STXS MEETING

EWK H+2j STXS UNCERTAINTIES

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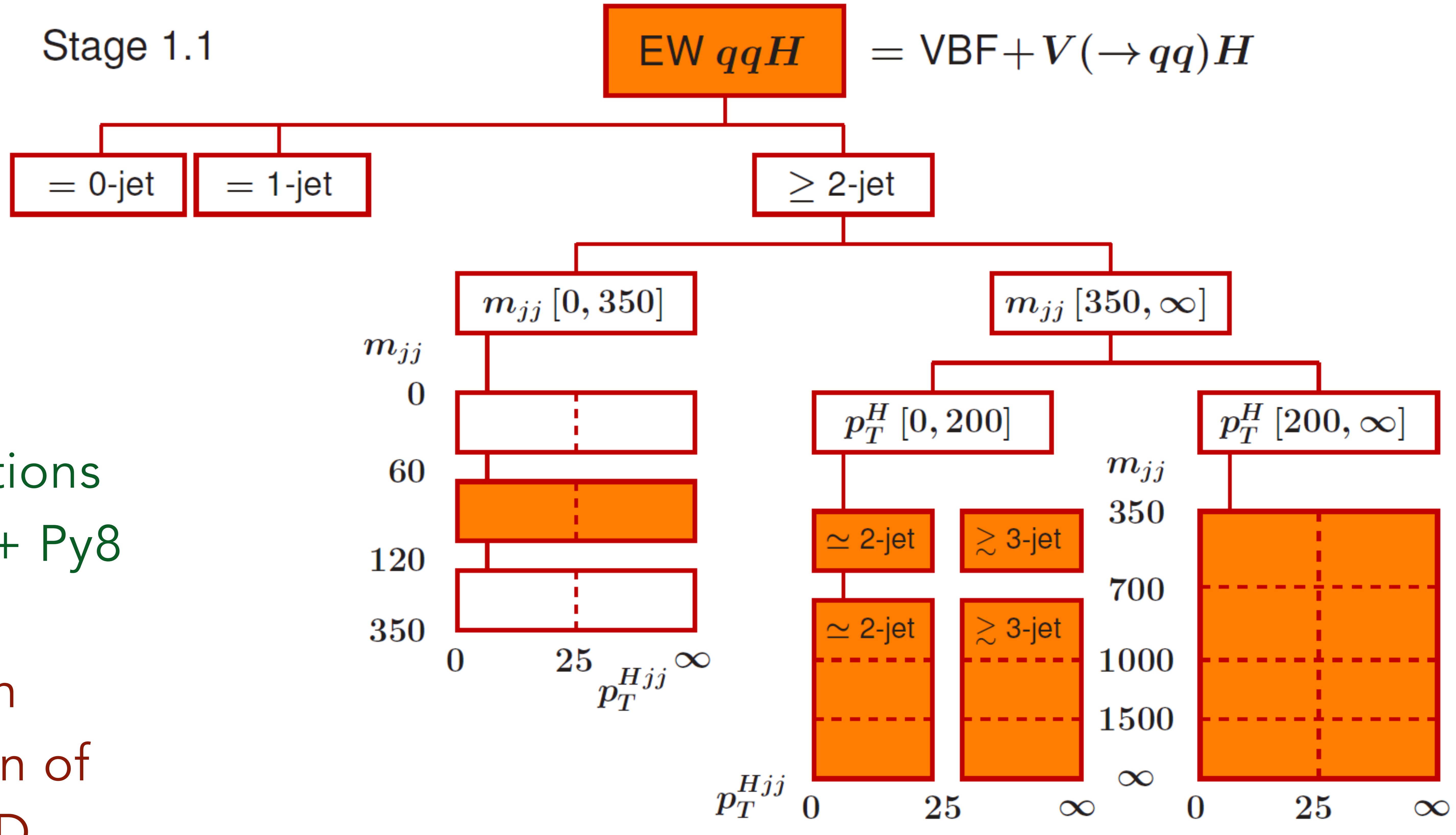
INTRODUCTION

- **10 QCD-nuisances accounted:**
  - **1 yields uncertainty ("overall" NP) on the inclusive cross-section, Δ_{tot}**
  - **9 migration uncertainties**
    - Δ_{2jet}, Δ_{200} and Δ_{25}
    - 6 NPs to describe M_{jj} spectrum
      - Estimated using ST method
  - **So far we had:**
    - Uncertainties extracted using FO calculations
    - Acceptances estimated using POWHEG + Py8
- **Inclusion of VH hadronic** NEW
  - Checking validity of the VBF approximation
  - Updating uncertainties using full calculation of H+2jet and H+3jet production at NLO QCD
- **Electroweak Corrections** NEW
  - EWK @NLO correction applied for every STXS bin



Previous update: https://indico.cern.ch/event/826136/contributions/3560473/attachments/1927391/3191007/STXS-uncertainties-VBF.pdf

LIMITS OF VBF APPROXIMATION

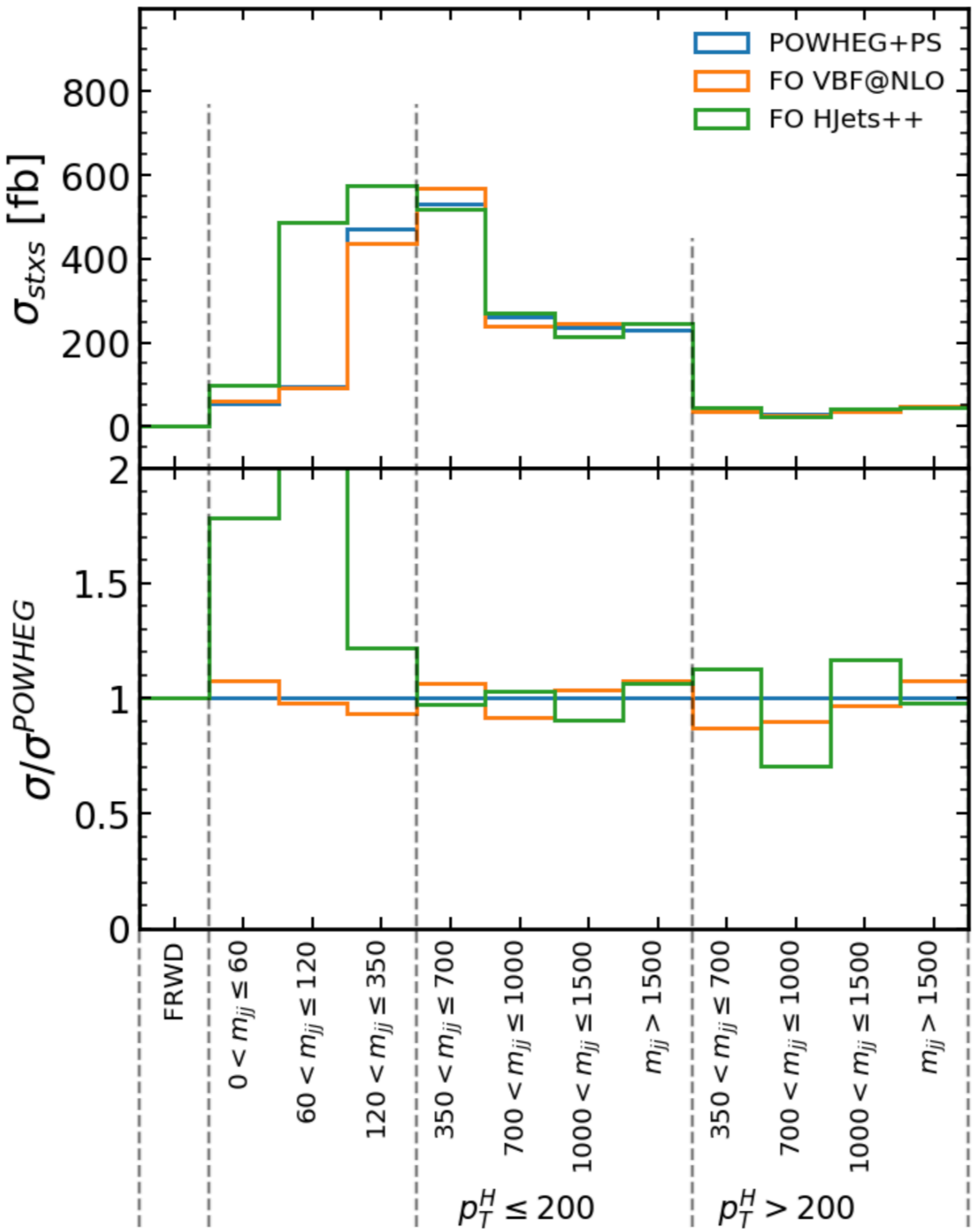
- **Most the VBF generators in the market run with the VBF approximate (only t- and u-channel).**
- **More accurate EW Higgs + 2 jets requires the inclusion of the s-channel component**
  - **Studies already initiated**

[Campanario, Figy, Plätzer, Sjödahl – PRL 111 (2013) 211802]
[Campanario, Figy, Plätzer, Rauch, Schichtel, Sjödahl – PRD 98 (2018) 033]

  - HJets++ provides full EW H+2jet and H+3jet calculation at NLO QCD (VBF+VHhad)

[Campanario, Figy, Plätzer, Sjödahl – PRL 111 (2013) 211802]

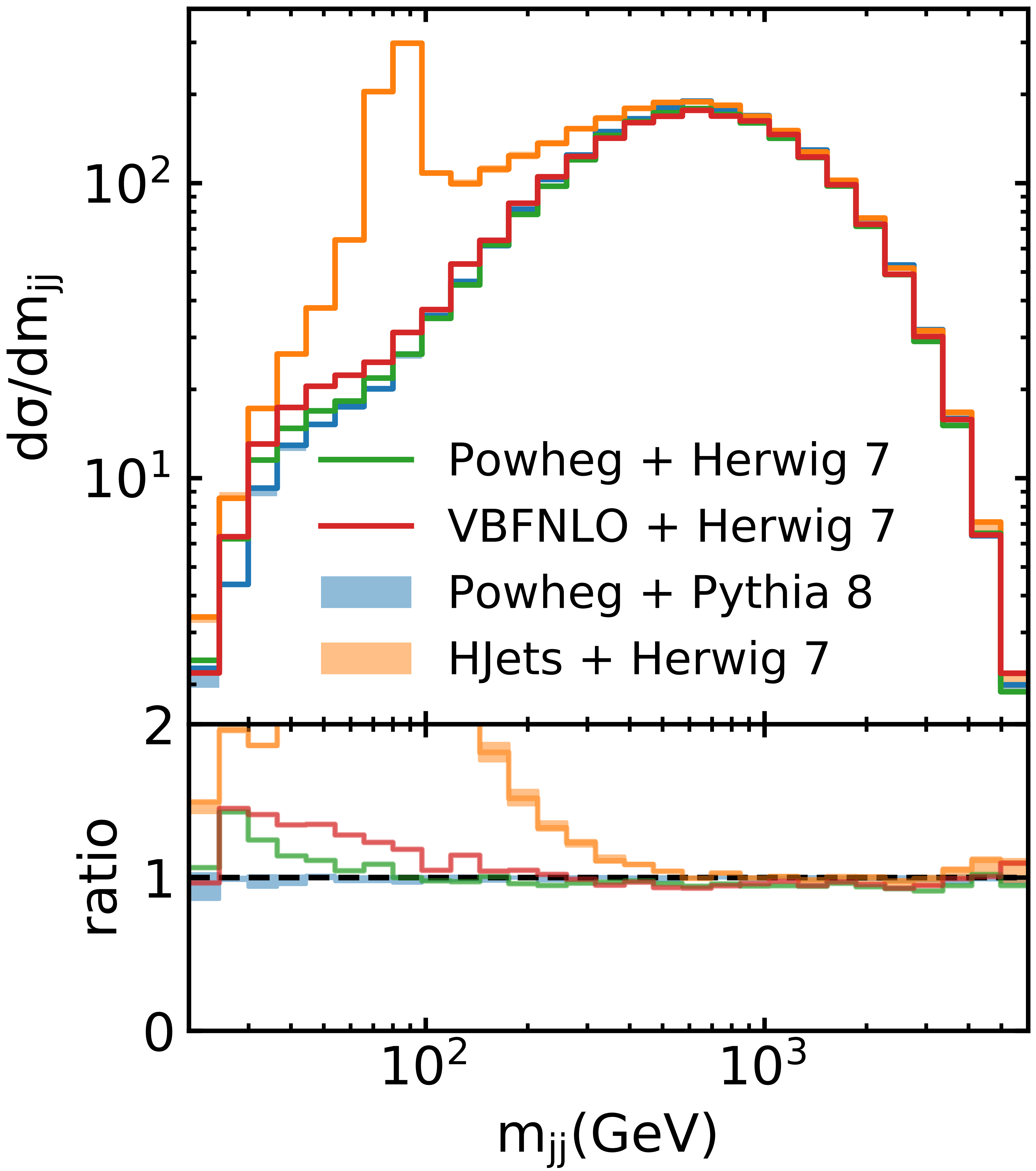
  - Little impact for VBF selection, more significant changes $m_{jj} < 350$ GeV



