



# *PH Plenary Meeting*

*CERN – 24 February 2014*

PH  
Physics  
Department

## *The CERN Physics Department* *Your department in 2013-2014*

*Livio Mapelli*

**Scientific Program**

**Organisational Structure**

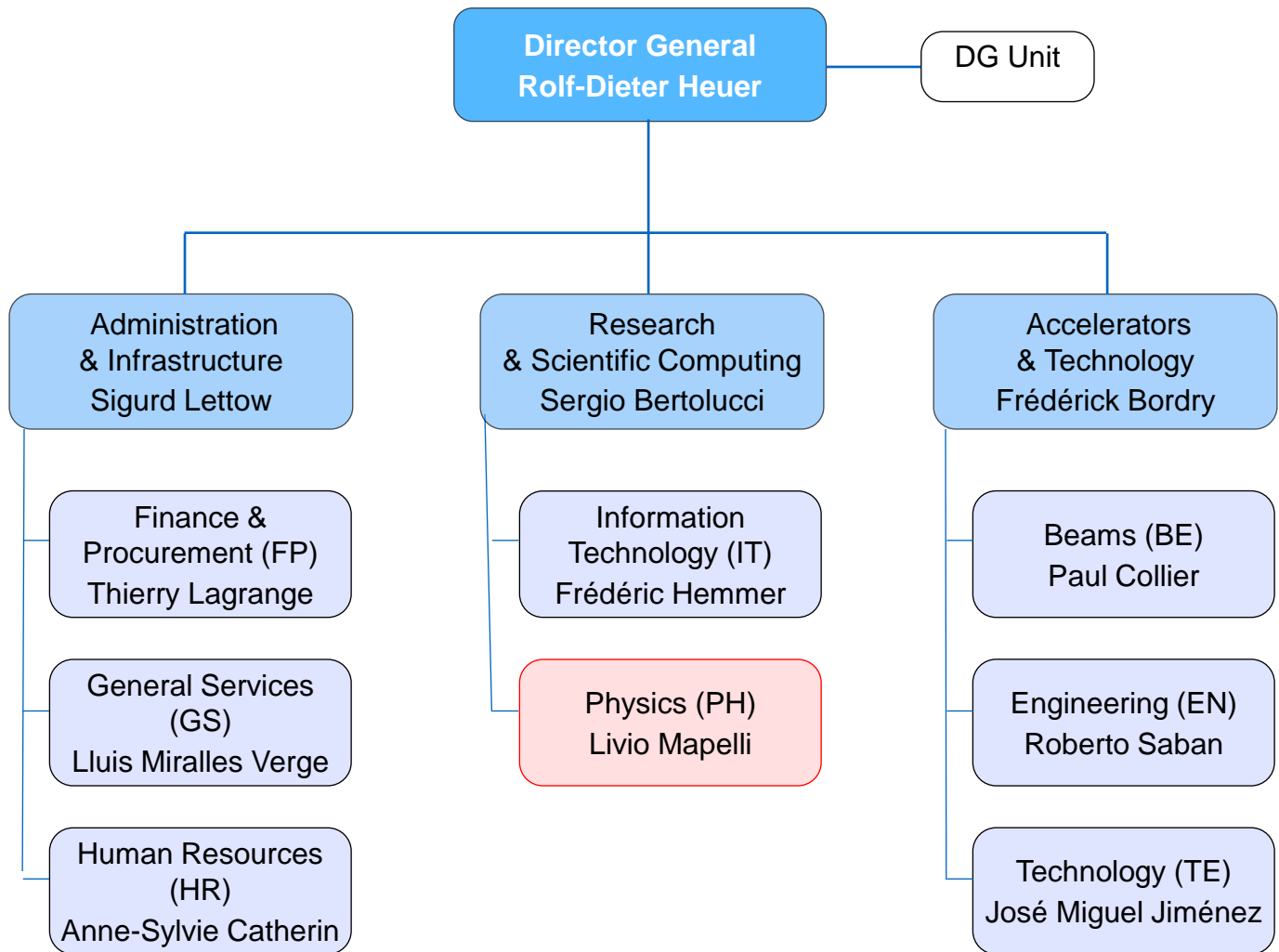
**Resources**



# PH in CERN

**3 Sectors**

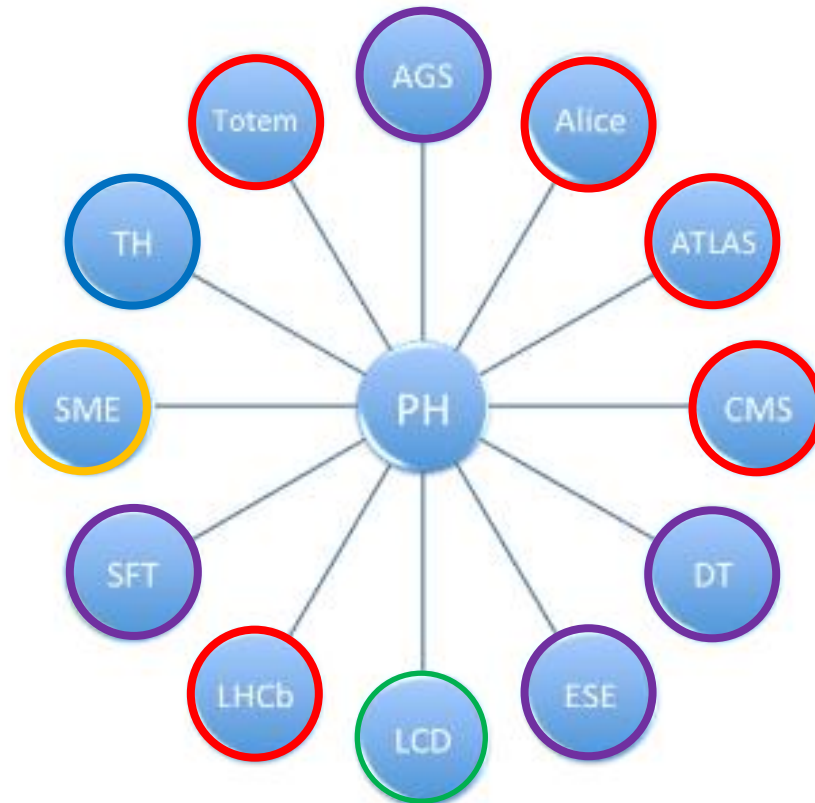
**8 Departments**



The **CERN Physics Department** carries out basic research in the field of **experimental and theoretical particle physics**.

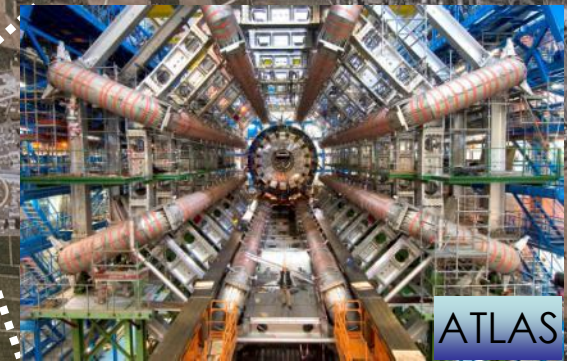
It aims at providing a stimulating scientific atmosphere and remains an **important reference centre** for the European physics community.

1. LHC experiments
2. Non-LHC experiments
3. Future experiments
4. Theory
5. Support groups



# 1. Experiments at the LHC

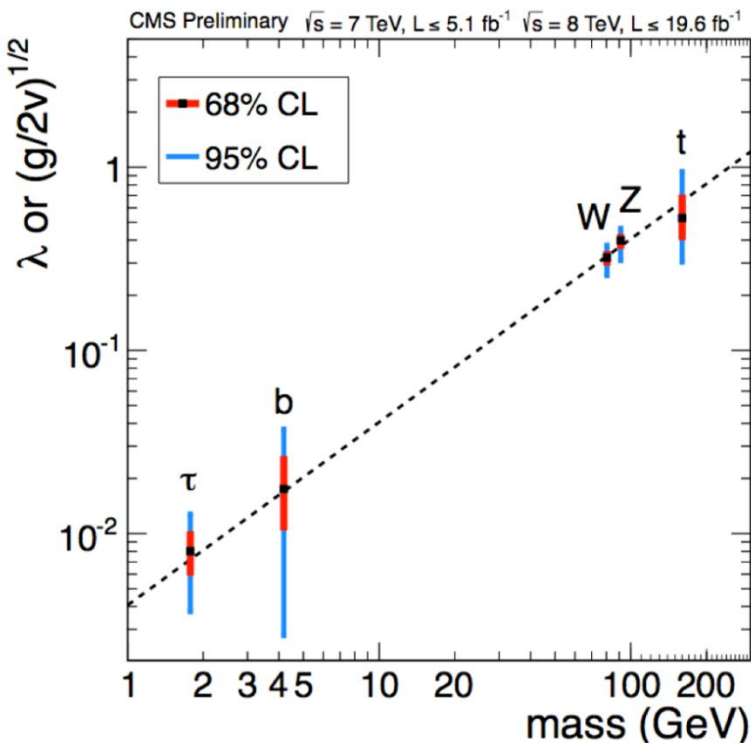
*A new era in fundamental science*



- General-Purpose Detectors, for energy-frontier physics
  - Studying Higgs boson properties, searching for new physics...

Higgs couplings

SUSY searches: no signal so far...



**ATLAS SUSY Searches\* - 95% CL Lower Limits**  
 Status: SUSY 2013

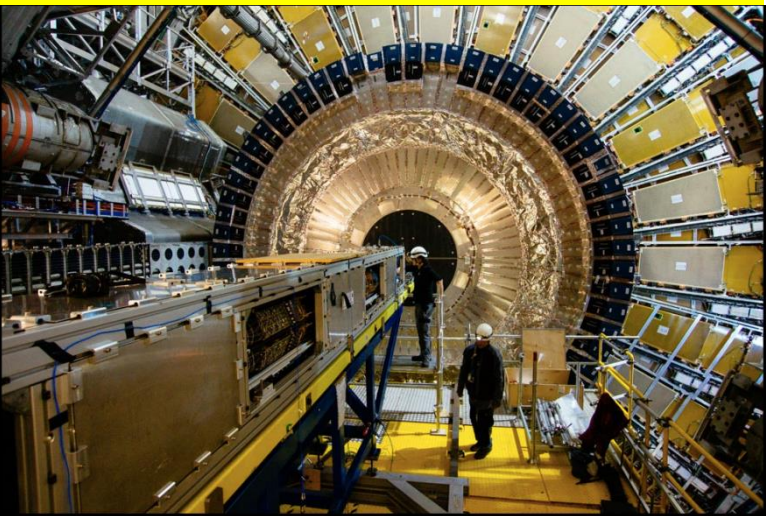
Reference: ATLAS Preliminary  $\int L dt = (4.6 - 22.9) \text{ fb}^{-1}$   $\sqrt{s} = 7, 8 \text{ TeV}$

