



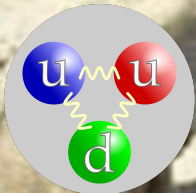
COSMALLOGY

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@infinitedoggomemes



ok, so basically
im very smol

MAIN CONNECTIONS BETWEEN COSMOLOGY & PARTICLE PHYSICS

THE EARLY
UNIVERSE

01

02

Λ CDM
MODEL

COSMIC
MICROWAVE
BACKGROUND

03

04

CERN
EXPERIMENTS





1

THE EARLY UNIVERSE



Georges Lemaître

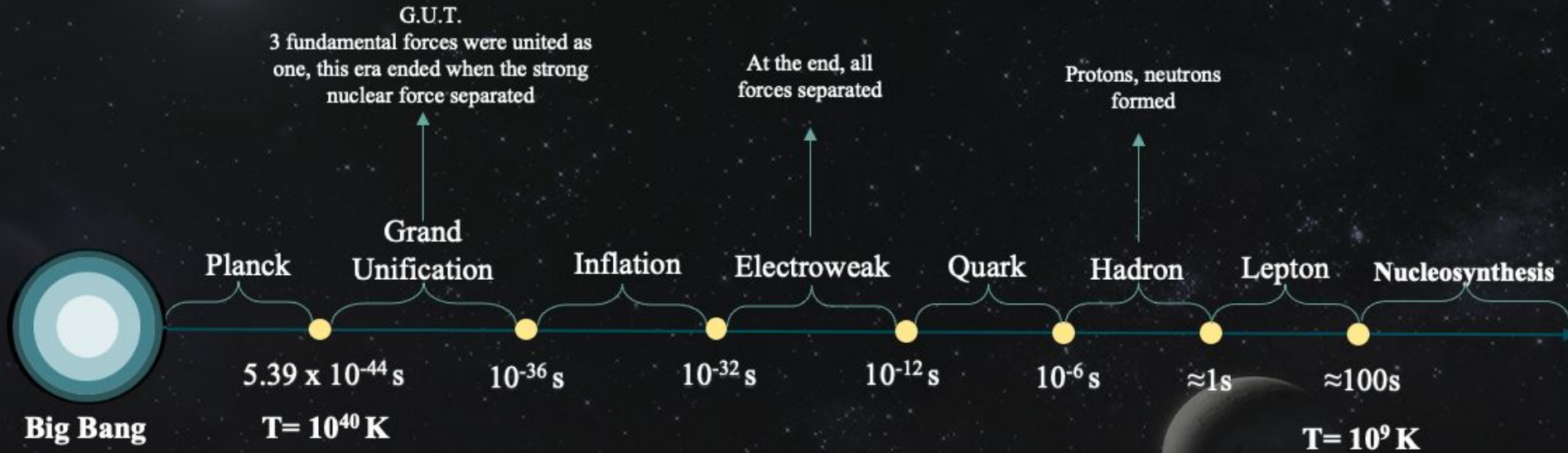
1927

Hypothesis of the Primeval Atom



Edwin Hubble

Radiation Era ≈ 50.000 years



* The strong nuclear force is responsible for the strong bond between neutrons and protons in atomic nuclei

* Weak nuclear force is responsible for the radioactive decay processes and the nuclear fusion inside stars

Source:
Author's own graph

I. PARTICLE BEHAVIOR IN THE EPOCHS

I. ELECTROWEAK

- Quark-gluon plasma
- Large numbers of exotic particles (W, Z, Higgs Bosons)

II. BETWEEN ELECTROWEAK-QUARK

- Baryogenesis (baryon asymmetry problem— quarks dominate)

III. QUARK

- Quarks, electrons, neutrinos form
- Quarks not bound in Hadrons!

