Testing some CAL specs

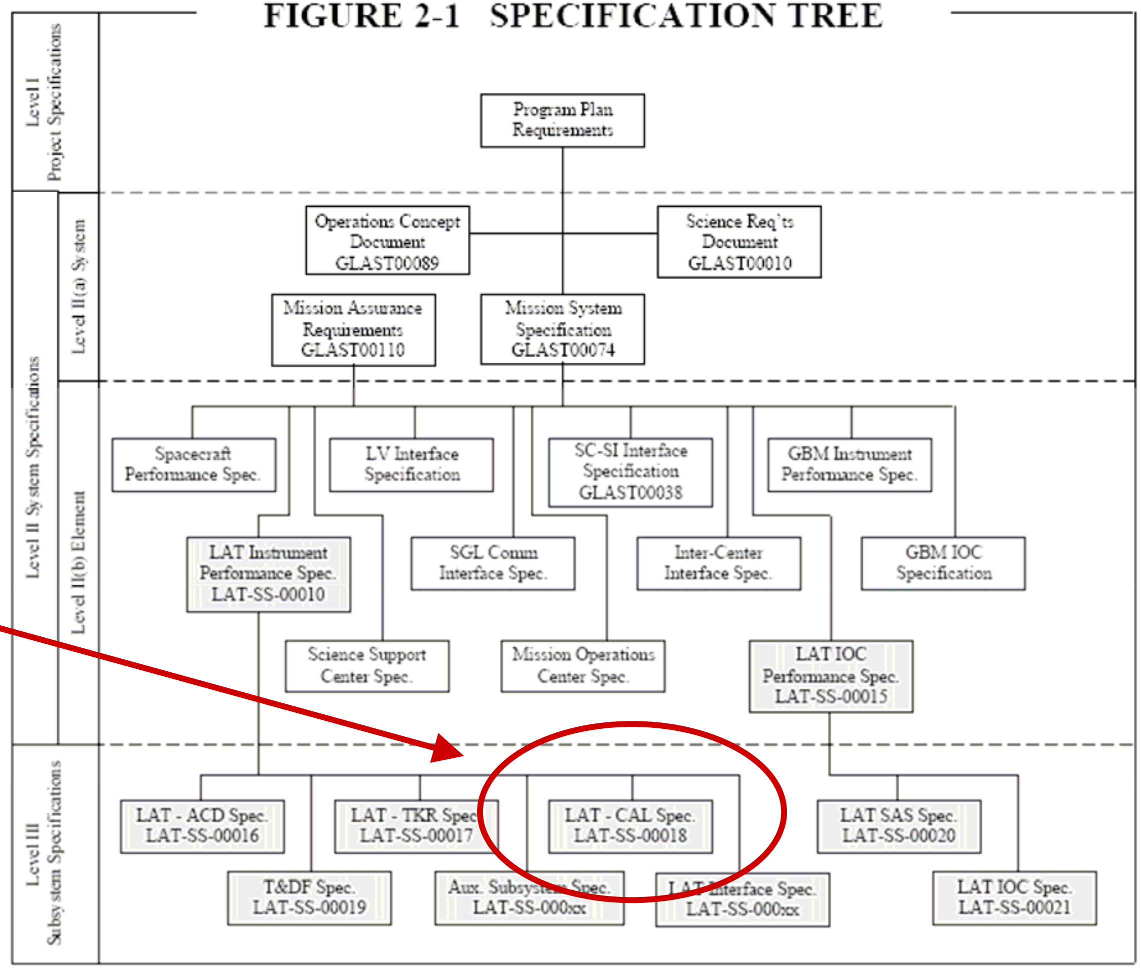
- Level 3 CAL requirement 5.5.5: <3 cm xyz position resolution per layer ("CAL MIP centroid")
- Level 3 CAL requirement 5.5.6: $<15^o \cos^2\theta$ for cosmic muons ("μ PSF")

Non-spec things

- Want LAC settings to be at 1 or 2 MeV (zero suppression), without overly hot channels nor overly inefficient channels.
- Tools used: my usual TKR extrapolation to CAL, as well as CALMip.

GLAST LAT SYSTEM SPECIFICATION	Document # LAT-SS-00018-10	Date Effective 21 Nov. 2004
	Prepared by(s) W. Neil Johnson	Supersedes LAT-SS-00018-09
	Subsystem/Office Calorimeter Subsystem	
Document Title LAT CAL Subsystem Specification - Level III Specification		

FIGURE 2-1 SPECIFICATION TREE



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This talk

Table 6-1. Requirements Verification Matrix

Note: Verification methods are T = Test, A = Analysis, D = Demonstrate, I = Inspect

Req't #	Title	Summary	Verif. Method
5.2.1	Energy Range	20 MeV – 300 GeV	A
5.2.2	Single CsI Crystal Energy Measurement Range	5 MeV – 100 GeV	A
5.3.1	On-axis Energy Resolution – Low Energies	<50% (20 – 100 MeV) <10% (100 MeV – 10 GeV)	A
5.3.2	On-axis Energy Resolution – High Energies	<20% (10 – 300 GeV)	A
5.3.3	Off-axis Energy Resolution – High Energies	<6% (> 10 GeV)	A
5.3.4	Single Crystal Energy Resolution	< 2% for high energy carbon	T,A
5.4	On-Orbit Calibration	Relative: <3%; Absolute <10%	A
5.5.1	Depth	> 8.4 radiation lengths of CsI	I
5.5.2	Hodoscopic Layers	Hodoscopic design	I
5.5.3	Active Area	>1050 cm^2/module on axis	I
5.5.4	Passive Material	No more than 10% of total mass of CAL	I
5.5.5	Position Resolution	< 3 cm in all 3 dimensions/layer	T
5.5.6	Angular Resolution	$<15 \times \cos^2(\theta)$ degrees for cosmic muons	T
5.6	Command and Data Interface	LAT standard protocols	I
5.7	Measurement Dead Time	<100 μsec	T
5.8	Overload Recovery	<500 μsec	T
5.9	Low Energy Trigger Signal	CAL to provide low-energy trigger signal to the LAT trigger system	I
5.10	High Energy Trigger Signal	CAL to provide high-energy trigger signal to the LAT trigger system	I
5.11	Operating Modes	Continuous thru orbits	A
5.12	Calorimeter Mass	Not to exceed 1440 kg.	I
5.13	Calorimeter Power	Not to exceed 71 W).	T
5.14	Environmental	Must withstand environmental conditions in LAT Instrument Performance Spec.	T
5.15	Performance Life	Specified performance for a minimum of 5 years	A
5.16	Reliability	Reliability minimum of 96% in 5 years.	A

The Method

[Review my IA Workshop #4 presentation if you like (14 July 2005).]

