Recent developments at NIU

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for the NICADD / NIU group

AHcal phone meeting
April 18, 2007

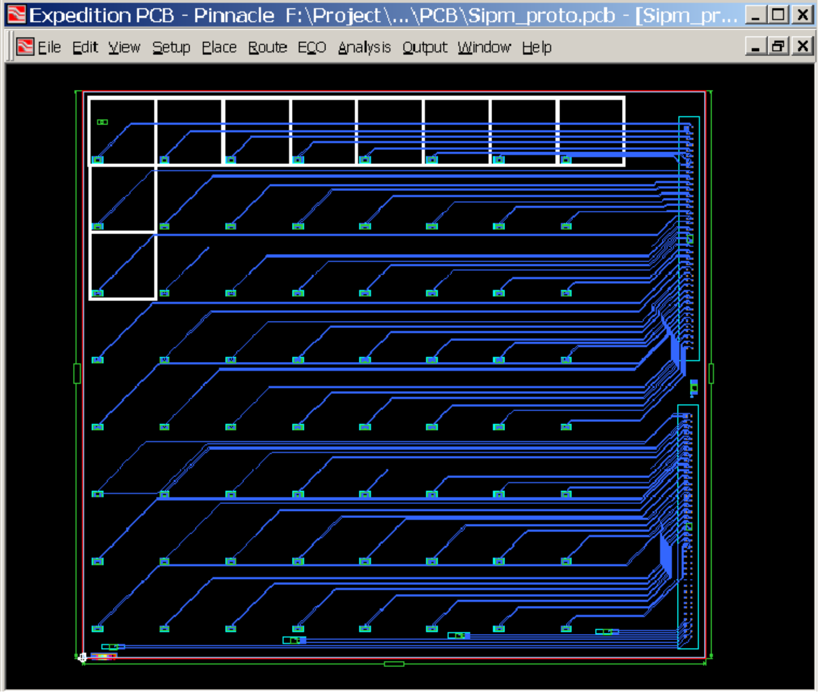
Outline

- Recent SiD workshop at Fermilab, on April 9-11, where we presented some preliminary Calice data analysis (two talks on Monday, April 9)
- Summary of our presentations at the SiD workshop:
  - Victor: direct coupling: cosmics tests and uniformity scans
  - Kurt: Tcmt stability for pedestals and gains
  - Guilherme: MC comparisons and combined analysis
- Full talks available from the workshop web site: http://ilc.fnal.gov/detector/rd/sid/sid07.htm

Direct coupling: premises

- **Fiberless readout is part of R&D to optimize the final design. WLS fiber readout has been extensively investigated**
- **Possibility of integration (Sensor-PCB-ASIC)**
- **Availability of SSPMs optimized for green light**

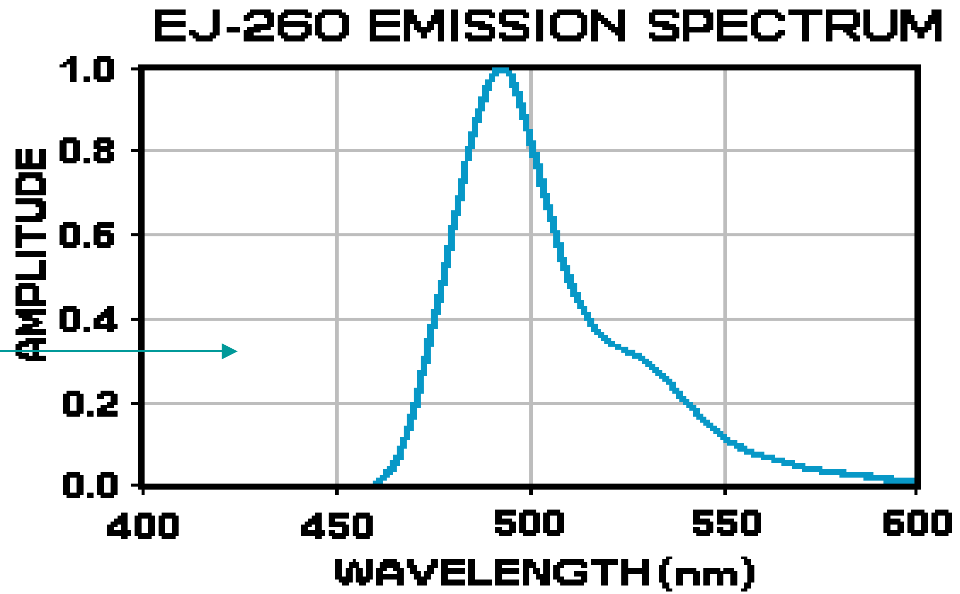
$1x1mm^2$ or $2x2\ mm^2$ from CPTA, Moscow

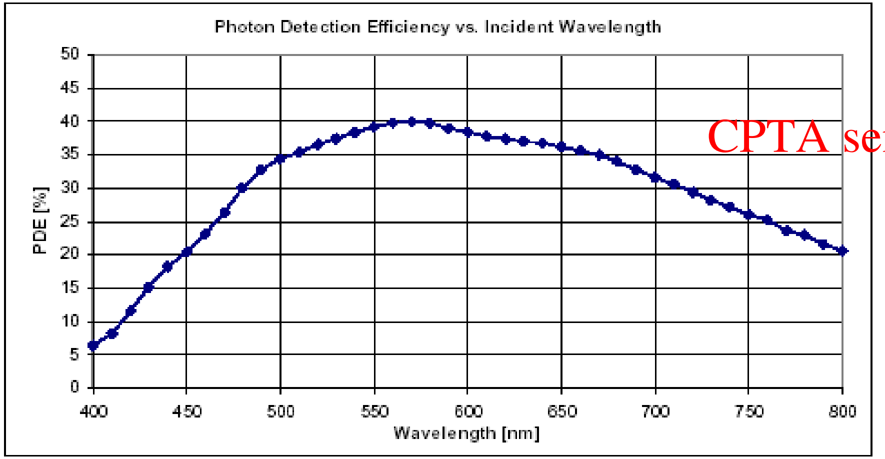


Scintillator and photo-sensors

We used 3*3 cm^2 green emission scintillator, wrapped in VM2000, 6.2 mm in thickness, edges cut, not polished, painted in white.

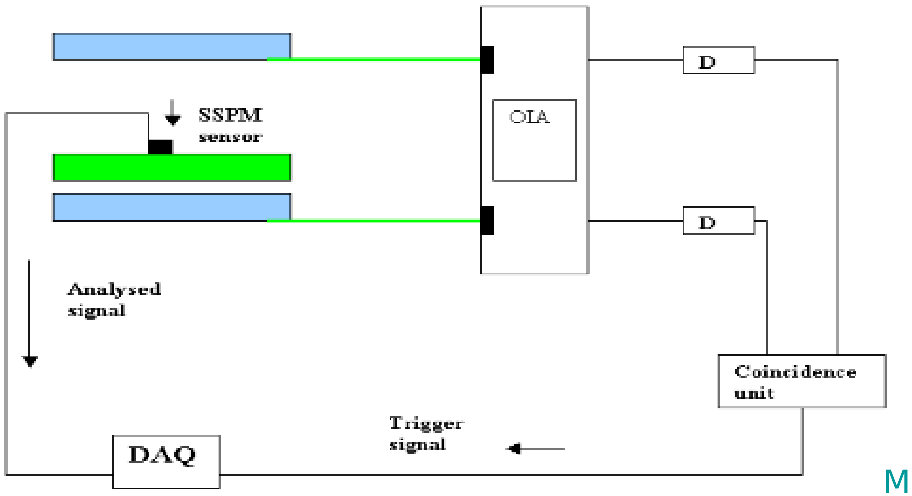
Light output (% anthracene)	60%
Wavelength max emission (nm)	490
Scintillation eff. (photons/1 MeV e-)	9200
# H atoms (10^22/cm^3)	5.21
# C atoms (10^22/cm^3)	4.70
# elecs (10^23/cm^3)	3.35
Density (g/cm^3)	1.02



