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CERN CH 1211 Geneva 23 Switzerland



# SUSTAINABLE DEVELOPMENT GOALS

**1 NO POVERTY**

**2 ZERO HUNGER**

**3 GOOD HEALTH AND WELL-BEING**

**4 QUALITY EDUCATION**

**5 GENDER EQUALITY**

**6 CLEAN WATER AND SANITATION**

**7 AFFORDABLE AND CLEAN ENERGY**

**8 DECENT WORK AND ECONOMIC GROWTH**

**9 INDUSTRY, INNOVATION AND INFRASTRUCTURE**

**10 REDUCED INEQUALITIES**

**11 SUSTAINABLE CITIES AND COMMUNITIES**

**12 RESPONSIBLE CONSUMPTION AND PRODUCTION**

**13 CLIMATE ACTION**

**14 LIFE BELOW WATER**

**15 LIFE ON LAND**

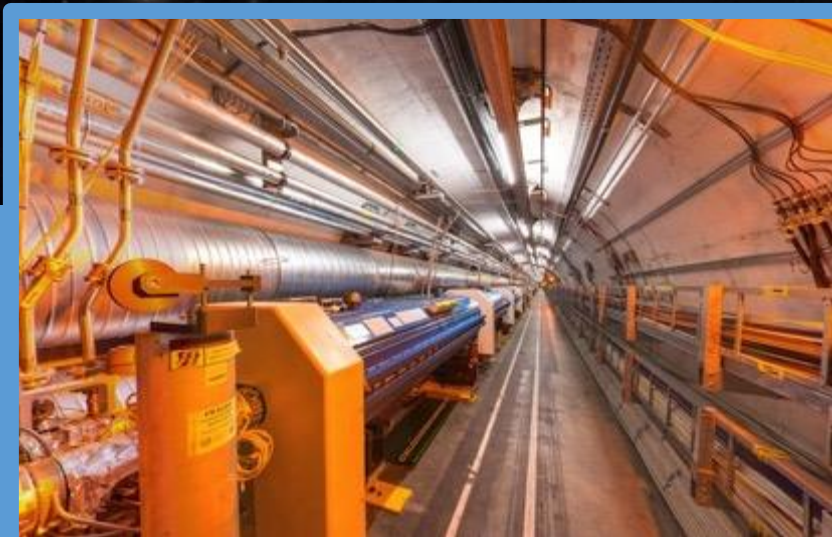
**16 PEACE, JUSTICE AND STRONG INSTITUTIONS**

**17 PARTNERSHIPS FOR THE GOALS**

**SUSTAINABLE DEVELOPMENT GOALS**



Fundamental research is a driver of innovation, and investment in basic research through mega-science projects is essential to unlock that potential with a wide societal impact



Fundamental research thrives in **collaboration**, and the investment in such collaborations pays societal dividends over time.

Higgs Boson

Large Hadron Collider

Birth of the Web

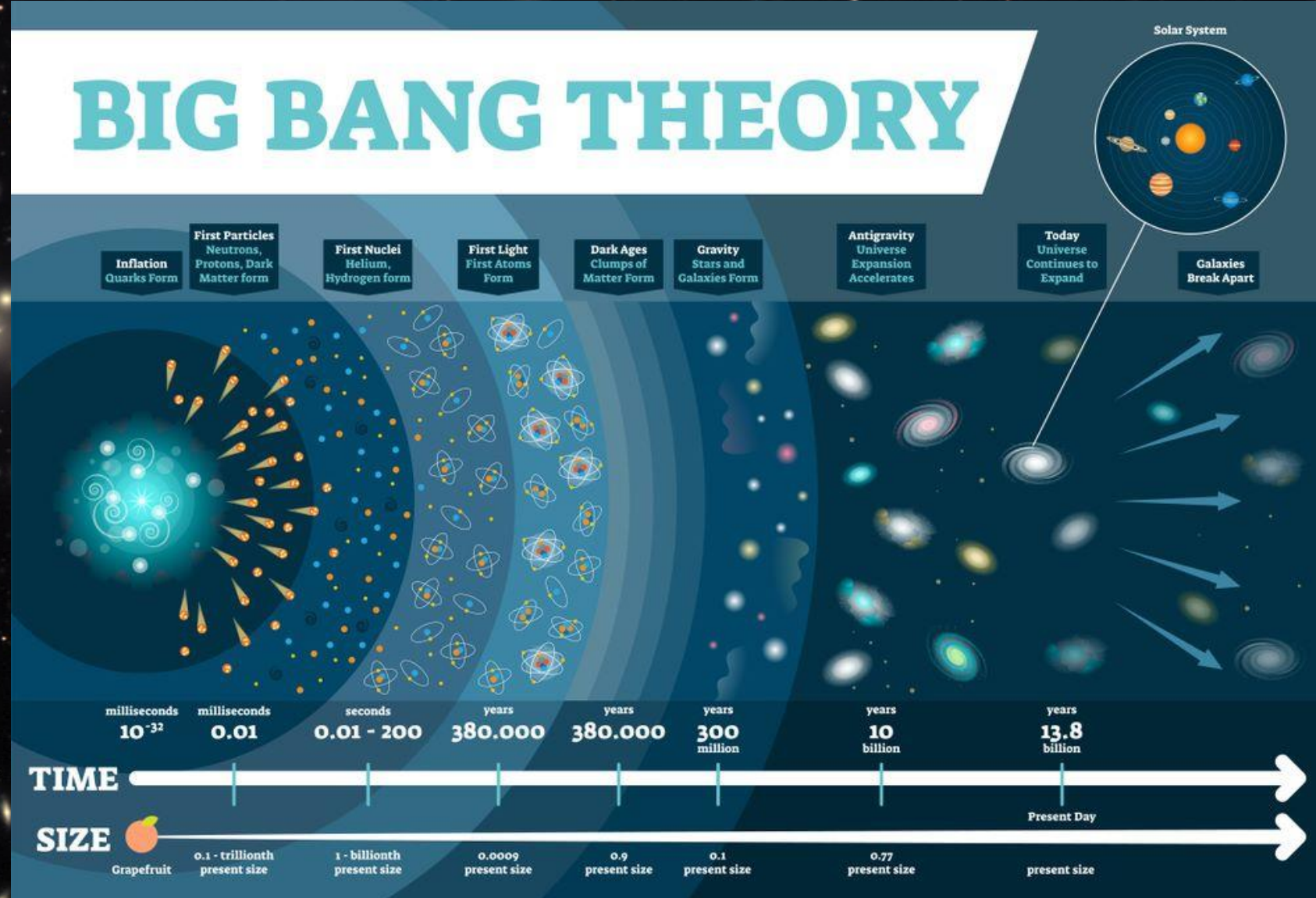
Antimatter

High-Luminosity LHC



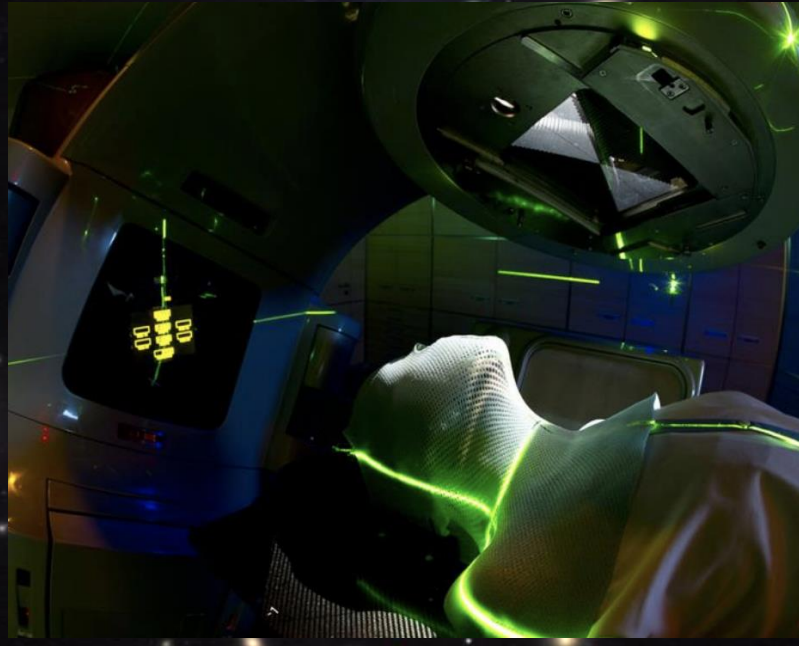
... Answers IMPACT ~~M~~ BILLIONS OF LIVES

What is the  
LARGE HADRON  
COLLIDER?



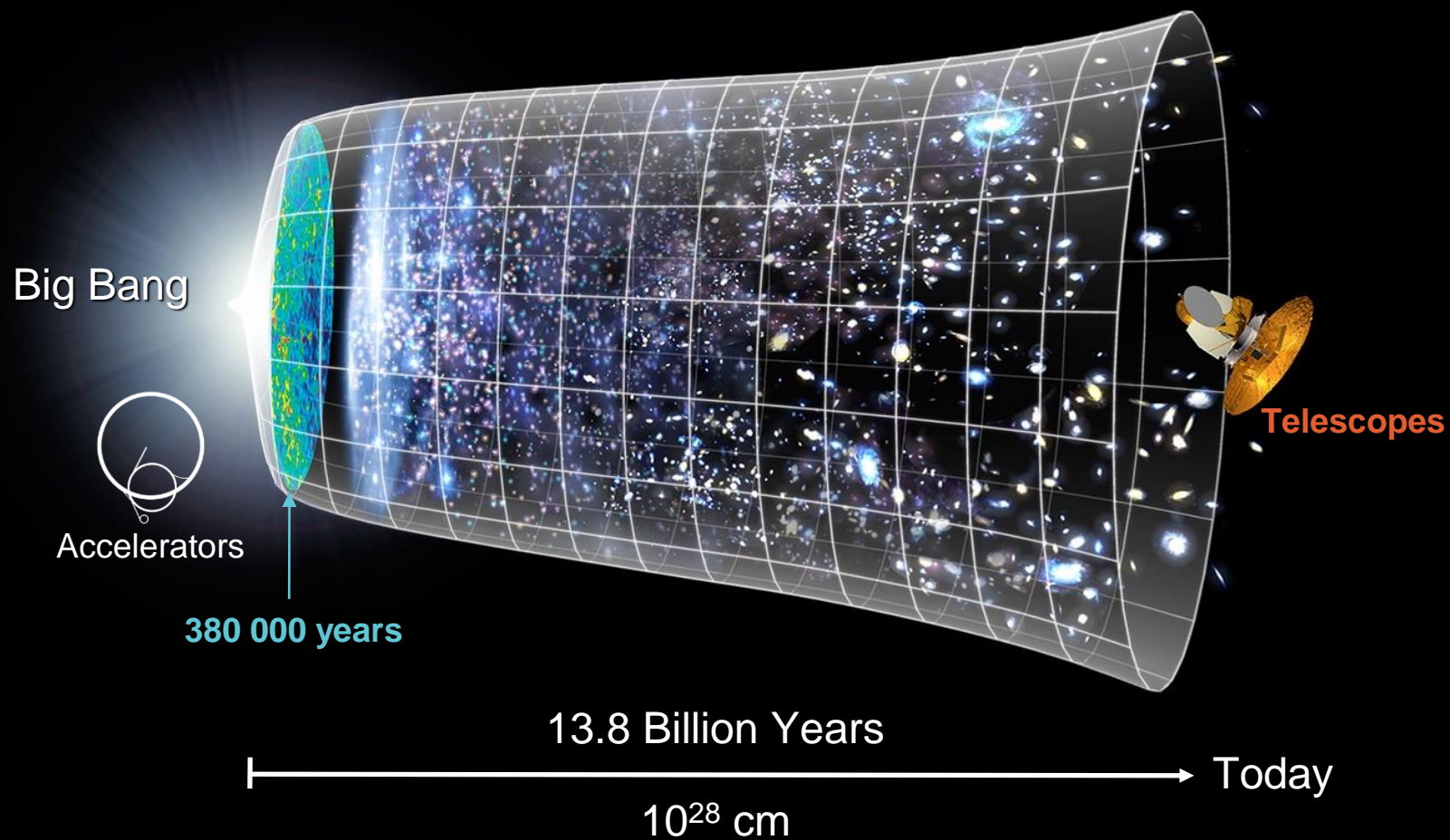


# Unlocking Secrets of the Universe Challenges and Opportunities



- Scientific Research
- Cutting edge technology R&D
- Social Impact
- Compelling engagement





