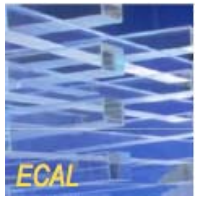


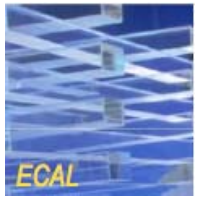
Status of ECAL Spikes

Adi Bornheim for ECAL DPG

17.03.2010

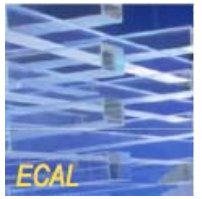
ASC task force meeting

Outline



- Recap : ECAL Spikes
- ECAL Spike tagging online and offline
- ECAL Spike event properties
- ECAL Spike studies outside P5
- Summary

Reminder : ECAL Spikes



- Tommaso Tabarelli de Fatis : http://indico.cern.ch/getFile.py/access?contribId=4&resId=1&materialId=slides&confId=81371
- (a) David Petyt : ECAL Data/MC Studies http://indico.cern.ch/getFile.py/access?contribId=0&resId=0&materialId=slides&confId=86084
- (b) Adi Bornheim : Status report on ECAL spike events http://indico.cern.ch/getFile.py/access?contribId=2&resId=1&materialId=slides&confId=84633
- (c) Elizabeth Locci : Cosmic Data/MC : "What about spikes .."
  https://hypernews.cern.ch/HyperNews/CMS/get/ecal-performance/277.html

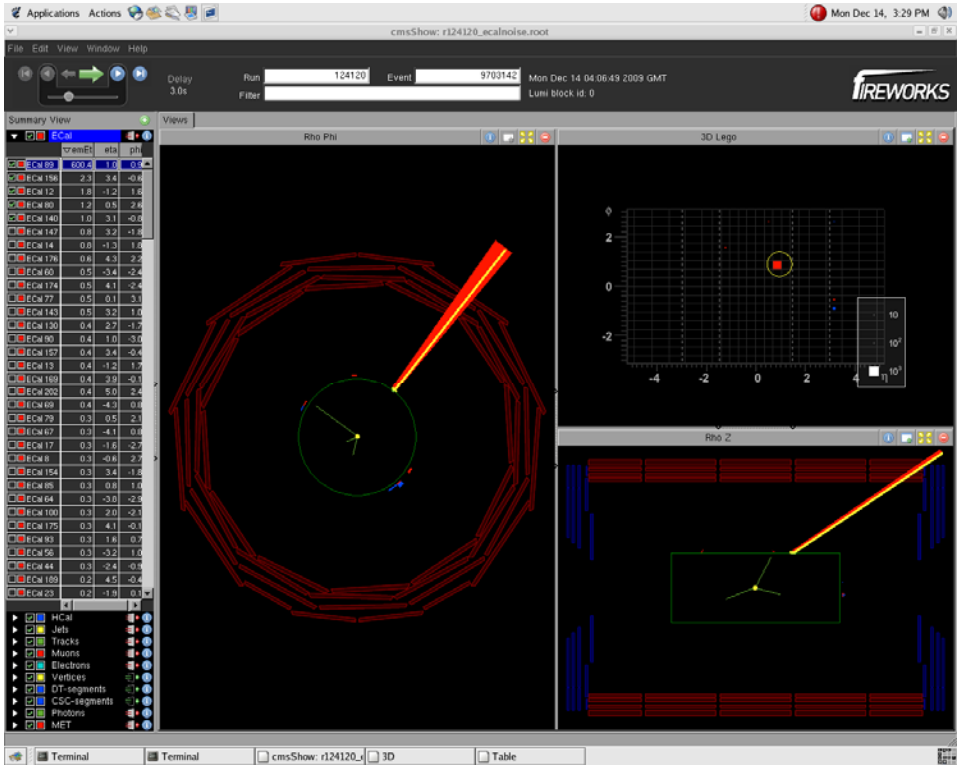
From Tommasos presentation :

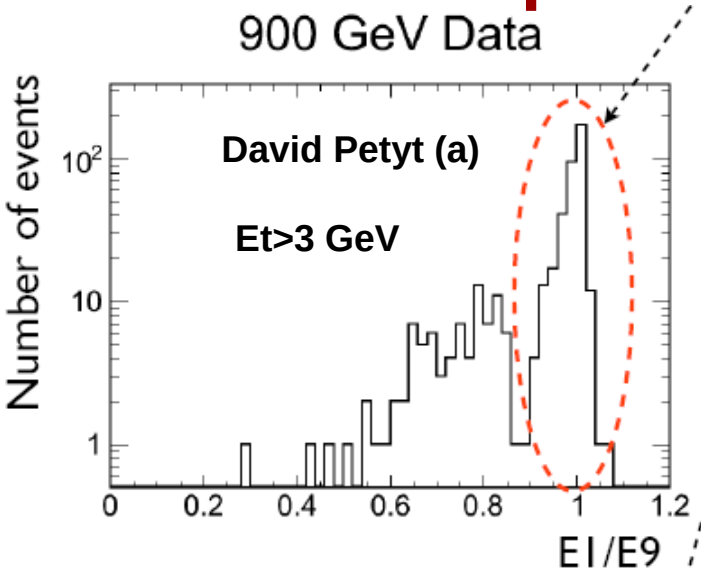
- [1]G.Landsberg, https://hypernews.cern.ch/HyperNews/CMS/get/exotica/500.html
- [2] A.Warren at al. http://indico.cern.ch/conferenceDisplay.py?confId=78057
- [3] E.Di Marco http://indico.cern.ch/getFile.py/access?contribId=1&resId=3&materialId=slides&confId=76903 ;
- LIP, http://indico.cern.ch/getFile.py/access?contribId=0&resId=1&materialId=1&confId=76903
- [4] A.Askew https://hypernews.cern.ch/HyperNews/CMS/get/ecal-performance/229.html
- [5] C,Seez, http://indico.cern.ch/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=76805
- [6] A.Apreysan, slide 9 of [14]
- [7]W.Andrews at al., http://indico.cern.ch/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=79613
- [8] J.Veverka and A.Bornheim, http://indico.cern.ch/getFile.py/access?contribId=2&resId=3&materialId=slides&confId=82920
- [9] J.Jackson, http://indico.cern.ch/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=76805
- [10] Y.Gershtain, http://indico.cern.ch/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=79613 and http://indico.cern.ch/getFile.py/access?contribId=6&resId=0&materialId=1&confId=76805

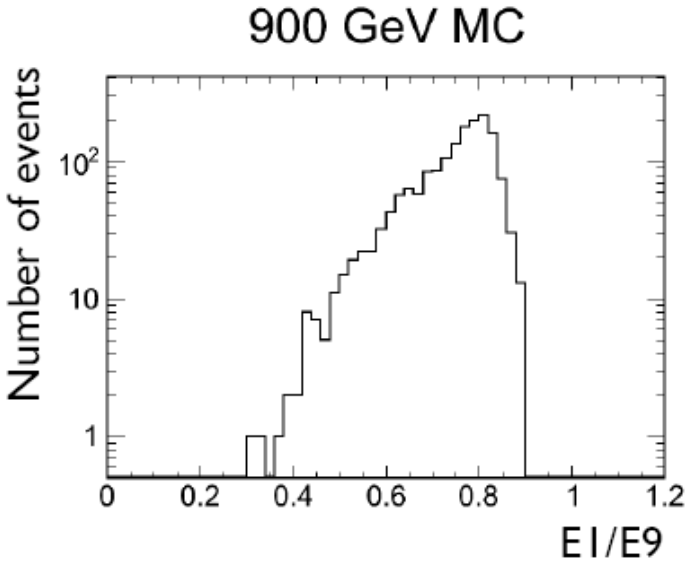
Recap : ECAL spikes

- **Single channels with sizable pulses and no surrounding activity**
  - Early observations by PAGs and POGs[1,2,3,4]
- **Shower shape inconsistent with energy depositions of real photons or electrons**
  → topological spike tagger

Spikes

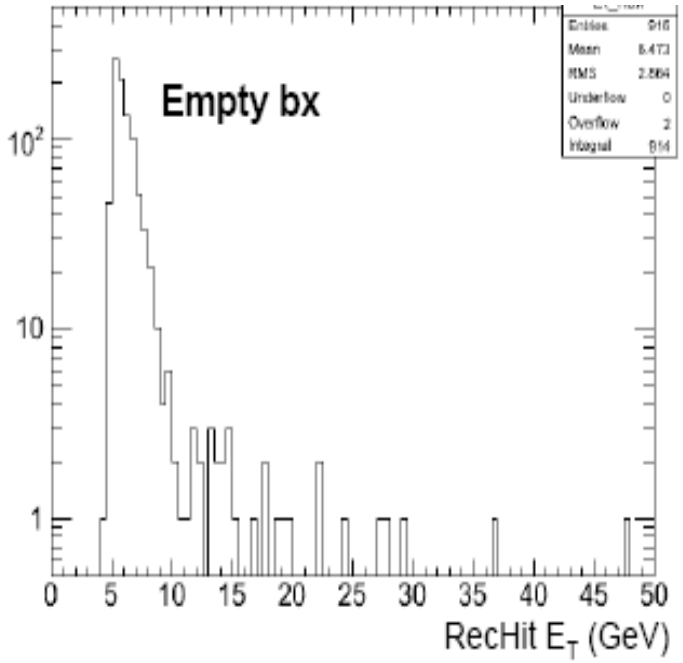


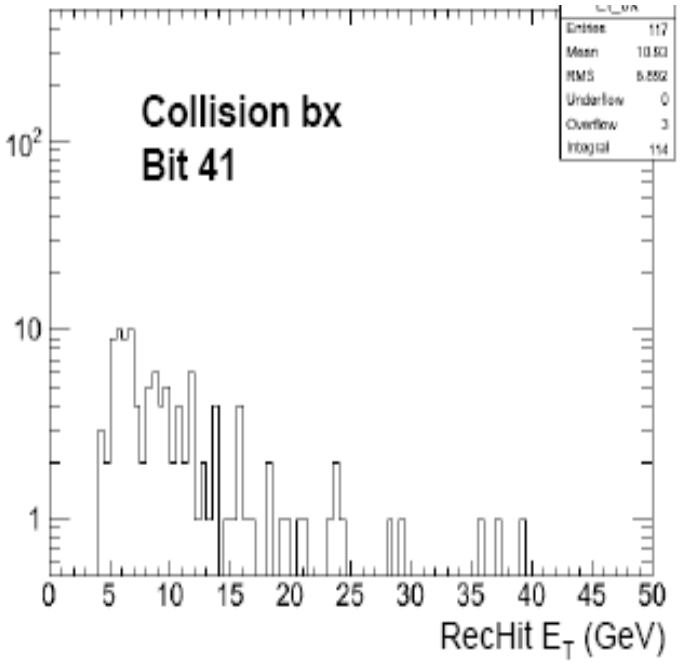




Spike RecHit energy spectra

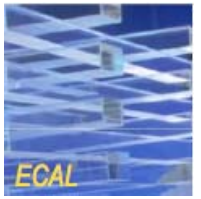
- **Seen in collision crossing (in BX), and in empty crossing (out of BX)**
  - Also observed in CRAFT data
- **Energy spectra harder in collision crossings**
  - Two different mechanisms?
  - Mostly low energies, but ranges up to O(100) GeV



