Top $\rightarrow$ Stop SUSY search by charm channel

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Nov. 14 2001

OUTLINE

Signal

physical process

Monte Carlo simulation

ISASUSY parameters

channel area in parameter space

21 signal points

background estimate

physics background

instrumental background

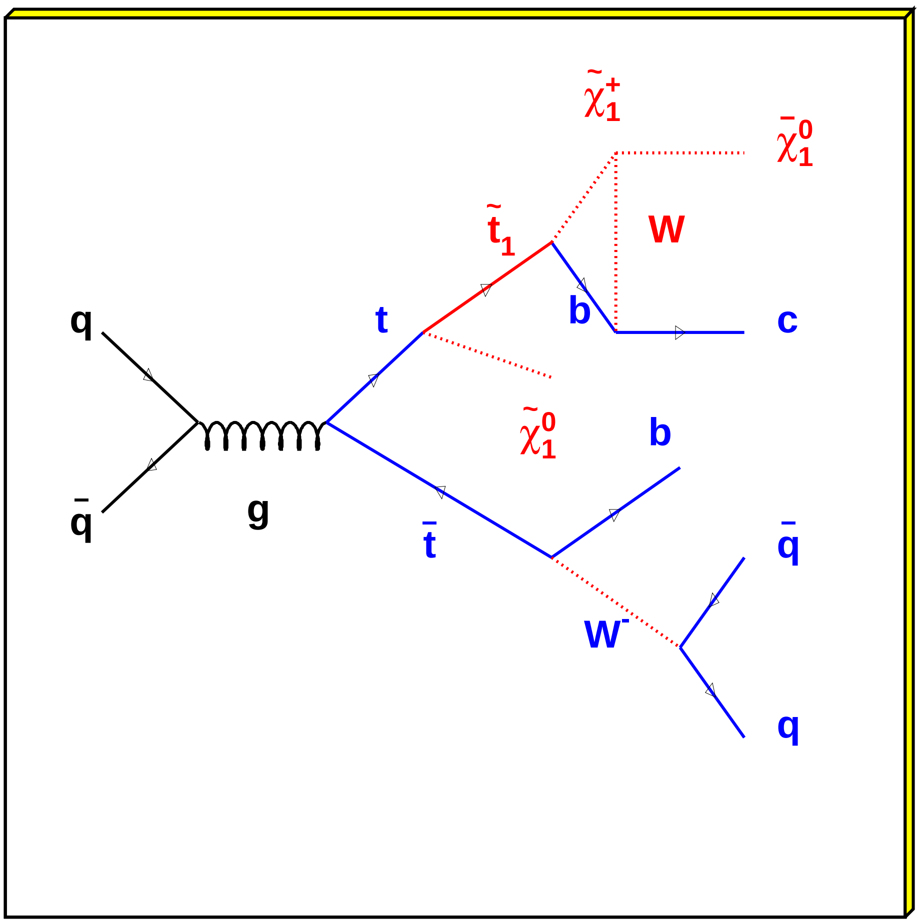
error estimate

Optimization

Work to be done

Signal: top $\to$ stop by charm channel

This analysis involves top quark pair $t\bar{t}$ decay, one follows standard model and the other in a way that supersymmetry describes. The top squark decays to c and neutralino and finally there are 4 jets and $\not{E}_T$.



Signal: top $\to$ stop by charm channel

Several main decay modes related to top to stop:

t	$\tilde{\chi}_1^0$		
	$\tilde{t}_1$	b	
		$\tilde{\chi}_1^+$	$\tilde{\chi}_1^0\ e^+\ \nu_e$
			$\tilde{\chi}_1^0\ \mu^+\ \nu_\mu$
			$\tilde{\chi}_1^0\ \tau^+\ \nu_\tau$
			$\tilde{\chi}_1^0\ u\ \bar{d}$
			$\tilde{\chi}_1^0\ c\ \bar{s}$

