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VBF-V: status and plans for YR

20 Jan 2022

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•Combined Theory+Exp chapter with joint Introduction, Recommendations



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ntroduction

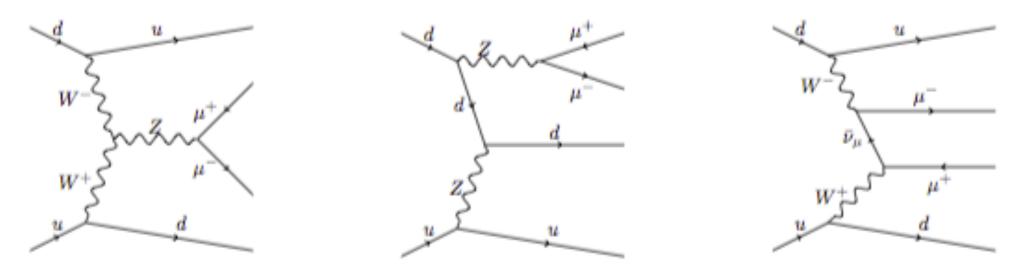
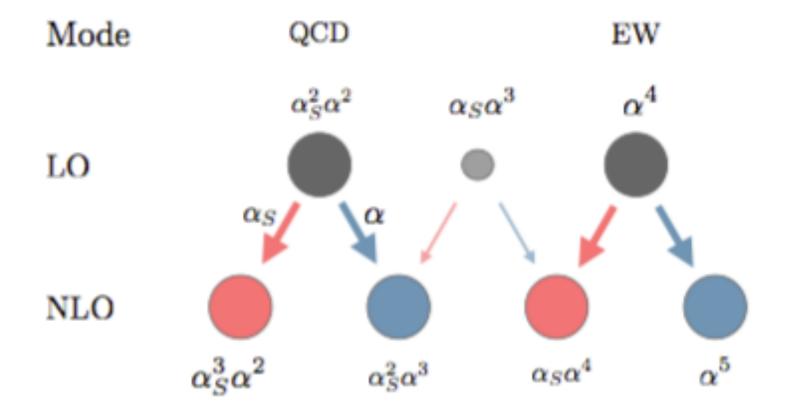


Fig. 4.1: Representative Feynman diagrams for the production of two charged leptons in association with two jets at order (α^4): vector boson fusion (left) bremsstrahlung-like (center). multi-peripheral (right),





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heory review & best practise

4.2.1 State of the art

VBF production

Higher-order QCD corrections to VBF production are known in the so-called *VBF approximation*, where the VBF subprocess alone (see Section 4.1.1) is considered and higher-order corrections ignore cross-talk between the quark lines [?, ?]. These corrections are available within VBFNLO [], and have been matched to parton showers within POWHEG-BOX [?, ?] and HERWIG7 []. NLO EW corrections to VBF production are currently not known.