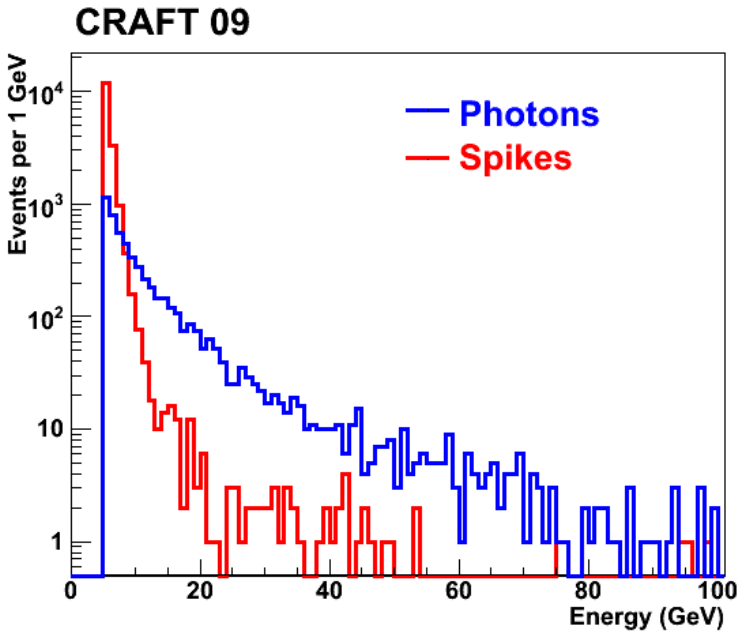


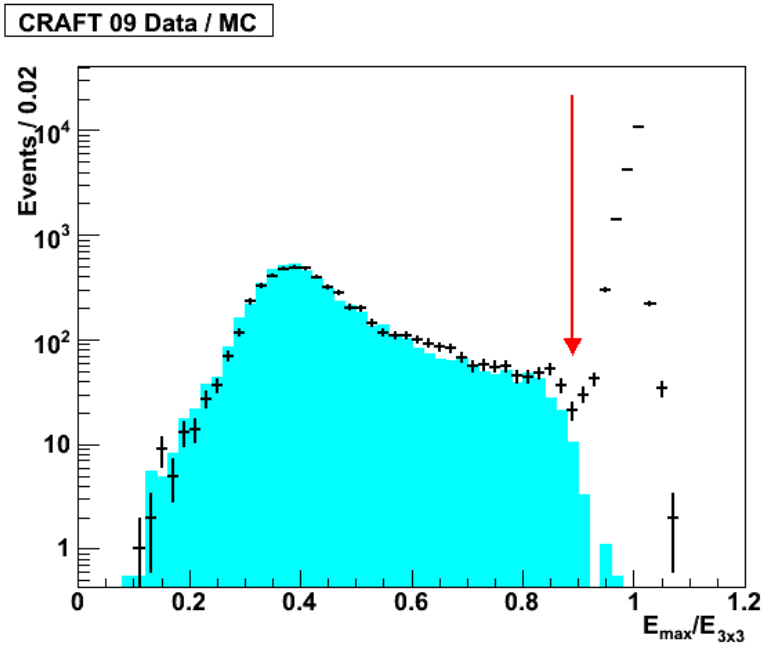
C.Seez [5], see also A.Bornheim, J.Veverka[8], J.Jackson [9], Y.Gershtain [10]

Spikes in CRAFT09



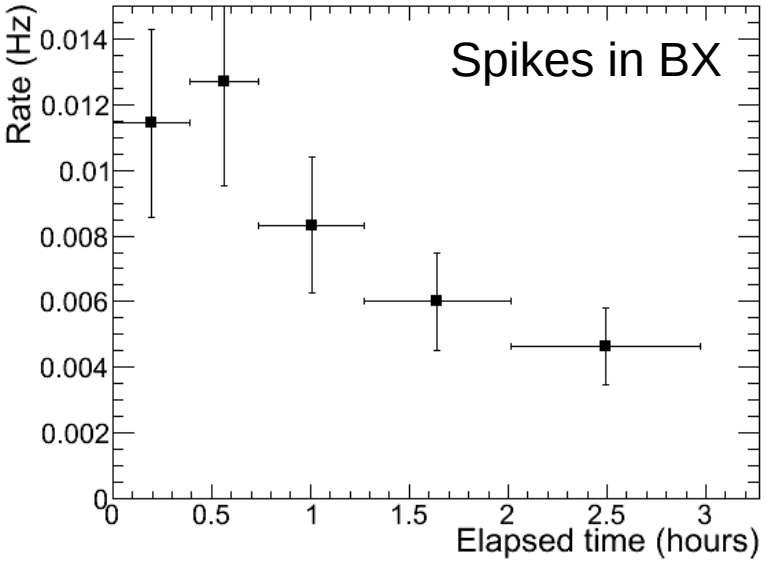
- Spikes in cosmic events : E > 5 GeV, E1/E9>0.95, photons : E > 5 GeV, E1/E9>0.9.
- Spike energy spectrum in cosmics softer than radiative photon spectum.
- There are no spikes in cosmic MC
- Rate of spikes appears to be larger for gain 50 than for gain 200

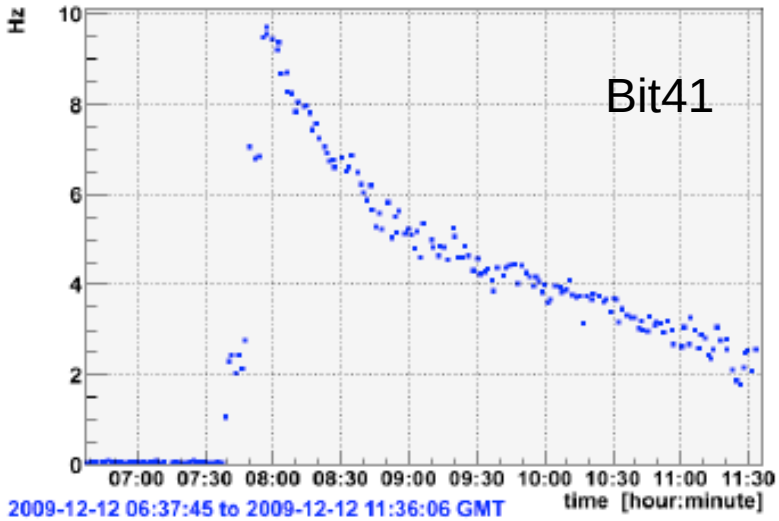




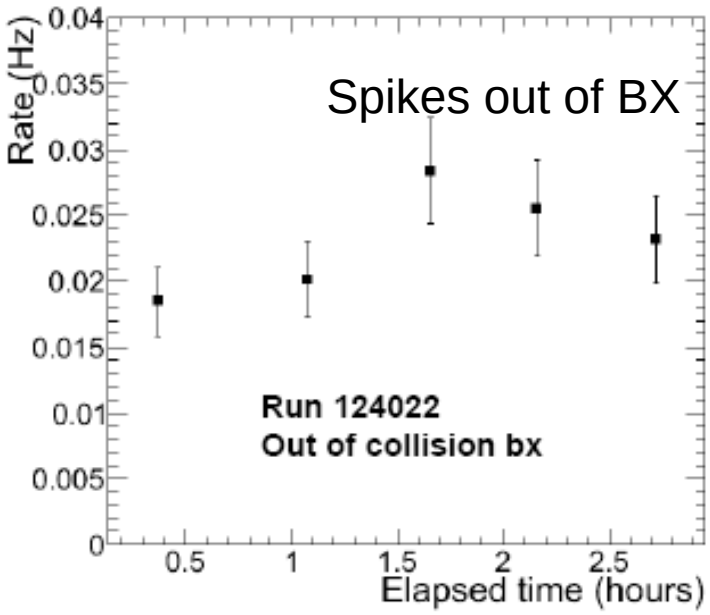
Jan Veverka (b), Elizabeth Locci (c)

Rates of Spikes in Collisions 2009





- **Rate in-BX inconsistent with accidental coincidences of out-of-BX spikes**
- **In-BX rate scales with luminosity**
  - Run 124022, E_T>3 GeV

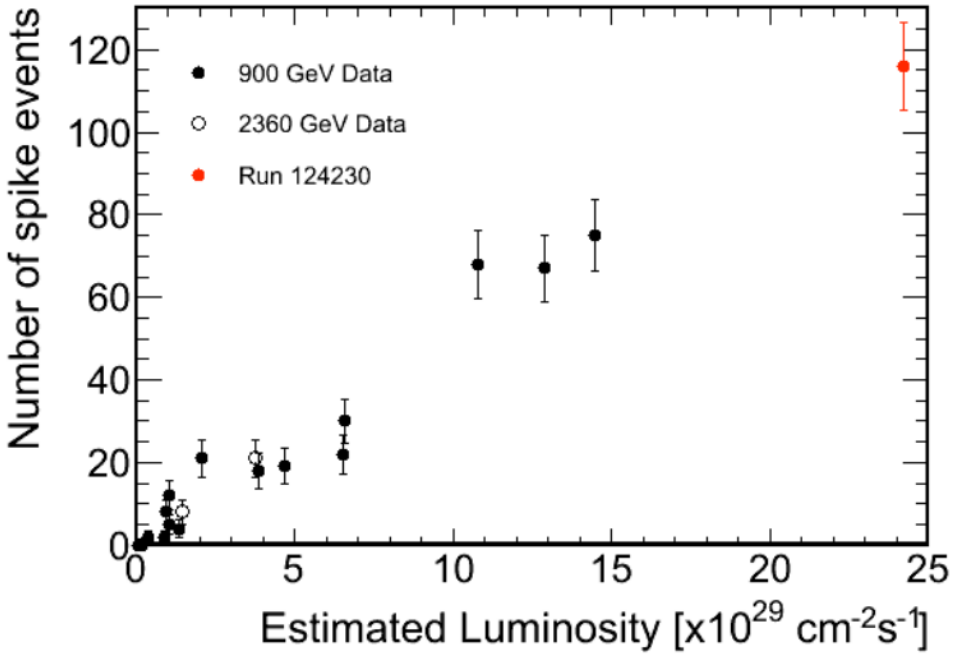


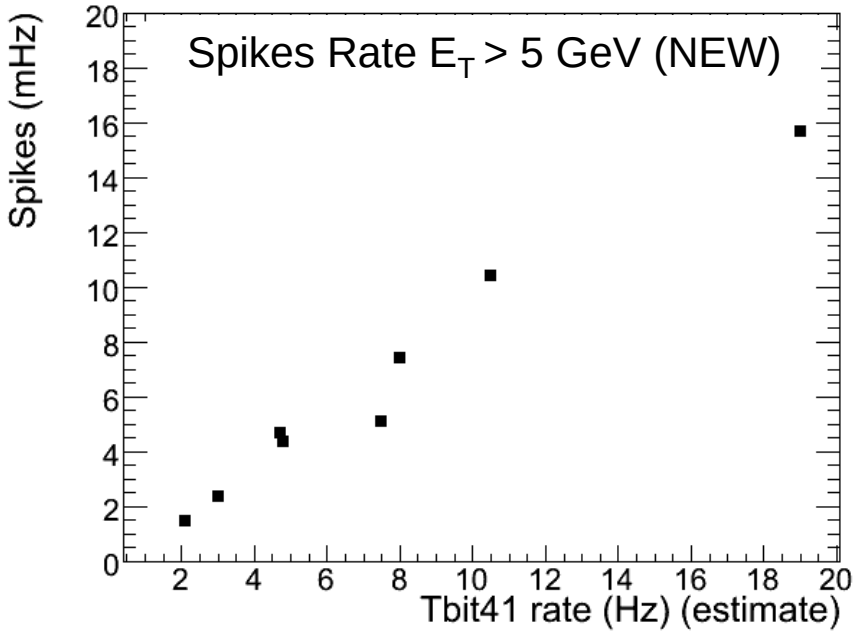
C.Seez [5], see also J.Jackson [9], Y.Gershtain [10]

David Petyt (b), Chirs Seez [5]

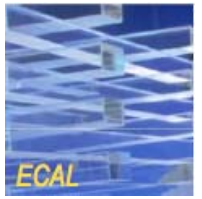
Spike rate vs luminosity

- Spikes rate (Et > 5GeV) equivalent to 0.001 per BIT40 triggered event.
- Extrapolated rate : 10 kHz @ 10^{32} (Et > 5 GeV), 4 kHz (Et > 10 GeV)





Spike tagging Online : L1 and HLT



- James Jackson : Implementation of strip fine grain bit (SFGB) spike veto in the L1 emulator, and online configuration
  http://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=87119

- Evgueni Vlassov : ECAL DAQ Meetings
  http://indico.cern.ch/getFile.py/access?contribId=1&resId=1&materialId=slides&confId=87683
  http://indico.cern.ch/getFile.py/access?contribId=0&resId=1&materialId=slides&confId=85910

