SPRACE Analysis Meetings

RSG $\rightarrow$ ZZ $\rightarrow$ Multijets Searches

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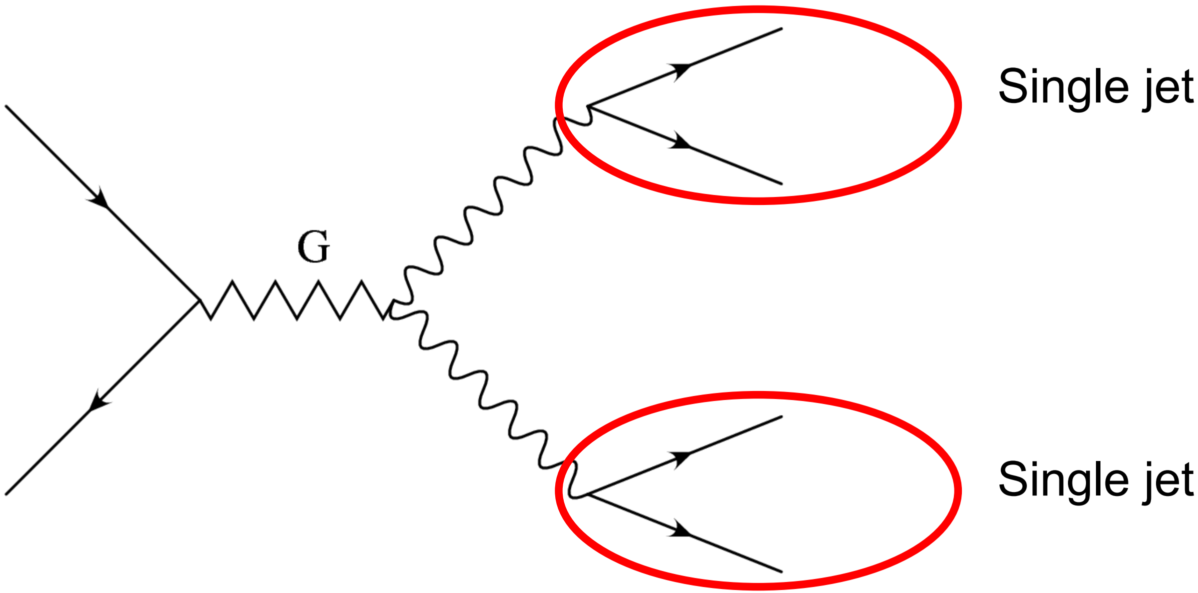
Introduction

- Main goal: search for heavy BSM resonances through fully hadronic decays of vector boson pairs.
- Main idea: in $G \rightarrow VV$ process, the vector bosons are highly boosted, so the decay product of each V ($V \rightarrow qq'$) tend to be very close in eta-phi space, and may be reconstructed as a single jet.*

* This happens often enough for this possibility to be considered – see my other talks.

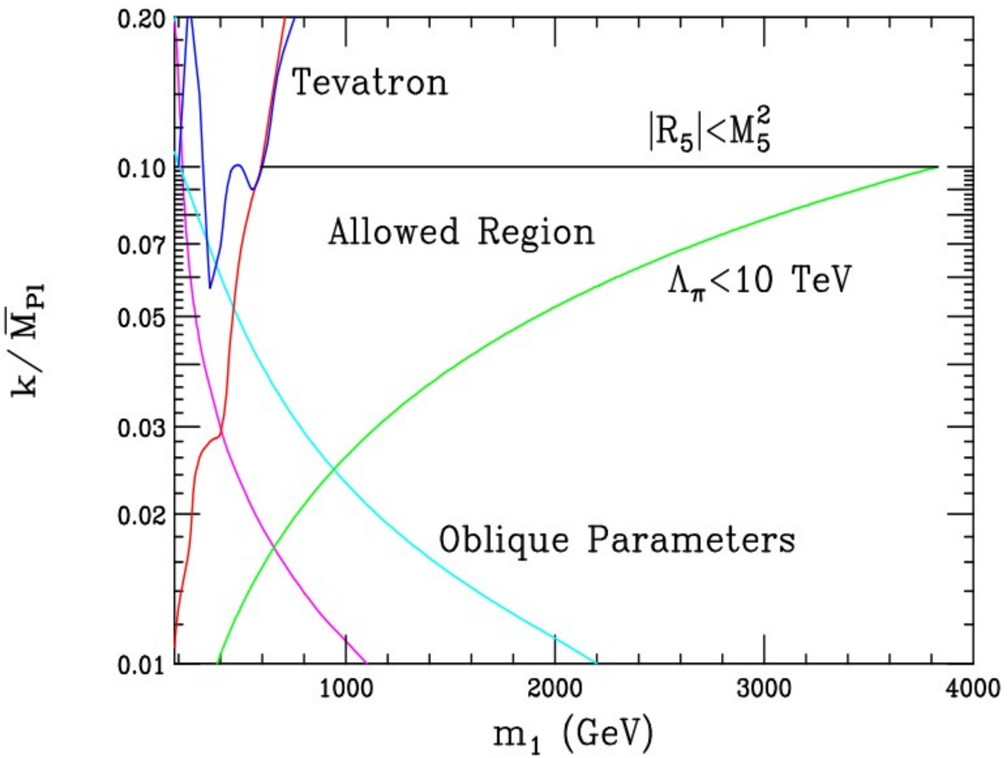


Datasets

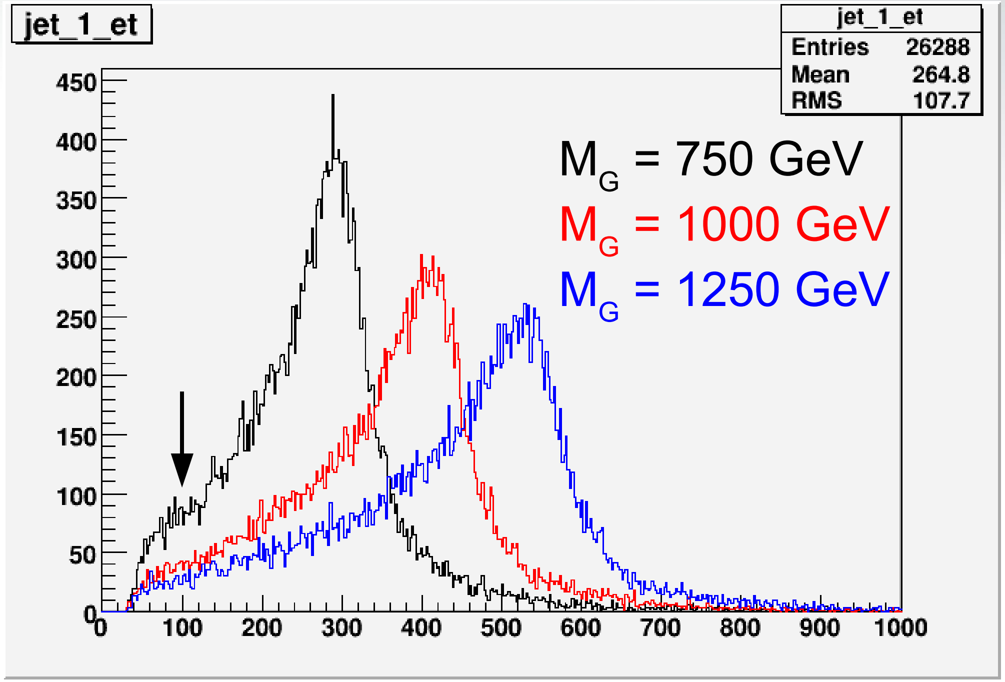
- Full Simulation, IDEAL_V9 conditions (10 TeV, 3.8T, 2E30 trigger)
- Signal: GEN_SIM_RAW with CMSSW_2_1_7
  - /Exotica_RSGravitonZZJetMET_MXXX/Summer08_IDEAL_V9_v1/GEN-SIM-RECO
  - XXX = 750, 1000, 1250 GeV (graviton mass). c = k/M_P fixed at 0.1 (max value)
  - Xsec ~ 1.15, 0.27, 0.08 pb.
- Background
  - /HerwigQCDPt170/Summer08_IDEAL_V9_v1/GEN-SIM-RECO
  - QCD sample, Xsec ~ 68000 pb.
  - The "170" means that there is a cut at MinKT = 170 GeV for the final state partons. Since it is a lower threshold, it can't be easily merged with other Herwig samples.
  - Chosen because, in samples with smaller cuts, ~ 0 events were passing.

