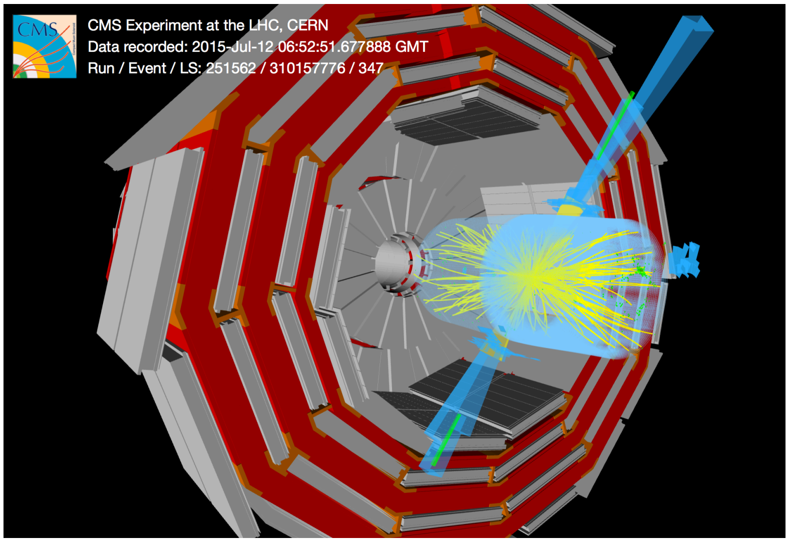
CMS presents first results with 13 TeV at 2015 EPS-HEP Conference

The CMS Collaboration at CERN is presenting a range of new physics results at the EPS-HEP conference in Vienna, Austria between 22 and 29 July 2015. The results will include the first analyses with the "LHC Run 2" data (13 TeV centre-of-mass energy, collected since June 2015) as well as more than 30 new analyses performed on the "Run 1" dataset (7 and 8 TeV, collected in 2011 and 2012 respectively). Below are summaries of some of the analyses shown at the conference.



A 13TeV collision recorded by the CMS detector showing two high-energy particle jets with a collective mass of 5 TeV

1. Production of charged hadrons

The highlight for CMS is the first physics result from the LHC using 13TeV data: the measurement of the number and trajectories of charged hadrons produced in the proton collisions. This is usually one of the first measurements performed at hadron colliders at the start of exploration at a new energy regime. Because protons are not elementary – they are made of quarks and gluons – when two protons collide at high energies it is actually the quarks and gluons inside them that interact. So every proton collision produces a spray of charged hadrons, such as pions and kaons, flying in all directions. The number of these particles depends on the collision energy – the greater the energy, the higher the number of produced particles. It is therefore important to determine precisely how many charged hadrons are produced at the new collision energy of the LHC in order to make sure that the theoretical models used in simulations are accurate. The CMS Tracker is responsible for determining the trajectories of charged hadrons and is used to perform this measurement, which involved a few hundred thousand collisions recorded at zero magnetic field. The CMS measurement is well described by the theoretical models and will help accurately determine the "background" levels in the searches for new physics at 13 TeV.

DETAILS: CMS measured the differential multiplicity distribution of charged hadrons ($dN/d\eta$) for pseudorapidity less than 2, as shown in Figure 1. In particular, the measurement in the mid-rapidity range

(|η|<0.5) was 5.49 ± 0.01 (stat.) ± 0.17 (syst.) per collision. The Letter with the result was submitted to *Physics Letters B* on 21 July and the pre-print can be found at https://cds.cern.ch/record/2036310/

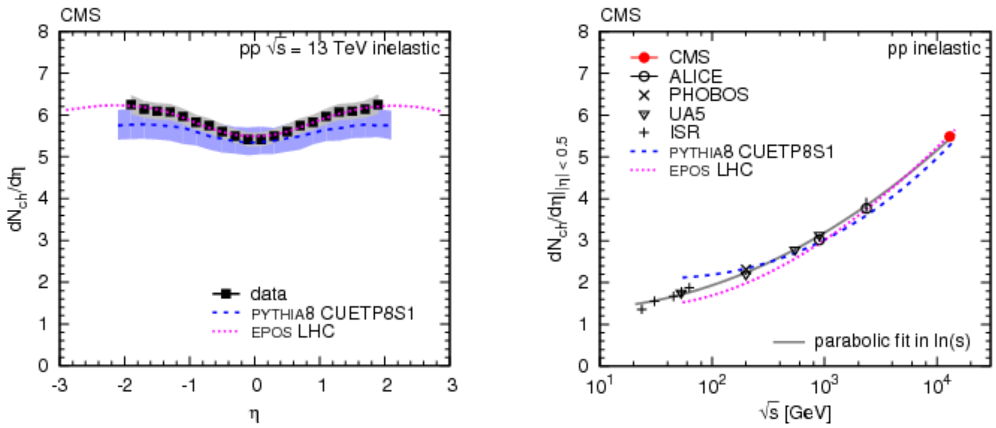


Figure 1: Measured charged-hadron production as a function of pseudorapidity (left), and the multiplicity in the central region compared to previous measurements at lower energies and theoretical models.

2. Re-discovering particles and testing the discovery potential

An important test of the CMS detector's performance at 13 TeV lies in its ability to observe known particles. Figure 2 is a mass histogram of pairs of muons produced from proton collisions in the CMS detector, clearly showing peaks in the data corresponding to particles ranging from the omega meson (ω) to the Z boson. The particles in this spectrum were originally discovered over several decades but it took CMS just weeks to observe them all at 13 TeV. Details about the CMS performance studies can be found at https://twiki.cern.ch/twiki/bin/view/CMSPublic/PublicPlotsEPS2015.

