Study of the SecVtx- SLT_{μ} tagged W+jets sample

Full Status

A. Taffard[a], T. Liss[a], L. Cerrito[b]

a) *University of Illinois, Champaign*

b) *University of Oxford*

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Outline

- Aim
  - Understand the double tag (SecVtx-SLT) sample
  - Look for any discrepancy between prediction & data
    - ✓ Counting (& kinematics)
- Method
  - Starting point SecVtx prediction (with/without H_T) using 162 pb^{-1}
  - Determining the efficiencies to get SLT tag in SecVtx tag jet/event
    - ✓ Wbb, Wcc, Wc, Diboson, single top, tt, Z+HF (MC)
    - ✓ NonW (Data)
    - ✓ Mistags (Data+MC)
- Putting it all together
- Summary

SecVtx Summary Table

- Summary table from PRD-cdf7138, Table XIII
  - ✓ With split for Diboson, single top, Z+HF (thanks Jason)

- Normalize to SecVtx measured tt cross section in >=3 jets

$$\sigma_{t\bar{t}} = 5.6^{+1.2}_{-1.1}(\text{stat.})^{+0.9}_{-0.6}(\text{sys.})$$

and propagate measured tt (& error) to 1 & 2 jet bins

- For >=3 jets: scale individual Mistags, Wbb, Wcc, Z+HF to corrected background for tt contribution in pretag
  - ✓ 1.14 no H_T
  - ✓ 1.32 with H_T

SecVtx Summary Table (cont.)

	W+1TJ	σ	W+2TJ	σ	No HT W+>=3TJ	σ	wHT W+>=3TJ	σ
Mistags	40.9	± 6.1	17	± 2.4	6.84	± 0.71	4.23	± 0.38
Wbb	37	± 11.2	22.5	± 6.5	5.78	± 1.22	3.17	± 0.68
Wcc	13.7	± 3.4	8	± 2.2	1.93	± 0.47	1.06	± 0.27
Wc	34.5	± 9	7.7	± 2	1.49	± 0.36	0.76	± 0.17
WW	0.06	± 0.1	1.2	± 0.2	0.4	± 0.00	0.12	± 0.01
WZ	0.5	± 0.1	1.1	± 0.2	0.3	± 0.10	0.12	± 0.01
ZZ	0.0	± 0.0	0.1	± 0.0	0.0	± 0.00	0.1	± 0.00
Z->ττ	1.1	± 0.2	0.3	± 0.1	0.0	± 0.00	0.0	± 0.00
nonW QCD	24.3	± 3.5	10.5	± 1.9	4.8	± 0.81	2.9	± 0.50
Single Top (S)	0.6	± 0.1	2.1	± 0.2	0.7	± 0.10	0.5	± 0.10
Single Top (T)	2	± 0.2	2.5	± 0.3	0.6	± 0.10	0.5	± 0.10
Zbb	0.7	± 0.2	0.3	± 0.1	0.09	± 0.09	0.04	± 0.02
Zcc	0.4	± 0.1	0.3	± 0.1	0.09	± 0.09	0.04	± 0.02
Expected ttbar	0.91	± 0.08	7.02	± 0.62	33.90	± 3.00	34.50	± 1.80

Scale to corrected bkg

$$N_{t\bar{t}} = (N_{tag} - N_{bkg}^{corr}) \mp \delta N_{bkg}^{corr}$$

tt in 1(2) jet bin determined by scaling $N_{tt}^{>=3j}$ by $R_{tt}^{3\to2}$ ($R_{tt}^{3\to1}$)

MC ε_{HJ} for Wbb, Wcc, Wc, Diboson, single top, tt

- ε_{HJ}: Efficiency to get an SLT tag in same SectVtx tag jet / event

$$\epsilon_{HJ} = \frac{N^R_{SLT} + N^F_{SLT} \times (1 - F_{hf})}{N_{SVX}}$$ for each jet bin

where

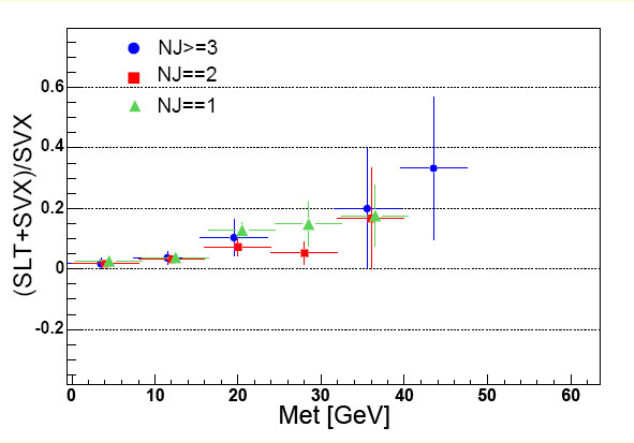
- N^R_{SLT}: # of event with a real SLT Tag in SVX tag jet
- N^F_{SLT}: # of event with a fake SLT Tag in SVX tag jet
- F_{hf}: fraction of Heavy Flavor in SLT fake matrix
- N_{SVX}: # of event with SVX Tag

- Wbb/Wcc: combined all 1,2,3 parton files to reduce stat. uncertainty
- $\varepsilon^{Wc}_{HJ} = \varepsilon^{Wcc}_{HJ}$