## How did the universe begin?

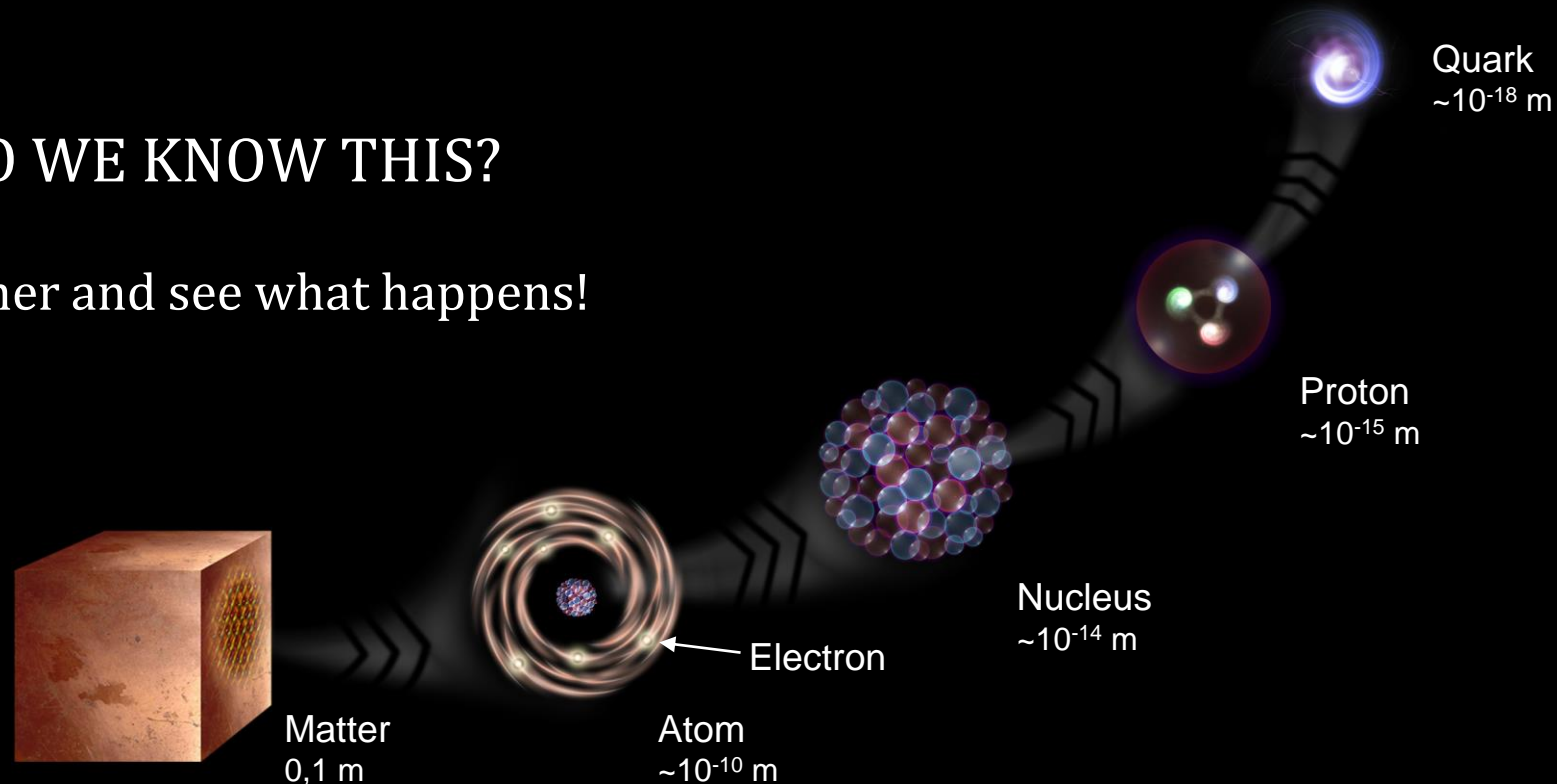
We reproduce the conditions a fraction of a second after the Big Bang, to gain insight into the structure and evolution of the universe.

# What is the universe made of?

We study the elementary building blocks of matter and the forces that control their behaviour

**BUT HOW DO WE KNOW THIS?**

Smash things together and see what happens!





Collision Energy



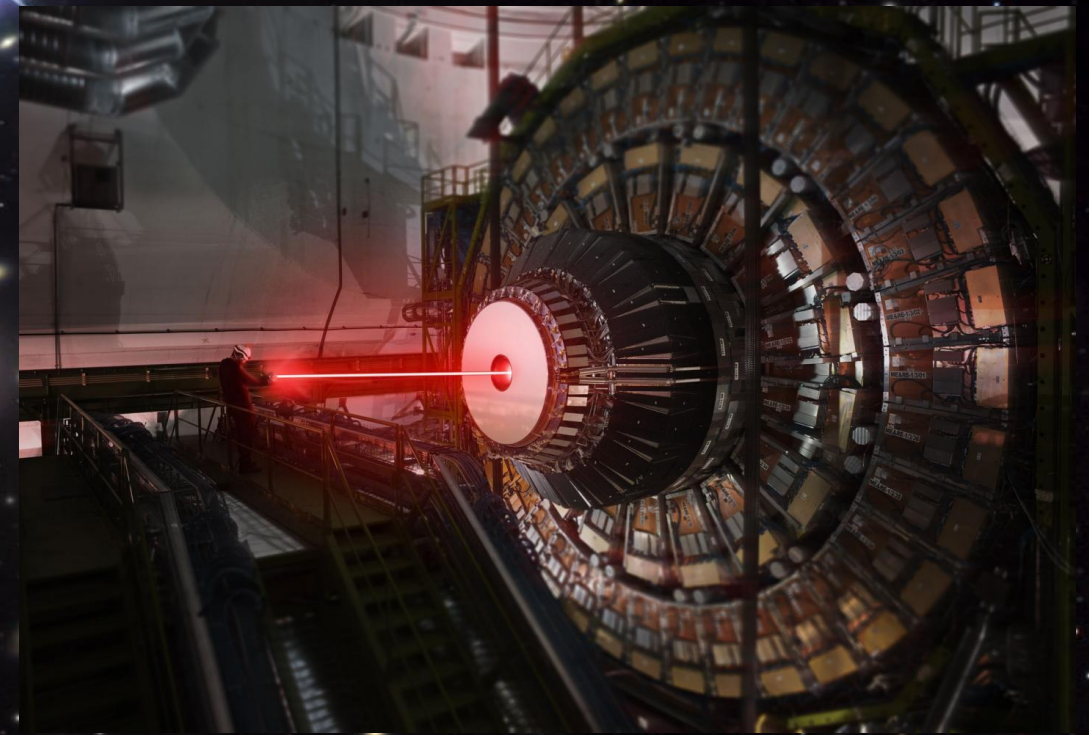
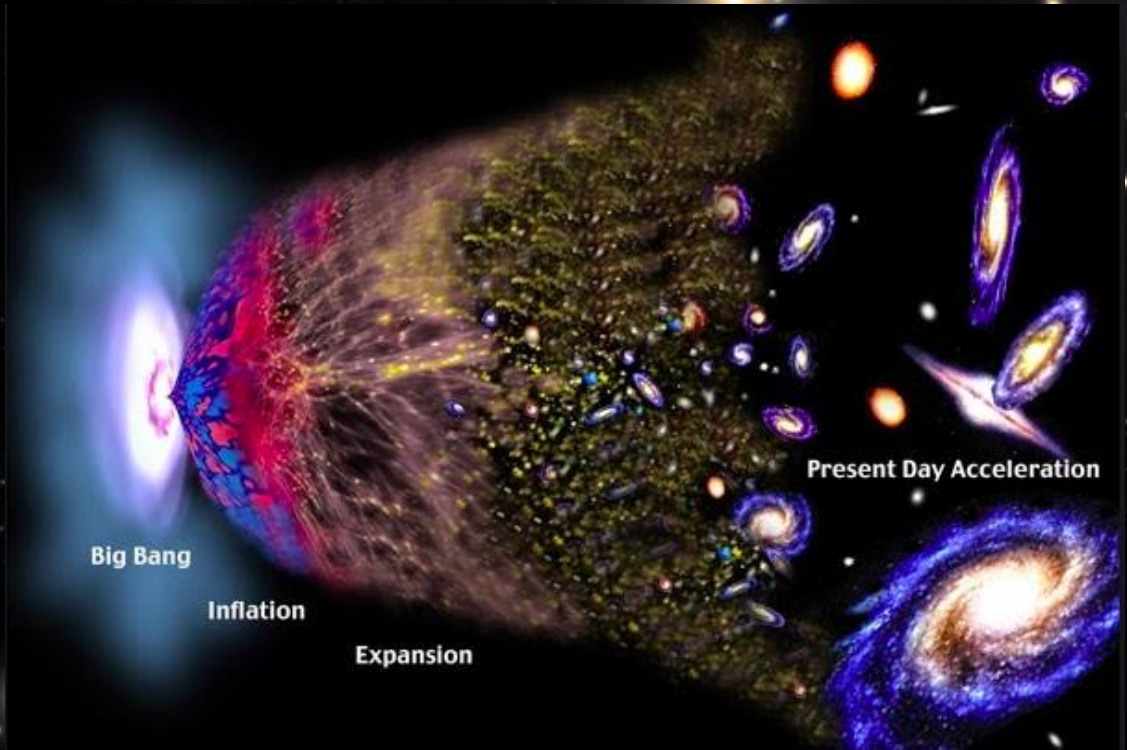




Collision Energy

# Open questions ?

- Origin of mass?
- Nature of Dark Matter?
- Matter versus antimatter ?
- Primordial plasma ?





The collision energy was used  
to create something new, that  
"did" exist but does not any more!



Accelerator Energy

Accelerator Energy



We can create particles from energy



Two beams of protons collide and generate, in a very tiny space, temperatures over a billion times higher than those prevailing at the center of the Sun.

Produce particles that may have existed at the beginning of the Universe, right after the

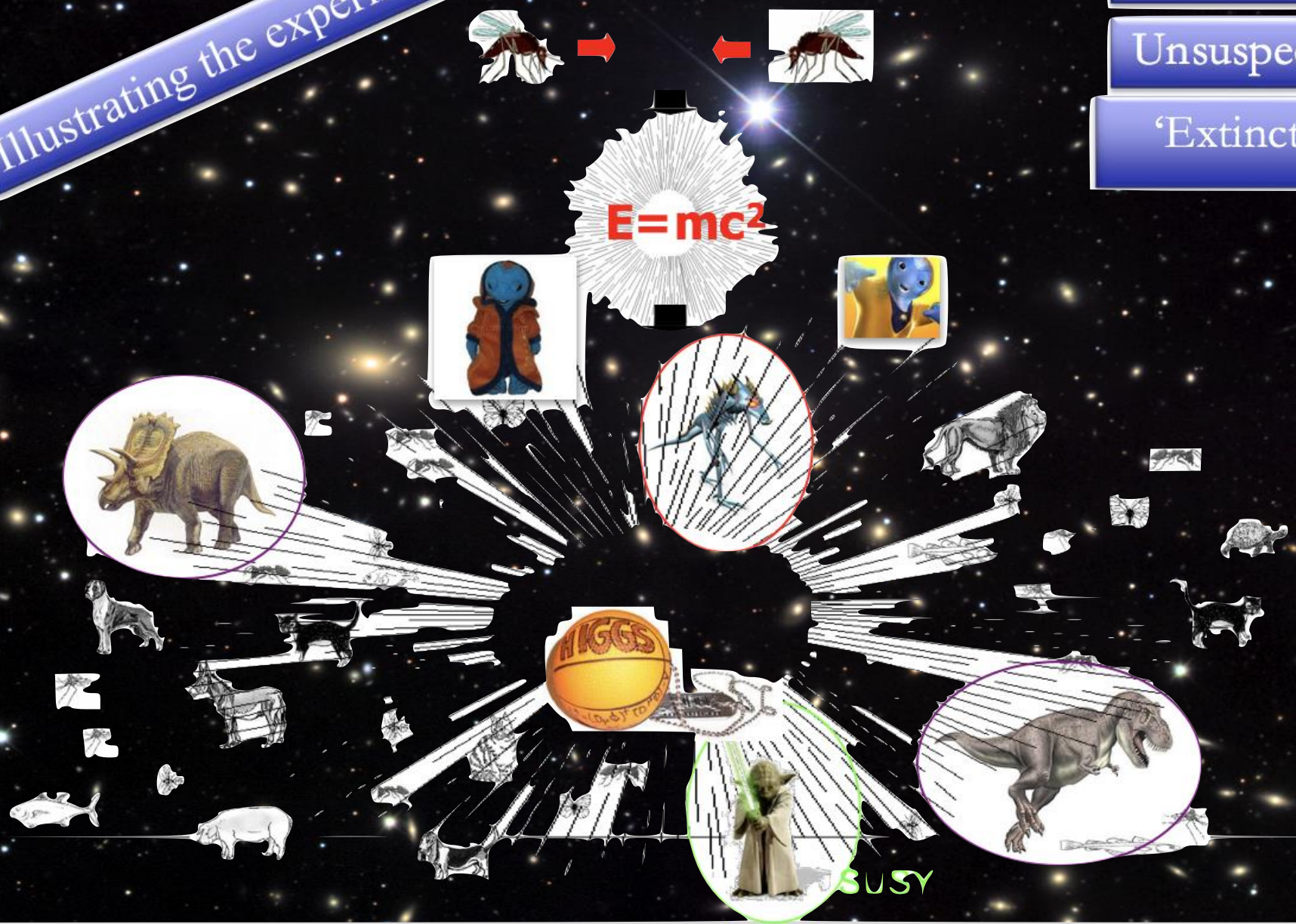
# Big Bang

Illustrating the experiment

Hypothetical

Unsuspected ?