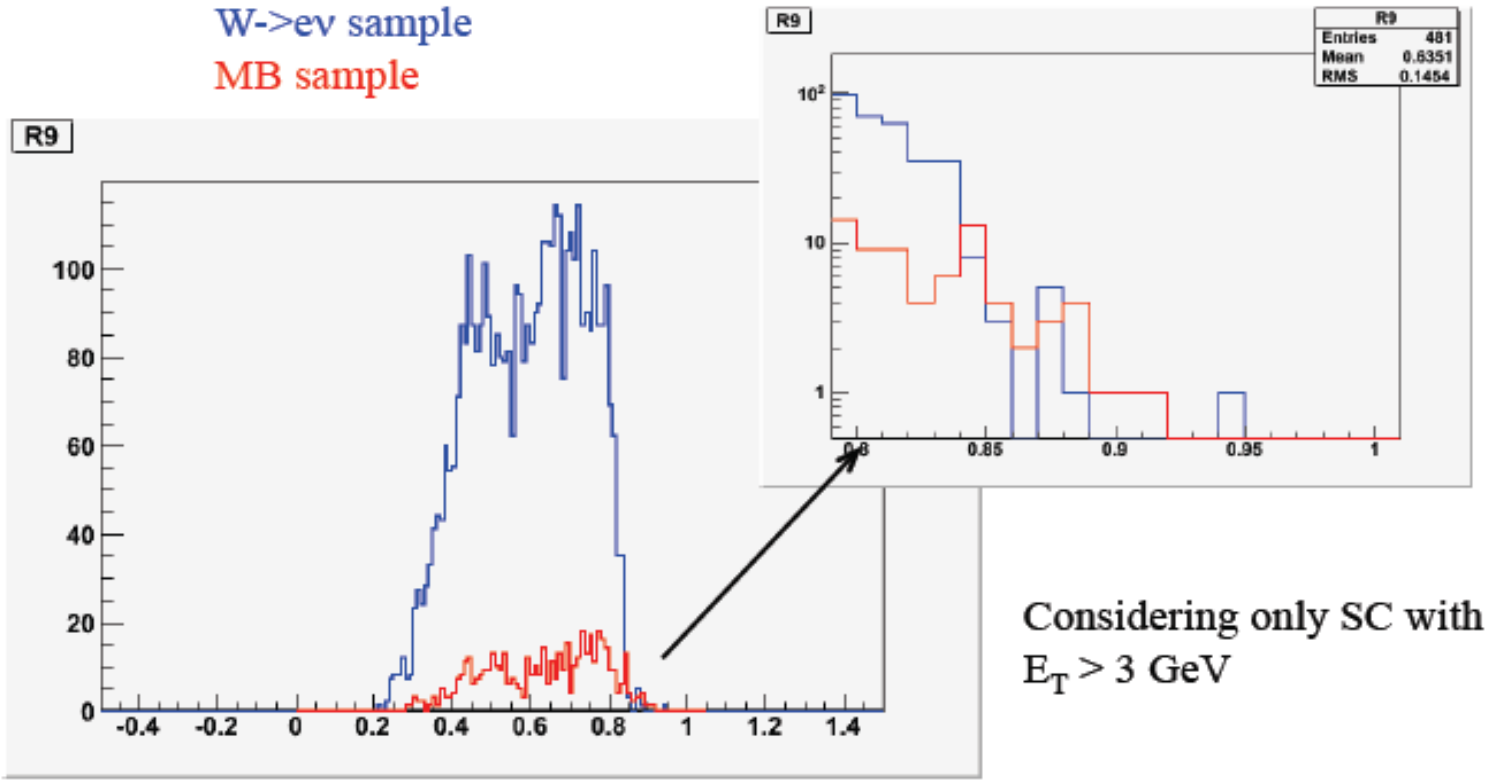
- (d) Alessio Ghezzi : Egamma HLT update
  http://indico.cern.ch/getFile.py/access?contribId=1&sessionId=1&resId=0&materialId=slides&confId=79091

- Tommaso Tabarelli de Fatis : ECAL DPG NEWS
  http://indico.cern.ch/getFile.py/access?contribId=0&resId=1&materialId=slides&confId=87119

For ECAL L1 Spike Status :
See following presentation by James !

Spike tagging Online : HLT

- **HLT (CMSSW_3_5_1) : E1/E9 for each SC, in every egamma path at startup, allows path dependent cuts.**
  - Eg. E1/E9 < 0.95 rejects >90% of spikes, signal (tested on W->ev sample, RelVal351), unaffected, additional CPU need small (< 0.5 ms per module run).
- **Will also serve (prescaled) to feed spike data set for continued studies.**



Spike tagging offline

- (e) Federico Ferri : Ecal Spike Cleaning for 7 TeV Startup
  http://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=86098
- (f) Federico Ferri : ECAL reconstruction - progress with 2009 data and prospects
  http://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=88136
- (g) Tommaso Tabarelli de Fatis : Offline spike rejection
  http://indico.cern.ch/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=87687
- (h) Seth Cooper : Progress with Ecal Timing
  http://indico.cern.ch/getFile.py/access?contribId=4&resId=0&materialId=slides&confId=87119
- (i) Kostas Theofilatos : Chi2 commissioning
  http://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=86084
- (j) Florian Beaudette : PF PAS Preapproval
  http://indico.cern.ch/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=84479

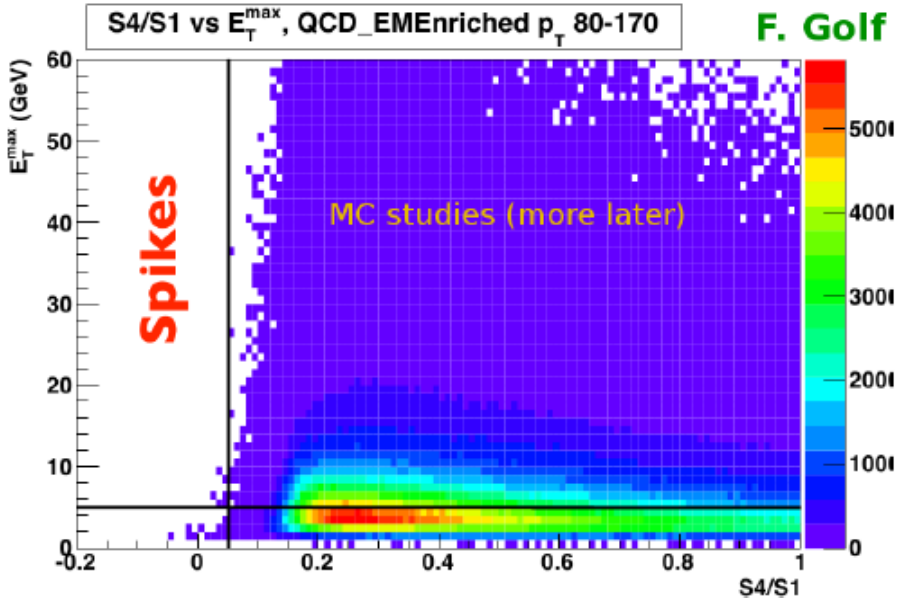
Note : I mostly say `tagging` which we will mostly do during startup. The transition to cleaning and filtering will be phased in as luminostiy goes up.

F. Ferri, F. Golf and JetMET Group (e)

Topological spike cleaning for CaloTowers (JetMET)

- Several algorithms based on the incompatibility of the spike with an e.m. shower
  - check energy deposit on neighbours w.r.t. the spike candidate
  - two of them currently available:
    - $S1/S4 \equiv E(\text{spiky crystal})/E(\text{swiss cross around})$
    - $E1/E9 \equiv E(\text{spiky crystal})/E(3 \times 3\text{matrix around})$
- very good discrimination without efficiency loss (MC tested)

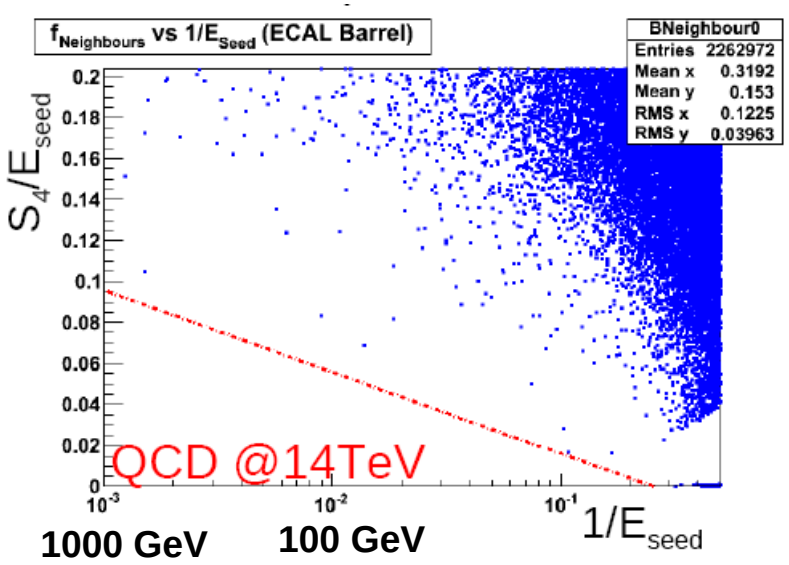
Sample	Rate (event)
$W \to e\nu$	1.7×10^{-6}
$Z \to ee$	3.9×10^{-6}
$t\bar{t}$	4.4×10^{-6}
QCDpt80	3.0×10^{-6}
QCDpt170	1.9×10^{-6}
QCDpt1400	4.2×10^{-6}
QCD EM pt80to170	3.9×10^{-6}
γ+Jet Pt20to30	0 / 13417
γ+Jet Pt50to80	0 / 25804
γ+Jet Pt170to300	1 / 51725
LM0	0 / 80505
LM4	0 / 83187
LM8	2 / 107066

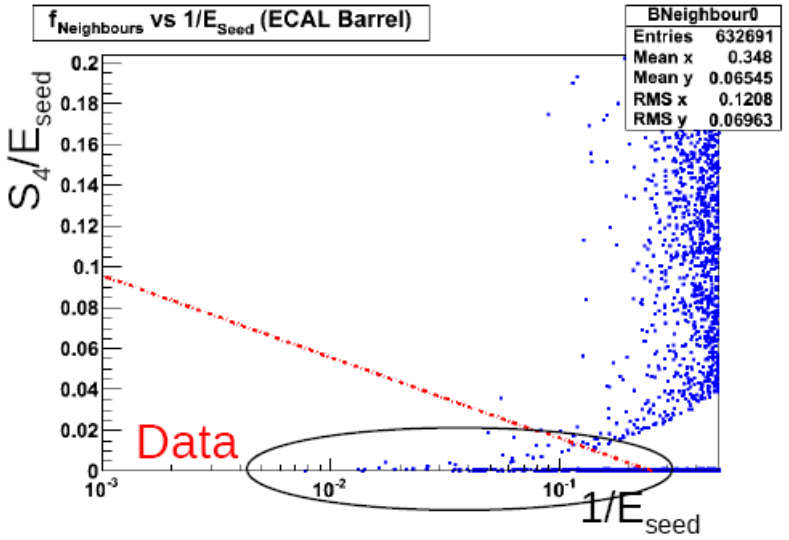


F. Beaudette et al., PF Group (j)

Topological Spike Cleaning Particle Flow

$$E4/E_{seed} < a \times \log_{10}(E_{seed}/E_0) \text{ if } E_{seed} > E_{thresh}$$





- **All currently used topological cuts very similar.**
- **Limited at low energies due to noise, limitations if spike does not have 8 active neighbours.**
- **Limited in case of embedded spikes due to surounding activity**

