

Ciaran O'Hare

 **@cajohare**



The cosmic pint

Q: What's in a pint of the Universe...

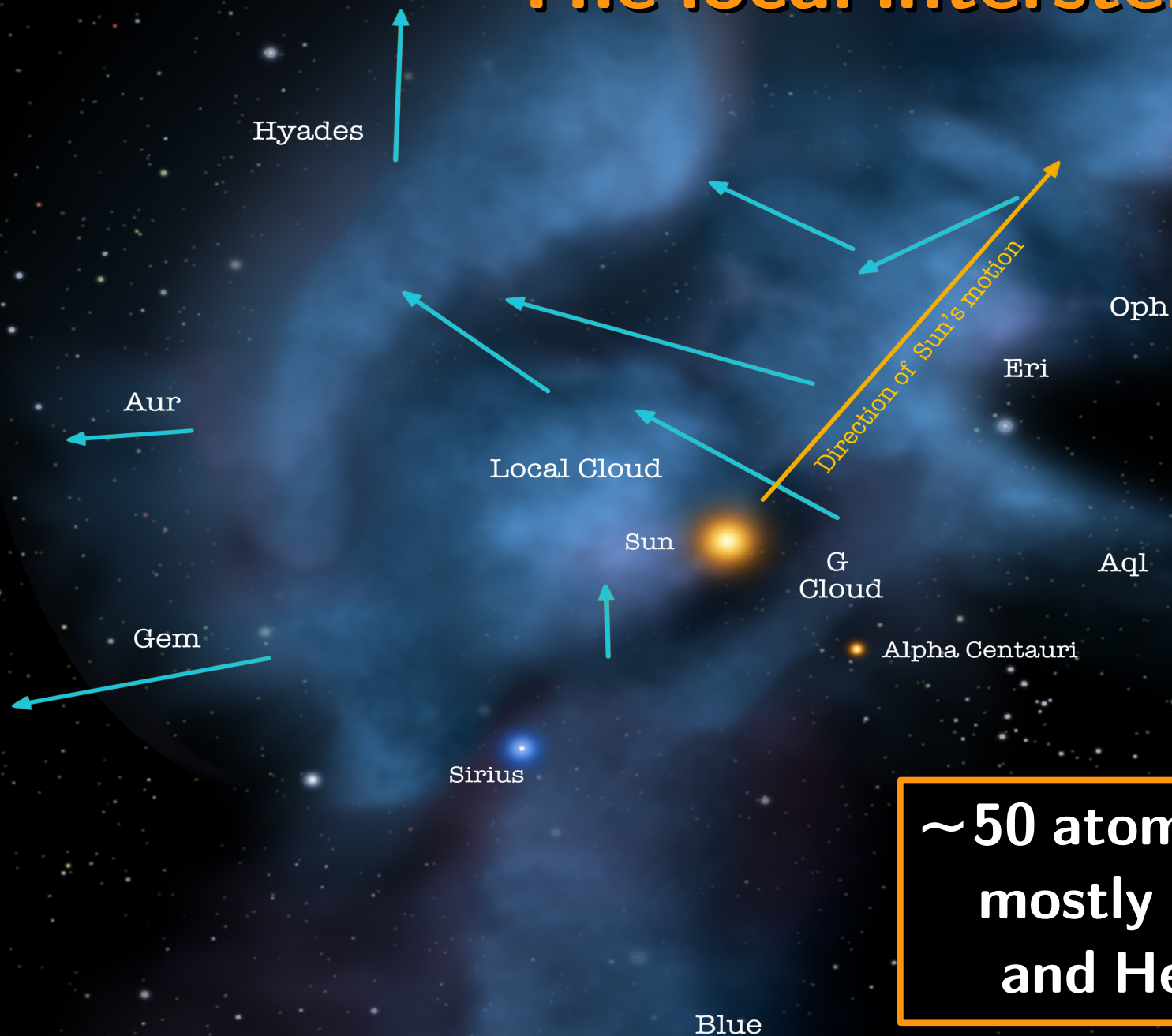


Ground rules:

- Get rid of the beer somehow
- ...and the rest of the Earth
- Assume we're out in space, not inside a star or a black hole