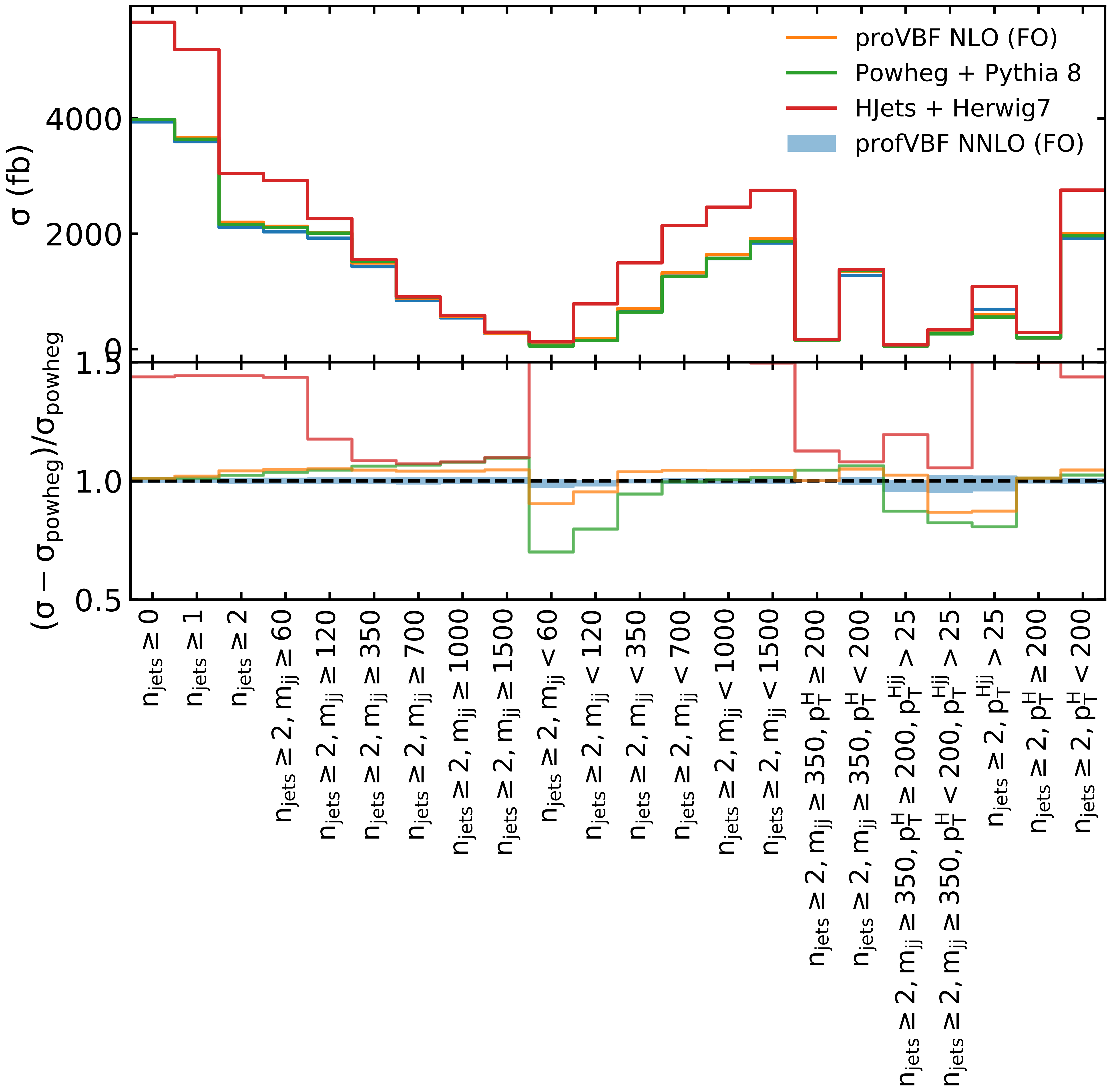
H+2J EWK: ADDING THE S-CHANNEL

- Compared various combinations of ME+PS:
  - POWHEG: NLO-QCD (3rd jet LO from PS)
    - VBF approximated: only t/u-channels
    - Interfaced with Herwig7 and Pythia8 (with `dipoleRecoil=on`)
  - VBFNLO : NLO-QCD (3rd jet LO from PS)
    - VBF approximated: only t/u-channels
    - Interfaced with Herwig7
  - HJets++ : NLO-QCD (3rd jet LO from PS)
    - Full EWK H+2 jets calculation
    - Interfaced with Herwig7

- **Stage 1.1 acceptances need to be updated to account for the s-channel contribution using HJet++**

