Born at the Big Bang
Neutrinos- The Ultimate Immortals

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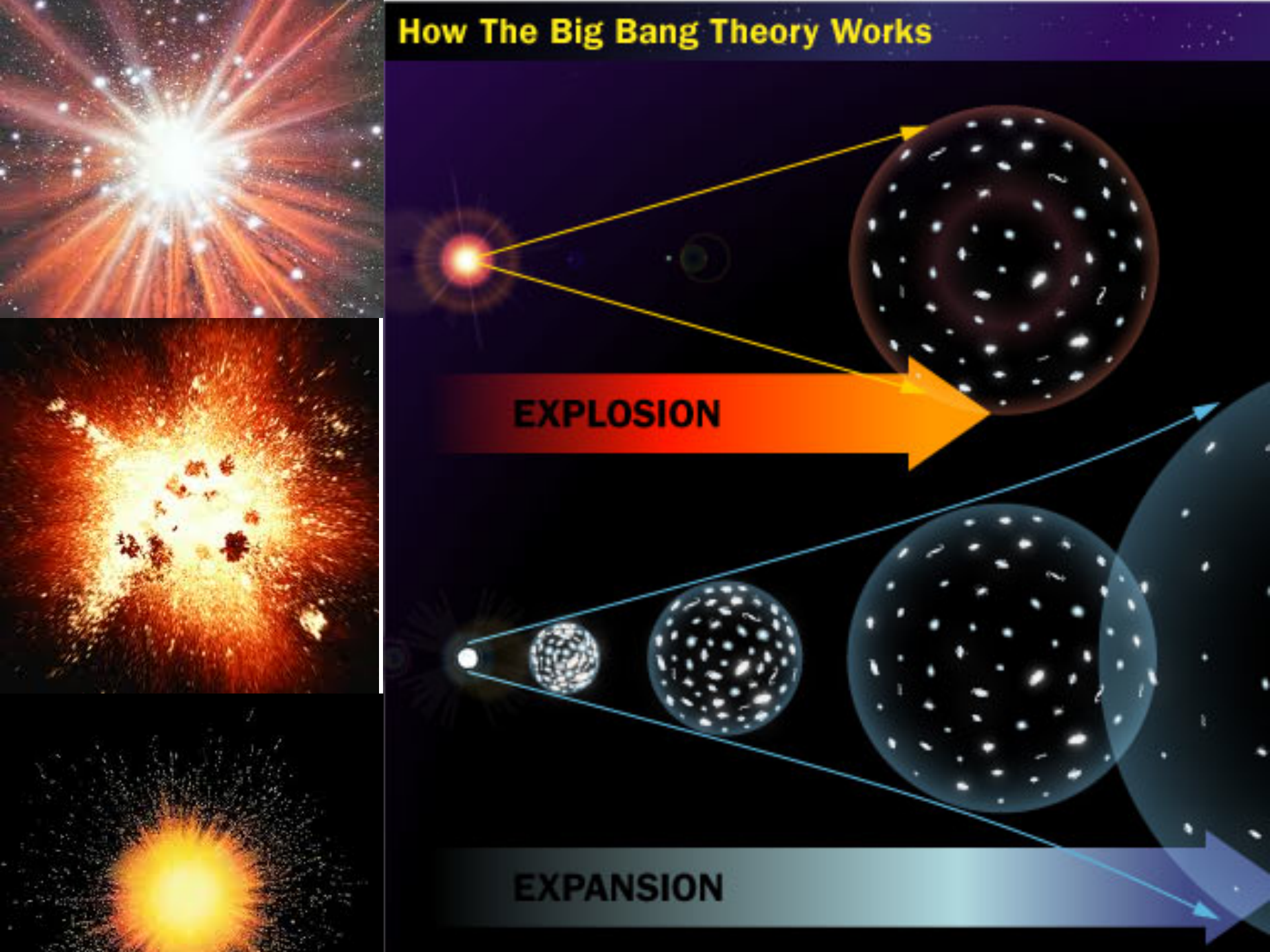
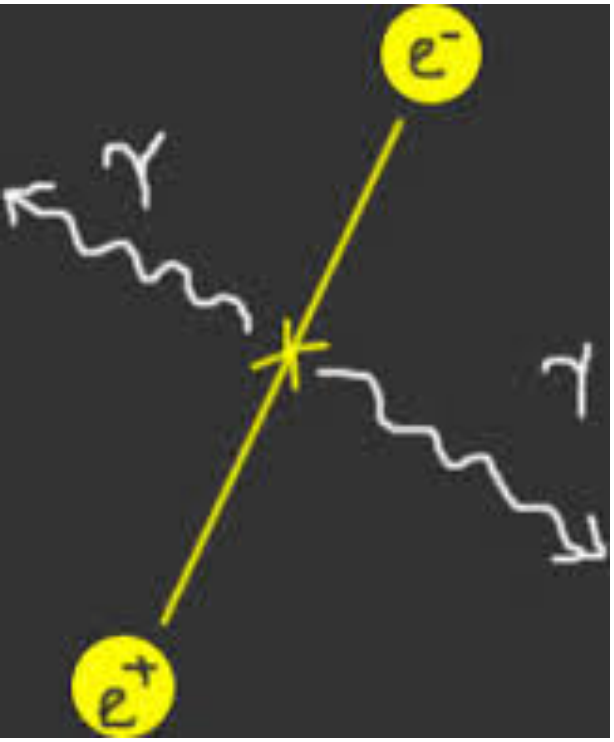
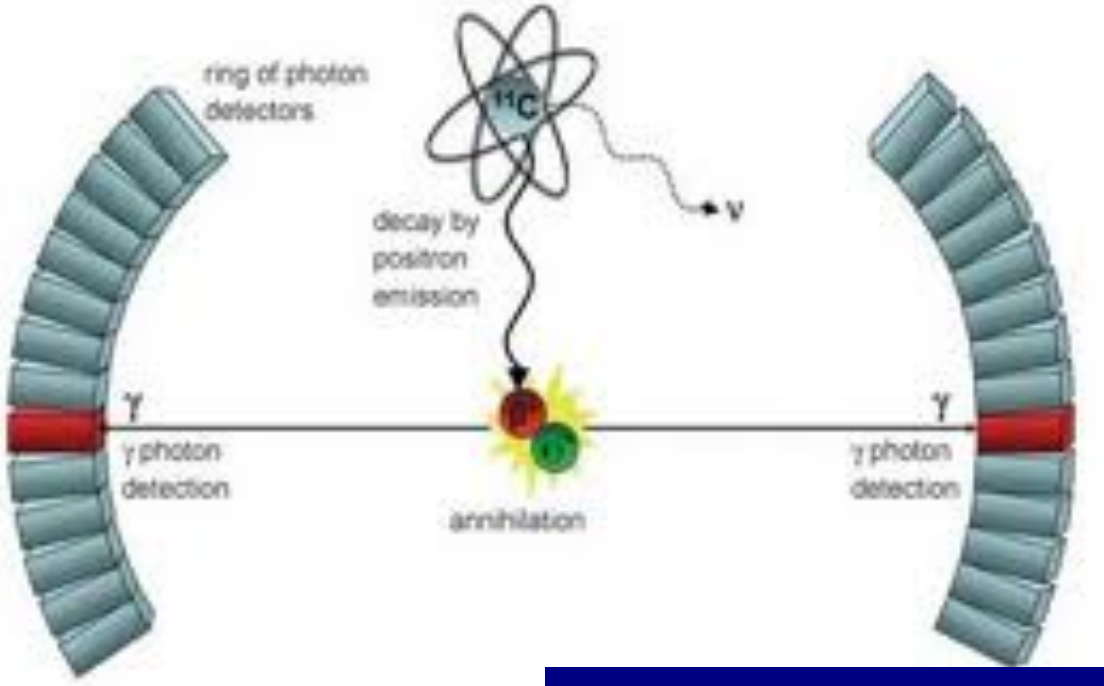
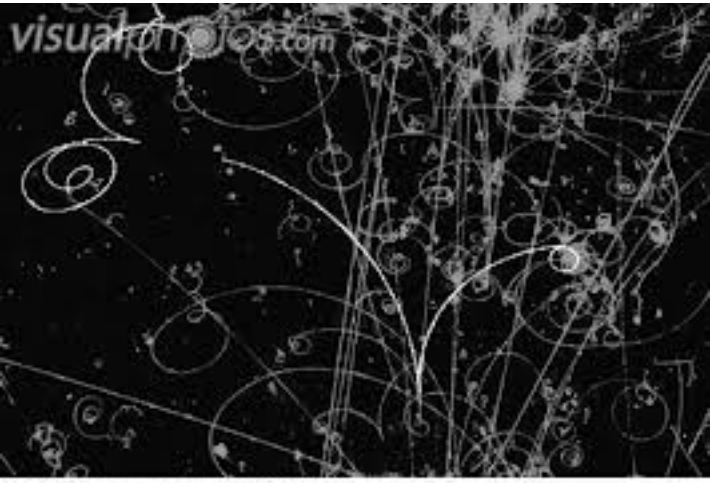
YORK
UNIVERSITÉ
UNIVERSITY