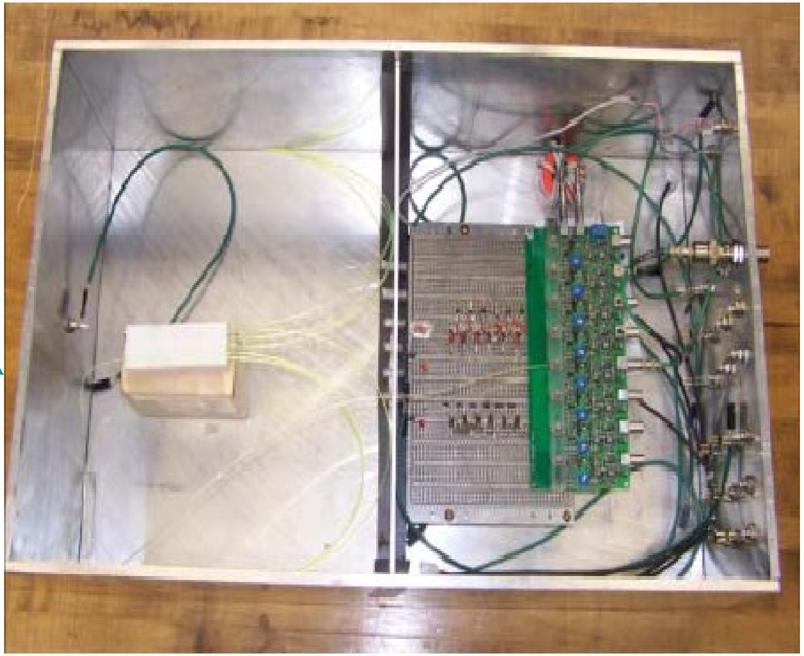


CPTA sensor

Cosmics test setup



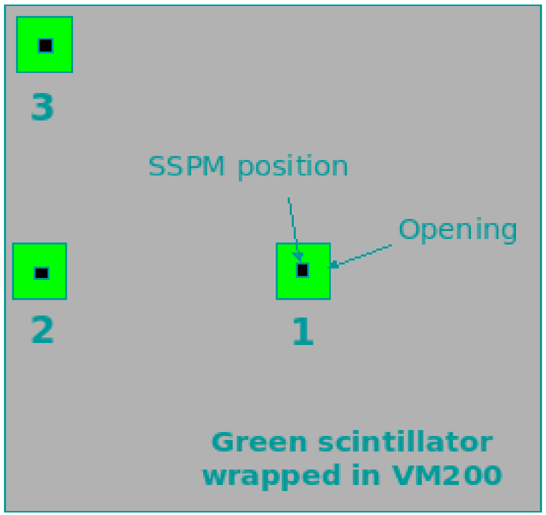
Magic
box

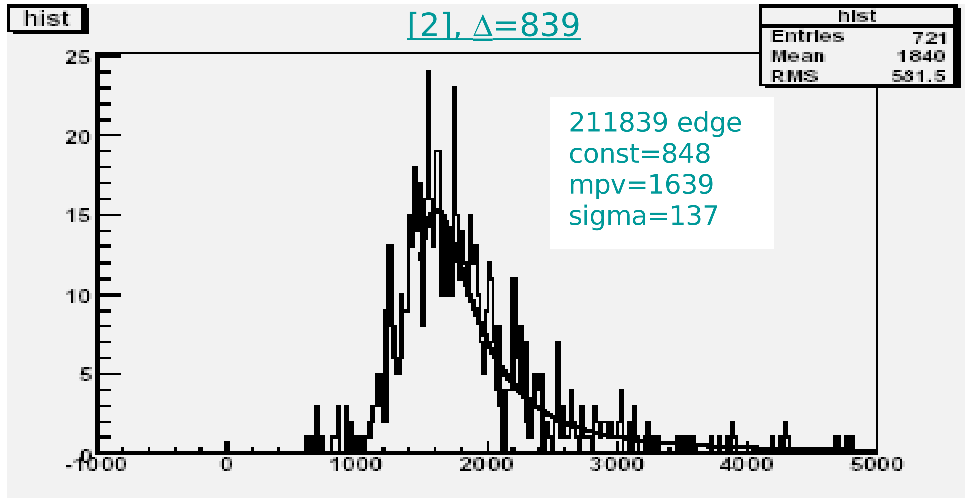


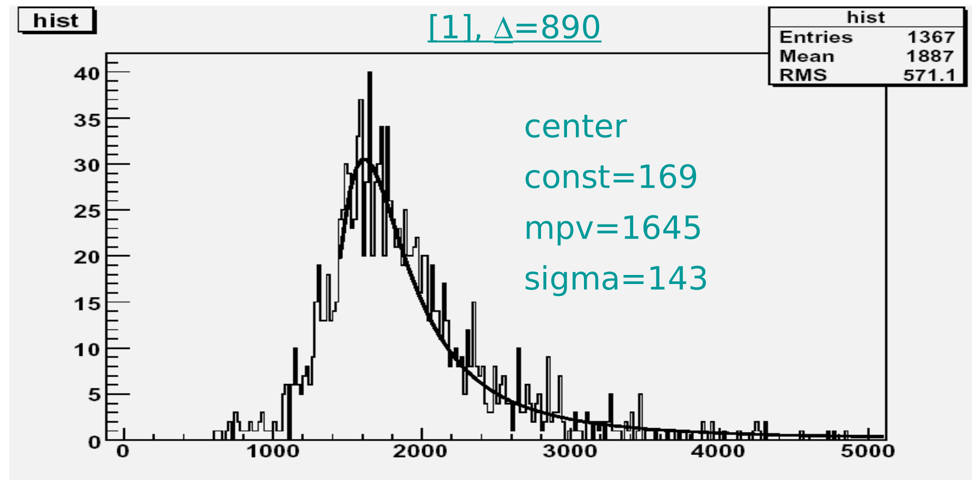
Noise rate at single counter ~ 150 Hz,

Threshold ~5 PE

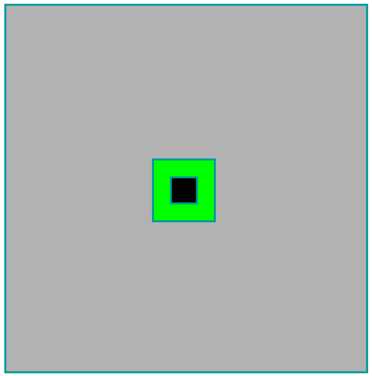
Amplitudes measured for different positions

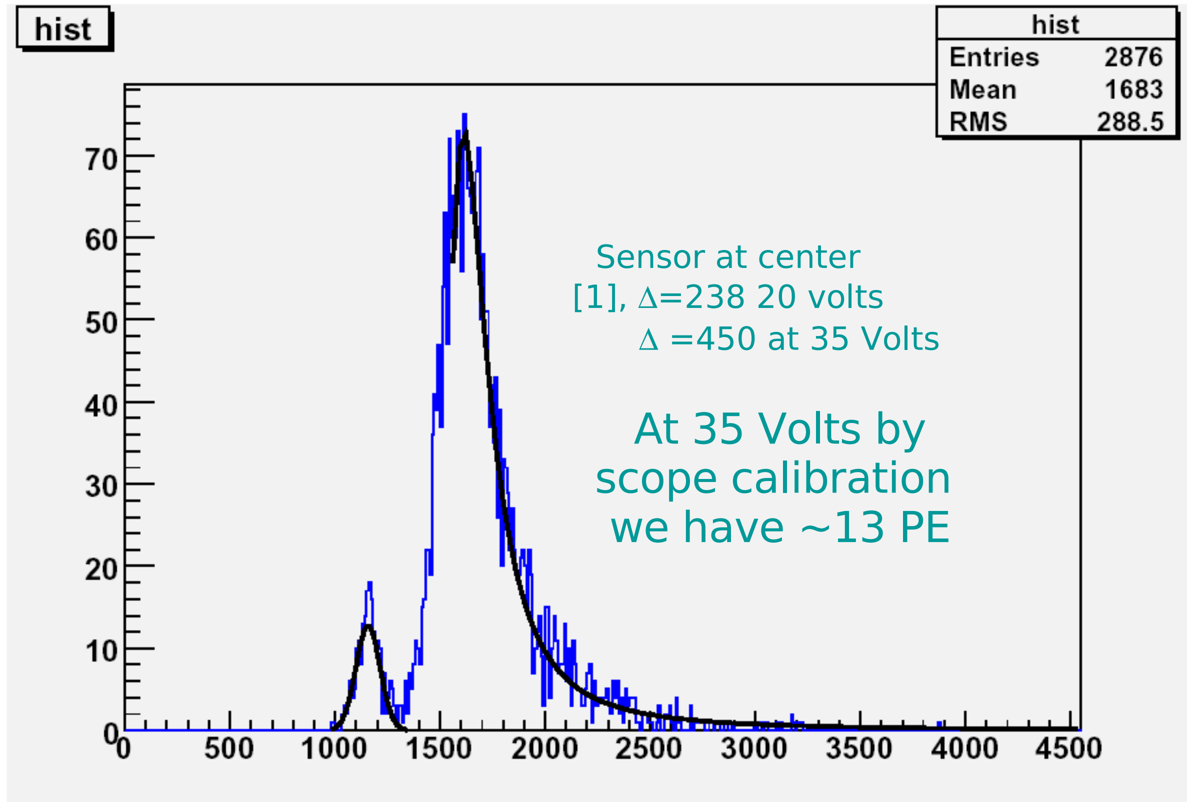






CPTA 2*2 mm^2 sensor in cosmics test





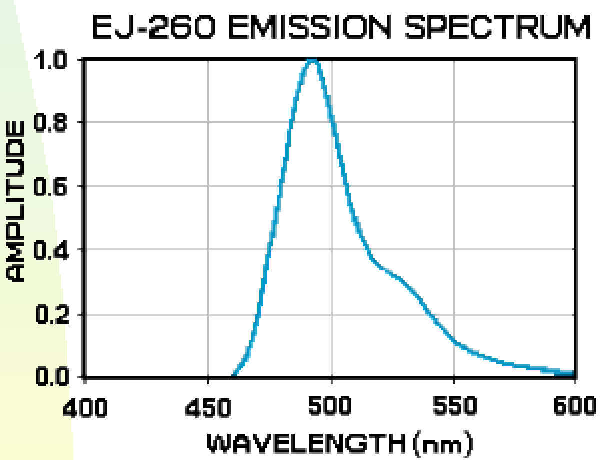
HAMAMATSU

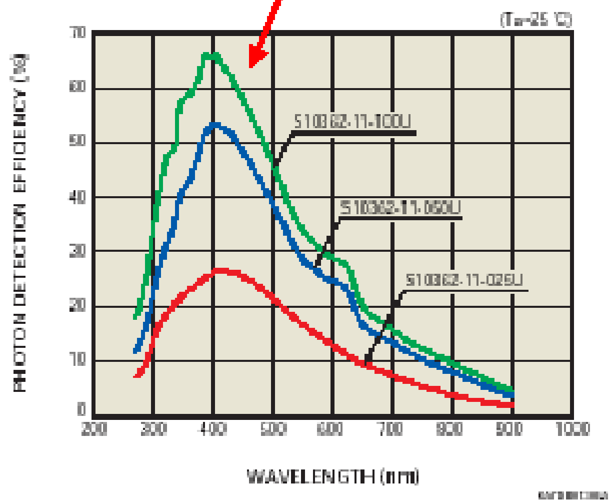
- 100 pixels
- 100X100 µm
- 78% - fill factor
- PDE~50%
- Gain~2.4*10^6

