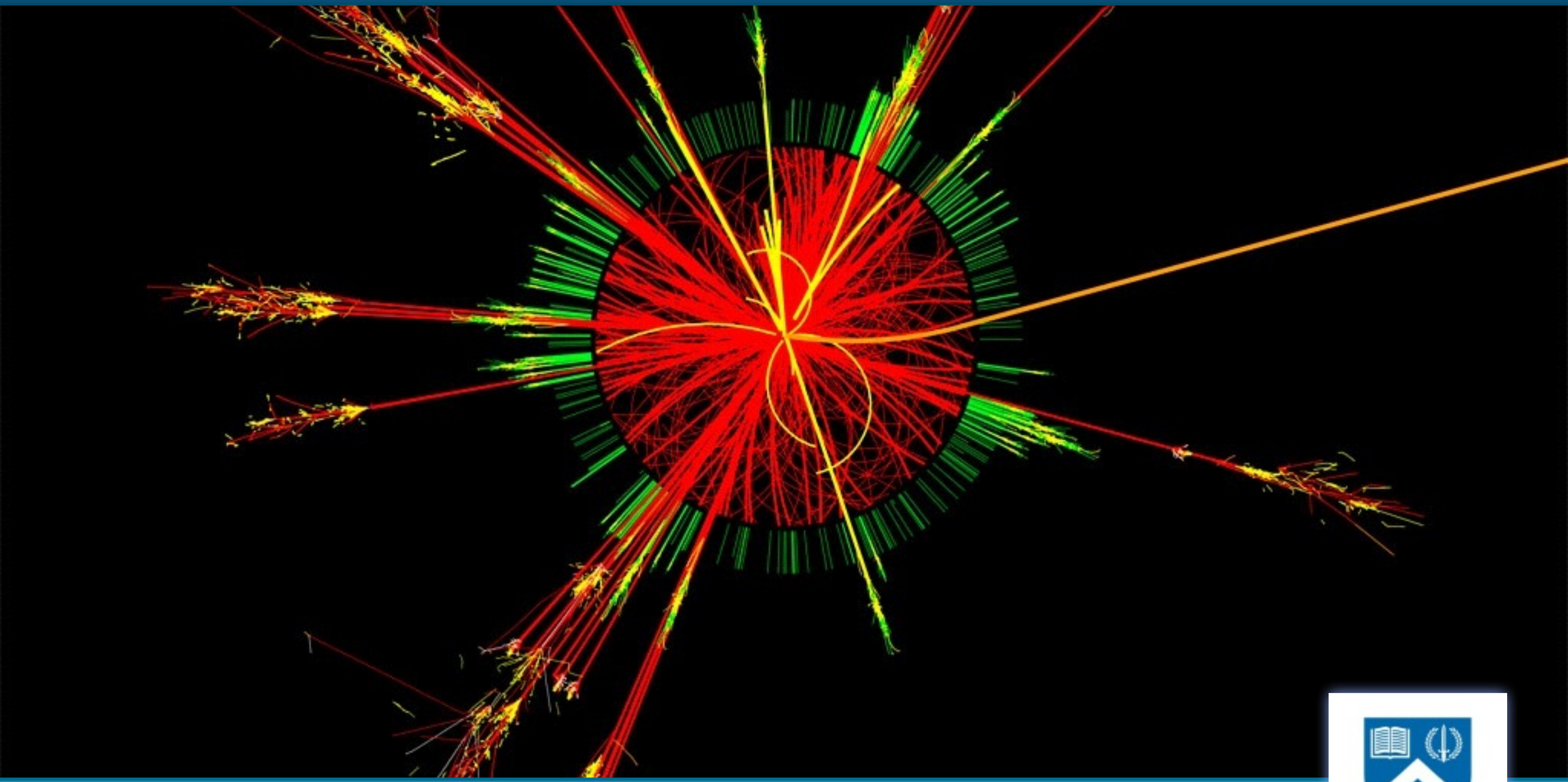
Particle Physics - Welcome

Dr. Peter Skands, Monash U & ARC Centre of Excellence for Physics at the Terascale

