VH STXS migration uncertainties

Aliya Nigamova, Adinda de Wit

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HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

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DESY.

Introduction

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- Maximum split scheme is used for flexibility

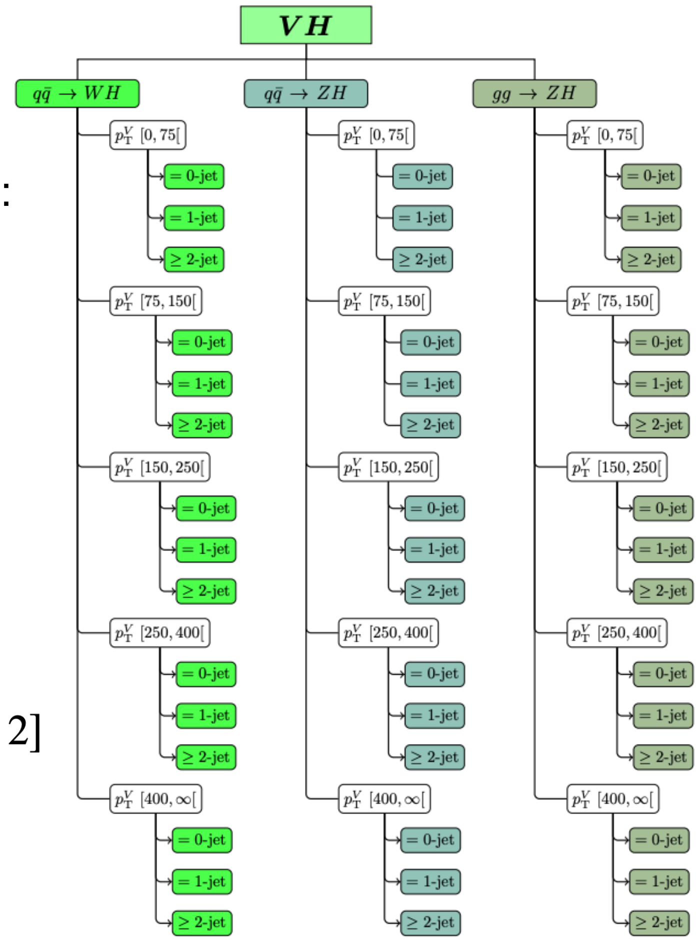
- POWHEG MINLO qqZH, GENEVA NNLO + NNLL' qqZH

- Assign an uncertainty source for each STXS bin boundary:
  N-jet bin boundaries: $\Delta_{1,2}$ correspond to jet-bins boundaries
  pT(V) bin boundaries: Δ_X, X= 75, 150, 250, 400 GeV

- Each Δ_X is calculated as the maximal deviation from the nominal case under scale variations at the corresponding boundary
  1) $\mu_{R(F)}$ renormalization (factorization) scales in case of POWHEG MINLO samples:

  $$[\mu_R/\mu_R^{nom}, \mu_F/\mu_F^{nom}] : [1/2, 1][1, 1/2][2, 1][1, 2][1/2, 1/2][2, 2]$$

  2) for the GENEVA NNLO + NNLL the resummation and fixed order scales are used, described in slide 13



Uncertainty correlation scheme

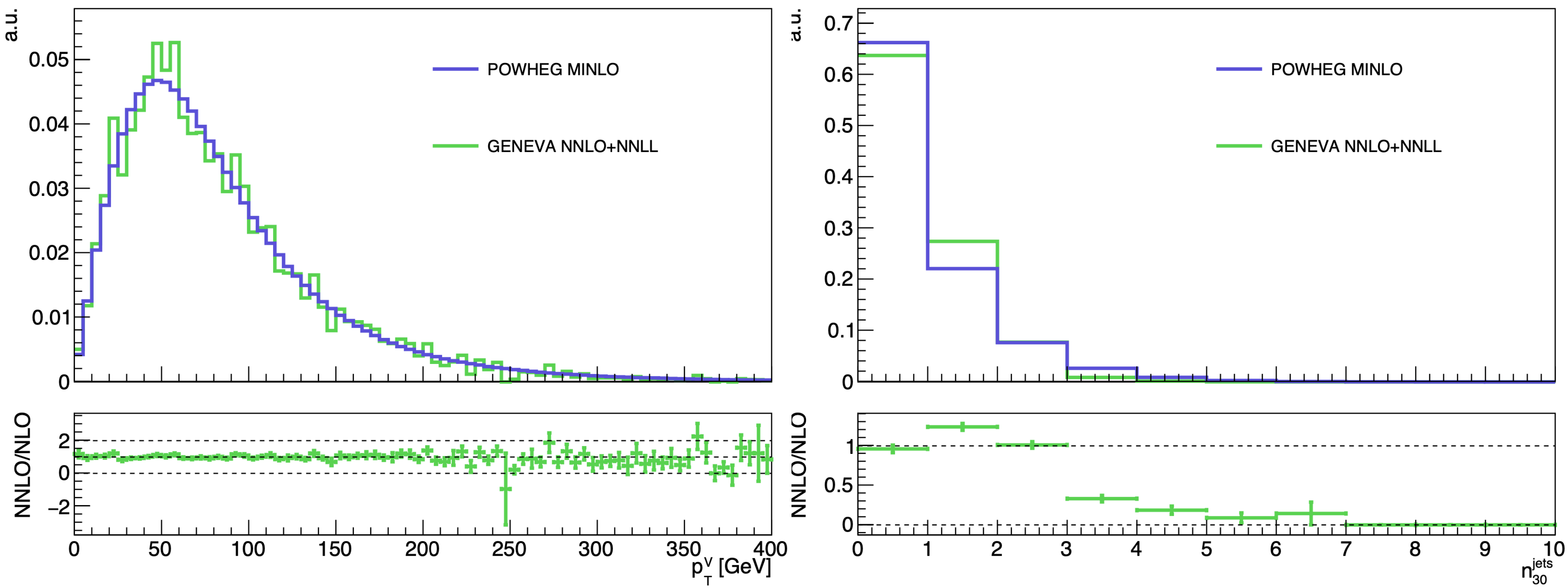
- Migration unc. should drop out for the total cross-section
- $p_T(V)$ and jet-bins related migrations are calculated independently

