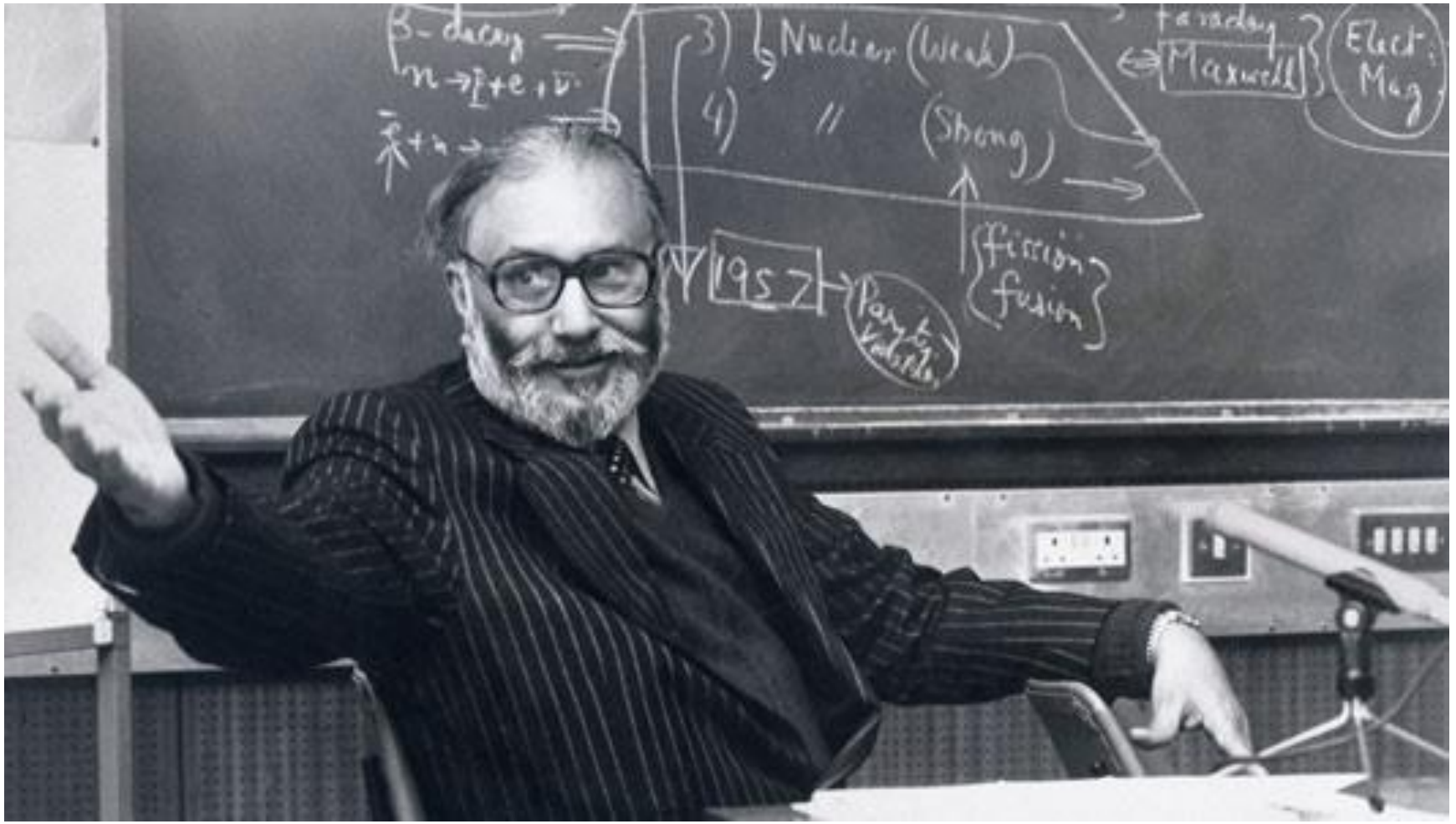
ICTP PHYSICS WITHOUT FRONTIERS

Workshop in Computational Cosmology and High Energy Physics

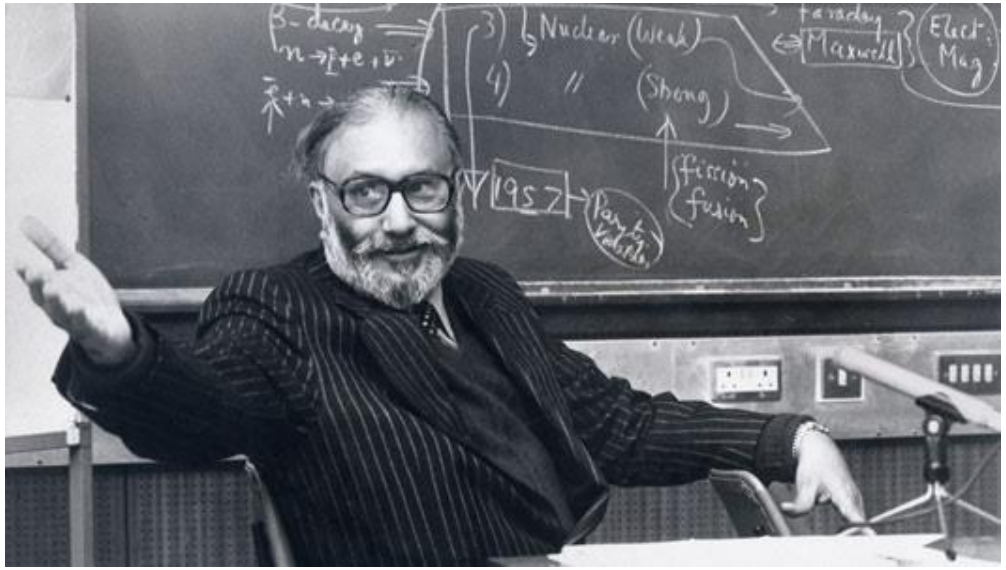
University of Phayao, Thailand
20-25 October 2025

Dr Kate Shaw
Associate Professor at the University of Sussex, & ICTP)
ATLAS experiment, CERN
Deep Underground Neutrino Experiment (DUNE)

Introduction to the ICTP



Introduction to the ICTP



The **Abdus Salam** **International Centre for Theoretical Physics (ICTP)** was founded in 1964 by Abdus Salam, in Trieste in the North-East of Italy who served as its director until 1993.

ICTP is a focal point of **cooperation** between the North and South, aiming to support scientists contribute to state-of-the-art research in **physics and mathematics**.

Introduction to the ICTP

The international Centre for Theoretical Physics (ICTP), Trieste, Italy.

During the Cold War era in the heart of Europe, a continent separated by the iron curtain, ICTP provided a rare line of communication between scientists from the East and West, and those from developing nations.

Introduction to the ICTP

ICTP organises more than 60 conferences and workshops, with 4000 – 5000 scientists from around 130 nations each year.

ICTP is an institute with 6 main areas of research:

- High energy, cosmology and astro-particle physics
- Condensed matter physics
- Mathematics
- Earth sciences
- Applied physics
- Quantative life sciences

Programmes include

- **<u>ICTP diploma: a pre PhD one year course with project</u>**
- Master programmes, including medical physics
- Sandwich (STEP) programmes
- Laboratory Opportunities
- Scientific Calander with many workshops and conferences

ICTP Physics Without Frontiers

ICTP Physics Without Frontiers works to teach, train and motivate physics and mathematics university students worldwide **to help build the next generation of scientists**. Each project is unique, developed with the country's specific needs in mind.

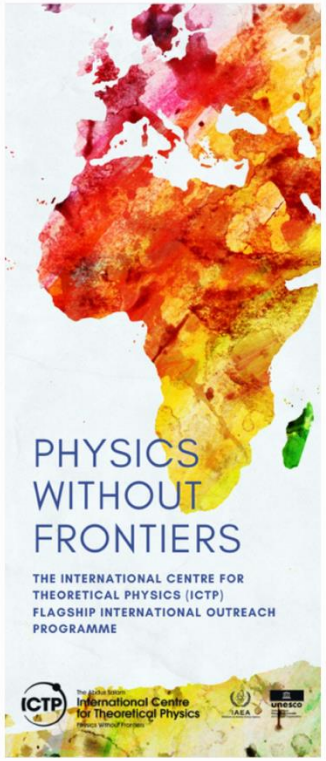
- **Inspire** and **motivate** the next generation of physicists
- **Train** and **educate** those with hands-on physics and transferable skills
- **Collaborate**, providing stimulating networking environments
- **Mentor** students onto further study and provide career advice


HEP Workshop, Afghanistan

ICTP Physics Without Frontiers

We work with over **50 countries** worldwide, and run around 25 PWF projects around the world every year, in all areas of physics