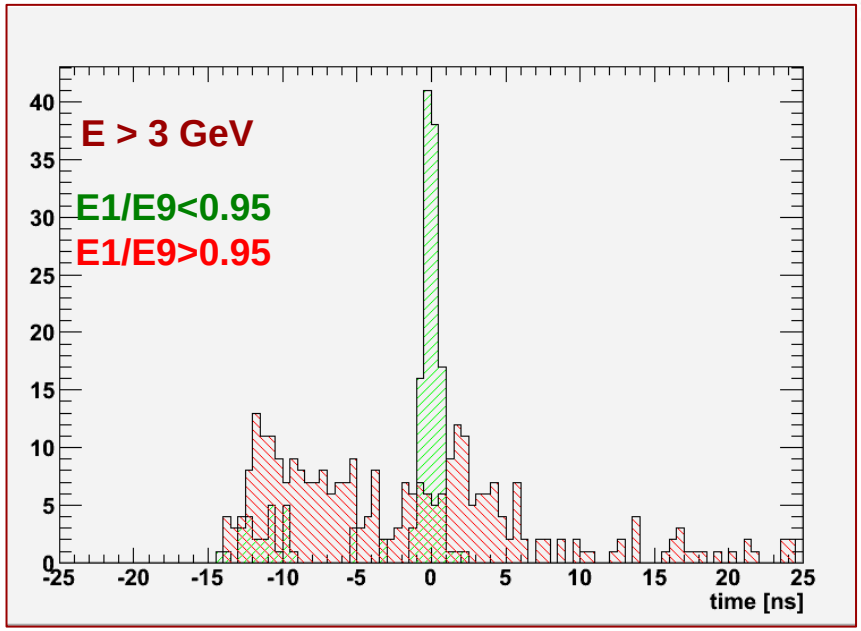
⇒ **Need to fully access the efficiency and purity of the methods.**

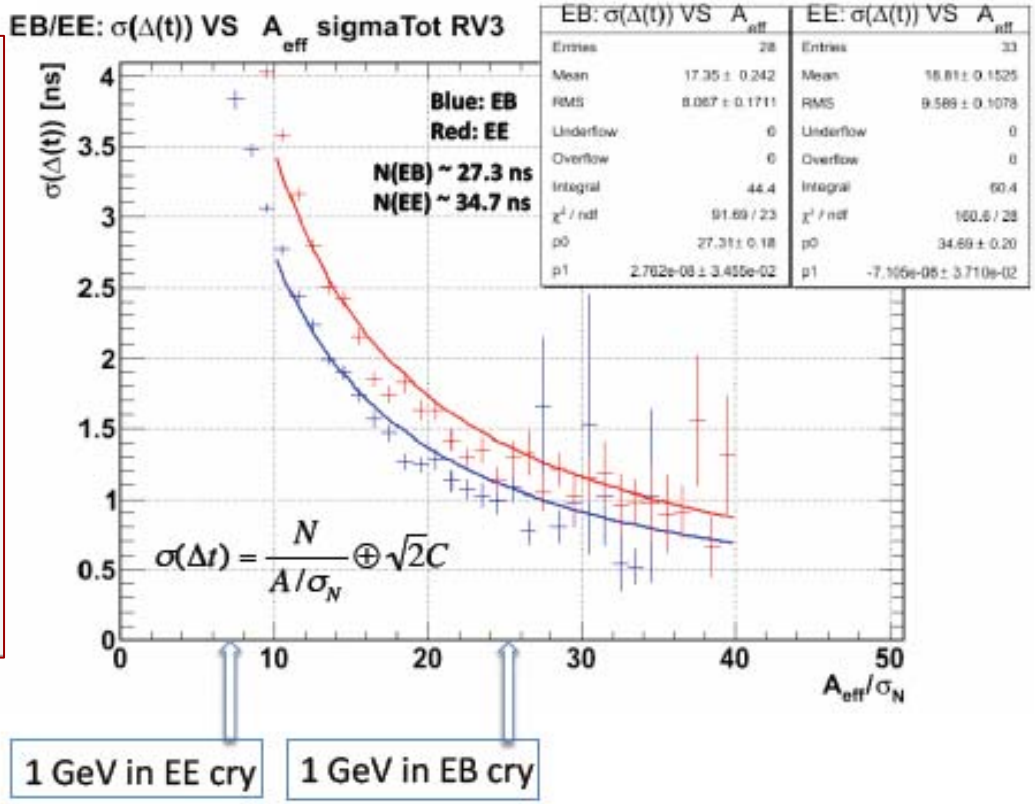
Tommaso Tabarelli de Fatis, Seth Cooper et al. (h)

Single RecHit tagging: Timing

- ECAL has very good time resolution.
- ECAL spikes have a peculiar timing distribution.

⇒ Cuts on the proper timing allow to tag spikes.





Single RecHit discriminants : Timing (cont.)

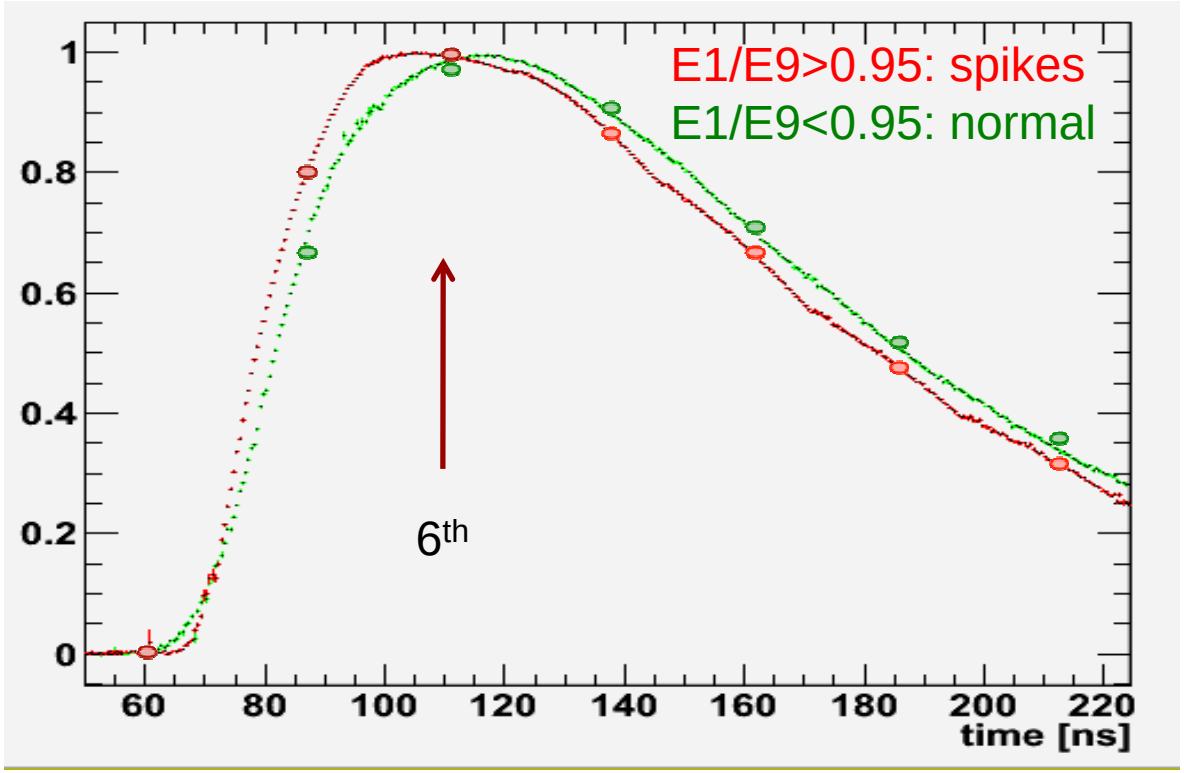
- With 5 sigma timing cut >80% spike reduction on 2009 data, RecHits with E > 3 GeV, E1/E9>0.9.
- 4 events with E > 3GeV, E1/E9<0.9 are identified.
- These 4 events also feature a spike like pulse shape.

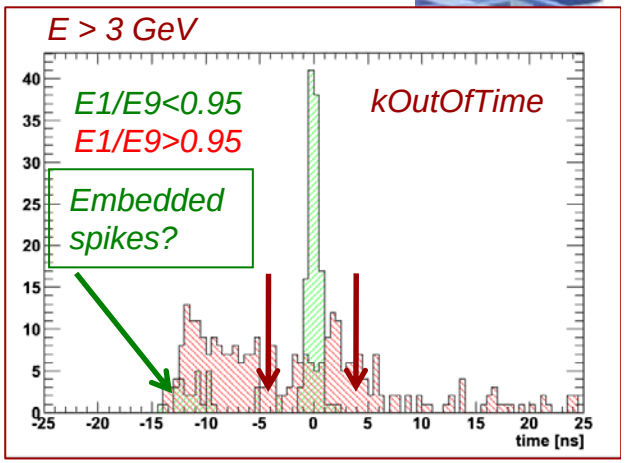
	Non-spikes (R19 < 0.9 && E > 3 GeV)		Spikes (R19 > 0.9 && E > 3 GeV)		
	In Time	kOutOfTime	In Time	kOutOfTime	Spike Reduction
Fixed	133	4	76	150	66%
5 Sigma	133	4	36	190	84%
4 Sigma	133	4	33	193	85%
3 Sigma	133	4	28	198	88%

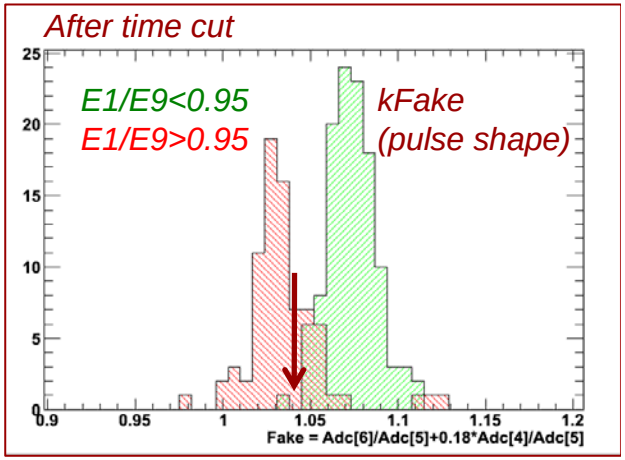
Tommaso Tabarelli de Fatis et al. (g)

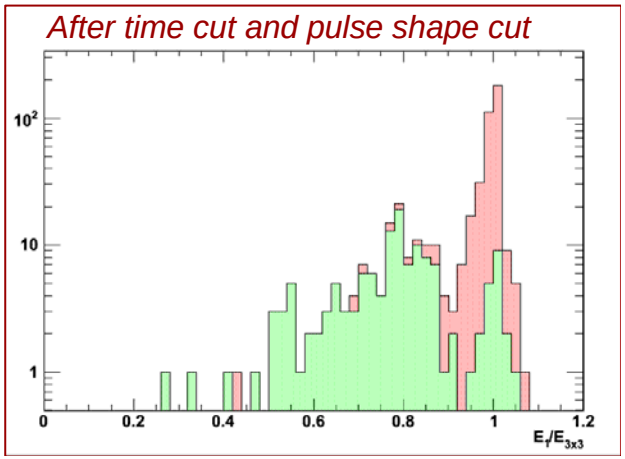
RecHit tagging – Pulse Shape

- **Timing**: separation power relies on the difference between the real time of a standard pulse and the "apparent time" of a spike
- **Pulse shape**: separation relies on the faster spike risetime
  Simple pulse shape discrimination :
  $R = ADC[7^{th}]/ADC[6^{th}] + 0.18 \cdot ADC[5^{th}]/ADC[6^{th}]$
  kFake is cut on this quantity



