



The Abdus Salam
International Centre
for Theoretical Physics
Physics Without Frontiers



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)

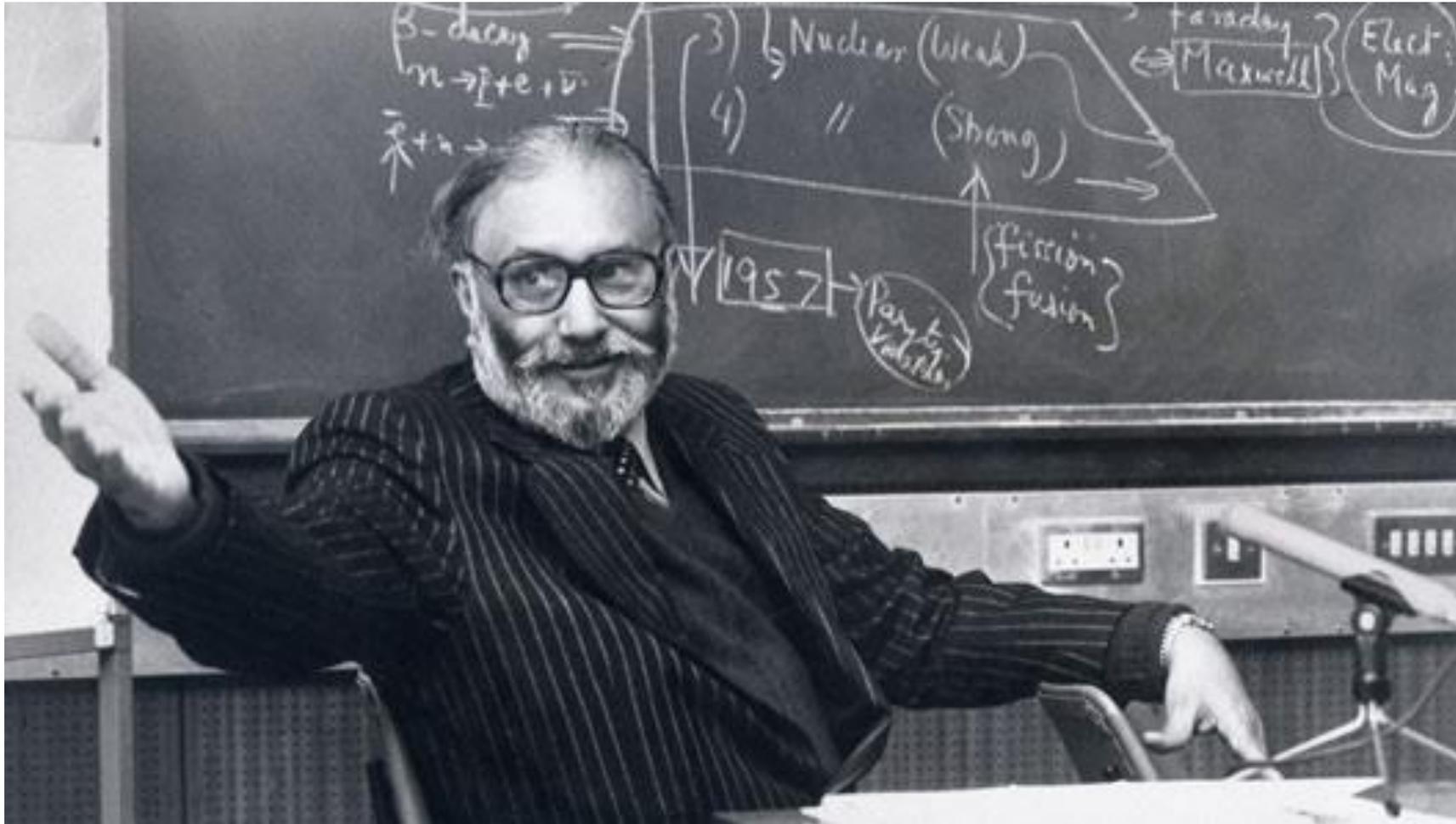
PHYSICS WITHOUT FRONTIERS THAILAND
WORKSHOP IN COMPUTATIONAL COSMOLOGY AND HIGH ENERGY PHYSICS
20 - 24 OCTOBER 2025, UNIVERSITY OF PHAYAO

MORE INFORMATION: [INDICO.ICTP.IT/EVENT/11072/](https://indico.ictp.it/event/11072/)
APPLY HERE: [FORMS.GLE/ORT5W8BKTEDBMC6B9](https://forms.gle/ORT5W8BKTEDBMC6B9)
DEADLINE: 30 SEPTEMBER 2025

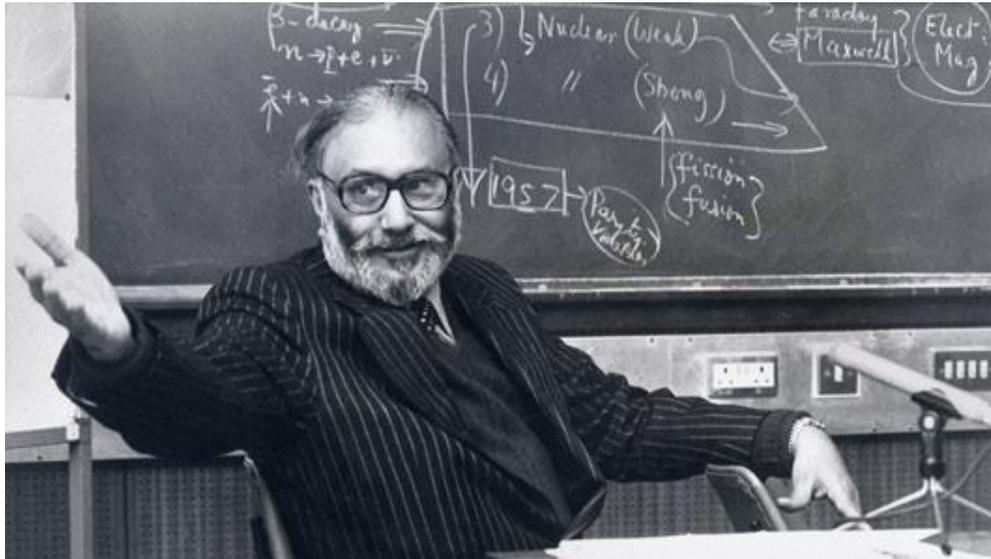
Project coordinator: Chonticha Kritpetch, University of Phayao, Thailand
Local coordinators:
Suphakorn Chunlen, University of Phayao, Thailand
Phongsaphat Rangdee, University of Phayao, Thailand
Guest Online Speakers:
John Ellis, Kings College London, UK
Tevong You, Kings College London, UK
Lecturers:
Kate Shaw, International Centre for Theoretical Physics (ICTP), Italy
Nandan Roy, Centre for Theoretical Physics and Natural Philosophy, Nakhon Sawan
Stadium for Advanced Studies (NAS), Mahidol University, Thailand
Suphakorn Chunlen, University of Phayao, Thailand

"COSMIC CLIFFS" IN THE CARINA NEBULA

Introduction to the ICTP



Introduction to the ICTP

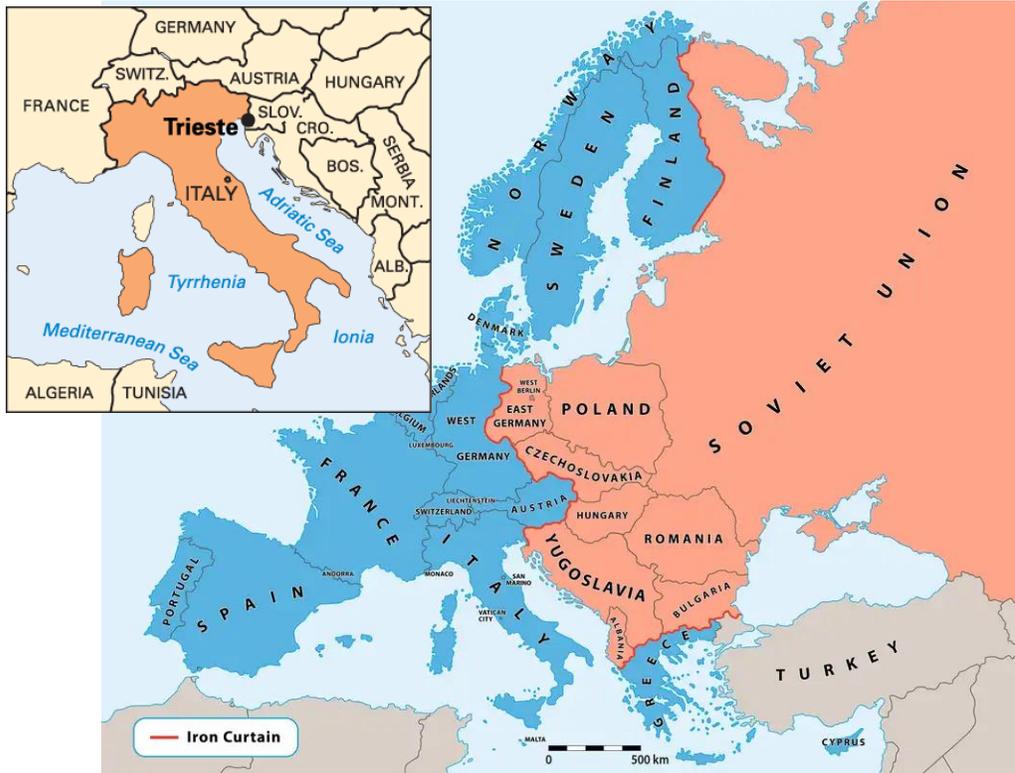


The **Abdus Salam International Centre for Theoretical Physics (ICTP)** was founded in 1964 by Abdus Salam, in Trieste in the North-East of Italy who served as its director until 1993.



