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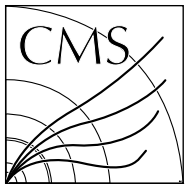

The Compact Muon Solenoid Experiment

Analysis Note

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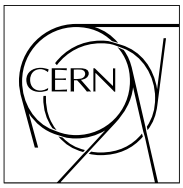

31 January 2010

Event displays of dijet events with highest p_T in pp collisions at $\sqrt{s} = 900$ GeV

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Abstract

We show event displays of dijet events with the highest p_T from the Decemeber 2009 CMS data sample at $\sqrt{s} = 900$ GeV. We show the 10 highest p_T dijet candidates. In eight of the candidate events both leading jets pass the loose jet ID requirements and remain in the standard dijet analysis. In two of the events one jet fails the loose jet ID due to ECAL noise and does not remain in the final dijet analysis sample. For each event we list some kinematic and ID quantities of the two leading jets. We also show a few dijet candidates with lower p_T that fail the jet ID due to HCAL cuts.

Contents

1 Motivation

We seek to explore the highest p_T dijet event candidates that are part of the standard dijet analysis for 900 GeV pp collisions in CMS AN-2010/009. We start with the same basic cuts for CaloJets as in that note, and show displays of the 10 highest p_T dijet candidate events before jet ID. We indicate the ones passing the loose jet ID and the ones failing, and the ones failing are all Ecal noise jets. We also show a few high p_T dijet events failing jet ID cuts intended to remove backgrounds originating in the HCAL only. These events are not in the 10 highest p_T dijet candidates, but are included to demonstrate a few events rejected by HCAL cuts.

2 Data sample and event selection

To make all event display plots in this note we used the re-reco data sample:

`dataset=/MinimumBias/BeamCommissioning09-Jan23ReReco-v1/RECO.`

This dataset was reconstructed in the CMS software release 3.3.6-patch3. We used Fireworks/cmsShow version 3.3.6 for the event display. ECAL and HCAL cell energies in the CaloTowers were only displayed if the CaloTower passed the p_T threshold of 0.3 GeV, the standard threshold for jet reconstruction. In the figures we list corrected jet p_T values for Anti-KT CaloJets with cone size $R = 0.5$ coming from the standard L2 (relative) and L3 (absolute) jet energy corrections for collisions with $\sqrt{s} = 900$ GeV. The leading jets are the two jets with highest corrected p_T. Following is a brief description of our event selection criteria.

- Basic event selection criteria
  - must pass beam-crossing technical trigger ("BPTX" / "bit 0")
  - must pass Beam Scintillation Counter technical triggers ("bit 40 OR 41")
  - must have a "physics declared" trigger bit pass
  - should not contain beam halo (*i.e.,* veto on technical trigger bits 36 to 39)
  - reject scraping (*i.e.,* containing "monster track") events
  - must contain a primary vertex with $|PVz| < 15$ cm
- Dijet candidate selection criteria:
  - both leading jets must have corrected $p_T > 10$ GeV
  - both leading jets must have $|\eta| < 3$
  - the two jets should be back-to-back in azimuthal angle within a tolerance window of 1 radian,*i.e.,* $|\Delta\phi - \pi| < 1.0$
- A dijet event passes the loose jet ID if both leading jets satisfy
  - electromagnetic energy fraction greater than 1% (*i.e.,* $emf > 0.01$) for jets with $|\eta| < 2.6$.
  - the number of calorimeter *rechits* containing 90% of jet energy is greater than 1 (*i.e.,* $N90hits > 1$)
  - fraction of the jet energy carried by the hottest hybrid photo diode in the hadronic calorimeter less than 98% (*i.e.,* $fHPD < 0.98$)

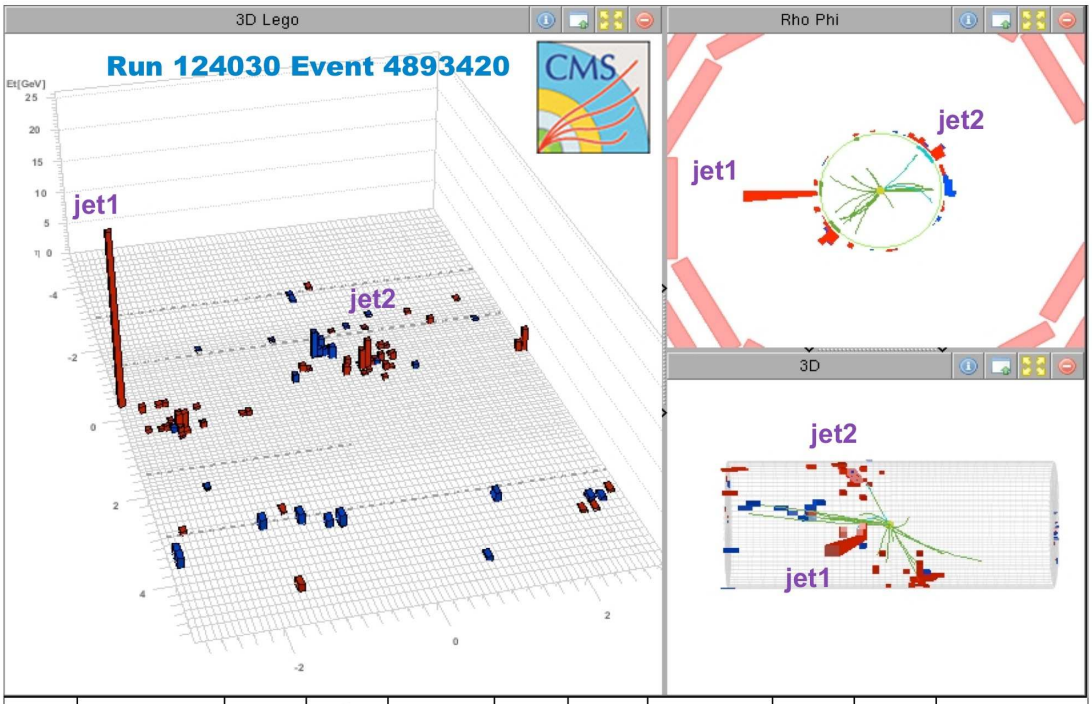
We ran over the data, found all events passing the dijet candidate selection critieria above, and we made event displays of the 10 events with the highest p_T leading jet. All 10 events are shown in this note, and in 8 of those events both leading jets pass the loose jet ID criteria above and remain in the standard dijet event selection of AN 2010/009.

