Extrapolation study on tW & s-channel measurements

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On behave of tW and s-channel groups

Top workshop
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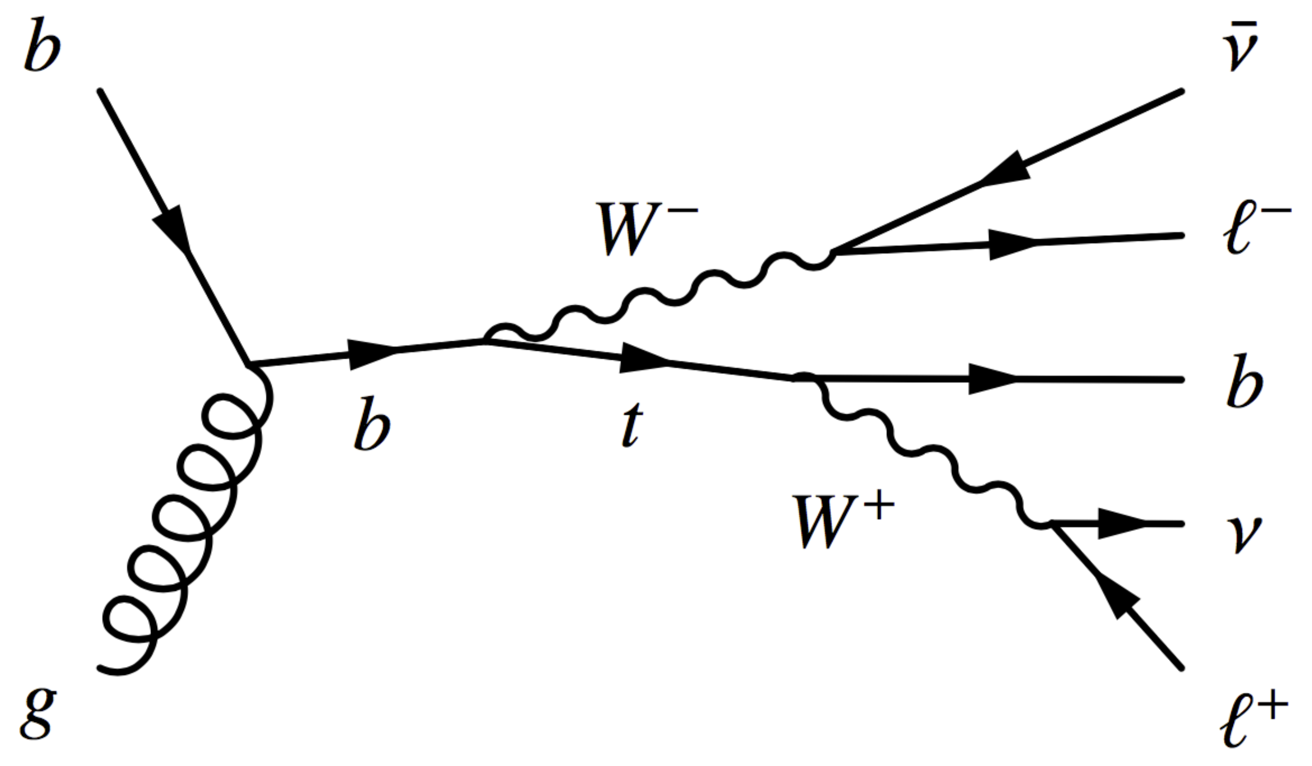
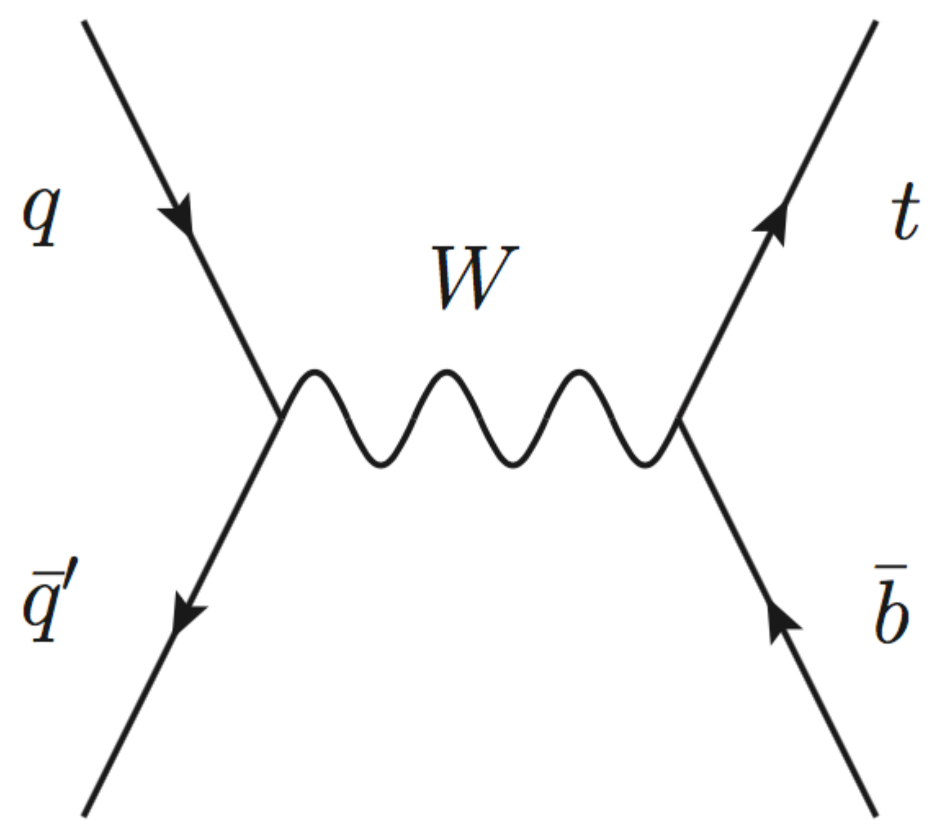
Introduction

- Single top production
  - ★ Sensitive to CKM matrix element V_{tb}

- tW channel



- s-channel



- ★ Fermionic propagator
- ★ Overlap/interference with $t\bar{t}$ production
  - diagram removal (DR) v.s. digram subtraction (DS)

- ★ Sensitive to new particles as a propagator
- ★ Probe anomalous couplings in an effective quantum field theory

