DE LA RECHERCHE À L'INDUSTRIE

French Alternative Energies and Atomic Energy Commission

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Overview of the activities of the Institute of Research into the Fundamental lows of the Universe (IRFU) with emphasis to HEP and Accelerator physics

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- *The Institute inside the CEA*
- *The French financial system*
- *The IRFU organization – the Divisions*
- *Few Highlights in HEP and in the domain of sterile neutrinos*
- *Magnet and Accelerator constructions – last six months highlights*

CEA: Alternative Energies & Atomic Energy Commission

Basic Research

16 000 Employees, 3 900 M€

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Basic Research

16 000 Employees, 3 900 M€

DEN (Nuclear Energy), DRT (Technological Research),

DAM (Military Applications)

DSM (Physical Sciences), DSV (Life Sciences) => DRF (Fundamental Research)

IRFU WITHIN DRF

DRF (*15 Institutes*)

- DRF (Head: Vincent Berger)
  - 6270 people
  - 690 PhD students
  - 870 Postdocs
  - 70 ERC Grants since 2012
  - Over 3500 publications per years
  - 564 active patents

Irfu (6 Divisions)

- IRFU (Head: A.-I. Etienvre)
  - 820 people
  - 92 PhD students
  - 72 post-docs
  - 16 ERC grants
  - 925 publications (2014)
  - 59 active patents

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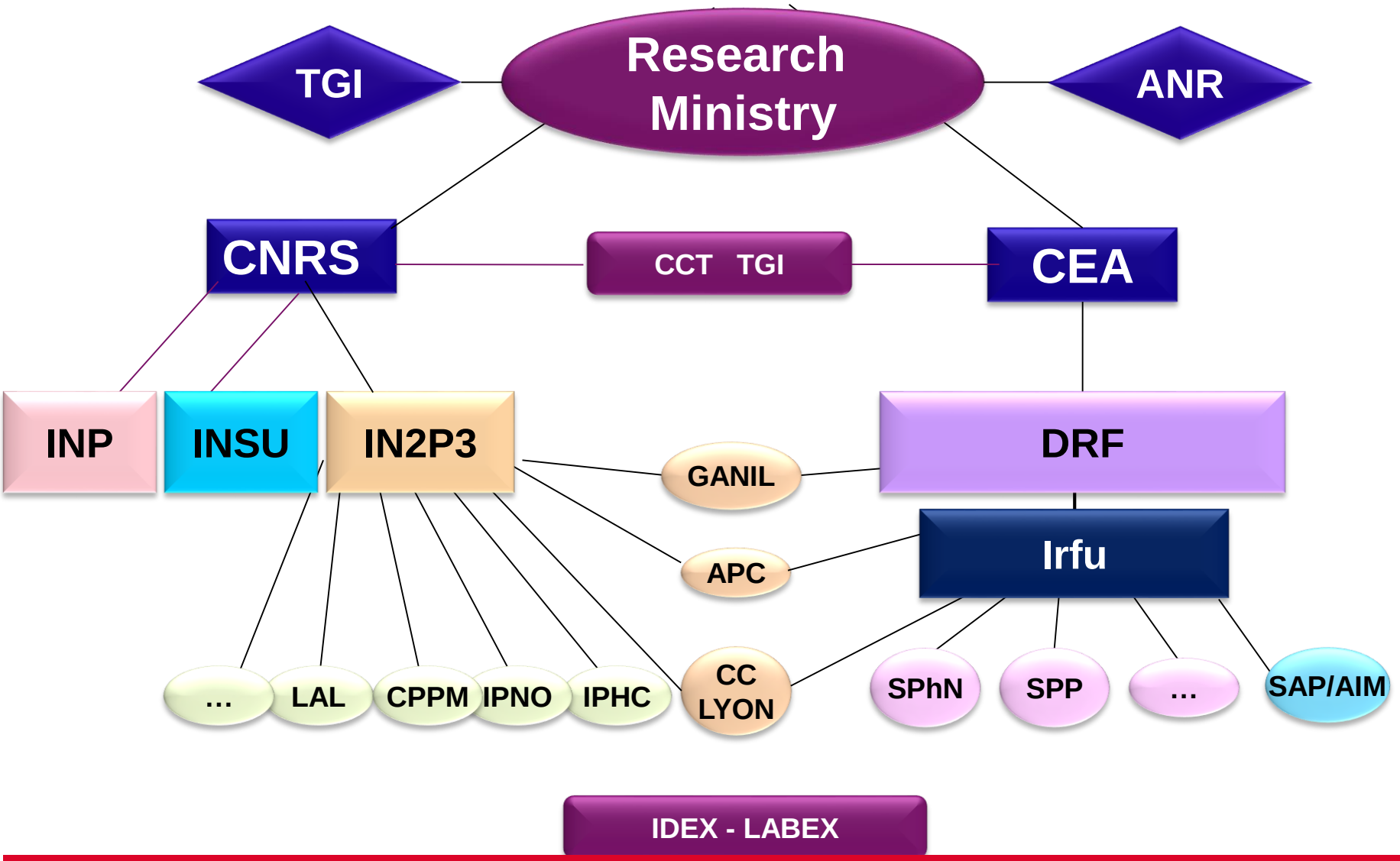
More tomorrow during the *Directorate meeting*



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IRFU RECENT INTERNAL EVOLUTIONS

Head of Institute

Anne-Isabelle Etienvre

Assistant: Josiane Parnas

Deputies: Nicolas Alamanos
Marie-Cécile Aubert

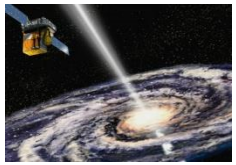
Larsim
Research on sciences matter lab
Etienne Klein

Assistants

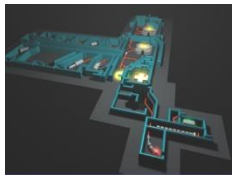
QSE*	Erick Blanchard
Project	Emmanuelle Bougamont
Communication	Sophie Kerhoas-Cavata
Budget	Nathalie Judas
Europe Programs	Sylvie Leray
Industrial Parterships	Christine Porcheray
Human Ressources	Christine Tiquet

Delegates

Computing & Simulation	Allan-Sacha Brun
Evaluation	Pascal Debu
Safety	Erick Blanchard
Computing ressources	Shebli Anvar
PhD Students	Jérôme Rodriguez



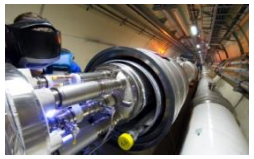
SAp
Astrophysics and
Space Technologies
Anne Decourchelle
Dep. Head: Pascale Delbourgo



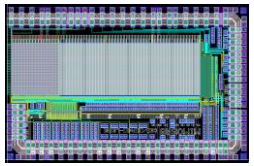
SPhN
Nuclear Physics
Héloïse Goutte
Dep.Head: Jacques Ball

SPP
Particle Physics
Gautier Hamel De Monchenault
Dep. Head: Georges Vasseur

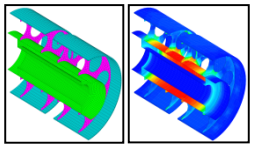
SACM
Accelerators, Cryogenics
and Magnetism
Pierre Védrine
Dep. Head: Ph. Brédy / O. Napoly



Sedi
Detectors, Electronics
and Computing
Eric Delagnes
Dep. Head: Philippe Bourgeois



SIS
Mechanical Design
and System Engineering
Christian Veyssière
Dep. Head: Frédéric Molinié

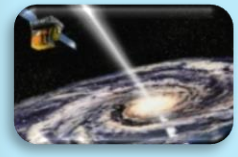


Irfu: A CEA INSTITUTE CREATED IN 1993
RESEARCH AND TECHNOLOGY

- **Research & Technology**
  - Physics: Infinitely large & small
  - Technology: Radiations

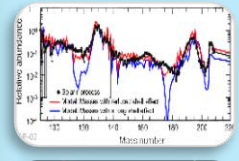
Irfu

Institute of Research into the Fundamental laws of Universe



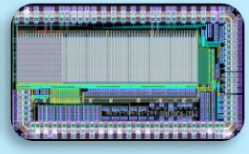
SAp: Astrophysics Space technologies

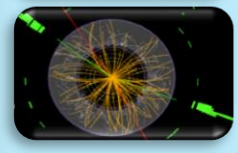
SACM: Accelerators, Supra. Magnets



SPhN: Nuclear Physics

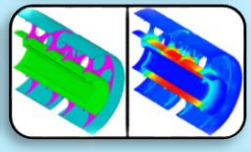
SEDI: Detectors, electronic, computing



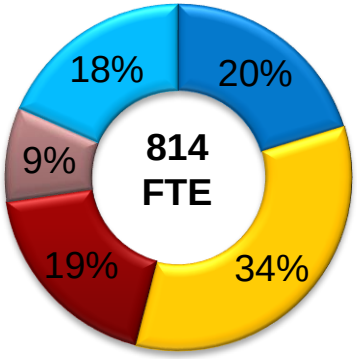


SPP: Particle Physics

SIS: Systems engineering



Irfu: LARGE CEA INSTITUTE CREATED IN 1993
RESEARCH AND TECHNOLOGY



814 FTE
632/615 CDI/CDI-CEA

- Physicists 165 FTE
- Engineers 274 FTE
- Technicians 152 FTE
- Adm. Staff 72 FTE
- PhD & Post Docs 150 FTE

- **Research & Technology**
  - Physics: Infinitely large & small
  - Technology: Radiations

Institute of Research into the Fundamental laws of Universe

116 CDI 94 CDD	**SAp**: Astrophysics Space technologies	**SACM**: Accelerators, Supra. Magnets	121 CDI 10 CDD
56 CDI 29 CDD	**SPhN**: Nuclear Physics	**SEDI**: Detectors, electronic, computing	125 CDI 11 CDD
72 CDI 45 CDD	**SPP**: Particle Physics	**SIS**: Systems engineering	97 CDI 8 CDD

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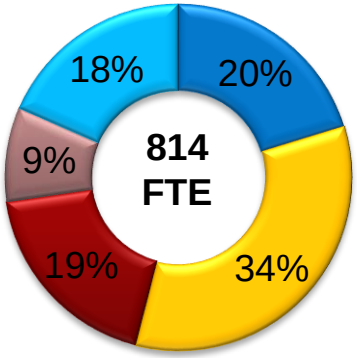

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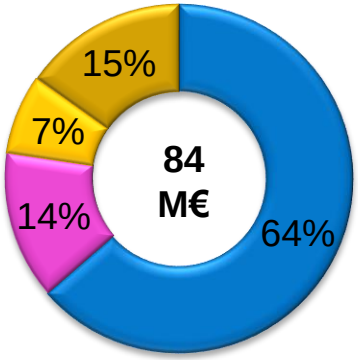
84 M€ (2012)
54 M€ Gov. Subsidies

- Gov. Subsidies 54 M€
- TGI & BA 12 M€
- CEA contracts 6M€
- External contracts 13M€



