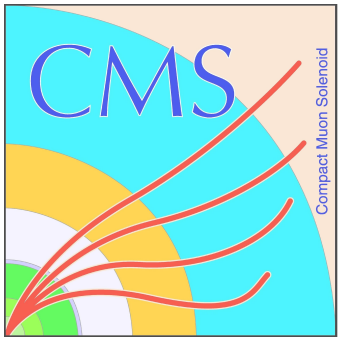


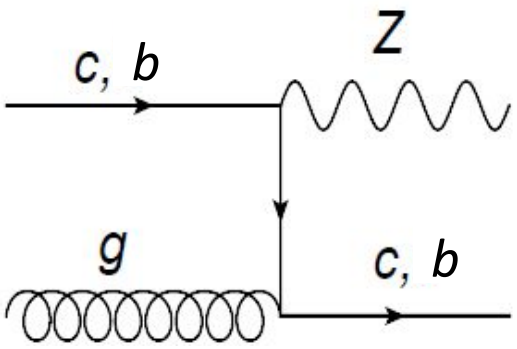
Vector boson associated with heavy-flavor jets in CMS

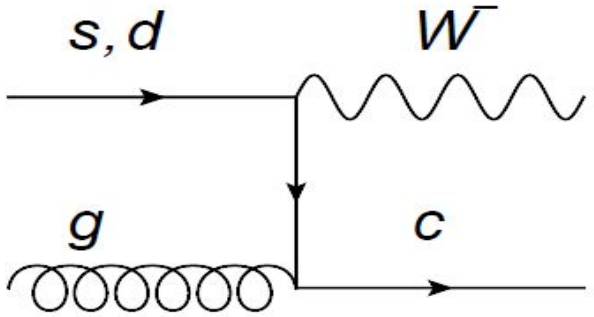
Sergio Sánchez Navas (CIEMAT)
on behalf of the CMS Collaboration

EPS-HEP2021
DESY and University of Hamburg (Virtual World)
26-07-2021

Motivation for the analyses

- Test SM and QCD predictions.
- Sensitivity to s, b and c parton distribution functions (PDFs).
- Background for other SM measurements and searches.



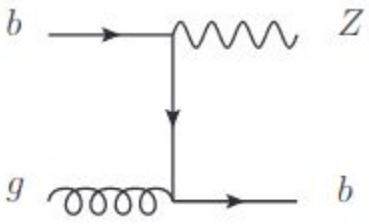


Event selection Z+b @ 13 TeV SMP-20-015

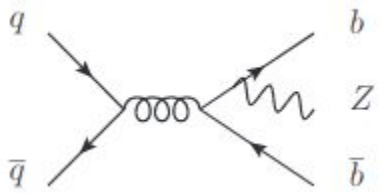
Data and MC from 2016, 2017 and 2018

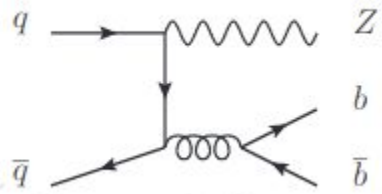
- $Z \rightarrow ll$:
  - pair of opposite charge, same flavour leptons (electron or muon)
  - pT(lead)> 35 GeV, pT(sublead)> 25 GeV
  - $|\eta(l)| < 2.4$,
  - 71 GeV < m_{ll}< 111 GeV

- Jets:
  - p_T(jet) > 30 GeV, $|\eta(jet)| < 2.4$
  - pT(miss) < 50 GeV
  - b jets selected with tight operating points of b tag discriminator



