Central Exclusive H→bb

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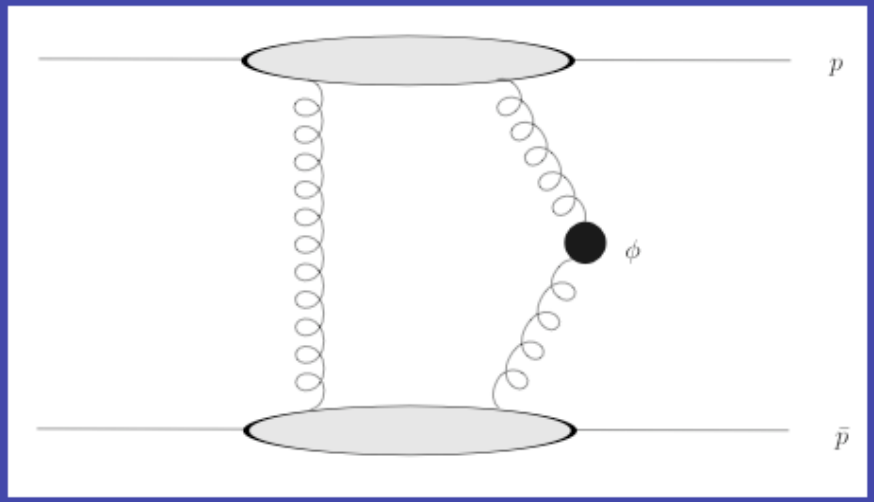
Central Exclusive (CEP) Higgs



In this study, CEP H→bb is simulated with ExHuME.

σ= 1.86fb (for M_H=120GeV)

pp→p + H + p

Mass of ϕ: $M_\phi^2 = \xi_1 \xi_2 s$

ξ_i = momentum loss of proton i.
s = pp collision centre-of-mass^2.

Rapidity of ϕ:
$y = 0.5 \ln(\xi_1/\xi_2)$

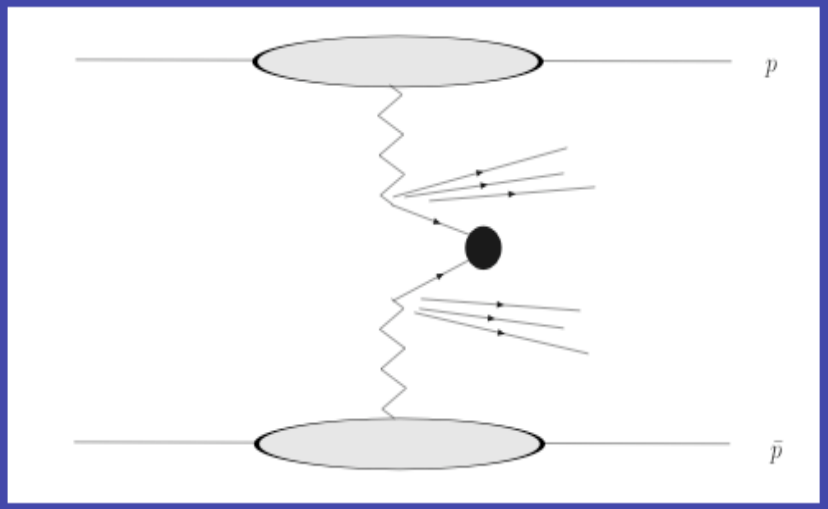
Backgrounds 1: CEP

- Backgrounds are:
  - **pp→p + bb + p** and
  - **pp→p + gg + p** (where both gluons are mis-identified as b quarks).

- Quark production is suppressed by m_q^2 / M^2 . This means that bb production is suppressed, but also that light quark backgrounds are negligible.

- These are also produced by ExHuME.

Backgrounds 2: DPE



This type of background is generated using the POMWIG MC.

pp→ p + A + bb + p
pp→ p + A + jj + p

A = other activity in the central system. i.e pomeron remnants.
j = light quark and gluon jets.

Note: $M \neq M_{bb}$

Backgrounds 3: Overlap

- The overlap background is a normal QCD (bb or jj) event + 2 single diffractive events in the same bunch crossing.

- $\sigma_{new} = (N-1)(N-2)\, P_i^2\, Q\, \sigma$
  - σ_{new}= observed cross section (fb)
  - N = no. of pile up events (luminosity dependent).
  - Q = quartic rejection factor (Q=0.025)
  - P_i = probability of pile up event being single diffractive which produces a proton and causes a hit in FP420 .
  - σ = input cross section for the QCD event.

