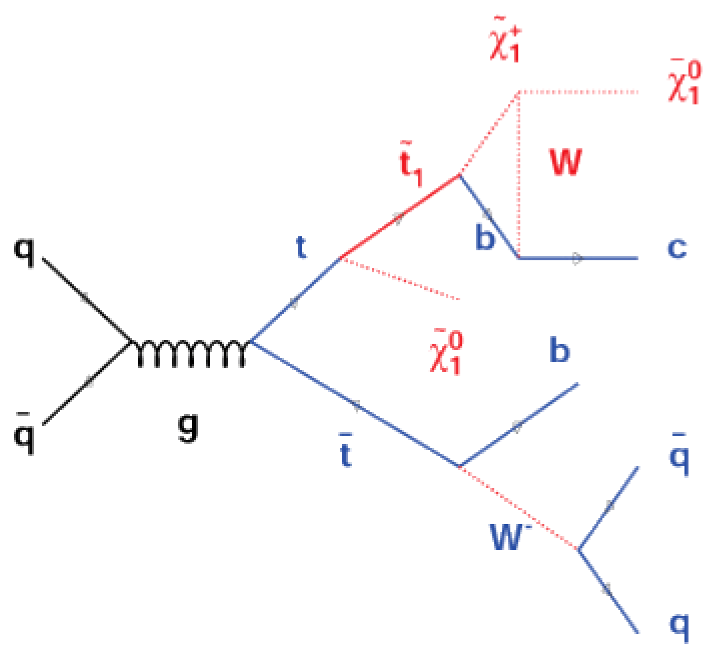
Top $\rightarrow$ stop by charm channel analysis using D0 runI data

OUTLINE

- *physics process of top to stop*
- *Monte Carlo simulation for signal*
- *data sample*
- *events selection*
- *QCD background estimate*
- *signal significance optimization*
- *conclusion*

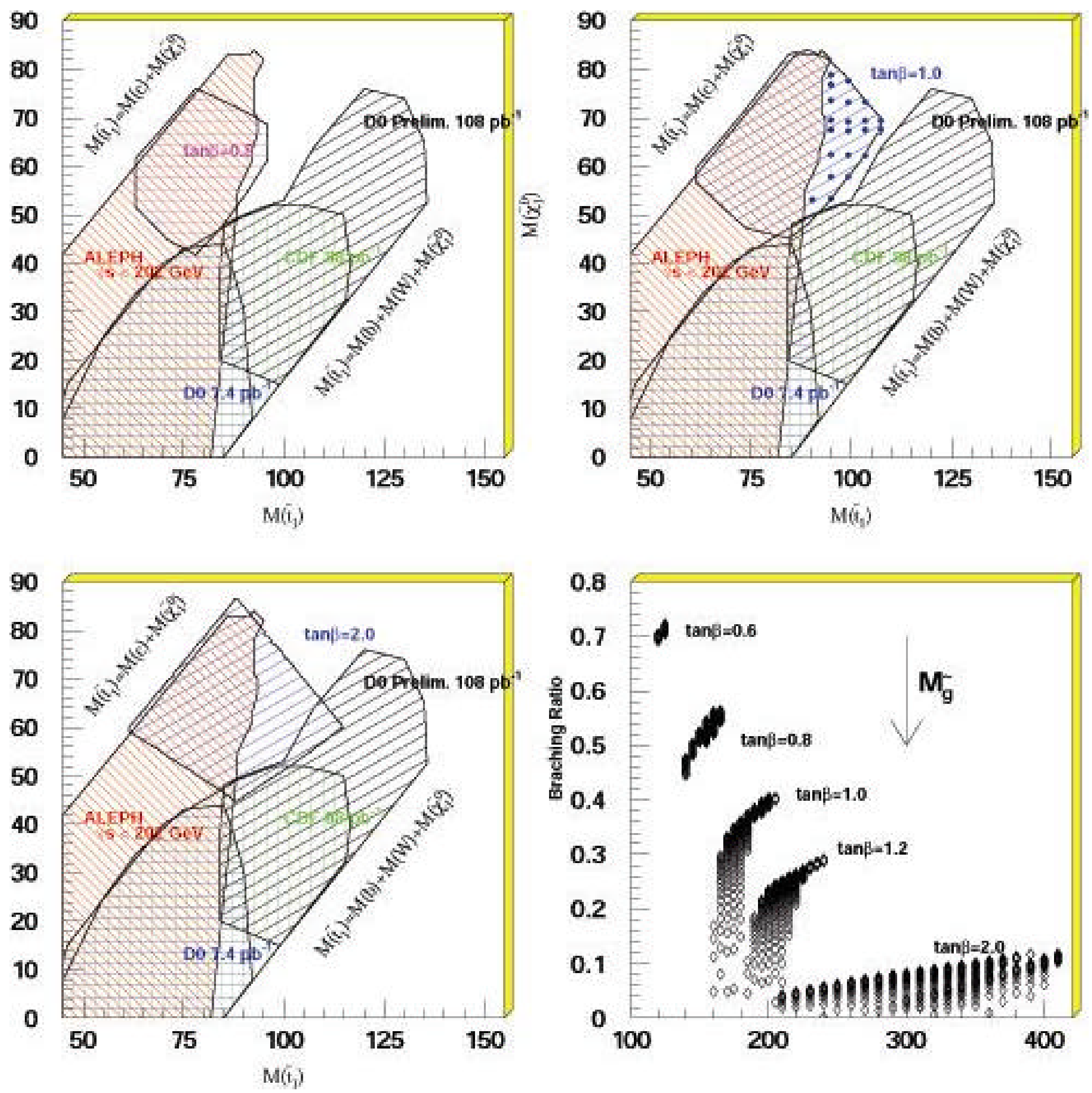
Physics process

$p\bar{p}$ produce $t\bar{t}$, one top quark decays to top squark (if it exists), the other top decays to b and w, w then decays to 2 jets. Top squark (stop) decays further to charm and neutralino (LSP). The final state is 4 jets and missing Et.



If the branching ratio from top to stop is b, the standard model decay is 1-b, considering the symmetry of t and $\bar{t}$, the total cross section is 2b(1-b)$s_{t\bar{t}}$, here $s_{t\bar{t}}$ is $t\dot{t}$ production cross section.

