



# Use of shape variables to characterize events of pp collisions in ALICE.

**Guy Paic, Antonio Ortiz Velásquez**  
Universidad Nacional Autónoma de México, México D. F.



# Definitions of shape variables.

Thrust at hadron colliders is defined in the transverse plane as:

$$T_{\perp,C} \equiv \max_{\vec{n}_T} \frac{\sum_{i \in C} |\vec{q}_{\perp,i} \cdot \vec{n}_T|}{\sum_{i \in C} |\vec{q}_{\perp,i}|}$$

$$\tau_{\perp,C} \equiv 1 - T_{\perp,C}$$

1-T is a measure of the sphericity but now restricted to the transverse plane. Its range starts from 0 for events with narrow back-to-back jets and 0.5 for events with an uniform distribution of momentum.

For the unitary vector  $\vec{n}_T$ , for the events through the maximization above, we can define the thrust minor as:

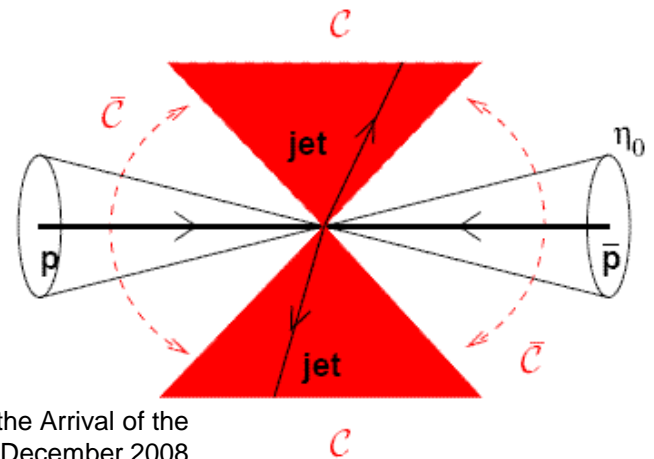
$$T_{m,C} \equiv \frac{\sum_{i \in C} |\vec{q}_{\perp,i} \times \vec{n}_T|}{\sum_{i \in C} |\vec{q}_i|}$$

If the thrust axis and beam direction define an event plane, then thrust minor is a measure of the radiation perpendicular to that plane.

Finally the recoil term is the vector sum of the transverse momentums within the central region:

$$R_{\perp,C} \equiv \frac{|\sum_{i \in C} \vec{q}_{\perp,i}|}{\sum_{i \in C} |\vec{q}_i|}$$

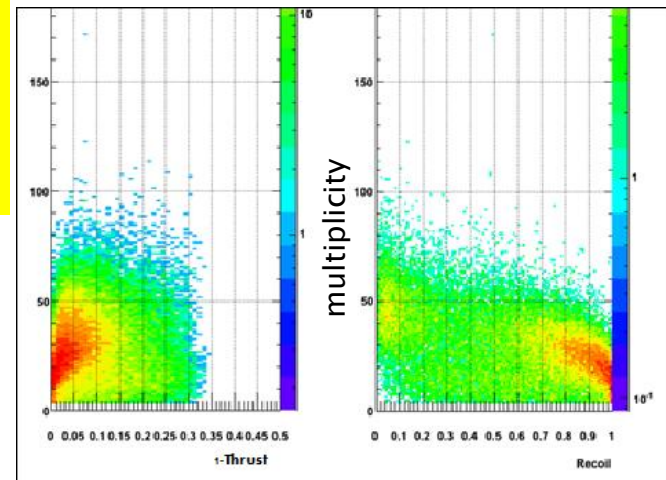
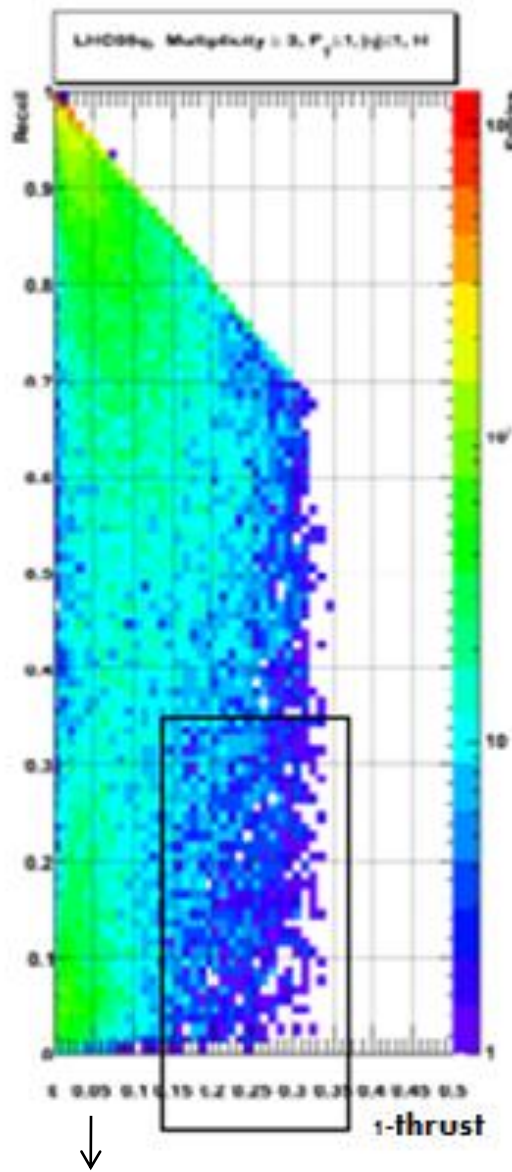
Recoil term is a measure of momentum which is outside from acceptance.



# Shape variables for the hard PT simulations.

Simulations: pp collisions,  
14 TeV,  $p_T$ -hard > 100  
GeV/c, Pythia generator,  
pdf: CTEQ5L  
To get event shape  
50,000 events.  
Variables:

1. At least 3 primary mc particles with transverse momentum above 1 GeV/c.
2. Particles have to be in the eta range  $+\sqrt{1}$



## Map of the events

Recoil term is used to select events which occurs completely in the acceptance of our interest. Lower values of recoil and  $1-T$  correspond to 2-jet events in the acceptance. On the other hand:  $1-T \ll 1$  and Recoil  $\sim 1$  corresponds to 1-jet event in the acceptance.

Lower values of  $1-T$  are related with 2-jet events.

