Why are we here?

Steve Boyd, Particle Physicist
University of Warwick

But first……

Who am I and How Did I Get This Way?

Me : Prof Steven Boyd

- I'm a particle physicist and academic in the Elementary Particle Physics group here at the University of Warwick
- I was born in Papua New Guinea and grew up in Australia.
- In High School I was going to be
  - a chemist but it turns out that I'm terrible at chemistry
  - a historian - still interested but the amount of writing I would have to do put me right off
  - a vet - but euthanising animals would have killed me as well
  - a wine producer - but it turns out I can drink the stuff, but am deadly to plants
- I actually failed Physics at the Aussie equivalent of the GCSE….

Me : Prof Steven Boyd

- I went to the Uni of Sydney in 1990 and I gently drifted into Physics. To my shock I found out that it seemed suddenly to make sense.

- 8 years later, I stumbled out with a brand new, minty fresh PhD and a feeling that I didn’t know as much as I thought I did.

- To my mild surprise, I got a research job at the University of Washington in Seattle, and then bounced around the planet for 10 years or so before I arrived in the UK

- I did not plan to be here – it just sort of happened.

Bouncing

Worked in Seattle at UW
Finally to the UK
Got my PhD & went to CERN
Then to Japan
To Pittsburgh
Born : Many centuries ago
Back home for a year
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What does an academic do?

Teach : I give lectures (like this) on different topics

I look after students : each academic has a small group of students we mentor and help through their degrees.

Research : I run a research group with PhD students, postdoctoral fellows, technicians and engineers

Papers : I write research papers to communicate the results of my research to the world.

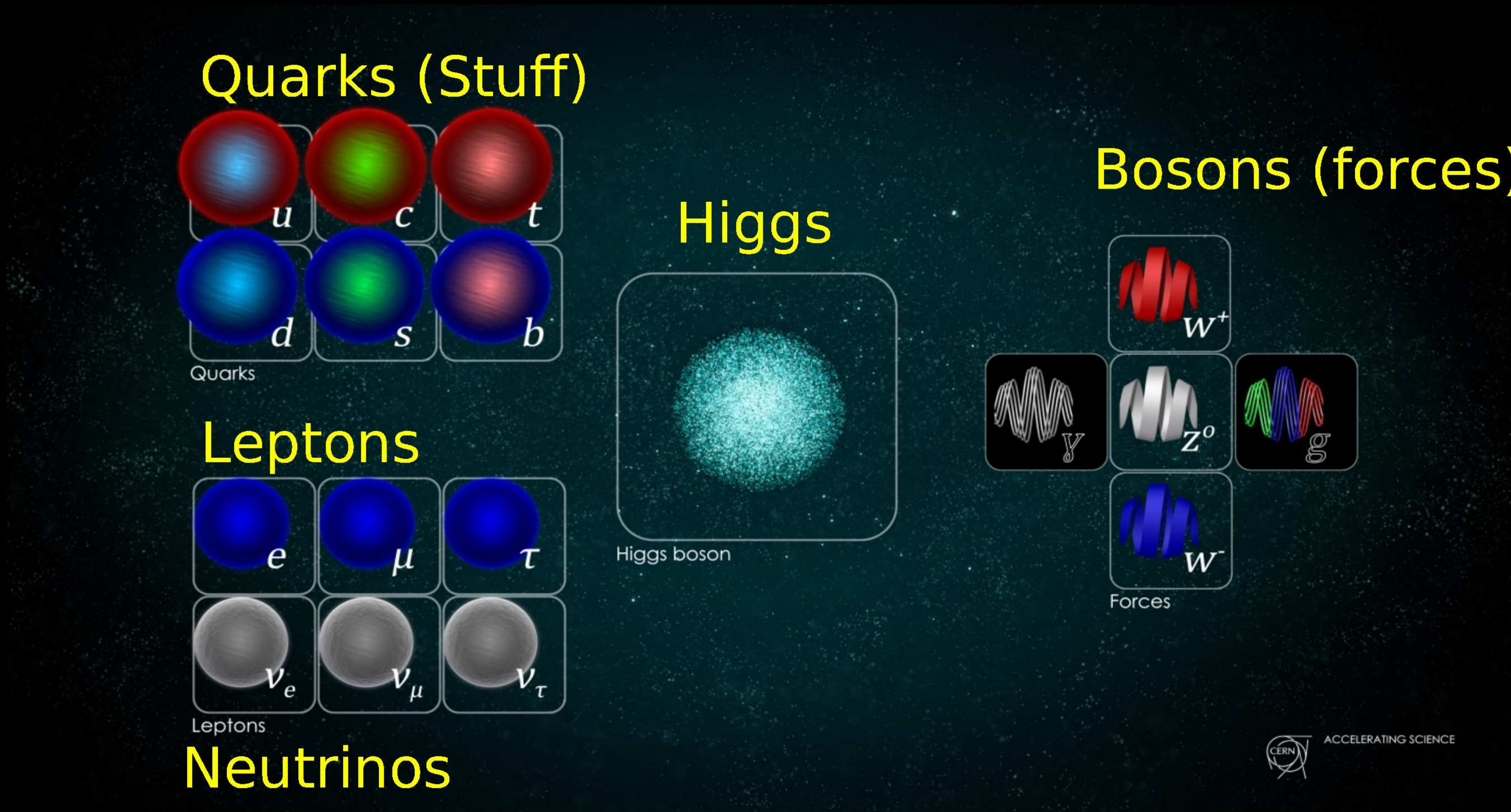
Money : I apply for cash to run the group with

But what is my research all about?

Any questions/comments?
I’ll (try to) answer anything....

What do I study?

- I'm a particle physicist – I study the properties of the fundamental building blocks of reality, and try to understand how the Universe ended up like this.