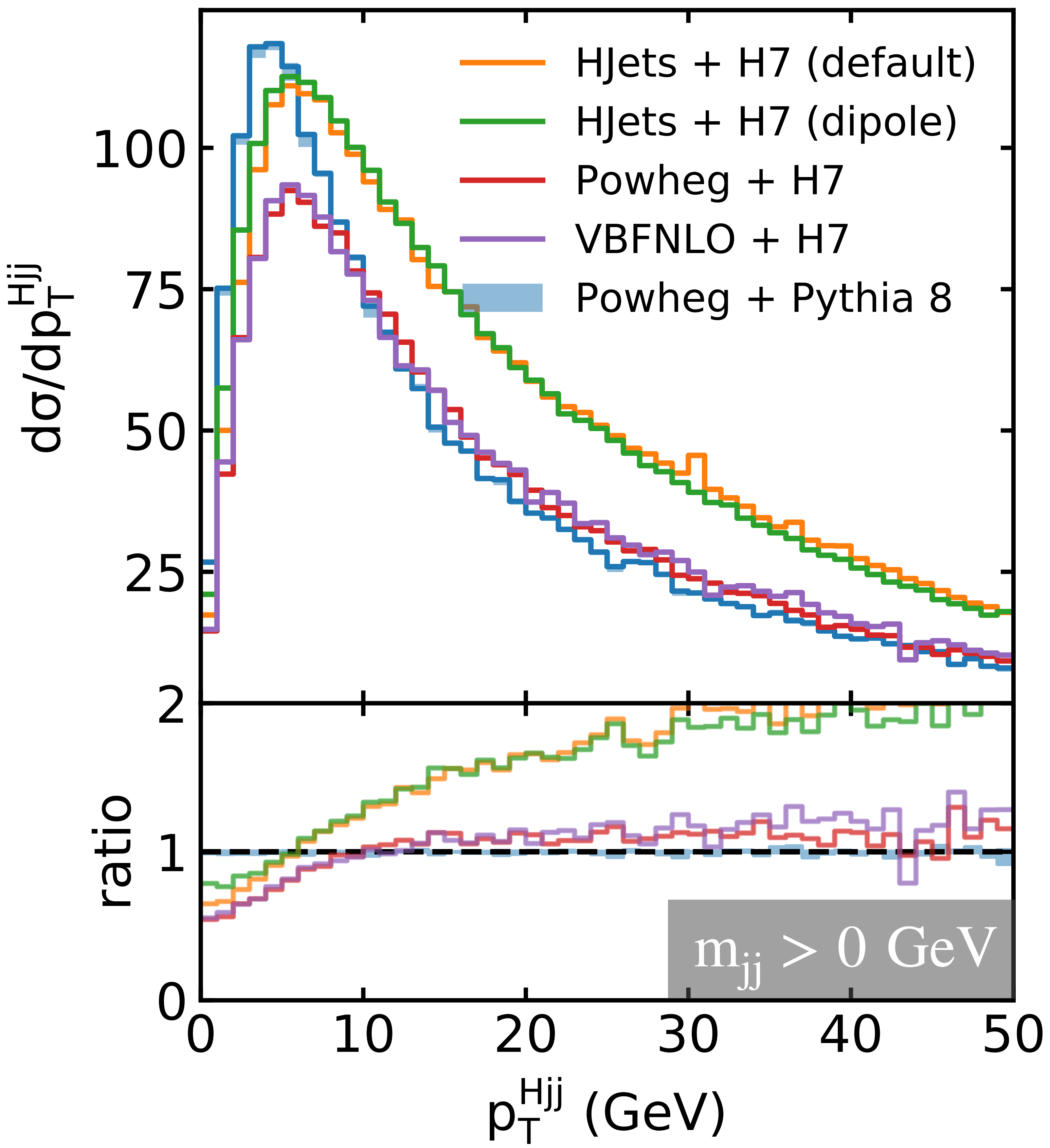


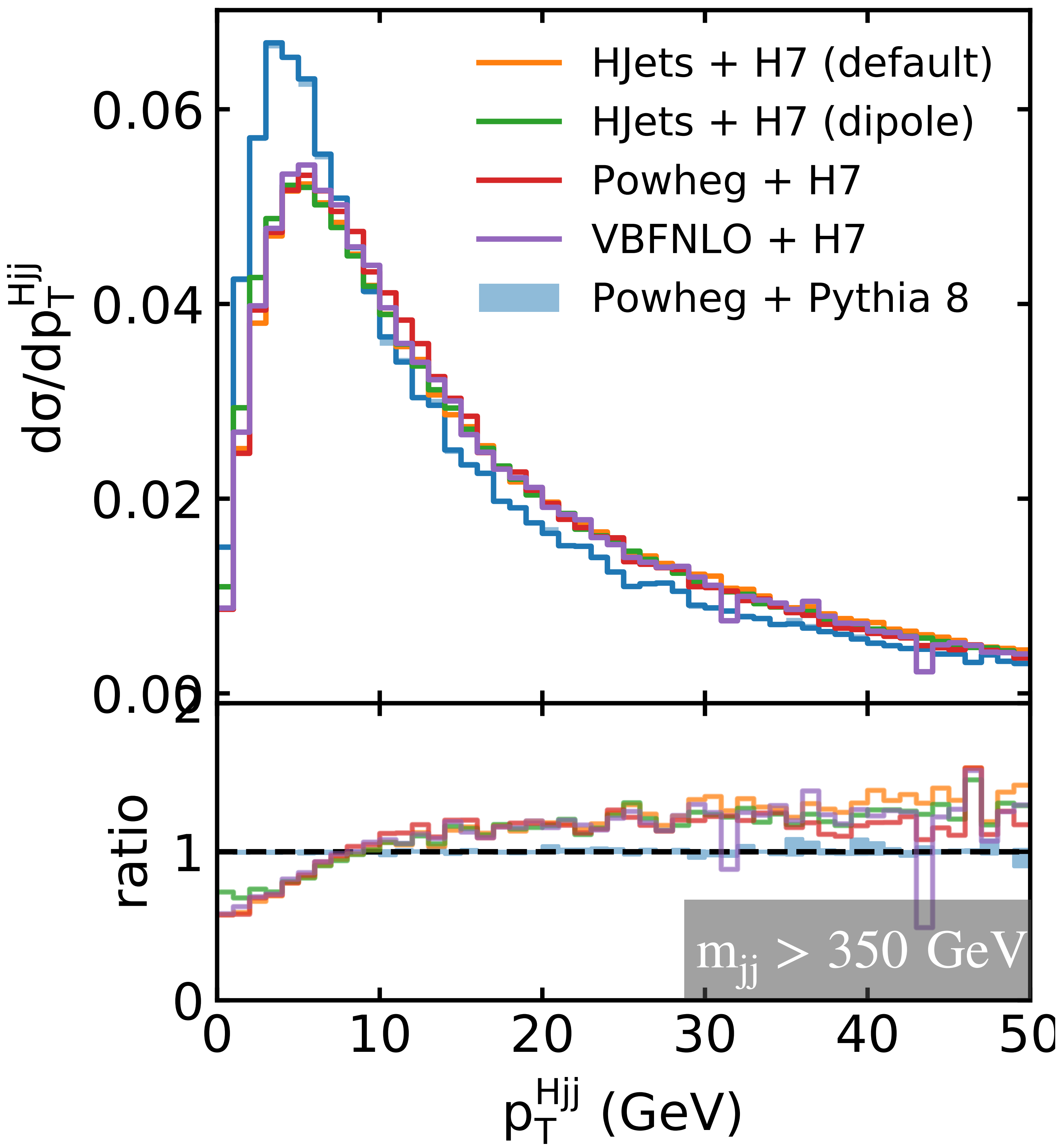
FIXED ORDER CALCULATION VS ME+PS

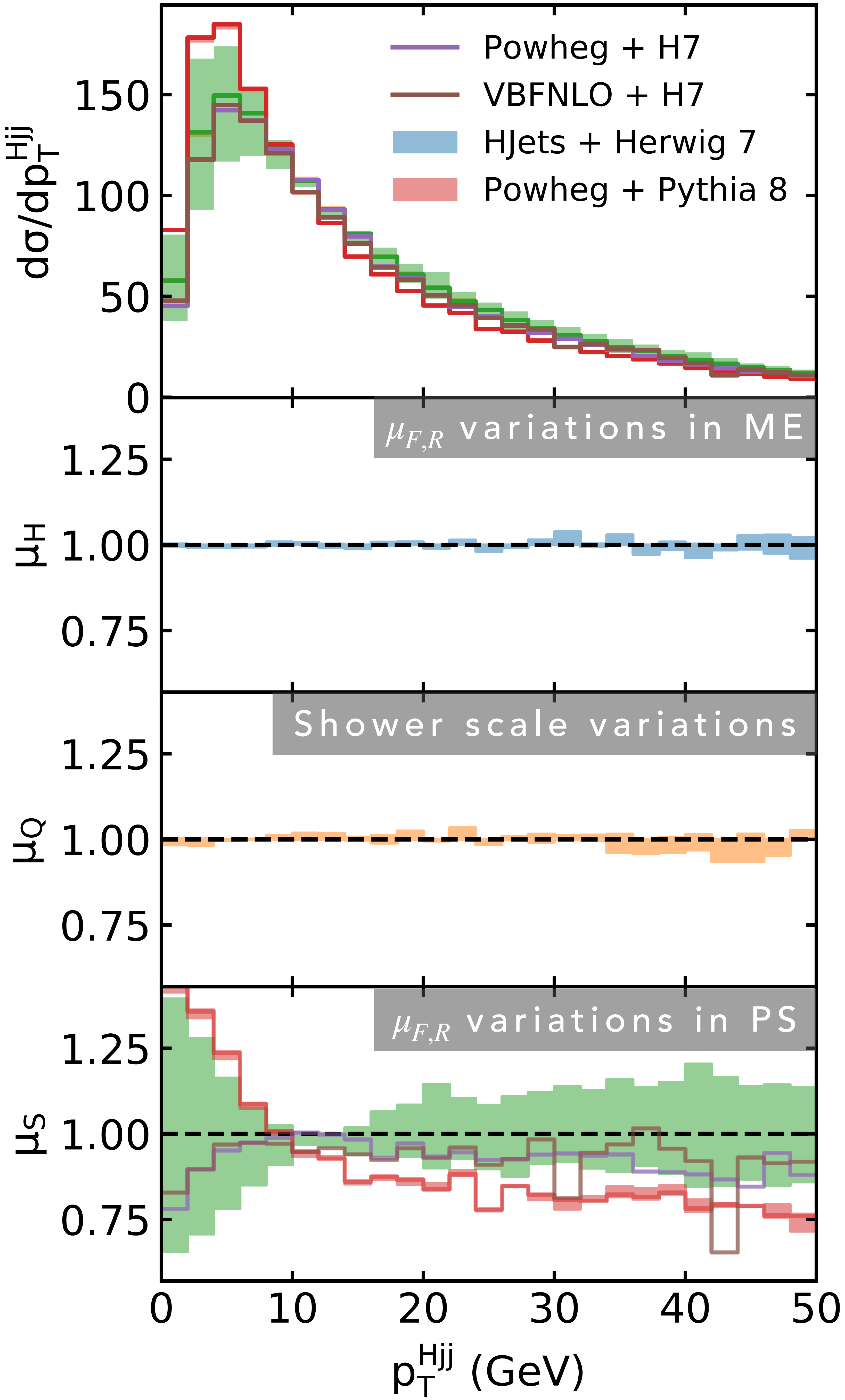


- Compared ME+PS to FO calculation from proVBF-H (NNLO-QCD)
- FO-NNLO-QCD cross-section estimate is consistent with POWHEG
  - Discrepancy at low m_{jj} is due to soft emissions present in the FO NNLO calculation
  - Good agreement of at large m_{jj} values

THE p_T^{Hjj} OBSERVABLE



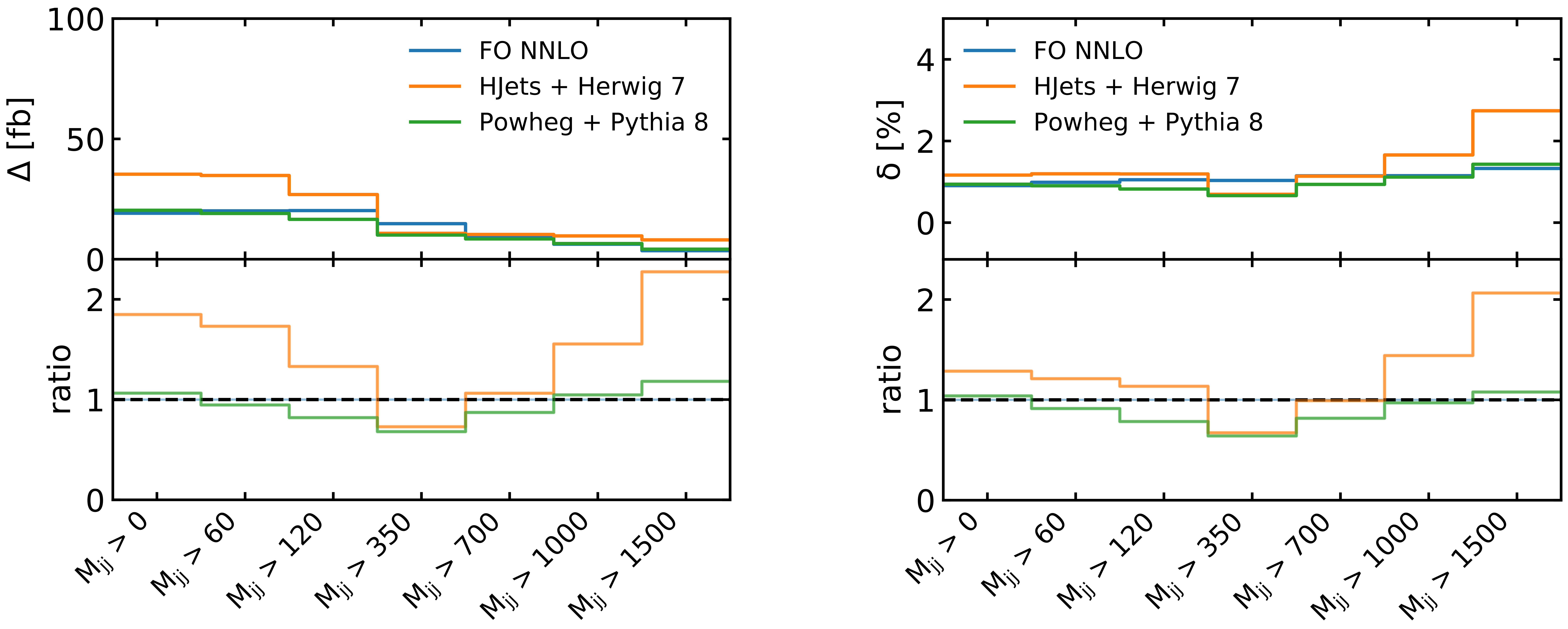




- **Over 40% discrepancy between H7 and Pythia8**
  - Region dominated by soft emissions
  - Expect large PS $\mu_{F,R}$ scale variation
  - Still investigating these differences with PS authors

COMPARING UNCERTAINTIES VS m_{jj}

- Hard process scale variations for every m_{jj} cut



UNCERTAINTIES PROPAGATION SCHEME

- **9 migration uncertainties Δ_{2jets}, Δ_{200} and Δ_{25}**
  - Δ_{2jets}, Δ_{200} and Δ_{25}
  - 6 NPs to describe M_{jj} spectrum
- **1 yield uncertainty on the inclusive cross-section, Δ_{tot}**

$$\Delta_{tot} = \sigma_{tot} \times \delta_{tot}$$

$$\Delta_{2j} = \sigma_{2j} \times (\delta^2_{2j} - \delta^2_{tot})^{1/2}$$

$$\Delta_{60} = \sigma_{m_{jj}>60} \times (\delta^2_{m_{jj}>60} - \delta^2_{2j})^{1/2}$$

$$\ldots = \ldots$$

$$\Delta_{350} = \sigma_{m_{jj}>350} \times (\delta^2_{m_{jj}>350} - \delta^2_{m_{jj}>120})^{1/2}$$

$$\ldots = \ldots$$

- **Uncertainties computed by varying the QCD scales**
  - Extracted using ME or FO NNLO
- **Bins acceptance computed with ME+PS**
  - Moved from the fraction of the Δ distributed across STSX bins to σ

- If undefined uncertainty (ex: $\delta_{[350,\infty]} < \delta_{[120,\infty]}$)

  → Replace with:

$$\Delta_{350} = \sigma_{m_{jj}>350} \times \rho \cdot \delta_{m_{jj}>350}$$

- ρ value of 1/2 is assumed for the remaining talk

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$$\Delta_{tot} = \sigma_{tot} \times \delta_{tot}$$

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$$\Delta_{60} = \sigma_{m_{jj}>60} \times (\delta^2_{m_{jj}>60} - \delta^2_{2j})^{1/2}$$

$$\ldots = \ldots$$

$$\Delta_{350} = \sigma_{m_{jj}>350} \times (\delta^2_{m_{jj}>350} - \delta^2_{m_{jj}>120})^{1/2}$$

$$\ldots = \ldots$$

- Total yield uncertainty taken from YR4 the $\delta_{\text{tot}} \sim 0.38\,\%$ (need to be updated)
- From δ_{2jet} remove contribution from δ_{tot}
- The effect of each migration Δ is anti-correlated for bins above/below

