My Contribution to the Testing and Characterization of the CMS Prototype 3D Silicon Pixel Detectors

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Introduction

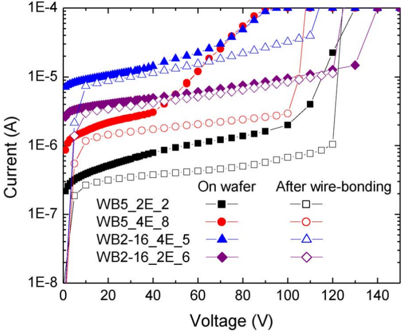
This presentation is to go over my contribution to the characterization and test results of the 3D silicon CMS Pixel detectors at Purdue University.

Software

- Set up local server to store pixel information.
- To avoid data loss that had happened with previous tests I created a redundant backup system both local and on the Purdue network.
- Created a MySQL database on the server that was interfaced through a custom written GUI for the storage of the data.
- All calculations and plotting automatically done with C++, root, and Perl.

Before/After Wire-Bonding

- All of the measurements that I personally did were after wire-bonding.

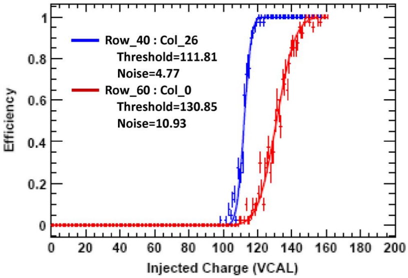


Comparing with the previous measurements done by measuring on the wafer we were able to see that there was an improvement across all the modules after wire-bonding. This is because when the sensors were tested on the wafers only a temporary metal layer was used to connect the columns led to extra leakage current.

I-V Measurement

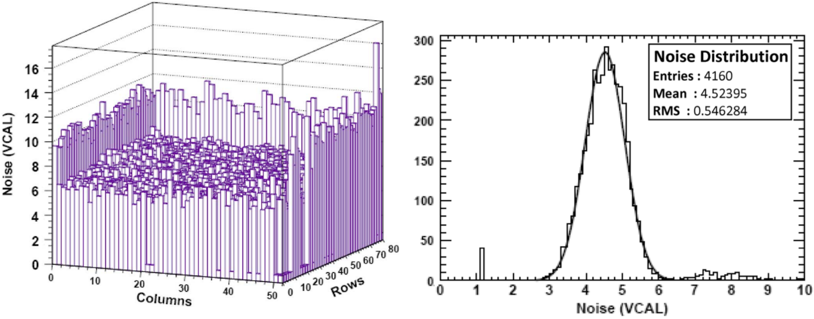
- On the ROC measured each pixel response for a set bias voltage.
- For each pixel I fit the IV curve to an S-curve (step function convoluted with a Gaussian).
- From the slope of the S curve at efficiency of 0.5 we calculate the equivalent noise charge (ENC).

$$ENC = \frac{1}{\sqrt{2\pi}}\frac{1}{s} \tag{1}$$



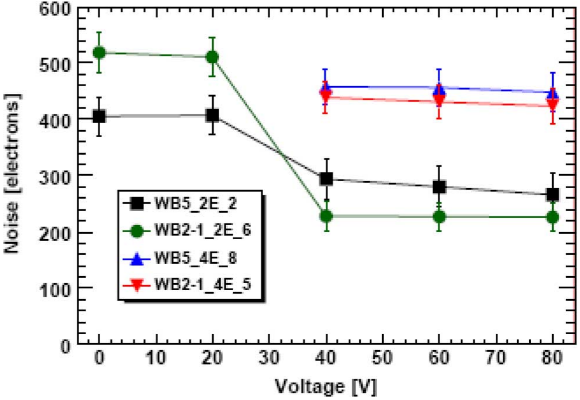
Noise

- After finding the ENC for each pixel the distribution is fit with a Gaussian.
- (1 VCAL = 65.5 electrons)

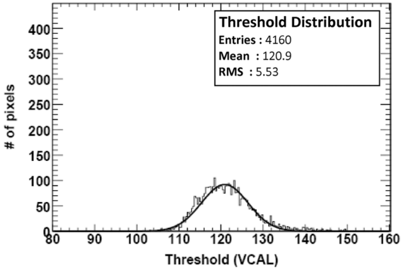


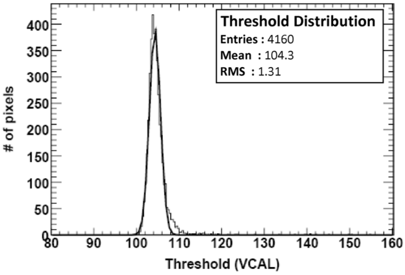
Bias Voltage

- Additionally you can calculate these values for varying bias voltages.
- We found that up till 40 V there is significant improvement but afterward the improvement levels off.



- The threshold is the voltage where efficiency equals 0.5 on the IV curve.
- This was measured both with and without trimming.





Conclusion

- The conclusion from my measurements with others in the group was that the signal to threshold (S/T) ratio for these detectors is around 3
- For the Super LHC you need a S/T ratio of around 4 in midlife and around 3 at the end of life so there needs to be more improvement in the noise for these types of 3D pixels to be acceptable.