

FYSC14 compulsory elements

Monday 3/11 (introduction)

Monday 24/11 (lab-prep)

Lab period 2 (Separate 2.5 hp grade)

Monday 15/12 (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.

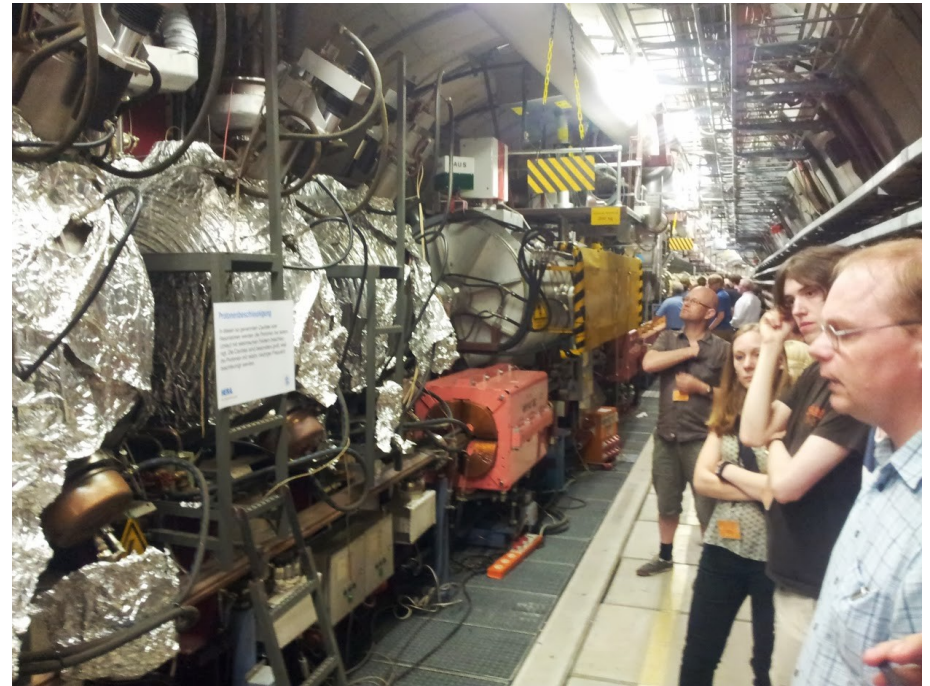
A final Swedish Grade – U, G, VG – (and a percentage/ECTS grade) will be provided.

DESY visit 15-17/1

- Compulsory element!
 - Dates: Thursday 15th of January to Saturday 17th of January
 - Friday 16th of January we visit DESY (Deutsches Elektronen-Synchrotron) in Hamburg Germany
 - 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



