Blessing

$t\bar{t}$ CROSS-SECTION WITH JET PROBABILITY

Gervasio Gómez, Enrique Palencia, Teresa Rodrigo,
Luca Scodellaro, Rocío Vilar
Instituto de Física de Cantabria, IFCA

Top Meeting
August 4, 2005

Outline

- What is new since preblessing
- Questions & Answers
- Plots and tables for blessing

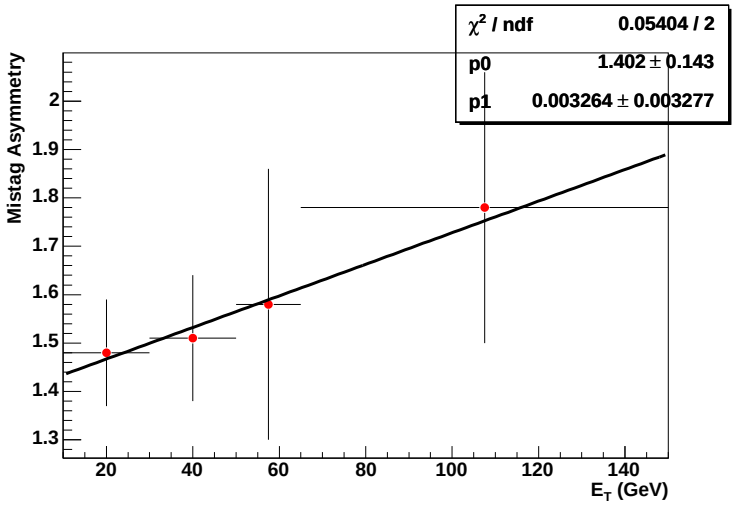
What is new since preblessing

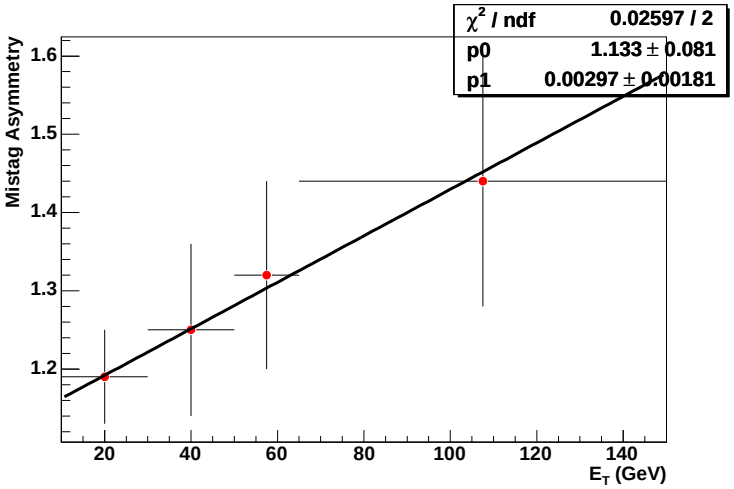
- Found a bug in computation of mistag background after correction. Pretag sample was rescaled subtracting only the expected number of tagged ttbar events, now we subtract the number of pretag ttbar events

- Mistag contribution to the total tagging efficiency is now calculated using the mistag matrix on ttbar MC
  - ♢ Before, the event tagging efficiency was calculated by applying the SF to the tagged jets in the event, with the caveat that the MC could not describe correctly the tag rate for light jets
  - ♢ Since we were requested to compute the mistag contribution to the signal (Q7), we estimated this possible bias by applying the mistag matrix to the light jets in the ttbar MC
  - ♢ Even if this effect is small, we use this method which, in principle, is more accurate
  - ♢ Also used for MC-derived backgrounds

What is new since preblessing

- Performed E_T dependence study of the mistag asymmetry factor (updated CDF note 7696)
  - ◊ Overall uncertainty increased from:
    1.57 $\pm$ 0.15 to 1.57 $\pm$ 0.18 for 1% cut
    1.27 $\pm$ 0.17 to 1.27 $\pm$ 0.20 for 5% cut





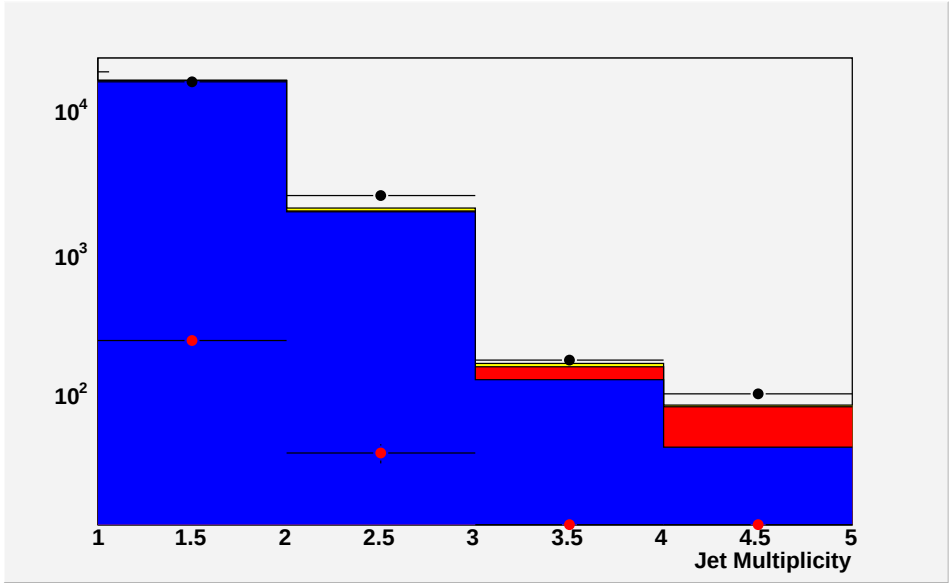
- We have fixed a (small) bug related with the tag-flags and P_T ordering of the jets that slightly affects W+HF tagging efficiencies
  - ◊ The effect on W+HF efficiency is $\leq$2% with a change in the cross-section of $\sim$0.05 pb

QUESTIONS & ANSWERS

Questions & Answers

- Q1: Estimate QCD background using the intermediate region
  - ◊ Region B: $\not\!\!E_T$ <15.0, Isol<0.1 → Region B': $\not\!\!E_T$ <15.0, 0.1<Isol<0.2
    Region D: $\not\!\!E_T$ >20.0, Isol<0.1 → Region D': $\not\!\!E_T$ >20.0, 0.1<Isol<0.2
  - ◊ $\not\!\!E_T$ vs ISO method, intermediate region B' → number of non-W events in region D' (Predicted non-W events)
  - ◊ Study the sample composition in region D

- Solid blue: W+jets
- Solid red: ttbar (σ = 6.1 pb)
- Solid yellow: MC Derived
- Black points: data in D
- Red points: data in D'



Questions & Answers

- Extrapolate the contribution of W+HF, ttbar and MC derived backgrounds to region D'. Comparing these contributions with data we extract an independent estimate of the non-W fraction in region D' (Expected non-W fraction)

Jet Multiplicity	1 jet	2 jets	3 jets	$\geq$ 4 jets
Electrons				
Events in region D'	1101	285	18	10
Predicted non-W events	905	171	9.6	4.9
Expected W+jets	244	49.7	2.9	2.0
Expected $t\bar{t}$	0.2	1	1.5	2.1
Predicted non-W fraction	0.82 $\pm$ 0.03	0.60 $\pm$ 0.05	0.53 $\pm$ 0.16	0.49 $\pm$ 0.21
Expected non-W fraction	0.78 $\pm$ 0.01	0.82 $\pm$ 0.02	0.76 $\pm$ 0.10	0.59 $\pm$ 0.16
Relative difference	-0.05	0.37	0.42	0.20
Muons				
Events in region D'	447	82	5	3
Predicted non-W events	183	34	2	1.2
Expected W+jets	136	30.	1.9	0.82
Expected $t\bar{t}$	0.1	0.5	0.9	1.4
Predicted non-W fraction	0.41 $\pm$ 0.03	0.41 $\pm$ 0.06	0.40 $\pm$ 0.23	0.40 $\pm$ 0.33
Expected non-W fraction	0.70 $\pm$ 0.02	0.62 $\pm$ 0.05	0.44 $\pm$ 0.22	0.26 $\pm$ 0.25
Relative difference	0.70	0.50	0.11	-0.35

- With the exception of the 1 jet bin for muons, the relative difference is always smaller than the systematic uncertainty (50%) on the predicted non-W fraction
- The systematic uncertainty is estimated by looking at the change in the non-W fraction predicted in the signal region for different definitions of the sideband regions

Questions & Answers

- Q2A: Show numbers for Mistags and W+HF before and after the correction.
  - These numbers are shown for the 4 analyses in CDF note 7697 (tables 19, 20, 25, 26, 32, 33, 36 and 37). For the 1% single tag analysis:

Jet Multiplicity	1 jet	2 jets	3 jets	$\geq$ 4 jets
Before correction				
MC Derived	9.3 ± 1.1	16.6 ± 1.9	2.3 ± 0.3	0.71 ± 0.09
$Wb\bar{b}$	83.0 ± 23.4	47.2 ± 13.2	6.0 ± 1.6	3.3 ± 0.9
$Wc\bar{c}$	31.2 ± 9.3	17.5 ± 5.2	2.3 ± 0.7	1.2 ± 0.4
Wc	86.4 ± 21.4	19.2 ± 5.0	1.4 ± 0.4	0.6 ± 0.2
Mistag	149.7 ± 17.9	52.1 ± 6.2	8.6 ± 1.0	6.8 ± 0.8
Non W	30.5 ± 15.6	8.6 ± 4.6	0.9 ± 0.6	0.5 ± 0.5
Total Background	390.2 ± 49.1	161.1 ± 22.0	21.5 ± 2.8	13.2 ± 1.7
$t\bar{t}$ (6.1 pb)	1.7 ± 0.4	14.0 ± 1.8	27.5 ± 3.3	39.4 ± 4.6
Data	350	191	52	68
After correction				
MC Derived	9.3 ± 1.1	16.6 ± 1.9	2.3 ± 0.3	0.71 ± 0.09
$Wb\bar{b}$	83.0 ± 23.4	46.6 ± 13.0	4.3 ± 1.2	1.1 ± 0.3
$Wc\bar{c}$	31.2 ± 9.3	17.3 ± 5.2	1.6 ± 0.5	0.4 ± 0.1
Wc	86.3 ± 21.4	19.0 ± 4.9	1.0 ± 0.3	0.21 ± 0.06
Mistag	149.7 ± 17.9	51.5 ± 6.1	6.2 ± 0.7	2.2 ± 0.3
Non W	30.5 ± 15.6	8.6 ± 4.6	0.9 ± 0.6	0.5 ± 0.5
Total Background	390.0 ± 49.1	159.6 ± 21.8	16.3 ± 2.0	5.1 ± 0.7
$t\bar{t}$ (8.9 pb)	2.5 ± 0.5	20.6 ± 2.5	40.4 ± 4.8	58.1 ± 6.8

Questions & Answers

- Q2B: I checked the corrected and raw background rates for summary table. One question is that why (corrected)/(raw) were different between mistag and W+HF? For example, in the $\geq$ 4 jet bin for 1 tag at 1%, 4.3/6.8 for mistag, but 1/3 for W+HF

  - ♢ As explained earlier, we corrected the mistag computation. As shwon in the table above, the corresponding corrected ratios are: 2.2/6.8 for mistag and 1.1/3.3 for W+HF

- Q3: Measure the inclusive muon W cross section

  - ♢ W $\longrightarrow$ lνX in $\geq$ 0 jets bin

  - ♢ Calculate the backgrounds for our analysis:
    - EW: use MC predictions, SF and theoretical cross sections
    - Non-W: same $\not{E}_T$ vs Iso method as in the analysis

Questions & Answers

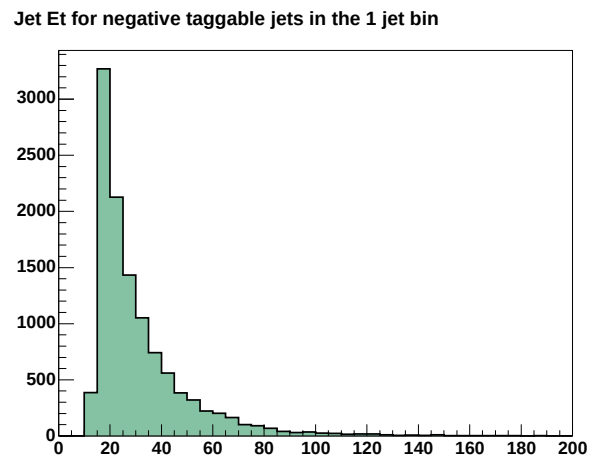
	CEM	CMUP	CMX
Luminosity (pb^{-1})	318.5 $\pm$ 18.8	318.5 $\pm$ 18.8	305.2 $\pm$ 18.0
Acceptance (%)	23.25 $\pm$ 0.04	13.10 $\pm$ 0.03	5.86 $\pm$ 0.02
Lepton ID SF x Z cuts eff.	0.907 $\pm$ 0.051	0.746 $\pm$ 0.043	0.897 $\pm$ 0.051
Observed Events	195936	99409	56101
EW, single top, $Z \to \tau^+\tau^-$	573 $\pm$ 45	394 $\pm$ 31	
$t\bar{t}$ events ($8.7\ pb^{-1}$)	133 $\pm$ 10	97 $\pm$ 6	
non-W	4525 $\pm$ 2263	1992 $\pm$ 997	
$Z \to l^+l^-$	596 $\pm$ 45	5570 $\pm$ 446	
$W \to \tau^+\tau^-$	4869 $\pm$ 503	3800 $\pm$ 450	
Cross Section	2755 $\pm$ 5 (stat.) $\pm$ 158 (syst.) $\pm$ 162 (lum.)	3046 $\pm$ 8 (stat.) $\pm$ 172 (syst.) $\pm$ 177 (lum.)	
CDF Measurement	2775 $\pm$ 10 (stat.) $\pm$ 53 (syst.) $\pm$ 167 (lum.)		

