


France
Midterm Report
2014-2017

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LAL Orsay and University Paris-Saclay


France General Facts

- Population: 67,02 M,
  - 2013: 65,6 M in 2013

  ➔Important steady growth rate !
- GDP per capita 31,3 k€
- R&D/GDP 2,2%

  ➔stable during the last years
- Geographical area 550 km2 (Metropolitan)
- CERN annual contribution in 2017:

  160 MCHF

  ➔ 3rd largest contributor 14,3%

France HEP organisation

Two main research organisations for HEP:

- IN2P3-CNRS: National Institute for nuclear and particle physics ~80%
- IRFU-CEA: Institute ~20%

These used to be the only resource providers but the situation has evolved quite a lot:

1. EU funds: ERC grants (PE2 panel), InfraDev, Marie Curie,…
   30 Starting grants, 5 Consolidator, 16 Advanced (Germany 30/21/23)
2. ANR (National Research Agency): funds projects of 100 k€-500 k€
3. Universities / « Investments for the future Plan » (PIA) :
   ~10 G€ plan for all of France
4. Regional funds
5. Etc.…

➔ About 30M€/year for all IN2P3 laboratories

« Investments for the future » Plan instruments

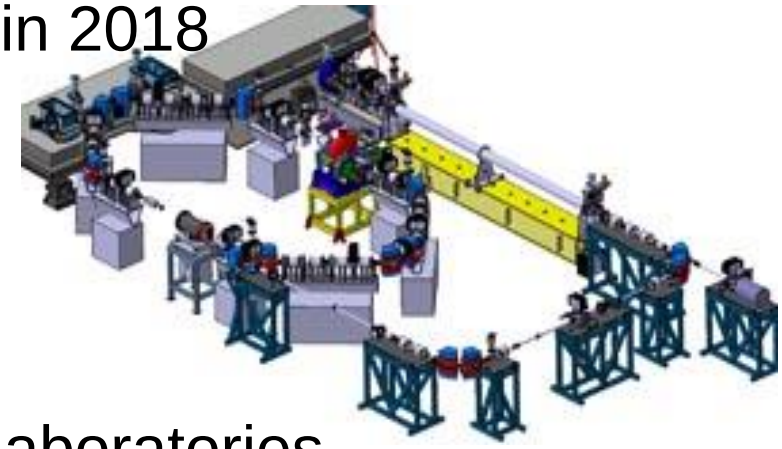
EQUIPEX: Large size local infrastructure ~10 M€
5 projects financed since 2011

One example : THOMX project, a new compact light source (12 M€) which will be commissioned in 2018

- TDR published in 2014

http://hal.in2p3.fr/file/index/docid/971281/filename/TDR_ThomX.pdf

- 10^{13} photons/s
- Energy range 50-100 keV



LABEX: 1 M€/year for local groups of laboratories

- P2IO : All labs SouthWest of Paris (IRFU, LAL, IPNO, LLR, LPT, IPhT, CNSNM, IAS, IMNC)
- OCEVU Marseille/Montpellier region
- ENIGMASS Grenoble/Annecy
- LIO Lyon
- ILP and Univearths (Paris)

« Investments for the future » Plan The Universities

- ~5 G€ devoted to Universities refurbishing and relocations (« Plan Campus »)
- IDEX instruments to regroup and merge Universities and engineering Schools (~100 M€ per year)

- ~10 IDEX in France. Those with HEP labs:
  - Paris-Saclay University
  - Grenoble,
  - Aix-Marseille
  - Université de Strasbourg
  - Université de Lyon
  - Université de Bordeaux
  - Sorbonne Paris-Cité
  - Sorbonne Universités

Paris-Saclay University

~15% of French R&D

160 ERC grants
1st in France
3rd in Europe

10 **Fields Medalists**

Projected Shanghai Ranking (2017)
16-20th

New research facilities and centres (2016-2019)


Neurosciences - 2017


Cell Integrative Biology 2018


Laboratory for Solid-State Physics Université Paris-Sud 2018


C2N Centre 2017


Aimé Cotton laboratory 2019


EDF R&D and EDF Campus 2016


ICE Climate & environment facility 2017


Institut de Mathématiques d'Orsay - 2017

13% of French research

9,000 researchers and professors

10 departments

12,000 publications/year

300 laboratories

60,000 students

9,000 in master degree

8 schools

45 master programs
350 master tracks

2016-2017 Academic year

~40,000 candidates
~9,000 master students in the mutualized programs

4,500 PhD students

20 doctoral schools

1,000 PhD/year
(support from LABEX, LIDEX, IDI...)

International Master Students : 30 %
International PhD students : 45%

Intensive Research

Innovative Cutting-Edge Academic Programmes

université PARIS-SACLAY

IN2P3 : an Institute of CNRS

MISSION : COORDINATE RESEARCH IN THE FIELDS OF NUCLEAR, PARTICLE and ASTROPARTICLE PHYSICS

EXPLORE

The Physics of the *two infinities:* from elementary particles to cosmology

OPERATE

Research Units, many in partnership with Universities and/or Research Organisations

COORDINATE

In partnership with CEA

National Research Programs and French participations in major Research Infrastructures

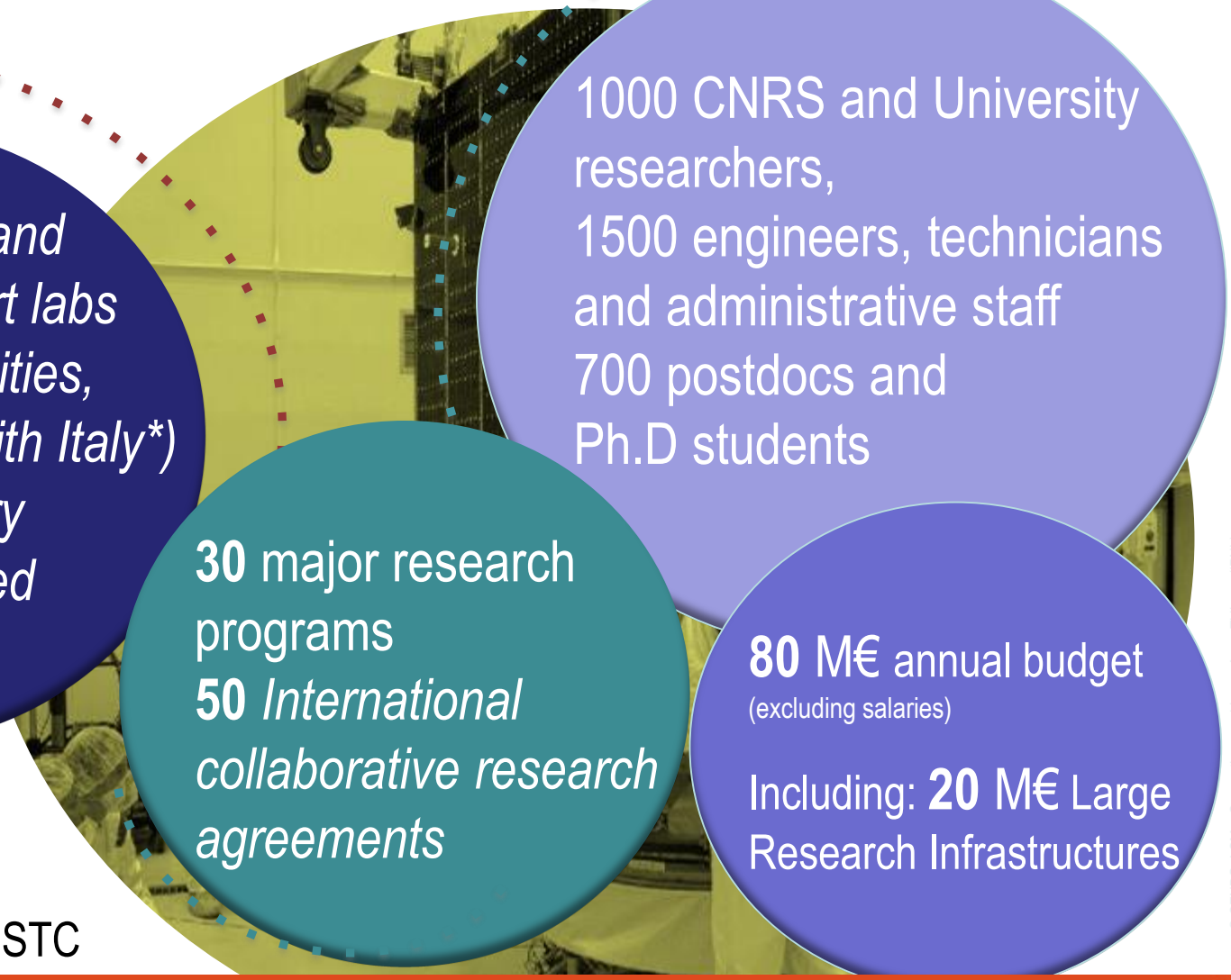
DEVELOP

Associated technologies, Applications and Interdisciplinary research

PROVIDE Expertise Teaching Training

LINKS WITH SOCIETY

IN2P3 : Key Figures



25 *laboratories and technical support labs (18 with Universities, 2 with CEA, 1 with Italy*)*
8 *interdisciplinary accelerator based platforms*

