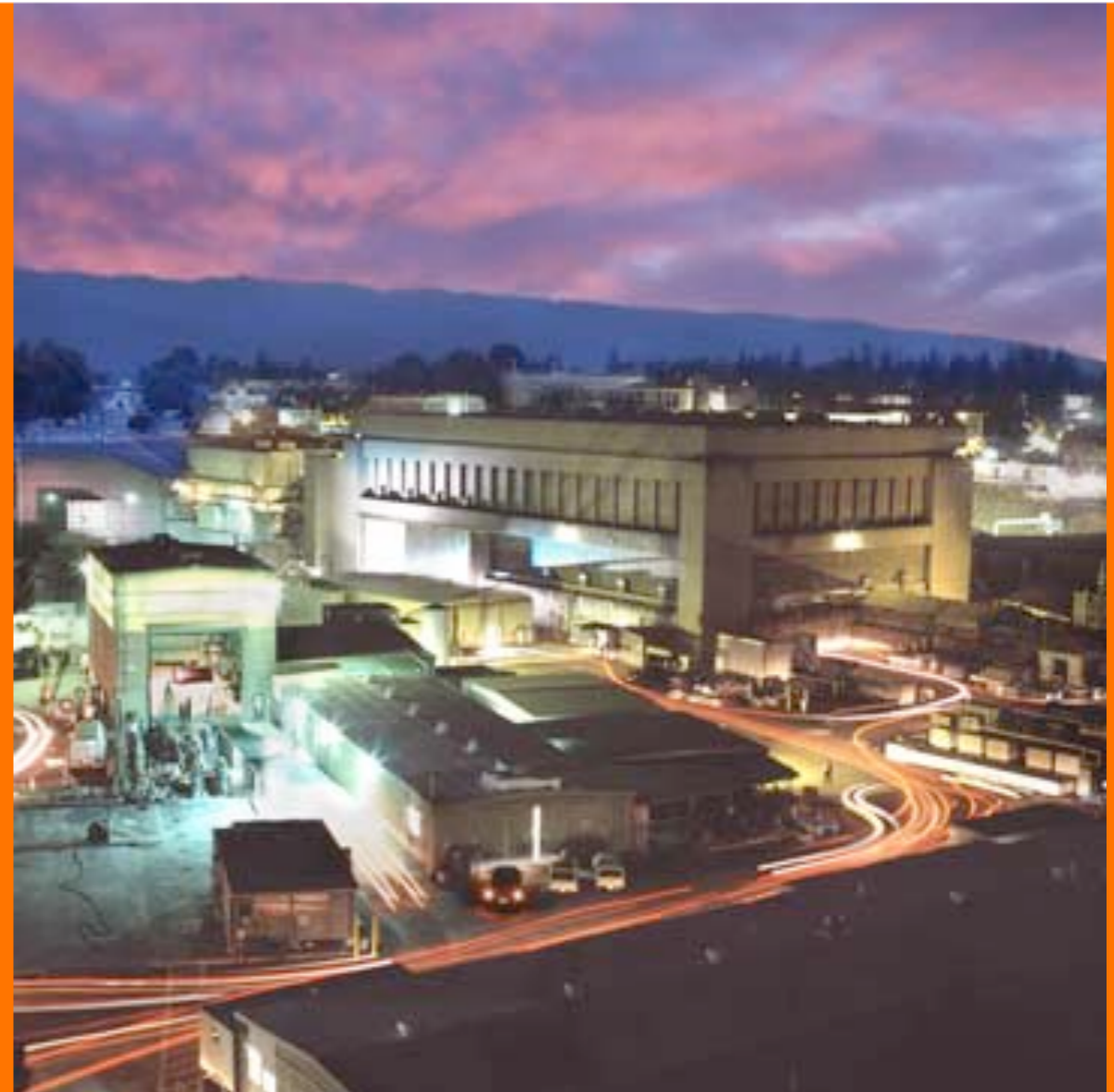


KPiX Test Beam at SLAC



Tim Nelson - **SLAC**

ALCPG07

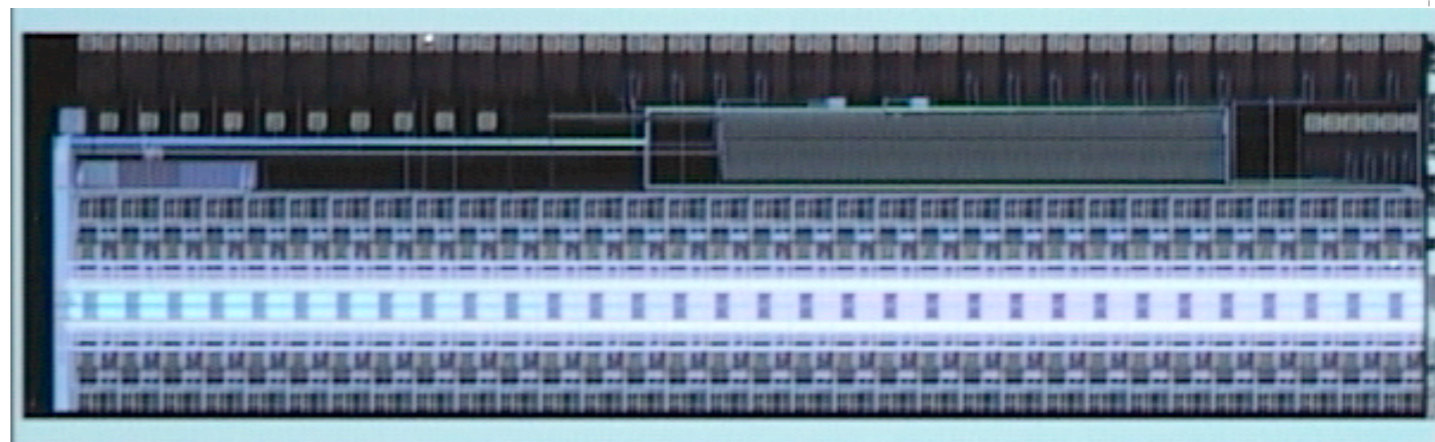
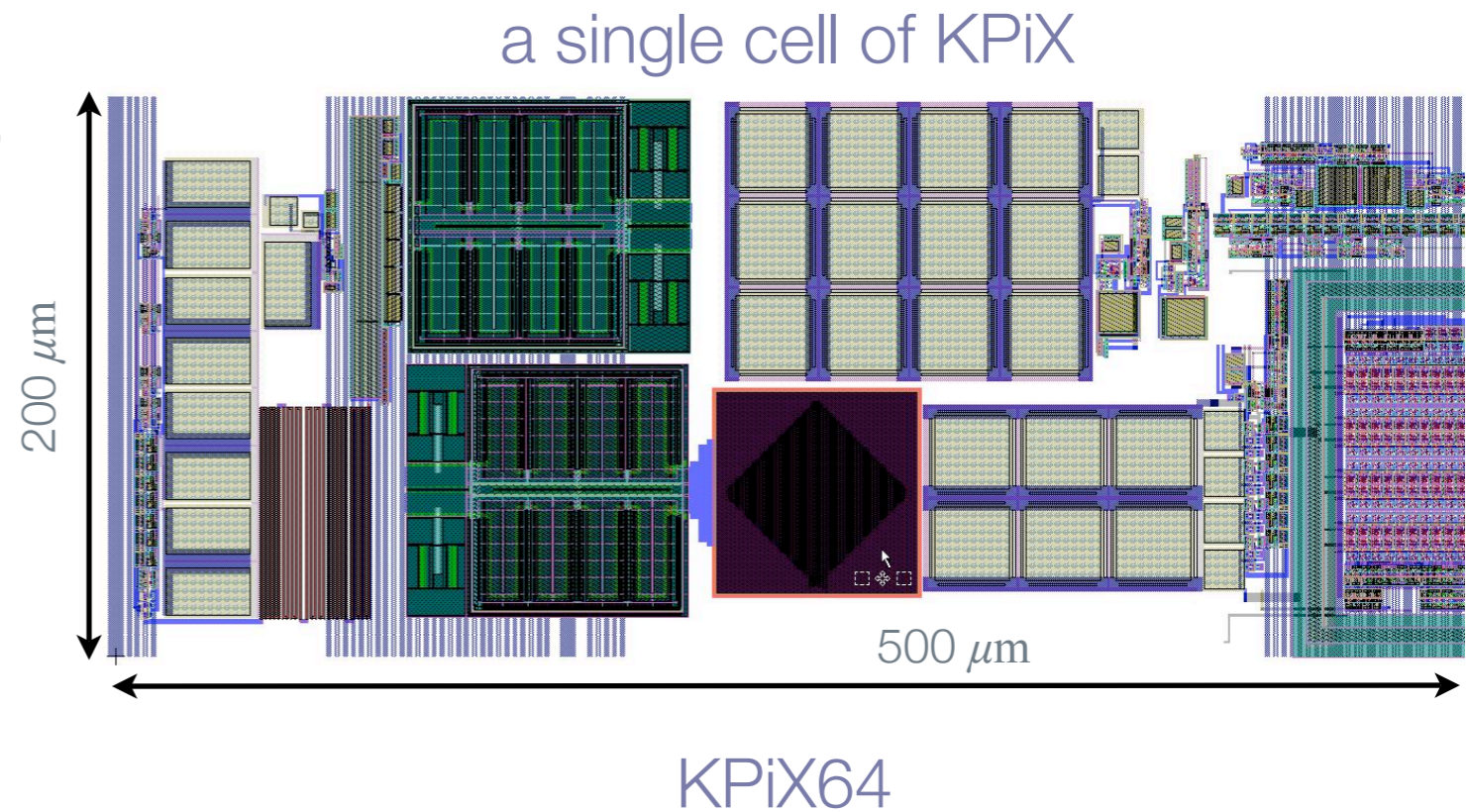
FNAL - October 24, 2007