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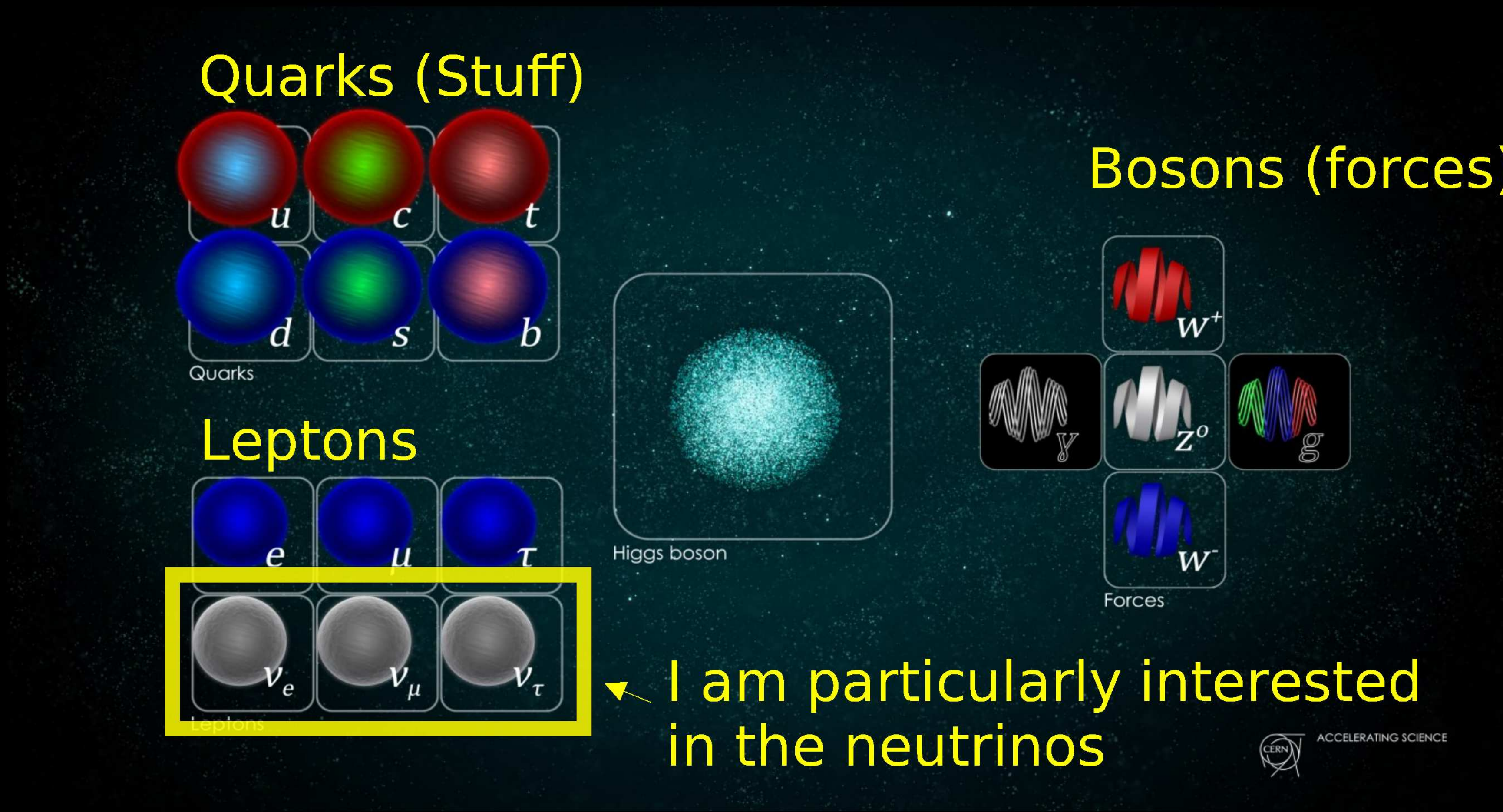


Neutrino Properties

- Rarely interact with matter – which makes them very hard to detect.

Electrically neutral – this makes them even harder to detect.

