

DE LA RECHERCHE À L'INDUSTRIE



# PARTICLE PHYSICS DIVISION (SPP)

CSI 2015 | Anne-Isabelle ETIENVRE

[www.cea.fr](http://www.cea.fr)



# **GENERAL OVERVIEW OF THE DIVISION**

*Ultimate  
Constituents  
of matter*

**Standard Model studies  
and BSM  
(large colliders)**

**D0 , Atlas and CMS**  
**Upgrades LHC phases 1 and 2**  
**R&D : ILC, FCC**

**Neutrinos**

**Accelerator: T2K, Laguna-LBNO**  
**Reactor: Double-Chooz, Nucifer,  
Cesox**  
 **$\nu$  astronomy: Antares**  
**Double beta**

*Energy content  
Of the Universe*

**Dark matter**

**Edelweiss**

**$\gamma$  Astronomy**

**HESS, CTA**

**Cosmology**

**SNLS, Planck, post-Planck**  
**BAO (BOSS, eBOSS, DESI)**

**Anti-hydrogen**

**GBAR**

**Instrumentation**

**CALIPSO, RD51**

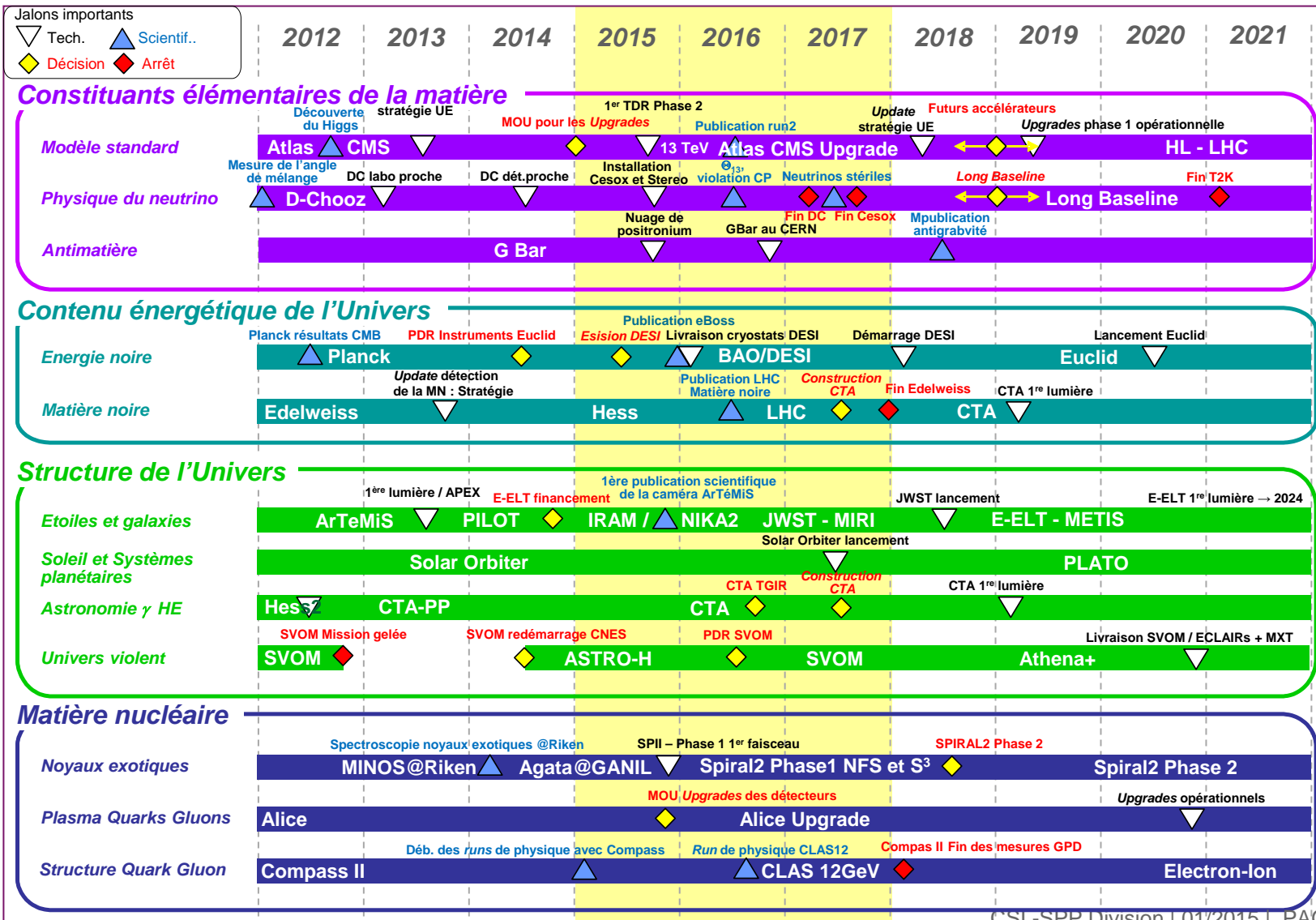
■ Data taking   ■ construction   ■ prospective

