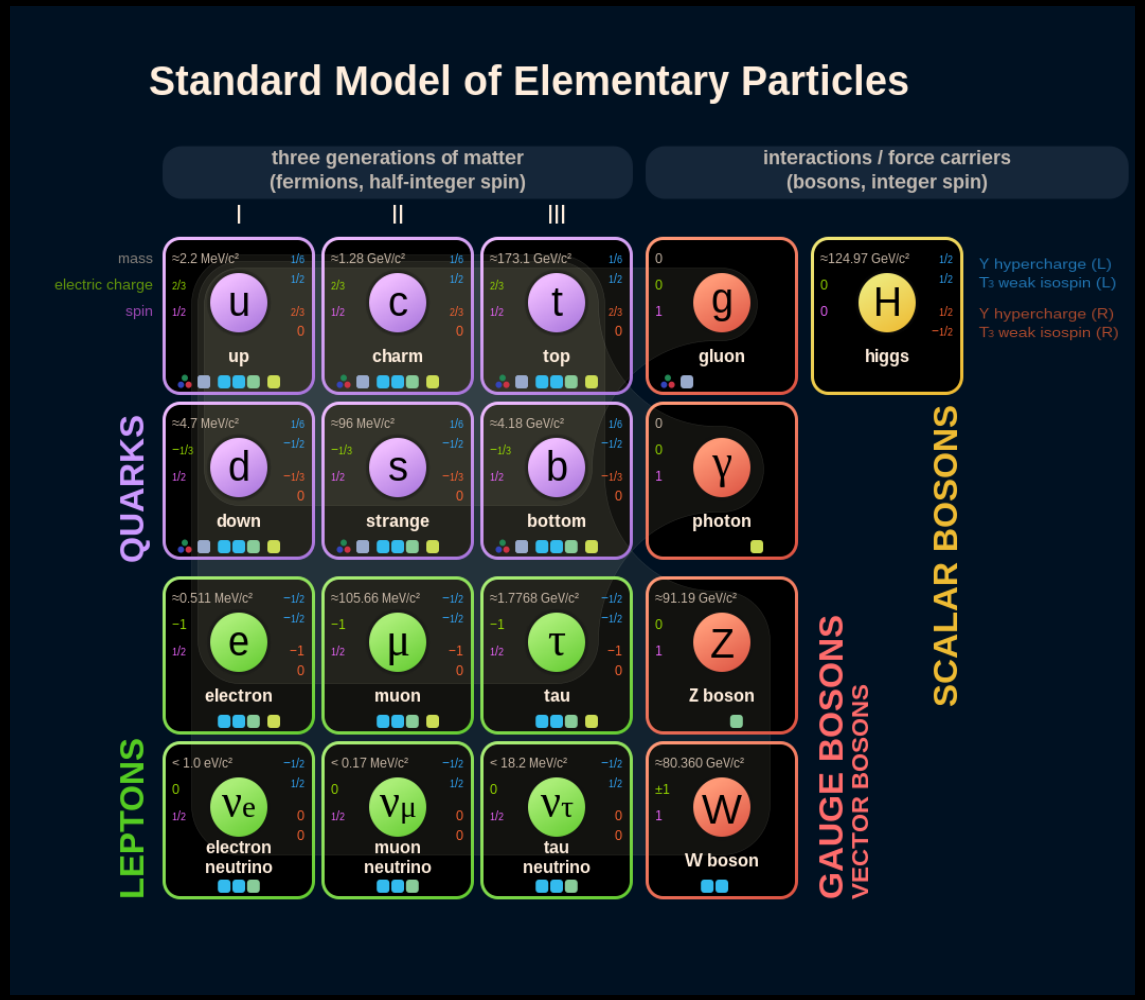
CERN
A Personal Introductory View

Pablo Garcia Tello, IdeaSquare, CERN

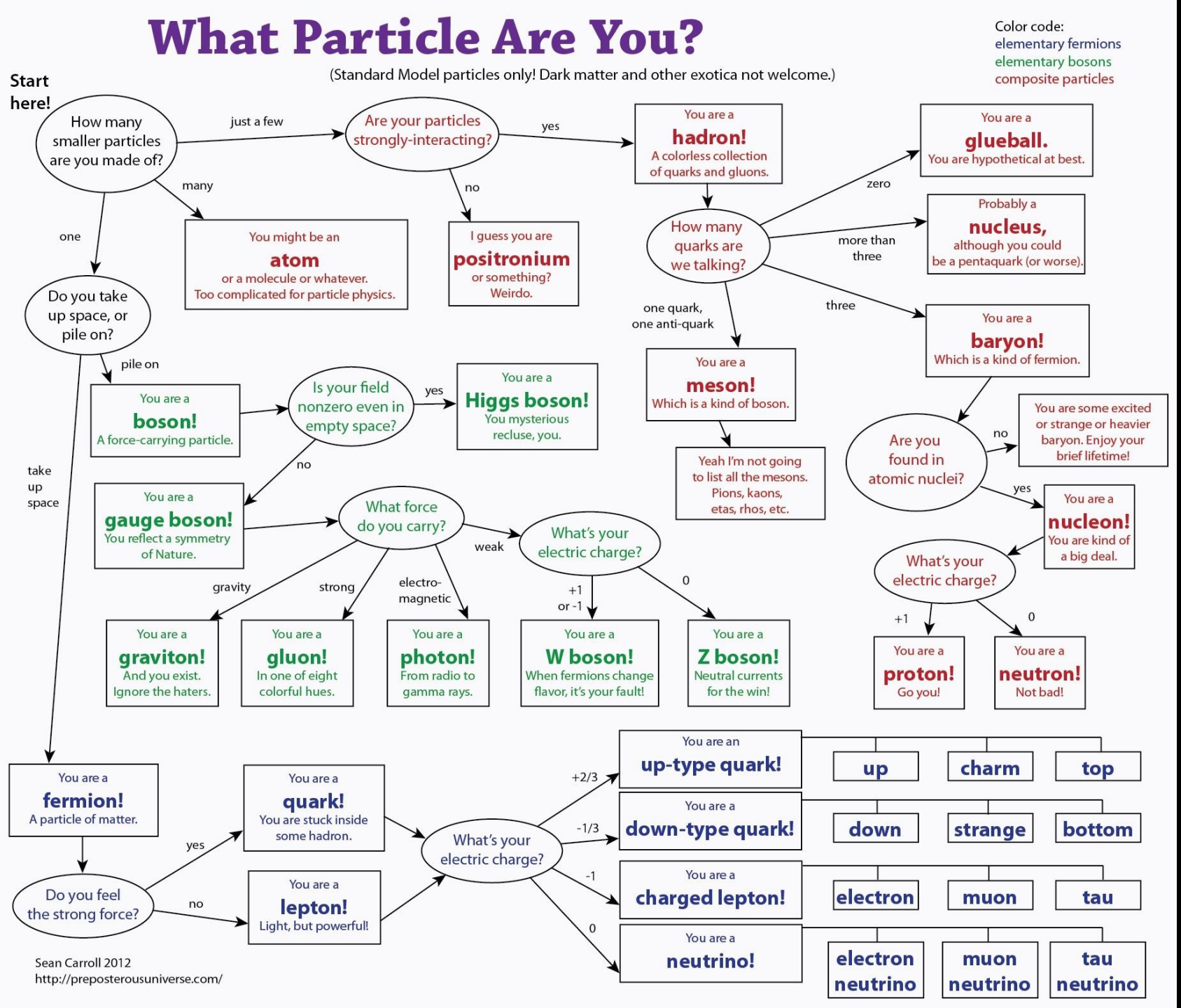
What is it that CERN is busy with?