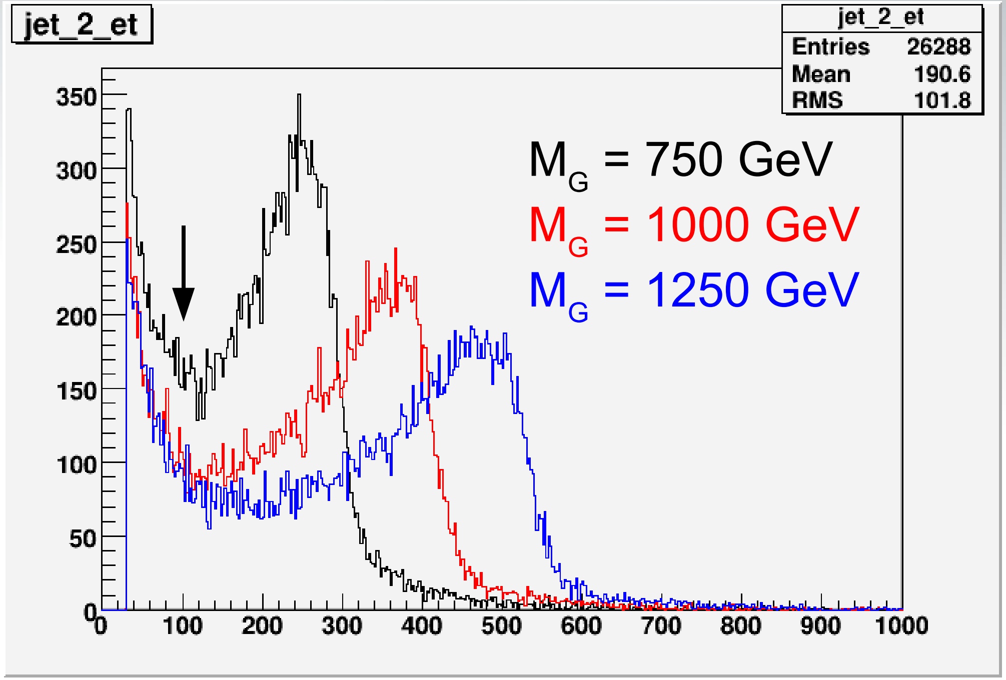
Modus Operandi

- Jet algorithm used
  - SISCone jets, $\Delta R = 0.7$
  - Input: caloTowers (standard calorimetric towers formed from ECAL and HCAL)
- Preliminary cut:
  - 2 jets, $E_T > 30$ GeV
- Baseline cuts:
  - 2 jets, $E_T > 100$ GeV
  - Jet masses in window of [60, 100] GeV
  - Dijet invariant mass > 600 GeV (Tevatron limit)



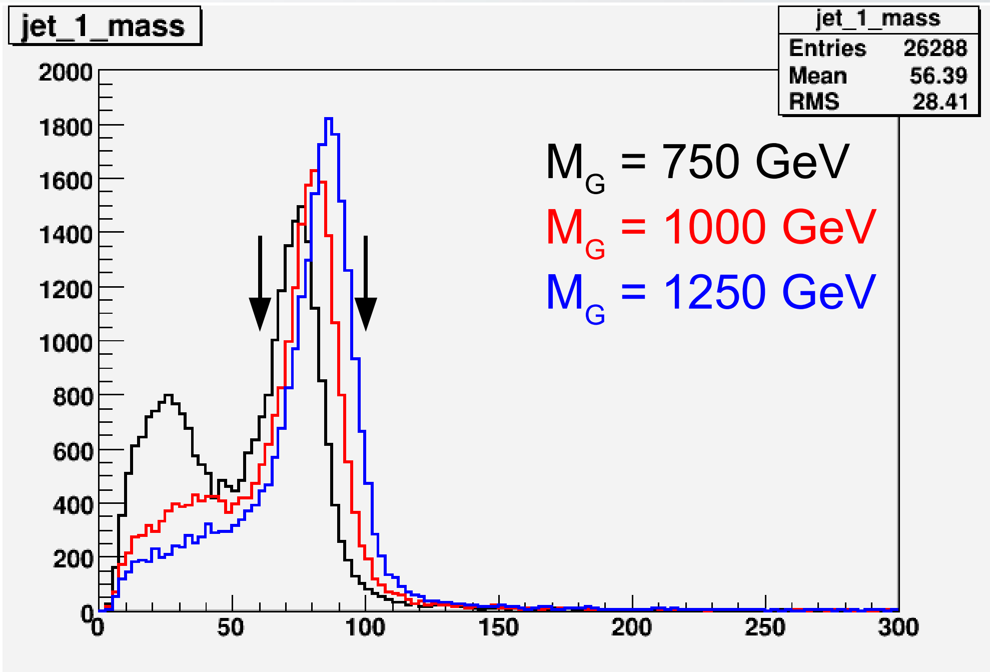
Jets E_T distribution for signal

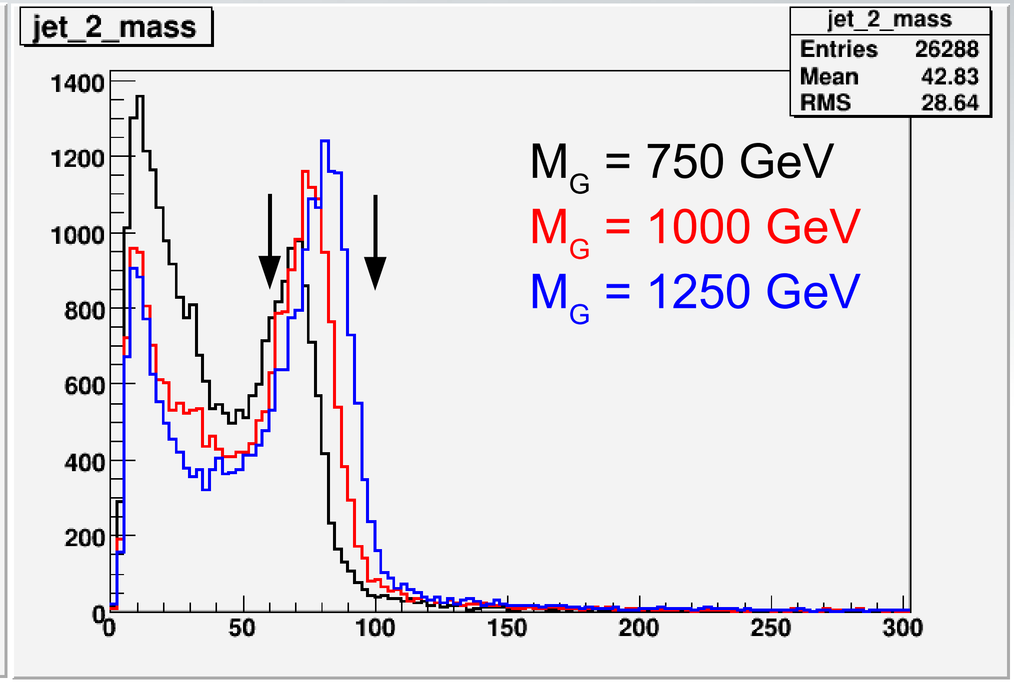




- The cut at 100 GeV for both first and second jet seems OK.

