KPIX Status

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U.S. DEPARTMENT OF ENERGY
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SLAC NATIONAL ACCELERATOR LABORATORY

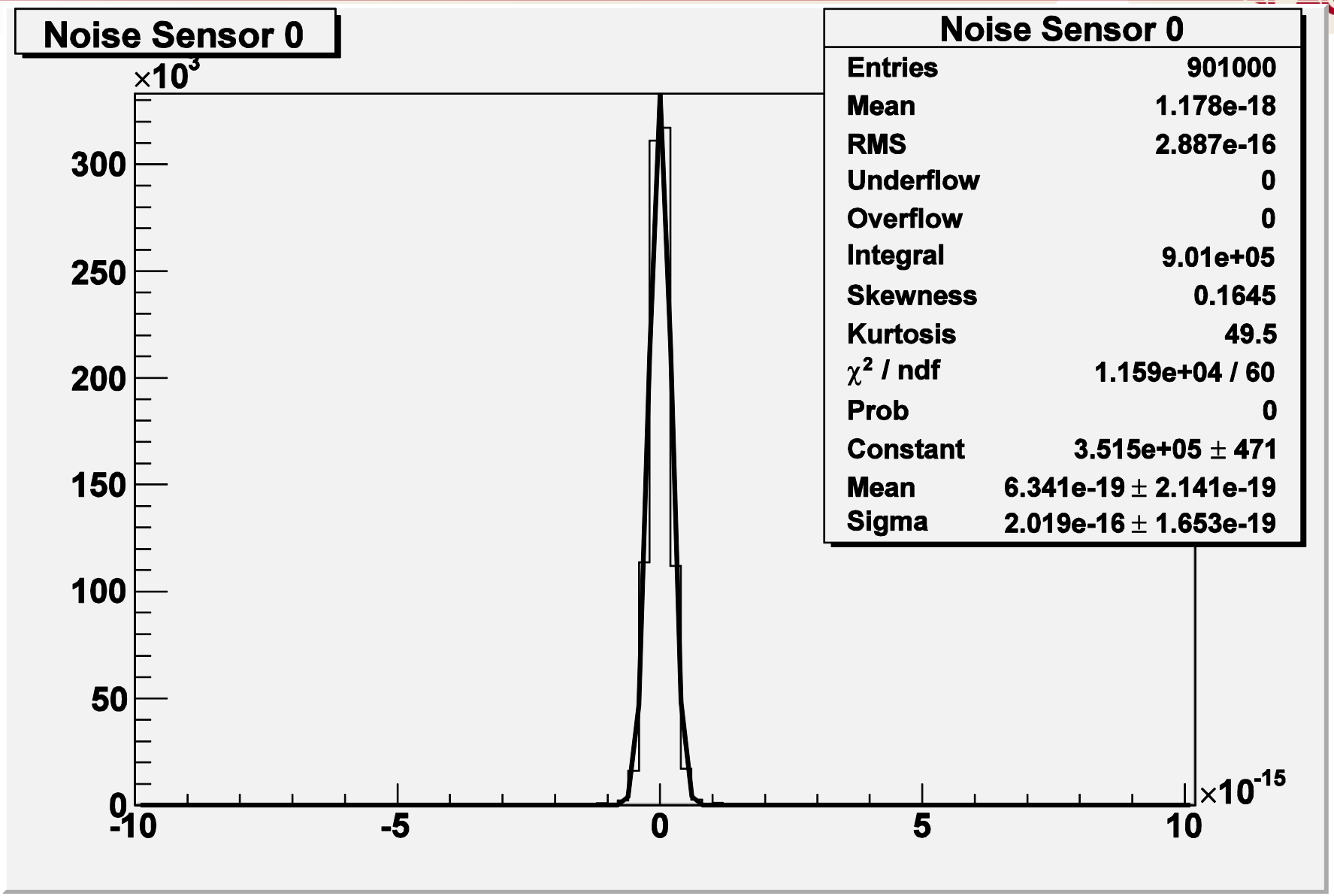
KPIX Status

- Bump-bonded 12 KPIX-A versions to Si pixel sensors for ECAL
- Bonded to cables
- Nine assembled in stack
- Used in test-beam
- Recorded lots of data
  - In general noise, linearity, etc good, but there are some performance issues to be addressed
    - Will show a couple of plots
- After that some performance issues (mainly crosstalk) will be discussed with possible solutions
- Followed by a list of requested design modifications (e.g. addressing during calibration, trigger threshold resolution)

