Thoughts on Jet Corrections in Top Quark Decays

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Outline:

1. **List of some issues regarding jets**
2. **Figures of merit**
3. **Eg: Underlying Event and Multiple Interactions**
4. **"Cone" corrections**
5. **Priorities for Future Work**

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List of Issues To Consider

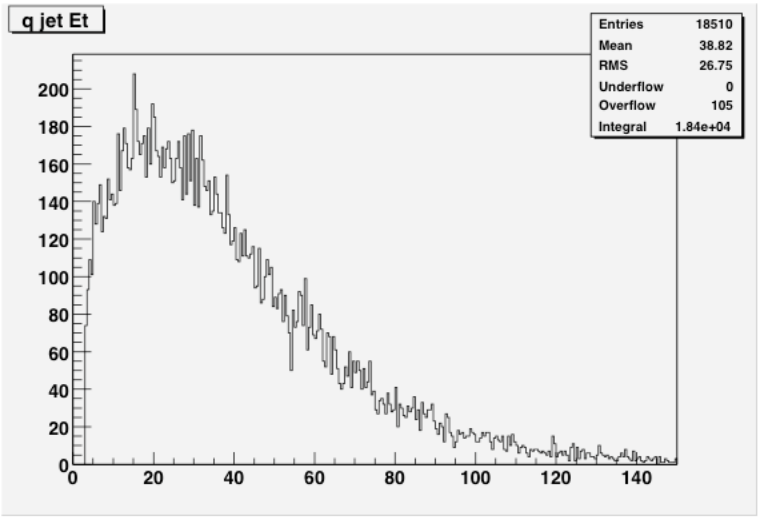
- **Maximize:**
  - **Energy resolution (and mass resolution)**
  - **Parton-jet matching efficiency**
- **Minimize:**
  - **Uncertainty due to energy scale**
    - Using in-situ absolute calibration (Z decays)
    - Gamma-jet balancing
  - **Calorimeter inhomogeneities**
    - Central-wall-plug scales
    - Cracks
  - **Effects associated with definition of jet**
    - Underlying event
    - Multiple interactions
    - Out-of-cone energy (fragmentation & showering)
      - **Connecting in-situ calibration with top quark events**

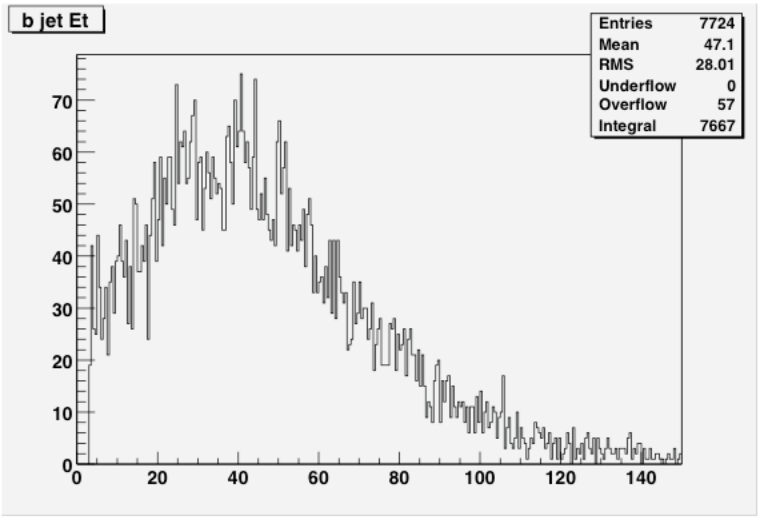
Figures of Merit

- **Need to define quantitative measures**
  - **W mass resolution**
  - **Top mass resolution**
    - Intrinsic resolution
    - Resolution arising from combinatorial effects
  - **Parton-jet matching efficiency**
  - **Size of systematic effects**
    - Calorimeter energy scale
    - Out-of-cone corrections
    - UE and MI corrections
    - Simulation of detector
    - Sensitivity to top quark kinematics