Model	$e, \mu, \tau, \gamma$	Jets	$E_{T}^{\text{miss}}$	$L \cdot dt (\text{fb}^{-1})$	Mass limit	Reference										
<b>Inclusive Searches</b>	MSUGRA/CMSM: 0, 2-6 jets, Yes, 20.3	MSUGRA/CMSM: 1 $e, \mu$ , 3-6 jets, Yes, 20.3	MSUGRA/CMSM: 0, 7-10 jets, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}$ : 0, 2-6 jets, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\nu/\nu\bar{\nu})$ : 2 $e, \mu$ , 2-4 jets, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\nu/\nu\bar{\nu})$ : 1 $e, \mu$ , 3-6 jets, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\nu/\nu\bar{\nu})$ : 2 $e, \mu$ , 0-3 jets, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\nu/\nu\bar{\nu})$ : 2 $e, \mu$ , 2-4 jets, Yes, 4.7	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\nu/\nu\bar{\nu})$ : 1.2 $\tau$ , 0-2 jets, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\nu/\nu\bar{\nu})$ : 2 $\gamma$ , - , Yes, 4.8	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\nu/\nu\bar{\nu})$ : 1 $e, \mu + \gamma$ , - , Yes, 4.8	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\nu/\nu\bar{\nu})$ : 2 $e, \mu$ (Z), 0-3 jets, Yes, 5.8	$\tilde{g}, \tilde{g} \rightarrow q\bar{q}(\ell\nu/\nu\bar{\nu})$ : Gravitino LSP, 0 mono-jet, Yes, 10.5	1.7 TeV, 1.2 TeV, 1.1 TeV, 740 GeV, 1.3 TeV, 1.18 TeV, 1.12 TeV, 1.24 TeV, 1.4 TeV, 1.07 TeV, 619 GeV, 900 GeV, 690 GeV, 645 GeV	$m(\tilde{g})=m(\tilde{g})$ , any $\tilde{g}$ , any $\tilde{g}$ , $m(\tilde{t})=0 \text{ GeV}$ , $m(\tilde{t})=0 \text{ GeV}$ , $m(\tilde{t})=200 \text{ GeV}, m(\tilde{t}')=0.5m(\tilde{t})+m(\tilde{g})$ , $m(\tilde{t})=0 \text{ GeV}$ , $\tan\beta > 18$ , $m(\tilde{t}) > 50 \text{ GeV}$ , $m(\tilde{t}') > 200 \text{ GeV}$ , $m(\tilde{t}') > 80 \text{ GeV}$ , $m(\tilde{t}') > 200 \text{ GeV}$ , $m(\tilde{t}') > 10^{-1} \text{ eV}$	ATLAS-CONF-2013-047, ATLAS-CONF-2013-062, 1308.1841, ATLAS-CONF-2013-047, ATLAS-CONF-2013-047, ATLAS-CONF-2013-062, ATLAS-CONF-2013-089, 1208.4688, ATLAS-CONF-2013-026, 1209.0793, ATLAS-CONF-2012-144, 1211.1167, ATLAS-CONF-2012-152, ATLAS-CONF-2012-147
<b>3rd gen. direct production</b>	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 0, 3 b, Yes, 20.1	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 0, 7-10 jets, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 0-1 $e, \mu$ , 3 b, Yes, 20.1	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 0, 2 b, Yes, 20.1	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 2 $e, \mu$ (SS), 0-3 b, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 1.2 $e, \mu$ , 1-2 b, Yes, 4.7	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 2 $e, \mu$ , 0-2 jets, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 2 $e, \mu$ , 2 jets, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 0, 2 b, Yes, 20.1	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 1 $e, \mu$ , 1 b, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 0, 2 b, Yes, 20.5	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 2 $e, \mu$ (Z), 1 b, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 3 $e, \mu$ (Z), 0 b, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow b\bar{b}$ : 100-620 GeV, 275-430 GeV, 110-647 GeV, 130-220 GeV, 225-525 GeV, 150-580 GeV, 200-510 GeV, 320-660 GeV, 90-200 GeV, 500 GeV, 271-920 GeV	$m(\tilde{t}) > 90 \text{ GeV}$ , $m(\tilde{t}) > 2 m(\tilde{t})$ , $m(\tilde{t}) > 55 \text{ GeV}$ , $m(\tilde{t}) = m(\tilde{t}), m(W) = 50 \text{ GeV}, m(\tilde{t}) < m(\tilde{t})$ , $m(\tilde{t}) > 0 \text{ GeV}$ , $m(\tilde{t}) > 200 \text{ GeV}, m(\tilde{t}') = m(\tilde{t}) + 5 \text{ GeV}$ , $m(\tilde{t}) > 0 \text{ GeV}$ , $m(\tilde{t}) > 150 \text{ GeV}$ , $m(\tilde{t}) = m(\tilde{t}) + 80 \text{ GeV}$	ATLAS-CONF-2013-061, ATLAS-CONF-2013-061, ATLAS-CONF-2013-061, 1308.2631, ATLAS-CONF-2013-007, 1208.3005, 1209.2102, ATLAS-CONF-2013-048, ATLAS-CONF-2013-065, 1308.2631, ATLAS-CONF-2013-027, ATLAS-CONF-2013-024, ATLAS-CONF-2013-068, ATLAS-CONF-2013-025, ATLAS-CONF-2013-025
<b>EW direct</b>	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 2 $e, \mu$ , 0, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 2 $e, \mu$ , 0, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 2 $e, \mu$ , 0, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 2 $\tau$ , - , Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 3 $e, \mu$ , 0, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 3 $e, \mu$ , 0, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 3 $e, \mu$ , 0, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 1 $e, \mu$ , 2 b, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 85-315 GeV, 125-450 GeV, 180-330 GeV, 600 GeV, 315 GeV, 285 GeV	$m(\tilde{t}) > 0 \text{ GeV}$ , $m(\tilde{t}) > 0 \text{ GeV}, m(\tilde{t}', \tilde{t}) = 0.5(m(\tilde{t}') + m(\tilde{t}'))$ , $m(\tilde{t}) > 0 \text{ GeV}, m(\tilde{t}', \tilde{t}) = 0.5(m(\tilde{t}') + m(\tilde{t}'))$ , $m(\tilde{t}) = m(\tilde{t}), m(\tilde{t}') = 0, m(\tilde{t}') = 0, \text{ sleptons decoupled}$ , $m(\tilde{t}) = m(\tilde{t}), m(\tilde{t}') = 0, \text{ sleptons decoupled}$	ATLAS-CONF-2013-049, ATLAS-CONF-2013-049, ATLAS-CONF-2013-028, ATLAS-CONF-2013-035, ATLAS-CONF-2013-035, ATLAS-CONF-2013-093					
<b>Long-lived particles</b>	Direct $\tilde{t}_1 \tilde{t}_1^*$ prod., long-lived $\tilde{t}_1^*$ : 0, 1 jet, Yes, 20.3	Stable, stopped $\tilde{t}_1$ R-hadron: 0, 1-5 jets, Yes, 22.9	GMSB, stopped $\tilde{t}_1 \tilde{t}_1^* \rightarrow (\tilde{t}_1, \mu) \rightarrow (e, \mu)$ : 1 $e, \mu$ , 1-2 jets, Yes, 15.9	GMSB $\tilde{t}_1 \tilde{t}_1^* \rightarrow \tilde{c} \text{ long-lived } \tilde{t}_1^*$ : 2 $\gamma$ , - , Yes, 4.7	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : 1 $\mu$ , displ. vtx, - , Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : LFV $pp \rightarrow \tau\bar{\tau} + X, \tilde{\nu}_\tau \rightarrow e + \mu$ : 2 $e, \mu$ , - , 4.6	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : LFV $pp \rightarrow \tau\bar{\tau} + X, \tilde{\nu}_\tau \rightarrow e(\mu) + \tau$ : 1 $e, \mu + \tau$ , - , 4.6	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : Bilinear RPV CMSM: 1 $e, \mu$ , 7 jets, Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : $\tilde{t}_1 \tilde{t}_1^* \rightarrow W\tilde{\nu}_\tau, \tilde{t}_1^* \rightarrow e\nu_e, e\nu_e$ : 4 $e, \mu$ , - , Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : $\tilde{t}_1 \tilde{t}_1^* \rightarrow W\tilde{\nu}_\tau, \tilde{t}_1^* \rightarrow \tau\nu_\tau, e\nu_e$ : 3 $e, \mu + \tau$ , - , Yes, 20.7	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : $\tilde{g} \rightarrow \tau\bar{\tau}, \tilde{t}_1 \rightarrow b\bar{s}$ : 0, 6-7 jets, Yes, 20.3	$\tilde{g}, \tilde{g} \rightarrow \tau\bar{\tau}$ : $\tilde{g} \rightarrow \tau\bar{\tau}, \tilde{t}_1 \rightarrow b\bar{s}$ : 2 $e, \mu$ (SS), 0-3 $\tau$ , Yes, 20.7	270 GeV, 832 GeV, 475 GeV, 230 GeV, 1.0 TeV, 1.61 TeV, 1.1 TeV, 1.2 TeV	$m(\tilde{t}) = m(\tilde{t}') = 160 \text{ MeV}, \tau(\tilde{t}_1^*) = 0.2 \text{ ns}$ , $m(\tilde{t}) = 100 \text{ GeV}, 10 \mu\text{s} < \tau(\tilde{t}_1^*) < 1000 \text{ s}$ , $10^{-10} \text{ s} < \tau(\tilde{t}_1^*) < 10^{-9} \text{ s}$ , $0.4 < \tau(\tilde{t}_1^*) < 2 \text{ ns}$ , $1.5 < c\tau < 156 \text{ mm}, \text{BR}(\tilde{t}_1 \rightarrow \mu) > 108 \text{ GeV}$	ATLAS-CONF-2013-069, ATLAS-CONF-2013-057, ATLAS-CONF-2013-058, 1304.6310, ATLAS-CONF-2013-092, 1212.1272, 1212.1272, ATLAS-CONF-2012-140, ATLAS-CONF-2013-036, ATLAS-CONF-2013-036, ATLAS-CONF-2013-091, ATLAS-CONF-2013-007	
<b>Other</b>	Scalar gluon pair, $sgluon \rightarrow q\bar{q}$ : 0, 4 jets, - , 4.6	Scalar gluon pair, $sgluon \rightarrow t\bar{t}$ : 2 $e, \mu$ (SS), 1 b, Yes, 14.3	WIMP interaction (DS, Dirac $\chi$ ): 0 mono-jet, Yes, 10.5	Scalar gluon pair, $sgluon \rightarrow q\bar{q}$ : 2 $e, \mu$ (SS), 1 b, Yes, 14.3	Scalar gluon pair, $sgluon \rightarrow t\bar{t}$ : 2 $e, \mu$ (SS), 1 b, Yes, 14.3	WIMP interaction (DS, Dirac $\chi$ ): 0 mono-jet, Yes, 10.5	Scalar gluon pair, $sgluon \rightarrow q\bar{q}$ : 2 $e, \mu$ (SS), 1 b, Yes, 14.3	Scalar gluon pair, $sgluon \rightarrow t\bar{t}$ : 2 $e, \mu$ (SS), 1 b, Yes, 14.3	WIMP interaction (DS, Dirac $\chi$ ): 0 mono-jet, Yes, 10.5	100-287 GeV, 800 GeV, 754 GeV	incl. limit from 1110.2693	1215.4826, ATLAS-CONF-2013-051, ATLAS-CONF-2012-147				

\*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1 $\sigma$  theoretical signal cross section uncertainty.

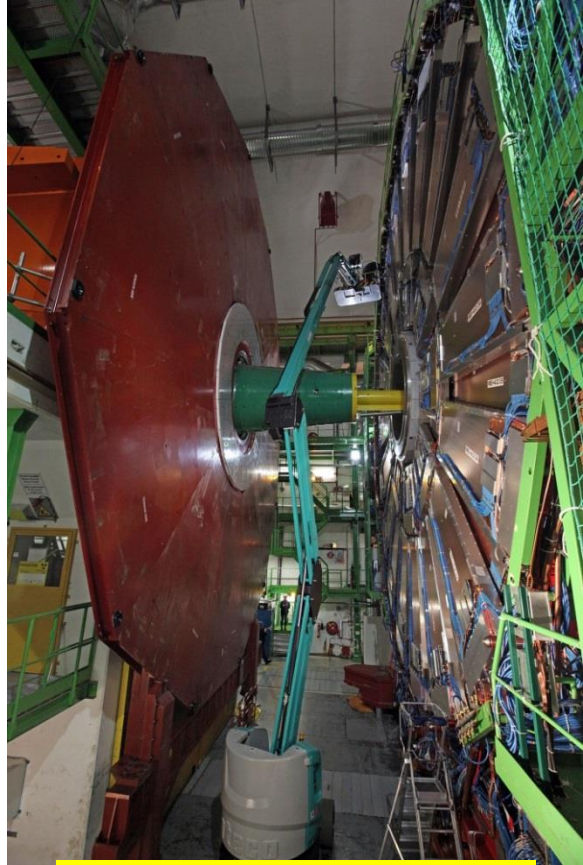
- CERN participates to the ATLAS collaboration
  - as an Institute
    - Detectors. Inner: BCM, Pixel, SCT, TRT; Calorimeters: Lar, Tile; Muon spectrometer; Forward detectors (Alfa)
    - Trigger and DAQ, Computing, Offline systems, Physics analysis
    - Upgrade activities
    - **286 papers so far**
  - as the Host Laboratory
    - Hosting ATLAS Management; Technical Coordination; Tier-0 Operation

Insertion of Pixel detector december 2013



nSW  
Micromegas sector-sized prototype fully assembled. Study panel deformation and sag, measure elastic & mechanical properties.

