SPRACE Group

Summary of Graviton Searches

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Samples Available

- **QCD Background:**

  - /QCD_Pt80/Summer09-MC_31X_V3_7TeV-v1/GEN-SIM-RECO

  - 3203440 FULLSIM events available

  - xsec = $9.238 \cdot 10^5$ pb $\rightarrow$ expect 92.38 M events @ 100/pb

  - Weight = 28.838

- **Signal: pp $\rightarrow$ G $\rightarrow$ ZZ $\rightarrow$ qqbar + nunubar**

  - Privately produced with PYTHIA v6.420

  - 5145 FULLSIM events available

  - M_G = 800 GeV, c = 0.05

  - xsec = $3.329 \cdot 10^{-2}$ pb $\rightarrow$ expect 3.329 events @ 100/pb

  - Weight = $6.47 \cdot 10^{-4}$

Signature-based Skimming

- Graviton decays on pair of high momentum Zs

  - Hadronically decaying Z $\rightarrow$ single, high-p_T massive jet.

  - Invisible Z $\rightarrow$ high missing E_T

- Skimming based on this signature:

  - Events with at least ONE hadronic jet, with EMF > 0.01

  - This jet has p_T > 60 GeV and mass > 40 GeV

  - Also, event missing E_T > 60 GeV.

- CAVEAT: these cuts are NOT optimized, but they look like a "reasonable" starting place.

Skimming Results

- QCD: 1395 events passed out of 3203440

  - Efficiency = 4.3547×10^{-4}

  - With the weight, we expect 40229 events surviving the selection.