'Extinct' since Big Bang



SUSY



# This Search Requires.....



**1. Accelerators** : powerful machines that accelerate particles to extremely high energies and bring them into collision with other particles

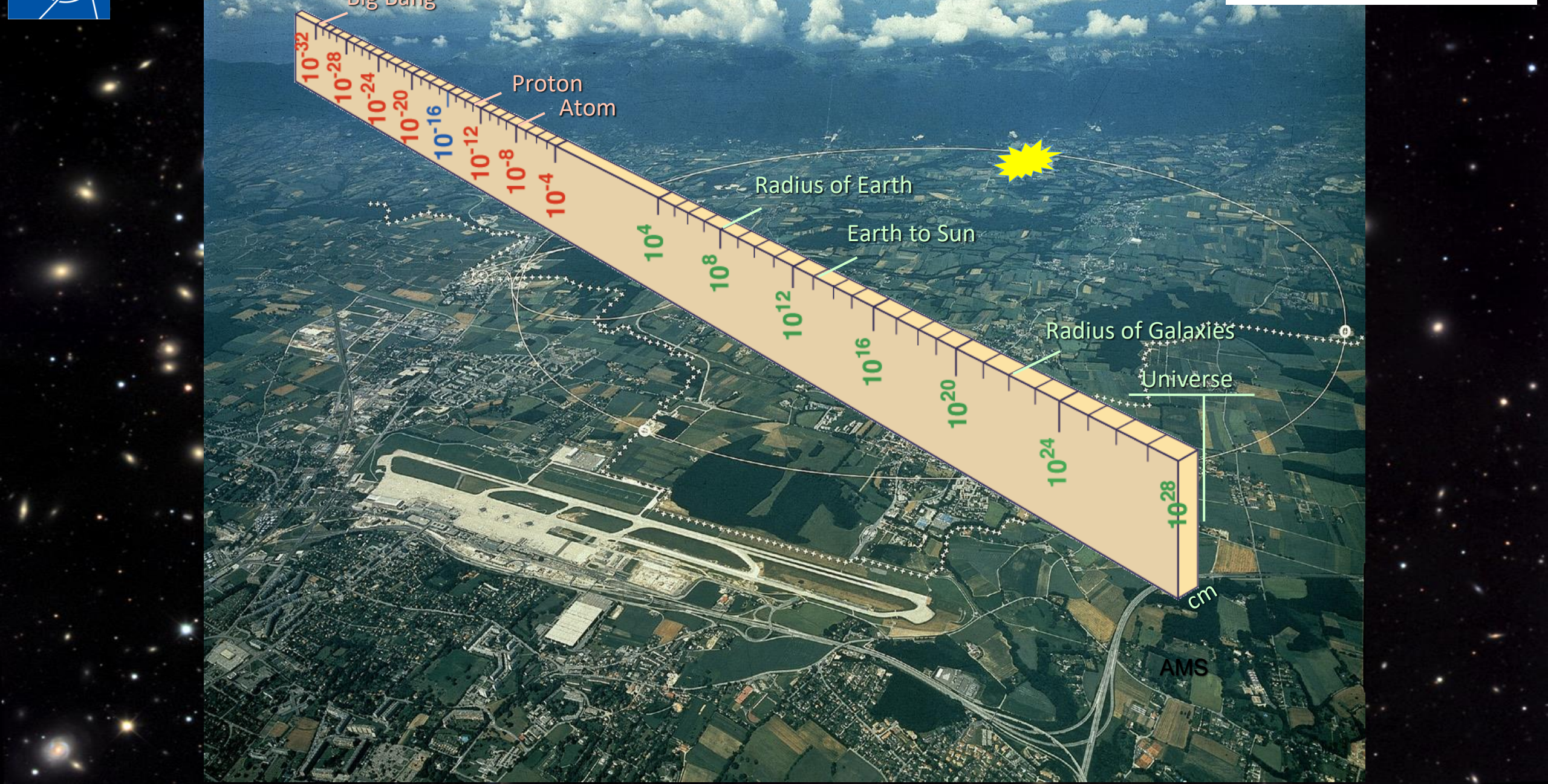
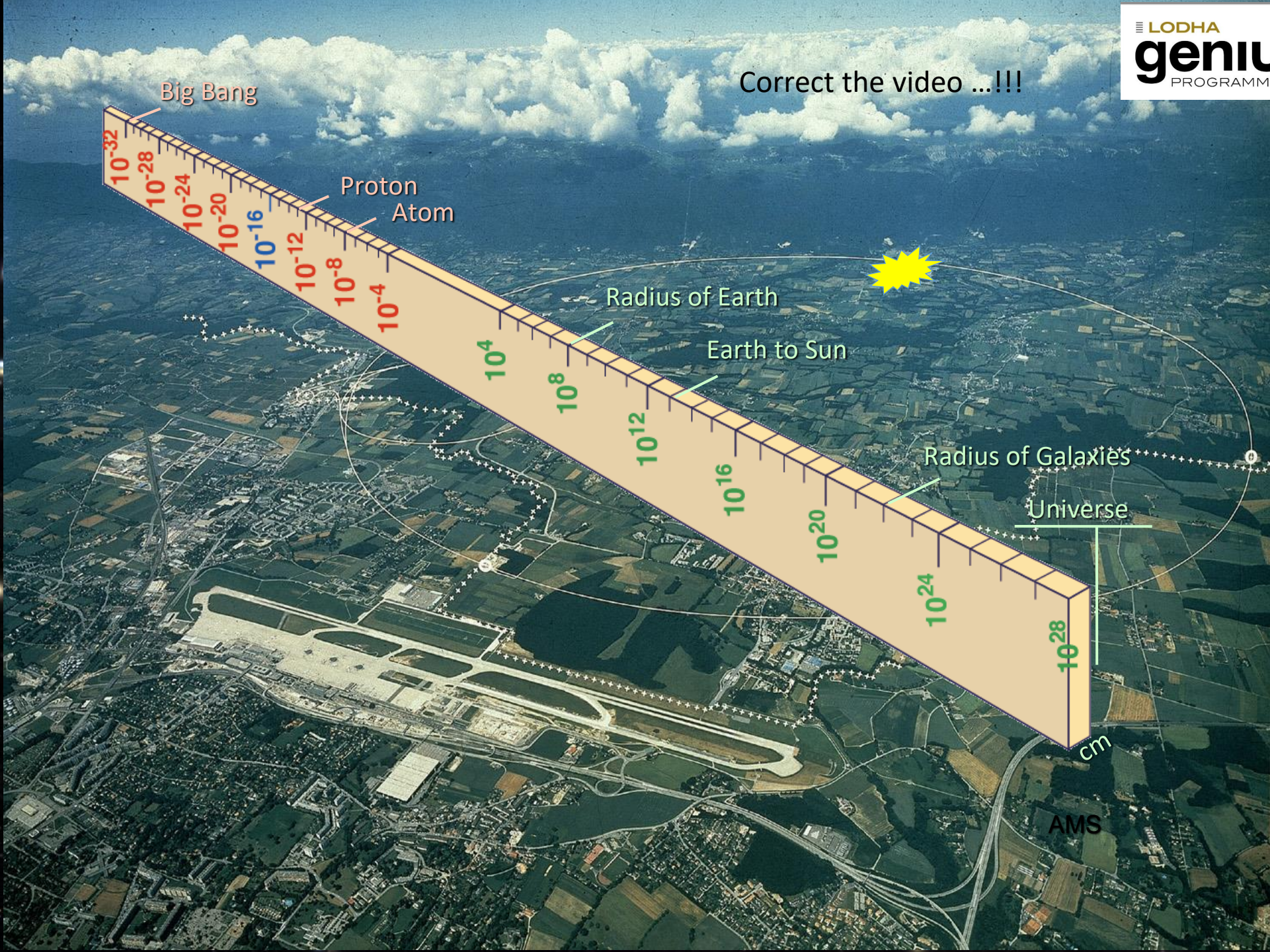
**2. Detectors** : gigantic instruments that record the resulting particles as they "stream" out from the point of collision.

**3. Computing** : to collect, store, distribute and analyse the vast amount of data produced by these detectors

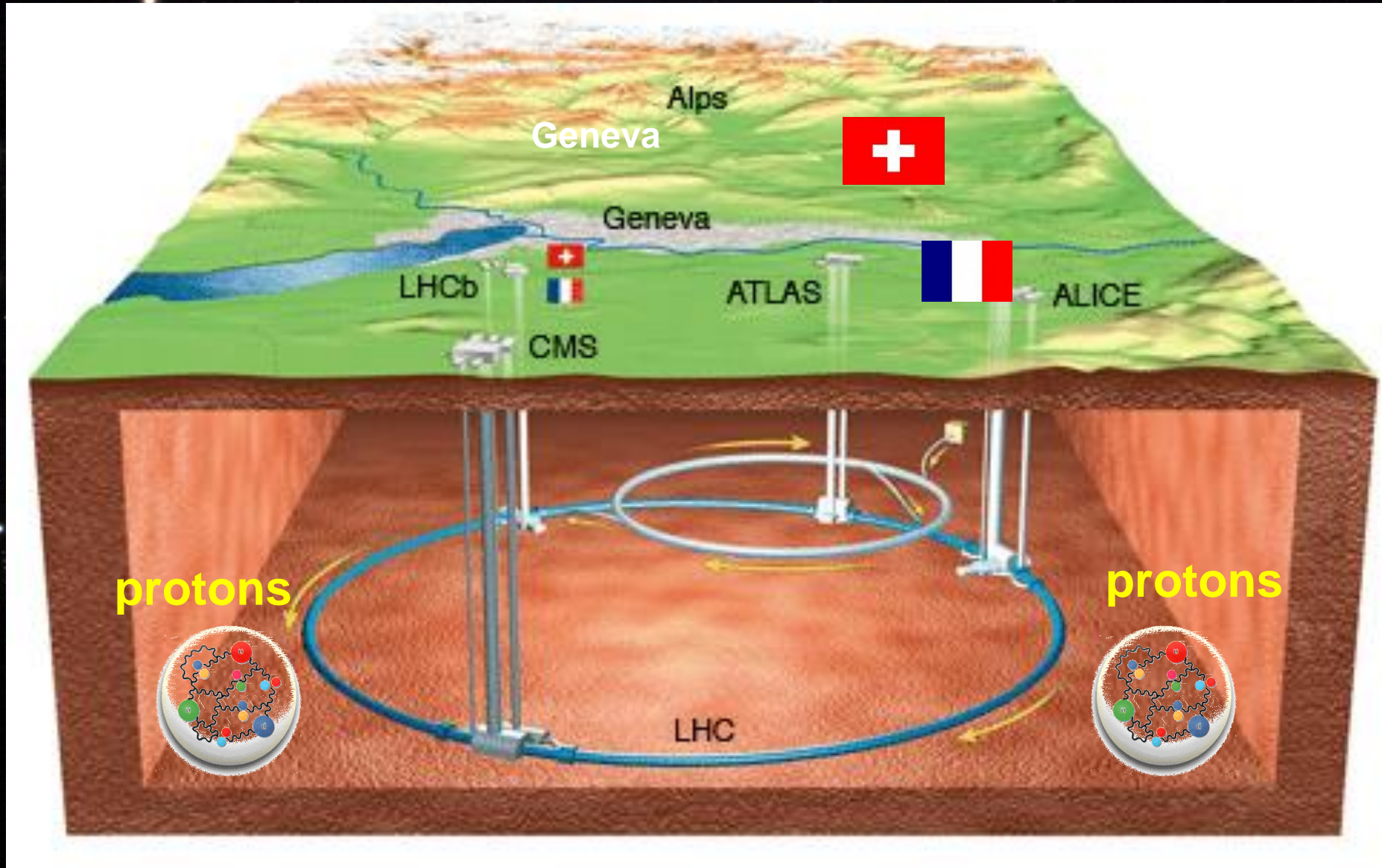
**4. Collaborative Science on Worldwide scale** : thousands of scientists, engineers, technicians and support staff to design, build and operate these complex "machines".