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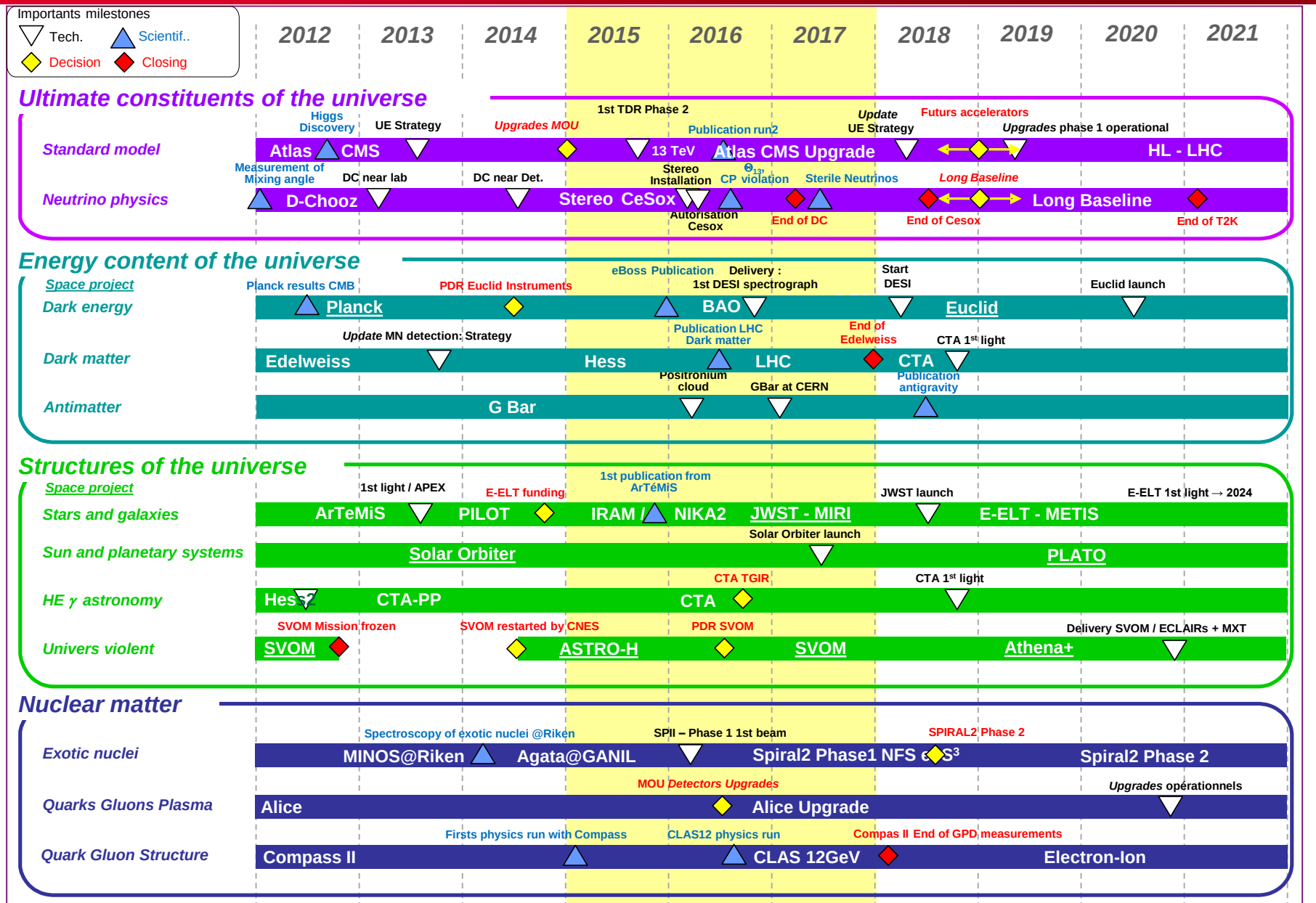
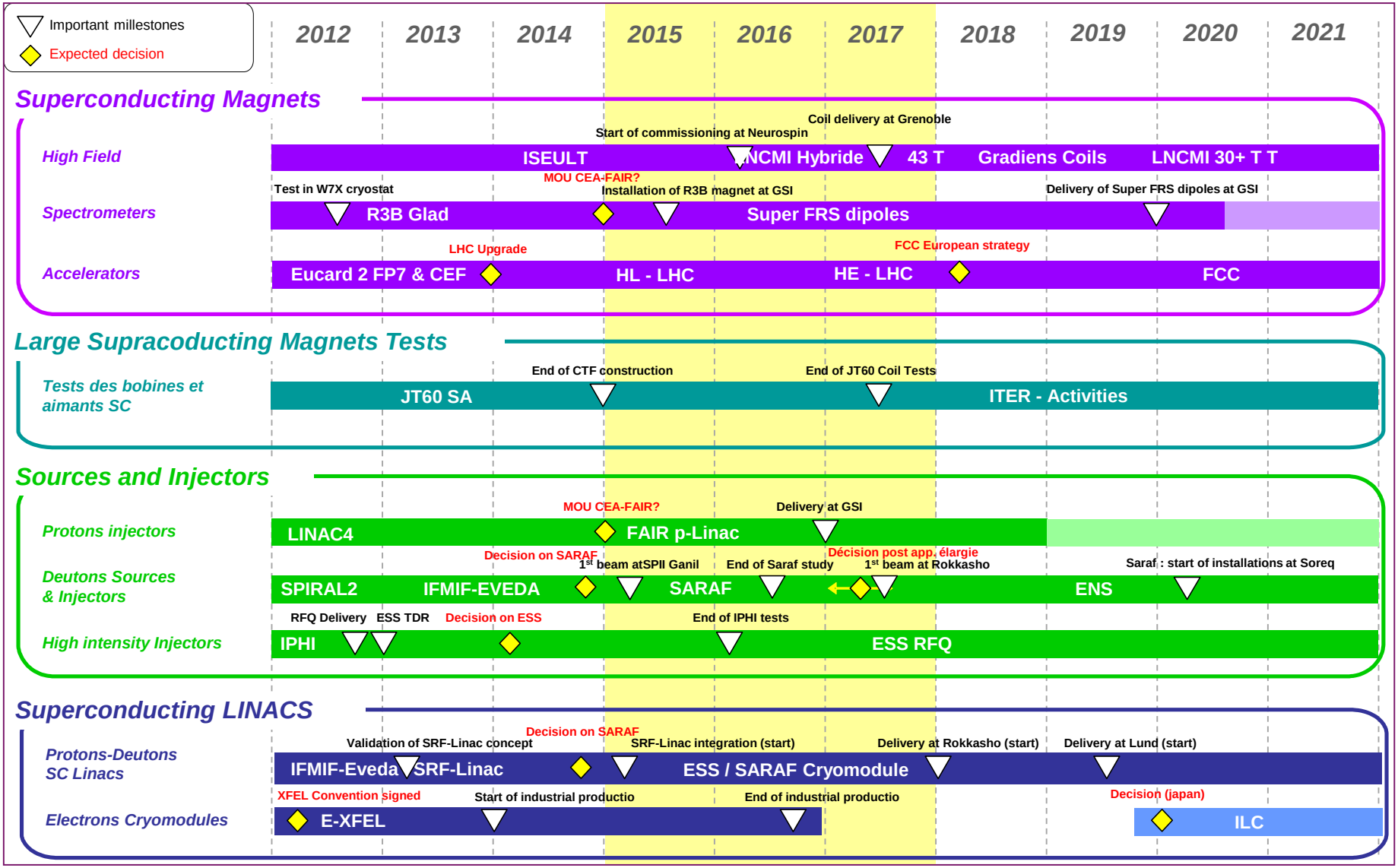
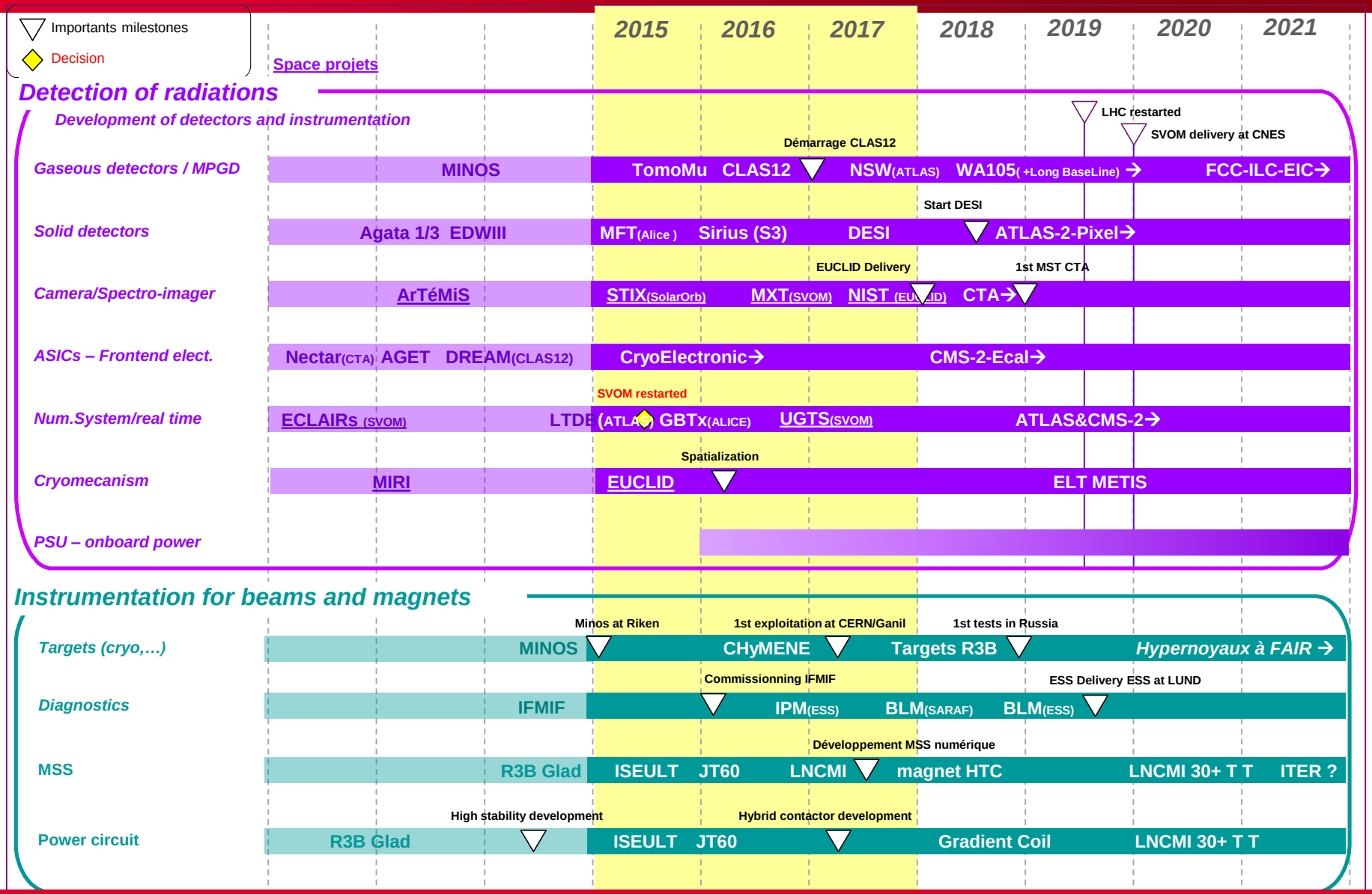
SCIENTIFIC ROADMAP



