Studies of Drell-Yan processes with CMS

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Joint Institute for Nuclear Research

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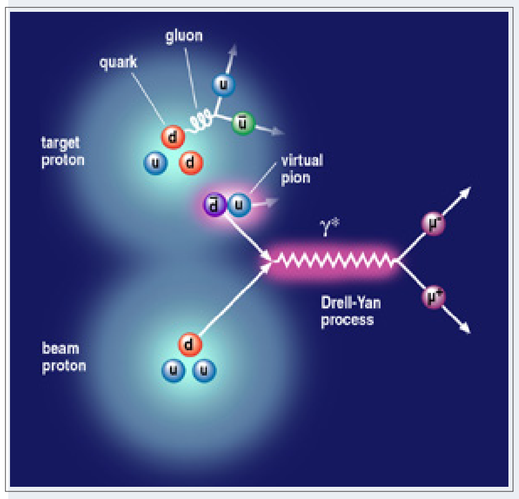
Drell-Yan Process and Forward-Backward Asymmetry (A_{FB})

The Drell-Yan Process



- The production of **ll** pairs in **pp**—collisions is described by the **s**—channel exchange of γ^***Z**
- Theoretical calculations established up to NNLO order
- Comparison of Data and MC provide tests of SM and constraints on evaluation PDFs
- DY is a major background for $t\bar{t}$ and diboson measurements as well as for searches for new physics (high mass dilepton resonances)
- Measurements are done at $\sqrt{s} = 8$ **TeV** on CMS data corresponding to **19.7 fb**$^{-1}$ of data
- Vector and axial-vector coupling of elecroweak bosons to fermions results in A_{FB} in the number of Drell-Yan leptons pairs:

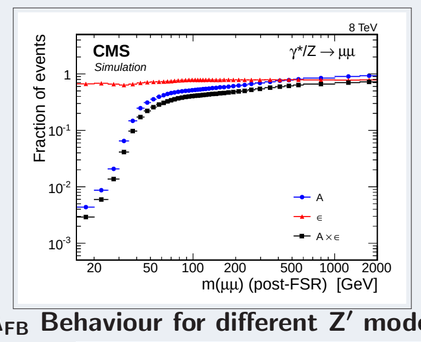
$$A_{FB} = \frac{\sigma_F - \sigma_B}{\sigma_F + \sigma_B} \quad (1)$$

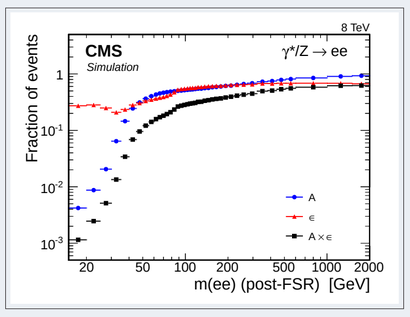
$$\sigma_F \pm \sigma_B = [\int_0^1 \pm \int_{-1}^0] \frac{d\sigma(q\bar{q} \to l\bar{l})}{d\cos\theta^\star} d\cos\theta^\star \quad (2)$$

where $\theta^\star$ is the angle between the outgoing negative muon and quark in the dimuon rest frame.

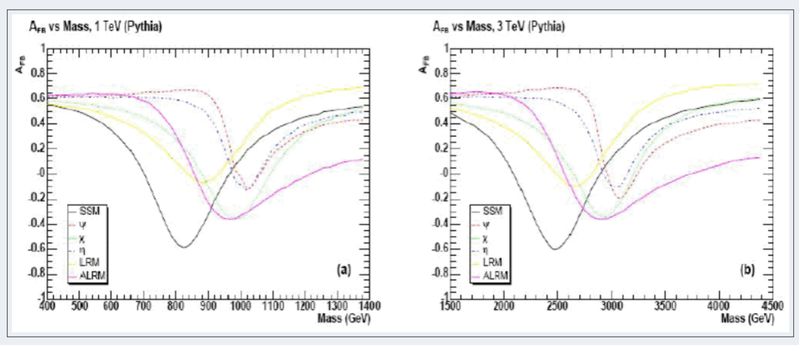
- Deviations from the SM prediction for A_{FB} may indicate the existence of BSM Physics (new neutral gauge bosons etc.)
- Measurement of A_{FB} can also improve QCD measurements, constrain PDFs and provide precise measurement of $\sin^2\theta_W$

