WW Production With a Jet Veto Made Simple(r)

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Jet Vetoes: What and Why?

Jet Vetoes: What?

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Jet Veto

A cut on the maximum p_t of a jet: $p_t^{(J)} \leq p_{t,veto}$

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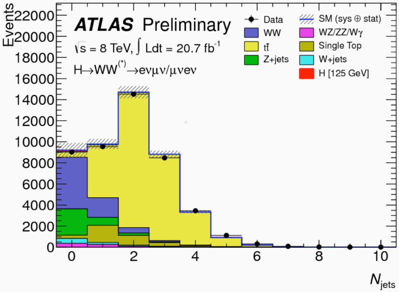

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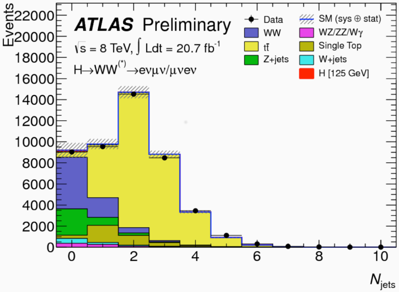

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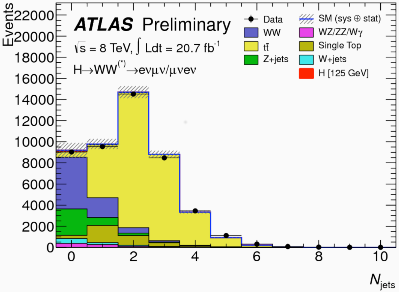

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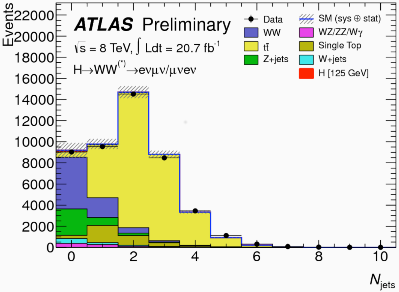

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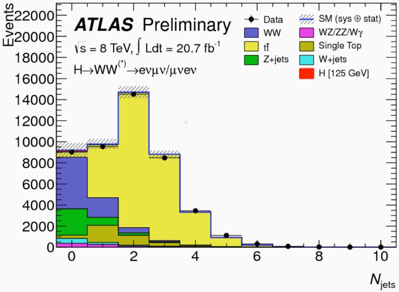

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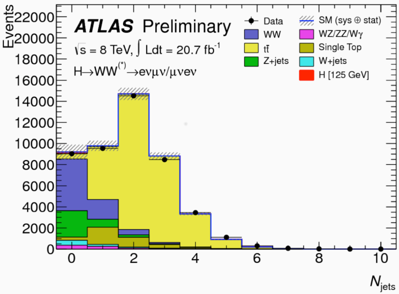

Higgs + 0-jet cross section becomes the quantity of interest

Need to quantify how the jet veto reduces the Higgs cross section and the non $t\bar{t}$ cross section

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- Lots of work already done on the Higgs production cross section: $NNLL + N^3LO + LL_R$ known
- WW is an interesting laboratory for new physics (even without the Higgs)
  - Top partners
  - Contact interactions

Outline

1. Jet veto resummation in a nutshell
2. Automation of jet veto resummation
3. A case study: $pp \to WW$

Jet Veto Resummation in a Nutshell

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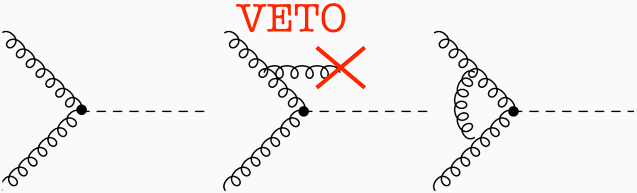

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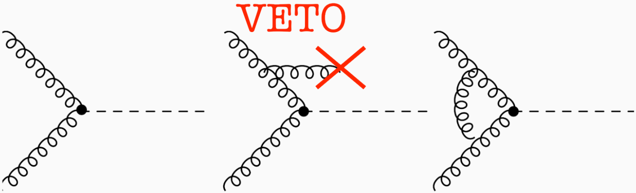

