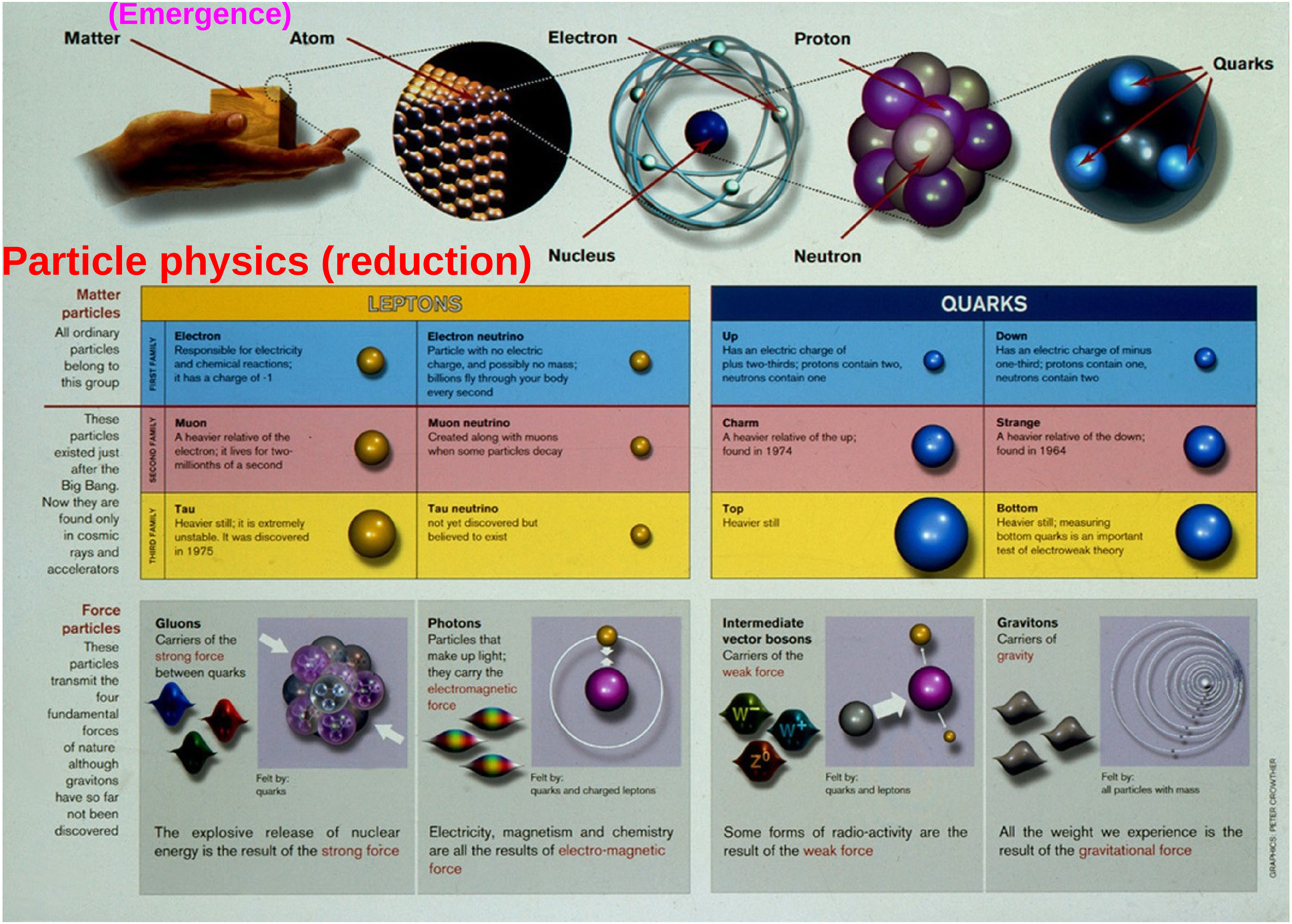
Solid state physics (Emergence) | Atomic physics | Nuclear physics

Particle physics (reduction)