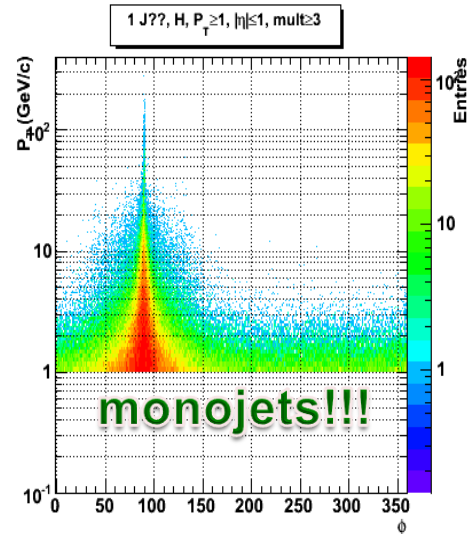
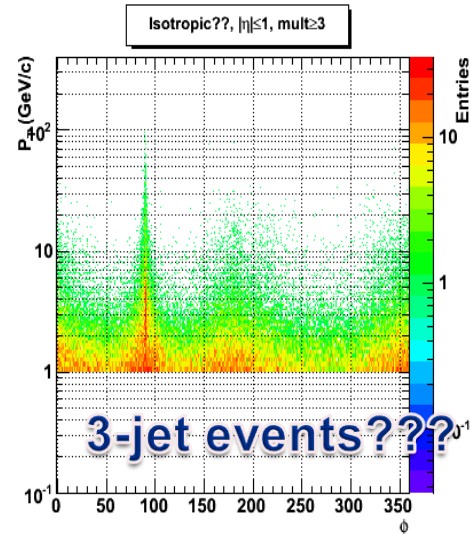
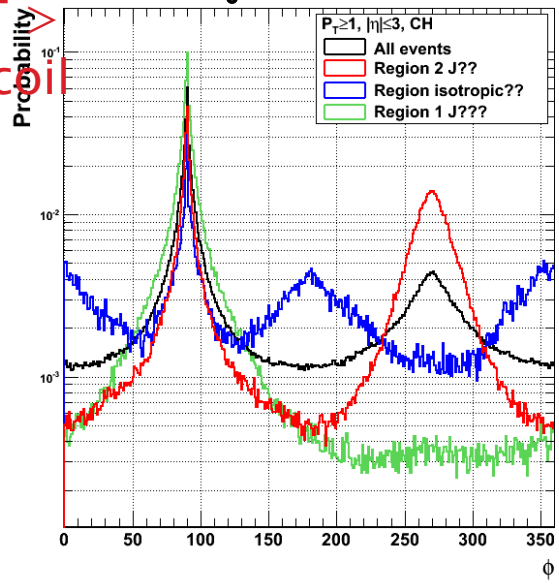
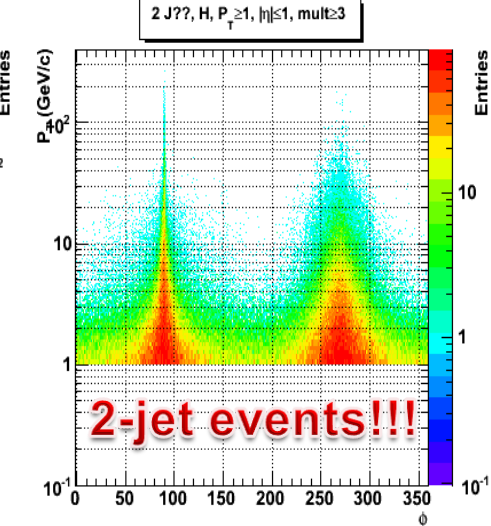
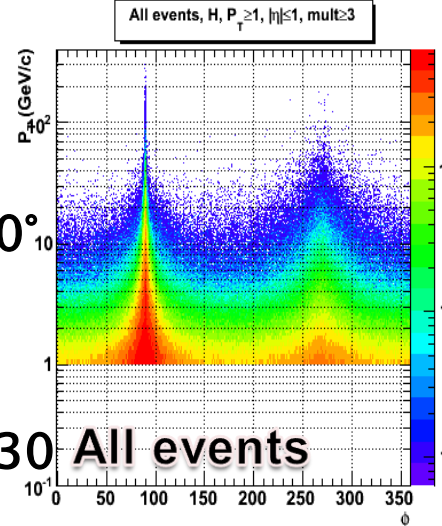
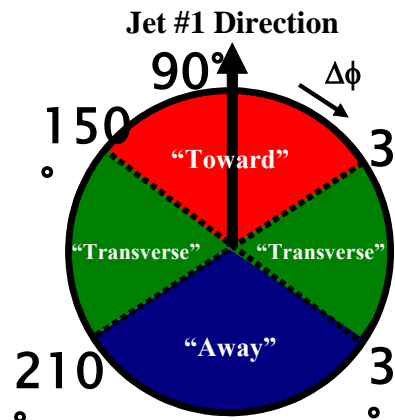
Exploring the topology of the

# Different regions of the thrust map.

1. 2-jet events:  $1 - T < 0.05$ , Recoil  $< 0.35$ .

2. 1-jet events:  $1 - T < 0.05$ , Recoil  $> 0.95$ .