	CMUP	CMX	CMUP	CMX
Luminosity (pb^{-1})	318.5 $\pm$ 18.8	305.2 $\pm$ 18.0	318.5 $\pm$ 18.8	305.2 $\pm$ 18.0
Acceptance (%)	13.1 $\pm$ 0.03	5.86 $\pm$ 0.02	13.1 $\pm$ 0.03	5.86 $\pm$ 0.02
Lepton ID SF x Z cuts eff.	0.746 $\pm$ 0.043	0.897 $\pm$ 0.051	0.746 $\pm$ 0.043	0.897 $\pm$ 0.051
χ^2 prob. SF	0.954 (from Corinne's talk)		0.987 (from SecVtx note 7536)	
Observed Events	91247	50704	91247	50704
EW, single top, $Z \to \tau^+\tau^-$	376 $\pm$ 30		389 $\pm$ 31	
$t\bar{t}$ events ($8.7\ pb^{-1}$)	93 $\pm$ 6		96 $\pm$ 6	
non-W	1992 $\pm$ 997		1992 $\pm$ 997	
$Z \to l^+l^-$	5314 $\pm$ 425		5498 $\pm$ 440	
$W \to \tau^+\tau^-$	3625 $\pm$ 429		3751 $\pm$ 444	
Cross Section	2901 $\pm$ 8 (stat.) $\pm$ 166 (syst.) $\pm$ 172 (lum.)		2797 $\pm$ 8 (stat.) $\pm$ 160 (syst.) $\pm$ 165 (lum.)	
$\sigma_{t\bar{t}}^{\geq 1\ tag}$ ($JP \leq 1\%$)	$8.9^{+1.0}_{-1.0}\ (stat.)^{+1.1}_{-1.1}\ (syst.)\ pb\ (+0.0\ pb)$		$8.8^{+1.0}_{-0.9}\ (stat.)^{+1.1}_{-1.1}\ (syst.)\ pb\ (-0.1\ pb)$	
$\sigma_{t\bar{t}}^{\geq 2\ tag}$ ($JP \leq 1\%$)	$11.0^{+2.3}_{-1.9}\ (stat.)^{+1.9}_{-1.9}\ (syst)\ pb\ (-0.1\ pb)$		$10.9^{+2.3}_{-1.9}\ (stat.)^{+1.9}_{-1.9}\ (syst.)\ pb\ (-0.2\ pb)$	

Questions & Answers

- Q4: Why your observed data for the one jet bin is below the total contribution while for SecVtx it is above? Compare backgrounds in one jet bin with SecVtx.
  - ◊ Background composition in SecVtx and JetProb are similar except for mistags
  - ◊ Matrix predicts 100.6 events, 11324 negative taggable jets $\Rightarrow$ observed negative tag rate $\sim$0.88 $\Rightarrow$ Our prediction is consistent
  - ◊ The final mistag contribution is the number predicted by the mistag matrix scaled by our mistag asymmetry of 1.57 and corrected for the non-W, single top and EW contributions to the pretag sample

1 Jet bin	SecVtx	JP $<$ 1%
MC Derived	11.13 (2.61 %)	9.3 (2.66 %)
non W	37.23 (8.72 %)	30.5 (8.71 %)
Mistag	93.08 (21.80 %)	149.7 (42.77 %)
W$b\bar{b}$	98.13 (22.98 %)	83.0 (23.71 %)
W$c\bar{c}$	33.25 (7.79 %)	31.2 (8.91 %)
Wc	98.9 (23.16 %)	86.4 (24.69 %)
Total Bkg.	371.71 (87.05 %)	390.2 (111.49 %)
Observed data	427	350



JP $<$ 1%	Jet 20	Jet 50
Negative Tag Rate	0.8	1.22

Questions & Answers

- Q4C: Can you check mistag events in W+2jet bin between JP and SecVtx? In W+1, there is a large discrepancy

2 Jets bin	SecVtx	JP $<$ 1%
MC Derived	19.59 (8.44 %)	16.6 (8.69 %)
non W	15.91 (6.86 %)	8.6 (4.50 %)
Mistag	38.23 (16.49 %)	52.1 (27.78 %)
W$b\bar{b}$	54.39 (23.44 %)	47.2 (24.71 %)
W$c\bar{c}$	19.92 (8.57 %)	17.5 (9.16 %)
Wc	20.78 (8.96 %)	19.2 (10.05 %)
Total Bkg.	168.81 (72.76 %)	161.1 (84.35 %)
Observed data	232	191

  - ♢ Agreement, for JP, between observed events and total background expectation in the 1 (2) jet bins is -2.1 (+2.2) $\times\sqrt{N_{obs}}$ (only statistical error on data)

Questions & Answers

- Q5: What is your prefered, a priori, analysis?
  - ♢ The single tag at 1% seems to have the best compromise between background contamination, statistics, and systematics
  - ♢ A better understanding of the SF would benefit the 1% analysis more than the 5% since the other bakcground uncertainties are smaller than for the 5% case

- Q6: Split the analysis for electrons and muons

	Total	Electrons	Muons
JP<1%			
Single	$8.9^{+1.0}_{-1.0} \pm 1.1$	$8.6^{+1.4}_{-1.2} \pm 1.1$	$9.4^{+1.7}_{-1.4} \pm 1.1$
Double	$11.1^{+2.3}_{-1.9} \pm 1.9$	$10.1^{+3.1}_{-2.4} \pm 1.8$	$12.4^{+3.9}_{-3.0} \pm 2.1$
JP<5%			
Single	$9.6^{+1.0}_{-0.9} \pm 1.2$	$9.4^{+1.3}_{-1.2} \pm 1.2$	$9.9^{+1.6}_{-1.4} \pm 1.2$
Double	$11.6^{+1.7}_{-1.5} \pm 1.9$	$10.6^{+2.2}_{-1.8} \pm 1.8$	$13.0^{+2.8}_{-2.3} \pm 2.1$

Questions & Answers

- Q7: Estimate the mistag contribution to the signal
  - ♢ Applying the mistag matrix to the light jets in the ttbar MC

	CEM	CMUP	CMX
Single tag, JP$\leq 1\%$			
hf contribution (%)	53.91 $\pm$ 0.24	53.26 $\pm$ 0.30	54.42 $\pm$ 0.52
total efficiency (%)	54.46 $\pm$ 0.21	53.87 $\pm$ 0.27	54.94 $\pm$ 0.47
total eff. w/ tag rate matrix (%)	54.70 $\pm$ 0.24	54.05 $\pm$ 0.30	55.21 $\pm$ 0.52
Double tag, JP$\leq 1\%$			
hf contribution (%)	11.90 $\pm$ 0.15	11.80 $\pm$ 0.19	12.66 $\pm$ 0.35
total efficiency (%)	12.46 $\pm$ 0.13	12.32 $\pm$ 0.17	13.16 $\pm$ 0.30
total eff. w/ tag rate matrix (%)	12.69 $\pm$ 0.16	12.58 $\pm$ 0.20	13.44 $\pm$ 0.35
Single tag, JP$\leq 5\%$			
hf contribution (%)	66.9 $\pm$ 0.2	66.7 $\pm$ 0.3	67.8 $\pm$ 0.5
total efficiency (%)	68.5 $\pm$ 0.2	68.3 $\pm$ 0.3	69.2 $\pm$ 0.4
total eff. w/ tag rate matrix (%)	68.8 $\pm$ 0.2	68.6 $\pm$ 0.3	69.6 $\pm$ 0.5
Double tag, JP$\leq 5\%$			
hf contribution (%)	21.5 $\pm$ 0.2	21.2 $\pm$ 0.2	22.4 $\pm$ 0.4
total efficiency (%)	23.9 $\pm$ 0.2	23.5 $\pm$ 0.2	24.4 $\pm$ 0.4
total eff. w/ tag rate matrix (%)	24.4 $\pm$ 0.2	24.1 $\pm$ 0.2	25.2 $\pm$ 0.5

  - ♢ We observe a relative increase $\sim$0.5% ($\sim$2%) in the efficiency of finding at least 1 (2) tags. This increase quantifies the bias due to poorly simulated mistags in the signal MC

Questions & Answers

- Q8: Compare with SecVtx the background contribution in the double tag analysis

	2 Jets		3 Jets		4 Jets	
	SecVtx	JP $<$ 1%	SecVtx	JP $<$ 1%	SecVtx	JP $<$ 1%
MC Derived	1.89 ± 0.29	1.4 ± 0.3	0.42 ± 0.09	0.33 ± 0.07	0.12 ± 0.03	0.10 ± 0.02
Non-W	0.31 ± 0.20	0.19 ± 0.12	0.31 ± 0.18	0.029 ± 0.018	0.57 ± 1.38	0.045 ± 0.030
Mistag	0.48 ± 0.11	0.21 ± 0.05	0.10 ± 0.04	0.097 ± 0.022	0.22 ± 0.04	0.12 ± 0.03
W+HF	8.25 ± 2.86	6.7 ± 2.1	0.89 ± 0.32	1.1 ± 0.3	0.26 ± 0.12	0.71 ± 0.24
Total Bkg.	10.93 ± 2.89	8.5 ± 2.3	1.71 ± 0.38	1.5 ± 0.4	1.17 ± 0.12	0.97 ± 0.25
Obs. Data	15	13	15	12	18	18

- ◊ Total backgrounds are consistent between the two analysis
- ◊ The mistags, in the double tagged sample, are calculated differently for the two analysis. We calculate our mistags by applying the mistag matrix to the pretag sample

Questions & Answers

- The difference in the double tag cross sections between JetProb and SecVtx could not in any case be explained by the difference in backgrounds, since they are small in the double tag sample

- Although the limited statistics do not allow to draw a significant conclusion, the number of observed events does not seem to scale with the efficiencies*SF between the two analysis

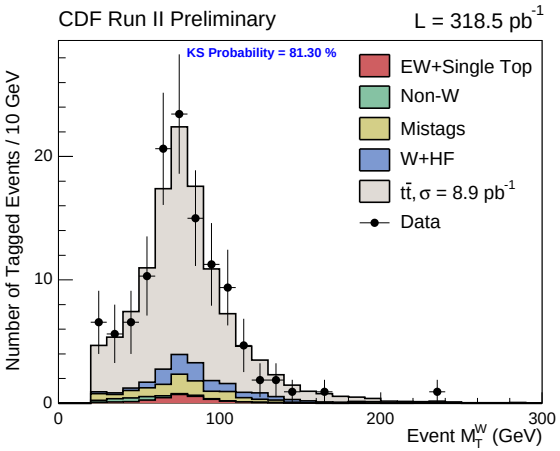
- We estimate, by running pseudo-experiments, the probability to measure our double tag cross section given the single tag measurement

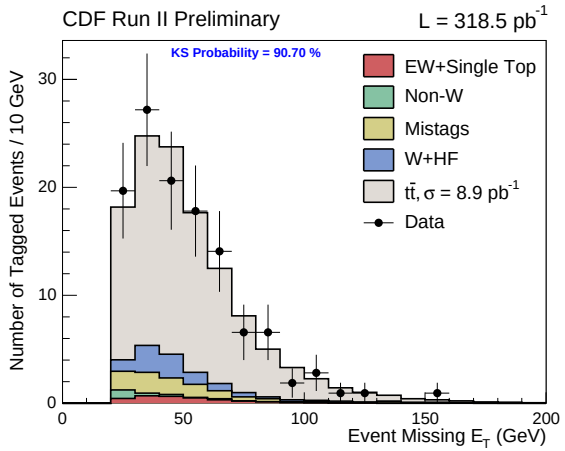
	SF - σ	SF	SF + σ
JP $<$ 1%	4.5 %	13.2 %	30 %
JP $<$ 5%	2.8 %	15.6 %	35 %

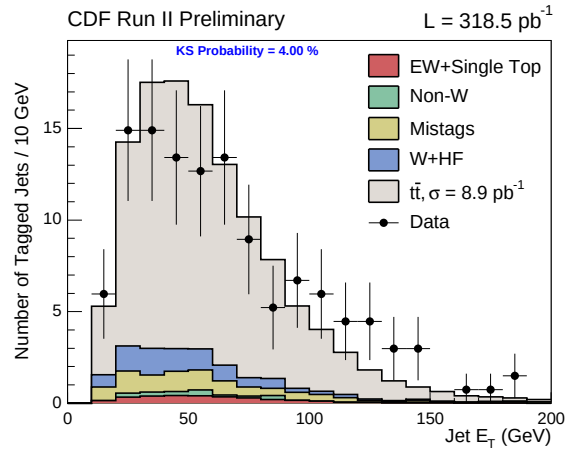
Questions & Answers

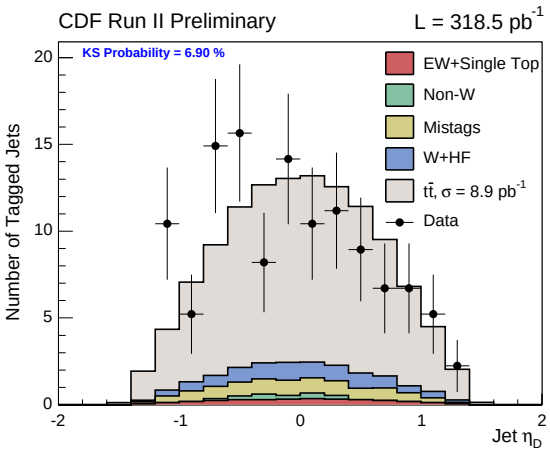
- Q9: Produce plots of all relevant jetprob tagging variables (in a similar style to the njet plot) using the measured cross section for the normalization
  - ♢ All these plots are in appendix B of the note and in our Q&A web page (http://www-cdf.fnal.gov/internal/physics/top/RunIIWjets/webpages/jetprob/gen5_questions/). Here, just a few of them
  - ♢ Single tag samples show a reasonable agreement with MC in all variables
  - ♢ For the double tag samples most of the variables are reasonably well described by MC but the ΣE_T of all jets in the 1% analysis. The discrepancy propagates to the H_T distribution. This could be due to the fact that this is sample with a high HF content and jet corrections are made for generic jets
  - ♢ We see a slight asymmetry in the jet η_D for both single and double tag samples. We can not explain this but there are possible explanations in the web page. It is also seen in other analyses/selections