Stop search status



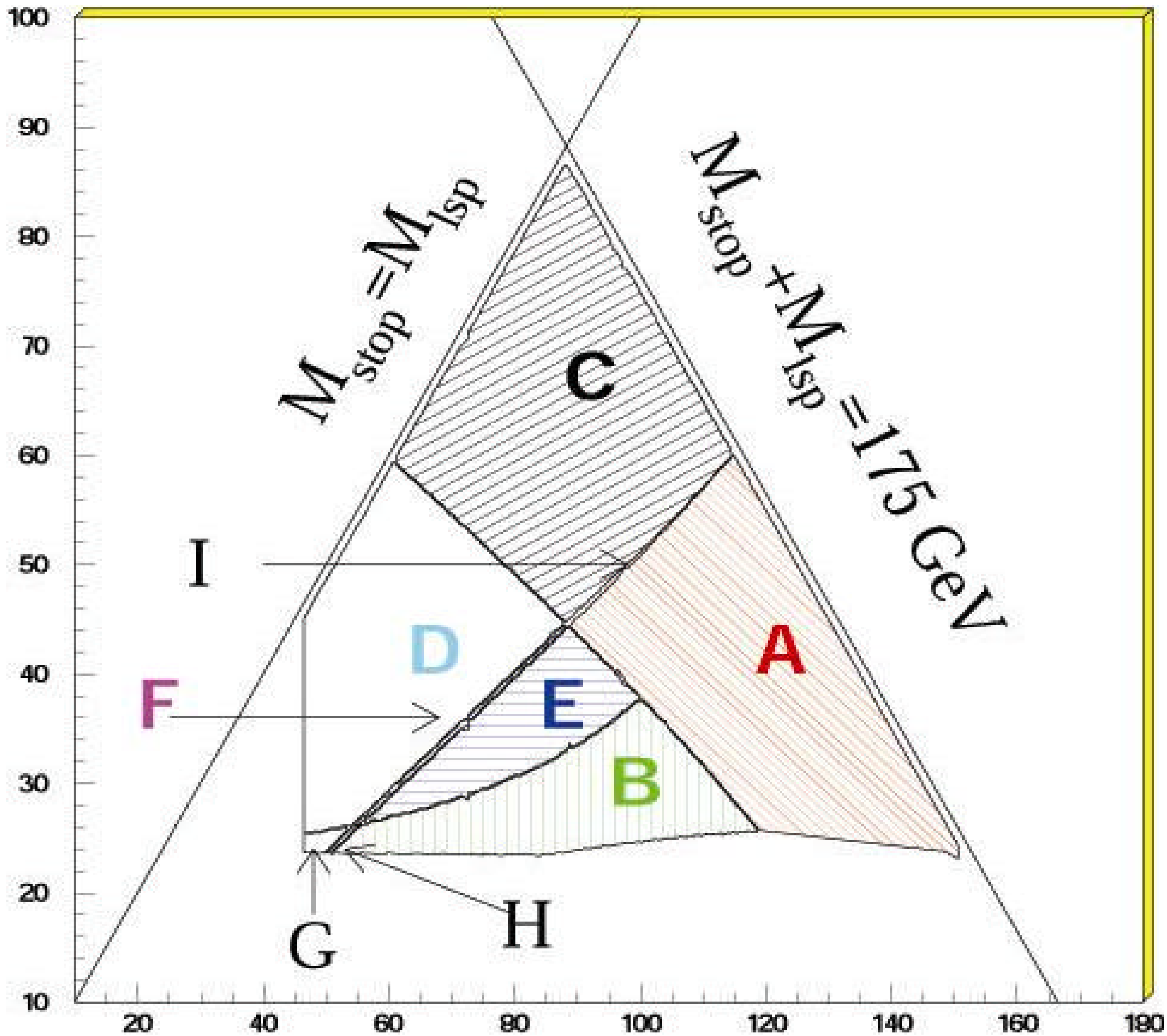
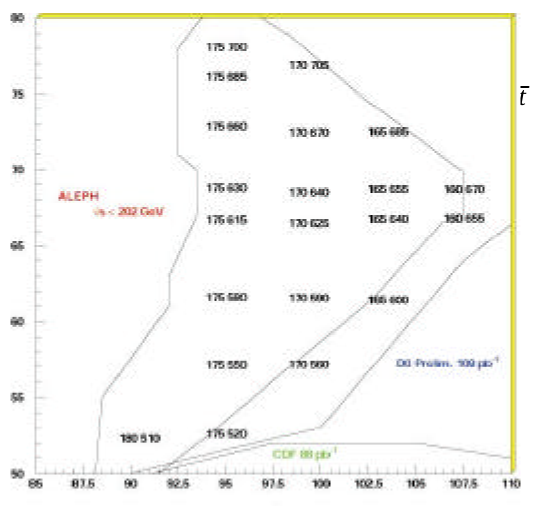


Table 1: Parameters used in ISASUSY Monte Carlo sample (GeV)

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



Data sample

Using missing_et trigger data collected in 1993-1995 (RunI B) at D0. The data was reconstructed by RECO version 12 with jet-finding algorithm of cone size 0.5. It includes run number 72250-93115 and total 1,556,505 events. The integrated luminosity 81.23 pb^{-1} (all bad run and duplicated run are removed).

Event selection

<u>CLEAN CUT</u>:

•total scalar transverse energy is between 0 and 1800 GeV;
•primary vertex is (-60,60)cm
•veto MainRing events
•scalar transverse energy at MainRing region > -10GeV