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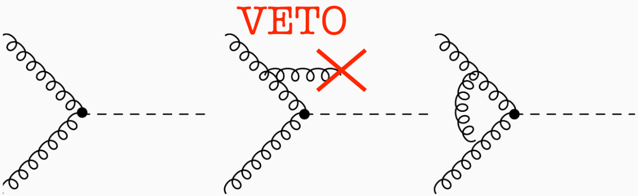

$$\sigma_{0-jet}(p_{t,veto}) \simeq \sigma_0 \left(1 + C\frac{\alpha_s}{\pi}\int \frac{d\omega}{\omega}\frac{d\theta^2}{\theta^2}\left(\Theta(p_{t,veto} - \omega\theta) - 1\right)\right)$$

$$\simeq \sigma_0 \left(1 - 2C\frac{\alpha_s}{\pi}\log^2\frac{M}{p_{t,veto}} + \dots\right)$$

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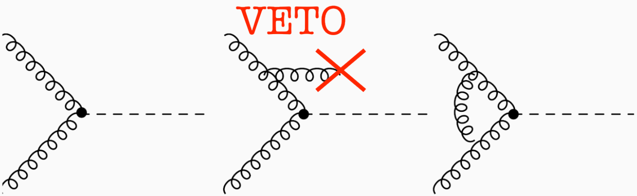

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Remnant logs left after cancellation of real and virtual divergences

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- Other methods based on SCET

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Automated Resummation of Jet Vetoes

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There must be a better way!

Utilise existing Monte Carlo code

MCFM + Resummation

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- Local subtraction terms helpful

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Completely unsuitable for numerical integration!

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Cleverly add zero by introducing a subtraction term $d\sigma^A$:

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- Sudakov form factor calculated and provided through an interface between `JetVHeto` and `MCFM`

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- Regularisation schemes
  - `MCFM` uses FDH scheme for most calculations
  - Need to match back to $\overline{MS}$

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Completely general!

A case study: $pp \to WW$

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$$\mathcal{L} \supseteq -\kappa_t \frac{m_t}{v} H \left(\bar{t}_R t_L + h.c. \right) + \kappa_g \frac{\alpha_s}{12\pi} \frac{H}{v} G^a_{\mu\nu} G^{\mu\nu,a}$$

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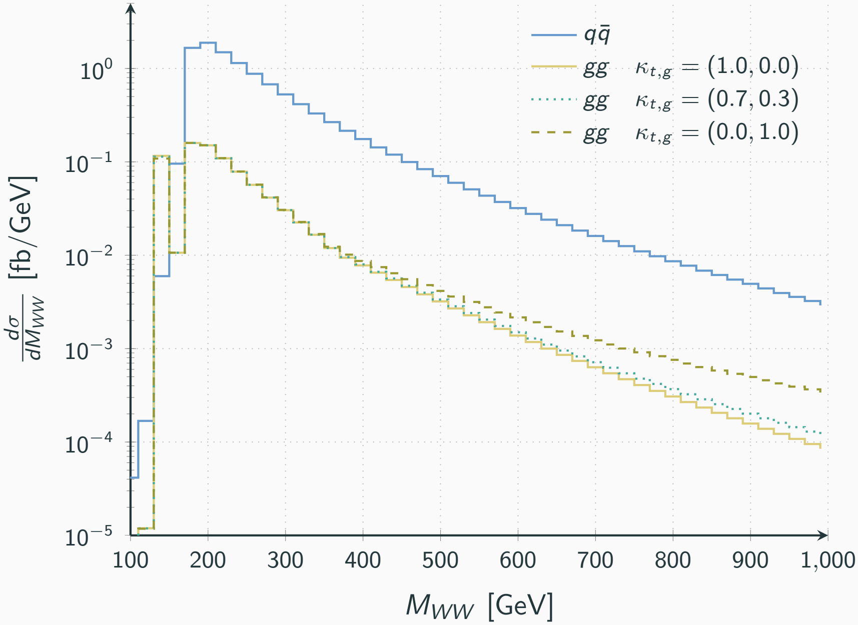
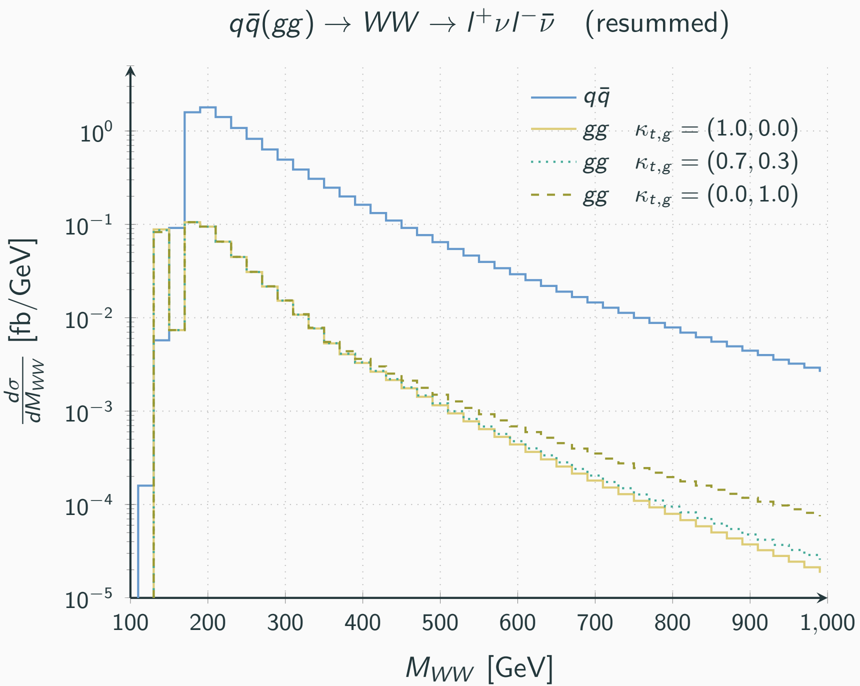
- Higgs total cross section must be kept constant: strongly constrained by experimental measurements
- Vary ggH and $t\bar{t}H$ couplings together
  $+$ fix $\kappa_t + \kappa_g = 1$

