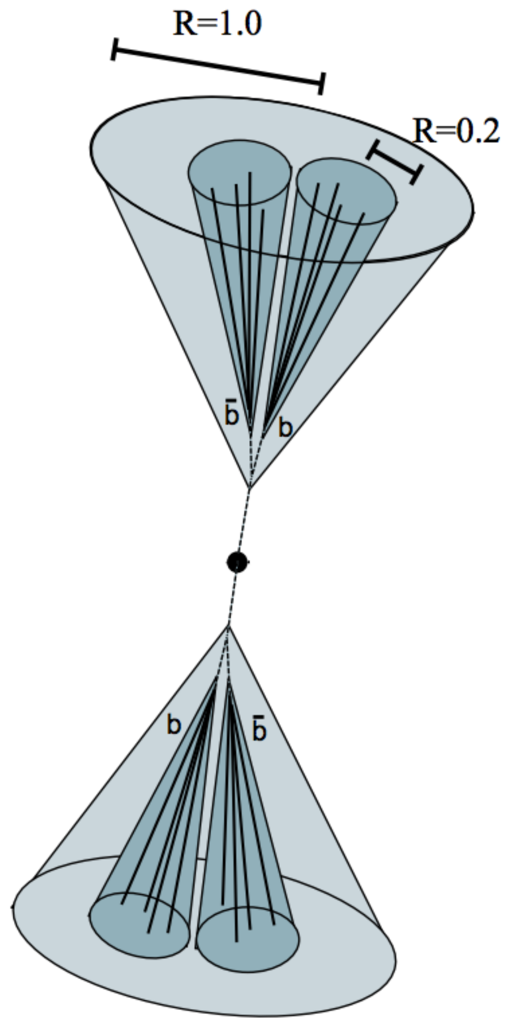
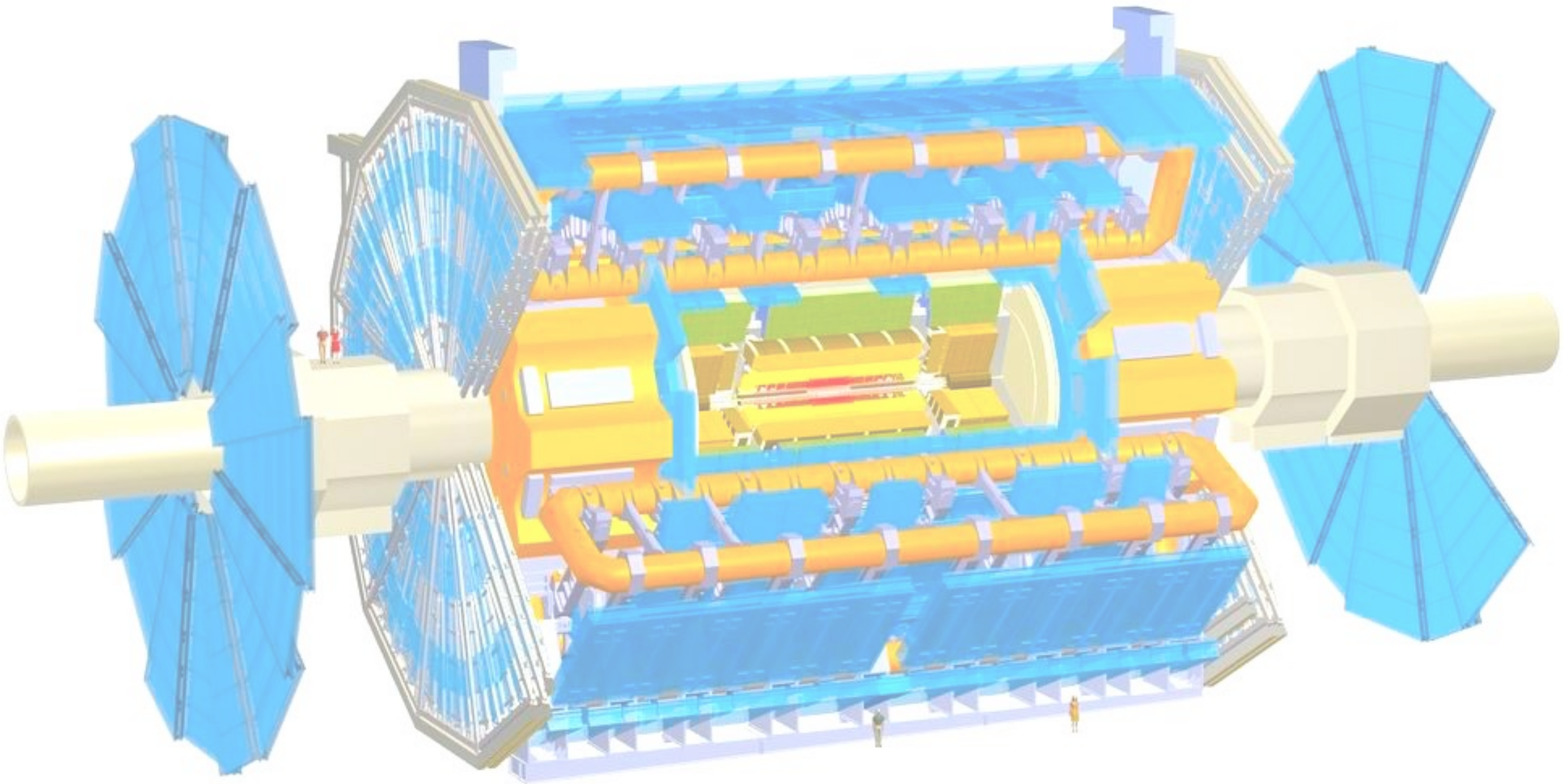
Links:
[RunI Results]
[15-only Moriond]
[16 ICHEP CONF Note]
[17 Boosted Int Note]
[17 Resolved Int Note]

hh4b Boosted Analysis Unblinding Closure





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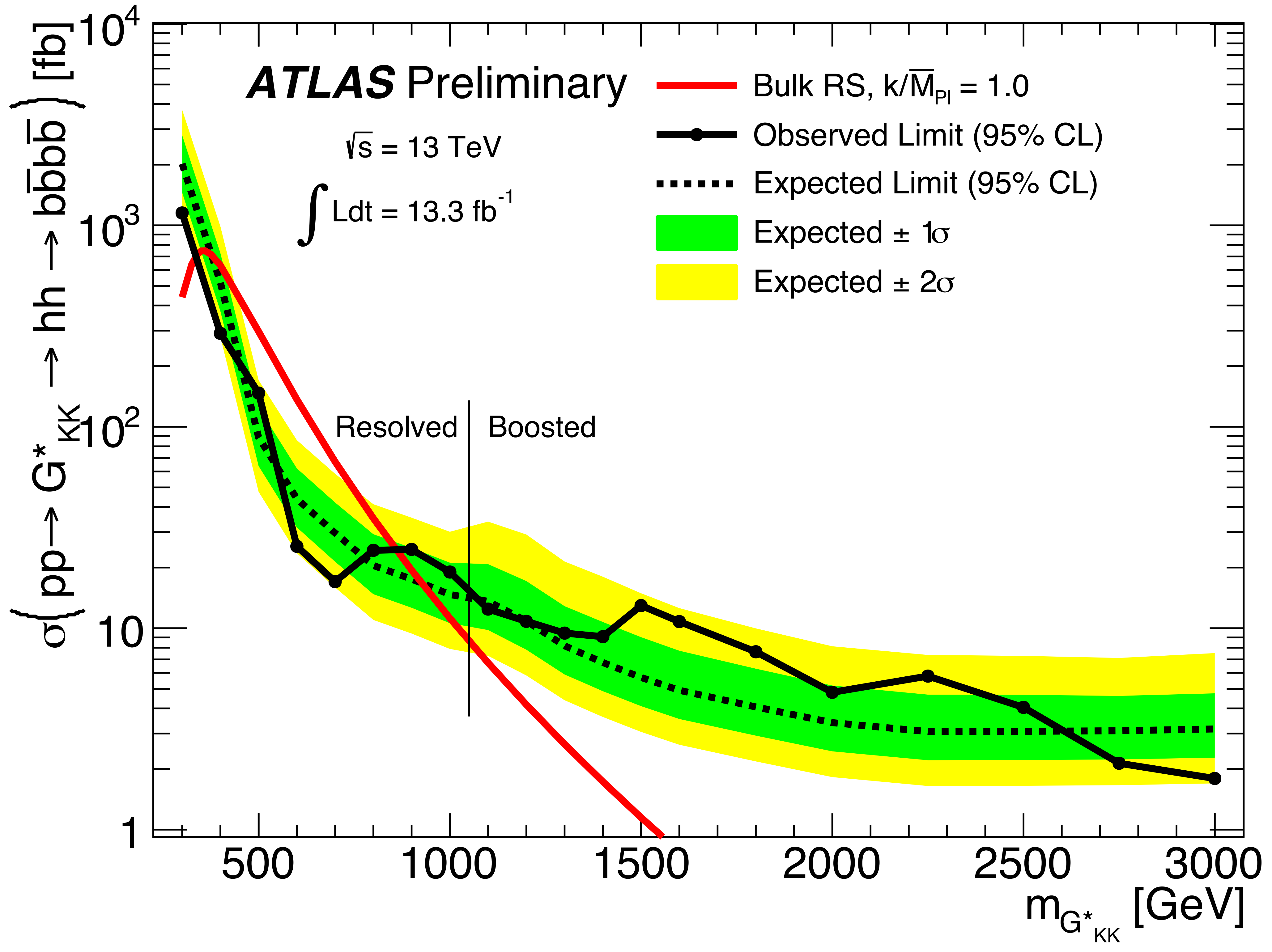
Jul 12, 2017 11:56 AM

Overview

- Outstanding issues:
  - Log-falling smoothing impact on modeling
  - ttbar smoothing variations
  - Acceptance up to 5 TeV
- List of investigations: (all in SB)
  - The dip in 2bs SB large-R jet pT at 800 GeV
  - The 3b sublHcand pT in SB
  - The deficit in 3b SB MJJ around 2000 GeV
  - The leadHCand lead trkjet pT discrepancy at low pT (2bs and 3b)

- Links:
  - CDS link to Note: Boosted; Resolved
  - EB meeting talks: 1st, 2nd, 3rd

ICHEP Run II 4b Limit, 13.2 fb^{-1}

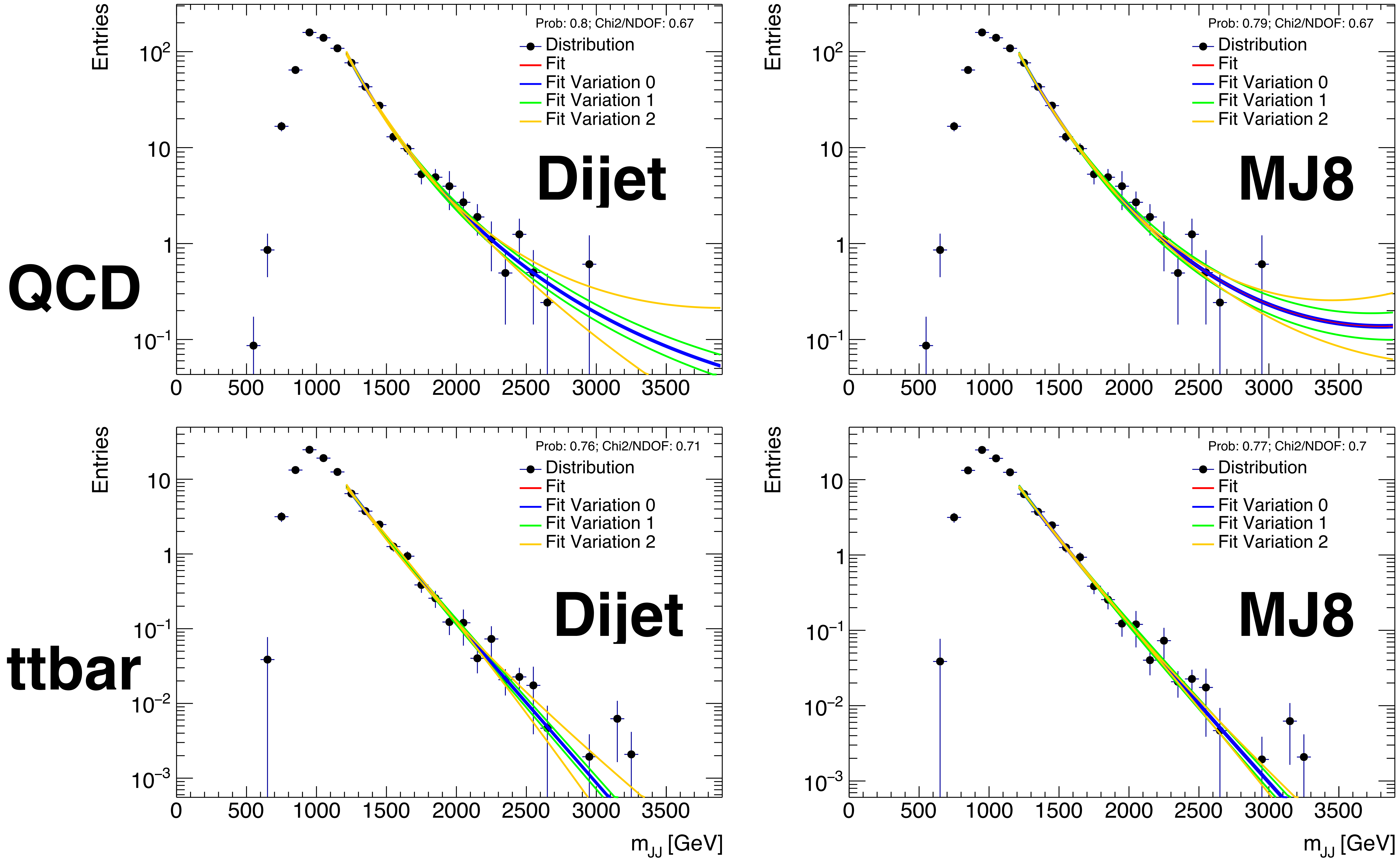


Signal Region: Smoothed

MJ8	$f_8(x) = \frac{p_0}{x^2}(1-x)^{p_1 - p_2 \ln x}$
MJ1 (Dijet)	$f_1(x) = p_0(1-x)^{p_1} x^{p_2}$