p_T^V bin [GeV]	Δ_{75}	Δ_{150}	Δ_{250}	Δ_{400}
[0, 75[	$-\Delta_{75}/\sigma_{[0,75[}$	0	0	0
[75, 150[	$+\Delta_{75}/\sigma_{[75,\infty[}$	$-\Delta_{150}/\sigma_{[75,150[}$	0	0
[150, 250[	$+\Delta_{75}/\sigma_{[75,\infty[}$	$+\Delta_{150}/\sigma_{[150,\infty[}$	$-\Delta_{250}/\sigma_{[150,250[}$	0
[250, 400[	$+\Delta_{75}/\sigma_{[75,\infty[}$	$+\Delta_{150}/\sigma_{[150,\infty[}$	$+\Delta_{250}/\sigma_{[250,\infty[}$	$-\Delta_{400}/\sigma_{[250,400[}$
[400, ∞[	$+\Delta_{75}/\sigma_{[75,\infty[}$	$+\Delta_{150}/\sigma_{[150,\infty[}$	$+\Delta_{250}/\sigma_{[250,\infty[}$	$+\Delta_{400}/\sigma_{[400,\infty[}$

$\Delta_{1,2}$ calculated in each $p_T(V)$ bin

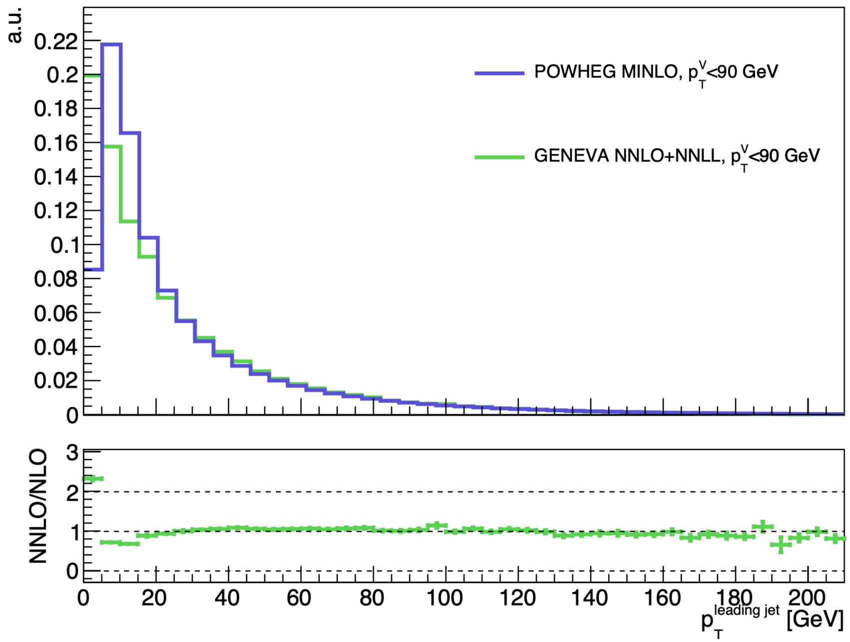
n_{jets} bin	Δ_1	Δ_2
0 jets	$-\Delta_1/\sigma_{n_{\text{jets}}=0}$	0
1 jet	$\Delta_1/\sigma_{n_{\text{jets}}\geq 1}$	$-\Delta_2/\sigma_{n_{\text{jets}}=1}$
≥ 2 jets	$\Delta_1/\sigma_{n_{\text{jets}}\geq 1}$	$\Delta_2/\sigma_{n_{\text{jets}}\geq 2}$

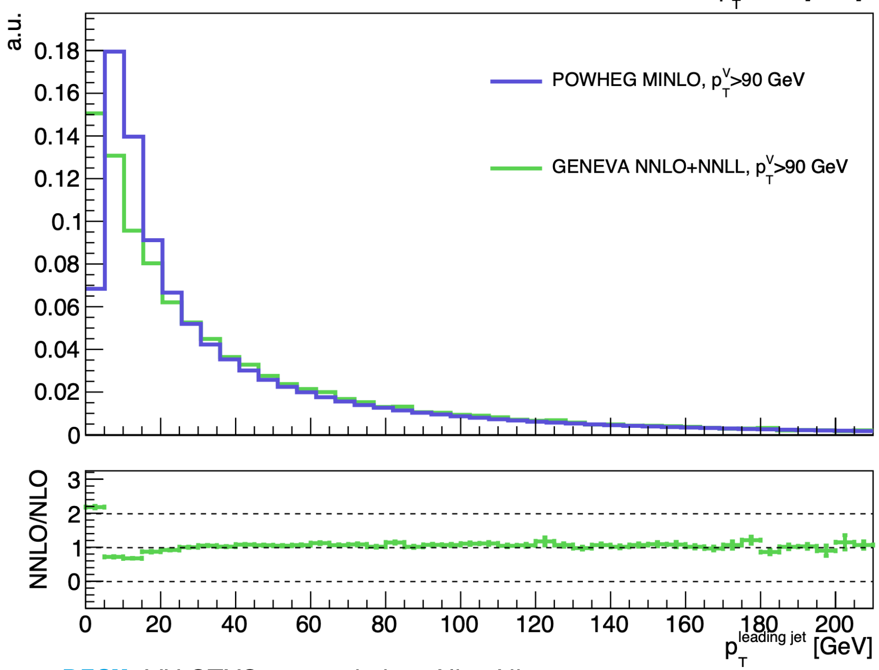
POWHEG vs Geneva: $p_T(V)$, number of jets with p_T >30 GeV