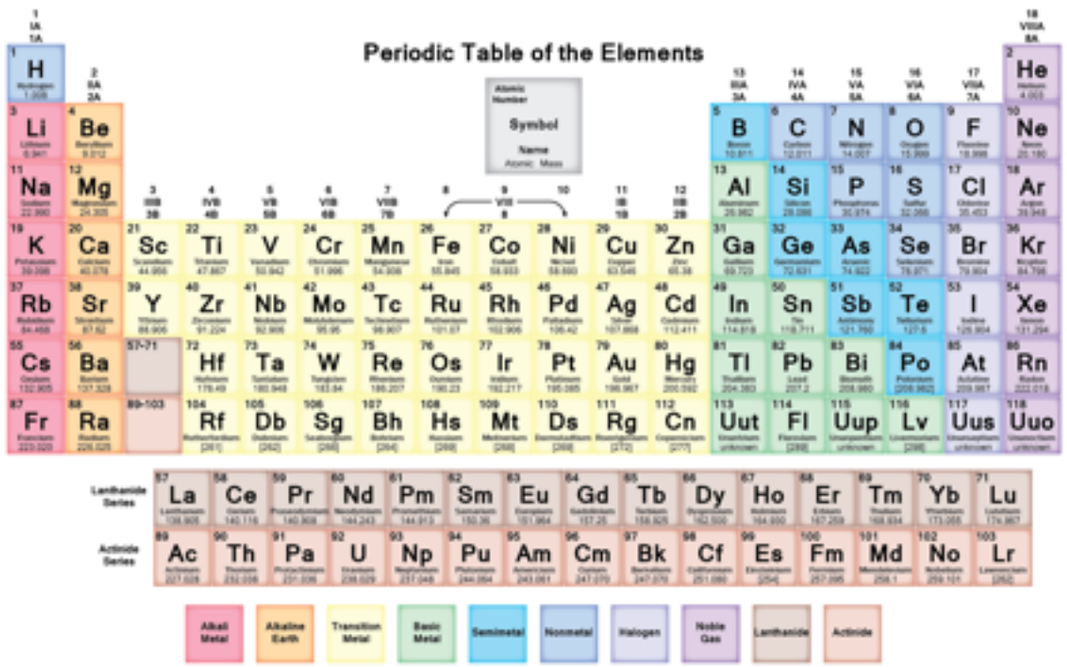


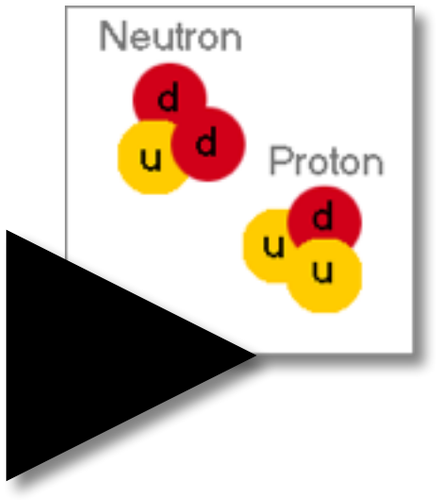
International Student Science Fair 2015

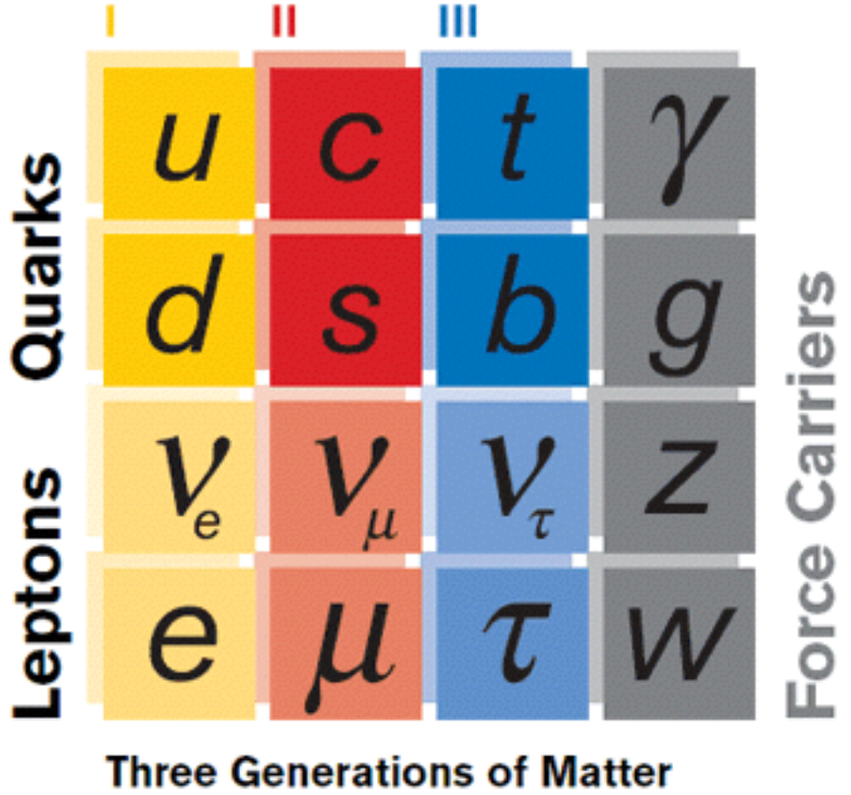
Monash University

Voyage to the Heart of Matter

About 100 years ago, Mendeleev proposed the periodic table.
Today, we know it can be reduced to just a few ultra-fundamental constituents and the forces that act between them







CHEMISTRY **PHYSICS**

With great imagination dubbed the "Standard Model" of Particle Physics

Called the most precisely tested theory in the history of science

What *is* a Fundamental Particle?

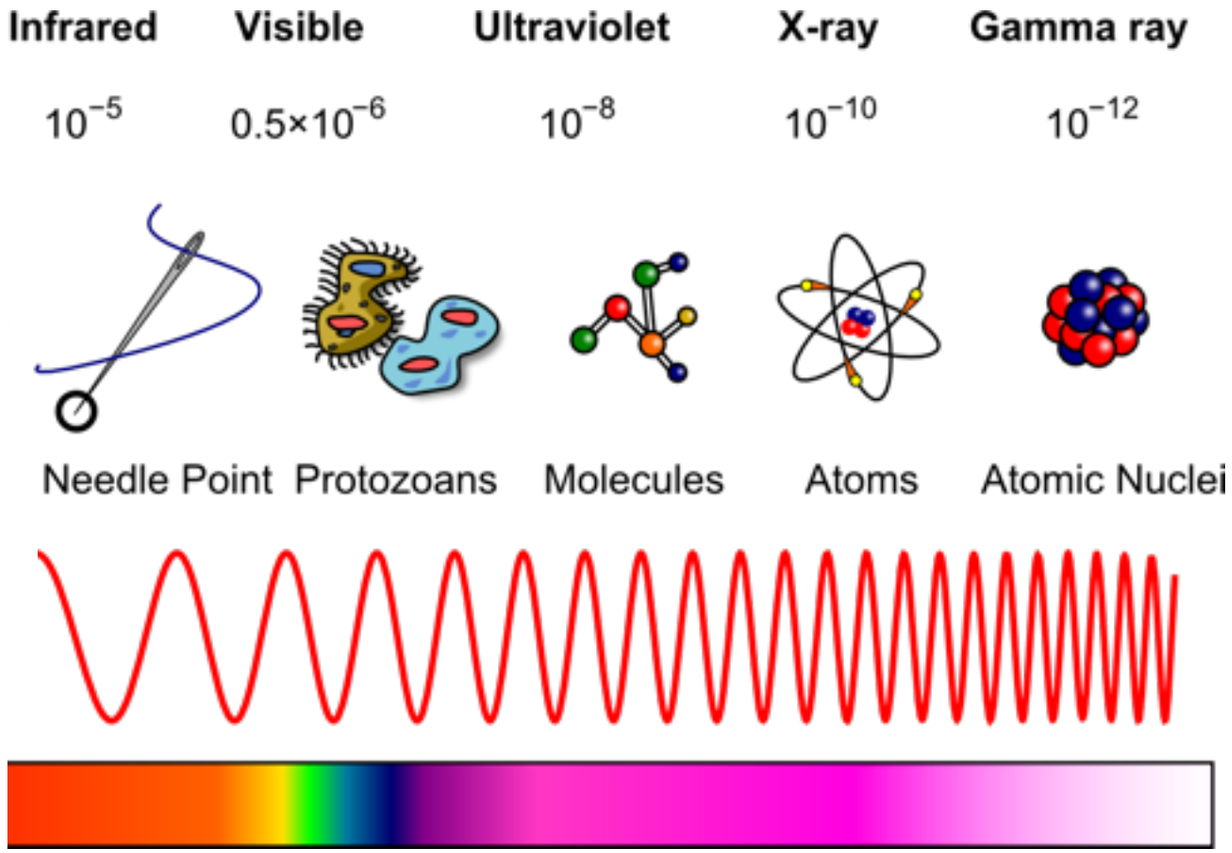
Abstractly, we think of an idealised "pointlike" particle

