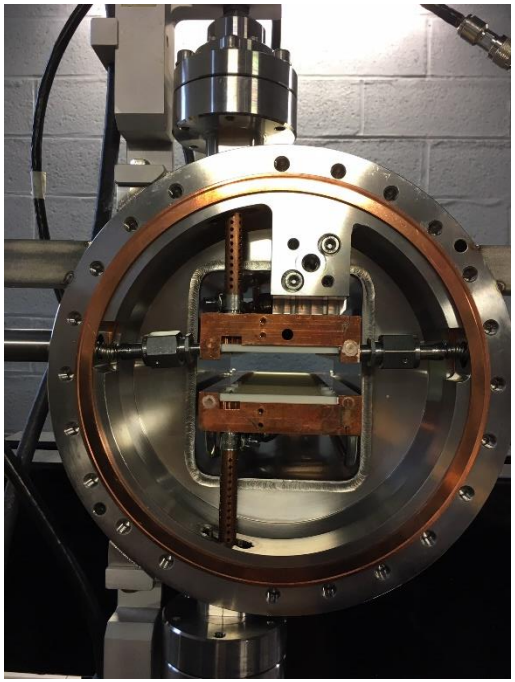
Planning and milestones

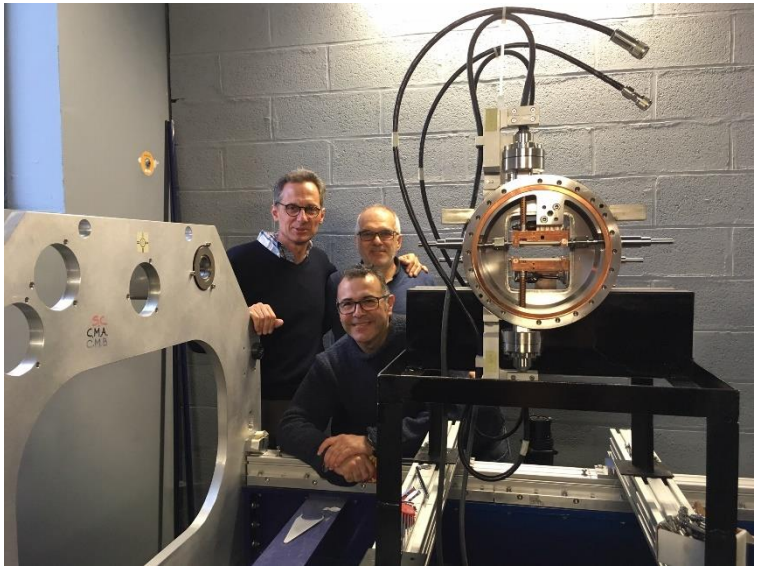


Single bunch selector

Single bunch selector;

To be tested in october 2019

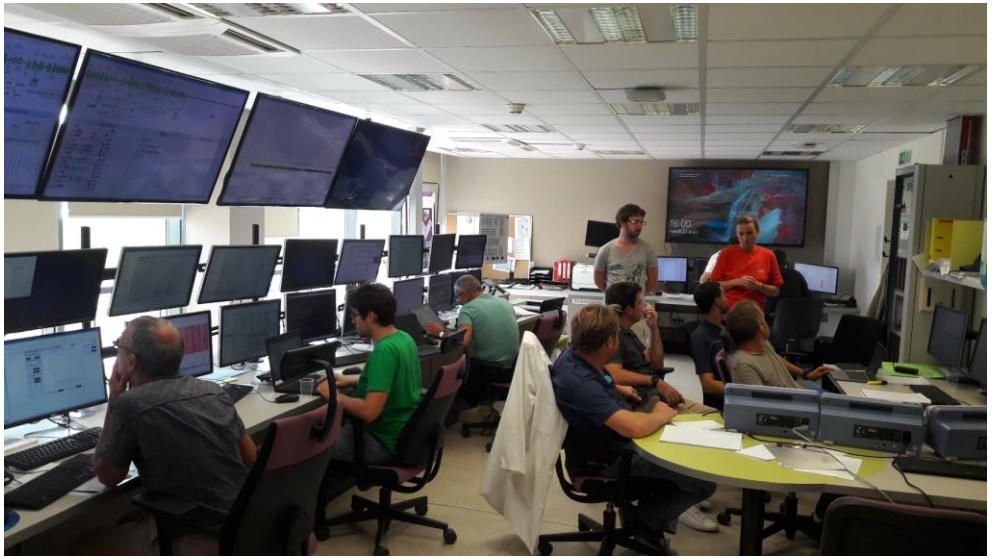




Next possible steps (aggressive schedule)

- **Our main goal for 2019** :
  => Global qualification of the accelerating system of the LINAC (October 10, 2019)

- **next steps :**
  => first injection of protons beam in the LINAC beam (October 28, 2019)



Thanks to the teams of

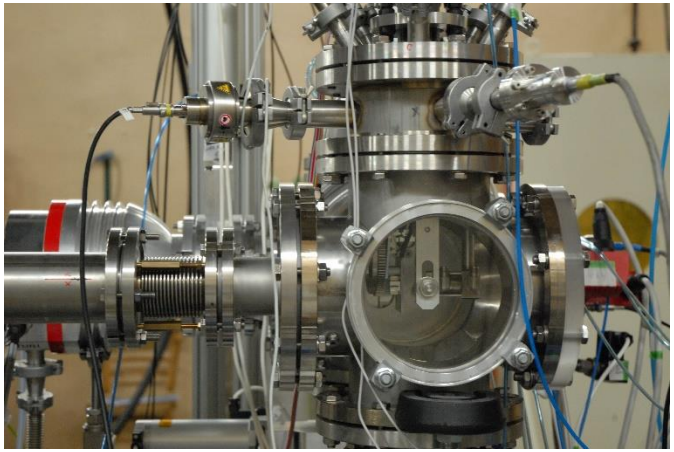
IPNO, DACM, DIS, IPNL, IPHC, LPSC, LAL, LPC, BARC, INFN, IFJPAN, SOREQ, IFIN-HH, INRNE-BAS, DP2I, SBT

A lot of work done in July and August !

NFS

Highlights

Irradiation station (Ujf, Czech Rep.)