What is the goal of the course

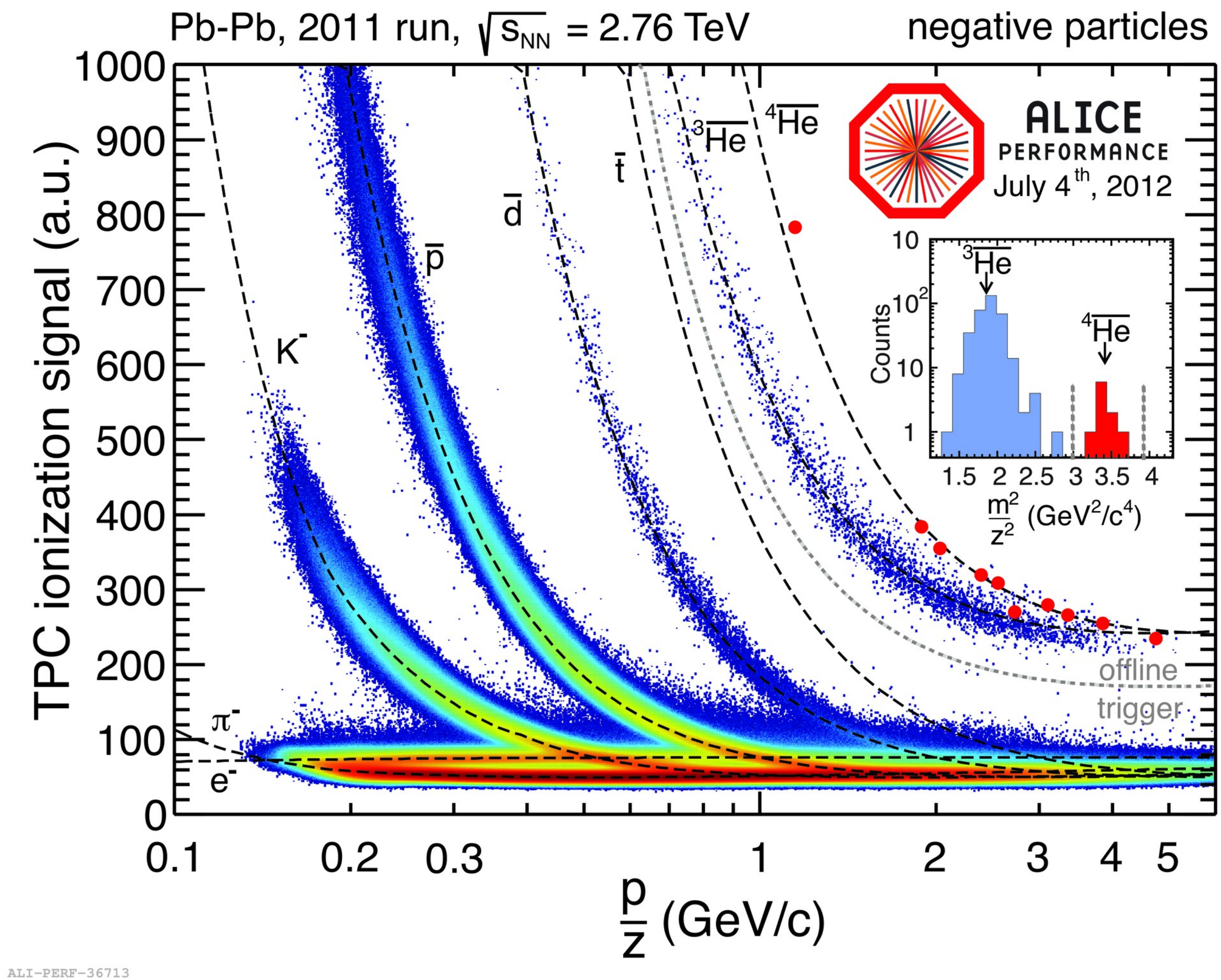
- Provide a broad overview of particle physics: theory and experiment – detectors, and accelerators
- You should after the course be able to be ambassadors for particle physics, i.e., answer these questions that people could ask:
  - Why should I believe in quarks when I cannot observe them?
  - If the strong interaction is so strong why do we not feel it. The electric force seems much stronger.
  - We know that the magnetic field cannot perform work so how do you accelerate particles in a magnetic ring?
  - Why is the observation of the Higgs more interesting than the study of anti-hydrogen? (Tomas Brage:-)

What we offer – Theory

- Particle physics includes a wealth of strange results, and one theory called the standard model that explains most of them. Hopefully this will (like QM) fundamentally change your view of nature
  - Anti-particles: all particles have anti-partners with the same mass but opposite charge
  - Quarks that we can never observe as free particles but that are confined inside hadrons like protons
    - And this is explained by the vacuum being polarized in a way that anti-screens the interactions, i.e., makes them stronger
  - Oscillations – many particles can oscillate from being one type to another: neutrinos, but also some hadrons
  - Parity violation: why does neutrinos (spin ½) only exist in one spin state (left-handed)
  - Gauge principle: we can actually derive all properties of the interactions
  - The Higgs mechanism: the vacuum is permeated by the Higgs field
    - Yet protons do not receive their mass this way but from the quarks being confined

Anti-particles: all particles have anti-partners with the same mass but opposite charge

Anti-alpha observed at LHC



What we offer – Theory

- Particle physics includes a wealth of strange results, and one theory called the standard model that explains most of them. Hopefully this will (like QM) fundamentally change your view of nature
  - Anti-particles: all particles have anti-partners with the same mass but opposite charge
  - Quarks that we can never observe as free particles but that are confined inside hadrons like protons
    - And this is explained by the vacuum being polarized in a way that anti-screens the interactions, i.e., makes them stronger
  - Oscillations – many particles can oscillate from being one type to another: neutrinos, but also some hadrons
  - Parity violation: why does neutrinos (spin ½) only exist in one spin state (left-handed)
  - Gauge principle: we can actually derive all properties of the interactions
  - The Higgs mechanism: the vacuum is permeated by the Higgs field
    - Yet protons do not receive their mass this way but from the quarks being confined

What we offer – Experiment

- The extreme requirements from particle physics has been the driving force in the development of accelerator and experimental techniques
- These accelerators and detectors are now used widely across physics
  - Local examples: MAX IV and ESS
- But also in industry and medicine!
- The same tools will likely play a major role in your own scientific career no matter where you pursue it!

Questions?

- Next, I will go through the course information: material, web pages, compulsory elements

FYSC14 compulsory elements

Monday 2/11 (introduction)

Monday 23/11 (lab-prep)

Lab period 2 (Separate 2.5 hp grade)

Monday 14/12 (lab-data analysis)

Two written assignments to be handed in (25% of final 5 hp grade)

Oral exam (75% of final 5 hp grade)

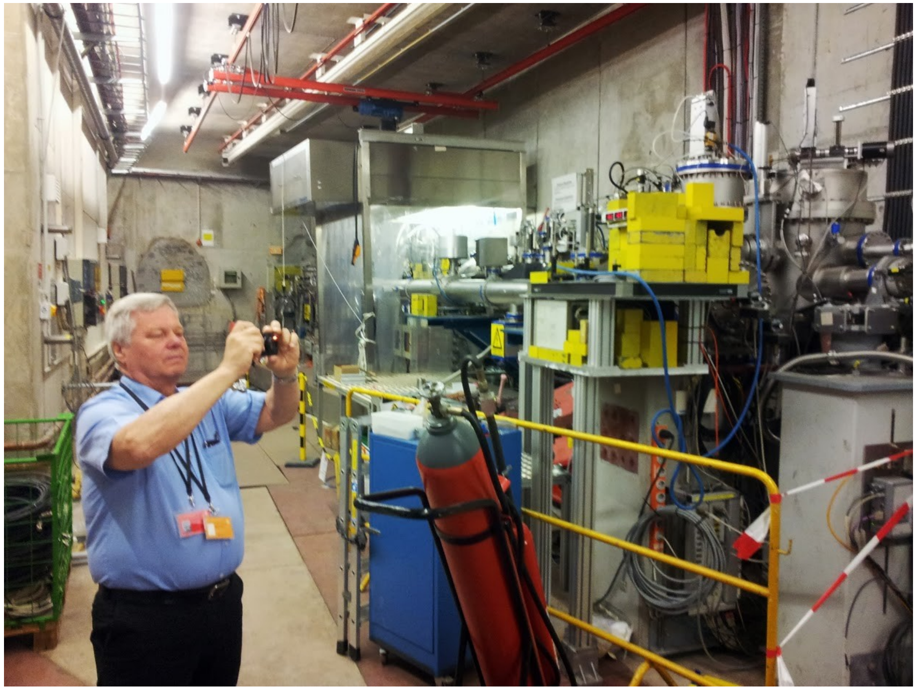
All partial elements of the course: written assignment 1+2, lab, oral exam, DESY trip have to be passed for the course to be passed.