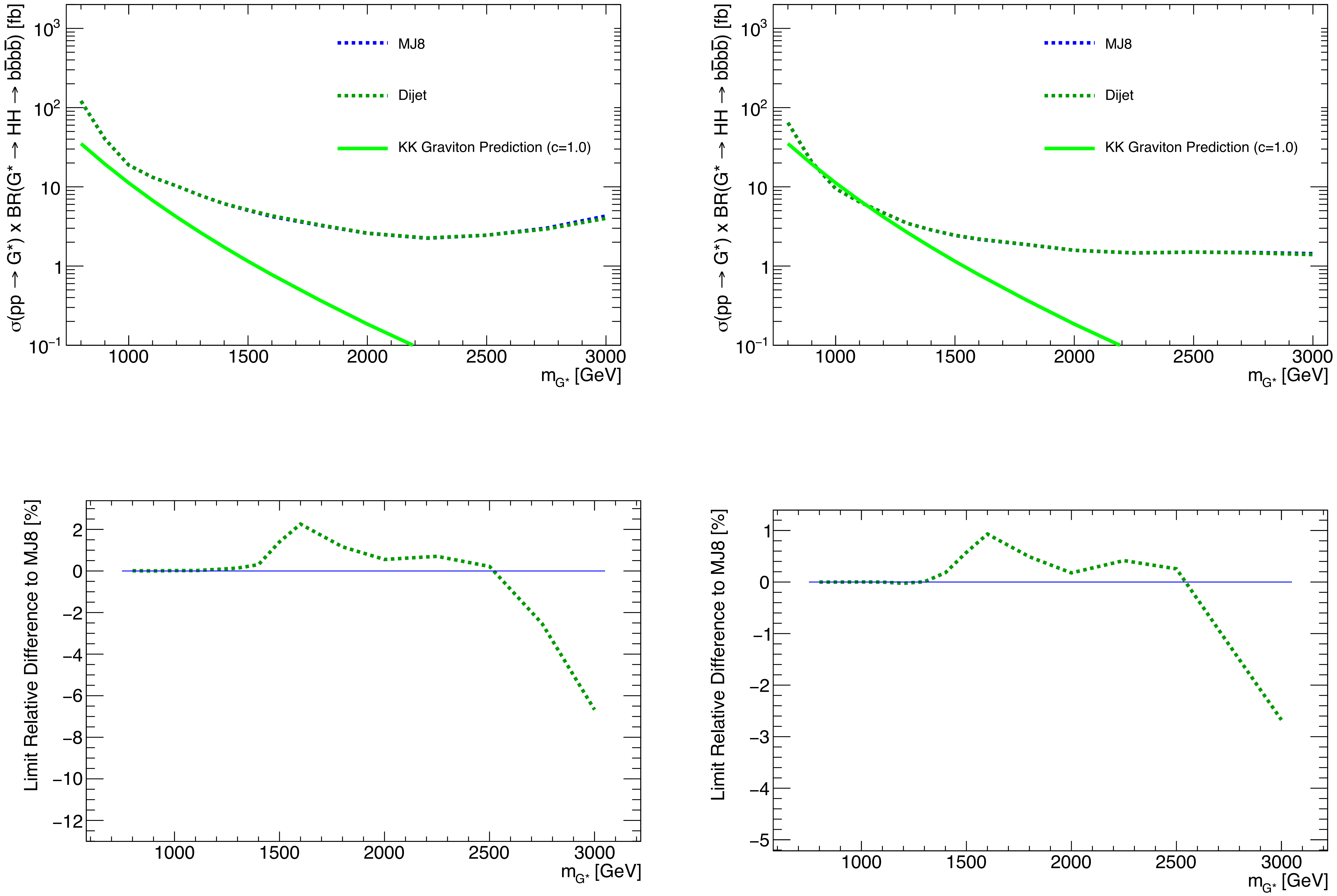
- MJ8 function is used to smooth both QCD and ttbar;

- Suggestion to test dijet function, results for 3b shown below, steeper tail



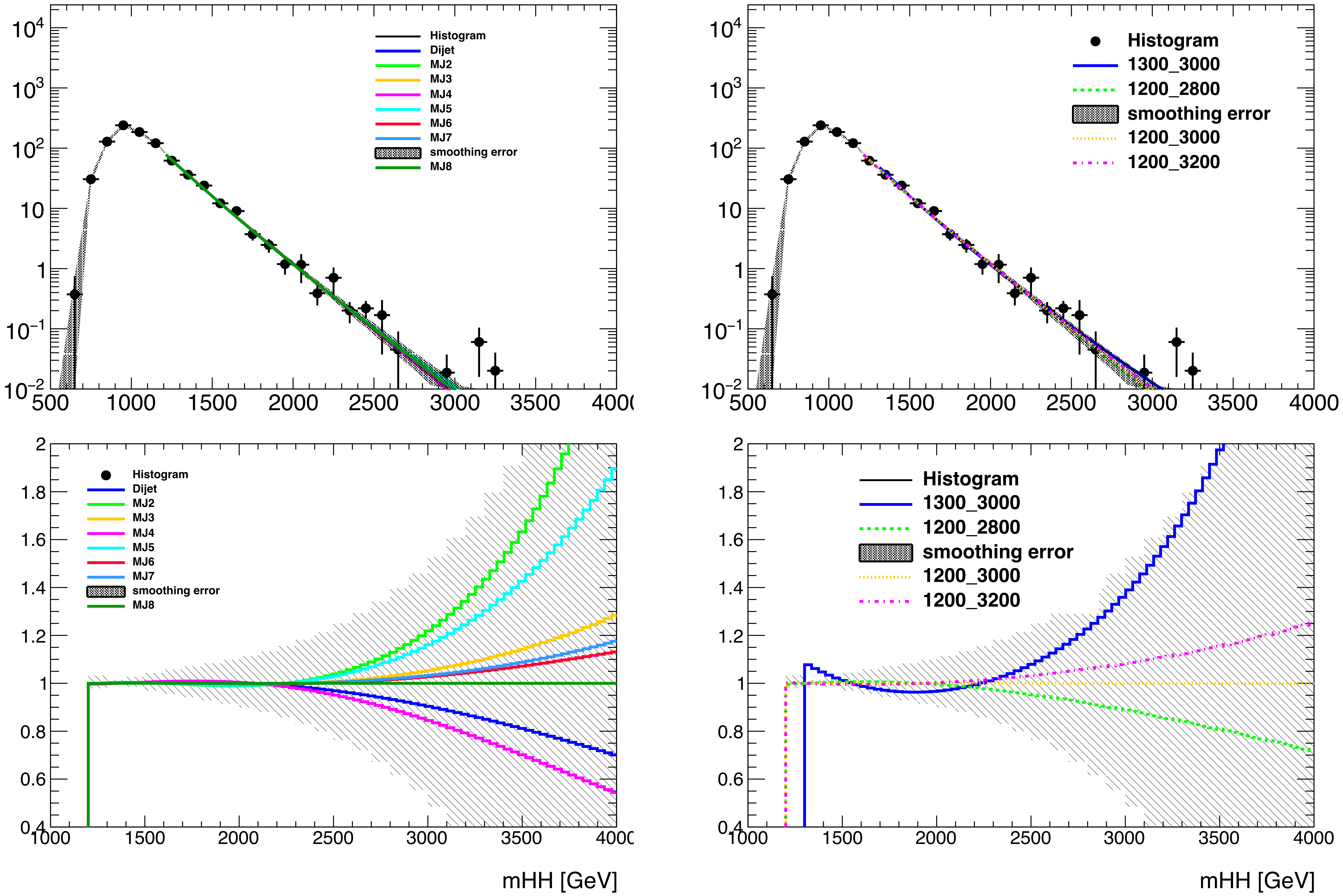
Limits

- All smoothing changed to dijet, compared with MJ8 on stat-only limits
- Impact on the limit minimal at high mass:
  - ~ 5% for 3b
  - ~ 2% for combined
- Variations are covered in the smoothing functional uncertainties



Functional Range and Functional Form variations

- Default is 1200-3000 GeV, vary range in SR prediction; drop the variations with prob < 0.001 and large normalization differences
- Default is MJ8, vary smoothing function in SR prediction
- Overall, the smoothing systematics is smaller than the smoothing error, maybe not necessary to assign



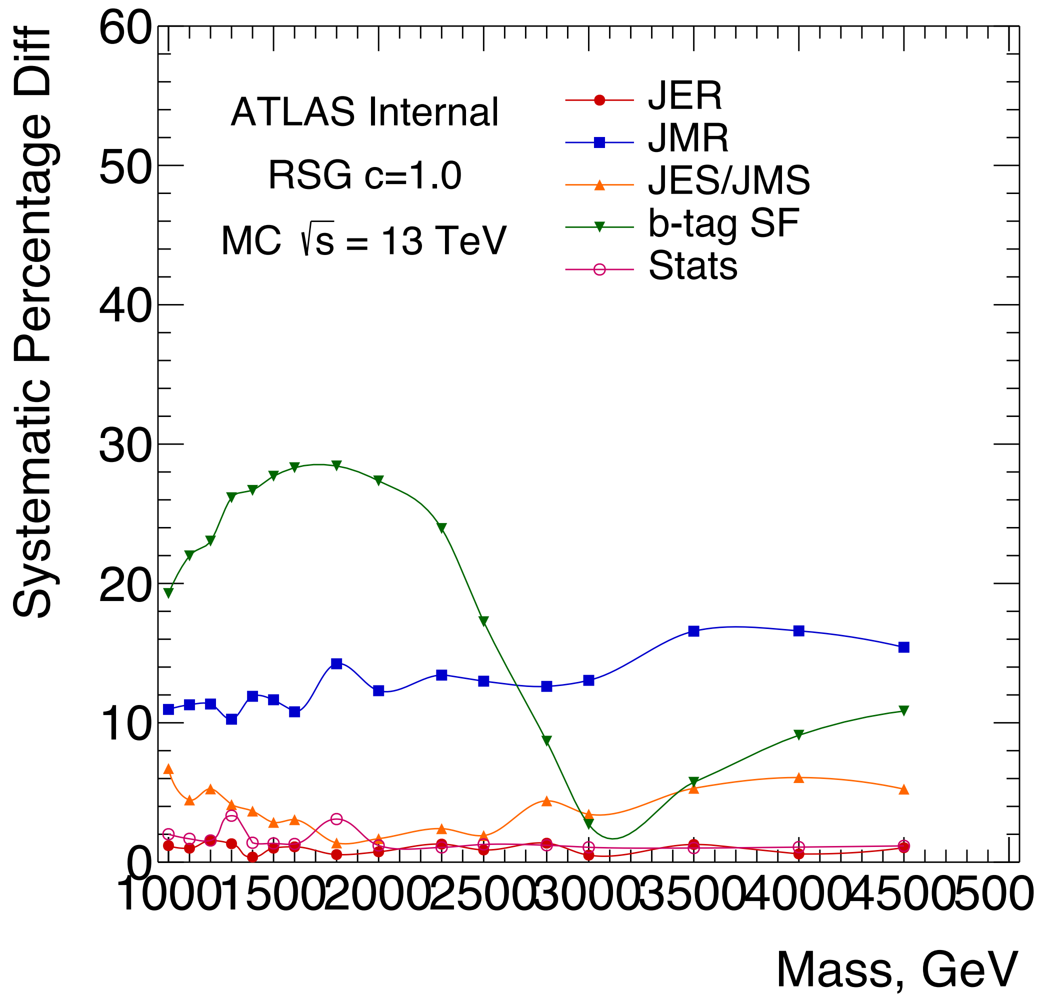
Acceptance up to 5 TeV

- Very few events…3.5 TeV have 0.058 events expected in Signal Region
- Also, only have >3 TeV samples for RSG c=1.0, not for 2HDM and RSG c=2.0