Specifications (Ta=25 °C)

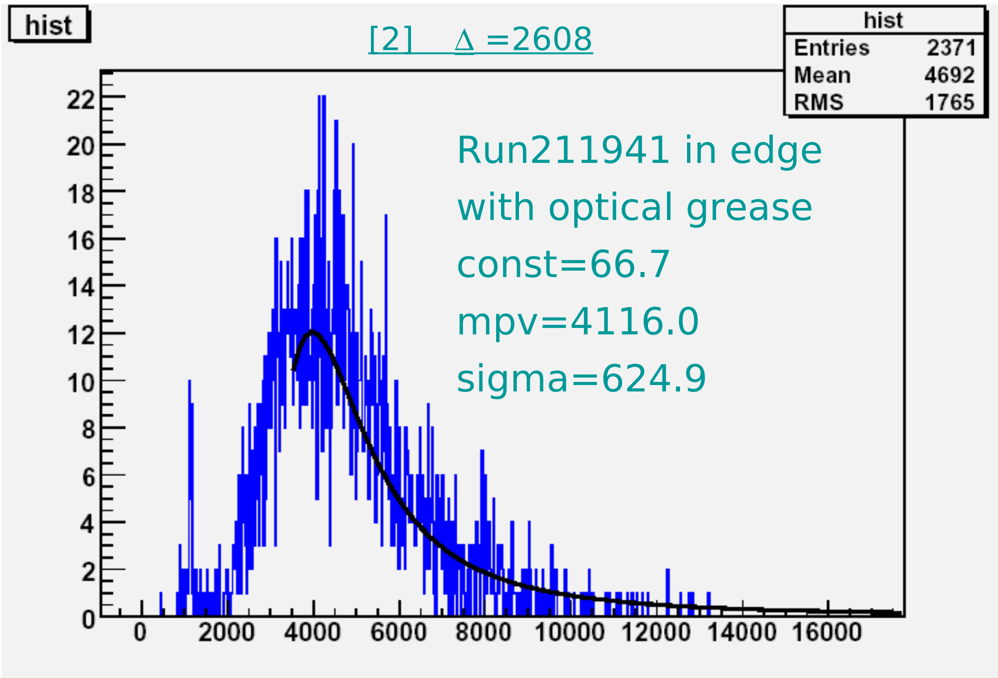
Parameter	Symbol	S10362-11 series			Unit
		-025U, -025C	-050U, -050C	-100U, -100C	
Chip size	-	1.5 x 1.5			mm
Effective active area	-	1 x 1			mm
Number of pixels	-	1600	400	100	-
Pixel size	-	25 x 25	50 x 50	100 x 100	µm
Fill factor *1	-	30.8	61.5	78.5	%
Spectral response range	λ	270 to 900			nm
Peak sensitivity wavelength	λp	400			nm
Quantum efficiency (λ=λp)	QE	70 Min.			%
Photon detection efficiency *2 (λ=λp)	PDE	25	50	65	%
Operating voltage	-	77 ± 10	70 ± 10	70 ± 10	V
Dark count	-	100	270	400	kcps
Terminal capacitance	Ct	35			pF
Time resolution (FWHM)	-	250	220	250	ps
Temperature coefficient of reverse bias	-	50			mV/°C
Gain	M	2.75 x 10^5	7.5 x 10^5	2.4 x 10^6	-

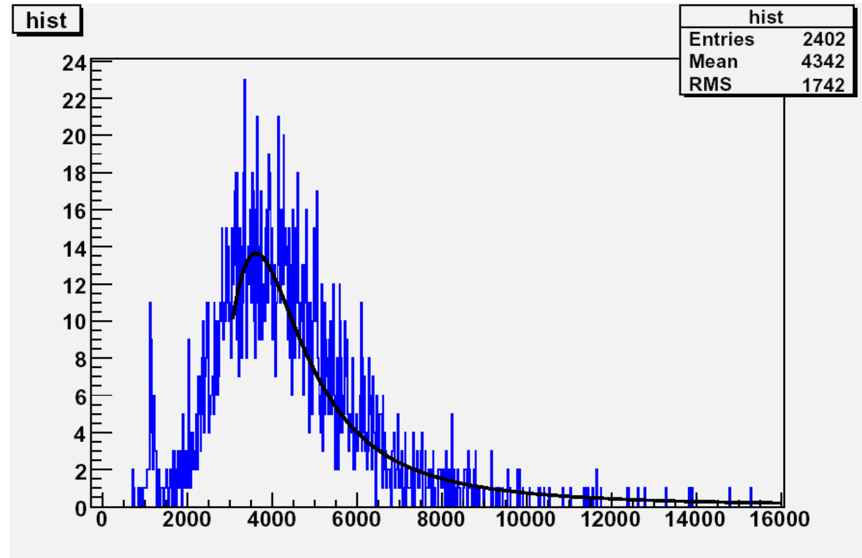
*1: Ratio of the active area of a pixel to the entire area of the pixel.
*2: Photon detection efficiency includes crosstalk and afterpulses.
Note: The last letter of each type number indicates package materials (U: metal, C: ceramic).