Unique Aspects of Top Jets

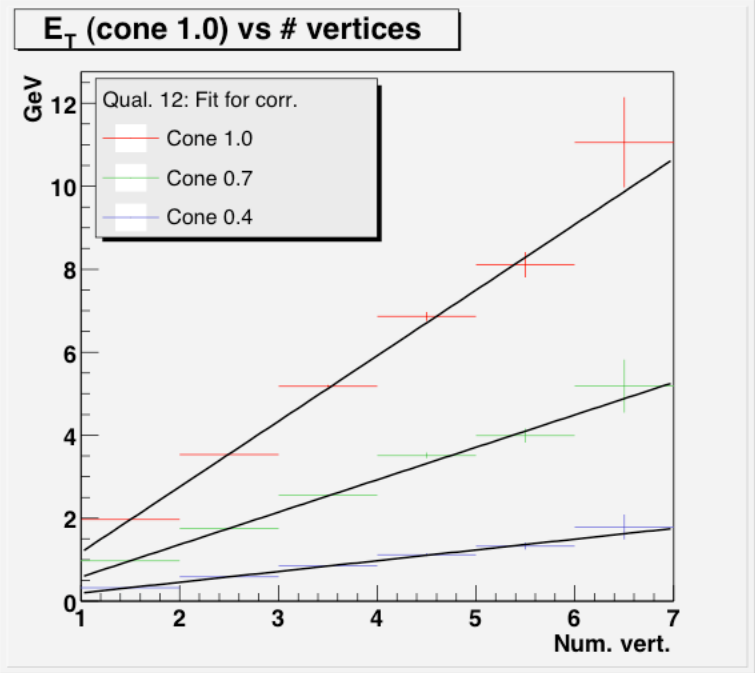
- **Low E_T scale**
  - Light quark jets have ~30 GeV
  - B jets have ~50 GeV
- **Large number in a given event**
  - Require at least 4 jets for lepton+jet channel
  - Additional jets from ISR and FSR
- **Physics issues**
  - W daughters
  - Colour flow
  - B jets





Eg: Underlying Event Studies

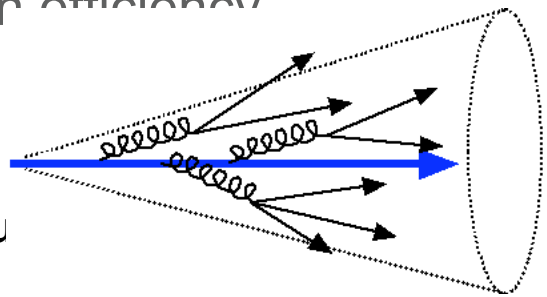
- **Have performed Run I study on Run II data**
  - **Look at dijet events and energy at 90° from jet axis**
  - **Count primary vertices using SVX/COT info**



- **Has some issues:**
  - **Is this CORRECT UE?**
    - Rises with sqrt(s)?
    - Some model-dependence?
  - **Calorimeter threshold effects need further study?**