3 Glossary of technical terms

We use the following technical terms throughout the text

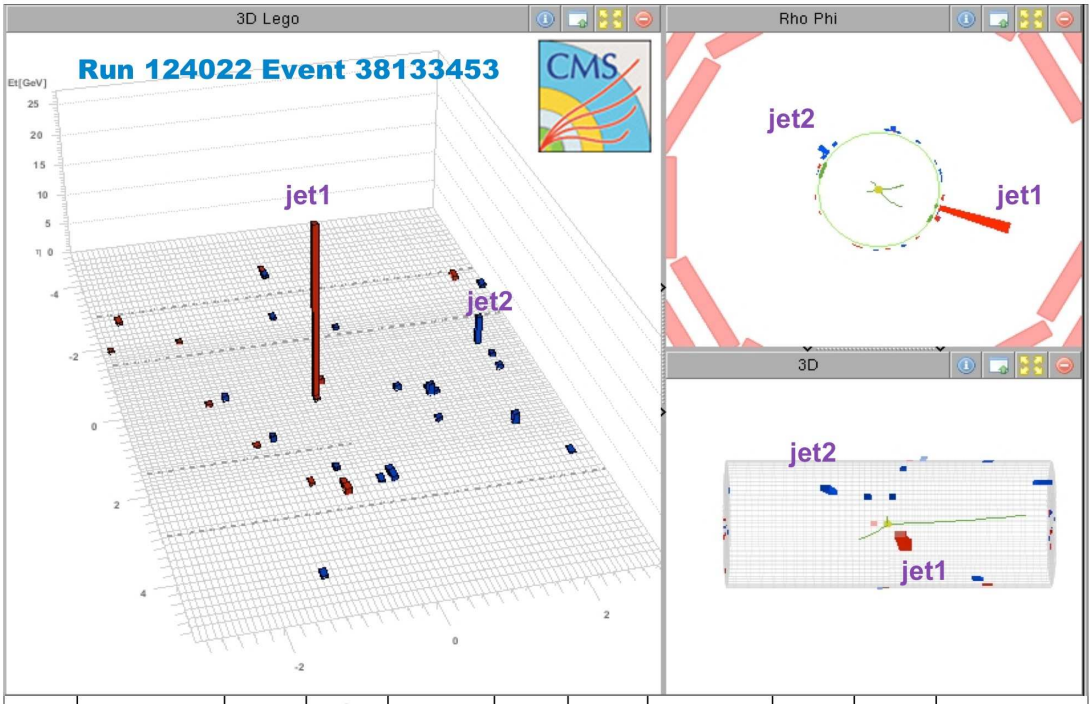
1. $\boldsymbol{p_T}$: transverse momentum of the jet (corrected, unless specified otherwise)
2. *CorPt*: corrected transverse momentum of the jet
3. $\boldsymbol{\eta}$: pseudo-rapidity of the jet calculated with respect to (0,0,0)
4. $\boldsymbol{\phi}$: azimuthal angle of the jet calculated with respect to (0,0,0) in the range $-\pi$ to π
5. *EMF*: electromagnetic energy fraction of the jet
6. *N90*: number of CaloTowers carrying 90% of the jet energy
7. *N90hits*: number of calorimeter *rechits* carrying 90% of the jet energy
8. *HPD*: a hybrid photo diode in the hadronic calorimeter
9. *fHPD*: fraction of jet energy carried by the "hottest" (or most energetic) HPD
10. *RBX*: a readout box (containing 4 hybrid photo diodes) in the hadronic calorimeter
11. *fRBX*: fraction of jet energy carried by the most energetic readout box
12. *nTrkCalo*: number of tracks associated to a jet at the calo face
13. *met/sumet*: ratio of missing transverse energy to the sum total energy in the event
14. *jet 1*: the leading (in $\boldsymbol{p_T}$) jet in the event
15. *jet 2*: the sub-leading (in $\boldsymbol{p_T}$) jet in the event
16. *3D*: three-dimensional view in the event display
17. $\boldsymbol{\rho}$: radial parameter of the cylindrical coordinate (*e.g.* $\boldsymbol{\rho - \phi}$ view in the event display).

4 900 GeV: Ten highest p_T dijet candidate events



Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	52	-0.4	-3.1	10	2	1	0	0	0	0.18
Jet2	33	-0.5	0.7	31	12	0.96	1	0.04	0.04	

Figure 1: Passes Jet ID. This is the dijet event with the highest p_T leading jet. The leading jet does not have an associated track at the calorimeter face. The leading jet is all electromagnetic and is made of many Ecal cells, indicated by $N90hits = 10$.



Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	47	0.2	-0.3	1	1	1	0	0	0	0.50
Jet2	14	-0.7	2.5	2	2	0	1	0.88	1	

Figure 2: Fails jet ID. The leading jet has its entire energy in the electromagnetic calorimeter, and fails the $N90hits$ cut, with all of its energy in a single ECAL crystal (see Fig 3). Event also has large MET/sumEt.