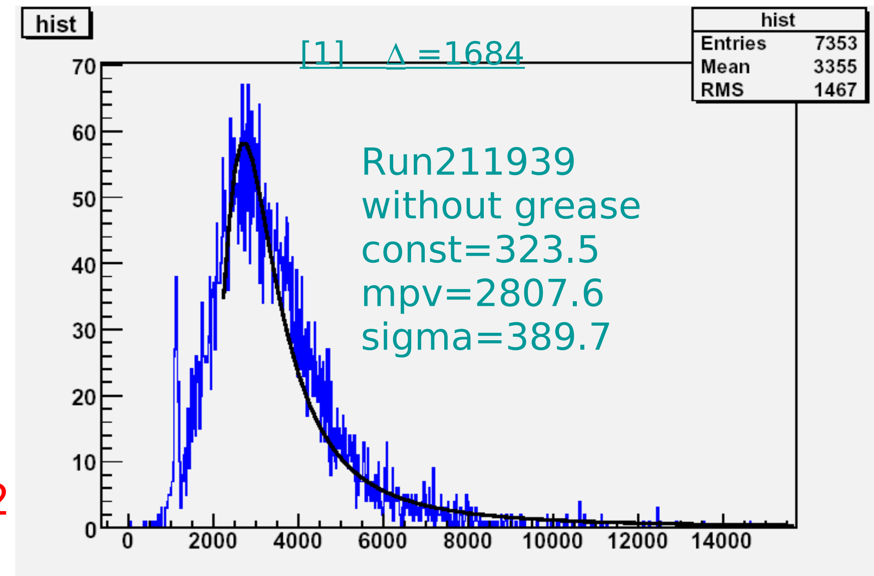




Hamamatsu sensor, signal from cosmics



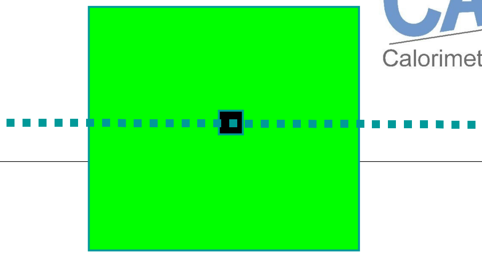




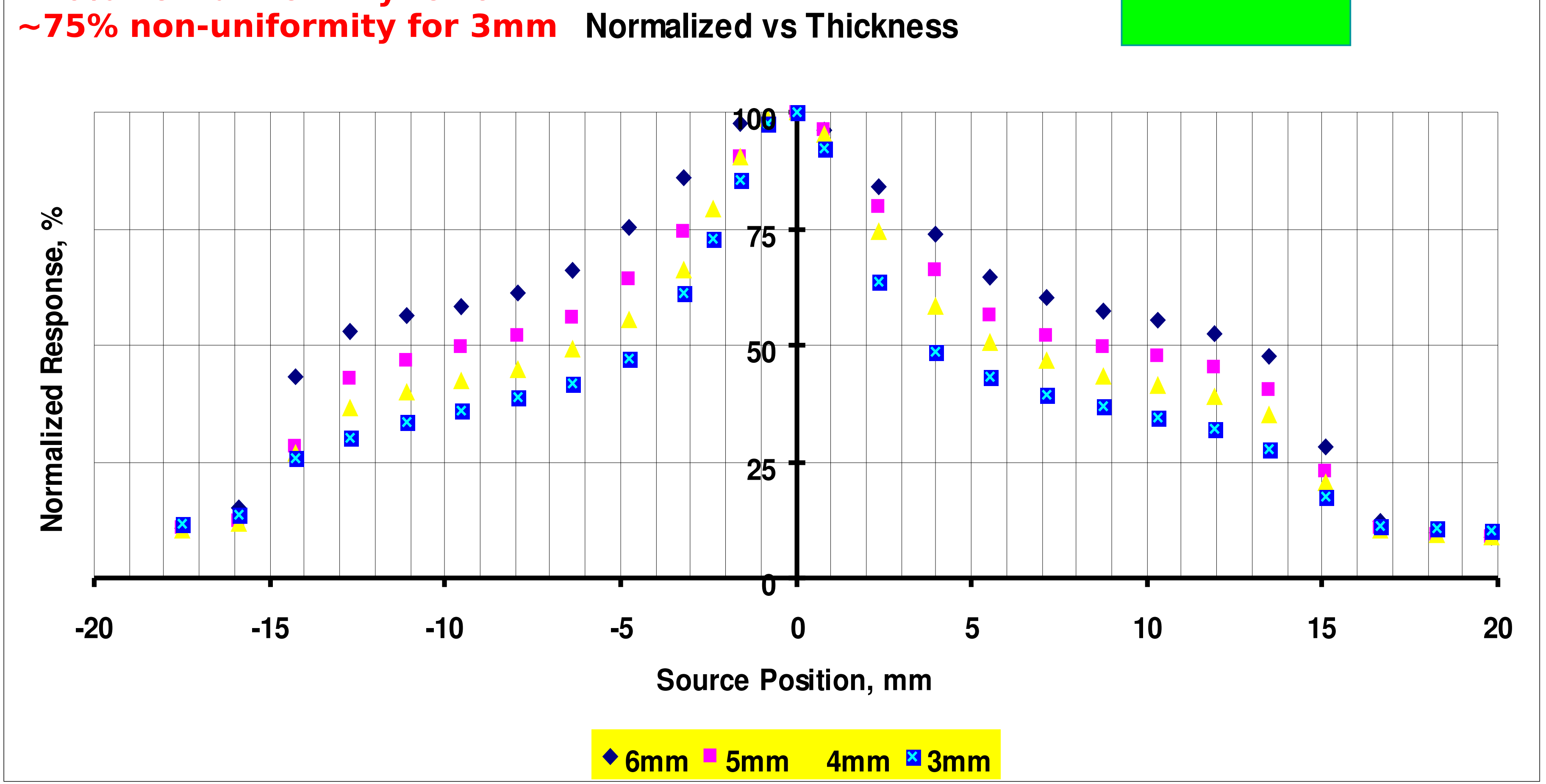
PDE at 500 nm ~ 45% --> (19.3 ± 3.0) PE

GREASE / NO GREASE = 1.5 ± 0.2

Comparative scan test



Thickness dependence
~40% non–uniformity for 6mm
~75% non-uniformity for 3mm



Direct coupling: summary

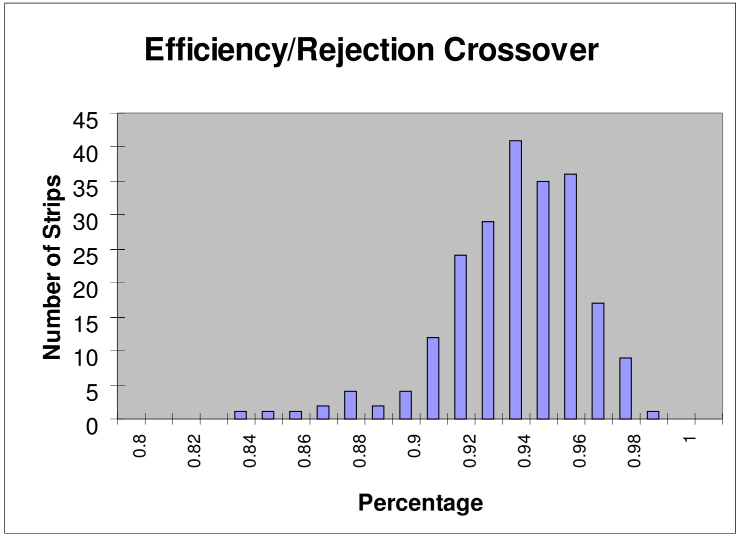
- Direct scintillator-sensor coupling looks promising
  - ~19 PE for the 100-pixels Hamamatsu sensor
- Uniformity scans show ~40% non-uniformity from center to edge for 6 mm thick green scintillator
  - Non-uniformity increases for decreasing thickness
- Optical coupling (with or without grease) still open for optimization
- More R&D is necessary

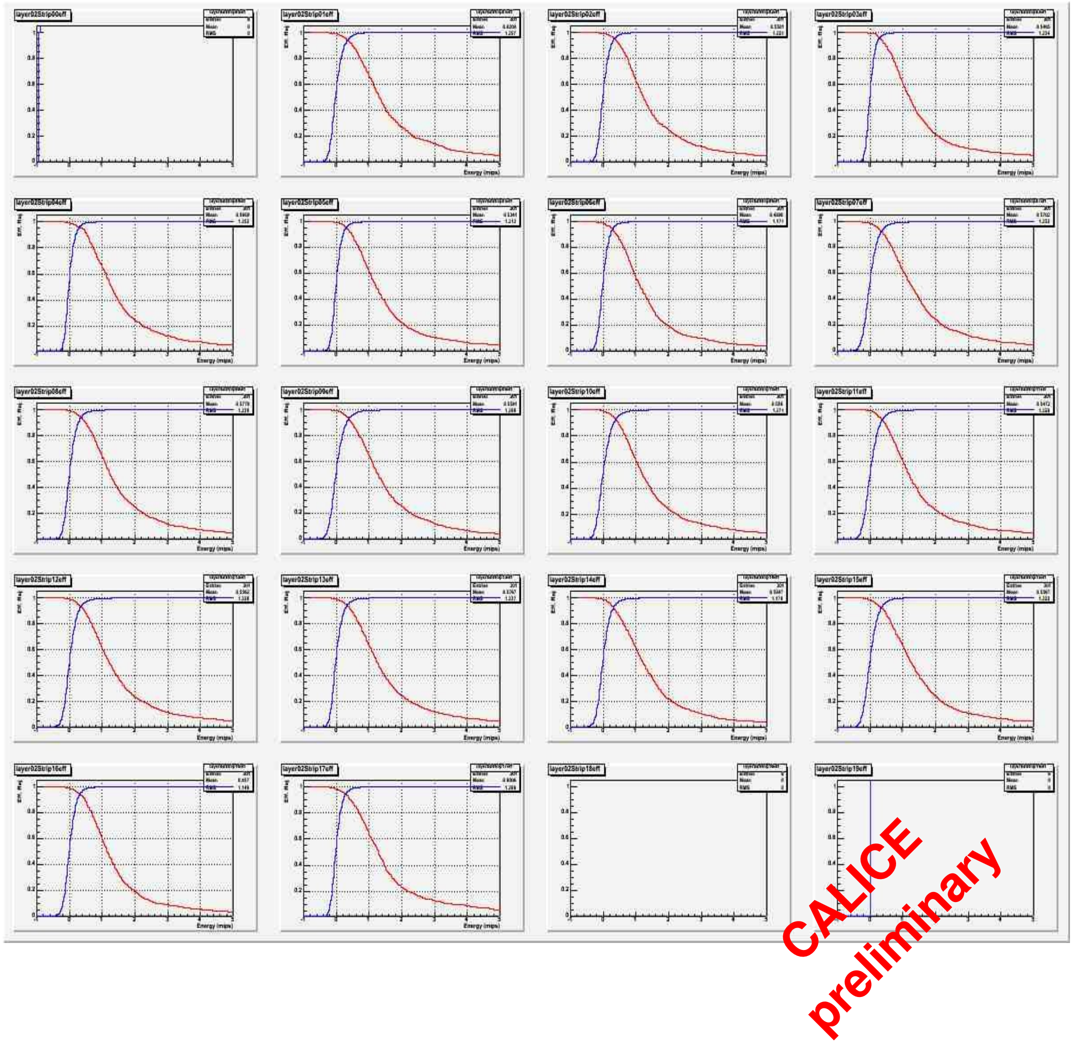
Tcmt stability studies (Kurt)

- Outline
  - Efficiency / rejection statistics
  - Gain statistics
  - Stability of pedestals
  - Stability of LED calibrations
- for more details, please look at Kurt's talk

Efficiency/Rejection Plots

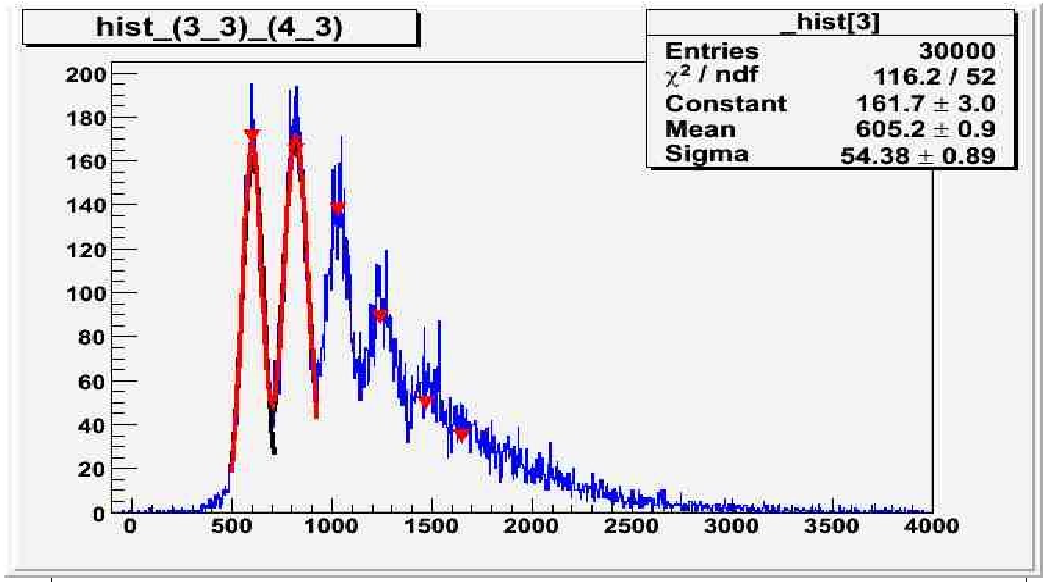
- Example: layer 2 →
- Efficiency in red, Rejection in blue
- Missing channels due to faulty sensor in parallel strips
- Average efficiency and rejection at crossover ~ 95%