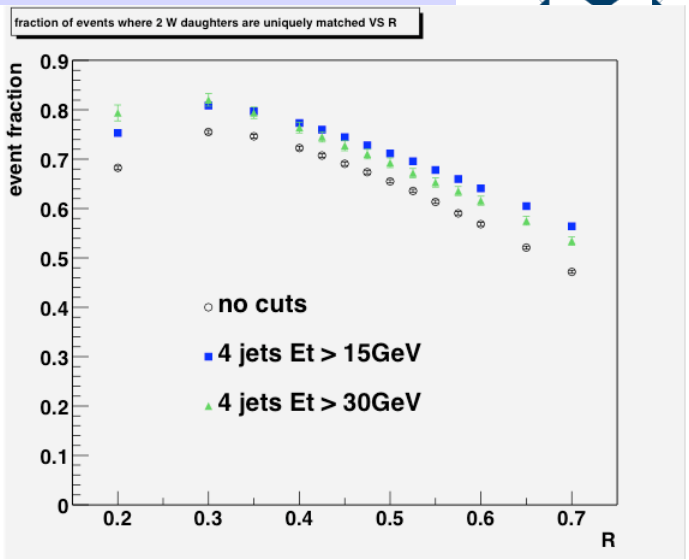
Cone Size Effects

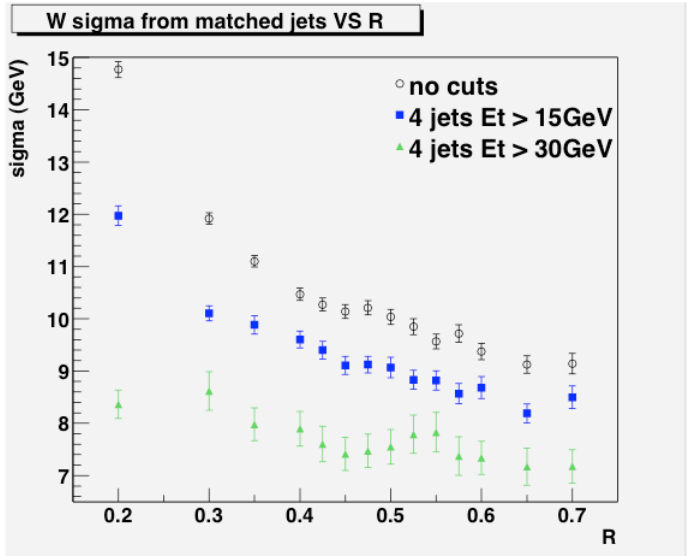
- **Are we using correct cone size?**
  - **Fedorko et al. (CDF 6360) looked at**
    - W mass resolution
    - 2-jet and 4-jet event reconstruction efficiency
  - **Studied fully simulated events**
    - Selected lepton + missing Et
      - **Require > 3 jets with different Et cu**
    - Clustered jets with different R
      - **Looked for jets matched with partons**
      - **Used cluster cone size for matching**
    - Worried about W daughters coalescing
      - **Turns out W P_T not high enough for this to be a significant effect**



Cone Size Conclusions

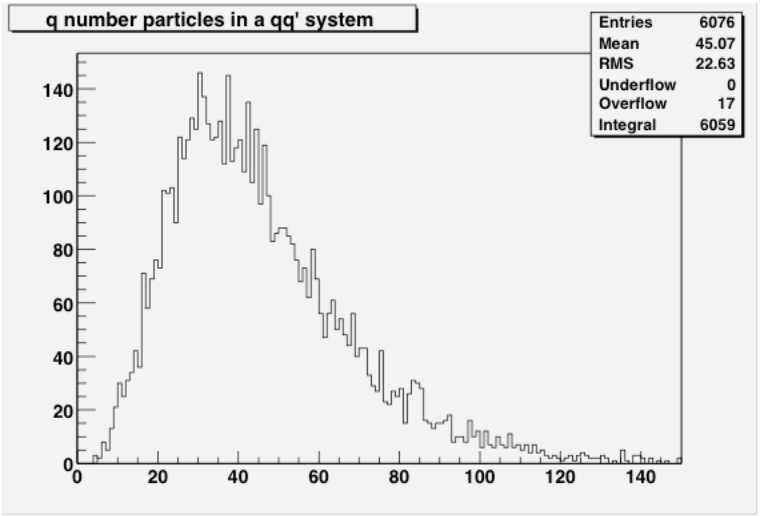
- **Observations:**
  - **R=0.35 or R=0.4 optimal for efficiency**
  - **No optimal R for W mass resolution**
- **Conclusions:**
  - **Use small cone size for event classification**
  - **Use alternate strategy for optimizing mass resolution**

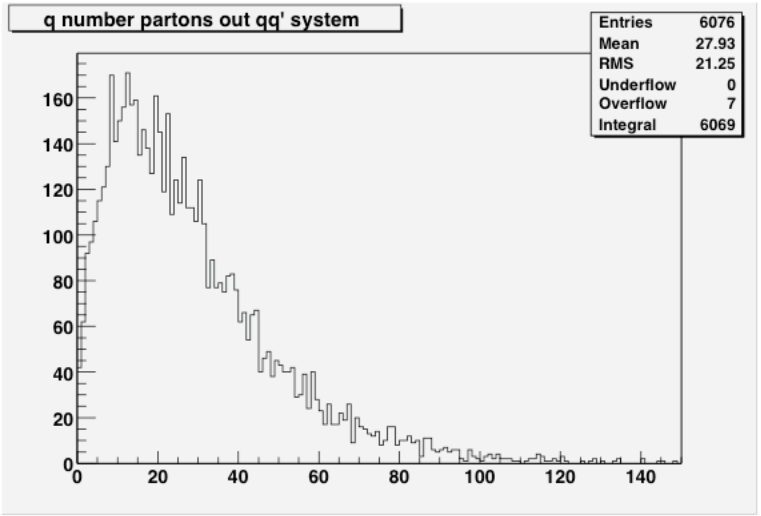




Fragmentation Effects

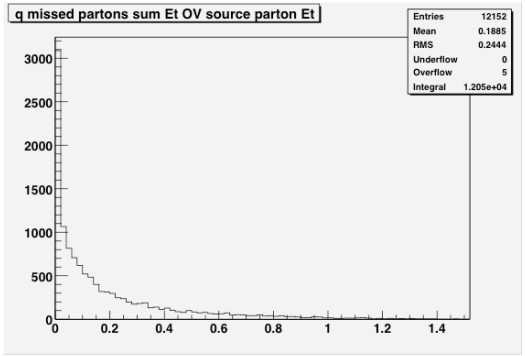
- **Out-of-cone corrections large**
  - **Look at jets from W decay (HERWIG)**
  - **Use R=0.4, trace partons from W□> qq'**
    - Count total number and number out of cone
    - See large fluctuations of particles out of cone
      - **Note that it is difficult to uniquely associate partons with a given jet -- look at total W system**