$$1 \text{ pint (approx.)} = 0.00057 \text{ m}^3 = 570 \text{ cm}^3$$

The local interstellar cloud



**~50 atoms per pint,
mostly Hydrogen
and Helium gas**

Cosmic rays

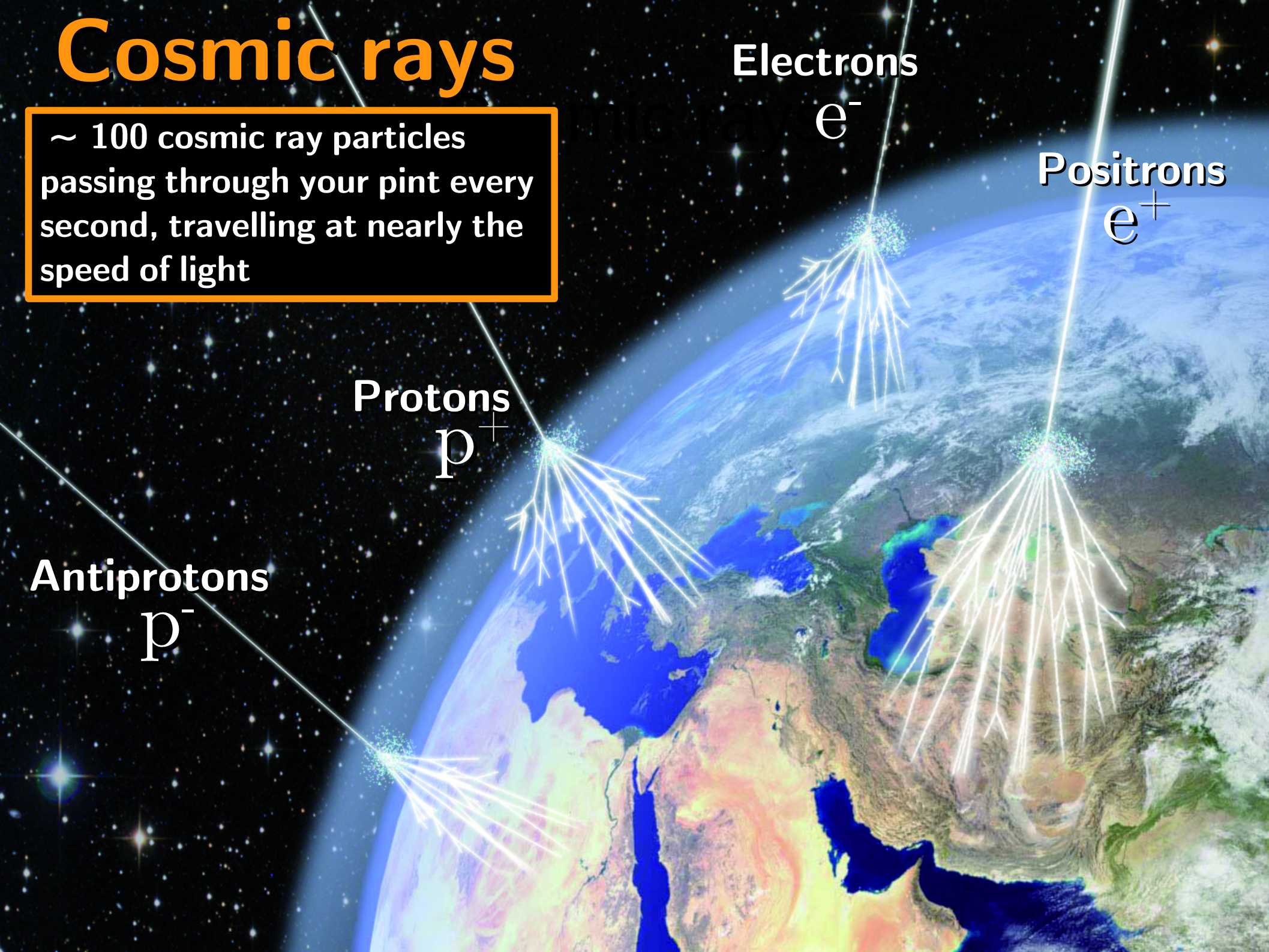
~ 100 cosmic ray particles
passing through your pint every
second, travelling at nearly the
speed of light

Electrons
 e^-

Positrons
 e^+

Protons
 p^+

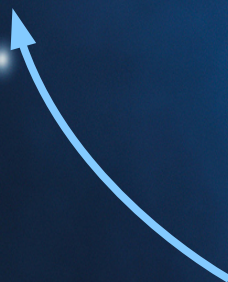
Antiprotons
 p^-



**Milky Way
disk**



Dark matter halo



The cosmic web

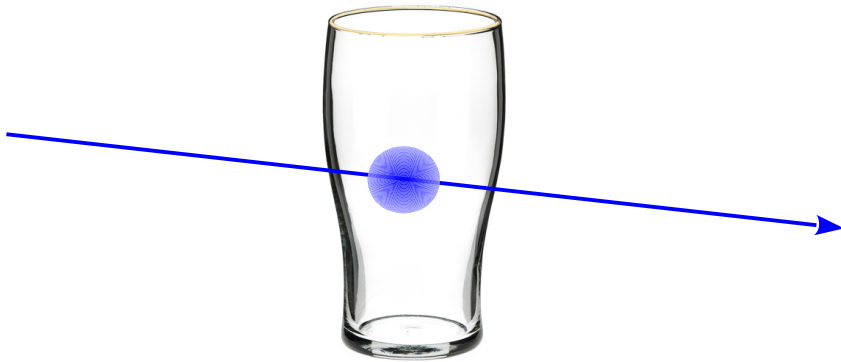
Distribution of dark matter in the Universe

What is dark matter?