Convertor installed (Irfu)

All the cables have been put and all the electronic racks are installed (gamma spectra measured in a Germanium detector)

NFS commissioning : strategy and chronology

First Beam in NFS : 34 safety pre-requisites

If everything OK with the LINAC; characterization of the beam in NFS hall will be tried in December 2019

Steps December 2019 - 2020:

1) Beam in CF11, to measure the current
2) Use of the Irradiation station

…

PAC in 2020: call for experiments will be open for NFS

A lot of parallel operations before the end of the year :

- RF qualification of the RF LINAC (26 cavities)
- cavities frequency tuning and RF system regulations for all cavities
- finalize cryogenic system regulation with all cavities RF power on (pressure stabilisation)
- LME beam tuning with single bunch selector
- Commissionning last safety sytems in beam configuration (global machine protection system and safety fast valves system).
- Start LINAC beam commissionning

all these operations must be precisely organized (tunnel access and interdependences between these operations)

S3

Highlights

- **S3 Workshop in June 2018 to define possible day1 exp. with SIRIUS and with LEB**

  To come: ESNT Workshop on laser spectroscopy Oct 2019

- **New steering committee for S3**: first meeting in March 2019: Convention being signed

- **Cooperative Research and Development Agreement (CRADA)** signed in Oct. 2018 with DOE Argonne National Laboratory to formalize the collaboration

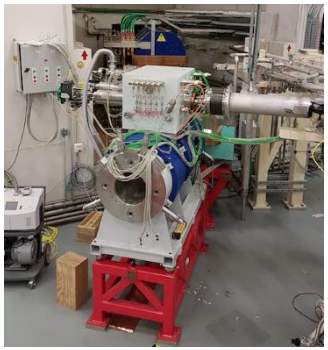
Spectrometer: highlights and milestones

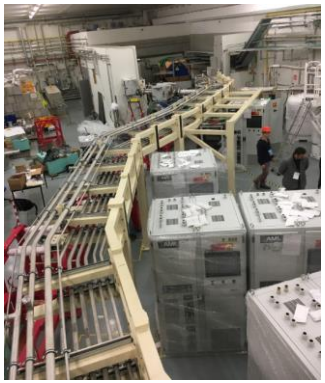
- Two SMT delivered at GANIL and cryogenic tests

of the first SMT done at GANIL in June 2019

Full qualification of one SMT plan to be completed by the end of 2019

Two additional SMTs to be delivered by end 2019



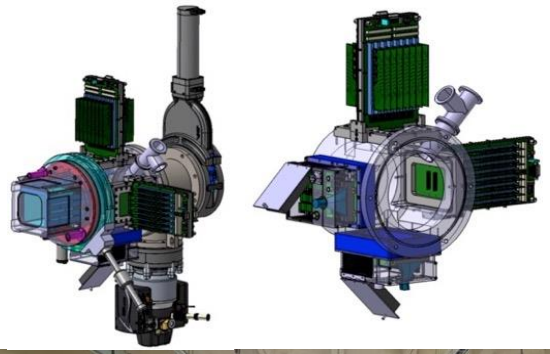


- All the PSS delivered at GANIL (January 2019) and will be tested this month

SIRIUS and LEB: Highlights and milestones

SIRIUS

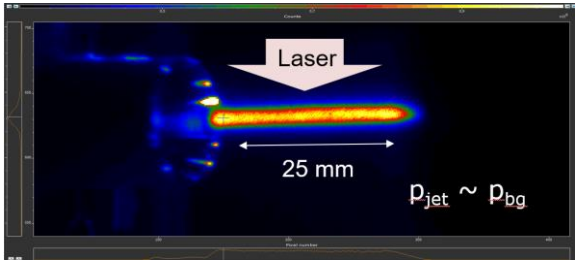
Installation of SIRIUS at GANIL: december 2019



LEB

Connection of the last elements in LPC

Caracterisation of the supersonic jet at KU Leuven ongoing



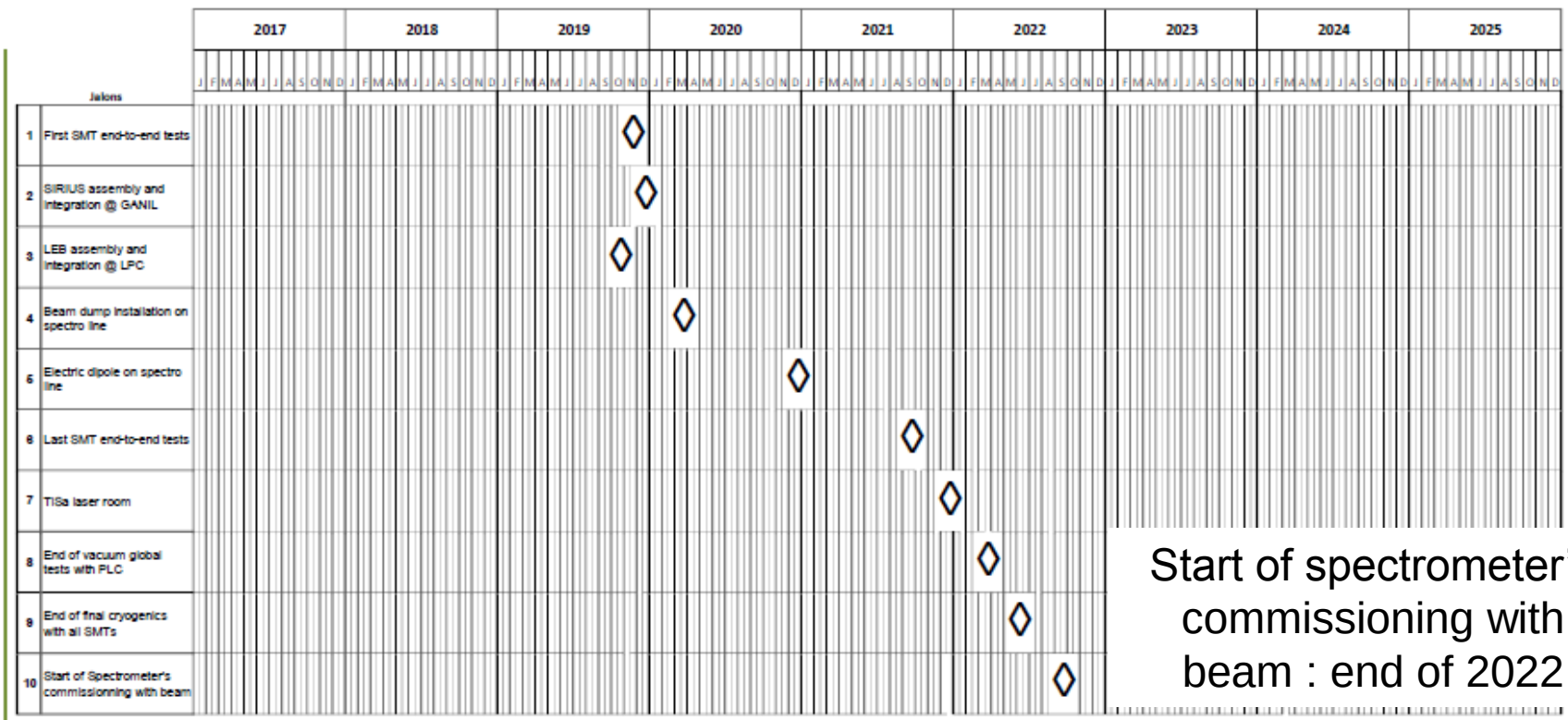
Planning

	Projet :	REF
GANIL / cnrs / cea	Super Séparateur Spectromètre (S3)	FAP S1 Page 5/5