1000 CNRS and University researchers,
1500 engineers, technicians and administrative staff
700 postdocs and Ph.D students

30 major research programs
50 *International collaborative research agreements*

80 M€ annual budget
(excluding salaries)

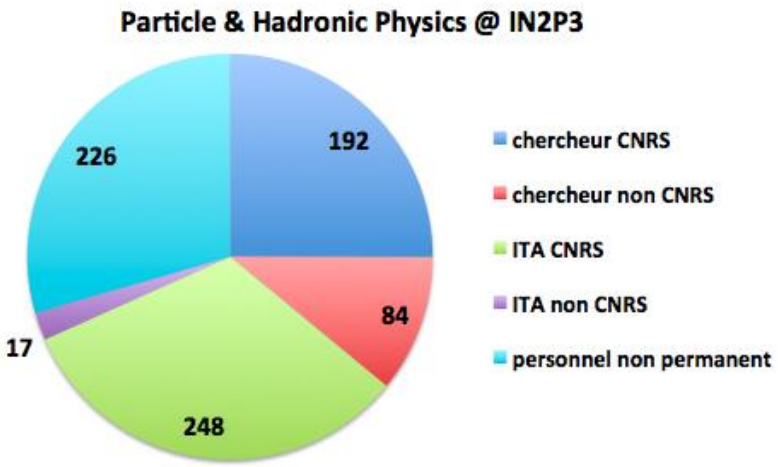
Including: **20** M€ Large Research Infrastructures

* EGO, + participations in CERN, FAIR, CTA and LSSTC

Particle and hadronic physics : overview

Human resources (2016):

300 permanents: CNRS researchers (2/3) and faculties (1/3)
55 post-docs and 120 PhD students
320 E&T (Engineers & technicians)



Gender (2016):

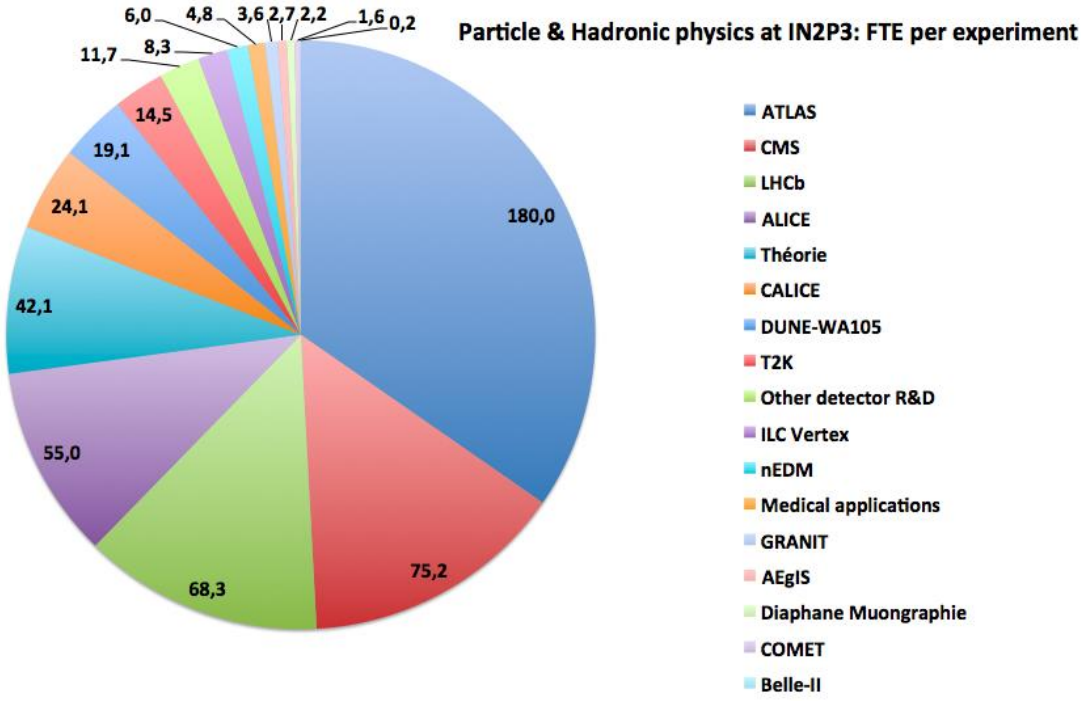
Women fraction among permanent physicists:

22,4% overall
24,6% among < 50 years old
34,0% among < 40 years old

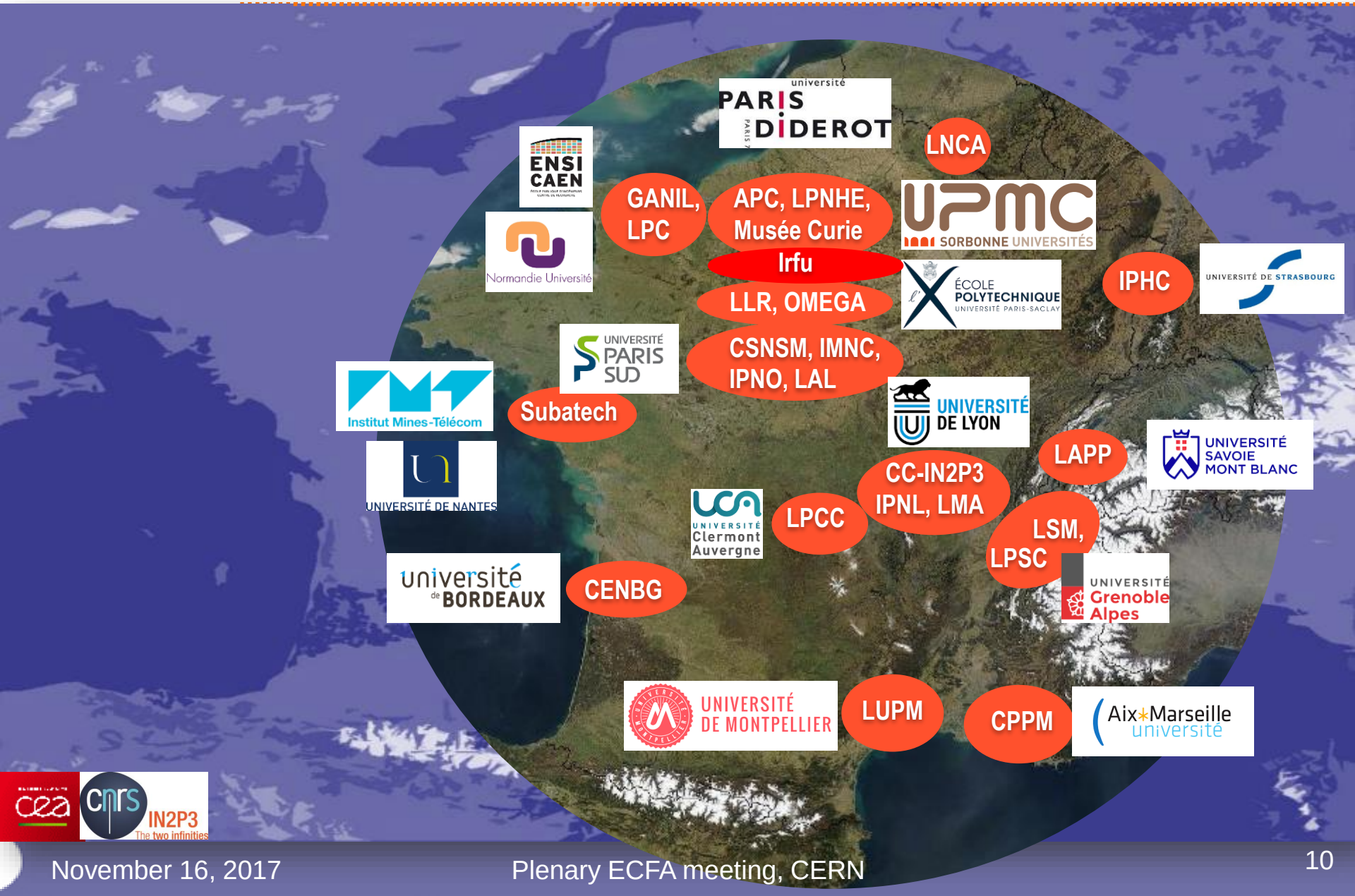
520 FTE in 2016:

73% on the 4 LHC experiments

Phase 2 upgrades for the HL-LHC:
➔ #FTE is growing (E&T)



