

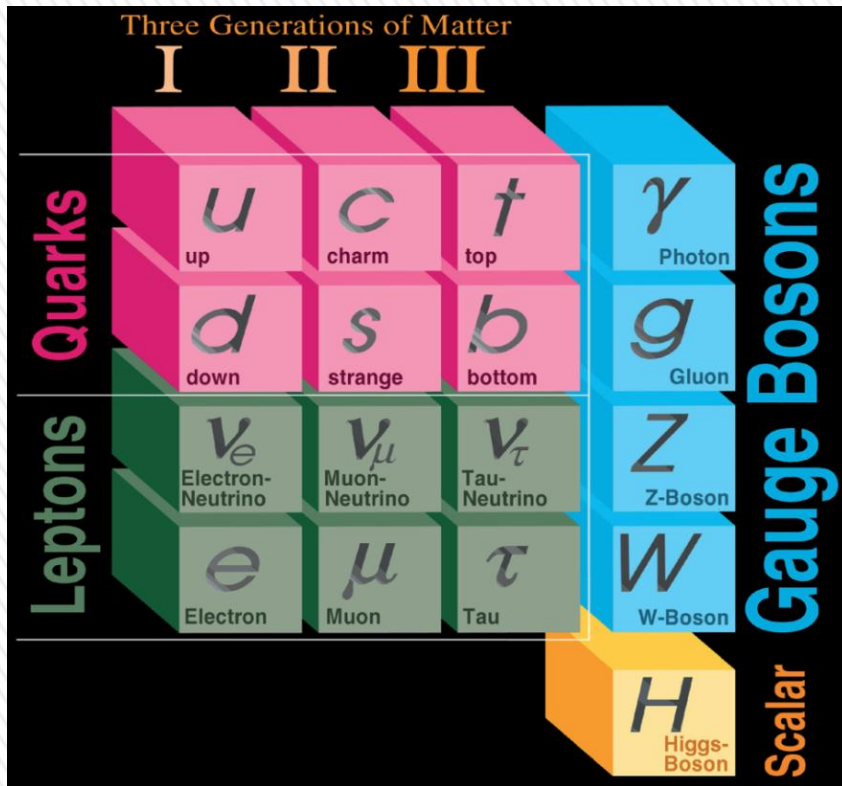


Z' Boson Decay to Di-Muon Final States

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The Standard Model



- Building blocks of matter: Leptons, quarks
- Force mediators: gauge bosons

The symmetry group of the Standard Model is:

$$SU(3)_C \times SU(2)_L \times U(1)_Y$$

- Strong force mediated by gluons
- Weak force mediated by W^+ , W^- , Z^0 boson
- Electromagnetic force mediated by photons



Theories Beyond the SM (BSM)

The short-comings of the SM leads to theories beyond the SM.

The Z' boson is a hypothetical particle beyond the SM that has been predicted by many theories.

Its existence could:

- Explain further how forces are related to one another
- Contribute to the search for extra dimensions
- Give insight into the mystery of dark matter