QCD background

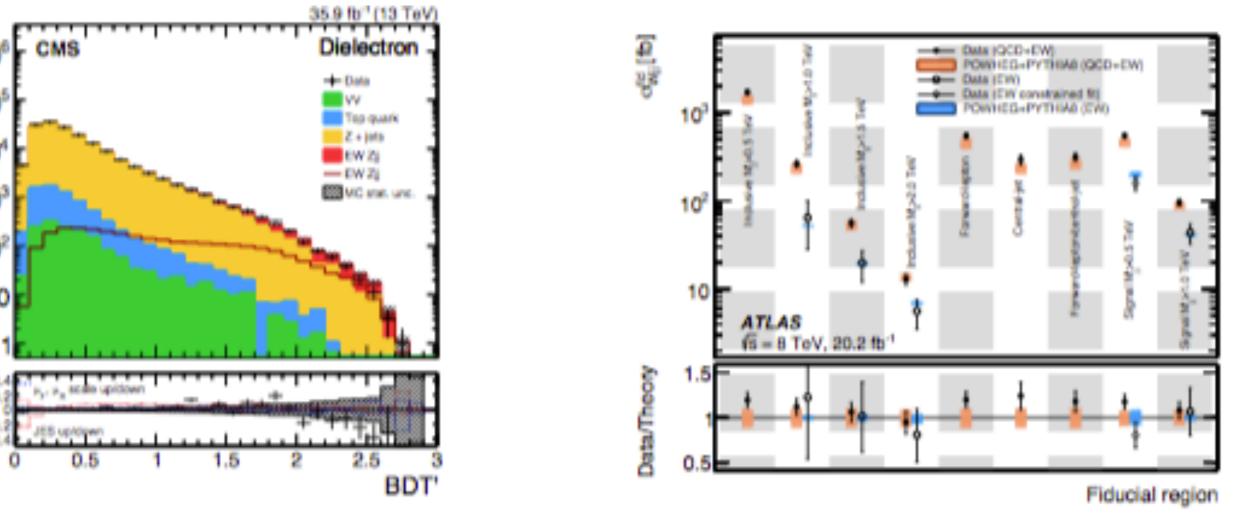
On the other hand higher-order corrections to the QCD background are very advanced. NLO QCD corrections to the QCD background are widely available in many automated automated Mnte Carlo frameworks. They have first been obtained at fixed-order in Refs. [?,?,?] (for $pp \rightarrow V + n$ jets with n > 2 see e.g. [?,?,?,?,?,?,?].). Also NLO QCD predictions matched to parton showers are readily available within general purpose shower Monte Carlo programs [?,?,?,?], where they typically enter Monte Carlo samples merging NLO predictions for V + 0, 1, 2 jets production [?,?,?,?]. Additionally, certain logarithmically enhanced corrections beyond fixed-order NLO are available [?,?,?]. NLO EW corrections to the QCD background to VBF production are known at fixed-order [?,?,?,?] and have also been combined with a QCD+QED parton shower in an approximation integrating out the photon radiation as part of the EW corrections [?].



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4.3.3	TGC/EFT measurements	÷ 1
4.4	Challenges	/MC -
4.4.1		Data / M
4.4.2		
4.5		Fig. 4.2 Ref. [?
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Experimental review: inclusive measurements



.2: Multivariate signal discrimanat output from Ref. [?] (left) and summary of fiducial cross section from [?] (right)



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•Experimental review: differential measurements