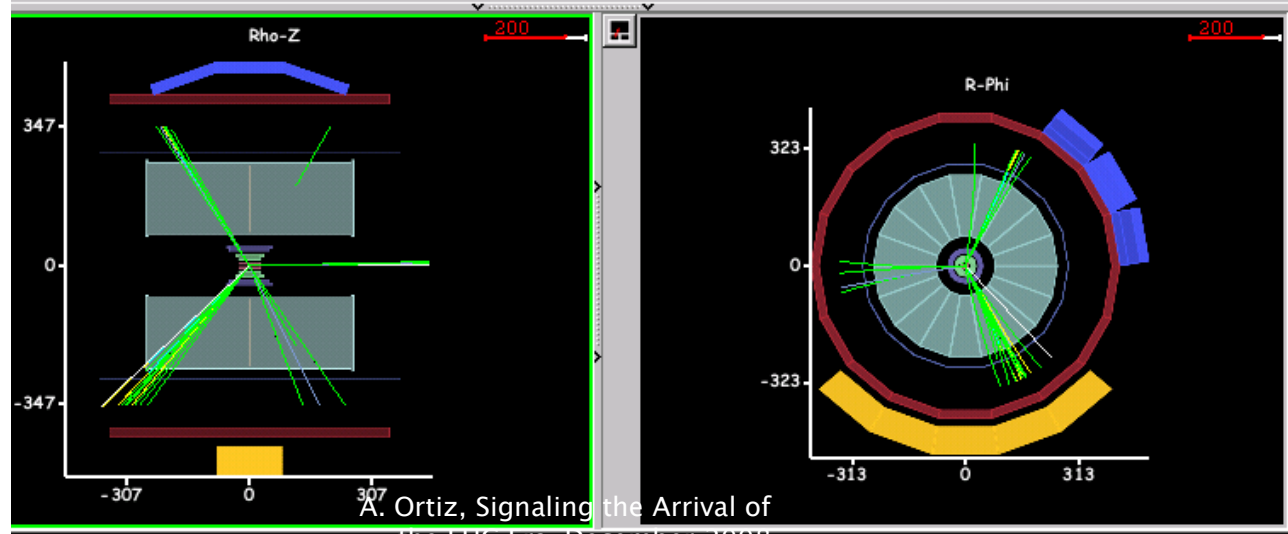
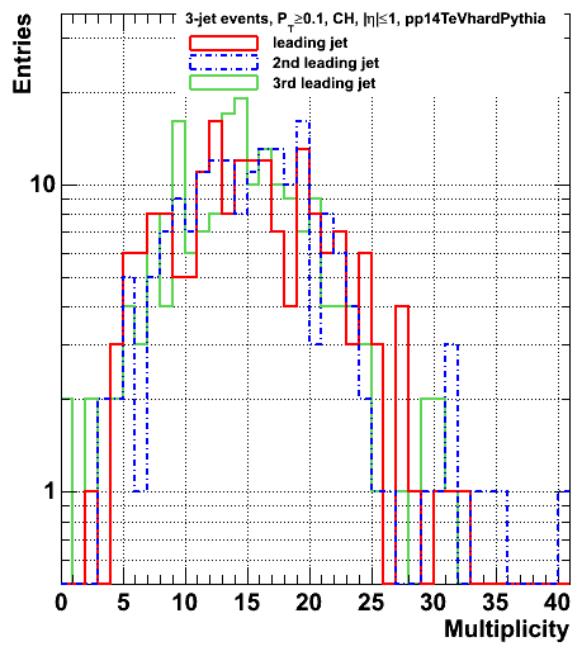
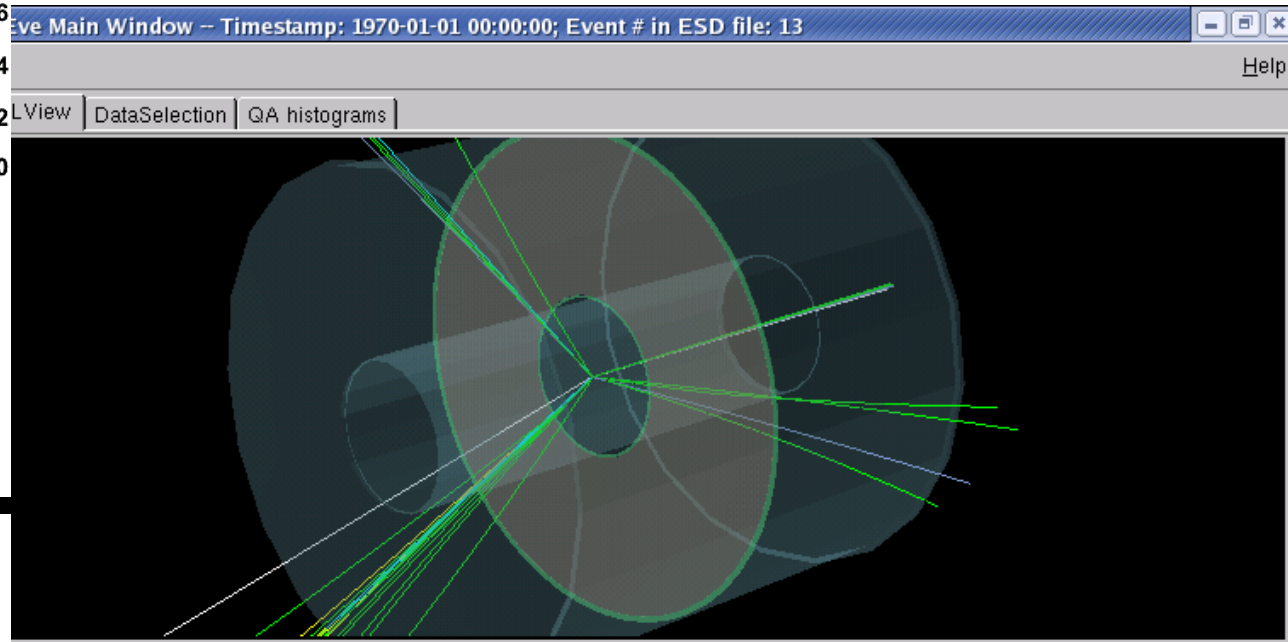
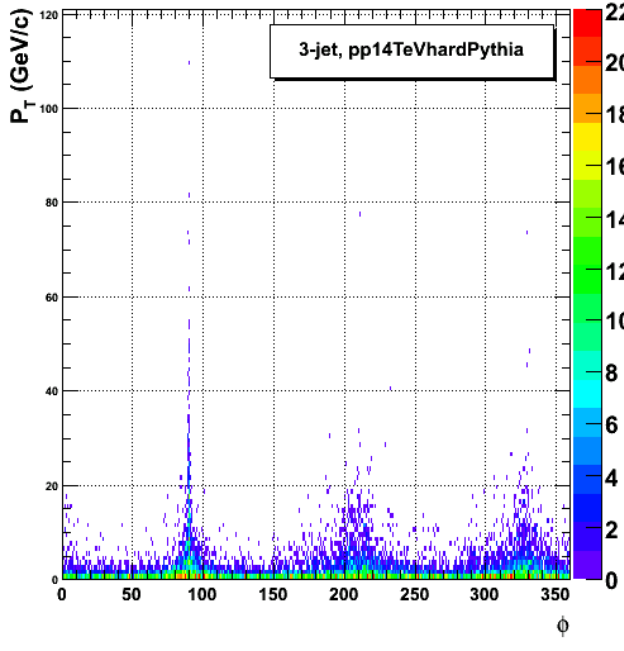
3. Isotropic events:  $1 - T > 0.3$  and Recoil  $< 0.35$



After of the selection of events through the use of thrust map. In these plots are shown the azimuthal distributions of the selected events. Particle with the highest transverse momentum are in  $90^\circ$ , we can see that using the selection of events according with their thrust value it is "easy" to separate events of 1 and 2 jets.

