



# Jet Id studies with collision data

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# Data sample



◆ This preliminary analysis uses run 123591--124030

- Min Bias data at  $\sqrt{s} = 900$  GeV

- Run Lumi (Physics Bit Enabled)

123591	1.09e+26
123592	6.13e+27
123596	1.32e+29
123615	4.58e+28
123732	8.72e+28
123815	1.47e+28
123818	3.63e+28
123906	9.23e+27
123908	5.69e+27
123909	4.34e+27
123970	2.07e+29
123977	3.01e+29
123978	1.04e+29
123985	9.13e+29
123987	9.37e+28
124009	3.84e+29
124020	6.55e+29
124022	1.45e+30
124023	1.29e+30
124024	1.08e+30
124025	1.05e+29
124027	4.69e+29
124030	6.50e+29

total: 8.04e+30

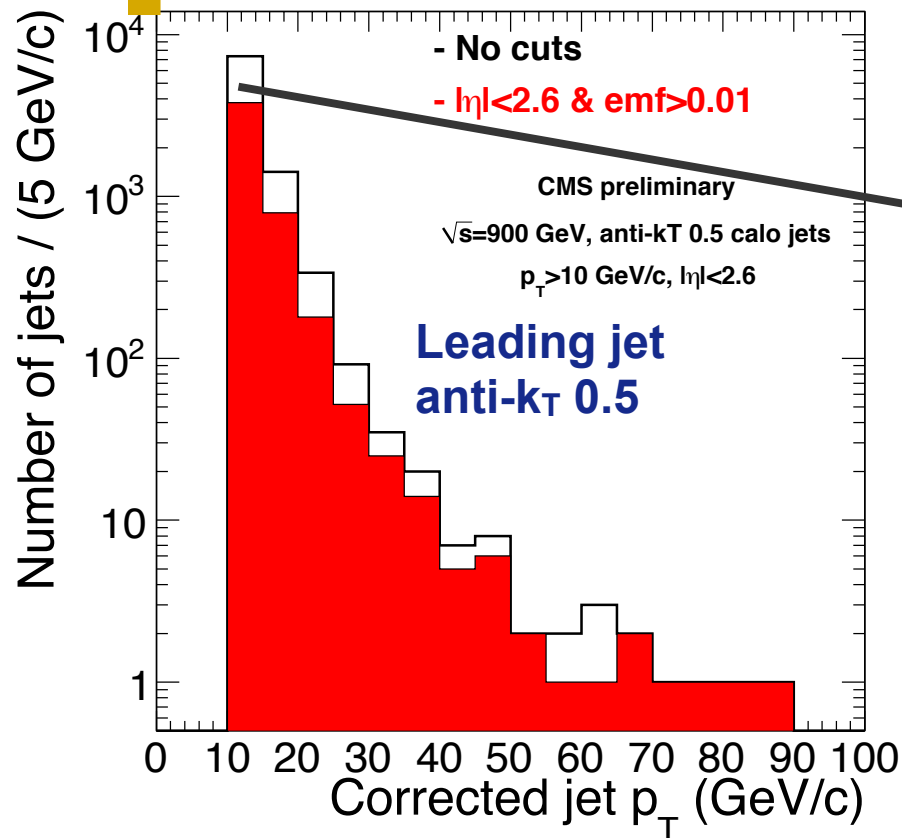
◆ Require to pass BPTX (“bit 0”) and BSC (“bits 40 OR 41”) technical triggers

◆ veto on beam halo (“bits 36--39”). Require a primary vertex.

**About 8  
 $\mu\text{b}^{-1}$  of 900  
GeV data**

**● Run 124120  
● 10341 events  
● About  $0.4 \mu\text{b}^{-1}$   
of 2.36 TeV data**

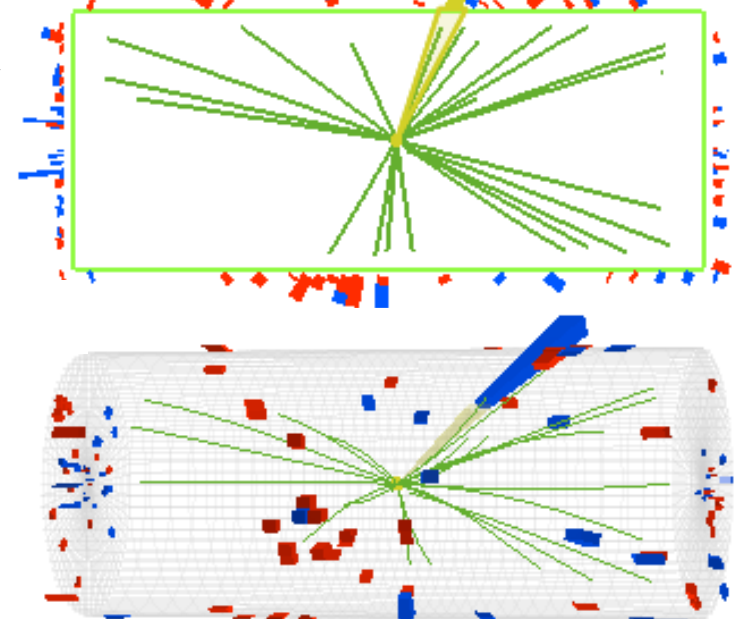
# 900 GeV: lead jet $p_T$ after minimal cleanup



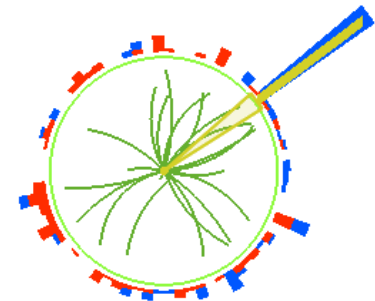
Run:124023

Event:10811337

$p_T = 11$  GeV  
EMF = 0.0

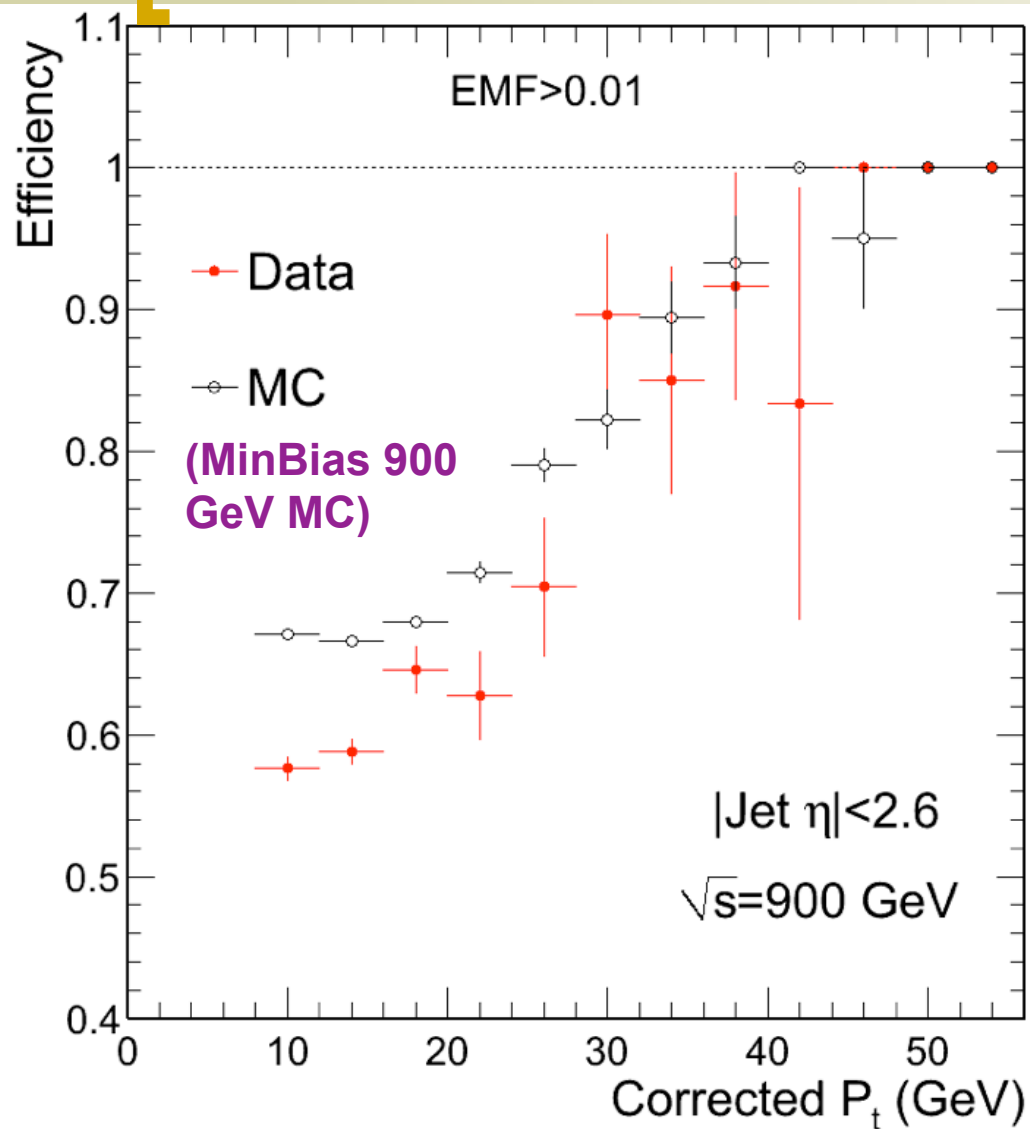


- ◆ Jets with  $EMF < 0.01$  have in fact EMF exactly equal to 0
- ◆ Suichi says that these jets are due to HCAL pedestal noise
- ◆ Most of the time there is a matching track !

