Particle Physics in the International Baccalaureate Diploma (IB)

A CERN HST-2010
working group proposal

IB Diploma programme

- Pre-university education for 16 $\rightarrow$ 19 year olds
- > 500,000 graduates since 1970
- 2183 schools in 138 countries
- All students must study at least one science (group 4) subject at Standard or Higher Level

IB Physics

- **Standard level**: 110 hours
  80 hours CORE +
  2 x 15 hour **OPTIONS**
- **Higher Level**: 180 hours
  135 hours CORE +
  2 x 22 hours **OPTIONS**
- Plus **Lab** hours
  (SL = 40 hours; HL = 60 hours)

Lab work in Particle Physics?

- “IA activities should ideally include a spread of content material from the core, **options** and, where relevant, AHL material.”
- “A minimum number of investigations to be carried out is not specified.”

IB Physics Guide

How much lab work?

- Not specified
- Each option takes 22 / 180 total theory teaching hours (~12%)

$\Rightarrow$ we should aim for 12% x 50 hours of total lab *(not including group 4 project)*

$\Rightarrow$ approx. **6 hours** for particle physics at Higher Level!

- Can include computer simulations / database tasks

it’s a free market…

HL options *(select any 2):*

- Astrophysics
- Communications
- Electromagnetic waves
- Relativity
- Medical physics
- **Particle physics**

Teachers might not choose particle physics because:

- It is a new option (2009)
  $\Rightarrow$ few example questions
- It is outside their specialist area of knowledge
- There are few good quality teaching resources available
- What to do for lab work?

aim of this project

… to produce a single, coherent, high quality set of teaching resources:
- PowerPoint
- Worksheets
- Suggestions for lab work
- Homework sheets
- Exemplars
- Extension materials

… to encourage more teachers to offer particle physics

… to improve the quality of teaching and learning in particle physics

A 2-way resource:

- From syllabus statements to content
  *(recognising that the IB syllabus booklet is the **prime document** for IB teachers)*

- A storyboard approach: telling the tale of particle physics
  (a new CERN-branded course that covers all IB criteria in a more engaging way)

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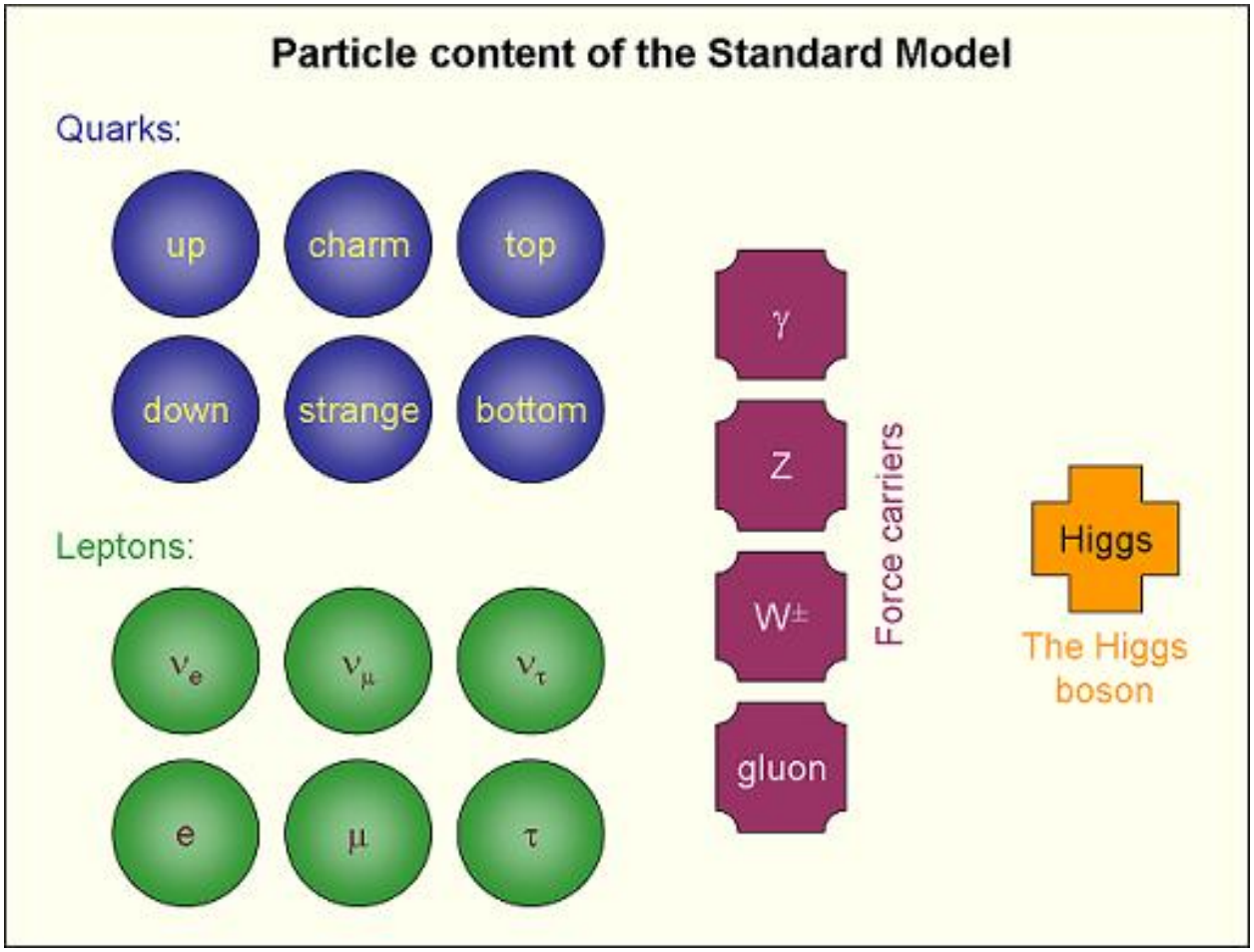
Syllabus to content…

- J1: Particles & interactions
- J2: Particle accelerators & detectors
- J3: Quarks
- J4: Leptons & the standard model
- J5: Experimental evidence for the quark & standard models
- J6: Cosmology & strings

J1: Particles & interactions

- J1.1: State what is meant by an elementary particle
- J1.2: Identify elementary particles
- J1.3: Describe particles in terms of mass and various quantum numbers
- J1.4: Classify particles according to spin
- J1.5: State what is meant by an antiparticle
- J1.6: State the Pauli exclusion principle
- J1.7: List the fundamental interactions
- J1.8: Describe the fundamental interactions in terms of exchange particles
- J1.9: Discuss the uncertainty principle for time and energy in the context of particle creation

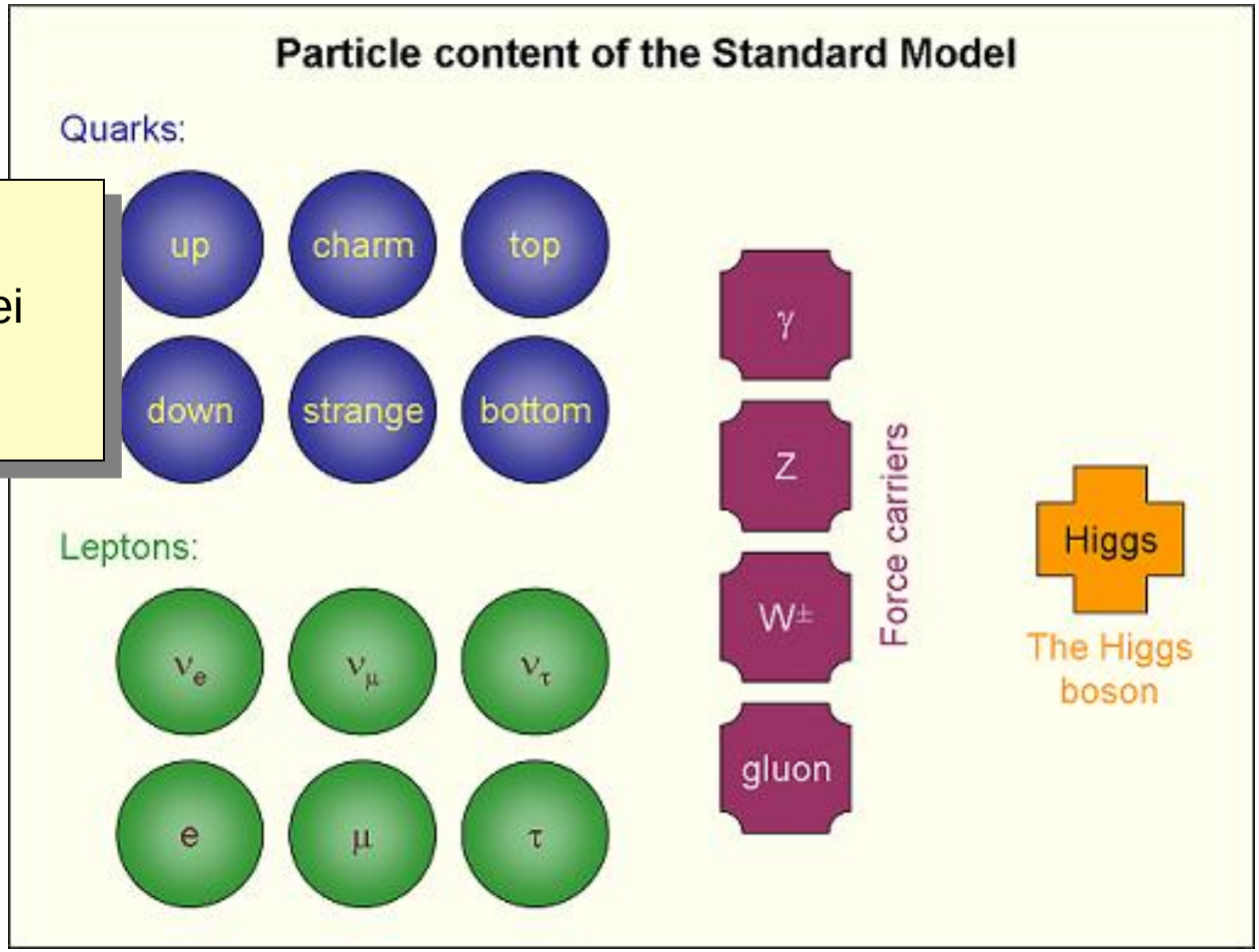
J1.2: Identify elementary particles



J1.2: Identify elementary particles

QUARKS:

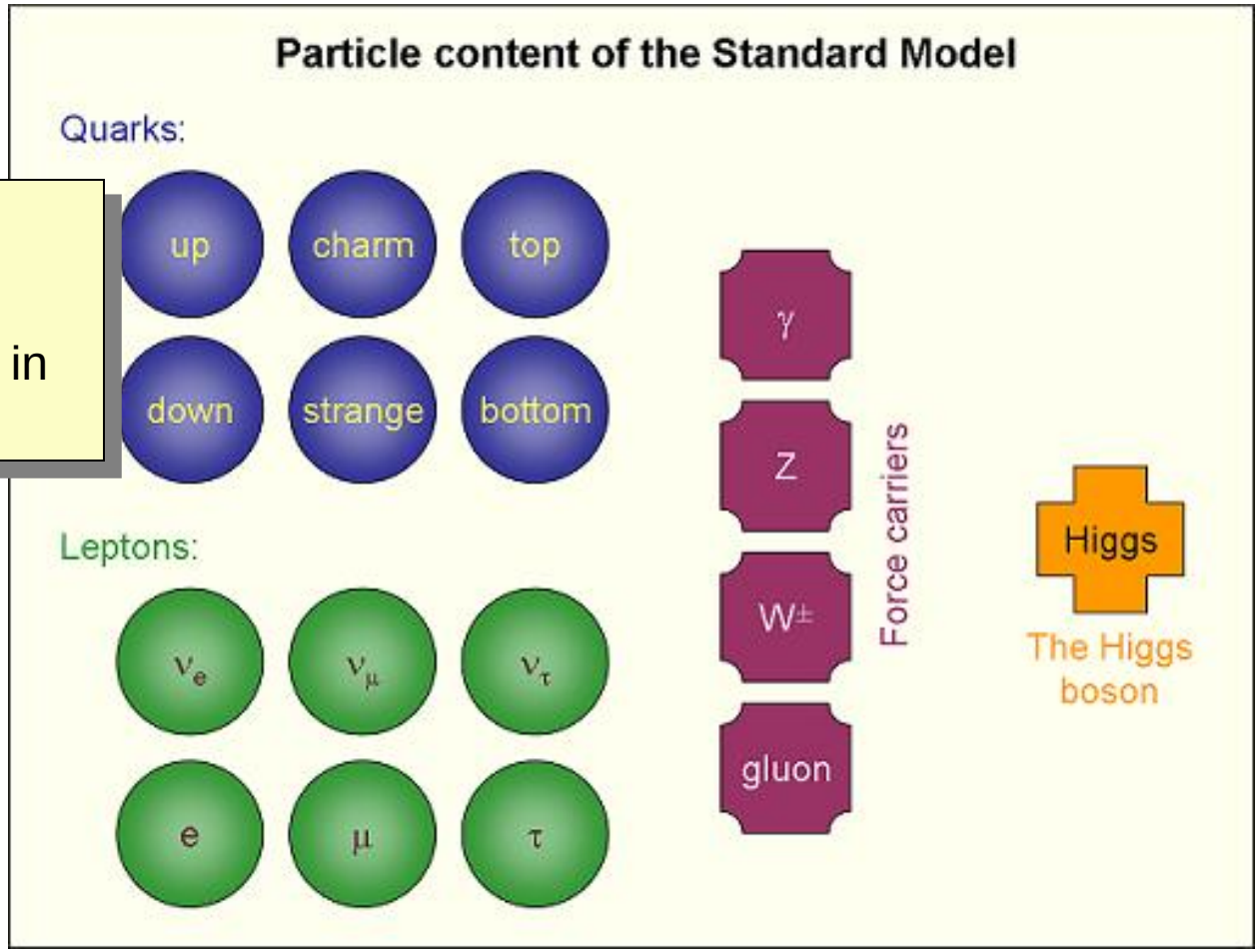
Atomic nuclei are made of these



J1.2: Identify elementary particles

QUARKS:

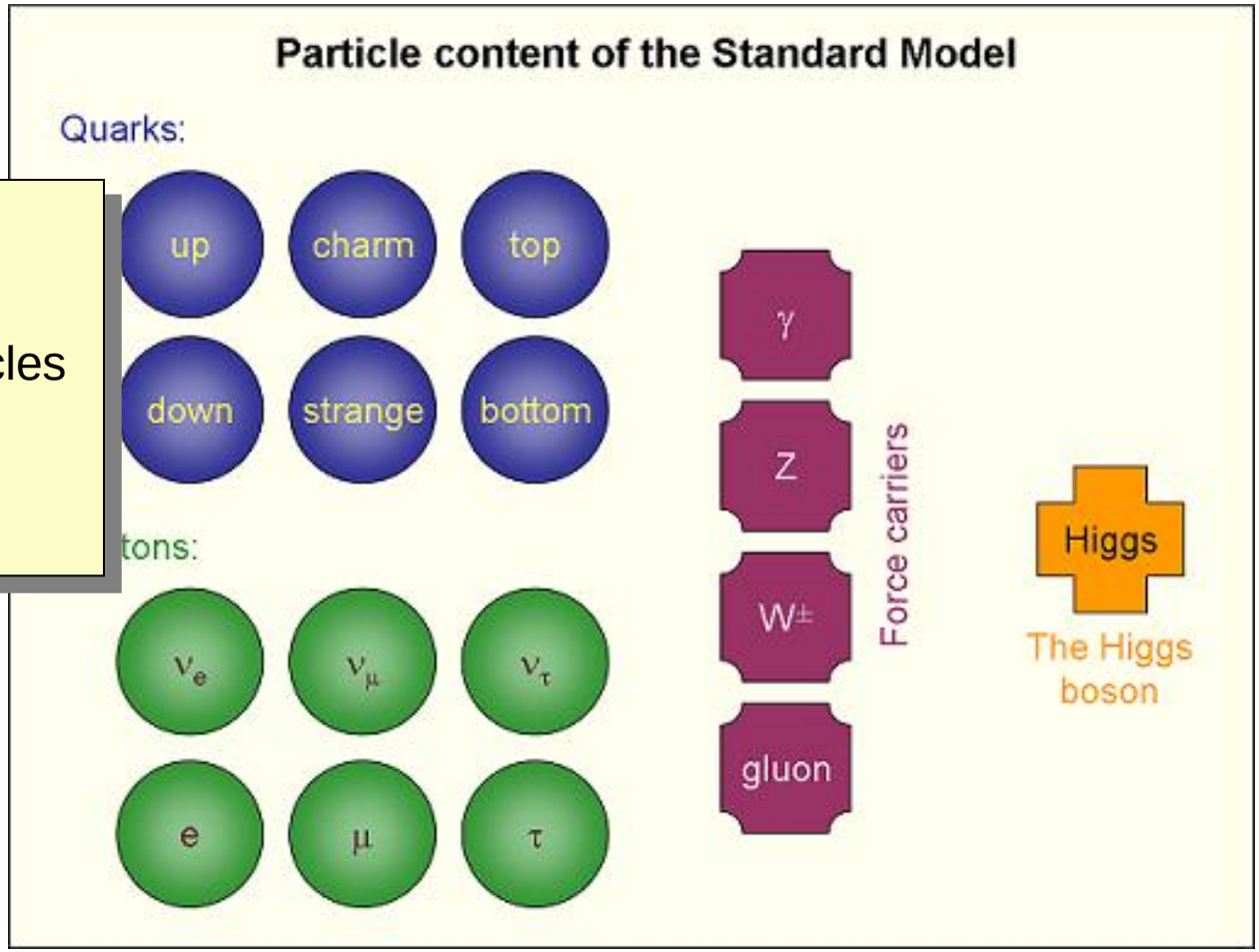
"feel" every known force in nature



J1.2: Identify elementary particles

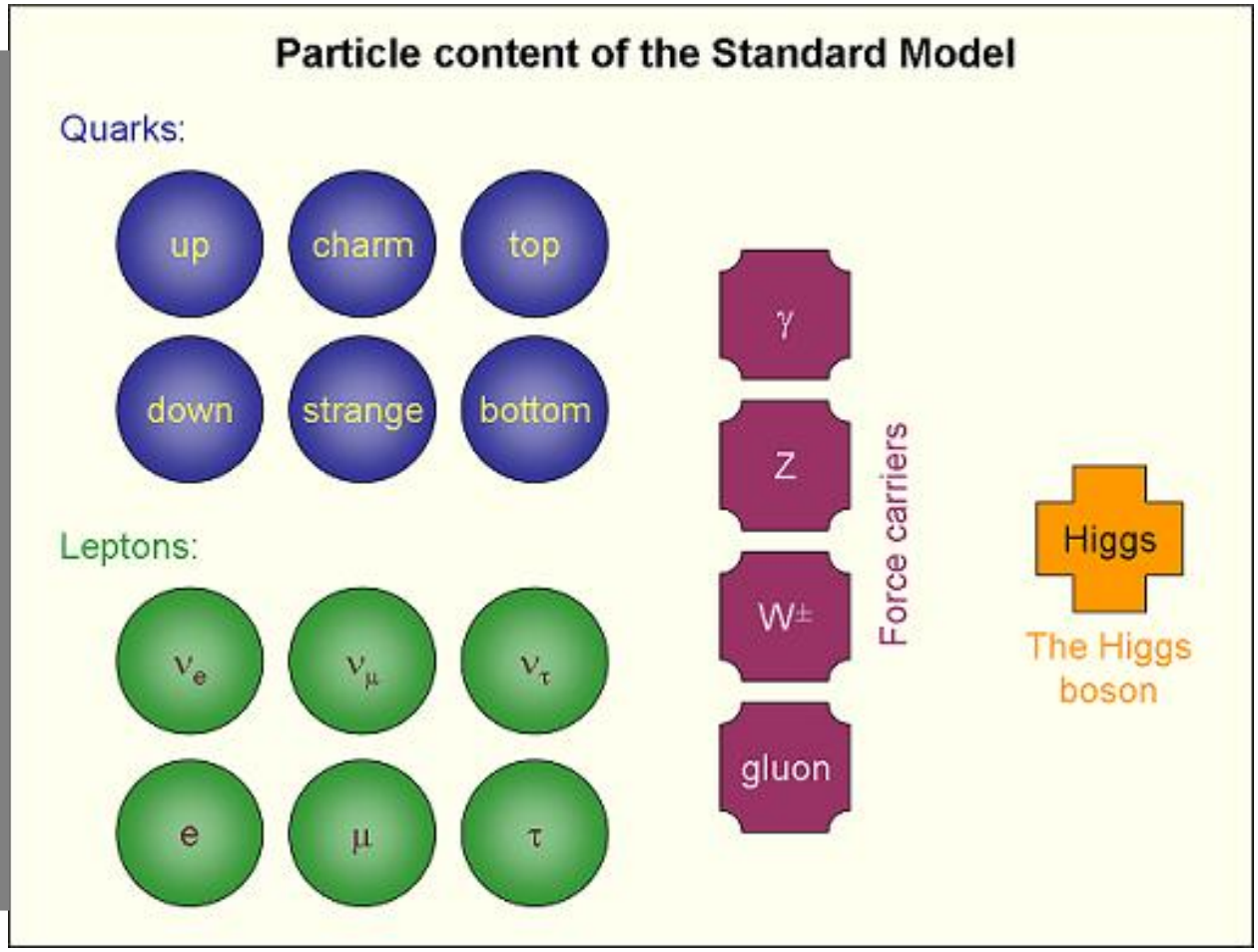
QUARKS:

are the only matter particles to “feel” the strong force



J1.2: Identify elementary particles

Electric charge:
+2/3
-1/3
0
-1



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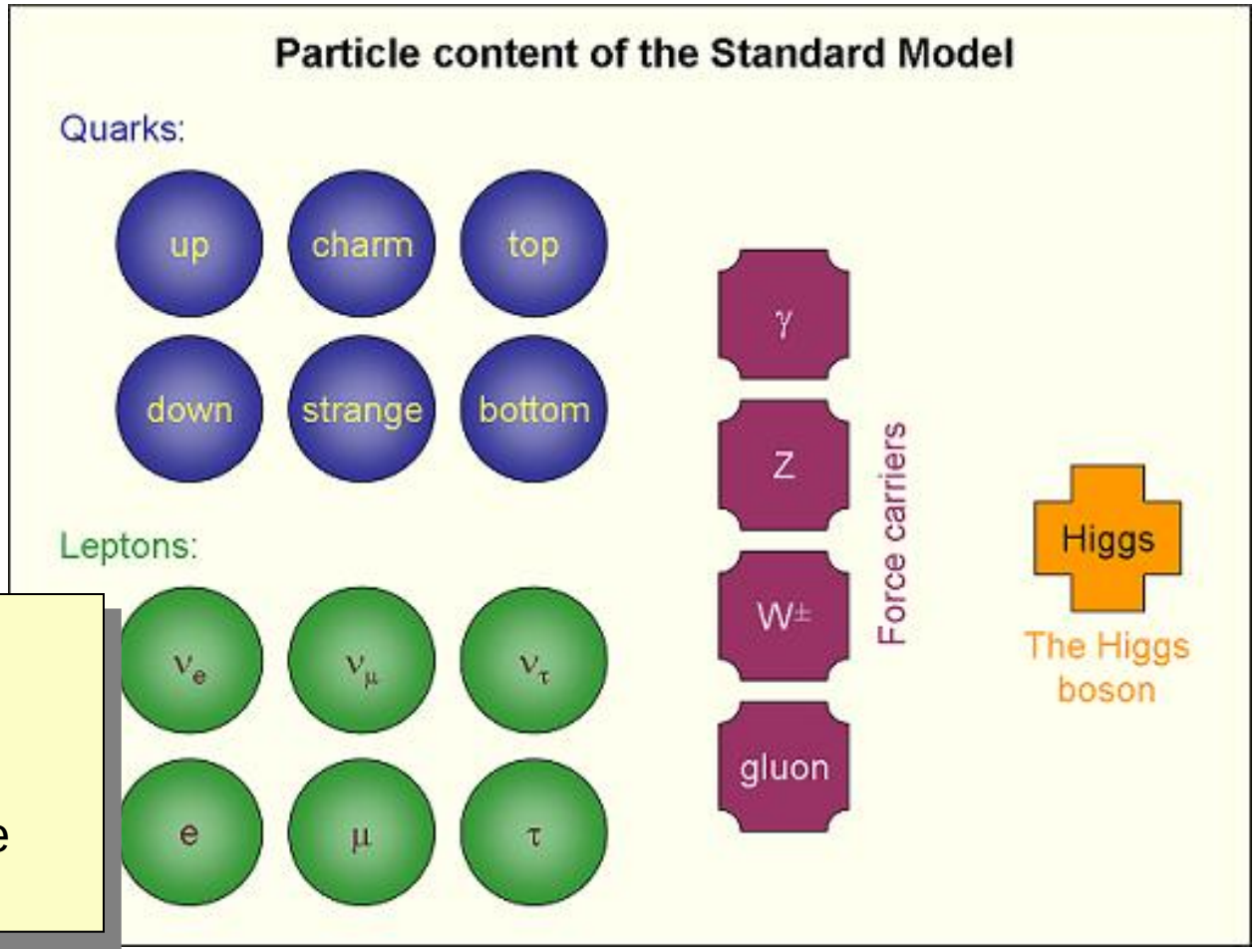
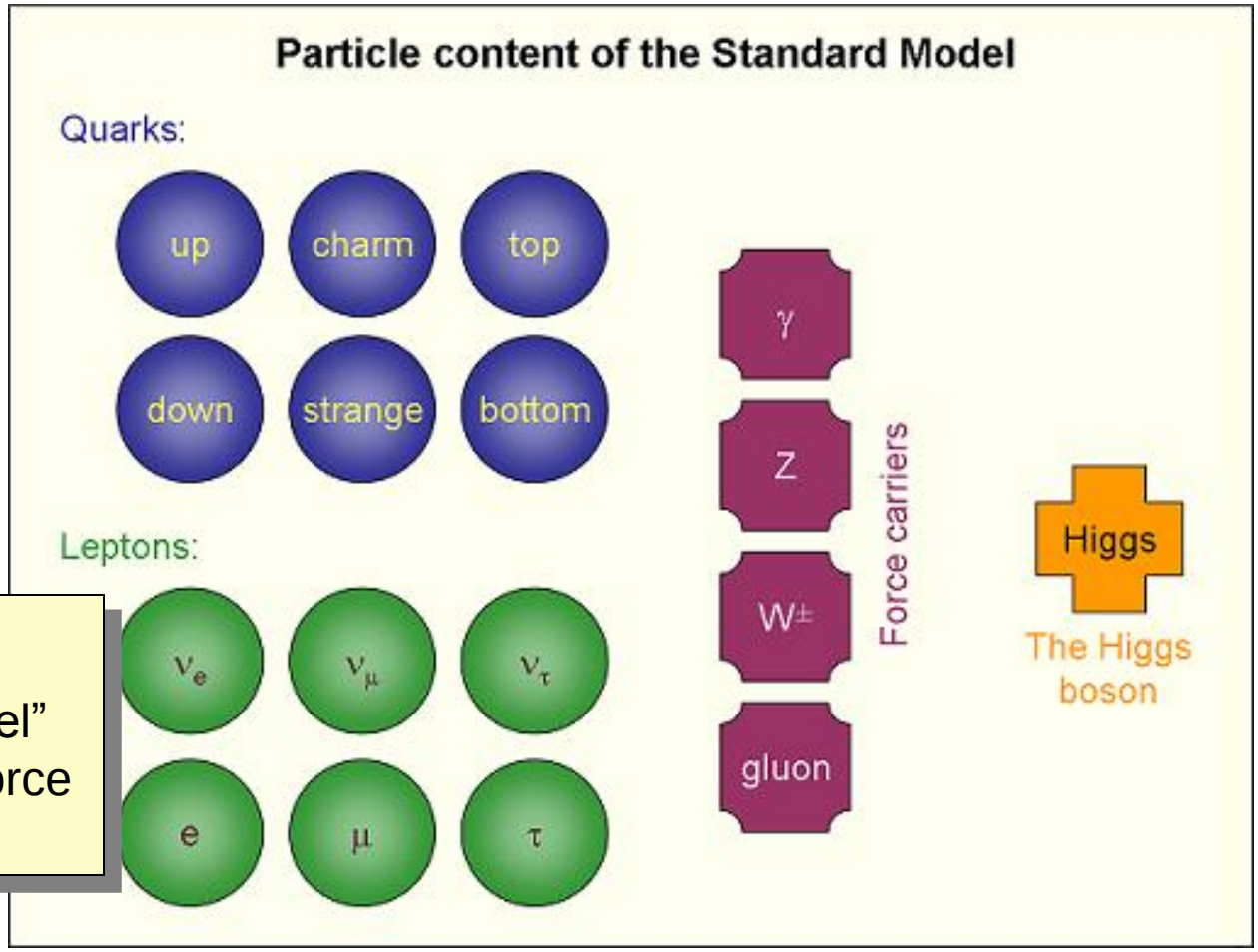


