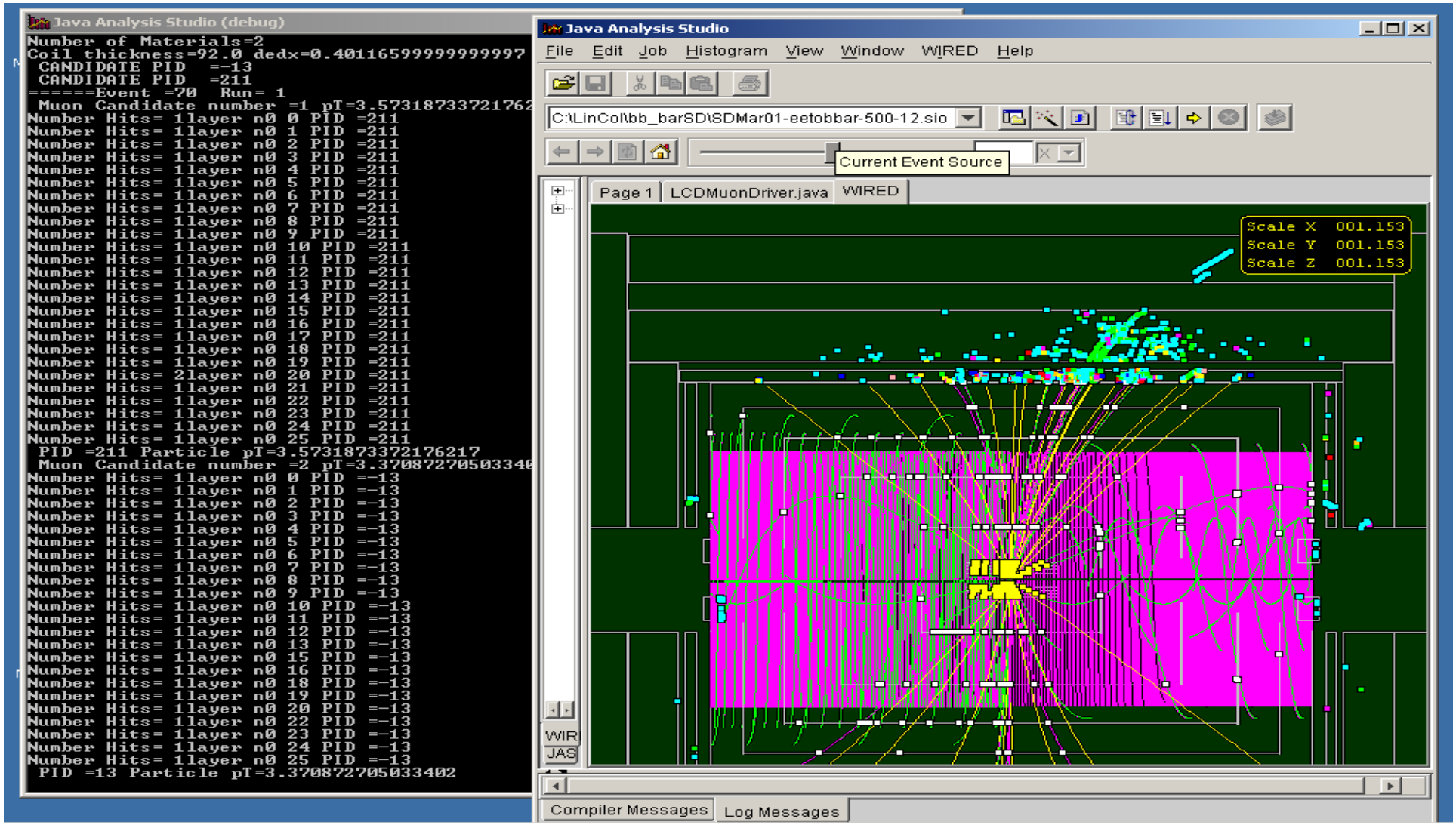
# HCAL to separate Mu & Hadrons in Jets

The jets were studied using 5000 B-Bbar events. The Algorithm was built only on the information from the tracker and the muon detector.
136 Non-Muons did pass our algorithm.

We found that for >70% of those Non-Muons, there is a Muon in the vicinity with a $\Phi$, $\Theta$ within the $\Delta\Phi$ and $\Delta\Theta$ cuts.
Checking the Muon-Detector one finds, indeed, an association to a Muon Hit located in the 1$^{st}$ Layer of the detector .

We will show that HCAL is helpful to remove those ambiguities
And might provide a useful mean of detection of low momenta Muons

# B-Bbar- 2 Mu “Candidates”
# 1Pi(3.6GeV)-1Mu(3.6GeV)
# Each 31 Layers- Sharing MuDet Hits(?)



# Typical cases Of Pi's Passing The Muon Algorithm

3 Cases with Hadrons passing the Muon Algorithm by SHARING the HITS with a Muon in the Muon Detector. This is ~95% of the cases of wrong Track ID passing the Algorithm.
Two such events are also shown in the Event Display.