KPiX64-4




BNL, UC Davis, Oregon, SLAC

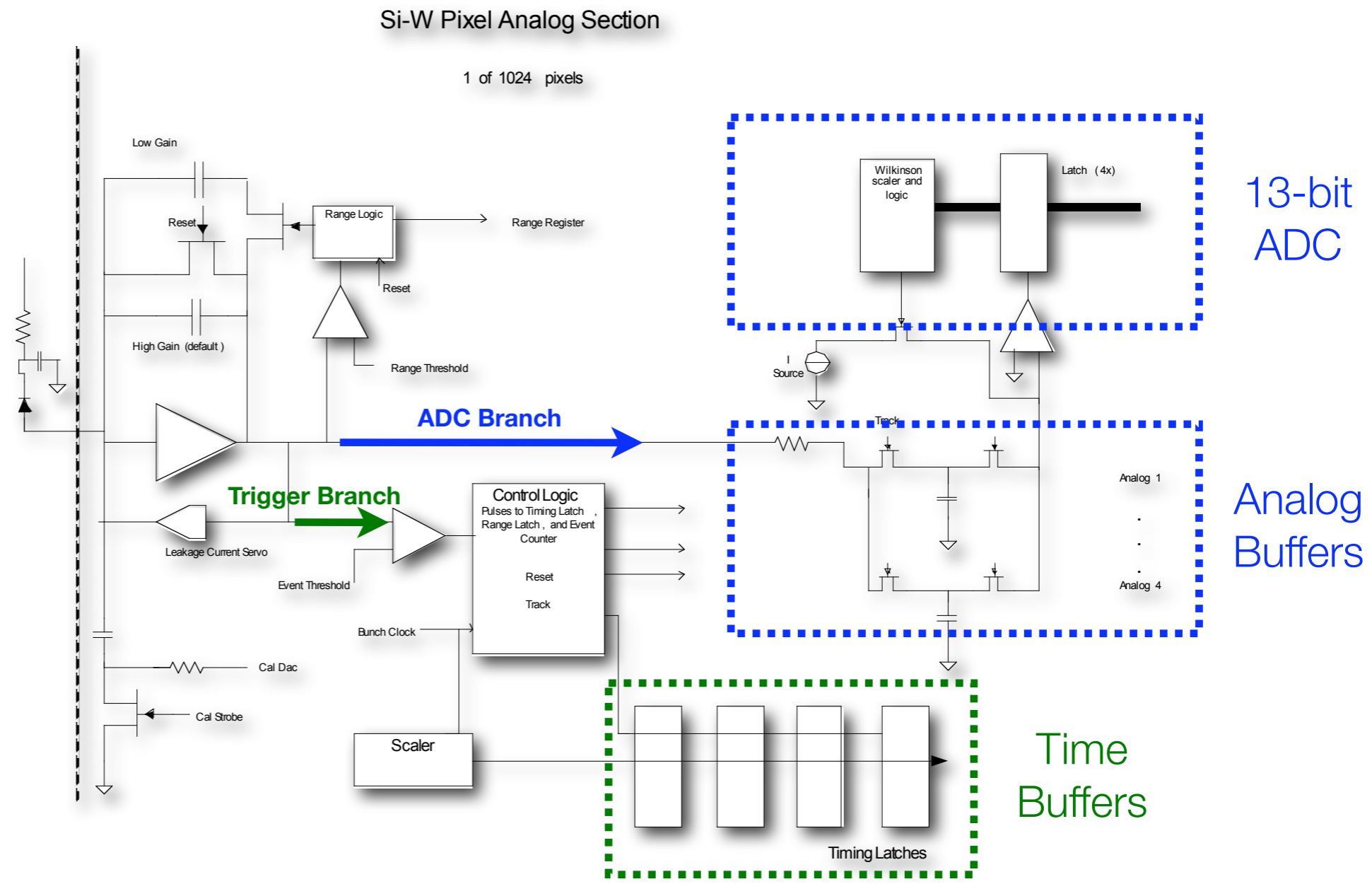
- ⬢ Power-pulsed ILC readout chip
 - ⬢ dynamic range select: ECal
 - ⬢ nearest-neighbor logic: strips
 - ⬢ inverted input: GEM DHCAL
- ⬢ 32×32 array = 1024 channels
 - ⬢ working with 2×32 prototypes in 0.25μm TSMC: KPiX64
 - ⬢ test beam with KPiX64-4
 - ⬢ KPiX64-5 in hand
 - ⬢ KPiX64-6 submitted



