New Higgs MultiJet Trigger

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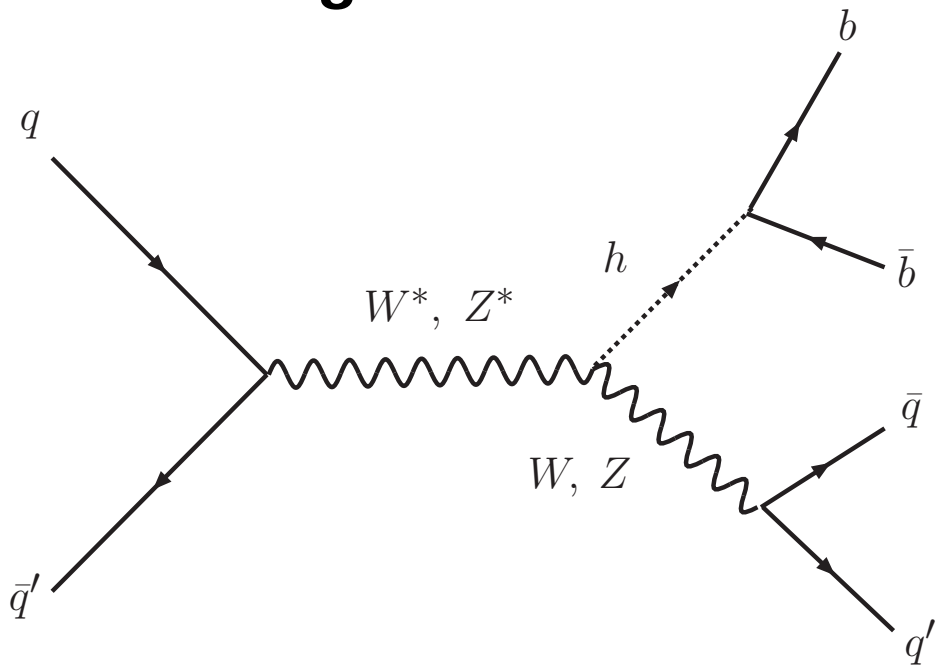
Outline

- Motivation
- Methods
- Results
- Conclusion

Our Signal:



Motivation

- Our goal is to search for SM Higgs in
  W/ZH → bbjj : signature is 4 jets
- TOP_MULTIJET triggers on this signature:
  L1_JET20
  L2_FOUR_JET15_SUMET175
  L3_FOUR_JET10
- L2_FOUR_JET15_SUMET175 is the tightest
  → L1 and L3 are true ~100% if L2 is true
- Try to come up with new L2 trigger(s)
- L2 of TOP_MULTIJET will be referred to as TOP_MULTIJET for brevity

Motivation cont'd

- (L2 of)TOP_MULTIJET is not optimal for our purpose ⟶ SumEt cut (175 GeV) may be suitable for (heavy) top quarks but is too tight for (lighter) Higgs bosons.

  Requiring 4 jets is also too tight for our signature (W/ZH ⟶ 4 jets)
- A new L2 trigger is needed for higgs searches

Methods

- CDF has switched to new clustering alg. (cone) since last shutdown in 2007
- Use Gene's code that emulates cone alg. in Stntuple to find L2 clusters in both Single-tower 10 data and higgs MC
- Apply different trigger criteria on L2 clusters found in both data and MC
- Goal is to have as much gain in Signal acceptance as possible with acceptable increase in the trigger rate
- New L2 trigger should have a modest growth term at high instantaneous luminosities

Methods cont'd

- How to justify "gain in Signal"?
- Take TOP_MULTIJET as reference:

Compare # of signal events passing new trigger(s) to # of events passing TOP_MULTIJET

- N_{NEW} = # of events passing NEW L2

  N_{TOP} = # of events passing TOP_MULTIJET

  $R_{SG} = N_{NEW} / N_{TOP}$ for Signal (higgs MC)

  $R_{DATA} = N_{NEW} / N_{TOP}$ for Data (Single-tower 10)

- "Gain in Signal " means $R_{SG} > 1$
- We want $R_{SG} >> 1$ with R_{DATA} staying as close to **1** as possible for new L2 triggers

Methods cont'd

- Check our trigger criteria by reproducing TOP_MULTIJET rate
- Apply our new L2 triggers on three higgs masses 100, 110 and 120 GeV to see how new triggers respond to higgs mass
- Our trigger criteria contain:

  # of jets, jet Et cuts and SumEt cuts

  (SumEt is the sum of Et of all jets)

Methods cont'd

- MC shows higgs signals tend to have jets in central region
- Introduce requirement of central jets (feature different from TOP_MULTIJET)
- Consider ≥ 3 jets and ≥ 2 central jets

1. First 3 leading jet Et ≥ 20, 20, 20 GeV respectively
2. First 3 leading jet Et ≥ 30, 20, 20 GeV respectively
3. First 3 leading jet Et ≥ 30, 30, 20 GeV respectively
4. First 3 leading jet Et ≥ 40, 30, 20 GeV respectively
5. First 3 leading jet Et ≥ 30, 30, 30 GeV respectively