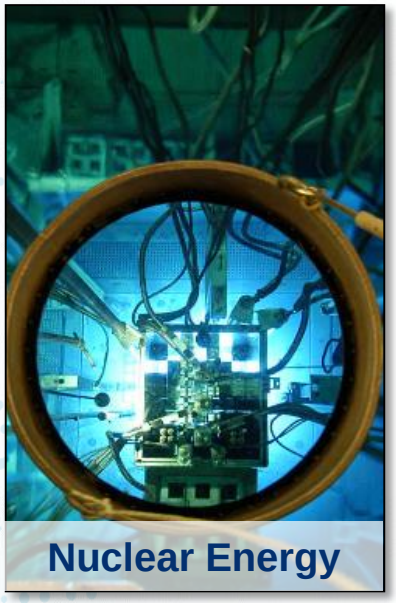
HEP-exp laboratories in France



cea cnrs IN2P3 The two infinities

CEA MISSIONS


Defense


Nuclear Energy


Industry

FUNDAMENTAL RESEARCH

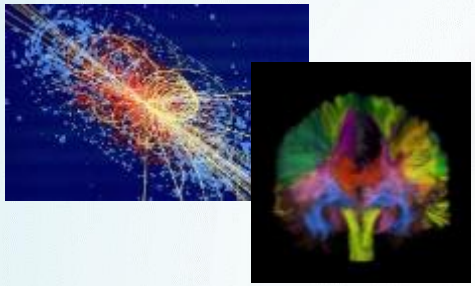
16 000
Technicians, engineers, researchers and staff

4 400
Million euros budget

10
Research centers in France

FUNDAMENTAL RESEARCH ACTIVITIES

PUSHING THE LIMITS OF TECHNOLOGY … TO ACHIEVE CUTTING EDGE SCIENCE



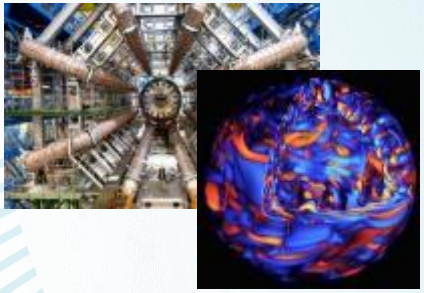
From basic research to applications

- Physics
  (Nuclear physics, high energy physics, astrophysics, fusion, quantum engineering)
- Material sciences, chemistry
- Biology and biotechnologies, health
- Climate & environmental studies

KNOWLEDGE

CEA Fundamental Research Division

KNOW-HOW



Infrastructures and instrumentation

- Cryotechnologies, accelerators, magnets, lasers, detectors
- Radioisotopic tagging, radiochemistry
- Genomics, proteomics, radiobiology, bio-imaging
- High performance computing
- Micro and Nanotechnologies, material processes

IRFU:OVERVIEW

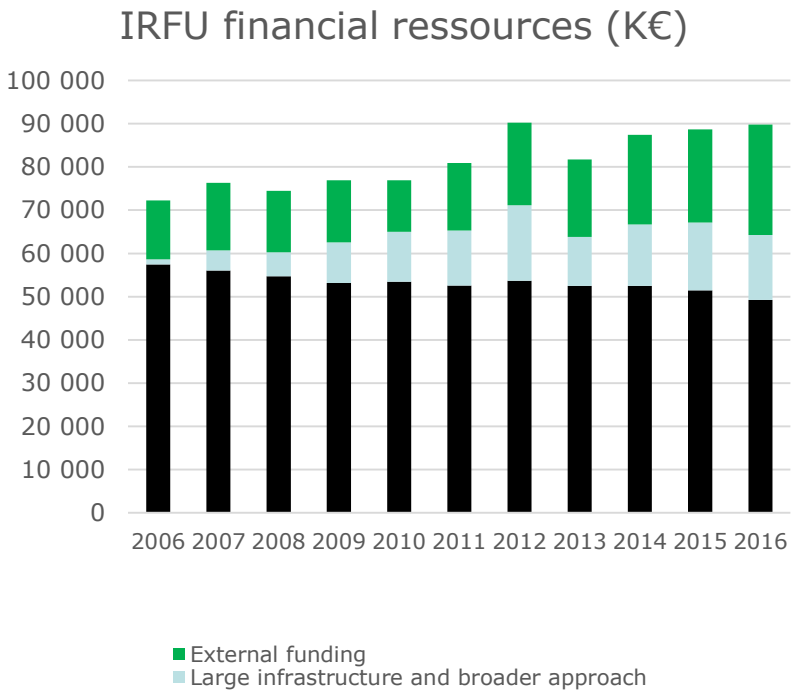
~ 950 FTE

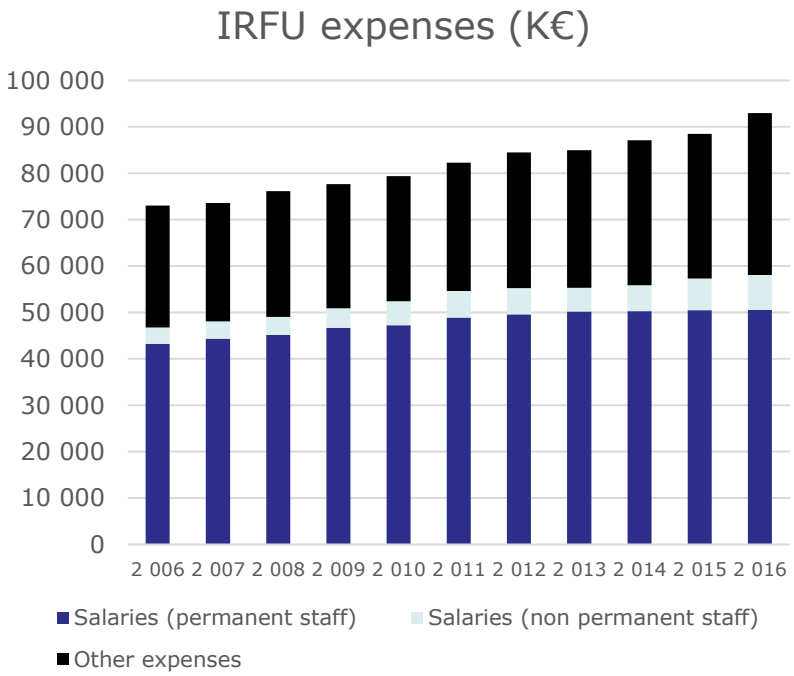
- 17 ERC
- 975 publications
- 65 active patents

Institut de recherche sur les lois fondamentales de l'univers

		GANIL	115 FTE
180 FTE	**DAp** Astrophysics	**DACM** Accelerators, Supra. Magnets	165 FTE
75 FTE	**DPhN** Nuclear Physics	**DEDIP** Detectors, Electronics, Computing	140 FTE
100 FTE	**DPhP** Particle Physics	**DIS** Engineering	130 FTE

IRFU FACTS AND FIGURES



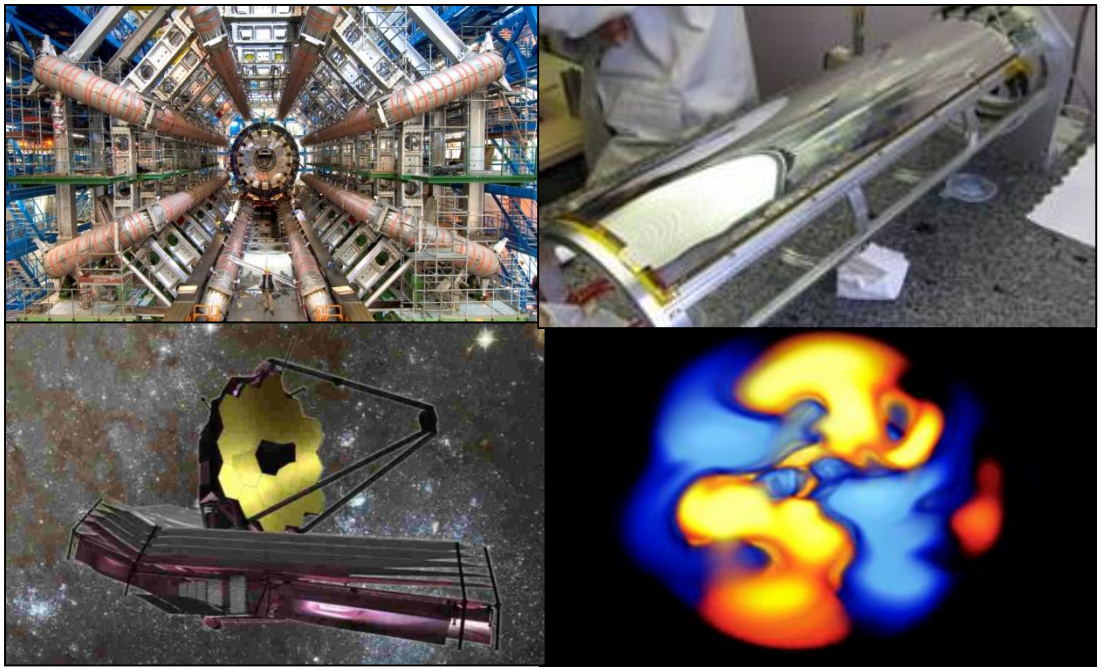


Accelerator and superconducting magnets

- *ESS (RFQ, cryomodules)*
- *FAIR (proton Linac, magnets)*
- *Saraf (Linac)*
- *Spiral2 (Source, RFQ, cryomodules)*
- *HL-LHC, FCC (magnets)*
- *Fusion projects*
- *MRI magnets (11.7 T)*

