

High Energy Physics in Belgium

A visualization of a particle detector, likely a calorimeter or tracking chamber, showing a central point of interaction with numerous tracks radiating outwards. The tracks are represented by thin lines, some solid and some dashed, against a dark background with a grid of points. The overall shape is roughly cylindrical or conical.

L. Favart

IIHE-Université Libre de Bruxelles
Research Director - F.R.S.-FNRS

ULB

**ESS Science Seminar in Belgium
Brussels 14th Sept 2017**

Content

- **The HEP community in Belgium**
- **Research activities**
 - **at Colliders**
 - **in neutrino Physics**
 - **in astroparticle**

HEP community

Universities

Flemish Community

with Part. Phys.

- **VUB:** Vrije Universiteit Brussel
- **KUL:** Katholieke Universiteit Leuven
- **UGent:** Universiteit Gent
- **UA:** Universiteit Antwerpen

no Part. Phys.

- Universiteit Hasselt

French Community

with Part. Phys.

- **ULB:** Université Libre de Bruxelles
- **UCL:** Université catholique de Louvain
- **ULg:** Université de Liège
- **UMons:** Université de Mons

no Part. Phys

- Université de Namur
- Université Saint-Louis Bruxelles

all large Universities train Phd in Particle Physics
exp. and/or theory

University Groups

Experimental

Theory

HEP

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Nuclear

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* UMons now closing experimental Part. Phys. dept.

University Groups

Experimental

Theory

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IIHE

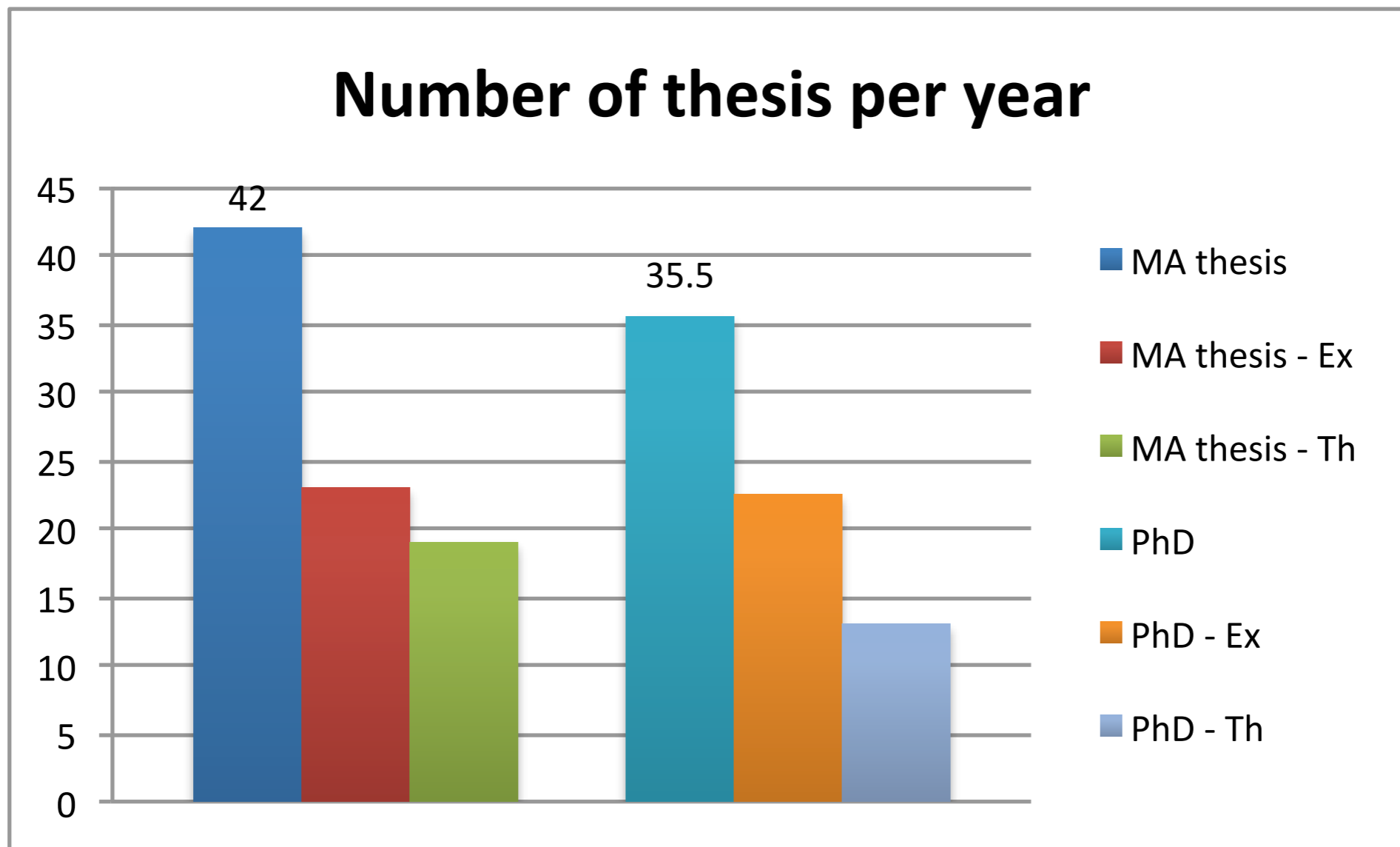
CP3

Nuclear

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University Groups



→ 3.2 PhD/y/Mhab

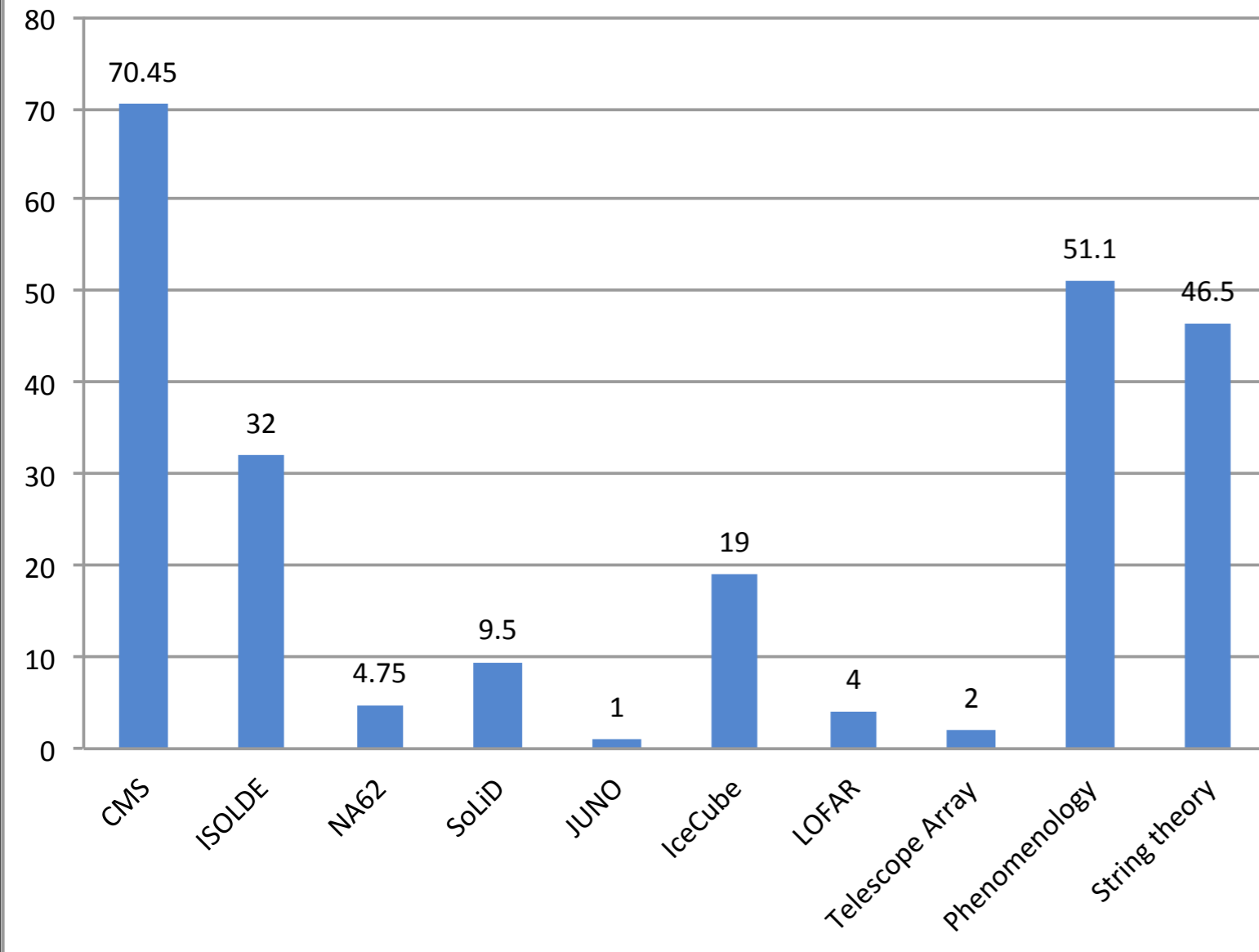
Manpower : physicists

permanents + postdocs + PhD

1/3 theory
2/3 experim.

pheno: DM, Higgs, SUSY,
neutrinos, QCD, cosmo,
astropart,...