Jets mass distribution for signal



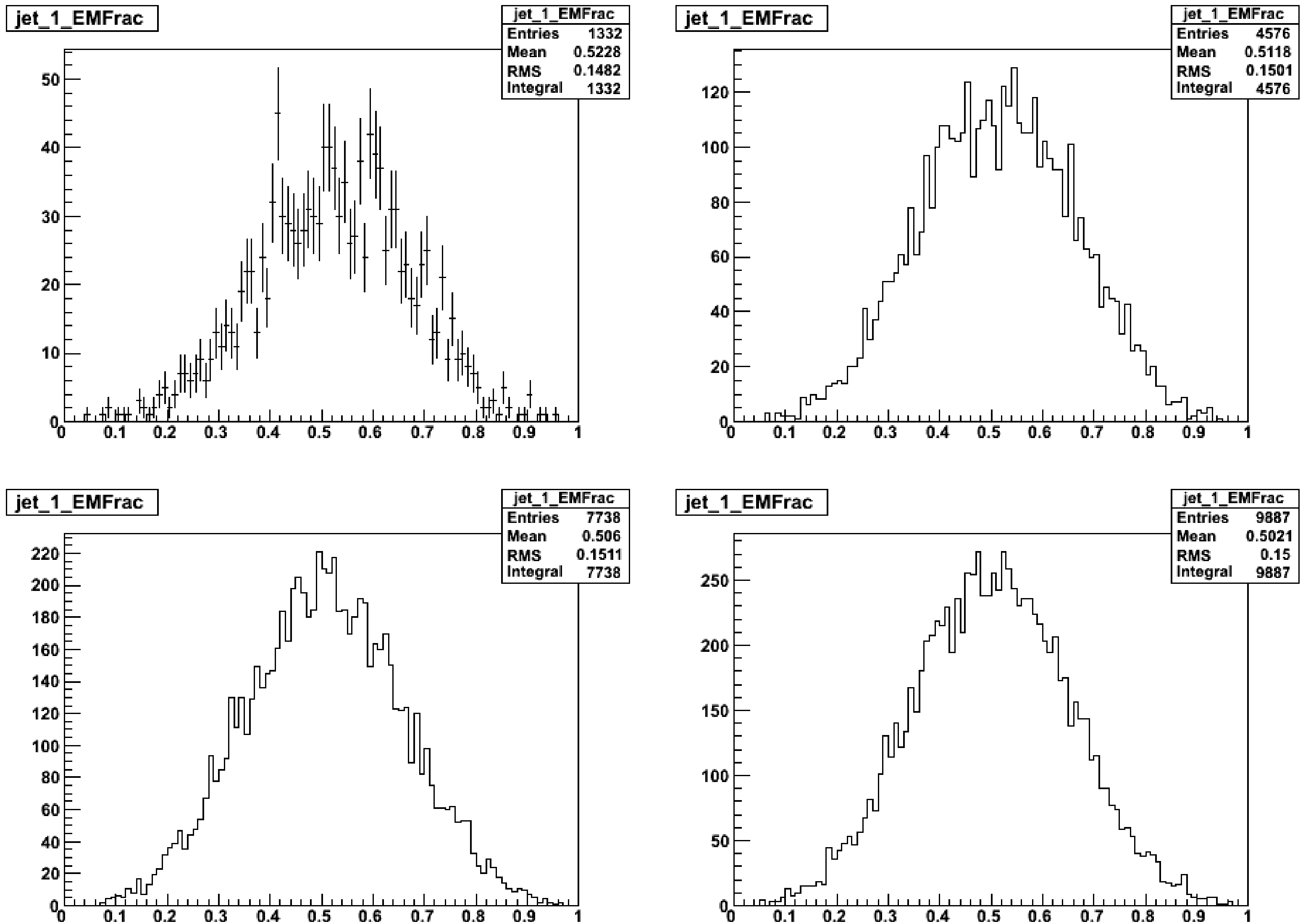


- In hindsight, perhaps I should have used a [50, 100] GeV window – there is room for some optimization.
- Q: Is it better to cut on the corrected or uncorrected jets?
- Q: Should I first look at RS → WW channel in order to make a common cut?

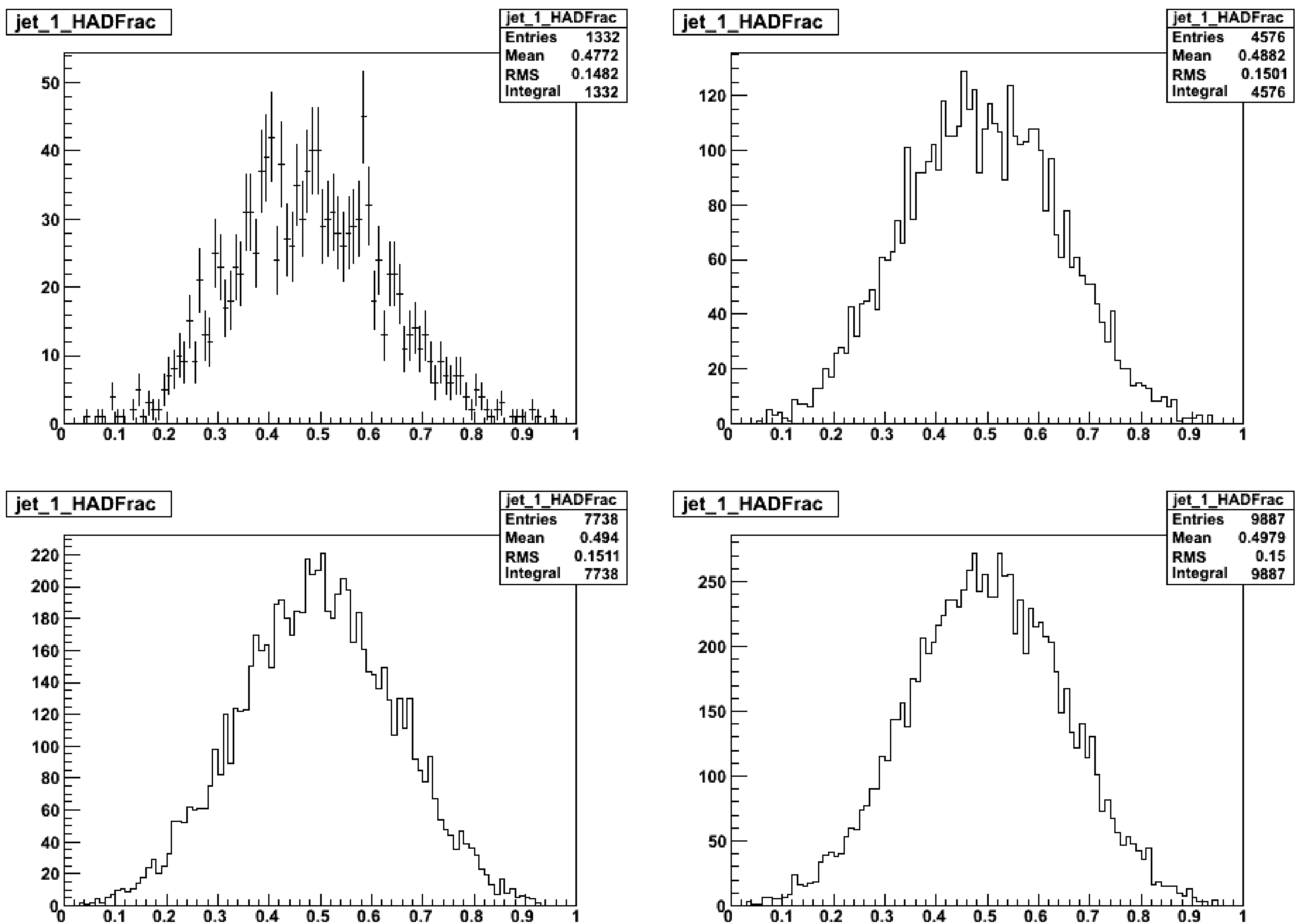
Extra Variables

- Looking at some extra variables in the jets for further distinguishing signal and background.
  - Jet electromagnetic energy fraction (emEnergyFraction)
  - Jet hadronic energy fraction (energyFractionHadronic)
  - Number of components carrying 60% and 90% of total jet energy (n60, n90)
  - eta-eta, eta-phi, phi-phi second moment, E_T weighted (etaetaMoment, etaphiMoment, phiphiMoment)
  - Dphi and dR between two leading jets.
  - Major value – see definition.
  - Number of tracks inside jet
  - Flow axis value – see definition.