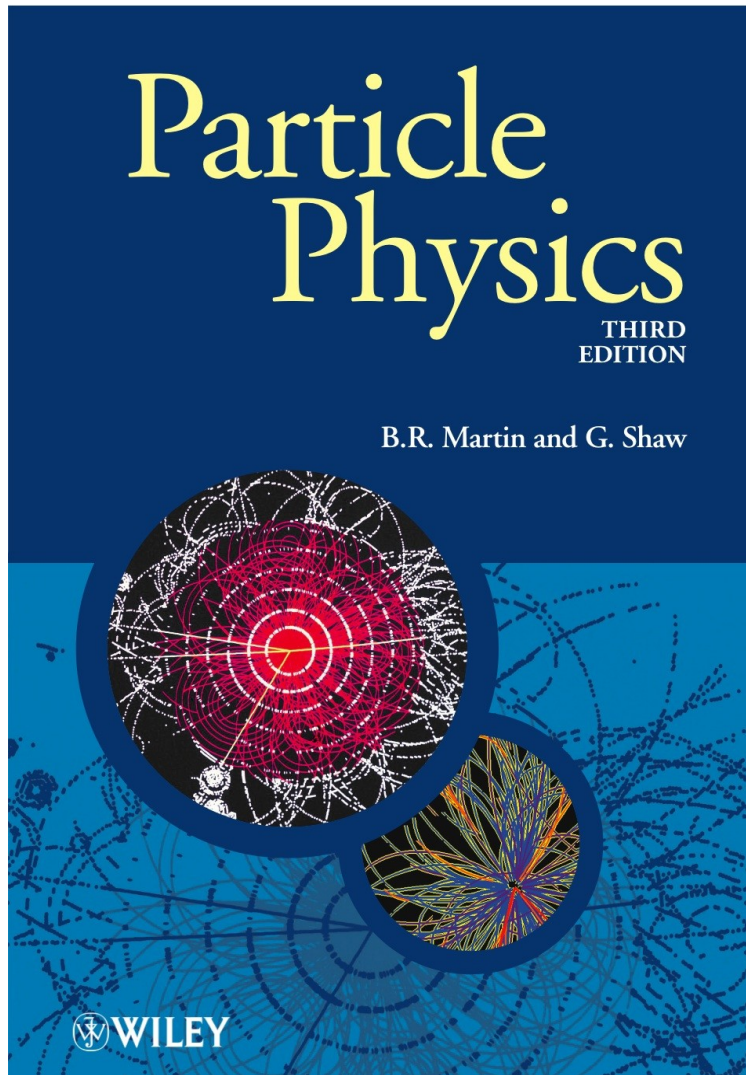
Material

- Please consult also:

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

Lecture materials (1/3)

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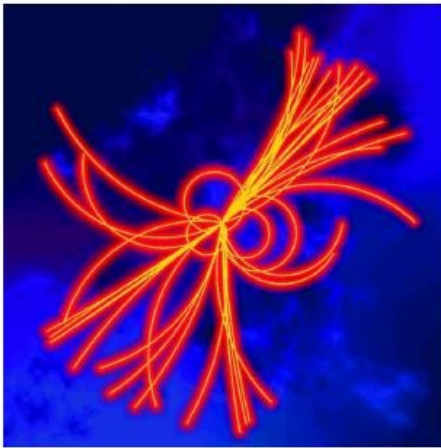


- This is the official book and this is the one we will follow!

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.
 - This time 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

