Use of event shapes variables to characterize events of pp collisions in ALICE.

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Outline

1. Introduction.
2. About ALICE experiment.
3. About jets.
4. Definitions of shape variables at hadron colliders.
5. Shape variables in Hard pt simulations.
6. Shape variables in MB simulations
7. Conclusions.

Introduction:

At LHC we will be confronted with a copious production of hard events resulting in jets. The multiplicity of these jets may be high. It is therefore important to be able to identify events with different numbers of jets and or jet topologies.

In the present work we applied to the proton - proton data, simulated in ALICE, a method based on the use of event shape variables appropriately adapted to the transverse region and the limited acceptance of ALICE

Using the ALICE framework for simulation, reconstruction and analysis (AliRoot) we report the results for minimum bias and hard pt simulations of pp collisions at LHC energies with the Pythia event generator.

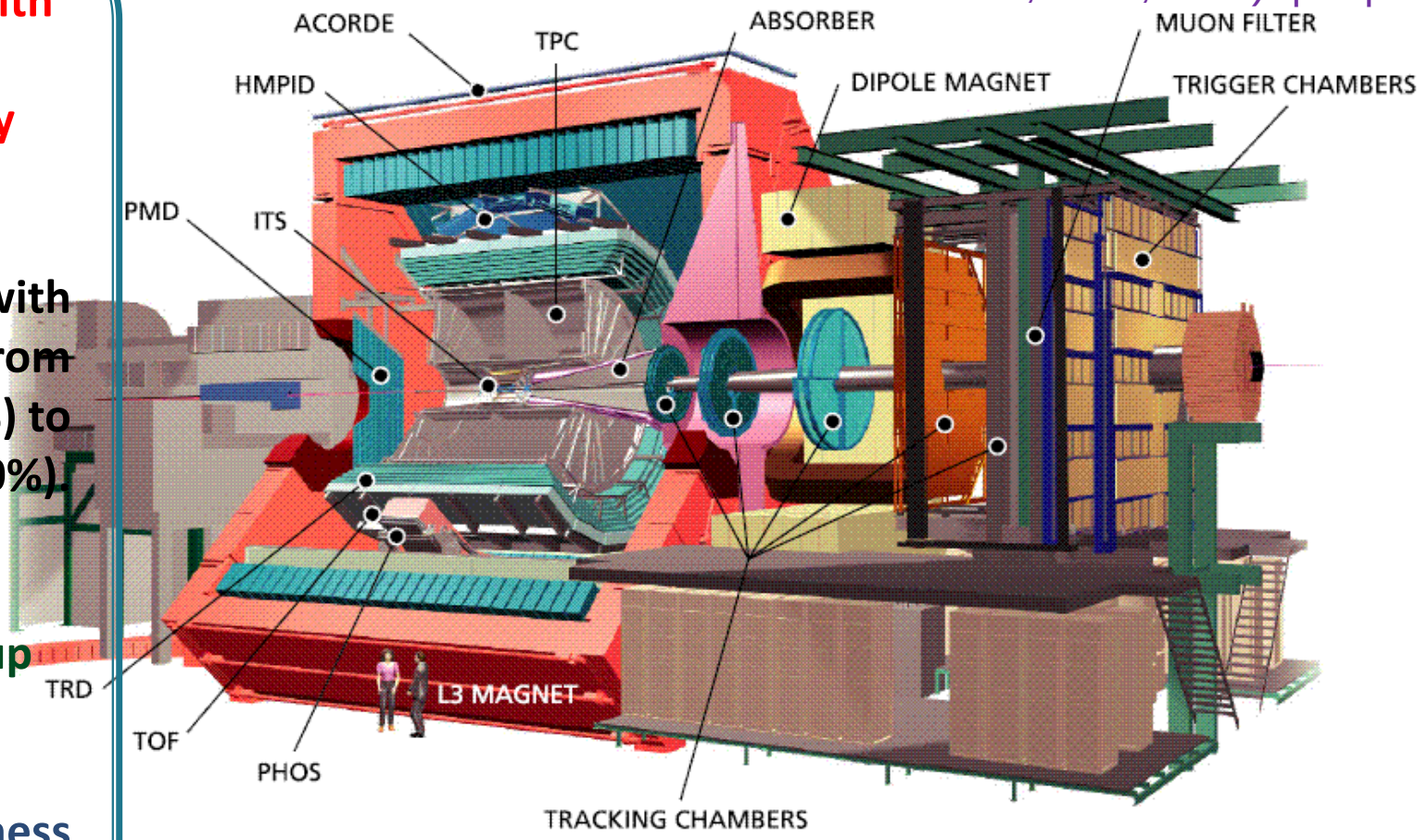
We will discuss the sensitivity of the method to the event multiplicity.

About ALICE experiment.

ALICE is a general-purpose heavy-ion experiment designed to study the physics of strongly interacting matter and the quark-gluon plasma in nucleus-nucleus collisions at the LHC.

Central part covers (ITS, TPC, TRD, TOF): |eta|<1

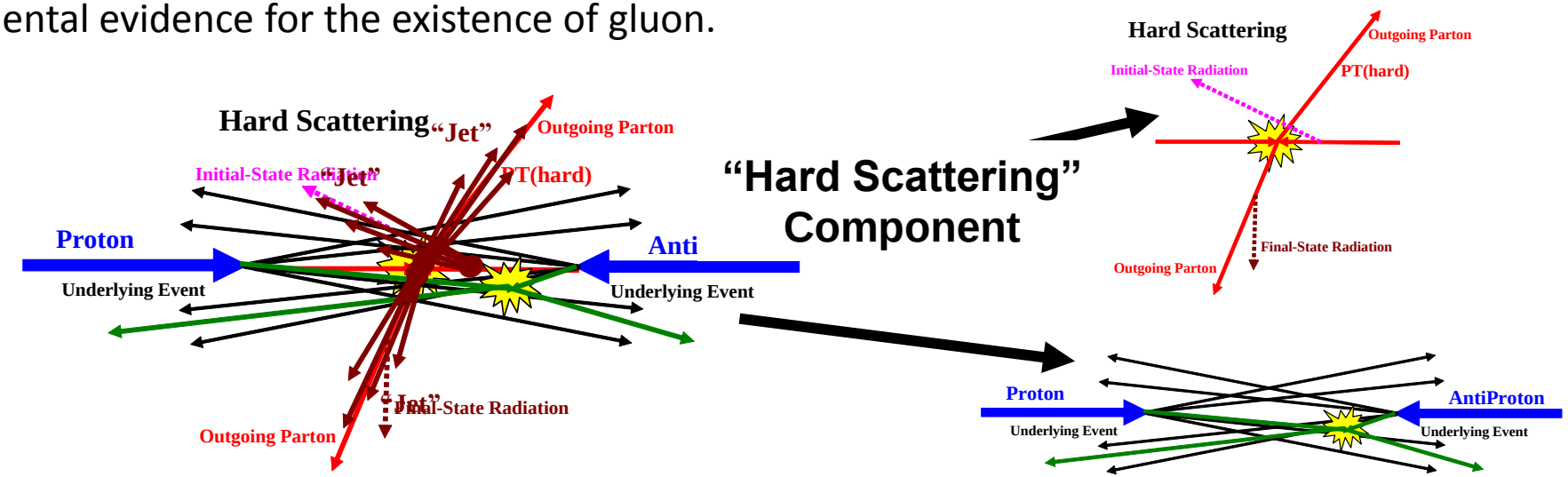
- **Designed to cope with multiplicities up to 8000 CH per rapidity unity.**
- **Powerful tracking with good resolution from 100 MeV/c (1-2%) to 100 GeV/c (10%).**
- **PID over a broad momentum range(up to 5 GeV/c for p).**
- **Low material thickness and low magnetic field (0.5 T).**



Important contributor to pp physics at the LHC!!!

Jets:

In QCD are defined as cascades of consecutive emissions of partons initiated by partons from initial hard scattering. The partons produce the observed hadrons due to confinement. Di-jets were discovered in 1975 in e+e- collisions, the observation of three coplanar jets has provided the first experimental evidence for the existence of gluon.



Experimentally, jets in pp collisions are defined as an excess of transverse energy over the background of the underlying events with a typical cone radius R_C=1 in η-ϕ.

Underlying events are formed from the beam-beam remnants, initial-state radiation and possible from soft and semi-hard multiple parton interactions.

Jet studies allow many important tests of both perturbative and non-perturbative aspects of QCD.

In ALICE we define and construct jets out using tracking measurements, the jets identification is based on different kind of algorithms for example the cone ones.

In this work we propose an alternative method to identify events with different jet topologies.