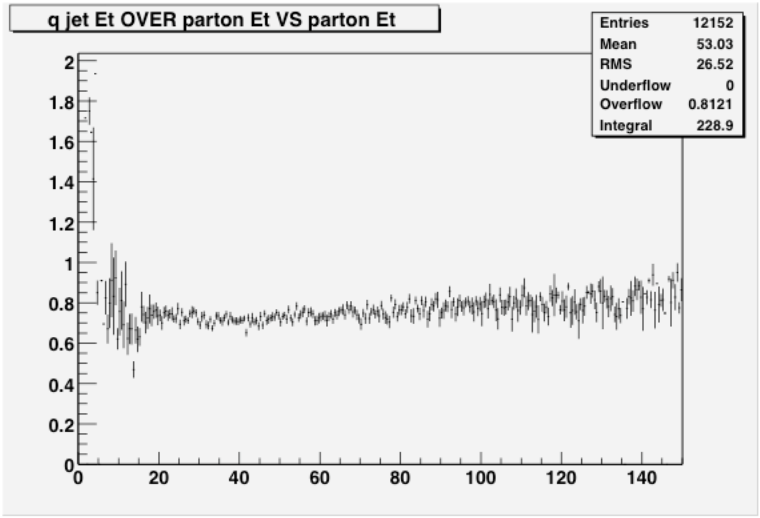


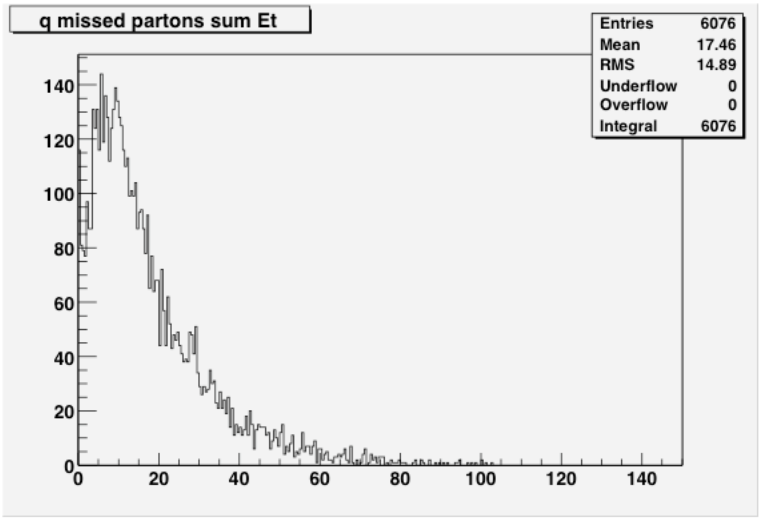


Energy Flow Out-of-Cone

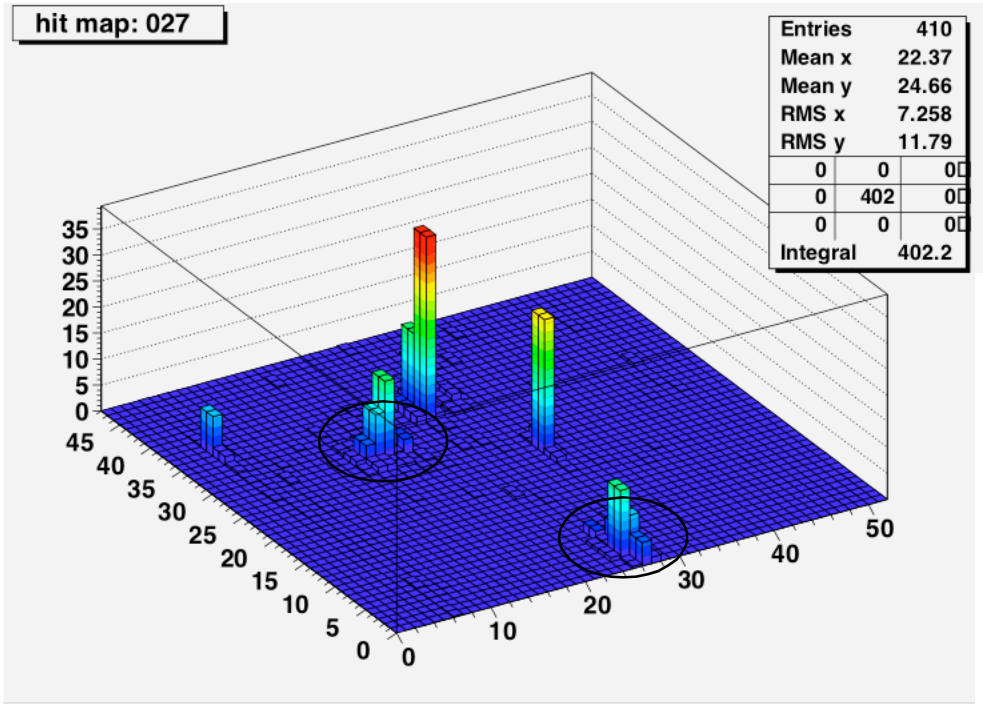
- **Energy flow key issue**
  - **Mean out-of-cone fraction is stable**
  - **Fluctuations are quite large**
- **Led us to look at the features of jets where out-of-cone energy is large**
  - **Select jets with fraction out-of-cone >60%**





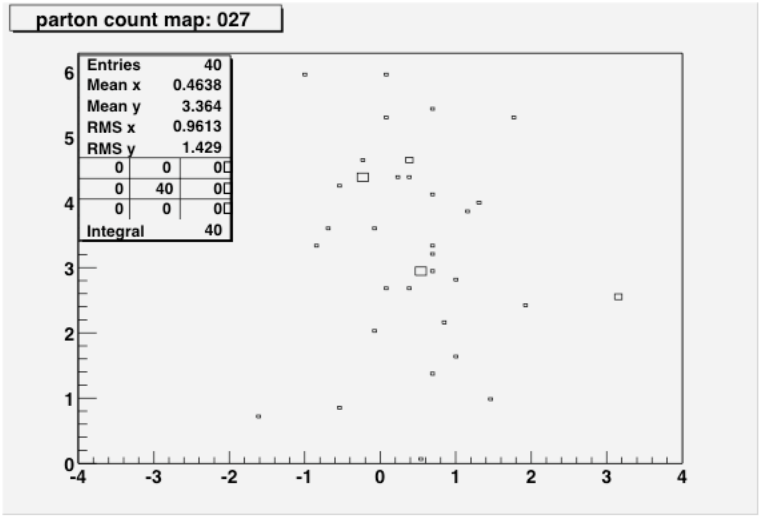


Typical Calorimeter Plot



Calorimeter E_T

□□□ location of W daughters



Conclusion: Challenge pattern recognition algorithms

More Jet Complications

- **Out-of-cone corrections will depend on fragmentation model**
  - **Can constrain models using QCD events**
    - Measure dN/dz, jet shapes, etc.
  - **Also look at b jets in semi-leptonic decays**

- **FSR in W decays is also an issue**
  - **Will have to calibrate this against real data**
    - Use observed number of 3rd jets as a x-check in Run I -- very crude!
  - **Make sure models reproduce 3rd jet properties from LEP, QCD hard scatter events**

Outstanding Issues

- **Physics effects are important**
  - QCD evolution of W jets differs from QCD jets
  - Colour flow makes it difficult to treat jets as independent objects
  - Have to quantify our uncertainty
- **Calibration of this will rely heavily on MC**
  - Need to constrain fragmentation model
  - Measure effects of FSR quantitatively
- **B jets present own problems**
  - Different energy scale and colour effects
  - Can we use tagged jets in semileptonic decays?

Summary

- **How well do we need to understand jets?**
  - **Physics effects may dominate uncertainty**
  - **Not clear that we can treat jets independently**
    - Jet energy corrections vs inter-jet separation?
- **How do we properly use in situ energy calibration?**
  - **Could be quite accurate, but extrapolation to top quark decays will create uncertainties**
- **How do we verify that simulation is actually working?**
  - **Need careful cross-checking and constant validation**
    - eg., see currently quarks in OBSP?!?