- **CERN as an Institute:**
  - flagship analyses: Higgs-> tau tau, 4 leptons, gamma-gamma and combination of results, top mass, SUSY searches. **328 papers so far**
  - RPC assembly and test in 904, installation half completed
  - Pixel CO2 cooling station
  - DAQ being re-architected
- **CERN as the Host Lab:**
  - 4th endcap shielding disk
    - 1 installed, 2nd being prepared for installation
    - Push-back system designed and tested
  - Preparation for new beam pipe installation



Muon chambers in B.904



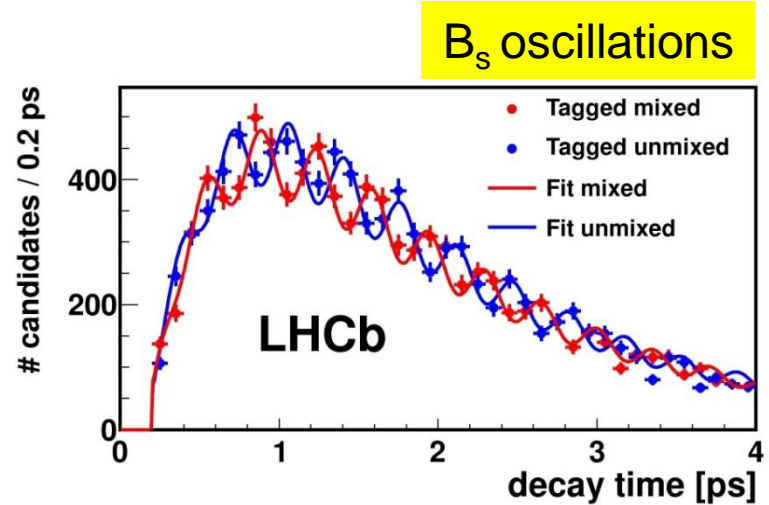
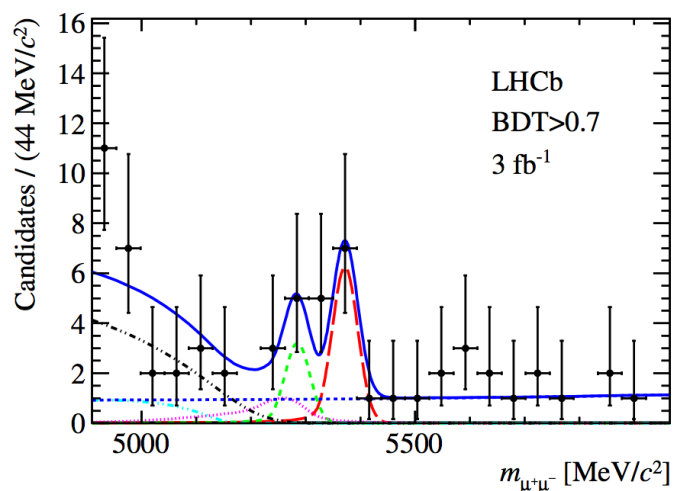
Muon chambers in B.904



Extraction of CMS beam pipe

- Dedicated to beauty and charm particles search for new physics in CP violation and rare decays
  - Short term program is based on data sample of  $\sim 8 \text{ fb}^{-1}$  collected within  $\sim 5$  years of LHC running
  - Longer term (with data sample of  $\sim 50 \text{ fb}^{-1}$ )  $\rightarrow$  study models of new physics (or further constrain it), with upgraded detector
  - **167 papers so far**, some with high impact

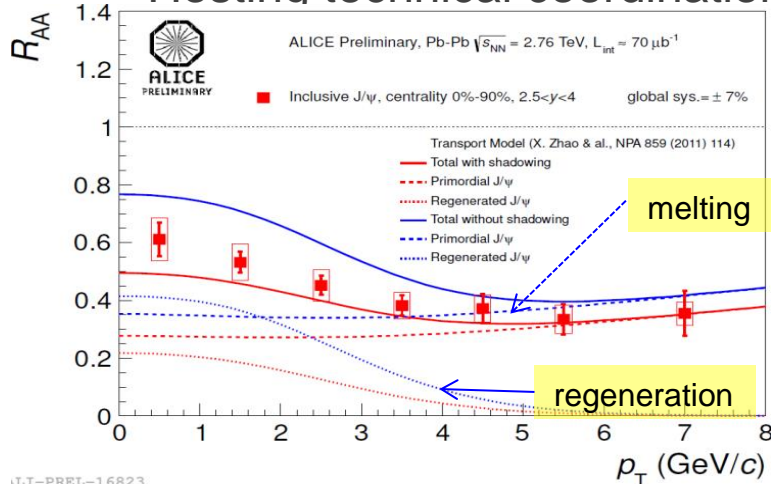
*First evidence for the very rare decay  $B_s \rightarrow \mu^+ \mu^-$*



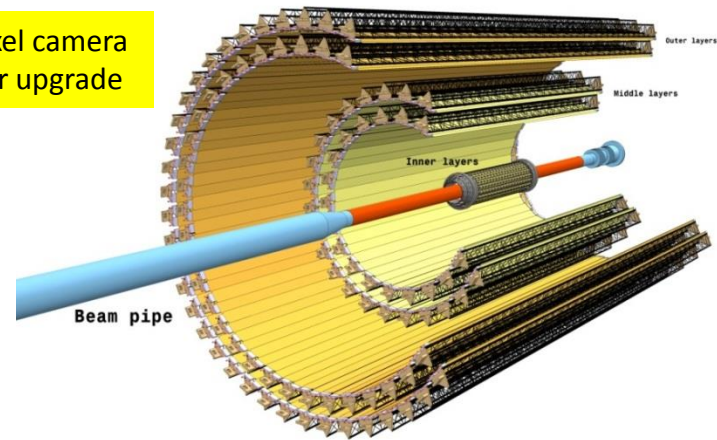


- **Dedicated heavy-ion detector for nucleus-nucleus collisions**
  - Physics of strongly-interacting matter at extreme energy densities
  - Formation of new phase of matter: quark-gluon plasma
  - Flagship results: J/psi enhancement, charm flow, collectivity in pA collisions
  - **78 papers so far, 400 conference presentations/year**
- **CERN as an Institute**
  - Detectors (SPD, TPC, HMPID); Online and Offline; Physics Analysis
  - Upgrade : ITS (Inner Tracking System) and O<sup>2</sup> (Online-Offline) projects
- **CERN as the Host Lab**

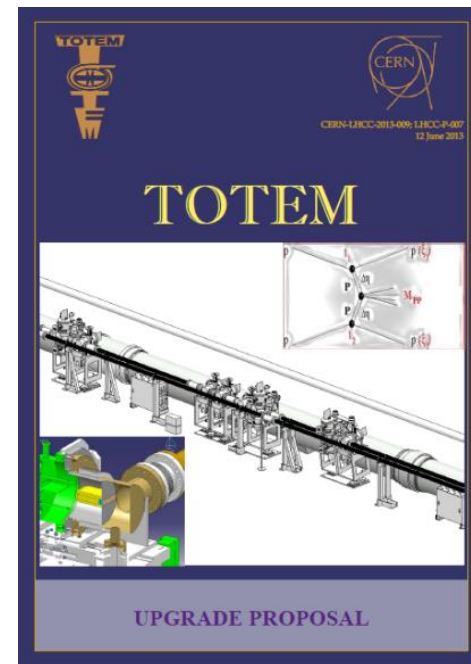
• Hosting technical coordination, major consolidation work in LS1; T0 operations



ITS: 25 G-pixel camera (~10 m<sup>2</sup>) for upgrade

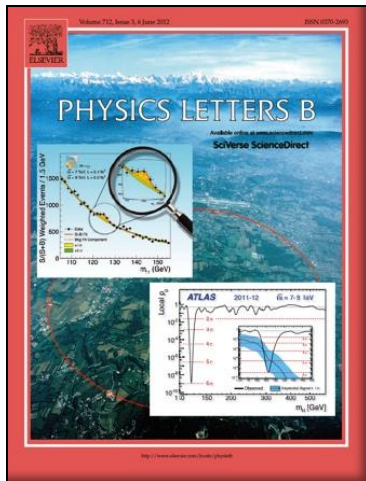
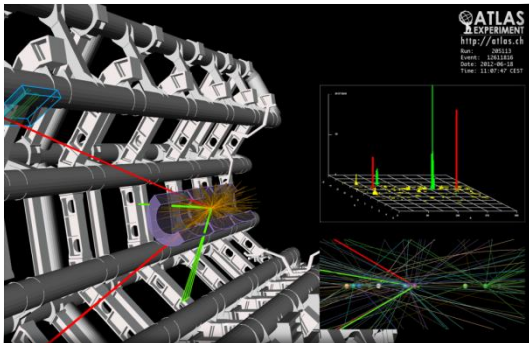
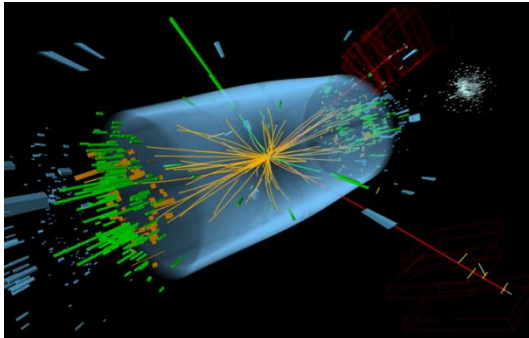


- Forward experiment at the CMS region, using Roman Pots
- Physics in 2013
  - Luminosity independent pp total cross-section at 8 TeV
  - Double diffraction cross-section at 7 TeV
  - Evidence of hadronic-Coulomb interference in pp elastic scattering at 8 TeV
  - **14 papers so far**
- Technological developments
  - RF optimized Roman Pot for high luminosity at LHC
  - Integration of new RP stations in LHC beam line and study of timing detectors in new cylindrical Roman Pot



## Other small experiments at the LHC

- LHCf: forward experiment at ATLAS region
- MoEDAL: search for magnetic monopoles with plastic sheets around the LHCb region



## The Nobel Prize in Physics 2013

[nobelprize.org/nobel\\_prizes/physics/laureates/2013/](http://nobelprize.org/nobel_prizes/physics/laureates/2013/)

### Nobel Prizes and Laureates

Photo: A. Mahmoud

#### François Englert

Photo: A. Mahmoud

#### Peter W. Higgs

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs "for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"

Photos: Copyright © The Nobel Foundation

To cite this page

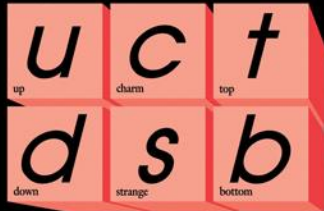
MLA style: "The Nobel Prize in Physics 2013". *Nobelprize.org*. Nobel Media AB 2013. Web. 14 Feb 2014. <[http://www.nobelprize.org/nobel\\_prizes/physics/laureates/2013/](http://www.nobelprize.org/nobel_prizes/physics/laureates/2013/)>