IV. HADRON

- Protons, neutrons formed



I. PARTICLE BEHAVIOR IN THE EPOCHS

V. LEPTON

- Leptogenesis (dominance of leptons over anti-leptons)

VI. NUCLEAR

- Atomic nuclei formed
- Energy dominated by photons



II. FUNDAMENTAL FORCES

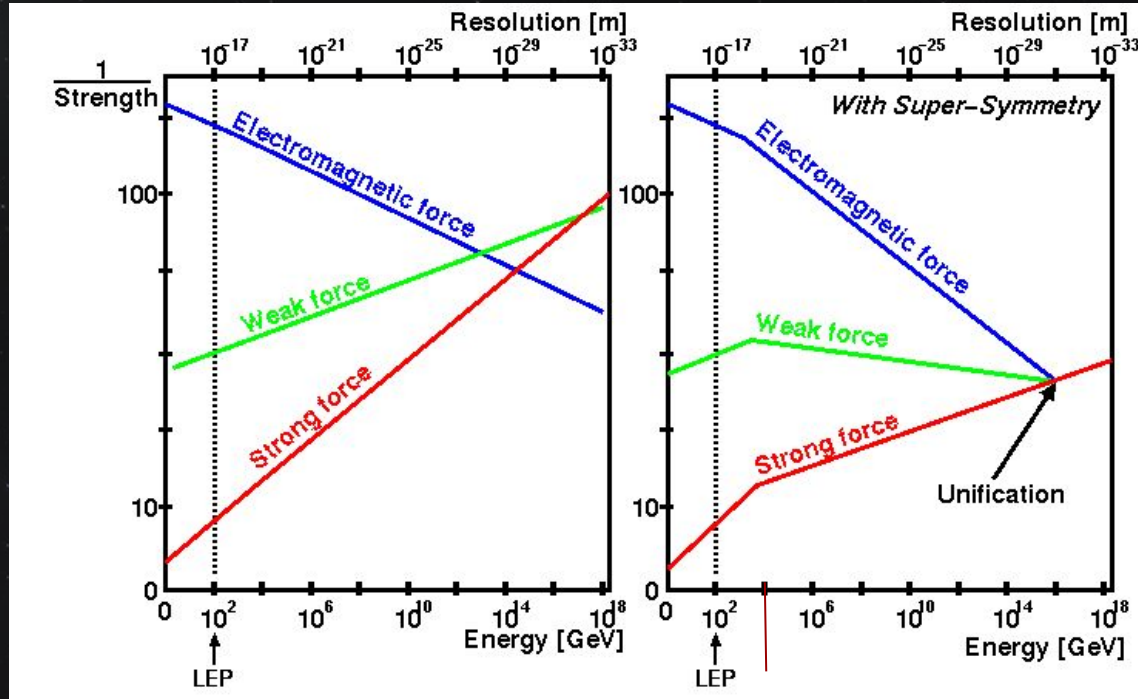


Figure 1: Strength reciprocal vs. energy graph not taking into account SUSY (left) and taking it (right)

Source: CERN, „Particle Physics Education CD-ROM,” 1999.

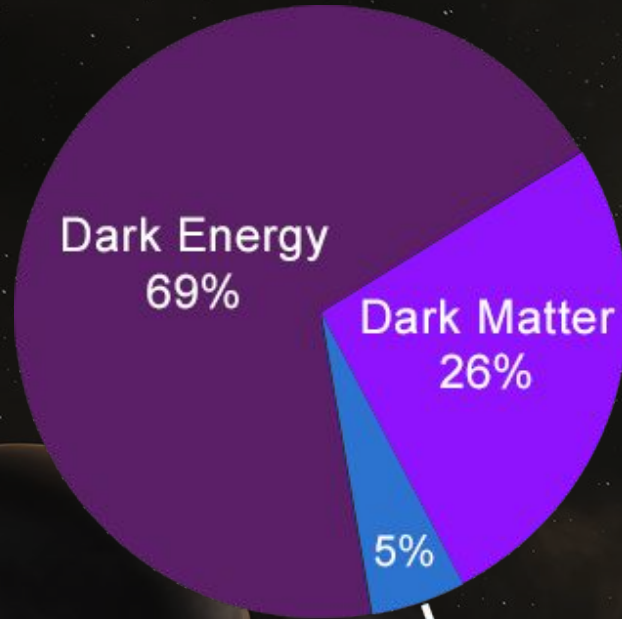


2

Λ CDM
MODEL



What are these particles?