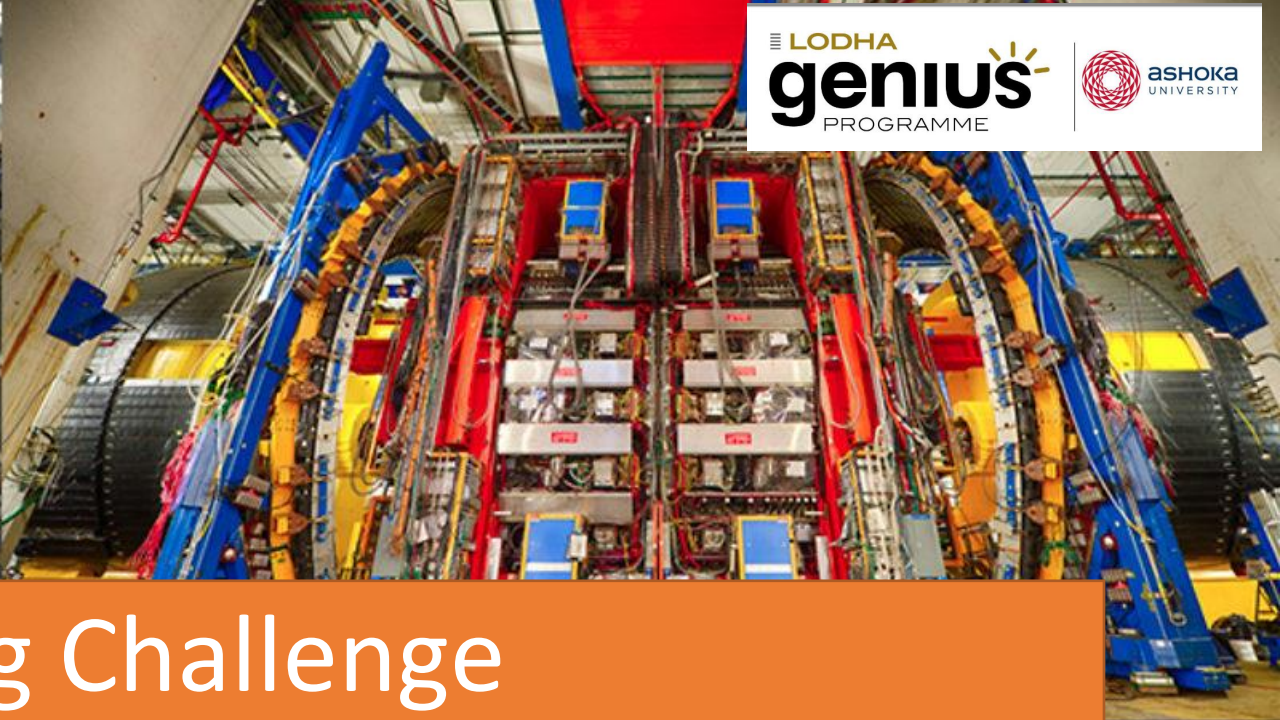
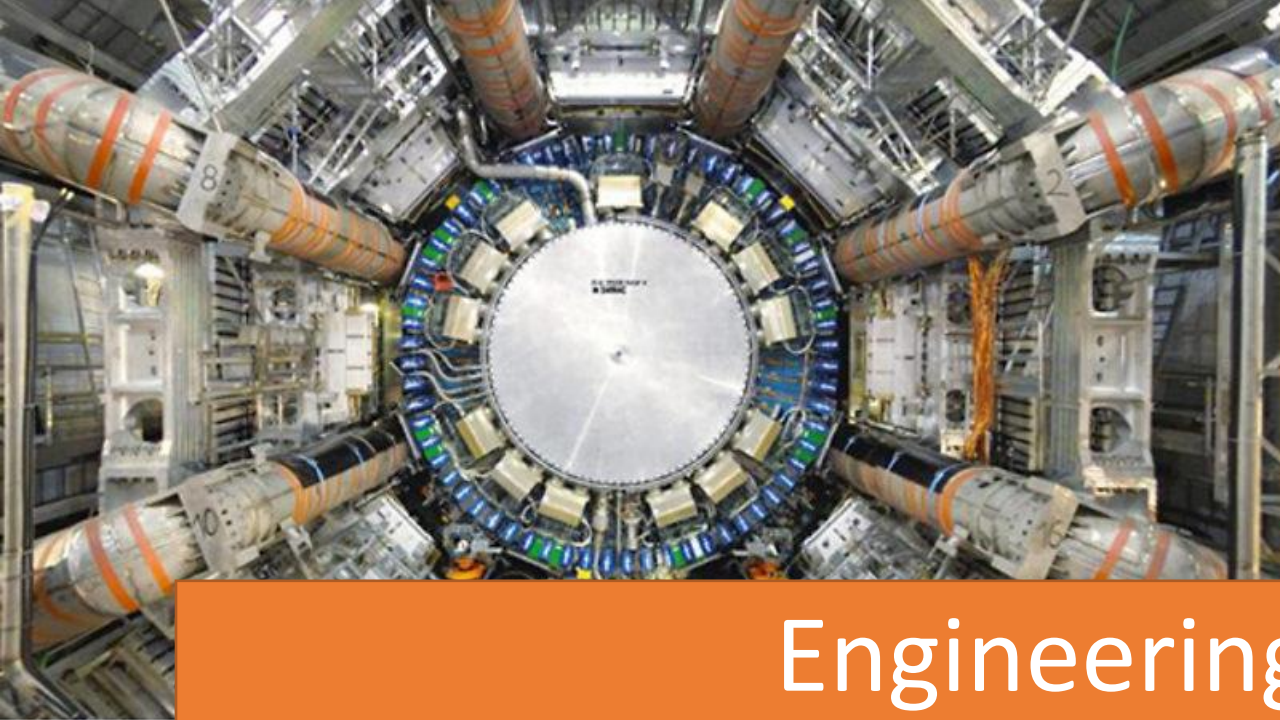
Correct the video ...!!!



# The Large Hadron Collider – the four experim







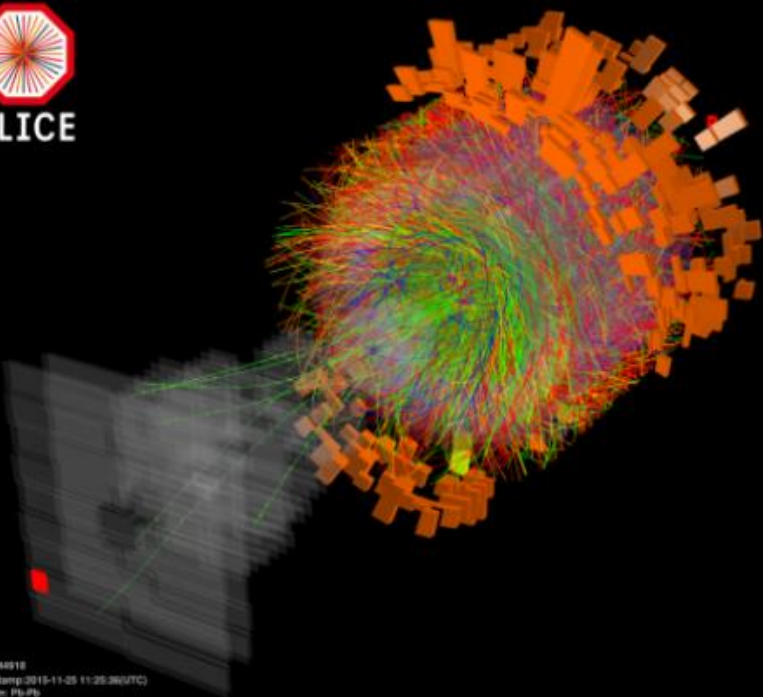
# Engineering Challenge

## Decades in preparation and operation





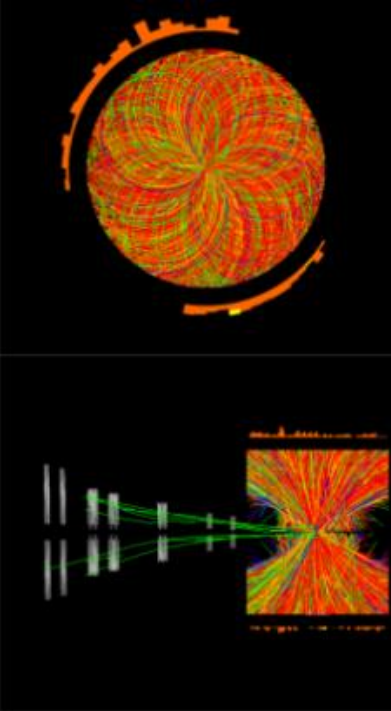
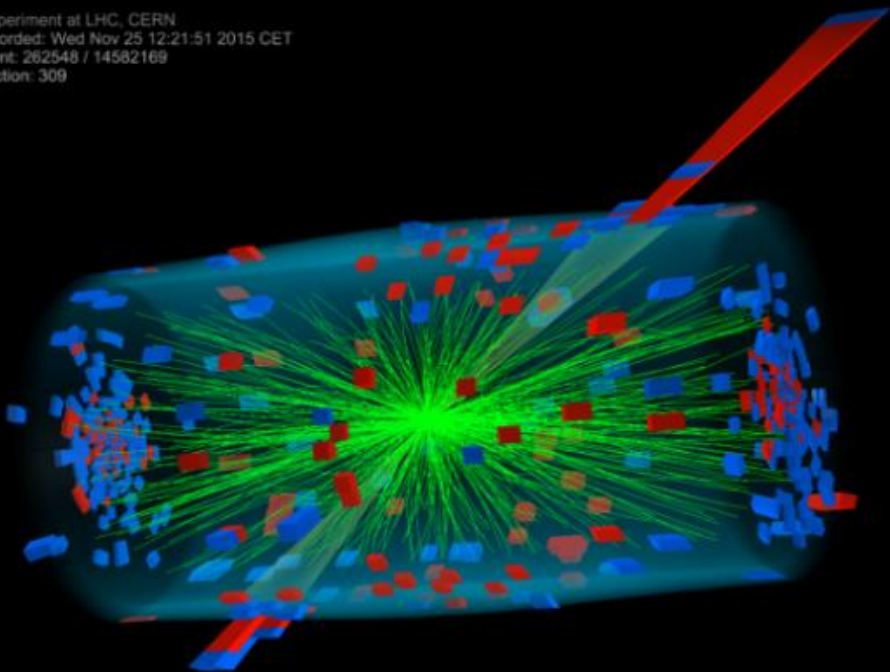
ALICE



Run: 244918  
Timestamp: 2015-11-25 11:25:36(UTC)  
System: Pb-Pb  
Energy: 5.02 TeV



CMS Experiment at LHC, CERN  
Data recorded: Wed Nov 25 12:21:51 2015 CET  
Run/Event: 262548 / 14582169  
Lumi section: 309



 **ATLAS**  
EXPERIMENT

LODHA  
**genius**  
PROGRAMME

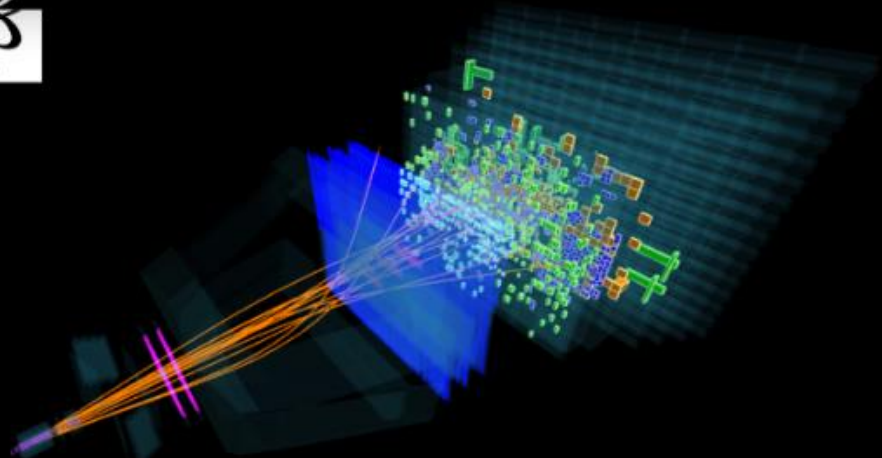


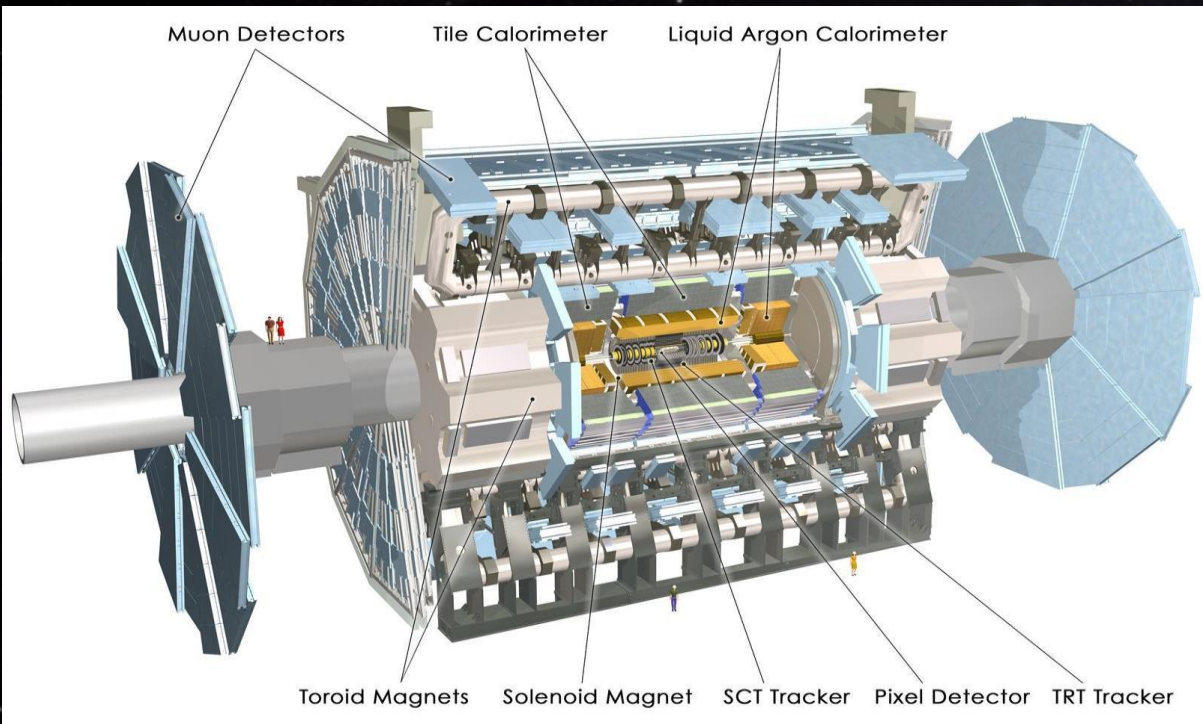
Run: 286665  
Event: 419161  
2015-11-25 11:12:50 CEST

