PH3520 / Particle Physics

Autumn term 2011

Glen Cowan
Stewart Boogert

Meet the team

Lecturers:

Glen Cowan
Wilson 262
g.cowan@rhul.ac.uk

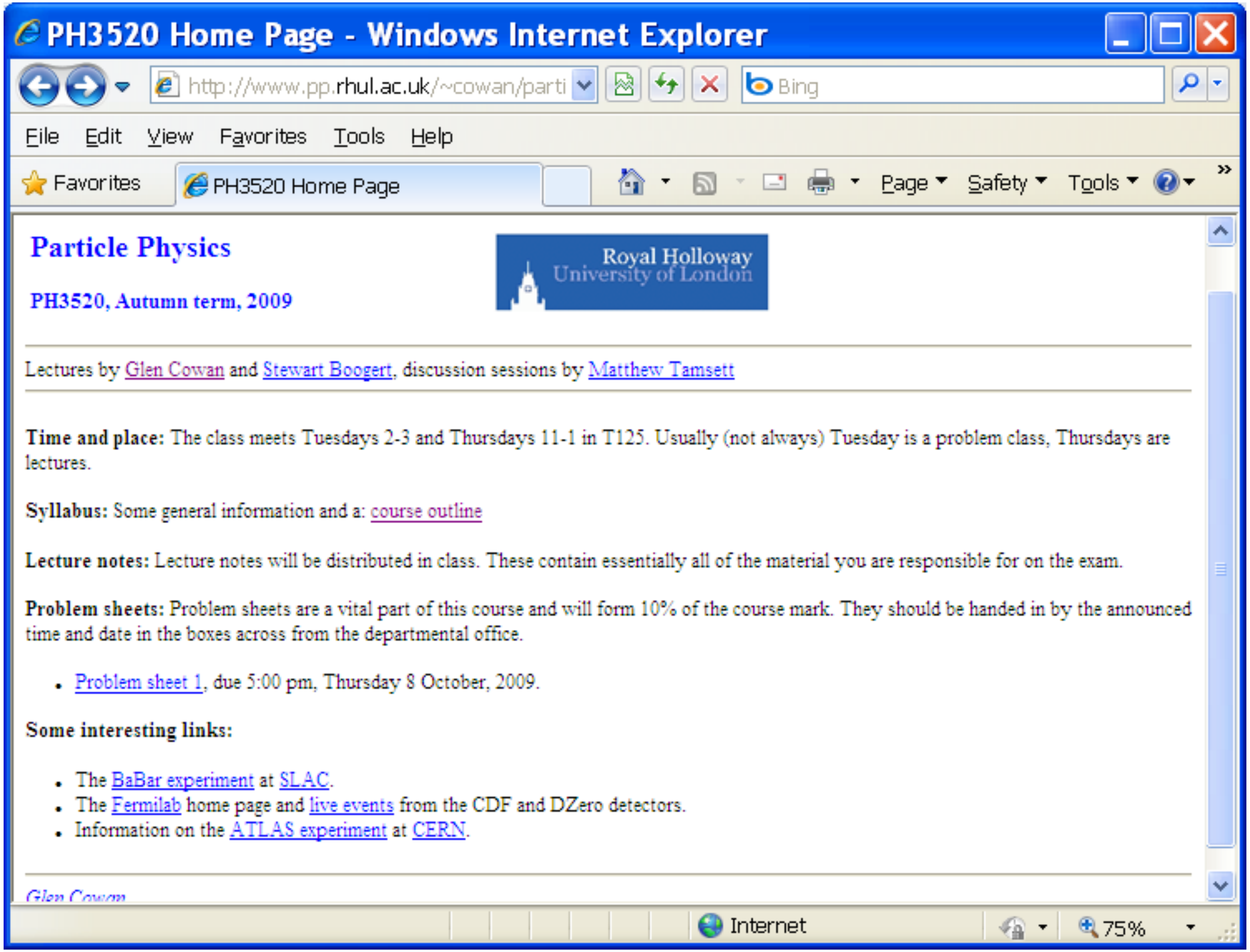
Stewart Boogert
Wilson 251
stewart.boogert@rhul.ac.uk

Discussion session leader:

Andrew Williams
Wilson 256
Andrew.Williams.2009@live.rhul.ac.uk

PH3520 Course webpage

http://www.pp.rhul.ac.uk/~cowan/particle.html


PH3520 Home Page - Windows Internet Explorer

Particle Physics

PH3520, Autumn term, 2009

Royal Holloway University of London

Lectures by Glen Cowan and Stewart Boogert, discussion sessions by Matthew Tamsett

Time and place: The class meets Tuesdays 2-3 and Thursdays 11-1 in T125. Usually (not always) Tuesday is a problem class, Thursdays are lectures.