# The Standard Model

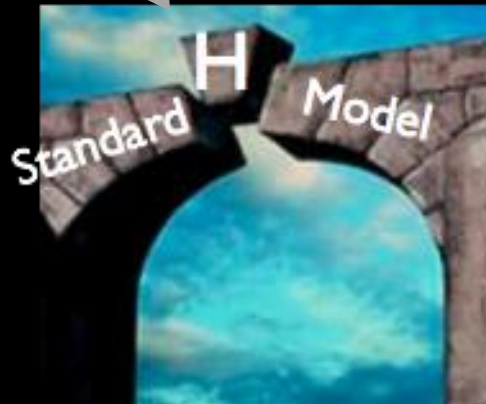
## Quarks



## Forces



## Leptons



- Now that we have discovered the BEH scalar boson
  - *That explains why particles have different masses and says the final word on the validity of the Standard Model*
  - *We remain with fundamental unanswered questions*

Astrophysical measurements indicate that the Universe is made of:

5% known matter  
25 % “dark matter”  
70% “dark energy”

*Today we understand only 5% of the Universe’s composition*



Theories beyond the Standard Model – such as **Supersymmetry** predict new heavy elementary particles

Among them the **neutralino**, our present best candidate for the dark matter *which may be light enough to be produced abundantly at the LHC*

- Ongoing physics analysis from Run 1
- Preparation for Run 2
  - Completion of LS1 work
  - Startup early in 2015
- Preparation of upgrades
  - Phase 1 in 2018/19
    - Large upgrades for LHCb and ALICE
    - “Small” for ATLAS and CMS
  - Phase 2 in 2023/24
    - With high-luminosity upgrade of machine (HL-LHC)
    - Large upgrades for ATLAS and CMS

### SME – Small and Medium sized Experiments

Hosts the non-LHC experiments

Maintains a diverse programme of physics at CERN

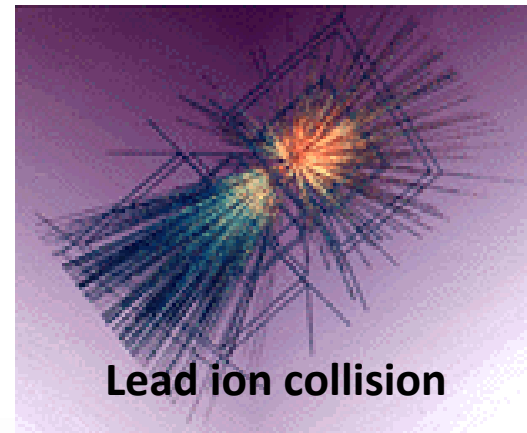
- PS and SPS Fixed-Target experiments
- AD experiments – Antiproton Decelerator
- ISOLDE + nTOF
  - Nuclear physics (Isotope separation, neutron time-of-flight)
- Other experiments
  - CLOUD, DIRAC, CAST

# Fixed target at the SPS

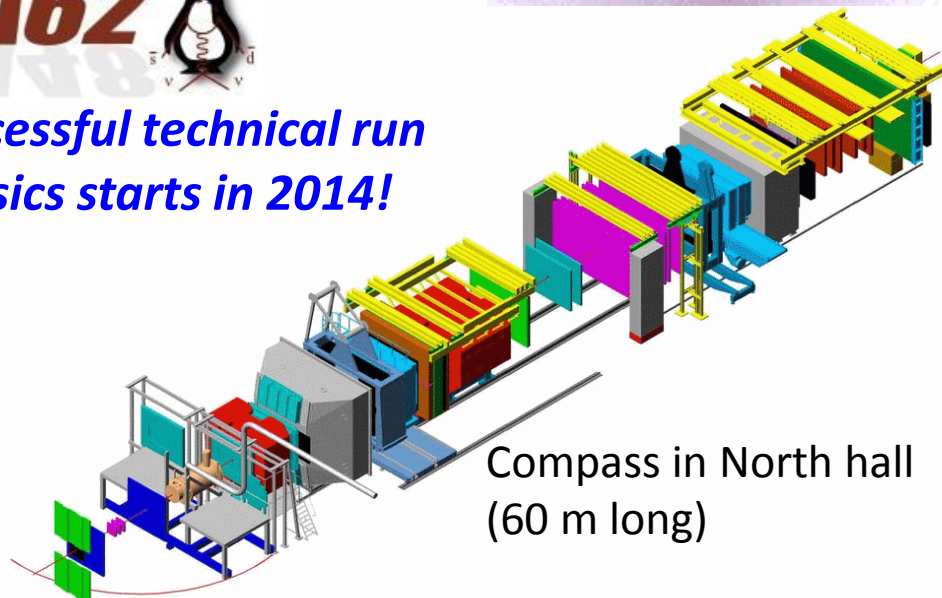
Lower energy experiments at PS or SPS allow precision measurements and comparison with theory.

**Deviations can be sign of new physics at higher energies.**

- DIRAC: **pionic atoms** (completed)
- COMPASS: **muon spin physics, spectroscopy**
- NA61: ion physics, **quark gluon plasma**
- NA62: **rare K decays**
- NA63: **electromagnetism** in extreme conditions



*Successful technical run  
Physics starts in 2014!*



Compass in North hall  
(60 m long)



## Matter-Antimatter comparison

*Very fundamental in the current theory of physics:  $m = \bar{m}$ ,  $g = \bar{g}$*

## ATRAP, ALPHA

Trapping and spectroscopy of Hbar in a "bottle"

## ASACUSA

Spectroscopy of exotic atoms and of in-flight Hbars

## BASE

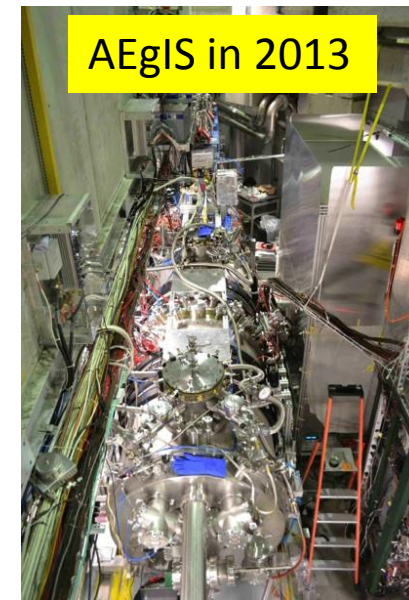
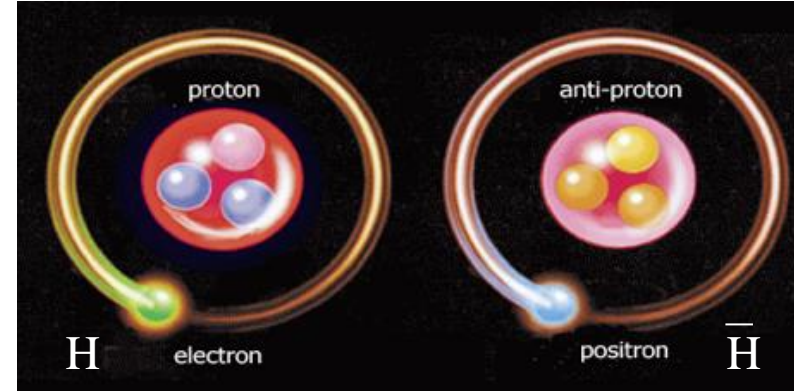
Magnetic moment of the antiproton

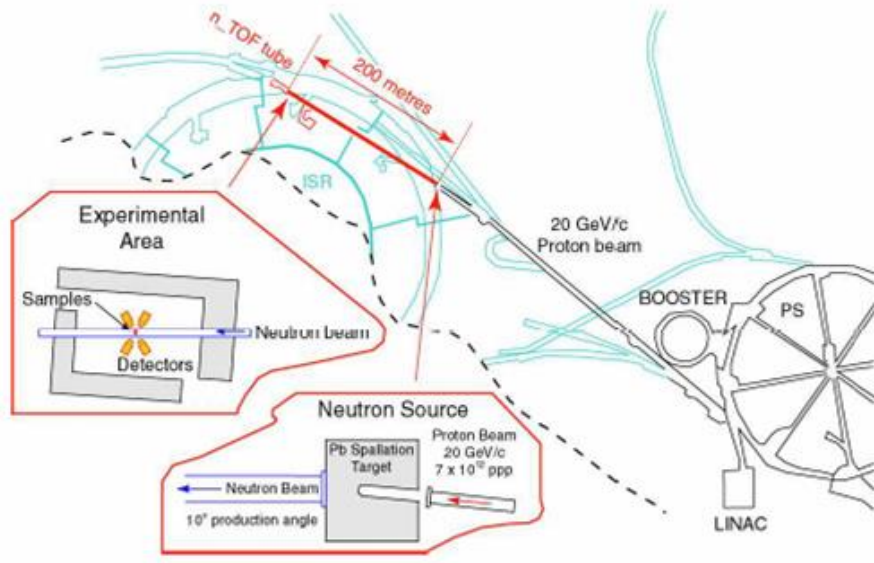
## AEgIS

Hbar free fall, gravity effect on antimatter  
Galileo's experiment for antimatter!

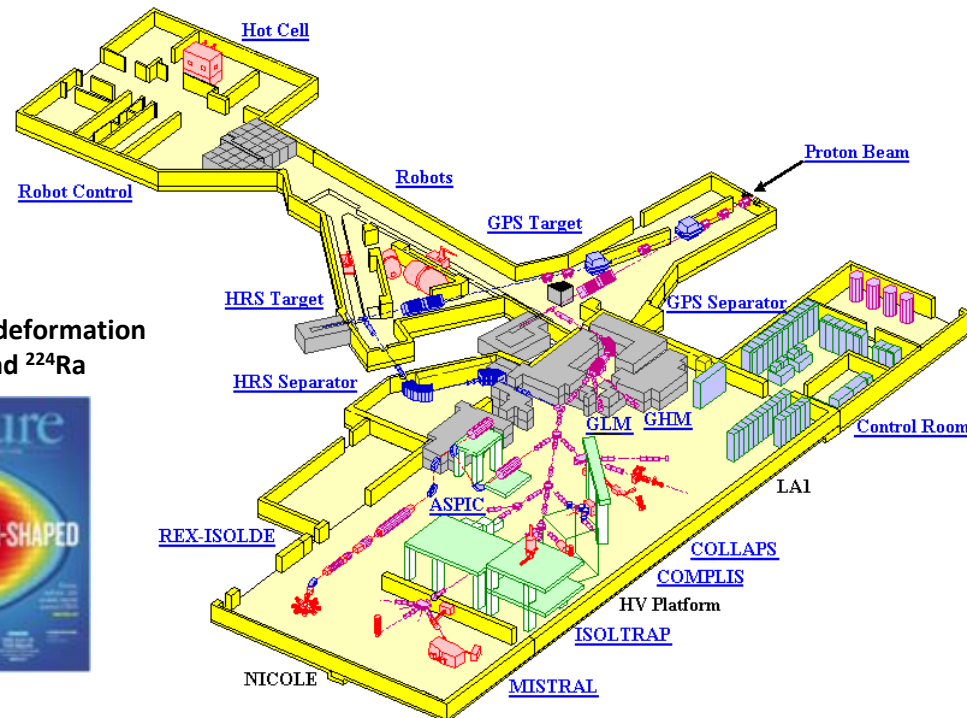
In 2014 **commissioning all steps of antihydrogen production:**

Positronium formation, laser excitation,  
Antihydrogen detection, etc.