- If undefined uncertainty (ex: $\delta_{[350,\infty]} < \delta_{[120,\infty]}$)
  → Replace with:

$$\Delta_{350} = \sigma_{m_{jj}>350} \times \rho \cdot \delta_{m_{jj}>350}$$

- ρ value of 1/2 is assumed for the remaining talk

DEFINITION OF ACCEPTANCES

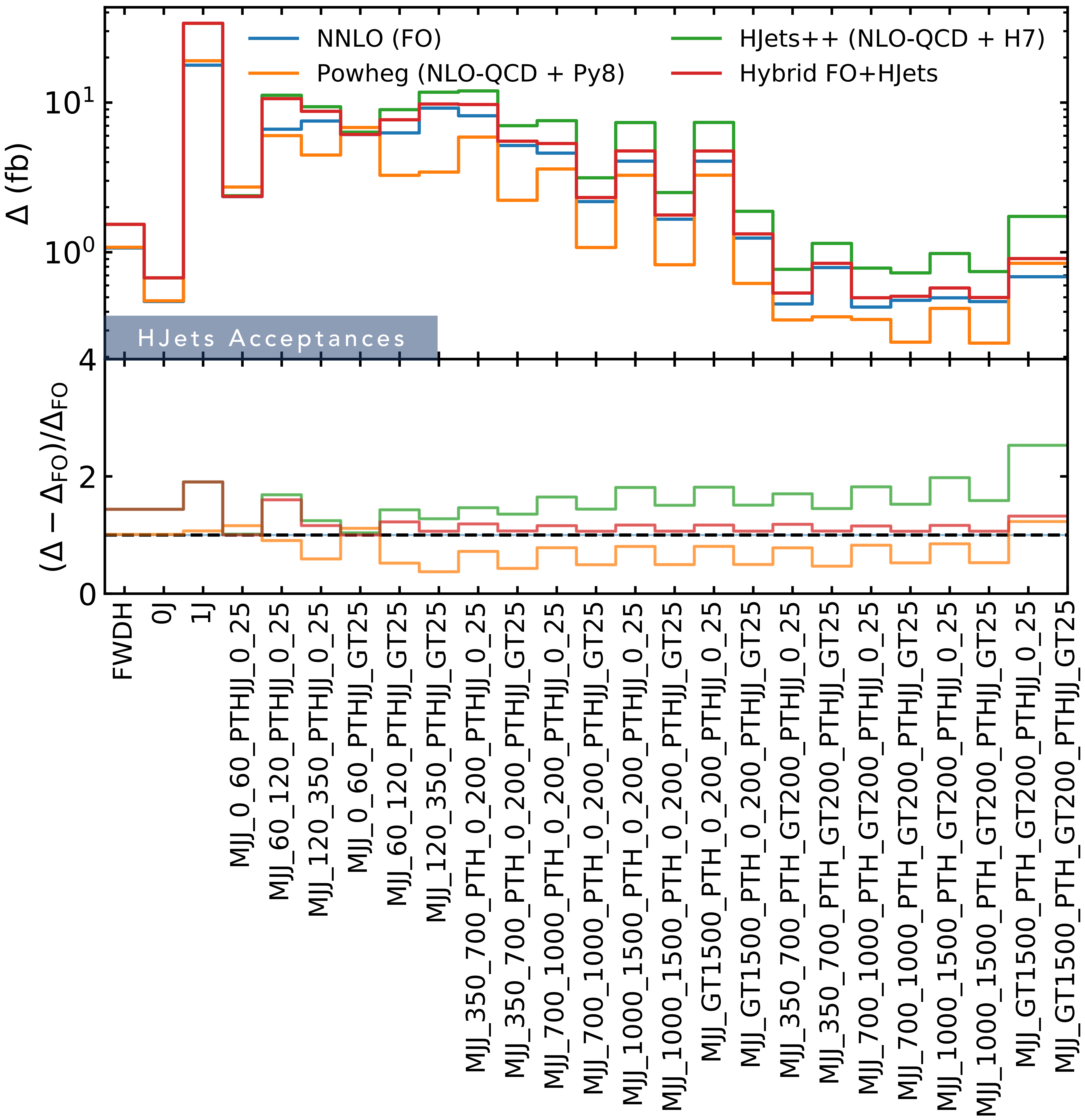
- Basic definition: bin cross-section divided by cross-section in the NP phase space
  - Exception: Δ_{XX} for bin with a cut : $m_{jj} < X$
- The effect of each migration Δ is anti-correlated for bins above/below

	Δ_{tot}	Δ_{200}	Δ_{60}	Δ_{120}	Δ_{350}	Δ_{700}	Δ_{1000}	Δ_{1500}	Δ_{25}	Δ_{2jets}
JET01	$\frac{\sigma_{N_{jets}<2}}{\sigma_{tot}}$	0	0	0	0	0	0	0	0	-1
MJJ_0_60_JET3	$\frac{\sigma_{0<m_{jj}<60\&p_T^{Hjj}>25}}{\sigma_{tot}}$	0	$-\frac{\sigma_{0<m_{jj}<60\&p_T^{Hjj}>25}}{\sigma_{0<m_{jj}<60}}$	...					$\frac{\sigma_{0<m_{jj}<60\&p_T^{Hjj}>25}}{\sigma_{p_T^{Hjj}>25}}$	$\frac{\sigma_{0<m_{jj}<60\&p_T^{Hjj}>25}}{\sigma_{N_{jets}>2}}$
MJJ_0_60_JET3VETO	$\frac{\sigma_{0<m_{jj}<60\&p_T^{Hjj}<25}}{\sigma_{tot}}$	0	$-\frac{\sigma_{0<m_{jj}<60\&p_T^{Hjj}<25}}{\sigma_{0<m_{jj}<60}}$	...					$\frac{\sigma_{0<m_{jj}<60\&p_T^{Hjj}>25}}{\sigma_{p_T^{Hjj}>25}}$	$\frac{\sigma_{0<m_{jj}<60\&p_T^{Hjj}<25}}{\sigma_{N_{jets}>2}}$
MJJ_60_120_JET3	$\frac{\sigma_{60<m_{jj}<120\&p_T^{Hjj}>25}}{\sigma_{tot}}$	0	$\frac{\sigma_{60<m_{jj}<120\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>60}}$	...					$\frac{\sigma_{60<m_{jj}<120\&p_T^{Hjj}>25}}{\sigma_{N_{jets}>2}}$	...
MJJ_60_120_JET3VETO	$\frac{\sigma_{60<m_{jj}<120\&p_T^{Hjj}<25}}{\sigma_{tot}}$	0	$\frac{\sigma_{60<m_{jj}<120\&p_T^{Hjj}<25}}{\sigma_{m_{jj}>60}}$	...						...
MJJ_120_350_JET3	$\frac{\sigma_{120<m_{jj}<350\&p_T^{Hjj}>25}}{\sigma_{tot}}$	0	$\frac{\sigma_{120<m_{jj}<350\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>60}}$	...	...	...	0	...	...	...
MJJ_120_350_JET3VETO	$\frac{\sigma_{120<m_{jj}<350\&p_T^{Hjj}<25}}{\sigma_{tot}}$	0	$\frac{\sigma_{120<m_{jj}<350\&p_T^{Hjj}<25}}{\sigma_{m_{jj}>60}}$	...						...
MJJ_350_700_pTH_0_200_JET3	$\frac{\sigma_{350<m_{jj}<700\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{tot}}$	$-\frac{\sigma_{350<m_{jj}<700\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{p_T^H<200}}$	$\frac{\sigma_{350<m_{jj}<700\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>60}}$	...					$\frac{\sigma_{350<m_{jj}<700\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{p_T^{Hjj}>25}}$	...
MJJ_350_700_pTH_0_200_JET3VETO	$\frac{\sigma_{350<m_{jj}<700\&p_T^H<200\&p_T^{Hjj}<25}}{\sigma_{tot}}$	$-\frac{\sigma_{350<m_{jj}<700\&p_T^H<200\&p_T^{Hjj}<25}}{\sigma_{p_T^H<200}}$	$\frac{\sigma_{350<m_{jj}<700\&p_T^H<200\&p_T^{Hjj}<25}}{\sigma_{m_{jj}>60}}$	...					$\frac{\sigma_{350<m_{jj}<700\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{p_T^{Hjj}>25}}$	...
...	...	...	...	...						...
MJJ_700_1000_pTH_0_200_JET3	$\frac{\sigma_{700<m_{jj}<1000\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{tot}}$	$-\frac{\sigma_{700<m_{jj}<1000\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{p_T^H<200}}$	$\frac{\sigma_{700<m_{jj}<1000\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>60}}$	...	...	...	$\sigma_{m_{jj}<1000}$	...	...	...
...	...	...	...	...	...	...	...	...	...	...
MJJ_1500_pTH_0_200_JET3	$\frac{\sigma_{m_{jj}>1500\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{tot}}$	$-\frac{\sigma_{m_{jj}>1500\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{p_T^H<200}}$	$\frac{\sigma_{m_{jj}>1500\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>60}}$	...	...	...	$\frac{\sigma_{m_{jj}>1500\&p_T^H<200\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>1000}}$	...	...	...
...	...	...	...	...	...	...	...	...	...	...
MJJ_350_700_pTH_gt200_JET3	$\frac{\sigma_{350<m_{jj}<700\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{tot}}$	$\frac{\sigma_{350<m_{jj}<700\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{p_T^H>200}}$	$\frac{\sigma_{350<m_{jj}<700\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>60}}$	...	...	...	0	...	...	...
MJJ_350_700_pTH_gt200_JET3VETO	$\frac{\sigma_{350<m_{jj}<700\&p_T^H>200\&p_T^{Hjj}<25}}{\sigma_{tot}}$	$\frac{\sigma_{350<m_{jj}<700\&p_T^H>200\&p_T^{Hjj}<25}}{\sigma_{p_T^H>200}}$	$\frac{\sigma_{350<m_{jj}<700\&p_T^H>200\&p_T^{Hjj}<25}}{\sigma_{m_{jj}>60}}$	...	...	...	0	...	...	...
...	...	...	...	...	...	...	...	...	...	...
MJJ_700_1000_pTH_gt200_JET3	$\frac{\sigma_{700<m_{jj}<1000\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{tot}}$	$\frac{\sigma_{700<m_{jj}<1000\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{p_T^H>200}}$	$\frac{\sigma_{700<m_{jj}<1000\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>60}}$ ...	...	...	...	$-\frac{\sigma_{700<m_{jj}<1000\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{m_{jj}<1000}}$		...	...
...	...	...	...	...	...		...	...	...	...
MJJ_1500_pTH_gt200_JET3	$\frac{\sigma_{m_{jj}>1500\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{tot}}$	$\frac{\sigma_{m_{jj}>1500\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{p_T^H>200}}$	$\frac{\sigma_{m_{jj}>1500\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>60}}$	...	...	...	$\frac{\sigma_{m_{jj}>1500\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{m_{jj}>1000}}$		$\frac{\sigma_{m_{jj}>1500\&p_T^H>200\&p_T^{Hjj}>25}}{\sigma_{p_T^{Hjj}>25}}$	...
...	...	...	...	...	...	...	...	...	...	...