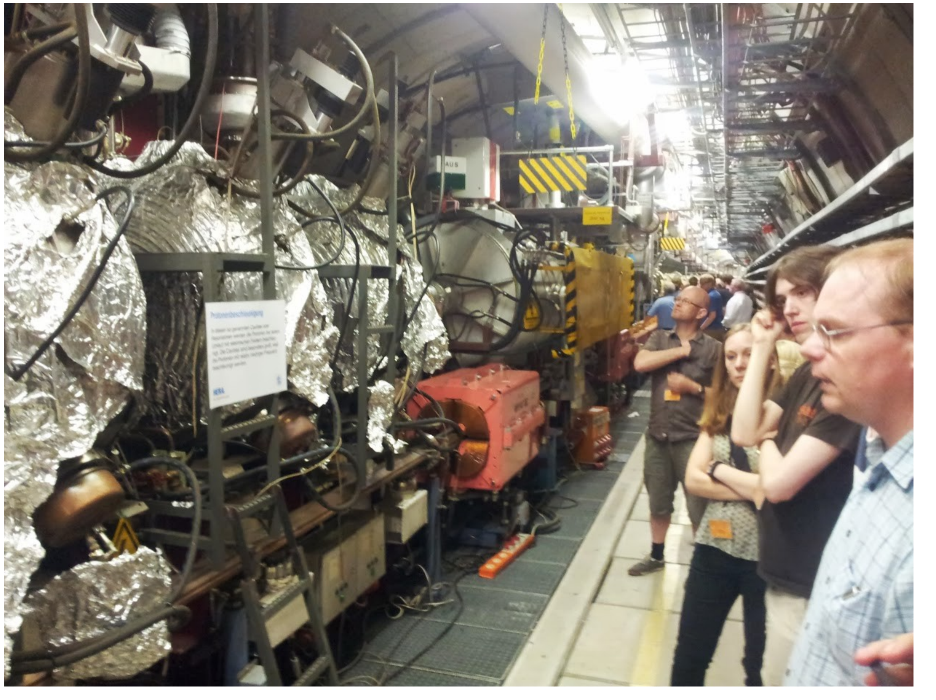
A final Swedish Grade – U, G, VG – (and a percentage/ECTS grade) will be provided.

DESY visit 14-16/1

- Compulsory element!
  - Dates: Thursday 14th of January to Saturday 16th of January
  - Friday 15th of January we visit DESY (Deutsches Elektronen-Synchrotron) in Hamburg Germany
  - To be confirmed: Deposit of 200 SEK needs to be paid to Naomi Facks on Thursday. Will get money back in Hamburg!
  - University pays for transport and hostel

