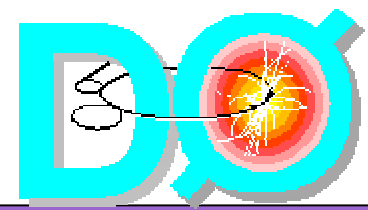


# Simulation Work at Nevis

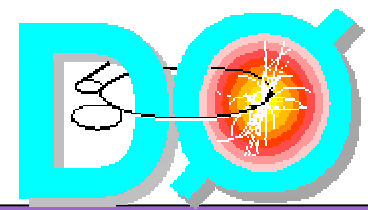
Jovan Mitrevski  
Columbia University  
DØ Workshop 2002@Oklahoma  
July 10, 2002



# Outline



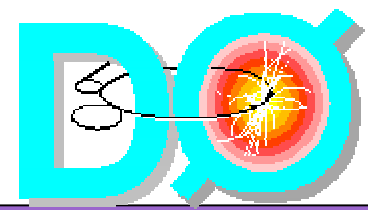
- ◆ Review of sliding window algorithms
- ◆ Jet algorithm choices
- ◆ ICR detectors' output in sliding window algorithms:  
include or not?
- ◆ First look at taus
- ◆ Electron algorithms
- ◆ Summary



# Sliding Window Algorithms



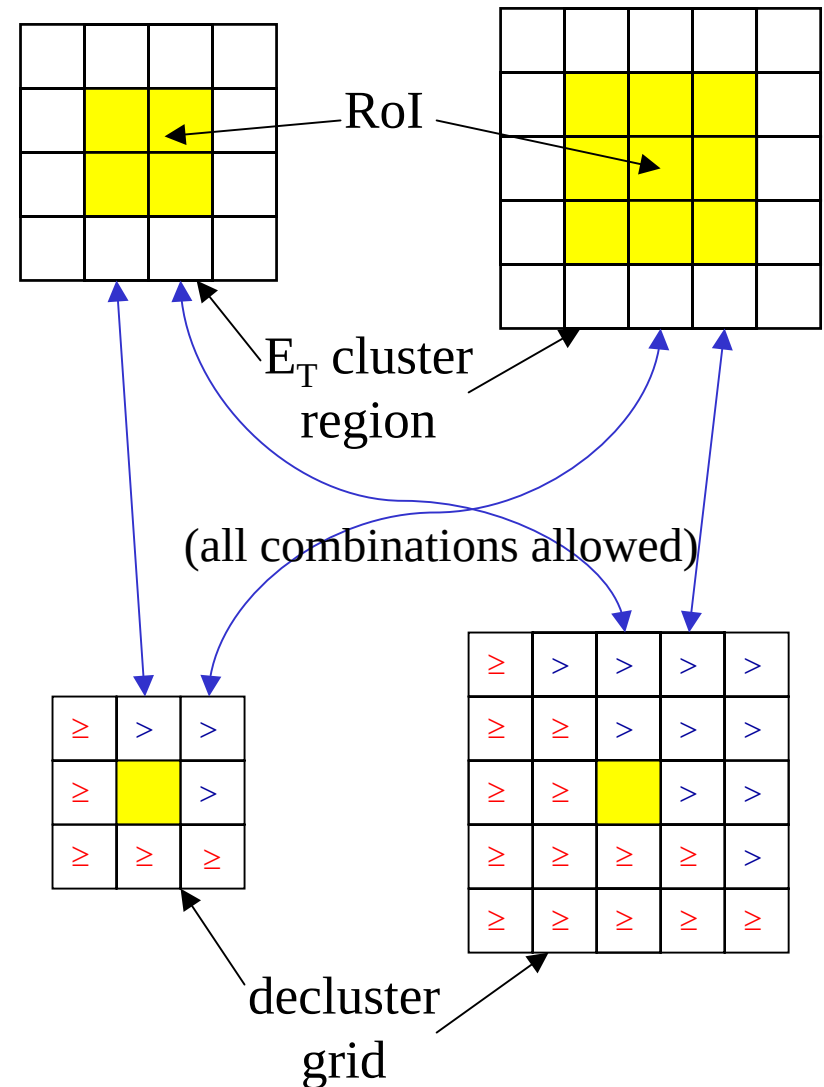
- ◆ A  $0.2 \times 0.2$  trigger tower is too small to contain all the jet energy, and furthermore, a jet or electron might fall on the border between two trigger towers.
  - ◆ Solution: use a sliding-window algorithm.
- ◆ Electron trigger algorithms must discriminate electrons from jets.
  - ◆ Plan is to use hadronic and isolation cuts.
- ◆ Tau trigger algorithms must discriminate tau jets from hadronic jets.
  - ◆ One idea is to use jet width; study is just getting under way.

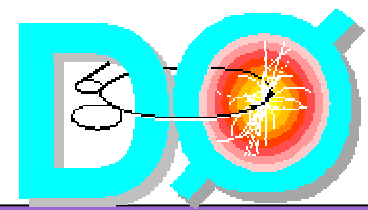


# Jet Sliding Window Algorithms

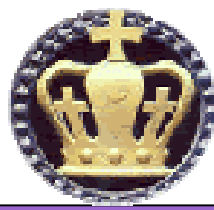


- ◆ Regions of Interest (RoIs) consisting of  $2 \times 2$  or  $3 \times 3$  grids of trigger towers.
- ◆ Decluster on  $3 \times 3$  or  $5 \times 5$  grids of RoI sums.
- ◆ Total reported cluster energy is expanded to a  $4 \times 4$  or  $5 \times 5$  grid of TTs, corresponding to a  $0.8 \times 0.8$  or  $1.0 \times 1.0$  region in  $\eta \times \phi$ .

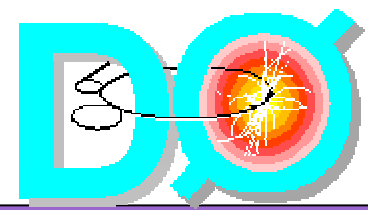




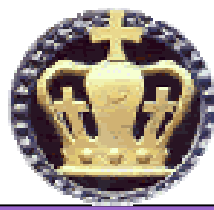
# Jet Algorithm Choices



- ◆ Studying four sliding window jet algorithms, which are named by the triplet (size of RoI, minimum separation of neighboring RoIs, expansion of RoI region to get  $E_T$  cluster energy):
  - (2, 0, 1): 2×2 RoI, 3×3 decluster, 4×4  $E_T$  region
  - (2, 1, 1): 2×2 RoI, 5×5 decluster, 4×4  $E_T$  region
  - (3, -1, 1): 3×3 RoI, 3×3 decluster, 5×5  $E_T$  region
  - (3, 0, 1): 3×3 RoI, 5×5 decluster, 5×5  $E_T$  region
- ◆ Applied the above algorithms to three types of events:  $ZH \rightarrow \nu\nu b\bar{b}$ ,  $WH \rightarrow e\nu b\bar{b}$ , inclusive  $t\bar{t}$ . All were from Michael Hildreth's run 2b projects with  $\sqrt{s}=7.5$ . The WH files are mcp07, while the others are mcp10.

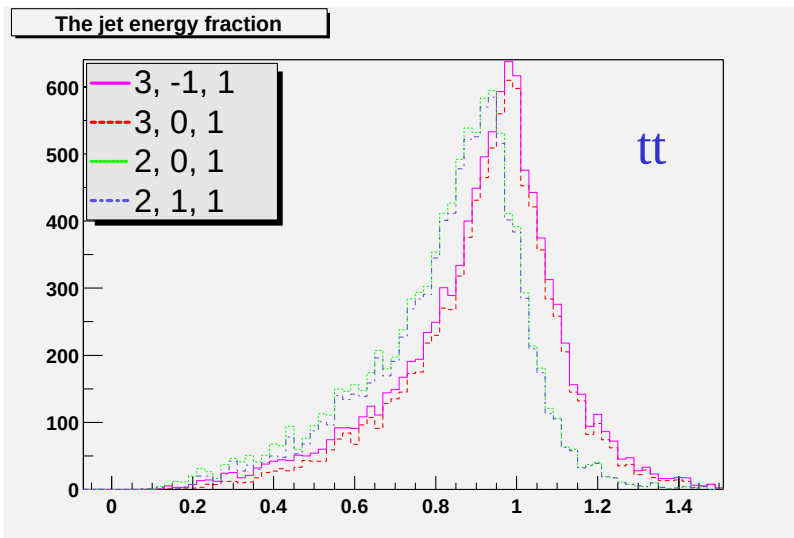
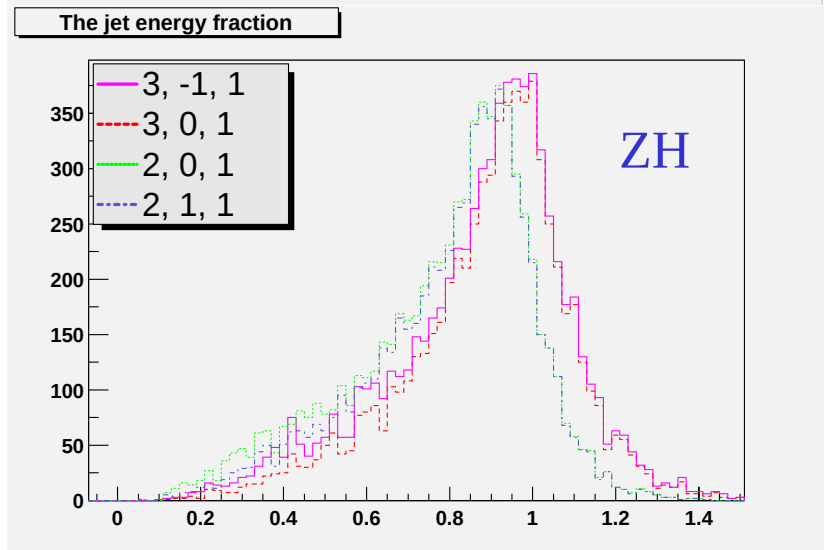
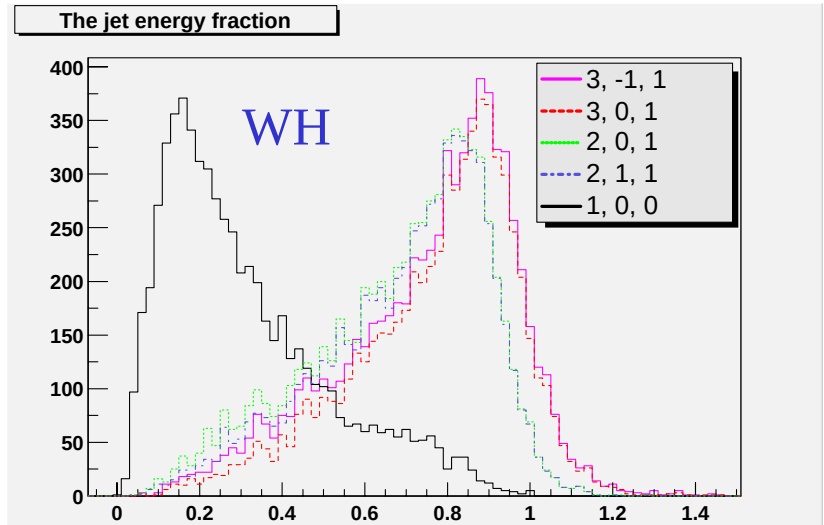


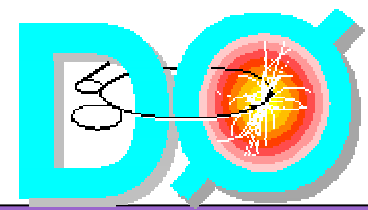
# $E_T(\text{trig. cluster}) / E_T(\text{jccb})$



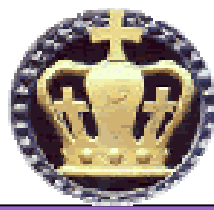
◆ For each JCCB jet, select the trig. cluster with the smallest  $\Delta R$ . Plots have the following cuts:

- ◆ jetid group certification cuts
- ◆ jccb  $E_T > 10$  GeV, tc  $E_T > 1.5$  GeV
- ◆ jccb det.  $|\eta| < 3.5$
- ◆  $\Delta R < 0.25$  (0.3) for 2x2 (3x3) RoI

