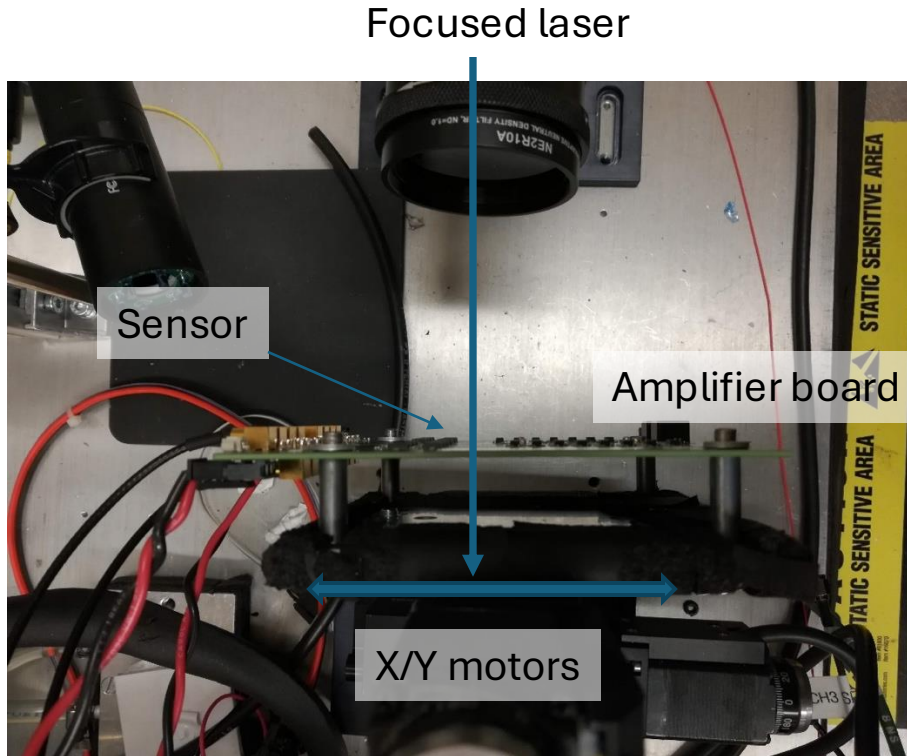




**AC-LGAD sensor irradiation
tests update**

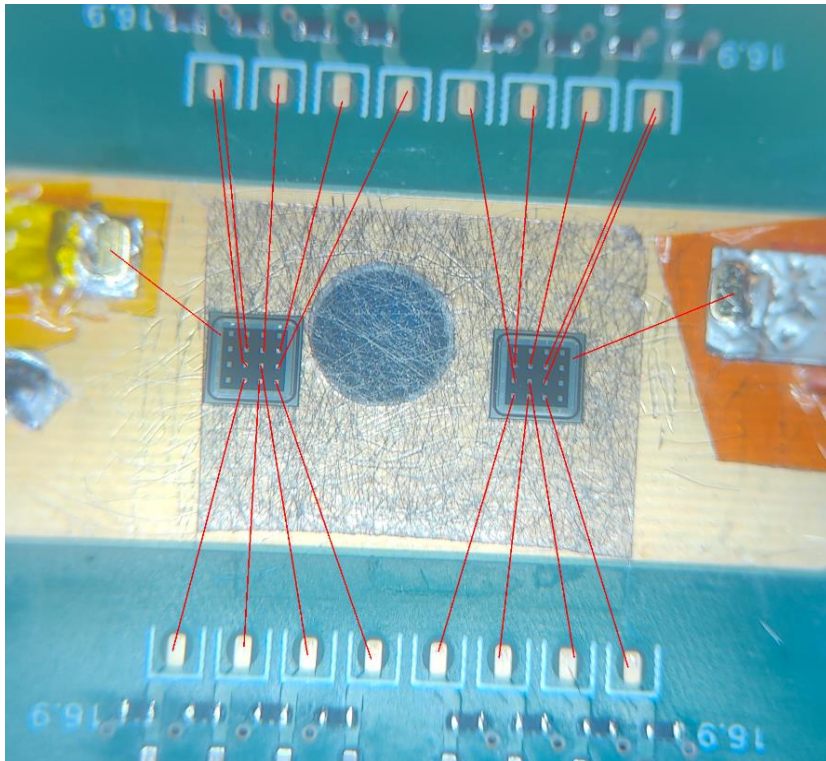
Sensor testing – Laser TCT setup



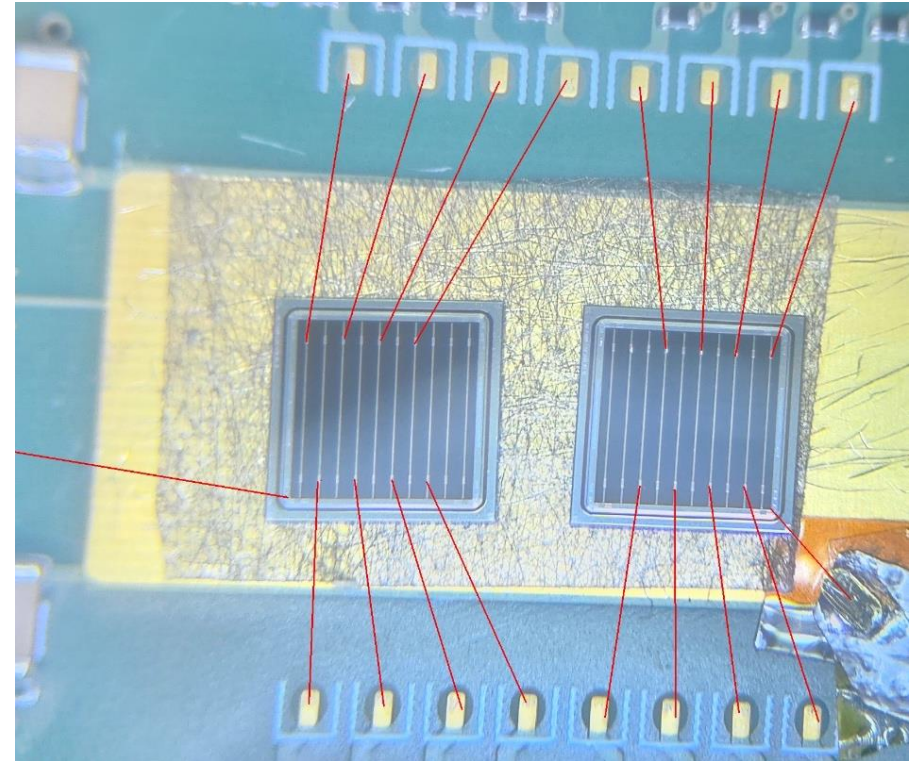
- Sensors are mounted on a multi-channel analog amplifier board with bandwidth ~ 1 GHz
 - Response is readout by a fast oscilloscope (2 GHz/20 Gs)
- **IR & Red lasers** mimics charge deposit of particles
 - Standard particulars lasers: 400ps pulse duration
 - New Katana10 laser: 35ps pulse duration
 - Focused beam spot width of < 20 μm
 - Metal structures of the sensors are not transparent to IR so no response can be seen when laser is on top of metal
- Amplifier board is mounted on X/Y moving stages
 - **Charge injection as a function of position**
- Cooling setup in place: 100W Peltier cell and liquid chiller heat exchanger
 - **No precise temperature control for now, working on it**

Measurements Taken

- TCT laser scans on strips and pixels with low irradiation compared directly with non-irradiated counterpart
 - For pixels, was only able to measure irradiated sensor