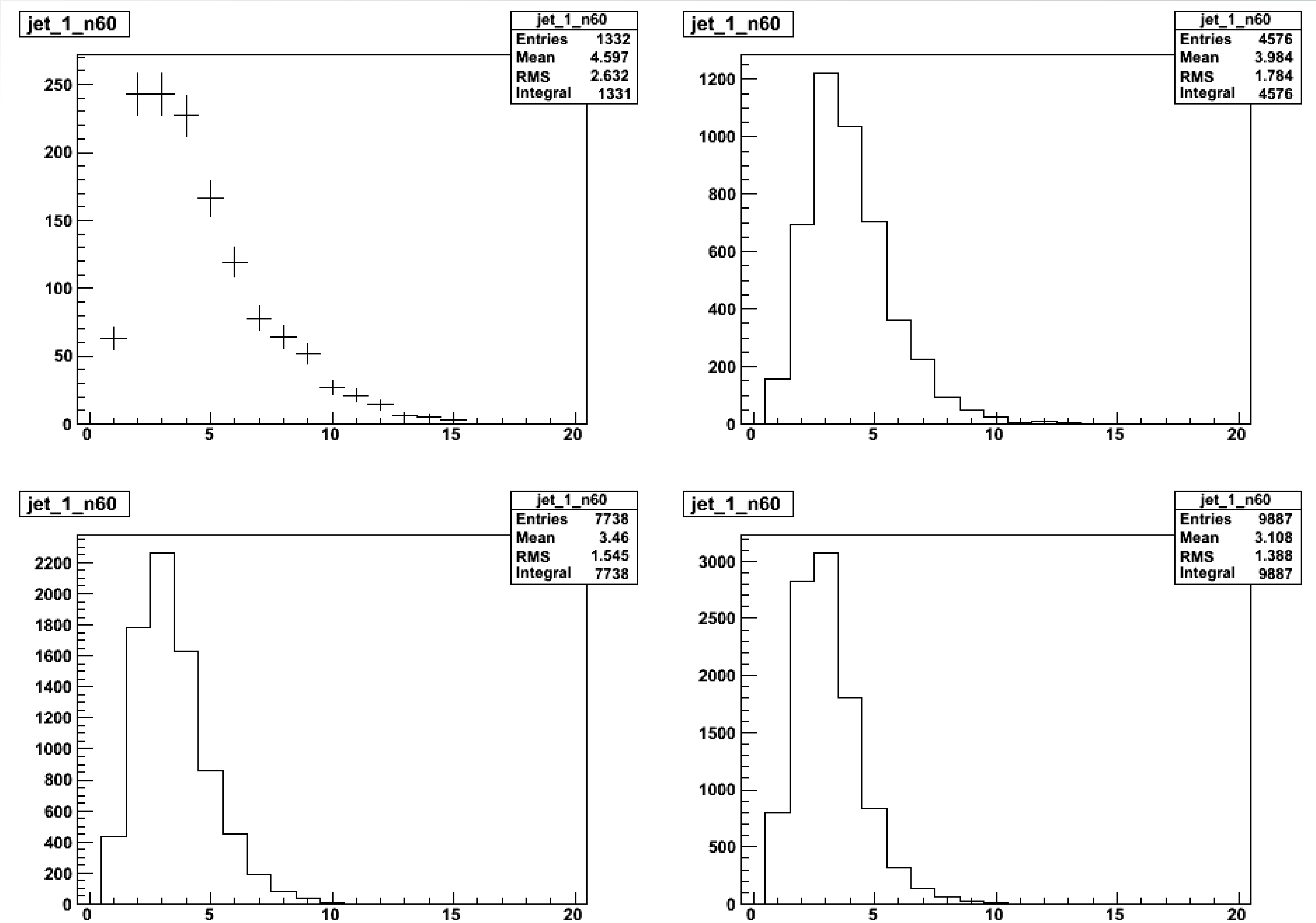
Electromagnetic fraction



Hadronic fraction

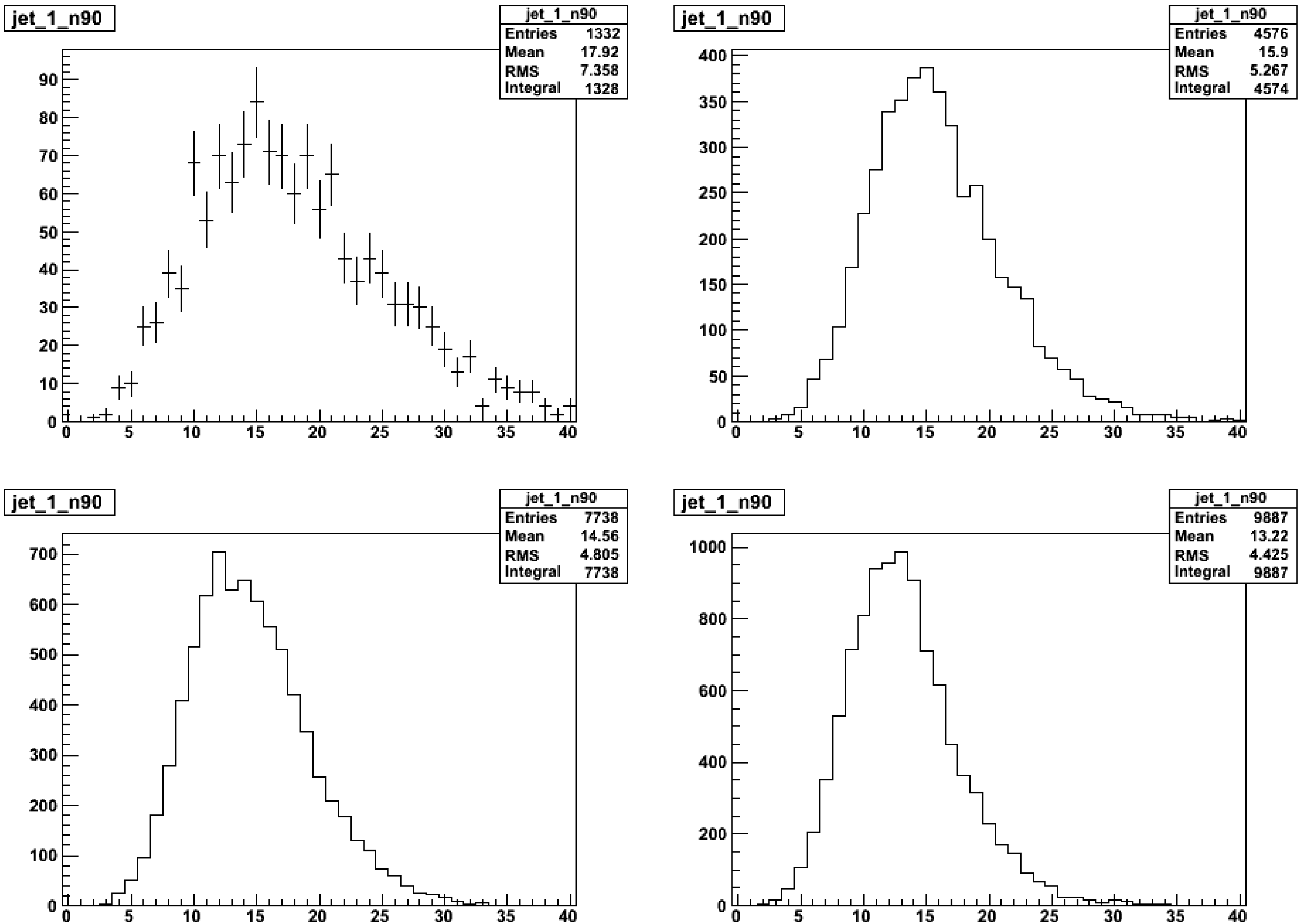


n60



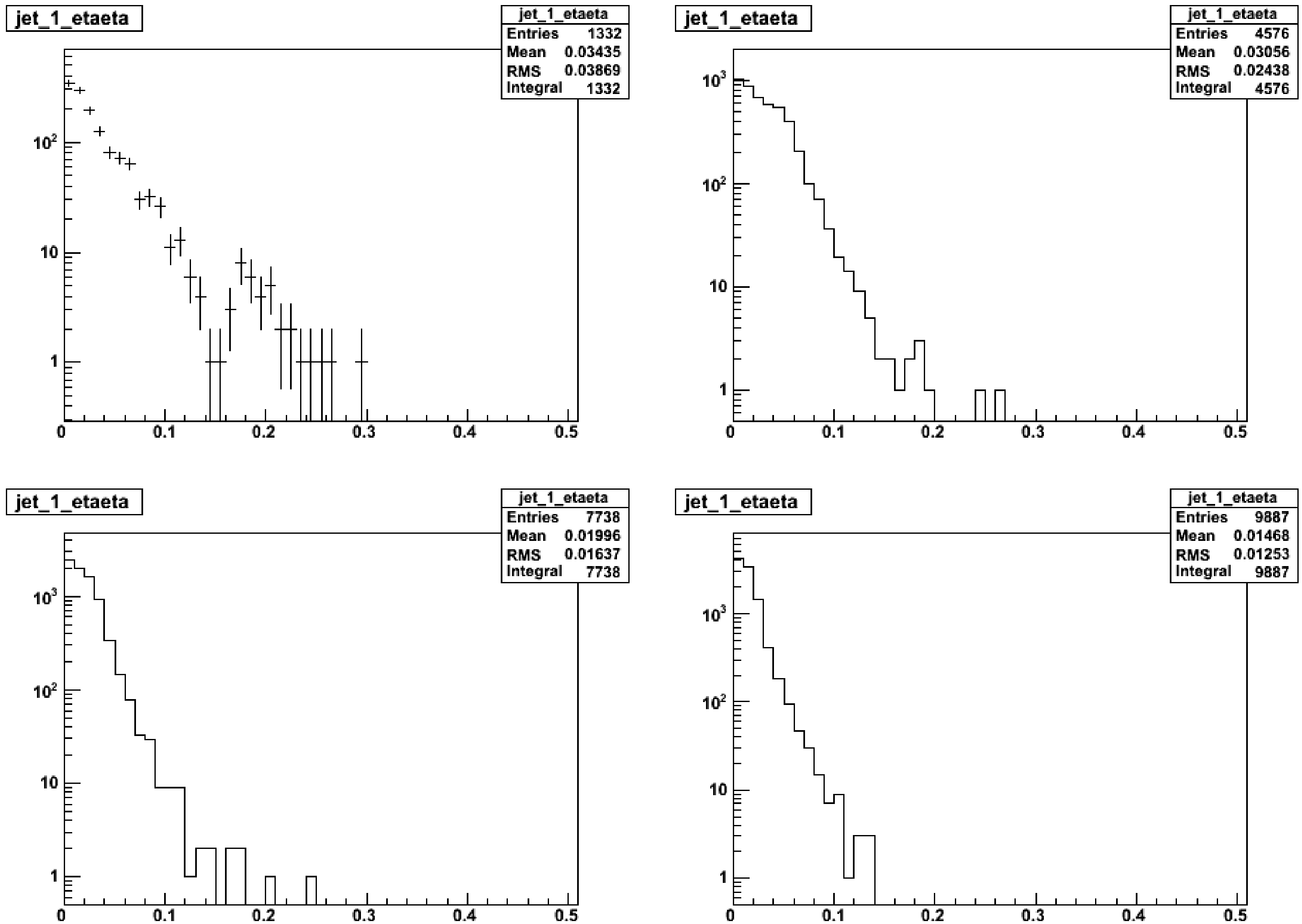
jet_1_n60
jet_1_n60
Entries 1332
Mean 4.597
RMS 2.632
Integral 1331
0
50
100
150
200
250
0
5
10
15
20
jet_1_n60
jet_1_n60
Entries 4576
Mean 3.984
RMS 1.784
Integral 4576
0
200
400
600
800
1000
1200
0
5
10
15
20
jet_1_n60
jet_1_n60
Entries 7738
Mean 3.46
RMS 1.545
Integral 7738
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
0
5
10
15
20
jet_1_n60
jet_1_n60
Entries 9887
Mean 3.108
RMS 1.388
Integral 9887
0
500
1000
1500
2000
2500
3000
0
5
10
15
20

