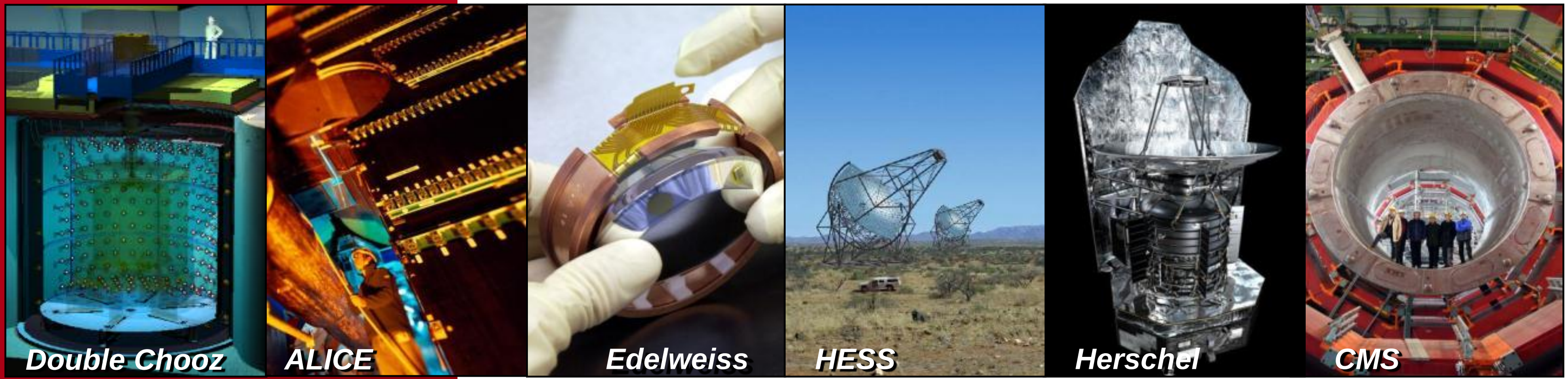
DE LA RECHERCHE À L'INDUSTRIE

2ND IRFU SCIENTIFIC COUNCIL

SYSTEM ENGINEERING DIVISION

OVERVIEW & PROGRESS SINCE 2013



Detecting radiations from the Universe.

F. ARDELLIER

January, 2015

www.cea.fr

1. Overview of SIS division :
   Missions, activities, skills & projects implications

2. Mechanical engineering activities
   1. Overview
   2. Future challenges
   3. Main progresses 2013-2015
   4. R&D

3. Instrumentation & Control Systems
   1. Overview
   2. Future challenges
   3. Main progresses 2013-2015
   4. R&D

4. Conclusion & Perspectives

Missions

Design

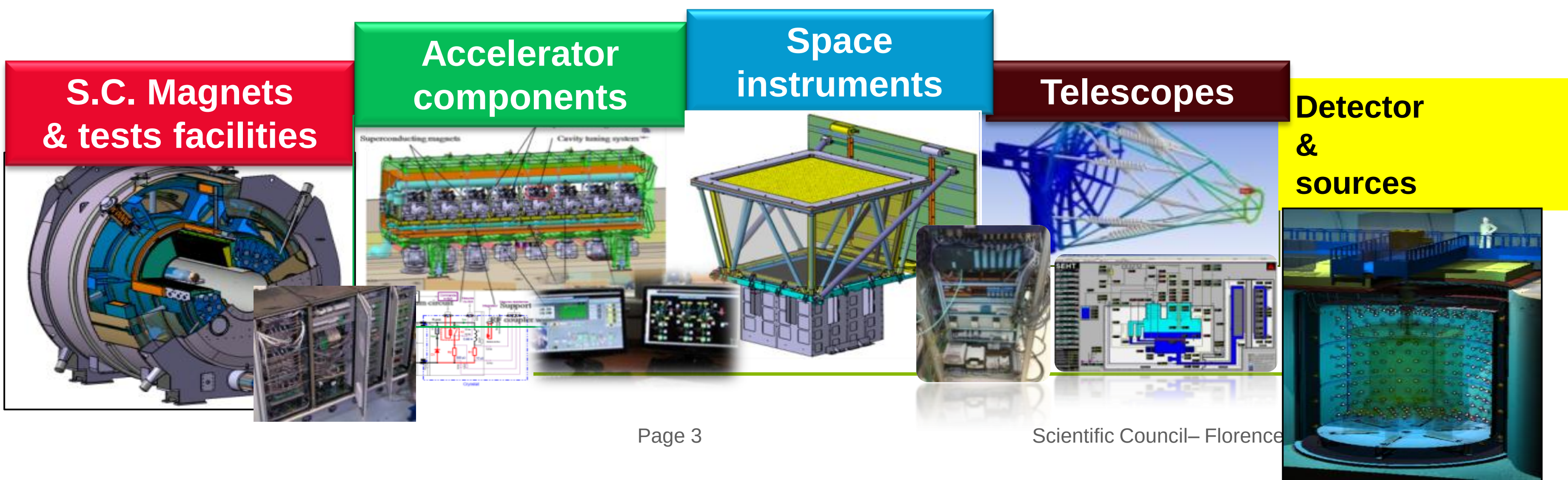
Development

Deploy and maintain

Innovative & complex instruments for Physics applications

Mechanical Engineering

Instrumentation & Control



ACTIVITIES

Mechanical Engineering

- Simulation & modeling
- Design, CAD
- Engineering support & industrial follow-up

Instrumentation & Control

- Measurement systems & instrumentation
- Command Control, remote supervision
- Electronics for experiments controls : Power Supply, MSS,..
- Electrical Engineering & Integration

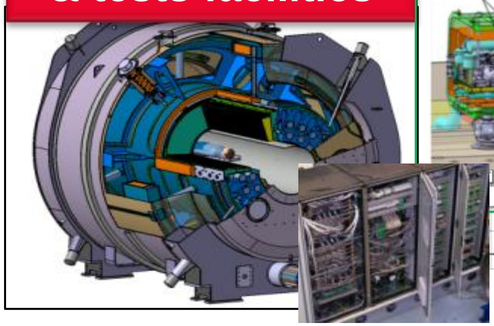
S.C. Magnets & tests facilities

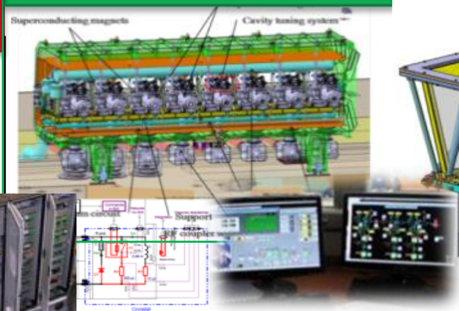
Accelerator components

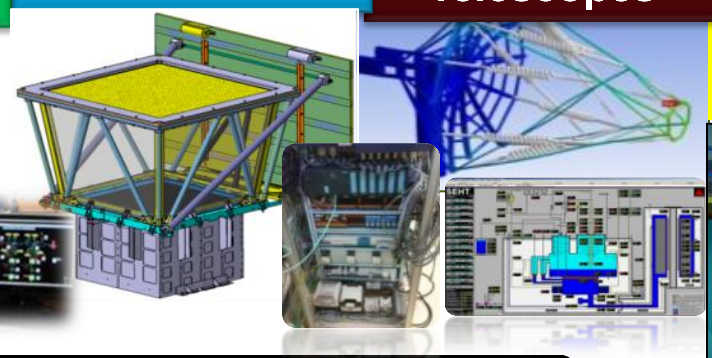
Space instruments

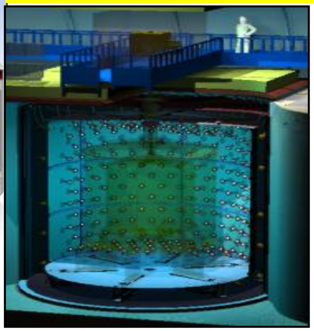
Telescopes

Detectors & Sources





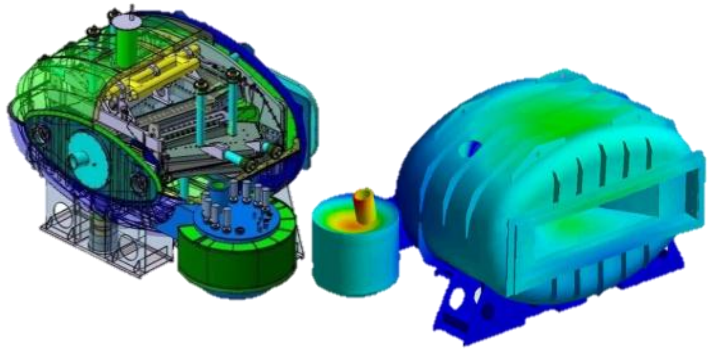




Generic & specific developments

SIS TEAMS : 100 PERMANENTS WITH VARIOUS SKILLS …

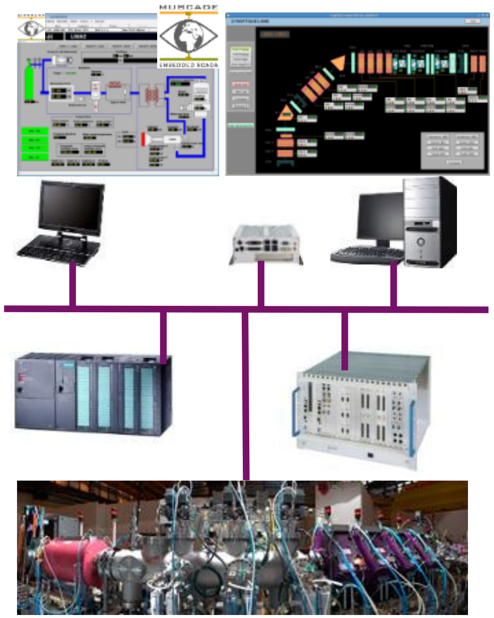
Mechanical Design



R3B magnet mechanical design :
cold mass & vaccum vessel

Industrial realisation follow-up

Control Systems & Process



SPIRAL 2 injector

Electronics for controls

Prototype of ICOS measurement station

Electrical Engineering & Integration

DIRECTION

F. Ardellier (head)

F. Molinié - (Deputy)

DIVISION ORGANISATION

Staff :
57 engineers, 42 technicians

LCAP
Mechanical Design
Bld 123

P. Manil

D. Leboeuf

LRI
Engineering support & industrial follow-up
Bld 123

V. Hennion

LDISC
Control Systems developments
Bld 472 / 484

G. Durand

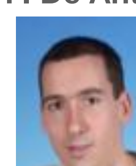
J. Belorgey

LEI
Electronics for Instrument Controls
Bld 472

P. De Antoni

S. Sube

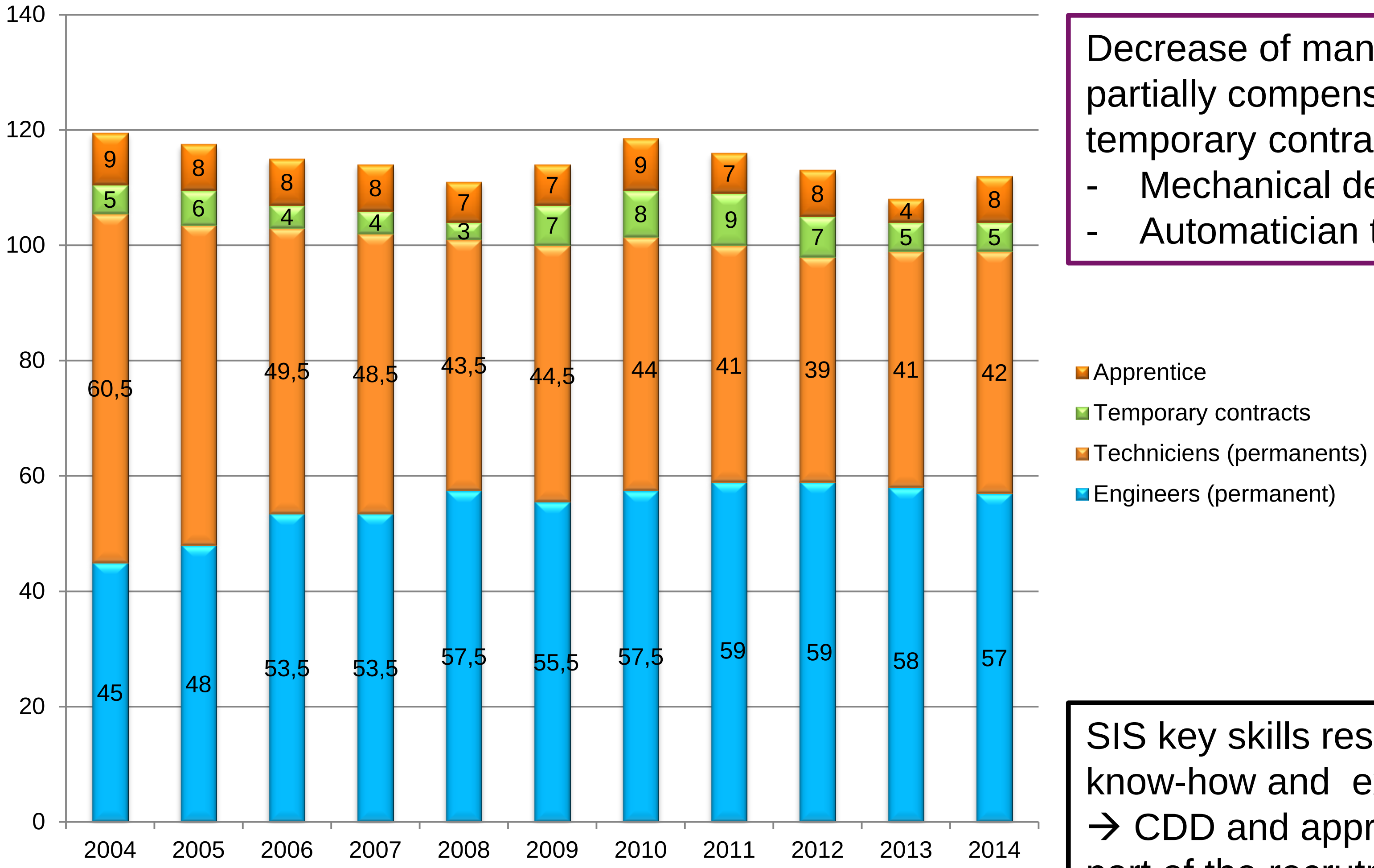
LEIGE
Electrical Engineering & Integration
Bld 472



J.C. Barrière

A. Sinanna

SIS MANPOWER SINCE 10 YEARS

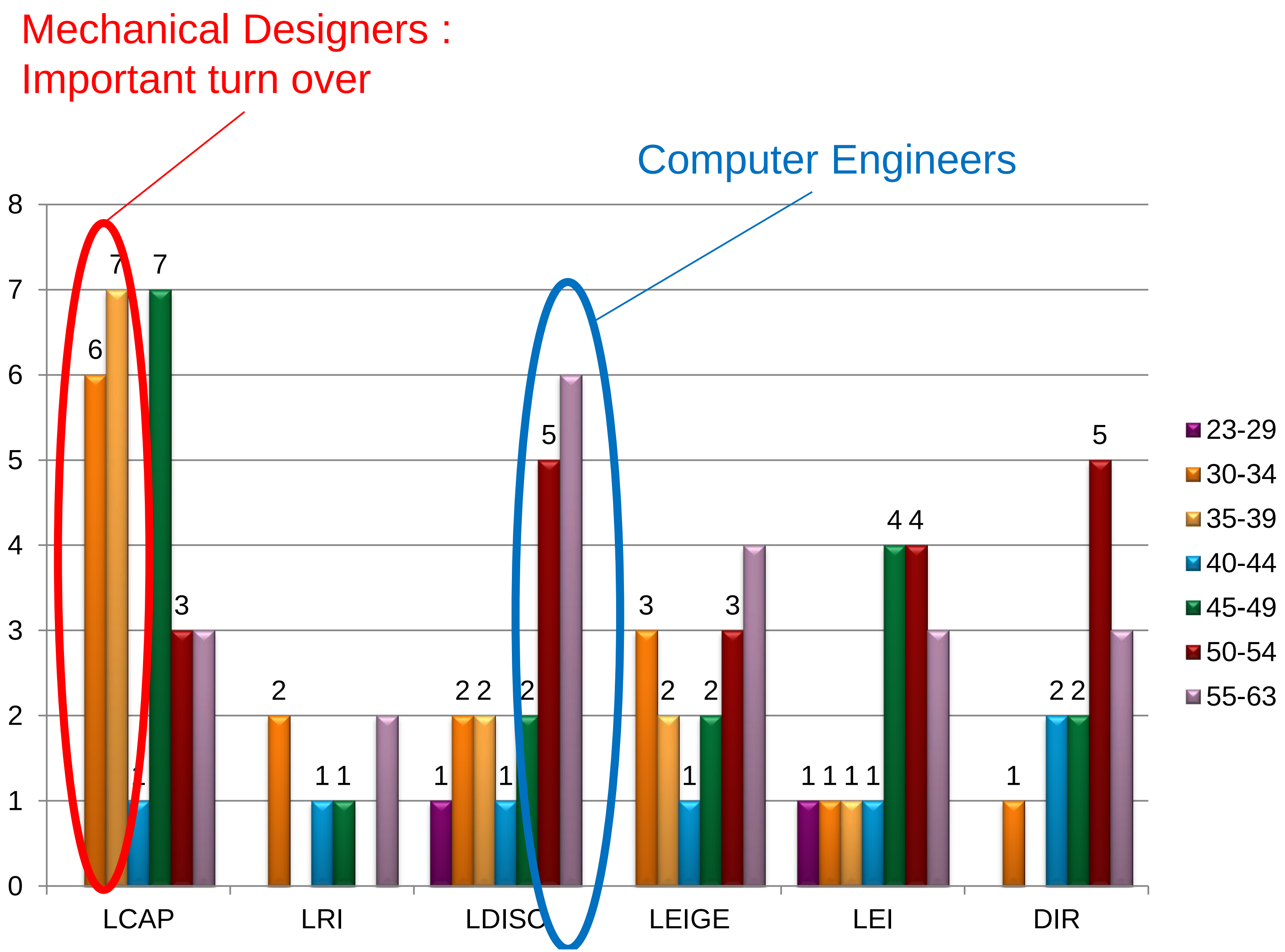


Decrease of manpower is partially compensated with temporary contracts :