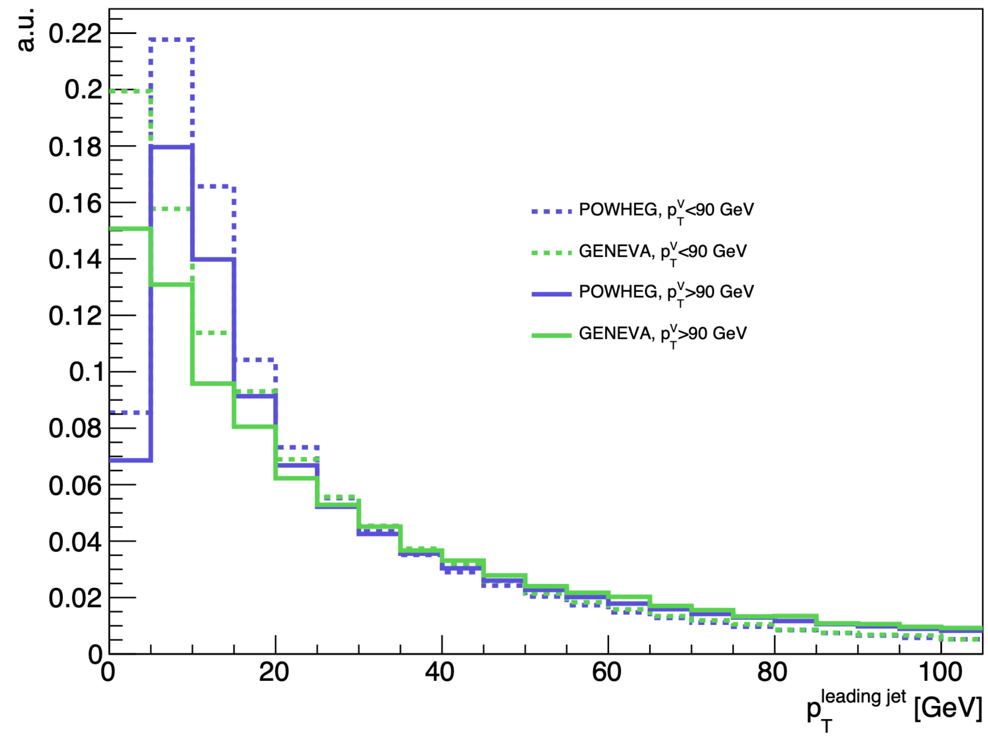


- $p_T(V)$ distributions are very similar.
- Some difference in n_{jets}^{30} distribution, possibly coming from jet kinematics differences.