The LHC

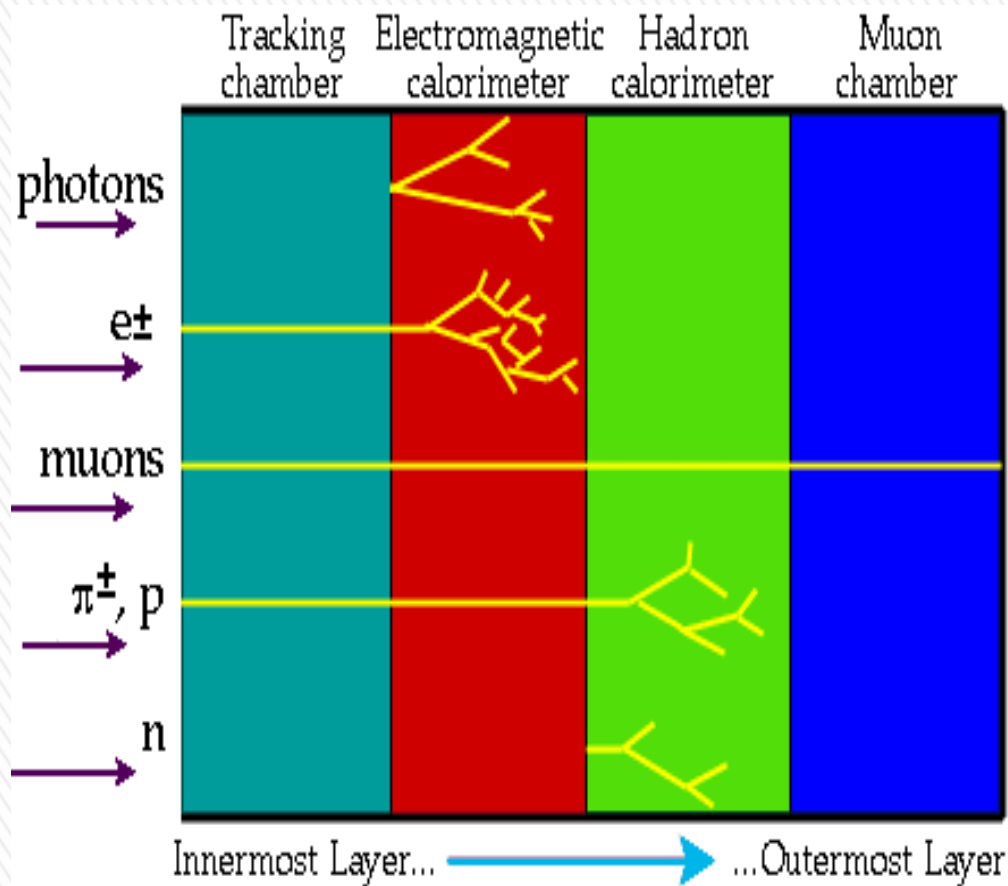
- Ring circumference: 27 km
- Built about 100 m underground in Geneva

LHC consists of a few smaller accelerating structures:

- LINAC 2 \rightarrow 50 MeV
- PSB \rightarrow 1.4 GeV
- PS \rightarrow 26 GeV
- SPS \rightarrow 450 GeV
- LHC ring \rightarrow 4 TeV



The ATLAS Detector

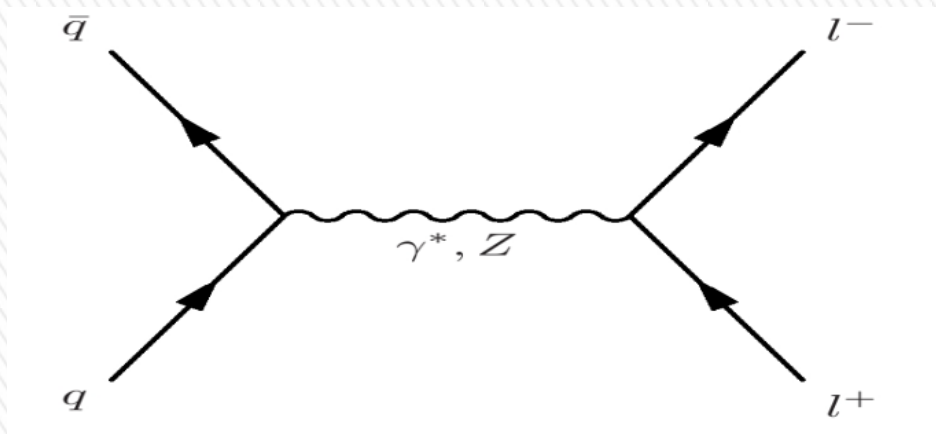


- ATLAS: one of the four major detectors
- Tracking chamber detects charged particles
- EM calorimeters measure electron and photon energy
- Hadronic calorimeters measure energy of hadrons
- Muon spectrometer slows down muons, and detect them as tracks



Experimental Method

- Samples :
 - Data from 8 TeV muon stream was used
 - Monte Carlo signals were generated with PYTHIA for masses at 1 TeV and 1.5 TeV.
 - Background generated with ALPGEN.
 - Background process: Drell-Yan process + 2 jets