## Scientific strategy

- **Participate significantly in the major research programs**
  - In consistency with the European Strategy
- **Propose original experiments**
- **Contribute to relevant technological innovations**
- **Contribute to all aspects of experimental particle physics**

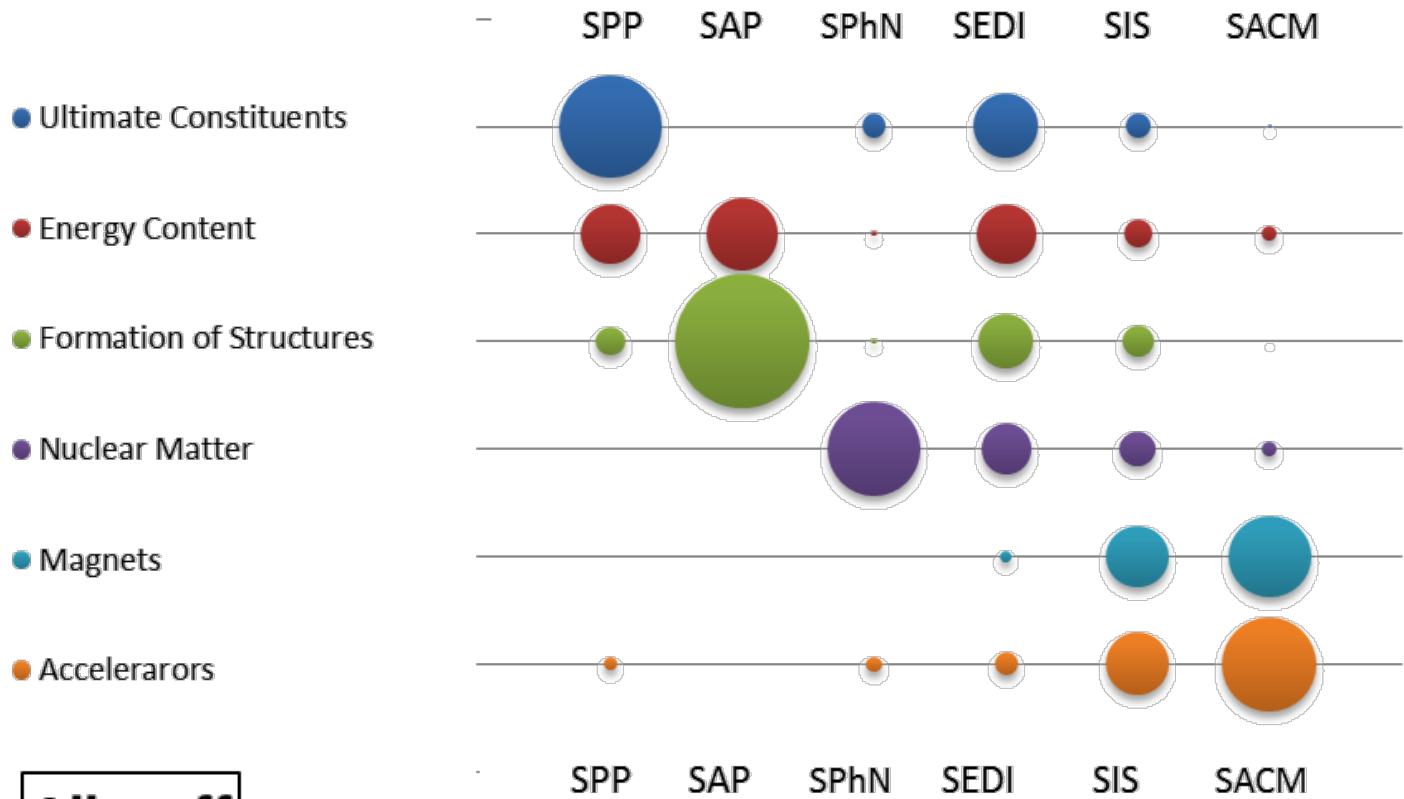
## Scientific and technical committee (CSTS)

- **Appointed every 3 years, 2 sessions/year in average**
- **7 internal members, 4 external members**
- **Advice on:**
  - Experiment proposals
  - Ongoing experiment
- **2014 : review of overall SPP prospective (5-10 years)**