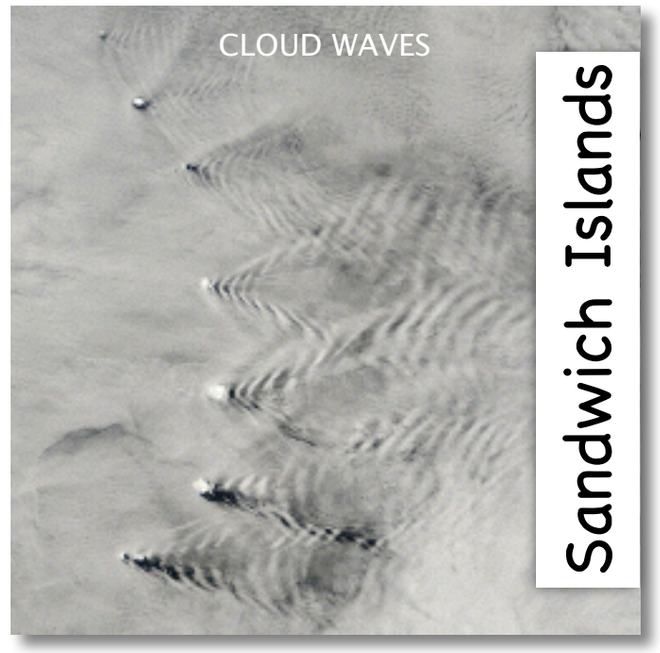
But could we ever really see "a point"?

How do we see, in the quantum world?

To see something small, we scatter waves off it

➜ Heisenberg's uncertainty principle.



