University of BRISTOL

Science & Technology Facilities Council
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Searching For Dark Matter

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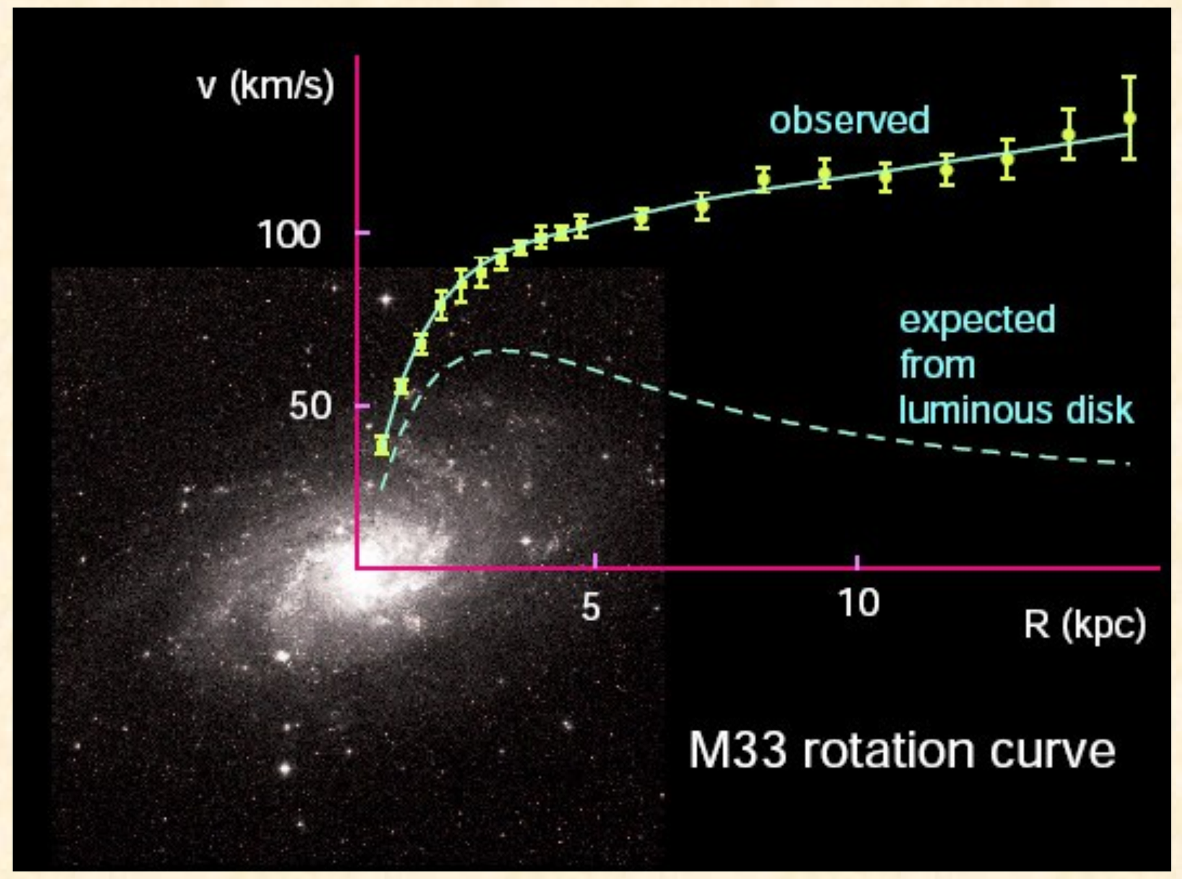
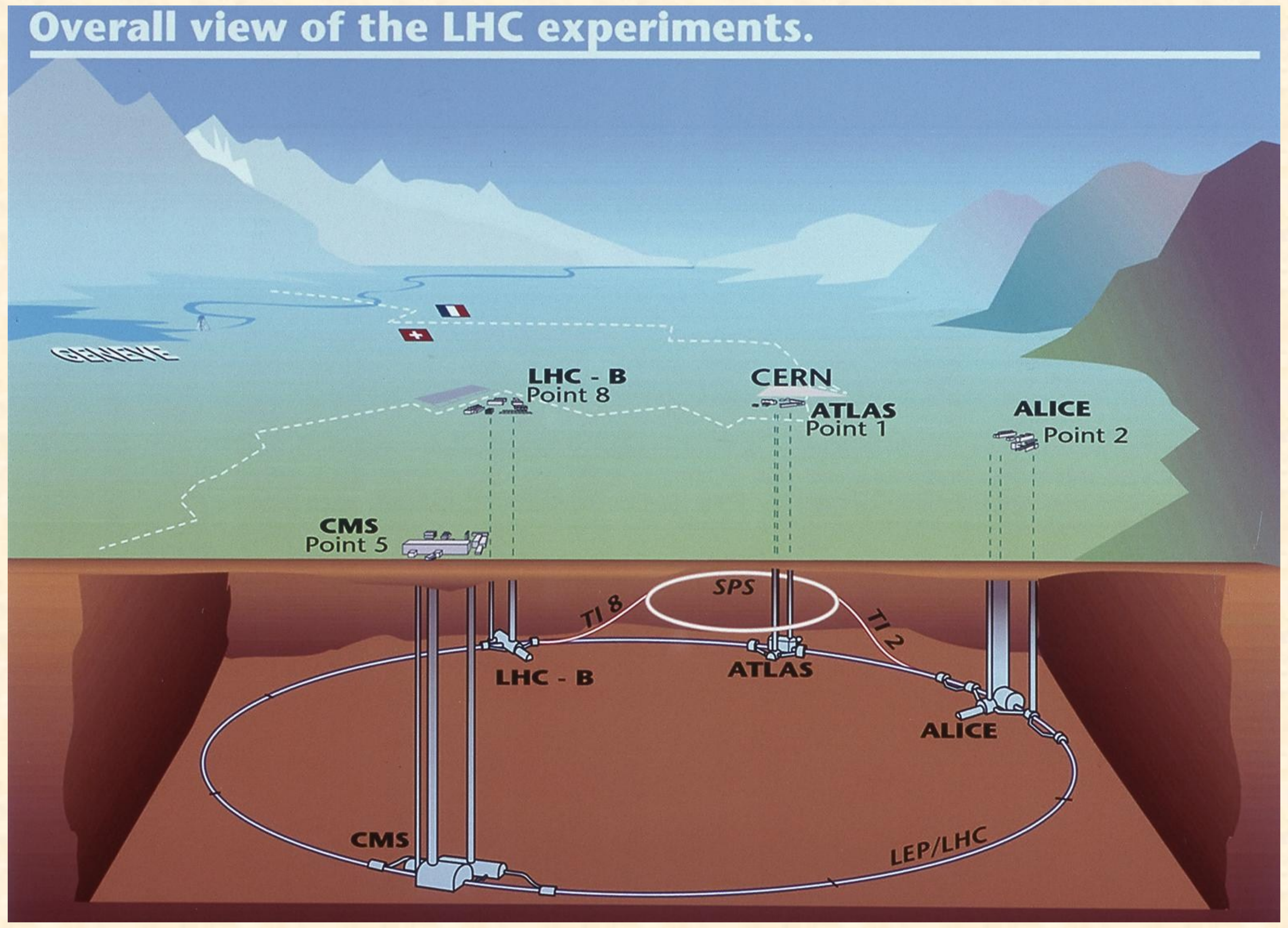