DESY trip pictures

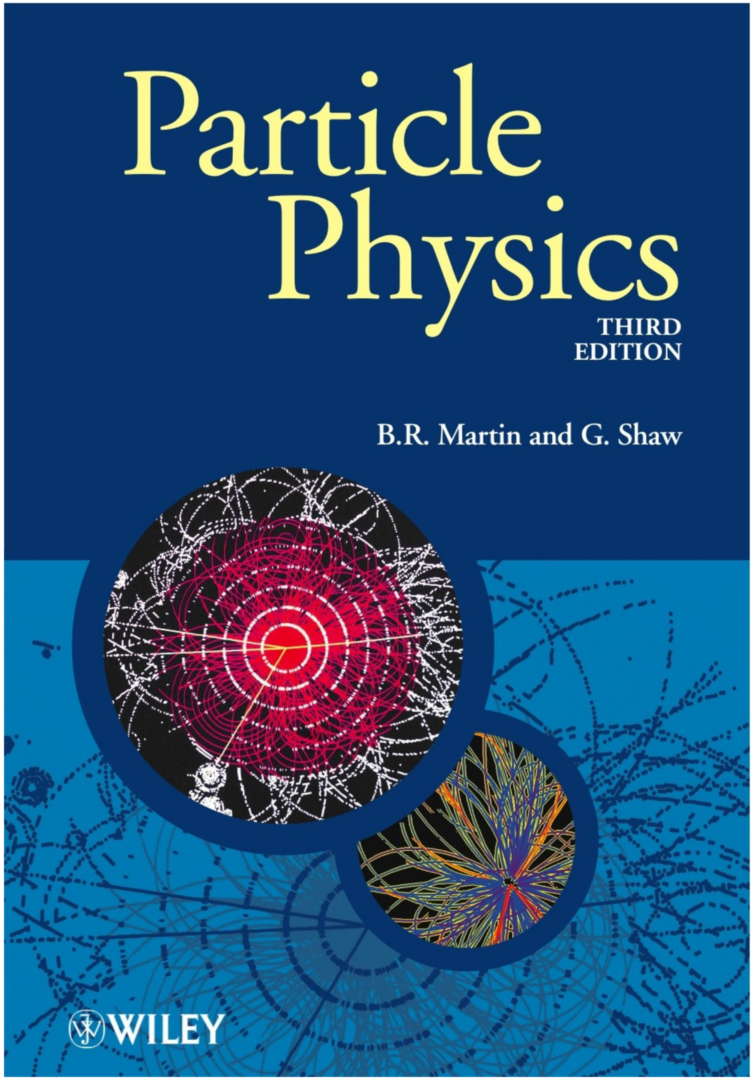




Material

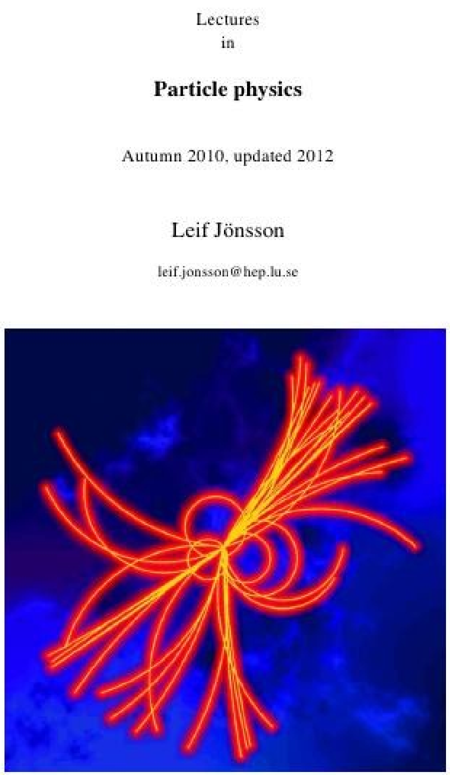
- Please consult also:
  http://www.utbildning.fysik.lu.se/tibet/template/personal%2CIndex.vm?pageid=241426&siteid=1000

Lecture materials (1/3) DEFAULT



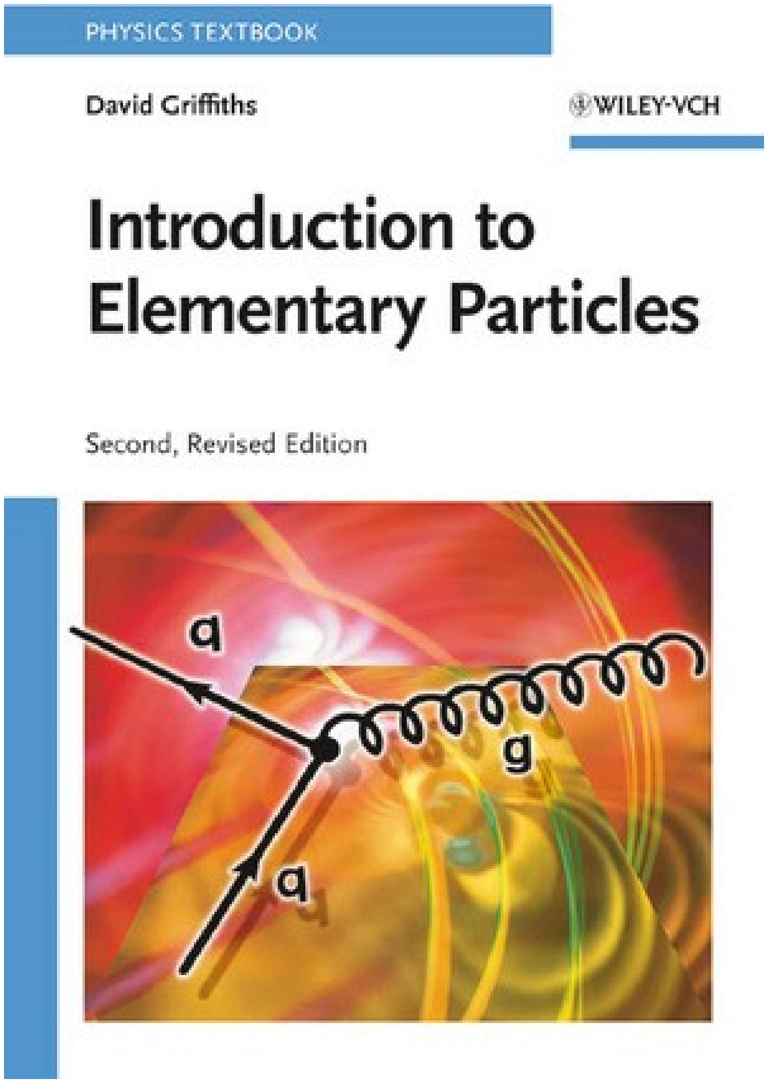
- This is the official book and this is the one we will follow!

Lecture material (2/3)
Condensed, extensive and free!



- Leif's notes. Leif was the original lecturer on this course and for many years.
- Chapter 1 is still part of the official colloquium for the course.
  - The notes will also be used in the introduction of Feynman diagrams and rules
- Short concise text with a lot of material

Lecture material (3/3)
More focus on theory



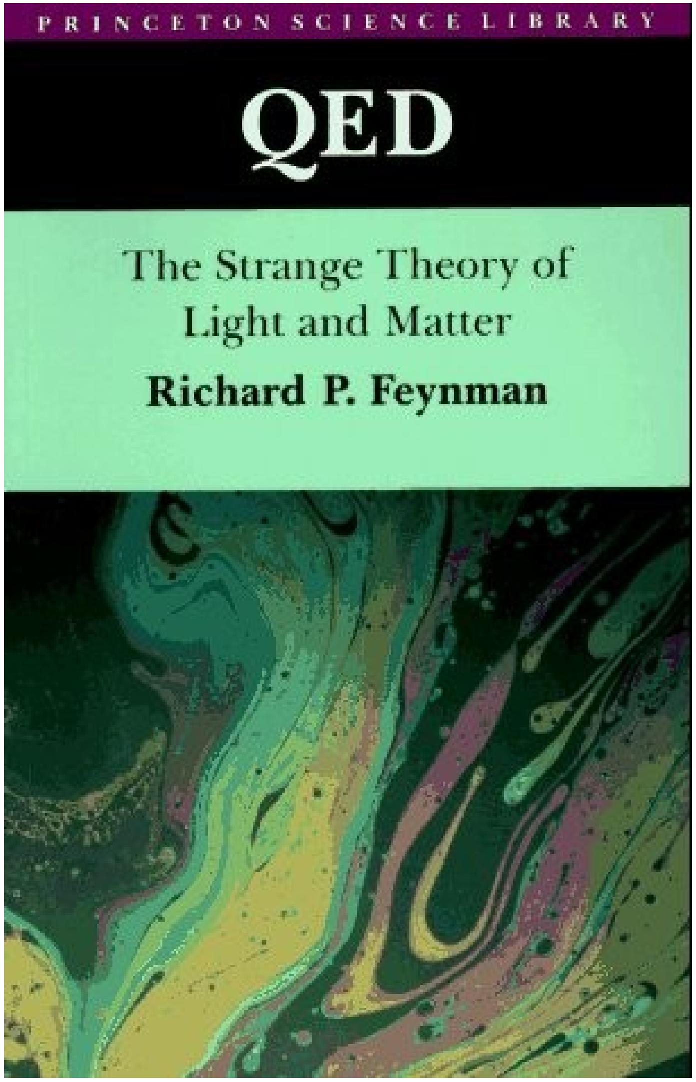
- Griffiths can give you a much better mathematical understanding of the Feynman diagrams.