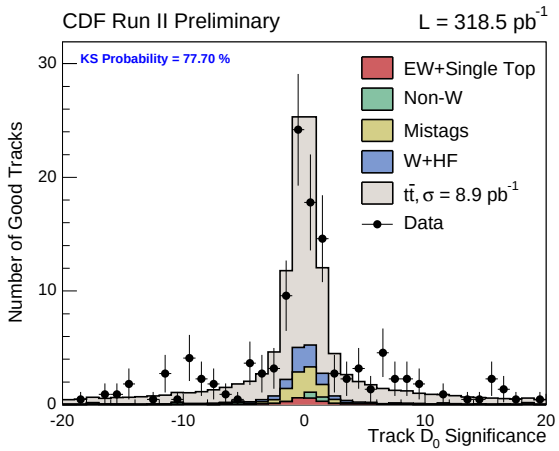
Questions & Answers

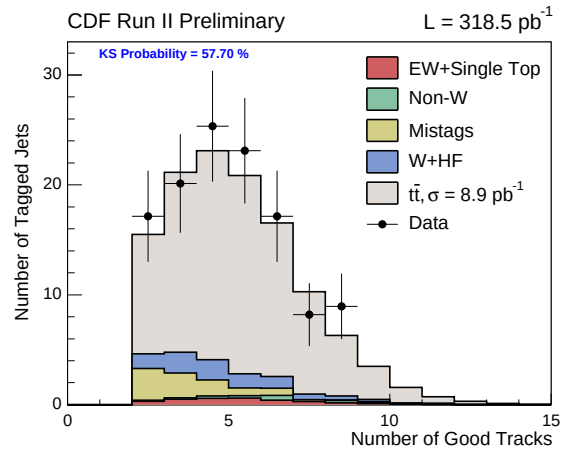






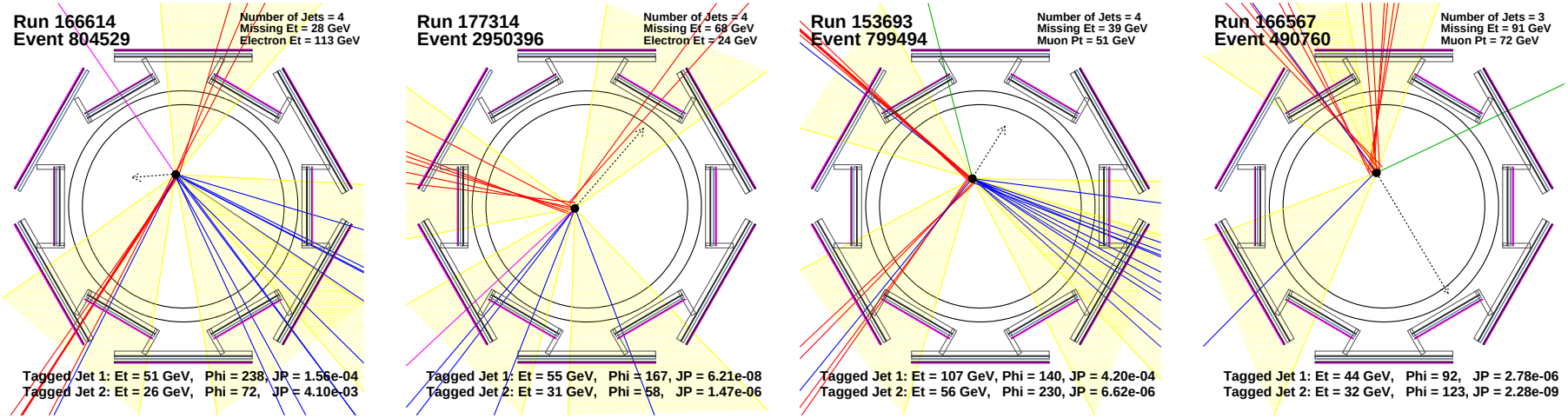






Questions & Answers

- Q10: Show "event displays" for your double tagged events as the Harvard group did.
  - These plots are in appendix C of the note and in our Q&A web page (http://www-cdf.fnal.gov/internal/physics/top/RunIIWjets/webpages/jetprob/gen5_questions/)



Questions & Answers

- Q11: Why do you use uncorrected jet E_T for the parameterization? I guess it makes little difference in the end...
  - ♢ Because this way the tag rate matrices can be used by everybody independently of the level of corrections they choose to make in their particular analysis.
  - ♢ This is the way both SecVtx and JetProb matrices have been defined (and blessed).
  - ♢ If the concern has to do with a slightly shifted E_T spectrum between the uncorrected jets used to parameterize the matrix and the jets used in the analysis, the answer is indeed that it makes a very little difference (http://www-cdf.fnal.gov/internal/people/links/GervasioGomez/JetProb/JP533_blessing/)

Questions & Answers

- Q12: Scale factor vs. E_T is measured in inclusive electron and jet50 (herwig&pythia), then weighted average is taken as slope, and this slope is used to set a systematic. In the 5% JP cut, the slope comes out at more or less 0, whereas inclusive electron slope is 2 sigma negative, Jet50 pythia 2 sigma positive, and pythia within 1 sigma of 0. The chisquared of the combination isn't so small. Perhaps you should use a larger slope to set your systematic less agressively?

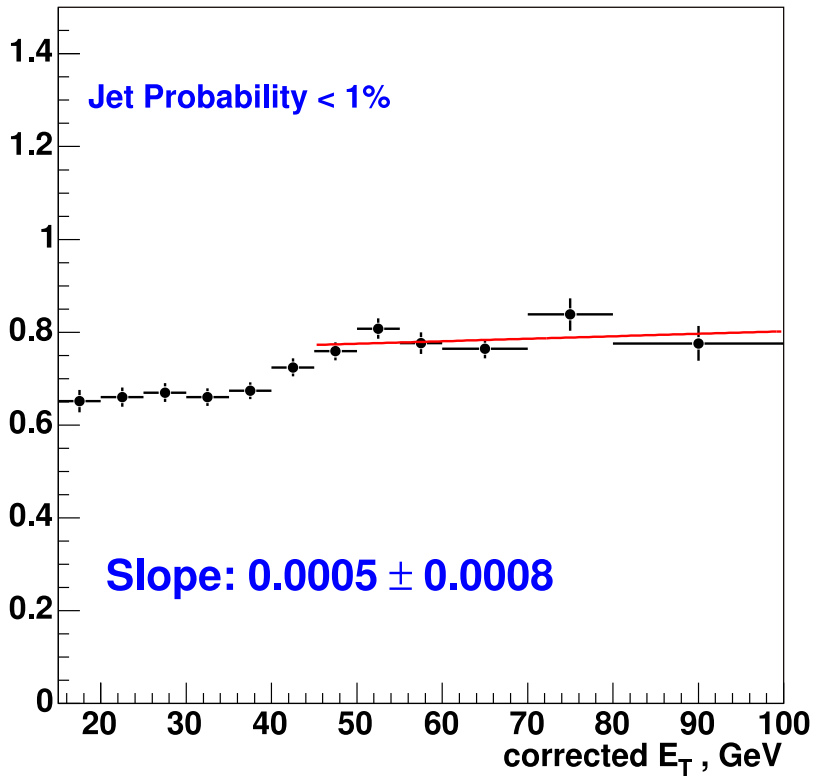
  - ♢ Table 1 in 7697 was quoting Gen4 numbers. It has been updated in the latest revision.

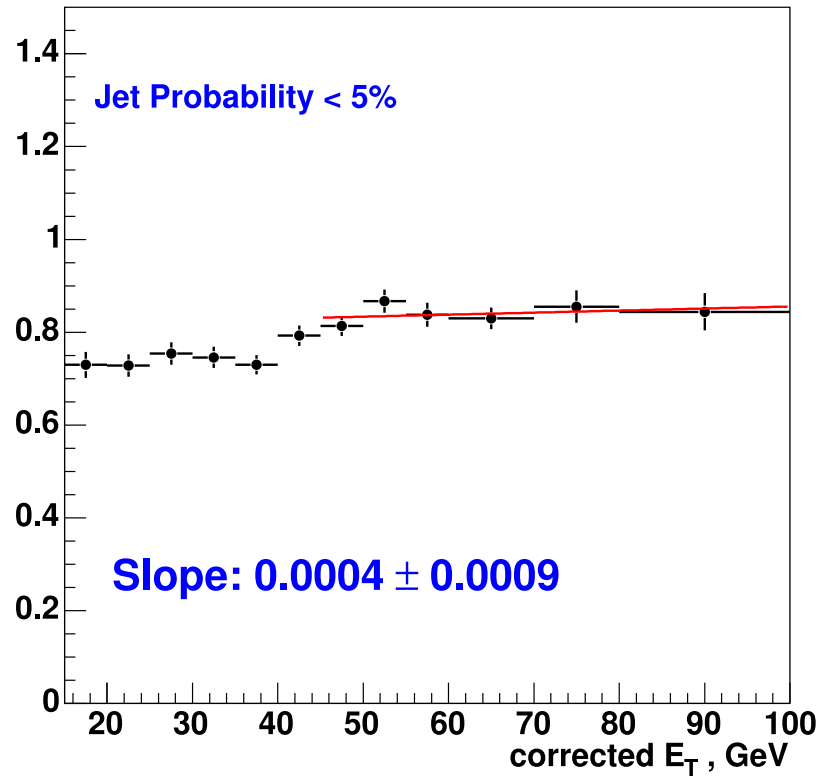
Sample	JP cut 1%	JP cut 5%
Incl. elec.	-0.0044 $\pm$ 0.0056	-0.0062 $\pm$ 0.0060
Jet 50	0.0005 $\pm$ 0.0008	0.0004 $\pm$ 0.0009
Weighted average	0.0004 $\pm$ 0.0008	0.0003 $\pm$ 0.0009

  - ♢ In both cases we measure a slope which is consistent with zero

Questions & Answers

- Q12B: Do you have χ^2 values for combined slope calculation in the note?
  - ◊ The note does not have a χ^2 value for the combined slope. The combined slope would be dominated in any case by the Jet50 measurement

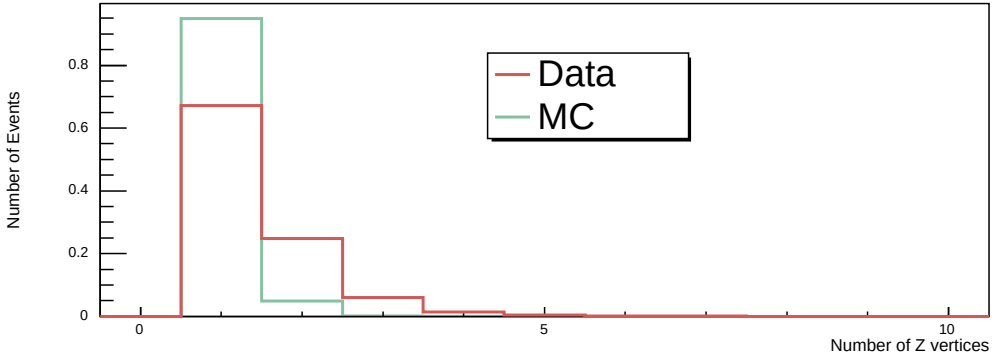


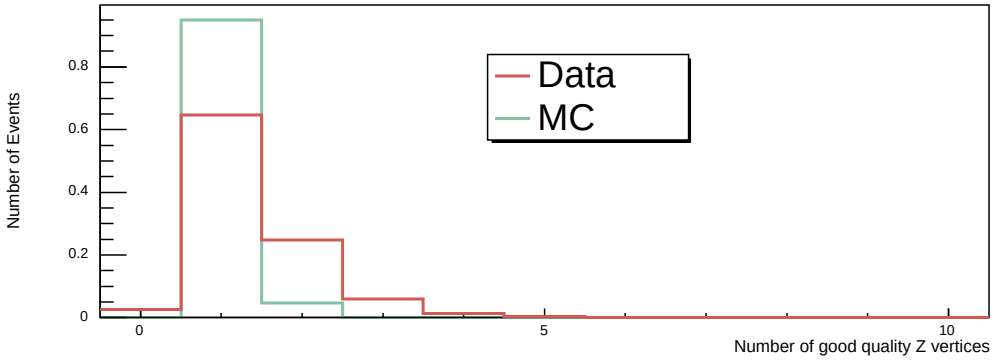


Questions & Answers

- Q13A: Do you understand why the new 5cm vtx cut has different efficiencies in data/MC? Is it related to multiple interactions? Is the number of zvtx well described, for example?

  - ♢ Events lost in the data when applying this cut are events in which the vertex closest to the lepton track is farther than 5 cm (in z) from the highest ΣP_T vertex
  - ♢ This effect probably arises due to multiple interactions, for which we do not trust the MC would give an accurate description
  - ♢ Fortunately the efficiency of the cut is close to 100% for both data and MC so we do not worry about taking the difference between them as a systematic uncertainty.





Questions & Answers

- Q13B: Multiple interaction: can you check multiple interaction effects using ttbar with minbias MC sample (we have it officially)

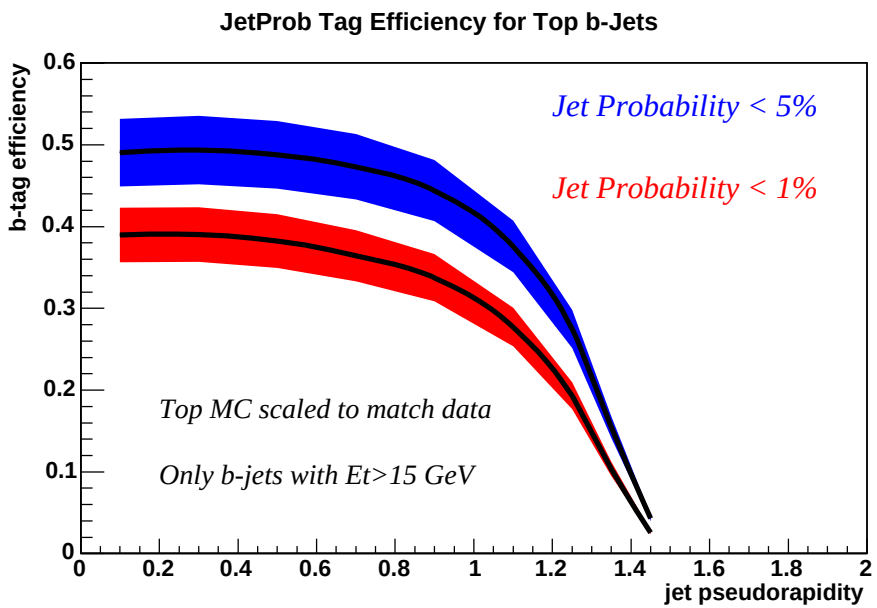
  - We have calculated the efficiency of the vertex-z cut in two more ttbar samples with min bias: ttop7v and ttop5v

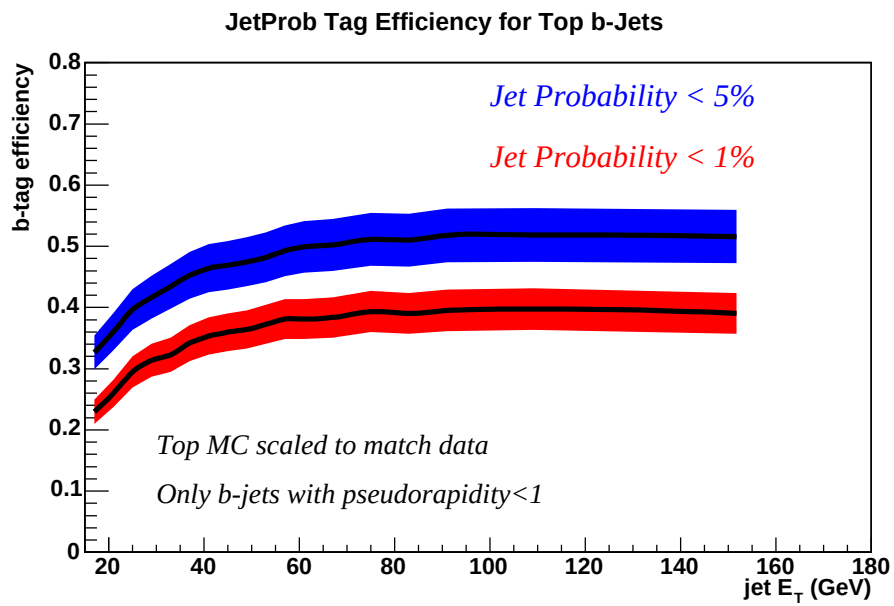
Sample	Z-Vtx cut Efficiency
ttopel	100%
ttop5v	99.4%
ttop7v	98.6%
data	98%