Everything else including all stars, planets, and us.

How do they work?

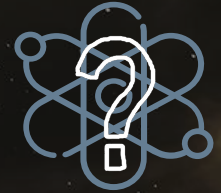


Figure 2: Content of the universe

Source: <https://chandra.harvard.edu/darkuniverse/>

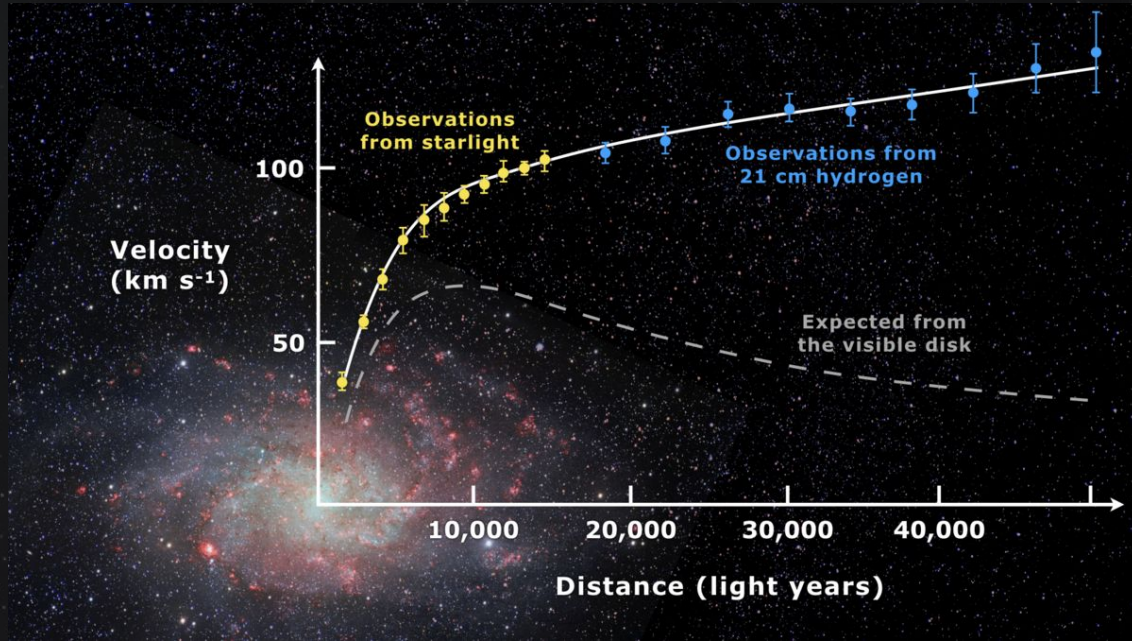


Figure 3: Observed vs expected galaxy velocities

Source: [https://commons.wikimedia.org/wiki/File:Rotation_curve_of_spiral_galaxy_Messier_33_\(Triangulum\).png](https://commons.wikimedia.org/wiki/File:Rotation_curve_of_spiral_galaxy_Messier_33_(Triangulum).png)



Vera Rubin



Fritz Zwicky

DARK MATTER

POSSIBLE CANDIDATES



I.

WIMPS

(Weakly interacting massive particle)

II.

AXIONS

III.

STERILE NEUTRINOS

THE WIMPS



Heavy, electromagnetically neutral subatomic particle that is hypothesized to make up most dark matter and therefore some 22% of the universe

Characteristics:

- They don't absorb/emit light
- They don't interact strongly with other particles