$$-\frac{\sigma_{0<m_{jj}<60\ \&\ p_T^{Hjj}<25}}{\sigma_{0<m_{jj}<60}}$$

$$+\frac{\sigma_{60<m_{jj}<120\ \&\ p_T^{Hjj}<25}}{\sigma_{m_{jj}>60}}$$

COMPARING UNCERTAINTIES

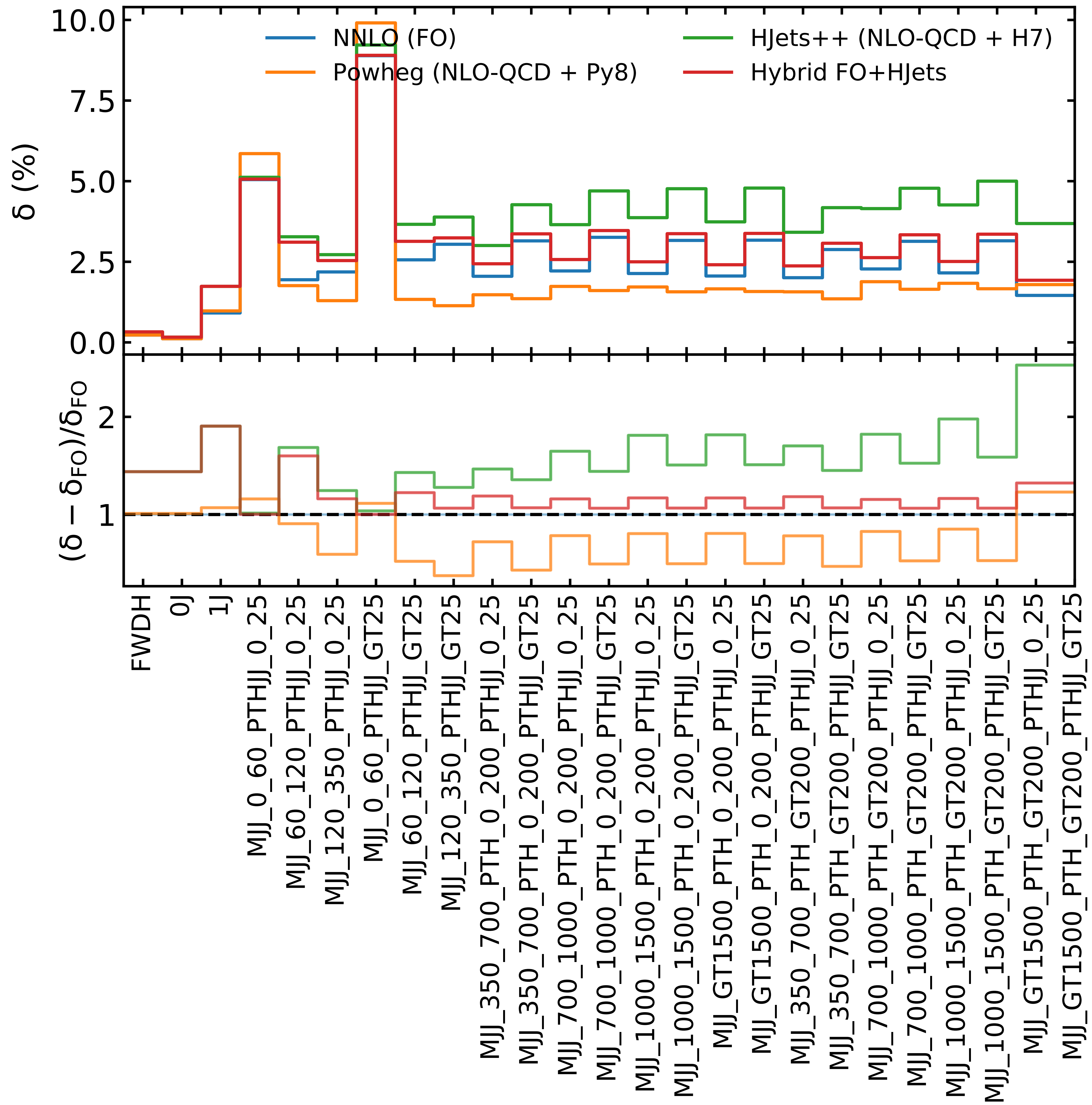


- **Acceptances updated using HJets + Herwig 7**
- **What to use for the uncertainty sources (the bing Δ)?**
  - The 3rd jet is generated in HJets/Powheg at LO and from PS, Hence the HJets/Powheg QCD scale uncertainties in the 2j/3j bins are not reliable. FO estimation should be used to estimate the uncertainties Δ_{25}

- **Hybrid sources solution:**
  - S-channel contributes only in the low Mjj region < 350 GeV, FO can be used for $\Delta_{350\text{-}1500}$, HJets for $\Delta_{60\text{-}120}$ and Δ_{2j}
  - Δ_{25} and Δ_{200} from FO

source [fb]	FO NNLO	POWHEG NLO	HJets NLO	MIXED
Delta_tot	14.972	15.131	21.539	21.539
Delta_200	0.622	1.081	2.989	0.622
Delta_Mjj60	8.057	9.511	8.003	8.003
Delta_Mjj120	6.84	8.286	13.446	13.446
Delta_Mjj350	7.389	5.025	5.385	7.389
Delta_Mjj700	4.201	5.973	8.158	4.201
Delta_Mjj1000	3.115	3.545	7.045	3.115
Delta_Mjj1500	1.764	2.614	6.404	1.764
Delta_25	27.387	2.674	35.46	27.387
Delta_2jet	17.355	18.617	33.412	33.412

COMPARING UNCERTAINTIES



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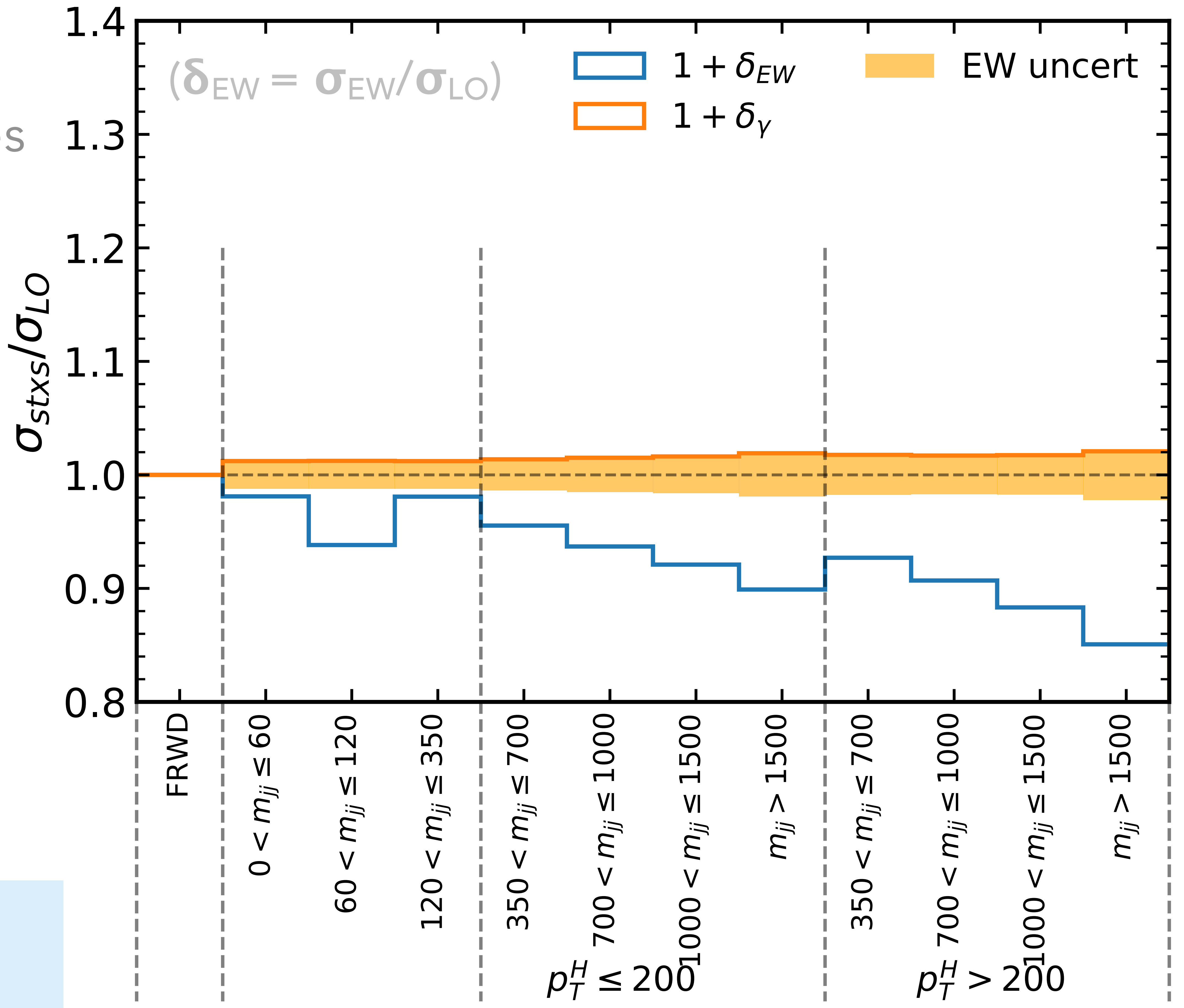
Delta_25	27.387	2.674	35.46	27.387
Delta_2jet	17.355	18.617	33.412	33.412

ELECTROWEAK CORRECTIONS IN STXS BINS

- **The state of the art calculation from HAWK 2.0**
  [Denner, Dittmaier, SK, Muck [arXiv:1412.5390]]
  - Provides complete NLO QCD and EWK corrections and includes s-channel and interferences
  - provides predictions for partonic channels with incoming photons as part of NLO EW corrections
- EW corrections of 5-10% in VBF production
- Enhanced electroweak corrections at high energies: driven by Sudakov $\log \alpha \to \alpha \log\left(Q/M_w\right)$ at Higgs p_T tail
  [Ciccolini, Denner, Dittmaier [arXiv:0710.4749]]
- Uncertainty estimated following the same prescription as in the Yellow Report 4

$$\Delta_{\rm EW} = \max\{0.5\,\%\,, \delta^2_{\rm EW}, \sigma_\gamma/\sigma_{\rm VBF}\}$$

- **Proposition:**
  - Since EW correction is driven by Sudakov log we can consider δ^2_{EW} as the pure Sudakov nuisance: $\Delta_{\rm sud}$
  - δ_γ can be considered as a separate nuisance for non-Sudakov nuisance: Δ_γ



HOW TO INCLUDE THE EW CORRECTIONS ?

	STXS bin	σ_{LO}(fb)	$(1+\delta_{EW})$	σ_γ(fb)	Δ_{EW}
	$0 < m_{jj} \leq 60$	6.67	0.981	0.081	0.012
	$60 < m_{jj} \leq 120$	601.78	0.938	7.440	0.012
	$120 < m_{jj} \leq 350$	540.59	0.981	6.567	0.012
$p_T^H \leq 200$	$350 < m_{jj} \leq 700$	659.75	0.955	9.056	0.014
$p_T^H \leq 200$	$700 < m_{jj} \leq 1000$	318.83	0.937	4.820	0.015
$p_T^H \leq 200$	$1000 < m_{jj} \leq 1500$	275.94	0.921	4.481	0.016
$p_T^H \leq 200$	$m_{jj} > 1500$	251.33	0.899	4.798	0.019
$p_T^H > 200$	$350 < m_{jj} \leq 700$	45.72	0.927	0.807	0.018
$p_T^H > 200$	$700 < m_{jj} \leq 1000$	37.91	0.907	0.647	0.017
$p_T^H > 200$	$1000 < m_{jj} \leq 1500$	44.03	0.883	0.765	0.017
$p_T^H > 200$	$m_{jj} > 1500$	55.99	0.851	1.165	0.022

- Start with best QCD prediction for VBF and assume approximate factorisation of corrections:

$$\sigma_{\mathrm{VBF}} = \sigma_{\mathrm{best}}(1+\delta_{\mathrm{EW}}) + \sigma_{\mathrm{gamma}} \text{ with } \sigma_{\mathrm{EW}} = \sigma_{\mathrm{EW}}/\sigma_{\mathrm{LO}}$$

- These correction are now implanted in the VBF-uncertainty tool

CONCLUSION

- Update uncertainties and acceptances are now available VBF uncertainty standalone tool [here]
  - The tool apply uncertainties as event weights (same strategy as ggH)
  - Acceptance and uncertainties updated with full EW H+2j calculation
  - Hybrid uncertainties using FO NNLO + HJets is set as default
    - Other configuration with only FO/POWHEG/HJets++ also available
  - Large differences observed in p_T^{Hjj} observable:
    - Values might change in the coming months depending on the PS authors inputs
- Electroweak correction have been estimated in STXS bins
  - Corrections of 5-10% in VBF production
  - Available in the VBF uncertainty tool
  - We still need input from EW expert on uncertainties