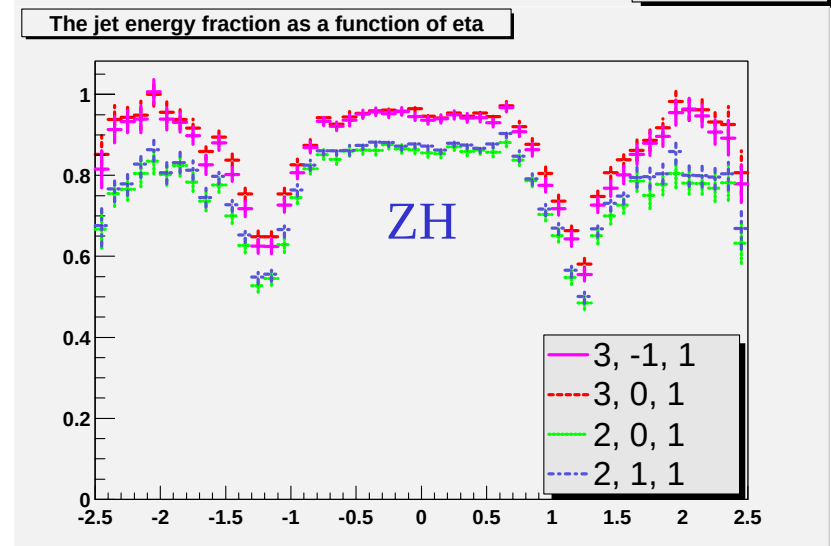
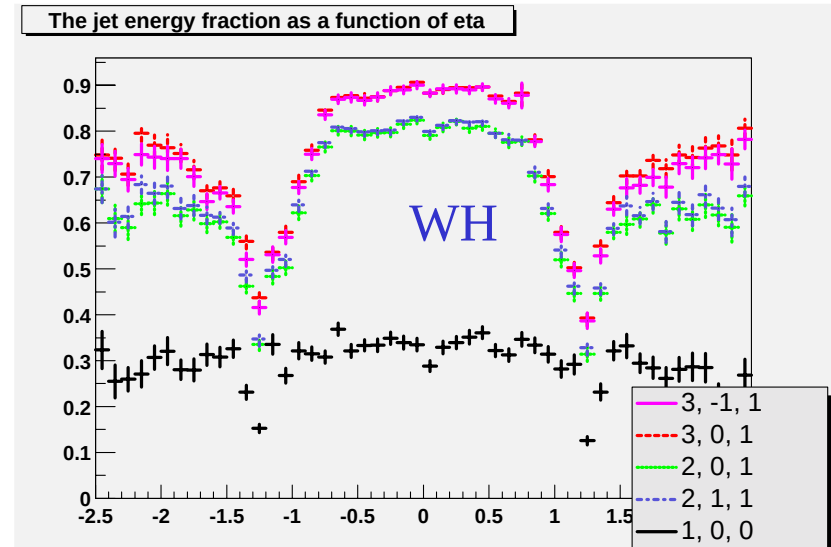
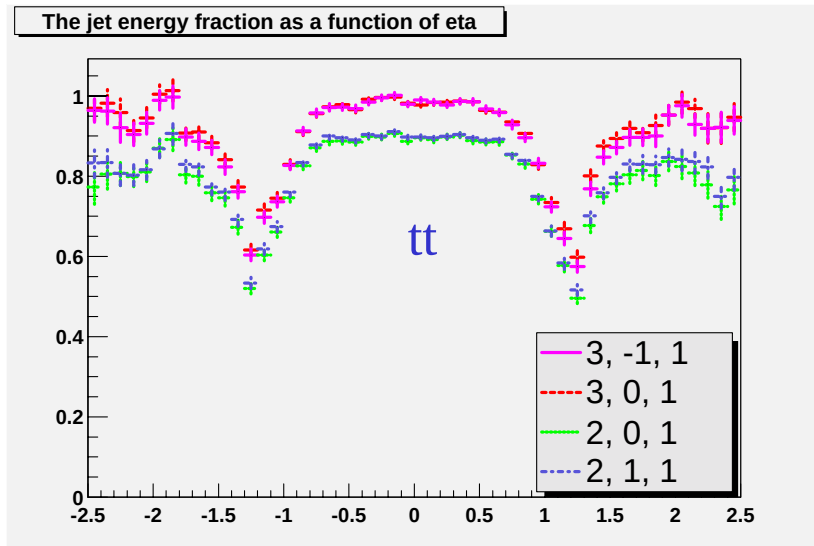


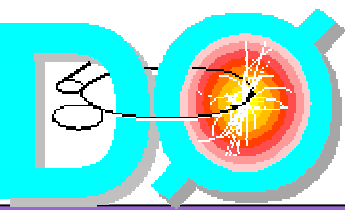


# $E_T(tc) / E_T(jccb) \text{ vs } \eta$

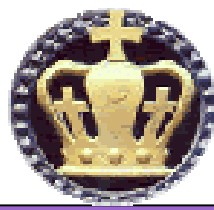


- ◆ For each JCCB jet, select the trig. cluster with the smallest  $\Delta R$ .  
Plots have the following cuts:
- ◆ jetid group certification cuts
- ◆ jccb  $E_T > 10 \text{ GeV}$
- ◆ trig. cluster  $E_T > 1.5 \text{ GeV}$
- ◆  $\Delta R < 0.25$  (0.3) for 2x2 (3x3) RoI



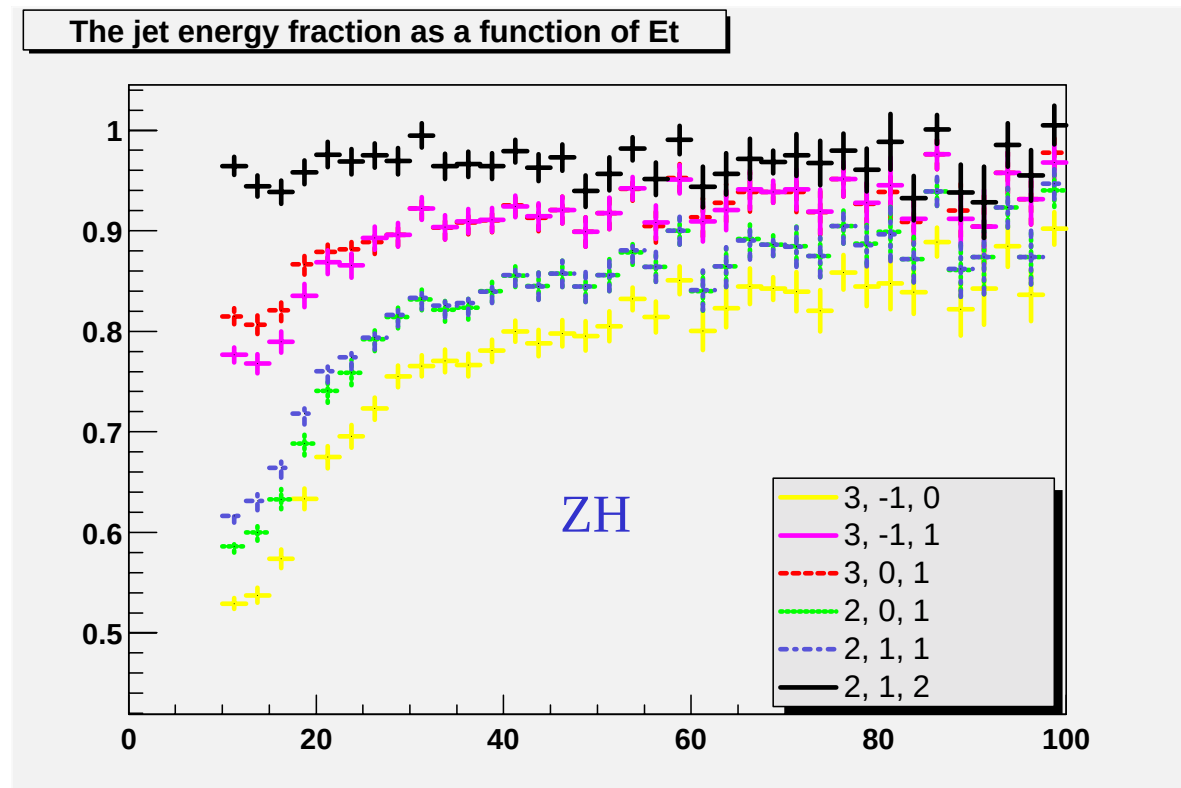


# $E_T(tc) / E_T(jccb) \text{ vs } E_T(jccb)$

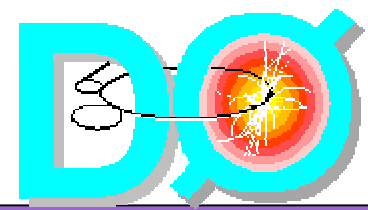


- ◆  $E_T(tc) / E_T(jccb)$  is a function of  $E_T(jccb)$ , as can be seen in this plot of the four algorithms under consideration and a few variants in a sample of  $ZH \rightarrow v\bar{v}bb$  events. The  $E_T$  cluster size has the primary effect.

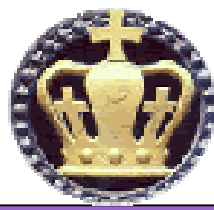
| Algorithm | Cluster size     |
|-----------|------------------|
| 3, -1, 0  | $0.6 \times 0.6$ |
| 2, 0, 1   | $0.8 \times 0.8$ |
| 2, 1, 1   | $0.8 \times 0.8$ |
| 3, -1, 1  | $1.0 \times 1.0$ |
| 3, 0, 1   | $1.0 \times 1.0$ |
| 2, 1, 2   | $1.2 \times 1.2$ |







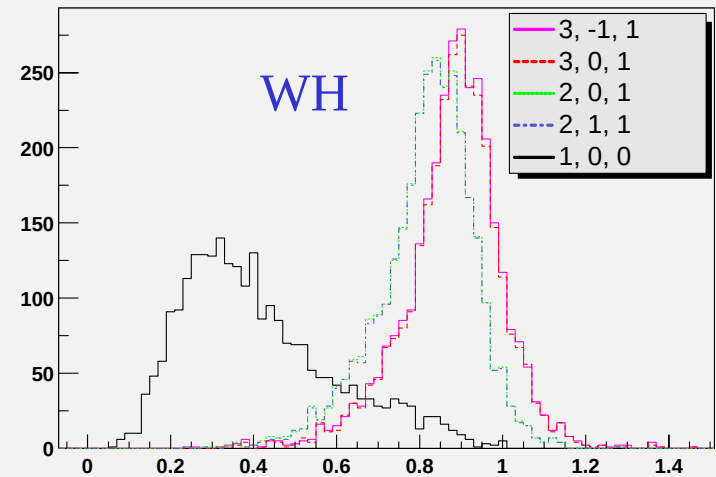
# $E_T(tc) / E_T(jccb)$ high $E_T$ , exclude ICR



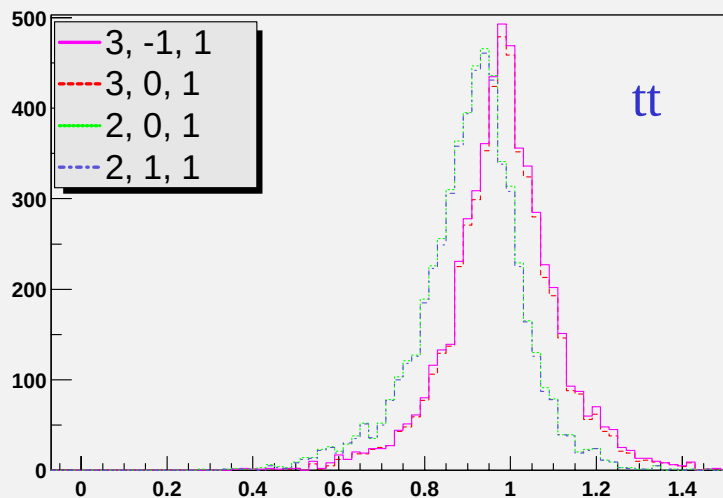
◆ High- $E_T$  jets that don't fall in the ICR result in narrower distributions. Applied cuts:

- ◆ jetid group certification cuts
- ◆ jccb  $E_T > 20$  GeV, tc  $E_T > 7$  GeV
- ◆ jccb det.  $|\eta| < 0.8 \parallel 1.6 < |\eta| < 3.5$
- ◆  $\Delta R < 0.25$  (0.3) for 2x2 (3x3) RoI