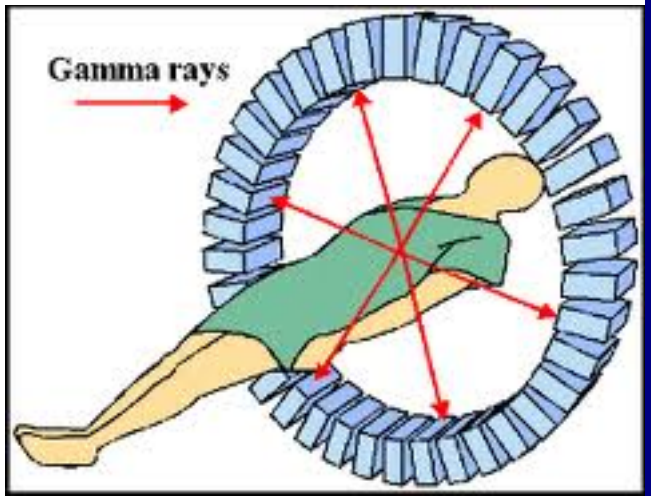

How The Big Bang Theory Works
EXPLOSION
EXPANSION

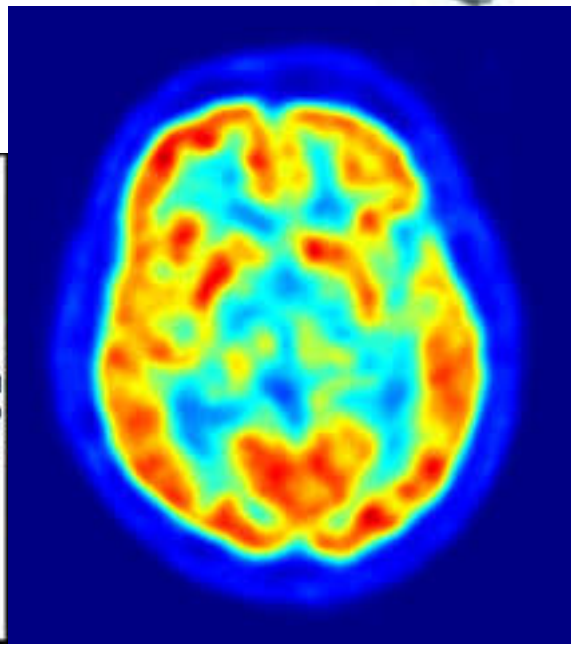
Particle-Antiparticle Creation and Annihilation - $E=mc^2$ Gone Crazy