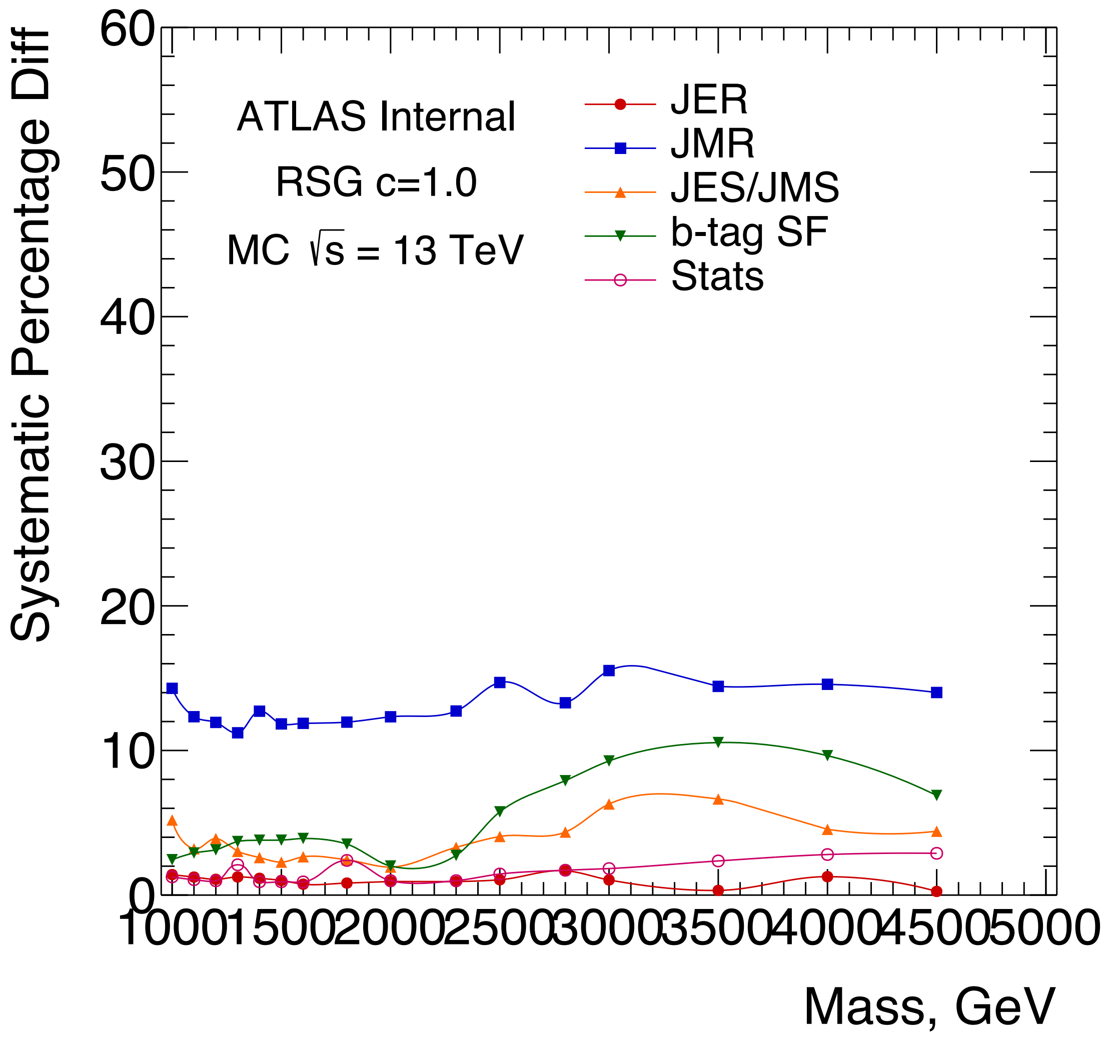
Resonance Mass [GeV]	Mini-ntuple Skimming	2 large-R jets	$\Delta\eta$	Xhh ¡ 1.6	2bs SR	3b SR	4b SR
500	317.31 ± 6.0	295.75 ± 5.79	164.5 ± 4.32	8.45 ± 0.99	1.08 ± 0.37	2.14 ± 0.52	0 ± 0
600	269.07 ± 3.64	247.94 ± 3.5	136.31 ± 2.59	11.31 ± 0.76	2.57 ± 0.37	3.84 ± 0.45	0.66 ± 0.19
700	253.68 ± 3.35	226.93 ± 3.16	124.83 ± 2.35	16.79 ± 0.86	3.74 ± 0.42	6.99 ± 0.56	1.91 ± 0.29
800	286.26 ± 2.28	245.36 ± 2.11	129.2 ± 1.53	24.41 ± 0.67	5.11 ± 0.31	11.27 ± 0.46	4.13 ± 0.27
900	306.51 ± 1.61	275.57 ± 1.52	158.03 ± 1.15	40.72 ± 0.59	8.81 ± 0.28	19.76 ± 0.41	7.5 ± 0.25
1000	238.2 ± 0.98	226.98 ± 0.96	165.2 ± 0.82	52.86 ± 0.47	10.87 ± 0.22	26.0 ± 0.33	10.07 ± 0.2
1100	164.5 ± 0.63	160.94 ± 0.63	132.53 ± 0.57	45.26 ± 0.34	9.55 ± 0.16	21.88 ± 0.23	9.03 ± 0.14
1200	109.24 ± 0.41	107.92 ± 0.4	93.45 ± 0.38	33.53 ± 0.23	6.96 ± 0.11	15.8 ± 0.16	7.38 ± 0.1
1300	72.72 ± 0.59	72.2 ± 0.59	63.74 ± 0.56	24.19 ± 0.35	5.02 ± 0.17	11.33 ± 0.24	5.45 ± 0.16
1400	48.83 ± 0.17	48.61 ± 0.17	42.96 ± 0.16	16.62 ± 0.1	3.72 ± 0.052	7.61 ± 0.07	3.68 ± 0.046
1500	33.13 ± 0.12	33.02 ± 0.12	29.25 ± 0.11	11.31 ± 0.07	2.67 ± 0.036	5.08 ± 0.047	2.44 ± 0.031
1600	22.81 ± 0.08	22.75 ± 0.08	20.16 ± 0.075	7.74 ± 0.048	1.93 ± 0.025	3.48 ± 0.032	1.53 ± 0.02
1800	11.2 ± 0.1	11.18 ± 0.1	9.93 ± 0.094	3.71 ± 0.059	1.1 ± 0.034	1.6 ± 0.038	0.6 ± 0.022
2000	5.72 ± 0.021	5.71 ± 0.021	5.07 ± 0.019	1.83 ± 0.012	0.6 ± 0.0072	0.76 ± 0.0076	0.25 ± 0.0041
2250	2.61 ± 0.0088	2.61 ± 0.0088	2.32 ± 0.0083	0.78 ± 0.005	0.31 ± 0.0032	0.3 ± 0.003	0.078 ± 0.0014
2500	1.24 ± 0.0054	1.24 ± 0.0054	1.11 ± 0.0051	0.33 ± 0.0028	0.16 ± 0.002	0.11 ± 0.0016	0.021 ± 0.00066
2750	0.6 ± 0.0026	0.6 ± 0.0026	0.54 ± 0.0025	0.14 ± 0.0013	0.081 ± 0.00099	0.038 ± 0.00065	0.0055 ± 0.00024
3000	0.3 ± 0.0011	0.3 ± 0.0011	0.27 ± 0.0011	0.058 ± 0.00051	0.039 ± 0.00041	0.013 ± 0.00023	0.0016 ± 8e-05
3500	0.081 ± 0.00027	0.081 ± 0.00027	0.073 ± 0.00026	0.012 ± 0.0001	0.0089 ± 9.1e-05	0.0017 ± 3.9e-05	0.00021 ± 1.3e-05
4000	0.023 ± 7.4e-05	0.023 ± 7.4e-05	0.021 ± 7.1e-05	0.0026 ± 2.5e-05	0.0021 ± 2.2e-05	0.00031 ± 8.7e-06	4.9e-05 ± 3.3e-06
4500	0.0066 ± 2.2e-05	0.0066 ± 2.2e-05	0.006 ± 2.1e-05	0.00065 ± 6.7e-06	0.00051 ± 5.9e-06	8.6e-05 ± 2.5e-06	1.7e-05 ± 1e-06
5000	0.002 ± 6.5e-06	0.002 ± 6.5e-06	0.0018 ± 6.2e-06	0.00018 ± 2e-06	0.00014 ± 1.7e-06	2.8e-05 ± 7.7e-07	6.5e-06 ± 3.6e-07
6000	0.00021 ± 6.9e-07	0.00021 ± 6.9e-07	0.00019 ± 6.6e-07	2.2e-05 ± 2.3e-07	1.4e-05 ± 1.8e-07	5.3e-06 ± 1.1e-07	1.4e-06 ± 5.5e-08

MC Syst

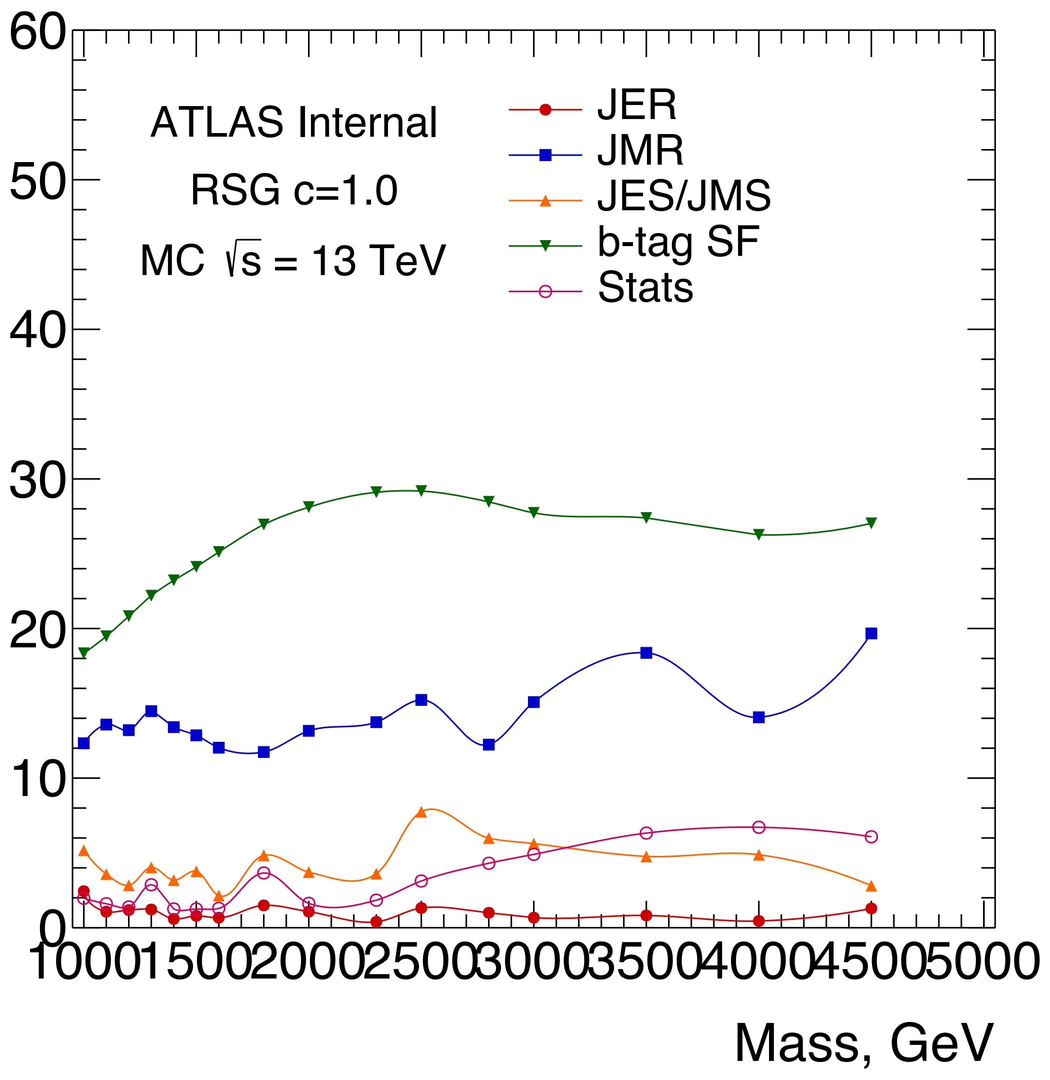
NEW **2bs**



3b



4b

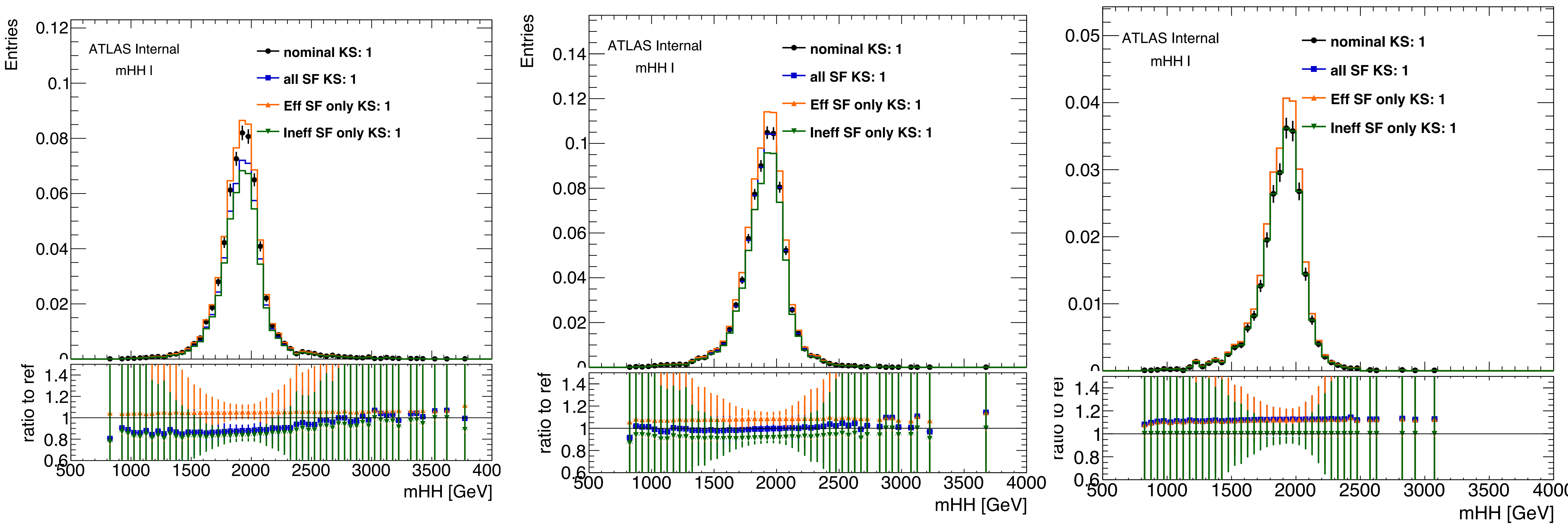


- Systematics up to 5 TeV seems reasonable
- Jet uncertainties grow larger

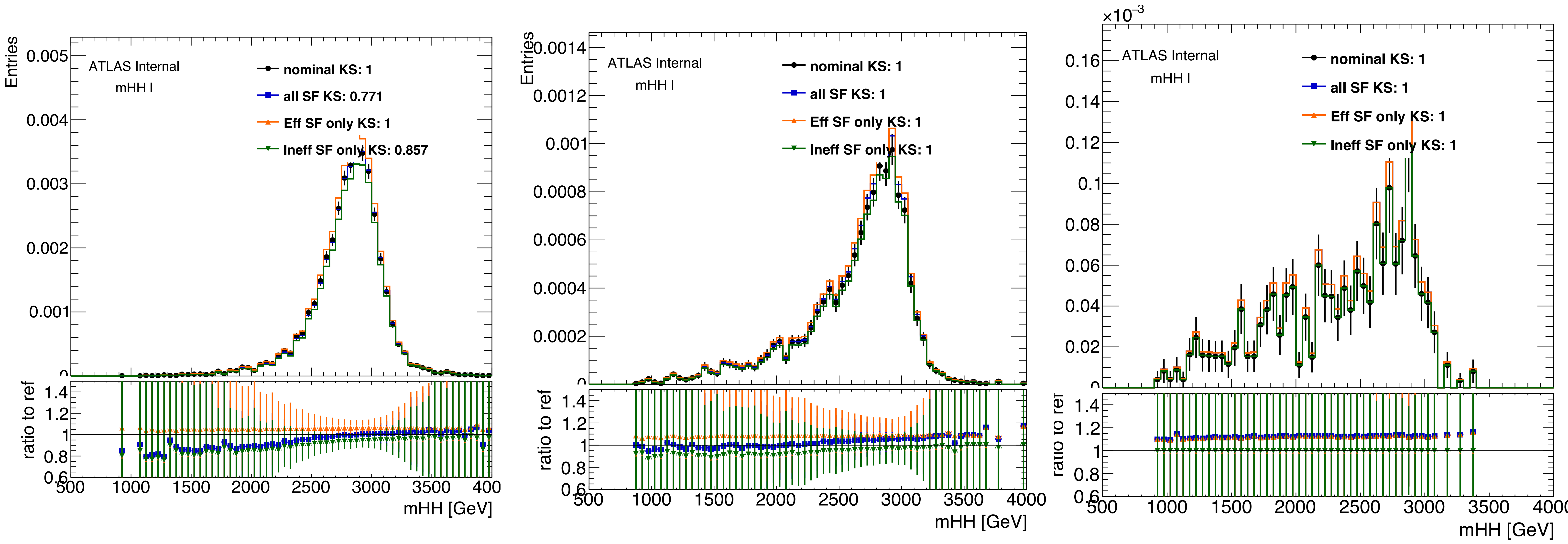
Detailed Study

- The reason 3 TeV 2bs b-tag SF uncertainty is smaller is because of the **anti-correlation** between the efficiency SF and the inefficiency SF
- Plotting:
    - Nominal: applying the normal SF
    - All SF: applying all the FT_EFF_Eigen_B_0__1down variation
    - EFF SF only: only apply the variation if the jet is b-tagged
    - Ineff SF only: only apply the variation if the jet is non-b-tagged
- 2bs 2 TeV have **larger impact from the inefficiency SF**, compared to 3 TeV, thus the smaller variation
- More on this can also be find on the 2015 Internal note section O