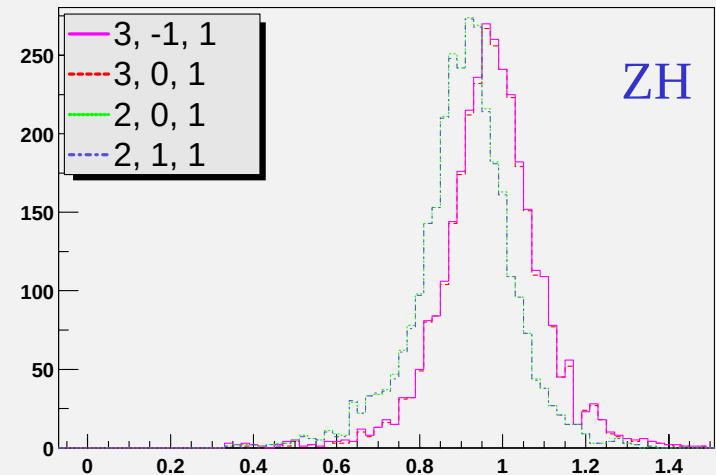
The jet energy fraction

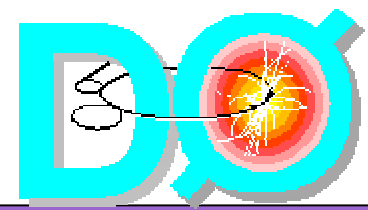


The jet energy fraction

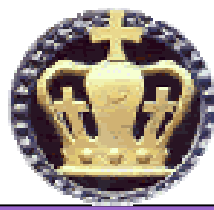


The jet energy fraction





# $E_T(tc) / E_T(jccb)$ Summary

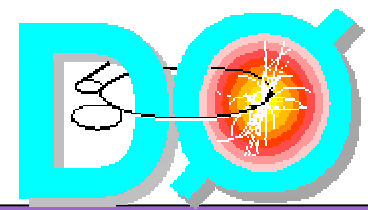


◆  $jccb E_T > 10 \text{ GeV}$ ,  $tc E_T > 1.5 \text{ GeV}$ ,  $|\eta| < 3.5$

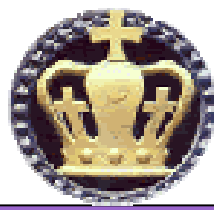
| Event Types  | 2, 0, 1 |      | 2, 1, 1 |      | 3, -1, 1 |      | 3, 0, 1 |      |
|--------------|---------|------|---------|------|----------|------|---------|------|
|              | mean    | rms  | mean    | rms  | mean     | rms  | mean    | rms  |
| WH -> evbb   | 0.68    | 0.21 | 0.70    | 0.20 | 0.76     | 0.21 | 0.77    | 0.20 |
| ZH -> vvbb   | 0.79    | 0.22 | 0.80    | 0.20 | 0.87     | 0.22 | 0.89    | 0.20 |
| inclusive tt | 0.82    | 0.20 | 0.83    | 0.19 | 0.91     | 0.20 | 0.92    | 0.19 |

◆  $jccb E_T > 10 \text{ GeV}$ ,  $tc E_T > 1.5 \text{ GeV}$ ,  $|\eta| < 0.8 \parallel 1.6 < |\eta| < 3.5$

| Event Types  | 2, 0, 1 |      | 2, 1, 1 |      | 3, -1, 1 |      | 3, 0, 1 |      |
|--------------|---------|------|---------|------|----------|------|---------|------|
|              | mean    | rms  | mean    | rms  | mean     | rms  | mean    | rms  |
| WH -> evbb   | 0.75    | 0.17 | 0.76    | 0.16 | 0.83     | 0.17 | 0.84    | 0.15 |
| ZH -> vvbb   | 0.84    | 0.19 | 0.86    | 0.17 | 0.93     | 0.18 | 0.95    | 0.17 |
| inclusive tt | 0.88    | 0.16 | 0.88    | 0.15 | 0.97     | 0.16 | 0.97    | 0.15 |



# $E_T(tc) / E_T(jccb)$ Sum. II

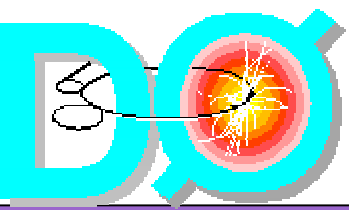


◆  $jccb E_T > 20 \text{ GeV}$ ,  $tc E_T > 7 \text{ GeV}$ ,  $|\eta| < 3.5$

| Event Types  | 2, 0, 1 |      | 2, 1, 1 |      | 3, -1, 1 |      | 3, 0, 1 |      |
|--------------|---------|------|---------|------|----------|------|---------|------|
|              | mean    | rms  | mean    | rms  | mean     | rms  | mean    | rms  |
| WH -> evbb   | 0.75    | 0.17 | 0.75    | 0.17 | 0.80     | 0.18 | 0.80    | 0.18 |
| ZH -> vvbb   | 0.85    | 0.17 | 0.86    | 0.17 | 0.92     | 0.17 | 0.92    | 0.17 |
| inclusive tt | 0.86    | 0.17 | 0.86    | 0.17 | 0.93     | 0.17 | 0.93    | 0.17 |

◆  $jccb E_T > 20 \text{ GeV}$ ,  $tc E_T > 7 \text{ GeV}$ ,  $|\eta| < 0.8 \parallel 1.6 < |\eta| < 3.5$

| Event Types  | 2, 0, 1 |      | 2, 1, 1 |      | 3, -1, 1 |      | 3, 0, 1 |      |
|--------------|---------|------|---------|------|----------|------|---------|------|
|              | mean    | rms  | mean    | rms  | mean     | rms  | mean    | rms  |
| WH -> evbb   | 0.82    | 0.12 | 0.82    | 0.12 | 0.89     | 0.12 | 0.88    | 0.12 |
| ZH -> vvbb   | 0.91    | 0.12 | 0.91    | 0.12 | 0.97     | 0.12 | 0.97    | 0.12 |
| inclusive tt | 0.91    | 0.12 | 0.91    | 0.12 | 0.98     | 0.13 | 0.98    | 0.12 |



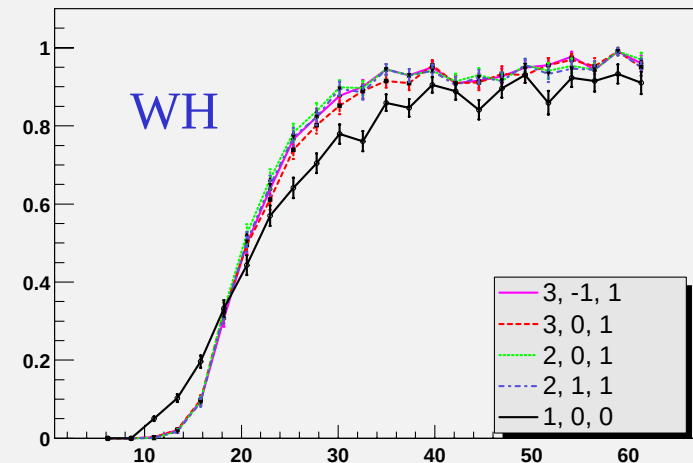
# Turn-on Curves



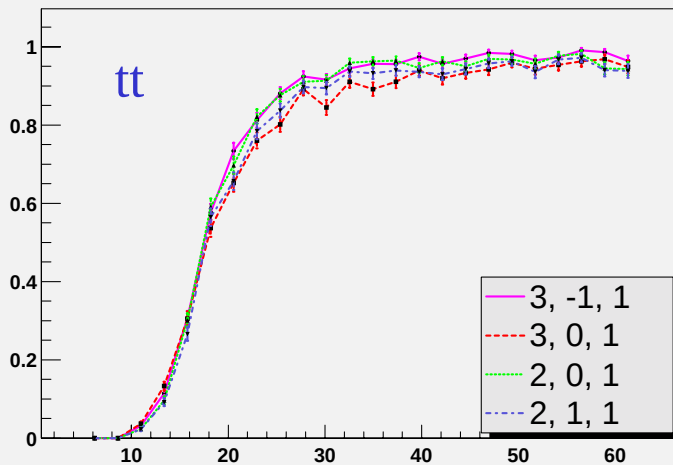
- ◆ All the sliding window algorithms result in similar turn-on curves, significantly better than the current algorithm's. Applied cuts:

- ◆ jetid group certification cuts
- ◆ jccb det.  $|\eta| < 3.5$

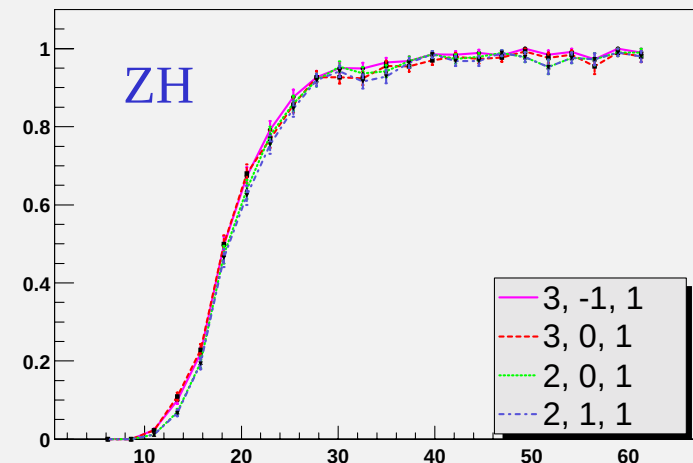
Turnon Curves for Jets that Pass Cert. Cuts

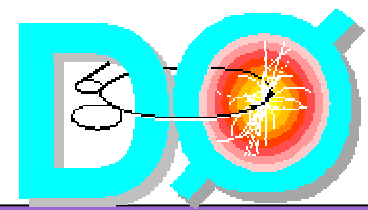


Turnon Curves for Jets that Pass Cert. Cuts

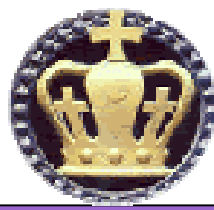


Turnon Curves for Jets that Pass Cert. Cuts



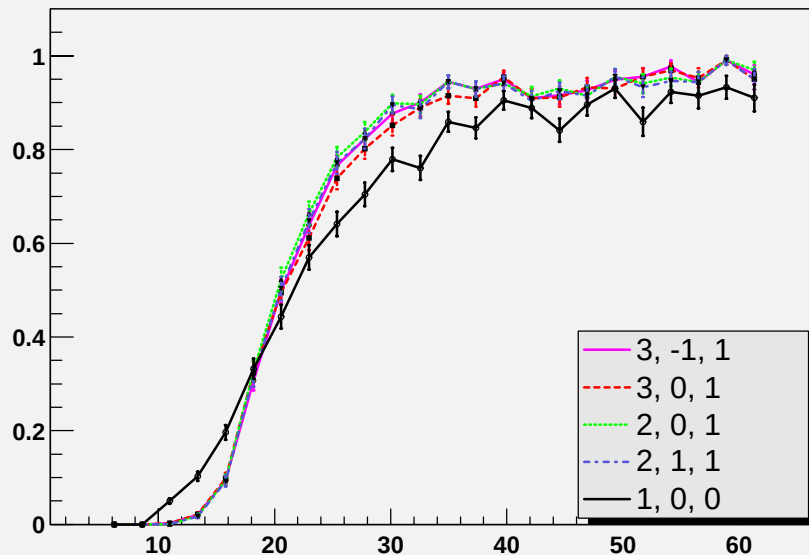


# Turn-on Curves

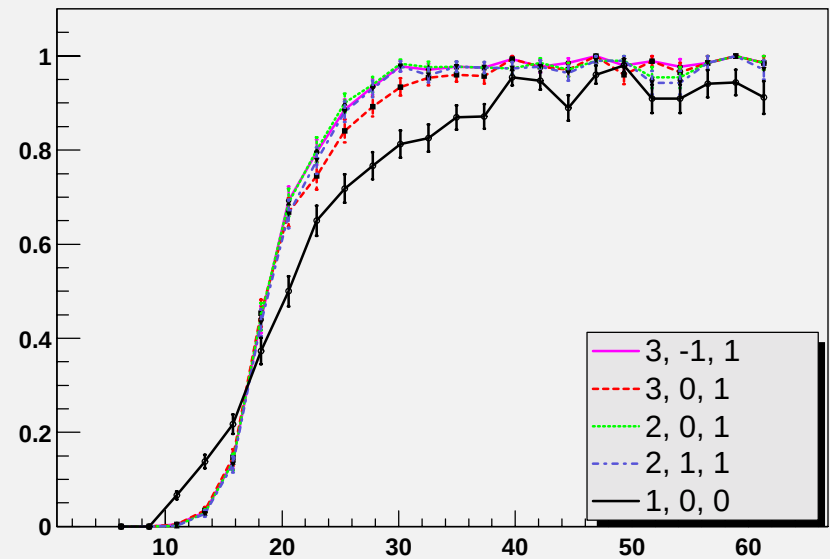


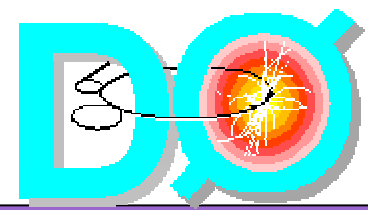
- ◆ The turn-on curve is sharpened if the area around the ICR is excluded. The left picture is the WH plot from before, the right further restricts the jccb detector eta of the jets to  $|\eta| < 0.8 \parallel 1.6 < |\eta| < 3.5$ .