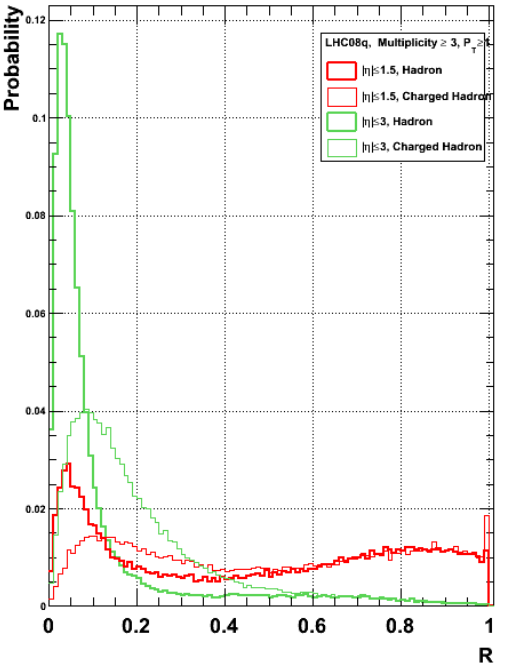
Definitions of shape variables.

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

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

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

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 a uniform distribution of momentum.



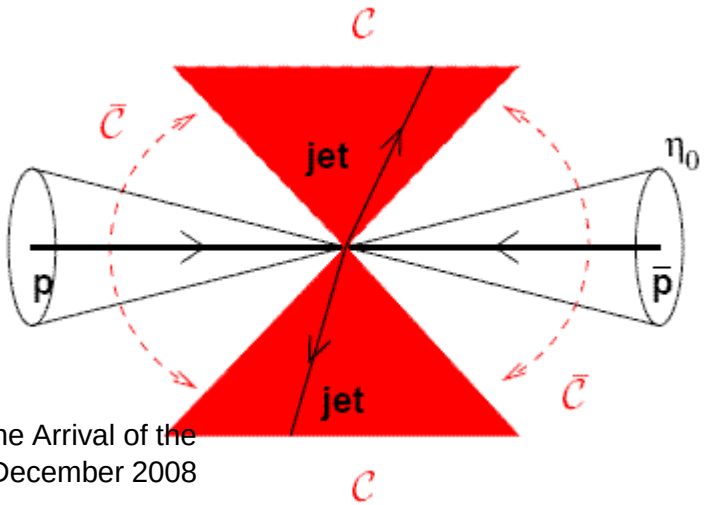
For the unitary vector nT, for the events through the maximization above, we can define the thrust minor as:

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

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

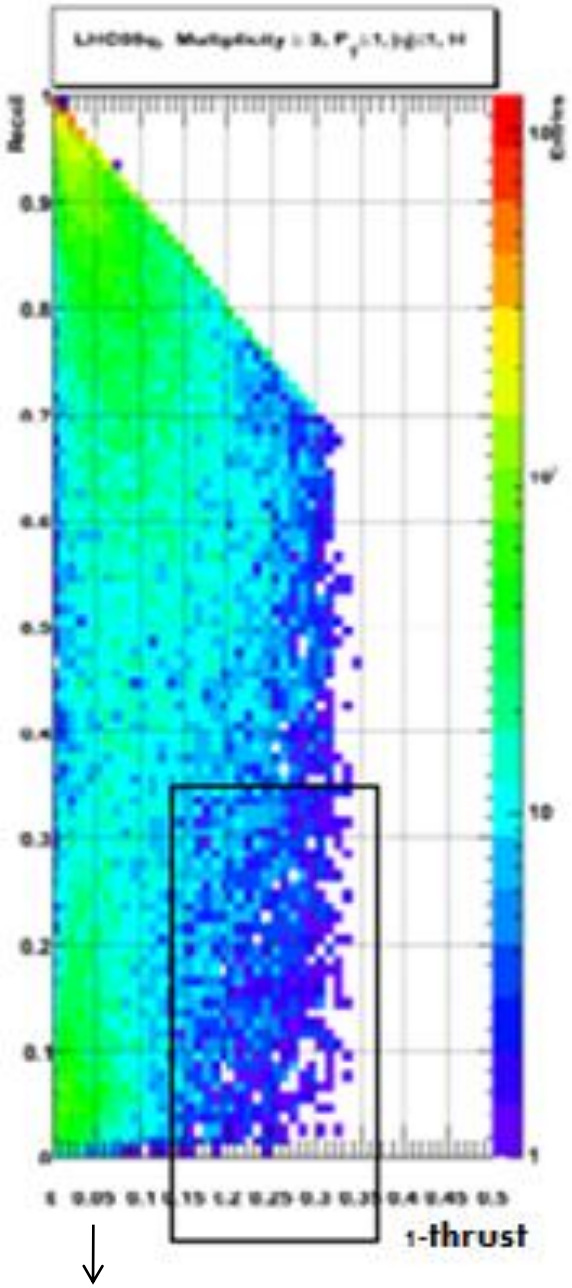
Finally the recoil term is the vector sum of the transverse momentums within the central region:

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



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

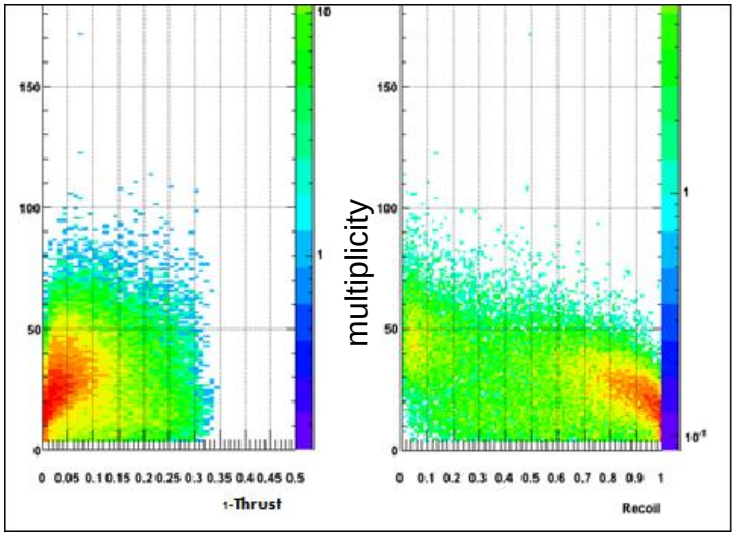
Shape variables for the hard PT simulations.



Simiulations: pp collisions, 14 TeV, pT-hard>100 GeV/c, Pythia generator, pdf: CTEQ5L 50,000 events.

To get event shape variables:

1. At least 3 mc particles with transverse momentum above 1 GeV/c.
2. Particles have to be in the eta range +/- 1



Map of the events

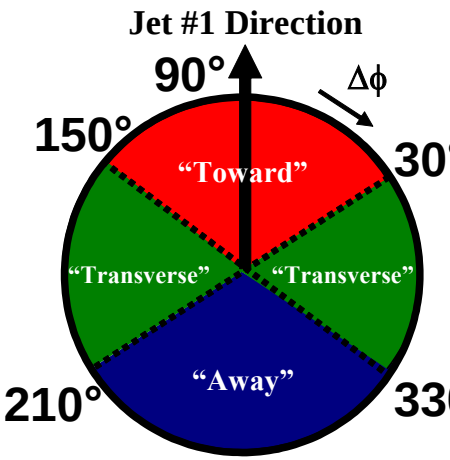
Recoil term is used to select events which occurs completely in the acceptance of our interest. Lower values of recoil and 1-T correspond to 2-jet events in the acceptance. On the other hand: 1-T << 1 and Recoil ~ 1 corresponds to 1 jet event in the acceptance.

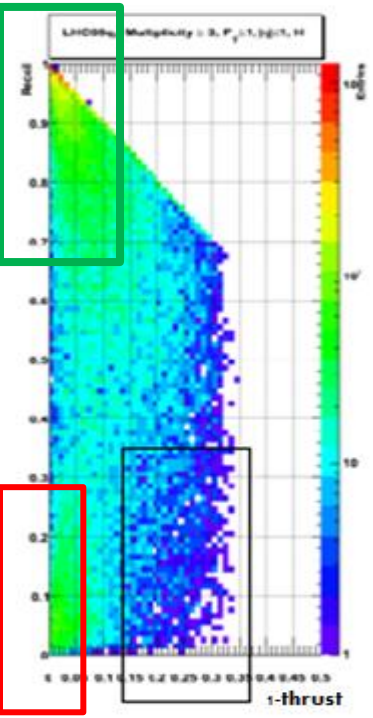
Lower values of 1-T are related with 2-jet events.