- Signal: 3914 events passed out of 5145

  - Efficiency = 0.761

  - With the weight, we expect 2.532 events surviving the selection.
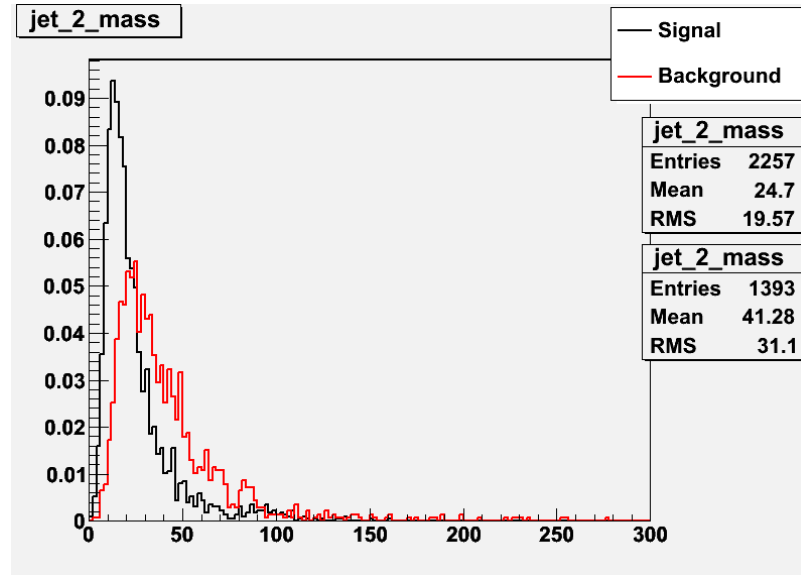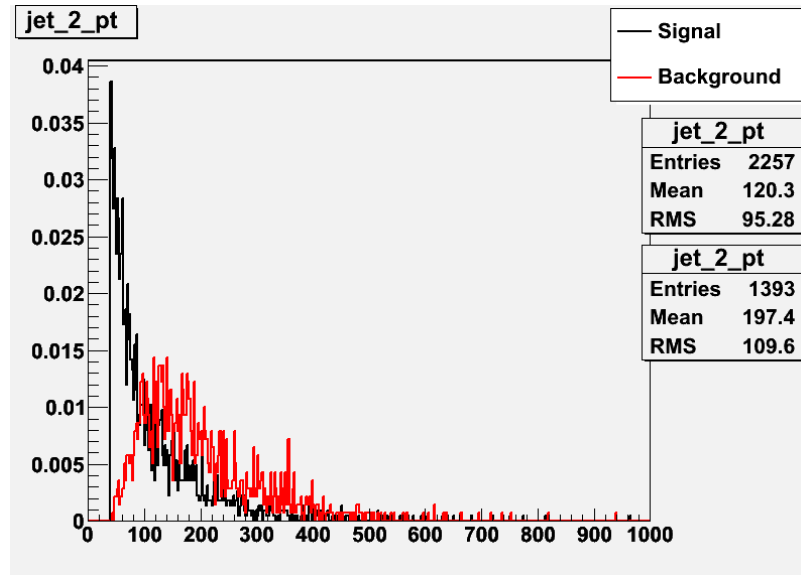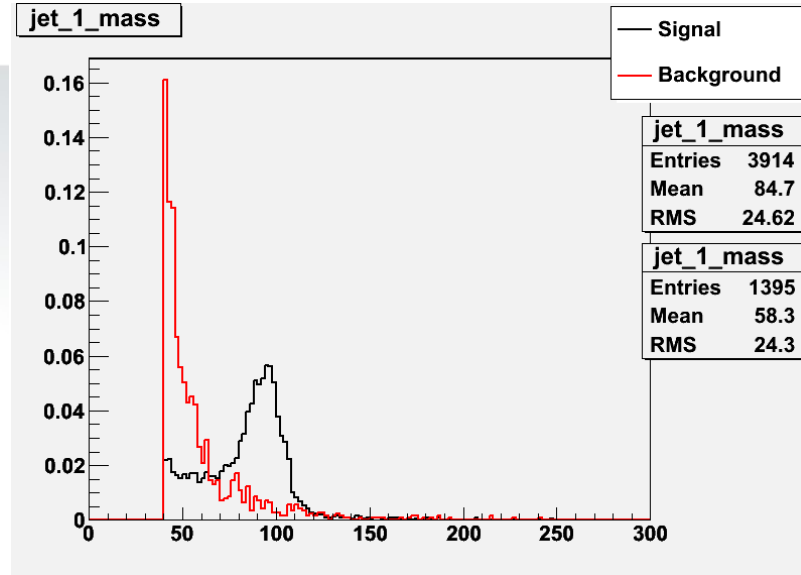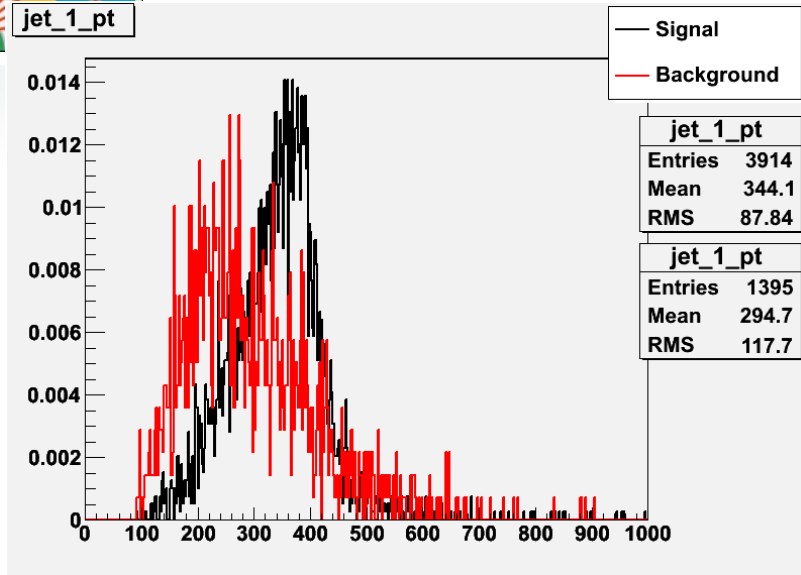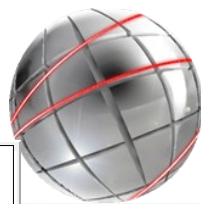
- Still not a winning situation!

Variable for S-B Discrimination

- Due to the missing E_T, we cannot fully reconstruct the graviton candidate.

  - Analogous to W boson situation

  - To select for W events, we use the "transverse mass' of the W.

    - Many different definitions in the literature.

  - We WILL use the following definition: $M_T = 2 \, p_T(1) \, p_T(2) \, (1 - \cos(\Delta\Phi))$

- Usage of the "graviton transverse mass" (GTM).

  - Really an event global variable.

  - In our case, $p_T(1)$ = missing E_T of the event, $p_T(2)$ = 1st jet p_T.