tW channel

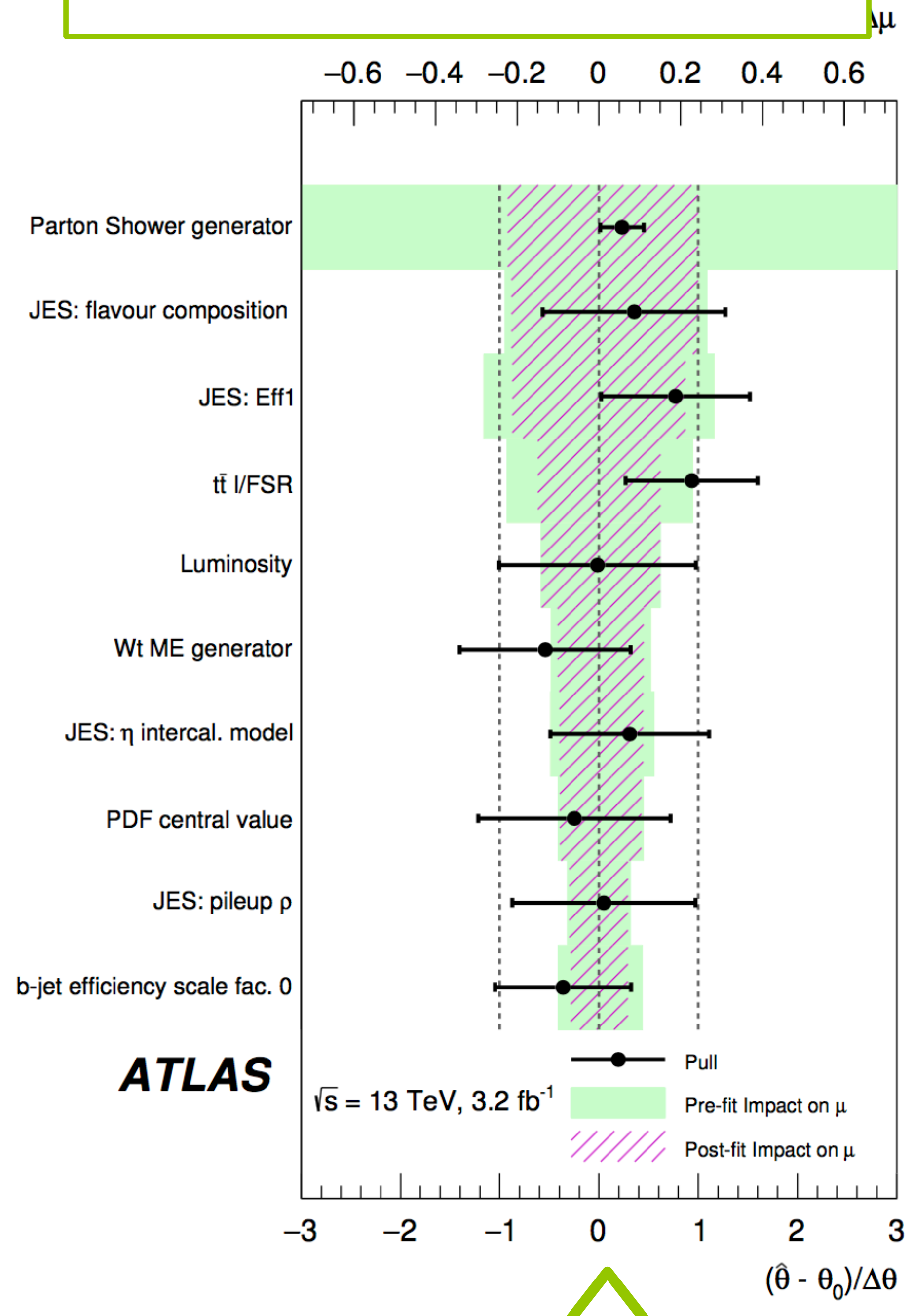
Recap of the analysis

Event selection

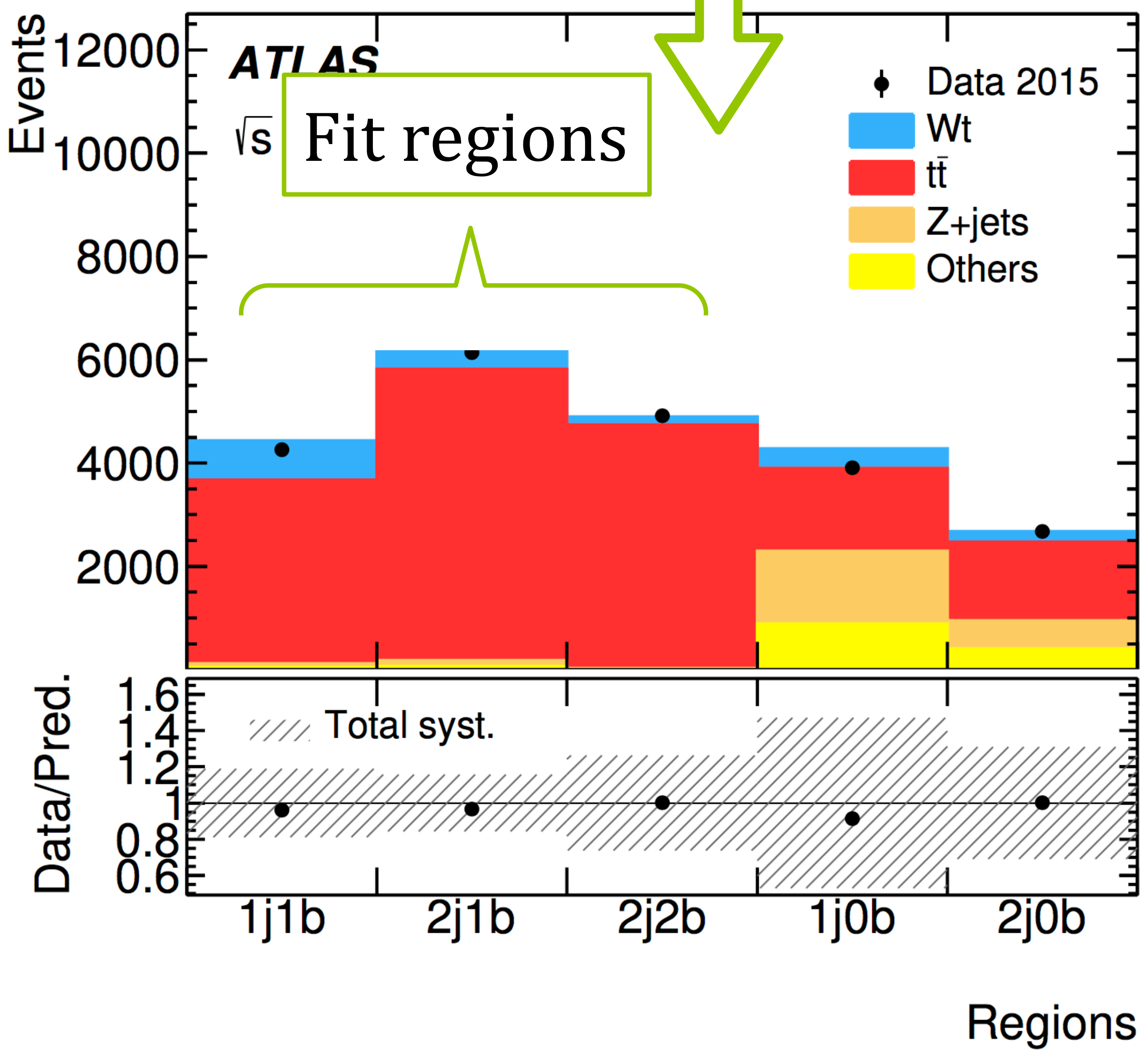
Table 1: Summary of event selection criteria used in the analysis.

At least one jet with $p_T > 25$ GeV, $\|\eta\| < 2.5$
Exactly two leptons of opposite charge with $p_T > 20$ GeV,
$\|\eta\| < 2.5$ for muons and $\|\eta\| < 2.47$ excluding $1.37 < \|\eta\| < 1.52$ for electrons
At least one lepton with $p_T > 25$ GeV, veto if third lepton with $p_T > 20$ GeV
At least one lepton matched to the trigger object

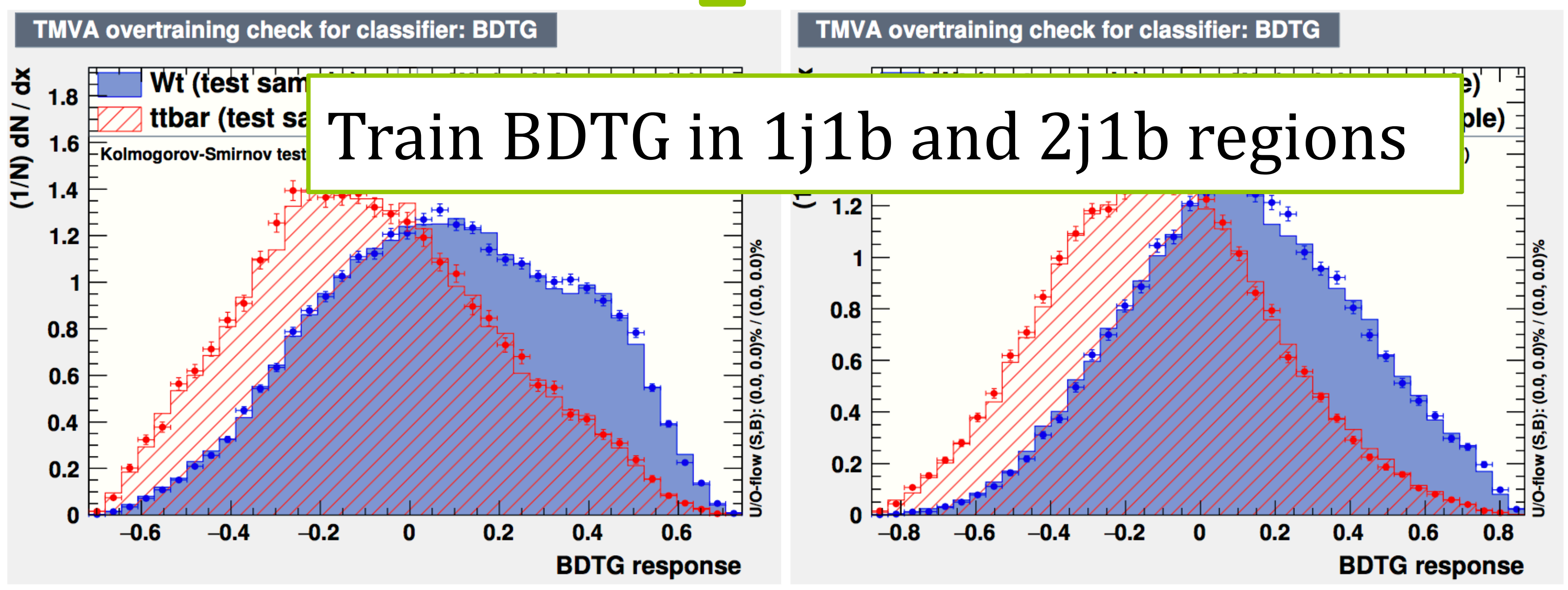
Binned likelihood fit



Fit regions



Train BDTG in 1j1b and 2j1b regions



Extrapolated results

- Results from the paper:

Asimov

- ★ mu_SIG 1.0 (+0.33,-0.29)
- ★ mu_TT 1.0 (+0.044,-0.042)

data

- ★ mu_SIG 1.31 (+0.41,-0.34)
- ★ mu_TT 0.98 (+0.046,-0.045)

3.2/fb	1j1b		2j1b		2j2b	
Observed events	4254		6138		4912	
Fitted events	4257		6139		4908	
Fitted Wt events	910	± 210	640	± 160	210	± 82
Fitted $t\bar{t}$ events	3230	± 210	5340	± 160	4670	± 110
Fitted Z + jets events	69	± 35	87	± 46	7.6	± 7.5
Fitted fake events	30	± 26	40	± 38	15	± 14
Fitted diboson events	23.5	± 6.0	24.8	± 6.2	0.91	± 0.23

X32

- **Extrapolate to 100 fb^{-1}**
  - ★ Scale nominal and systematic templates
  - ★ Luminosity uncertainty unchanged

Yields 100/fb	1j1b	2j1b	2j2b
Observed events	134705	194325	155576
Fitted events	134744.62 ± 477.40	194266.32 ± 552.65	155595.67 ± 694.37
Fitted tW events	31792.57 ± 4316.15	23003.58 ± 3539.30	9514.55 ± 1520.78
Fitted $t\bar{t}$ events	95248.55 ± 4282.30	168232.43 ± 3411.86	145426.58 ± 1767.22
Fitted Z+jets events	1686.96 ± 767.75	921.25 ± 392.83	$223.53^{+228.22}_{-223.53}$
Fitted fake events	5355.26 ± 1047.56	1341.86 ± 1004.13	$402.30^{+422.68}_{-402.30}$
MC expected events	140345.19 ± 24805.65	201105.47 ± 24825.34	155178.30 ± 38966.08
Exp. tW events	24043.66 ± 4149.30	16671.75 ± 2511.84	5179.49 ± 1395.12
Exp. $t\bar{t}$ events	112417.37 ± 21268.15	178734.94 ± 23689.45	149285.38 ± 38026.24
Exp. Z+jets events	2349.44 ± 1175.75	3749.42 ± 1876.36	235.82 ± 234.69
Exp. fake events	783.69 ± 779.94	1160.17 ± 1154.63	448.88 ± 446.73