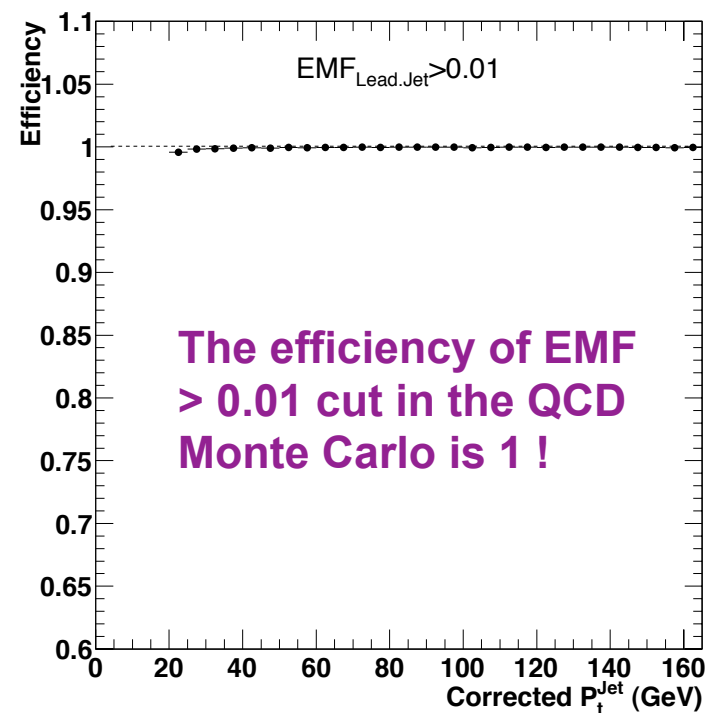




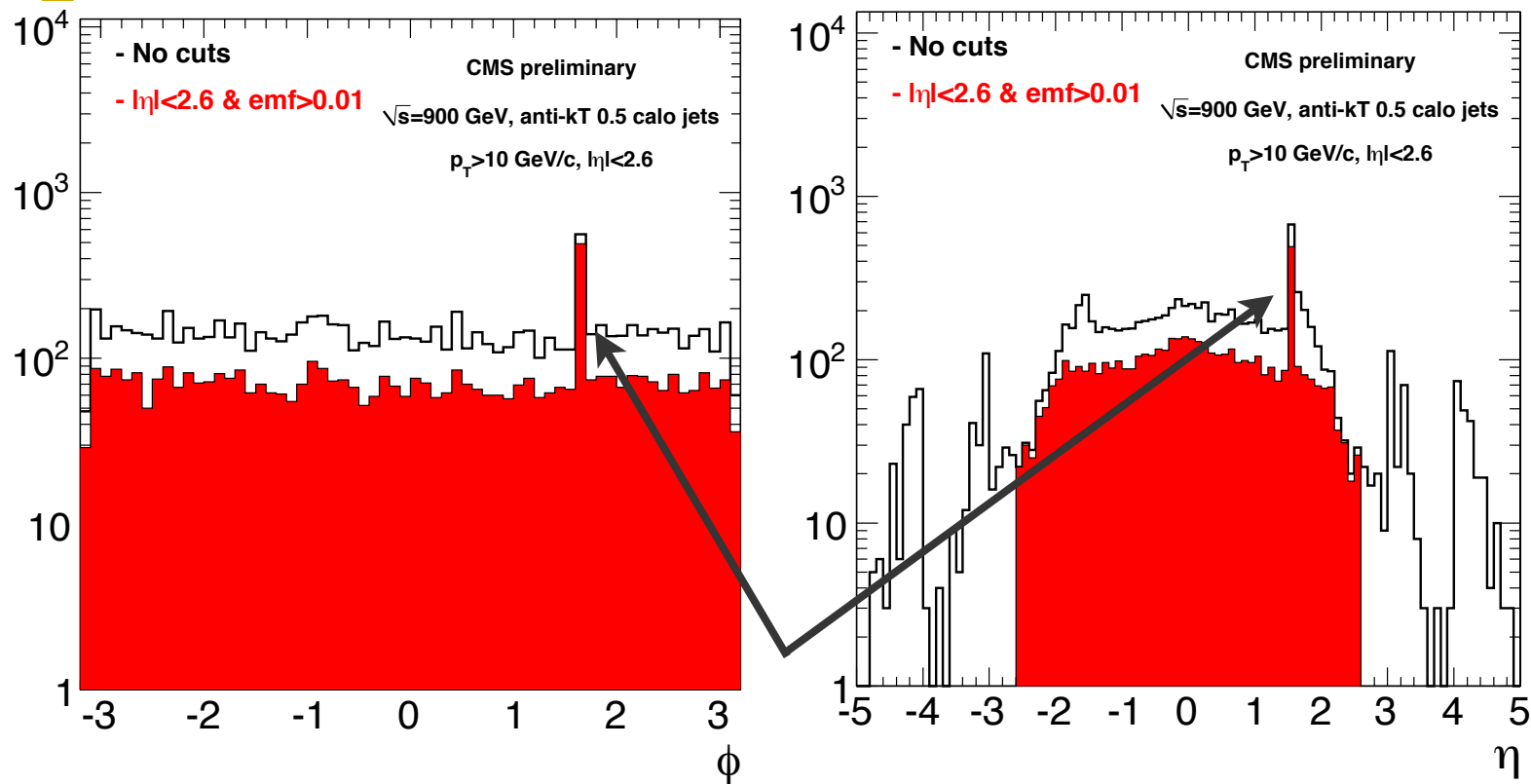
# Efficiency for EMF > 0.01 cut



The efficiency becomes 1 at about 40 GeV/c. The cut is very effective in removing the HCAL pedestal noise. We should stick with this recommended cut.

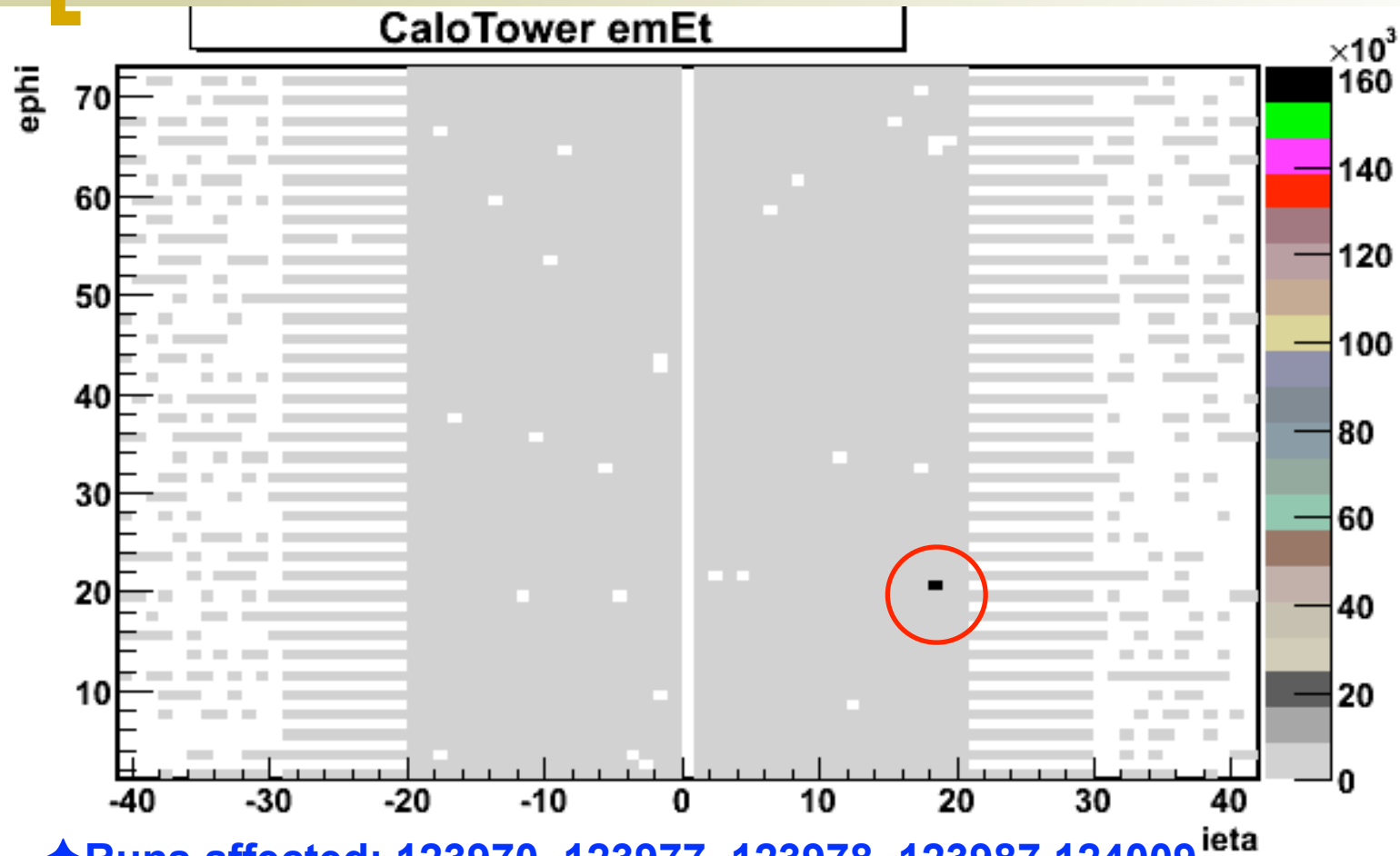


# 900 GeV: lead jet $\eta$ , $\phi$ after minimal cleanup



- ◆ The spike is in the bin:  $1.5 < \eta < 1.6$ ,  $1.6 < \phi < 1.7$
- ◆ Spread across several runs
- ◆ Appears only in the lead jet distribution
- ◆ Probably from ECAL noise → see next 2 slides

# More on spike



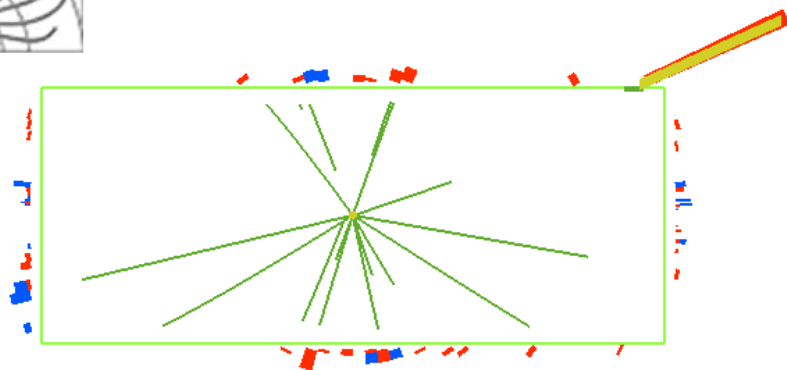
- ◆ Runs affected: 123970, 123977, 123978, 123987, 124009
- ◆ Due to a noisy crystal in EE
- ◆ Also causes asymmetry in, e.g., MET  $\phi$  distribution

<https://hypernews.cern.ch/HyperNews/CMS/get/jetmet-dqm/10.html>

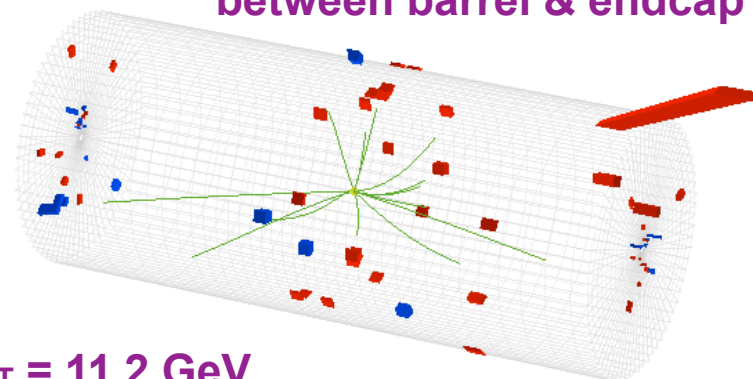
# An event from the spiky bin



Run:124009  
Event:20663888

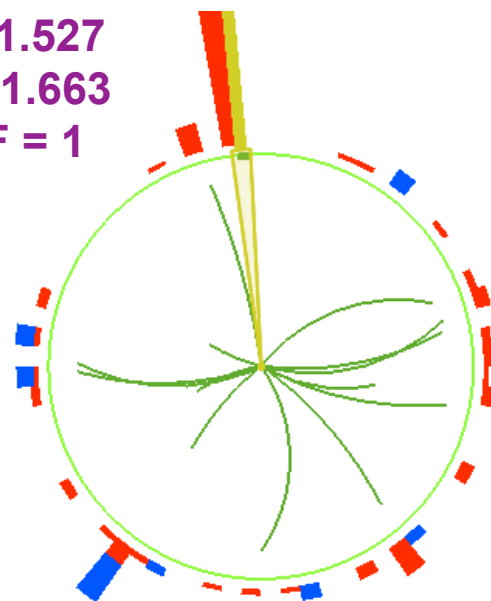


In the transition region  
between barrel & endcap



$p_T = 11.2 \text{ GeV}$   
 $\eta = 1.527$   
 $\phi = 1.663$   
EMF = 1

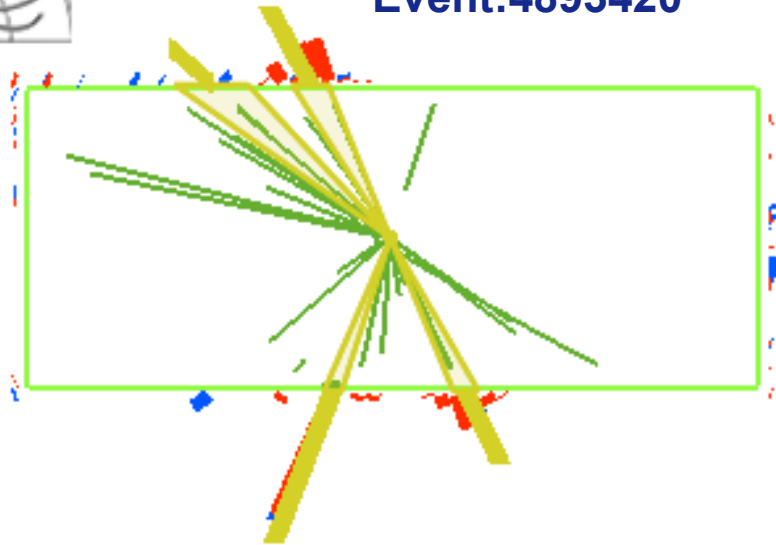
Most of these events have EMF = 1 and n90 sharply peaking at 1.



However, a jet with EMF=1 can be a good one!