Date de mise à jour du planning : date

PLANNING

	Jalons
1	First SMT end-to-end tests
2	SIRIUS assembly and integration @ GANIL
3	LEB assembly and integration @ LPC
4	Beam dump installation on spectro line
6	Electric dipole on spectro line
6	Last SMT end-to-end tests
7	TISa laser room
8	End of vacuum global tests with PLC
9	End of final cryogenics with all SMTs
10	Start of Spectrometer's commissionning with beam

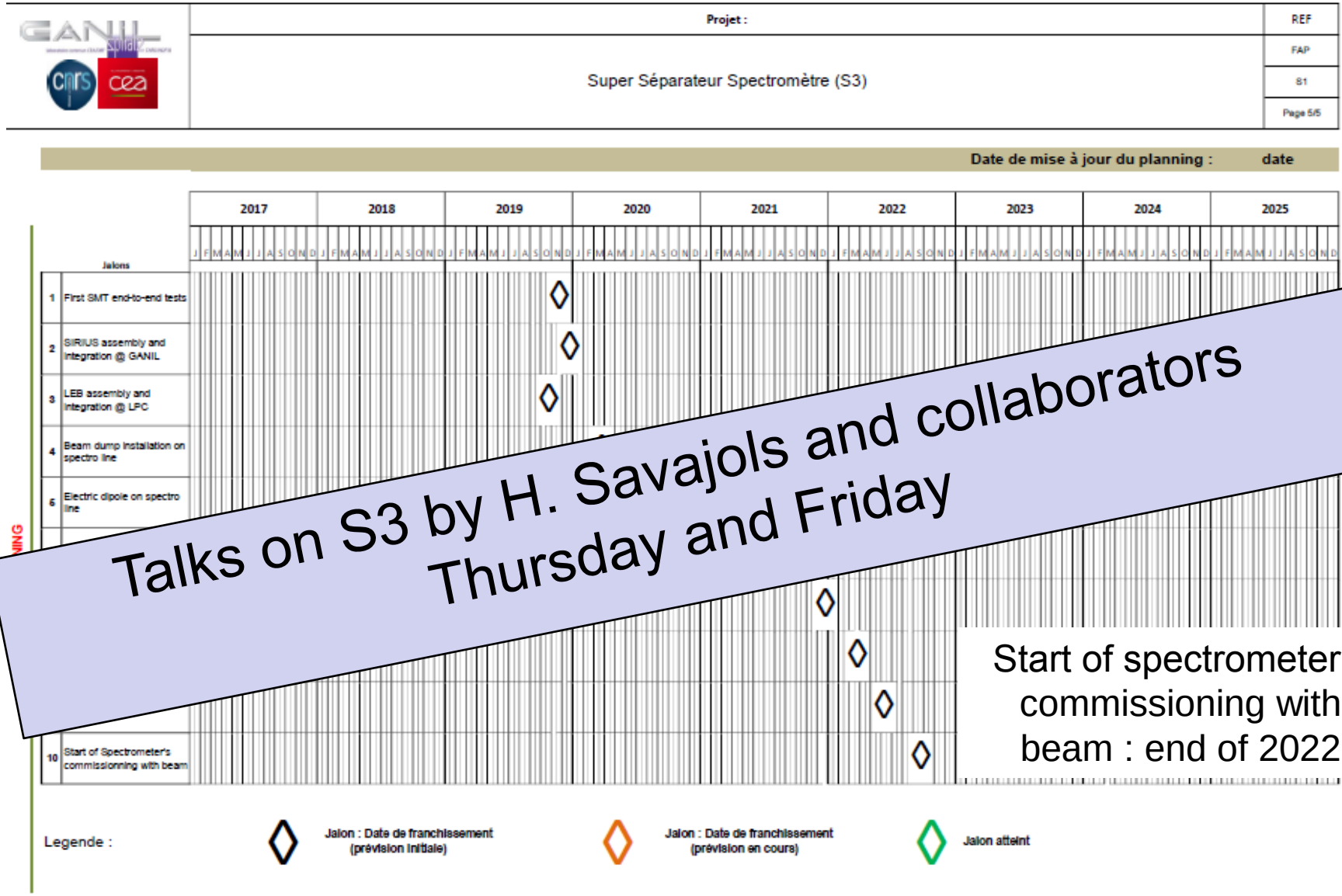


Start of spectrometer's commissioning with beam : end of 2022

Legende :

- Jalon : Date de franchissement (prévision initiale)
- Jalon : Date de franchissement (prévision en cours)
- Jalon atteint

