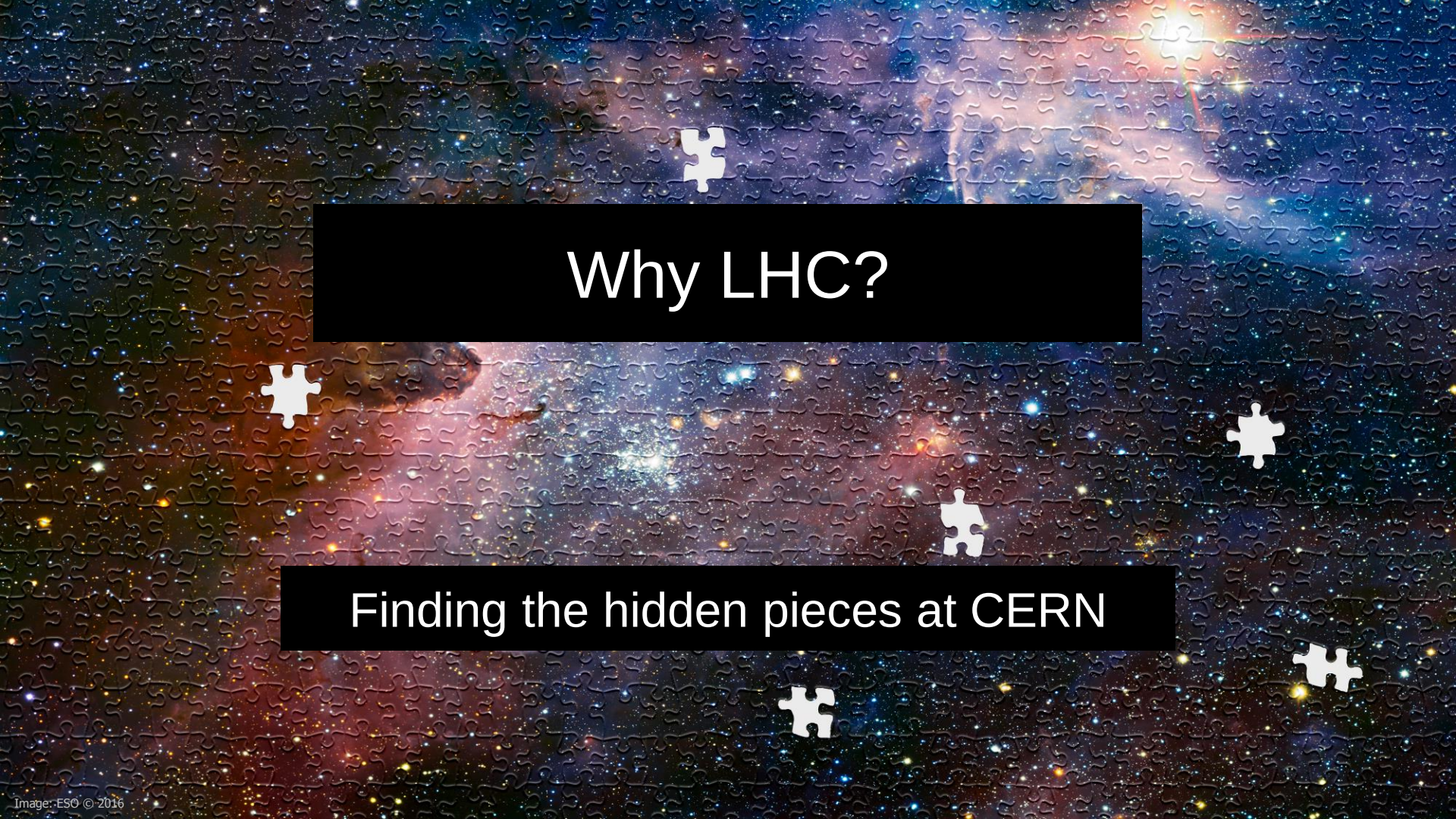
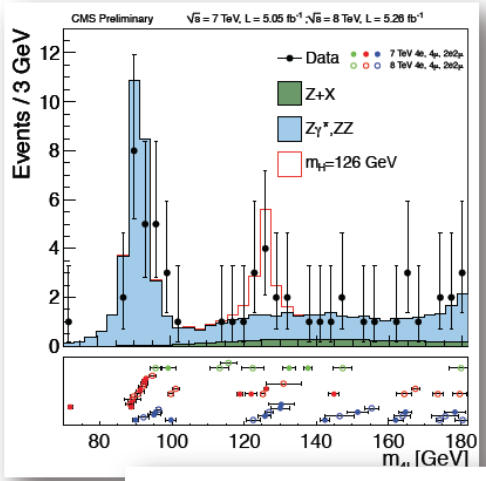
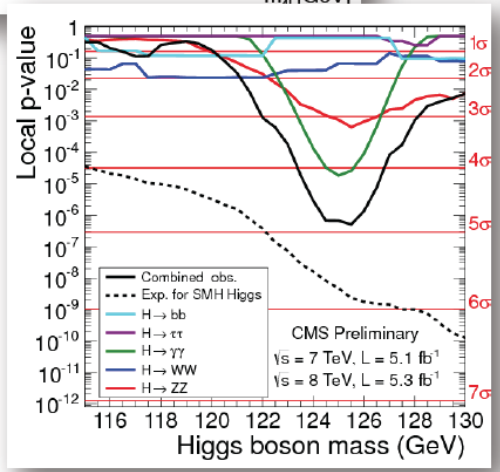

Why LHC?
Finding the hidden pieces at CERN
Image: ESO © 2016

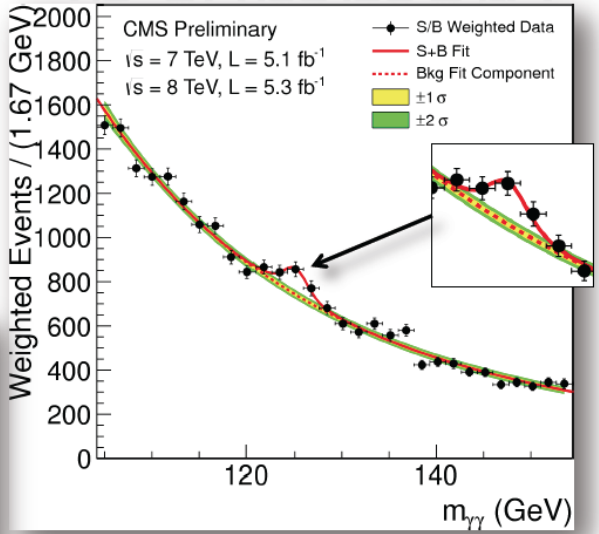

Warning:
This talk contains actual facts. It might not be convenient for audiences who prefer “alternative facts” or outright lies. Follow at your own risk.

Physics Seminar – 4 July 2012

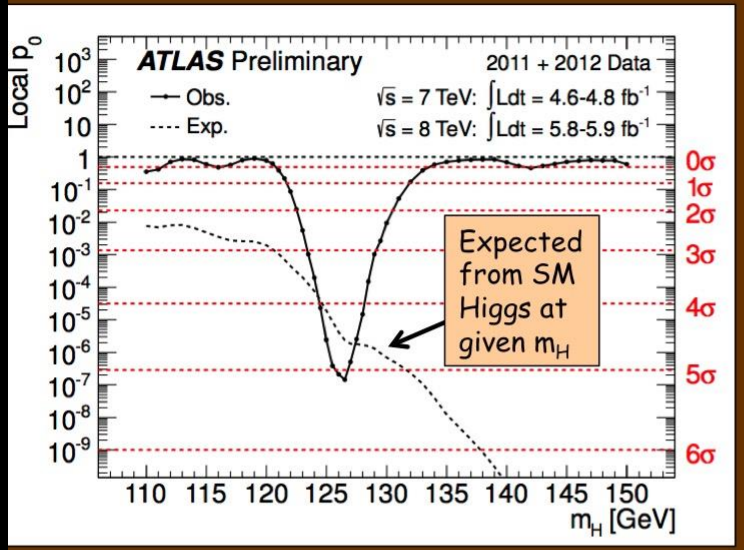
In summary

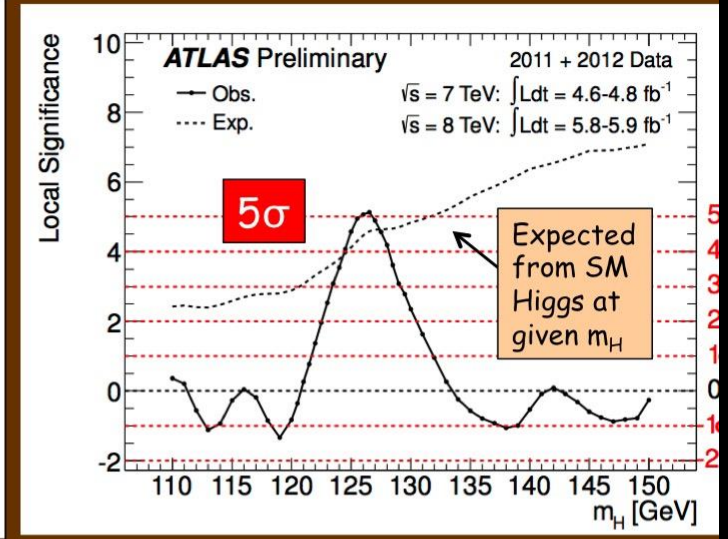

CMS Preliminary
√s = 7 TeV, L = 5.05 fb⁻¹ ; √s = 8 TeV, L = 5.26 fb⁻¹
Data
Z+X
Zγ*,ZZ
m_H=126 GeV
Events / 3 GeV
m_4l [GeV]


Local p-value
Combined obs.
Exp. for SMH Higgs
H→ bb
H→ ττ
H→ γγ
H→ WW
H→ ZZ
CMS Preliminary
√s = 7 TeV, L = 5.1 fb⁻¹
√s = 8 TeV, L = 5.3 fb⁻¹
Higgs boson mass (GeV)


CMS Preliminary
√s = 7 TeV, L = 5.1 fb⁻¹
√s = 8 TeV, L = 5.3 fb⁻¹
S/B Weighted Data
S+B Fit
Bkg Fit Component
±1σ
±2σ
Weighted Events / (1.67 GeV)
m_γγ (GeV)