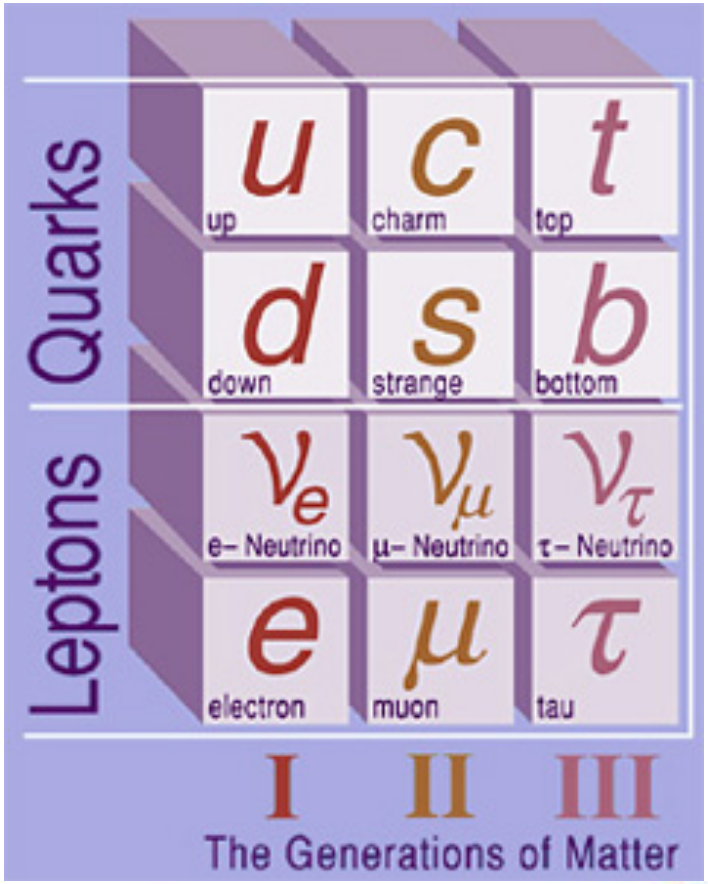


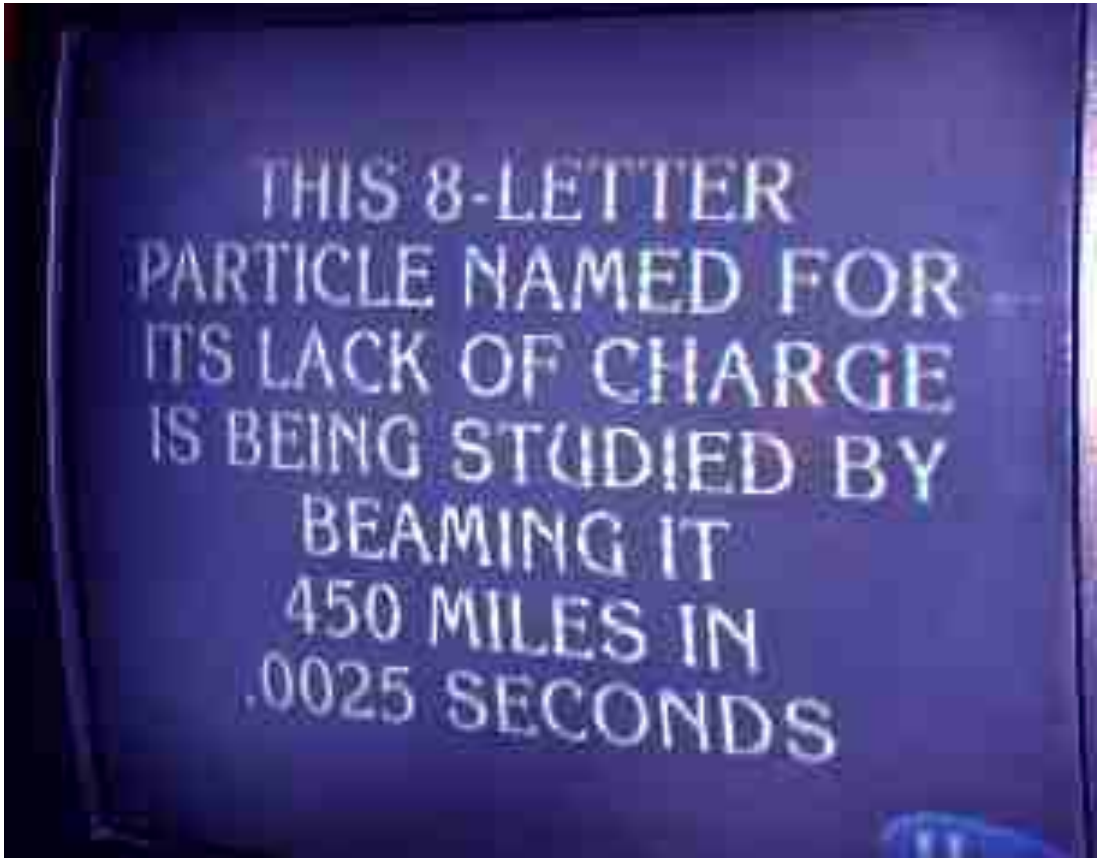


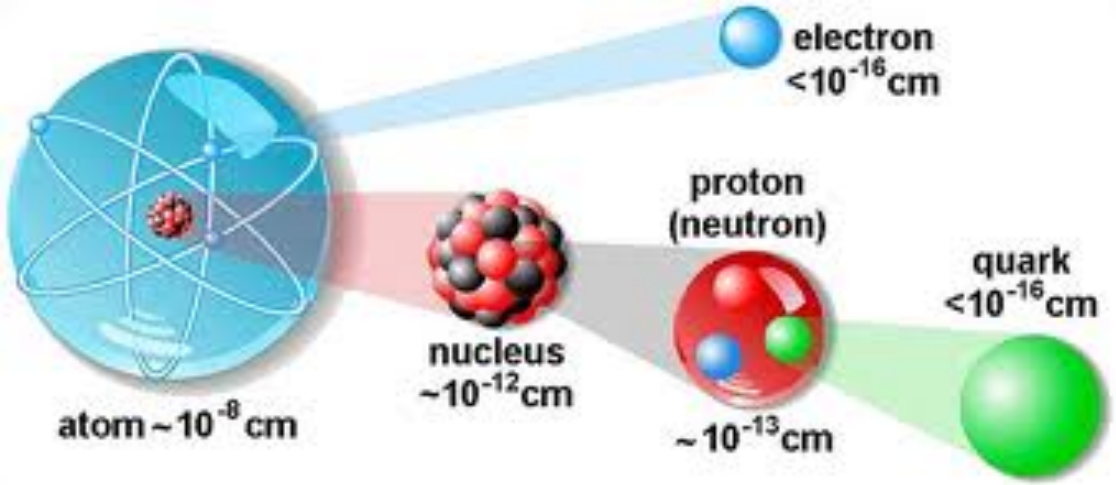


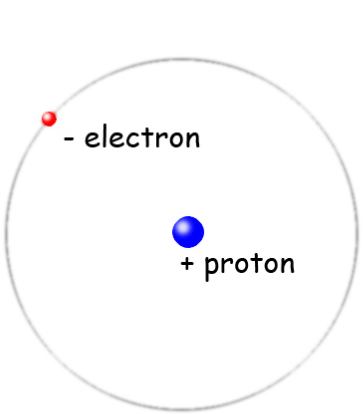


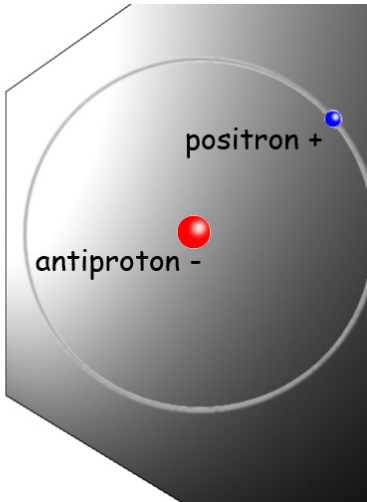



Quarks
Leptons
u
up
c
charm
t
top
d
down
s
strange
b
bottom
ν_e
e– Neutrino
ν_μ
μ– Neutrino
ν_τ
τ– Neutrino
e
electron
μ
muon
τ
tau
I
II
III
The Generations of Matter