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

- **ICTP diploma: a pre PhD one year course with project**
- 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



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



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"COSMIC CLIFFS" IN THE CARINA NEBULA

Logos: UPU, ICTP, IAEA, UNESCO



Chonticha Kritpetch,
University of Phayao



Suphakorn Chunlen,
University of Phayao



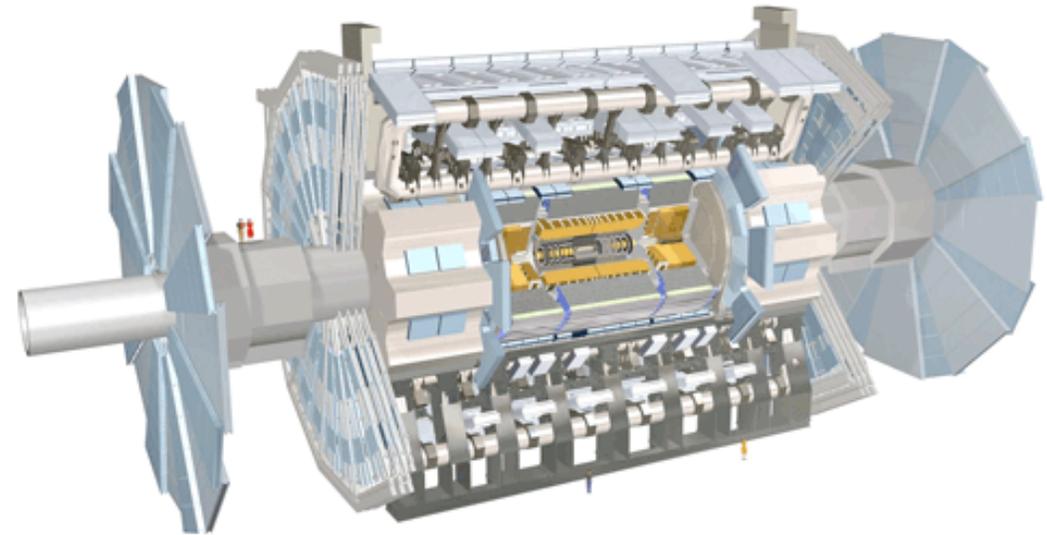
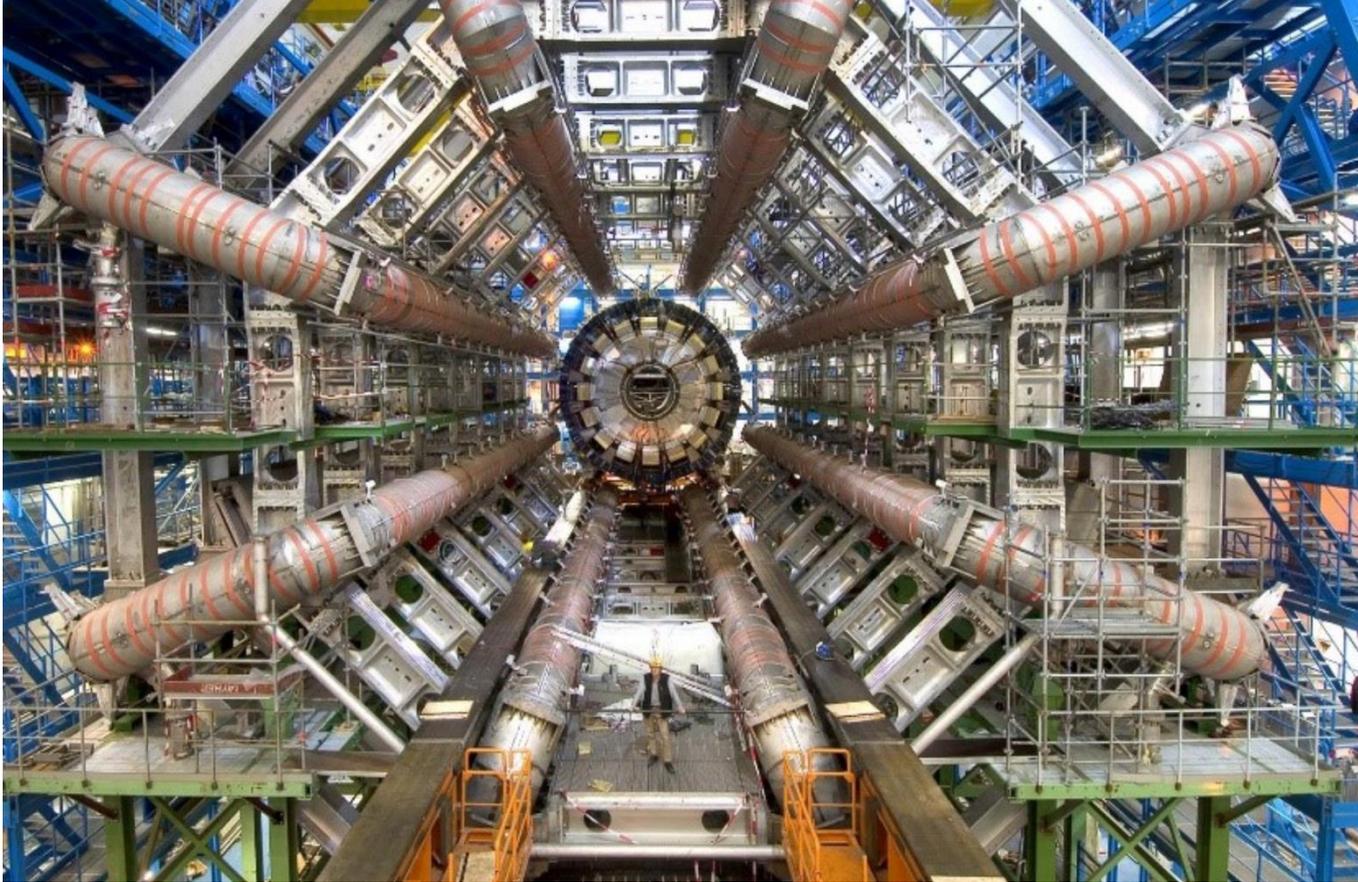
Phongsaphat Rangdee,
University of Phayao

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

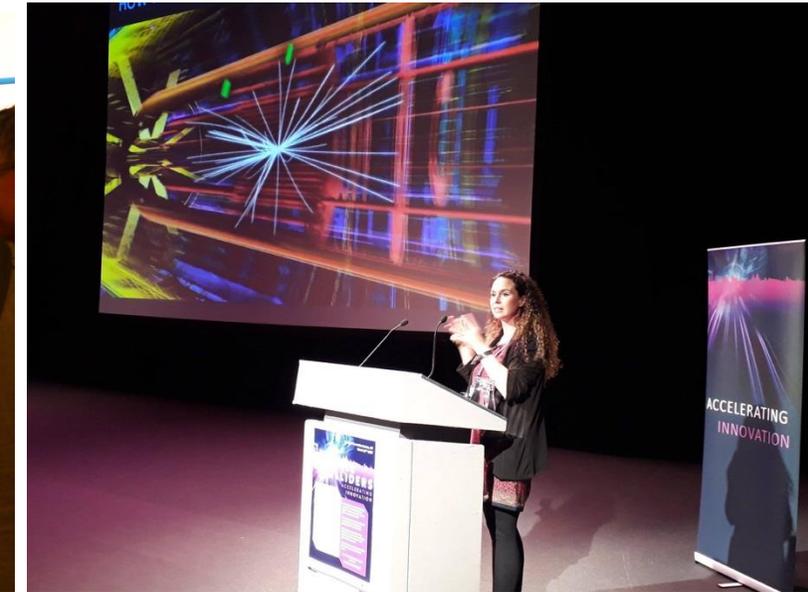
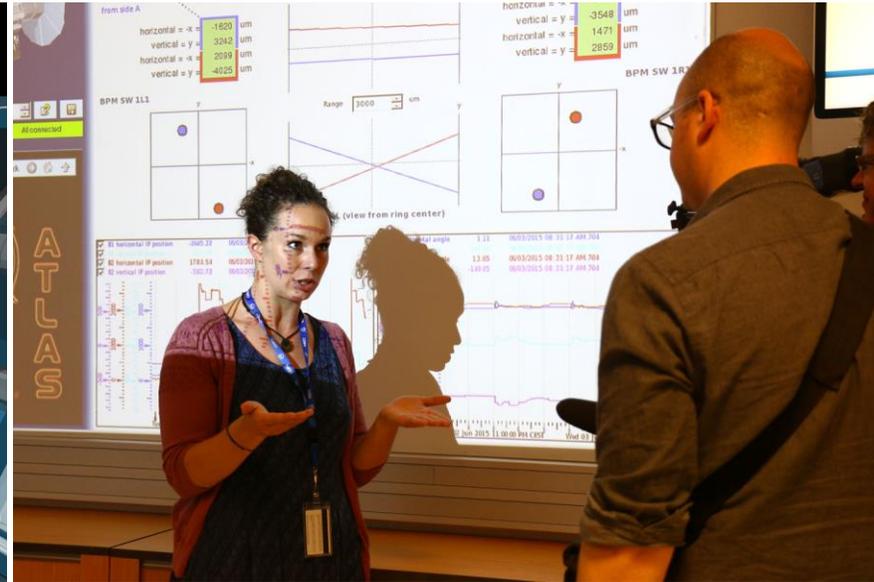
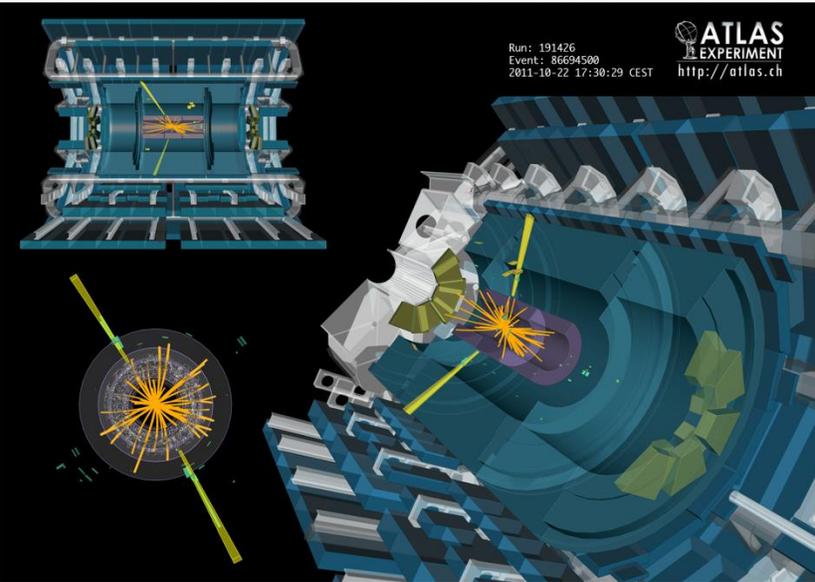