AXIONS

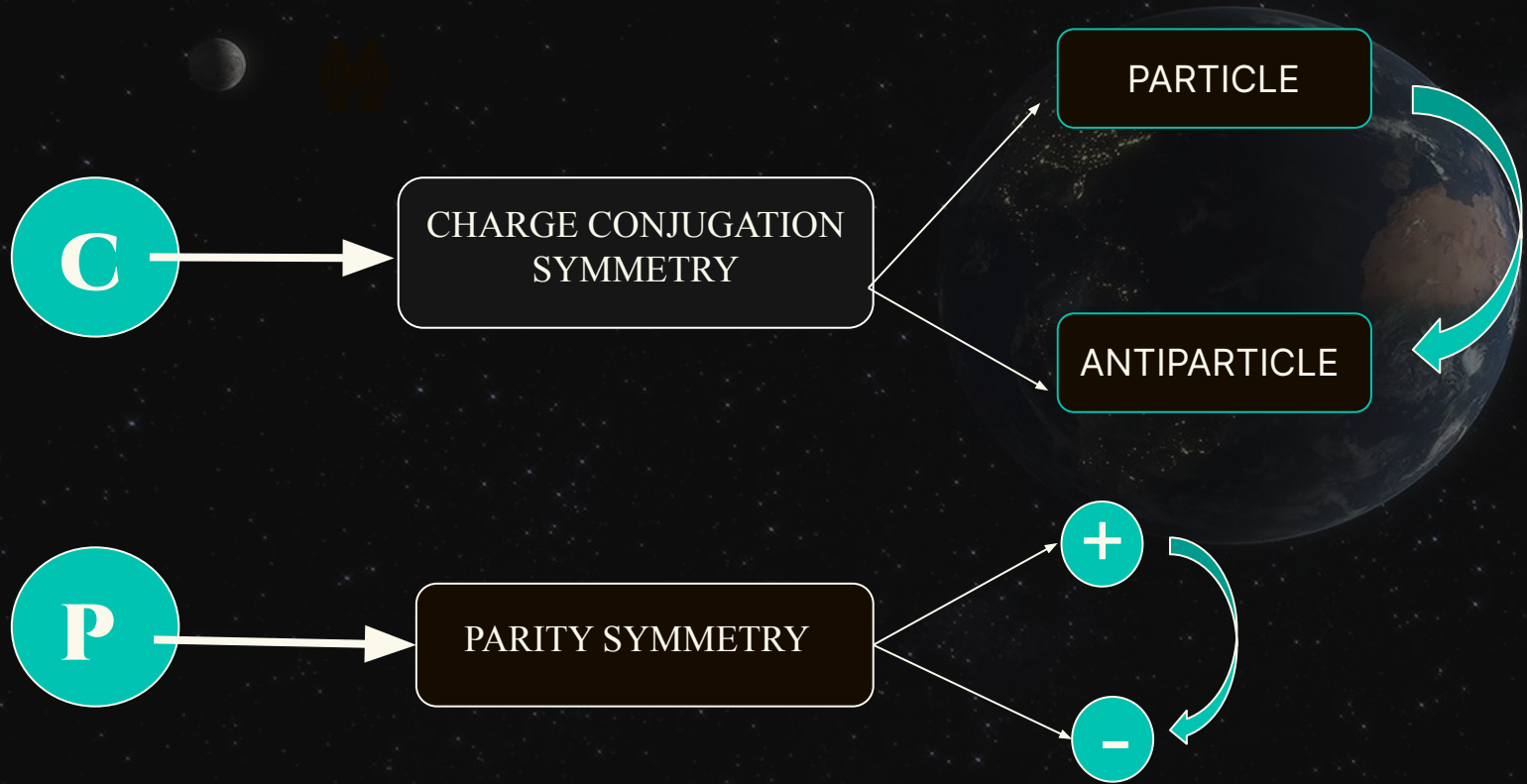


Axions are another well-motivated dark matter candidate. They were proposed to resolve the strong CP problem.

Characteristics:

- No electric charge
- Very small mass
- Very low interaction for strong and weak forces

CP PROBLEM



Source:
Author's own graph

STERILE NEUTRINOS



A special kind of neutrino that has been proposed to explain some unexpected experimental results, but they have not been definitively discovered. Scientists are looking hard for them in many different experiments.