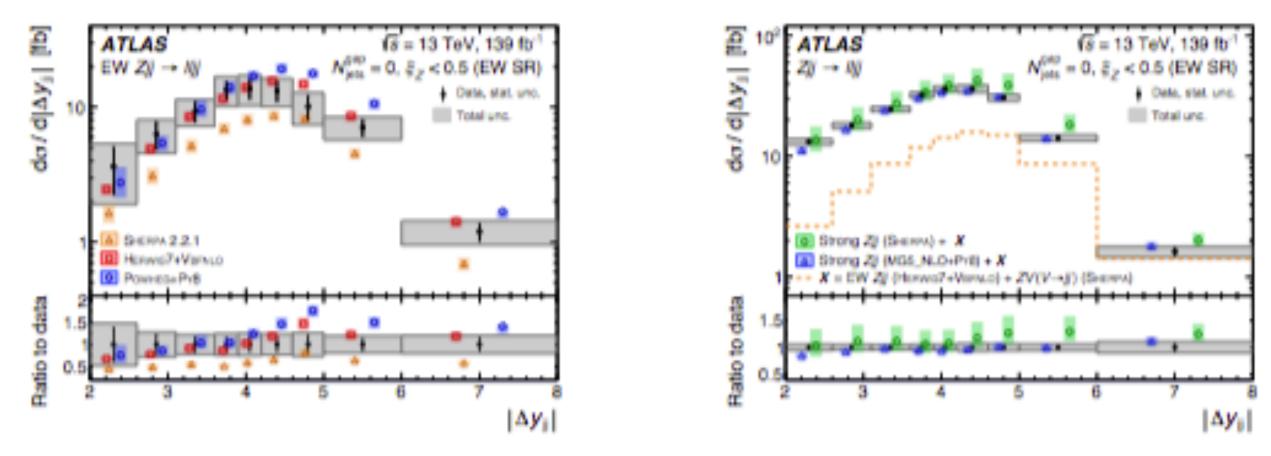
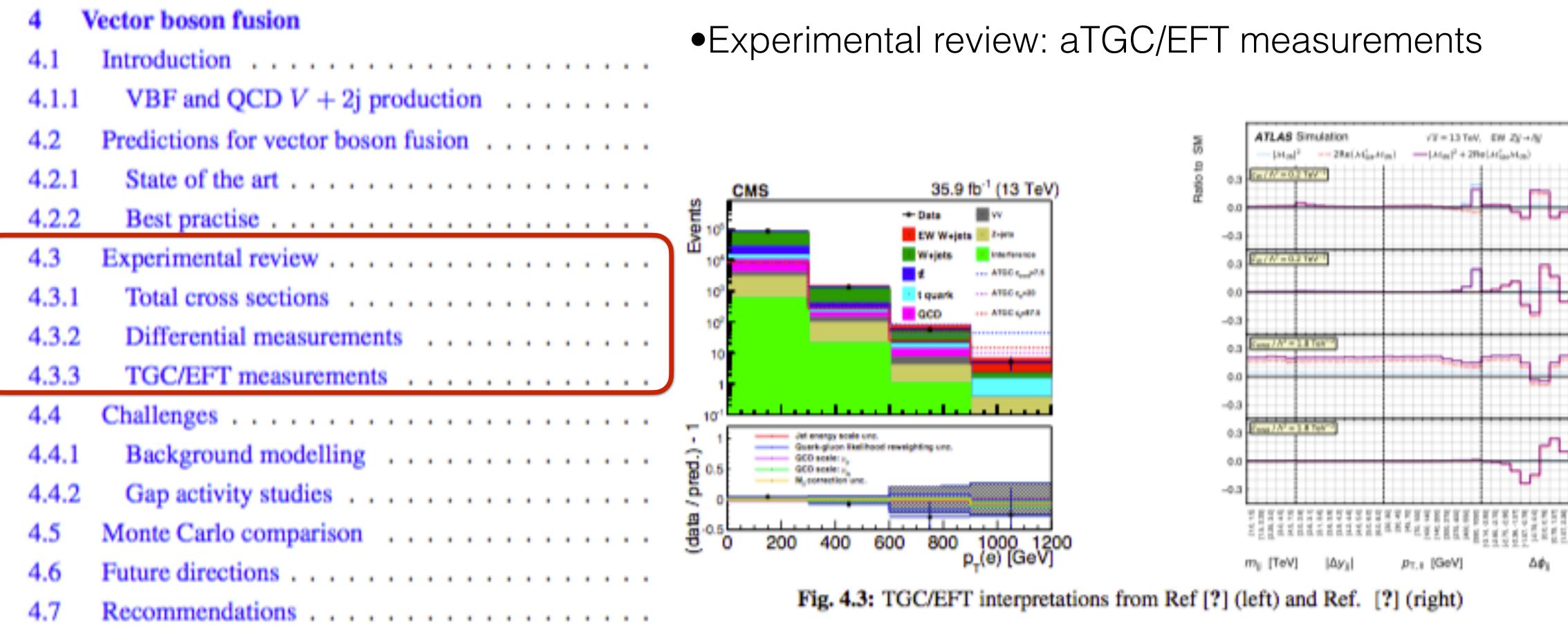


Fig. 4.3: Unfolded differential cross sections from Ref. [?]







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Vector boson fusion 4 •Challenges: background modelling 4.14.1.14.2 4.2.15 = 13 TeV, 139 fb⁻¹ 4.2.2 EW ZJ (PowersePv8) -* EW ZJ (HERMO+VIEW.O),* hong ZJ (MG5+Pril) ang ZJ (MG5_NLO+Pvil) + EW ZJ (Secreta) 4.3 4.3.1 Total cross sections 4.3.2 Differential measurements TGC/EFT measurements 4.3.3 4.4 2×10' 3×10' 3×10² 4.4.14.4.2 4.5 4.6 4.7