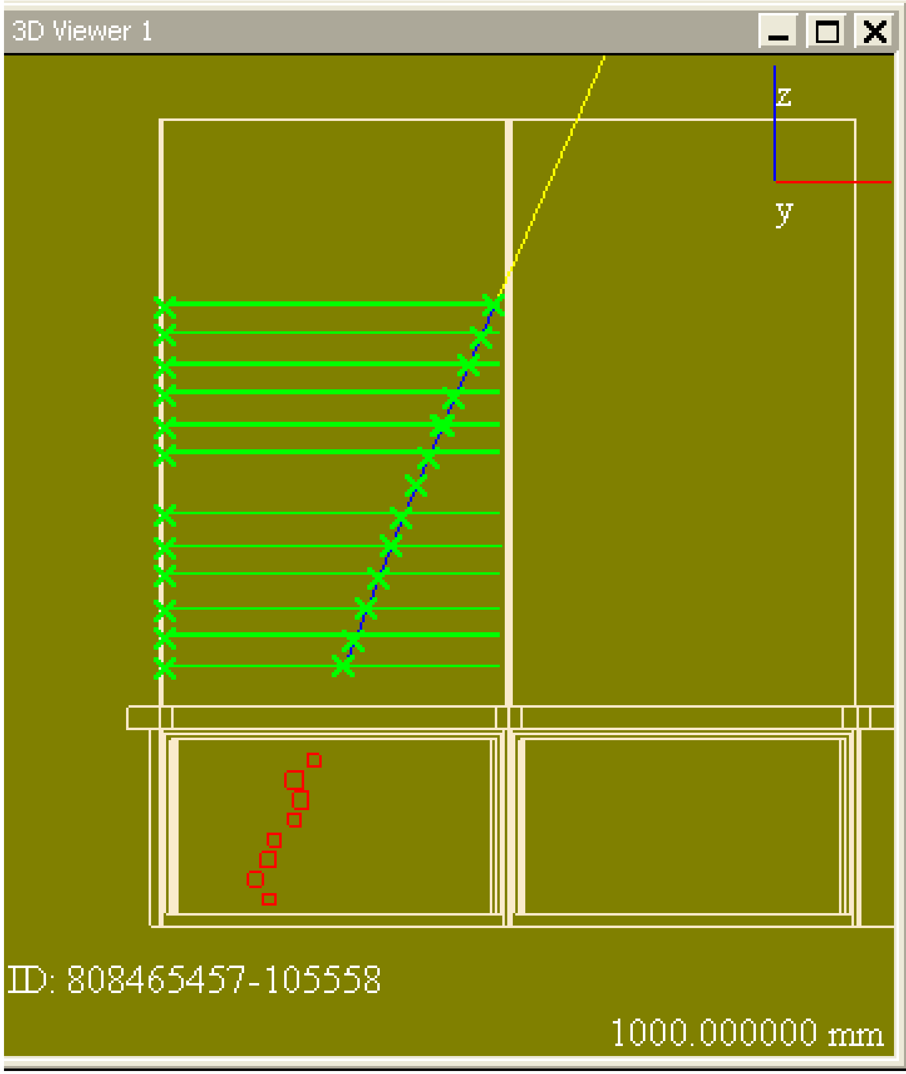
• Extrapolate TKR track to CAL, predict which crystals get hit. Look at energy deposits, positions.

• Use Tkr1EndPos, Dir. Stay a few cm away from crystal ends.

• Require:
TkrNumTracks == 1
Tkr1KalThetaMs < 0.03
Tkr1NumHits > 15

<2 MeV in adjacent crystals
Extrapolation of track must traverse top & bottom of crystal.

• Energy corrected for $\cos\theta$.



The data sample

Red: six B30 runs (135005404 to 14)

Blue: ~22 (twenty-two) B2 runs (135005345 to 89), re-processed with the “muon track” hypothesis

Yellow: 4M Surface Muons (v5r0703p5)

CAL level 3 req't 5.5.5: <3cm xyz position resolution per layer

5.5.5 Position Resolution

[Derived from LAT SS-00010 5.2.2, 5.2.12]

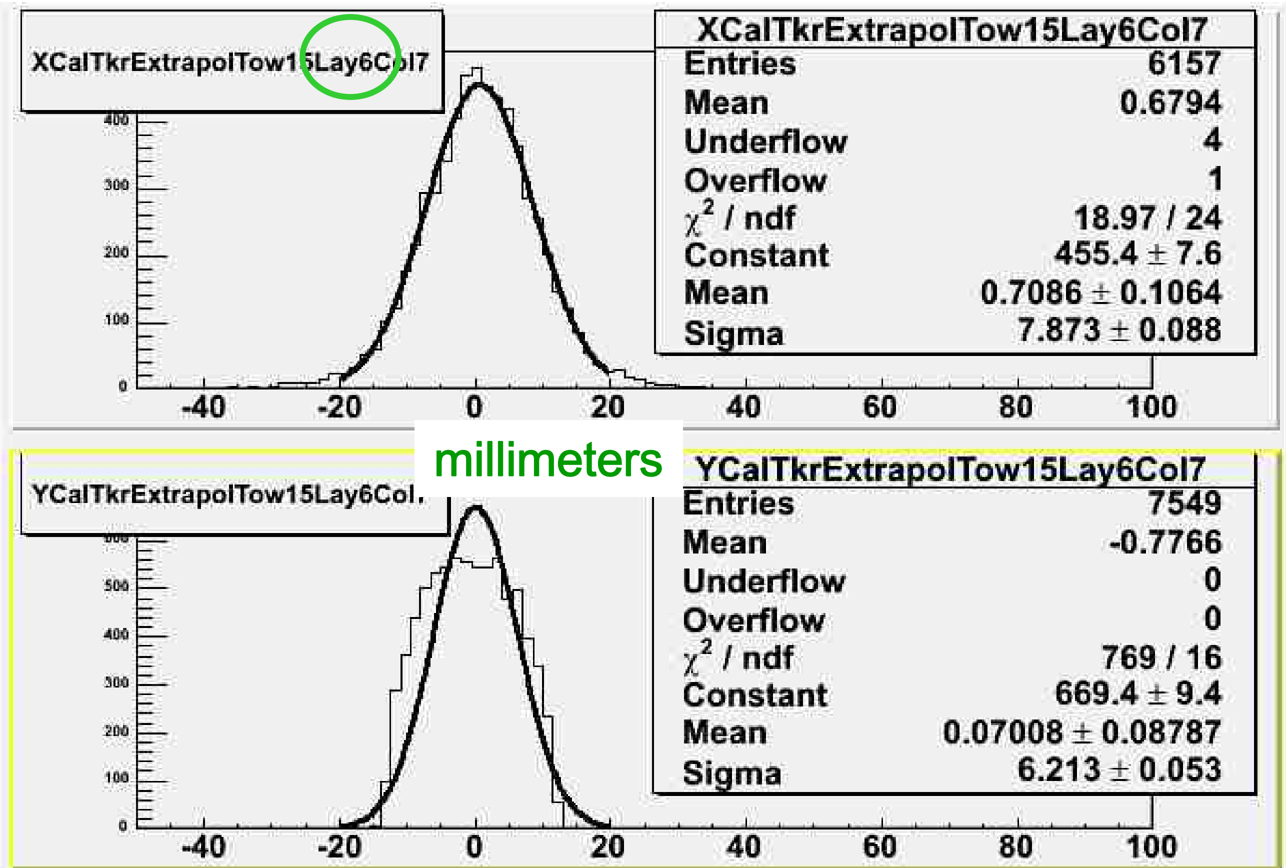
Each layer of the calorimeter shall position the centroid of a Minimum Ionizing charged particle energy deposition to less than 3.0 cm (1σ) in all three dimensions for particle incident angles of less than 45 degrees off axis.

