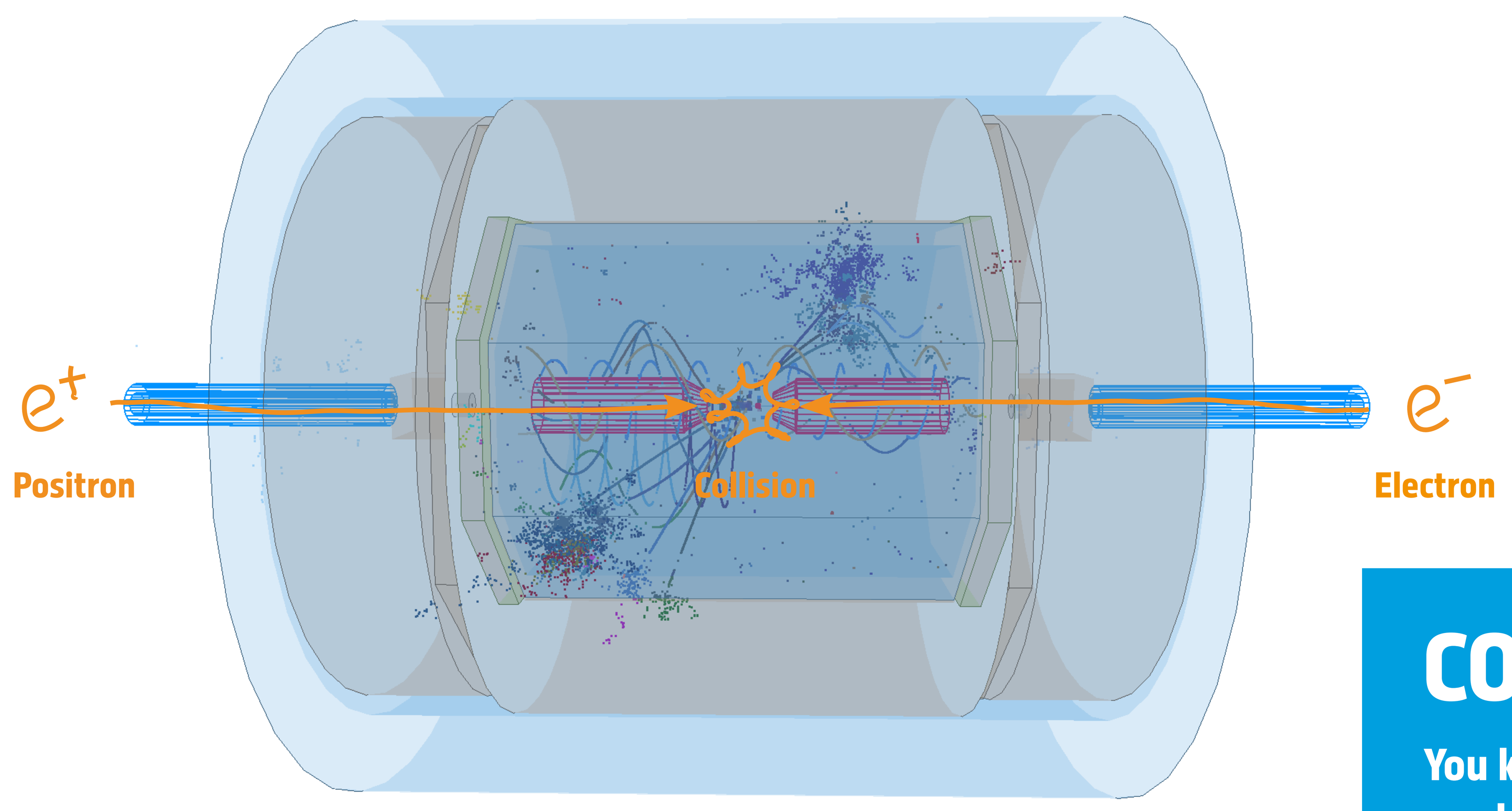