FOR BLESSING

Jet Probability PR Plots: Efficiency

- Efficiency to tag b-jets in a top Monte Carlo sample. The bands represent the systematic error on the data/MC scale factors



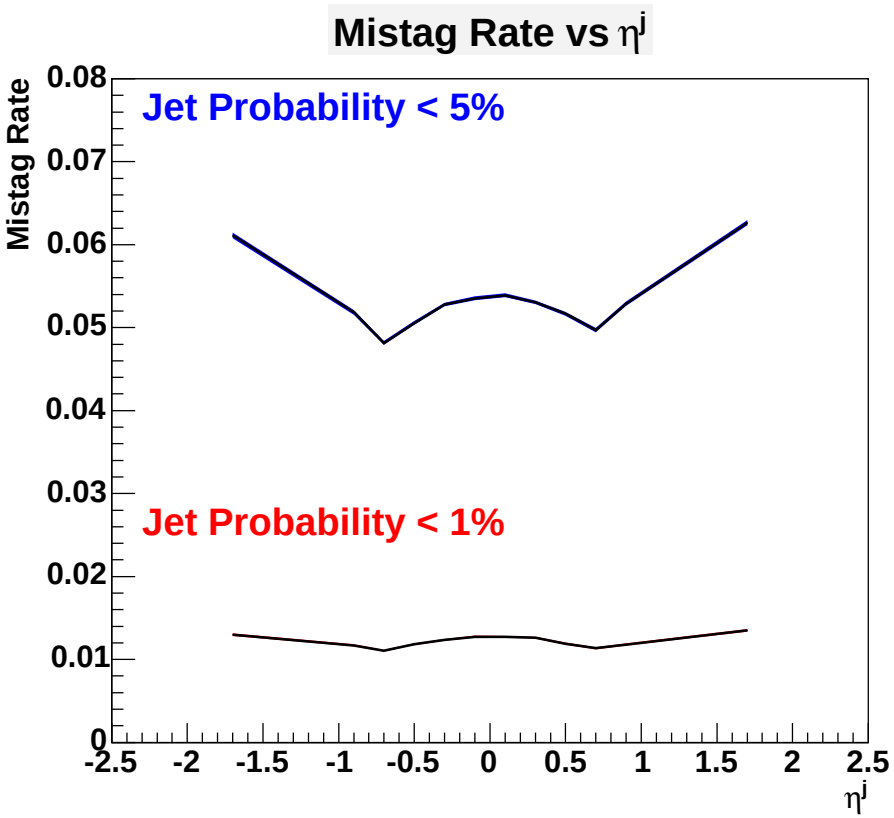


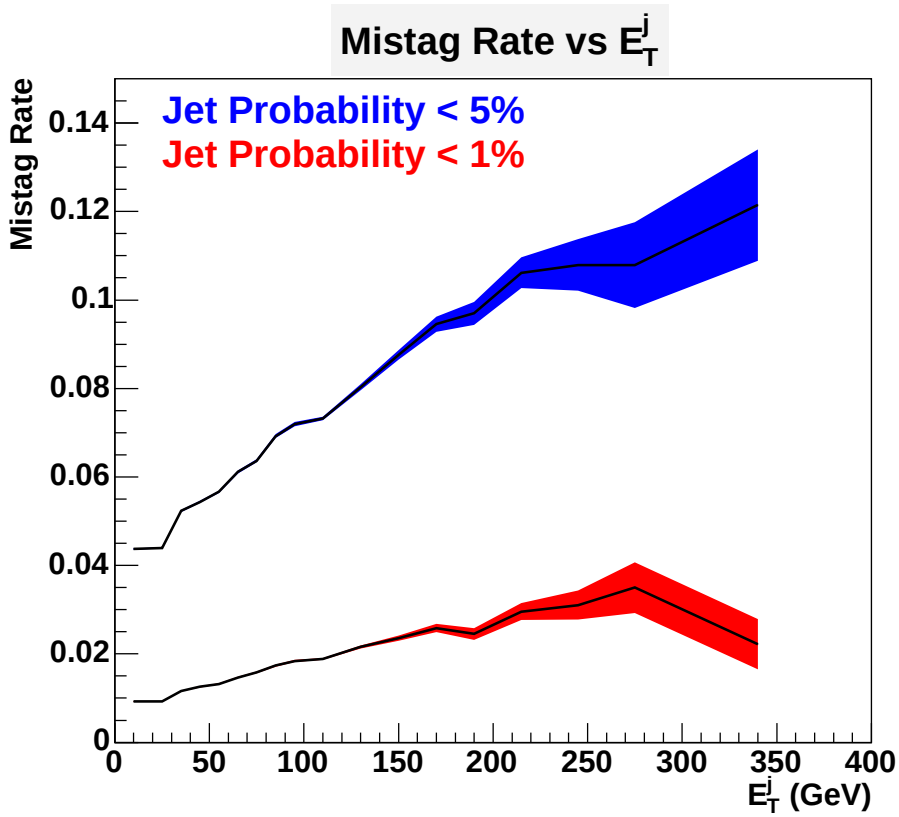
- Average efficiency for tight b-jets and c-jets jets after ttbar selection

	b jets		c jets	
	Raw	Scaled	Raw	Scaled
JP $<$ 1%	43.2 $\pm$ 0.1 %	35.3 $\pm$ 3.0 %	9.6 $\pm$ 0.2 %	7.8 $\pm$ 0.7 %
JP $<$ 5%	54.6 $\pm$ 0.1 %	46.5 $\pm$ 3.9 %	20.3 $\pm$ 0.2 %	17.3 $\pm$ 1.5 %

Jet Probability PR Plots: Mistag Rate

- Jet Probability Mistag rate as a function of jet E_T and jet η. They are derived from an inclusive jet data sample which includes all of the 5.3.3 jet20, jet50, jet70 and jet100 datasets. The bands represent the statistical uncertainty





Yield of Events

Jet Multiplicity	1 jet	2 jet	3 jet	$\geq$ 4 jets
Pretag events				
CEM	16897	2657	182	105
CMUP	8169	1175	83	44
CMX	4273	610	35	17
Total	29339	4442	300	166

Jet Mult.	1 jet	2 jets	3 jets	$\geq$ 4 jets
Single tagged events (JP$<$1%)				
CEM	207	106	33	36
CMUP	92	58	13	24
CMX	51	27	6	8
Total	350	191	52	68
Single tagged events (JP$<$5%)				
CEM	571	230	53	53
CMUP	256	105	24	29
CMX	148	50	10	11
Total	975	385	87	93

Jet Mult.	2 jets	3 jets	$\geq$ 4 jets
Double tagged events (JP$<$1%)			
CEM	8	7	9
CMUP	3	4	8
CMX	2	1	1
Total	13	12	18
Double tagged events (JP$<$5%)			
CEM	16	15	18
CMUP	9	4	17
CMX	3	3	4
Total	28	22	39

Acceptances

Quantity	CEM	CMUP	CMX
Acc. No Tag	$3.665 \pm 0.017 \pm 0.279$	$1.919 \pm 0.011 \pm 0.147$	$0.751 \pm 0.008 \pm 0.057$
Lum.(pb^{-1})	318.5 ± 18.8	318.5 ± 18.8	318.5 ± 18.8
Single tag, JP<1% (SF = 0.817 ± 0.070)			
Tag Eff.	$54.70 \pm 0.24 \pm 3.59$	$54.05 \pm 0.30 \pm 3.54$	$55.21 \pm 0.52 \pm 3.57$
Average Tag Eff.	$54.5 \pm 0.17 \pm 3.57$		
Acc. with Tag	$2.00 \pm 0.01 \pm 0.20$	$1.04 \pm 0.01 \pm 0.10$	$0.41 \pm 0.01 \pm 0.04$
$\epsilon_{t\bar{t}} \int$L dt	$6.38 \pm 0.04 \pm 0.74$	$3.30 \pm 0.03 \pm 0.39$	$1.32 \pm 0.02 \pm 0.15$
Double tag, JP<1% (SF = 0.817 ± 0.070)			
Tag Eff.	$12.69 \pm 0.16 \pm 2.07$	$12.58 \pm 0.20 \pm 2.04$	$13.44 \pm 0.35 \pm 2.19$
Average Tag Eff.	$12.74 \pm 0.12 \pm 2.07$		
Acc. with Tag	$0.465 \pm 0.006 \pm 0.084$	$0.241 \pm 0.004 \pm 0.043$	$0.101 \pm 0.003 \pm 0.018$
$\epsilon_{t\bar{t}} \int$L dt	$1.48 \pm 0.02 \pm 0.28$	$0.77 \pm 0.01 \pm 0.15$	$0.32 \pm 0.01 \pm 0.06$
Single tag, JP<5% (SF = 0.852 ± 0.072)			
Tag Eff.	$68.8 \pm 0.2 \pm 3.7$	$68.6 \pm 0.3 \pm 3.7$	$69.6 \pm 0.5 \pm 3.7$
Average Tag Eff.	$68.8 \pm 0.2 \pm 3.7$		
Acc. with Tag	$2.5 \pm 0.01 \pm 0.23$	$1.315 \pm 0.009 \pm 0.123$	$0.523 \pm 0.006 \pm 0.049$
$\epsilon_{t\bar{t}} \int$L dt	$8.03 \pm 0.05 \pm 0.88$	$4.19 \pm 0.03 \pm 0.46$	$1.67 \pm 0.02 \pm 0.18$
Double tag, JP<5% (SF = 0.852 ± 0.072)			
Tag Eff.	$24.4 \pm 0.2 \pm 3.6$	$24.1 \pm 0.3 \pm 3.6$	$25.2 \pm 0.5 \pm 3.7$
Average Tag Eff.	$24.4 \pm 0.2 \pm 3.6$		
Acc. with Tag	$0.895 \pm 0.009 \pm 0.148$	$0.462 \pm 0.006 \pm 0.0077$	$0.189 \pm 0.004 \pm 0.032$
$\epsilon_{t\bar{t}} \int$L dt	$2.85 \pm 0.03 \pm 0.50$	$1.47 \pm 0.02 \pm 0.26$	$0.60 \pm 0.011 \pm 0.11$

Summary Backgrounds (Single tag, JP$<$1%)

Jet Multiplicity	1 jet	2 jet	3 jet	$\geq$ 4 jets
MC Derived Backgrounds				
WW	2.2 $\pm$ 0.3	5.0 $\pm$ 0.6	0.7 $\pm$ 0.1	0.28 $\pm$ 0.06
WZ	1.0 $\pm$ 0.1	2.0 $\pm$ 0.2	0.23 $\pm$ 0.04	0.09 $\pm$ 0.02
ZZ	0.027 $\pm$ 0.006	0.09 $\pm$ 0.01	0.012 $\pm$ 0.004	0.007 $\pm$ 0.002
Single top $W-g$	4.1 $\pm$ 0.5	4.9 $\pm$ 0.6	0.7$\pm$ 0.09	0.20 $\pm$ 0.03
Single top W^*	1.3 $\pm$ 0.2	4.2 $\pm$ 0.5	0.60 $\pm$ 0.07	0.14 $\pm$ 0.02
$Z \to \tau^-\tau^+$	0.74 $\pm$ 0.3	0.4 $\pm$ 0.2	0.04 $\pm$ 0.04	0.0 $\pm$ 0.
Total	9.3 $\pm$ 1.1	16.6 $\pm$ 1.9	2.3 $\pm$ 0.3	0.71 $\pm$ 0.09
W + Heavy Flavour				
W$b\bar{b}$	83.0 $\pm$ 23.4	47.2 $\pm$ 13.2	6.0 $\pm$ 1.6	3.3 $\pm$ 0.9
W$c\bar{c}$	31.2 $\pm$ 9.3	17.5 $\pm$ 5.2	2.3 $\pm$ 0.7	1.2 $\pm$ 0.4
Wc	86.4 $\pm$ 21.4	19.2 $\pm$ 5.0	1.4 $\pm$ 0.4	0.6 $\pm$ 0.2
Total	200.6 $\pm$ 42.2	83.8 $\pm$ 19.8	9.6 $\pm$ 2.4	5.2 $\pm$ 1.4
Others				
Mistag	149.7 $\pm$ 17.9	52.1 $\pm$ 6.2	8.6 $\pm$ 1.0	6.8 $\pm$ 0.8
non W	30.5 $\pm$ 15.6	8.6 $\pm$ 4.6	0.9 $\pm$ 0.6	0.5 $\pm$ 0.5
Total Background	390.2 $\pm$ 49.1	161.1 $\pm$ 22.0	21.5 $\pm$ 2.8	13.2 $\pm$ 1.7
$t\bar{t}$ (6.1 pb)	1.7 $\pm$ 0.4	14.0 $\pm$ 1.8	27.5 $\pm$ 3.3	39.6 $\pm$ 4.6
Data	350	191	52	68
After correction				
W$b\bar{b}$	83.0 $\pm$ 23.4	46.6 $\pm$ 13.0	4.3 $\pm$ 1.2	1.1 $\pm$ 0.3
W$c\bar{c}$	31.2 $\pm$ 9.3	17.3 $\pm$ 5.2	1.6 $\pm$ 0.5	0.4 $\pm$ 0.1
Wc	86.3 $\pm$ 21.4	19.0 $\pm$ 4.9	1.0 $\pm$ 0.3	0.21 $\pm$ 0.06
Mistag	149.7 $\pm$ 17.9	51.5 $\pm$ 6.1	6.2 $\pm$ 0.7	2.2 $\pm$ 0.3
Total Background	390.0 $\pm$ 49.1	159.6 $\pm$ 21.8	16.3 $\pm$ 2.0	5.1 $\pm$ 0.7
$t\bar{t}$ (8.9 pb)	2.5 $\pm$ 0.5	20.6 $\pm$ 2.5	40.4 $\pm$ 4.8	58.1 $\pm$ 6.8

Summary Backgrounds (Double tag, JP$<$1%)