## Strong interactions with other Irfu divisions

- Crucial to play a leading role in the definition/construction of experiments

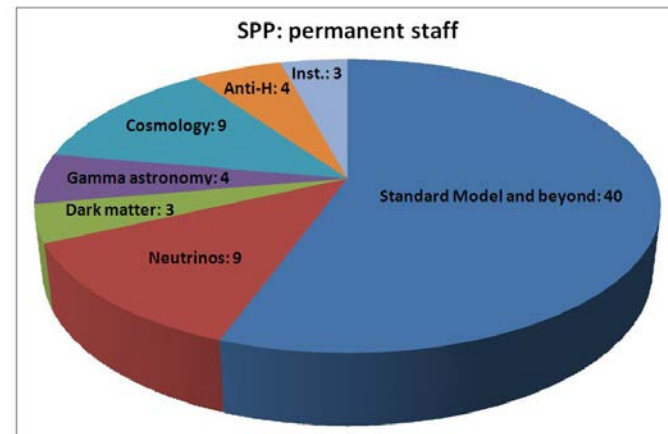


Surface proportional to nb of FTE

**All staff**

## Permanent staff

- **74 : 72 CEA (70 physicist, 2 adm.),  
1 Prof. (Univ. Paris Diderot), 1 CNRS**
- **2/3 : ultimate constituents of matter,  
1/3 : energy content of the Universe**
- **Recruitments: international calls for permanent positions  
evaluated by an internal committee**
- **Strong links with the academic partners**
  - 20% teach in several Universities/engineer schools
  - Strong involvement in research networks
  - Strong involvement in Université Paris Saclay (LabEx P2IO, Research Department, Doctorate School, Master)



## Non permanent staff

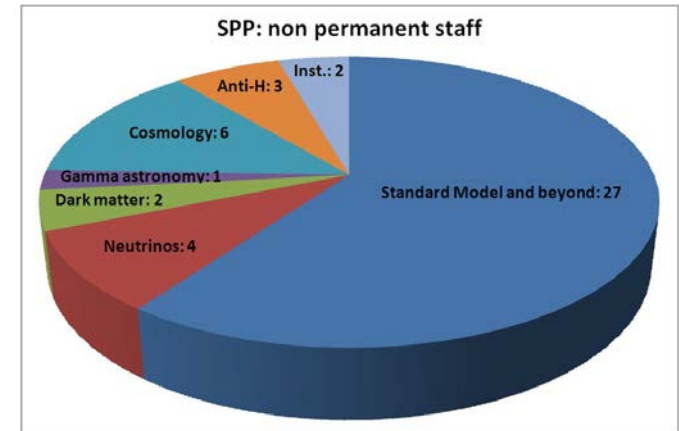
### ■ PhD students:

- 31 ongoing
- several funding sources
- 1/3 from abroad
- Careful follow-up of the post-doctoral insertion

### ■ Post-doc:

- 10 ongoing
- 2/3 from abroad

### ■ 2 representatives of students and postdocs within the « Division Council »





## Life in the lab

### ■ Scientific exchanges:

- Weekly seminars
- « Aperos du SPP »: internal seminar, general information
- Since 2014 : journal club driven by non permanent staff

### ■ Thematic exchanges:

- Cosmo club : bi-weekly journal club with IPhT and SAp
- Neutrino club: regular journal club open to other labs
- ILC club

### ■ General assembly once a year

**EXPERIMENTS: EVOLUTIONS  
SINCE LAST CSI**

## RUN 1 physics analysis

### Expertise and responsibilities in major analysis , and management

#### ■ Electroweak measurements

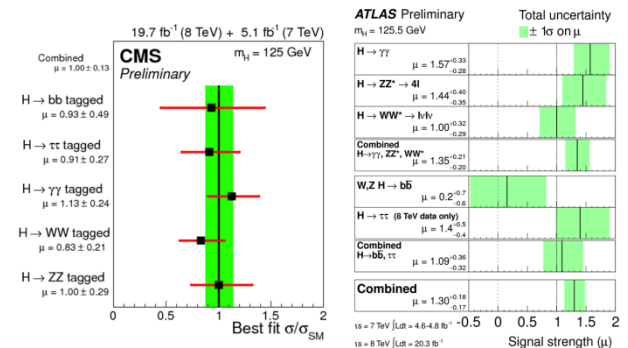
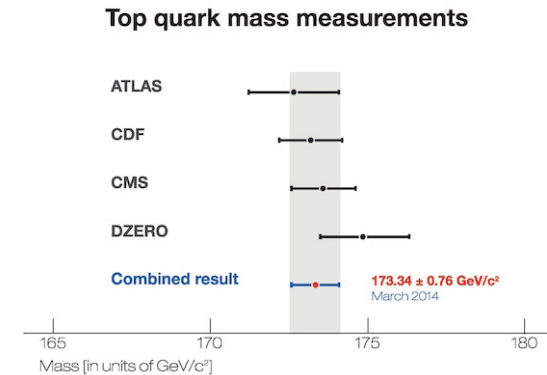
- 2 ERC (ATLAS)
- Top, W mass
- Dibosons
- W, Z + jets