This is an *even* layer…

…so the x-direction is the *longitudinal* meas't (light ratio from the two crystal ends)…

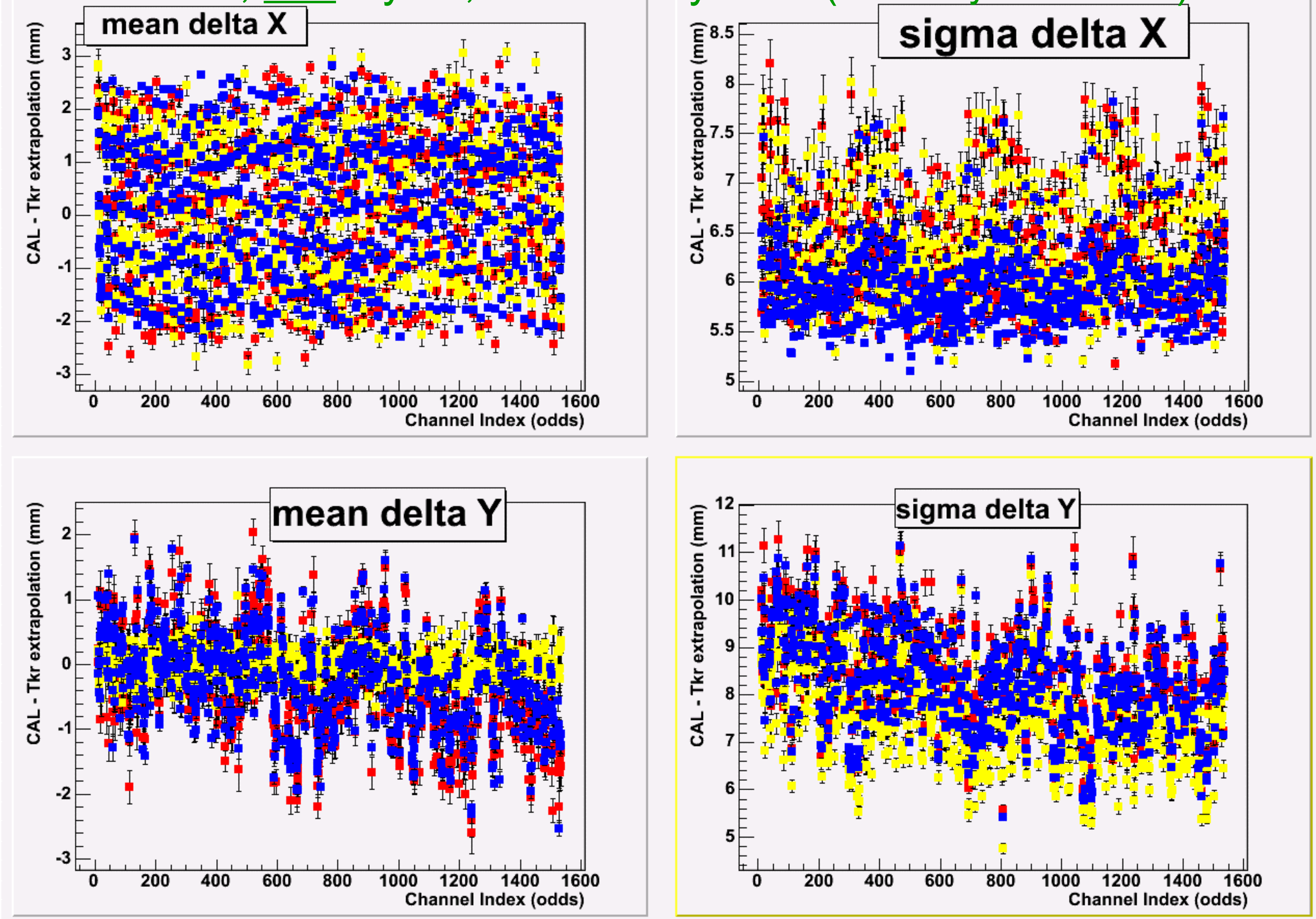
…whereas the y-direction is just the *transverse* crystal profile.

Z-direction like y.