- They are present in the Universe in vast numbers


5,000,000,000,000,000 solar
neutrinos just went through you

Neutrino Properties

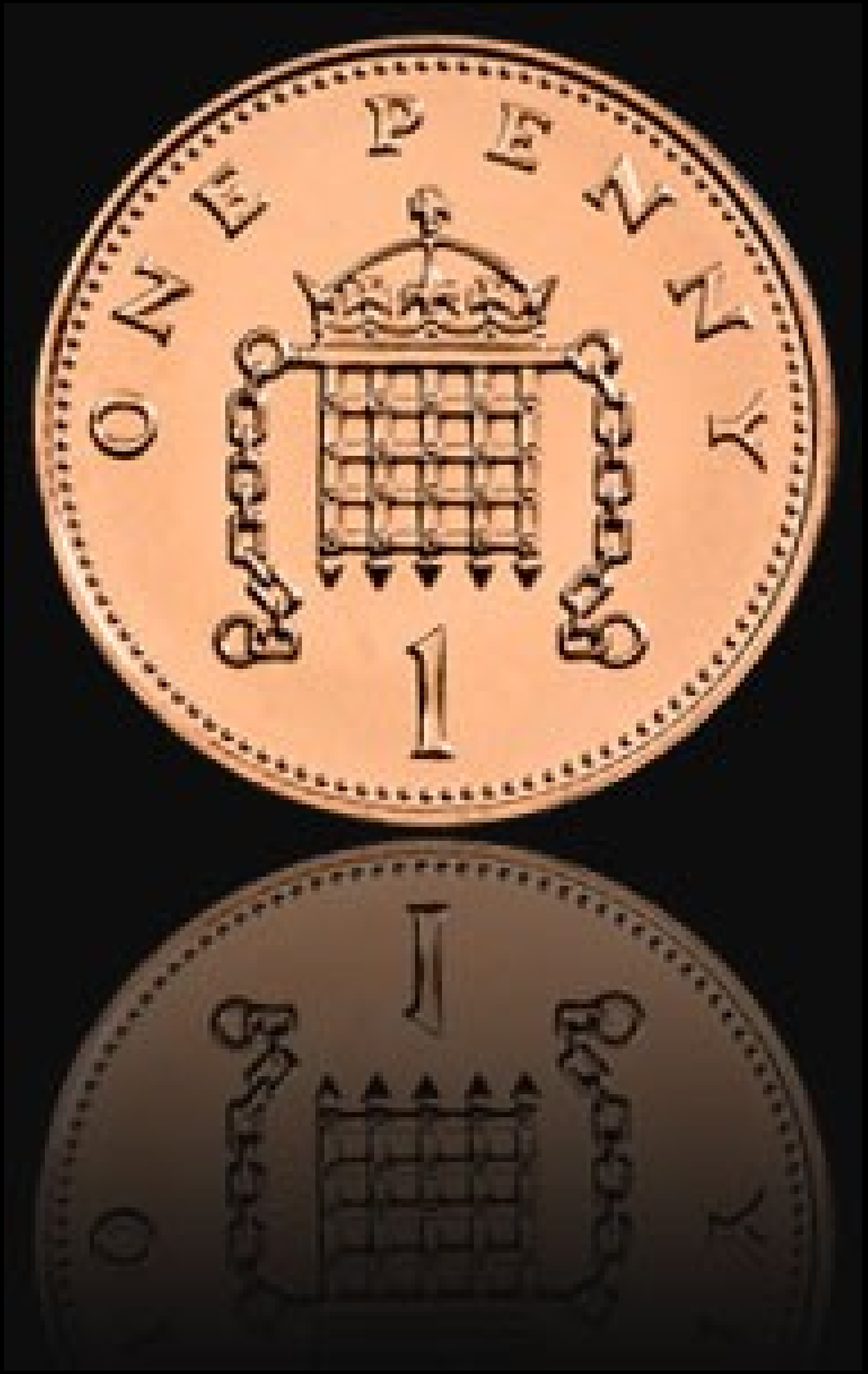
- Rarely interact with matter – which makes them very hard to detect.

Electrically neutral – this makes them even harder to detect.

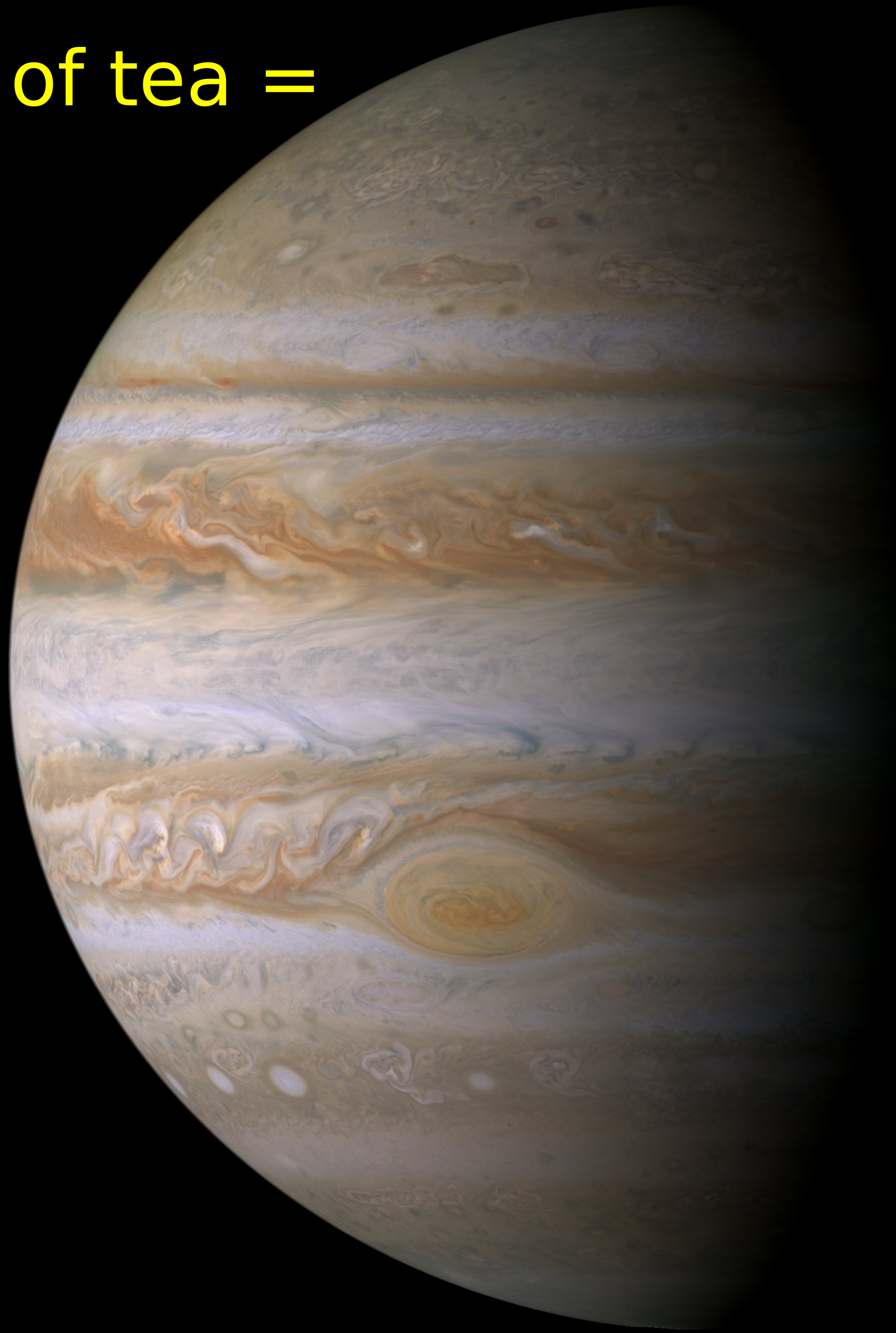
- They are present in the Universe in vast numbers