$q\bar{q}(gg) \to WW \to l^+\nu l^-\bar{\nu}$ (fixed-order)





$q\bar{q}(gg) \to WW \to l^+\nu l^-\bar{\nu}$ (resumed)
$q\bar{q}$
gg $\kappa_{t,g} = (1.0, 0.0)$
gg $\kappa_{t,g} = (0.7, 0.3)$
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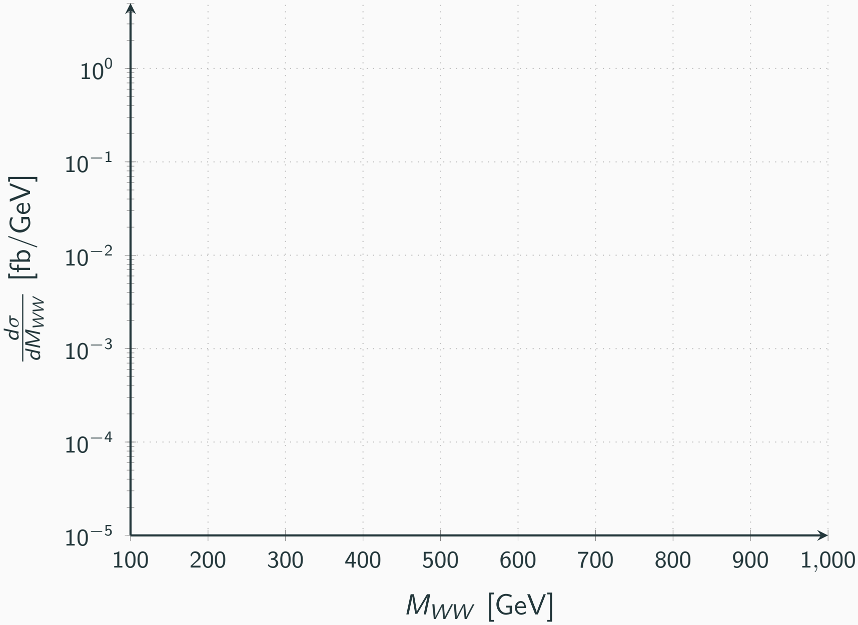
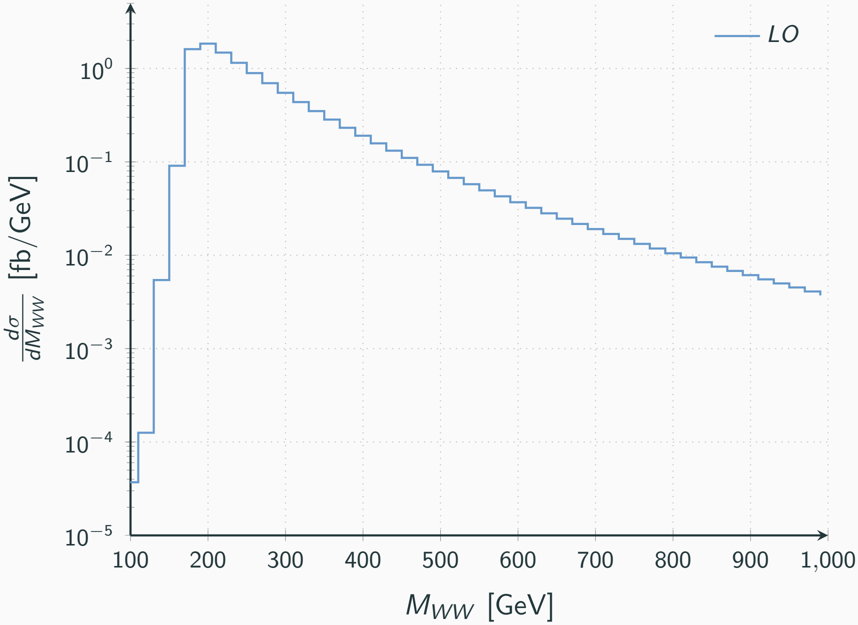
$\frac{d\sigma}{dM_{WW}}$ [fb/GeV]
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
100
200
300
400
500
600
700
800
900
1,000
M_{WW} [GeV]