Simulation of the Overlap

- Generate QCD event with HERWIG. JIMMY is used for the underlying event.
- To construct the single diffractive protons, just need ξ and t values for each proton. These are constructed using standard Monte Carlo techniques and using the single diffractive cross section given in hep-ph/0609312.
- This single diffractive cross section can also be used to calculate the probability of a single diffractive event giving a hit in FP420, $P_i = 0.0085$.

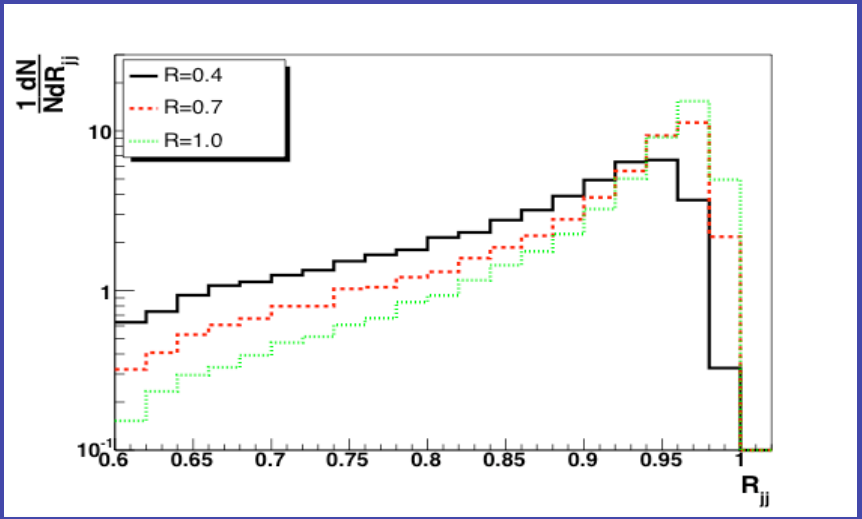
Central Exclusive Dijet Variables

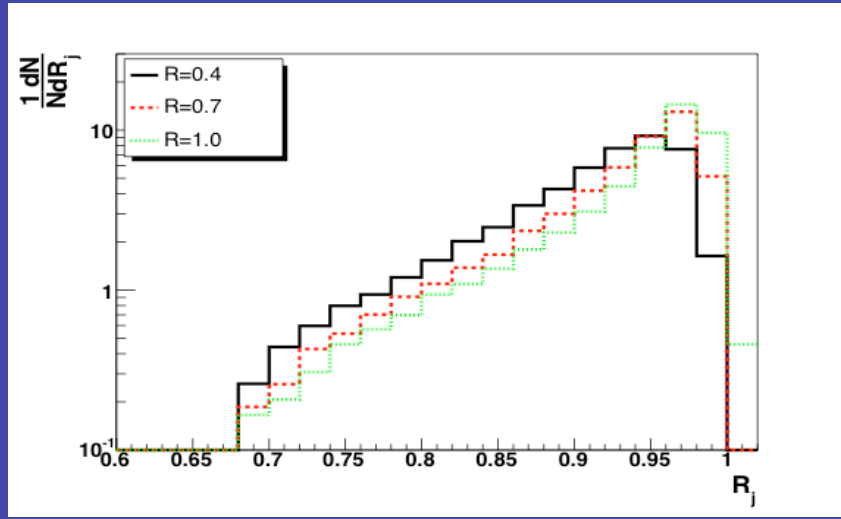
- Mass fraction definitions:
  - $\mathbf{R_{jj} = M_{jj} / M}$ (CDF)
  - $\mathbf{R_j = 2E_T \cosh(\eta_1 - y) / M}$ (Durham)
- Rapidity definition
  - $\mathbf{\Delta y = y - 0.5(\eta_1 + \eta_2)}$

