Institut national de physique nucléaire
et de physique des particules

www.cnrs.fr

Particle Physics @ IN2P3

2016 Workshop of the France–Korea (FKPPL) and France-Japan (TYL/FJPPL)
Particle Physics Laboratories

Patrice Verdier, IN2P3 Scientific Director for Particle & Hadronic Physics
19/05/2016

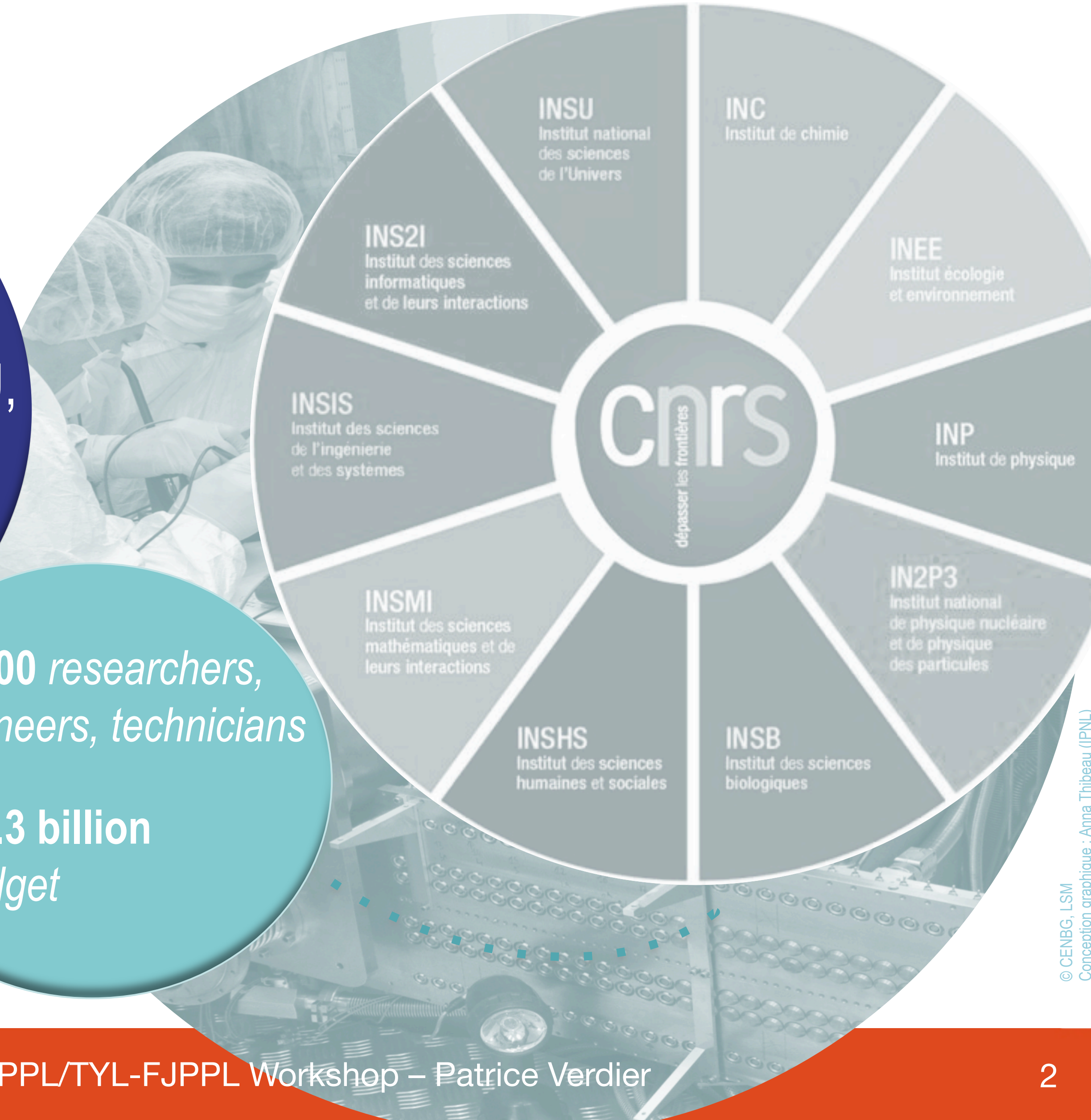
IN2P3, ONE OF CNRS INSTITUTES

CNRS

10 institutes
(**3** national: INSMI, INSU, IN2P3)
1 100 research units
(95% in partnership)

34 000 *researchers, engineers, technicians*

€ 3.3 billion
budget



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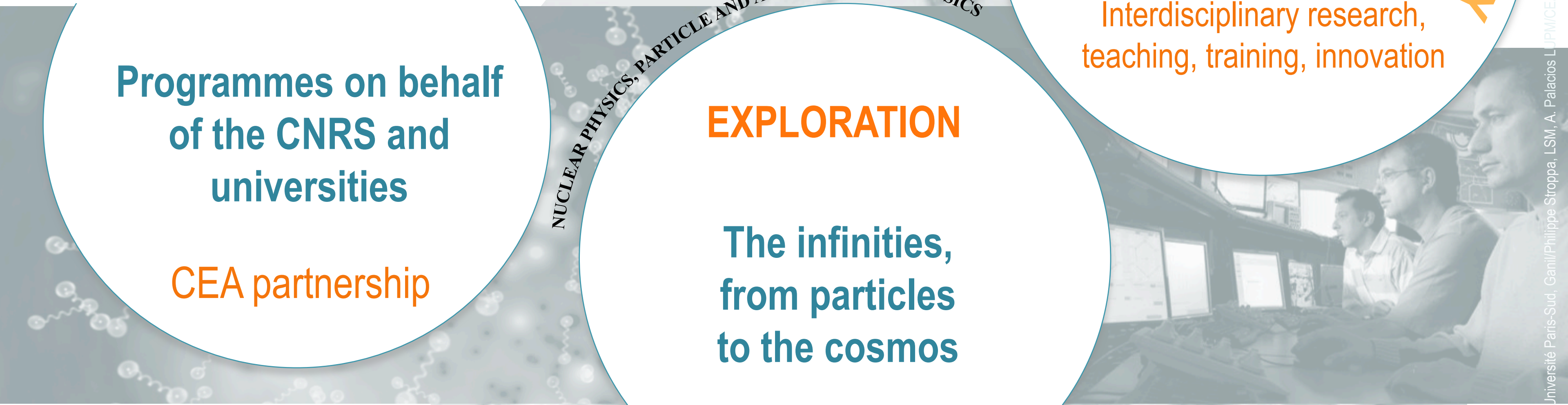
IN2P3 MISSIONS