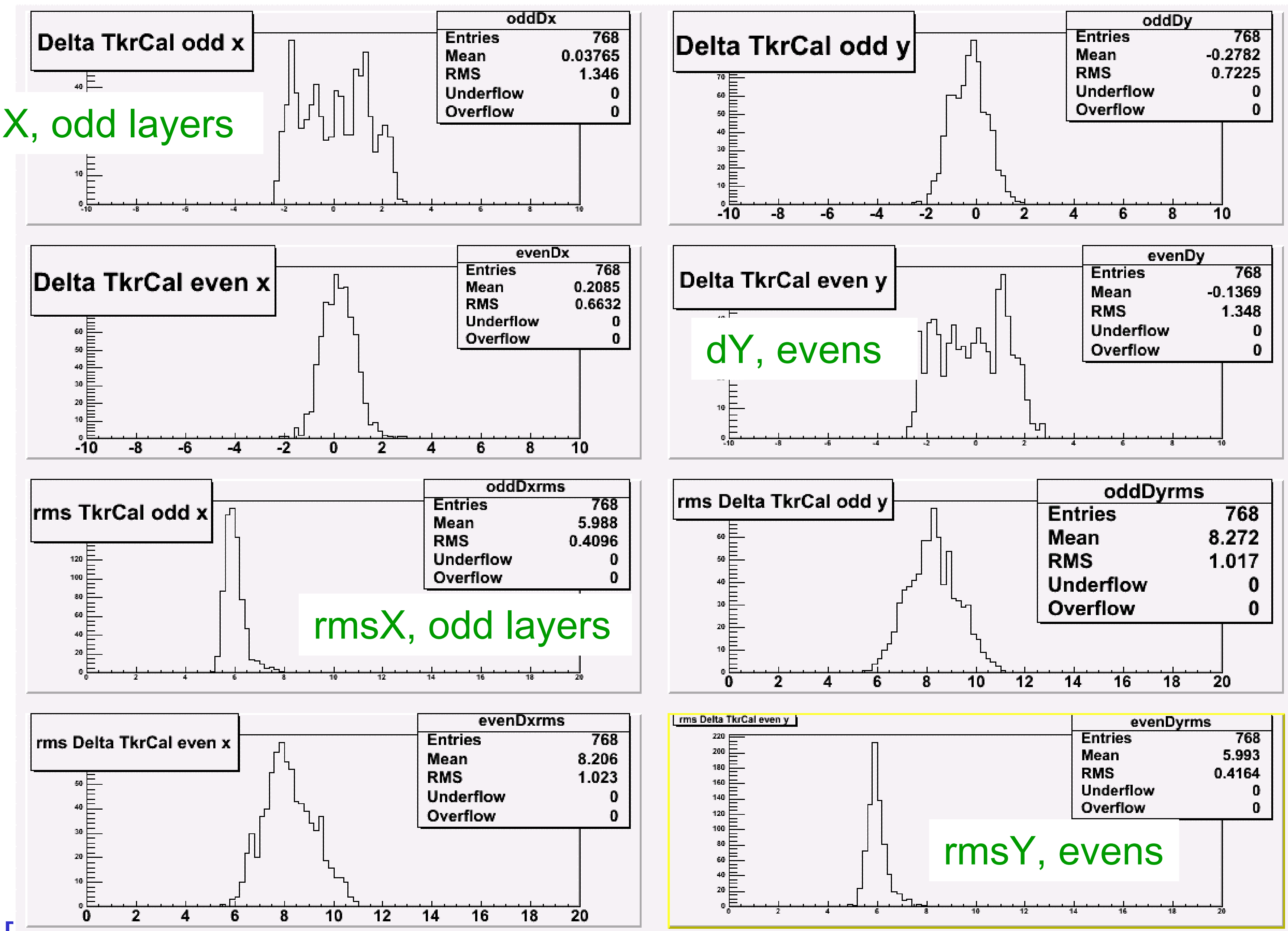


CAL position vs extrapolated TKR position

Here, odd layers, all 1536 crystals. (Even layers similar.)



All rms's << 30 mm: req't met



CAL level 3 req't 5.5.6: <15°$\cos^2\theta$ for cosmic muons

5.5.6 Angular Resolution

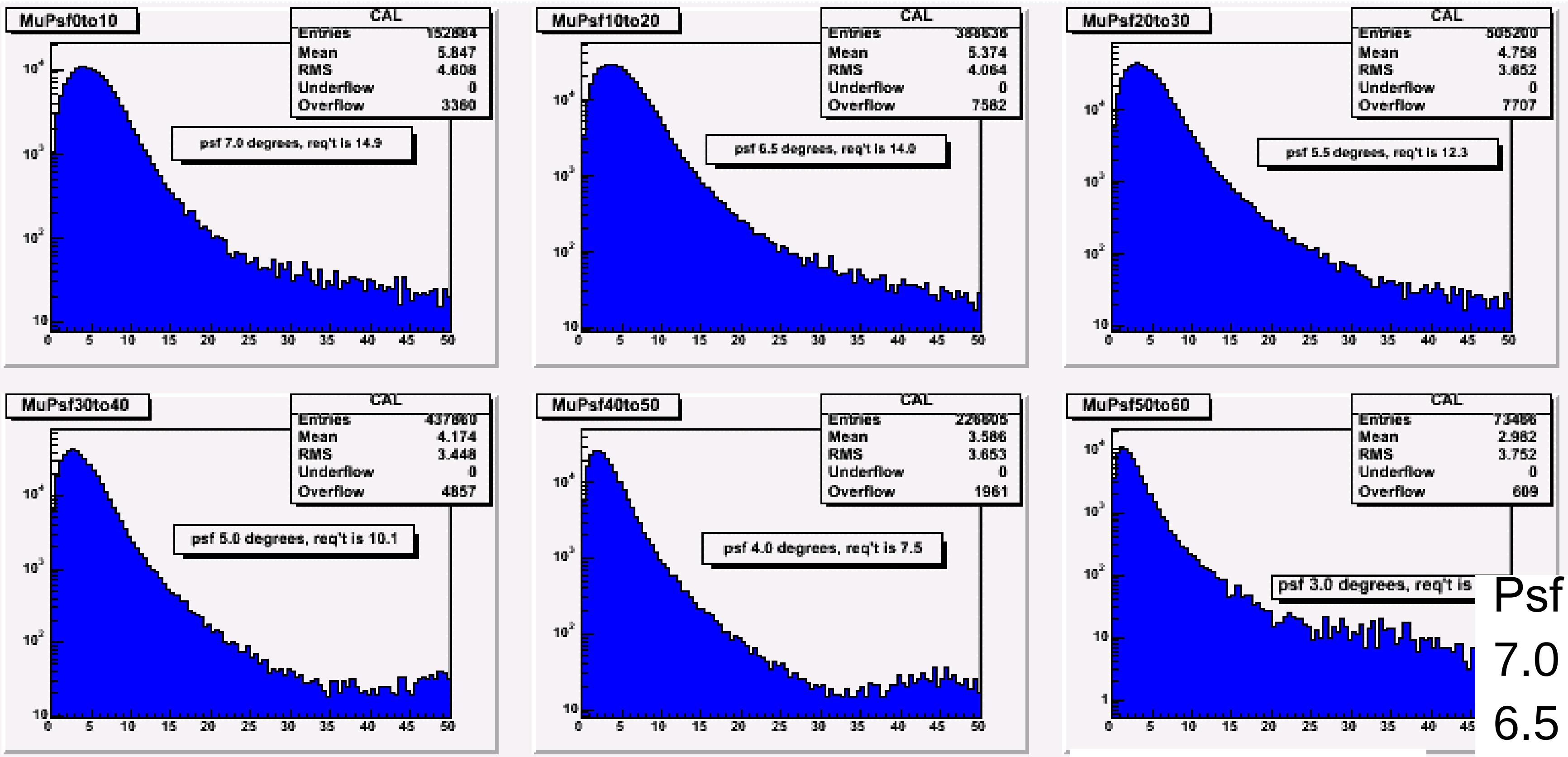
[Derived from LAT SS-00010 5.2.2, 5.2.12]