Plus, both central jet Et ≥ 15, 20, … , 45 GeV

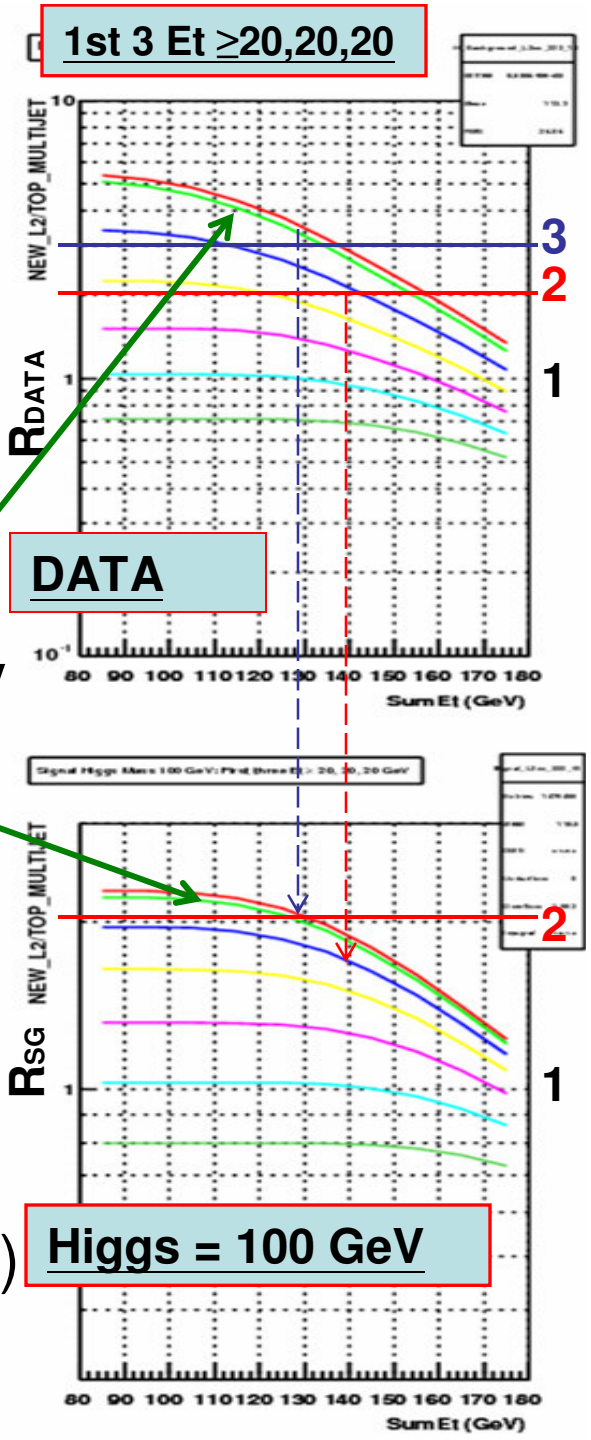
SumEt ≥ 80, 90, … , 180 GeV

Results (higgs 100 GeV)