Extrapolated results

- Extrapolate to 100 fb^{-1}

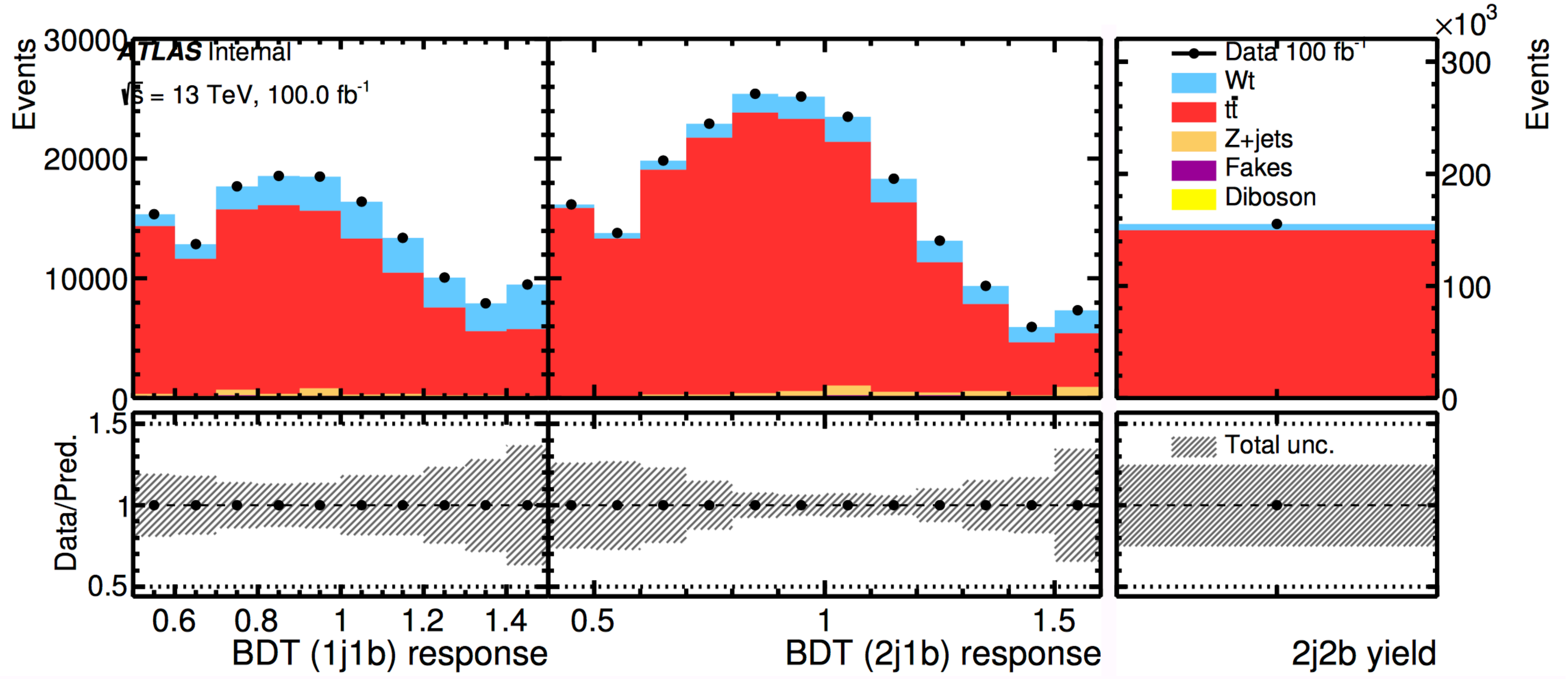
Asimov

- ★ mu_SIG 1.0 (+0.20,-0.19)
- ★ mu_TT 1.0 (+0.030,-0.028)

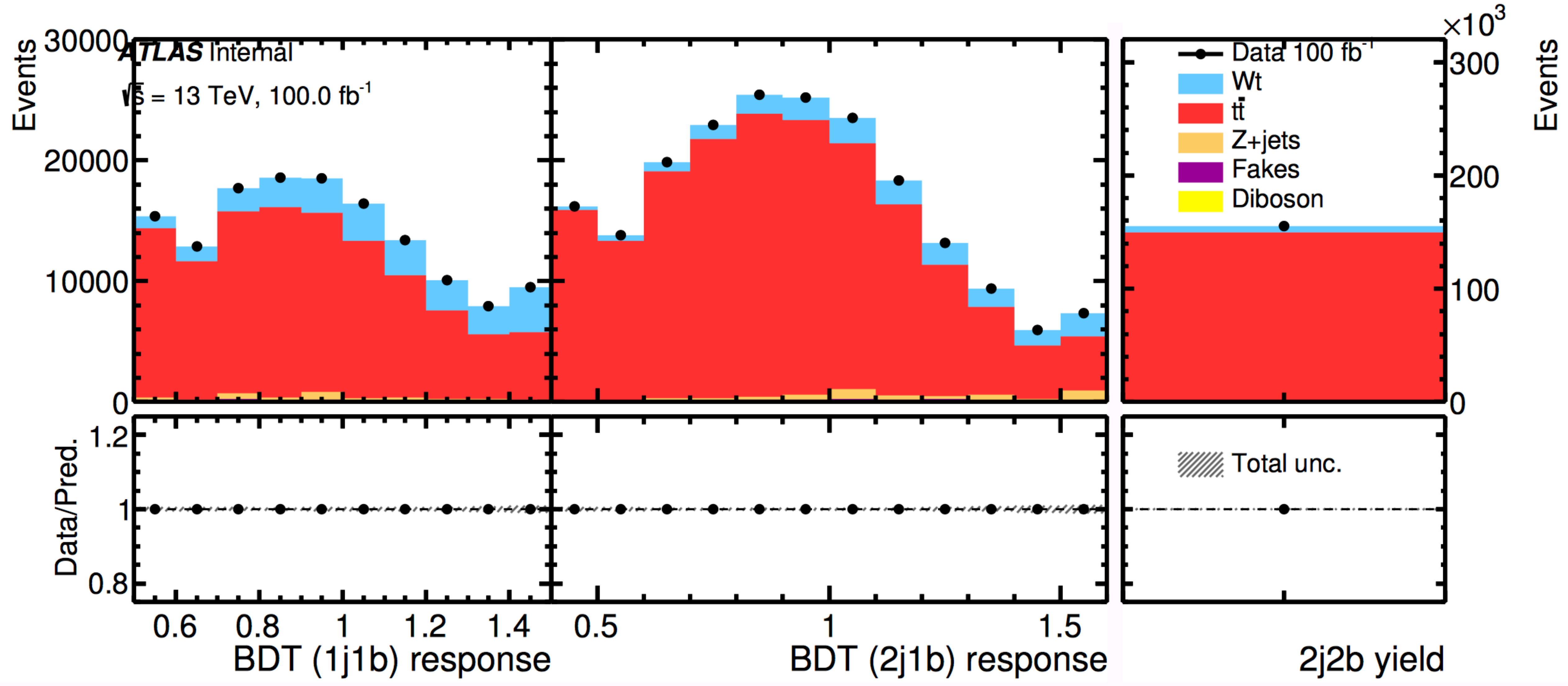
Compare to the results from the paper

- ★ mu_SIG 1.0 (+0.33,-0.29)
- ★ mu_TT 1.0 (+0.044,-0.042)