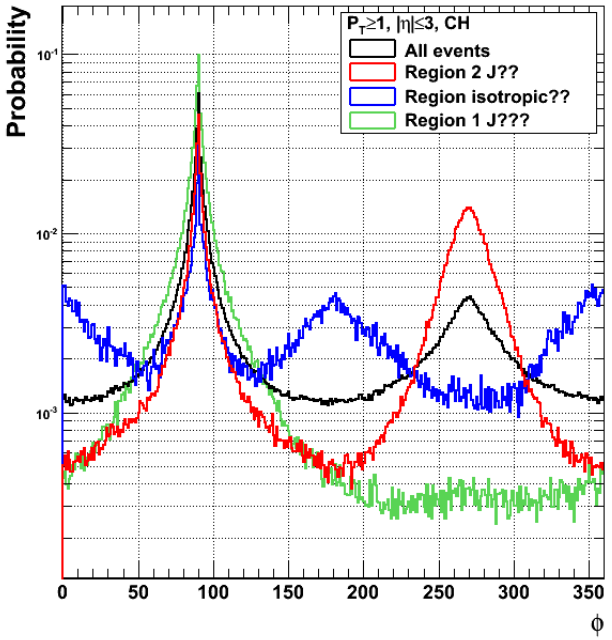
Exploring the topology of the events…

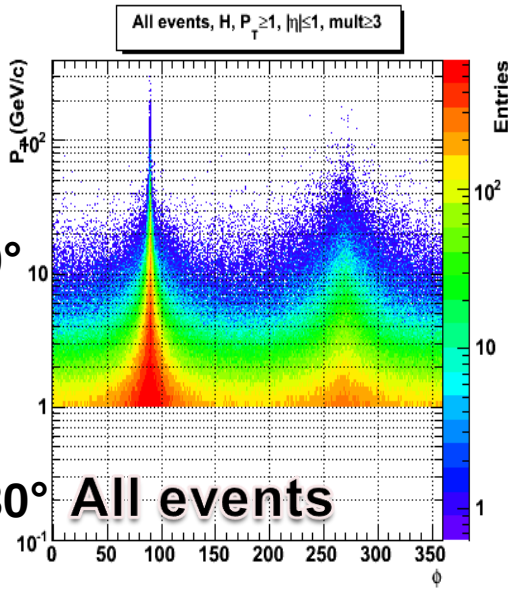
Different regions of the thrust map.

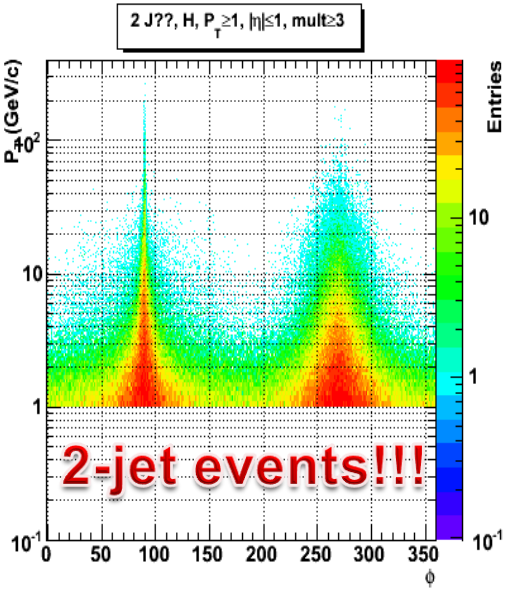
1. 2-jet events: 1-T < 0.05, Recoil < 0.35.
2. 1-Jet evetns: 1-T < 0.05, Recoil > 0.95.
3. Isotropic events: 1-T > 0.3 and Recoil < 0.35