Detecting

- *Gaseous detectors (Micromegas)*
- *Solid detectors (bolometers)*
- *Electronics (ASICS)*



Observing : spatial devices

- *Camera, spectroimaging*
- *cryomecanisms*

Simulating

- *HPC*
- *Grid*

Research Areas

Particles & hadronic physics

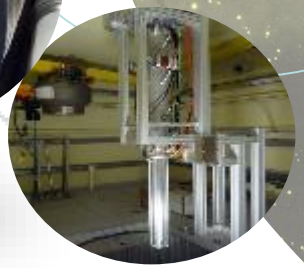
Matter's most elementary constituents and fundamental interactions

Nuclear physics & Applications

Structure of nuclear matter, nuclear energy and medical applications

Accelerator & Technology

Major R&D domains

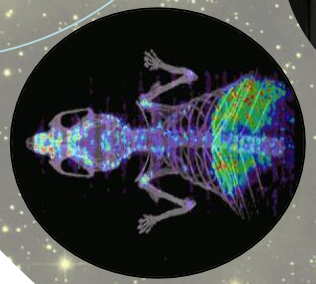


Astroparticle physics and Cosmology

Universe's composition and behaviour

Computing & Data

Data Science and Computing research



Large Research Infrastructures in France

IN2P3 in Europe

Jyväskylä
(Finland)

JINR Dubna
(Russia)

DESY FAIR GSI (Germany)

SCK-CEN/ SoLid, Myrrha
Belgium

CERN LHC,
ISOLDE

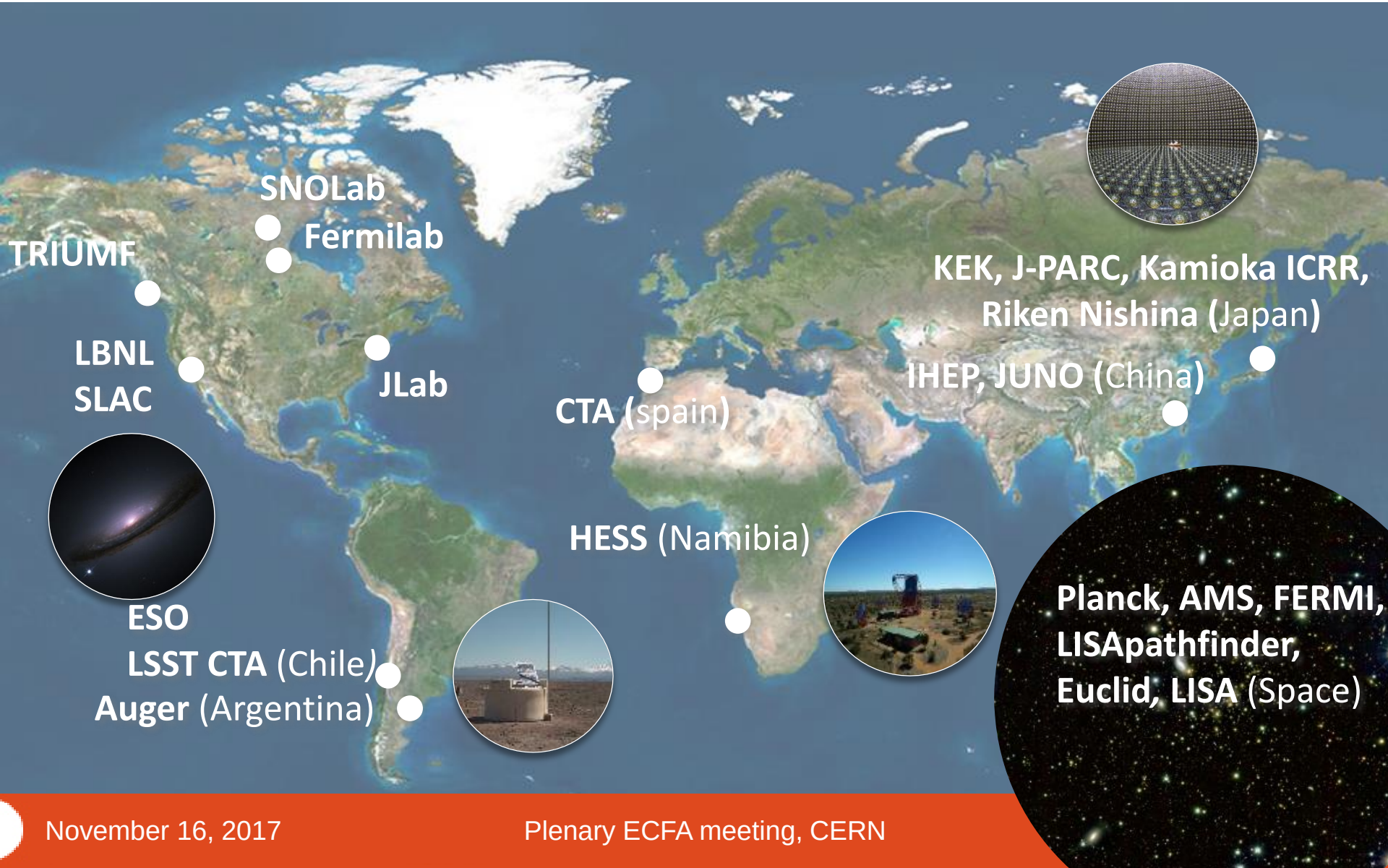
PSI / nEDM
(Switzerland)

EGO / Virgo
(Italy)

ELI-NP
(Roumania)

LNGS / XENON
(Italy)

IN2P3 internationally …

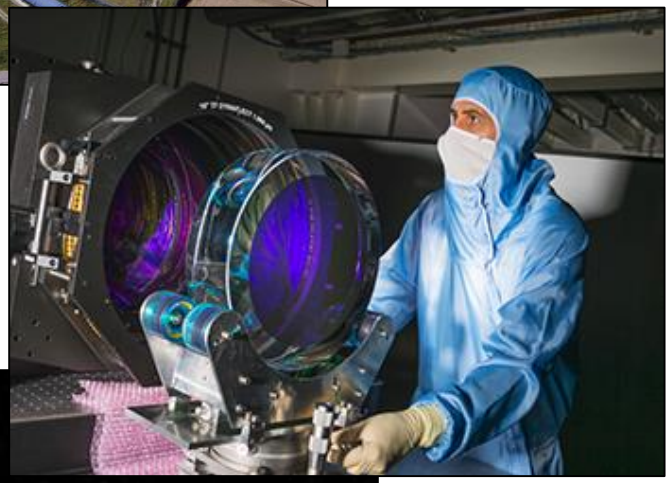


STRONG INTERNATIONAL COLLABORATIONS

Highlight : Gravitational Waves

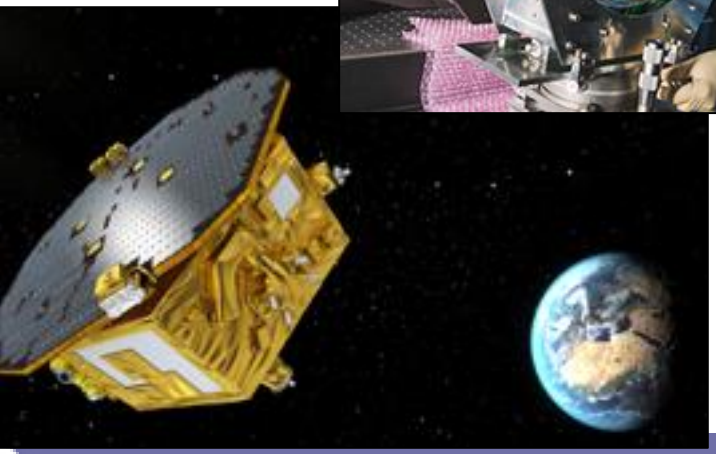
Inauguration of advanced Virgo
February 20, 2017

- Commissioning run with LIGO in fall 2017 ended with discoveries



- Mirrors produced in LMA Laboratory also selected for KAGRA interferometer (and used by LIGO)

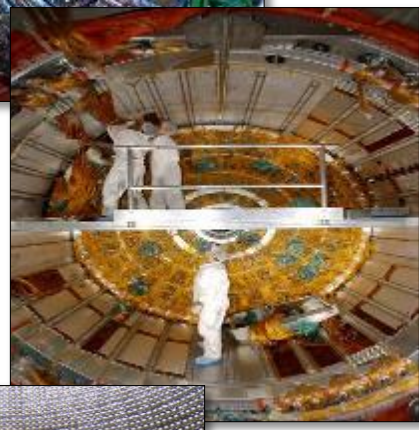
→ Worldwide most reflecting mirrors (99,999% !)