2TeV 2bs 3b 4b

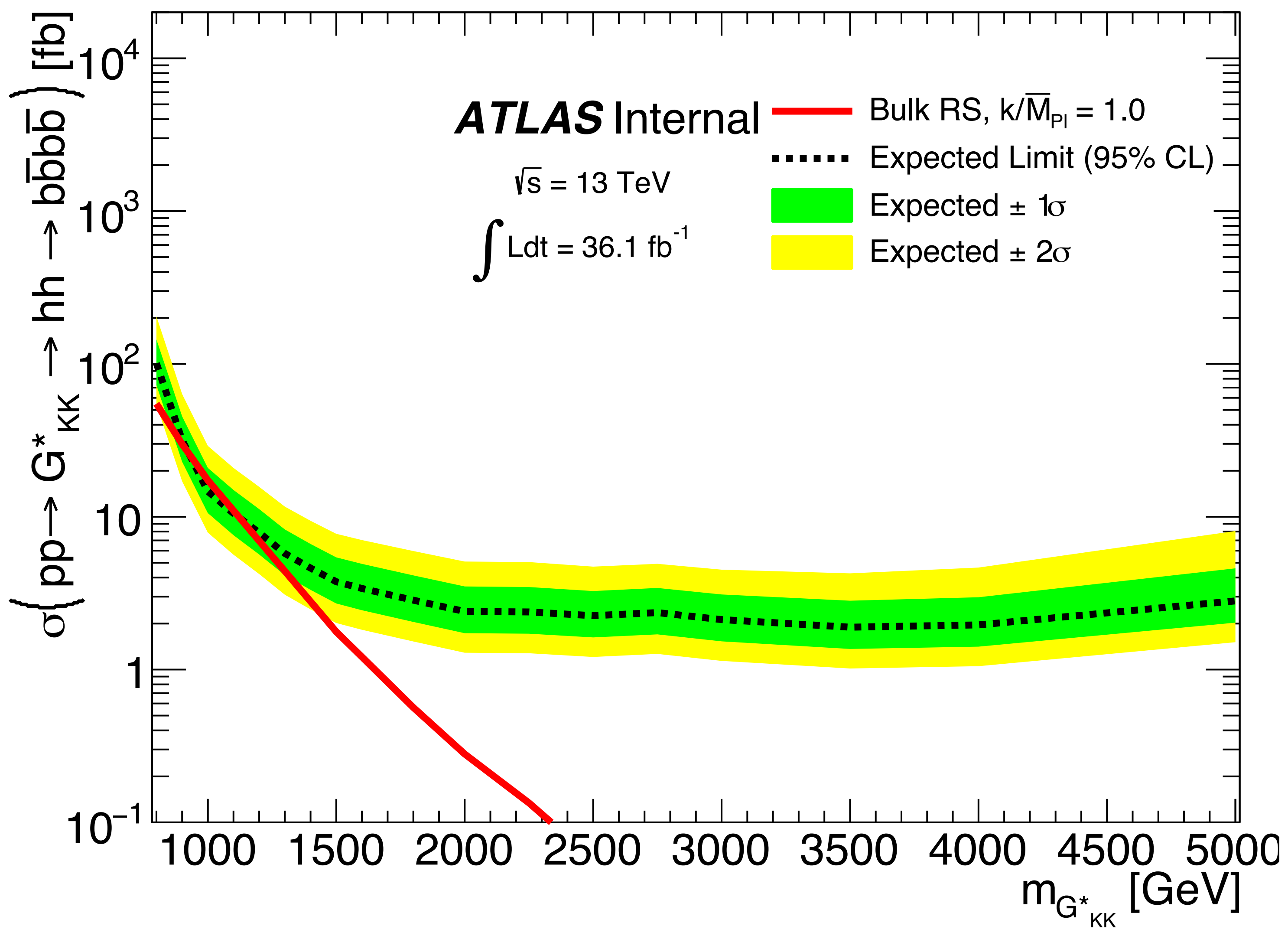


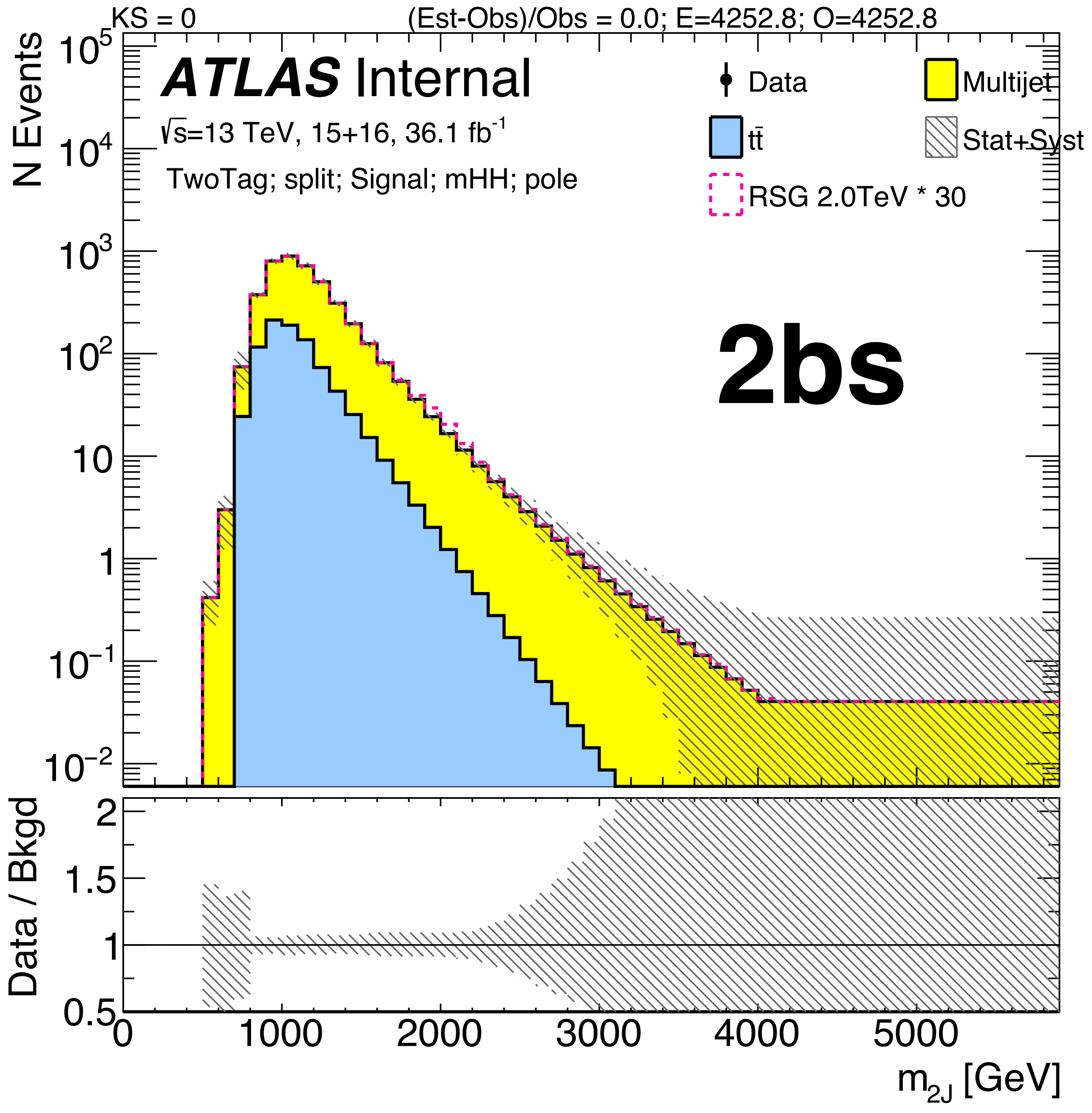
3TeV 2bs 3b 4b

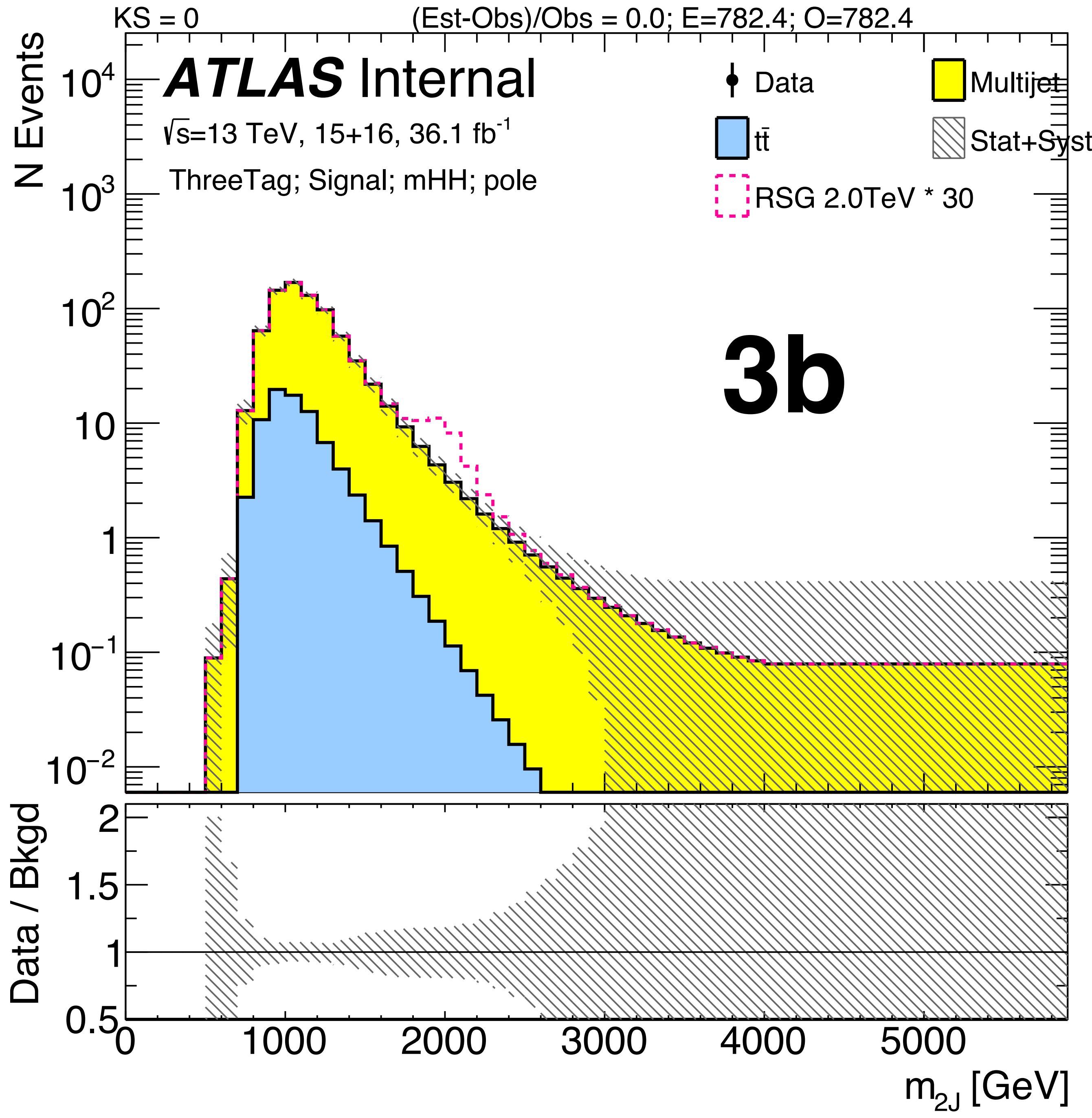


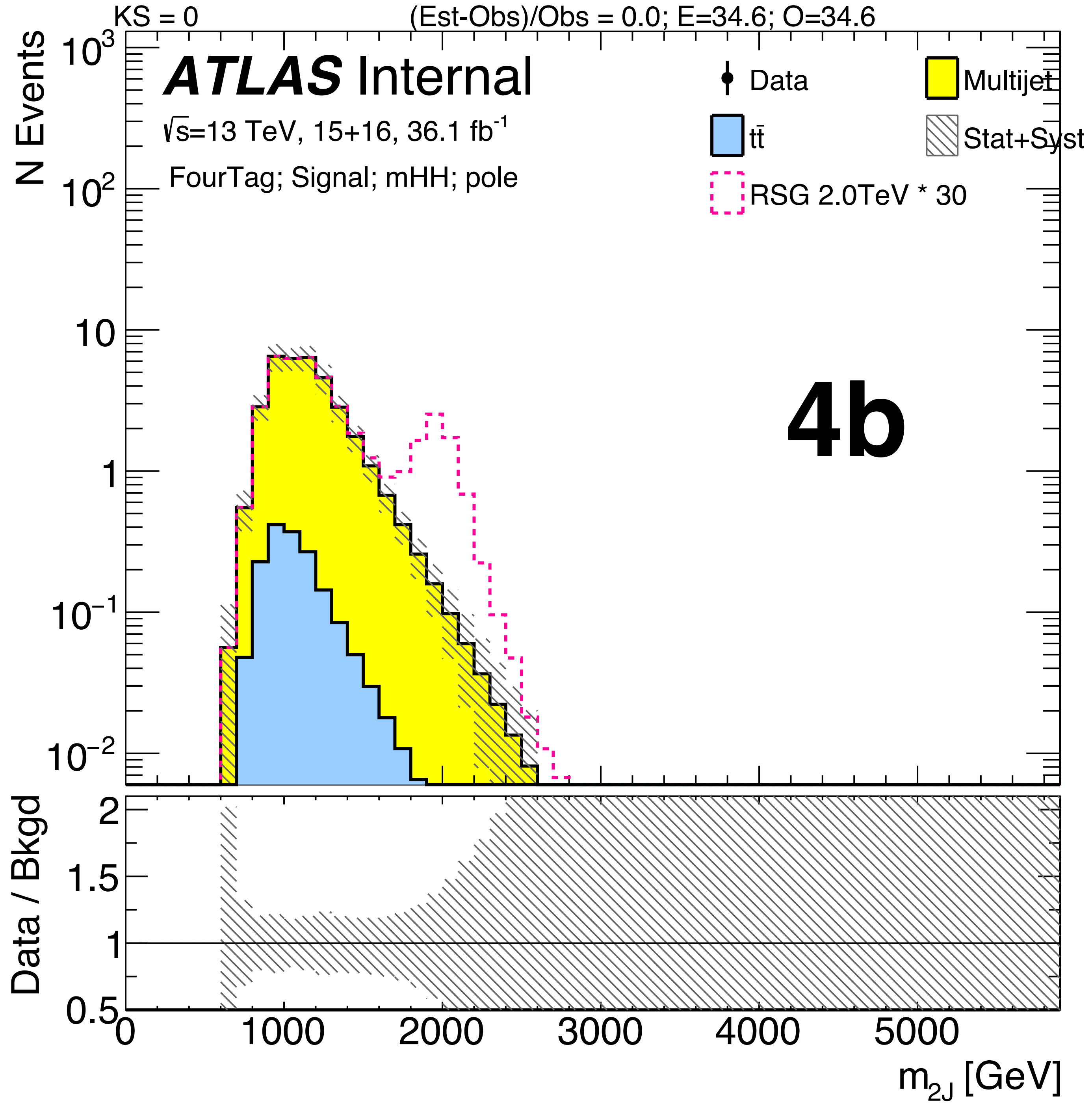
Signal Region Predictions

- Use the last non-increasing bin if the functional form starts to increase in the tail, hence the flat prediction
- Limits could be evaluated up to 5 TeV