We currently have two big ideas:

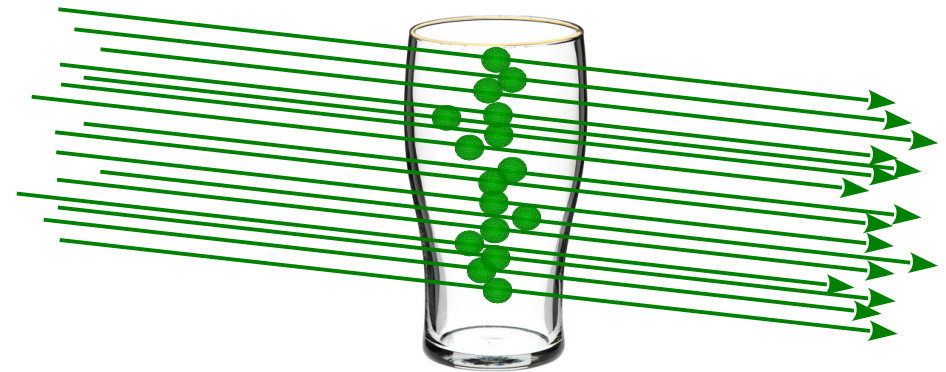
WIMPs

Weakly Interacting
Massive Particles



Very heavy
~ 1 WIMP per pint

Axions

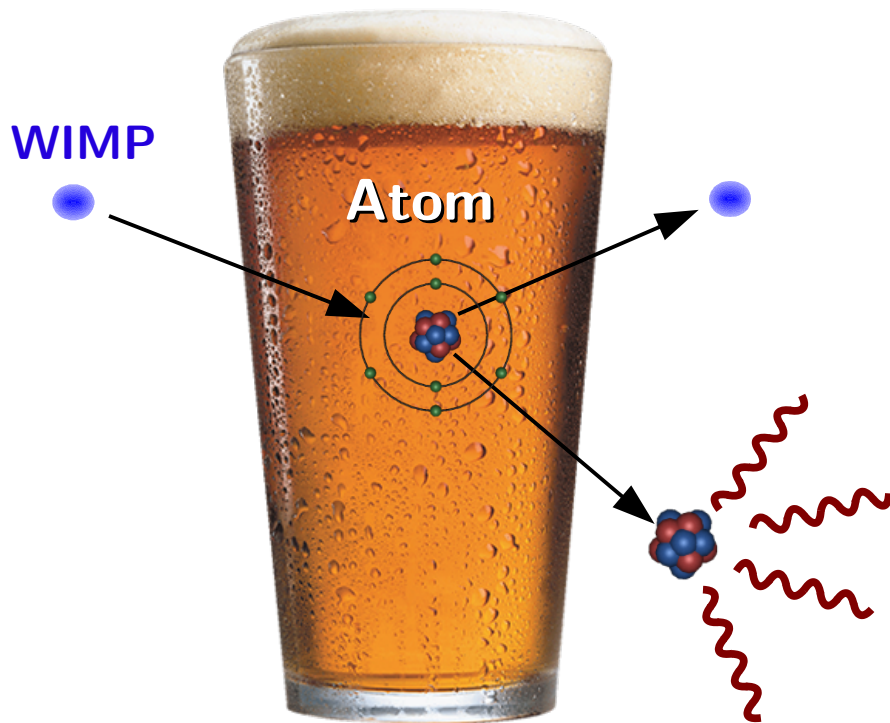


Extremely light
~ 10^{17} per pint

How to detect dark matter with your pint..

WIMPs

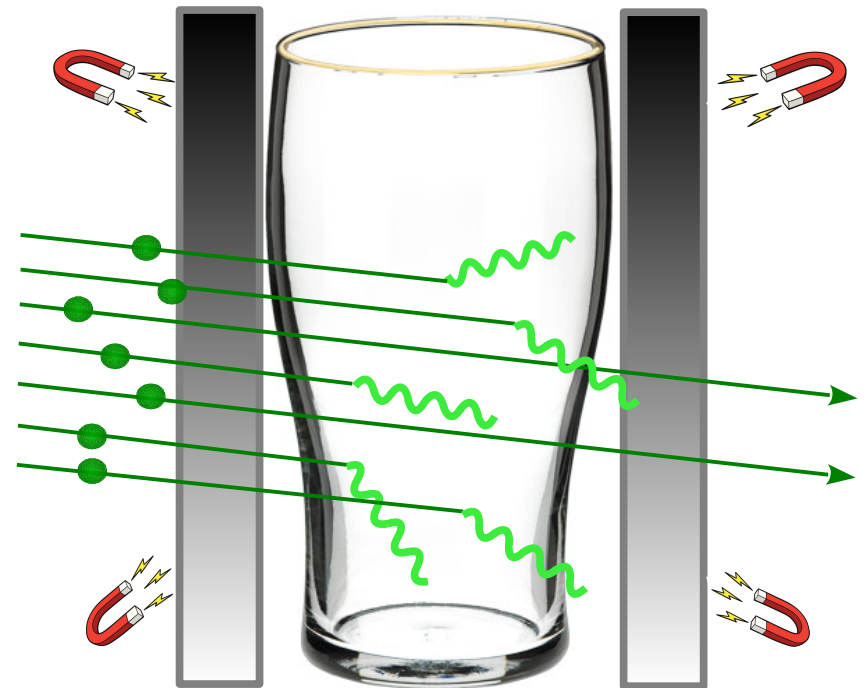
Fill your pint with some atoms e.g. beer



