



Reducing Uncertainties in the W+jets Background to Single Top

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Outline

- 1) Quick Review of Tevatron and LHC Single Top Status
- 2) Experimental Suggestion: Constraining $g \rightarrow bb, cc$ with $W+1$ jet events
- 3) Theoretical Suggestion: Studying subsets of $W+2$ jets at NLO

Primarily based on:

MB hep-ph/0503110

MB, S. Ellis, M. Strassler hep-ph/0412223

Discovery of Single Top: Status

- Tevatron: W +jets is currently preventing discovery
 - W +jets rate after one b -tag is ~ 15 times the signal and \sim twice $t\bar{t}$ (BES)
 - Experiments currently can't normalize W +jets (after tagging) from data or predict it with sufficiently small uncertainties
- LHC: Discovery still appears probable
 - Charge asymmetry method (JS, MB) cleanly removes $t\bar{t}$, but not W +jets
 - W +jets still doesn't appear to prohibit discovery, but is certainly the most likely source of future problems

BES – MB, S. Ellis, M. Strassler hep-ph/0412223

JS – G. Jikia, S. Slabospitsky Phys Lett B 295 (1992)

MB - hep-ph/0503110

Tevatron: W +jets subsets

Wjj Channel	b-jet	c-jet	non b/c-jet	Total	
Wqq	2%	1%	6%	9%	
Wqg	11%	8%	14%	33%	
Wgg	7%	5%	5%	17%	
Wcq	0%	14%	1%	15%	
Wcg	1%	10%	0%	11%	
Wcc	0%	5%	0%	5%	
Wbb	10%	0%	0%	10%	

Short-distance final states' contribution to total W +jets contribution after b -tagging. Taken from BES, Table IX

- Culprit: gluon-splitting to cc , bb pairs is nearly 1/3 the total W +jets background

Theory of Gluon-splitting

- Theoretical predictions for gluon-splitting to bb , cc pairs are subject to large uncertainties
- Main theory-experiment overlap is at e^+e^- colliders in $e^+e^- \rightarrow Z \rightarrow qqg \rightarrow qqbb$ (e.g. OPAL, SLD)
 - Only done for narrow energy range (10-40 GeV gluons)
 - Theoretical prediction has uncertainty $\sim 30\%$
 - Experimental measurements have uncertainty $\sim 30\%$
- Status of work at Tevatron? (see CDF reference)

OPAL:hep-ex/0010029; SLD:hep-ex/0102002; CDF: hep-ex/0311051
See BES for more references

Any Way to Reduce Gluon-splitting Uncertainties?

- One idea: $W + 1$ Jet Events
 - At LO, over half sample is Wg
 - Look for multiple secondary vertices, soft leptons
 - No contamination from $t\bar{t}$, Single Top
 - Is this already being done?
- One place to check PS predictions; possibly constrain gluon-splitting
- Something TeV (maybe) can do 4 LHC

LHC: Charge Asymmetry

- N_+ : Number of events with only 1 high p_T positively-charged lepton
- N_- : Number of events with only 1 high p_T negatively-charged lepton
- Δ : $N_+ - N_-$
- Charge Asymmetry:

$$A_C = \frac{N_+ - N_-}{N_+ + N_-}$$

➤ s-channel and t-channel both have cross-sections with charge asymmetries $A_C \sim 0.25$

Single Tag Sample

- S:B ~ 3:2
- Can't simulate QCD background, but it's charge-symmetric and thus shouldn't contribute to Δ

Number of events for 10 fb⁻¹

Channel	N_{total}	Δ	$\sqrt{N_{total}}$
s-channel	4,500	990	67
t-channel	116,000	30,900	340
Wbb	21,900	4,800	150
Wjj	236,000	18,000	490
tt	958,000	-479	980

Item	p_T	$ \eta $
lepton	≥ 20 GeV	≤ 2.5
MET	≥ 20 GeV	-
jets (b-tag)	≥ 30 GeV	≤ 2.5
jets (no b-tag)	≥ 30 GeV	≤ 4.5

Prediction of Δ for tt has correct sign, but is an upper bound on the expected magnitude of the asymmetry

Single-tag W +jets subsets

- Tagging taken from ATLAS TDR (Fig 10-24) $c \sim 10\%$, $g \sim 1.3\%$, $q \sim 0.5\%$
- Advocate that W_{jj} subsets be studied individually
- Factorization and renormalization scales should be determined on a channel-by-channel basis
- **Mostly charm mistags**
- **Cancellations mask systematics in Δ**

Cross-section after single tag

Channel	σ (fb)	A_c
W_{cc}	390	0.15
W_{cg}	7,900	-0.03
W_{cq}	6,200	0.02
W_{gg}	690	0.24
W_{gq}	7,400	0.22
W_{qq}	<1,600	-
W_{jj}	23,600	0.07

Not published – presently only for illustration purposes

NLO Normalizations for W +jets

- Currently: same k-factor for all W +jets subsets (Wqq , Wqg , Wcc , Wcq ,...)
 - $k\text{-factor} = \text{NLO}(\text{sum of all}) / \text{LO}(\text{sum of all})$
- This doesn't mean relative ratios of subsets correctly mirror NLO ratios
- Ex: Wbb has large corrections at NLO due to entrance of gluon PDF (CE)
- Wcc should have similar issue; Wgg might as well

Proposal: check k-factors for individual subsets

Double Tag Sample

- S:B ~ 5:2
- Single top can be studied in double-tag channel!

Warning: W_{bb} cross-section has LARGE NLO k-factors ~ 2.3, with LARGE uncertainties from scale variation ~20% (Campbell et al '03)

Number of events for 10 fb^{-1}

Channel	N_{total}	Δ	$\sqrt{N_{\text{total}}}$
s-channel	1,790	330	42
t-channel	15,100	4,030	120
W_{bb}	8,800	1,800	94
W_{jj}	1,550	30	40
$t\bar{t}$	336,000	-167	580

The End