Nandan Roy, Centre for
Theoretical Physics and Natural
Philosophy, Nakhon Sawan
Studiorum for Advanced Studies
(NAS), Mahidol University

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

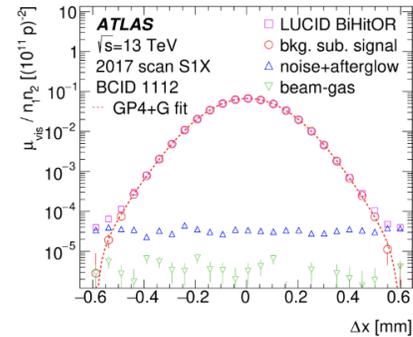
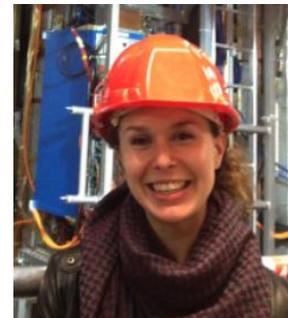
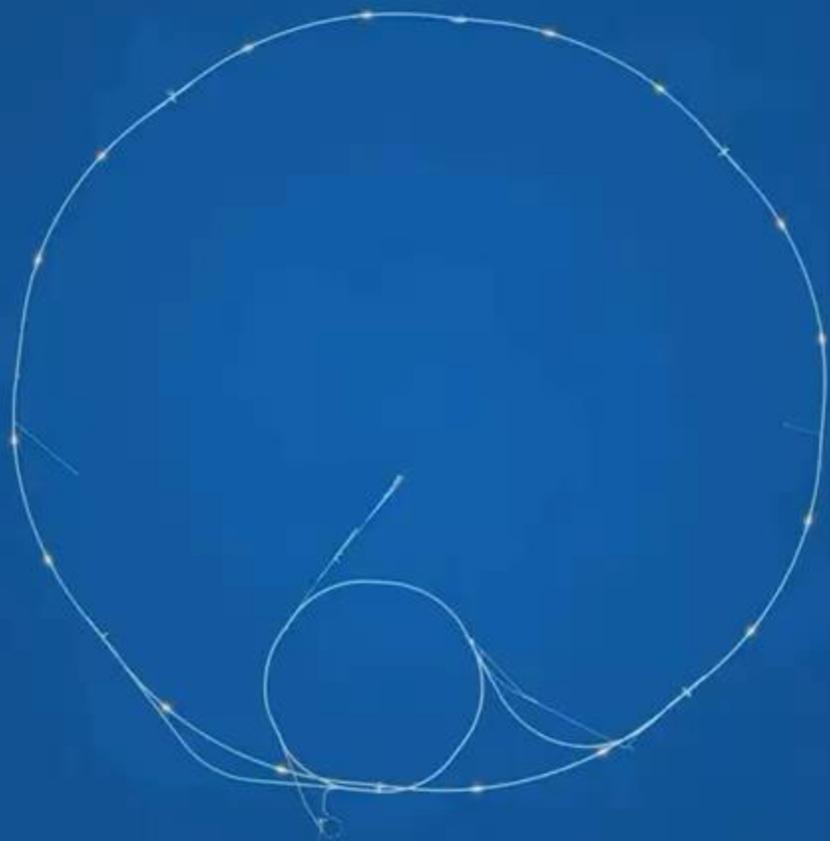


Figure 1: Van der Meer (vdM) scan curve, showing the number of visible interactions normalised by the number of protons in the bunches, as a function of the beam separation in the horizontal plane for one colliding bunch pair, measured with the LUCID-2 sub-detector in 2017. The curve is fitted and backgrounds 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



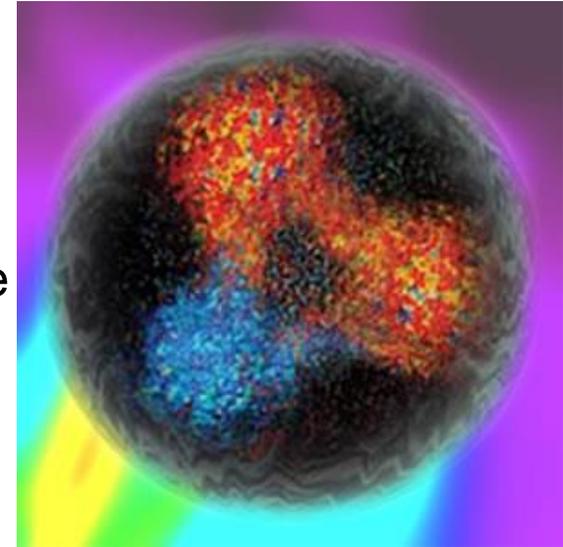


The Large Hadron Collider

The LHC accelerates some of the **smallest** objects in the universe

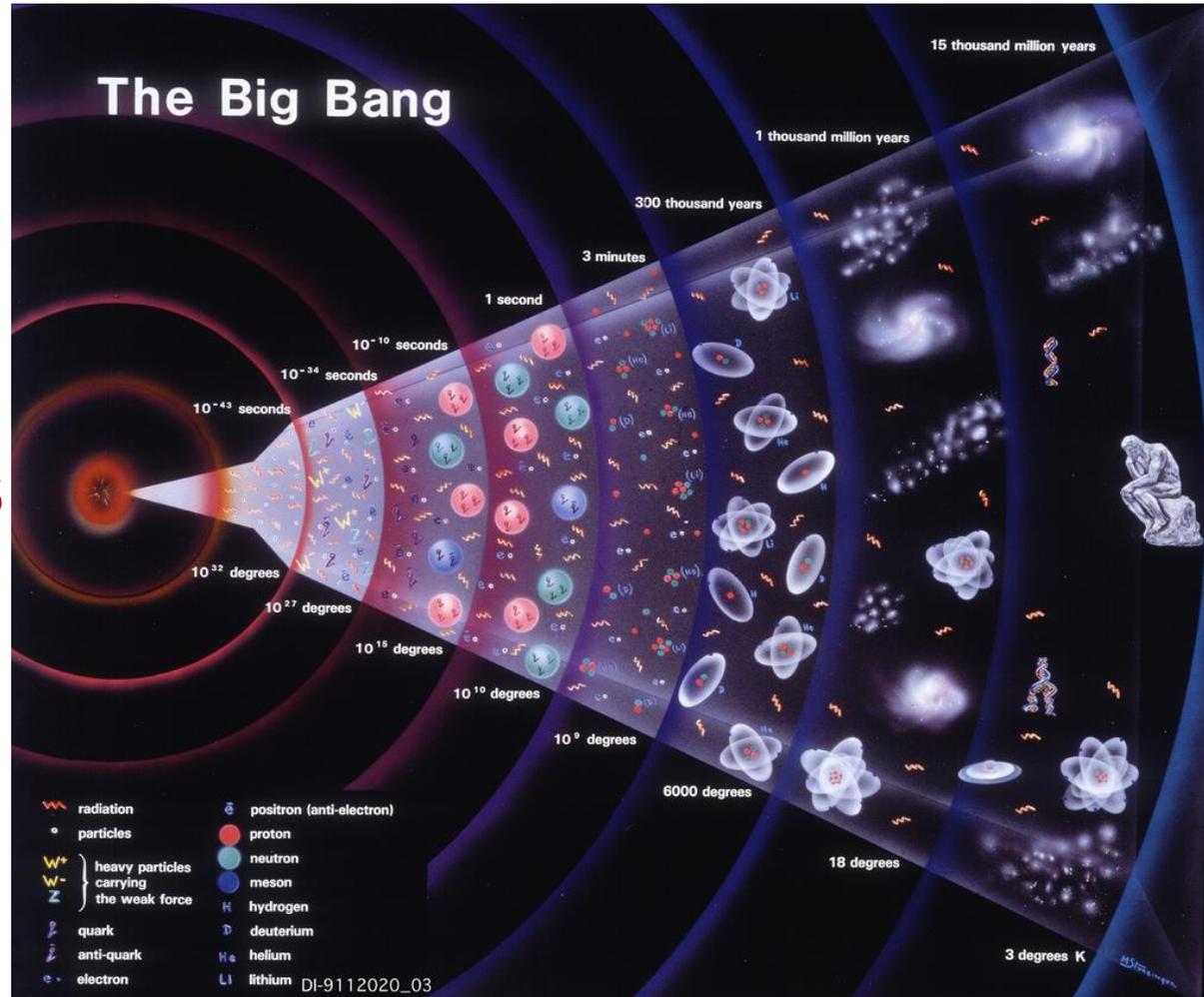
up to almost the **fastest** speeds possible in the universe!

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?



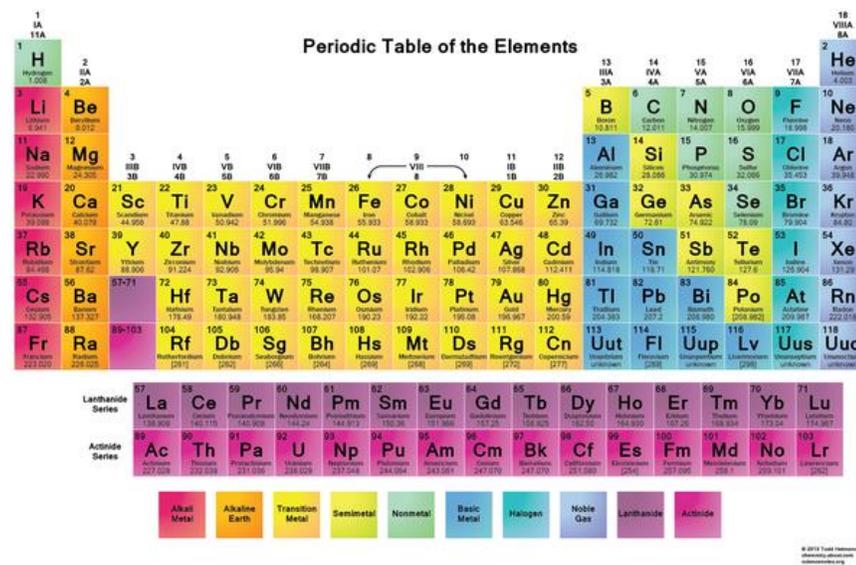
What is everything made out of?