- Mechanical designers
- Automatician techniciens

SIS key skills results from know-how and experiences → CDD and apprentices are part of the recrutment strategy

SIS DIVISION AGE STRUCTURE



Nominations :

- **Quality Assurance Correspondant :** S. Faict-Bastin

- **Communication correspondant :** N. Berton

SIS internal seminars :

- **General assembly** : 1 / year (end of january)
- **« Trainees Day » :** 1/ year (june)
- **13HSIS** : upon demand
- **R&D day** : 1 / year
- **Unit Council** : 1 / year

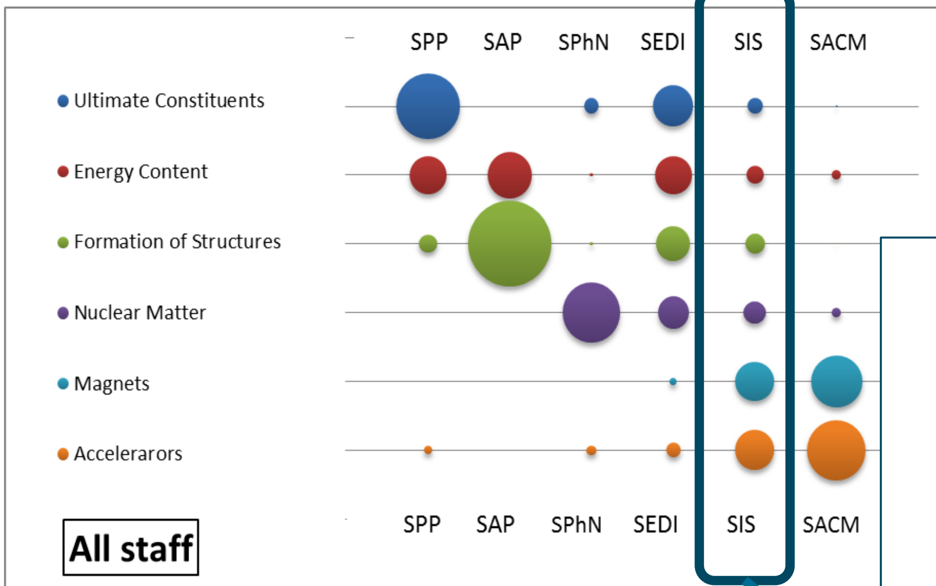
SIS and PARIS SACLAY CAMPUS

- **Dispatch between 3 departements**
  - **P2I (65%),**
  - **SPU (25%)** : member of the Instrumentation Working Group
  - **MEP (10%)**

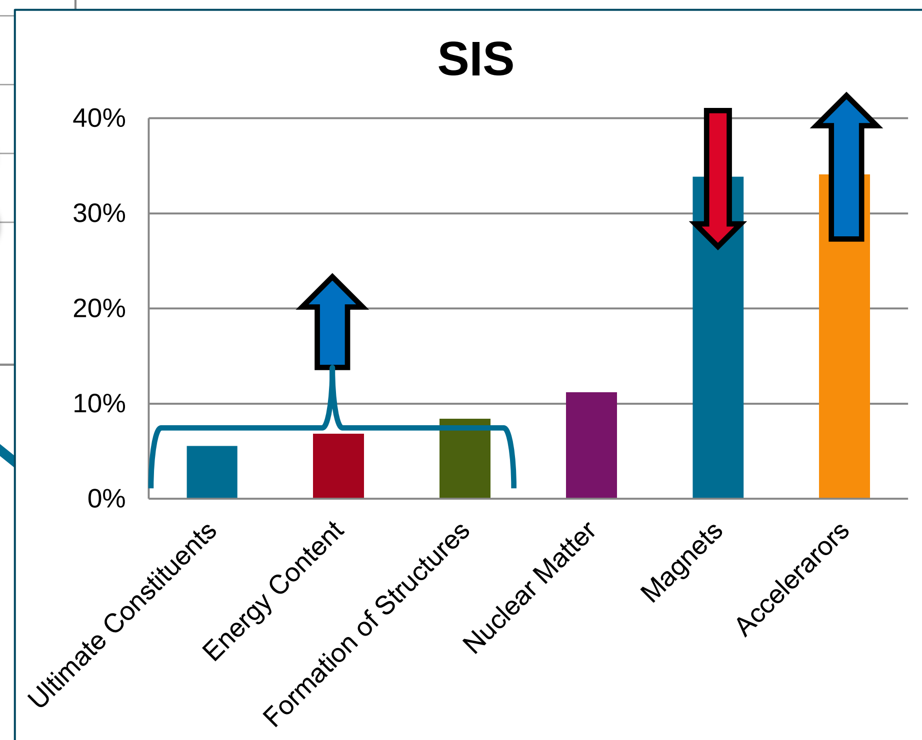
SIS POSITION WITHIN IRFU

Interfaces with all Irfu divisions

Trend 2015-2020



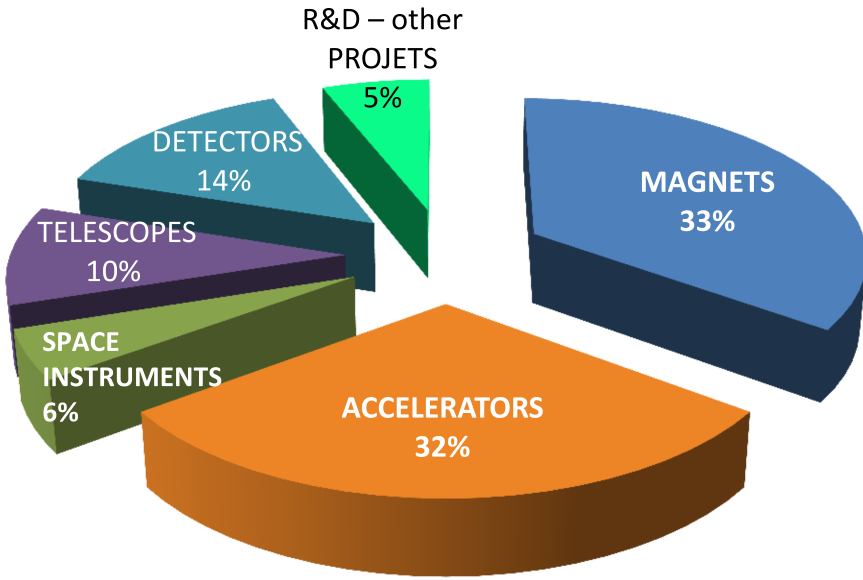
Status in 2013



SIS CONTRIBUTIONS TO PROJECTS (2013)

R&D - Others

- **COCASCOPE (*)**
- **LOTUS (*)**
- **PETAL + (*)**
- **ICOS**



Legend :
(*) Irfu project manager
(**) Experiment project manager
: <u>more than 10 SIS FTE / year</u>

MAGNETS

- **<u>ISEULT</u>**
- **<u>R3B</u>**
- **<u>JT-60SA</u>**
- **T2K**
- **LOTUS**
- **LNCMI**
- **HFM**
- **KATRIN**

ACCELERATORS

- **<u>SPIRAL-2 (*),</u> NFS (*),S3 (**),**
- **<u>IFMIF</u>**
- **IPHI**
- **LINAC4**
- **GBAR**
- **ESS**
- **CLIC**
- **FAIR**

SPACE INSTRUMENTS

- **MIRIM**
- **EULID VIS & NISP**
- ***SVOM ECLAIRs & MXT***

TELESCOPES

- **ARTEMIS**
- **CAMISTIC**
- **DESY**
- **CTA**
- **ELT METIS**

DETECTORS

- **COMPASS – CAMERA (*)**
- **CLAS 12GeV**
- **DOUBLE CHOOZ (**)**
- **NUCIFER,**
- **STEREO**
- **CeLAND (*)**
- **MINOS, CHyMENE**
- **AGATA**
- **LHC Upgrade** : NSW (*)

EVOLUTIONS OF THE SIS CONTRIBUTION SINCE 2013

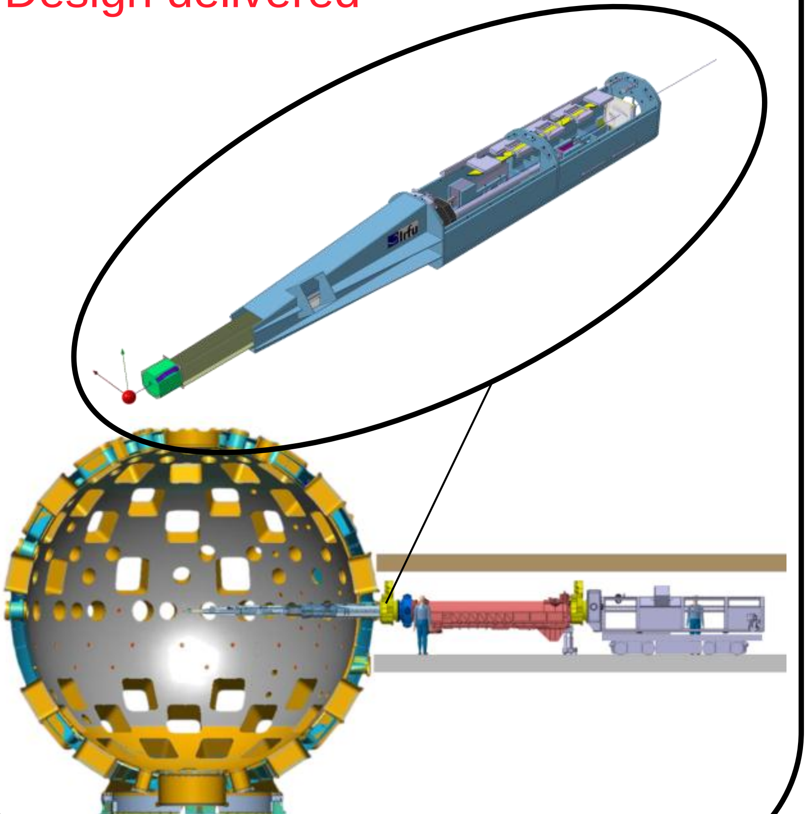
	MAGNETS	ACCELERATORS	SPACE INSTRUMENTS	TELESCOPES	DETECTORS & SOURCES
NEW	• LHC Upgrades • FAIR dipôles	• SARAF	• TALC		• VAMOS Gas Field • CeSox (*)
DEVELOPMENT ON GOING	• ISEULT • LNCMI • HFM • JT-60SA Structures	• S3 (**), • NFS • IFMIF SCL • GBAR • ESS • FAIR Protons Linac	• EULID VIS • EUCLID NISP • SVOM ECLAIRs • SVOM MXT • *SVOM antenna*	•DESY •CTA •ELT METIS	• AGATA • ATLAS – NSW • CLAS 12GeV • STEREO
DELIVERED or UNDER INSTALLATION	• T2K • LOTUS • JT-60SA CTF • R3B-GLAD	• CLIC • LINAC4 • IFMIF Injector • IPHI • SPIRAL 2	• MIRIM	•CAMISTIC •ARTEMIS	- COMPASS / CAMERA •DOUBLE CHOOZ (**) •NUCIFER • AGATA • CHyMENE • MINOS

PETAL + :

Collaboration : DAM, DSM

SEPAGE : e- / p+ diagnostics for laser experiments

Design delivered

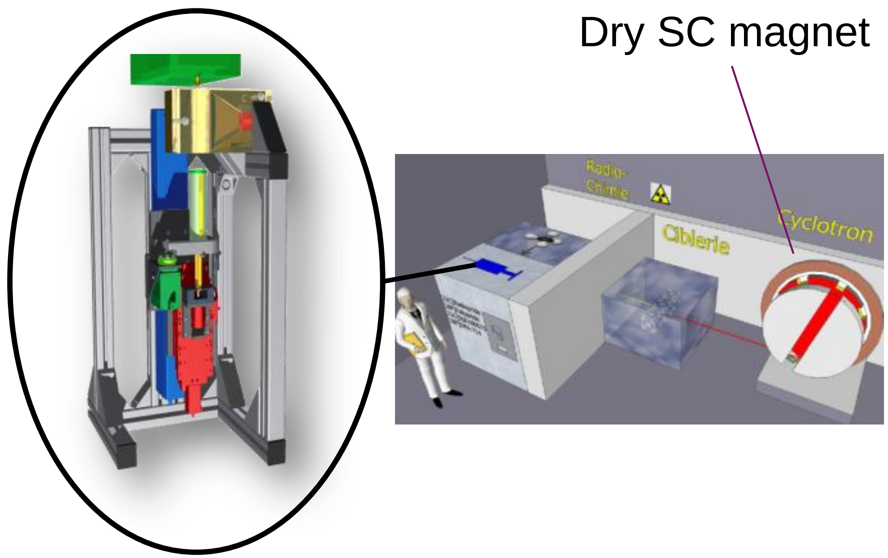


Technology for Health : LOTUS

Technology transfer

Collaboration : DSV (expertise), DRT (detection), DSM

Robot to load tracers in a syringe without manual intervention

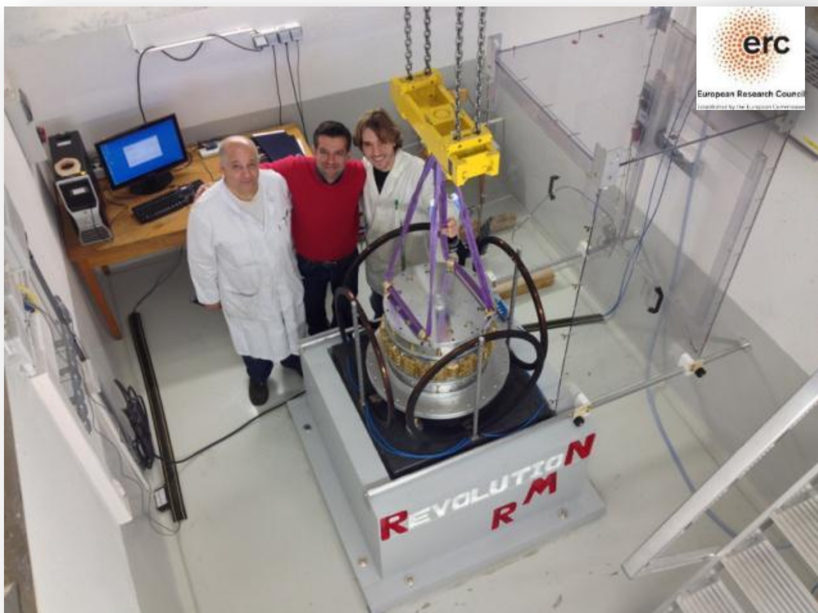


- General Architecture is defined
- Tests of the automate are foreseen in 2015 @ PMB firm

ROTATING FIELD

Magnet for Magnetic Resonance :
Delivered in spring 2014

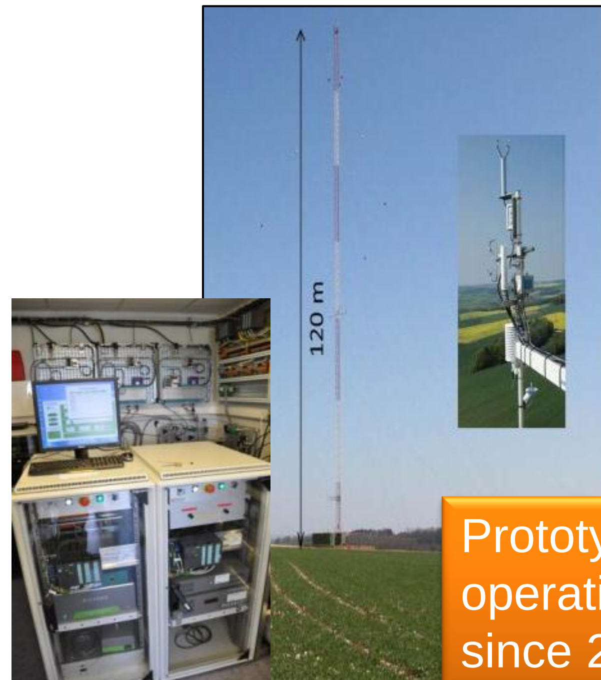
Collaboration : DSM – IRAMIS / Irfu –SIS