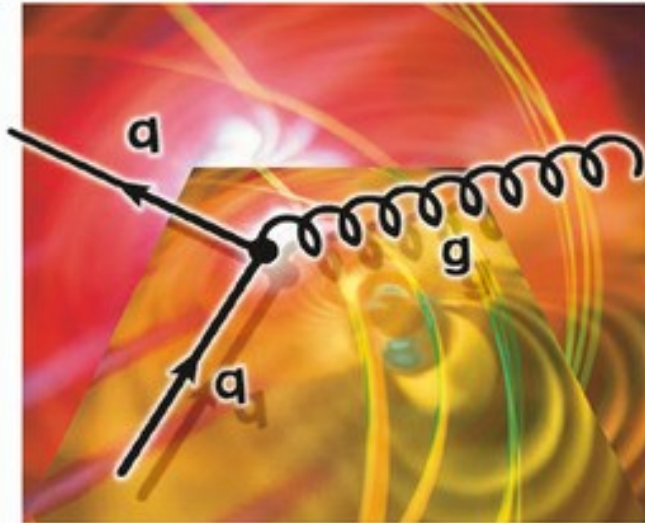
PHYSICS TEXTBOOK

David Griffiths

WILEY-VCH

Introduction to Elementary Particles

Second, Revised Edition

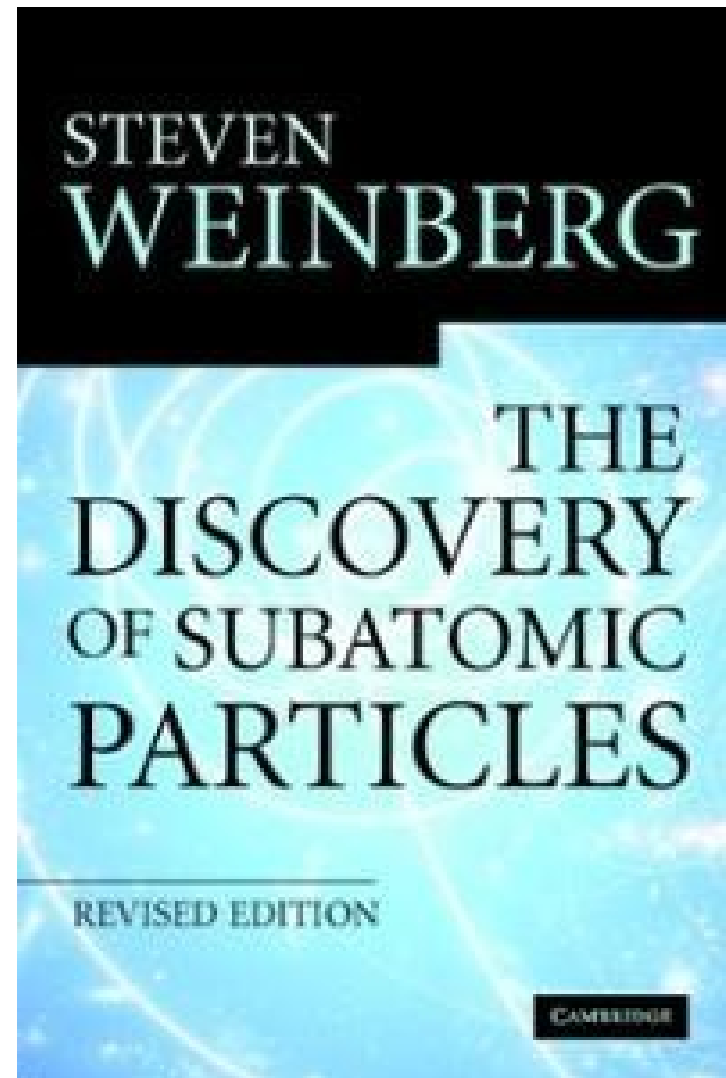
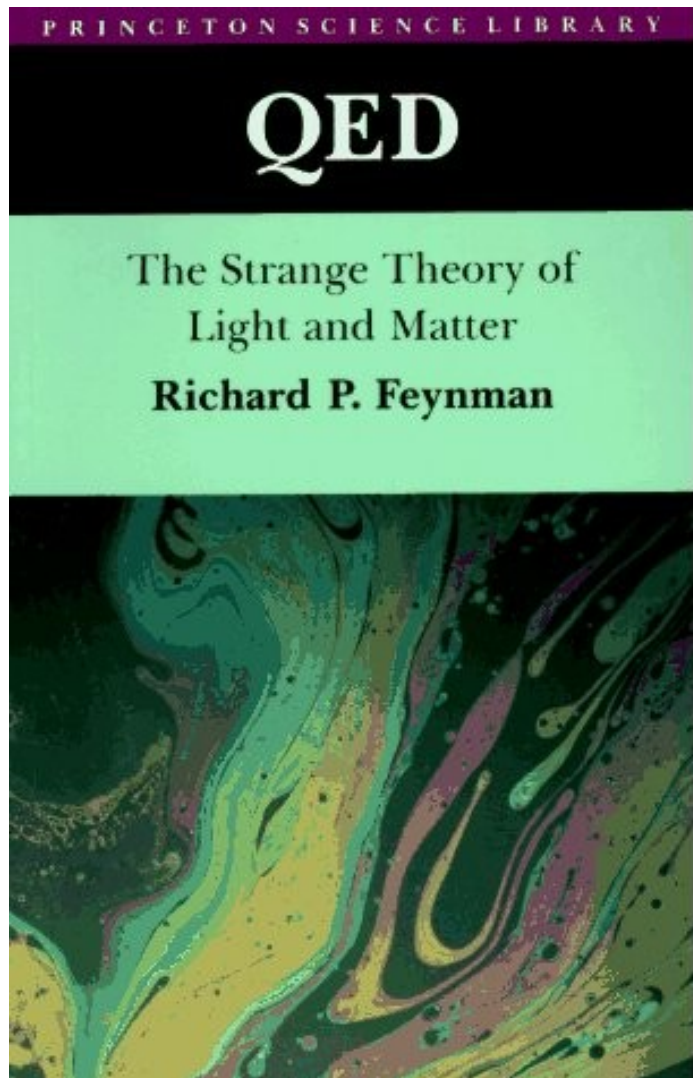