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 image shows a standard periodic table of elements, color-coded by groups. The title "Periodic Table of the Elements" is centered at the top. The table includes element symbols, names, and atomic numbers. Below the main table, there are two rows for the Lanthanide and Actinide series. A legend at the bottom identifies color-coded categories: Alkali Metal (pink), Alkaline Earth (orange), Transition Metal (yellow), Semimetal (light green), Nonmetal (green), Basic Metal (blue), Halogen (light blue), Noble Gas (purple), Lanthanide (dark purple), and Actinide (magenta).

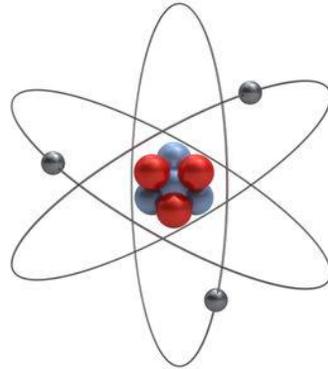
The periodic table, arranges chemical elements by atomic mass.

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



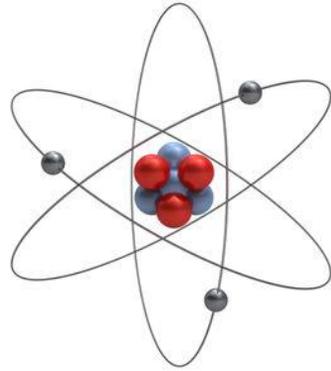
Periodic Table of the Elements

1 IA H Hydrogen 1.008	2 IIA He Helium 4.003	3 IIIA Li Lithium 6.941	4 IVA Be Beryllium 9.012	5 VA B Boron 10.811	6 VIA C Carbon 12.011	7 VIIA N Nitrogen 14.007	8 VIIIA O Oxygen 15.999	9 VIIIA F Fluorine 18.998	10 VIIIA Ne Neon 20.180	11 IB Na Sodium 22.990	12 IIB Mg Magnesium 24.305	13 IIIA Al Aluminum 26.982	14 IVA Si Silicon 28.086	15 VA P Phosphorus 30.974	16 VIA S Sulfur 32.065	17 VIIA Cl Chlorine 35.453	18 VIIIA Ar Argon 39.948	19 IB K Potassium 39.098	20 IIB Ca Calcium 40.078	21 IIIB Sc Scandium 44.956	22 IVB Ti Titanium 47.88	23 VB V Vanadium 50.942	24 VIB Cr Chromium 51.996	25 VIB Mn Manganese 54.938	26 VIII Fe Iron 55.845	27 VIII Co Cobalt 58.933	28 VIII Ni Nickel 58.693	29 VIII Cu Copper 63.546	30 VIII Zn Zinc 65.39	31 IIIB Ga Gallium 69.723	32 IVB Ge Germanium 72.61	33 VB As Arsenic 74.922	34 VIB Se Selenium 78.96	35 VIIA Br Bromine 79.904	36 VIIIA Kr Krypton 83.80	37 IB Rb Rubidium 85.468	38 IIB Sr Strontium 87.62	39-48 Lanthanide Series La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu	40 IIB Y Yttrium 88.906	41 IVB Zr Zirconium 91.224	42 VB Nb Niobium 92.906	43 VIB Mo Molybdenum 95.94	44 VIII Tc Technetium 98.907	45 VIII Ru Ruthenium 101.07	46 VIII Rh Rhodium 102.906	47 VIII Pd Palladium 106.42	48 VIII Ag Silver 107.868	49 IIB Cd Cadmium 112.411	50 IIIB In Indium 114.818	51 IVB Sn Tin 118.71	52 VB Sb Antimony 121.760	53 VIB Te Tellurium 127.6	54 VIIA I Iodine 126.905	55 VIIIA Xe Xenon 131.29	56 IB Cs Cesium 132.905	57 IIB Ba Barium 137.327	58-71 Actinide Series Ac Th Pa U Np Pu Am Cm Bk Cf Es Fm Md No Lr	72 IIB Hf Hafnium 178.49	73 IVB Ta Tantalum 180.948	74 VB W Tungsten 183.85	75 VIB Re Rhenium 186.207	76 VIII Os Osmium 190.23	77 VIII Ir Iridium 192.22	78 VIII Pt Platinum 195.08	79 VIII Au Gold 196.967	80 IIB Hg Mercury 200.59	81 IIIB Tl Thallium 204.383	82 IVB Pb Lead 207.2	83 VB Bi Bismuth 208.980	84 VIB Po Polonium [209]	85 VIIA At Astatine [209]	86 VIIIA Rn Radon [222]	87 IB Fr Francium [223]	88 IIB Ra Radium [226]	89-103 Lanthanide Series La Ce Pr Nd Pm Sm Eu Gd Tb Dy Ho Er Tm Yb Lu	104 IIB Rf Rutherfordium [261]	105 IVB Db Dubnium [262]	106 VB Sg Seaborgium [266]	107 VIB Bh Bohrium [264]	108 VIII Hs Hassium [265]	109 VIII Mt Meitnerium [268]	110 VIII Ds Darmstadtium [271]	111 VIII Rg Roentgenium [272]	112 IIB Cn Copernicium [285]	113 IIIB Uut Ununtrium [288]	114 IVB Fl Flerovium [289]	115 VB Uup Ununpentium [288]	116 VIB Lv Livermorium [293]	117 VIIA Uus Ununseptium [289]	118 VIIIA Uuo Ununoctium [294]
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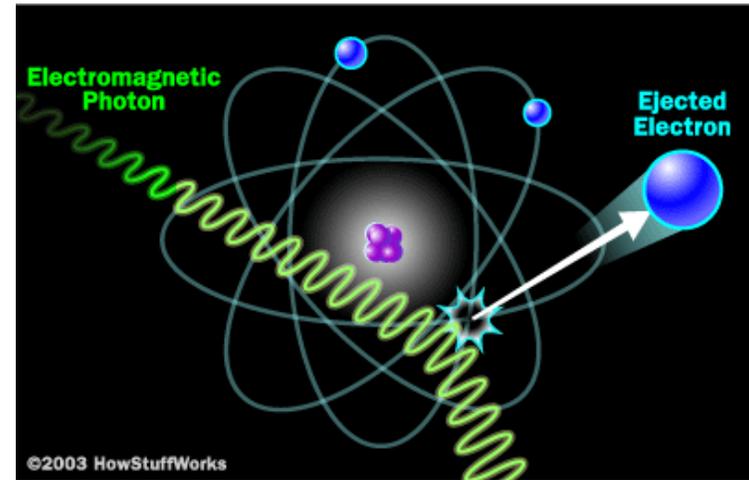


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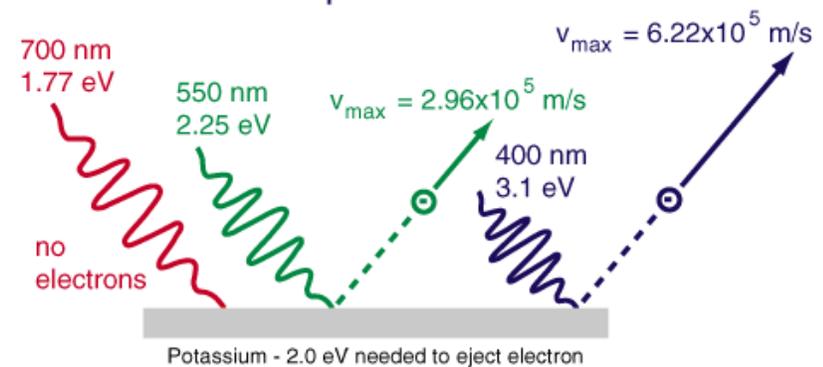
1932 **neutron** discovered by James Chadwick

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



$$E_{\text{photon}} = h\nu$$

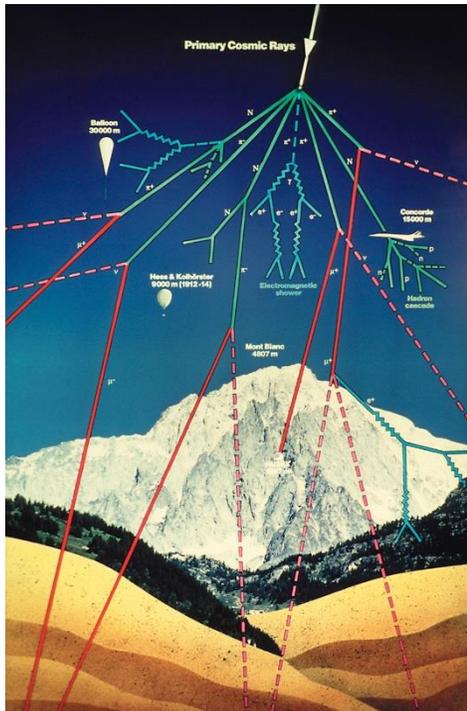


Photoelectric effect

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?