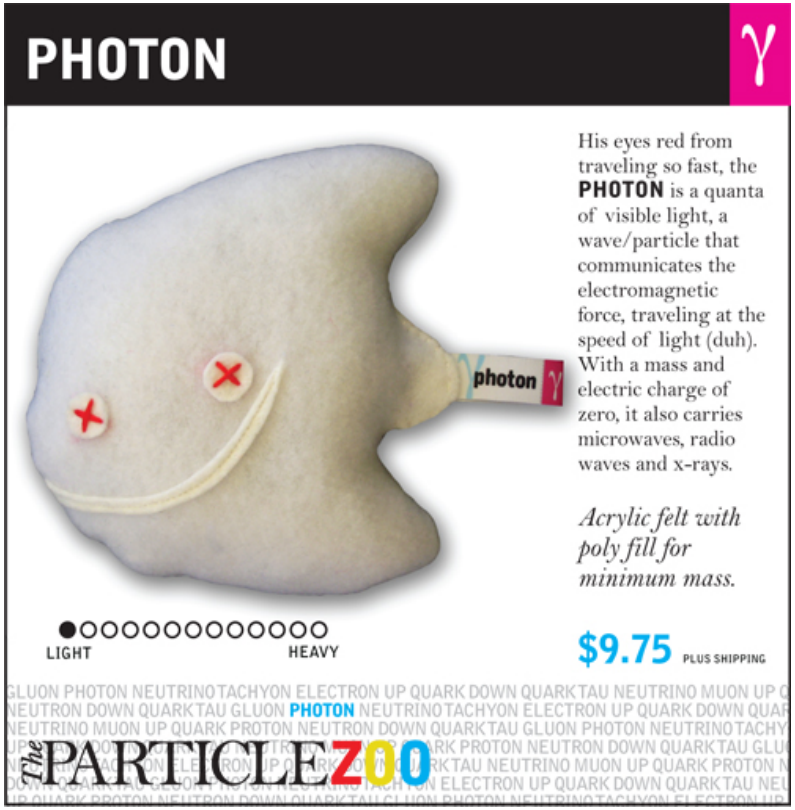

THIS 8-LETTER
PARTICLE NAMED FOR
ITS LACK OF CHARGE
IS BEING STUDIED BY
BEAMING IT
450 MILES IN
.0025 SECONDS

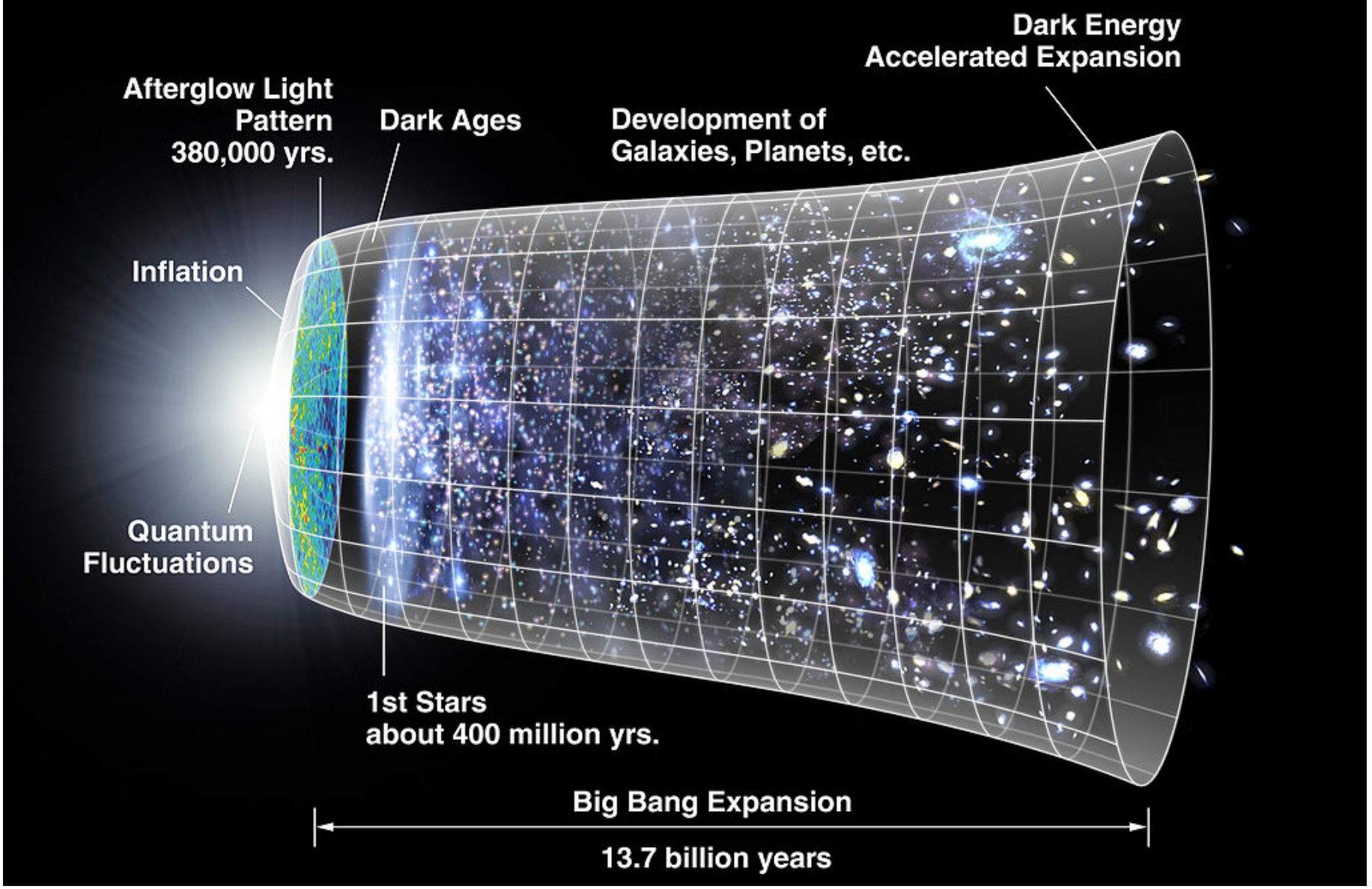

electron
<10^-16 cm
proton
(neutron)
quark
<10^-16 cm
nucleus
~10^-12 cm
atom ~10^-8 cm
~10^-13 cm


- electron
+ proton


positron +
antiproton -

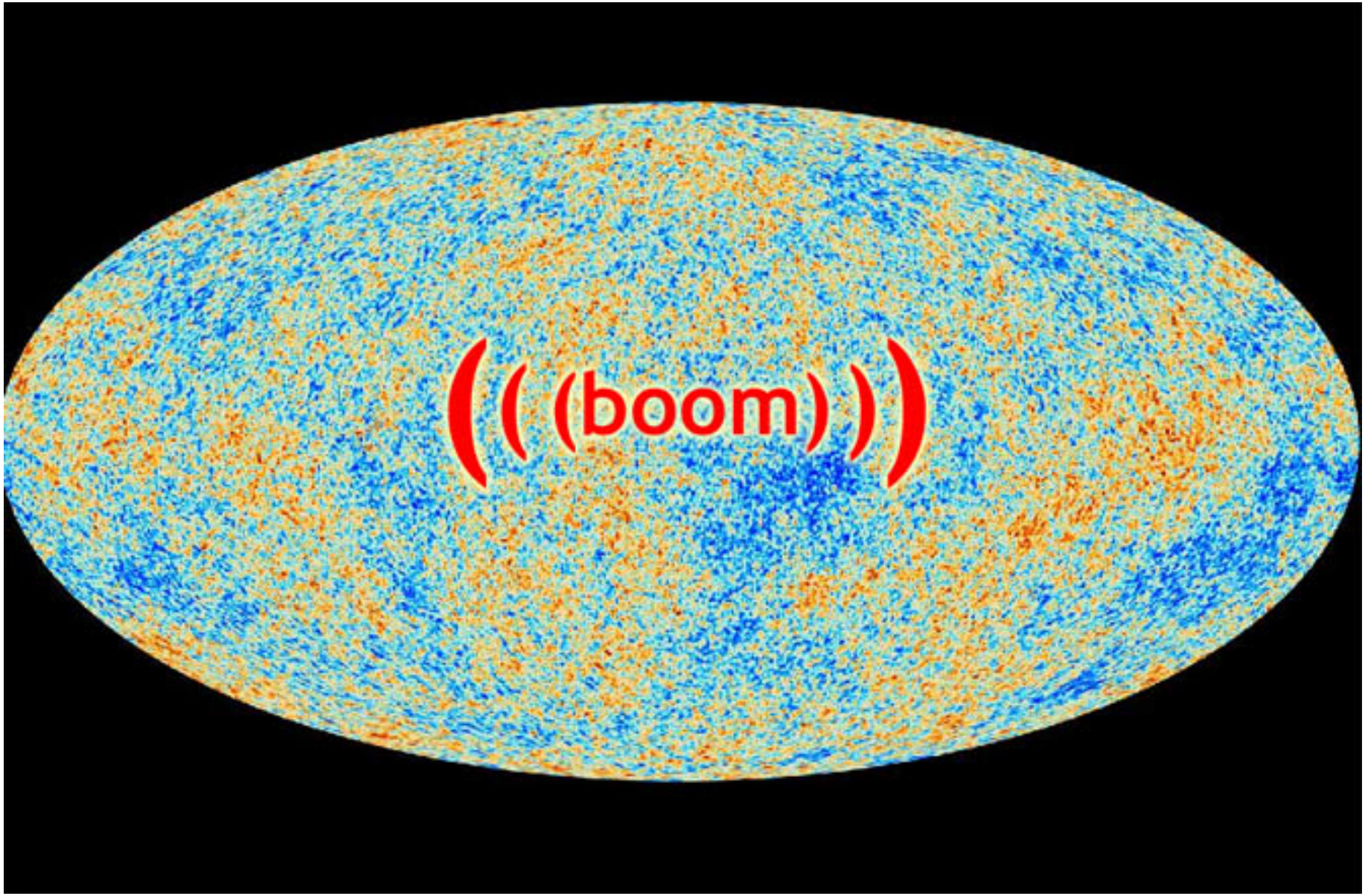
Quark and Lepton Plush Toys





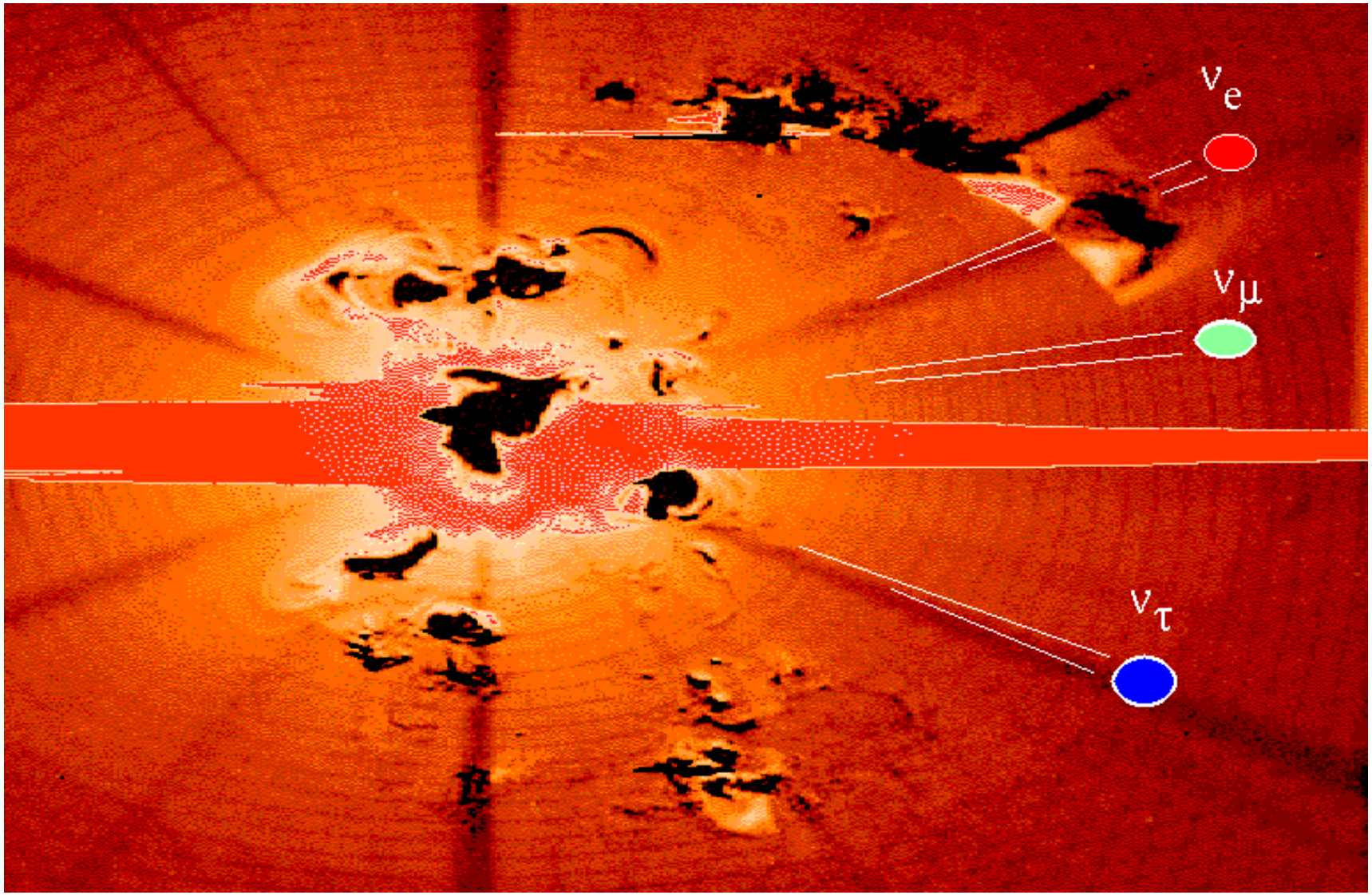
- There are photons still around from when the universe was 380,000 years old – the so-called Cosmic Microwave Background.
- There are neutrinos still around from when the universe was 1 SECOND old! These "Relic" neutrinos constitute the Cosmic Neutrino Background (CνB).