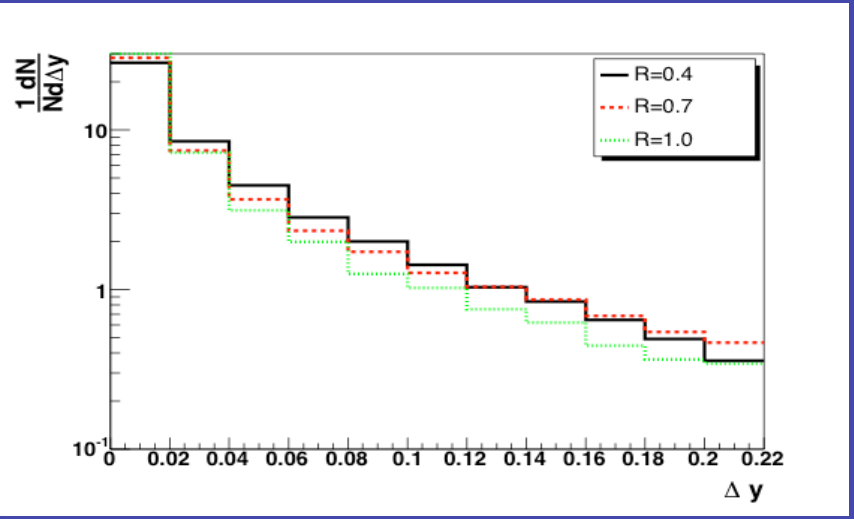
- M_{jj} = mass of dijet system
- E_T= transverse energy of leading jet
- η_1 = eta of leading jet

- Only use events that has one jet with $E_T > 40$GeV.