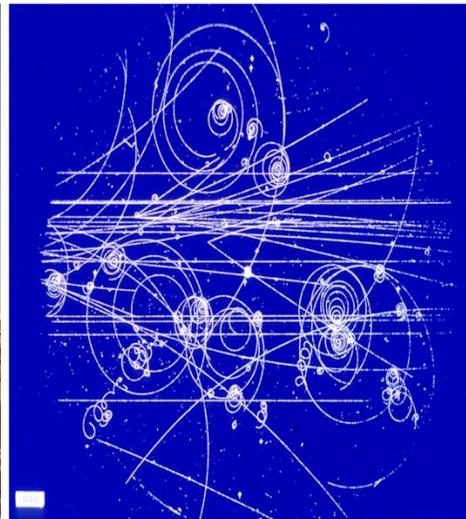
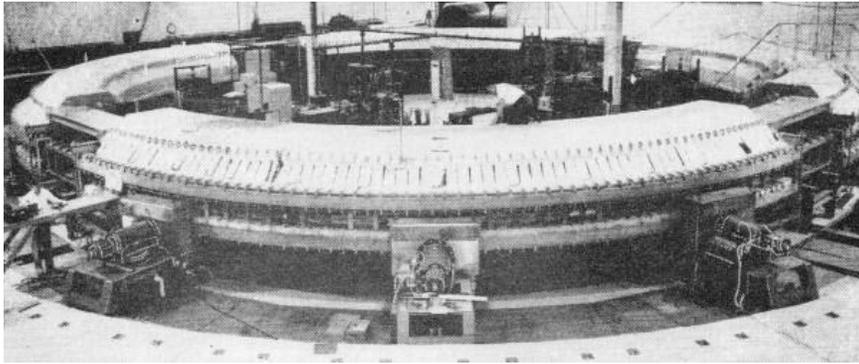
- 1947 pions (a type of meson) were also discovered!!

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!

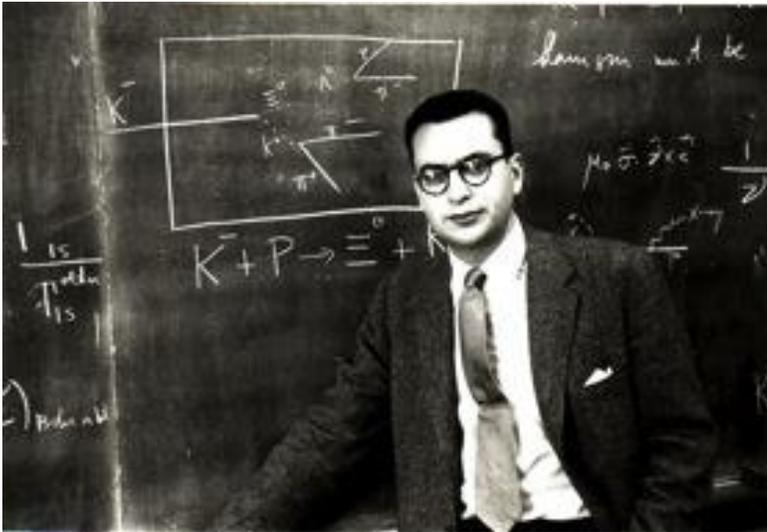
Sigma particles, rho particles, Delta particles, kaons, Lambda...

Some of the Particles in the "Particle Zoo"

p^+ n^0 Σ^- Σ^0 Σ^+ Σ^{++} Δ^- Δ^0 Δ^+ Δ^{++}
 Λ^0 Ω^- Ω^0 Ω^+ e^+ e^- π^+ π^0 π^-
 Ξ^- Ξ^0 Ξ^+ Ξ^{++} τ^+ τ^-
 η η' μ^+ μ^- ω ρ^+ ρ^0 ρ^-
 ν_e ν_μ ν_τ ϕ γ K^+ K^0 K^-

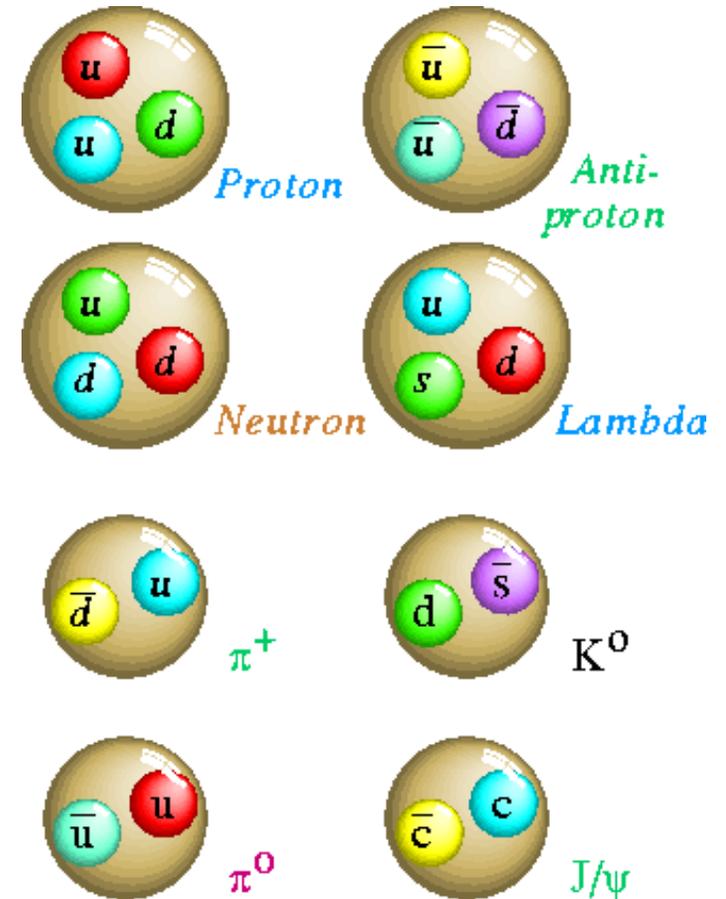
What is everything made out of?

Break Through!



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

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



What is everything made out of?

DISCOVERY: Bottom, Top, WZ, HIGGS!

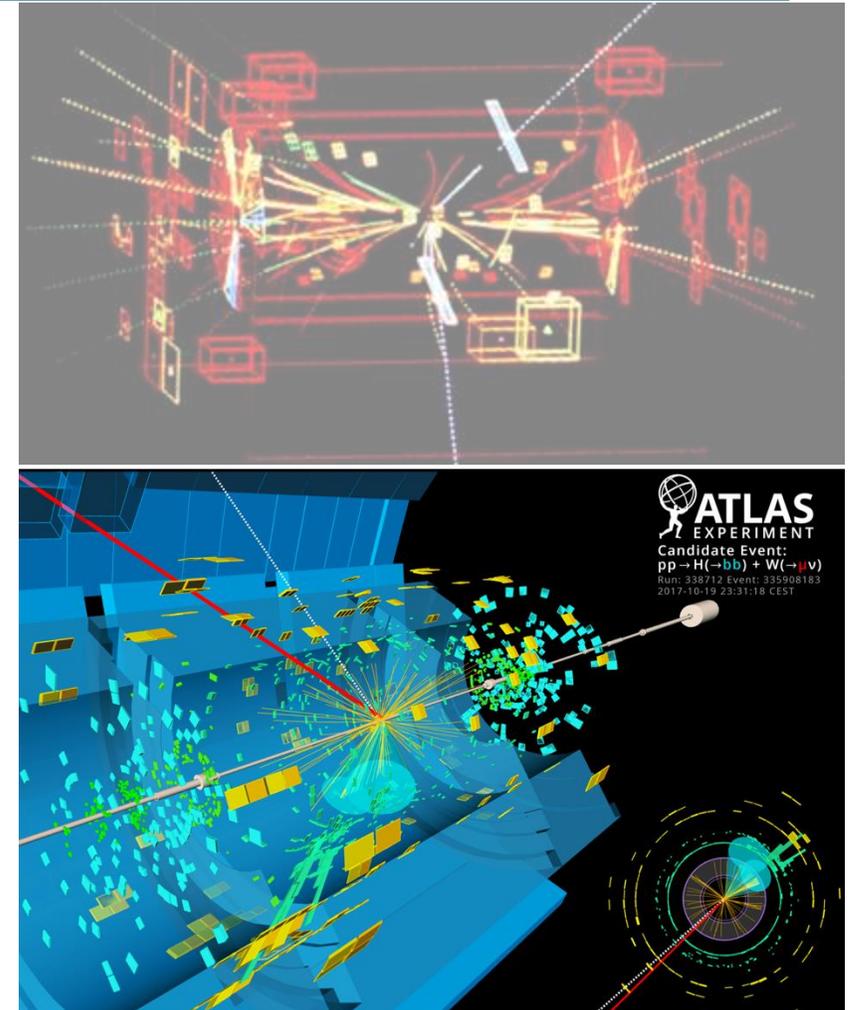
1977 Bottom quark discovered at Fermilab

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?