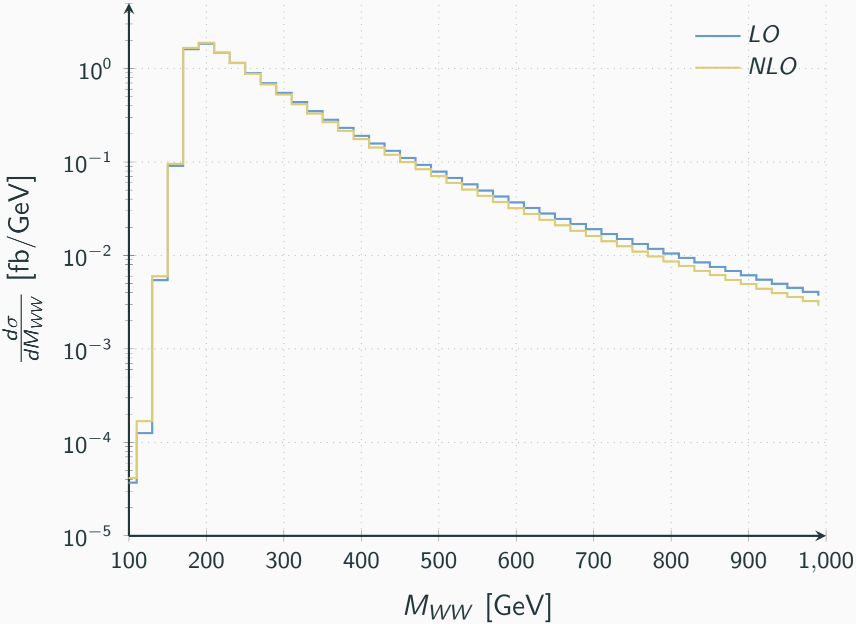
$q\bar{q} \to WW \to l^+\nu l^-\bar{\nu}$ (fixed-order vs. resummed)