TO PROMOTE AND UNIFY RESEARCH ACTIVITIES IN THE FIELD OF SUBATOMIC PHYSICS



COORDINATION

Programmes on behalf of the CNRS and universities

CEA partnership

NUCLEAR PHYSICS, PARTICLE AND ASTROPARTICLE PHYSICS

EXPLORATION

The infinities, from particles to the cosmos

PROVIDING LINKS WITH SOCIETY

Competencies, expertise

Interdisciplinary research, teaching, training, innovation

IN2P3 KEY FIGURES

40 major international projects
17 *international research networks*

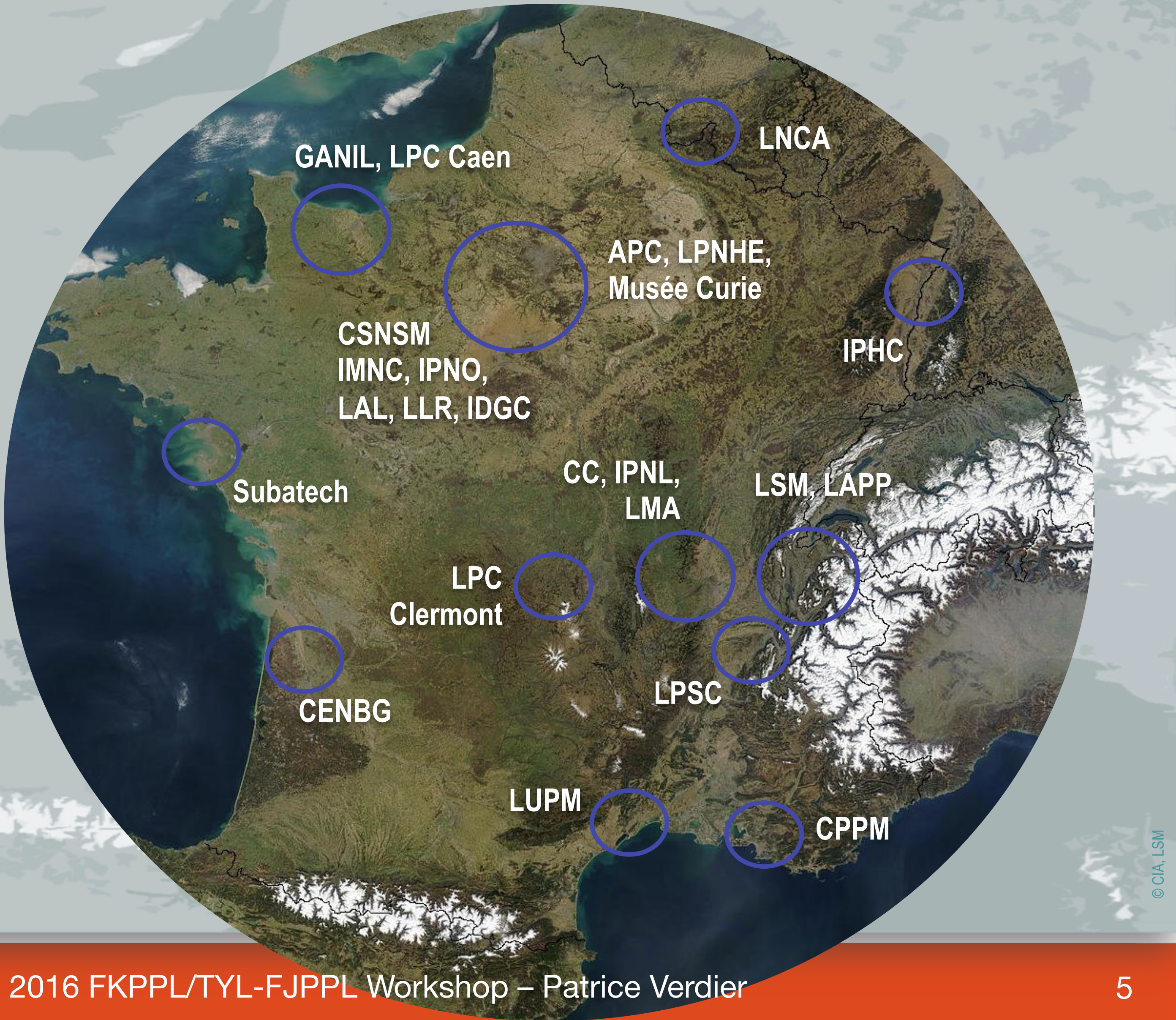
3 100
researchers, engineers and technicians

70 M€
annual budget
(excluding salaries)

TGIR

25 *laboratories*

NETWORKED LABORATORIES



IN2P3 DIRECTION

Conseil de direction

Conseil scientifique d'institut (CSI)

Comité des directeurs d'unités (CDU)

Laboratoires et plateformes

APC
CENBG
CC-IN2P3
CPPM
CSNSM
GANIL
IDGC
IMNC
IPHC
IPNL
IPNO
LAL
LAPP
LLR
LMA
LNCA
LPC Caen
LPC Clermont
LPNHE
LPSC
LSM
LUPM
Musée Curie
OMEGA
SUBATECH

Sûreté nucléaire et radioprotection
Cyril Thieffry

Interdisciplinaire
Sylvain David
Directeur adjoint scientifique

Enseignement supérieur
XX (CM)

Formation
Thierry Ollivier *(CM)*

Valorisation
Céline Tanguy *(CM)*

Information scientifique et technique
Sandrine Guesnon *(CM)*
Stéphane Plaszczynski *(CM)*

Directeur
Reynald Pain

Directrice adjointe
Ursula Bassler

Assistante de direction
Caroline Hello

Directrice adjointe administrative
Laurence Mathy-Montalescot

Adjoint DAA
Steve Pannetier

Directeur adjoint technique
Christian Olivetto

Management de projet et qualité
Philippe Laborie *(CM)*

CAO électronique
Claude Colledani *(CM)*

Cellule IAO/CAO
Alexandre Perrier *(CM)*
Mathieu Walter *(CM)*

Emploi, ressources humaines, structures et instances
Françoise Gaudy

Budget et finances
Georgette Diaby

Partenariats, Europe et coopération internationale
Marine Moguen Toursel

Communication
Ana Poletto

SI projets
Laurent Malet

Particules et hadronique
Patrice Verdier
Directeur adjoint scientifique

Astroparticules et cosmologie
Berrie Giebels
Directeur adjoint scientifique

Nucléaire et applications
Fanny Farget
Directrice adjointe scientifique

Accélérateurs et technologies
Jean-Luc Biarrotte
Directeur adjoint scientifique

Calcul et données
Volker Beckmann
Directeur adjoint scientifique

CM : chargé(e) de mission

SCIENTIFIC THEMES

Particles & hadronic physics

Matter's most elementary constituents and fundamental interactions

Nuclear physics & Applications

Structure of nuclear matter, nuclear energy and medical applications

Astroparticle physics and Cosmology

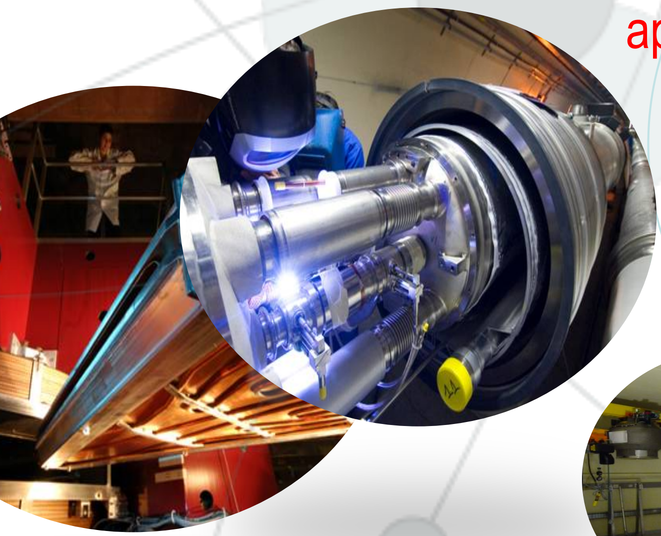
Universe's composition and behaviour

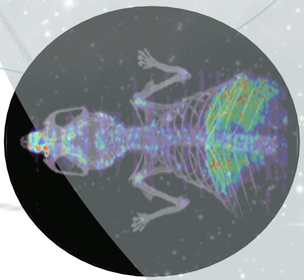
Computing & Data

Data Science and Computing research

Accelerator & Technology

Major R&D domains





PARTICLE AND HADRONIC PHYSICS

ELEMENTARY CONSTITUENTS, FUNDAMENTAL INTERACTIONS

- Higgs Physics
- Searches for new physics and Supersymmetry
- Matter-Antimatter asymetries
- QCD and quark-gluon plasma
- Neutrino mass hierarchy and CP violation

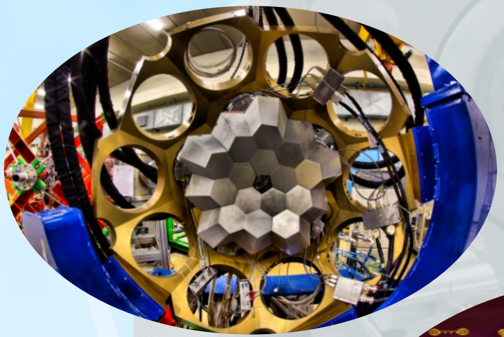
COLLISIONS SUPERSYMMETRY ANTIMATTER
HIGGS BOSON DETECTORS STANDARD MODEL

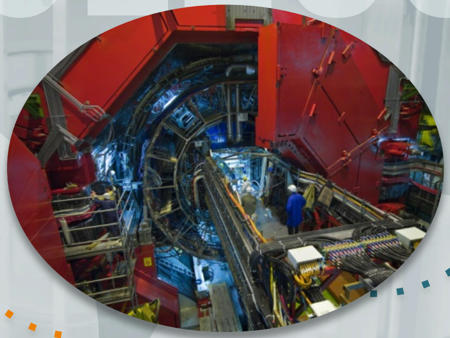
NUCLEAR PHYSICS & APPLICATIONS

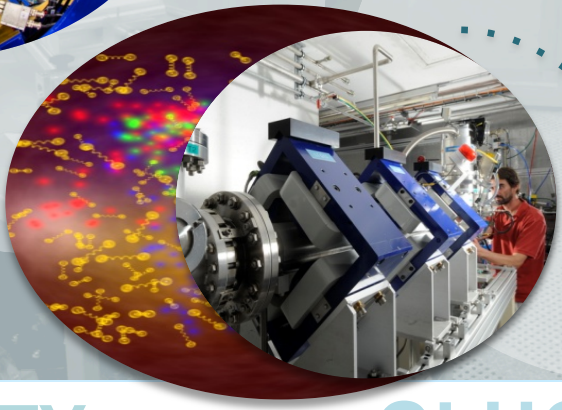
PROTON AND NUCLEUS

NUCLEON AND NUCLEI: THE EMERGENCE OF COMPLEXITY

- Nuclear structure
- Exotic nuclei
- Nuclear astrophysics
- Nuclear energy
- Health application
- Neutrino mass hierarchy and sterile Neutrinos







EXTREME STATES STABILITY GLUONS

EXOTIC NUCLEI SUPERHEAVY QG PLASMA

ASTROPARTICLE PHYSICS & COSMOLOGY

UNIVERSE' S COMPOSITION AND BEHAVIOUR

- Universe's history
- Dark matter and dark energy
- Cosmic rays
- Gravitational waves
- Cosmic neutrinos and neutrino's nature