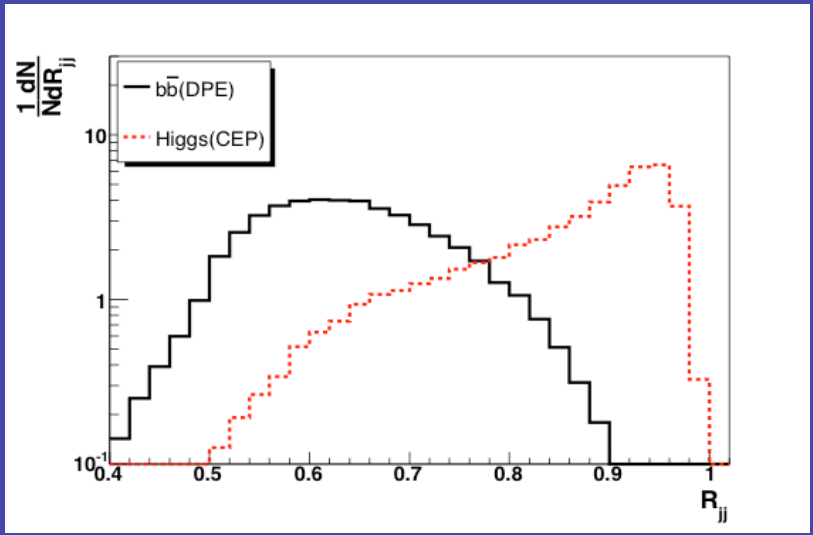
Signal Reconstruction

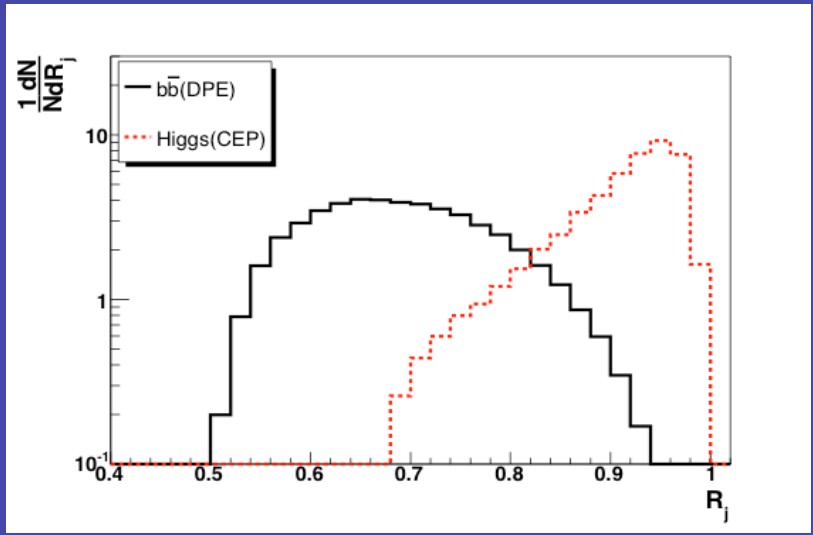


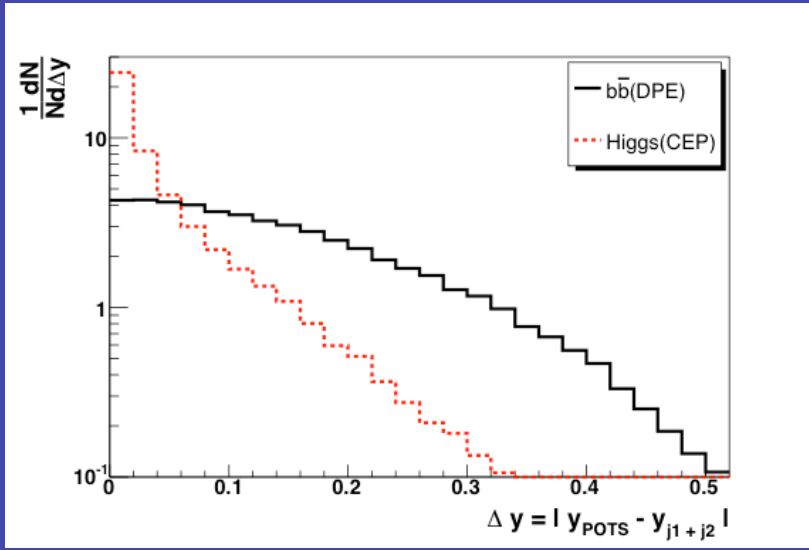




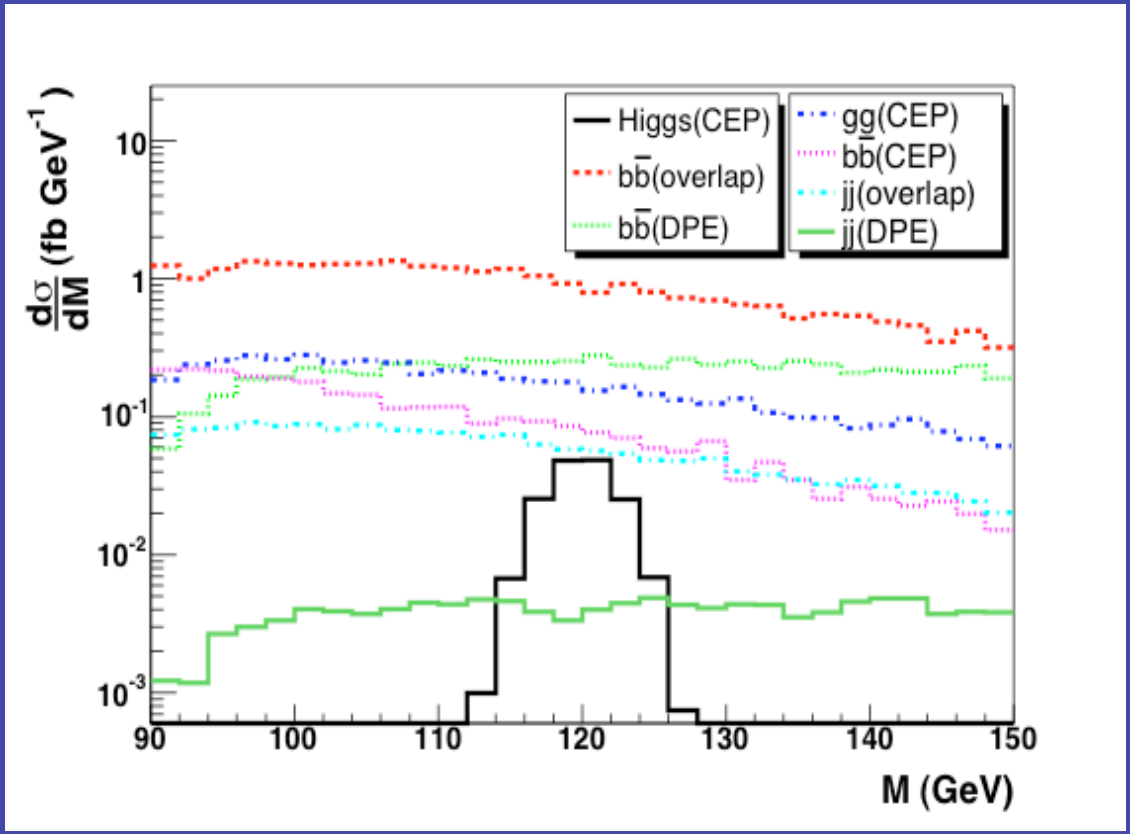
Signal vs DPE







The intermediate Mass plot



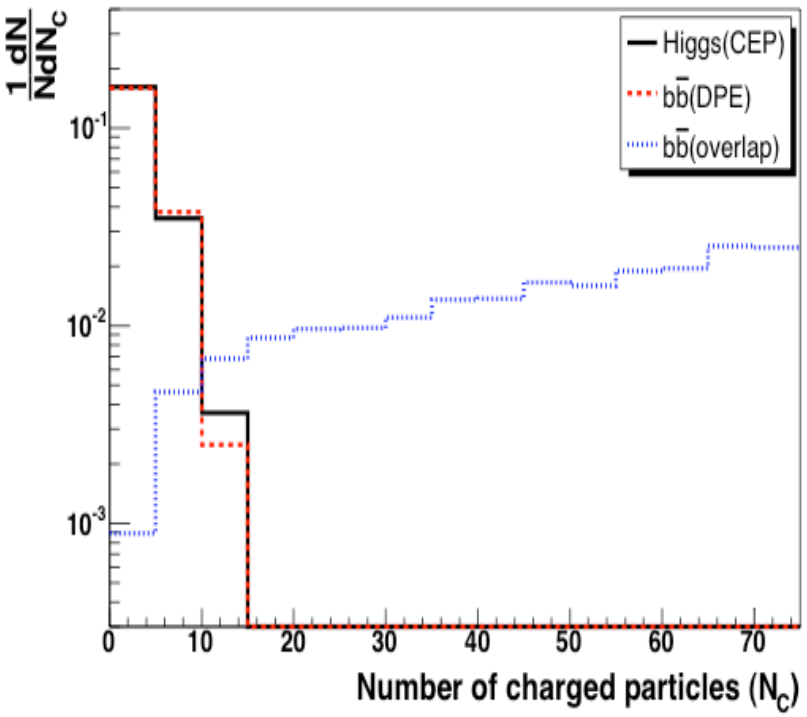
IMPORTANT:

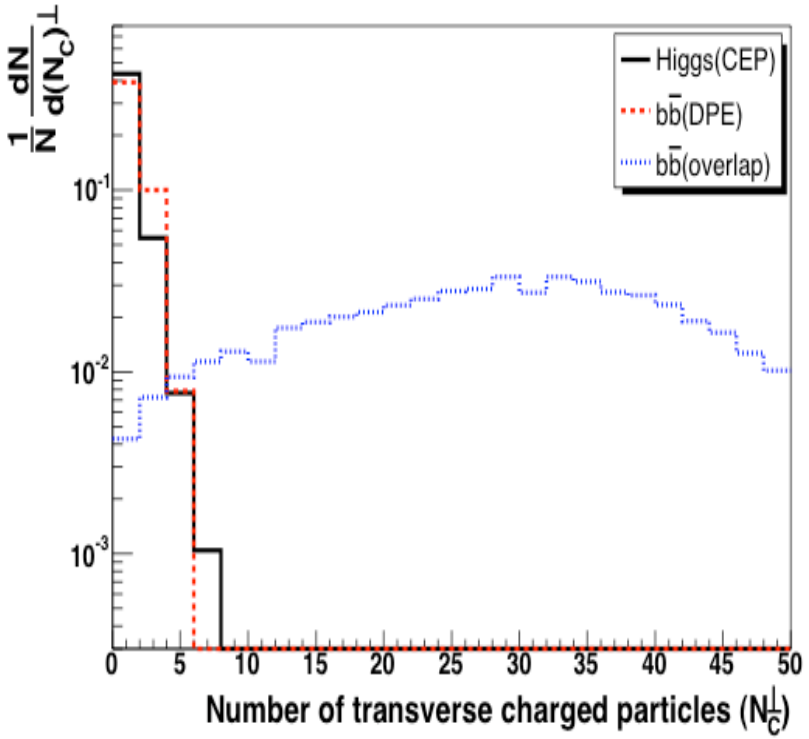
Overlap backgrounds are luminosity dependent. Unless otherwise stated, they are defined at $L=2x10^{33}$ cm^{-2} s^{-1}

CUT: 116 < M < 124

Additional Exclusivity cuts

- Observe that non-diffractive events have a possibility of secondary scatters between the protons (underlying event). This should result in additional particles in these events. Can't use rapidity gaps because of large pile-up at LHC. However, could use charged particle cut due to excellent vertex reconstruction.
  - N_C = no. of charged particles associated with primary vertex, but outside of jets.
  - $N_C^{\perp}$ = no. of transverse charged particles.
    - This is the number of charged particles that satisfy $60^{\circ} < \Delta\phi_{ik} < 120^{\circ}$ where $\Delta\phi_{ik}$ is the angle between the jeading jet, i, and the particle, k.
  - Initially assume that charged particles must satisfy
    - $p_T > 0.5\text{GeV}$
    - $|\eta| < 2.5$