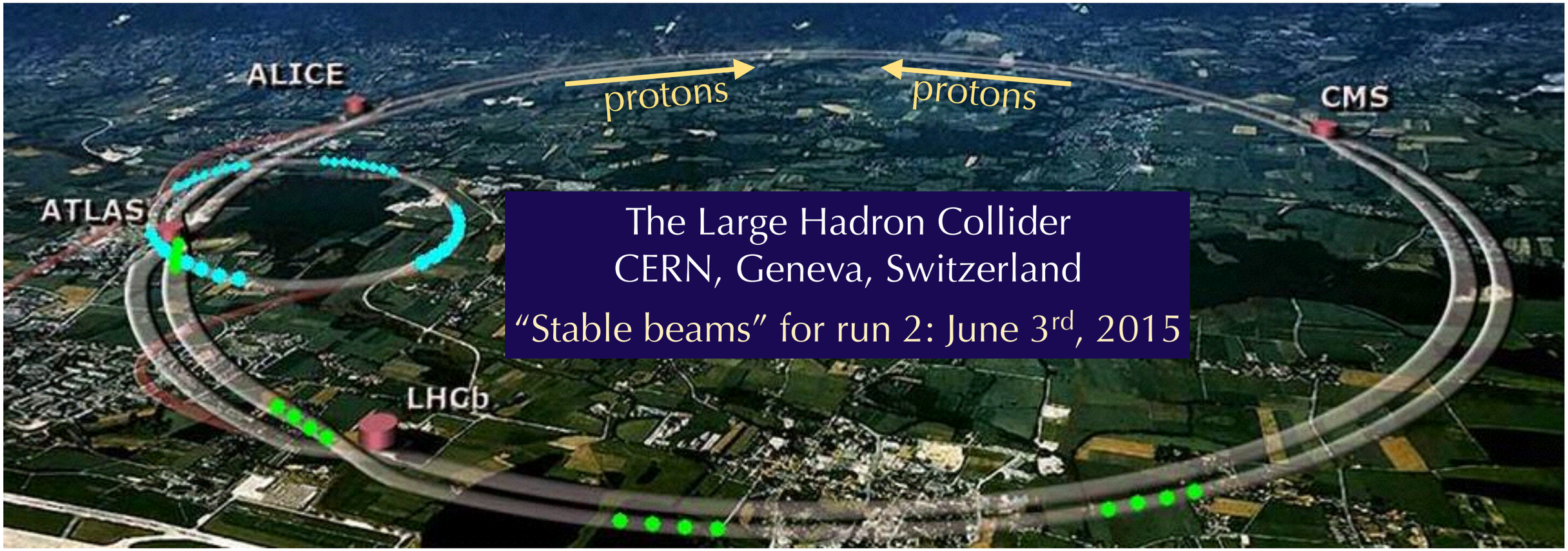


NASA – MODIS

To resolve "a point", we would need infinitely short wavelengths

Heisenberg would then give it an infinitely hard kick

Kick it as hard as we can

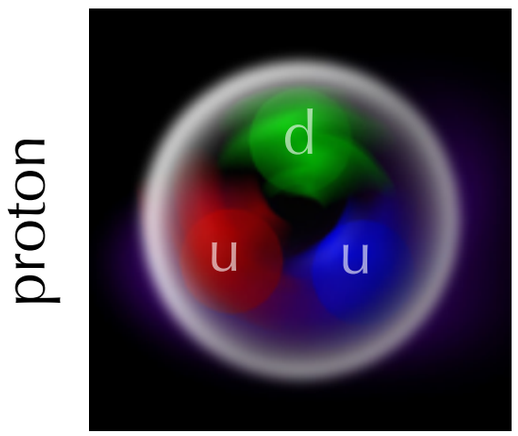


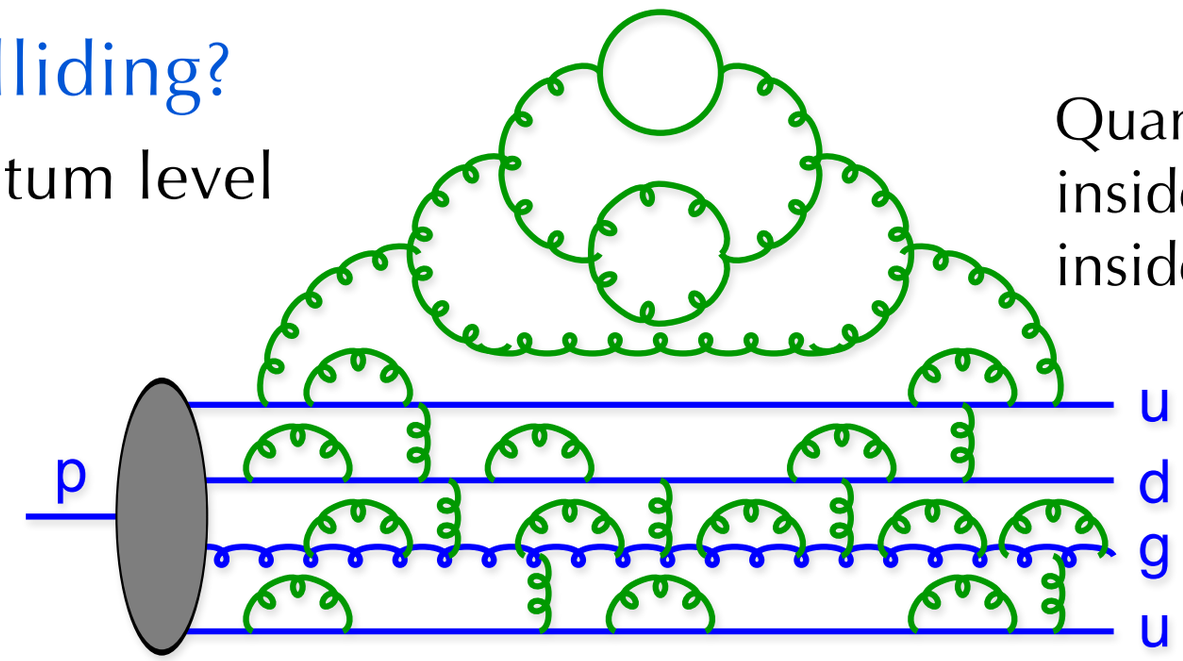
The Large Hadron Collider
CERN, Geneva, Switzerland

"Stable beams" for run 2: June 3rd, 2015

What are we really colliding?