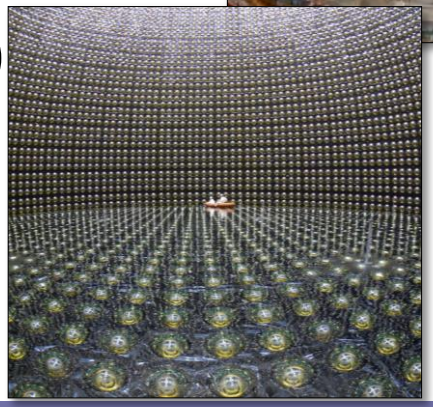


Lisa Pathfinder Mission very successful : free floating test masses and laser measurement system better than specs

Particle and hadronic physics

- Participation in all 4 major LHC experiments at CERN :
  - Physics at and beyond the standard model
  - B-physics and fundamental symetries
  - Heavy-Ion physics
- Participation in precision physics experiments nEDM (PSI), Comet (J-PARC), Gbar (CERN), …
- Accelerator based neutrino physics
  - T2K/SK, DUNE (ProtoDUNE at CERN)
- B physics at KEK (Belle-II)
- Structure of the nucleon (Jlab)





Belle-2

- IN2P3 is joining the Belle-2 collaboration (October 2017)
- 2 laboratories :
  - IPHC Strasbourg and LAL Orsay
  - ~10 physicists so far
- Foreseen contributions:
  - Already since 2014 : beam background monitoring and diagnostic
    Beast project: CMOS sensors (IPHC),
    ATF2 (LAL)
  - ARICH commissioning
  - Physics: CP asymetry in B -> K⇨πγ
  - Computing at CCIN2P3

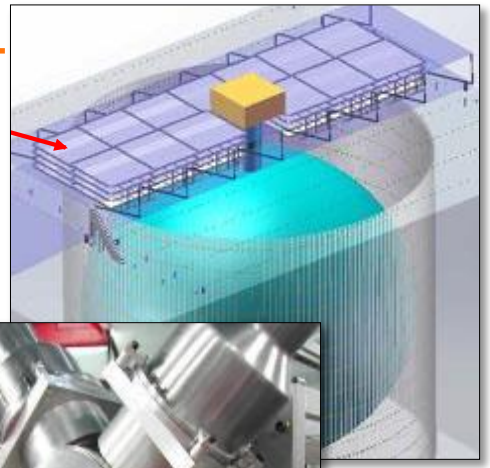
Collaborations with Bonn, DESY, KIT, MPI

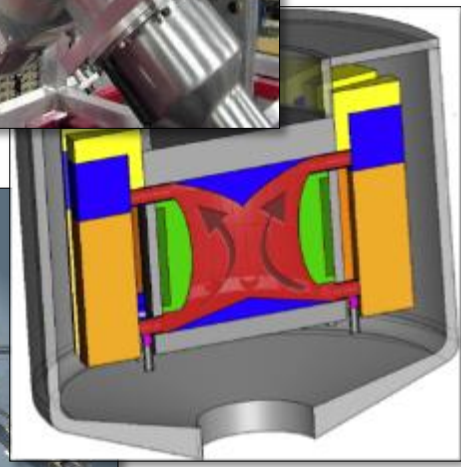
Nuclear physics and Applications

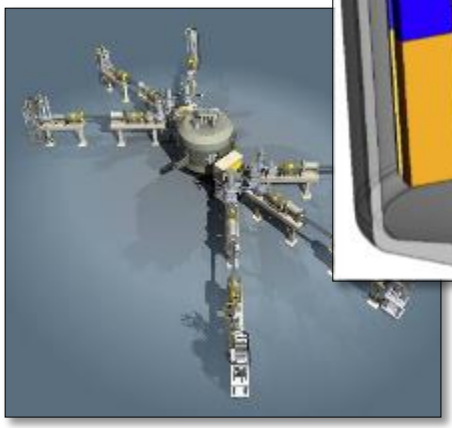
- **Reactor based neutrino physics**
  Double-CHOOZ, Stereo, Solid, JUNO

- **Health and life-science applications**
  Hadrontherapy, dose control, radioisotope production, imaging technics, simulations

- **Nuclear Energy**
  Modelisation of reactors and scenarios
  Experimental reactor physics (ADS)
  Nuclear data
  Material irradiation
  Radioisotopes in material and environment







Astroparticle physics and Cosmology

Understanding the history of the Universe, Inflation Dark Energy
- LSST, DESI, EUCLID, QUBIC

Search for Dark matter
- EDELWEISS, XENON

Gravitational Waves
- VIRGO, LISA

Gamma-astronomy
- FERMI, HESS and CTA

Studying Cosmic Rays
- Pierre Auger Observatory, AMS

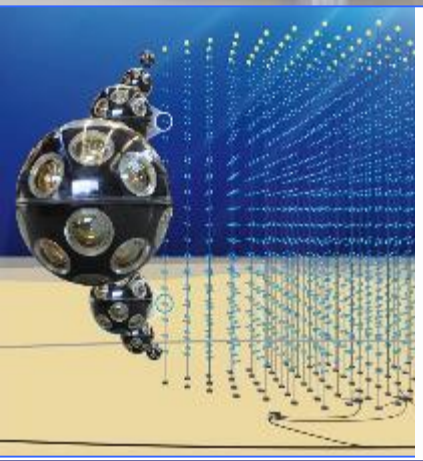
Cosmic neutrinos
- ANTARES, KM3NET

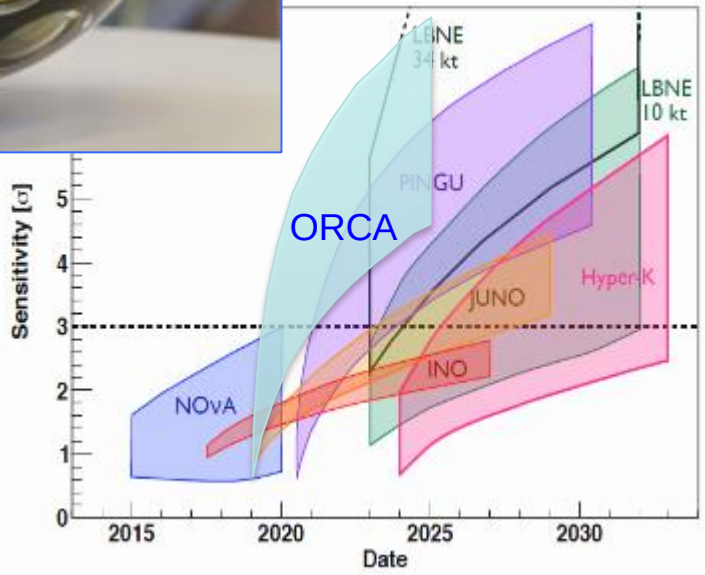
Low background double beta decay experiments
- SuperNEMO, Lumineu, DAMIC, …

Recent highlights in astroparticles physics

KM3NET: 2 sites

- Arca (Italy) : large volume dedicated to neutrino astronomy
- Orca (France) : dense array for the measurement of the neutrino mass hierarchy



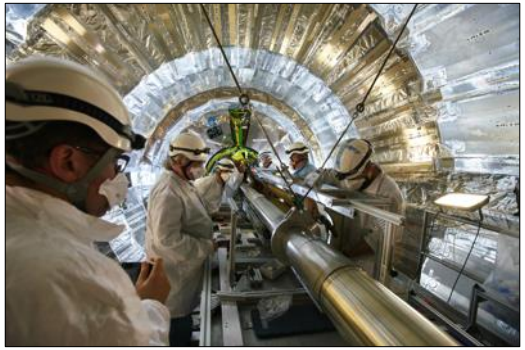


Deployment of new optical strings has successfully started ! Full array expected by 2020+

LHC phase 1 upgrades

CMS (finished in 2017)