- They are almost ghosts – they have a tiny, tiny mass.

mass of a neutrino =

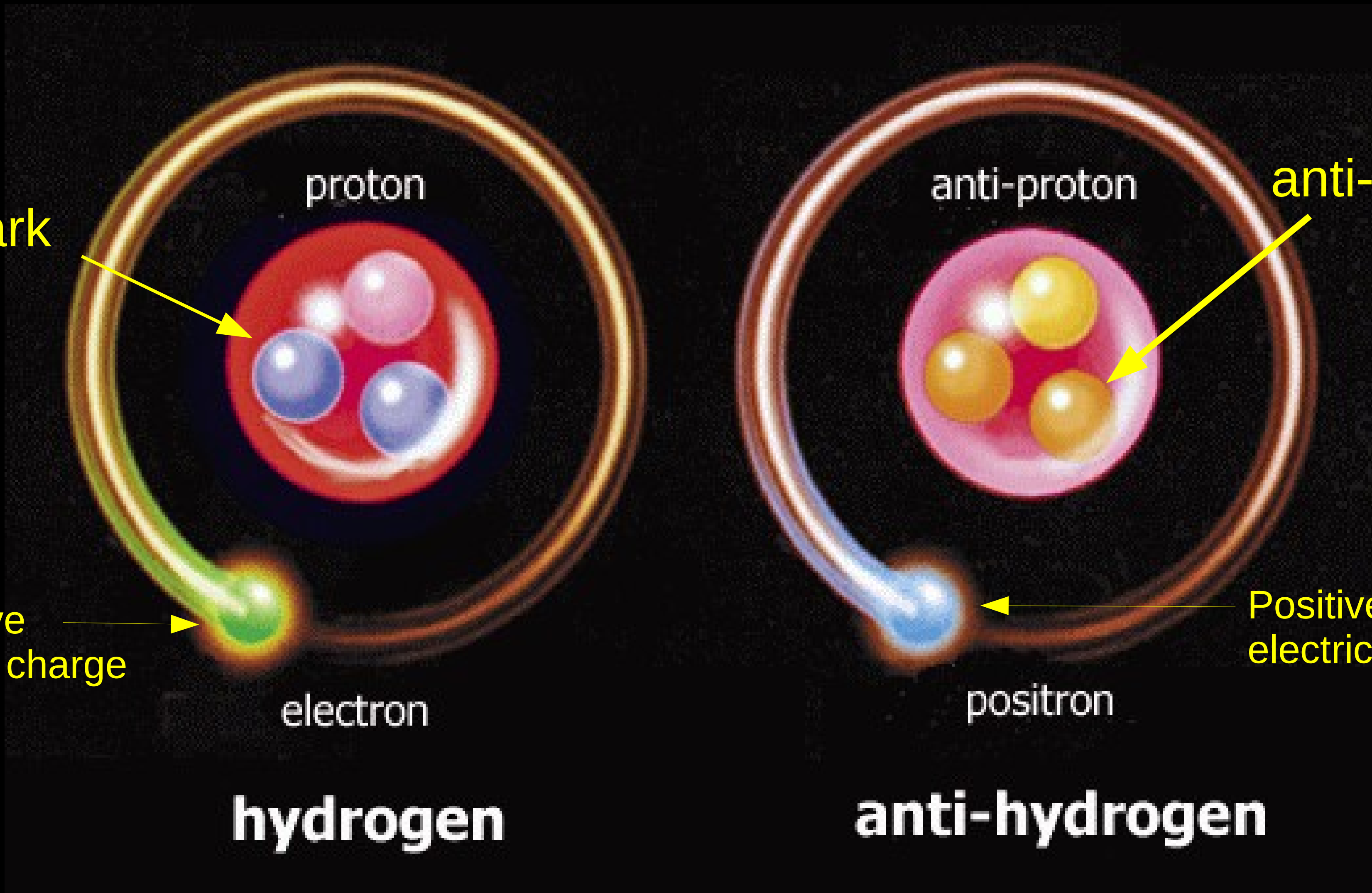


mass of a nice cup of tea =



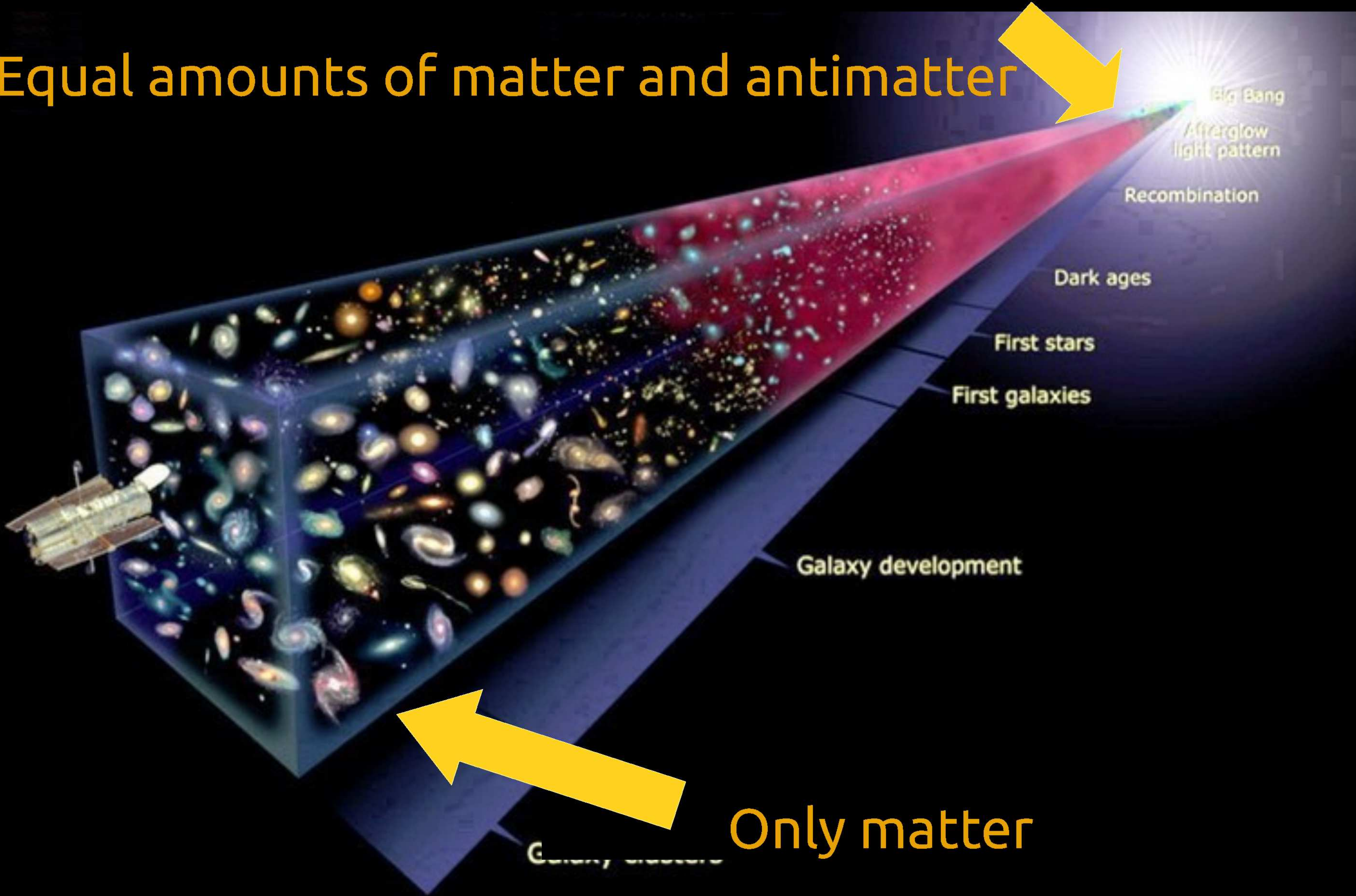
The matter/antimatter puzzle

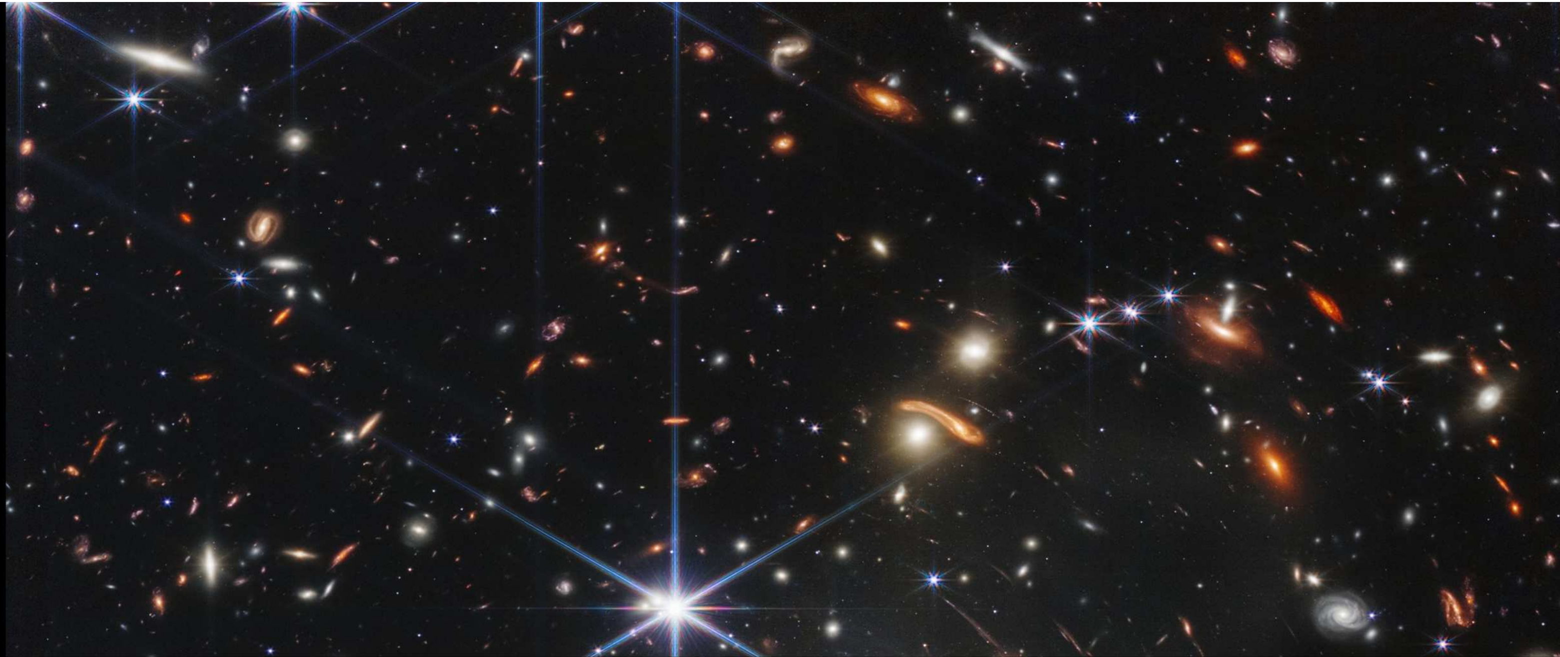
Matter Anti-Matter



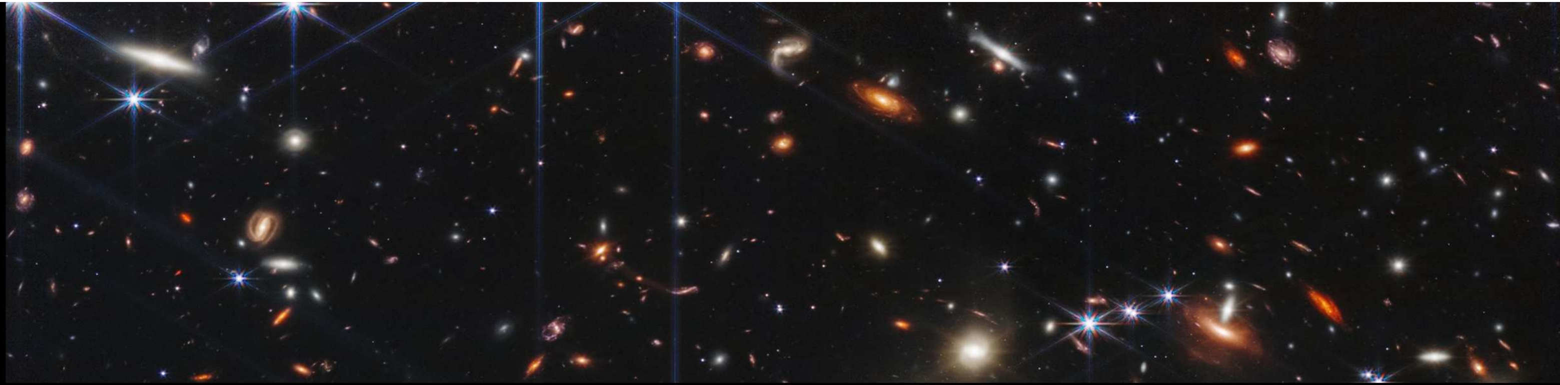
Predicted by Dirac in 1928
Discovered by Anderson in 1932

The Antimatter Problem





Where did all the antimatter go?