Acceptance, efficiency, and acceptance-efficiency with CMS



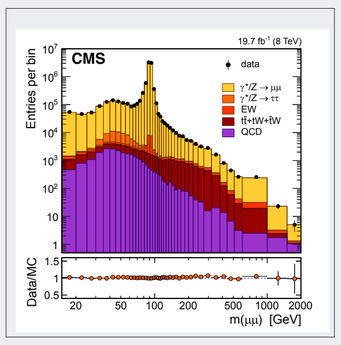


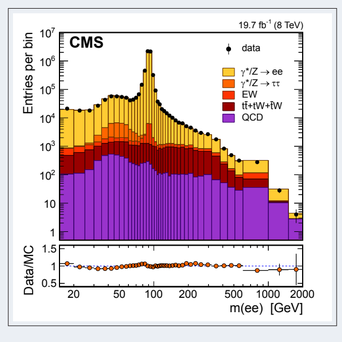
A_{FB} Behaviour for different Z′ models



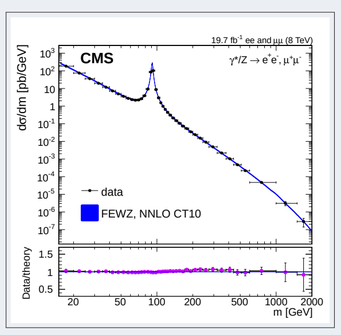
Differential and Double-differential Drell-Yan Cross Sections

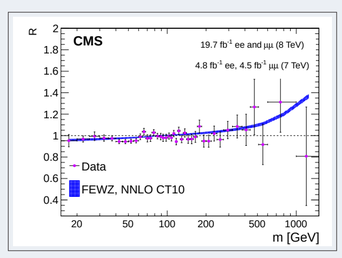
Data vs MC Comparison for 1D





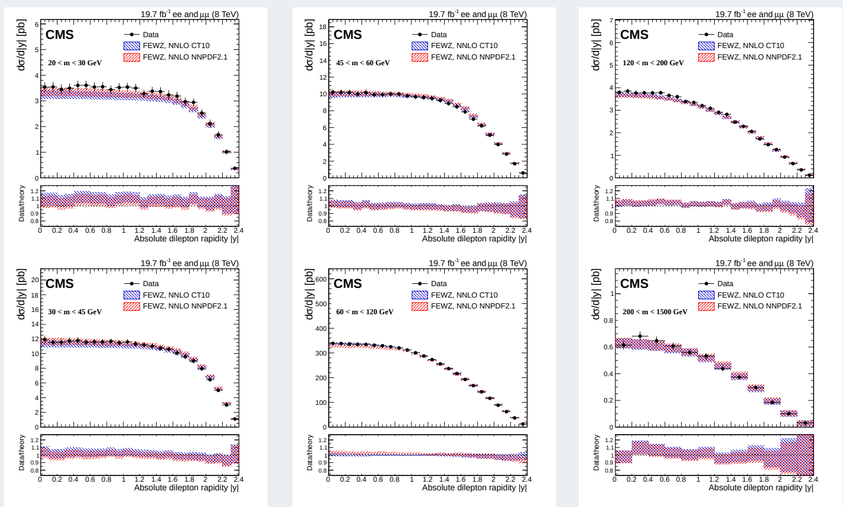
Absolute Cross Section and Double Ratio in 1D





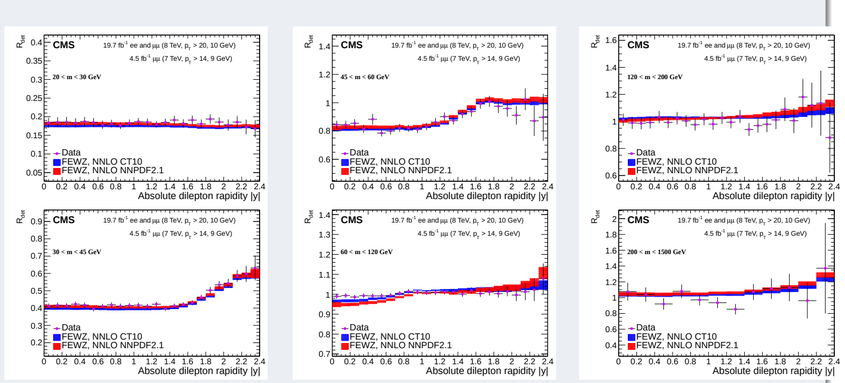
Cross section $\sigma^i = \frac{N^i_u}{A^i \epsilon^i L_{int}}$ (left) and 7 to 8 Tev ratio (right)