ACCELERATORS AND CRYOTECHNOLOGY ROADMAP



INSTRUMENTATION ROADMAP



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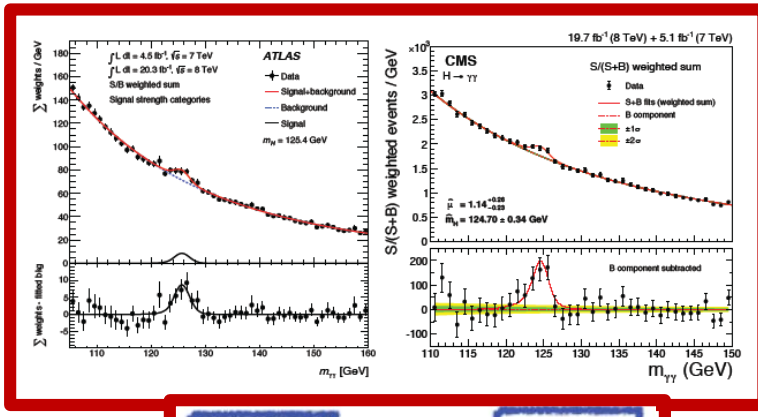
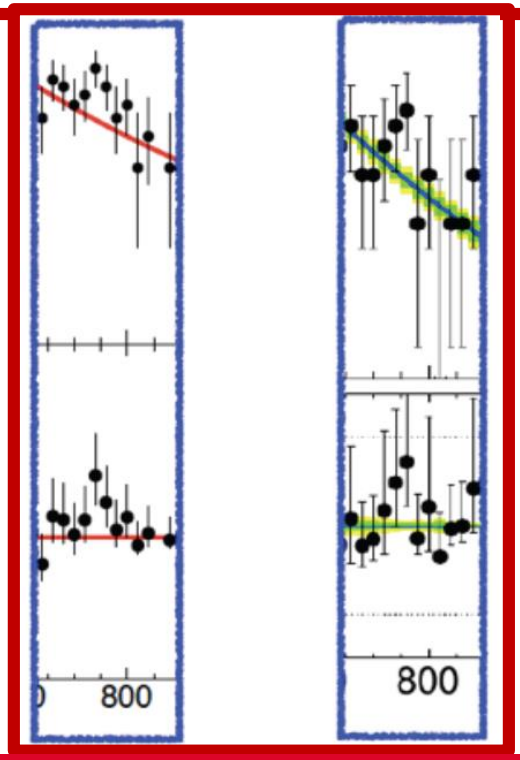
IN HEP WE ARE LEAVING EXTRAORDINARY TIMES

- Discovery of the Higgs Boson !
- Gravitational waves ?
- Fluctuations or revolution ?
- Sterile neutrinos ?
- Cosmology !
- Polarization of the cosmic microwave background (Pr. M. Hasegawa)

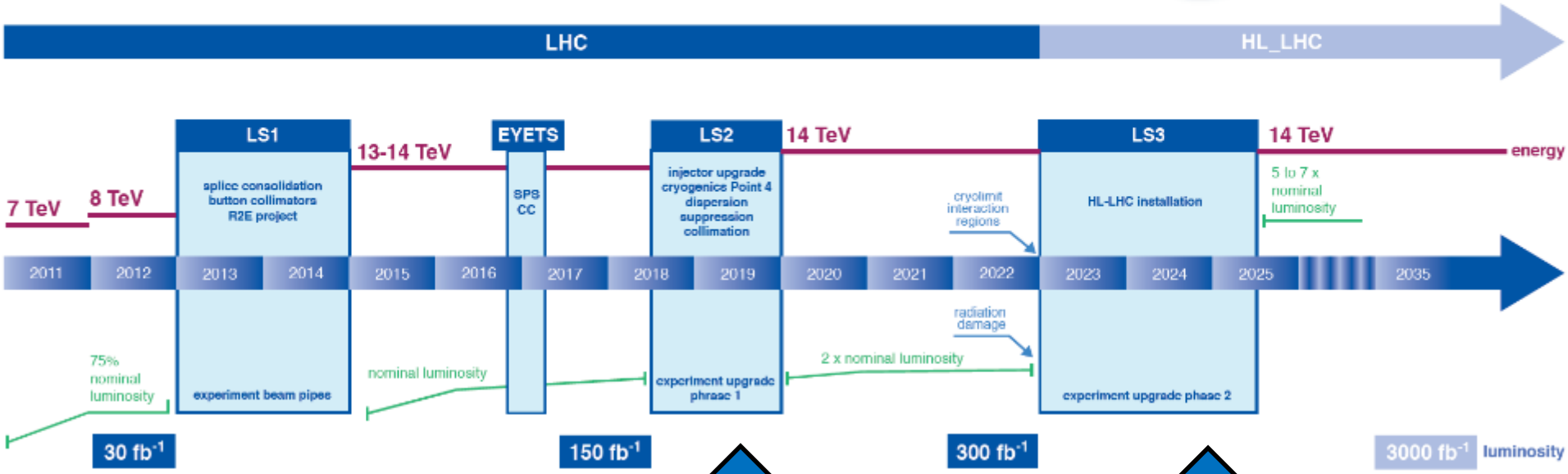


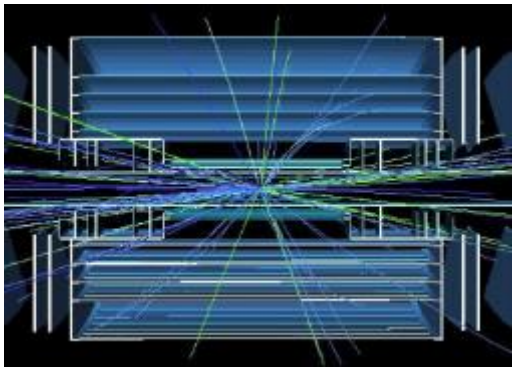


LHC-UPGRADES / COURTESY BY ERIC DELAGNES

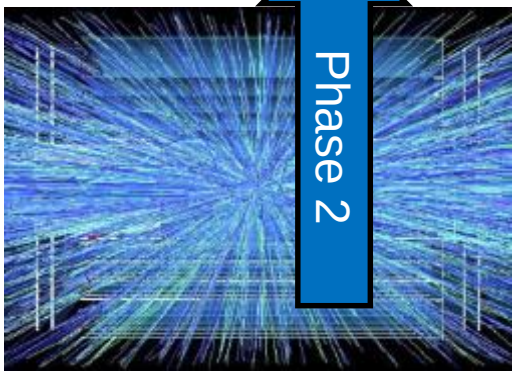
LHC / HL-LHC Plan

High Luminosity LHC





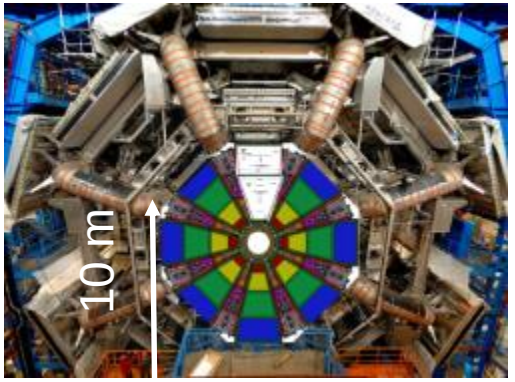
Phase 1



Phase 2

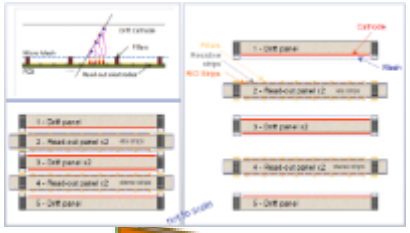
New Muon detectors in the forward region to deal with the increased luminosity:

- High flux operation
- Better Track reconstruction
- Improved fake trigger rejection
- 2 technologies (Stgc + resistive **Micromegas**)



Micromegas wheels

- 4 types of Module build by 4 sites = complex assembly
  Stack of 4 Micromegas chambers=> 5 PCBs
  Few 10 µm precision required
  More than 1000 assembly operations

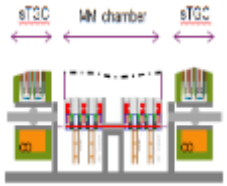


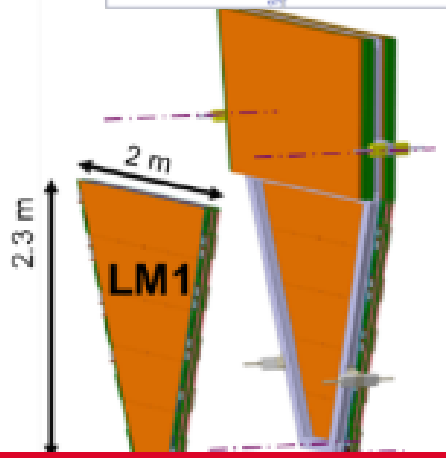
- **IRFU's commitment :**

  Design & production of (32 +2) LM1 modules

  ~ 400m^2 detection surface

- **Require special tools & Infrastructure**





ATLAS-NSW UPGRADE PHASE I / COURTESY BY E.D.

2014-2015

- Design of modules and definition of process operations
- Design of tools, including metrology
- Definition of facilities (DATCHA + clean room):
- MLO = First prototype built: Allowed to detect and solve a large number of problems for the module0

2016 => Pre-Production

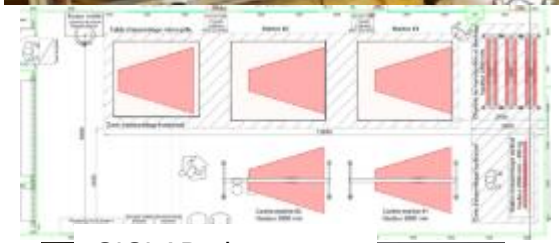
- A lot of manpower is now involved on the project
- Module 0 construction in the DATCHA facility has started Expected to be finished for fall 2016
- 130 m^2 clean room for production will be ready in Summer 2016
- End of 2106 :Start of the first production module in the clean room
- Preparation of the test infrastructure in progress (cosmic & Xray bench..)

2017-2018 => Production

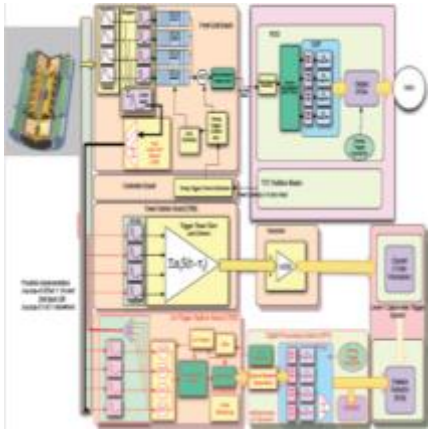
- Very tight schedule
- Challenge: build one module every 2 weeks.