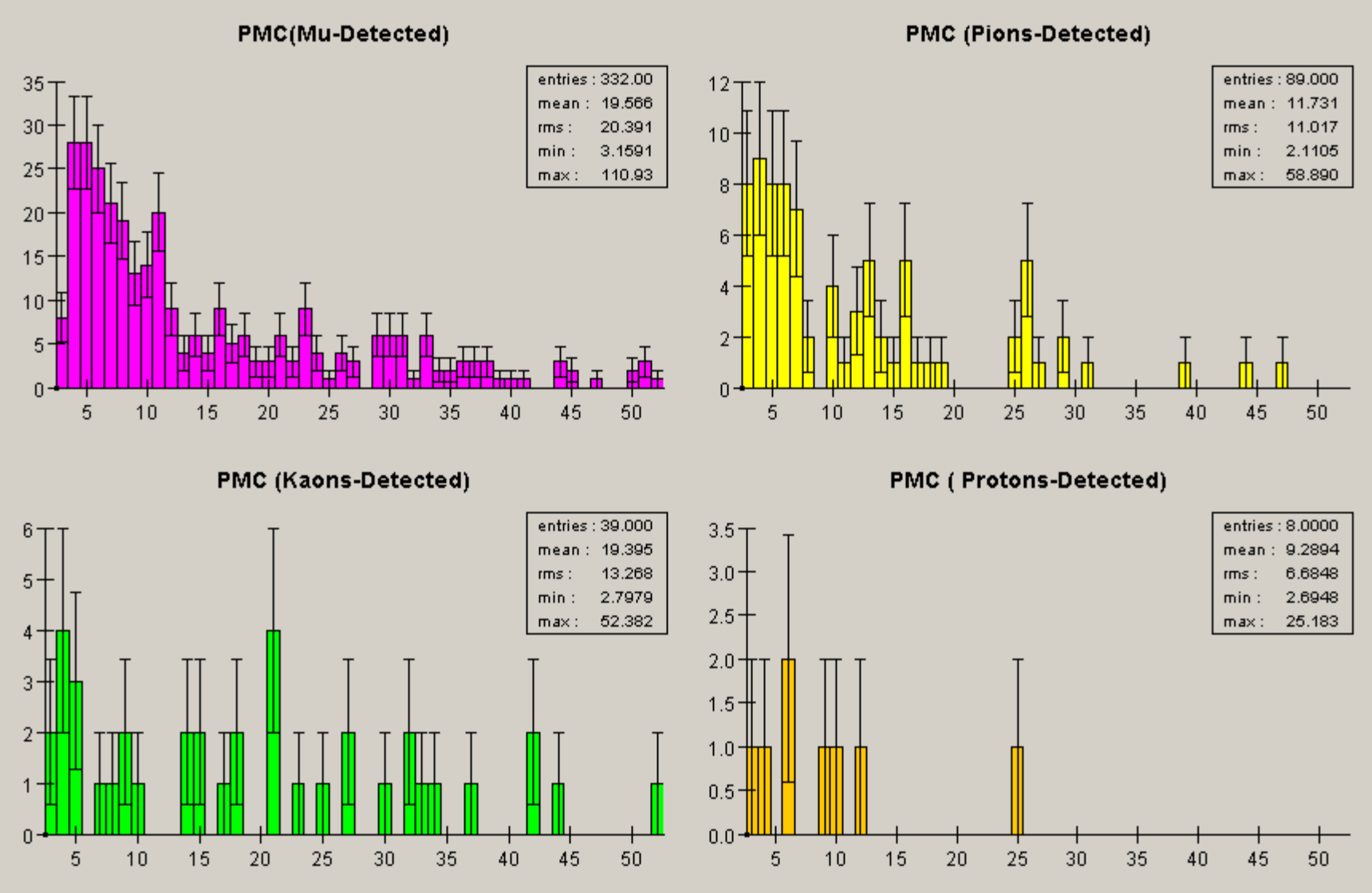
- Pi-Track associated to Mu Hit in Event Number = 112-Run 11
  **PI** : p=4.4744 GeV, phi=112.42
  **MU**: p=5.10158GeV, phi=112.68

- Pi-Track associated to Mu Hit in Event Number = 158 –Run 11
  **PI** : p=29.43 GeV ,phi=201.93
  **MU** : p=-51.52GeV , phi=201.53

- Pi-&K Tracks associated to Mu Hit in Event Number =326-Run13
  **K** : p=16.62,phi =338.24
  **PI**: p=16.26,phi =338.503
  **MU**: p=16.44, phi =335.908