Combined results: the excess

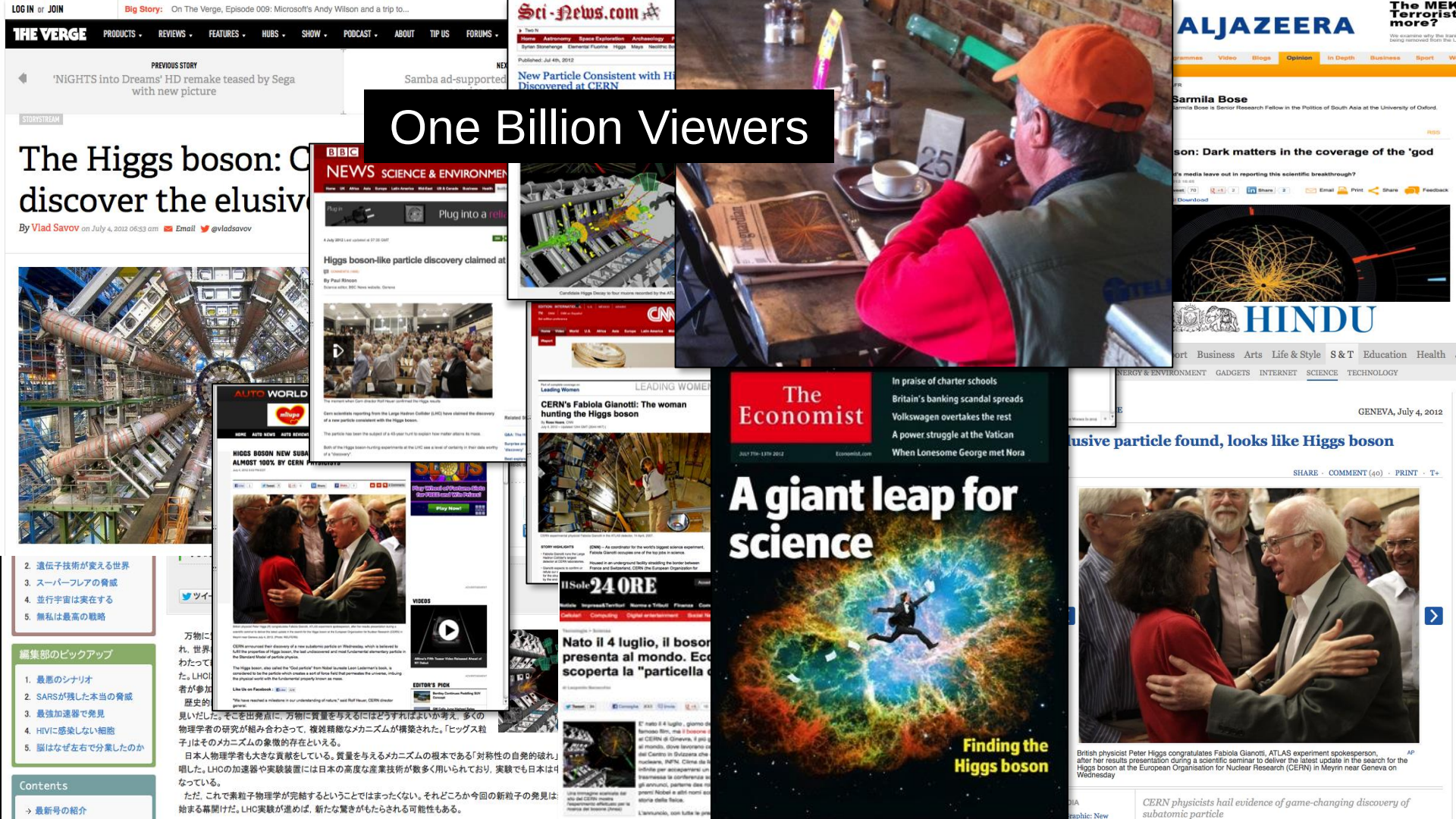




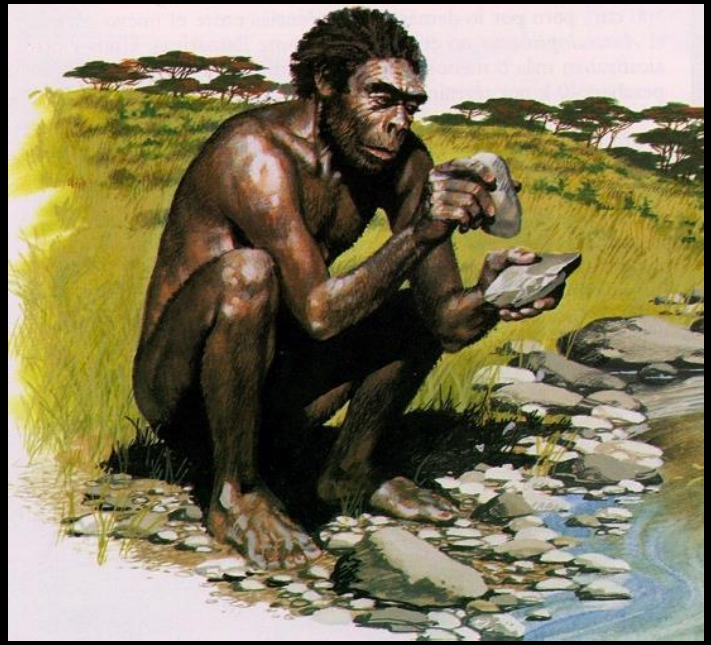
Maximum excess observed at	m_H = 126.5 GeV
Local significance (including energy-scale systematics)	5.0 σ
Probability of background up-fluctuation	3 x 10^{-7}
Expected from SM Higgs m_H=126.5	4.6 σ

Global significance: 4.1-4.3 σ (for LEE over 110-600 or 110-150 GeV)

One Billion Viewers

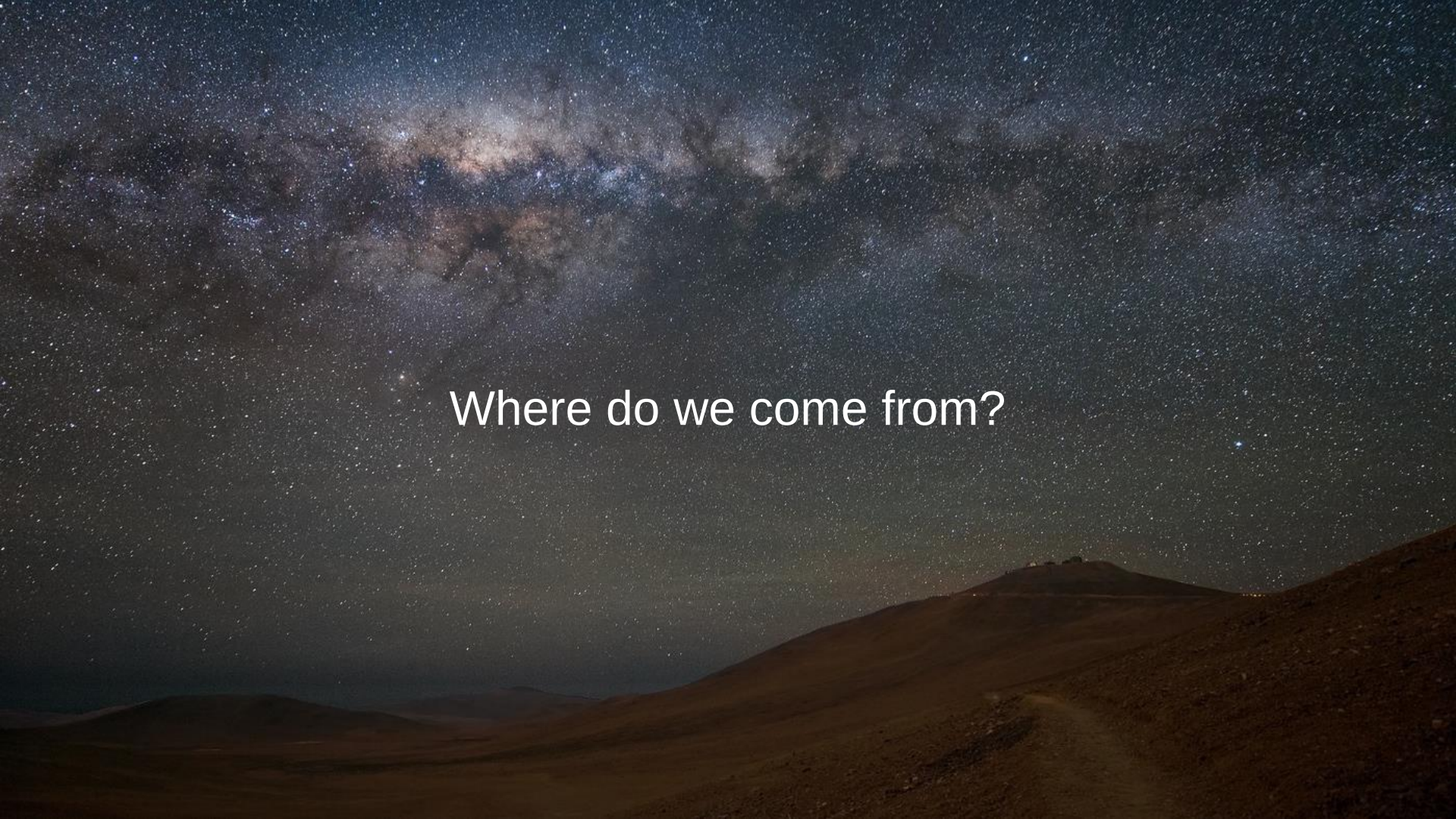



Why?



Physics Seminar – 4 July 2000012 BCE


The Big Questions:


Where do we come from?


What are we made of ?


What is our destiny?


What are the rules behind all this?


Is there anything else we don’t see?

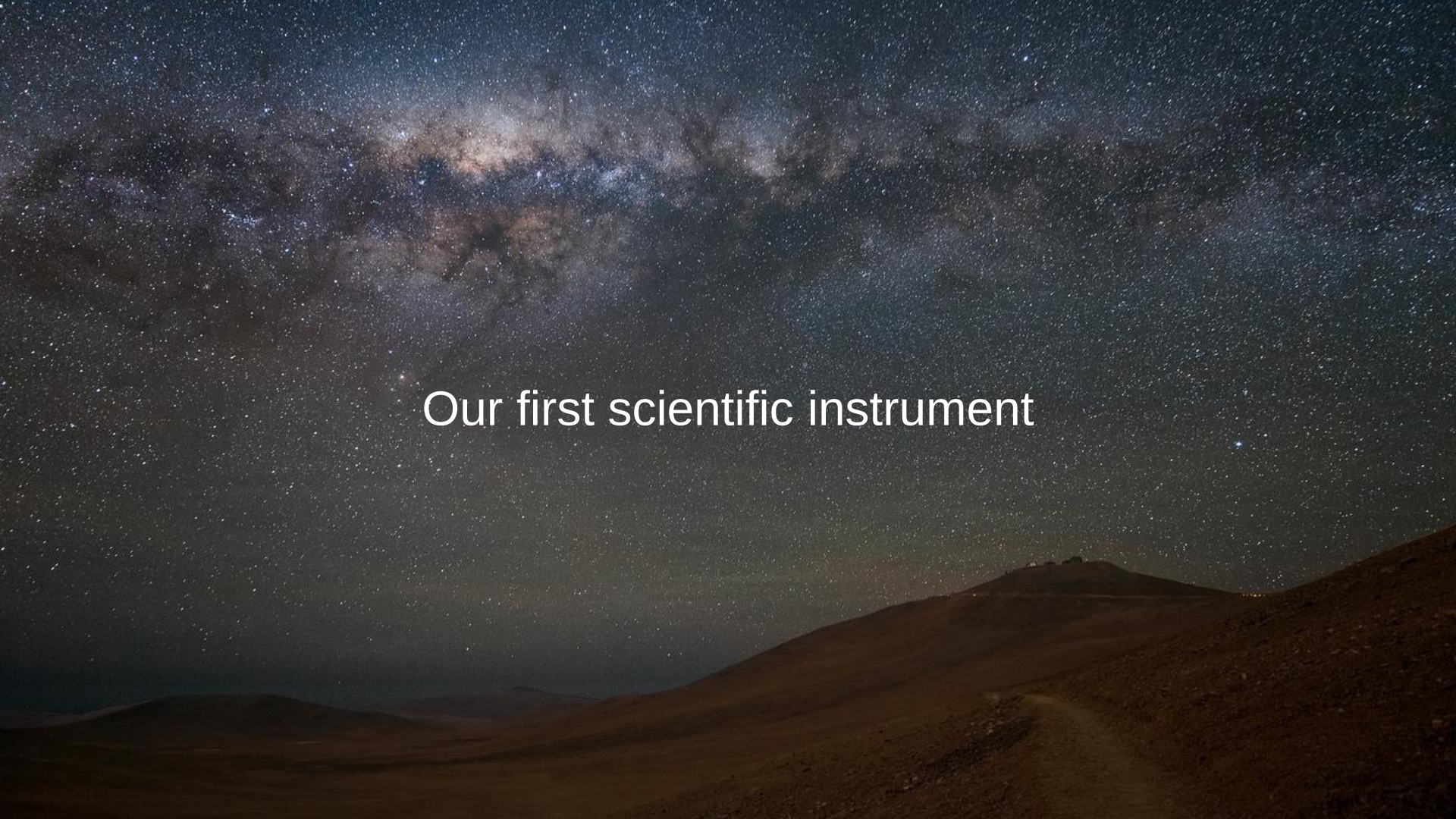

Our first scientific instrument

Photo: Eric Wiessner CC-BY-SA

Human Hair (15cm away)

Andromeda (2.5 million light years away)

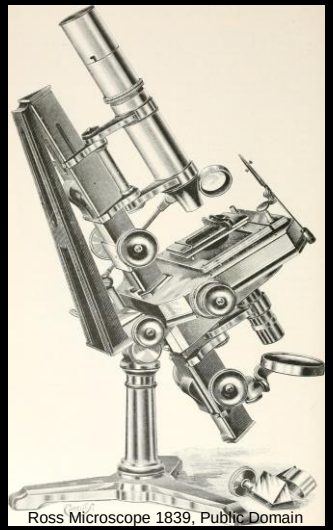
Good enough?

Never!

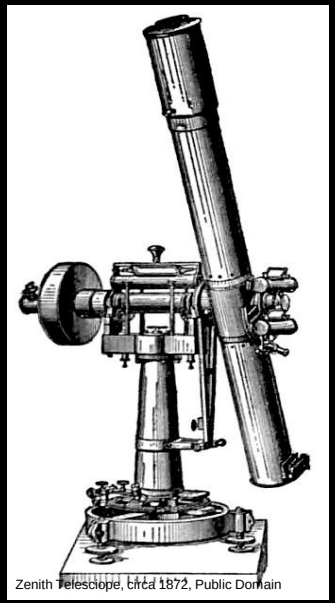
Flammarion Woodcut 1888. Public Domain

How do we measure what we can’t see?