Decay A

t	$\tilde{\chi}_1^0$	
	$\tilde{t}_1$	$\tilde{\chi}_1^0$
		c

Decay C

t	$\tilde{\chi}_1^0$	
	$\tilde{t}_1$	c
	$\tilde{t}_1$	$\tilde{\chi}_1^0$
	$\tilde{\chi}_2^0$	$\tilde{\chi}_1^0\ e^-\ e^+$
		$\tilde{\chi}_1^0\ \mu^-\ \mu^+$
		$\tilde{\chi}_1^0\ \tau^-\ \tau^+$
		$\tilde{\chi}_1^0\ \nu_e\ \nu_{\bar{e}}$
		$\tilde{\chi}_1^0\ \nu_\mu\ \nu_{\bar{\mu}}$
		$\tilde{\chi}_1^0\ \nu_\tau\ \nu_{\bar{\tau}}$
		$\tilde{\chi}_1^0\ u\ \bar{u}$
		$\tilde{\chi}_1^0\ d\ \bar{d}$
		$\tilde{\chi}_1^0\ s\ \bar{s}$
		$\tilde{\chi}_1^0\ c\ \bar{c}$
		$\tilde{\chi}_1^0\ b\ \bar{b}$

Decay D

other modes are more complicated.

Signal: top $\rightarrow$ stop by charm channel

Table 1: Parameters used in ISASUSY Monte Carlo sample (GeV)

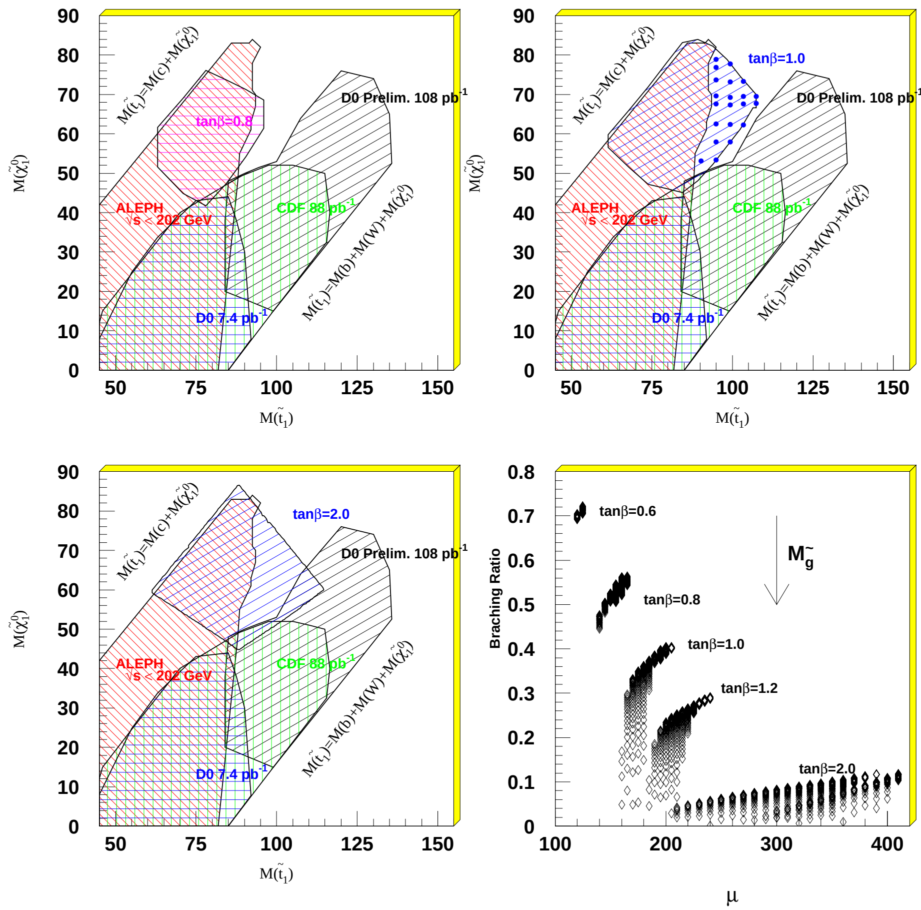
$M_{\tilde{q}}$=350	M_{lL}=200	M_{lR}=150	$M_{\tilde{\nu}}$=150	$M_{\tilde{t}L}$=300
A_T=-300	$M_{\tilde{b}R}$ =350	A_B=-750	$M_{\tilde{t}R}$=200	M_{hA}=400

Table 2: Signal Monte Carlo properties of top to stop by charm channel at $tan\beta = 1$. Here α is branching ratio of top to stop.