Z + ≥ 1 b jet



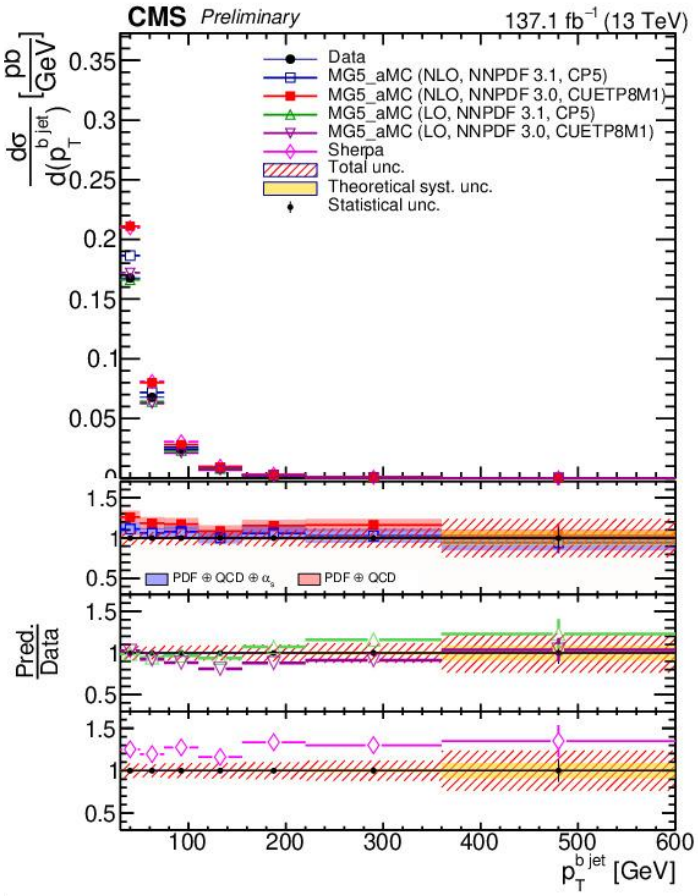


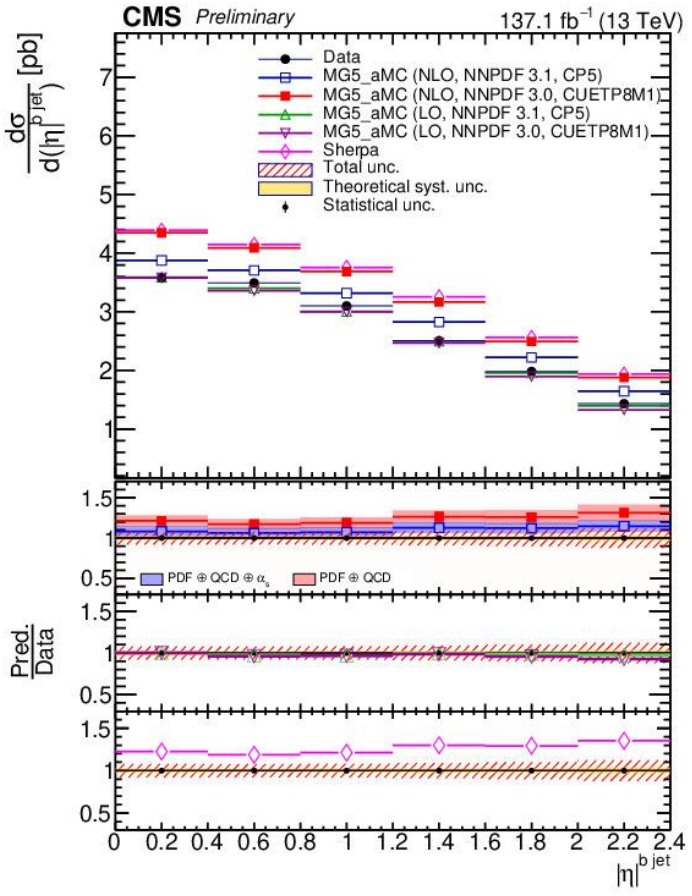
Z + ≥ 2 b jets 4-flavour and 5-flavour schemes

Results: Z+b @ 13 TeV SMP-20-015

Differential cross section as function of p_T and |η| of b jet.

