KPiX Readout Chip Status

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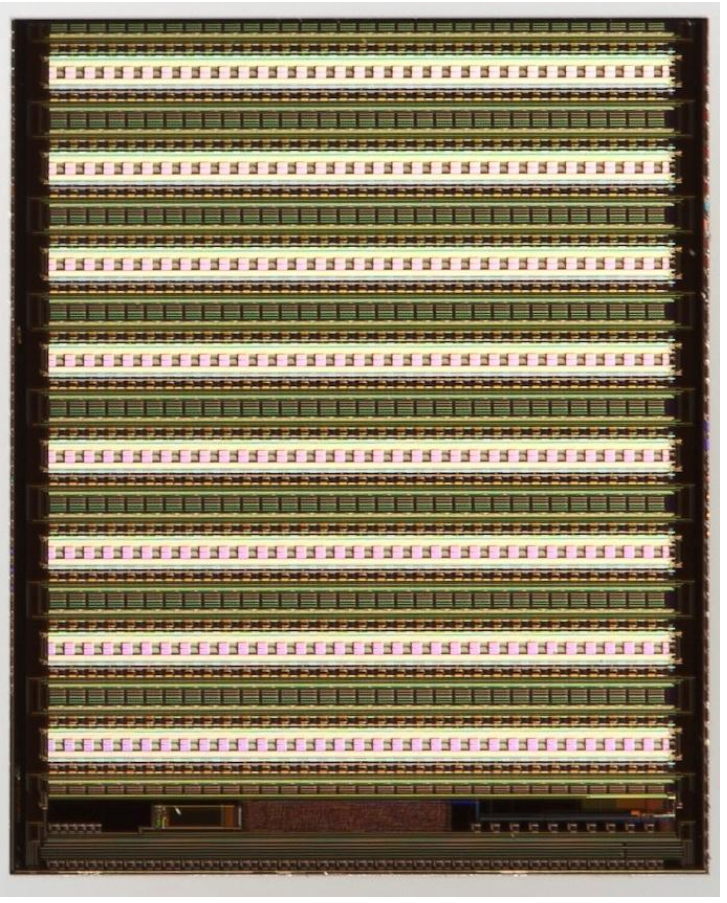
KPiX Brief History

- The most recent versions of KPiX are versions 7, 8, 9 and A.
- You will see these referred to as KPiX-7, KPiX-A and so on.
- KPiX-7 was released in 2008 with 64 channels.
- KPiX-8 was released in 2009 with 256 channels.
- KPiX-9 was released in 2010 with 512 channels.
- KPiX-A was released in 2011 with 1024 channels.
- If KPiX-A functions properly, it will be the final version.



Underside of KPiX-9

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KPiX Features

- KPiX is largely motivated by Silicon Detector (SiD) for the International Linear Collider (ILC).
- KPiX operates to read, process and output small charge signals.
- External control signals are used for control of system clock, reset and issuing commands. All other controls are internal, including triggers.
- External triggering is available.
- Power pulsing allows for ~40 mW power consumption for a full-sized chip.
- Dynamic range switching capability allows gain to decrease when signals exceed ~400 fC, increasing signal range to 10 pC.
- Noise floor of 0.15 fC, 1000 electrons. For reference: a MIP is 25000 electrons.

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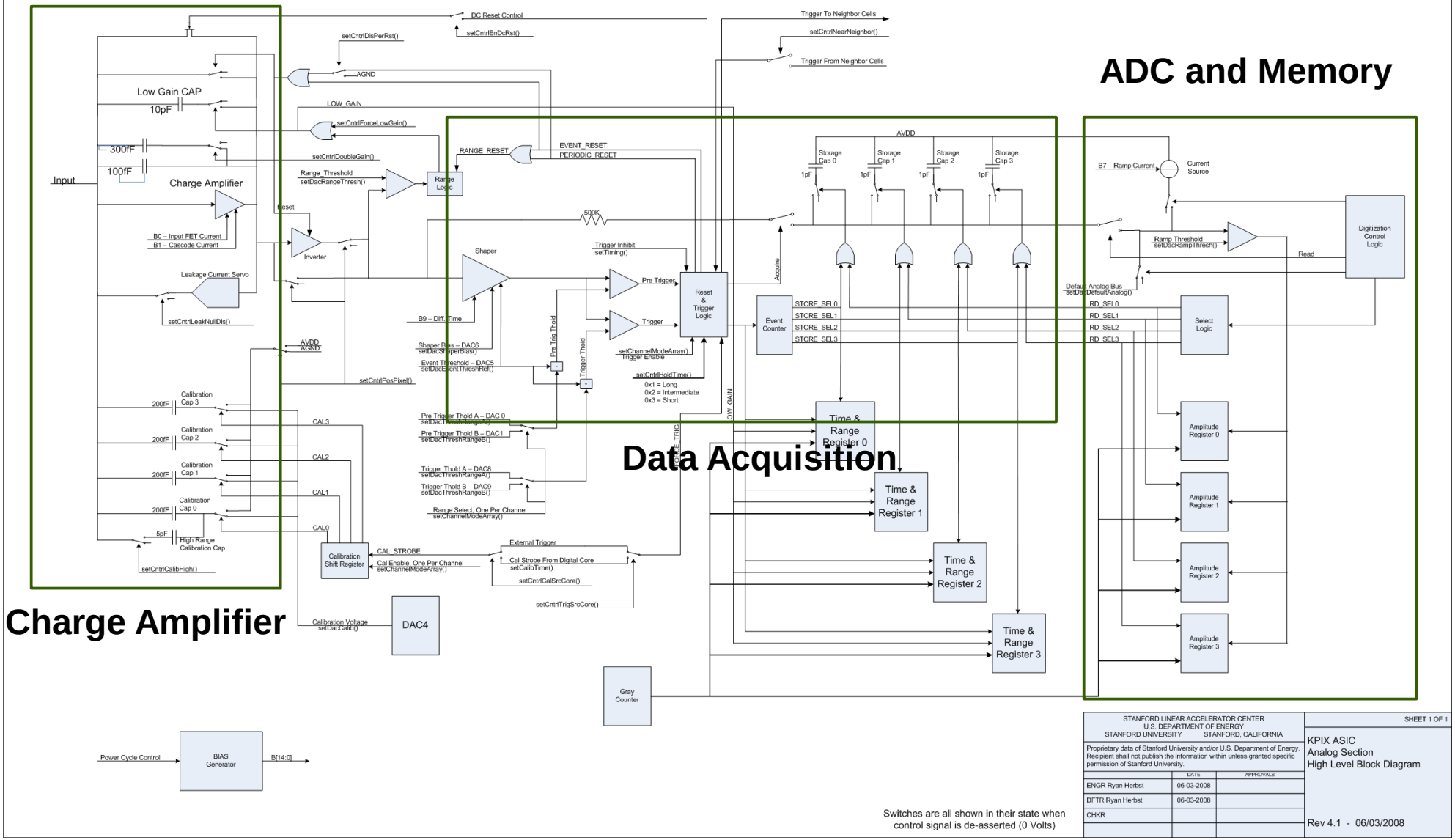