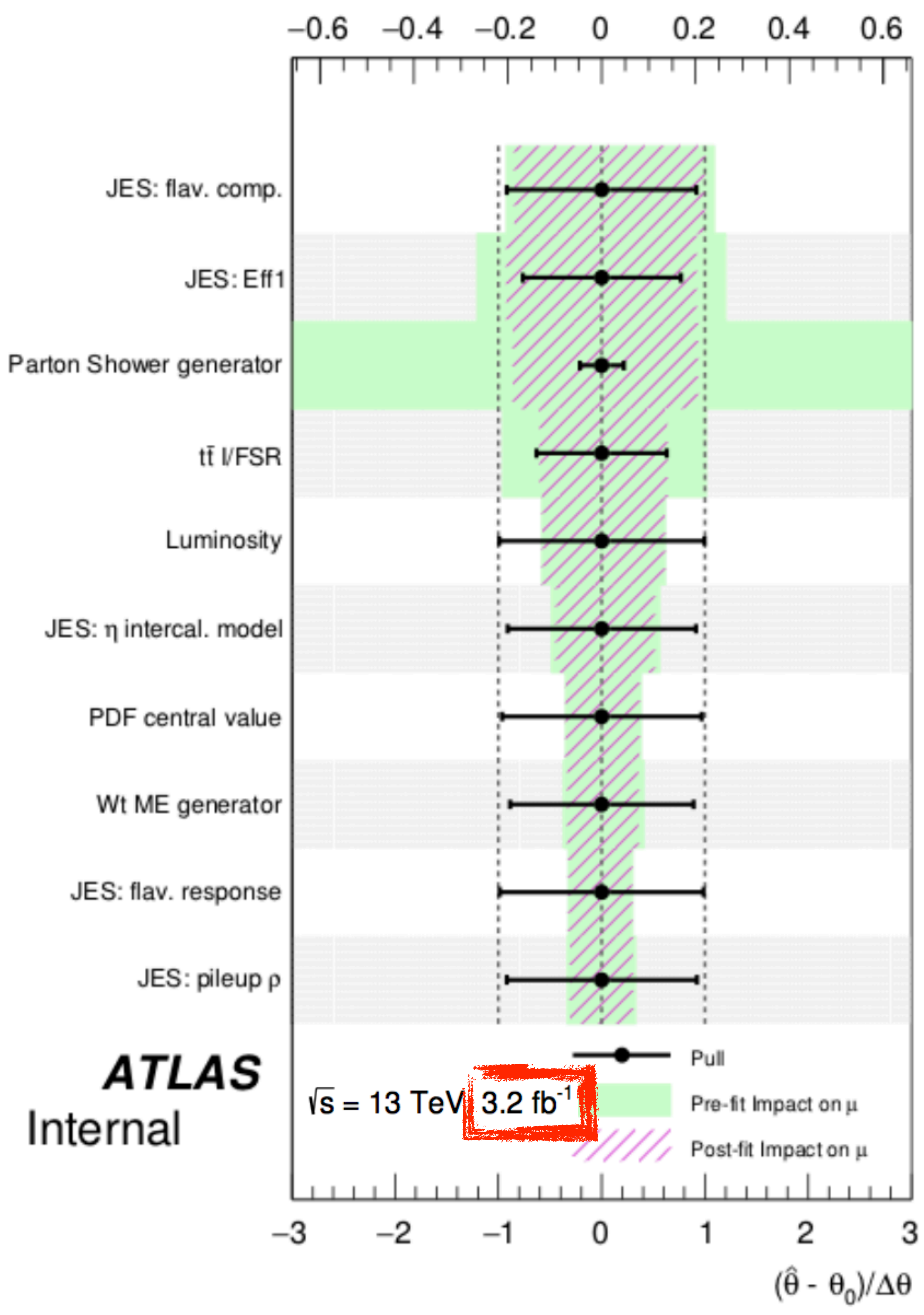
Prefit

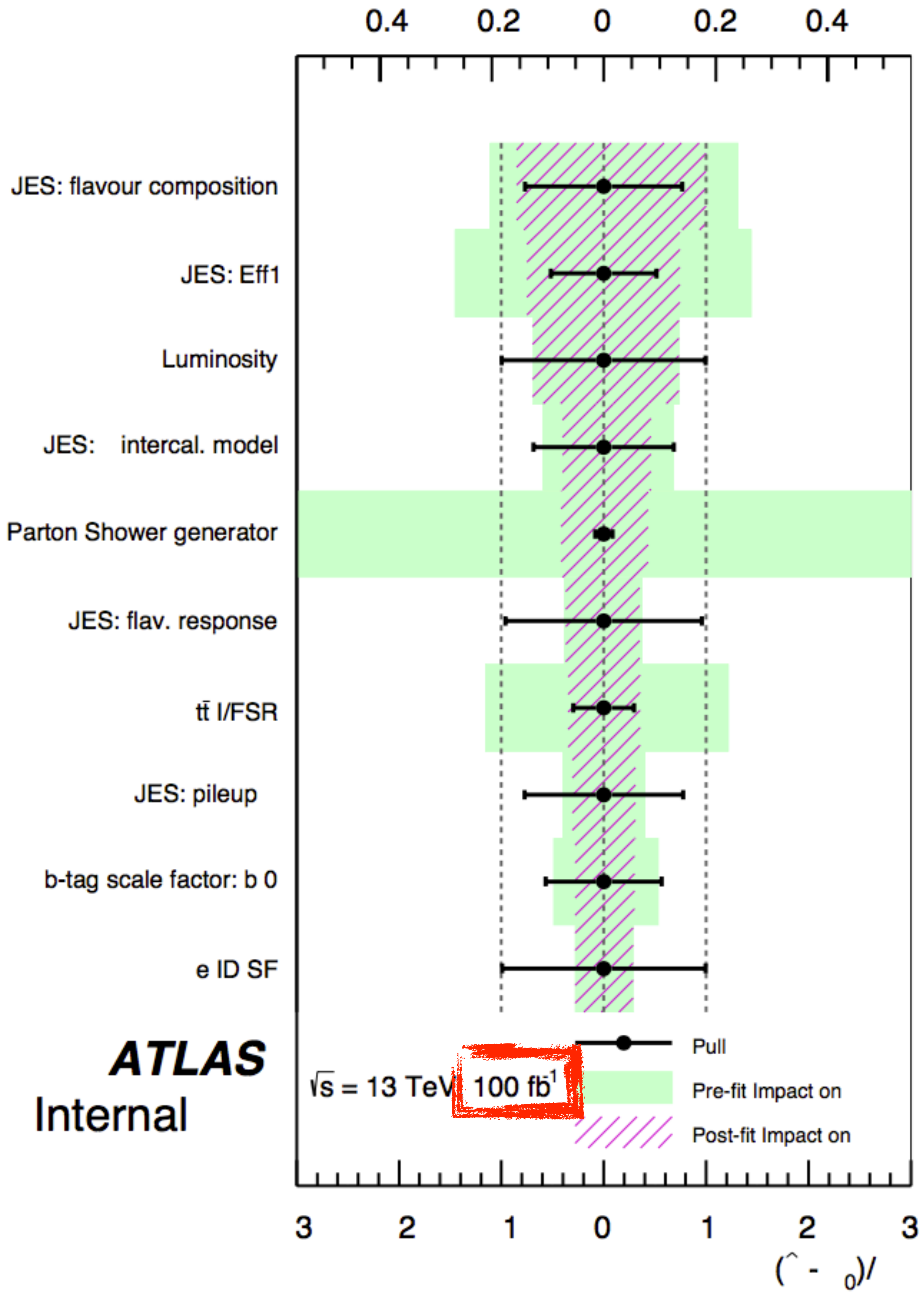


Postfit



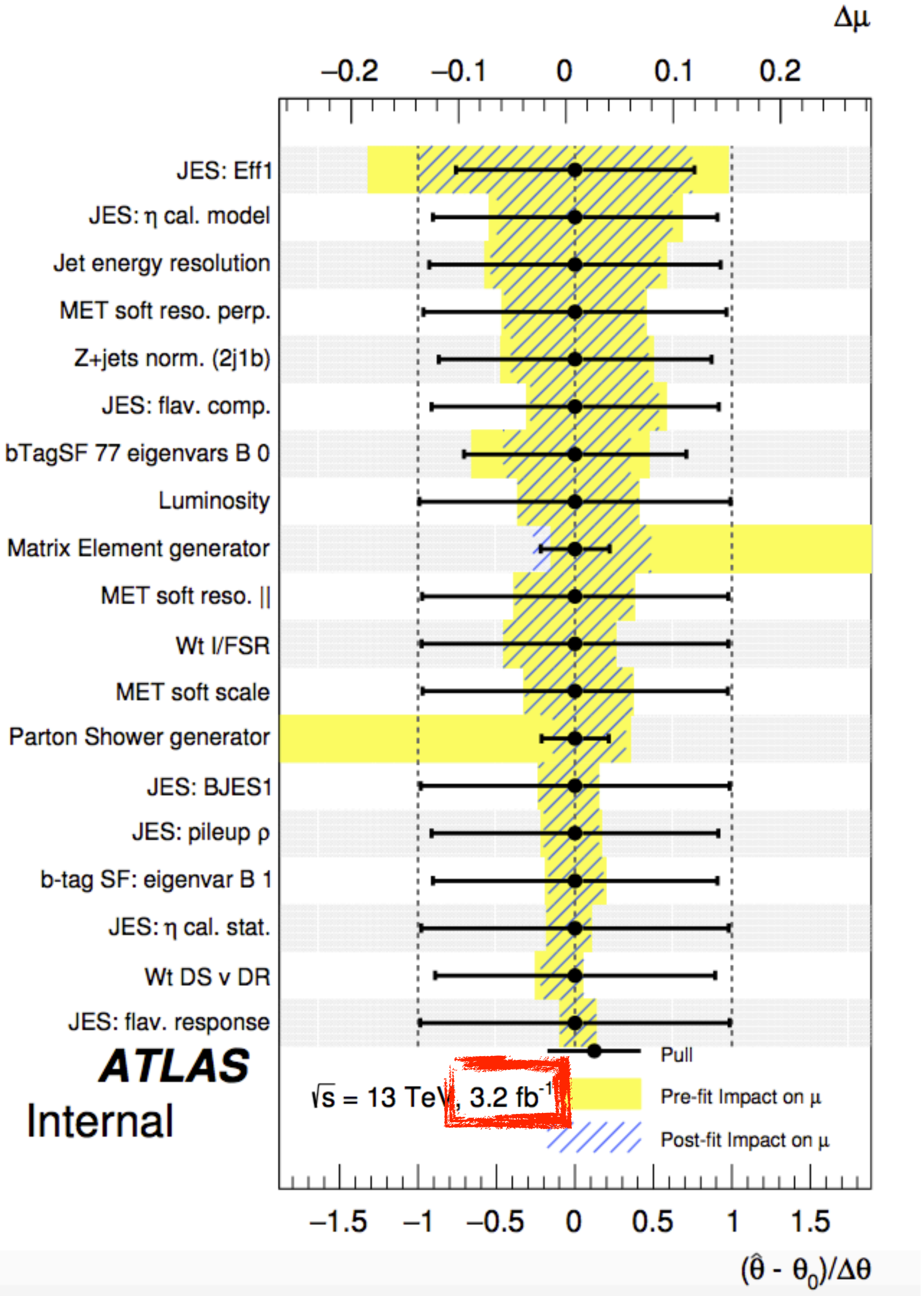
Extrapolated results - ranking plots I

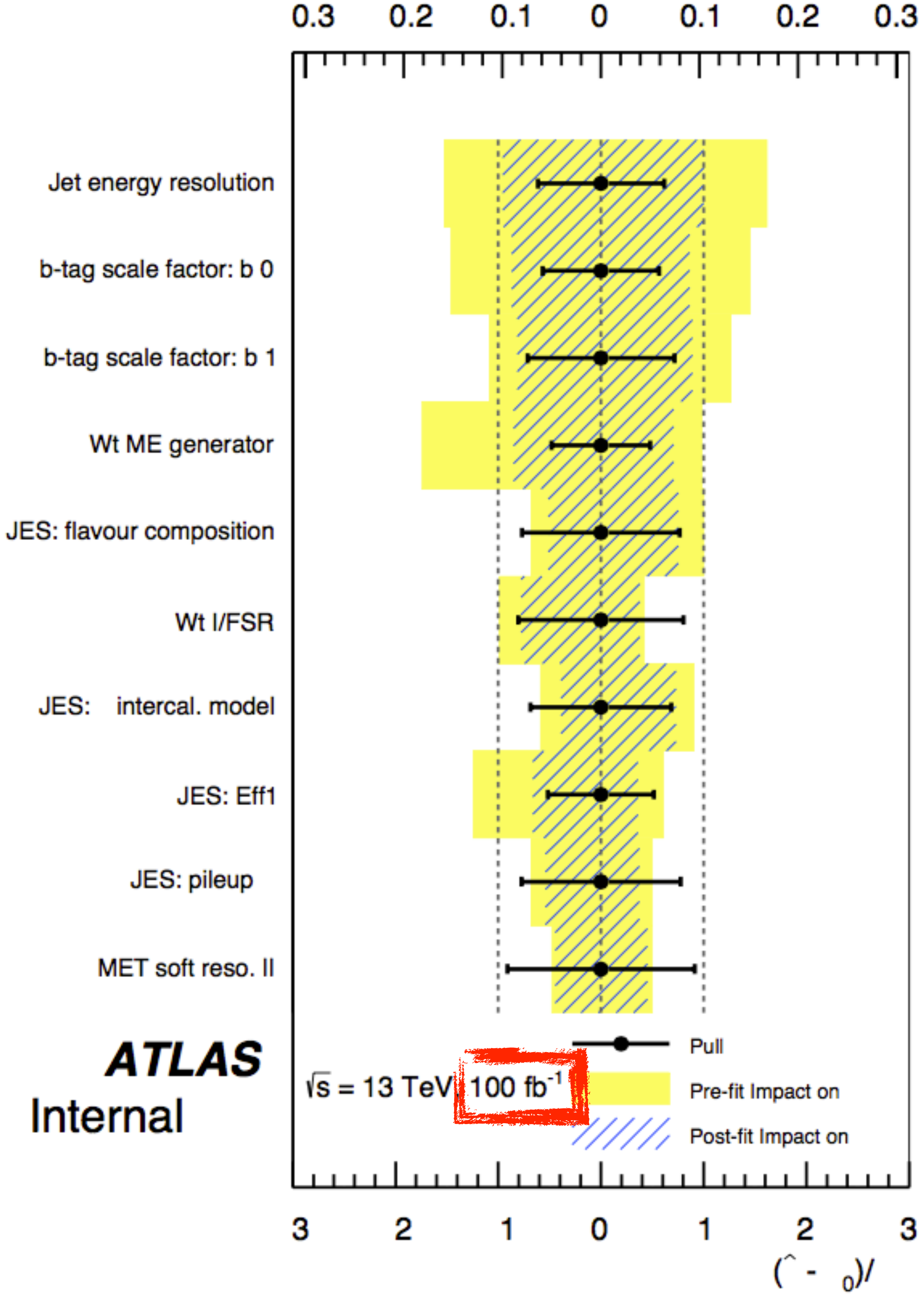




Other NPs are fixed to best fit when varying the studied NP

Extrapolated results - ranking plots II





Other NPs are floated to best fit when varying the studied NP

Differential cross-section measurement

- Projecting to 100fb^{-1}, we redid the BDT cut optimisation
- The best BDT cut is at 0.3, the same as what we have now
- Slight drop on total uncertainty
- May improve if BDT training improves

36.1 fb^{-1}

$\frac{d\sigma}{dE(b)}$, $r_{BDT} > 0.3$					
Statistical uncertainty	14.84	11.87	19.53	23.34	9.83
Total systematic uncertainty	52.48	98.48	47.41	107.55	76.72
Total uncertainty	54.54	99.19	51.28	110.06	77.35
$\frac{1}{\sigma}\frac{d\sigma}{dE(b)}$, $r_{BDT} > 0.3$					
Statistical uncertainty	14.84	11.87	19.53	23.34	9.83
Total systematic uncertainty	32.43	25.29	32.92	36.78	18.05
Total uncertainty	35.67	27.94	38.28	43.56	20.56

100 fb^{-1}

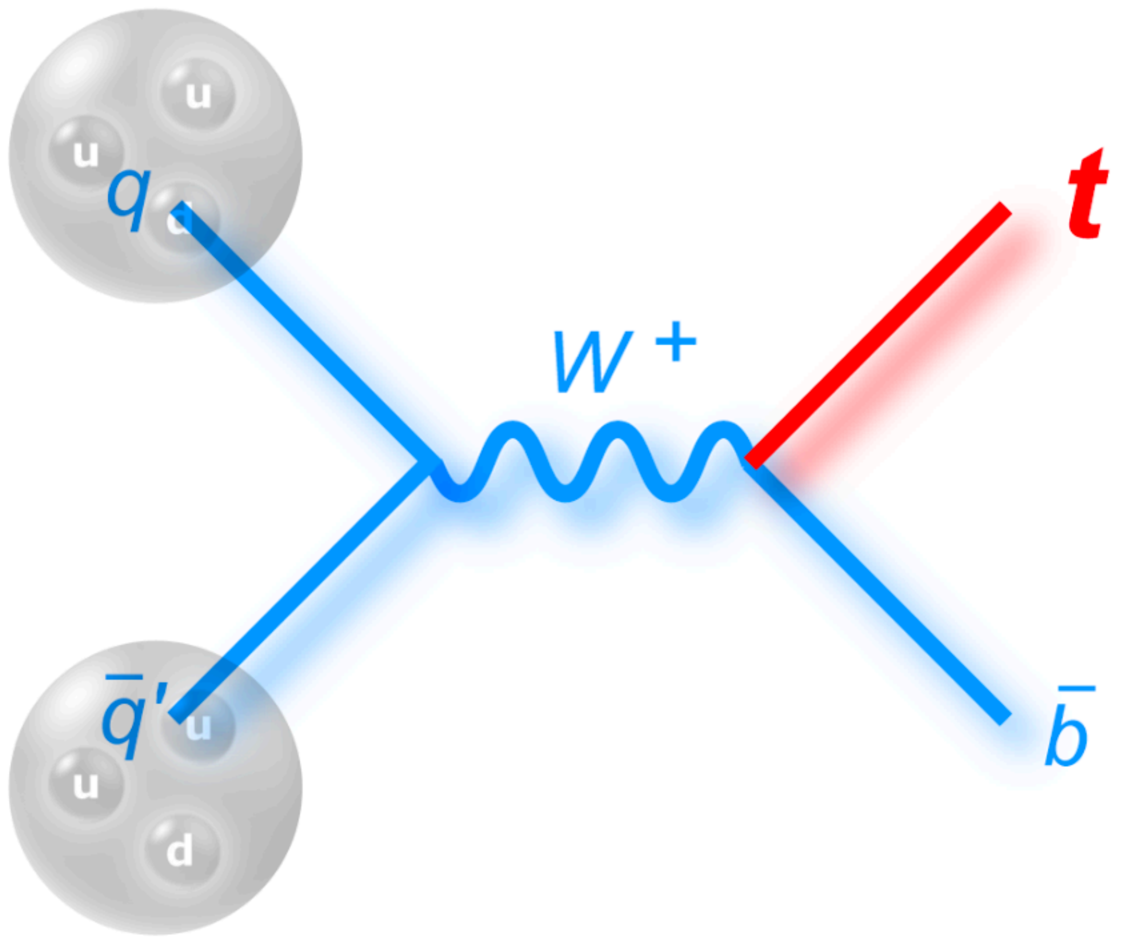
$\frac{d\sigma}{dE(b)}$, $r_{BDT} > 0.3$					
Statistical uncertainty	8.91	7.13	11.71	14.00	5.90
Total systematic uncertainty	52.49	98.48	47.40	107.52	76.74
Total uncertainty	53.24	98.74	48.83	108.43	76.97
