STUDY OF TOP PAIR PRODUCTION NEAR THRESHOLD

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T. Horiguchi (Tohoku Univ.)

A.Ishikawa[1] H.Yamamoto[1] K.Fujii[2] Y.Sumino[1] Y.Kiyo[3]

[1] Tohoku Univ. , [2]KEK , [3]Juntendo Univ.

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- Motivation of top study
- Simulation tool
- Method of reconstruction
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- Summary and Plan

MOTIVATION

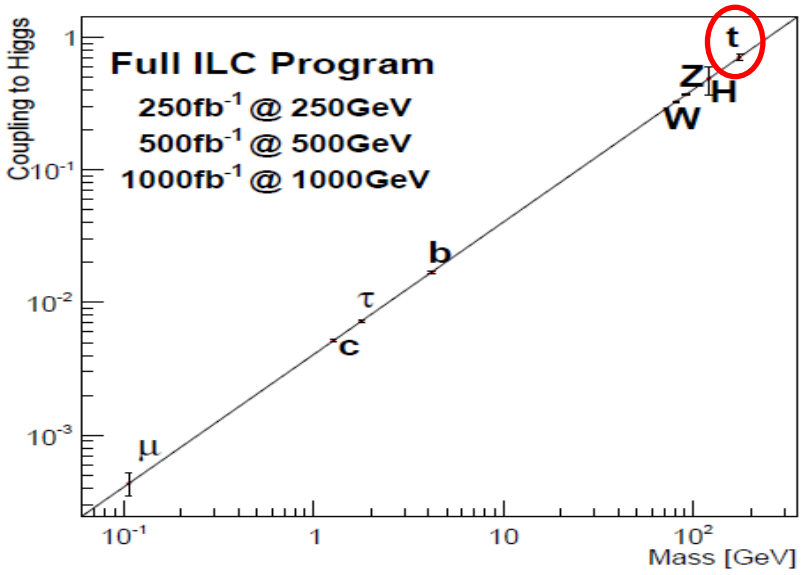
Top quark is much heavier than other quarks and it decays before hadronization. This feature allows us to measure basic properties of top quark precisely and perform clean test of QCD at the ILC.

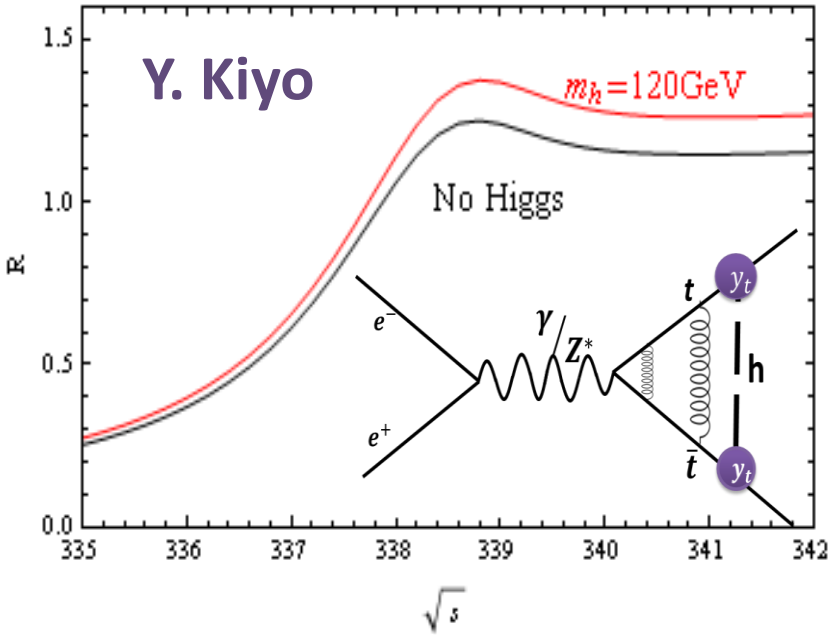
Our Targets

1. top mass(pole & $\overline{\mathrm{MS}}$ scheme)
2. top width
3. α_s
4. top yukawa coupling
5. Wave function of top pair system

TOP YUKAWA FROM TTBAR CROSS SECTION

Quarks acquire mass by coupling with Higgs boson in the Standard Model, Yukawa coupling. The relation of mass and coupling in the SM is shown in right figure.
If it is not linear function for fermions, it indicates new physics .





Contribution of Higgs exchange diagram to total cross section is about 9%.
So if we can measure total cross section precisely, we can extract **top Yukawa coupling** before going to Ecm=500GeV. (note. Current theoretical uncertainty in the cross section is about 4% and I hope this will be improved in coming 10 years)

CONDITION OF THE ANALYSIS

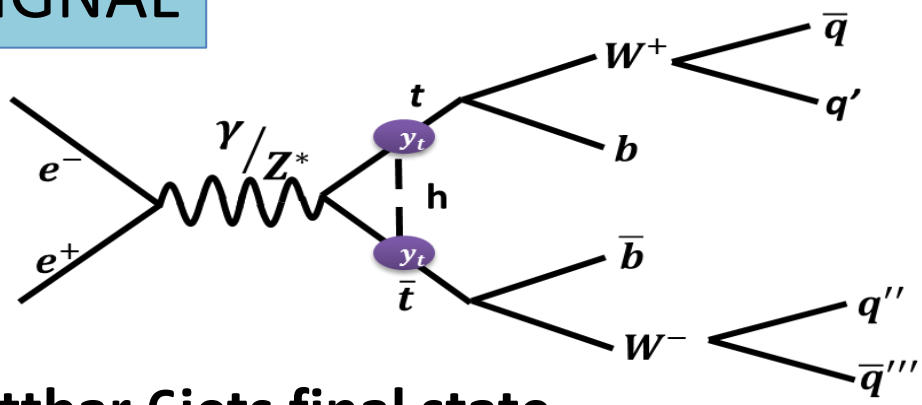
SIMULATION

Top mass = 174 GeV Ecm (using threshold scan)	340～350GeV (every 1 GeV)
Polarization	(e^-, e^+)=(-0.8, +0.3) (+0.8, -0.3)
Number of events	10 fb^{-1} (each Ecm and polarization)
Top pair generator	Physsim
Background generator	Whizard 1.95
Detector simulation	Mokka ILD_o1_v05 -v01-16-p00 (DBD ver.)
Reconstruction	ILCSoft v01-16 (DBD ver.)

This is full simulation study of ILD detector.

SIGNAL AND BACKGROUND

SIGNAL

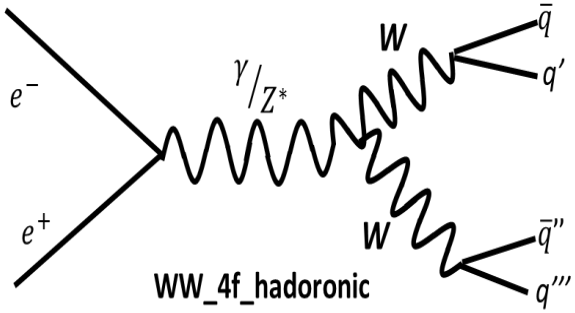


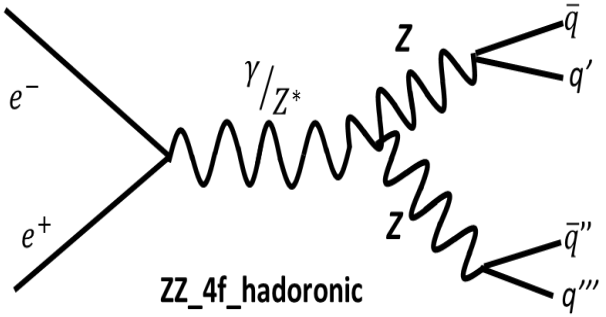
ttbar 6jets final state

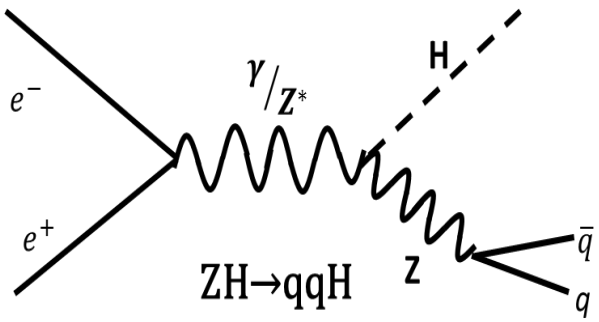
Branching Ratio	
6jets	45%
$4\mathrm{j}1l1\nu$	44%
$2\mathrm{j}2l2\nu$	11%

Main BG.

$$ee \rightarrow WW\ (\rightarrow qq'q''q''')\ \ q = (u, d, s, c, b)$$
$$\rightarrow\ ZZ\ \ (\rightarrow q\bar{q}q'\bar{q}')$$
$$\rightarrow\ ZH\ \ (\rightarrow qq\,\mathrm{H})$$