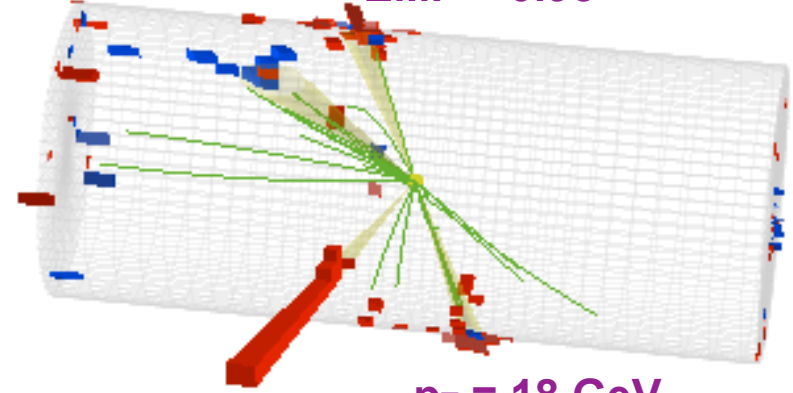


Run:124030  
Event:4893420



$p_T = 12$  GeV  
EMF = 0.12

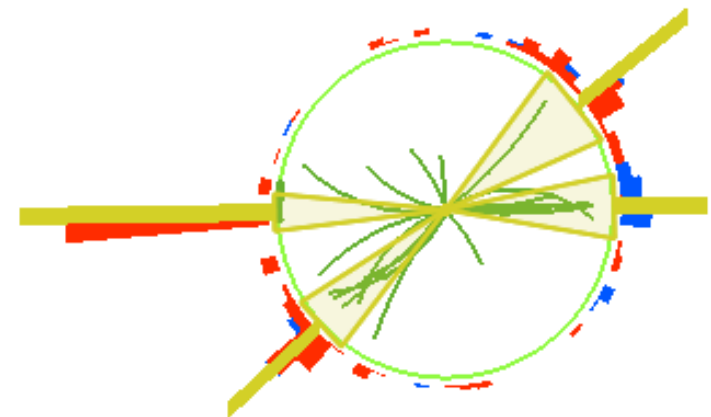
$p_T = 16$  GeV  
EMF = 0.95



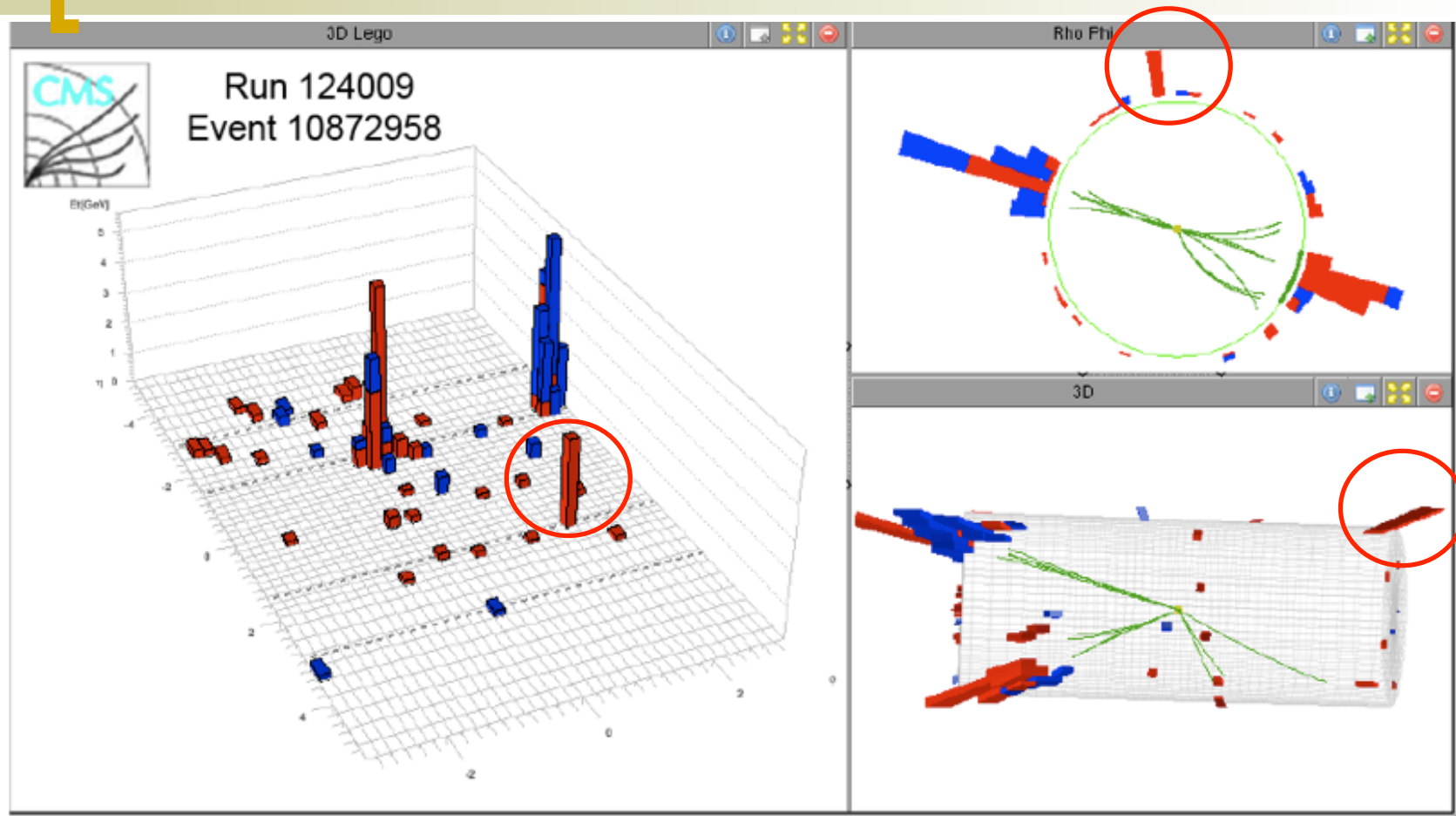
$p_T = 33$  GeV  
EMF = 1

$p_T = 18$  GeV  
EMF = 0.96

An interesting 4-jet event !

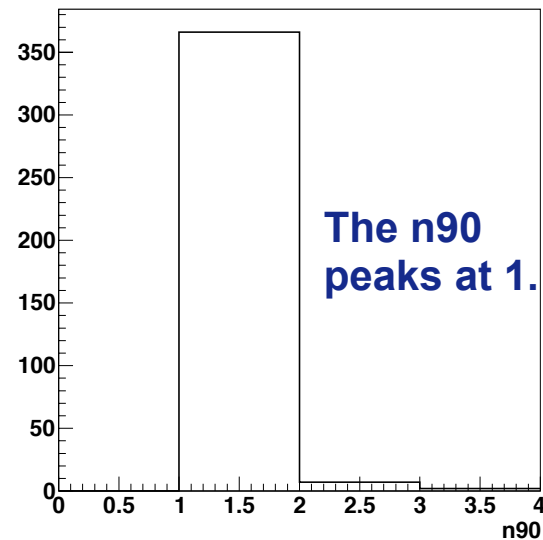
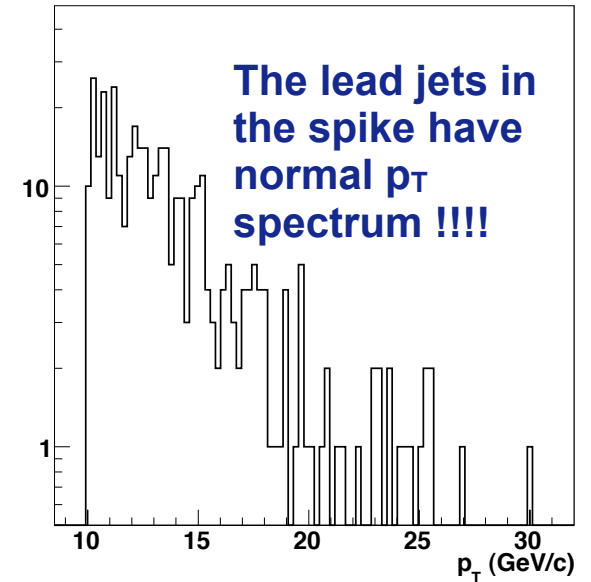
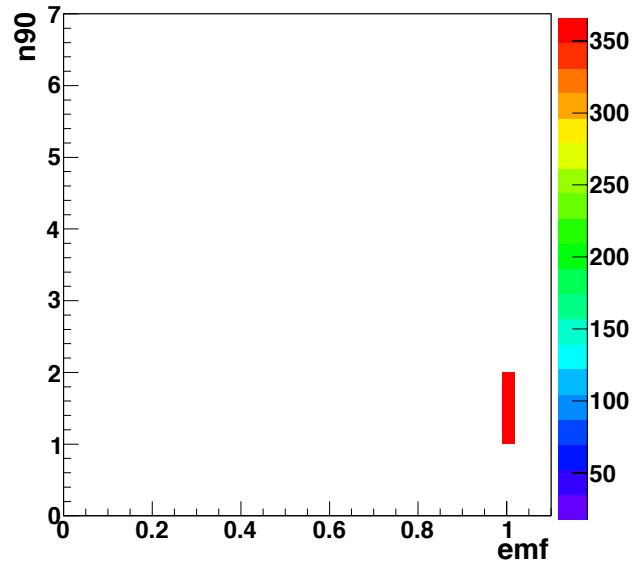
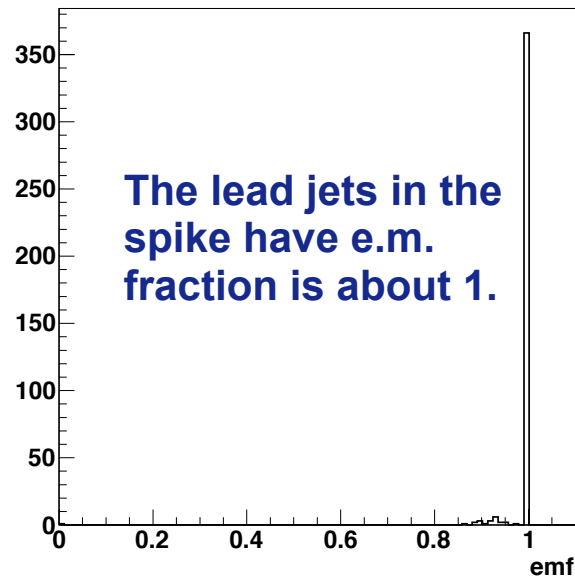


Also a spiky may contain good jets !



AK5 CaloJets	Corr. $P_T$ (GeV)	$\eta$	$\phi$	EM Fraction
Jet 1	45	-1.7	2.8	0.4
Jet 2	38	-1.2	-0.3	0.8

# Further investigation of the spike

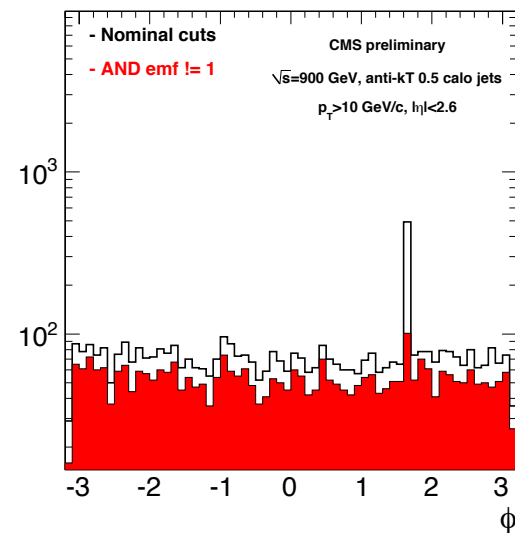
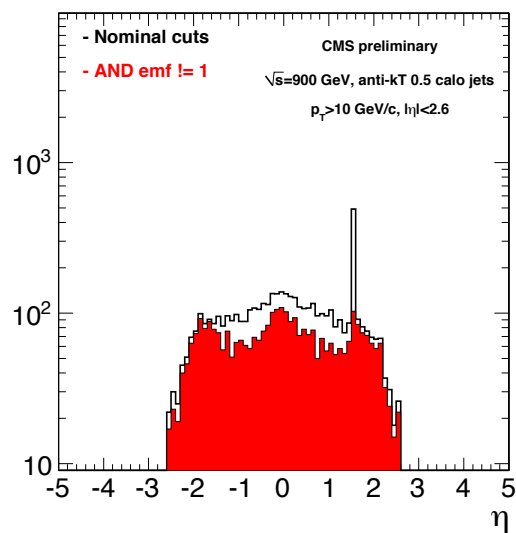
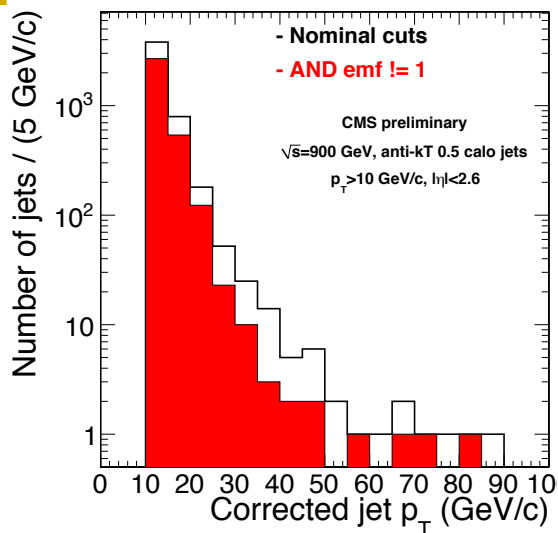