Data

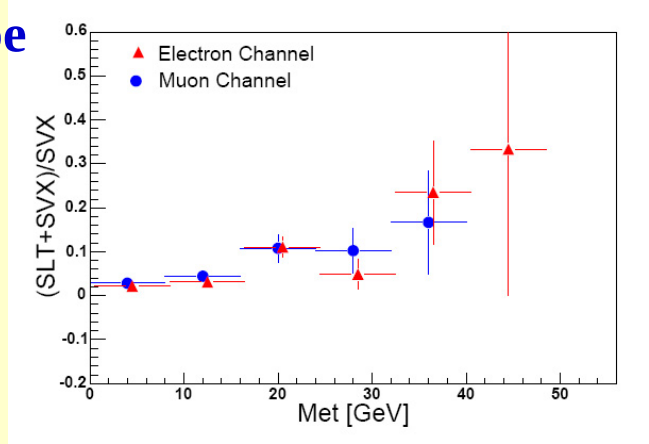
ε_{HJ} for NonW

ε_{HJ} independent of nJet

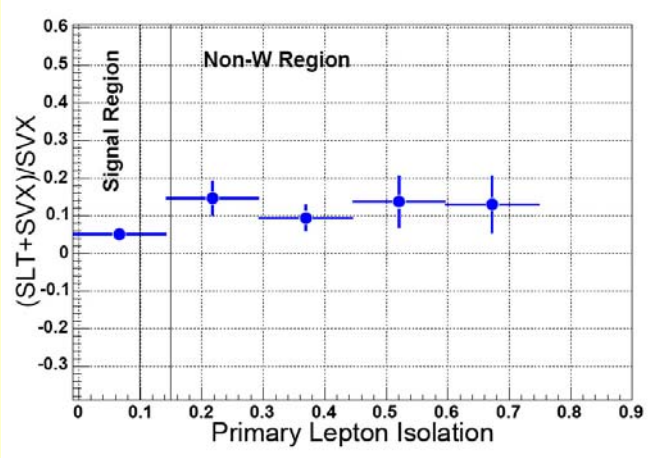


SLT tag rate usually dependent on Met

ε_{HJ} independent of TL type



ε_{HJ} independent of TL Iso



Combine all jet bins & TL

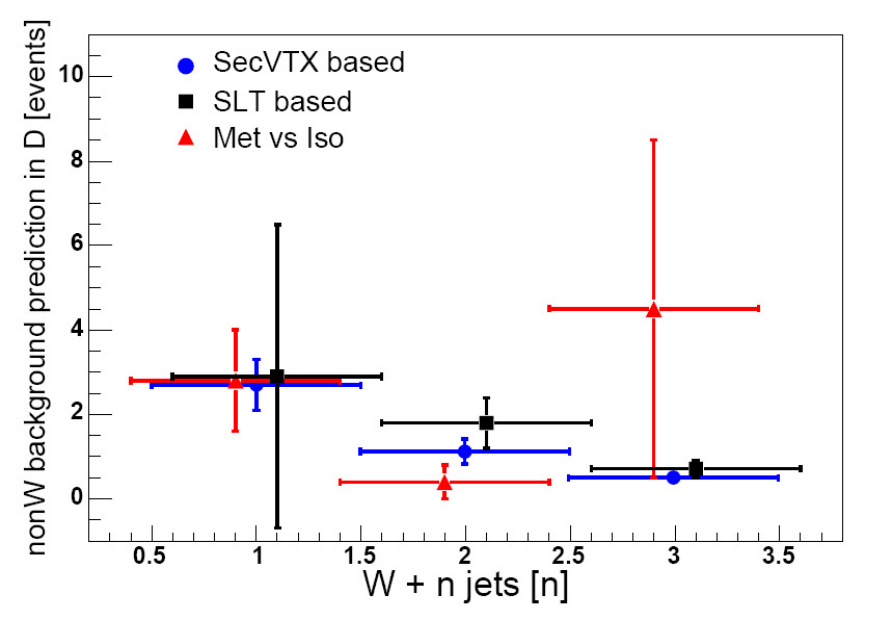
Measure ε_{HJ} in Region C

$$\epsilon_{HJ}^{\text{nonW}} = \frac{N_{SLT}}{N_{SVX}} = 11 \pm 2\%$$

ε_{HJ} for NonW cross check

- Use same method but starting from the SLT tag jet
  - Similar featur, small dependency on TL type ε'_{HJ} = 18 ± 4 %
- Use Met-Iso HJ plane to get N_{nonW}

Jet Multiplicity	W+1j	W+2j	W+≥ 3
SLT analysis (194 pb^{-1})	19.6±24.2	12.4± 3.5	1.6±0.3(*)
SecVTX analysis (164 pb^{-1})	24.3± 3.5	10.5±1.9	4.8±1.7
ϵ_{SLT}	0.11±0.02	0.11±0.02	0.11±0.02
ϵ_{SVX}	0.18±0.04	0.18±0.04	0.18±0.04
SecVTX based estimate	2.7±0.6	1.1±0.3	0.5±0.2
SLT based estimate	2.9±3.6	1.8±0.6	0.7±0.2
Met-Iso	2.8±1.2	0.4±0.4	4.5±4.0



3 methods show consistent results

Data & MC

Determining ε_{HJ} (cont)

❖ Mistags

$$\epsilon_{HJ}^{mistag} = N_{tagg}^{SLT} \cdot < FR > \cdot (1 - F_{hf})$$

where

- N^{SLT}_{tagg}: mean # SLT taggable track in SectVtx Neg tag jet in W+jets MC (2 → 3)
- <FR>: SLT average fake rate (0.7% ± 0.07 %)
- F_{hf}: fraction of Heavy Flavor in SLT fake matrix (21.0 ± 1.4 %)

Assume that get 1 SecVtx mistag per event

Very small contribution.

May revise this.

