Search for new heavy bosons and measurement of high-mass Drell-Yan production

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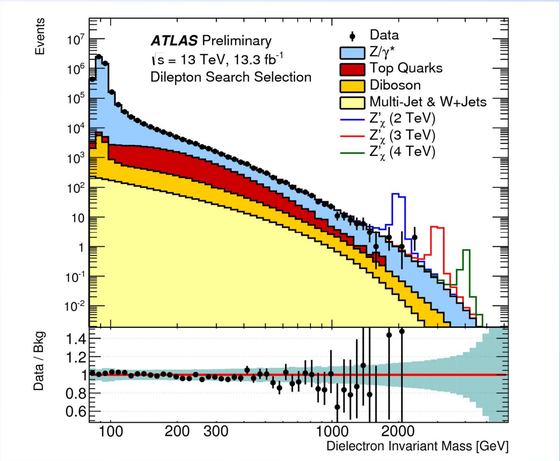
Motivation

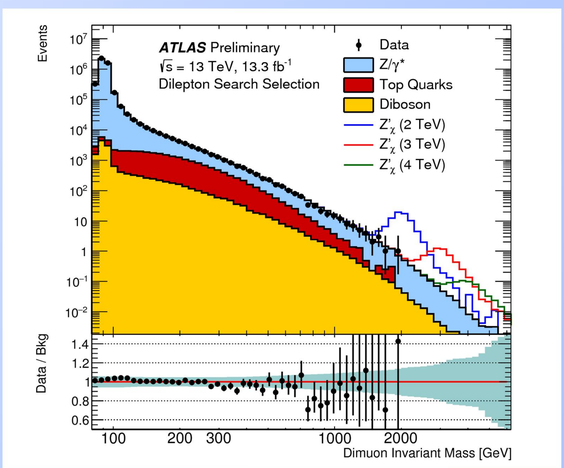
Some extensions of the Standard Model (SM) predict new massive spin-1 gauge bosons. These new bosons can be neutral (so-called Z') and therefore decay into **two leptons** or charged (so-called W') and therefore decay in to a **lepton and a neutrino**. Such new particles can be searched for by looking for an excess in data with respect to the SM background. Since 2015 the Large Hadron Collider at CERN provides collisions of protons at a new record energy of $\sqrt{s}$ = 13 TeV. Data recorded by the ATLAS experiment from these collisions is analyzed to search for such new heavy gauge bosons. Results for data taken in both 2015 and 2016 are presented.

Even if the data does not contain new physics processes beyond the SM, it still remains interesting. The spectra in which the new particles are searched can be unfolded to obtain the cross section of the SM processes. These cross sections can contain important information about the parton distribution functions (PDFs) or, for example, higher-order electroweak effects.

Dilepton final state

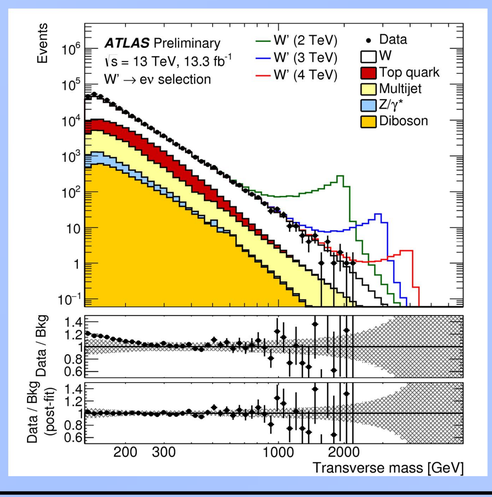
- Events containing two electrons or two muons are considered
- Both leptons have to have high transverse momentum: p_T > 30 GeV
- Use invariant mass spectrum of the two leptons to search for an excess
- Resonance in electron channel much more narrow due to superior resolution
- SM background estimated from Monte Carlo simulations and data driven methods (matrix method)
- Largest systematic uncertainty at high invariant masses coming from the uncertainties of the parton distribution functions (PDFs)

