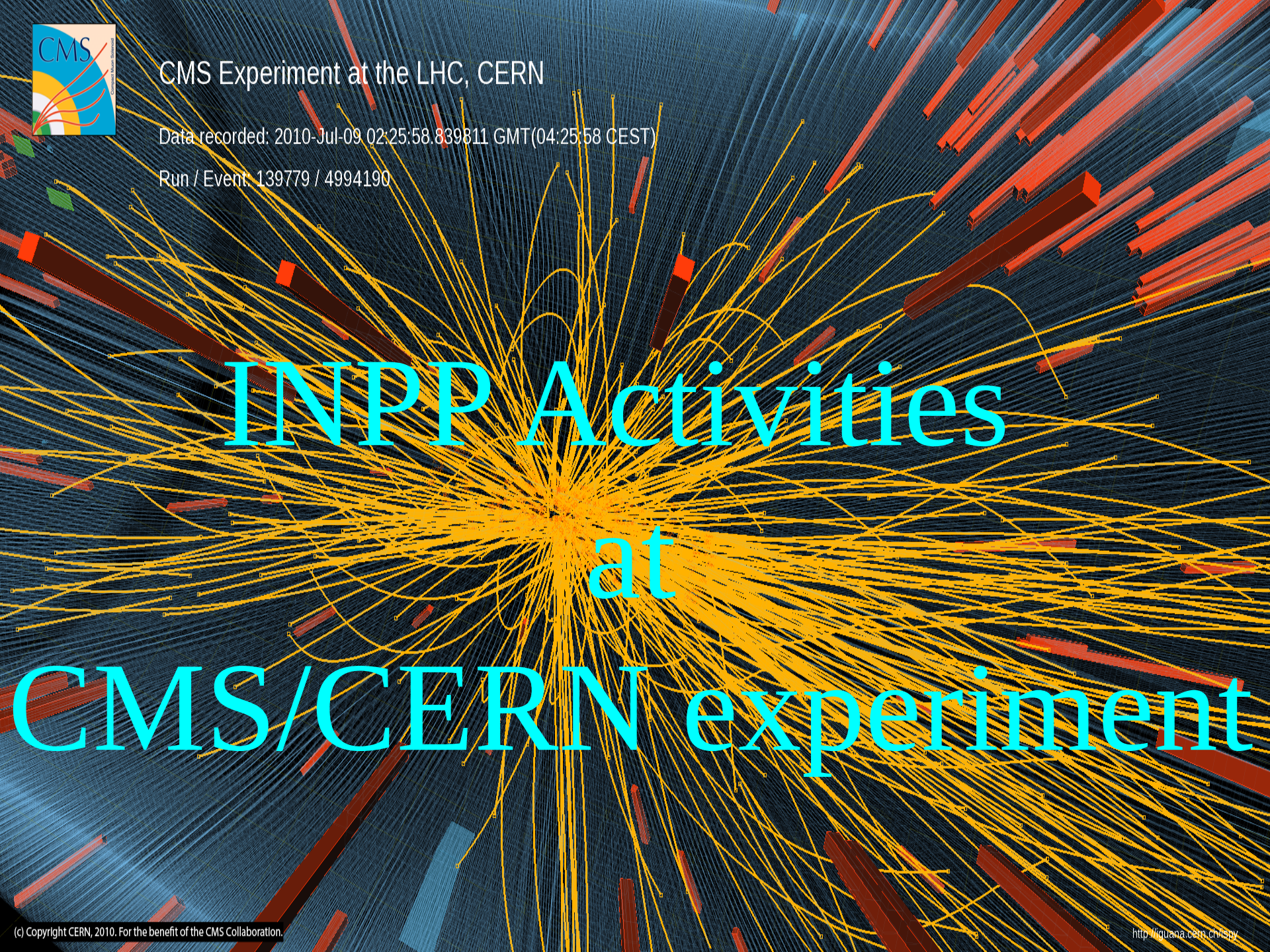


INPP Activities at CMS/CERN experiment

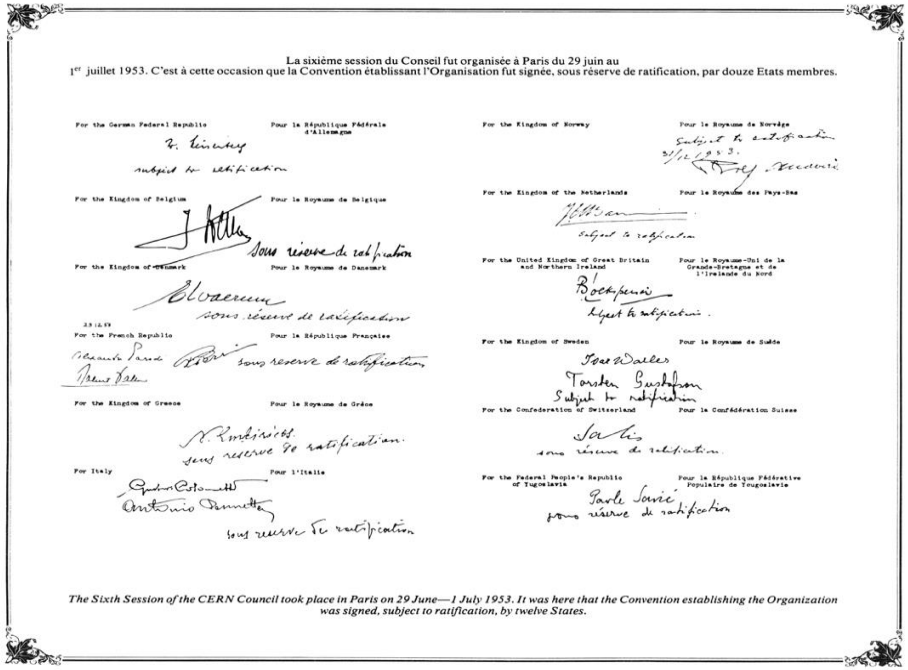
CERN

Founded in 1954 by 12 European countries

Today:

2400 Staff
584 Fellows and Associates
199 Students
9534 Users (~ 100 nationalities)

Budget (2009) 1177 MCHF



La sixième session du Conseil fut organisée à Paris du 29 juin au 1er juillet 1953. C'est à cette occasion que la Convention établissant l'Organisation fut signée, sous réserve de ratification, par douze Etats membres.

The Sixth Session of the CERN Council took place in Paris on 29 June—1 July 1953. It was here that the Convention establishing the Organization was signed, subject to ratification, by twelve States.

1954: Convention establishing the organization - original signatures

The 20 member states

Some history for HEP at NCSR "D"

1962 : E.Simopoulou . Built prototype **Spark Chamber.**

1964 : Tom Ypsilantis, Rigas Rigopoulos (CERN) and A. Filippas are invited by **Themis Kanellopoulos** (Director of Demokritos – employed by CERN previously) who is willing to create a HEP team.

1965 : Tom Ypsilantis. **The team is funded with a significant budget**
Participation in **Bubble Chamber** experiment at CERN
Equipment: First Computer (1966), 1 Enetra machine, scanning tables

1963 – 1979: Anna Vayaki neutrino physics (BEBC, BNL)

1980 : Manolis Dris initiates **instrumentation** (electronics + detectors)