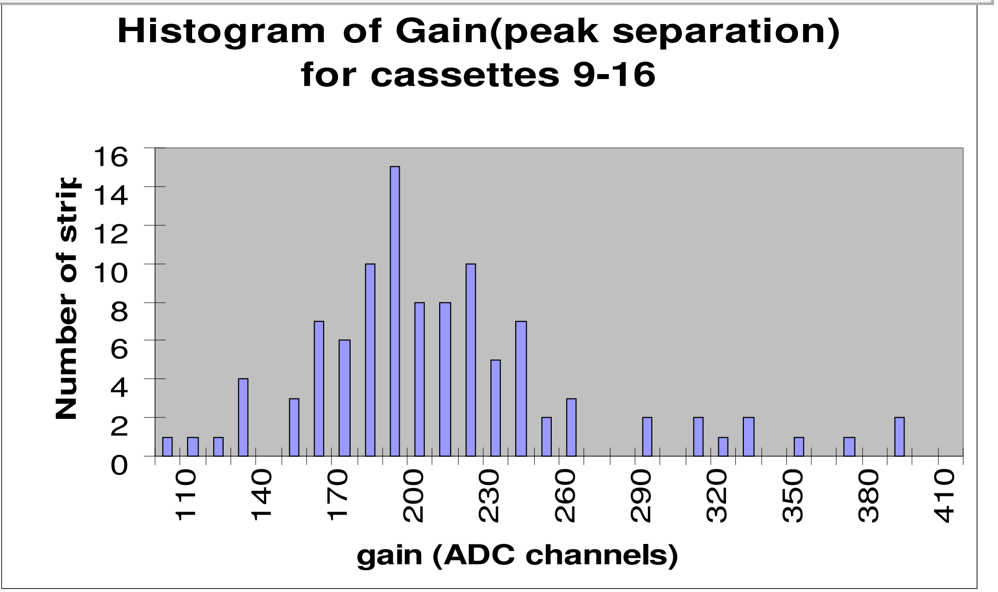




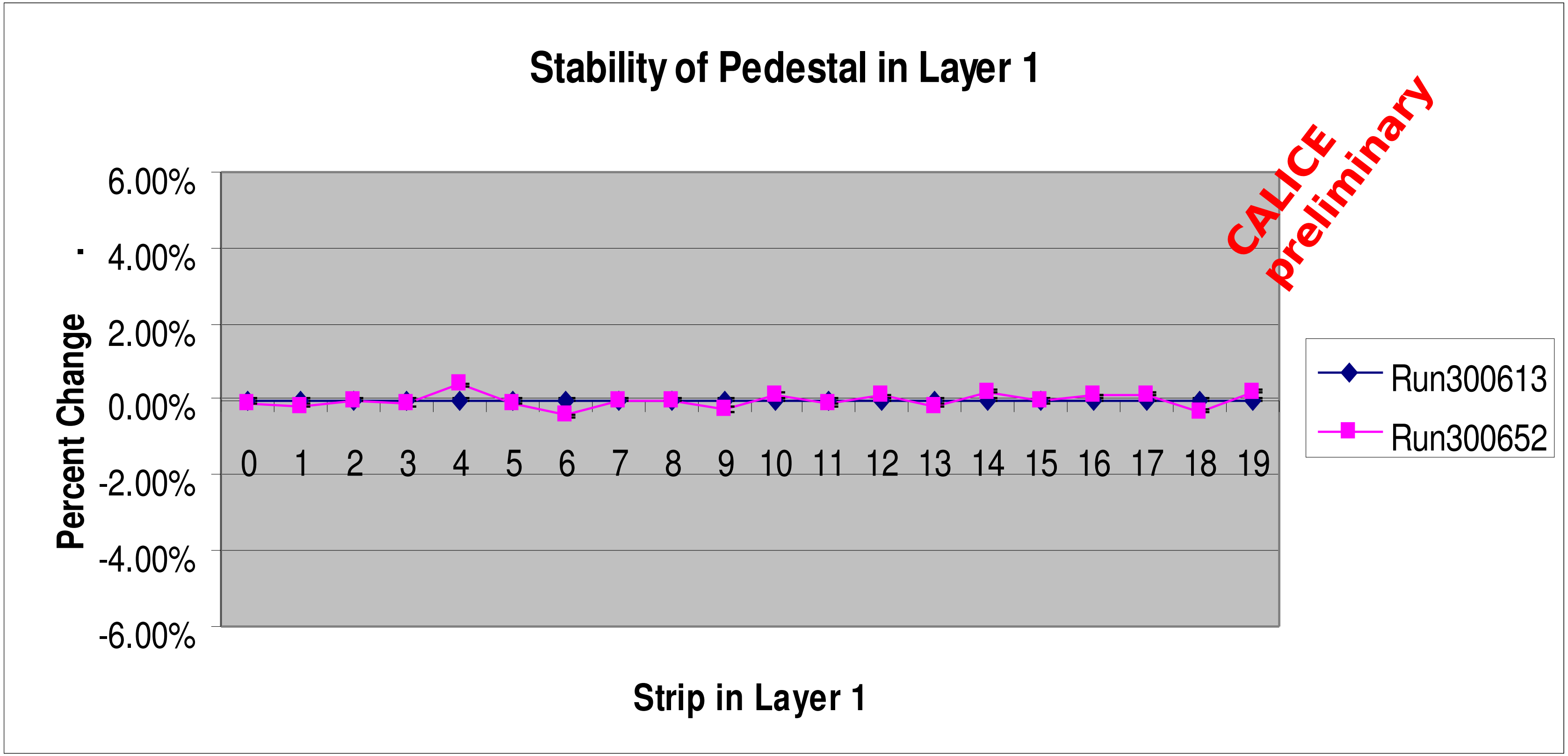
Gain measurements

- LED Calibration system:
  - Blue/UV LED for each strip
  - Amplitude controlled by DAQ software
  - Fine adjustments for each channel with TrimDAC
  - Low amplitude setting used to acquire S.P.E. spectra for each strip to calculate gain
  - High amplitude setting for mode to mode intercalibration measurements and long term stability studies
  - Note: DAQ systems operates in a high gain calib mode and a wider range physics mode (ratio of 7 to 12 times depending on ASIC)
- Automated software finds peaks in spectra and fits first two peaks to find gain in terms of ADC counts
- Average gain ~ 200 ADC counts / P.E.