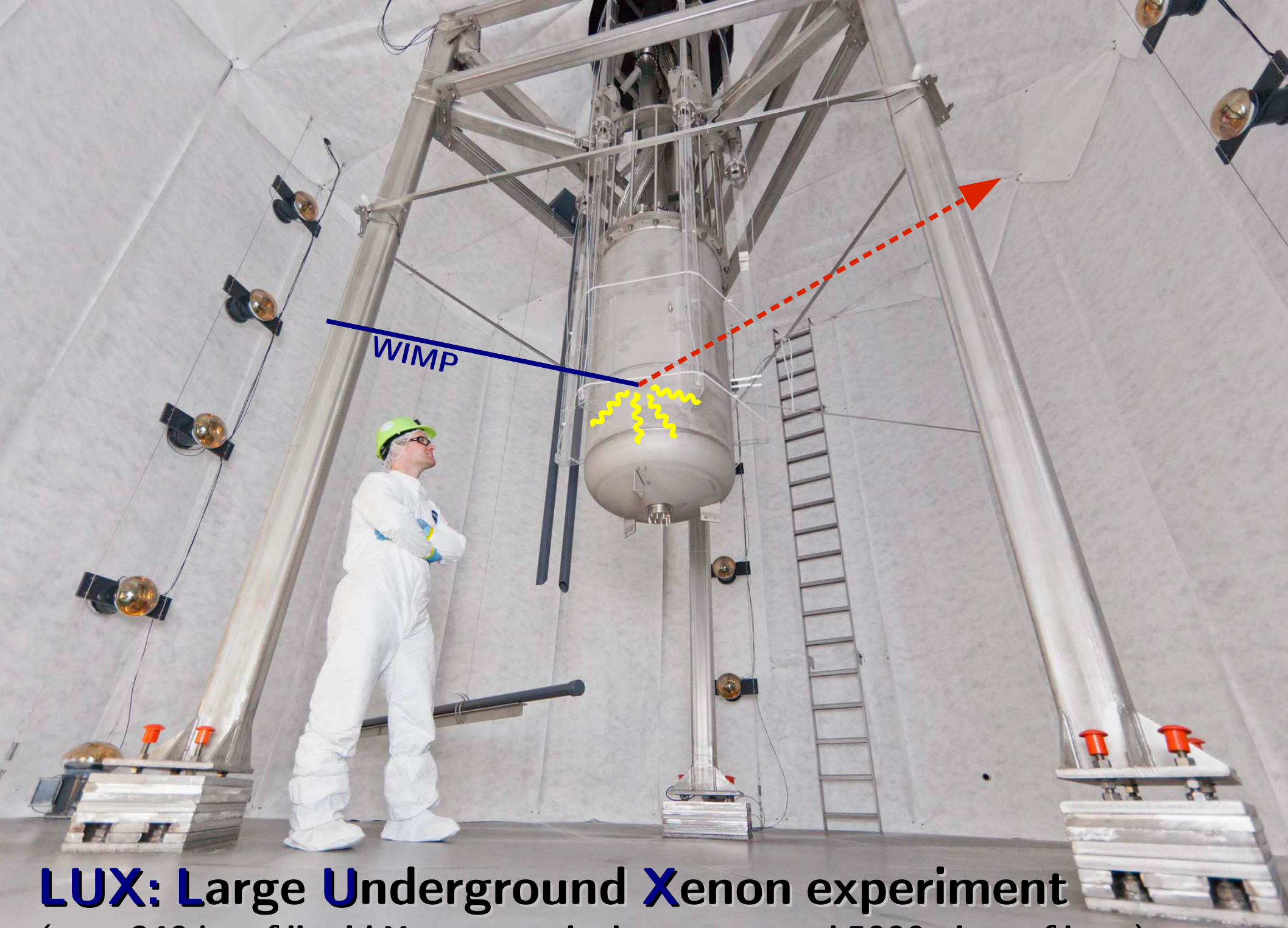
→ recoiling nuclei
~ once every 1000 years

