

# LHO Cosmic Rays in S5

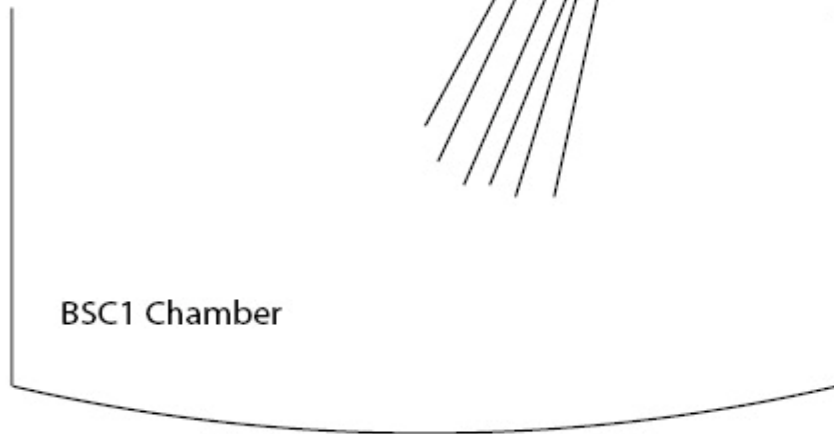
Ray. Frey, U Oregon

G060447-00-Z

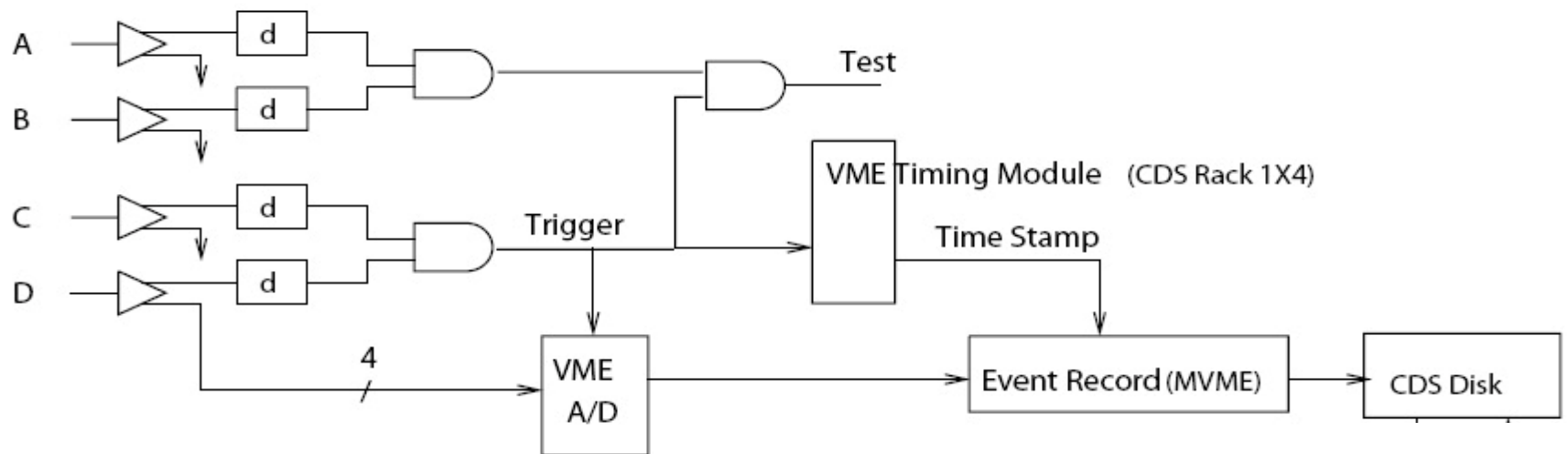
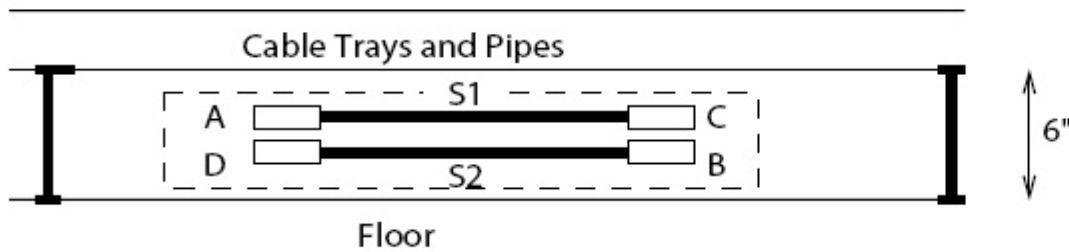
- Cosmic ray data for S5 starting 2/06
  - Late start: VME problem identified 8/05; addressed 1/06
  - Livetime ~70% (relative to calendar time) → should be ~95%