Turnon Curves for Jets that Pass Cert. Cuts



Turnon Curves for Jets that Pass Cert. Cuts



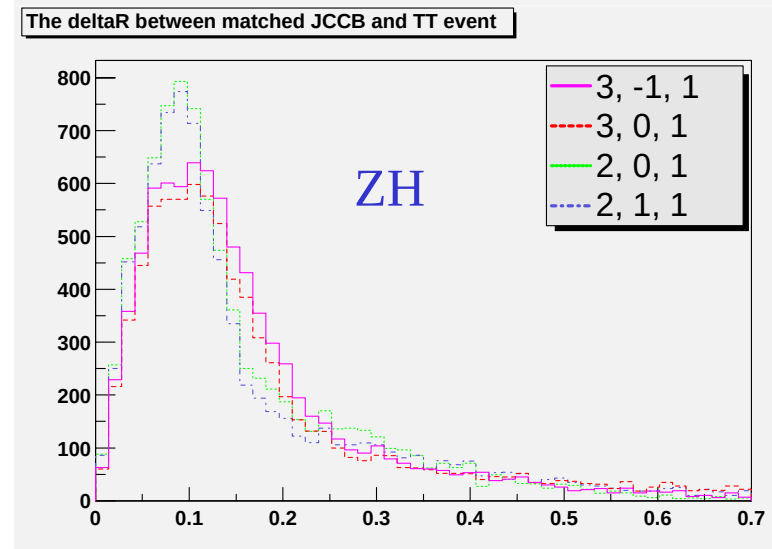
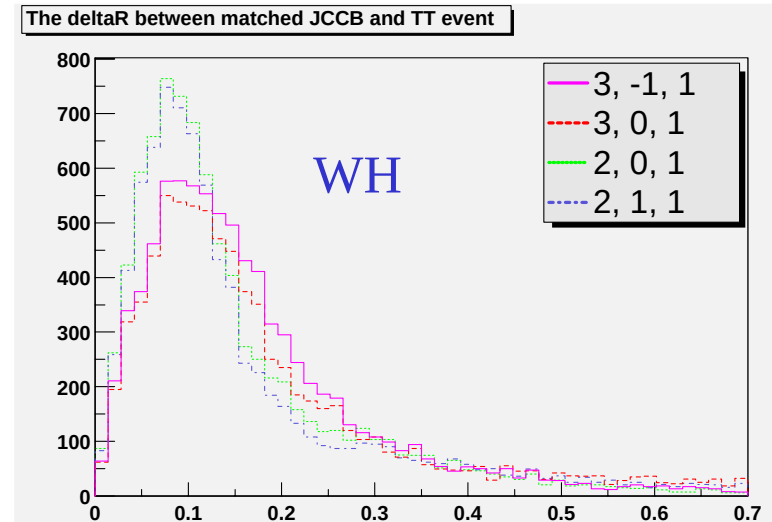
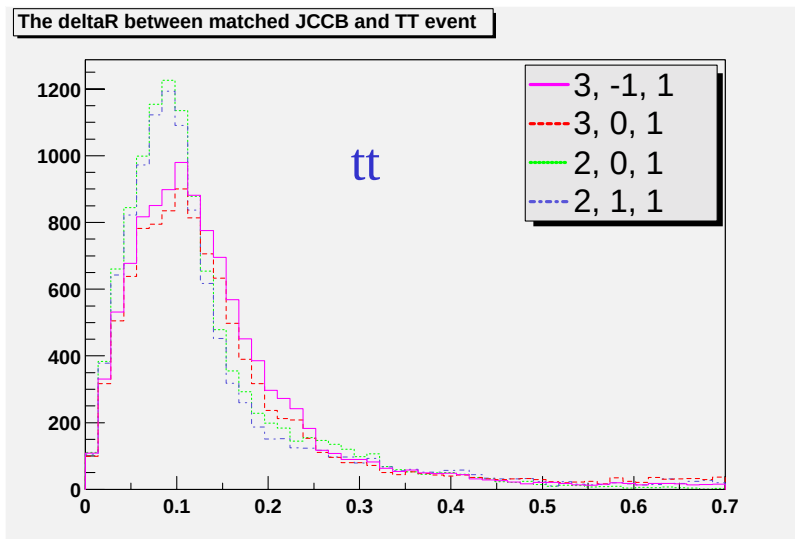


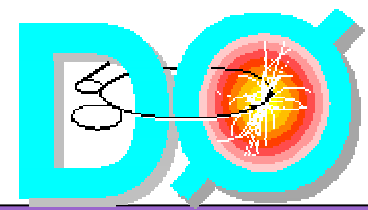
# Accuracy in Position



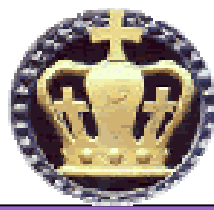
◆ The accuracy in the position of a jet is important for track matching. Plots reco-tc delta-R. Applied cuts:

- ◆ jetid group certification cuts
- ◆ reco  $E_T > 10$  GeV
- ◆ trig. cluster  $E_T > 1.5$  GeV



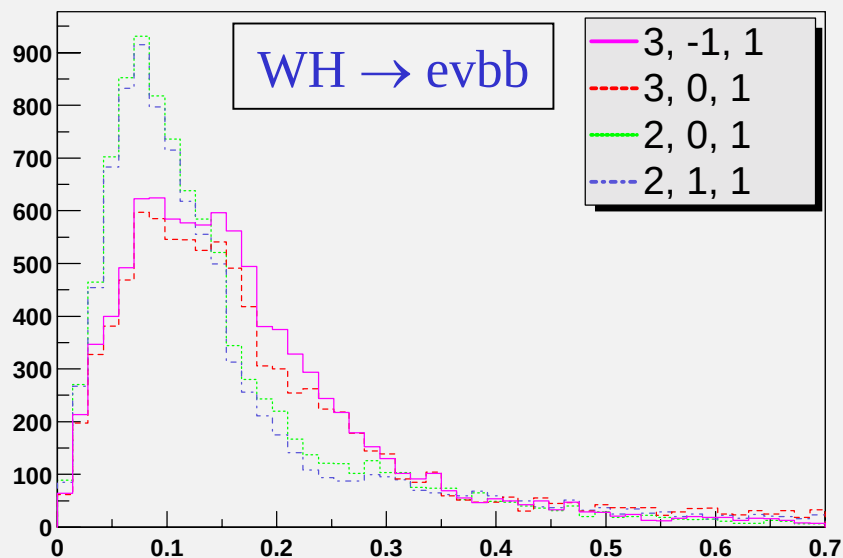


# Accuracy in Position for Taus and Electrons

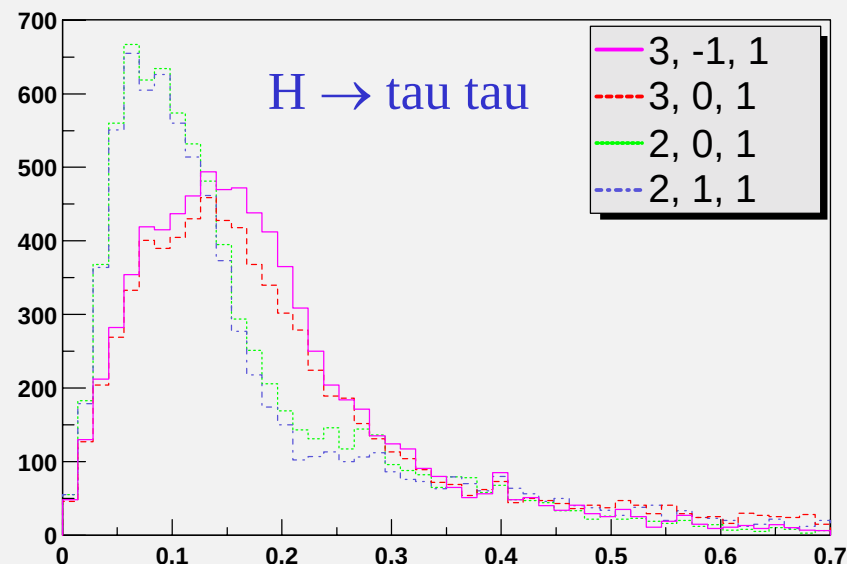


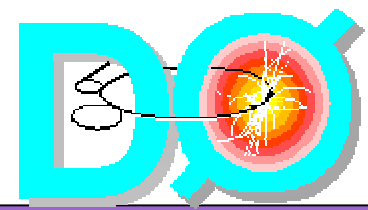
- ◆ The algorithms with the  $2 \times 2$  RoI have slightly better accuracy in the position than do the algorithms with a  $3 \times 3$  RoI. For narrow events, such as taus and electrons, the advantage of the  $2 \times 2$  RoI algorithms increases.
- ◆ The plot on the left is for  $WH \rightarrow e\nu b\bar{b}$  events where the jetid cuts are not applied, thus including an electron “jet.”
- ◆ The plot on the right is  $H \rightarrow \text{tau tau}$ . The jetid cuts are not applied.

The deltaR between matched JCCB and TT event

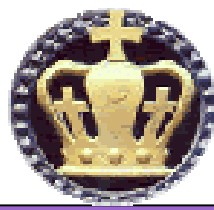


The deltaR between matched JCCB and TT event





# (3, -1, 1) Double Counting

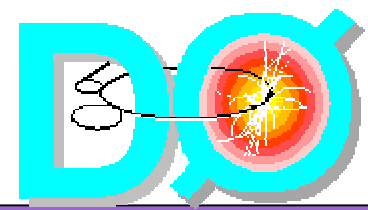


- ◆ Of the four jet sliding-window algorithms studied, only the one using a  $3 \times 3$  RoI,  $3 \times 3$  decluster matrix allows two jets to share RoIs:
- ◆ Situation where the “sig” cell contains a narrow shower (such as an electron) and the “ns” cells both contain noise cause one jet to be considered two.
- ◆ In a sample  $t\bar{t}$  file, roughly 15% of the electrons were recognized as two jets.

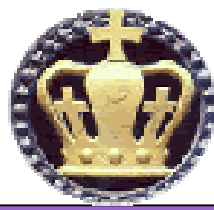
|  |    |  |     |  |    |  |
|--|----|--|-----|--|----|--|
|  |    |  |     |  |    |  |
|  | ns |  |     |  | ns |  |
|  |    |  |     |  |    |  |
|  |    |  | sig |  |    |  |
|  |    |  |     |  |    |  |

As an aside, all these algorithms can double-count energy if there are two neighboring jets since the  $4 \times 4$  or  $5 \times 5$  clusters can overlap.