ε_{HJ} Systematic Uncertainty

- For the real part
  - $\pm 1\sigma$ of the ε_{SLT} parameterization $\rightarrow$ 1%
  - Systematic error on ε_{SLT} due to the non-isolation $\rightarrow$ +0%, -8%
- For the fake part
  - Systematic error on the SLT fake matrix $\rightarrow$ 10%
- Common to both
  - Systematic error on the SF tracking reconstruction $\rightarrow$ 5%

- Take the systematic $\delta\epsilon_{HJ}^{t\bar{t}\ sys}$ & $\delta\epsilon_{HJ}^{bkg_i\ sys}$ as correlated

ε_{HJ} summary table

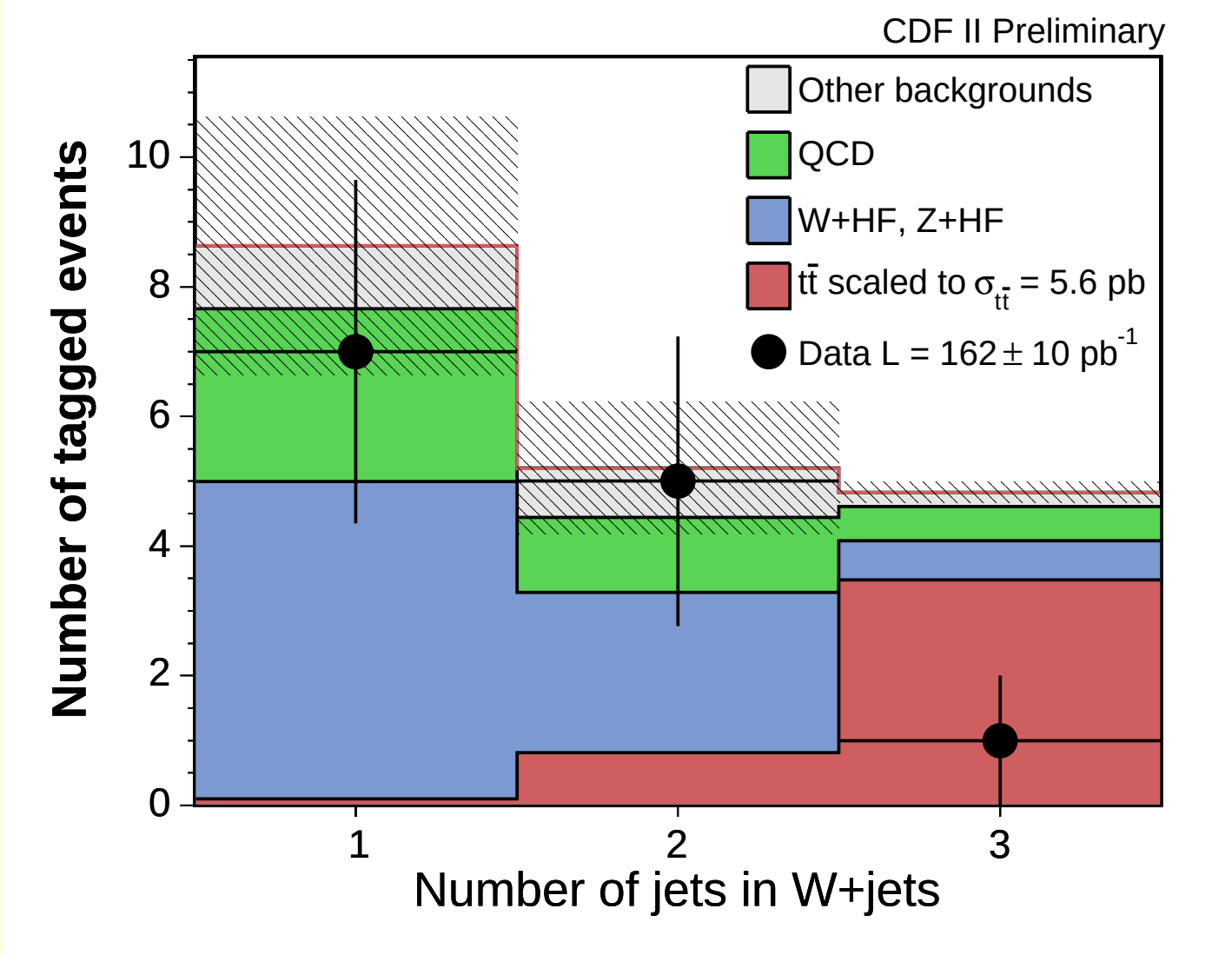
							No HT			wHT		
	W+1TJ		σ	W+2TJ		σ	W+>=3TJ		σ	W+>=3TJ		σ
Mistags	0.017	±	0.002	0.014	±	0.002	0.012	±	0.001	0.010	±	0.001
Wbb	0.072	+	0.006	0.080	+	0.006	0.078	+	0.007	0.082	+	0.009
		-	0.008		-	0.009		-	0.010		-	0.011
Wcc/Wc	0.045	+	0.005	0.040	+	0.005	0.042	+	0.007	0.046	+	0.008
		-	0.006		-	0.006		-	0.007		-	0.009
WW	0.029	+	0.007	0.035	+	0.006	0.038	+	0.010	0.043	+	0.013
		-	0.007		-	0.007		-	0.010		-	0.014
WZ	0.043	+	0.017	0.086	+	0.019	0.063	+	0.026	0.080	+	0.042
		-	0.017		-	0.021		-	0.027		-	0.044
ZZ	0.164	+	0.067	0.083	+	0.033	0.059	+	0.034	0.083	+	0.054
		-	0.074		-	0.037		-	0.036		-	0.058
Z->ττ	0.050	+	0.054	0.000	+	0.000	0.000	+	0.000	0.000	+	0.000
		-	0.056		-	0.000		-	0.000		-	0.000
nonW QCD	0.110	±	0.020	0.110	±	0.020	0.110	±	0.020	0.110	±	0.020
Single Top S	0.078	+	0.009	0.098	+	0.009	0.094	+	0.011	0.091	+	0.011
		-	0.012		-	0.012		-	0.013		-	0.014
Single Top T	0.071	+	0.008	0.072	+	0.008	0.068	+	0.011	0.065	+	0.012
		-	0.010		-	0.010		-	0.013		-	0.014
Zbb	0.072	+	0.006	0.080	+	0.006	0.078	+	0.007	0.082	+	0.009
		-	0.008		-	0.009		-	0.010		-	0.011
Zcc	0.045	+	0.005	0.040	+	0.005	0.042	+	0.007	0.046	+	0.008
		-	0.006		-	0.006		-	0.007		-	0.009
Expected ttbar	0.115	+	0.018	0.116	+	0.010	0.103	+	0.007	0.103	+	0.007
		-	0.021		-	0.014		-	0.010		-	0.010