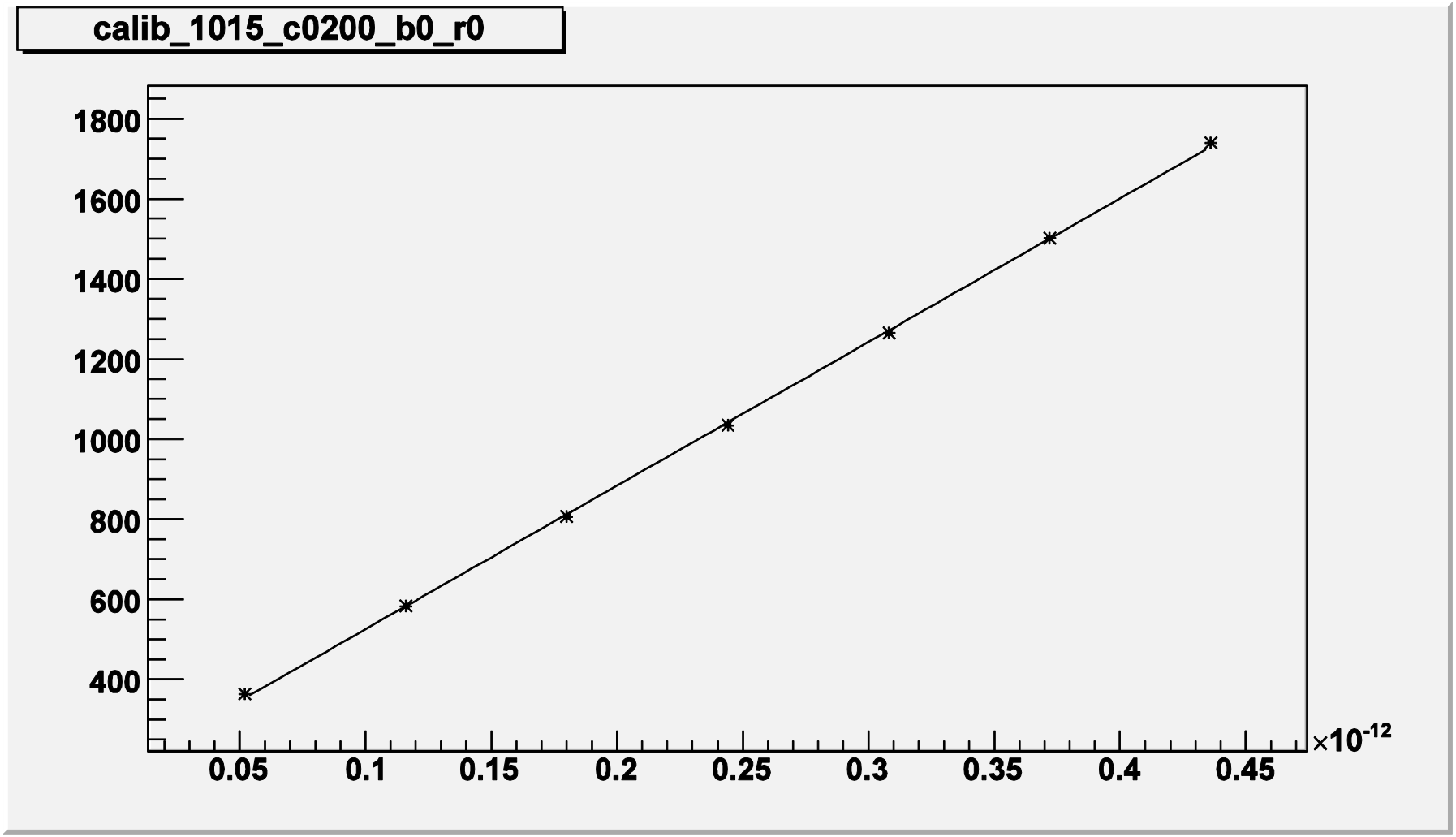
DAQ & Analysis

- Standalone DAQ exists for unit and beam tests
  - Current version supports 32-KPIX devices per FPGA
  - Both hardware and software is stable
  - GUI based
  - Python scripting support
  - XML configuration files with configuration stored with run data
  - Capable of receiving SLAC EVG fiber optic timing
- Offline and online analysis packages exists for data analysis
  - Both JAS and root support libraries exist
  - Libraries support both online and offline data sources