New pixel detector : DAQ
L1 ECAL trigger
Tracker CO_2 cooling

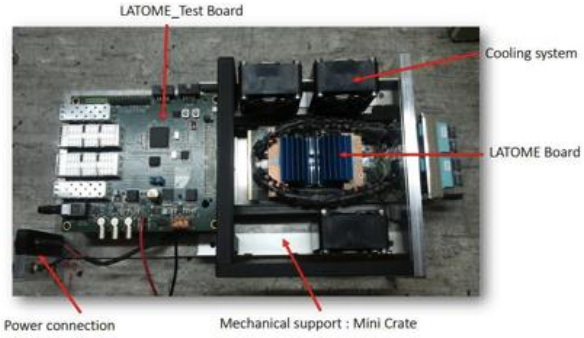


LHCb

Calorimeter electronics
Scintillating Fiber tracker
DAQ system

ATLAS

Pixel Inner Barrel Layer (2014)
Liquid argon calorimeter: electronics

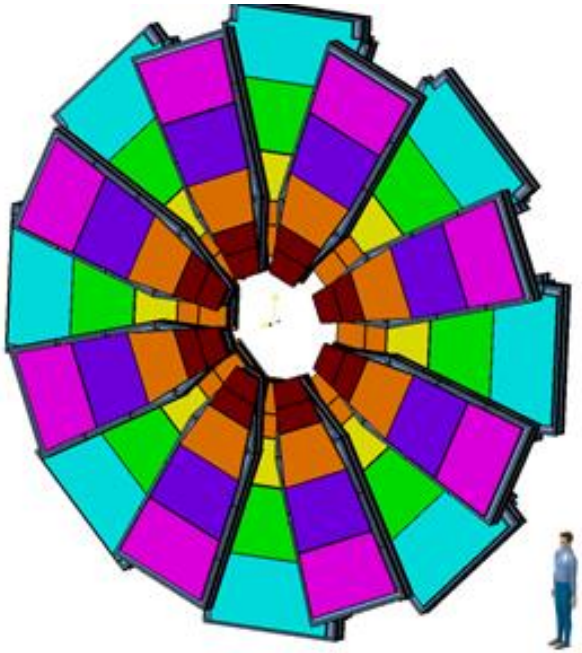


ALICE

Muon System
Inner Tracking System
Muon Forward Tracker

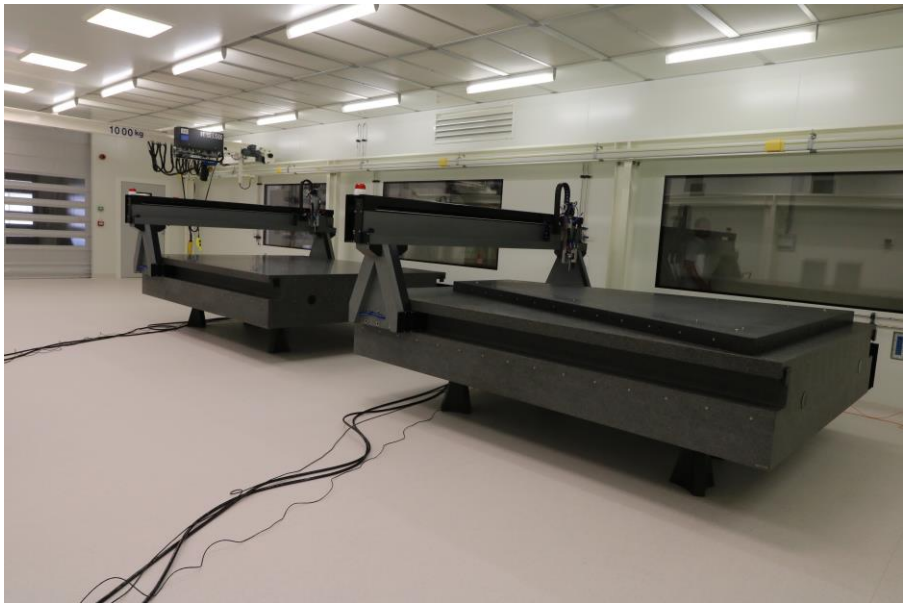
IRFU ATLAS Phase 1 : New Small Wheels

New Small Wheels ATLAS (LHC au CERN)



IRFU Contributions :

- 1/3 of 1200 m^2 MicroMegas detectors
- large surface modules (3 m^2)
- high spatial resolution (40 µm)

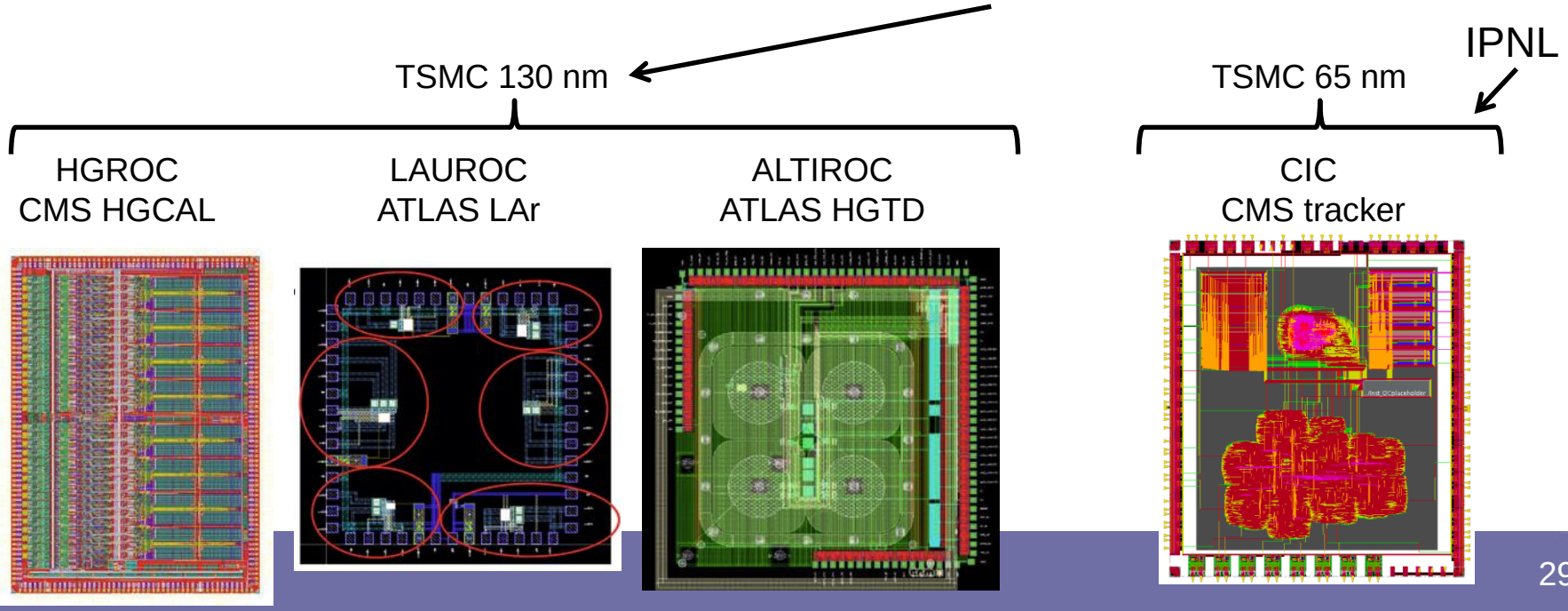


- Technical coordination : CERN
- Industrial partnership : Elvia (Fr), Eltos (It)
- Integration at IRFU (Saclay)

LHC phase 2 upgrades

- ATLAS
  - Inner Tracker: sensors, electronics, track trigger, mechanics
  - Liquid argon calorimeter: electronics
  - Tile calorimeter: mechanics and HV
  - High Granularity Timing Detector
- CMS
  - Tracker: electronics, endcap mechanics & cooling, DAQ
  - High Granularity Calorimeter: electronics, mechanics, trigger
  - RPC Muon Chambers: electronics

- Largest R&D contribution: electronic. ASICs design (OMEGA laboratory)

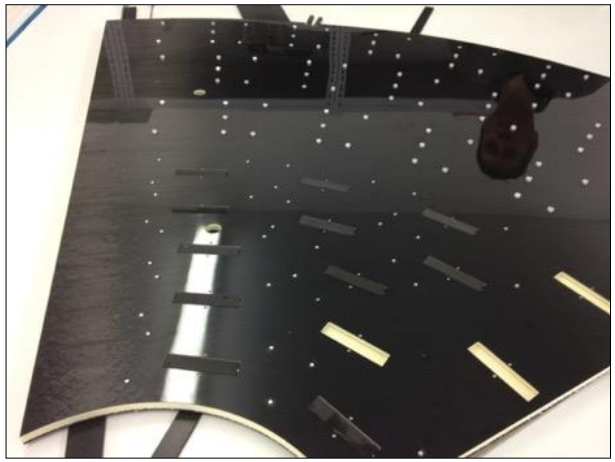


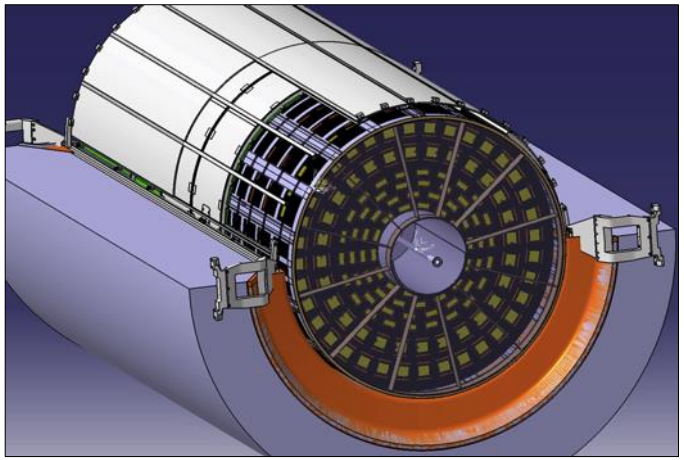
LHC phase 2 upgrades: CMS tracker endcap