Jet Multiplicity	2 jet	3 jet	$\geq$ 4 jets
MC Derived Backgrounds			
WW	0.048 $\pm$ 0.02	0.03 $\pm$ 0.018	0.006 $\pm$ 0.007
WZ	0.25 $\pm$ 0.06	0.033 $\pm$ 0.012	0.013 $\pm$ 0.006
ZZ	0.014 $\pm$ 0.005	0.001 $\pm$ 0.001	0.001 $\pm$ 0.001
Single top $W-g$	0.17 $\pm$ 0.03	0.12 $\pm$ 0.03	0.046 $\pm$ 0.011
Single top W^*	0.88 $\pm$ 0.17	0.14 $\pm$ 0.028	0.035 $\pm$ 0.008
$Z \to \tau^- \tau^+$	0.06 $\pm$ 0.06	0. $\pm$ 0.	0. $\pm$ 0.
Total	1.4 $\pm$ 0.3	0.33 $\pm$ 0.07	0.10 $\pm$ 0.02
W + Heavy Flavour			
W$b\bar{b}$	6.2 $\pm$ 2.0	0.89 $\pm$ 0.29	0.61 $\pm$ 0.21
W$c\bar{c}$	0.38 $\pm$ 0.17	0.13 $\pm$ 0.06	0.077 $\pm$ 0.046
Wc	0.13 $\pm$ 0.08	0.032 $\pm$ 0.026	0.020 $\pm$ 0.020
Total	6.7 $\pm$ 2.1	1.1 $\pm$ 0.3	0.71 $\pm$ 0.24
Others			
Mistag	0.21 $\pm$ 0.05	0.097 $\pm$ 0.022	0.12 $\pm$ 0.03
non W	0.19 $\pm$ 0.12	0.029 $\pm$ 0.018	0.045 $\pm$ 0.030
Total Background	8.5 $\pm$ 2.3	1.5 $\pm$ 0.4	0.97 $\pm$ 0.25
$t\bar{t}$ (6.1 pb)	2.2 $\pm$ 0.5	5.6 $\pm$ 1.1	10. $\pm$ 2.
Data	13	12	18
After Correction			
W$b\bar{b}$	6.1 $\pm$ 1.9	0.57 $\pm$ 0.19	0.10 $\pm$ 0.03
W$c\bar{c}$	0.38 $\pm$ 0.17	0.085 $\pm$ 0.042	0.013 $\pm$ 0.008
Wc	0.12 $\pm$ 0.08	0.021 $\pm$ 0.017	0.0034 $\pm$ 0.0034
Mistag	0.21 $\pm$ 0.05	0.063 $\pm$ 0.015	0.019 $\pm$ 0.004
Total	8.4 $\pm$ 2.2	1.1 $\pm$ 0.3	0.28 $\pm$ 0.06
$t\bar{t}$ (11.12 pb)	3.9 $\pm$ 0.9	10.2 $\pm$ 2.0	18.4 $\pm$ 3.5

Summary Backgrounds (Single tag, JP$<$5%)

Jet Multiplicity	1 jet	2 jet	3 jet	$\geq$ 4 jets
MC Derived Backgrounds				
WW	5.5 $\pm$ 0.6	12.5 $\pm$ 1.4	1.81 $\pm$ 0.22	0.74 $\pm$ 0.10
WZ	1.6 $\pm$ 0.2	3.3 $\pm$ 0.3	0.40 $\pm$ 0.05	0.16 $\pm$ 0.03
ZZ	0.049 $\pm$ 0.009	0.14 $\pm$ 0.02	0.027 $\pm$ 0.006	0.014 $\pm$ 0.004
Single top $W-g$	5.4 $\pm$ 0.7	6.5 $\pm$ 0.8	0.92 $\pm$ 0.10	0.26 $\pm$ 0.03
Single top W^*	1.7 $\pm$ 0.2	5.2 $\pm$ 0.6	0.74 $\pm$ 0.08	0.17 $\pm$ 0.02
$Z \to \tau^- \tau^+$	2.10 $\pm$ 0.5	1.1 $\pm$ 0.3	0.13 $\pm$ 0.10	0. $\pm$ 0.
Total	16.3 $\pm$ 1.9	28.8 $\pm$ 3.1	4.0 $\pm$ 0.4	1.4 $\pm$ 0.2
W + Heavy Flavour				
W$b\bar{b}$	111.5 $\pm$ 31.4	60.6 $\pm$ 16.9	7.4 $\pm$ 2.0	4.1 $\pm$ 1.2
W$c\bar{c}$	67.9 $\pm$ 20.2	36.5 $\pm$ 10.8	4.6 $\pm$ 1.4	2.7 $\pm$ 0.8
Wc	183.6 $\pm$ 45.2	40.0 $\pm$ 10.1	3.2 $\pm$ 0.8	1.7 $\pm$ 0.5
Total	363.0 $\pm$ 74.5	137.1 $\pm$ 31.2	15.2 $\pm$ 3.6	8.5 $\pm$ 2.1
Others				
Mistag	584.8 $\pm$ 91.9	193.8 $\pm$ 30.5	28.2 $\pm$ 4.4	22.1 $\pm$ 3.5
non W	68.8 $\pm$ 34.8	21.4 $\pm$ 11.1	1.3 $\pm$ 0.9	0.79 $\pm$ 0.74
Total Background	1033.0 $\pm$ 124.6	381.1 $\pm$ 46.1	48.8 $\pm$ 5.9	32.7 $\pm$ 4.2
$t\bar{t}$ (6.1 pb)	2.3 $\pm$ 0.4	18.0$\pm$ 2.2	34.9 $\pm$ 4.0	50.0 $\pm$ 5.5
Data	975	385	87	93
After Correction				
W$b\bar{b}$	111.4 $\pm$ 31.3	59.9 $\pm$ 16.7	5.2 $\pm$ 1.4	1.1 $\pm$ 0.3
W$c\bar{c}$	67.9 $\pm$ 20.1	36.1 $\pm$ 10.7	3.2 $\pm$ 1.0	0.76 $\pm$ 0.24
Wc	183.5 $\pm$ 45.3	39.5 $\pm$ 10.0	2.2 $\pm$ 0.6	0.5 $\pm$ 0.13
Mistag	584.6 $\pm$ 91.8	191.4 $\pm$ 30.1	19.6 $\pm$ 3.1	6.1 $\pm$ 1.0
Total Background	1032.6 $\pm$ 124.6	377.0 $\pm$ 45.6	35.5 $\pm$ 4.2	10.6 $\pm$ 1.4
$t\bar{t}$ (9.63 pb)	3.6 $\pm$ 0.6	28.4 $\pm$ 3.4	55.1 $\pm$ 6.3	78.6 $\pm$ 8.6

Summary Backgrounds (Double tag, JP$<$5%)

Jet Multiplicity	2 jet	3 jet	$\geq$ 4 jets
MC Derived Backgrounds			
WW	0.29 $\pm$ 0.06	0.13 $\pm$ 0.04	0.073 $\pm$ 0.027
WZ	0.51 $\pm$ 0.11	0.063 $\pm$ 0.017	0.029 $\pm$ 0.010
ZZ	0.026 $\pm$ 0.007	0.0040 $\pm$ 0.0023	0.0016 $\pm$ 0.0013
Single top $W-g$	0.39 $\pm$ 0.07	0.23 $\pm$ 0.04	0.085 $\pm$ 0.017
Single top W^*	1.5 $\pm$ 0.3	0.26 $\pm$ 0.05	0.064 $\pm$ 0.012
$Z \to \tau^-\tau^+$	0.07 $\pm$ 0.07	0. $\pm$ 0.	0. $\pm$ 0.
Total	2.8 $\pm$ 0.5	0.70 $\pm$ 0.12	0.25 $\pm$ 0.05
W + Heavy Flavour			
W$b\bar{b}$	11.5 $\pm$ 3.7	1.8 $\pm$ 0.6	1.2 $\pm$ 0.4
W$c\bar{c}$	2.4 $\pm$ 0.91	0.61 $\pm$ 0.24	0.45 $\pm$ 0.19
Wc	0.98 $\pm$ 0.38	0.25 $\pm$ 0.11	0.19 $\pm$ 0.09
Total	14.9 $\pm$ 4.7	2.6 $\pm$ 0.8	1.9 $\pm$ 0.6
Others			
Mistag	2.7 $\pm$ 0.9	1.0 $\pm$ 0.3	1.3 $\pm$ 0.4
non W	0.63 $\pm$ 0.34	0.093 $\pm$ 0.052	0.14 $\pm$ 0.09
Total Background	21.1 $\pm$ 5.1	4.4 $\pm$ 0.9	3.5 $\pm$ 0.7
$t\bar{t}$ (6.1 pb)	3.9 $\pm$ 0.8	10.8 $\pm$ 2.0	19.3 $\pm$ 3.4
Data	28	22	39
After Correction			
W$b\bar{b}$	11.4 $\pm$ 3.6	1.1 $\pm$ 0.3	0.16 $\pm$ 0.05
W$c\bar{c}$	2.3 $\pm$ 0.9	0.38 $\pm$ 0.15	0.061 $\pm$ 0.025
Wc	0.97 $\pm$ 0.37	0.16 $\pm$ 0.07	0.025 $\pm$ 0.012
Mistag	2.7 $\pm$ 0.8	0.65 $\pm$ 0.20	0.15 $\pm$ 0.05
Total Background	20.9 $\pm$ 5.0	3.1 $\pm$ 0.6	0.80 $\pm$ 0.15
$t\bar{t}$ (11.59 pb)	7.5 $\pm$ 1.5	20.5 $\pm$ 3.8	36.6 $\pm$ 6.4

Statistical Uncertainties, JP $<$ 1%

Source	Fractional Stat. Uncert.	Contribution to $\sigma_{t\bar{t}}$
Single tag, JP $<$ 1%		
MC Acceptance	0.34%	0.34%
Mistag Matrix Prediction	0.71%	0.06%
Non-W Fraction	15.7%	0.10%
Non-W Prediction	44.4%	0.63%
W+HF Prediction	2.9%	0.25%
Other MC Background	3.9%	0.12%
Observed Data	+9.6%,-8.7%	+11.6%,-10.6%
Total Statistical Uncertainty		+11.7%,-10.7%
Double tag, JP $<$ 1%		
MC Acceptance	0.34%	0.34%
Mistag Matrix Prediction	0.48%	0.003%
Non-W Fraction	15.7%	0.020%
Non-W Prediction	31.1%	0.080%
W+HF Prediction	7.7%	0.21%
Other MC Background	6.3%	0.095%
Observed Data	+20%,-16.7%	+21.0%,-17.5%
Total Statistical Uncertainty		+21.0%,-17.5%

Statistical Uncertainties, JP $<$ 5%

Source	Fractional Stat. Uncert.	Contribution to $\sigma_{t\bar{t}}$
Single tag, JP $<$ 5%		
MC Acceptance	0.34%	0.34%
Mistag Matrix Prediction	0.27%	0.070%
Non-W Fraction	15.7%	0.18%
Non-W Prediction	40.6%	0.64%
W+HF Prediction	2.5%	0.24%
Other MC Background	3.6%	0.14%
Observed Data	+7.7%,-7.2%	+10.4%,-9.7%
Total Statistical Uncertainty		+10.4%,-9.7%
Double tag, JP $<$ 5%		
MC Acceptance	0.34%	0.34%
Mistag Matrix Prediction	0.35%	0.012%
non-W Fraction	15.7%	0.029%
Non-W Prediction	22.4%	0.093%
W+HF Prediction	5.4%	0.18%
Other MC Background	5.7%	0.095%
Observed Data	+13.6%,-12.0%	+14.6%,-12.8%
Total Statistical Uncertainty		+14.6%,-12.8%

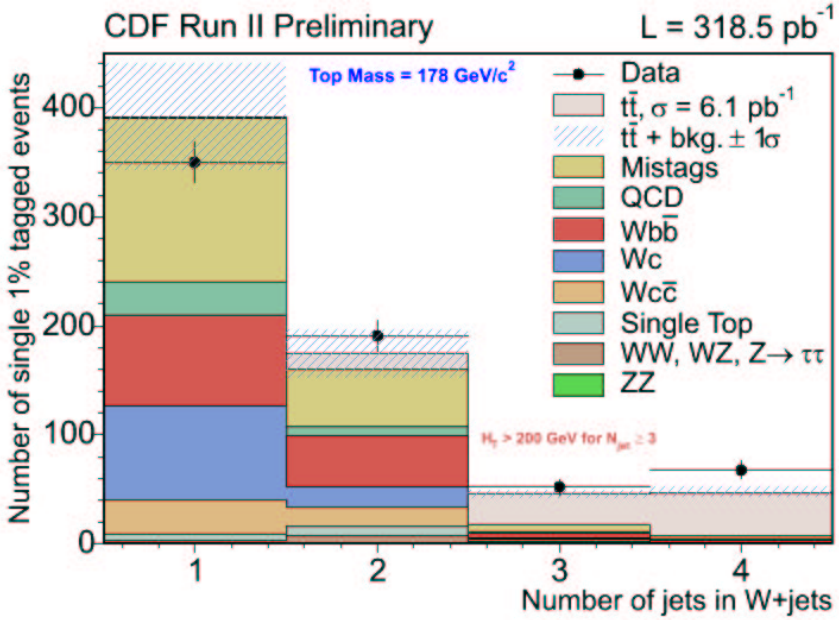
Systematic Uncertainties, JP $<$ 1%

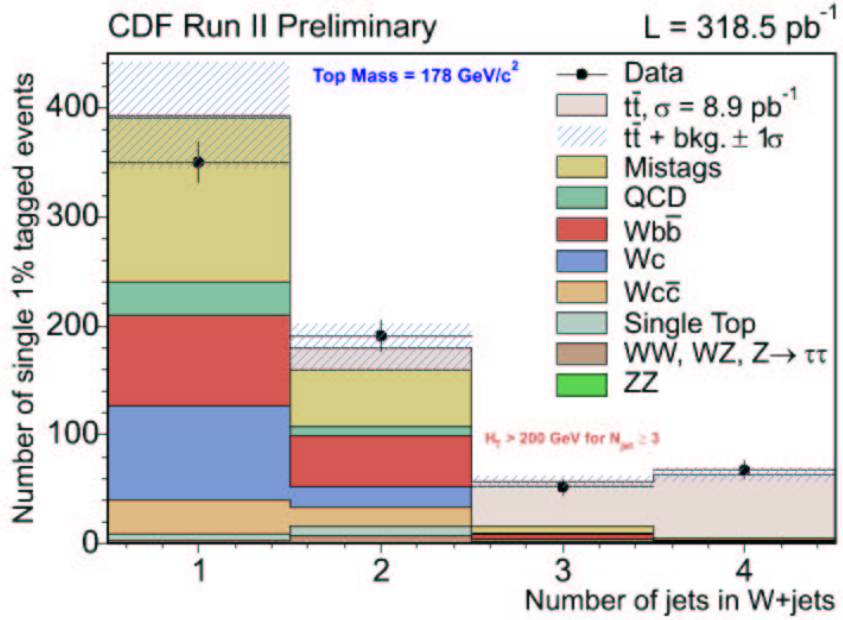
	Single tag, JP $<$ 1%		Double tag, JP $<$ 1%	
Source	Fractional Syst. Uncert.	Contribution to $\sigma_{t\bar{t}}$	Fractional Syst. Uncert.	Contribution to $\sigma_{t\bar{t}}$
Central Electron ID	1.6%	0.97%	1.6%	0.96%
Central Muon ID	1.9%	0.61%	1.9%	0.60%
CMX Muon ID	1.8%	0.22%	1.8%	0.21%
PDF	2%	2.0%	2%	2.0%
Jet Energy Scale	4.2%	4.2%	4.2%	4.1%
Lepton Isolation	5%	4.9%	5%	4.8%
Initial and Final State Radiation	1.3%	1.3%	1.3%	1.3%
Monta Carlo Modeling	1.6%	1.6%	1.6%	1.6%
Z Vertex	2.0%	2.1%	2.0%	2.0%
Tagging Scale Factor (b's/c's)	8.6/12.9%	7.2%	8.6/12.9%	14.7%
Mistag Asimmetry	11.5%	1.0%	23.0%	0.07%
Non-W Fraction	50%	0.33%	50%	0.060%
Non-W Prediction	50%	0.71%	50%	0.13%
W+HF Prediction	30%	2.6%	30%	0.84%
Other MC backgrounds	1.8%	0.056%	1.8%	0.027%
Luminosity	5.9%	5.7%	5.9%	5.7%
Total Systematic Uncertainty		12.2%		17.4%