μ	$M_{\tilde{g}}$	M_{stop}	M_{LSP}	α
160	655	106.454	66.570	0.1692
160	670	106.454	68.434	0.0481
165	600	102.452	61.163	0.2976
165	640	102.452	66.515	0.2557
165	655	102.452	68.456	0.2274
165	685	102.452	72.239	0.0803
170	560	98.283	56.945	0.3325
170	590	98.283	61.312	0.3237
170	625	98.283	66.244	0.3030
170	640	98.283	68.259	0.2889
170	670	98.283	72.192	0.2430
170	705	98.283	76.622	0.0483
175	520	93.925	52.324	0.3483
175	550	93.925	56.897	0.3481
175	580	93.925	61.357	0.3440
175	615	93.925	66.465	0.3321
175	630	93.925	68.540	0.3239
175	660	93.925	72.595	0.2986
175	685	93.925	75.881	0.2618
175	700	93.925	77.813	0.2258
180	510	89.351	52.043	0.3586

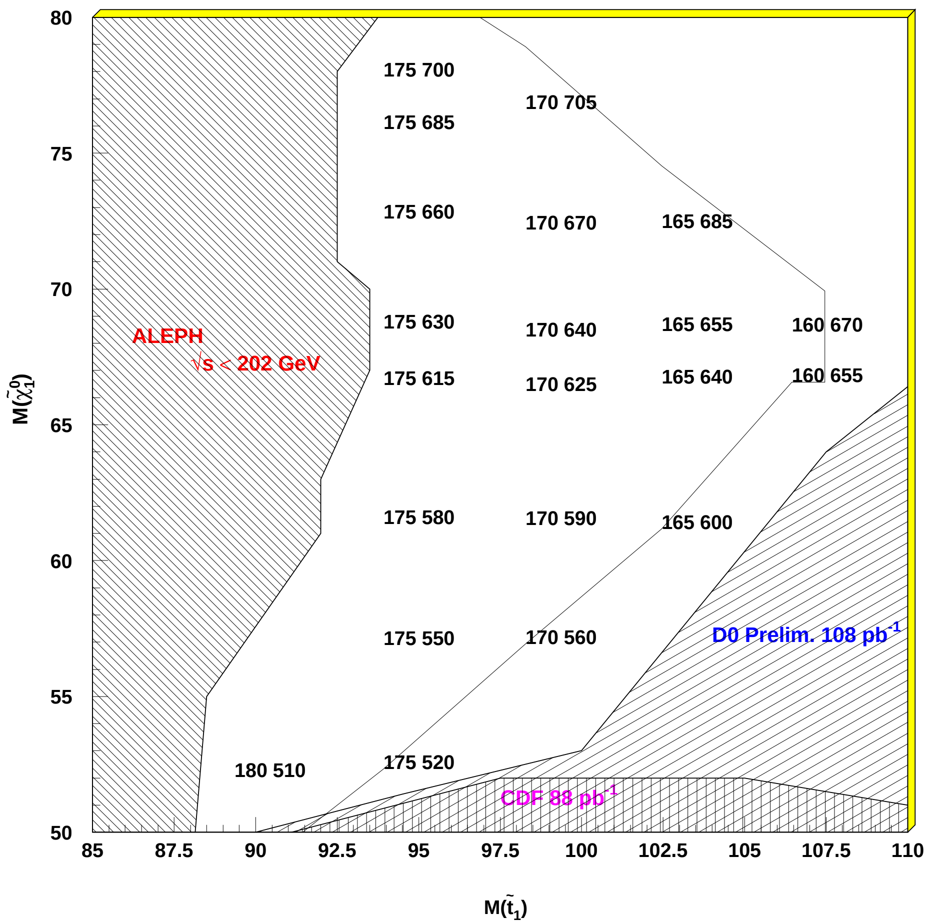
Signal: top → stop by charm channel

Possible area of signal at different $tan\beta$ values.



Signal: top $\rightarrow$ stop by charm channel

A zoom in of signal points in parameter space (M_{stop}, M_{LSP}) when $tan\beta = 1$. μ and $M_{\tilde{g}}$ are given to denote these points. Shadded area are excluded.



Data : top → stop by charm channel

Collide Data:

This analysis is based on Run1B data (run number 72250-93115) at Tevetron collected by MISSING_ET trigger. The data was reconstructed by RECO version 12 with standard DØ fixed cone jet-finding algorithm of cone size 0.5. The jets and $\not\!\!E_T$ were corrected by CAFIX 5.1. Totally there are 1,556,505 events in my data sample and the luminosity is 81.23 pb^{-1} (all bad run are removed).