Results

jet_1_pt

Signal
Background

jet_1_pt	
Entries	3914
Mean	344.1
RMS	87.84

jet_1_pt	
Entries	1395
Mean	294.7
RMS	117.7

jet_1_mass

Signal
Background

jet_1_mass	
Entries	3914
Mean	84.7
RMS	24.62

jet_1_mass	
Entries	1395
Mean	58.3
RMS	24.3

jet_2_pt

Signal
Background

jet_2_pt	
Entries	2257
Mean	120.3
RMS	95.28

jet_2_pt	
Entries	1393
Mean	197.4
RMS	109.6

jet_2_mass

Signal
Background

jet_2_mass	
Entries	2257
Mean	24.7
RMS	19.57

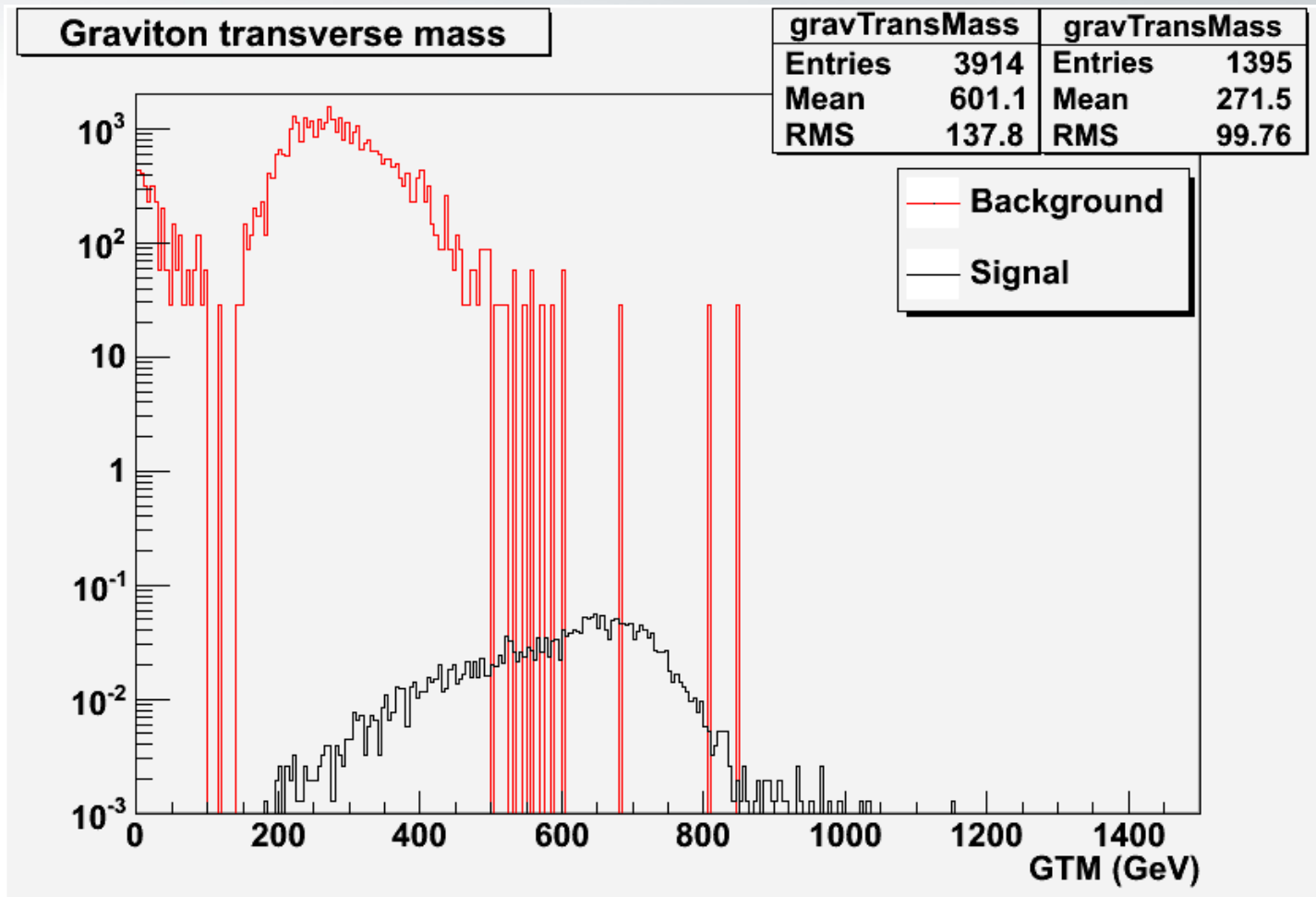| jet_2_mass	
Entries	1393
Mean	41.28
RMS	31.1

Results

- In these plots, all distributions are normalized to 1.
  - In reality, signal is ~ invisible compared to background
- What we learn is that the GTM is a reasonable variable for signal-background

Results

Actual situation is much worse.