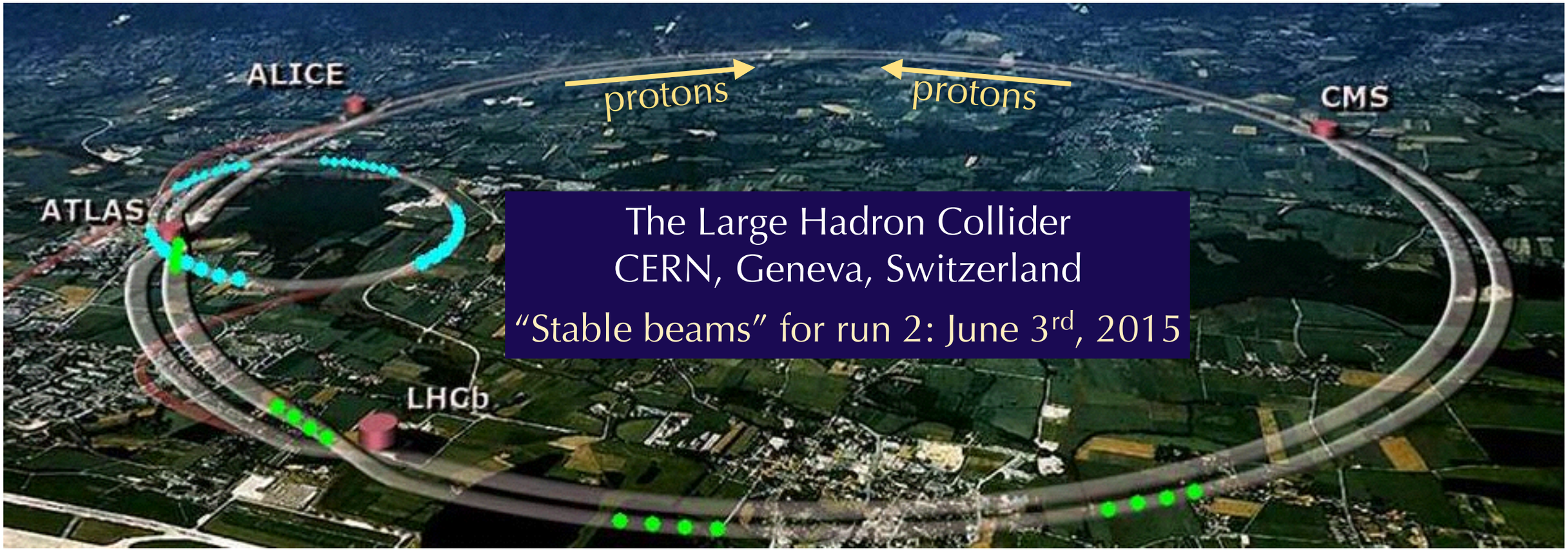
Take a look at the quantum level





Quantum fluctuations
inside fluctuations
inside fluctuations …

Kick it as hard as we can

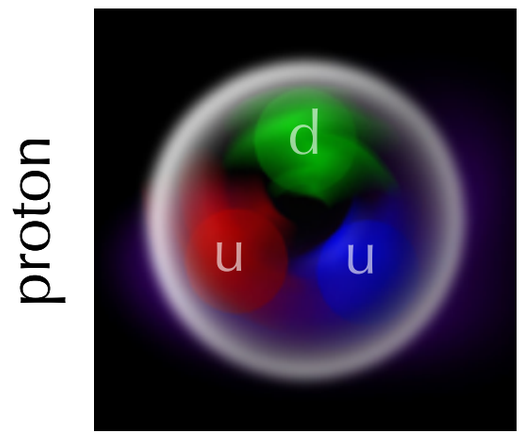


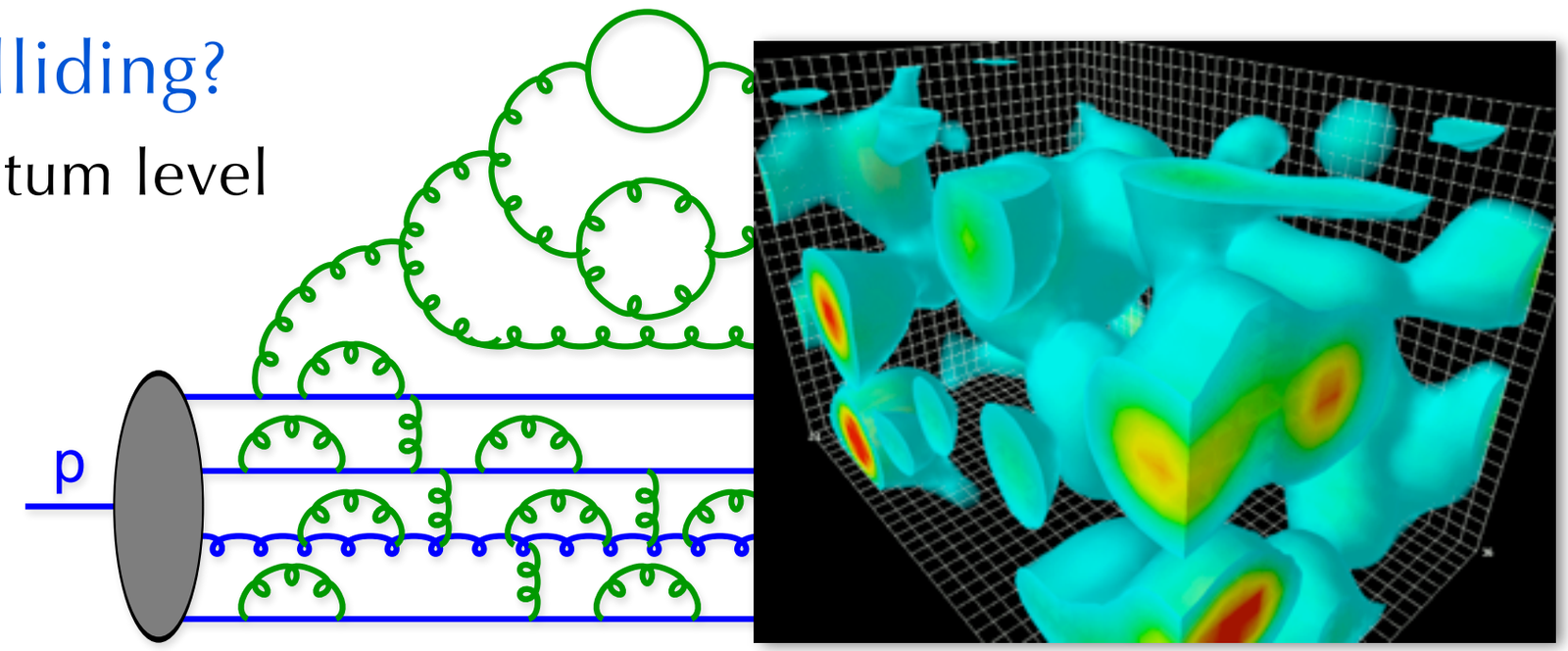
The Large Hadron Collider
CERN, Geneva, Switzerland

"Stable beams" for run 2: June 3rd, 2015

What are we really colliding?