ICOS

EU network to standardize the measures of Greenhouse gases

Collaboration : LSCE / Irfu –SIS



Prototype operational since 2012

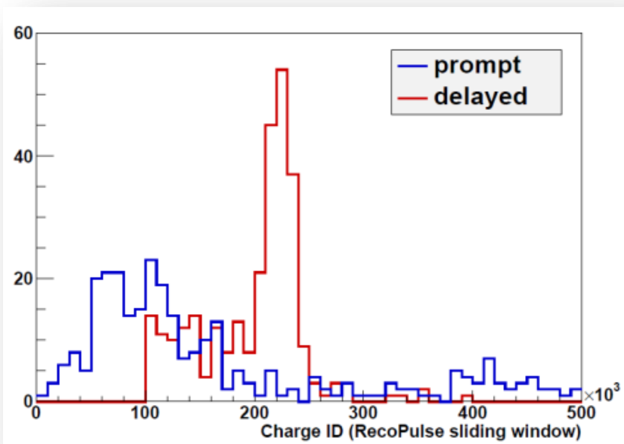
DOUBLE-CHOOZ - 2014

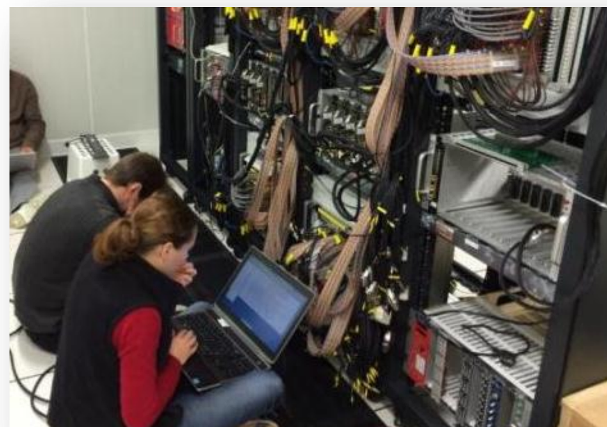
End of the assembly of the 2nd detector : summer

Close of the Gamma Catcher Vessel

Shield installed

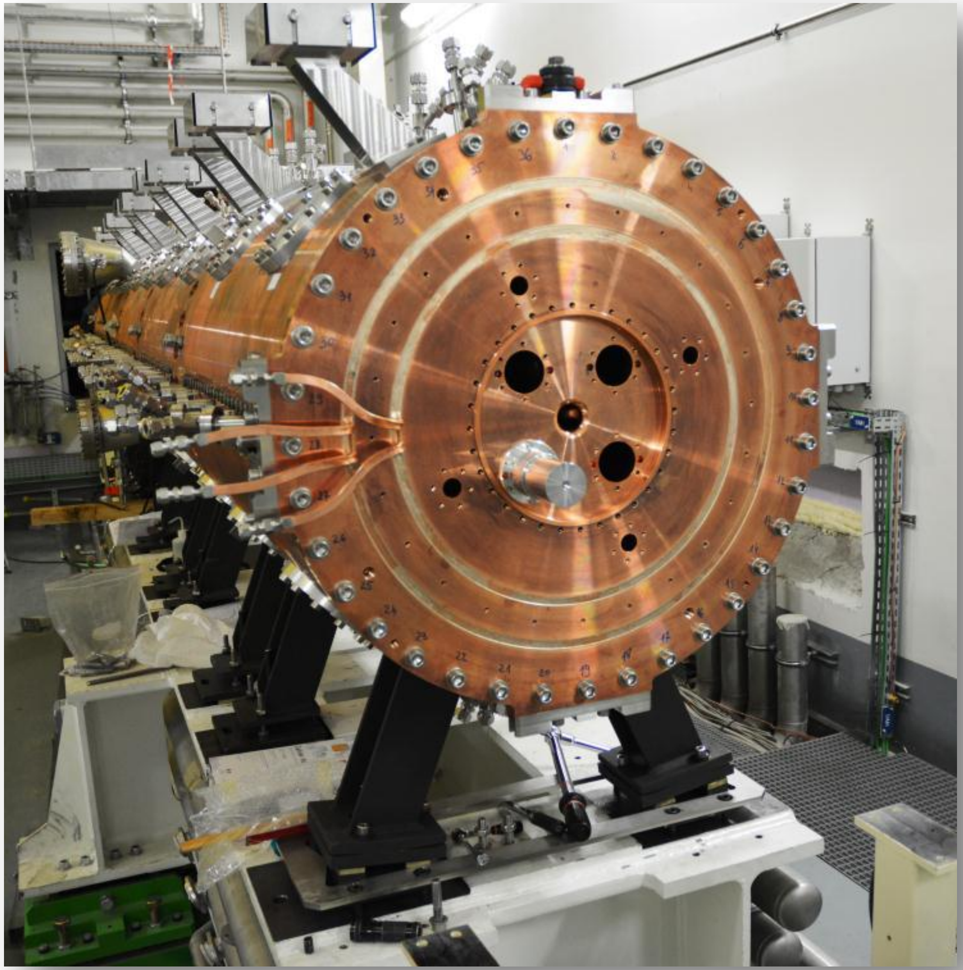
1st neutrino candidate : Oct 2014





Start of data acquisition with both detectors on 24th december 2014

SPIRAL-2 / RFQ DELIVERY IN 2014



- Tests and Installation @ GANIL : T4 -2014
- Bead-pull tests : ☺

DE LA RECHERCHE À L'INDUSTRIE

MECHANICAL ENGINEERING

Florence ARDELLIER – IRFU/SIS

www.cea.fr

Mechanical Engineering: « from concept until reality… »

LCAP
Mechanical Design

16 engineers , 11 technicians
8 trainees, 4 temporary contracts

P. Manil

D. Leboeuf

LRI
Engineering support & industrial follow-up

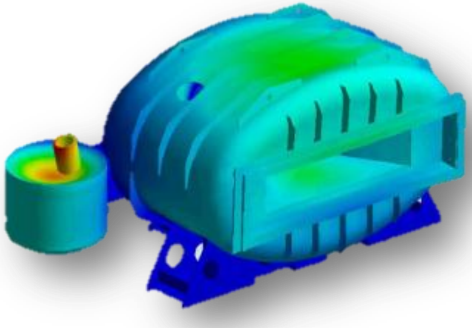
4 engineers, 2 technicians

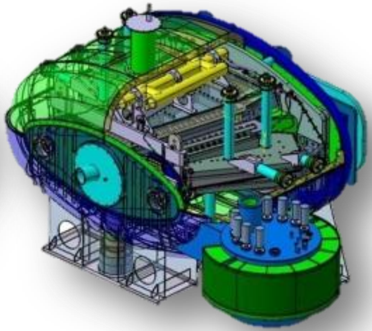
V. Hennion

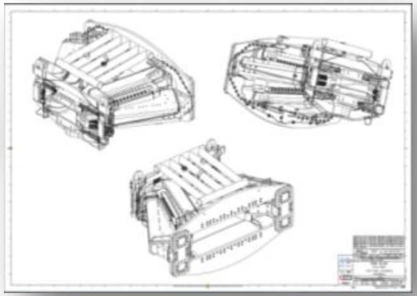
Design Simulations

CAD & Mechanical Integration

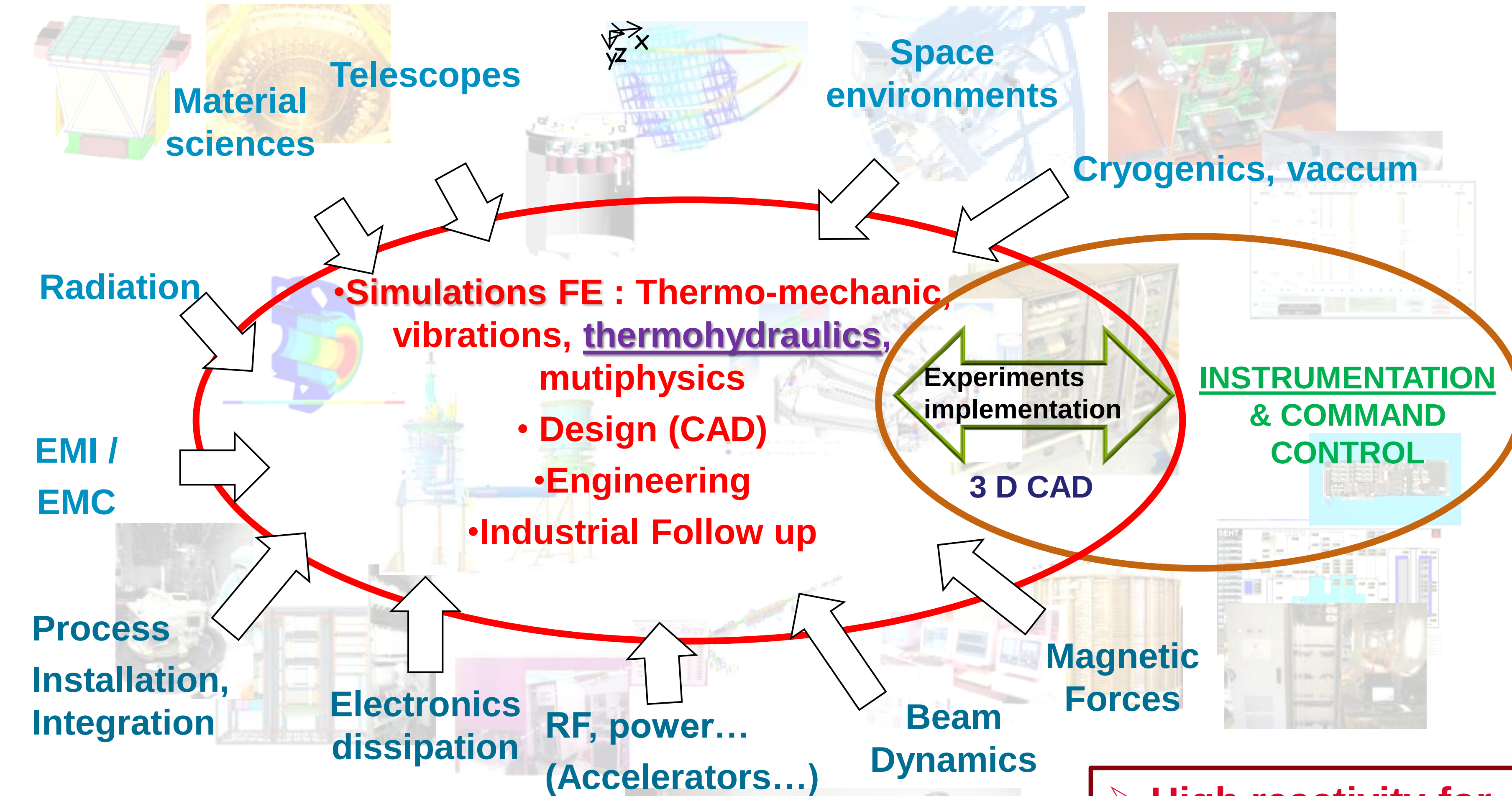
Engineering support and industrials follow-up





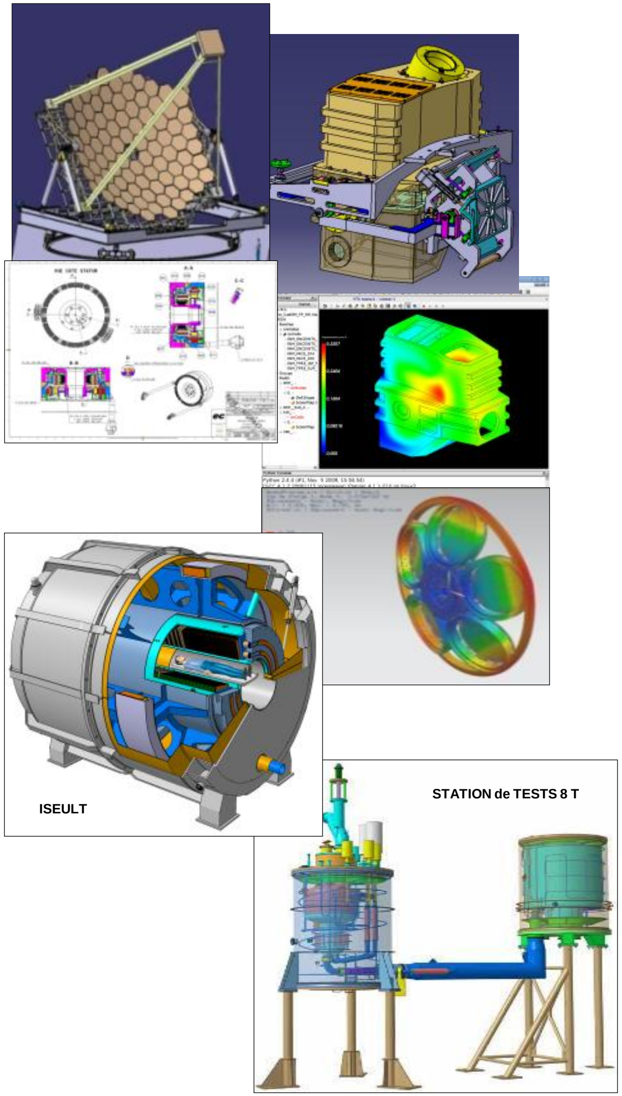


Mechanical engineering methodology : system approach



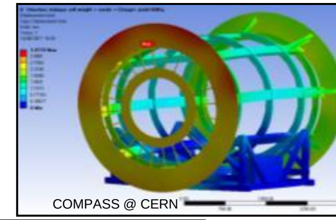
Integration of the multi-disciplinary boundaries
Multi skills interactions are essential during design
Capitalisation from one project to another

- **High reactivity for preliminary studies (details drawings are externalised)**
- **High flexibility**



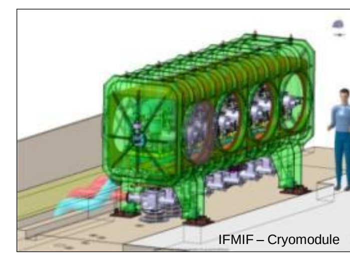
Instruments for physics experiences

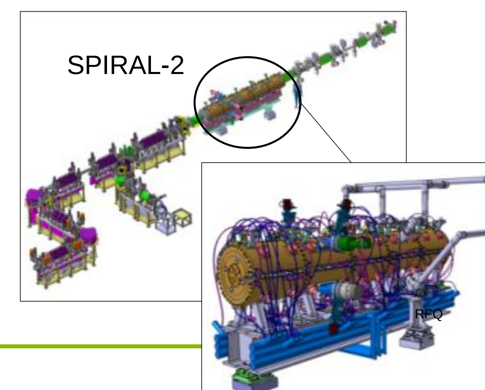
- ✓ Detectors systems
- ✓ Telescopes & Cameras
- ✓ Space instruments



Machines for sciences (magnets & accelerators)

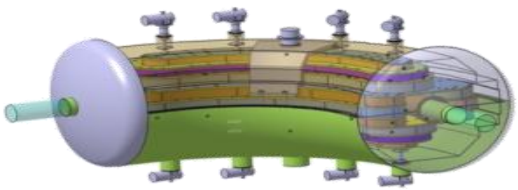
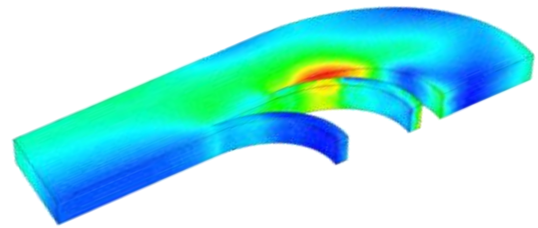
- ✓SC Magnets & Cold tests facilities
- ✓SC Linac cavities
- ✓RFQ
- ✓Accelerator Implantations





TOOLS OF THE MECHANICAL DESIGN

Tools

CAD integration	Design & simulation	Engineering support
		

- CATIA V5
- Smarteam
- Reprography
- Archive policy
- **3D printer (2013)**
- **CATIA Composer + touchscreen**

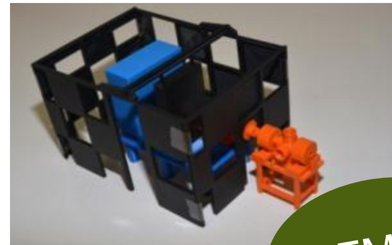
- Cast3m
- ANSYS
- NX NASTRAN
- SNCT, SicapNet
- Specific tools :
  OpenFoam, Europlexus, LS-Dyna, TRI-OU,

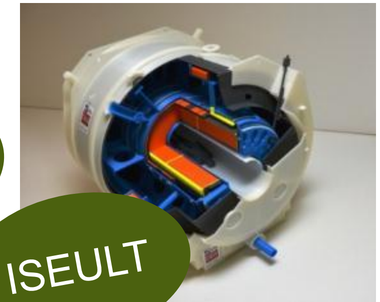
- ASME
- CODAP
- Eurocode
- Local databases
- Specific tools