Background : top $\rightarrow$ stop by charm channel

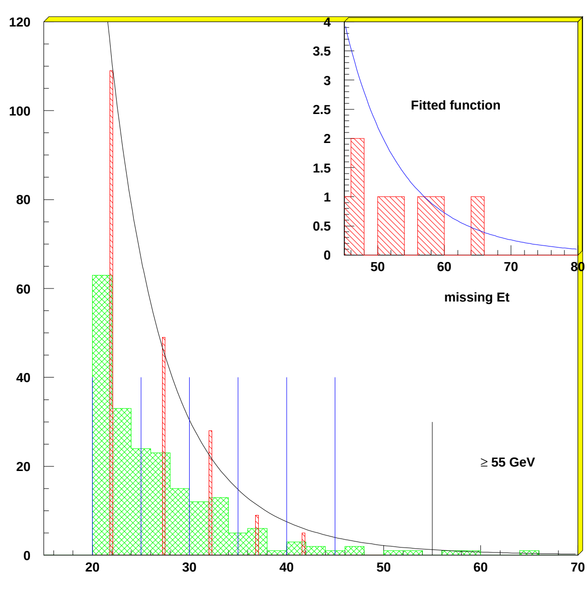
Background

Physics background

$t\bar{t}$, W+jets, WW,WZ, $Z \rightarrow \nu\nu$ and $Z \rightarrow \tau\tau$

QCD background

Use inclusive jet trigger jet_3_mon and jet_30 when leading jet energy is less than 45 GeV to estimate, use jet_50 when leading jet energy is less than 75 GeV and use jet_85 when leading jet energy is larger than 120 GeV. Making $\not{E}_T$ spectrum at low range and extrapolate to higher range by fitting with analytic functions, the one with minimum χ^2 is used to calculate to area under this function when $\not{E}_T$ is larger than a threshod ${\not{E}_T}_c$.



Error estimate: top $\rightarrow$ stop by charm channel

Systematic error

cross section quadrature summation over $t\bar{t}$, W+jets,WW, WZ

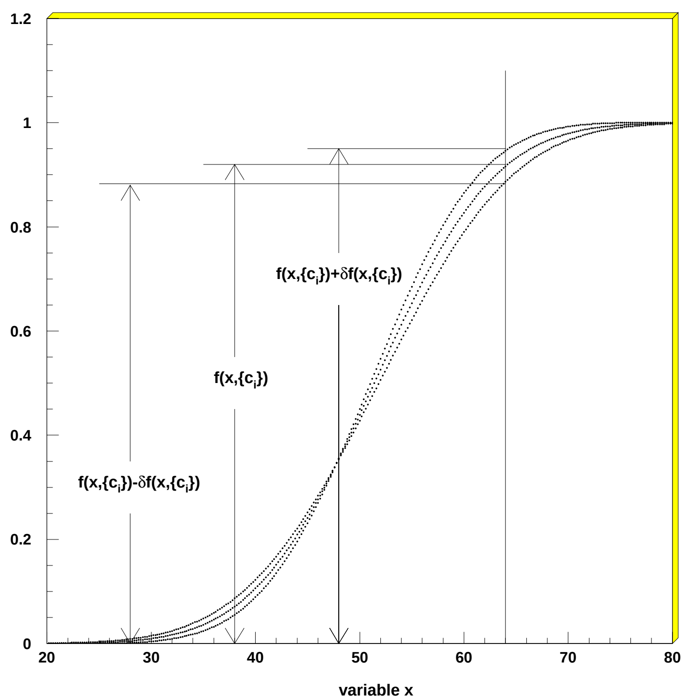
and linear summation of $Z \rightarrow \nu\nu$ and $Z \rightarrow \tau\tau$.

luminosity 5.35%

energy scale linear summation

efficiency

$$\Delta f(x, \{c_i\}) \equiv 2 \left| \frac{\delta f(x, \{c_i\})}{f(x, \{c_i\})} \right|$$



Error estimate: top $\rightarrow$ stop by charm channel

QCD fitting from fitted function

$$\sigma^2_{N\alpha} = \sum_{i=1} \left(\frac{\partial N_\alpha}{\partial C_i}\right)^2 (\delta C_i)^2$$

where α referrs to Gaussian or exponential function and δC_i is the error of C_i that comes from the fitting.

statistic error

$$\Delta\bar{n} = \sum^{i} \bar{n}_i \sqrt{\frac{N^i_{tot} - N^i_p}{N^i_p N^i_{tot}}}.$$

here N_{tot} is total number of events in our MC samples, N_p is the number of events passed our cuts.