*first stable beams heavy-ion collisions*

**LHCb**  
EXPERIMENT

Event 2598326  
Run 168486  
Wed, 25 Nov 2015 12:51:53





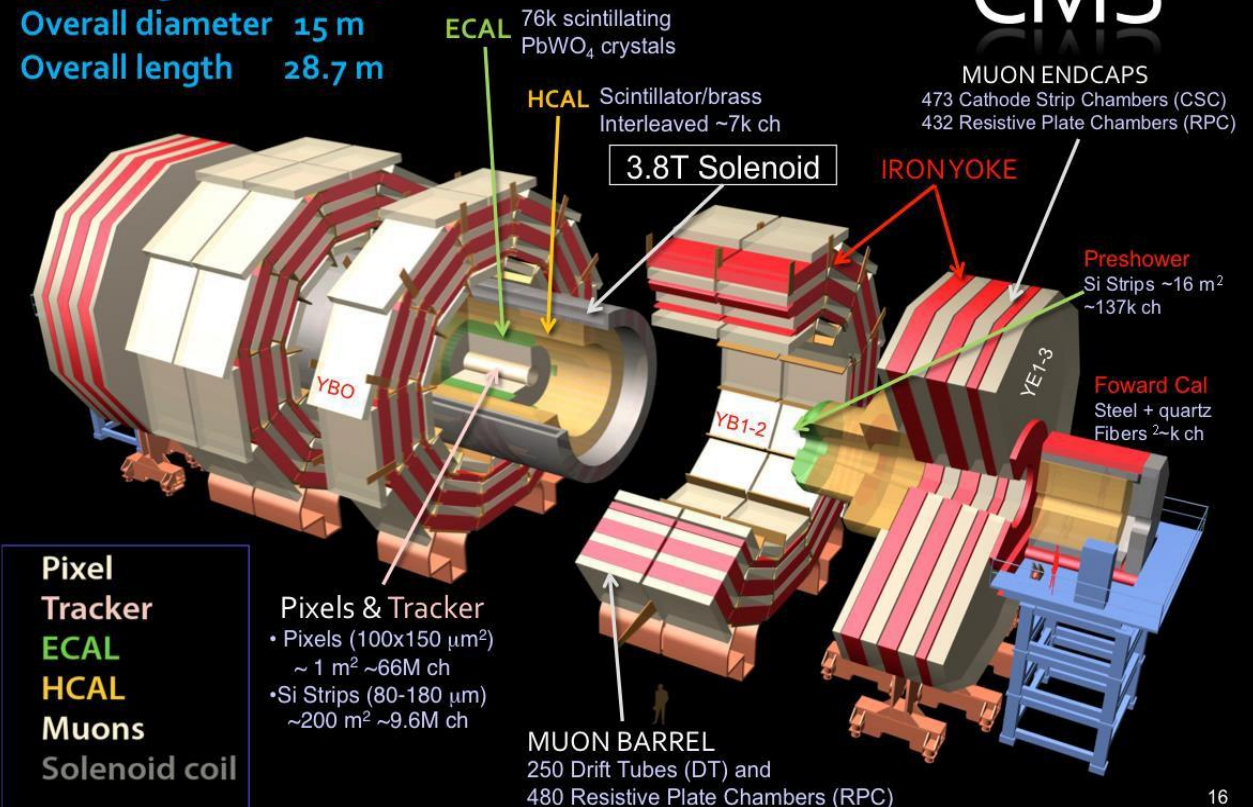
## The ATLAS experiment

These experiments use different technologies for their detector components

## The CMS experiment

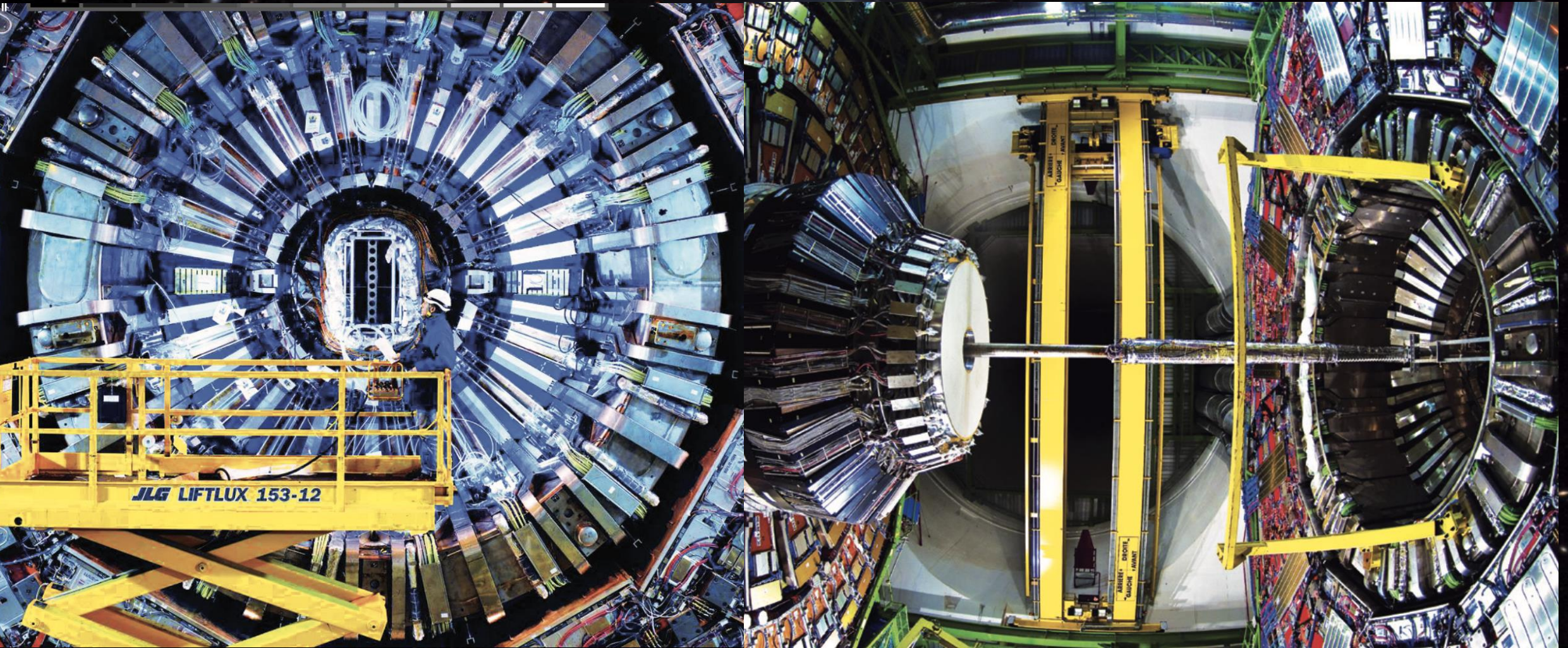
Total weight 14000 t  
 Overall diameter 15 m  
 Overall length 28.7 m

# CMS





# Engineering Challenge





# The power of collaboration





# July 4<sup>th</sup> 2012



Official announcement of the discovery of a Higgs-like particle with mass of 125-126 GeV by CMS and ATLAS.

Historic seminar at CERN with simultaneous transmission and live link at the large particle physics conference of 2012 in Melbourne, Australia

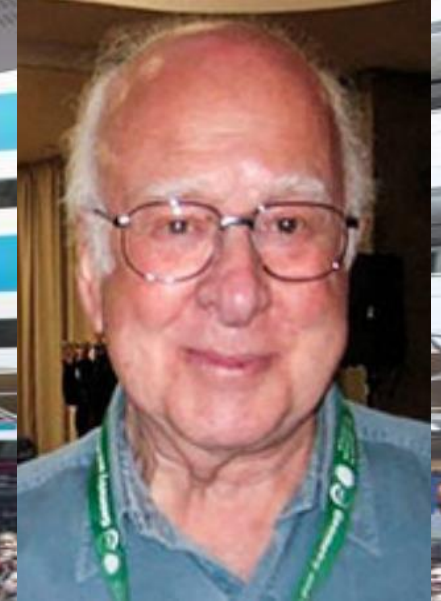


Melbourne

Followed live around the world...



# Tuesday 8 October 2013 Nobel Prize





# Big Science at CERN Nobel Prizes







CERN's technological innovations have applications in many fields

CERN is the birthplace of  
the World Wide Web

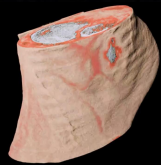
**And there are many more examples**

Medical imaging, cancer therapy, material science, cultural heritage,  
aerospace, automotive, environment, health & safety, industrial processes.



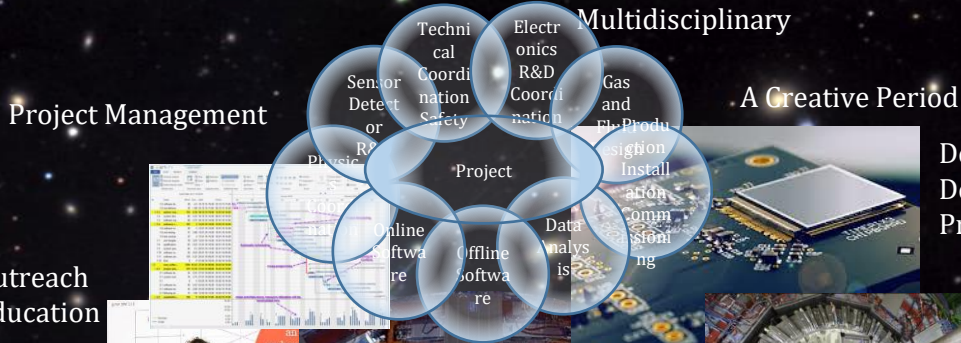
# Are you a Particle physicist?

The skill set is unique – “a new value” creation: Multidimensional Growth



PET (Positron Emission Tomography)

© Archana Sharma CERN 2018



Project Management

A Creative Period

Detector/Sensor Development Prototyping

Execution Period

Monitoring Physics Discovery !

Exploitation Period

Big Data Analytics

Machine Learning Artificial intelligence

Financial Management

Risk Management

Mechanical Engineering

Meteorology

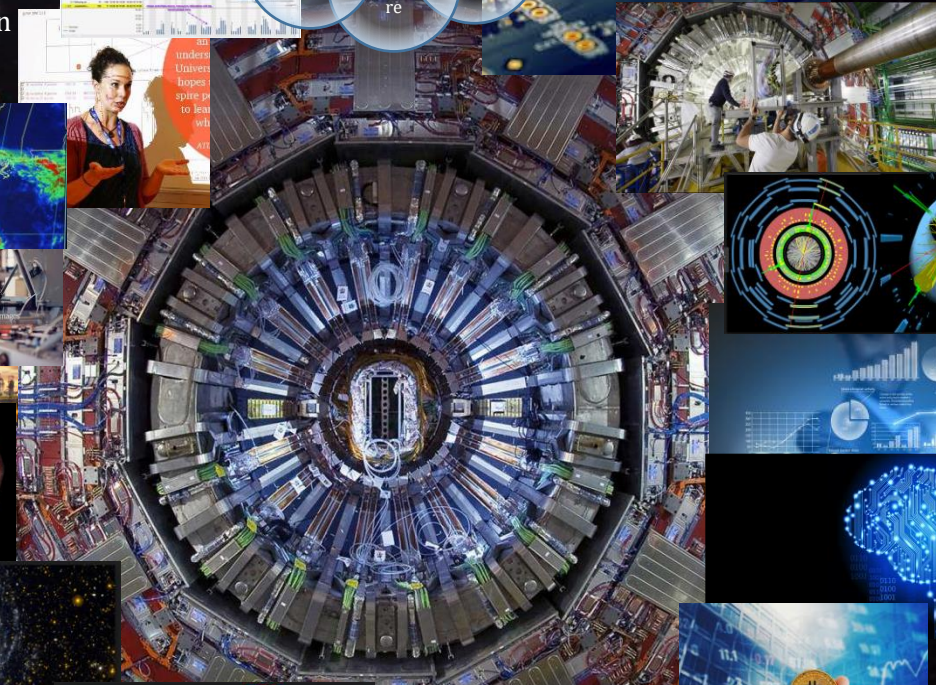
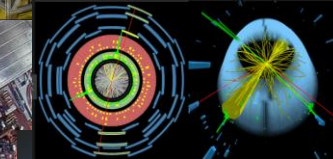
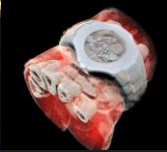
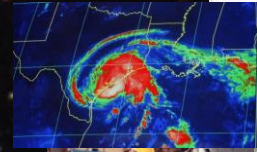
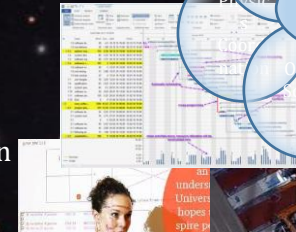
Outreach Education