Z + ≥ 1 b jet



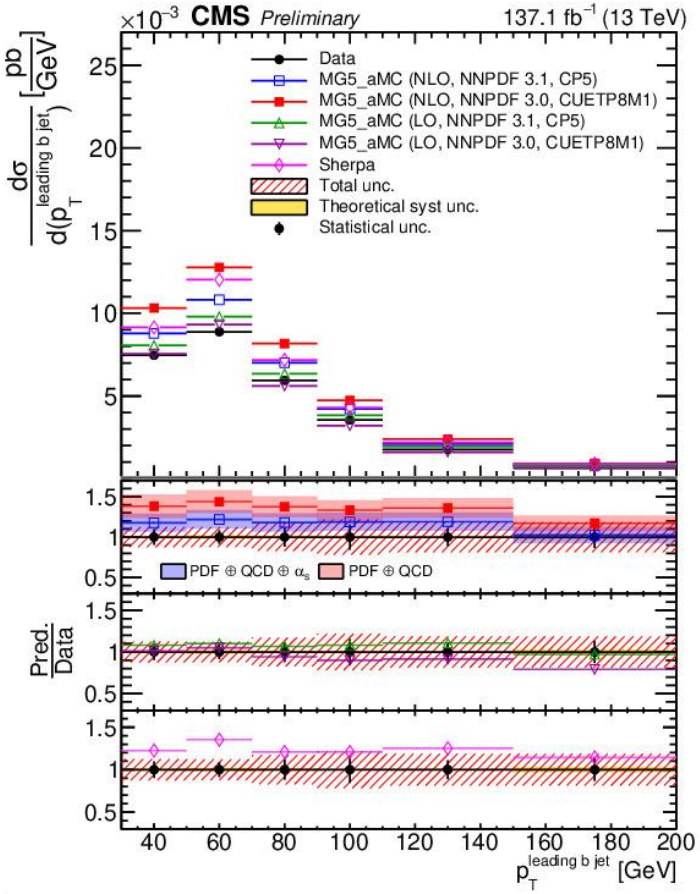


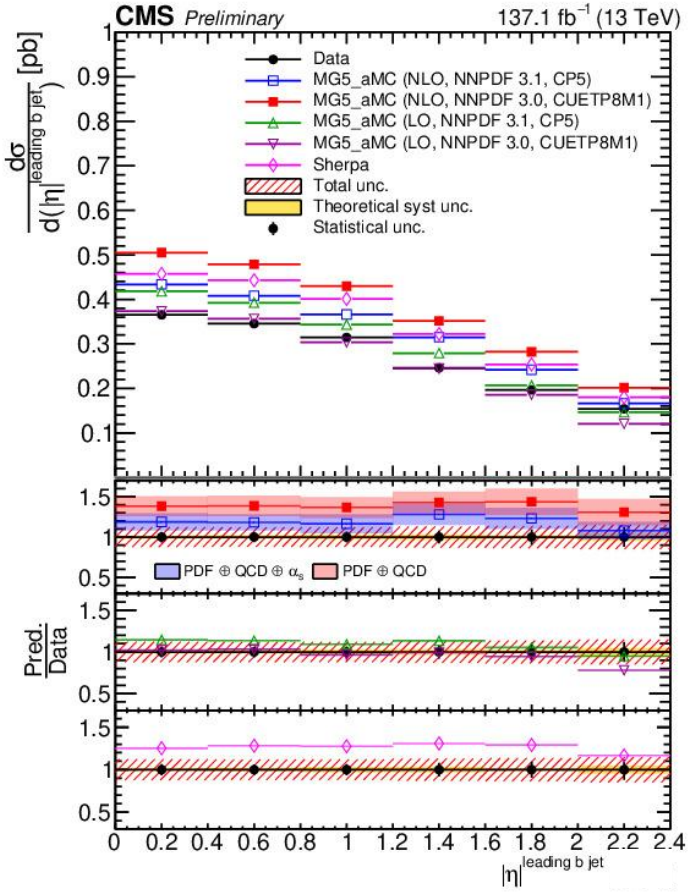
σ = 6.52 ± 0.04 (stat) ± 0.40 (syst) ± 0.14 (theo) pb

Results: Z+b @ 13 TeV SMP-20-015

Differential cross section as function of p_T and $|\eta|$ of leading b jet.