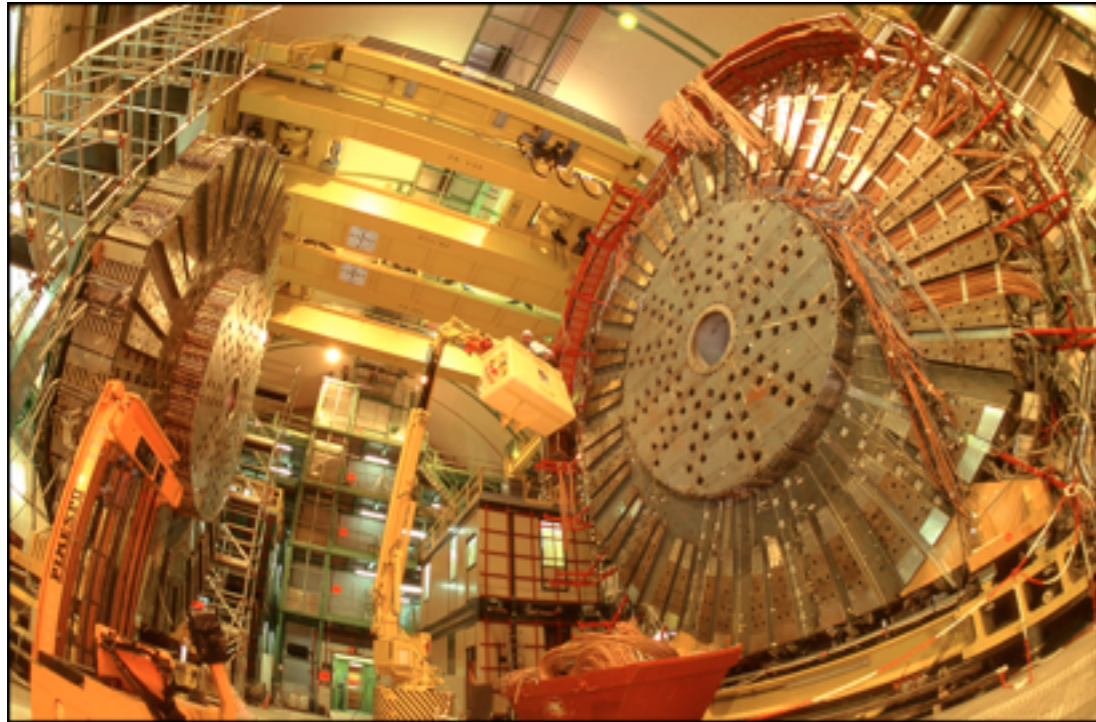
BE manpower - 277 FTE in total



HEP research at Colliders

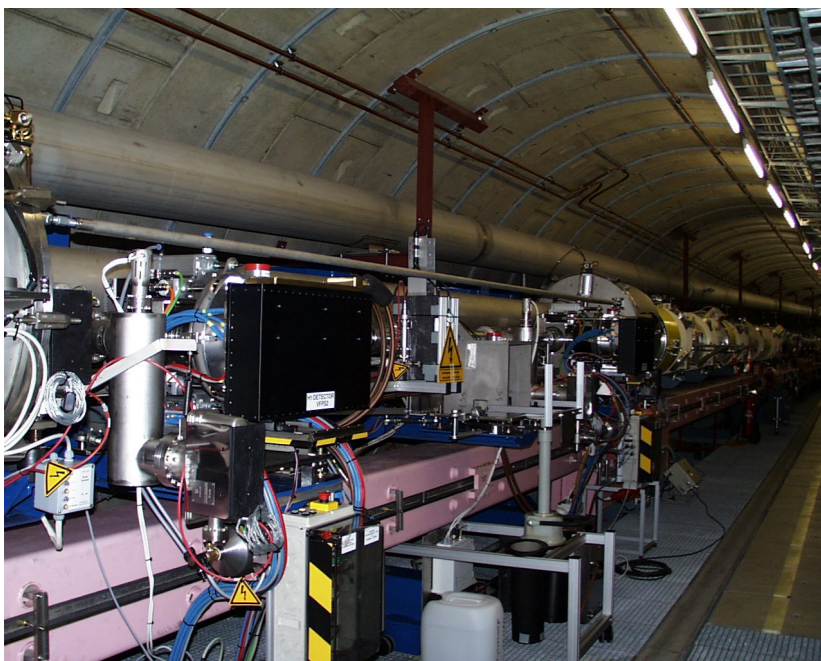
Colliders : past

- LEP (CERN): DELPHI (1989-2000)



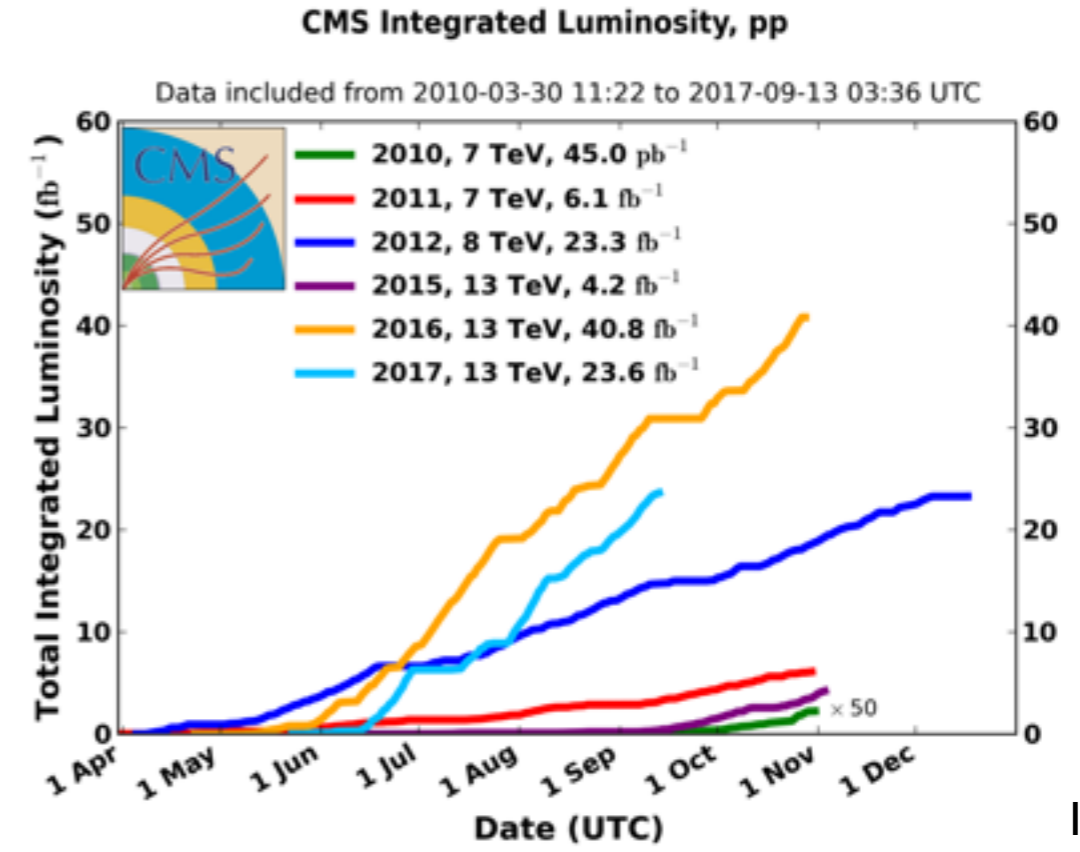
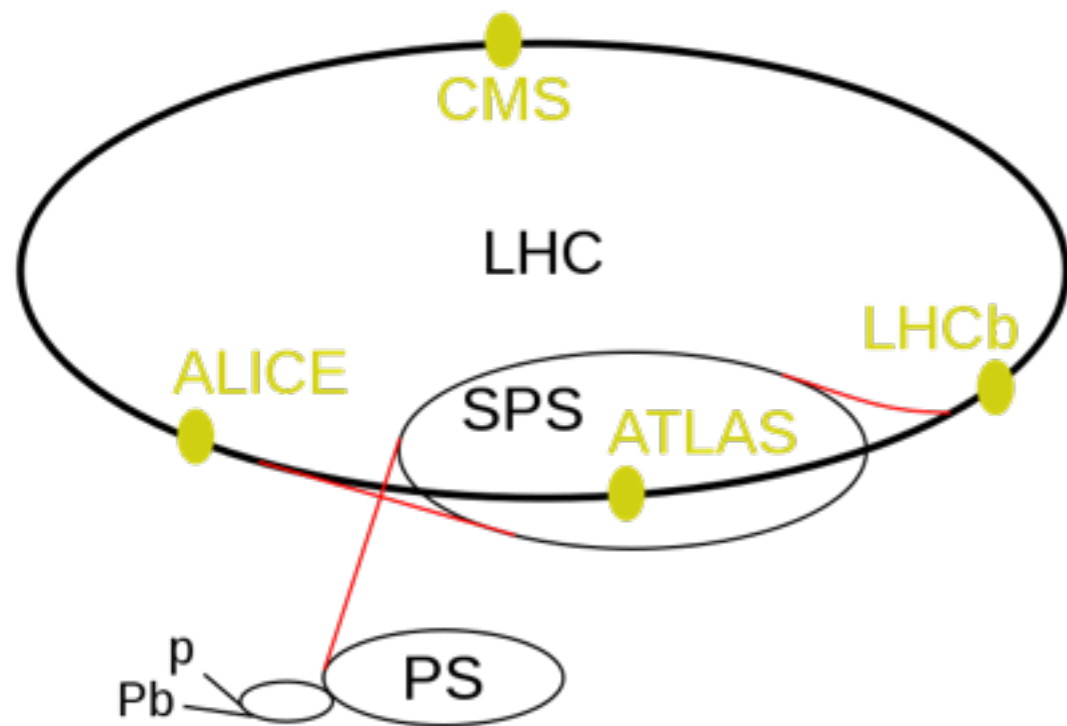
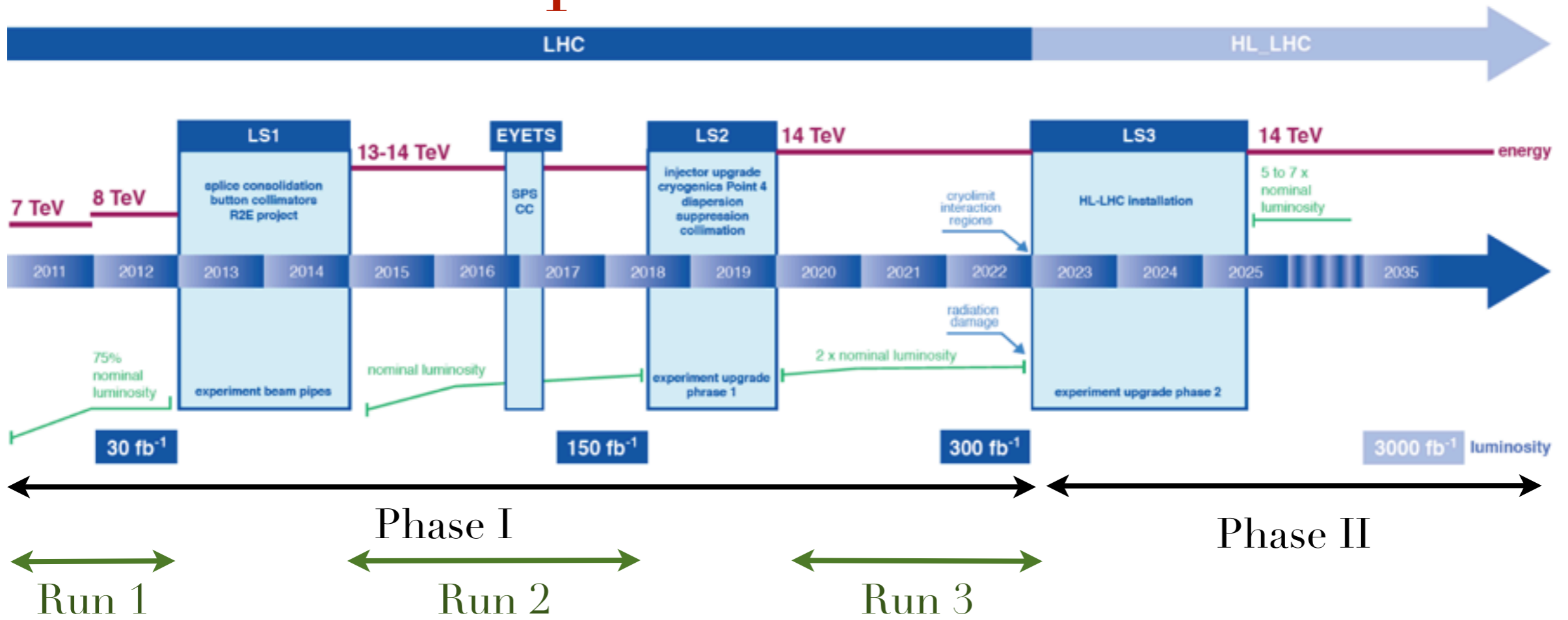
- R&D Construction of the DELPHI Forward Muon system
- Involvement in Central Trigger and reconstruction code
- Analyses on Standard Model (W, Z bosons), new phys. search (13 PhDs)