Industrial Applications

Medical Imaging Diagnostics

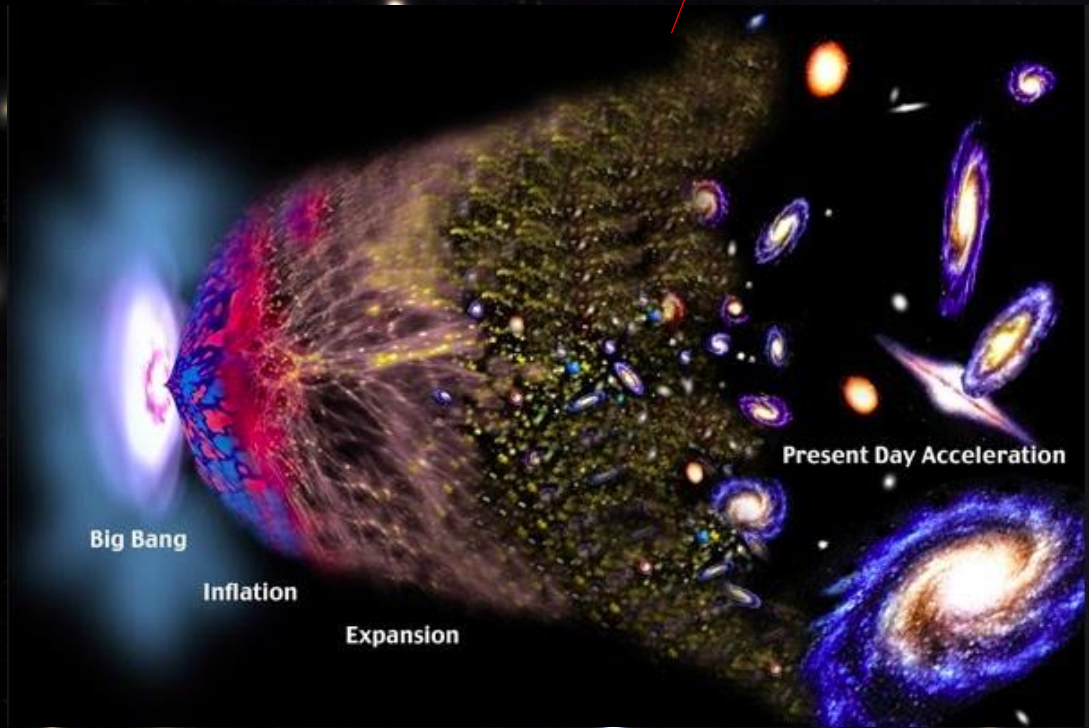
Astrophysics Cosmology

Space Science





# Curiosity about the Universe ... Answers IMPACT MBILLIONS OF LIVES



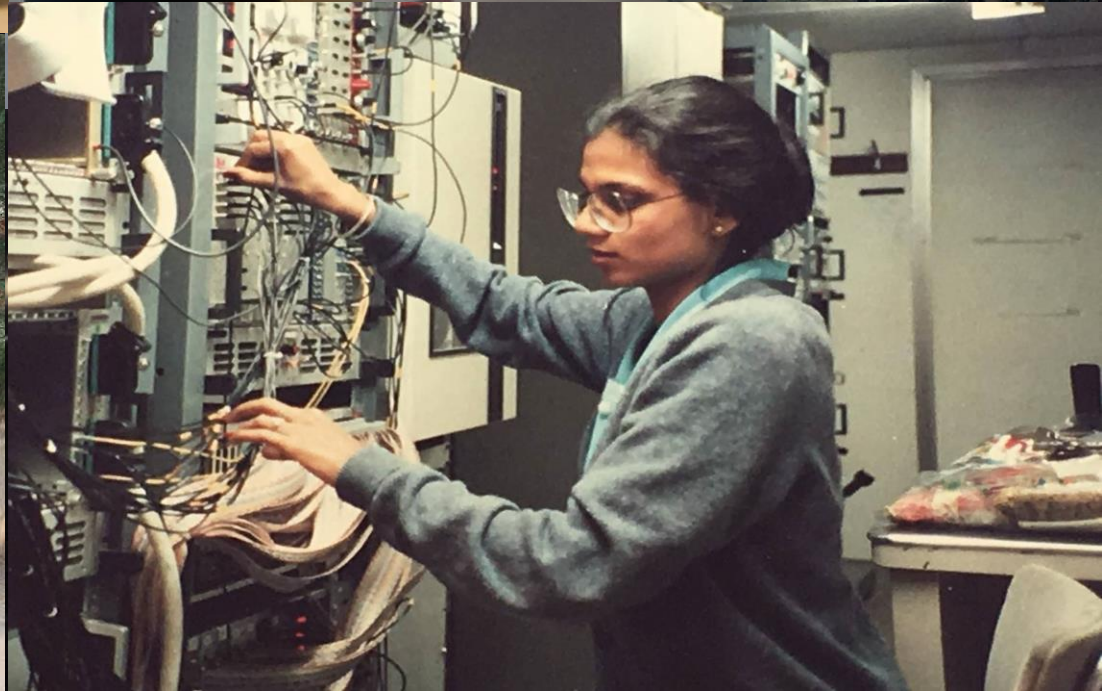
PRESENT  
&  
FUTURE PROJECTS

CERN GENEVA  
SWITZERLAND

## SUSTAINABLE DEVELOPMENT GOALS

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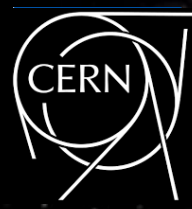


An impossible dream in 2009 .... Written down in 2012



Installed in 2019-2020 - First Phase II detector in





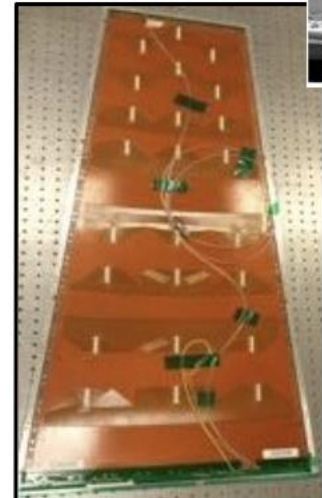
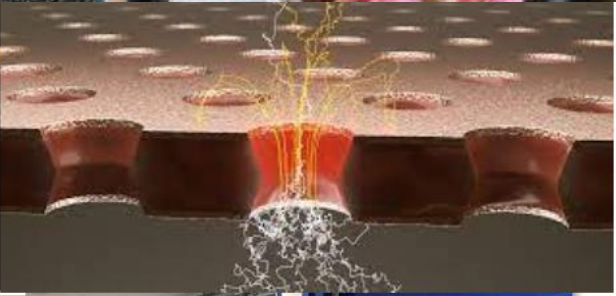
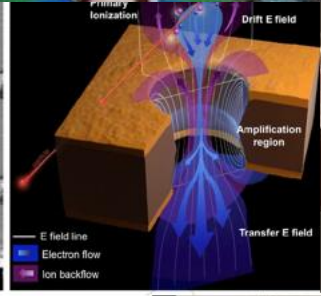
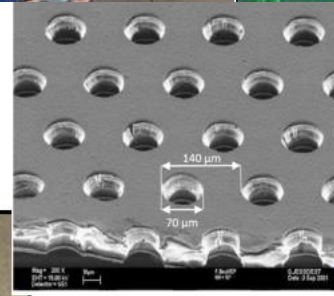
An impossible dream in 2009 ... Written down in 2012



Installed in 2019-2020 - First Phase II detector in



# CMS GEMs



# A worldwide collaboration

- **4 Continents (16 Time Zones)**
- **20 Countries**
- **37 Institutes**
- **More than 300 people in the team (Physicists, Engineers, Students, Technicians)**









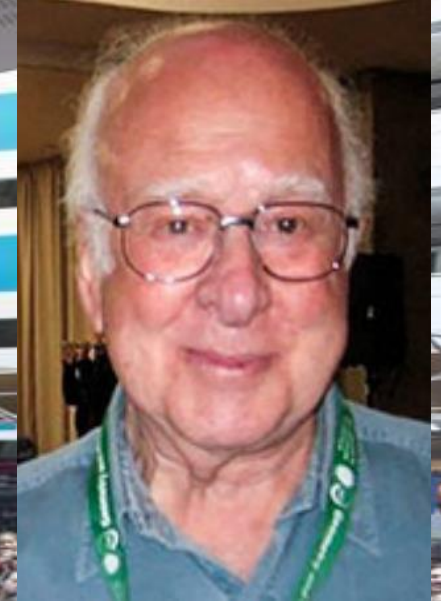
GEMs-GE11-Archana-2020





# Tuesday 8 October 2013 Nobel Prize

LODHA  
**genius**  
PROGRAMME



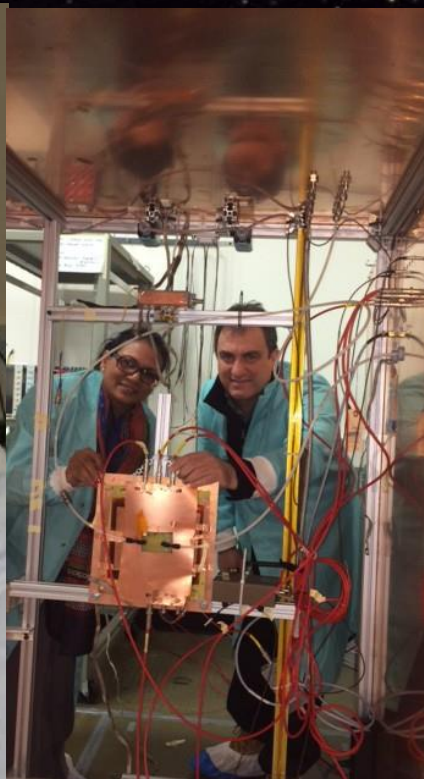
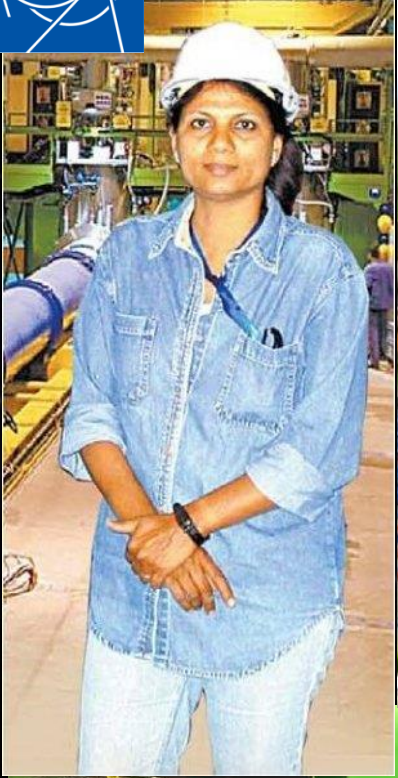


# The power of collaboration



INDIA CMS

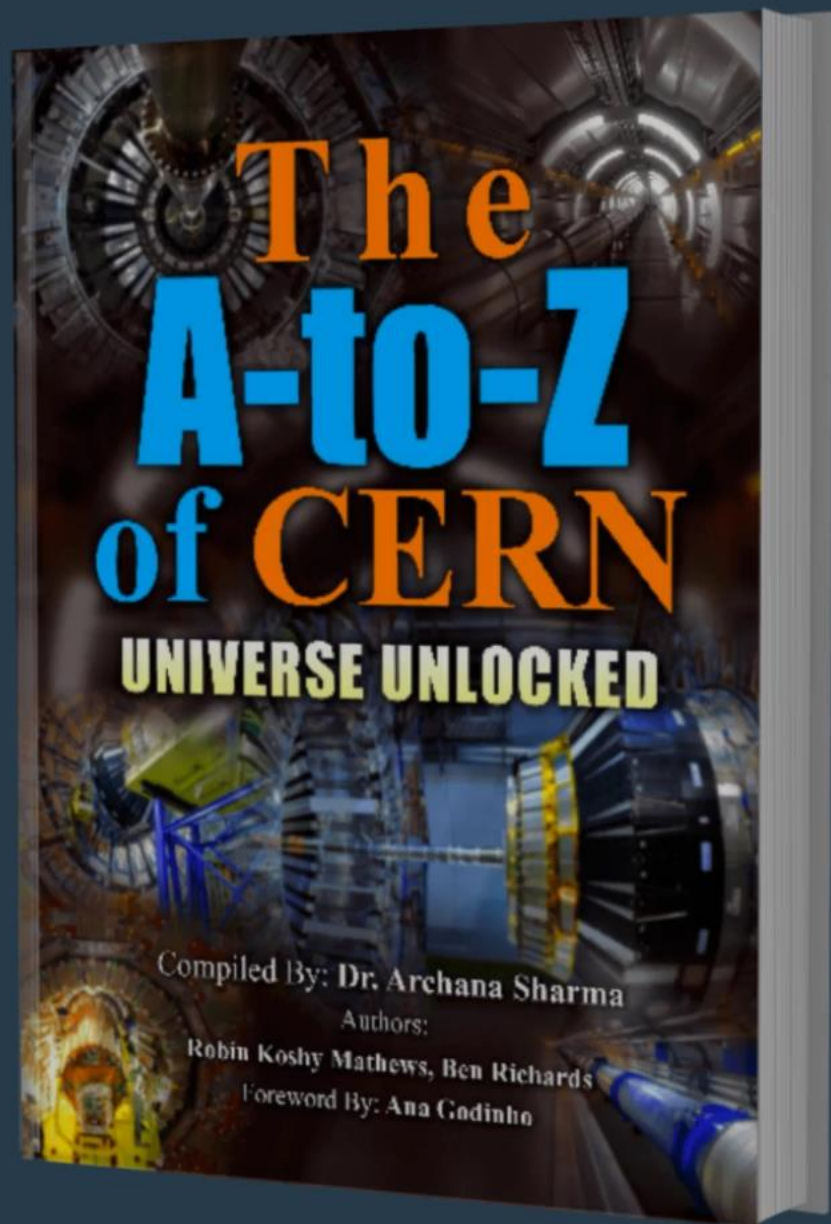






# YOUNG DIVERSE PEOPLE ARE KEY









# YOUNG DIVERSE PEOPLE ARE HERE





# Self Leadership

**Expertise in your chosen field**

**Not being afraid of being criticised**

**Resilience**

**Trying to find solutions and options**

**Not being afraid of failing, redefining failures as stepping stones**

**Finding role models**

**Working really hard at learning**



Curiosity about the Universe  
... Answers IMPACT **MBILLIONS OF LIVES**

# SUSTAINABLE DEVELOPMENT GOALS

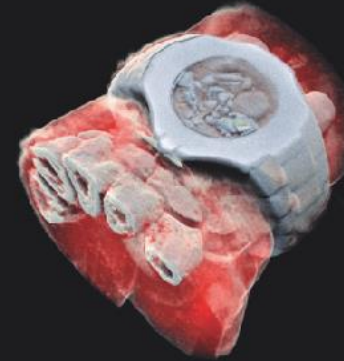
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## Important applications in medicine and healthcare

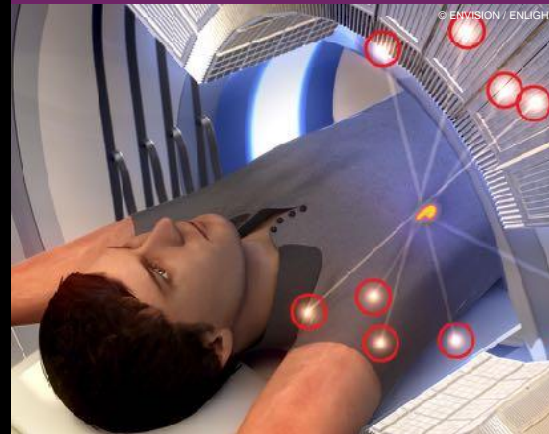


Technologies applied at CERN are also used in PET, for medical imaging and diagnostics.