Figuring out the
fundamental building
blocks of our Universe



How far we have gone?

- **Quarks**: Fundamental constituent of matter. combine to form protons and neutrons.
- **Leptons**: Also, fundamental constituents of matter. Not composed of anything as far as we know. Two main classes: charged leptons (the electron-like leptons or muons), and neutral leptons (neutrinos).
- **Gauge Bosons**: The force carriers (like electromagnetism)
- **Scalar Bosons**: The Higgs. It gives a rest mass to many particles.



The Standard Model works as a catalogue…

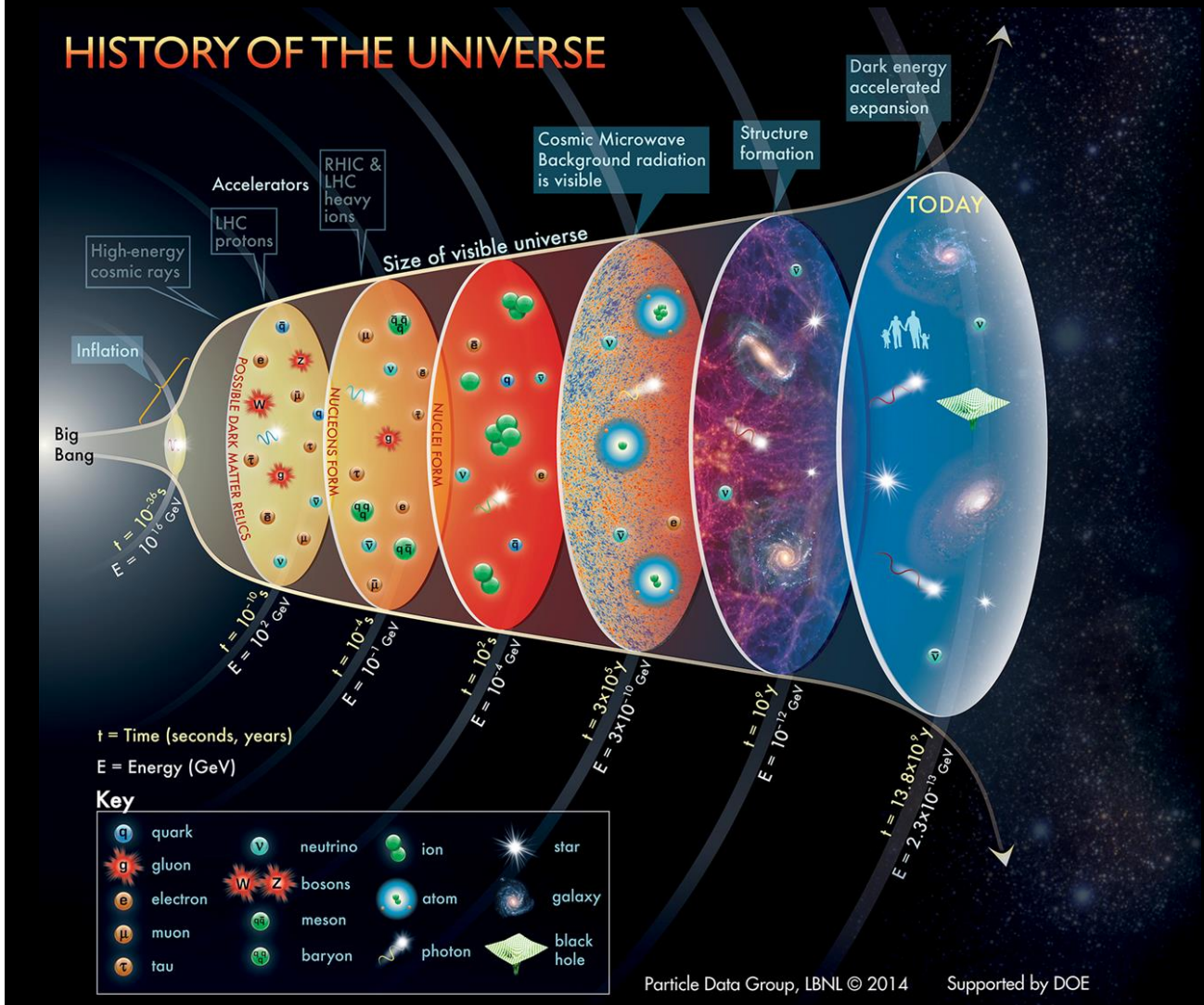
Tools we use for figuring out the building blocks of our Universe