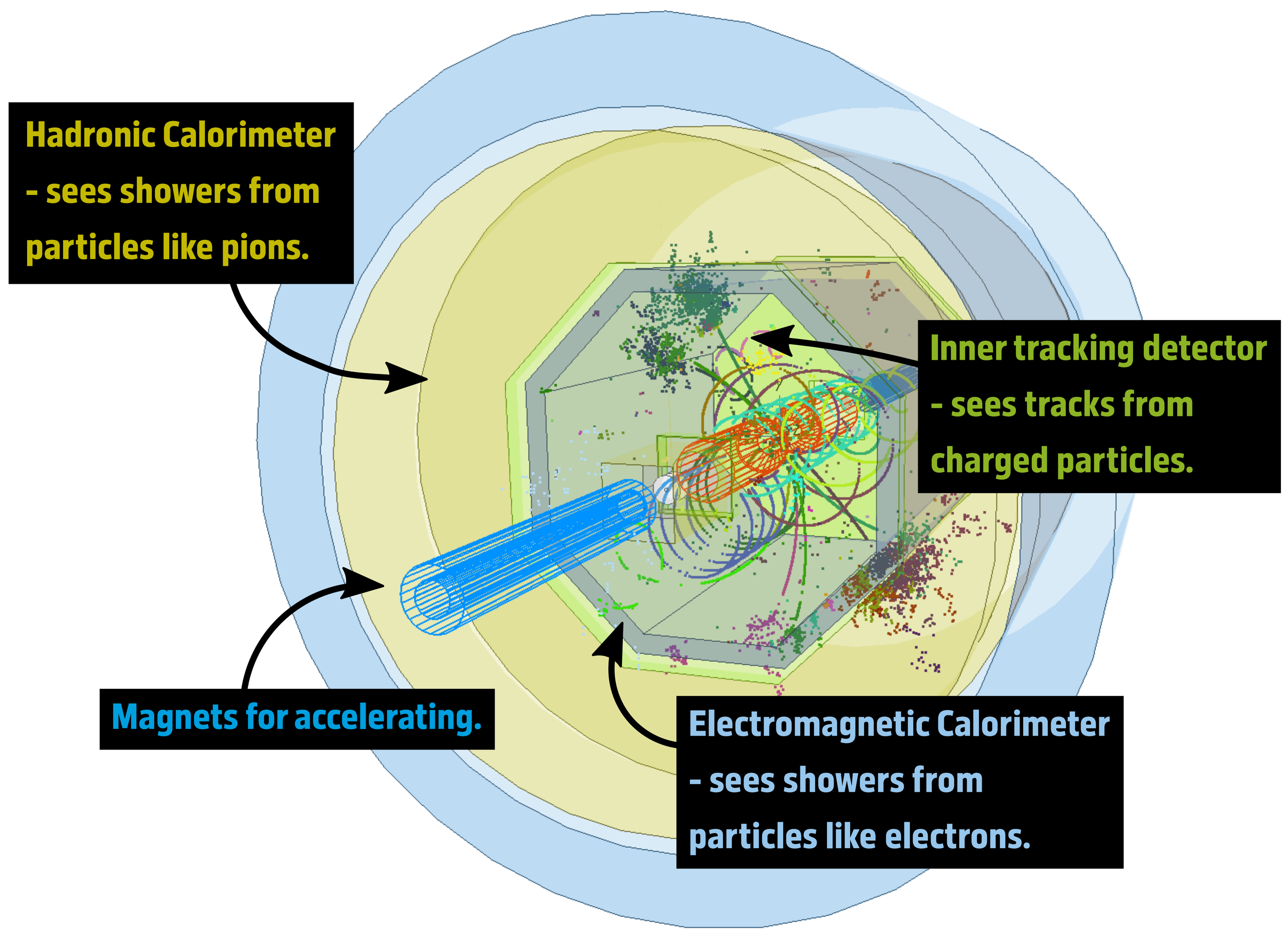
DETECTOR

