



# Hidden Pieces

An introduction to the ATLAS Experiment





The background of the slide is a photograph of a night sky. The Milky Way galaxy is visible as a bright, hazy band of light stretching across the upper half of the frame. Below the sky, there are dark, rolling sand dunes. A small, distant light source, possibly a planet or star, is visible on the right side of the sky.

## **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



PREVIOUS STORY

'NIGHTS into Dreams' HD remake teased by Sega with new picture

Samba ad-supported

Published: Jul 4th, 2012

New Particle Consistent with Higgs Discovered at CERN

# The Higgs boson: CERN discover the elusive

By **Vlad Savov** on July 4, 2012 06:53 am Email @vladsavov



2. 遺伝子技術が変える世界
3. スーパープレアの脅威
4. 並行宇宙は実在する
5. 無私は最高の戦略

## 編集部ピックアップ

1. 最悪のシナリオ
2. SARSが残した本当の脅威
3. 最強加速器で発見
4. HIVに感染しない細胞
5. 脳はなぜ左右で分業したのか

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A July 2012 Last updated at 07:10 GMT

Higgs boson-like particle discovery claimed at CERN

By Paul Rincon  
Science editor, BBC News website, Science

The Higgs boson-like particle discovery claimed at CERN

CERN scientists reporting from the Large Hadron Collider (LHC) have claimed the discovery of a new particle consistent with the Higgs boson.

The particle has been the subject of a 40-year hunt to explain how matter gets its mass.

Birth of the Higgs boson hunting experiments at the LHC saw a series of updates in their case work at CERN.

The Higgs boson-like particle discovery claimed at CERN

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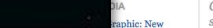
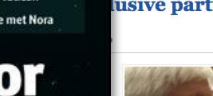
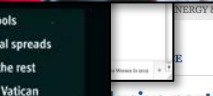
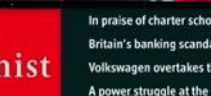
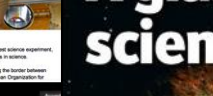
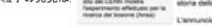
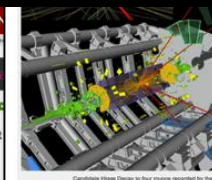
The Higgs boson-like particle discovery claimed at CERN

The Higgs boson-like particle discovery claimed at CERN

The Higgs boson-like particle discovery claimed at CERN

The Higgs boson-like particle discovery claimed at CERN

# One Billion Viewers



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PR

Sarmila Bose

Sarmila Bose is Senior Research Fellow in the Politics of South Asia at the University of Oxford.

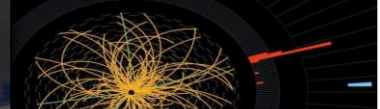
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son: Dark matters in the coverage of the 'god'

It's media leave out in reporting this scientific breakthrough?

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GENEVA, July 4, 2012

## usive particle found, looks like Higgs boson

SHARE COMMENT (40) PRINT T+



British physicist Peter Higgs congratulates Fabiola Gianotti, ATLAS experiment spokesperson, after her results presentation during a scientific seminar to deliver the latest update in the search for the Higgs boson at the European Organisation for Nuclear Research (CERN) in Meyrin near Geneva on Wednesday.

PHOTO: New

CERN physicists hail evidence of game-changing discovery of subatomic particle

## The Economist

July 7th - 13th 2012 Economist.com

In praise of charter schools  
Britain's banking scandal spreads  
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A power struggle at the Vatican  
When Lonesome George met Nora


# A giant leap for science



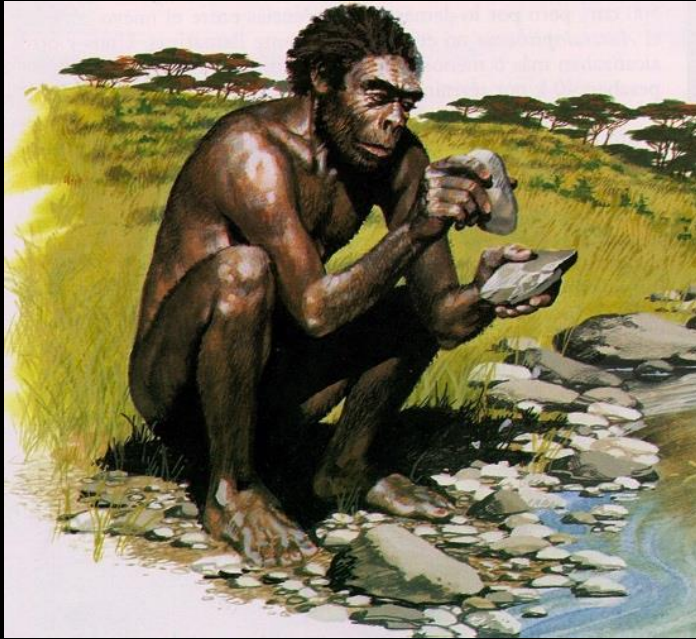
## Finding the Higgs boson





A wide-angle photograph of a night sky over a desert landscape. The Milky Way galaxy is prominently visible, stretching diagonally across the upper half of the frame. The sky is filled with numerous stars of varying brightness. The foreground shows dark, rolling sand dunes under the starry sky. The word "Why?" is centered in the middle of the image in a white, sans-serif font.

Why?



Physics Seminar – 4 July 2000012 BCE



A long-exposure photograph of a night sky. The Milky Way galaxy is visible as a bright, hazy band of light stretching across the upper half of the frame. The sky is filled with numerous stars of varying brightness. In the foreground, the dark, silhouetted ridges of sand dunes are visible against the starry background. The overall scene is dark and atmospheric, evoking a sense of vastness and wonder.

We have Big Questions...



A long-exposure photograph of a night sky over a desert landscape. The Milky Way galaxy is prominently visible, stretching across the upper half of the frame. The sky is filled with numerous stars, and the foreground shows dark, rolling sand dunes under a clear night sky. The text "Where do we come from?" is centered in the middle of the image.

Where do we come from?



A wide-angle photograph of a desert landscape at night. The foreground shows rolling sand dunes under a dark sky. The Milky Way galaxy is prominently visible, stretching across the upper half of the frame. The text "What are we made of ?" is centered in the middle of the image.

What are we made of ?



A wide-angle photograph of a desert landscape at night. The foreground shows rolling sand dunes under a dark sky. The Milky Way galaxy is prominently visible, stretching across the upper half of the frame. The text "What is our destiny?" is centered in the middle of the image.

What is our destiny?





What are the rules behind all this?





Is there anything else we don't see?





Photo: Eric Wiessner CC-BY-SA



Human Hair (15cm away)



Photo: Steven Goldfarb, CC-BY-SA

Andromeda (2.5 million light years away)



Photo: Thomas Bresson, CC-BY-SA



Good enough?



Never!



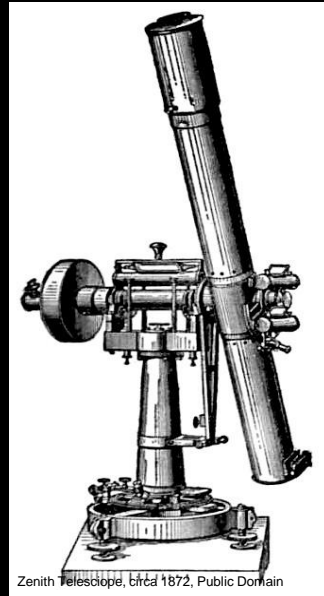
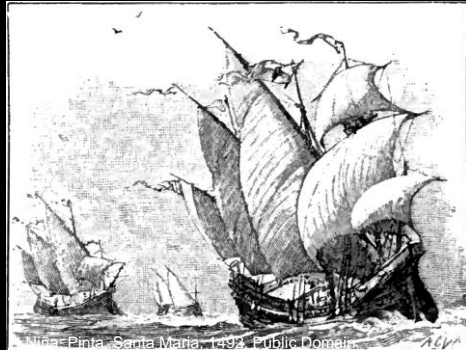
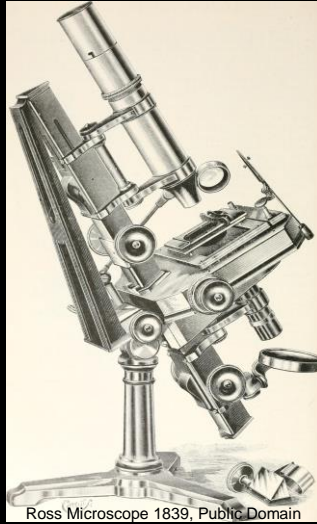




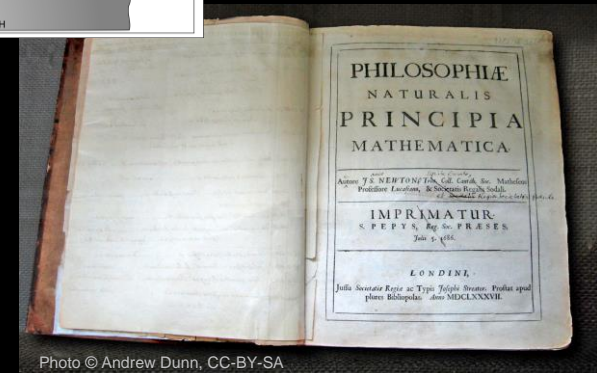
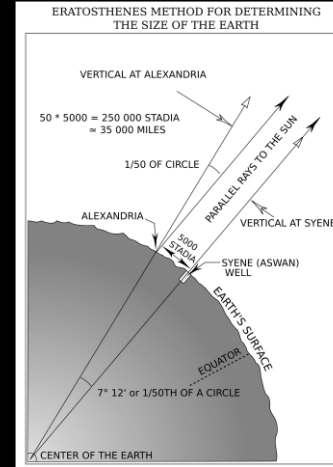
How do we measure what we can't see?