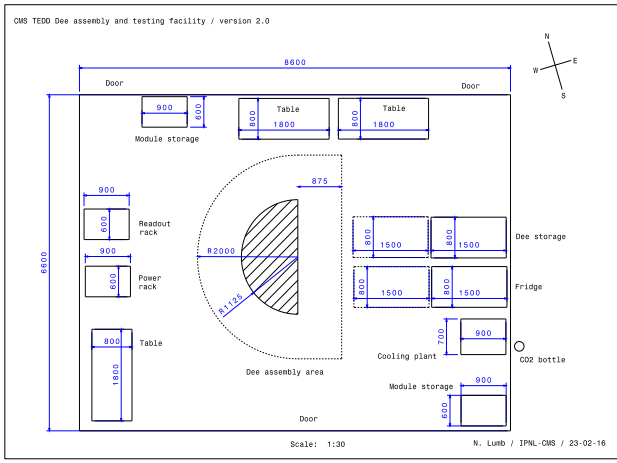
Intense R&D on endcap
Dees mechanics and cooling

Dees support & assembly

Clean rooms and
assembly hall in Lyon







➔Full Dee prototype in 2019

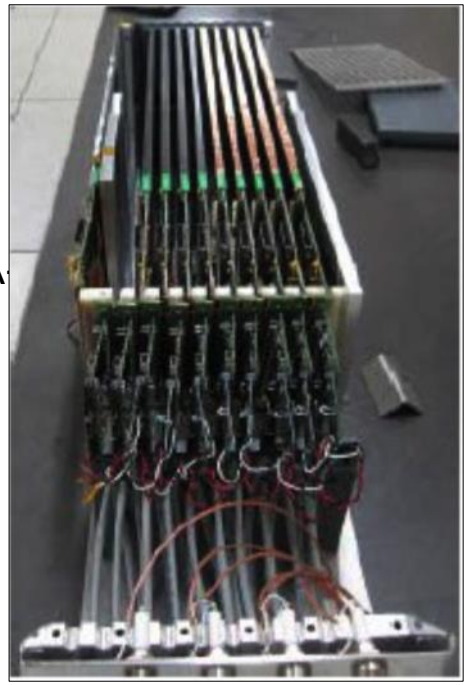
➔ Produce/assemble/test part of the dees of future phase II tracker

- Collaboration between DESY and IPN Lyon (Belgium also involved)
  - 40 Dees to be produced
  - 2 types of Dees needed by CMS tracker endcap
  - A lot of expertise acquired (in the lab and with industrials): planarity specs, CO_2 cooling, heat transfers, mechanics, gluing, etc…

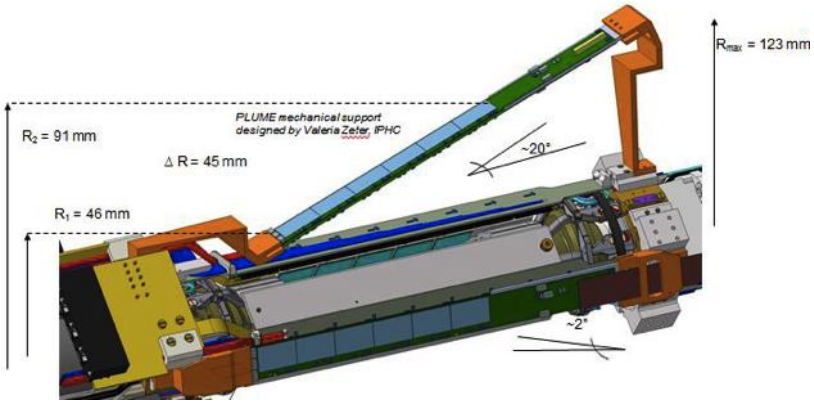
  The 2 CMS endcaps should at the end be “identical”

International Linear Collider

- CALICE R&D program at IN2P3
  - Semi Digital Hadronic calorimeter (IPNL, LAPP)
  - Silicon Tungsten Electromagnetic Calorimeter (LLR, LAL, LPNHE)
  - Many collaborations with DESY (also within AIDA-2020)
    - AHCAL electronics
    - Beam tests
    - Detector design and integration
  - Claude Vallée is currently at DESY



- CMOS sensors @ IPHC Strasbourg: high granularity and low material budget
  - Ultimate goal: micro-vertex detector for the ILC
  - Large spectra of applications:
    - Beam monitoring (beast at SuperKeKB), medical applications, photon detection (SOLEIL)
  - Current effort mainly for vertex detector MVD for CBM at FAIR (with Frankfurt and GSI)
  - Collaborations with Bonn, Frankfurt, Karlsruhe, Heidelberg

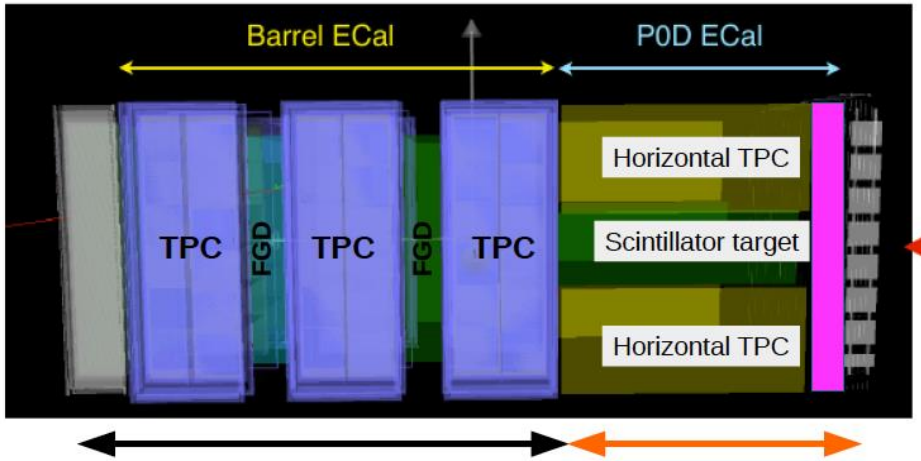


Neutrinos

- DUNE at Fermilab
  - Analogic cryogenic electronics
  - Mechanics
  - Neutrino platform at CERN (WA105 and ProtoDune-DP)
  - IN2P3 is involved in 4 of the 9 DUNE consortiums: DAQ, DP-CRP, DP-electronics, DP-photon detection

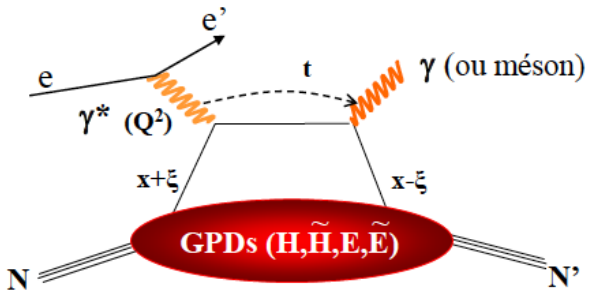
The ND280 upgraded detector concept

- T2K/SK, HK
  - Interest for T2K upgrades ND280
  - And for HK in a near future



Hadronic physics, other precision physics

- Largest involvement is now on QGP physics at the LHC: ALICE + CMS HI + LHCb HI/smog

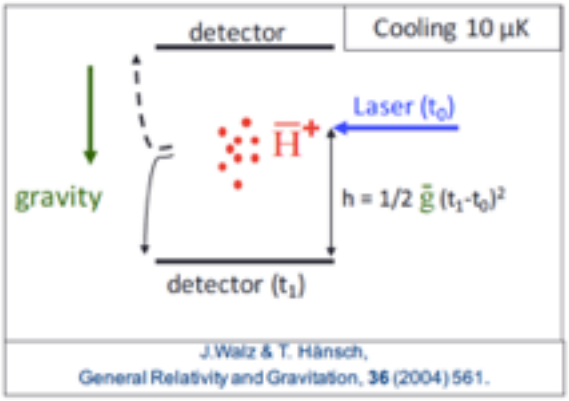


- nEDM at PSI
  - n2EDM upgrade project
  - LPSC Grenoble, LPC Caen, CSNSM Orsay / Berlin, Mainz

- AEgIS and Gbar at CERN
  - AEgIS : Proton source and Moiré Deflectometer: IPN Lyon and Kirchhoff-Institut für Physik, Heidelberg
  - Gbar: IRFU, CSNSM Orsay and Mainz