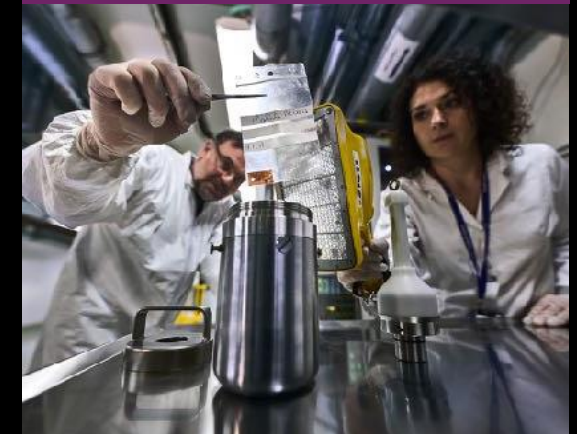


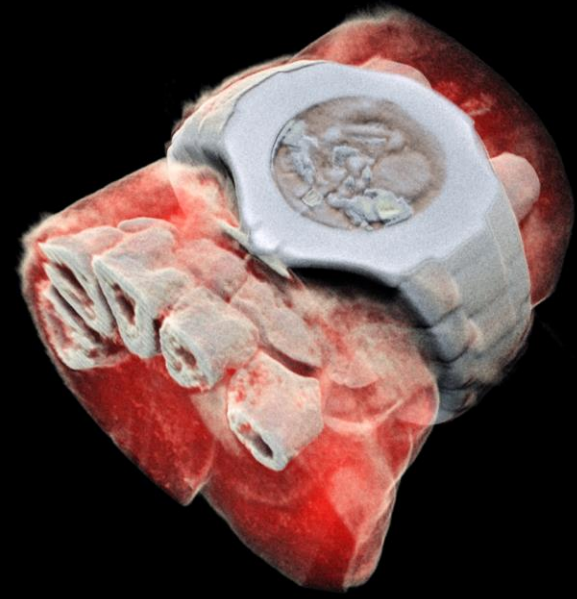
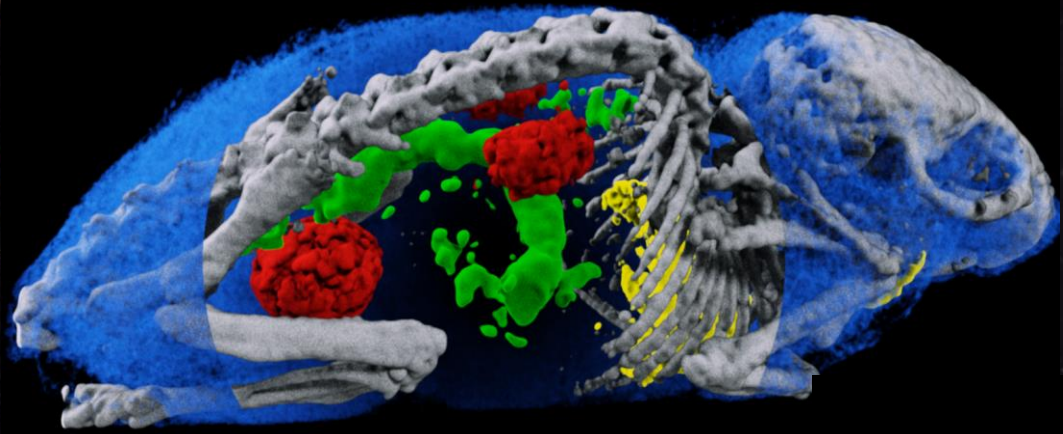
CERN produces innovative radioisotopes for nuclear medicine research.

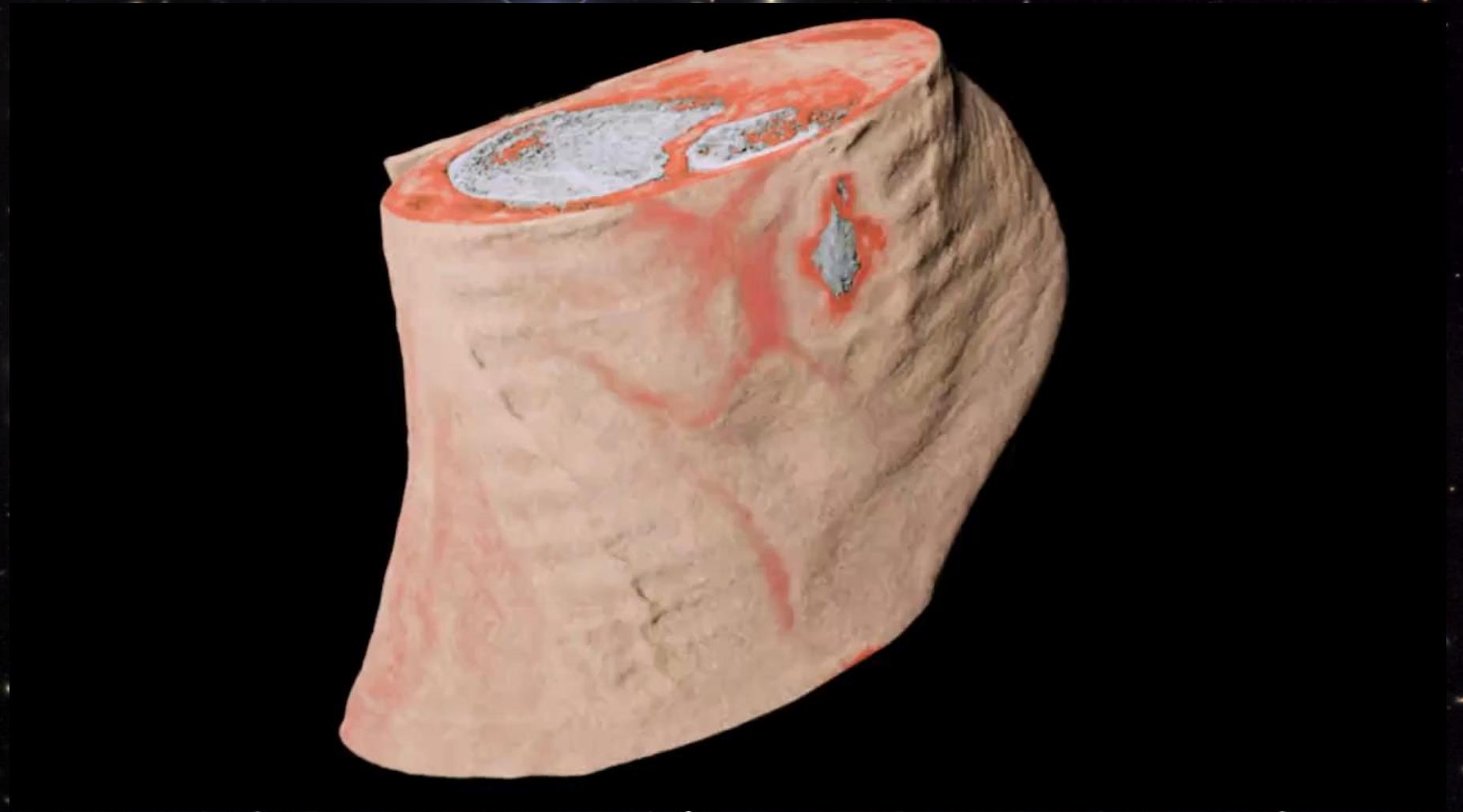
Accelerator technologies are applied in cancer radiotherapy with protons, ions and electrons.



Pixel detector technologies are used for high resolution 3D colour X-ray imaging.

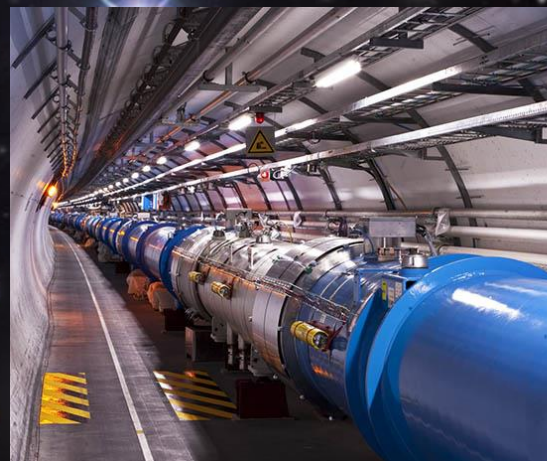








- Scientific Research
- Cutting edge technology R&D
- Social Impact
- Compelling business & industrial engagement

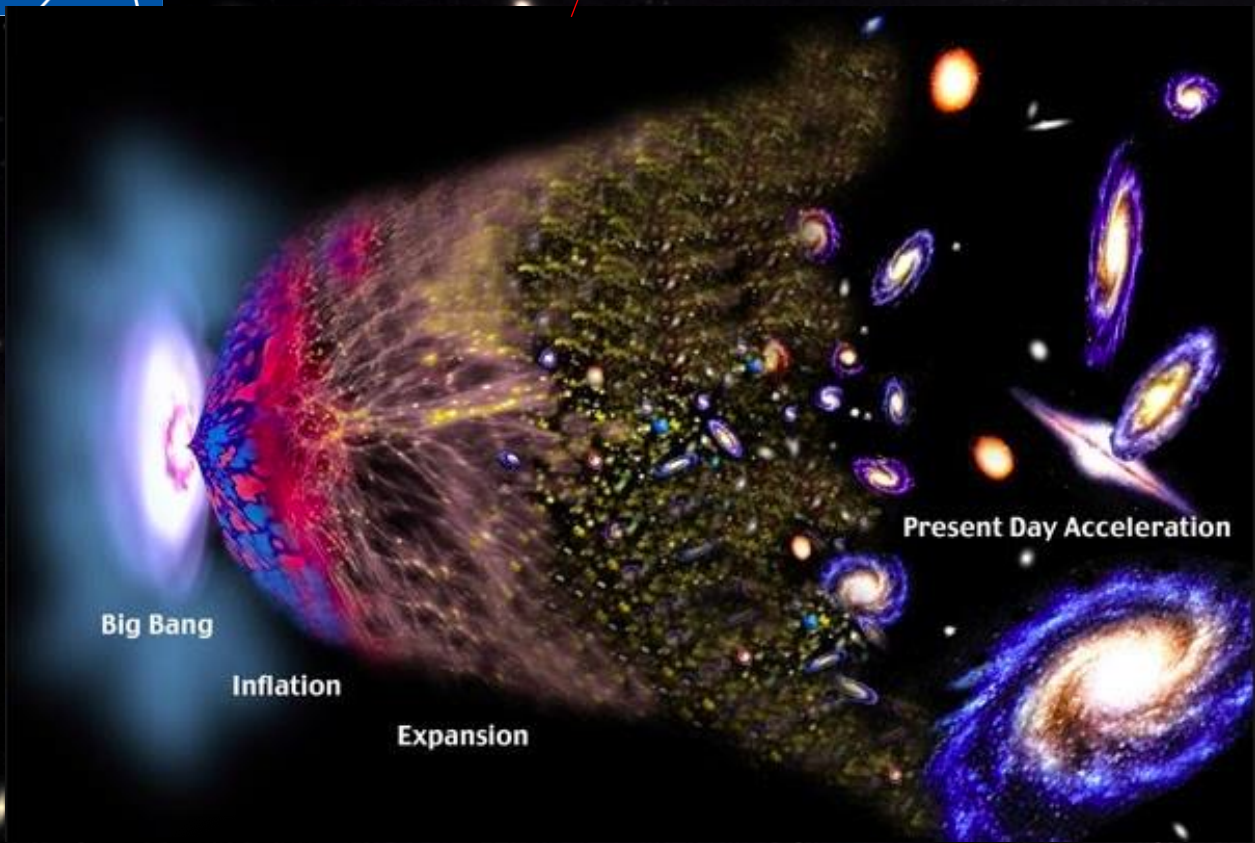








# Curiosity about the Universe ... Answers IMPACT MBILLIONS OF LIVES



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Opportunities  
Up-skilling for National Priorities via National and International Projects





**THANK YOU!**





# INDIA

## **We need to work on**

Innovation index (2020), India ranks 48th overall the top 15 nations in Informat

Expenditure in research and development has reached US\$ 96.50 billion in 20

## **Improving Policies:**

Empower the nation to improve its key strategic industries, including space, en



# INDIA

**Strong focus on S&T**, engine for economic growth.

Top in the field of scientific research, one of the top 5 for space

**Enrichment of knowledge** base in the fields of Science

**Premier institutions, R&D Labs**, advanced medical centres (with research facilities), experimental labs, and varied advanced industries.