<u>JETS CUT:</u>

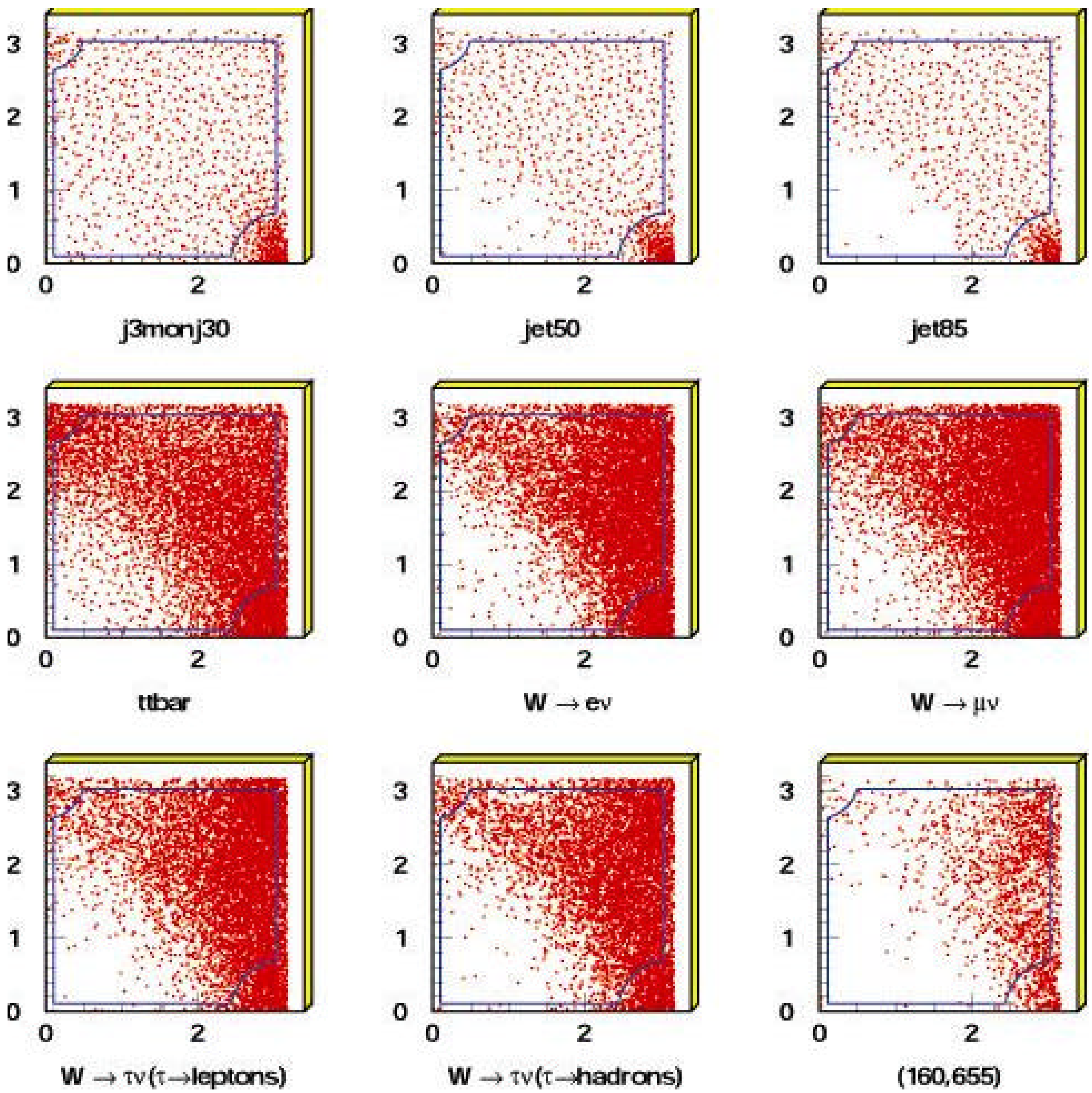
•at least 4 jets > 15GeV
•at least one of the four jets is central ($|h_{det}|<11$).
•only leading jet is removed in ICD region ($11<|h_{det}|<14$)
•all jets >15GeV must have good quality:

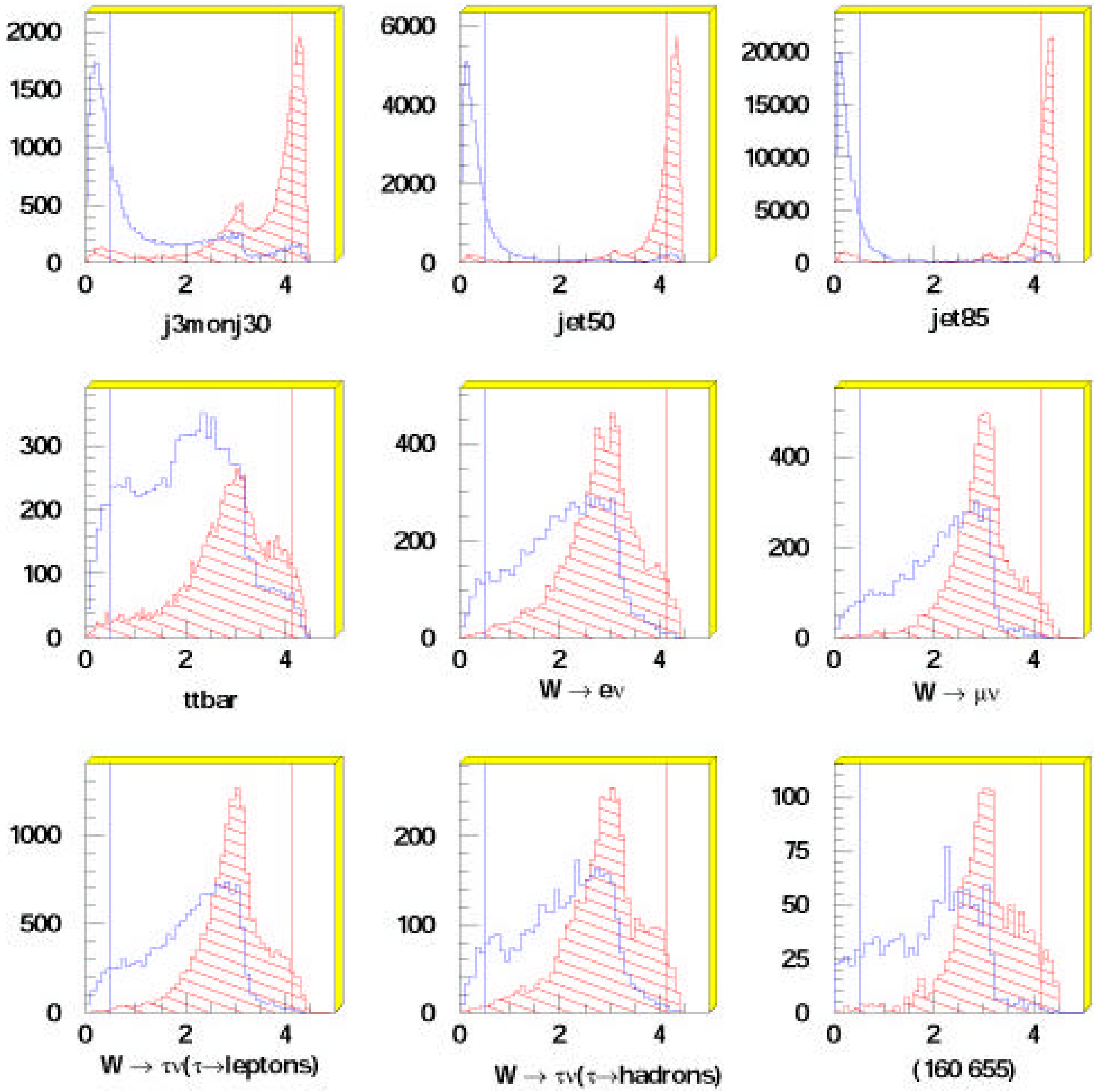
$$|h_{det}|<3.5 \quad 0.1<EMF<0.9 \quad CHF<0.4$$