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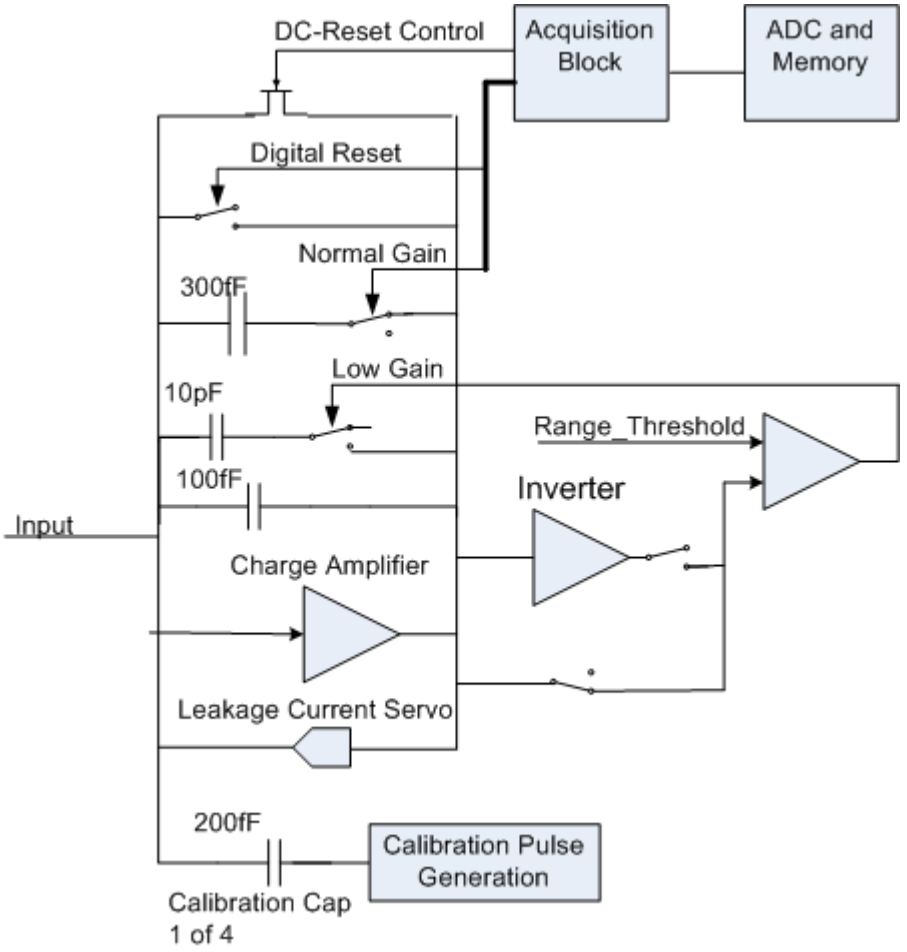
Charge Amplifier

- Signal at input is converted to voltage signal at output of amplifier with gain dependent on feedback capacitance.
- Range switching occurs automatically if signal is outside normal range.
- Negative polarity signals are inverted automatically.
- Servo compensates for DC coupling.
- Up to four calibration signals can be sent. Settings for calibration are defined in the set-up cycle.
- Resets are controlled by the data acquisition block.



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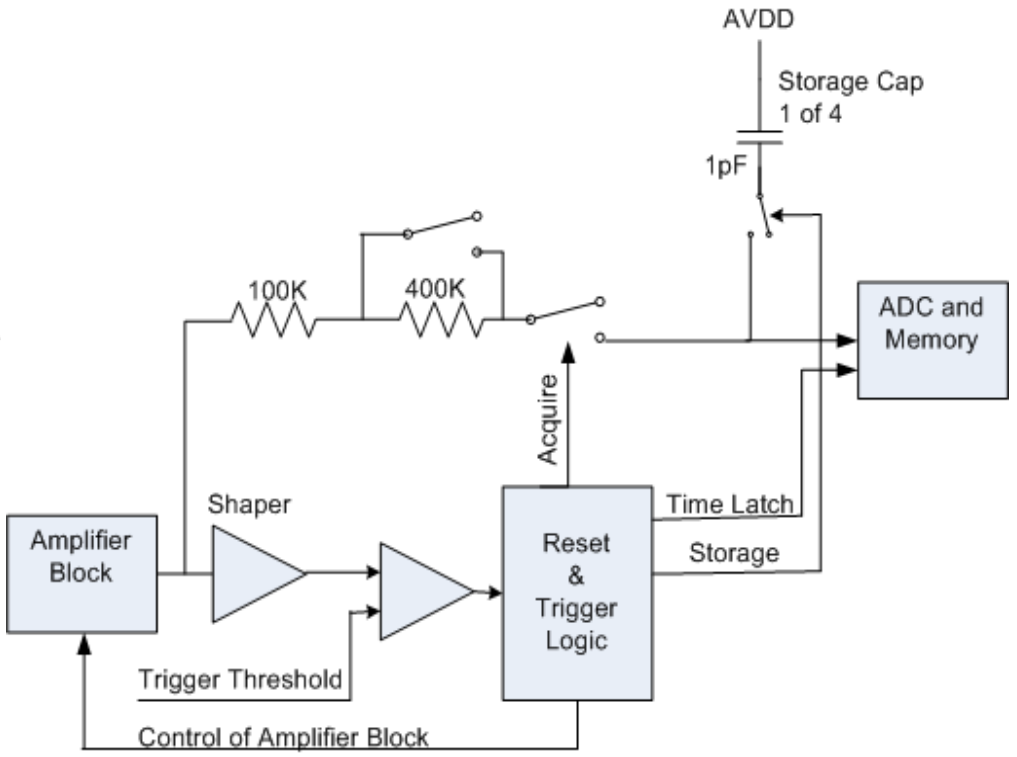
Data Acquisition