- ◆ Many of these jets have associated track at calo face
- ◆ The spike can be removed either by requiring  $EMF \neq 1$  or by requiring  $n90 > 1$
- ◆ In the next slide we will investigate each cut

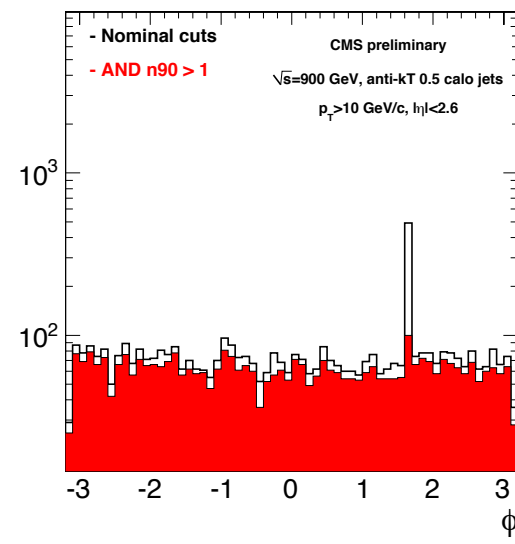
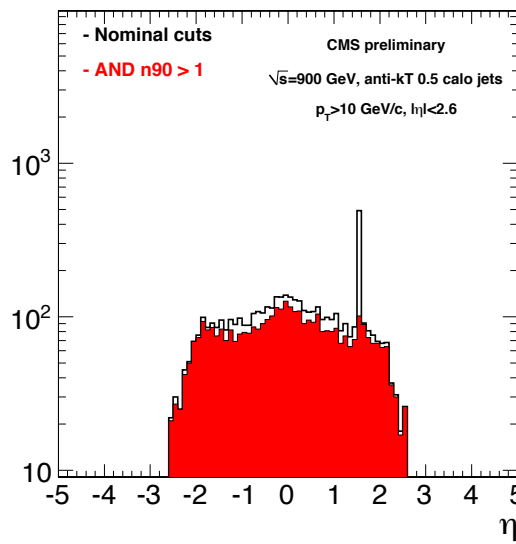
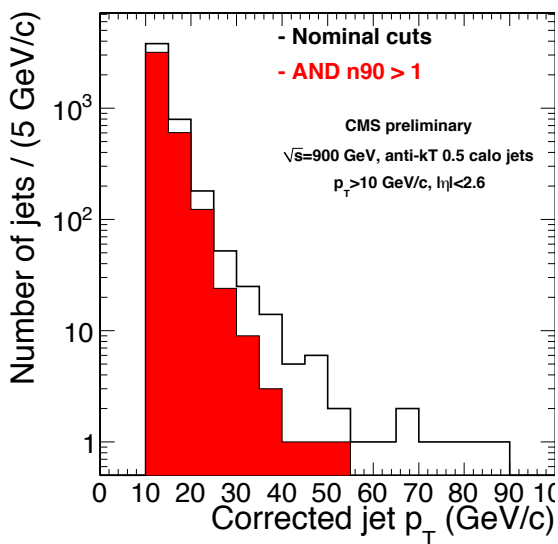


# Two ways to get rid of the spike

Using  
EMF  $\neq$   
1 cut

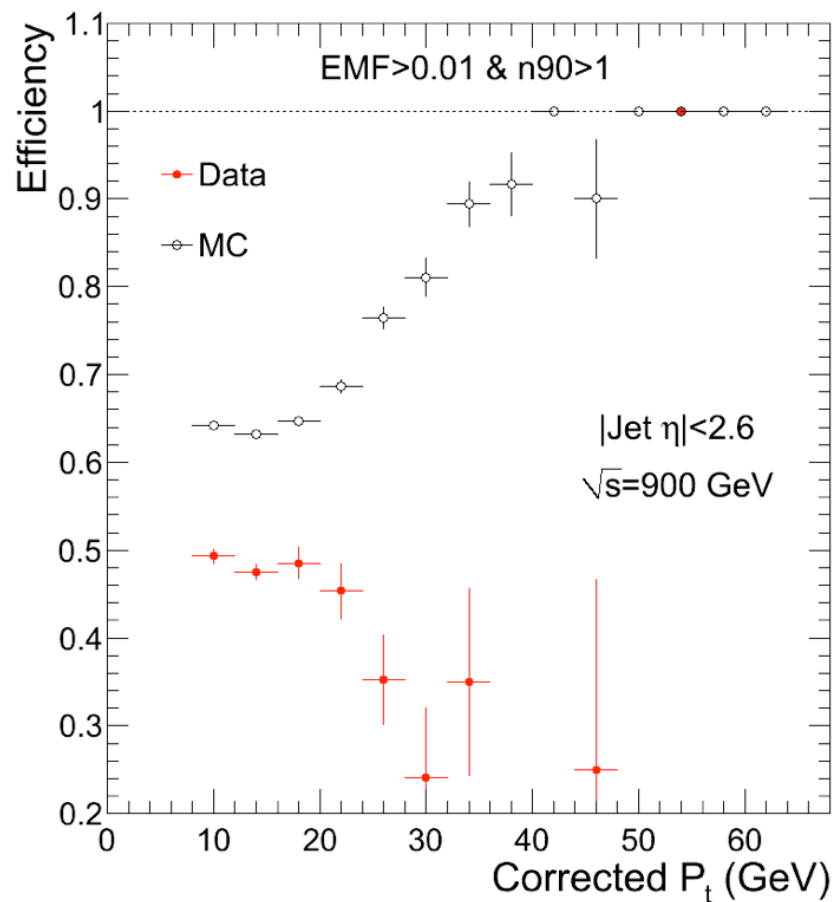
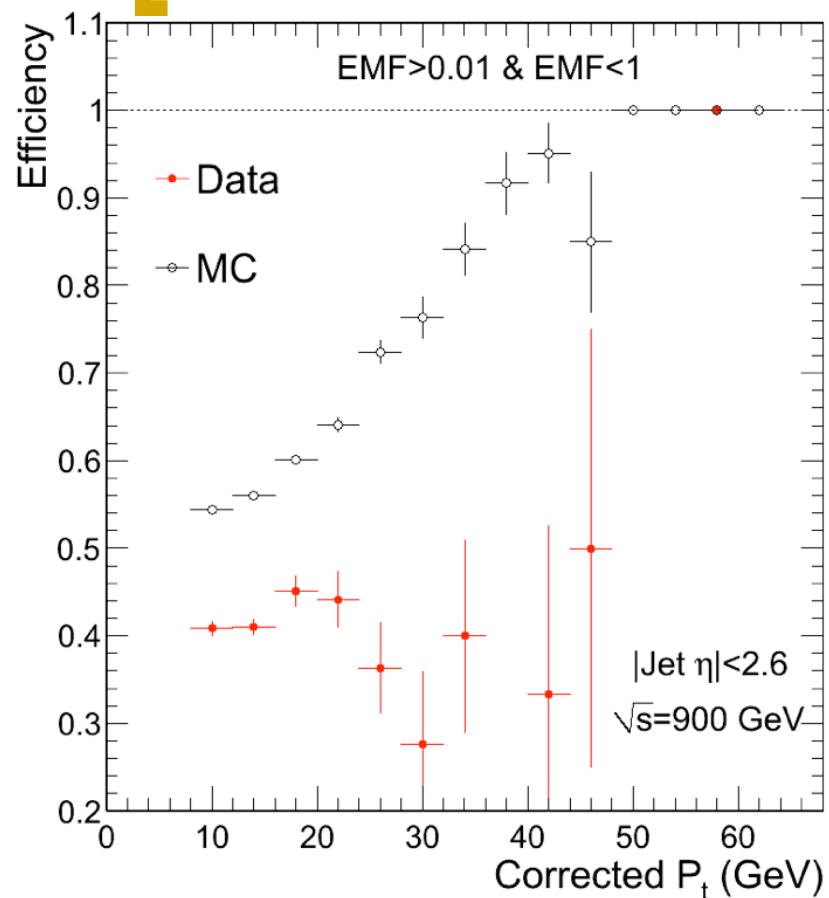


Using  
n90 > 1  
cut





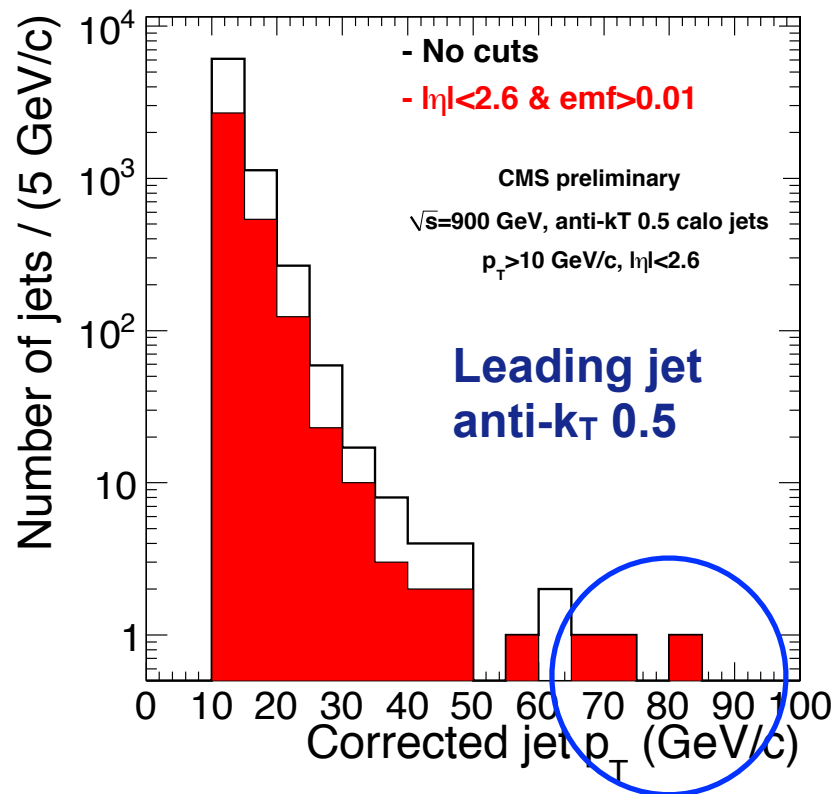
# Efficiency of the two cuts



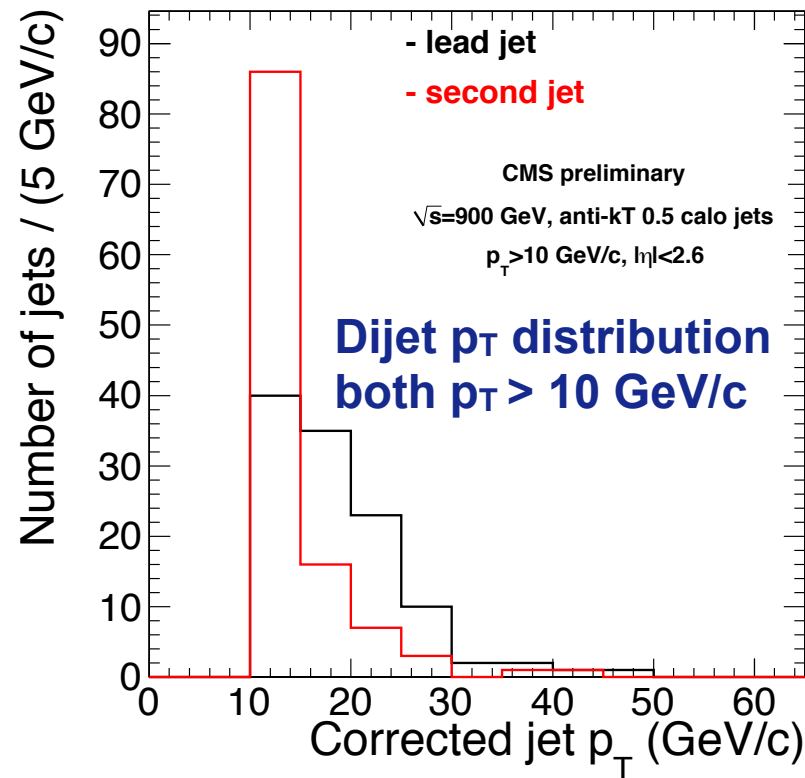
- ◆ The n90 cut seems to be more efficient than EMF < 1 cut
- ◆ Another advantage of n90 cut is that it very effectively removes mono jet events as we will see in later slides