Will simplify this a little bit by combining ε_{HJ} for different jet bin when possible

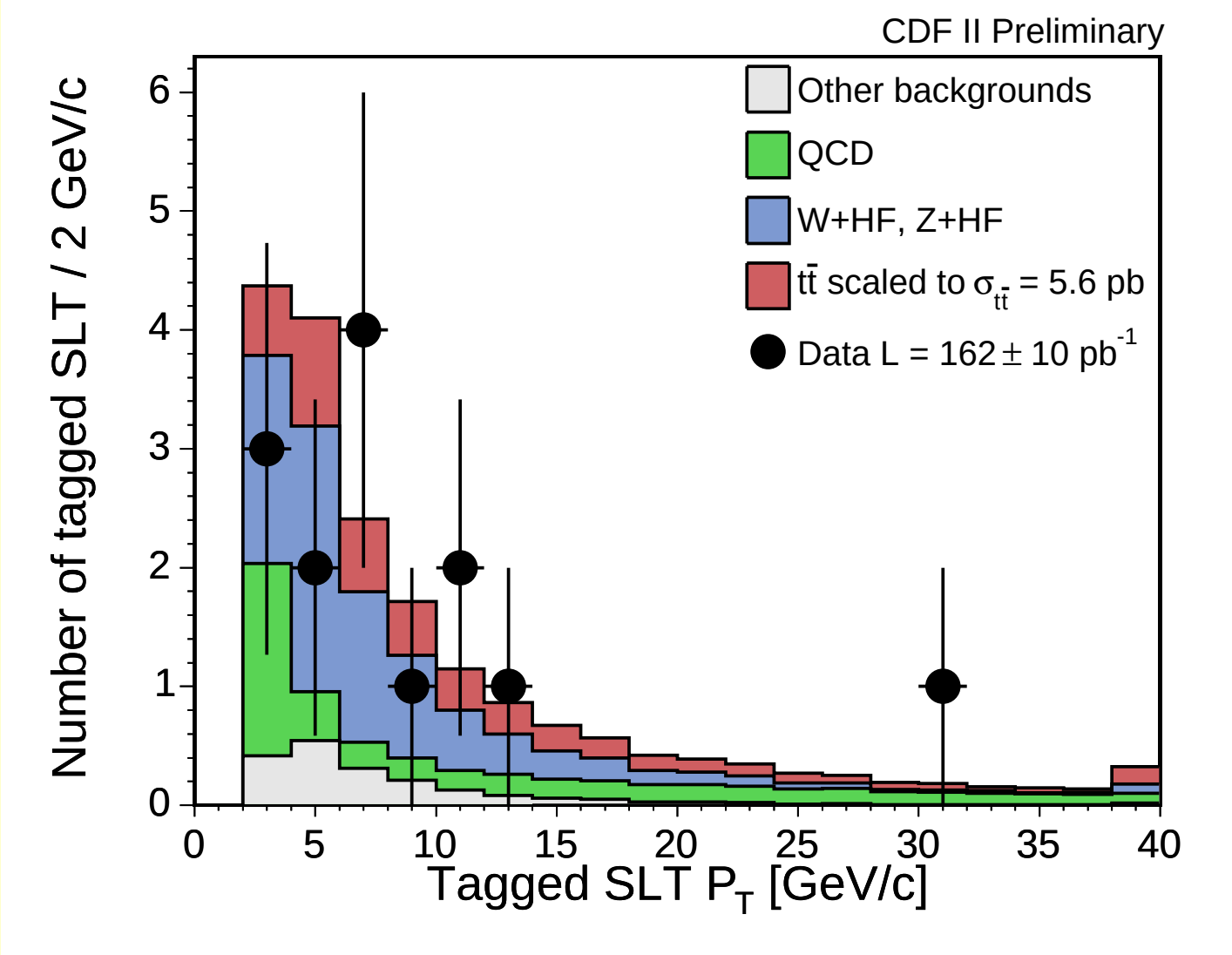
Summary Table

				No HT	wHT
	W+1TJ	W+2TJ	W+>=3TJ	W+>=3TJ
Mistags	0.697 ± 0.134	0.231 ± 0.043	0.079 ± 0.013	0.043 ± 0.007
Wbb	2.662 ± 0.822	1.805 ± 0.534	0.451 ± 0.099	0.261 ± 0.059
Wcc	0.613 ± 0.158	0.324 ± 0.092	0.081 ± 0.021	0.048 ± 0.014
Wc	1.544 ± 0.416	0.311 ± 0.084	0.062 ± 0.016	0.034 ± 0.009
DiBoson, Z->tt	0.078 ± 0.058	0.144 ± 0.025	0.034 ± 0.010	0.023 ± 0.007
nonW QCD	2.673 ± 0.620	1.155 ± 0.296	0.528 ± 0.131	0.319 ± 0.080
Single Top	0.190 ± 0.019	0.385 ± 0.034	0.106 ± 0.014	0.078 ± 0.013
Z+HF	0.068 ± 0.015	0.036 ± 0.009	0.010 ± 0.008	0.006 ± 0.002
Expected ttbar	0.105 ± 0.015	0.812 ± 0.084	3.478 ± 0.333	3.552 ± 0.211
Total	8.63 ± 1.99	5.20 ± 1.02	4.83 ± 0.16	4.36 ± 0.10
Observed tag	7	5	1	1
Poisson Prob	40%	58%	5%	7%