Z + ≥ 2 b jets



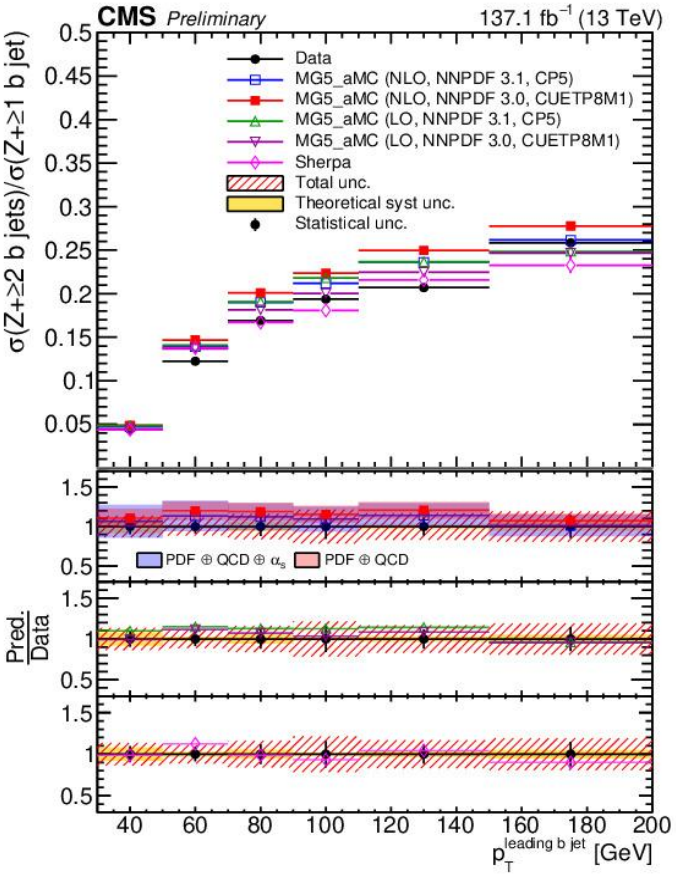


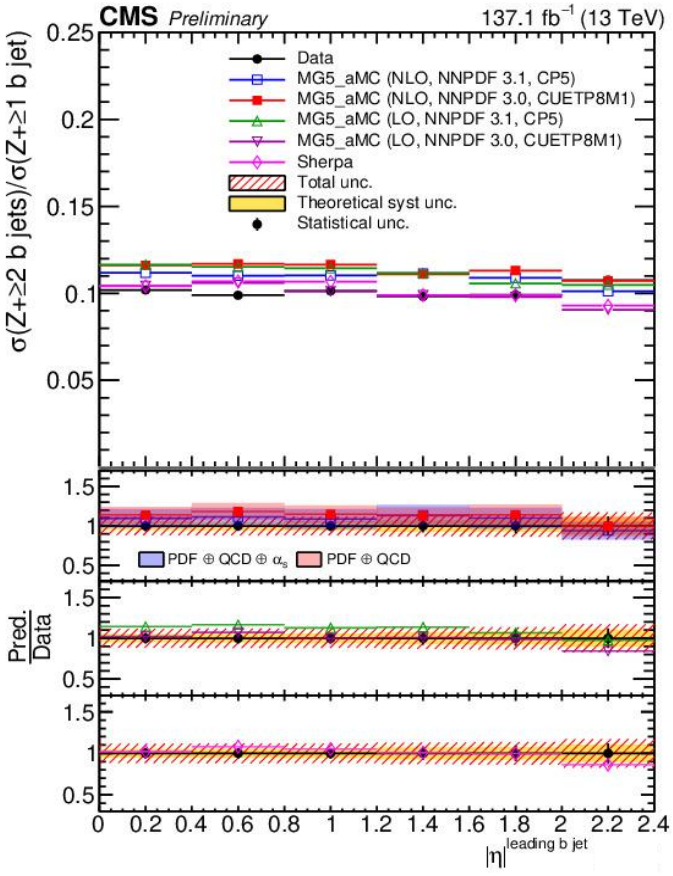
σ = 0.65 ± 0.03 (stat) ± 0.07 (syst) ± 0.02 (theo) pb

Results: Z+b @ 13 TeV SMP-20-015

Differential cross section as function of p_T and $|\eta|$ of leading b jet.