BACKUP

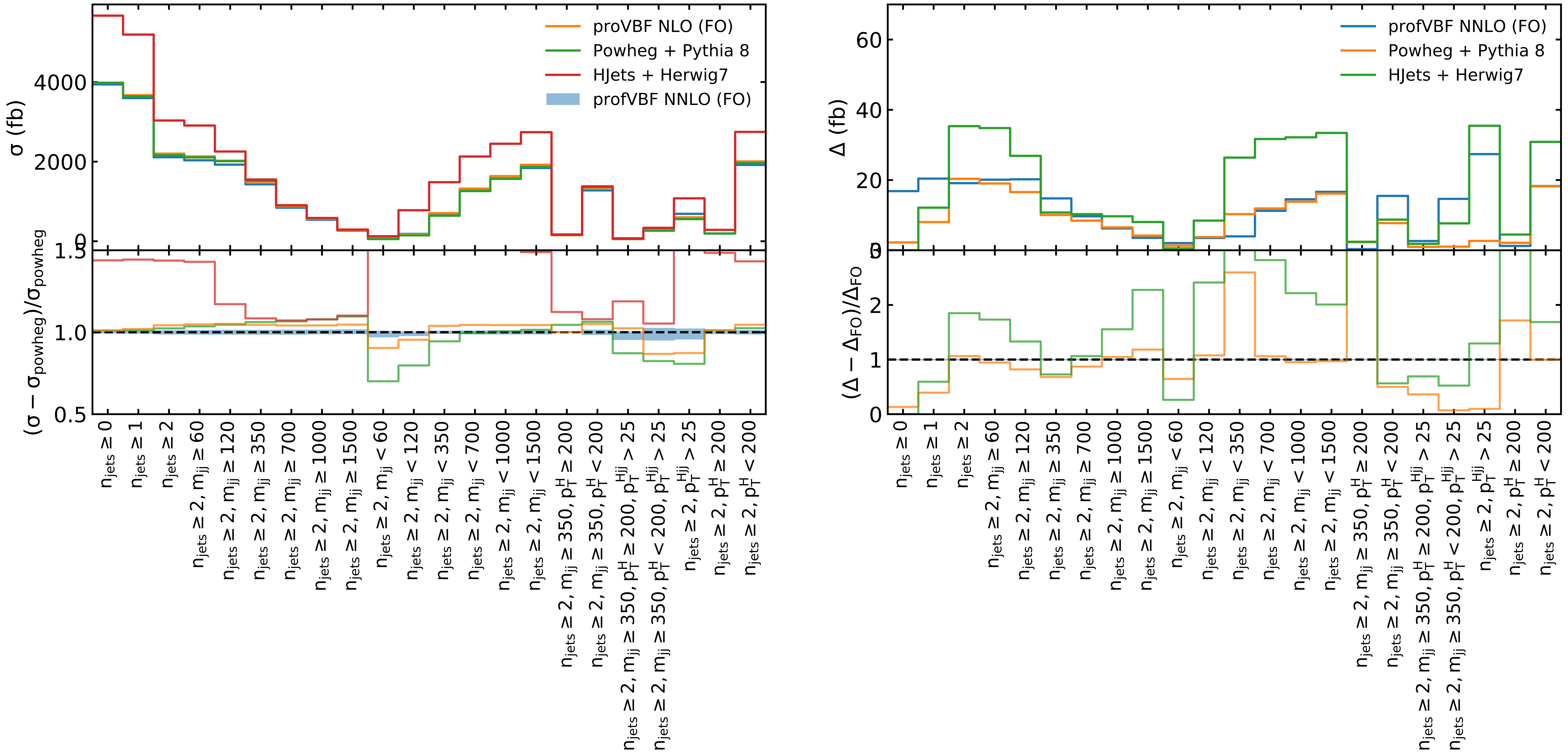
SETUP AND DEFINITIONS

- Extracted using QCD variations of the renormalisation and factorisation scales μ_r , μ_f from POWHEG + PYTHIA 8
  - Keeping only variations with $1/2 \leq \mu_r , \mu_f \leq 2$, $1/2 \leq \mu_r/\mu_f \leq 2$
  - Take uncertainty envelope
- Uncertainty propagation based on Stewart-Tackmann method [1] :

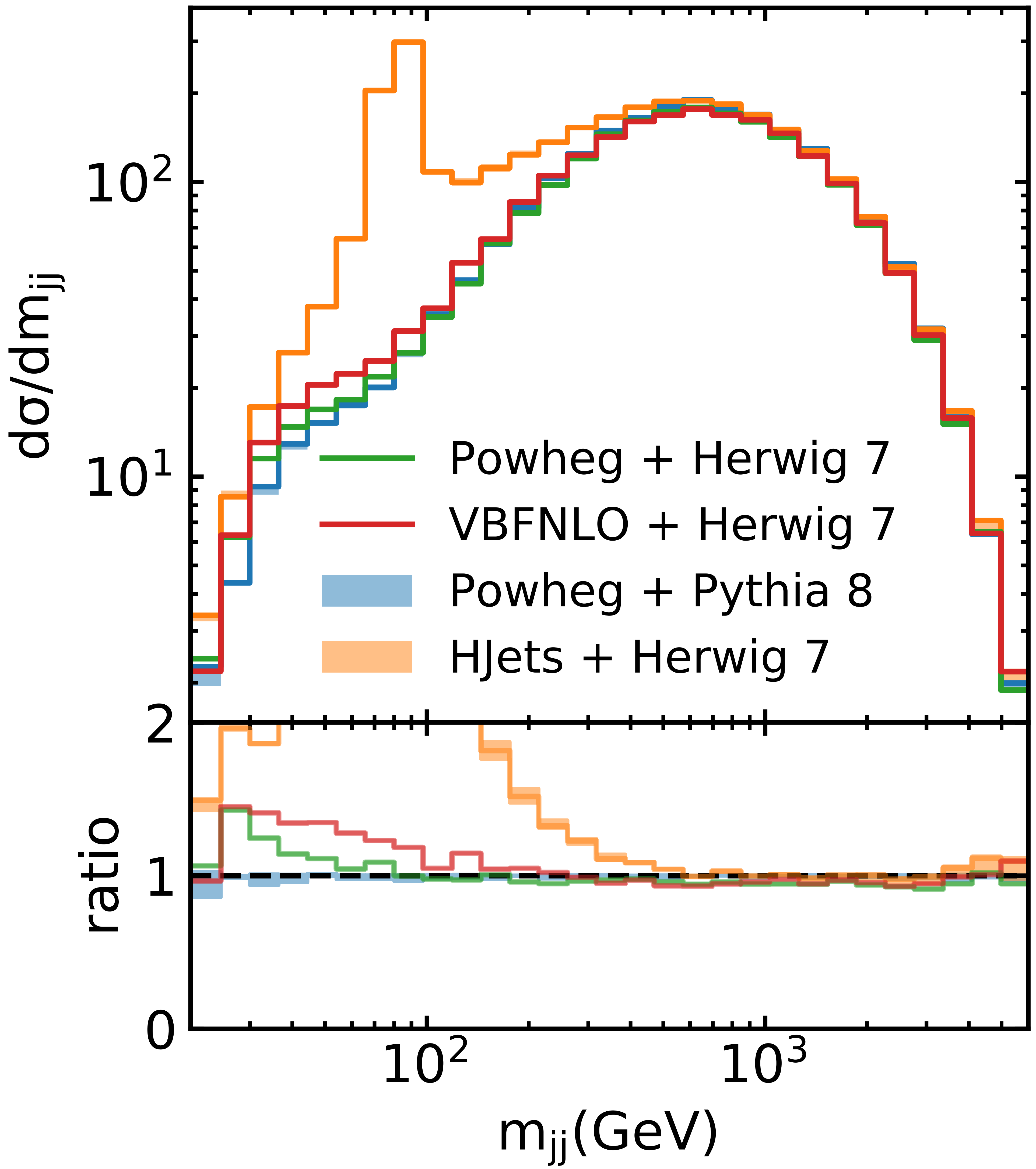
$$C(\{\sigma_0, \sigma_{\geq 1}\}) = \begin{pmatrix} (\Delta_0^y)^2 & \Delta_0^y \Delta_{\geq 1}^y \\ \Delta_0^y \Delta_{\geq 1}^y & (\Delta_{\geq 1}^y)^2 \end{pmatrix} + \begin{pmatrix} \Delta_{cut}^2 & -\Delta_{cut}^2 \\ -\Delta_{cut}^2 & \Delta_{cut}^2 \end{pmatrix}$$

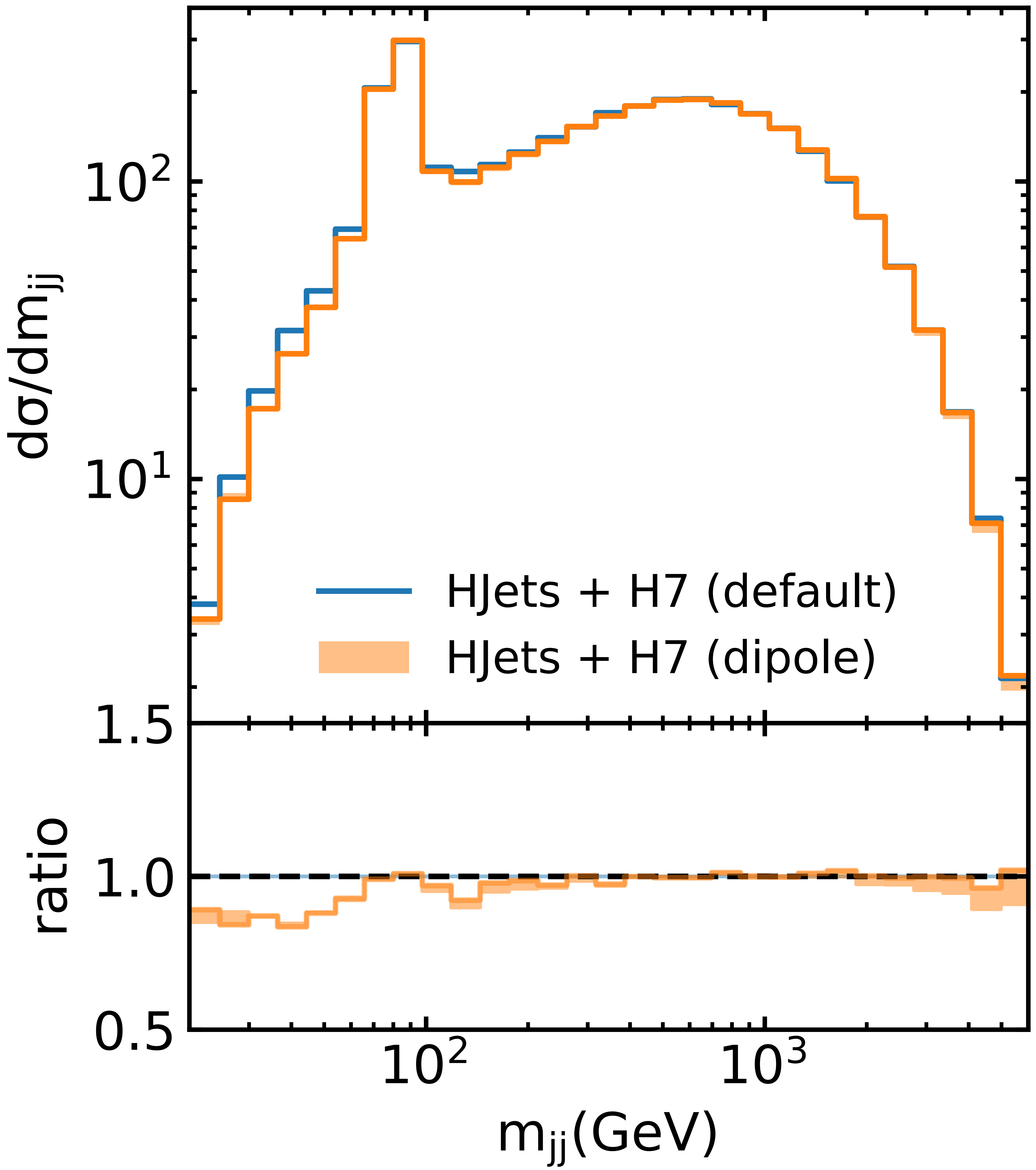
- Jet definition :
  - Higgs decay products are ignored
  - Jets built using anti-k_T R = 0.4 from all stable particles
  - Only jet with pT > 30 GeV and |η| < 4.7