Take a look at the quantum level





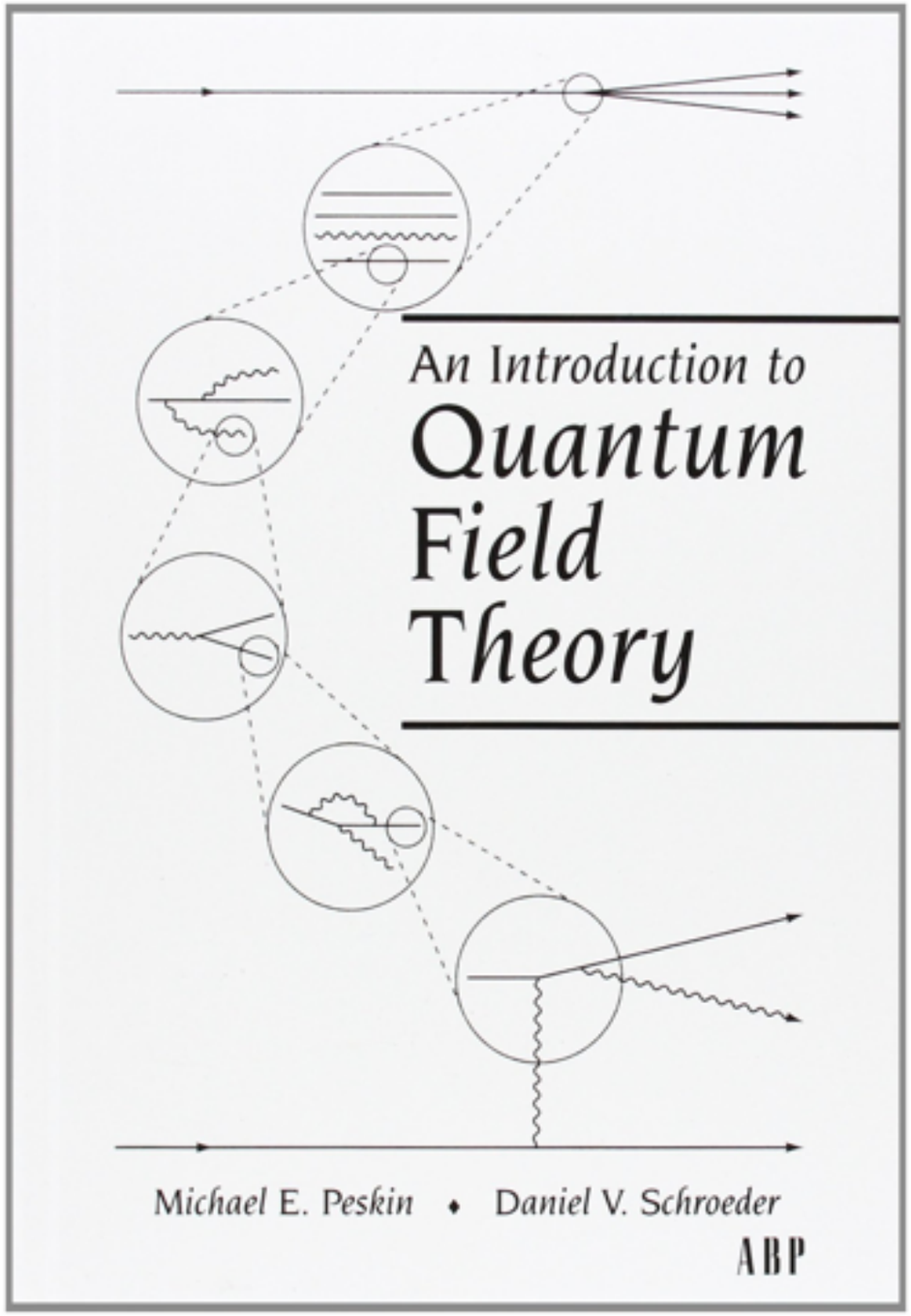
The Structure of Quantum Fields

What we see when we look at the quarks inside the proton

An ever-repeating self-similar pattern of quantum fluctuations

At increasingly smaller distance scales: ***scaling***

To our best knowledge, this is what a fundamental ('elementary') particle really looks like