Physics Without Frontiers: Thailand

Chonticha Kritpetch, University of Phayao

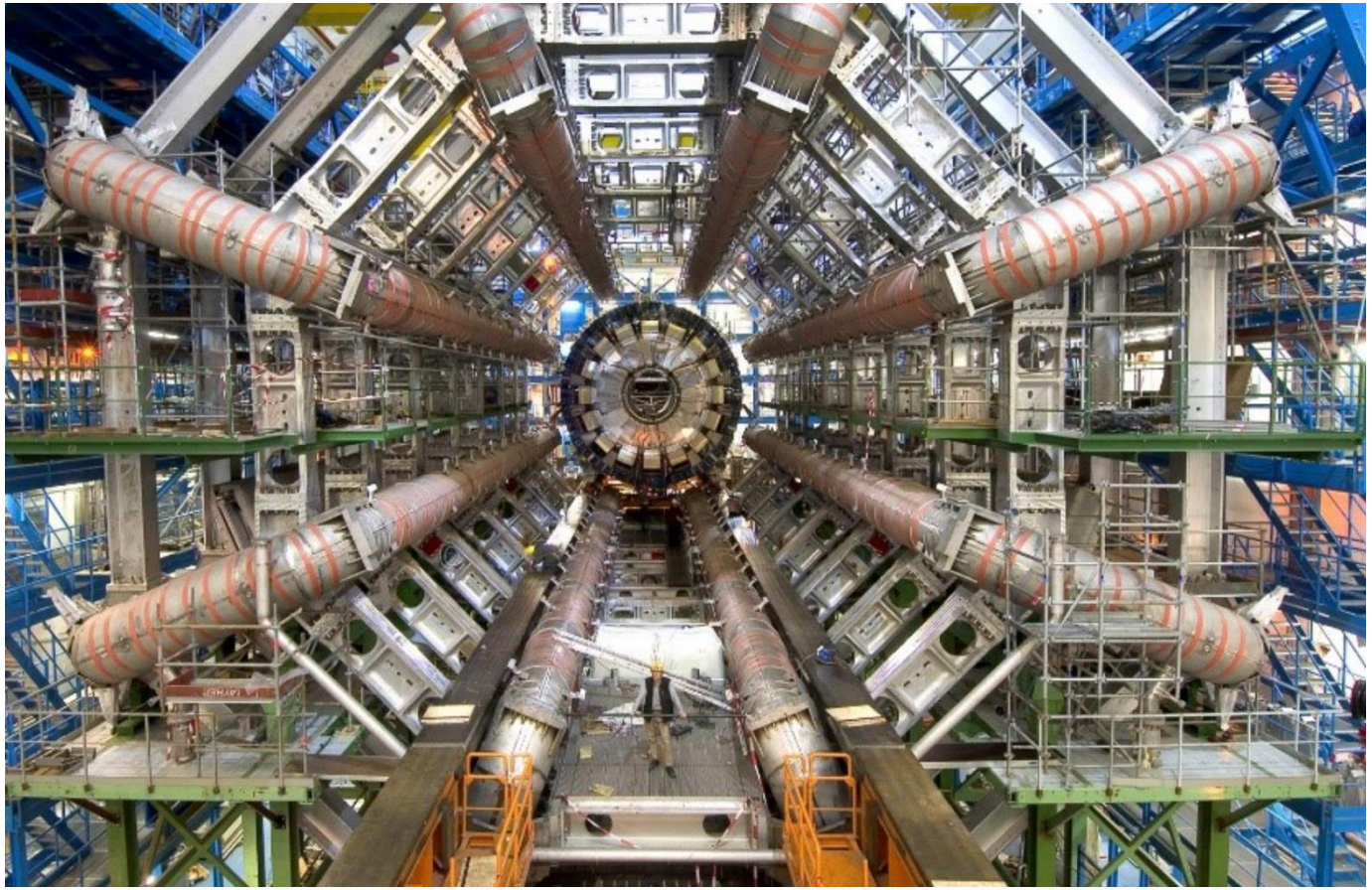
Suphakorn Chunlen, University of Phayao

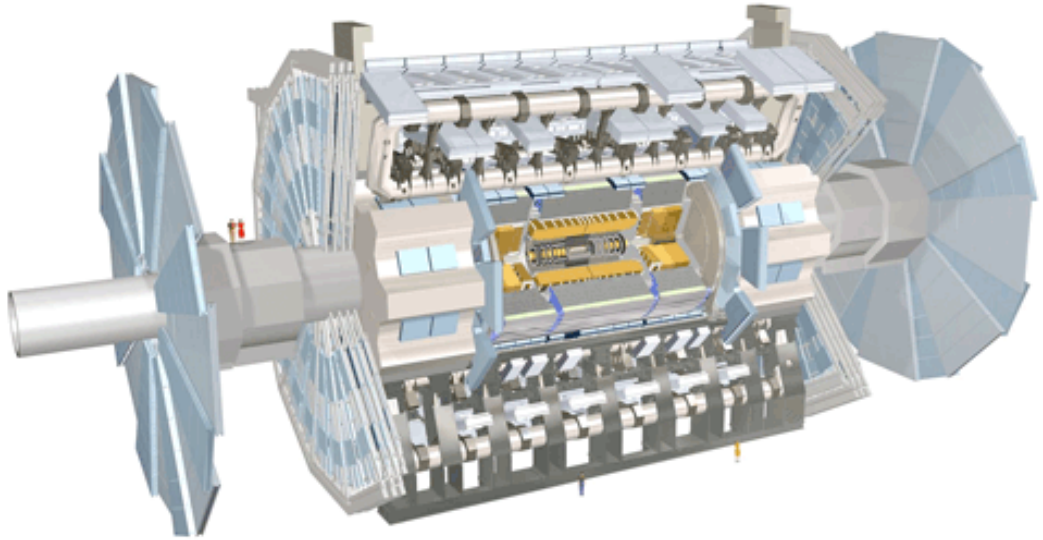
Phongsaphat Rangdee, University of Phayao

Nandan Roy, Centre for Theoretical Physics and Natural Philosophy, Nakhon Sawan Studiorum for Advanced Studies (NAS), Mahidol University

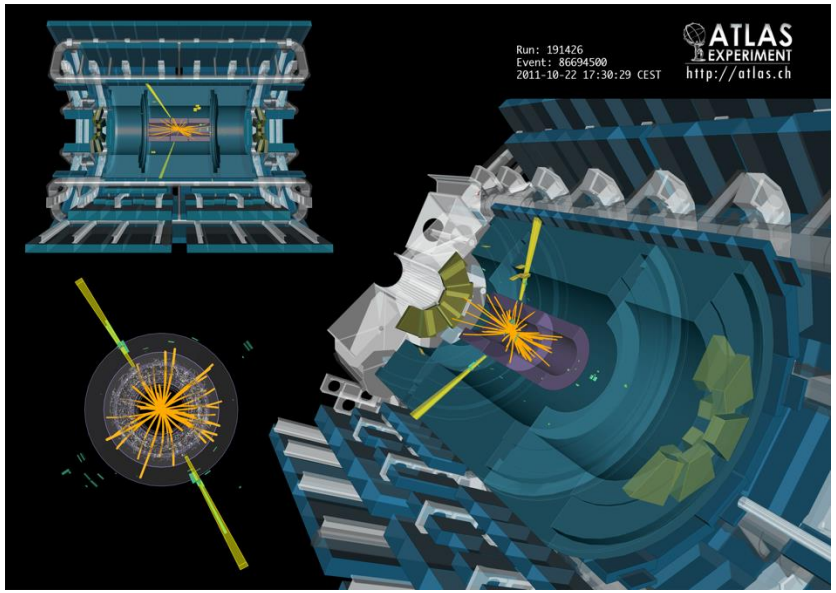
Thank you *to the organisers and the whole team at the University of Phayao for all their hard work!*

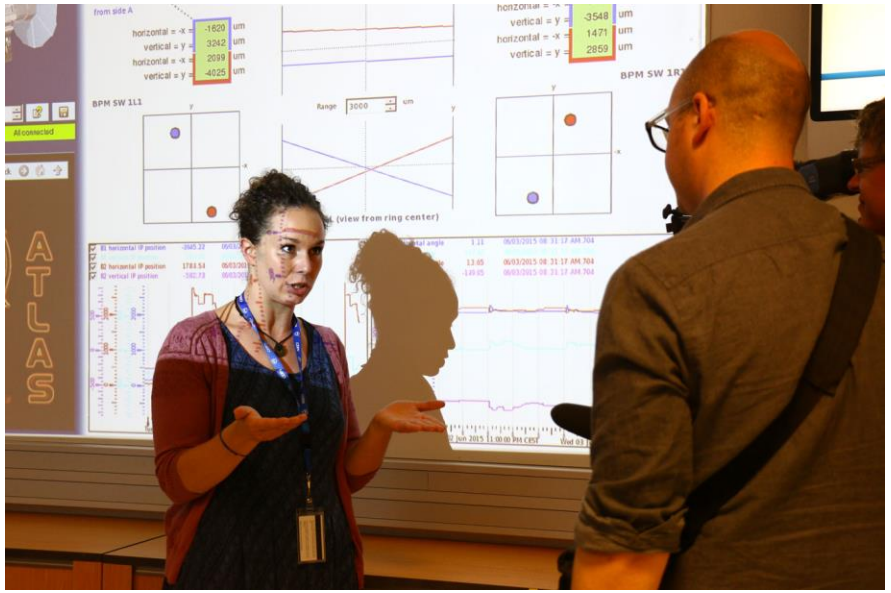
High Energy Physics

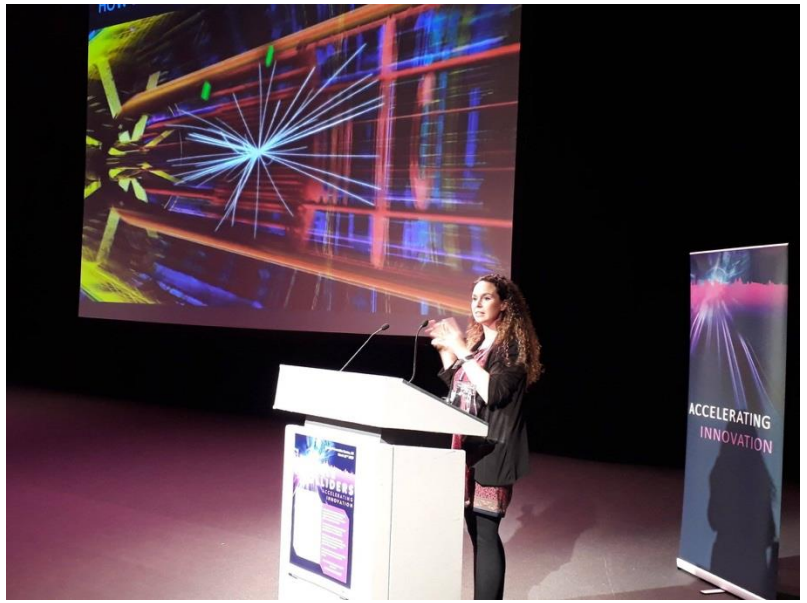




My Journey







19 years working on the ATLAS experiment at CERN

2002–2006 **Degree in Physics**, University of Liverpool, MSc on ATLAS

2006-2010 **PhD University of Sheffield**, building inner detector, vertex reconstruction, 1.5 years based at CERN

2010-2016 **Postdoctoral Fellow at ICTP**, based at CERN, Top physics and Luminosity measurements

2016-present **Staff Scientist at ICTP** (2016-2019 based at CERN) Top and Higgs Physics, using EFT

2018–present **Associate Professor at the University of Sussex** (Research on ATLAS experiment and DUNE experiment)