Improved exchange and analysis of 3D CAD files

MAIN REALISATIONS WITH 3D PRINTER


SARAF


IFMIF


ISEULT

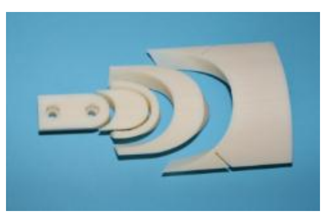

CoCaSCOPE

PETAL +


MIRIM


WAVE

HL-LHC




TALC


CLAS - 12

~4000 hours

CHALLENGES FOR MECHANICAL ENGINEERING

1. **Reinforce** the team working on mechanical design of accelerators components (permanents and non permanents)
   - → set up a « competence pool » for sharing experience between IFMIF, ESS and SARAF

2. Use of **new tools** :
   - Additive fabrication (3D printer) since 2013
   - 3D « touch screen» to break fthe ence between designers and project teams
   - Innovative partenarship use with French industrials
   - Links creation with academic partners in France and abroad (ex : école d'ingénieur ParisTech Shanghai Jiao Tong)

3. **Maintain R&D** activities to **anticipe future** needs
   - Reinforce the Competence pool for multi-physics and coupled-field simulations
   - Welcome of students, post docs and PhD

4. Care for **« Licensing »**
   - Take into account in the system approach as soon as possible
   - Temporary contract for dedicated project (IFMIF)

DE LA RECHERCHE À L'INDUSTRIE

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MECHANICAL ENGINEERING

SOME PROGRESSES

2013 -2015

→ CTA – MST CAMERA : THERMAL DESIGN

→ JT-60SA STRUCTURES

→ ACCELERATOR COMPONENTS SIMULATIONS : ESS-RFQ

→ R&D : COCASCOPE AND OTHER TOPICS

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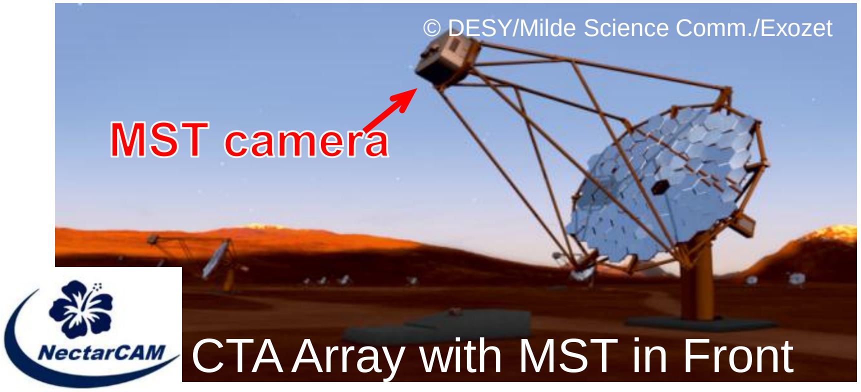
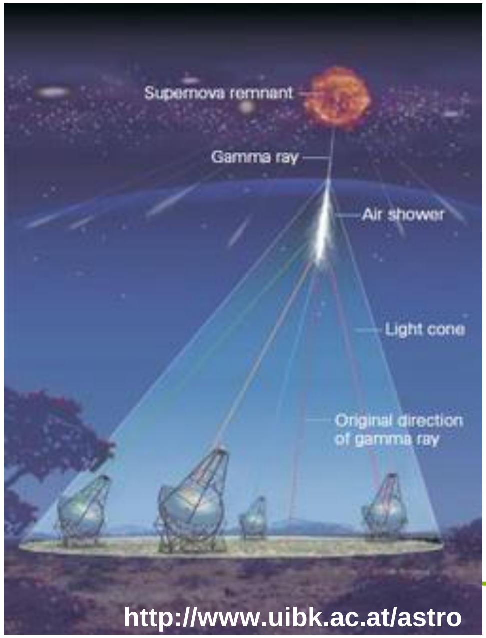
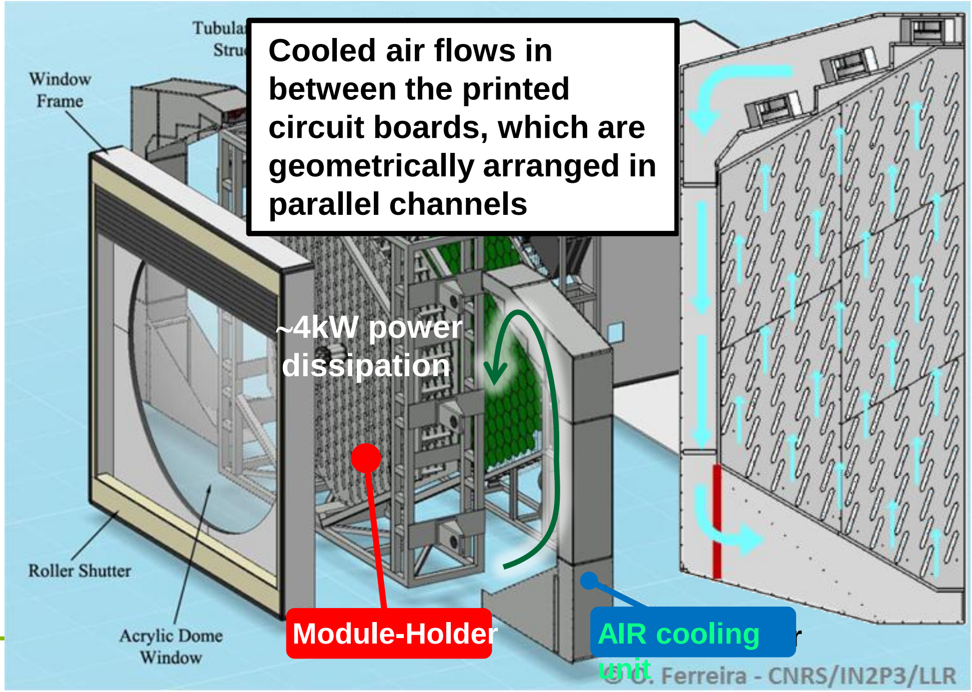
Irfu

Thermal demonstrator of the module-holder of the NectarCAM MST camera :
→ evaluate the electronic front-end boards temperature gradient across the camera (< +/-5C)







F. Nunio

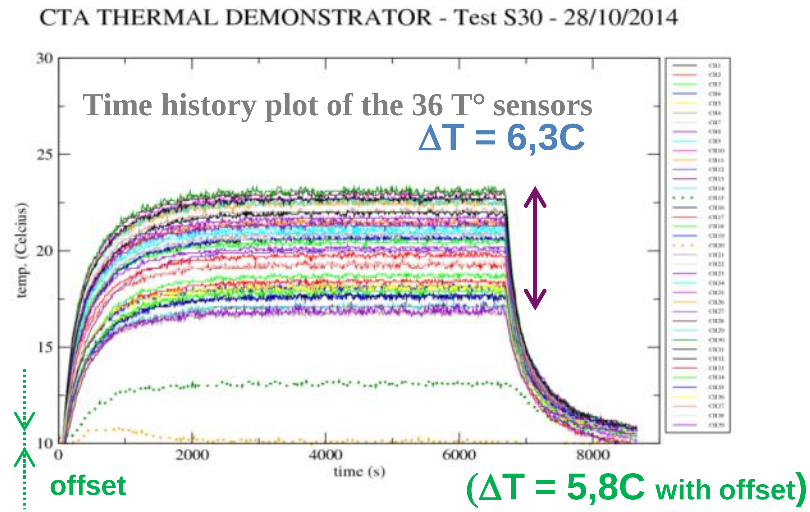
CTA camera thermal design

Thermal demonstrator of the module-holder of the NectarCAM MST camera :
→ evaluate the electronic front-end boards temperature gradient across the camera (< +/-5C)

The thermal demonstrator (1/2 camera) is equipped with current powered dummy front-end boards, driven by a variable power supply, and monitored with temperature and flow rate sensors.

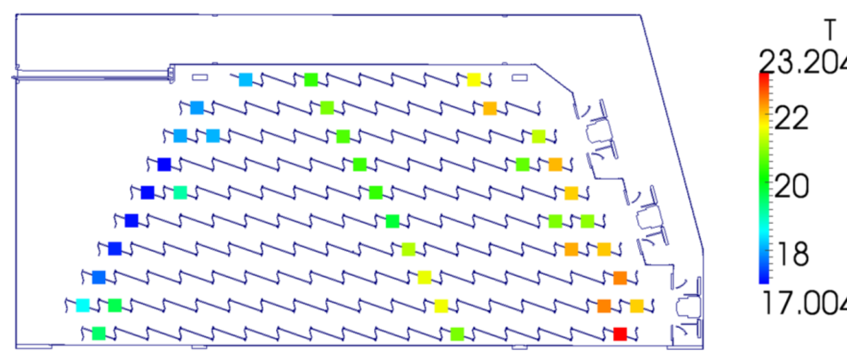
- the temperature gradient is lower than 10°C. We measured a thermal gradient lower than 7°C
- the air flow is well balanced between the channels
- the mean air temperature in the channels is close to 20°C

=> the dynamic behavior of the demonstrator still need to be studied

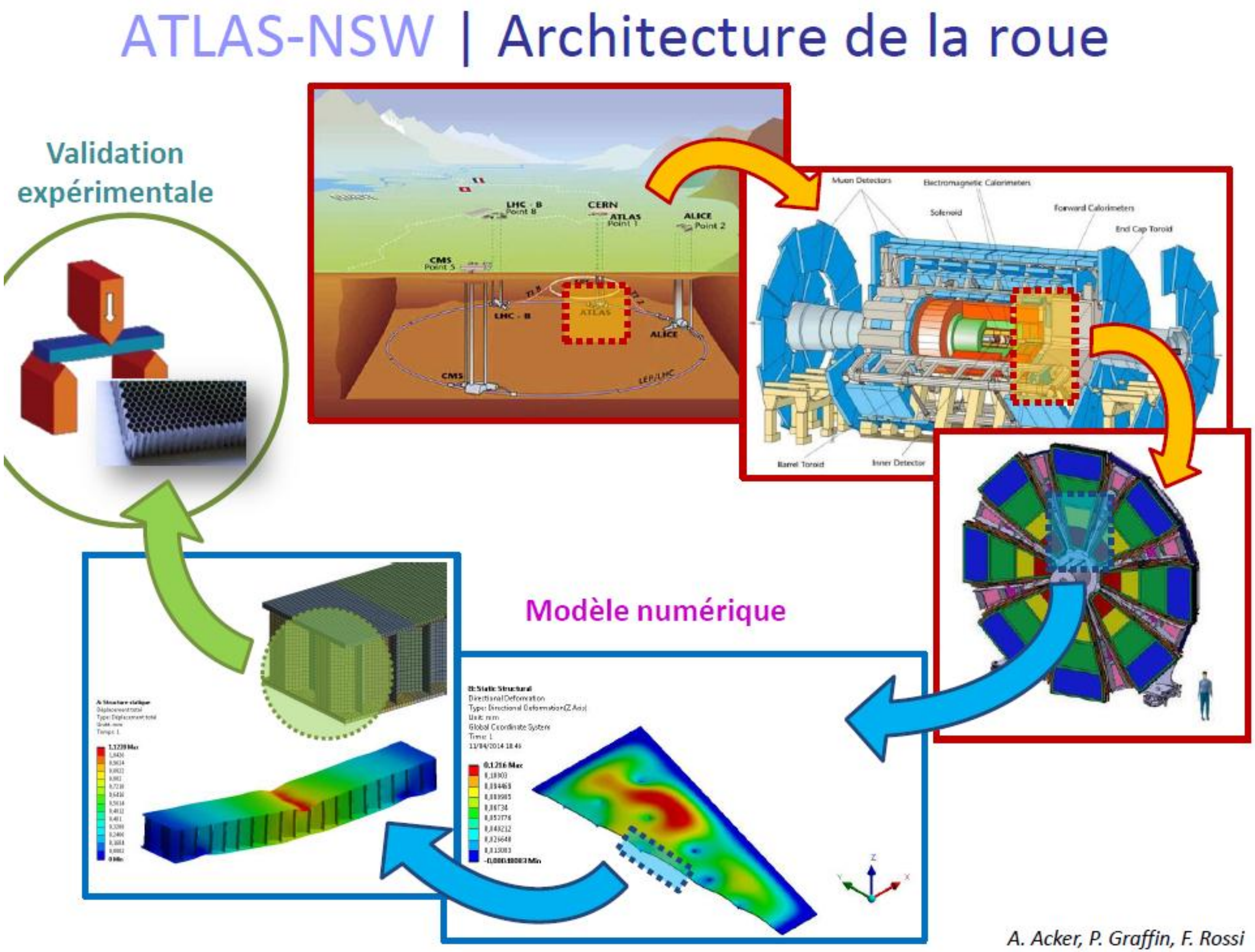


Spatial plot of the 36 T° sensors (t=6000s)

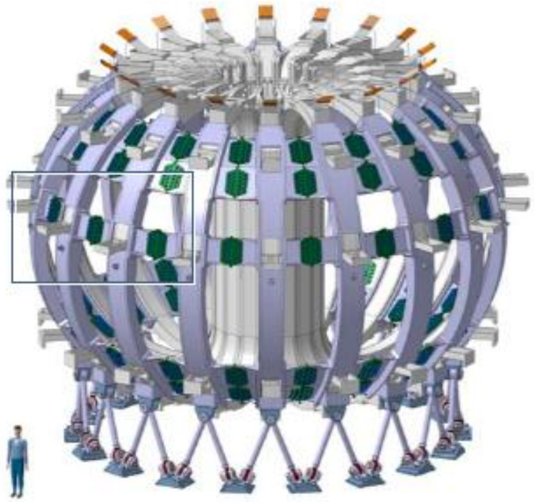
Whp=2kW / Vfx=10V / TsetChill=10C / **TsetRoom=10C**

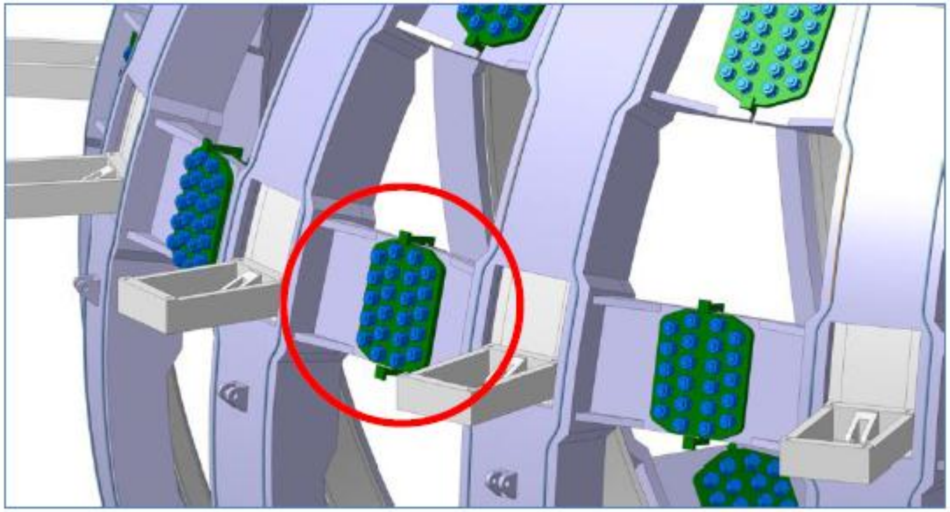


F. Nunio


ATLAS-NSW | Architecture de la roue
Validation expérimentale
Modèle numérique
CERN
ATLAS
ALICE
CMS
LHC - B
Muon Detectors
Electromagnetic Calorimeters
Solenoid
Forward Calorimeters
End Cap Toroid
Barrel Toroid
Inner Detector
A. Acker, P. Graffin, F. Rossi

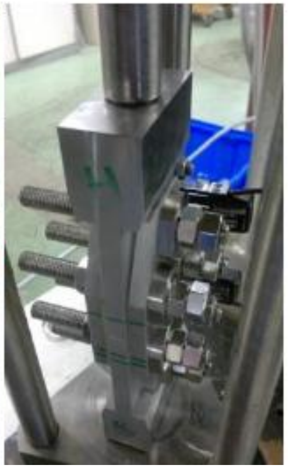
OIS - Qualification of components

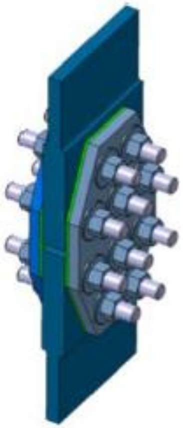




Shear Panel → slip-resistant connections

The main concerns are the quantifying of :
→ the loss of preload due to the tightening
→ the sliding behavior of the bolted joint
→ the creep of the G11 insulation spacer