Leptons:

Are found everywhere EXCEPT the nucleus

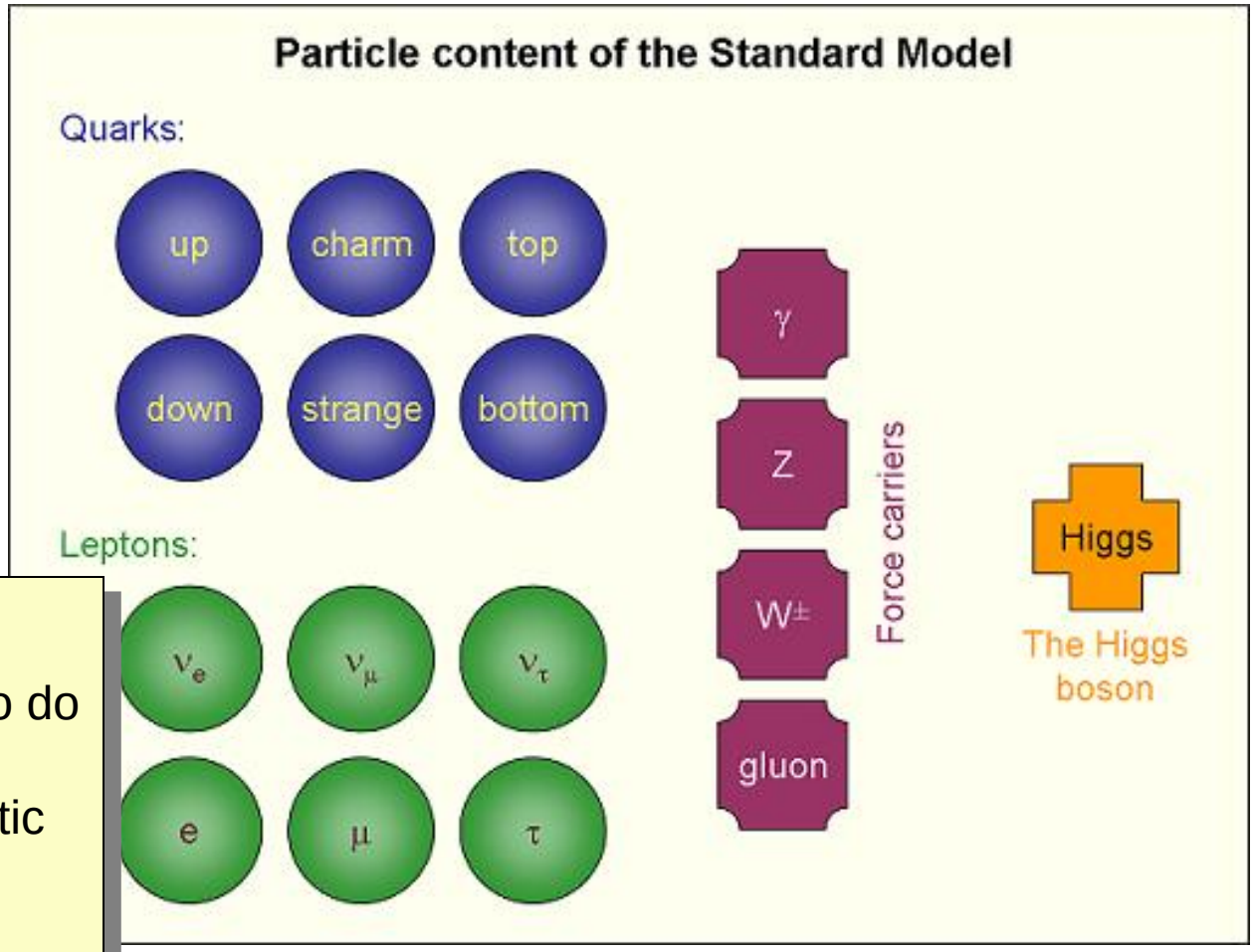
J1.2: Identify elementary particles



Leptons:

DO NOT “feel” the strong force

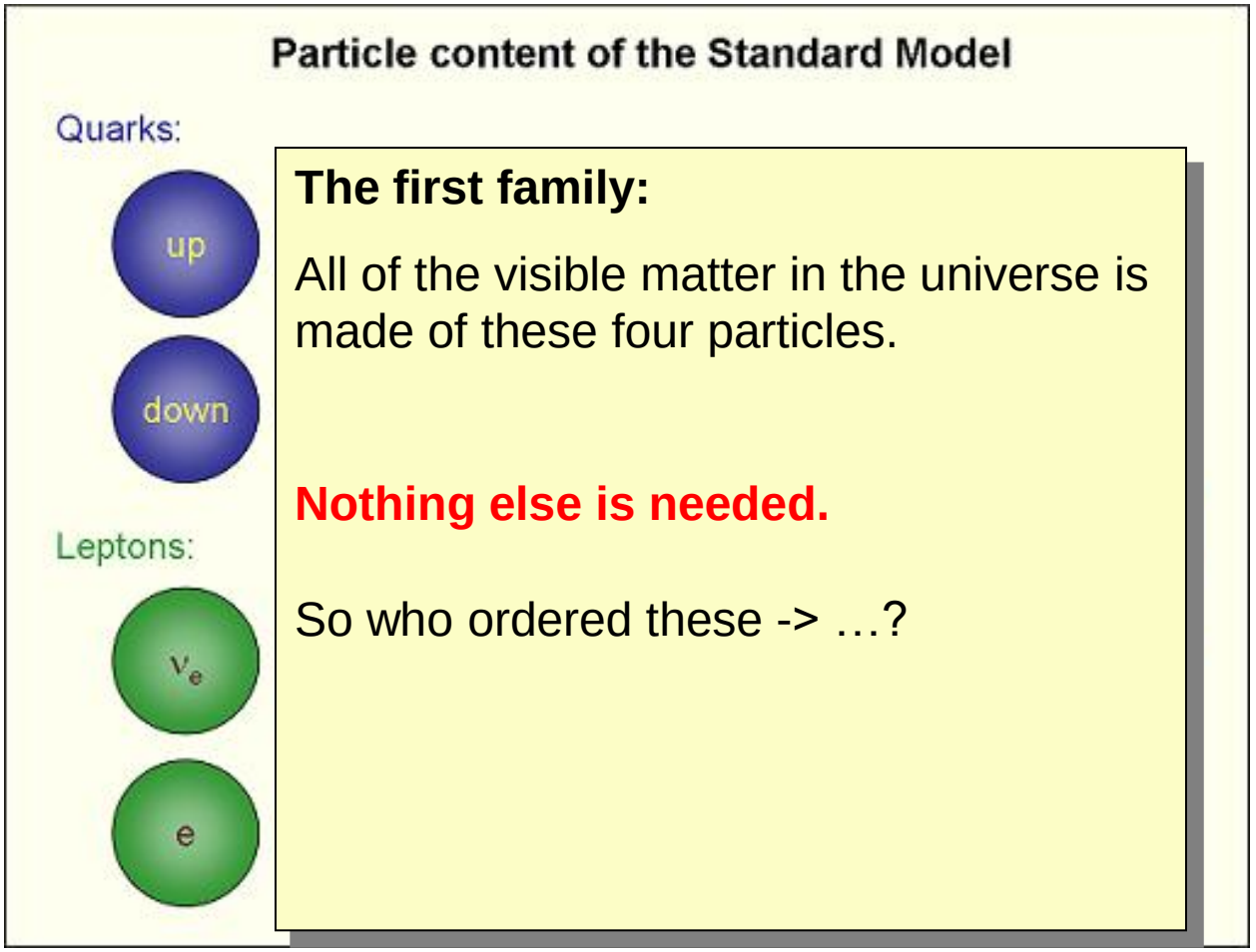
J1.2: Identify elementary particles



Leptons:

Neutrinos also do not “feel” the electromagnetic force

J1.2: Identify elementary particles



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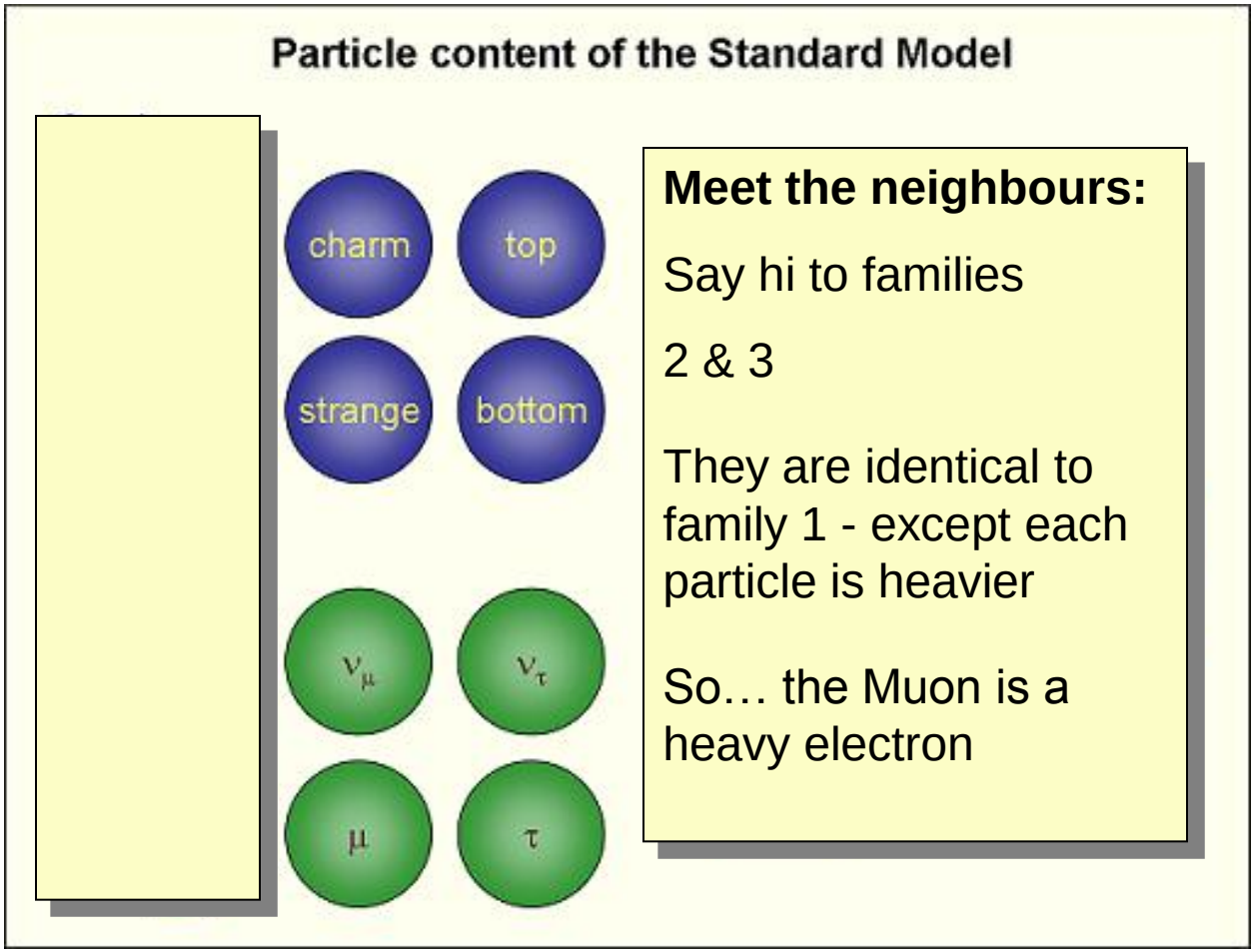

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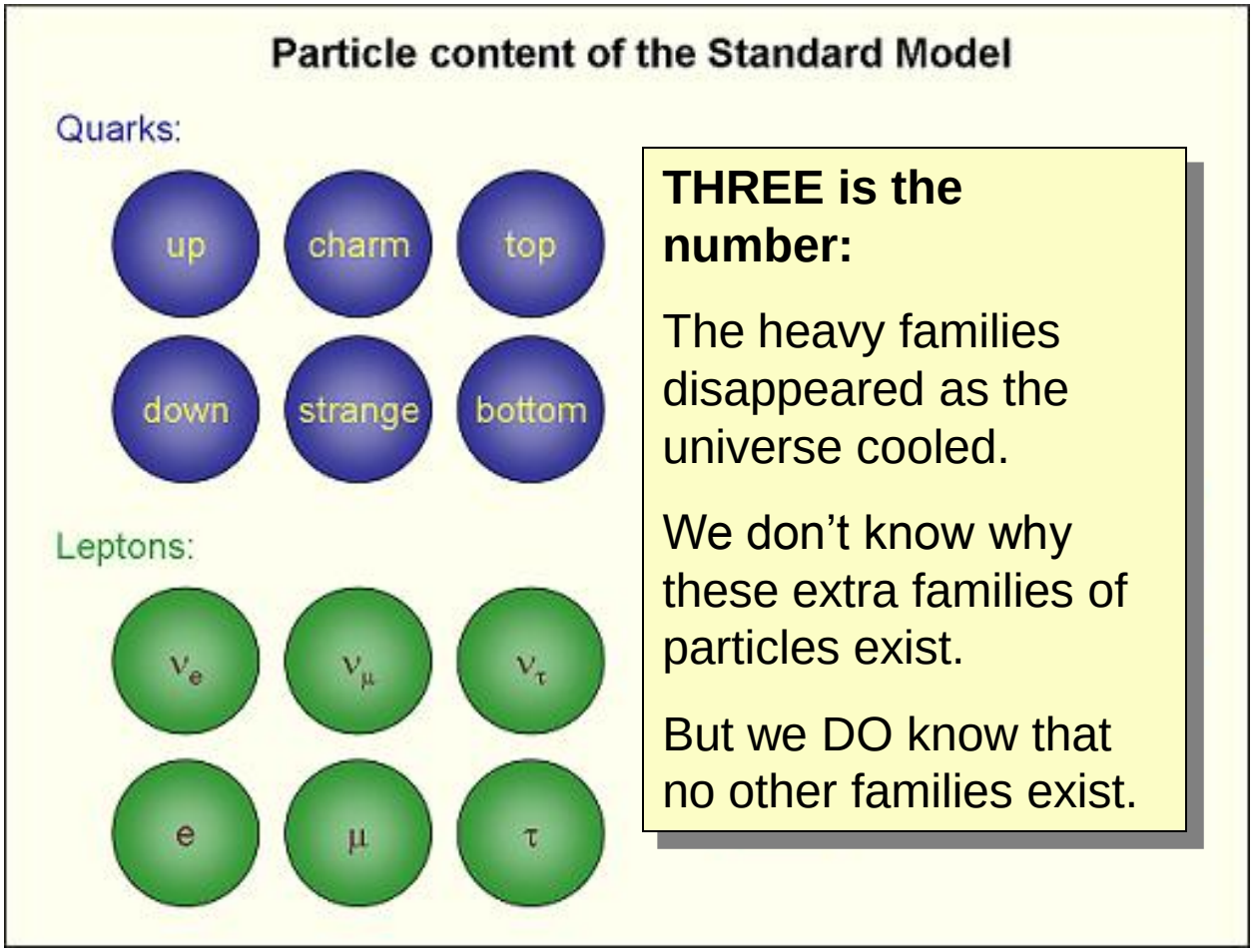


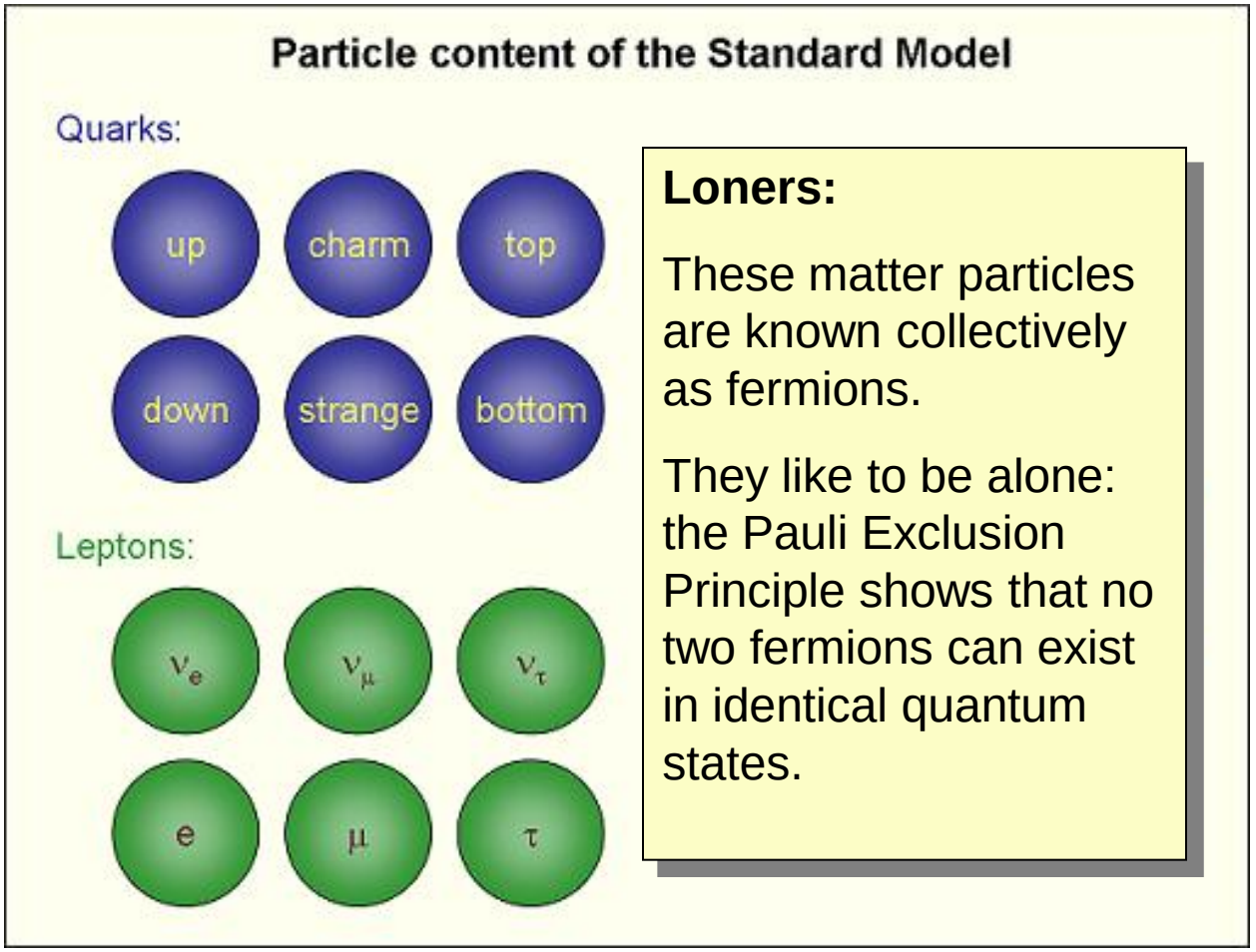
THREE is the number:

The heavy families disappeared as the universe cooled.

We don't know why these extra families of particles exist.

But we DO know that no other families exist.

J1.2: Identify elementary particles

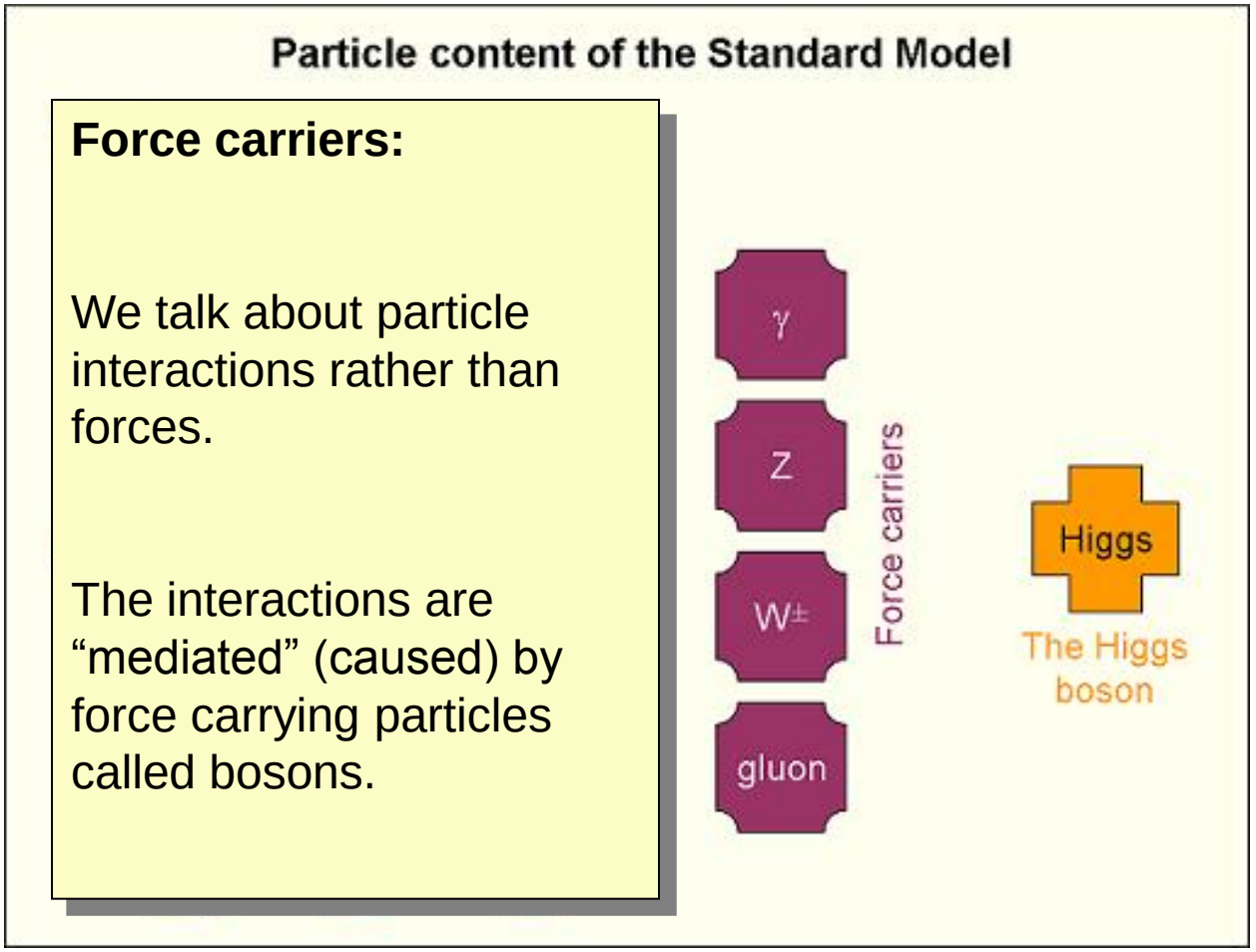


Loners:

These matter particles are known collectively as fermions.

They like to be alone: the Pauli Exclusion Principle shows that no two fermions can exist in identical quantum states.

J1.2: Identify elementary particles



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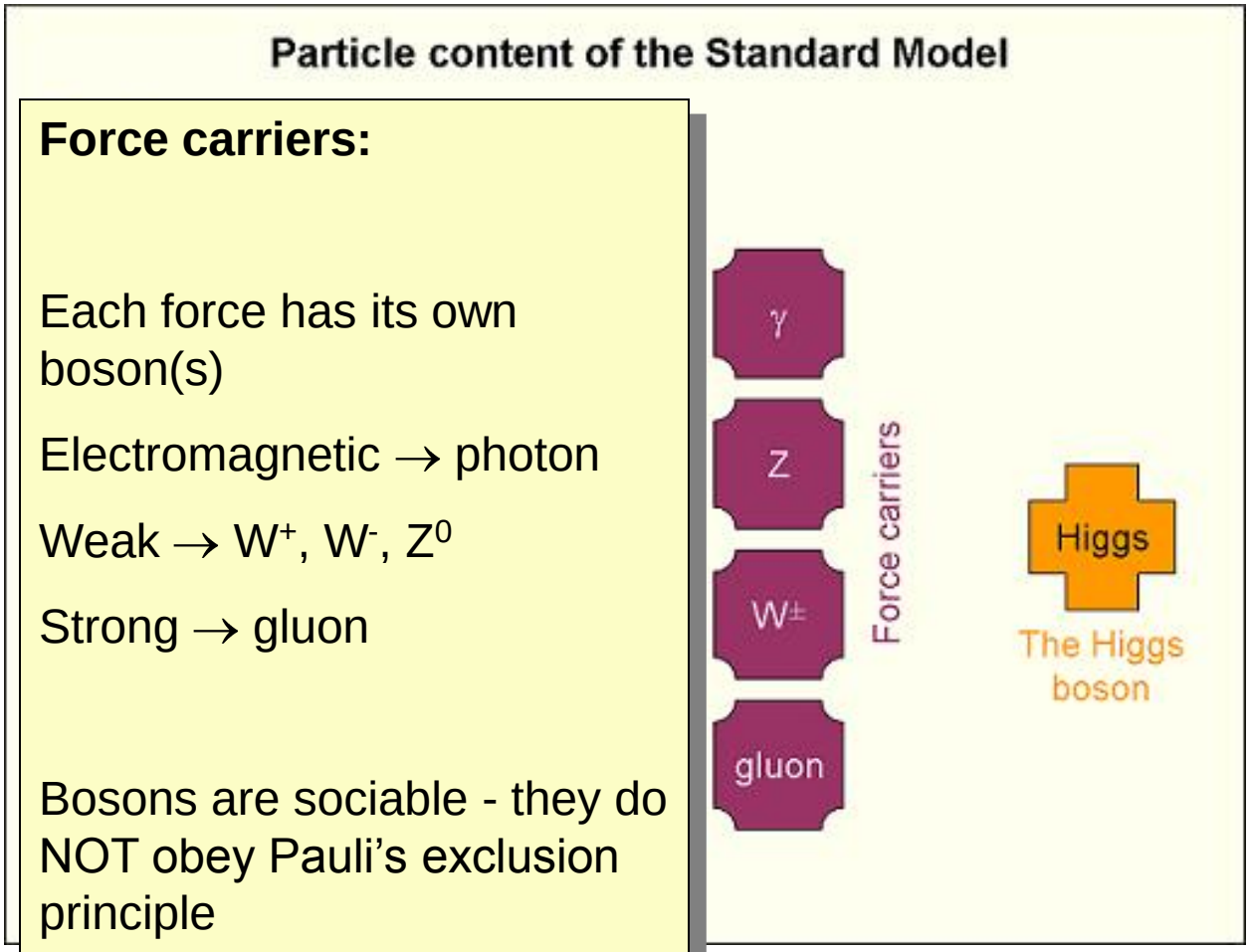