My Journey

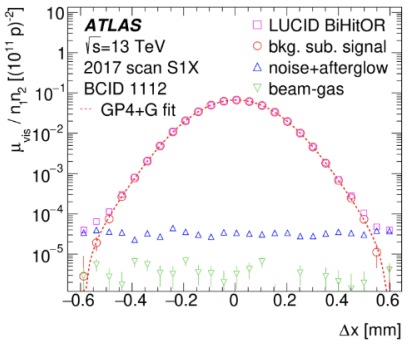
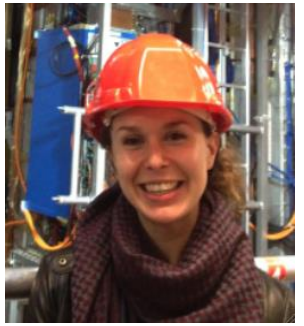
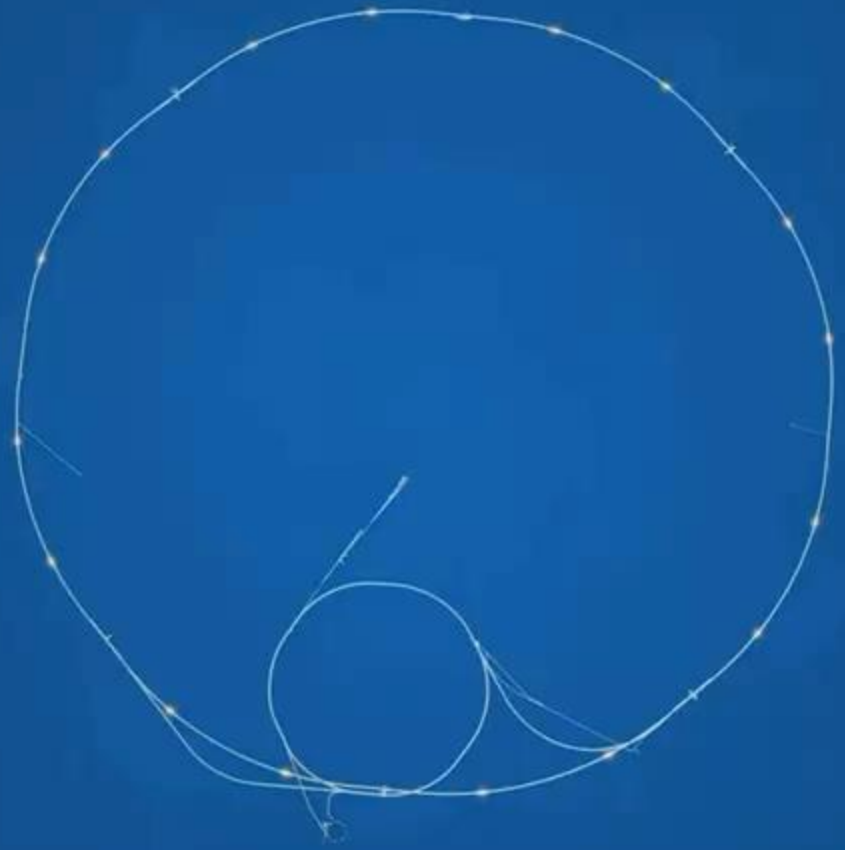


Figure 1: Van der Meer (vdM) scan curve, showing the number of visible interactions normalised by the number of protons in the bunches, as a function of the beam separation in the horizontal plane for one colliding bunch pair, measured with the LUCID-2 sub-detector in 2017. The curve is fitted and backgrounds are subtracted to extract the width of the beams in the scanned direction. (Image: ATLAS Collaboration/CERN)

- **Inner detector commissioning, vertex reconstruction, luminosity measurements and calibration**
- **Top quark and Higgs measurements and looking for new particles with the ATLAS experiment at CERN**
- **Joined the Deep Underground Neutrino experiment (DUNE) in 2022**
- **Outreach coordinator 5 years (initiated ATLAS Open Data project)**
- **International public talks, training and courses, co-founder of Physics Without Frontiers**



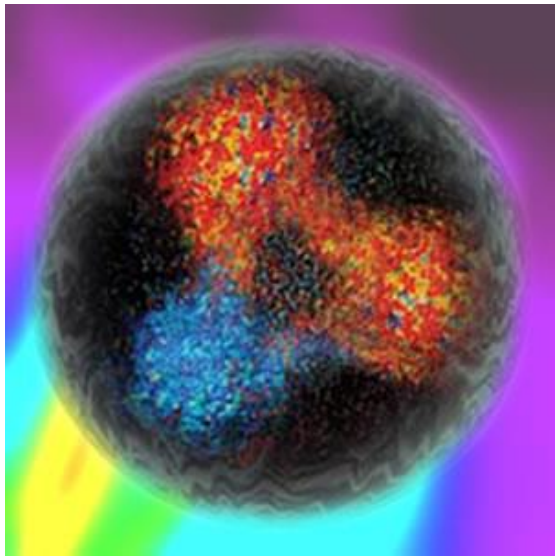


The Large Hadron Collider

The LHC accelerates some of the

smallest objects in the universe

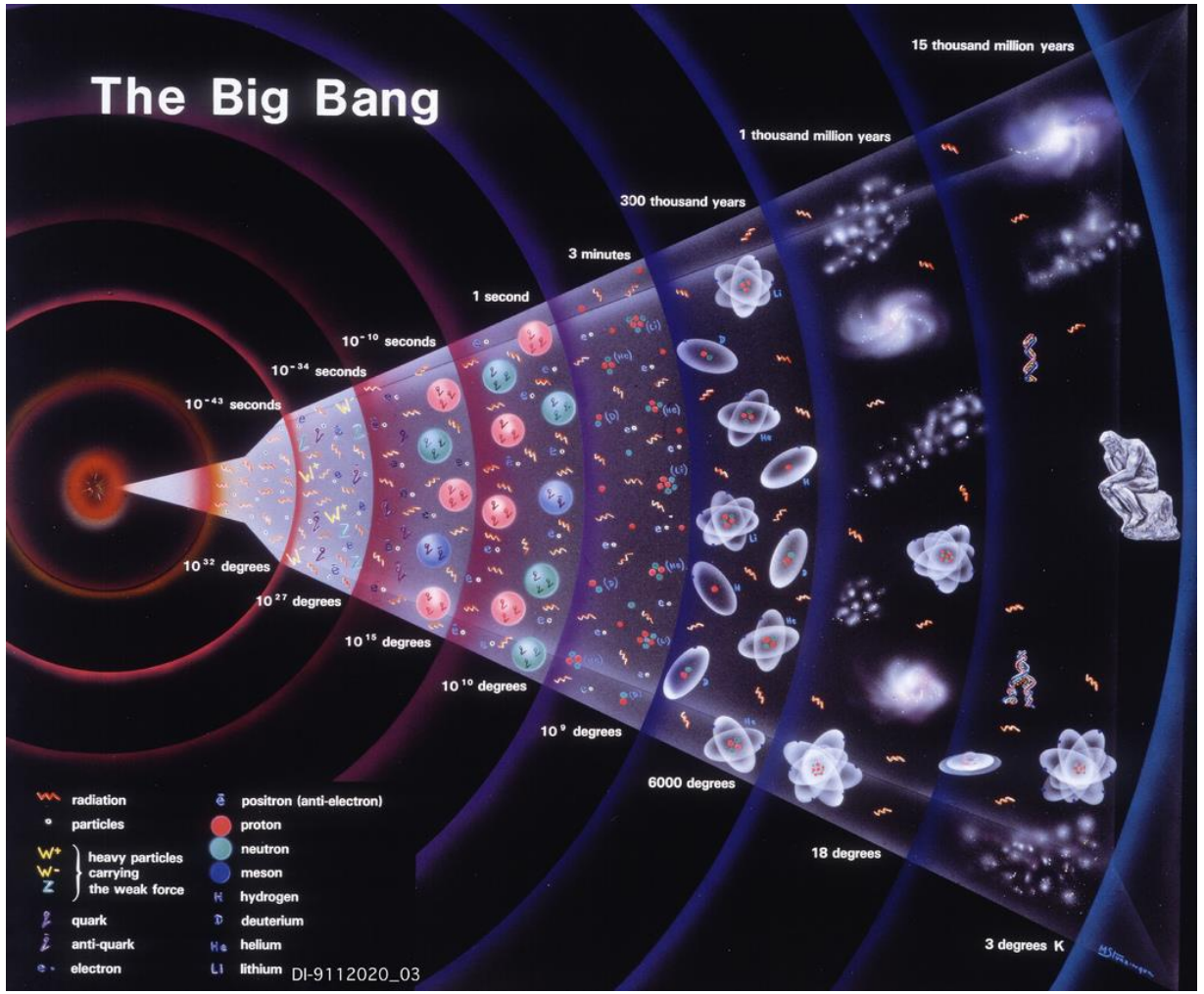
up to almost the fastest speeds possible in the universe!



Using magnets 1.9 K (-271.3°C), colder than outer space!

The Large Hadron Collider

WHY do we smash protons together at high energies millions of times a second?



What does a Particle Physicist do?

Questions we ask:

- **Where** did everything come from?
- **What** is everything made out of?
- **How** does it work together to make our Universe?

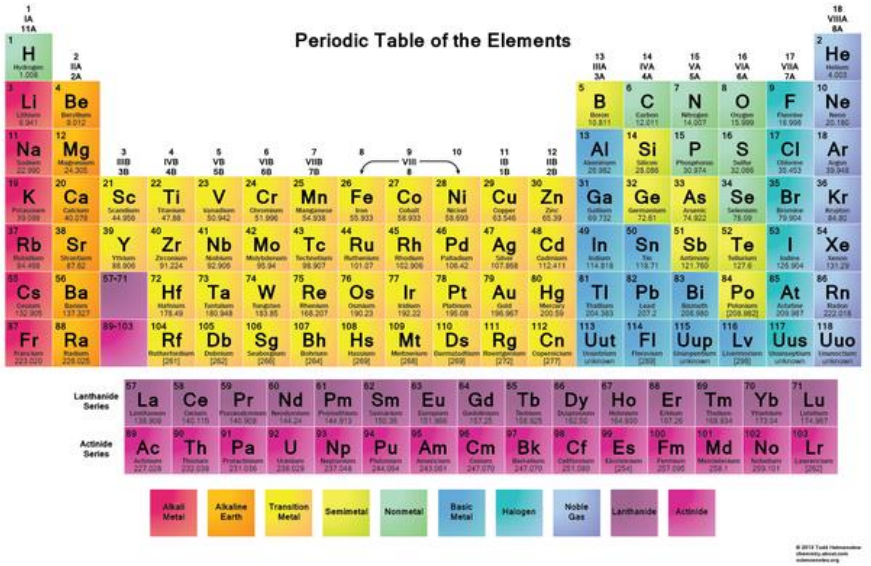
What is everything made out of?