All 3 Particles share the Mu Hits in MUDet

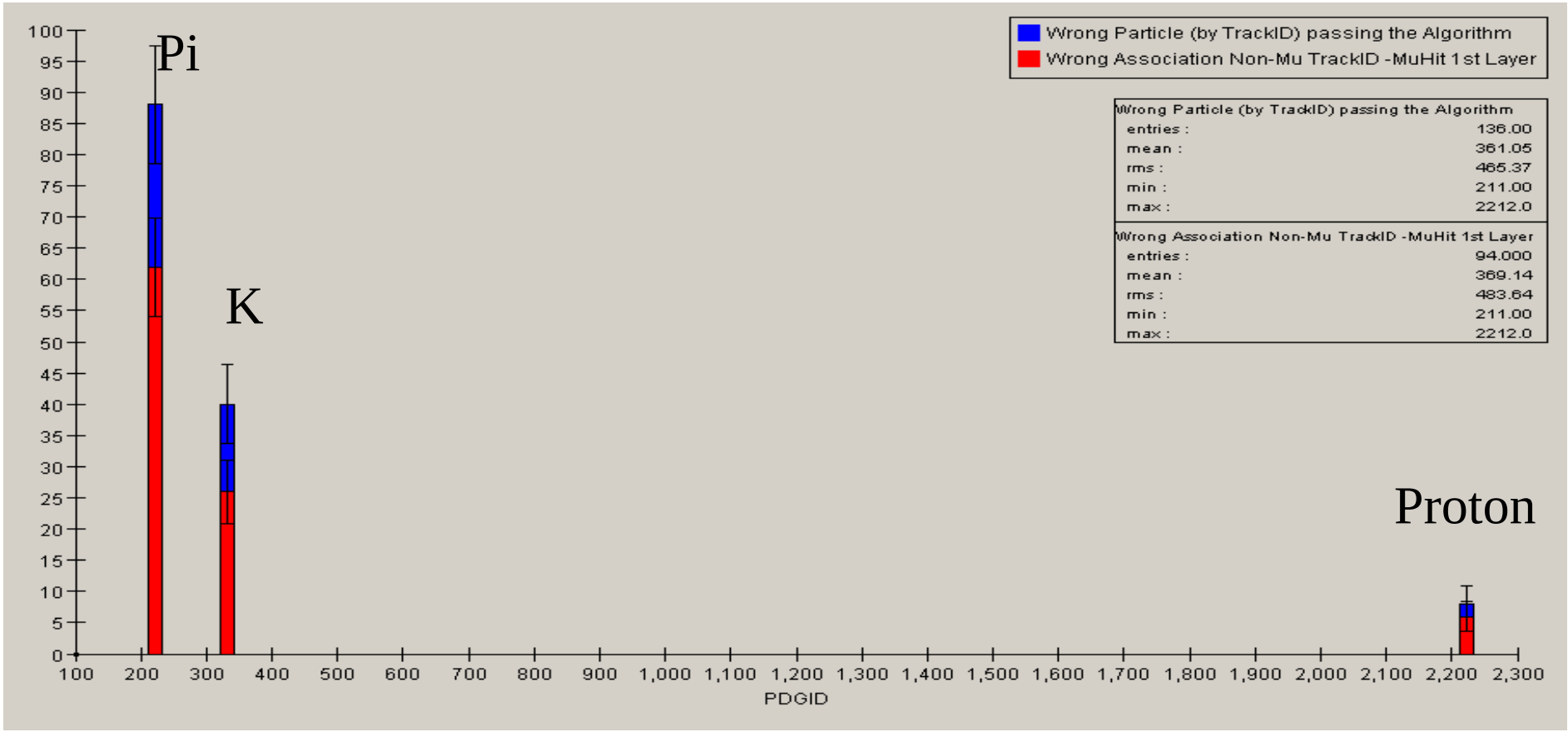
# Hadron Contamination- From 5000 B-Bbar



# Wrong Particle Wrong Association-From 5000 B- Bbar events

In Blue: Non Muons passing the Algorithm,136 tracks

In Red : Those non-Muons with a Hit in the 1st layer of MuCal with a Muon Monte-Carlo ID, 94/136 = ~70% of them



# The response of the Hadron Calorimeter

•One requests that 1Hit of the track in the Hadron Calorimeter and no requirements from the MuDet.
We will first compare the hit Pattern of Muons and Pions, looking her too, at the Multiplicity and the number of layers with activity.

•We used single Pions and Muons at 3,5,10,20,50 GeV/c

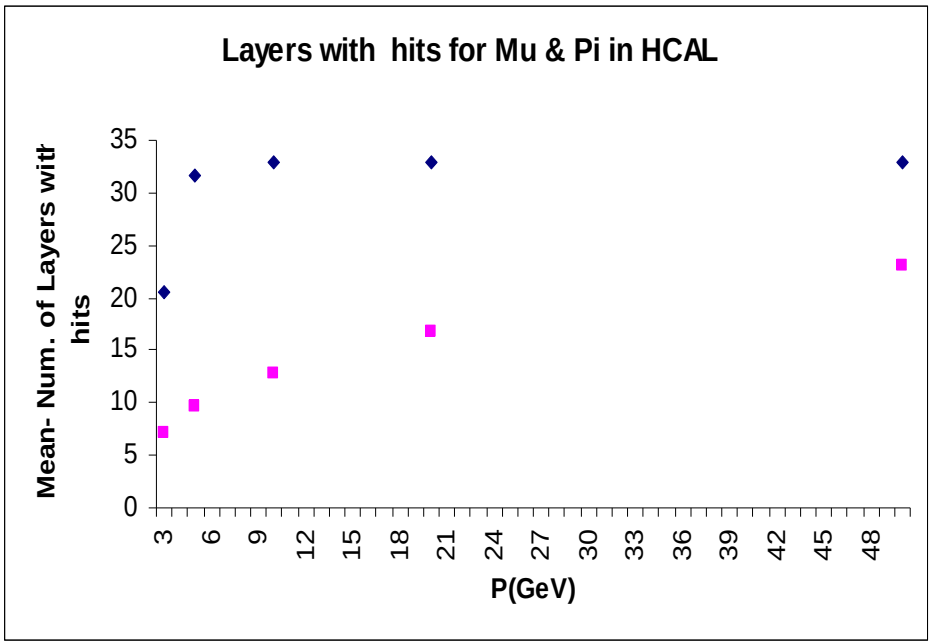
•In the next slide the figures represent:The mean number of layers with hits as well as the mean number of hits/layer/track for both single Pions and Muons