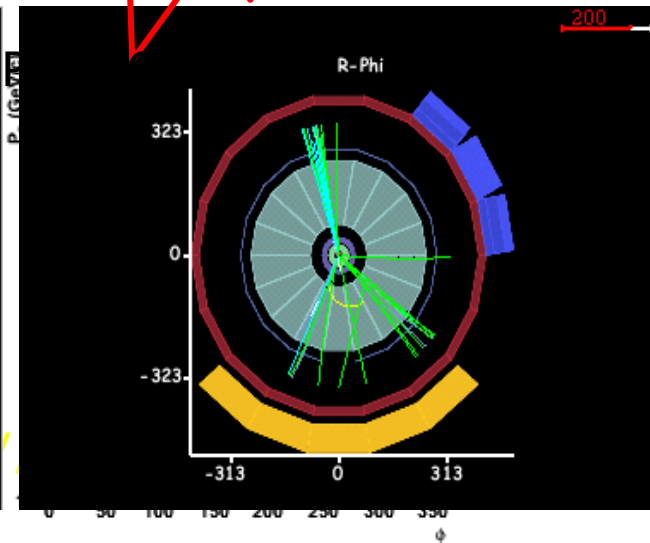
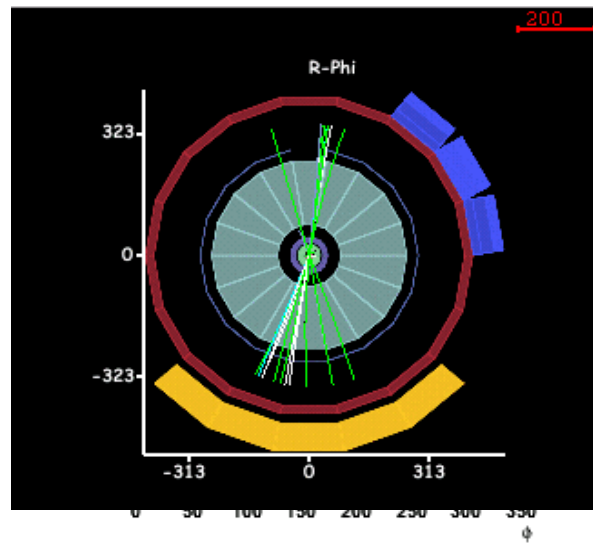
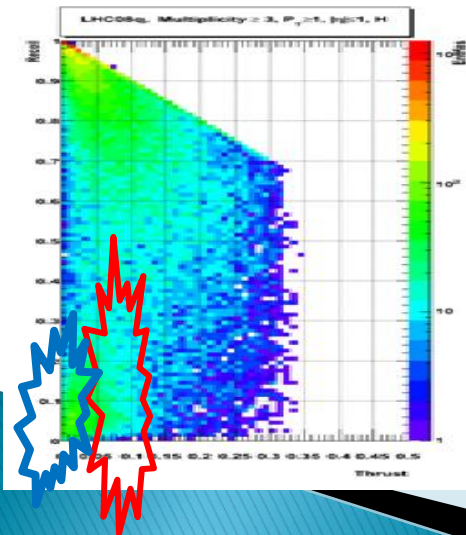
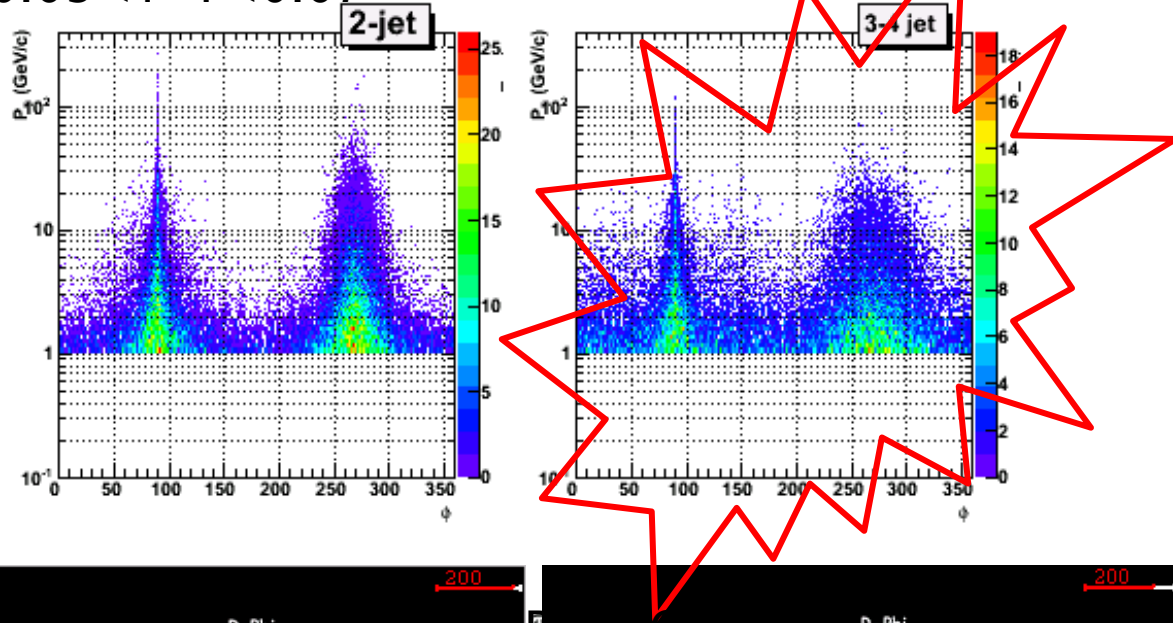
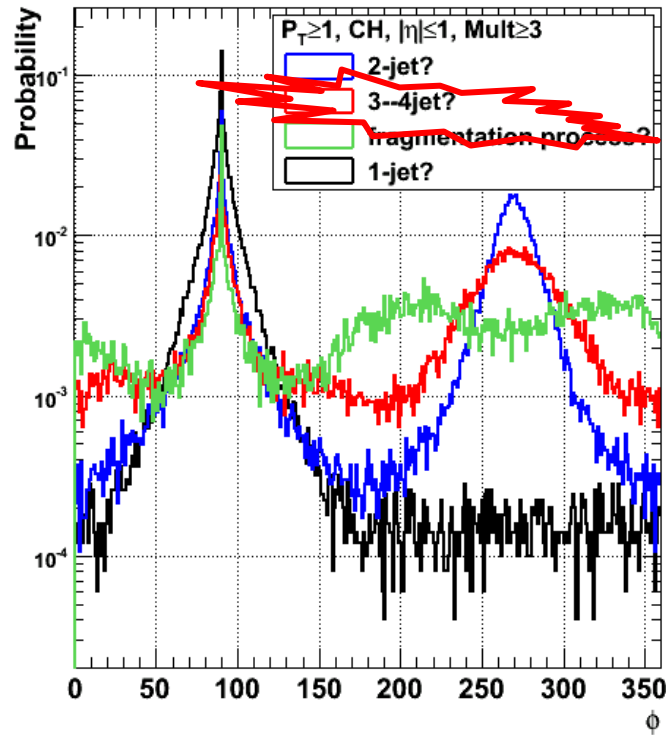
# 100 events (of 3-jet candidates) were scanned, and we find...