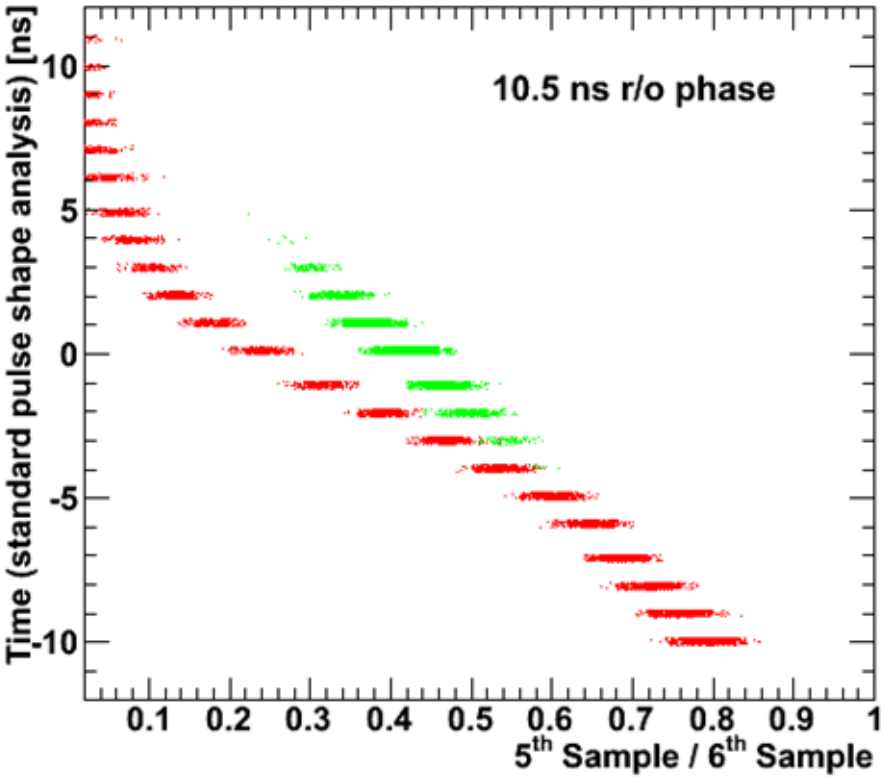


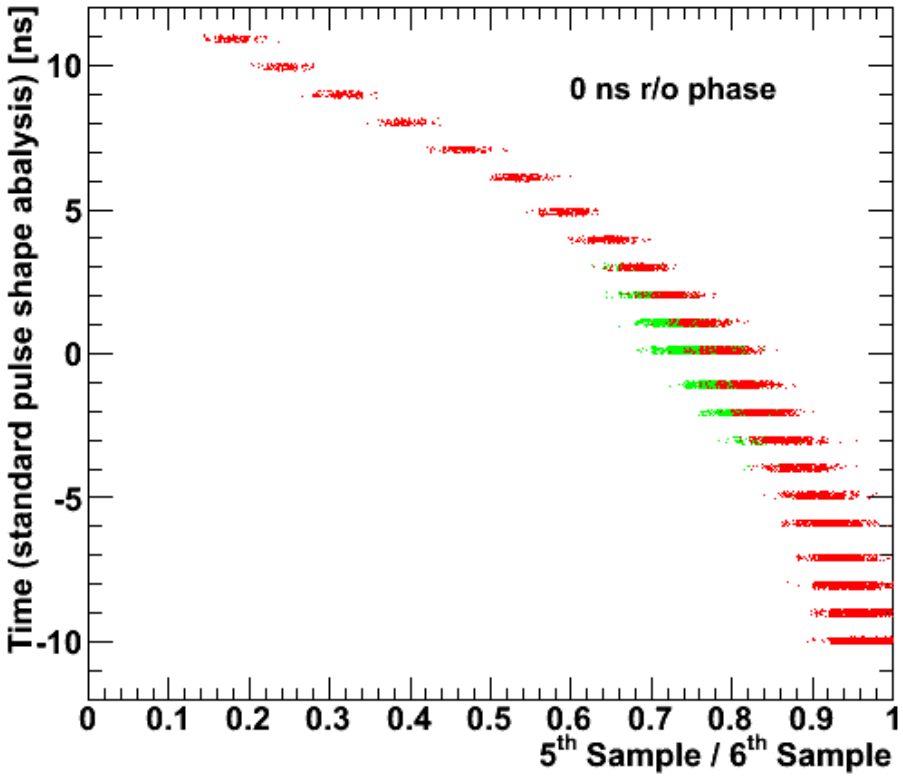




Readout phase dependency of sample ratios

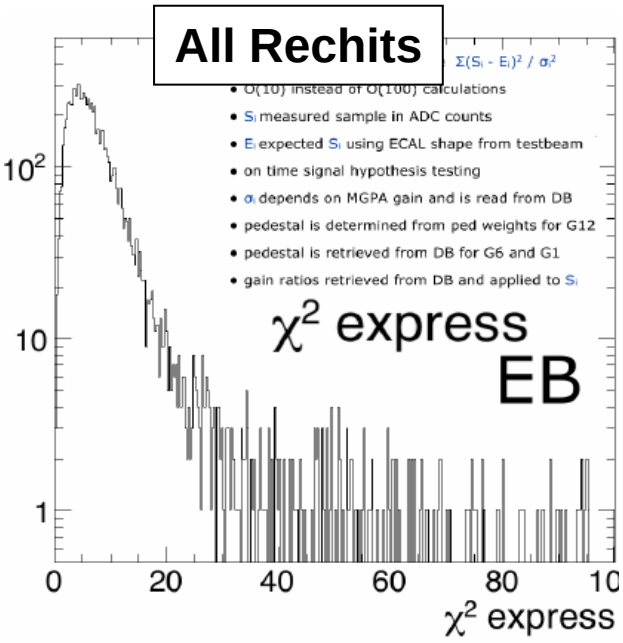
- **Separation power is lost! (or is limited to time info)**
  - Notice that in both figures the time on the Y scale is offline timing calibrated)
- **A r/o phase of 10 ns is about optimal for spike rejection**
  - (for optimal performance of the energy reconstruction 0 ns optimal)

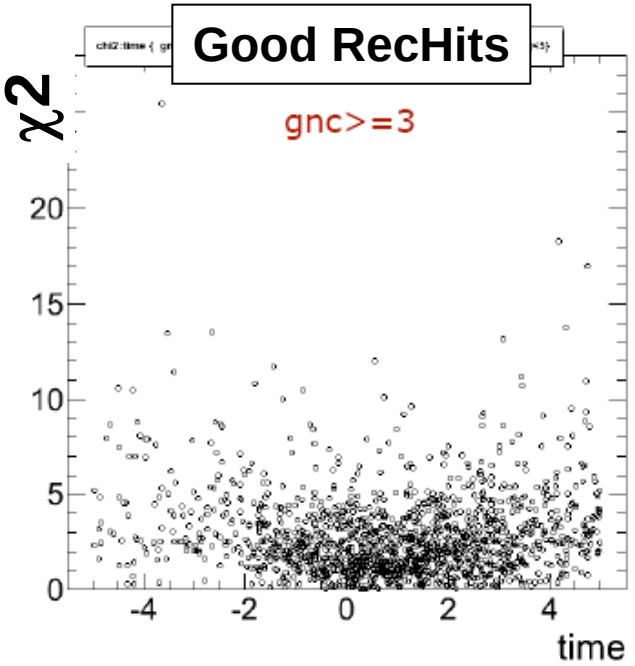


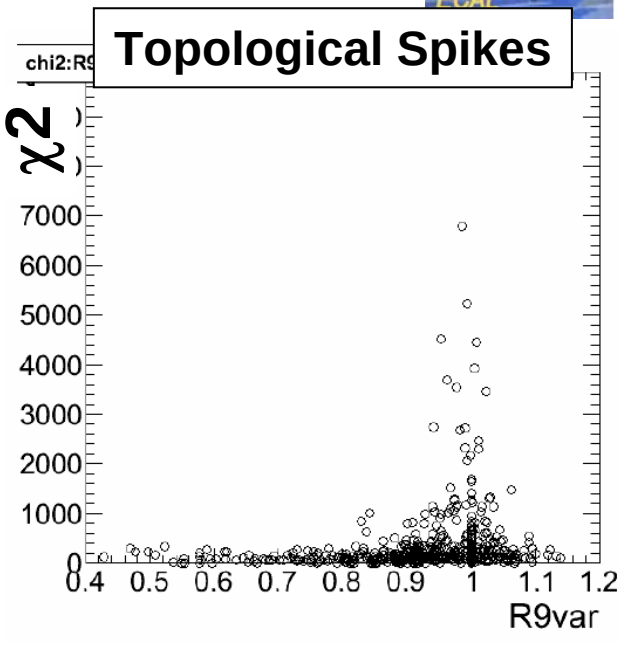


Kostas Theofilatos, Federico Ferri (i)

Pulse shape based tagging : χ^2 Commissioning







- **Usage of the all 10 samples possibly more powerful**

  ⇒ **Chi2 :** $\sum_i (sample_i - exp_i)^2 / \sigma^2$

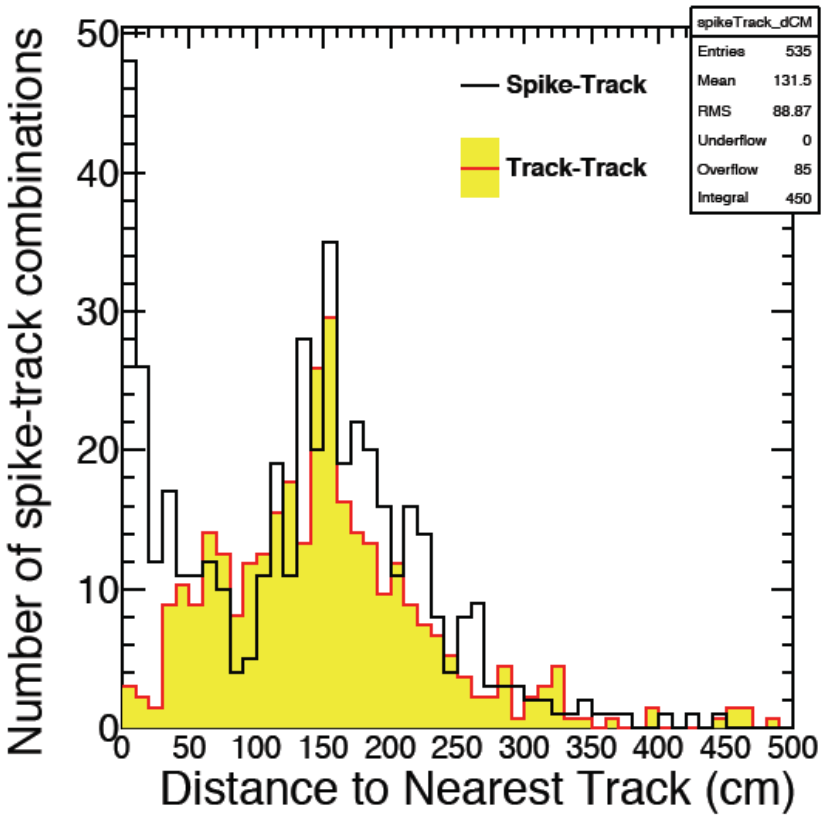
- **Chi2 commissioning ongoing**
- **Very subtle since very sensitive to readout phase, exact shape, noise, amplitude, FE gain, etc.**

Spike event properties

- (k) Artur Apresyan : Event properties of ECAL spike events
  http://indico.cern.ch/getFile.py/access?contribId=1&resId=1&materialId=slides&confId=87687
- (l) David Wardrope : Matching between Tracks and ECAL Spikes
  http://indico.cern.ch/getFile.py/access?contribId=5&resId=1&materialId=slides&confId=83918
- (l) JimBranson : What We can Learn by Matching Tracks to the APD Hits In The Data
  http://indico.cern.ch/getFile.py/access?contribId=2&resId=0&materialId=slides&confId=83918

Track-Spike matching

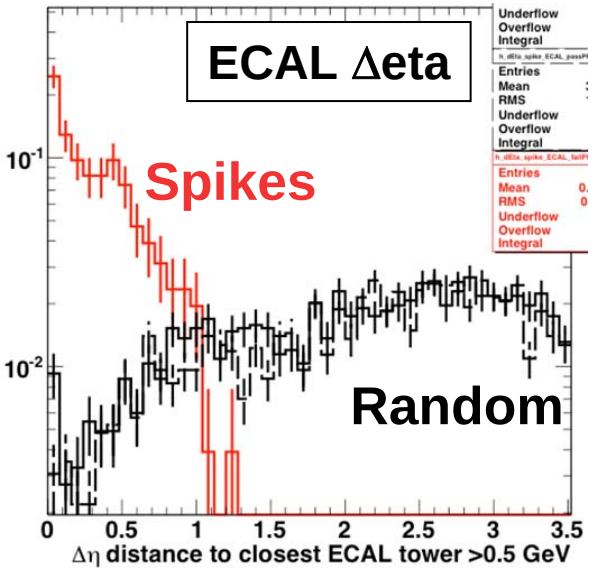
- With loose criteria (eg. within 30 cm) one finds a fraction of the spikes (15% - 50%) having a `matching` track.