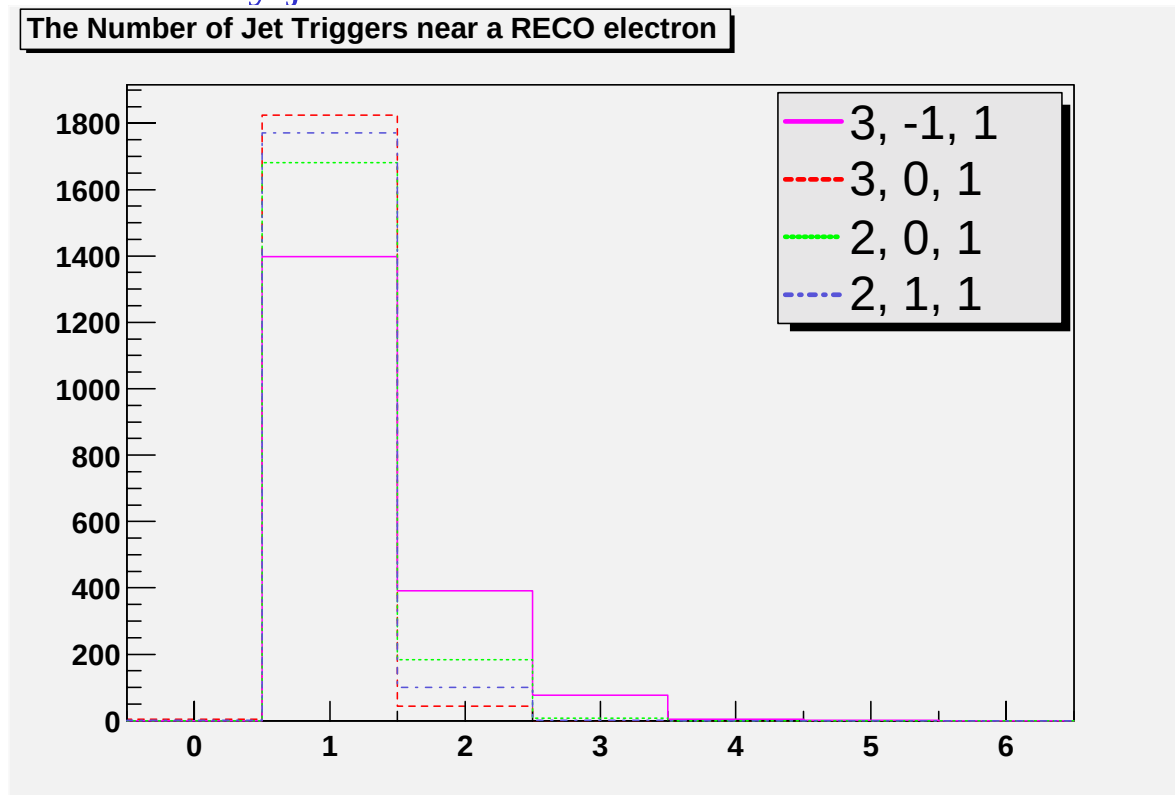


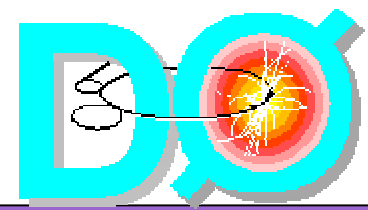


# Evidence for Double Counting



- ◆ This plot is of  $WH \rightarrow e\nu b\bar{b}$  events. It displays the number jet triggers with an  $E_T > 8$  GeV within a radius of 0.6 from from an EMPART\_Z electron (passing emid cuts) with  $P_T > 15$  GeV/c. One trigger is expected, with two occurring on occasion due to a nearby jet.

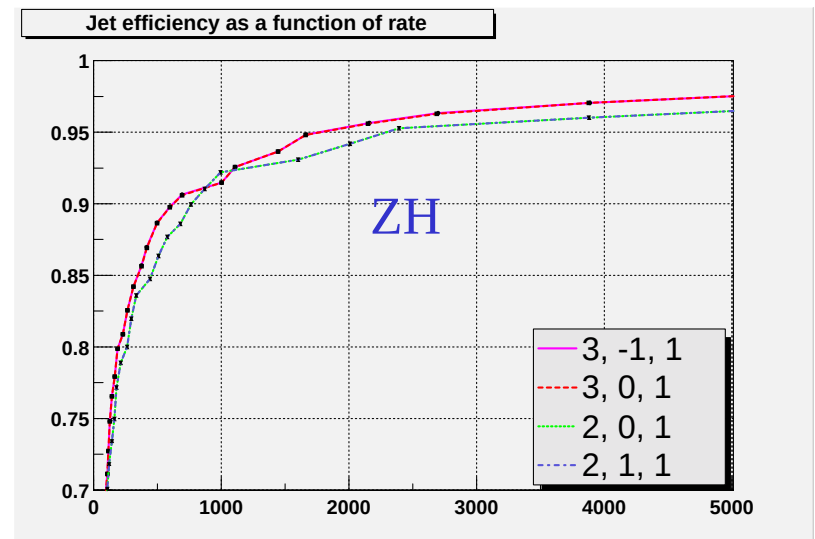
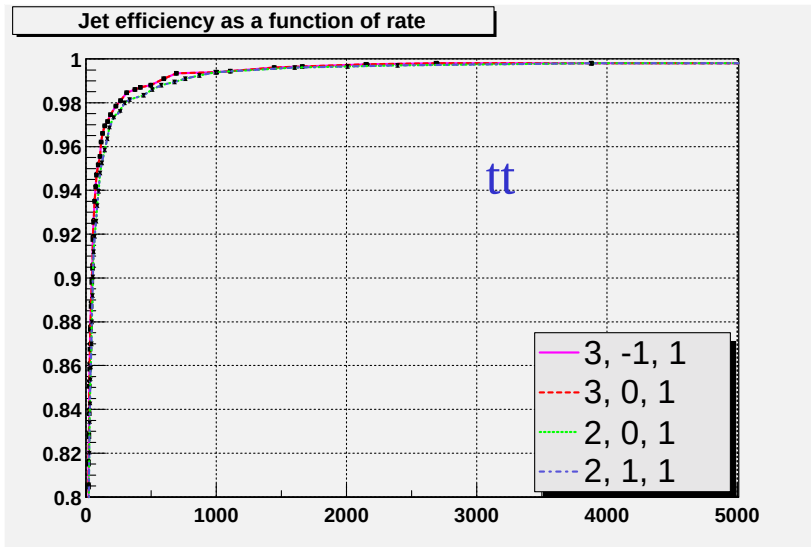
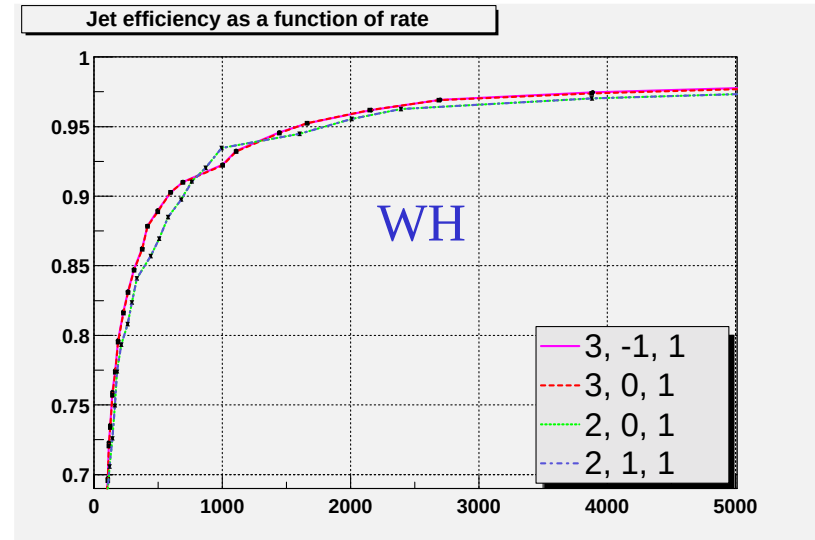


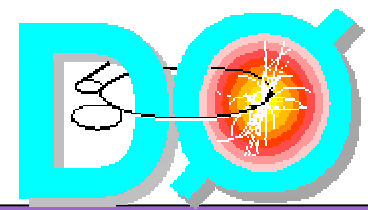


# Single Jet Trigger



- ◆ Efficiency (fraction of events that trigger) vs. rate, for single jet triggers,  $|\eta| < 3.5$ . Assumed luminosity:  $5 \times 10^{32} \text{ cm}^{-2}\text{s}^{-1}$ .

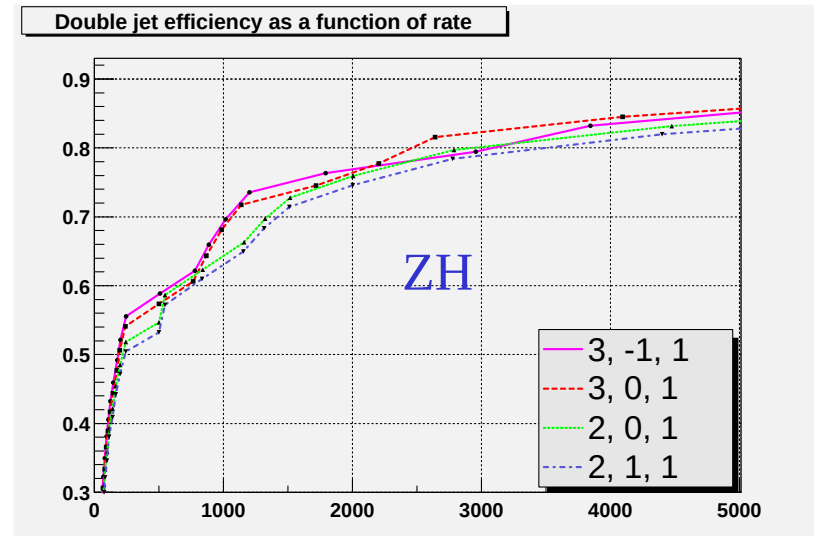
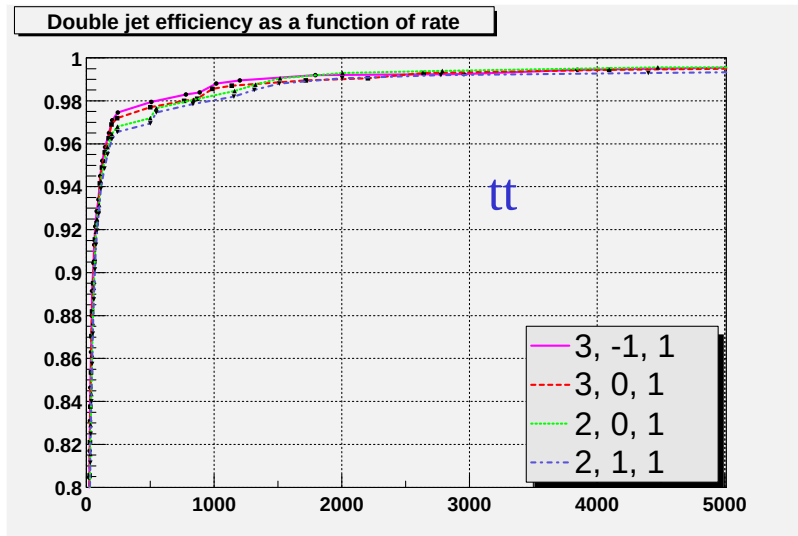
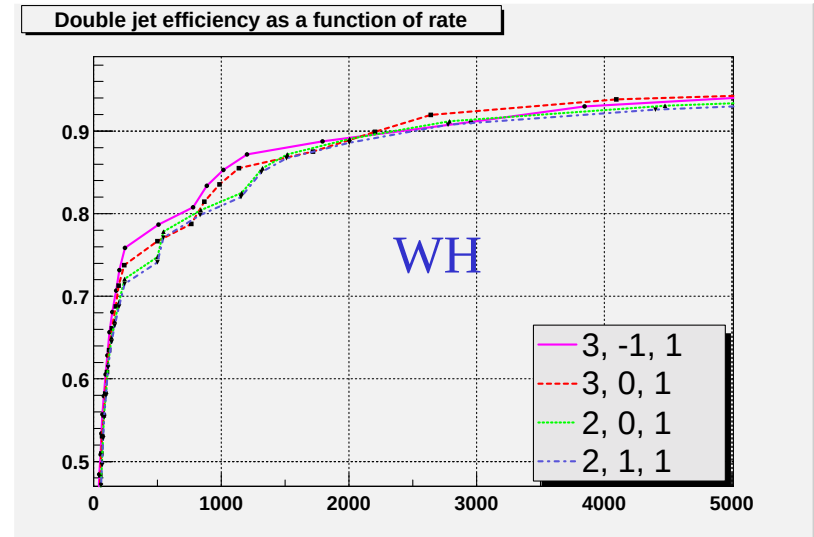


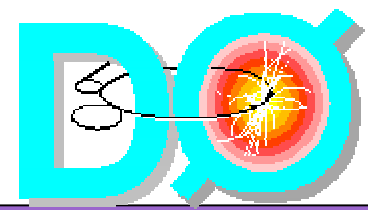


# Double Jet Trigger



- ◆ Efficiency (fraction of events that trigger) vs. rate, for double jet triggers ( $E_T$  cutoff the same for both jets),  $|\eta| < 3.5$ .  
Assumed luminosity:  $5 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$ .