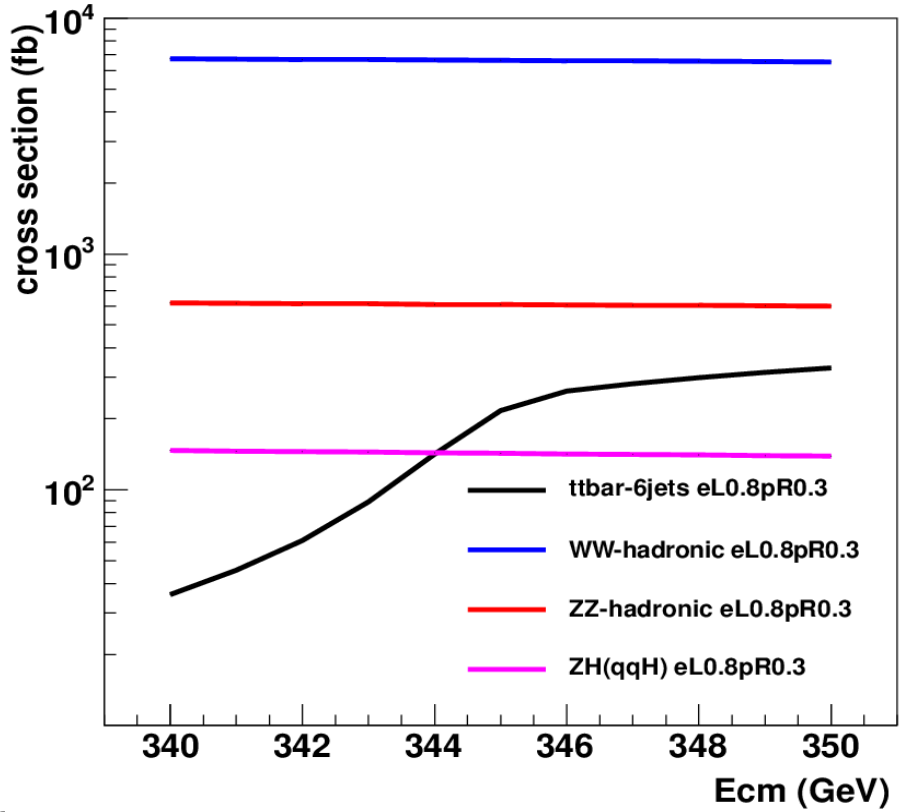
For future plan, we will add WWZ, ZZZ, tbW.

CROSS SECTION OF TTBAR AND BG.

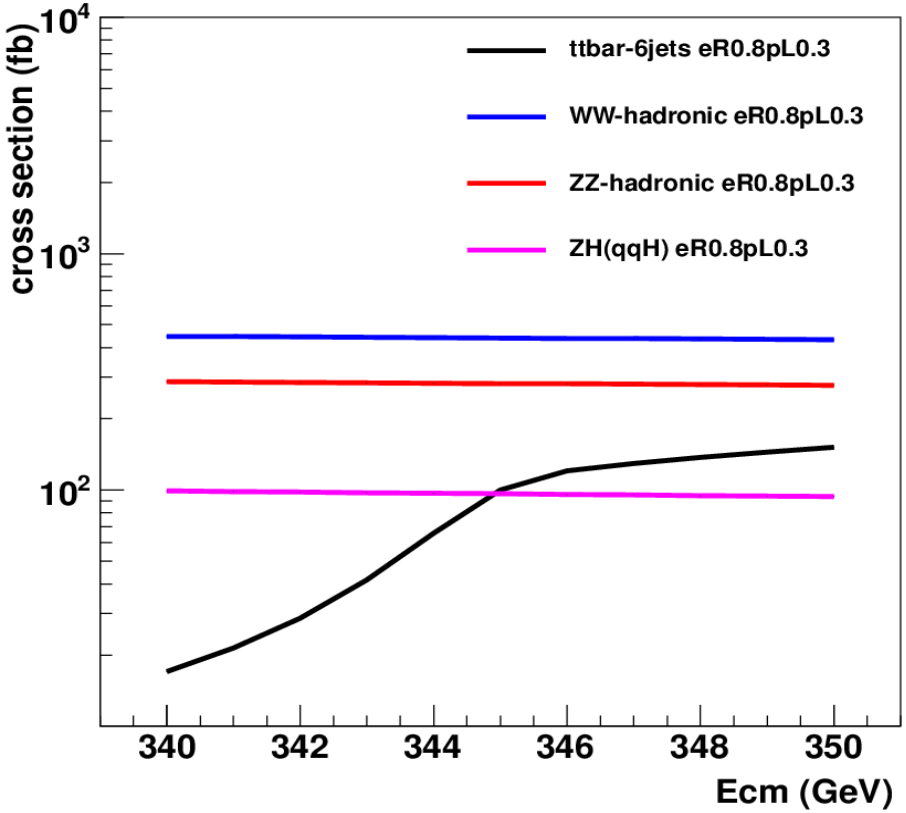
Since we can see 1S peak, precise measurement of energy dependence near the threshold of the cross section of top pair production is very important.

And since left-handed and right-handed top quarks have different SU(2) and U(1) charge, the cross section has difference between left- and right-handed polarizations.

Cross section (e^-, e^+)=(-0.8, +0.3)



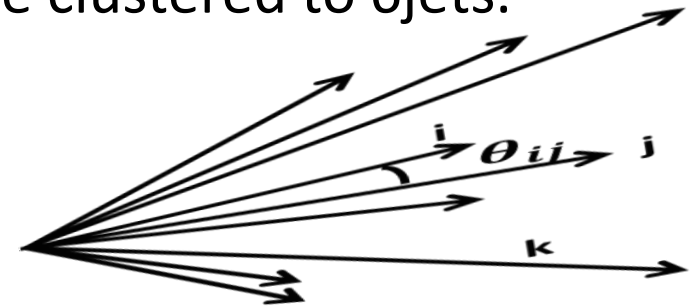
Cross section (e^-, e^+)=(+0.8, -0.3)



RECONSTRUCTION

① Using Durham algorism, objects are clustered to 6jets.

$$Y_{ij} = \frac{2E_iE_j(1-cos\theta_{ij})}{{E_{vis}}^2}$$



② b quark tagging : LCFIPlus
Selection of highest b jet and secondary highest b jet

③ Two Ws are reconstructed from 4jets except two highest b jets.

④ top quarks are reconstructed by pairing W and b.

⑤ The best candidate of jet combination is selected by minimizing χ^2 from W and top mass.

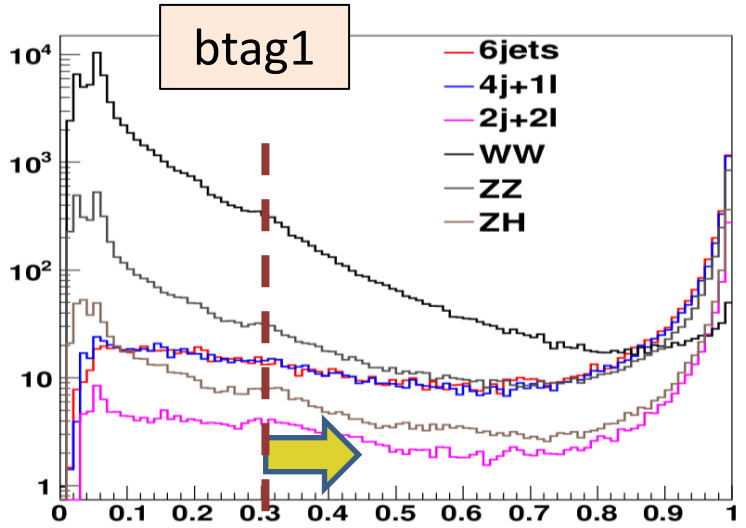
$$\chi^2 = \frac{(M_{2j}-M_{W_1})^2}{\sigma_{W_1}} + \frac{(M_{2j}-M_{W_2})^2}{\sigma_{W_2}} + \frac{(M_{3j}-M_{t_1})^2}{\sigma_{t_1}} + \frac{(M_{3j}-M_{t_2})^2}{\sigma_{t_2}}$$