Feynman diagram
of Drell-Yan
process



Experimental Method

- Truth Level and Detector Level invariant mass were considered
- MC signals: Truth Level and Detector Level plots
- Data: Detector Level plots
- Histograms generated with ROOT



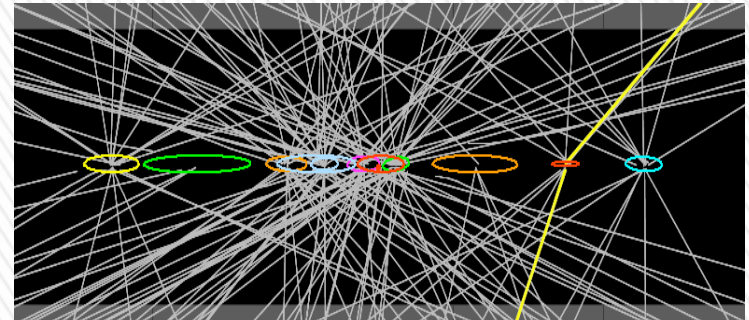
Experimental Method

- Truth Level: Z' boson's invariant mass reconstructed if muons originate from same parent particle.

- Detector Level:

Object reconstruction and pre-selection

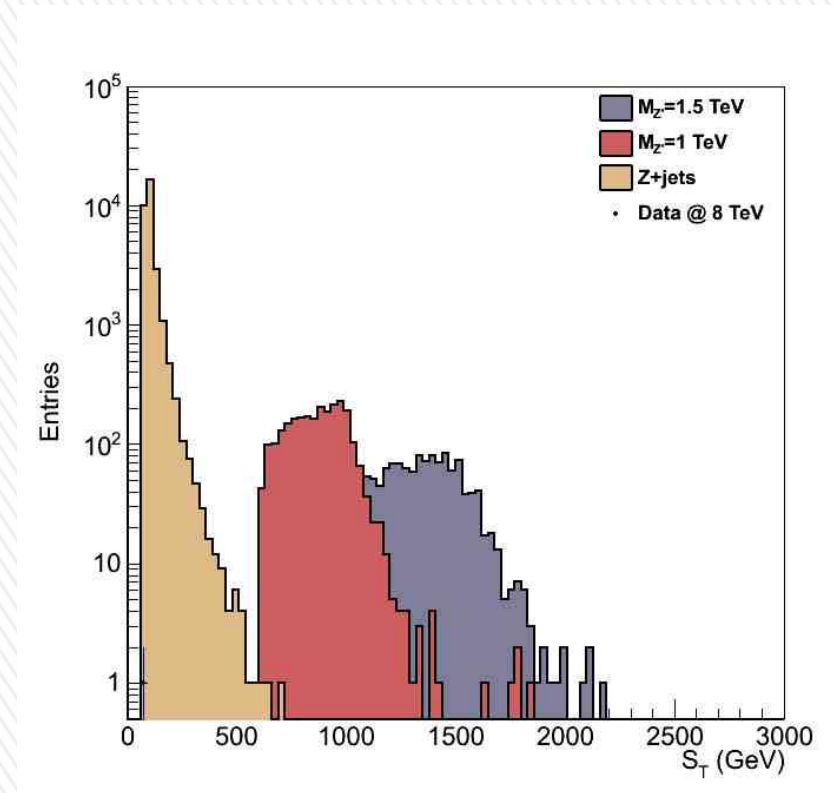
- Primary vertex requirements: at least one vertex with at least two tracks.
- Isolate objects to identify muons, electrons, jets:
 - $\Delta R > 0.2$ for lepton-lepton
 - $\Delta R > 0.5$ for lepton-jet
- Muons: $|\eta| < 2.5$, $P_T > 20\text{GeV}$
- Electrons: $|\eta| < 2.47$, $1.37 < |\eta| < 1.52$ ("crack" region), $P_T > 20\text{GeV}$
- Jets: $|\eta| < 4.0$, $P_T > 20\text{GeV}$