Characteristics:

- No electric charge
- Very small mass
- Very low interaction for strong and weak forces

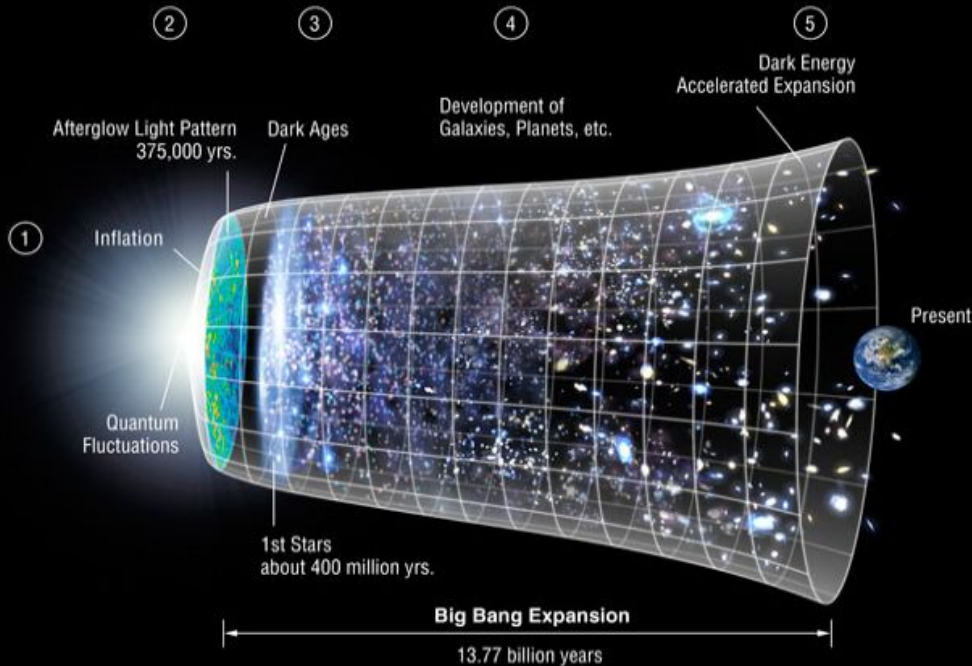


EXPANSION OF THE UNIVERSE



QUINTESSENCE

Λ CDM MODEL OF COSMOLOGY



This model proposes specifically cold matter, such as:

1. Non - baryonic
2. Cold
3. Dissipationless
4. Collisionless

Figure 4: Big Bang Expansion
https://lambda.gsfc.nasa.gov/education/graphic_history/univ_evol.html



3

**COSMIC
MICROWAVE
BACKGROUND**

Matter Era – until today



Source:
Author's own graph

COSMIC MICROWAVE BACKGROUND

- Isotropic photon background with a blackbody spectrum ($T=2.725$ K)
- Before recombination: hot, dense plasma of particles (photons scattered off , Thomson scattering)
- Proves that photons/baryons **must** have existed in a highly interacting thermal state
- Small irregularities: Random quantum fluctuations before recombination

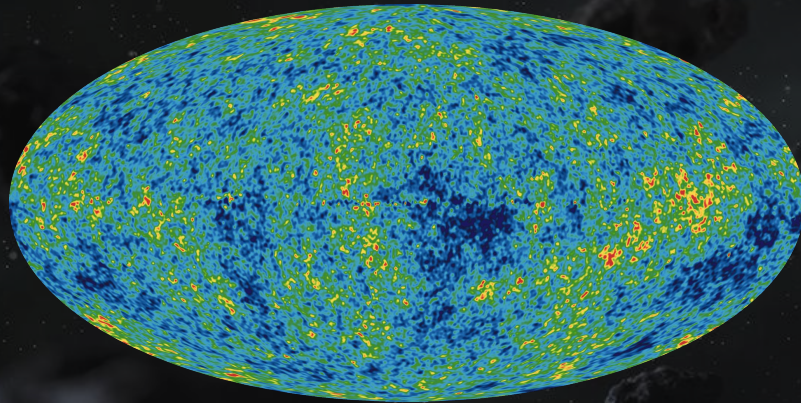


Figure 5: Cosmic Microwave Background (blue spots colder than red spots)

Source: *WMAP*



4

CERN
EXPERIMENTS

The background of the slide is a dark, star-filled space. On the right side, a large, detailed image of the Earth is visible, showing continents and clouds. In the upper left quadrant, a smaller, crescent-shaped image of the Moon is visible.