Ht CUT

$$H_T = \sum_{n=2}^{N} E_T(n) \qquad E_T > 25\mathrm{GeV}, |h_{\det}| < 2.5$$

QCD ELIMINATION:




j3monj30
jet50
jet85
ttbar
W → eν
W → μν
W → τν(τ→leptons)
W → τν(τ→hadrons)
(160 655)

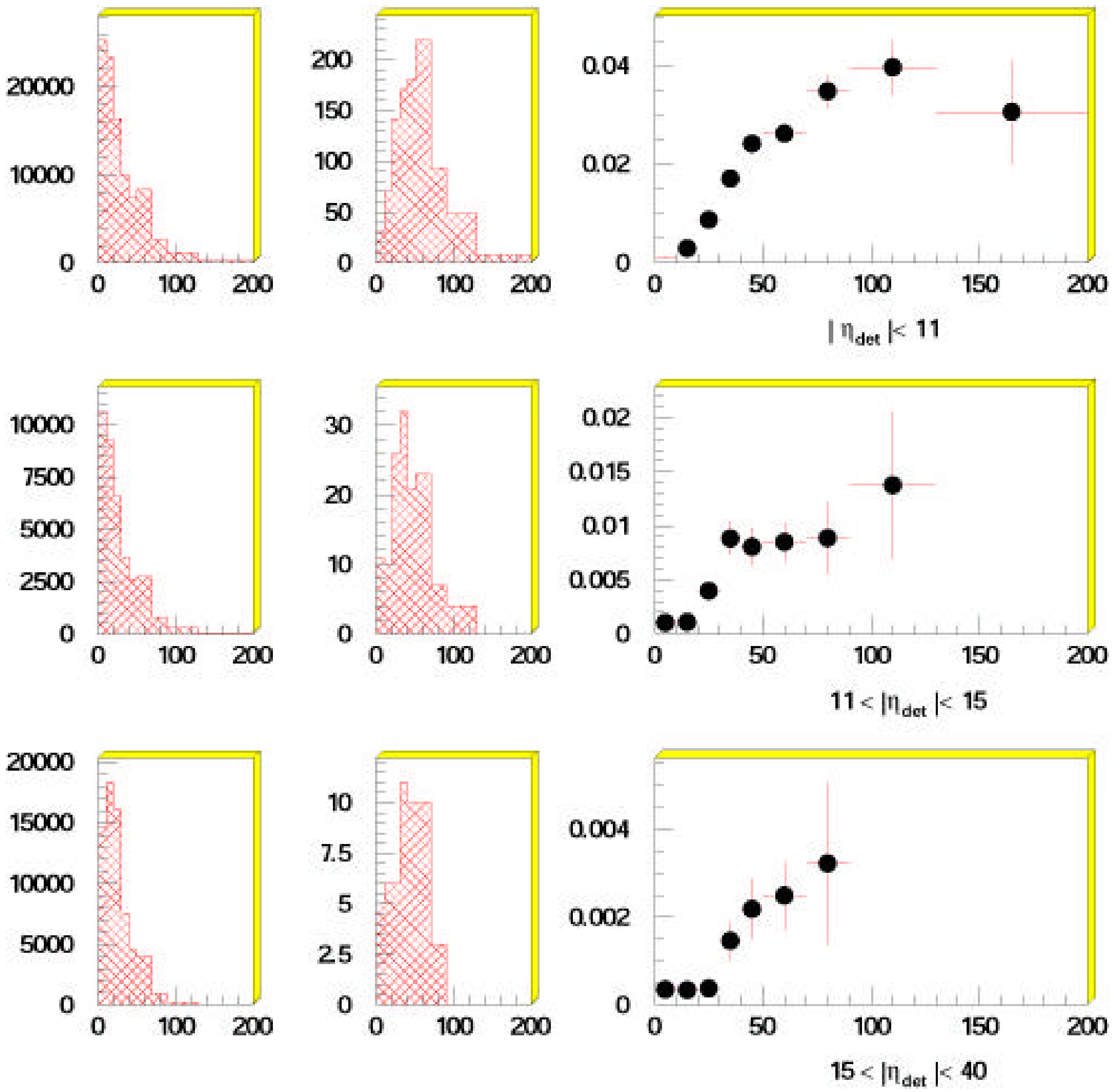
m VETO (top group loose cut):

Prezap:Only central toroid muon is considered, fot posrzap: both central and end toroid magnets muons are considered. Muons are required to have P_T >15GeV and not A-stub. If Hfrac>0.6 & Efrac>0 or Hfrac=1, that muon is good but will be vetoed only when it is isolated (with closest jet > 0.5 in distance)
For Monte Carlo sample, the muon will be rejected by rate