Planning

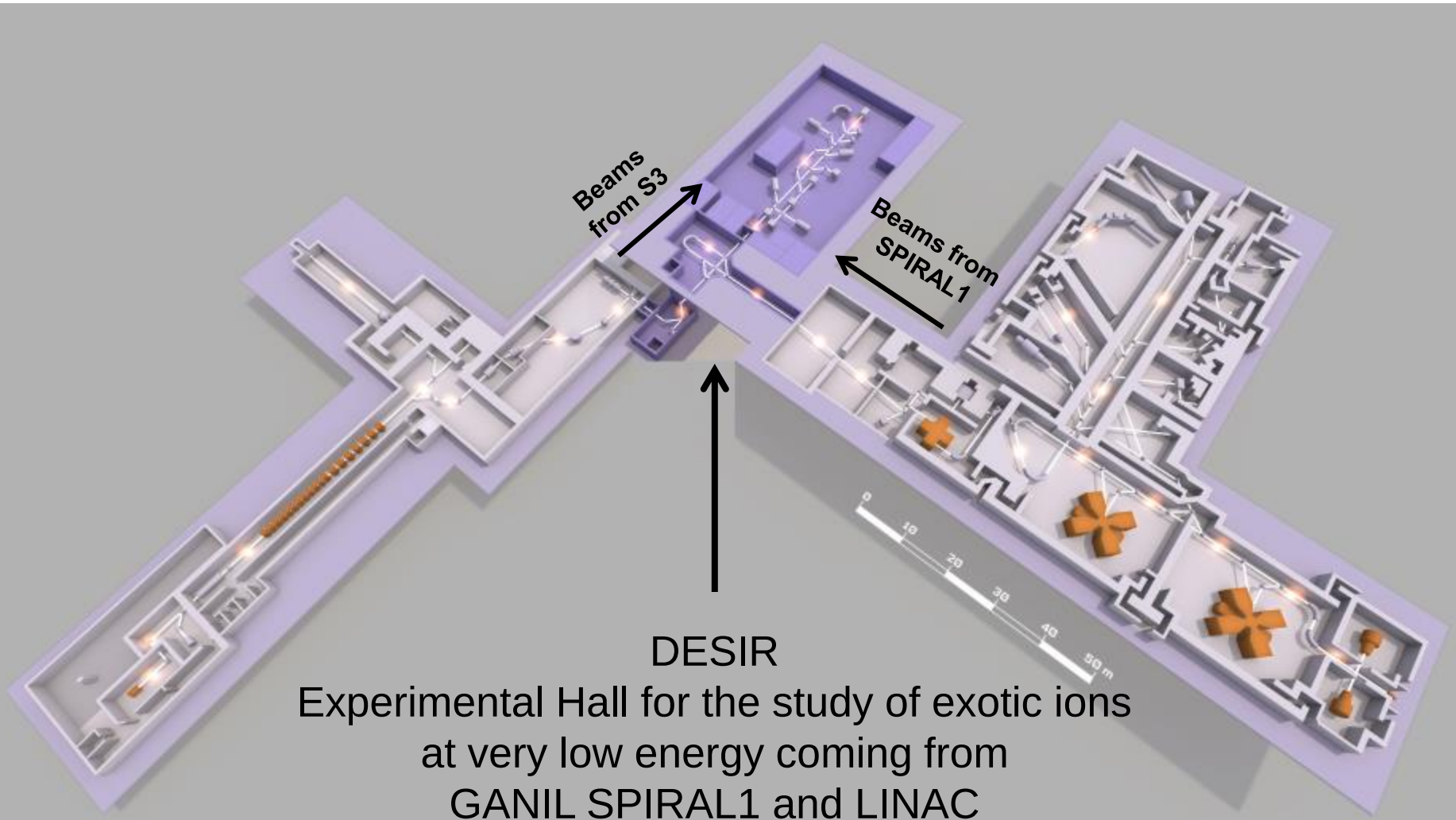


Talks on S3 by H. Savajols and collaborators
Thursday and Friday

Start of spectrometer's commissioning with beam : end of 2022

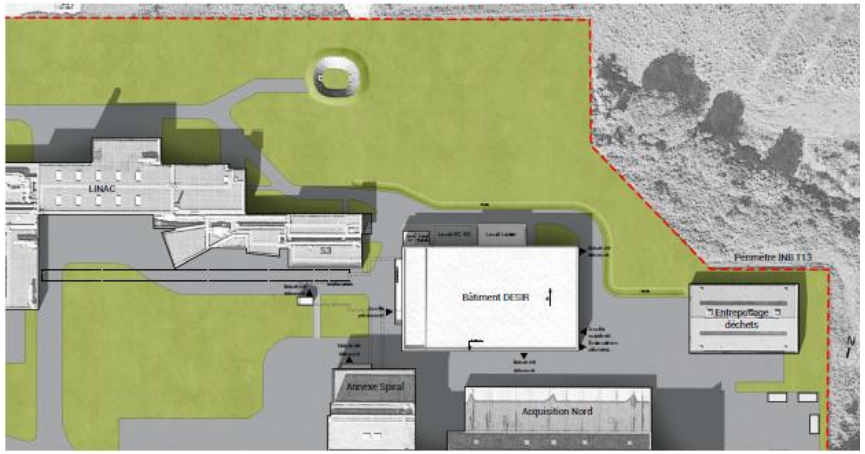
DESIR

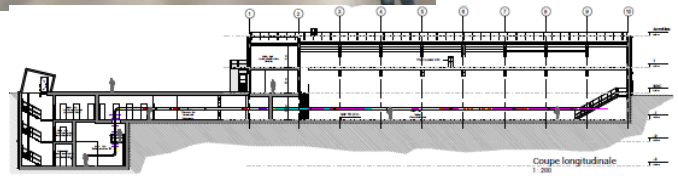
DESIR



DESIR
Experimental Hall for the study of exotic ions
at very low energy coming from
GANIL SPIRAL1 and LINAC

DESIR building



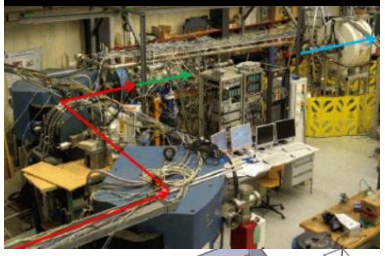


- Setting up of a steering committee; autumn 2018
- Signature of a contract for the building « contrat de MOE Bâtiments » : sept. 2018
- Starting of the APD phase: august 2019