n90

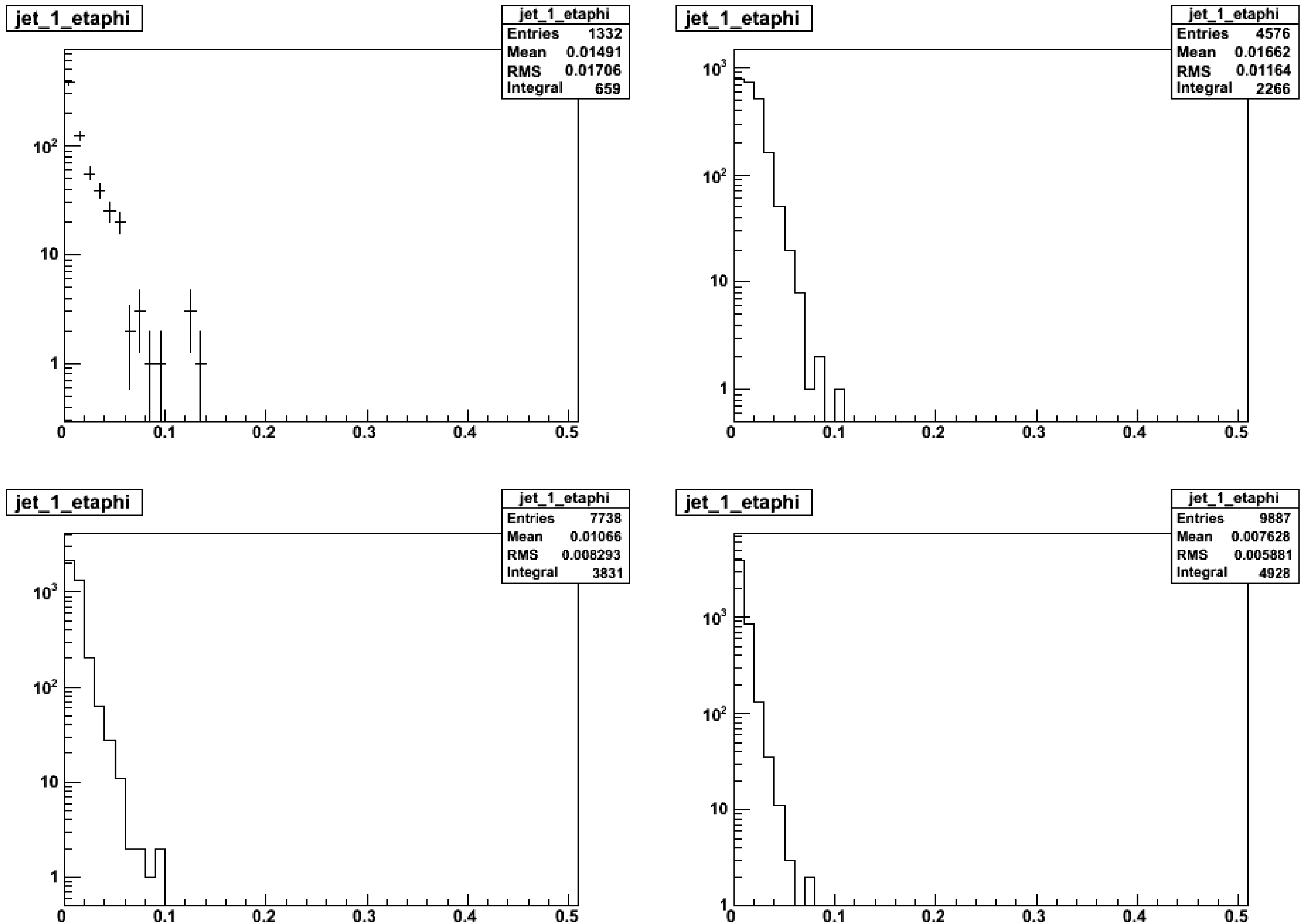


jet_1_n90
Entries 1332
Mean 17.92
RMS 7.358
Integral 1328
jet_1_n90
Entries 4576
Mean 15.9
RMS 5.267
Integral 4574
jet_1_n90
Entries 7738
Mean 14.56
RMS 4.805
Integral 7738
jet_1_n90
Entries 9887
Mean 13.22
RMS 4.425
Integral 9887