- HERA (DESY): H1, HERMES (1993-2007)



- Phase I: Construction of the Central Proportional Chamber (COP)
- Phase II: conception and construction of the Very Forward Proton Spectrometer at 220m
- Analyses on QCD, proton structure (18 PhDs)

CMS experiment at the LHC



CMS experiment

CMS Collaboration

3500 physicists+engineers
182 institutes
42 countries

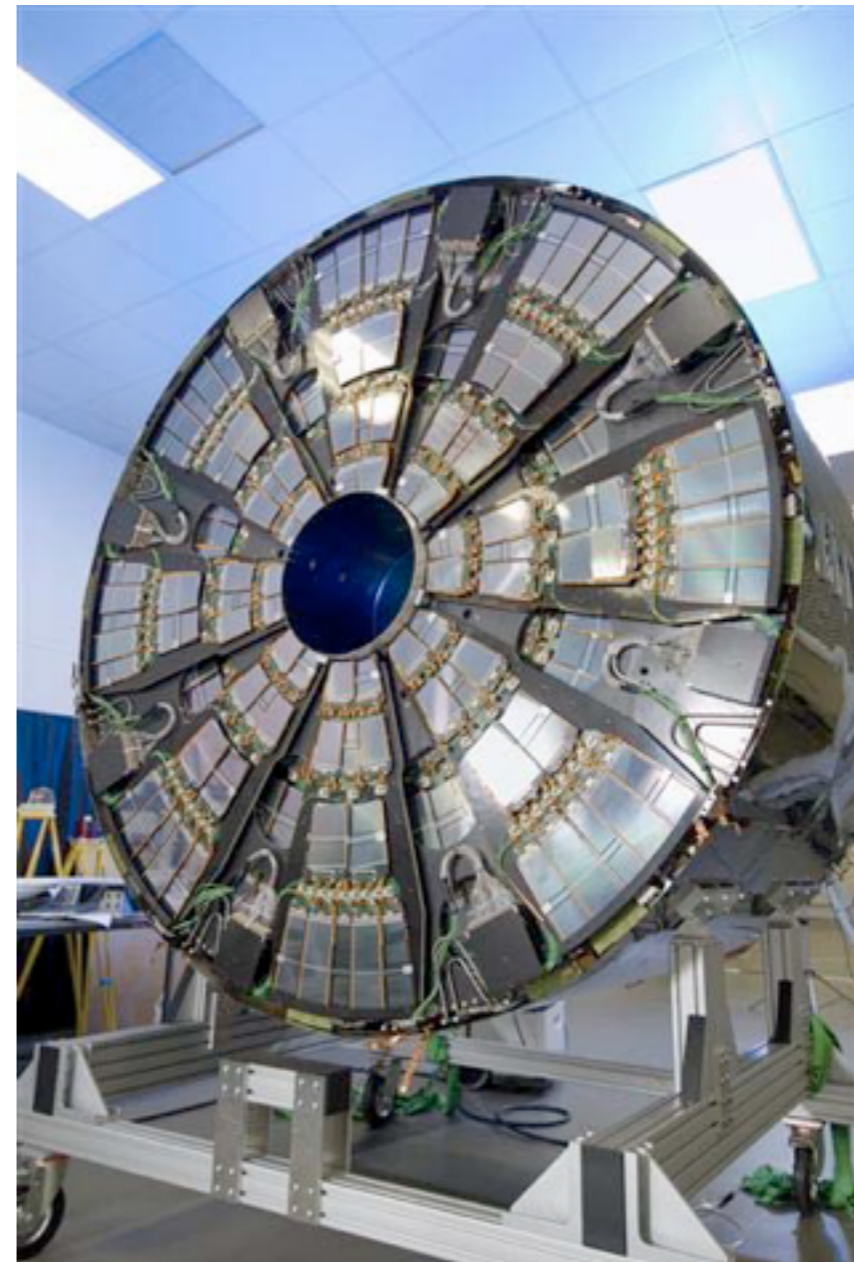
CMS Belgium

All exp. group in HEP are in CMS:
5 Belgian University groups