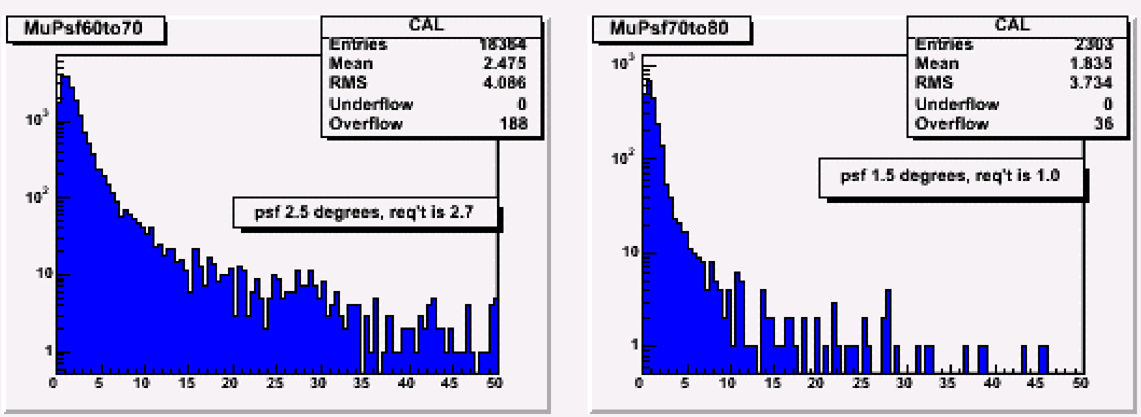
The single particle angular resolution at 68% containment for the calorimeter shall be better than $15 \times \cos^2(\theta)$ degrees for cosmic muons traversing all eight layers. (θ is the off-axis angle.)

- Use *all* B2 "muon TKR hypothesis" MeritTuple files (runs 135005345 to 89)
- TCut OneTrack = "TkrNumTracks==1 && CalMipNum==1"
- TCut AteLayers = "CalELayer0>8 && …&& CalELayer7>8 "
- Let $\cos\xi$ = -CalDir•VtxDir (angle between CALMIP and TKR tracks)

  (using Montpellier MIP finder.)
- Make 9 bins of 10 degrees each, histogram ξ, find 68% point.

Nine 10º zenith angle intervals





Psf	req
7.0	15
6.5	14
5.5	12
5.0	10
4.0	8
3.0	5
2.5	2.7
1.5	1.0

req't met:

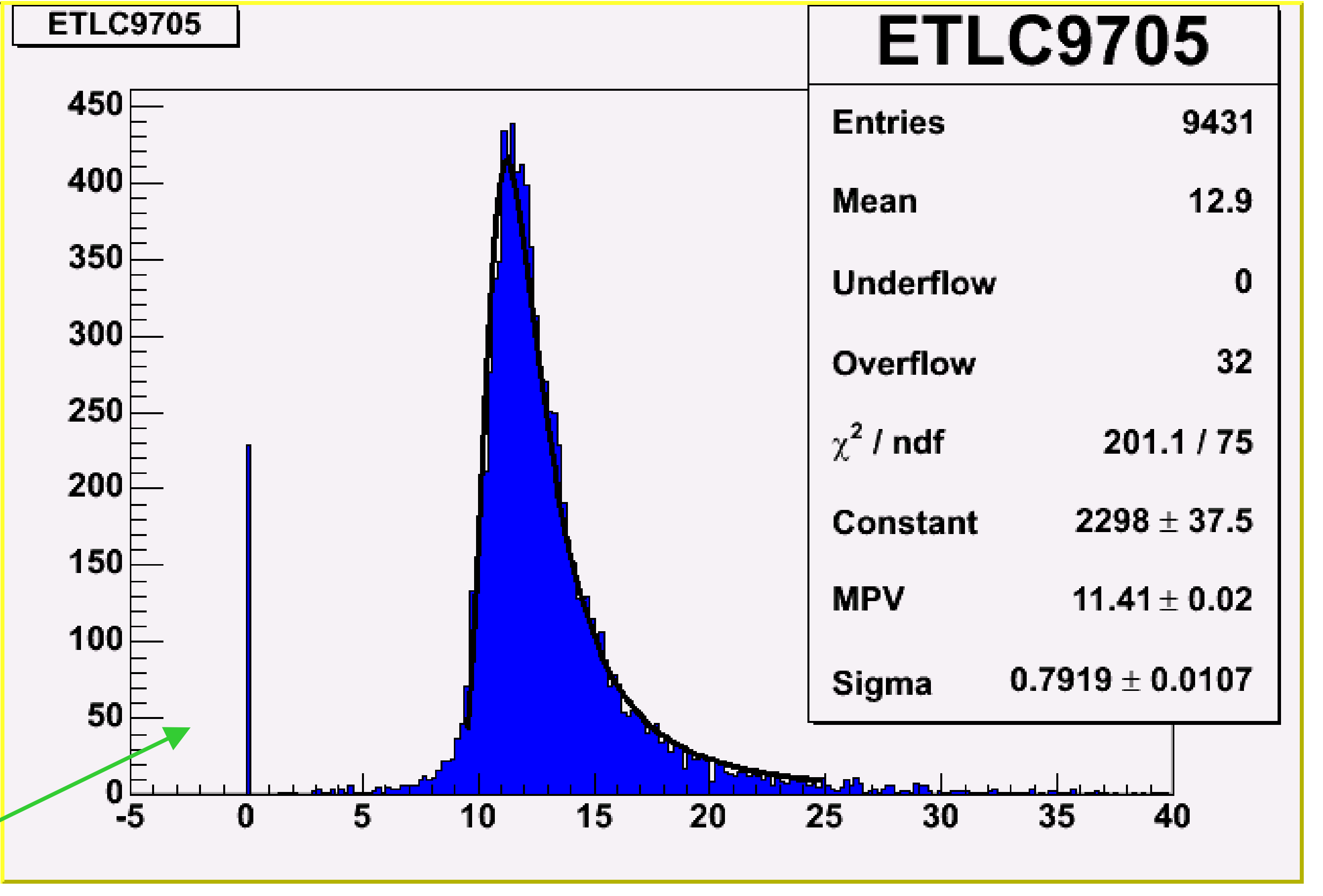
Gets marginal beyond 70 degrees off axis.