At the beginning of the 20th Century Lord Kelvin said the Physics was basically finished

Along came

- Quantum Mechanics
- Special and General Relativity
- Quantum field theory that led to the Standard Model of particle physics

The Modern World was born!



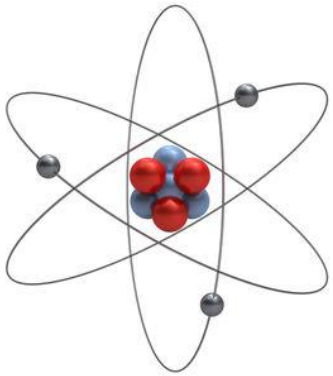
The periodic table, arranges chemical elements by atomic mass.

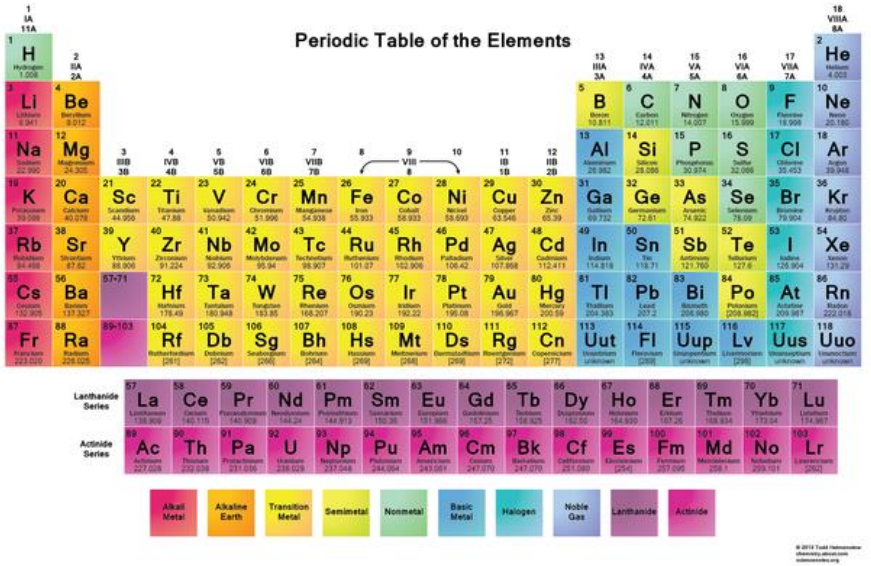
What is everything made out of?

1897 **electron** discovered by J.J. Thompson

1911 **nucleus** of the atom discovered by Ernest Rutherford, and nucleus of hydrogen a **proton**

1932 **neutron** discovered by James Chadwick





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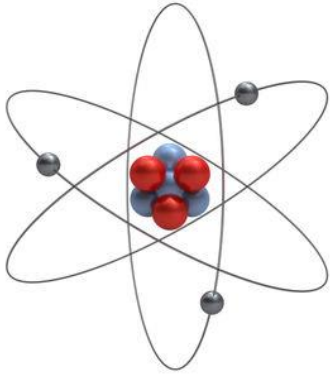
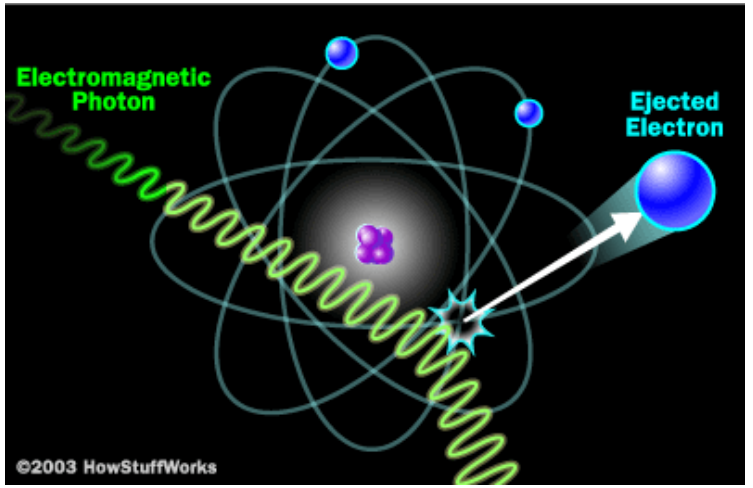


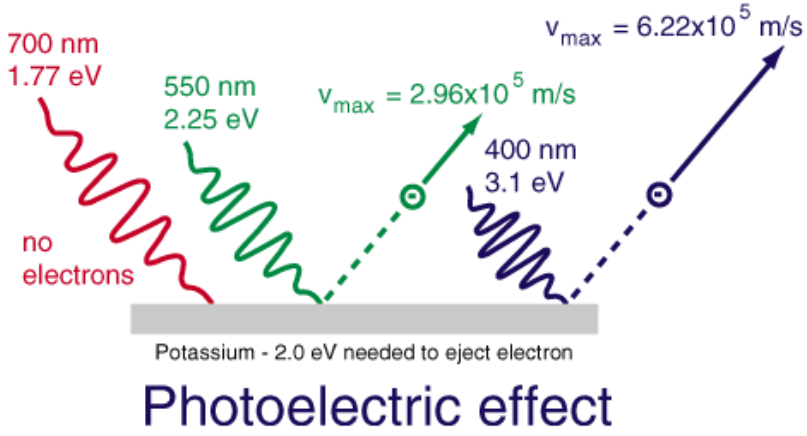
1932 **neutron** discovered by James Chadwick

1905 **photon** – particle of light and of the electromagnetic force suggested by Einstein in 1905

Electromagnetic waves could only exist as discrete wave packets – light quantum or photon



$E_{photon} = h\nu$

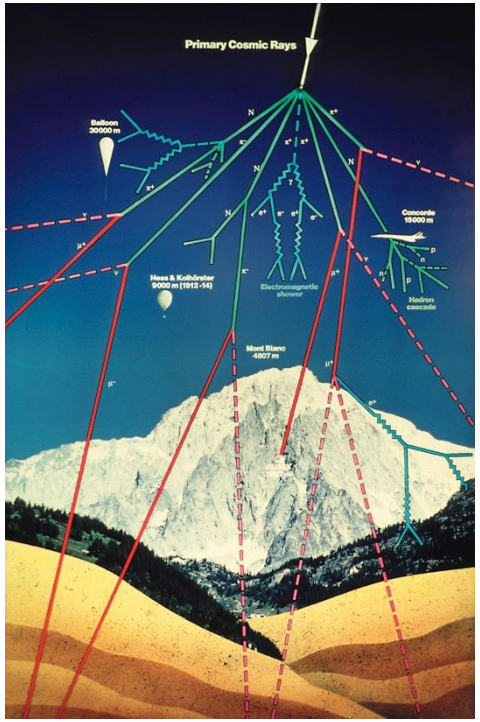


Photoelectric effect

What is everything made out of?

However other particles not part of the atom seemed to appear!

- 1932 **positron** detected (predicted by Dirac in 1928)
- 1934 **neutrinos** established in theory – detected in 1956



- 1937 muons were discovered in cosmic rays

  Who ordered that?

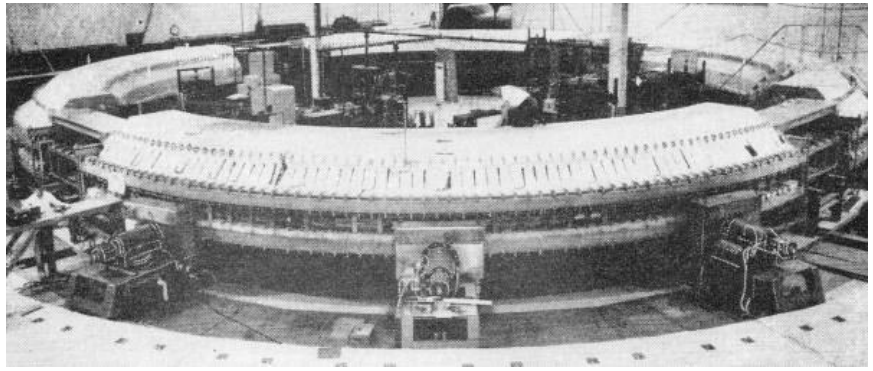
- 1947 pions (a type of meson) were also discovered!!

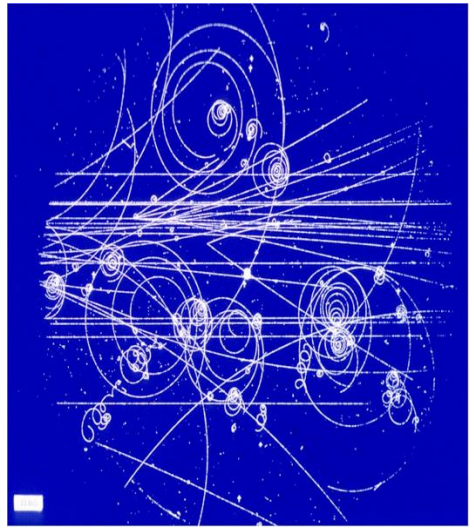
Things were getting out of hand!

What were all these particles?

What is everything made out of?

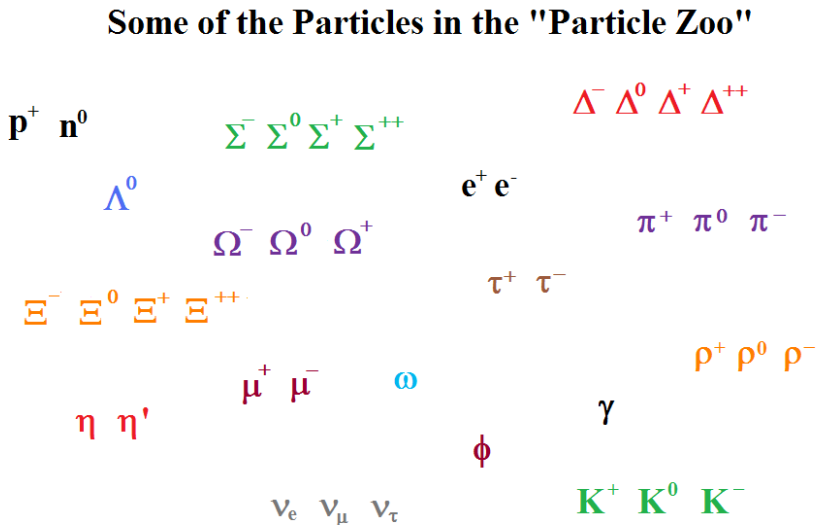
Atom smashers (1950s)





Plethora of NEW particles started coming out of these atom smashes!

