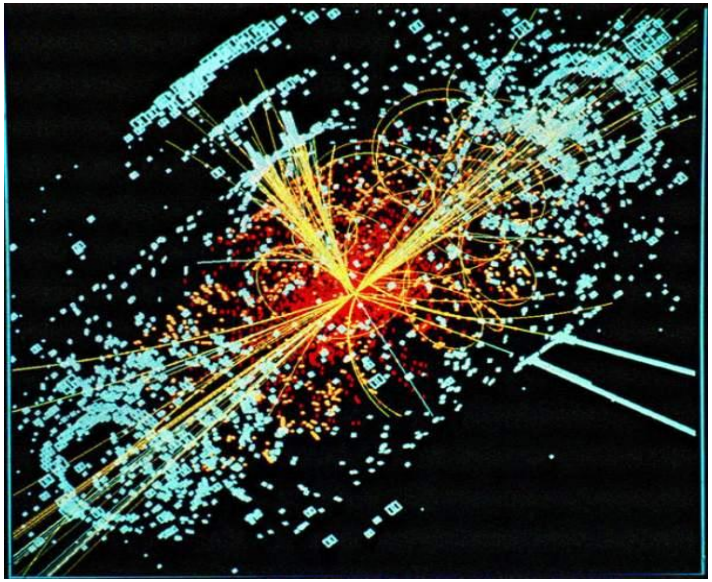
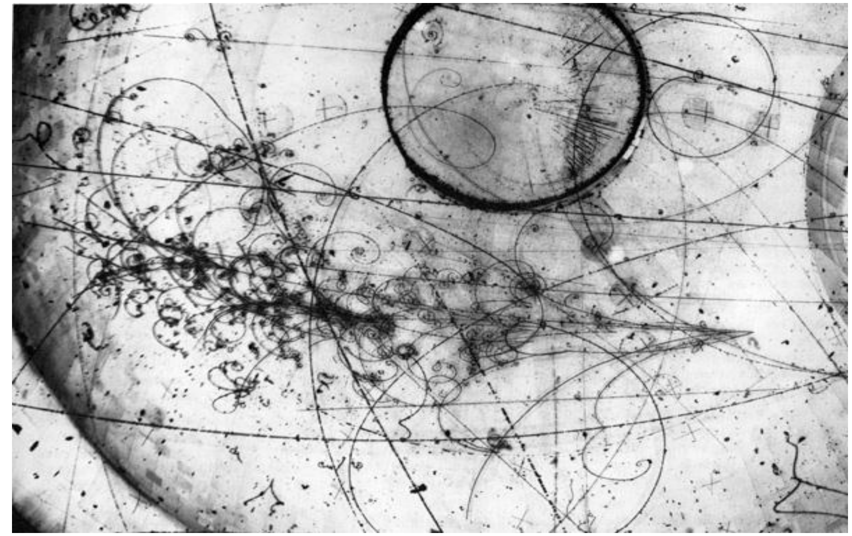
AIM



Discovery of New High Mass Particles	
Requirements	"Centre-of-Mass" energy > 1000GeV High Coverage

AIM

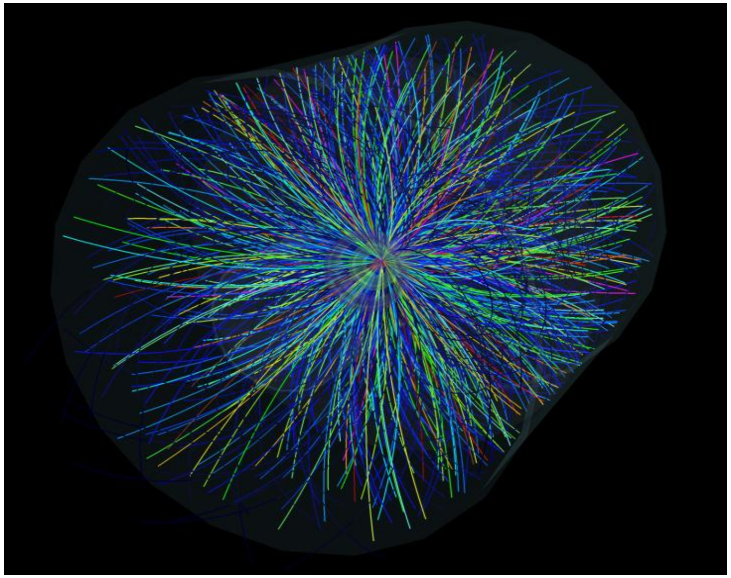


Study of Rare Interactions	
Requirements	•Energy 500GeV •High precision •Lots of events (high luminosity)