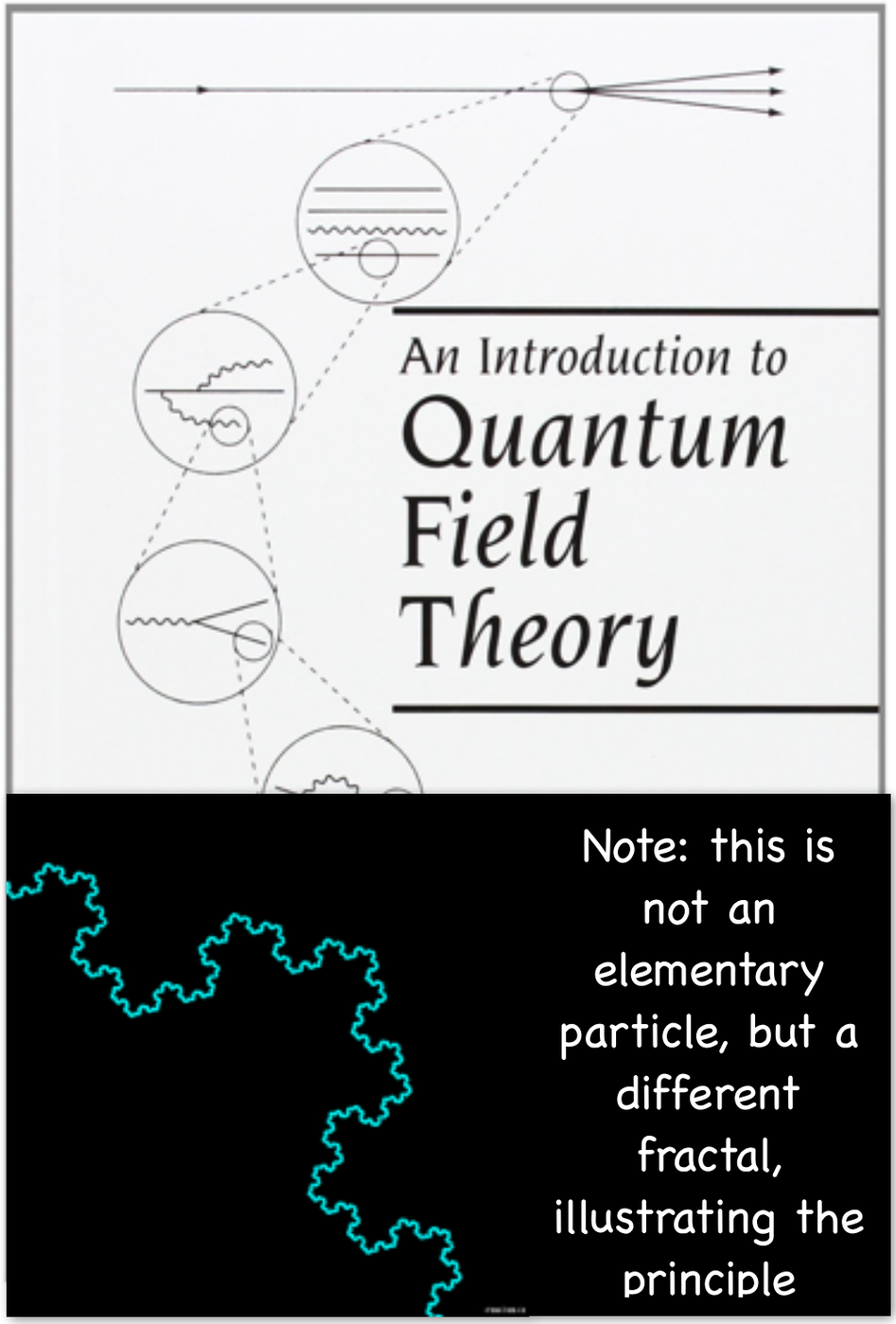
The Structure of Quantum Fields

What we see when we look at the quarks inside the proton

An ever-repeating self-similar pattern of quantum fluctuations

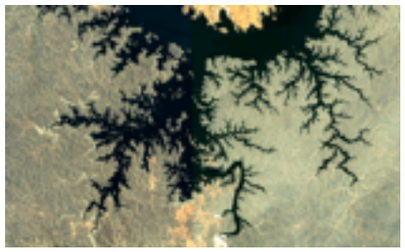
At increasingly smaller distance scales: ***scaling***

To our best knowledge, this is what a fundamental ('elementary') particle really looks like



Nature makes copious use of such structures

Called **Fractals**



Note: this is not an elementary particle, but a different fractal, illustrating the principle

The Meaning of Fundamental

Similar phenomenon when you kick/hit particles:

Accelerated charges radiate

➜ Self-similar pattern of bremsstrahlung; **"jets"**

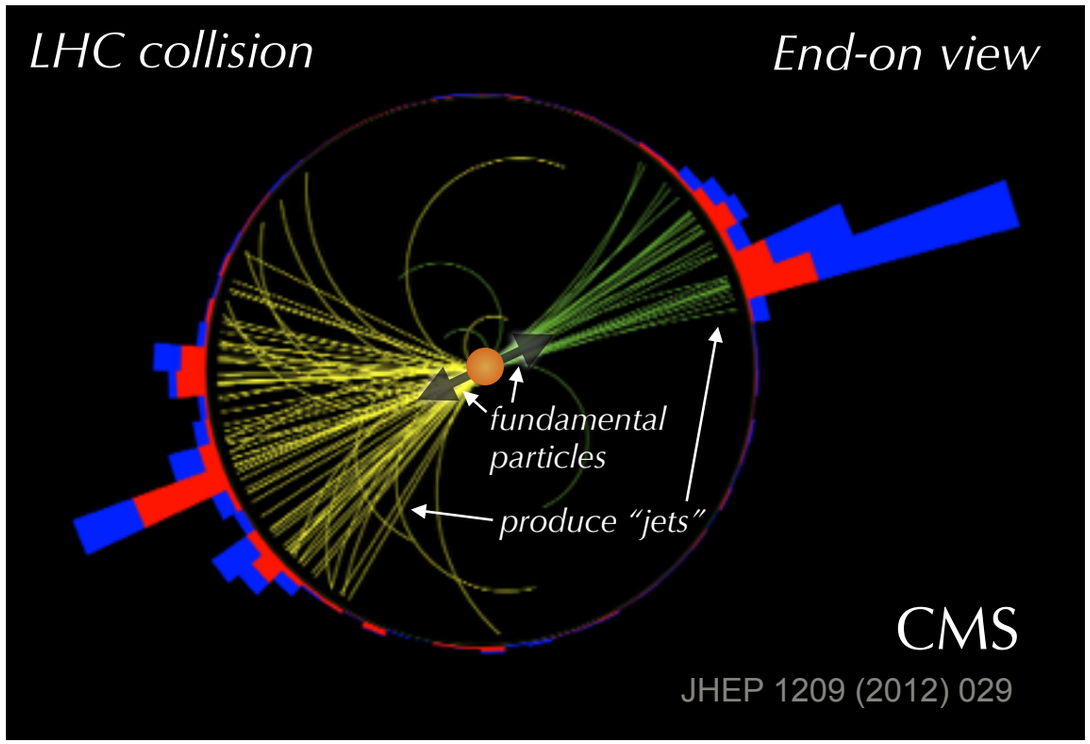
Any deviation from this ever-repeating scaling behaviour

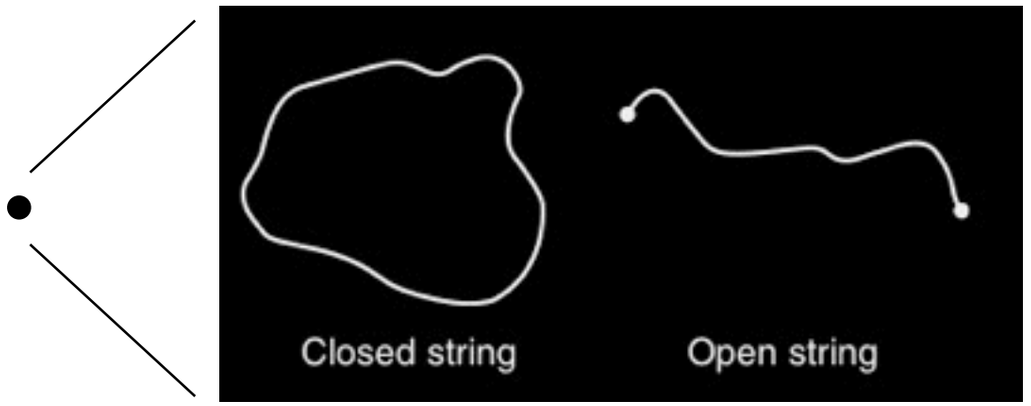
Would indicate "substructure"
A *new level of fundamental*

Superstring theory?