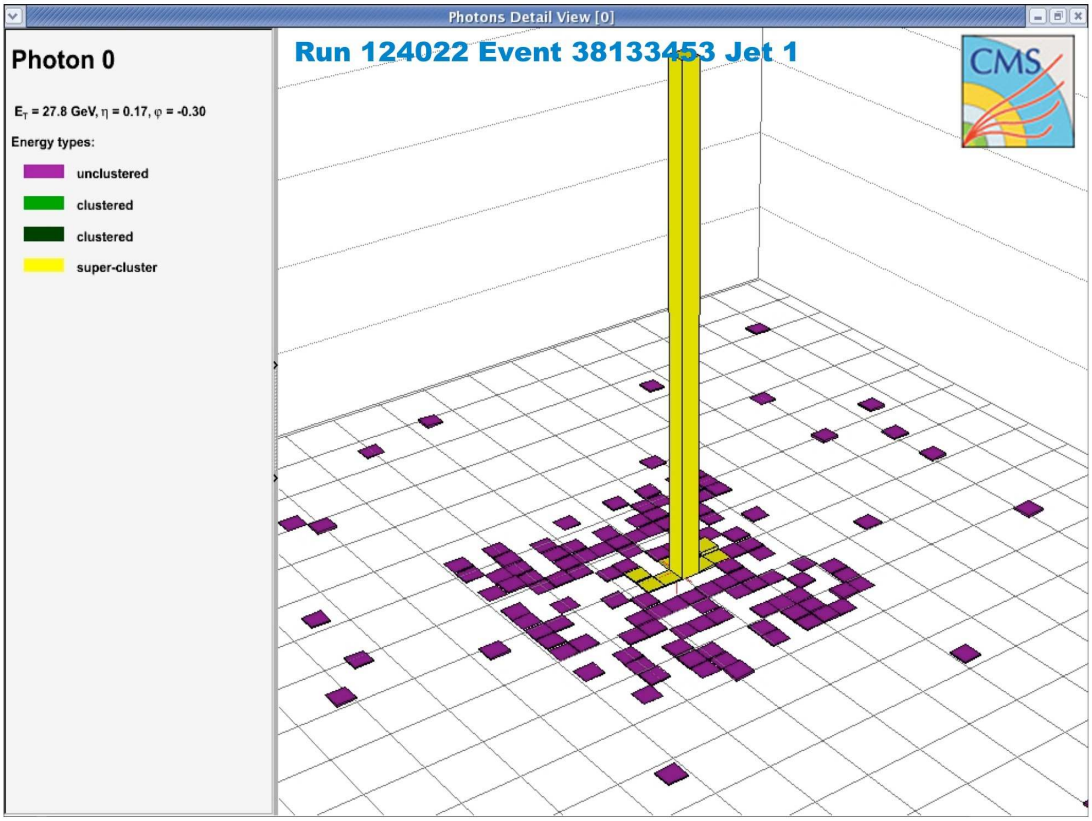
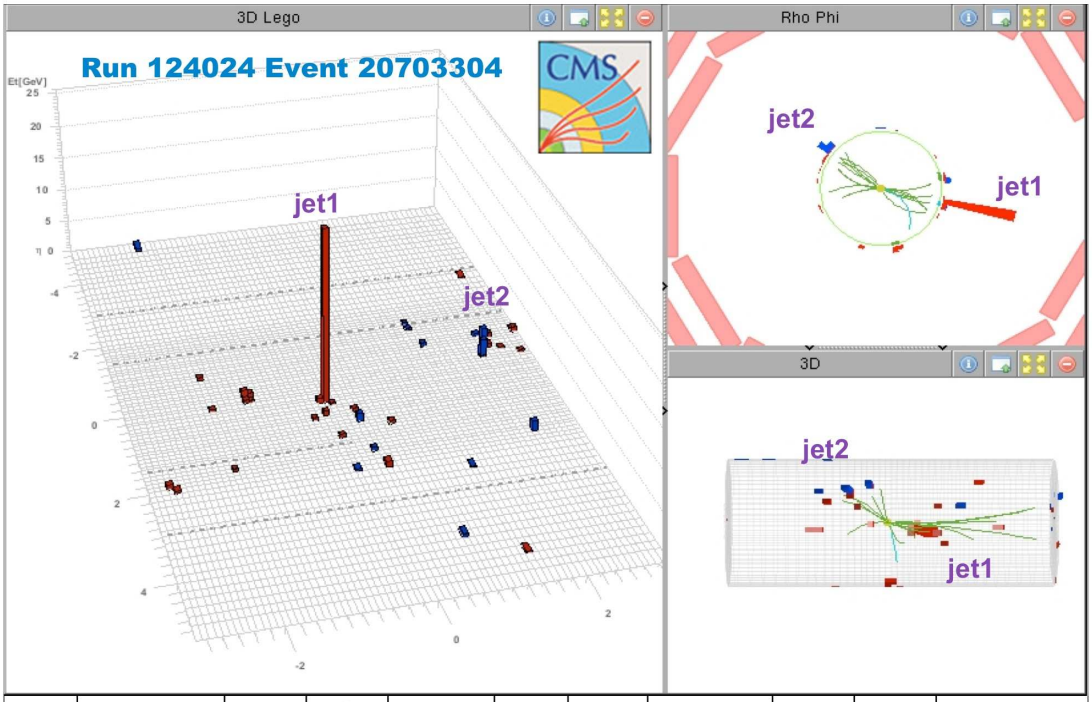


Figure 3: "Photon view" of the leading jet in Fig 2 which fails jet ID. In this display every cell is a single crystal. The leading jet energy is dominated by a single Ecal crystal, and this jet is rejected by the $N90hits > 1$ cut.



Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	46	0.4	-0.3	1	1	1	3	0	0	0.42
Jet2	19	-0.5	2.5	9	5	0.31	5	0.41	0.69	

Figure 4: Fails jet ID. The leading jet has its entire energy in the electromagnetic calorimeter, and fails the $N90hits$ cut, with more than 90% of its energy in a single ECAL crystal (see Fig 5). Event also has large MET/SumEt.