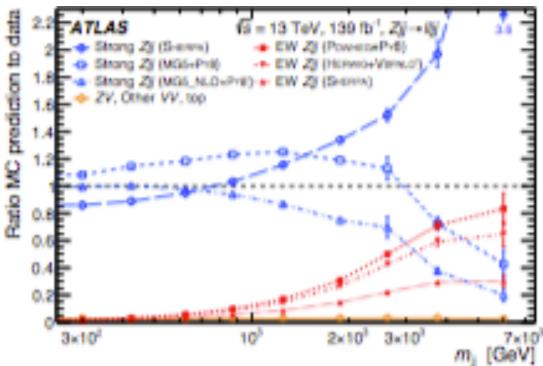


Fig. 4.4: Comparison of Monte Carlo predictions and data for the dijet invariant mass distribution from Ref. [?]







Vector boson fusion 4 •Challenges: gap activity studies 4.14.1.14.2 35.9 fb⁻¹ (13 TeV CMS veto efficiency efficiency µ + e events: BDT > 0.95 4.2.1Outs lackground-only 4.2.2 ickpround + EWK WJ (MOS. #MC LO + PytNeE ckpround + EWK Wj (MG5_aMC LO + Herwig) veto 4.3 ° Gap 4.3.1Total cross sections Ö 4.3.2 TGC/EFT measurements 4.3.3 103 4.4 10 Soft H_T [GeV] 4.4.14.4.2 4.5 4.6 4.7

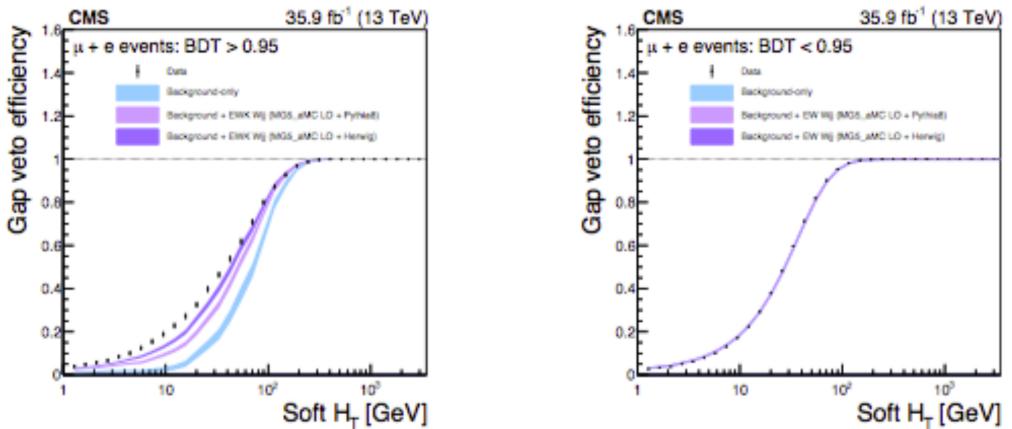


Fig. 4.6: Event veto efficiencies of hadronic gap activity [?], evaluated with charged particles in (left) signalenriched and (right) background-enriched regions. The data are compared with the background-only prediction as well as background plus signal with PYTHIA or HERWIG parton showering.



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 Monte Carlo comparison Like-for-like comparison of MC samples in ATLAS and CMS Based on ATLAS VBF-Z rivet routine ATLAS_2020_11803608





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ecommendations

What to measure

- Always measure actual (differential) cross section
- Always produce results for sum of QCD+EW+interference modes and separation in EW only

iducial definition

- Proposed benchmark cuts. CMS and ATLAS should try to adapt (avoid slightly different cuts). Can we even agree on the exact definition (also for lepton pT,eta)?
- Always particle level definitions, parton level optional for easy of comparison to fixed order
- Always use dressed leptons, dR=0.1
- Use real four vector quantities, i.e pT not ET, y not eta

bservables

- Mjj
- ...

Iodelling

- Ensure PS modelling is suitable for VBF/VBS processes: recoil scheme etc

erform studies for gap activity

- Measure third jet activity: pTj3, HT
- Charged hadrons in the rap gap
- BSM interpretation
 - Stick to SMEFT models
 - Consider both, interference-only and quadratic EFT

Input regarding recommendations?