COSMIC RAYS DARK ENERGY UNIVERSE SUPERNOVAE BIG BANG GRAVITATIONAL

COMPUTING AND DATA

High Throughput Computing and Data treatment

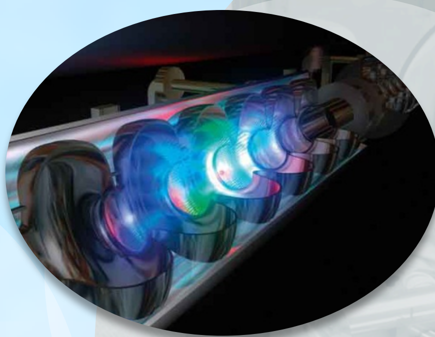
- Grid & Cloud development
- Services for distributed infrastructures
- Software and algorithms for new hardware architectures
- Data-management
- Biomedical applications

INFRASTRUCTURES DATA STORAGE NETWORKS
INTERFACES COMPUTING CENTERS LCG

ACCELERATORS & TECHNOLOGY

ACCELERATOR R&D, TECHNOLOGICAL PLATFORMS

- Superconducting accelerator cavities and cryotechnology
- Ion and electron sources
- Target/source for radioactive beams
- Beam dynamics
- Laser acceleration
- High-tech mirrors



INTENSE BEAMS LASERS SUPERCONDUC
ION SOURCES PLATFORMS CRYOTECHNOLOGY

INSTRUMENTATION AND DETECTORS

INSTRUMENTATION, DETECTORS, TECHNOLOGY TRANSFER

- Silicon detectors
- Photo-detectors, new generation scintillators
- Gaseous detectors
- Bolometers
- Microelectronics

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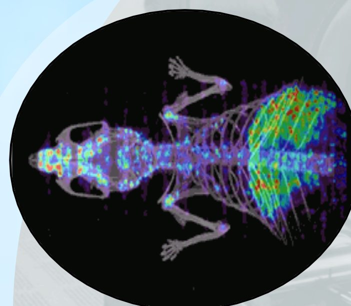
MICROELECTRONICS BOLOMETERS CMOS
HODOSCOPES IMAGERS ULTRA-GRANULARY

LINKS WITH INDUSTRIES

INDUSTRIAL PARTNERSHIP AND APPLICATIONS

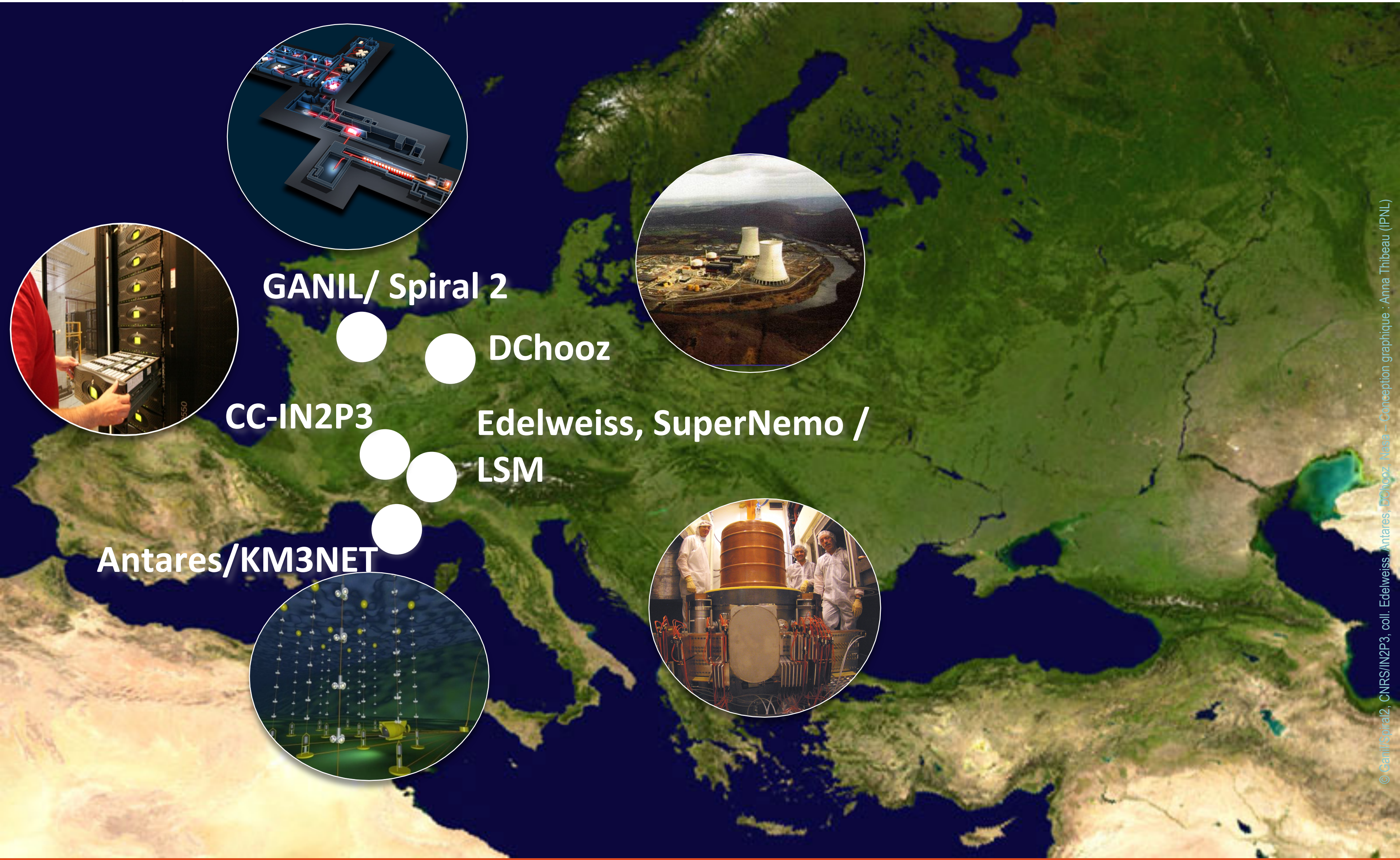
→ *Expertise / high technology resources transferred to industry*

- Health (medical imaging)
- Space industry
- Environment (measurement of weak radioactivity through the Becquerel network)
- Electronics