- Signal from charge amplifier is amplified, shaped and compared to threshold.
- If signal is above threshold, then data acquisition cycle begins.
- Nearest neighbor triggering is selectable for tracking.
- Signal is passed through a low-pass filter to be held on one of four storage capacitors.
- Time between beginning and end of acquisition cycle is precisely controlled.
- Second signal is generated to indicate event time and is sent to memory block.
- Resets are generated, allowing four events to be fed to storage block each storage cycle.



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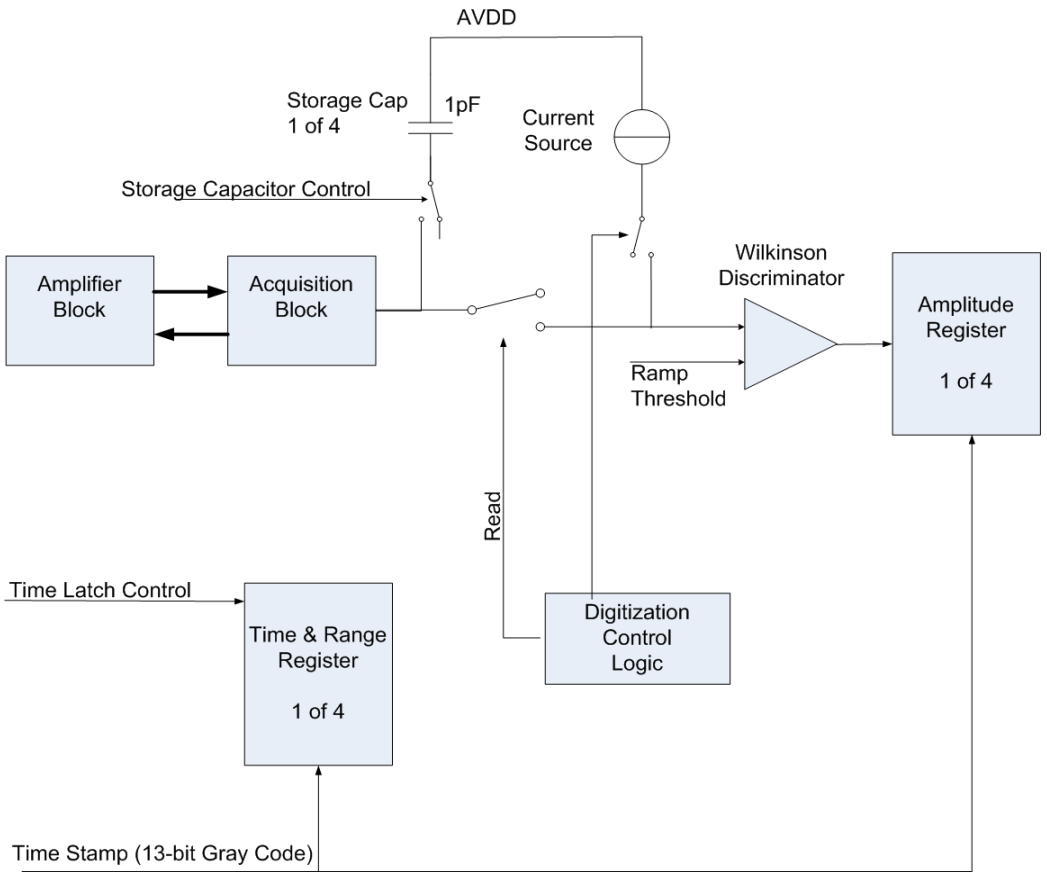
ADC and Memory

- For each channel, signal on the storage capacitor is digitized and subsequently stored in memory.

- Signals are digitized using the Wilkinson method. Current source has selectable value which is referred to as the “front-end” current.

- ADC has 13 bits of resolution.