Syllabus: Some general information and a: course outline

Lecture notes: Lecture notes will be distributed in class. These contain essentially all of the material you are responsible for on the exam.

Problem sheets: Problem sheets are a vital part of this course and will form 10% of the course mark. They should be handed in by the announced time and date in the boxes across from the departmental office.

- Problem sheet 1, due 5:00 pm, Thursday 8 October, 2009.

Some interesting links:

- The BaBar experiment at SLAC.
- The Fermilab home page and live events from the CDF and DZero detectors.
- Information on the ATLAS experiment at CERN.

Glen Cowan

PH3520 Course Outline

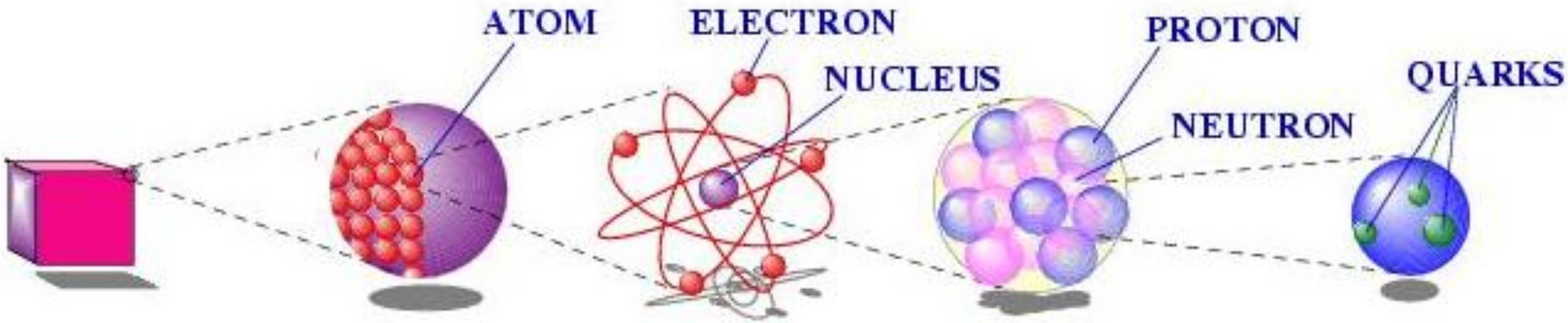
PH3520 Course outline (approximate by week)

1. Overview of particle physics, units, special relativity, cross sections, decay rates.
2. Theoretical framework: Feynman diagrams, electromagnetic, weak and strong interactions, coupling strengths, virtual particles.
3. Particle accelerators: linear vs. circular, fixed target vs. colliding beams.
4. Particle detectors: ionization energy loss, tracking detectors, calorimeters, multicomponent detector systems.
5. Leptons: the electron, positron, muon, neutrino, τ lepton.
6. Hadrons: nuclear forces, the pion, strange particles, hadron resonances, the quark model of hadrons.

PH3520 Course Outline (II)

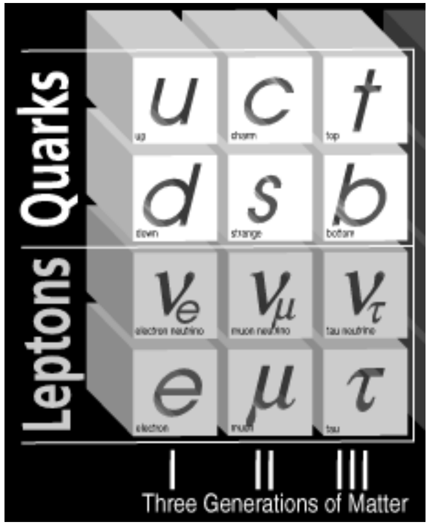
7. Inside hadrons: electron–proton scattering, the size of the proton, deep inelastic scattering, evidence for partons.
8. Heavy quarks: the GIM mechanism, discovery of charm, bottom, top quarks, the CKM matrix.
9. The electroweak standard model: theoretical need for W and Z, weak neutral currents, discovery of the W and Z, LEP physics.
10. Quantum chromodynamics: colour, the strong coupling constant, confinement, jets of hadrons.
11. The Higgs mechanism: gauge invariance and the need for the Higgs boson, properties of the Higgs, experimental searches for the Higgs.