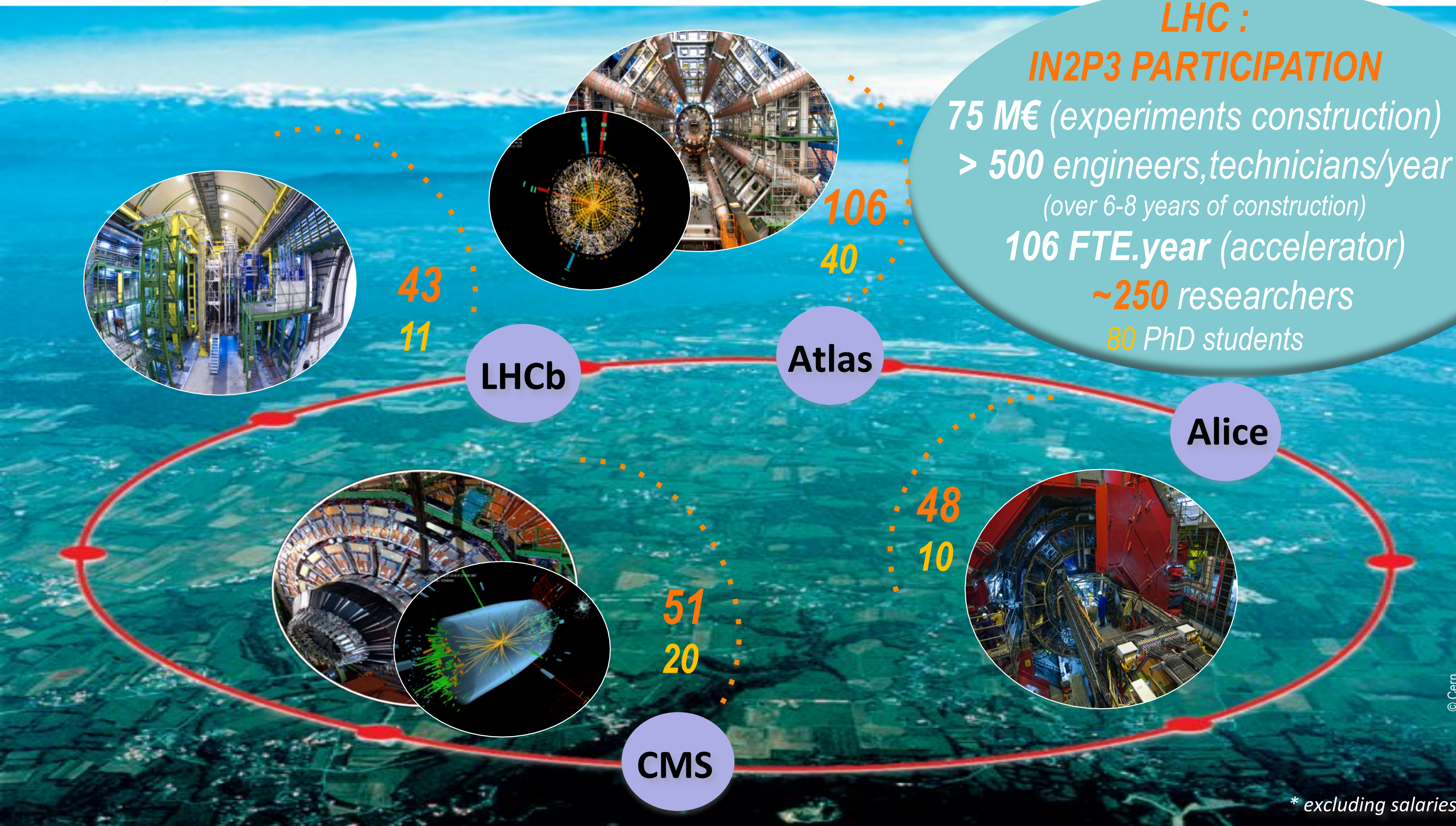
MICROELECTRONICS PRECISION OPTICS TECHNO
MEDICAL IMAGING SIMULATIONS EXPERTISE

FRANCE: LARGE INFRASTRUCTURES



INTERNATIONAL COLLABORATIONS

INTERNATIONAL COLLABORATIONS

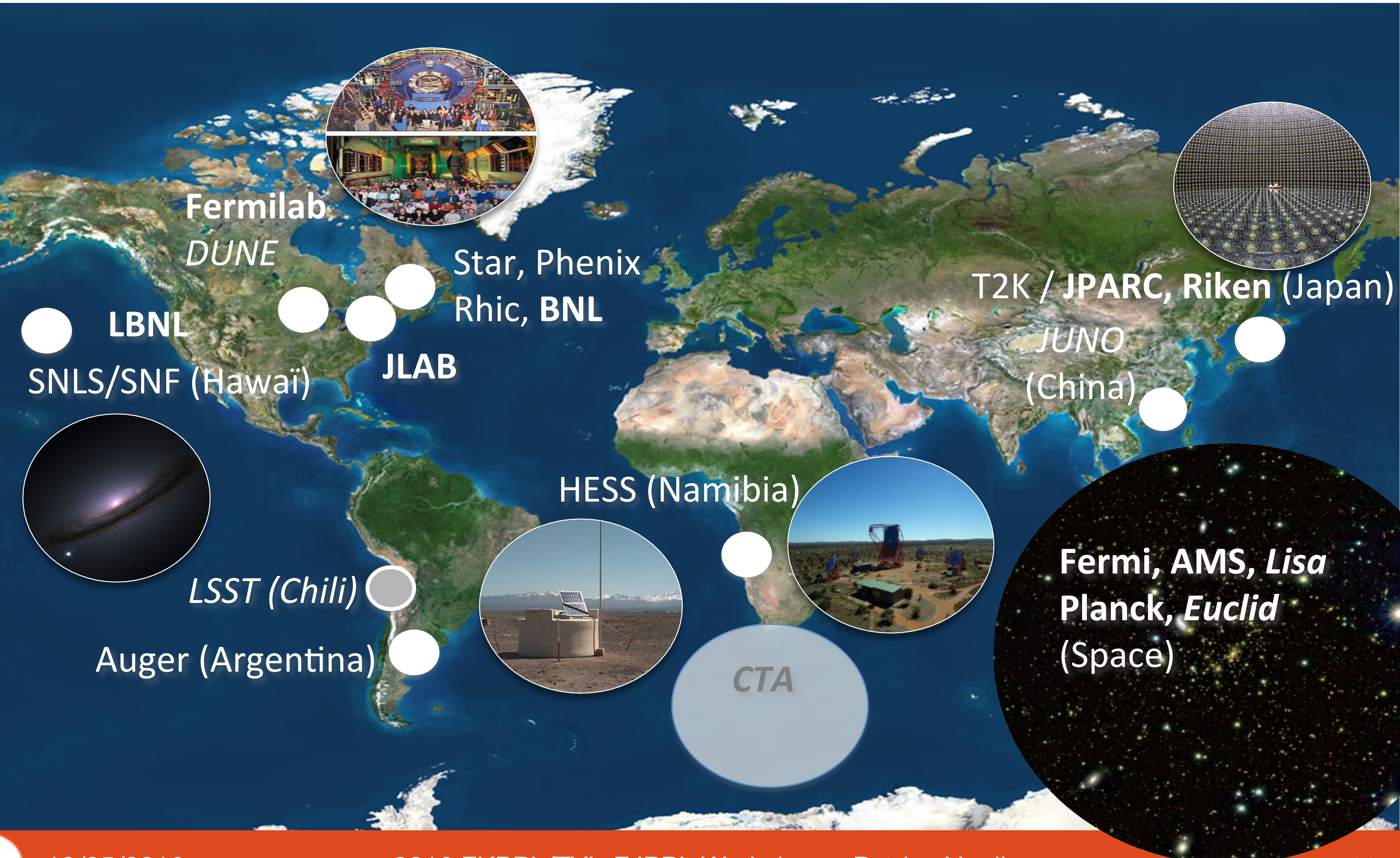


LHC :
IN2P3 PARTICIPATION

75 M€ *(experiments construction)*
> 500 *engineers,technicians/year*
(over 6-8 years of construction)
106 FTE.year *(accelerator)*
~250 *researchers*
80 PhD students

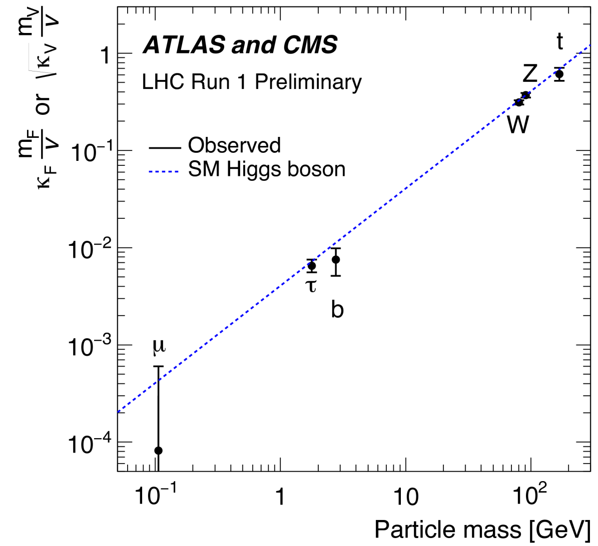
** excluding salaries*

INTERNATIONAL COLLABORATIONS



ATLAS & CMS: EWSB & top physics

- **Precise measurements of the 125 GeV Higgs boson is a prioriy of LHC physics program**
  - New decay channel: H ➔ bb
  - New production channels: VBS, ttH
  - Accumulate 300 fb^{-1} per experiment by 2023



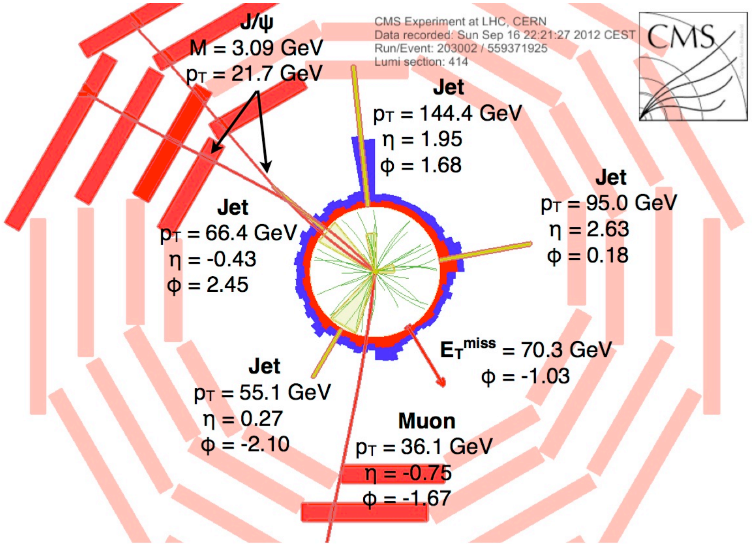
- **The LHC is a top quark factory:**

CMS Combination:

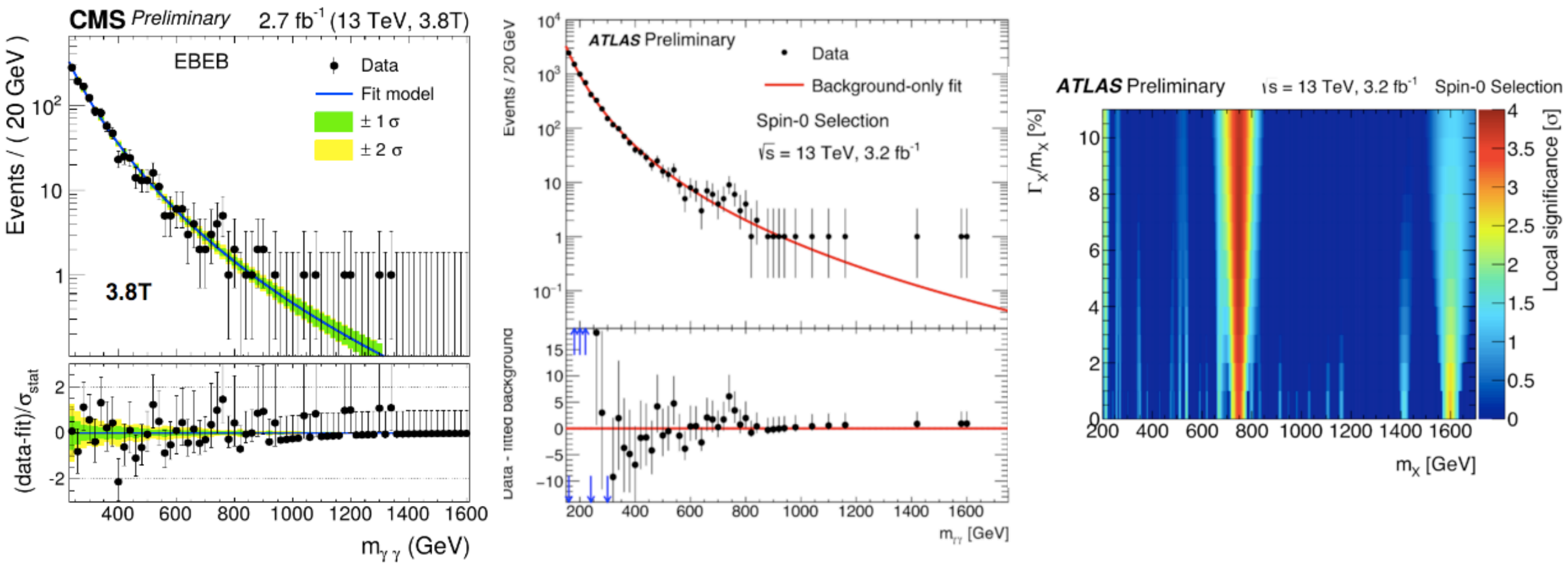
M(top) = 172.44 ± 0.13 (stat.) ± 0.47 (syst.) GeV

Alternative methods, ex.: J/ψ (8 TeV, 20fb^{-1})

M(top) = 173.5 ± 3.0 (stat.) ± 0.9 (syst.) GeV

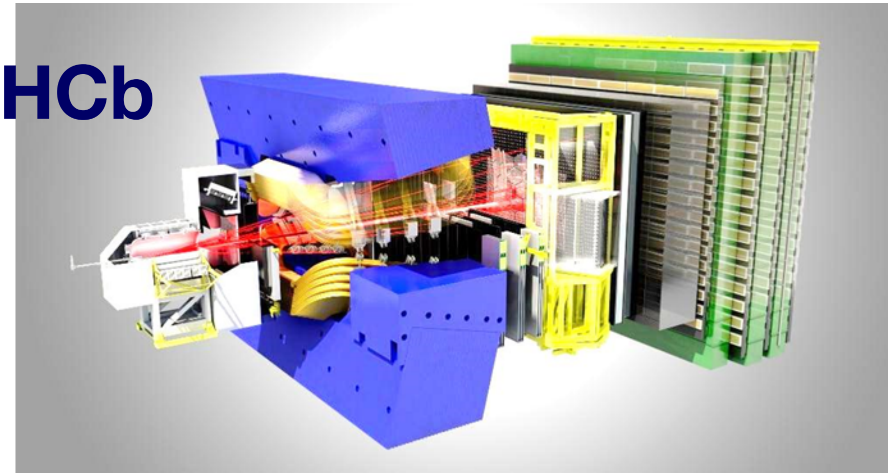


ATLAS & CMS: New Physics

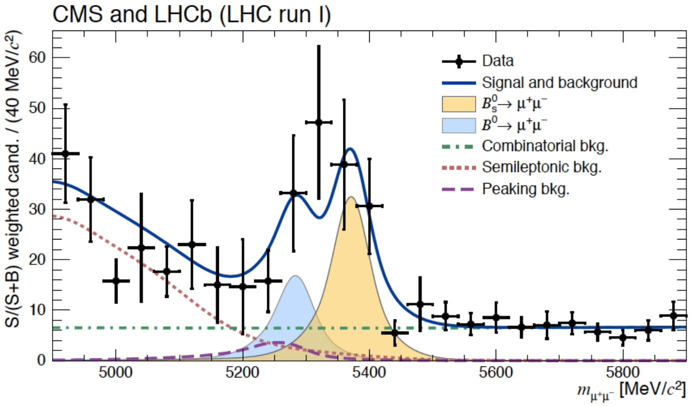


- **750 GeV diphoton excess:**
  - 2016 data will give an answer very soon !
- **Exploring the energy frontier is a priority at the LHC to search for physics beyond the SM**
  - 3 fb^{-1} in 2015, 300 fb^{-1} in 2023: only 1% of 13 TeV pp data have been recorded and analyzed so far !

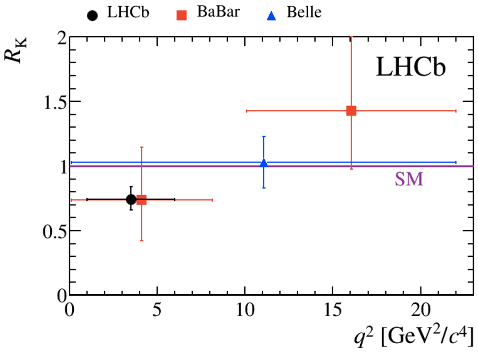
FLAVOR PHYSICS: LHCb



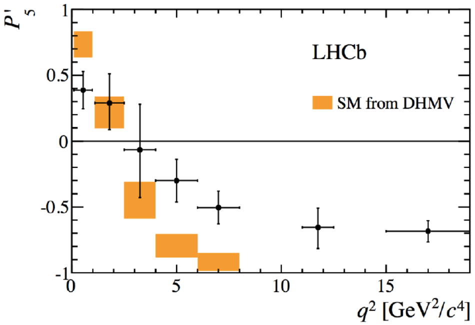
- **Precision measurements:**
  - Flavor physics and CKM matrix
  - And NP probes
  - Several anomalies to be followed carefully at Run 2

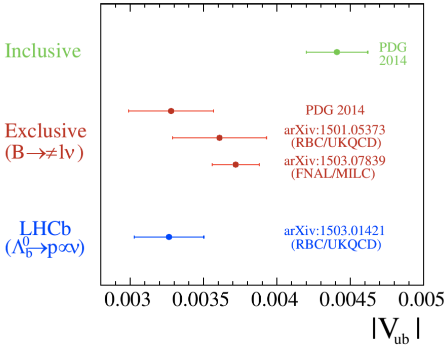


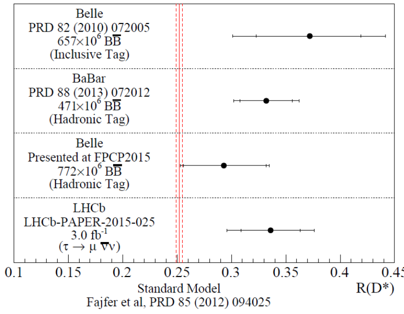
$$R_K = \frac{\int_{q^2_{\min}}^{q^2_{\max}} \frac{d\Gamma[B^+ \to K^+\mu^+\mu^-]}{dq^2} dq^2}{\int_{q^2_{\min}}^{q^2_{\max}} \frac{d\Gamma[B^+ \to K^+e^+e^-]}{dq^2} dq^2}$$



$$B^0 \to K^{*0}\mu^+\mu^-$$



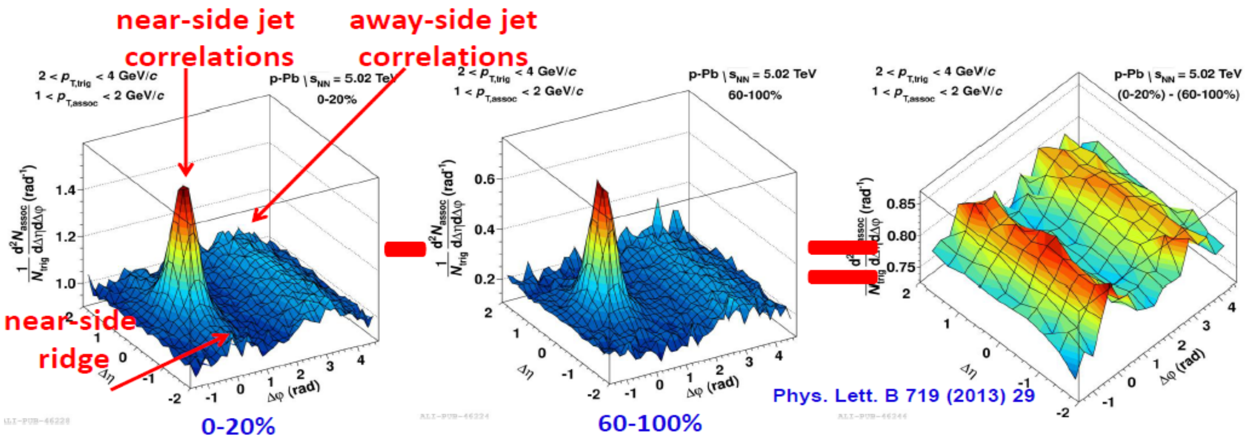


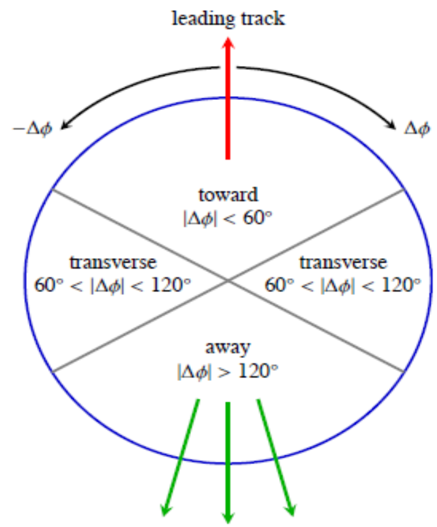


$B \to D^* \tau \nu$ [arXiv:1504.06339]