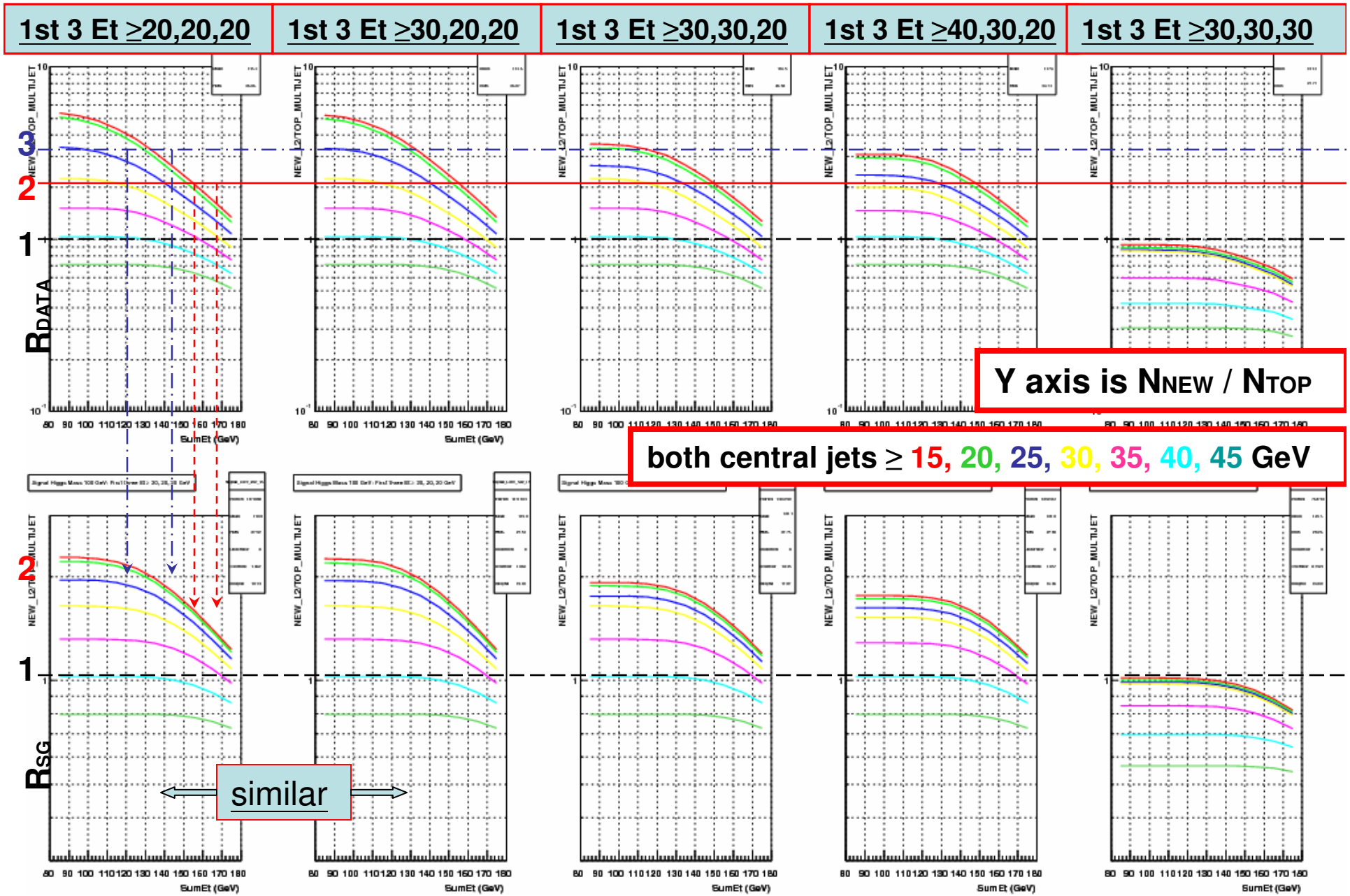
- Y axis is **R_{DATA}** (top plot) and **R_{SG}** (bottom)
- X axis is SumEt cuts, curves are c-jet cuts
- **$R_{DATA/SG}$** = 2(3) means New L2 pass 2(3) times as many events as TOP_MULTIJET within some instantaneous luminosity range (0-300 X 10^{30}/cm^2/s for our study)
- For example: for 1st 3 Et ≥ 20, 20, 20 GeV and 1st 2 cjet Et ≥20 (green curve), SumEt ≥ 130 GeV

  → New L2 rate = 3 X TOP_MULTIJET for Data, while

  New L2 acceptance ~ 2 X TOP_MULTIJET for Signal
- ~100% gain in Signal (w.r.t. TOP_MULTIJET) is possible for Higgs = 100 GeV!



R_{DATA} vs R_{SG} for Higgs mass = 100 GeV [Top: Data, Bottom: Signal]



Preferred trigger configurations

- We *define* preferred trigger configurations to be those giving Signal acceptance **closest to** 2 X TOP_MULTIJET
- Table shows configuration that best fit the above criterion for Higgs mass = 100 GeV is 1st 3 jet Et ≥ 20, 20, 20 GeV
- Numbers are **($R_{DATA}=N_{NEW}$ / N_{TOP})** for DATA

  ($R_{SG}=N_{NEW}$ / N_{TOP}) for Signal
- 1st 3 jet Et ≥ 30, 20, 20 GeV produces very similar results
- Other configurations give worse Signal acceptances

SumEt cut / cjetEt cut	110	120	130	140
15	Best signal accpt			2.61/1.80
20			2.96/1.93	2.43/1.76
25	2.97/1.92	2.66/1.86	2.30/1.76	

Preferred trigger configurations for Higgs 110 GeV

- Two comparable configurations:

  1st 3 jet Et $\geq$ 20, 20, 20 GeV, $\geq$ 30, 20, 20 GeV
- Other configurations are worse
- Drop in R_{SG} from Higgs 100 to 110 GeV (more events pass TOP_MULTIJET for heavier higgs

→ bigger N_{TOP} in $R_{SG} = N_{NEW}/N_{TOP}$)

- Best one is ~1.8 X TOPMULTIJET

cjetEt cut \ SumEt cut	110	120	130	140
15				2.61/1.72
20			2.96/1.82	2.43/1.68
25	2.97/1.79	2.66/1.75	2.30/1.68	