Fermions: spin = 1/2 particles

Quarks

u up	c charm	t top
d down	s strange	b bottom

Leptons

e electron	μ muon	τ tau
ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino

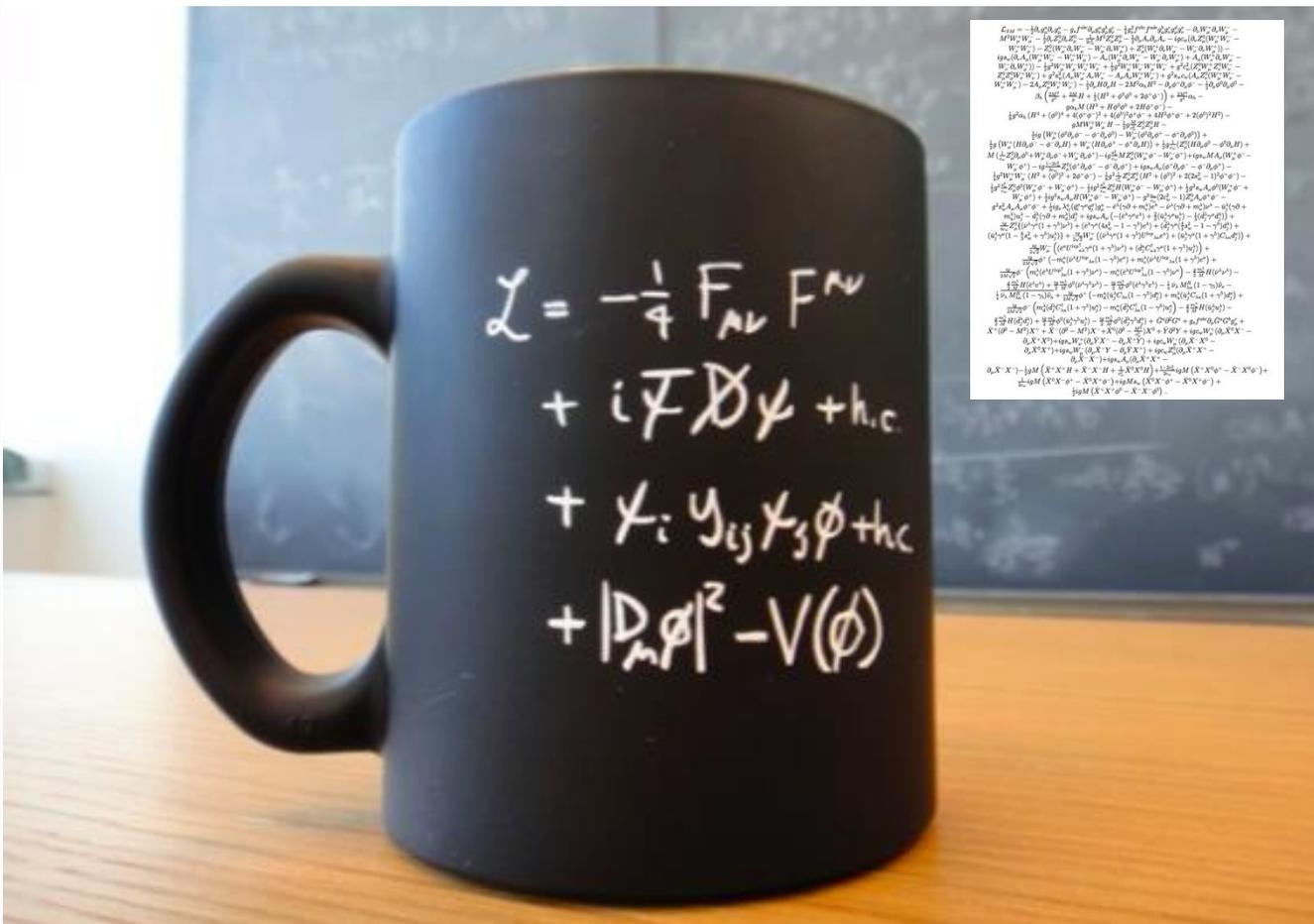
Vector Bosons: spin = 1 particles

Forces

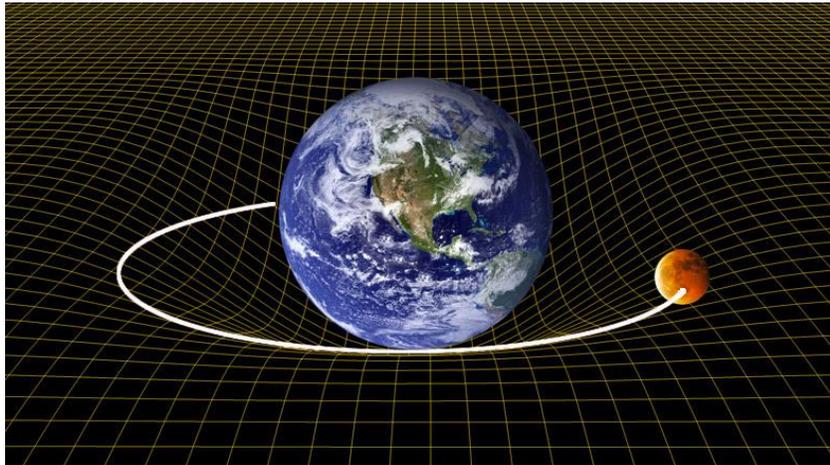
Z Z boson	γ photon
W W boson	g gluon

Higgs Boson: spin = 0 fundamental scalar particle

H
Higgs boson

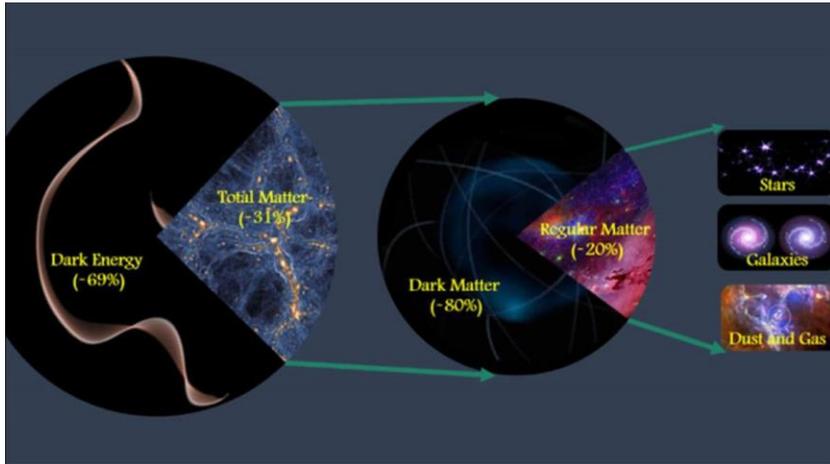
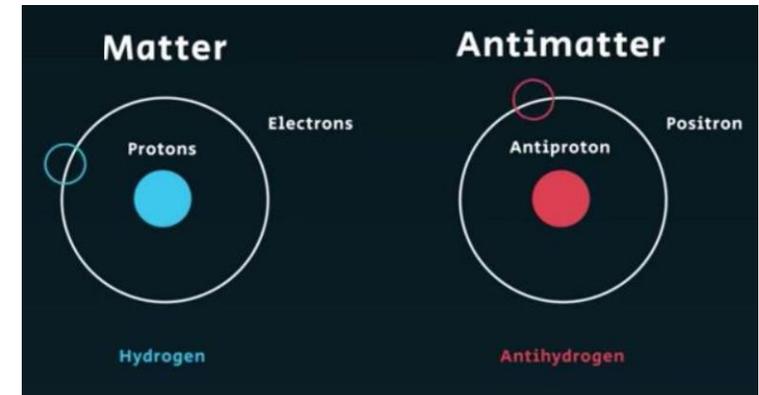


Problems



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

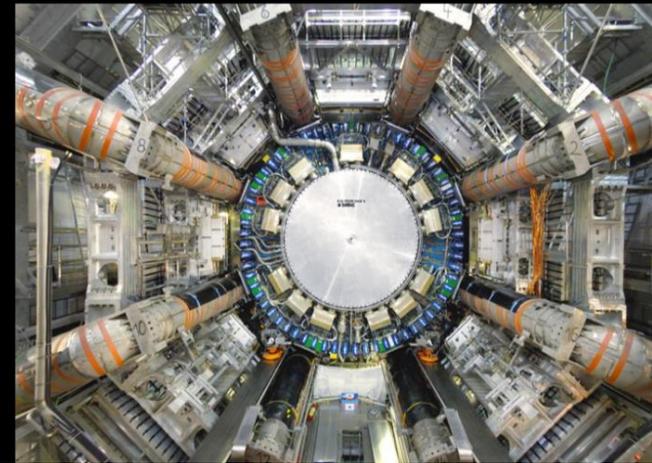
Matter-Antimatter
Asymmetry
-> Why is
everything made of
matter and not
antimatter?



Dark Matter and Dark energy still not explained!

CERN – An International Laboratory!

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

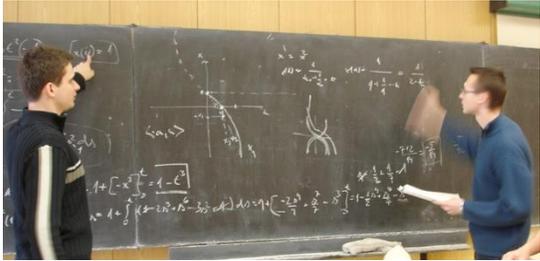


CERN is a hugely inspirational place for fundamental research and training!

Opportunities for Summer Placements

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

Why do Fundamental Sciences?



Fundamental Science



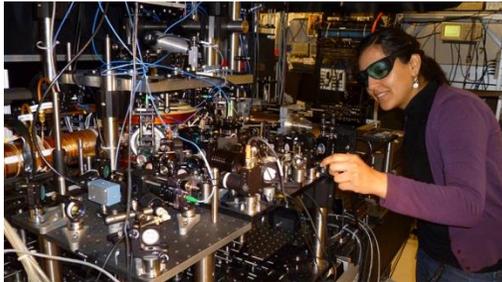
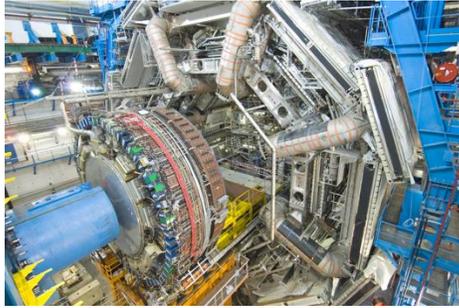
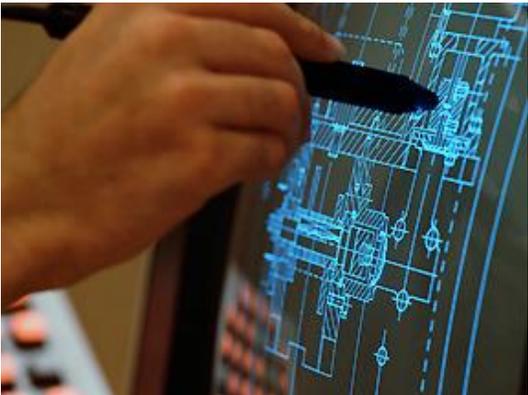
Applied Science