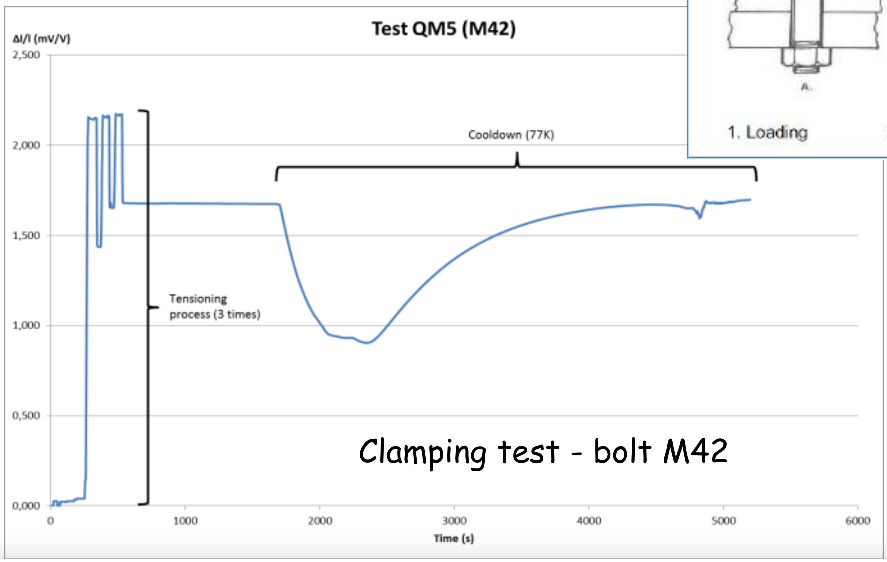


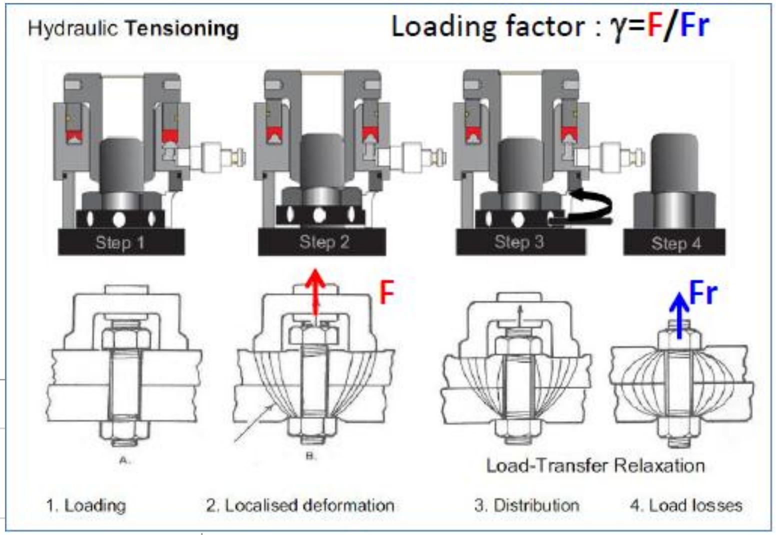


INSTITUT NANOSCIENCES ET CRYOGÉNIE

QUALIFICATION TESTS CAMPAIGN

Study of the loss of preload due to the tightening





In addition :
- the use of a **narrow pitch thread** tend to reduce the loss of preload
- **simultaneous tightening** reduces the dispersion in the tightening loads

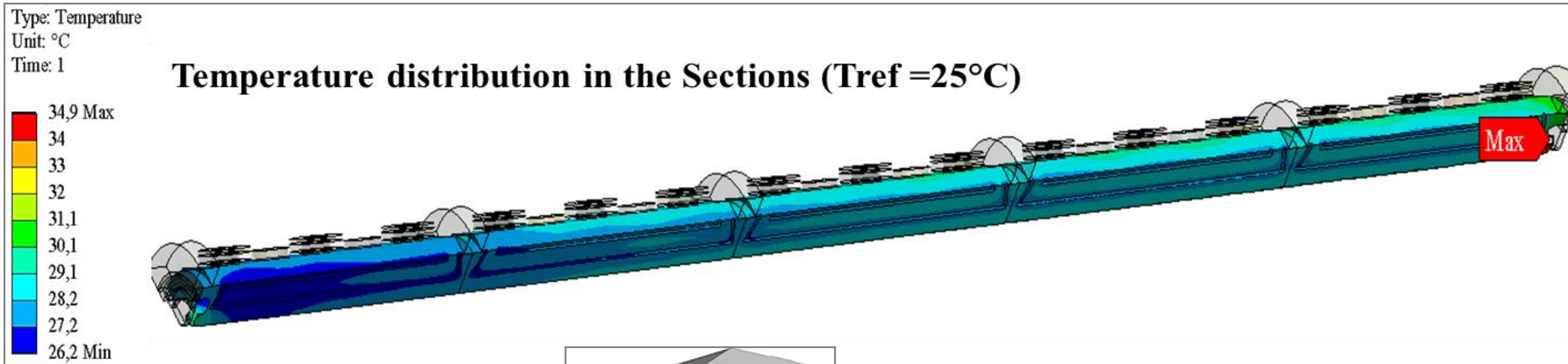
STATUS OF JT-60SA STRUCTURES PROJECT

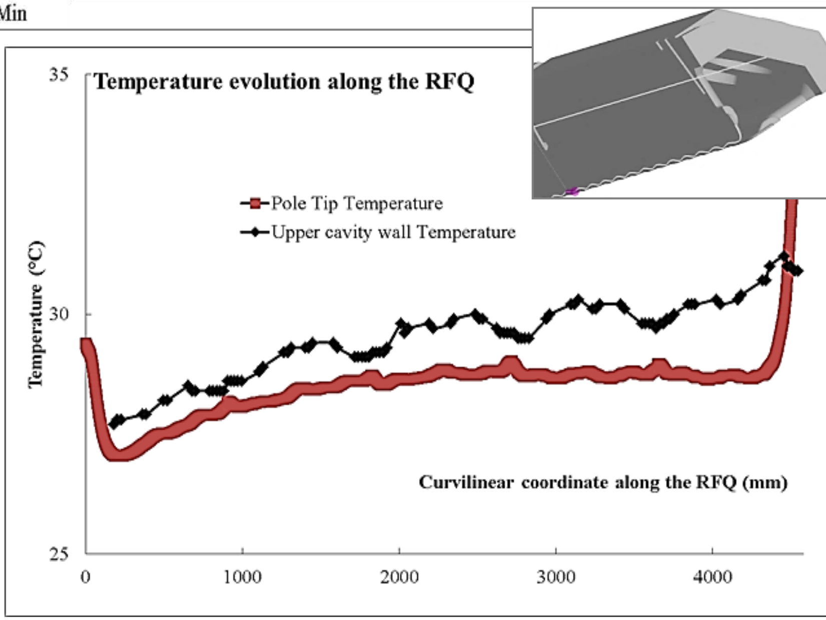
SDMS
la chaudronnerie blanche®

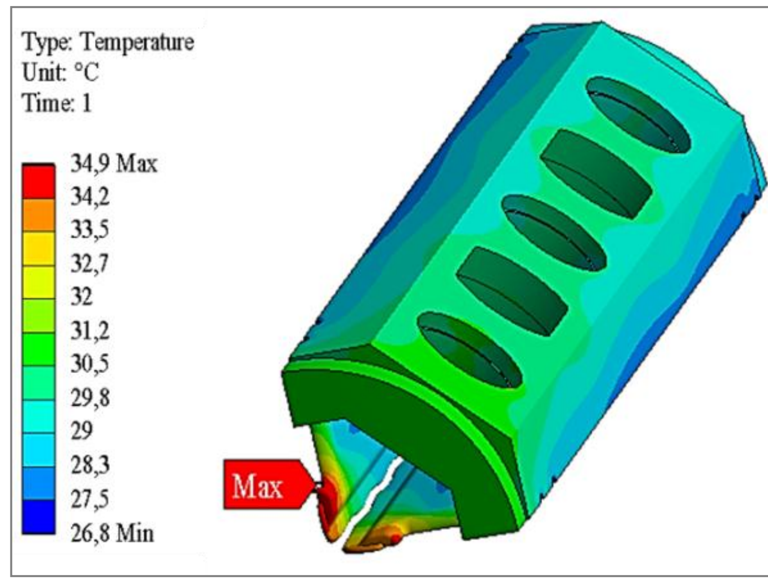
OIS machining

Gravity support manufacturing

Thermal studies : ESS RFQ Sections



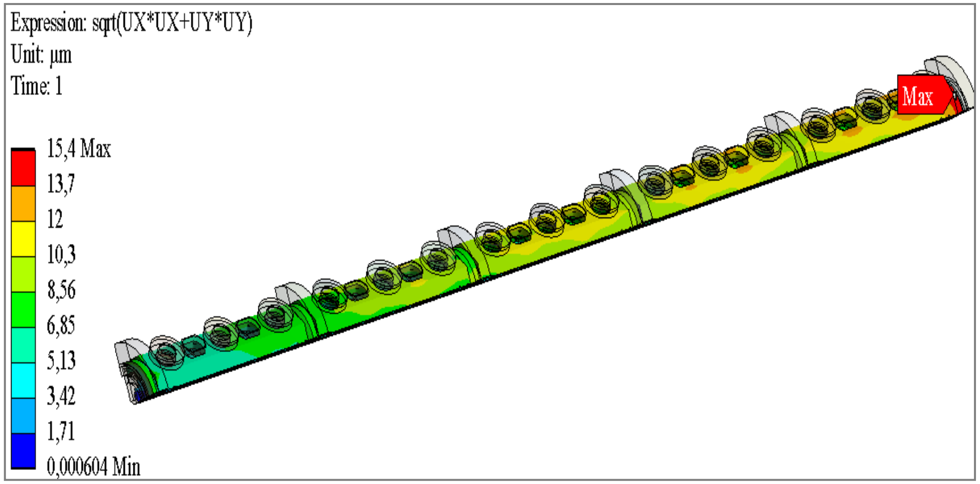


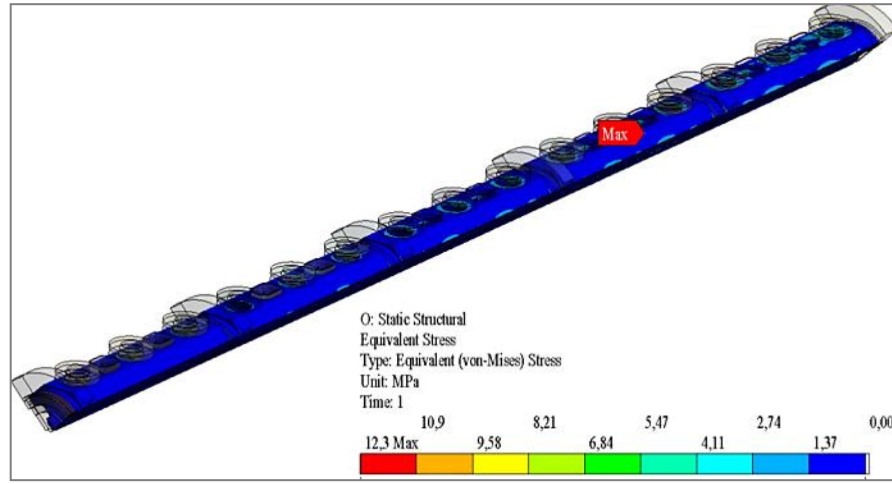


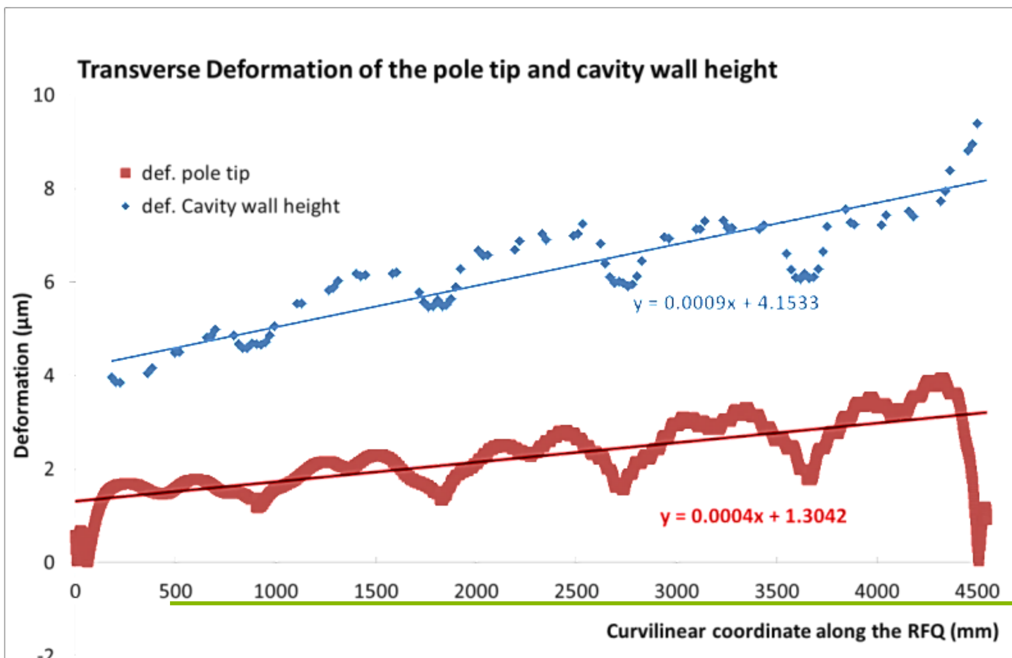
- ✓ Temperature peak in regions with the highest magnetic field
- ✓ Temperature uniform over a wide portion of the pole line

S5 (max temp. on the undercut)

RFQ Sections (cont.)







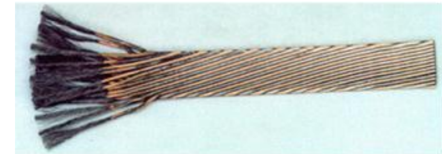
✓ Transverse deformation **does not exceed 16µm** in the ESS RFQ for this set conditions.

→ The **maximum VM equivalent stresses** in the copper is at a vacuum grid port and is **~12MPa** which is < ~2/3 of the yield stress => no plastic deformation in the RFQ

→ The 3D estimate of the deformation ratio between the pole tip and the cavity wall height varies between 3 (front end) and 2.6 (backend) along the RFQ => Consistent with the 2D results

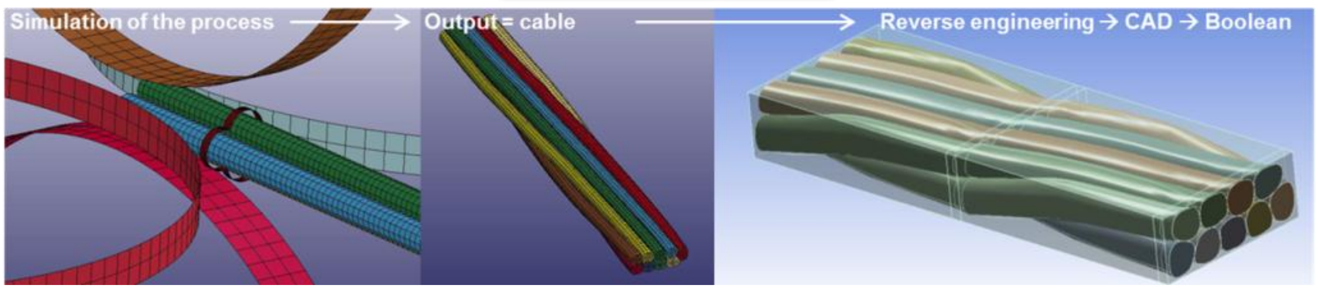
Context: Mechanical design of very high field magnets (~20T)

Ultimate goal: **multi-scale** modeling of the **mechanics** of **superconducting cables** during operation, correlated with experimental data.

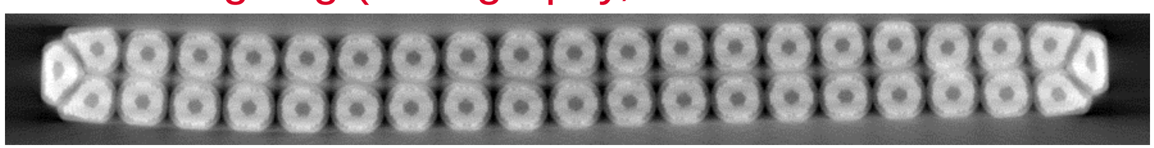


Partners:

Status: - First model of the cabling process has been built



Data collection on-going (tomography, material characterization)



Next steps: **Postdoctoral position** for building the model of the cable during operation, enriched with relevant behavior laws of materials and interfaces.