- Ideas
- Hypothesis
- Figuring out Experiments

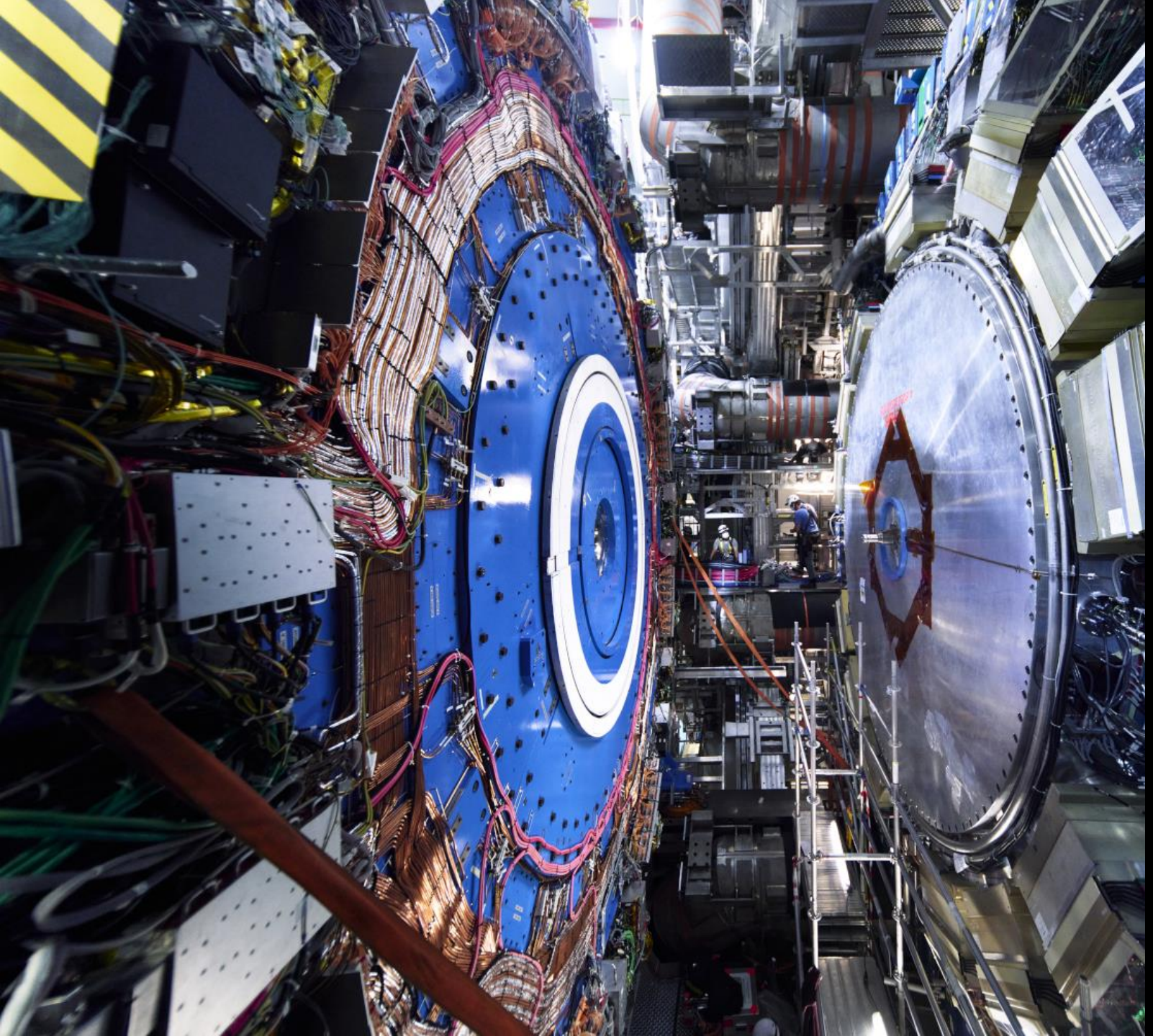
Tools we use for figuring out the building blocks of our Universe

- “Replicate the Big Bang”
- “Vacuum Shaker”
- “Time Machine”

Searching for the Higgs



LHC beam energy of 6.8 TeV
(13.6 TeV collision energy)