KPIX64-4

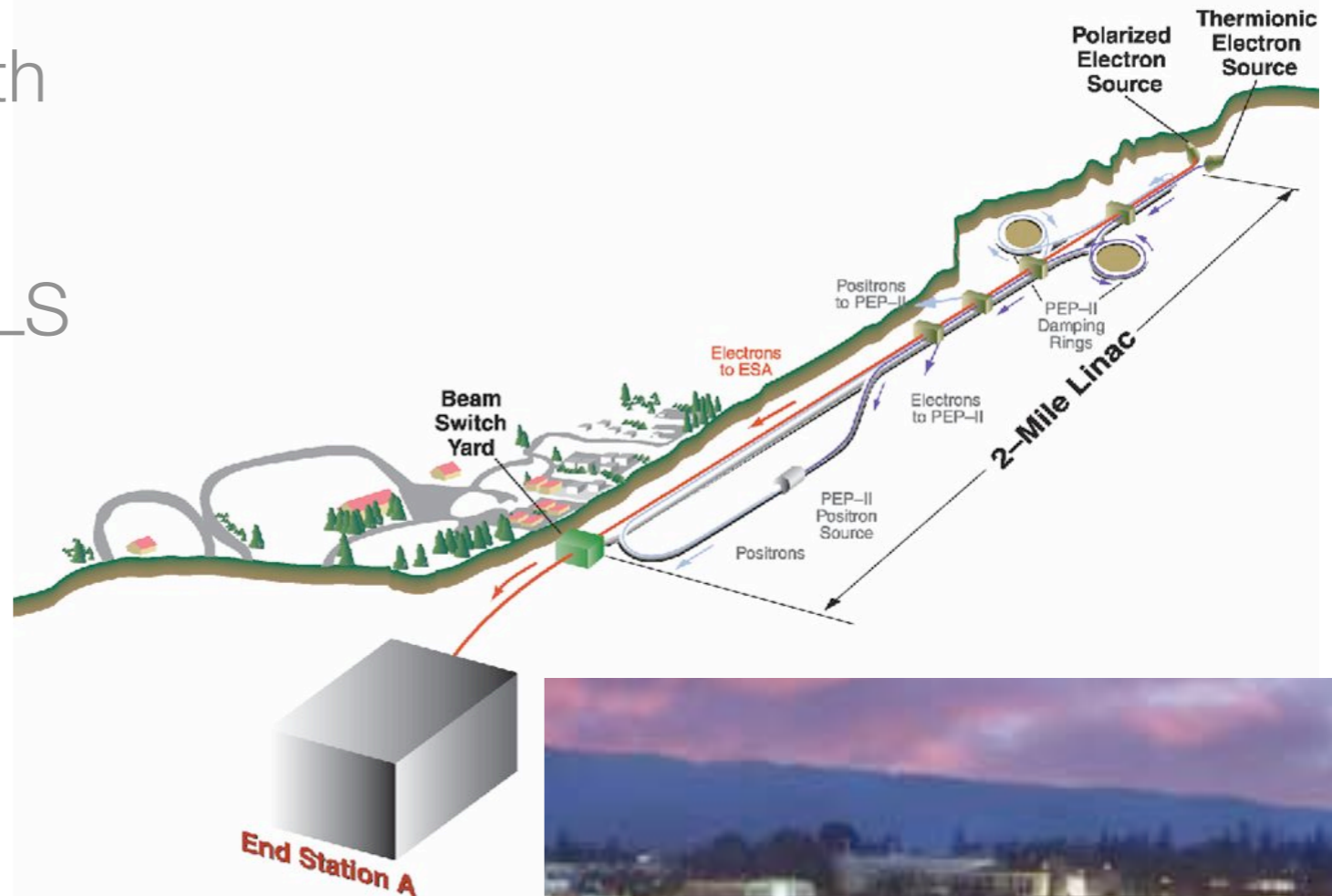
BNL, UC Davis, Oregon, SLAC

-  Two operational modes:
 -  self-triggered (ILC mode)
 -  external trigger (test beam)



ESA at SLAC

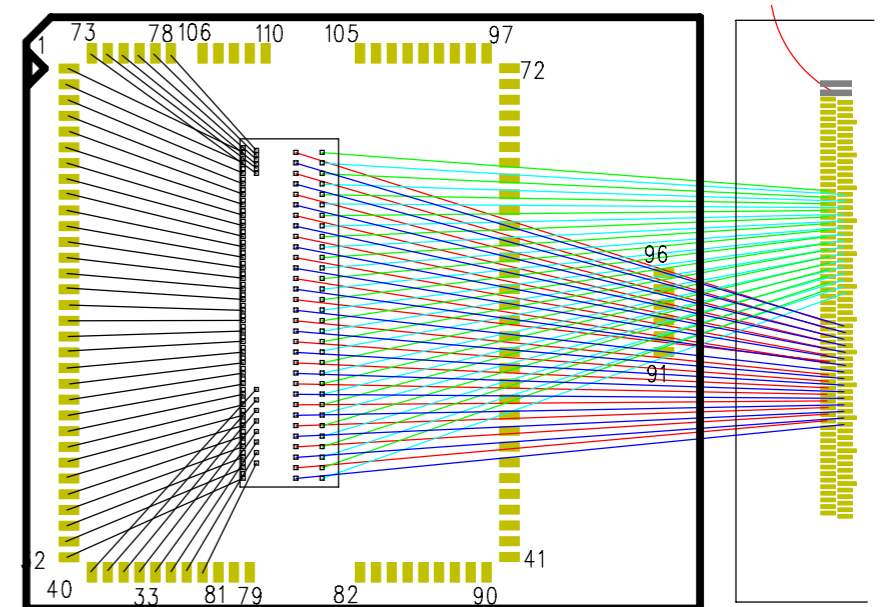
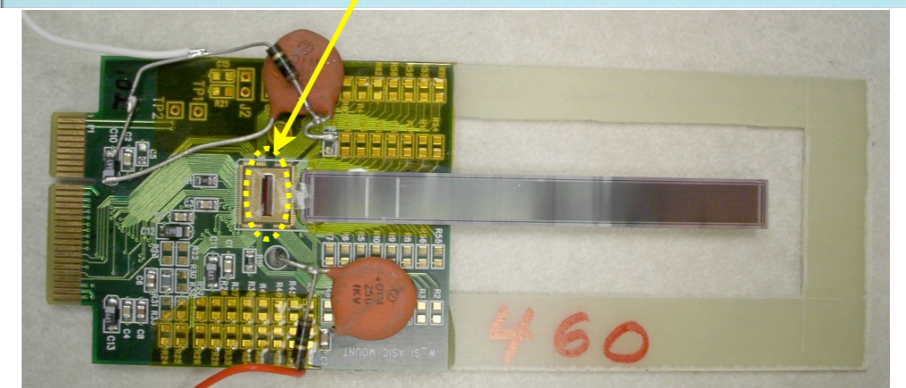
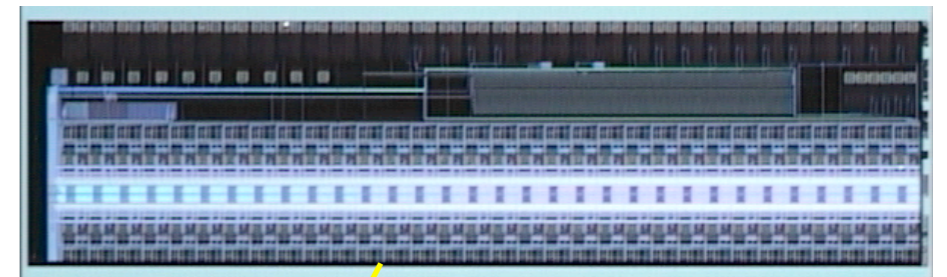
- ⬢ Large experimental hall with good infrastructure
- ⬢ Secondary beam from LCLS
 - ⬢ 10 GeV e^- , some pions
 - ⬢ 10-30 Hz pulse rate
 - ⬢ ~0.25 particles/pulse
 - ⬢ $\sigma_{\text{beam}} \cong 2\text{mm}$



