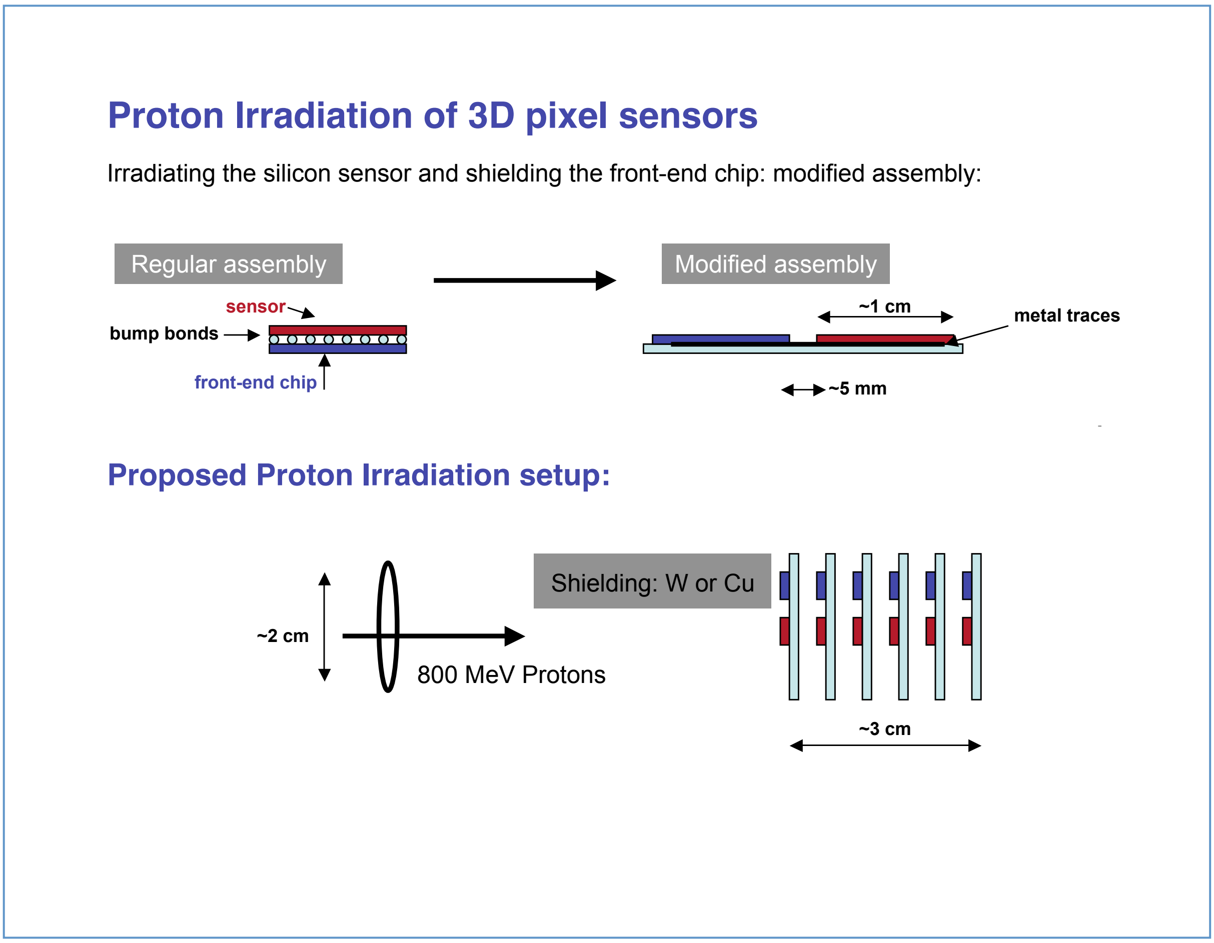
Systematic Tests of 3D sensors for irradiation

Notes from Per Hansson (last update 22/07/09)

The irradiation to super-LHC fluencies, >10^16neutron equivalent, of 3D sensors will take place at Los Alamos. The sensors are still done using the FE-I3 electronics that is built to withstand fluencies up to 10^15 neutron equivalent. In order to circumvent this problem C. Kenney is producing a special setup in which the FE-I3 are not, as normally is the case, located directly on top of the sensor but some distance away so that shielding of the electronics is possible. To do this a special carrier board in is fabricated which connect the sensor read-out with the FE-I3.