The Cosmic Microwave Background

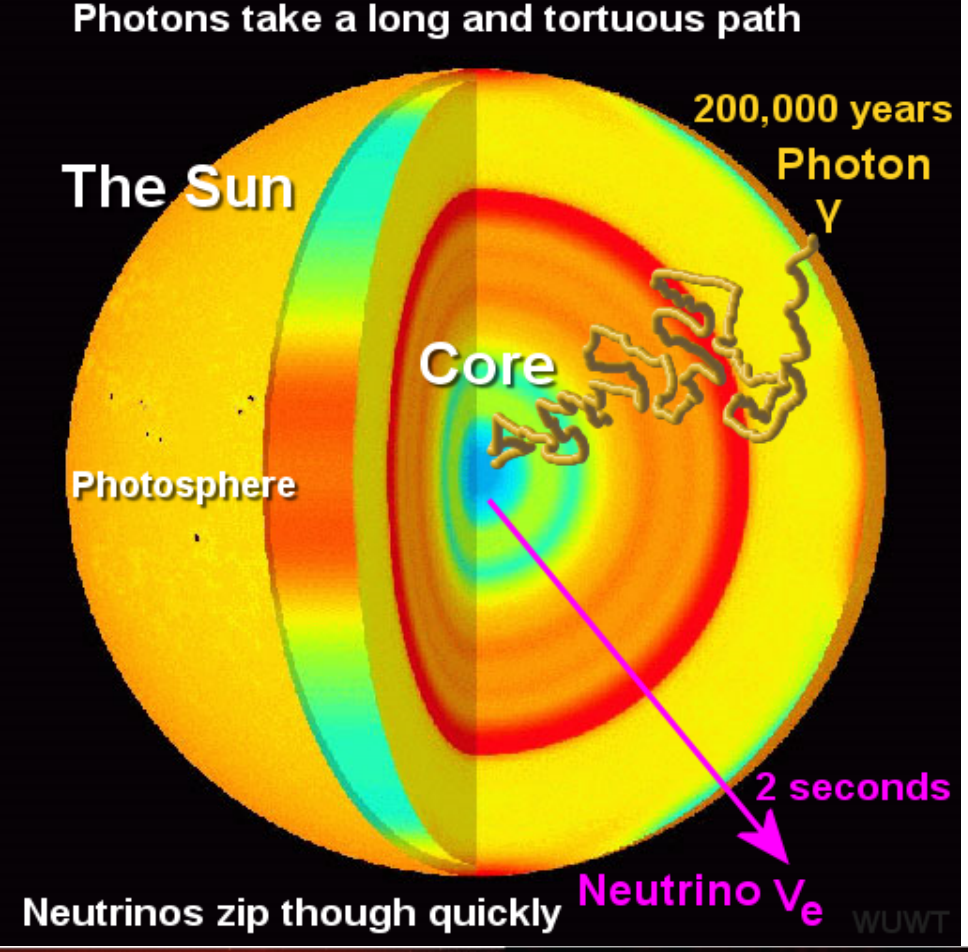


"Listen" to the Big Bang at https://soundcloud.com/uw-today/bigbangsound100

Why Not Just Measure the CνB?

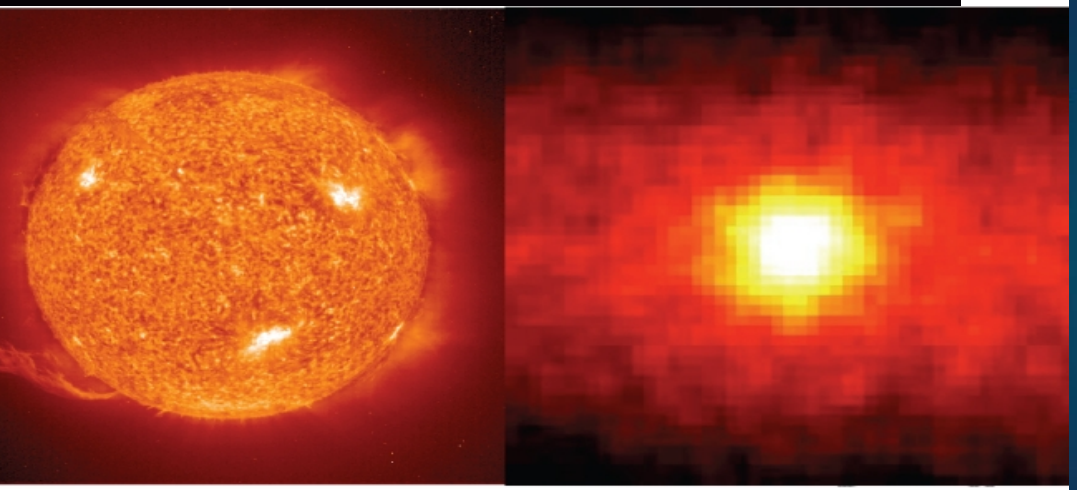


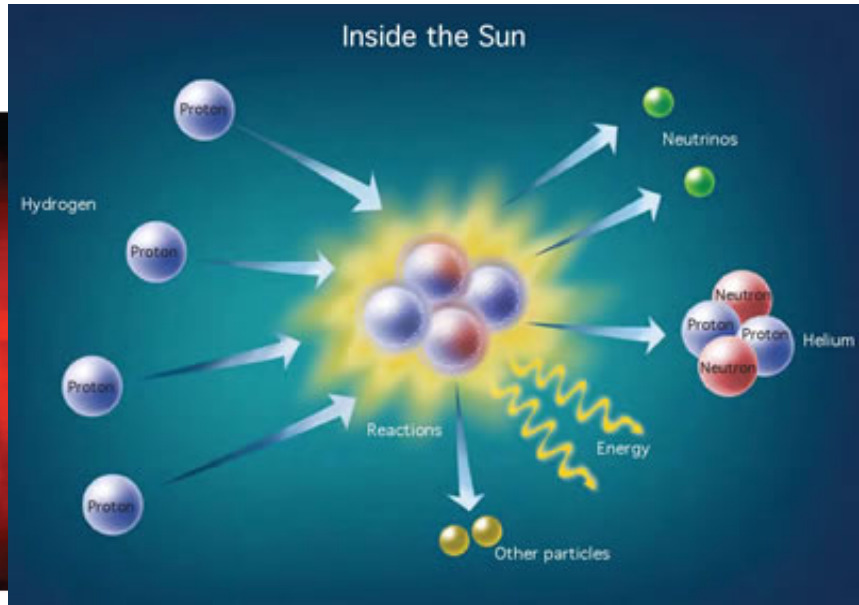
We're trying! But neutrinos are shy little devils.