POWHEG vs Geneva: additional leading jet p_T

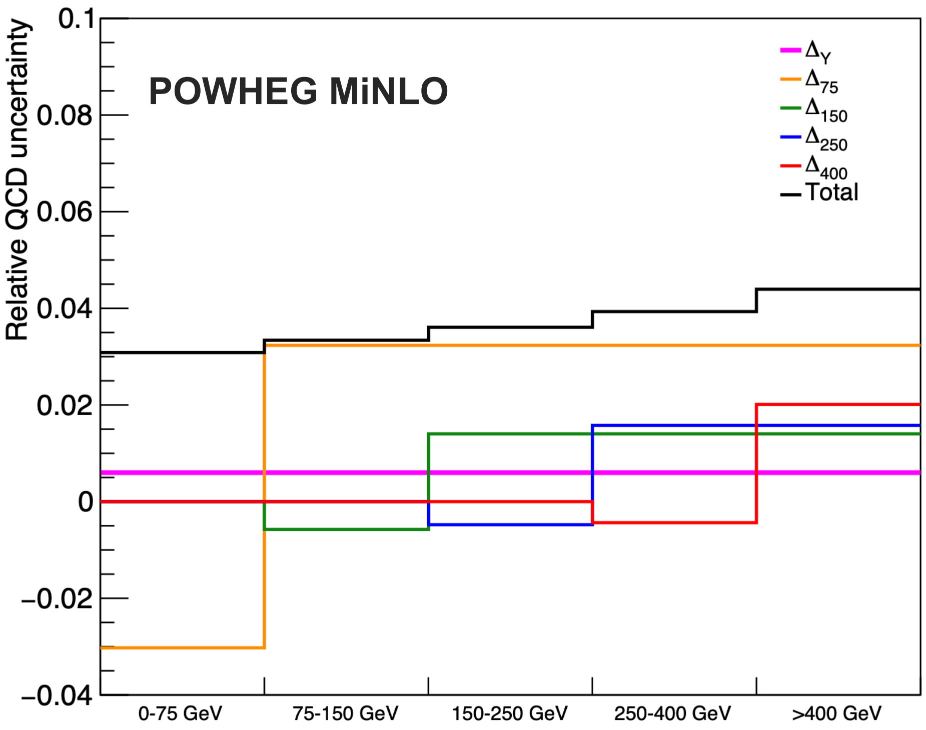


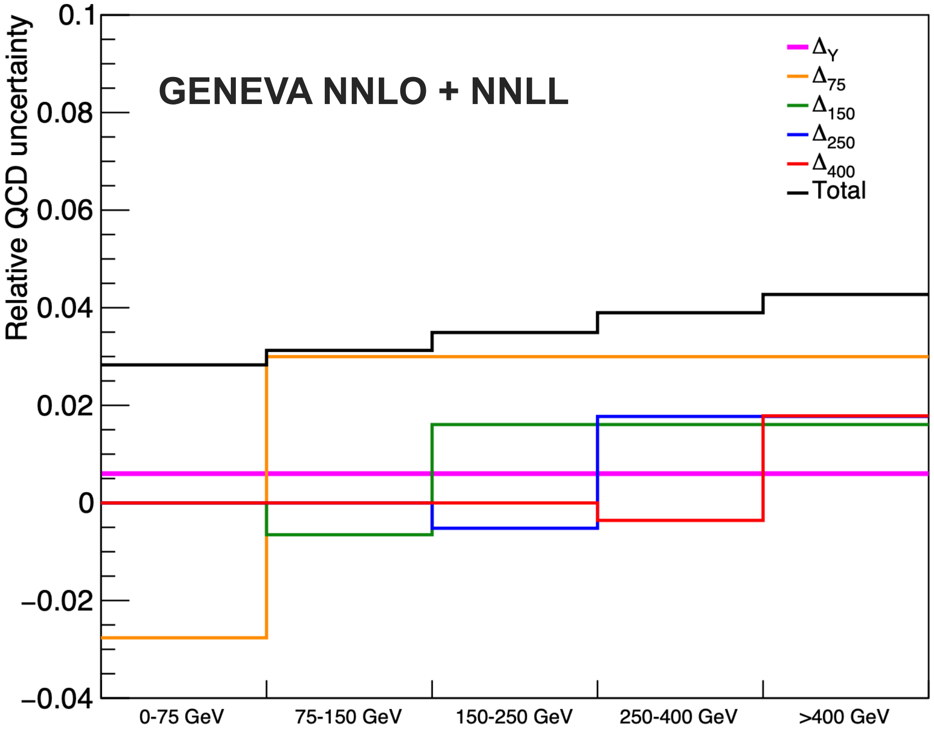




A significant GENEVA vs POWHEG difference below 50 GeV, expected due to a different resummation accuracy affecting low p_T region. Results in disagreement in the n_{jets}^{30} distribution (previous slide)

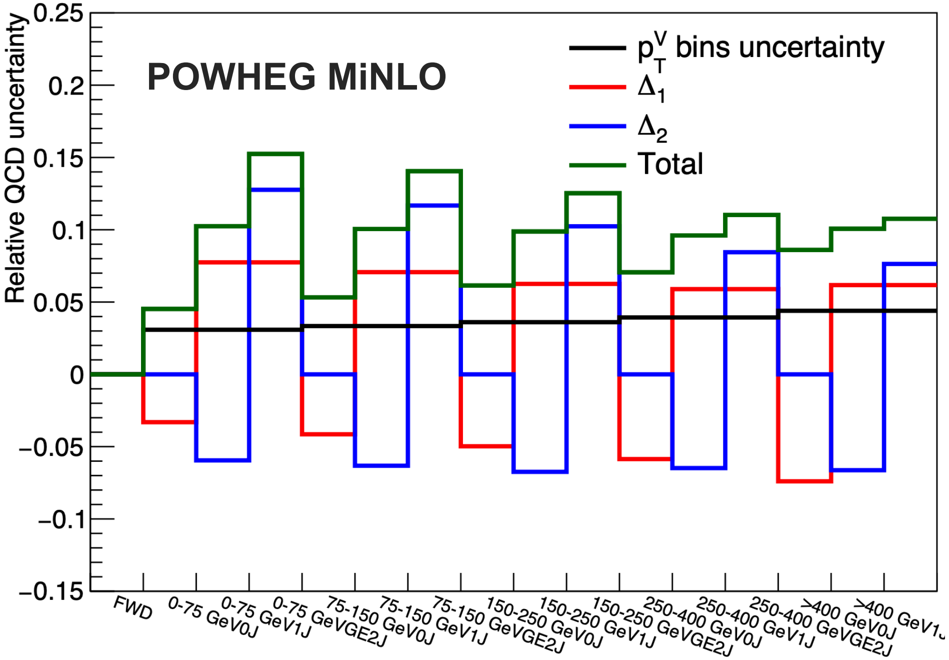
Results: MiNLO vs NNLO + NNLL'