Axions

Fill your pint with a magnetic field

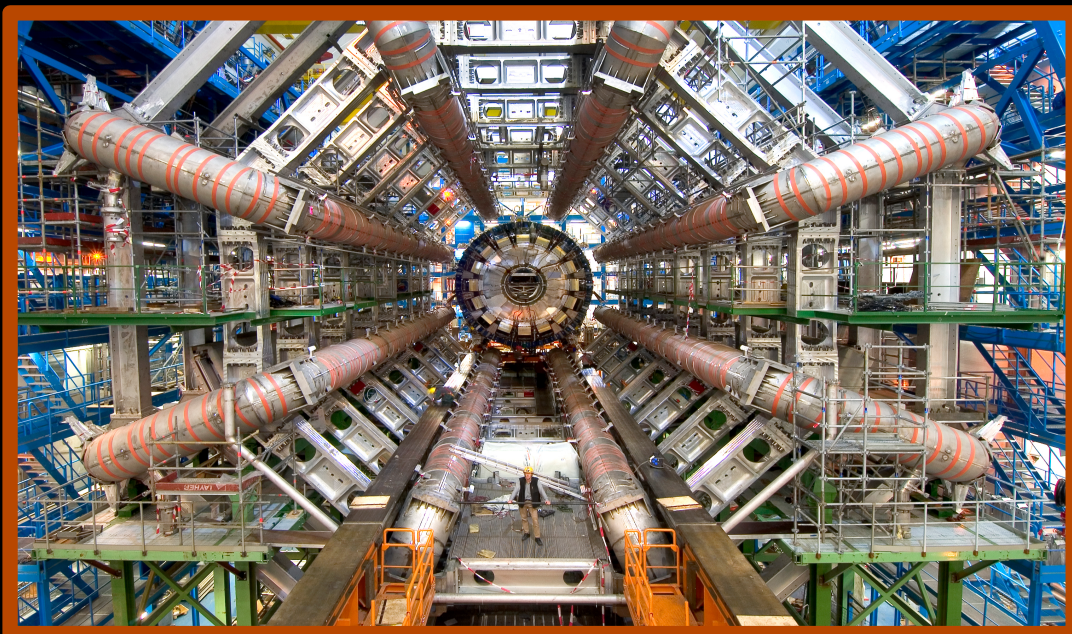


→ electromagnetic field
~ 30 W bulb located on Mars



WIMP

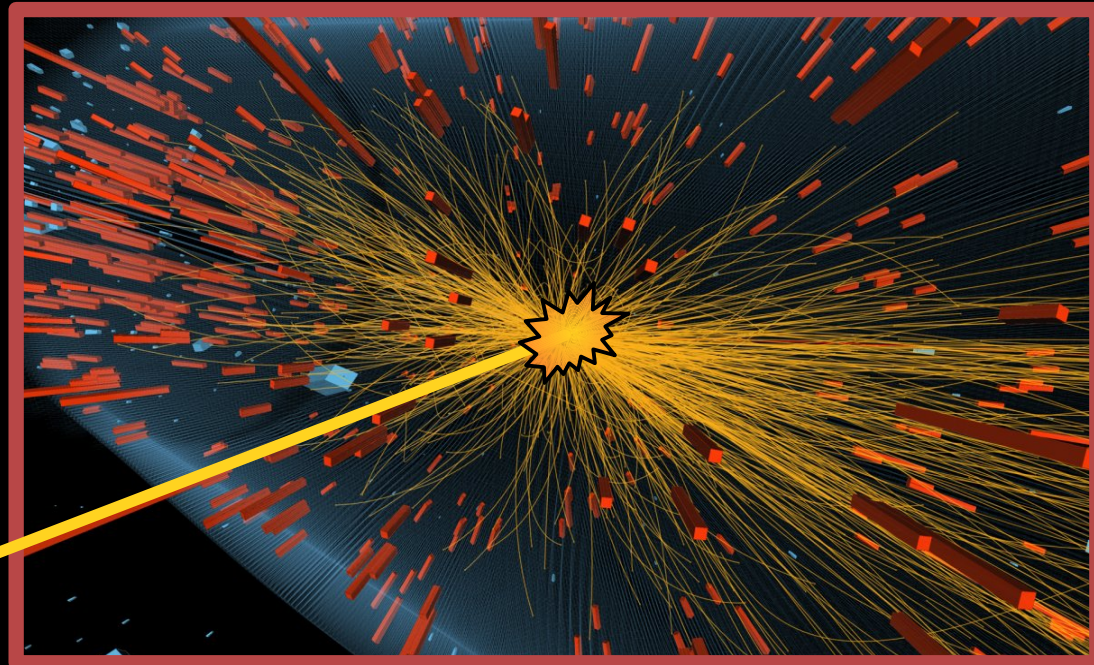
LUX: Large Underground Xenon experiment
(uses 340 kg of liquid Xenon, equivalent to around 5000 pints of beer)



We are trying to *make*
dark matter at the
Large Hadron Collider
(LHC)