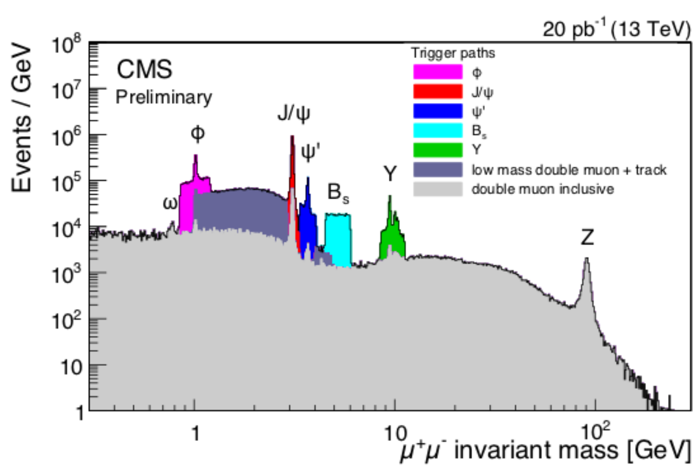


Figure 2: The di-muon invariant mass spectrum at 13 TeV

Several processes in the 13TeV data have been studied in some detail. One highlight of this effort is a first look at the di-jet invariant-mass spectrum up to approximately 5 TeV (Figure 3), demonstrating the readiness of CMS for new physics at these high energies.

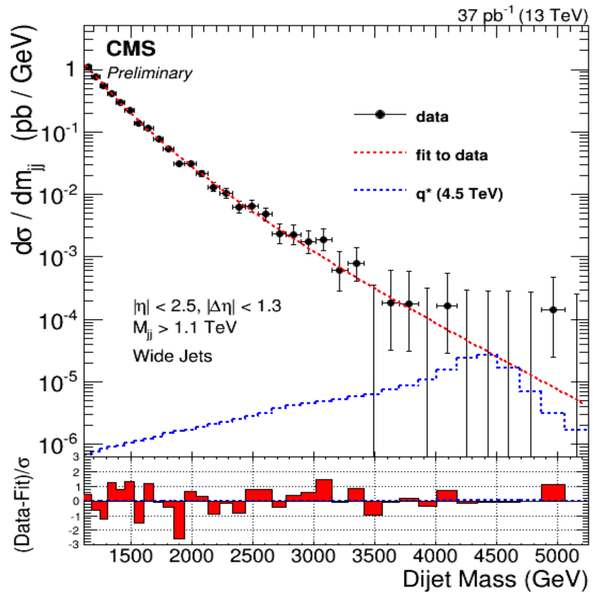


Figure 3: Di-jet invariant mass spectrum, showing the expected signal distribution from a hypothetical particle with 4.5 TeV transforming into two jets

3. Wrapping up analysis of "Run 1" data

CMS continues to perform physics analysis on the "Run 1" data collected at 7 and 8 TeV, with more than 30 new results approved recently for the EPS-HEP conference. These include measurements of the two-photon production of W-boson pairs (FSQ-13-008), the production rates for particle jets at 2.76 TeV compared to 8 TeV (SMP-14-017), the production of two photons along with jets (SMP-14-021) and electroweak production of a W boson with two jets (SMP-13-012).

Discovered over two decades ago, the top quark continues to play a vital role in physics analysis for both measurements and searches. New CMS results with this fermion include measurements of the top-antitop production rates in the fully hadronic sample (TOP-14-018) and a measurement of the top-antitop+bottom-antibottom process in the lepton+jets channel (TOP-13-016). In addition, searches for signs of new physics continue, most recently in the process t→cH, where the Higgs boson transforms to photons (TOP-14-019).

Meanwhile, on the Higgs front itself, three new searches have been performed for non-Standard-Model Higgs bosons containing tau leptons in the decay products (HIG-14-029, HIG-14-033, HIG-14-034), while on the supersymmetry front, analyses have been performed looking for dark-matter candidates and other supersymmetric particles (SUS-13-023, SUS-14-003, SUS-14-015).

Heavy-ion results from Run 1, utilising proton-proton, proton-lead and lead-lead collisions, include Upsilon (Y) polarisation as a function of charged-particle multiplicity in proton-proton collisions (HIN-15-003), Z-boson production (HIN-15-002), jet-fragmentation functions in proton-lead collisions (HIN-15-004), and nuclear modification of Upsilon (Y) states in lead-lead collisions (HIN-15-001).

More information: http://cern.ch/cms, or contact: cms.outreach@cern.ch.

CMS is one of two general-purpose experiments at the LHC that have been built to search for new physics. It is designed to detect a wide range of particles and phenomena produced in the LHC's high-energy proton-proton and heavy-ion collisions and will help to answer questions such as: "What is the Universe really made of and what forces act within it?" It will also measure the properties of well-known particles with unprecedented precision and be on the lookout for completely new, unpredicted phenomena. Such research not only increases our understanding of the way the Universe works, but may eventually spark new technologies that change the world in which we live as has often been true in the past.

The conceptual design of the CMS experiment dates back to 1992. The construction of the gigantic detector (15 m diameter by nearly 29 m long with a weight of 14000 tonnes) took 16 years of effort from one of the largest international scientific collaborations ever assembled: CMS currently has around 2900 scientists (including nearly 1000 graduate students) plus over 1000 engineers and technicians, from 182 institutions and research laboratories distributed in 42 countries all over the world.