**Knowledge warehouse with (24,000 PhDs per year) qualified and trained manpower** (Innovation bed for Microsoft, Google among others)

**Ranks third in terms of the most attractive investment destinations** for technology transactions globally. Apple and Samsung (production in India among others)



# INDIA

**AI: The inception of National Artificial Intelligence Strategy (NITI Aayog)**

**IISERs - efforts to nurture the basic sciences at both the undergraduate**

**Engineering Science & Science Engineering**

**Innovation index**

**—>Switzerland example patent capital / 8.5 million**

**With the focus on Science, India is progressively marching towards becoming**



# INDIA -from 'challenges' to 'hope'

Our developments' optimism to steer our spotlight

Application driven science and technology

Students are taking interest in innovation and entrepreneurship through Atal Inn

India is focusing S&T related to sports and flip the cusp to become capable of ho



# Governance : Project Follow-up



- Experiments put in place a project management
- In case of technical difficulties in a component
  - internal review identifies origin and initiates mitigation actions (by Technical Coordinator or Spokesperson)
  - Competent review committee signals failure and exposes problem
  - Milestone tracking
  - Spokesperson negotiates new solutions and reports to Resource Review Board
- Schedule changes
  - Agreed upon with the Spokesperson, the Technical Groups (and the CERN directorate)



# Governance : Resource Management



- The construction of the experiment necessitates joint purchases of some infrastructure
  - support structures that hold the detector in place
  - specific cooling, heating, distribution systems, ...
  - components not covered by the host laboratory responsibilities, since they are specific to the experiment (Common Fund)
  - financed by funding agencies
  - monitored by RRB
- Host lab responsibilities cover the cost to enable an experiment in the first place: experimental cavern, radiation protection, supply of services such as electricity, cooling and gas; provision of transport of components to the site...





# Governance : Maintenance and Operation



- Technical and Resource Coordinators) presents on an annual basis a budget for Maintenance and Operation (M&O) of the experiment to the **Resource Review Board (RRB)** and its subordinate expert body, the **Scrutiny Group**.
  - before submission to the RRB the M&O requests are scrutinized internally by the experiments
- The M&O budget is used for (M&A)
  - maintenance of detector components
  - replacement of broken or obsolete equipment
  - maintenance of online system (typical useful life time of CPUs ~4 years)
- Detector specific Maintenance and Operation budget (M&O B)
  - institutes that contribute to a specific detector
- The **RRB** is composed of members of the **funding agencies** contributing to the experiments and meets twice a year
- M&O sharing is based on the number of authors with PhD, updated every year

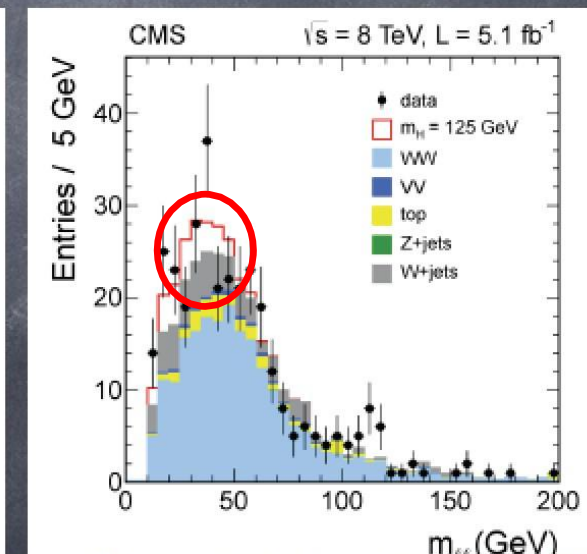
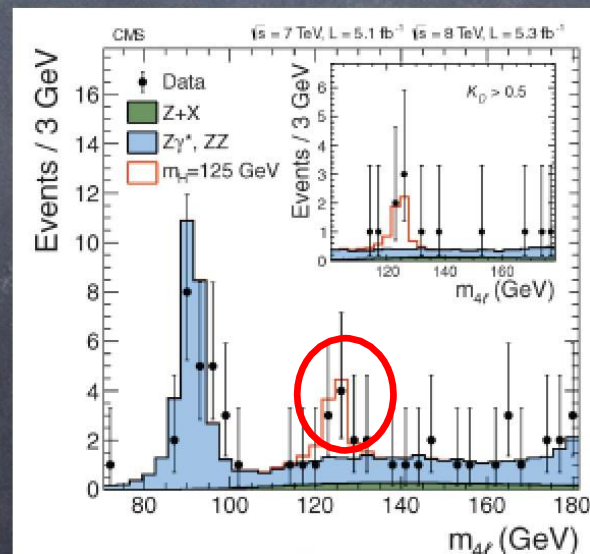
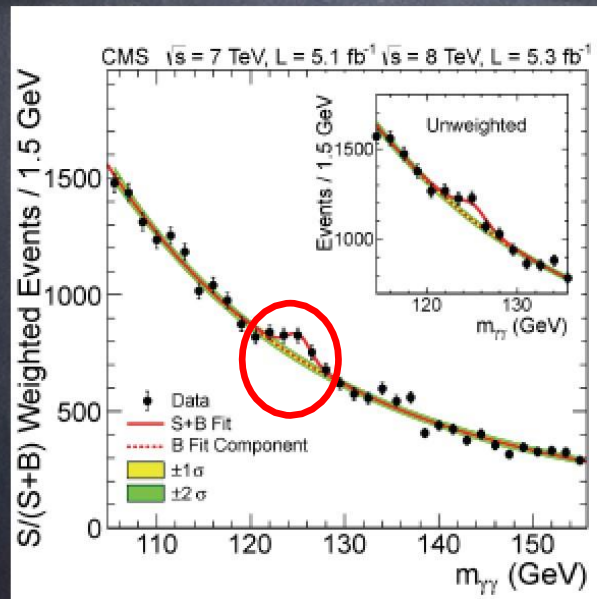
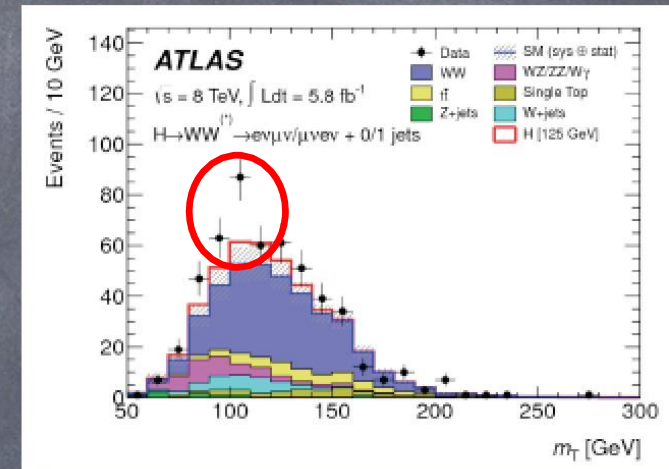
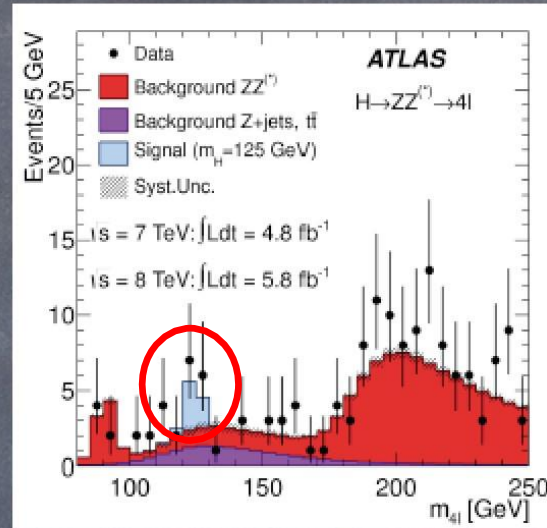
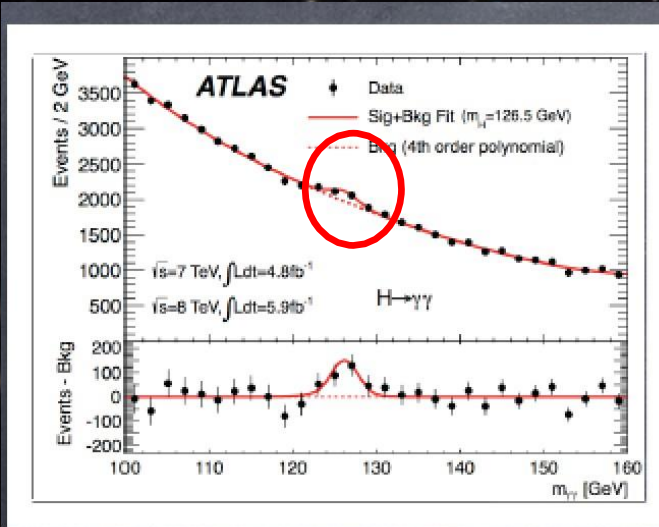


# Governance Risks Mitigation



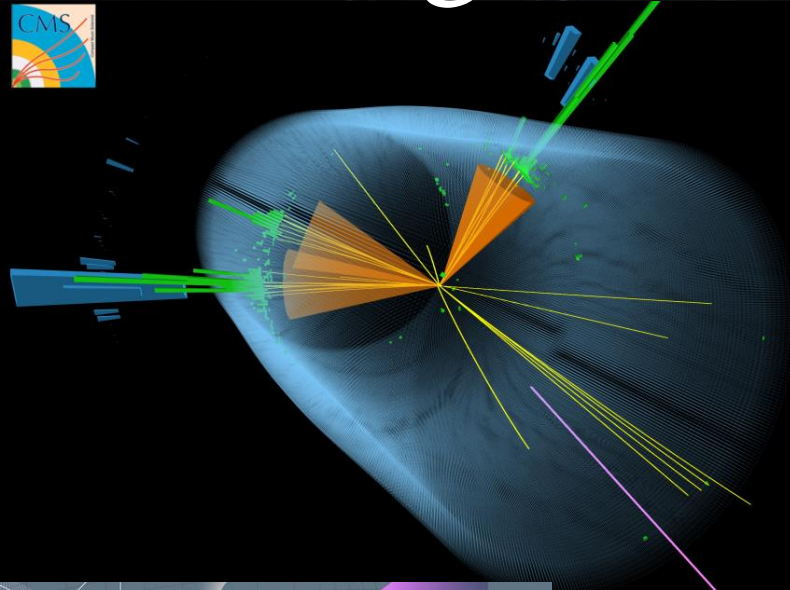
- The governance of scientific experiments has a long and highly successful tradition
- It has grown from small experiments of some ten people in the 1960s to the large collaborations comprising more than 6000 members today
- It is built on fair sharing, on a joint (physics) goal and the determination to succeed
- Risks are transparently and well managed
- The monitoring of the scientific success and the efficient use of resources involves committees with international experts
- The experiment results and data are available in the spirit of Open Science

# Higgs $\rightarrow$ 2 photons!! Higgs $\rightarrow$ ZZ $\rightarrow$ 4 leptons!! Higgs $\rightarrow$ 2W $\rightarrow$ 2l2v!!



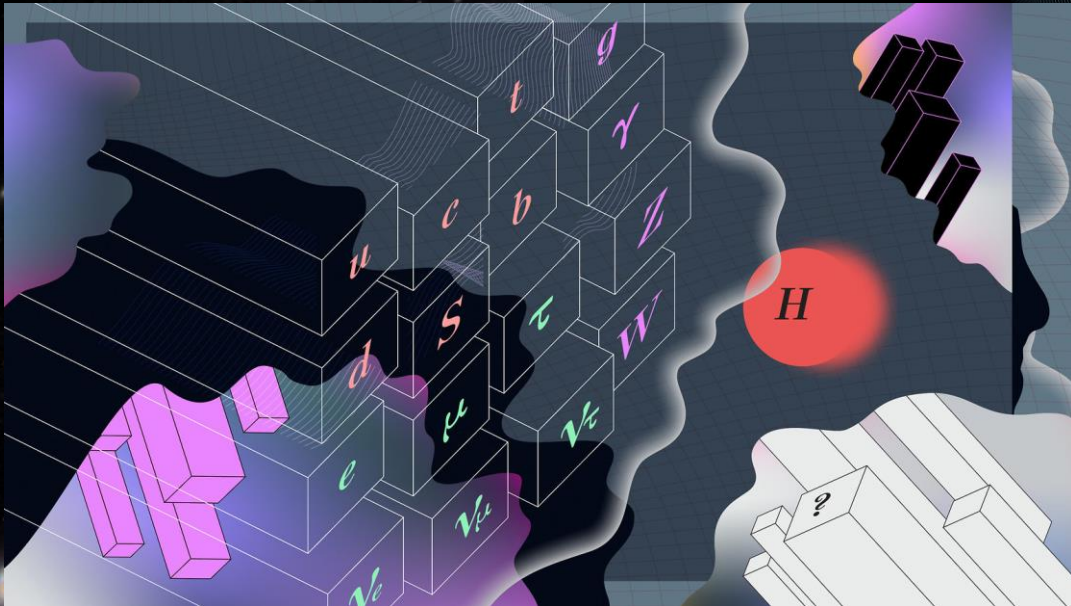


# Data Challenge



Artificial Neural Networks search for exotic particles

Machine-Learning Technology to track odd events among LHC data



Picture from Symmetry magazine



# Scientific Leadership and Global Impact



Beyond the suffering it's already causing, worse climate change could increase existential risks from other causes and affect standards of living far into the future.

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