DATCHA


MLO


CICLAD clean room

DIGITAL TRIGGER TOWER BUILDER BOARD FOR ATLAS CALORIMETER (UPGRADE PHASE 1)



Increased luminosity => better granularity to build trigger:

- Compatibility with existing (TBB) trigger system
- Analog => Analog-Digital mixed mode system
- ~300 ADC channels/ board => 200 Gbit/s throughput

Demonstrator board designed and tested in 2014-2015:

- French (digital mezzanines) vs US design (analog mezzanines)
- Both proven & taking data @LHC

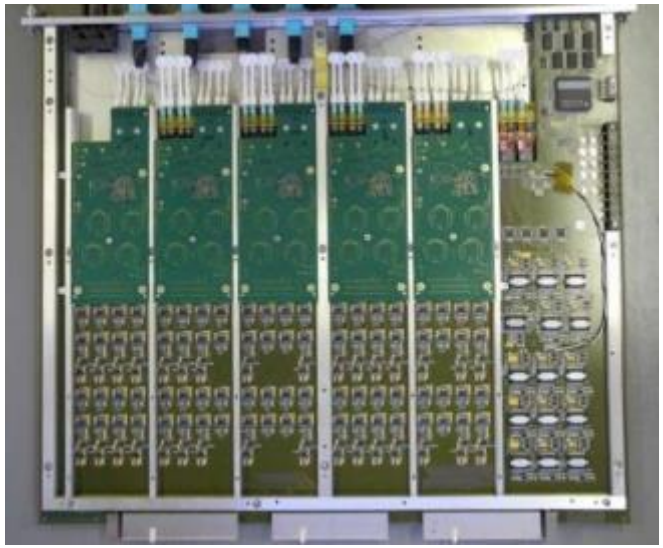
2016 : design of the final board

- Joint design Saclay/Brookhaven
- Rad-hard

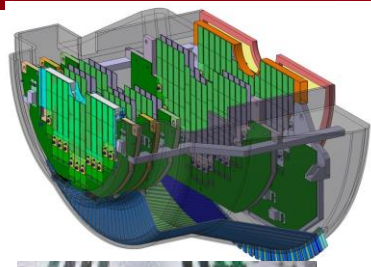
- ***Irfu's comitments :***

  Test bench

  Production of ~150 boards (2017-2018)

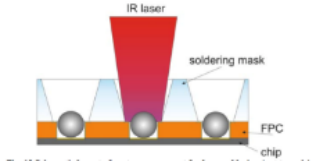


UPGRADE ALICE (PHASE 1) (SEE TALK G. BATIGNE)



MFT : Silicon tracker (MAPS) upstream the ALICE DiMuon arm

- 2014-2015:succesful R&D on PIXAM chip
  => decision to move to a solution common with ITS
- 2015-2016 : Contribution to the design of the final ALPIDE chip
- 2016-2018: Responsibilities :



Production & postprocess of chips

Chips soldering on ladders (@ CERN)

Dimuon Arm Electronics

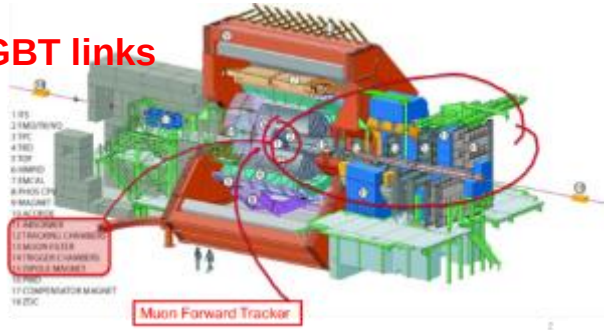
- Totally new « SAMPA » electronics
- **IRFU/Sédi involvement:**

Rad Hard concentrator boards « SOLAR » with high speed digital GBT links

2016 : prototype design

2017 : Manufacture & test of 600 boards

Firmware of the Back-end electronics receiving the data from SOLAR



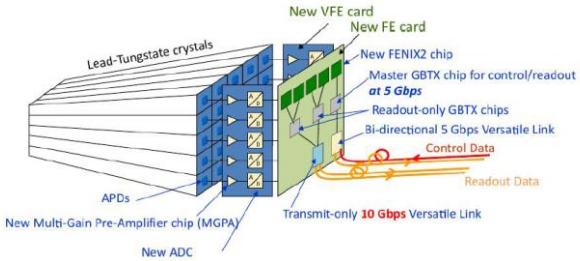
BEGINNING OF THE R&D FOR LHC-UPGRADE PHASE2

CMS ECAL:Barrel (historical involvement)

- VERY FRONT-END ELECTRONICS : HOW TO KEEP A GOOD ENERGY RESOLUTION WITH AGED CRYSTALS, LEAKY APDS, AND INCREASED PILEUP

Design of a chip prototype in progress

=> Collaboration meeting in Saclay last week

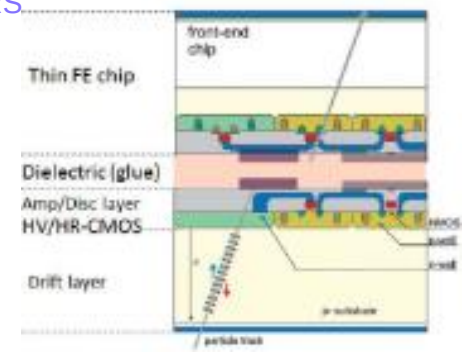


CMS HGCAL:

- CLOCK DISTRIBUTION (10 PS PRECISION) :

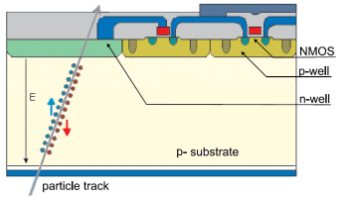
TIMING WILL BE A KEY MEASUREMENT PARAMETER FOR THE UPGRADED DETECTORS

- JET TRIGGER
- TIMING MEASUREMENT IN THE VFE CHIP ?



ATLAS pixel tracker : (New involvement)

- HVCMOS SENSOR (CONTINUATION OF MAPS R&D, BUT FASTER)
- MAJOR CONTRIBUTION TO A PROTOTYPE CHIP USING LFOUNDRY PROCESS (HYBRID HVCMOS TECHNOLOGY).
- COST EFFECTIVE & RAD-HARD



Timing detector (ATLAS forward region)

- R&D ON TIMING MICROMEGAS & HVCMOS

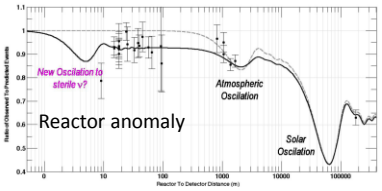
STEREO: LAST MMINUTE NEWS…

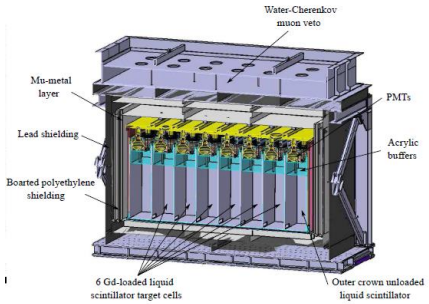
TUESDAY (10/05/2016)

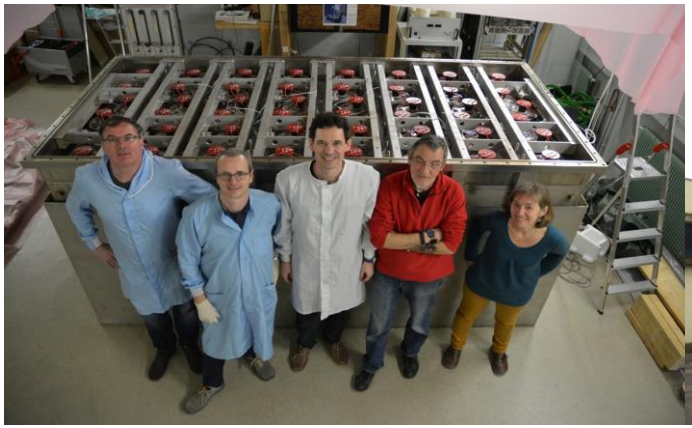
Search for sterile neutrino @ ILL nuclear reactor (Grenoble)

- OBSERVATION OF SHORT DISTANCE $\overline{\nu}E$ OSCILLATION
- DETECTOR SEGMENTED IN 6 CELLS:
  - TOTAL VOLUME OF $2M^3$
  - FILLED WITH GD LOADED SCINTILLATING LIQUID (INVERSE β DECAY)
  - LIGHT READ WITH PMT
  - ACTIVE VETO TO IMPROVE BACKGROUND REJECTION
- R&D 2014-2105 => CONSTRUCTION IN 2016
- DATA TAKING: SEPT 2016

Physics Case







Integration @LPSC Grenoble (Apr 2016)

the detector is inside the ILL reactor building since last Tuesday (10/05/2016)

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- *The IRFU organization – the Divisions*
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- *Magnet and Accelerator constructions – last six months highlights*