Systematic Uncertainties, JP $<$ 5%

	Single tag, JP $<$ 5%		Double tag, JP $<$ 5%	
Source	Fractional Syst. Uncert.	Contribution to $\sigma_{t\bar{t}}$	Fractional Syst. Uncert.	Contribution to $\sigma_{t\bar{t}}$
Central Electron ID	1.6%	0.98%	1.6%	0.96%
Central Muon ID	1.9%	0.61%	1.9%	0.60%
CMX Muon ID	1.8%	0.22%	1.8%	0.21%
PDF	2%	2.0%	2%	2.0%
Jet Energy Scale	4.2%	4.2%	4.2%	4.1%
Lepton Isolation	5%	5.0%	5%	4.8%
Initial and Final State Radiation	1.3%	1.3%	1.3%	1.3%
Monta Carlo Modeling	1.6%	1.6%	1.6%	1.6%
Z Vertex	2.0%	2.1%	2.0%	2.0%
Tagging Scale Factor (b's/c's)	8.5/12.7%	6.3%	8.5/12.7%	13.6%
Mistag Asimmetry	15.5%	3.0%	31.1%	0.44%
Non-W Fraction	50%	0.56%	50%	0.092%
Non-W Prediction	50%	0.79%	50%	0.21%
W+HF Prediction	30%	2.9%	30%	1.0
Other MC backgrounds	1.8%	0.072%	1.8%	0.030%
Luminosity	5.9%	5.8%	5.9%	5.7%
Total Systematic Uncertainty		12.2%		16.5%