Science & Technology Facilities Council

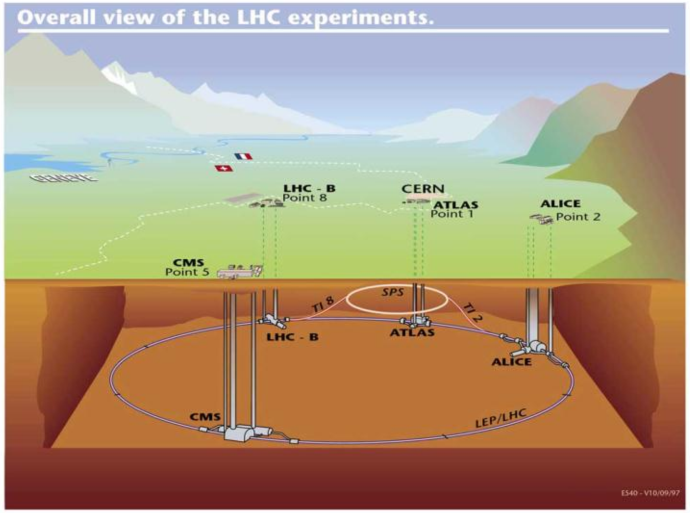
University of BRISTOL

AIM



Study of heavy ion properties	
Requirements	•Energy ~1000GeV •Ability to readout vast amounts of data •High resolution

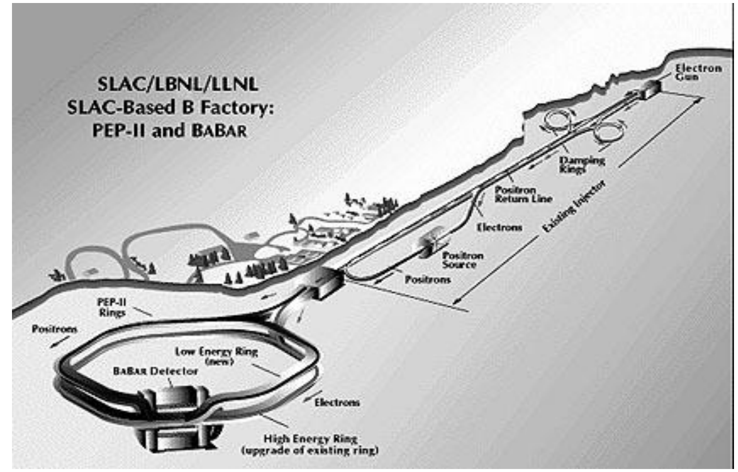
ACCELERATOR



The LHC at CERN

Proton-proton collider	
Proton-proton accelerators allow very high energy collisions. However since protons are made up of smaller particles their interactions are messy and physics signatures can easily be lost.	
Advantages	Higher centre of mass energy achievable than electron-positron.
Disadvantages	Requires highly engineered magnets to steer same-sign particles in different directions.
Cost	£2,100,000,000

ACCELERATOR



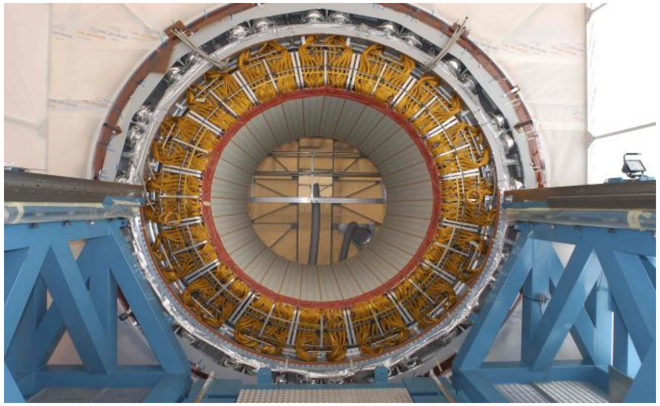
The Stanford Linear Accelerator Centre in the USA

Linear Electron-positron collider	
The low mass of the electron means that it is more susceptible to 'synchrotron radiation' losses when accelerated in rings. This limits the energy that can be achieved for a given ring size. Linear collider required for higher energies. However, because electrons are fundamental their collisions are very clean and can be interpreted very easily.	
Advantages	Very clear events produced
Disadvantages	Lower energy
Cost	£4,200,000,000