Some projects : Magnets and Accelerators

Last 6 months highlights

- *The SPIRAL2 project (NΦ)*
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- *IFMIF EVEDA (Fusion)*
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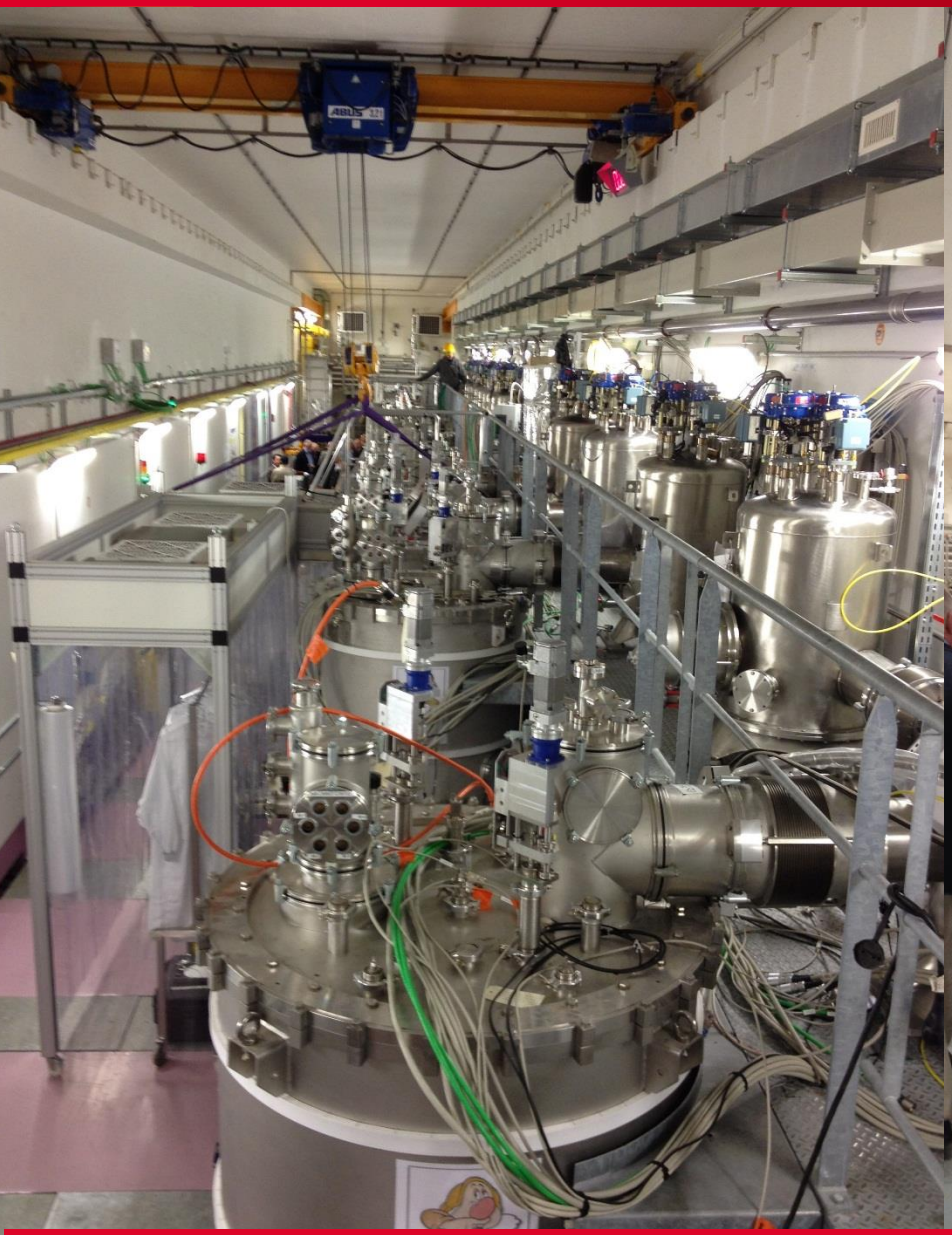
- *XFEL (Prefiguration of the construction of the ILC)*
- *CERN (FCC,…)*

COMMISSIONING OF SPIRAL2

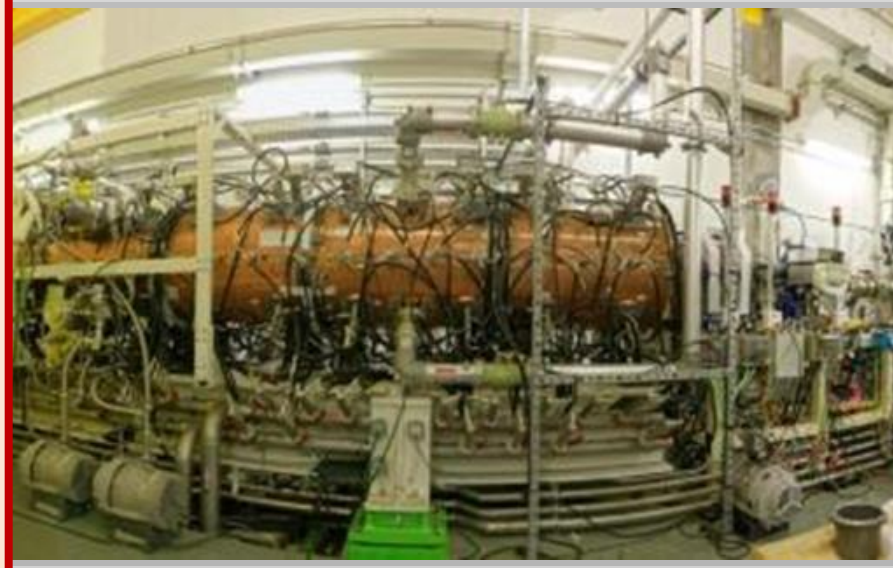


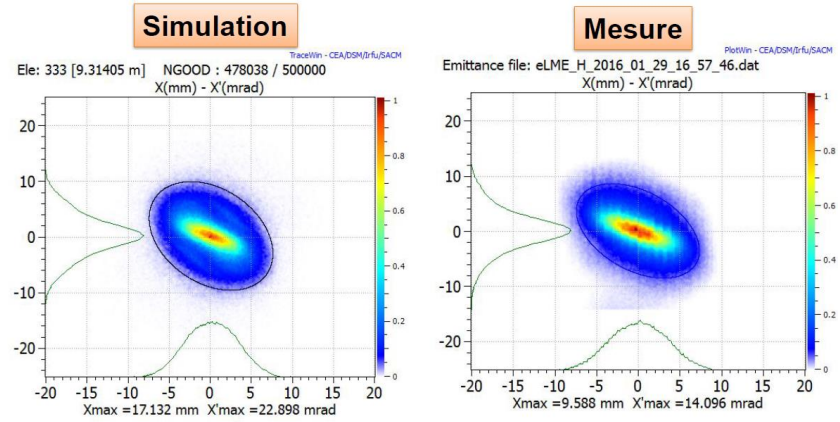
COMMISSIONING OF SPIRAL2

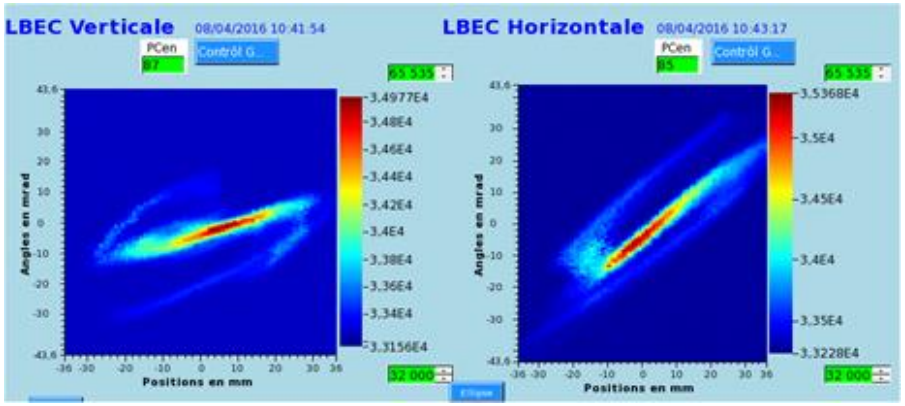
COMMISSIONING OF SPIRAL2 / RFQ

First beam in RFQ 3/12/2015

- Emittance measurements in good agreements with simulations
- Next steps Deuteron, $^{18}O^{6+}$, $^{58}Ni^{19+}$ (Q/A=1/3)

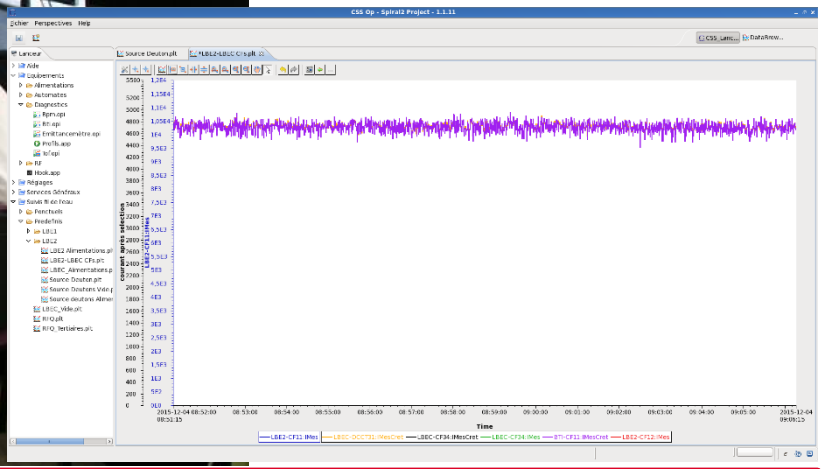






COMMISSIONING OF SPIRAL2

The 3 of December 2015 a proton beam (5mA) was injected into the RFQ



…….. Thus, at 9:00 –(3/12/2015) we have started ….. a few hours later a 5 mA proton beam was injected into the RFQ. Quickly after 100% of the beam was extracted ……. under the expected setting conditions .....

Some projects : Magnets and Accelerators

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SARAF TLR : beams: p, and d (5mA, 40MeV)

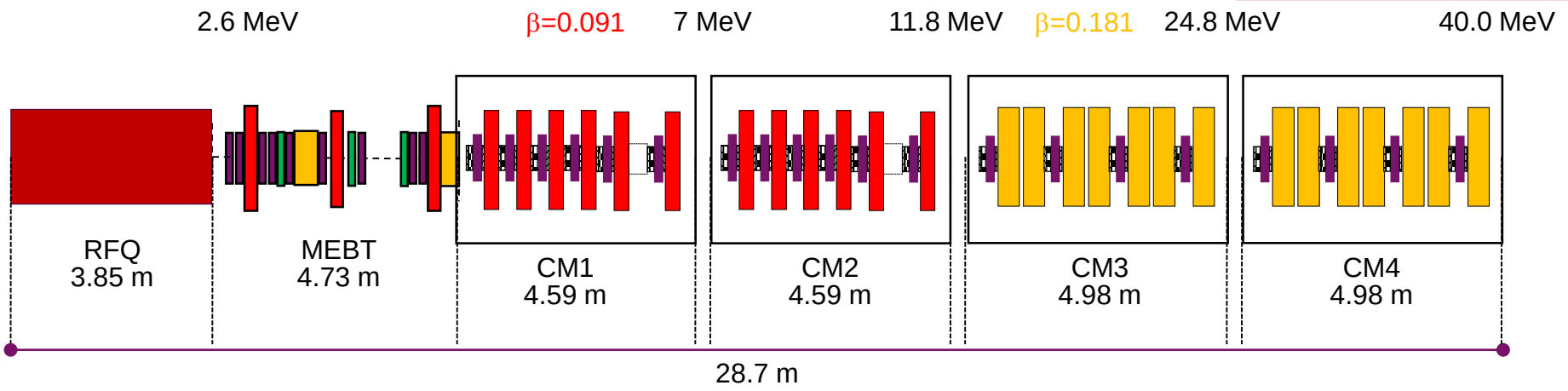
=> Replace the existing reactor

THE SARAF 2 PROJECT
SOREQ APPLIED RESEARCH ACCELERATOR FACILITY

An Israeli project of an accelerator based neutron source to replace a nuclear reactor