Why look for Dark Matter?

According to Newton the speed at which a galaxy rotates depends upon how much matter is in the galaxy. However we observe galaxies that rotate faster than can be explained by the visible matter. One possible explanation is that invisible 'dark matter' accounts for the galaxy's fast rotation.

The 'standard model' of particle physics describes everything we seen around us but there remains unexplained inconsistencies. (e.g. why is gravity so weak). Various theories (e.g. supersymmetric particles, 'Hidden Valley' particles) propose solutions, and if true could be witnessed as long lived, dark matter particles.



What to Look For and How To Find It

Some predicted attributes of dark matter particles are used in the search:

Dark matter particles may be behind an energy barrier, in a 'hidden valley', that prevent us seeing them. A high energy collision might allow dark matter to decay into 'Long Lived' particles that can pass through this energy barrier. ('High energy' to a particle physicist is ~ 8 TeV, about the kinetic energy of a flying mosquito, but with all this energy concentrated into a very small space.).

The Large Hadron Collider (LHC) at CERN produces many very high energy collisions

'Long Lived' to a particle physicist means the particle will exist for ~ 0.000,000,001—0.000,000,003 seconds before it decays further

This means a long lived particle might travel from the original impact point (IP) some 20—100 cm to its 'decay vertex' (DV)

Some of these long lived particle are predicted to decay into electrons

The Compact Muon Spectrometer (CMS) detector at the LHC can observe electrons in the Electromagnetic Calorimeter (ECAL)