# Exploration

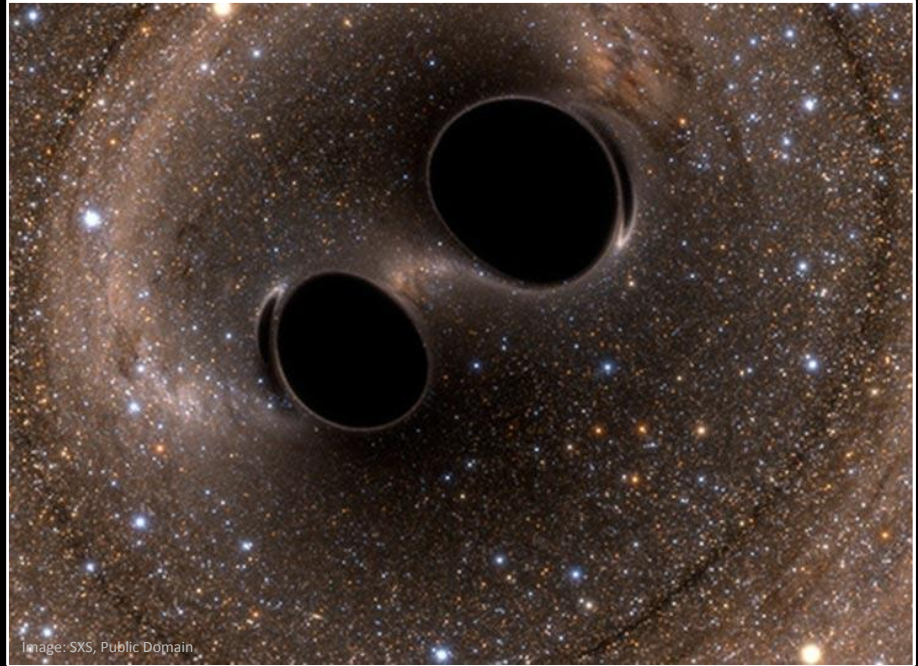
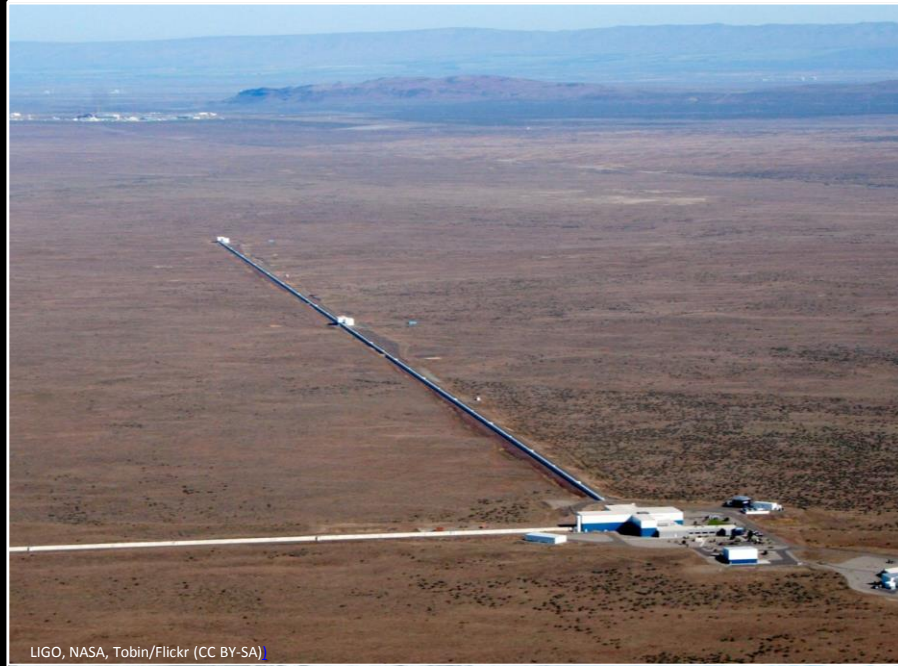


# Extrapolation



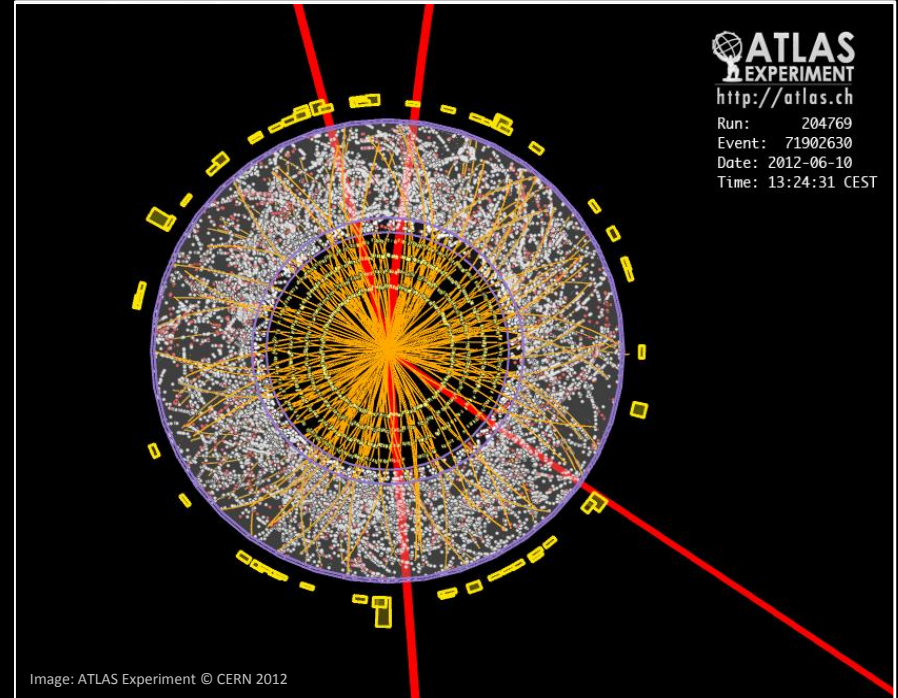
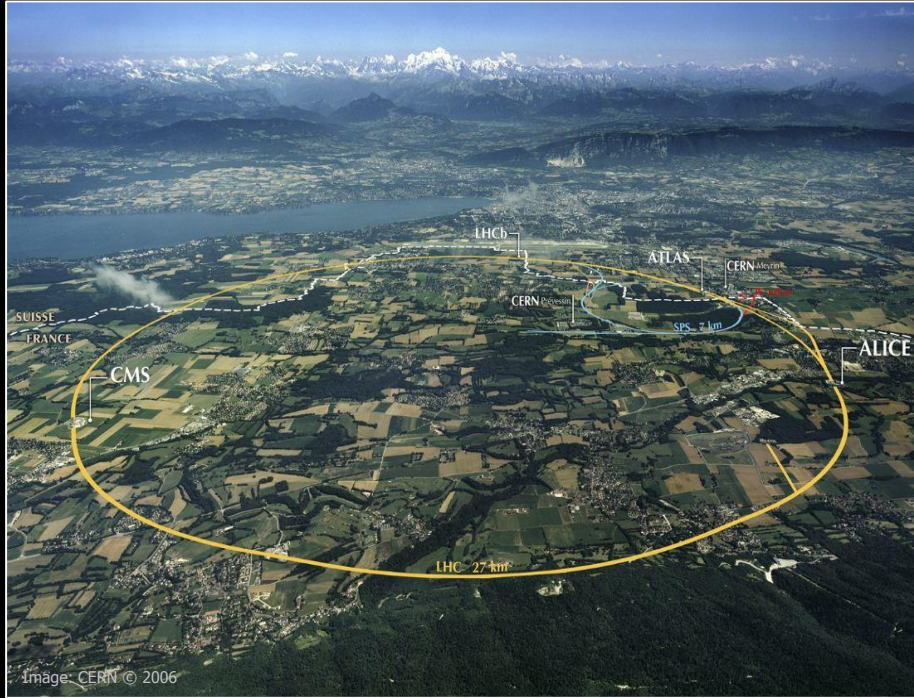


# Looking out





# Looking in



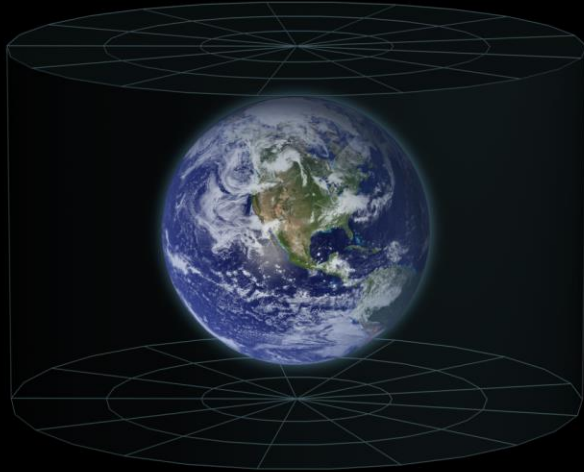


A long-exposure photograph of a night sky. The Milky Way galaxy is visible as a bright, hazy band of light stretching across the upper half of the frame. The sky is filled with numerous stars of varying brightness. In the foreground, the dark, undulating silhouettes of sand dunes are visible against the starry background. The overall scene is a vast, open landscape under a clear, star-filled sky.

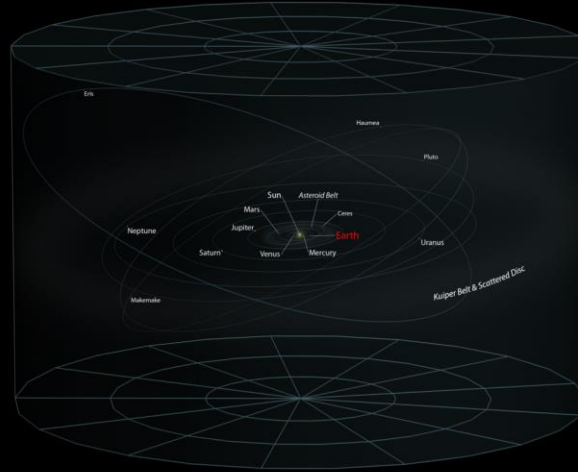
What have we learned?