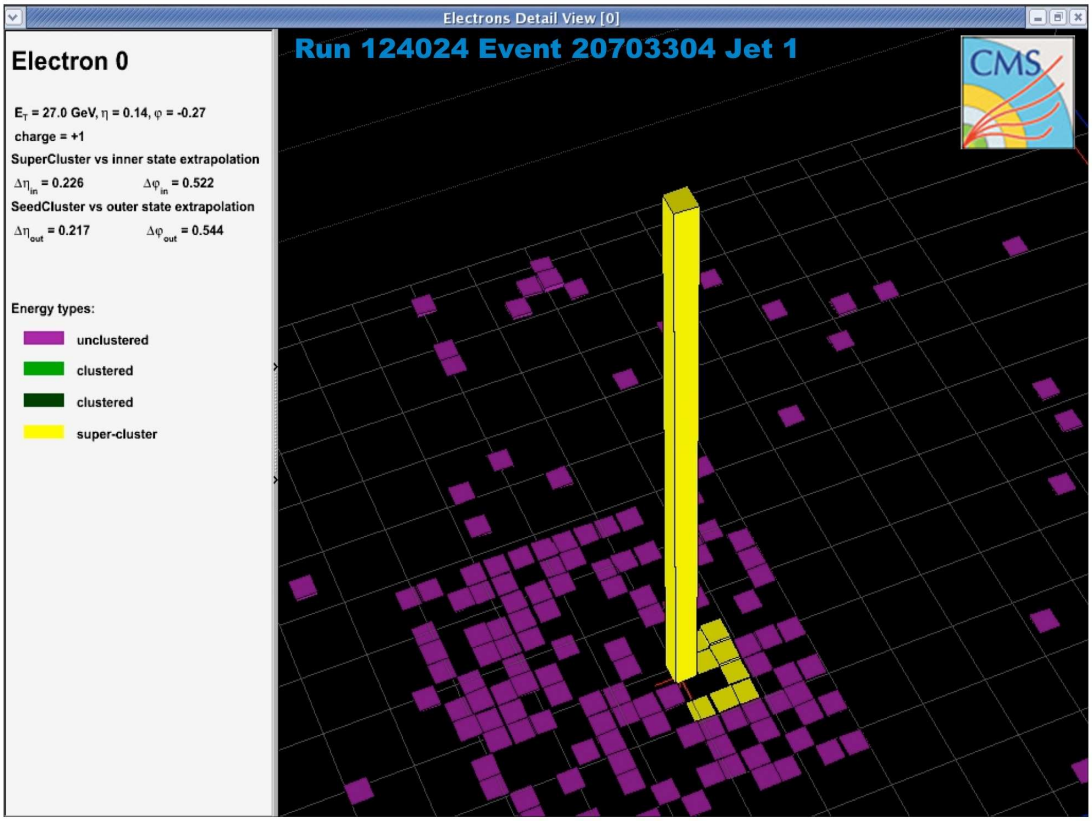
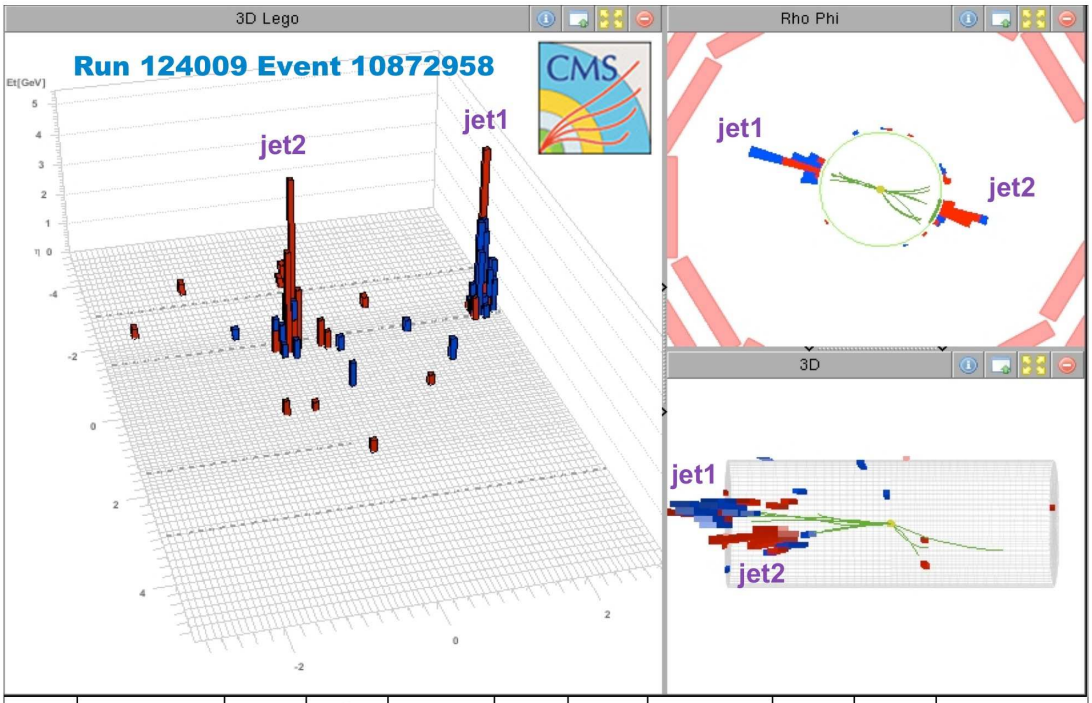
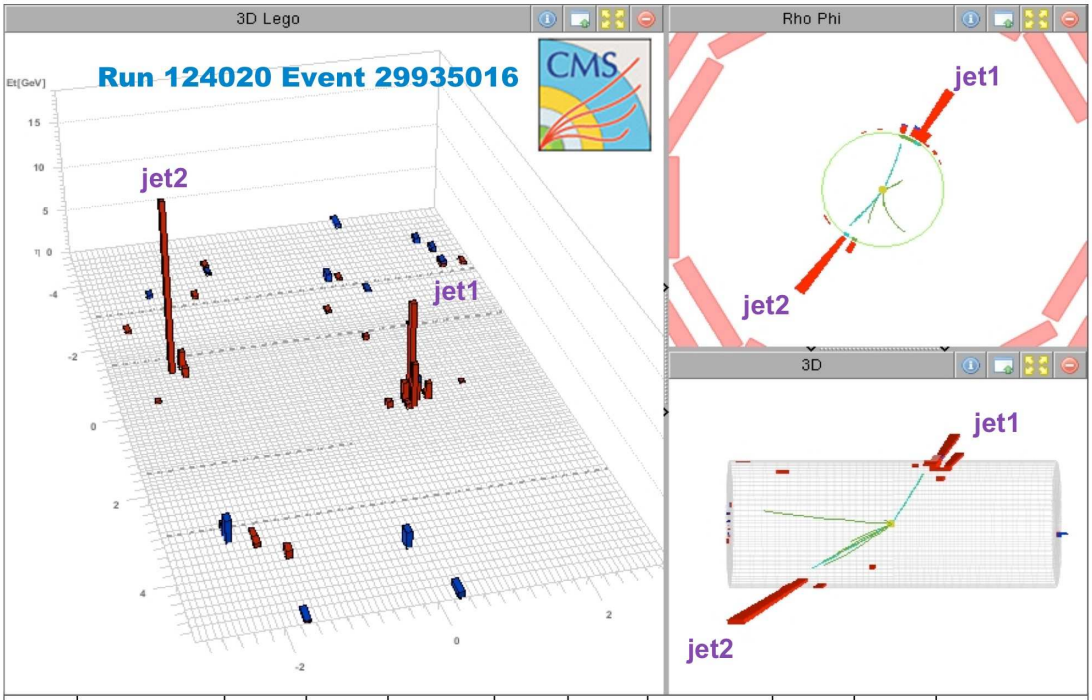


Figure 5: "Electron view" of the leading jet in Fig 4 which fails jet ID. In this display every cell is a single crystal. The leading jet energy is dominated by a single Ecal crystal, and this jet is rejected by the $N90hits > 1$ cut.