#### ■ Higgs physics

- Several channels, combination

#### ■ BSM searches

- Top compositeness
- SUSY
- Extra-dimensions

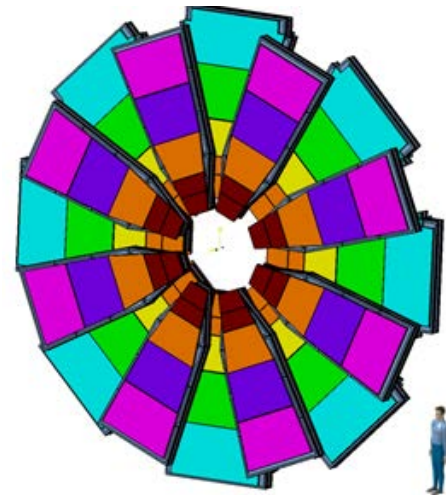


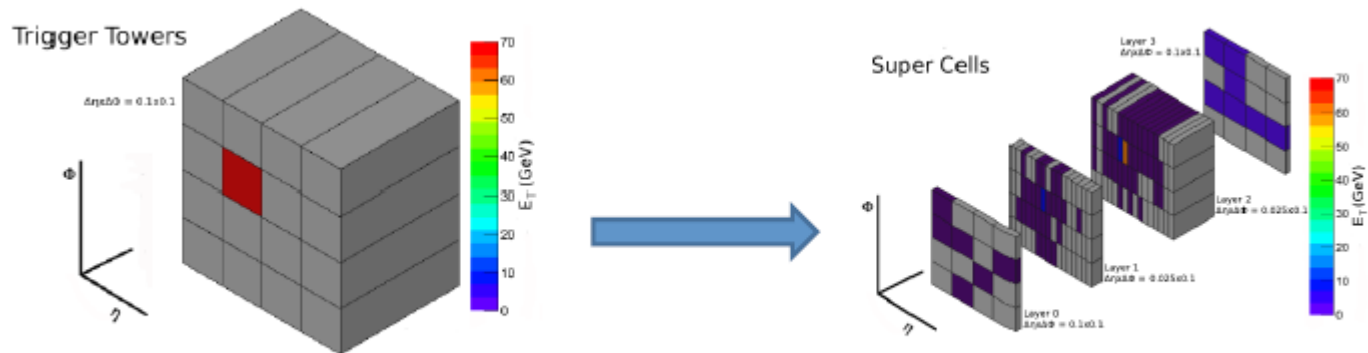
→ Talk by M. Boonekamp  
→ Ready for RUN 2

*Prepare the experiments for  $300 \text{ fb}^{-1}$  (2019-2021)  
with an instantaneous luminosity of  $2-3 \cdot 10^{34} \text{ cm}^{-2}\text{s}^{-1}$*

## New Small Wheel

- Preserve and enhance the trigger capacity in the forward region
- Reconstruct muons in a high multiplicity environment
- Technologies: Micromegas and sTGC
- Important Saclay contribution:
  - 350 m<sup>2</sup> (out of 1200 m<sup>2</sup>)
  - Budget : 3 M€ (total cost estimate : 17 M€)
  - Management: technical coordination
- Schedule:
  - 2014 : important progress on the first prototype
  - End of 2015-2017 : production phase



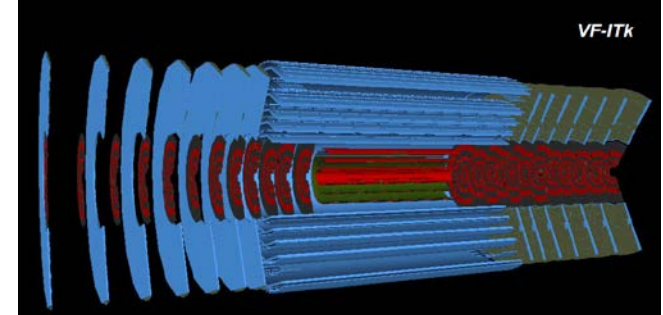


- **Preserve and enhance the trigger capacity for electrons and photons**
- **Increase the granularity and flexibility of the trigger**
- **Saclay implication :**
  - Analogic part of the electronic card
  - Budget : 0.8 M€
- **Schedule:**
  - 2014 : first card (demonstrator) installed in ATLAS, concluding tests
  - 2015 – 2016 : production

## Inner tracker upgrade (pixel):

### HVCMOS-based sensors seem promising

- Fast ( < 20 ns) and rad-hard
- Reduced size
- Reduced cost



### Default option : planar hybrid sensor

### Demonstration of feasibility by 2016, in time for pixel Phase II TDR ( foreseen end of 2017)

### Saclay possible implication:

- microelectronic design (MAPS), pixel sensors in-lab tests and irradiations, readout systems
- Pixel detector design and performances for physics
- Next step: participation to the design of demonstrators (collaboration with CPPM)