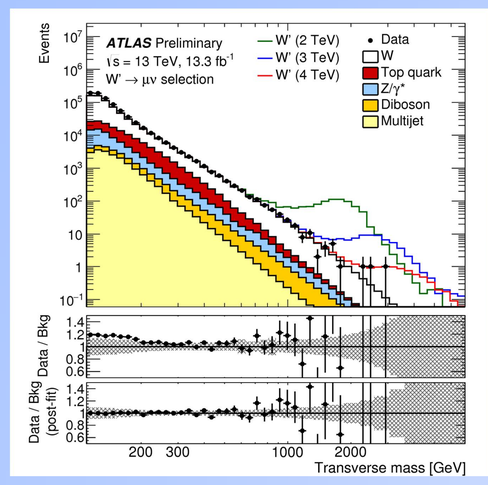




Lepton+E_T^{miss} final state

- Events containing one electron or muon are considered
- Leptons have to have high transverse momentum: p_T > 65 GeV ($e^{+/-}$), p_T > 55 GeV ($\mu^{+/-}$)
- Event does to have high amount of missing transverse momentum: E_T^{miss} > 65 GeV ($e^{+/-}$), E_T^{miss} > 55 GeV ($\mu^{+/-}$)
- Use transverse mass spectrum of the lepton to search for an excess
- SM background estimated from Monte Carlo simulations and data driven methods (matrix method)





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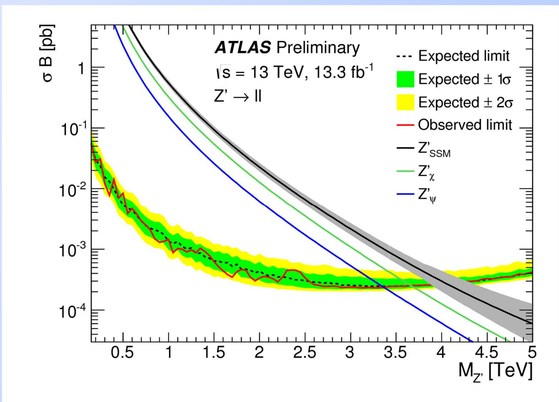
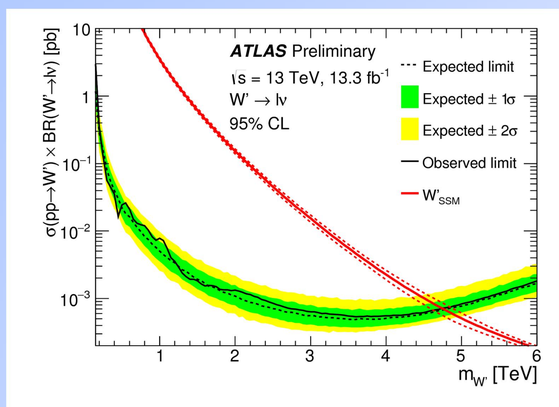
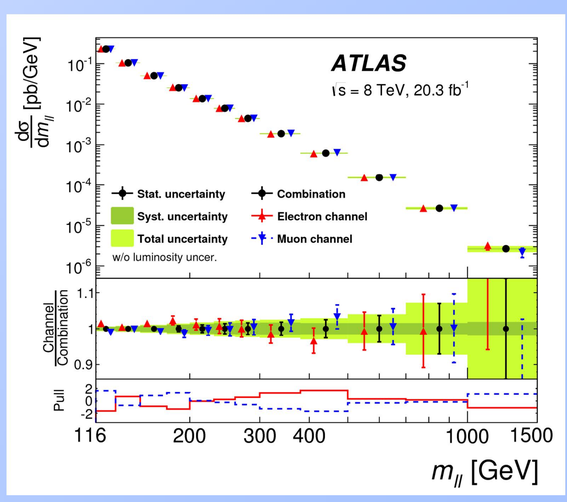