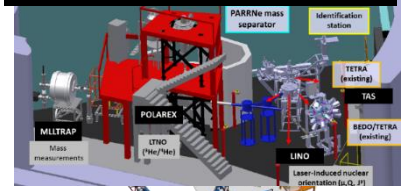
DESIR Technical developments

SHIRAC2 @LPC Caen

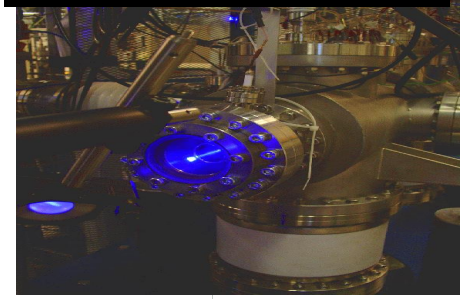
MLLTrap @ LMU Munich



MLLTrap and LINO @ l'IPNO

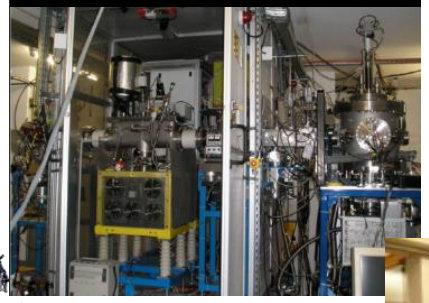


LUMIERE : IKS Leuven Univ. Manchester



PIPERADE @ CENBG

LPCTrap @ GANIL

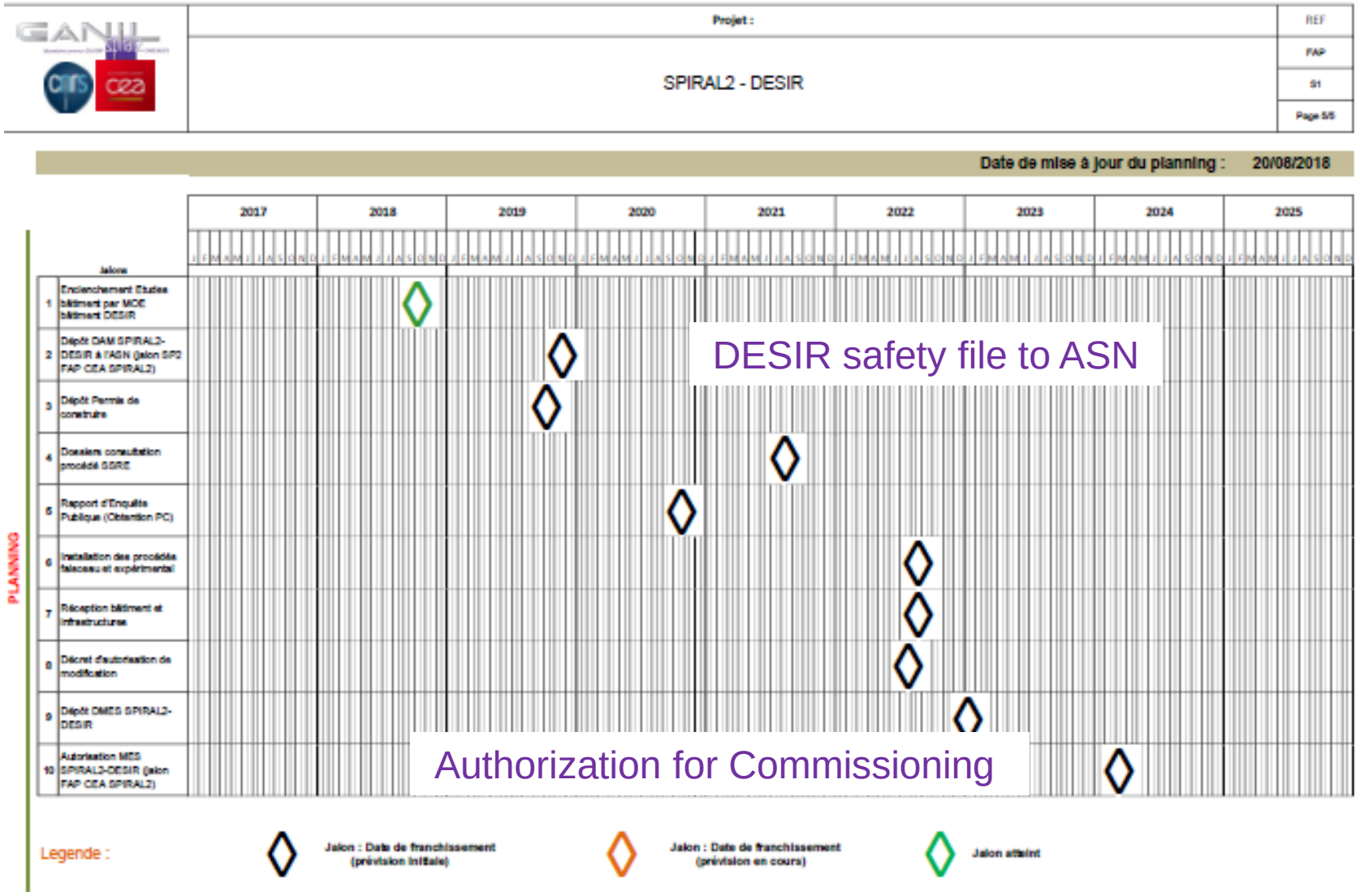


HRS1P and GPIB @ CENBG

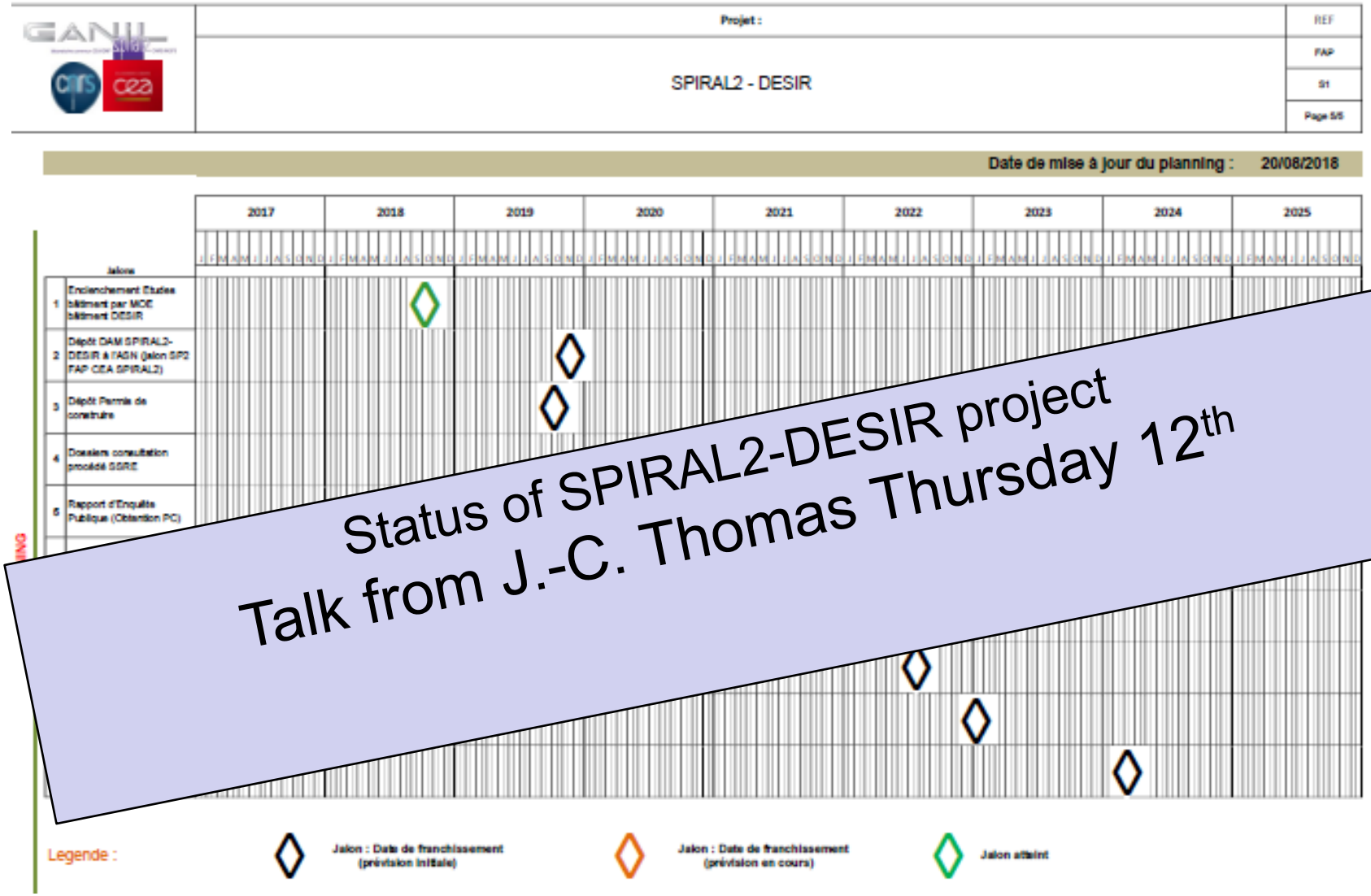