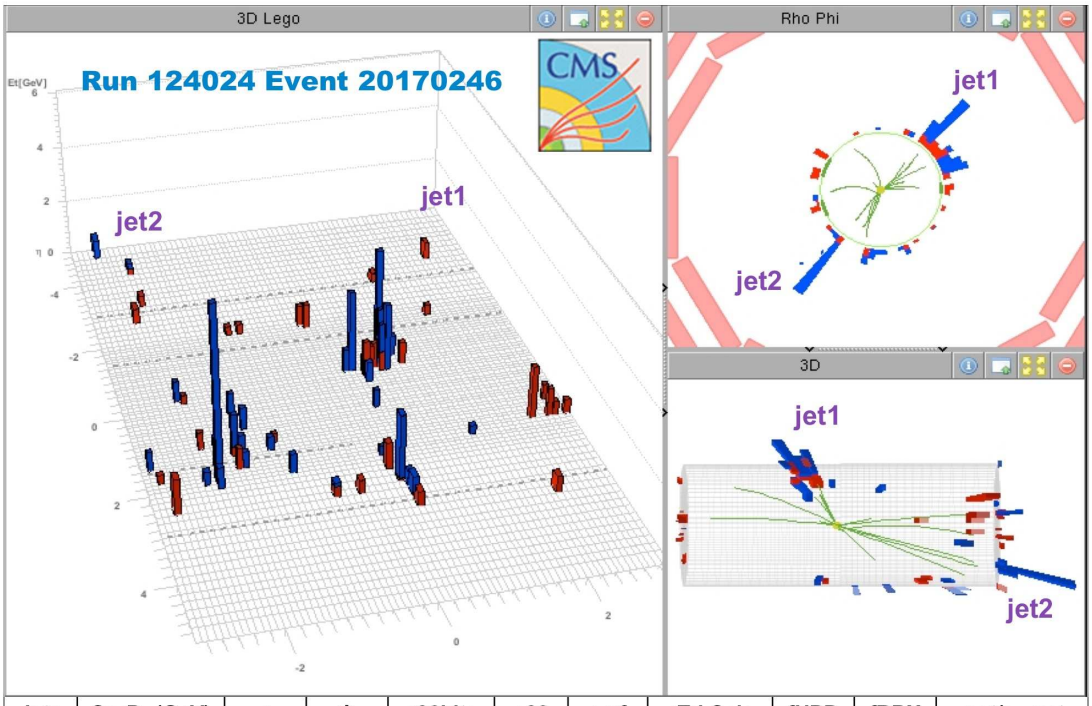
Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	45	-1.7	2.8	18	11	0.35	4	0.21	0.54	0.08
Jet2	37	-1.2	-0.3	32	8	0.84	4	0.07	0.14	

Figure 6: Passes jet ID. This was the cleanest dijet event we could find. It is the event with the 2nd highest p_T leading jet in the standard dijet analysis. Both jets have high p_T for a $\sqrt{s} = 900$ GeV *MinimumBias* collision event. The two jets are back-to-back in ϕ. Both are in the endcaps of the calorimeter. Each jet has energy in the hadronic calorimeter and in the electromagnetic calorimeter. Both jets pass our basic quality criteria.



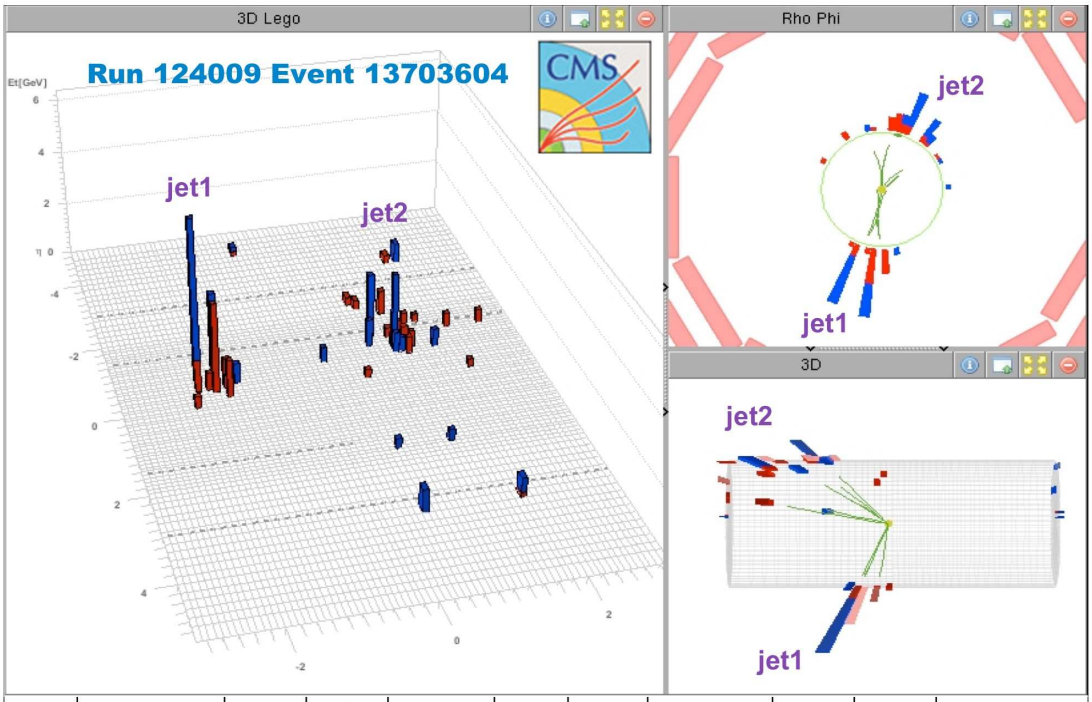
Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	42	0.6	1.0	26	6	0.98	1	0.02	0.02	0.03
Jet2	42	-1.1	-2.2	9	2	1	2	0	0	

Figure 7: Passes Jet ID. Both jets are in the barrel. Both have their entire energy in the electromagnetic calorimeter, but look like good jets.