F. Nunio, P. Manil, MATTEIS lab

- **Simulations of Multi-Physics phenomena :**
  - Magneto-mechanics with SALOME platform
  - Magneto-thermal simulations with SALOME platform for DEMO programm (fusion)
- **Thermal management solutions for mechanical design**

See Nadia Sellami's talk

Connections to others lab : CEA-DEN, DSM-DSM-IRFM, CNRS- LECI, ENS Cachan, Centrale…

- Technological transfers : study of the use of the new "decret" called **" innovative partenariat"**

DE LA RECHERCHE À L'INDUSTRIE

INSTRUMENTATION & CONTROL SYSTEMS

2013 -2015

Florence ARDELLIER – IRFU/SIS

www.cea.fr

Instrumentation & Control Systems

LDISC
Control Systems developments

17 engineers, 2 technicians
3 trainees, 1 temporary contract

LEI
Electronics for Instrument Controls

10 engineers, 5 technicians
1 trainee

LEIGE
Electrical Engineering & Integration

8 engineers, 11 technicians
2 trainees


G. Durand


J. Belorgey


P. De Antoni


S. Sube


J.C. Barrière


A. Sinnana

Automatism
Supervision of Experimental settings

UNIX development and applications real time under VX WORKS

Industrial Applications under Windows and Embedded Systems

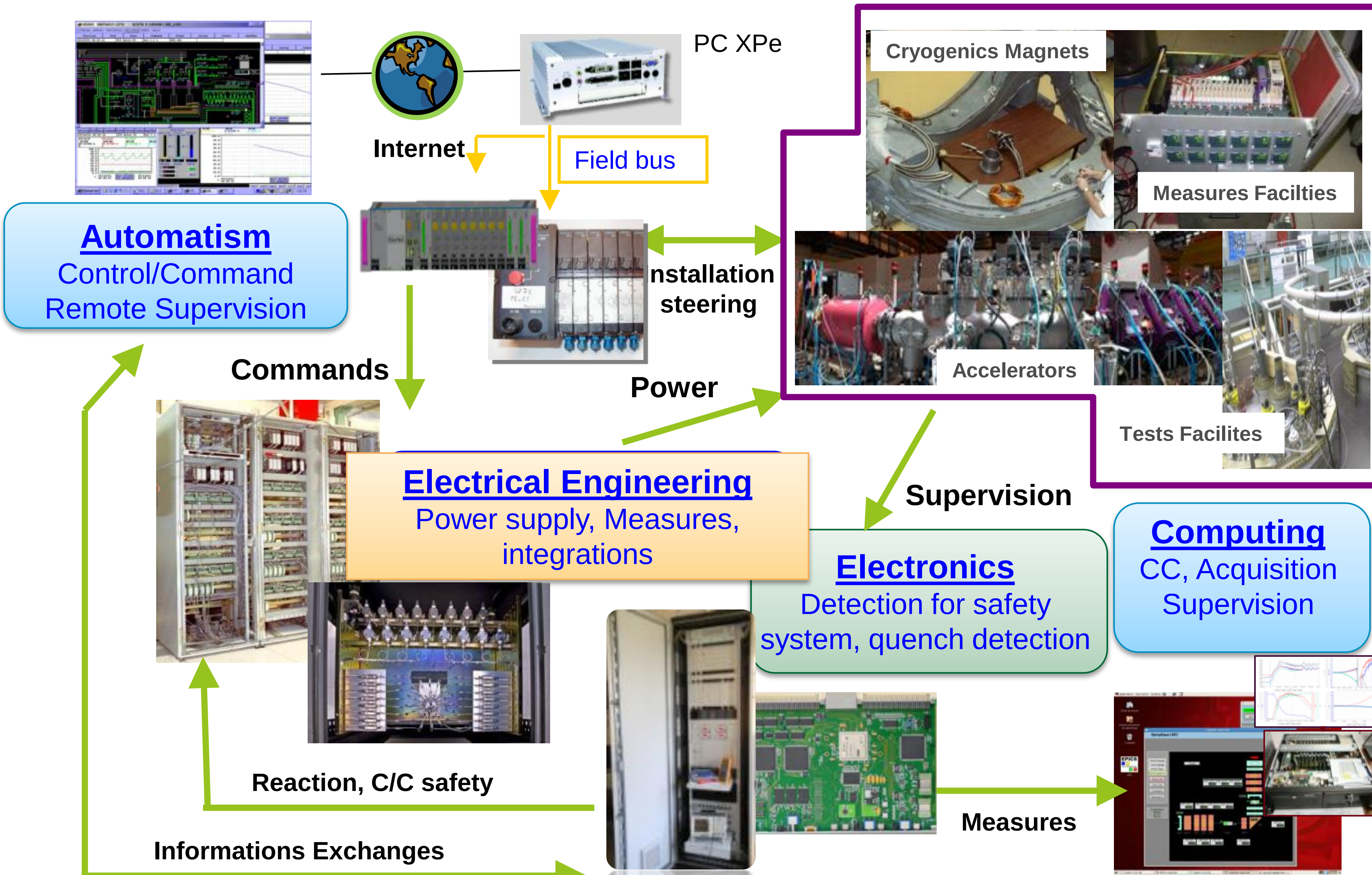
Electronics Developments for control of the experiences

Electrotechnical Studies and realisations

Industrial follow up for tests facilities

Power electronics

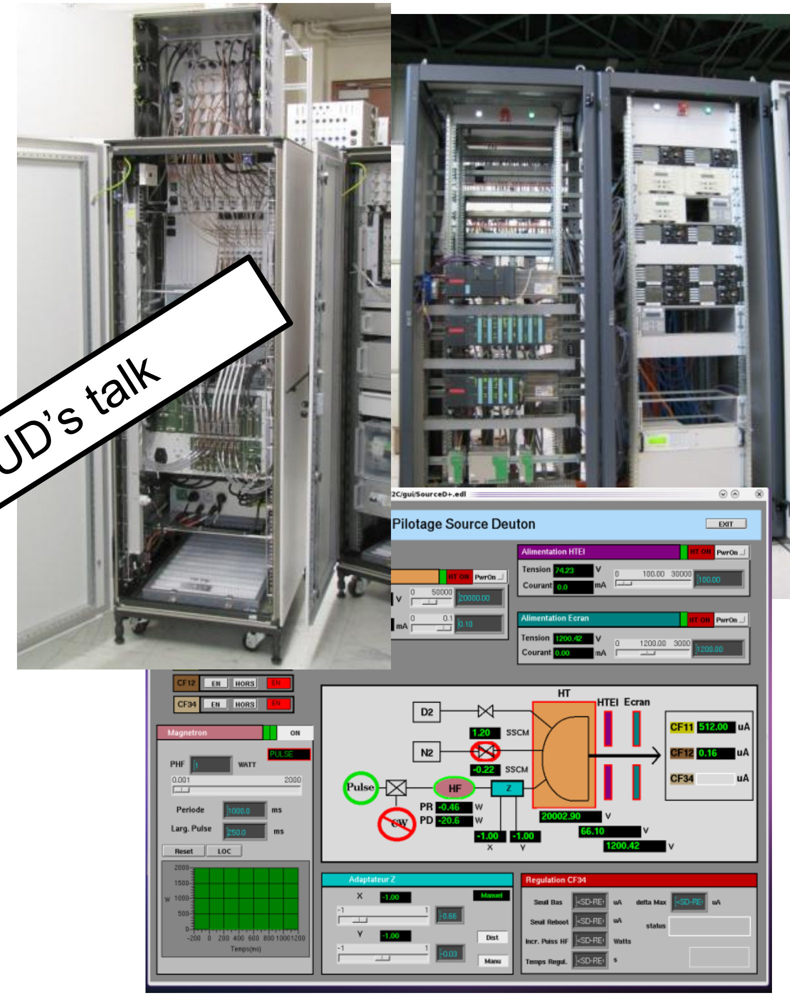
Instrumentation measurements


PC XPe
Internet
Field bus
Automatism
Control/Command
Remote Supervision
Installation steering
Commands
Power
Cryogenics Magnets
Measures Facilties
Accelerators
Tests Facilites
Electrical Engineering
Power supply, Measures, integrations
Supervision
Electronics
Detection for safety system, quench detection
Computing
CC, Acquisition
Supervision
Reaction, C/C safety
Measures
Informations Exchanges

ACCELERATORS INSTALLATION

IFMIF @ Rokkasho

SPIRAL-2 @ GANIL

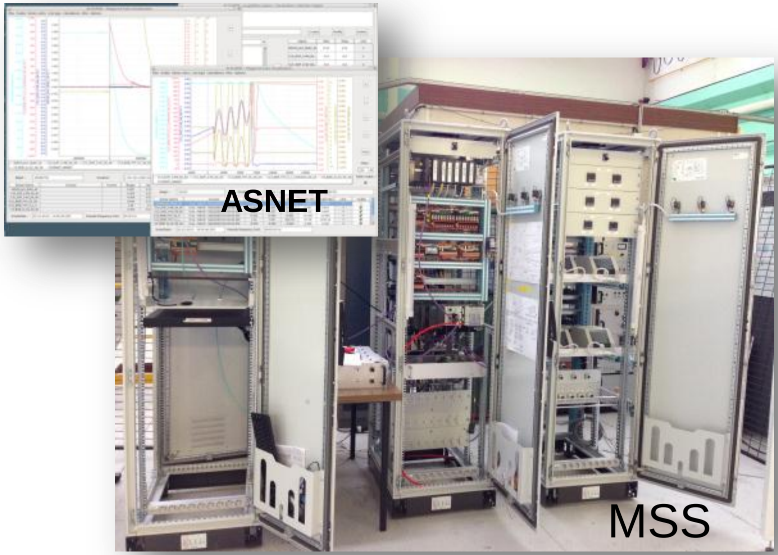


EPICS

See F. GOUGNAUD's talk

<u>CLOSE FUTURE</u> : ESS, SARAF, …

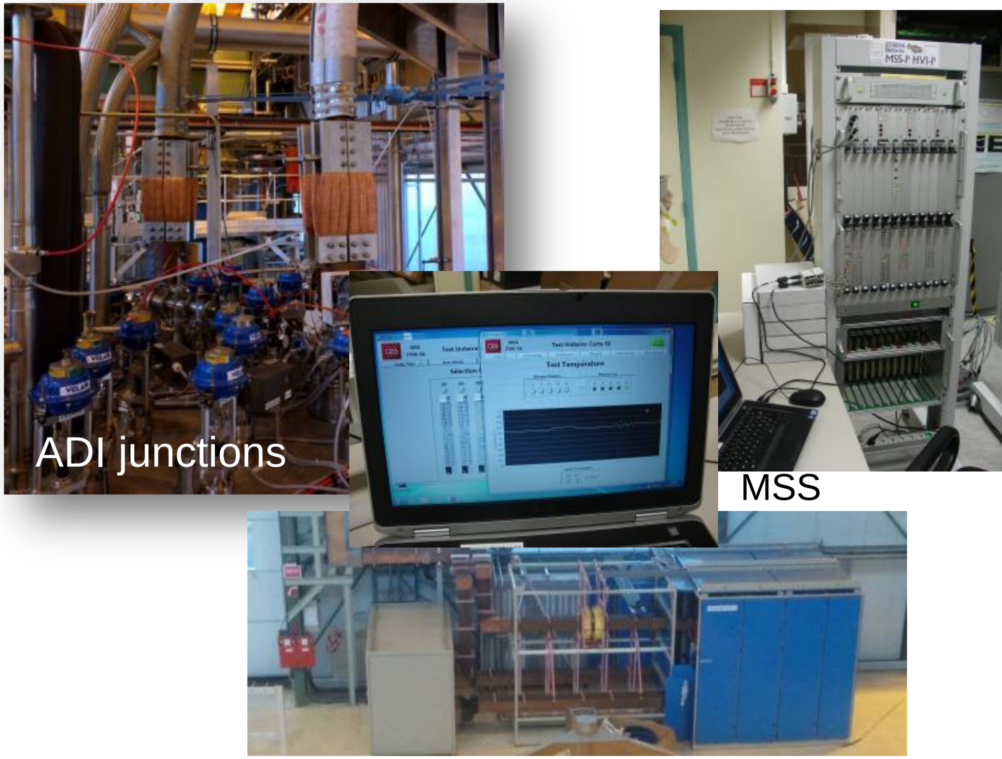
R3B – GLAD magnet



ISEULT

Under construction

JT-60SA – Tests Facility



Power supply cabinet

Telescops : ARTEMIS, CAMISTIC, IR detector test bench

Nuclear physics: AGATA, CHYMENE, MINOS …

DE LA RECHERCHE À L'INDUSTRIE

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INSTRUMENTATION & CONTROL SYSTEMS

STATUS OF « internal R&D »

1. SERVO CONTROL SYSTEMS : MAGNET SAFETY SYSTEMS

2. « BORANET » : MODULAR SENSOR CONDITIONER

3. ACQUISITION « ASNET »

4. MUSCADE ®

5. CRYOMECHANISMS

Irfu

CHALLENGES FOR INSTRUMENTATION & CONTROL

<u>1. Requirements for future architectures :</u>

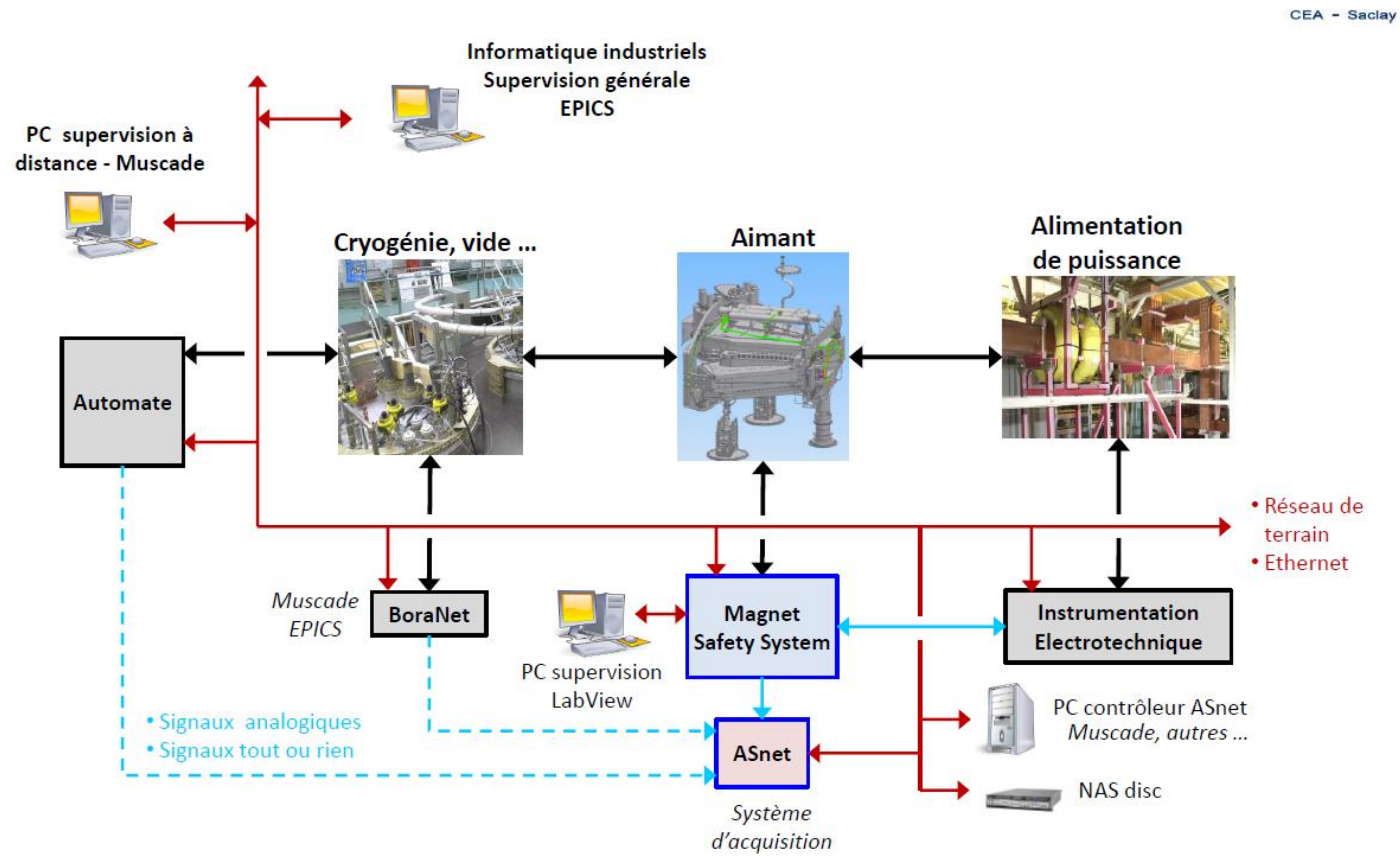
- Larger exepriments develop in parallel
- More complex
- Integrated system
- Flexible
- Reconfigurable
- Reliable

Development of «custom » and « generic » components :