We can discriminate 3-jet events with a “mercedes” topology!!!



A. Ortiz, Signaling the Arrival of the LHC Era, December 2008

Moving to another region of thrust map we can see the topology of events which are in the region  $0.03 < 1-T < 0.07$

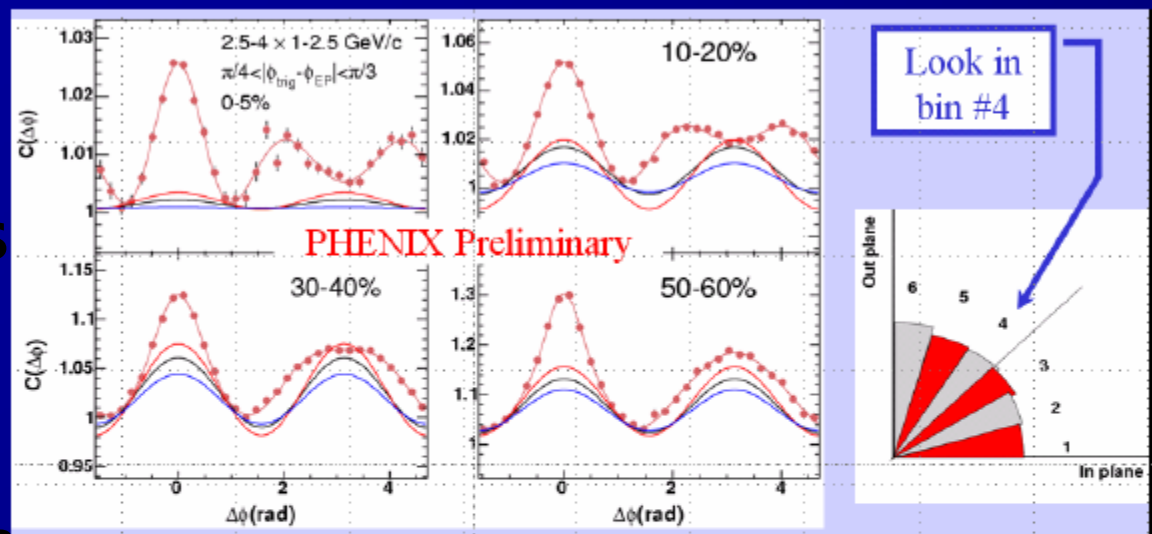


# From Phenix collaboration...

## (qm08) Medium response: conical? flow

Con nuestro método podemos aislar eventos de una topología similar.

