

• Hubble Deep Field Picture

- Picture of a particularly dark piece of sky (about $\frac{1}{30}$ th the diameter of the moon) near the plough. This is a very small sample - about $\frac{1}{37000000}$ - of the whole sky.
- Each bright spot (about 6000 of them in the picture) is a galaxy.
- Our sun is a typical star in a typical spiral galaxy called the Milky Way, which contains about 10^{11} stars.

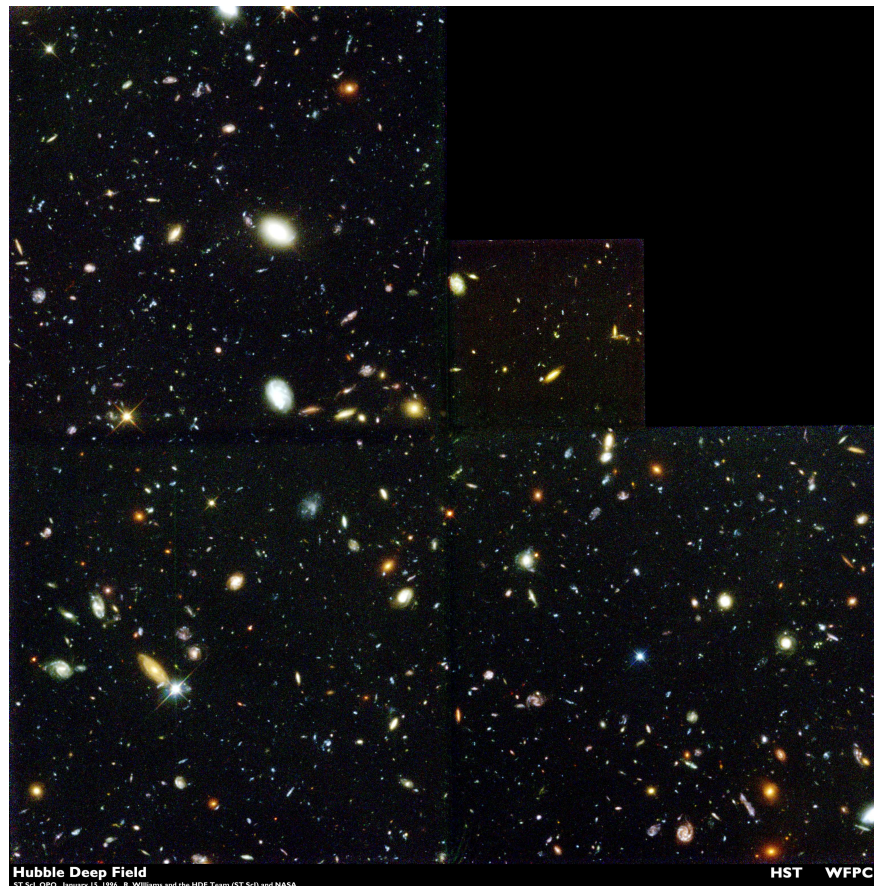


Figure 1: For more details - not part of course - GOOGLE: "hubble deep field" wikipedia

- **Question:** If our sun has a mass of about 2×10^{30} kg, estimate the total mass of all the stars in the universe that Hubble could 'see'.

• **Answer:**

$$N(\text{galaxies in universe}) \approx N(\text{galaxies in Hubble picture}) \times N(\text{Hubble pictures in whole sky})$$

$$= 6000 \times 37000000 \sim 2 \times 10^{11}$$

$$N(\text{stars in universe}) \approx N(\text{galaxies in universe}) \times N(\text{stars in a typical galaxy})$$

$$= (2 \times 10^{11}) \times 10^{11} \sim 2 \times 10^{22}$$

$$\text{Mass of universe} \approx N(\text{stars in universe}) \times \text{mass of sun}$$

$$= (2 \times 10^{22}) \times 2 \times 10^{30} \text{ kg} \sim 4 \times 10^{52} \text{ kg}$$

$$= 40000\ 000000\ 000000\ 000000\ 000000\ 000000\ 000000\ 000000\ 000000\ 000000\ 000000\ \text{kg}$$

- **Comment:** This is a lower limit - what about matter that doesn't shine, so we can't see it? Astronomers estimate that our figure is less than 5% of the total mass of the universe. About 22% is *dark matter* which we'll discuss, while ~73% is *dark energy* which is mysteriously accelerating the universe's expansion.