It escapes undetected,
so we must look for
missing energy

Dark matter



**But what if we get rid of
all the galaxies and all the
dark matter?**

Relics from the Big Bang



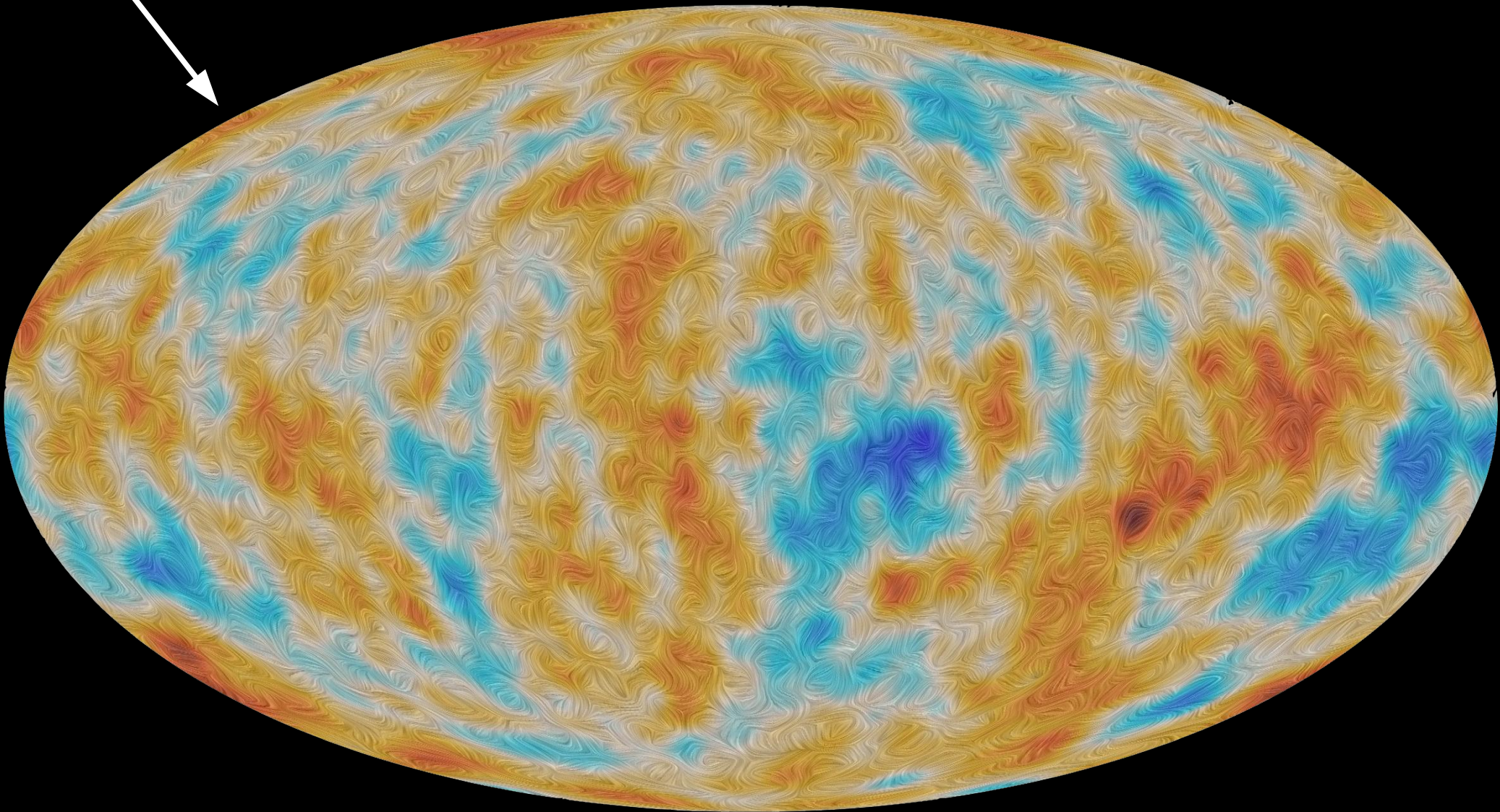
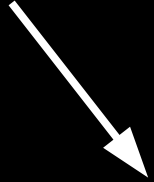
How much in a pint?

~ Microwave photons ~ 210,000

• Neutrinos ~ 190,000

Relics from the Big Bang

Hot and cold spots in the “Cosmic Microwave Background”



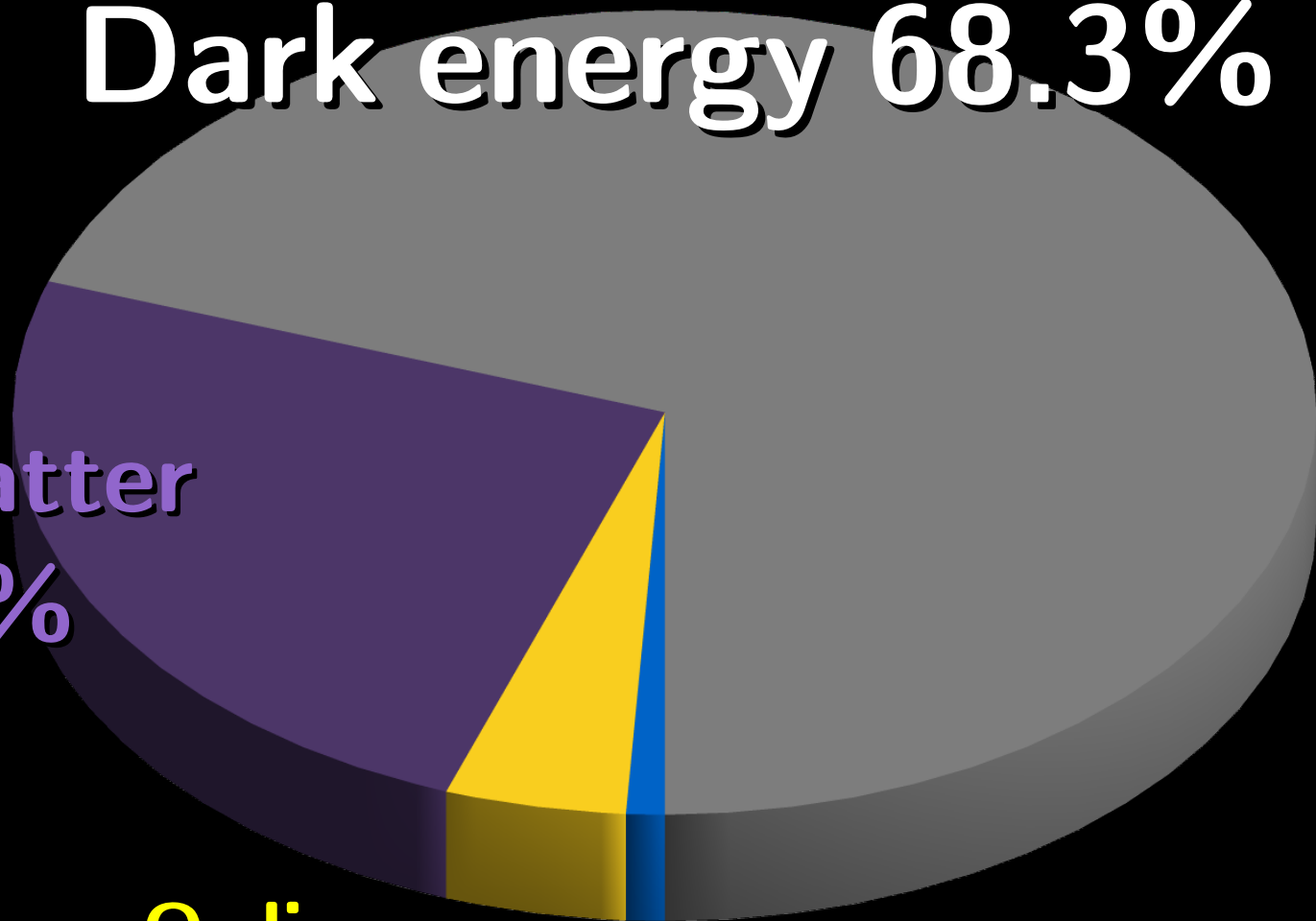
Polarisation map measured by the Planck satellite