An excellent facility for ILC detector testing

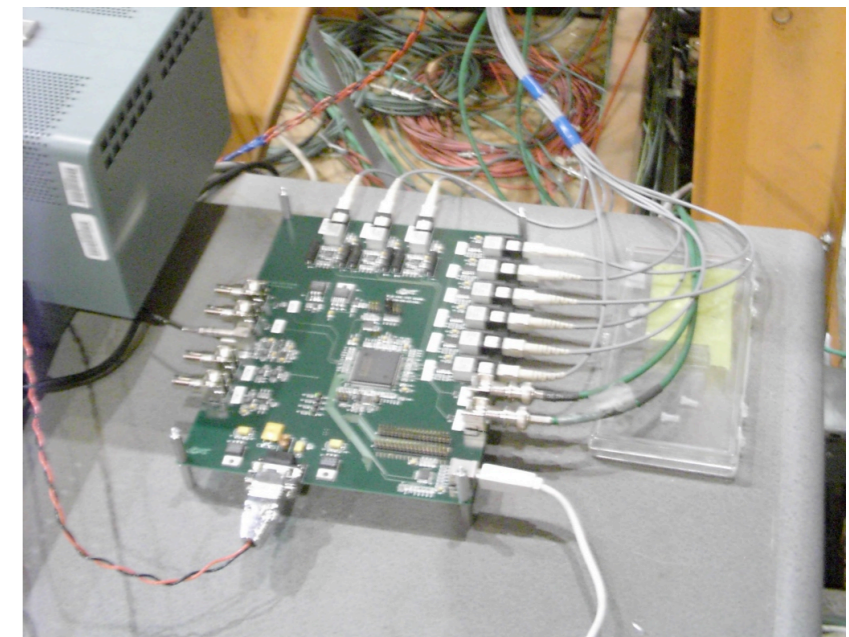
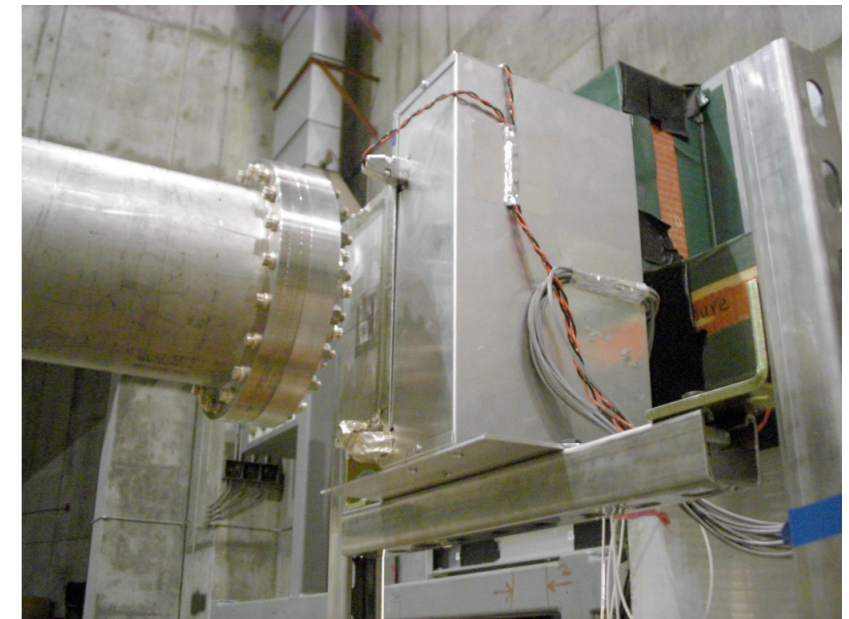
Apparatus

- ❏ Narrow (128-channel) CDF Layer 00 sensors, 25(50) μm sense(readout) pitch, 70V bias
- ❏ Standard *KPiX* test boards w/ additional filtering
- ❏ Wirebonding preserves neighbor relationships
 - ❏ 2x1.6mm sections w/ 0.4mm dead in center
 - ❏ Some touching wires in crossover region
- ❏ Three vertically oriented planes, roughly aligned to increase coincidence (not strip parallelism)
- ❏ Not a telescope: Goal is to test *KPiX* acquisition in ILC-like conditions, verify output normalization



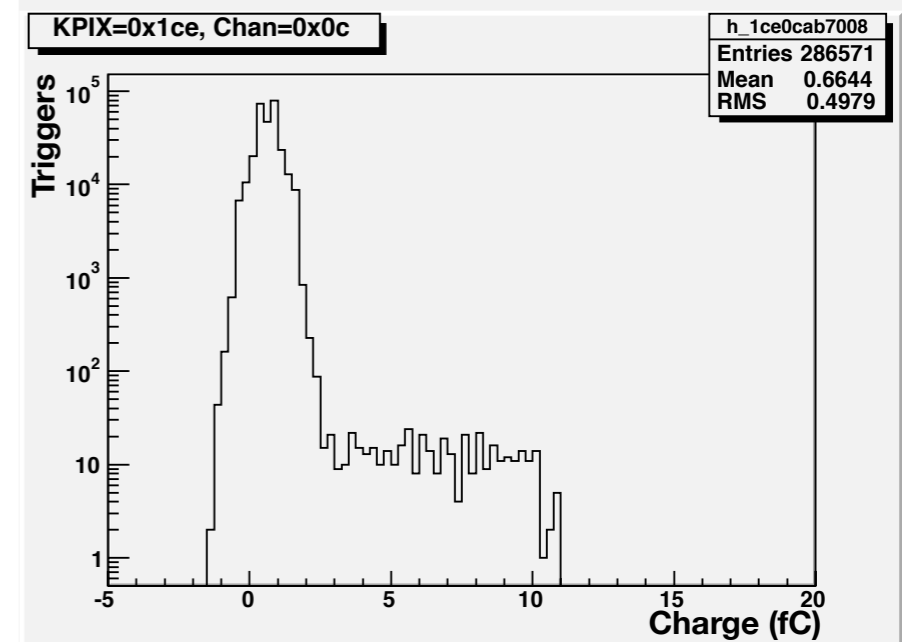
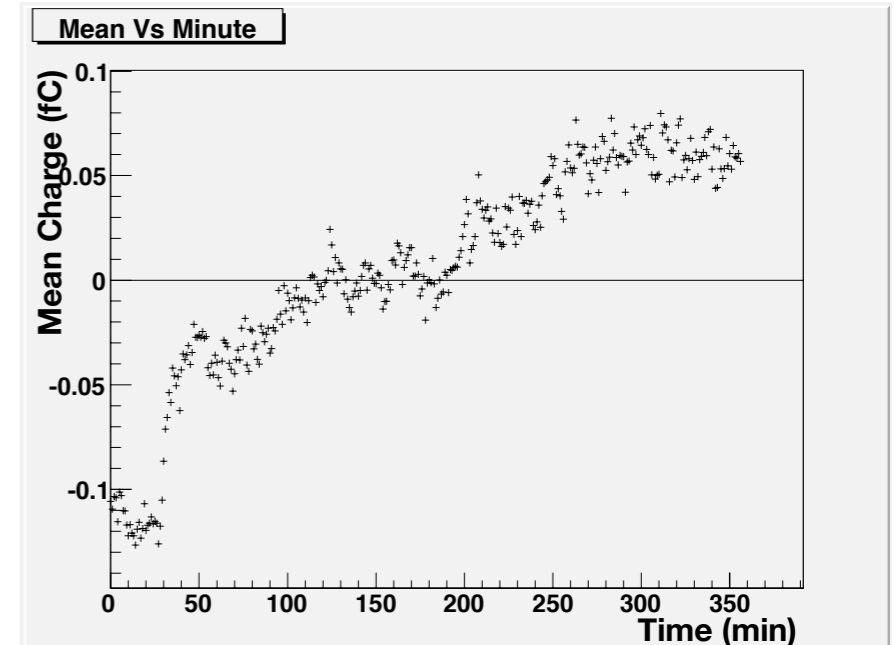
ESA Setup