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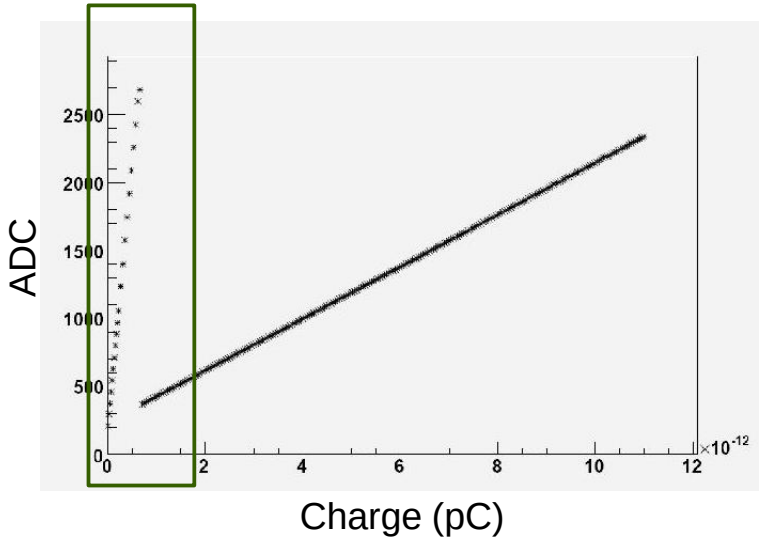
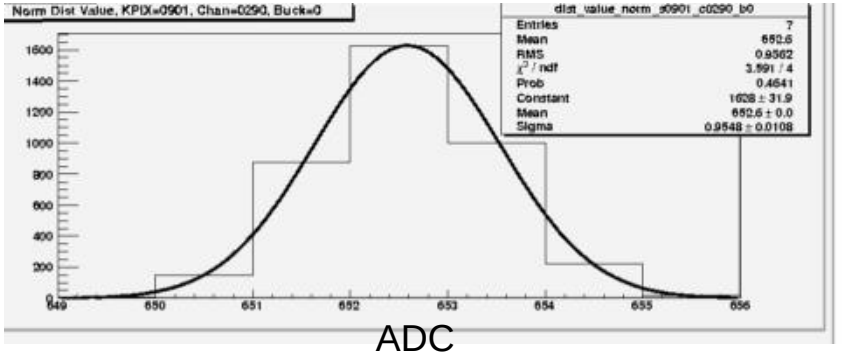
KPiX Example Calibration



- Above is an example of an ADC calibration featuring dynamic range switching.
- Precise calibration signals are delivered to the charge amplifier. Each signal is converted to an ADC count.
- Notice the range switch at ~500 fC.



- The second plot is an ADC histogram, each event was force triggered.
- A typical gain (normal) is 5 ADC/fC
- Sigma is ~1 ADC which gives 0.2 fC noise

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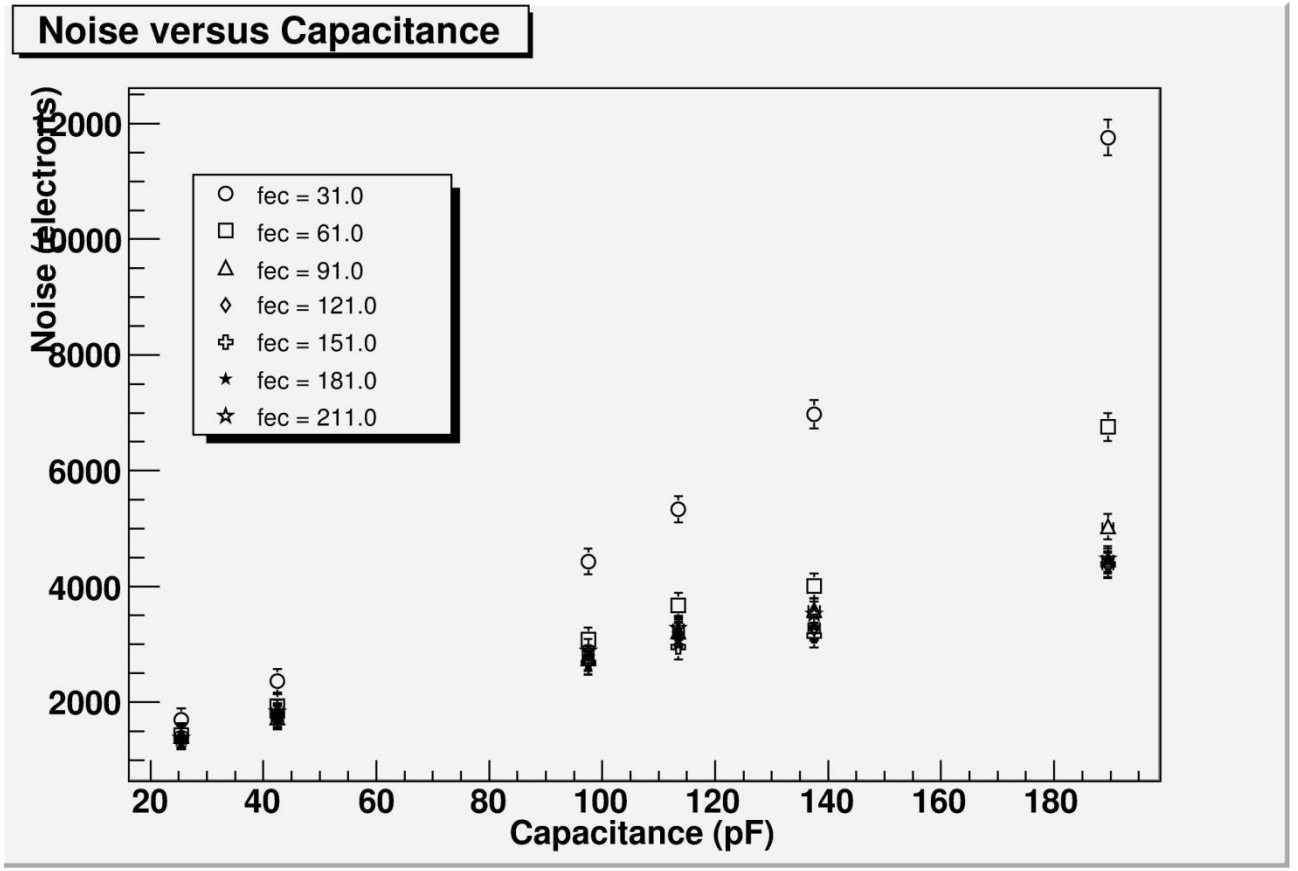
KPiX-8 Load Measurements

- When bonded to Si wafer, a capacitive load on the order of 10 pF is expected.
- For a single channel, a load capacitor is attached between input and AVDD.
- A range of front end currents and load capacitors are used to study their effects on noise.
- Noise is determined using the previously described method.