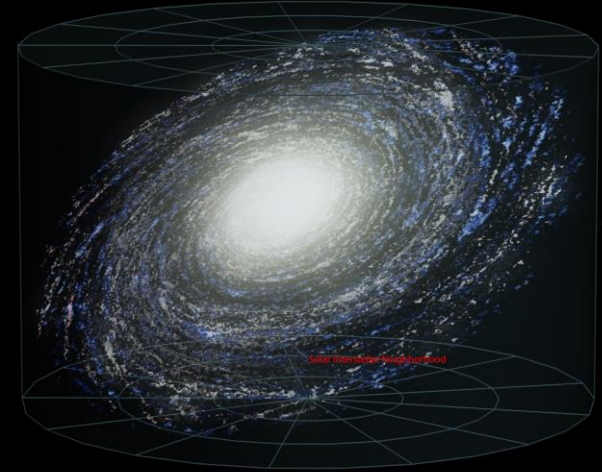
## EARTH



## SOLAR SYSTEM



## MILKY WAY GALAXY



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

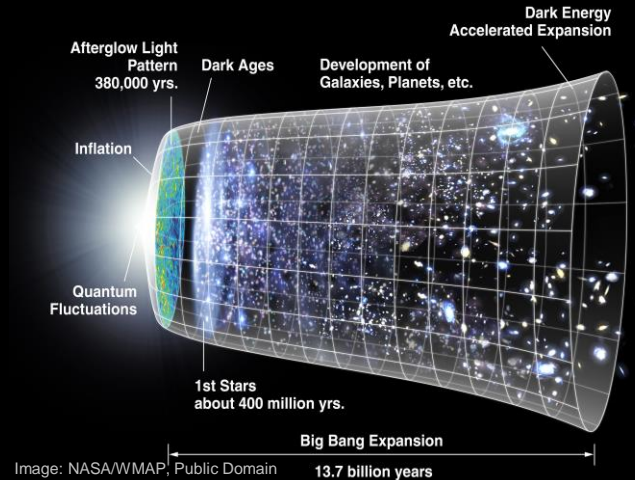
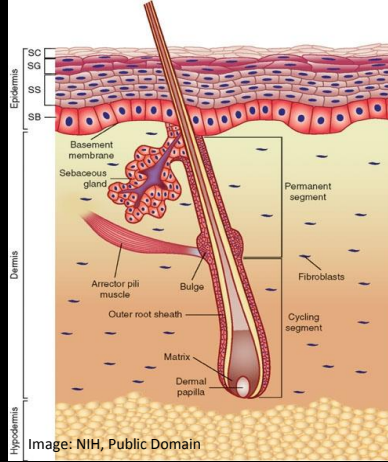
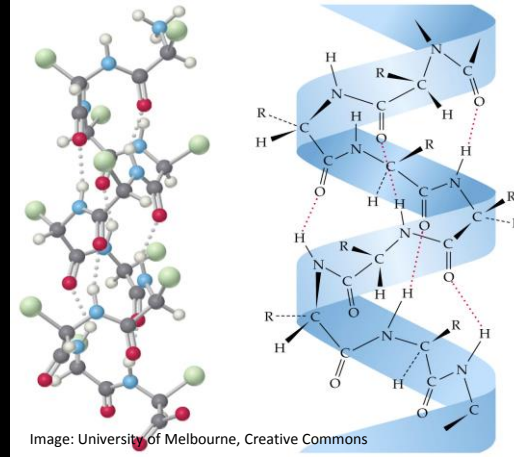


Image: NASA/WMAP, Public Domain

## CELL



## MOLECULE



## ATOM

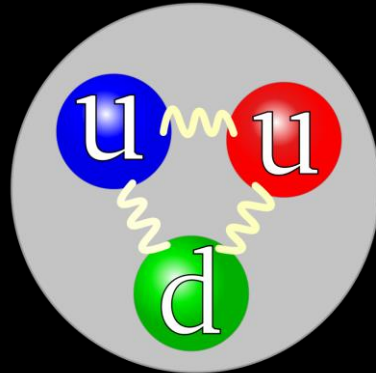
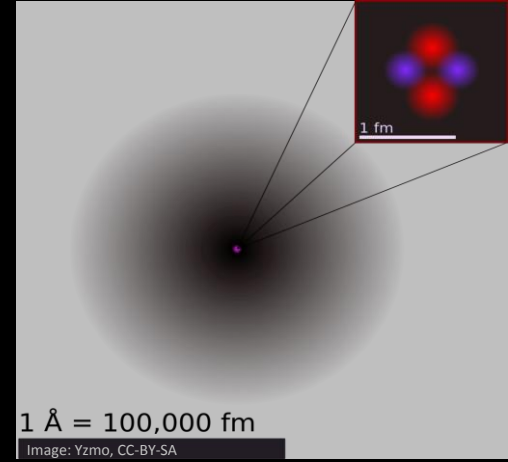


Image: Arpad Horvath, CC-BY-SA

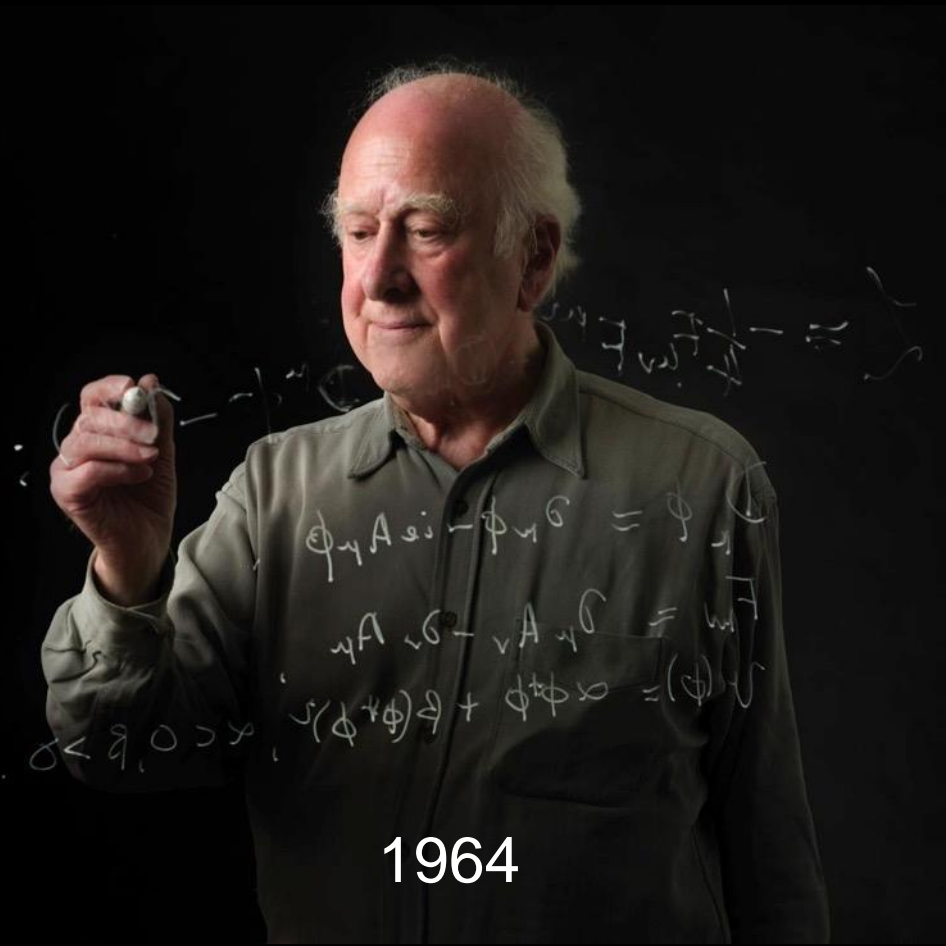
LEPTONS	mass charge spin	$\approx 2.4 \text{ MeV}/c^2$ $2/3$ $1/2$ <b>u</b> up	$\approx 1.275 \text{ GeV}/c^2$ $2/3$ $1/2$ <b>c</b> charm	$\approx 172.44 \text{ GeV}/c^2$ $2/3$ $1/2$ <b>t</b> top	$0$ $0$ $1$ <b>g</b> gluon
		$\approx 4.8 \text{ MeV}/c^2$ $-1/3$ $1/2$ <b>d</b> down	$\approx 95 \text{ MeV}/c^2$ $-1/3$ $1/2$ <b>s</b> strange	$\approx 4.18 \text{ GeV}/c^2$ $-1/3$ $1/2$ <b>b</b> bottom	$0$ $0$ $1$ <b><math>\gamma</math></b> photon
		$\approx 0.511 \text{ MeV}/c^2$ $-1$ $1/2$ <b>e</b> electron	$\approx 105.67 \text{ MeV}/c^2$ $-1$ $1/2$ <b><math>\mu</math></b> muon	$\approx 1.7768 \text{ GeV}/c^2$ $-1$ $1/2$ <b><math>\tau</math></b> tau	$0$ $0$ $1$ <b>Z</b> Z boson
		$< 2.2 \text{ eV}/c^2$ $0$ $1/2$ <b><math>\nu_e</math></b> electron neutrino	$< 1.7 \text{ MeV}/c^2$ $0$ $1/2$ <b><math>\nu_\mu</math></b> muon neutrino	$< 15.5 \text{ MeV}/c^2$ $0$ $1/2$ <b><math>\nu_\tau</math></b> tau neutrino	$\approx 80.39 \text{ GeV}/c^2$ $\pm 1$ $1$ <b>W</b> W boson
GAUGE BOSONS					



A wide-angle photograph of a desert landscape at night. The foreground shows dark, rolling sand dunes. The sky is filled with stars, and the Milky Way galaxy is prominently visible as a bright, cloudy band of light stretching across the upper half of the frame. The text "Fundamental particles have mass?" is centered in the middle of the image.