Total error:

$$\Delta\bar{n} = \left[\sum_{i,j}^{(1)} (\Delta f_j \; n_i)^2 + \sum_{i}^{(2)} \left(\frac{\Delta\sigma_i}{\sigma_i} \; n_i\right)^2 + \left(\sum_{i}^{(3)} \frac{\Delta\sigma_i}{\sigma_i} \; n_i\right)^2 + \right.$$

$$\left. \sum_i \left(n^i_{+\sigma_i} - n^i_{-\sigma_i}\right)^2 + 0.0535^2 \sum_i \; n_i^2 \right]^{1/2}$$

the summation is over all efficiency cuts j before summation over all decay modes i, summation (2) means over $t\bar{t}, W+$ jets and WW, WZ backgrounds, summmation (3) referrs to summation over $Z \rightarrow \nu\nu$ and $Z \rightarrow \tau\tau$.

Optimization: top $\rightarrow$ stop by charm channel

To find the best cuts for signal efficiency, we scan global range of several important parameters, they are

$\not\!\!E_T$: (40, 60, 80, 100, 120, 140)
leading jet energy: (40, 60, 80, 100)
$\not\!\!E_T + \sum_{i=2}^{4} E_T(i)$: (100, 120, 140, 160, 180,200)
leading jet and $\not\!\!E_T$ arc radius: (0.7)
second jet and $\not\!\!E_T$ arc radius: (0.5)

The results are listed in two tables. Z_{nn1} means sample $Z \rightarrow \nu\nu$ with $25 < P_T < 50$, Z_{nn2} means sample $Z \rightarrow \nu\nu$ with $50 < P_T < 100$, Z_{nn3} means sample $Z \rightarrow \nu\nu$ with $100 < P_T < 200$ and Z_{nn4} mean $200 < P_T < 400$. Z_{tt1} means sample $Z \rightarrow \tau\tau$ with $25 < P_T < 50$, Z_{tt2} means sample $Z \rightarrow \tau\tau$ with $50 < P_T < 100$. Z_{tt3} Z_{tt4} could be understood in the same way. W_{th} means $W \rightarrow \tau + \nu$ and τ decays hadronically, W_{en} mean $W \rightarrow e + \nu$, W_{mn} means $W \rightarrow \mu\nu$ and W_{tl} means $W \rightarrow \tau\nu$ and τ decays leptonically.

Table 3: Details of background

$\not{E}_T$	j1	$\not{E}_T + E_T$	arc1	arc2	$t\bar{t}$	Wth	Wen	Wmn	Wtl	WW	WZ	Z_{nn1}	Z_{nn2}	Z_{nn3}	Z_{nn4}	Z_{tt1}	Z_{tt2}	Z_{tt3}	Z_{tt4}
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
60.00	40.00	200.00	0.70	0.50	10.21	10.16	7.44	11.90	13.98	0.46	0.02	0.00	0.04	0.04	0.01	0.00	0.00	0.03	0.009
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
80.00	80.00	200.00	0.70	0.50	4.13	7.11	4.96	5.45	5.49	0.26	0.01	0.00	0.02	0.04	0.01	0.00	0.00	0.00	0.008
80.00	40.00	200.00	0.70	0.50	7.07	6.10	5.95	10.91	11.48	0.35	0.01	0.00	0.03	0.04	0.01	0.00	0.00	0.03	0.008
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
80.00	80.00	200.00	0.70	0.50	4.13	7.11	4.96	5.45	5.49	0.26	0.01	0.00	0.02	0.04	0.01	0.00	0.00	0.00	0.008
80.00	40.00	200.00	0.70	0.50	7.07	6.10	5.95	10.91	11.48	0.35	0.01	0.00	0.03	0.04	0.01	0.00	0.00	0.03	0.008
80.00	40.00	200.00	0.70	0.50	7.07	6.10	5.95	10.91	11.48	0.35	0.01	0.00	0.03	0.04	0.01	0.00	0.00	0.03	0.008
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
80.00	60.00	200.00	0.70	0.50	6.39	8.13	3.97	8.93	9.48	0.38	0.01	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.008
80.00	60.00	200.00	0.70	0.50	6.39	8.13	3.97	8.93	9.48	0.38	0.01	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.008
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
60.00	40.00	180.00	0.70	0.50	13.33	18.29	9.42	18.35	26.46	0.64	0.02	0.00	0.05	0.05	0.01	0.00	0.03	0.03	0.009
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009
80.00	60.00	200.00	0.70	0.50	6.39	8.13	3.97	8.93	9.48	0.38	0.01	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.008
60.00	60.00	200.00	0.70	0.50	9.34	12.19	5.45	9.92	10.48	0.43	0.02	0.00	0.03	0.04	0.01	0.00	0.00	0.00	0.009