quadrant	efficiency	
	Musmear Postzap	Non-musmear
CF	0.937	0.815
EF	0.4	0.337

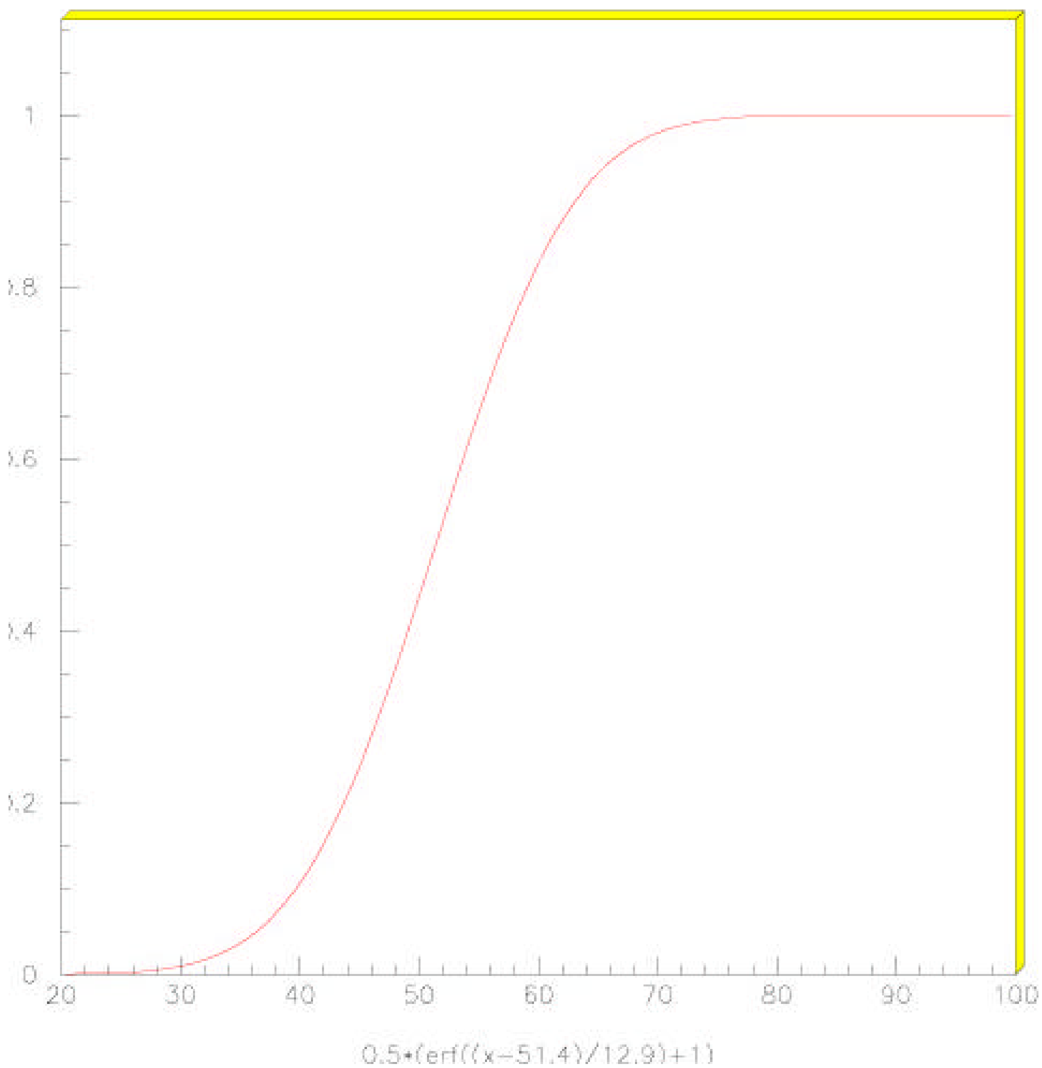
HOT CELL:

If one of the cells are removed by AIDA and this cell is within DR=0.5 of the axis of the jet in $h \times f$ space, this event will be removed if this jets has $E_T > 15$ and $| h_{\mathrm{det}} |< 3.5$



MissingEt TRIGGER EFFICIENCY:

		run <85276	run>85276
level 1	$\|\eta_{det}\|$	≤ 4	
	E_T	≥ 3	≥ 5
	$\not\!\!E_T$	≥ 30	≥ 40
level 2	$\not\!\!E_T$	≥ 35	≥ 40
luminosity (pb^{-1})		22.86	58.37



VERTEX CONFIRMATION:

The misidentified vertex may give rise mismeasured large $\not{E}_T$, these events are likely collected by our cuts as candidates of our new physics. To eliminate these events, we must confirm if the vertex is the true interaction point.

An event is a good candidate of our signal if the following criteria applies:

(1) At least one of the four jets is central $|h_{\mathrm{det}}| < 1.1$

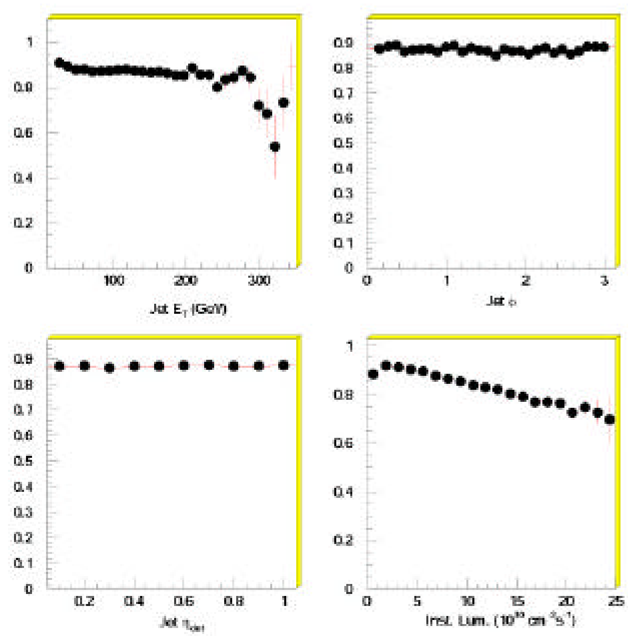
(2) There are good tracks in the event corresponding to the central jet and their distance is less than 0.4

(3) More than half of these good tracks emanate from (-60,60)

(4) There are more tracks coming from primary vertex than coming from 2nd/3rd vertices.

Using jet_85 and jet_max data (STA/DST) to get jetpointing efficiency.

All jets are required to have $\not{E}_T$ <20GeV in order to avoid misvertex. Two leading jets pass all the trigger requirements and one jet also pass jetpointing criteria, the ratio of the two jets give the efficiencies.