Proton Irradiation of 3D pixel sensors

Irradiating the silicon sensor and shielding the front-end chip: modified assembly:

Proposed Proton Irradiation setup:

Figure from C. Kenney

Here are some notes on the type of tests that can be performed in order to characterize these modified boards. These notes are based on the systematic tests done for the sensors being considered for the May test beam 2009 by Alessandro La Rosa and Ole Rohne. Please give any feedback on missing tests or details on how to perform the measurements. It can also be noted that full characterization, which is essentially the test suggested below, will be necessary if we want to put them into the test beam later and it is very good to have the FE configuration files from this characterization to compare with.

General comments

- Remember to load the FE calibration constants prior to any measurements involving charge injection and remember to save the configuration files as they are produced.
- Use Pixel's ModuleAnalysis (a ROOT application) wherever applicable, store key plots for documentation.
- The tuning targets are expected to depend on actual sensor capacitance/
  noise and signal yield. For the Stanford-3D we've traditionally used:
    - threshold: 3200e-
    - time over threshold: 60ToT at 20000e-
    - For the custom made boards the noise is expected to be higher. The threshold might have to be increased?
    - Not all 2880 pixels are connected with the custom boards and needs to be taken care, how?, masks in TurboDaq?

Critical tests before irradiation

These tests are considered critical in order to be able to draw any conclusions from the irradiation and also to establish that a specific chip is functional (enough) in order for it to be useful in the irradiation.

FE register check

In order to configure the FE correctly run a quick test of the registers.:

- Run a Digital Test SRAM, verify that the number of hits read-back is 100 for the connected pixels

Leakage current measurements

- Run an I-V scan if GPIB is available. Otherwise manually sample the bias voltage with 2-3V steps and measure the leakage current. Remember to stop after the approximate breakdown voltage is established.
- Run a monleak scan which measures the leakage current for each pixel individually. **NOTE** that the IF dac value has to be set to IF=1, the resulting scale should be 1DAC≈125pA.

We need to find a (HV) power supply for the bias voltage. It needs to reach 60-70V. If there is a GPIB then TurboDaq can be used automatically to measure the I-V curve.

All the above is done at room temperature?

Threshold tuning & noise measurement

This procedure both adjusts the threshold but measures the noise when validating the thresholds in the scan:

- Start with default (as they are before loading any configuration): GDAC=?, TDAC=64, FDAC=4
- Run Threshold Scan- Internal Cal, get initial thresholds

- Adjust GDAC and re-run Threshold Scan- Internal Cal. until mean over all pixels is approximately at the target value
- Run TDAC Tune – Internal-Cal to tune the threshold for each pixel separately
- Move the resulting TDAC tuning file into the tdac/ folder and load it
- Verify with a Threshold scan that the threshold dispersion is now small (how small?) and note what the noise is.

Noise versus bias:

Measurement of the noise vs bias voltage is important and can be done manually by running a threshold scan (which also reports the noise from the S-fit) for each bias voltage

- Preferably select the configuration with the adjusted TDAC and GDAC given above
- Run a threshold scan-Internal-Cal for each step of high voltage. Stop close to breakdown voltage

Source Test

The source tests are the only way of checking for disconnected bumps and to check the full chain. There are several options

- Am241 and Cd109 gamma source tests used in self-triggered mode. Run source scans long enough to acquire at least 15-20 hits in the least hit pixel to avoid declaring pixels as disconnected or dead
- Sr90 beta source test in self or external trigger mode (latter can give the Landau response) Depending on if we want to check any efficiency or calibration then we need to use external trigger e.g. scintillator trigger. This requires some work usually.

List of sources available?
Scintillator for external trigger?

Non-critical tests before irradiation

These tests are considered non-critical in the sense that if time do not permit there is no catastrophe if these tests are not done before sending the sensors to irradiation.

Time over threshold tuning

- Run a FDAC Tune Initial Scan (don't save any histograms or results) to get initial ToT measurements
- Change the IF manually and repeat the above scan until the ToT mean is reasonably close to the target ToT
- Run FDAC Tune Internal Cal to tune the feedback current foreach pixel separately
- Move the resulting FDAC file to the fdac folder and load it
- Verify the tuning with a FDAC Tune Initial Scan
- One can re-evaluate the thresholds as they can be slightly affected by the ToT calibration

ToT calibration

This calibrates the ToT response for a given injected charge for the configuration created in the above steps:

- Run ToT Calibration Internal-Cal CLow
- Run ToT Calibration Interal-Cal CHigh

The reason for running CHigh is that timewalk measurements might be important in the test beam later on?

Timewalk measurements?