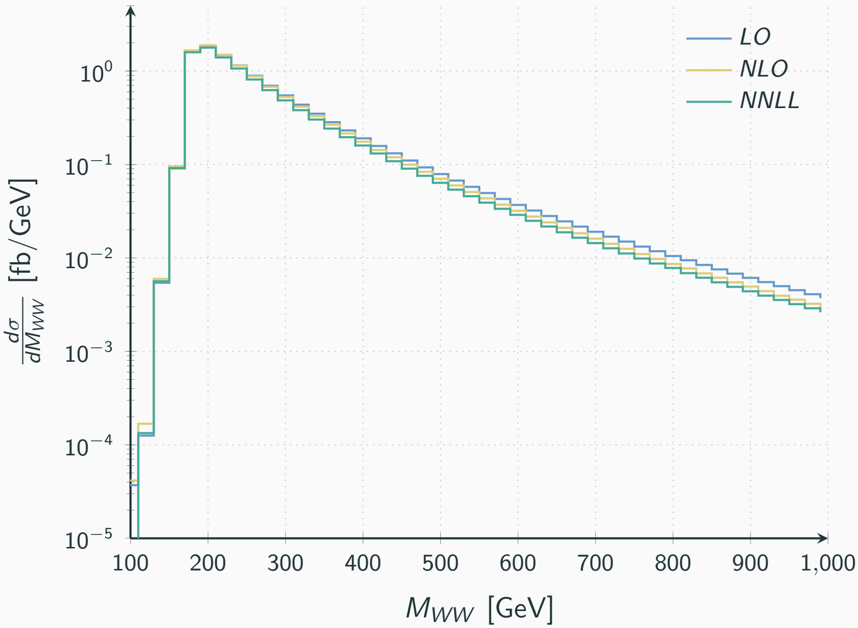
$q\bar{q} \to WW \to l^+\nu l^-\bar{\nu}$ (fixed-order vs. resummed)



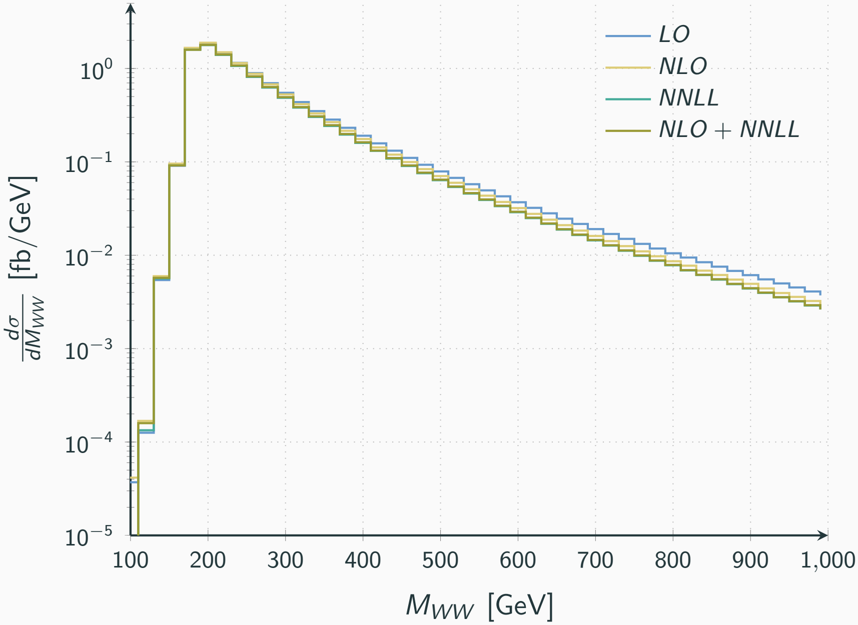
$q\bar{q} \to WW \to l^+\nu l^-\bar{\nu}$ (fixed-order vs. resummed)



$q\bar{q} \to WW \to l^+ \nu l^- \bar{\nu}$ (fixed-order vs. resummed)



$q\bar{q} \to WW \to l^+\nu l^-\bar{\nu}$ (fixed-order vs. resummed)