- ⦿ Detector box at end of beampipe in ESA
 - ⦿ Al tape windows on front and back of box
 - ⦿ Standard readout board with optical interface
- ⦿ Piggybacked on another apparatus (T-469xx)
 - ⦿ Initial alignment w.r.t. T-469xx hodoscope
 - ⦿ Tuning required to achieve optimal alignment
- ⦿ Synchronous trigger signal 1ms before pulse to power-up and begin *KPiX* acquisition cycle.
- ⦿ Additional signal 20ns before pulse for debugging.
- ⦿ Began with force-triggered operation: latch all channels at correct beam-crossing time



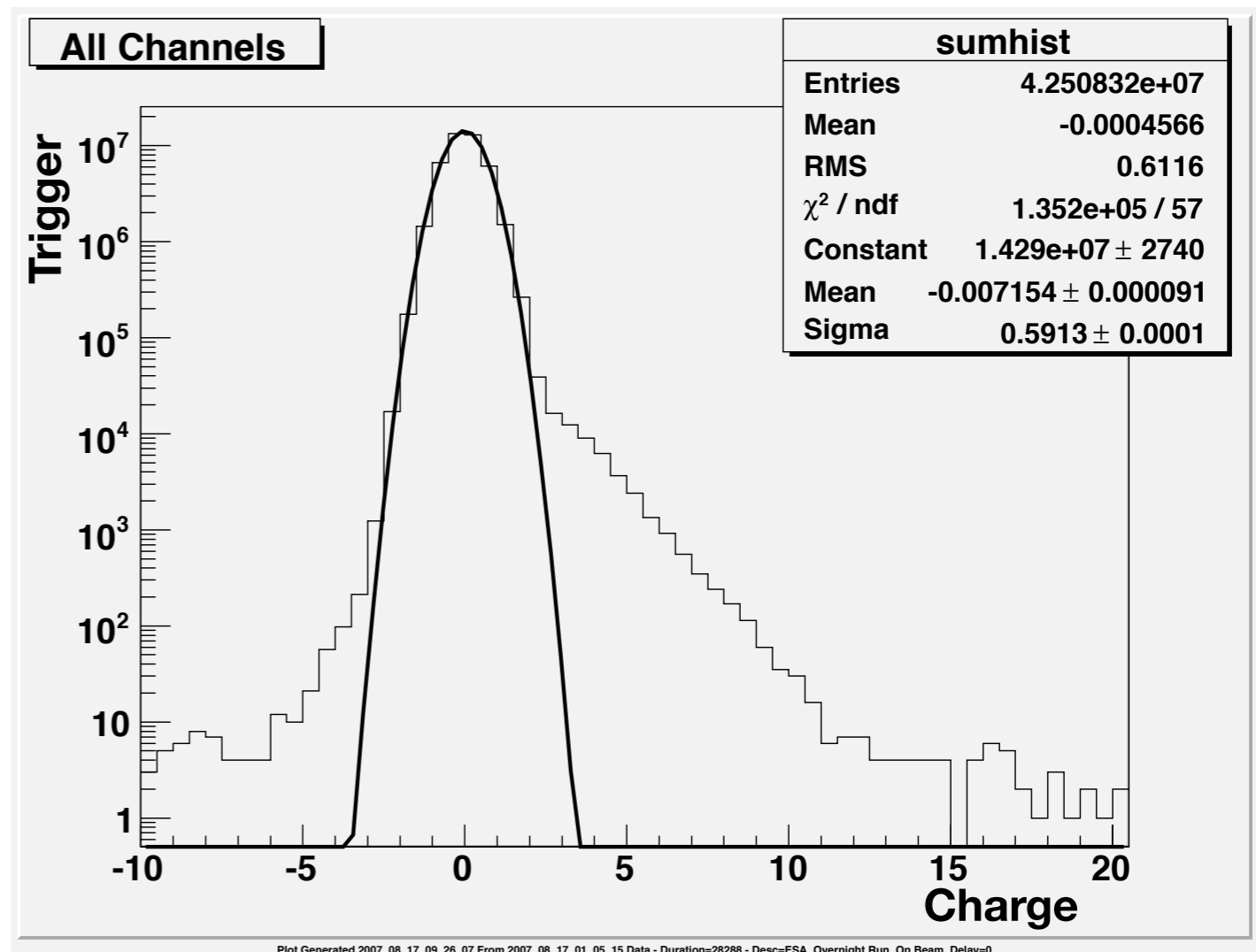
The School of Hard Knocks

- pedestal shift between calibration and operation
- low occupancy: calibrate with data
- drifts in time: temperature dependence?
- anomalously noisy channels
- timing spot-on, but... where's the beam?
- tough odds: instrumented a small fraction of 0.25 particles per 192 readouts