## ECAL barrel/ front end electronics

### Continuity of the Saclay historical commitments

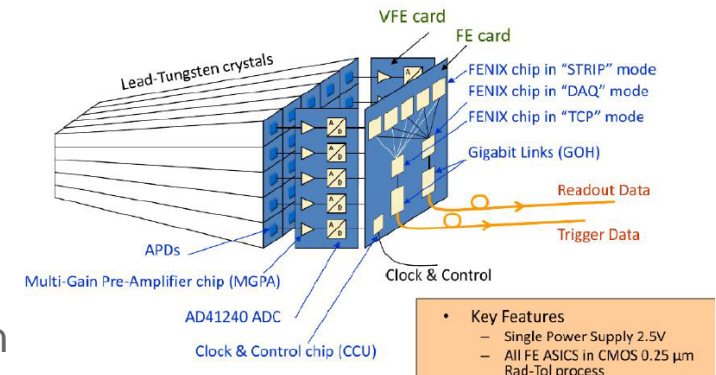
- ECAL calibration, laser monitoring of ECAL crystals, selective readout processors (trigger)
- Mandatory for in particular  $H \rightarrow \gamma\gamma$

### HL-LHC challenges for CMS ECAL:

- 1 crystal anomalous signal/crossing @HL-LHC
- pile-up (140/ crossing)
- APD leakage current increase
- → change of electronics:
  - increase of trigger rate (1 MHz),
  - latency time (12  $\mu$ s)
  - readout with full granularity for L1 trigger

### Saclay implication:

- Upgrade of the laser monitoring under discussion
- very front end electronics (TDR 2016)
- readout and trigger under discussion

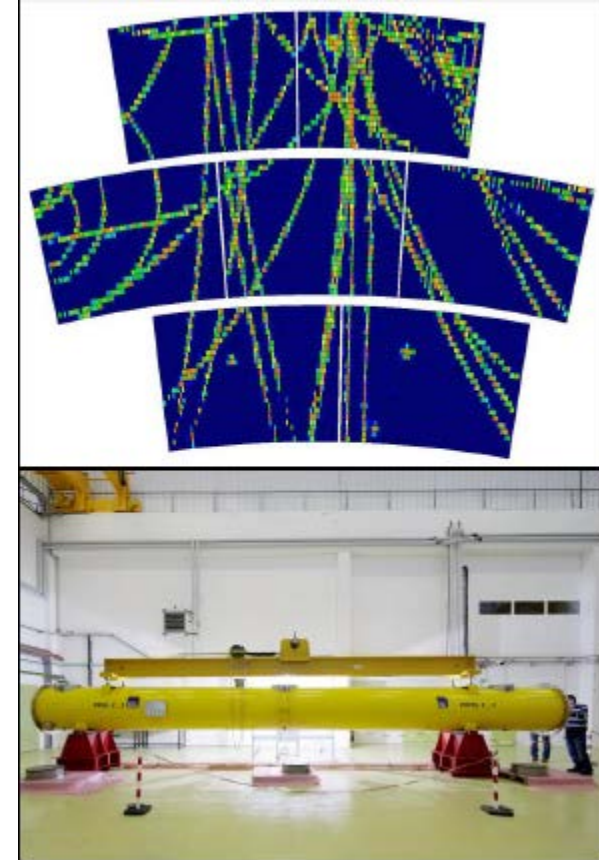


## Status

- Awaiting Japanese proposal
- Decision expected in 2016
- 2 detectors (ILD/SiD)

## Irfu implication

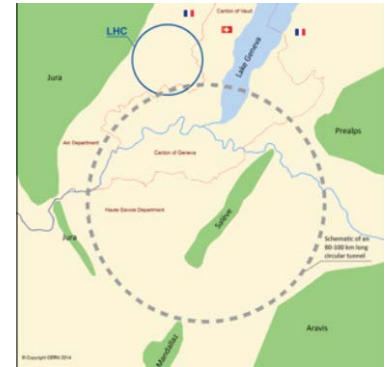
- **R&D (TPC, Micromegas)**
  - 7 modules prototype successfully tested @ DESY
  - Close collaboration within RD51
  - Participation in Eudet, Aida European program
- **Physics: journal club**
- **Management**
  - Member of LCC Technical Board
  - Decision (2014) : join ILD Collaboration



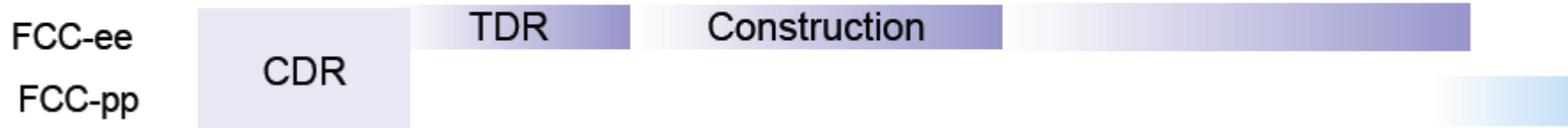


## Context

- 80km circonference circular collider based at CERN
- e+e- collider (350 GeV)/ pp collider ( up to 100 TeV)
- Kick-off meeting in 2014