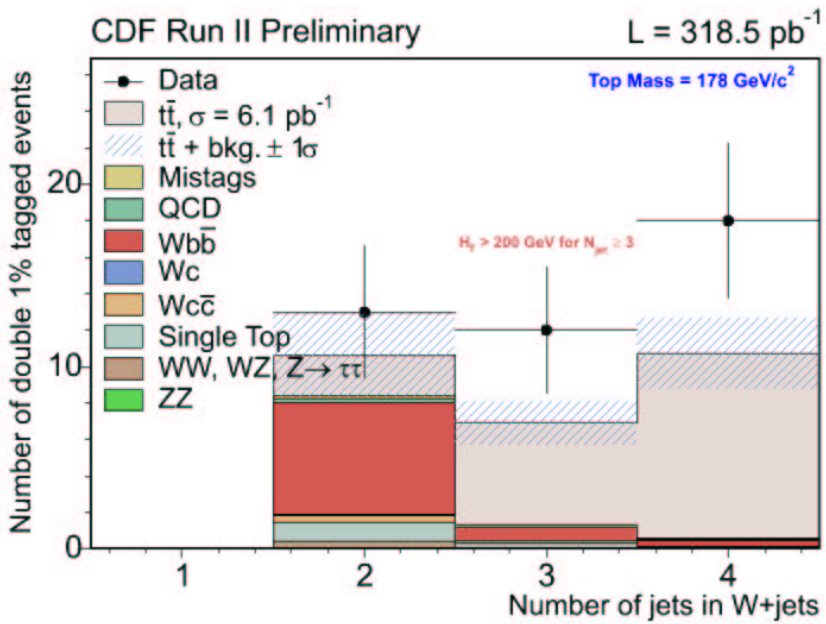
Single Tag, JP $<$ 1%

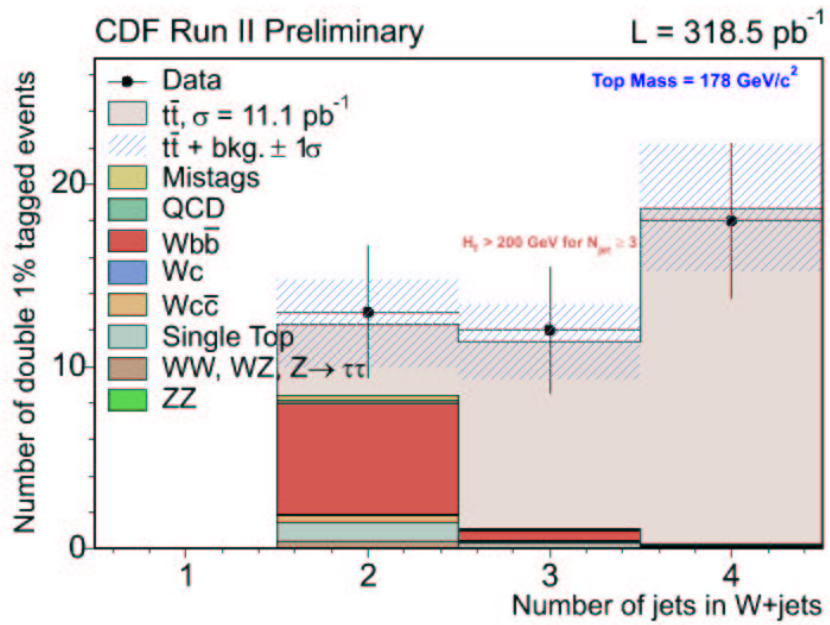




$\sigma_{t\bar{t}}$ = $8.9^{+1.0}_{-1.0}$ (stat.)$\pm$1.1(syst.) pb

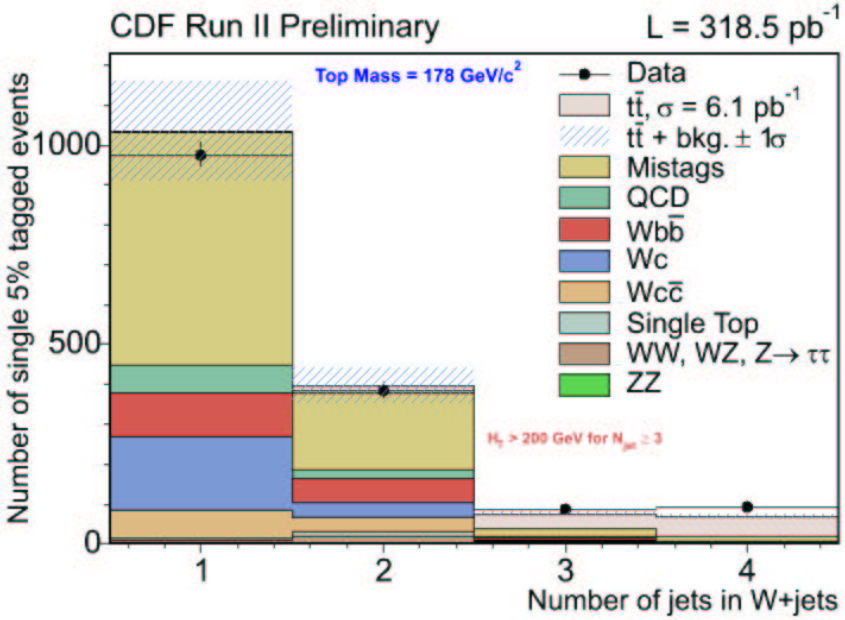
Double Tag, JP $<$ 1%

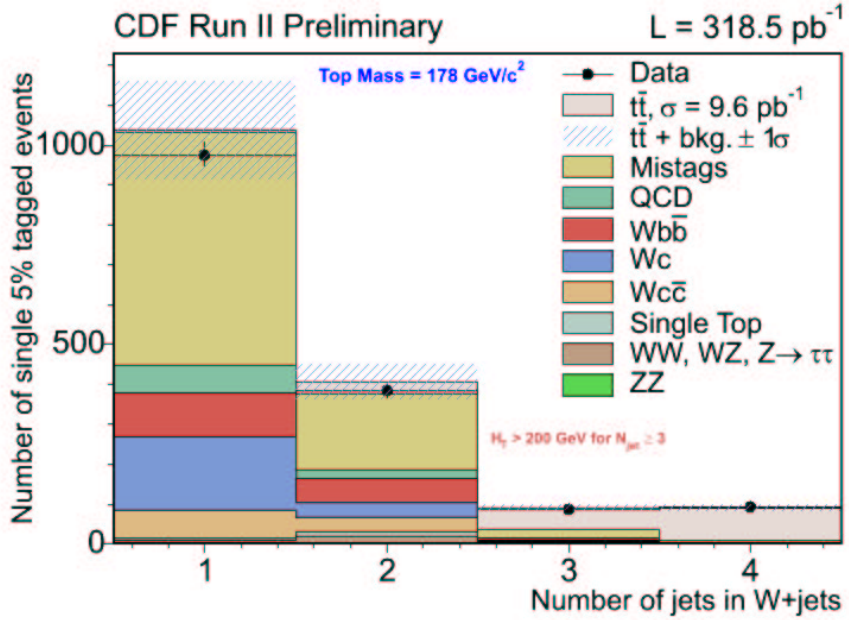




$\sigma_{t\bar{t}}$ = $11.1^{+2.3}_{-1.9}$ (stat.)±1.9(syst.) pb

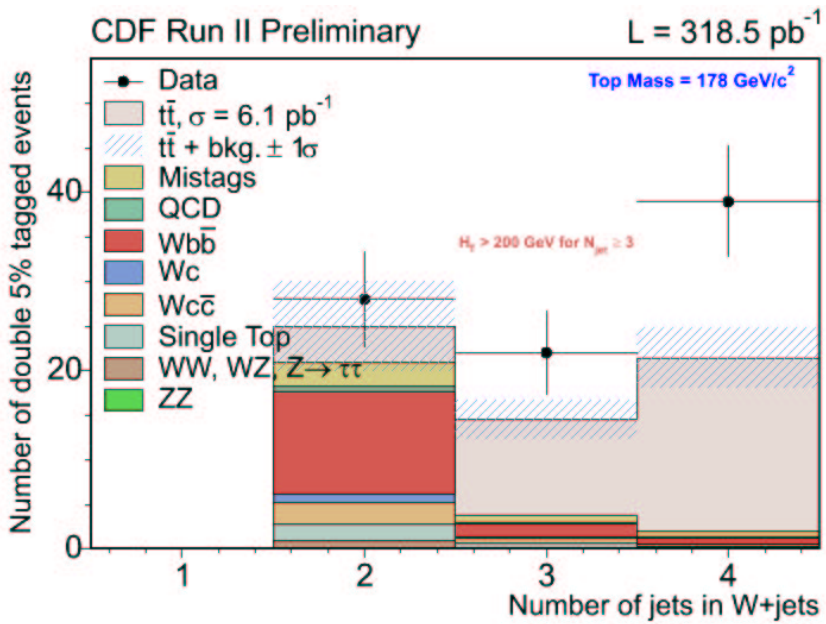
Single Tag, JP $<$ 5%

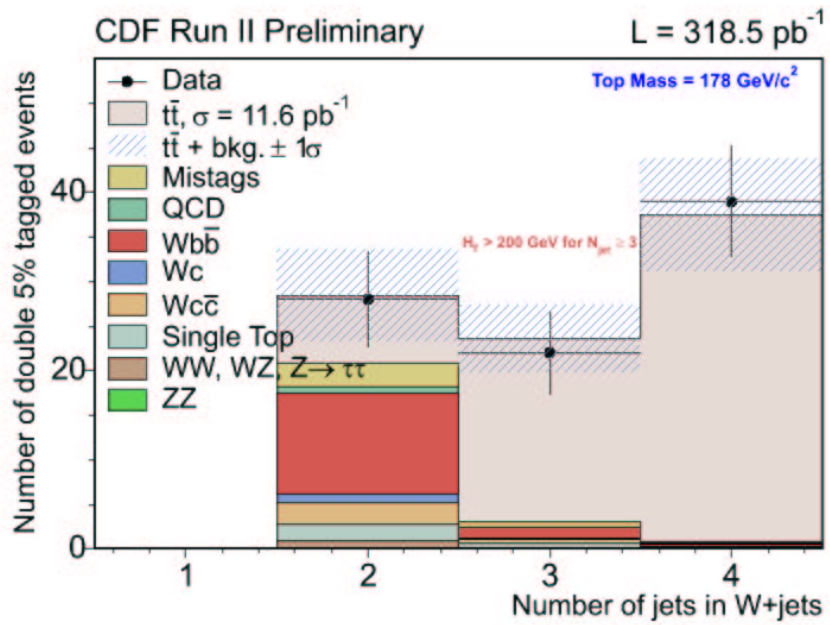




$\sigma_{t\bar{t}}$ = $9.6^{+1.0}_{-0.9}$ (stat.)±1.2(syst.) pb

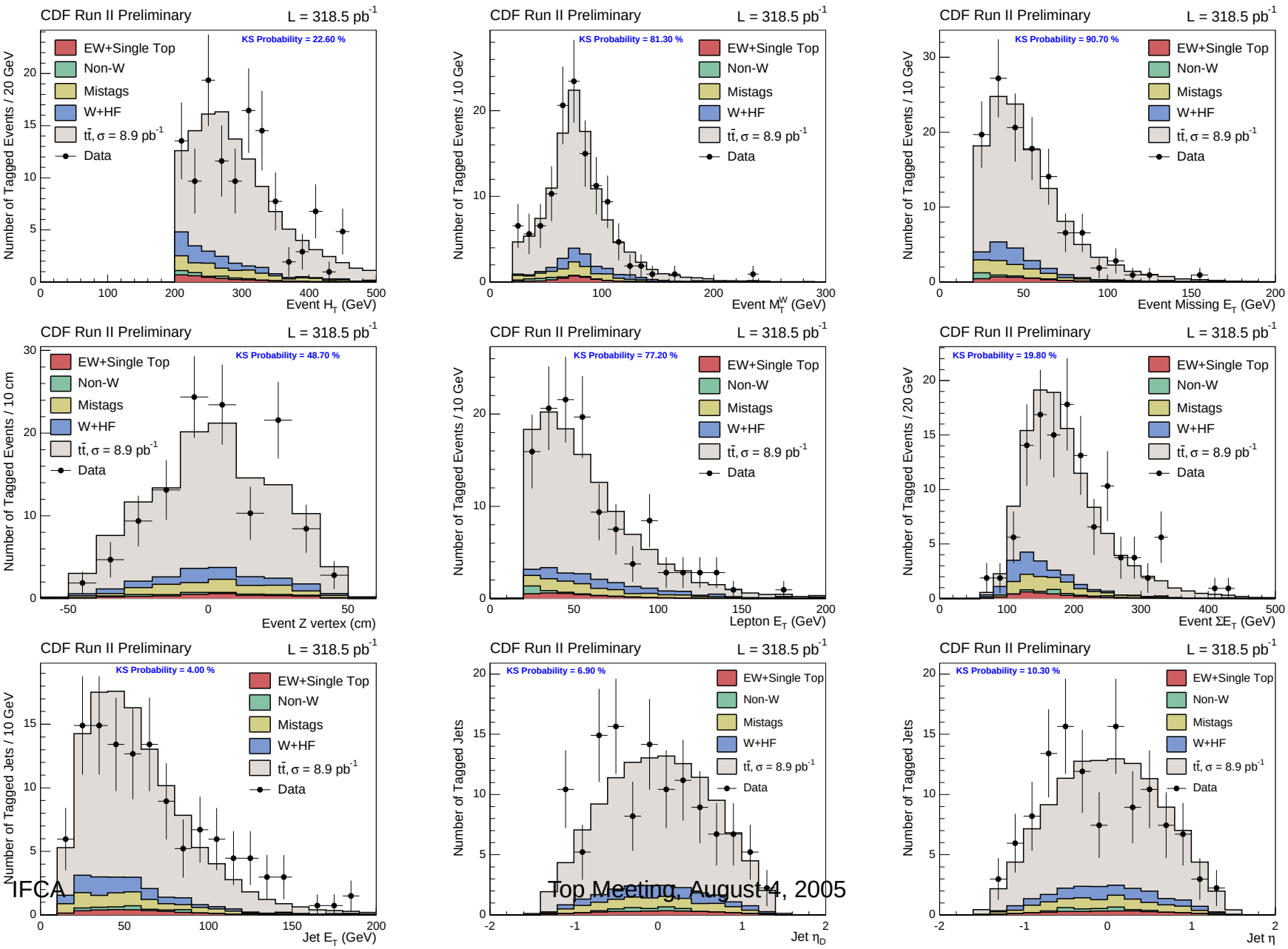
Double Tag, JP $<$ 5%



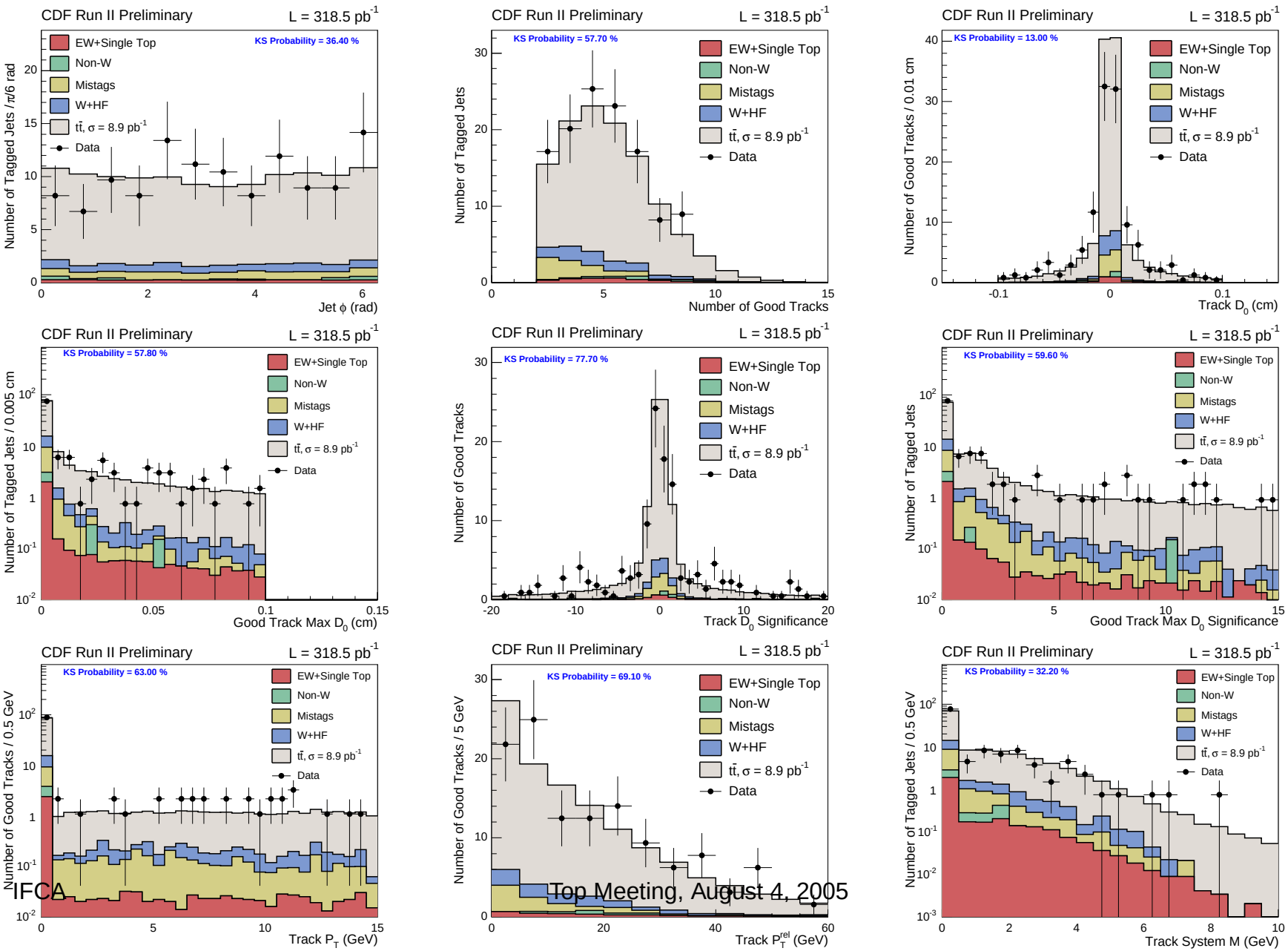


$\sigma_{t\bar{t}}$ = $11.6^{+1.7}_{-1.5}$ (stat.)$\pm$1.9(syst.) pb

Kinematic Distributions (Single Tag, JP $<$ 1%)

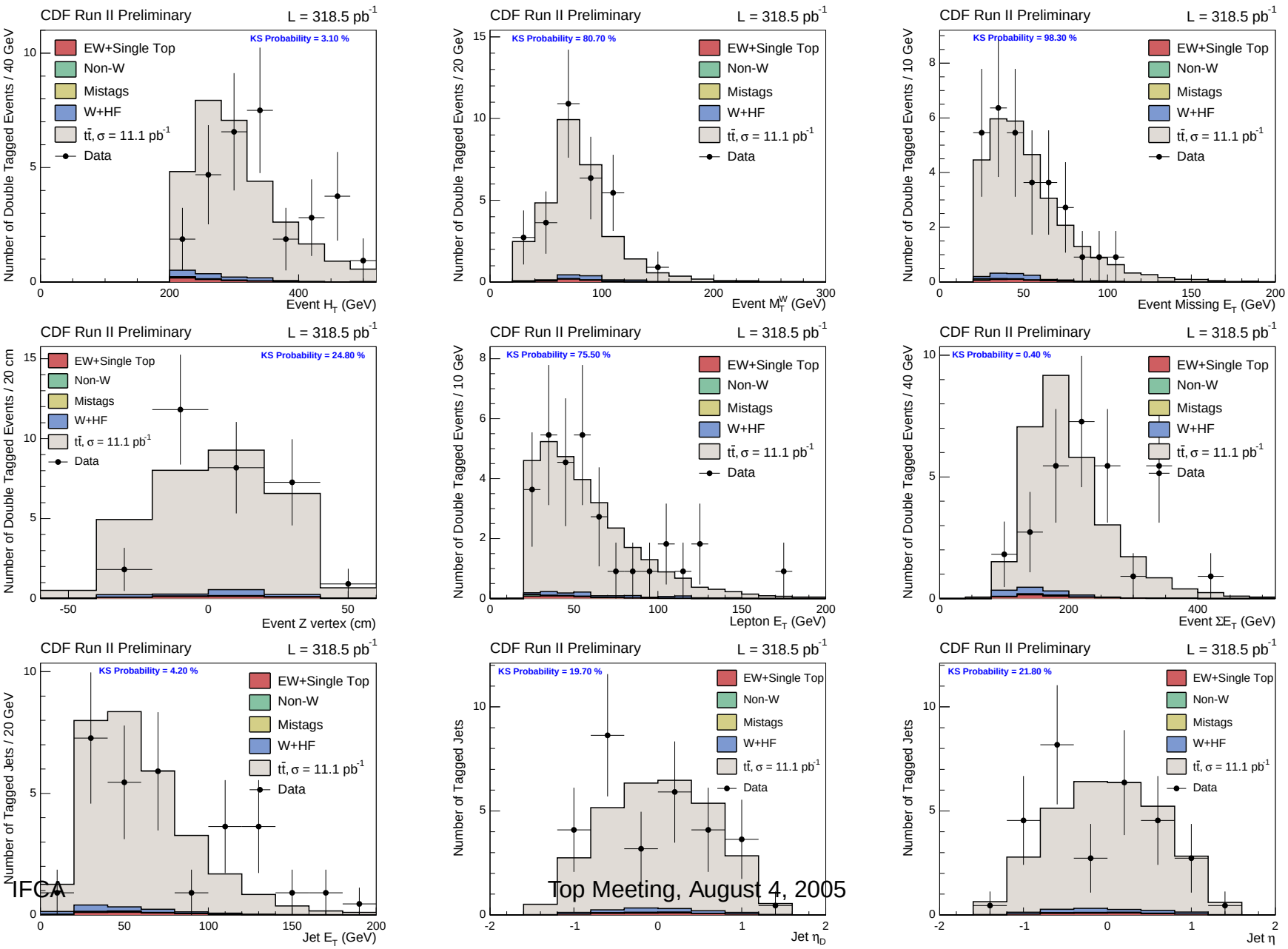


Kinematic Distributions (Single Tag, JP $<$ 1%)