+ IPHC on the identification station

Optical part @ IPNO

DESIR Future milestones



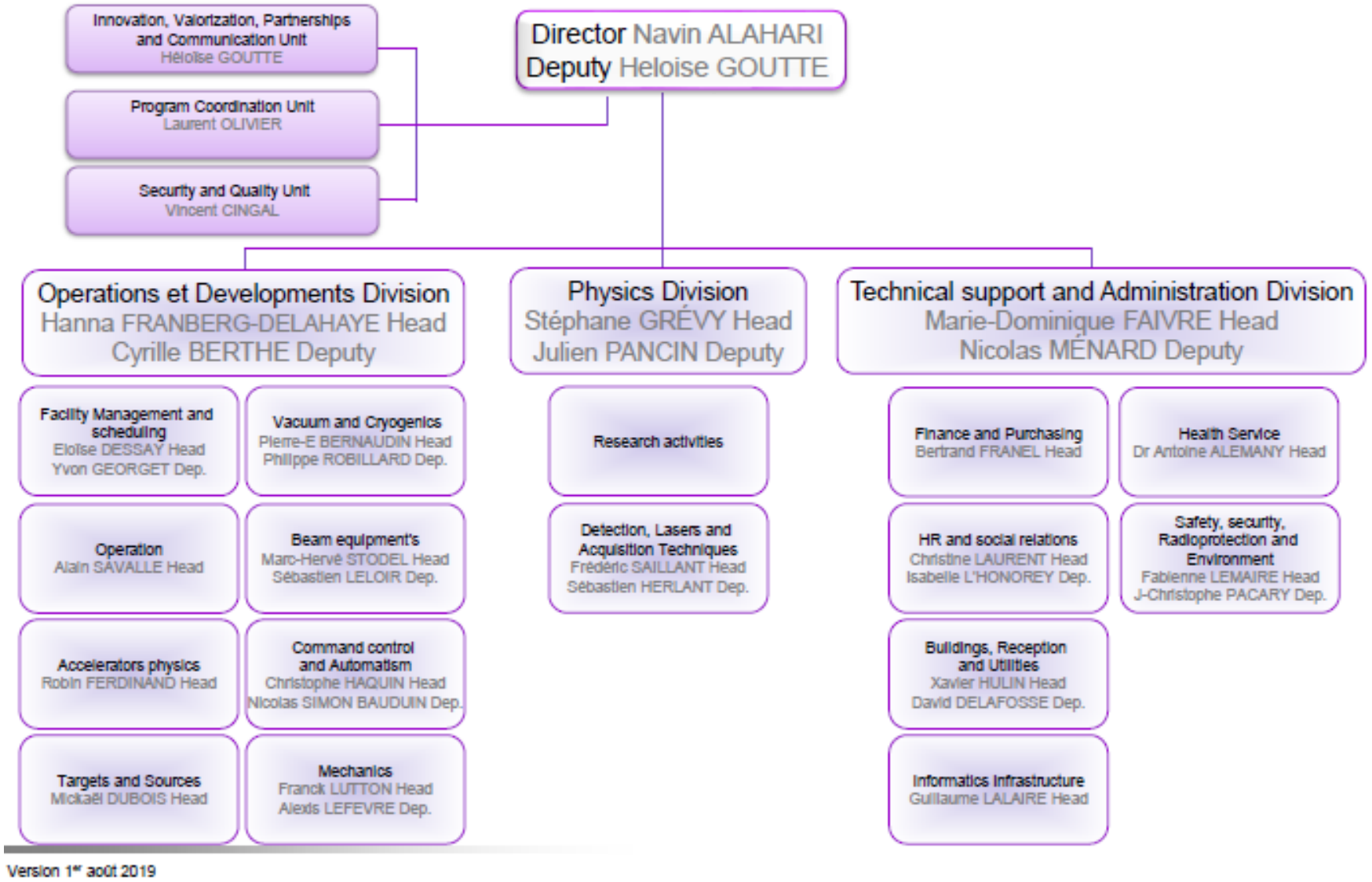
DESIR Future milestones



Status of SPIRAL2-DESIR project
Talk from J.-C. Thomas Thursday 12th

Some evolutions

New internal organization (set up on Feb 1st 2019)

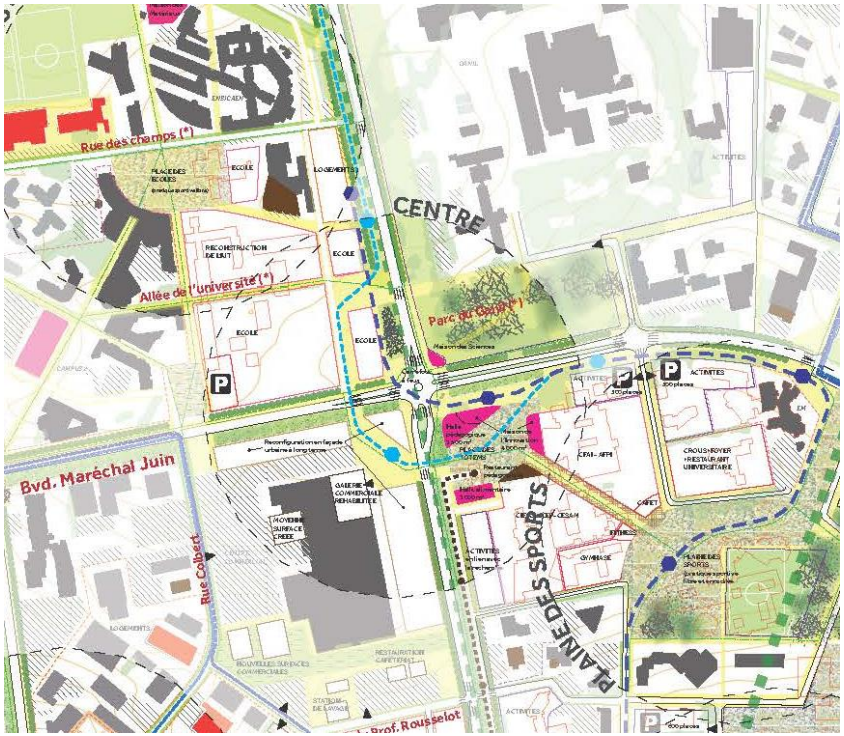


New campus (created in April 2019)