Think Outside The Box

- Signal is 1 massive jet + missing E_T.

  - QCD doesn't have real missing E_T – where is it coming from?

  - Same thing for the massive jet.

  - Probably mismeasurement in both cases (but should check if MC has those features as well).

- Bottom line: with enough statistics, QCD can fake almost everything...

  - But notice the 3rd plot on slide 6...

  - QCD has a SECOND hard jet.

  - Leading order QCD process is $2 \to 2$ scattering.

  - It is VERY HARD to fake MONOJET.

Dijet X Monojet
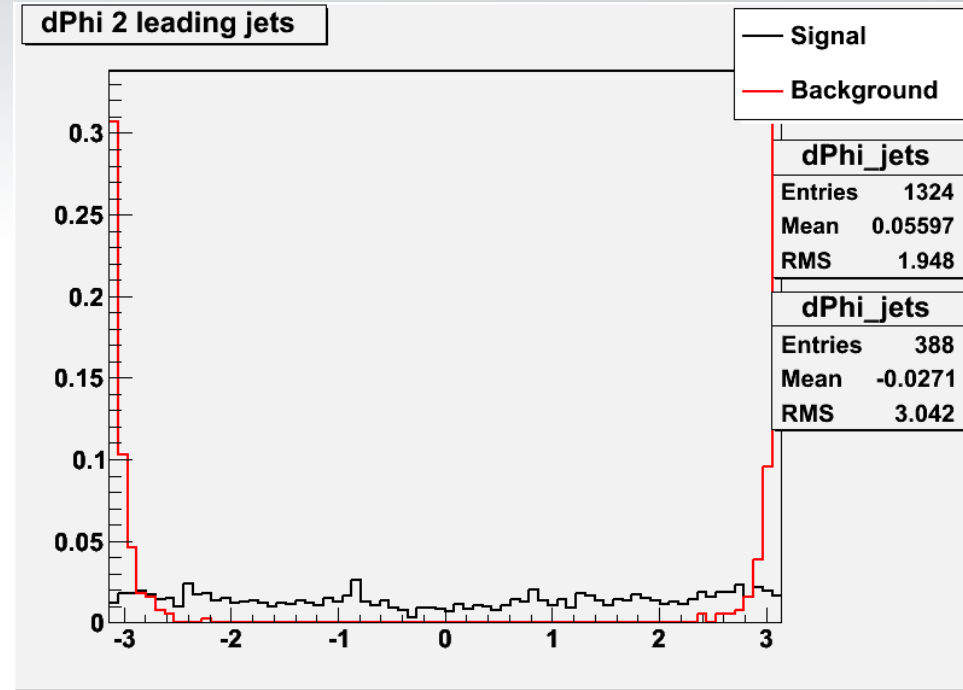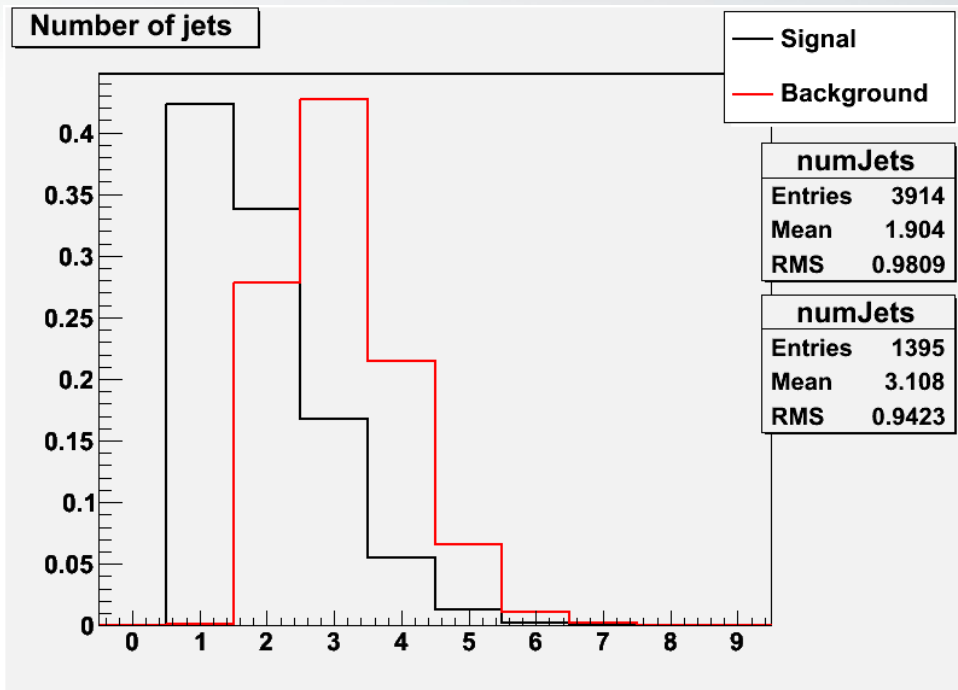
- Considering jets with $p_T > 40$ GeV, EMF > 0.01