Removing all the antimatter requires the laws of physics to behave differently for matter and antimatter.

Do they?

Surprisingly….yes !

We now know that the laws of nature treat matter and antimatter differently

But we don't know why ☹

This is one of the Big Questions™ in particle physics

How might neutrinos help us understand this matter/antimatter imbalance?

An imbalance can occur if the laws of physics act differently on matter and antimatter.

Mario

Anti-Mario

Indiana

Anti-Indiana

[redacted]

Neutrinos are Masters of Disguise – they change their identity as they travel

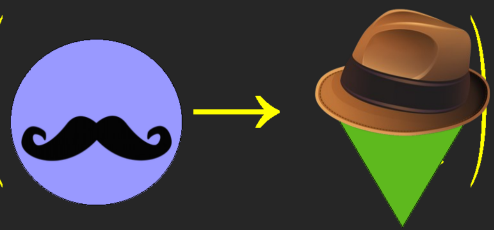
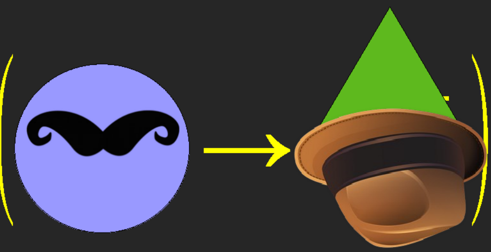
Source

Detector

"Flavour Change"

How can we use this effect?

If matter and antimatter behave differently

$Prob\Big($  $\Big) \neq Prob\Big($  $\Big)$?

An idea floating around suggests that,
if this happens, then we may be able to
explain the matter-antimatter imbalance and
hence, why are able to exist