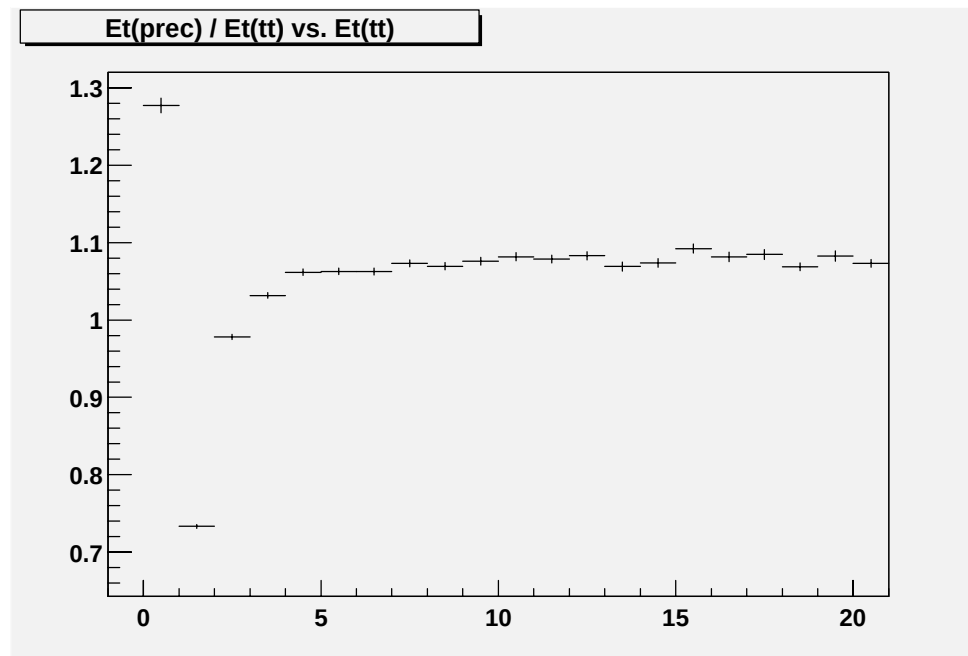


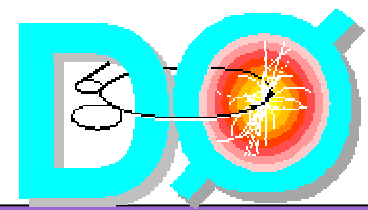


# ICR Question



- ◆ A question that needs to be answered is whether the detectors in the ICR should be used by the L1 calorimeter trigger.
- ◆ Simulation preliminary: trigsim does not model the ICR well, so we need to use trigger towers recreated from the precision readout. Absolute scales are not comparable, but trends provide info:



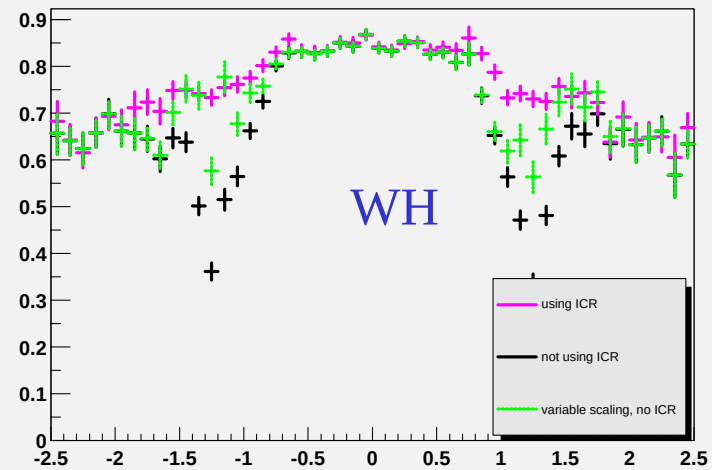


# $E_T(tc) / E_T(jccb)$ vs Eta

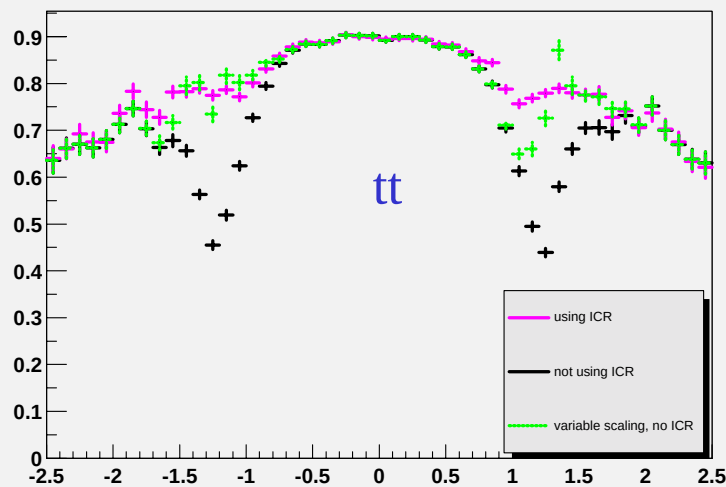


- ◆ Including the ICR detectors improves the trigger uniformity.
- ◆ Attempts can be made to tune the ICR response without actually using the detectors.

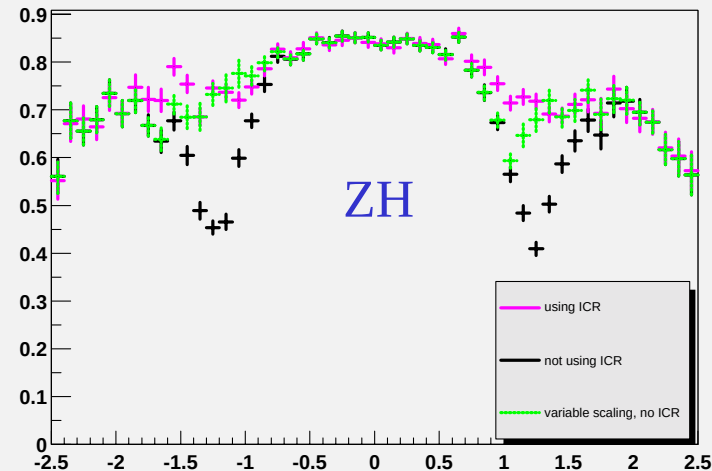
The jet energy fraction as a function of eta

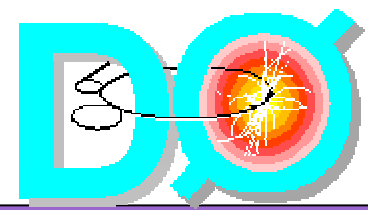


The jet energy fraction as a function of eta



The jet energy fraction as a function of eta

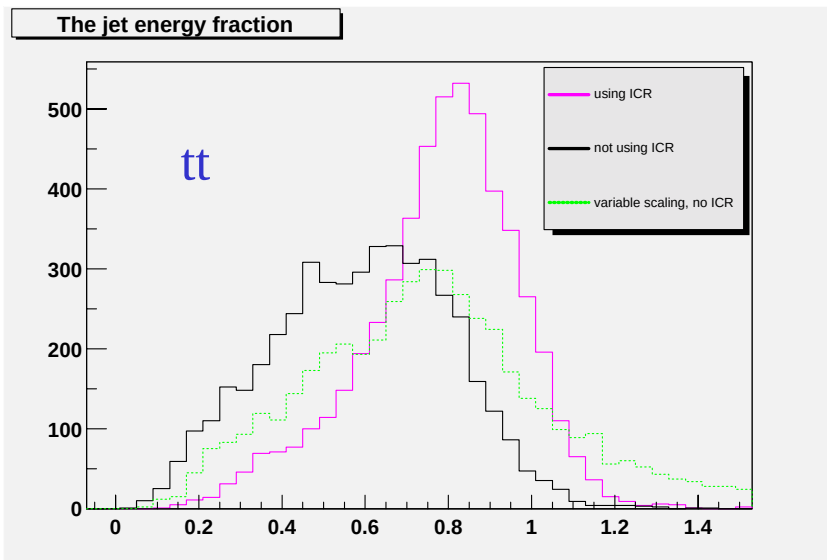
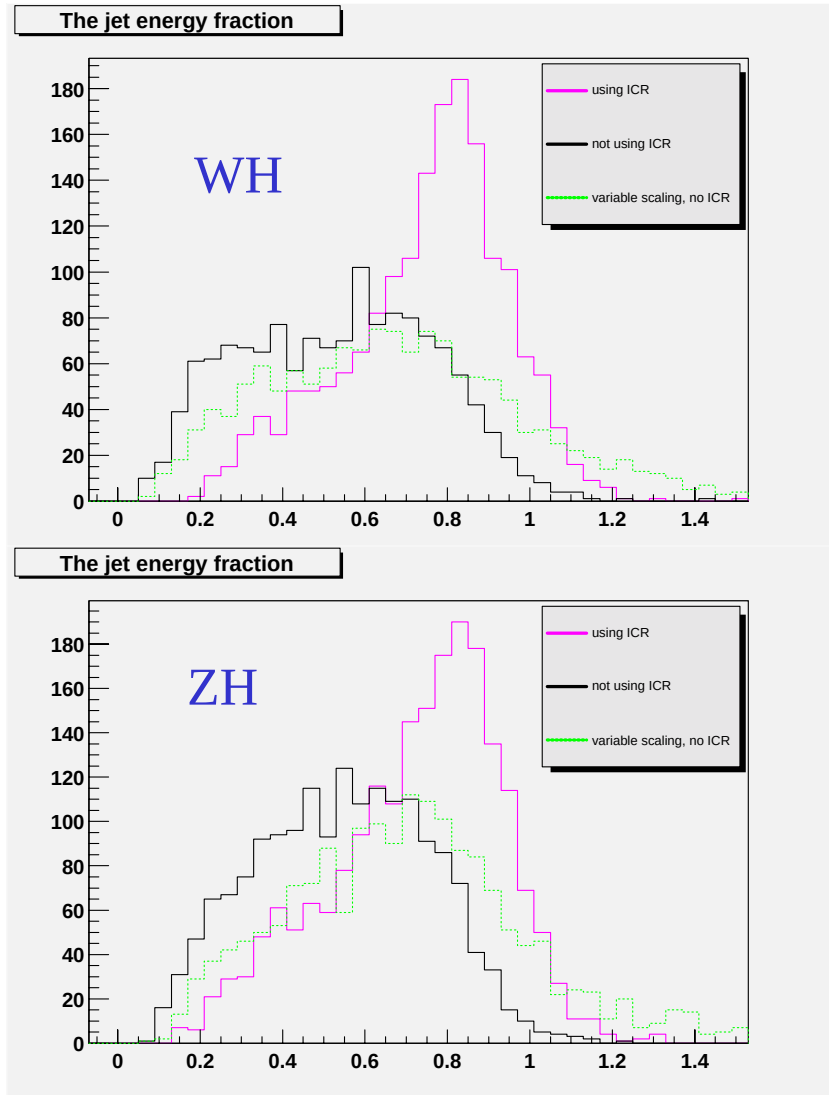


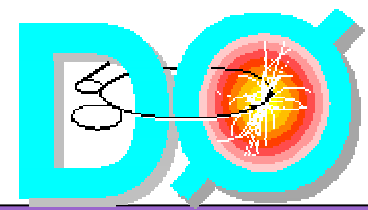


# $E_T(tc) / E_T(jccb)$ in ICR



- ◆ Not including the ICR detectors results in poor resolution in the ICR, even if some scaling is employed.
- ◆ Plots are of  $0.9 < |\eta| < 1.5$