## Goals

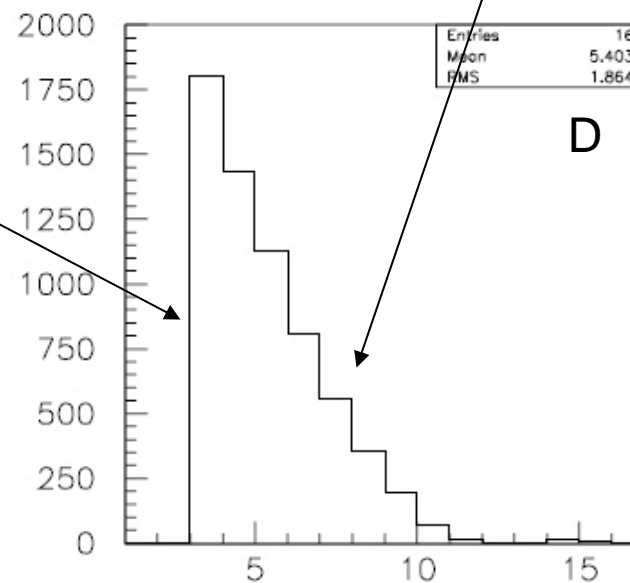
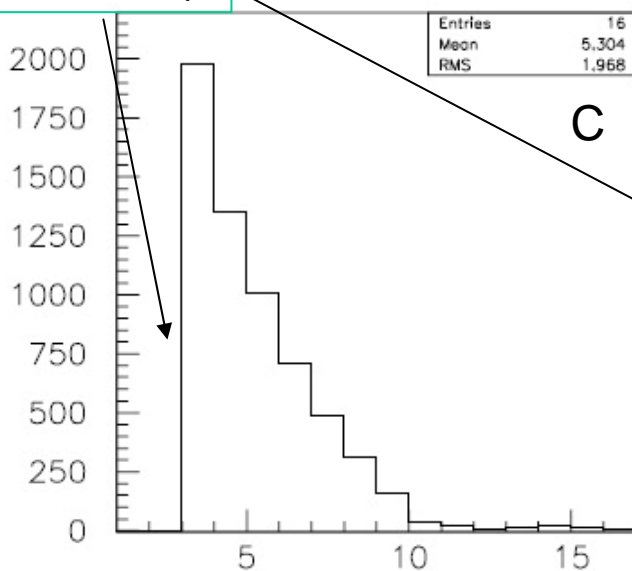
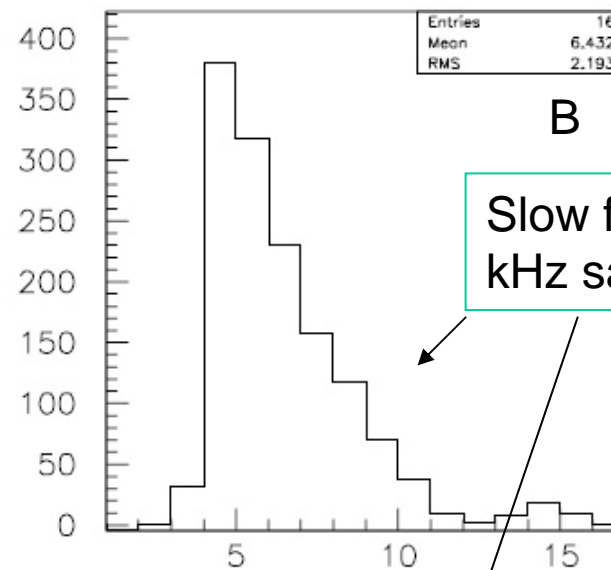
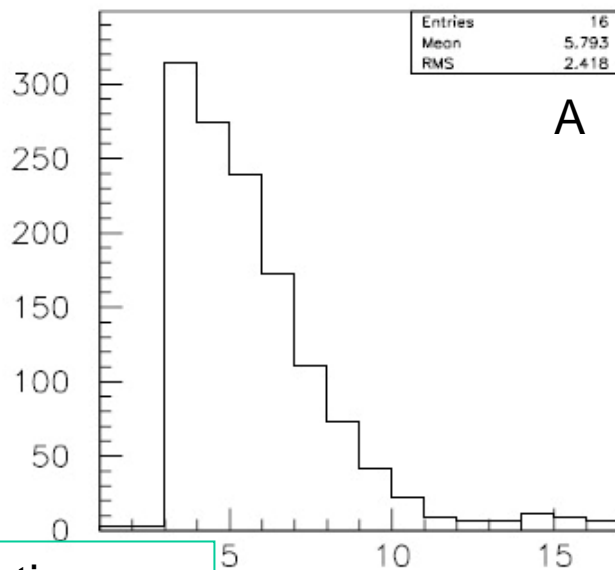
- Determine if there is an association between cosmic rays and IFO
  - Direct momentum transfer to TM, or TM modes excitation (heat)
    - Calculation says these are negligible, perhaps also for AdL
  - Perturbation of the electrostatic charge distribution on TM
  - Initial exploration reported here
- Veto – This is limited: Only one TM is instrumented: H1 ITMY (BSC1)
  - Do not *expect* this to be an important issue now – whether this is true depends on the result of the association study
  - Must consider this for the future.