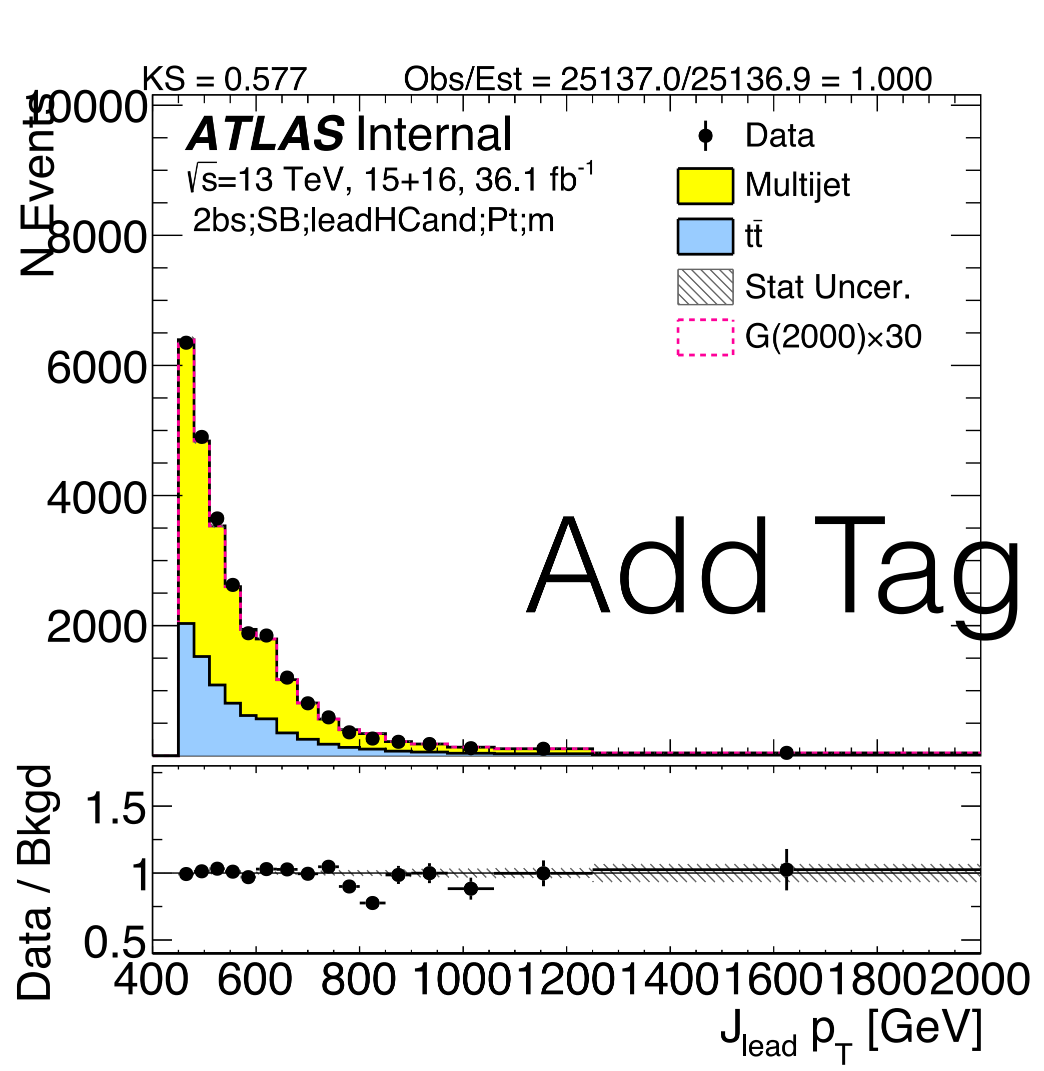


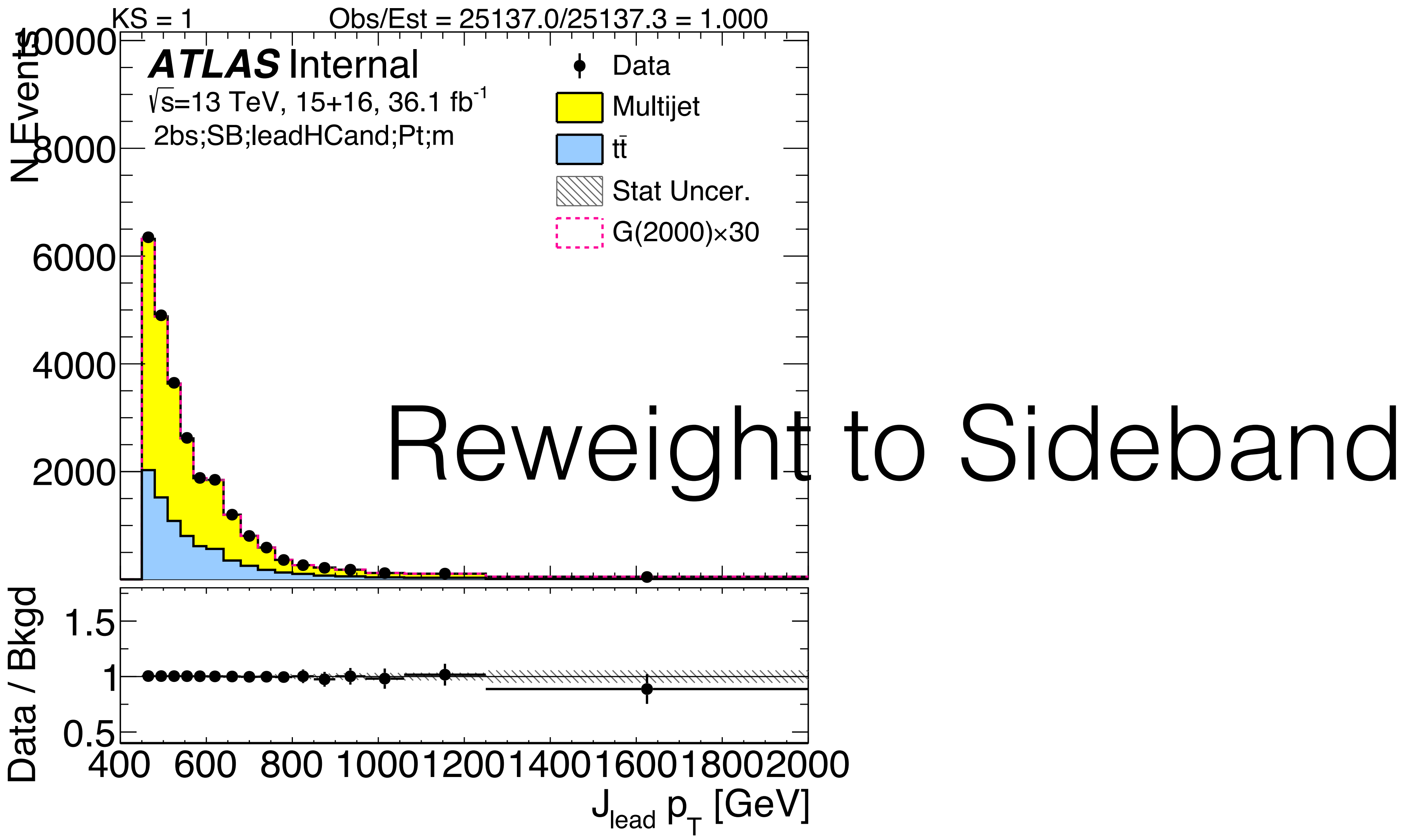
Introduction of Method

- List of investigations: (all in SB)
  - The dip in 2bs SB large-R jet pT at 800 GeV
  - The 3b sublHcand pT in SB
  - The deficit in 3b SB MJJ around 2000 GeV
  - The leadHCand lead trkjet pT discrepancy at low pT (2bs and 3b)

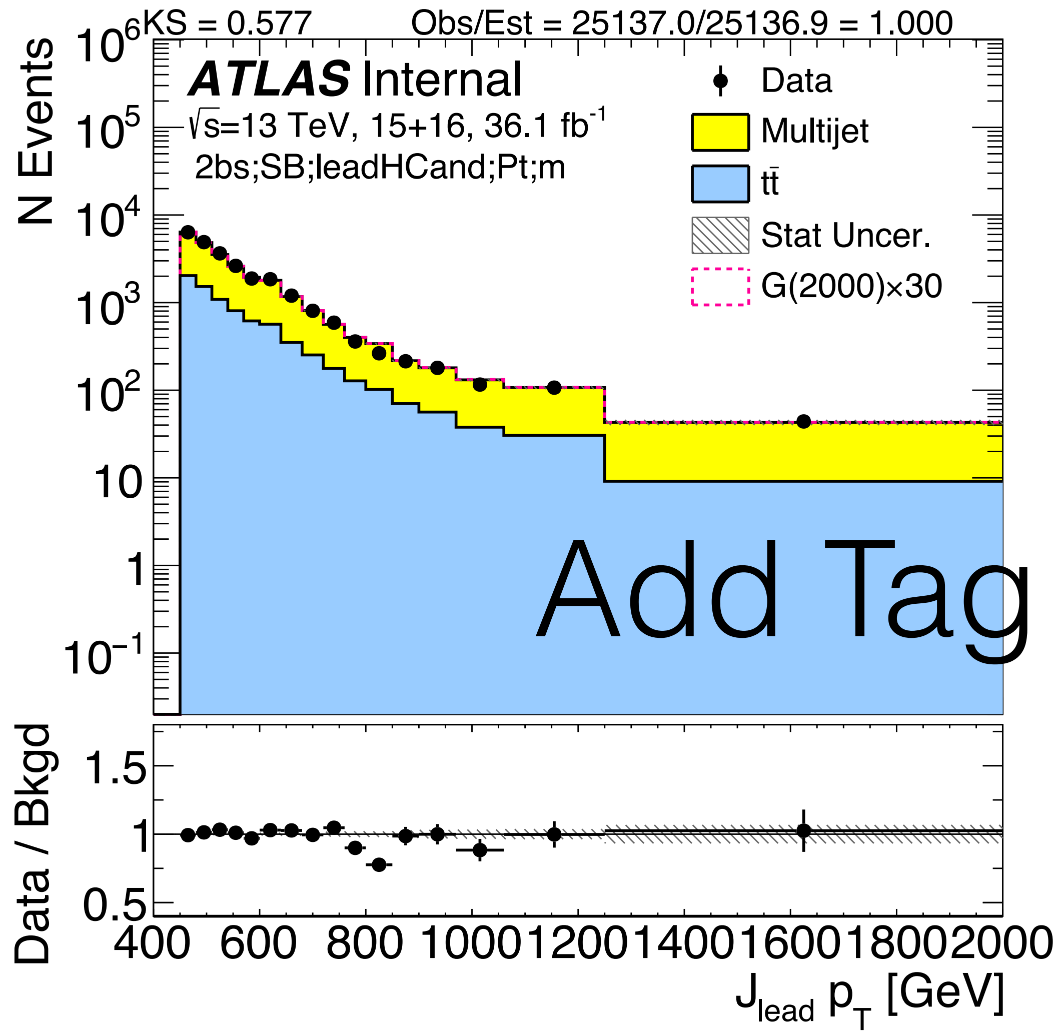
- In general, no significant mis-modeling; could come from statistical fluctuations
- Can test the old reweighting method where leadingHcand pT and all track jets pT in the 1b/2b/2b samples are reweighed to 2bs/3b/4b sideband region distributions
- Will by definition have better modeling and can then compare SR predictions

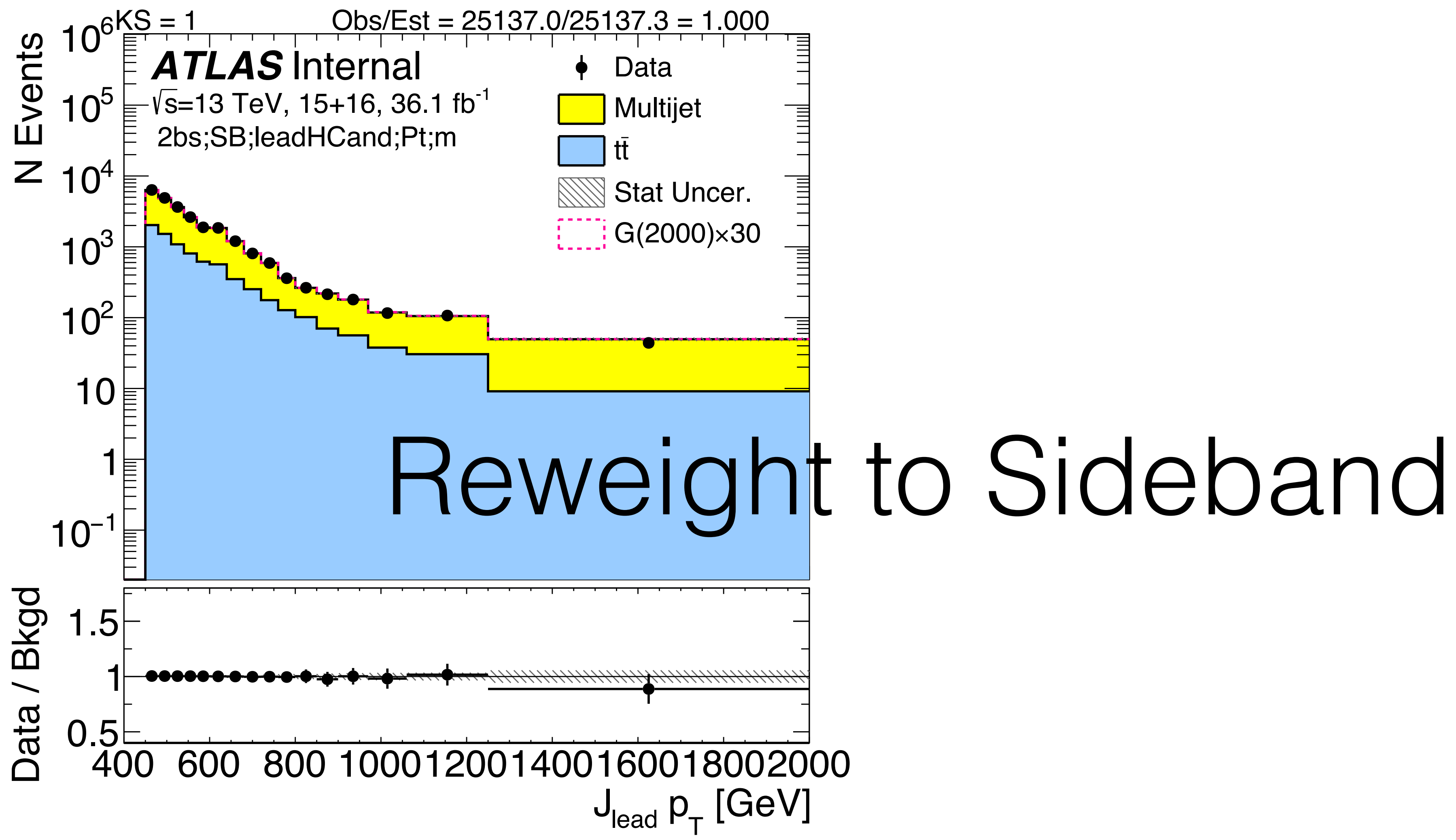
The dip in 2bs SB large-R jet pT at 800 GeV