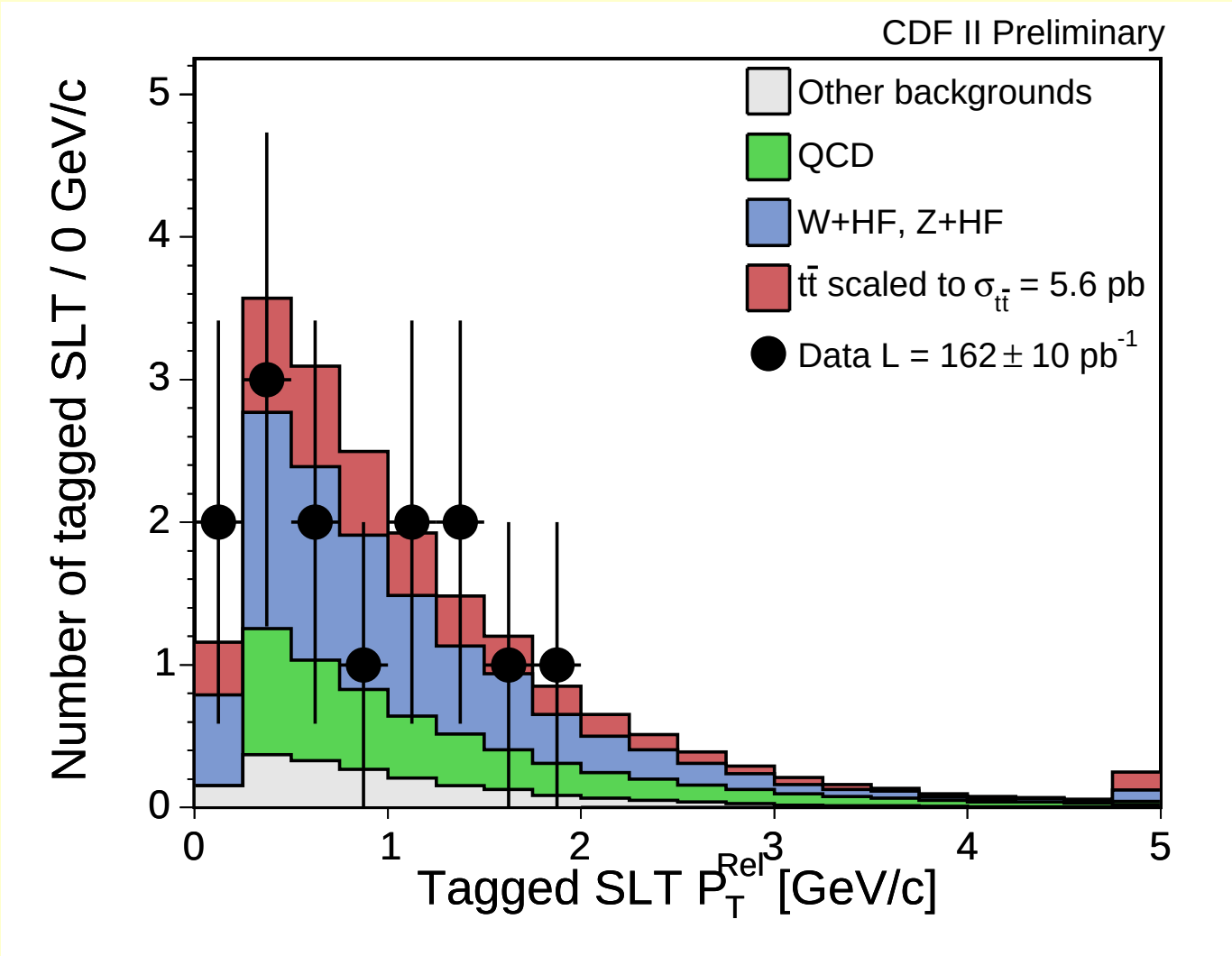
Summary Plot



SLT P_T

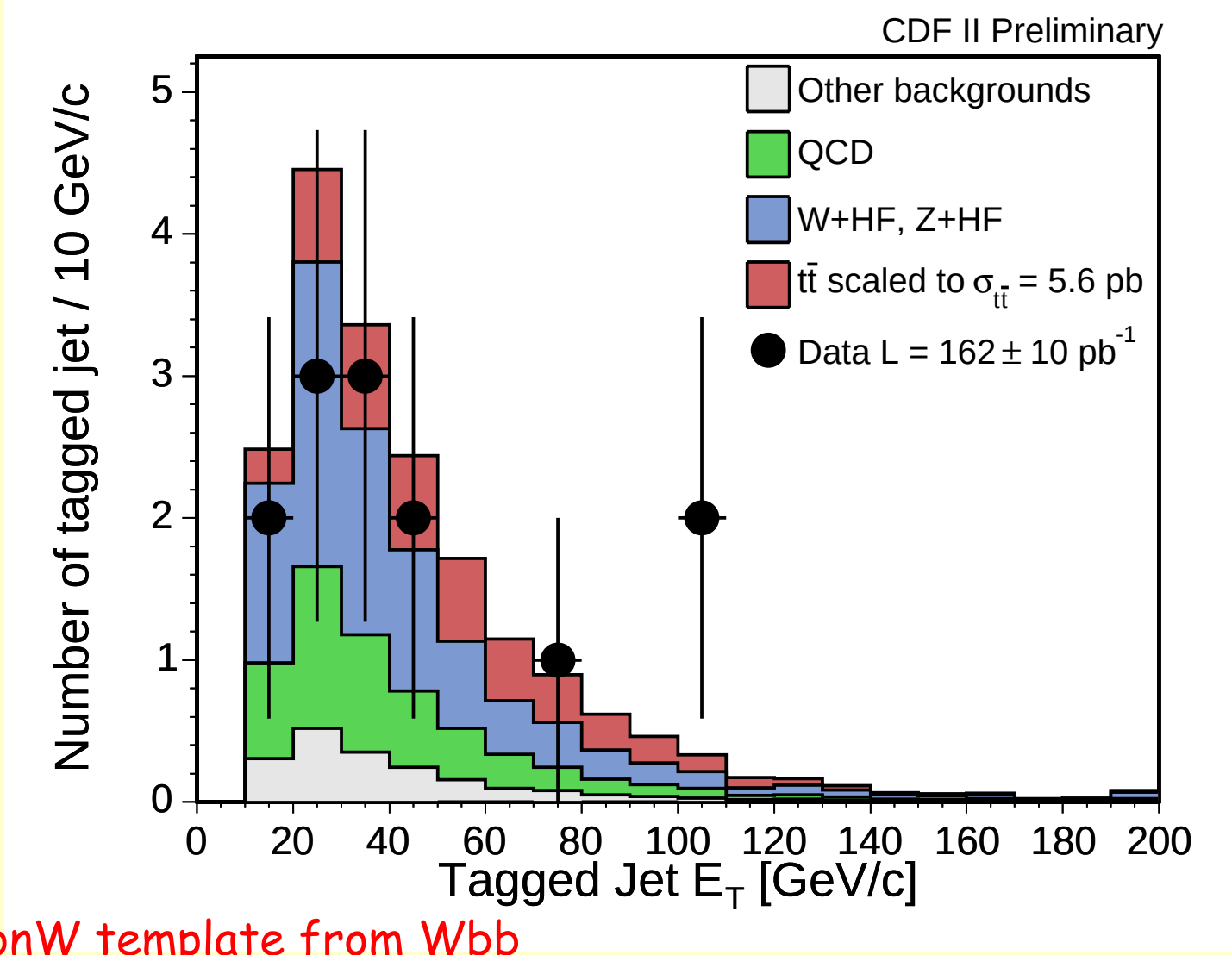

CDF II Preliminary
Other backgrounds
QCD
W+HF, Z+HF
$t\bar{t}$ scaled to $\sigma_{t\bar{t}}$ = 5.6 pb
Data L = 162 ± 10 pb^{-1}
Number of tagged SLT / 2 GeV/c
Tagged SLT P_T [GeV/c]
0
1
2
3
4
5
6
0
5
10
15
20
25
30
35
40