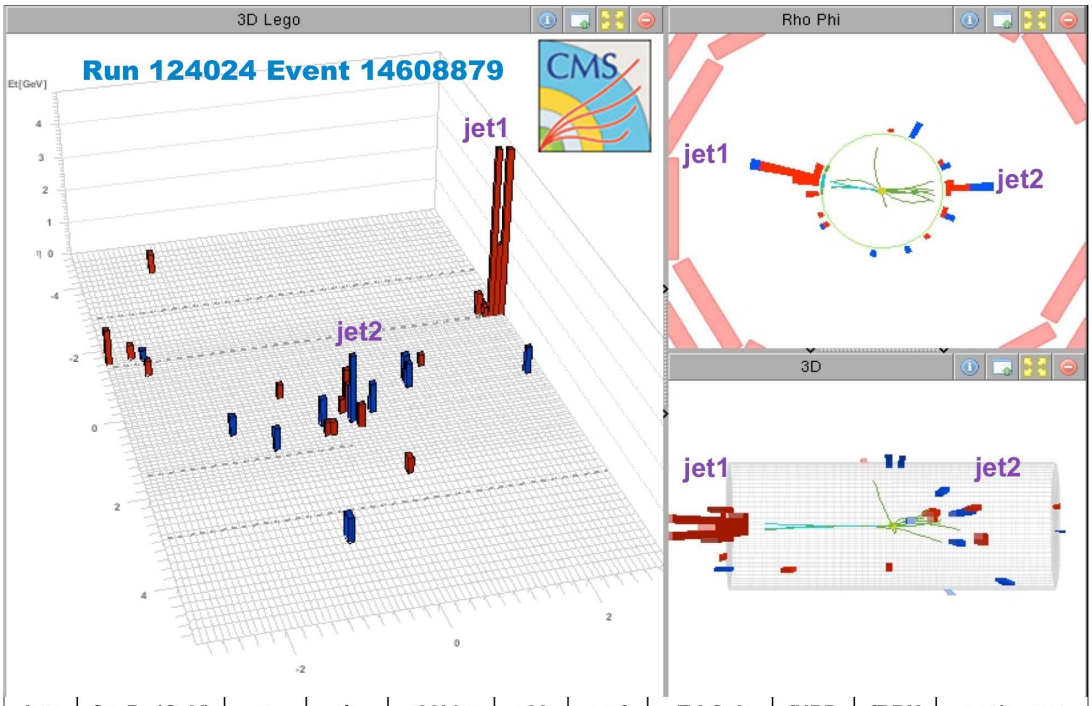
Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	39	-0.4	0.7	15	13	0.33	5	0.33	0.36	0.16
Jet2	22	1.9	-2.2	5	4	0.06	3	0.66	0.89	

Figure 8: Passes jet ID. Second jet is in the endcap.



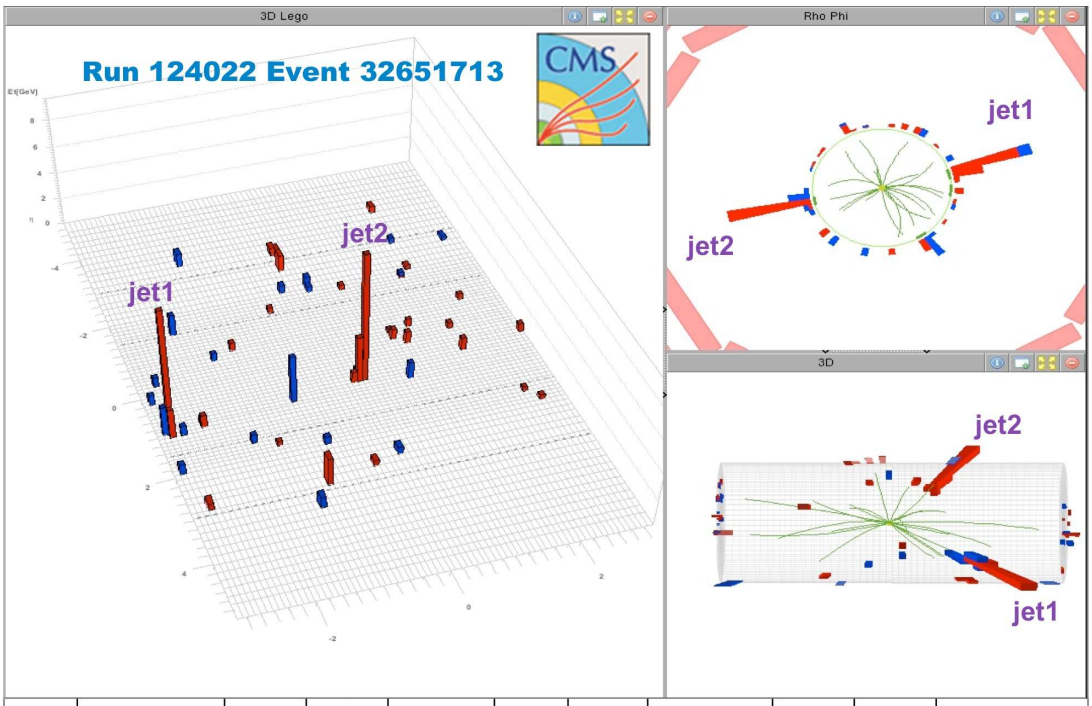
Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	33	-0.4	-1.8	13	6	0.46	4	0.29	0.29	0.06
Jet2	27	-1.1	1.2	14	10	0.39	3	0.27	0.48	

Figure 9: Passes Jet ID. Both jets are in the barrel.



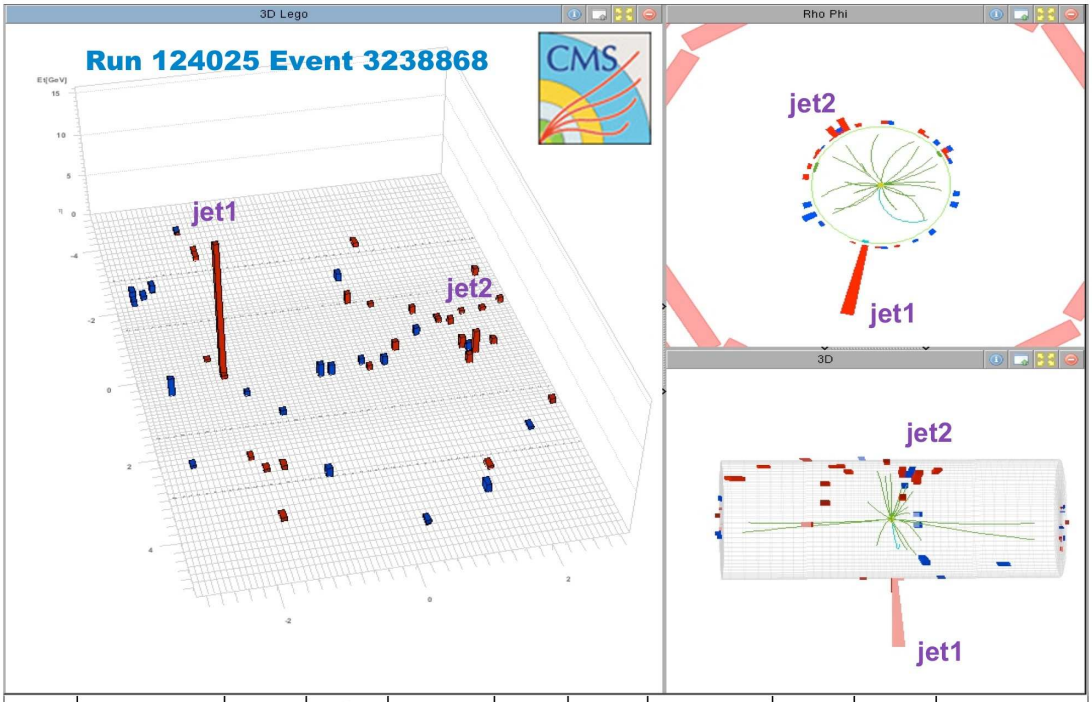
Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	33	-1.6	3.0	13	5	1	3	0	0	0.27
Jet2	17	0.7	0.1	8	5	0.51	5	0.35	0.35	

Figure 10: Passes jet ID. Leading jet has its entire energy in the electromagnetic calorimeter.



Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	31	1.0	-2.9	7	3	0.80	4	0.15	0.15	0.08
Jet2	29	0.6	0.3	9	3	1	1	0	0	

Figure 11: Passes Jet ID. Both jets are in the barrel and sufficiently back-to-back in ϕ. The p_T of the two jets balance each other well.



Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	31	0.1	-1.8	4	1	1	0	0	0	0.22
Jet2	17	0.3	2.2	10	5	0.87	2	0.13	0.13	

Figure 12: Passes jet ID. Both jets are in the barrel. The jet which has EMF=1 and N90=1 looks like a good EM shower with $N90hits$ of 4(see Fig 13).

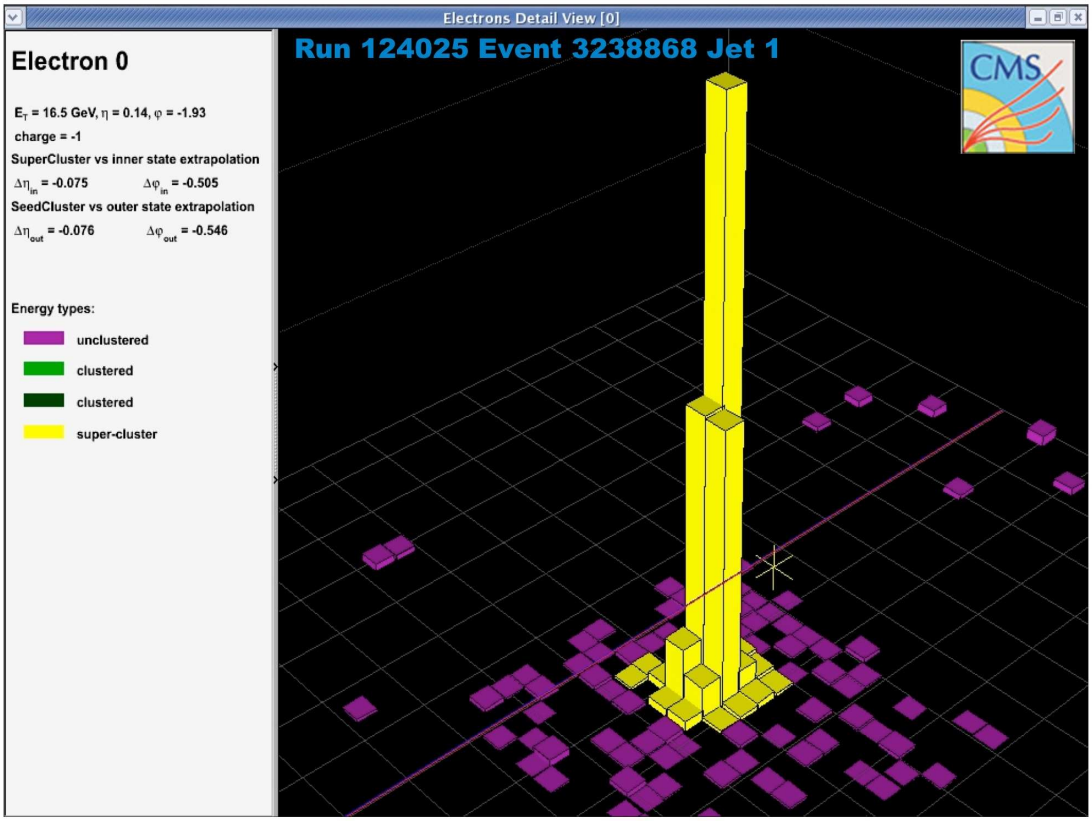
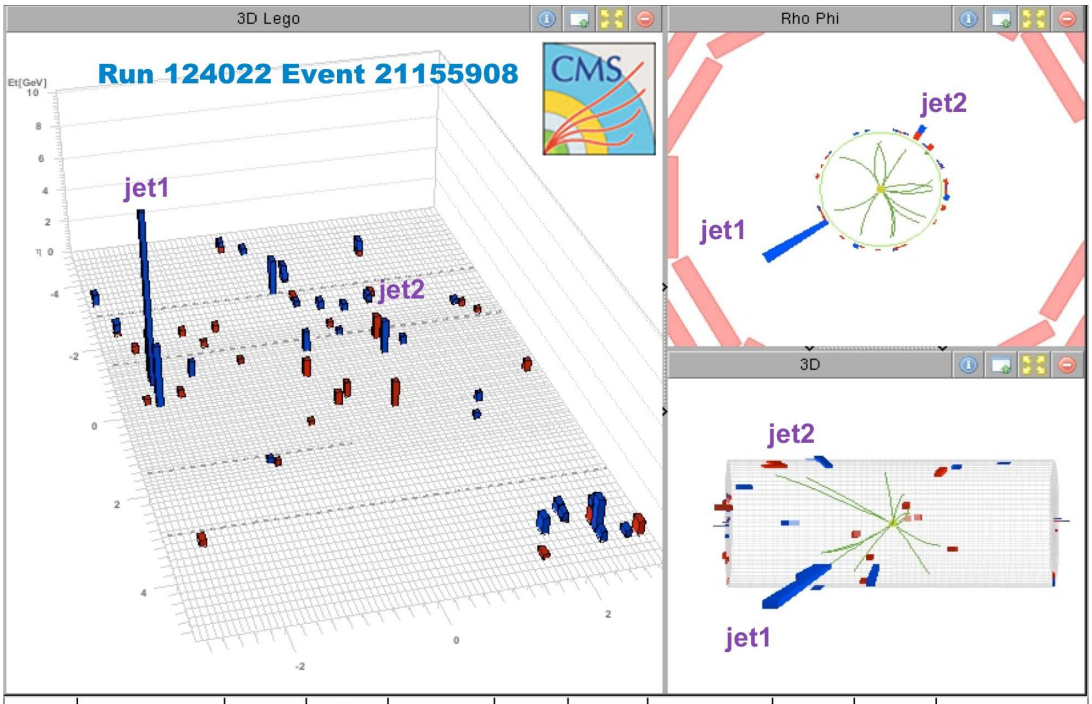