The Hubble Deep Field (HDF) telescope shows us the universe when it was about 1 billion (10^9) years old.

- **The earliest moments of the universe**

We cannot with telescopes look back to the earliest moments - because, the, the universe was not transparent.

The exploration of the earliest moments is left to particle physicists who use big machines called 'accelerators' to re-create - on a tiny scale - the conditions that existed a few millionths (10^{-6}) of a second after the Big Bang; we call them 'little bangs'.

We do this by colliding atomic nuclei - travelling in opposite directions at 99.9999991% the speed of light - together in a pipe 29 km long, about 100 metres underground.

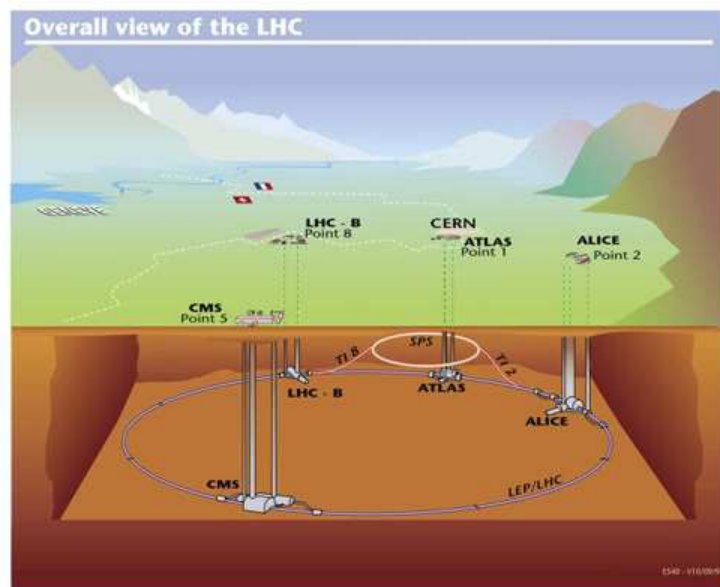


Figure 2: Plan of experiments underground and control rooms on the surface

Each 'little bang' will expand like a little universe sending thousands of particles into detectors that surround the collision point. This picture shows a magnet through the middle of which the pipe will pass. The volume around the pipe will be filled with the most advanced electronic equipment, ready to start taking data next year.

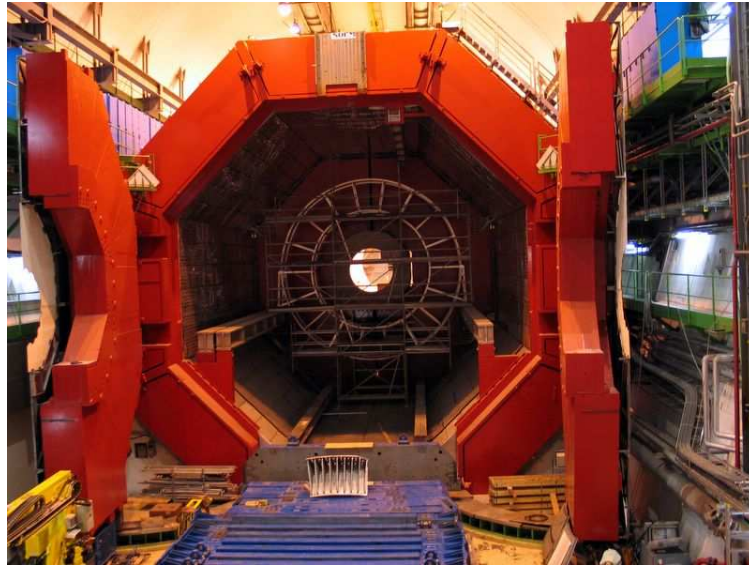


Figure 3: A double-decker bus would (almost) fit inside this magnet

The amount of information we will store in one year in the ALICE experiment is equivalent to about 3.3 million CDs - if stacked side-by-side (not in their boxes) this would be about 3.3 km long. (See ALICE comic in book box.)

Science is an international activity: we all - Australians, Bulgarians, Chinese, Dutch, English, French, Germans, Hungarians, Indians, Jordanians, Koreans, Latvians, Mexicans, Nepalis, Omanis, Pakistanis, Qataris, Russians, Spaniards, Taiwanese, Uzbeks, Vietnamese, Welsh, Yemenis and Zambians - do the same science.