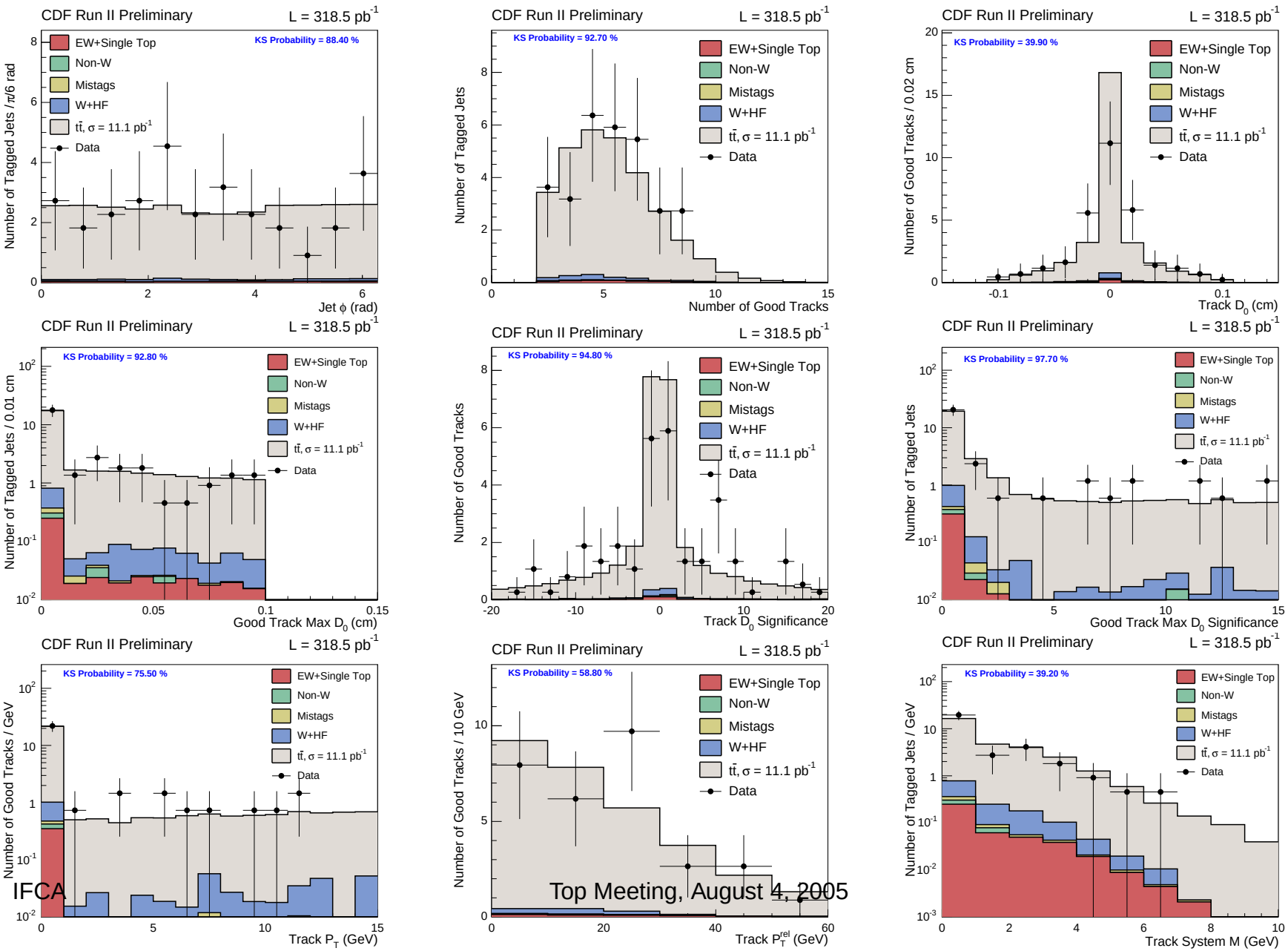


BACK-UP SLIDES

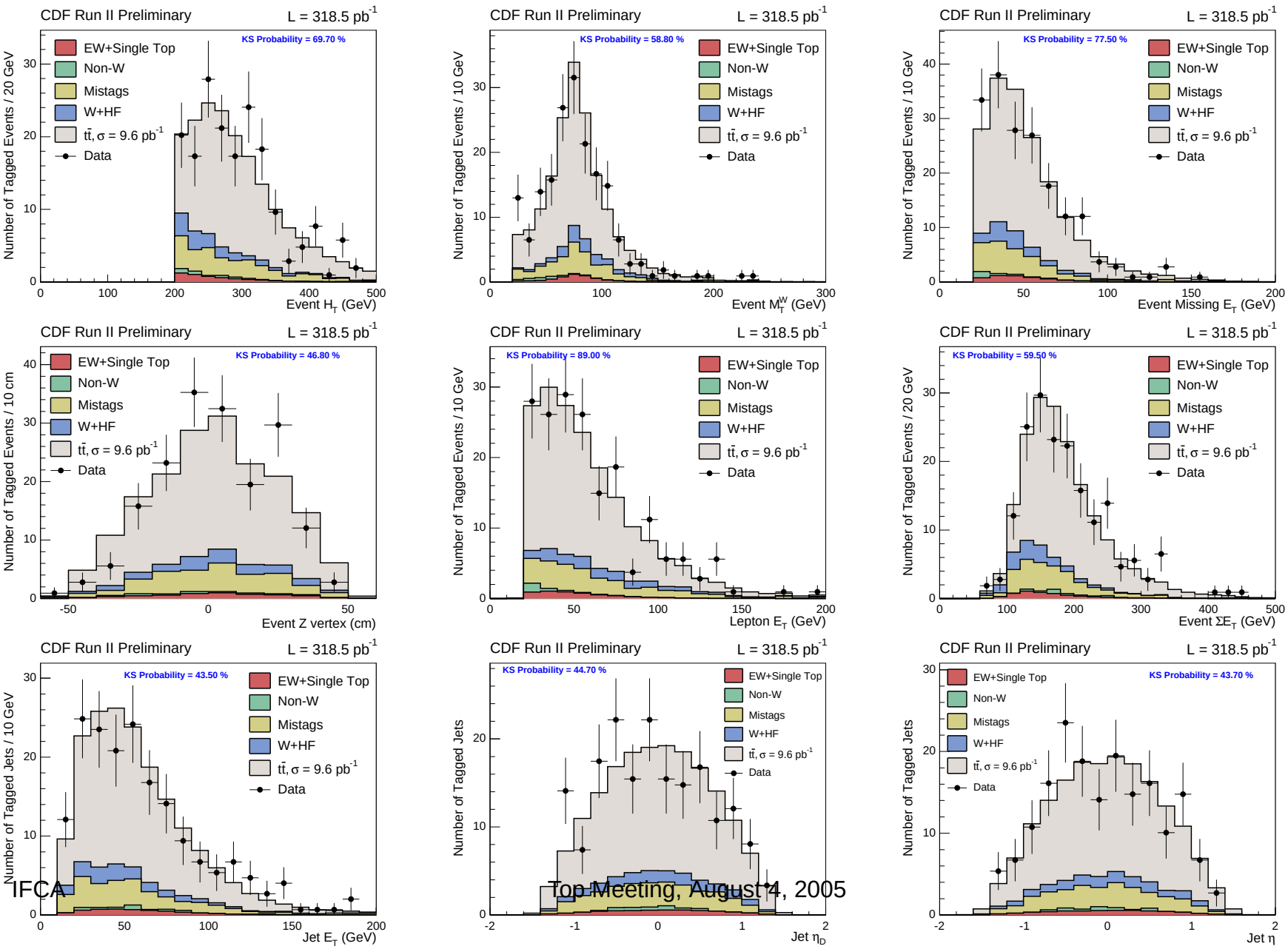
Kinematic Distributions (Double Tag, JP $<$ 1%)



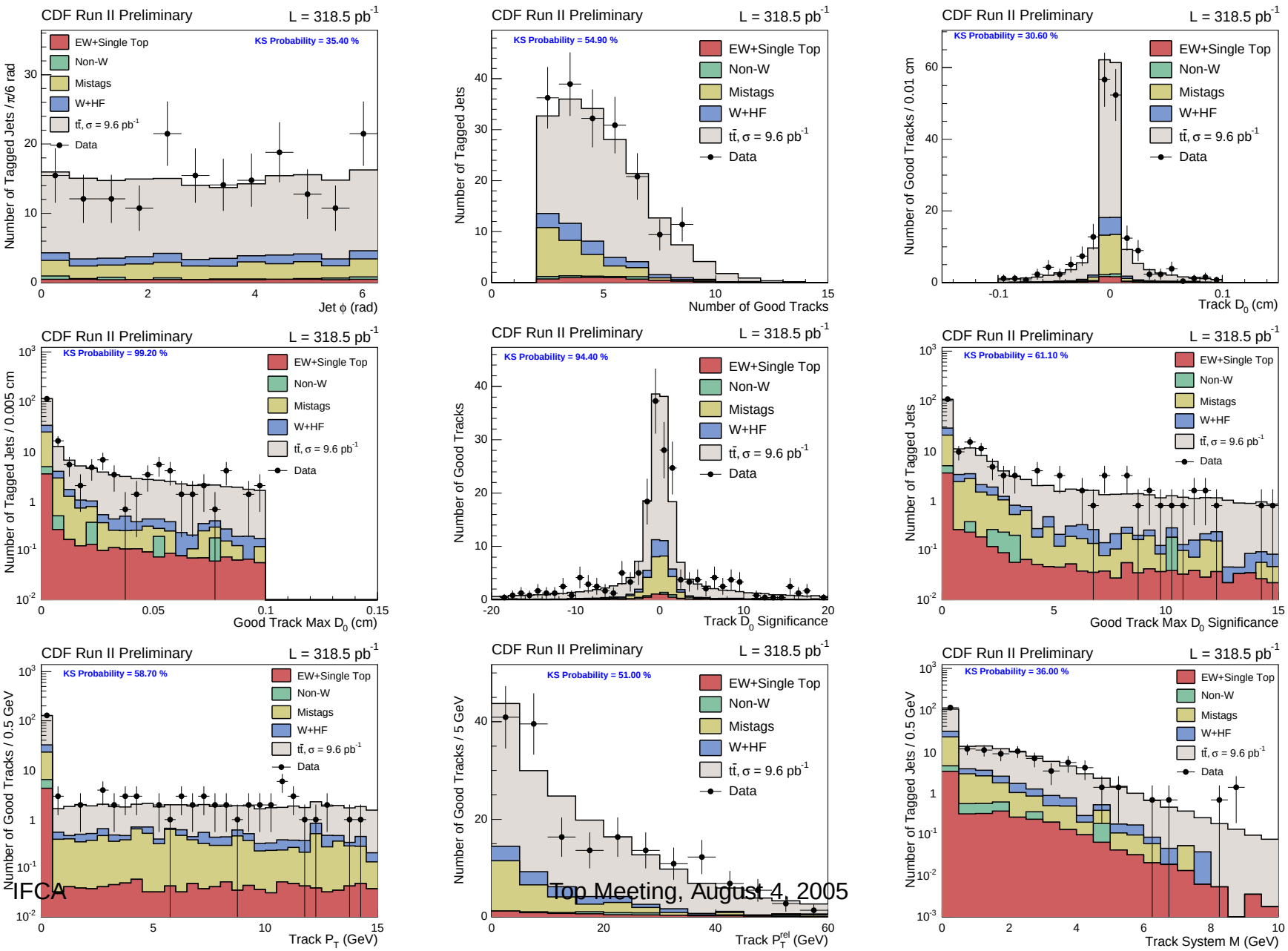
Kinematic Distributions (Double Tag, JP $<$ 1%)



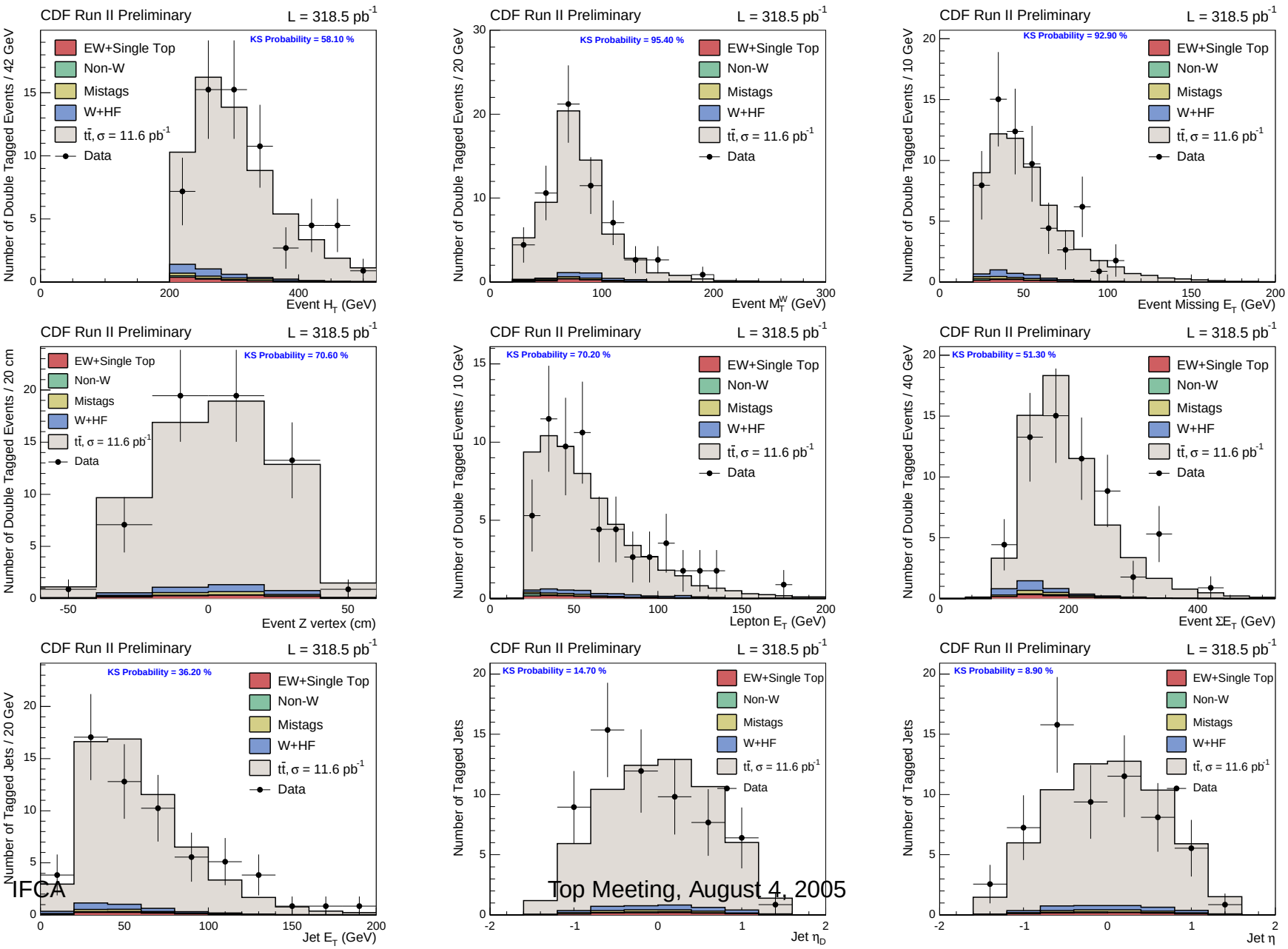
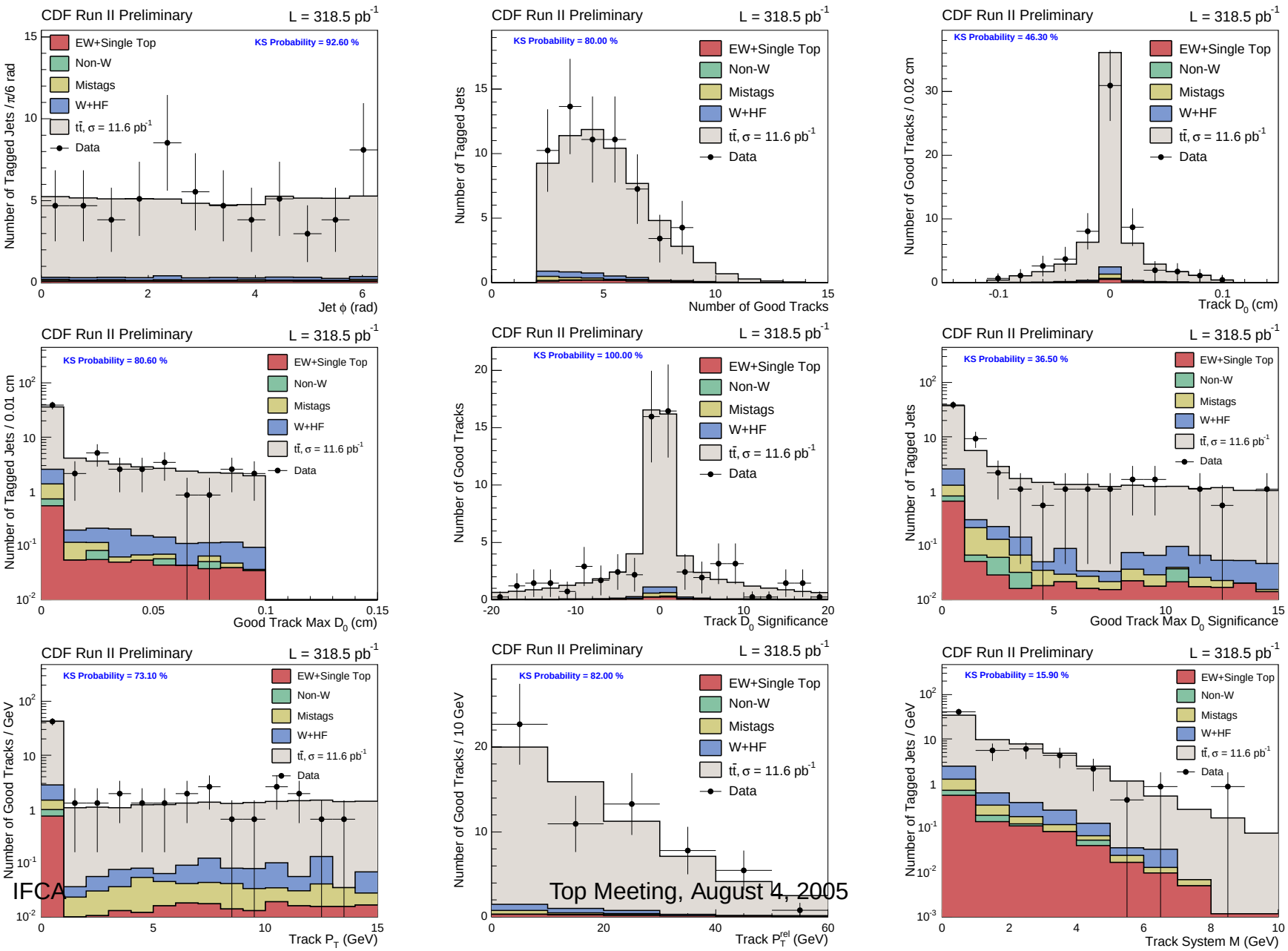
Kinematic Distributions (Single Tag, JP $<$ 5%)



Kinematic Distributions (Single Tag, JP $<$ 5%)



Kinematic Distributions (Double Tag, JP $<$ 5%)



Kinematic Distributions (Double Tag, JP $<$ 5%)