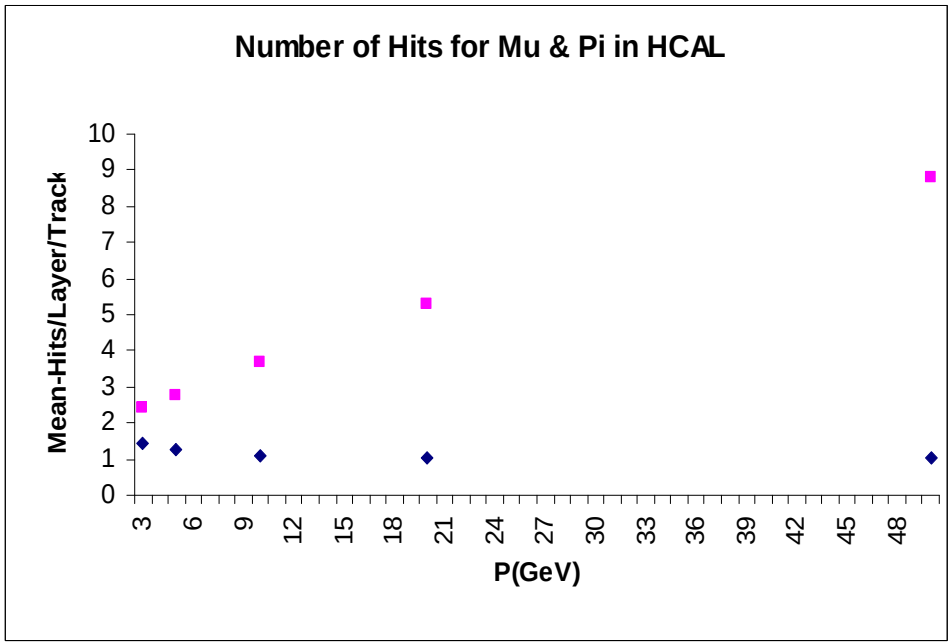
# Hit Pattern in HCAL

Blue Diamonds: The Muons, Pink squares: the Pions are shown as A function of Momentum.

Left Figure, above 3 GeV the Muon leaves hits all the way to layer 34, not so for the Pions.

Right Figure, the hits/layer each track is also fairly constant ~1 hit/layer for the Muons, not so for the Pions.