Technology, Engineering and Innovation

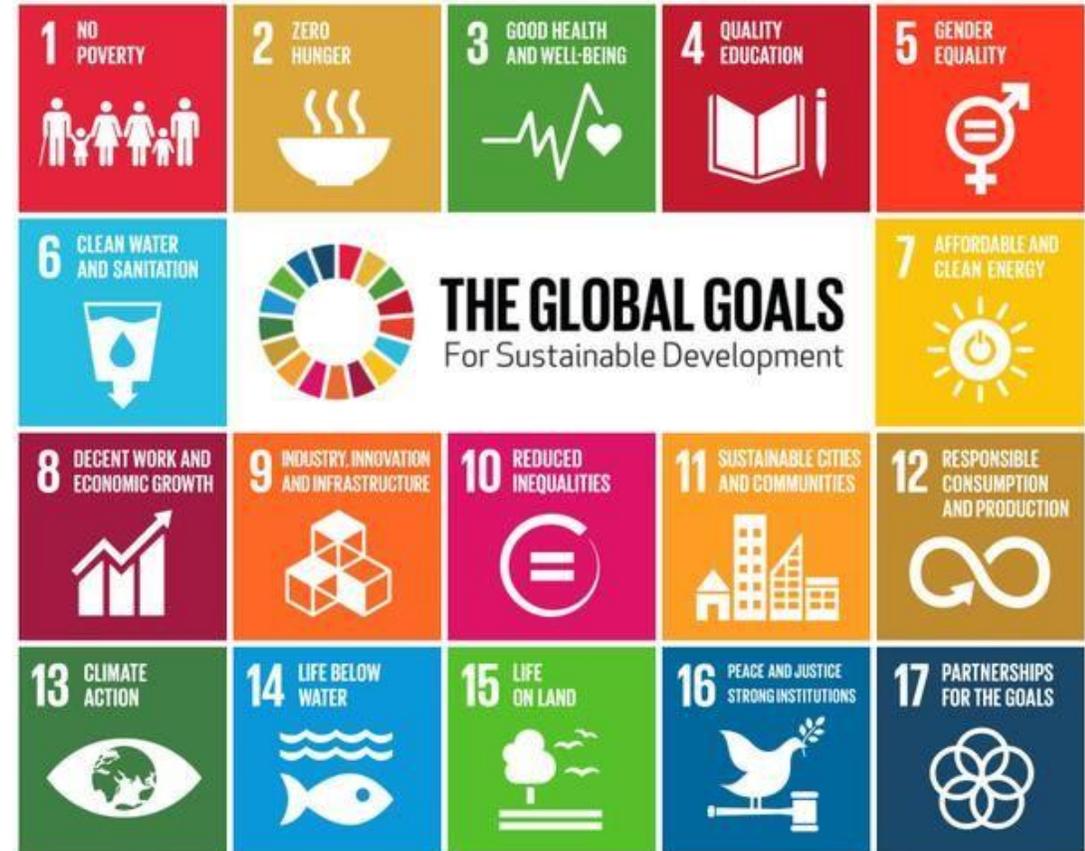


Sustainable Development



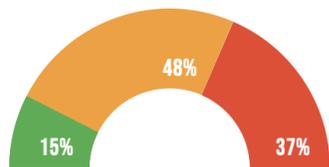
Sustainable Development & SDGs

- 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**



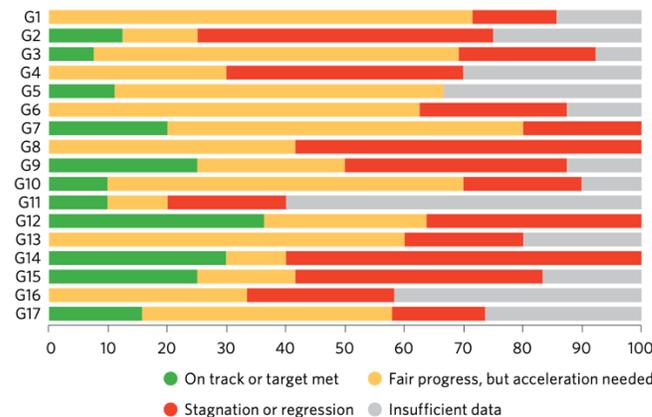
The Sustainable Development Goals Report:
<https://sdgs.un.org/documents/sustainable-development-goals-report-2023-53220>

A CONCERNING PICTURE OF SDG PROGRESS AT THE MIDPOINT:



- ON TRACK
- MODERATELY OR SEVERELY OFF TRACK
- STAGNATION OR REGRESSION

Progress assessment for the 17 Goals based on assessed targets, 2023 or latest data (percentage)



Sustainable Development & SDGs

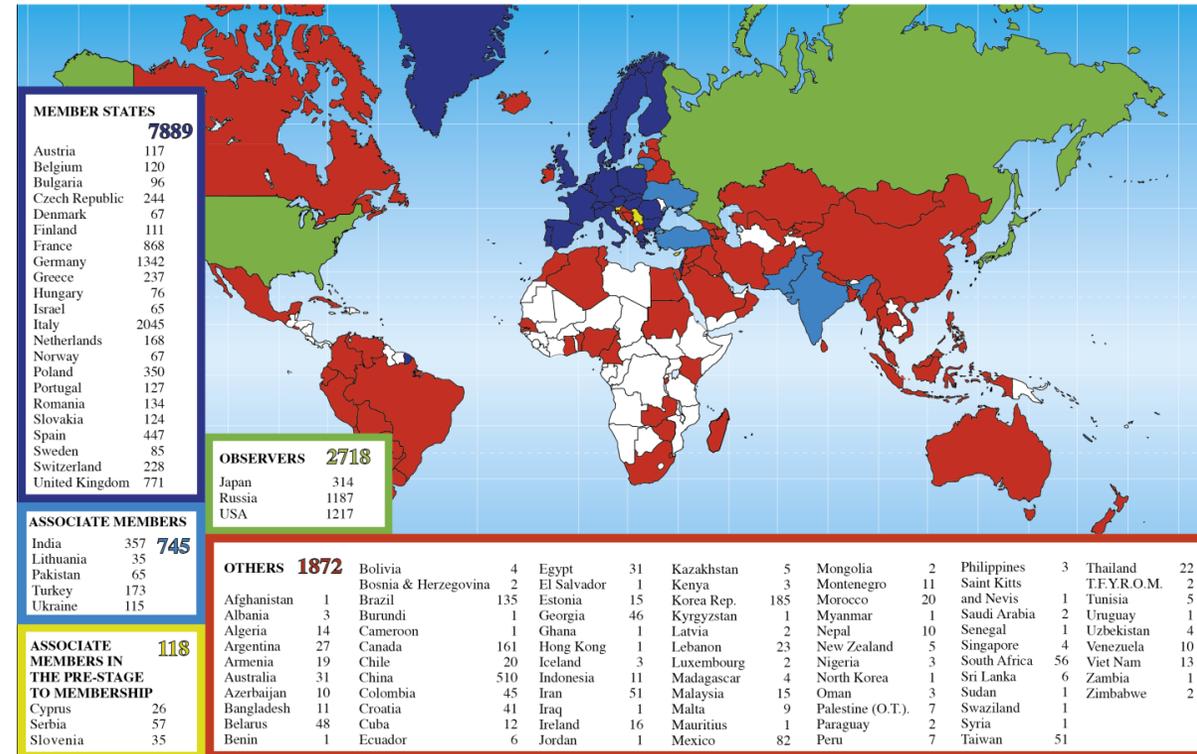
- The need to solve environmental and developmental problems requires **scientists** and scientific and **educational institutions**
- **Education** and investment into educational, technological and cultural institutions play a key role in growing a knowledge-based economy
- Scientific research at universities **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.

Distribution of All CERN Users by Nationality on 24 January 2018



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 unprecedented 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!**

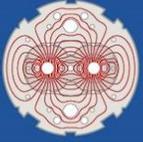
The importance of fundamental science for development



*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

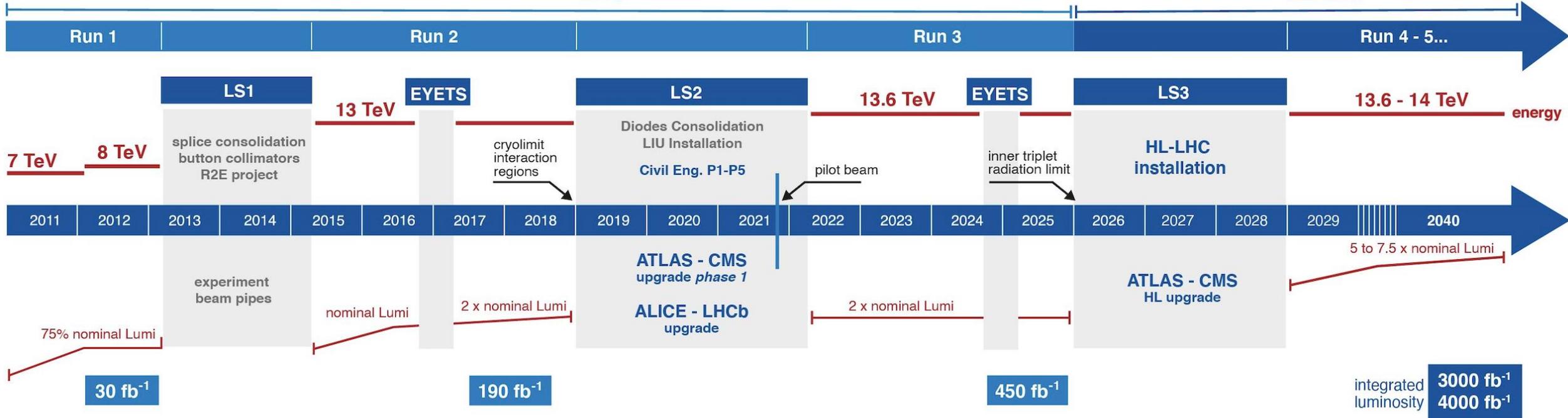


LHC / HL-LHC Plan



LHC

HL-LHC



HL-LHC TECHNICAL EQUIPMENT:

DESIGN STUDY



PROTOTYPES

CONSTRUCTION

INSTALLATION & COMM.