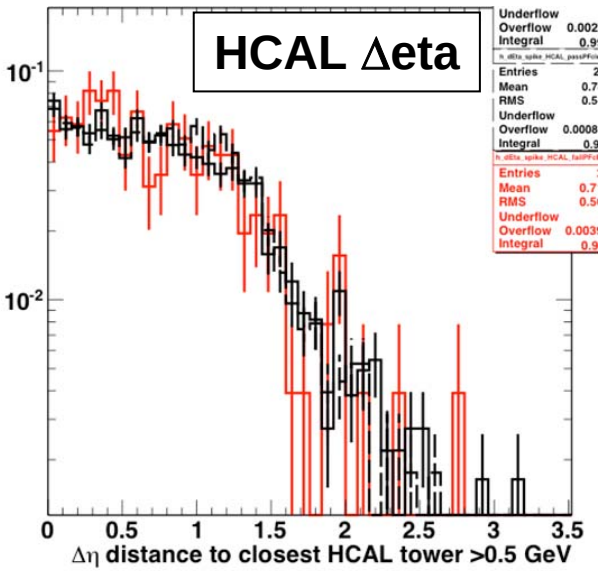


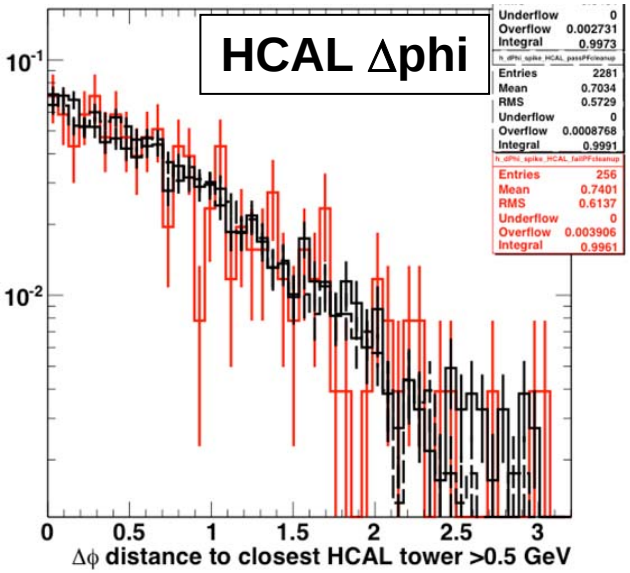
Artur Apresyan (k)

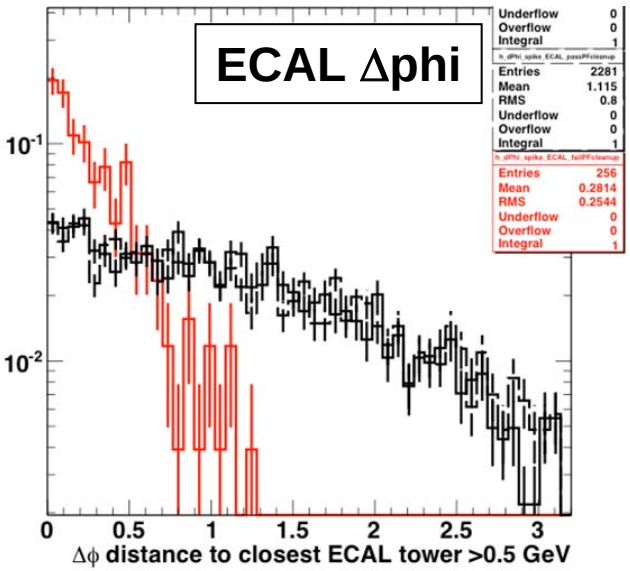
Activity in ECAL/HCAL around `isolated` Spikes

- Correlations between calorimeter hits and spikes :
  - Closest ECAL/HCAL Tower E>0.5 GeV
  - Red : Spikes identified according to PF cut
  - Black solid : ECAL seeds >2 GeV
  - Back dashed : ECAL seeds >2 GeV MC
- Extra ECAL activity in the spike vicinity.



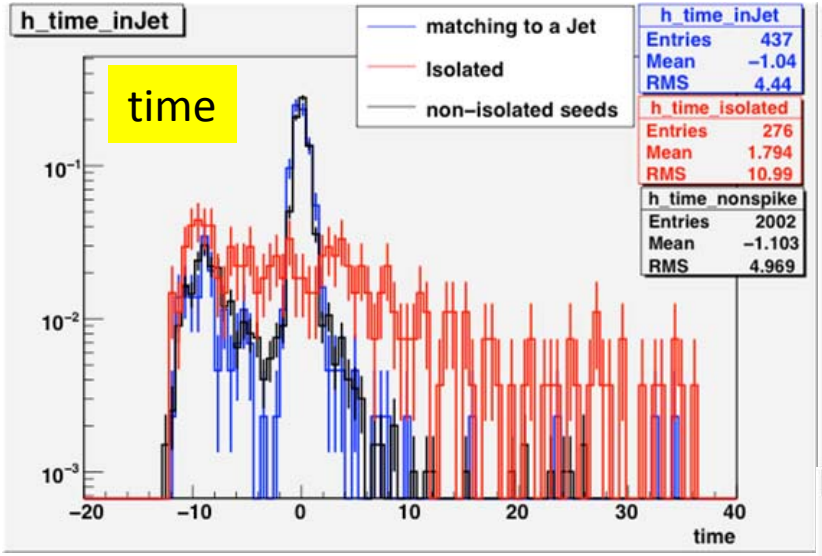


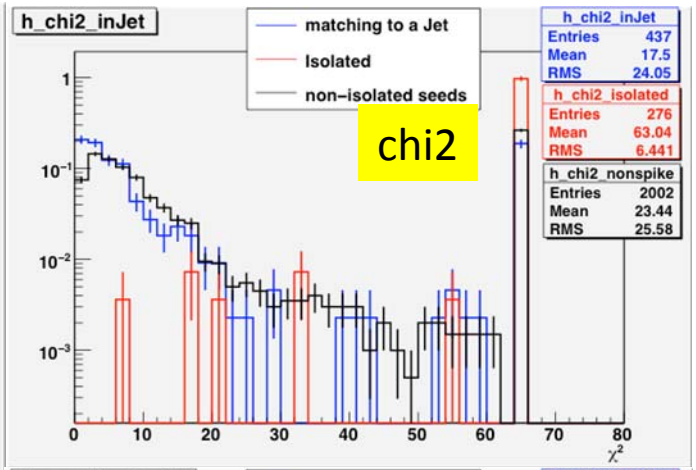


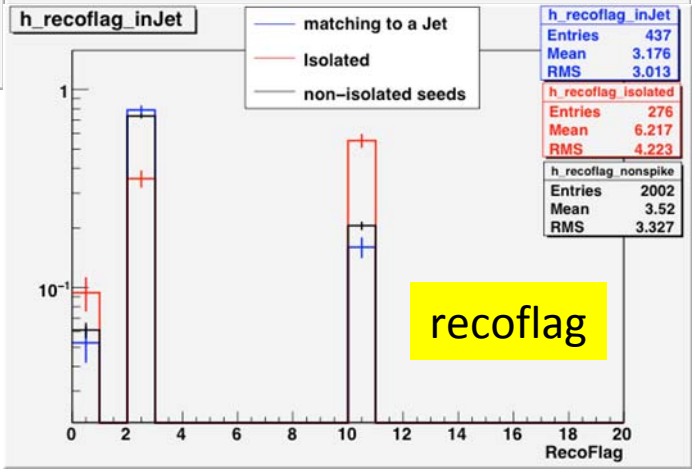


Spikes embedded in Jets in 2009 collision data

- Check for RecHits in jets that fail good signal criteria : Chi2, kFake, Time
- Loop over ECAL (EB) seeds and see if they match to an AK5 Jet within dR<0.5 Jet Pt>4.0 GeV and Had/EM>10%







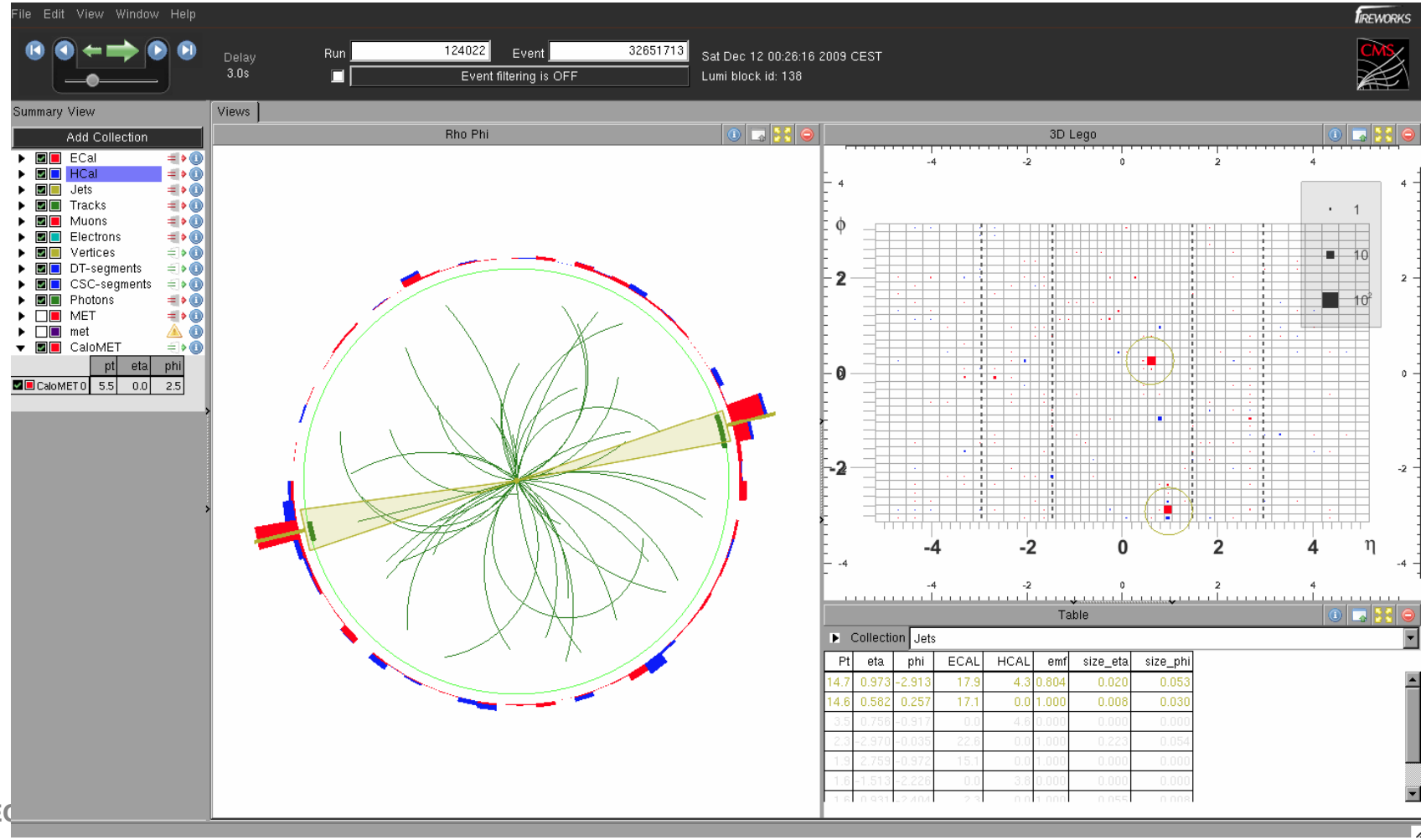
Matching to a Jet: xtal E>1 GeV
Isolated: defined on p5, xtal E>4 GeV
All seeds (excl. spikes) : xtalE>2 GeV

Chi2 saturates at value64

CMSSW version used here had a bug in calculation of kOutOfTime (bin 2)