A typical crystal: tower 9 Layer 7 Column 5

0.79/11.4 = 7%, for sigma of landau

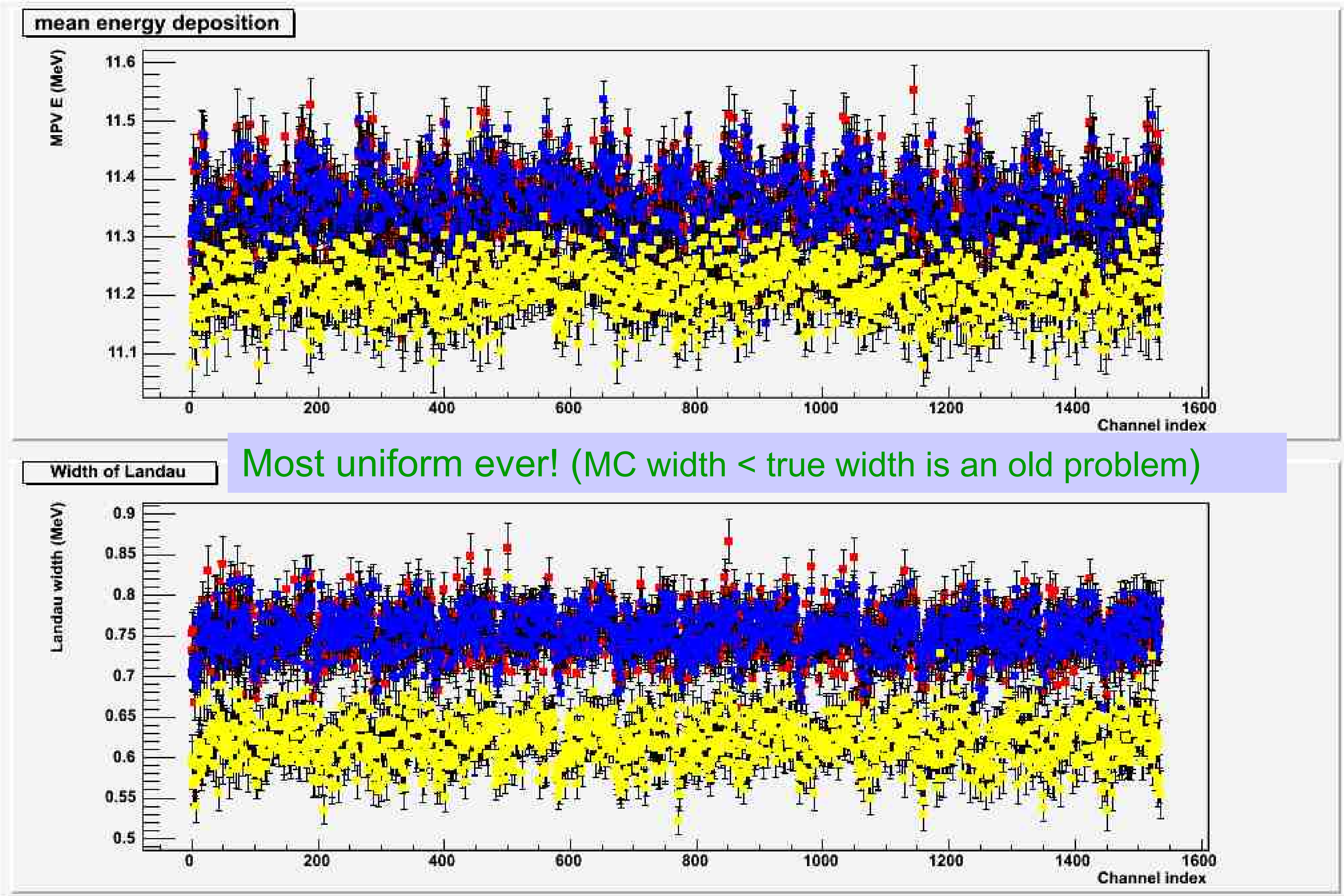
σ ~ rms ~ fwhm/2.36
= .45/2.36 = 0.19

0.19/11.4 = 1.7%



Spike contains ~230/9431 = 2.5%, which is roughly the inter-crystal gap (thickness of the carbon fiber wall…)

Energy deposit vs crystal index



Most uniform ever! (MC width < true width is an old problem)

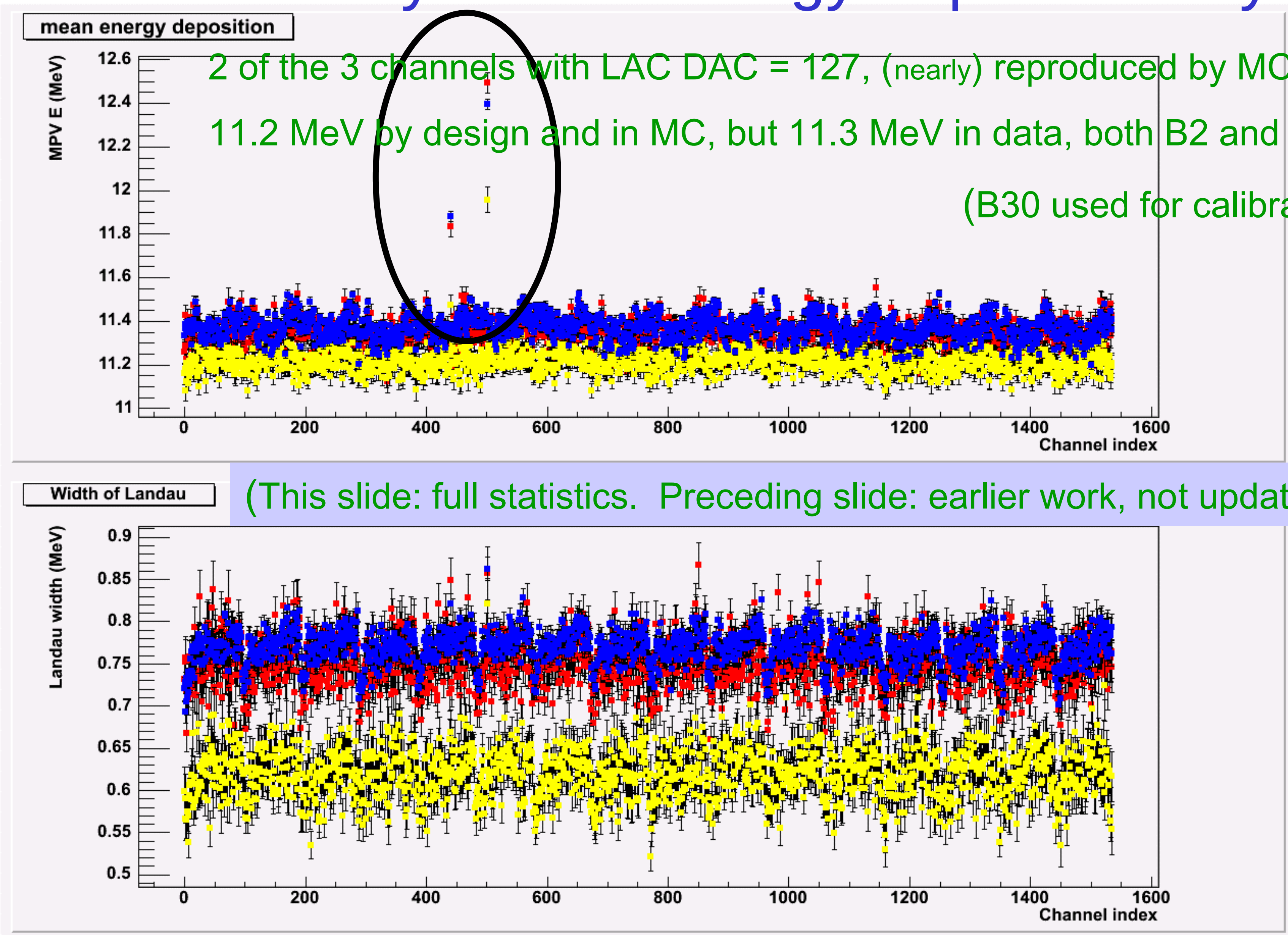
Un-zoom y-axis of energy deposit vs crystal

2 of the 3 channels with LAC DAC = 127, (nearly) reproduced by MC.