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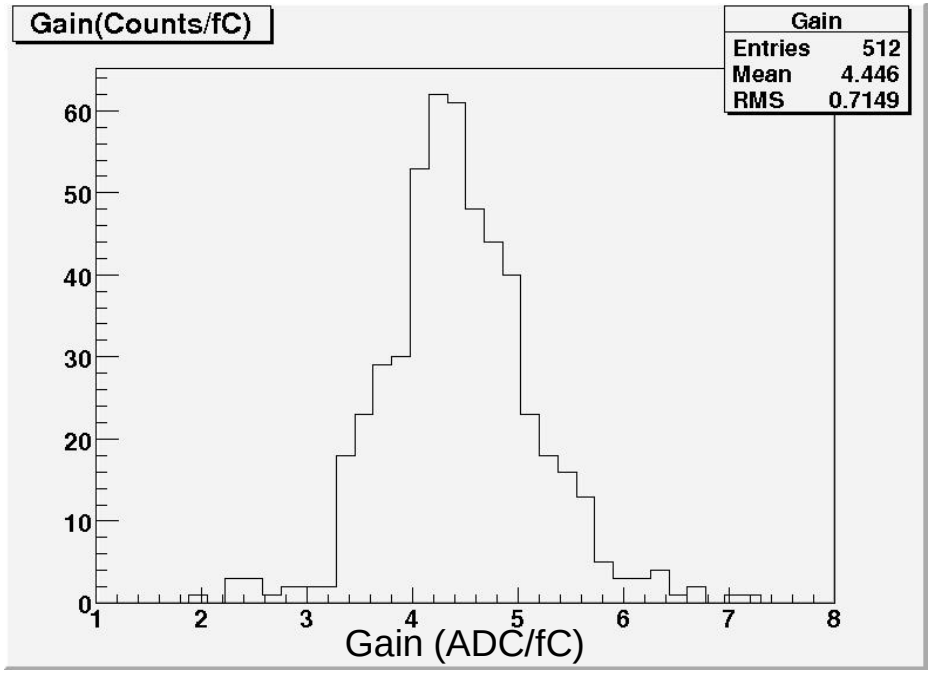
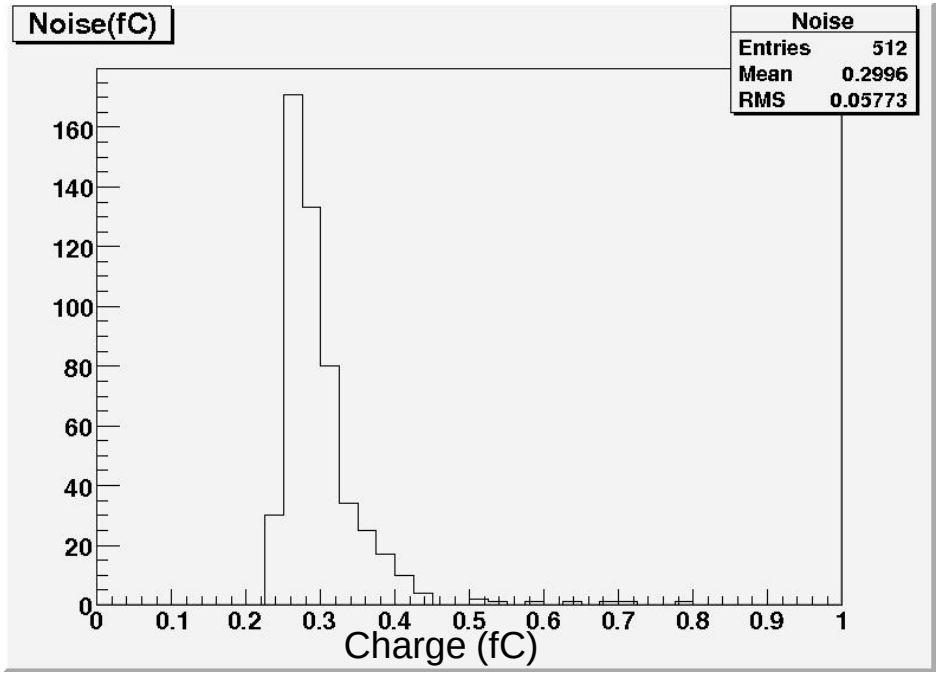
KPiX-9 Calibration





- All channels of KPiX-9 are calibrated, the gains are histogrammed above.

- Noise was measured for all channels using force triggers.