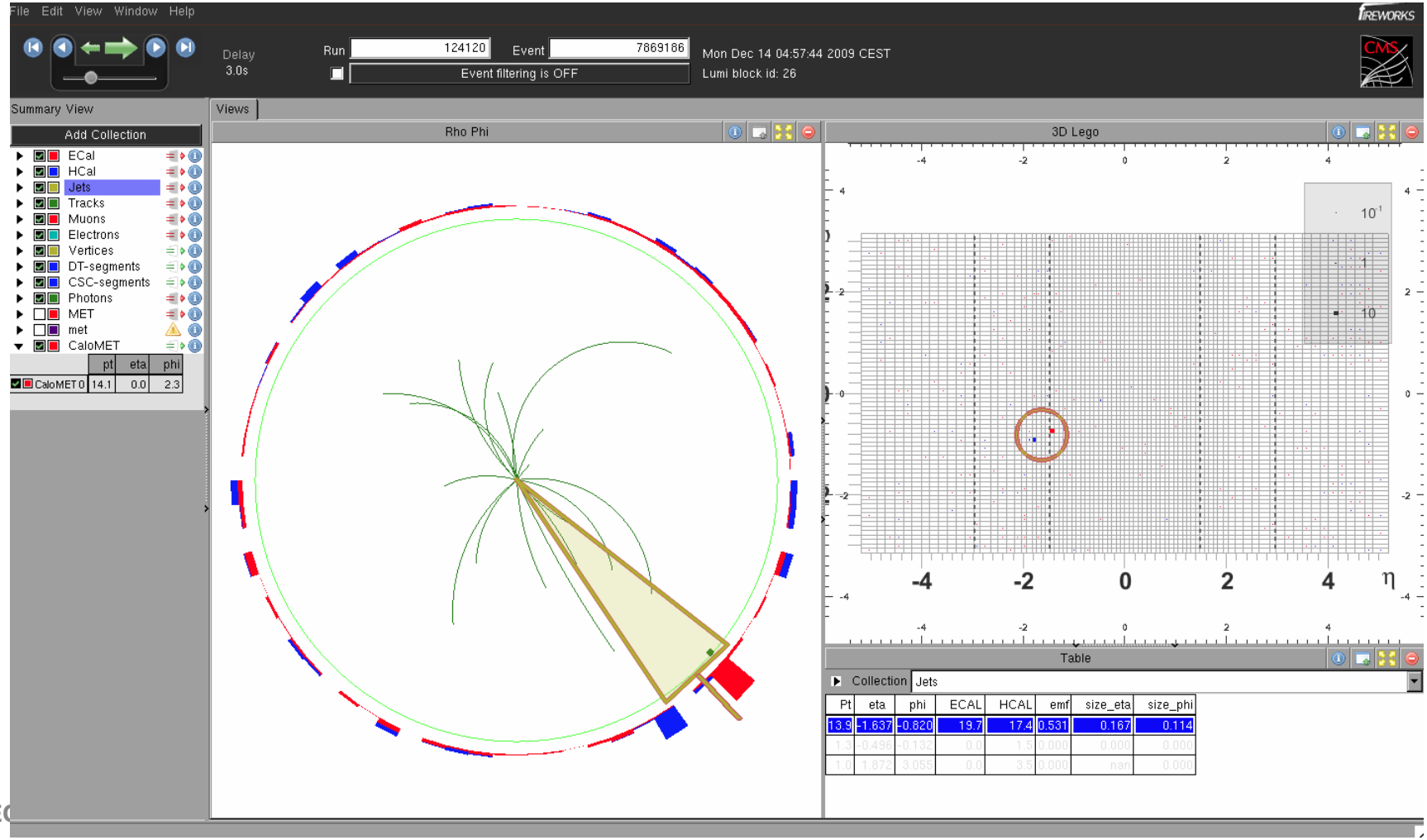
Spike candidate in a Jet (1)

- 900 GeV data with a spike candidate (passes PF isolation ID)
  - The ECAL crystal fails: Chi2 and timing cuts and is flagged as kFake
- Quite balanced event and little MET…



Spike candidate in a Jet (2)

- An event from 2.36 TeV with isolated (PF cut) spike candidate :
  - The ECAL crystal fails Chi2 cut and is flagged as kFake
  - Jet Pt=13.9 GeV, MET=14.1 GeV



Spike studies outside P5

- (m) Igor Vodopiyanov : ECAL APD spikes in TB2006
  http://indico.cern.ch/getFile.py/access?contribId=0&resId=1&materialId=slides&confId=87687
- (n) Renyuan Zhu : Neutron Induced Nuclear Counter Effect in a Pair of CMS APD
  http://indico.cern.ch/getFile.py/access?contribId=3&resId=0&materialId=slides&confId=88136
- (o) Andre Holzner et al. : APD Hits in the Simulation :
  http://indico.cern.ch/getFile.py/access?contribId=6&resId=1&materialId=slides&confId=83918
- (p) Sunanda Banerjee : Simulation of Energy Depostis in the APD
  http://indico.cern.ch/getFile.py/access?sessionId=3&resId=0&materialId=0&confId=87477

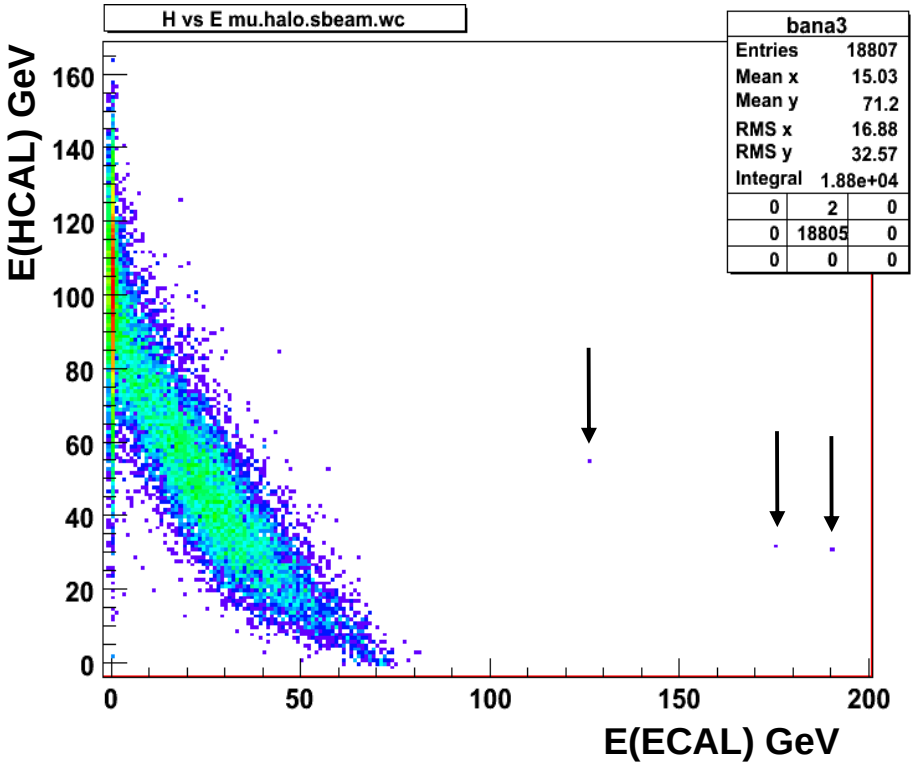
Igor Vodopiyanov (m)

Spikes in test beam – analysis of 2006 data

- 2006 study restricted to E(HCAL+ECAL)>Ebeam to investigate ADP nuclear counter effect.
- Looked within beam spot and in vicinity of APDs, then checked S1/S7x7 and timing for consistency with APD response signature.
- 2010 re-analysis inspired by topological cuts, looking in a larger area and at all energies.

2006 analysis :

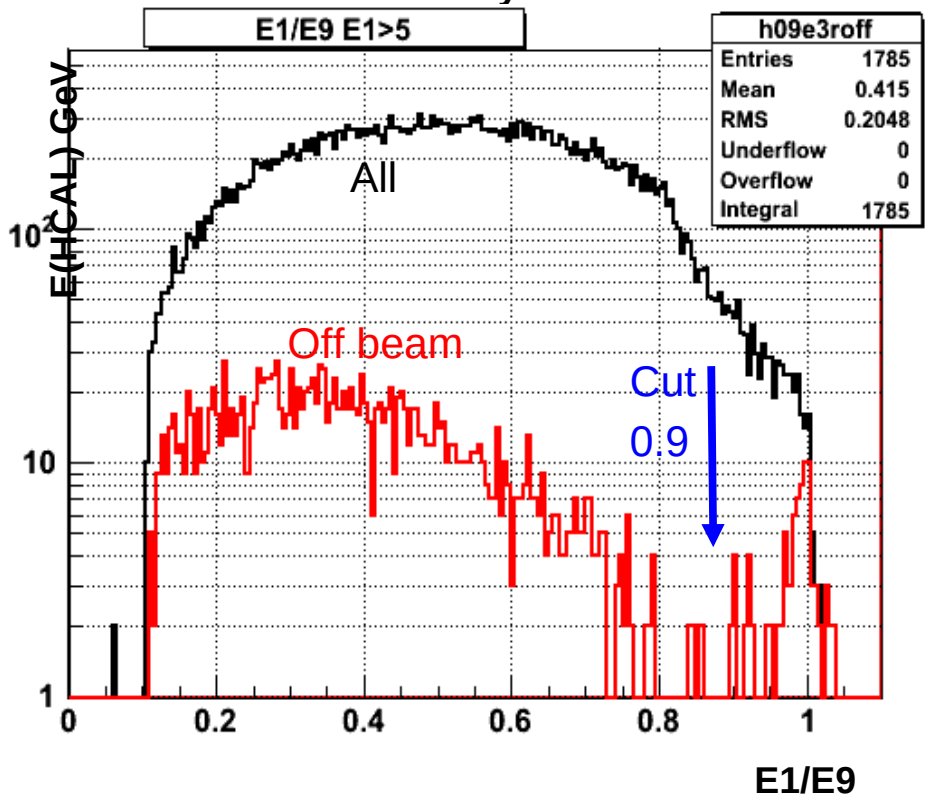
E(HCAL) vs (ECAL) in 100 GeV pion data



2010 analysis :

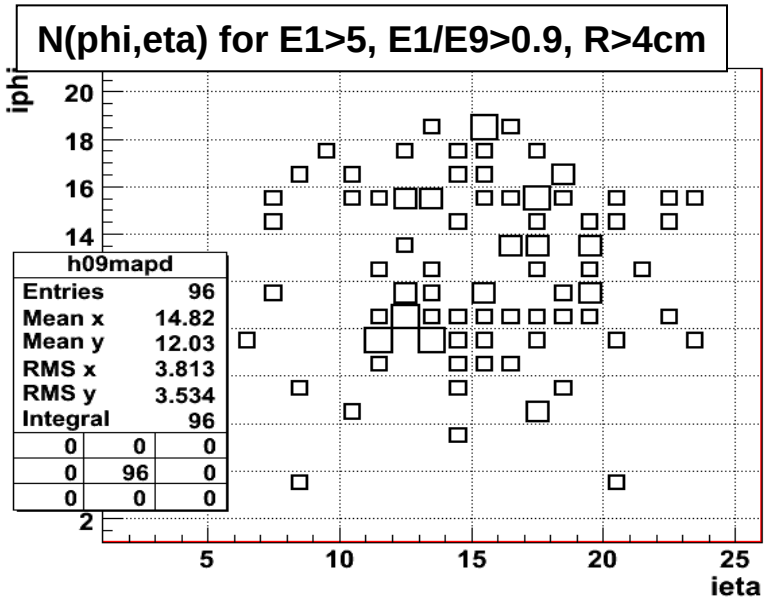
E1/E9 for all E1>5 GeV

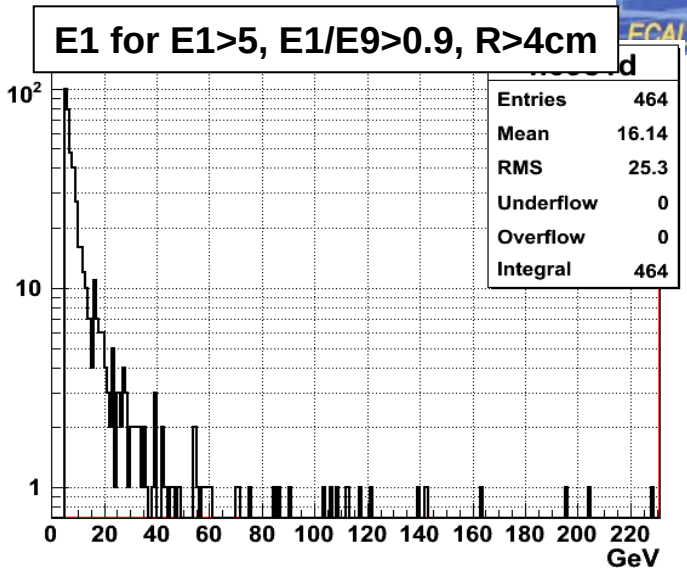
Off beam : more than 2 crystals from beam axis

