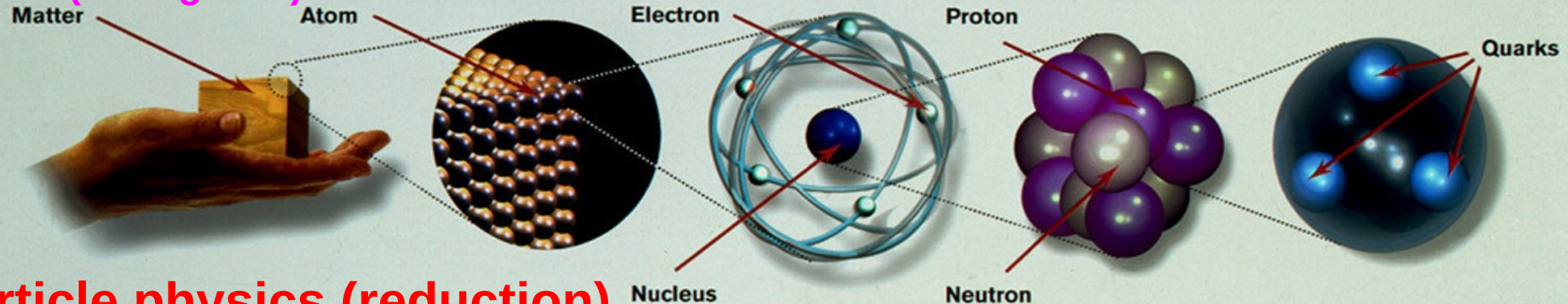


Solid state physics (Emergence)

Atomic physics

Nuclear physics



Particle physics (reduction)

Matter particles All ordinary particles belong to this group	LEPTONS		
	FIRST FAMILY	Electron Responsible for electricity and chemical reactions; it has a charge of -1	Electron neutrino Particle with no electric charge, and possibly no mass; billions fly through your body every second
These particles existed just after the Big Bang. Now they are found only in cosmic rays and accelerators	SECOND FAMILY	Muon A heavier relative of the electron; it lives for two-millionths of a second	Muon neutrino Created along with muons when some particles decay
	THIRD FAMILY	Tau Heavier still; it is extremely unstable. It was discovered in 1975	Tau neutrino not yet discovered but believed to exist

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Force particles

These particles transmit the four fundamental forces of nature although gravitons have so far not been discovered

Gluons
Carriers of the strong force between quarks

Felt by: quarks

The explosive release of nuclear energy is the result of the strong force

Photons
Particles that make up light; they carry the electromagnetic force

Felt by: quarks and charged leptons

Electricity, magnetism and chemistry are all the results of electro-magnetic force