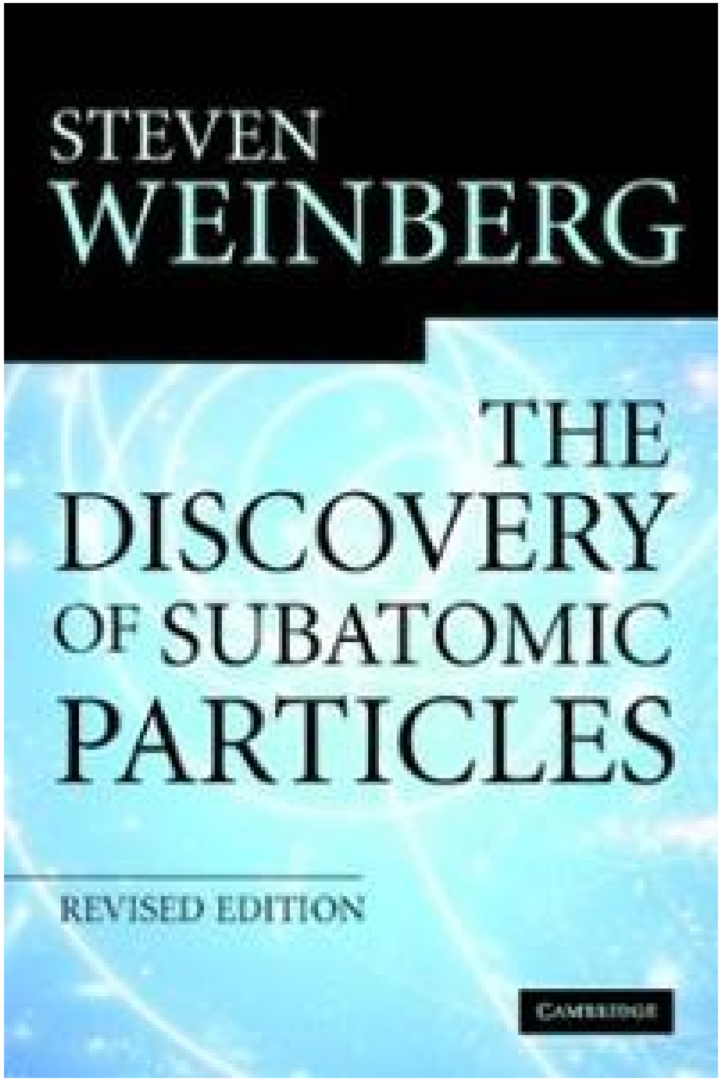
Our opinion

- People are different and in particular learn different, e.g., visual contra verbal learners.
- Try to read a bit in a few books and find the one that fits you the best

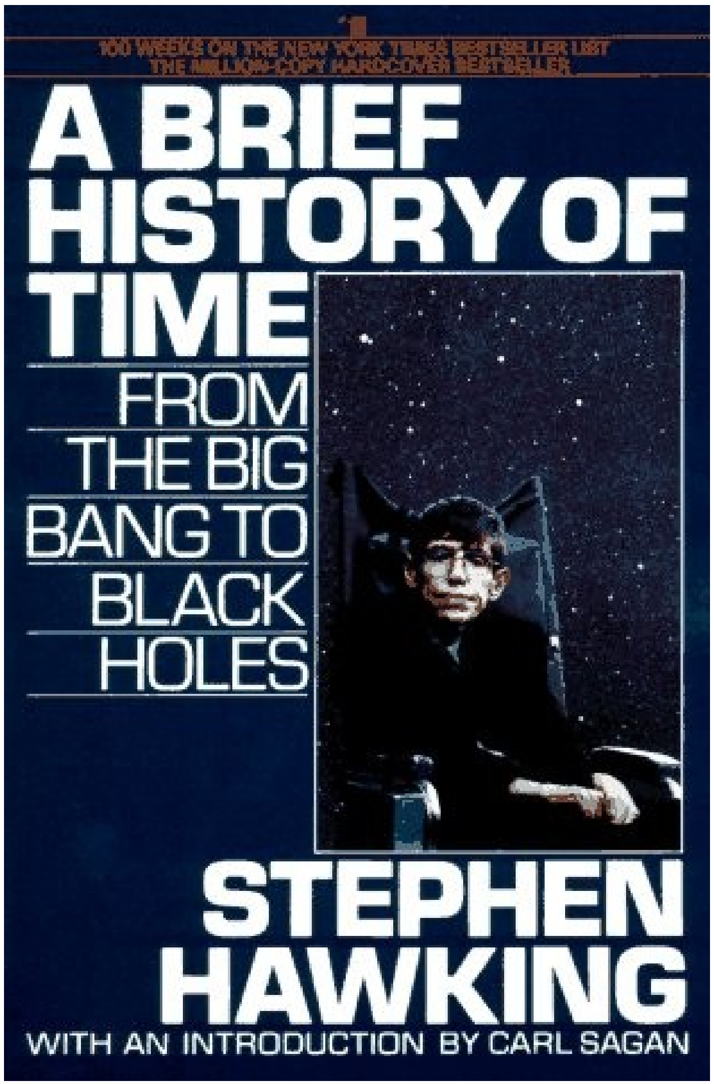
- In some cases you can also have a look at older presentations, e.g., on Peter's web page