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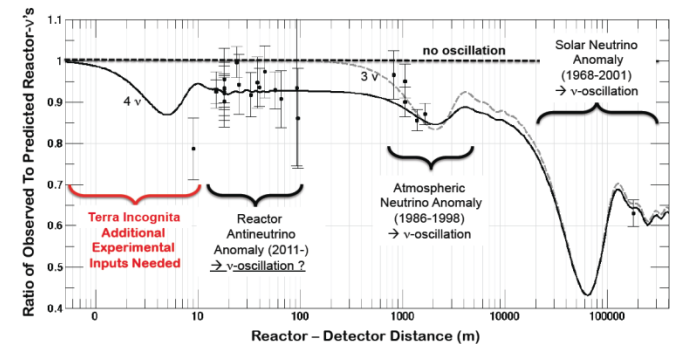
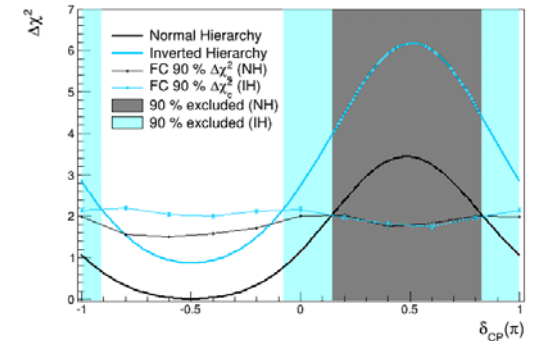
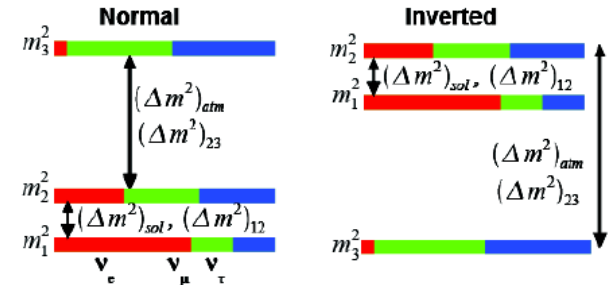
## Irfu implication

- Increasing implication
  - Detectors (TPC FCC-ee, magnet layout FCC-pp)
  - Accelerators
  - Physics
- Strong collaboration with SACM/SEDI
- Design study (H2020)

## Intense field of research

- Mass hierarchy
- CP violation ( $\delta$  phase measurement)
- Precision tests of the PMNS matrix
- Sterile neutrinos?
- Dirac or Majorana neutrinos?

→ **Complementary approach**  
 → **Talk by M. Zito & A. Letourneau**



## ■ T2K

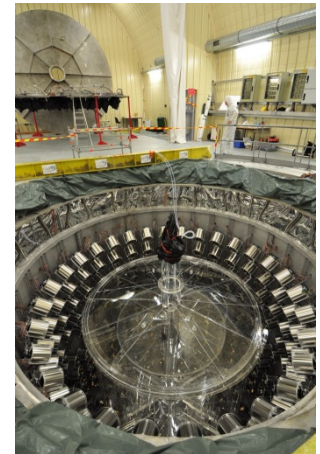
- Detector contributions: TPC (near detector)
- Participation to several analysis

## ■ Future long baseline experiments

- Active actor of European long baseline studies (LAGUNA)
- Exploring in parallel LBNF (US), HK (Japan)
- Important participation to WA105
  - Demonstrator: double phase Liquid Argon TPC

## ■ Low energy neutrinos (collaboration with SPhN)

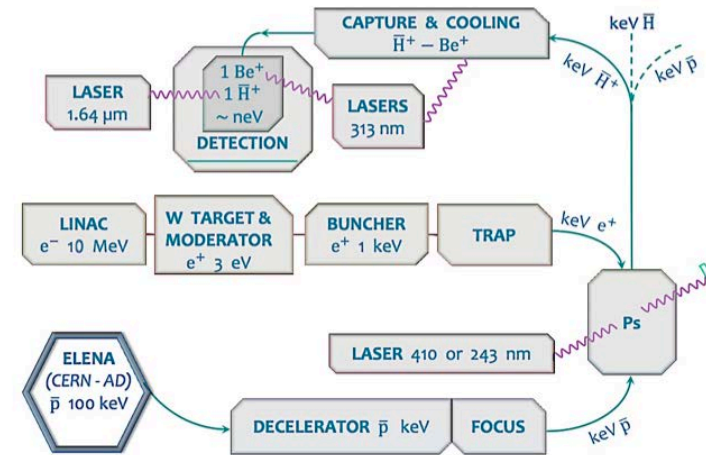
- Double Chooz: near detector start
- Cesox : installation of a  $^{144}\text{Ce}$  source inside Borexino (2015)
- Nucifer: nuclear reactor monitoring (IAEA)