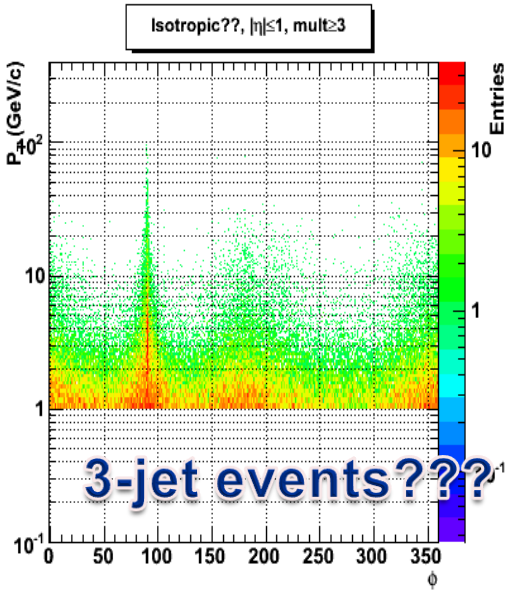


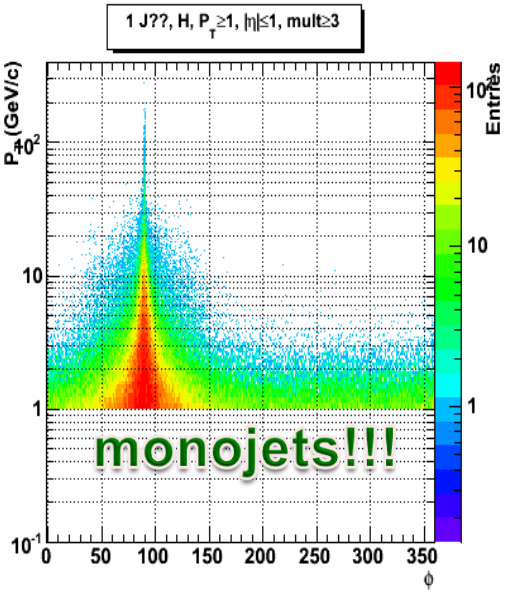








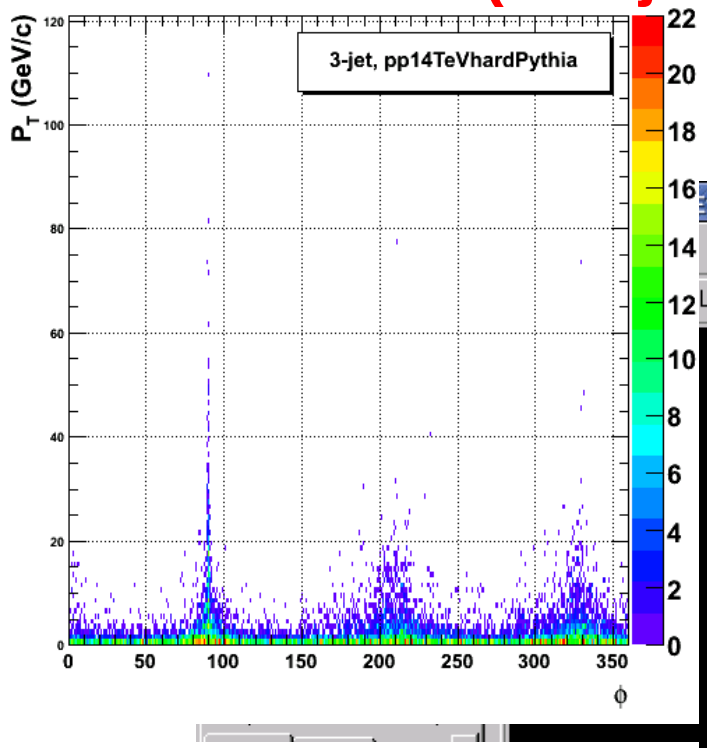




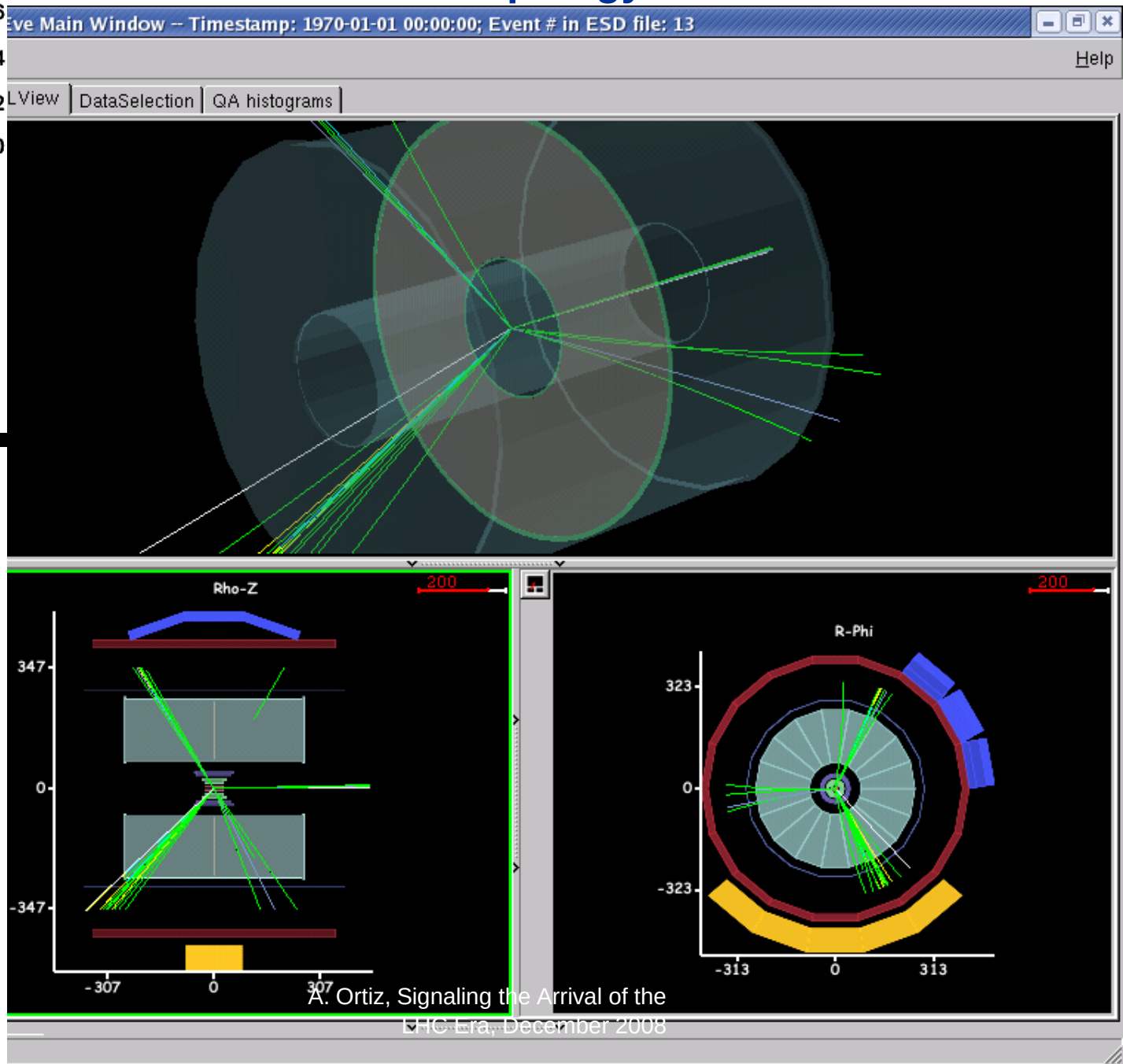
After of the selection of events through the use of thrust map. In these plots are shown the azimuthal distributions of the selected events. Particle with the highest transverse momentum are in 90°, we can see that using the selection of events according with their thrust value it is "easy" to separate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

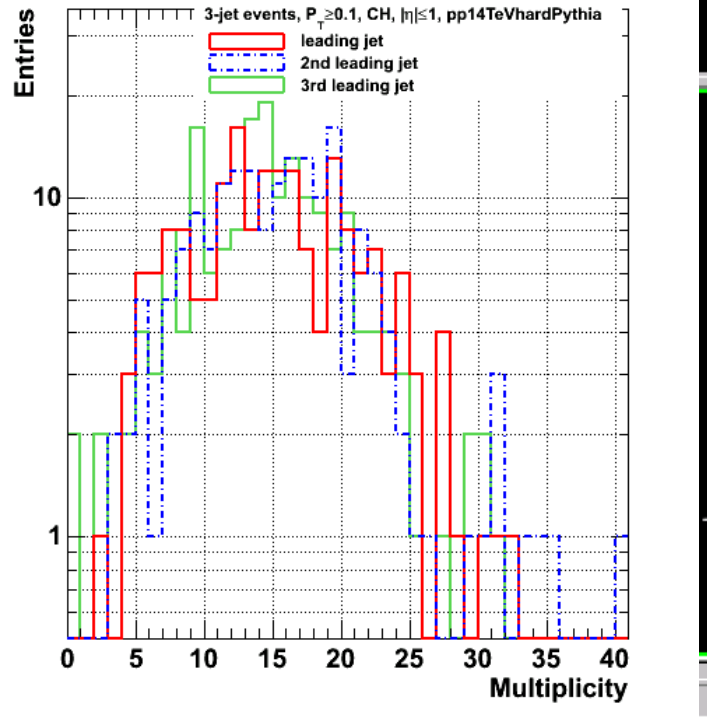
A. Ortiz, Signaling the Arrival of the LHC Era, December 2008

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

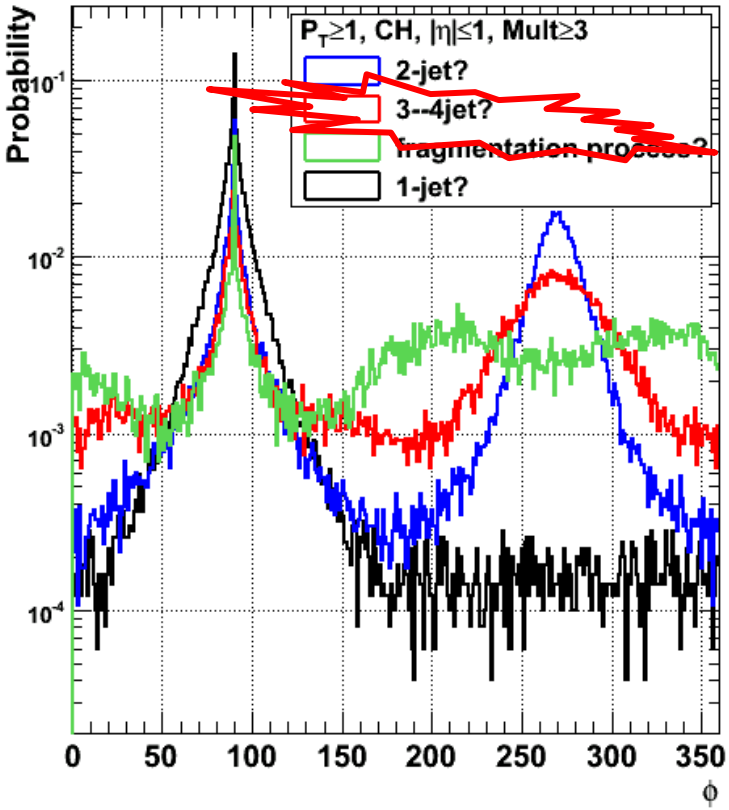


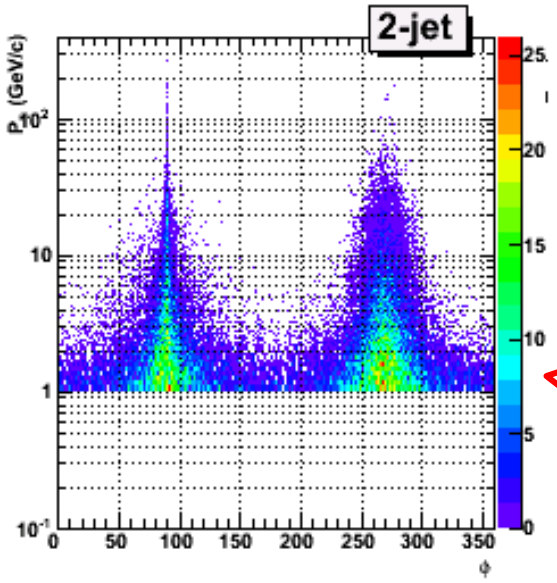
We can discriminate 3-jet events with a “mercedes” topology!!!