- **How is it that we can make such grand statements about the universe?**

We **believe** in science.

- **What is Science?**

Science is an activity based on the **belief** that the **material** universe is ordered and that this order can be understood by the human mind; it is carried out by performing **experiments** - repeatable and checkable, whose results are taken as truths - and then analysing these results using the tools of **logic and mathematics**.

- **What is Religion?**

Religion is based on the belief that there is purpose and meaning behind the order/rationality of the universe and of our existence within it. For many (but not all) the source of this meaning and purpose is God. Alternatives range from some sort of 'cosmic reason/intelligence' to mathematics. Aethism is the belief that there is no purpose or meaning to the fact that the material universe is ordered and rational.

- **Science is inclusive**

In performing their scientific activities, scientists do not actively involve God. Buddhist, Christian, Hindu, Jewish, and Muslim scientists work harmoniously with atheists. Often they will work together for many years without discussing or even knowing about each other's beliefs.

So, science does not distinguish between people of different races or beliefs.

This is not so different from the words of Joseph Priestley about the Lunar Society of Birmingham, one of the leading scientific groups of the late 18th century:

We had nothing to do with the religious or political principles of each other; we were united by a common love of science which we thought sufficient to bring together persons of all distinctions - Christians, Jews, Mohametans and heathens, Monarchists and Republicans.

From **Joseph Priestley** by J E Thorpe

- **The Heritages of Western Civilization**

Western civilization, it seems to me, stands by two great heritages. One is the scientific spirit of adventure - the adventure into the unknown, an unknown which must be recognised as being unknown in order to be explored; the demand that the unanswerable mysteries of the universe remain unanswered; the attitude that all is uncertain; to summarize it - the humility of the intellect. The other great heritage is Christian ethics - the basis of action on love, the brotherhood of all men, the value of the individual - the humility of the spirit.

These two heritages are logically, thoroughly consistent. But logic is not all; one needs one's heart to follow an idea. If people are going back to religion, what are they going back to? Is the modern church a place to give comfort to a man who doubts God - more, one who disbelieves in God? Is the modern church a place to give comfort and encouragement to the value of such doubts? So far, have we not drawn strength and comfort to maintain the one or the other of these consistent heritages in a way which attacks the values of the other? Is this unavoidable? How can we draw inspiration to support these two pillars of Western civilization so that they may stand together in full vigor, mutually unafraid? Is this not the central problem of our time?

The Relation of Science and Religion
Richard P Feynman

Aim of this lecture: to try to give an overview of the development of Western science, so as to provide a context for thinking about the way we see things today.

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Answer:

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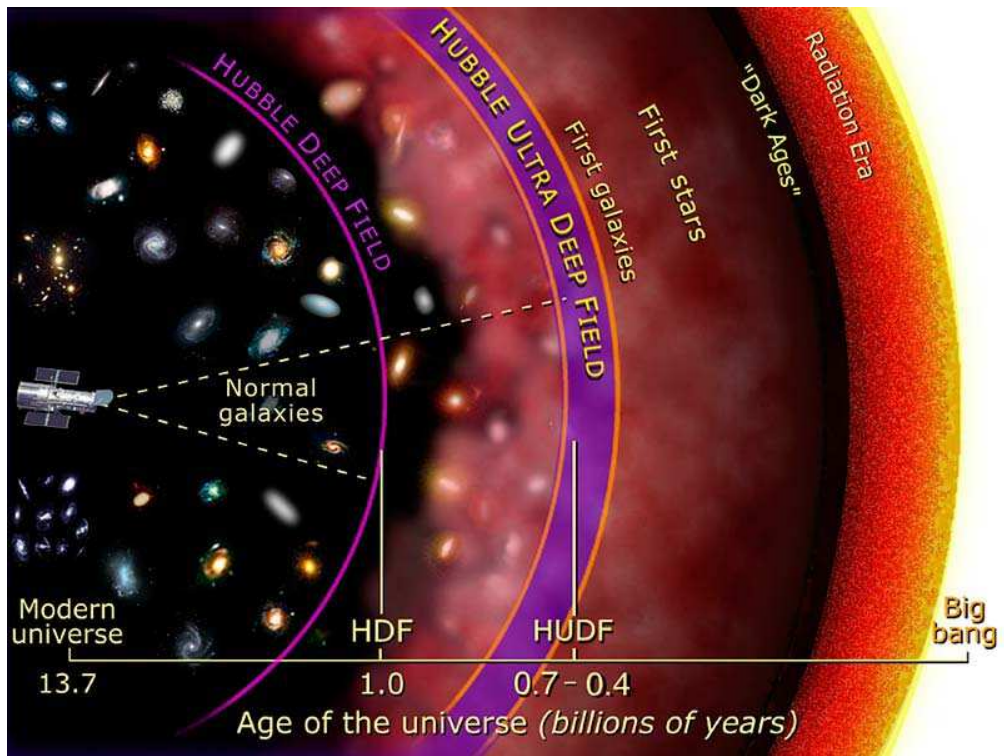