$\frac{1}{N}\frac{dN}{dN_c}$
Higgs(CEP)
$b\bar{b}$(DPE)
$b\bar{b}$(overlap)
10^{-1}
10^{-2}
10^{-3}
0
10
20
30
40
50
60
70
Number of charged particles (N_c)


$\frac{1}{N}\frac{dN}{d(N_c)^{\perp}}$
Higgs(CEP)
$b\bar{b}$(DPE)
$b\bar{b}$(overlap)
10^{-1}
10^{-2}
10^{-3}
0
5
10
15
20
25
30
35
40
45
50
Number of transverse charged particles ($N_c^{\perp}$)

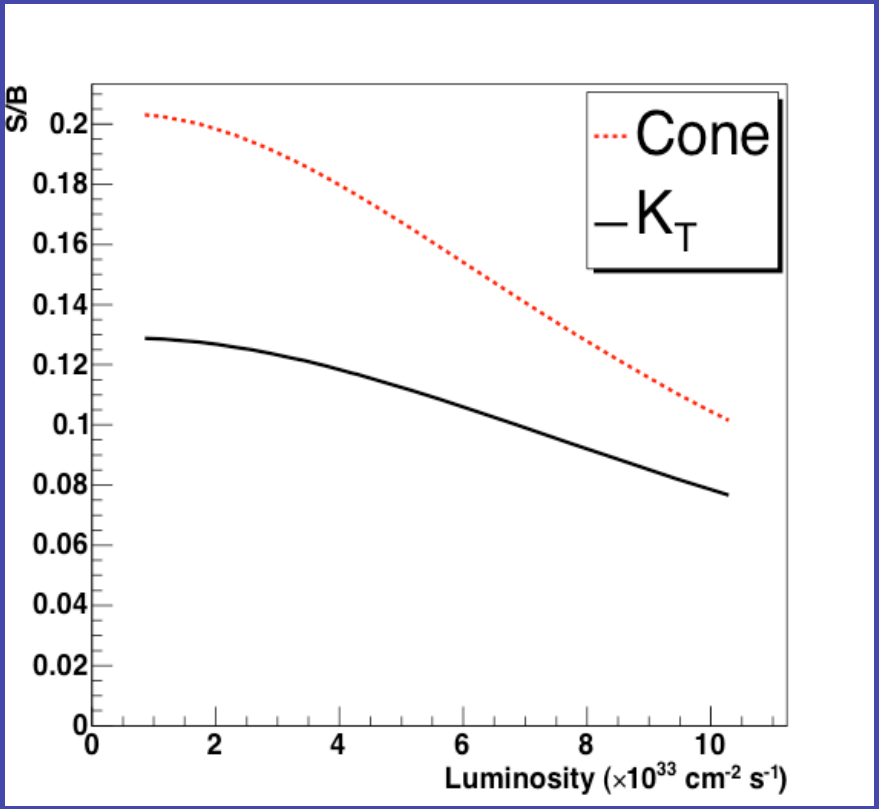
Final Cuts (Cone Algorithm)