**nTOF (neutron time-of-flight)**  
**Measures neutron cross-sections**  
*Astrophysics*  
*Burning of nuclear waste*  
 New experimental area EAR-2 in preparation



## ISOLDE: radioactive ion beams

*Nuclear physics*

*Astrophysics*

*Solid State Physics*

*Medical applications*

**3 papers in Nature in 2013**

Upgrade to higher intensity (HIE-ISOLDE) in progress

Octupole deformation in  $^{220}\text{Rn}$  and  $^{224}\text{Ra}$



## CLOUD - Study effect of cosmic rays on cloud formation

Cosmic rays “simulated” by T11 beam, clouds created in a large climatic chamber

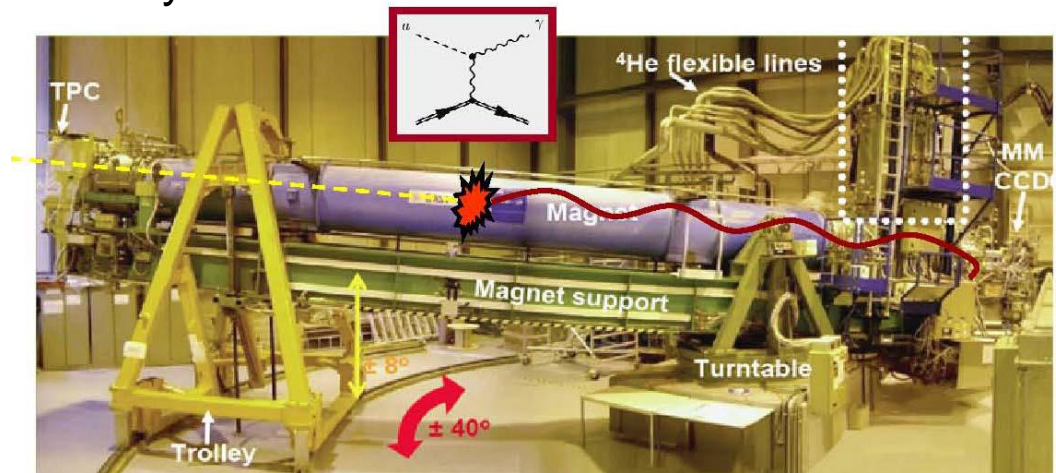


## CAST - Search for axions from sun

Using a spare LHC dipole, pointing at sun  
Study for successor (IAXO) underway

## OSQAR - Search for photon regeneration

Using another spare dipole and laser source



- LCD – Linear Collider Detector**

Studying the detector design for possible future  $e^+e^-$  linear colliders (ILC & CLIC)

Participating in detector and physics studies (CLICdp)

- FCC – Future Circular Collider study**

80–100 km circumference machine to study pp collisions at 100 TeV, as well as ee or ep options

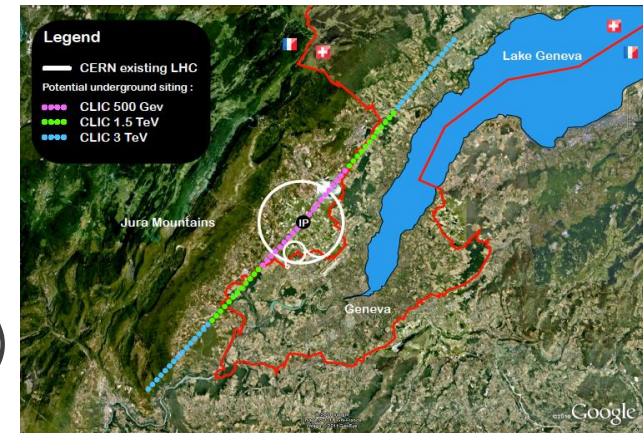
Kick-off meeting 12-15 February,

PH staff contributing

- New approved projects and proposals in preparation**

R&D for future neutrino detectors: WA104 (Icarus), WA105 (Laguna)

Other proposals under review: beam dump at the SPS, IAXO axion telescope



## Mandate:

### Linear Collider Detector

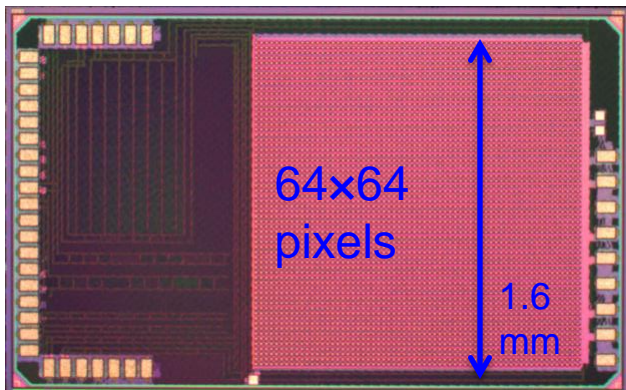
- Hardware R&D (ILC/CLIC)
- Software development



### CLICdp (~collaboration, 22 institutes)

- Host lab
- R&D (CLIC-specific) + Physics studies

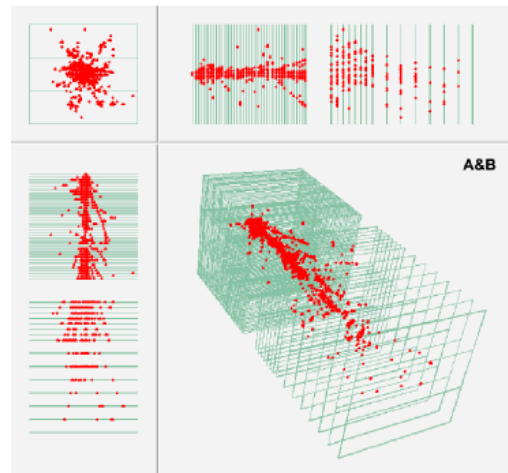
## Ongoing activities



### Pixel R&D

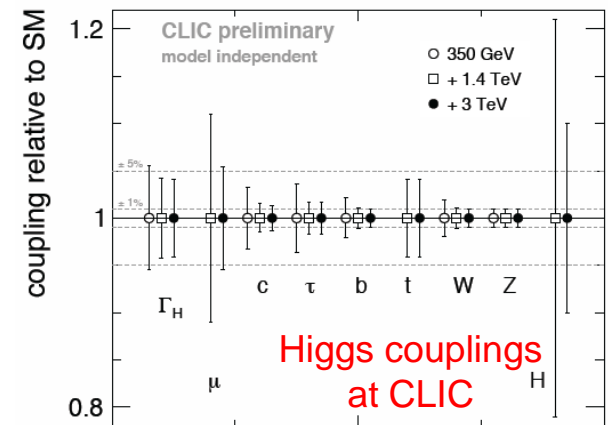
Progress on:

- Electronics
- Pixel assemblies
- Engineering



### Calorimeter R&D

- Test beam analysis
- Lab test SiPM-scintillator



### Physics studies

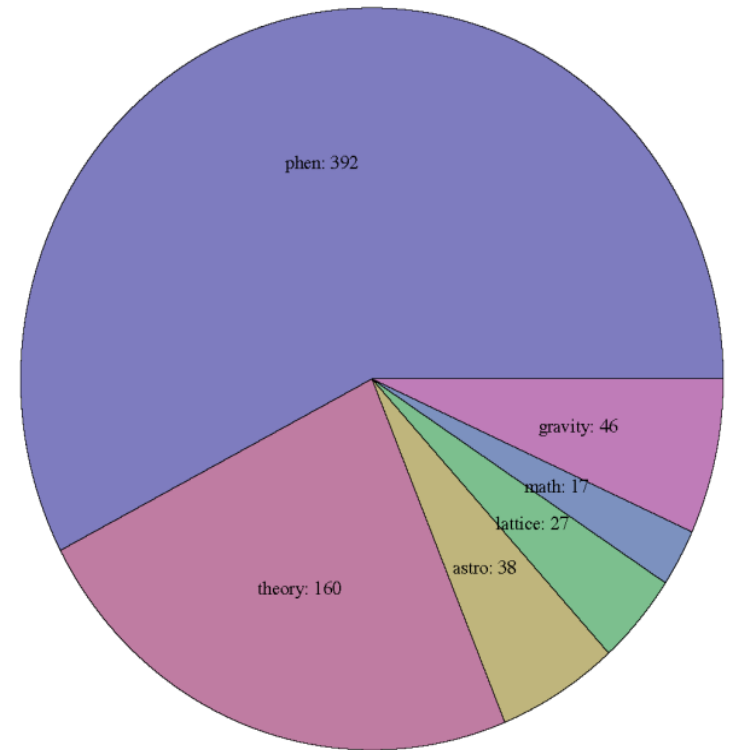
## Exploring synergies with other CERN projects:

- Medipix/Timepix, RD53
- HL+LHC, FCC, AIDA-2

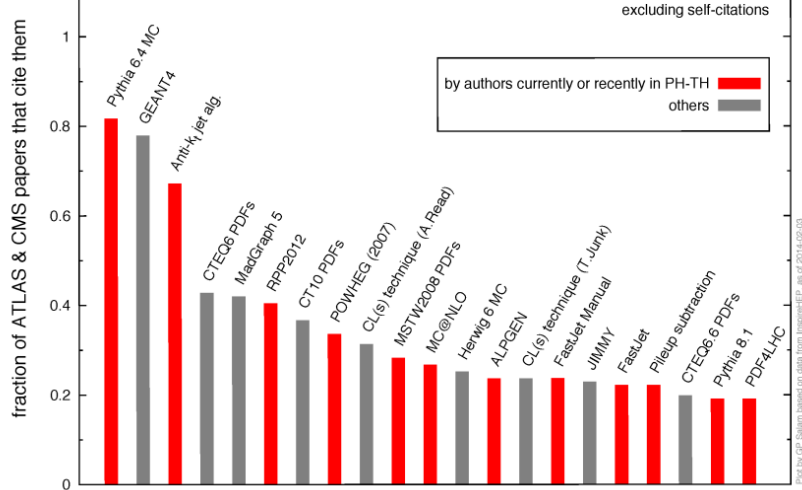
# 4. Theory

- Excellence and creativity in all vital areas of theoretical physics research
  - Standard Model, collider phenomenology
  - Heavy ion physics
  - Beyond the SM, including neutrinos and non-accelerator experiments
  - Astroparticle physics and cosmology
  - Quantum Field Theory and string theory
  - Lattice field theory
- Average > one paper per day in 2013!
  - (including weekends)

Papers versus fields, CERN TH 2013

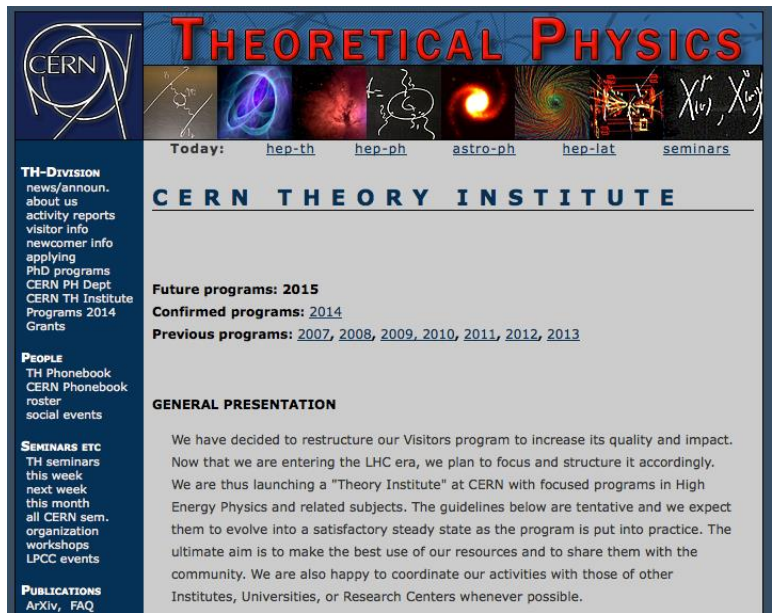


Papers commonly cited by ATLAS and CMS in 2013/14  
excluding self-citations



- Support the experimental program of CERN
  - and profit from its stimulating environment
  
- Contribute to training and outreach
  - academic training, high school teachers, summer students, CERN schools, ...
  
- Reference center for the international theoretical physics community

- Theory Institutes planned in 2014
  - CERN winter school (3-7 Feb)
  - Questioning fundamental physical principles (6-9 May)
  - Numerical holography (2-13 June)
  - Resurgence and trans-series (30 June-4 July)
  - Lattice gauge theory (21 July-1 August)
  - Gauge theories in diverse dimensions (11-22 August)
  - Understanding the early Universe (2 weeks in Autumn)



**THEORETICAL PHYSICS**

Today: [hep-th](#) [hep-ph](#) [astro-ph](#) [hep-lat](#) [seminars](#)

**CERN THEORY INSTITUTE**

**TH-DIVISION**  
 news/announ.  
 about us  
 activity reports  
 visitor info  
 newcomer info  
 applying  
 PhD programs  
 CERN PH Dept  
 CERN TH Institute  
 Programs 2014  
 Grants

**PEOPLE**  
 TH Phonebook  
 CERN Phonebook  
 roster  
 social events

**SEMINARS ETC**  
 TH seminars  
 this week  
 next week  
 this month  
 all CERN sem.  
 organization  
 workshops  
 LPCC events

**PUBLICATIONS**  
 ArXiv, FAQ

**Future programs: 2015**  
**Confirmed programs: 2014**  
**Previous programs: 2007, 2008, 2009, 2010, 2011, 2012, 2013**

**GENERAL PRESENTATION**

We have decided to restructure our Visitors program to increase its quality and impact. Now that we are entering the LHC era, we plan to focus and structure it accordingly. We are thus launching a "Theory Institute" at CERN with focused programs in High Energy Physics and related subjects. The guidelines below are tentative and we expect them to evolve into a satisfactory steady state as the program is put into practice. The ultimate aim is to make the best use of our resources and to share them with the community. We are also happy to coordinate our activities with those of other Institutes, Universities, or Research Centers whenever possible.

**AGS Administration and General Services**

**DT Detector Technologies**

Development, construction, operation and maintenance of particle detectors  
Detector infrastructure for the experiments at CERN  
Services for detector R&D

**ESE Electronic Systems for Experiments**

Design and maintenance of electronics systems for experiments at CERN  
Supply of electronics related services

**SFT SoFTware design for experiments**

Development and maintenance of common scientific software for the CERN experimental programme





# Administrative General Services

PH  
Physics  
Department

Secretarial support  
to experiments and groups



USERS' Office



Space management  
and infrastructure



## • Projects

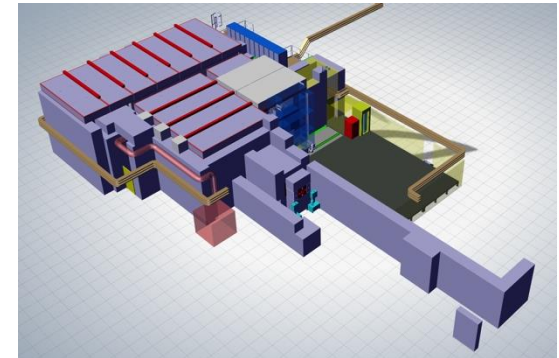
- Focus on operational and engineering support to **LHC experiments during LS1** and to **SME** (NA62, CAST, AEGIS, CLOUD)
- Contributions to new detector systems: *ATLAS IBL*, *NA62 Straw Tracker*
- **LHC detector upgrades**: *LHCb SciFi & TORCH*, *ALICE ITS*, *ATLAS Micromegas*, *TK upgrades*



NA62 Straw Tracker Module

## • Services

- Guarantee **services and infrastructure** for LHC running: Gas, Detector Cooling, Magnet controls and support
- **Facilities** for detector R&D: *GIF++* and *PS facilities*



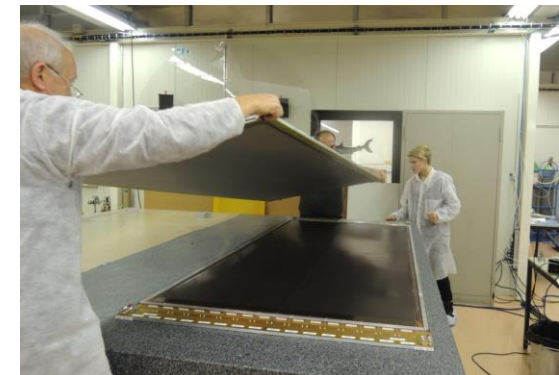
GIF++ in ENH1

## • Strategic R&D projects

RD50, RD51, LCD hardware effort

## • Consolidation of new activities

- CO<sub>2</sub> cooling, micro-fabrication, composite development, effective integration of the former **TE PCB workshop in PH**



Large MicroMegas prototype detector for ATLAS



- Services

- Pool, Power & Crates, IC technologies access (65 nm)

- White-Paper projects finalization and production

- Rad-hard DC-DC converter, Versatile link components and GBT chipset

- Experiments

- Many projects in ALICE, ATLAS, CMS and LHCb
- ATLAS-CMS-LCD common development of pixel readout ASIC (65 nm)
- Electronics coordinators of all LHC experiments are in ESE
- NA62 (Gigatracker (ASIC), Straw detector and LKr RO)

- Medipix

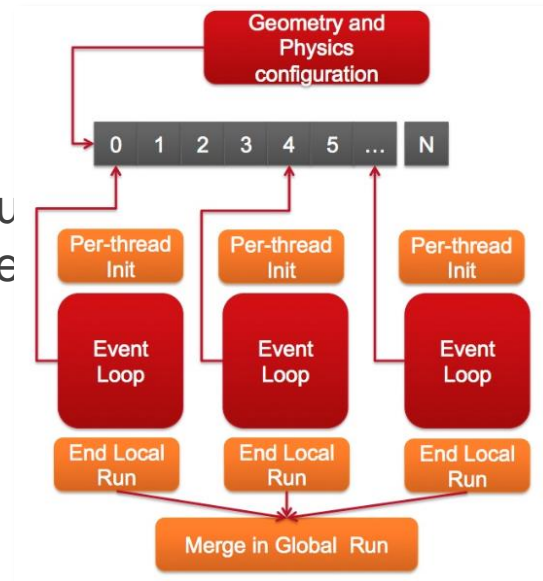
- Development of several ASICs and Through Silicon Vias

- New R&D or services

- High speed low power optical link, Power for extremely high radiation, xTCA (VME replacement), IC technologies and IP blocks, RD53

- Three main projects:

- *Geant4*. Released major new version (10) of the simulation toolkit with multi-threaded event parallelism
- *ROOT*. Working towards major version 6 with the full support of all LHC experiments (new C++ interpreter based on open source LLVM/Clang compiler)
- *CernVM*. Virtual Machine approach for Desktop and Cloud Computing. Companion [File System](#) is now indispensable for all experiments.



- In 2014:

- Prepare for data taking in 2015
- Improve quality, performance and maintainability
- Continue R&D (Concurrent programming, Vectorisation, HEP-wide Software Collaboration)
- New funding opportunities (e.g. Horizon-2020)



# Safety in PH

## Summary of the CERN Safety Objectives from the DG for 2014

- Improvement of road safety prevention
  - Infrastructure
  - Behaviour
- Incident prevention in view of LS1 and restart
- Emergency preparedness
  - Evacuation exercises
  - Evacuation signalization
- Management of hazardous chemicals
- Safety of activities: work at height
  - Lifelines
  - Personnel Protection Equipment (PPE)
- Environmental Protection
  - Continuous improvement to limit greenhouse gas emissions
  - Optimize consumption of drinking water
  - Limitation of waste products
- Conformity of machine workshops (ongoing from 2012)

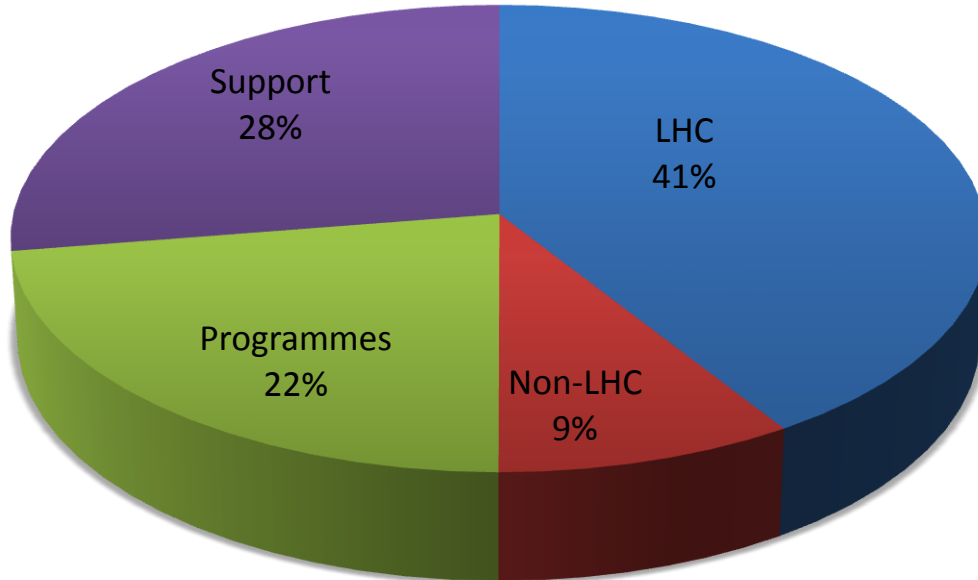
***Safety concerns  
each and all  
of us!***



# ***Resources***

## ***PH in numbers: people and money***

In 2013 the budget for exploitation was  
**26.6 MCHF**



**LHC Operation:** operation of ALICE, ATLAS, CMS, LHCb, TOTEM, LPCC, SFT and general LHC.

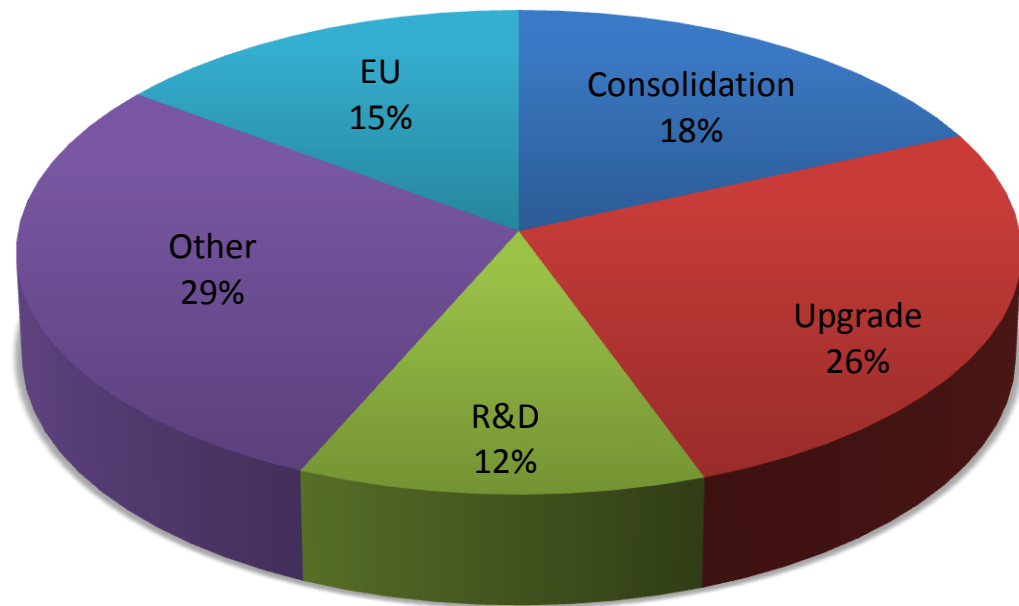
**SUPPORT:** operation of AGS, DT, ESE, Outreach and TH.

**PROGRAMMES:** budgets for Scientific Associates, Technical Associates and Students.

**NON-LHC:** operation of Aegis, Cast, Cloud, Compass, Isolde, NA62 and other small experimental activities, generic R&D and operation of the LCD group.