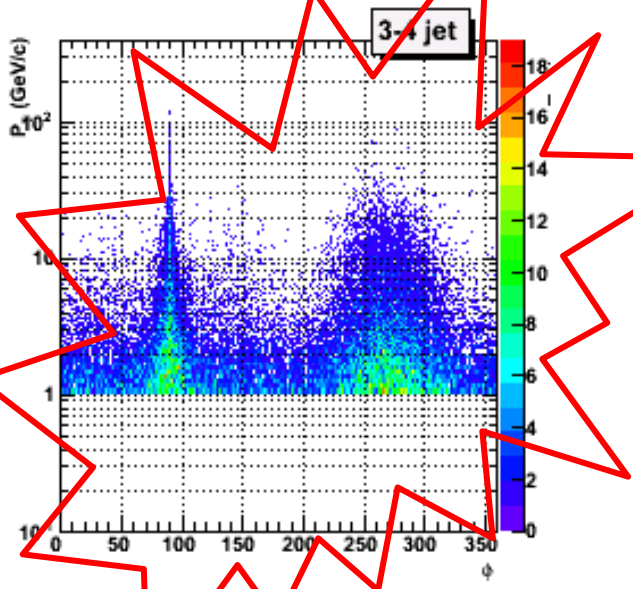


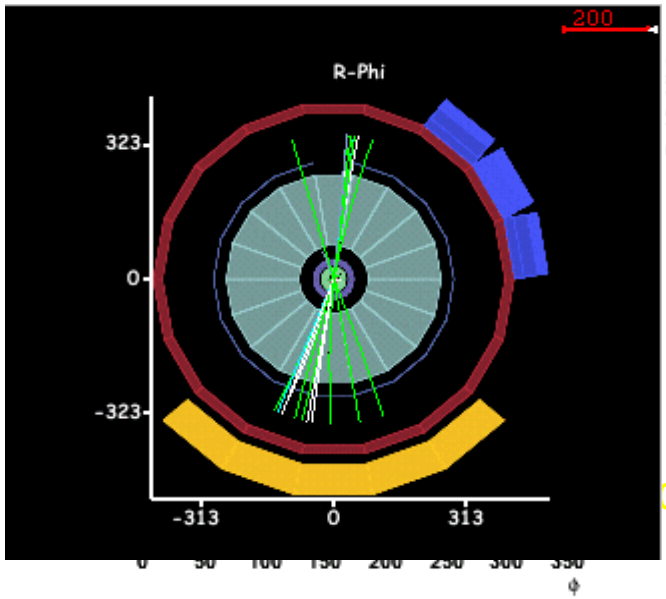


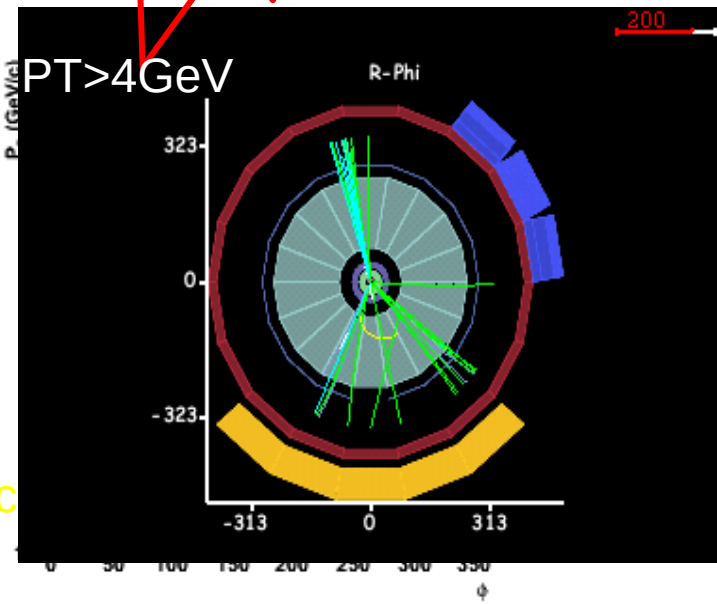
Moving to another region of thrust map we can see the topology of events which are in the region 0.03<1-T<0.07

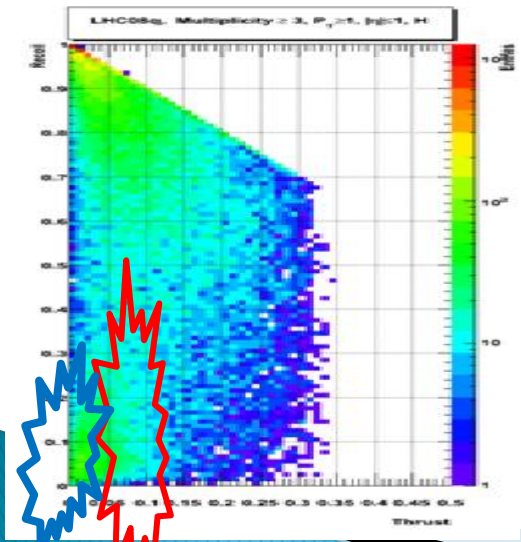








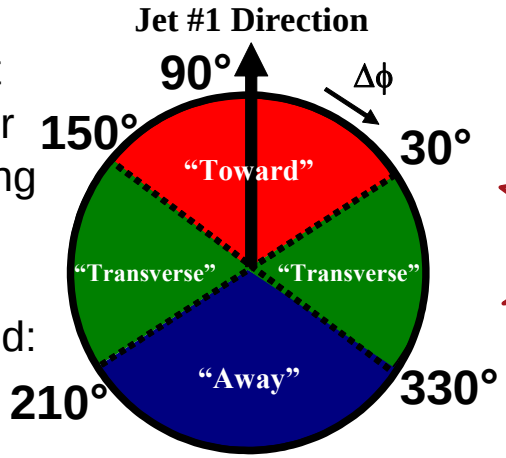


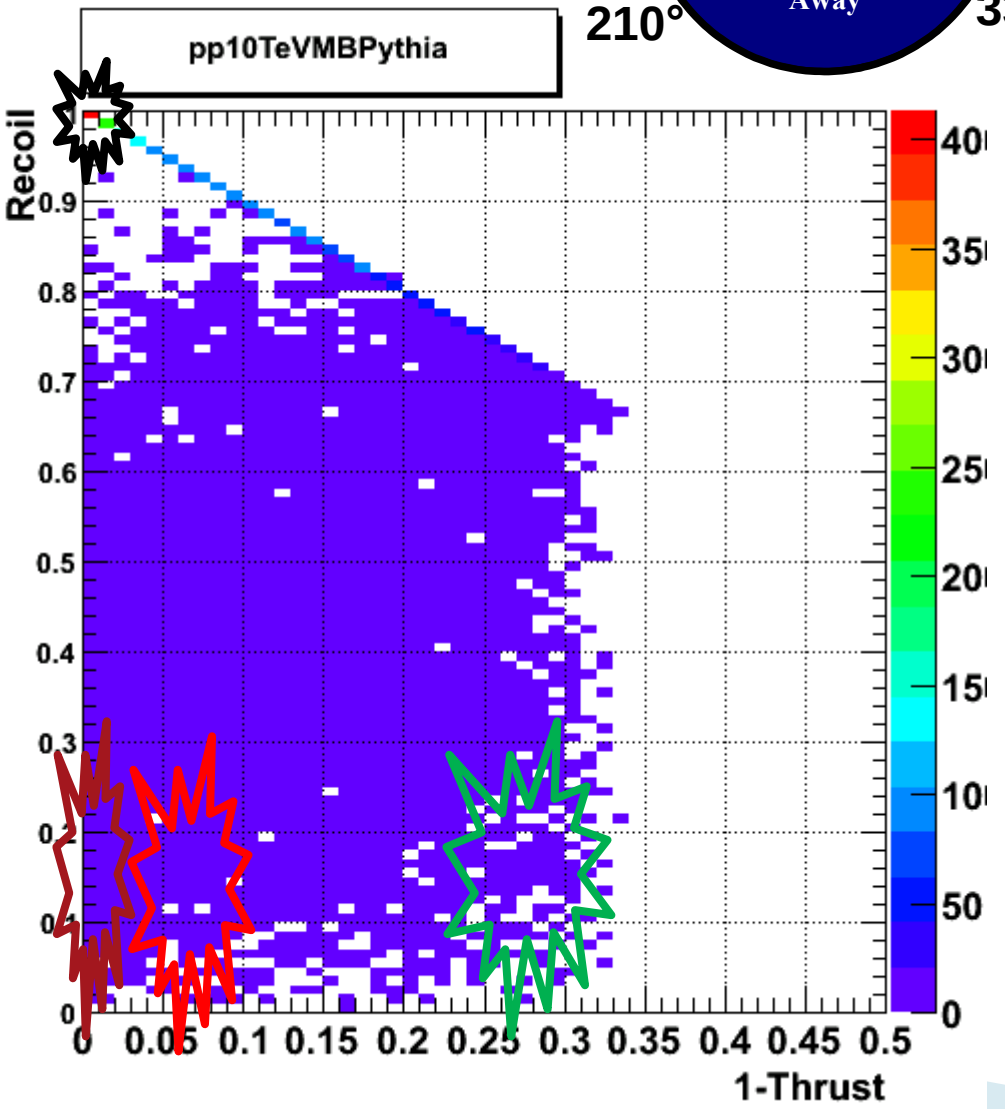


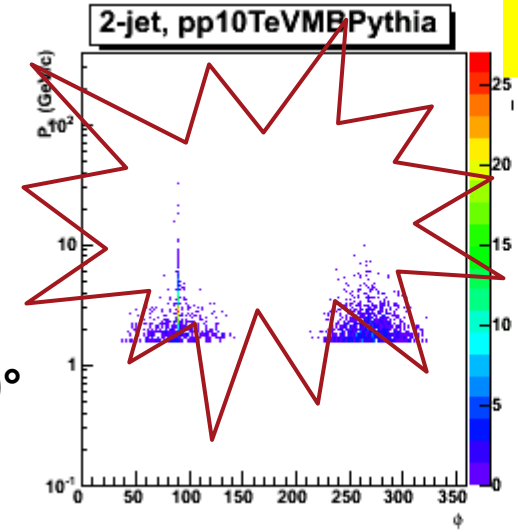
Shape variables for the MB simulations.