Dark energy 68.3%

**Dark matter
26.8%**

**Ordinary
matter 4.9%**

Relics <0.001%

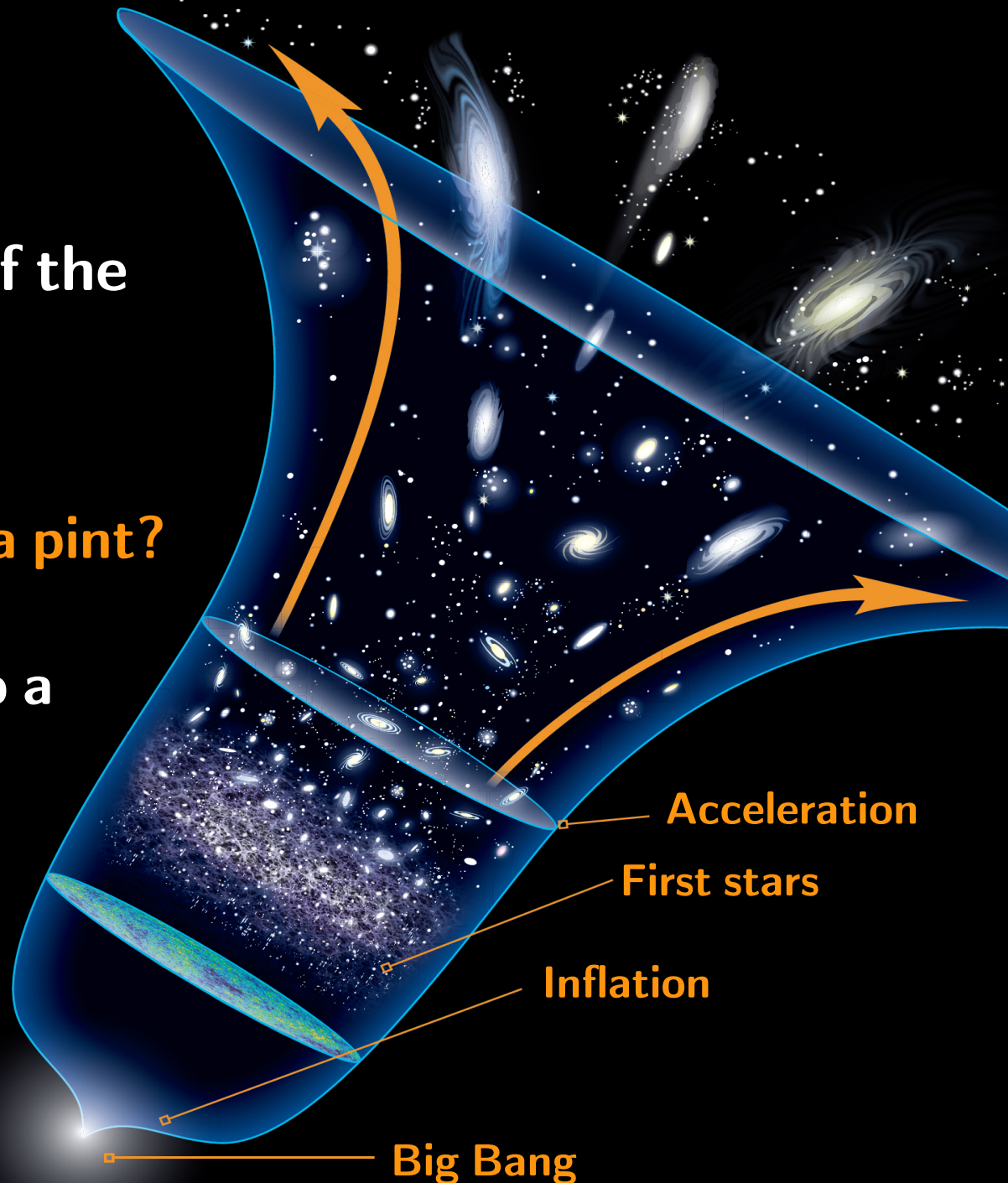


Dark energy

→ Causes the expansion of the Universe to accelerate

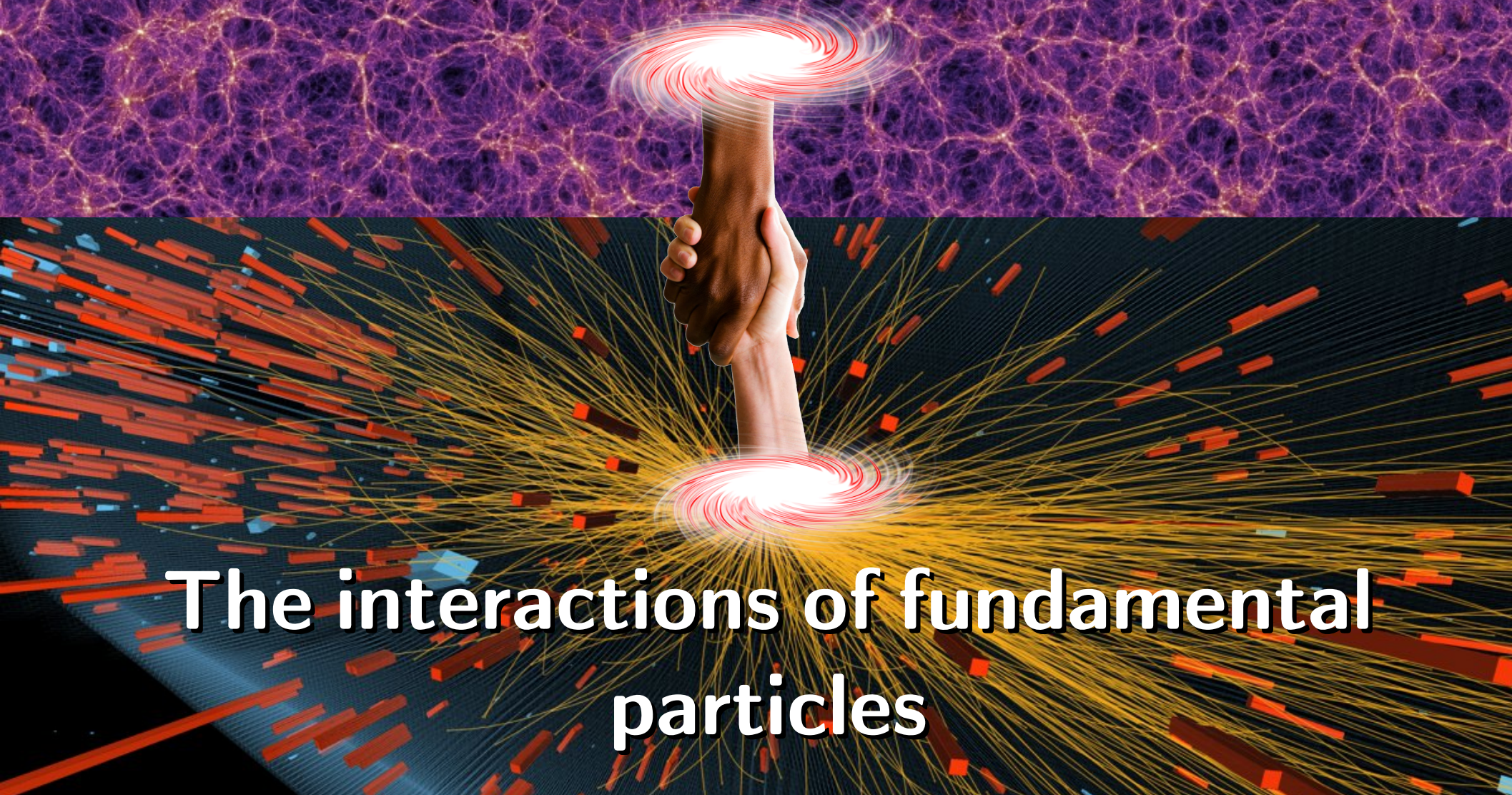
How much dark energy in a pint?

About the energy of your eardrums while listening to a whisper for 1 second



Particle Cosmology

The Universe on the largest scales



The interactions of fundamental particles

The Cosmic Pint

Always show your working...

→ Go to my twitter for a link to the full details of my calculations, as well as these slides

 @cajohare

Ciaran O'Hare



The University of
Nottingham