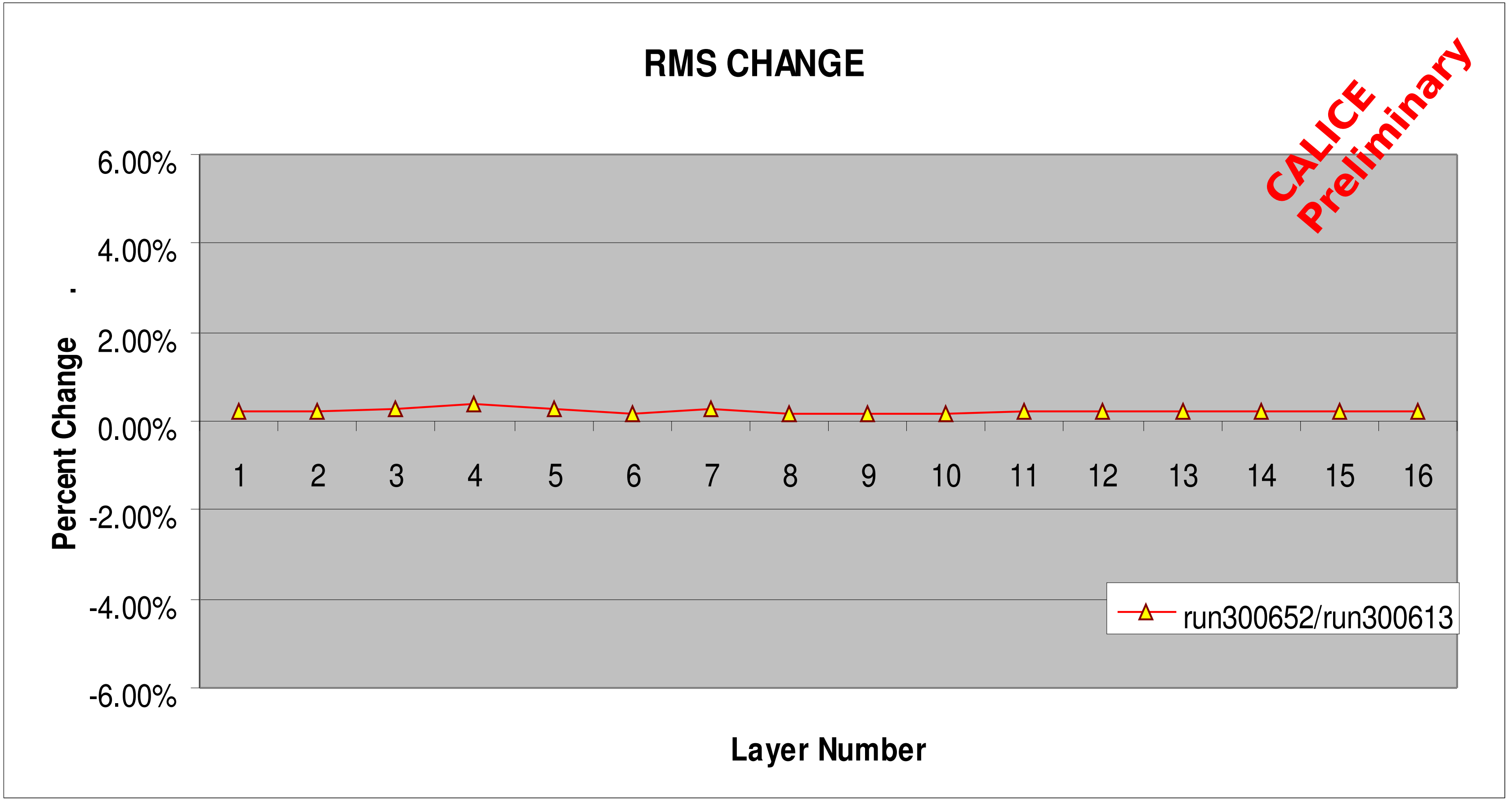


Pedestal Stability



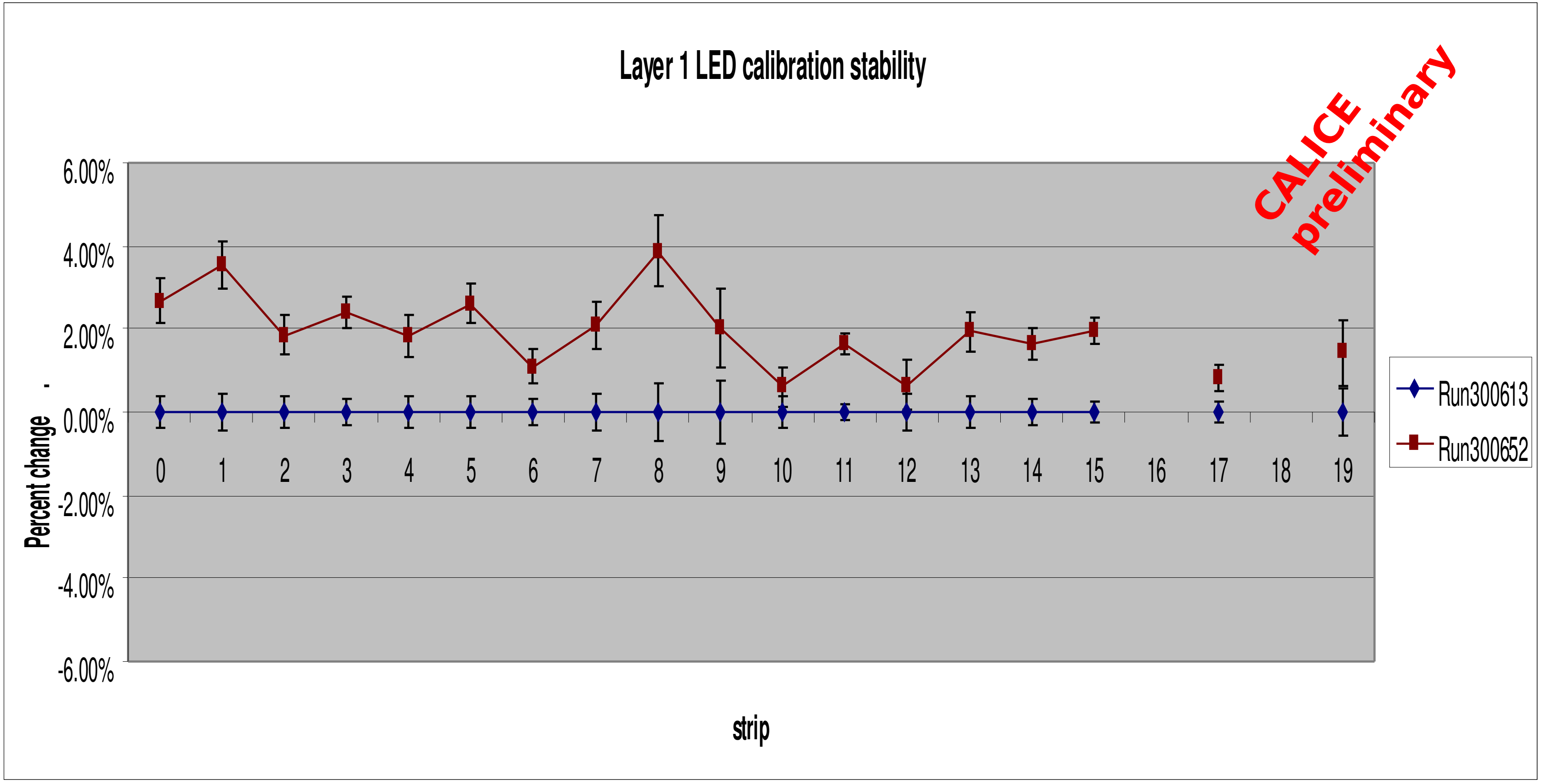
Example of 20 strips from one cassette.
Pedestal data taken from interspill events from each run.
Runs approximately 26 hours apart.

Pedestal Stability



Plots Standard deviation of all 20 strips in each layer
Average RMS change over 16 layers ~ .23%

LED Calibration Stability



Combined analysis: outline

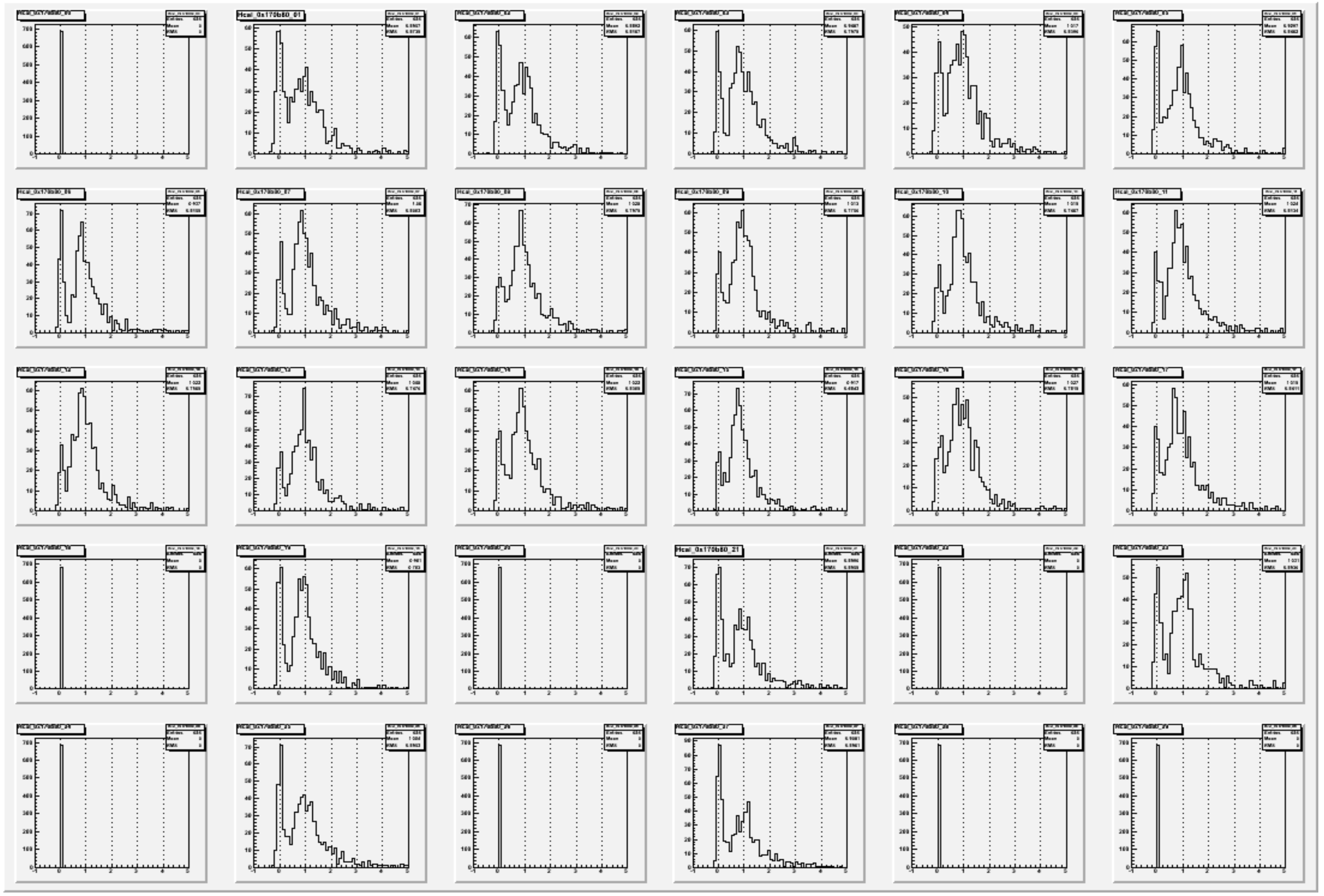
- Sanity checks:
  - Verify Ecal and Hcal calibrations
  - Hit selection and background rejection
  - Compare Monte Carlo vs. real data
- Present status:
  - Interesting results on energy resolution (Emc + Ahc + Tcmt) at several beam energies

Data processing chain

- Real data processing
  - Data: Niels' list of best hadron beam runs in October/06
    http://polywww.in2p3.fr:8081/CALICE/Members/watson/lcws07/runlist_Oktober.xls
  - LCIO-converted files from the grid: /grid/calice/tb-cern/raw/conv_v0402
- Monte Carlo processing:
  - Mokka (Geant4): version 06-03-p01 with TBCern1006_01 geometry model
  - Roman's Hcal ganging processor
  - DigiSim: energy threshold and MIP calibrations (E > 0.5 mip and E > 2sigma_ped)
- Output: calibrated hits, zero suppressed, global hit positions
- Data analysis: Marlin processors, root ntuples and scripts