Preferred trigger configurations for Higgs 120 GeV

- Best two configurations are

  1st 3 jet Et $\geq$ 20, 20, 20 GeV, $\geq$ 30, 20, 20 GeV

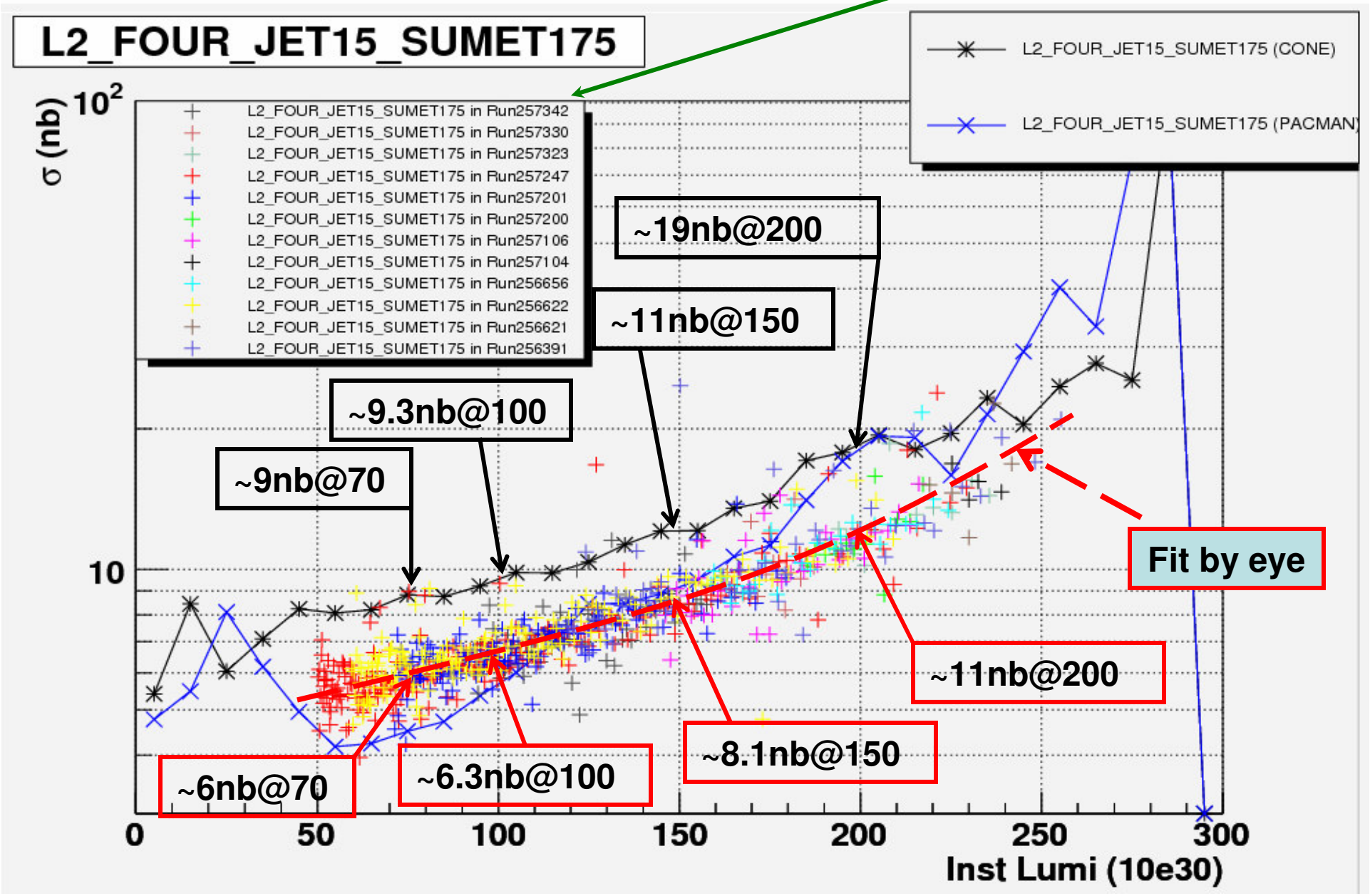
  produce similar results
- Drop in Singal R_{SG} from Higgs 110 to 120 GeV (even more events pass TOP_MULTIJET for even heavier higgs)
- Best is ~1.7 X TOP_MULTIJET

SumEt cut / cjetEt cut	110	120	130
20			2.96/1.72
25	2.97/1.67		

- R_{DATA} vs R_{SG} plots show us:

  Our New L2 triggers do better job collecting Signal events of lighter higgs than TOP_MULTIJET
- We have to check if we can reproduce real TOP_MULTIJET as seen in data
- Have to check how the new L2 trigger will behave as a function of instantaneous luminosity

Predicted TOP_MULTIJET rate (data from 2008)