120 CMS members



Phase I detector contribution

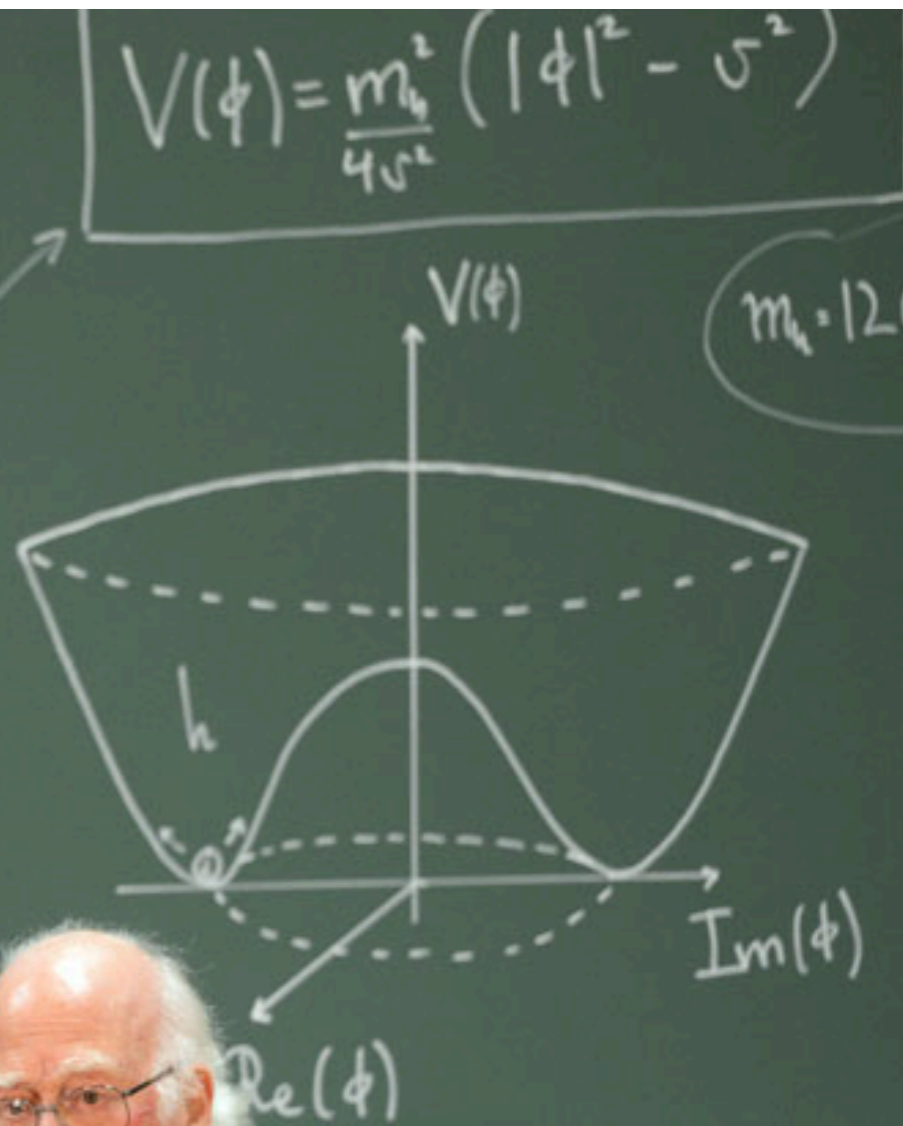
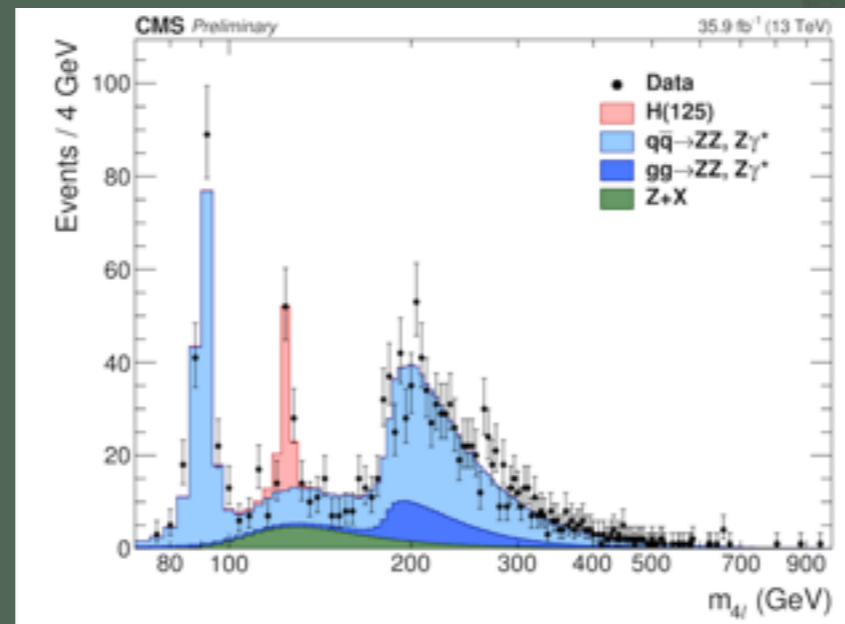
- Assembly + tests of petals of silicone detectors for the CMS tracker (2005-06)



Discovery of the Standard Model Scalar

CMS +ATLAS :
run 1 (2009-2012)

Discovery of the Higgs
boson in 2012



Englert (ULB) + Higgs: Nobel Prize in 2013

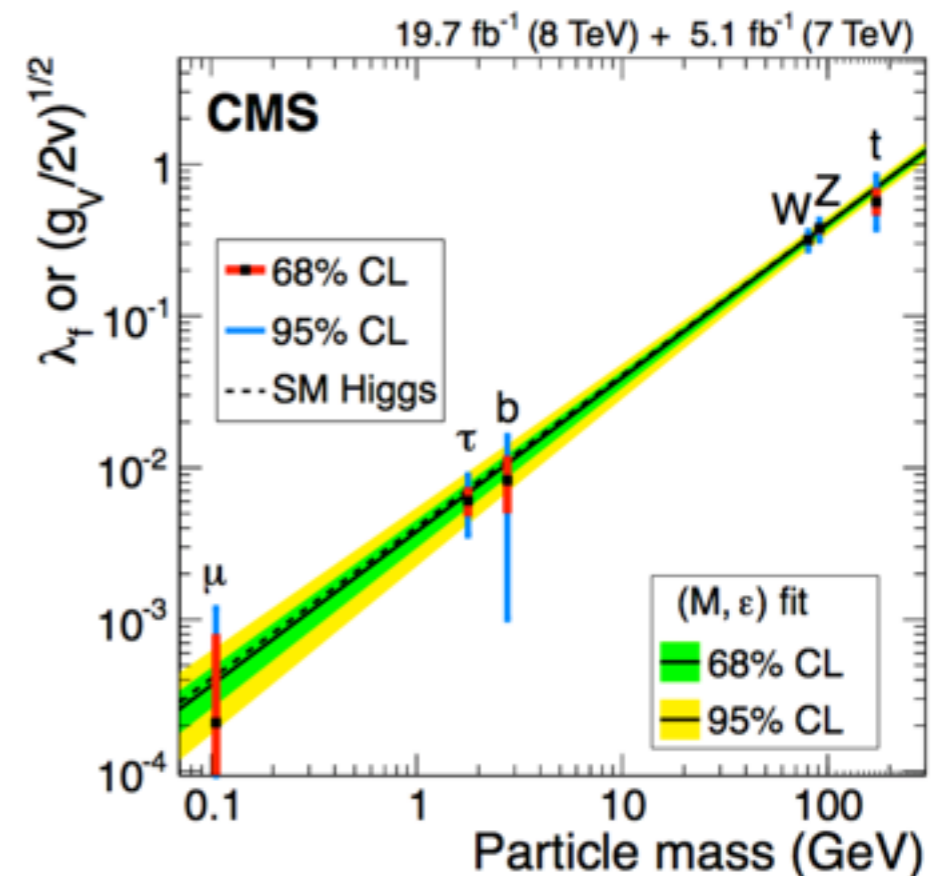
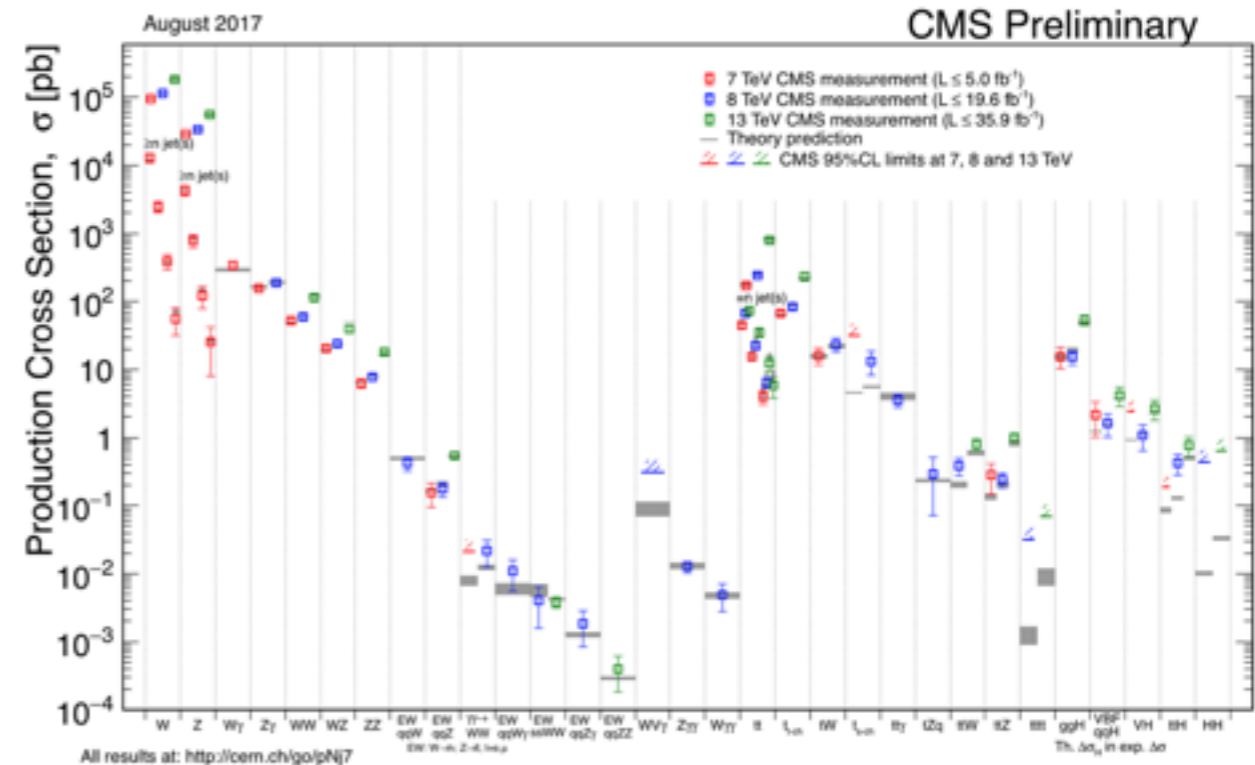