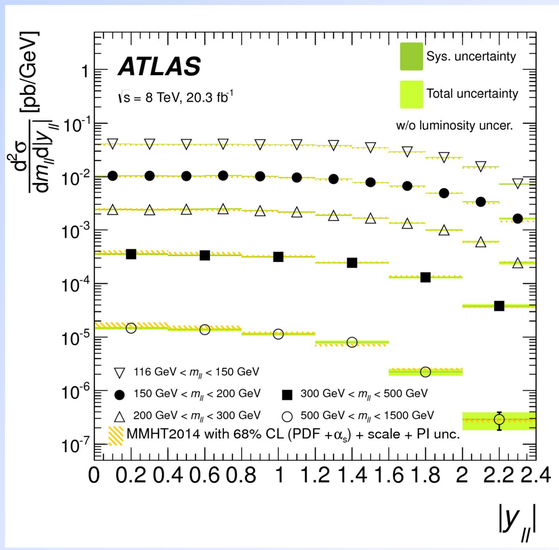
- Good agreement between SM backgrounds and data in both searches
- Exclusion limits on cross section times branching ratio of a W'/Z' are set using a Bayesian approach
- Lower limits on the mass of new bosons which are predicted by several Beyond SM models are set
- E.g. limits on the mass of a Sequential Standard Model W'/Z' (heavier copy of the SM W/Z) are calculated
- The limits calculated at 13 TeV are significantly stronger than previous limits due to the increase in center of mass energy



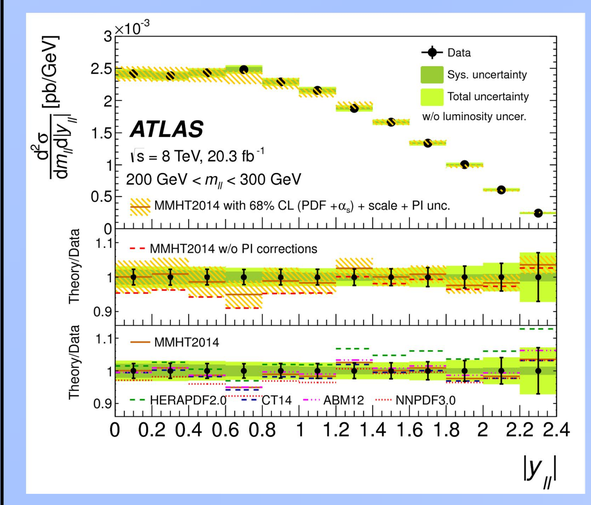
No resonance ? Limit calculated ? Measure Standard Model process precisely...



- Even if the tails of the invariant mass and transverse mass distributions do not contain BSM physics, they still contain a lot of interesting SM physics which can be studied (PDFs, EW corrections, etc.)
- Systematics usually do not play a huge role in the search for a bump in the tail of a distribution, but become crucial when trying to perform a precise measurement
  → Measurement of the SM process therefore takes more time
- Such a measurement of the Drell-Yan ($Z/\gamma^* \rightarrow l^+l^-$) cross section has been performed using the data recorded at 8 TeV
- Cross sections have been unfolded with bin-by-bin correction factors
- Electron and muon channel cross section are combined to reduce uncertainties
- Three different cross sections have been measured
  → Single-differential as a function of invariant mass
  → Double-differential as a function of invariant mass and absolute dilepton rapidity
  → Double-differential as a function of invariant mass and absolute pseudorapidity separation
- Systematic uncertainty in most regions of phase space smaller than statistical uncer.
- Total uncertainty partially below 1%



Interpret measurement...



- The measurement has been compared to NNLO perturbative QCD predictions using different PDF sets and including NLO electroweak effects
- Uncertainty on the measurement smaller than the uncertainty on the predictions in most regions of the phase space
- Largest theoretical uncertainties are coming from PDFs
  → Potential of the data to constrain these PDFs
- Measurement includes a photon-induced contribution ($\gamma\gamma \rightarrow l^+l^-$)
- Photon PDF NNPDF2.3qed has large uncertainties due to missing experimental data which constrains the PDF
- Bayesian reweighting study has been performed, showing that the measurement has a huge impact on the uncertainty of the photon PDF