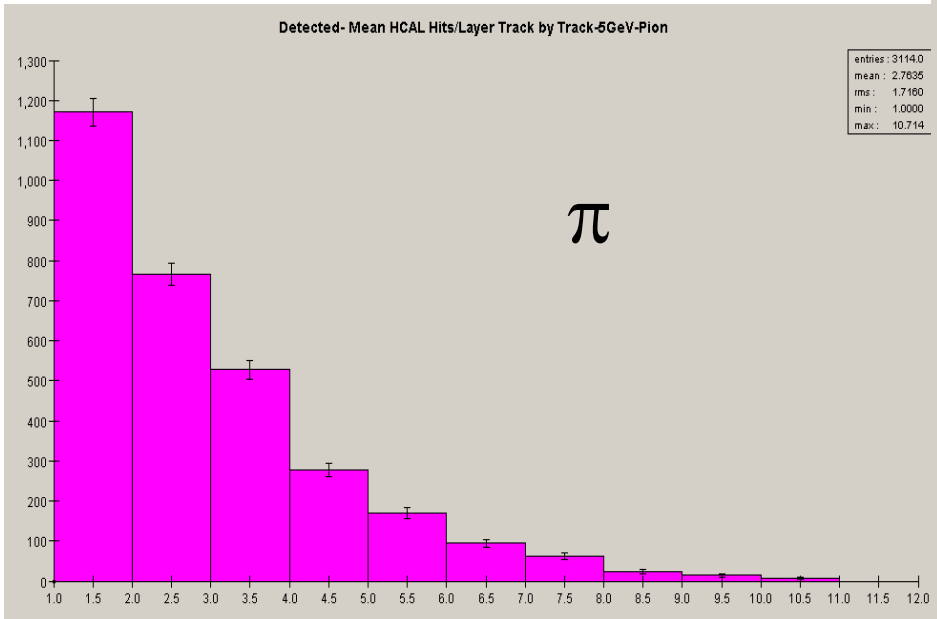


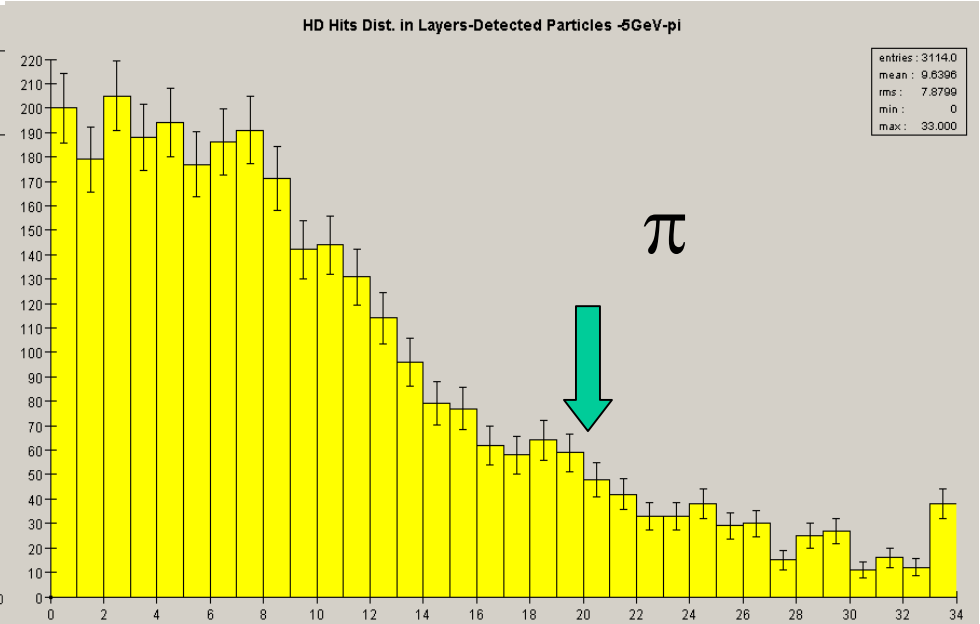



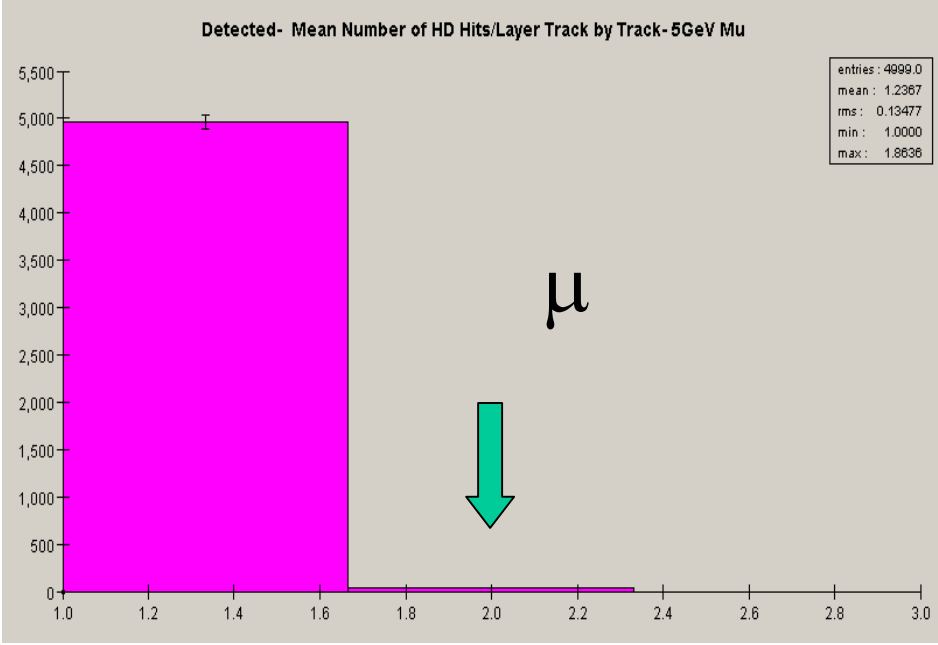
# Differentiating Patterns(continue)

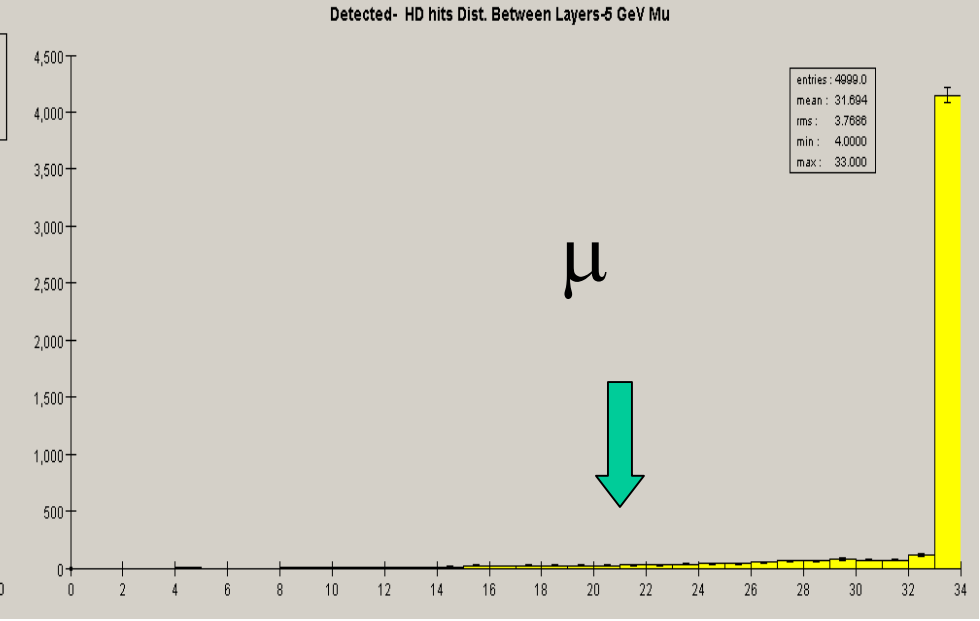
•The total number of layers involved in each event is shown In the next 2 transparencies at 5GeV and 10 GeV.
•A cut at 20 Layers can be used from 5 GeV. It allows to get rid of the bulk of the Pions without really depleting the Muons.
•At higher Momentum the cut could be shifted at 25 layers as seen on the 10 GeV slide.