Probably beyond our reach

Still, the fundamental content of the universe is …





Expect we could resolve something like this at the "Planck Scale" > billion times LHC energies …

The Meaning of Fundamental

Similar phenomenon when you kick/hit particles:

Accelerated charges radiate

➜ Self-similar pattern of bremsstrahlung; **"jets"**

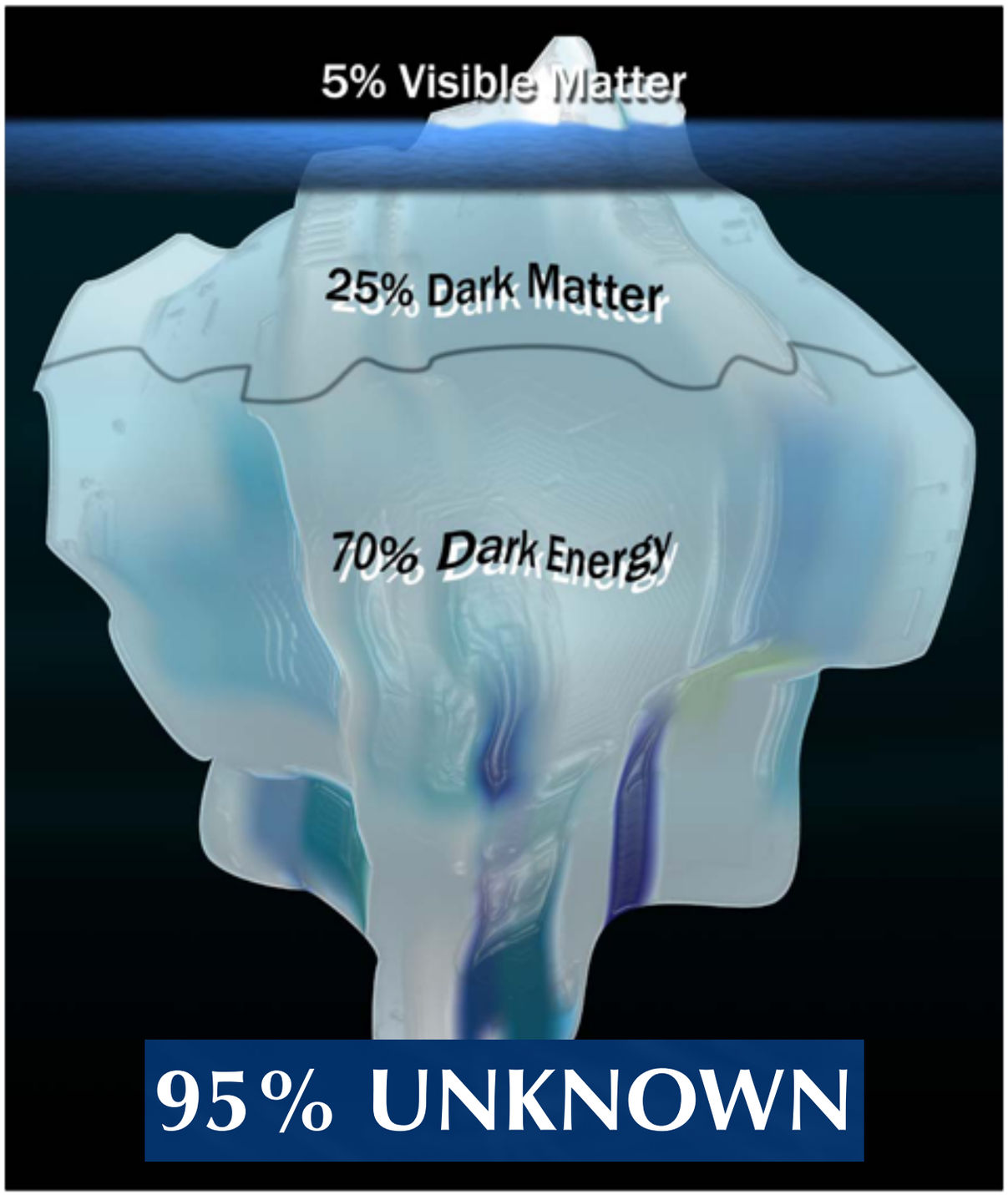
Any deviation from this ever-repeating scaling behaviour

Would indicate "substructure"
A *new level of fundamental*

Superstring theory?

Probably beyond our reach

Still, the fundamental content of the universe is …



This Morning

- Play **"Quantum Tic-Tac-Toe"** to learn hands-on the weird rules of Quantum Mechanical "superpositions"
- Play **"Virtual Atom Smasher"** to adjust the parameters of a real-world particle-physics simulation to agree with data
- Listen to brief **presentations** by our scientists about favourite research topics of theirs
- Ask **questions** about anything from antimatter to relativity, what we know about dark matter, what the difference is between the Higgs *field* and the Higgs *boson,* or anything else you want to know about particles, the fundamental laws of nature, or relativistic quantum theory

Welcome to Monash University