$\frac{1}{\sigma}\frac{d\sigma}{dE(b)}$, $r_{BDT} > 0.3$					
Statistical uncertainty	8.91	7.13	11.71	14.00	5.90
Total systematic uncertainty	18.10	25.30	32.42	32.95	36.75
Total uncertainty	33.62	26.28	34.97	39.33	19.04

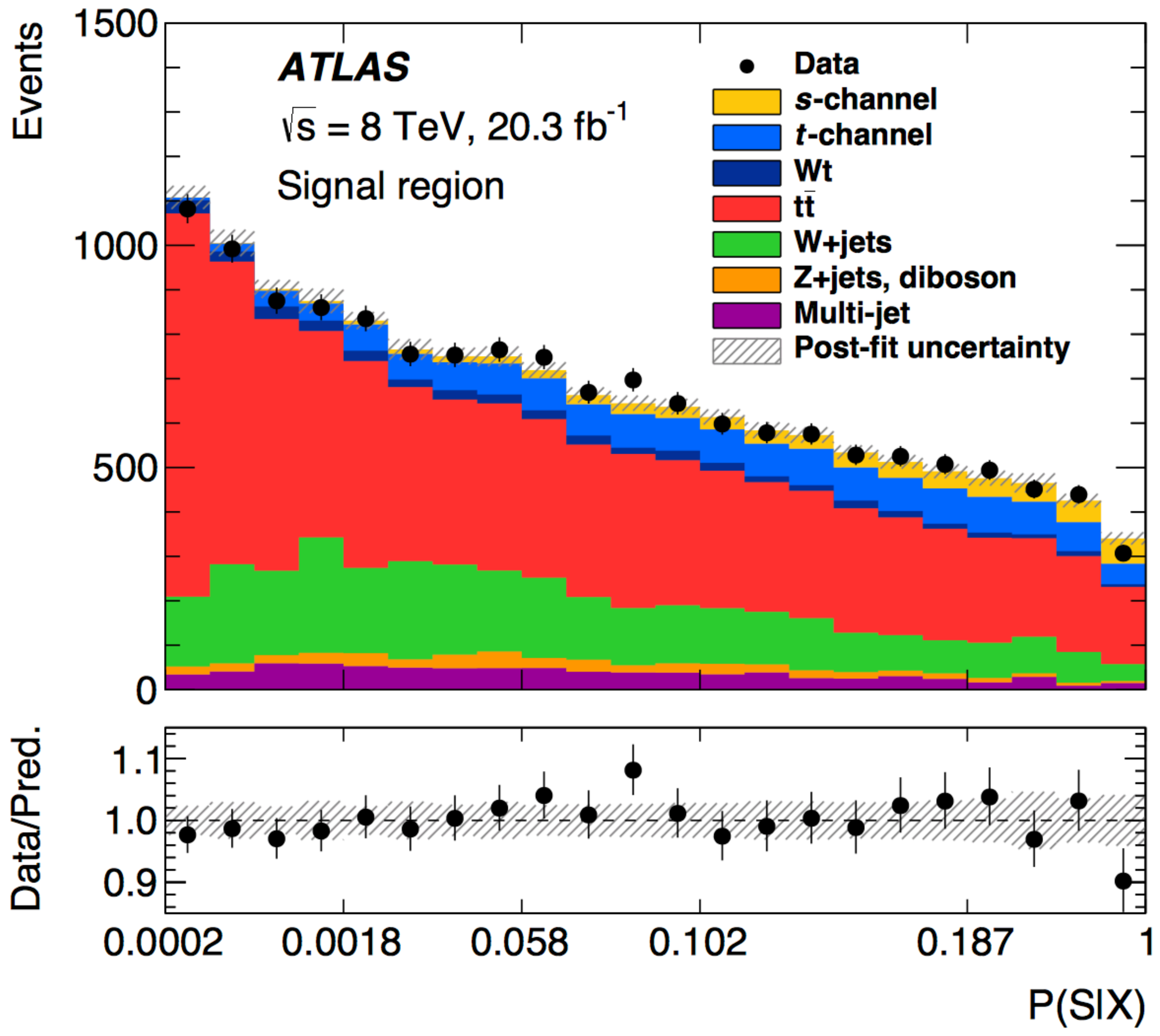
Analysis improvements

- Generator uncertainties
  - PS: Plan to use other better modelled generator such as Herwig7 to reduce generator uncertainties
  - ME: The h_damp parameter in Powheg-box, which gives a cut-off scale for the first gluon emission, was set to be m_top. More recent study at 13TeV indicates that 1.5*m_top is the most optimal value. Future samples will employ this value
  - DS/DR: The DR2 sample is now available in aMC. If it will be available also in Powheg, the estimation of the interference of tW and ttbar will be better understood
- JES uncertainties
  - JES flav. Comp. can be reduced by assign proper flav. Comp
  - How to design the analysis to be more robust against JES (perhaps alternative BDT training)
- Particle flow jet study ongoing
- MVA
  - Study NeuroBayes with respect to BDT techniques
  - Consider including shape information for 2j2b bin
- Differential cross section measurement
  - With current BDT training, the improvement is small

s-channel

Recap of the analysis





(a) ME discriminant

Event selection:

- Isolated high-p_t e|μ & 2 b-jets & large $\not{E}_t$
- Main backgrounds: $t\bar{t}$, W+jets, single-top *t*-channel

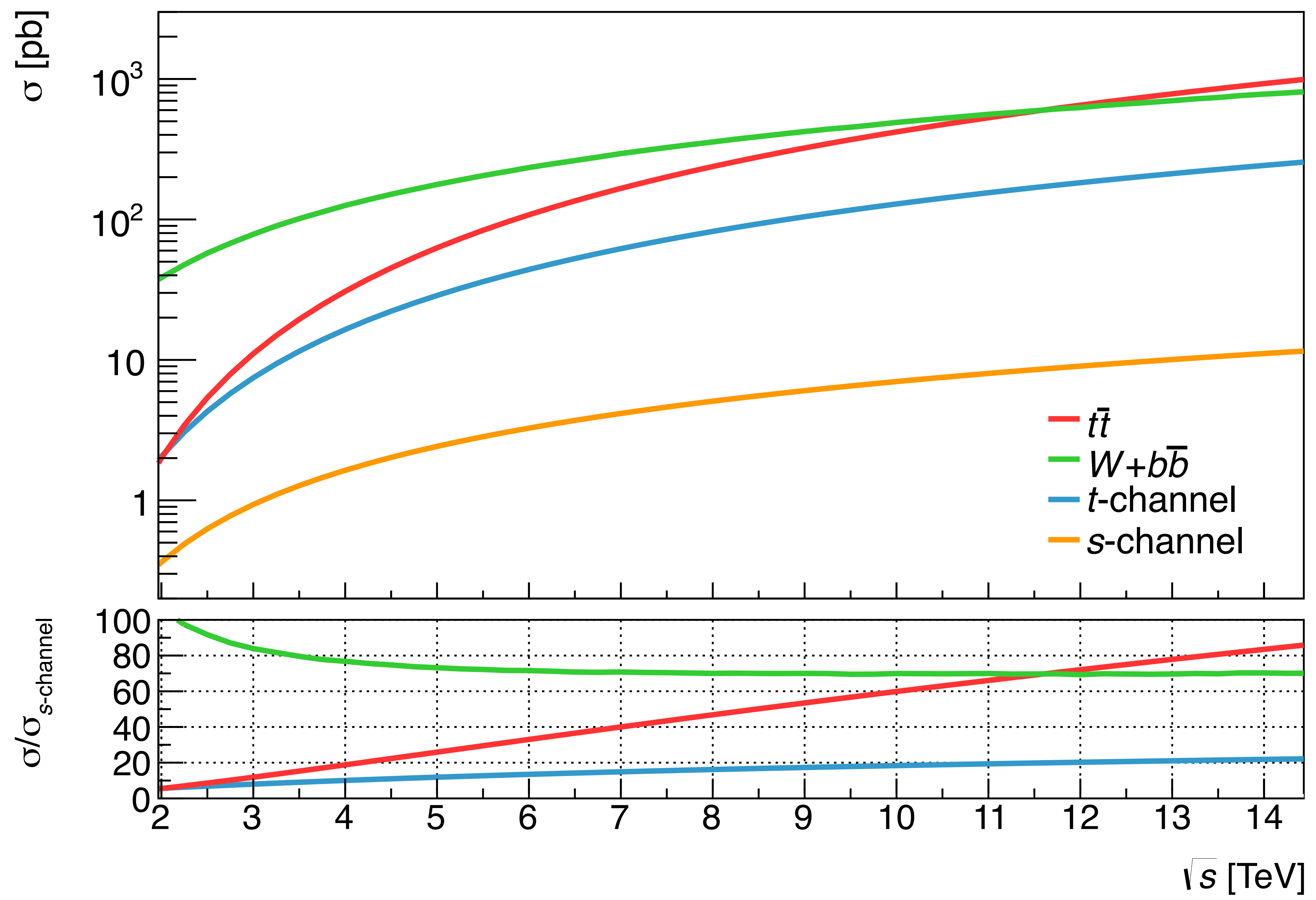
Matrix element method

★ Build likelihood from partonic cross-sections of the hard scatter

s-Channel Measurement

Projection from 8 TeV to 13 TeV (study by Patrick Rieck)

- Reminder: *s*-channel observed at 8 TeV with 3.2σ



- $t\bar{t}$ and *t*-channel cross-sections (main backgrounds) increase more than the *s*-channel
  ➔ larger backgrounds ➔ measurement more difficult
- Fraction of W+jets bkg. stays mainly the same