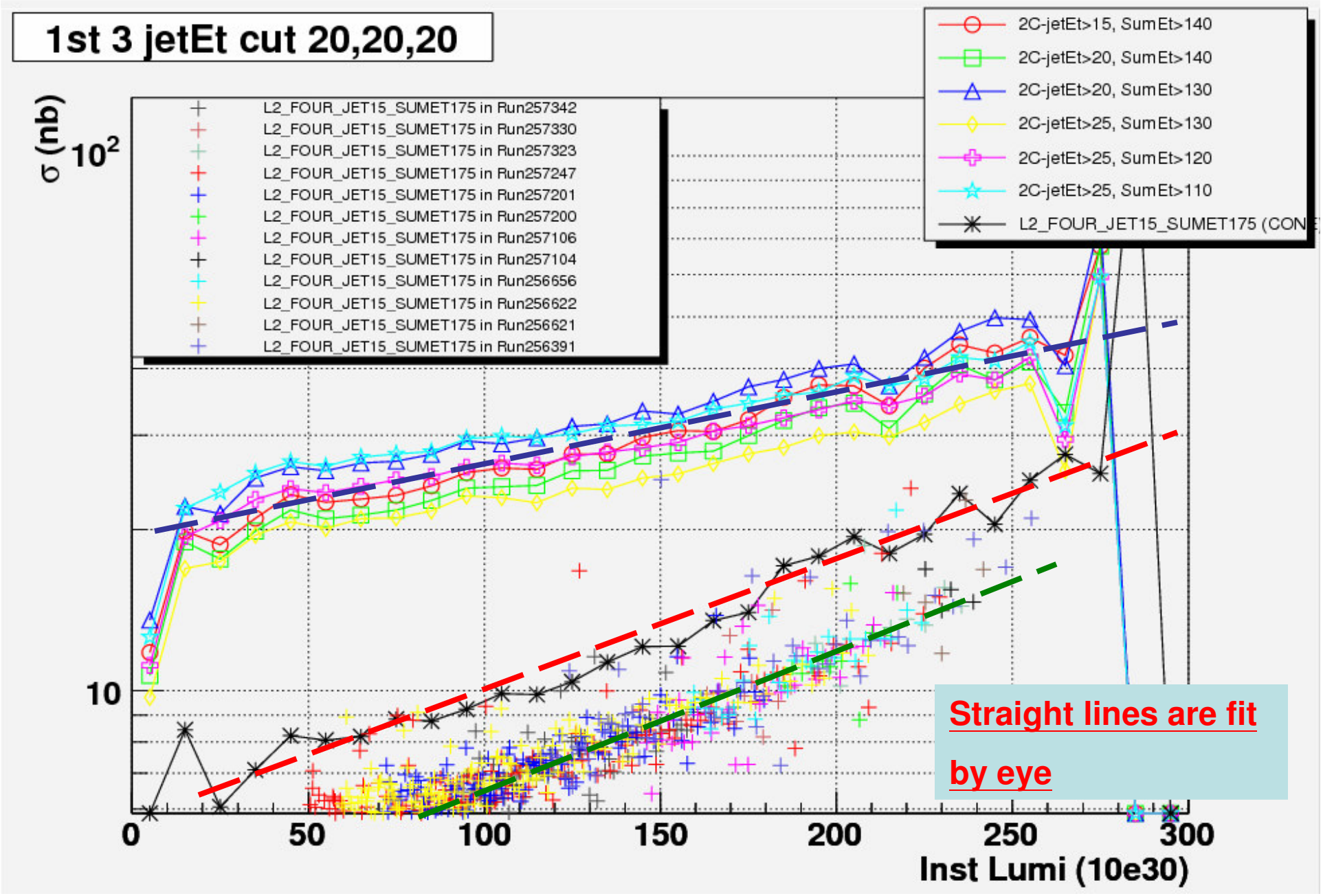


- N_{JET20} = # of events passed L1_JET20

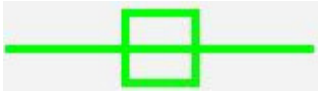
  L1_JET20 rate is ~1840 nb for 20 ≤ inst.lumi. ≤ 120
- N_{TOP} = # of events that pass L1_JET20 and then TOP_MULTIJET
- Predicted TOP_MULTIJET

  Rate (nb) = (N_{TOP} / N_{JET20}) X 1840 nb
- Same method used to obtain rates for other L2 triggers
- Our predicted TOP_MULTIJET rate agrees with real TOP_MULTIJET rate within a factor of ~ 1.5
- Our predicted TOP_MULTIJET rate grows in a similar way to real TOP_MULTIJET

Trigger rates with respect to Inst. Lumi.