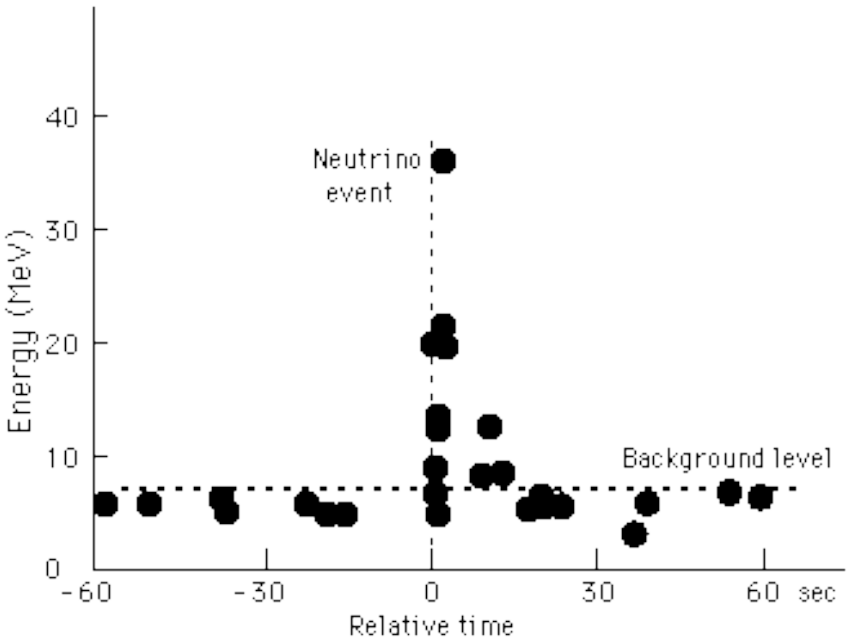
The fusion process that fuels the sun leads to an enormous number of neutrinos streaming though all of us – about a trillion/second!

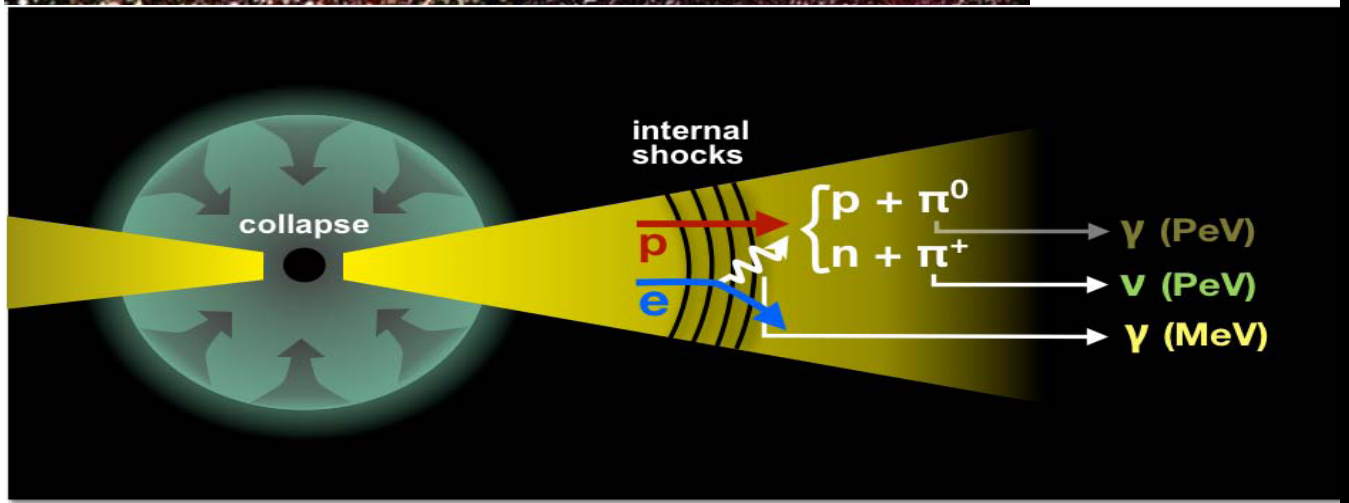
- And one or two will interact with an atom in your body in your lifetime!

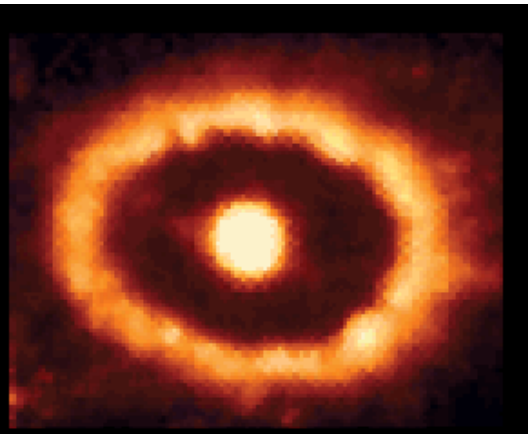




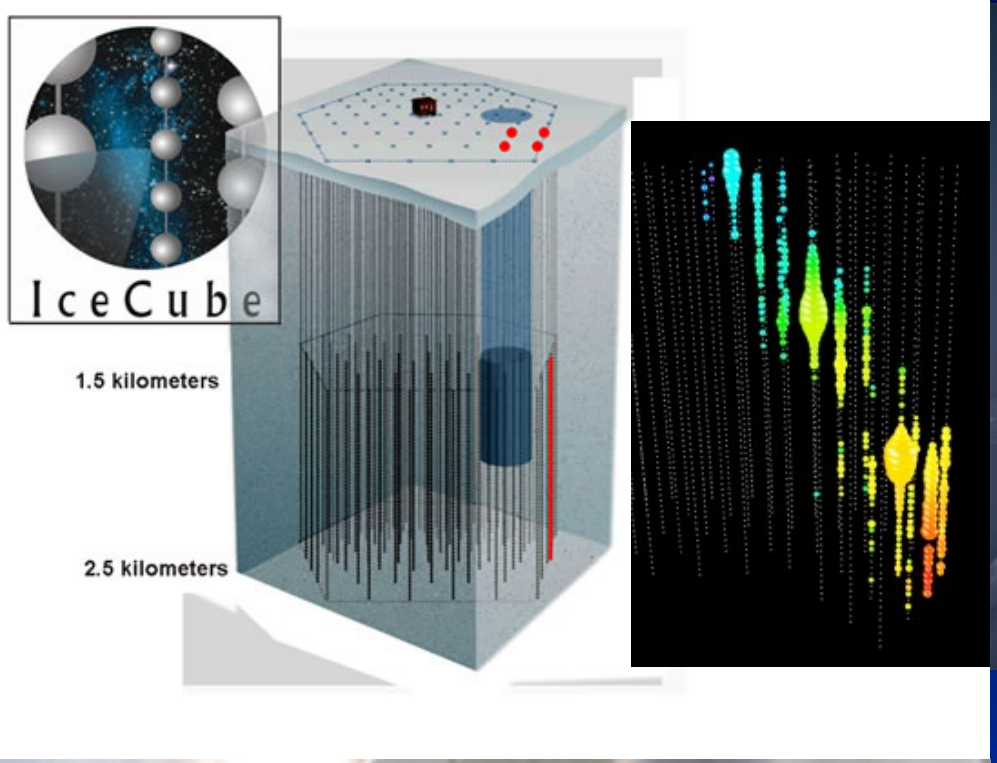
“Watching” a Supernovae Evolve – Supernova 1987 “eh”