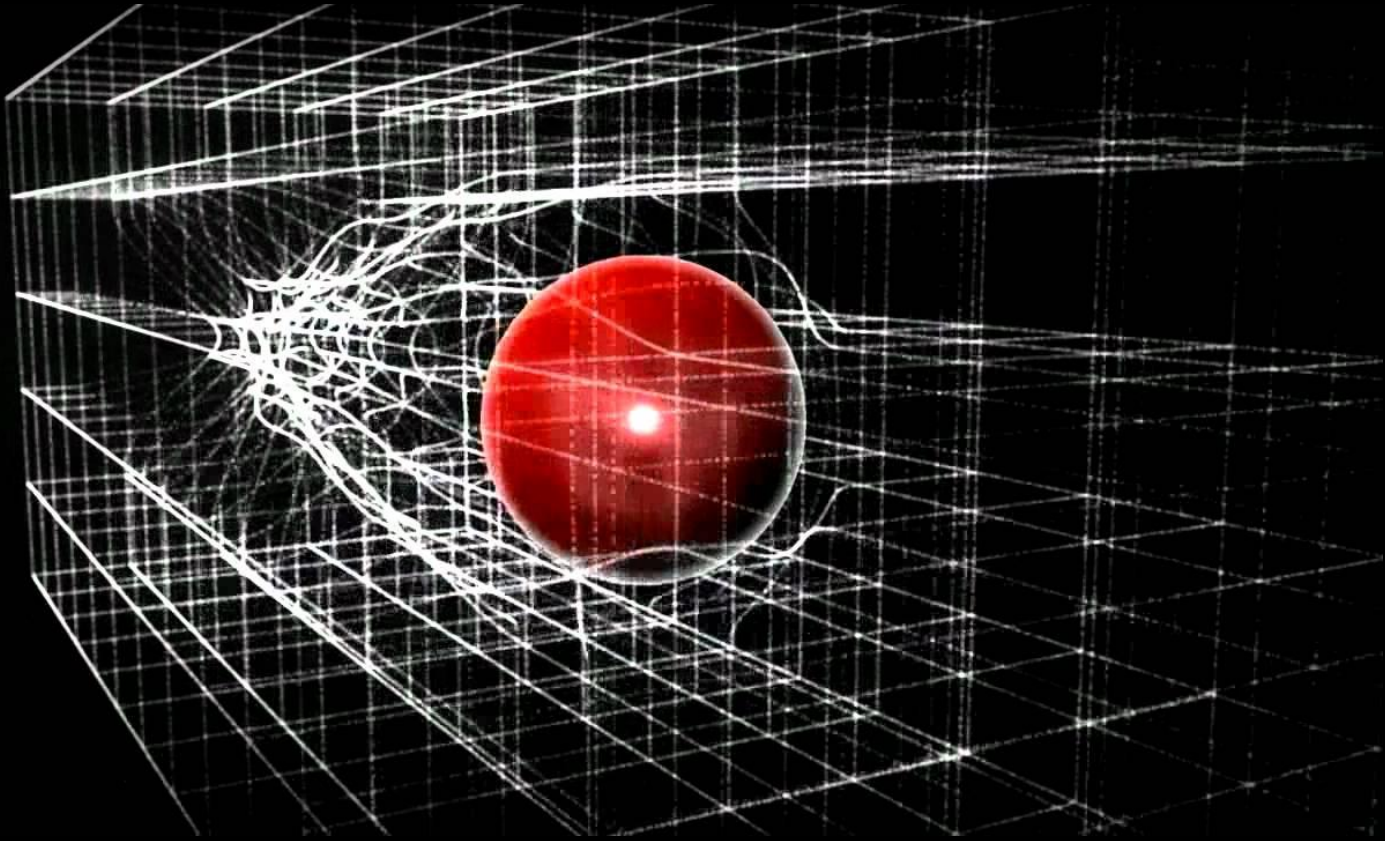
Fundamental particles have mass?

How?