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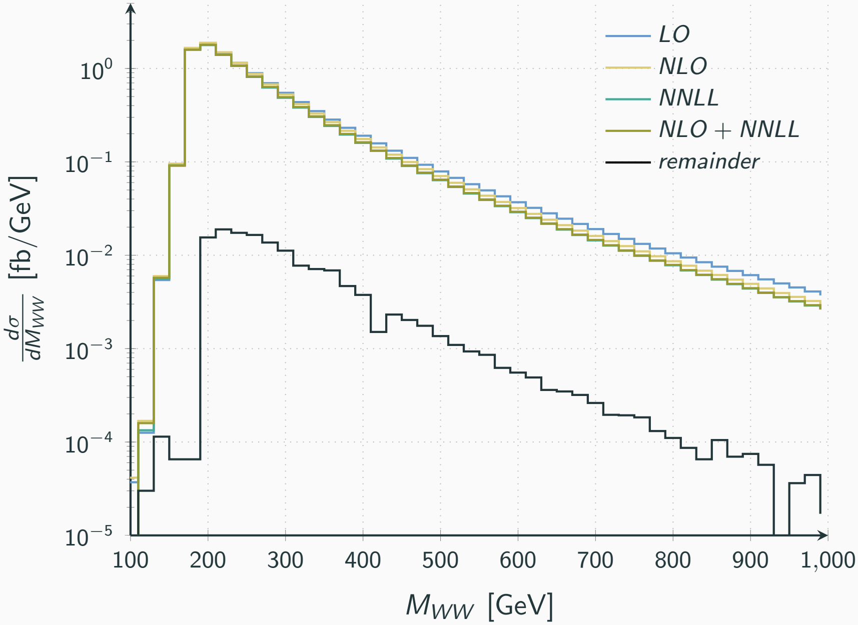
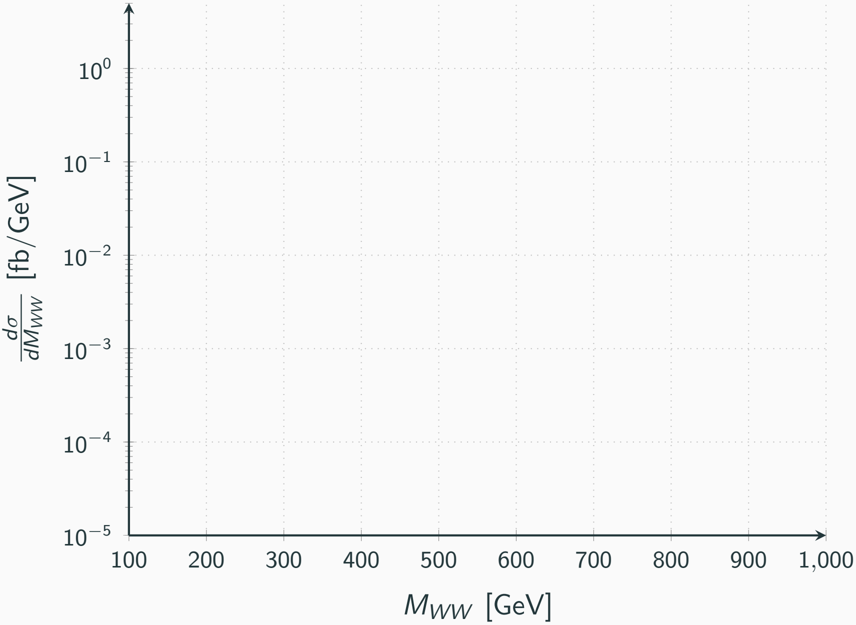
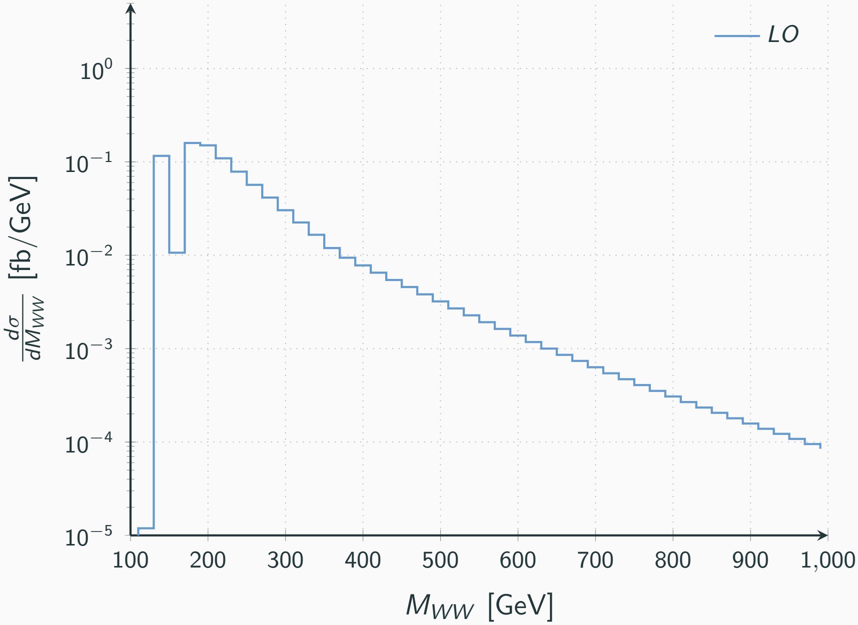