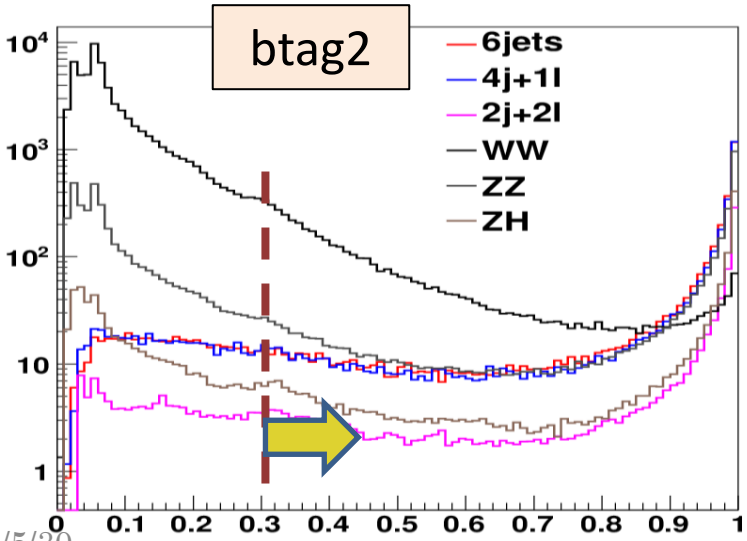
EVENT SELECTION

B QUARK TAGGING CUT

$(e^-, e^+)=(-0.8, +0.3)$

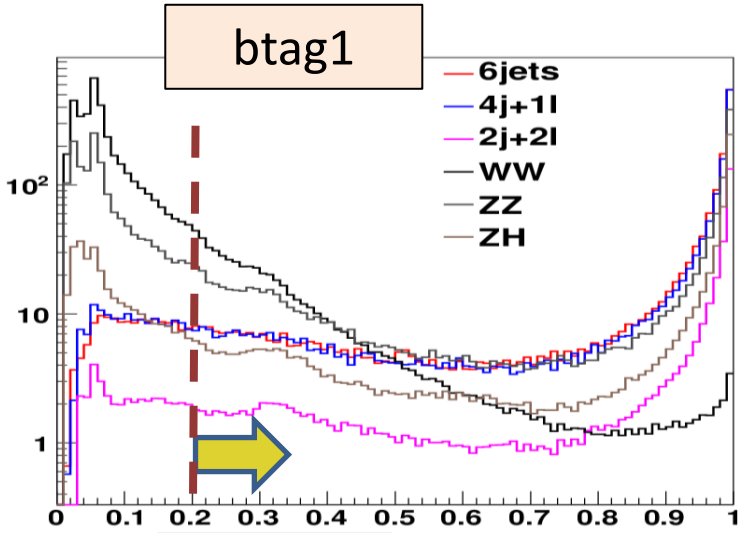
cut1 : btag1 >0.3 + btag2 >0.3

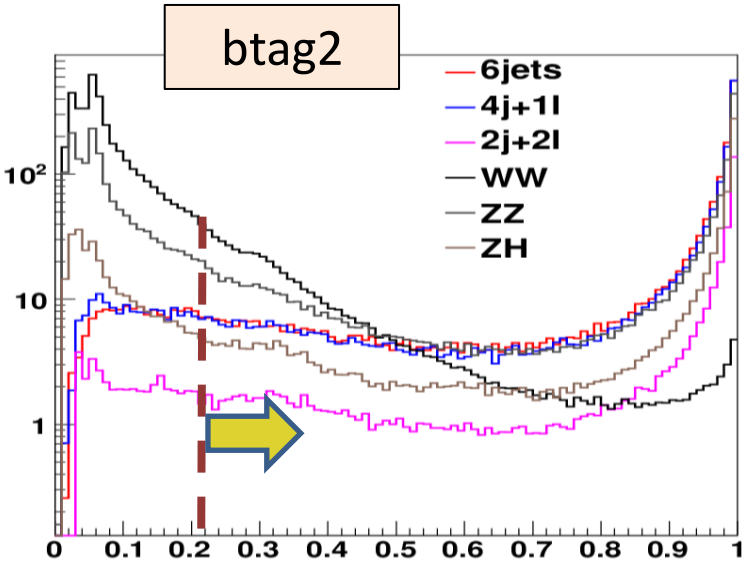




$(e^-, e^+)=(+0.8, -0.3)$

cut1 : btag1 >0.2 + btag2 >0.2



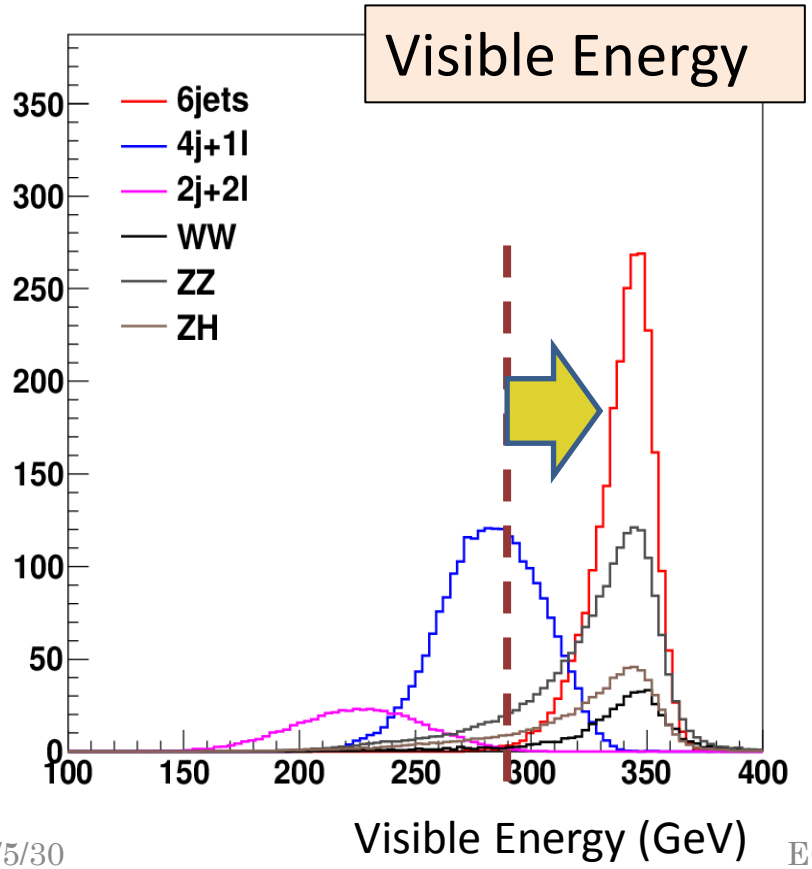


VISIBLE ENERGY CUT

4j + 1l and 2j +2l can be suppressed strongly.