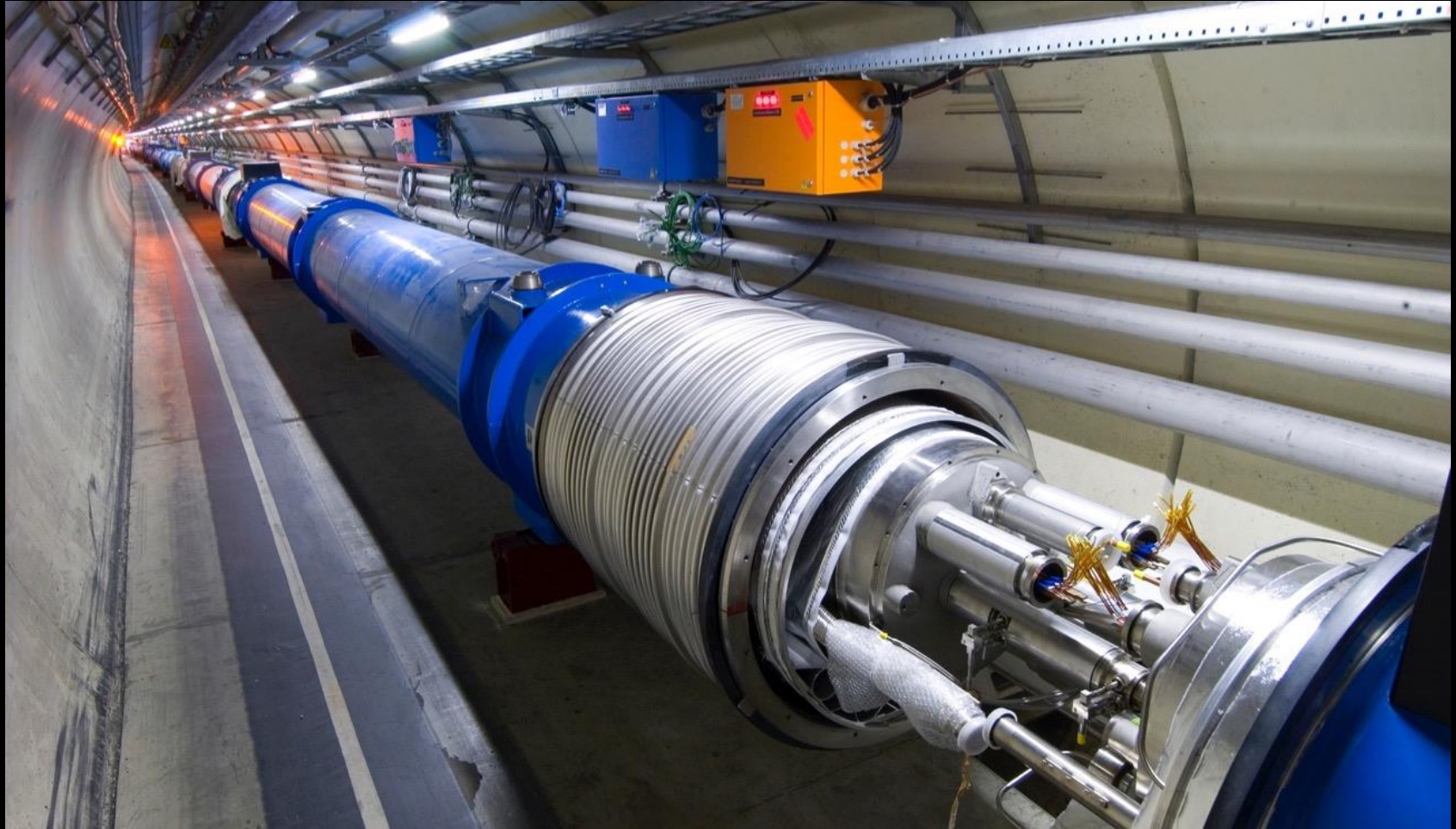
1964





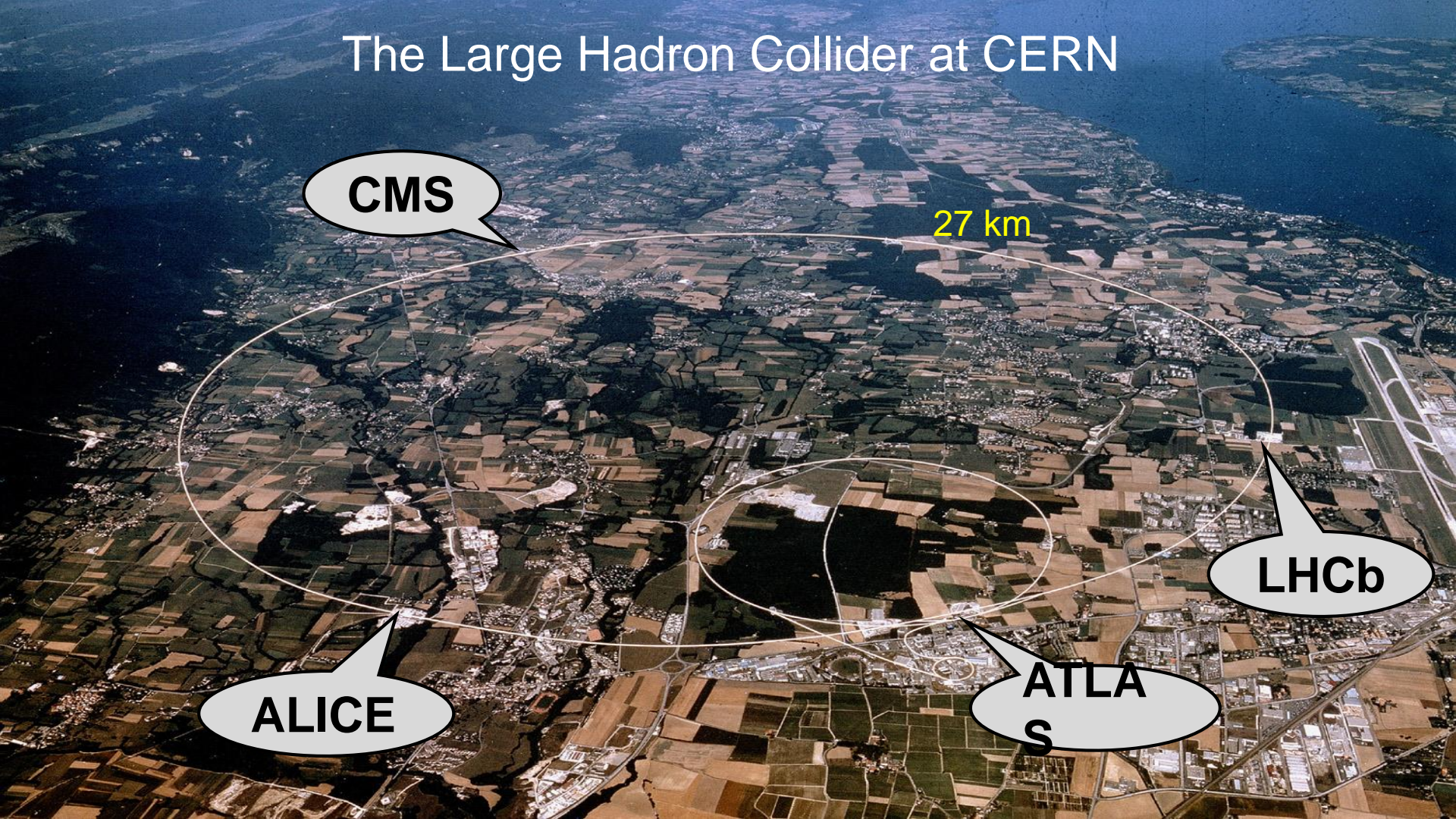
The Brout-Englert-Higgs Mechanism

# The Large Hadron Collider at CERN





# The Large Hadron Collider at CERN



**CMS**

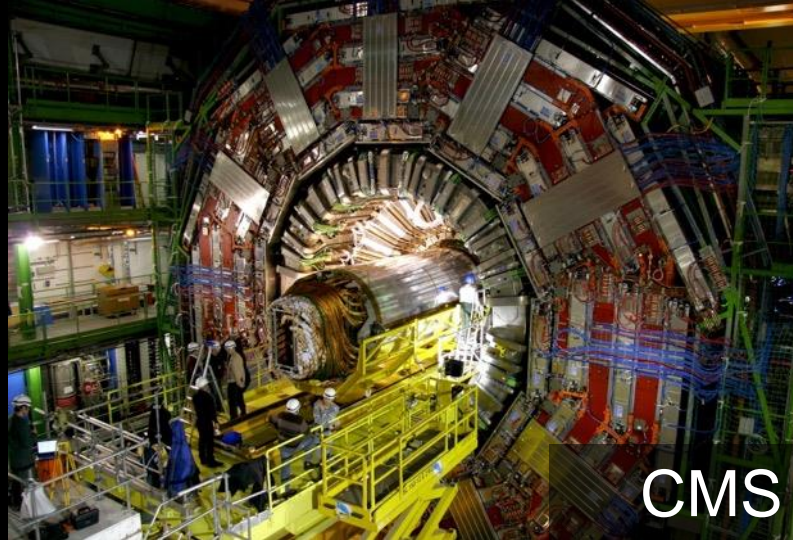
27 km

**LHCb**

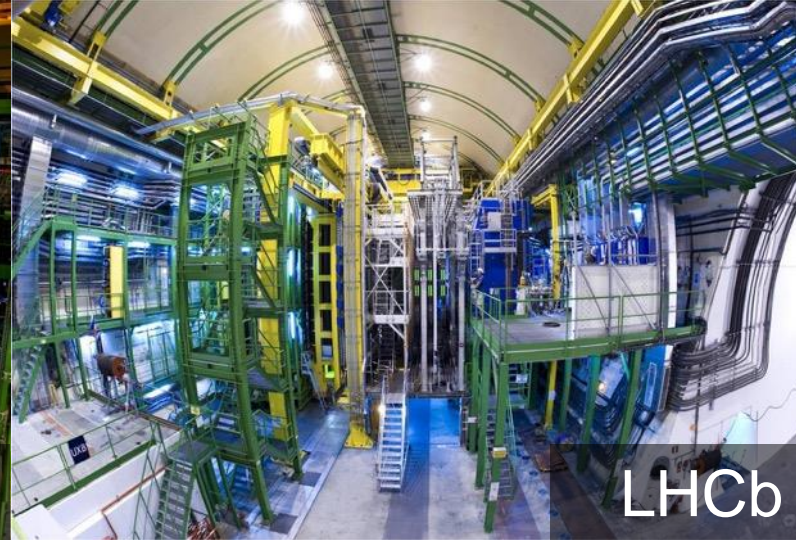
**ALICE**

**ATLAS**

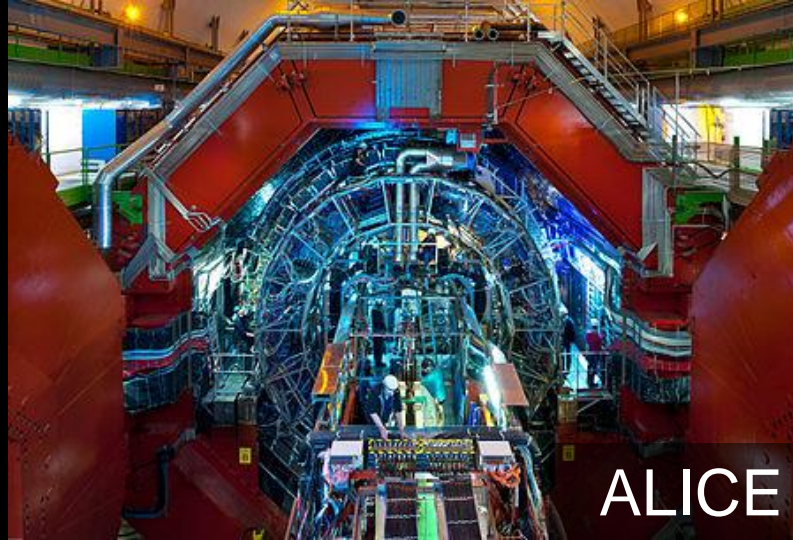