Here at DESY, one detector that we are particularly interested in is the International Large Detector (ILD). The ILD will detect collisions created by the International Linear Collider (ILC). Neither of those names are particularly creative; you can take them quite literally. This collider (and it's detector) doesn't actually exist yet, and it is planned for construction in the future. One of its key features is a high granularity calorimeter (like a high resolution camera, only in 3D). This high resolution calorimeter is likely to be a feature on any new detector that is built, because it is very good for identifying the fragments in a jet.



Above you can see the detector from the side. Electrons and positrons would be fired in from the left and the right, to collide in the centre of the detector.



Currently, the largest particle accelerator in the world is the Large Hadron Collider at CERN. As seems only reasonable given the name, this detector collides hadrons. Hadrons are made up from quarks, and they are quite easy to accelerate and collide in circular colliders like the LHC.

Rather than colliding hadrons, the ILC will collide electrons and their antiparticle positrons. This is possible because it will be linear, rather than circular like the LHC. Electrons and positrons are not made up of other particles, they are called fundamental particles. Colliding fundamental particles will create a much cleaner signals. We have finer control over the energy, and expect to see less other background activity with each collision.

COLOUR CONFINEMENT

You know how the force between two magnets gets weaker as you pull them apart? Imagine pulling apart two objects that became more strongly attracted to each other the further apart they got. That's how colour charge works.

Not all particles have colour charge - for example electrons and photons don't. But the particles that do, quarks and gluons, are involved in some very important physics.

These colour charged particles can't exist on their own. Normally they exist in colour neutral groups called hadrons. But if one gets produced with a lot of momentum and energy, say in a particle collision, it still won't end up going off on it's own. The energy of the quark will actually create lots more particles, (remember $e=mc^2$) until colour neutral groups form again. We then see this as a jet in the detector.

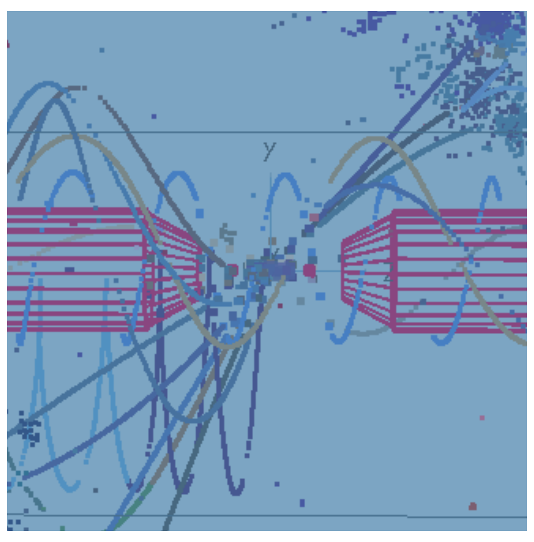
Do you know where gluons were first discovered? Ask us!

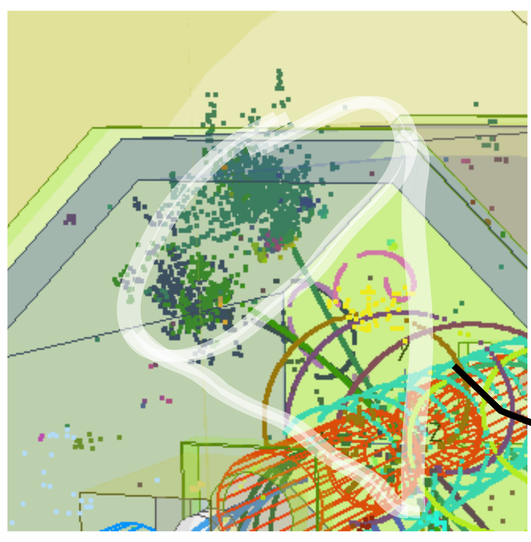
PARTICLE IDENTIFICATION

What does a particle actually look like? Perhaps unsurprisingly, the answer depends on both the particle and the detector. Some particles can travel alone and leave long string-like tracks, other particles immediatly form groups. When a group is broken, they produce a spray of fragments like a firework.

This firework like feature is called a jet. Colour confinement is the reason that these particles need to form groups. You can read more about colour confinement in the section above. We only see particles that experience colour confinement as jets.

Right in the centre of our detector is the collision point. Beams of particles fired in from the left and right collide here. We are interested in unstable particles created right in the centre where the energy is highest, so we look for things that seem to have come out of the centre.