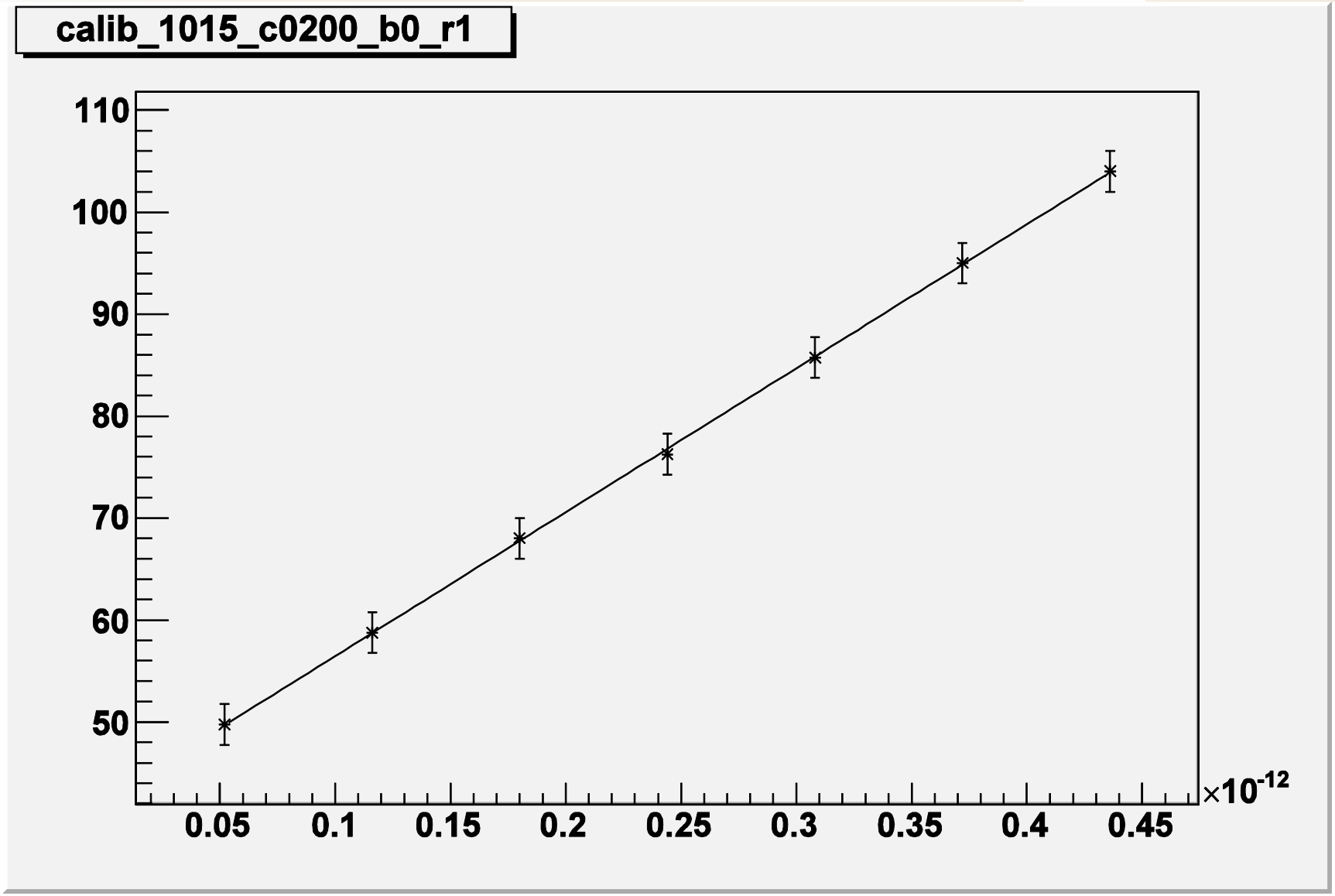
First some results



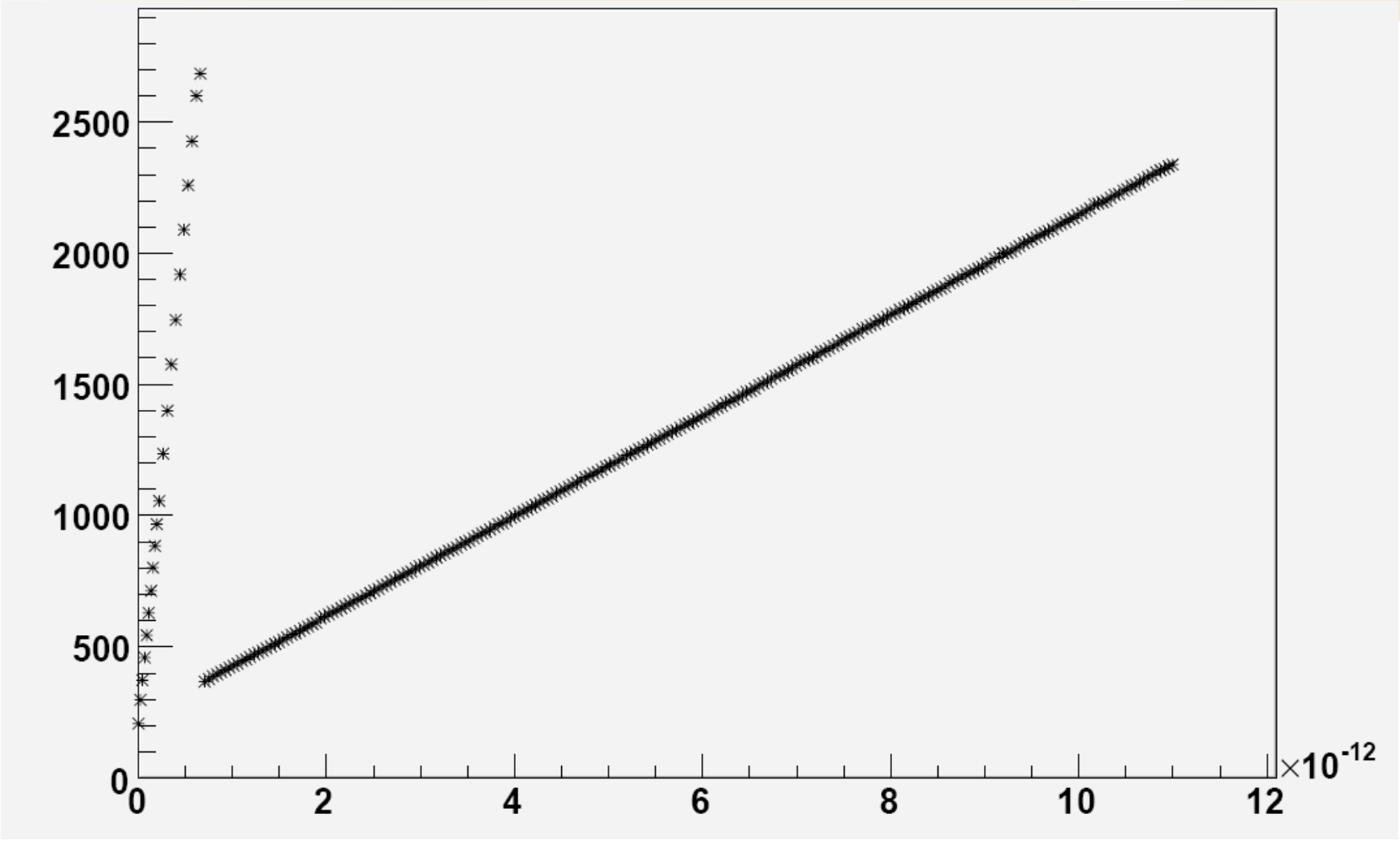
Normal Gain Calibration



Low Gain Calibration



Range Switch



Performance issues to be addressed: Cross-talk

- There are two types of crosstalk to other channels
  - In-time (at the same time as the channel receiving the signal)
  - Out-of-time (at the time when the reset on the primary channel occurs)
- Especially an issue for large events when many channels are hit, leads to “monster” events where most channels on KPIX are triggered
- There may be two types of out-of-time cross talk depending on the amount of charge collected on the detector and the number of channels involved.

In-time crosstalk

- Cause: parasitic capacitances on sensor between pixels (several pF, mainly due to traces on top of pixels)
  - Charge-amplifier has finite response time so signal deposited at input takes time of order 100 ns to be removed by the amplifier -> voltage transient at input node -> coupling to other channels
    - Causes other channels to trigger, but measured charge in ADC branch is very small or negative (since it is transient)
  - Discussions are ongoing whether this issue is acceptable in real running, but still plan to remove the crosstalk

In-time crosstalk

- Solutions
  - Reduce parasitic capacitances on sensor
    - Would require additional shielding metal layer, only where input traces cross other pixels
      - Being investigated, but might be difficult