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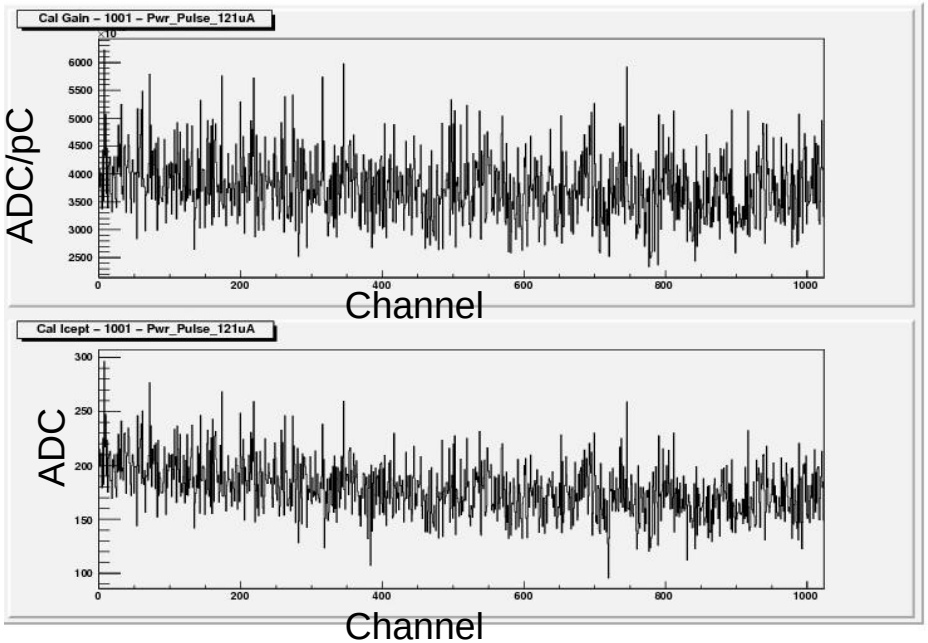
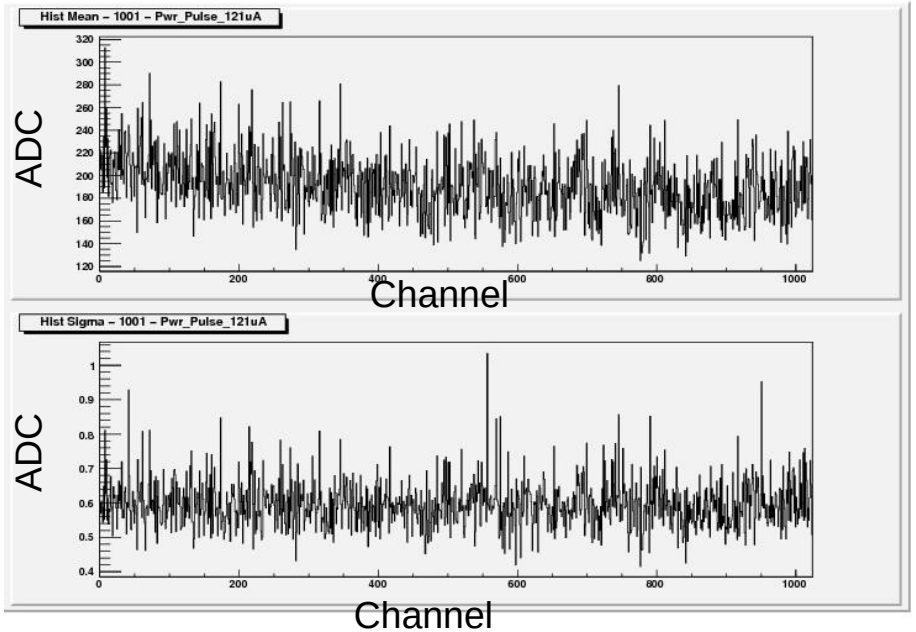
KPiX-A Calibration Summary



- All channels of KPiX-A are calibrated.
- Gain vs. channel appears in top plot.
- y-intercept vs. channel appears in bottom plot.



- Force triggers are histogrammed and fit witha Gaussian.
- The bottom plot displays sigma of Gaussian fit for each channel.

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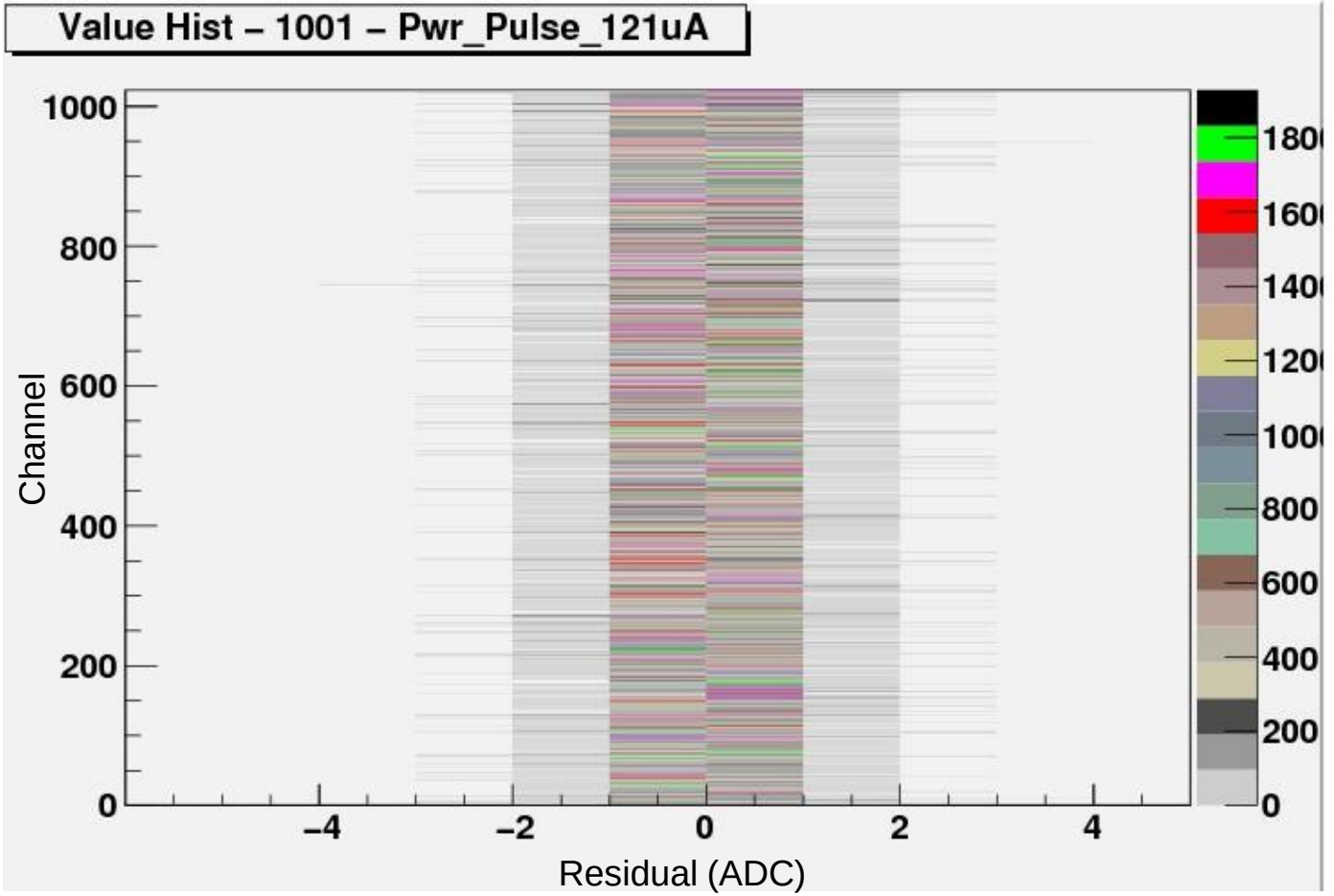
KPiX-A Noise Summary