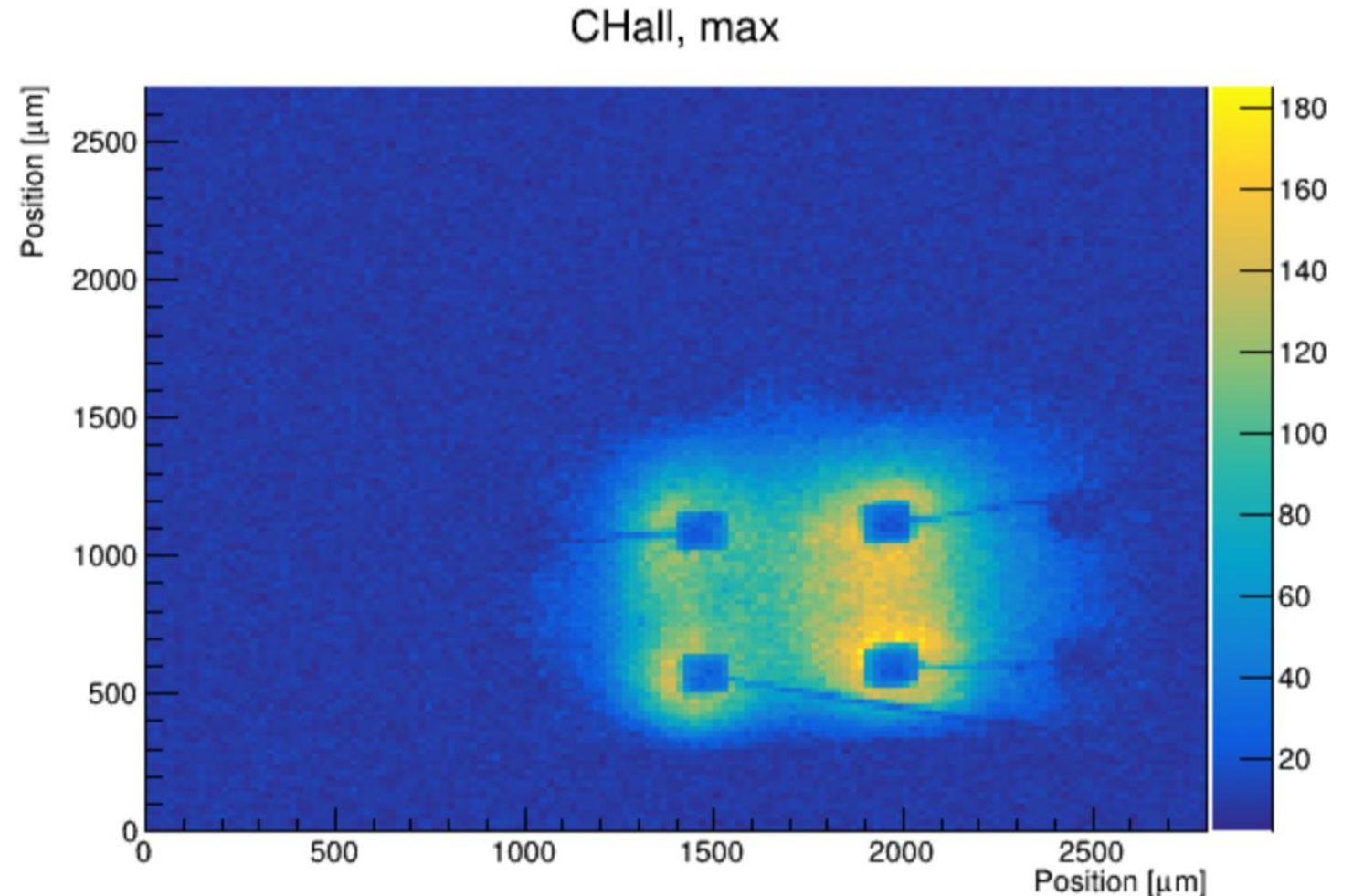
HPK W9 pixel 4x4, 500x150 (1e12Neq)



HPK W2 strip 0.5 cm, 500x50 (1e14Neq)