EPOPEA

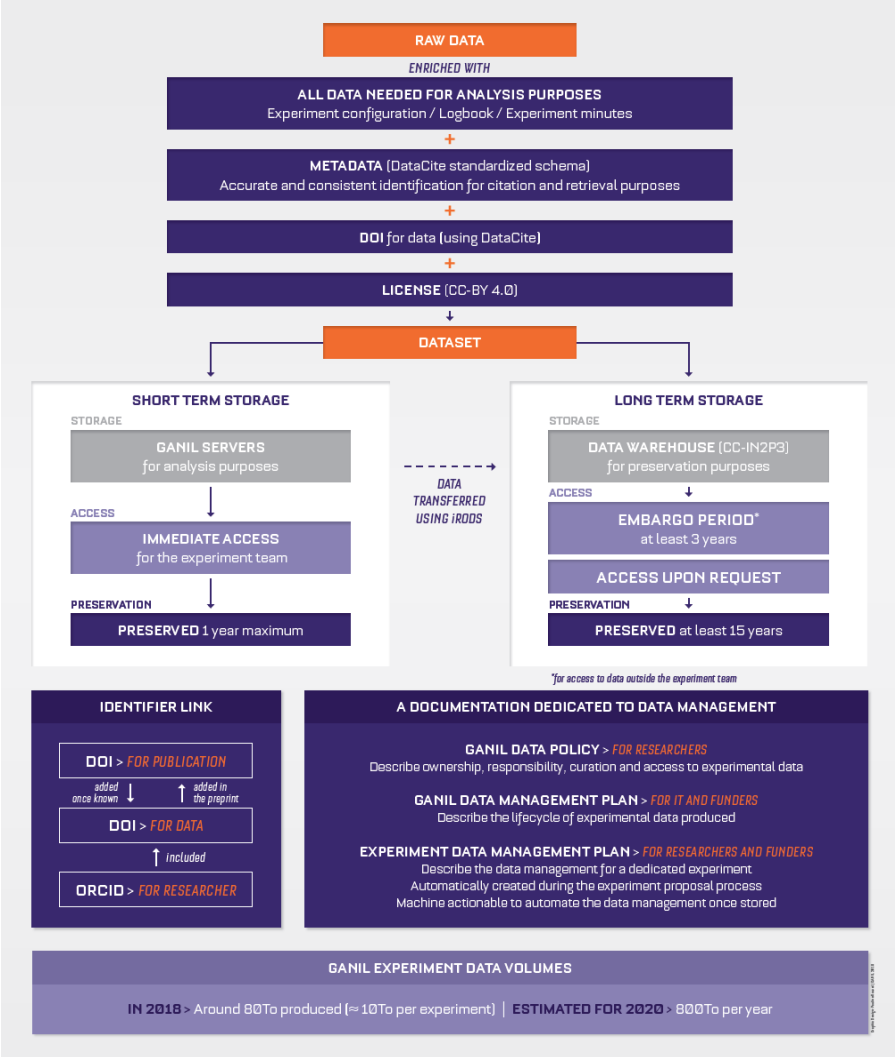
CAEN NORMANDIE

SCIENCE & INNOVATION PARK



Data management plan under construction

ENSURE DATA PRESERVATION | OFFER OPEN ACCESS | INCREASE GANIL AND RESEARCHERS VISIBILITY



www.ganil-spiral2.eu

IDEAL is funded by the European Union's Horizon 2020 research and innovation programme under grant agreement n° 730988

JNSO 2018 December 4 > 6, 2018 Paris | FRANCE

AUTHOR | B. Fasbert
CONTACT | benjamin.fasbert@ganil.fr

Main objectives:

- ❑ ensure data preservation
- ❑ offer open access
- ❑ Increase researchers and GANIL visibility

Data policy

- ❑ validated by the GUEC in June 2019
- ❑ Main items:
  - All the data produced at GANIL are concerned
  - By default: a 3-years period of embargo before open data (on request)
  - Data stored 1 year at GANIL and then long-term storage at CCIN2P3

Data management plan : next steps

Next steps:

- **The Data policy document:** will be put on portal in September 2019

- Each experiment and data set will have a **unique persistent identifier DOI.**

Anybody publishing results based on open access data must quote the DOI.

- Test phase for experiments performed in 2019
- Full speed for 2020 experiments

For any questions: dmp@ganil.fr

GANIL NEWSLETTER

JULY 2019 | #3

News

> Administrative authorization for the commissioning of SPIRAL2 facility at GANIL
> The 2019 experimental campaign with the cyclotrons continues at GANIL: new experimental challenges

Events

> 21st Colloque GANIL

Edito

The GANIL facility continues its twofold strategy of sharing resources between running experiments with the cyclotrons and continuing work on the technical aspects for the LINAC. July 2019 marked a decisive step in the start-up of the SPIRAL2 facility at GANIL, with the arrival of the administrative authorization from the nuclear safety authority. This now opens the way for tests of the accelerating cavities of the LINAC and the subsequent in-beam commissioning. In parallel, the 2019 experimental campaign continues with the cyclotrons until the end of July. Many new state-of-the-art detectors and new beams have been developed and used this year.

Administrative authorization for the commissioning of SPIRAL2 facility at GANIL

On 8th July, the French nuclear safety authority gave the administrative authorization to start up the full SPIRAL2 facility at GANIL. This opens the way for the various steps involved in the commissioning of the accelerator, eventually leading to the first beams for experiments.

Read more

New web site :https://www.ganil-spiral2.eu/

Towards the Internationalisation of GANIL

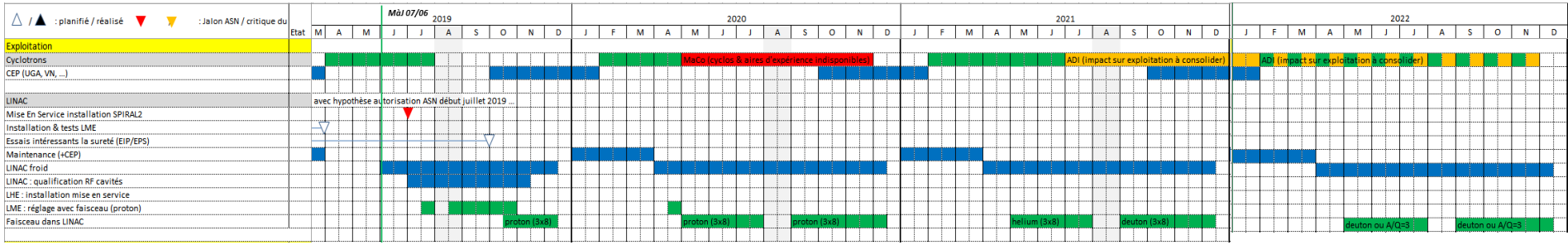
General provision for the status of scientific partner approved by the GANIL CODIR in December 2019

Fanny Farget, Yorick Blumenfeld, Pascal Debu, Marek Lewitowicz, Sylvie Leray, Laura Petersen, Ketel Turzo, Nicolas Alamanos, Navin, HG

IDEAL International DEvelopment of gAnil-spirAL2

GANIL medium and long range plan

2020 and beyond: providing more beam time



2019

6 months of functioning

- 4 months cyclotrons
- 2 months commissioning Linac protons

2020

9 months of functioning :

- 3 months cyclotrons
- 6 months Linac protons :
  - ✓ 3 months commissioning protons
  - ✓ 3 months commissioning NFS
  - ✓ First simple experiments

2021

11 months of functioning :

- 5 months cyclos with 2 months // Linac
- 6 months Linac :
  - ✓ 3 months commissioning helium
  - ✓ 3 months experiments deutons NFS