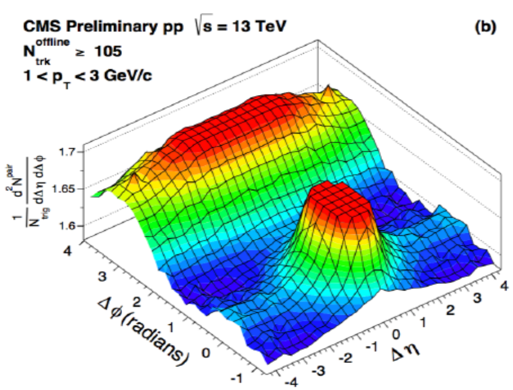
Hadronic Physics

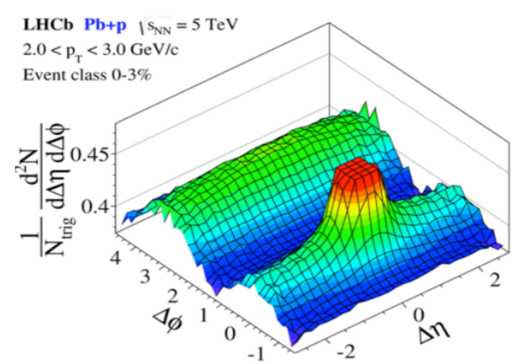
- **IN2P3 is involved in LHC Heavy Ions program in ALICE, CMS and LHCb**



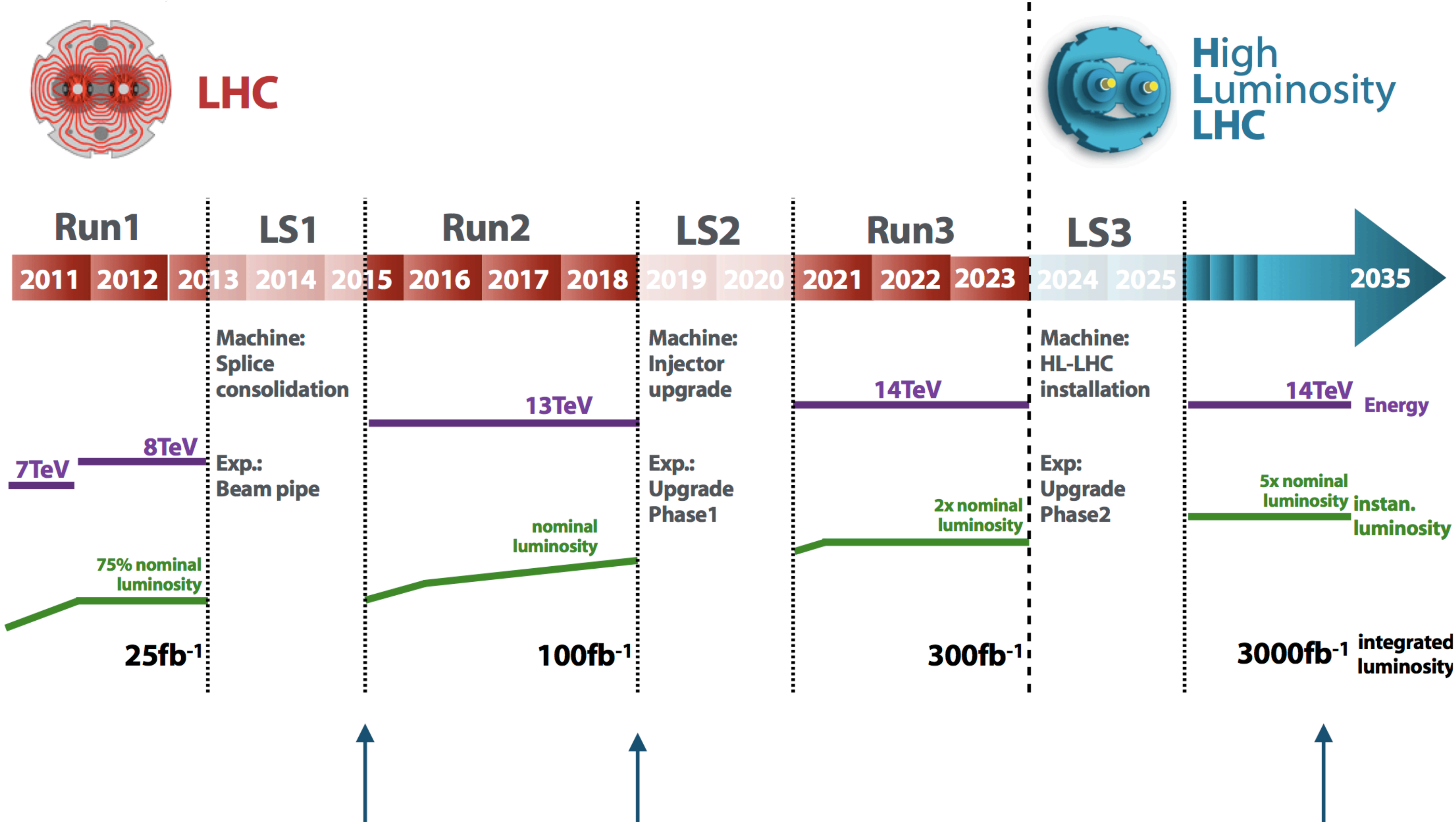


high multi





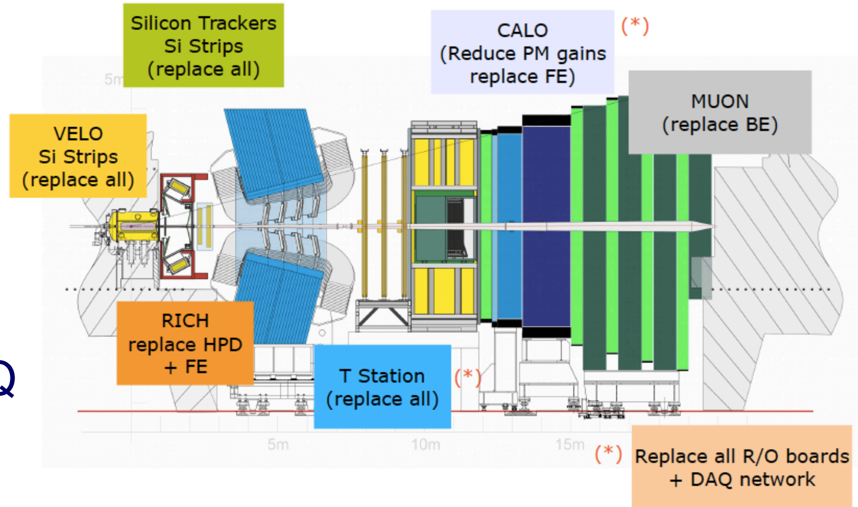
LHC upgrades



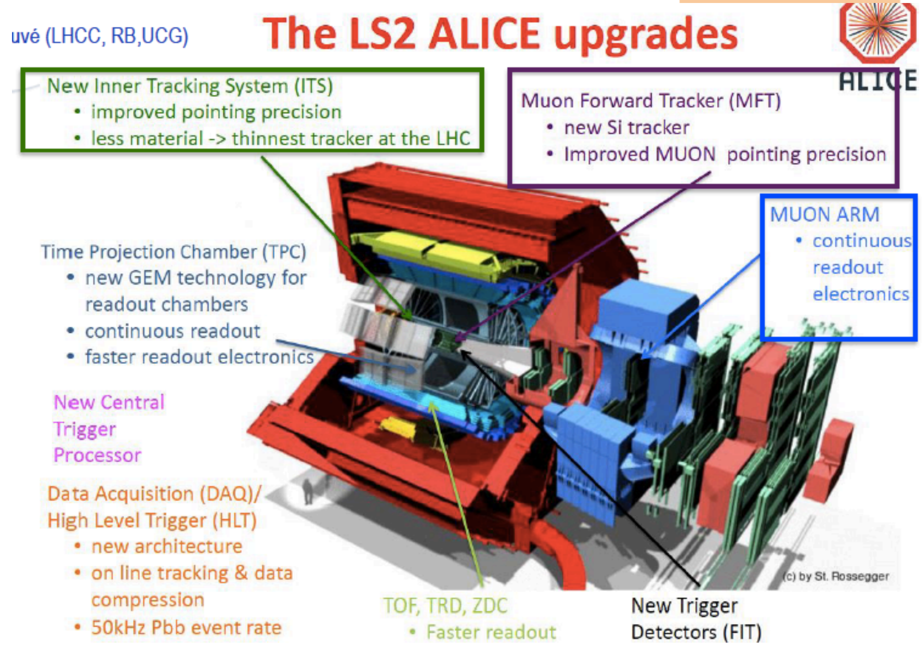
Phase 1 Upgrades

IN2P3 contributions:

- **to LHCb upgrades:**
  - Calorimeter, SciFi Tracker, Trigger/DAQ



- **to ALICE upgrades :**
  - ITS, MFT and Muon spectrometer



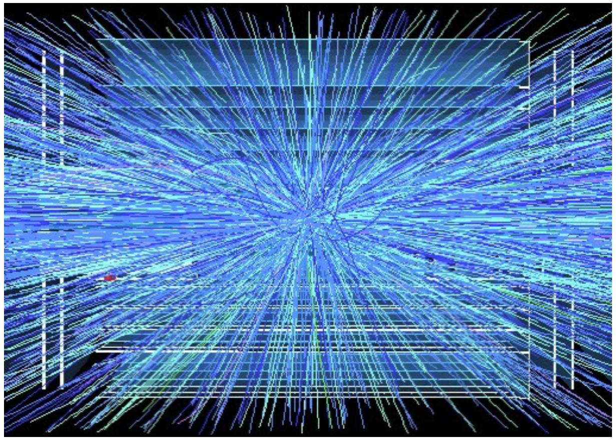
- **And also to ATLAS and CMS:**
  - ATLAS LAr electronics
  - CMS Tracker DAQ & cooling, ECAL Trigger

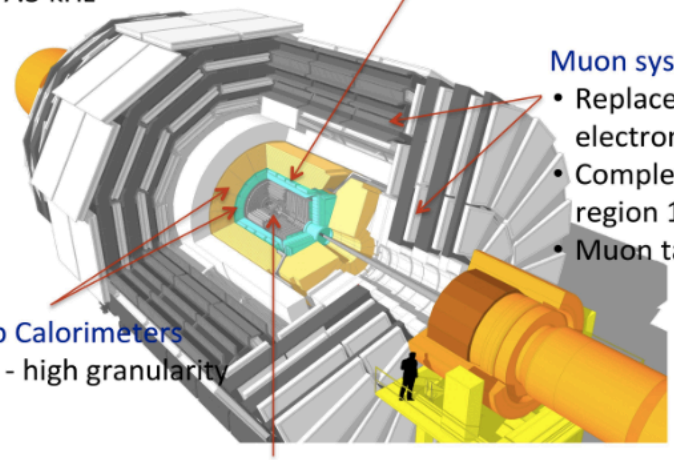
Phase 2 Upgrades @ IN2P3

IN2P3 plans for CMS & ATLAS Phase 2 upgrades:

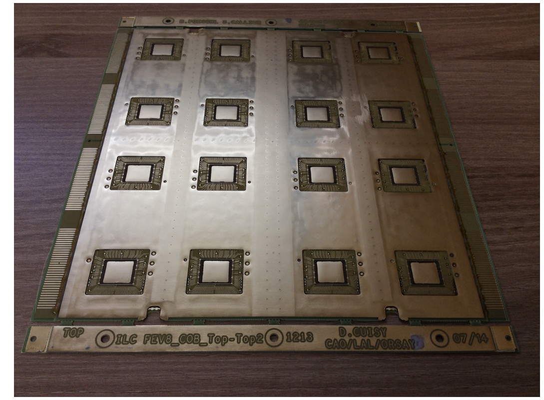
- **CMS:**
  - **Tracker :** Electronic, L1 Track Trigger, DAQ, endcap mechanics & cooling
  - **HGCAL :** Electronics, mechanics, Trigger
  - **Muons :** Forward RPC Muon chambers
- **ATLAS:**
  - **Tracker:** Sensors, L1 Track Trigger, Mechanics & cooling
  - **Liquid Argon calorimeter:** Electronics, Trigger
  - **Tile calorimeter:** Electronics
  - **HGTD:** Detectors and electronics

Run 4-5
Pile up of
<140 to 200>





Detectors for future colliders

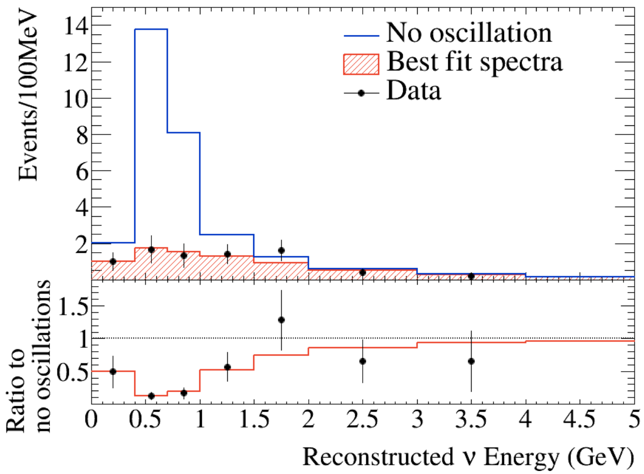


- **Strong implications of IN2P3 labs on ILC activities**
  - Beam studies at ATF2
  - Developing high granularity calorimeters (CALICE): Si-W and SDHCAL
  - Vertex detector
  - Detector electronics
- **Those developments are now key inputs for HL-LHC upgrades:**
  - HGCAL (CMS) and HGTD (ATLAS)
  - Muon Forward Chambers (CMS)
- **ILC, HE-LHC, FCC-pp/ee , CEPC:**
  - An important milestone will be the update of European strategy for particle physics in 2019-2020

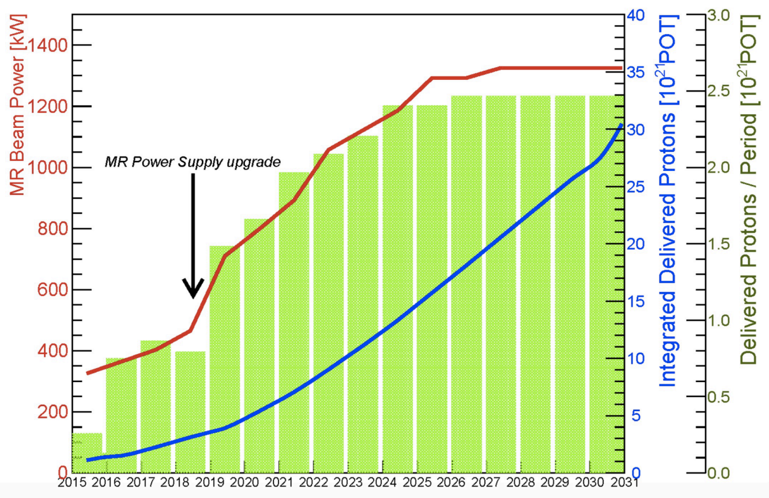
Neutrinos

- **Neutrino program at IN2P3:**
  - OPERA (dismanteling)
  - T2K (NA61 and WAGASCI)
  - Double-Chooz
  - JUNO
  - STEREO
  - SOLID
  - ANTARES
  - Km3Net/Orca

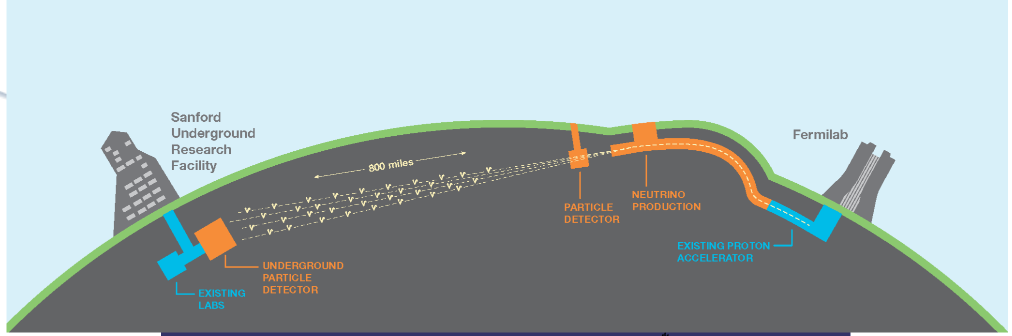
- **T2K phase 2 and Hyper-K:**
  - interest from French physicists currently involved in T2K