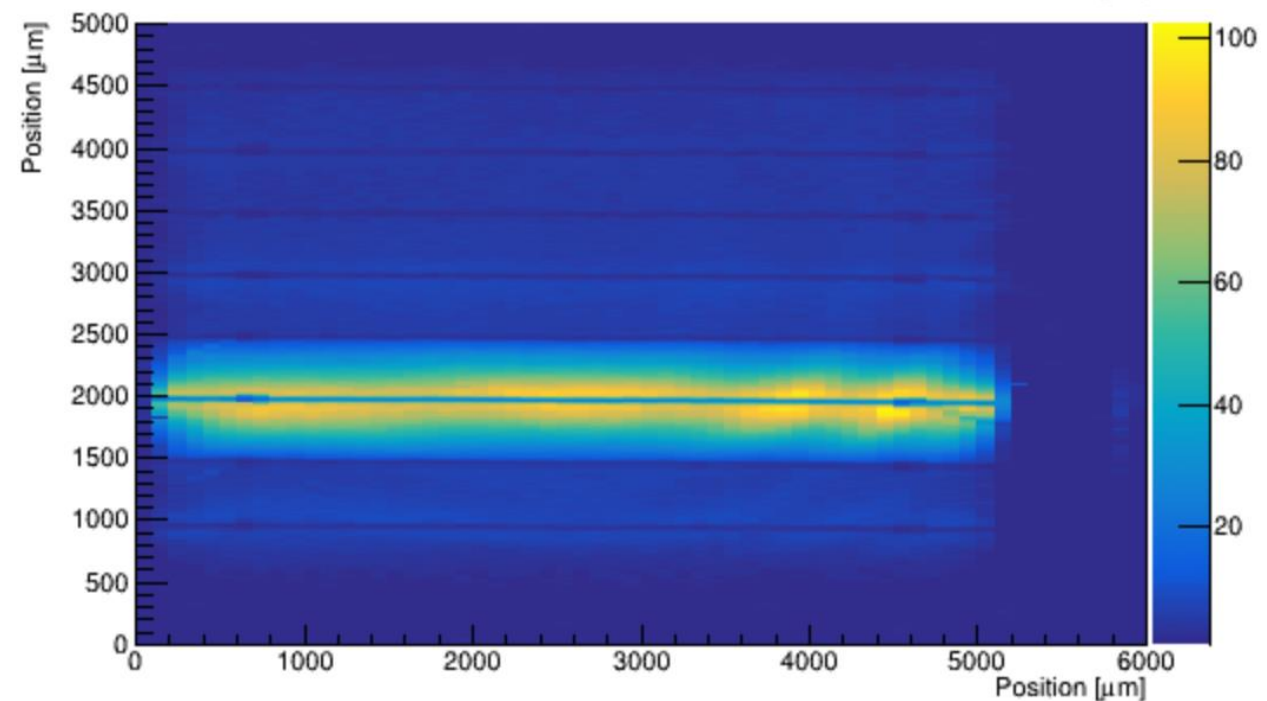
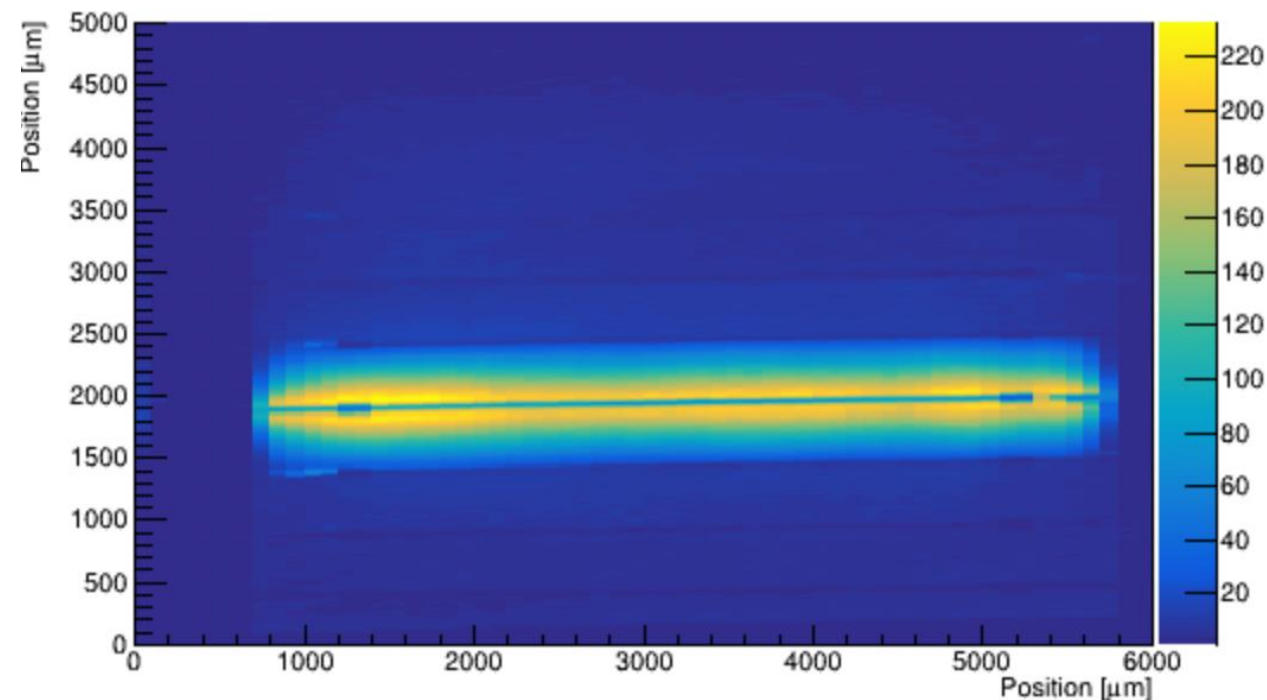
HPK W9 pixel 4x4, 500x150, 1e12Neq

