

Follow along worksheet for

The Large Hadron Collider by Dr. Harder

- 00:00:00 **1.** Name of person giving presentation: *Kristian*
- 00:01:00 **2.** The standard model explains how the universe works at the most *fundamental* level.
- 00:01:40 **3.** There are two problems with the standard model: it is *incomplete* and *wrong*.
- 00:02:00 **4.** We cannot explain which force? Gravity
- 00:03:10 **5.** Probabilities *should* add up to *100* %
- 00:04:20 **6.** The discovery of the Higgs boson was almost *10* years ago now.
- 00:04:50 **7.** W and Z are among the most *massive* particles we know of.
- 00:05:40 **8.** An extra *force* was postulated.
- 00:06:20 **9.** Every force in the standard model has a force *carrier* particle
- 00:07:00 **10.** The Higgs Field is even in Kristian's *kitchen* cupboard.
- 00:08:00 **11.** Physicists searched for half a *century* without finding the Higgs boson.
- 00:08:05 **12.** They didn't find it because they didn't have enough *energy* in the experiments to create Higgs bosons.
- 00:09:20 **13.** It was obvious it was a new force carrier from how it *decays* into other particles.
- 00:09:40 **14.** The delivery cost of the higgs was a few *billion*
- 00:11:20 **15.** There is an *asymmetry* between matter and antimatter that is stronger than the standard model predicts.
- 00:12:40 **16.** We are actually not trying to create *black holes* to swallow earth..
- 00:12:50 **17.** Or open a *portal*
- 00:13:40 **18.** The easiest way to investigate matter is to *break* it.
- 00:14:37 **19.** There is nothing in the pile of rubble that wasn't part of one of the cars before the *collision*.
- 00:14:50 **20.** Higgs bosons are generated from *energy* released.
- 00:15:20 **21.** With enough energy we can get particles of higher *mass* that we've never seen before.
- 00:15:40 **22.** The circumference of the LHC is *27* km
- 00:16:10 **23.** The tunnel has a diameter of about *4*m.
- 00:16:30 **24.** You *ionise* hydrogen gas to get protons.
- 00:17:10 **25.** The protons are kept in *vacuum* pipes

- 00:17:15 **26.** at roughly the speed of **light**.
- 00:18:00 **27.** The energy of the proton beam is roughly the same as the Eurostar going at **100** mph.
- 00:19:20 **28.** The LHC is huge because we cannot build magnets which are **strong** enough.
- 00:20:00 **29.** The energy of the beam and the field strength is **increasing**.
- 00:20:40 **30.** The coldest regions of outer space are around **3** kelvin.
- 00:21:50 **31.** The LHC is even sensitive to extra rain in lake **Geneva**.
- 00:22:30 **32.** There are **4** regions where the beams can interact.
- 00:24:20 **33.** Here at RAL we are involved in **3** out of the 4 experiments.
- 00:25:10 **34.** The detectors are a few **millimetres** away from the collision.
- 00:26:10 **35.** We cannot see **neutrinos** with our detectors.
- 00:26:10 **36.** Quarks, gluons and sometimes **photons** create jets of particles.
- 00:26:50 **37.** Charged particles kick out **electrons** of the material they pass through.
- 00:27:50 **38.** We use the **trajectory** of the particles and extrapolate to see where they came from.
- 00:28:20 **39.** Curvature corresponds to **momentum**.
- 00:29:00 **40.** Calorimeters are used to study **neutral** particles.
- 00:30:40 **41.** We use **thousands** of tonnes of materials to try to stop all particles.
- 00:31:00 **42.** Particles detected by the electronic calorimeter will predominantly interact with the **hull** of the absorber atoms.
- 00:31:00 **43.** Particles detected by the hadronic calorimeter will predominantly interact with the **nucleus** of the absorber atoms.
- 00:32:00 **44.** Muon detectors sit on the **outside** of the detector.
- 00:34:00 **45.** We look for missing **momentum** to see if a particle passed through undetected.
- 00:34:50 **46.** The **tracking** detector at the centre of ATLAS was built here in the UK.
- 00:35:50 **47.** The most famous picture of ATLAS shows just the magnet **coils** for the muon detectors.
- 00:37:20 **48.** There are around **40** million events per second.
- 00:38:20 **49.** Most of the data produced is discarded within **4** microseconds.
- 00:41:50 **50.** Software is **crucial** in particle physics.
- 00:43:30 **51.** Control rooms are staffed around the **clock**.