I. LHCb / LHCf

II. ALICE

III. OTHERS (ATLAS, CMS, ELENA/AD)

LARGE HADRON COLLIDER BEAUTY LARGE HADRON COLLIDER FORWARD

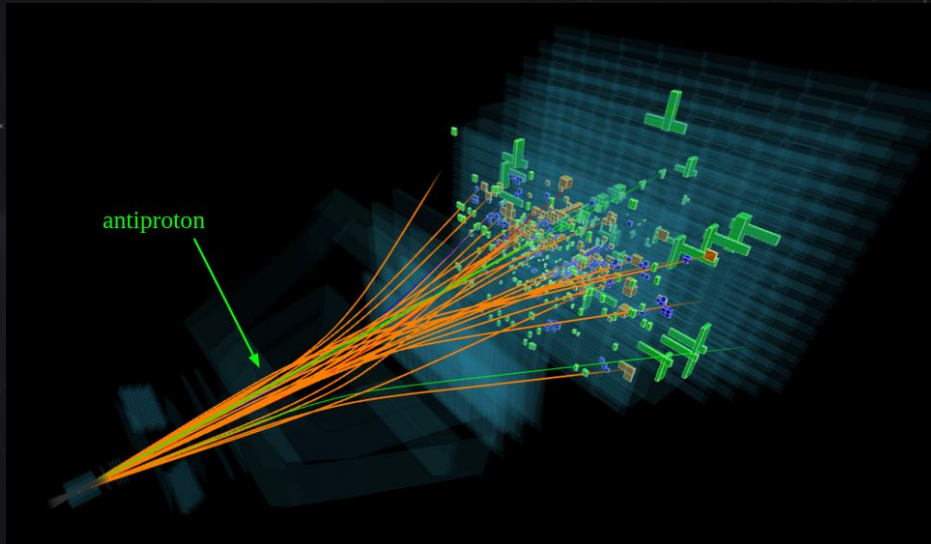


Figure 6: proton-proton collision at LHCb
<https://home.web.cern.ch/news/news/physics/lhcb-reveals-secret-antimatter-creation-cosmic-collisions>