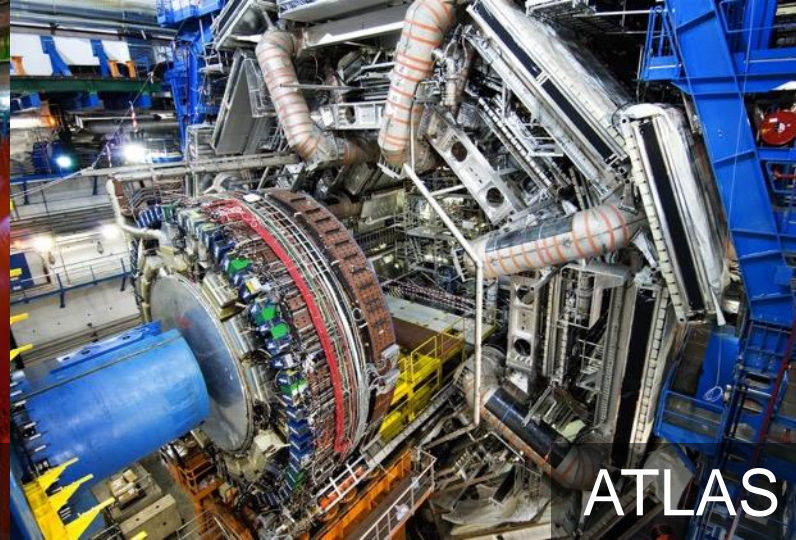
CMS



LHCb

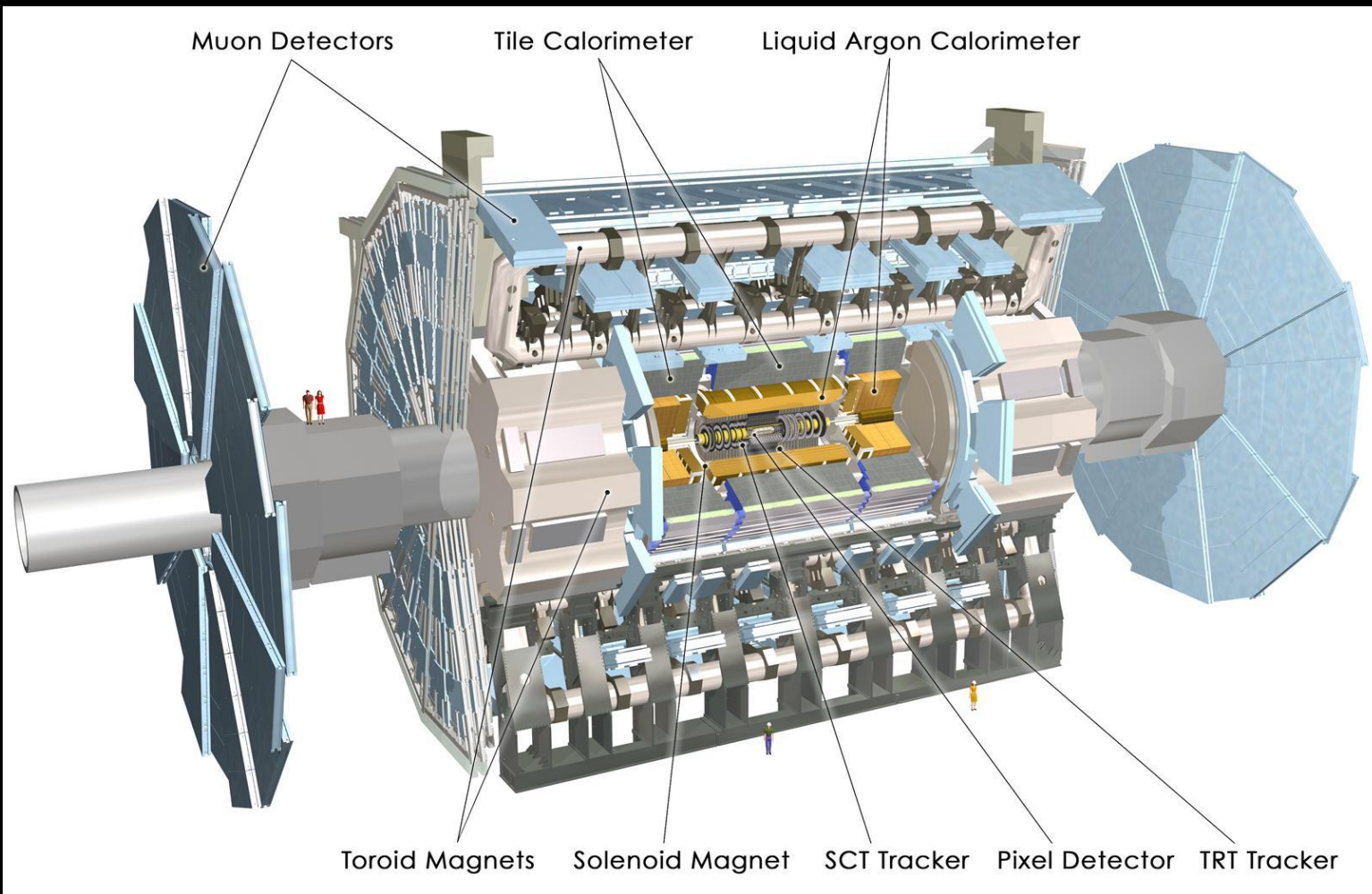


ALICE

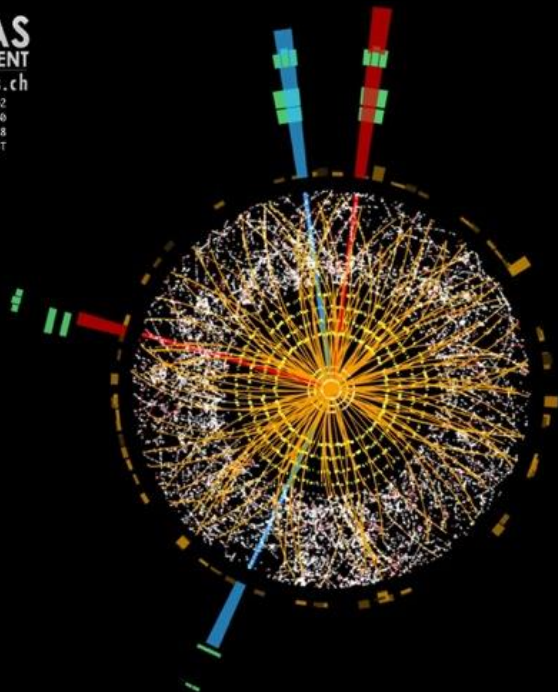


ATLAS

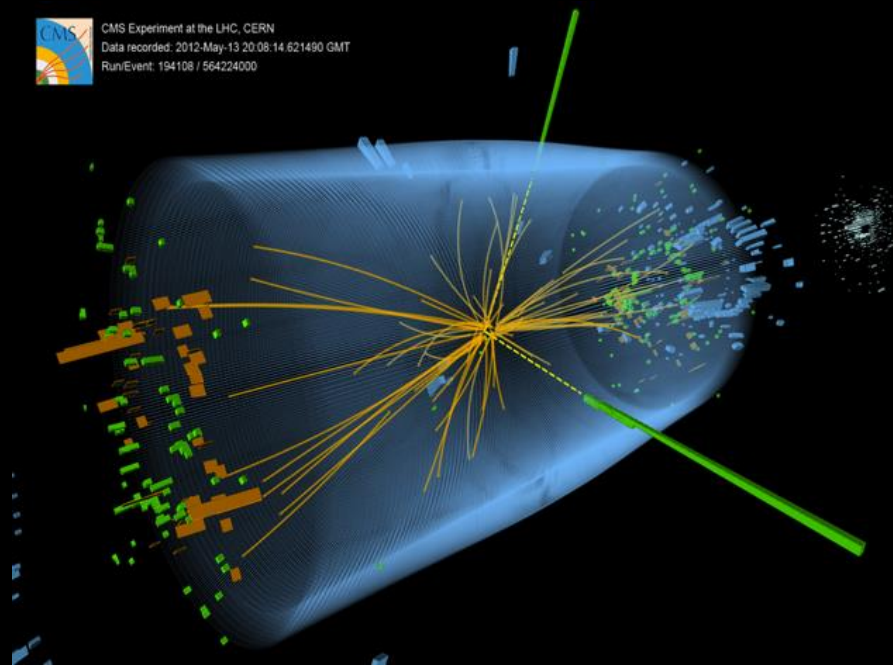




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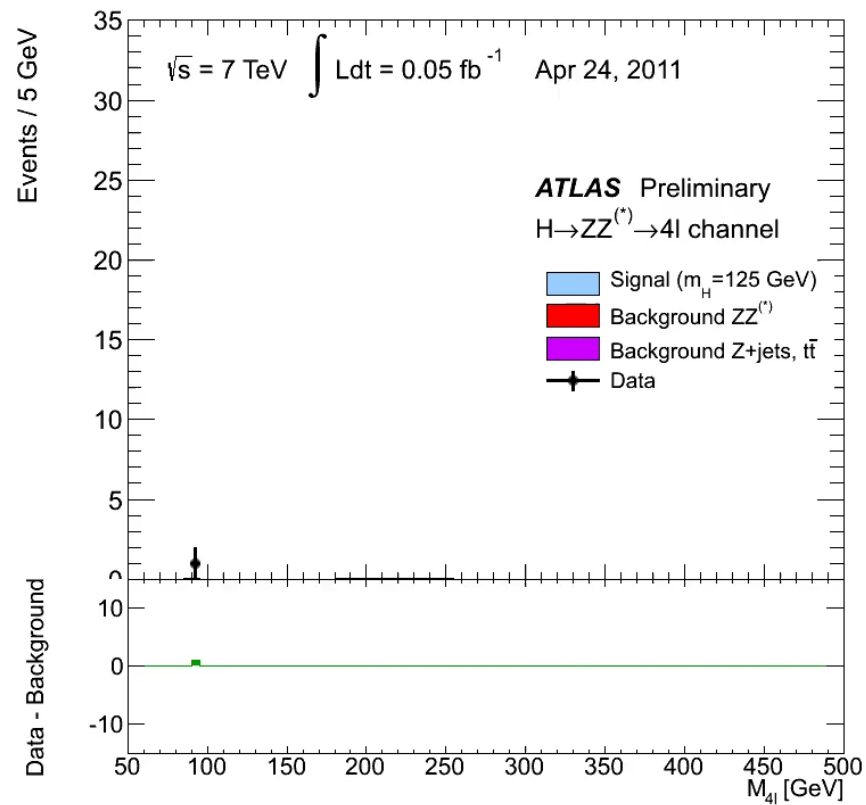
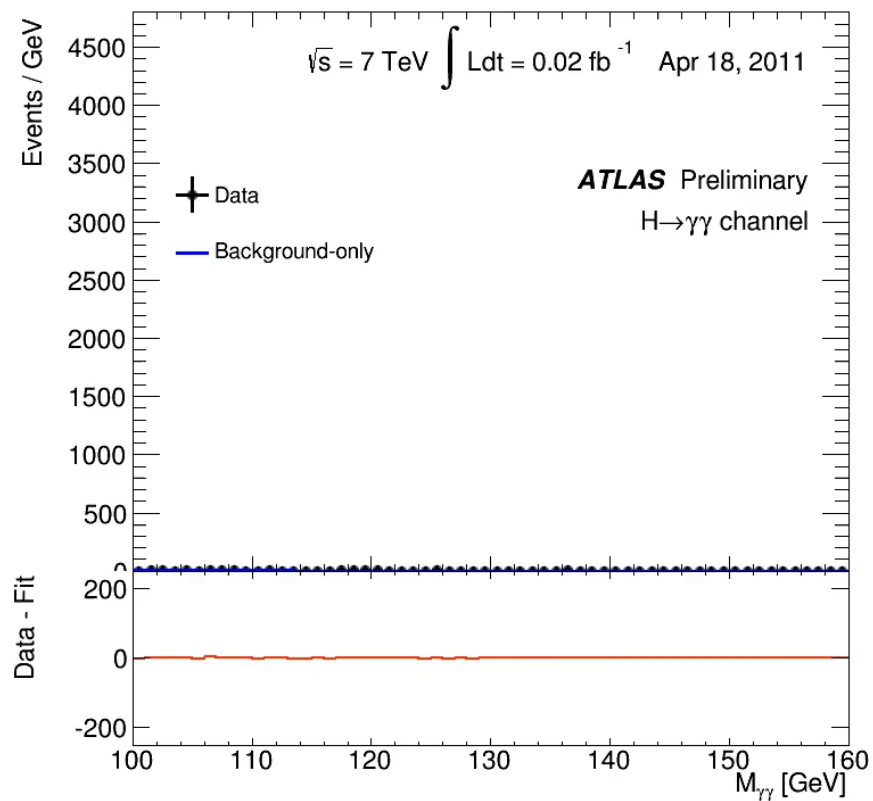