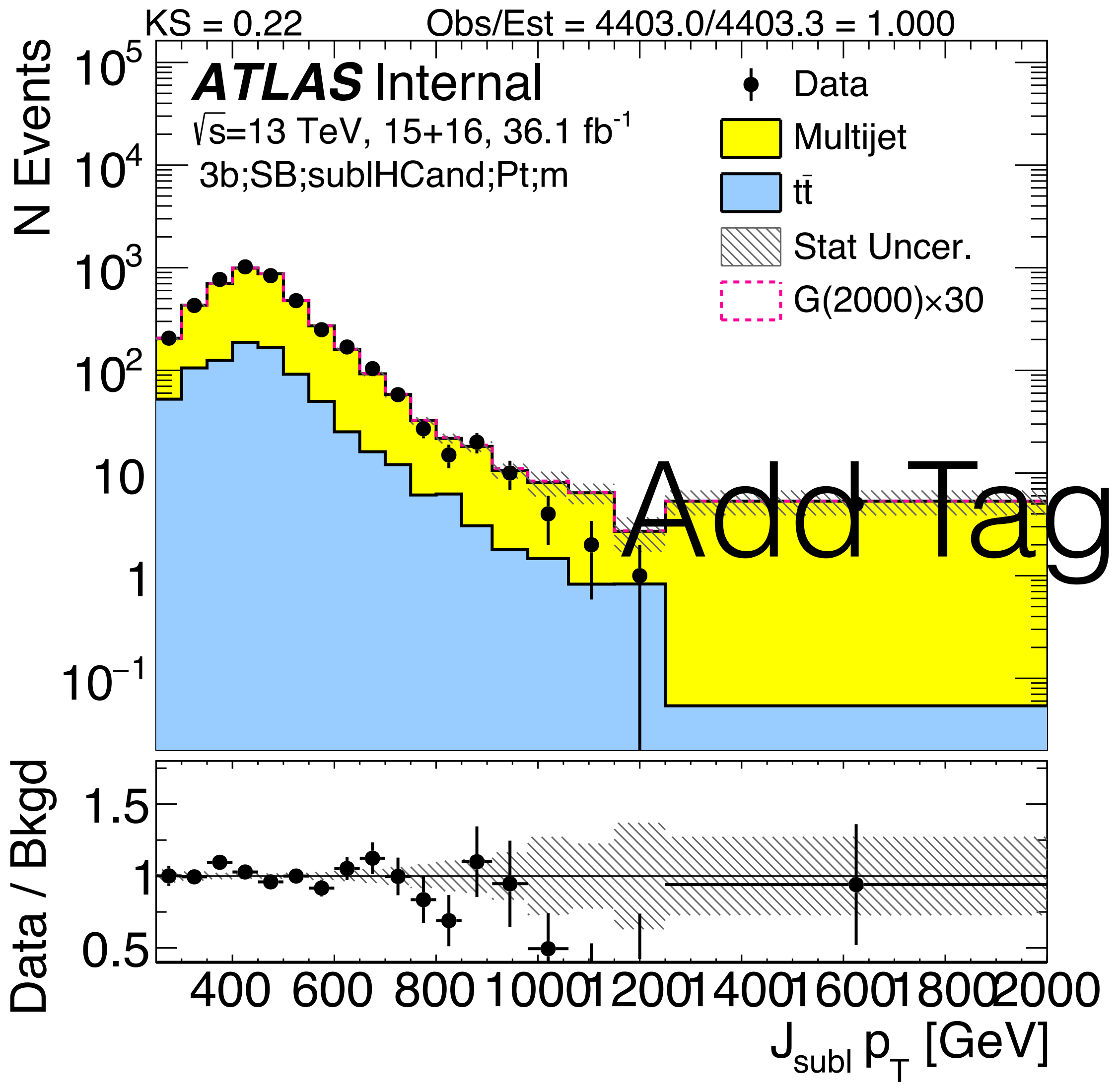
- Better modeling of these variables by construction

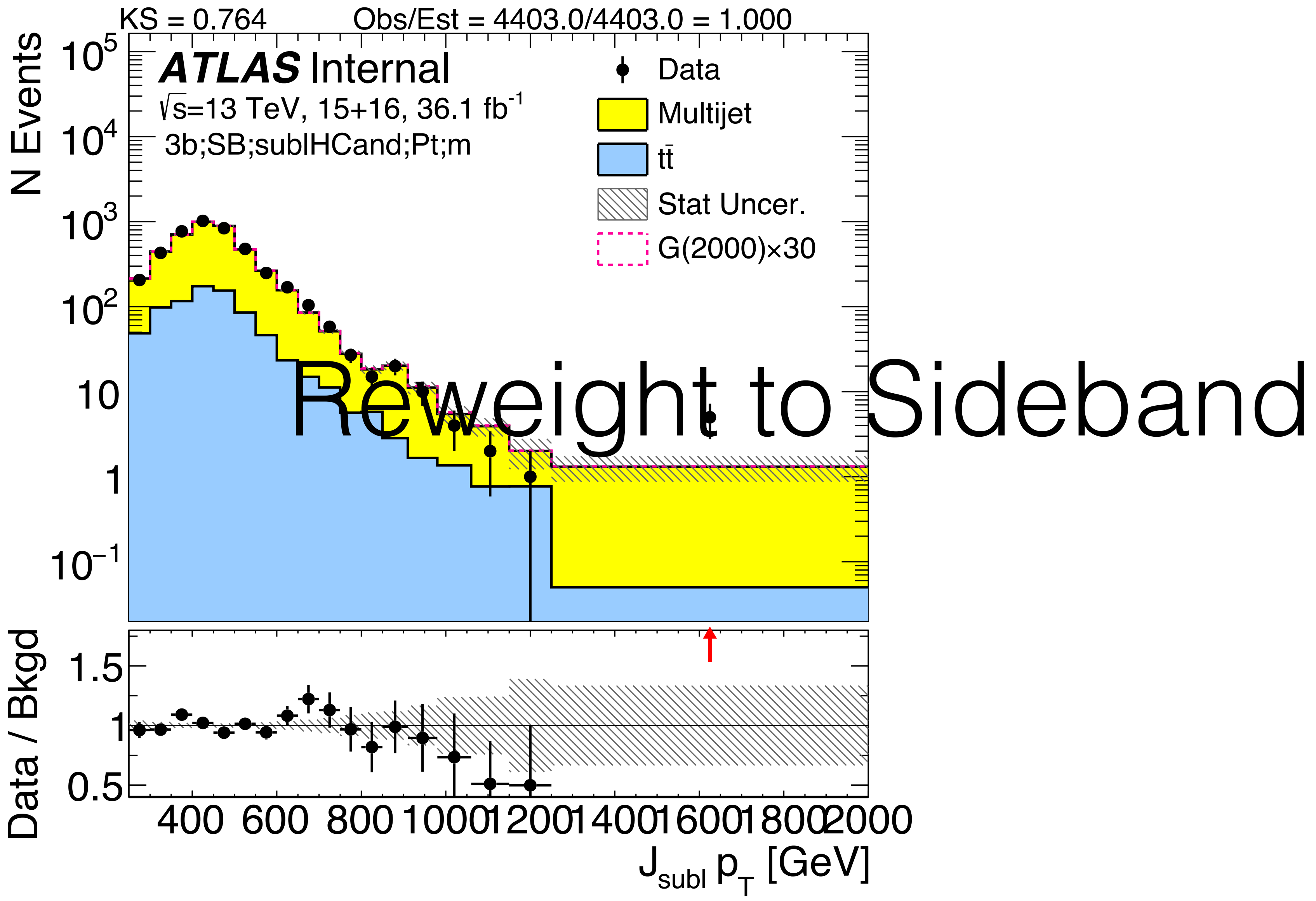


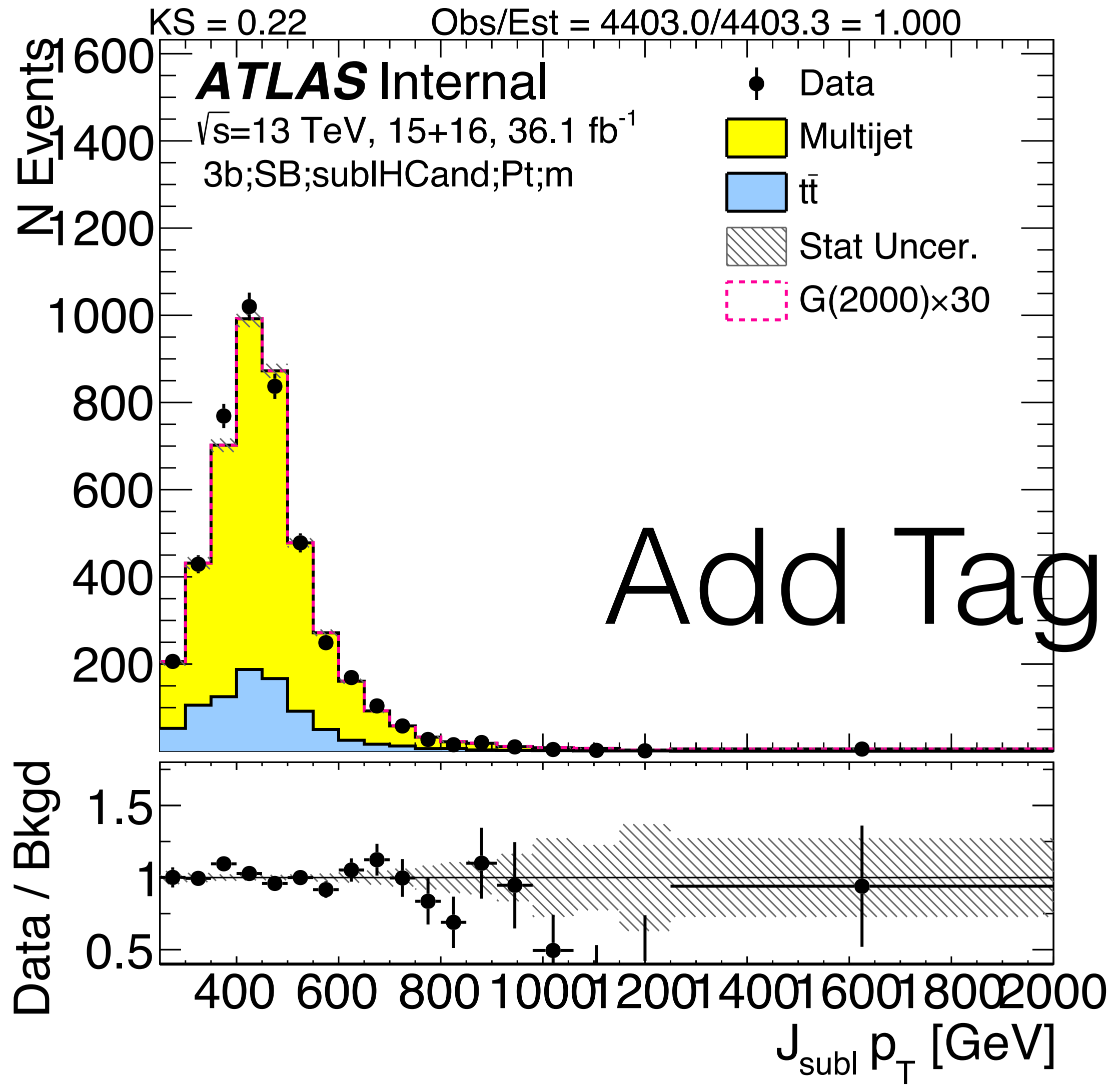


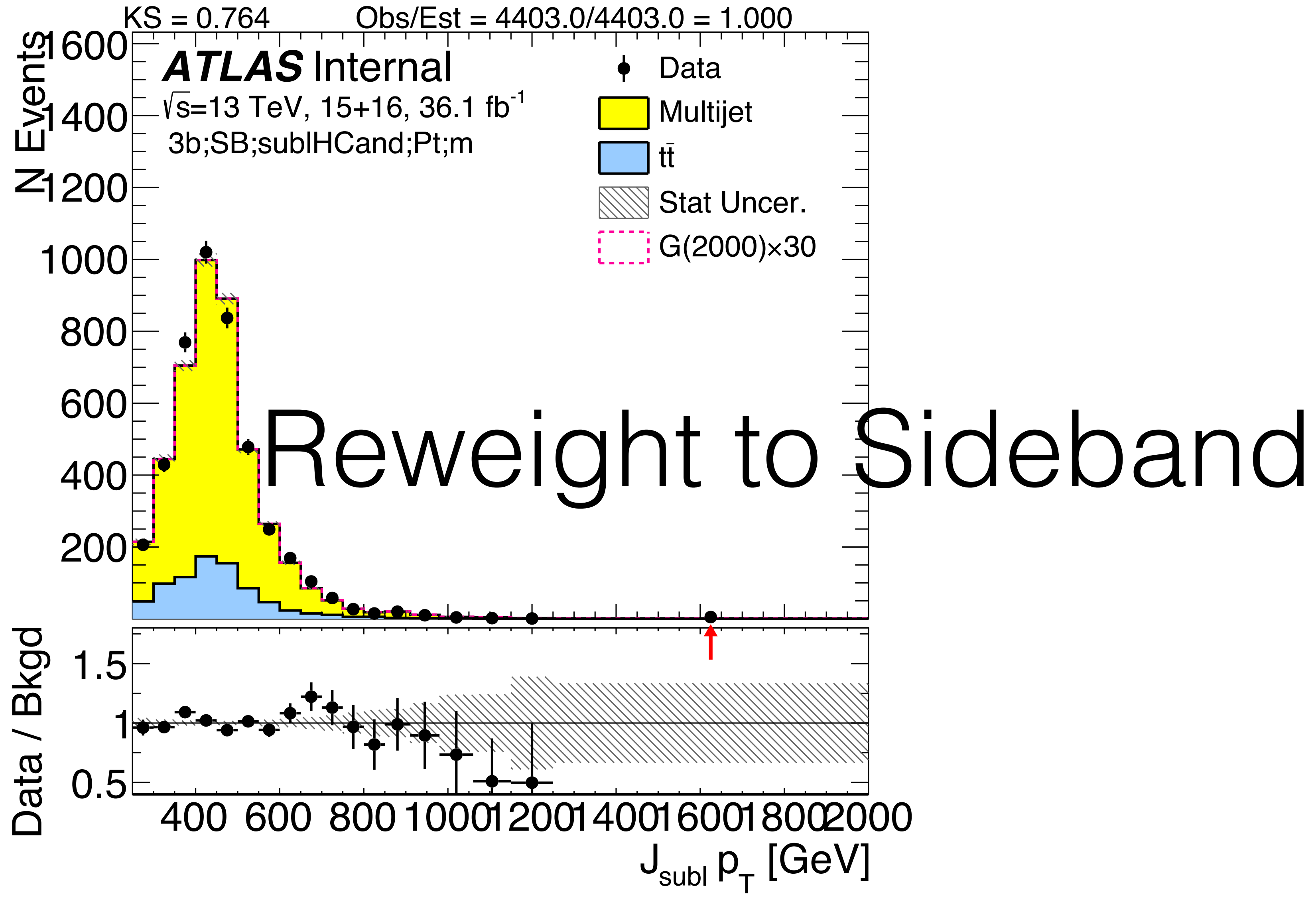
The 3b sublHcand pT in SB

- Comparable modeling, since this variable in the reweight to sideband case is not reweighed directly