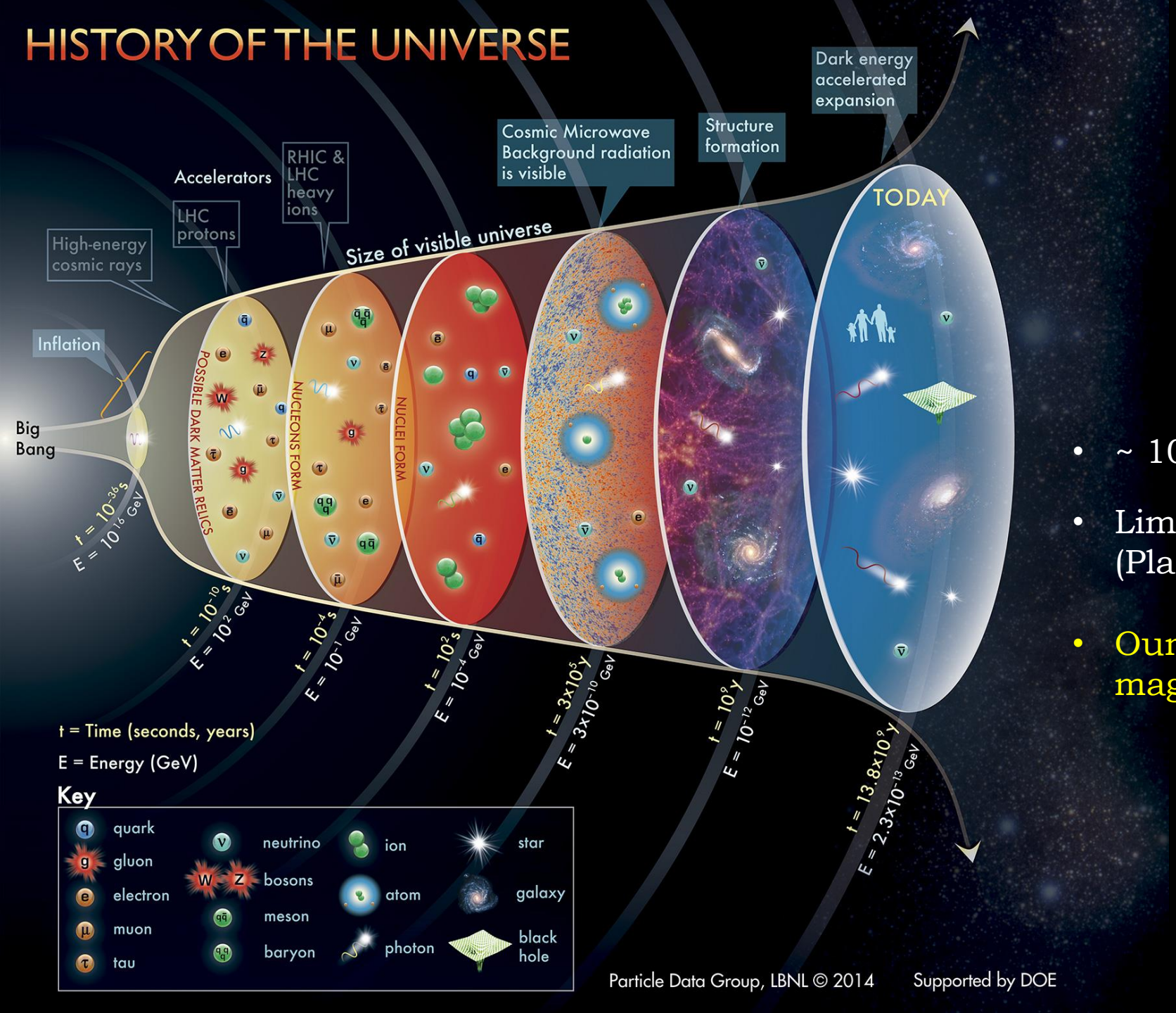


Tools we use for figuring out the building blocks of our Universe

- Detect the Building Blocks
- “Hyper-fast Camera”
- “Particle DNA Detector”

Tools we use for figuring out the building blocks of our Universe

- Analyse Data
- Proving/Disproving Hypothesis



How far back in time can we describe the Universe?

- ~ 10^{-12} s after the Big Bang
- Limit of Physics as we know it ~10^{-44} s (Planck Time)
- Our mission is (44-12)~32 orders of magnitude!

Parenthesis: 10 facts you didn't know about the LHC and its Experiments

When the 27-km long circular tunnel was excavated, between Lake Geneva and the Jura mountain range, the two ends met up to within 1 cm.

Each of the 6000-9000 superconducting filaments of niobium–titanium in the cable produced for the LHC is about 0.007 mm thick, about 10 times thinner than a normal human hair. If you added all the filaments together, they would stretch to the Sun and back six times with enough left over for about 150 trips to the Moon.

Protons at the design energy in the LHC travel at 0.999999991 times the speed of light. Each proton goes round the 27 km ring more than 11000 times a second.

At full energy, each of the two proton beams in the LHC have a total energy equivalent to a 400 t train (like the French TGV) travelling at 150 km/h. This is enough energy to melt 500 kg of copper.

The Sun never sets on the ATLAS collaboration. Scientists working on the experiment come from every continent in the world, except Antarctica.

Almost all the protons accelerated at CERN are obtained from standard Hydrogen. Although proton beams at the LHC are very intense, only 2 nanograms of Hydrogen are accelerated each day. Therefore, it would take the LHC about 1 million years to accelerate 1 gram of Hydrogen.