- Irfu responsible for the superconducting Linac
- Commissioning in 2022

Deutons /protons
40 MeV
5 mA CW
Be / Li targets
200 kW
2 10^{15} n/s



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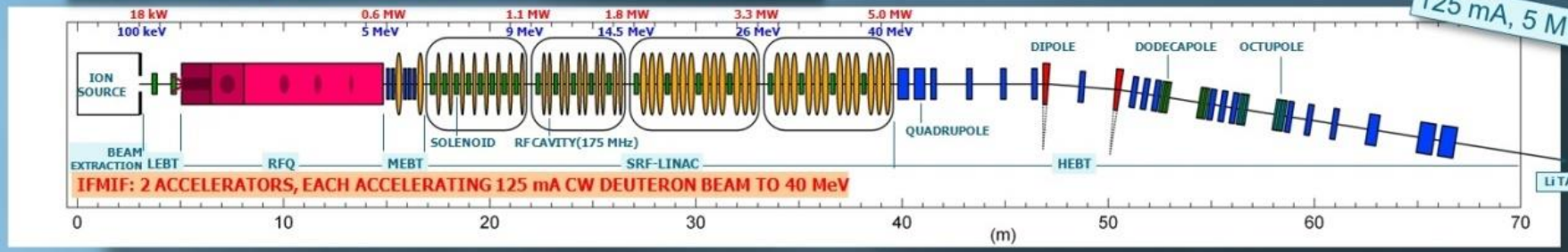
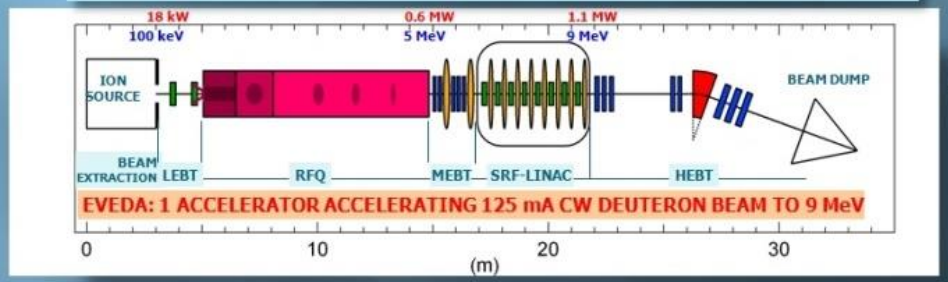
INTERNATIONAL FUSION MATERIALS IRRADIATION FACILITY



125 mA, 5 MW

ENGINEERING VALIDATION ENGINEERING DESIGN ACTIVITY

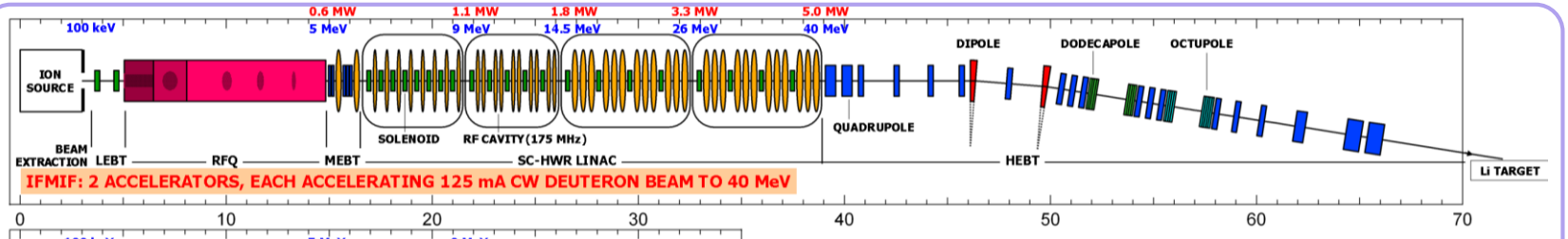


125 mA, 1 MW

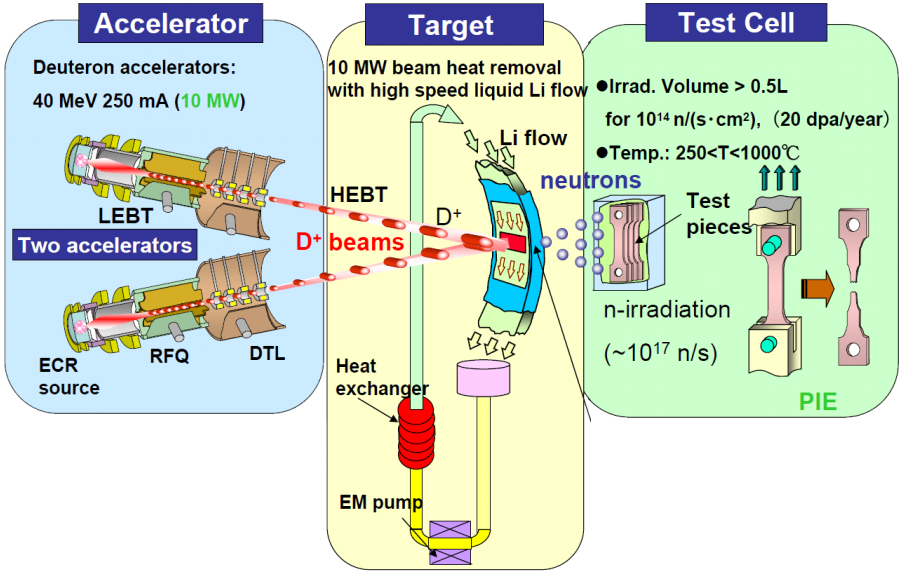
Being constructed

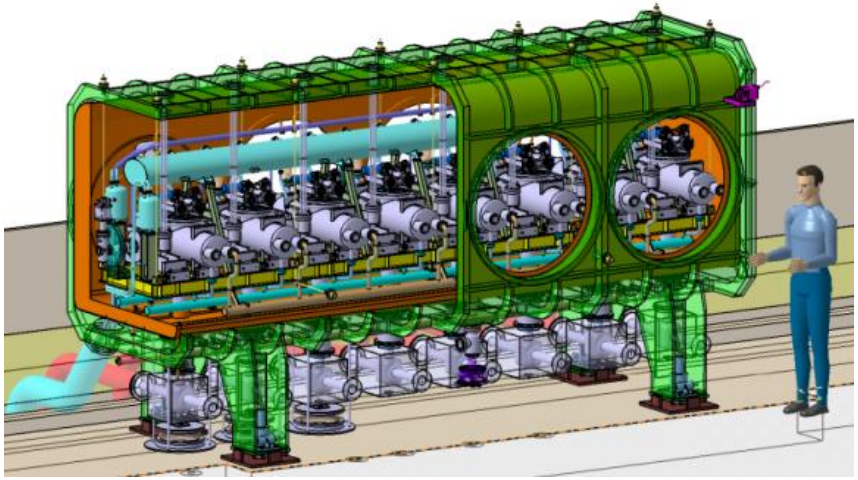
Involvement of CEA Saclay in IFMIF-EVEDA

IFMIF Accelerator



IFMIF-EVEDA Prototype Accelerator





Inauguration at Rokkasho 21/04/2016

Some projects : Magnets and Accelerators

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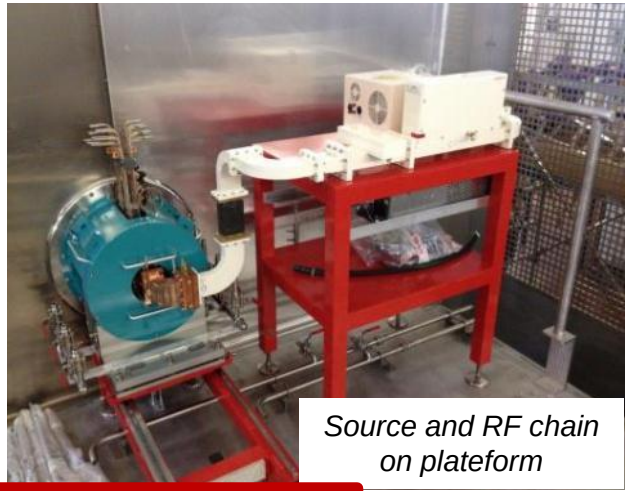
FAIR PROTON LINAC INJECTOR INSTALLED AT SACLAY

- Ions source, RF chain and accelerating column installed on HV platform

H^+ beam,
100 keV
100 mA total
70 mA after cone
PULSED ONLY

FAIR LEBT



Source and RF chain on plateform

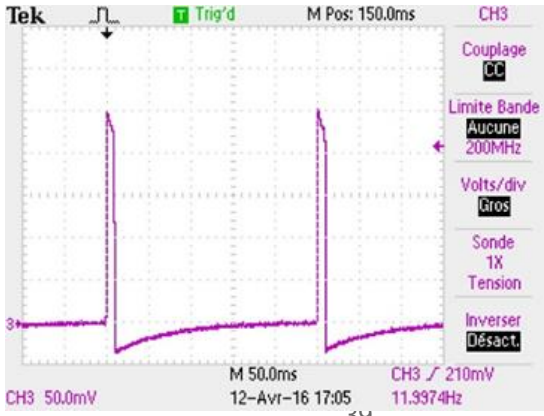
First beam extraction test performed with a 3mm diameter plasma electrode

1st 500A/50V power supply for LEBT solenoids available
Reception of the 2nd power supply in April/May

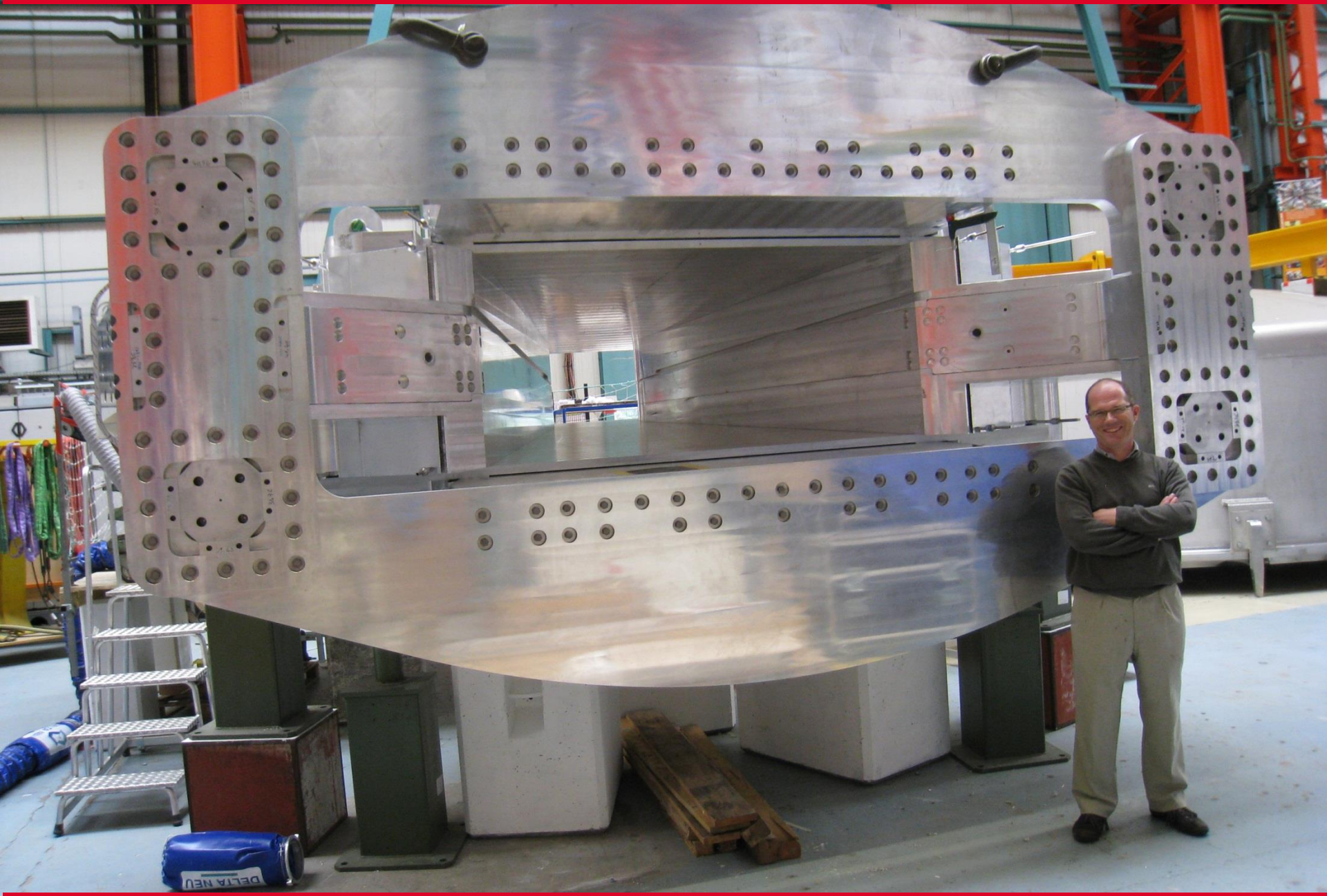
Ready to start the test of the injector.