11.2 MeV by design and in MC, but 11.3 MeV in data, both B2 and B30.

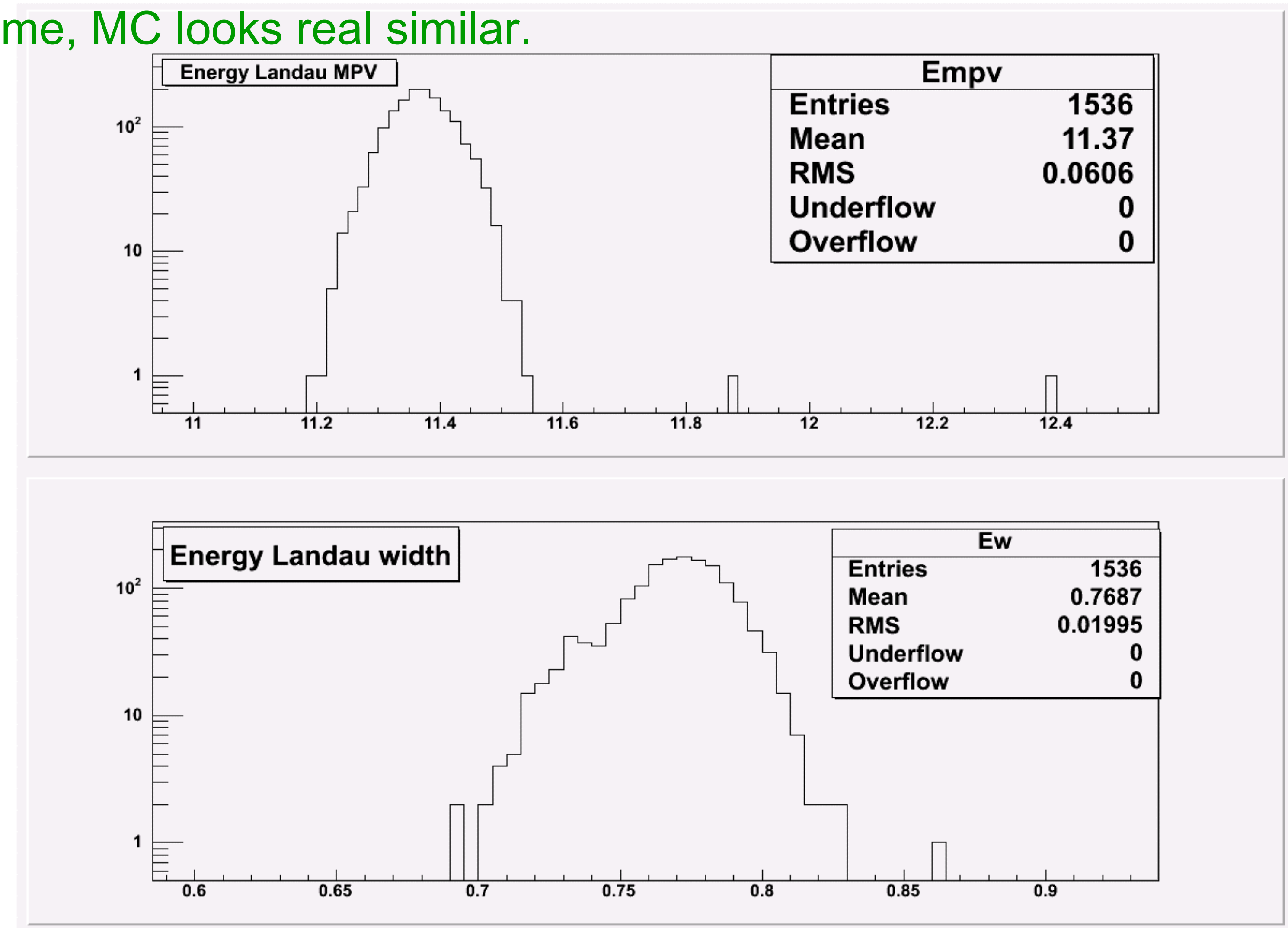
(B30 used for calibration.)

(This slide: full statistics. Preceding slide: earlier work, not updated.)



Energy deposit histograms

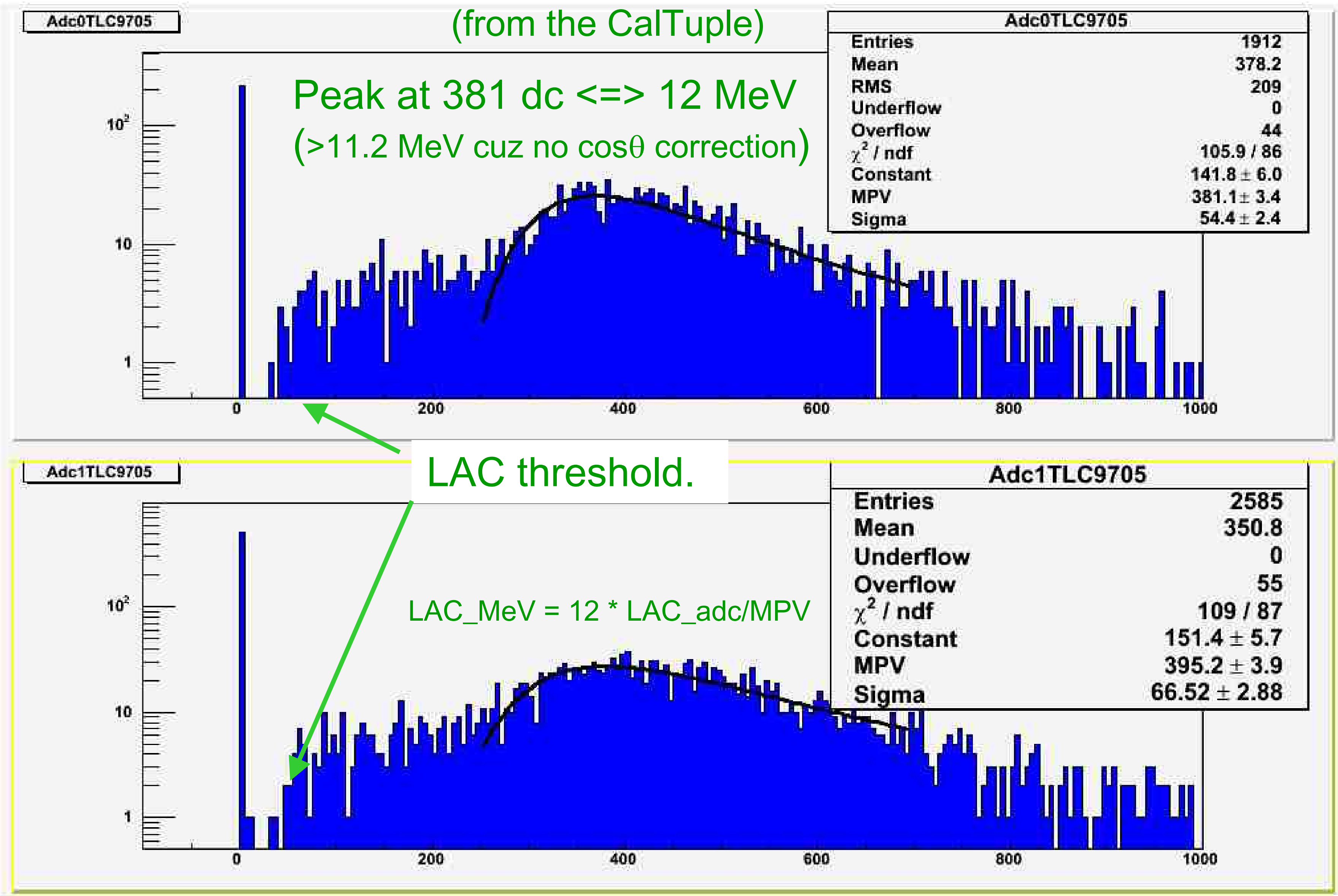
Here, all B2 runs, with "muon" track hypothesis.
B30 looks same, MC looks real similar.