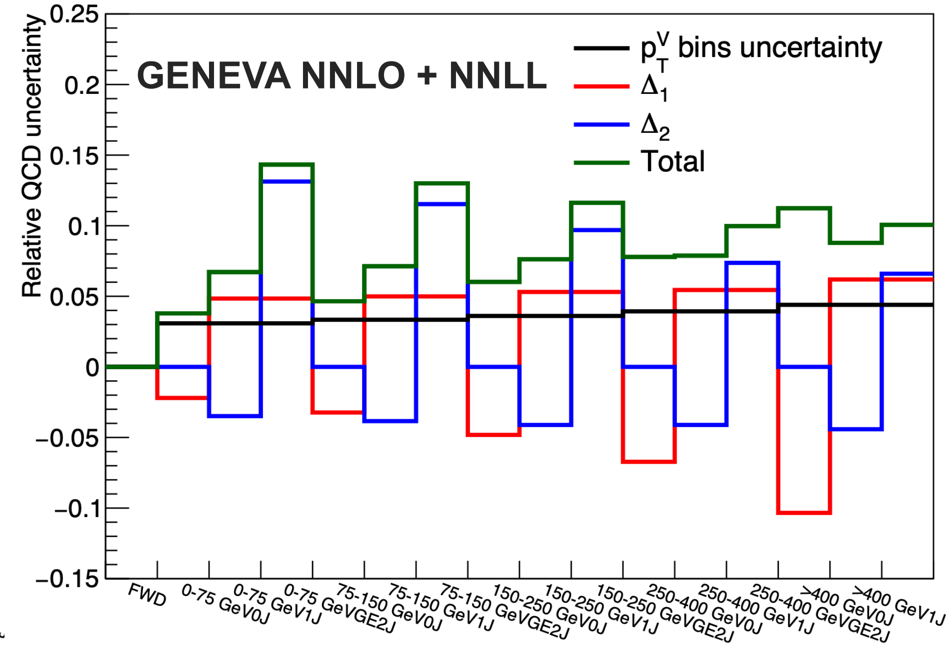




Compatible results, no effect on $p_T(V)$ distributions

Results: MiNLO vs NNLO + NNLL





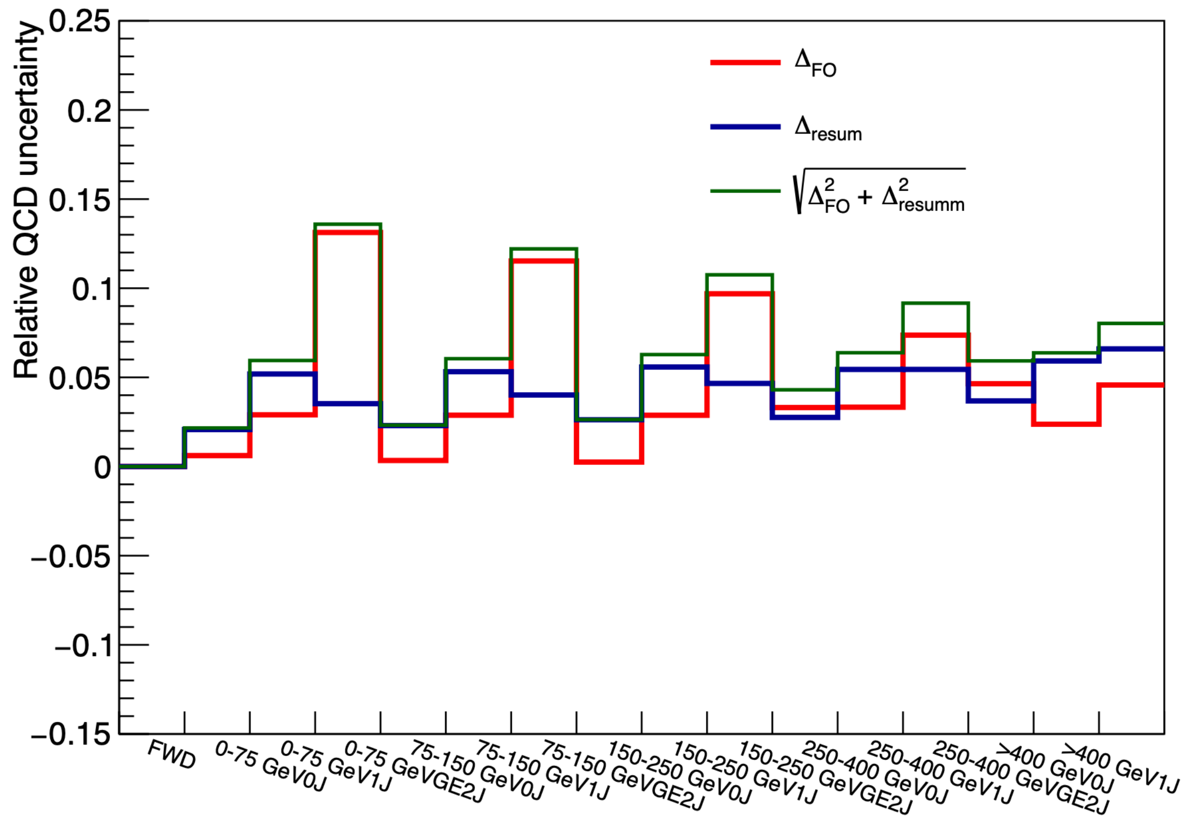
Lower uncertainties for 0 and 1-jet bins in case of **NNLO + NNLL**, due to better a resummation sensitivity at low p_T^{jet}

Cross-check: GENEVA resummation jet-bins uncertainties

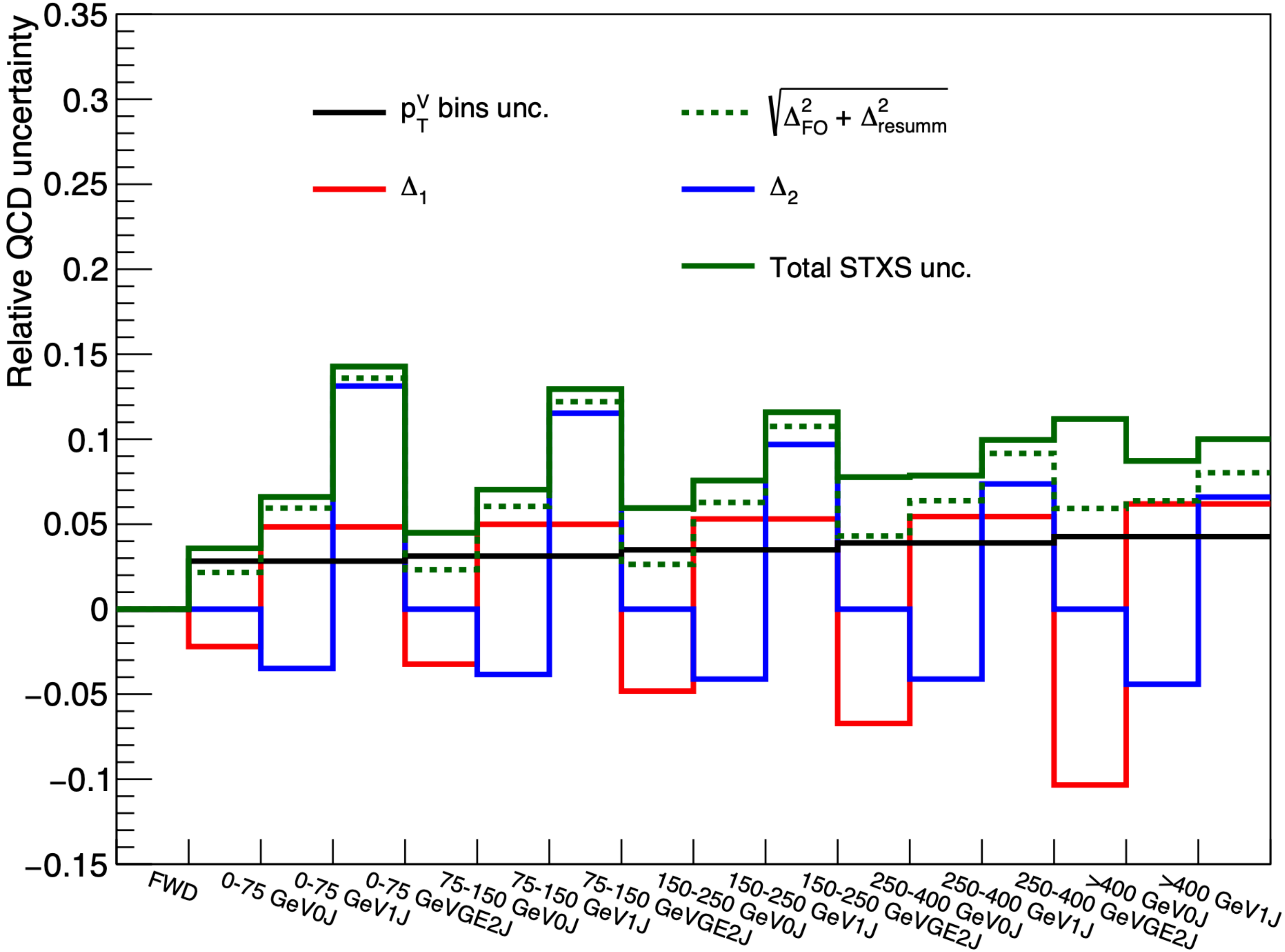
With the use of available fixed order and resummation weights in GENEVA samples it is possible to estimate the total jet-bins uncertainty:

$\Delta_{tot} = \sqrt{\Delta_{FO}{}^2 + \Delta_{resum}{}^2}$, where Δ_{FO} (weights described in a). from slide 13),

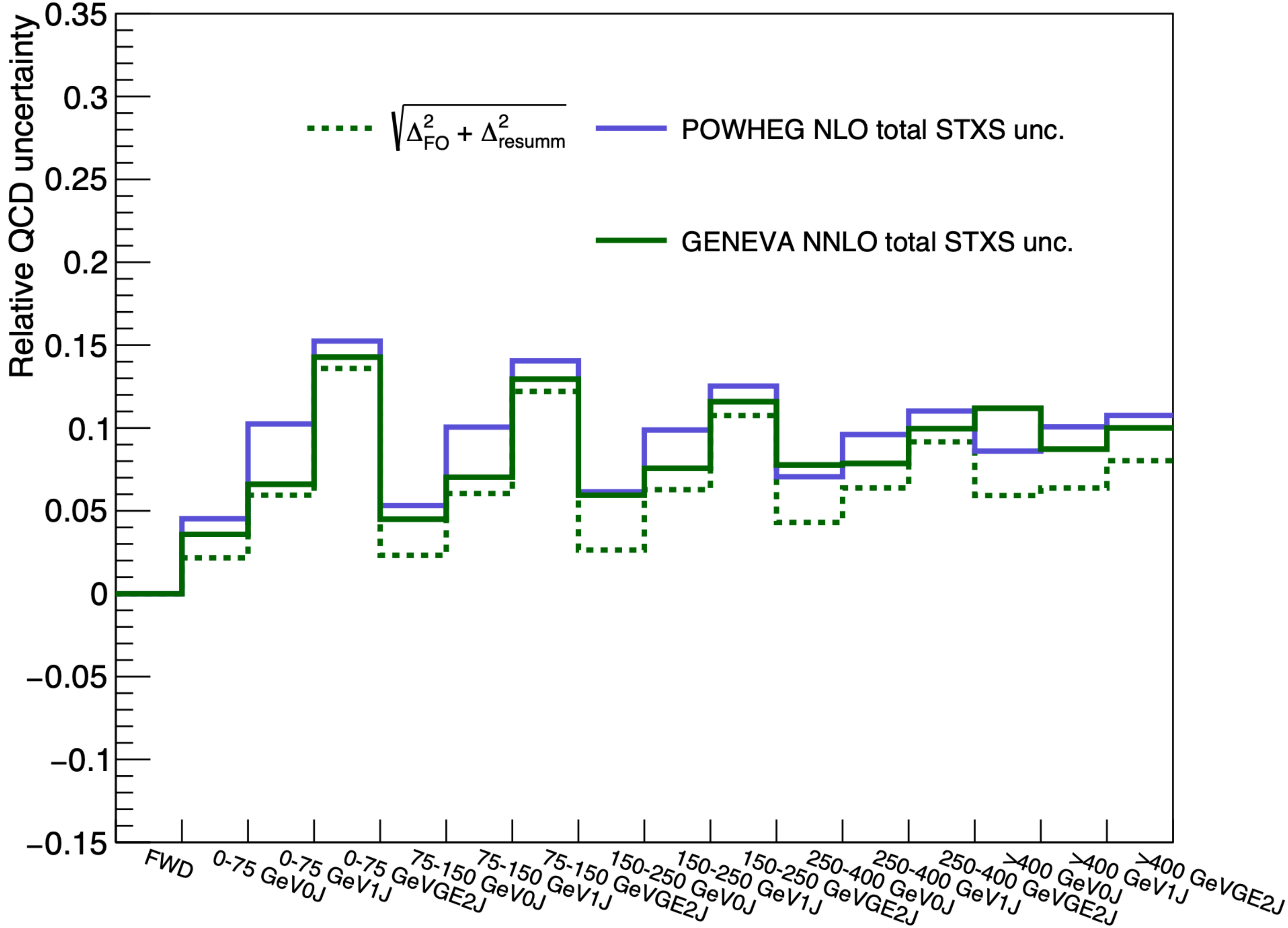
Δ_{resum} (weights described in b). from slide 13)



Jet-bins resummation uncertainties vs STXS GENEVA unc.