SLT P_T^{Rel}



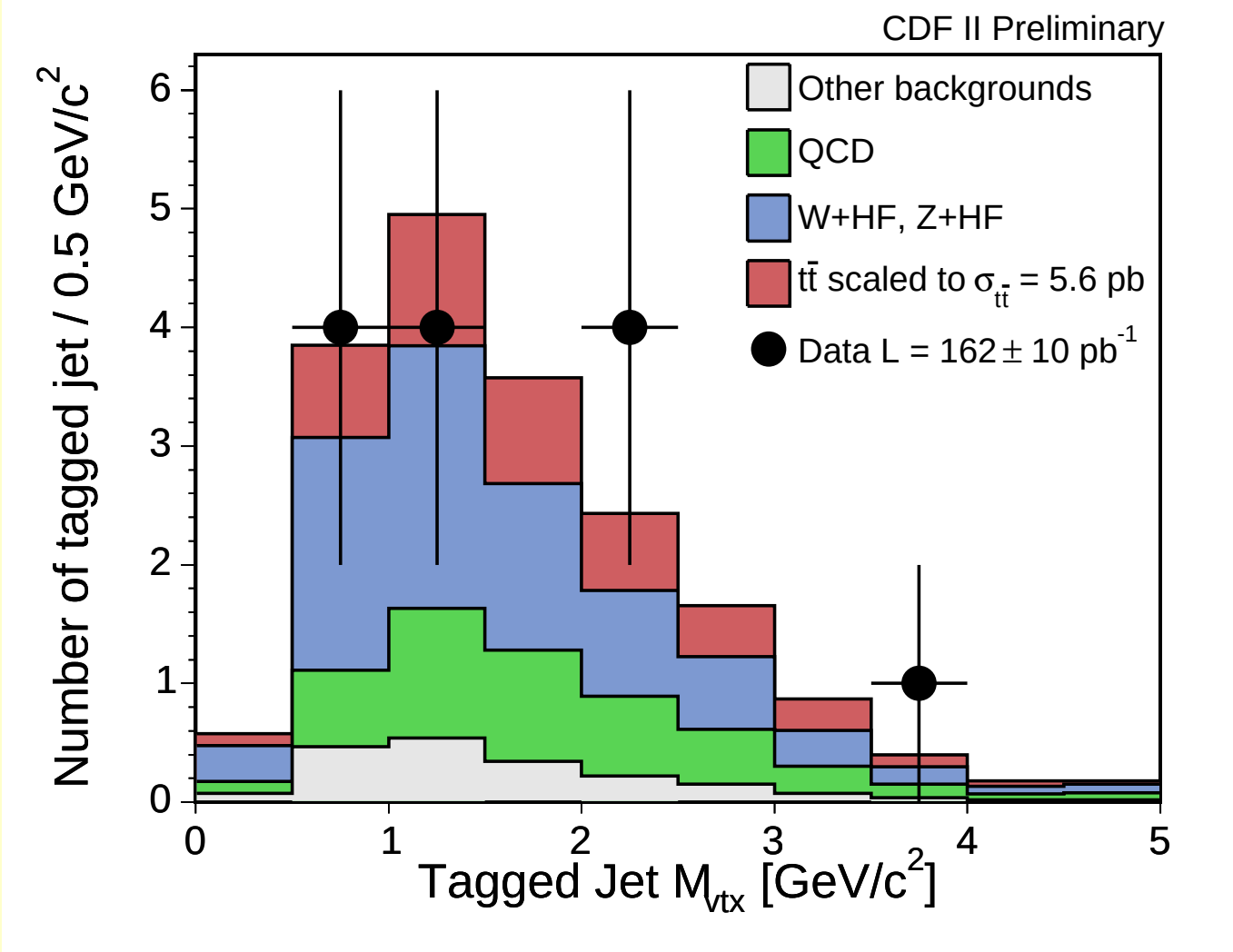
NB: NonW template from Wbb

SecVtx-SLT Tagged Jet E_T



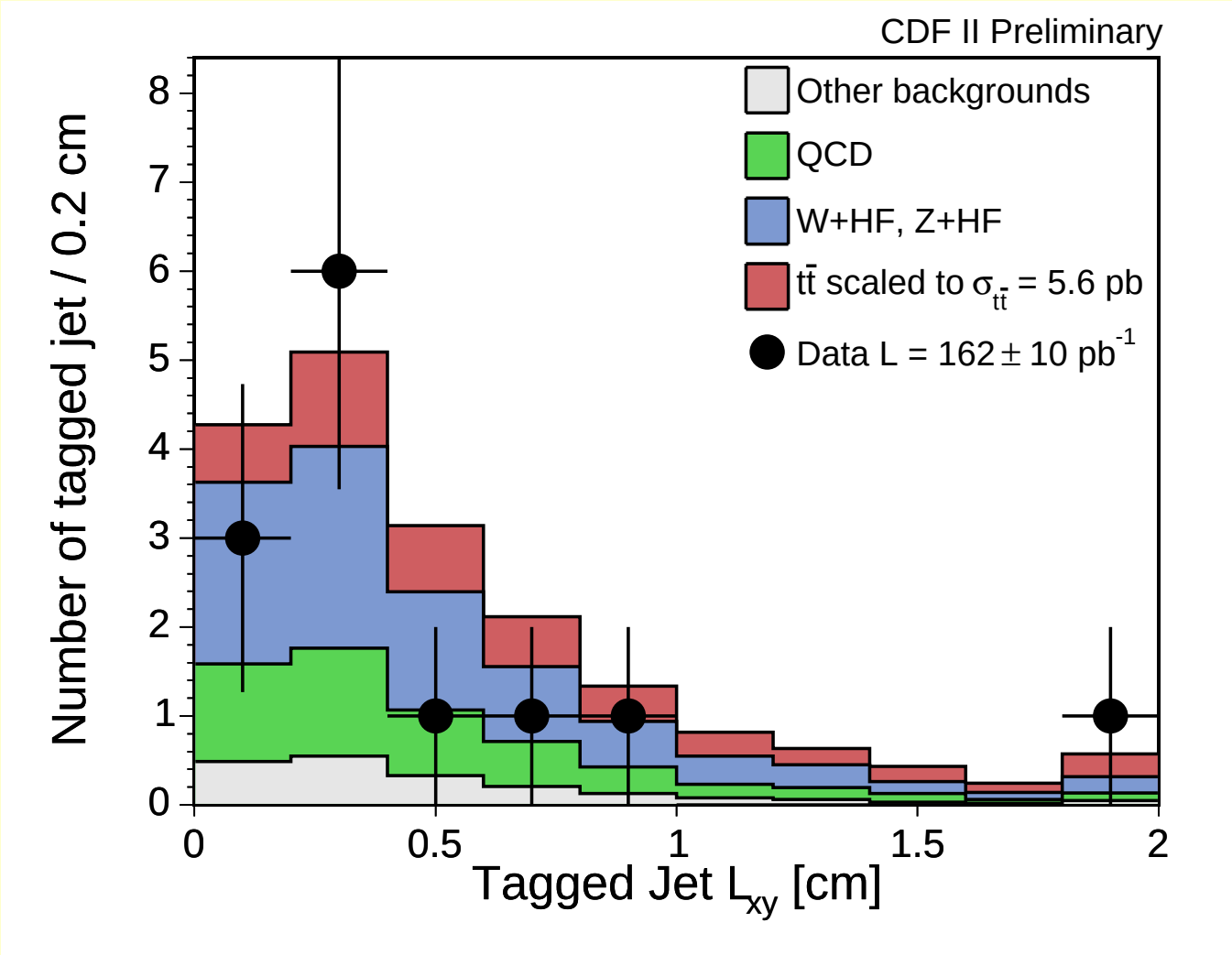
NB: NonW template from Wbb

SecVtx-SLT Tagged Jet Vertex Mass



NB: NonW template from Wbb

SecVtx-SLT Tagged Jet L_{xy}



NB: NonW template from Wbb

Summary

- Do not see any significant discrepancy between SM predicted and observed
- Plan: calcutate CL. Limit excluding excess of events
- Prebless in 2 weeks and document in a paper (possibly PRL)
  - D0 has already published a PRL setting limits on tt-like and Wbb-like models.

SecVtx

TABLE XIII: Background summary for the single-tag selection. The total backgrounds are given before and after the correction for $t\bar{t}$ events in the pretag W+jets sample.