s-Channel Measurement

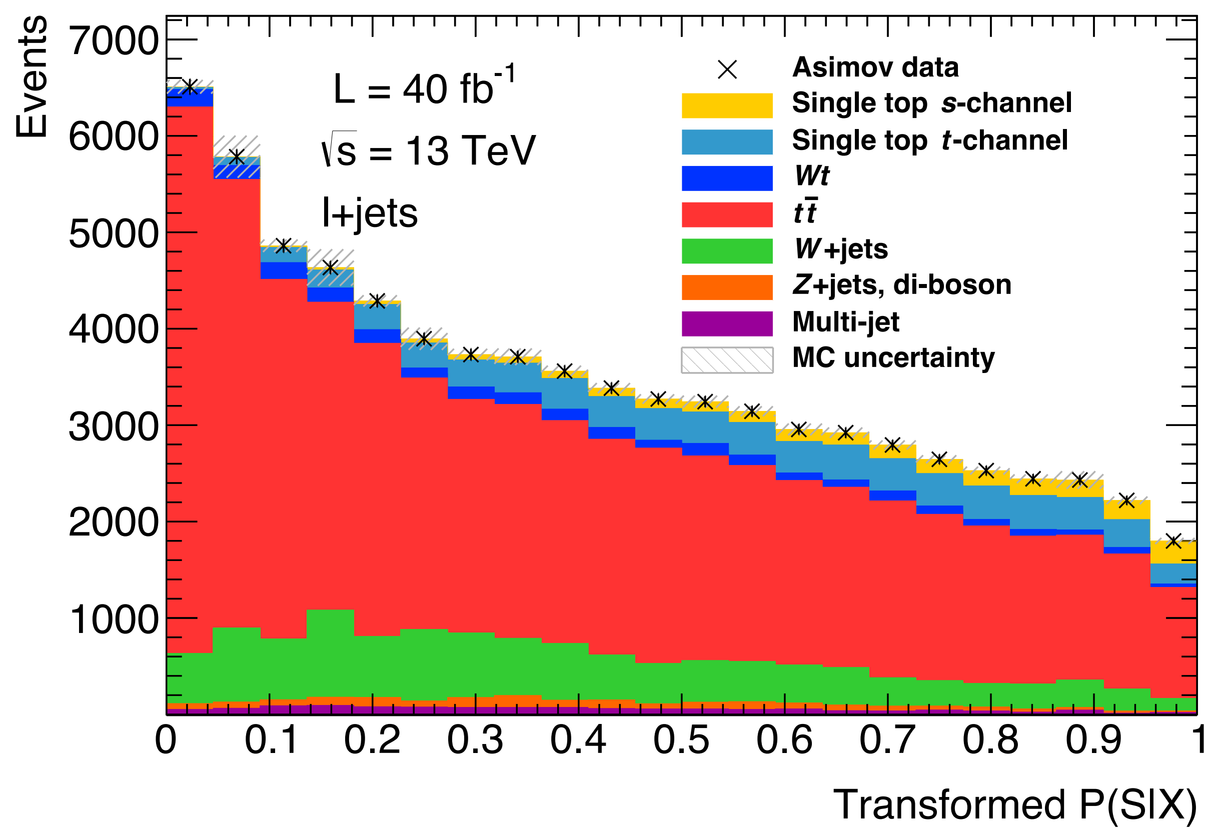
Projection from 8 TeV to 13 TeV

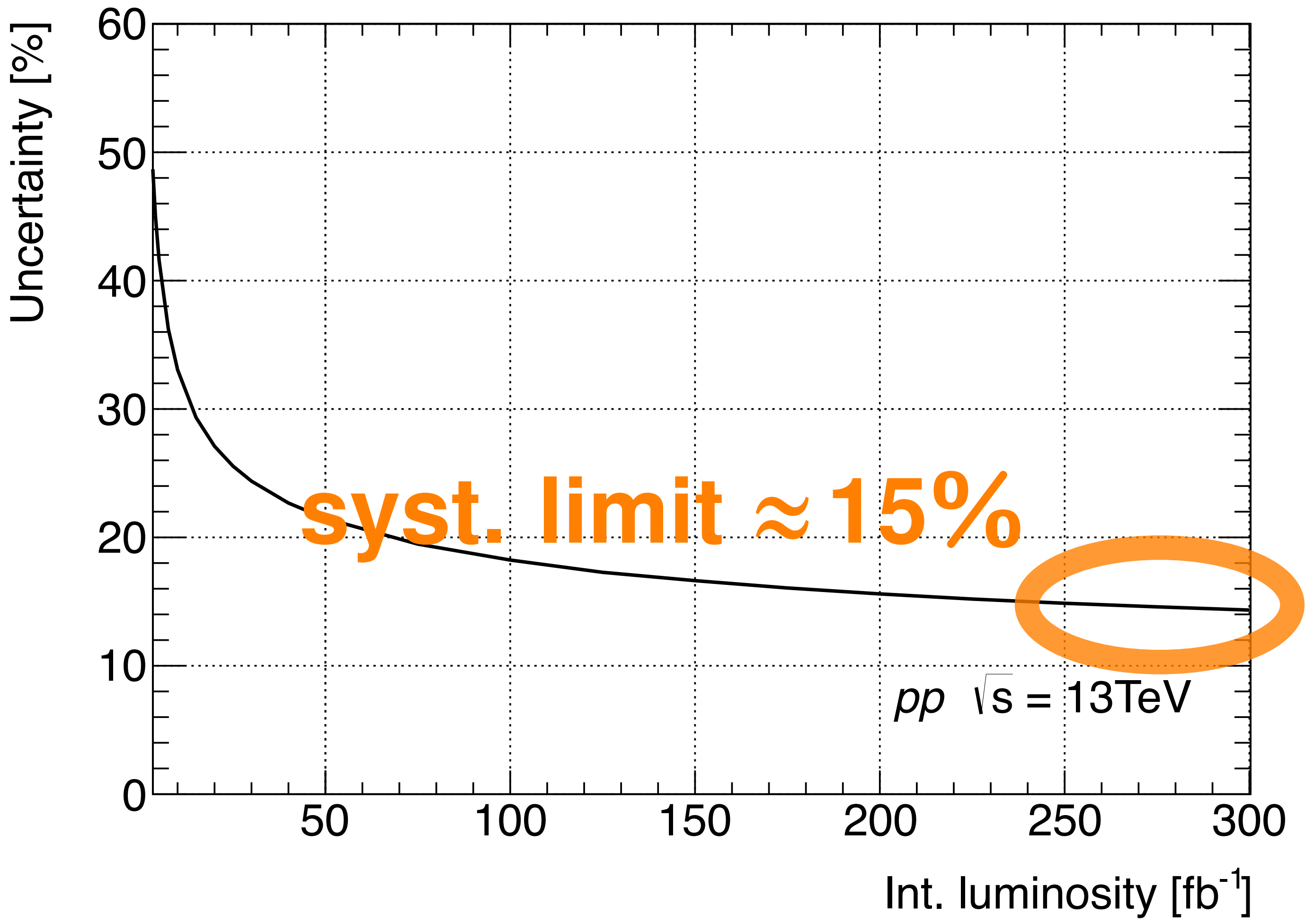
1. Reweight all processes by $\frac{\sigma(13\,\text{TeV})}{\sigma(8\,\text{TeV})}$
   (Use same fraction for multi-jet as for 8 TeV)
2. Reweight all contributions to new integrated luminosity
3. Adopt all systematics from 8 TeV analysis (neglect MC statistics)
4. Repeat signal extraction fit & compute significance

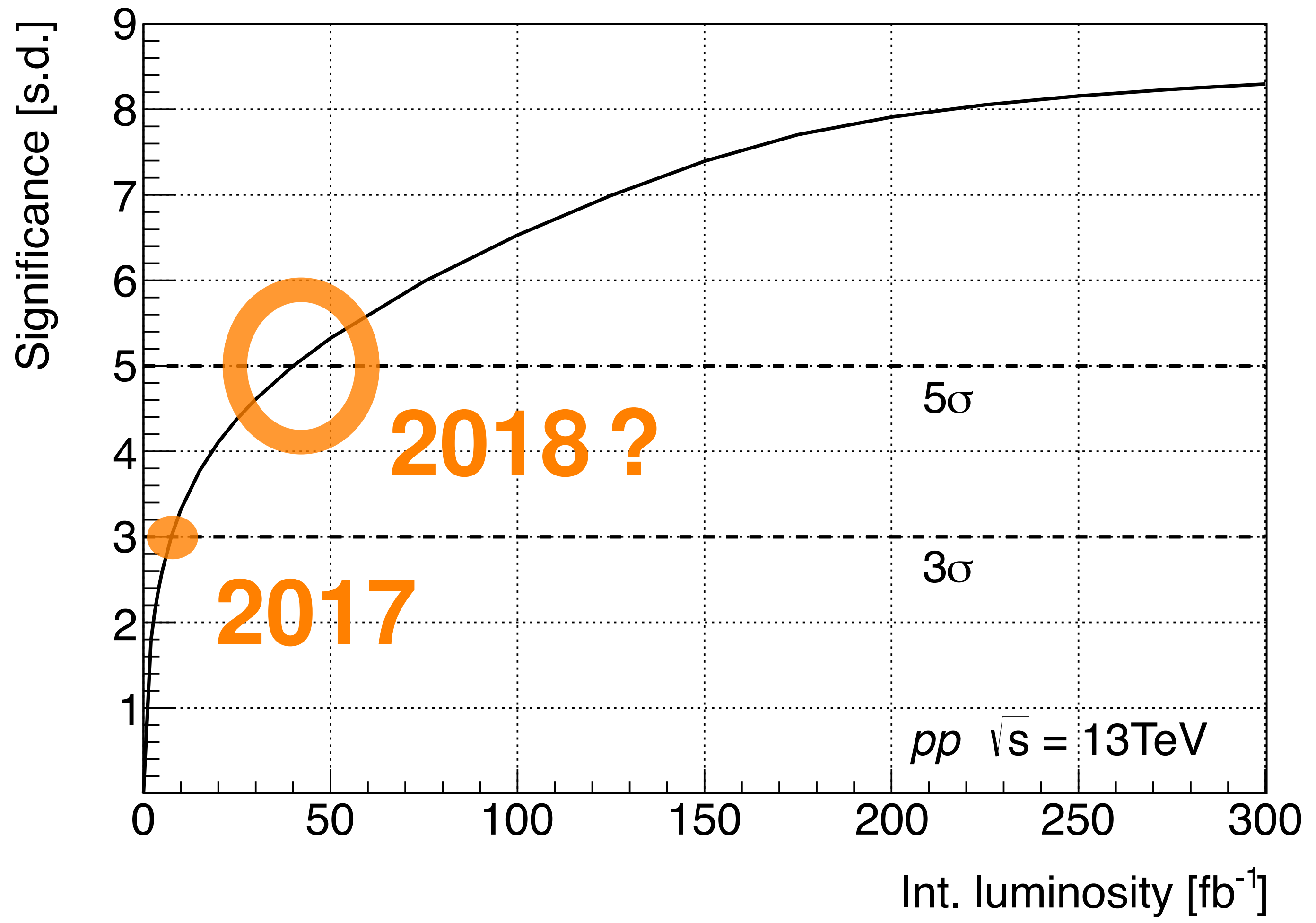
➔ luminosity dependence

Example: $\mathcal{L} = 40\,\text{fb}^{-1}$

ME discriminant





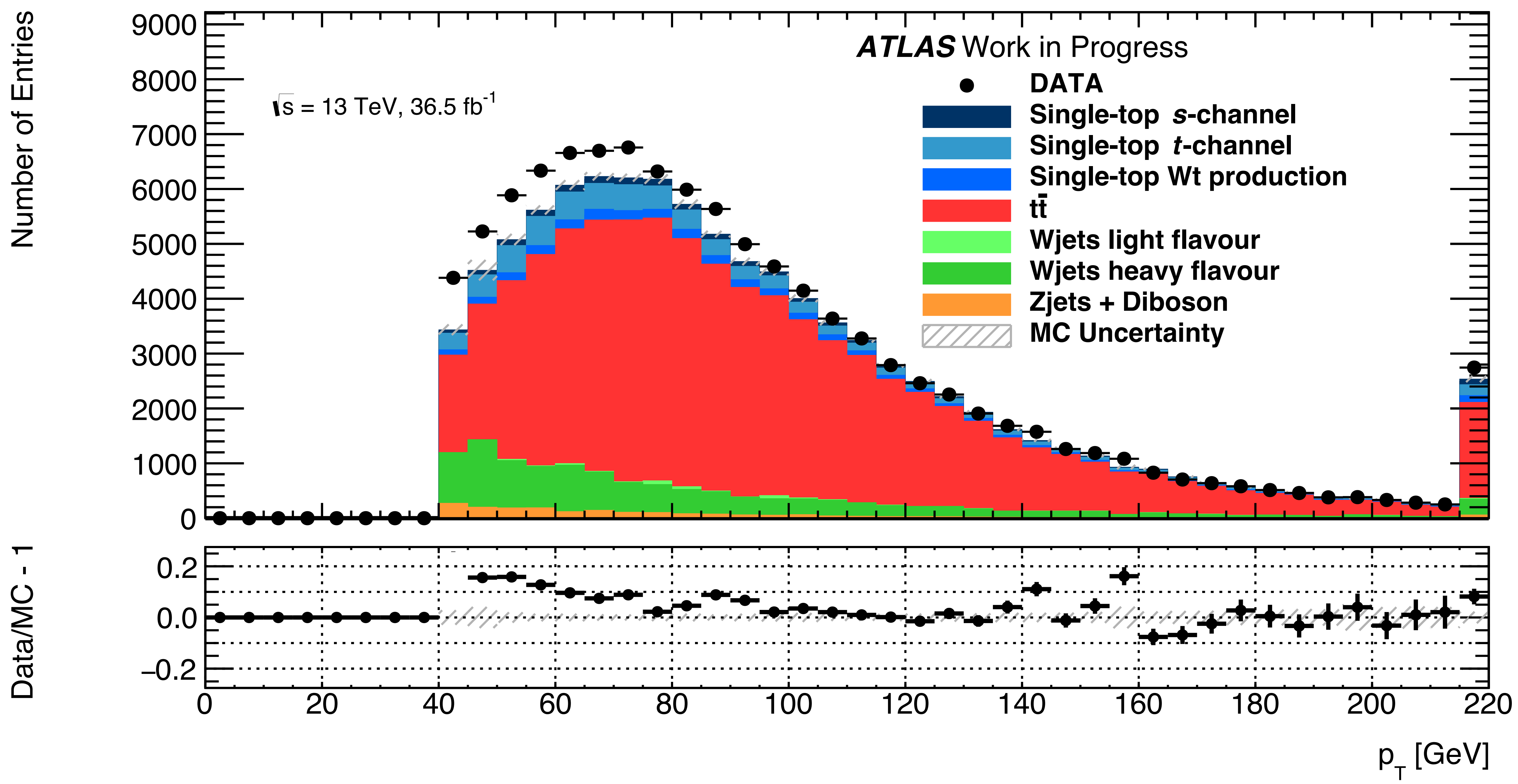


s-Channel Measurement @13 TeV

Status:

- Analysis project recently started (Stephan, Oliver)
- Based on SgTop-D3PDs v15
- Currently working on analysis set-up, multi-jet estimate, cut optimization etc.