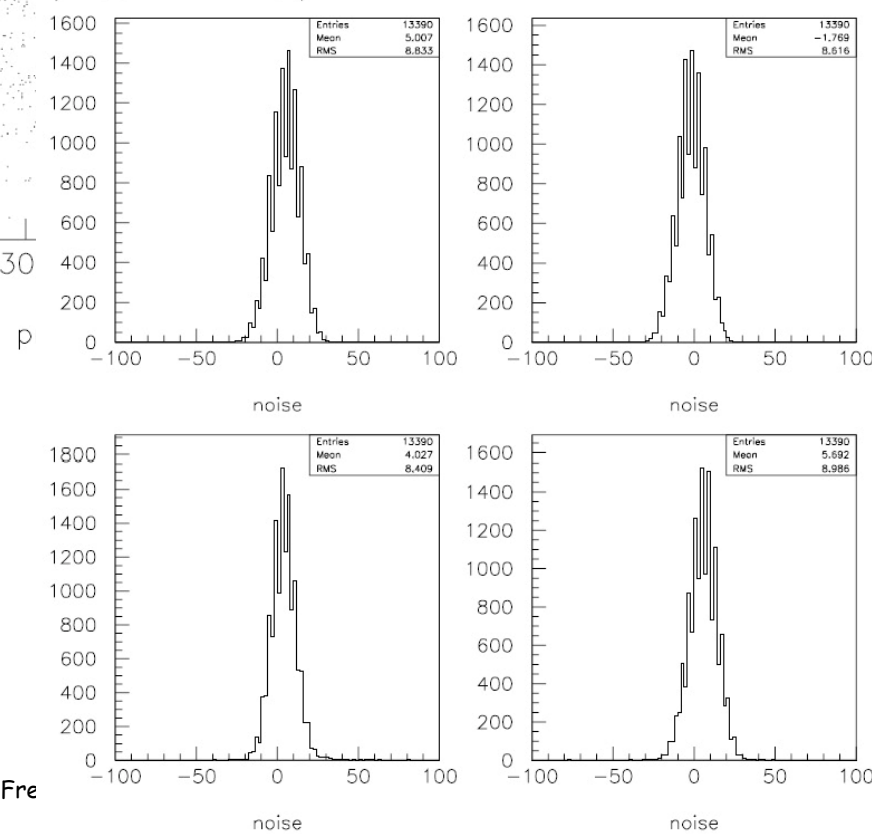
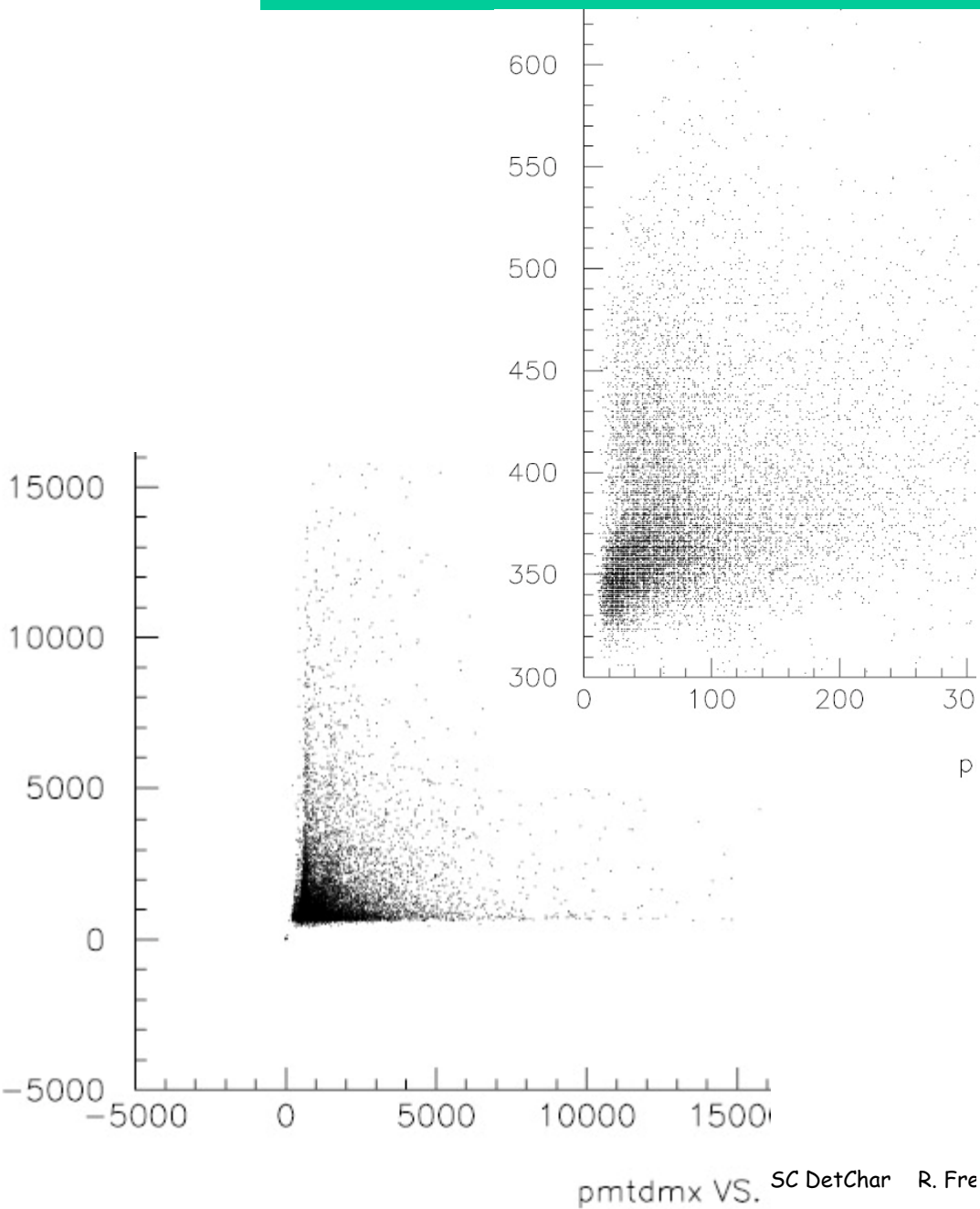
S1, S2 : 31"x31"x1" plastic scintillator  
 A, B : 10stage PMT (low gain)  
 C, D : 11stage PMT (high gain)  
 d : Discriminator/comparator  
 A/D : 3123 voltage sampling (80 kHz)  
 follows Q/V amp with ~10 us shaping