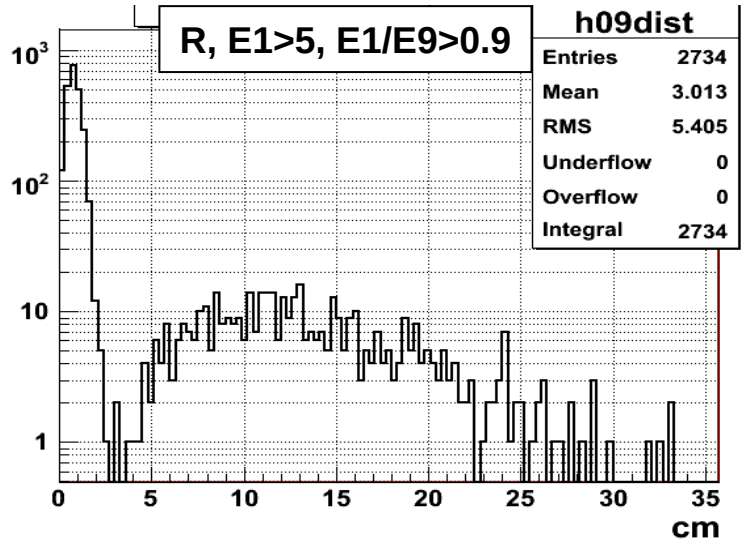


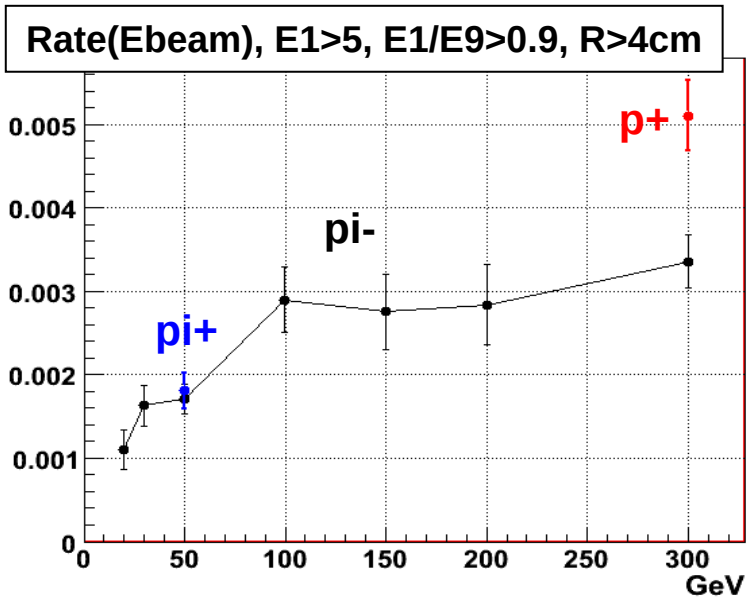
Igor Vodopiyanov (m)

Spikes in test beam 2006







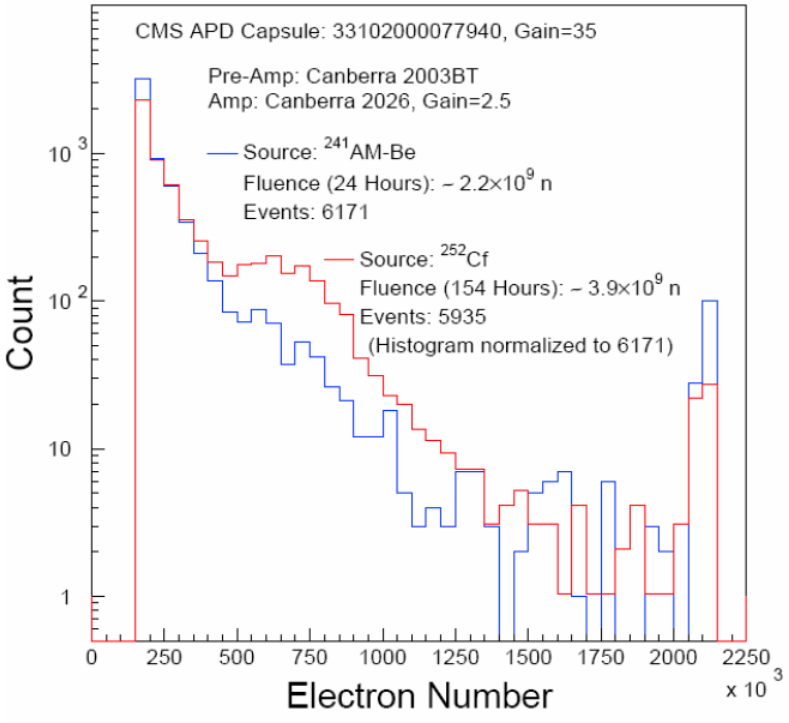


⇒ **Several properties of spikes can be analysed in detail**

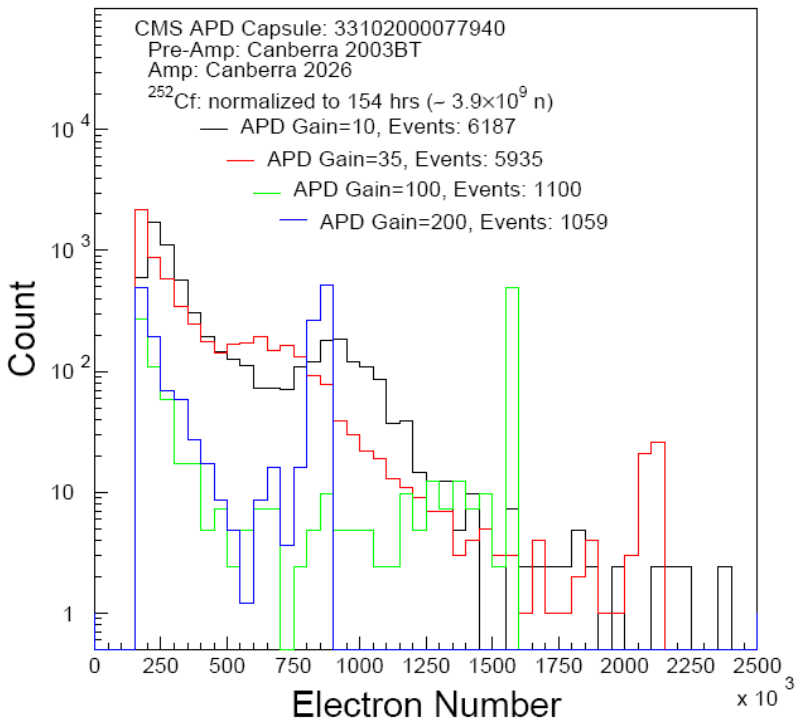
APD response to MeV neutrons

- Expose standard CMS APD capsule to ^{241}Am-Be, ^{252}Cf and various γ-sources.
- Large APD signals (up to several 100 GeV equivalent) observed, compatible with neutron depositing its entire energy in the active layer of APD.
- APD response to MeV neutrons seems gain dependent, with less high energy deposits for higher gains. Possible explanation for observations in CRAFT ?

^{241}Am-Be and ^{252}Cf



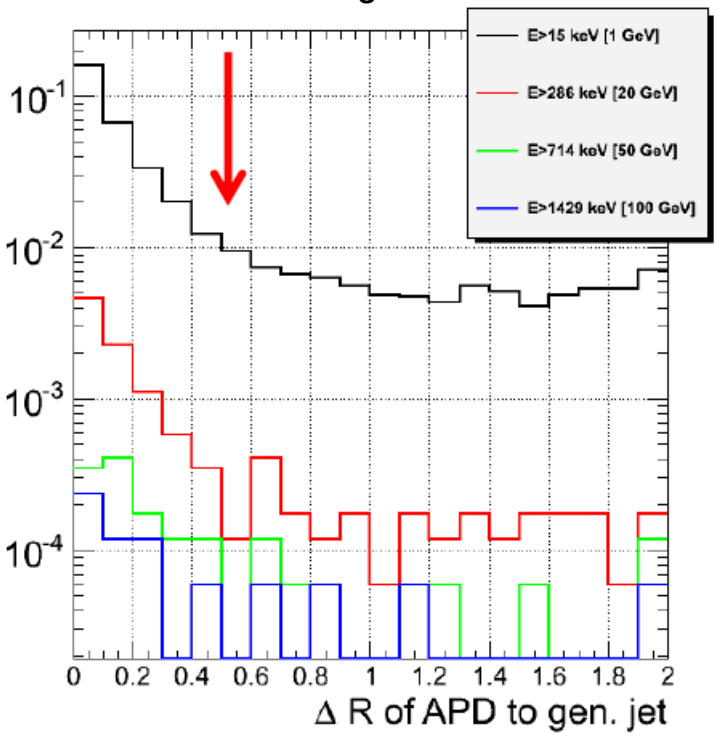
^{252}Cf Spectrum



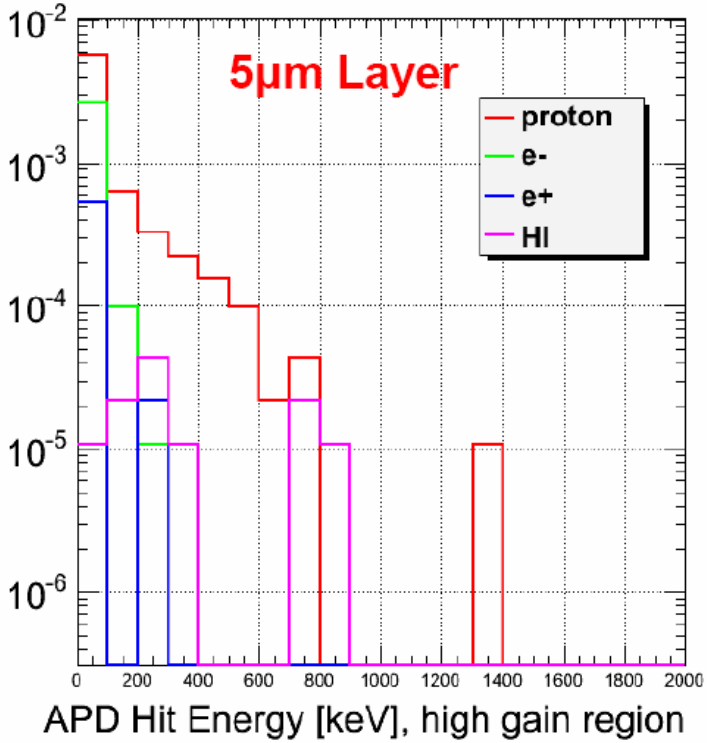
Detailed simulation of the APD

- Extensive effort to implement a detailed simulation of the APD and to study cause of spikes in MC.
- Goal is to have a proper simulation of spikes (timing, energy, spatial correlation to event activity) including mixed spike/scintillation hits.

ΔR of APD hits in a jet (Et>200 GeV, eta>1.3)
Relative to the generator Jet axis



ID of particles deposting large amount of energy in the APD



Summary

- **Significant progress on ECAL spikes in many areas :**
  - Understanding of the origin of spikes and spike event properties
  - Developing spike tagging (filtering) for the L1 and HLT trigger.
  - Improving offline tools to tag spikes.

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