PHYSICS

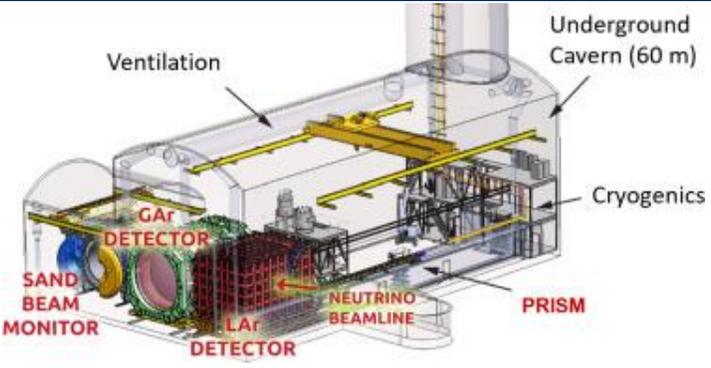
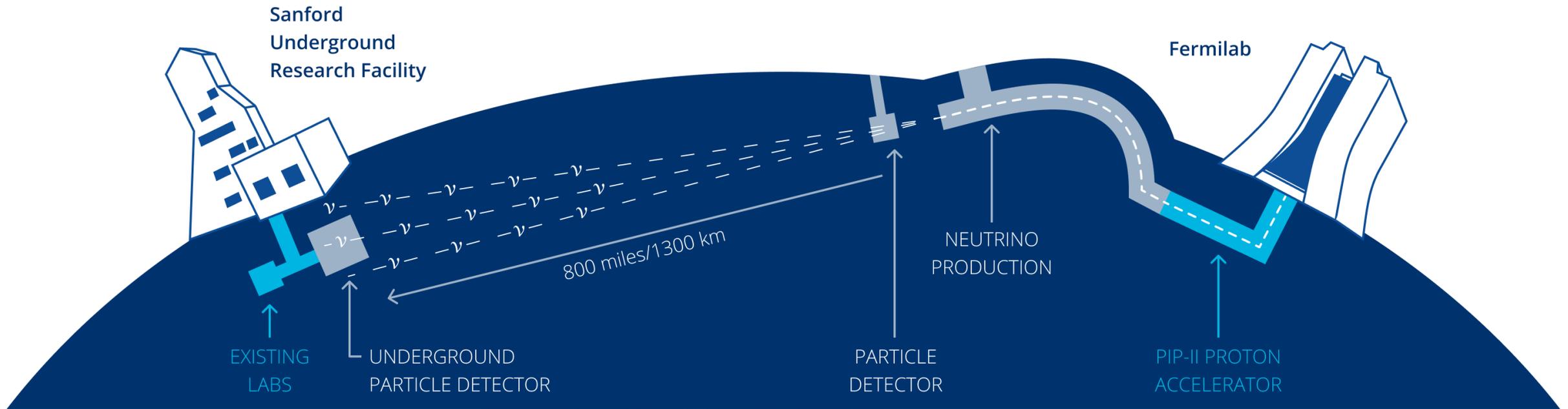
HL-LHC CIVIL ENGINEERING:

DEFINITION

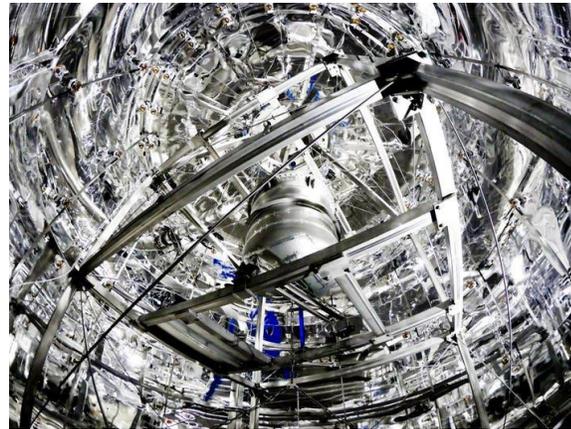
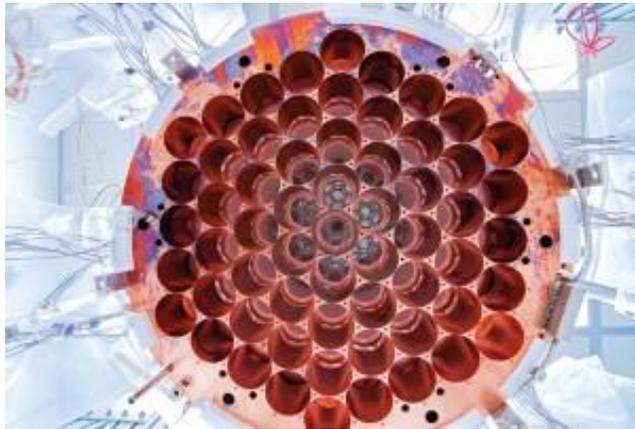
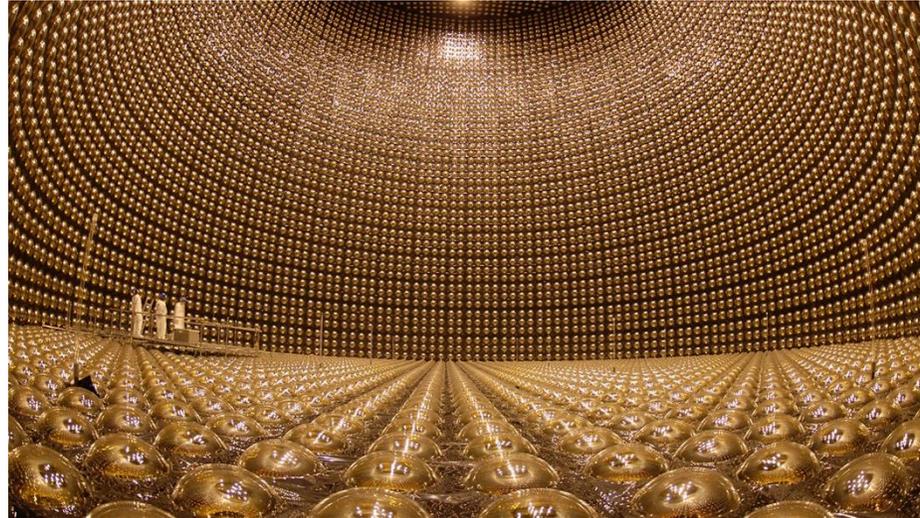
EXCAVATION

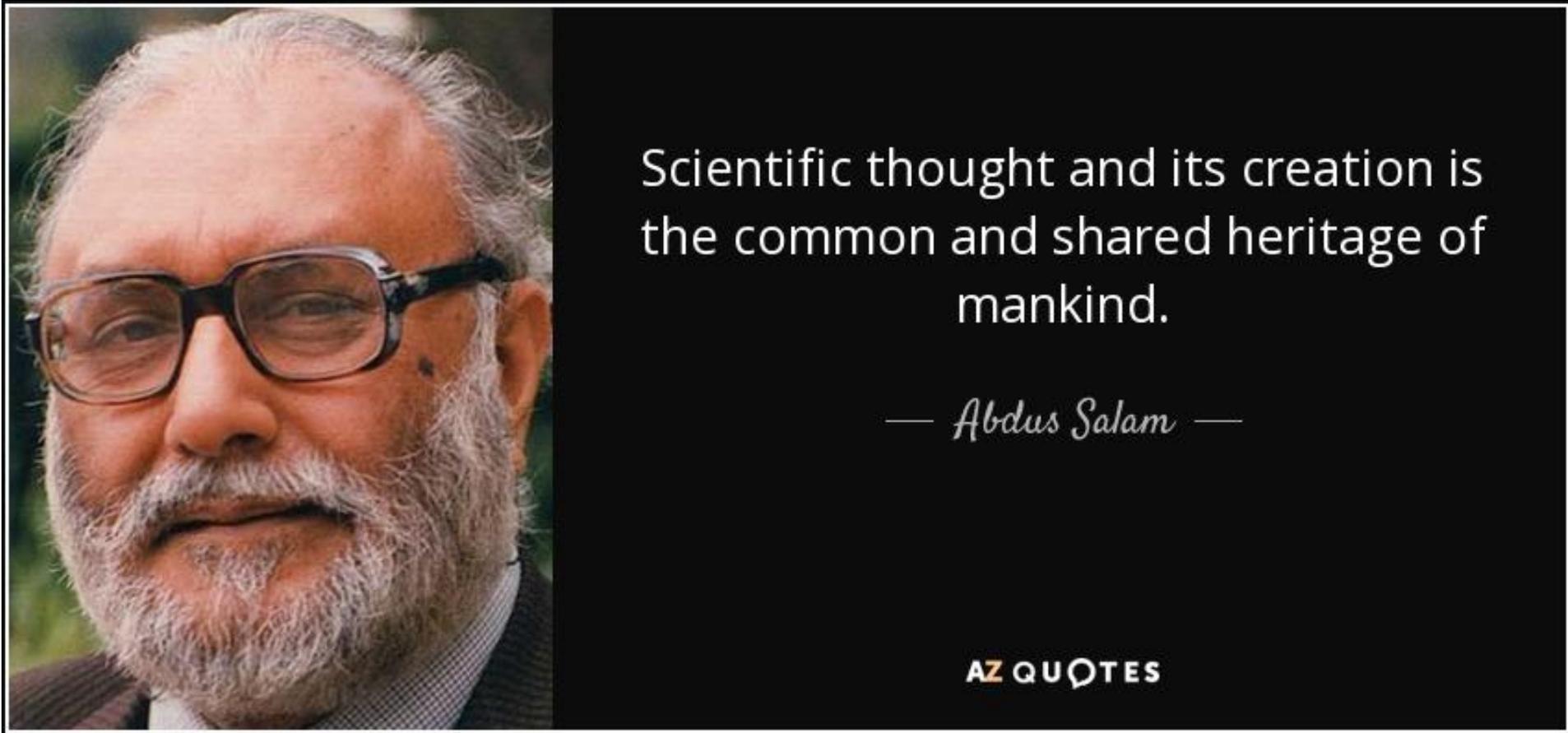
BUILDINGS

DEEP UNDERGROUND NEUTRINO EXPERIMENT



Particle Physics Experiments





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

Thank you

PWF Website:

<https://www.ictp.it/physics-without-frontiers.aspx>

Social Media: @ictpPWF

Twitter, Facebook, Instagram, LinkedIn

Mailing list:

Email pwf-subscribe@lists.ictp.it with the title SUBSCRIBE

Email us: pwf@ictp.it

Annual Meeting: November 2025

Annual Call: December 2025-January 2026

Email me: k.shaw@ictp.it

OUR IMPACT

We have worked with **160 universities** in over **50 countries** in the Global South impacting more than **14,000 students** worldwide, organising hundreds of activities and events, and stimulating research environments.

50 COUNTRIES IN THE GLOBAL SOUTH	160 UNIVERSITIES
14k STUDENTS	600 ALUMNI

Over 600 students have been **mentored onto further study**, and are now PhD students, postdocs, & faculty around the world, and many **volunteer** for PWF!

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UNESCO