# a CR event



# Pulse height distributions



# Considerations for a CR-IFO effect

Momentum transfer ( $1/f^2$ ) and TM mode ring up small

...except for an abnormally energetic and dense shower ( $\sim 10^4$  muons)

- Will look for this and characterize effect/limit

## Electrostatics

- Test masses can charge up (eg due to contact to a different material)
- Coulomb interactions between TM and environment give rise to displacement noise, as discussed by Rai Weiss (LIGO-T960137 and 2006 elog)
  - Expect excess noise, if any, in 30-100 Hz with  $1/f^3$  spectrum
  - Confirmed by the S5 EQ stop-noise reduction event ??
- Hypothesis: A CR shower can perturb the charge distribution, giving rise to increased displacement fluctuations
  - See also Braginsky, et al, , LIGO-G050457

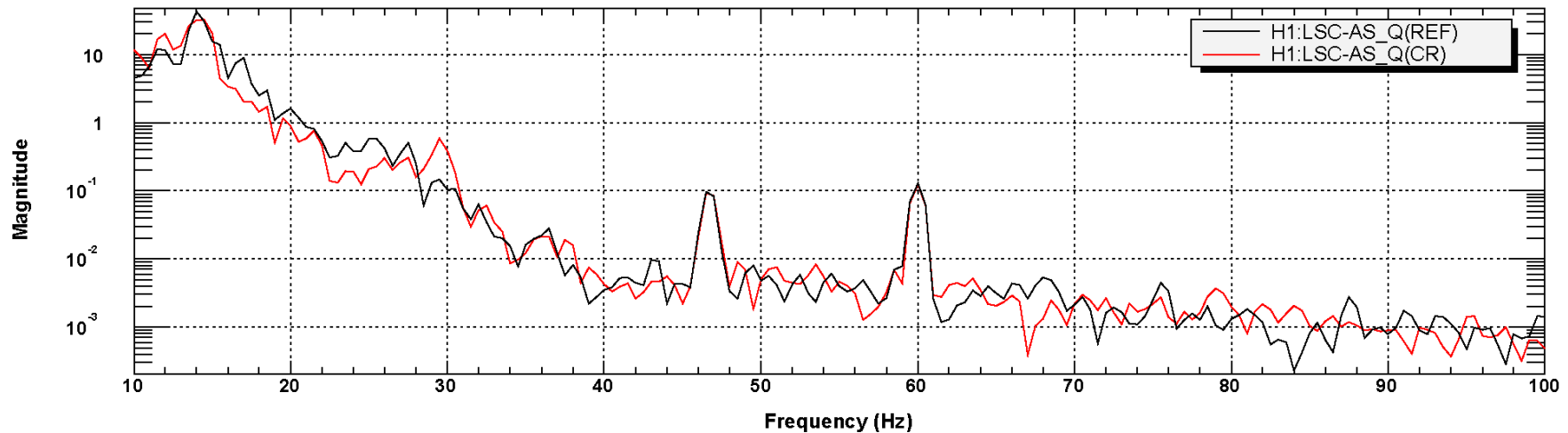
# First look for a CR-IFO association

First, look at individual CR events

- 1-sec spectrum starting at CR time =  $t_{\text{CR}}$
- 1-sec spectrum at  $t_{\text{CR}} - 10$

“a typical event”

Power spectrum



\*T0=27/07/2006 07:04:53.457031

Avg=2

BW=0.75

Plots: Emelie Harstad

# the biggest CR showers (thru 7/26)

```

/NIUPLE/SCAN: Name 'day' underlined
PAW > nt/scan //lun1/10 pmtDmx.gt.10000..and.pmtCmx.gt.10000. !!! pmtCmx pmt$

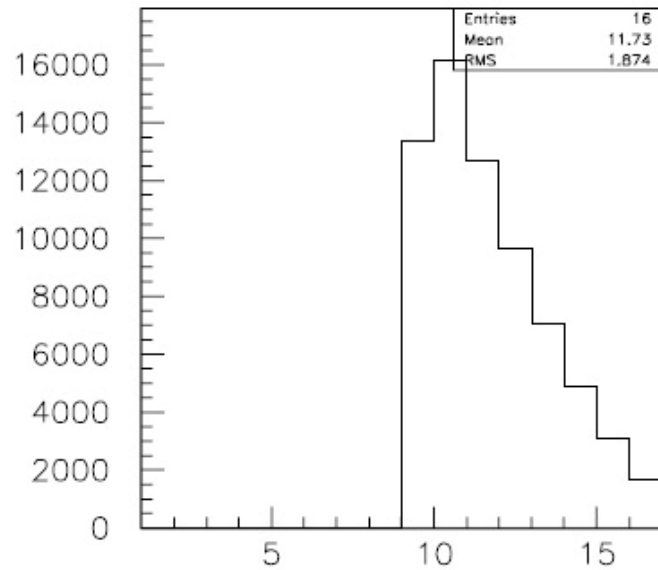
```

Event	pmtcmx	pmtdmx	pmtamx	pmtbmx	iday	ihour	minute	second
830	14354.	18720.	3639.	776.	65	11	48	12.3166
1914	16778.	19569.	1898.	595.	73	10	48	1.48167
2951	12975.	13792.	3488.	571.	80	20	21	43.9539
3921	12455.	11285.	2990.	842.	87	19	2	34.2231
4258	14206.	13716.	1246.	711.	90	9	36	21.7345
5263	10951.	10446.	4154.	576.	58	7	46	13.1903
6504	15463.	20389.	2223.	599.	122	17	30	55.5436
7864	11258.	13540.	1720.	524.	144	17	7	14.7696
7919	33092.	33122.	16162.	8026.	150	22	55	18.8928
8099	22002.	14019.	15748.	771.	152	15	26	33.7081
8920	10366.	10609.	683.	565.	167	8	57	7.96514
9213	16549.	11476.	2282.	578.	169	20	7	20.1955
9234	11380.	10493.	434.	520.	169	23	26	58.6306
10667	16186.	13170.	3013.	892.	190	10	52	5.38254
10977	18387.	10849.	2195.	555.	183	3	0	40.5776
11910	11026.	10768.	658.	581.	195	6	6	59.5717
12553	14251.	11341.	695.	384.	199	22	53	7.62606
13219	16106.	11779.	526.	491.	205	15	10	49.2643