# Layers & Hits - 5GeV Single Pi's & Mu's

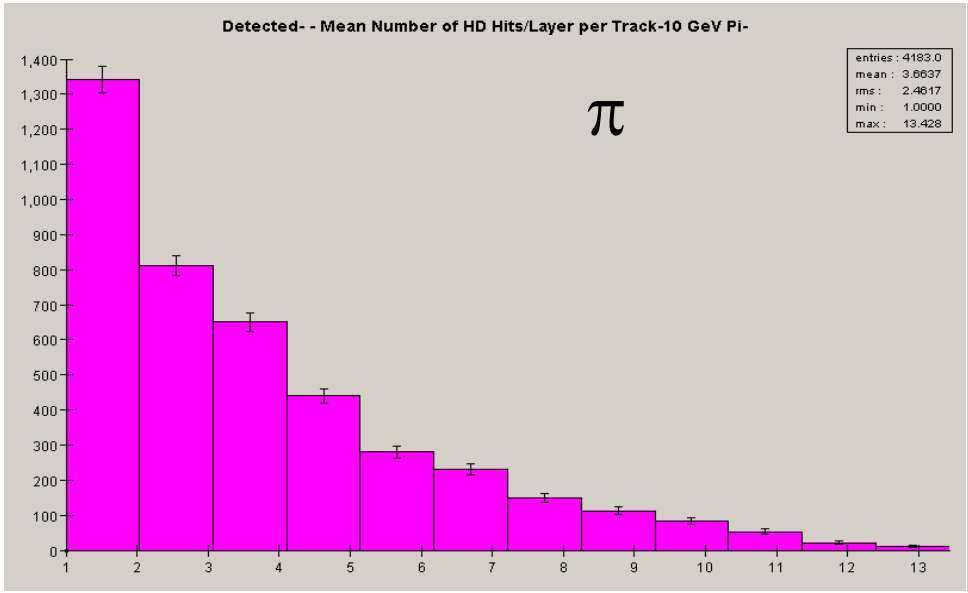


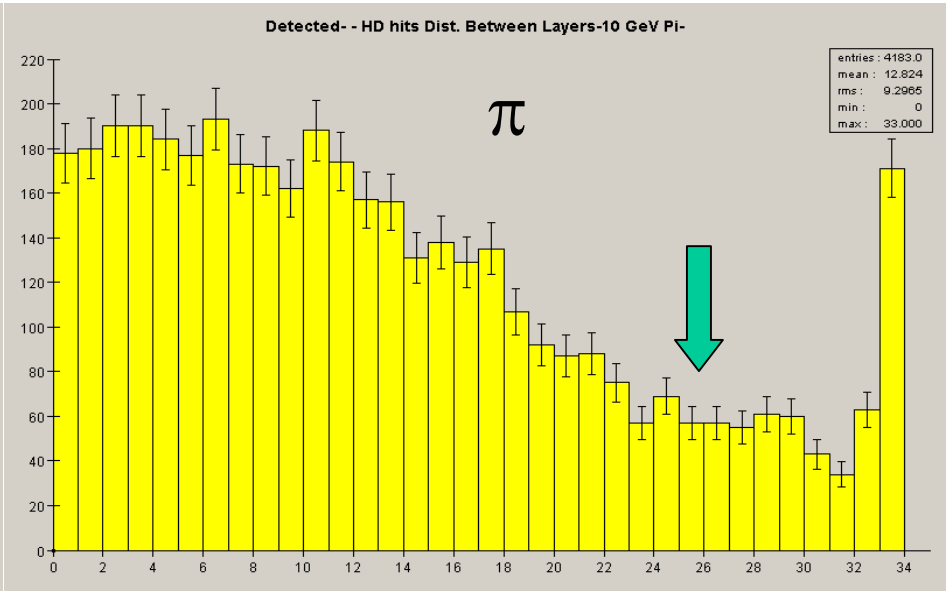



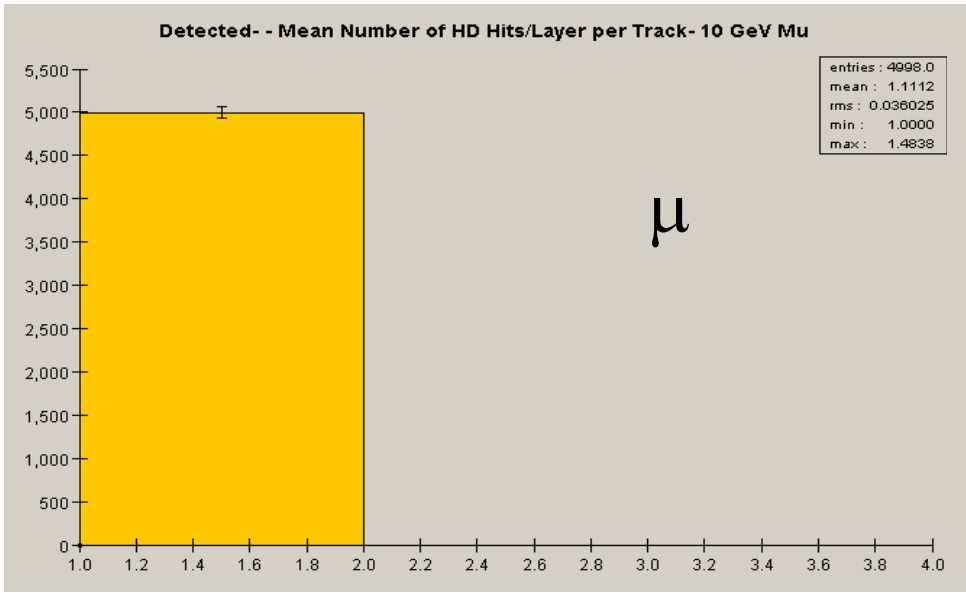



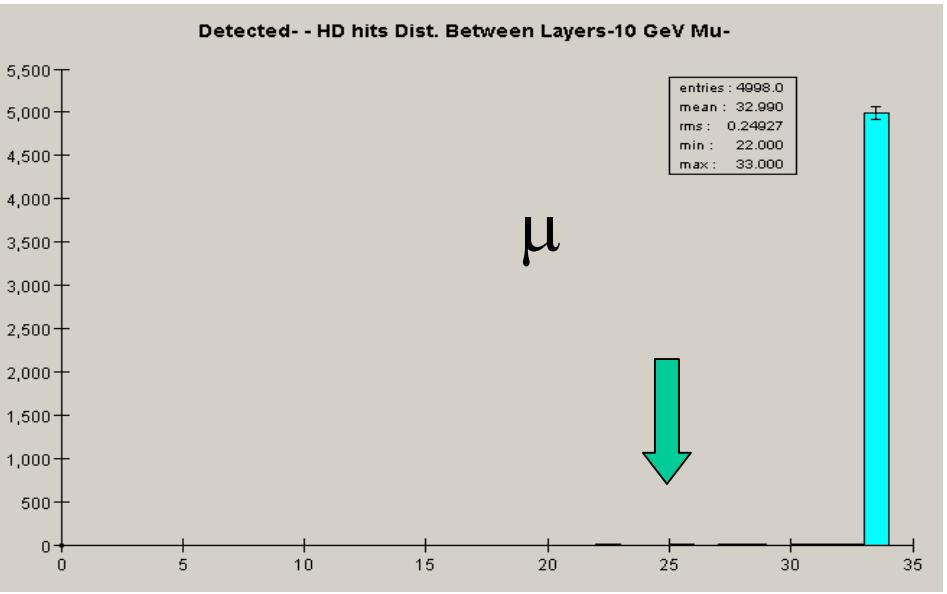



# Layers & Hits - 10 GeV Single Pi's & Mu's



# Applying the cuts in B-Bbar Jets Events

•To resolve the ambiguities the cut in the Maximum number of Layers with hits per track is applied and the 2 next slides show the Muons and the Contamination before and after the cut.