The particle scale



The current picture

Matter...



\+ force carriers...

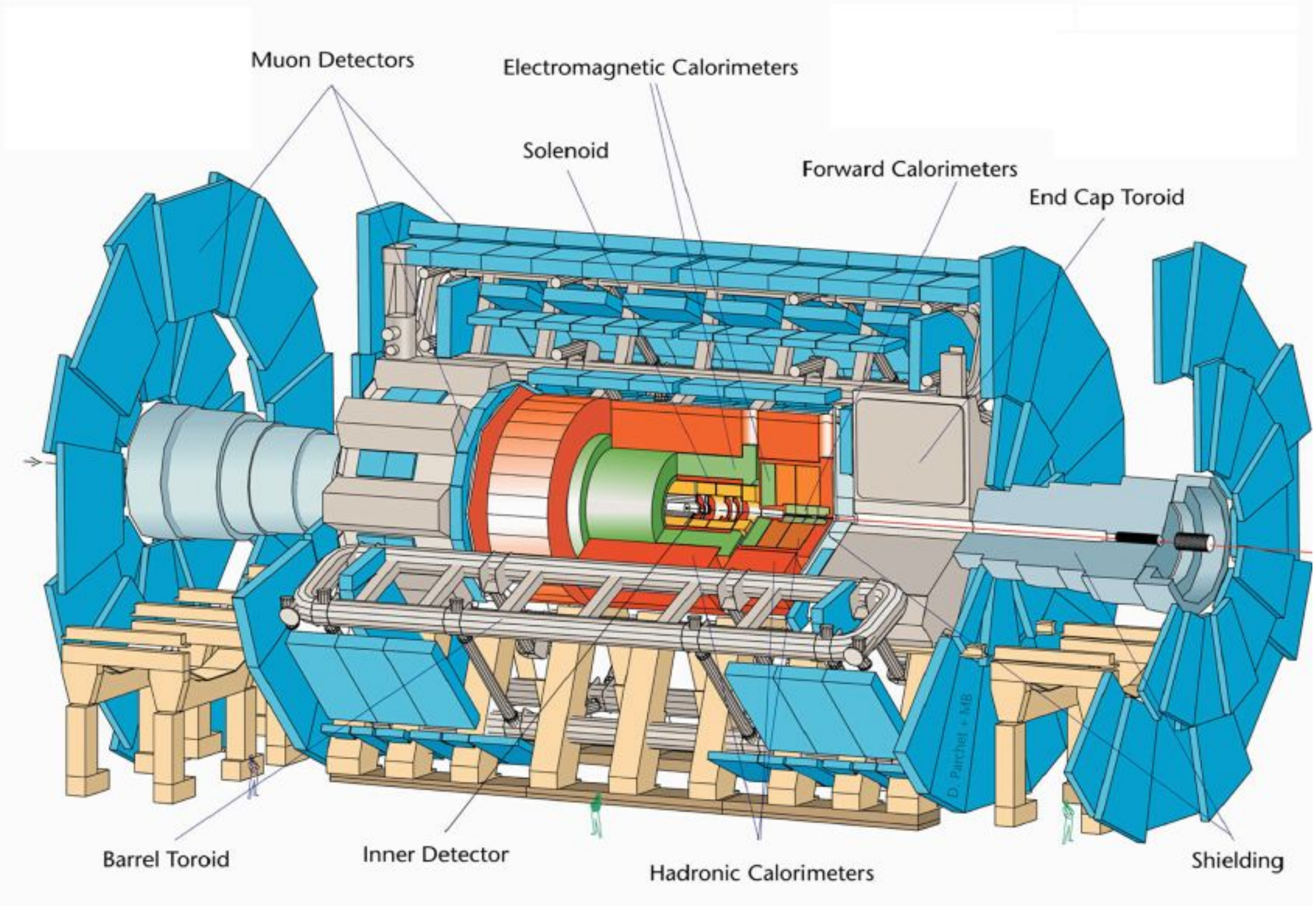
photon (γ)
$W^{\pm}$
Z
gluon (g)