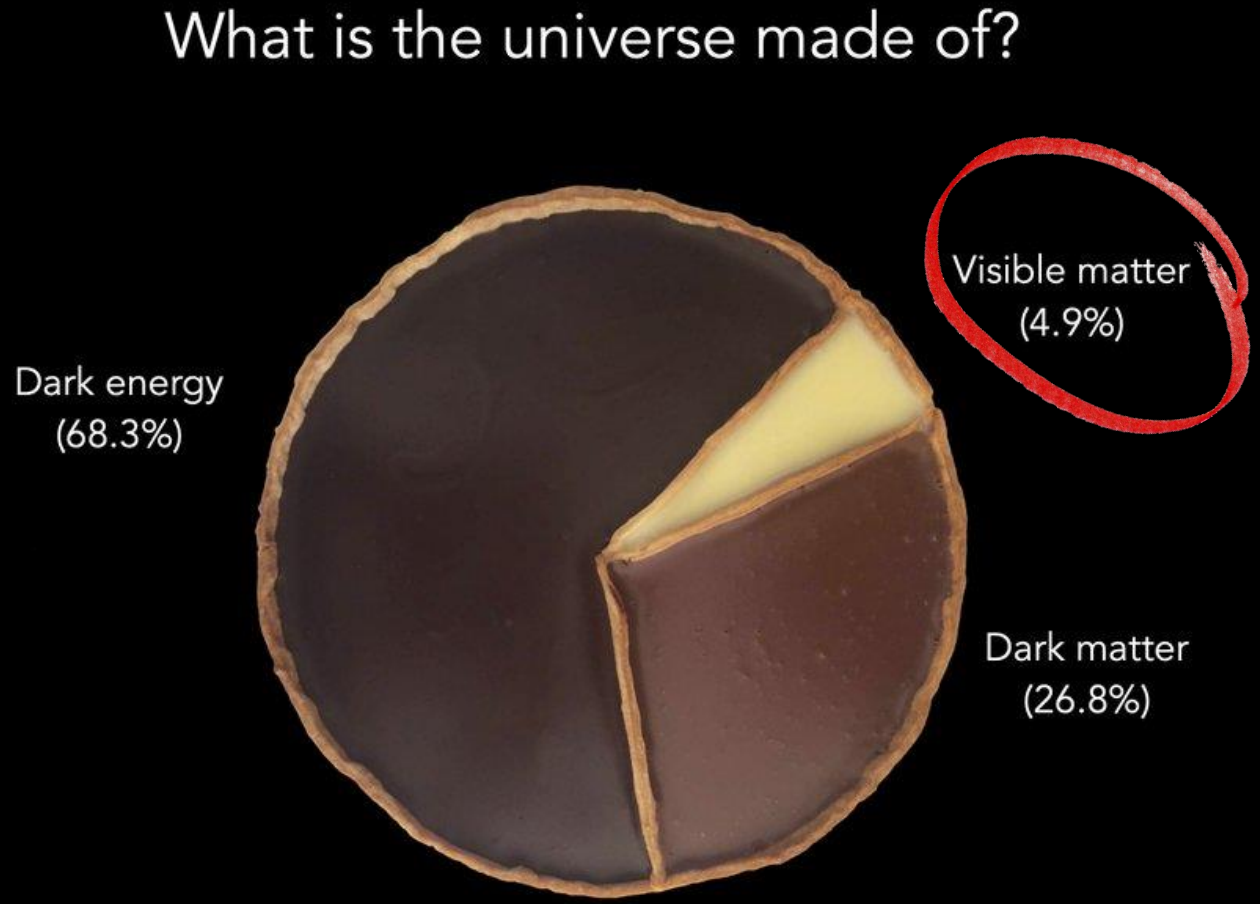
The CMS magnet system contains about 10000 t of iron, which is more iron than in the Eiffel Tower.

The central part of the LHC is the world's largest fridge. At a temperature colder than deep outer space, it contains iron, steel and the all-important superconducting coils.

The data recorded by the big experiments at the LHC are enough to fill around 50000 1 TB hard disks every year. ATLAS produces ~ 1 GB/s ;CMS ~1 GB/s; LHCb ~0.6 GB/s; ALICE produces several GB/s during heavy-ion running.

The pressure in the beam pipes of the LHC is about like the atmosphere of the Moon. This is an ultrahigh vacuum.

So far, so cool…now, what is the “dark problem”?



As cool as it might look like, we only know this far about the Universe!!!

The Standard Model does not explain **Gravity**. Moreover, it is widely considered to be incompatible with the most successful theory of gravity to date, General Relativity.

Neutrinos do not have mass in the Standard Model. We know experimentally that they do have it. It can be added to the Standard Model by hand, but it leads to new theoretical problems.

Matter-Antimatter asymmetry. Our Universe is made from mostly matter. However, the Standard Model predicts that matter and antimatter should have been created in (almost) equal amounts. Yet, there is no mechanism in the Standard Model to sufficiently explain this asymmetry.

In theoretical physics, the **Hierarchy Problem** concerns the large discrepancy between aspects of the weak force and gravity. There is no scientific consensus on why, for example, the weak force is 10^{24} times stronger than gravity.

Free Parameters – the Standard Model depends on 19 parameter numbers. Their values are known from experiment, but they lack a theoretical explanation.

Strong CP Problem. Imagine a scenario where swapping particles with their antiparticles (C) and mirroring everything (P) doesn't behave the same way as in our regular world. This is what CP violation is about. According to the Standard Model, this violation is predicted to occur more frequently than experiments show, and the puzzling part is that there's no obvious reason for this discrepancy.

So, after all, we know way less than we thought…and this is exciting!

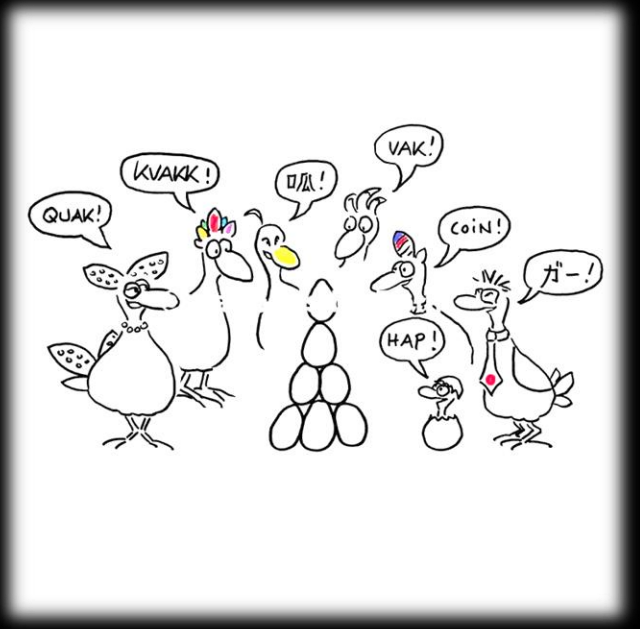
Why is this exciting?

Because history and philosophy of science have proven once and again that a deeper understanding in Physics emerges out of crossroad situations.

"Carlsberg Beer and its Consequences" from Gamow's book "Thirty Years that Shook Physics".

How do we go from here?