Science & Technology Facilities Council

University of BRISTOL

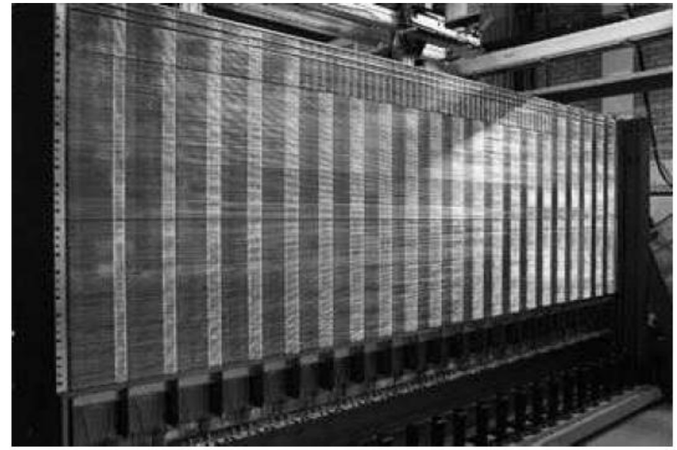
CALORIMETRY



ATLAS calorimeter during installation – steel and plastic

Sampling Calorimeter	
High energy particles interact in sheets of an absorber producing a "shower" of particles. Interleaved between these are detectors to measure the energy of the particle via its shower. Often used to detect energy deposited by hadrons, which produce large, hard to predict showers, such that poor energy resolution is less important than other factors.	
Advantages	Lower cost than homogeneous calorimeter
Disadvantages	Relatively poor precision energy measurement
Cost	£15,000,000

CALORIMETRY



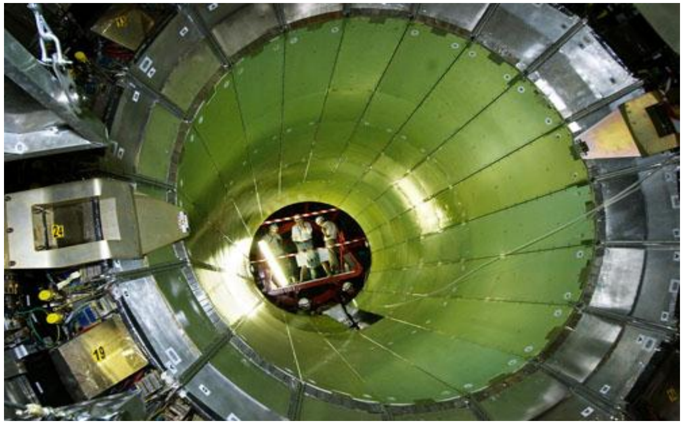
Section of the ZEUS Compensating Calorimeter

Compensating Calorimeter	
This is a particular type of sampling calorimeter. Most calorimeters give a different response (signal size from the detectors) to electrons/photons that they do to hadrons, which is undesirable. Much of this difference is due to energy lost in breaking up nuclei in the absorber, which isn't measurable by the detectors. If the absorbers are made partly from depleted uranium the fission of the nuclei releases energy which compensates for this.	
Advantages	Same response for hadrons and electrons/photons; improves resolution
Disadvantages	Need large amount of depleted U
Cost	£23,000,000

Science & Technology Facilities Council

University of BRISTOL

CALORIMETRY



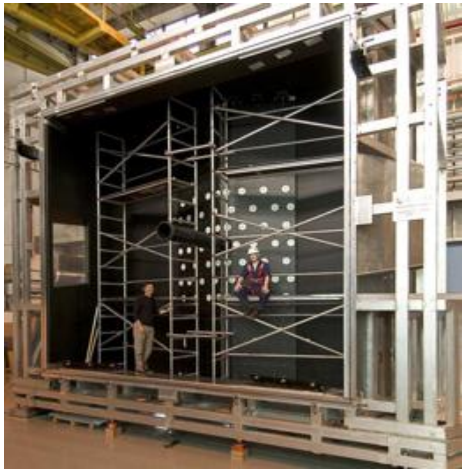
The CMS Lead Tungstate electromagnetic calorimeter

Homogeneous Calorimeter	
Unlike a sampling calorimeter, the absorbing medium is also the detection medium. Usually made from scintillating crystals (e.g. Lead Tungstate) which absorb the energy of particles in the shower and reemit some of it as light. Because all the detector is sensitive to particles the measurement error is lower than with a sampling calorimeter. Often used to detect the energy deposited by electrons/photons and in conjunction with a sampling calorimeter to measure hadrons.	
Advantages	Good precision energy measurements
Disadvantages	More expensive than sampling calorimeter
Cost	£30,000,000