Hyper-Kamiokande Experiment

Hyper-Kamiokande Experiment

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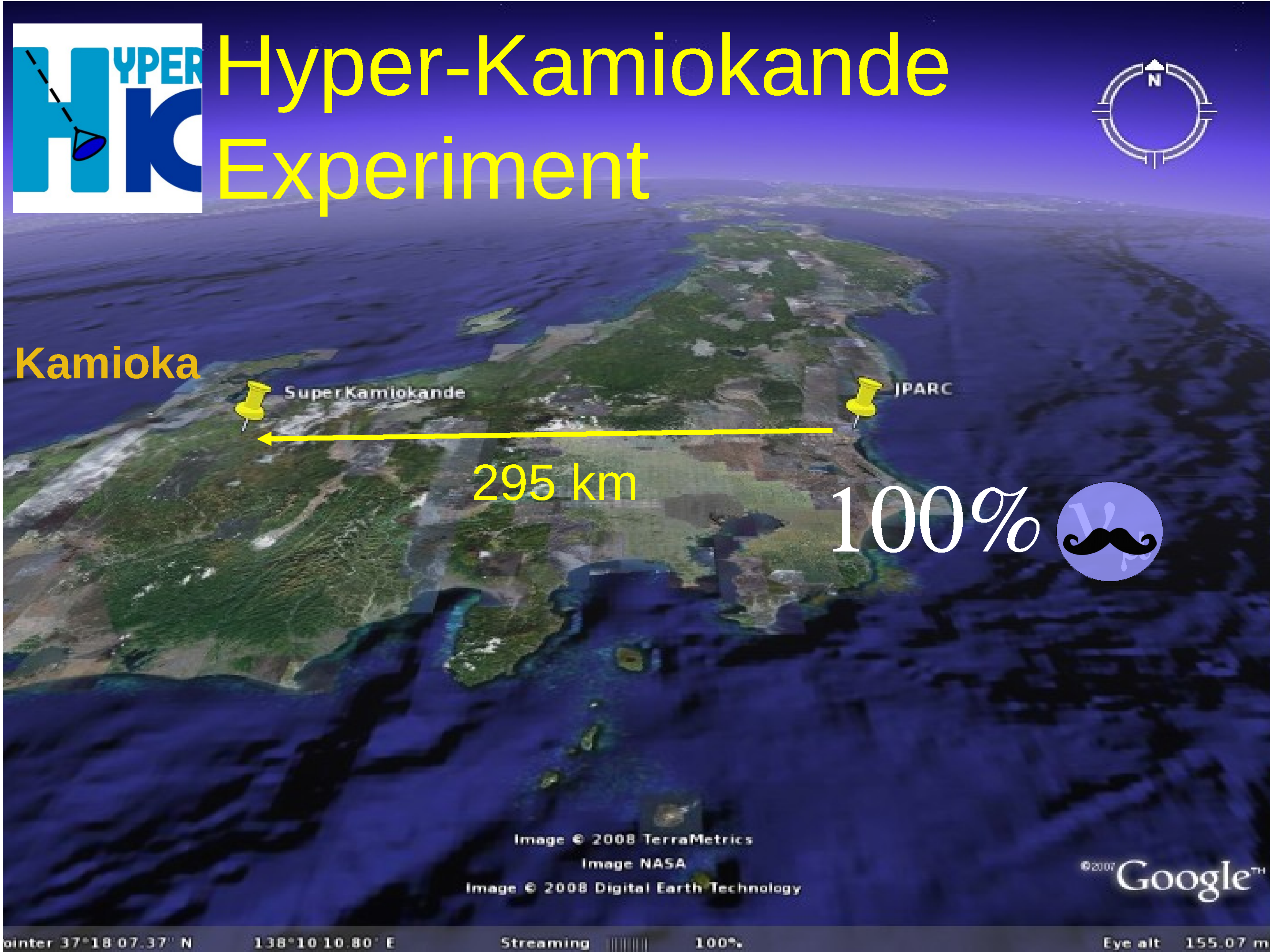