- Griffiths can give you a much better mathematical understanding of the Feynman diagrams.

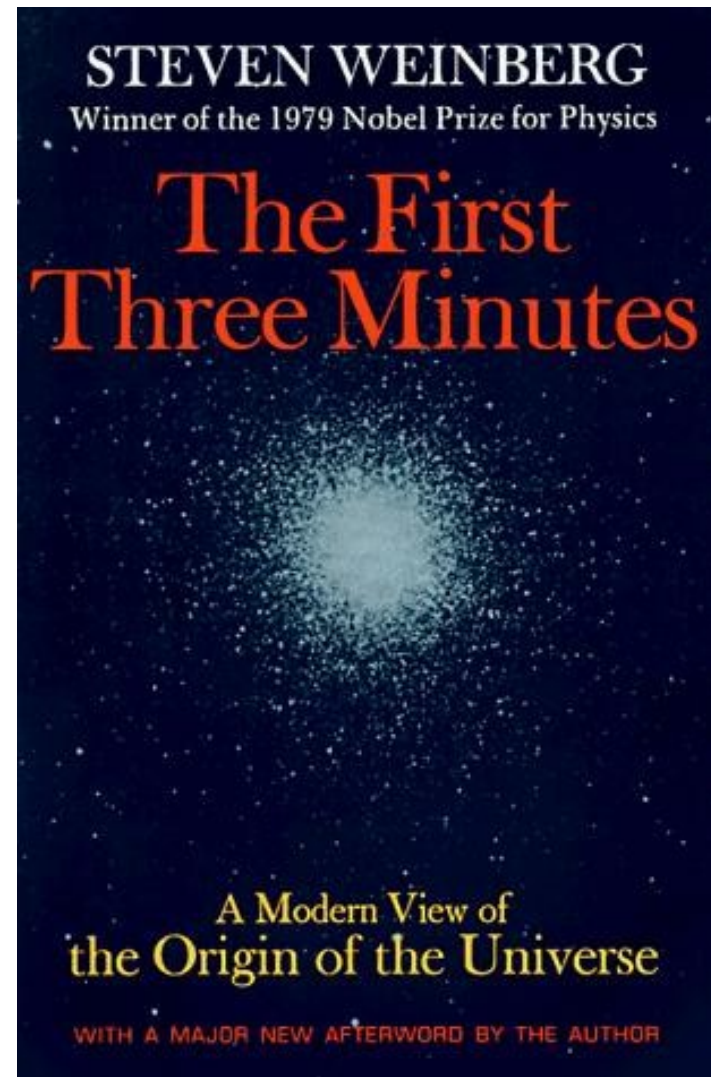
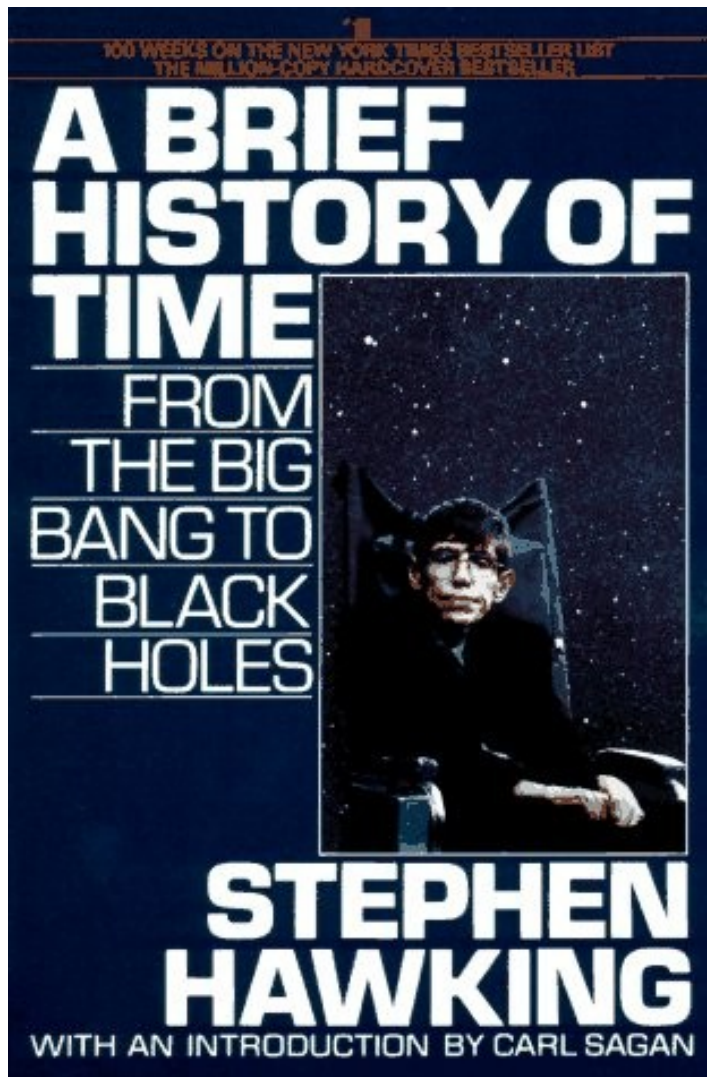
Our opinion