# $p_T$ distribution after emf $\neq 1$ cut



**Mono-jets, have large MET  
Event display of one such  
event on a later slide**



**There are more than 100 back-to-back dijet events in this run**

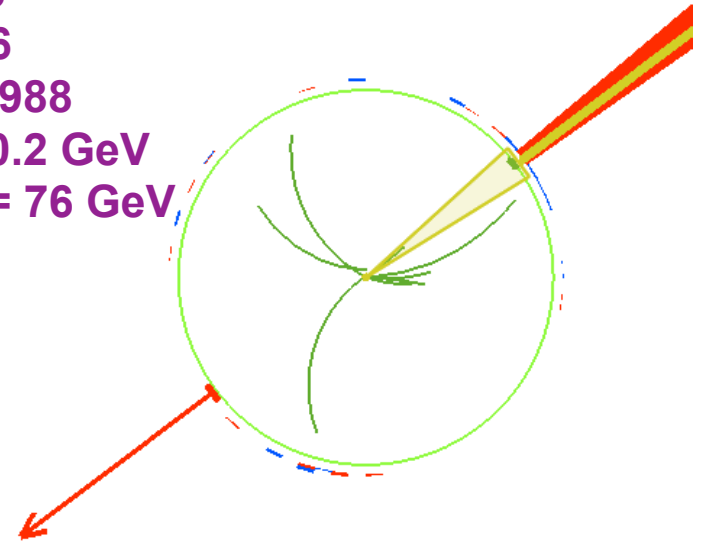
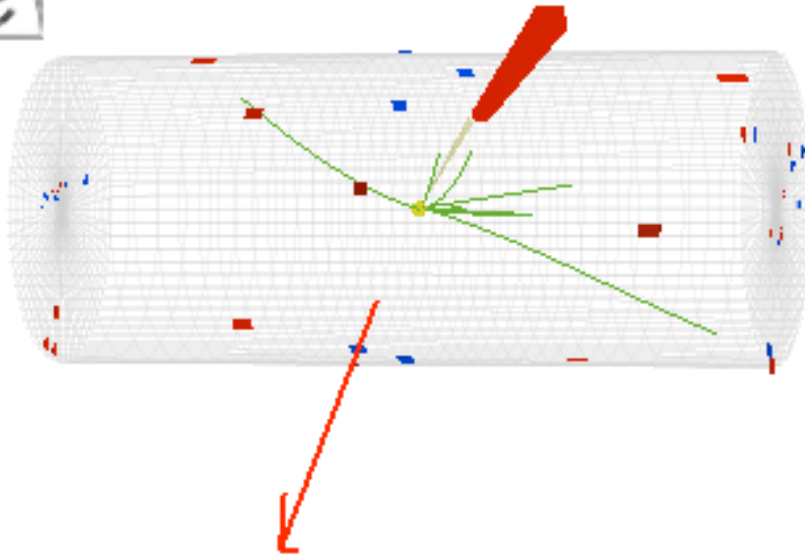
**See next slide for the event display of a typical mono jet event**

# Event display of a mono jet event



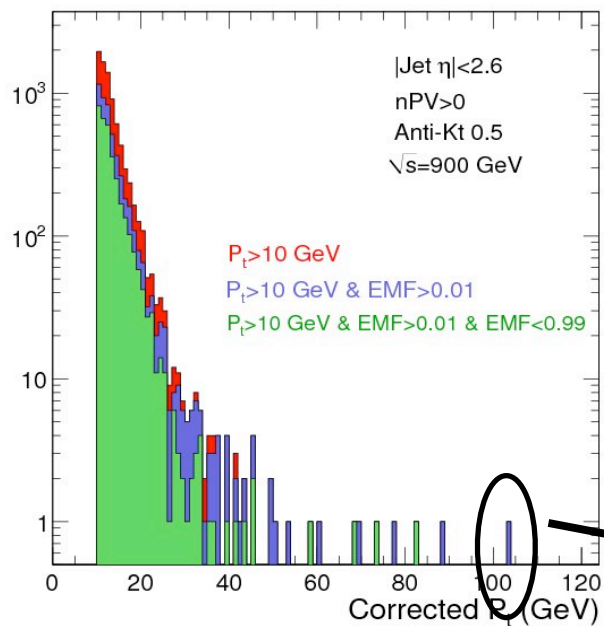
Run:124023  
Event:11347694

$p_T = 58.4 \text{ GeV}$   
 $\eta = 0.166$   
 $\phi = 0.646$   
EMF = 0.988  
MET = 60.2 GeV  
Sum  $E_T = 76 \text{ GeV}$

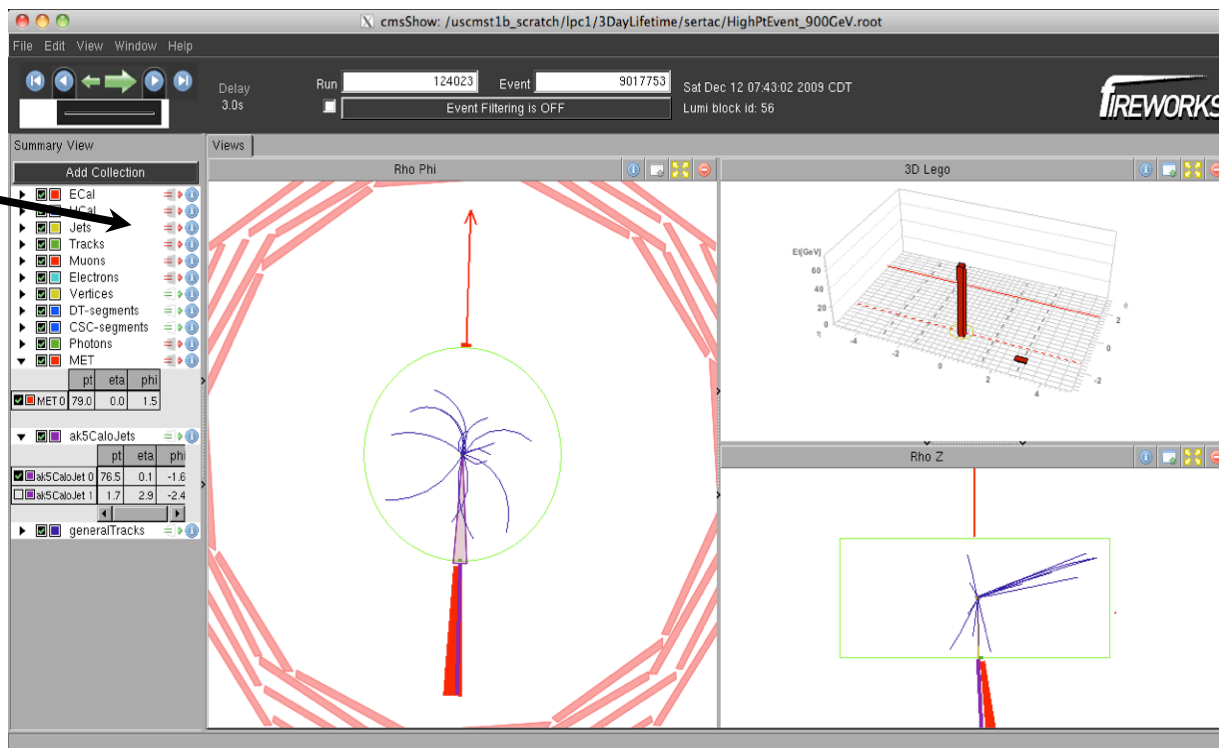


- ◆ The above mono jet passes all of our nominal quality criteria
- ◆ Almost all mono jet events have high missing  $E_T$
- ◆ Obviously, these events get rejected when requiring two back-to-back jets
- ◆ Most of the time there is a matching track at the calo face !!!
- ◆ It seems **nTracks at calo face > 0** requirement would not remove any significant amount of background (after BSC, EMF, and primary vertex cuts)
- ◆ Requiring **n90 > 1** removes the mono jet events !!!!

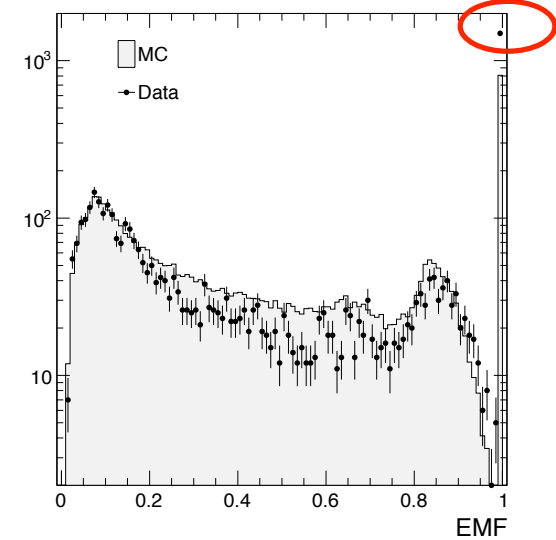
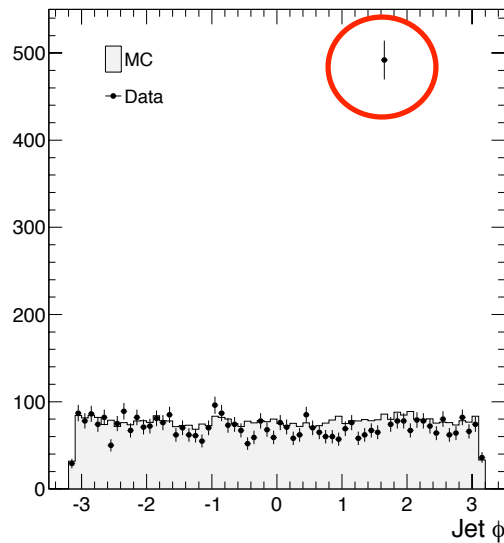
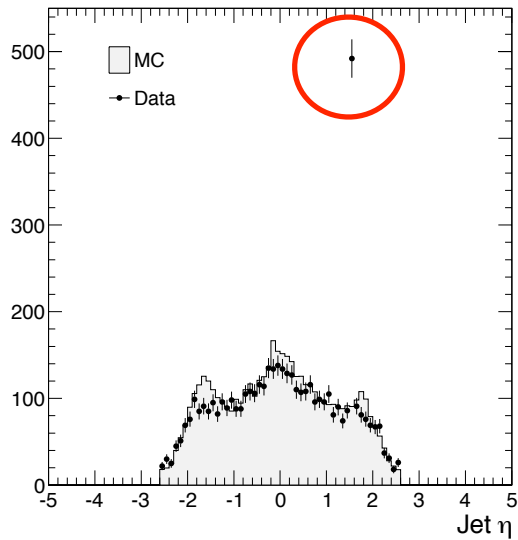
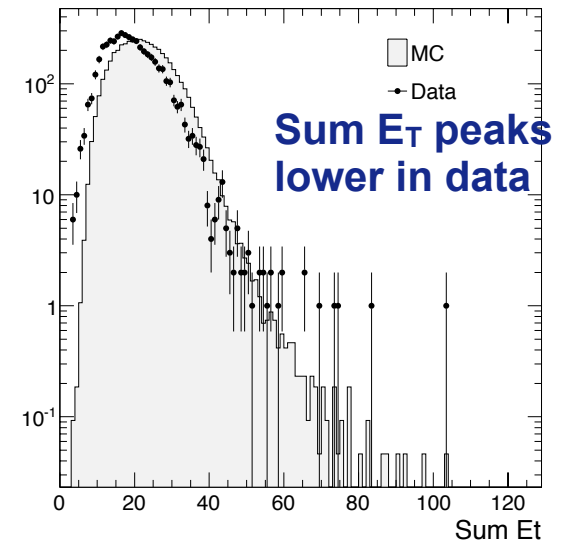
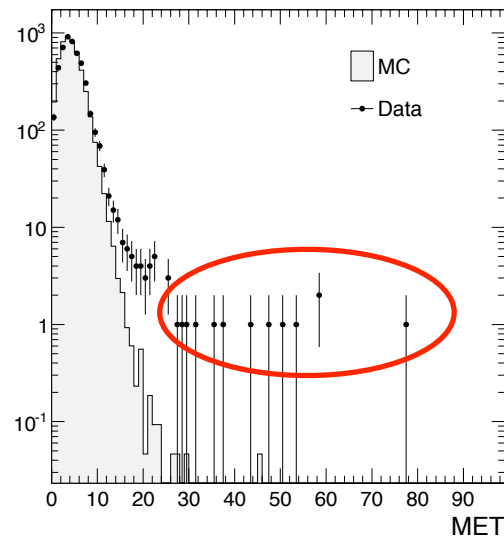
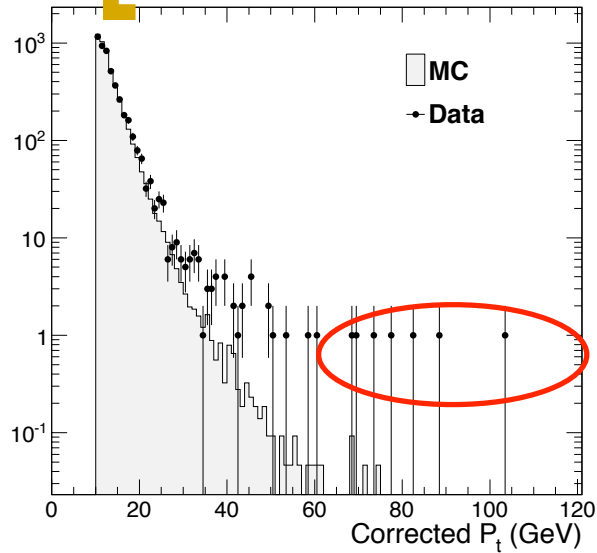
# Another energetic mono jet