Science & Technology Facilities Council

University of BRISTOL

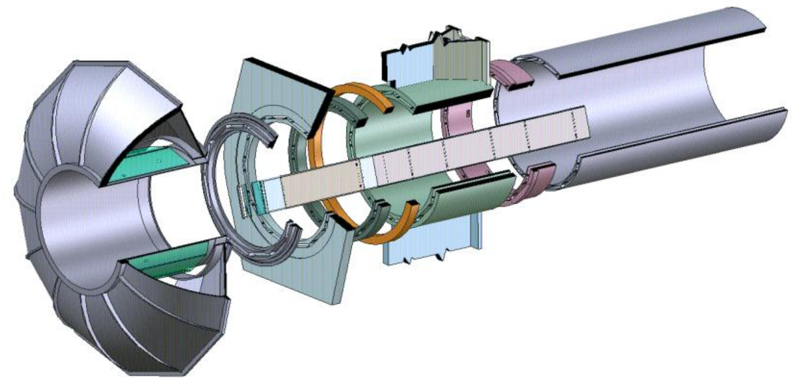
PARTICLE-ID



RICH-2 from LHCb

Ring Imaging Cerenkov Detector (RICH)	
Particles travelling at faster than the apparent velocity of light in a transparent medium emit visible light. (Cerenkov Radiation). Cerenkov radiation is dependent on the velocity of the particle not its energy or its momentum. Ring Imaging Cerenkov detectors focus the emitted light into a ring.	
Advantages	When used with other detectors can be used to identify particles
Disadvantages	Hard to fit inside solenoid. High velocity particles all give almost the same signal
Cost	£4,000,000

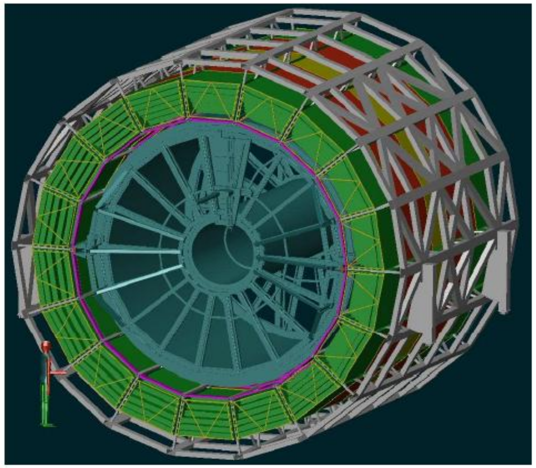
PARTICLE-ID



Simulation of the DIRC from BaBar

Detection of Internally Reflected Cerenkov Radiation (DIRC)	
A type of ring imaging Cerenkov detector. Uses light guides (e.g. Quartz) to take the light to a suitable location to be measured resulting in a narrower design.	
Advantages	Easy to fit inside solenoid
Disadvantages	Difficult to produce
Cost	£8,000,000

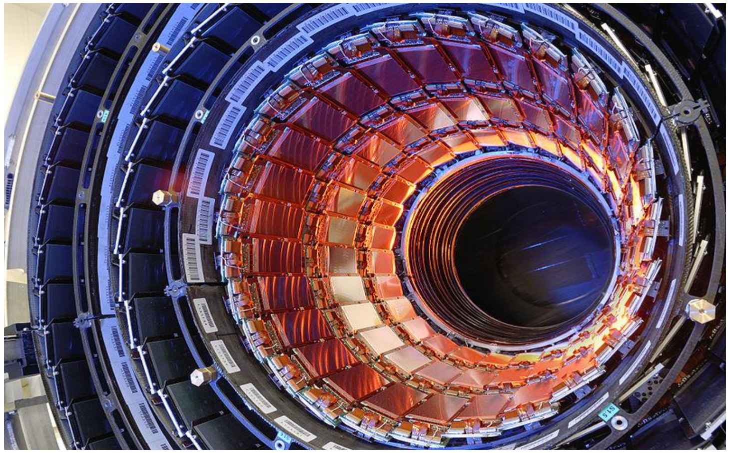
PARTICLE-ID



The TRD for ALICE

Transition Radiation Detector (TRD)	
Transition radiation is radiation in the X-ray region, that arises when ultra-relativistic particles cross a boundary between 2 media with different dielectric constant. Related to Cerenkov radiation, but more sensitive to small differences in velocity of high energy particles than Cerenkov radiation.	
Advantages	Works well for high-energy particles
Disadvantages	Signal small and often difficult to detect. (Many instances in particle physics where TRDs never worked properly).
Cost	£4,000,000

