Subatomic Physics

“Subatomic Physics” explores the phenomena which take place at subatomic distances scales.

Practically, subatomic physics is divided into two research areas:

- **Nuclear Physics**
- **Particle Physics**

The particle and nuclear topics will be covered by different lecturers - both of whom is also an active researcher in that field.

- **Dr Dan Watts - Nuclear Physics**
  - dwatts1@ph.ed.ac.uk JCMB 8209
- **Dr Victoria Martin - Particle Physics**
  - victoria.martin@ed.ac.uk JCMB 5419

Lectures, Tutorials & Notes

- **Lectures** are Tuesday & Friday at 10am in **JCMB C**

- **Tutorials** are on Wednesdays, 11am-12noon & 12noon-1pm in JCMB 5212, starting week 3.
  - No tutorials weeks 6 and 12 (to avoid clash with Research Methods in Physics).

- Tutorials will be attended by the lecturer plus 1 or 2 assistants. Questions sheets will be circulated in advance of the tutorials.

- The tutorials will give you an opportunity to work on the problems, ask for help and advice on the problems and lectures.

- Notes for the lectures, problem sheets etc will be linked from:
  www2.ph.ed.ac.uk/~vjm/Lectures/SubatomicPhysics/Subatomic2010.html
  www2.ph.ed.ac.uk/~dwatts1/sa_09.htm

We'll link to the School of Physics & Astronomy wiki too!