Again the HDCal information allow to get rid of ~50%
Of the contamination leaving the Muons almost untouched

Using also the Cut on the Hits/layer event by event, together With the Maximum Number of Layers cut allow to get rid Of 75% of the Contamination.

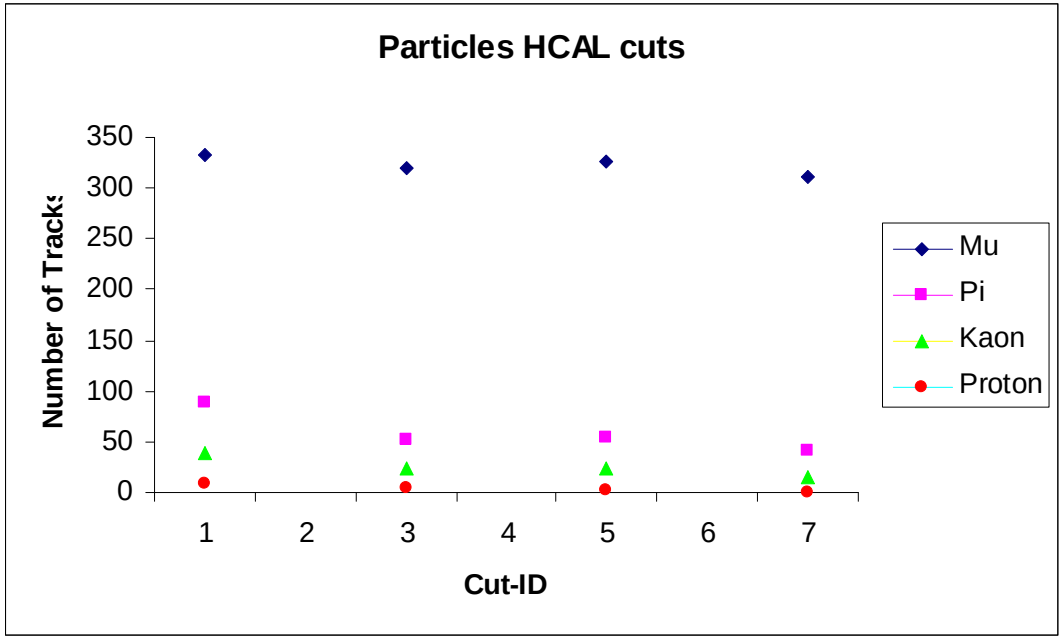
# The Sample of Muons and Hadrons Before and After HCAL Cuts have been included