Collaborating



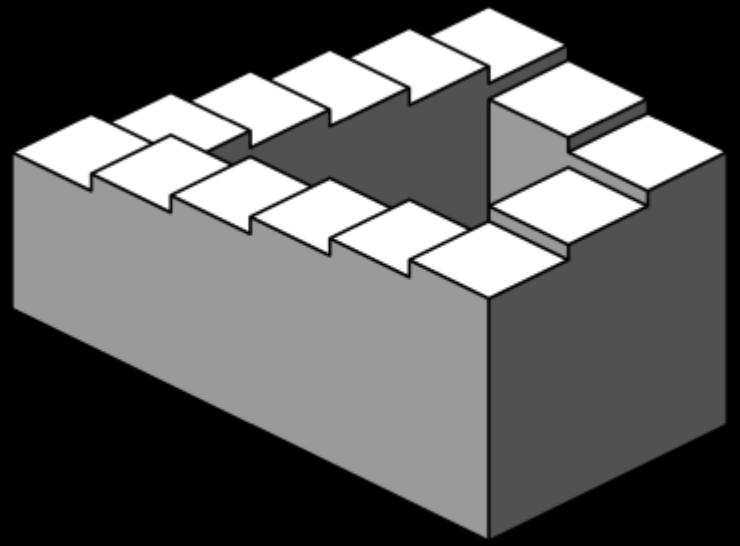
Welcoming
Diversity

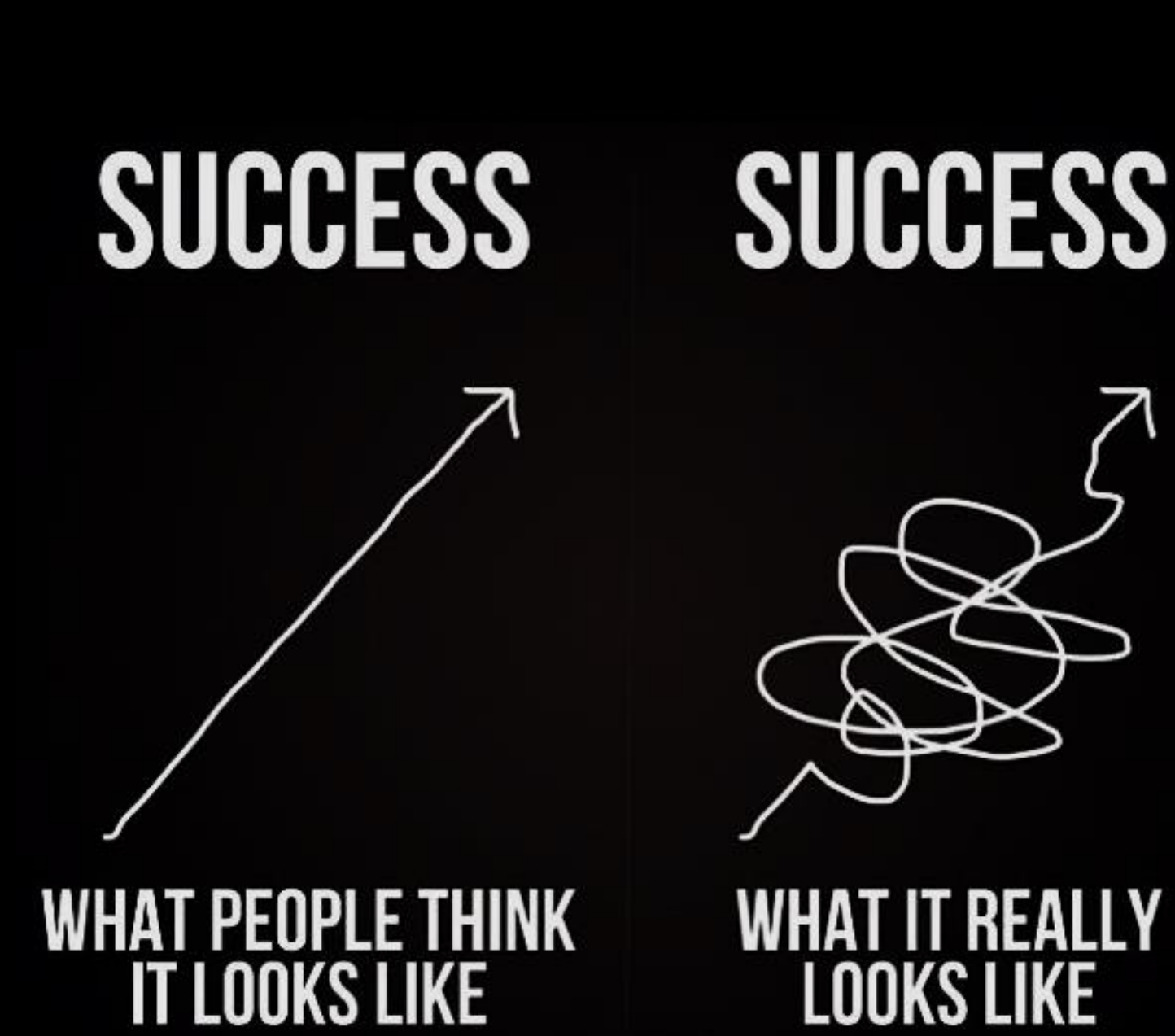
Embracing
Uncertainty

Hypothesizing
and
Experimenting

Staying Curious

Challenging
Assumptions





Accepting R&D

As a non-linear process

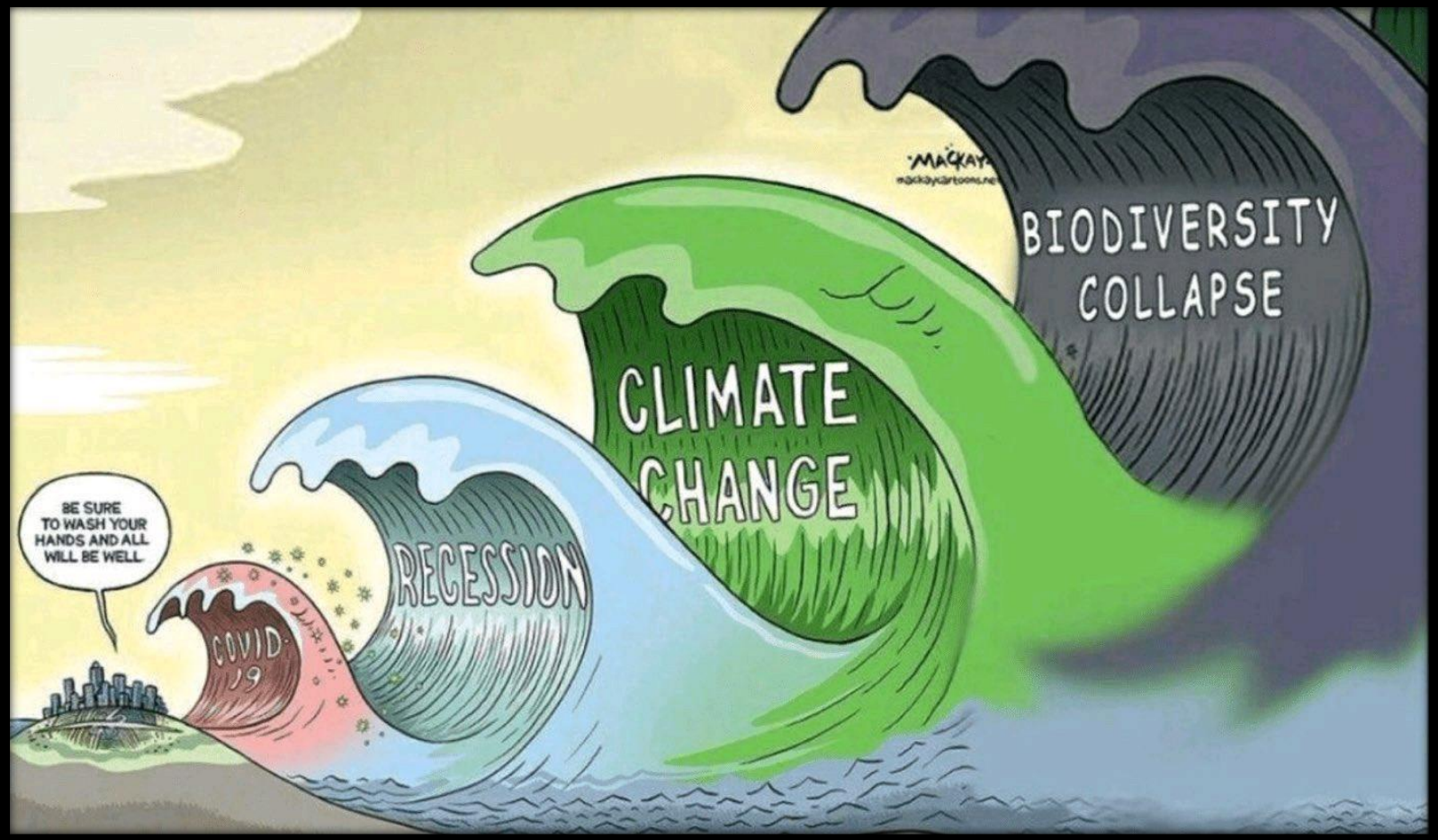
The CERN spirit

Simple Macro-rules

- Establish bottom-up collaboration frameworks that honour individual autonomy and eschew rigid hierarchies.
- Select leaders based on technical proficiency, credibility, and trust, prioritizing these qualities over ego-driven authority.
- Facilitate the spontaneous formation of ad-hoc expert teams, enabling swift responses to scientific and technical challenges as they arise.