From BAC talk QM 2005



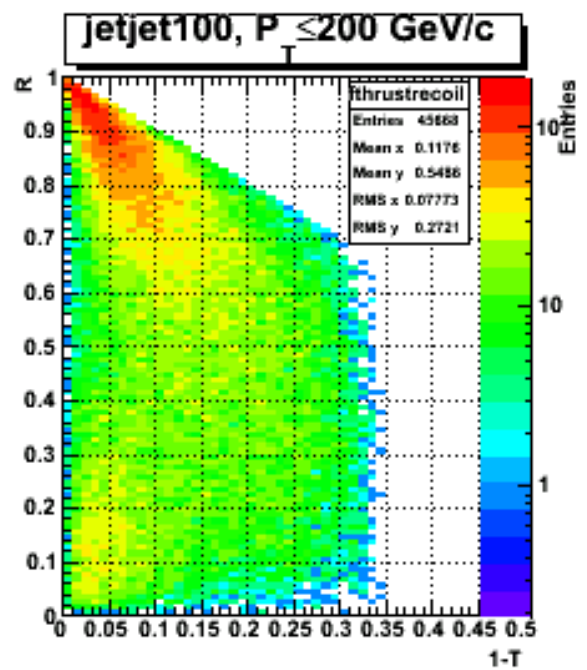
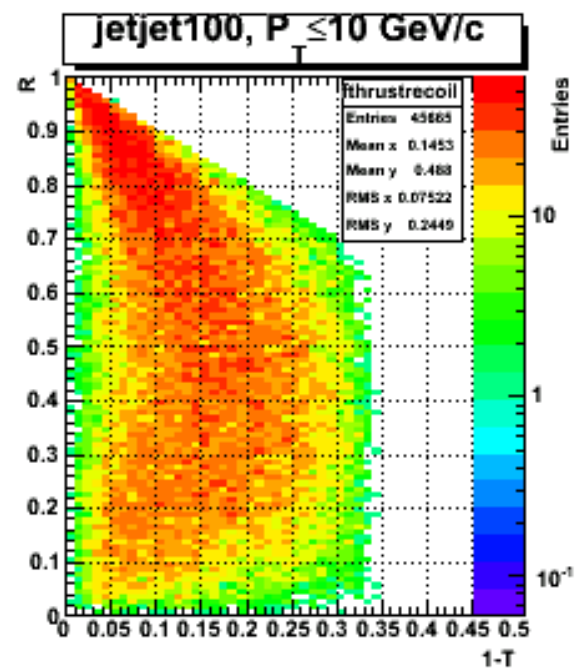
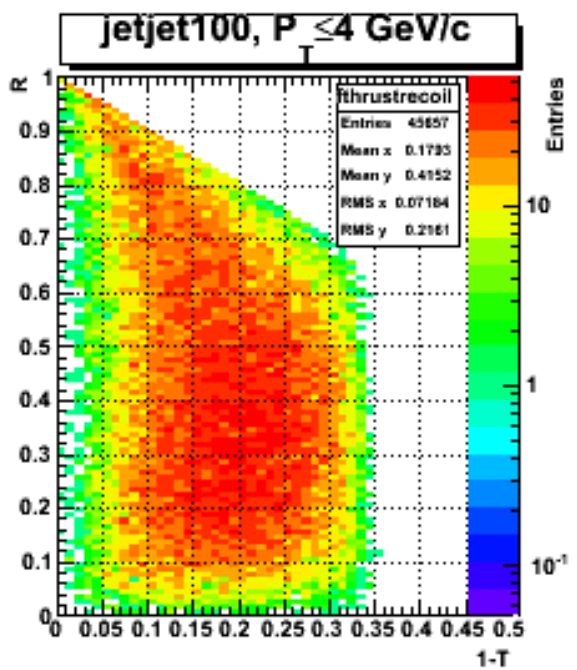
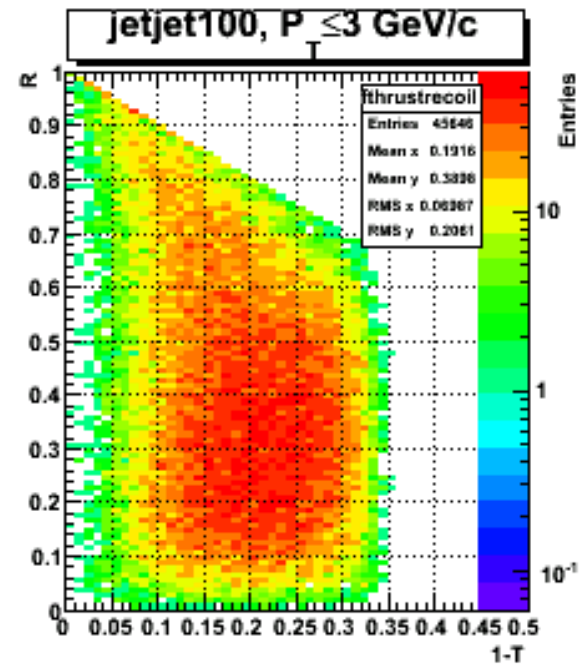
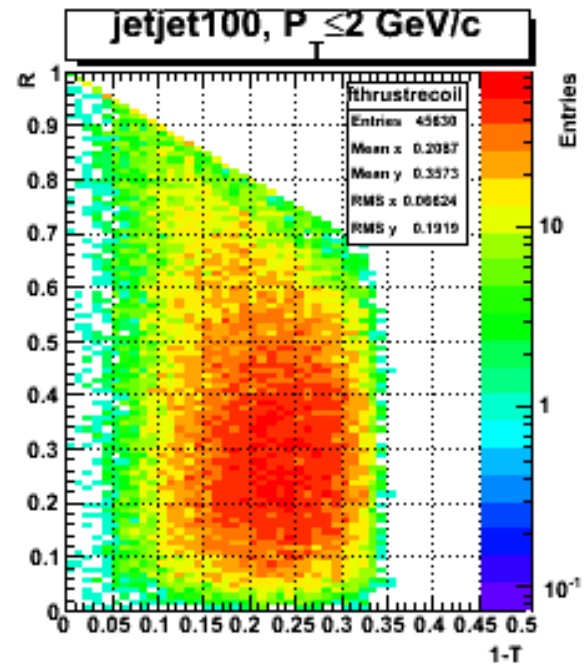
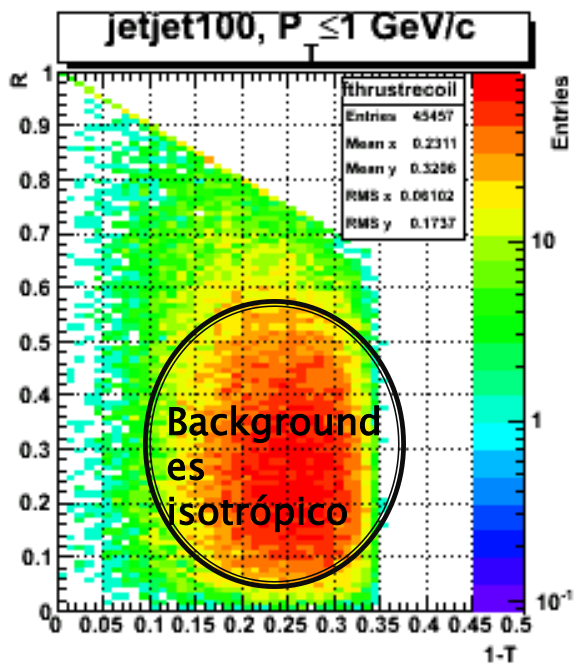
- For PHENIX reaction plane resolution & chosen bin sizes,  $\Delta\phi_{\text{trig}}$  bin 4 has smallest flow effects.
- Even without subtracting flow contribution, a dip is seen for central collisions.