H+2J EWK: ADDING THE S-CHANNEL



COMPARISON WITH DIPOLE SHOWER

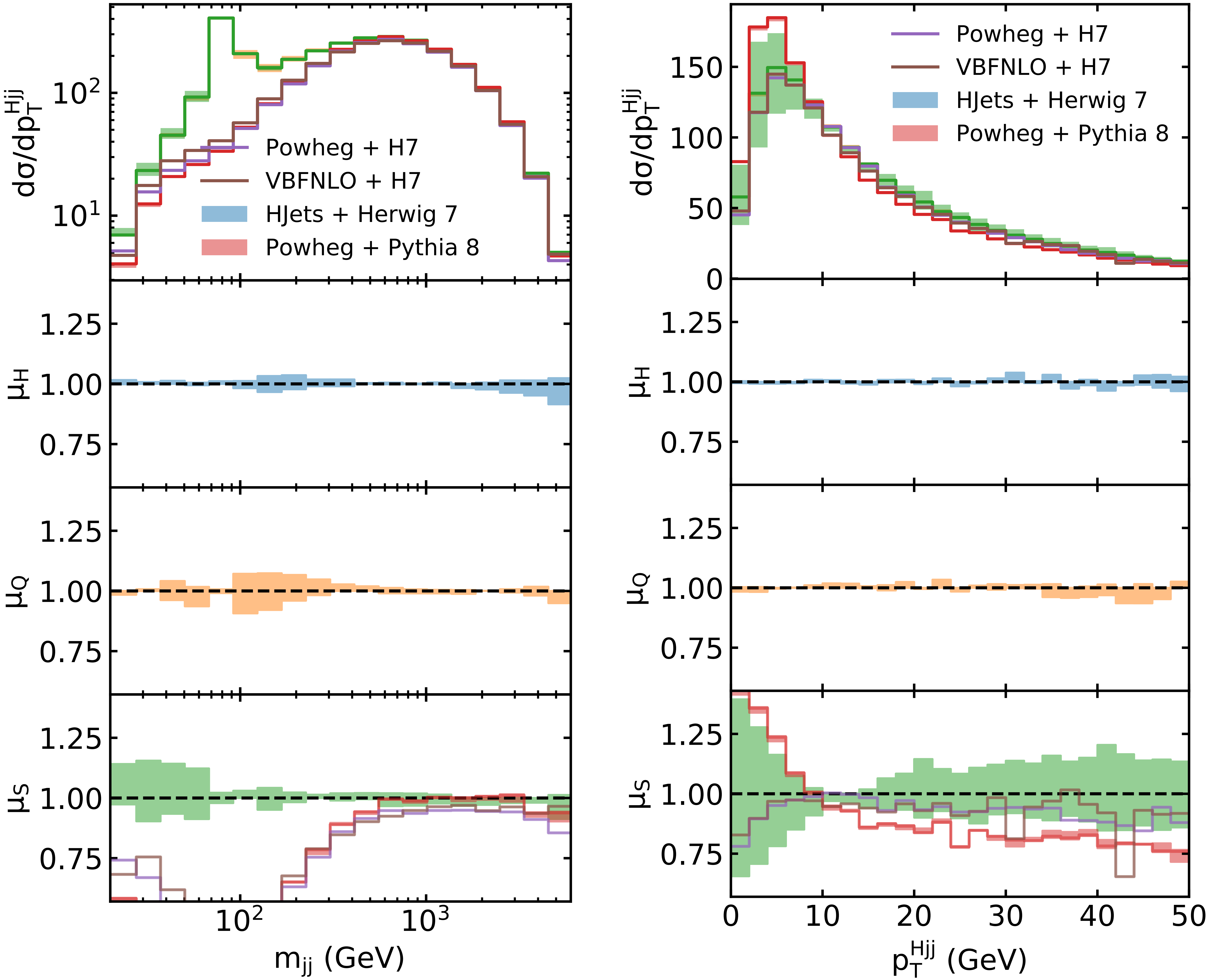




PARTON SHOWER UNCERTAINTIES

- μ_H: variation of the renormalisation and factorisation scales in the hard process (Matrix Element)
- μ_S : Shower scale, it is the argument of α_s and PDFs in the PS.
  - The band also includes variations in the hard process as well as the variation in renormalisation and factorisation scales for the NLO Matching and Merging
- μ_Q: veto scale: the boundary of the hardness of emissions in the PS

- low p_T^{Hjj} the PS uncertainties are huge, but expected, reaching ~40%. This is also visible on the m_{jj} distribution where the PS variation gets larger in the low values where also soft emissions dominate. However, the discrepancy between Pythia8 and Herwig is till larger Thant the uncertainty.



ELECTROWEAK UNCERTAINTIES

The scale uncertainty, Δ_{scale}, results from a variation of the factorization and renormalization scales (I.5.3) by a factor of 2 keeping $\mu_{\text{F}} = \mu_{\text{R}}$, as indicated above, and the combined PDF$\oplus\alpha_{\text{s}}$ uncertainty $\Delta_{\text{PDF}\oplus\alpha_{\text{s}}}$ is obtained following the PDF4LHC recipe [35]. Both Δ_{scale} and $\Delta_{\text{PDF}\oplus\alpha_{\text{s}}}$ are actually obtained from $\sigma^{\text{DIS}}_{\text{NNLOQCD}}$, but this QCD-driven uncertainties can be taken over as uncertainty estimates for σ^{VBF} as well. The theoretical uncertainties of integrated cross sections originating from unknown higher-order EW effects can be estimated by

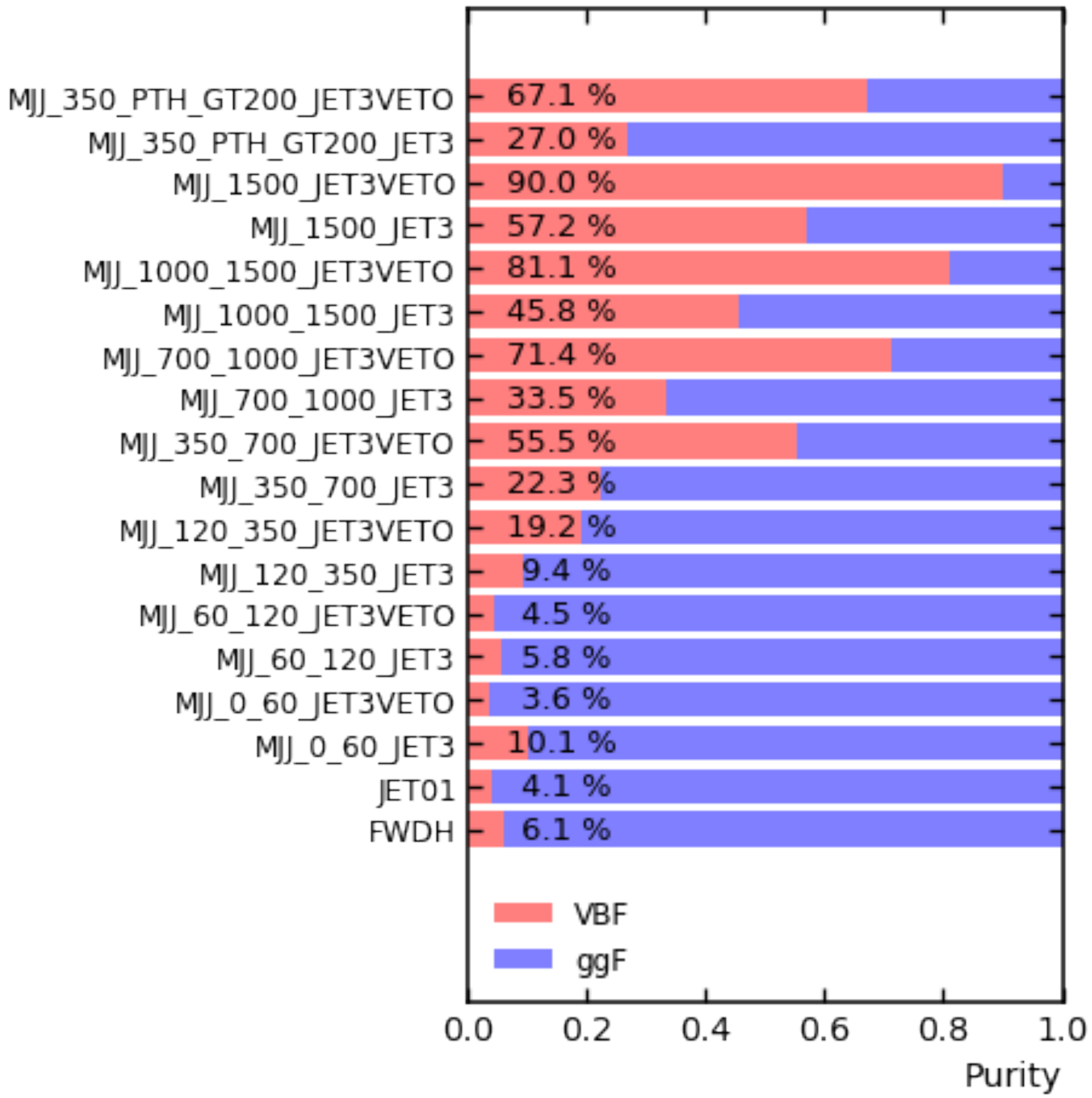
$$\Delta_{\text{EW}} = \max\{0.5\%, \delta^2_{\text{EW}}, \sigma_\gamma/\sigma^{\text{VBF}}\}. \quad \text{(I.5.7)}$$

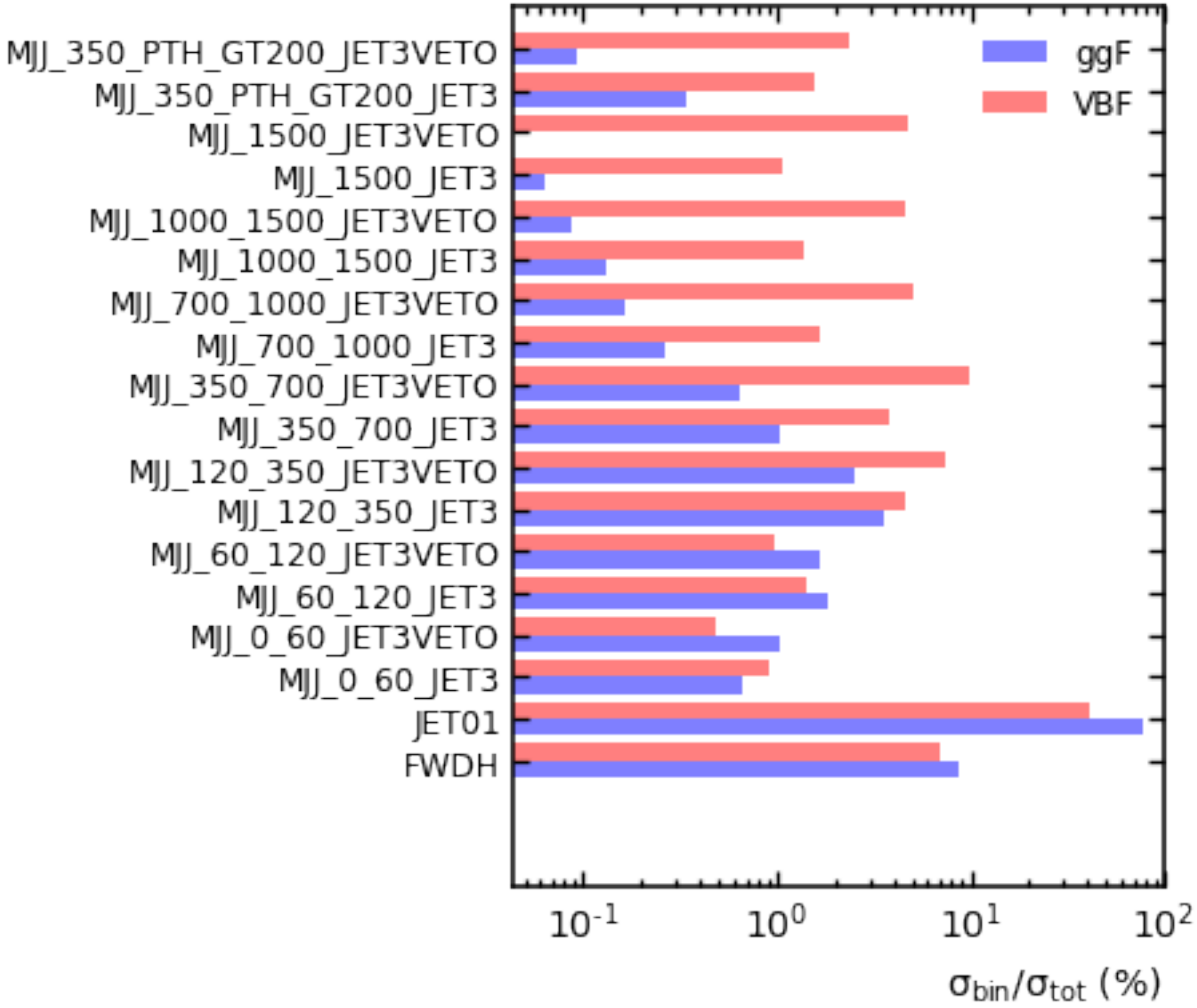
The first entry represents the generic size of NNLO EW corrections, while the second accounts for potential enhancement effects. Note that the whole photon-induced cross-section contribution σ_γ is treated as uncertainty here, because the PDF uncertainty of σ_γ is estimated to be 100% with the NNPDF2.3QED PDF set. At present, this source, which is about 1.5%, dominates the EW uncertainty of the integrated VBF cross section