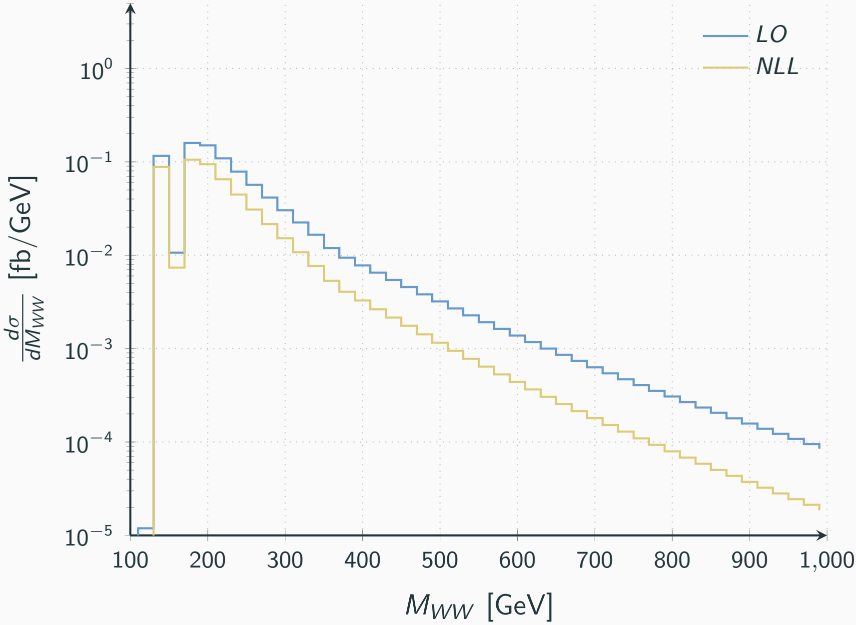
$gg \to WW \to l^+\nu l^-\bar{\nu}$ (fixed-order vs. resummed)



$gg \to WW \to l^+\nu l^-\bar{\nu}$ (fixed-order vs. resummed)



$gg \to WW \to l^+ \nu l^- \bar{\nu}$ (fixed-order vs. resummed)



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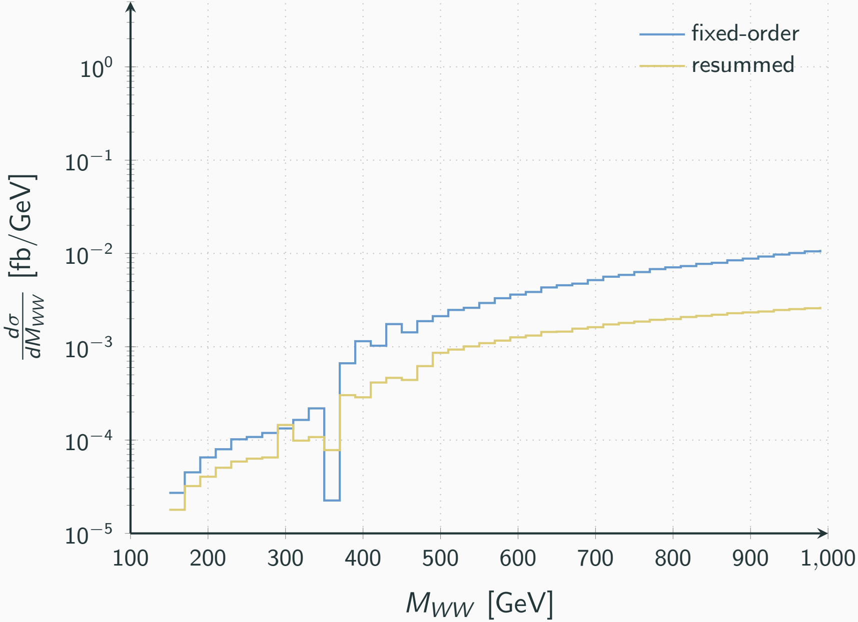
- Parameterise the discrepancy with respect to the Standard Model:

$$\delta = \frac{\sigma_{gg}^{BSM} - \sigma_{gg}^{SM}}{\sigma^{SM}}$$

δ (fixed-order vs. resummation)



Conclusion

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- WIP comparison with Parton Shower Monte Carlos