\+ relativity + quantum mechanics + symmetries...
= "The Standard Model"

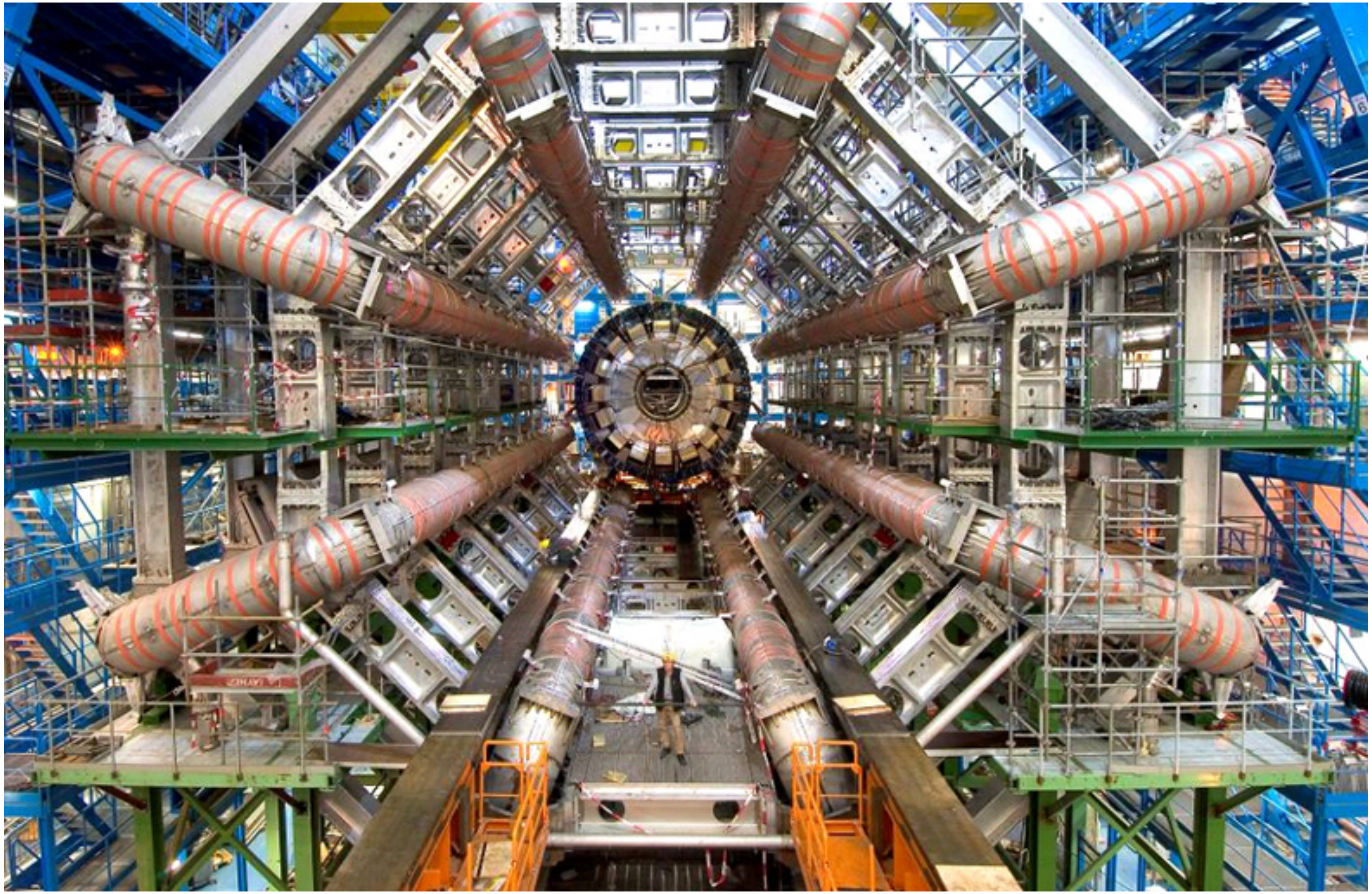
- almost certainly incomplete
- no gravity yet
- 25 free parameters (!)
- agrees with all experimental observations!