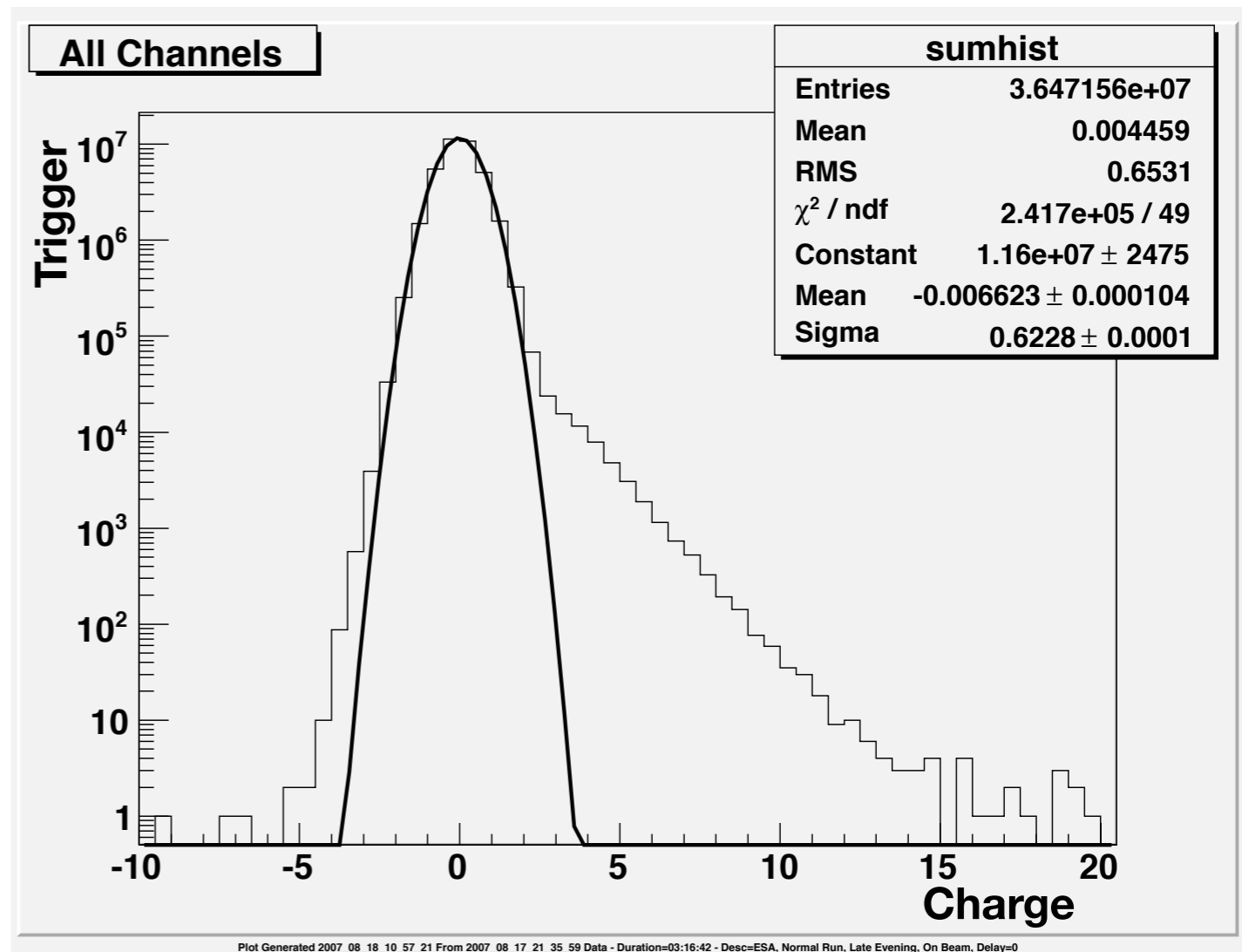
Raw Data

- When out of alignment beam splash causes negative entries.
- Level shifts due to large charge deposits?



Raw Data

- ⬢ Good alignment achieved after a few days of fussing
- ⬢ Some chasing of external changes to beam position
- ⬢ Total data on-alignment: ~62 hours. About 40 hours in one exact position.
- ⬢ Several hours of pure off-beam data for calibration



Clustering

Elimination of bad channels

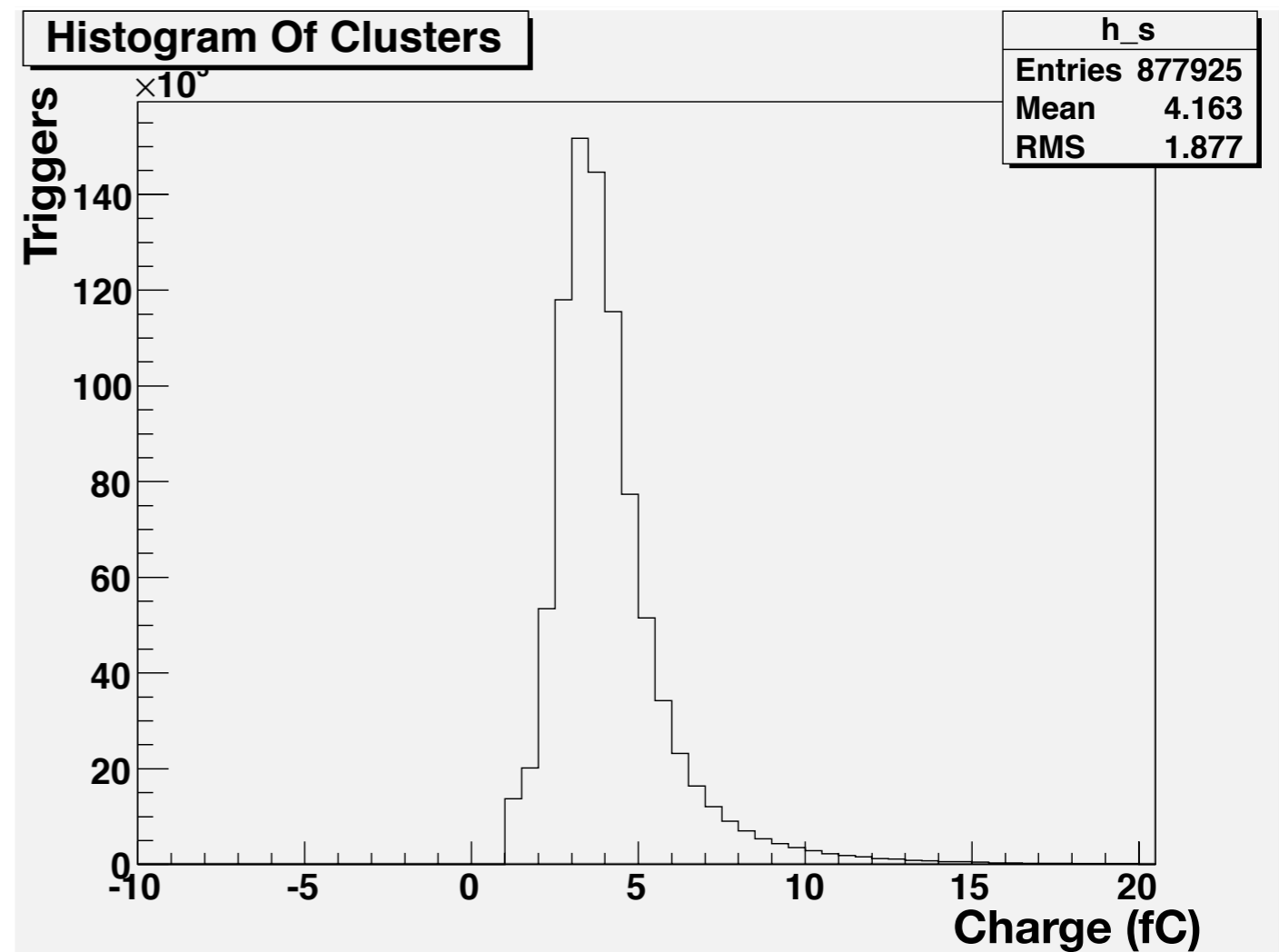
- those with anomalous behavior
- those with noise > 0.6 fC