Ratio
Z + ≥ 1 b / Z ≥ 2 b





σ = 0.100 ± 0.005 (stat) ± 0.007 (syst) ± 0.003 (theo)

Event selection Z+c @ 13 TeV SMP-19-011

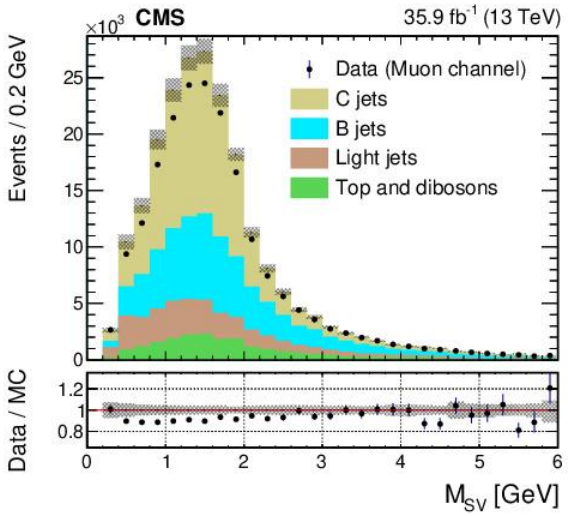
Data and MC from 2016

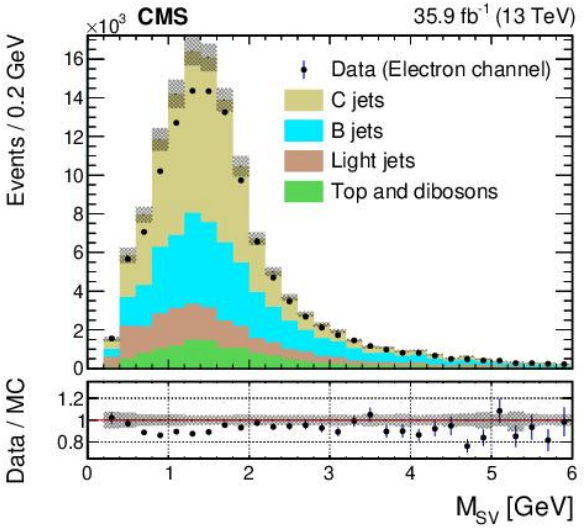
- $Z \rightarrow ll$:
  - pair of opposite charge, same flavour leptons pT(ll)> 10 GeV
  - pT(e)> 29 GeV, pT(μ)> 26 GeV (at least one)
  - $|\eta(l)| < 2.4$,
  - 71 GeV < m_{ll}< 111 GeV

- Jets:
  - p_T(jet) > 30 GeV, $|\eta(jet)| < 2.4$
  - tight c-tagging criteria using the deep combined secondary vertices algorithm.

- Charm identification:

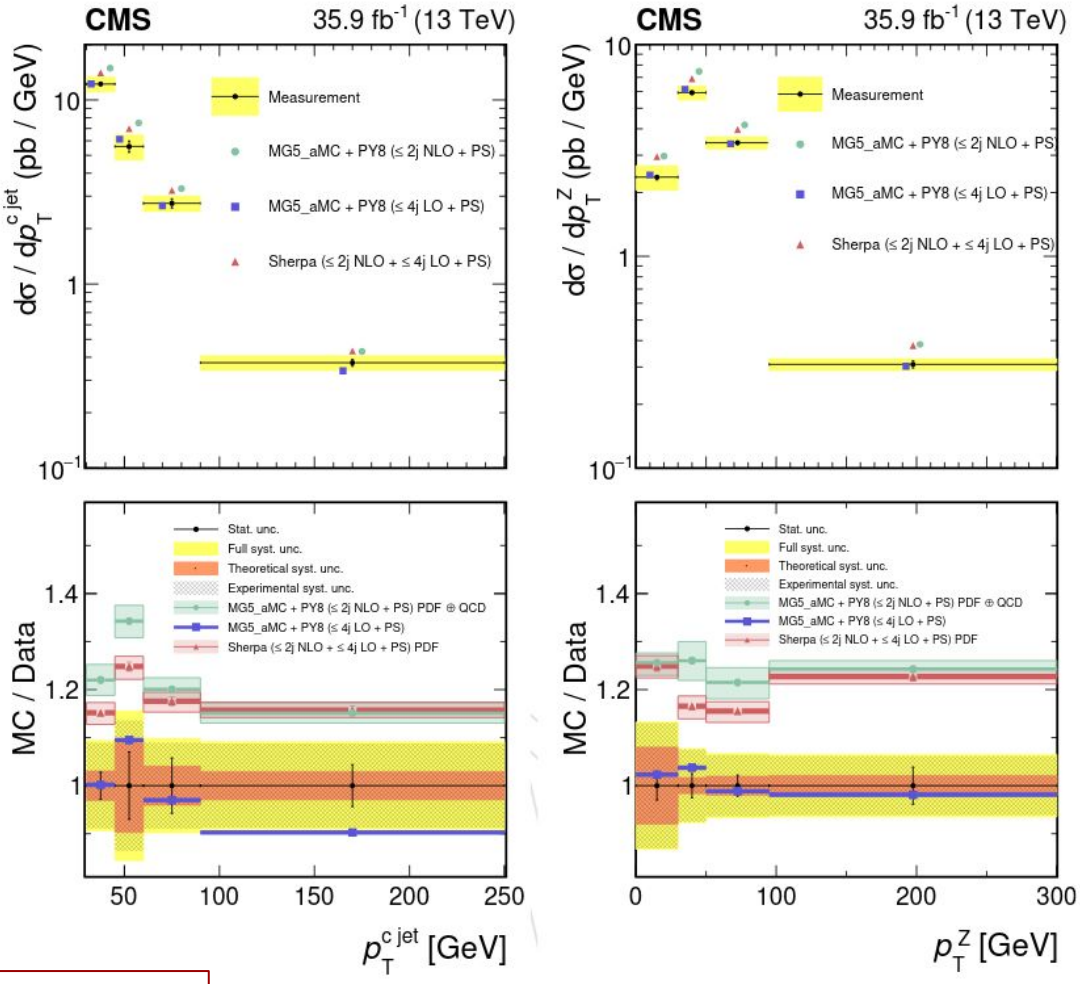
Hadronic decays of charm hadrons. Displaced secondary vertices reconstructed with inclusive vertex finder (IVF) algorithms





Results: Z+c @ 13 TeV SMP-19-011

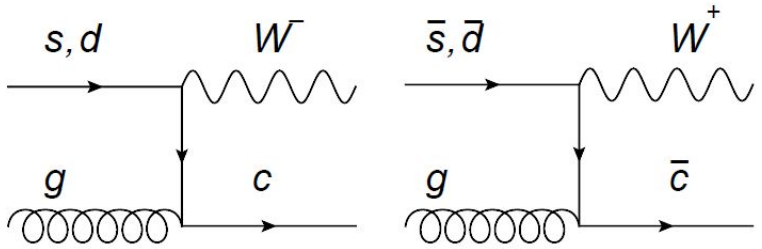
Differential cross sections for inclusive Z+c jet production as function of the p_T of the c-jet or the Z boson



σ = 405.4 ± 5.6 (stat) ± 24.3 (exp) ± 3.7 (theo) pb

W+c : Opposite Sign-Same Sign (OS-SS) technique

- In order to measure σ(W+c), need to reduce or suppress background.
  (W+light, W+b, etc)