- Ensure inclusive participation by granting everyone a voice and maintaining open lines of sharing and communication.
- Institute peer review processes and arbitration mechanisms to uphold the integrity and quality of collaborative endeavours.

Simple Micro-rules

- Allow people to dream (5% makes already a difference).
- Tolerate diversity.
- Let the Physics decide, not the hierarchy.
- Collaborate and compete.
- Expose the challenges and issues rather than hiding them.
- Question and justify – Respect the Dukes of Doubt rather than Kings of Truth.
- Reward anyone and everyone contributing.


BE SURE TO WASH YOUR HANDS AND ALL WILL BE WELL
COVID-19
RECESSION
CLIMATE CHANGE
BIODIVERSITY COLLAPSE

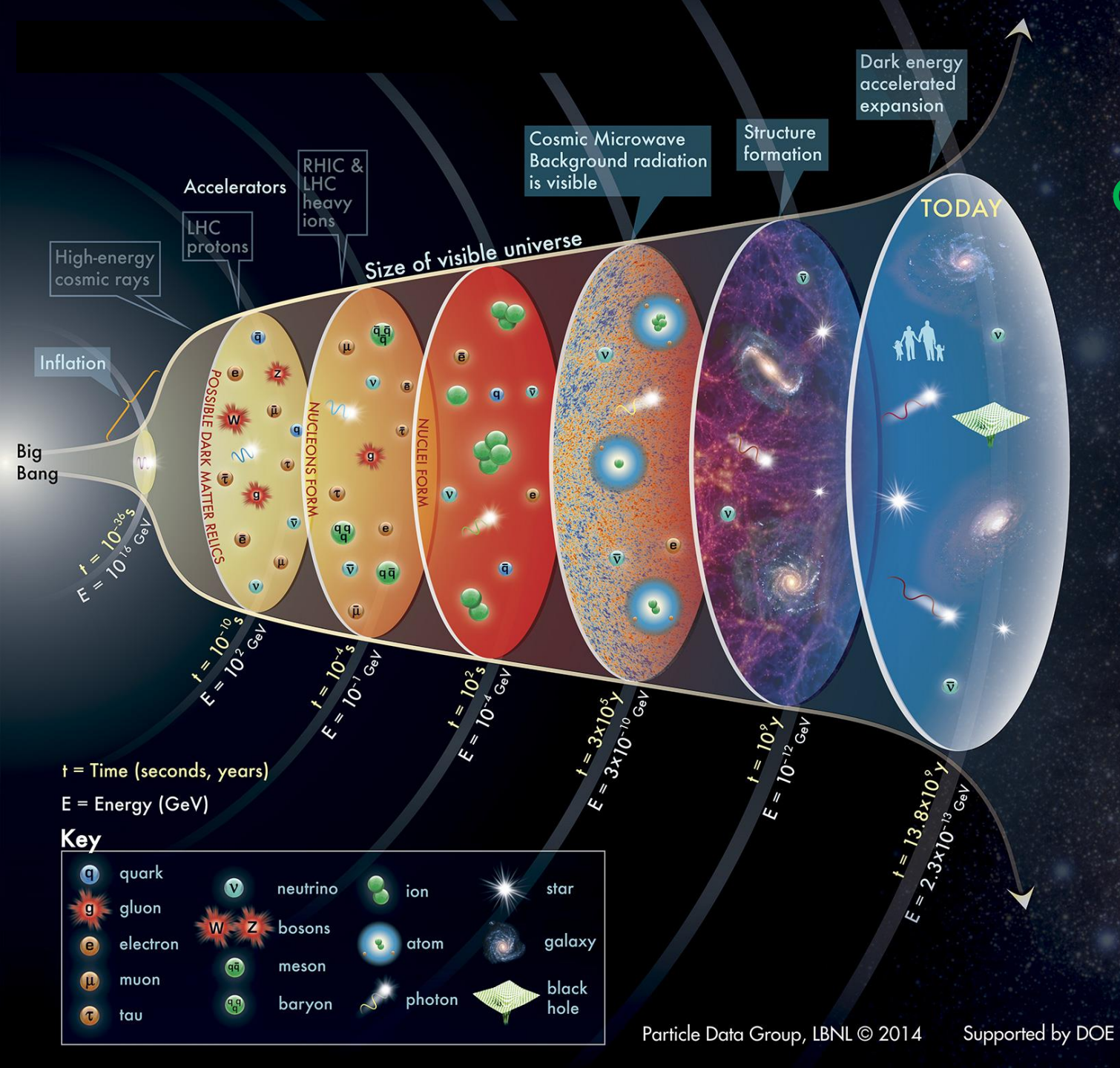
Why?

