Theory inputs to analysis

Photon-induced Workshop IPPP Durham • 03.11.2022

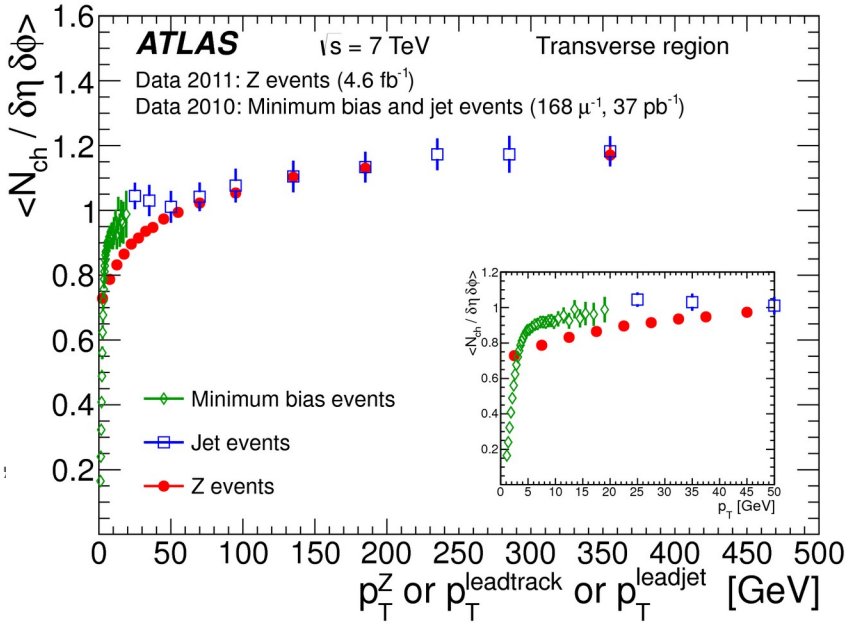
Three main interfaces of theory in measurements

- Description of exclusive signal
  - Reduction of cross section due to rescattering
- Description of semi-dissociative ~signal
  - Fragmentation of proton remnant and intact proton on the other side
- Description of charged particle distribution
  - Hadronic activity that is experimentally accessible to reject background
  - Pile-up that deteriorates the signal efficiency

→ **Discussion in reverse order**

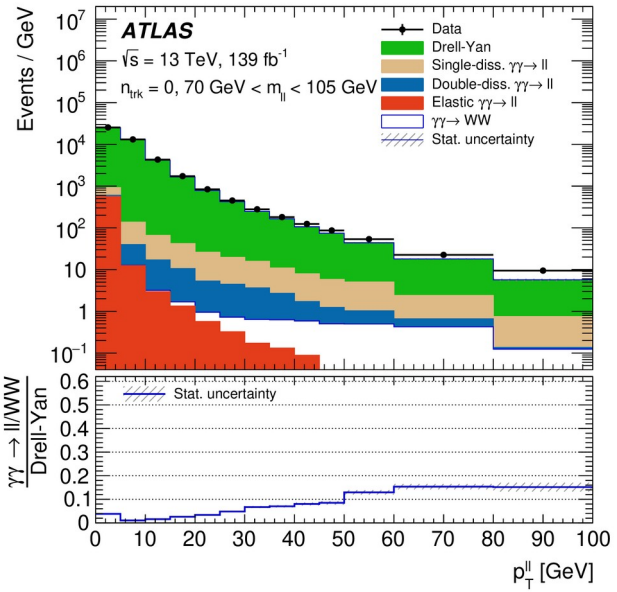
Underlying event

- Charged particle distributions usually not well modelled
- But can assume that it is similar for quark-induced production of different colourless final states of comparable momentum
- If control region is good enough to determine background (yy → ll, AFP tag), no need for detailled modelling → otherwise: Needed

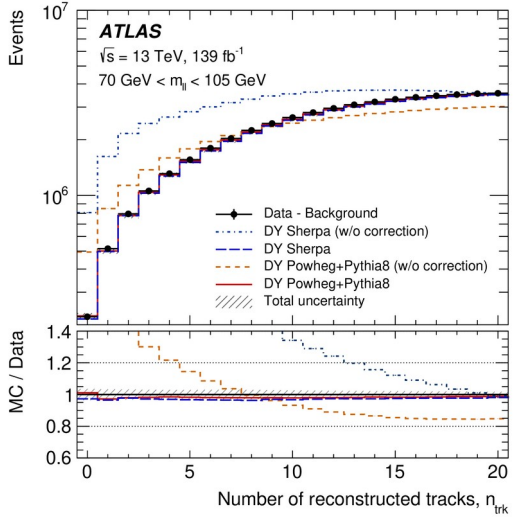


Underlying event corrections

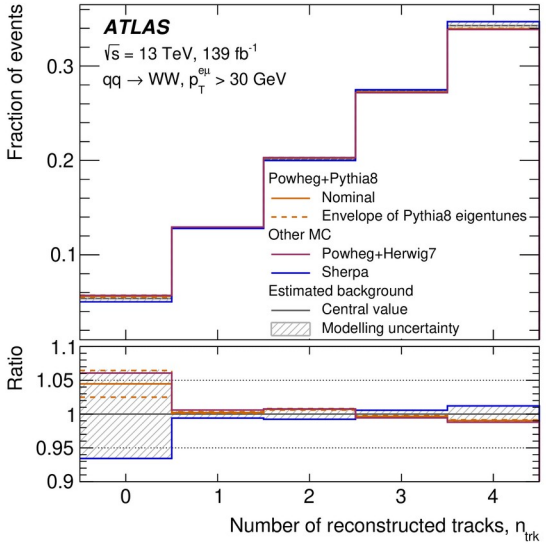
- For yy → WW (without AFP tag):
  - Use Z boson and unfold charged particle distribution as function of:
    – particle multiplicity
    – p_T(ll) (measure for p_T([di]boson))
- Low ntrk (~low pT(ll)) is of general interest:
  - Extract normalization of photon-induced backgrounds in tails
    (good signal description needed)
  - 2D Unfolding



Underlying event corrections



- For qq→WW: Good agreement for $1 \leq n_{trk} \leq 4$
  but $n_{trk}=0$ has large differences between hadronic models
- Use midpoint and envelope for WW prediction
  (7% syst.)

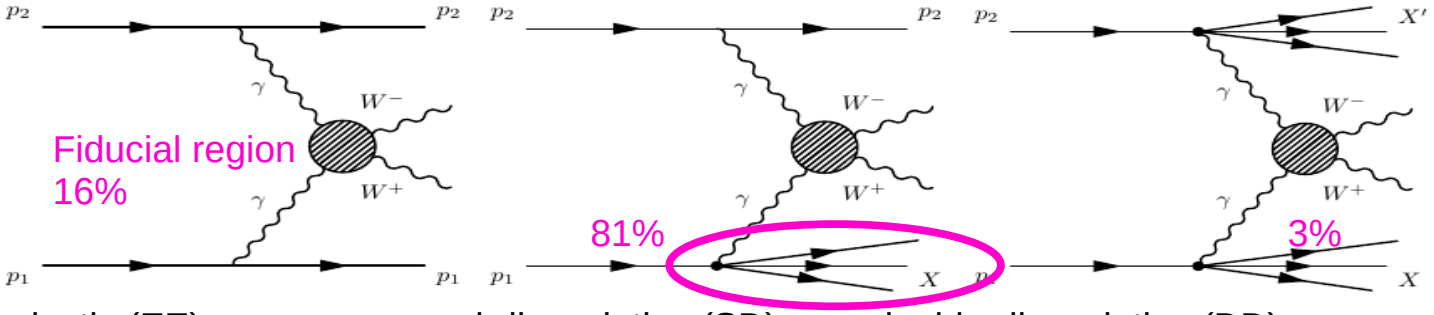


- Correction can be up to a factor of 5!
  → good agreement with data afterwards
- Apply unfolded charged particle distribution as function of $p_T(V)$ to DY
  (as function of $p_T(VV)$ to diboson events)

Semi-dissociative modelling

- Standalone codes (LPAIR, Pythia, Superchic) → often with limited processes implemented
- MG5 flexible models+processes → but needs interfacing to hadronization
  - → solved for Pythia (after a number of bug fixes)
    - FSR/ISR and subsequent hadronization of non-dissociative proton
    - Setting of shower parameters (different from defaults) (see e.g. yyWW Superchic publication)
  - More unclear for other generators

Survival factor

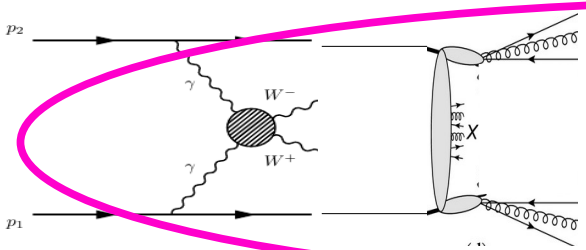


elastic (EE)
most reliable theory

semi-dissociative (SD)

double-dissociative (DD)

Difficult to model!!

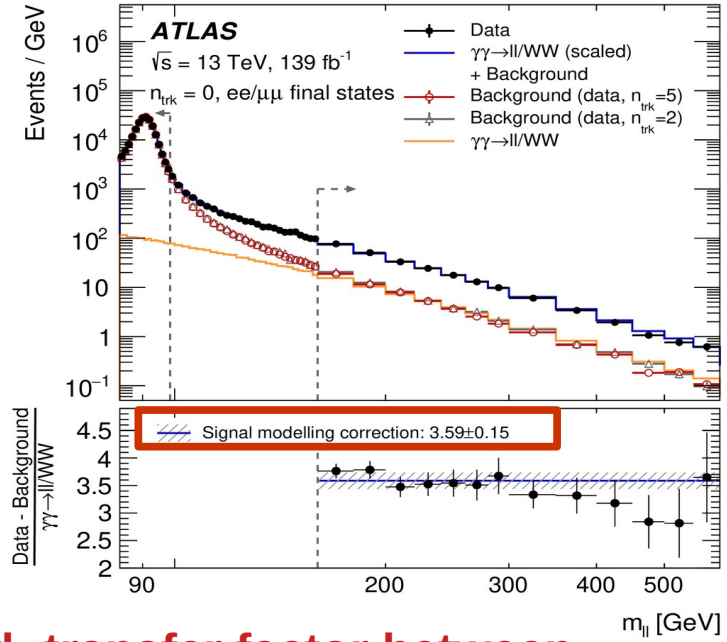


Second scattering: “survival factor” (phenological)

→ Reduces “visible” cross-section of elastic production → additional particles

Survival factor (measured)

- Data-driven scaling of $\gamma\gamma \rightarrow WW$ using $\gamma\gamma \rightarrow \ell\ell$ same flavour events for a signal-like selection ($n_{trk}=0$, $m_{\ell\ell} > 160$ MeV)
- **Shape** of pp-induced backgrounds extracted for **$n_{trk}= 5$** (less than 1% $\gamma\gamma$)
- **Normalization** from *Z*-peak region (**m_Z+/- 7.5 GeV**) (~0.5% of $\gamma\gamma$)
- Both varied for systematics ~4%
- Scaling of $\gamma\gamma \rightarrow WW/\ell\ell$ by **3.59 ± 0.15** yields good data/MC agreement



NOT accounted: transfer factor between yyWW and yyll (Lucian Harland-Lang)

Thank you!