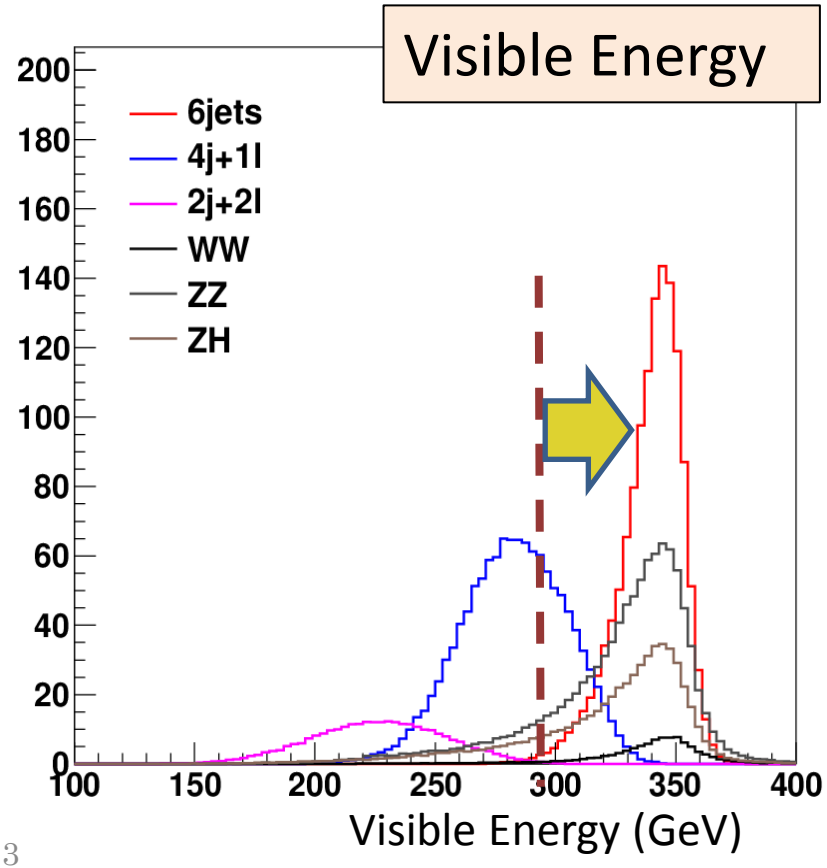
$(e^-, e^+)=(-0.8, +0.3)$

cut2: Evis > 290 GeV



$(e^-, e^+)=(+0.8, -0.3)$

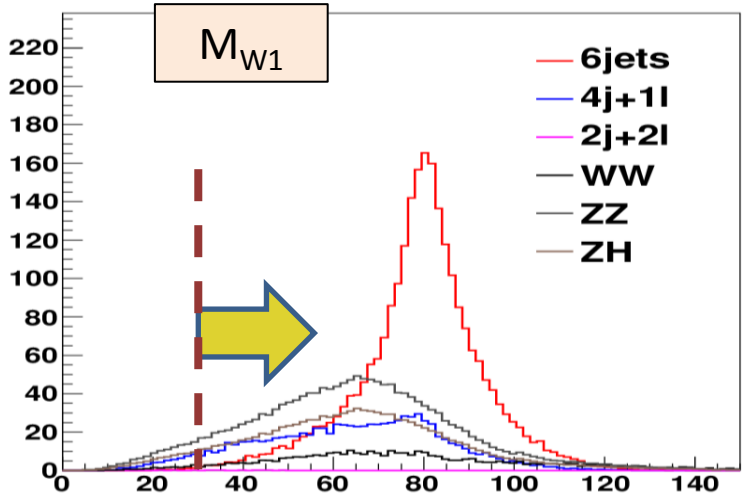
cut2 : Evis > 290GeV

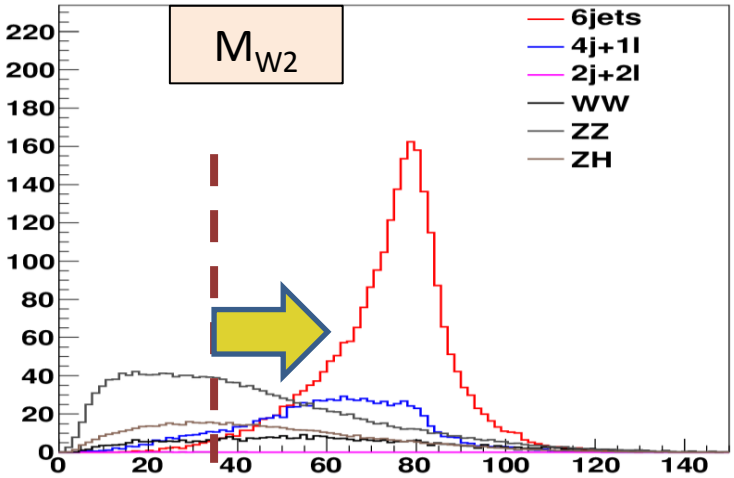


W MASS CUT

$(e^-, e^+)=(-0.8, +0.3)$

cut3: $M_{W1} > 30$ GeV + $M_{W2} > 35$ GeV

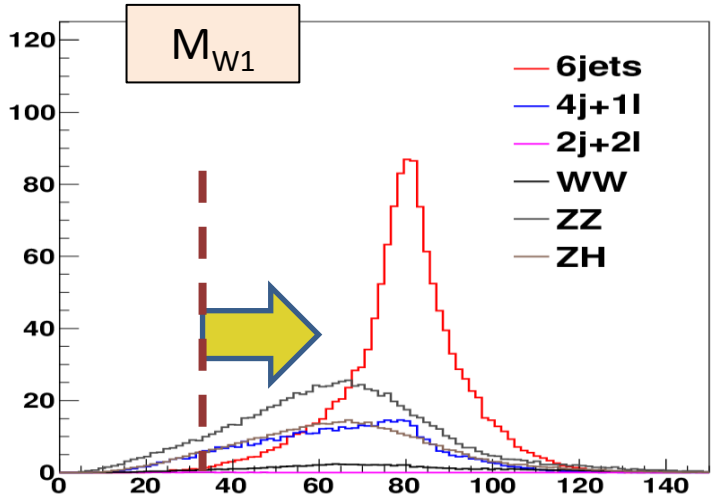


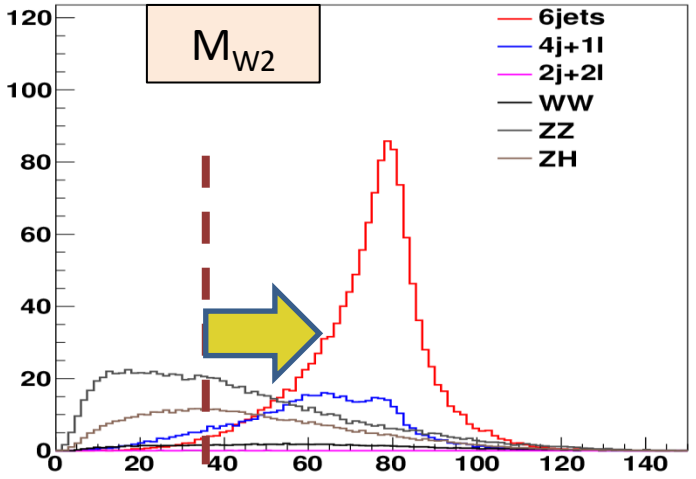


W mass (GeV)

$(e^-, e^+)=(+0.8, -0.3)$

cut3 : $M_{W1} > 30$ GeV + $M_{W2} > 35$GeV





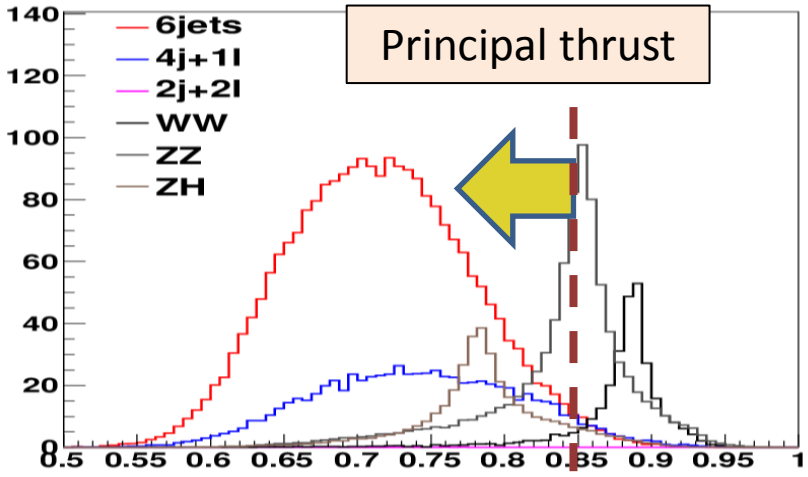
W mass (GeV)