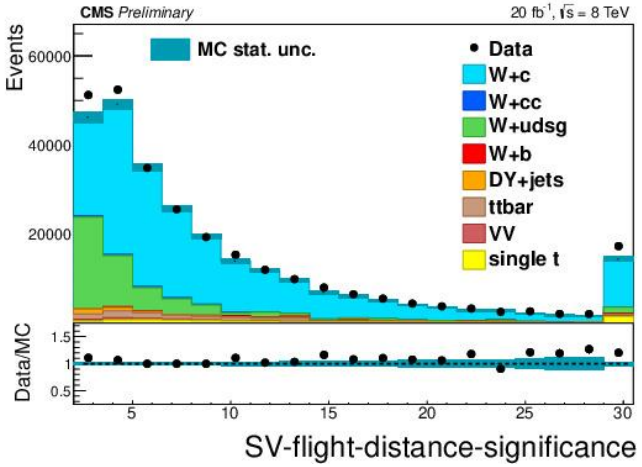


- In W+c events, the electric charge of the W is opposite to the charge of the c quark.
  - Charge of the W reconstructed from the charge of the isolated lepton
  - Charge of the charm quark from the charge of the muon inside the jet or the SV charge
- In most of the background, there are equal amounts of SS and OS events with identical kinematic properties.

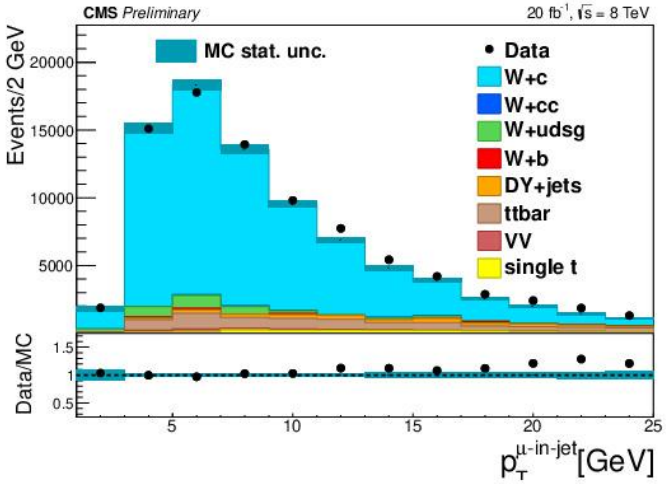
Event selection W+c @ 8 TeV SMP-18-013

Data and MC from 2012

- $W \rightarrow l+\nu$:
  - $p_T(e) > 27$ GeV, $p_T(\mu) > 24$ GeV,
  - $|\eta(l)| < 2.1$
  - Exclude events with two isolated leptons with opposite sign to reduce ttbar background.
  - $M_T > 55$ GeV
- Jets:
  - $p_T(\text{jet}) > 25$ GeV, $|\eta(\text{jet})| < 2.5$