- 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

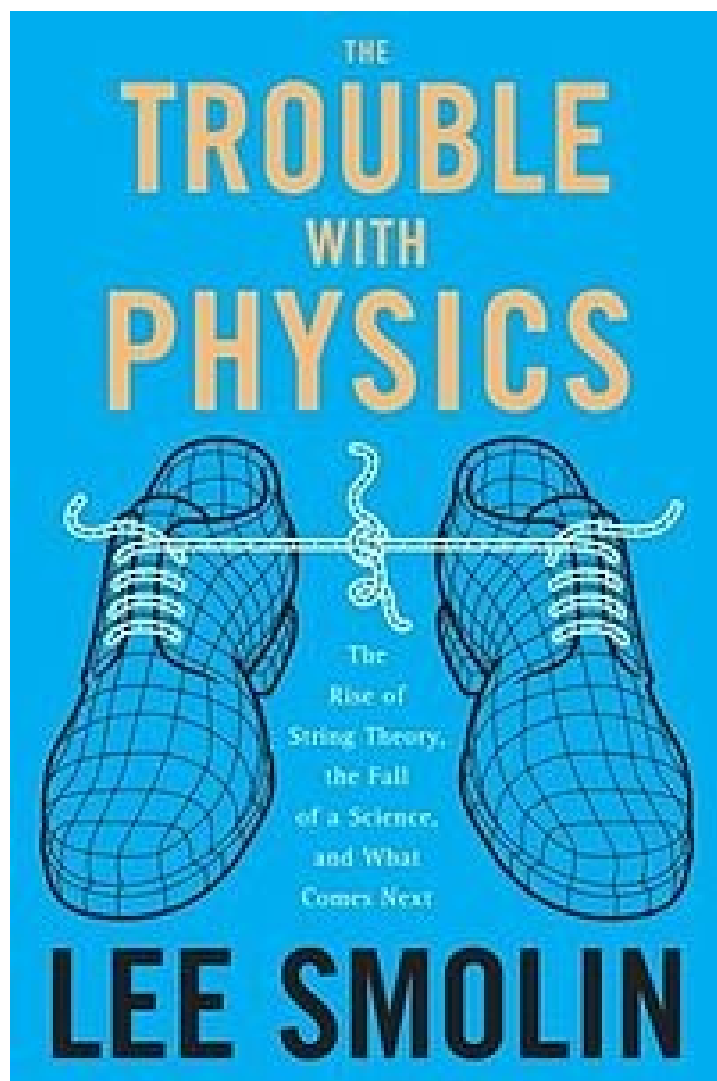
Popular physics (1/4)