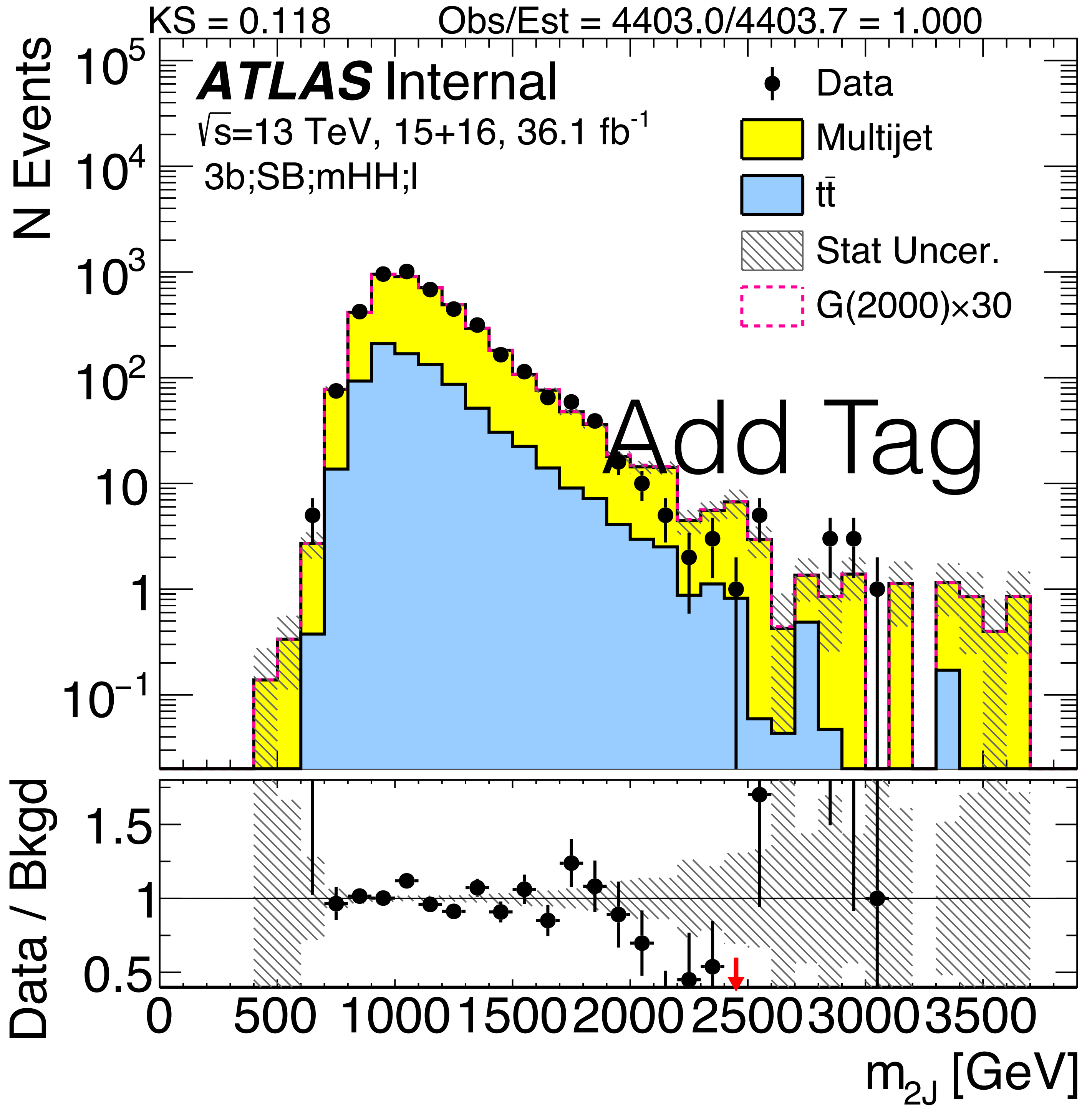


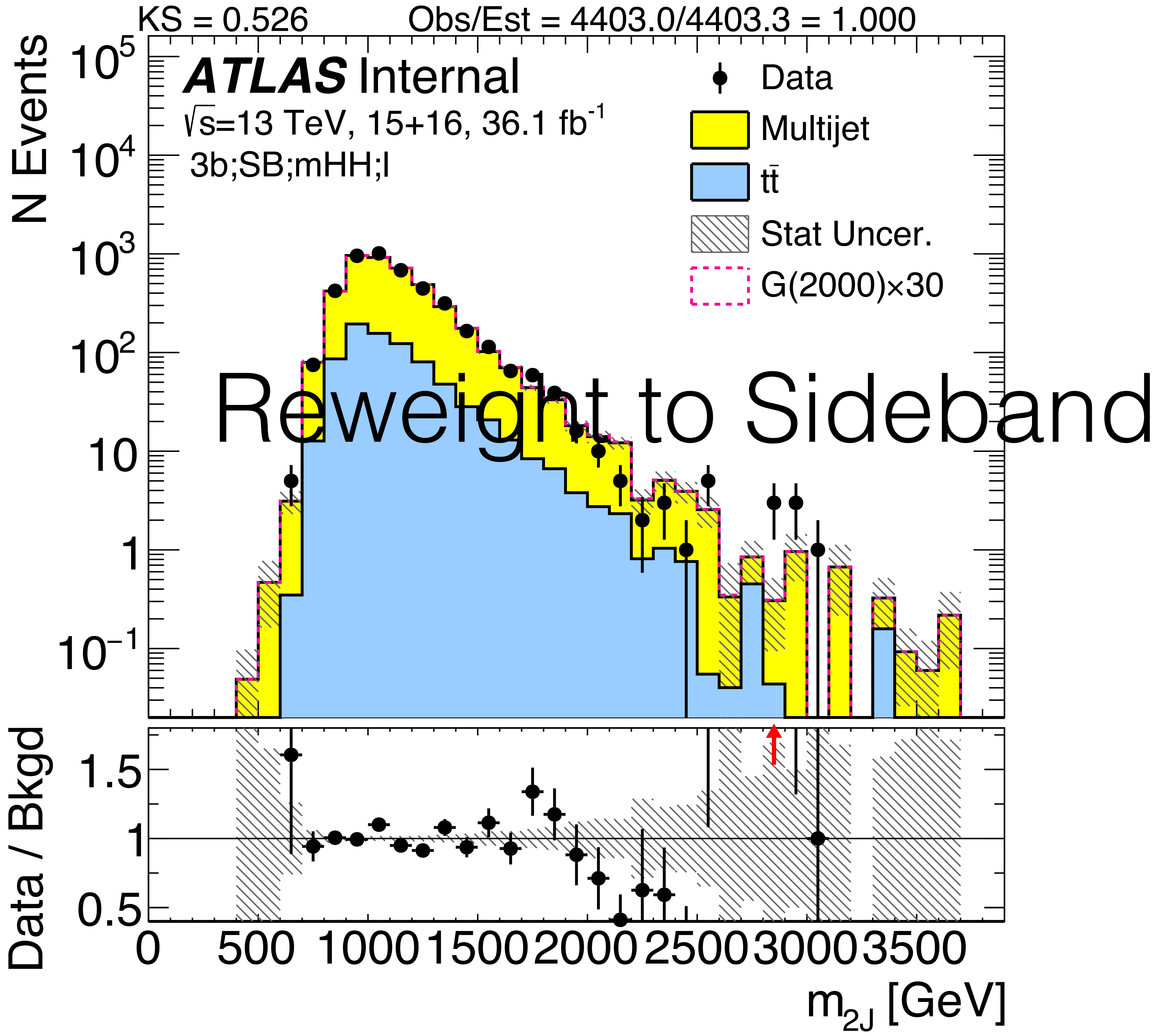




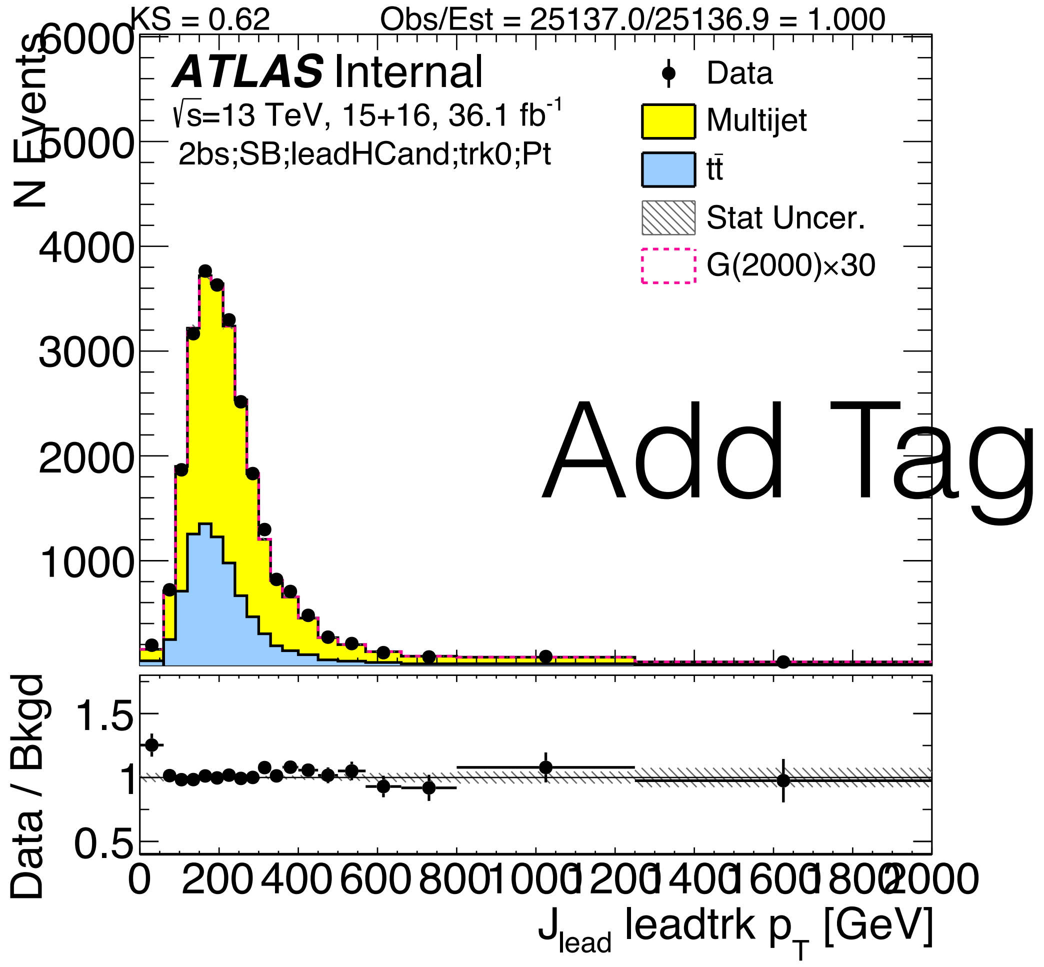
The deficit in 3b SB MJJ around 2000 GeV

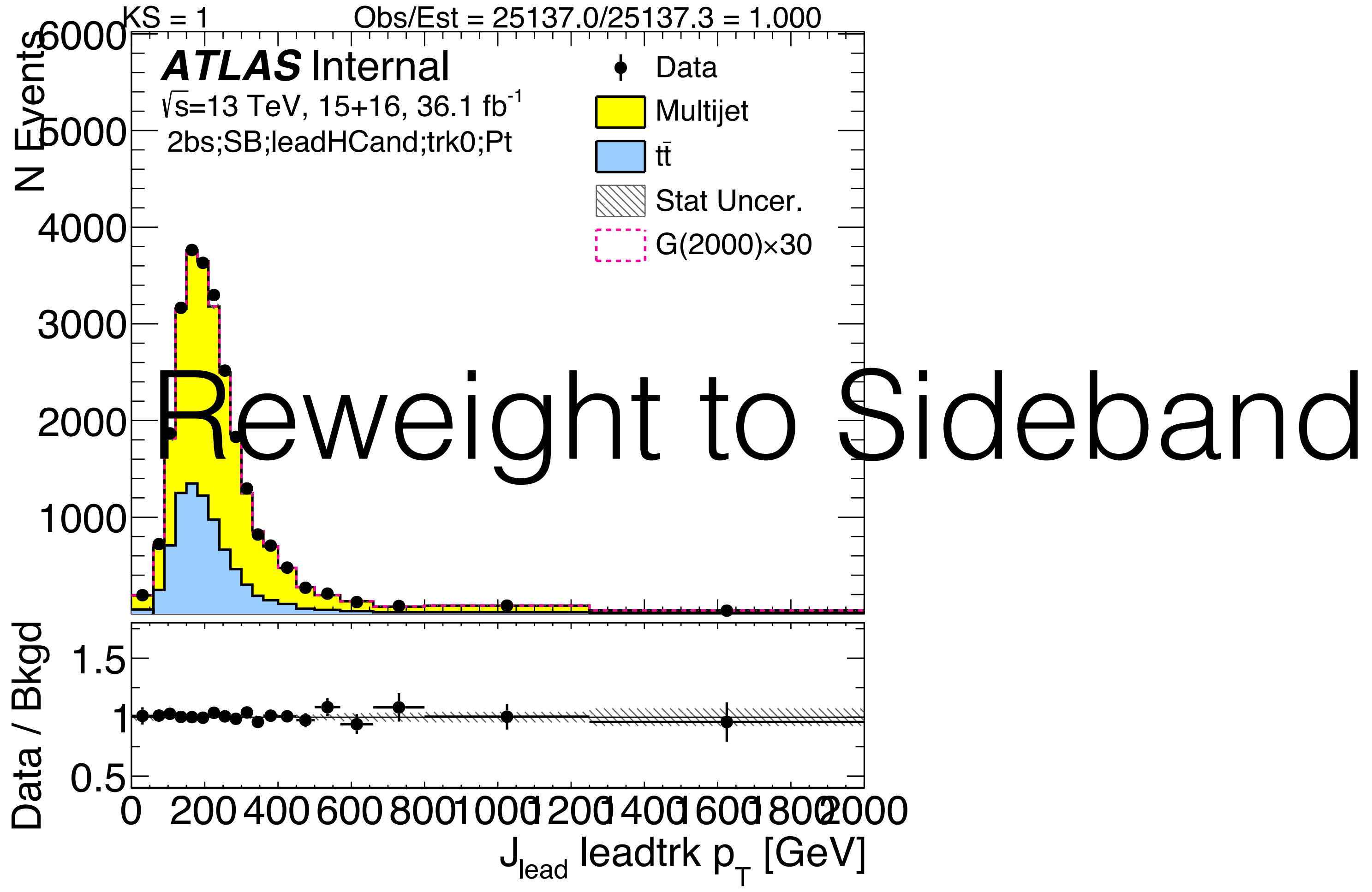
- Dip still observed
- Fluctuation in data is non-smooth