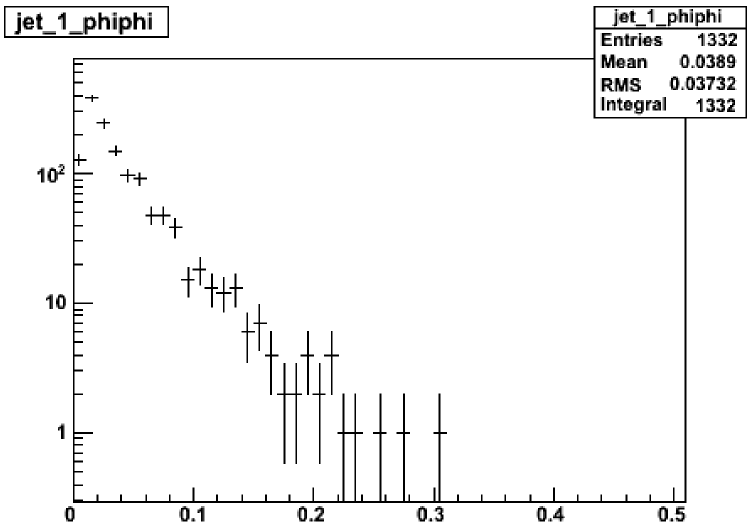
Etaeta moment

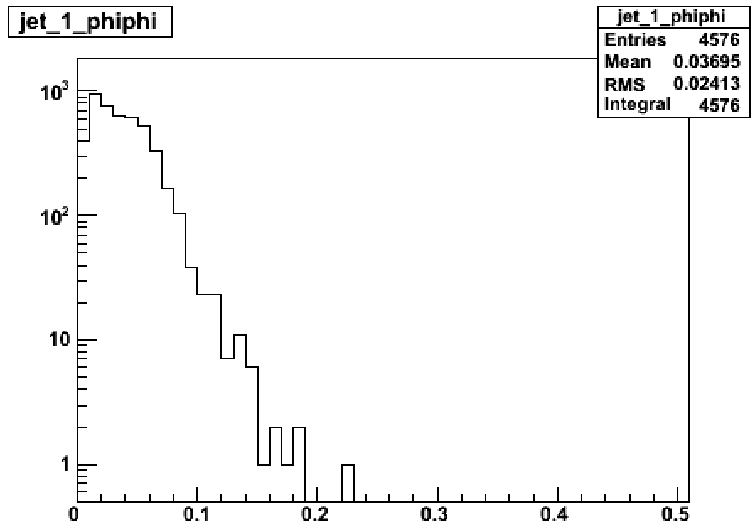


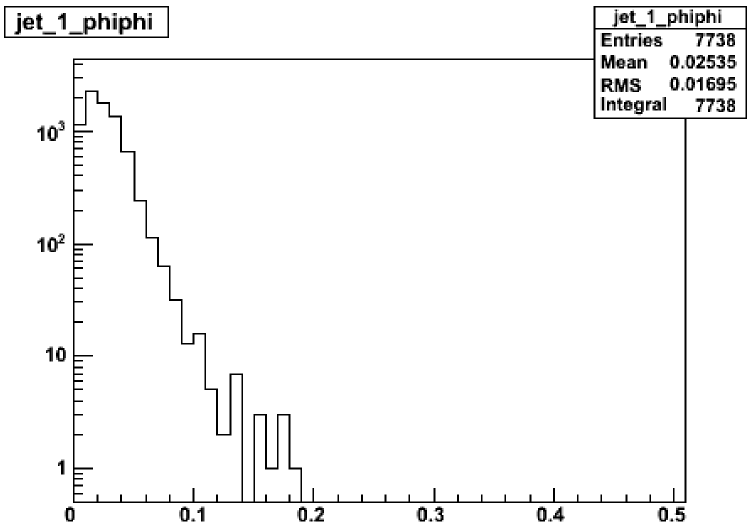
Etaphi moment

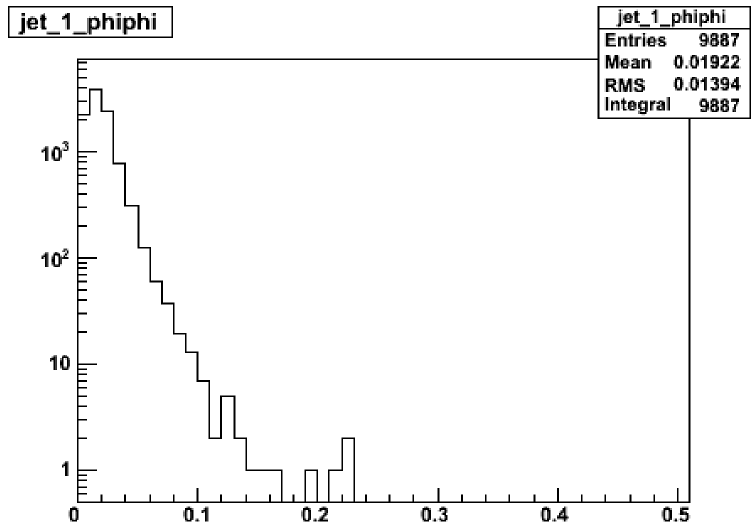


Phiphi moment

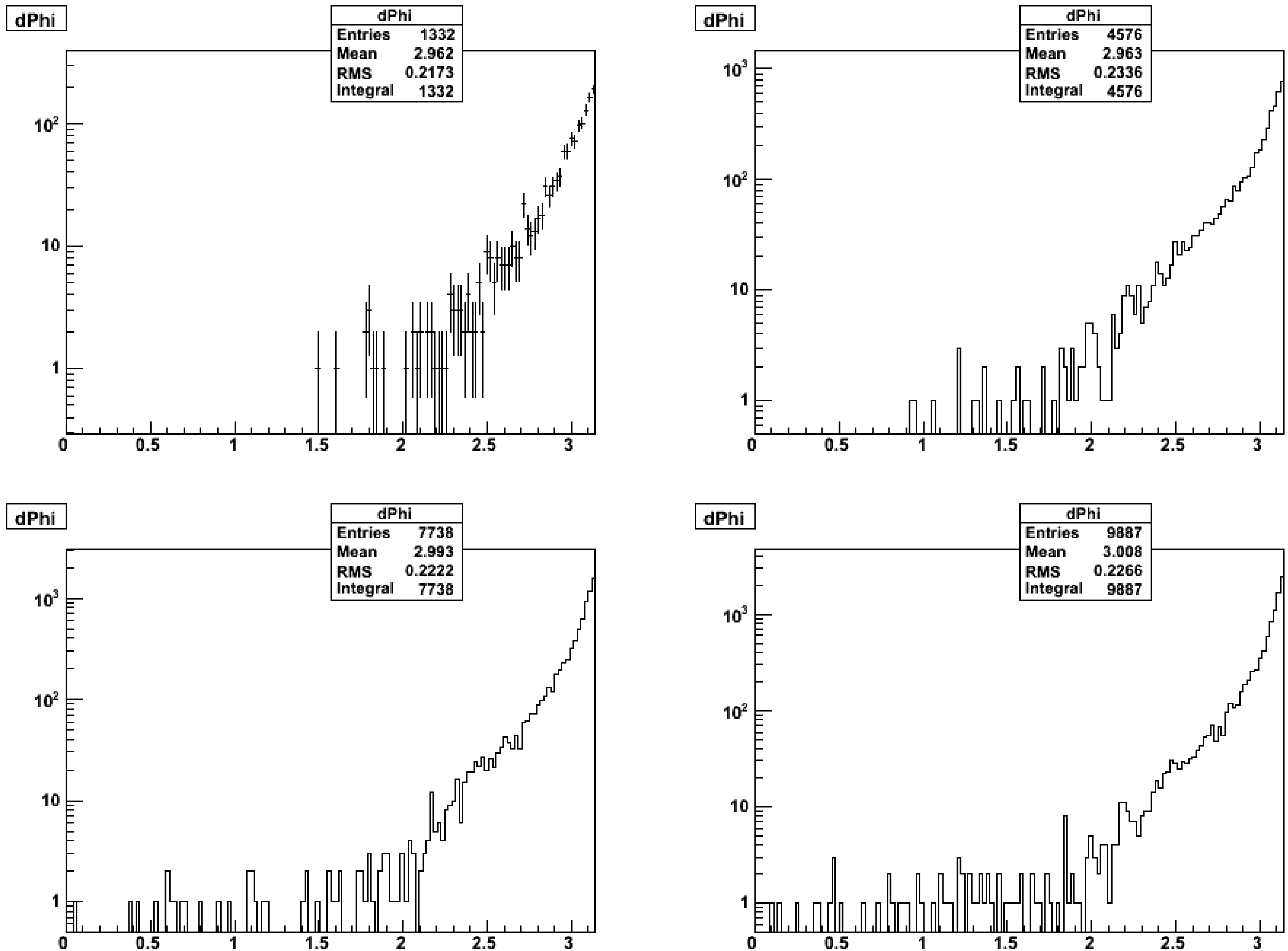






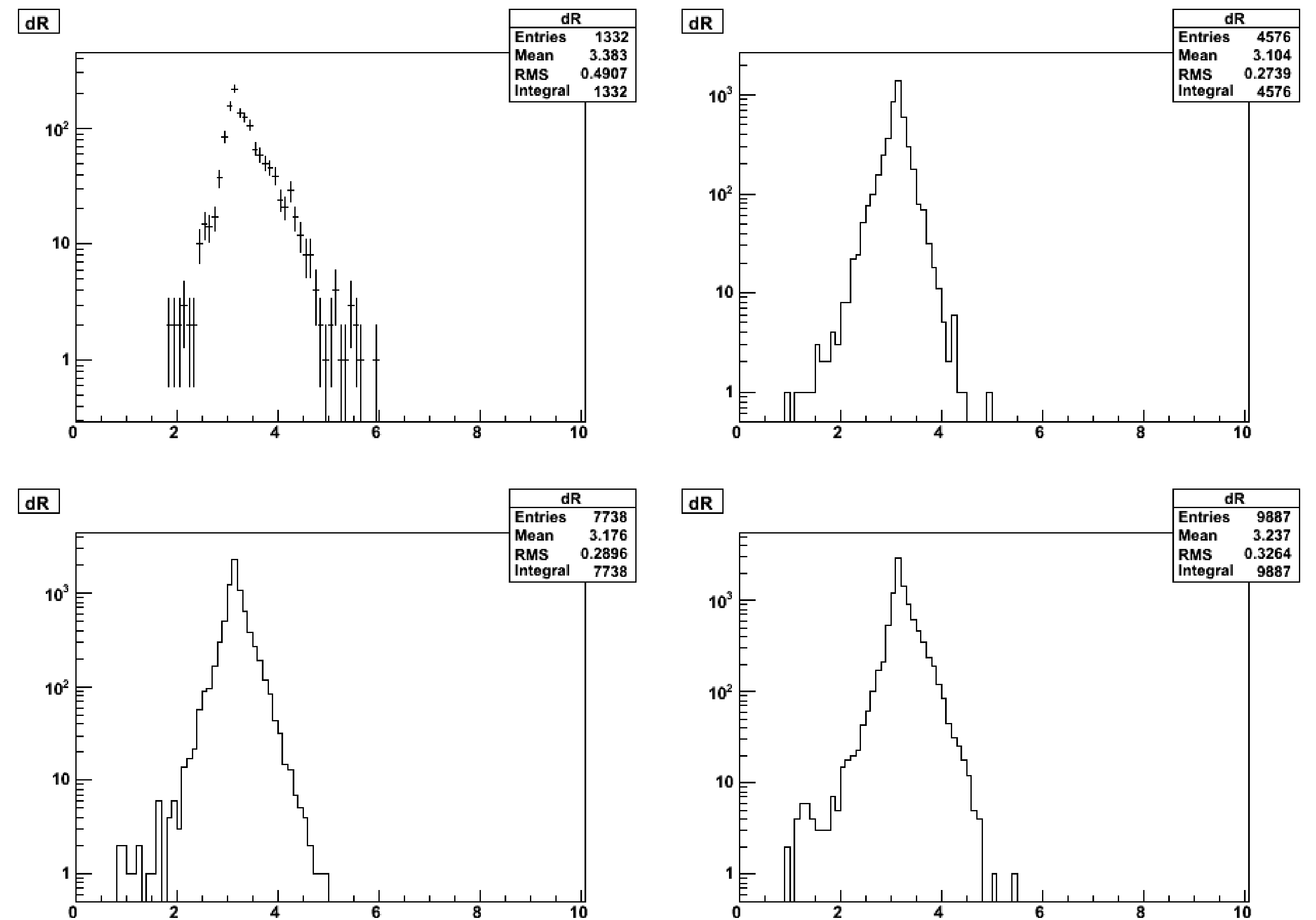


dPhi



dPhi
dPhi
Entries 1332
Mean 2.962
RMS 0.2173
Integral 1332
dPhi
dPhi
Entries 4576
Mean 2.963
RMS 0.2336
Integral 4576
dPhi
dPhi
Entries 7738
Mean 2.993
RMS 0.2222
Integral 7738
dPhi
dPhi
Entries 9887
Mean 3.008
RMS 0.2266
Integral 9887
10^3
10^2
10
1
0
0.5
1
1.5
2
2.5
3