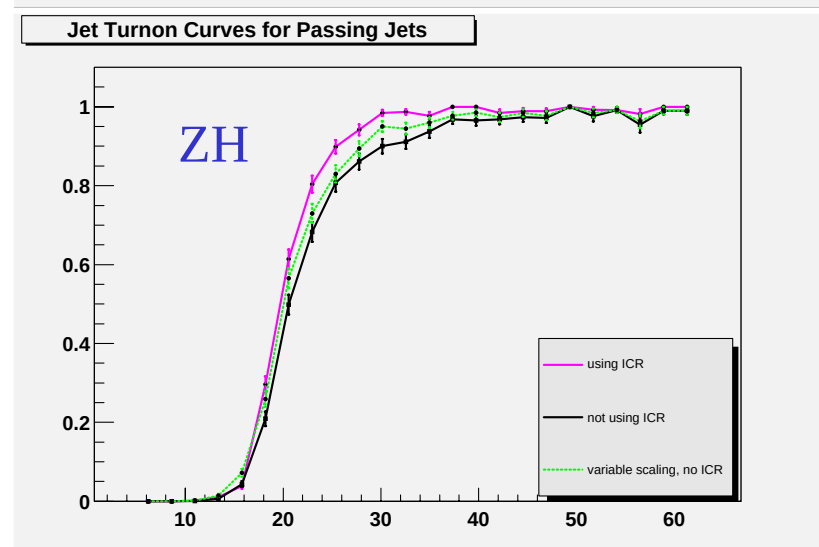
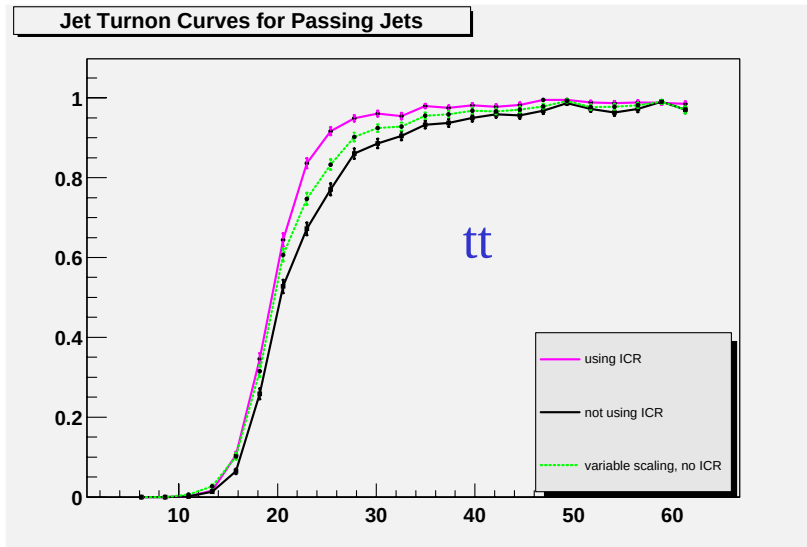
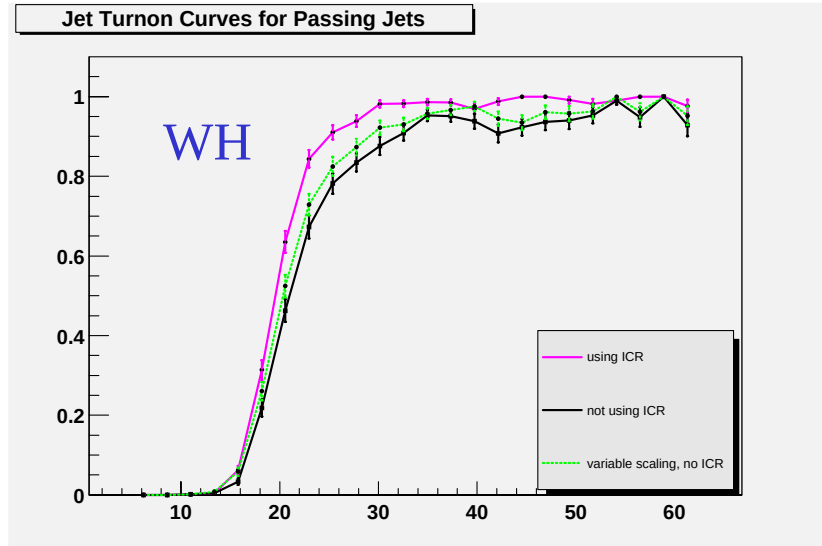


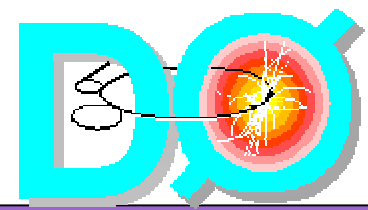


# Turn-on Curves



- ◆ Including the ICR detectors improves the turn-on curves.
- ◆ The simple scaling schemes is shown to perform in between the with ICR and the plain without ICR schemes.

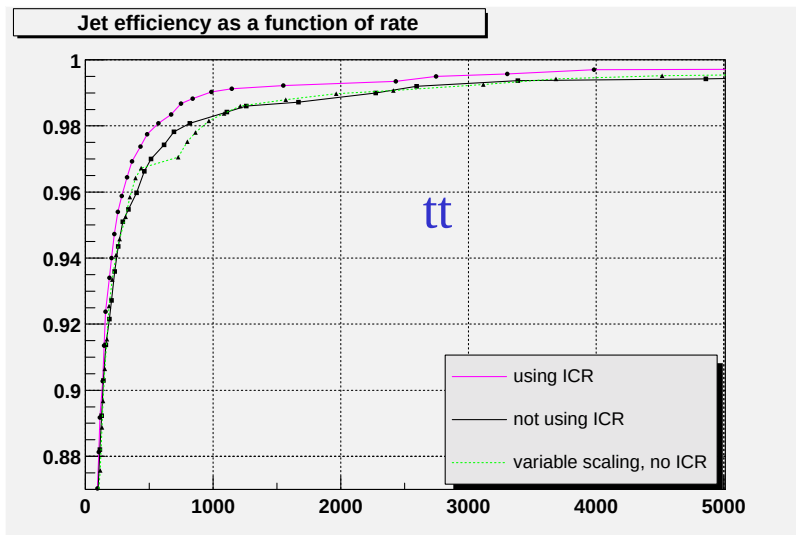
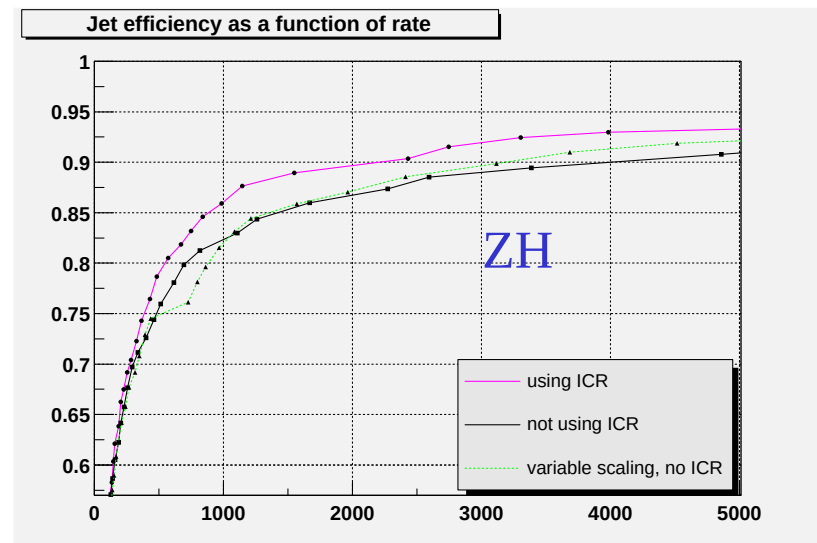
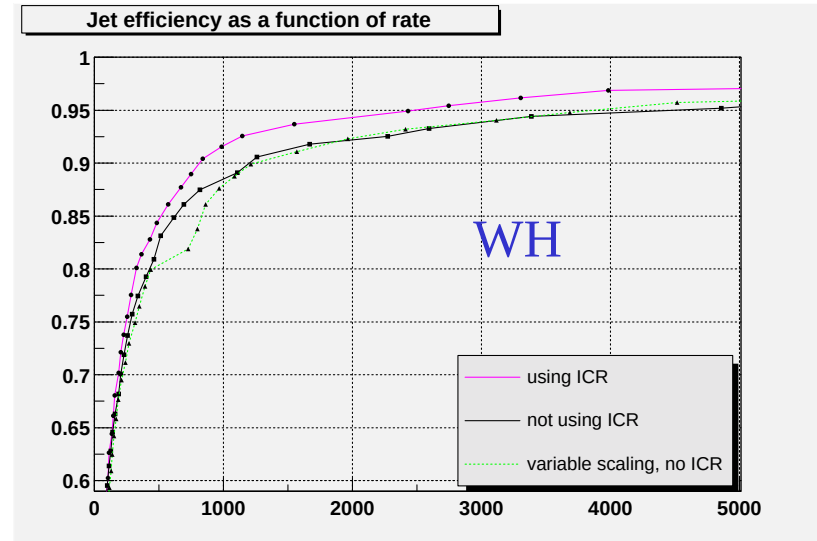




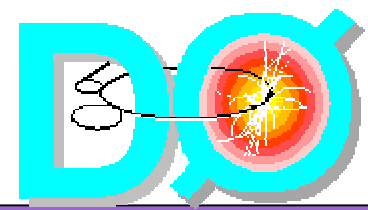
# Single Jet Trigger



- ◆ Including the ICR detectors improves the efficiency vs. rate curves for single jet triggers.
- ◆ The simple scaling scheme's effect is minimal, but maybe a better scaling scheme (e.g. scaling before algorithm) will have more of an effect.



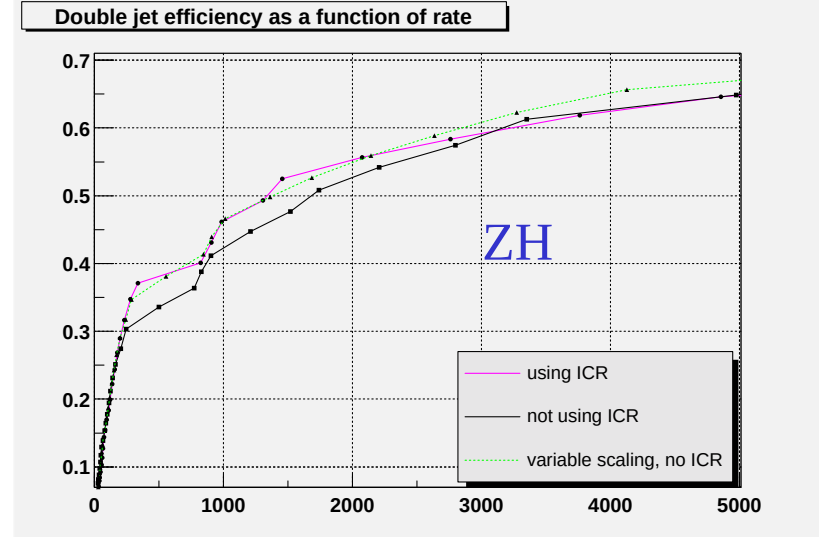
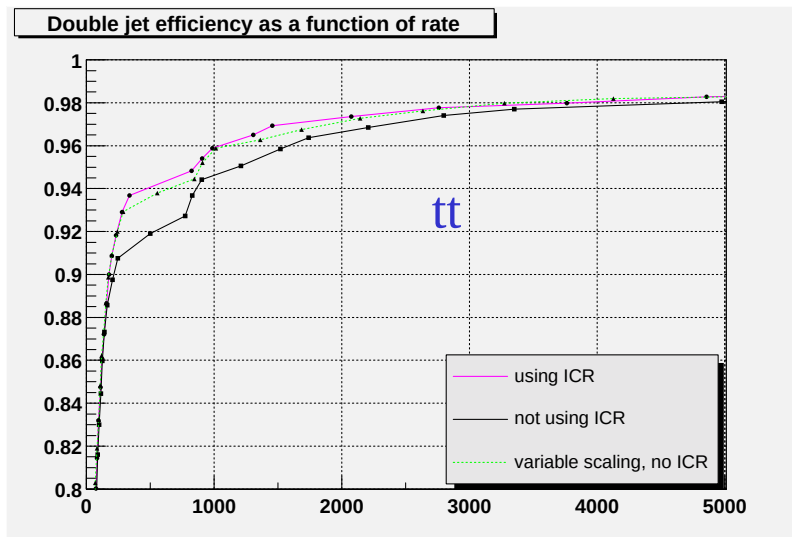
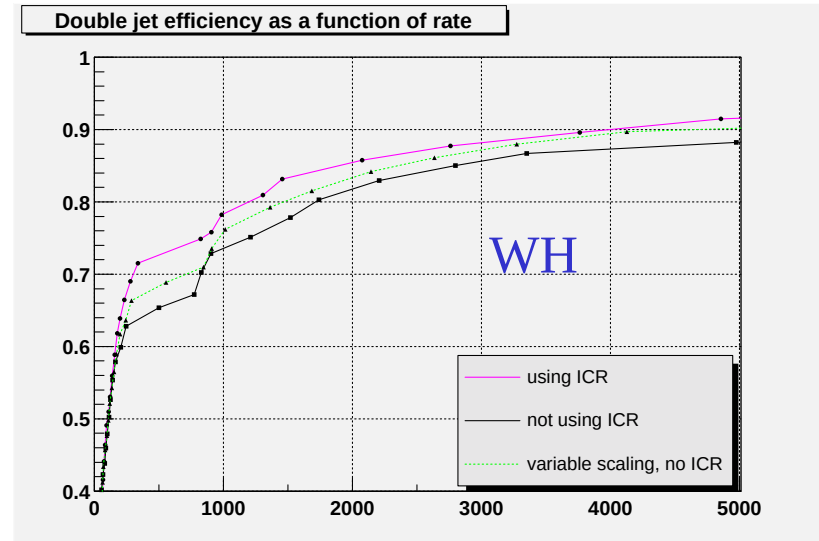


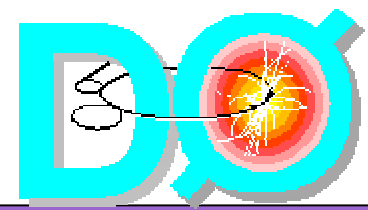


# Double Jet Trigger



- ◆ Including the ICR detectors improves the efficiency vs. rate curves for double jet triggers.
- ◆ The simple scaling scheme performs in between the with ICR and the plain without ICR scheme.