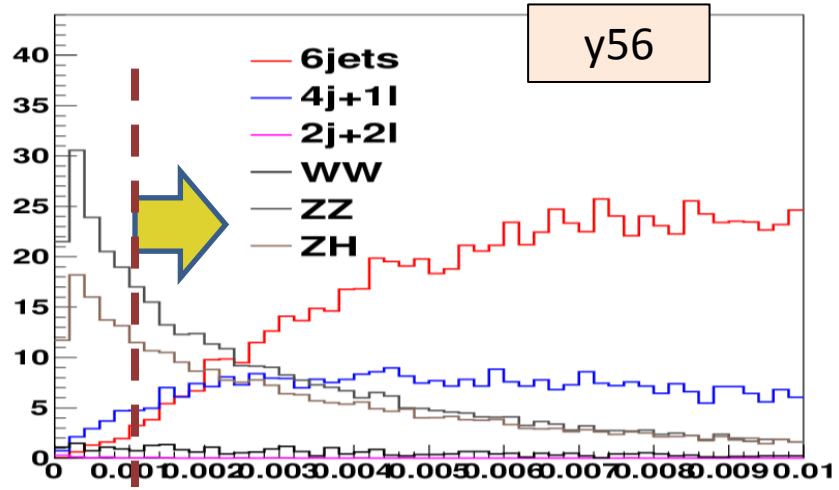
PRINCIPAL THRUST CUT / Y CUT

$(e^-, e^+)=(-0.8, +0.3)$

cut4: pthrust < 0.85

final cut: y56 > 0.001

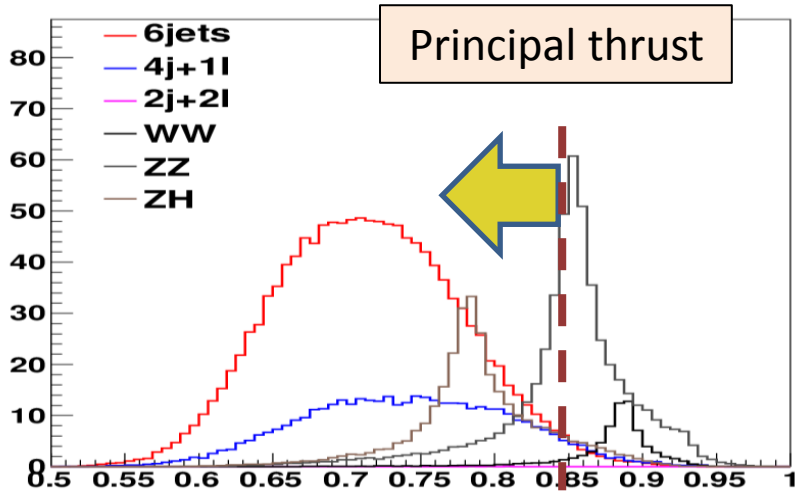


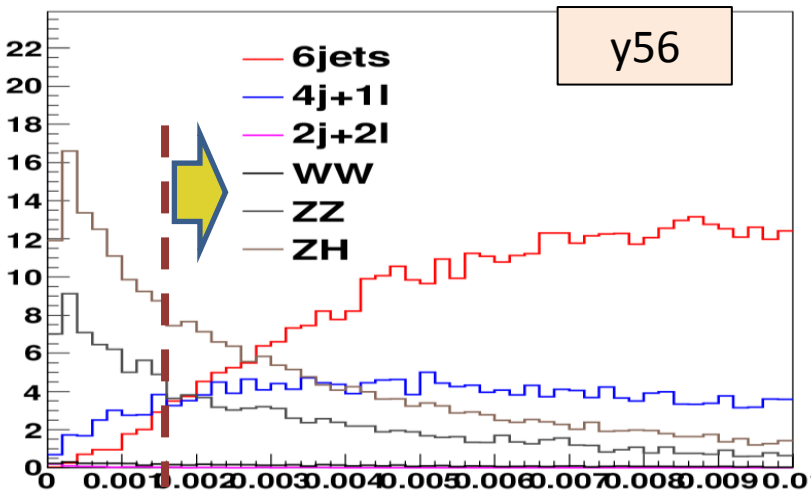


$(e^-, e^+)=(+0.8, -0.3)$

cut4 : pthrust < 0.84

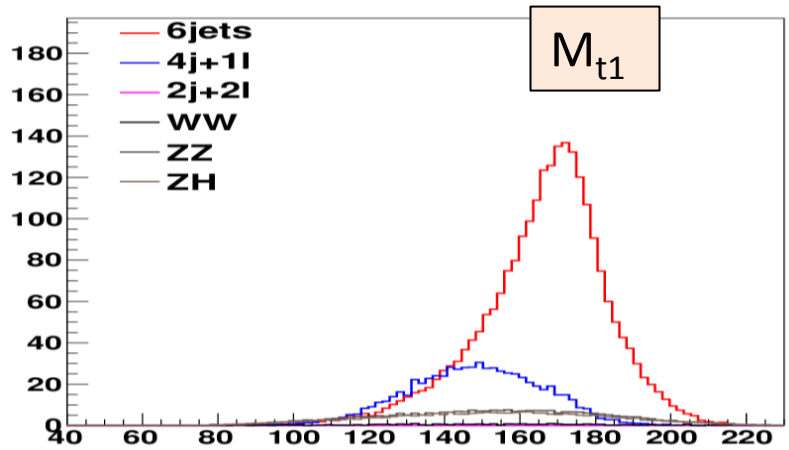
final cut : y56 > 0.0015

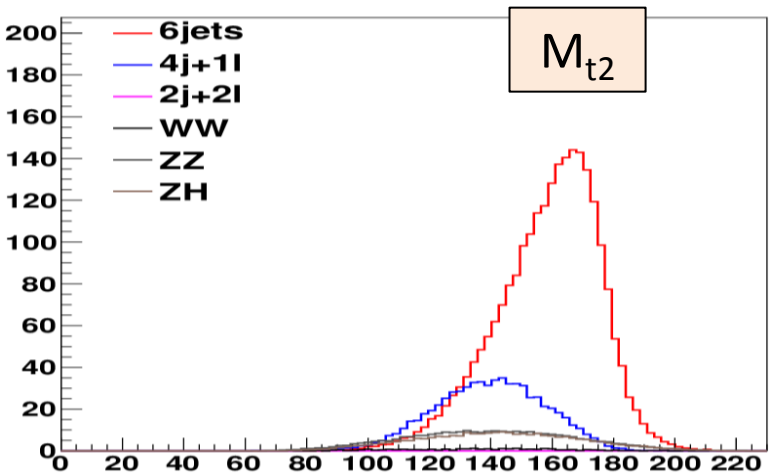




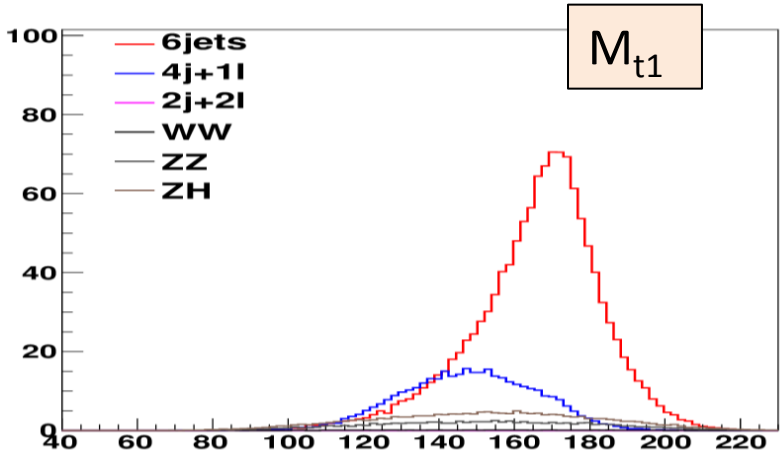
TOP MASS (AFTER ALL CUT)

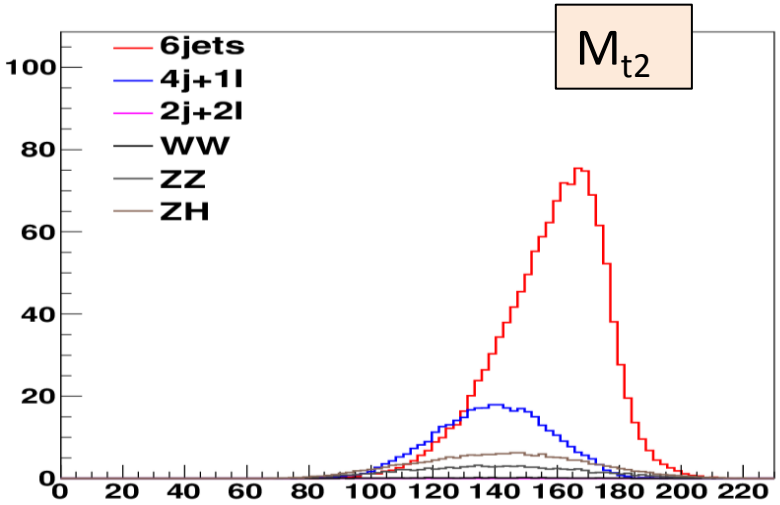
$(e^-, e^+)=(-0.8, +0.3)$





$(e^-, e^+)=(+0.8, -0.3)$





Top mass histograms are above. They are not useful for selections.

NUMBER OF EVENTS AND SIGNIFICANCE

NUMBERS OF EVENTS AND SIGNIFICANCE

This is the cut based analysis table at center of mass energy 350(GeV).

Luminosity = 10 fb^{-1} , polarization **e(-80%)p(+30%)**

btag : btag1>0.3 + btag2 >0.3, Evis : evis>290, W mass : M_{W1}>30 + M_{W2}>35
pthrust : pthrust<0.85, y56 : y56>0.001

Ecm=350 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	3287.6	3166.9	762.7	65328.3	6008.4	1389	11.63	25.53
btag	2471.0	2317.3	551.6	431.9	1887.8	754.9	26.94	58.42
Evis	2462.0	888.6	4.327	397.0	1663.1	633.6	31.66	48.84
W mass	2425.2	737.4	1.790	286.5	823.99	364.2	35.61	53.22
pthrust	2387.7	693.1	1.430	36.09	418.4	333.2	38.38	56.94
y56	2383.2	678.8	0.792	30.95	302.7	261.5	39.40	58.25

Statistic error for cross section is 1/39.40 = 2.54%

NUMBERS OF EVENTS AND SIGNIFICANCE

This is the cut based analysis table at center of mass energy 350(GeV).

Luminosity = 10 fb^{-1} , polarization **e(+80%)p(-30%)**

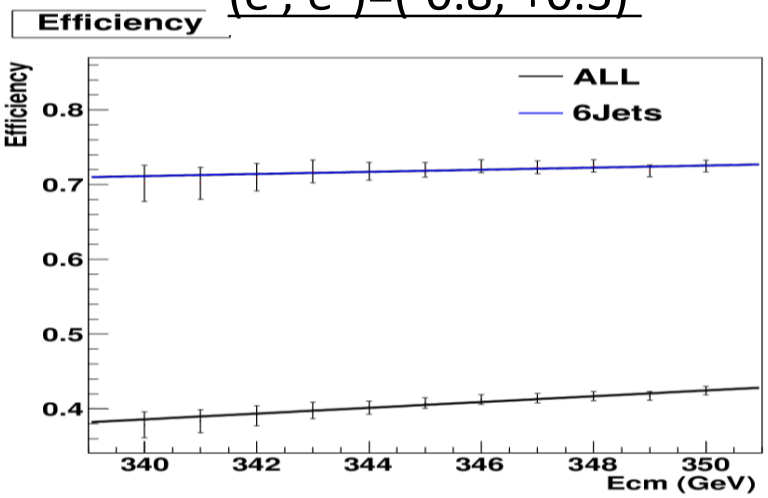
btag : btag1>0.2 + btag2 >0.2, Evis : evis>290, W mass : M_{W1}>30 + M_{W2}>35
pthrust : pthrust<0.84, y56 : y56>0.0015