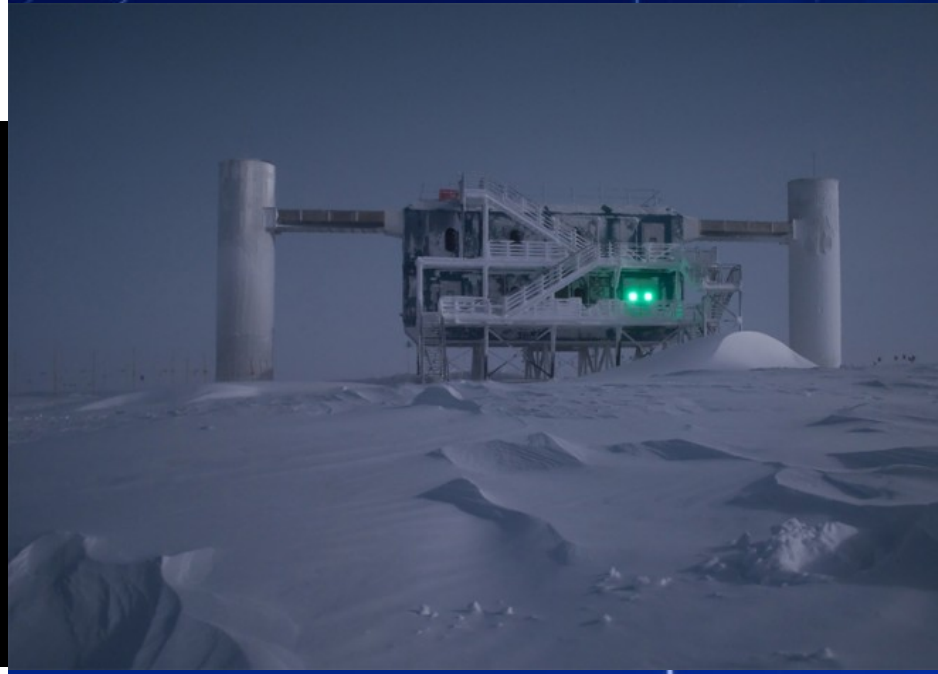




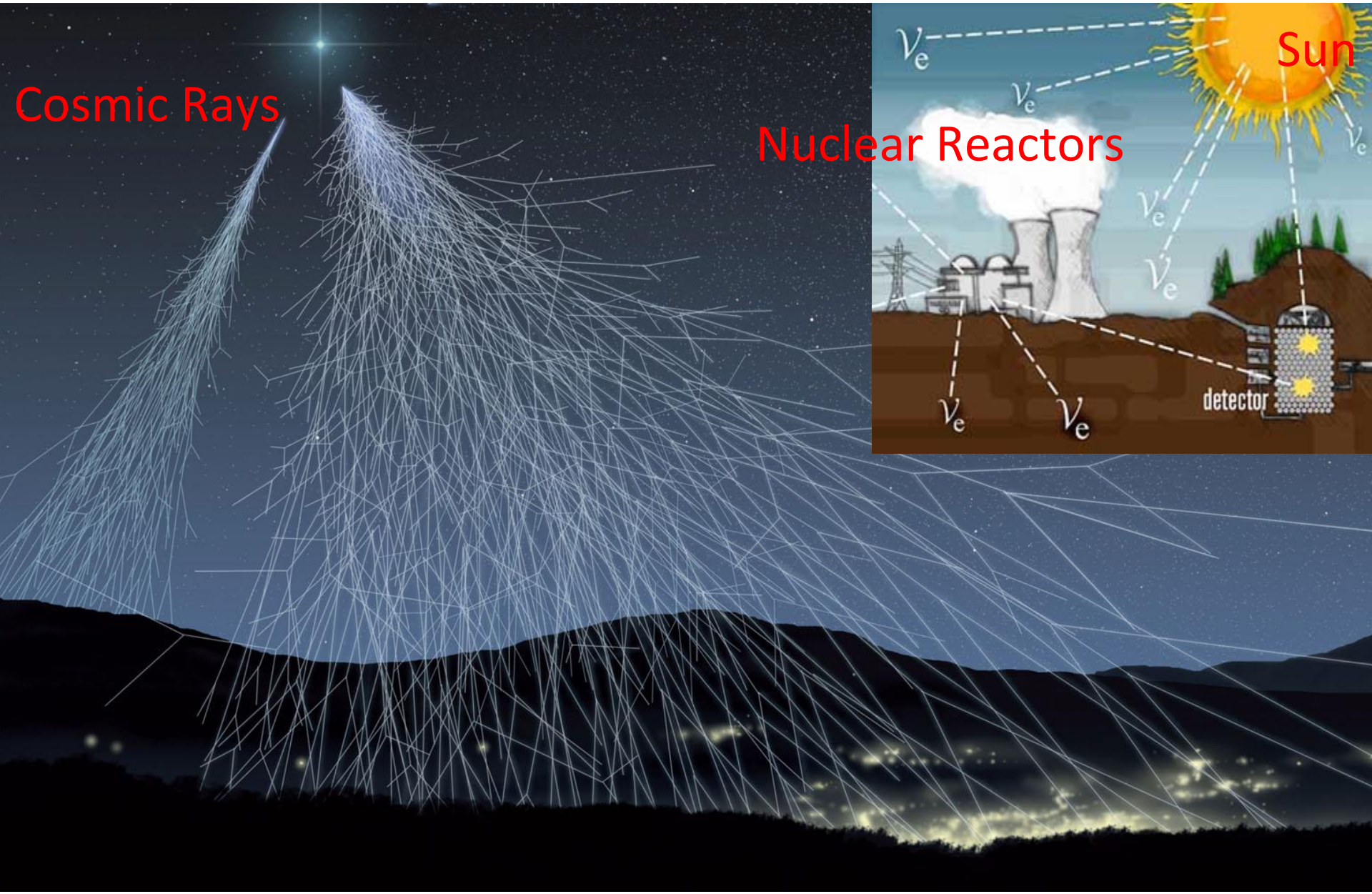


09/1994

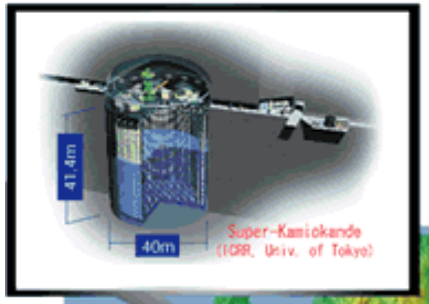

IceCube
1.5 kilometers
2.5 kilometers

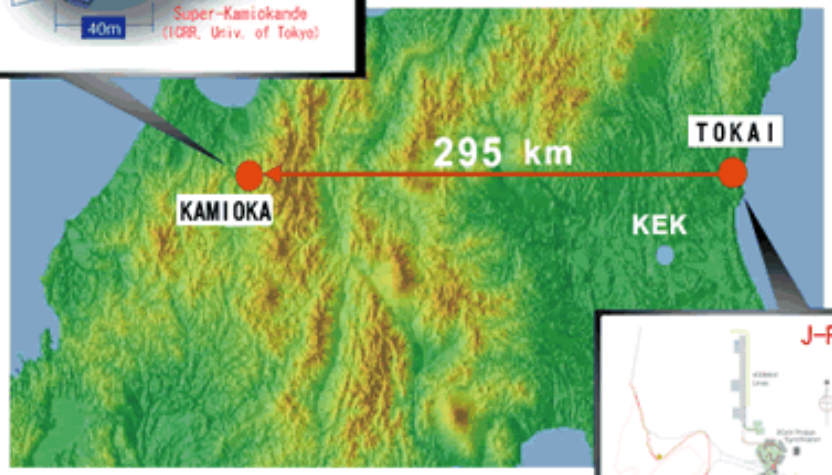


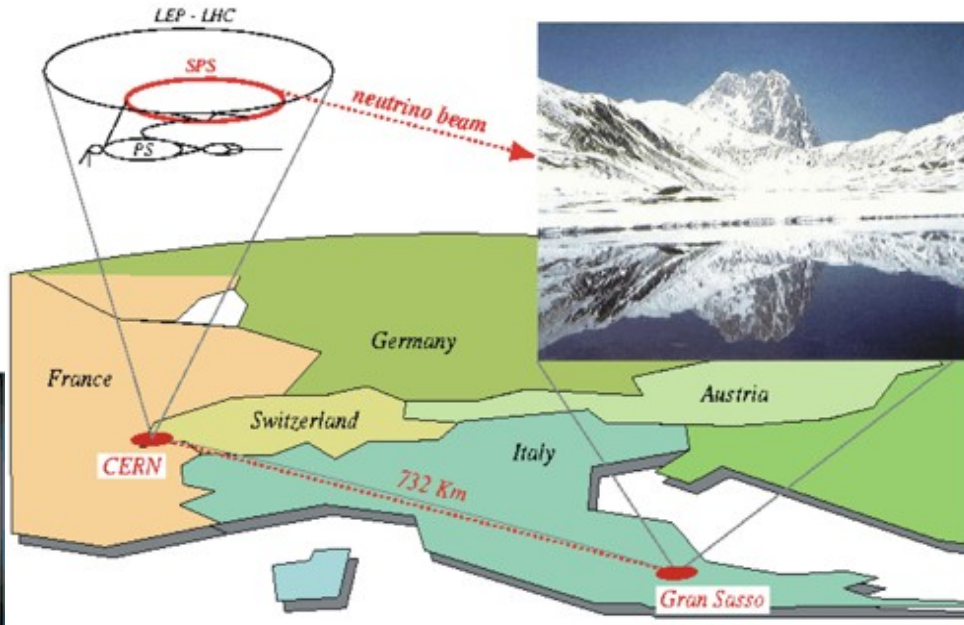
There are Lots of Sources of Neutrinos - Both Natural and Man-made

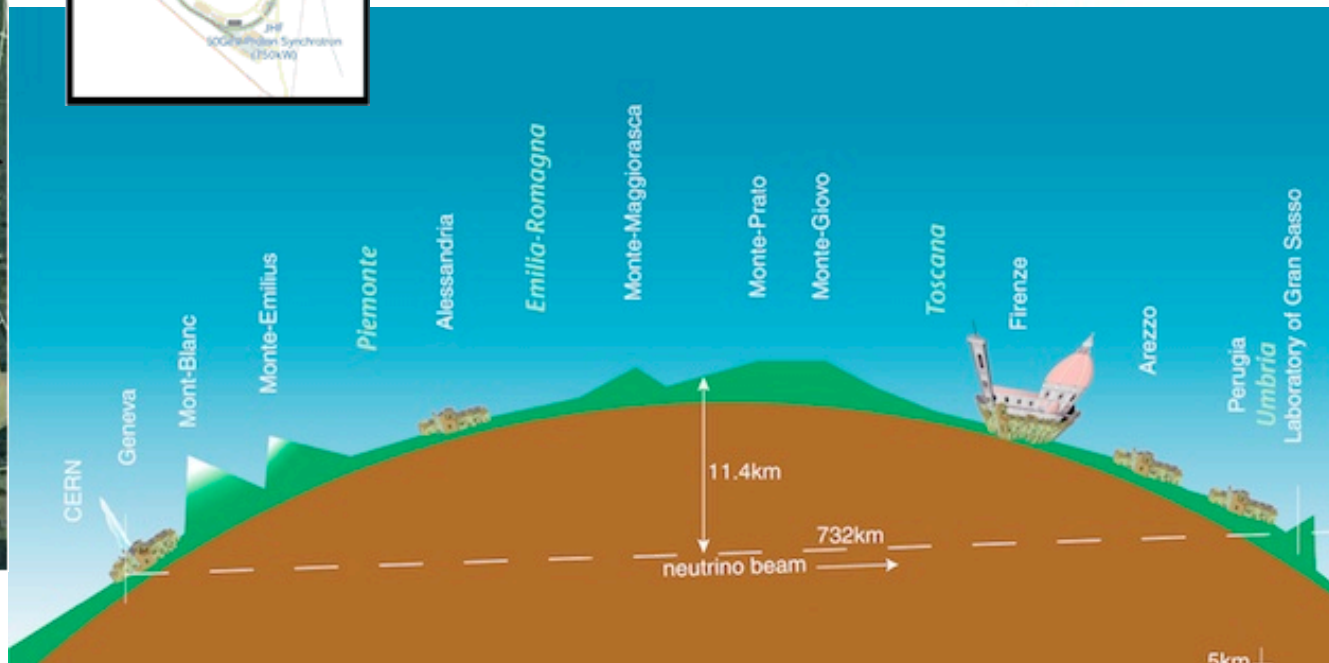


Neutrinos from Accelerators Sent Through the Earth





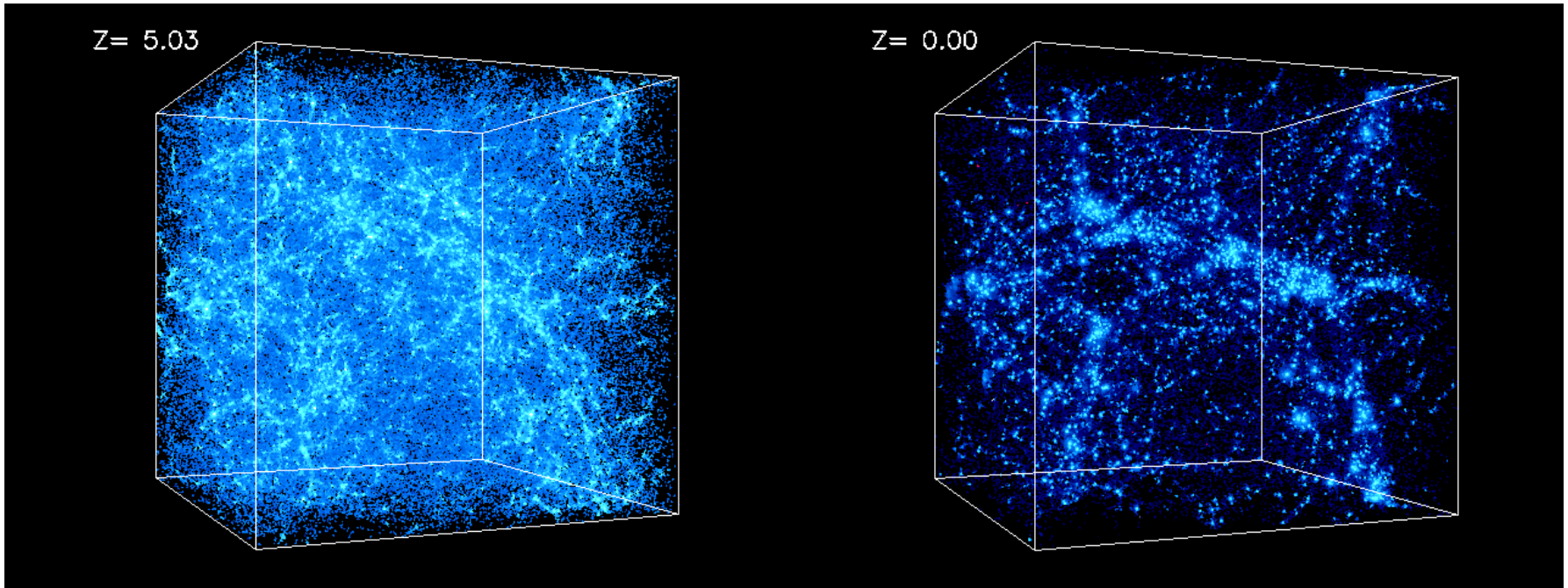




There are lots of neutrinos around – they are the second most abundant particle in the universe after microwave background photons. The problem is that they are very low energy and so very, very difficult (maybe impossible) to detect.

But relic neutrinos are slow enough ("non-relativistic") and they have mass (albeit tiny) so they can be trapped gravitationally by galaxies. Hence they can be observed in how they affect the evolution of the large scale structure of the universe.

the 8.4-meter-diameter Large Synoptic Survey Telescope begins operating in Chile in 2014



Neutrinos continue to inform and surprise us, revealing many hidden corners of the universe – even as far back as the Big Bang. Who knows what they will tell us next but you know it will be surprising so stay tuned.