W+jets decay modes selection:

$w \longrightarrow en_e$:Use ISAJET lepton ID $e(12)\bar{n}_e(-11)$

$e^+(-12)n_e(11)$ and then require invariant mass (78,82)

$w \longrightarrow mn_m$: Use ID $m(14)\bar{n}_m(-13)$ $\bar{m}(-14)n_h(13)$

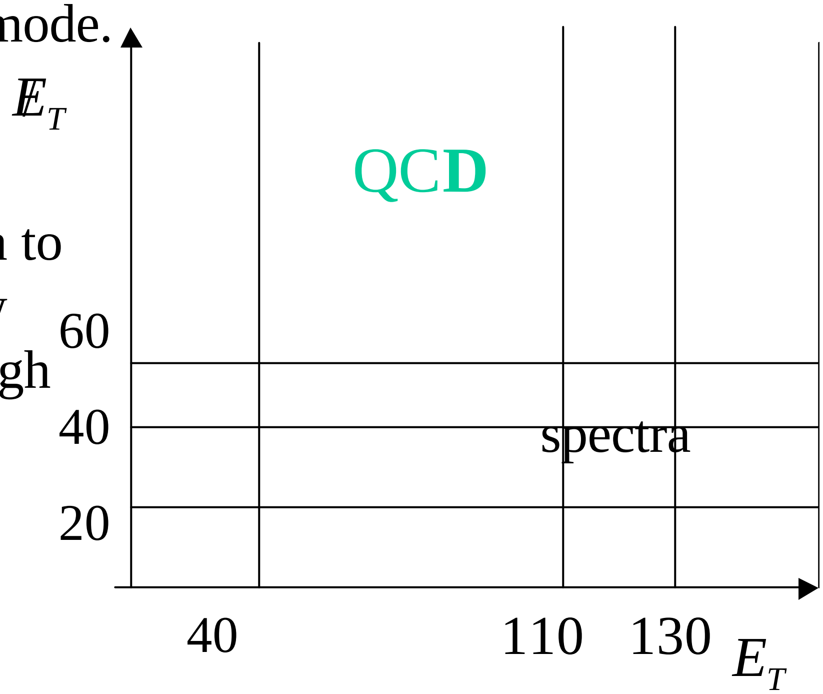
and also require the invariant mass of the two objects be within (78,82)

$w \rightarrow tn_t$ and: t hadronically decay:

Require the final product have two leptons and both have the same ID=11

$w \longrightarrow tn_t$ and t leptonically decay:

Exclude all the above three kinds of decay modes, the remaining is this decay mode.



QCD estimate:

Use jet_85+jet_max data to make $\not{E}_T$ spectra at low E_T region (20,40) but high $\not{E}_T$ region(110,130). Use func

h= $e^{a+bE_T+c\sqrt{\not{E}_T}}$

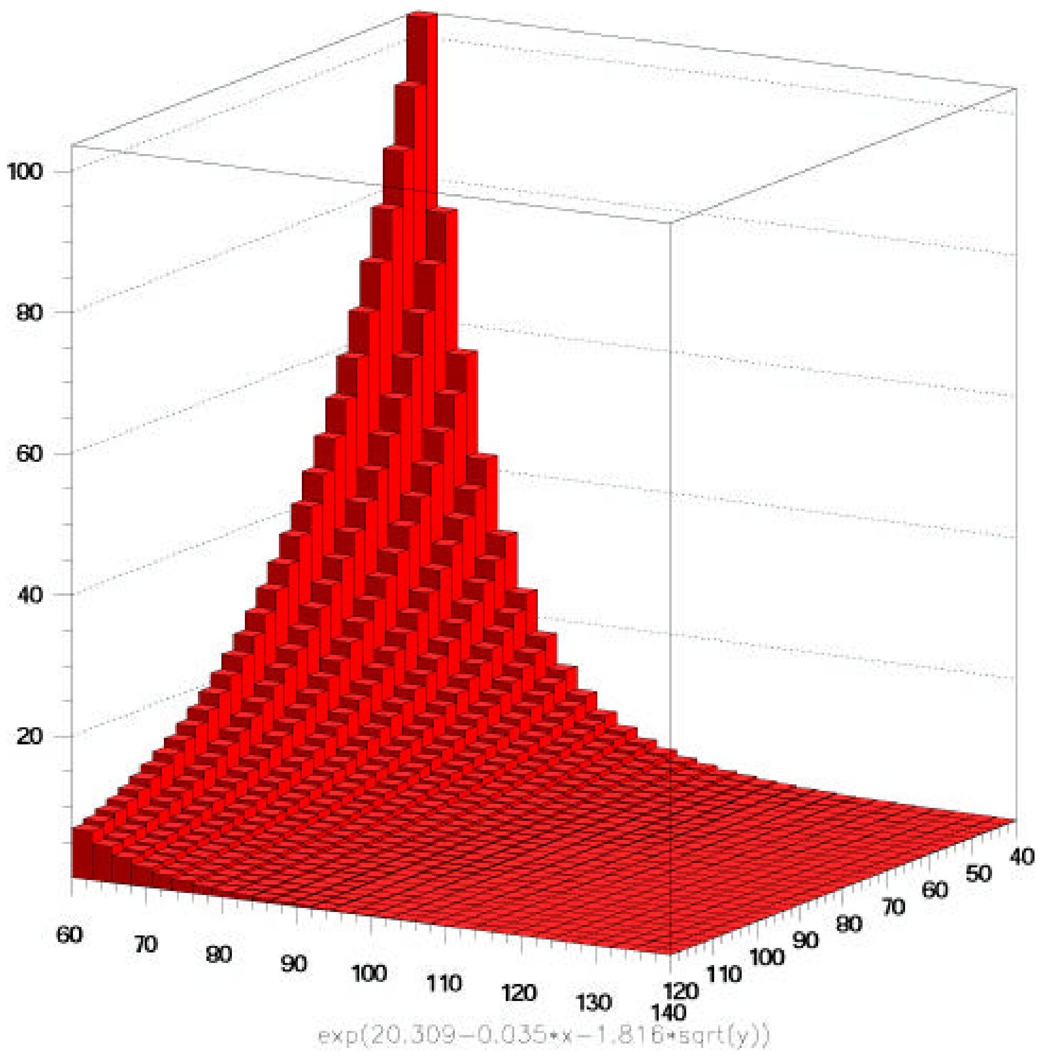
$$Z \rightarrow \ln(h(E_T, \not{E}_T)) \qquad X \rightarrow E_T \qquad Y \rightarrow \sqrt{\not{E}_T}$$

We can change the least square problem

$$\min[S(E_T, \not{E}_T) - e^{a+bE_T+\sqrt{\not{E}_T}}]$$

to a 2-d linea r regression $\quad Z = a + bX + cY$

to get the best fitting of the spectra. The error is greatly reduced.



Signal significance optimization:

Let $\not\!\!E_T$ = 60,70,80,90,100,110,120,130,140 GeV

E_T =40,50,60,70,80,90,100,110,120 GeV

H_T = 70GeV

arc1=0.5, arc2=0

Apply all the cuts to background sample and data, calculate merit function signal/sqrt(phy bkg+QCD) to get the best significance.