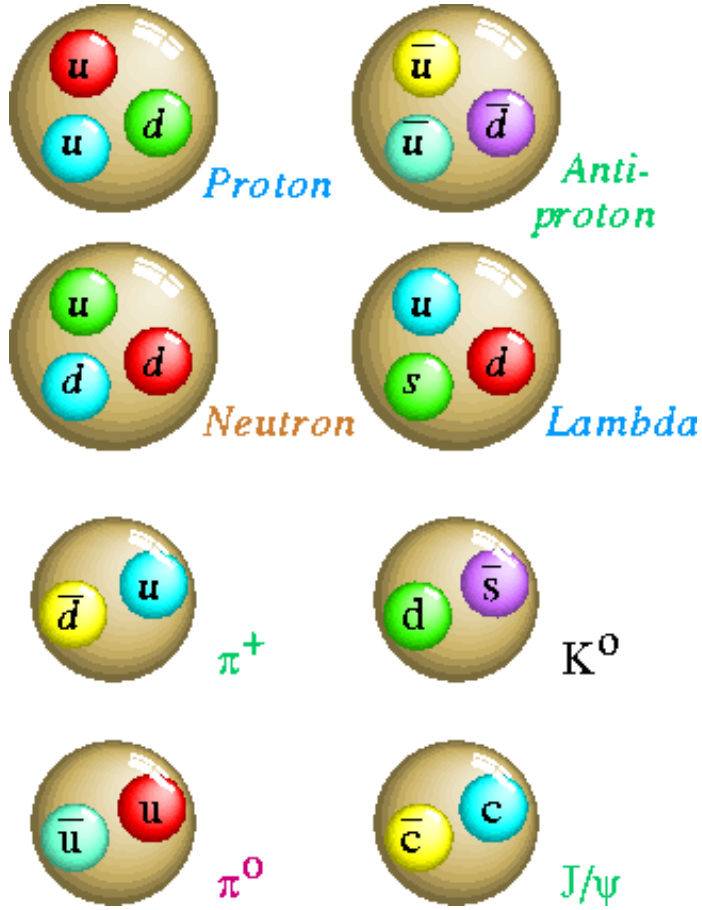
Sigma particles, rho particles, Delta particles, kaons, Lambda…



What is everything made out of?

Break Through!

1960s Murray Gell-Mann of Caltech said **hadrons** are composed of more fundamental particles which he called **quarks**.



The word comes from a line in Finnegans Wake, a book written by James Joyce.

What is everything made out of?

DISCOVERY: Bottom, Top, WZ, HIGGS!

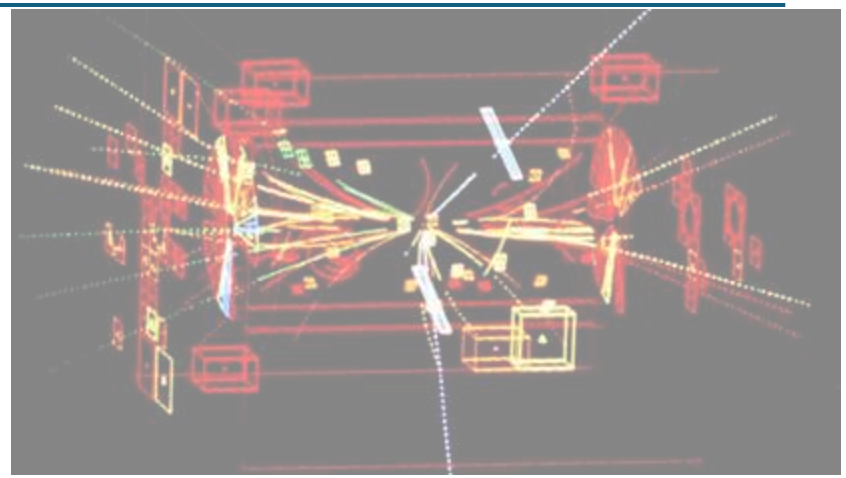
1977 Bottom quark discovered at Fermilab