First 3 leading jet Et cuts 20, 20, 20 GeV

Instant. Luminosity (TOP_MULTIJET) / Configurations	150 (9 nb)	200 (19 nb)	250 (23 nb)
SumEt≥140GeV 2 cjets≥15GeV 	30 nb/3.3	37 nb/1.9	45 nb/2.0
SumEt≥140GeV 2 cjets≥20GeV 	27 nb/3.0	34 nb/1.8	40 nb/1.7
SumEt≥130GeV 2 cjets≥20GeV 	33 nb/3.7	40 nb/2.1	50 nb/2.2
SumEt≥130GeV 2 cjets≥25GeV	25 nb/2.8	30 nb/1.6	36 nb/1.6
SumEt≥120GeV 2 cjets≥25GeV 	28 nb/3.1	34 nb/1.8	40 nb/1.7
SumEt≥110GeV 2 cjets≥25GeV 	32 nb/3.6	37 nb/1.9	43 nb/1.9

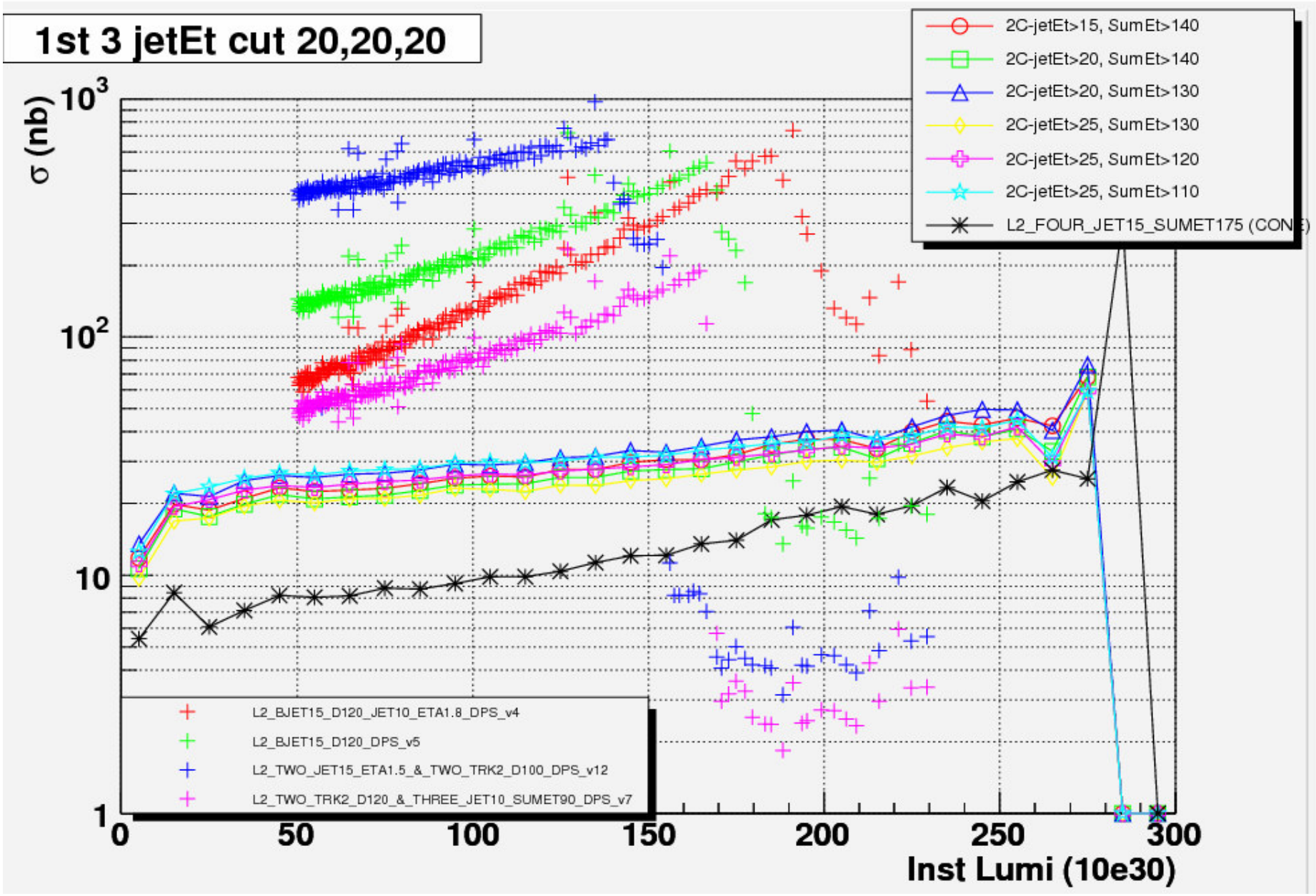
Red #s = NEW_L2 rate / TOP_MULTIJET rate

- Our new L2 triggers grow slower than TOP_MULTIJET
- New L2 trigger rates~(2-4)X TOP_MULTIJET
- Current TOP_MULTIJET has very low rate compared to other CDF triggers:

1. L2_BJET15_D120_JET10_ETA1.8_DPS
2. L2_BJET15_D120_DPS
3. L2_TWO_JET15_ETA1.5_&_TWO_TRK2_D100_DPS
4. L2_TWO_TRK2_D120_&_THREE_JET10_SUMET90_DPS

...and a bunch of others

Data taken from Run 257247 (Feb. 4, 2008)



- Considering offline cuts, we propose

L1_JET20

L2_THREE_JET20_TWO_CJET20_SUMET130

1. $\geq$ 3 jets
2. $\geq$ 2 central jets
3. First 3 leading jet Et $\geq$ 20, 20, 20 GeV
4. First 2 leading central jet Et $\geq$ 20, 20 GeV
5. SumEt $\geq$ 130 GeV