1985 – 87 : CPLEAR experiment – Work on Trigger system

1980 LEP: **ALEPH and DELPHI** experiments

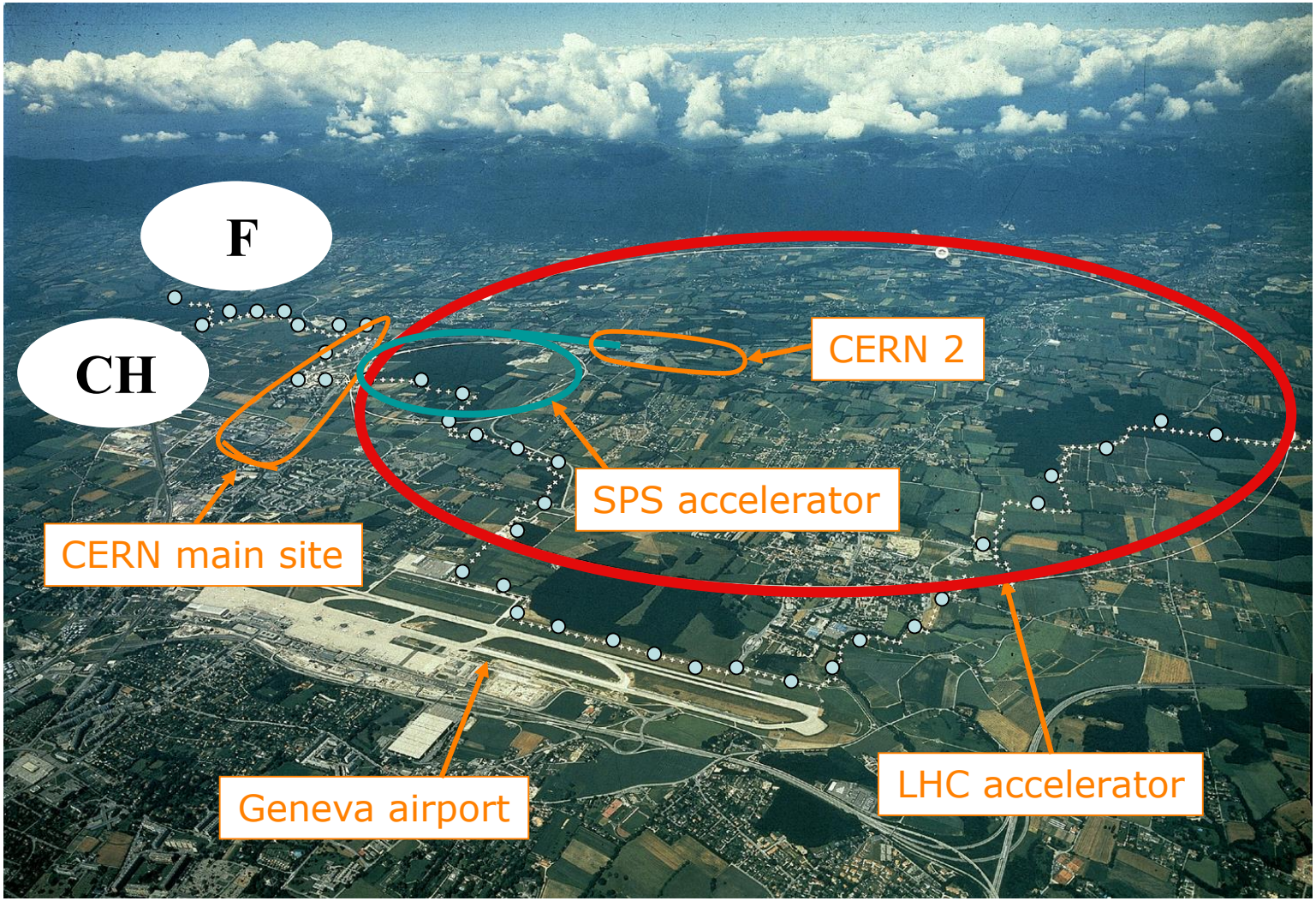
1984 - 89 : Participation in the construction of the **ALEPH TPC**.

1984 – 1993 DELPHI: Ring Imaging CHerenkov (RICH) (T. Ypsilantis),
Barel RICH Drift Field frames
RICH Calibration system, Forward RICH.

… **2002 :** Data analysis with **ALEPH** and **DELPHI** at **LEP I** and **LEP II**

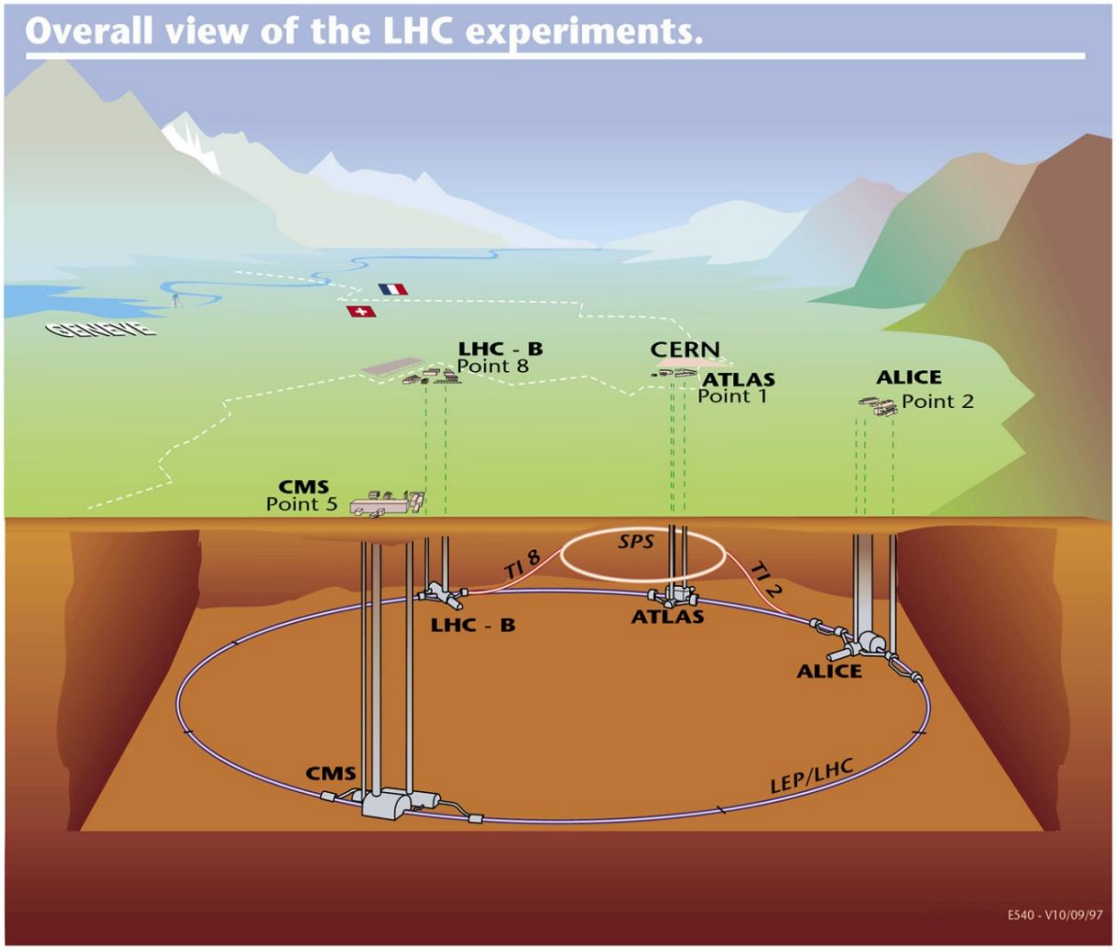
1995 .. : Work within the CMS collaboration at the LHC (Silicon detectors, Trigger and DAQ, Physics Analysis)

Large Hadron Collider



LHC Experiments

With colliding protons, we use $E = Mc^2$ to convert Energy into Matter to explore
New Forces and New building blocks of matter.



The Nobel Prize in Physics 2013

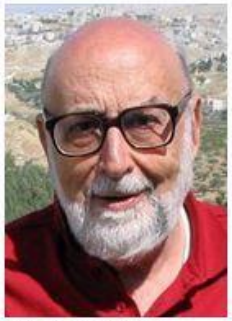


Photo: Pnicolet via Wikimedia Commons
François Englert

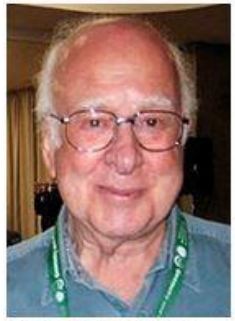
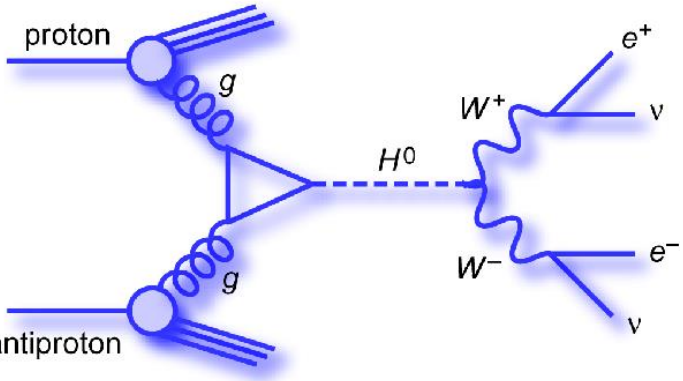
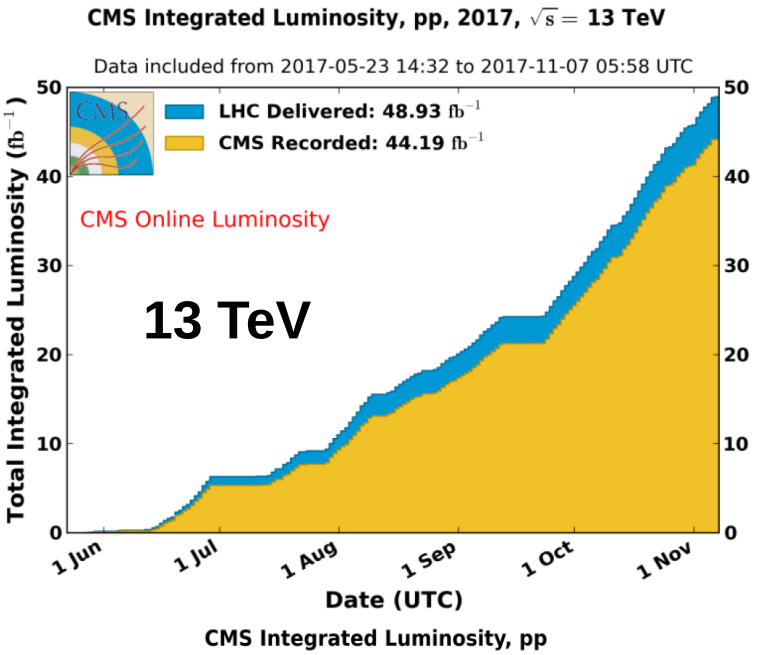