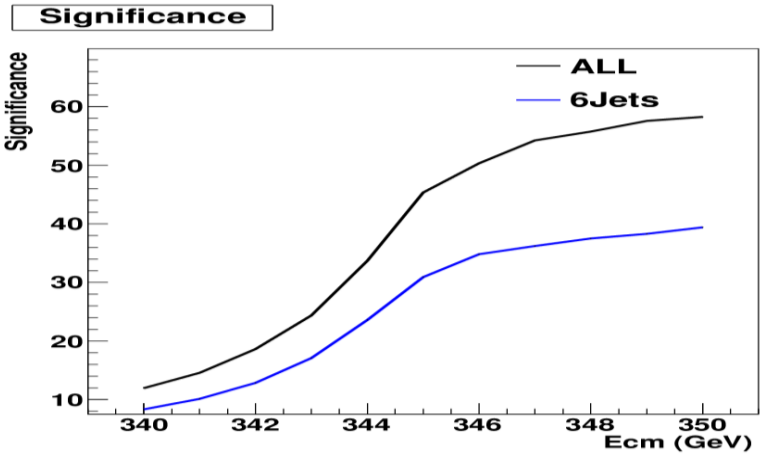
Ecm=350 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	1572.4	1514.9	364.8	4326.0	2773.1	936.7	14.67	32.21
btag	1312.8	1232.2	293.0	103.3	1013.3	569.8	19.52	42.26
evis	1308.6	472.1	2.314	96.25	887.8	475.1	22.98	35.72
W mass	1297.5	417.0	1.360	73.55	502.9	314.8	25.41	38.58
pthrust	1267.5	383.8	0.994	7.362	143.5	274.4	27.81	41.75
y56	1259.5	366.6	0.386	5.739	95.85	186.1	28.79	42.92

Statistic error for cross section is 1/28.79= 3.47%

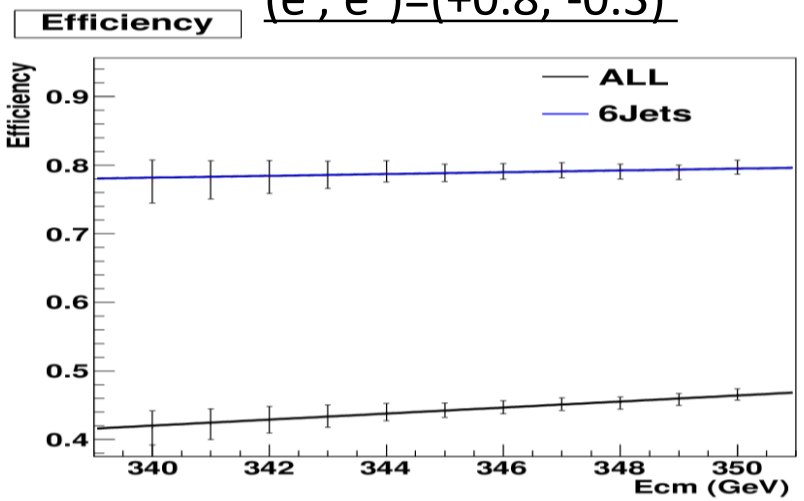
EFFICIENCY & SIGNIFICANCE

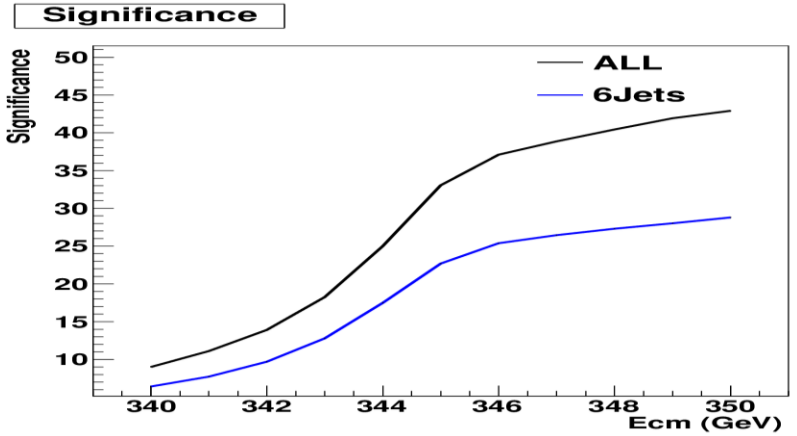
$(e^-, e^+)=(-0.8, +0.3)$





$(e^-, e^+)=(+0.8, -0.3)$

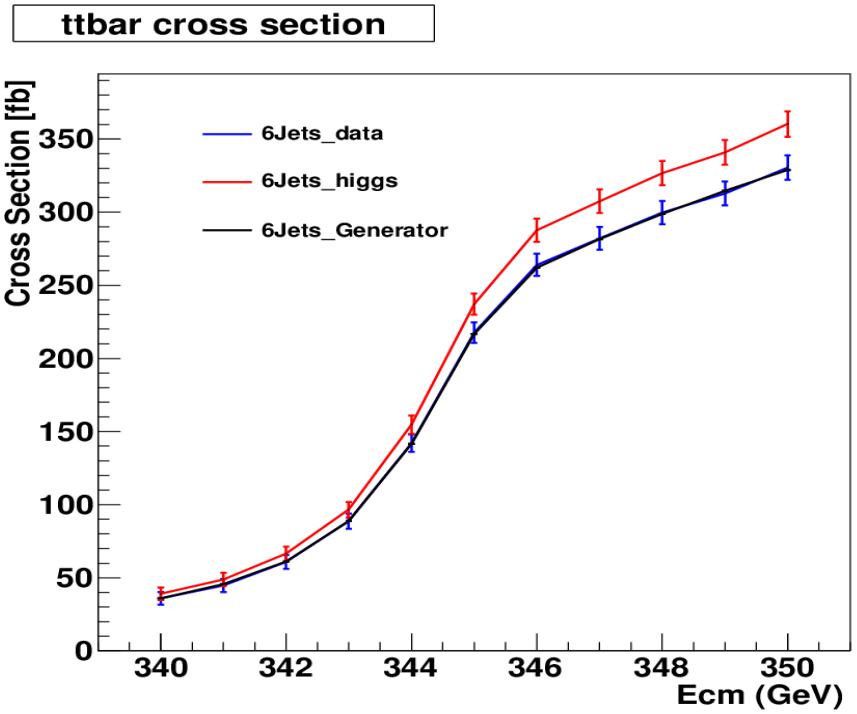




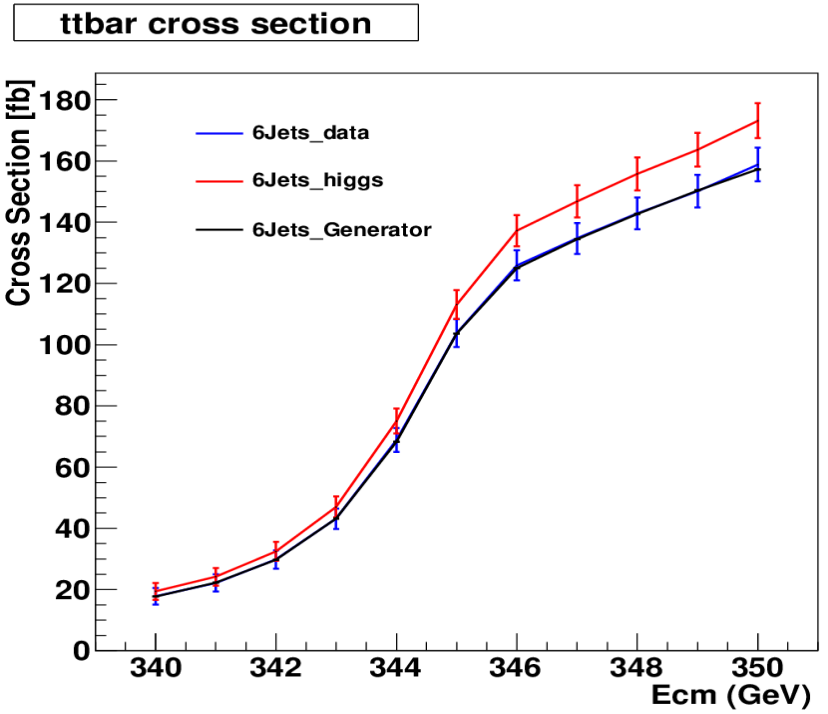
The efficiencies for the selections can be approximately linear function. The right-handed efficiency is better than right-handed one, but left-handed significance is better than right-handed.

CROSS SECTION (6 JETS)

$(e^-, e^+)=(-0.8, +0.3)$



$(e^-, e^+)=(+0.8, -0.3)$



If we combine highest 3 data points (348, 349, 350 GeV), the statistic error for cross sections are 1.5%(left-handed) and 2.1%(right-handed). If we fit the full spectrum, the uncertainty becomes smaller. (theoretical uncertainty is 4%).