Experimental Method

Analysis Selection

- Muon cuts:
 - Need at least 2 good muons
 - 1 TeV: $P_T > 300\text{GeV}$
 - 1.5 TeV: $P_T > 500\text{GeV}$
- $S_T = \sum p_{T\mu 1} + p_{T\mu 2}$
- $S_T > 300\text{ GeV}$
 - Reduced the background



Experimental Method

- Invariant mass was calculated from the relativistic energy-momentum equation:

$$m = (E^2 - P^2)^{1/2}, c=1$$

Where $P = p_x + p_y + p_z$

and $p_x = P_T \cos(\Phi)$

$p_y = P_T \sin(\Phi)$

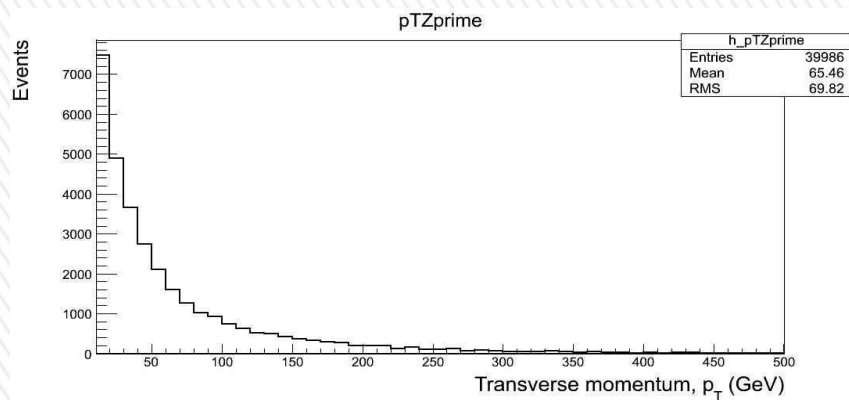
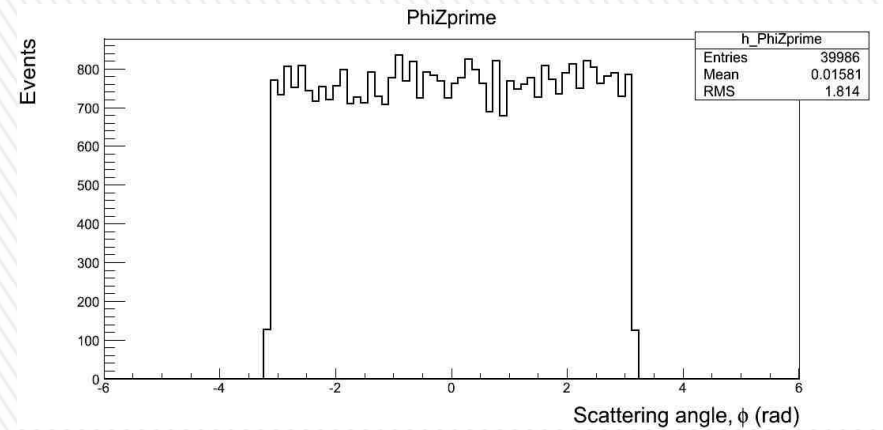
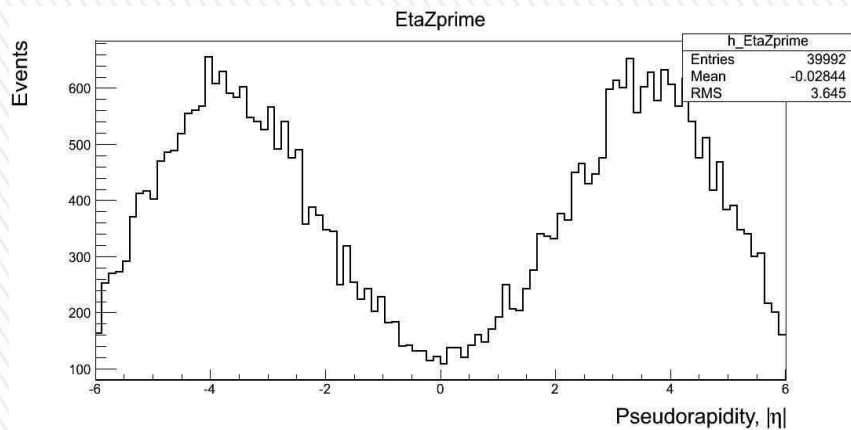
$p_z = P_T \sin(\eta)$

- Required muon information: pseudorapidity ($|\eta|$), scattering angle ϕ (Φ) and transverse momentum (P_T).