			$H_T > 0$ GeV		$H_T > 200$ GeV	
Jet multiplicity	W + 1 jet	W + 2 jets	W + 3 jets	W + $\geq$ 4 jets	W + 3 jets	W + $\geq$ 4 jets
Pretag	15314	2448	387	107	179	91
Mistags	40.9 ± 6.1	17.0 ± 2.4	5.2 ± 0.7	2.6 ± 0.4	3.3 ± 0.4	2.3 ± 0.3
$Wb\bar{b}$	37.0 ± 11.2	22.5 ± 6.5	5.0 ± 1.3	1.6 ± 0.5	2.8 ± 0.8	1.4 ± 0.4
$Wc\bar{c}$	13.7 ± 3.4	8.0 ± 2.2	1.6 ± 0.5	0.6 ± 0.2	0.9 ± 0.3	0.5 ± 0.2
Wc	34.5 ± 9.0	7.7 ± 2.0	1.4 ± 0.4	0.3 ± 0.1	0.7 ± 0.2	0.3 ± 0.1
$WW/WZ/ZZ, Z \to \tau\tau$	2.2 ± 0.4	2.5 ± 0.4	0.6 ± 0.1	0.1 ± 0.0	0.3 ± 0.1	0.1 ± 0.0
non-W QCD	24.3 ± 3.5	10.5 ± 1.9	3.4 ± 0.7	1.4 ± 0.4	1.7 ± 0.4	1.2 ± 0.3
single top	2.6 ± 0.3	4.6 ± 0.5	1.1 ± 0.1	0.2 ± 0.0	0.8 ± 0.1	0.2 ± 0.0
Z+HF	1.1 ± 0.3	0.6 ± 0.2	0.2 ± 0.1		0.10 ± 0.05	
Total	156.3 ± 19.1	73.4 ± 9.8	18.5 ± 2.2	6.9 ± 0.9	10.5 ± 1.3	6.0 ± 0.8
Corrected Total	156.3 ± 19.1	73.4 ± 9.8	23.1 ± 3.0		13.5 ± 1.8	
Data	160	73	29	28	21	27

Calculating the error

- Not so straight forward since use N_{tt} from the measured SVX Xs, hence correlation between background and tt

$\geq$ 3 jets

$$N_{t\bar{t}}^{HJ} \pm \delta N_{t\bar{t}}^{HJ} = N_{t\bar{t}} \times \epsilon_{HJ}^{t\bar{t}} \pm \sqrt{(N_{t\bar{t}} \times \delta\epsilon_{HJ}^{t\bar{t}})^2 + (\delta N_{bkg}^{corr} \times \epsilon_{HJ}^{t\bar{t}})^2}$$

$$\pm \qquad \mp$$

$$N_{bkg_i}^{HJ} \pm \delta N_{bkg_i}^{HJ} = N_{bkg_i} \times \epsilon_{HJ}^{bkg_i} \pm \sqrt{(N_{bkg_i} \times \delta\epsilon_{HJ}^{bkg_i})^2 + (\delta N_{bkg_i} \times \epsilon_{HJ}^{bkg_i})^2}$$

$$\pm \qquad \pm$$

$$N^{HJ} \pm \delta N^{HJ} = N_{t\bar{t}}^{HJ} + \sum N_{bkg_i}^{HJ}$$

$$\pm\sqrt{(N_{t\bar{t}} \times \delta\epsilon_{HJ}^{t\bar{t}})^2 + \sum (N_{bkg_i} \times \delta\epsilon_{HJ}^{bkg_i})^2 + \sum [(\epsilon_{HJ}^{t\bar{t}} - \epsilon_{HJ}^{bkg_i}) \times \delta N_{bkg_i}]^2}$$

Calculating the error (cont)

- 2(1) jet bin:
  - Issue is that N^{2j}_{tt} is related to the cross section measure ≥3 jets bin ($N^{\geq 3j}_{tt}$). Hence δN^{2j}_{tt} is related to $\delta N^{\geq 3j}_{tt}$

$$N^{2j}_{t\bar{t}} \pm \delta N^{2j}_{t\bar{t}} = (N^{3j}_{t\bar{t}} \mp \delta N^{3j}_{t\bar{t}}) \times R_{3\to 2}$$

$$N^{HJ\ 2j}_{t\bar{t}} \pm \delta N^{HJ\ 2j}_{t\bar{t}} = N^{2j}_{t\bar{t}} \times \epsilon^{t\bar{t}\ 2j}_{HJ} \pm \sqrt{(N^{2j}_{t\bar{t}} \times \delta\epsilon^{t\bar{t}\ 2j}_{HJ})^2 + (\delta N^{2j}_{bkg} \times \epsilon^{t\bar{t}\ 2j}_{HJ})^2}$$

$$\pm \qquad \mp$$

$$N^{HJ\ 2j}_{bkg_i} \pm \delta N^{HJ\ 2j}_{bkg_i} = N^{2j}_{bkg_i} \times \epsilon^{bkg_i\ 2j}_{HJ} \pm \sqrt{(N^{2j}_{bkg_i} \times \delta\epsilon^{bkg_i\ 2j}_{HJ})^2 + (\delta N^{2j}_{bkg_i} \times \epsilon^{bkg_i\ 2j}_{HJ})^2}$$

$$\pm \qquad \pm$$

$$N^{HJ\ 2j} = N^{HJ\ 2j}_{t\bar{t}} + \sum N^{HJ\ 2j}_{bkg_i}$$

100% anti-correlated

$$\delta N^{HJ\ 2j} = N^{2j}_{t\bar{t}} \times \delta\epsilon^{t\bar{t}\ 2j}_{HJ} \oplus N^{2j}_{bkg_i} \times \delta\epsilon^{bkg_i\ 2j}_{HJ} \oplus (\delta N^{2j}_{bkg} \times \epsilon^{t\bar{t}\ 2j}_{HJ} - \sum \delta N^{2j}_{bkg_i} \times \epsilon^{bkg_i\ 2j}_{HJ})$$

uncorrelated

$$\delta N^{HJ\ 2j} = N^{2j}_{t\bar{t}} \times \delta\epsilon^{t\bar{t}\ 2j}_{HJ} \oplus N^{2j}_{bkg_i} \times \delta\epsilon^{bkg_i\ 2j}_{HJ} \oplus \delta N^{2j}_{bkg} \times \epsilon^{t\bar{t}\ 2j}_{HJ} \oplus \sum \delta N^{2j}_{bkg_i} \times \epsilon^{bkg_i\ 2j}_{HJ}$$