X=Cut Label: 1= No Cuts

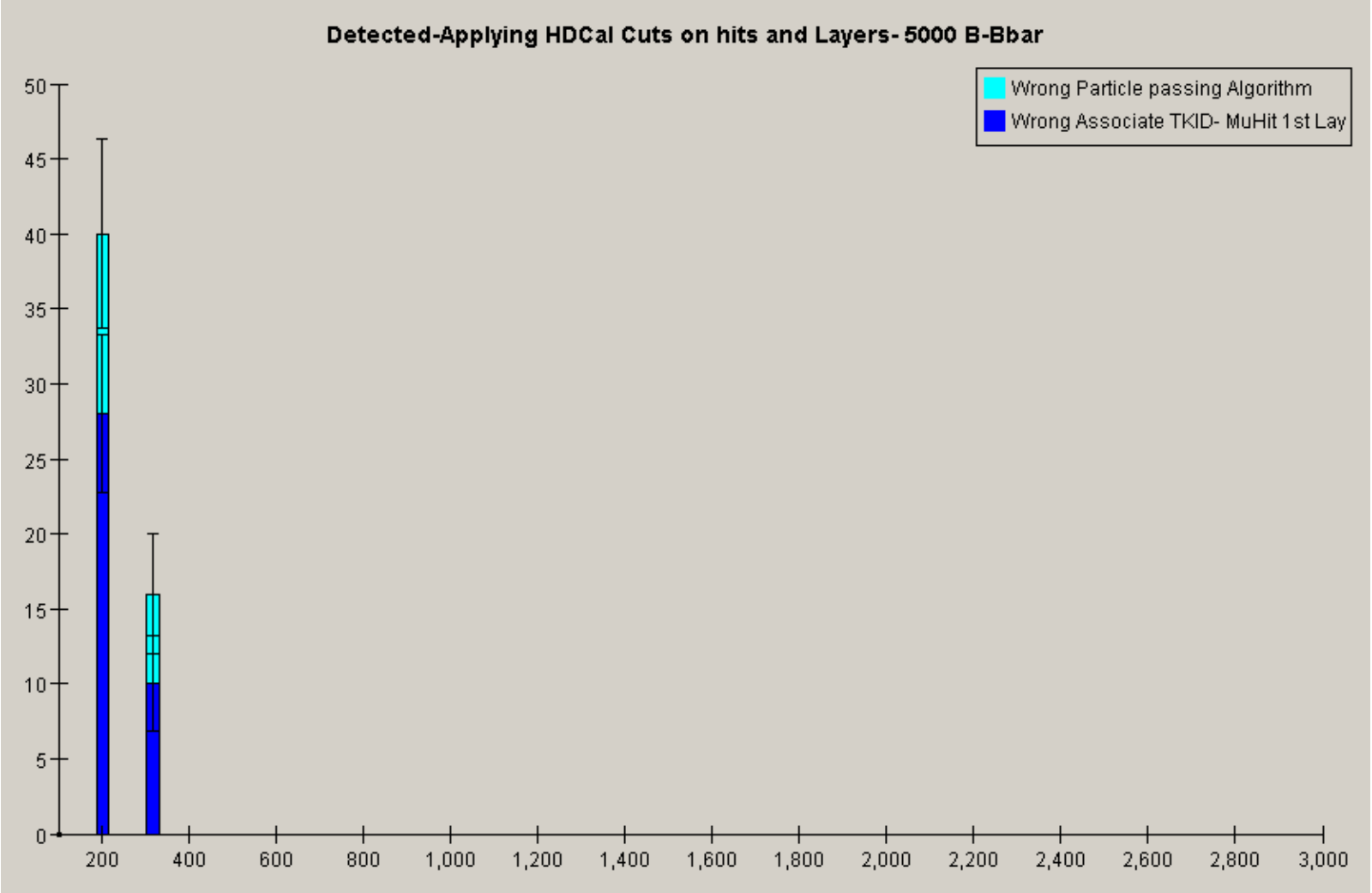
3= Hits/Layer/Track cut

5= Cut on the Number of Layers

7= Combined cuts



# Wrong Particle Wrong Association After HD Layers and Hits Cuts-5000 B-Bbar



# Conclusion

A great deal of the Hadron Background has been taken care
Of by the cuts once applied to the B-Bbar jetty environment.

We are now studying other cuts which take advantage of the
Uniformity of the muon signal .