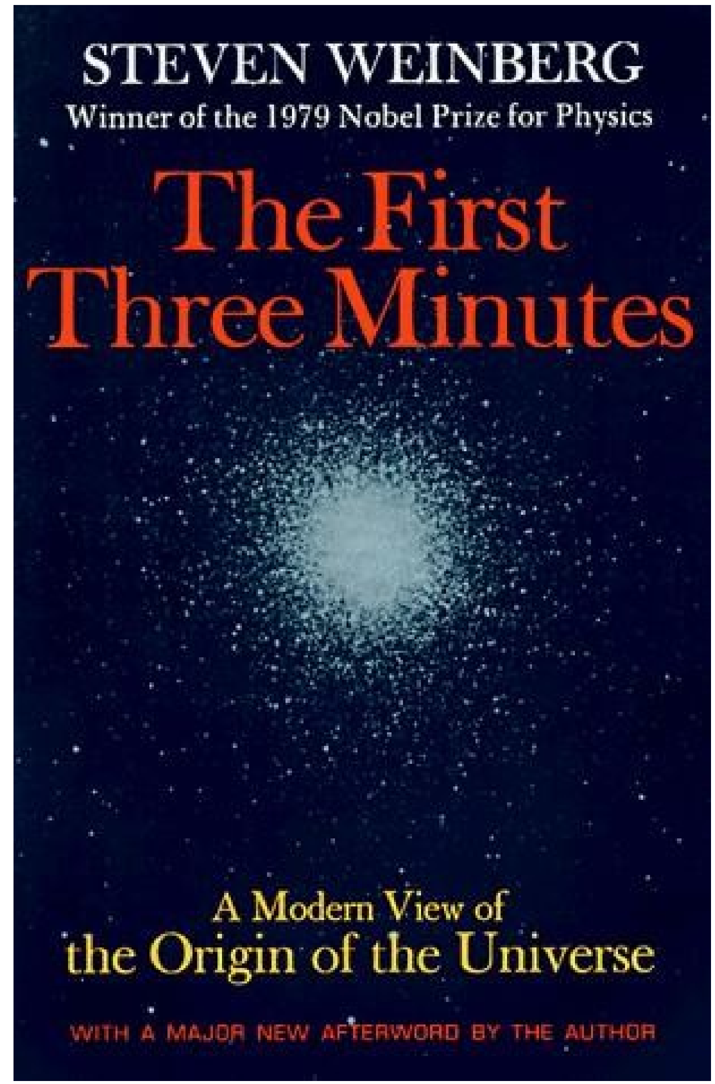
Popular physics (1/4)



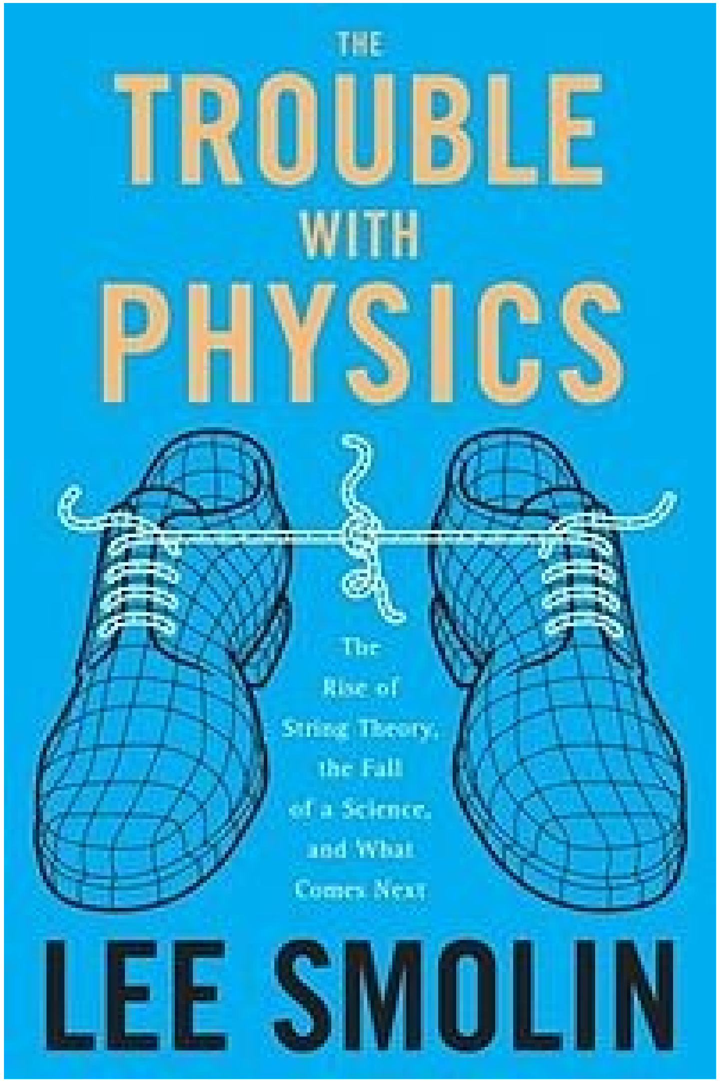


Popular physics (2/4)





Popular physics (3/4)



- Not always popular among theorists but I really recommend it

Popular physics (4/4)

- YouTube contains a lot of nice popular science but also a lot of videos with physics icons

The oral exam

- 30 minutes preparation + 30 minutes examination
- No material can be used in the preparation
- Have to be able to present and discuss details of the standard model and answer 3 randomly selected questions on:
  - A specific particle physics topic
  - Draw one or more Feynman diagrams
  - Detectors or accelerators

Questions?

What would Zlatan do?