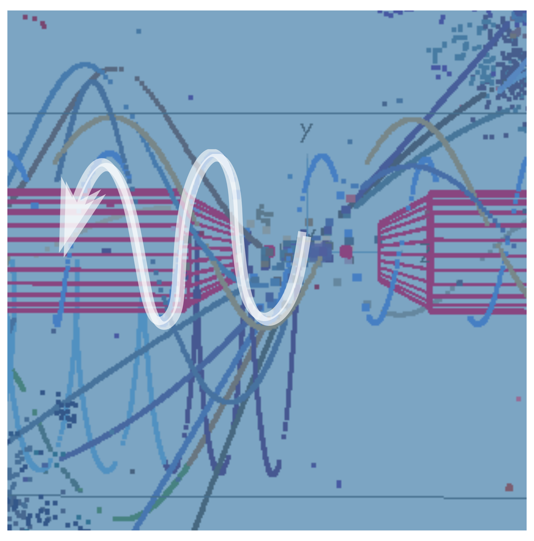


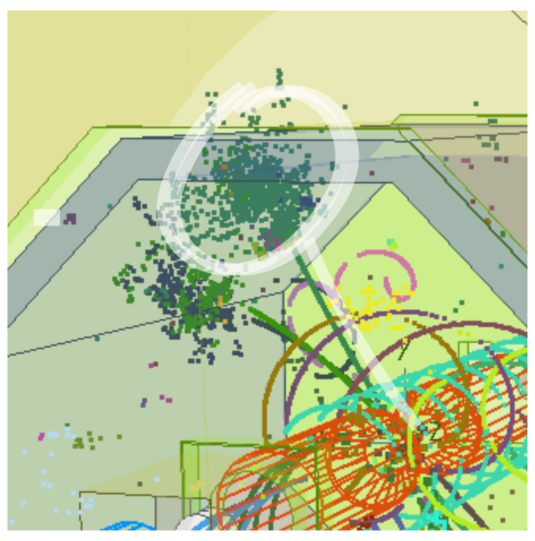


All together, this cluster of hits is a jet. It was created by a quark or gluon that broke into fragments (decayed) very close to the collision point. The jet is defined by gathering high energy hits that are close together.

Each plot contains one jet that we will need to classify, i.e. identify if it came from a quark or a gluon.

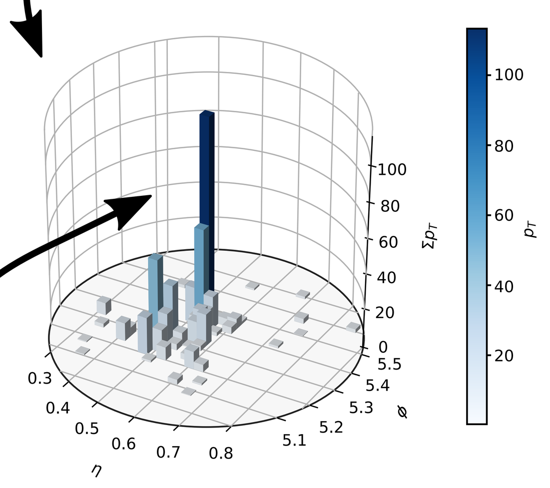
The particles that spiralling around near the centre must be charged. Only charged particles leave tracks in the inner part of the detector. It is spiralling because the detector has a strong magnetic field, which makes charged particles curve. We can tell if the charge was positive or negative by the direction of the spiral.

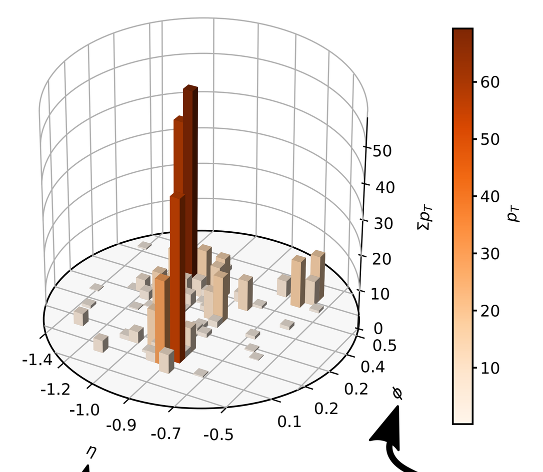




One of the fragments from the jet above is breaking into more fragments in the calorimeter, forming a shower. We can see that this fragment was a charged particle, because it left a track in the inner part of the detector as well.

Here is a gluon jet in blue and a quark jet in orange. They don't look that different, do they?





Each cuboid represents one pixel that measured some energy from a particle fragment.

The colour and height of the cuboid represents how much transverse momentum (writen as "pT") was in that pixel. This is roughly the same as energy.

η (pronounced "eta") and φ (pronounced "phi") measure the angle of the pixel from the collision point.

OUR DATA

In the Machine Learning task described on the poster next door, we are working to identify QCD jets. Specifically, we will consider jets from quarks and gluons. Quark jets are normally the ones we are really intrested in, they are produced in lots of intresting interactions, for example when a Higgs boson decays it produces quark jets. Gluon jets look pretty similar, but normally they are just noise that we need to filter out. So it's important we can distingush the two.

The first step is to split the data into seperate jets, each of which should have come from exactly one quark or gluon. That has already been done for this dataset.

Then to try an identify the jet, we will look at the fragments it is made up of. We need the angle that each fragment left the collision point at, and the transverse momentum of each fragment. Transverse momentum is roughly proportional to energy, and it's often written as "pT".

The angle is described by two values; η (pronounced "eta") and φ (pronounced "phi"). η tells us how close to the incoming beam the particle was, and φ tells us the rotation of the particle around the axis of the beam.

Using the η, φ and pT of each fragment we will decide if the jet is from a quark or a gluon.

Try particle identification at our computer!

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