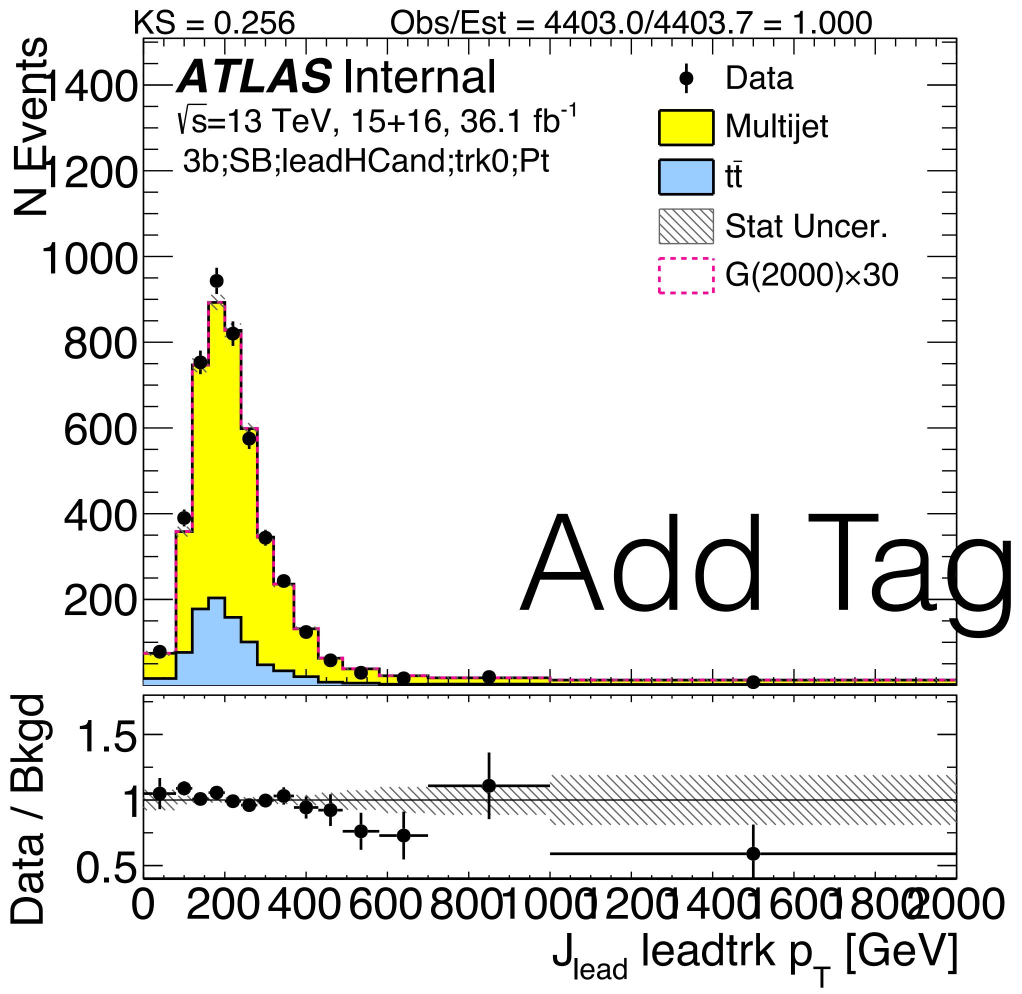


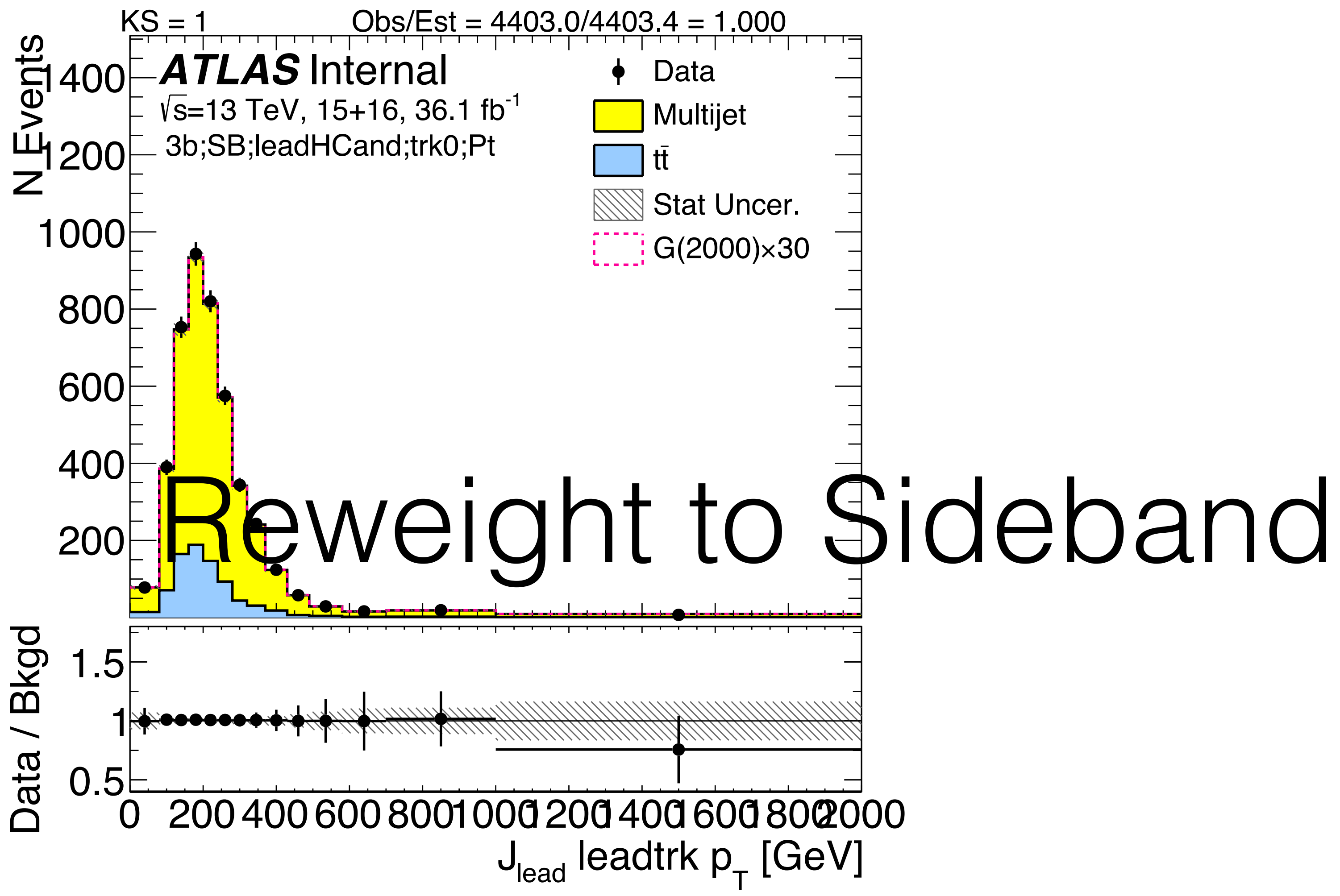
The leadHCand lead trkjet pT at low pT (2bs/3b)





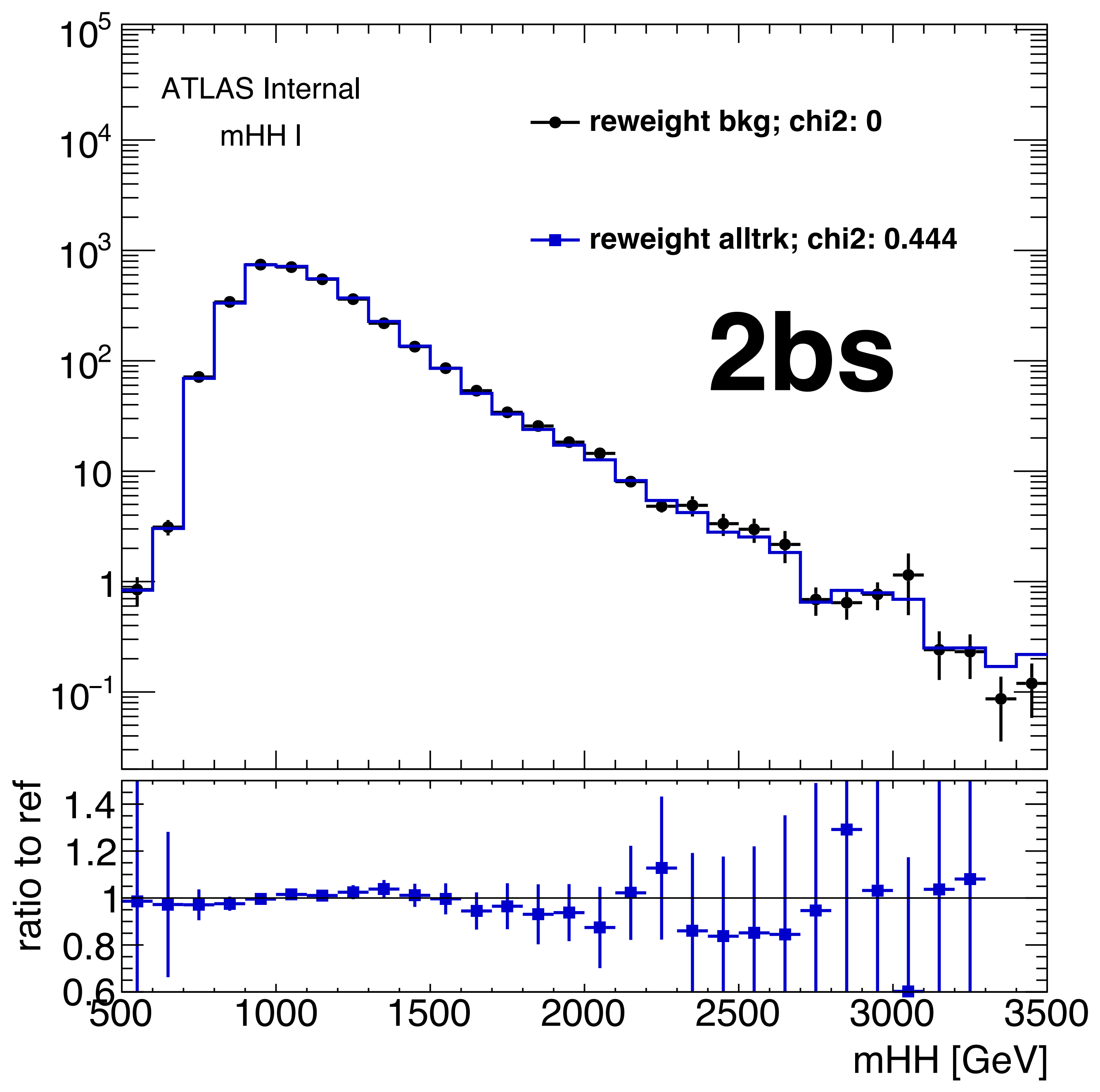
- First bin issue in the Add Tag method gets solved

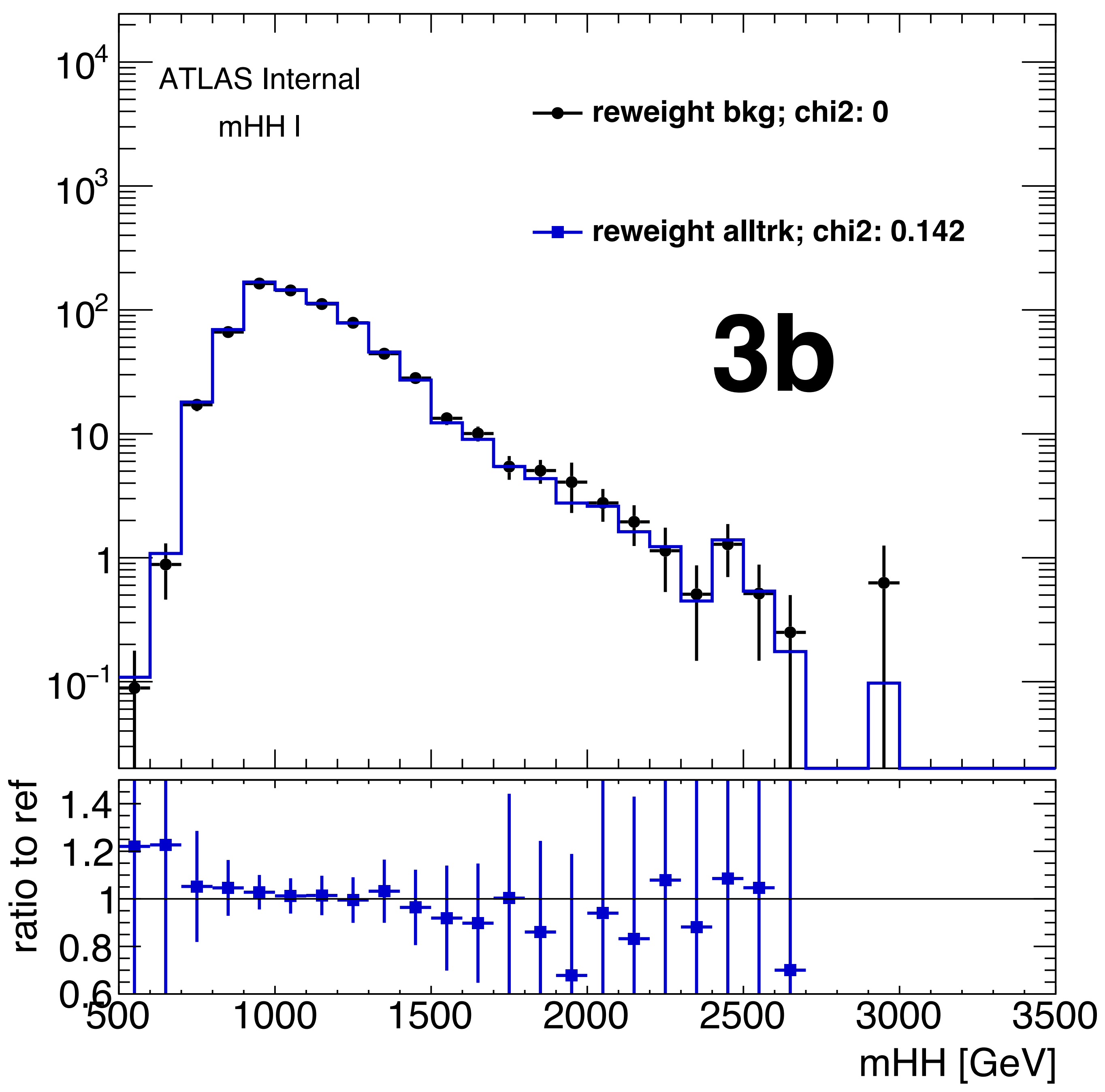




Different Method's Impact on SR prediction

- Here the qcd background estimations from the AddTag and the sideband reweighting is directly compared, without normalizing
- Almost all bin's value agrees within statistical uncertainty
- The impact of the potential mis-modeling on the signal region mJJ is minimal





Back up Slides

Functional Form variations

Name	Functional Form
MJ1 (Dijet)	$f_1(x) = p_0(1-x)^{p_1} x^{p_2}$
MJ2	$f_2(x) = p_0(1-x)^{p_1} e^{p_2 x^2}$
MJ3	$f_3(x) = p_0(1-x)^{p_1} x^{p_2 x}$
MJ4	$f_4(x) = p_0(1-x)^{p_1} x^{p_2 \ln x}$
MJ5	$f_5(x) = p_0(1-x)^{p_1} (1+x)^{p_2 x}$
MJ6	$f_6(x) = p_0(1-x)^{p_1} (1+x)^{p_2 \ln x}$
MJ7	$f_7(x) = \frac{p_0}{x}(1-x)^{p_1 - p_2 \ln x}$
MJ8	$f_8(x) = \frac{p_0}{x^2}(1-x)^{p_1 - p_2 \ln x}$

- Default is MJ8, vary smoothing function in SR prediction