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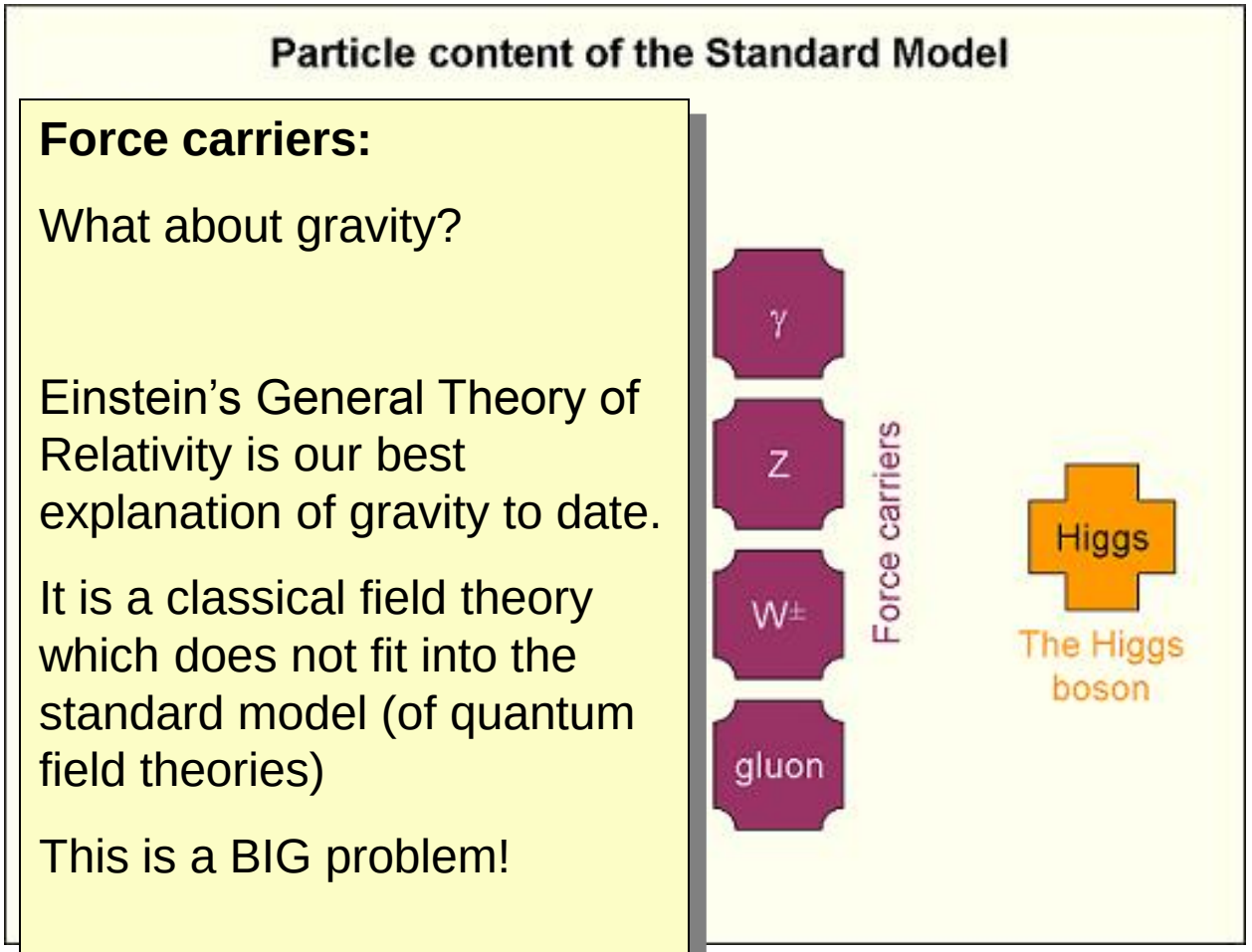

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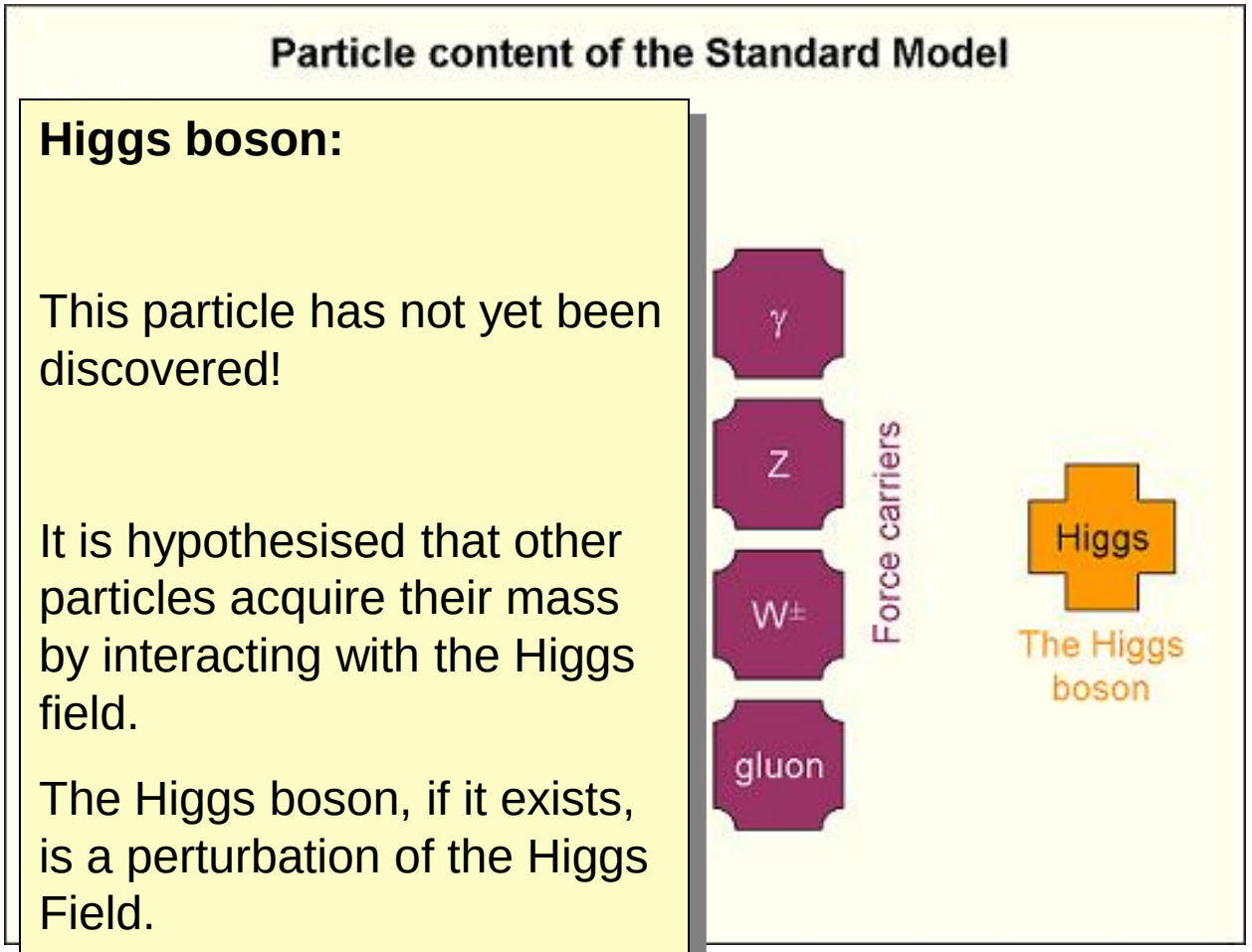