dR



dR
dR
Entries 1332
Mean 3.383
RMS 0.4907
Integral 1332
dR
dR
Entries 4576
Mean 3.104
RMS 0.2739
Integral 4576
dR
dR
Entries 7738
Mean 3.176
RMS 0.2896
Integral 7738
dR
dR
Entries 9887
Mean 3.237
RMS 0.3264
Integral 9887

Major and Flow definition

- Major definition:

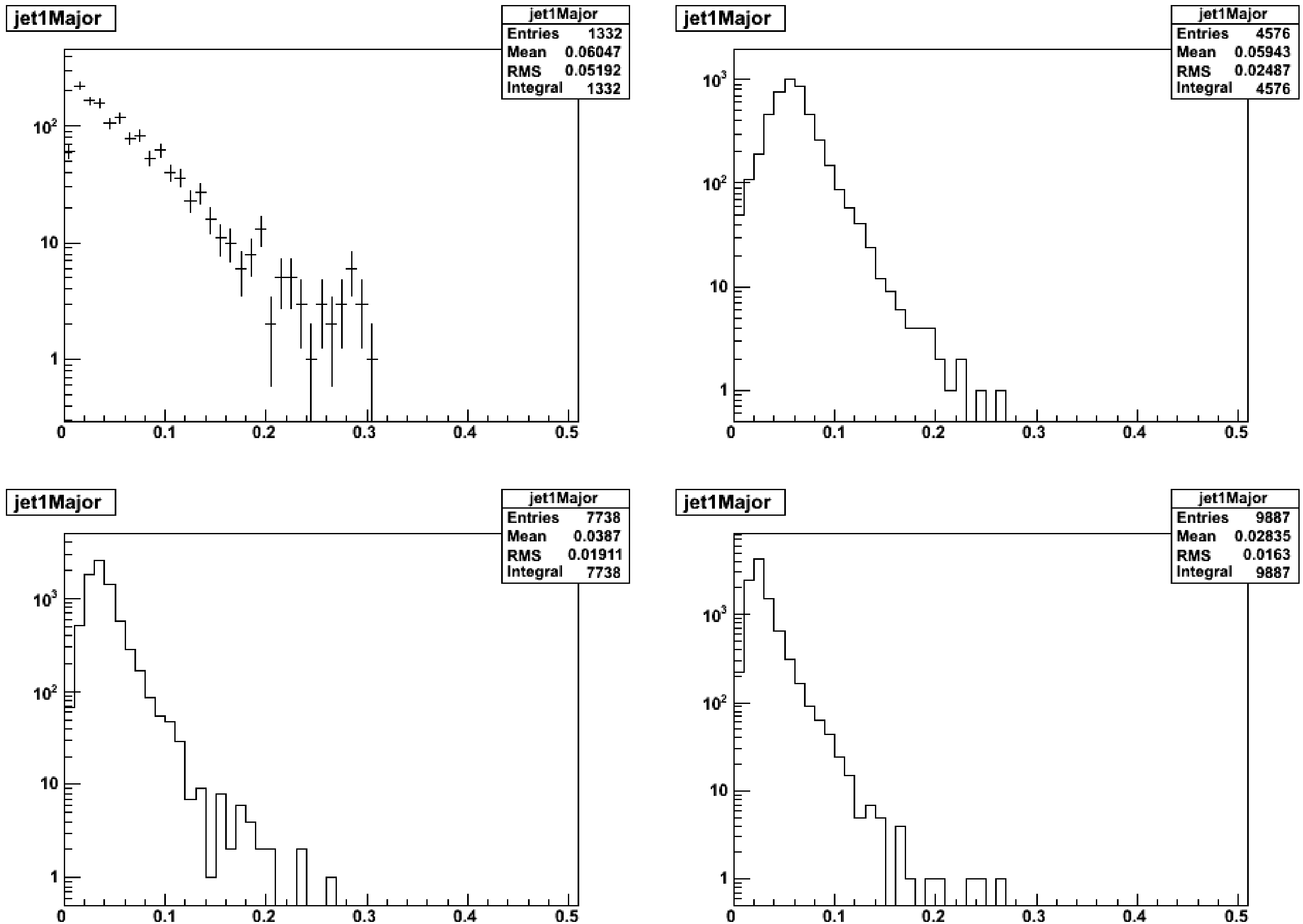
$$M = \sigma_{\eta\eta} + \sigma_{\phi\phi} + \frac{1}{2}\sqrt{(\sigma_{\eta\eta} - \sigma_{\phi\phi})^2 + 4(\sigma_{\eta\phi})^2}$$

- Flow definition: let *P* be the plane orthogonal to the jet axis, and $\{x_i\}$ a collection of vectors in that plane. Let **n** be an unit vector such that

$$F = \frac{\sum_i \boldsymbol{x}_i \cdot \boldsymbol{n}}{\sum_i \boldsymbol{x}_i}$$

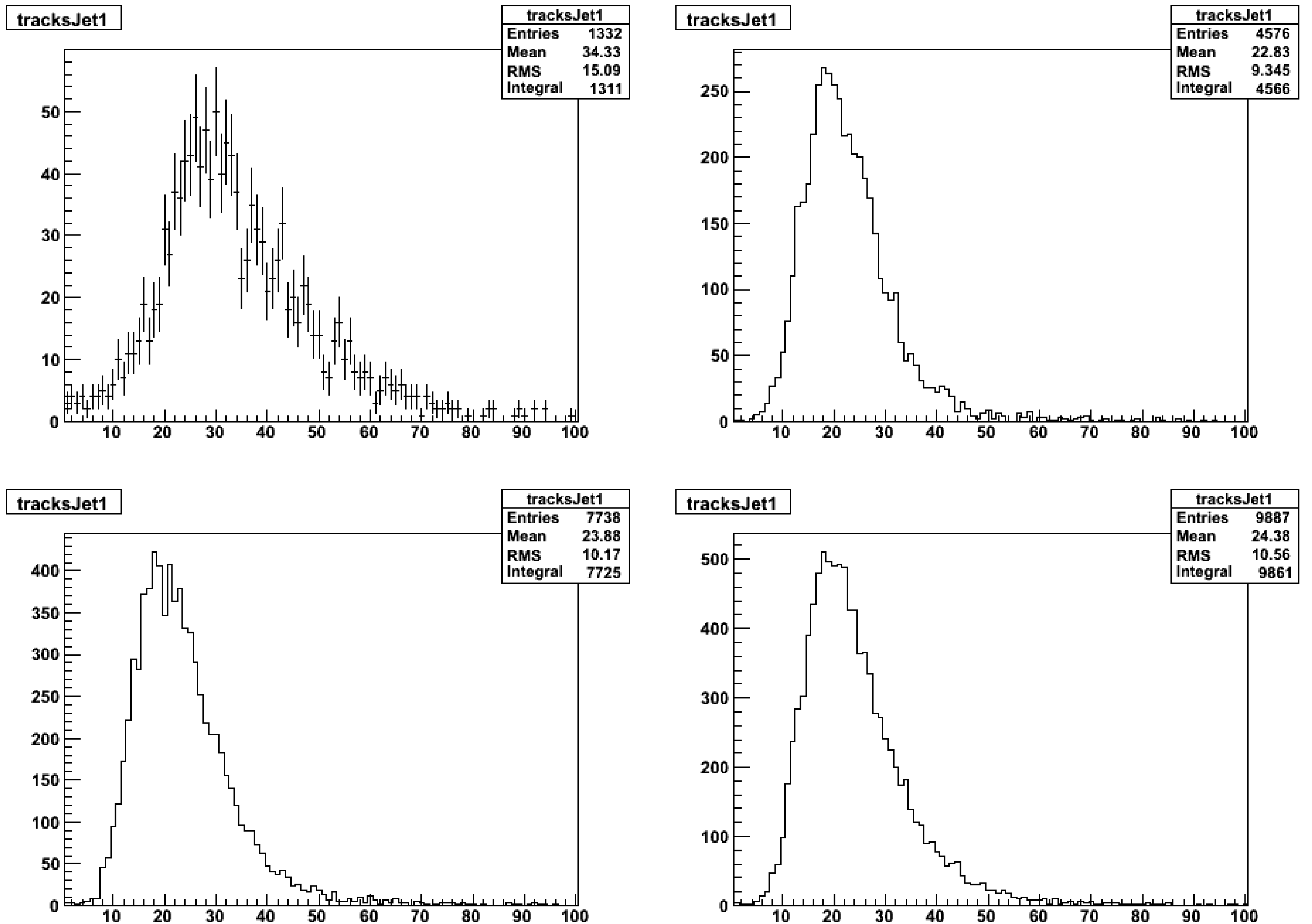
is maximum. Then **n** is the flow vector and *F* is the flow. For my calculations, $\{x_i\}$ are the vectors of the tracks inside the jet cone, projected on *P*.