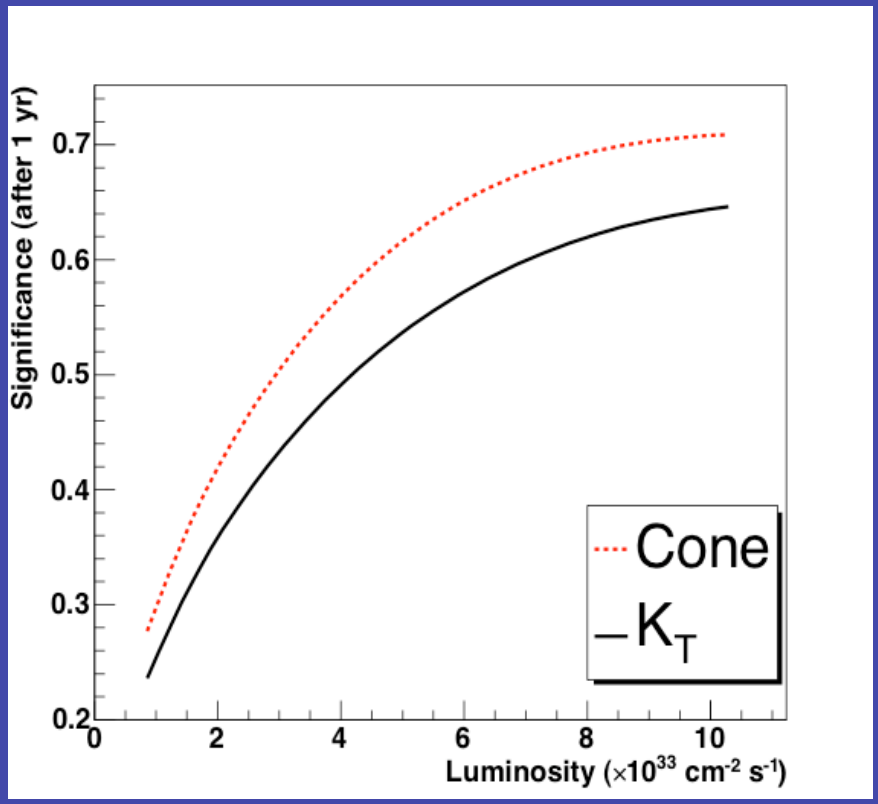
- Acceptance FP420:
  - $0.0023 < \xi_1 < 0.0129$
  - $0.0029 < \xi_2 < 0.0171$
- Kinematic Matching:
  - $0.875 < R_j < 1.1$
  - $\Delta y < 0.1$
- Underlying event:
  - $N_C^{\perp} < 2$
  - $N_C < 8$
- Initial state radiation:
  - $|\Delta\phi - \pi| < 0.2$

Process	σ_{K_T} (fb)	σ_{cone} (fb)
H→bb (CEP)	0.057	0.053
bb (CEP)	0.12	0.10
gg (CEP)	0.18	0.08
bb (DPE)	0.14	0.08
jj (DPE)	0.002	<0.001
bb (OLAP)	0.007	0.006
jj (OLAP)	<0.001	<0.001

Cross sections after all cuts. Note that the overlap (olap) background is luminosity dependent and has been defined at a luminosity of $L = 2 \times 10^{33}$ cm^{-2} s^{-1}. At high luminosity, the bb overlap background (cone alg) becomes 0.22fb and swamps the signal.

Standard Model Higgs Discovery Potential?





SuperSymmetric Higgs bosons?

- Can have increased cross sections in MSSM for Higgs boson production.
- This would boost significance.
- More studies needed, i.e a parameter scan.
- Here, studied production of lightest Higgs boson in two points in the intense coupling region of MSSM - m_A = 130GeV and
  - tanβ = 30 (cross section increase of ~3 compared to SM)
  - tanβ = 50 (x7.8 w.r.t SM)
  - Both points observable if all events retained.