- Expected average Trigger rate / Signal acceptance ~ 3 / 2 w.r.t. TOP_MULTIJET

1st 3 jetEt ≥20 GeV, 1st 2 cjets ≥20GeV, SumEt ≥130GeV

Trigger rates			
Inst. Lumi.	150	200	250
New_L2/TOP	33 nb/9 nb	40 nb/19 nb	50 nb/23 nb

Higgs mass (GeV)	Average Signal Acceptance					
	Preferred New L2			TOP_MULTIJET		
	Non pre-selected	**3 jets**	**3jet+1bjet**	**Non pre-selected**	**3 jets**	**3jet+1bjet**
100	40 %	48 %	54 %	21 %	25 %	28 %
110	46 %	54 %	60 %	25 %	30 %	33 %
120	52 %	59 %	66 %	30 %	35 %	38 %

Conclusion

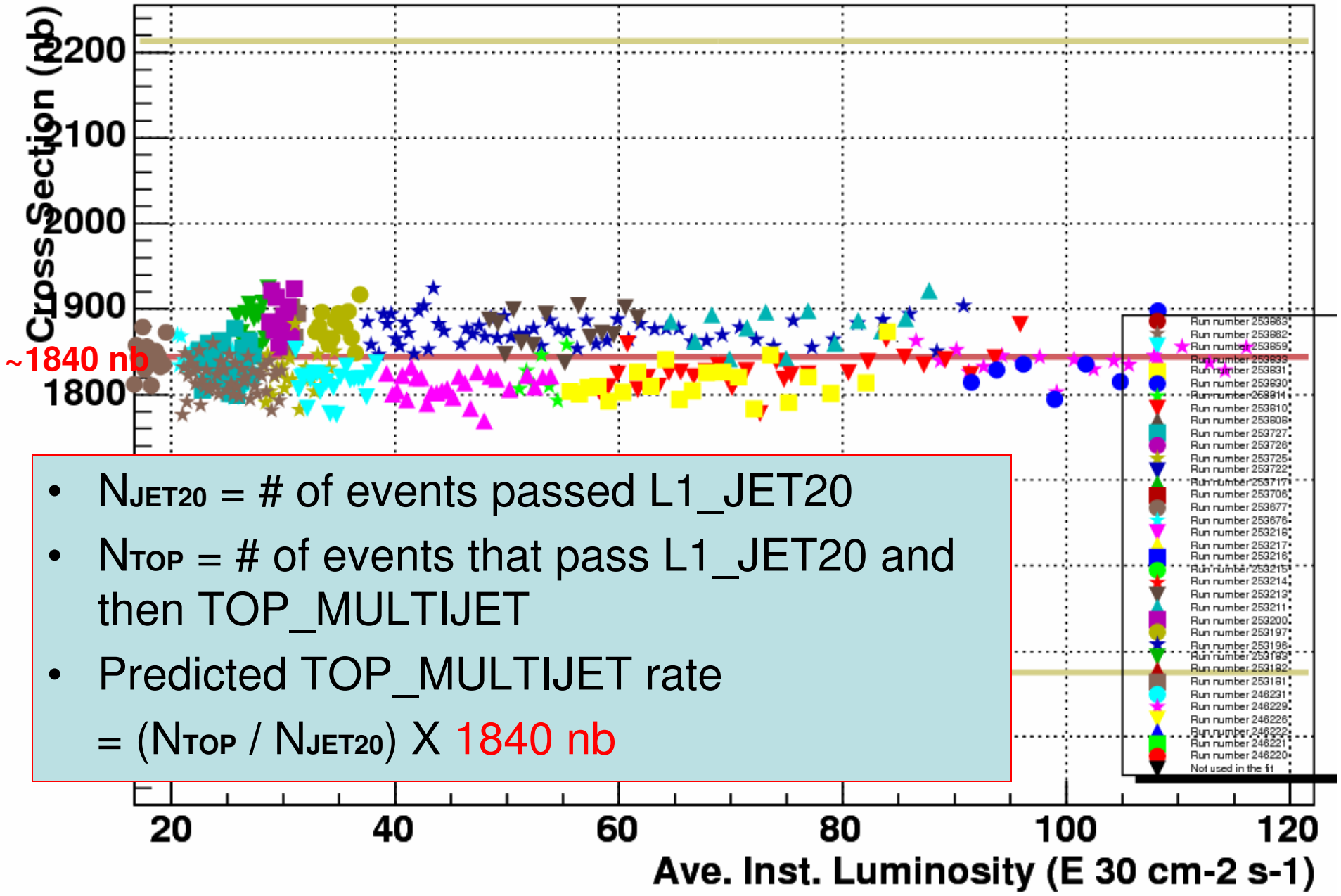
- Our signature for W/ZH → bbjj is 4 jets
- Current TOP_MULTIJET is too tight for signal
- With new clustering (cone) alg. we are able to come up with triggers that can produce ~2 times as much signal events as TOP_MULTIJET can
- Our new triggers have very modest growth at high luminosities w.r.t. TOP_MULTIJET
- We propose