Absolute Cross Section for 2D



Y dilepton rapidity spectrum, plotted for different mass regions, as measured in the combined dilepton channel and as predicted by NNLO FEWZ 3.1 with CT10 PDF and NNLO NNPDF2.1 PDF calculations (statistical and the PDF uncertainties)

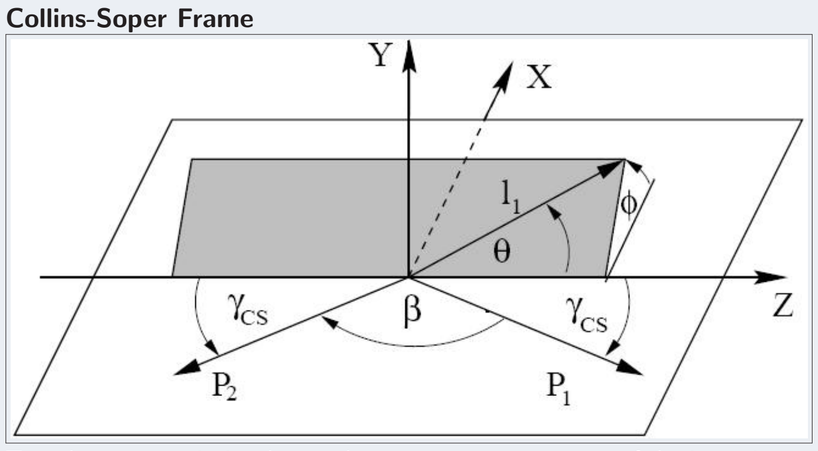
Double ratio measurement for 2D



Measured ratio of DY normalized differential cross sections between the LHC center of mass energies of 7 and 8 TeV in the combined dilepton channel plotted for 200-1500 GeV mass region , as compared to NNLO FEWZ 3.1 calculations obtained with CT10 PDF (statistical and the PDF uncertainties) Eur.Phys.J. C 75 (2015) 147, arXiv:1412.1115, CERN-PH-EP-2014-289

Measurement of A_{FB} at CMS

Collins-Soper Frame



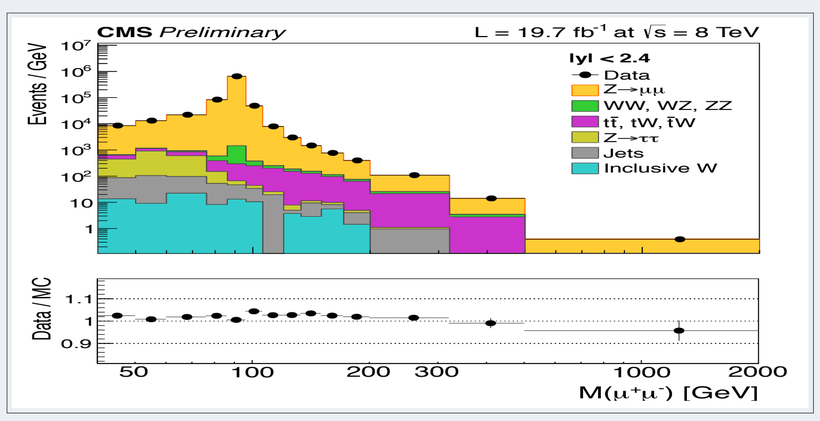
To reduce uncertainties due to the transverse momentum of the incoming quarks Collins-Soper frame is used. In this frame, $\theta^\star$ is defined to be the angle between the muon momentum and a **z′** axis that bisects the angle between **q** and $\bar{\mathbf{q}}$ and the angle $\theta^\star$ is given by using quantities measured in the lab frame:

$$\cos\theta^\star = \frac{2(P_1^+P_2^- - P_1^-P_2^+)}{\sqrt{Q^2(Q^2 + Q_T^2)}} \quad (3)$$

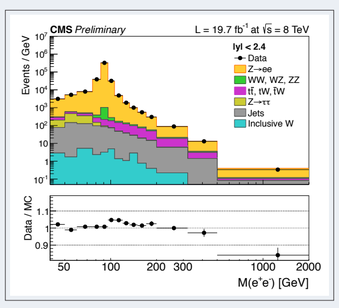
where **Q** and $\mathbf{Q_T}$ are the four-momentum and the transverse momentum of the di-muon system, $P_i^\pm = 2^{-1/2}(P_i^0 \pm P_i^3)$, $i = 1$ for μ and $i = 2$ for $\bar{\mu}$. **Backgrounds**

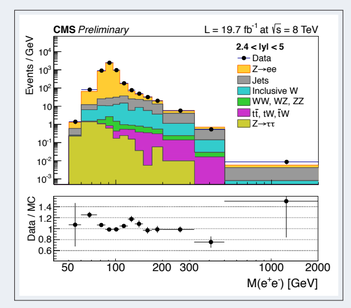
The main source of backgrounds are: for the low mass region $Z \to \tau\tau$, QCD dijets and $t\bar{t}$ for the high mass region.

Data vs MC Comparison for Muons

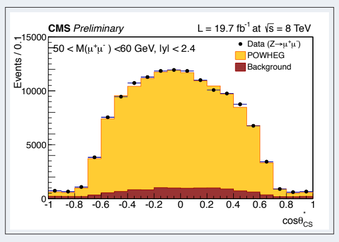


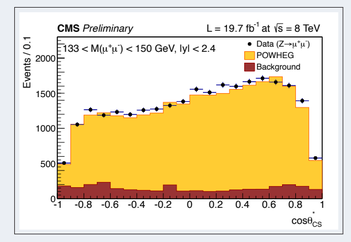
Data vs MC Comparison for Electrons



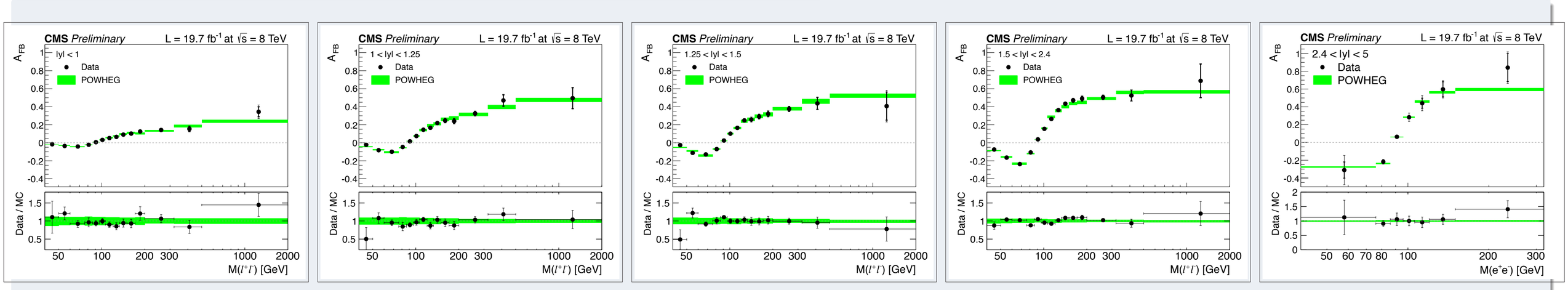


The cos$\theta^\star$ distributions for muons





Combined A_{FB} Measurement



$\sin^2\theta_w = 0.228 \pm 0.0077(\text{stat}) \pm 0.0036(\text{syst.})$ (Phys. ReV. D 84, 112002(2011)), CMS-PAS-SMP-14-004

References

- CMS Collaboration, "Measurement of the weak mixing angle with the Drell-Yan process", Phys. Rev. D 84, 112002 (2011)
- CMS Collaboration, "Drell-Yan forward-backward asymmetry at 8 TeV", CMS-PAS-SMP-14-004
- CMS Collaboration, "Measurements of differential and double-differential Drell-Yan cross sections in proton-proton collisions at $\sqrt{s} = 8$ **TeV**", Eur.Phys.J. C 75 (2015) 147, CERN-PH-EP-2014-289, arXiv:1412.1115

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