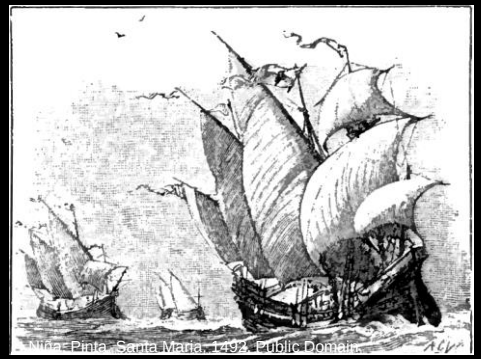
Exploration



Ross Microscope 1839, Public Domain

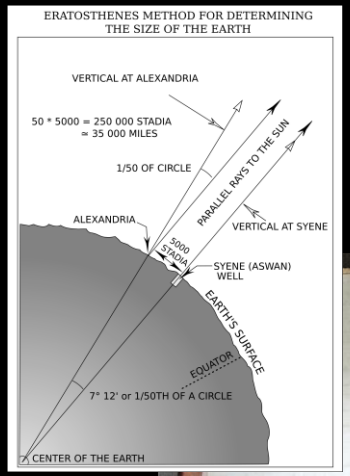


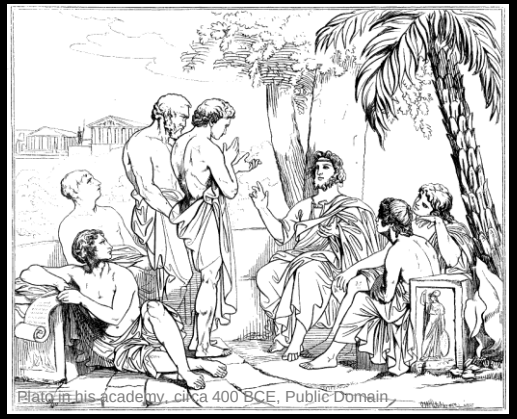
Zenith Telescope, circa 1872, Public Domain



Niña, Pinta, Santa María, 1492, Public Domain

Extrapolation





Plato in his academy, circa 400 BCE, Public Domain

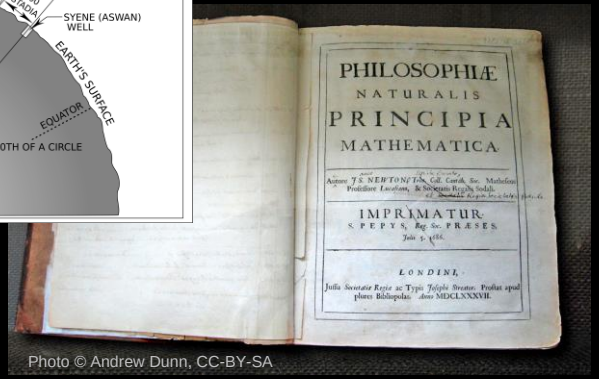
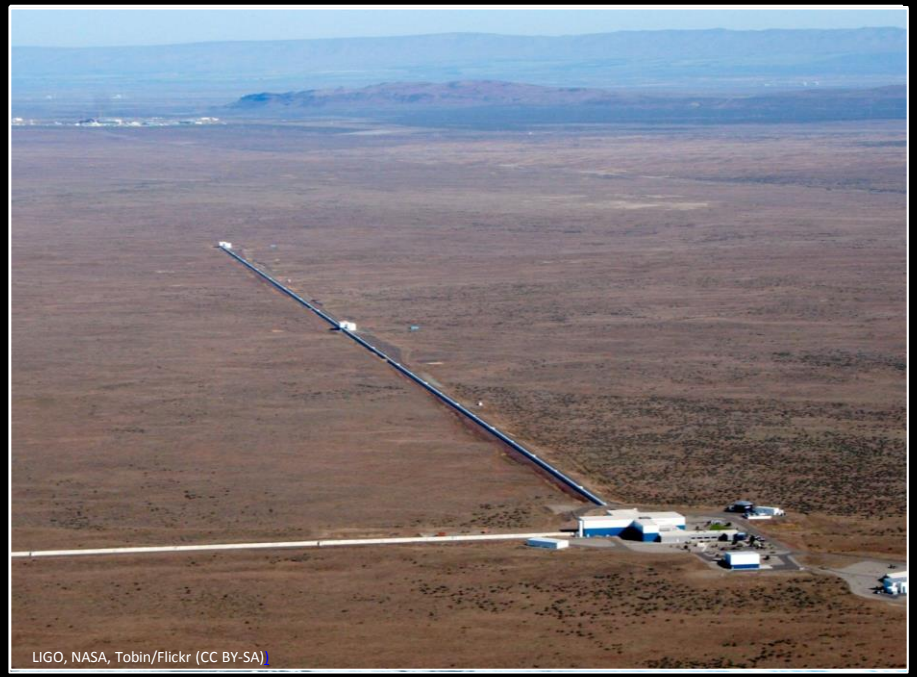


Photo © Andrew Dunn, CC-BY-SA

Looking out



LIGO, NASA, Tobin/Flickr (CC BY-SA)

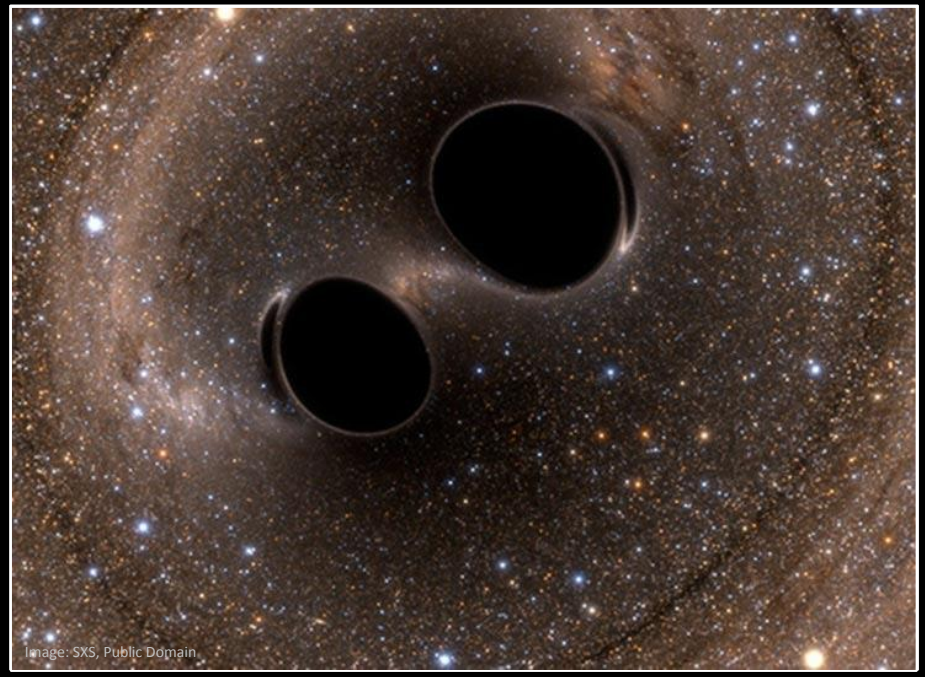
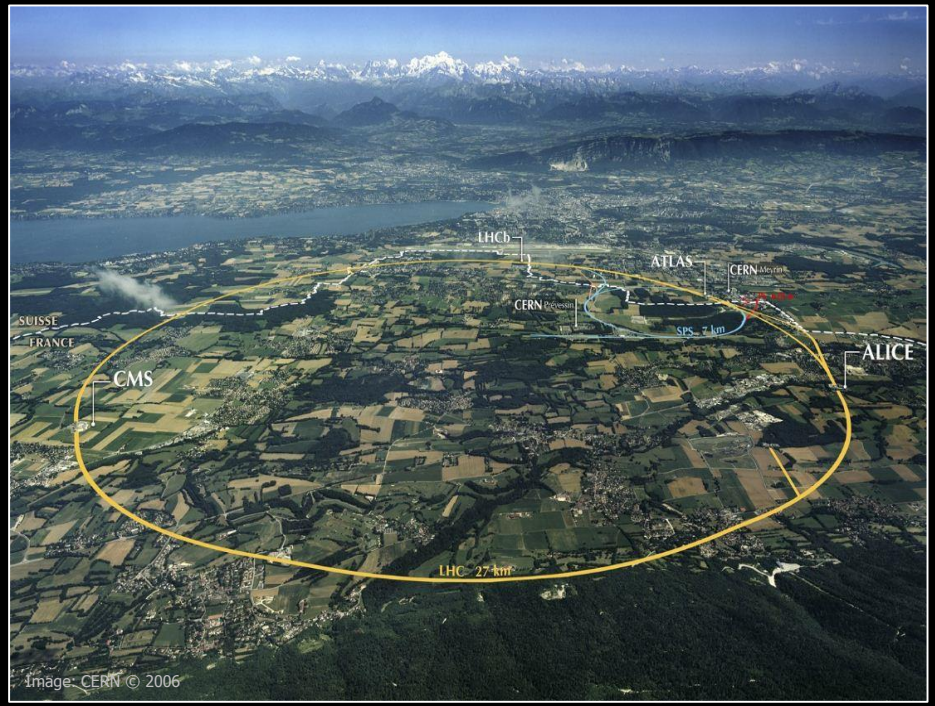
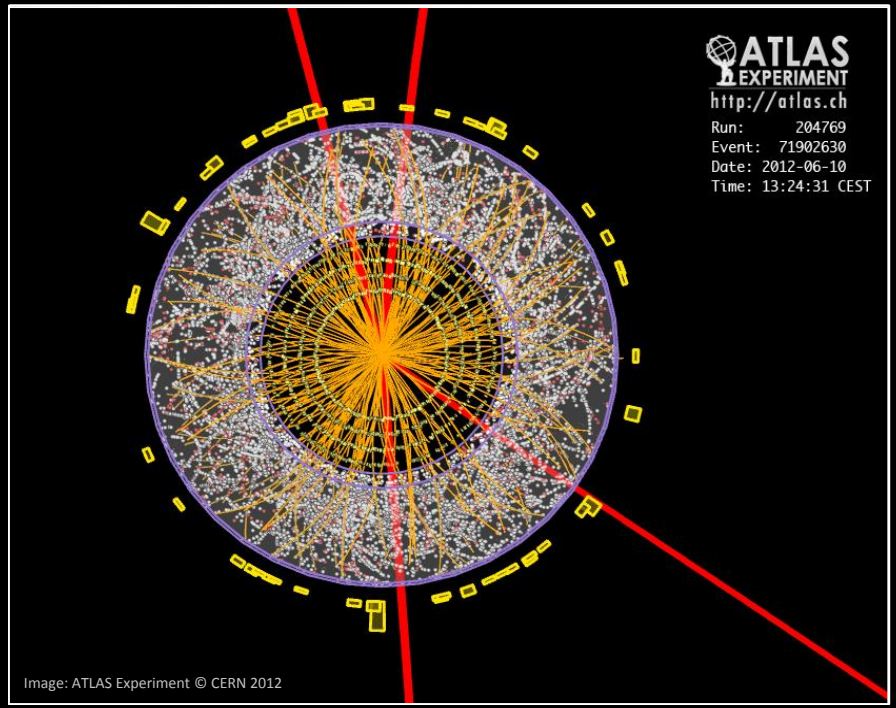


Image: SXS, Public Domain

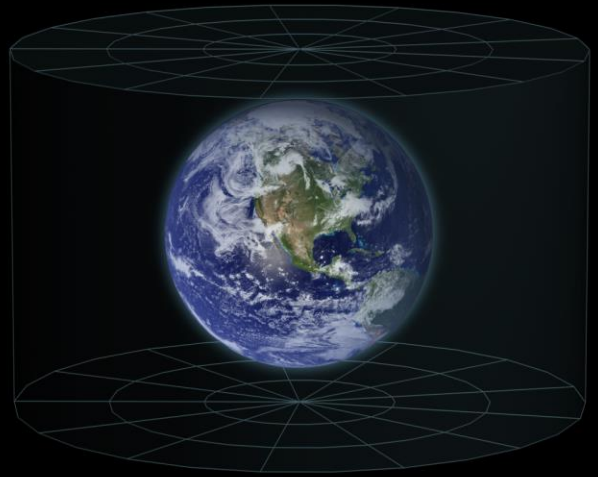
Looking in


LHCb
ATLAS
CERN Meyrin
CERN Prévessin
SPS 7 km
SUISSE
FRANCE
CMS
ALICE
LHC 27 km
Image: CERN © 2006

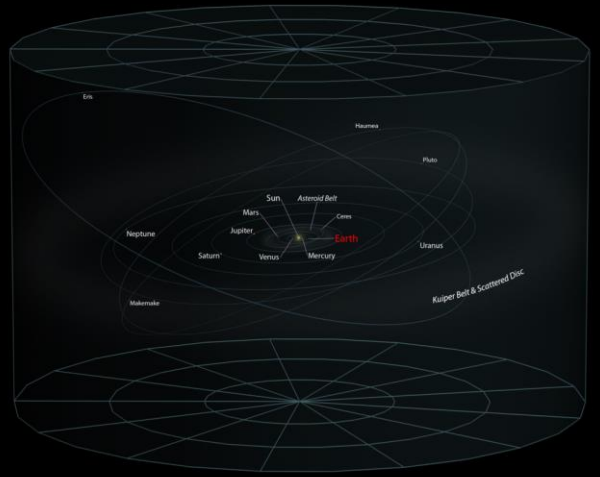

ATLAS
EXPERIMENT
http://atlas.ch
Run: 204769
Event: 71902630
Date: 2012-06-10
Time: 13:24:31 CEST
Image: ATLAS Experiment © CERN 2012

What have we learned?

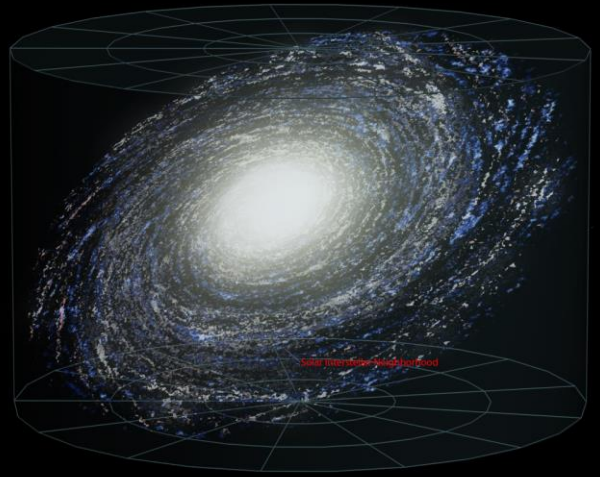
EARTH



SOLAR SYSTEM



MILKY WAY GALAXY



Images: Andrew Z. Colvin, CC-BY-SA

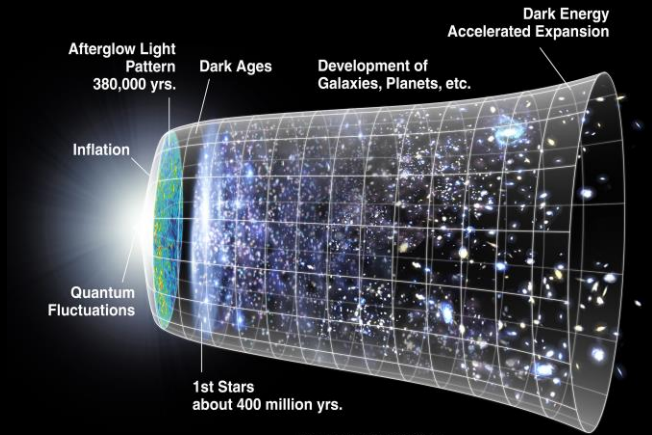


Image: NASA/WMAP, Public Domain

CELL

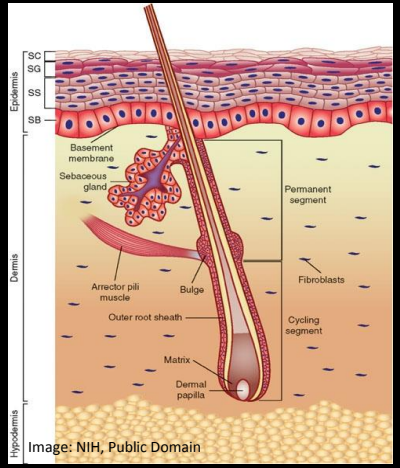


Image: NIH, Public Domain

MOLECULE

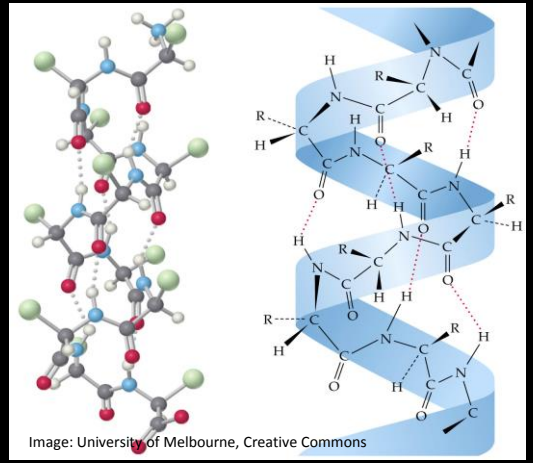


Image: University of Melbourne, Creative Commons

ATOM

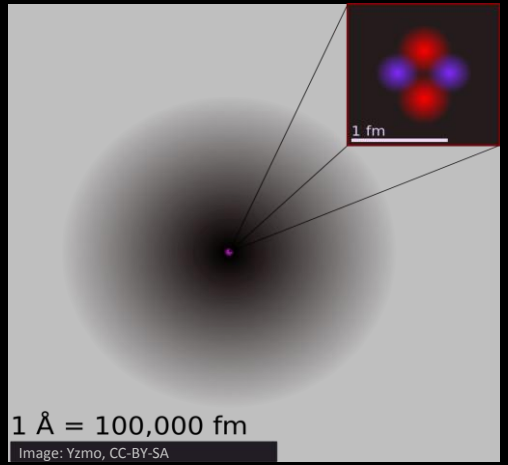


Image: Yzmo, CC-BY-SA

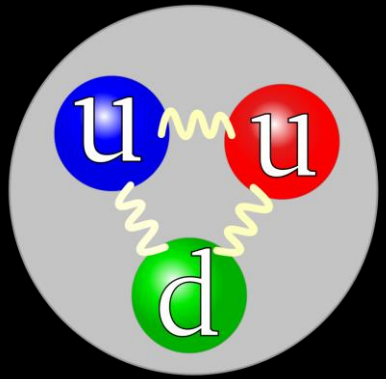
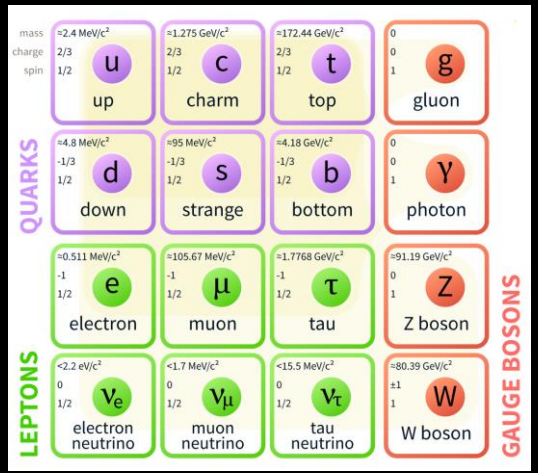
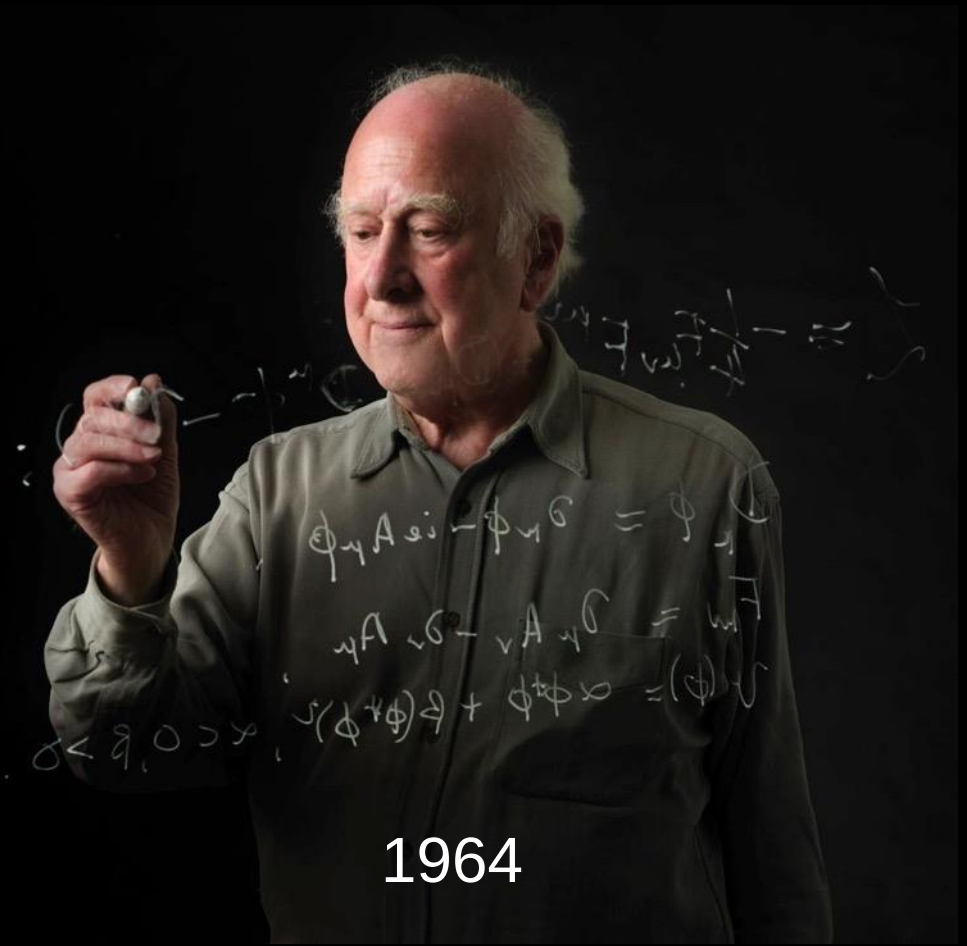


Image: Arpad Horvath, CC-BY-SA

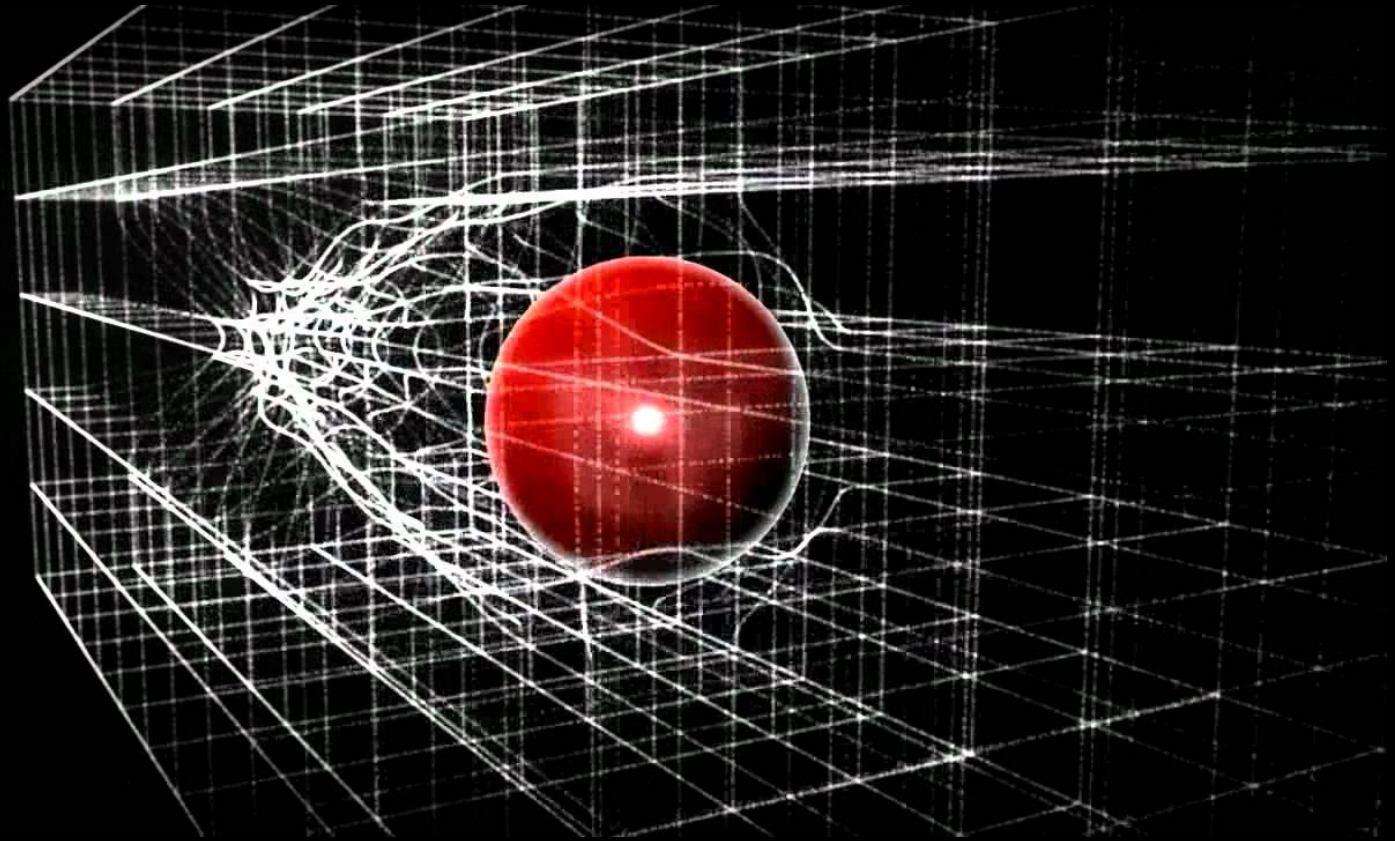



Why mass?

How do fundamental particles attain mass?

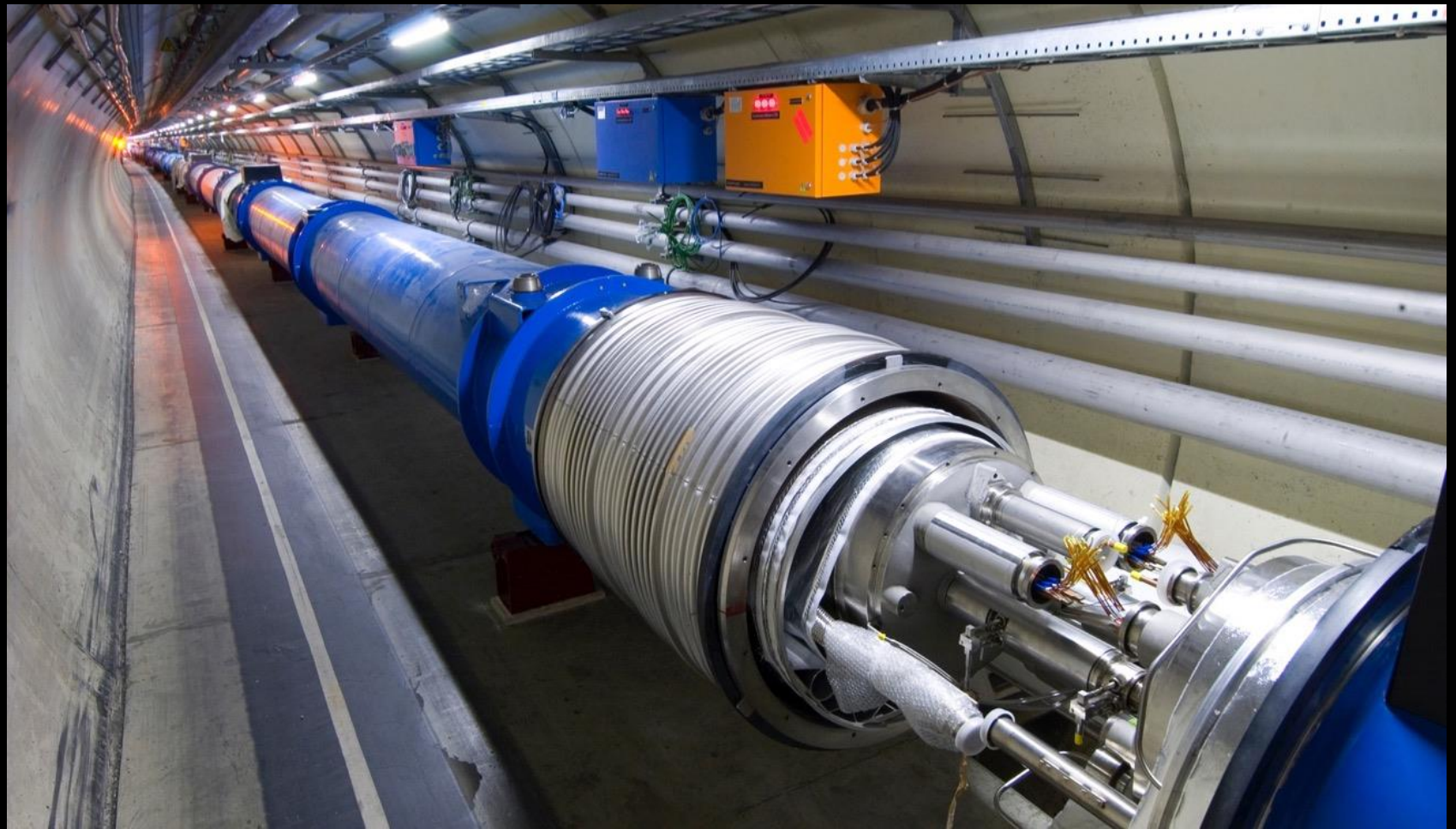


1964

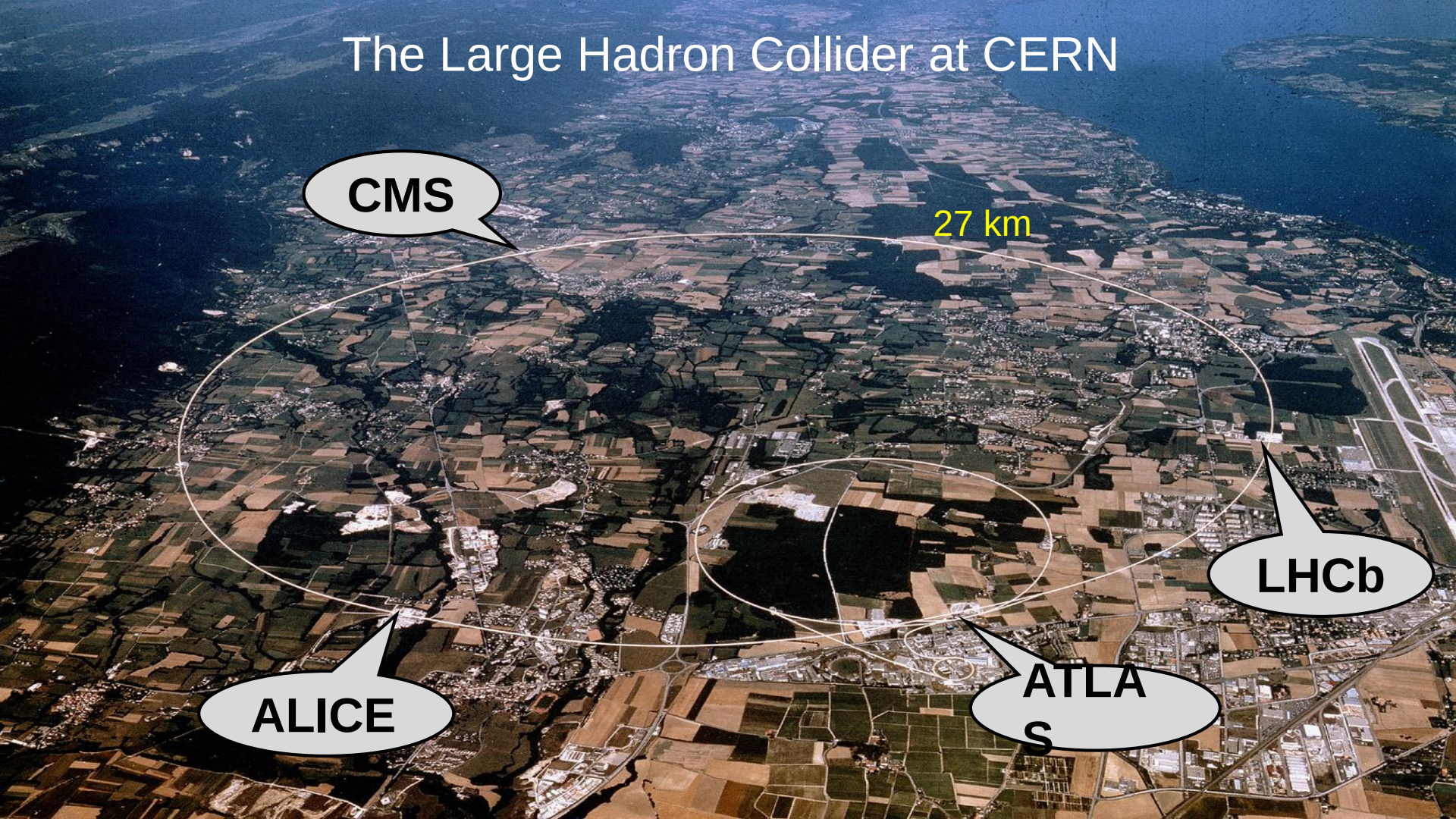


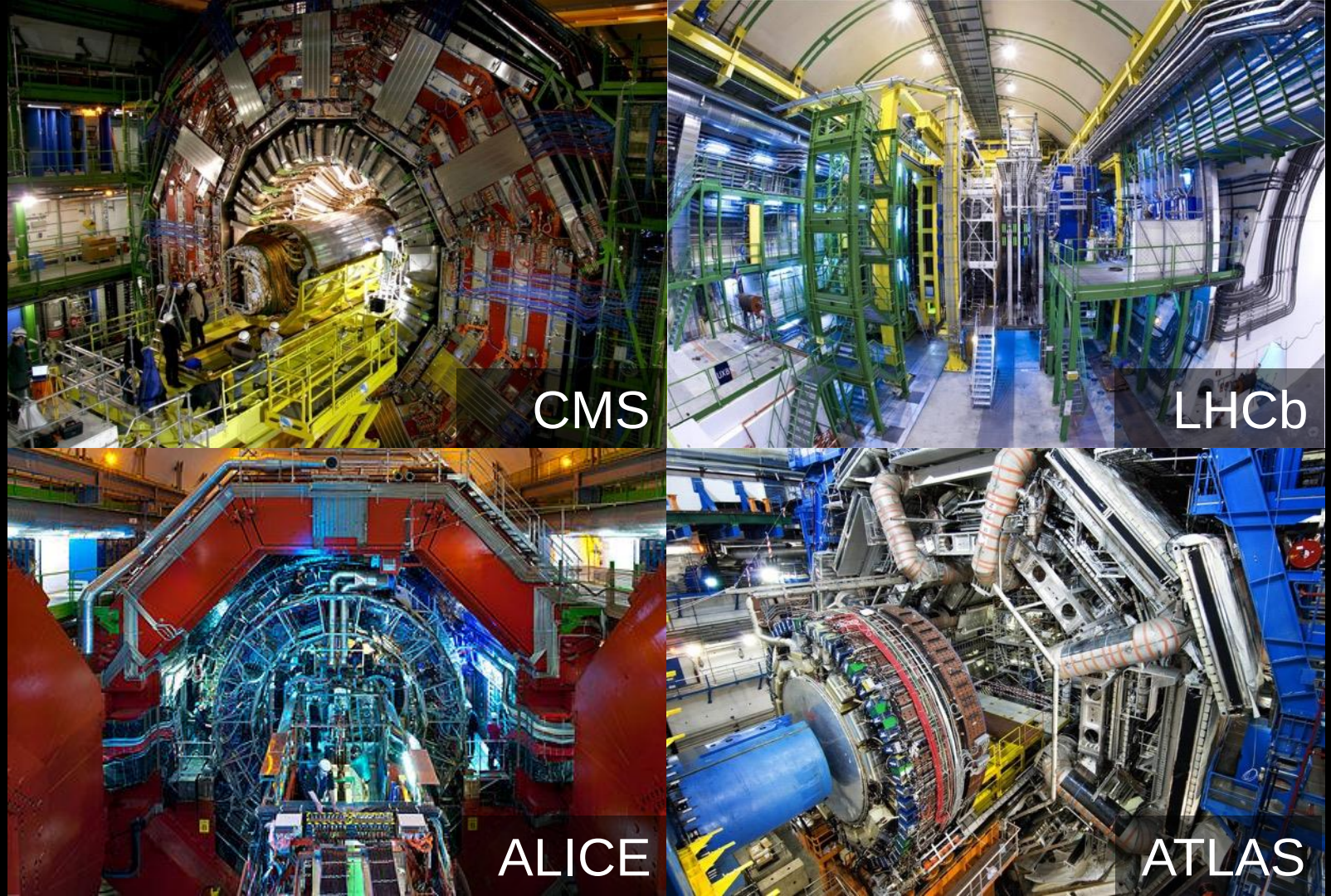
The Brout-Englert-Higgs Mechanism

The Large Hadron Collider at CERN

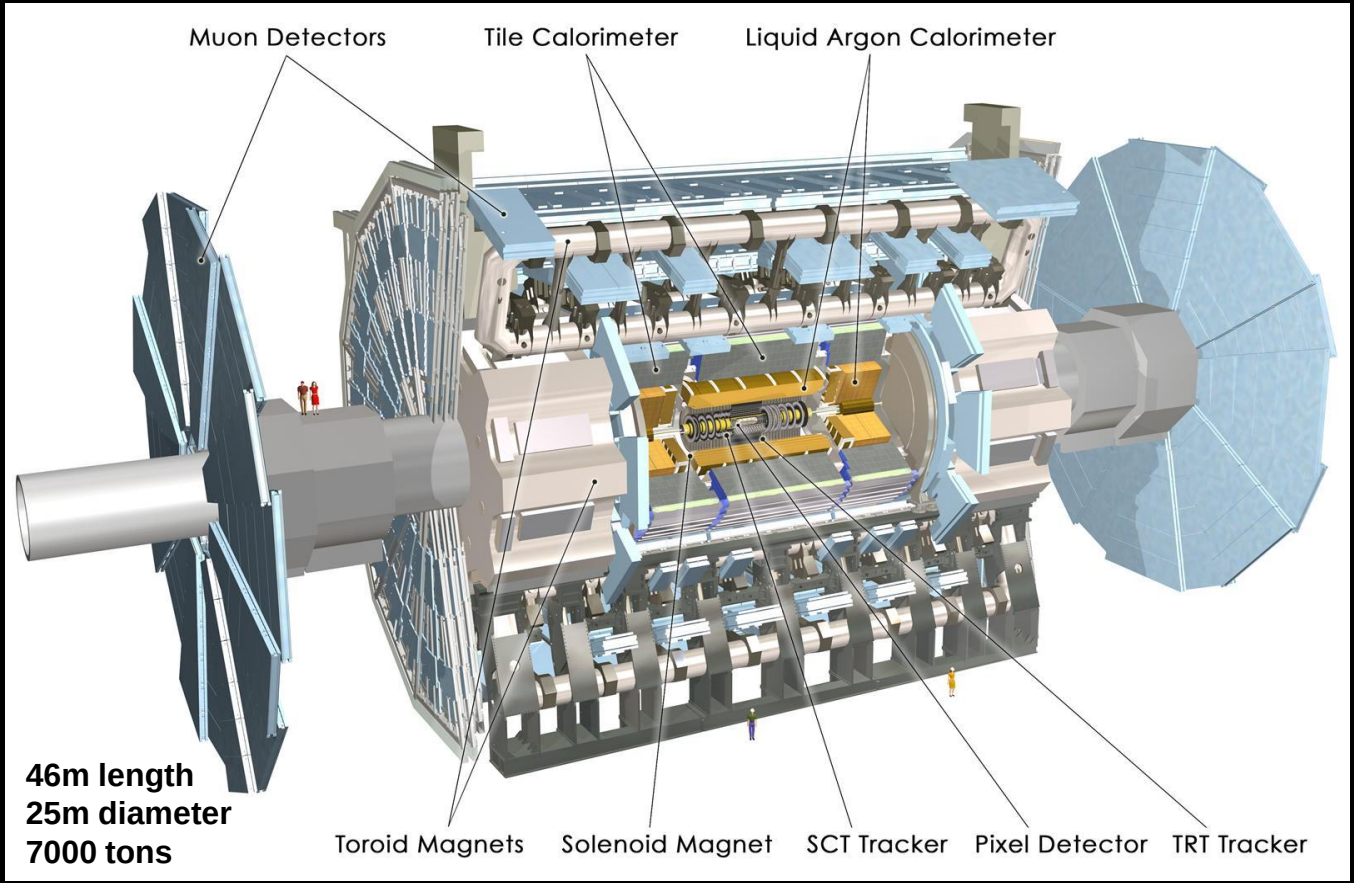


The Large Hadron Collider at CERN

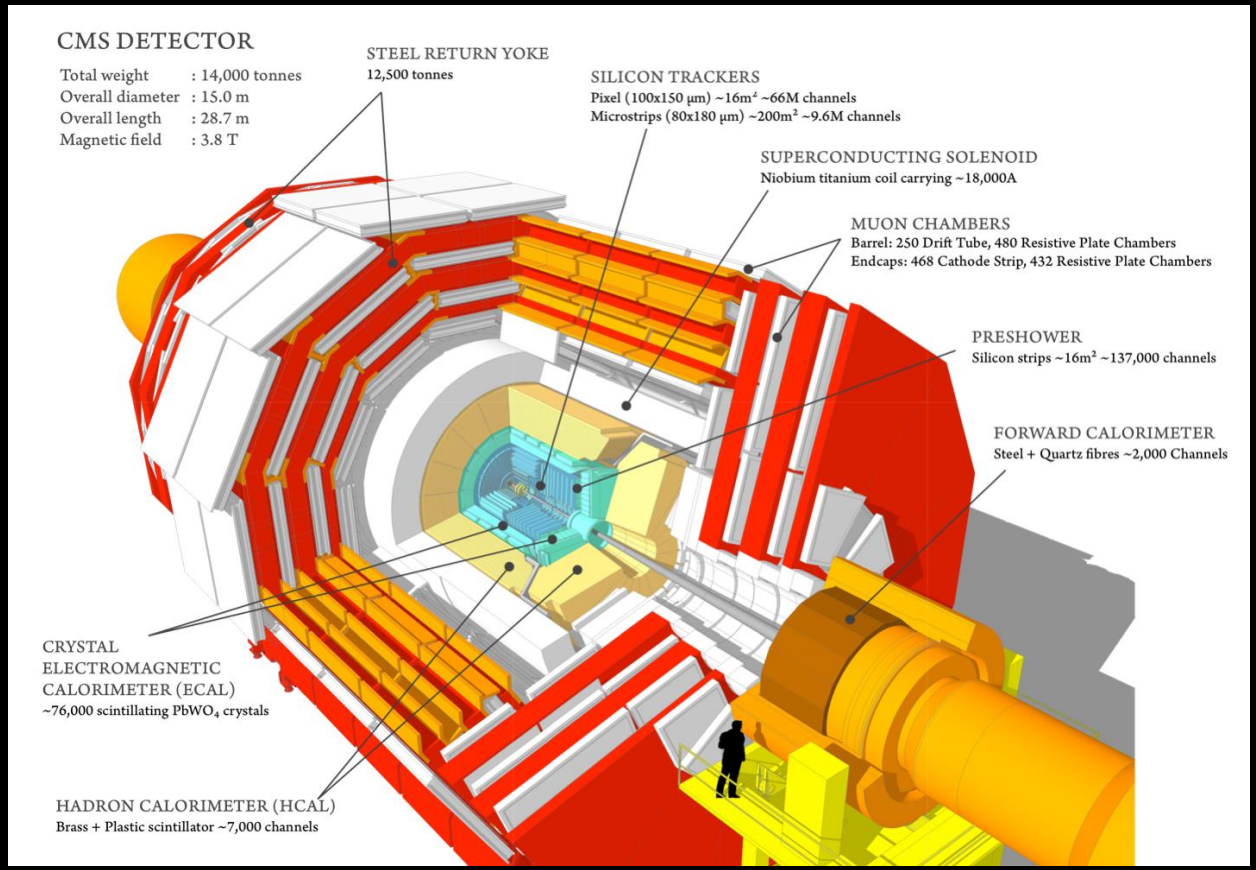



CMS
LHCb
ALICE
ATLAS

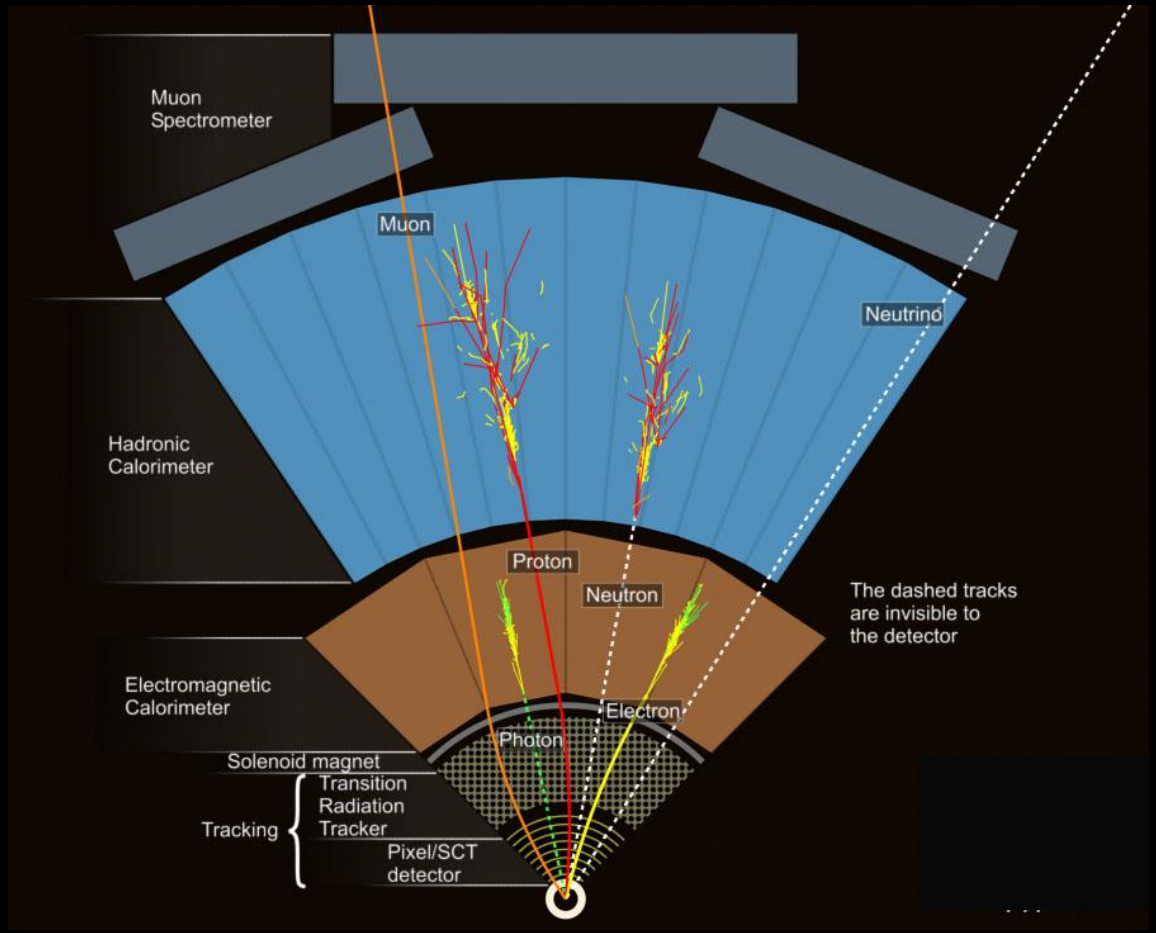
The ATLAS Detector

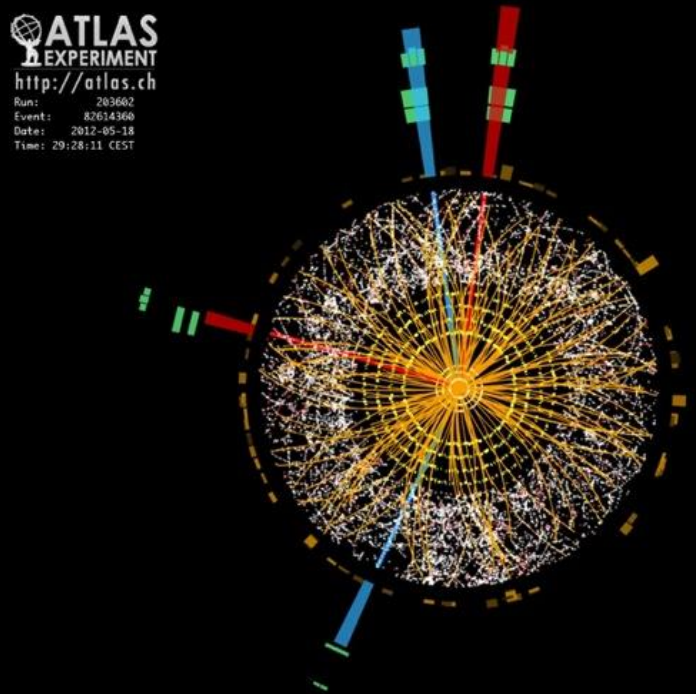


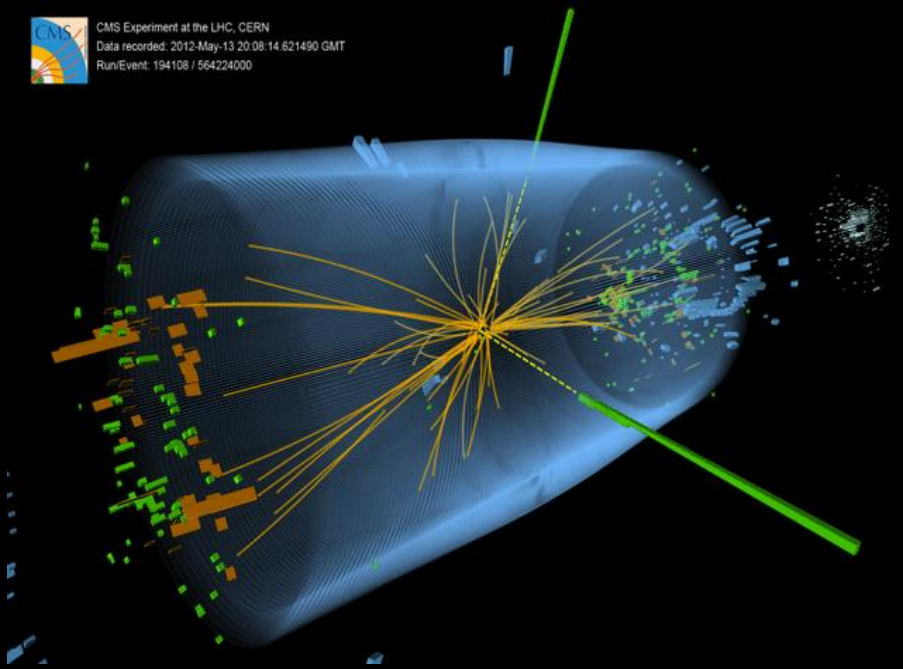
The CMS Detector



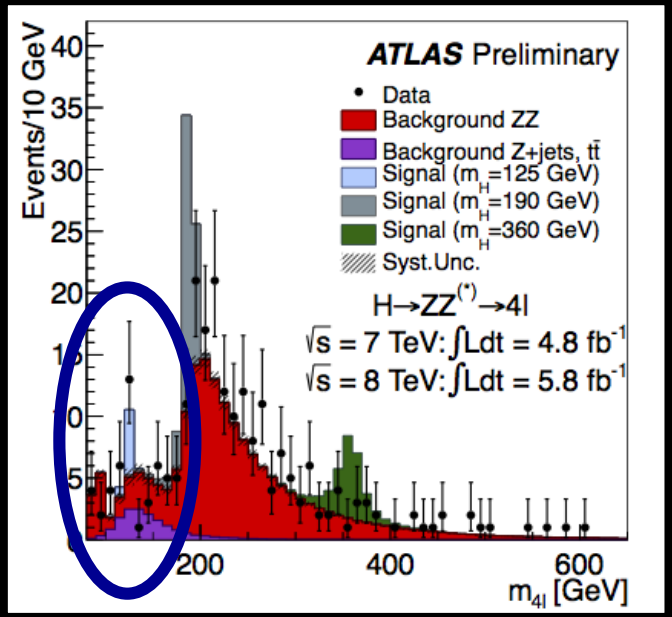
Particle Detection in ATLAS

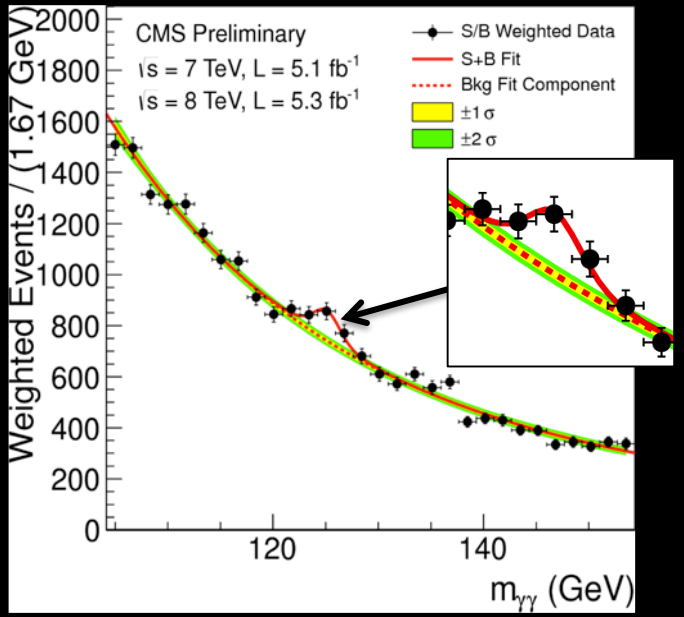


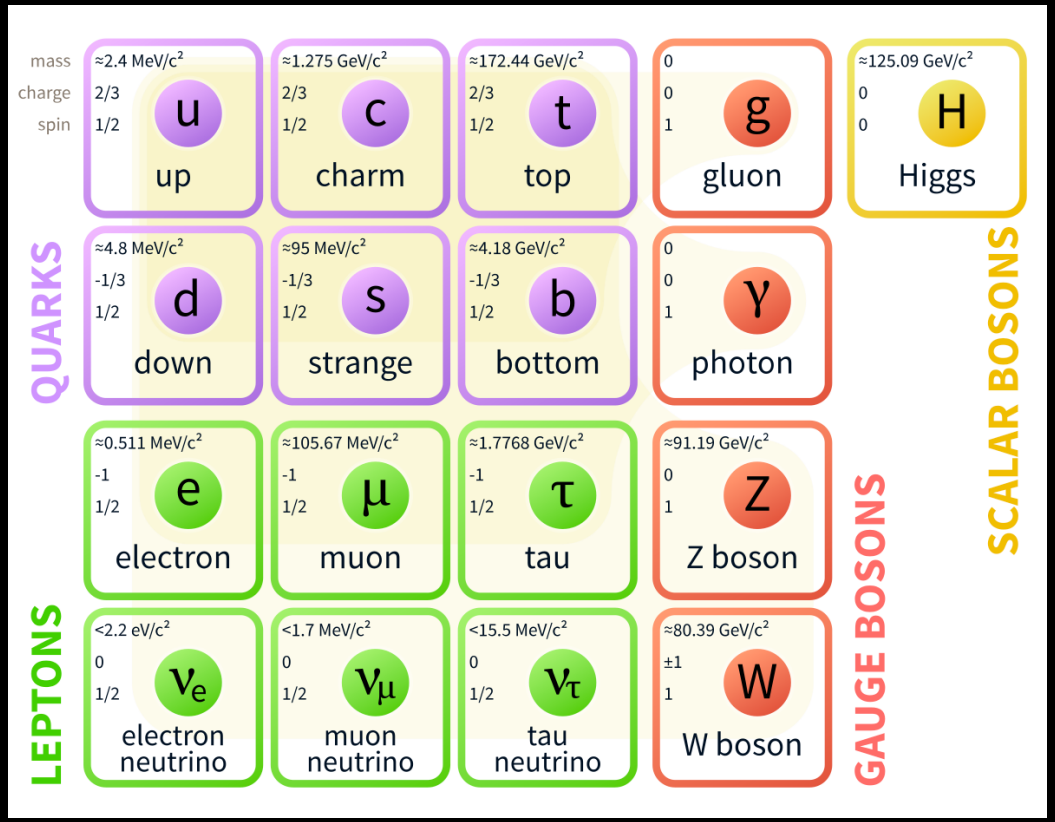

ATLAS
EXPERIMENT
http://atlas.ch
Run: 203602
Event: 82614360
Date: 2012-05-18
Time: 29:28:11 CEST

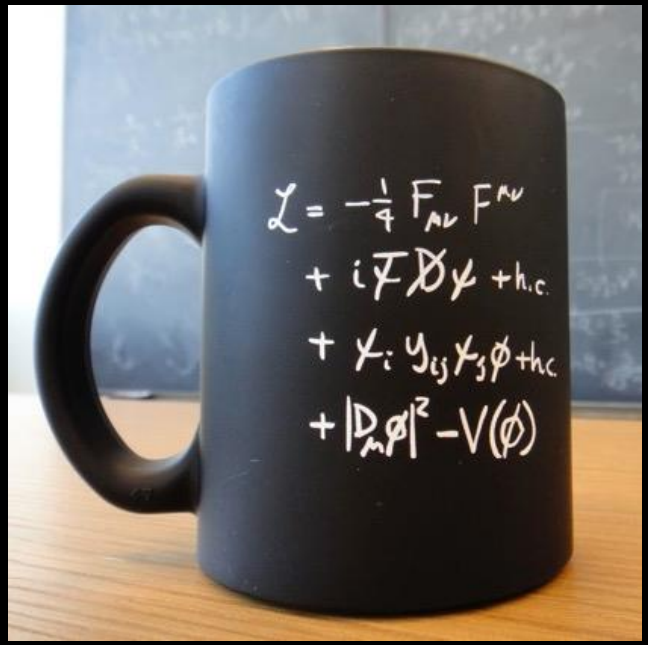

CMS Experiment at the LHC, CERN
Data recorded: 2012-May-13 20:08:14.621490 GMT
Run/Event: 194108 / 564224000

2012


ATLAS Preliminary
Data
Background ZZ
Background Z+jets, tt̄
Signal (m_H=125 GeV)
Signal (m_H=190 GeV)
Signal (m_H=360 GeV)
Syst.Unc.
H→ZZ^(*)→4l
√s = 7 TeV: ∫Ldt = 4.8 fb^-1
√s = 8 TeV: ∫Ldt = 5.8 fb^-1
Events/10 GeV
m_4l [GeV]


CMS Preliminary
√s = 7 TeV, L = 5.1 fb^-1
√s = 8 TeV, L = 5.3 fb^-1
S/B Weighted Data
S+B Fit
Bkg Fit Component
±1σ
±2σ
Weighted Events / (1.67 GeV)
m_γγ (GeV)





The Standard Model of Particle Physics

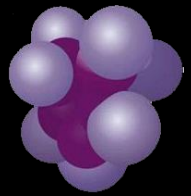

What we still don’t know

Where do we come from?
Where are we going?


Why do we exist at all?

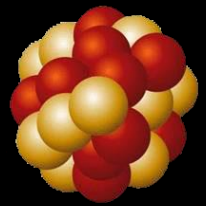
What are we made of ?

10^{-1} m
visible stuff

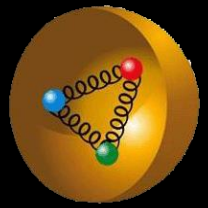


10^{-9} m
molecule

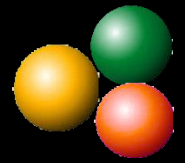
10^{-10} m
atom



10^{-14} m
nucleus

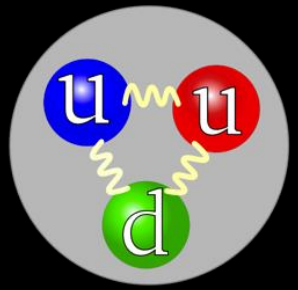


10^{-15} m
proton
neutron

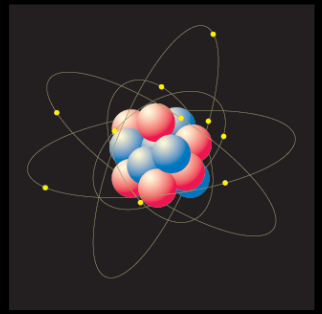


$< 10^{-18}$ m
quark
electron

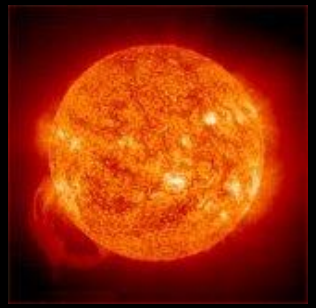
Why is gravity so weak?



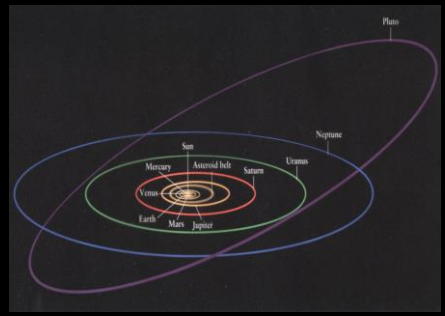
Strong Nuclear
60



Electromagnetism
1



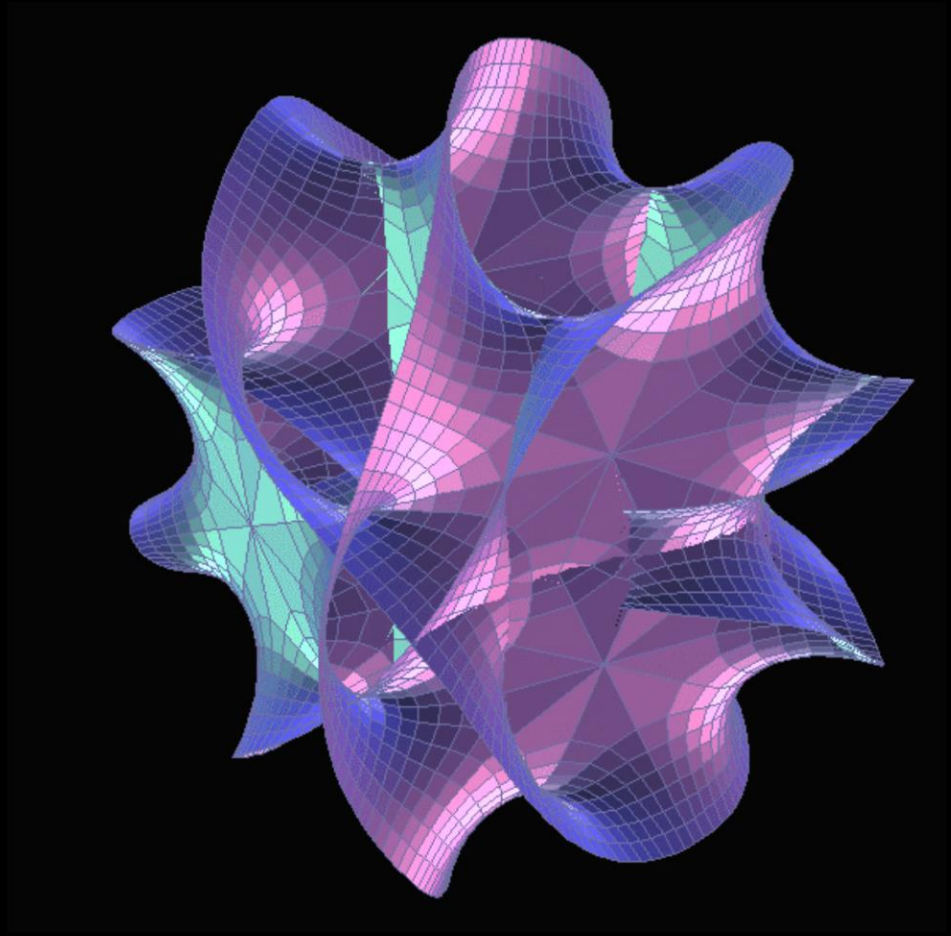
Weak Nuclear
10^{-4}



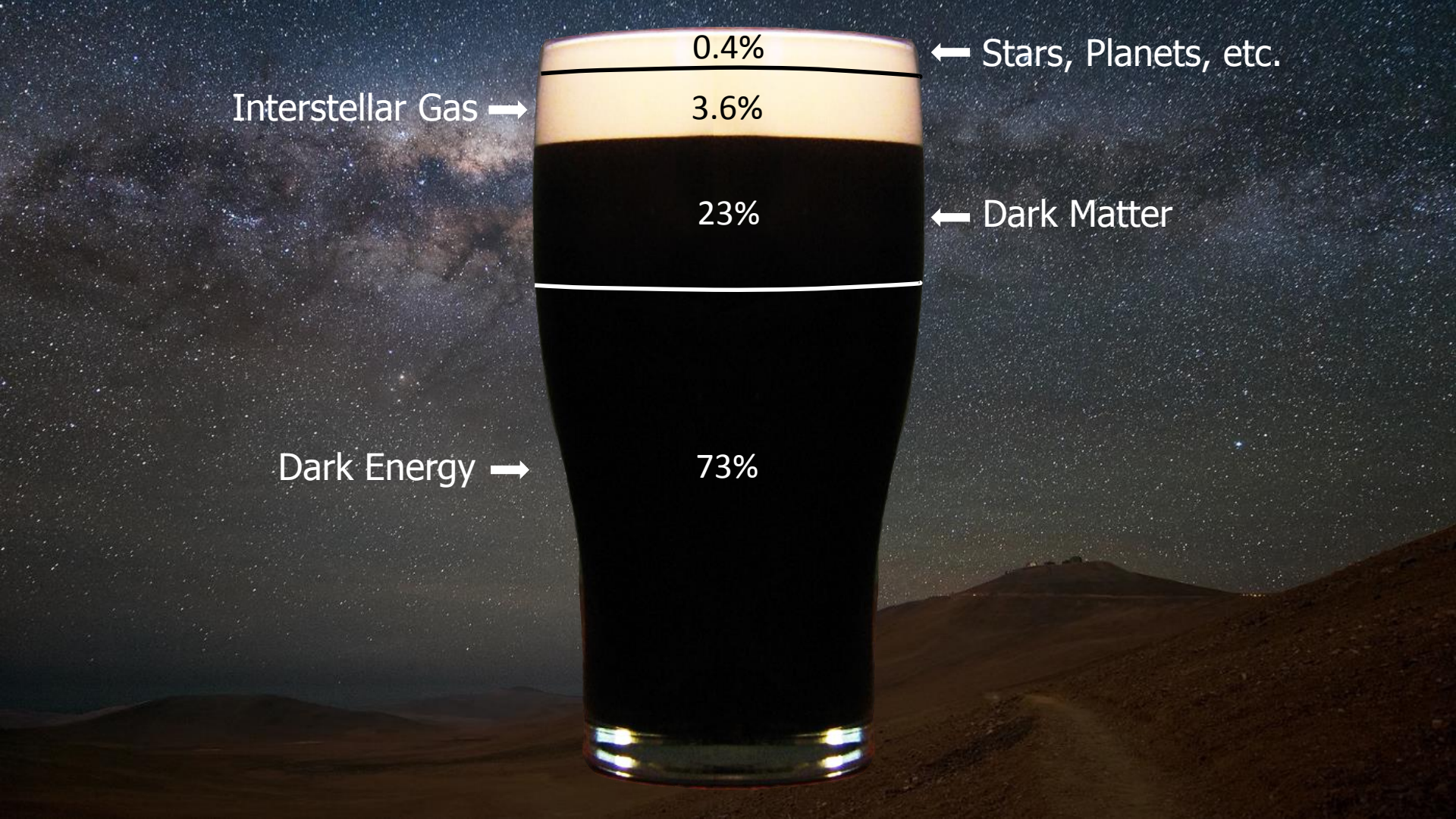
Gravity
10^{-41}

Relative force strengths specified at scale of quarks and gluons

Could there be other dimensions?

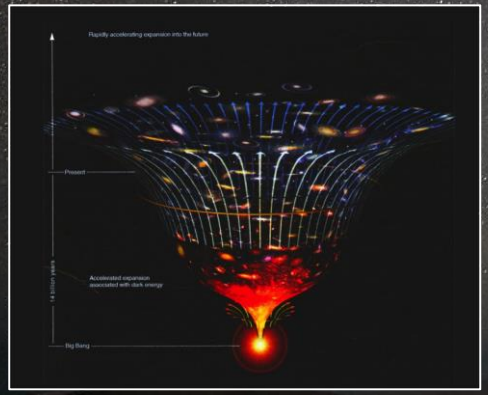


What is holding this together?


0.4%
Stars, Planets, etc.
Interstellar Gas
3.6%
23%
Dark Matter
Dark Energy
73%

?

?


Rapidly accelerating expansion into the future
Present
Accelerated expansion
associated with dark energy
Big Bang

0.4%

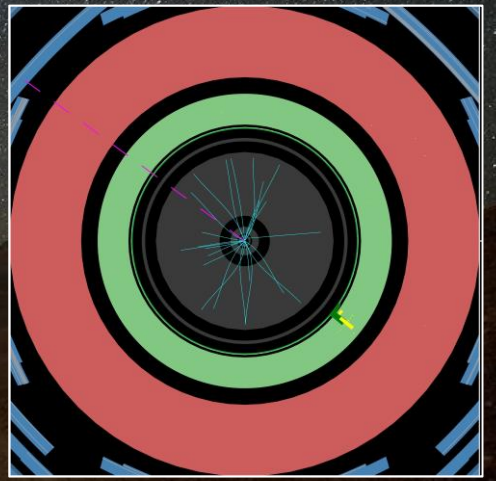
3.6%

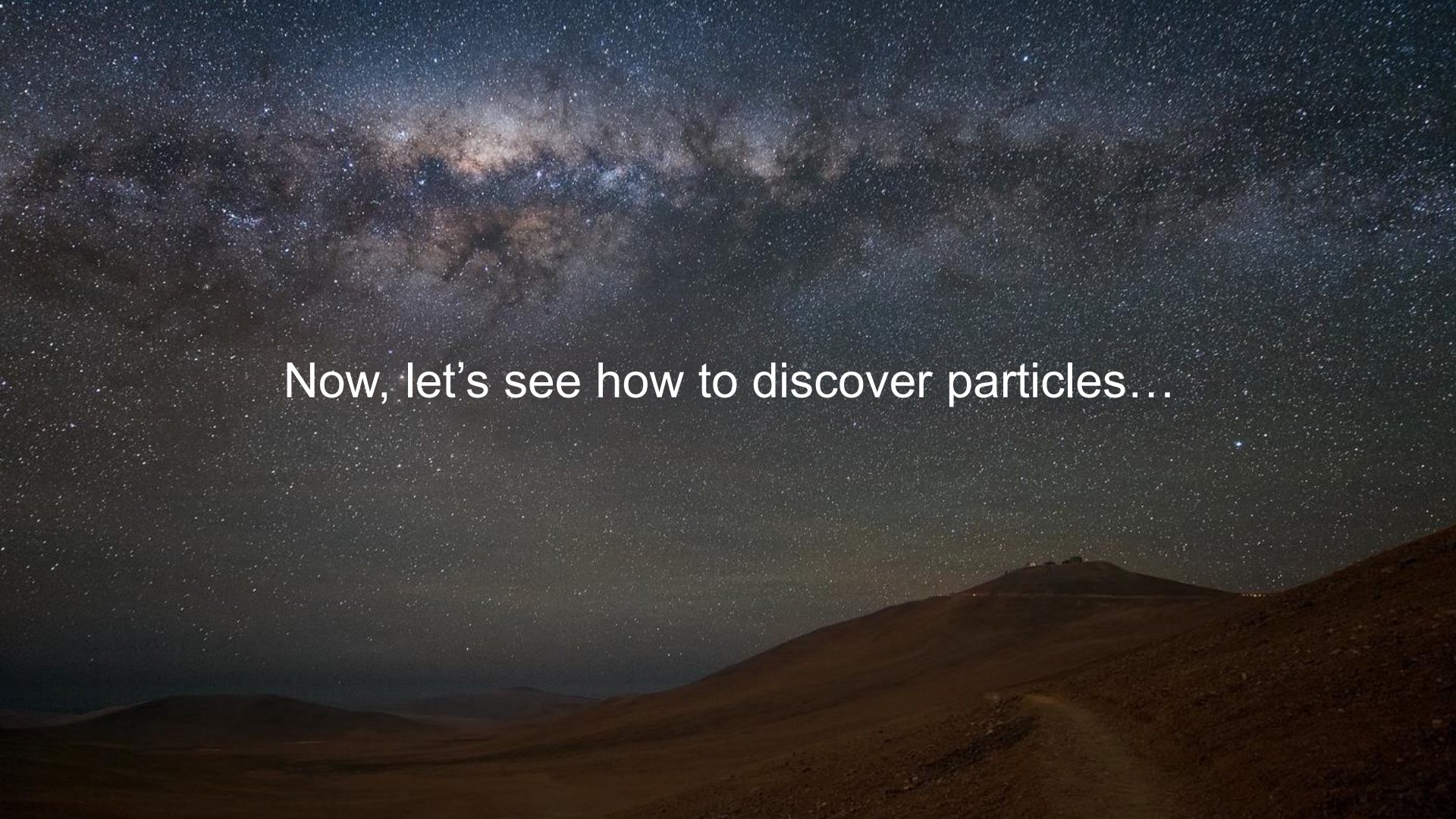
23%

73%


LONDON
PRIDE

?




Now, let’s see how to discover particles…