Figure 4: Looking deep into space is like looking back in time

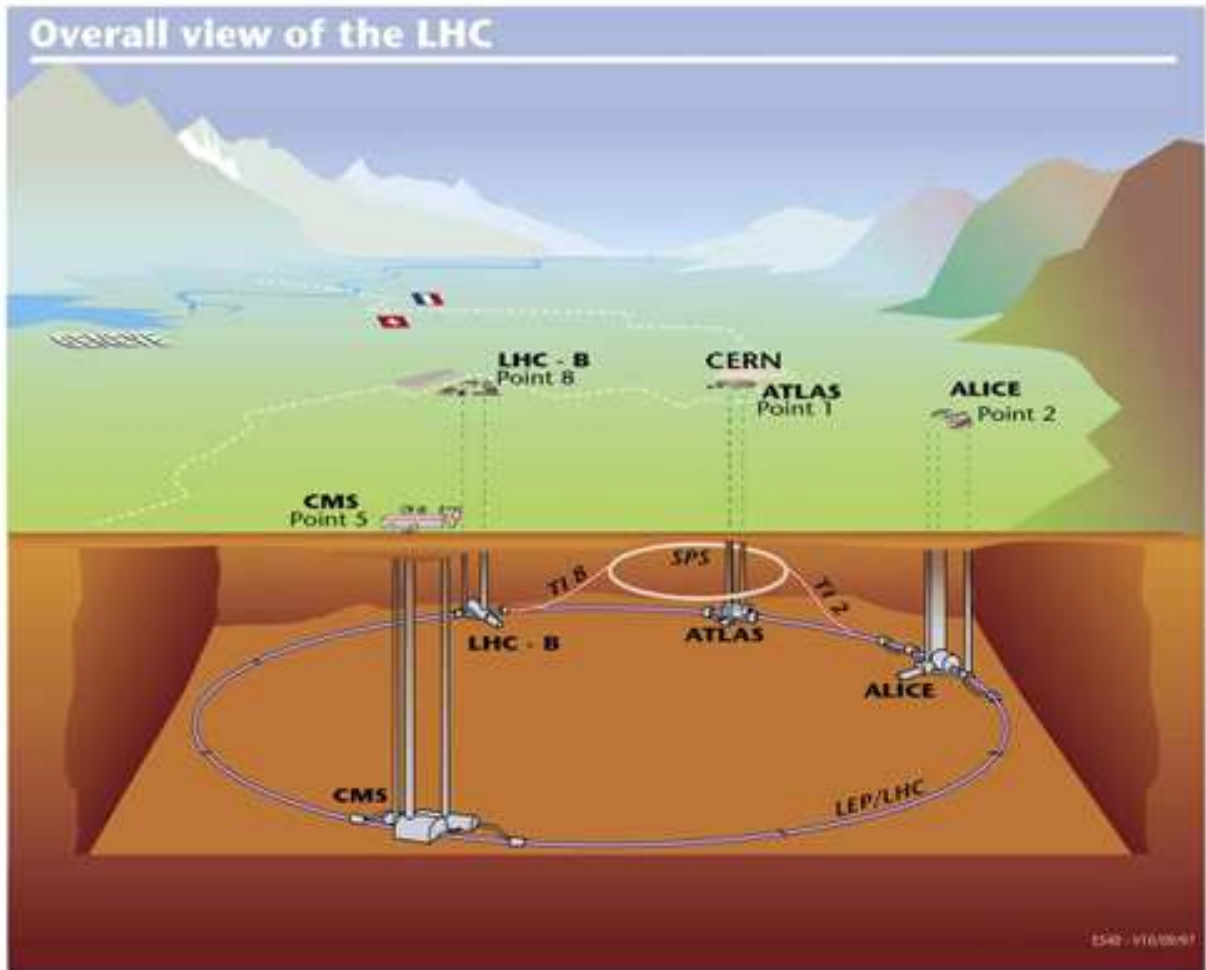