## GBAR: behavior of anti-hydrogen w.r.t. gravitation

### *Experimental concept from Irfu*

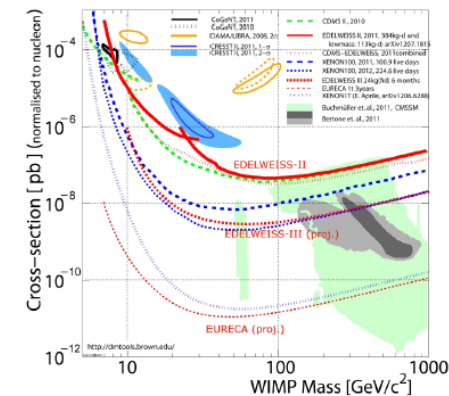
- **Important progress in 2014:**
  - Antiproton deceleration
  - Positron production and accumulation
    - Agreement on Linac
    - Huge work on accumulation ongoing
  - Antihydrogen cooling and preparation
  - Detection: collaboration with ETHZ
    - Ready end 2015
  
- **Installation @ CERN (AD Hall)**
  - First data in 2017
- **Strong collaboration with atomic community**
- **Important work on cross section prediction**
  - “Highlights of the year 2013 of New Journal of Physics”



## 2014 : Edelweiss-III start

### *Dark matter searches with bolometers at Modane*

- **Installation of full inter-digit detectors**  
*800g each, 24 detectors*
- **Data taking, 3000 kg-days expected by mid-2015**
- **Emphasis on low mass region:**
  - Possible use of HEMTs in 2015-2016
- **Post-Edelweiss III:**
  - Technological « wakefulness » within Eureka/SuperCDMS
  - Depending on LHC-Run2, Xenon 1t results



## Scientific goals

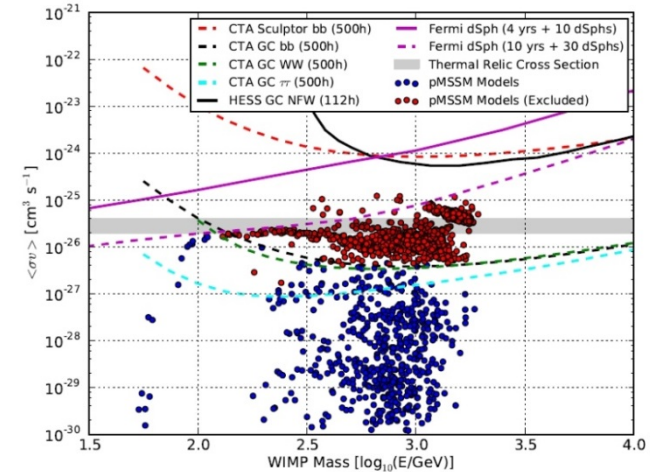
- Indirect search for dark matter
- Indirect search for axions
- Observation of central galactic black holes, dwarf galaxies

## HESS-2

- Conception and realization of L2 trigger
- Data taking ongoing

## CTA

- Major project in gamma astronomy
- 100 telescopes, 2 sites, 29 countries involved
- Irfu implication important since the preparatory phase





## Mirrors

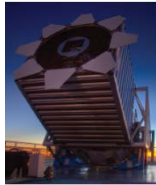
- **Successful development of composite mirror design**
  - Need: 3500 mirrors, 4200 m<sup>2</sup>
- **Mirror test facility installed at Saclay**
- **Collaboration established with a French company**
  - First batch produced (50 mirrors)



## NectarCam

- **Structuring project for the French CTA community**
- **7 modules prototype successfully tested**
- **Next step: 19 modules prototype to be built, required for design selection**





## Baryonic Acoustic Oscillations – Irfu strategy

### BOSS (2009-2014):

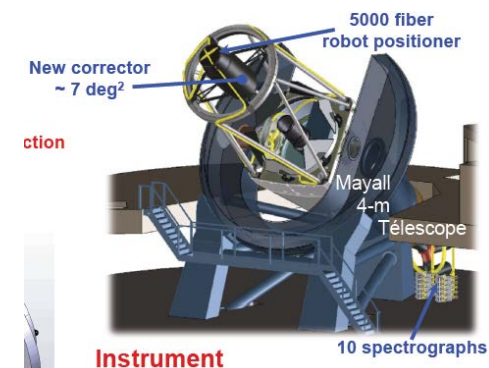
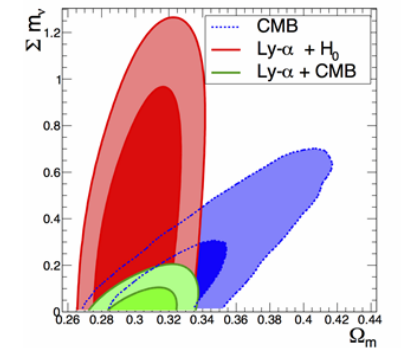
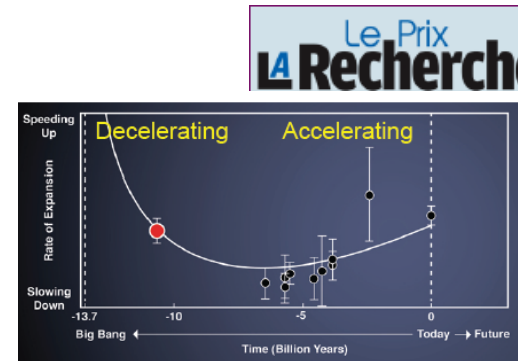
- Development of expertise on quasars Lyman- $\alpha$  forest
- 2013 : Observation of the deceleration of the expansion of the primordial Universe
- Constraints on  $\sum m(\nu) < 0.15 \text{ eV @ 95\% C. L.}$