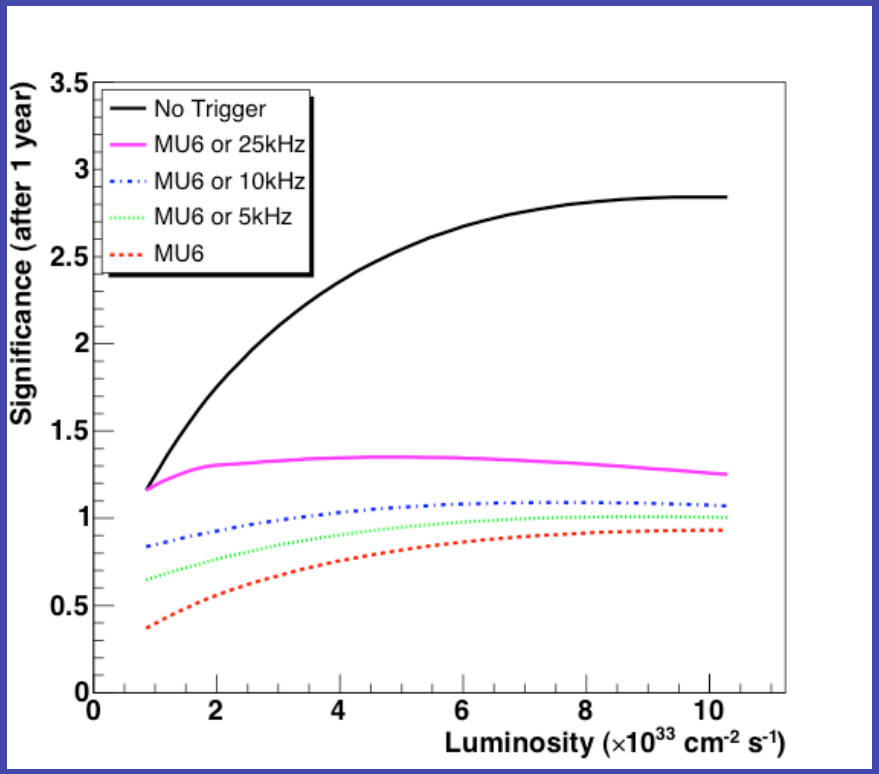
How to keep those events

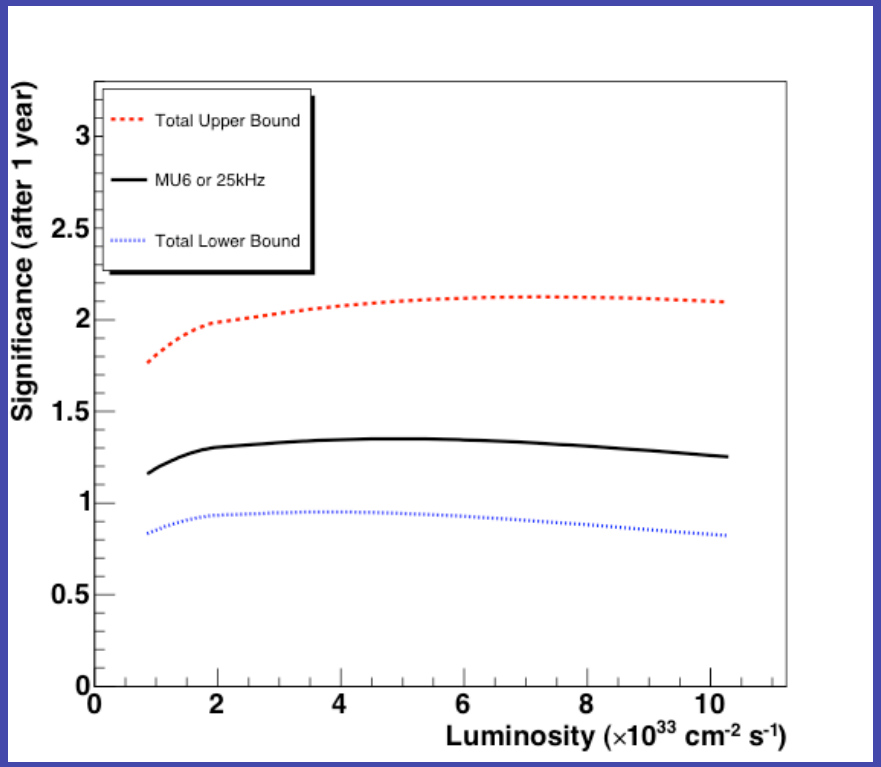
- Cannot use current jet triggers so…..
- Use low p_T muon triggers (as the b can decay to muon)
  - At ATLAS p_T > 6GeV
  - Retains 11% of events
- New Jet trigger?
  - Possible in principle to have large rate at level 1 and veto at level 2 using FP420. Level 2 rate of 20Hz (1%).
  - Veto on level 2 is 2 proton hits in FP420.
  - Additional veto on vertexing could be possible using QUARTIC TOF.
  - So choose E_T > 40GeV and prescale to a fixed jet rate at level 1. i.e 1kHz, 5kHz or larger?

Level 2 Rejection Factors

Luminosity ($x10^{33}$ cm^{-2} s^{-1})	Rejection A (2 protons) ($x\ 10^{-2}$)	Rejection B (A + QUARTIC) ($x\ 10^{-3}$)
1.0	0.027	0.0068
2.0	0.58	0.15
5.0	1.8	0.46
10.0	8.1	2

MSSM after triggers





This is for the MSSM point defined by m_A = 130GeV and tanβ = 50

Conclusions

- Standard Model Higgs not possible in the bb decay channel (unless we are very patient).
- MSSM possible in this channel if
  - a) tanβ is large and cross section increased and a new jet trigger is incorporated that uses level 2 veto, or
  - b) the cross section is increased by a factor of >50.
- Central exclusive uncertainties large, need Tevatron measurements.