- Data from calibration of all channels was used to make this plot.
- For each channel the residuals of the fit are determined and histogrammed in that channel's slice.
- The color corresponds to height of the histogram's bin.
- The “width” of the histogram is a measure of that channel’s noise.



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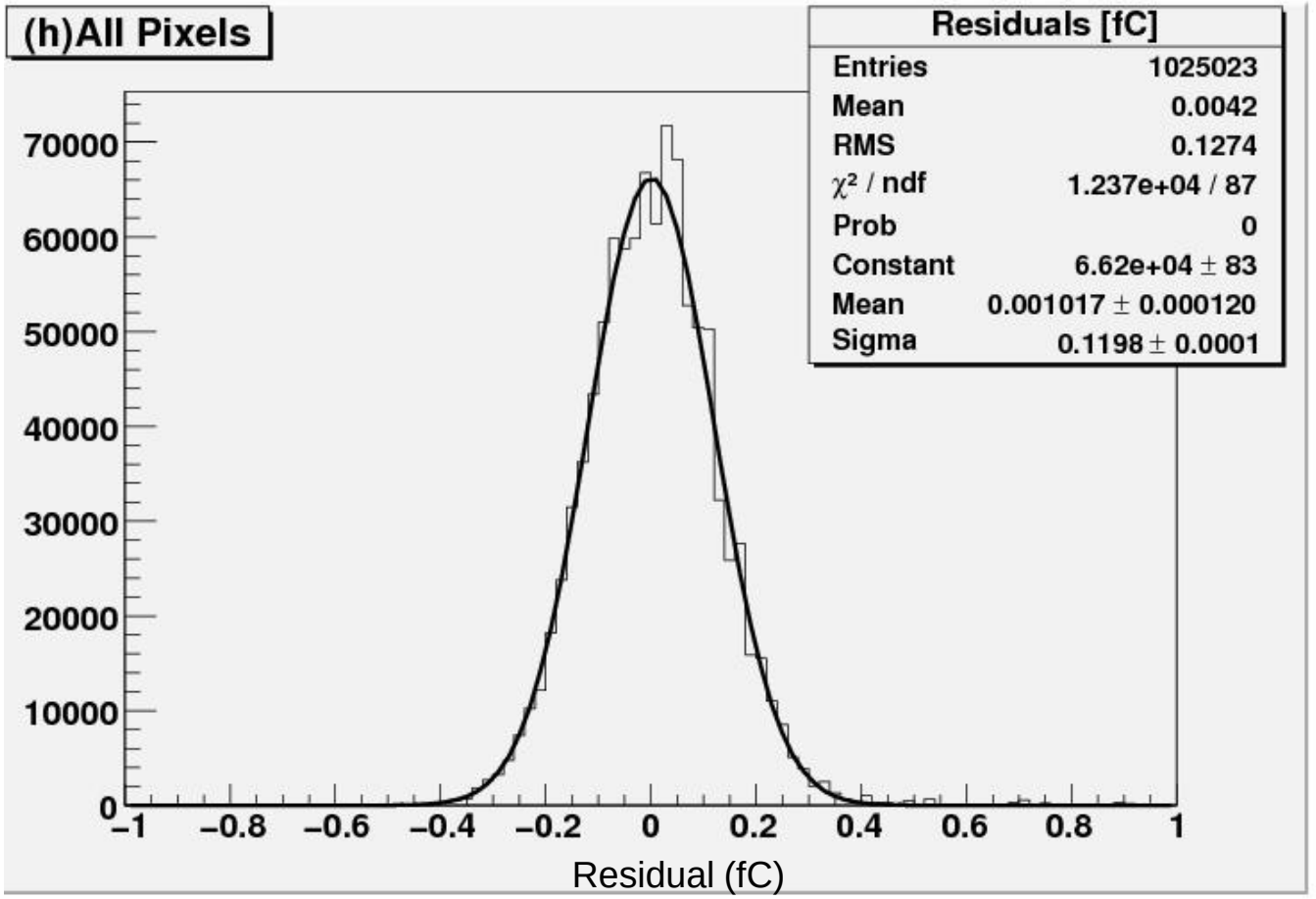
KPiX-Noise Summary (2)

- Residuals from fits of all the channels are histogrammed to the right.
- Sigma of Gaussian fit is 0.1198 fC (~750 electrons).
- Note that a MIP is ~25000 electrons.