  L2_THREE_JET20_TWO_CJET20_SUMET130

  as our new test L2 trigger

Backup

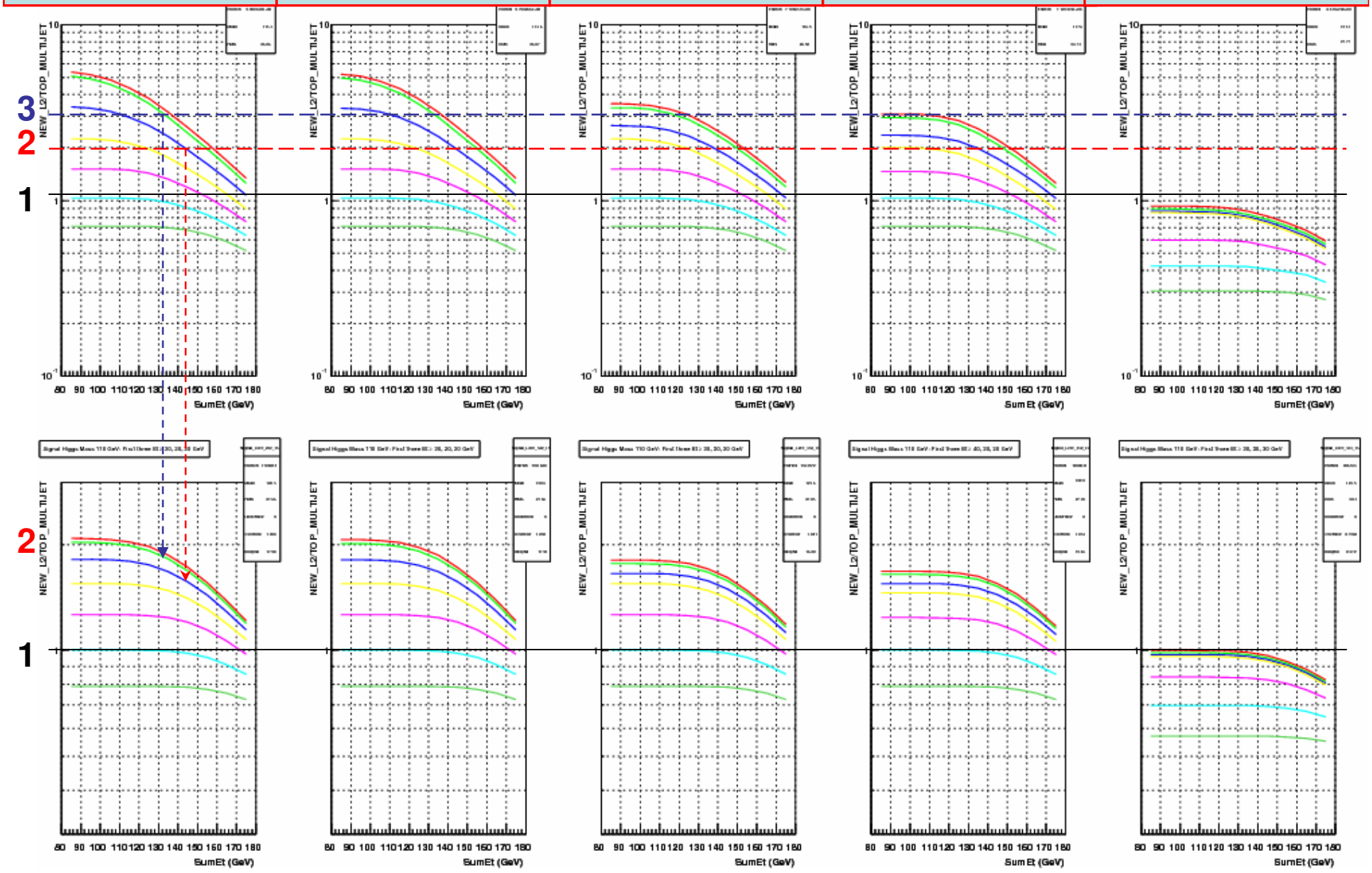
L1_JET20_v1 Cross Section vs. Inst. Lum



- N_{JET20} = # of events passed L1_JET20
- N_{TOP} = # of events that pass L1_JET20 and then TOP_MULTIJET
- Predicted TOP_MULTIJET rate
  = (N_{TOP} / N_{JET20}) X 1840 nb

Higgs mass = 110 GeV [Top: Data, Bottom: Signal]

1st 3 Et ≥20,20,20	1st 3 Et ≥30,20,20	1st 3 Et ≥30,30,20	1st 3 Et ≥40,30,20	1st 3 Et ≥30,30,30



Higgs mass = 120 GeV [Top: Data, Bottom: Signal]