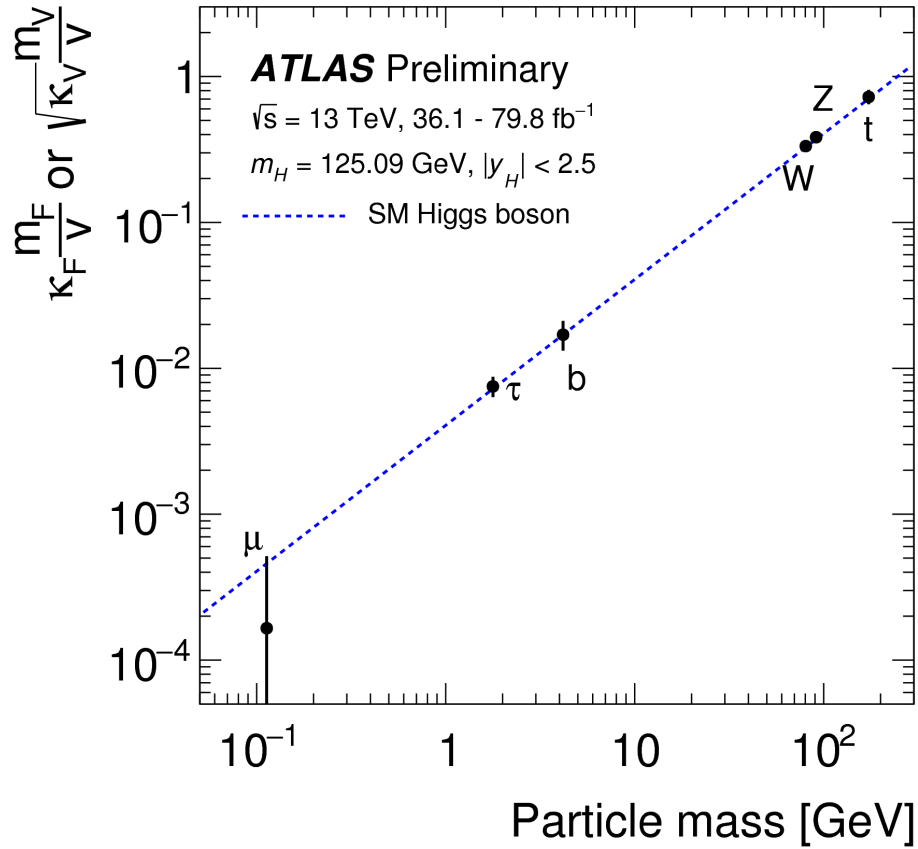
CMS Experiment at the LHC, CERN  
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2012

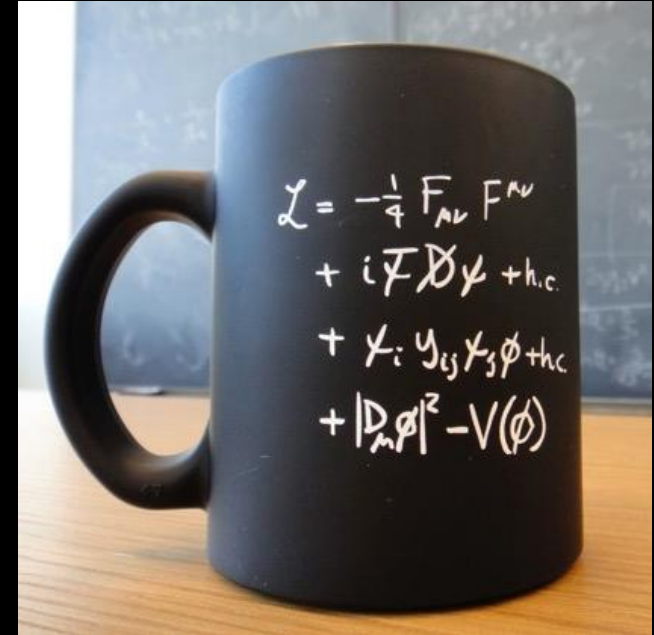








LEPTONS	QUARKS	mass charge spin	$\approx 2.4 \text{ MeV}/c^2$ $2/3$ $1/2$ <b>u</b> up	$\approx 1.275 \text{ GeV}/c^2$ $2/3$ $1/2$ <b>c</b> charm	$\approx 172.44 \text{ GeV}/c^2$ $2/3$ $1/2$ <b>t</b> top	0 0 1 <b>g</b> gluon	$\approx 125.09 \text{ GeV}/c^2$ 0 0 0 <b>H</b> Higgs
			$\approx 4.8 \text{ MeV}/c^2$ $-1/3$ $1/2$ <b>d</b> down	$\approx 95 \text{ MeV}/c^2$ $-1/3$ $1/2$ <b>s</b> strange	$\approx 4.18 \text{ GeV}/c^2$ $-1/3$ $1/2$ <b>b</b> bottom	0 0 1 <b><math>\gamma</math></b> photon	
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			$< 2.2 \text{ eV}/c^2$ 0 $1/2$ <b><math>\nu_e</math></b> electron neutrino	$< 1.7 \text{ MeV}/c^2$ 0 $1/2$ <b><math>\nu_\mu</math></b> muon neutrino	$< 15.5 \text{ MeV}/c^2$ 0 $1/2$ <b><math>\nu_\tau</math></b> tau neutrino	$\approx 80.39 \text{ GeV}/c^2$ $\pm 1$ 1 <b>W</b> W boson	
						GAUGE BOSONS	SCALAR BOSONS



# The Standard Model of Particle Physics

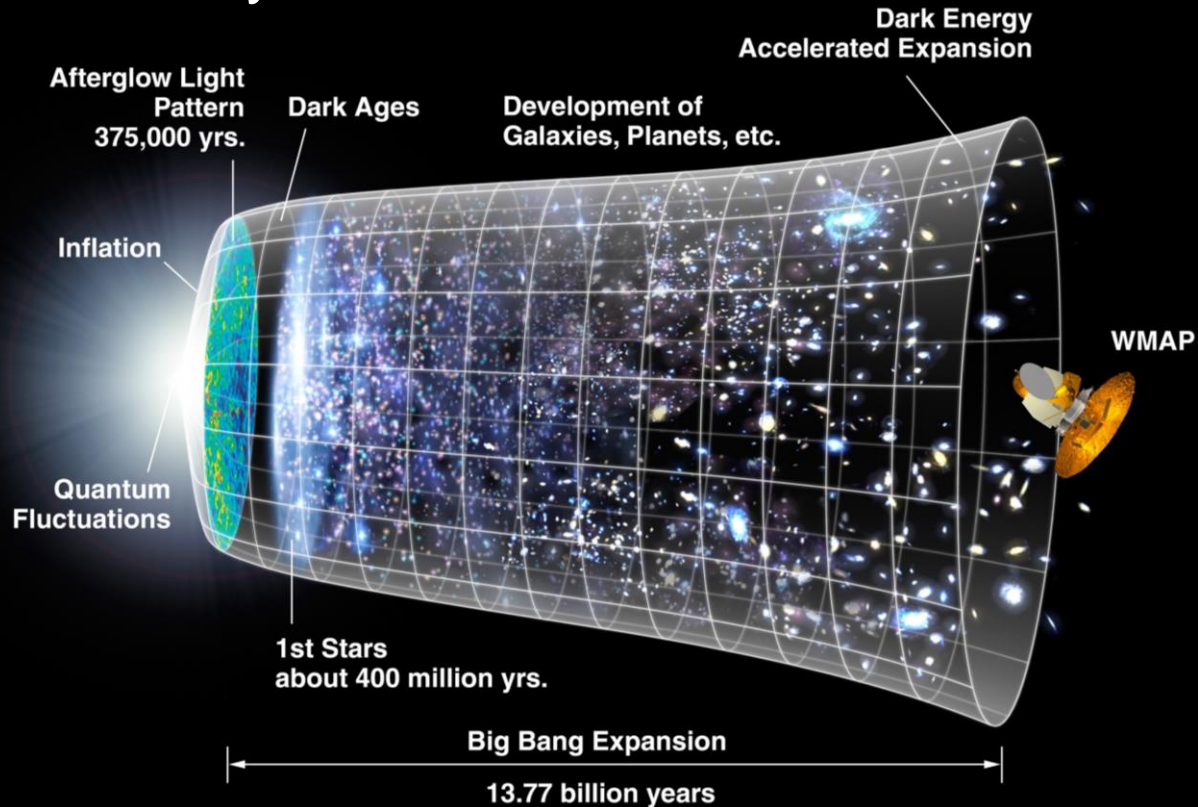
A wide-angle photograph of a desert landscape at night. The foreground shows dark, rolling sand dunes. In the background, a small hill or mesa is visible under a vast, star-filled sky. The Milky Way galaxy is prominently displayed, stretching across the upper half of the frame. The text "What we still don't know" is centered in the middle of the image.