Run: 124023, Event: 9017753  
Raw  $p_T = 76.5 \text{ GeV}$ , EMF = 1  
 $N_{\text{Track}} = 1$ , MET = 79 GeV, n90 = 1



# Some data MC comparisons



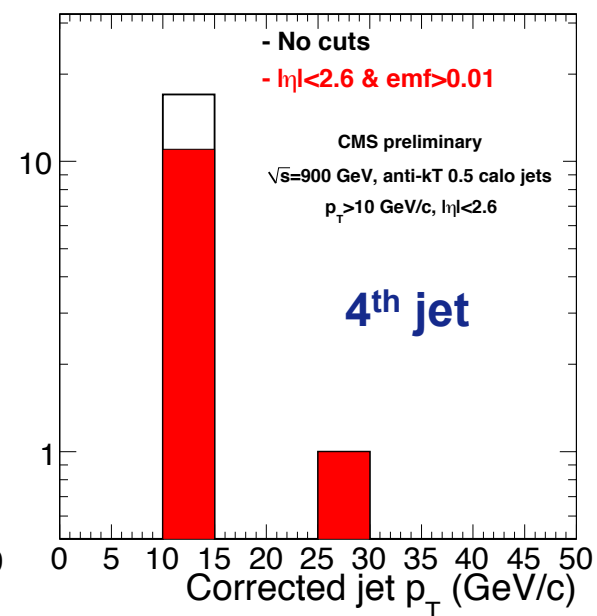
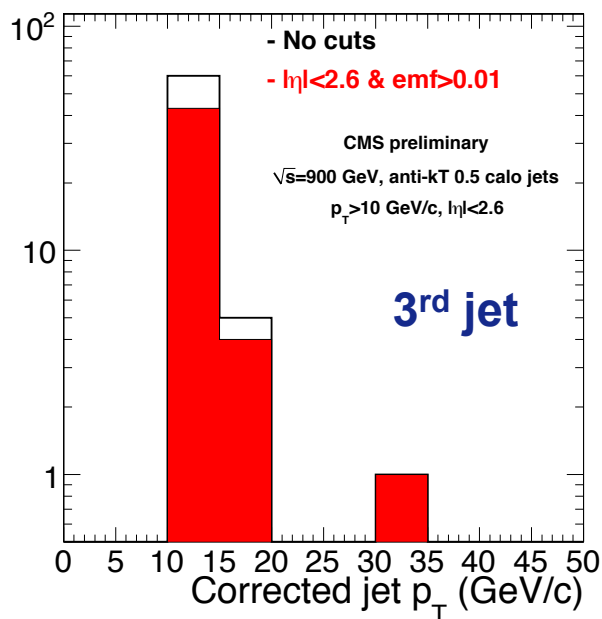
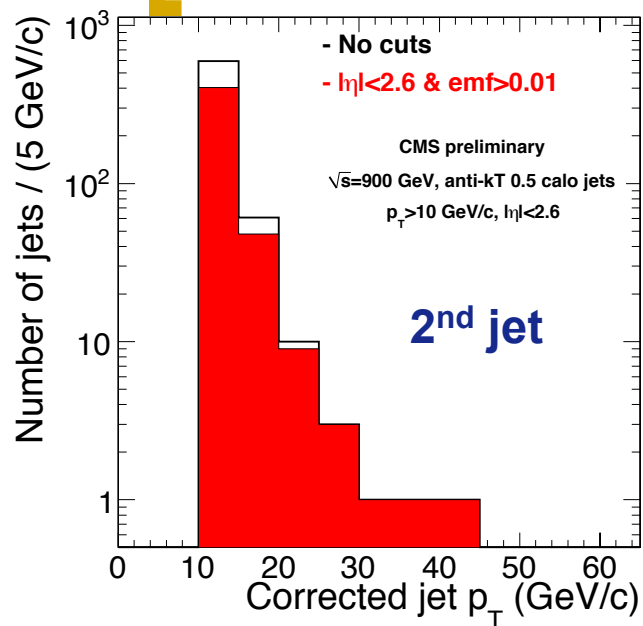
# Summary



- We have done a preliminary study of the jet id in collision data
- We find the lower EMF cut ( $>0.01$ ) to be quite effective in reducing the HCAL pedestal noise
  - MinBias MC used looks similar to data but different than QCD MC
- We find that ECAL noise and mono jet events can be removed by applying  $n90 > 1$  cut
  - An upper cut on EMF is not as effective, and has larger inefficiency
- A requirement of minimum one track at calo face does not help much in reducing the above backgrounds
- Requiring two back-to-back events (i.e., a dijet) removes many of the noisy events

**Backup slides**

# 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, and 5<sup>th</sup> jet p<sub>T</sub>

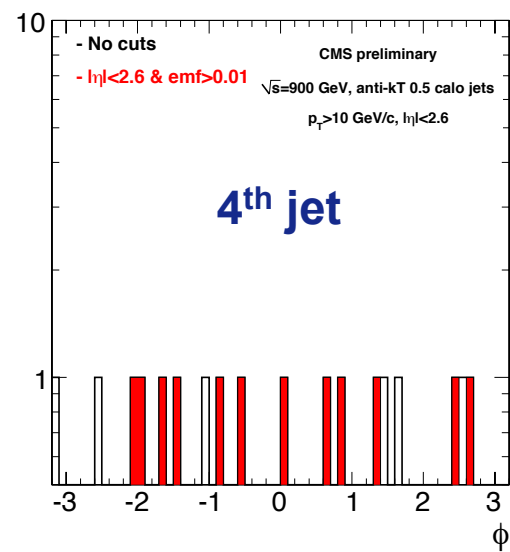
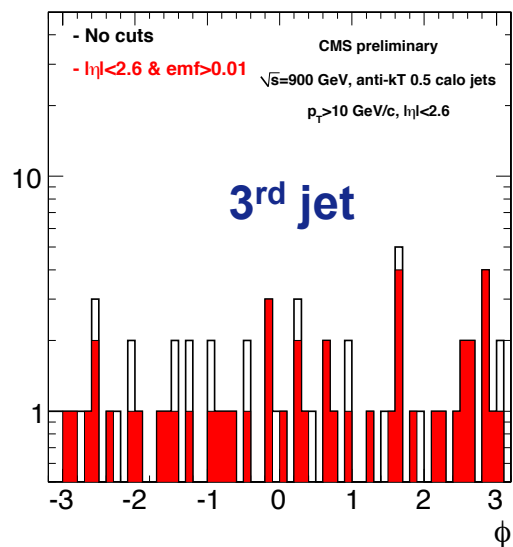
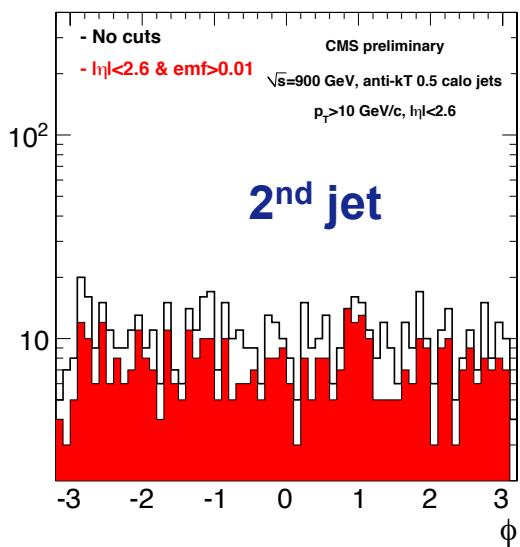
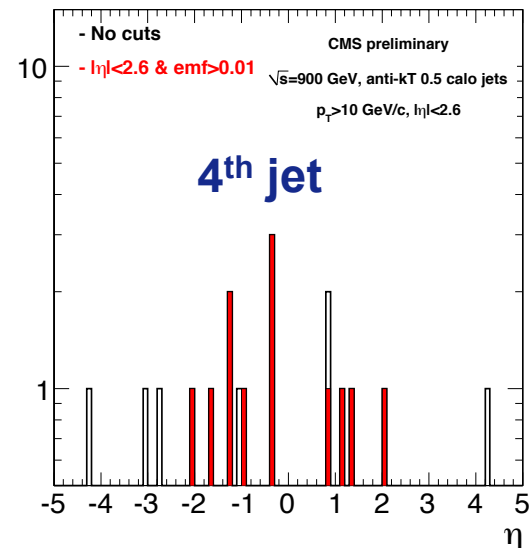
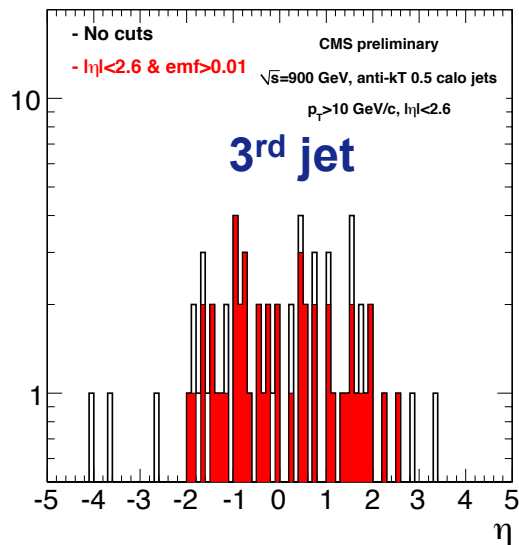
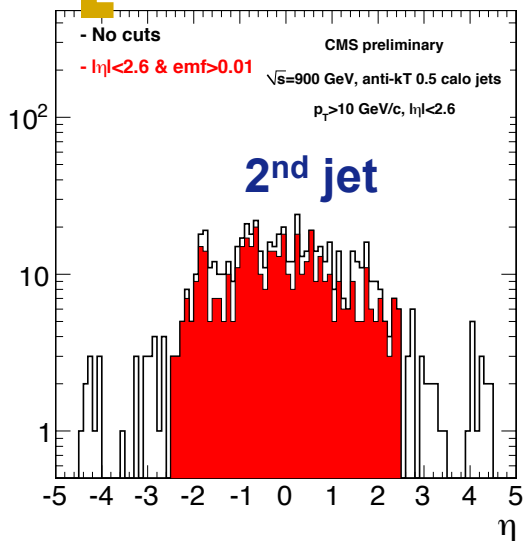


We even have a 5-jet event (with each jet p<sub>T</sub> > 10 GeV/c) !!!