Simple clustering

- seed threshold: 3 sigma
- add threshold: 2 sigma
- cluster threshold: 3 sigma

Only 15% have > 1 strip

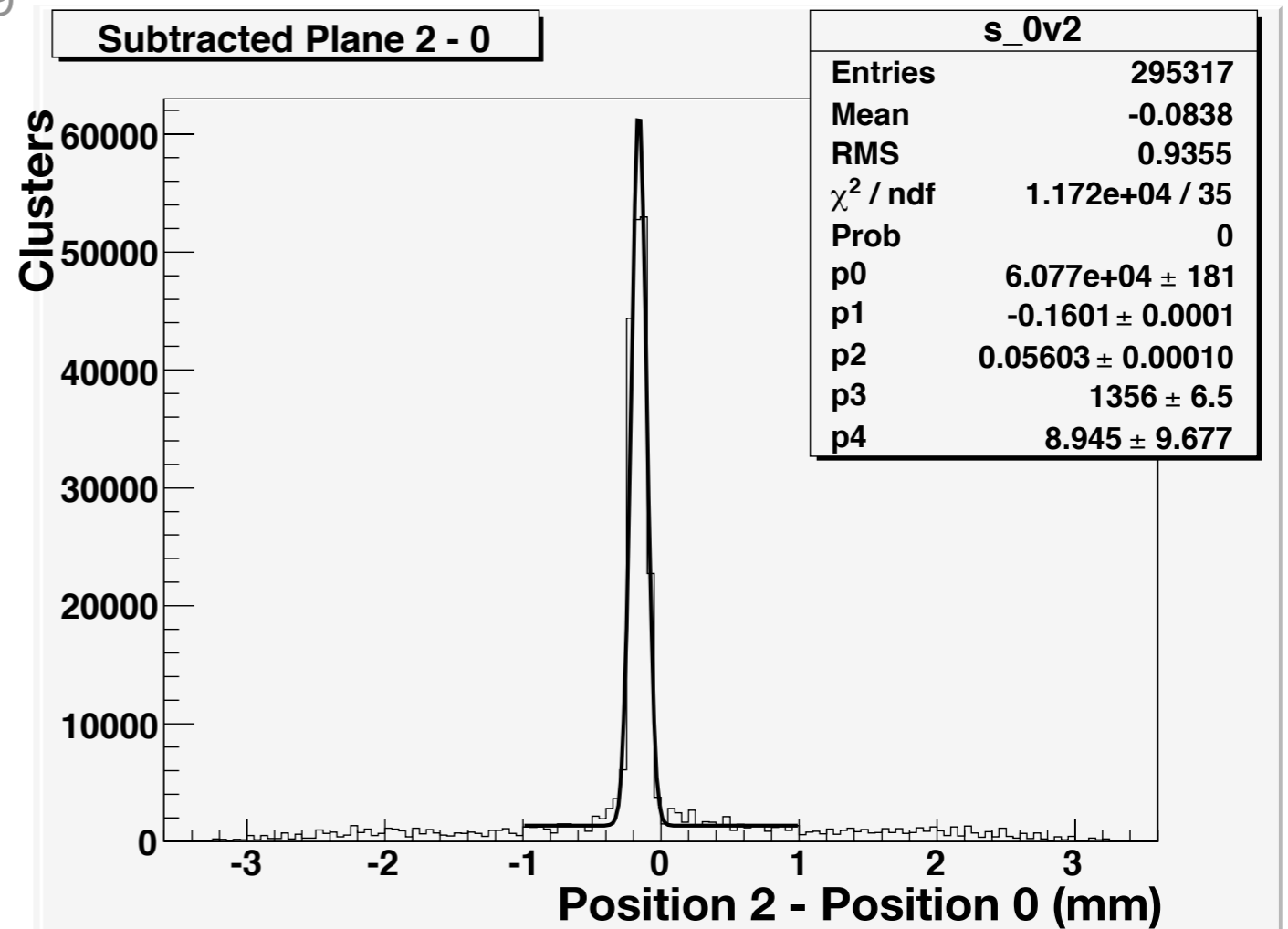
90-95% pure signal



Coincidence

Strips are nearly parallel, do something simple first: plot position differences

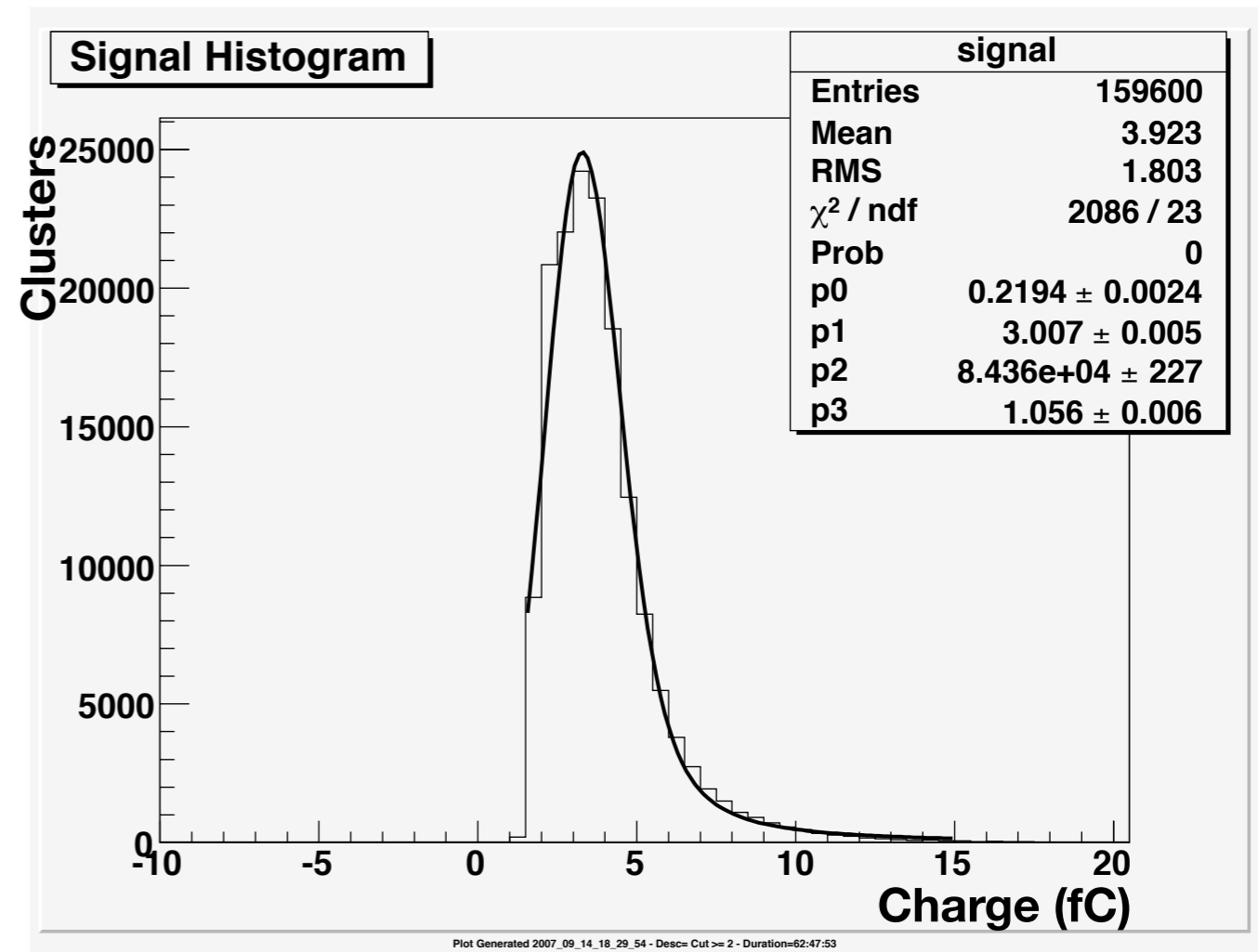
- 🔺 Signal region $< 2\sigma$
- 🔺 Background region $> 4\sigma$
- 🔺 Plot only hits in signal regions
- 🔺 Can use sidebands to estimate remaining background
- 🔺 Spread is image of beam profile due to strip misalignment: can use correlations to further narrow signal window for triple coincidences