CMS Physics

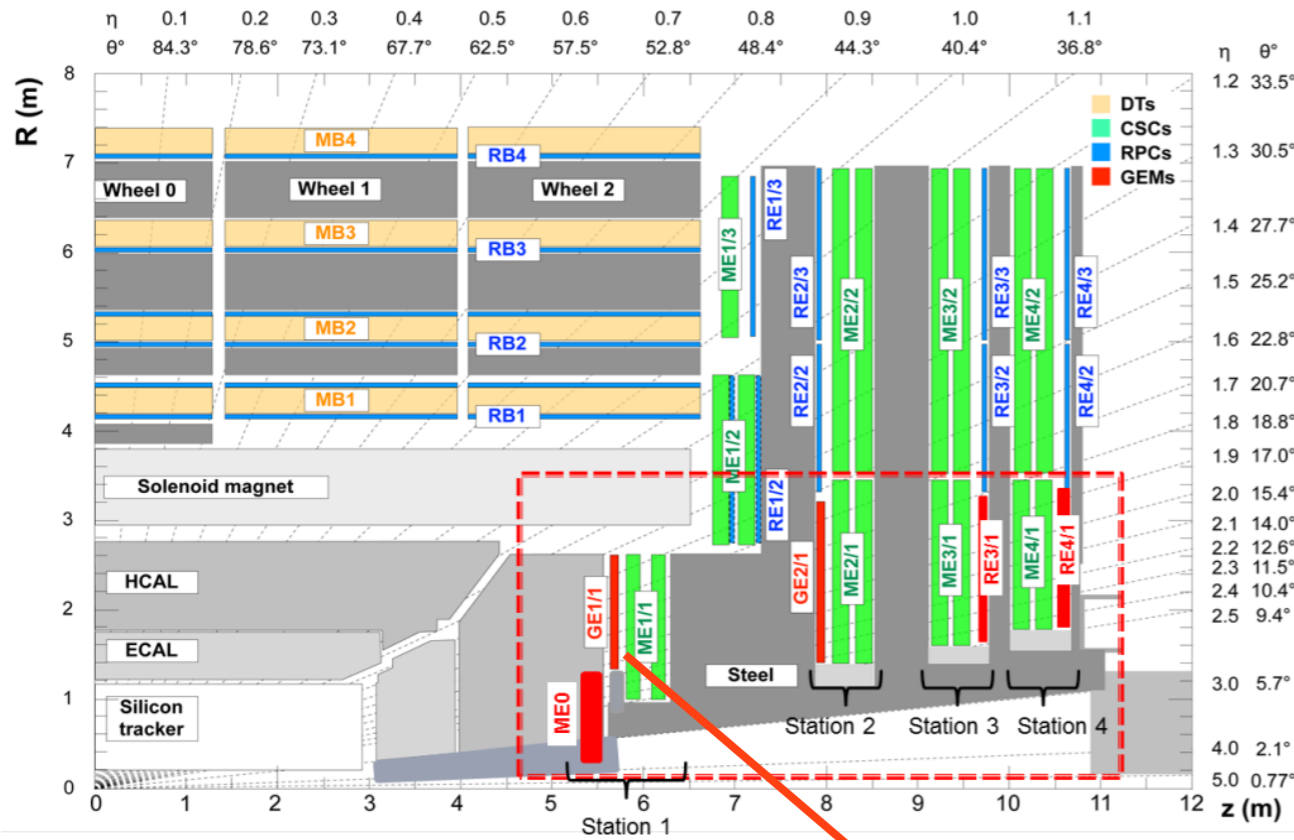
- Belgium involved at all levels of the experiment
- in all Phys. analysis groups (except heavy ions):
 - Standard Model (EW, QCD, top quark)
 - Higgs measurements
 - Searches: other H, BSM, SUSY
- 8 out of the 22 CMS thesis awards have been awarded to Belgians

Phase II potential

- precision measurement of Higgs, H coupling to muons (5%), H self-coupling
- searches for new physics

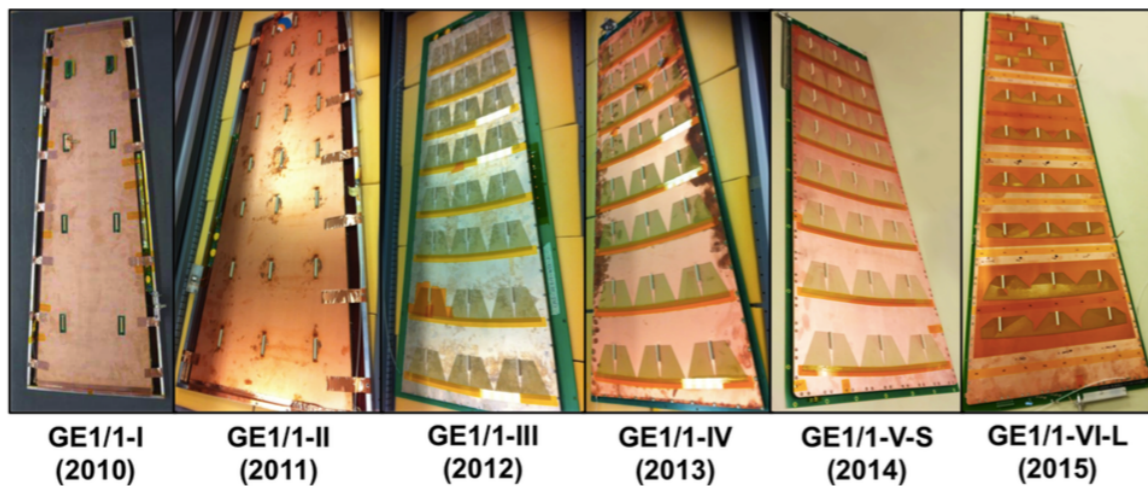


CMS Muon system upgrade for Phase II



To increase the muon system redundancy, improve tracking and trigger

→ Gas Electron Multiplier detector (GEM)