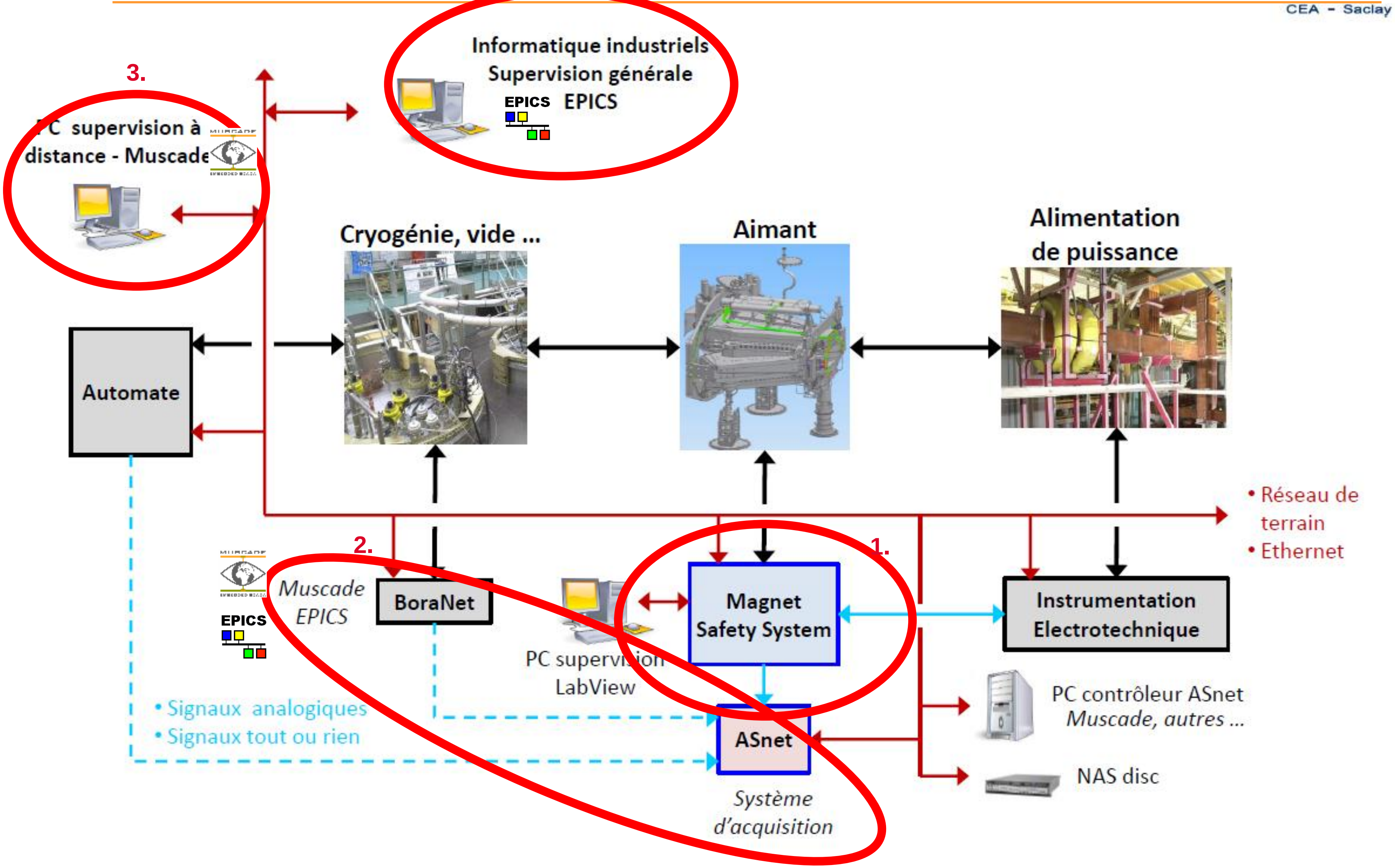
→ BORANET : modular sensors conditioner
→ ASNET : fast acquisition system
→ Muscade® : web remote supervision module
→ EPICS : collaborative platform for accelerator control

2. Maintenance of experimental

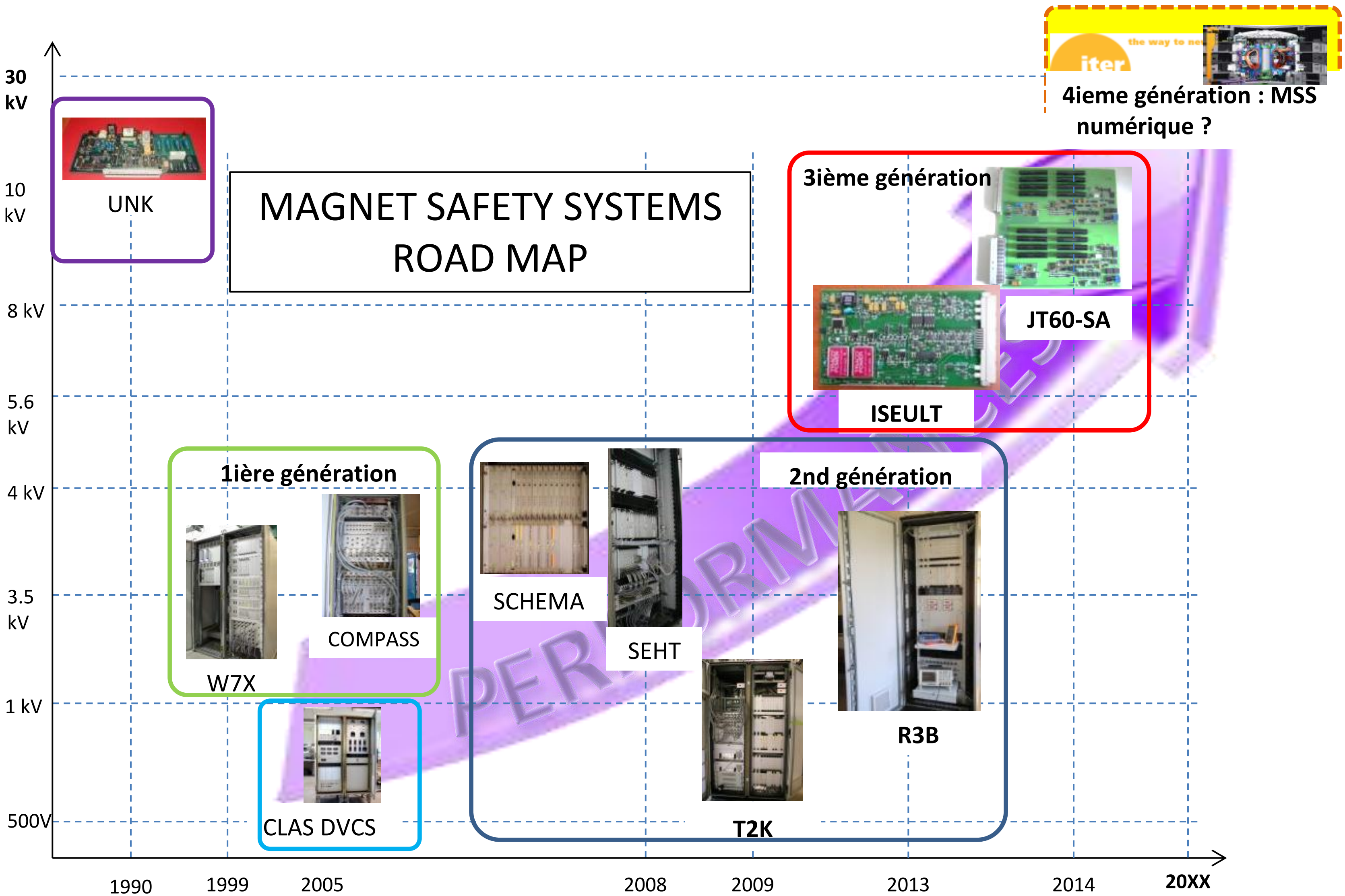
SIS Working Group has proposed a scheme
It has to be approved by collaborators


CEA - Saclay
Informatique industriels
Supervision générale
EPICS
PC supervision à distance - Muscade
Cryogénie, vide ...
Aimant
Alimentation de puissance
Automate
Réseau de terrain
Ethernet
Muscade EPICS
BoraNet
PC supervision LabView
Magnet Safety System
Instrumentation Electrotechnique
PC contrôleur ASnet
Muscade, autres ...
Signaux analogiques
Signaux tout ou rien
ASnet
Système d'acquisition
NAS disc

INTEGRATED SOLUTION FROM SENSORS TO ACQUISITION



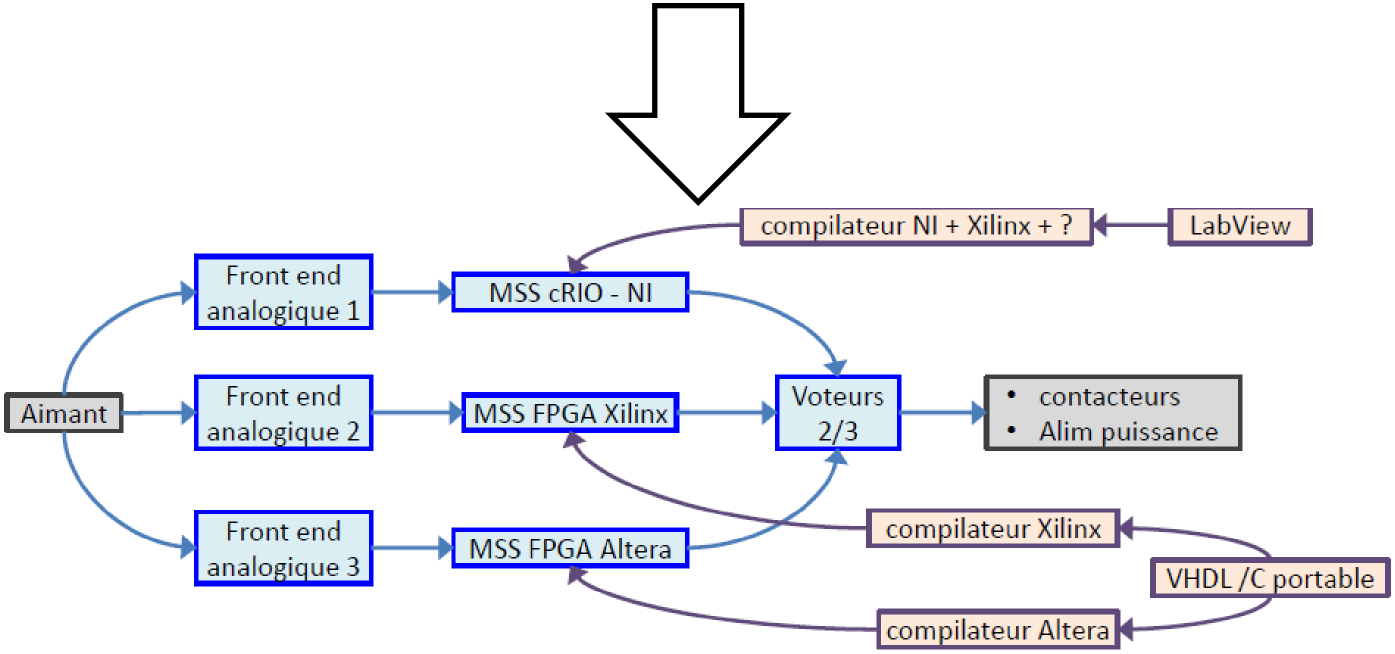
1. Magnet Safety System



1. MSS 4ST GENERATION : NUMERICAL?

REQUIREMENTS for the future MSS :

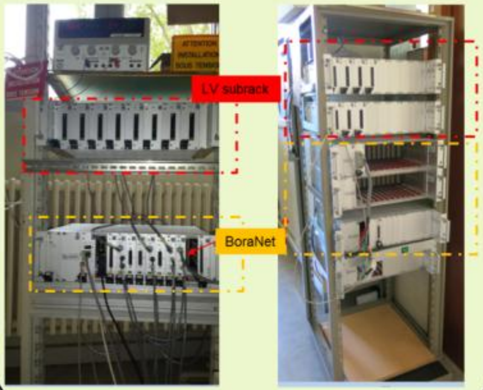
- Increase of the channels numbers
- Increase of the isolation
- Compacity to limite cablings
- Increase of the quenchs equation for new magnets
- HTS conductors
- Need of flexibility for the threshold setting



2. « BORANET » : MODULAR SENSORS CONDITIONER

Juillet 2014: Tests and validation of BoraNet subracks and low votage subracks

→ 5 BoraNet system and 3 subrack low votage are realized and tested



Important dates:

■ **Juin 2013:** First the prototype BoraNet System : Controller board, Current\Voltage Board, He Level Board

■ **September 2014**: Tests et validation of the prototype Cernox Board

■ **Octobre 2014**: Tests and validation measure of pressure with BoraNet system on JT60-SA installation

■ **December 2014:** Tests and validation measure of Helium Level with BoraNet system with Dewar

December 2014: First Cryotest at Saclay using BoraNet System with He Level Modular (MCNHe)

→ Results obtained are well

October 2014: Integration one BoraNet and Low Voltage Subrack on the Cabinet

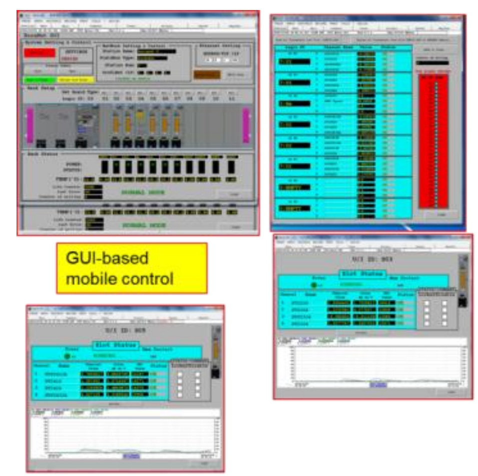
→ 14 sensors of Pressure transducer and 1 He Level

Perpectives 2015 :

■ **JT60-SA Project:**
- Tests and validation Cernox Board on JT60-SA installation
- Integration of two BoraNet system on the cabinet

■ **ISEULT Project:**
- Tests and Integration of two BoraNet and two LV Subrack system on the cabinet

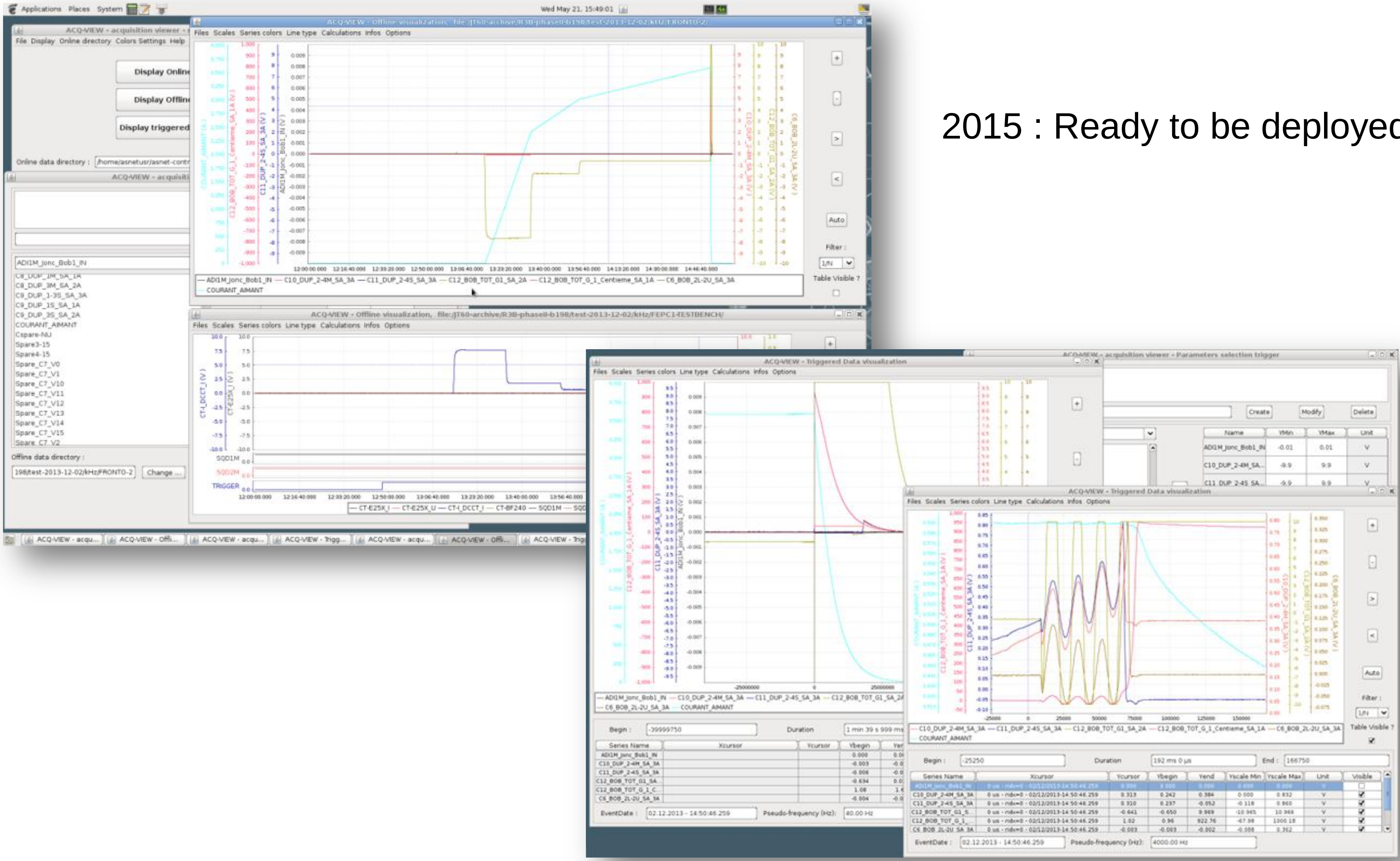
■ **ESS ECCTD Project:**
- Realization 1 BoraNet system for 12 sensors of Pressure transducer and 2 Helium level



System Control Software main screen showing the status of multi-channel modules.

| PAGE 8

2. ACQUISITION SYSTEM « ASNET »



2015 : Ready to be deployed

3. HOME MADE WEB MODULE MUSCADE®

What is Muscade®?

- Human Machine Interface
- Remote supervision module
- Monitor of device which manage the alarm (SMS, Email)

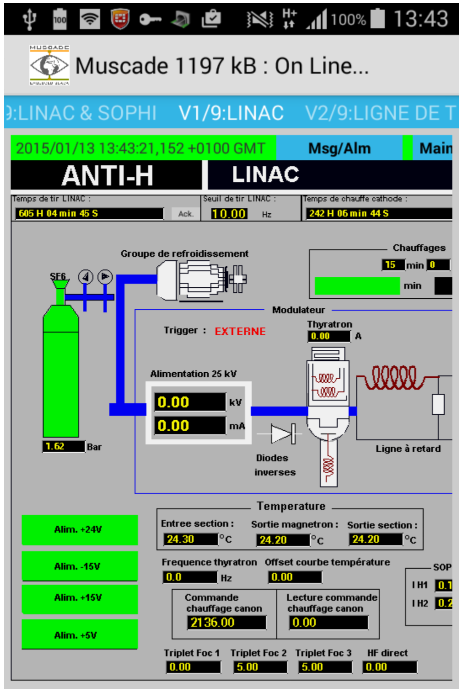
What could you do with Muscade®?