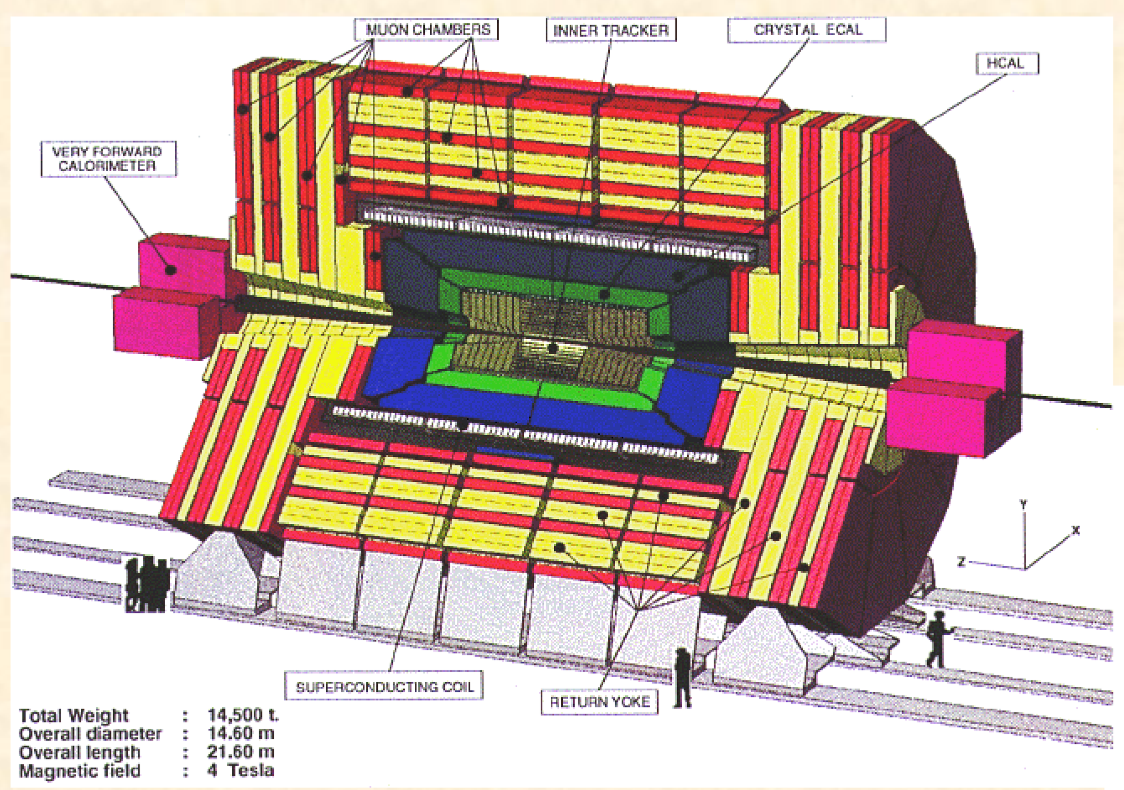
A long lived particle is expect to have no electric charge, so leaving no trace of the path it followed from its origination until it decays

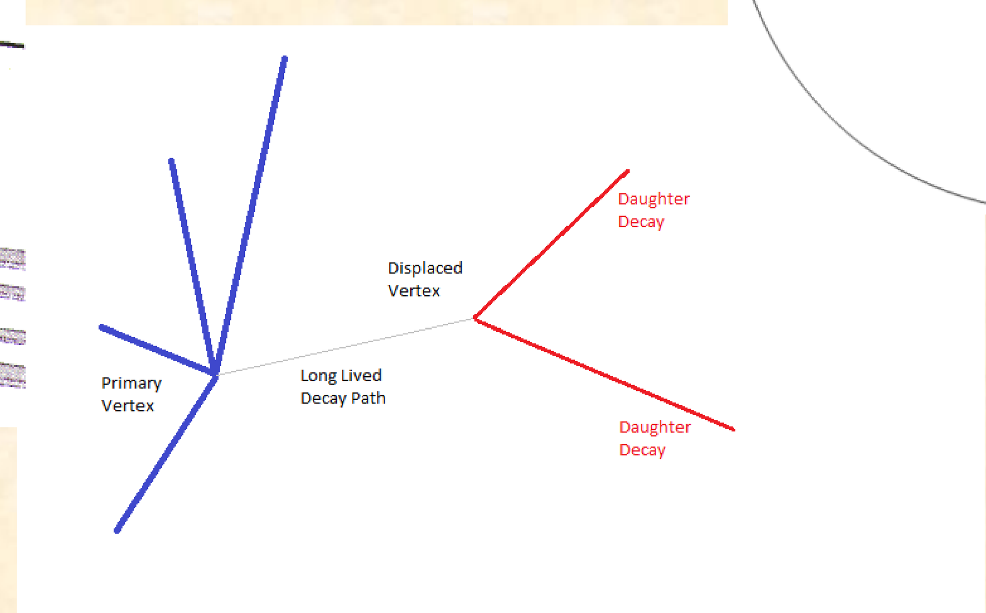
Look for two 'daughter' electrons that originate away from the original impact point (IP) with no observed preceding 'mother' particle