Total comparison



Summary

- The STXS migration uncertainties for qqZH process were presented
- Estimated using POWHEG NLO sample and GENEVA NNLO + NNLL
    - The results are in agreement, the difference in jet-bins uncertainties can be explained by different orders of resummation
- The total jet-bins perturbative uncertainties were calculated using GENEVA samples as a cross-check to provide an estimate for comparison with the STXS uncertainties

Backup

GENEVA scales' description

https://arxiv.org/pdf/1909.02026.pdf

$$\mu_H = \mu_{\rm NS}\,,$$
$$\mu_S(\mathcal{T}_0) = \mu_{\rm NS} f_{\rm run}(\mathcal{T}_0/Q)\,,$$
$$\mu_B(\mathcal{T}_0) = \mu_{\rm NS}\sqrt{f_{\rm run}(\mathcal{T}_0/Q)}\,,$$

$$f_{\rm run}(x) = \begin{cases} x_0\left[1+(x/x_0)^2/4\right] & x \le 2x_0\,, \\ x & 2x_0 \le x \le x_1\,, \\ x + \frac{(2-x_2-x_3)(x-x_1)^2}{2(x_2-x_1)(x_3-x_1)} & x_1 \le x \le x_2\,, \\ 1 - \frac{(2-x_1-x_2)(x-x_3)^2}{2(x_3-x_1)(x_3-x_2)} & x_2 \le x \le x_3\,, \\ 1 & x_3 \le x\,. \end{cases}$$

$$x_0 = 2.5\,\mathrm{GeV}/Q\,, \quad \{x_1, x_2, x_3\} = \{0.2, 0.45, 0.7\}$$

GENEVA provides 11 weights in total:

Nominal (1)

a) Fixed order scale variation μ_{FO} = 2Q, Q/2 (+2)

b) Resummation scale variations
  - μ_S, μ_B up/down variations (+4)
  - transition points x_1, x_2, x_3 are varied by ±0.05 simultaneously (+2)

c) Tuned FO scale variation (corrected for inclusive cross-section) (+2)