LAC = Log Accept (for zero suppresion)

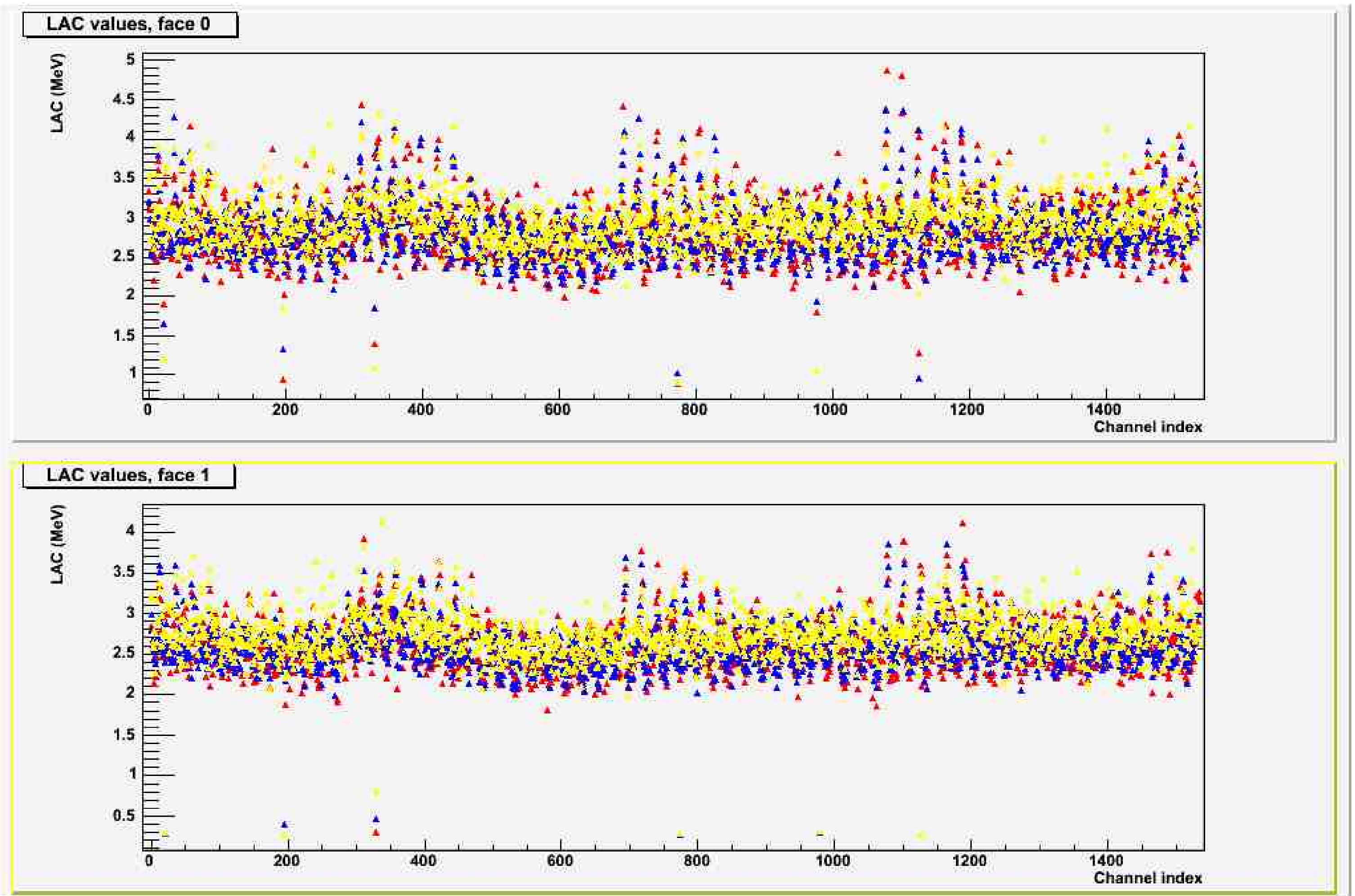
- Each crystal end has a discriminator, to decide whether there's a signal worth reading out. The discriminator threshold is set using the "LAC DAC".
  - if it's too low, event size becomes unnecessarily large, leading to acquisition deadtime issues.
  - If it's too high, you can miss teeny energy deposits that help with background rejection.
  - We're aiming for the 1 or 2 MeV range.
- Here, look at the end of the analysis chain to check that the settings come out okay

Single diode pedestal-subtracted ADC counts



Observed LAC thresholds for all channels

- Find the LAC turn on, in ADC counts, crystal-by-crystal.
- Tuning in progress -- presently what I find is (maybe) 2x too high.



IA, CERN testbeams and DC2

- In IA we've looked at mostly muons, at the micro micro level
- Beginning Wednesday, we hope to look at gammas at the macro macro level (*like, the Universe, man!*)
- How to transition? Real gamma rays coming this summer… simulated CERN gamma rays on disk… opportunity to learn how the DC2 "photon lists" get filled.

Conclusions

- < 30 cm MIP centroid requirement 5.5.5 is satisfied.
- $<15^o \cos^2\theta$ PSF for μ's requirement 5.5.6 is satisfied.
- LAC settings (zero suppression) are 1 or 2 MeV. A few warm and cool channels are being taken care of.