  - Use knowledge of when signal arrives, make trigger sensitive only for a short duration in ~500 ns bunch crossing period
    - Would eliminate above crosstalk. Simulations show that one can gate shaper and comparator in a way to ignore transient signal.
    - Requires circuit modification in pixel and new submission
  - Increasing current in charge amplifier decreases crosstalk by reducing response time, but not a solution, trade-off with power dissipation

- There seems also to be crosstalk internal to KPIX when many pixels, e.g. most of a column, is triggered
  - Being investigate, might be due to trace coupling to trigger threshold voltage
    - Was already modified in KIPX-C (in-hand) but not measured yet

Out-of-time crosstalk

- Crosstalk that is apparently due to the switching (i.e. charge amplifier reset) in the KPIX
  - Again due to the parasitic input capacitances to other pixels, charge deposited at input of pixel being reset causes other pixels to trigger
  - At reset time, so usec's after driven channel receives charge at input
  - For events when there is signal charge in many channel (large events), can lead to "Monster" events, channels getting parasitically triggered and in turn trigger other channels when they are reset
    - "Monster" events appear to be related to internal KPIX structures
- Solutions
  - Reducing sensor coupling (see last slide)
  - Use knowledge when reset occurs to gate when channels are sensitive (-> from simulations)
    - Requires circuit change and resubmission

Additional change requests: Calibration

- Normally baseline in a channel is obtained in a calibration run by lowering threshold until channels trigger without any input signal (just noise)
  - Can't be done in current KPIX, threshold does not extend low enough
  - Also makes it hard to quantify threshold noise

- Request
  - Modify threshold DAC to be able to self-trigger on noise. At same time increase resolution of DAC to improve ability to measure efficiency of trigger

- Current calibration mode used to obtain gains and baseline:
  - Charge is injected one channel at a time using internal calibration capacitors.
  - All channels are triggered simultaneously using a "forced" trigger
    - Using the "self-trigger" mode is not a good option due to the crosstalk issue
  - But forcing all channels simultaneously seems to result in different baseline when extrapolating to 0 input signal
    - Large events where multiple channels are triggered simultaneously may suffer similar baseline shift

- Request
  - Add masking in each pixel so "forced" trigger can be applied to single (or arbitrary pattern) of pixels.
  - Modify calibration DAC, already addressed above

Summary

In general good results, works as intended but

- several requests for modifications to address performance issues discovered during test-beam
- seems to be all doable but need additional ASIC fabrication run

Credits

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