The Large Hadron Collider (CERN)

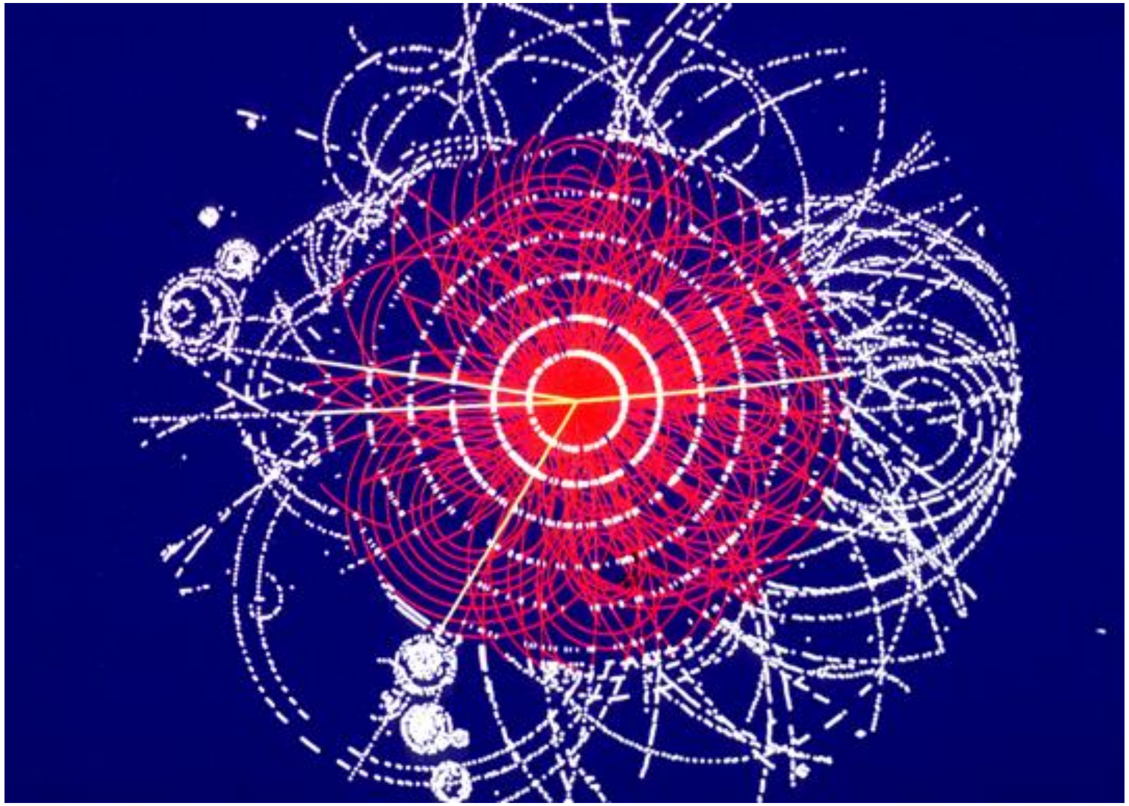
The ATLAS experiment at the LHC



The ATLAS detector during installation

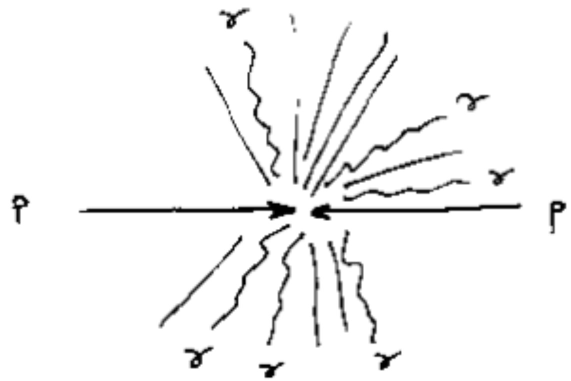


A simulated ATLAS event



An example using invariant mass

A proton-proton collision can results in many photons.



For each γγ pair, compute invariant mass:

$$
\begin{aligned}
m_{ij}^2 &= (E_i + E_j)^2 - (\mathbf{p}_i + \mathbf{p}_j)^2 \\
&= E_i^2 + 2E_iE_j + E_j^2 - (p_i^2 + 2\mathbf{p}_i \cdot \mathbf{p}_j + p_j^2) \\
&= 2E_iE_j(1 - \cos\theta_{ij}) \ ,
\end{aligned}
$$

and enter value in histogram.

A particle that decays to γγ shows up as a peak at that particle's mass: