Measurement of the Drell-Yan transverse momentum dependence over a wide mass range at 13 TeV from CMS

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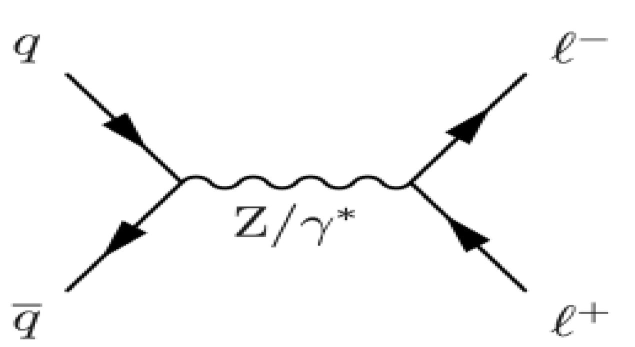
Introduction

- s-channel $Z/\gamma*$ exchange factorised to collinear quark and antiquark proton parton distribution functions (PDF)
- Important insights into the partonic structure of hadrons and the parton evolution
- Measurement of Drell-Yan transverse momentum (p_T).
- Measurement of Drell-Yan transverse momentum (p_T) provides sensitivity to resummation/TMDs in low pt region, pQCD in high p_T region and their matching in moderate p_T region.
- Precisely measured process and high precision MS based predictions.
- Clean final state.



Event selection

2016 data (35.9fb^{-1})

Base selection:

- Double- and single-lepton triggers
- e^+e^- or $\mu^+\mu^-$
- $p_T > 25,20$ GeV
- $|\eta| < 2.4$
- Medium identification, tight muon isolation
- Veto on extra leptons with p_T >10 GeV,

Jets selection (for Z+1 jet category) - not shown here:

- Anti- k_T with R = 0.4
- $p_T > 30$ GeV, $|y| < 2.4$
- Angular separation from leptons $\Delta R(l, j) > 0.4$

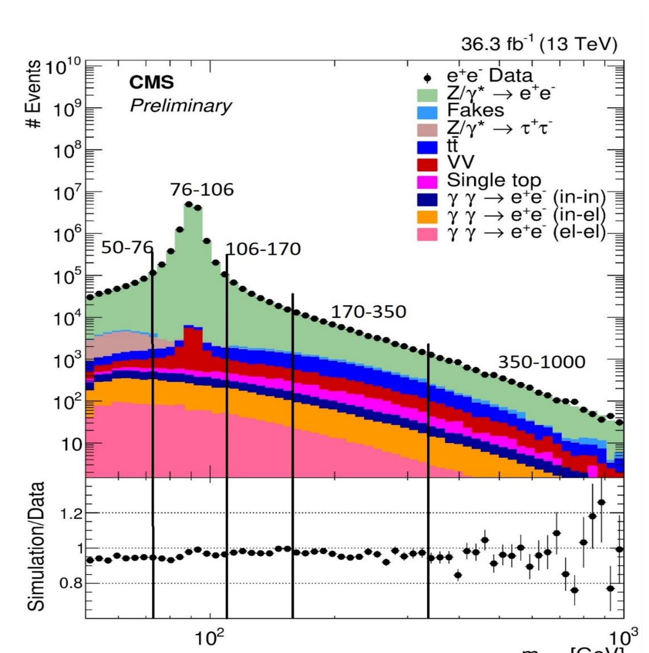
Background

Monte-Carlo based:

- $t\bar{t}$ and single top - high mass, high p_T
- $\gamma\gamma \to l^+l^-$ - low p_T
- $Z/\gamma^* \to \tau^+\tau^-$ - low mass
- WW, ZW, ZZ

Data-driven:

Fake electrons

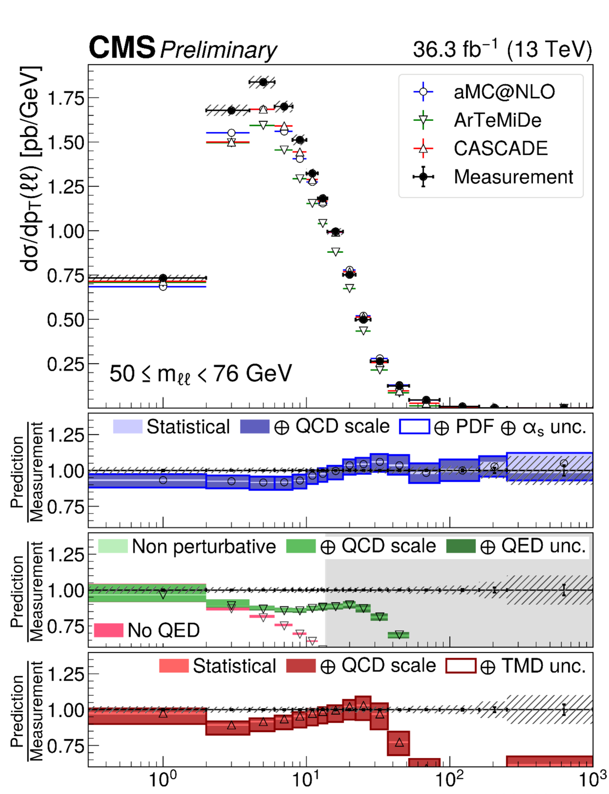


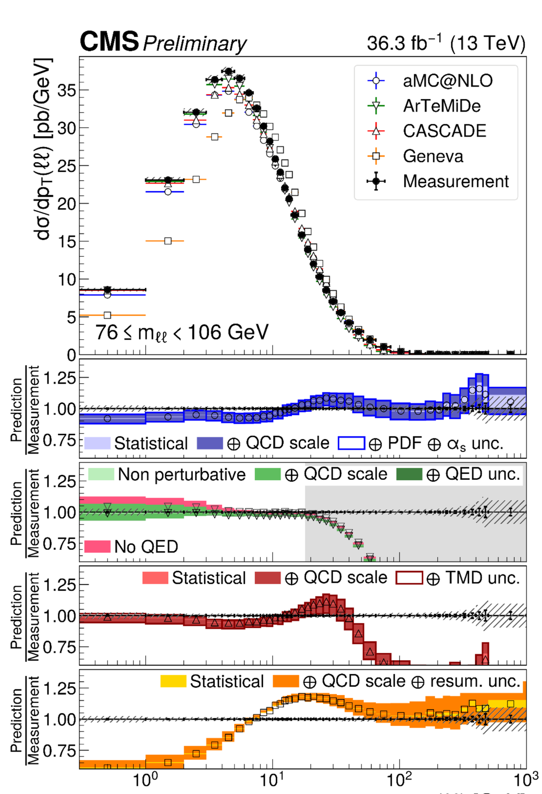
Results [CMS-PAS-SMP-20-003]

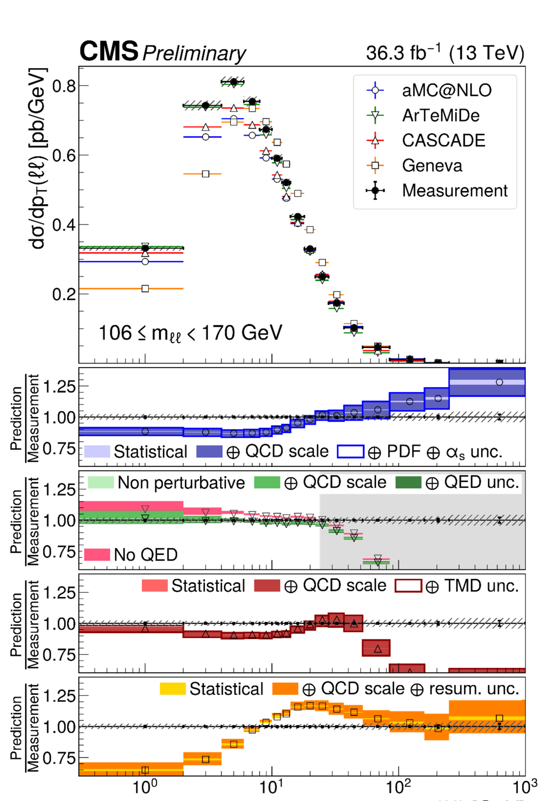
Predictions

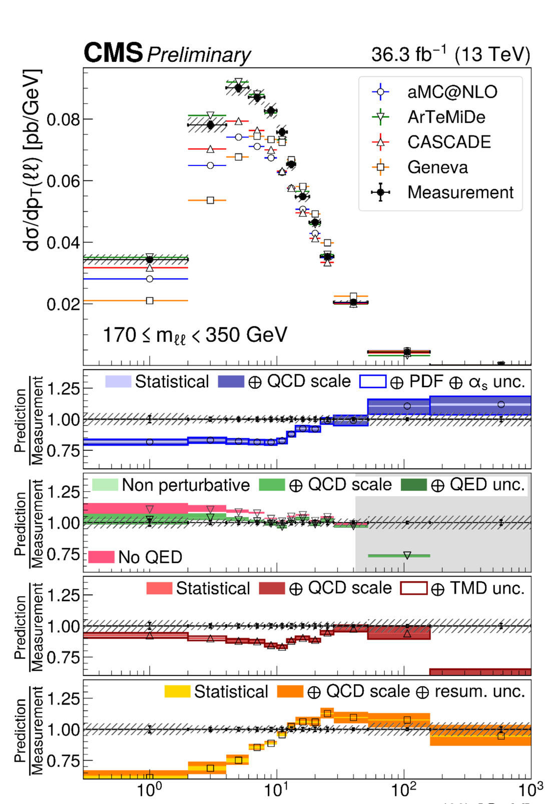
	AMC@NLO	ARTEMIDE	CASCADE	GENEVA
Inclusive	NLO	/	NLO	NNLO
≥ 1 jet	NLO	N/A	NLO	NLO
Resummation	PS(PYTHIA8)	N^3LL	PB TMD	$NNLL_\tau$’
Parton shower	PYTHIA8	Our correction	PYTHIA6	PYTHIA8
QED FSR	PYTHIA8	Our correction	PYTHIA6	PYTHIA8

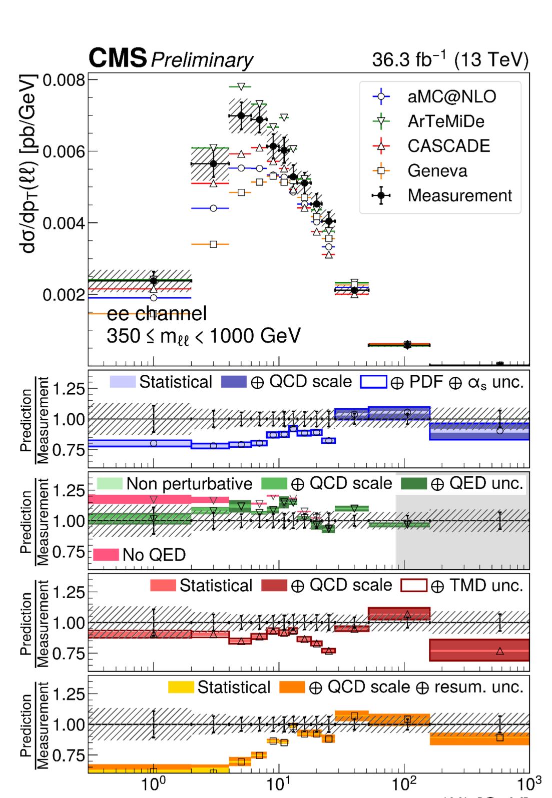
Cross sections: $p_T(ll)$



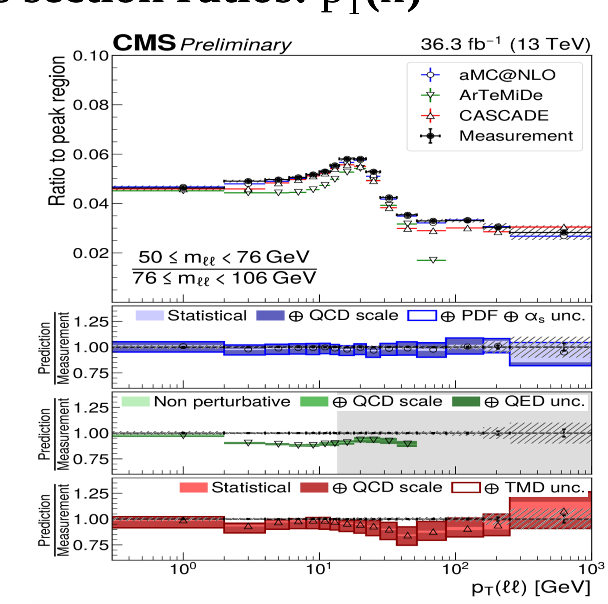


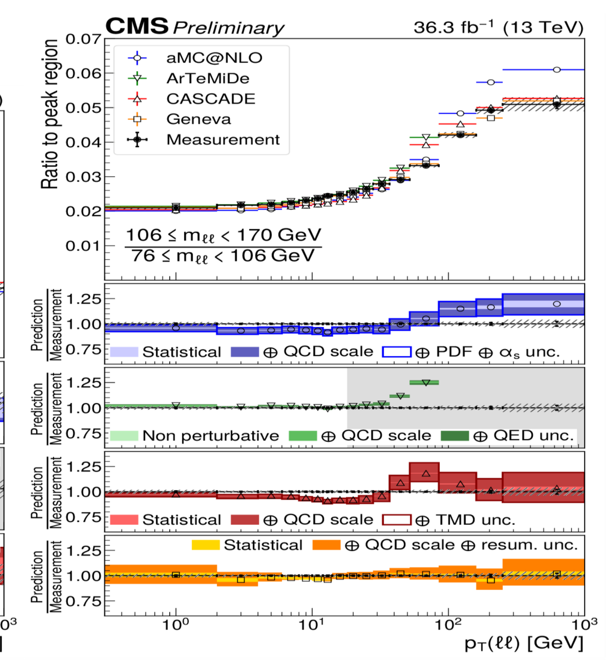


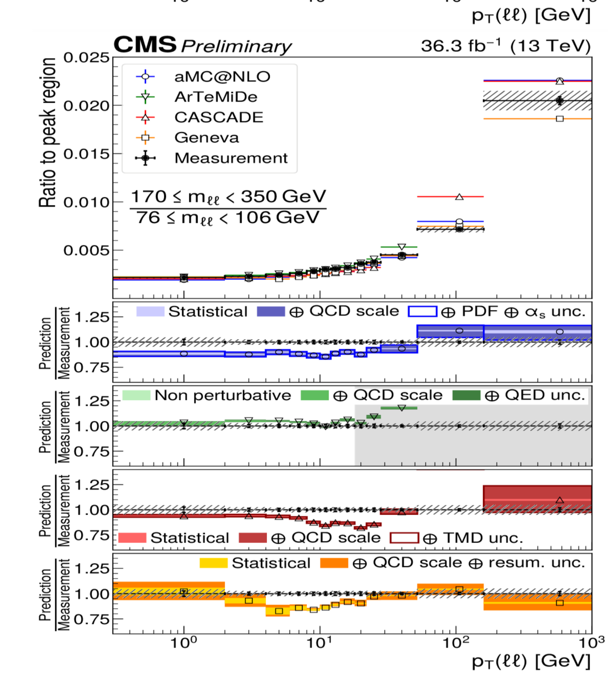


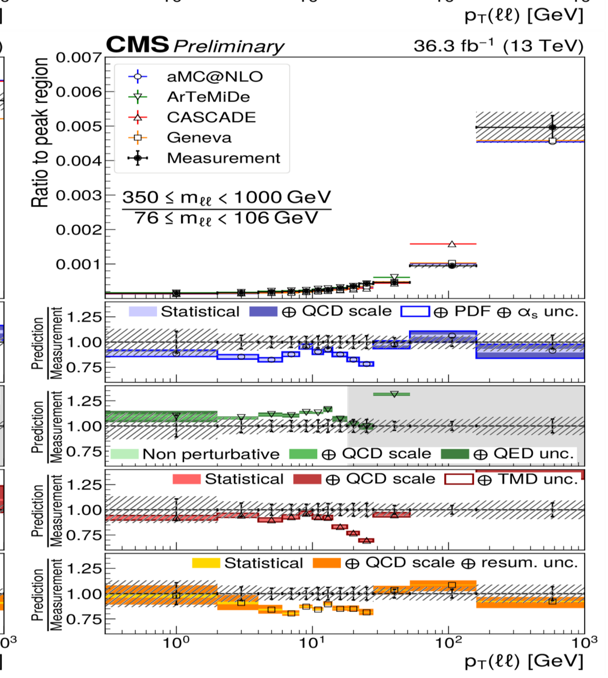


Cross section ratios: $p_T(ll)$









AMC@NLO : Disagreement at low p_T , increasing with m_{ll}; region sensitive to resummation. Disagreement for high p_T region, only for 106 < m_{ll} < 170.

ArTeMiDe : Good agreement in validity region.

CASCADE: PB TMD improves agreement in low p_T in comparison with MadGraph. Higher order ME needed for high p_T .

Geneva: Good description in high p_T region.

To increase precision at low p_T , φ^* cross sections and ratios are also measured in the same mass ranges but are not shown here.

Conclusion

- Precision measurement of DY properties
- Electron and muon channels were used, 2016 data (35.9 fb^{-1})
- 5 invariant mass bins from 50 to 1000 GeV.
- The baseline NLO MadGraph sample is robust all over the covered phase space, but disagrees with data at low p_T — up to 20 % above the Z mass peak
- TMD based predictions (Artemide, Cascade) improve the description at low p_T ; merged or NNLO required for high p_T
- Geneva $NNLL_\tau$’ does not describe distributions correctly (depends on αs choice)
- QED FSR effects are significant, especially just below the Z peak
- The cross section ratios can be predicted even by models that fail to predict the absolute cross section (Cascade, Geneva)