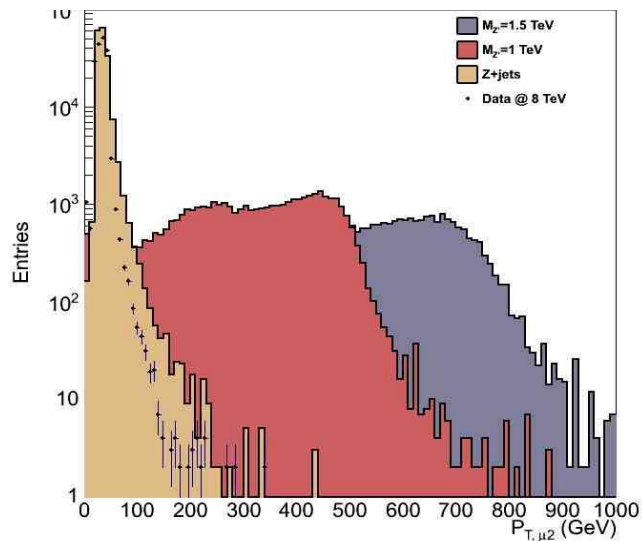
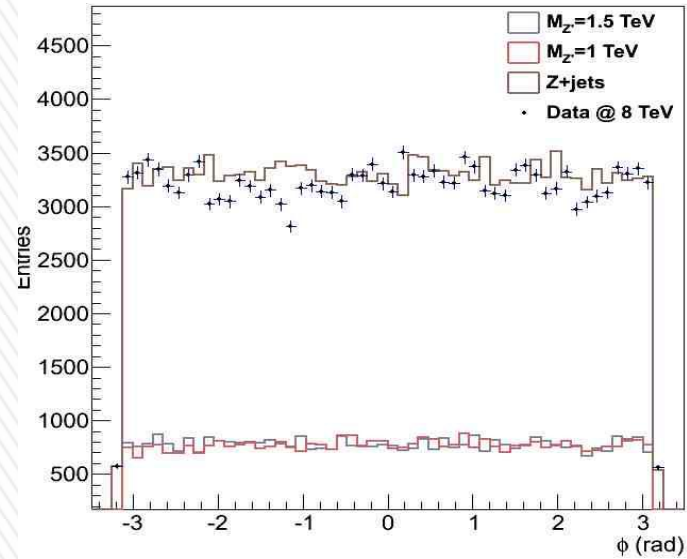
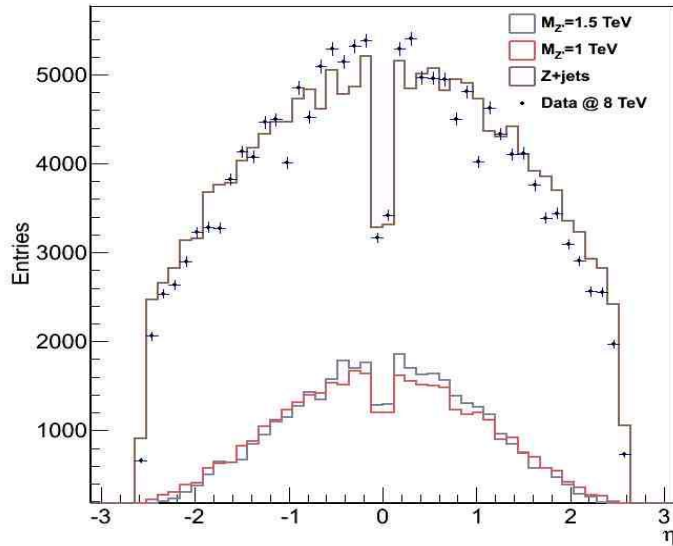
η , Φ , P_T Plots