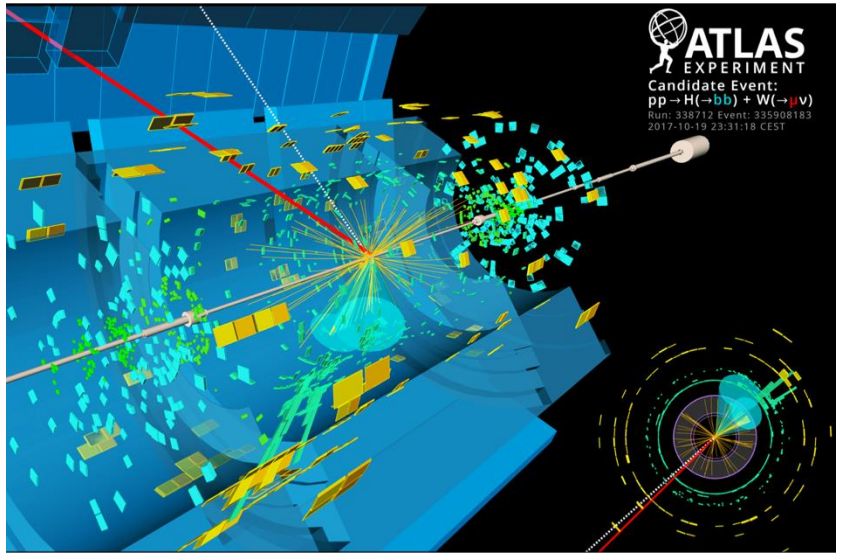
1983 W and Z bosons discovered at CERN

1995 TOP (the best particle!) discovered at Fermilab

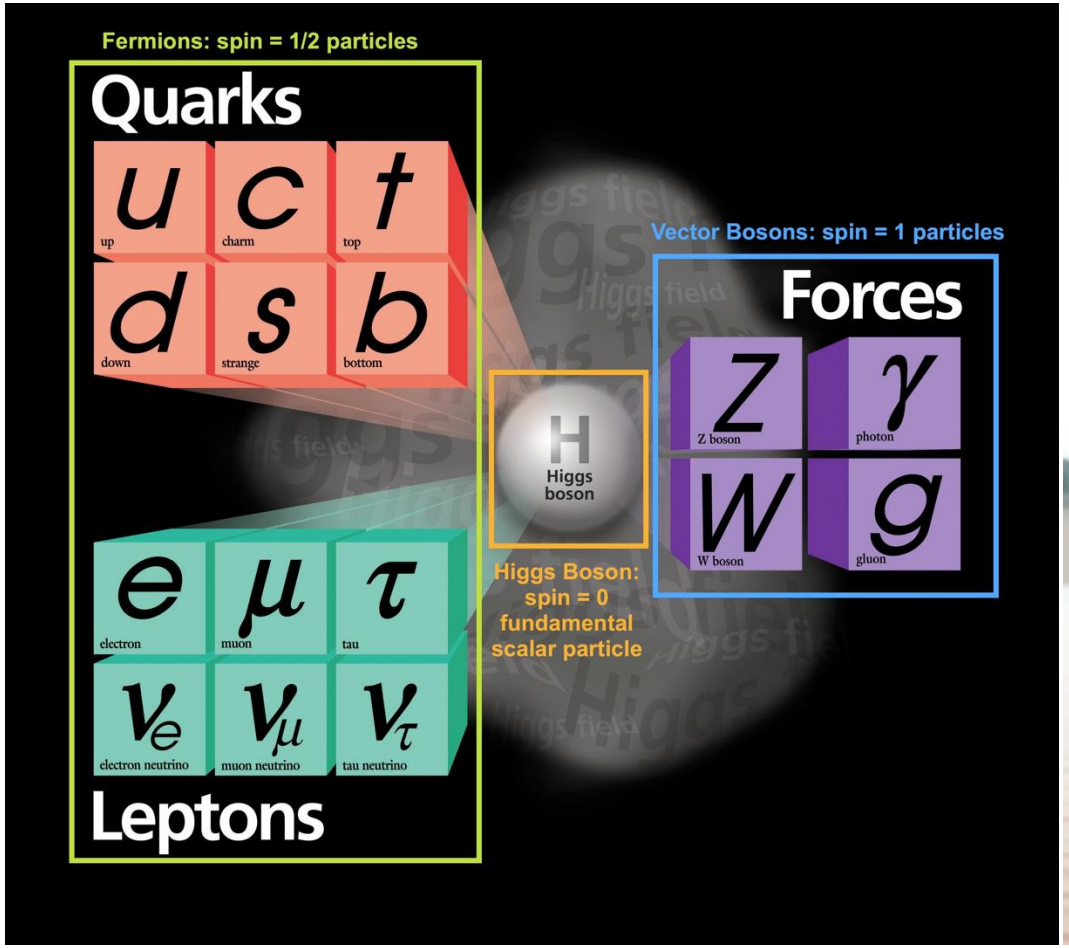
2000 Tau neutrino Fermilab

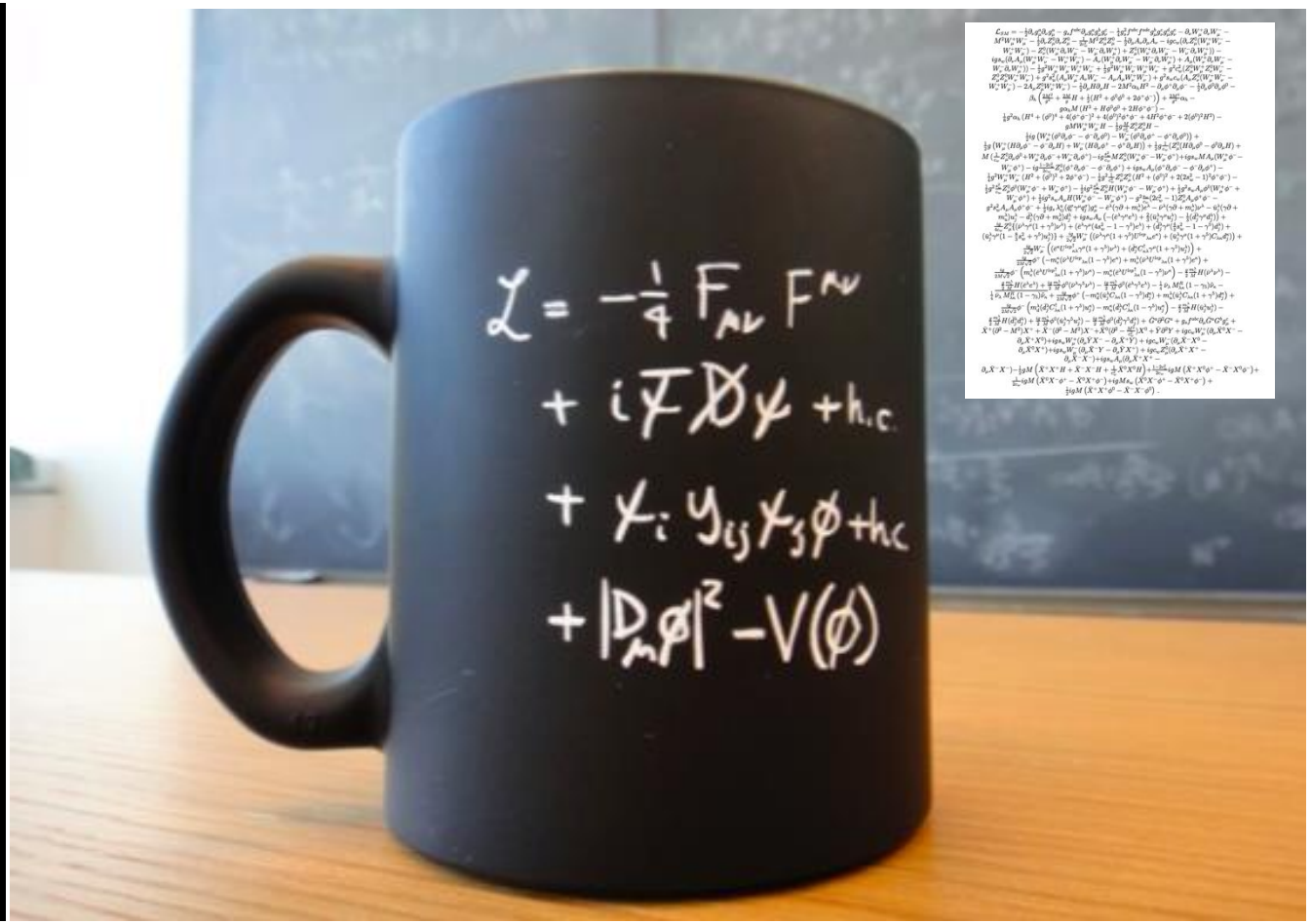
2012 Higgs at LHC, CERN



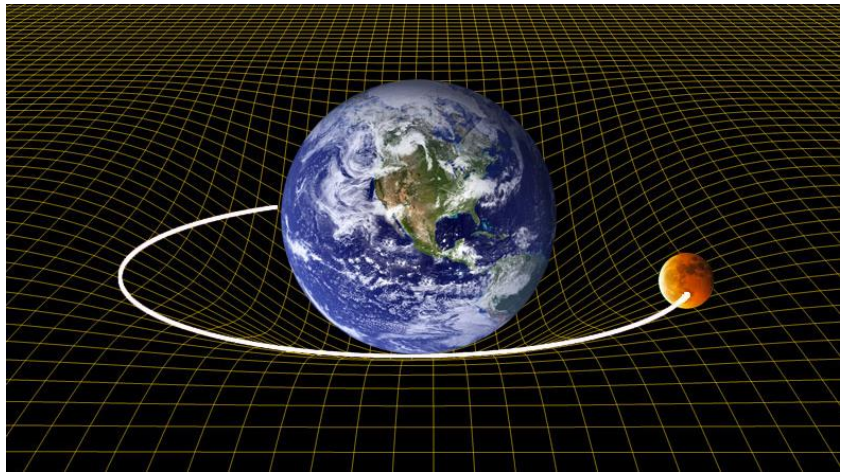


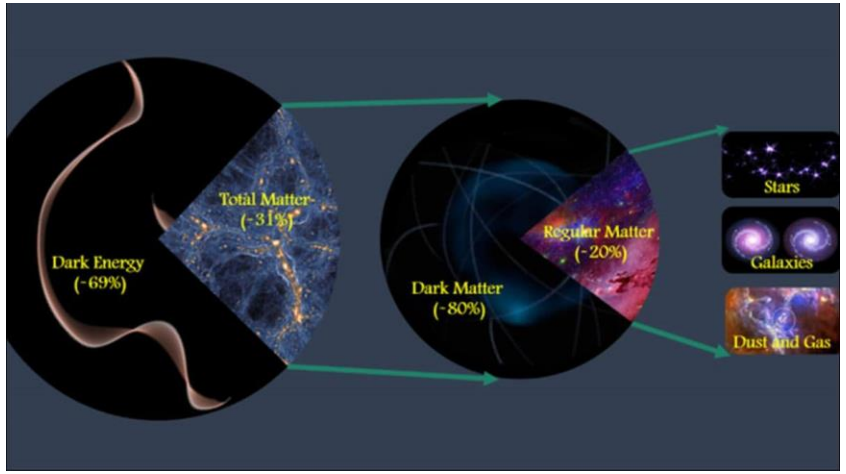
What is everything made out of and how does it interact?





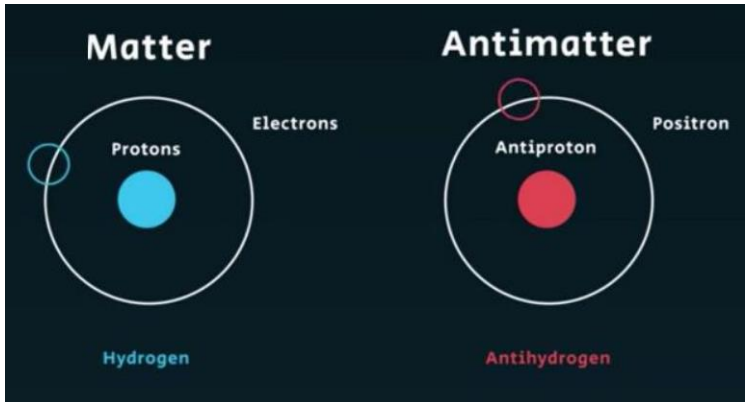
Problems





No Quantum description of Gravity!
➔ Is not described by the Standard Model!
➔ No Graviton has been detected

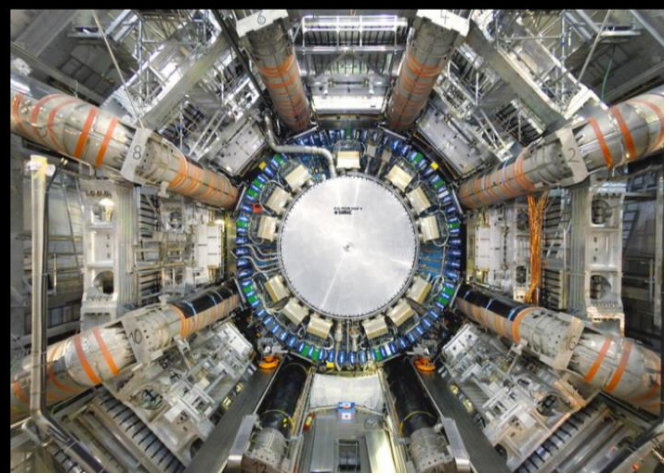
Matter-Antimatter Asymmetry -> Why is everything made of matter and not antimatter?



Dark Matter and Dark energy still not explained!

CERN – An International Laboratory!

CERN and Thailand signed an International Cooperation Agreement (ICA) in 2018.

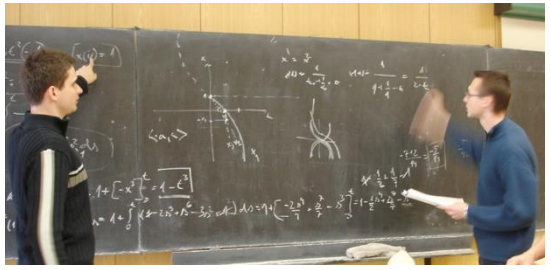


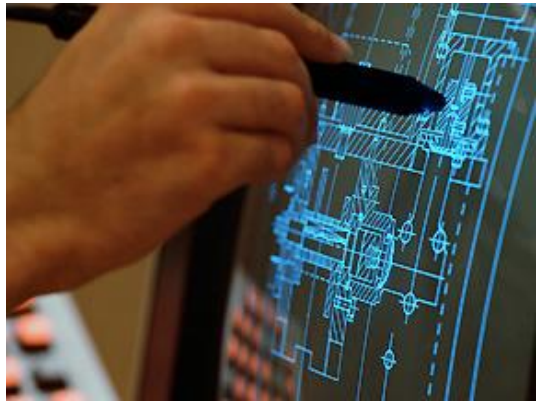
CERN is a hugely inspirational place for fundamental research and training!

Opportunities for Summer Placements

https://home.web.cern.ch/summer-student-programme

Why do Fundamental Sciences?