Pulse 5ms @4Hz

I_{ext}=7,5mA@35kV



The GLAD magnet was delivered at GSI November 2015



THE GLAD MAGNET LEAVING SACLAY - ARRIVING AT GSI

(NOVEMBER 2015)

THE GLAD MAGNET LEAVING SACLAY - ARRIVING AT GSI

(NOVEMBER 2015)

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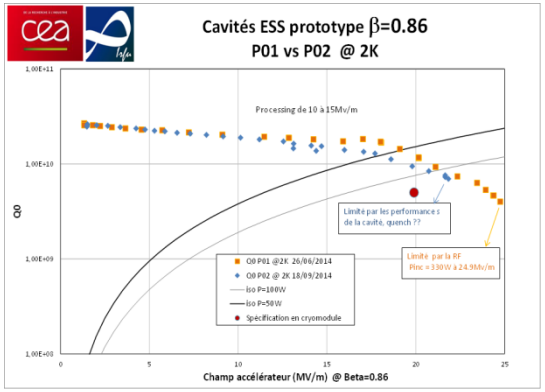
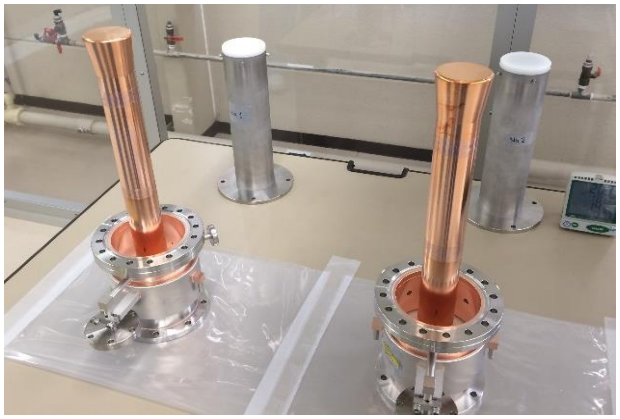
ESS CRYOMODULES

- 704 MHz high beta cavities: the two prototypes have been tested and are above the ESS specifications



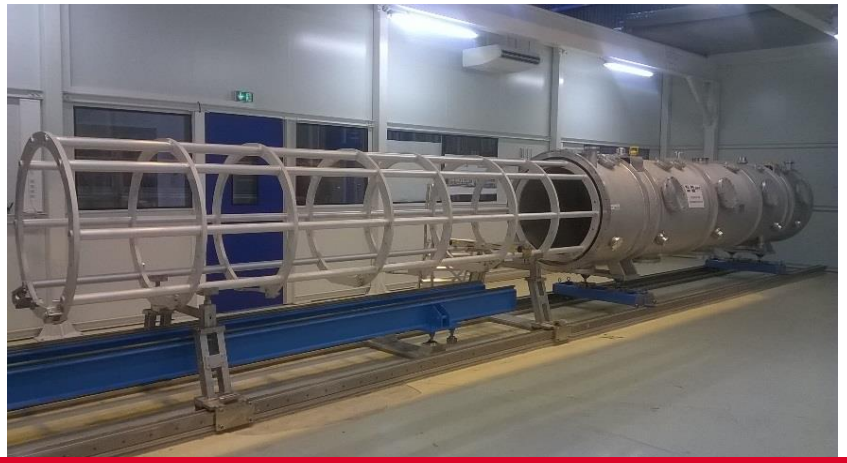
- 704 MHz coupler : first tests at 1.1 MW in pulsed mode are expected in june 2016



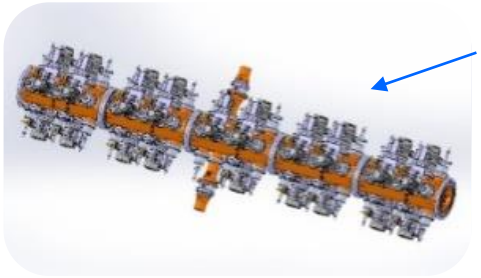
- 704 MHz medium beta cavities

the first test at 2K of the 1st cavity has revealed a problem of "100 K" effect (Q-desease), the hydrogen degassing heat treatment at 600 ° C is expected to achieve performance

- Vacuum vessel and spaceframe: integration testing and blank assembly are underway at CEA

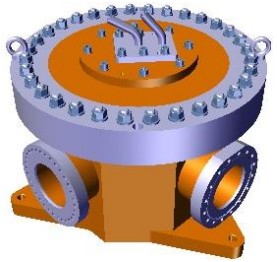


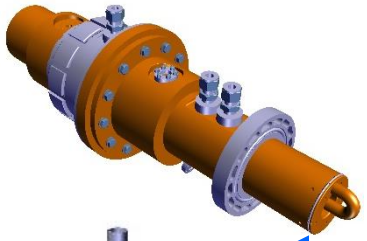
ESS RFQ



RFQ:

- RFQ Critical Design Review with ESS in December 2015:
- ESS agreement to launch the call for tender.
- Offers received, order in preparation





Test Cavity de test et pièces auxiliaires

- AO publié 27/11/15, Plis ouverts le 26/01/16
- Réunions de négociation en cours

Couplers

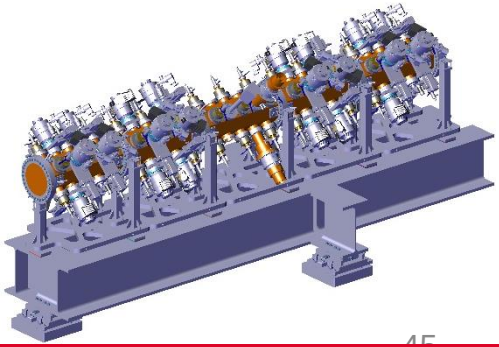
- Offers received. Contract to be placed

Tuners

- Prototype in production – Delivery
- Call fo r tender Finalisation CdC nécessaire pour AO à lancer mi février

RFQ support

- Design ongoing



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THE EUROPEAN XFEL CRYOMODULE PRODUCTION

Integration of XFEL cryomodules (Saclay)

- Each cavity string contains 8 cavities, 8 RF couplers , one quadrupole, one BPM and two vacuum valves

Transfer of cryomodule in clean room roll-out area

Transfer of cryomodule in RF coupler assembly area

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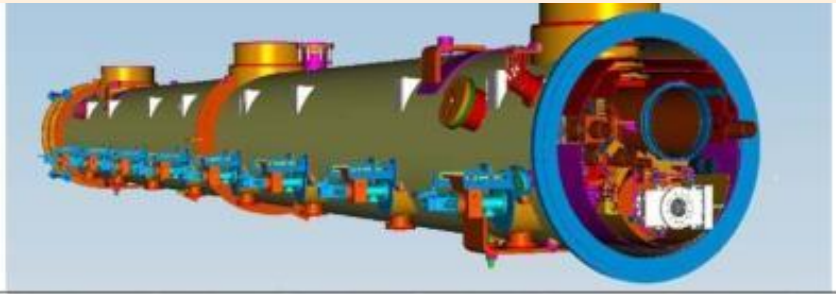
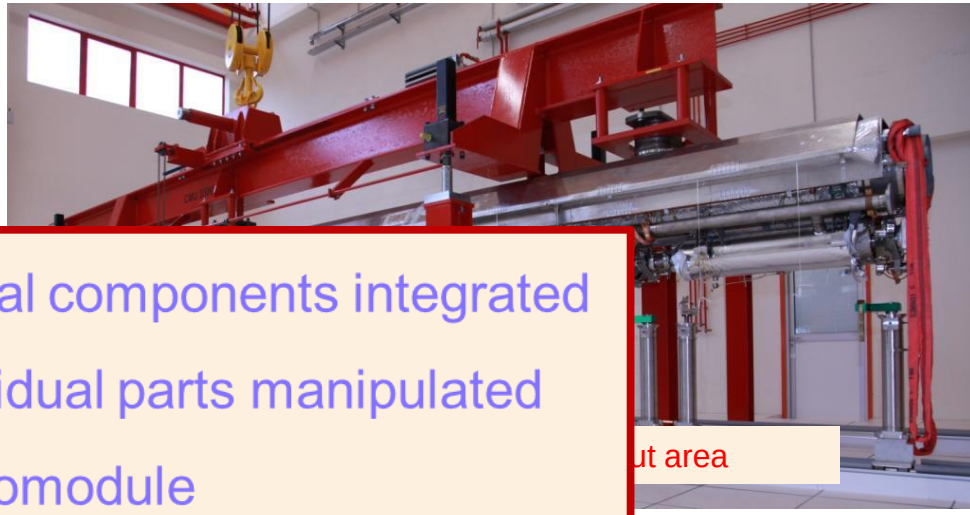
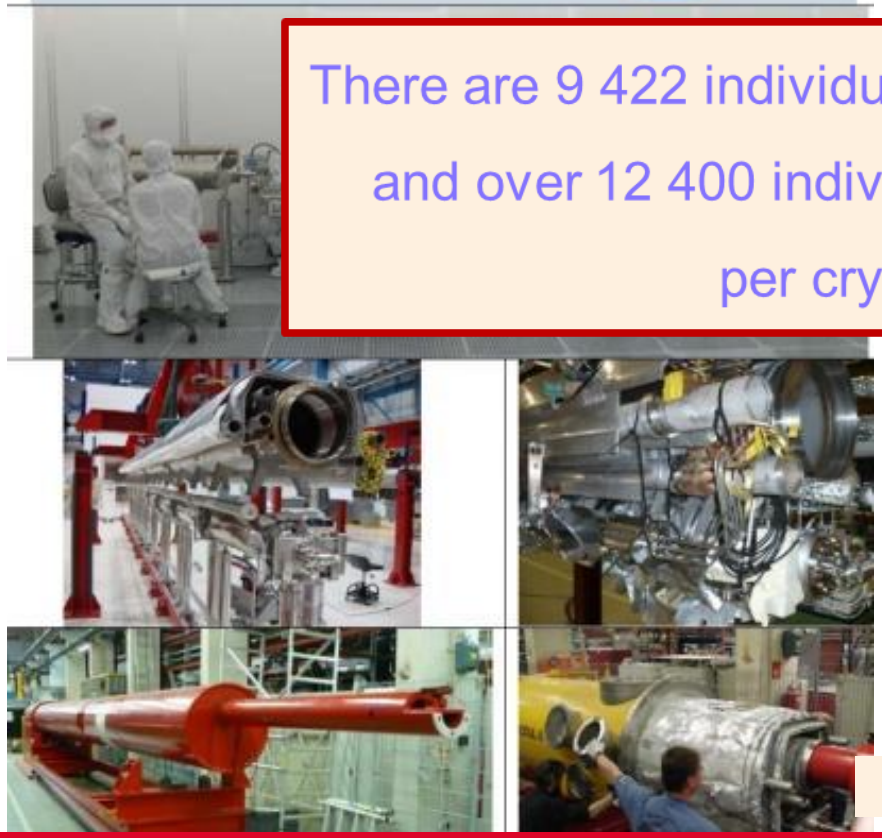




ut area

There are 9 422 individual components integrated and over 12 400 individual parts manipulated per cryomodule