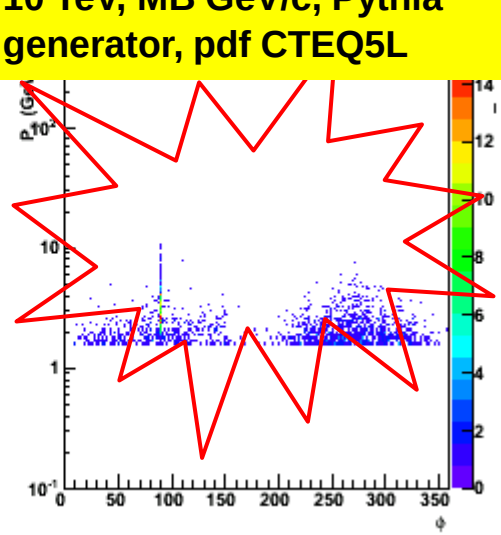
Simiulations: pp collisions, 10 TeV, MB GeV/c, Pythia generator, pdf CTEQ5L

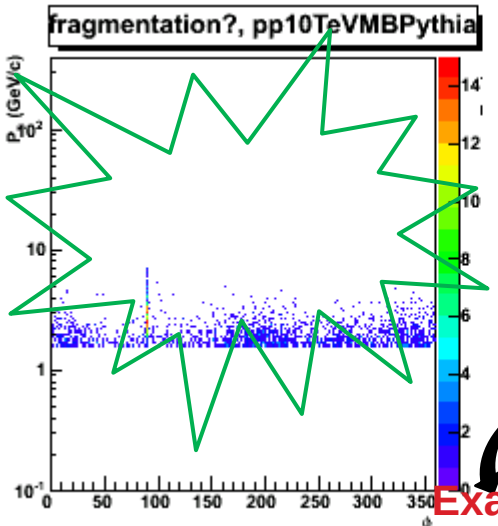
200K events were analyzed. At least 3 particles (pt>1.5 in order to reduce the effect of underlying events) in the ALICE acceptance. In this case the following thrust map is obtained:

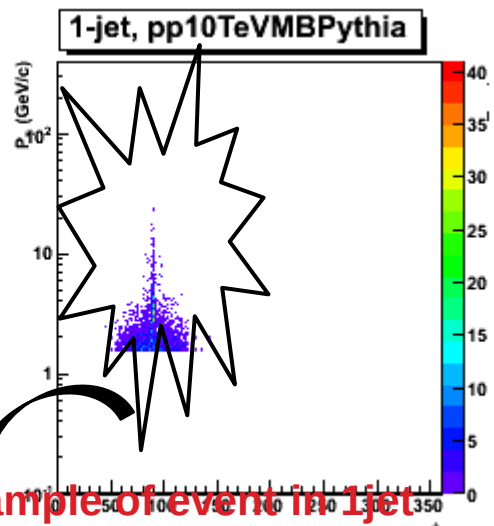




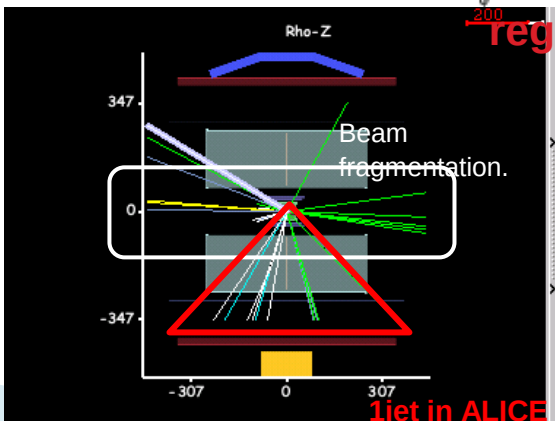


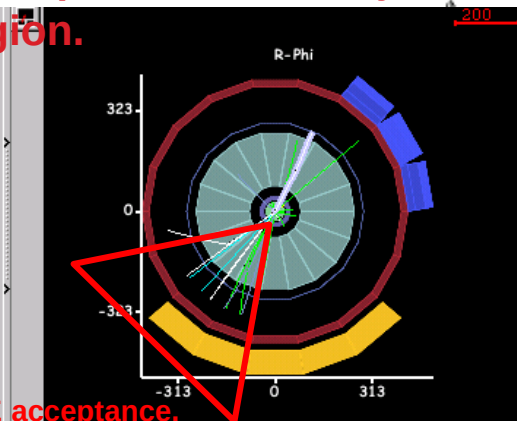






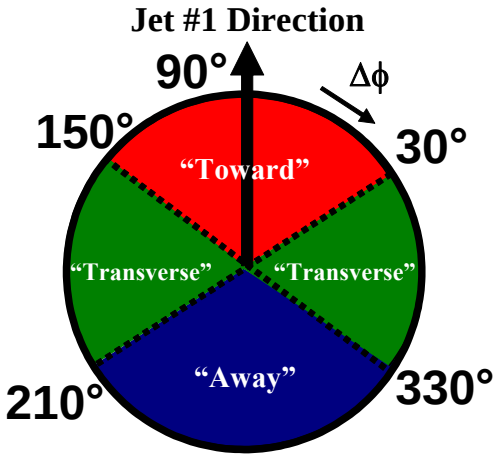
Example of event in 1jet region.





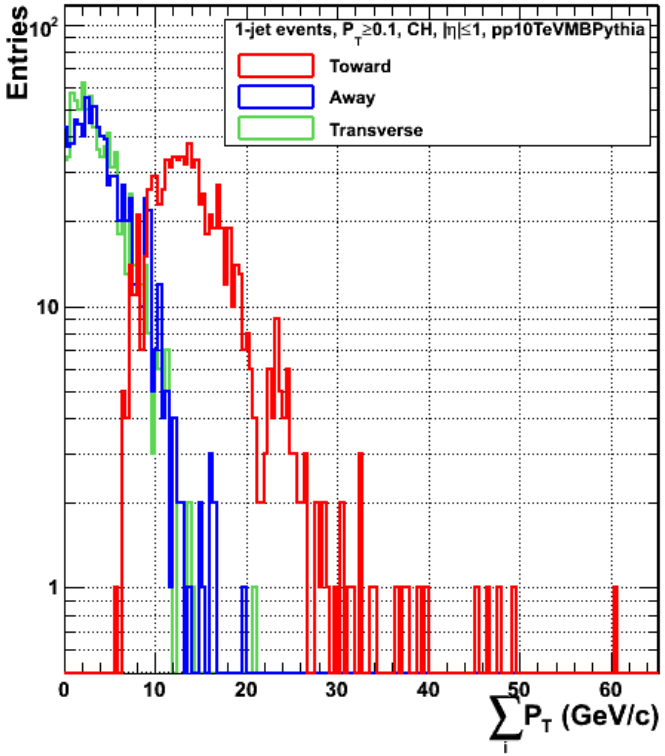
1jet in ALICE acceptance.