- Do you think Zlatan became the star he is today because:
  - a) he went to practice (lectures)
  - b) he played a lot outside practice (homework)
  - c) he constantly challenged himself to perform (thinking about physics)
  - d) all of the above
    - That would be our answer:-)

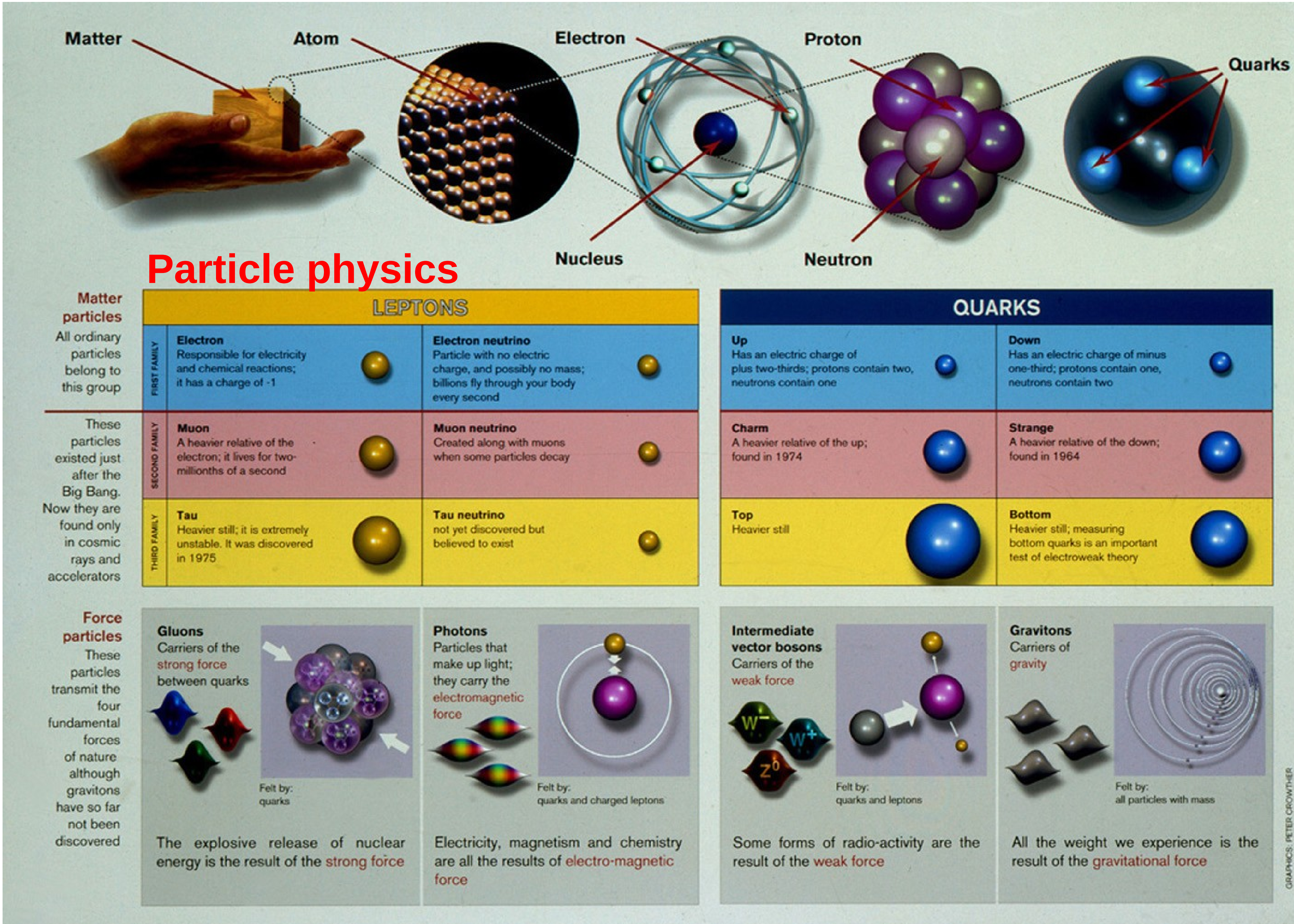
Concrete expectations/suggestions

- We assume that
  - you are here because you want to be here
  - it is your responsibility to learn/study. The course assumes that the lectures will be followed up by self study: reading, exercise solving, and attempting to create a particle physics understanding of the world

- If you have problems with a topic (typically we hear that Feynman diagrams are difficult) you are always welcome to contact us
  - BUT we suggest that you also try to first see what you can do on your own by thinking, solving problems, and looking around for an alternative source of information: text books, articles, and even the internet (being careful here to not trust all you read:-)
    BECAUSE this is how you will have to approach the situation after University
    AND this is in fact exactly a way to get new inspiration for scientific research

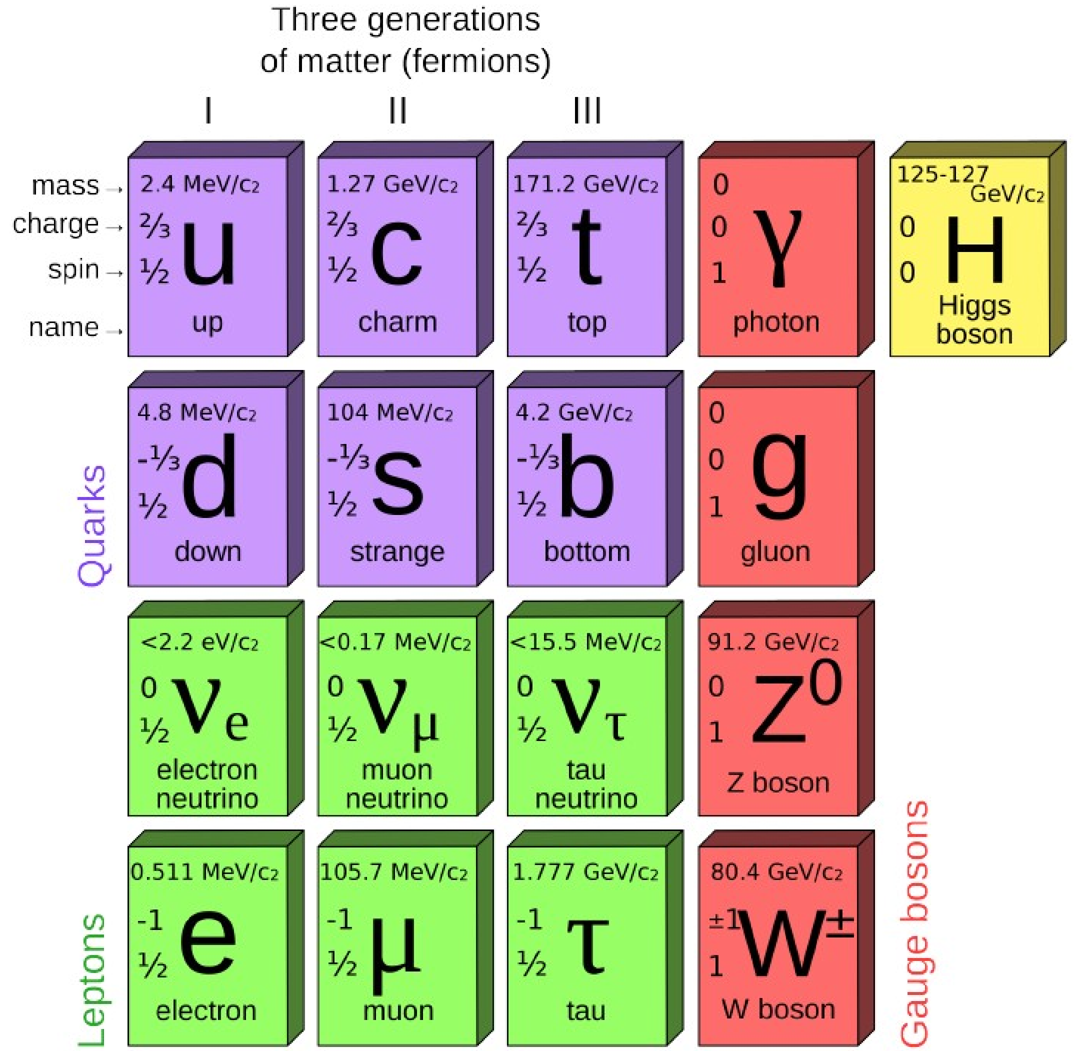
Questions?