Landau Fit

Fit all double-coincidence clusters with Landau convoluted with Gaussian

- ⬢ MPV = 19,000 electrons
- ⬢ Expect ~20,000 with capacitively coupled intermediate strip
- ⬢ We now have high-precision measurements of silicon positions: can perform 3-d tracking and reconstruct vertical beam profile

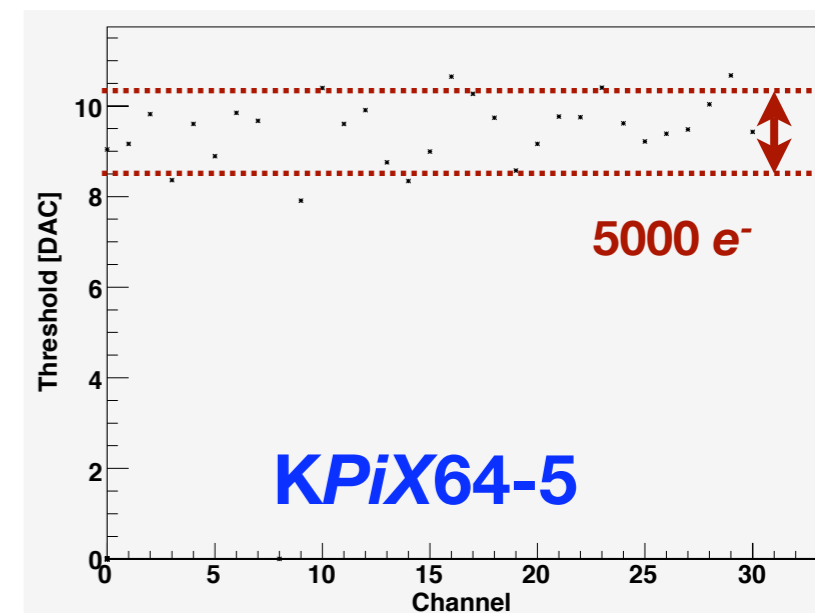
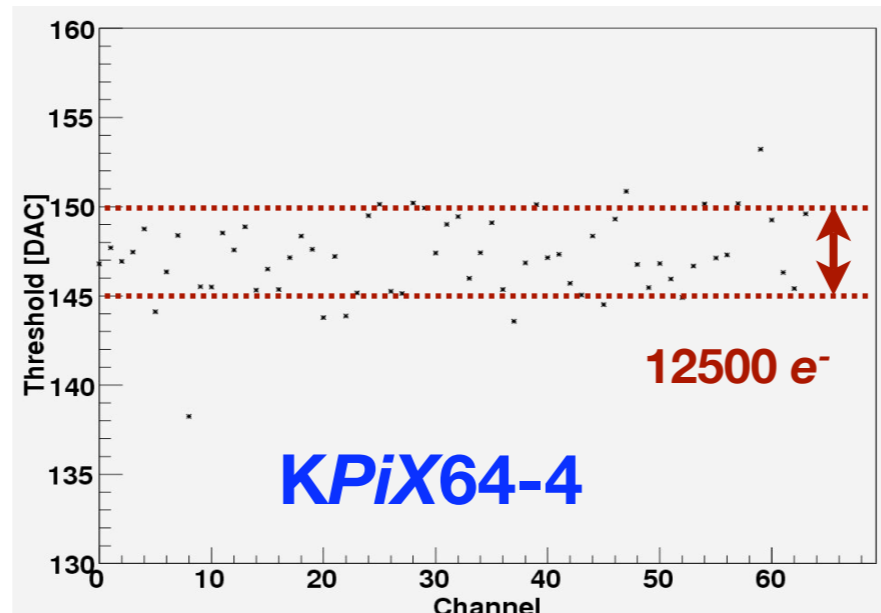
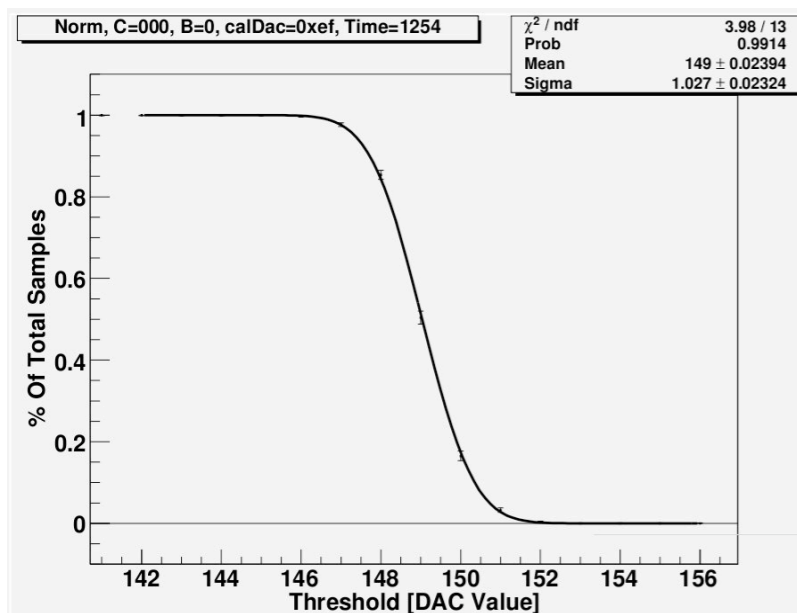


not background subtracted



Self Triggered Operation?

- ⌘ Pedestals and noise in trigger branch measured by threshold scan
- ⌘ Self-triggered mode in KPiX64-4 not sufficient
 - ⌘ Pedestal variations are large: $12500 e^-$
 - ⌘ Only two thresholds available for all channels: one used to turn off bad channels
- ⌘ KPiX64-5 in hand: variations $\sim 5000 e^-$, ability to disable individual channels



Summary

- ❏ Test beam with *KPiX* in ESA at SLAC has provided valuable operational experience.
- ❏ *KPiX* works, not all features required for ILC operation are ready.
- ❏ Able to reconstruct clean clusters in strip detectors and produce Landau consistent with expectations using forced-trigger mode.
- ❏ *KPiX64-5* will allow beam test using ILC (self-triggered) mode. Work on bump-bonding and new sensor prototypes for both ECal and Tracker will allow test of real readout configurations
- ❏ We will be quite well prepared next time: further opportunities for test beam in ESA from 12/07 - 9/08