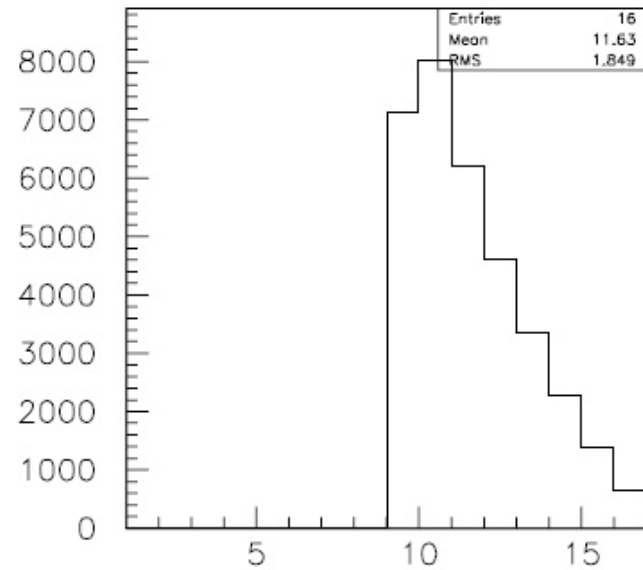
==> 18 events satisfied the imposed cuts

**Shower energy  
deposition ~ 10<sup>3</sup> muons**

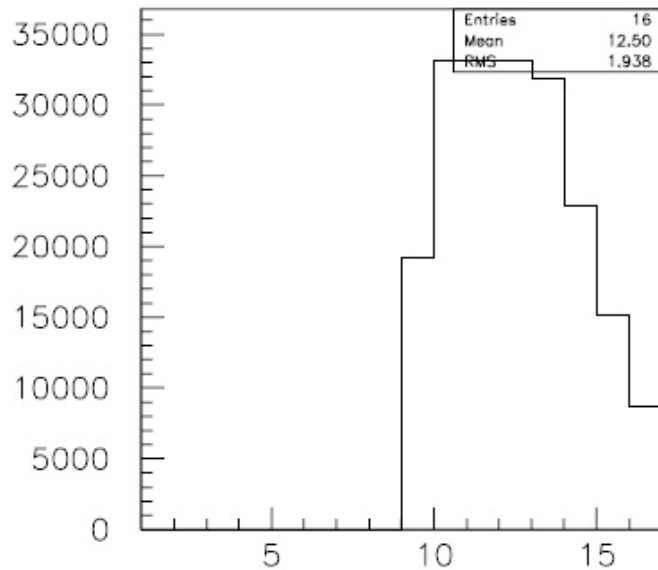
# the biggest CR shower



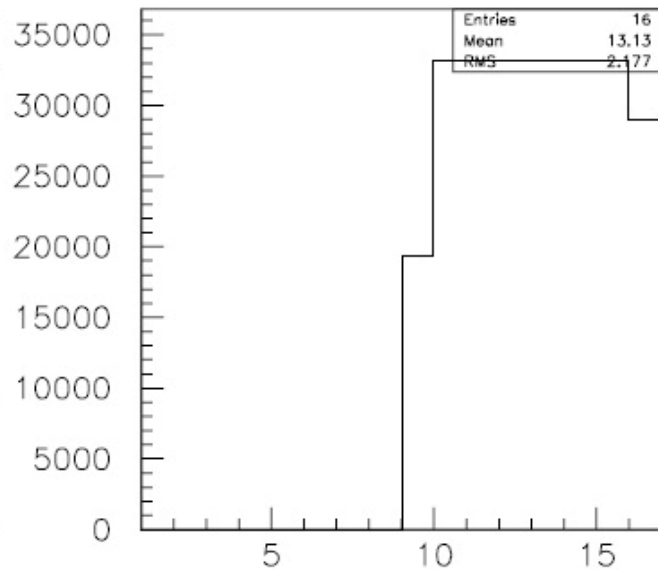
pmt A



pmt B



pmt C

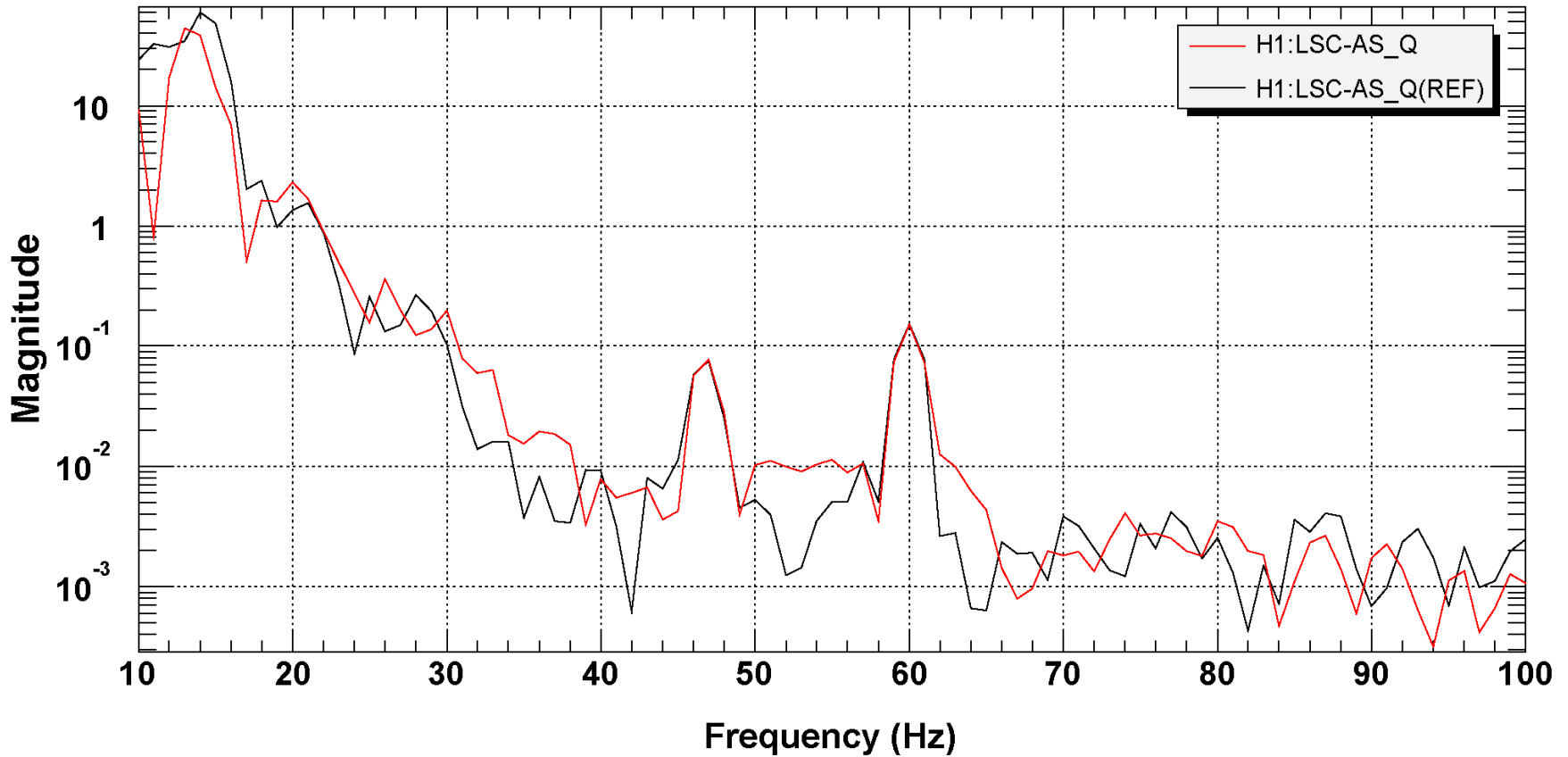


pmt D



# the biggest CR shower (contd)

## Power spectrum



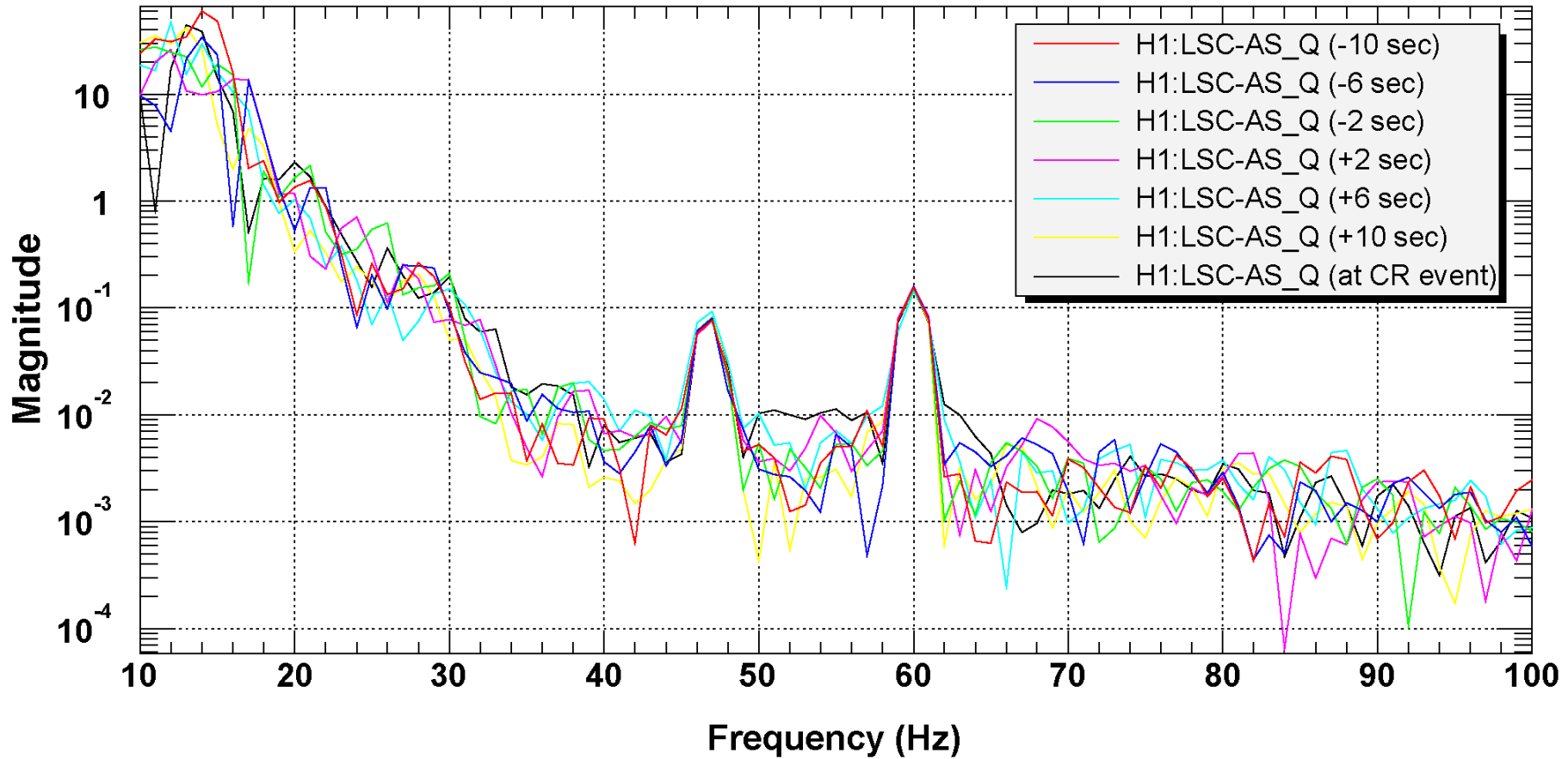
**\*T0=30/05/2006 22:55:18.894531**

**Avg=1**

**BW=1.5**

# the biggest CR shower (contd)

## Power spectrum



\*T0=30/05/2006 22:55:08.894531

Avg=1

BW=1.5

# Next...

- Studies just getting underway
- Check all biggest individual events
- Sum over all CR events, compare on-time vs off-time
  - For a range of time windows
  - Spectra and blrms
- Determine excess noise (limit) as function of CR signal (# of charges) and time window (i.e. charge re-distribution relaxation time)

## Operations

- Recent reliability issues with VME CPU/CDS (the “standard” stuff)
  - ⇒ LHO will take over operation of the DAQ elements (good!)
- The S5 events will be put in the LIGO data base soon (ligo light weight)
- LHO considering frames insertion
- LLO ?? (Note: ITMY was where CR detector was originally located.)

# the biggest CR shower (contd)