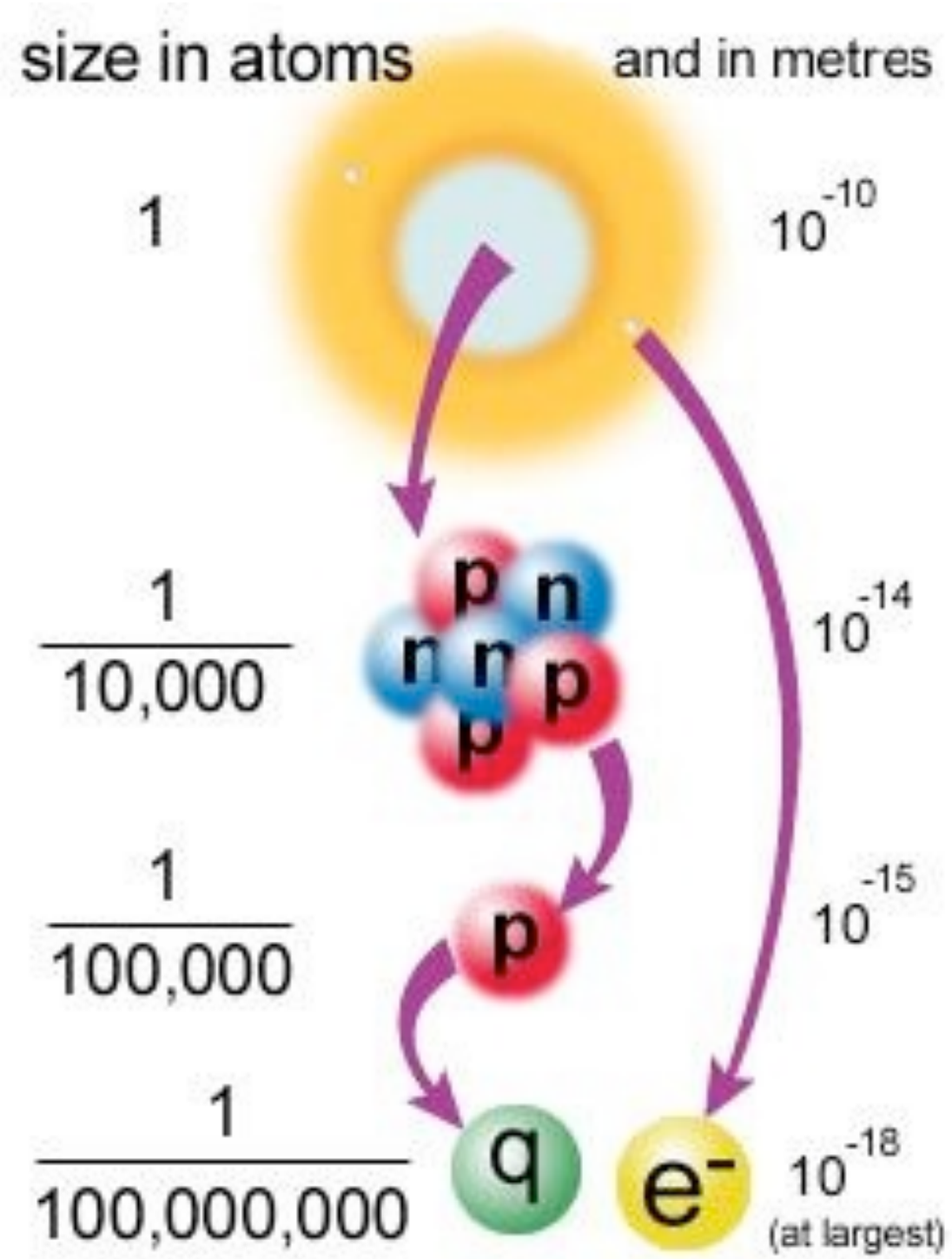
From the Atom to Subatomic

atom

nucleus

protons & neutrons

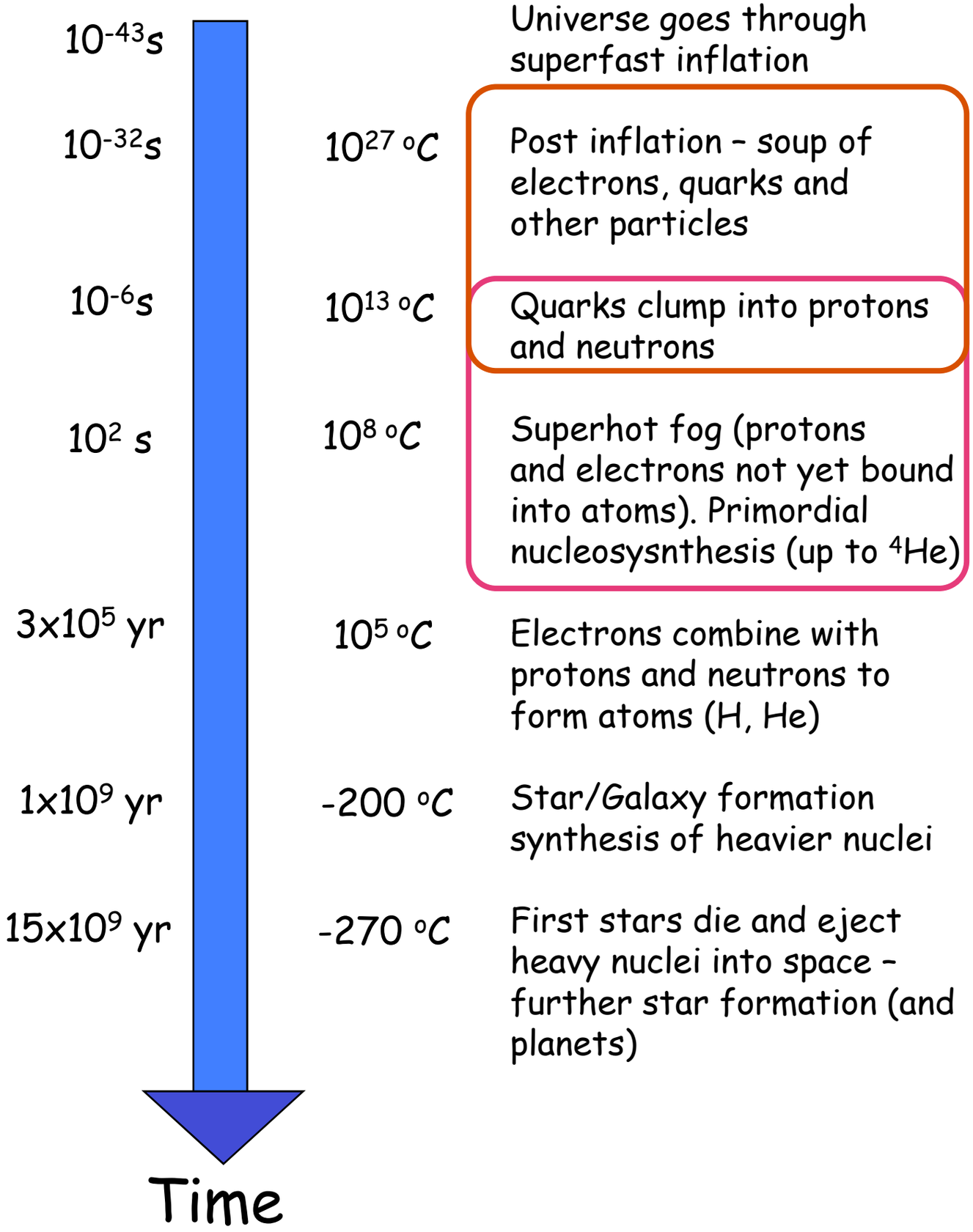
quarks & electrons



Nuclear Physics

Particle Physics

History of the Universe



Particle Physics

Nuclear Physics

Subatomic physics looks at:

- (very) short distances
- (very) early time in the universe
- (very) high energy densities

To understand subatomic phenomena we need:

- quantum mechanics (as things are very small)
- relativity (as things have high energies)

Subatomic Forces

- At subatomic scales interactions between particles and nuclei are caused by the **three subatomic forces:**
  - The **electromagnetic** force
  - The **weak** nuclear force
  - The **strong** nuclear force

- The course will focus on phenomena occurring at subatomic scales, as opposed the mathematical framework describing the forces.

- The interactions due to these forces are evident in:
  - **Scattering:** e.g. scattering of protons on protons at the LHC
  - Particle **Decay**: e.g. decay of radioactive nuclei, decays of cosmic-ray muons
  - Nuclear **Fission** and **Fusion,** e.g.: reactions in a nuclear reactor

$$^{235}_{92}\mathrm{U} + \mathrm{n} \rightarrow {}^{236}_{92}\mathrm{U} \rightarrow {}^{144}_{56}\mathrm{Ba} + {}^{89}_{36}\mathrm{Kr} + 3\mathrm{n}$$

Why Separate Nuclear and Particle?

- Particle and Nuclear physics look, broadly, at the same underlying physics, but a different energy/length scales.
  - ➡ Although the underlying physics is the same, different phenomena exhibited at these different scales.

- Electromagnetic force stops me from putting my hand through the table.
  - ➡ Using quantum description of electromagnetic force between each electron is much too complex!
  - ➡ Instead use van der Waals interaction to describe electromagnetic potential between atoms
- Similarly, nuclear fission is due to interplay of strong and electro-magnetic forces in nuclei.
  - ➡ A particle physicist would consider strong and electroweak force between each quark in the nuclei!
  - ➡ Ingenious nuclear physicists describe fission much more simply…

- Particle & Nuclear Physics probe scales just different enough to require different descriptions to obtain a good understanding of the phenomena.