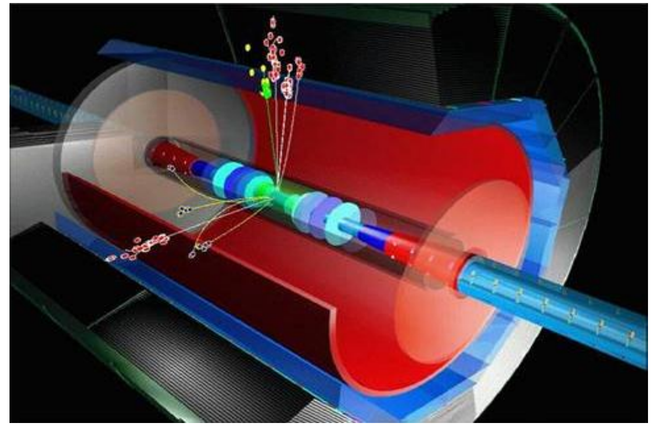
TRACKER



The CMS silicon tracker

Silicon Tracker	
An electrically charged particle ionizes the solid it is passing through. Using semiconductor technology millions of tiny diodes are produced on silicon wafers. A particle passing through a reverse biased diode results in a small current, indicating a "hit". The tracker of a charged particle can be measured by joining the hits together to reconstruct its path. Often used in conjunction with a magnetic field to measure momentum.	
Advantages	Excellent precision measurements
Disadvantages	High cost. Millions of readout channels.
Cost	£20,000,000

TRACKER



Gaseous Tracker for International Linear Collider

Gaseous Tracker	
Electrically charged particles ionise gas (usually argon with a mix of other gasses) as they pass through. The electrons and ions released drift towards electrodes (often fine wires strung in the chamber). Often used in conjunction with a magnet, when the momentum of a charged particle is measured by detecting curvature of its path in a magnetic field. Tracks the decay products of short-lived particles back to the position where they decayed.	
Advantages	Reasonable cost compared to Si
Disadvantages	Moderate precision measurements
Cost	£5,000,000

Science & Technology Facilities Council

University of BRISTOL

MAGNET

The CMS superconducting solenoid in its iron return yoke

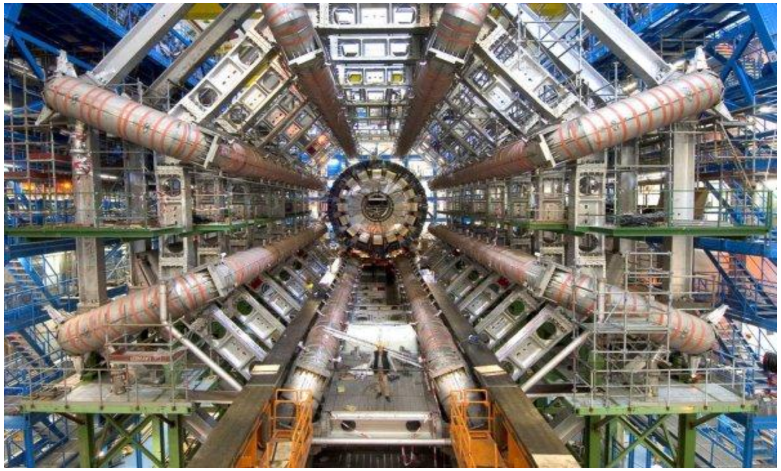
Superconducting Magnet	
At low temperature (<20K) some materials develop a very low electrical resistance. They are known as superconductors, and can produce a given magnetic field with a relatively low power dissipation.	
Advantages	Small physics size. Low "dead material" High field possible than conventional
Disadvantages	Expensive to build Tricky to build
Cost	£40,000,000

MAGNET

Magnet for Omni Purpose Apparatus (OPAL at LEP)

Conventional Magnet	
A conventional magnet is composed of a normally conducting metal (often copper). They require relatively high power to produce a given magnetic field. Lots of "dead material" that absorb particle energy.	
Advantages	Relatively cheap to build Operates at room temperature Reliable
Disadvantages	Large physical size Lots of "dead material"
Cost	£20,000,000

MAGNET



The eight toroidal magnets of ATLAS

Toroidal Magnet	
Usually a solenoid is used to create a highly uniform magnetic field in the tracker of an experiment, but they work best when they are small and creating a solenoid for a large experiment can be very expensive. For this reason larger detectors often employ toroidal – donut shaped – magnets instead.	
Advantages	More uniform fields can be achieved Cheaper to produce on a large scale
Disadvantages	Less powerful than a solenoid
Cost	£30,000,000

Science & Technology Facilities Council

University of BRISTOL