What we still don't know



# Where do we come from?

## What is our destiny?

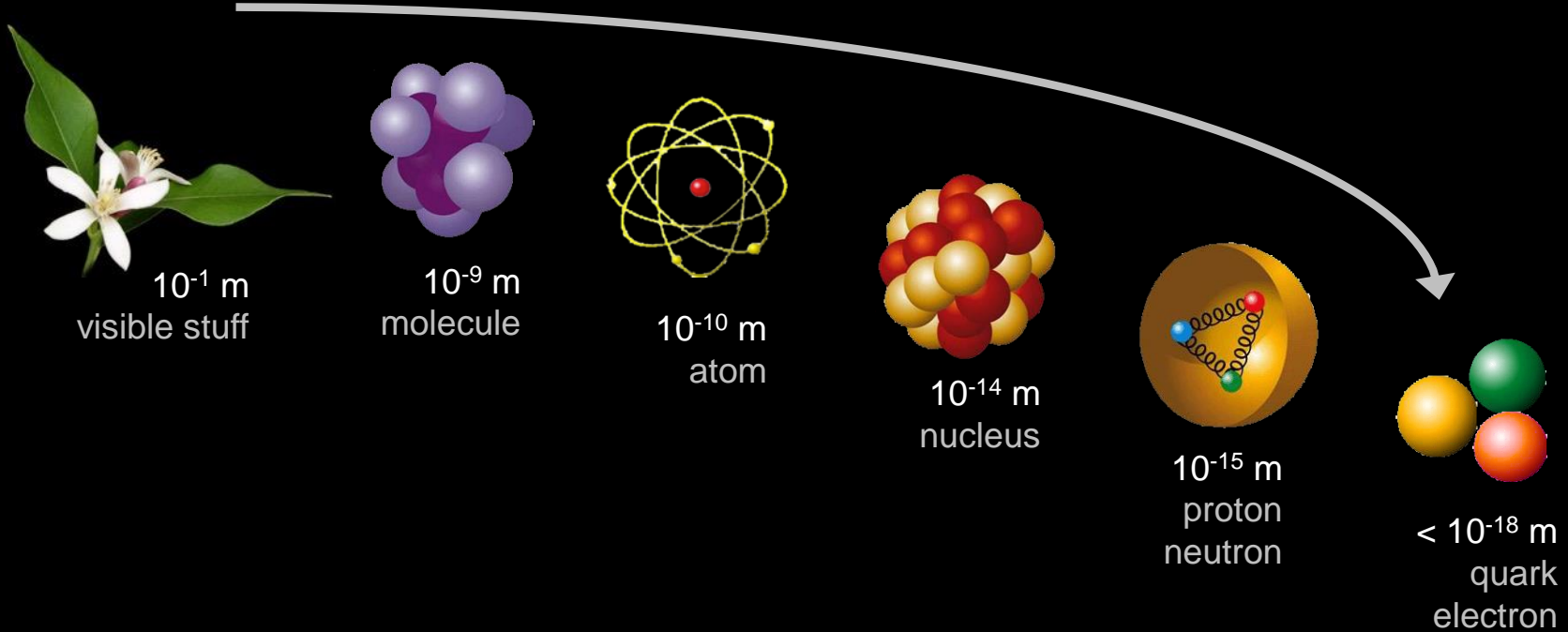


Why do we exist?

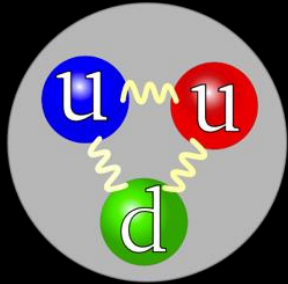




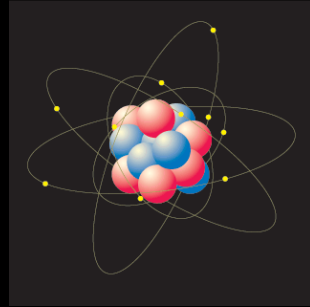
# What are we made of ?



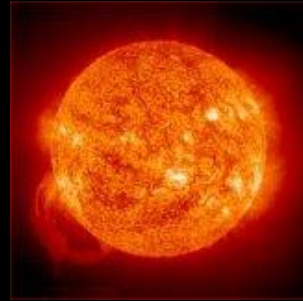
# Why is gravity so weak?



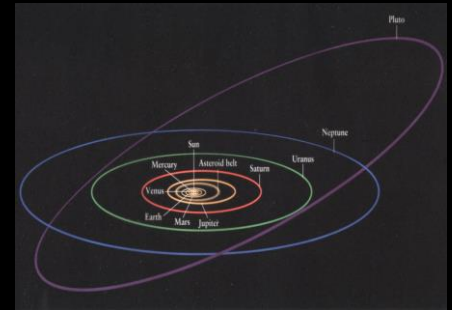
Strong Nuclear  
60



Electromagnetism  
1



Weak Nuclear  
 $10^{-4}$

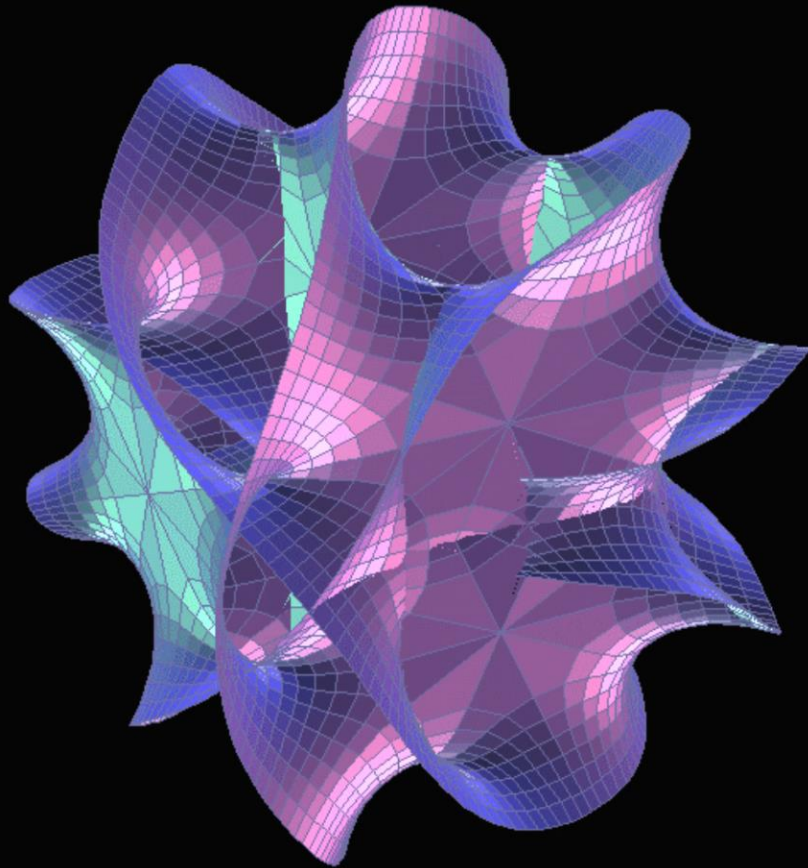


Gravity  
 $10^{-41}$

Relative force strengths specified at scale of quarks and gluons



Could there be other dimensions?

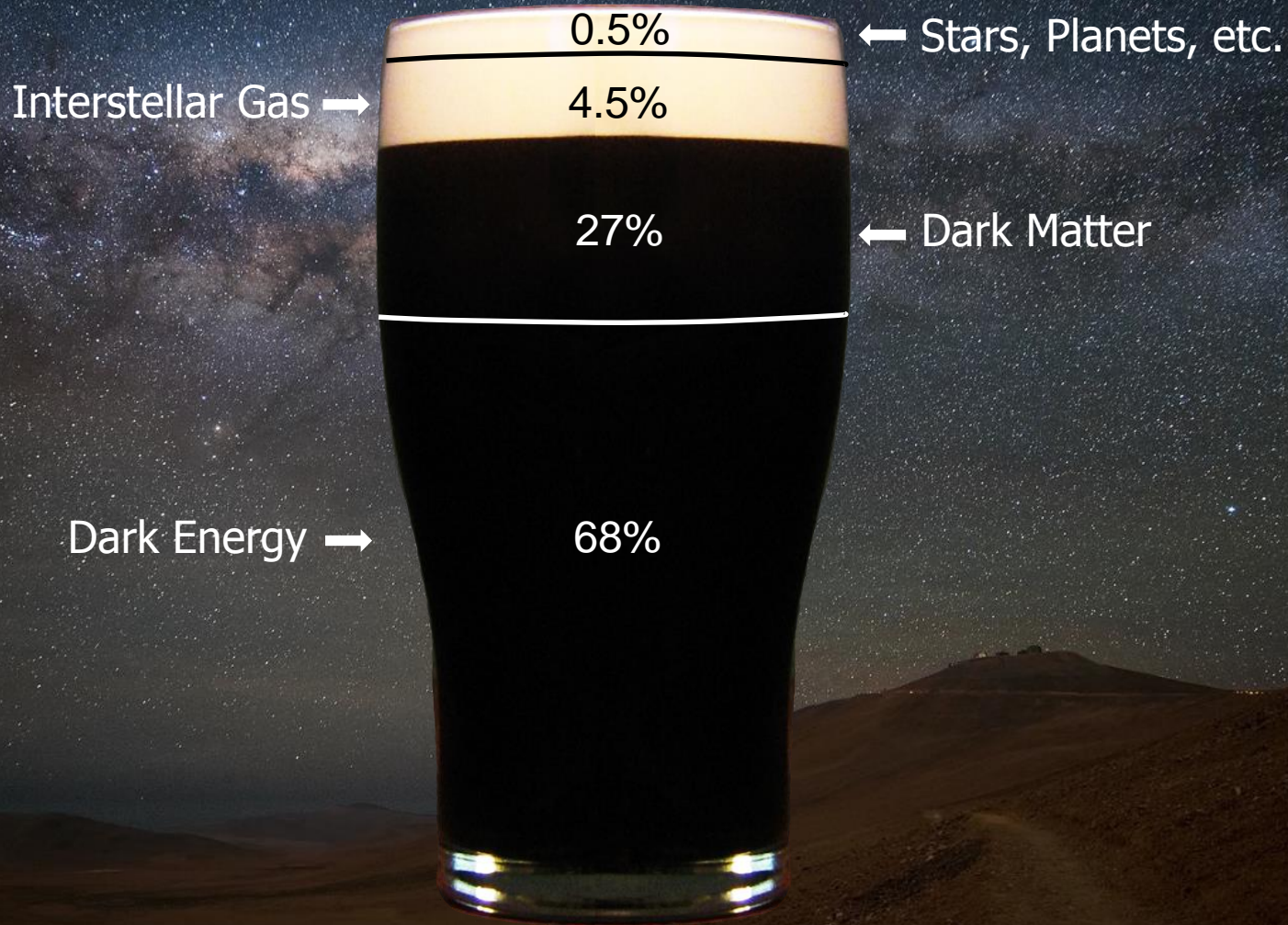


What is holding this together?



Vera Rubin







Can we possibly understand all this?