Checking mip calibration in Hcal

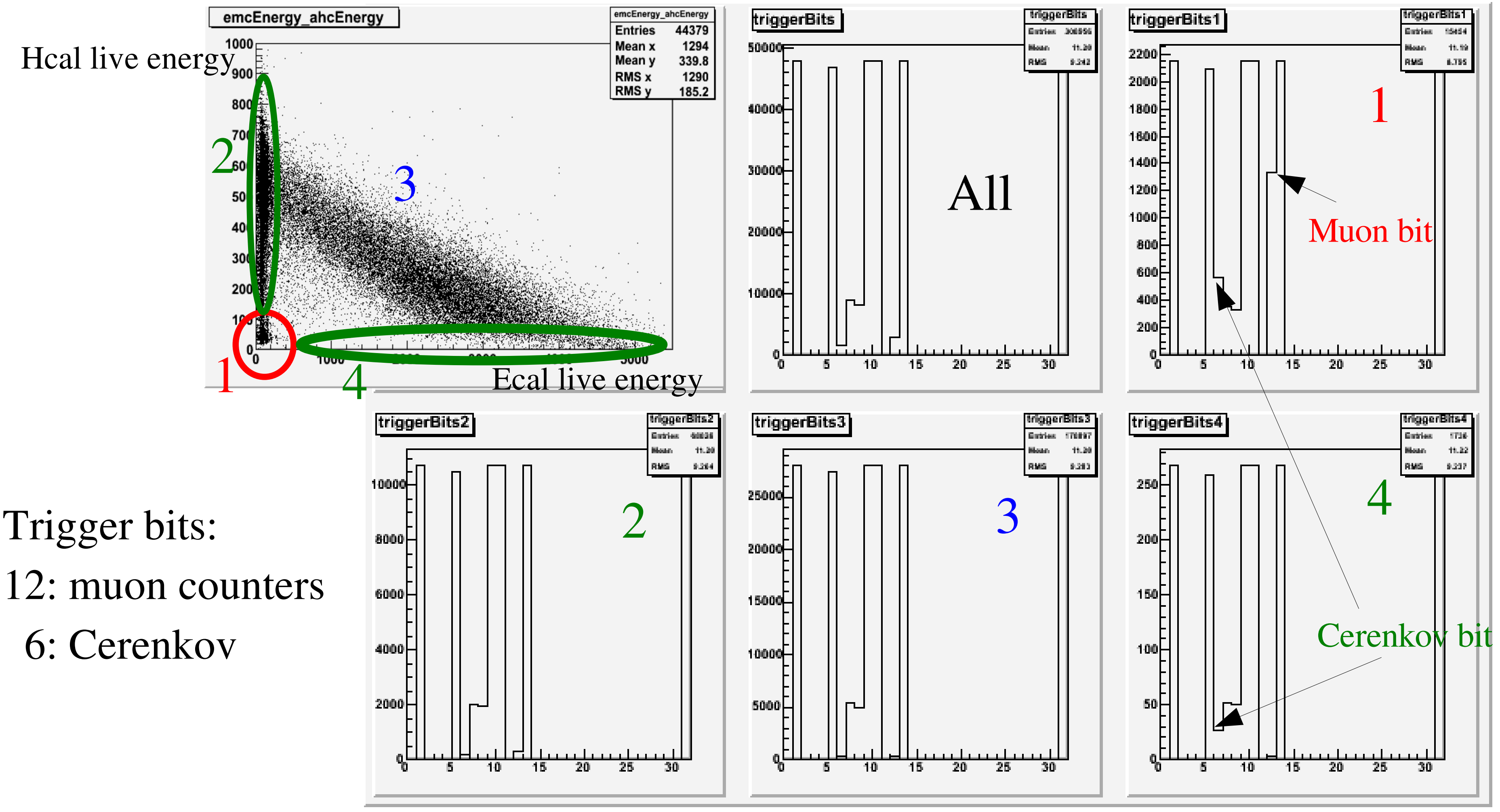
Use software triggering to select mip tracks (8 aligned hits), plot response of every cell.



Thanks to DESY group for Hcal calib work and for support to verify it (see plots)

ECAL also OK

Background rejection: muons in pion samples

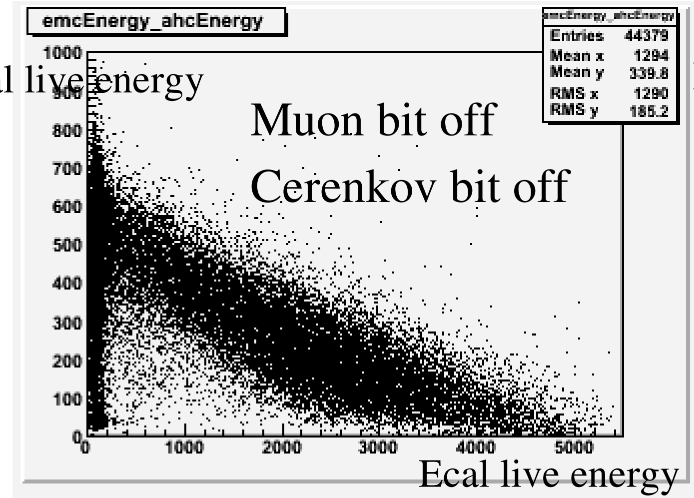


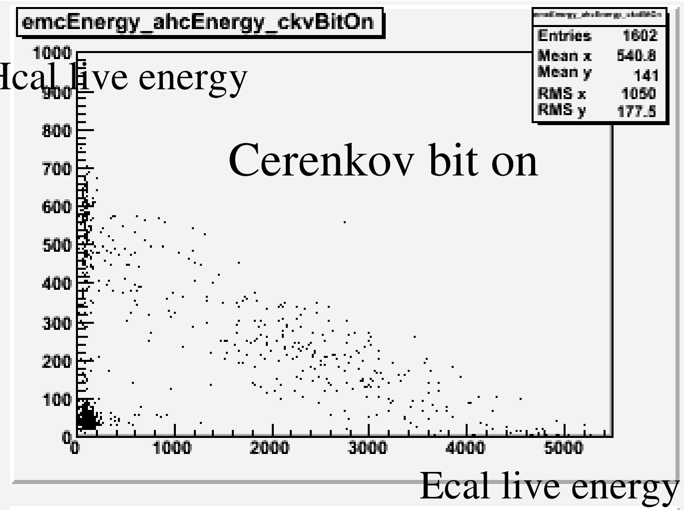
Trigger bits:

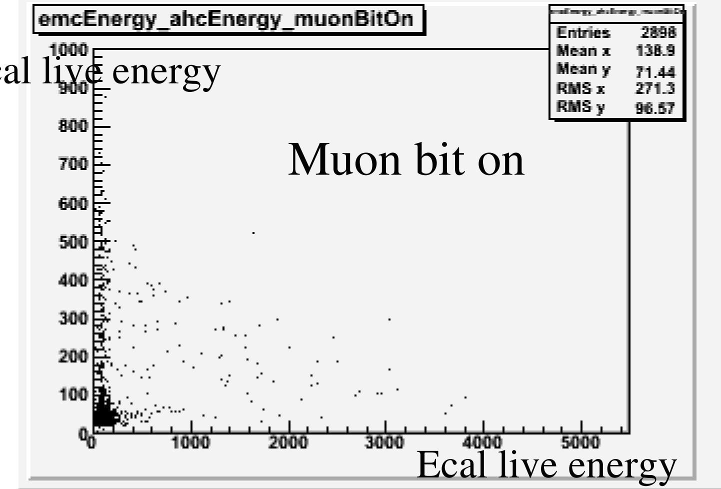
12: muon counters

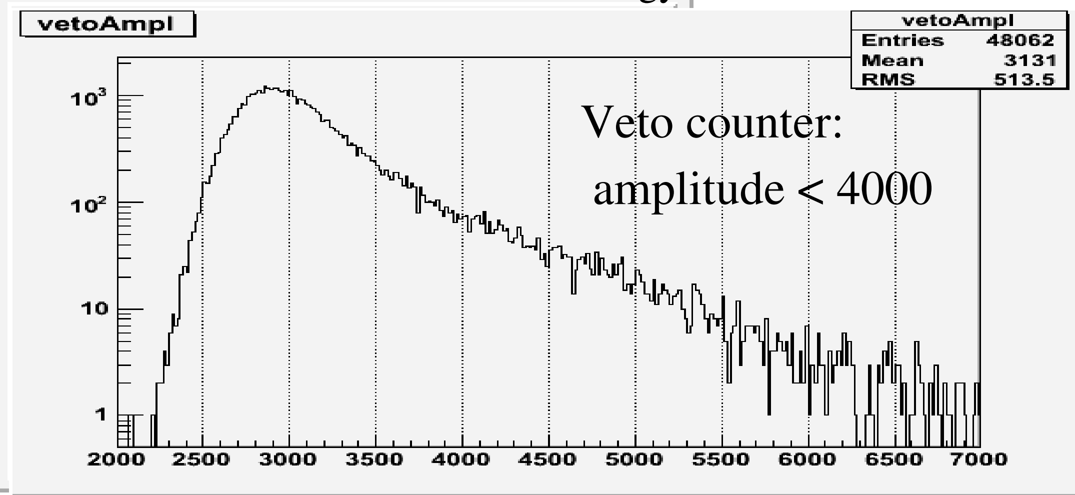
6: Cerenkov

Background rejection handles









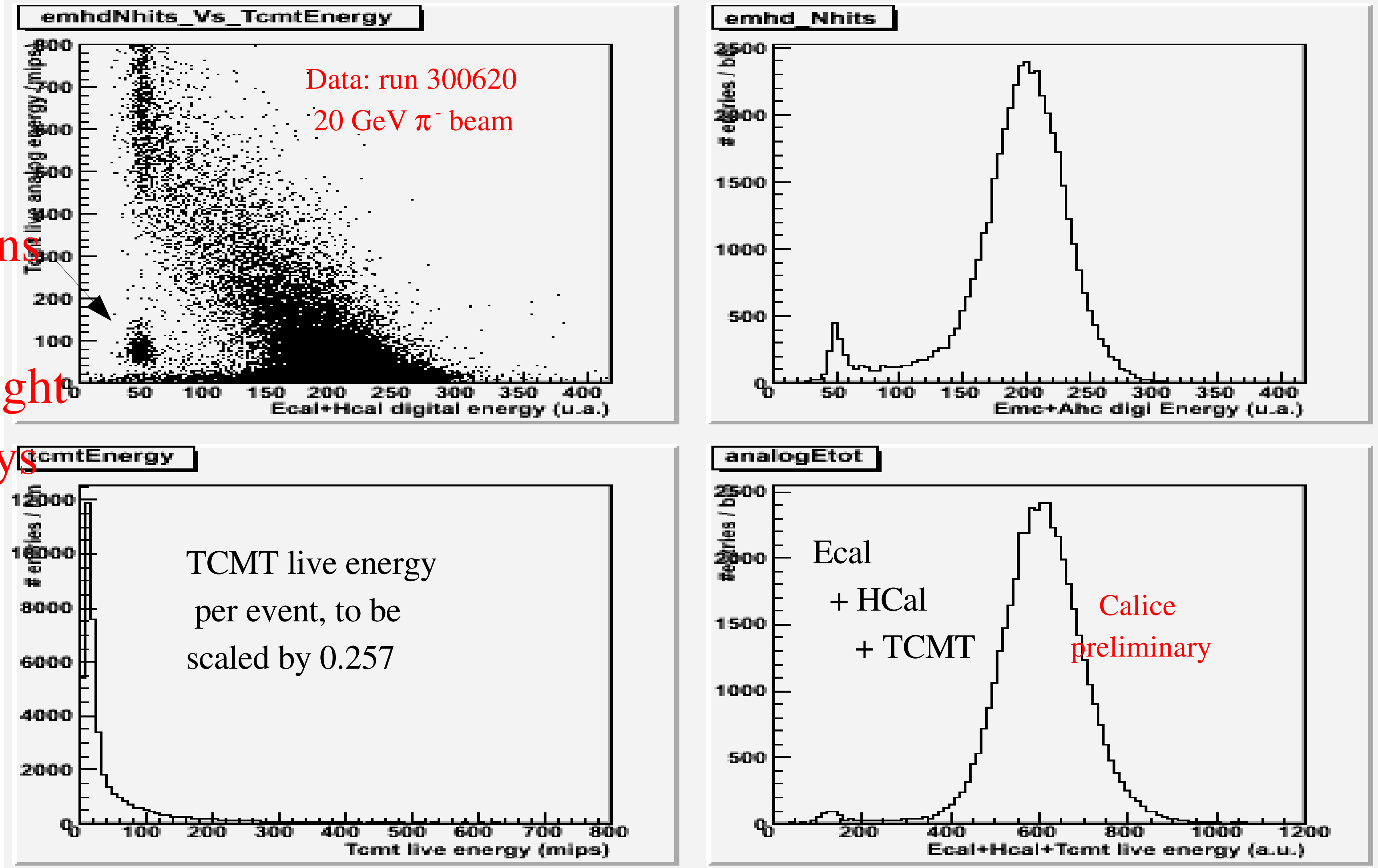
Energy correlations in a sample of 20 GeV π^-

- Energy combination accounts for relative intra-component absorber thicknesses (Rel.Abs.Th.) and for inter-component sampling fractions (ICF)
- SW_analog = (Rel.Abs.Thickness) * (ICF_analog) and similar for digital
- Simple-minded ICF factors: angular coefficient of a line representing the anti-correlation scatter-plots.

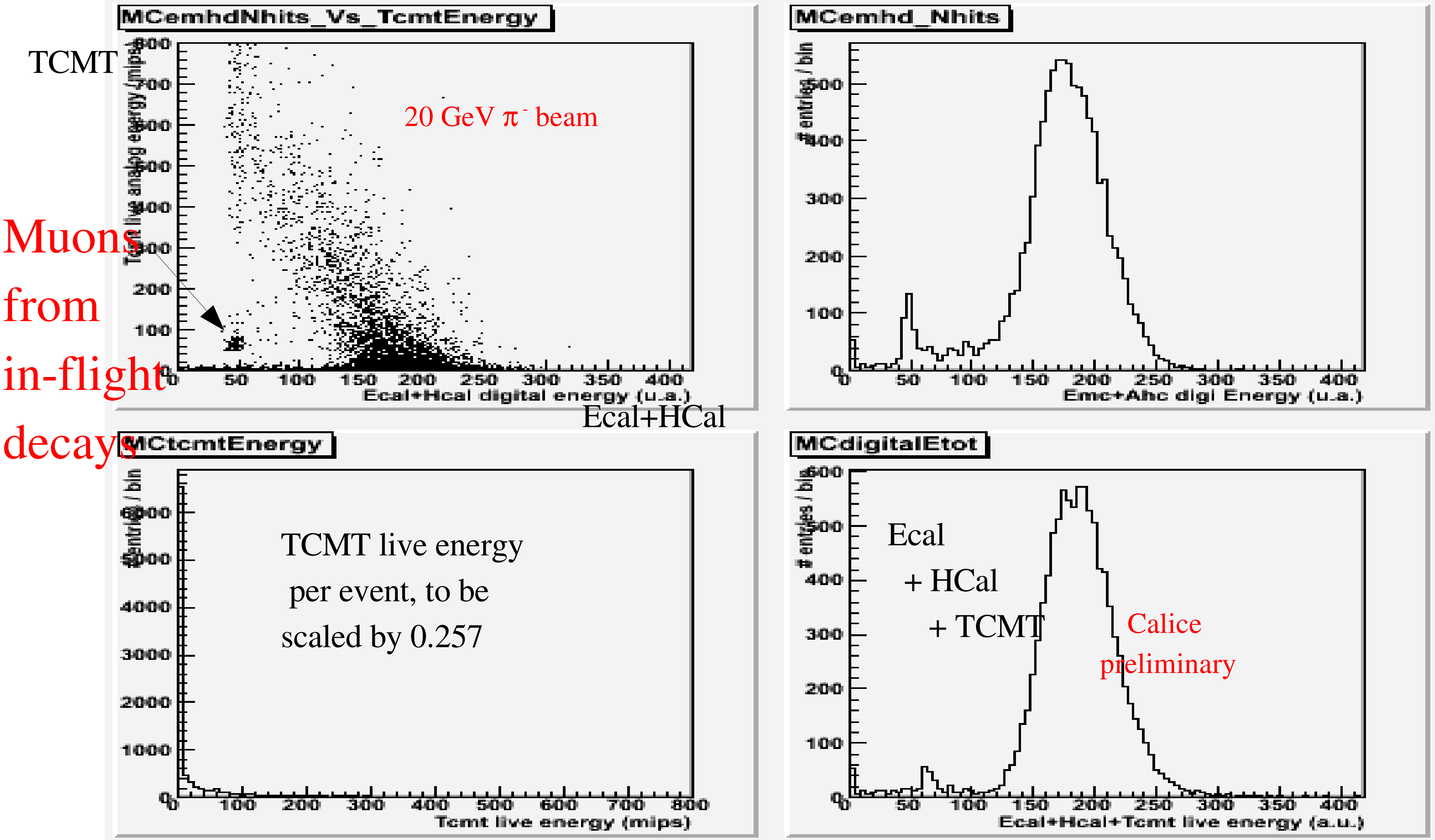
	Rel.Abs.Th	ICF_ana	ICF_digi	SW_ana	SW_digi
Ecal1	1	0.153	0.292	0.1526	0.292
Ecal2	2	0.153	0.292	0.3052	0.584
Ecal3	3	0.153	0.292	0.4578	0.876
Hcal1	1	1.000	1.000	1.0000	1.000
Hcal2	2	1.000	1.000	2.0000	2.000
Tcmt1	1	0.909	0.257	0.9091	0.257
Tcmt2	4.92	0.909	0.257	4.4728	1.264

Combining EM+HD and TCMT (hit counting) – TB data

Muons from in-flight decays



Combining EM+HD and TCMT (hit counting) - MC



Things to do next

- Short term (LCWS'07?):
  - Continue stability studies of pedestals, LED calibration, gains, etc.
  - More sophisticated hit weighting schemes, for better energy resolution
  - A Calice Note is being prepared in time for LCWS'07
- Longer term:
  - Hcal/TCMT alignment and digitization effects (crosstalks, noise, etc.)
  - look at transverse shower shapes, clustering
  - Introduce corrections for SiPM saturation effects in TCMT (+ conditionsDB)
  - Energy resolution studies and comparisons to MC hadronic shower models

Summary

- Lots of test beam data already available, detailed analysis is just starting
  - Still more data to come (Jul/Aug '07 @ CERN, late 2007 @ MTBF/FNAL)
- Analysis machinery is being integrated (mostly in place)
- Prototype's high granularity allows a detailed study of shower shapes
  - validation of hadronic shower simulation models
  - evaluation (and developments) of clustering and particle flow algorithms in future, high-granularity calorimeters
- Preliminary results look very encouraging!
  - But still a lot of things to do...