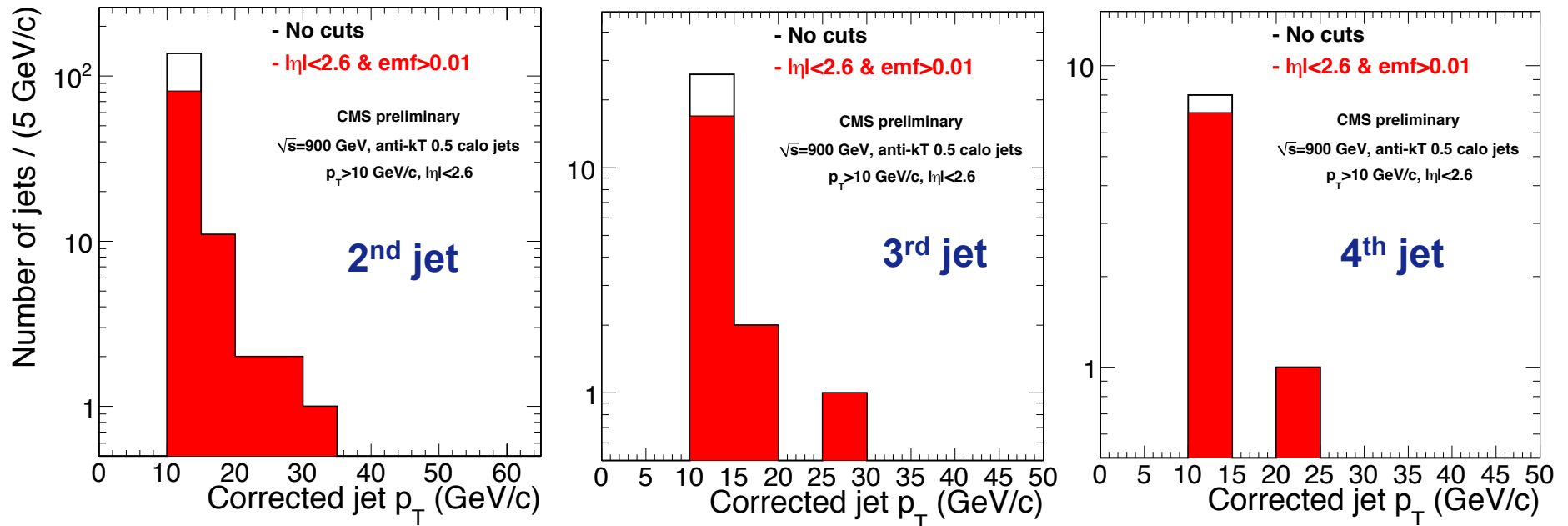
	p <sub>T</sub> (GeV)	η	φ	emf
jet #1	17.12	-1.36	-0.58	0.37
jet #2	14.90	-0.31	2.71	0.83
jet #3	11.10	-0.03	0.22	1
jet #4	10.40	-1.68	2.61	0.25
jet #5	10.18	-0.52	1.29	0.44

Run No: 124024  
 Event No: 10233506  
 MET: 3.94 GeV  
 Sum E<sub>T</sub>: 44.57 GeV

# 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> jet $\eta$ , $\phi$



# 2.36 TeV run: 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup> jet p<sub>T</sub>



We even have two 5-jet event (with each jet p<sub>T</sub> > 10 GeV/c) !!!

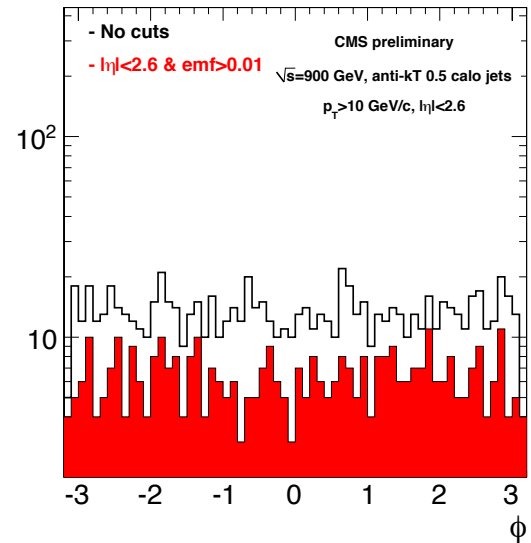
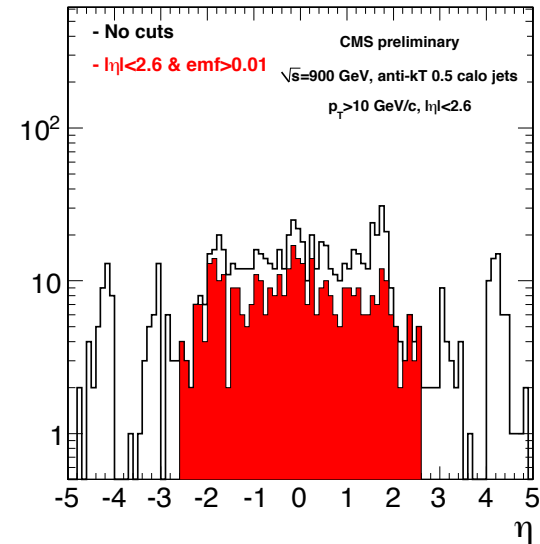
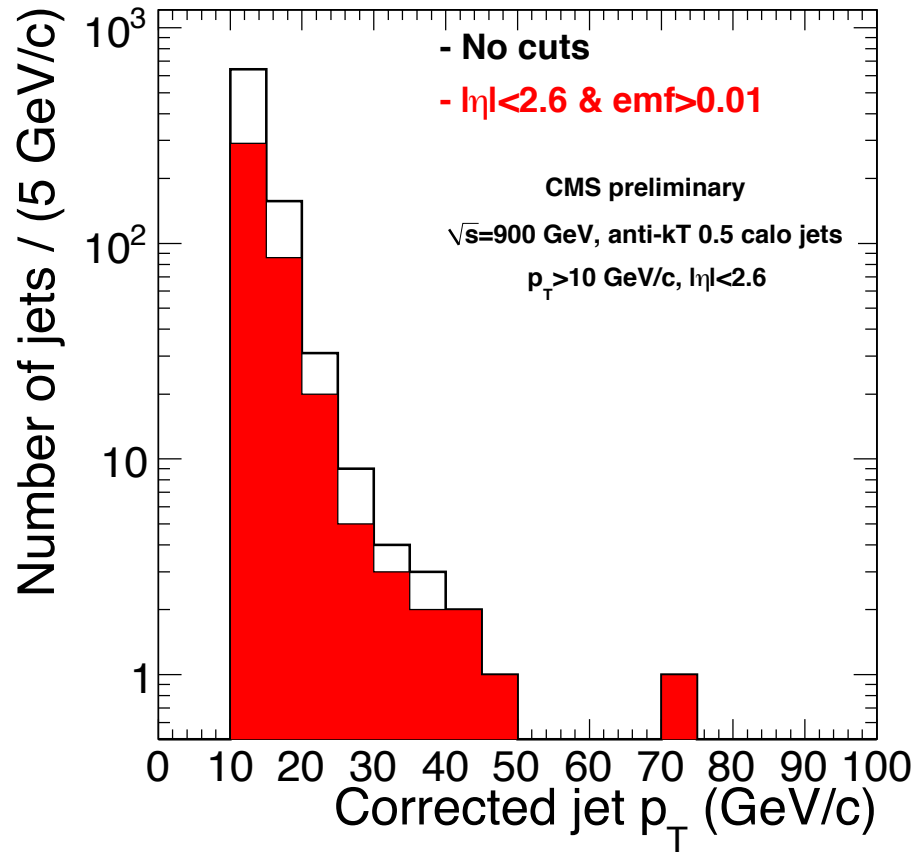
	p <sub>T</sub> (GeV)	η	φ	emf
jet #1	36.46	0.63	-1.63	0.75
jet #2	33.93	-0.91	0.43	0.49
jet #3	26.06	1.73	-1.87	0.74
jet #4	23.34	-1.92	2.41	0.25
jet #5	10.98	-1.08	-0.15	0.60

Run No: 124120  
 Event No: 6613074  
 MET: 9.02 GeV  
 Sum E<sub>T</sub>: 81.89 GeV

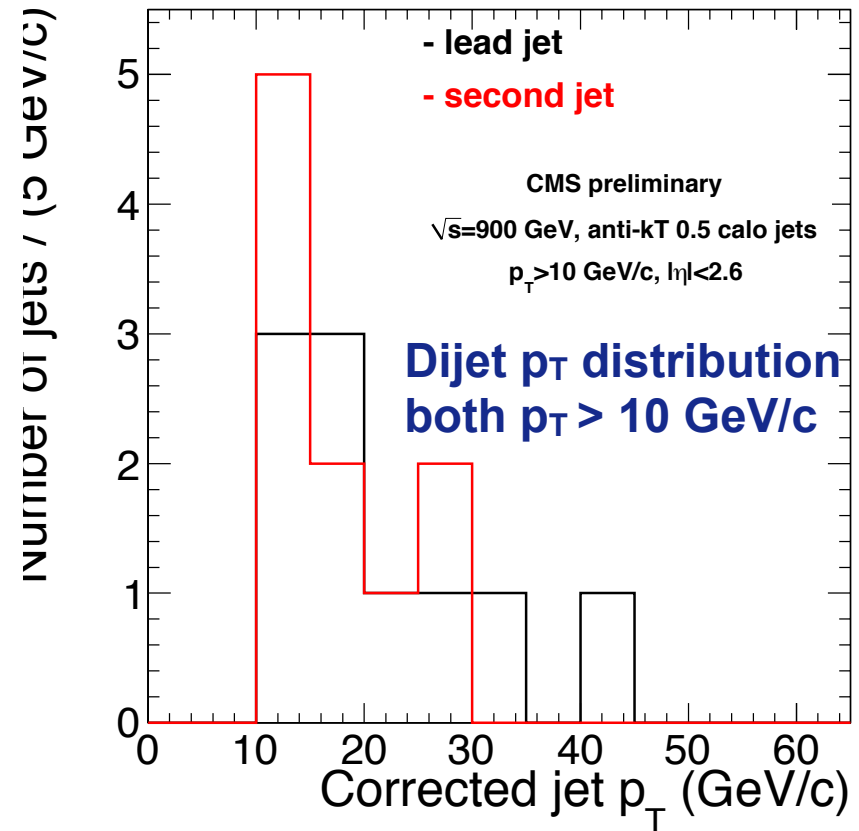
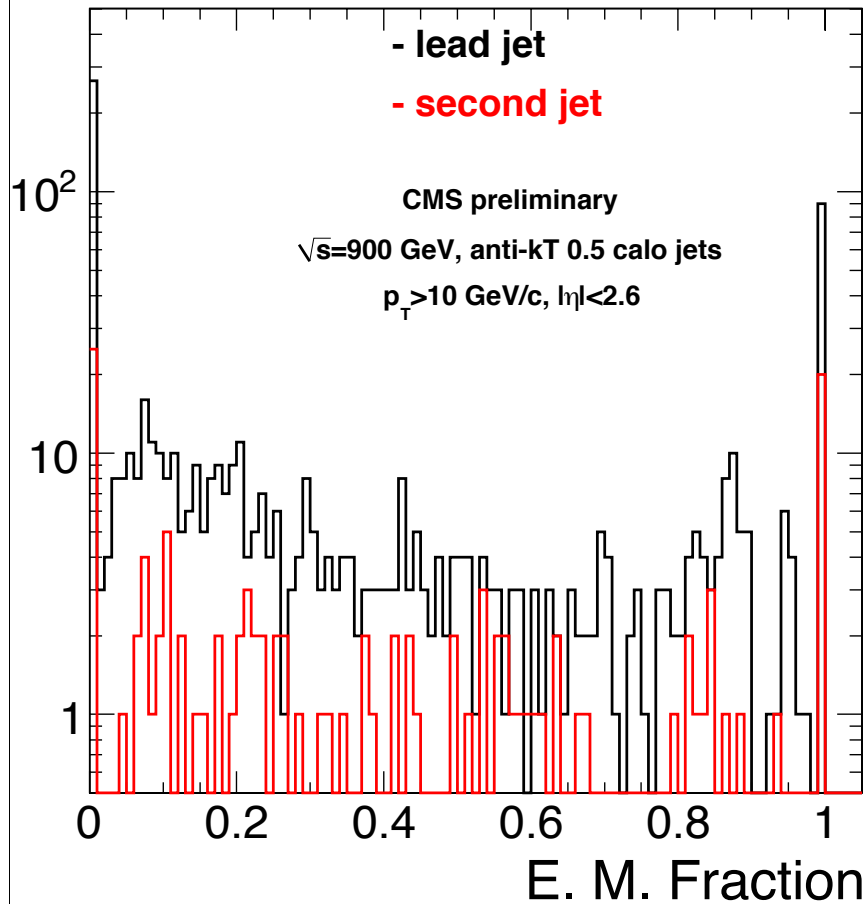
Other event in  
 the same run:  
 7843920