- Overview all of the experiment
- Watch a specific element state
- Control all the experiment: Start/Stop
- Control one element of the system
- Archive data and replay them

Muscade® Assests ?

- Flexible, configurable for development, commissioning and maintenance of complex prototypes, evolutive and distant

Update 2014 : available with ANDROID system



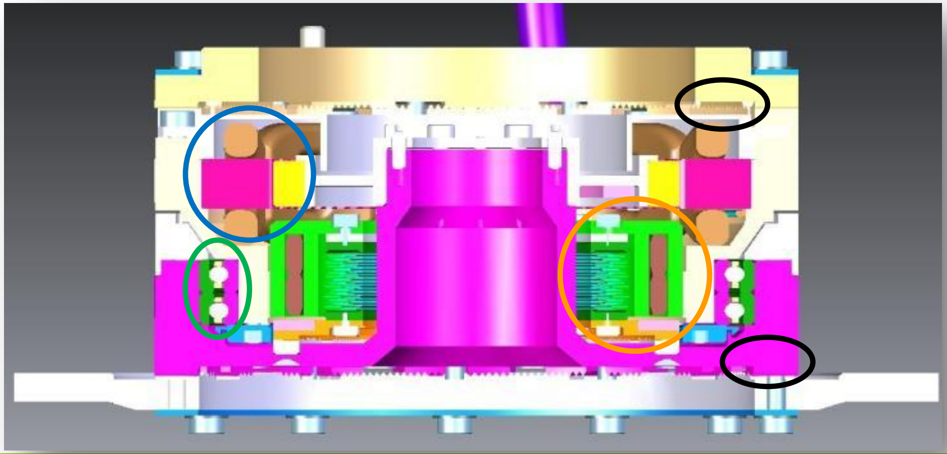
Technological transfer : via a Start-Up ?

WHAT IS A CRYOMECHANISM ?

<u>For IR instruments</u> : Cryogenic motorisation unit which rotates an optical wheel in a stable, repeatable angular position (10 arc.sec) between Room Temperature until few K. No power consumption in steady state, 360 positions/turn.

Cryomechanism functionalities	Component
Motorisation	SAGEM Stepper Motor
Wheel support	ADR Bearings
Wheel position indexing	Clutch subsystem
Wheel and structure IF	Athermal interfaces

Designed, developped and qualified @Irfu



2002 2013 2017 2022

VLT - VISIR

10 entities

« Space qualif.»

MIRI

Back-up - MV

CAMISTIC

Concordia

Sélection

EUCLID

~ 8 à 10 modèles

Sélection tbc

ELT METIS

~ 35 Cryomechanisms (tbc)

CM-21 (200 positions), CM-35 type MIRI ou EUCLID (360 positions), CM-57 à concevoir (1000 positions)

<u>Strategy of « component development » :</u>

- Industrial partnership to set-up
- *Relationship with ENS Cachan (M2)*

▼ **livraison**

IRFU CRYOMECHANISMS : LEGACY & PERSPECTIVES

2002 2013 2017 2022

VLT - VISIR

10 entities

« Space qualif.»

MIRI

Back-up - MV

CAMISTIC

Concordia

Sélection

EUCLID

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Sélection tbc

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▼ livraison

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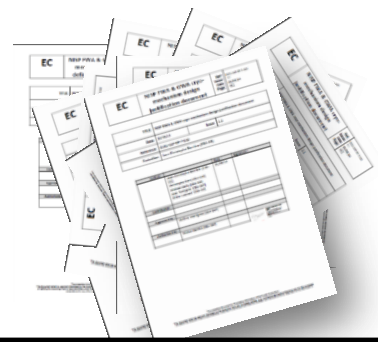
CM-21 (200 positions), CM-35 type MIRI ou EUCLID (360 positions), CM-57 à concevoir (1000 positions)

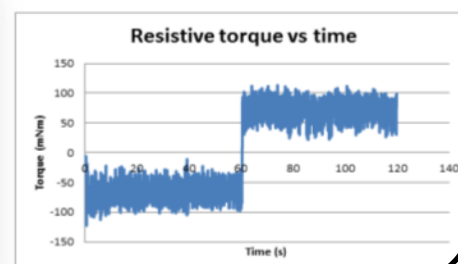
EUCLID CRYOMECHANISMS – 2014 ACHIEVEMENTS

Delivery of 2 Structural and Thermal Models (STM) in June



Successfull PDR in October 2014

Start of BBM (BreadBoard Model) test program from September 2014



DE LA RECHERCHE À L'INDUSTRIE

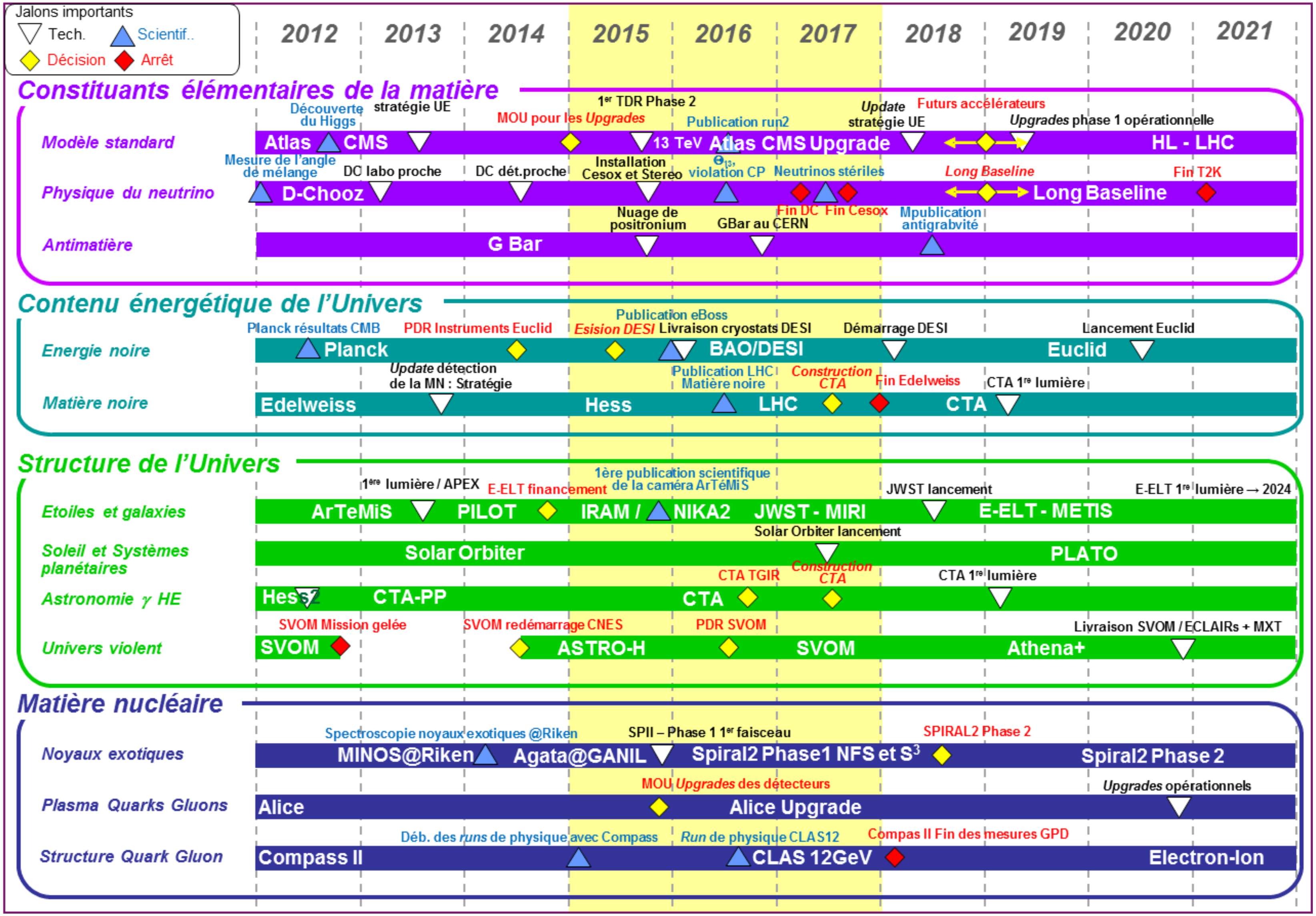
PERSPECTIVES

&

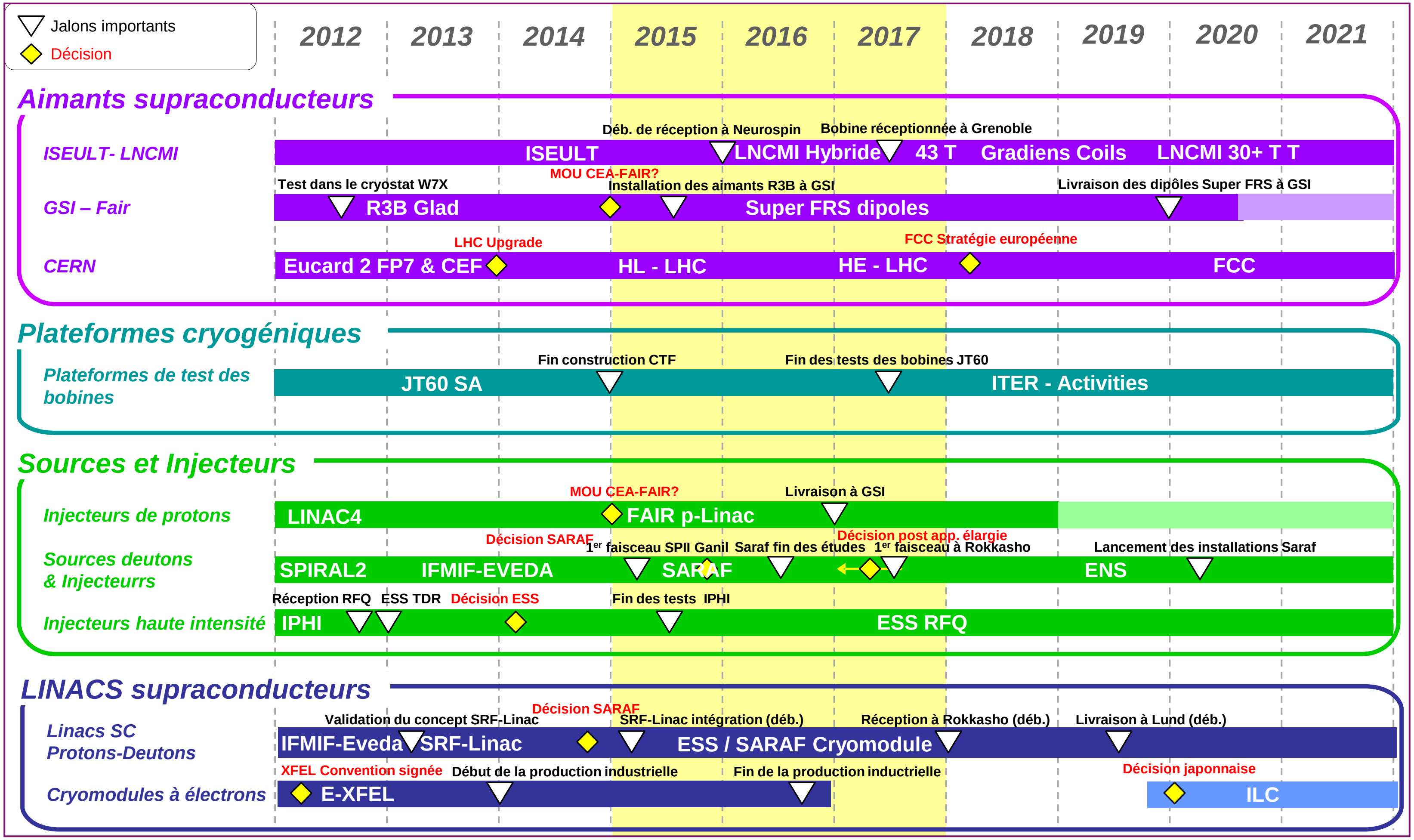
CONCLUSION

www.cea.fr

PERSPECTIVES



PERSPECTIVES



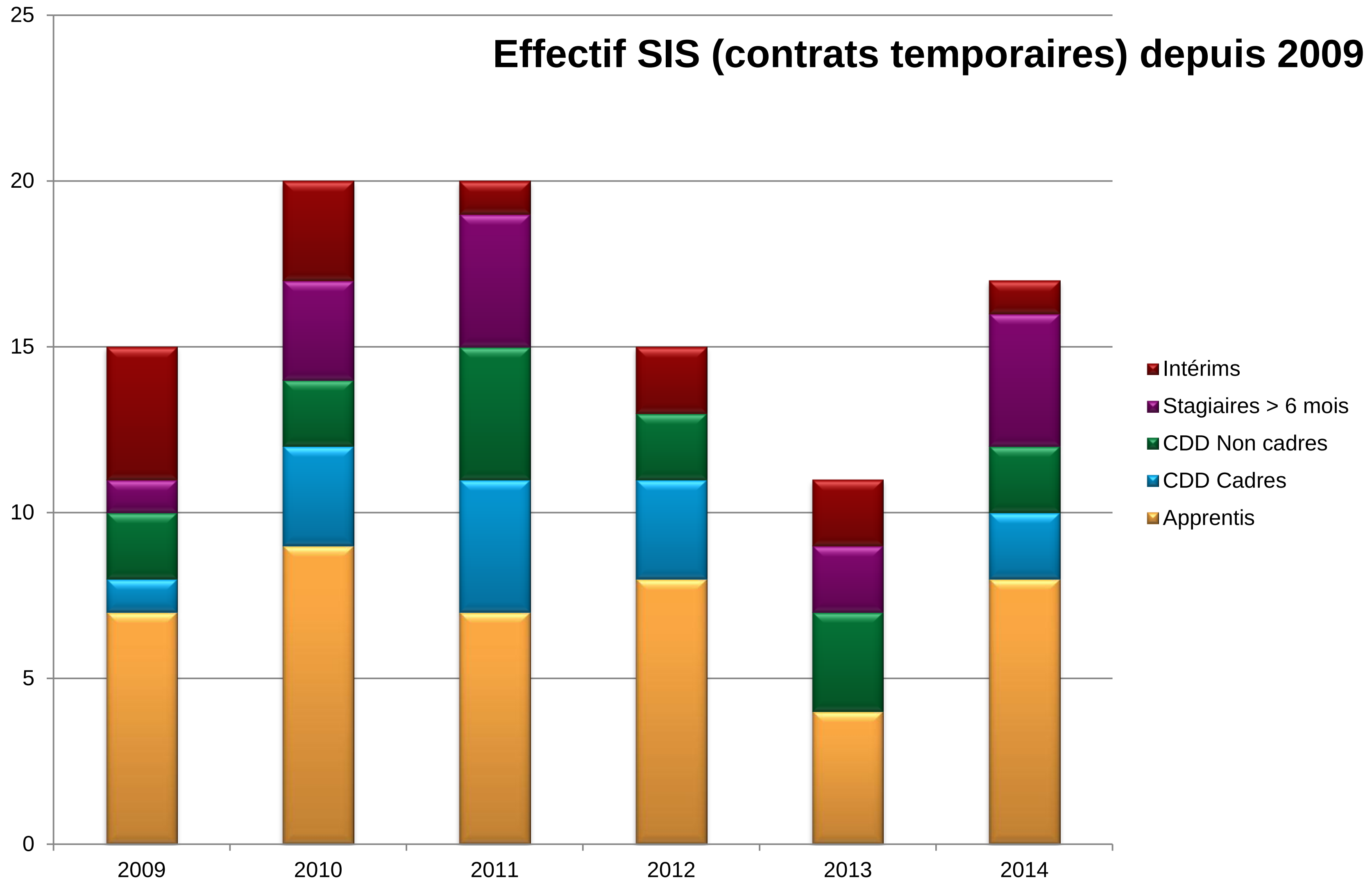
PERSPECTIVES & CONCLUSION

- SIS will contribute to the developments of almost all the instruments listed on the Irfu RoadMap → heavy workload for the next 5 years
    - Accelerator field
    - LHC upgrades and detectors
    - Space instruments and telescops

- Technical resource is very constrained :
    - workload requires hiring temporary contracts ;
    - work methodology is constantly adapted to keep efficiency and reactivity

- Expertise of SIS is more and more recognised :
    - Scientific talks and papers ~ 8 to 10 / year
    - Organisation of an international workshop
    - Links with academic partners are improving
    - Expertise invited by the Shanghai Institute of Applied Physics on the mechanical design

- SIS is ready to welcome PhD and Post Doc for R&D programms



Effectif SIS (contrats temporaires) depuis 2009
25
20
15
10
5
0
2009
2010
2011
2012
2013
2014
Intérims
Stagiaires > 6 mois
CDD Non cadres
CDD Cadres
Apprentis