[HXSWG Yellow Report 4: CERN-2017-002-M]

PURITY OF EW qqH BINS

- Only **ggF** and **VBF** production considered so far
- Higher VBF purity obtained thanks to the high Mjj split





ACCEPTANCES

```
// acceptances for VBH+VHHad: extracted from NJets (NLO) + H7
// it includes the full H+2Jets EWK calculation
static std::map<int, std::vector<double> > stxs_acc =
{ //stxs  tot     ptH200  mjj60   mjj120  mjj350  mjj700  mjj1000 mjj1500 ptHjj25 jet2
  { 200, {0.083 , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0    }}, // FWD
  { 201, {0.0735, 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   ,-0.1762 }}, // Jet0
  { 202, {0.3438, 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0   ,-0.8238 }}, // Jet1
  { 203, {0.0082, 0.0   ,-0.4038, 0.0   , 0.0   , 0.0   , 0.0   , 0.0   ,-0.0256, 0.0164 }}, // Mjj 0-60,      PTHjj 0-25
  { 204, {0.0603, 0.0   , 0.1258,-0.5825, 0.0   , 0.0   , 0.0   , 0.0   ,-0.1876, 0.1206 }}, // Mjj 60-120,    PTHjj 0-25
  { 205, {0.0608, 0.0   , 0.1268, 0.1617,-0.5332, 0.0   , 0.0   , 0.0   ,-0.1891, 0.1216 }}, // Mjj 120-350,   PTHjj 0-25
  { 206, {0.0121, 0.0   ,-0.5962, 0.0   , 0.0   , 0.0   , 0.0   , 0.0   , 0.0681, 0.0243 }}, // Mjj 350-700,   PTHjj 0-25    , pTH 0-200
  { 207, {0.0432, 0.0   , 0.0901,-0.4175, 0.0   , 0.0   , 0.0   , 0.0   , 0.2423, 0.0865 }}, // Mjj 700-1000,  PTHjj 0-25    , pTH 0-200
  { 208, {0.0532, 0.0   , 0.111 , 0.1416,-0.4668, 0.0   , 0.0   , 0.0   , 0.2986, 0.1065 }}, // Mjj 1000-1500, PTHjj 0-25    , pTH 0-200
  { 209, {0.0702,-0.3026, 0.1465, 0.1868, 0.2682,-0.6504, 0.0   , 0.0   ,-0.2185, 0.1405 }}, // Mjj 1500-inf , PTHjj 0-25    , pTH 0-200
  { 210, {0.0289,-0.1247, 0.0604, 0.077 , 0.1105,-0.2681, 0.0   , 0.0   , 0.1624, 0.0579 }}, // Mjj 350-700,   PTHjj 0-25    , pTH 200-inf
  { 211, {0.0366,-0.1576, 0.0763, 0.0973, 0.1397, 0.2377,-0.6724, 0.0   ,-0.1138, 0.0732 }}, // Mjj 700-1000,  PTHjj 0-25    , pTH 200-inf
  { 212, {0.0118,-0.0509, 0.0246, 0.0314, 0.0451, 0.0767,-0.217 , 0.0   , 0.0662, 0.0236 }}, // Mjj 1000-1500, PTHjj 0-25    , pTH 200-inf
  { 213, {0.0335,-0.1445, 0.07  , 0.0892, 0.1281, 0.218 , 0.3371,-0.6777,-0.1043, 0.0671 }}, // Mjj 1500-inf , PTHjj 0-25    , pTH 200-inf
  { 214, {0.0093,-0.04  , 0.0193, 0.0247, 0.0354, 0.0603, 0.0932,-0.1874, 0.052 , 0.0186 }}, // Mjj 0-60,      PTHjj 25-inf
  { 215, {0.0348,-0.1498, 0.0725, 0.0925, 0.1328, 0.226 , 0.3495, 0.6955,-0.1082, 0.0696 }}, // Mjj 60-120,    PTHjj 25-inf
  { 216, {0.0069,-0.0298, 0.0144, 0.0184, 0.0264, 0.045 , 0.0695, 0.1384, 0.0388, 0.0138 }}, // Mjj 120-350,   PTHjj 25-inf
  { 217, {0.004 , 0.1332, 0.0083, 0.0106, 0.0152,-0.0368, 0.0   , 0.0   ,-0.0123, 0.0079 }}, // Mjj 350-700,   PTHjj 25-inf  , pTH 0-200
  { 218, {0.0048, 0.1623, 0.0101, 0.0129, 0.0185,-0.0448, 0.0   , 0.0   , 0.0271, 0.0097 }}, // Mjj 700-1000,  PTHjj 25-inf  , pTH 0-200
  { 219, {0.0033, 0.1118, 0.0069, 0.0089, 0.0127, 0.0216,-0.0612, 0.0   ,-0.0104, 0.0067 }}, // Mjj 1000-1500, PTHjj 25-inf  , pTH 0-200
  { 220, {0.0027, 0.0901, 0.0056, 0.0071, 0.0103, 0.0175,-0.0494, 0.0   , 0.0151, 0.0054 }}, // Mjj 1500-inf , PTHjj 25-inf  , pTH 0-200
  { 221, {0.0041, 0.1361, 0.0085, 0.0108, 0.0155, 0.0264, 0.0408,-0.082 ,-0.0126, 0.0081 }}, // Mjj 350-700,   PTHjj 25-inf  , pTH 200-inf
  { 222, {0.0026, 0.0879, 0.0055, 0.007 , 0.01  , 0.017 , 0.0263,-0.0529, 0.0147, 0.0052 }}, // Mjj 700-1000,  PTHjj 25-inf  , pTH 200-inf
  { 223, {0.0057, 0.19  , 0.0118, 0.0151, 0.0216, 0.0368, 0.0569, 0.1133,-0.0176, 0.0113 }}, // Mjj 1000-1500, PTHjj 25-inf  , pTH 200-inf
  { 224, {0.0026, 0.0886, 0.0055, 0.007 , 0.0101, 0.0172, 0.0265, 0.0528, 0.0148, 0.0053 }}  // Mjj 1500-inf , PTHjj 25-inf  , pTH 200-inf
};
```

ACCEPTANCES

```
// bin acceptances extracted from POWHEG VBFH (NLO)
static std::map<int, std::vector<double> > stxs_acc_powheg = {
  //stxs    total     ptH_200 mjj_60    mjj_120  mjj_350  mjj_700    mjj_1000   mjj_1500    ptHjj_25     njets_30_2
   { 200 , {0.0668,  0.0000, 0.0000,  0.0000,  0.0000,  0.0000,   0.0000,   0.0000,   0.0000,    0.0000}},
   { 201 , {0.0765,  0.0000, 0.0000,  0.0000,  0.0000,  0.0000,   0.0000,   0.0000,   0.0000,   -0.1821}},
   { 202 , {0.3435,  0.0000, 0.0000,  0.0000,  0.0000,  0.0000,   0.0000,   0.0000,   0.0000,   -0.8179}},
   { 203 , {0.0048,  0.0000,-0.3761,  0.0000,  0.0000,  0.0000,   0.0000,   0.0000,  -0.0126,    0.0093}},
   { 204 , {0.0096,  0.0000, 0.0192, -0.4400,  0.0000,  0.0000,   0.0000,   0.0000,  -0.0253,    0.0187}},
   { 205 , {0.0782,  0.0000, 0.1564,  0.1635, -0.6859,  0.0000,   0.0000,   0.0000,  -0.2056,    0.1525}},
   { 206 , {0.0079,  0.0000,-0.6239,  0.0000,  0.0000,  0.0000,   0.0000,   0.0000,   0.0599,    0.0155}},
   { 207 , {0.0122,  0.0000, 0.0245, -0.5600,  0.0000,  0.0000,   0.0000,   0.0000,   0.0923,    0.0239}},
   { 208 , {0.0358,  0.0000, 0.0716,  0.0749, -0.3141,  0.0000,   0.0000,   0.0000,   0.2701,    0.0698}},
   { 209 , {0.1061, -0.3265, 0.2121,  0.2218,  0.2912, -0.7233,   0.0000,   0.0000,  -0.2789,    0.2068}},
   { 210 , {0.0306, -0.0940, 0.0611,  0.0639,  0.0838, -0.2083,   0.0000,   0.0000,   0.2304,    0.0595}},
   { 211 , {0.0545, -0.1678, 0.1090,  0.1140,  0.1497,  0.2505,  -0.7179,   0.0000,  -0.1434,    0.1063}},
   { 212 , {0.0136, -0.0417, 0.0271,  0.0283,  0.0372,  0.0623,  -0.1784,   0.0000,   0.1022,    0.0264}},
   { 213 , {0.0504, -0.1550, 0.1007,  0.1052,  0.1382,  0.2313,   0.3553,  -0.7105,  -0.1324,    0.0982}},
   { 214 , {0.0111, -0.0341, 0.0222,  0.0232,  0.0305,  0.0510,   0.0783,  -0.1566,   0.0837,    0.0216}},
   { 215 , {0.0507, -0.1560, 0.1013,  0.1060,  0.1391,  0.2328,   0.3576,   0.7154,  -0.1333,    0.0988}},
   { 216 , {0.0081, -0.0248, 0.0161,  0.0168,  0.0221,  0.0370,   0.0568,   0.1136,   0.0607,    0.0157}},
   { 217 , {0.0058,  0.1466, 0.0116,  0.0121,  0.0159, -0.0394,   0.0000,   0.0000,  -0.0152,    0.0113}},
   { 218 , {0.0042,  0.1076, 0.0085,  0.0089,  0.0117, -0.0290,   0.0000,   0.0000,   0.0320,    0.0083}},
   { 219 , {0.0050,  0.1273, 0.0100,  0.0105,  0.0138,  0.0231,  -0.0661,   0.0000,  -0.0132,    0.0098}},
   { 220 , {0.0029,  0.0724, 0.0057,  0.0060,  0.0078,  0.0131,  -0.0376,   0.0000,   0.0215,    0.0056}},
   { 221 , {0.0064,  0.1628, 0.0128,  0.0134,  0.0176,  0.0295,   0.0453,  -0.0906,  -0.0169,    0.0125}},
   { 222 , {0.0030,  0.0763, 0.0060,  0.0063,  0.0083,  0.0138,   0.0212,  -0.0424,   0.0227,    0.0059}},
   { 223 , {0.0089,  0.2249, 0.0177,  0.0185,  0.0243,  0.0408,   0.0626,   0.1252,  -0.0233,    0.0173}},
   { 224 , {0.0032,  0.0821, 0.0065,  0.0068,  0.0089,  0.0149,   0.0229,   0.0457,   0.0244,    0.0063}}
};
```