- Truth Level

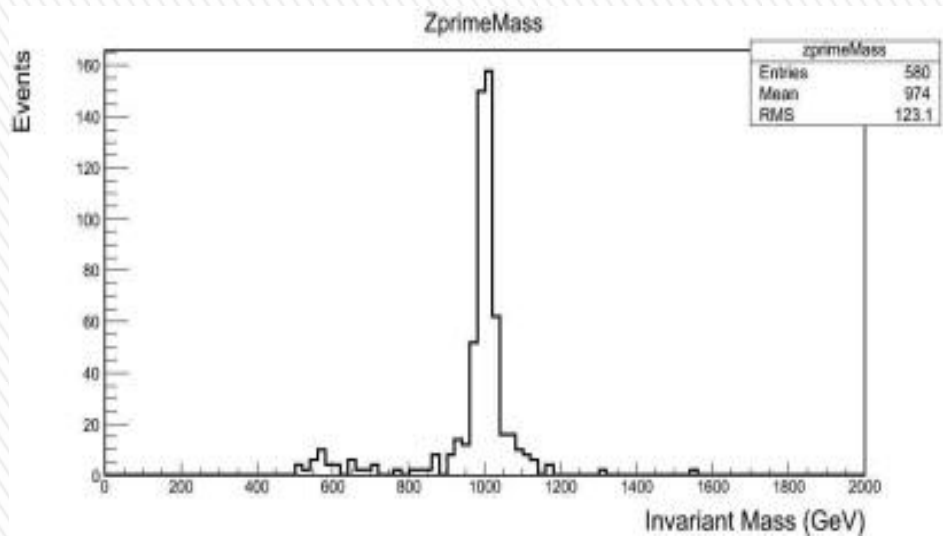


η , Φ , P_T Plots

- Detector Level

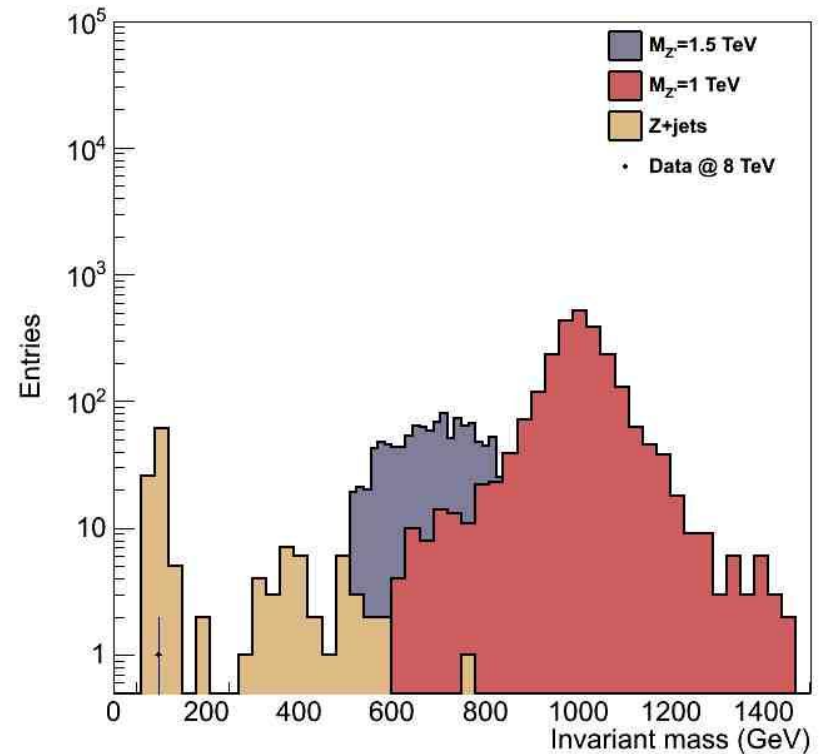


Invariant Mass Plots



← Truth Level: Signal at 1 TeV

Detector Level: Data, signal, background →





Thank You!