Example for leading lepton p_t (without multi-jet bkg)



EFT Interpretation Prospects

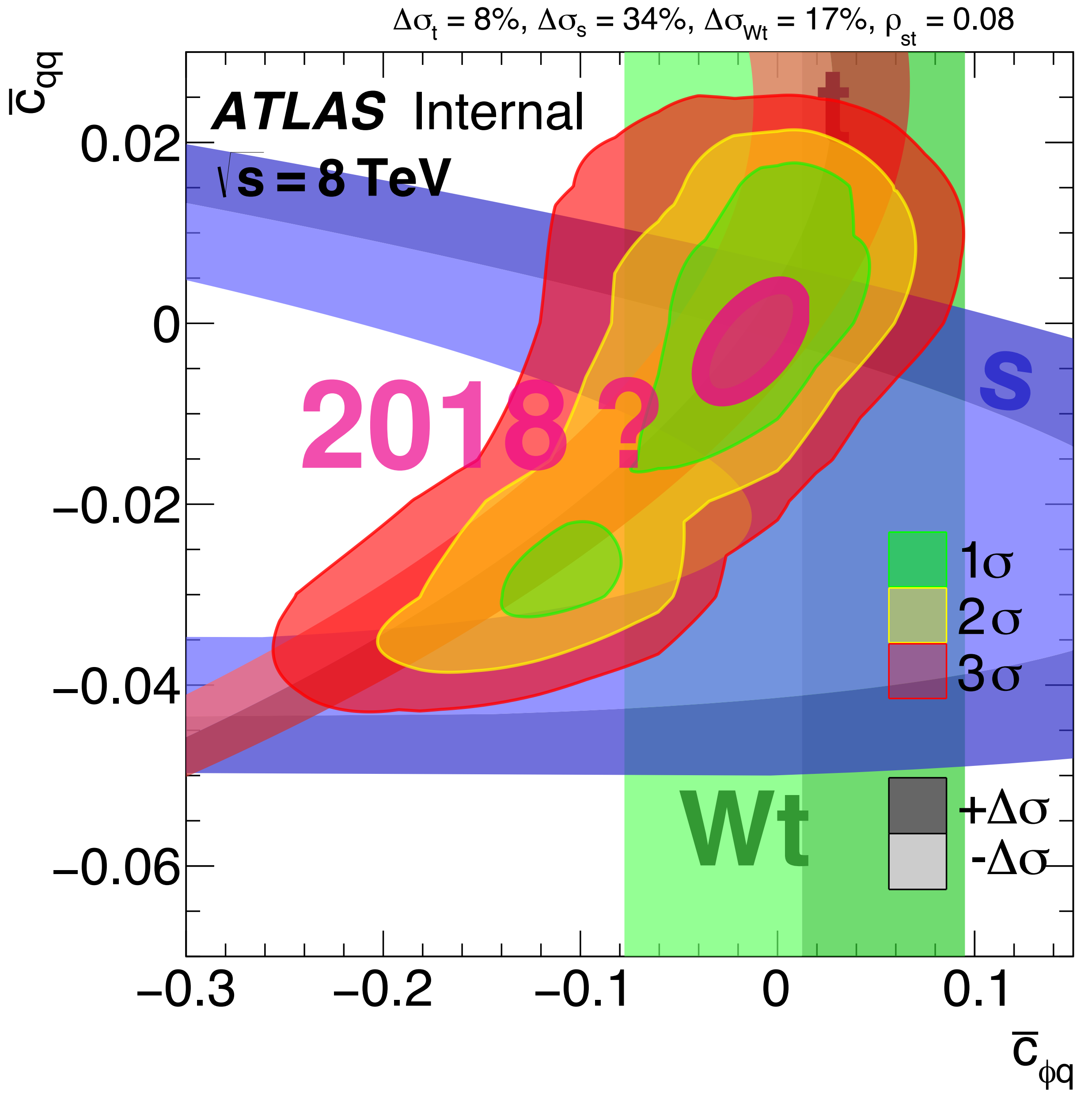
Simultaneous s|t-channel analysis:

- Allows determination of effective couplings:

  $c_{\phi q}$: corrections to the Wtb vertex by new physiscs

  c_{qq} : four-fermion interactions by new massive gauge mediators

Results for 8 TeV:



A reduction of the *s*-channel uncertainty from 34% (8 TeV) to 15% (13 TeV estimate) would allow

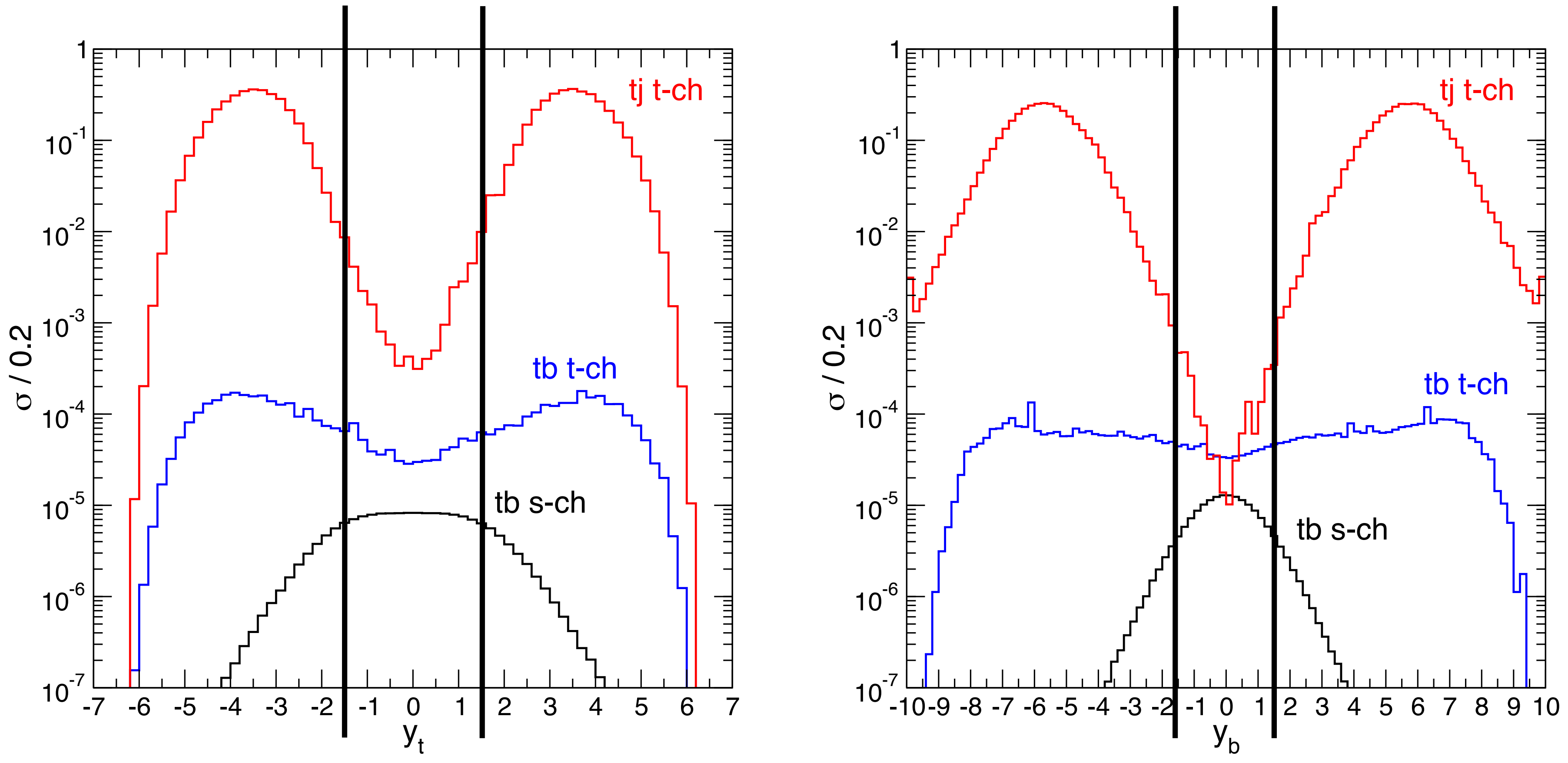
- to resolve the ambiguity for the 1σ region of c_{qq} and $c_{\phi q}$
- to narrow the limit for c_{qq} by ≈ 2

High-q^2 s-Channel Analysis

- Proposed by M. Mangano & J. A. Aguilar-Saavedra for a 100 TeV collider
- See This Talk
- Basic idea: look at *s*-channel events with high momentum transfer

  ➔ large invariant tb masses (+ jets)
- Motivation: high-q^2 *s*-channel events very sensitive to the anomalous coupling $|g_R|^2$
- Large *t*-channel backgrounds

Rapidity distributions for $m_{tb} > 10$ TeV



- Not sure whether this proposal works at LHC energies
- A sensitivy study is clearly needed before any further decision

Conclusion

- tW inclusive measurement
  - Will benefit from higher statistics
  - Better BDT training
  - Current modelling systematics trend to be overestimated
- tW differential
  - No improvement from purely BDT cut optimisation
  - May improve by other aspects such as better BDT training
- S-channel
  - More challenging at 13 TeV
  - Hope for an observation