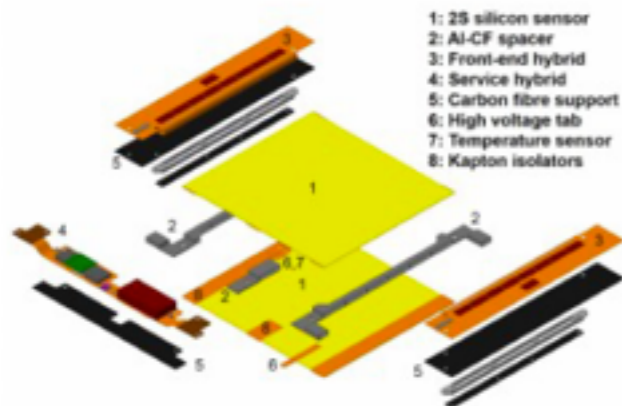
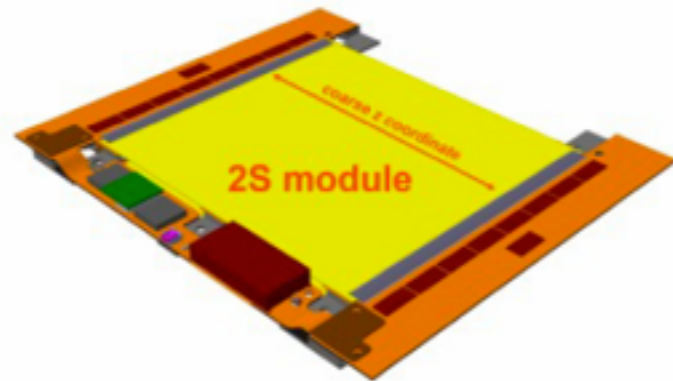
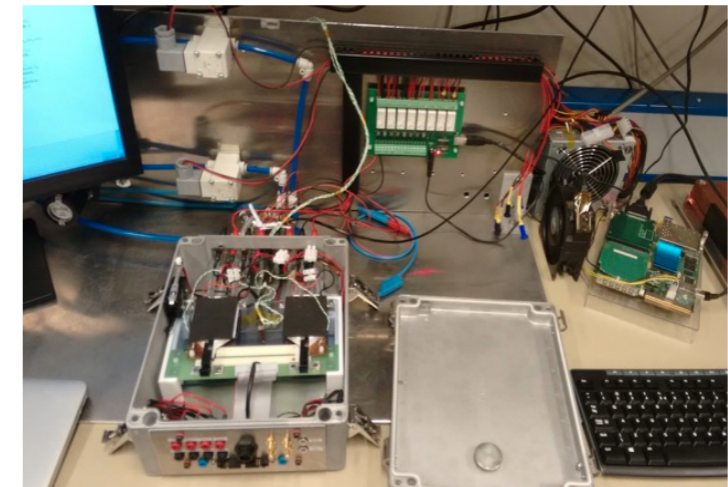
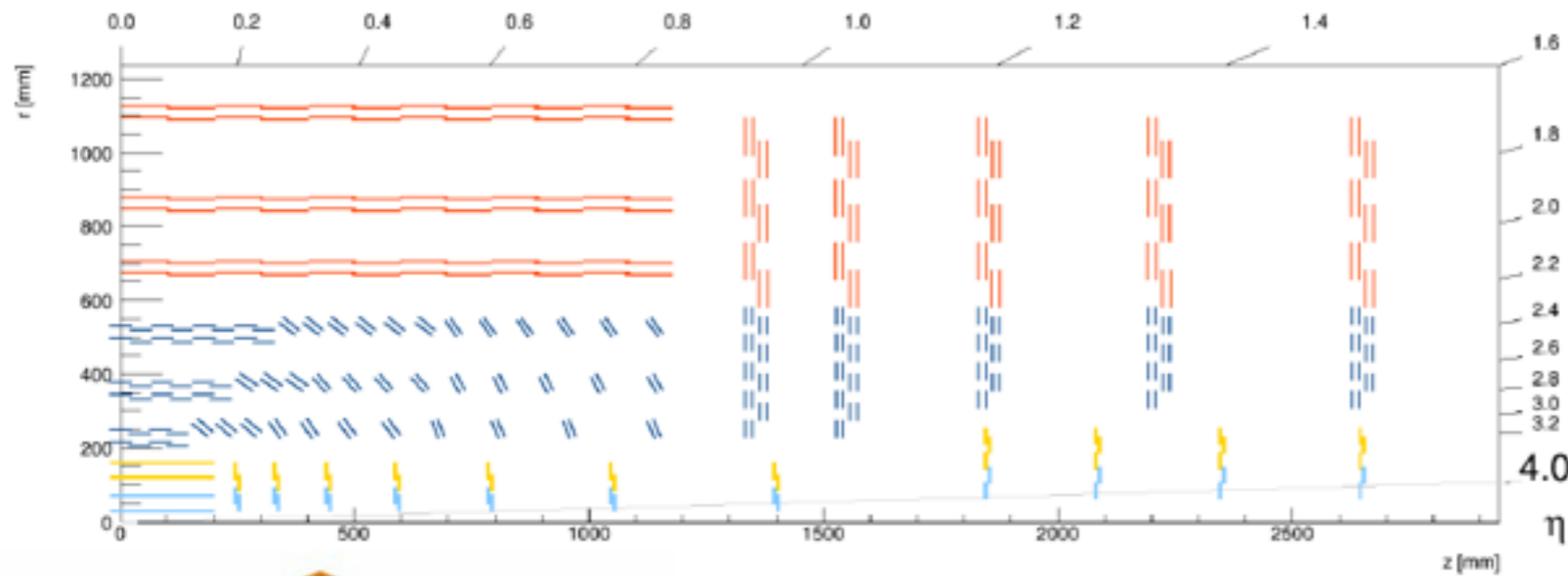
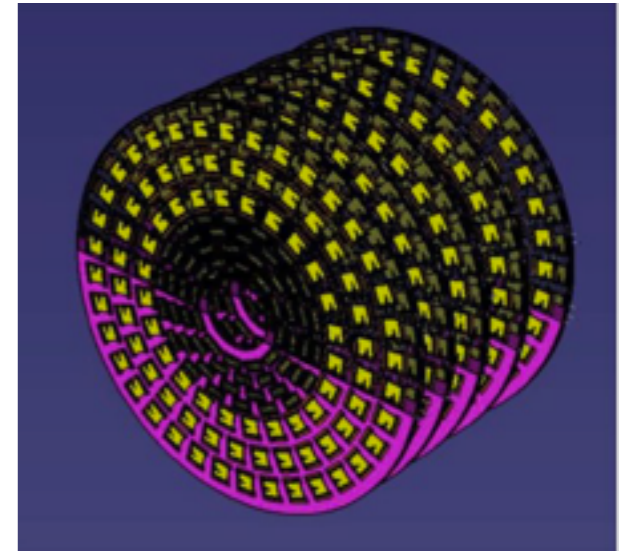


Important role played by Belgium

- leading the Triple-GEM detector electronics

CMS tracker upgrade for Phase II

The construction of the phase-2 CMS tracker is the central project that brings together the Belgian experimental physics community for the coming years.



- Test of detector prototypes (in the labs and in test beams)
- Development of test system for the electronics
- Development of test systems at cold (-30°C)
- Development of the module assembly set-up
- Module assembly and test
- Development of the Dees assembly set-up
- Dees assembly and test
- Endcap assembly and commissioning

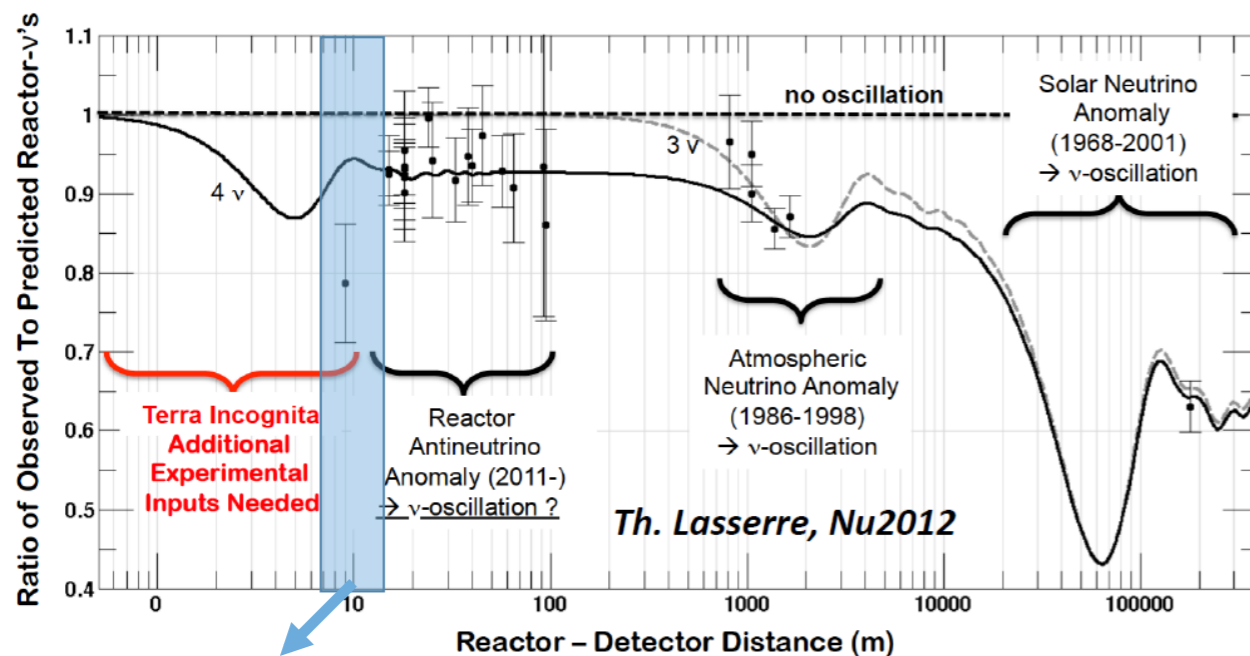
Research in neutrino Physics

Neutrino experiments

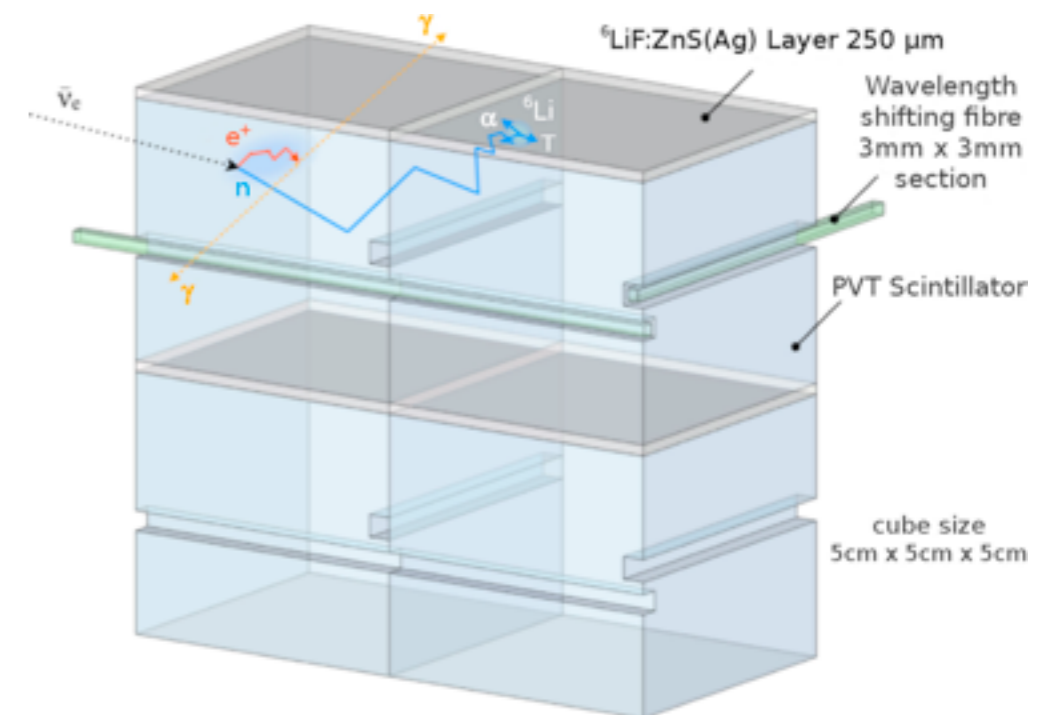
- Belgium involved since a long time in neutrinos experiments (Gargamelle, BEBC, CHARM II...)