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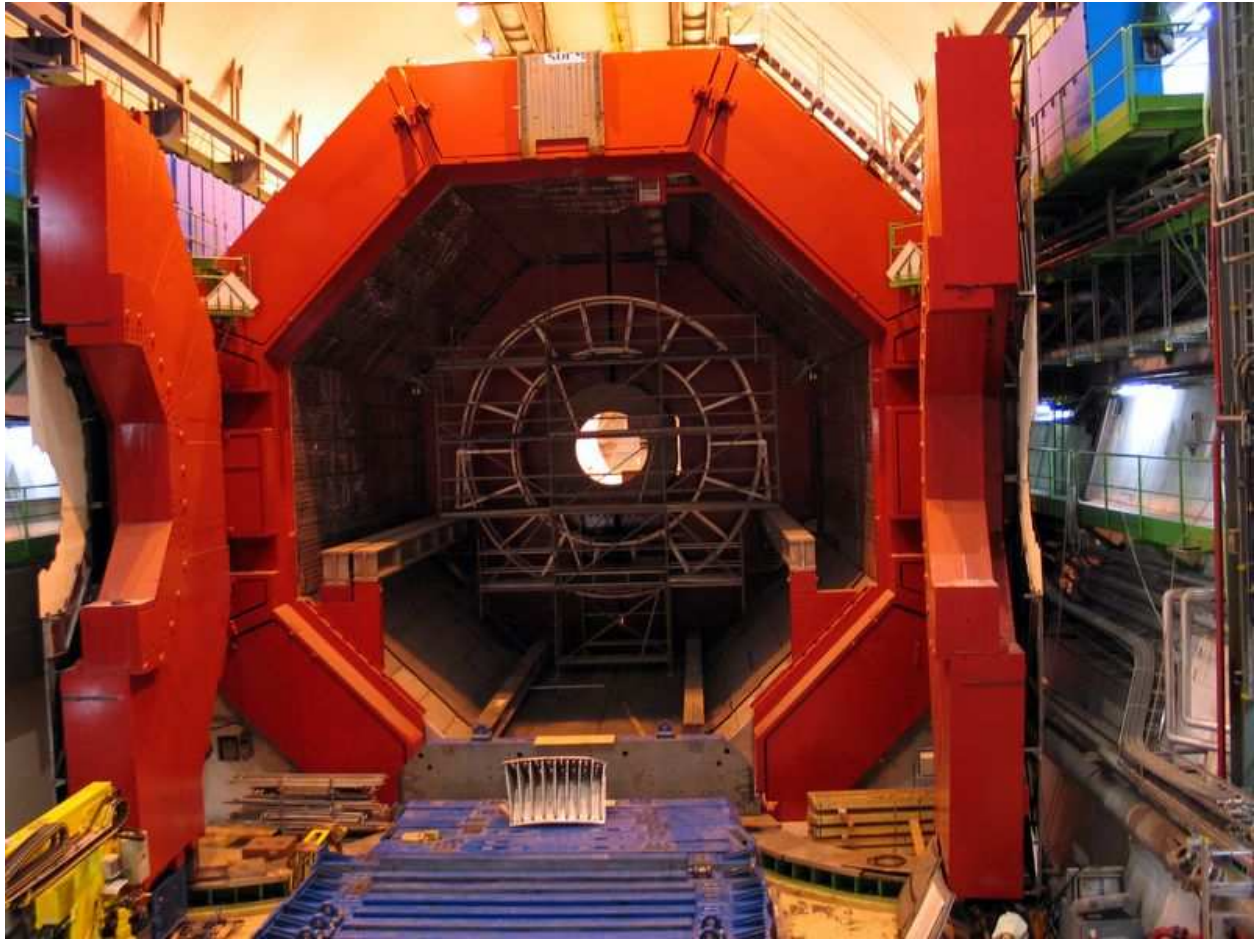


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