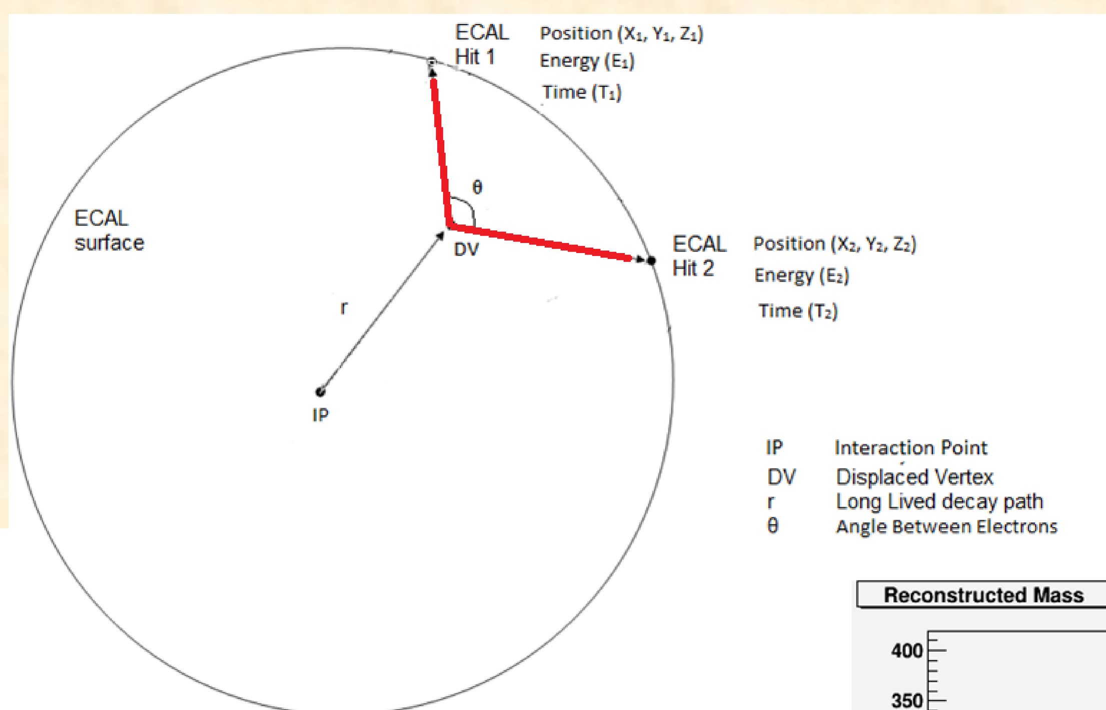
A long lived particle is heavy, so travels slowly ('slowly' to a particle physicist is ~ 200,000,000 ms^{-1}. The speed of light ~299,792,458 ms^{-1})

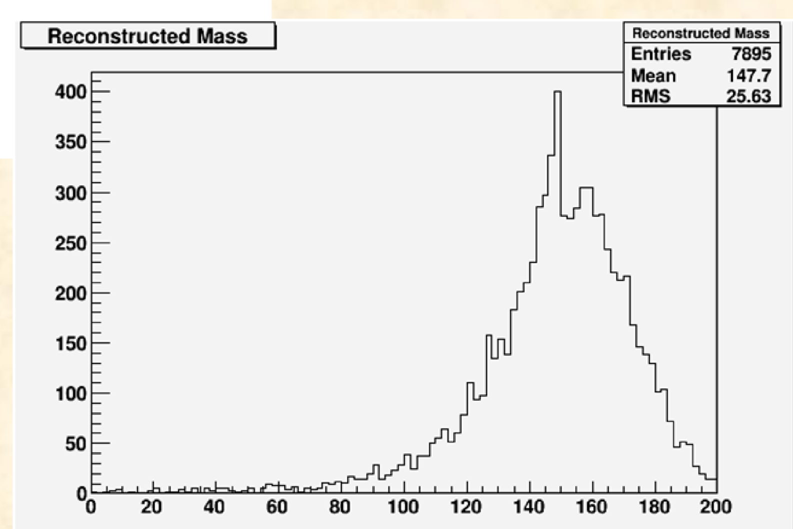
If the long lived particle travels slowly then the two electrons will be observed arriving late at the ECAL, which has a time resolution of 0.2 ns (0.000,000,000,2 s)

CMS Detector









Have we found Dark Matter?

1. If we observe two late arriving electrons
2. Measure their exact hit locations, energy deposits and hit times in the ECAL
3. Calculate the long lived particle's decay vertex, flight length, velocity, the angle between the two electron paths
4. Calculate the long lived particle's mass:

$$m = \sqrt{2E_1E_2(1 - cos\theta)}$$

5. Shown are results from a simulated sample of a long lived particles with mass 150 GeV