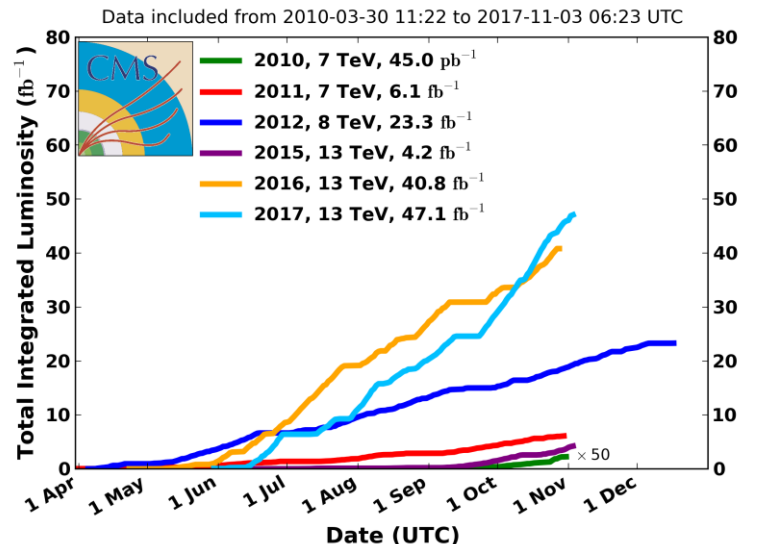
Photo: G-M Greuel via Wikimedia Commons
Peter W. Higgs



CMS Experiment



1700 physicists,
700 students,
950 engineers/technicians,
180 institutions from 43 countries



~ 700 papers in various physics topics.

INPP @ CMS

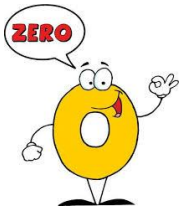
NCSR 'Demokritos', Institute of Nuclear & Particle Physics

Staff

G. Anagnostou,
G. Daskalakis,
A. Kyriakis,
D. Loukas*

* Institution Representative

Postdocs



Ph.D. Students

P. Asenov (ΕΛΙΔΕΚ),
P. Assiouras,
G. Paspalaki

Engineers

I. Kazas (on contract)

ACTIVITIES during the life cycle of the CMS EXPERIMENT

CONSTRUCTION & OPERATION

- **Pre-shower detector**
- **Trigger/DAQ**
- **Test-Beams & Service work**
- **New analysis techniques/algorithms**
- **Physics Measurements**
- **CMS Upgrade for Phase-II**

PHYSICS MEASUREMENTS

INPP-CMS group have made <u>significant contributions</u> in several areas:

Standard Model (SM), TOP, Higgs, Searches beyond SM, Supersymmetry

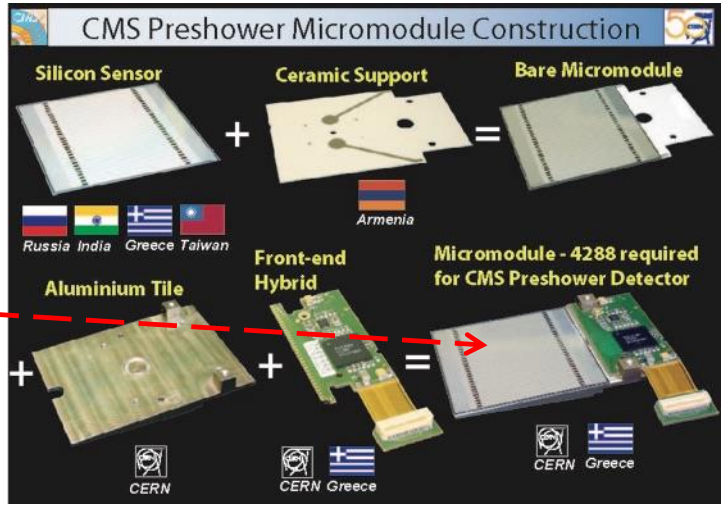
Preshower Detector

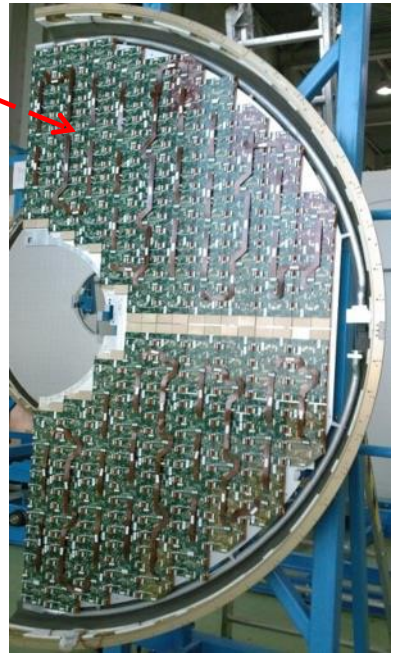
- ***The CMS Preshower Detector***

- ***14 years of development & construction***
- ***4288 micromodules in 8 Dees***
- ***600 micromodules made by I.N.P.P.***
- **Close collaboration with Greek Industry**

4500 hybrids assembled by PRISMA

Greek Contribution: ~ 1.3 Meuro
Industry Return: ~ 300 k euro





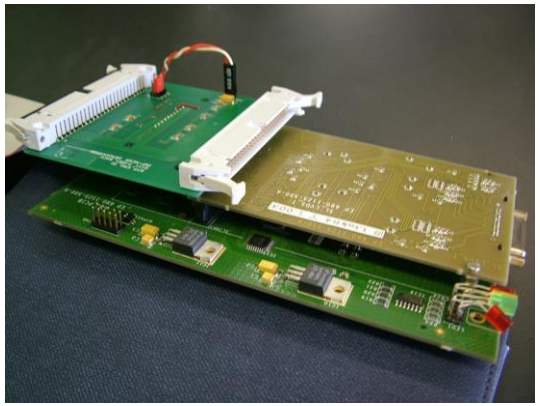
The CMS Trigger and DAQ

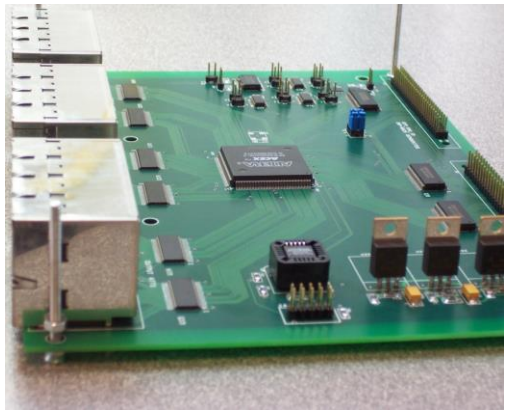
CMS Trigger and Data Acquisition System:

LHC collisions at 40MHz, Level1 Trigger at 100kHz High Level Trigger at 100 Hz

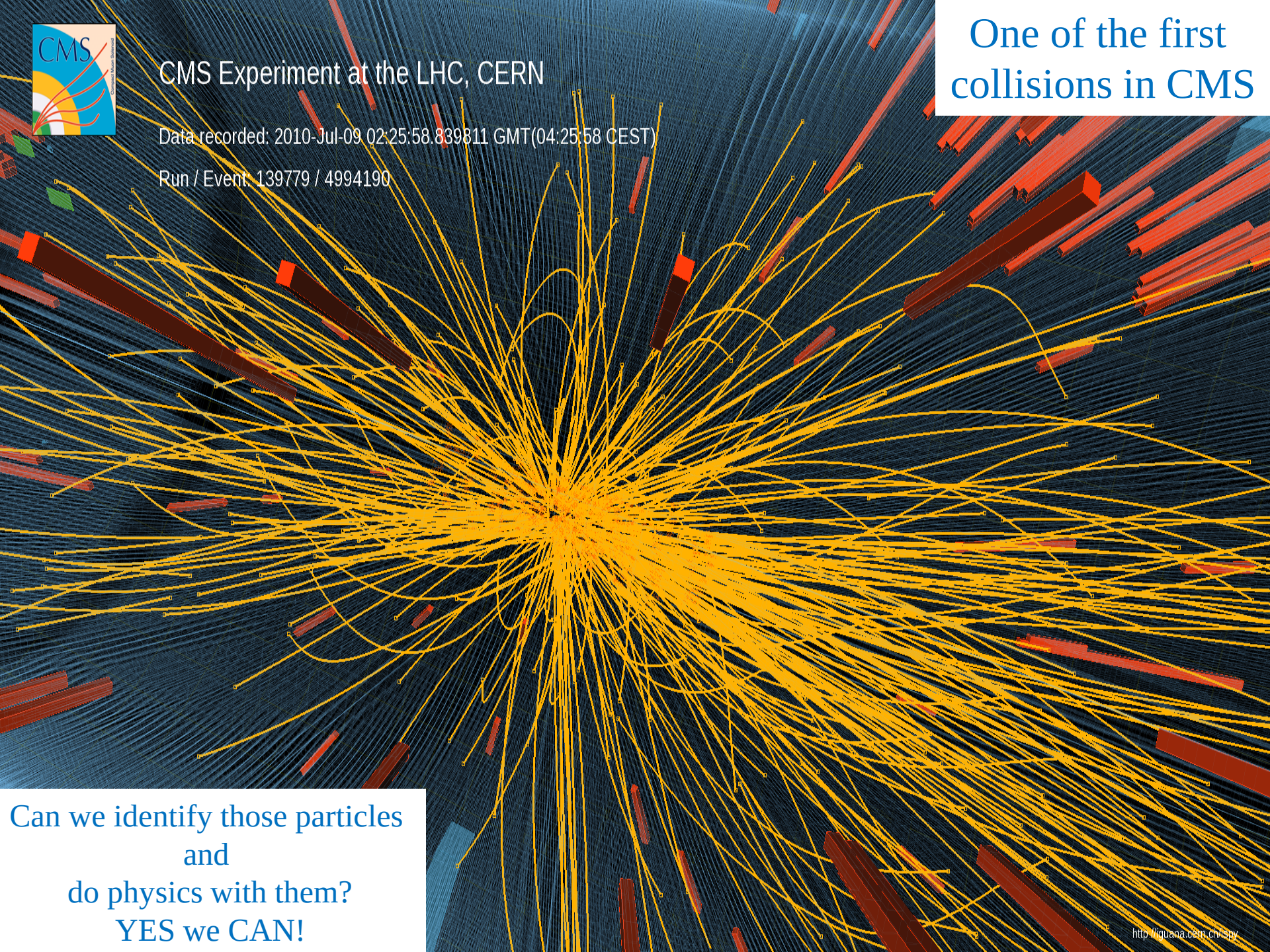
1) **Read Out Units (Rus)**
   Constructed and tested in collaboration with Greek Industry, 22 RU units (IOPs) Validated the feasibility of the Trigger and DAQ System

2) Global Trigger Processor Emulator – GTPe: 10 Full systems delivered to CMS. Designed, Built, mounted and tested at INPP. FPGA 400kGates (Mixed firmware VHDL and Handel-C) developed at INPP





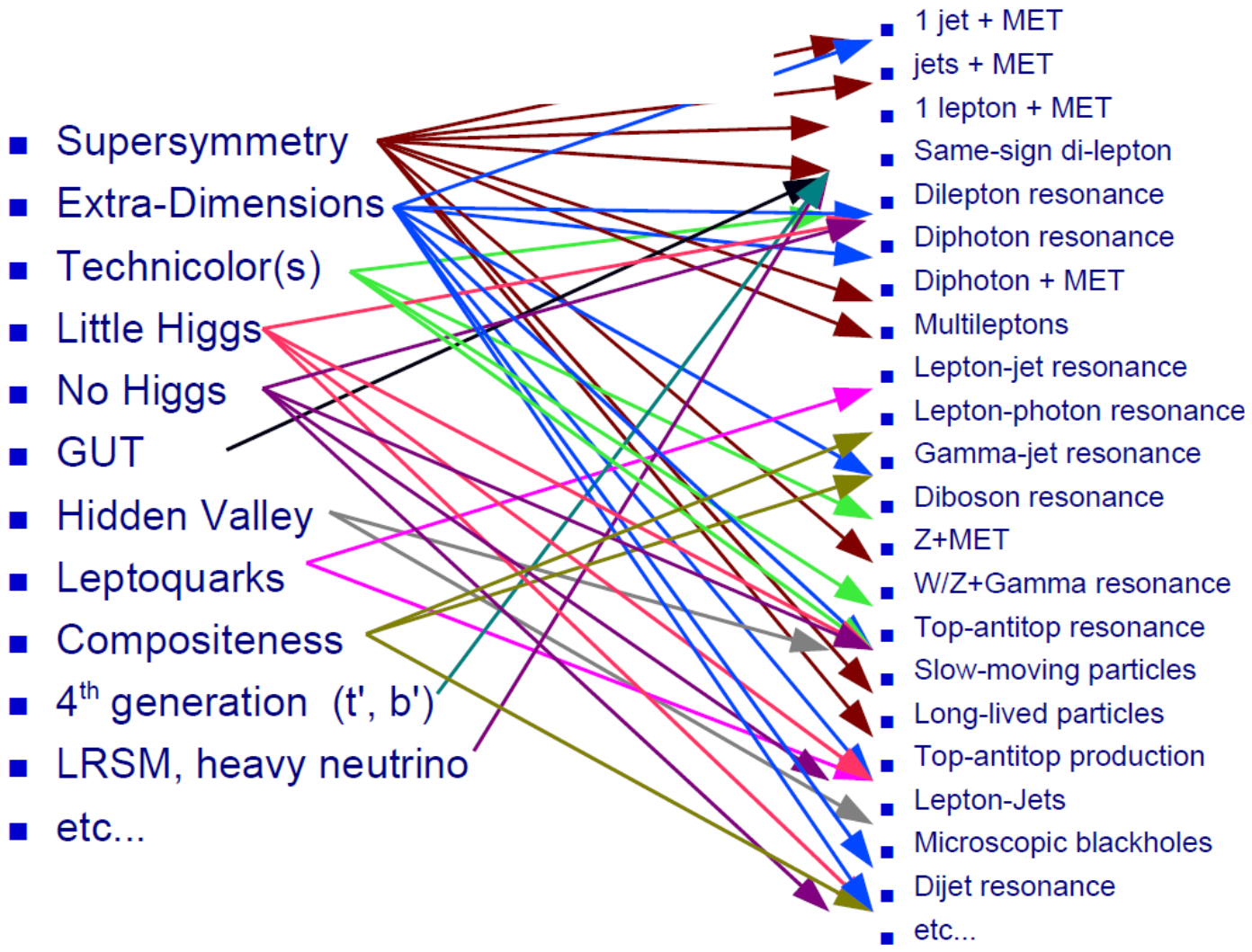
"The Global Trigger Processor Emulator for the CMS experiment"
has been published in
IEEE Trans.Nucl.Sci.52:1679-1684,2005



One of the first collisions in CMS

Can we identify those particles
and
do physics with them?
YES we CAN!

MODELs vs Final States

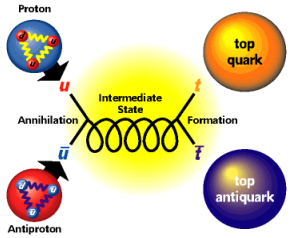


PHYSICS @ CMS

The CMS Group of Demokritos has made marked contributions in the preparation of the experiment **before data taking** as well as in Physics measurements with the **collected data** at 7, 8 & 13 TeV.

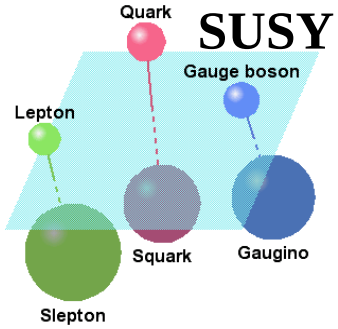
The **new data** collected at **13** TeV might open a window to **new physics**.

Standard Model

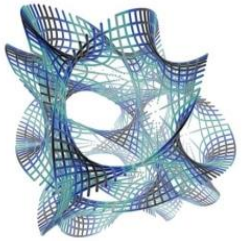


Dark Matter

SUSY



Extra Dimensions



Over 700 physics publications in peer reviewed journals

*It would be extremely helpful if we could receive some support concerning **personnel** (postdocs/students) as well as **travel budget**.*

Recent ('16-'18) Analysis Work @ CMS

CMS AN-2018/021 -- Search for high-mass resonances in the di-electron final state with 2017 data
Authors: B. Clerbaux, D. Cockerill, G. Daskalakis, Sh. Elgammal, W. Fang, X. Gao, R. Goldouzian, S. Harper, A.K. Kalsi, Ph. Mine, E. Olaiya, D. Petyt, J.-F. Schulte, C. Shepherd-Themistocleous
Working Group: EXO

CMS AN-2017/343 -- Search in two-dimensional mass space for T'T' to W'b W' b in the dilepton final state in proton-proton collisions at 13 TeV
Authors: Georgios Anagnostou, Georgios Daskalakis
Working Group: B2G

CMS AN-2017/131 -- Search for general gauge-mediated supersymmetry in final states with two photons and missing transverse momentum
Authors: A. Askew, A. Reinsvold Hall, M. Hildreth, A. Kyriakis, T. McCauley, G. Paspalaki
Working Group: SUS

CMS AN-2017/346 -- Performance of Flavour Tagging Algorithms at 13 TeV with 2017 data
Authors: Pierguilio Lenzi, Christopher A. Palmer, Joshuha Thomas-Wilsker, Oliver Rieger, Andrzej Novak, Anthony Lefeld, Joseph L. Dulemba, Sergio Sanchez Navas, Garyfallia Paspalaki, et.al.
Working Group: BTAG

CMS AN-2016/404 -- Search for high mass di-electron resonances with the full 2016 data
Authors: B. Clerbaux, D. Cockerill, G. Daskalakis, Sh. Elgammal, G. Fasanella, W. Fang, X. Gao, R. Goldouzian, S. Harper, Ph. Mine, E. Olaiya, D. Petyt, A. Randle-Conde, C. Shepherd-Themistocleous
Working Group: EXO

CMS CR-2016/235 -- Top Physics (CMS)
Authors: Georgios Daskalakis for the CMS Collaboration
Categories: PHYSICS

CMS AN-2016/190 -- Search for High Mass Di-Electron Resonances with 2016 Data
Authors: B. Clerbaux, D. Cockerill, G. Daskalakis, Sh. Elgammal, G. Fasanella, W. Fang, X. Gao, R. Goldouzian, S. Harper, Ph. Mine, E. Olaiya, D. Petyt, A. Randle-Conde, C. Shepherd-Themistocleous
Working Group: EXO

CMS AN-2016/138 -- Combination of the 8 TeV and 13 TeV Z' to Dilepton Limits
Authors: G. Abbiendi, G. Bagliesi, D. Bourilkov, R. Castello, J.E. Chaves, S.S. Chhibra, B. Clerbaux, D. Cockerill, A. Colaleo, R. Cousins, G. Daskalakis, N. De Filippis, Sh. Elgammal, A. Escalante del Valle, G. Fasanella, W. Fang, A. Florent, V. Giakoumopoulou, R. Goldouzian, S. Harper, et. al.
Working Group: EXO

CMS AN-2016/053 -- PDF Uncertainties for Z' searches at 13 TeV with Electron Pair or Muon Pair Final States
Authors: D. Bourilkov and G. Daskalakis
Working Group: EXO

Contributions & Obligations @ CMS

Physics Analysis (Paper production)

… *Convener of Physics groups (several Institutions)*
… *Editor of physics papers*
… *Leader of new Analysis efforts*
… *Reviewer of CMS papers before submitted to journals (Analysis Review Committees)*

Development of Novel analysis techniques

…to enhance the discovery potential of LHC experiments

Physics Tools development

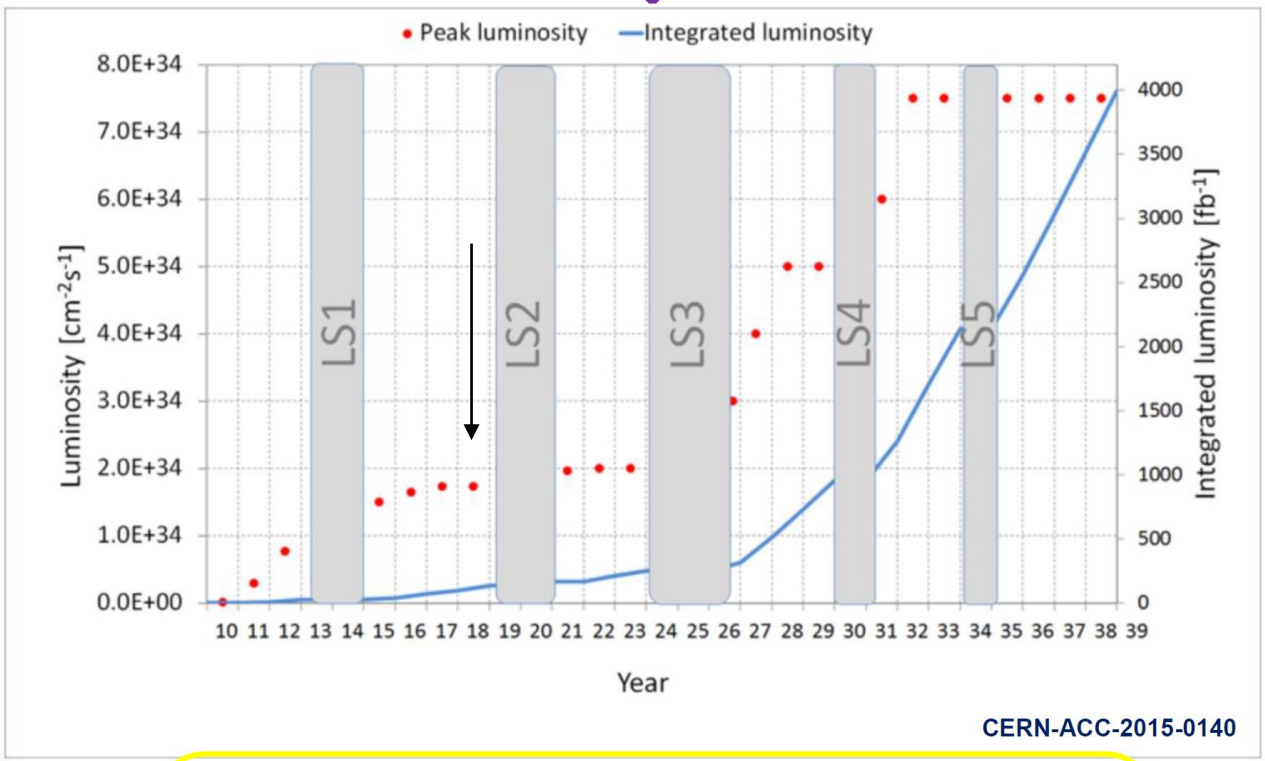
…to be used by the whole collaboration

ADDITIONAL work/roles:

- Shifts for CMS operation during data taking
- Beam tests: Shifts / Analysis
- Institutional Review of CMS papers before submission

The next decades : HL-LHC

Forecast for LHC and HL-LHC Operation



The goal for HI-LHC:

- ***Peak Luminosity : 5.0 (7.5) x 10^{34} cm^{-2} s^{-1}***
- ***Integrated Luminosity over 10 years: 3000 fb^{-1}***
- ***PU: 150-200***

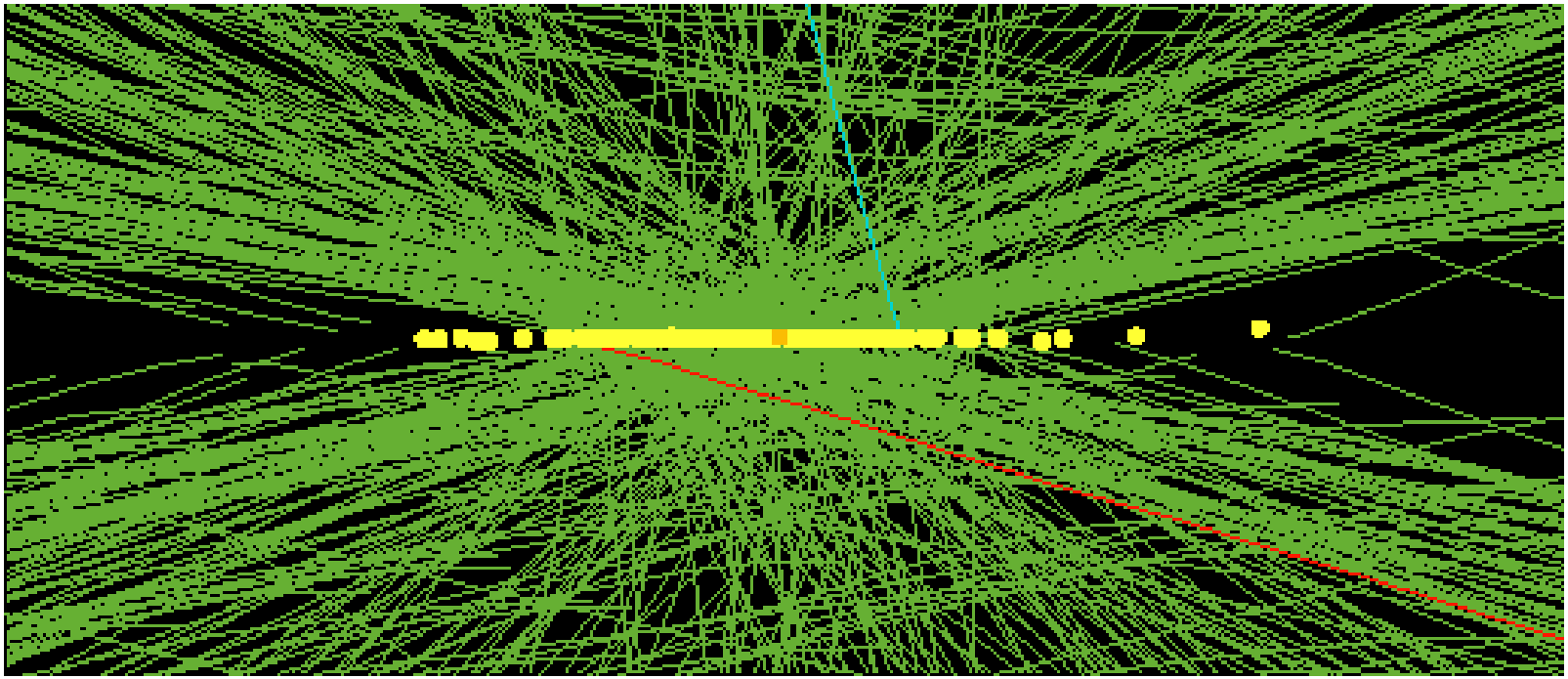
Challenges @ CMS

Mean number of pile ups in 2016 (*L=1.5x10^{34} cm^{-2} s^{-1}*) : 53

Mean number of pile ups in HI-LHC (*L=5x10^{34} cm^{-2} s^{-1}*) : 140

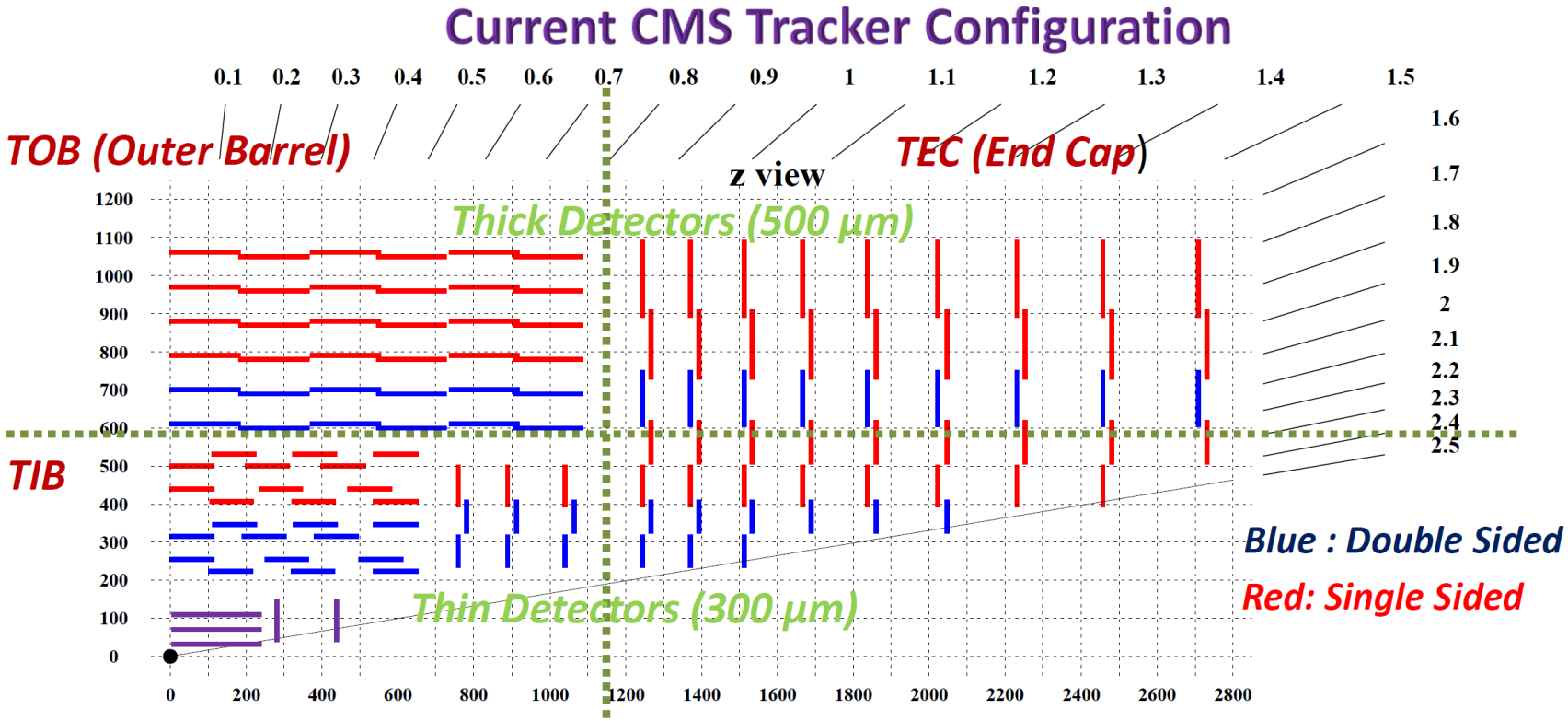
Mean number of pile ups in HI-LHC (*L=7x10^{34} cm^{-2} s^{-1}*) : 200

non ”hard” pp collisions, early & late OOT pile ups, extra energy to calorimeters …



High pile up event with 78 reconstructed vertices

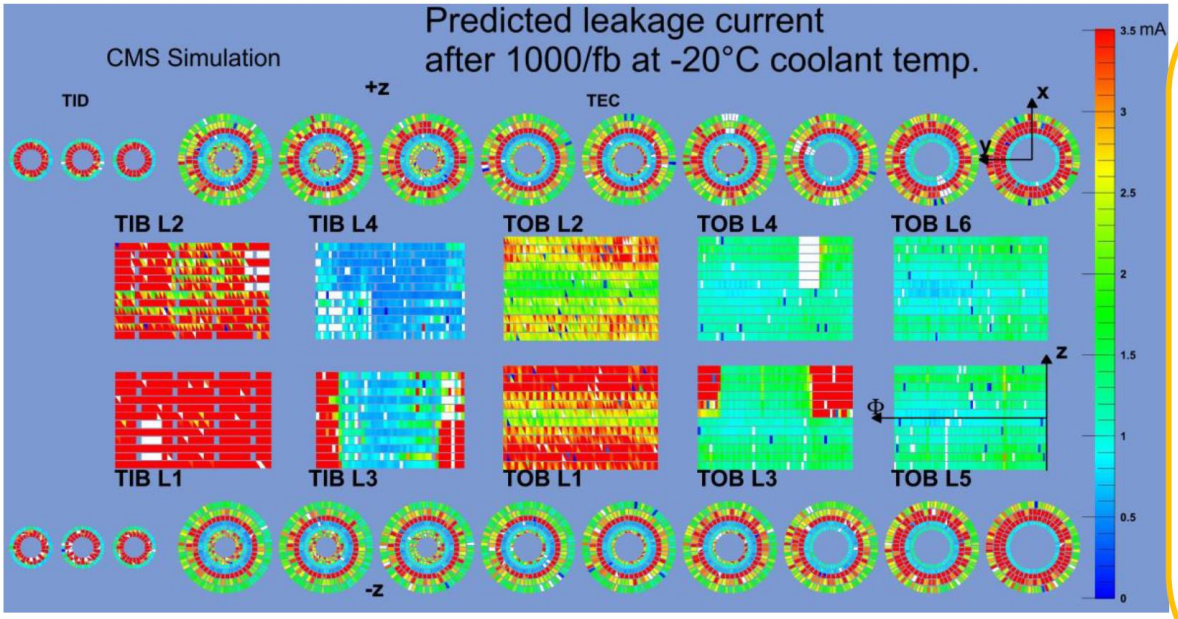
Tracker @ CMS

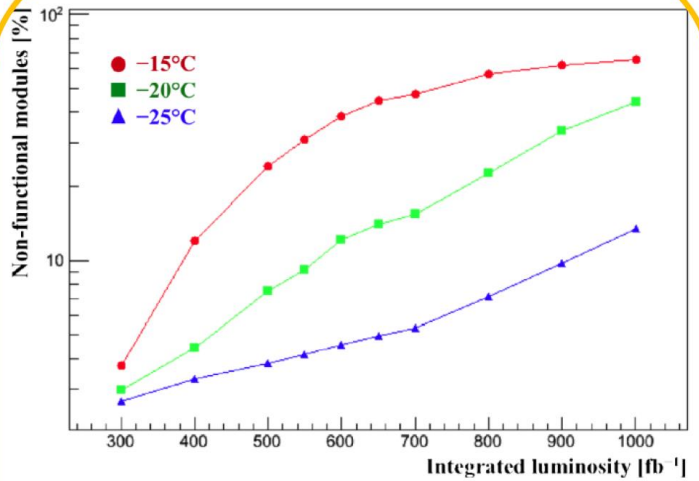


Sensor Technology : p-in-n
Design occupancy : 1-2%
Outer cell size : ~20cm x 100-200μm
Inner cell side : ~10 cm x 80 cm
Pixel cell size: 100 μm² x 150 μm²

Operation : -15C
Signal / noise: ~20 (above 10 after radiation)
Radiation tolerance: ~1.5 x 10^{14}

The problem…

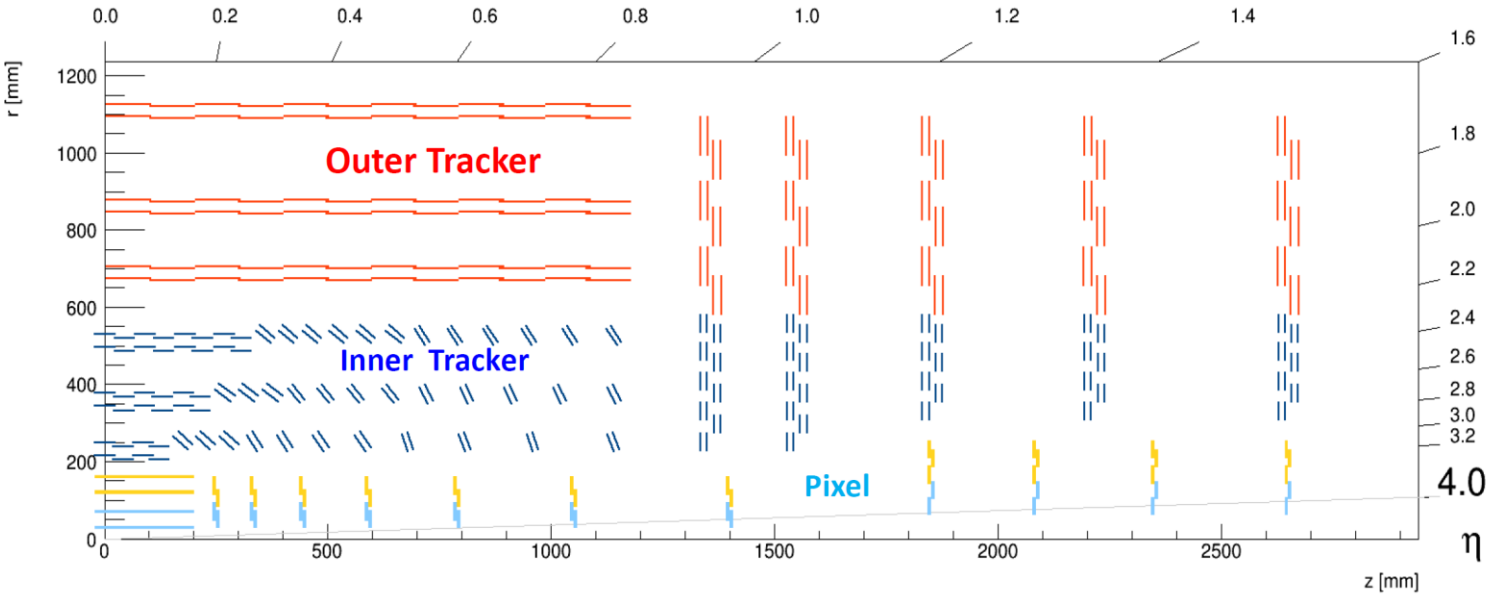




Expected fraction of non-functional modules in the Outer Tracker as a function of integrated luminosity

Total Tracker Replacement

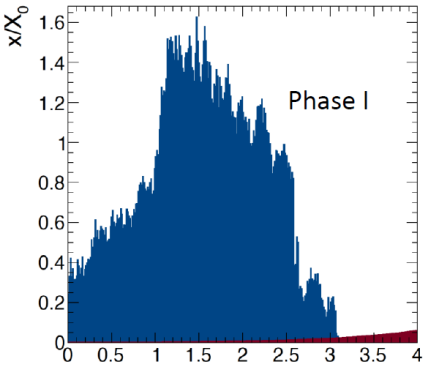
… and its solution

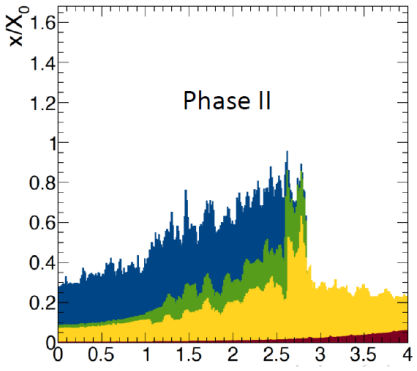


Red: Strip-Strip (2S) modules, *Blue: Pixel-Strip (PS) modules,* *Blue light : pixel,* *orange : pixel*

200 µm thick sensors

Outer Tracker based on 2 type modules only





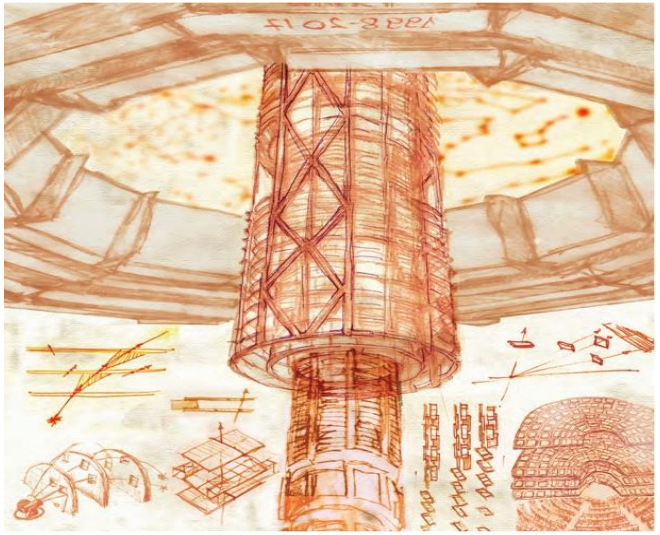
2S strip-strip double-layers
~8400 modules
~34M channels
~155m^2

PS strip-strixel double-layers
~7000 modules
~230M channels
~62m^2

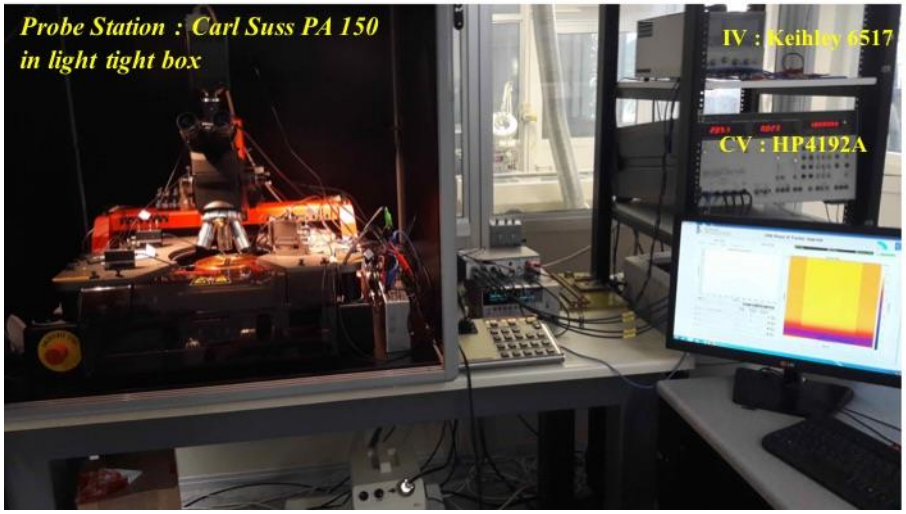
Greek Committments @ CMS

The Phase II CMS Tracker Upgrade :

- ***10 years of R&D***
- ***Over 100 MCHF core cost***
- ***1.4 MCHF foreseen Greek contribution***

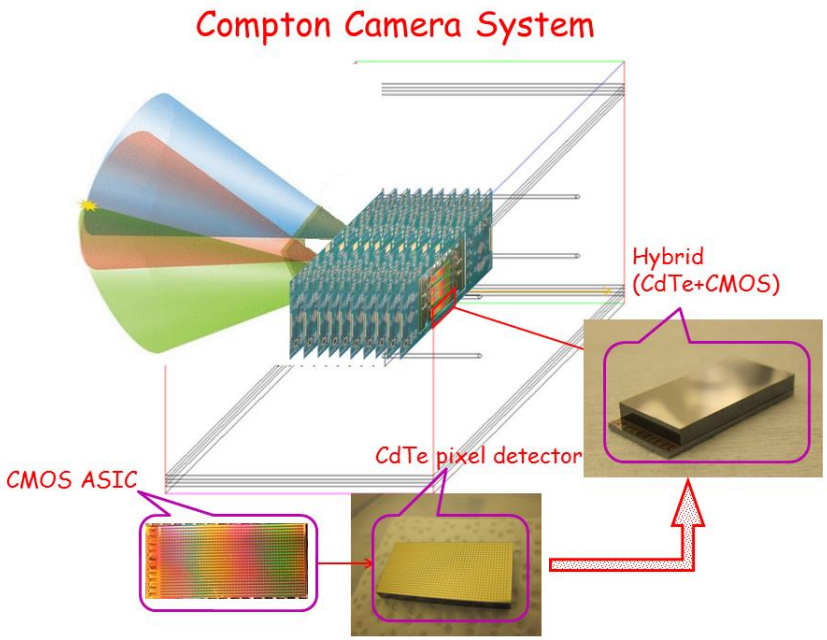


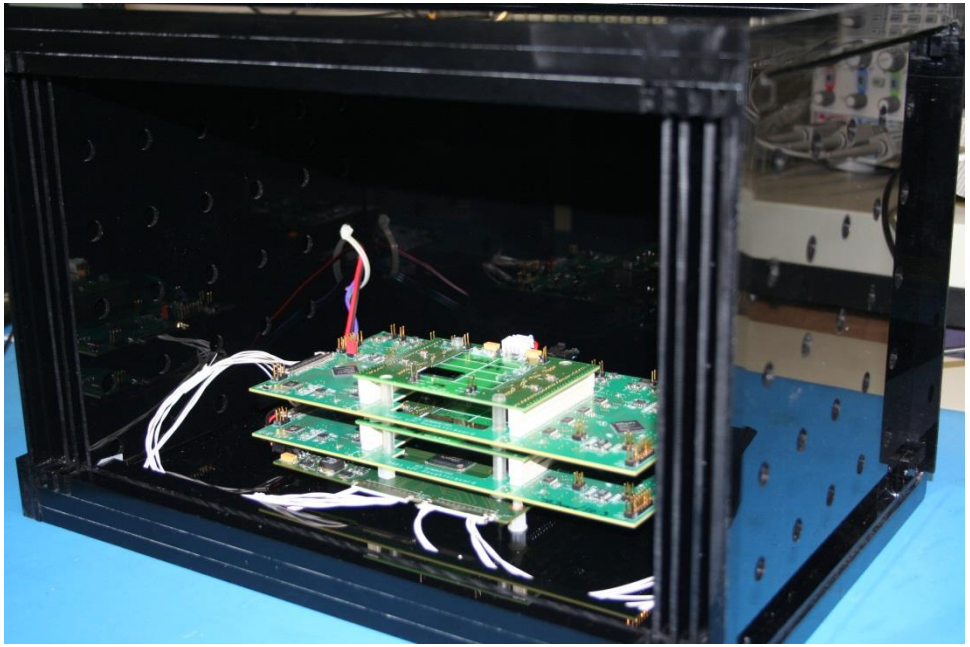
- ***Greek activities focused on***
  - ***Sensor Quality Control***
  - ***Process Quality Control***



Spin-off Activities

P4DI : Photon 4-dimensional Digital Information
hybrid of the COCAE Compton Camera





D. Hatzistratis, G. Theodoratos, I. Kazas, E. Zervakis, D. Loukas, S. Vlassis, and C.P. Lambropoulos

Spin-off Companies

- ***Athena Semiconductors***
- ***ADVEOS***
- ***European Sensor Systems***

CMS INPP Funding 2005-2015

We list below the funded programs that support the INPP/CMS group activities:

1) Aristeia 2002 – 2006 (Competitiveness Call).
   Post Docs and Technicians = 59.7 k€, Mobility 36.5 k€,
   Total for INPP/CMS in 2005 – 2006 = **96 k€**
2) "Participation of th Greek Research and Technology Institutes in International Organizations", 2003 – 2006, Total for INPP/CMS (2005 – 2006) = **73 k€**
3) "Aristeia 2006 – 2008",
   Post Docs + Technicians + Equipment = 140 k€, Mobility = 25 k€,
   Total for INPP/CMS (2006 – 2008) = **165 k€**
4) Matching funds Total for INPP/CMS (2005 – 2012) = **124 k€**
5) "THALIS" (GENESIS @LHC) (2012 – 2015): Total 600 k€,
   Total for INPP/CMS (2012 – 2015) = **140 k€**
6) "THALIS"(DIBOSON) (2012 – 2015): Total 600 k€,
   Total for INPP/CMS (2012 – 2015) = **100 k€**
7) "KRHPIS" ("ΟΡΑΣΥ" E-1784) (2013 – 2015): Total 1,400 k€, for HEP activities
   total 670 k€ of which Total for INPP/CMS (2012 – 2015) analysis = **180 k€**
   Part of the activity of the DIL lab = 229k€, → **100k€**
   Part of the activity of the ELEA lab = 262k€ → **50k€**
8) TECHNOLOGY/THEPIS/0609(BE)/18 Total for INPP/CMS (2012 – 2015) = **26 k€**

TOTAL = 1,054 k€

CMS INPP Immediate Needs

We urgently need: **POSTDOCs** **&** **Support for our Ph.D. Students**

last ones from ΚΡΗΠΙΣ-Ι
(end 2015)

Travel Money for CMS Shifts + Presentations + Conferences + Maintenance

We need ~ 50.000 euros per Year.

3-4 major CMS Meetings + 7-6 weeks for CMS Shifts

(CMS is asking for 12 weeks per author)

5 persons × 10 weeks × 1000 euro = 50.000 euros

Support for the CMS Upgrades

OUTCOME:

- **Publications**
- **PhDs/MS Thesis (Education)**
- **INPP/Demokritos Visibility**
- **Technology transfer & Spin-offs**
- **Outreach**

CMS INPP long-term needs

To make important contributions in the long-term and to meet the operational needs of the experiment, an instrumentation upgrade of our local infrastructure of ~700 000 euros would be necessary in the next few years.

- Refurbishment of 40 m^2 as ISO7 (class 10,000) clean room

  Storage (RH <30% & T = 20 °C ± 5 °C)

  Measurements (RH <10% & T =20 °C ± 2 °C)

- New semiconductor Characterization System

  Keithley 4200-SCS or KEYSIGHT B1500

- New semiconductor Switch Matrix

  Keithley 707B (up to six 8x12 matrix cards)

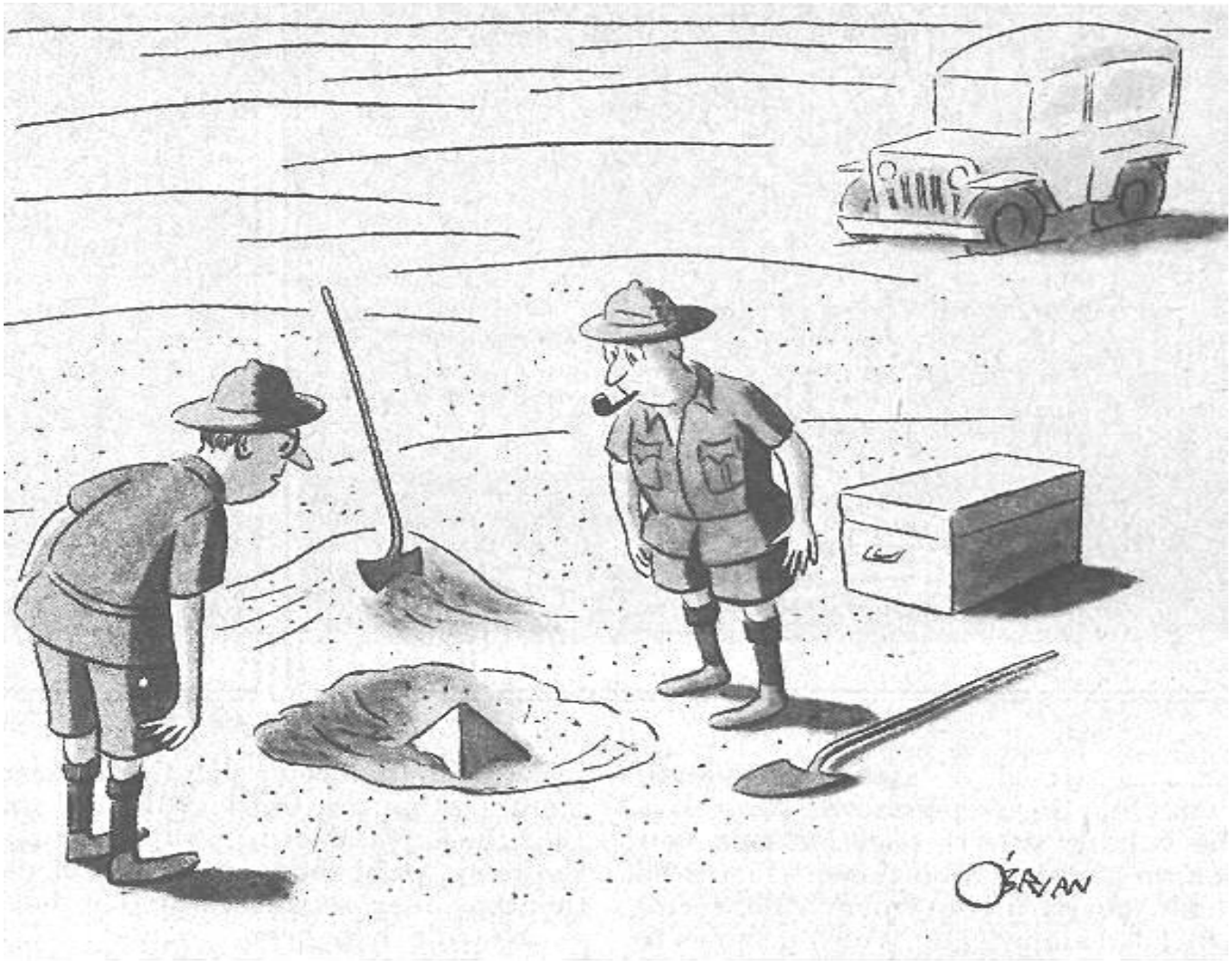
- New semiconductor wire bonding machine

  F&K Model G5 64000 (compatibility with CERN)

- New Probe station

  included in a proposal submitted to the last call from ELIDEK

CMS INPP Future



"This could be the discovery of the century. Depending, of course, on how far down it goes."