*Extension*

**This extension sheet is to be used in conjunction with the foundation sheet on this topic.**

# Have we found the Higgs boson?

**The Large Hadron Collider (LHC) at CERN, one of the world's biggest international projects, regularly hits the headlines for its new discoveries. One particle they are looking for is the Higgs boson, but with so much data to collect, how will we know when they find it?**

BBC news article

## Large Hadron Collider results excite scientists

The Large Hadron Collider (LHC) has picked up tantalising fluctuations which might - or might not - be hints of the sought-after Higgs boson particle. But scientists stress caution over these "excess events", because similar wrinkles have been detected before only to disappear after further analysis.

The most significant of these is a surplus of unusual particle events at a mass of 140-145 gigaelectronvolts (GeV). A Higgs particle with this mass would be at the low end of the range allowed for the boson, right where physicists predict it is most likely to be found.

Either way, if the sub-atomic particle exists it is running out of places to hide, says the head of the European Organization for Nuclear Research (Cern), which runs the LHC. He told BBC News the collider had now ruled out more of the "mass range" where the Higgs might be.

***bbc.co.uk/news 23rd July 2011***

## Questions

Read through the foundation information sheet and the news article on this extension sheet, then answer these questions:

### Reporting the experiments

**Q1** Discuss the two news articles with a partner. Why do they report different results? Should this be a surprise?

**Q2** A footballer scores three goals in the first match of the season, but by the end is no more than an average player. Use this example to explain why exciting initial results from the LHC may not be significant in the long run.

### The numbers

**Q3** What is the radius of the LHC ring, assuming it is circular?

**Q4** How fast do protons travel in the LHC? Compare this figure to the speed of light as recorded in your textbook. What do you notice?

**Q5** Plot both of the sets of figures overleaf on the same set of axes. They show how different detectors – one sensitive to the nearest GeV, the other to the nearest 2GeV – affect how easy it is to see a peak in data from the same experiment. Do any of the results look statistically significant (unlikely to be chance alone?)

Science & Technology Facilities Council

www.imascientist.org.uk

This information sheet is sponsored by the STFC. Created by Gallomanor. 

| Energy range (GeV) | Frequency (events) |
|---|---|
| 140-142 | 8 |
| 142-144 | 6 |
| 144-146 | 10 |
| 146-148 | 6 |
| 148-150 | 10 |
| 150-152 | 12 |
| 152-154 | 6 |
| 154-156 | 10 |
| 156-158 | 6 |
| 158-160 | 8 |

| Energy range (GeV) | Frequency (events) |
|---|---|
| 140-141 | 3 |
| 141-142 | 5 |
| 142-143 | 3 |
| 143-144 | 3 |
| 144-145 | 5 |
| 145-146 | 5 |
| 146-147 | 4 |
| 147-148 | 2 |
| 148-149 | 2 |
| 149-150 | 8 |
| 150-151 | 11 |
| 151-152 | 1 |
| 152-153 | 3 |
| 153-154 | 3 |
| 154-155 | 4 |
| 155-156 | 6 |
| 156-157 | 3 |
| 157-158 | 3 |
| 158-159 | 5 |
| 159-160 | 3 |

## Justifying the search for the Higgs

These questions may need a little more time to answer.

**Q6** As well as the improved theoretical understanding of matter, there are practical 'spin-offs' like more powerful magnets, computer technologies and better medical diagnosis and treatment. Research these benefits online, then list reasons **for** and **against** funding the project. A starting point for your research is http://www.lhc.ac.uk/About+the+LHC/11837.aspx

**Q7** Using the articles above and your own research, write a one minute news story for TV or a podcast to explain to key stage 3 pupils:
- what the Large Hadron Collider does.
- why scientists think it is important.

## Further Research

To do these questions you may need to do more research on the topics.

**Q8** Scientists once thought a substance called phlogiston was used up whenever materials were burned. Although wrong, the experiments they did to investigate phlogiston gave useful information about how combustion really worked. Find out more about phlogiston and explain how it is relevant to the search for the Higgs boson, a particle which may not even exist.

**Q9** Choose one of the 'one page explanations' of the Higgs Boson linked from the page http://www.phy.uct.ac.za/courses/phy400w/particle/higgs.htm and explain how you would demonstrate this, either in the classroom or by animation.