Intermediate vector bosons
Carriers of the weak force

Felt by: quarks and leptons

Some forms of radio-activity are the result of the weak force

Gravitons
Carriers of gravity

Felt by: all particles with mass

All the weight we experience is the result of the gravitational force

What is the goal of the course

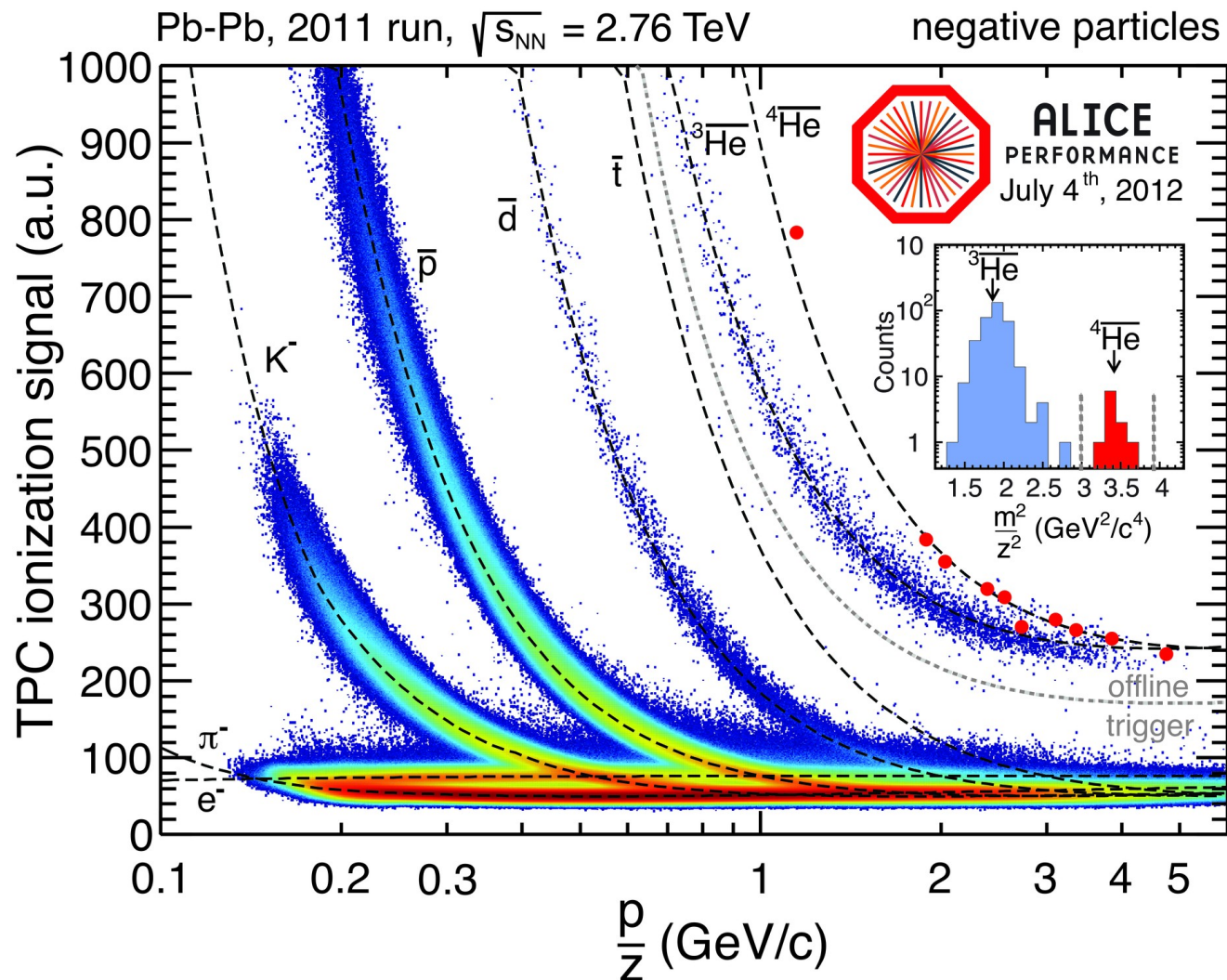
- Provide a broad overview of particle physics: theory and experiment – detectors, and accelerators
- You should after the course be able to be ambassadors for particle physics, i.e., answer these questions that people could ask:
 - Why should I believe in quarks when I cannot observe them?
 - If the 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 $\frac{1}{2}$) 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



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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.

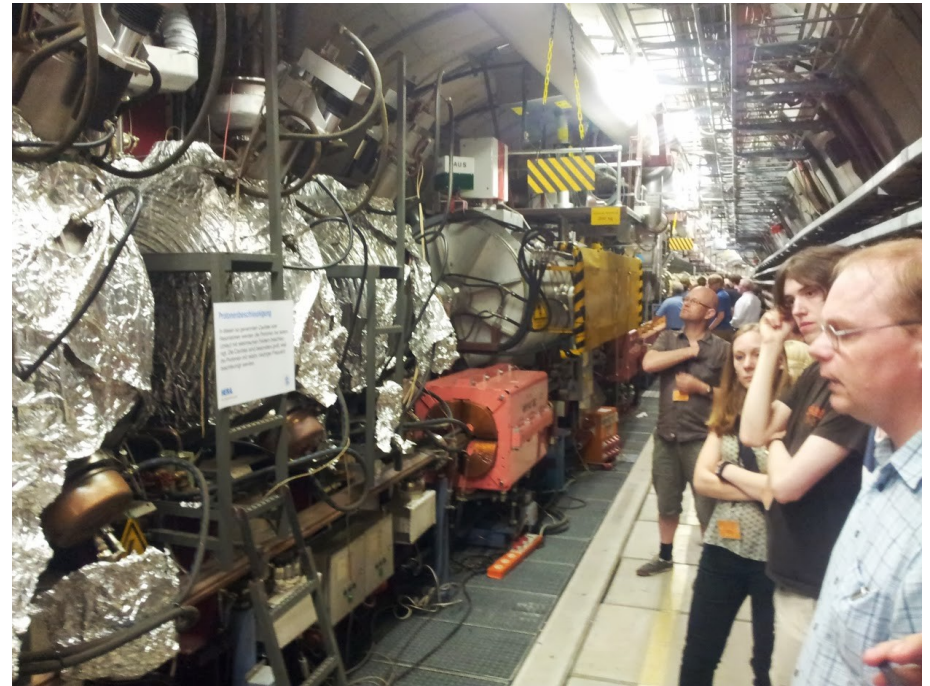
A final Swedish Grade – U, G, VG – (and a percentage/ECTS grade) will be provided.

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



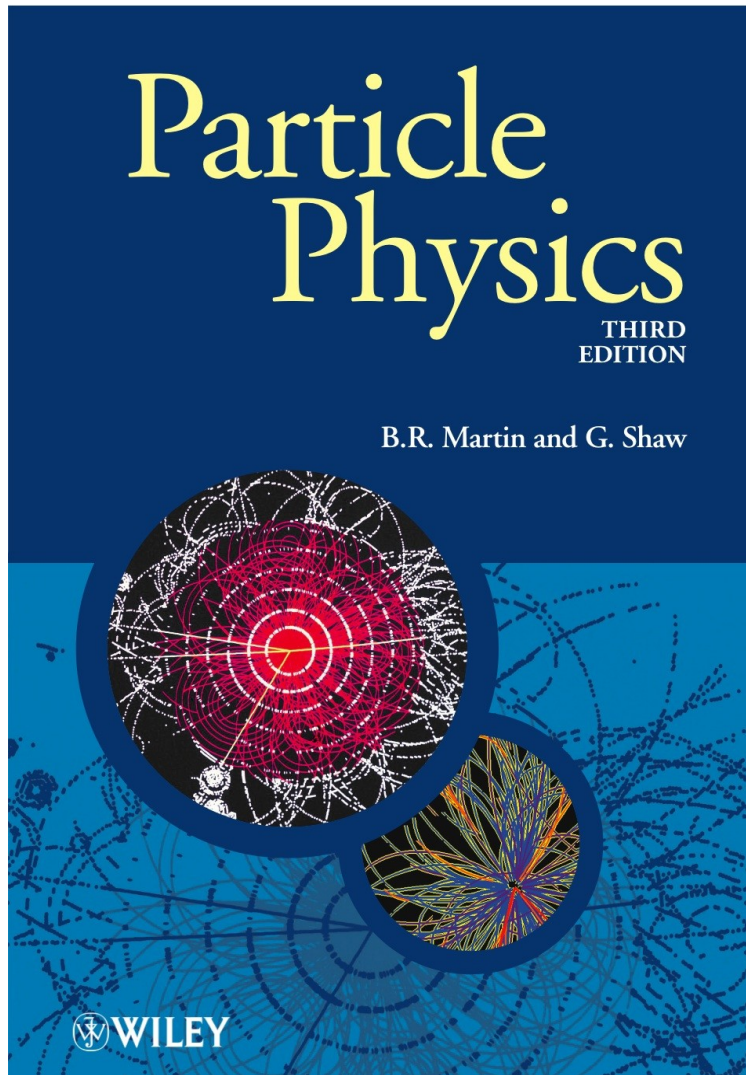
Material

- Please consult also:

<http://www.utbildning.fysik.lu.se/tibet/template/personal%2CIndex.vm?pageid=241426&siteid=1000>

Lecture materials (1/3)

DEFAULT

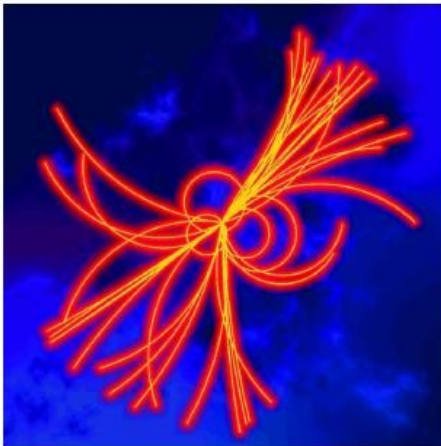


- This is the official book and this is the one we will follow!

Lecture material (2/3)

Condensed, extensive and free!

Lectures
in
Particle physics
Autumn 2010, updated 2012
Leif Jönsson
leif.jonsson@hep.lu.se



- 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

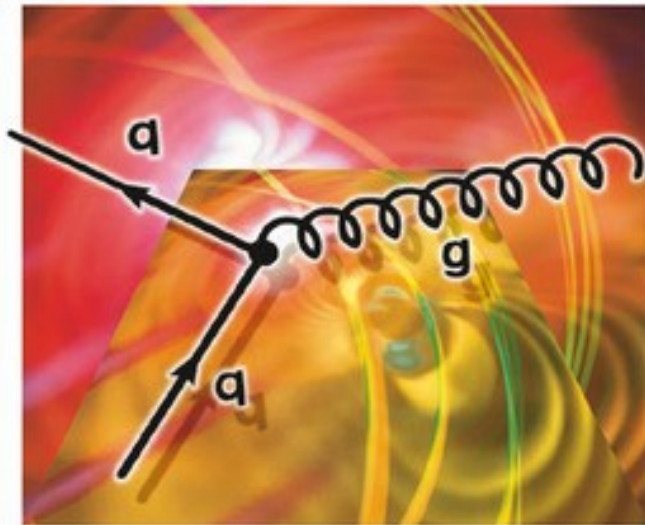
PHYSICS TEXTBOOK

David Griffiths

WILEY-VCH

Introduction to Elementary Particles

Second, Revised Edition

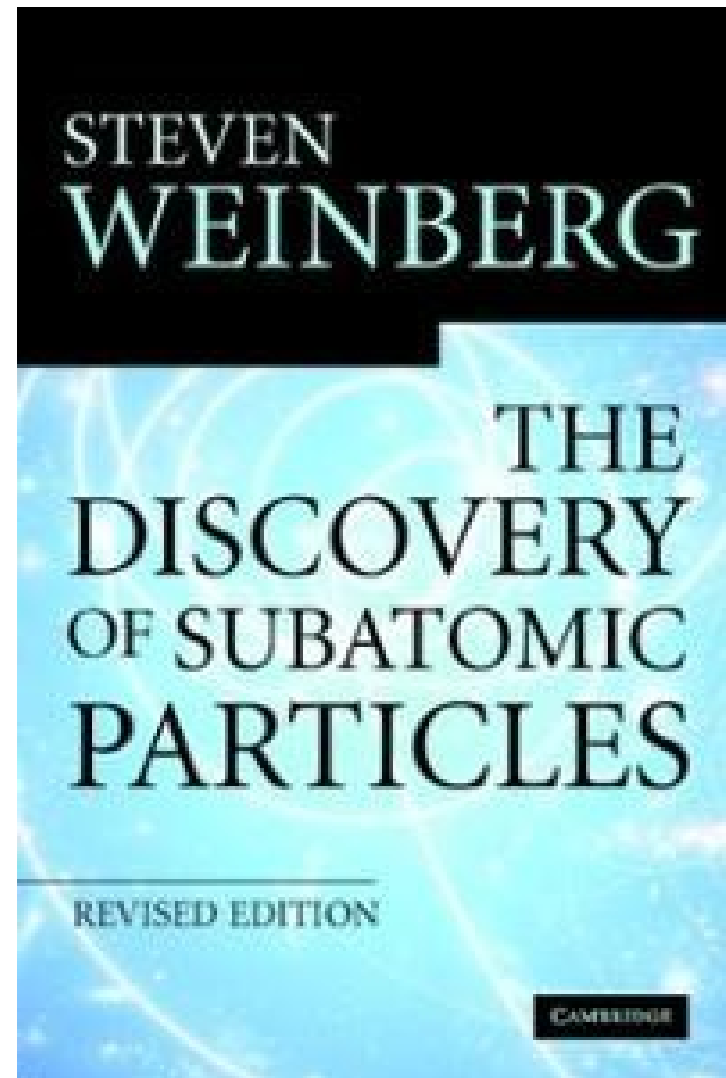
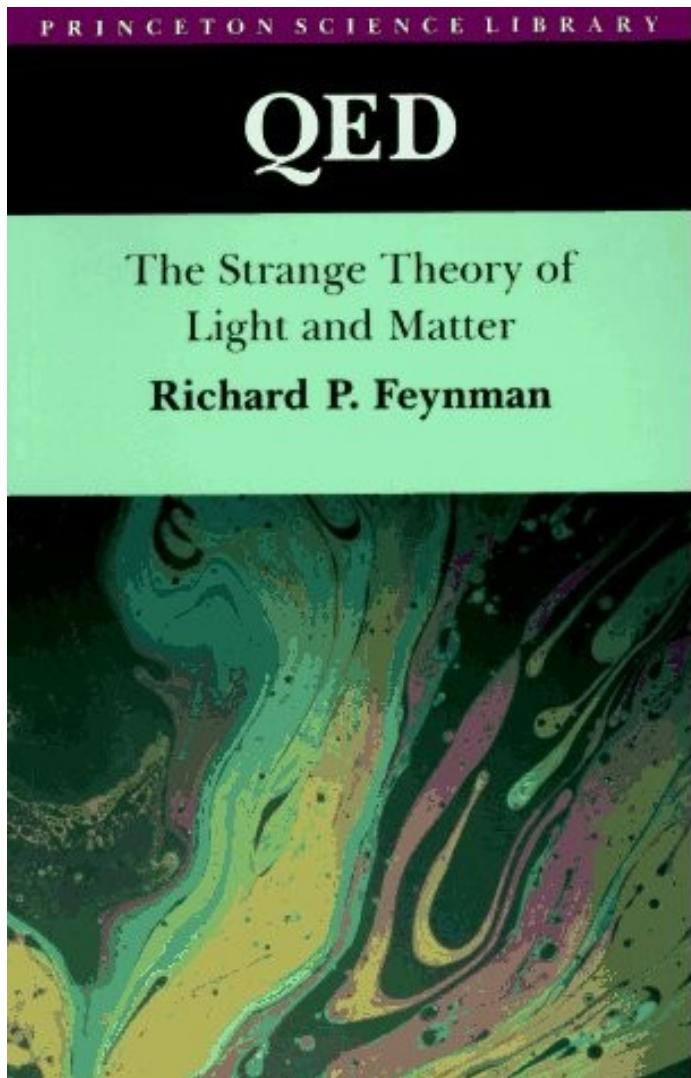


- Griffiths can give you a much better mathematical understanding of the Feynman diagrams.

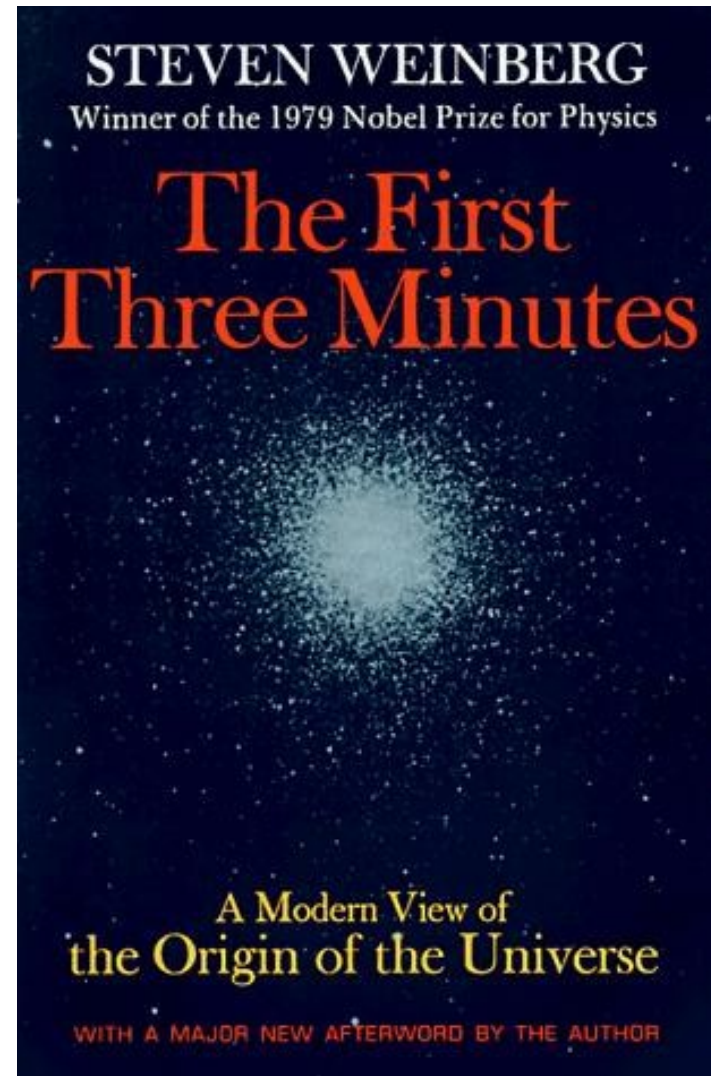
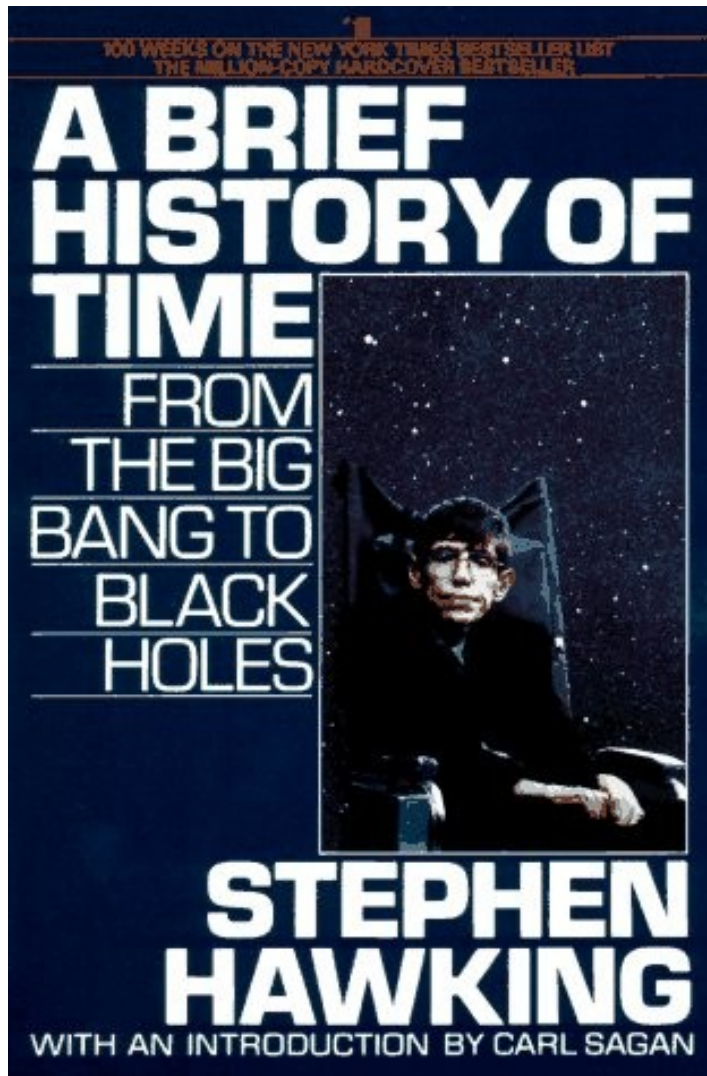
Our opinion

- 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

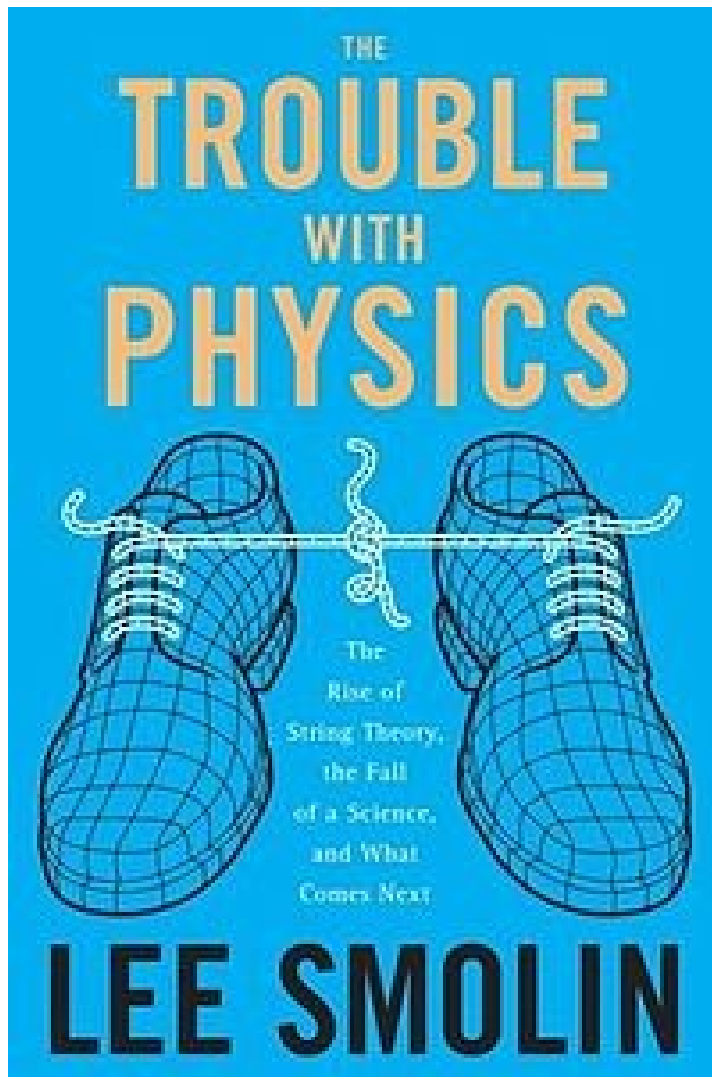
Popular physics (1/4)



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

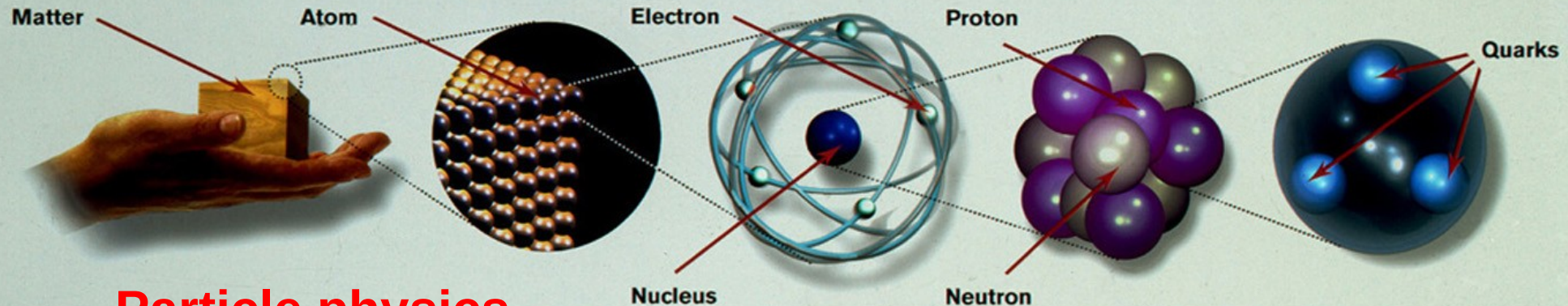
- We assume that
 - you are here because you want to be here
 - it is your responsibility to learn/study. The course assumes that the lectures will be followed up by self study: reading, exercise solving, and attempting to create a particle physics understanding of the world
- If you have problems with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

Matter particles
All ordinary particles belong to this group

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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 $3.1 \text{ GeV}/c^2$ (~ 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 $9.5 \text{ GeV}/c^2$ (~ 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