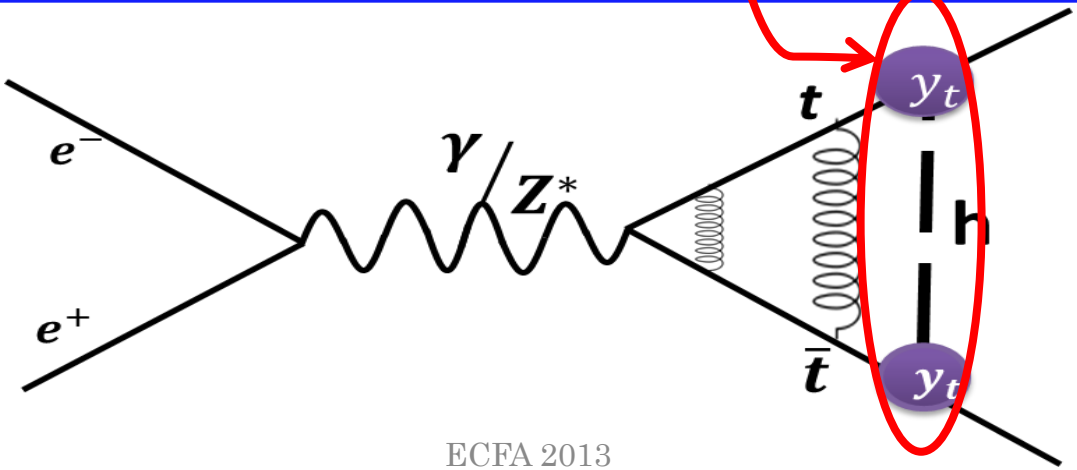
COMBINED STATISTIC ERROR OF TOP YUKAWA

Because of 9% enhance by exchanging higgs boson, we can estimate the statistic error to top yukawa following formula. Exchanging higgs boson, higgs is couple with top twice. So y_t is squred.

$$\sigma \sim |\mathcal{M}|^2 = |\mathcal{M}_{no\ higgs\ exchange} + y_t{}^2 \mathcal{M}_{higgs\ exchange}|^2$$

$$(|\mathcal{M}_{no\ higgs\ exchange}|^2 \gg |y_t{}^2 \mathcal{M}_{higgs\ exchange}|^2)$$

$$\frac{\delta\sigma}{\sigma} \sim \frac{1}{significance}, \frac{\delta y_t}{y_t} \sim \frac{109 \times \frac{1}{2} \times \frac{\delta\sigma}{\sigma}}{9}$$



Coupling twice !!

COMBINED STATISTIC ERROR OF TOP YUKAWA

Summing the selections of all the center of mass energy, the statistic error of the cross section and top yukawa coupling were estimated. We can measure cross section of top pair production precisely.

The estimation of Statistic error	Left	Right	Combined
Cross section	1.1%	1.5%	
Top yukawa	6.7%	9.1%	5.2%

SUMMARY & PLAN

<SUMMARY>

- We measure the top pair cross section at threshold to extract top yukawa coupling.
- The cross section of top pair and its energy dependence are measured with 6jets final state.
- The estimated statistic error of the combined top yukawa coupling is 5.2%.

<PLAN>

- By fitting ttbar cross section, we will calculate the accuracy of top mass, width, α_s.
- Other BG.(ZZZ, WWZ, tbW) will be added.
- 4jets + 1l study will be started.

BACKUP

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(-0.8, +0.3)$

cut 1 : btag1 >0.3 + btag2 >0.3 btagging
cut 2 : cut 1 + evis>290 visible energy
cut 3 : cut 2 + mw1>30 + mw2>35 W mass
cut 4 : cut 3 + pthrust<0.85 principal thrust
final cut :cut 4 + y56>0.001 y cut

Ecm=340 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	359.6	346.4	83.44	67232.1	6199.8	1468.0	1.307	2.870
Cut 1	263.8	249.8	59.41	444.5	1948.0	797.8	4.299	9.399
Cut 2	261.2	60.79	0.085	408.5	1716.0	669.7	4.679	6.842
Cut 3	256.7	51.36	0.050	294.9	850.2	384.9	5.987	8.599
Cut 4	253.1	47.90	0.034	37.14	431.7	352.2	7.556	10.85
Final Cut	252.4	46.57	0.0004	31.86	312.3	276.4	8.322	11.94

Ecm=341 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	455.6	438.9	105.7	67050.4	6180.09	1459.9	1.656	3.635
Cut 1	333.9	315.5	75.11	443.3	1941.8	793.4	5.344	11.76
Cut 2	330.3	82.63	0.212	407.4	1710.6	666.0	5.842	8.705
Cut 3	325.1	69.51	0.064	294.1	847.5	382.8	7.421	10.77
Cut 4	320.6	65.55	0.063	37.04	430.4	350.2	9.239	13.34
Final Cut	319.8	63.65	0.042	31.77	311.3	274.8	10.11	14.56

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(-0.8, +0.3)$

cut 1 : btag1 >0.3 + btag2 >0.3 btagging
cut 2 : cut 1 + evis>290 visible energy
cut 3 : cut 2 + mw1>30 + mw2>35 W mass
cut 4 : cut 3 + pthrust<0.85 principal thrust
final cut :cut 4 + y56>0.001 y cut

Ecm=342 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	609.5	587.1	141.4	66811.6	6161.4	14522.0	2.21	4.86
Cut 1	450.5	425.5	101.4	441.7	1935.9	789.1	7.00	15.23
Cut 2	447.1	118.4	0.200	406.0	1705.4	662.4	7.74	11.53
Cut 3	439.8	98.66	0.059	293.0	845.0	380.7	9.70	14.16
Cut 4	433.6	92.58	0.058	36.91	429.0	348.3	11.84	17.23
Final Cut	432.7	90.12	0.030	31.66	310.4	273.4	12.83	18.62

Ecm=343 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	886.1	853.6	205.6	66662.2	6143.4	1443.6	3.21	7.048
Cut 1	662.0	624.4	144.8	440.8	1930.2	784.6	9.77	21.20
Cut 2	657.0	178.6	0.255	405.1	1700.4	658.5	10.95	16.14
Cut 3	645.1	151.1	0.044	292.4	842.5	378.6	13.42	19.36
Cut 4	637.6	141.2	0.0021	36.83	427.8	346.3	15.99	22.87
Final Cut	635.9	138.1	0.0011	31.59	309.5	271.8	17.08	24.36

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(-0.8, +0.3)$

cut 1 : btag1 >0.3 + btag2 >0.3 btagging
cut 2 : cut 1 + evis>290 visible energy
cut 3 : cut 2 + mw1>30 + mw2>35 W mass
cut 4 : cut 3 + pthrust<0.85 principal thrust
final cut :cut 4 + y56>0.001 y cut

Ecm=344 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	1415.9	1363.8	328.4	66466.9	6116.9	1435.7	5.098	11.19
Cut 1	1054.9	998.6	235.5	439.5	1921.9	780.3	14.31	31.17
Cut 2	1050.4	300.5	0.795	403.9	1693.1	654.9	16.40	24.20
Cut 3	1033.7	253.0	0.330	291.5	838.9	376.5	19.56	28.18
Cut 4	1018.6	237.6	0.327	36.72	426.0	344.4	22.42	32.15
Final Cut	1016.4	231.9	0.066	31.49	308.2	270.3	23.58	33.72

Ecm=345 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	2167.0	2087.5	502.7	66255.7	6095.8	1427.5	7.732	16.97
Cut 1	1619.3	1532.2	358.2	438.1	1915.3	775.9	19.87	43.43
Cut 2	1612.2	491.5	1.011	402.6	1687.3	651.2	23.16	35.16
Cut 3	1587.0	413.5	0.314	290.6	836.0	374.3	26.82	39.66
Cut 4	1563.9	388.4	0.312	36.60	424.5	342.5	29.79	43.73
Final Cut	1560.0	379.5	0.204	31.39	307.1	268.8	30.91	45.36

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(-0.8, +0.3)$

cut 1 : btag1 >0.3 + btag2 >0.3 btagging
cut 2 : cut 1 + evis>290 visible energy
cut 3 : cut 2 + mw1>30 + mw2>35 W mass
cut 4 : cut 3 + pthrust<0.85 principal thrust
final cut :cut 4 + y56>0.001 y cut

Ecm=346 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	2620.3	2523.8	607.8	66070.5	6082.6	1419.7	9.303	20.42
Cut 1	1970.9	1856.6	438.8	436.8	1911.1	771.6	22.93	49.47
Cut 2	1960.9	623.1	1.935	401.5	1683.6	647.6	26.89	40.42
Cut 3	1932.7	518.6	0.727	289.8	834.2	372.3	30.76	44.97
Cut 4	1902.4	484.7	0.389	36.50	423.6	340.6	33.69	48.91
Final Cut	1898.7	473.3	0.146	31.31	306.4	267.3	34.80	50.34

Ecm=347 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	2815.4	2711.7	653.2	65891	6060.7	1411.8	9.98	21.91
Cut 1	2111.5	1981.8	468.7	435.7	1904.2	767.3	24.11	52.93
Cut 2	2102.8	680.7	2.070	400.4	1677.5	644.0	28.33	43.98
Cut 3	2070.8	573.1	0.981	289.0	831.1	370.2	32.20	48.70
Cut 4	2040.3	534.5	0.655	36.40	422.0	338.7	35.13	52.75
Final Cut	2035.9	523.9	0.245	31.22	305.3	265.8	36.20	54.23

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(-0.8, +0.3)$

cut 1 : btag1 >0.3 + btag2 >0.3 btagging
cut 2 : cut 1 + evis>290 visible energy
cut 3 : cut 2 + mw1>30 + mw2>35 W mass
cut 4 : cut 3 + pthrust<0.85 principal thrust
final cut :cut 4 + y56>0.001 y cut