# Plots from 2.36 TeV run: leading jet

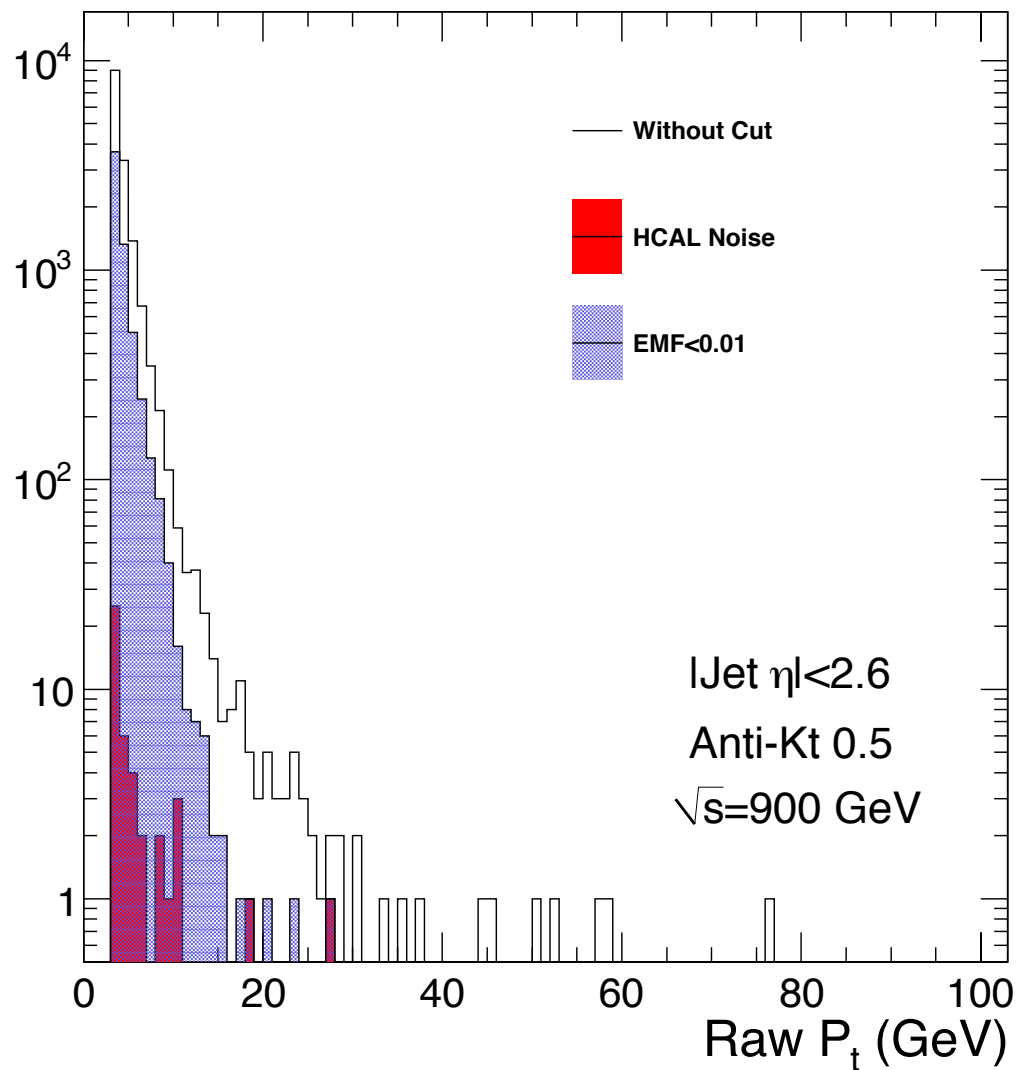


# Plots from 2.36 TeV run: other distributions



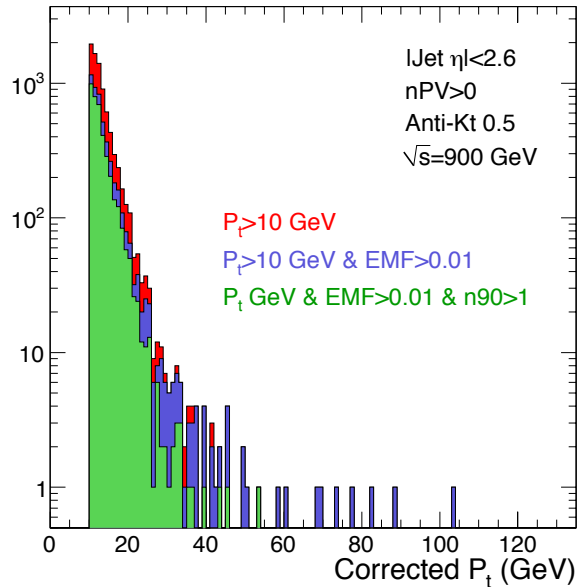
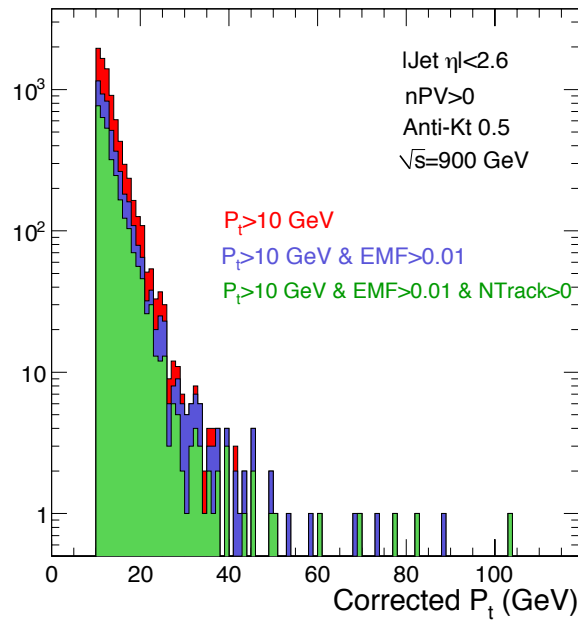
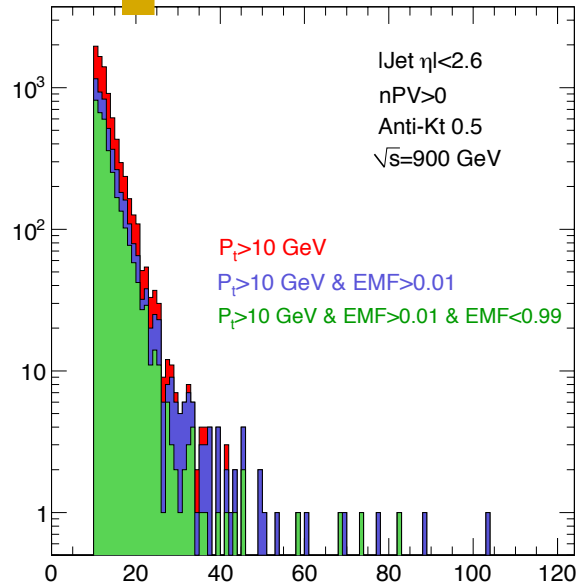
**There are 10 back-to-back dijet events in this run**

# How many events are HCAL noise ?

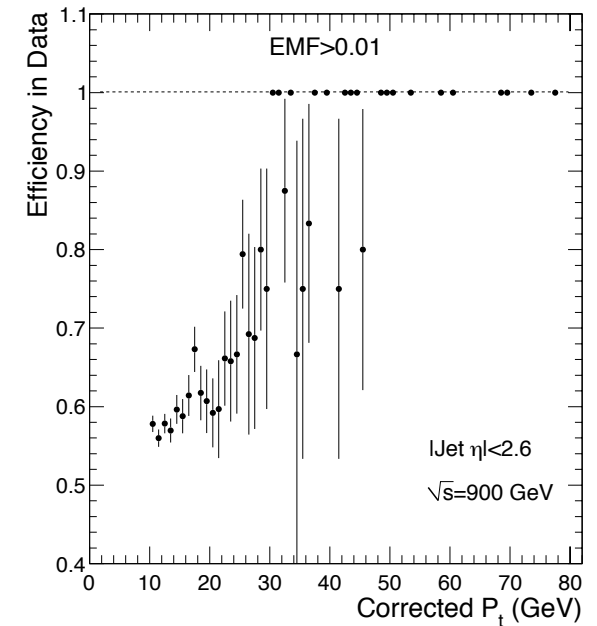


About 1/3rd of the events with a jet are consistent with being HCAL noise using “loose” criteria.

# $p_T$ distribution after successive cuts



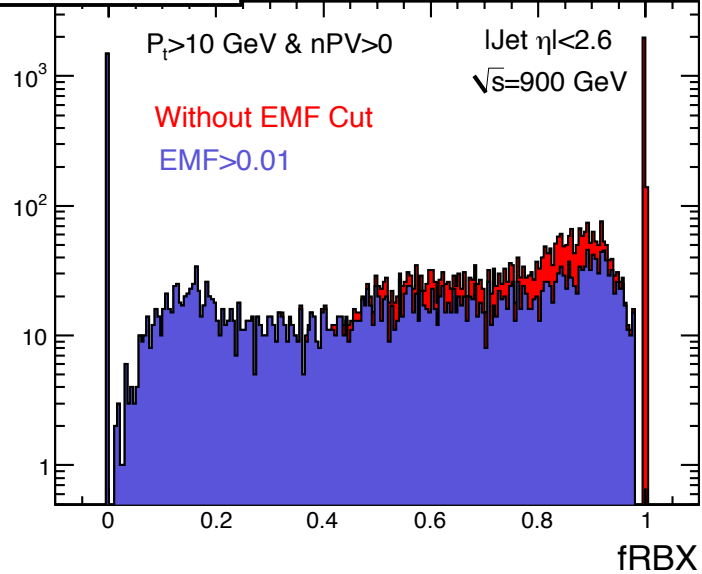
## Efficiency of EM fraction lower cut



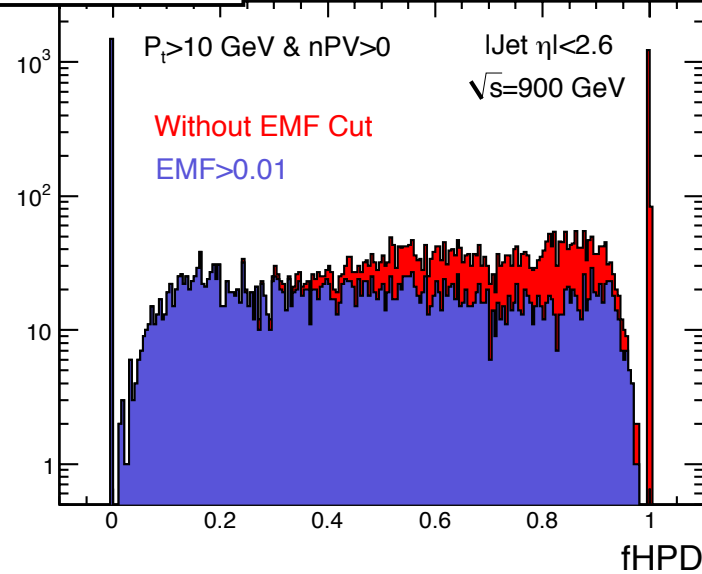
# Jet Id explorations



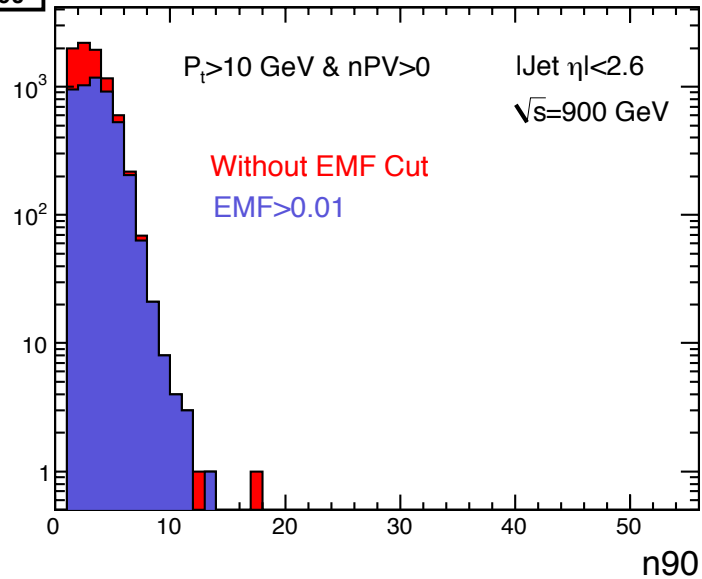
Fraction of RBX



Fraction of HPD



N90



Number of Track