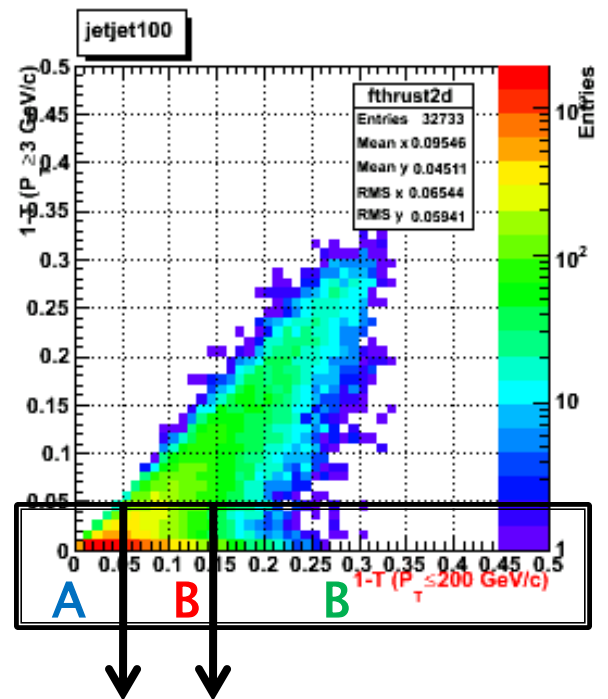
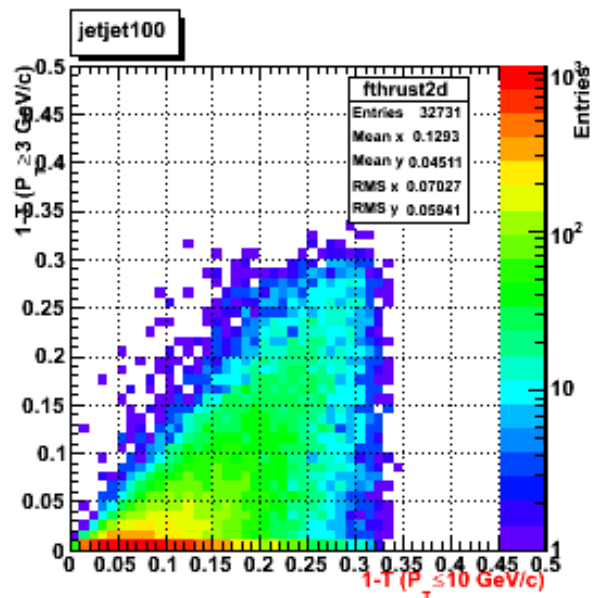
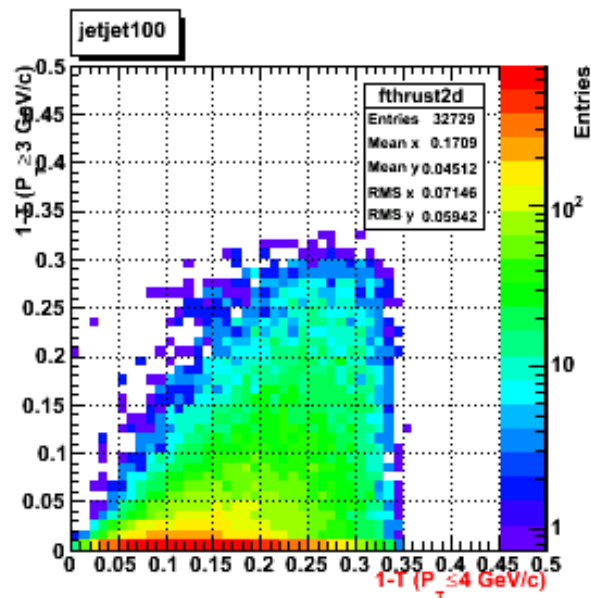
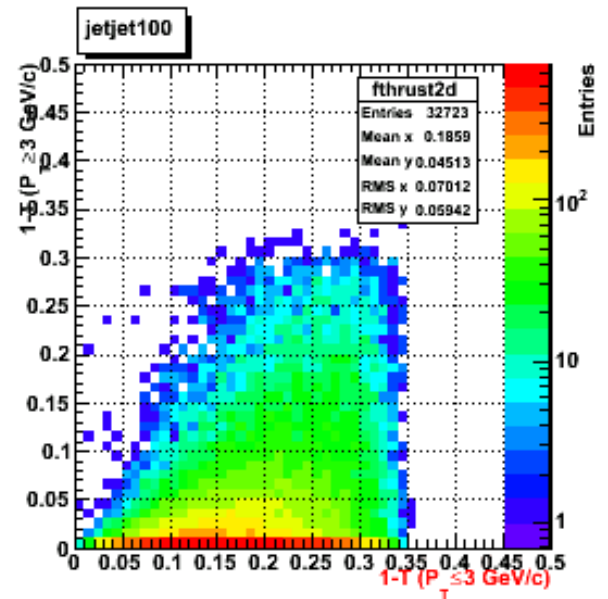
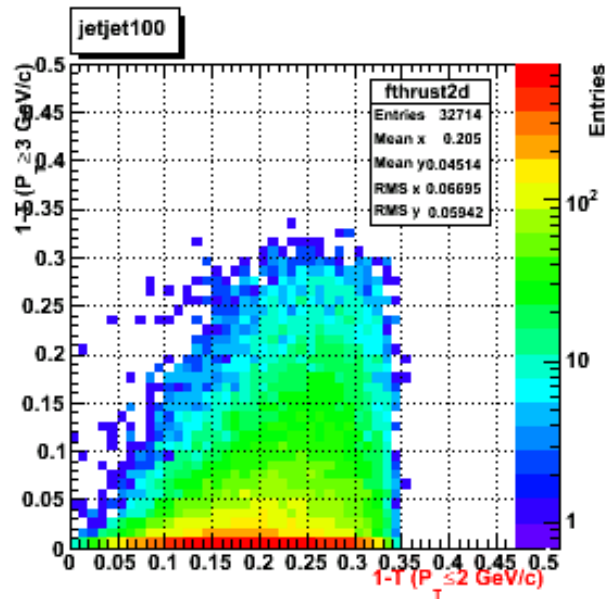
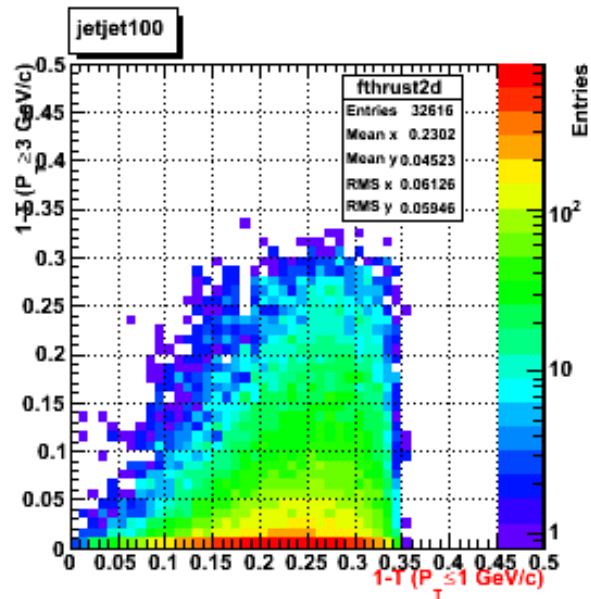
### • Let's get one thing straight:

- The cones? are not an artifact of background subtraction!
- We should not have to discuss this issue any more ...