Table 4: Comparision of data and backgrounds at optimized cuts

μ	$M_{\tilde{g}}$	$\not{E}_T$	jet1	$\not{E}_T + E_T$	arc1	arc2	$s/\sqrt{b}$	signal	Phy bkg	QCD	error	data
160	655	60.0	60.0	200.0	0.7	0.5	1.1	8.0±1.9	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
160	670	60.0	40.0	200.0	0.7	0.5	0.3	2.7±0.8	$54.3 \pm 5.2\ ^{10.0}_{10.0}$	0.0 ± 0.1	54.3 ± 15.0	58
165	600	60.0	60.0	200.0	0.7	0.5	1.5	11.6±2.1	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
165	640	60.0	60.0	200.0	0.7	0.5	1.3	10.2±2.7	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
165	655	80.0	80.0	200.0	0.7	0.5	1.4	8.0±2.1	$27.5 \pm 3.9\ ^{3.9}_{4.2}$	0.0 ± 0.3	27.5 ± 5.9	24
165	685	80.0	40.0	200.0	0.7	0.5	0.5	3.7±1.1	$42.0 \pm 4.5\ ^{7.4}_{8.5}$	0.0 ± 0.0	42.0 ± 11.6	33
170	560	60.0	60.0	200.0	0.7	0.5	1.5	11.5±3.1	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
170	590	60.0	60.0	200.0	0.7	0.5	1.6	11.9±3.2	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
170	625	60.0	60.0	200.0	0.7	0.5	1.4	10.4±2.8	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
170	640	60.0	60.0	200.0	0.7	0.5	1.5	11.2±3.0	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
170	670	80.0	80.0	200.0	0.7	0.5	1.2	7.1±1.9	$27.5 \pm 3.9\ ^{3.9}_{4.2}$	0.0 ± 0.3	27.5 ± 5.9	24
170	705	80.0	40.0	200.0	0.7	0.5	0.2	1.6±0.5	$42.0 \pm 4.5\ ^{7.4}_{8.5}$	0.0 ± 0.0	42.0 ± 11.6	33
175	520	80.0	40.0	200.0	0.7	0.5	1.5	11.3±3.0	$42.0 \pm 4.5\ ^{7.4}_{8.5}$	0.0 ± 0.0	42.0 ± 11.6	33
175	550	60.0	60.0	200.0	0.7	0.5	1.6	11.9±3.2	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
175	580	80.0	60.0	200.0	0.7	0.5	1.5	10.2±2.7	$37.4 \pm 4.4\ ^{6.5}_{7.8}$	0.0 ± 0.0	37.4 ± 7.5	32
175	615	80.0	60.0	200.0	0.7	0.5	1.5	10.2±2.8	$37.4 \pm 4.4\ ^{6.5}_{7.8}$	0.0 ± 0.0	37.4 ± 7.5	32
175	630	60.0	60.0	200.0	0.7	0.5	1.4	10.8±2.9	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
175	660	60.0	40.0	180.0	0.7	0.5	1.2	12.7±3.4	$86.7 \pm 6.8\ ^{15.2}_{14.8}$	0.0 ± 0.0	86.7 ± 19.6	88
175	685	60.0	60.0	200.0	0.7	0.5	1.4	10.2±2.4	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57
175	700	80.0	60.0	200.0	0.7	0.5	1.3	8.6±2.3	$37.4 \pm 4.4\ ^{6.5}_{7.8}$	0.0 ± 0.0	37.4 ± 7.5	32
180	510	60.0	60.0	200.0	0.7	0.5	1.8	13.5±3.6	$47.9 \pm 5.0\ ^{7.4}_{9.3}$	0.0 ± 0.1	47.9 ± 9.3	57

Next: top $\rightarrow$ stop by charm channel

Because of the large backgrounds and s-mall signals after the cuts, no point of 21 signal models could be excluded, some better cuts should be developed.