Major axis

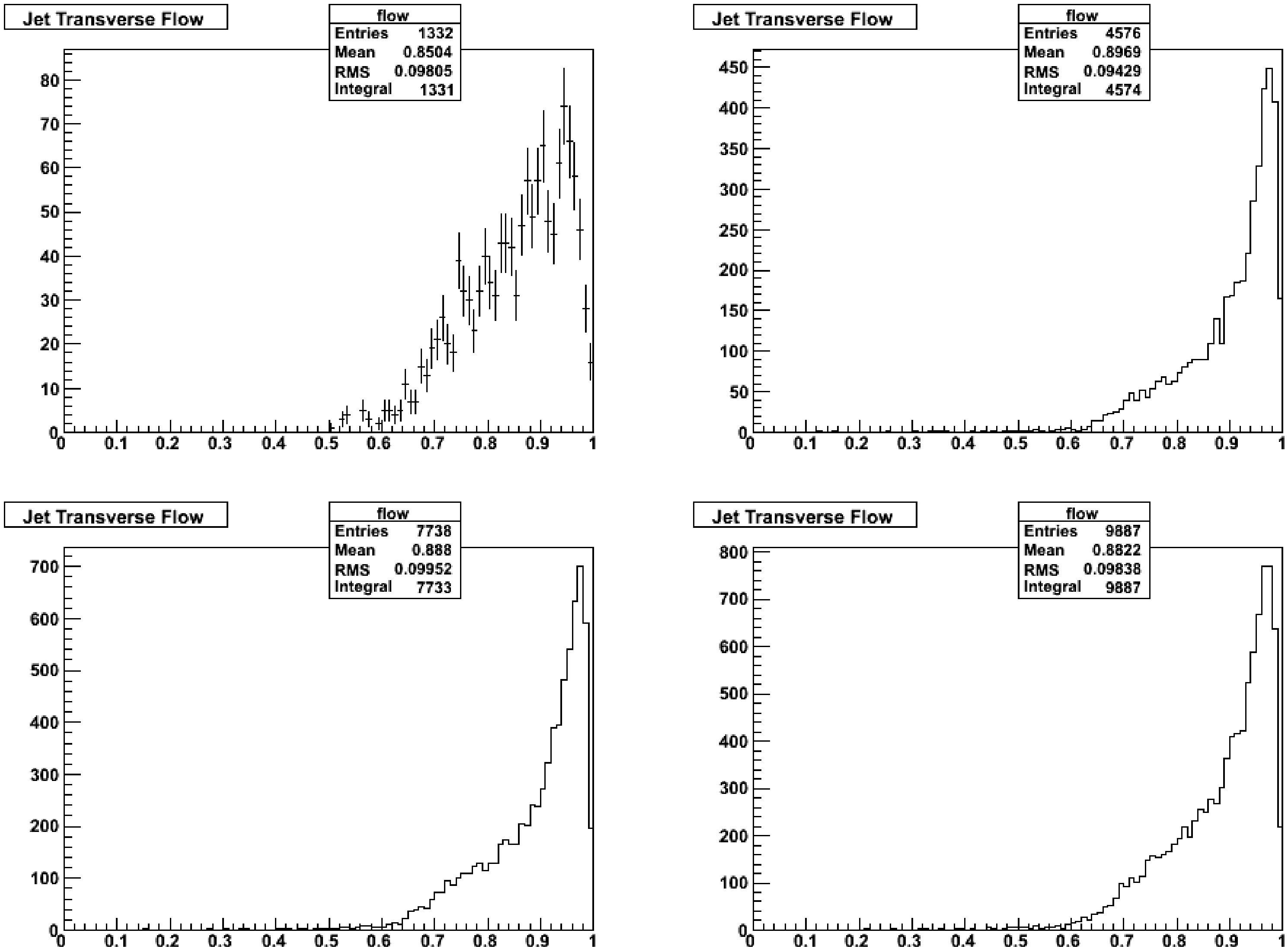


jet1Major
Entries 1332
Mean 0.06047
RMS 0.05192
Integral 1332
jet1Major
Entries 4576
Mean 0.05943
RMS 0.02487
Integral 4576
jet1Major
Entries 7738
Mean 0.0387
RMS 0.01911
Integral 7738
jet1Major
Entries 9887
Mean 0.02835
RMS 0.0163
Integral 9887

Number of tracks



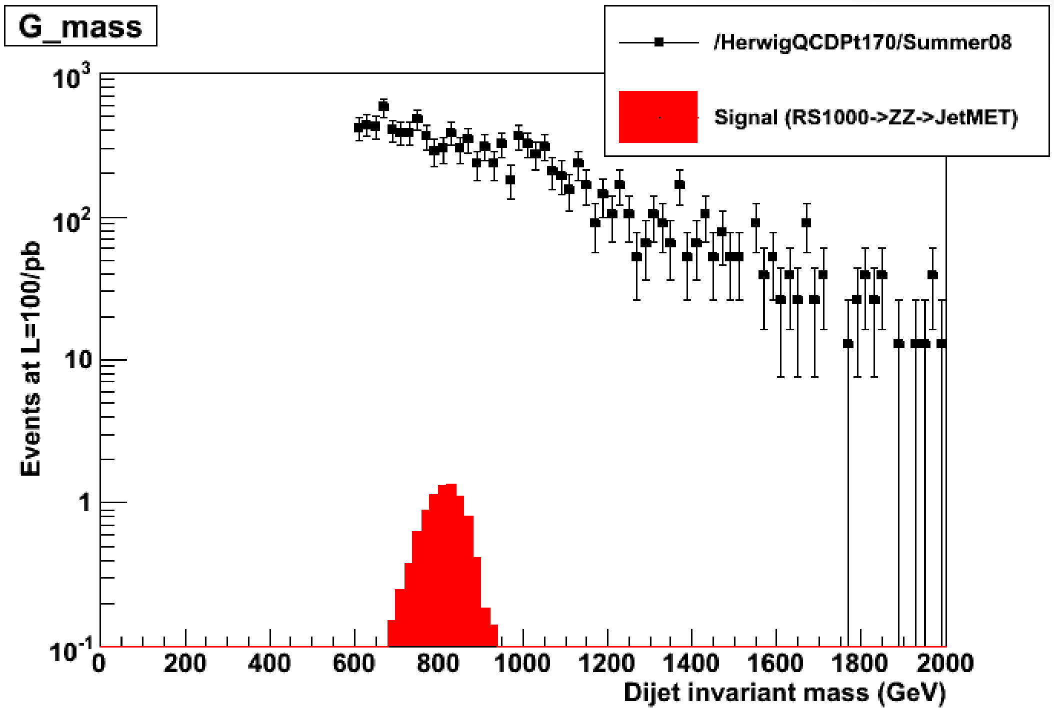
Flow



Jet Transverse Flow
flow
Entries 1332
Mean 0.8504
RMS 0.09805
Integral 1331
Jet Transverse Flow
flow
Entries 4576
Mean 0.8969
RMS 0.09429
Integral 4574
Jet Transverse Flow
flow
Entries 7738
Mean 0.888
RMS 0.09952
Integral 7733
Jet Transverse Flow
flow
Entries 9887
Mean 0.8822
RMS 0.09838
Integral 9887

Results

- With only those the baseline cuts, at 100/pb:



- I would say the analysis is better suited for 1/fb.
- More separation is needed in between background and signal.
- Different variables?
  - Jet profiling?
  - Vetoing smaller jets?
  - Different algorithms (k_T, C-A – boosted tops)?
- Optimization?