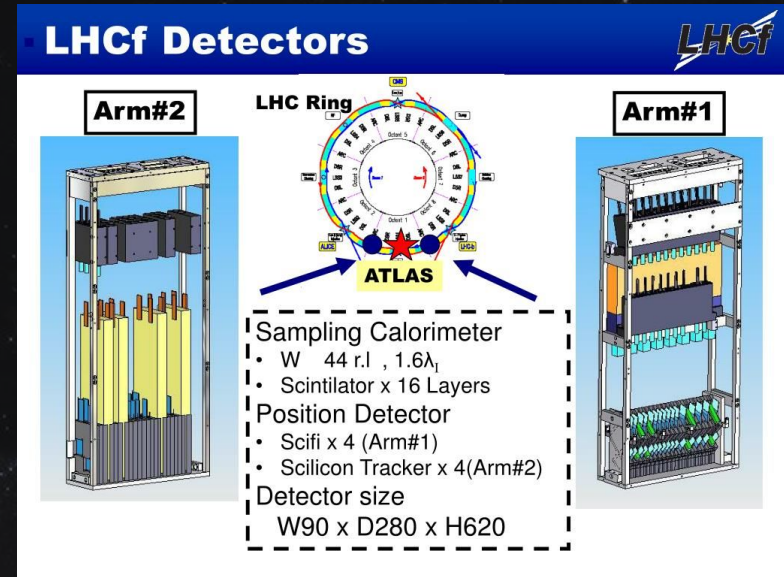
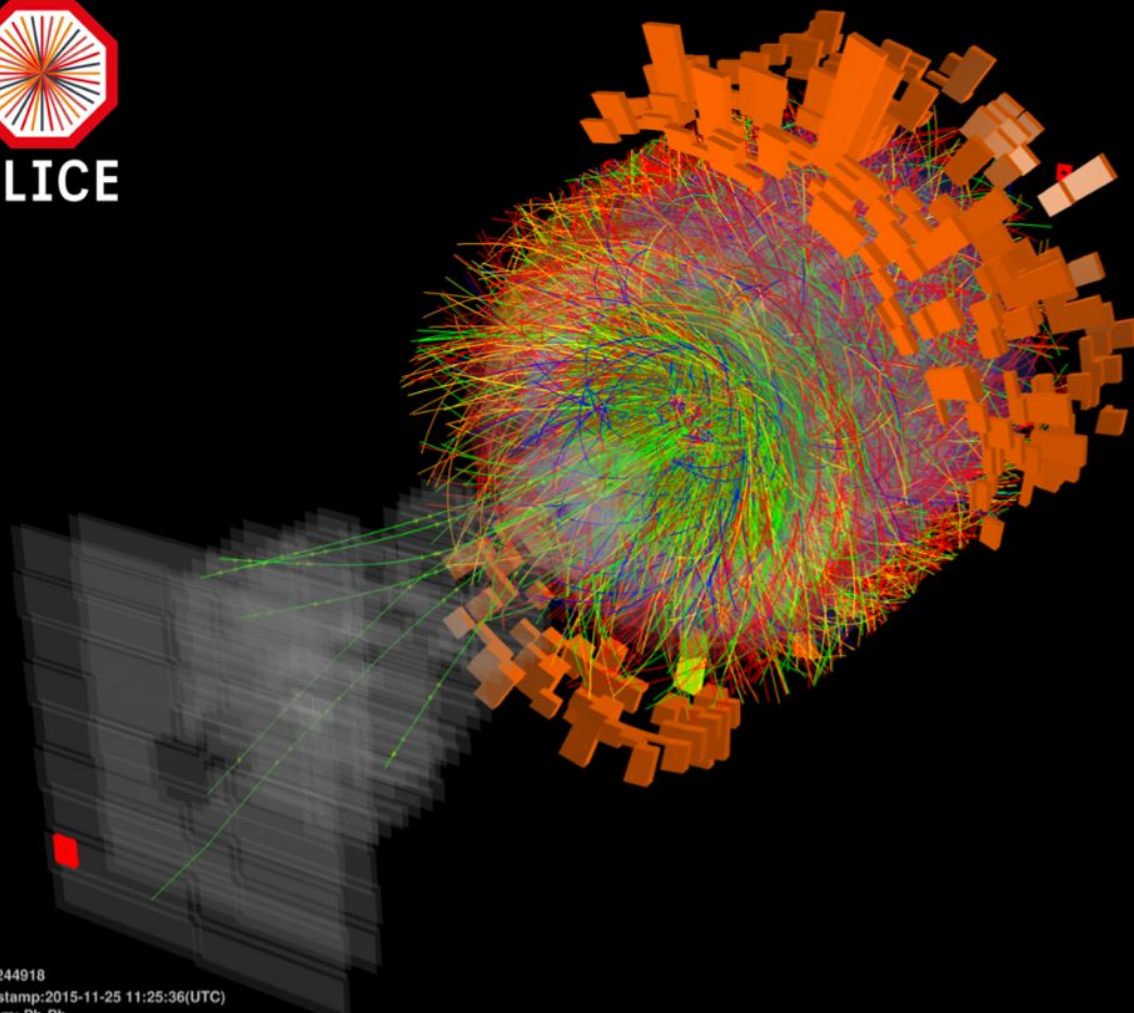


Figure 7: LHCf Detectors
<https://www.slideserve.com/varick/lhcf-detectors>



ALICE

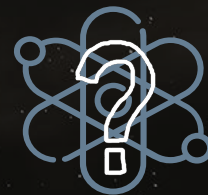


Run:244918
Timestamp:2015-11-25 11:25:36(UTC)
System: Pb-Pb
Energy: 5.02 TeV

<https://home.cern/news/news/physics/alice-explores-hidden-charm-quark-gluon-plasma>



What is the quark-gluon plasma state?



What happens at ALICE?

RESOURCES

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