### eBOSS (2014-2020)

- cross-correlation analysis, Ly- $\alpha$  target selection
- Update on  $\sum m(\nu)$

### DESI (2018-2023)

- 1 order of magnitude improvement
- IRFU responsible of quasar selection
- Instrumental contribution from Irfu: cryostats (30)  
First 3 cryo. for first spectrograph ready summer 2015





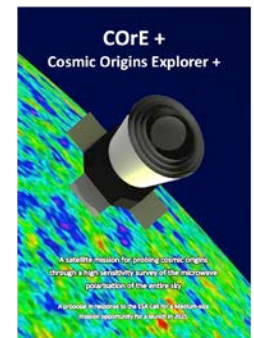
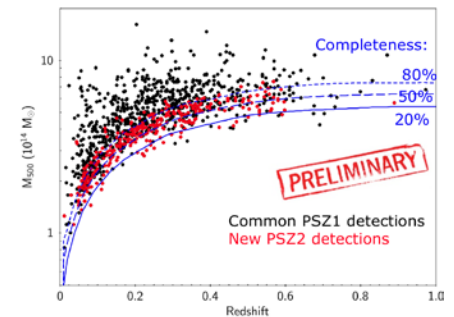
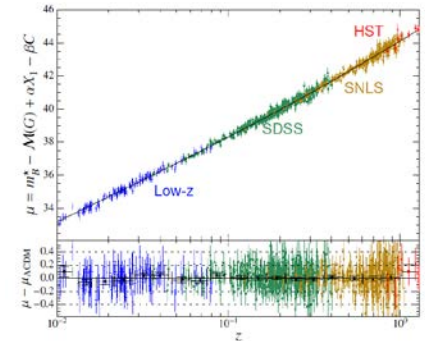
## SNLS : SuperNovae as standard candles

- Development of successful photometric SNIa typing
- Combined search for scalar fields  
SNLS(galileon)/CMS(branon) → extra dimensions
- Ongoing: 5 year data set → cosmological analysis

## PLANCK

- 2014 : new results
- SPP contribution:
  - galaxy cluster extraction
  - catalogue construction
  - associated cosmological constraints
- Preparing post-PLANCK (ESA M4)
  - Optimised for CMB polarization measurements
  - SPP: coordination of the Large Scale Structure science case

**Strong interactions with SAp**



# RECOMMENDATIONS

## Scientific recommandations

### ■ **Scientific strategy:**

*Should be focused on visible contributions on high-class projects*

- Careful examination of new proposals by CSTS
- 2014 : report on
  - scientific strategy (2014-2024),
  - Human resources evolution within 10 years
  - open discussions

*Should not be driven by funding opportunities*

- All proposals to various funding sources have to be validated internally before submission

## Scientific strategy

### ■ Phase 2 upgrades : best possible involvement

increasing work since 18 months, in both ATLAS and CMS, despite uncertainties on funding and already strong involvement in phase 1 (ATLAS)

### ■ Neutrinos: experiment on sterile neutrino in a short term

→ important program with strong responsibilities, (Cesox, Stereo)

→ collaboration with SphN

### ■ CTA : clearer articulation between SAp and SPP

→ nomination of one single representative, regular common meetings

### ■ Develop specific links with theory labs

→ Journal clubs, welcome visitors for long stays

## Human resources, budget

*“how to maintain this excellence in the future?” (AERES)*

### ■ **Slowing down of recruitment (tight budget, change of retirement age)**

- *Critical (2008 → 2013: 78 → 72 permanent positions), but general problem*
- *2015 : open international call for one permanent position*
- *Prospective (2014-2018) on possible retirements → recruitments optimization*

### ■ **Budget**

- *Huge effort made by physicists to find external resources*
  - *Support from Irfu well appreciated*
- *LHC, CTA : funding resources from “Large Infrastructure” budget (Ministry)*

- **Rich physics program**  
*Benefits strongly from other Irfu divisions*
  
- **Important results and evolutions in 2014 despite strong constraints**  
*LHC : run 1, upgrades phase 1 and 2*  
*Future colliders*  
*Neutrinos : T2K results, Cesox*  
*Cosmology: Planck, BAO*  
*Dark matter: Edelweiss III start*  
*Gamma astronomy: CTA (instrumental progress)*  
*GBAR : important progress*
  
- **Next years promising**  
*Results from LHC*  
*Decision (future colliders)*  
*Start of Cesox, GBAR, DESI, CTA..*  
*Long baseline neutrinos*