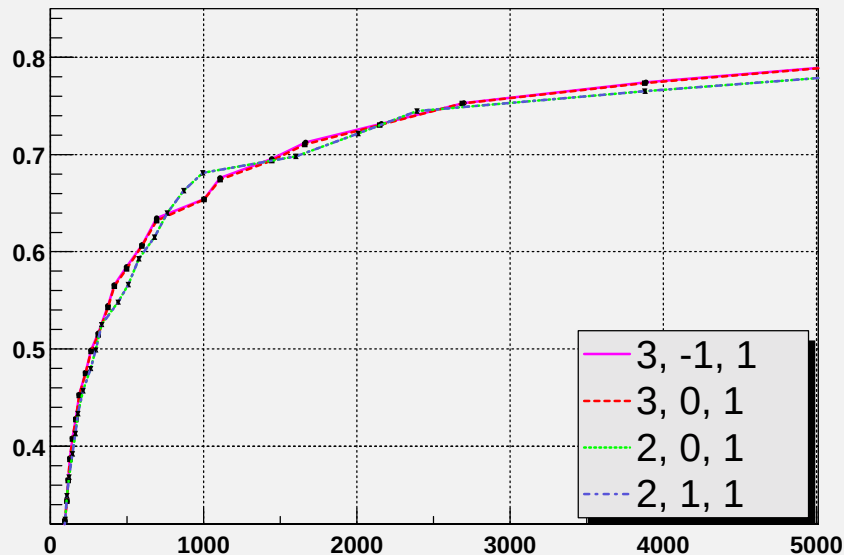


# First Look at Taus

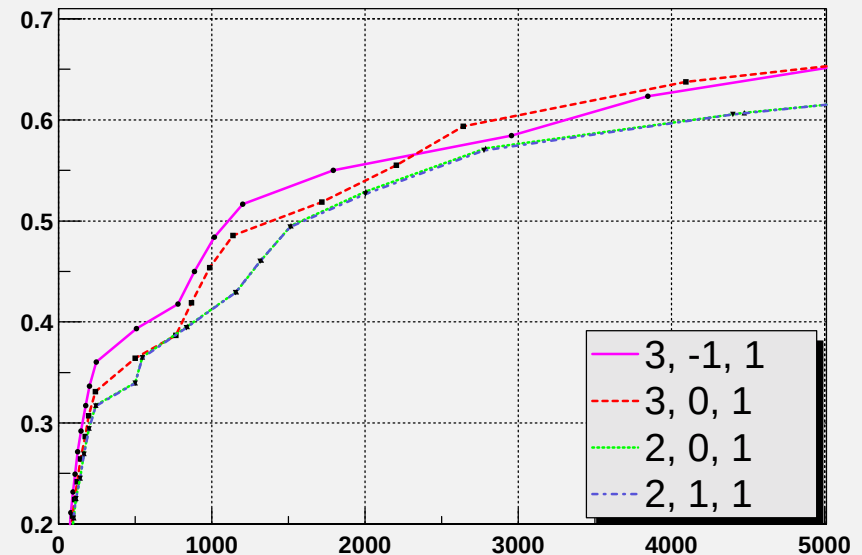


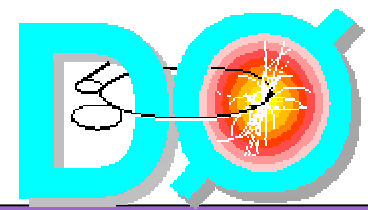
- ◆ The  $H \rightarrow \tau\tau$  reaction could be important for the discovery of the Higgs.
- ◆ It is difficult to trigger on this reaction with just jet triggers while keeping the rate low:

Jet efficiency as a function of rate

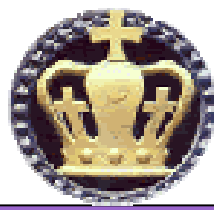


Double jet efficiency as a function of rate

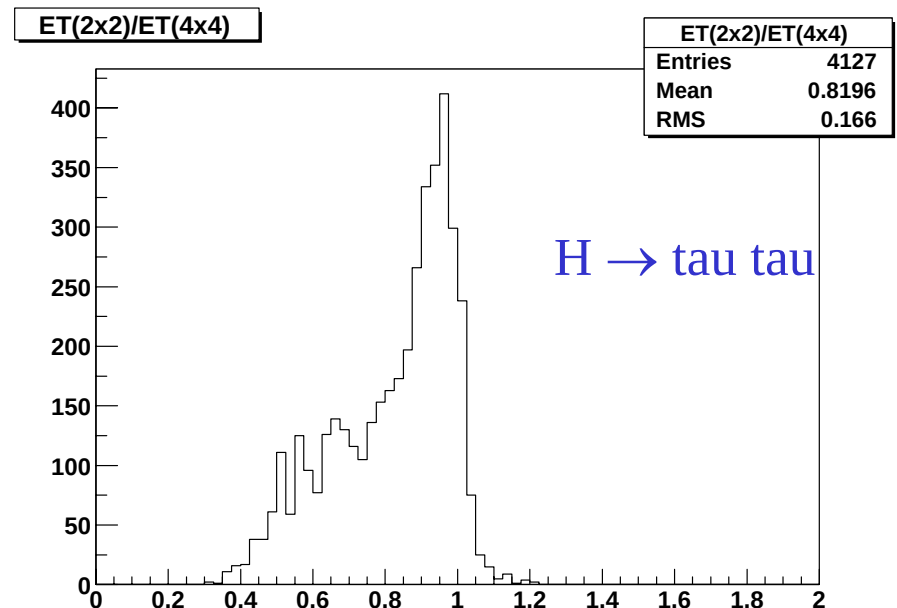
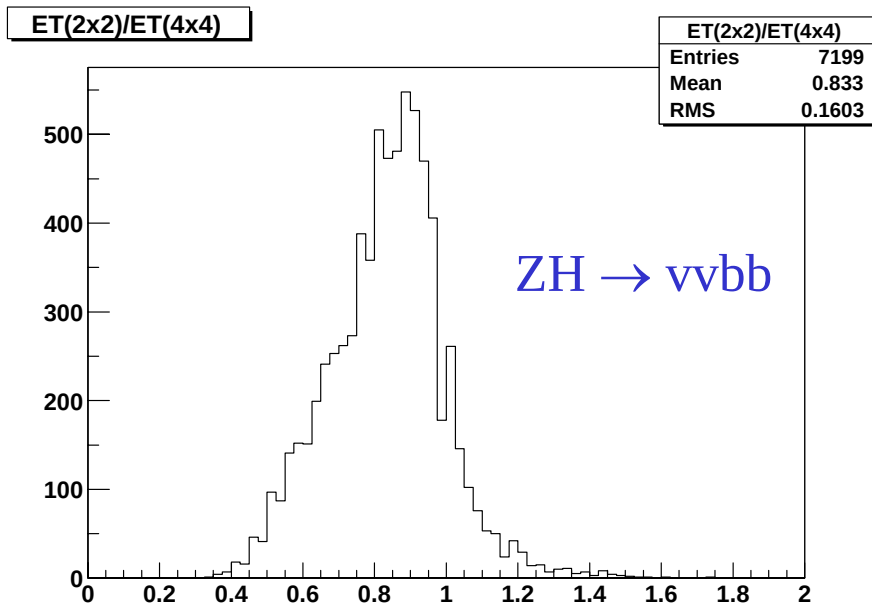


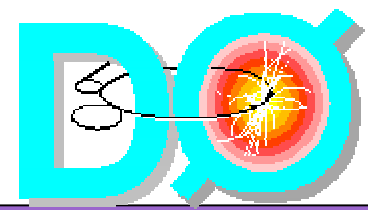


# First Look at Taus



- ◆ Tau jets tend to be narrower than hadronic jets.
- ◆ A possible tau trigger could be envisioned that looks for narrow jets, cutting on the ratio  $E(2 \times 2) / E(4 \times 4)$ .
- ◆ A jet algorithm with a  $2 \times 2$  RoI makes this easy to do .

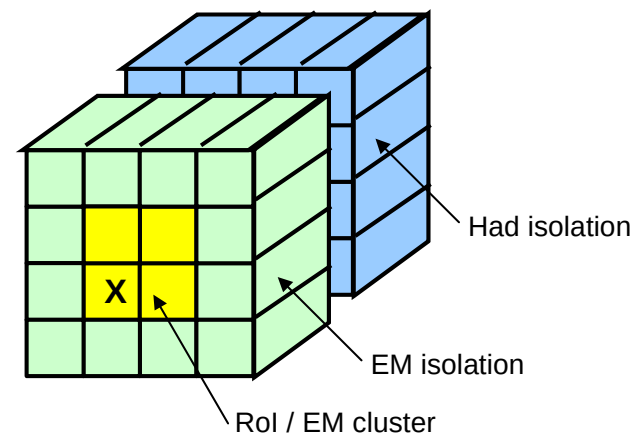


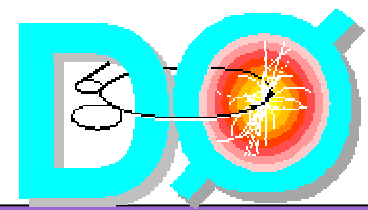


# Electron Trigger



- ◆ We have started intensely studying the electron trigger algorithms.
  - ◆ Atlas scheme or regular  $2 \times 2$  sliding window scheme or none of the above?
  - ◆ What are appropriate EM and hadronic isolation cuts?
    - ◆ Does TT energy saturation need to be handled differently for hadronic cut?
- ◆ First results to come shortly.

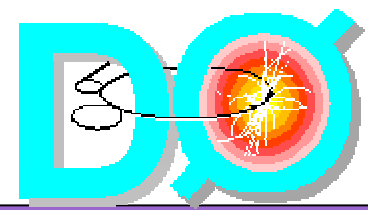




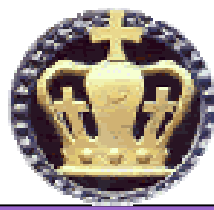
# Summary



- ◆ At Nevis we are undertaking simulation studies to decide:
  - ◆ Which jet algorithm to implement—all have similar performance
    - ◆ Bigger cluster results in better low energy jet resolution.
    - ◆ Smaller cluster and decluster matrix find more jets in busy events as ttbar
    - ◆ 2×2 RoI has better accuracy in position.
    - ◆ 3×3 RoI must be paired with 5×5 decluster to avoid double-counting, resulting in a very complicated algorithm.
    - ◆ 2×2 RoI is more compatible with tau and electron algorithms.
    - ◆ Larger decluster results in better energy resolution of found jets.
    - ◆ Designs for larger decluster matrix algorithms allow for smaller matrix algorithm to be implemented as a backup, but not visa versa.
  - ◆ Should the ICR detectors be included in the algorithms?
  - ◆ Can a tau trigger be designed?
  - ◆ What electron algorithm should be implemented?



# Recommendation so Far



- ◆ The (2, 1, 1) algorithm ( $2 \times 2$  RoI,  $5 \times 5$  decluster,  $4 \times 4$   $E_T$  region) is the one we should design for:
  - ◆ More flexible than the (2, 0, 1) algorithm. For example:
    - ◆ the (2, 0, 1) algorithm can be implemented in a (2, 1, 1) design, but not visa versa
    - ◆ expanding the  $E_T$  cluster size may be possible.
  - ◆ Easier to incorporate alongside the tau and electron algorithms, which are  $2 \times 2$  in structure, than a  $3 \times 3$  algorithm is.
  - ◆ The only well-performing  $3 \times 3$  algorithm is the (3, 0, 1), but that is too complicated, and it suffers in busy events due to the large size.