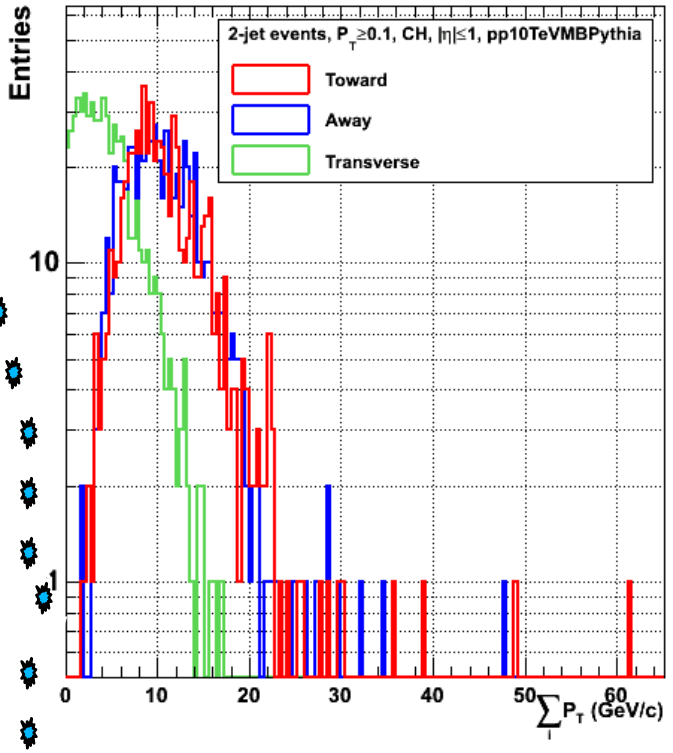
Comparison between toward and away side in 1-2 jet events…

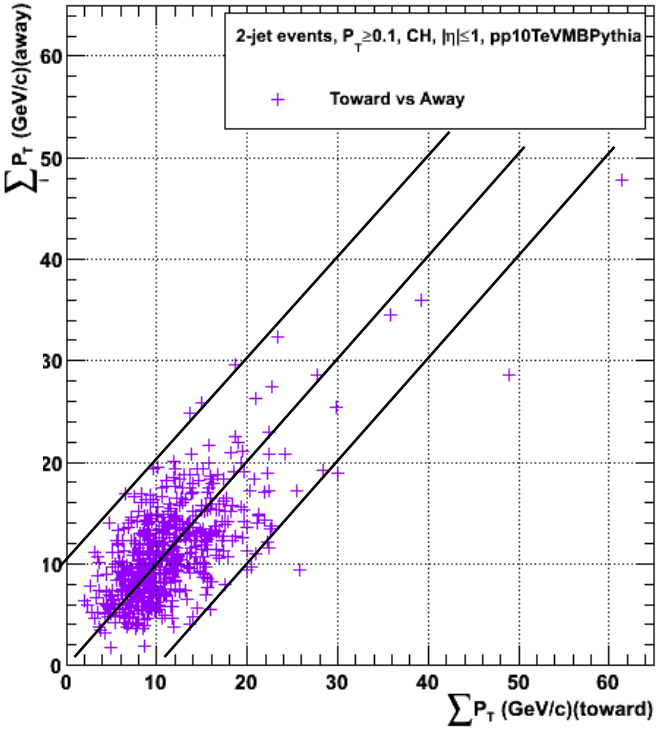


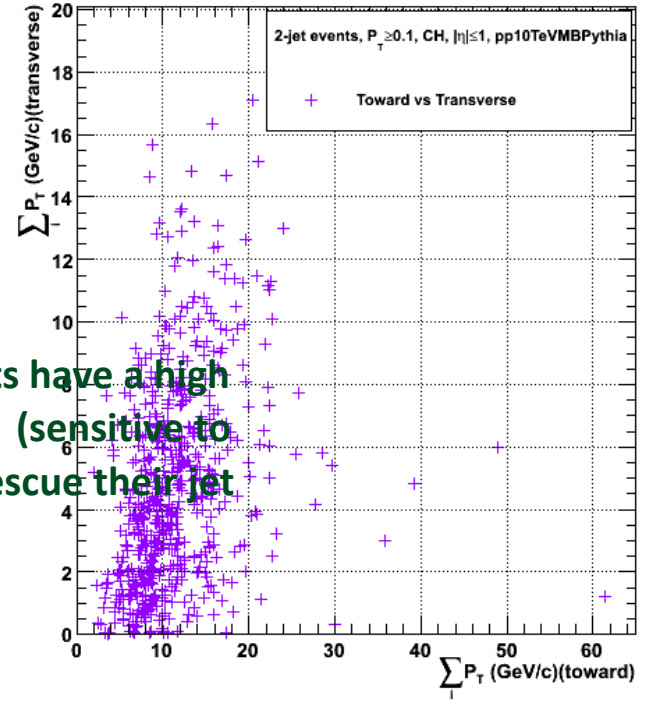
In 1-jet event the contributions from away side are comparable with the background from underlying events.

We can study 1-2 jet events in a wide range of energy. Note the power of shape variables to discriminate these kind of events from MB sample.





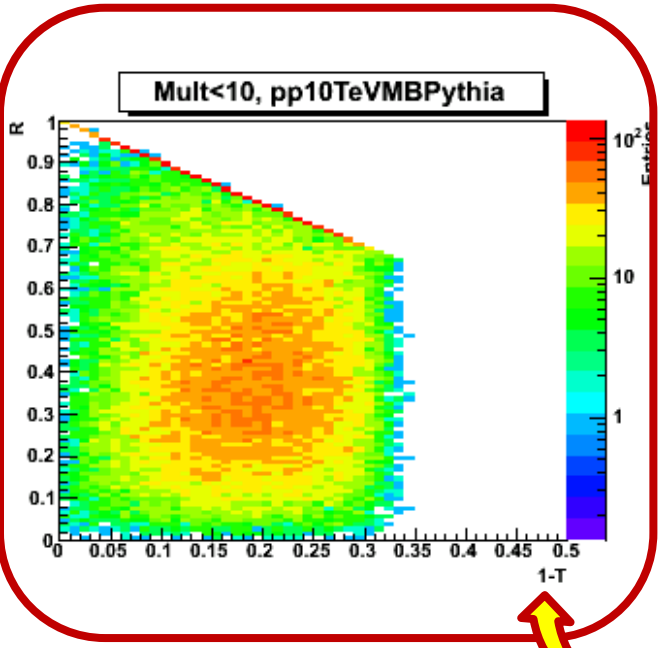


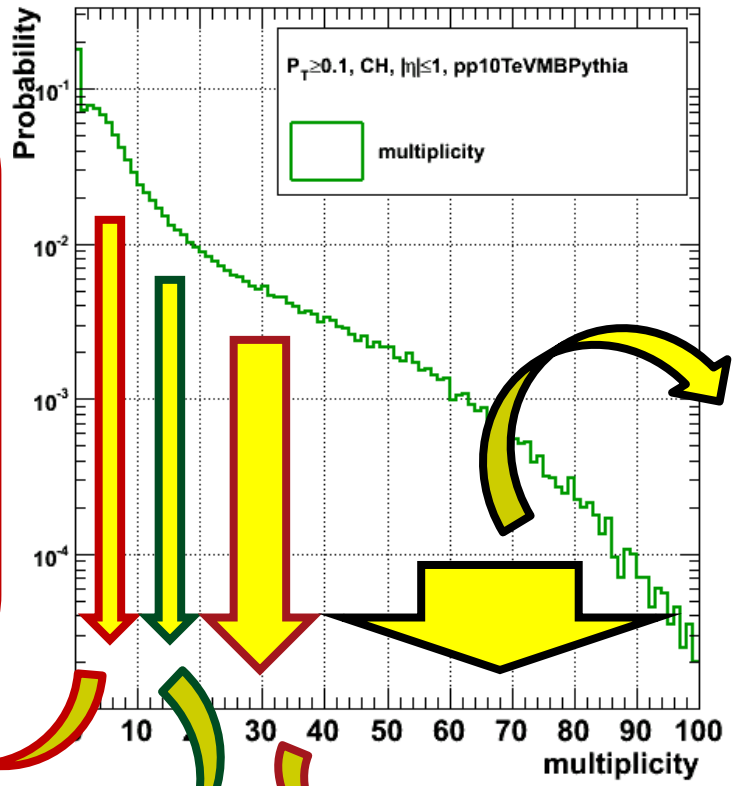


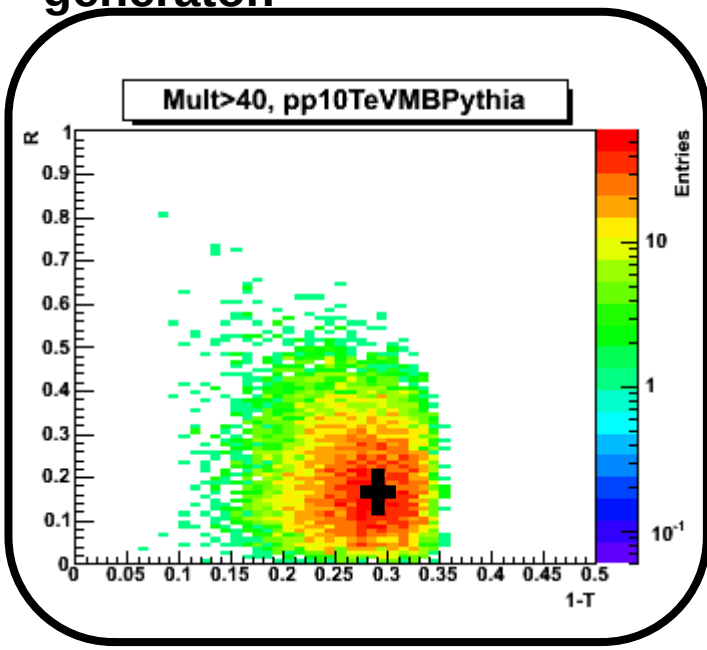
In spite of events with low energy jets have a high contribution from transverse regions (sensitive to underlying events), it is possible to rescue their jet structure.