CERN IdeaSquare

Our Job

How? “Think like CERN”


Anticipation



Order of Magnitude Thinking

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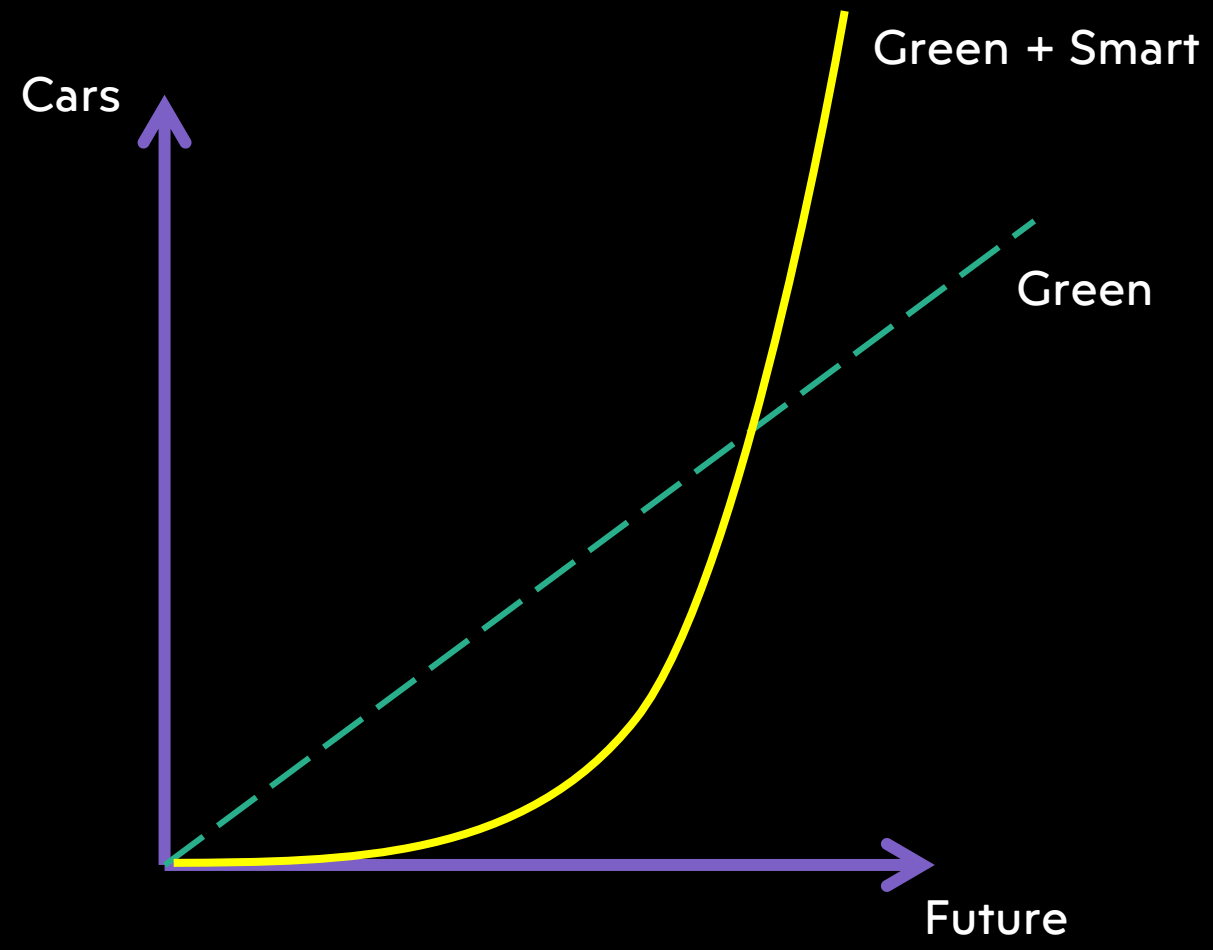
Challenging Assumptions



Challenging Assumptions

WWW's logo, created by Robert Cailliau in 1990

Stay tuned, the fun just started!

Thanks, and Questions