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 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 (1/2)

- 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

What we offer (2/2)

- 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: MAXIV 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!

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

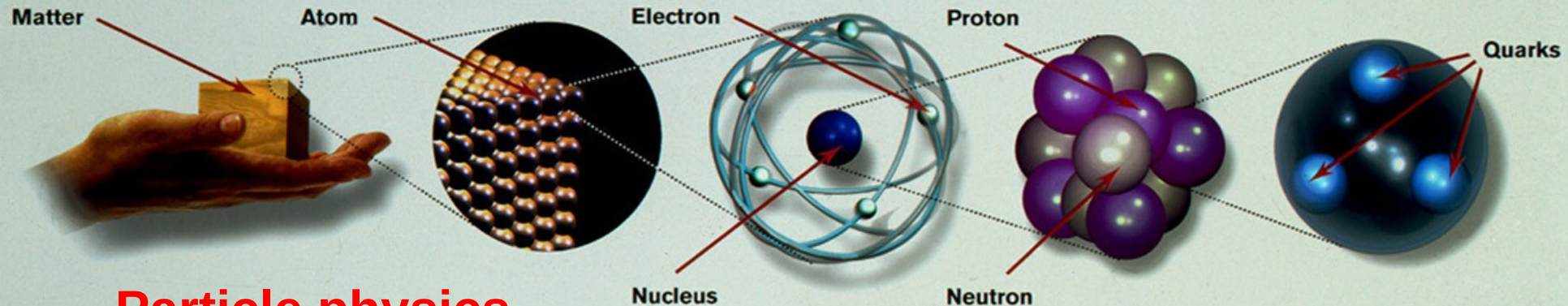
- We assume that
 - you are here because you want to be here
 - it is your responsibility to learn/study. The course assumes that the lectures will be followed up by self study: reading, exercise solving, and attempting to create a particle physics understanding of the world
- If you have problems with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

Questions?

Solid state physics

Atomic physics

Nuclear physics



Particle physics

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
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

QUARKS	
Up Has an electric charge of plus two-thirds; protons contain two, neutrons contain one	Down Has an electric charge of minus one-third; protons contain one, neutrons contain two
Charm A heavier relative of the up; found in 1974	Strange A heavier relative of the down; found in 1964
Top Heavier still	Bottom Heavier still; measuring bottom quarks is an important test of electroweak theory

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

The particle zoo

Three generations of matter (fermions)

	I	II	III		
mass →	2.4 MeV/c ²	1.27 GeV/c ²	171.2 GeV/c ²	0	125-127 GeV/c ²
charge →	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0	0
spin →	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
name →	u up	c charm	t top	γ photon	H Higgs boson
	4.8 MeV/c ²	104 MeV/c ²	4.2 GeV/c ²	0	
	$-\frac{1}{3}$	$-\frac{1}{3}$	$-\frac{1}{3}$	0	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
Quarks	d down	s strange	b bottom	g gluon	
	<2.2 eV/c ²	<0.17 MeV/c ²	<15.5 MeV/c ²	91.2 GeV/c ²	
	0	0	0	0	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	Z⁰ Z boson	
	0.511 MeV/c ²	105.7 MeV/c ²	1.777 GeV/c ²	80.4 GeV/c ²	
	-1	-1	-1	±1	
	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	
Leptons	e electron	μ muon	τ tau	W[±] W boson	Gauge bosons

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

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