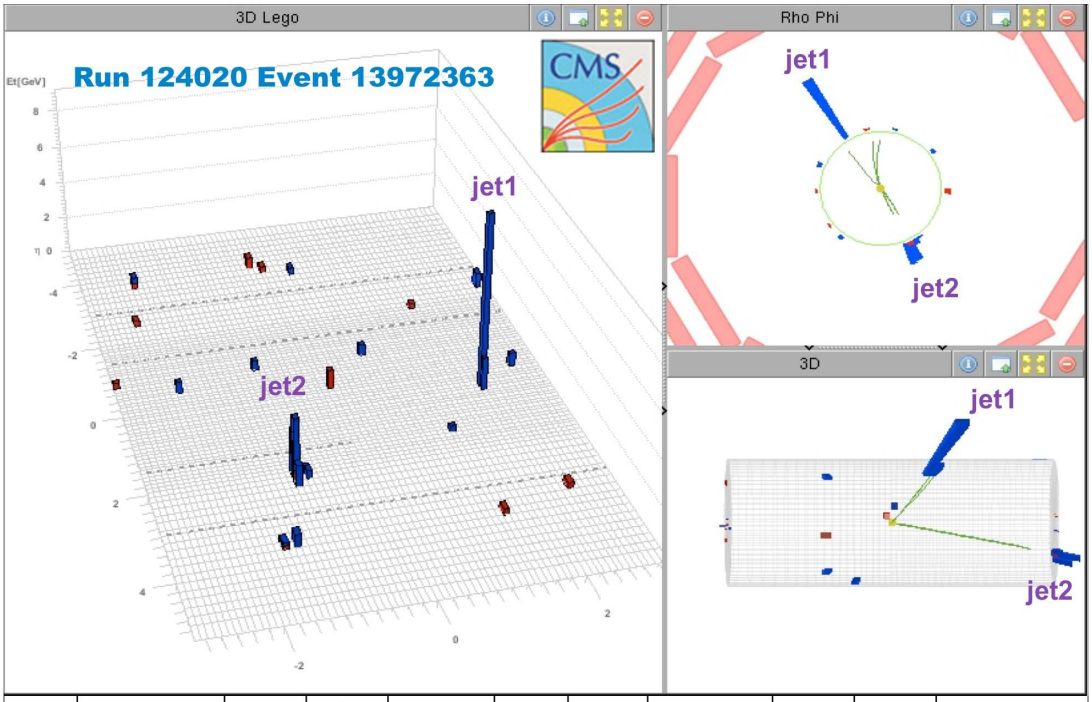
Figure 13: "Electron view" of the leading jet in Fig 12 which passes jet ID. In this display every cell is a single crystal. This jet with $N90hits = 4$ looks like it originates from a good EM shower of reasonable tranverse width.

5 900 GeV: Dijet candidate events failing jet ID due to HCAL energy



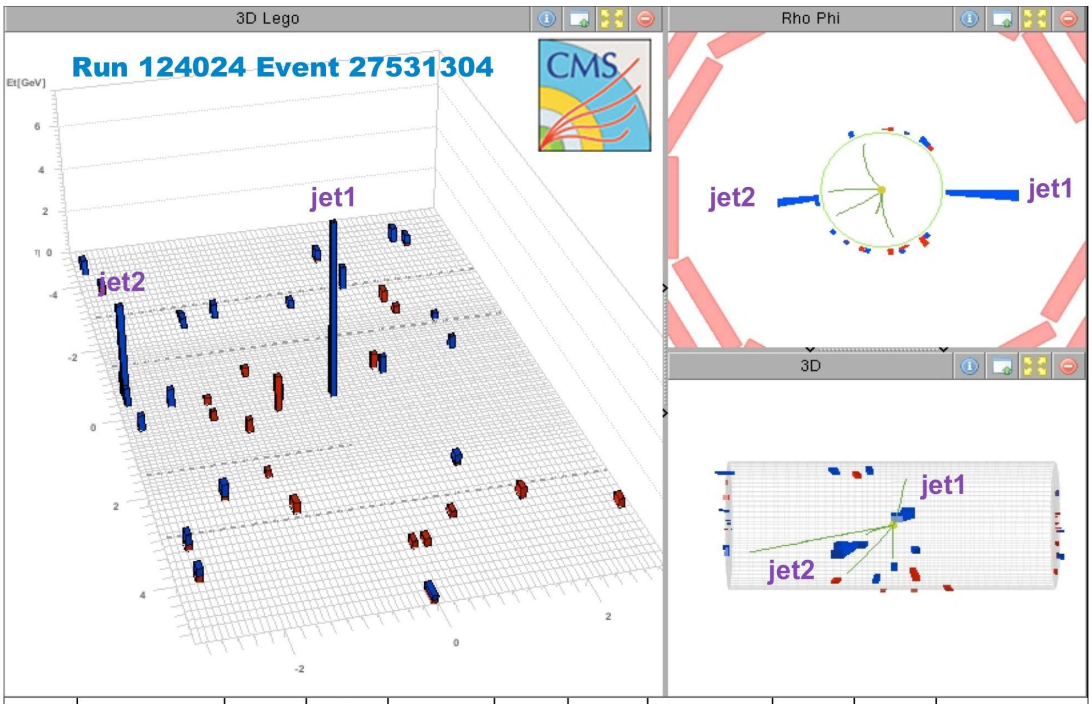
Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	28	-0.9	-2.6	2	2	0	1	1	1	0.22
Jet2	12	-1.1	1.0	8	3	0.5	1	0.39	0.39	

Figure 14: Fails jet ID. Jet 1 has all hadronic energy and hence fails the $EMF > 0.01$ cut. It semes to be confined to a single HPD in the hadronic calorimeter, and hence fails the $fHPD < 0.98$ cut.



Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	24	0.5	2.1	2	2	0	1	1	1	0.12
Jet2	17	2.1	-1.1	7	4	0.08	2	0.46	0.92	

Figure 15: Fails jet ID. Jet 1 has its entire energy in the hadronic calorimeter, and hence fails the $EMF > 0.01$ cut. It is also in a single HPD and hence fails the $fHPD < 0.98$ cut.



Jets	CorP$_T$ (GeV)	η	Φ	n90hits	n90	emf	nTrkCalo	fHPD	fRBX	met/sumet
Jet1	22	0.1	0.0	2	2	0	1	1	1	0.13
Jet2	15	-0.5	-3.0	3	3	0	1	1	1	

Figure 16: Fails jet ID. Both jets have entire energy in the hadronic calorimeter, and hence fails the $EMF > 0.01$ cut, and is contained in a single HPD, and fails the $fHPD < 0.98$ cut.