# PH project budget

In 2013 the budget allocated for projects was  
**17.5 MCHF**



**UPGRADE** for LHC detectors.

**CONSOLIDATION**  
budget ending in 2014.

**R&D line**  
R&D for LHC Upgrade and GETP.

**OTHER** all non-LHC experiments like Aegis, NA62 and Compass, Isolde building, GIF++ project, LCD R&D, EPLANET and TT.

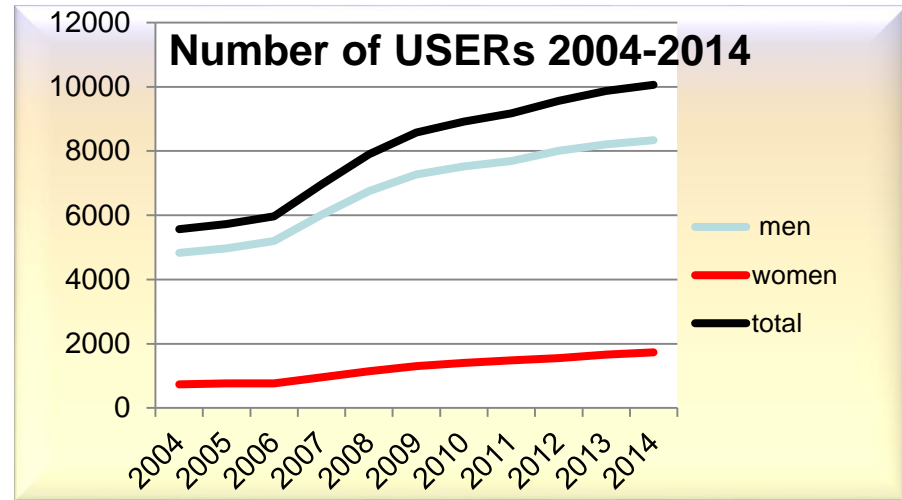
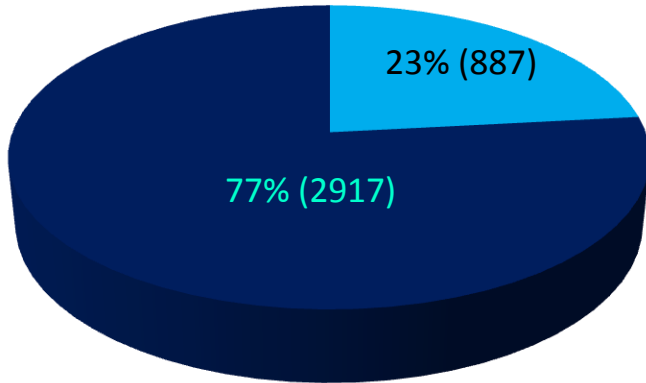
**EU** projects financed by the European Commission.



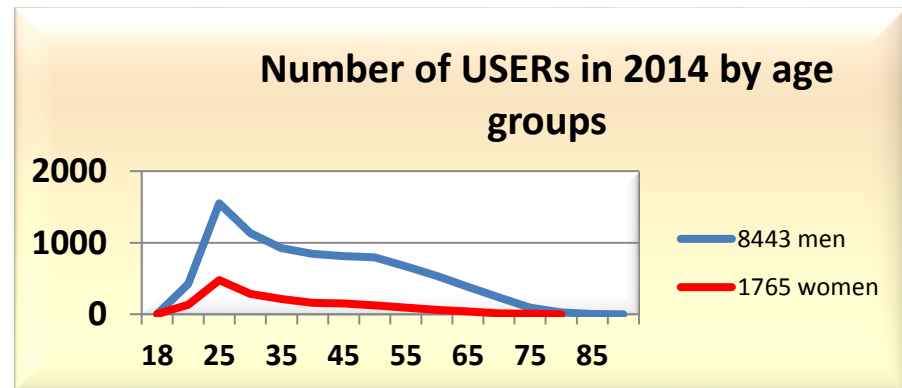
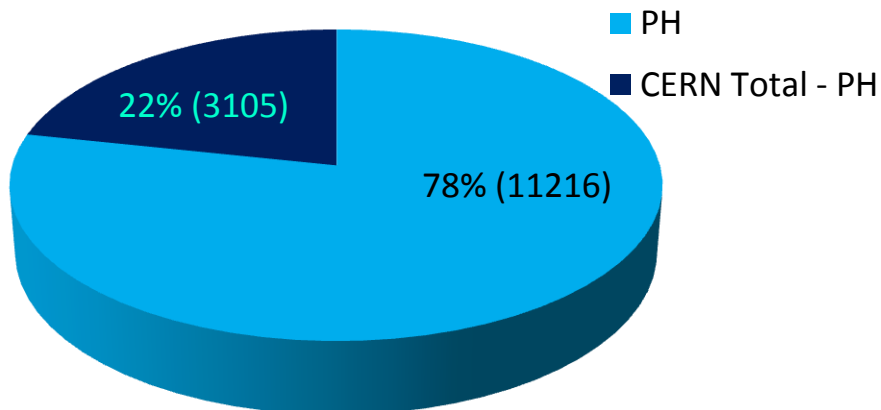


# Personnel in PH compared to CERN

■ PH  
■ CERN Total  
**CERN / PH - without Users**

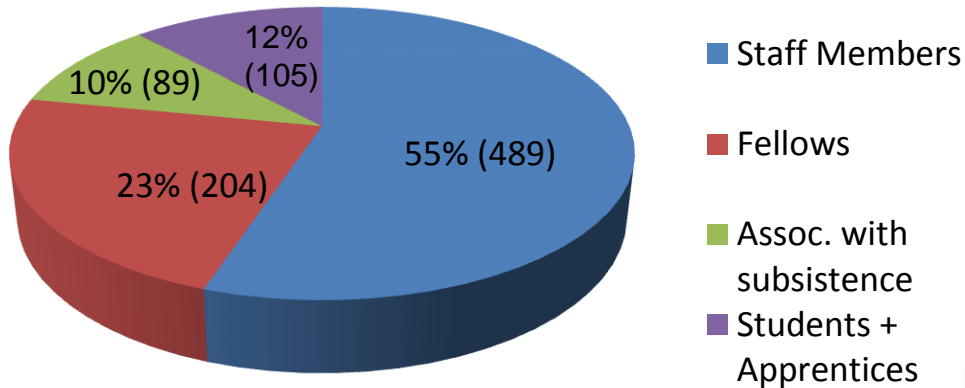


**CERN / PH - All categories of personnel**

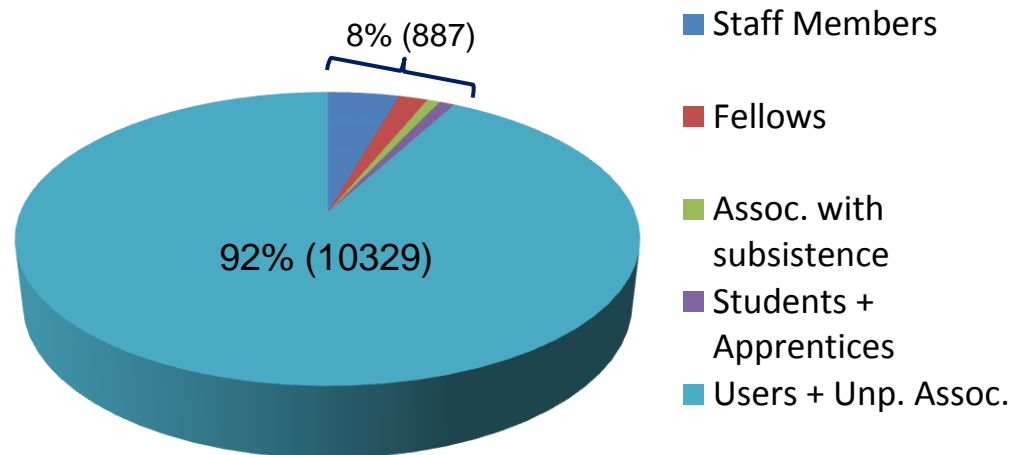


Nationalities: Users, 99; Staff: 26

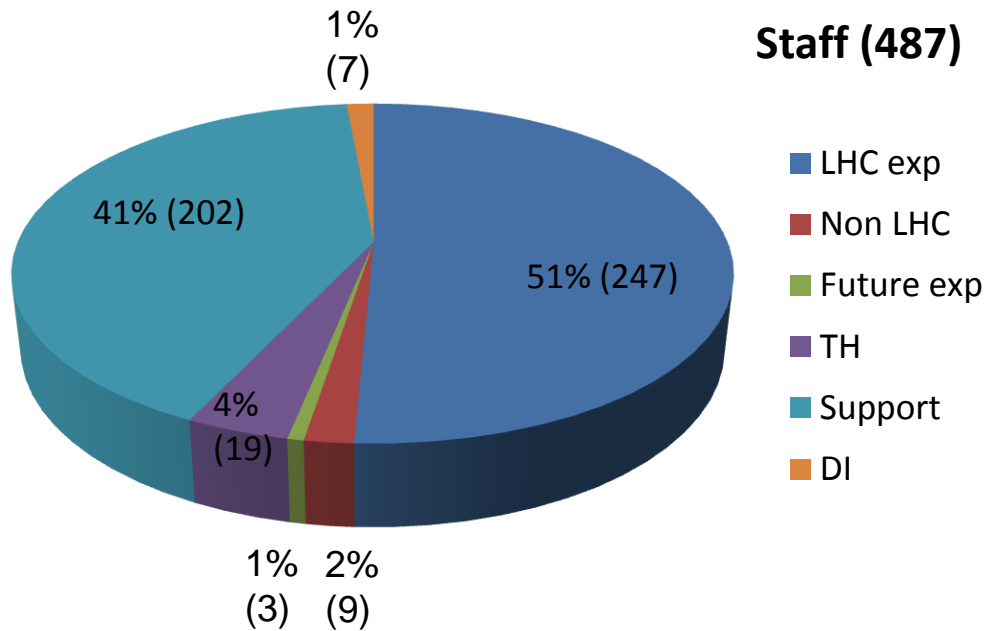
## Different categories of Personnel in PH (w/o Users)



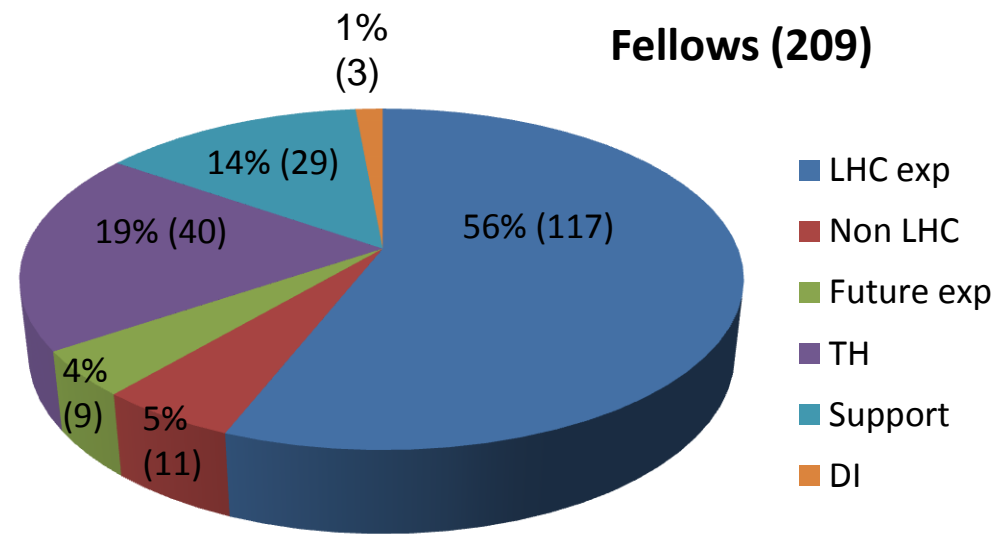
## Different categories of Personnel in PH (with Users)