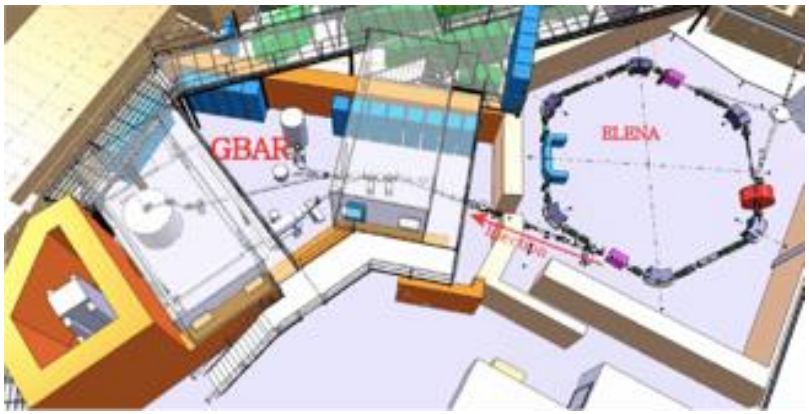
GBAR at CERN

Study the behaviour of anti-hydrogen atoms in free fall in the gravitational field of the Earth



IRFU teams at the origin of the experiment concept

- positron line and traps (buffer gas and Penning)
- cooling of anti-hydrogen ions
- laser system
- detection setup in the free-fall cell



Theory

- Covering many HEP aspects :
  - QCD at low and high energy, precision EW Physics, neutrinos, BSM model building and phenomenology, string theory

- Theory for HEP : 2 CNRS institutes and IPhT (CEA/CNRS)
  - INP (~2/3) and IN2P3 (~1/3)

- GDR International “Terascale”:
  - CNRS in France, Heidelberg, Bonn, Brussels, Durham

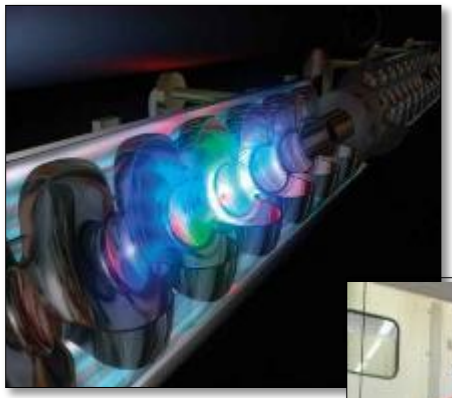
Accelerators and Technologies

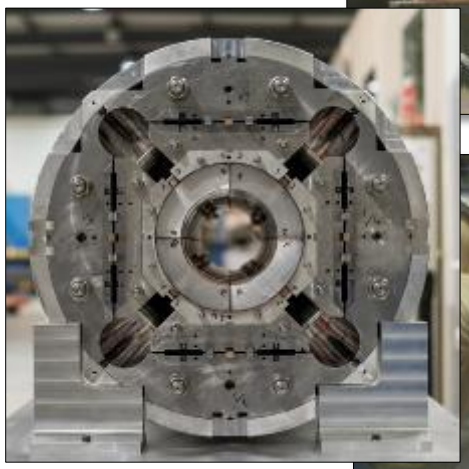
SPIRAL2

ESS, FAIR

XFEL

- Development of superconducting cavities and cryotechnology
- Ion and electron sources
- Beam targets for radioactive beams
- Beam dynamics
- Laser/accelerator synergies
- Detector developments : Si-detectors, photo-detectors, gaseous detectors, calorimeters, bolometers, …
- Micro-electronics





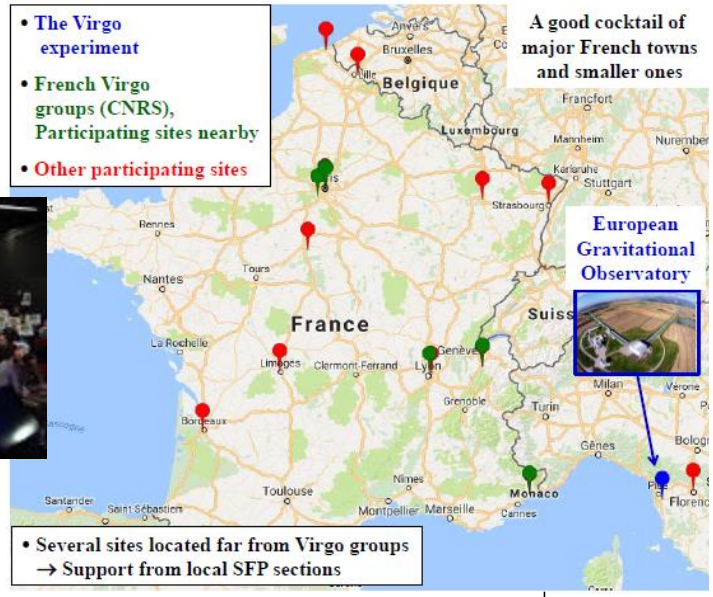
Computing and Data

CC-IN2P3 in Lyon:

- National Datacenter
- Tier 1 for w-LCG, but also computing for 70 other projects
- Major challenge to come: HL-LHC, LSST, Euclid and CTA
- France Grille: distributed grid and cloud computing over 9 regional site
- Participation in EOSC and HelixNebula projects
- Software developments

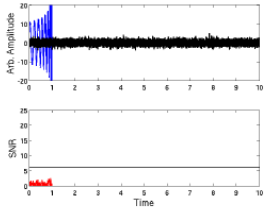
Outreach : The night of the Gravitational Waves

A recent example, presented at EPS 2017 in Venice
An ambitious multi-site event related to GW discovery (March 20, 2017)
~5000 people present in the various sites

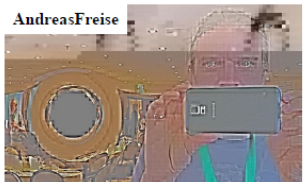


Contests

- All open to the general audience and to students
  - Schoolchildren included!
- Two science-oriented contests
  - Data analysis: how to detect signals buried in noise
    → Chirp signals span the audible frequency band:
    - convert them into sound,
    - mix them with (acoustic), noise,
    - varying their signal-to-noise ratios
  - Experimental work: design some setup to generate/study (quadrupolar), waves
    → Gravitational waves are way too weak: use analogies
- Two more artistic ones
  - Write a short story or draw a comics
  - Send images including a picture shot with the Pocket Black Hole app

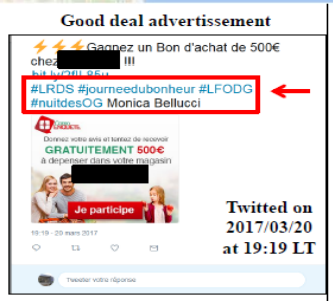


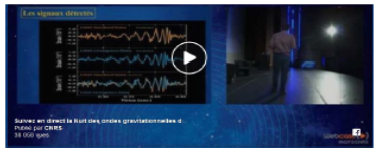
https://www.laserlabs.org



Social network coverage

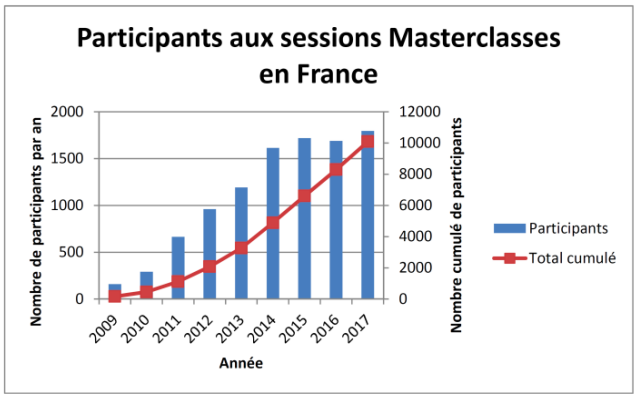
- Media used to ask questions live
- Twitter + Periscope
  - Hashtag #NuitDesOG
    → 684 tweets + 1896 retweets:
    7 Mpeople « reached »
    → Second topic discussed that evening
    - Debate for the presidential election on TV
- Live on CNRS Facebook page
  - https://www.facebook.com/cnrs.fr/videos/1475770485779895
  - 30,000 connections during event
    Reach: 130,000 people
    → Within the top audiences for the page
  - Replay: 38 kViews
- CC-IN2P3 webcast to watch the Paris event live from remote
  - 300+ connections continuously over the evening





Outreach and communication

- **Main target: schools, students, general public**
- **Interactions with media and press for major discoveries and events:** Gravitational waves, Higgs boson, Spiral 2/XFel Inauguration
- **Education/teacher programs and resources:** Masterclasses, “Cosmos à l’école”, Passport for the 2 infinities (3rd edition) **HSSIP**
- **Partnership and networks:** IN2P3 labs, CEA, Cern, “Science à l’école”, Interactions, Ippog
- **Publications, exhibitions:** annual “Science en fête”
- **Social networks, websites,**



Scientific and Technical Information

France joined effort on Inspire :
French « documentalists » contribute to curating Meta-data in Inspire

- Content concerning publications with French authors is transferred automatically to the French publication repository HAL
- Improvement of French affiliations in Inspire
- Improvement of number of publications included in HAL
- Incitation to use OrcId in general

Conclusion

- HEP in France is in a very good shape !!!
- Very rich and exciting physics program in all fields
- Ready to strongly participate in the upgrade of the European Strategy
- Strong increase of the diversity of funding sources in the recent years
- Important changes in the Universities

- No special comments on 2013 ECFA letter since it was quite positive