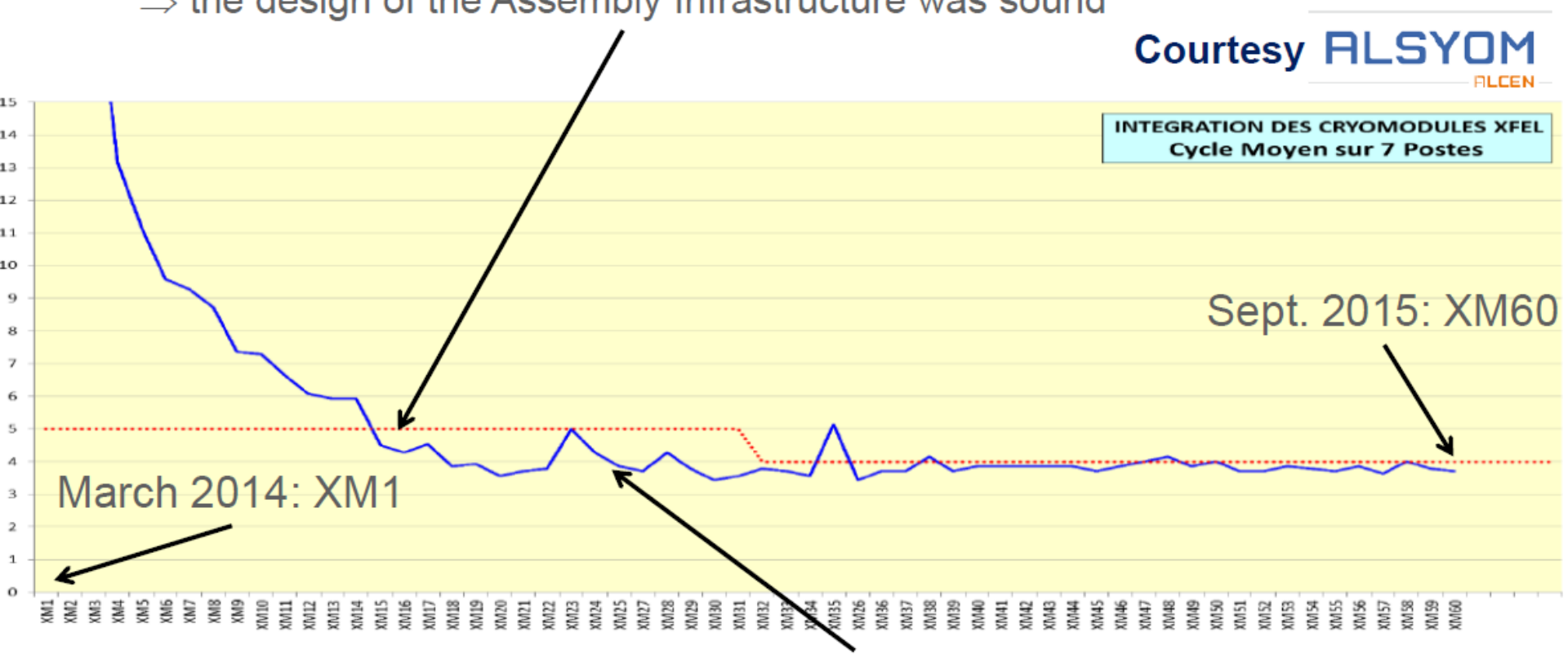


Transfer of cryomodule in RF coupler assembly area

PRODUCTION RATE

- 5 day throughput was reached **mid-October 2014** with **XM15**
  ⇒ the design of the Assembly Infrastructure was sound

Courtesy ALSYOM ALCEN



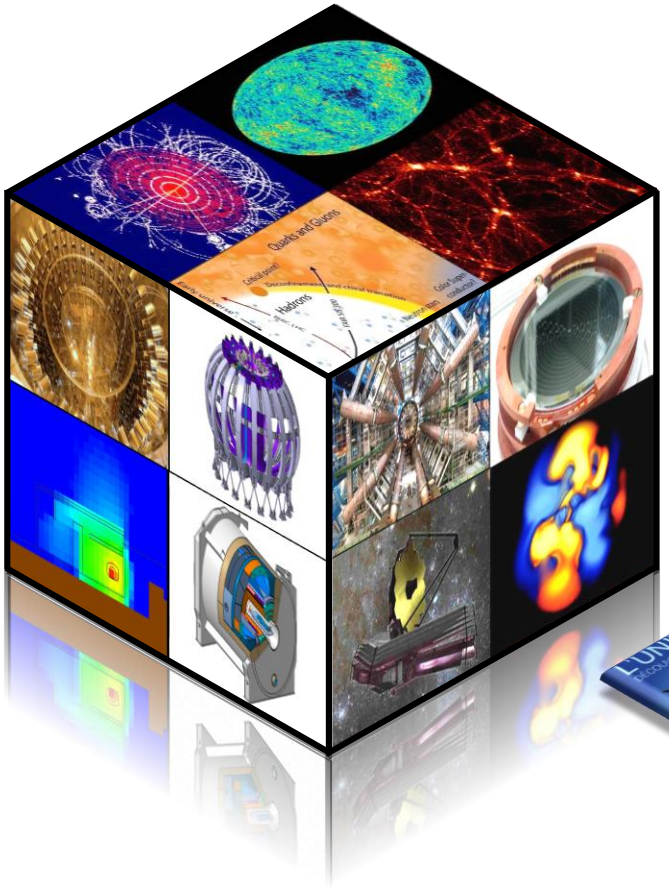
4-day throughput was reached **in January 2015** with **XM25**

In May 2016: 96 cryomodules have been delivered.

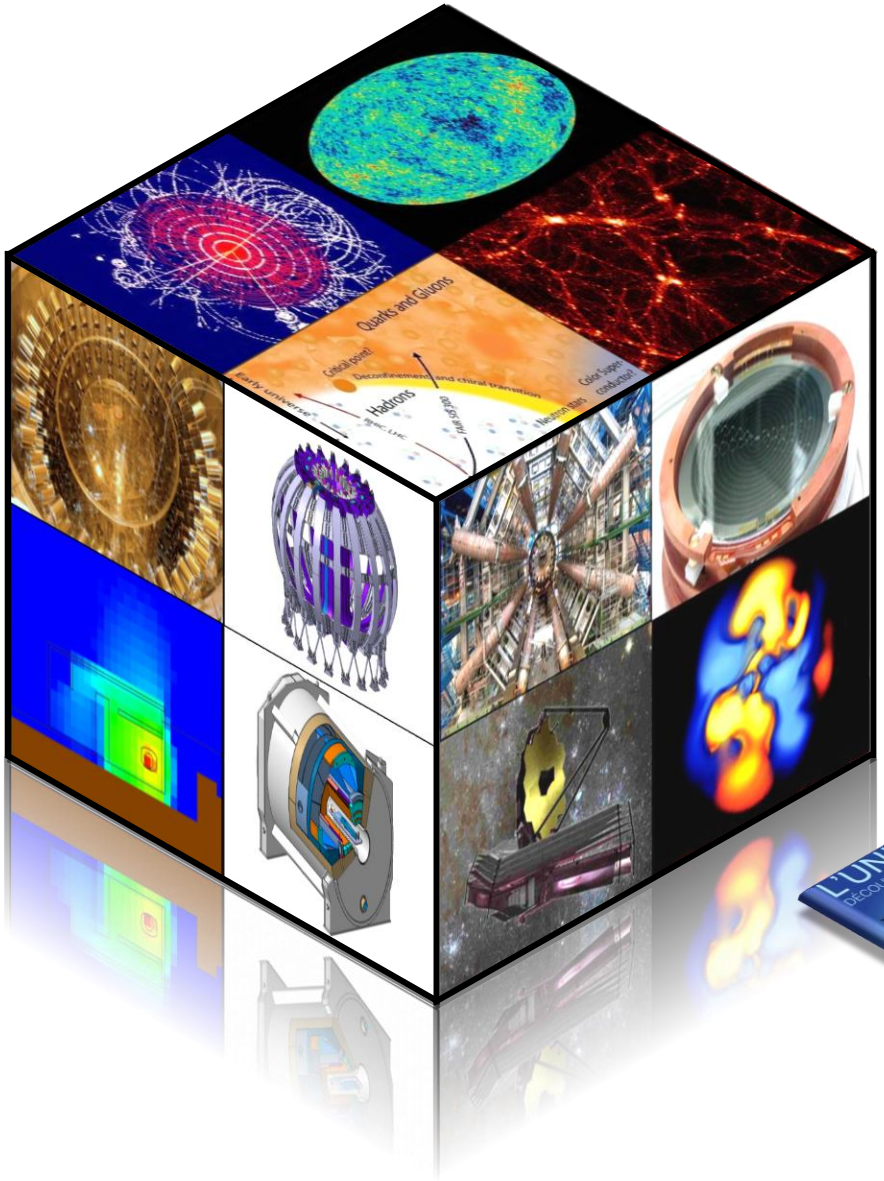
An average accelerating field of 27,6 MV/m was obtained , well above (~17%) the specification.

The end of the integration is foreseeing before summer with the assembly and delivery of cryomodule XM100.

A Celebration of the end of the project will be organized



Thank you for your attention


Quarks and Gluons
Hadrons
Deconfinement and chiral restoration
Color superconductor
Early universe
Neutron stars

Irfu


L'UNIVERS
DÉCOUVREZ SES MYSTÈRES
ANNÉE MONDIALE DE L'ASTRONOMIE
2009