@30 November 2013

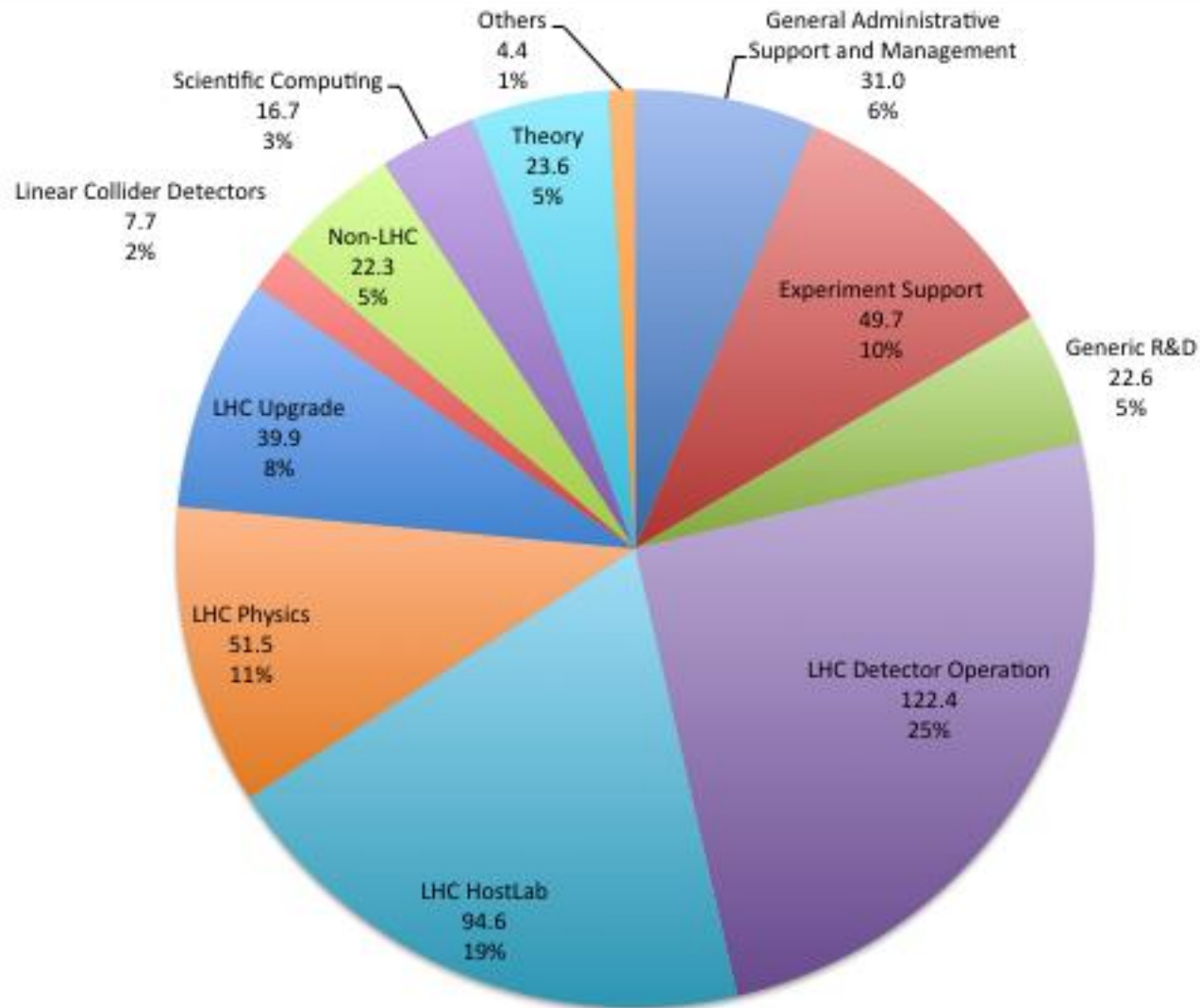


- LHC exp
- Non LHC
- Future exp
- TH
- Support
- DI



- LHC exp
- Non LHC
- Future exp
- TH
- Support
- DI

# Summary by activities (Staff)



In 2013, PH had  
a material budget of **43.1 MCHF**  
for operation and projects  
includes financial support to students and associates  
  
a personnel budget of **122.5 MCHF**  
for salaries of staff members and fellows  
includes administrative support of ~11000 users

***We have a big responsibility!***



# **Acknowledgments**

## **For the preparation of this presentation**

DH Deputies: Ignatios Antoniadis, Roger Forty

Planning Officers: Catherine Decosse, Cécile Granier

Group and Team Leaders: Joachim Baechler, Mar Capeans-Garrido,  
Wisla Carena, Michael Doser, Philippe Farthouat, John Harvey,  
Lucie Linssen, Giuseppe Mornacchi, Monica Pepe-Altarelli,  
Achille Petrilli, José Salicio-Diez

Organisers: Valérie Brunner, Gilles Gautheron, Philippe Moret, Kate Ross

## **For the definition, inspiration and support of our work**

Research Director: Sergio Bertolucci

**For the essence of this presentation  
the biggest thanks go to you  
the people of PH!**



# People of PH

Duccio Abbaneo Hossein Aghai Khozani Gianluca Aglieri Rinella Lucie Aguirre Giulio Aielli Eric Albert Juan Antonio Aldea Armenteros Martin Aleksa Federico Alessio Muhammad Alhroob Maf Alidra Niloufar Alipour Tehrani Mohsen Alishahiha Bruno Allongue Jerome Alexandre Aloyz Diego Alvarez Feito Luis Alvarez-Gaume Alexandre Manuel Alves Dos Santos Antonio Augusto Alves Junior Nansi Andari Gabriel Andrei Anastasio Andronici Francis Anghinolfi Alberto Anvari Vladimir Anosov Didier Anstett Federico Antinori Ignatios Antoniadis John Apostolakis Flavio Archilli Samir Arfaoui Stefano Argiro Aaron James Armbruster Andres Artamonov Paul Aspell Kristi Asvola Ivan Atansov Benjamin Jean Audren Sebastian Auerbach Etienneau Auffray Heliemann Andre Augustinus Gergo Auzinger Roberto Auzzi Valentina Avai Giuseppe Alovo Aleksandr Azatov Max Baak Michael Bachtis Moritz Backes Malte Backhaus Simon David Badger Joachim Baechler Olivia Bailey Austin Ball Rafael Ballabriga Sune Stephane Bally Fernando Baltasar Dos Santos Pedro Audrey Balzano Lalaine Barbon Strebler Martin Barisits David Barney Sophie Baran Laurence Barrin Manoel Barros Marin Colin Barschel Nicoletta Barzaghini Luca Barzile Steven Bass Joao Carlos Batista Lopes Laurent Baulieu Christophe Bault Tomasz Adrian Bawe Marie-Noelle Beaumont Thomas Beermann Marcia Begalli Bertrand Bellonot Francesca Bellini Olga Beltramello Faraah Ben Mimoun Bel Had Andrea Davide Benaglia Josh Bendavid Jerome Bendotti Lamia Benhabib Yan Benhammou Mathieu Benoit Philippe Benoit Felix Bergsma Colin Bernes Mirko Berretti Gaia Maria Berruti Didier Bertet Valerio Bertone Dario Berzano Maria Ilaria Besana Latchezar Betev Giuseppe Bevilacqua Wojciech Bialas Giovanni Bianchi Michele Bianco Karl Bicker Erwin Roland Bielert Michela Biglietti Alexander Bitadze Pascal Herve Blanc Georges Blanchot Monika Blanke Diego Blas Temino Philippe Bloch Jakob Blomer Vincent Bobiller Andrea Bocci Alain Bock Sandro Bonacini Nikolai Bondar Olivier Bondu Walter Bonivento Jean Bos Cristina Botta Gaëlle Boudoul Nicolas Bourgeois Philippe Bouvier Jamie Boyd Andre Braem Loic Brarda Roman Brenden Horst Breuker Bernard Bruner Valerie Brunner Stefania Bufalino Predrag Bunčić Helfried Burkhardt Piotr Rafal Burrows Jan Buytaert Pierluigi Campana Michael Campbell Daniel Hugo Campora Perez Tiziano Camporese Philippe Canal Bernard Cantin Marc Capeans Garrido Alessandro Caratelli Roberta Cardinale Franco Carena Wisla Carena Tancredi Carli Federico Carninatti Patrick Carrie Stefano Casasso Lucia Castillo Garcia Andrea Catinaccio Ariella Cattai Marco Cattaneo Thomas Caudron Costanza Cavicchioli Augusto Cecucci Damiano Celeste Davide Ceresa Gianluca Cerminara Matevz Cerv Bernard Chadaj Ioannis Chalkiadakis Sylvain Chapelain Mikhail Chaponchikov Ioannis Charalampidis Panagiotis Charitos Andrzej Charkiewicz Philippe Charpentier Nicholas Edward Charron Michel Chauvet Olivier Chaze Mohamed Chebbi Xinyi Chen Vasco Chibante Barroso Mauro Chiesa Peter Chochula Jorgen Christiansen Doris Chromek-Burkhardt Nikolaos Chrysochelos Dimitri Ciaglia Kamil Norbert Cichy Xabier Cid Vidal Vitaliano Cifulli Philip Clark Marco Clemencic Frank Cliff Julia Rose Kahn Cline Joel Closier Victor Coco Stefano Colafranceschi Paula Collins Tommaso Colombo Antonio Conde Garcia Michelle Connor Didier Claude Nektardo Cristian Contescu Andrea Contu Francesco Conventi Bernard Corajod Gloria Corti Gabriele Cosmo Filippo Costa Didier Gerard Cotte Olivier Couet Ben Couturier Bianca-Cristina Cristescu Andreas Crivellin Leticia Cunqueiro Mendez Benoit Cure Mariorasaria D'Alfonso Camelo D'Ambrosio Andrea D'Auria Antonio Da Cruz Baptista Dias Anne Dabrowski Mieczyslaw Maria Dabrowski Jerome Daguin Hans Danielsson Dominik Dannheim Vincenzo Daponte Shirin Davarpanah Martin Davenport Claude David Joel Murray Davies Joao De Almeida Simoes Johannes Christof De Fine Licht Massimiliano De Gaspari Federico De Gulo Christophe De La Taille Louis-Philippe De Menezes Rui De Oliveira Francisco Rui De Oliveira Albert De Roeck Simon De Visscher Catherine Decosse Gerard Degrande Jordan Degrande Audrey Deidda Mario Deile Christian Deldicke Andrea Dell'Acqua Jennifer Annabel Dembski Laurent Deront Martine Desnyder-Ivesdal Stephane Detraz Karola Dette Dominique Deyraill Evelynne Dho Angelo Di Santo Beniamino Di Girolamo Salvatore Di Guida Antonello Di Mauro Nicola Di Vira Sandro Di Vincenzo Hans Dijkstra Gancho Dimitrov Biliana Stephanova Dimitrova Savas Dimopoulos Fido Dittus Roberto Divia Neil Dixon Daniel Dobos Marc Dobson Katayoun Doroud Silverio Dos Santos Michael Doser Andrea Dotti Frederic Alexandre Dreyer James Drummond Serge Duarte Pinto Fernando Duarte Ramos Lada Duceckova Alexey Dudarev Michael Dührssen-Debling Raphael Dumps Gaëlle Dupierrier Myerica Amund Dupout Niels Dupont Claudia Dupraz Guy Duthion Piotr Dziurdzia Sebastian Ehrhart Ingrid Andersen Eidsvaag Lars Eklund Sverre Nabil El Showk Anna Elliott-Peiser Jonathan R. 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***To conclude***

**The CERN Physics Department  
is your department**

***Its success is in your hands!***

**I wish you all a nice and satisfactory 2014**