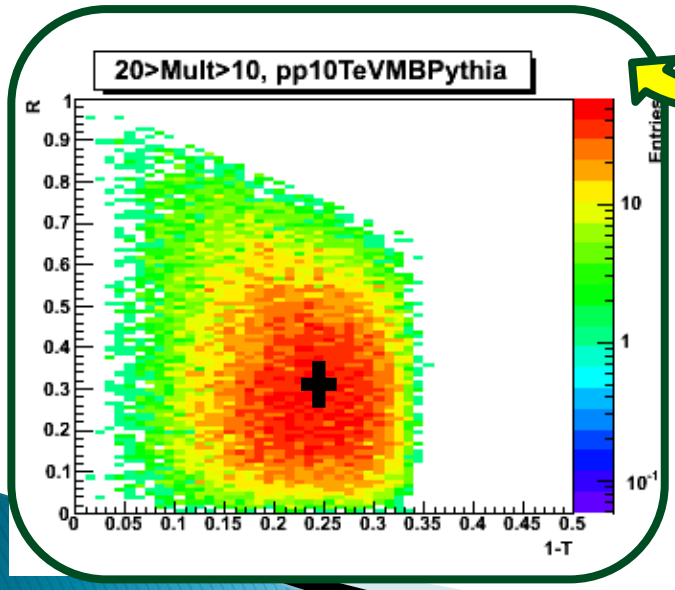
Selecting high multiplicity events from MB sample using the thrust map.

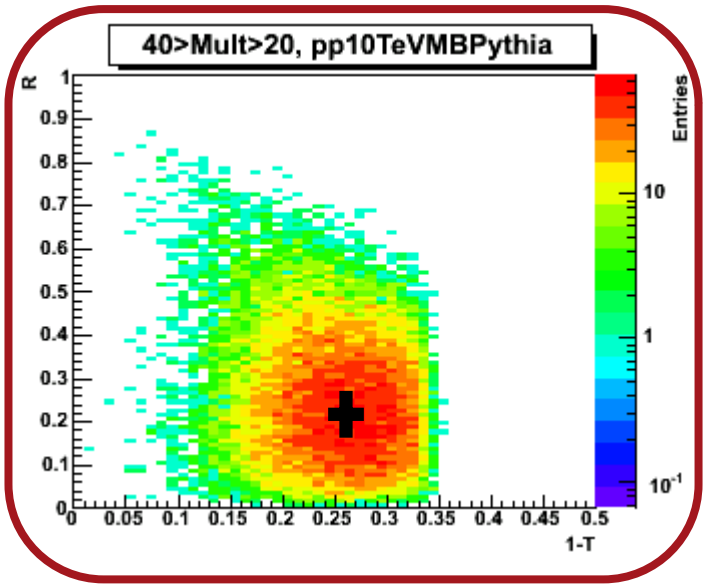
Simiulations: pp collisions, 10 TeV, MB, Pythia generator.







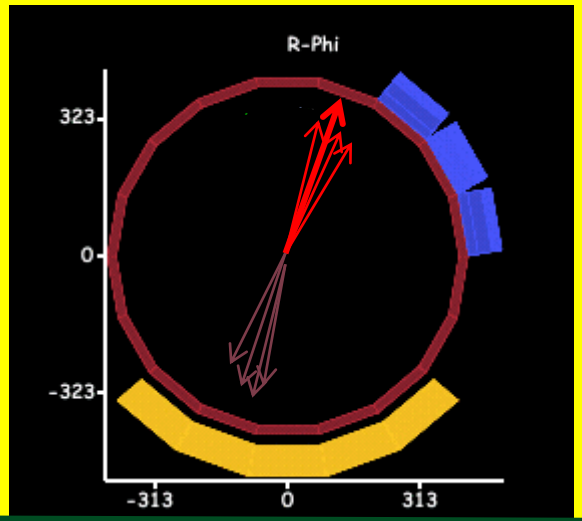




Thrust is sensitive to events with high multiplicity. In order to get these values: pt>0.1 GeV/c, at least 3 MC particles.

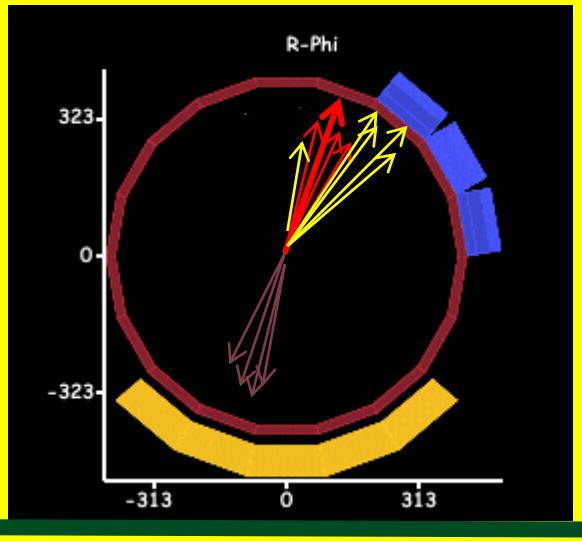
Conclusions…

1. Thrust and recoil term have been calculated for two samples (MB and hard PT sample).
2. As result of the analysis of the thrust map is possible to discriminate different kind of hard events according with their topology. The following table summarize the better results.



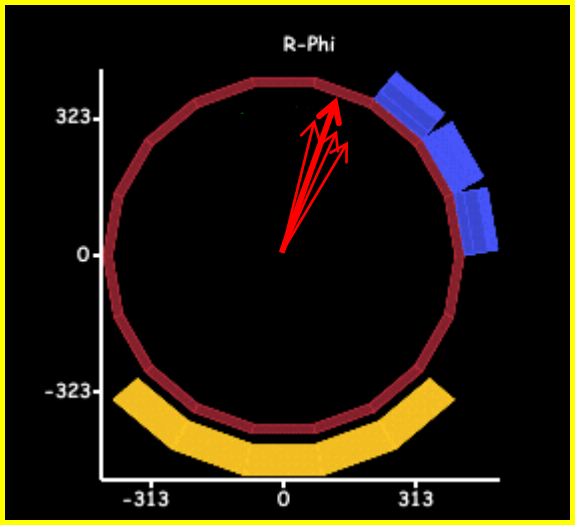
Back-to-back 2-jet events

- *1-T < 0.03*
- *R < 0.25*
- *At least 3 particles with PT > 1.5 GeV/c .*



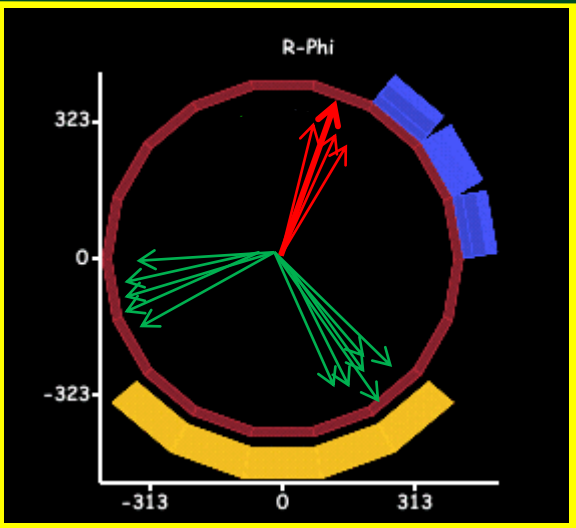
3-jet events (gluon jet)

- *0.07 > 1-T > 0.03*
- *R < 0.25*
- *At least 3 particles with PT > 3 GeV/c .*



1-jet events

- *1-T < 0.03*
- *R > 0.95*
- *At least 3 particles with PT > 1.5 GeV/c .*



3-jet events ("mercedes")

- *1-T > 0.25*
- *R < 0.25*
- *At least 3 particles with PT > 8 GeV/c .*

3. To select events with high multiplicity we demand at least 3 particles with PT > 0.3 GeV/c and 1-T > 0.25