Hyper-Kamiokande Experiment

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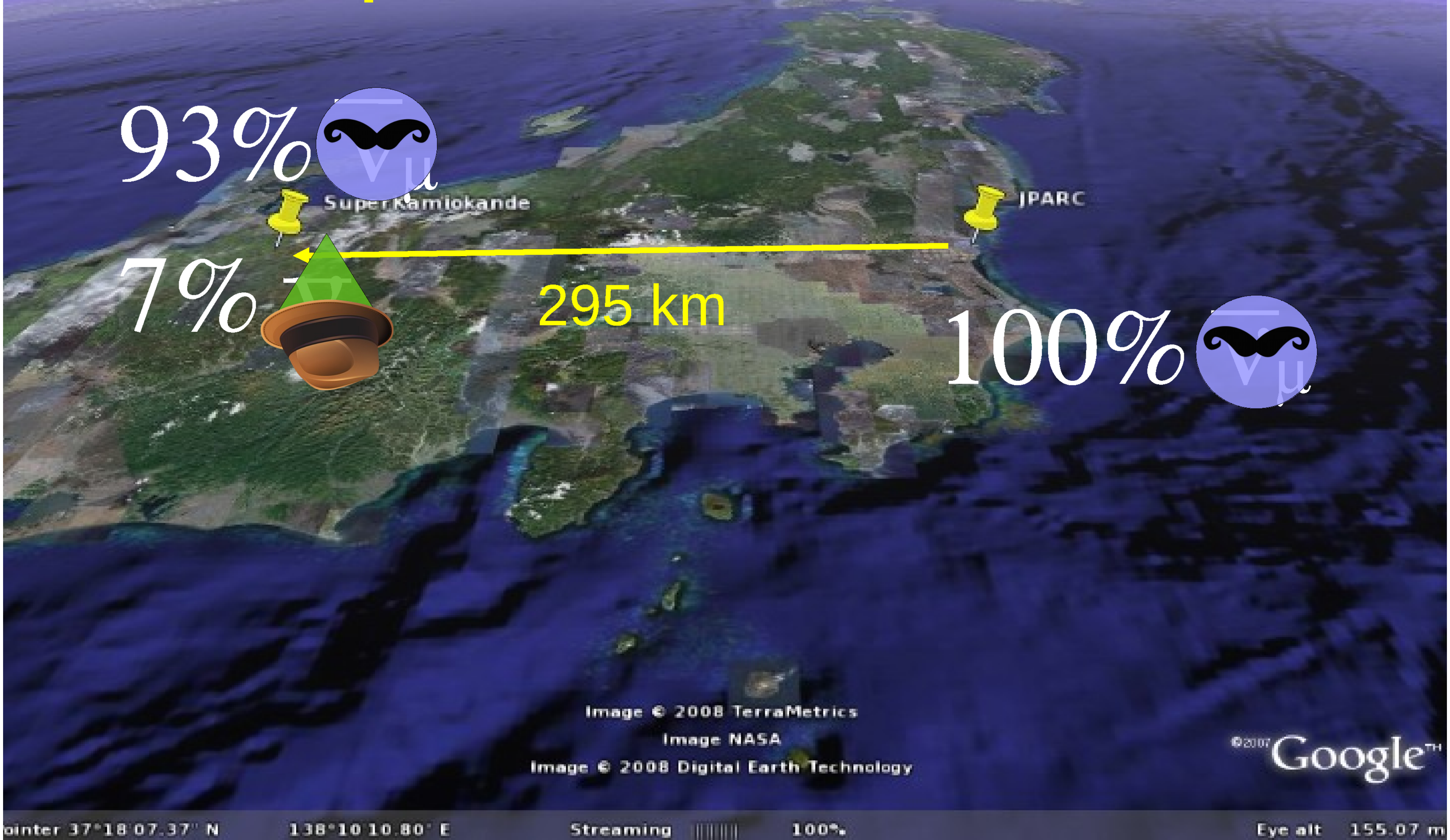
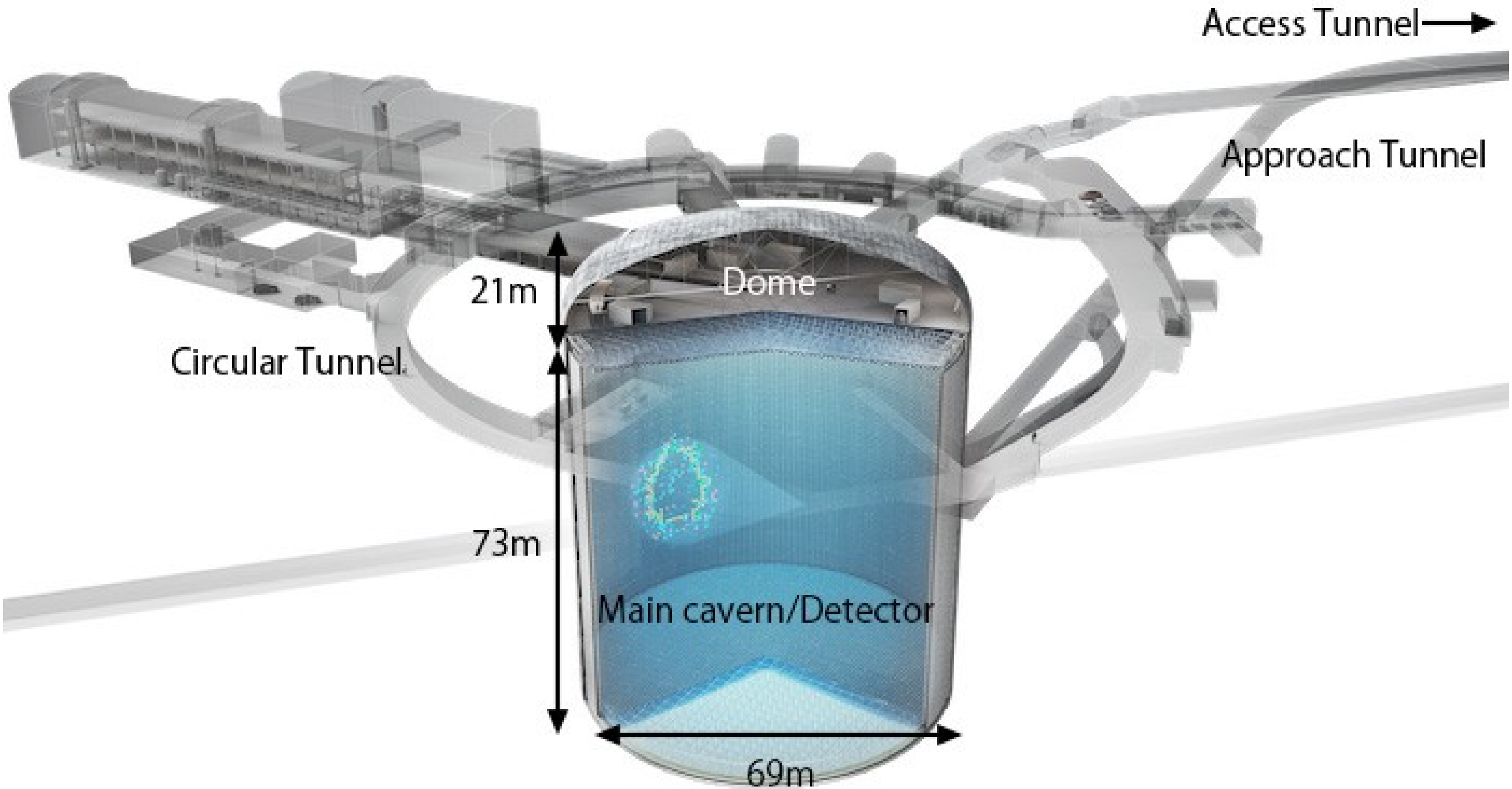



Hyper-Kamiokande
Experiment
N
Super-Kamiokande
"Far" detector
Neutrino beam
JPARC
Tokai
Image © 2008 TerraMetrics
Image NASA
Image © 2008 Digital Earth Technology
©2007 Google™
ointer 37°18'07.37" N
138°10'10.80" E
Streaming
100%
Eye alt 155.07 m

Meanwhile, at the core of Mt Nijugo....



We are building a detector containing 200 kton of pure water


Dome
Main cavern/Detector
69m


June ‘26

Why are we here?

- The laws of physics behave differently when applied to matter than when applied to antimatter.
- This is the reason why there is stuff around at all.
- The lightest and most numerous (but hardest to study) particle in the universe, the ***neutrino***, may just hold the key to understanding *why* the laws are different!
- Hyper-K will help us find out...

Other work in EPP

We work on many projects in the EPP group

- Another neutrino experiment (DUNE in the USA)
- Studying the Higgs Boson with the ATLAS experiment @ CERN
- Studying matter-antimatter asymmetry with quarks using the LHCb experiment @ CERN
- Studying neutrino mass using the LEGEND experiment
- Quantum technologies and sensor development
- Development of next generation accelerators (muon colliders, high flux neutrino beams)
- Development of software tools (GEANT, for example)