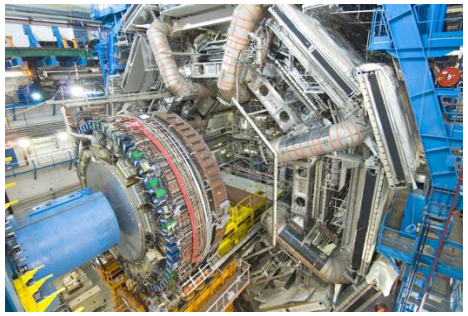


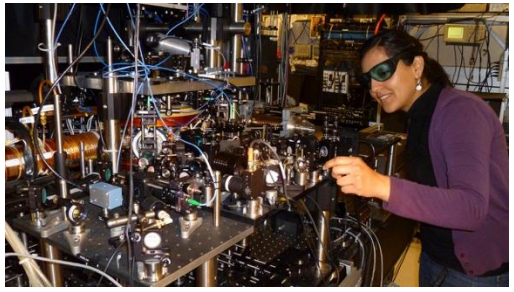
Fundamental Science

Applied Science

Technology, Engineering and Innovation

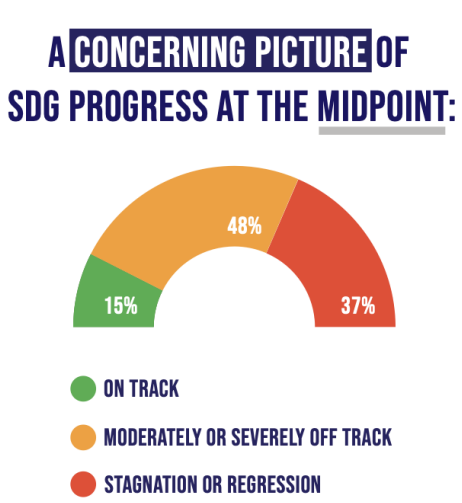
Sustainable Development

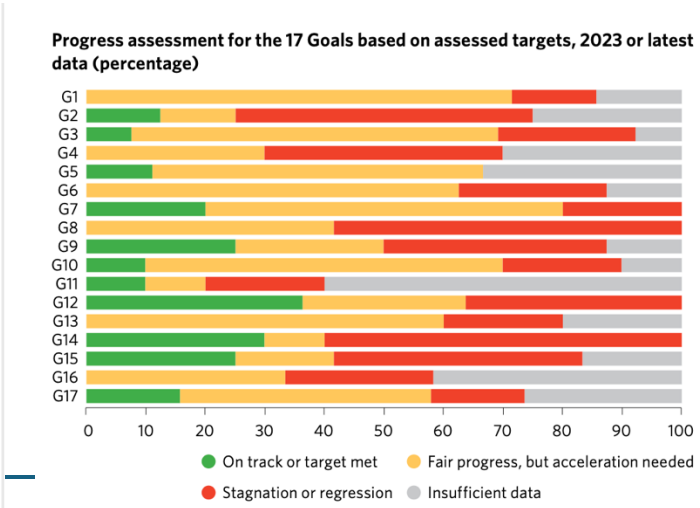




Sustainable Development & SDGs

- Countries at all income levels are looking to transition towards **digital** and **green** economies
- This vitally involves **investment into science**, and accelerating technology transfer into industry
- To reach SDG by 2030 countries will need to **invest more into research and innovation**





The Sustainable Development Goals Report: https://sdgs.un.org/documents/sustainable-development-goals-report-2023-53220

Sustainable Development & SDGs

- The need to solve environmental and developmental problems requires **scientists** and scientific and **educationa institutions**

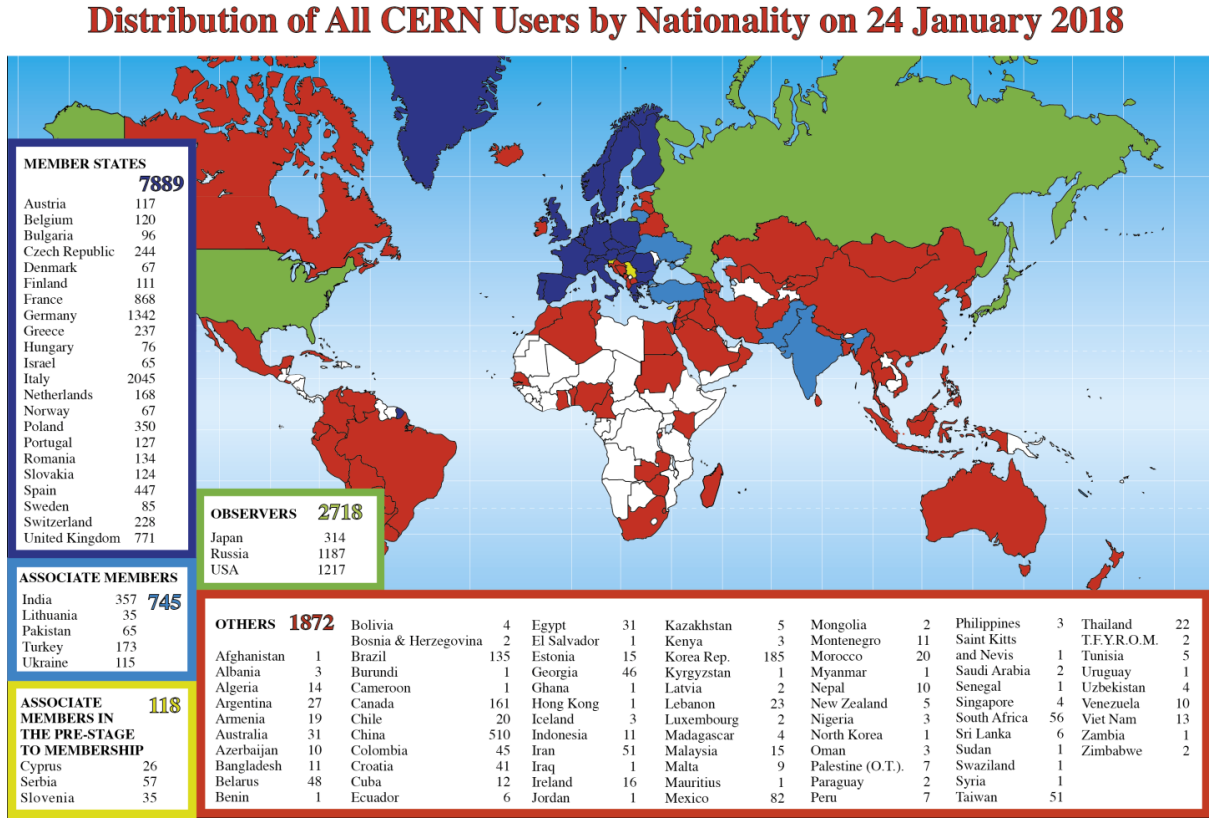
- **Education** and investment into educational, technological and cultural institutions play a key role in growing a knowledge-based economy

- Scientific research at universities **drives** and **improves** the level & quality of education at all stages




Sustainable Development & SDGs

- International **cooperation builds bridges across nations**, **soft diplomacy** has real impact! We must intensify and improve **scientific cooperation** between countries
- Today, CERN has become a model for cooperation in terms of research, embodying the '**one-earth**' approach that the world needs to tackle the global challenges we are facing.
- Today CERN has **23** member states, and many countries participate, Over **11000 scientists** from ~100 nations use CERN's laboratories.



Working for Science for Peace!

The importance of fundamental science for development

Report on the UNESCO forum on Higher Education, Research and Knowledge:

In recent years many countries' governments have placed unprecendented emphasis on **fundamental science research** as a key motor for national development.

Scientific research is central to adapt and adopt technologies which is needed in any technology transfer process

- It can ignite technological progress, economic growth, societal well being, and cultural enhancement

Investing funding and allowing scientist time to **participate** in international research not only strengthens the national scientific capacity, it also provides opportunities for **young** people to **train up in international cutting edge fields**!

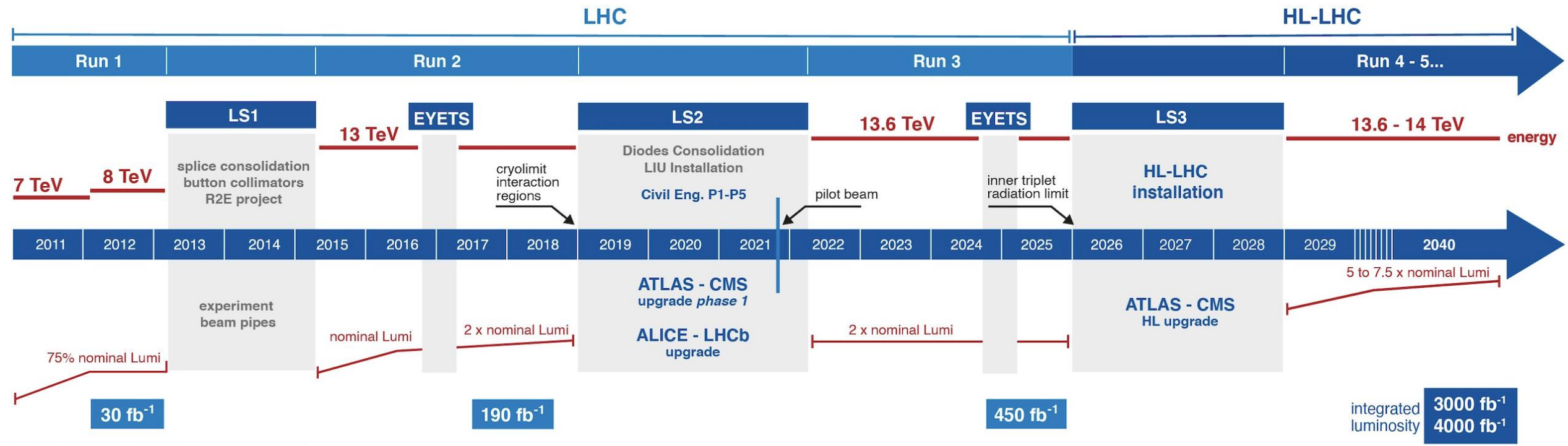
The importance of fundamental science for development

*Investment into **fundamental science centres** and **researchers** can accelerate the pace of scientific discovery in the understanding of our Universe and its fundamental particles.*

*Students will learn the application of cutting-edge **data science** and **artificial intelligence**, equipping them with enviable technical and computational skills that comes from a **rigorous scientific background**.*

They have the potential to transform sectors and contribute to the national economy