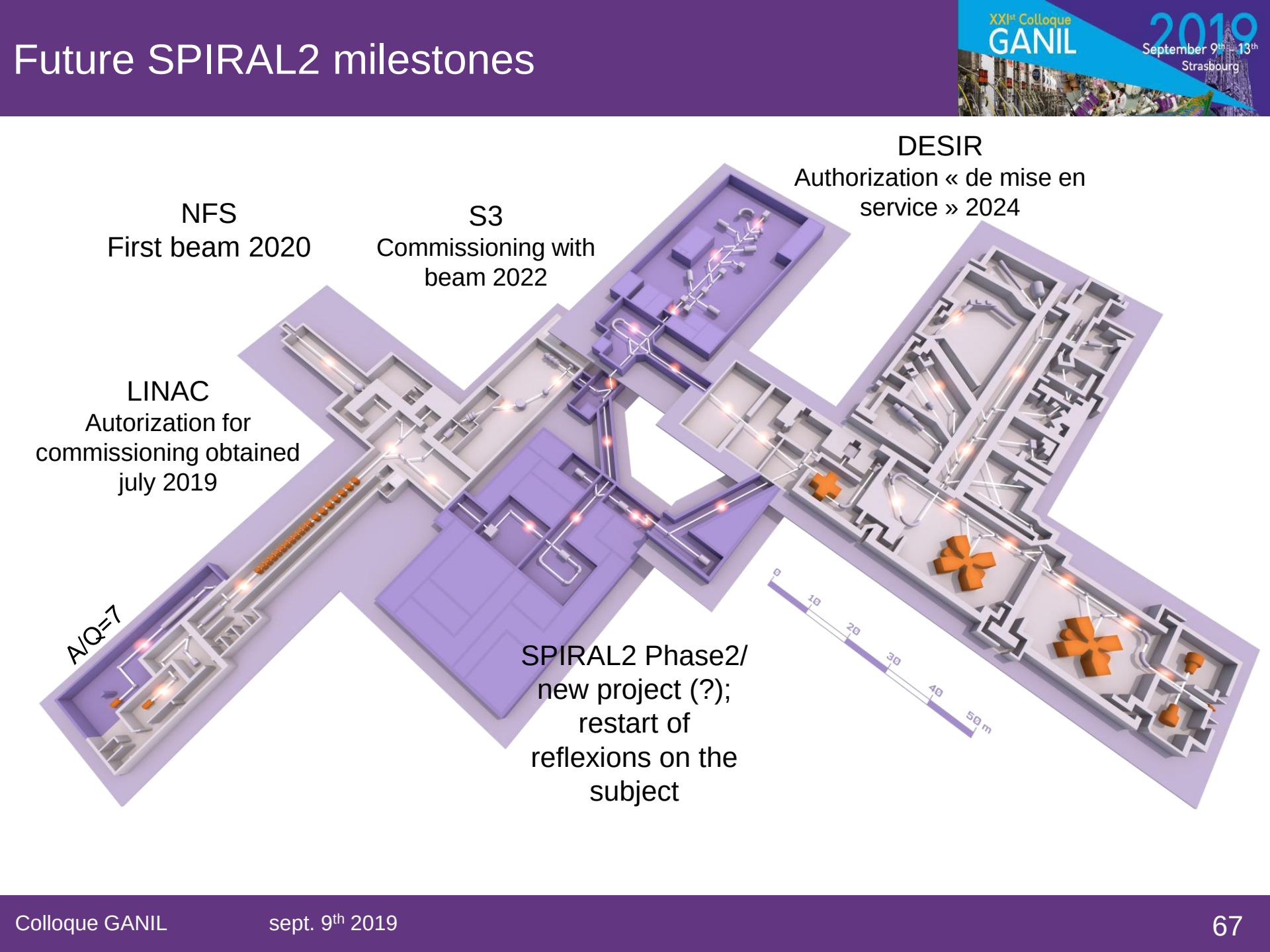
2022

11 months of functioning

- 5 months cyclos with 2 months // Linac
- 6 months Linac

consolidation on going in terms of RH and financial ressources

Future SPIRAL2 milestones



Building the future together

- **Meeting of the GUEC** this week: important inputs for the planning of best utilization of beams and the discussion about theory initiatives

- Collaboration agreements under discussion:
  - within S3, DESIR, … collaborations
  - with laboratories in the context of scientific partnership (IDEAAL)

- A resource-loaded short, medium and long term plan (2020-2029) is under construction
  - It will be in coherence with the IN2P3 prospectives and the CEA reflexions
  - An expert committee will be appointed by CEA and CNRS to look at the long term future of GANIL.

Building the future together

- **Meeting of the GUEC** this evening : important inputs for th… ning of best utilization of beams and the discussion ab…

- Collab…

WARM THANKS TO THE GUEC

GUEC Session TODAY

…ntext of scientific partnership (IDEAAL)

…rce-loaded short, medium and long term plan (2020-2029) is under construction

  - It will be in coherence with the IN2P3 prospectives and the CEA reflexions
  - An expert committee will be appointed by CEA and CNRS to look at the long term future of GANIL.

Next meetings

- Physics Advisory Committees
  - Next IPAC meeting: 27th September 2019
  - Next PAC meeting: 17th-18th October 2019

- GANIL Scientific Council in January 2020

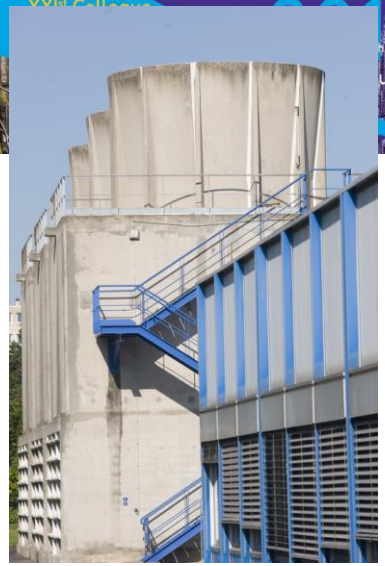
- SPIRAL2 LINAC commissioning review in March 2020

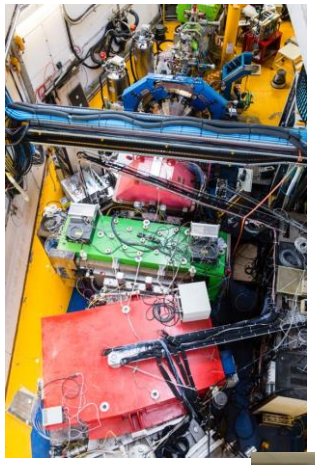
Thanks to all the people who helped me to prepare this talk, **Navin, Jean-Charles, Stephane, Olivier, Patrick, Xavier, Hervé, François, Valerian …**

Thanks to the Colloque Organizing Committee

Marie-Laure Abavent, GANIL Caen
François Didierjean, IPHC Strasbourg
Olivier Dorvaux, IPHC Strasbourg
Kseniia Rezynkina, IPHC Strasbourg
Kamila Sieja, IPHC Strasbourg (co-chair)
Piet Van Isacker, GANIL Caen (co-chair)

Thanks





Have a nice
2019 COLLOQUE GANIL