Ecm=348 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	2986.9	2877.2	692.8	65648.8	6050.5	1403.9	10.58	23.23
Cut 1	2243.9	2111.2	500.1	434.1	1901.0	763.0	25.16	54.81
Cut 2	2236	733.9	2.480	398.9	1674.7	640.4	29.65	45.82
Cut 3	2201.8	617.7	1.134	287.9	829.8	368.1	33.55	50.51
Cut 4	2169.1	579.1	0.811	36.27	421.3	336.8	36.44	54.42
Final Cut	2165.4	568.3	0.530	31.11	304.8	264.3	37.50	55.74

Ecm=349 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	3145.4	3029.8	729.6	65504.9	6028.7	1396.2	11.13	24.43
Cut 1	2344.1	2231.4	524.3	433.1	1894.2	758.9	25.91	56.92
Cut 2	2334.6	816.9	2.975	398.0	1668.7	636.9	30.50	47.78
Cut 3	2299.7	677.0	1.173	287.3	826.8	366.1	34.44	52.36
Cut 4	2264.2	635.8	0.712	36.19	419.8	335.0	37.27	56.18
Final Cut	2259.4	621.3	0.465	31.038	303.7	262.9	38.31	57.57

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(+0.8, -0.3)$

cut 1 : prob31 >0.2 + prob32 >0.2	btagging
cut 2 : cut1 + evis>290	Visible energy
cut 3 : cut2 + mw1>30 + mw2>35	W mass
cut 4 : cut3 + pthrust<0.84	principal thrust
Final cut :cut 4 + y56>0.0015	y cut

Ecm=340 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance 6j	Significance ALL
No cut	177.2	170.7	41.12	4467.4	2870.4	990.3	1.898	4.167
Cut 1	145.3	136.9	32.43	106.6	1048.9	602.41	3.192	6.904
Cut 2	143.9	33.62	0.086	99.39	918.9	502.3	3.491	5.044
Cut 3	142.5	29.65	0.039	75.96	520.6	332.8	4.295	6.118
Cut 4	139.6	27.15	0.024	7.603	148.5	290.1	5.638	7.965
Final Cut	138.6	25.65	0.007	5.927	99.21	196.7	6.418	9.018

Ecm=341 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	222.8	214.6	51.67	4453.7	2861.2	984.7	2.376	5.216
Cut 1	182.9	171.9	41.08	106.3	1045.5	59.99	3.947	8.597
Cut 2	181.1	44.07	0.131	99.09	916.0	499.5	4.343	6.418
Cut 3	179.6	39.09	0.058	75.72	518.9	330.9	5.310	7.713
Cut 4	175.7	35.99	0.040	7.579	148.1	288.5	6.861	9.922
Final Cut	174.4	34.23	0.010	5.909	98.89	195.6	7.730	11.118

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(+0.8, -0.3)$

cut 1 : prob31 >0.2 + prob32 >0.2	btagging
cut 2 : cut1 + evis>290	Visible energy
cut 3 : cut2 + mw1>30 + mw2>35	W mass
cut 4 : cut3 + pthrust<0.84	principal thrust
Final cut :cut 4 + y56>0.0015	y cut

Ecm=342 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance 6j	Significance ALL
No cut	297.2	286.2	68.94	4436.0	2852.9	979.0	3.147	6.908
Cut 1	244.5	230.7	54.54	105.9	1042.5	595.6	5.128	11.15
Cut 2	242.8	63.70	0.147	98.69	913.3	496.6	5.698	8.446
Cut 3	240.6	56.00	0.088	75.42	517.4	329.0	6.893	10.05
Cut 4	235.5	51.90	0.064	7.549	147.6	286.8	8.719	12.59
Final Cut	234.2	49.34	0.049	5.885	98.60	194.5	9.702	13.90

Ecm=343 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	431.6	415.7	100.1	4424.7	2843.5	973.9	4.503	9.885
Cut 1	356.7	334.6	79.83	105.6	1039.1	592.4	7.123	15.39
Cut 2	354.3	96.42	0.319	98.44	910.3	494.0	8.015	11.76
Cut 3	351.0	85.86	0.111	75.23	515.7	327.3	9.535	13.78
Cut 4	343.4	78.46	0.055	7.530	147.1	285.3	11.70	16.79
Final Cut	341.5	74.88	0.038	5.870	98.28	193.5	12.78	18.25

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(+0.8, -0.3)$

cut 1 : prob31 >0.2 + prob32 >0.2	btagging
cut 2 : cut1 + evis>290	Visible energy
cut 3 : cut2 + mw1>30 + mw2>35	W mass
cut 4 : cut3 + pthrust<0.84	principal thrust
Final cut :cut 4 + y56>0.0015	y cut

Ecm=344 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance 6j	Significance ALL
No cut	682.8	657.7	158.4	4409.9	2830.5	968.3	6.930	15.21
Cut 1	567.6	530.8	125.5	105.3	1034.3	589.0	10.45	22.63
Cut 2	564.3	161.5	0.531	98.11	906.2	491.2	11.97	17.69
Cut 3	558.7	142.1	0.269	74.98	513.3	325.4	13.90	20.18
Cut 4	546.3	130.1	0.118	7.505	146.5	283.7	16.37	23.51
Final Cut	543.5	124.2	0.028	5.851	97.83	192.3	17.51	25.00

Ecm=345 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	1036.5	998.3	240.4	4394.7	2821.5	963.0	10.14	22.25
Cut 1	861.4	812.8	190.6	104.9	1031.0	585.8	14.38	31.17
Cut 2	856.0	258.4	0.571	97.78	903.3	488.5	16.77	25.23
Cut 3	847.9	225.6	0.373	74.72	511.7	323.7	19.04	28.11
Cut 4	827.9	205.5	0.331	7.479	146.0	282.1	21.60	31.63
Final Cut	822.7	196.2	0.084	5.831	97.52	191.3	22.70	33.07

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(+0.8, -0.3)$

cut 1 : prob31 >0.2 + prob32 >0.2	btagging
cut 2 : cut1 + evis>290	Visible energy
cut 3 : cut2 + mw1>30 + mw2>35	W mass
cut 4 : cut3 + pthrust<0.84	principal thrust
Final cut :cut 4 + y56>0.0015	y cut

Ecm=346 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance 6j	Significance ALL
No cut	1249.8	1203.8	290.0	4381.0	2812.3	957.6	11.97	26.28
Cut 1	1037.4	976.6	232.7	104.6	1027.6	582.5	16.48	35.78
Cut 2	1031.8	325.1	0.768	97.47	900.3	485.7	19.36	29.45
Cut 3	1022.9	284.9	0.400	74.49	510.0	321.8	21.74	32.38
Cut 4	999.8	257.4	0.215	7.456	145.5	280.5	24.31	35.76
Final Cut	993.7	246.7	0.070	5.813	97.20	190.2	25.37	37.10

Ecm=347 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	1344.0	1294.5	311.7	4367.6	2803.4	952.3	12.77	28.03
Cut 1	1119.1	1054.0	248.8	104.3	1024.4	579.3	17.41	37.74
Cut 2	1114.1	361.4	1.099	97.17	897.5	483.1	20.50	31.30
Cut 3	1105.0	318.3	0.574	74.26	508.4	320.1	22.91	34.30
Cut 4	1077.5	289.4	0.360	7.433	145.1	279.0	25.41	37.61
Final Cut	1070.9	277.0	0.184	5.795	96.89	189.2	26.44	38.87

NUMBERS OF EVENTS AND SIGNIFICANCE

$(e^-, e^+)=(+0.8, -0.3)$

cut 1 : prob31 >0.2 + prob32 >0.2	btagging
cut 2 : cut1 + evis>290	Visible energy
cut 3 : cut2 + mw1>30 + mw2>35	W mass
cut 4 : cut3 + pthrust<0.84	principal thrust
Final cut :cut 4 + y56>0.0015	y cut

Ecm=348 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance 6j	Significance ALL
No cut	1427.1	1374.7	331.1	4350.3	2793.5	947.0	13.47	29.57
Cut 1	1182.8	1121.3	265.1	103.8	1020.8	576.1	18.10	39.44
Cut 2	1178.4	395.8	1.340	96.79	894.3	480.4	21.35	32.88
Cut 3	1168.2	346.6	0.773	73.97	506.6	318.3	23.77	35.88
Cut 4	1140.6	316.6	0.511	7.403	144.6	277.4	26.26	39.23
Final Cut	1134.5	302.7	0.232	5.772	96.55	188.1	27.29	40.43

Ecm=349 (GeV)	tt6j	tt4j+1l	tt2j+2l	WW	ZZ	ZH	Significance6j	SignificanceALL
No cut	1503.8	1448.4	348.8	4338.8	2785.6	942.0	14.10	30.96
Cut 1	1250.0	1177.4	279.9	103.6	1017.9	573.0	18.84	41.01
Cut 2	1244.9	433.1	1.663	96.53	891.8	477.8	22.20	34.37
Cut 3	1232.6	382.8	0.755	73.77	505.2	316.6	24.59	37.40
Cut 4	1202.7	352.0	0.492	7.384	144.1	275.9	27.01	40.69
Final Cut	1195.4	336.6	0.259	5.757	96.28	187.1	28.01	41.94