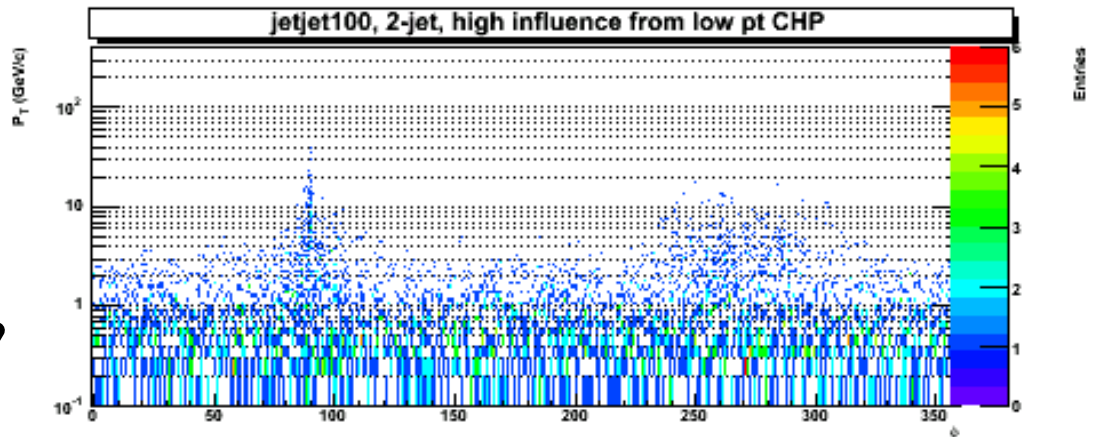
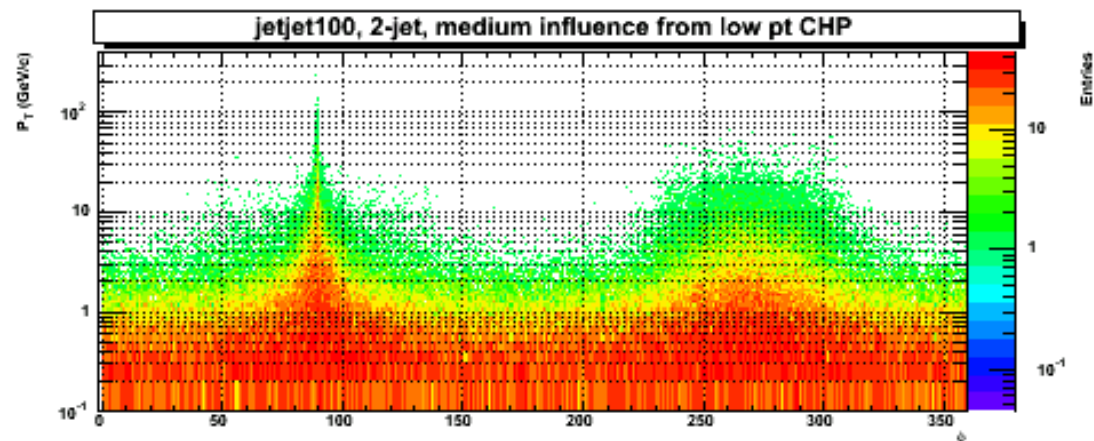
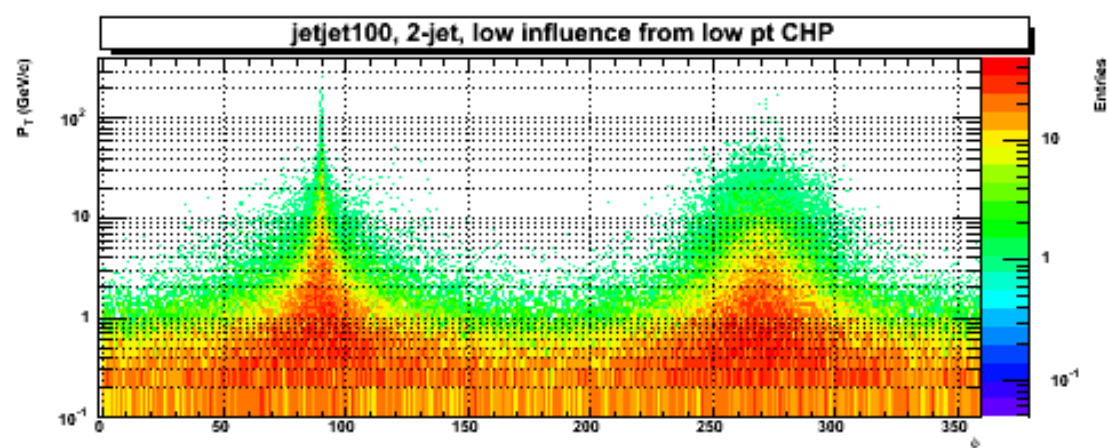
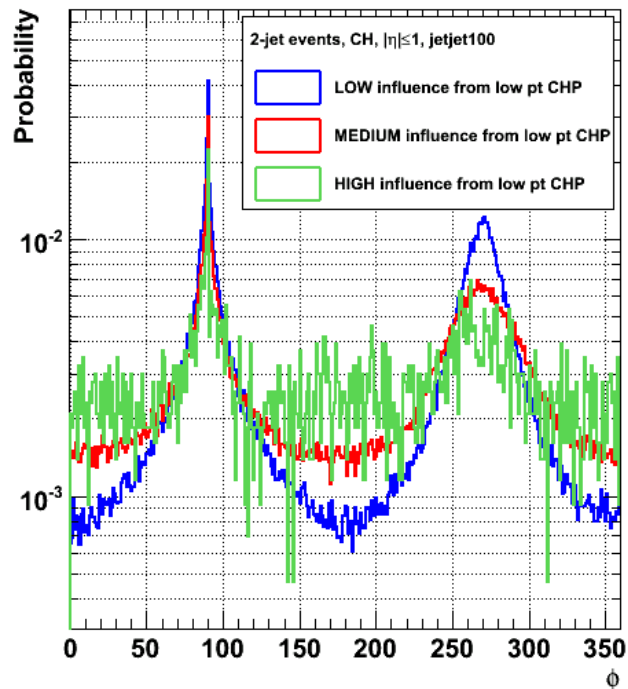
# SENSIBILIDAD DE LOS EVENTOS A LAS PARTÍCULAS DE BAJO MOMENTO.

- ▶ Si para cada evento calculamos las variables de forma usando partículas con  $PT \leq \text{umbral}$ , entonces los eventos lucen más isotrópicos, esto es debido a que en este caso se incluyen eventos underlying.





- ▶ La contribución de las partículas de bajo momento en el valor de las variables de forma, se incrementa conforme la energía del jet disminuye. Como puede verse la región B tiene un background aparentemente más uniforme que la región A. Para la obtención de estas regiones se consideró el calculo de thrust y recoil usando el corte duro  $p_T > 3 \text{ GeV}/c$  (“**THRUST DURO**”). Esta zona ya se estudió y corresponde a 2-jets. Es interesante notar que jugando con los valores de thrust obtenidos mediante la consideración de las partículas de bajo  $p_T > 0.1$  (“**THRUST SUAVE**”), entonces podemos discriminar jets de baja energía (opiniones???) – Si la contribución de las partículas de bajo  $p_T$  se va haciendo más pequeña, entonces seleccionamos jets mas y mas energéticos.



Estos son eventos de 2 jets,  
fueron seleccionando  
usando el mapa de las  
variables de forma  
obtenidas mediante el corte:  
 $PT > 3 \text{ GeV}/c$ .

Conforme se incrementa  
el "thrust suave", el valor  
de la leading disminuye,  
el backgroun es más  
uniformel