nominal

μ_{FO} up — μ_{FO} down

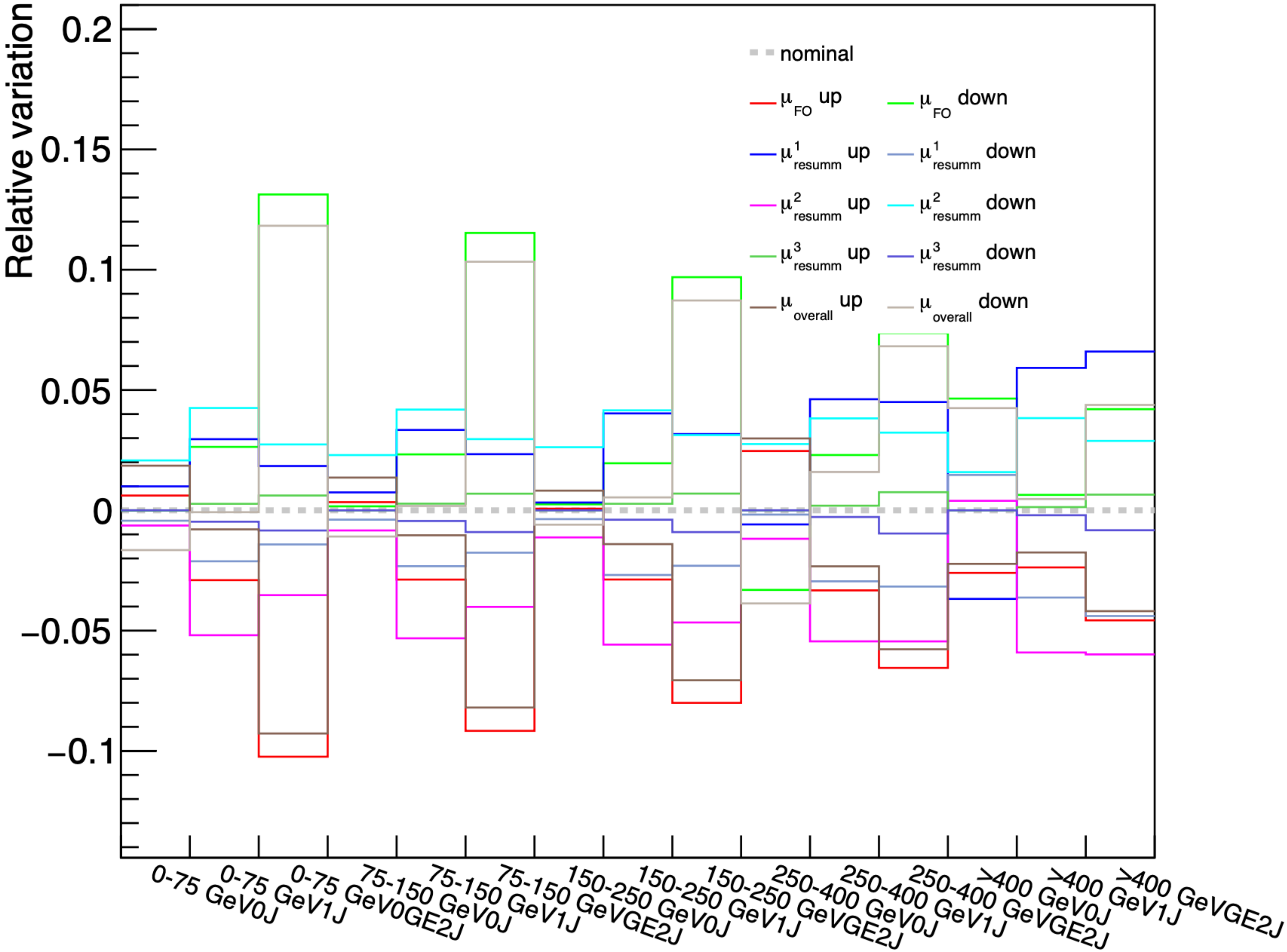
μ^1_{resumm} up — μ^1_{resumm} down

μ^2_{resumm} up — μ^2_{resumm} down

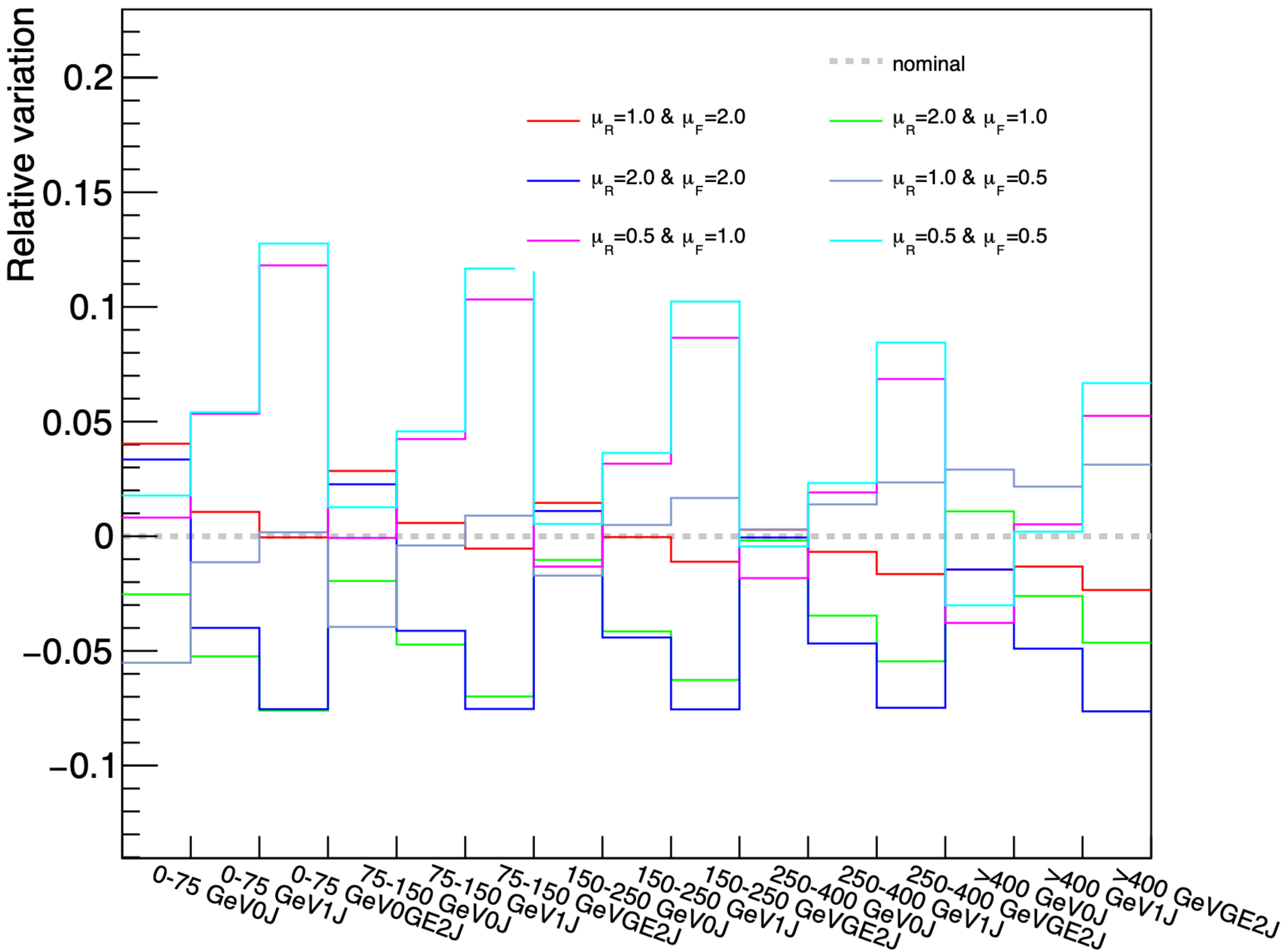
μ^3_{resumm} up — μ^3_{resumm} down

$\mu_{overall}$ up — $\mu_{overall}$ down

GENEVA scale variations



POWHEG scale variations



Total uncertainties

	GENEVA STXS	GENEVA resum.	POWHEG STXS
ZH_PTV_0_75_0J	0.036	0.021	0.045
ZH_PTV_0_75_1J	0.066	0.059	0.102
ZH_PTV_0_75_GE2J	0.143	0.136	0.152
ZH_PTV_75_150_0J	0.045	0.023	0.053
ZH_PTV_75_150_1J	0.07	0.06	0.10
ZH_PTV_75_150_GE2J	0.129	0.122	0.141
ZH_PTV_150_250_0J	0.059	0.026	0.061
ZH_PTV_150_250_1J	0.076	0.062	0.099
ZH_PTV_150_250_GE2J	0.012	0.011	0.125
ZH_PTV_250_400_0J	0.078	0.043	0.071
ZH_PTV_250_400_1J	0.079	0.064	0.096
ZH_PTV_250_400_GE2J	0.099	0.092	0.11
ZH_PTV_GT400_0J	0.112	0.059	0.086
ZH_PTV_GT400_1J	0.087	0.063	0.10
ZH_PTV_GT400_GE2J	0.10	0.08	0.11

Uncertainty distribution among STXS bins

(c) option from slide 13)