- QCD has a strong preference for 2 back to back jets, but 3 jets are even more common.

- Signal has 1 jet more than anything, but 2 and 3 also present.

Dijet X Monojet

- **New event selection on number of jets:**

  - 1 jet: PASS

  - 2 jets: PASS if $|\Delta\Phi| < 2.8$, otherwise DISCARD

  - 3 or more jets: DISCARD

- **Results of this new, extra selection:**

  - 23 QCD events pass $\rightarrow$ correspond to 663 real events.

  - 2796 signal events pass $\rightarrow$ correspond to 1.8 real events.

  - NONE of the QCD events in the hig GTM range.

Results
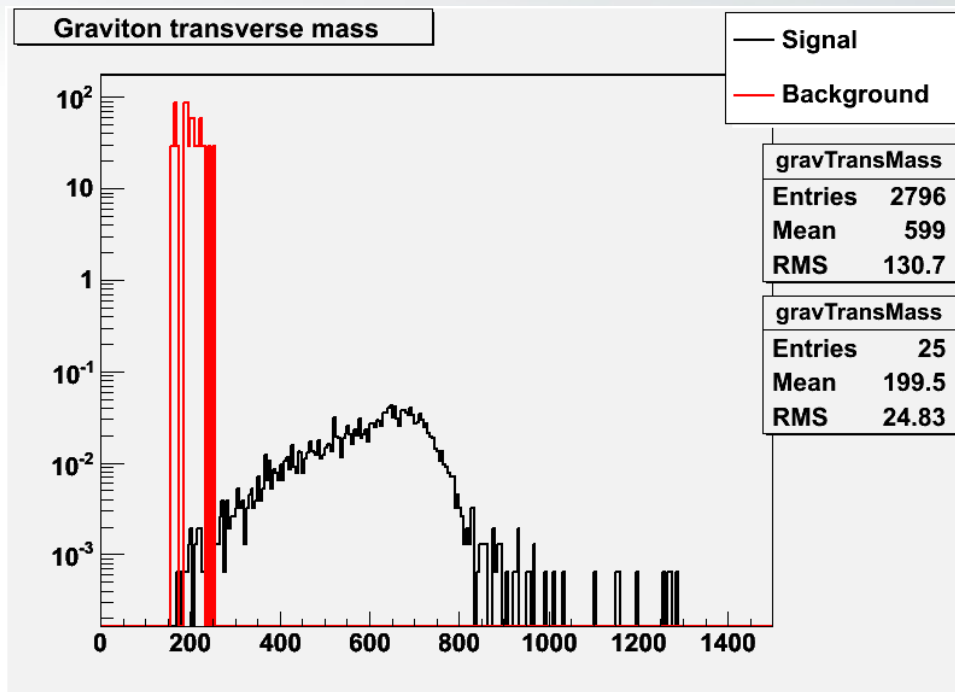
- **Much better situation!**

  - But now we will be bitten by lack of statistics for the QCD sample.

  - Also, ZERO predicted background is not so good – we need some background to fit for the shape.

  - Also, with so little signal events, hard to quantify the graviton mass if we actually see something.

  - Also, since 3+ jets channel is largest QCD channel, we should move to something that actually predicts it (ALPGEN).