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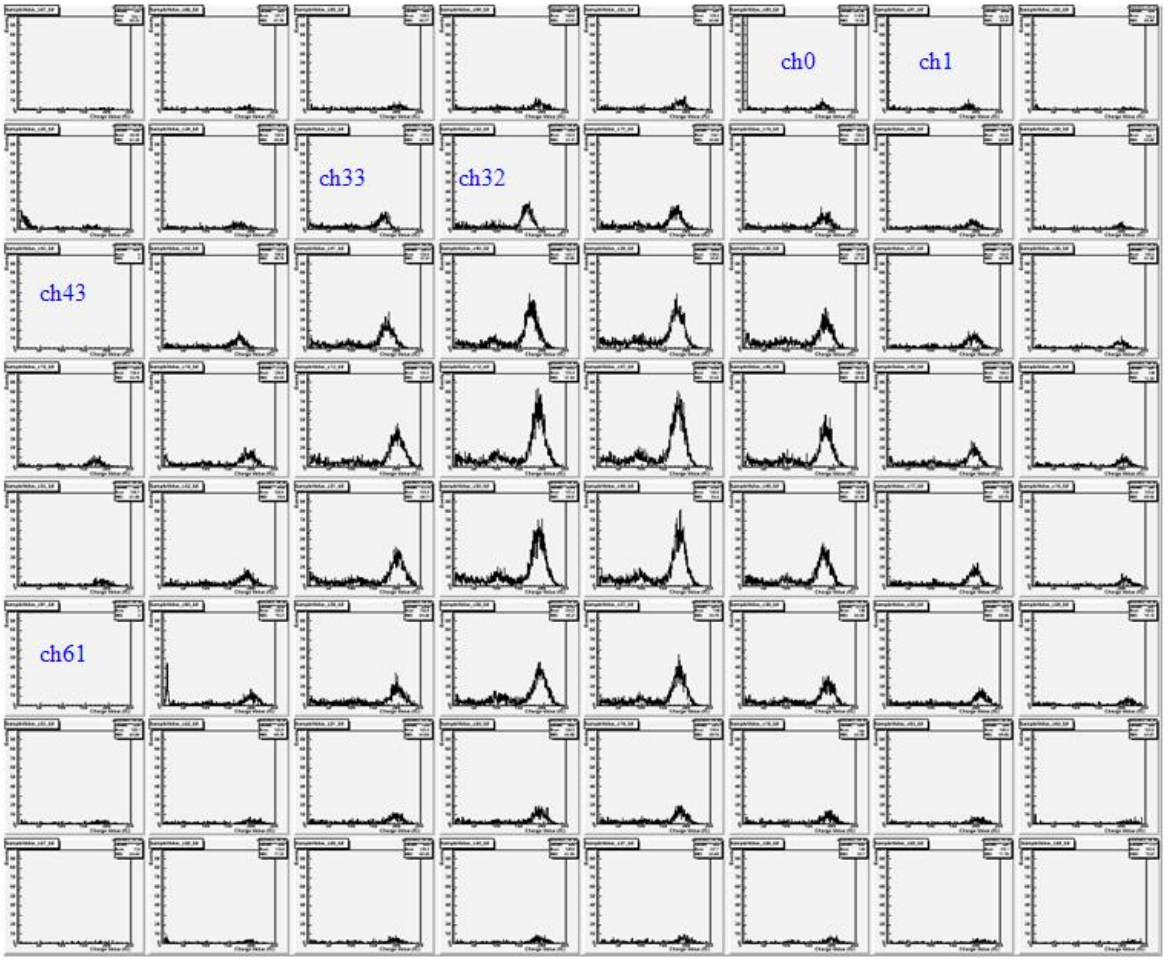
Fe55 Source and GEM

- 64 channels of a KPiX-7 are connected to GEM detectors.
- An Fe55 source is positioned over the GEM-KPiX apparatus.
- A histogram of measured charge is presented to the right (for each channel).
- Note the well-defined spectrum.
- These measurements were conducted by Seongtae at UTA.



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Summary and Future

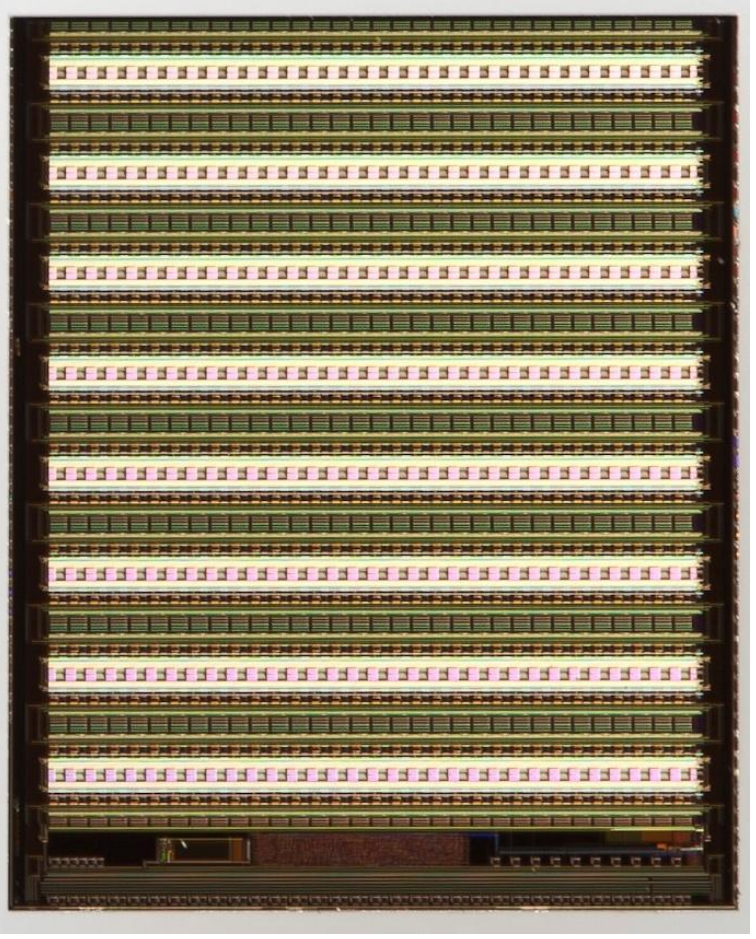
- KPiX is designed for use in SiD, but has applications outside of ILC.

- We are currently conducting tests of the 10th KPiX prototype.

- As demonstrated, tests are proving successful.

- Successful bump bonding to Si wafer will allow tests to be conducted on KPiX with capacitive load on all channels.

- Beam tests at SLAC could also be in the near future.



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