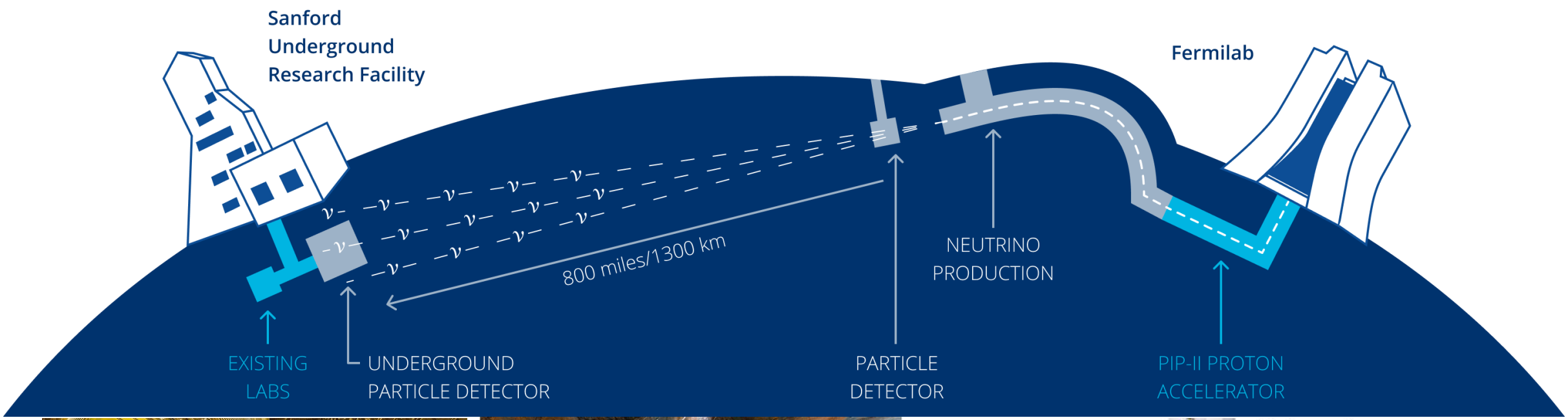
LHC / HL-LHC Plan

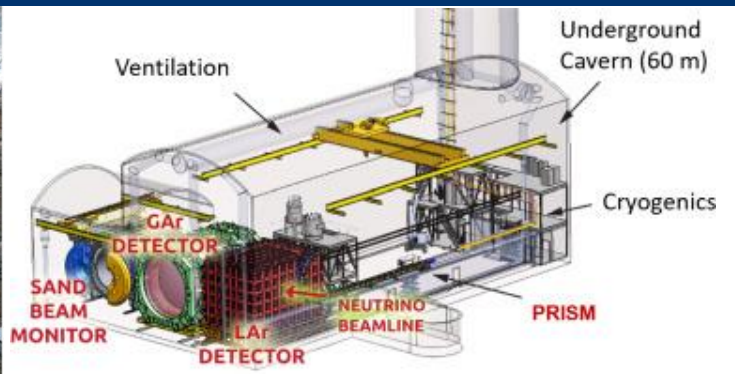


HL-LHC TECHNICAL EQUIPMENT:

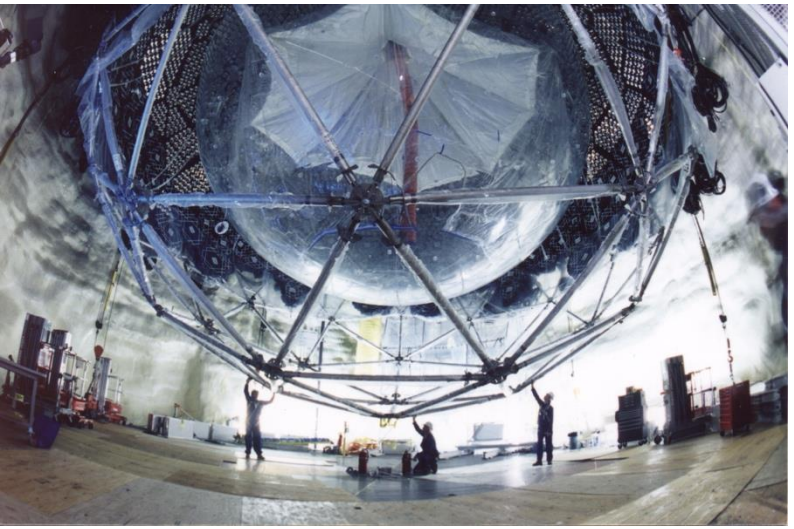
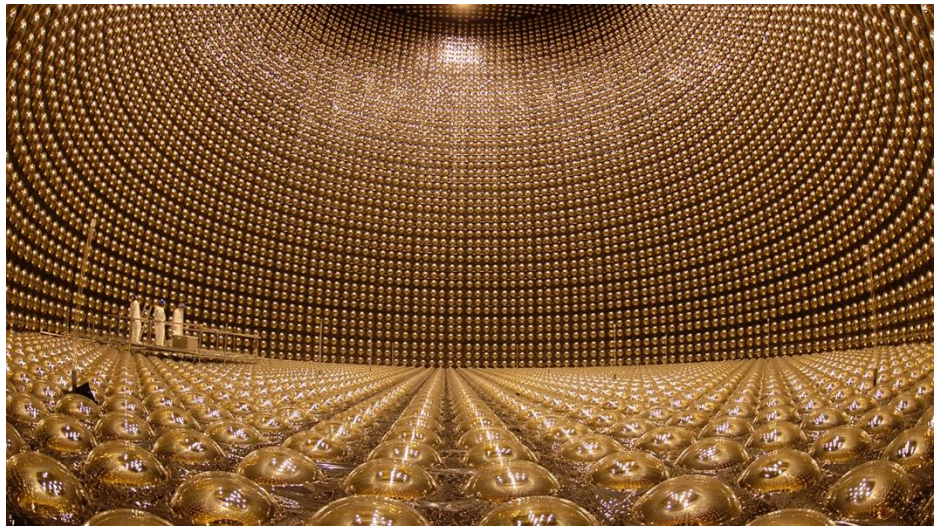
HL-LHC CIVIL ENGINEERING:

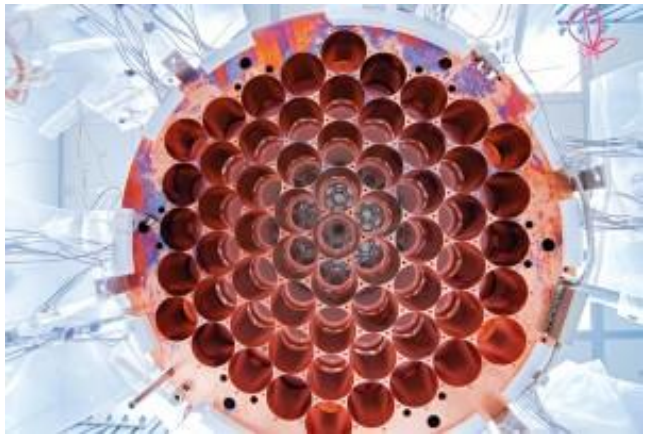
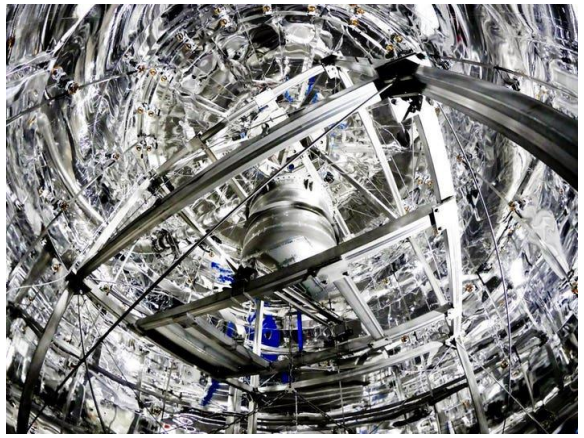
DEEP UNDERGROUND NEUTIRNO EXPERIMENT

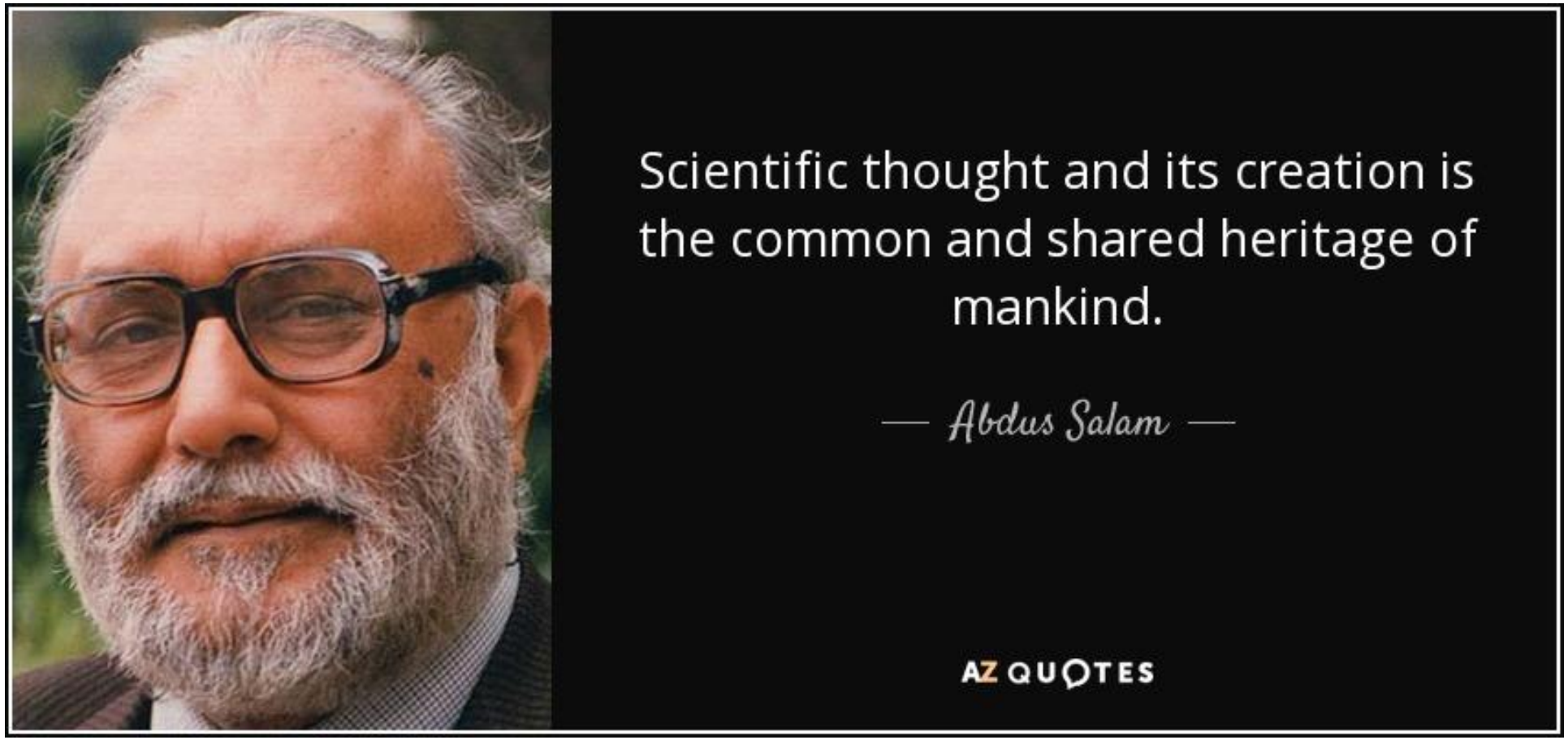




Particle Physics Experiments

Human Right to Science - Article 27 of the UN Declaration of Human Rights (1948)

Thank you

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Annual Meeting: November 2025
Annual Call: December 2025-January 2026
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