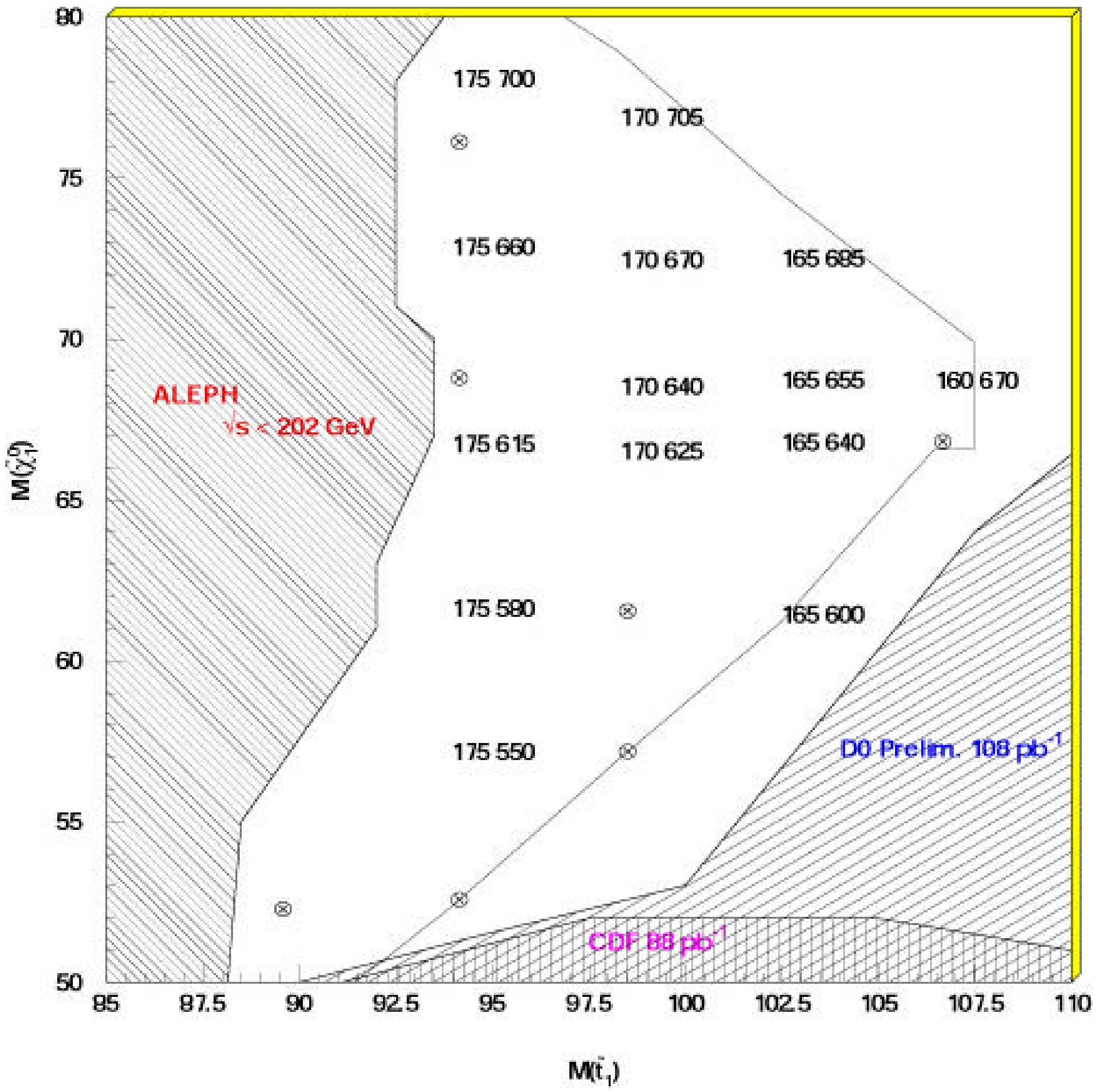
Preliminary results :