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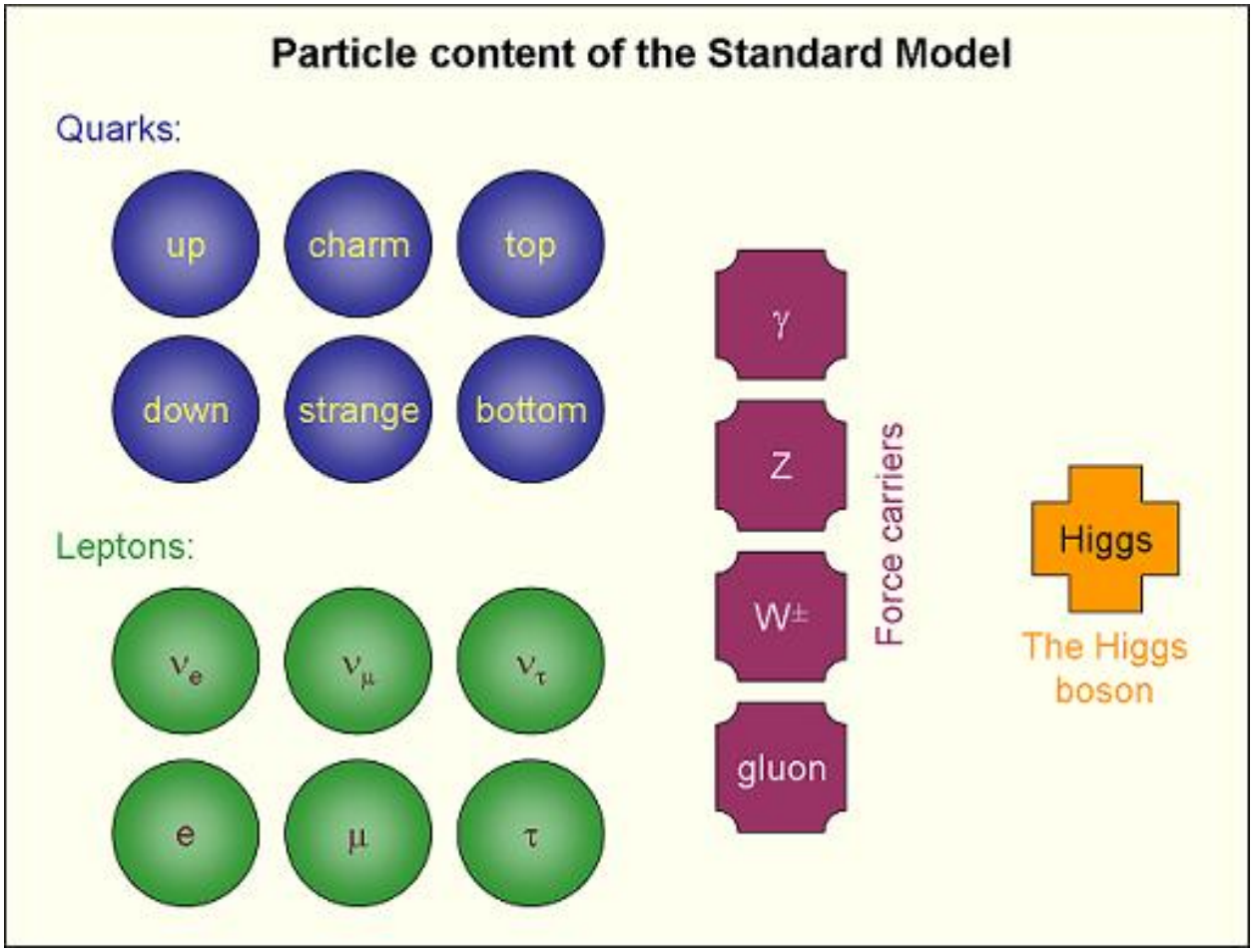

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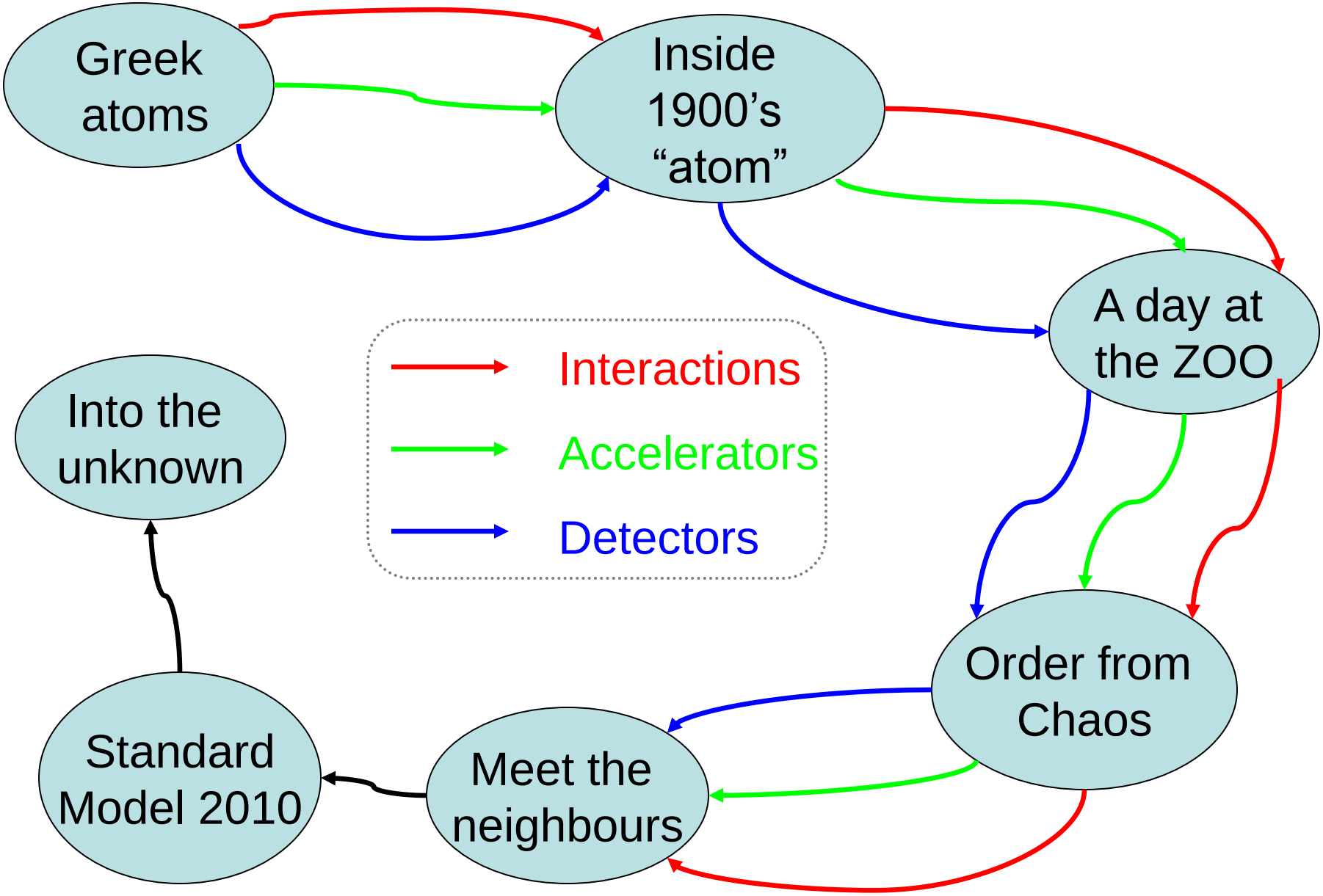
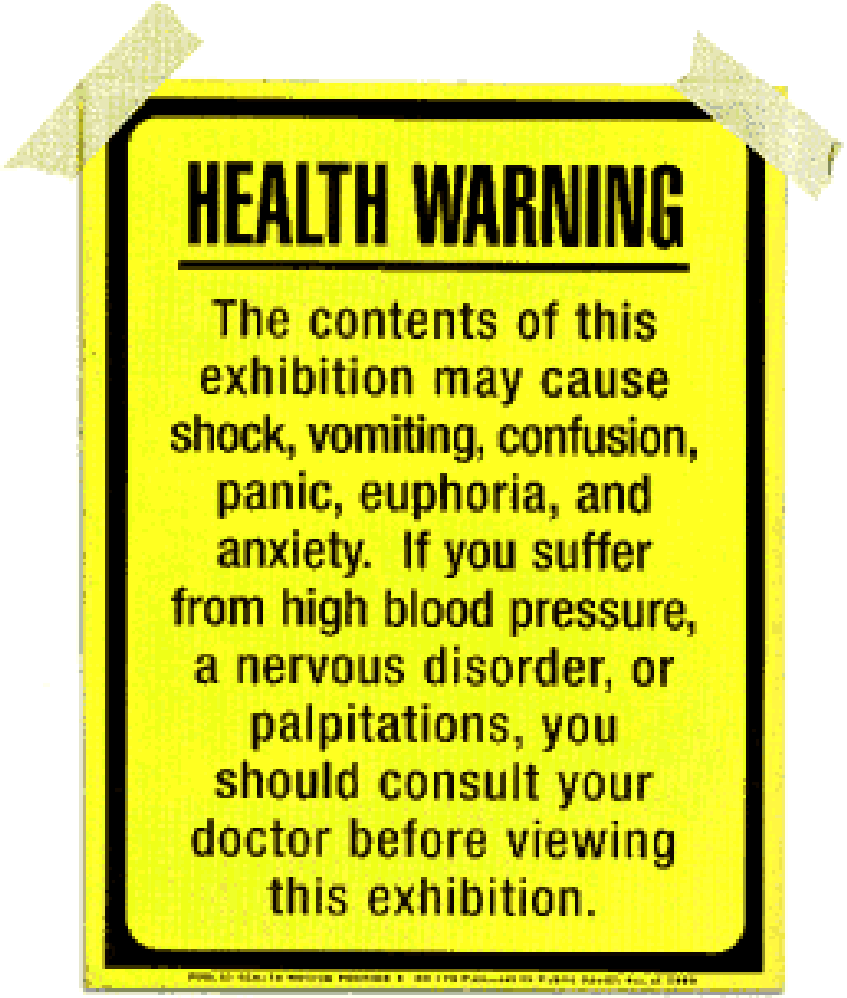

Greek atoms
Inside 1900's "atom"
A day at the ZOO
Order from Chaos
Meet the neighbours
Standard Model 2010
Into the unknown
Interactions
Accelerators
Detectors

Aim for this working group

- Brainstorm: generate ideas!
- Find existing resources and edit them into a coherent style / format
- Write new resources (in both directions)
- Produce homework sheets
- Produce ideas for lab assignments

Health warning!



Health warning!

- This is the start of an extended project!
- The working group will contribute to the project but WILL NOT complete the project in the next 2 weeks
- Very high standards of work are required
- Work will be edited prior to publication

…end

…end

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