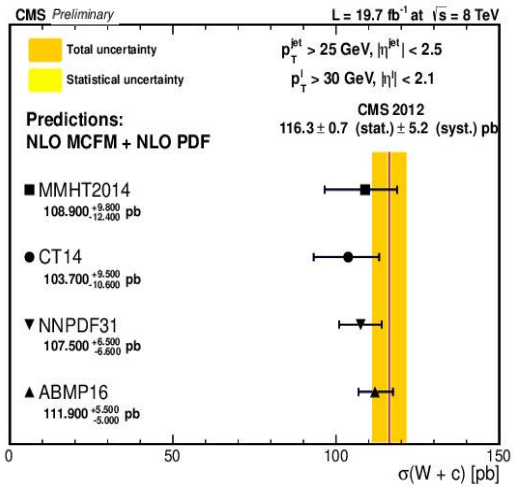


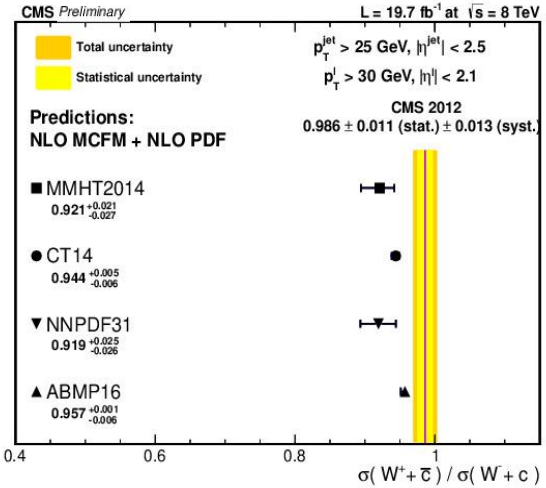
- Charm identification (**SV channel**): Hadronic decays of charm hadrons. Displaced secondary vertices reconstructed with simple secondary vertex (SSV) or inclusive vertex finder (IVF) algorithms
- Charm identification (**SL channel**): Semileptonic decays of charm hadrons. Muon inside a jet. $p_T(\mu) < 25$ GeV, $|\eta(\mu)| < 2.1$, iso>0.2



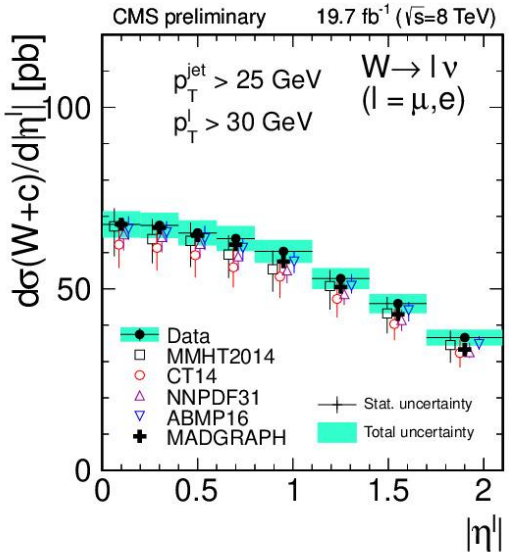
Results: W+c @ 8 TeV SMP-18-013

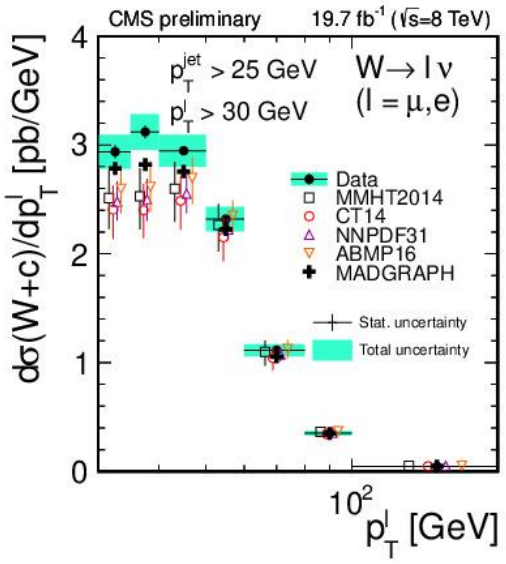
Inclusive cross section and comparison with theoretical predictions.





Differential cross section as a function of p_T and $|\eta|$ of the lepton from the W boson.





Conclusions

- Z+b:

Better described by the MG5 aMC (LO) simulation but overestimated by MG5 aMC (NLO) and SHERPA predictions. Attributable to variations in shapes of observables and settings (PDFs, MC tunes, matching schemes) in simulations.

- Z+c:

Good agreement with MADGRAPH5 aMC@NLO at leading order, while both MADGRAPH5 aMC@NLO and SHERPA at next-to-leading order tend to overestimate σ. Could indicate that the PDFs overestimate the charm content.

- W+c :

Consistent within uncertainties of MADGRAPH MC simulation. Analytical calculations from the MCFM program using different NLO PDF sets in fair agreement with $d(\sigma)/d|\eta|$.