Neutrino oscillations

- CHORUS (1994-97): CERN SPS : search for $\nu_\mu - \nu_\tau$ oscillation
- OPERA (2008-12): CERN CNGS-Gran Sasso: ν_τ appearance in emulsion in ν_μ beam
- **SoLid** (2012-...): sterile ν search at the SCK-CEN (BR2)
 - 3 Belgian groups involved (+SCK-CEN)



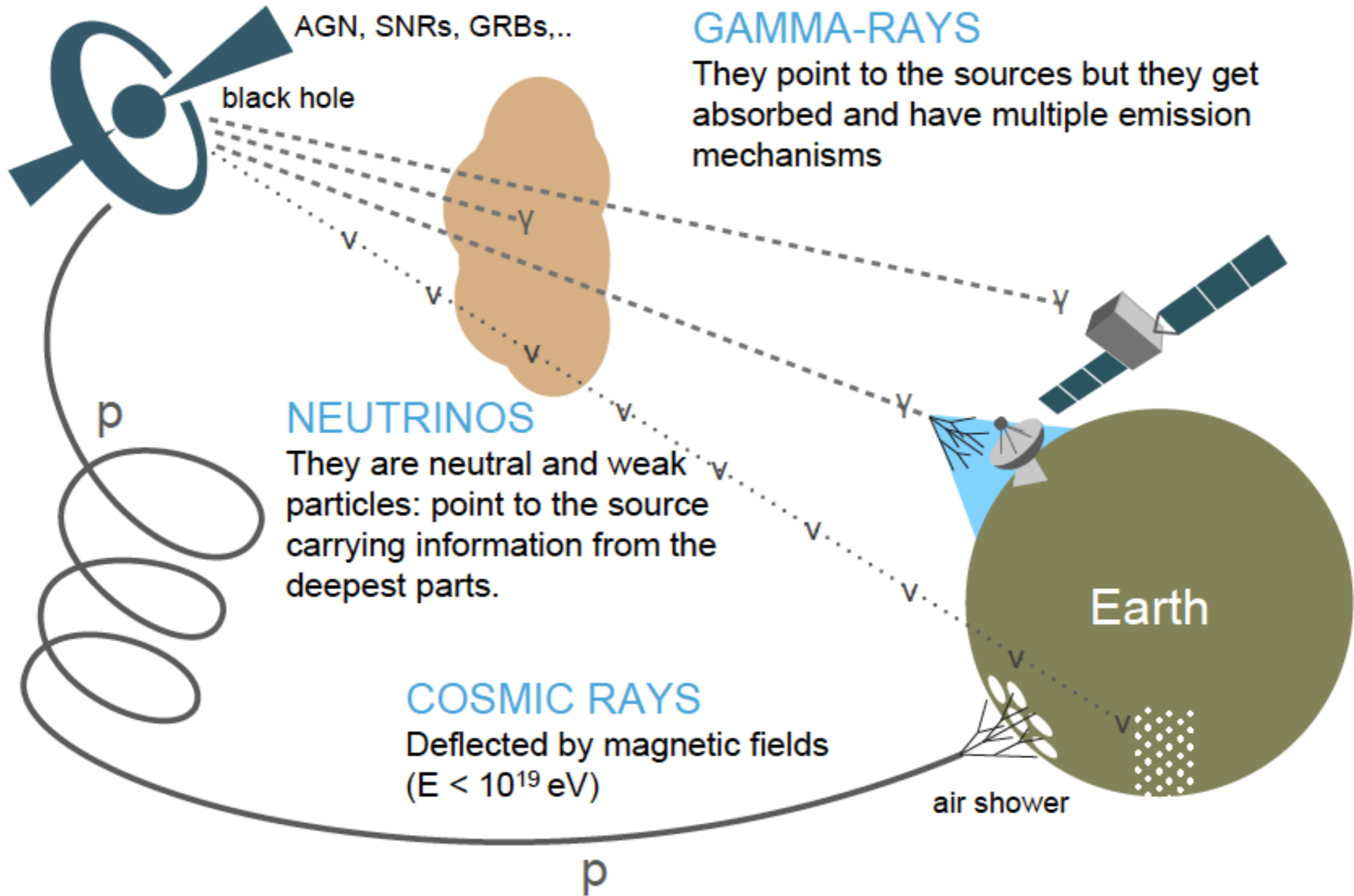
SoLid



- **JUNO** (2020-....): ν mass hierarchy, at 50 km from Chinese reactors

Research in astroparticle

Astroparticle



Astroparticle

AGN, SNRs, GRBs,...

black hole

GAMMA-RAYS

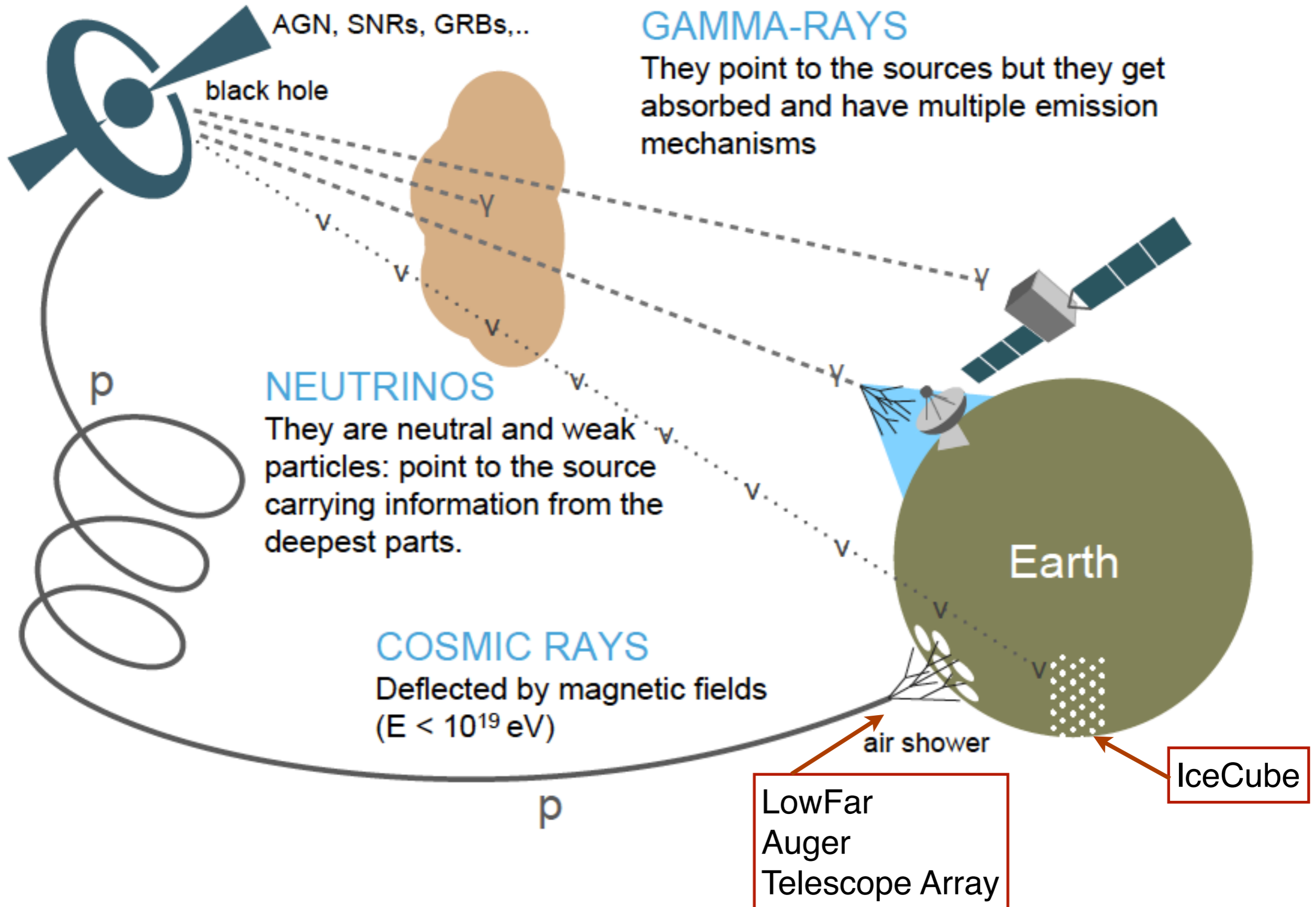
They point to the sources but they get absorbed and have multiple emission mechanisms

NEUTRINOS

They are neutral and weak particles: point to the source carrying information from the deepest parts.