Table 1: Comparision of data and backgrounds at optimized cuts

μ	$M_{\tilde{g}}$	$\not\!\!E_T$	jet1	$s/\sqrt{b}$	signal	Phy bkg	QCD	bkgd	data	90	95	limit
160	655	130.0	60.0	2.8	4.0	$1.7 \pm 0.2\,^{0.3}_{0.3}$	0.3 ± 0.0	2.0 ± 0.4	1	1.61	2.21	1.66
160	670	100.0	100.0	0.9	1.7	$2.8 \pm 0.3\,^{0.6}_{0.6}$	0.9 ± 0.2	3.8 ± 0.7	6	4.76	8.21	0.54
165	600	110.0	70.0	5.0	10.0	$2.8 \pm 0.2\,^{0.5}_{0.5}$	1.2 ± 0.2	4.0 ± 0.6	6	2.51	3.53	2.47
165	640	100.0	100.0	4.2	7.3	$2.0 \pm 0.2\,^{0.4}_{0.4}$	0.9 ± 0.2	3.0 ± 0.5	6	2.66	3.21	2.25
165	655	100.0	90.0	3.5	7.2	$2.9 \pm 0.3\,^{0.6}_{0.5}$	1.3 ± 0.3	4.3 ± 0.7	9	3.18	3.78	2.07
165	685	130.0	80.0	1.3	1.7	$1.6 \pm 0.2\,^{0.3}_{0.3}$	0.2 ± 0.0	1.7 ± 0.4	1	1.76	2.33	0.87
170	560	140.0	100.0	5.2	4.0	$0.6 \pm 0.1\,^{0.1}_{0.1}$	0.0 ± 0.0	0.6 ± 0.2	0	1.93	2.67	2.62
170	590	130.0	60.0	4.4	5.6	$1.3 \pm 0.2\,^{0.3}_{0.2}$	0.3 ± 0.0	1.6 ± 0.3	1	2.05	3.04	2.58
170	625	140.0	80.0	4.1	3.7	$0.7 \pm 0.1\,^{0.1}_{0.2}$	0.1 ± 0.0	0.8 ± 0.2	1	2.69	3.48	2.49
170	640	130.0	80.0	5.2	5.8	$1.1 \pm 0.2\,^{0.3}_{0.3}$	0.2 ± 0.0	1.3 ± 0.3	1	2.82	5.36	2.42
170	670	140.0	80.0	5.0	4.8	$0.8 \pm 0.1\,^{0.3}_{0.3}$	0.1 ± 0.0	0.9 ± 0.3	1	6.25	14.34	2.17
170	705	130.0	70.0	0.6	0.9	$1.9 \pm 0.2\,^{0.4}_{0.4}$	0.2 ± 0.0	2.1 ± 0.5	1	4.08	8.19	0.54
175	520	130.0	80.0	6.3	6.8	$1.0 \pm 0.1\,^{0.2}_{0.2}$	0.2 ± 0.0	1.2 ± 0.3	1	1.85	2.62	2.68
175	550	140.0	80.0	4.0	3.5	$0.7 \pm 0.1\,^{0.1}_{0.2}$	0.1 ± 0.0	0.8 ± 0.2	1	7.29	16.24	2.68
175	580	130.0	80.0	5.0	5.4	$1.0 \pm 0.1\,^{0.2}_{0.2}$	0.2 ± 0.0	1.2 ± 0.3	1	9.44	20.35	2.66
175	615	140.0	80.0	4.4	3.9	$0.7 \pm 0.1\,^{0.1}_{0.2}$	0.1 ± 0.0	0.8 ± 0.2	1	4.33	7.45	2.62
175	630	130.0	80.0	4.8	5.2	$1.0 \pm 0.1\,^{0.2}_{0.2}$	0.2 ± 0.0	1.2 ± 0.3	1	2.16	2.99	2.58
175	660	140.0	80.0	4.8	4.3	$0.7 \pm 0.1\,^{0.2}_{0.2}$	0.1 ± 0.0	0.8 ± 0.2	1	2.51	3.43	2.47
175	685	130.0	70.0	4.2	5.2	$1.3 \pm 0.2\,^{0.3}_{0.3}$	0.2 ± 0.0	1.6 ± 0.3	1	1.93	2.70	2.28
175	700	140.0	80.0	3.9	3.7	$0.8 \pm 0.1\,^{0.2}_{0.2}$	0.1 ± 0.0	0.9 ± 0.3	1	2.47	3.39	2.06
180	510	140.0	80.0	5.1	4.4	$0.7 \pm 0.1\,^{0.1}_{0.2}$	0.1 ± 0.0	0.8 ± 0.2	1	2.37	3.03	2.71
400	350	130.0	80.0	4.1	4.9	$1.2 \pm 0.2\,^{0.3}_{0.3}$	0.2 ± 0.0	1.4 ± 0.3	1	1.93	2.8	2.01
370	350	110.0	70.0	2.5	5.3	$3.4 \pm 0.3\,^{0.7}_{0.7}$	1.2 ± 0.2	4.6 ± 0.8	6	7.9	14.54	1.69
370	400	140.0	80.0	2.4	2.5	$1.0 \pm 0.2\,^{0.2}_{0.3}$	0.1 ± 0.0	1.1 ± 0.3	1	4.01	8.77	1.14
350	400	90.0	70.0	1.4	5.2	$6.9 \pm 0.4\,^{1.3}_{1.3}$	6.5 ± 1.5	13.5 ± 2.2	13	1.79	2.24	1.05
330	400	120.0	100.0	1.5	1.9	$1.5 \pm 0.2\,^{0.3}_{0.3}$	0.2 ± 0.0	1.7 ± 0.4		4.55	10.43	0.95
330	450	100.0	80.0	1.1	2.8	$4.4 \pm 0.3\,^{0.9}_{0.9}$	1.9 ± 0.4	6.3 ± 1.1	10	3.62	4.57	0.87
300	450	120.0	90.0	0.9	1.4	$2.2 \pm 0.2\,^{0.4}_{0.4}$	0.3 ± 0.0	2.4 ± 0.5	1	1.47	2.01	0.58

d backgrounds at optimized cuts

QCD	bkgd	data	90	95	limit
0.3 ± 0.0	2.0 ± 0.4	1	1.61	2.21	1.66
0.9 ± 0.2	3.8 ± 0.7	6	4.76	8.21	0.54
1.2 ± 0.2	4.0 ± 0.6	6	2.51	3.53	2.47
0.9 ± 0.2	3.0 ± 0.5	6	2.66	3.21	2.25
1.3 ± 0.3	4.3 ± 0.7	9	3.18	3.78	2.07
0.2 ± 0.0	1.7 ± 0.4	1	1.76	2.33	0.87
0.0 ± 0.0	0.6 ± 0.2	0	1.93	2.67	2.62
0.3 ± 0.0	1.6 ± 0.3	1	2.05	3.04	2.58
0.1 ± 0.0	0.8 ± 0.2	1	2.69	3.48	2.49
0.2 ± 0.0	1.3 ± 0.3	1	2.82	5.36	2.42
0.1 ± 0.0	0.9 ± 0.3	1	6.25	14.34	2.17
0.2 ± 0.0	2.1 ± 0.5	1	4.08	8.19	0.54
0.2 ± 0.0	1.2 ± 0.3	1	1.85	2.62	2.68
0.1 ± 0.0	0.8 ± 0.2	1	7.29	16.24	2.68
0.2 ± 0.0	1.2 ± 0.3	1	9.44	20.35	2.66
0.1 ± 0.0	0.8 ± 0.2	1	4.33	7.45	2.62
0.2 ± 0.0	1.2 ± 0.3	1	2.16	2.90	2.58
0.1 ± 0.0	0.8 ± 0.2	1	2.51	3.43	2.47
0.2 ± 0.0	1.6 ± 0.3	1	1.93	2.70	2.28
0.1 ± 0.0	0.9 ± 0.3	1	2.47	3.39	2.06
0.1 ± 0.0	0.8 ± 0.2	1	2.37	3.03	2.71
0.2 ± 0.0	1.4 ± 0.3	1	1.93	2.8	2.01
1.2 ± 0.2	4.6 ± 0.8	6	7.9	14.54	1.69
0.1 ± 0.0	1.1 ± 0.3	1	4.01	8.77	1.14
6.5 ± 1.5	13.5 ± 2.2	13	1.79	2.24	1.05
0.2 ± 0.0	1.7 ± 0.4		4.55	10.43	0.95
1.9 ± 0.4	6.3 ± 1.1	10	3.62	4.57	0.87
0.3 ± 0.0	2.4 ± 0.5	1	1.47	2.01	0.58



Next:

- double check all the code and cuts
- improve acceptance and reduce errors
- Use equal-probabilities test to set limit at 95%CL