Solid state physics Atomic physics Nuclear physics



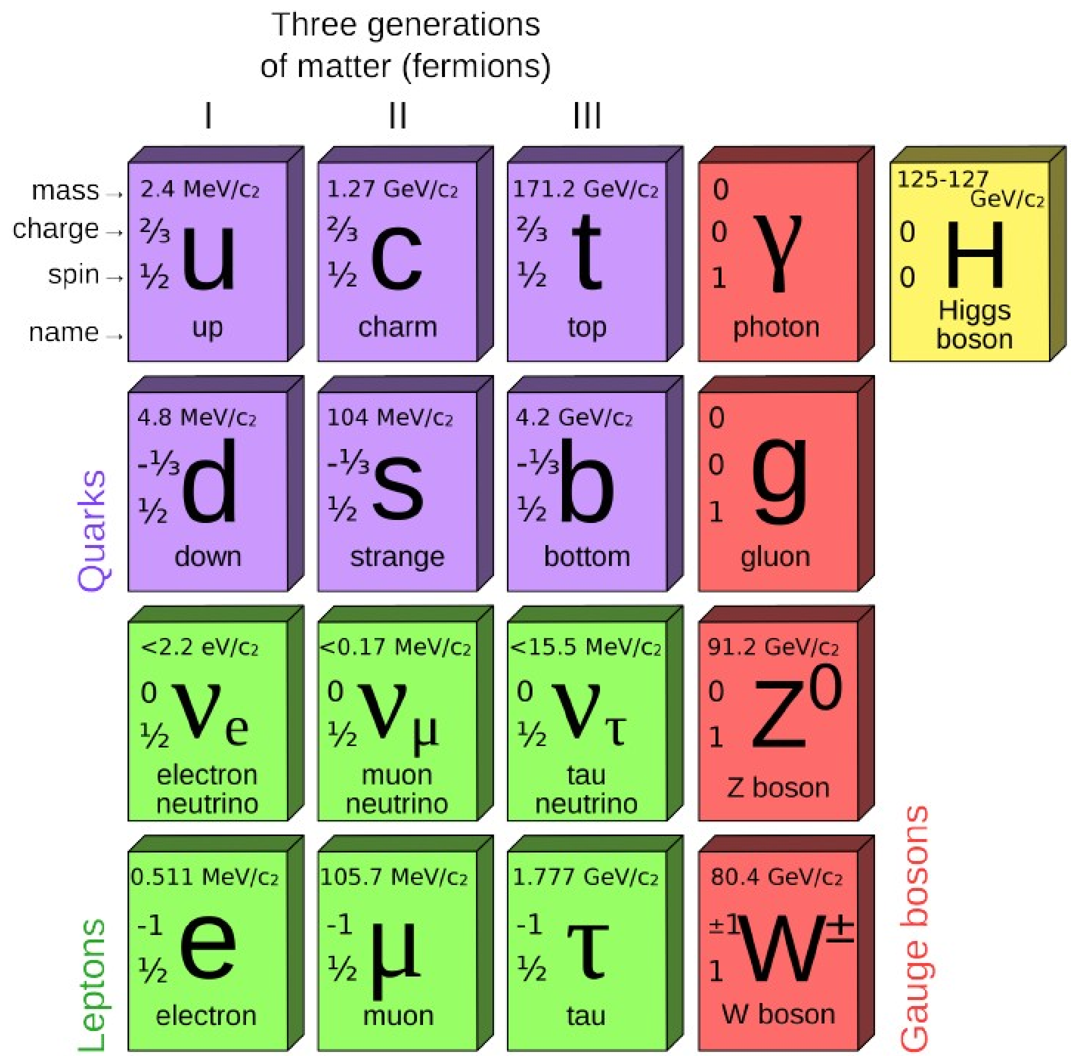
Particle physics

The particle zoo



The main goal of the course is to give you an understanding of the particle zoo and how it works together as the standard model – the underlying framework for all known physics processes

What particles do you know?



Need to know

- Each year at DESY Leif always asks the same two questions:
  - What is a J/ψ (J/Psi): it is a bound state of a charm and an anti-charm quark that weights 3.1 GeV/c^2 (~3 times the proton mass)
  - What is an Y (Ypsilon) : it is a bound state of a bottom and an anti-bottom quark that weights 9.5 GeV/c^2 (~10 times the proton mass)

Goal of today's and tomorrow's lecture

- Introduce four momentum vectors and Feynman diagrams which are important tools for our understanding of the standard model