COSMIC RAYS

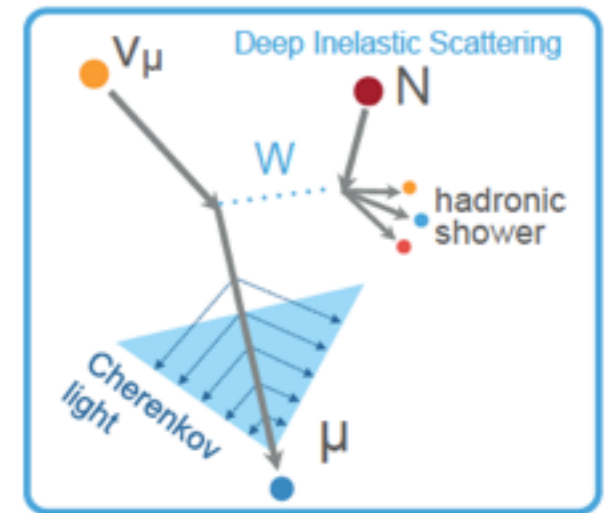
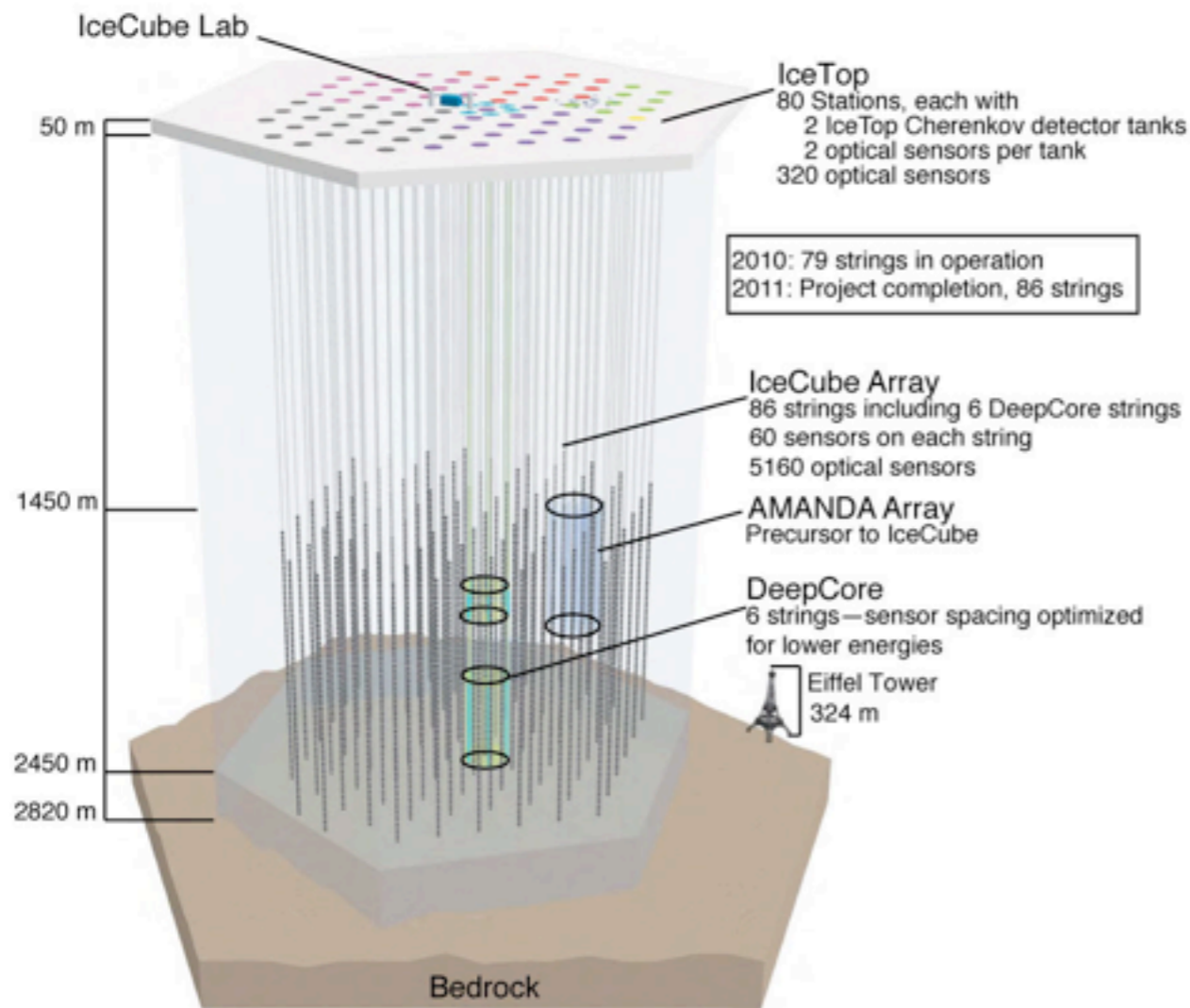
Deflected by magnetic fields
($E < 10^{19}$ eV)



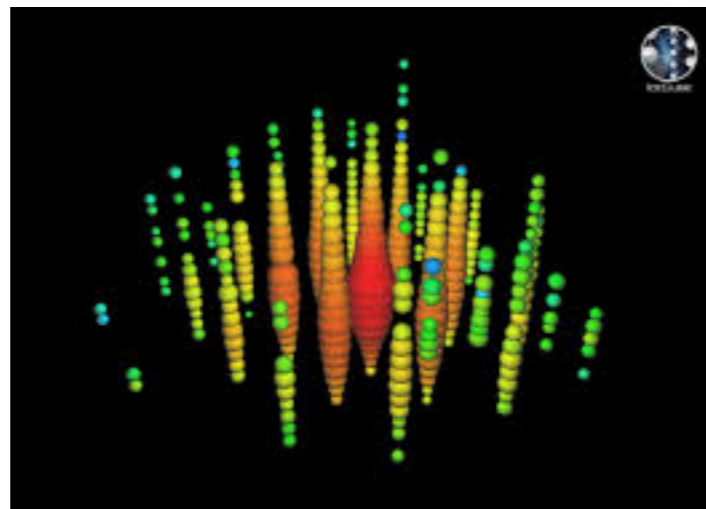
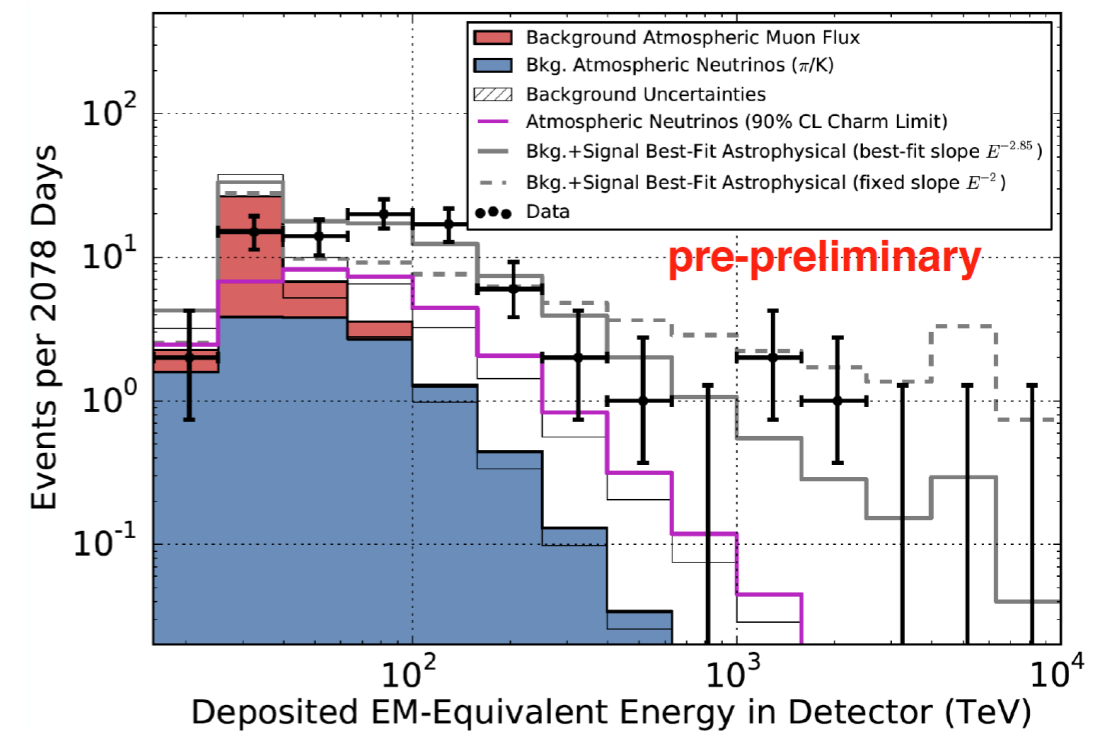
LowFar
Auger
Telescope Array

IceCube

IceCube (south Pole)



- Measurement of (very) high energy neutrinos from astrophysical source



- First measurement of (probably) extragalactic high energy particles

Conclusion

- HEP is an important and active community in Belgium
- Important common effort in CMS at the LHC
- detector R&D in tracking and in electronics
- fruitful collaboration between theorists and experimentalists
- Long history and constant interest in neutrino physics
- Community developing fast in astroparticle

* sorry for not mentioning contributions to: NA62 (CERN), LIGO, ILC CALICE/
TRAPPISTe, CLIC, p-therapy