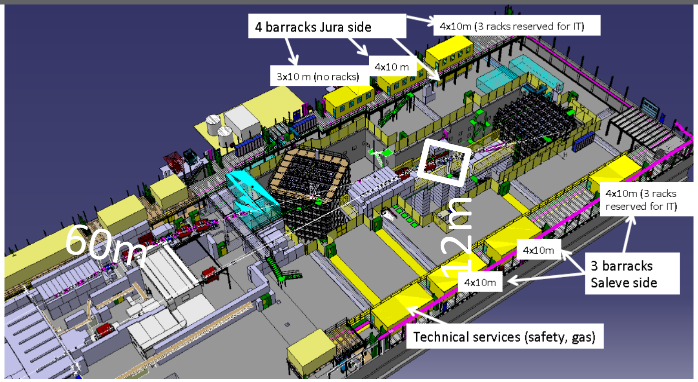


J-PARC MR Expected Performance

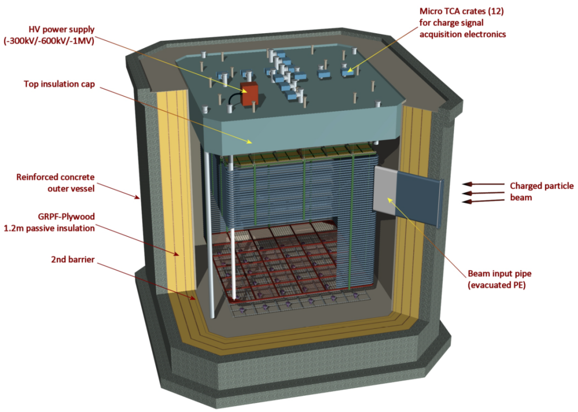


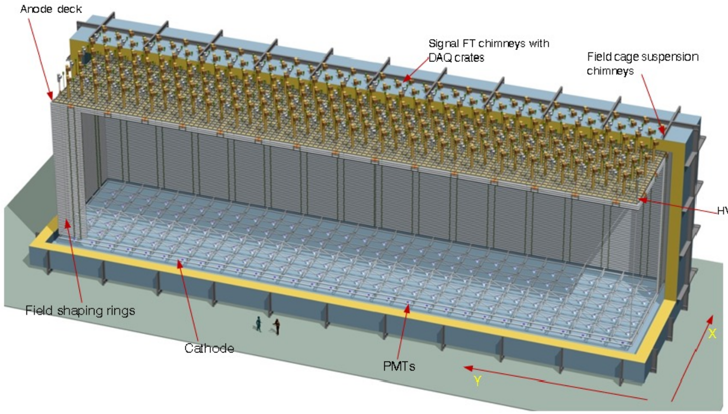
Neutrinos





- **R&D on liquid argon double-phase TPC for future neutrino long baseline project:**
  - R&D with WA105 prototype @ CERN
  - DUNE experiment at Fermilab/SURF





Conclusion

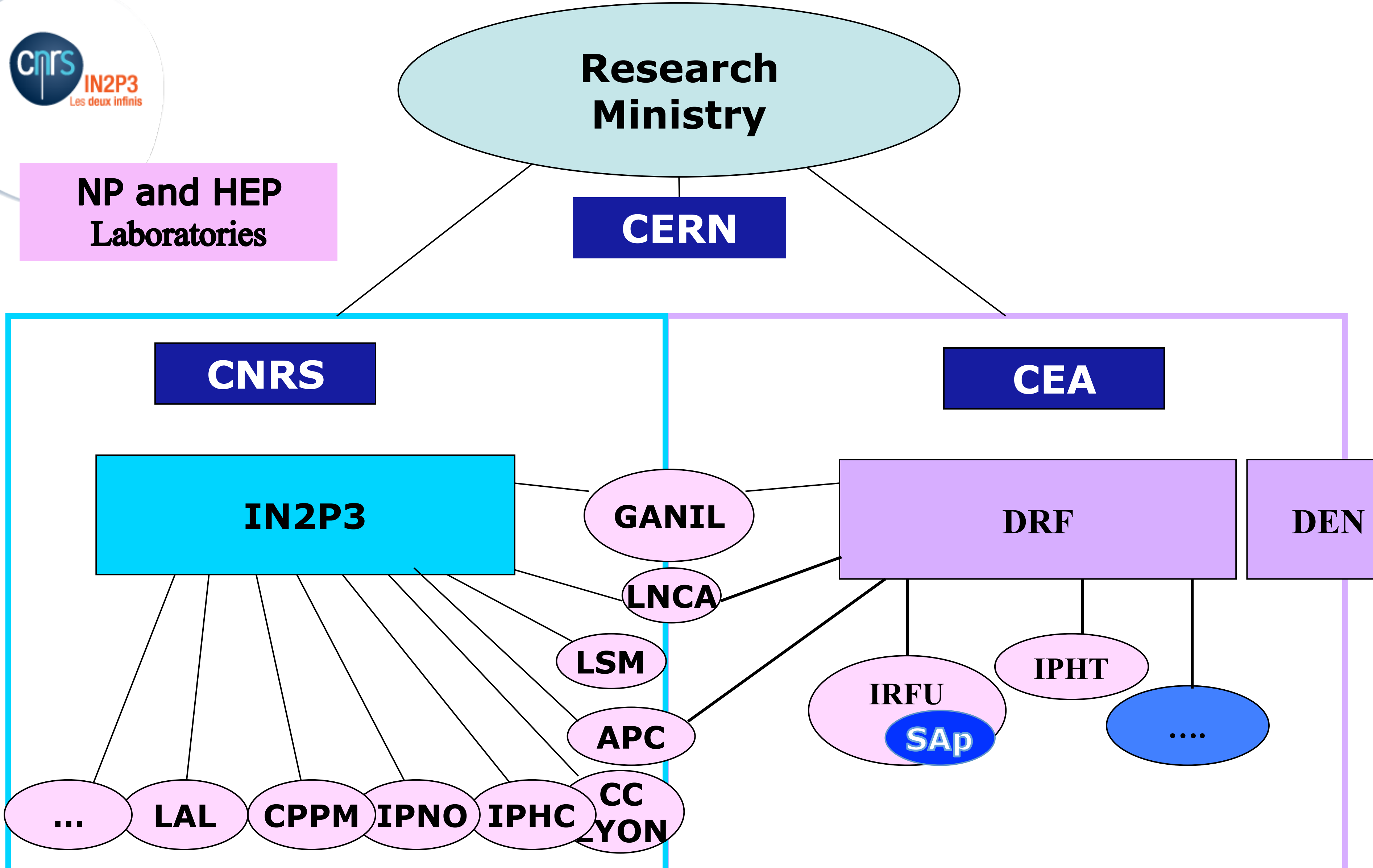
- **IN2P3 labs are also contributing to :**
  - COMET experiment at J-Parc
  - Neutron EDM at PSI
  - Effect of gravity on Anti-matter : AEgIS and Gbar experiments at CERN's AD
  - Dark Matter Search: EDELWEISS, XENON, DarkSide
  - Double beta decay: SuperNEMO, LUMINEU

  And there are interests to work on Super-KEKB and the Belle-2 experiment to be further examined

- **There is a rich particle physics program at IN2P3 with strong and fruitful collaborations with Korea and Japan**

Réserve

NP and HEP Laboratories



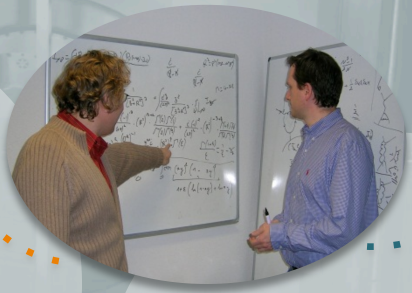
25 laboratories associated with universities
3100 FTE about 300M€ total budget

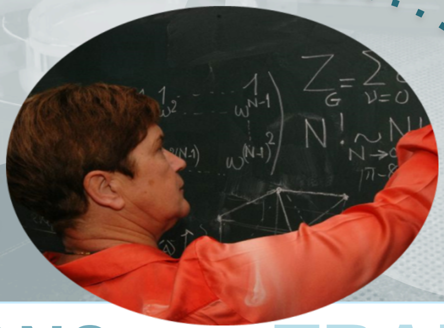
GANIL + IRFU-SAp (Astrohysics)
700 FTE about 80M€ total budget

HIGHER EDUCATION

PARTNERSHIP, CONTRACTUALISATION, TRAINING

- Teaching
- IN2P3 projects → visibility for universities/*grandes écoles* (Europe and International)
- Laboratory contracts
- Regular coordination meetings IN2P3 / Universities
- Students' training (including nuclear energy and nuclear medicine)





LABORATORIES COLLABORATIONS TRAINING
YOUNG RESEARCHERS CONTRACTS VISIBILITY

COMMUNICATIONS

INCREASING VISIBILITY, PROMOTING RESEARCH ACTIVITIES

- **Press and media**
- **Education/teacher programs and resources** (Masterclasses, “Cosmos à l’école”…)
- **Partnership and networks** (IN2P3 labs, Cern, CEA, “Science à l’école”, Interactions, Ippog)
- **Publications, website, exhibitions…**

EXHIBITIONS PRESS AND MEDIA PROMOTION
EDUCATION PROGRAMS NETWORKS VISIBILITY