- Took measurements on the irradiated sensor, but unable to do a direct comparison with the non-irradiated counterpart
- 2D Scan with katana laser at 200V
- Inhomogeneous distribution between the pads; some pads have higher pulses than others



HPK W2 strip 0.5 cm, 500x50 Before/After $1e14\text{Neq}$ Irradiation

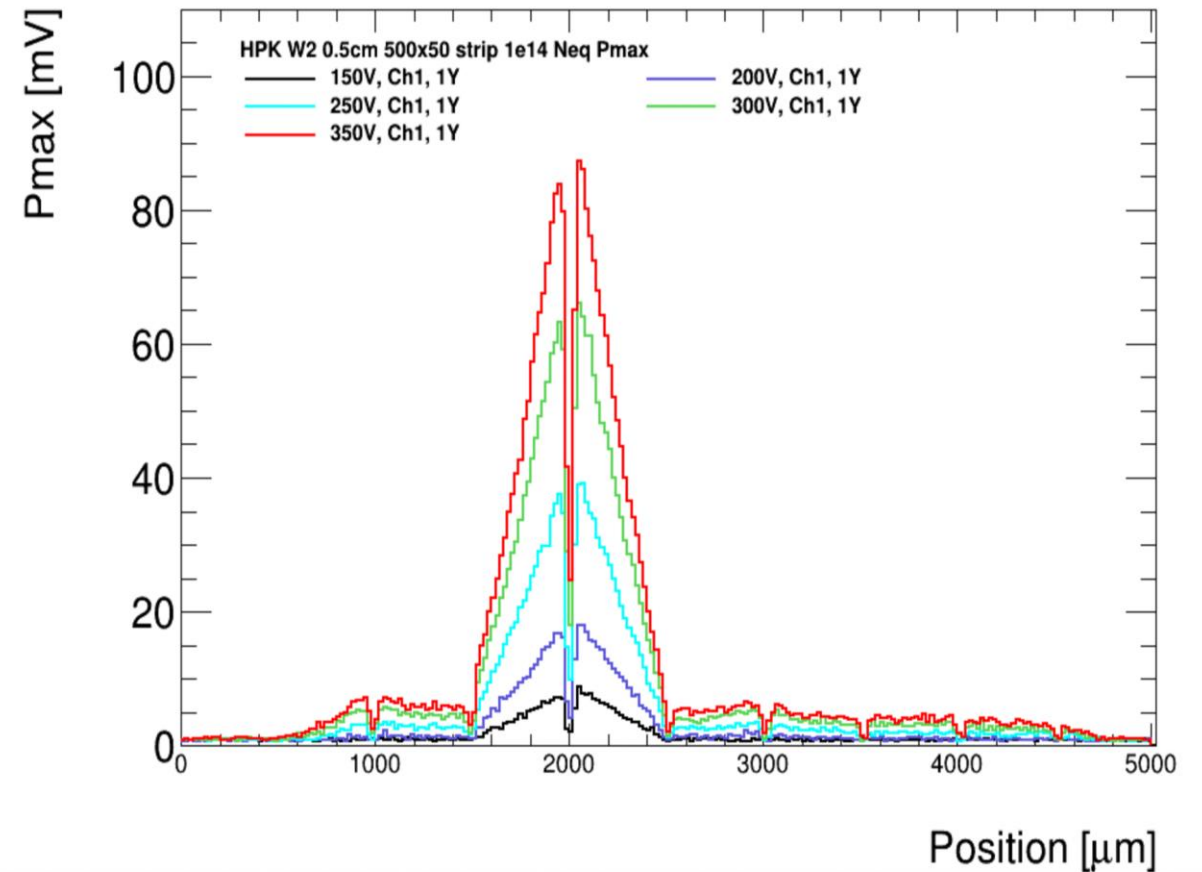
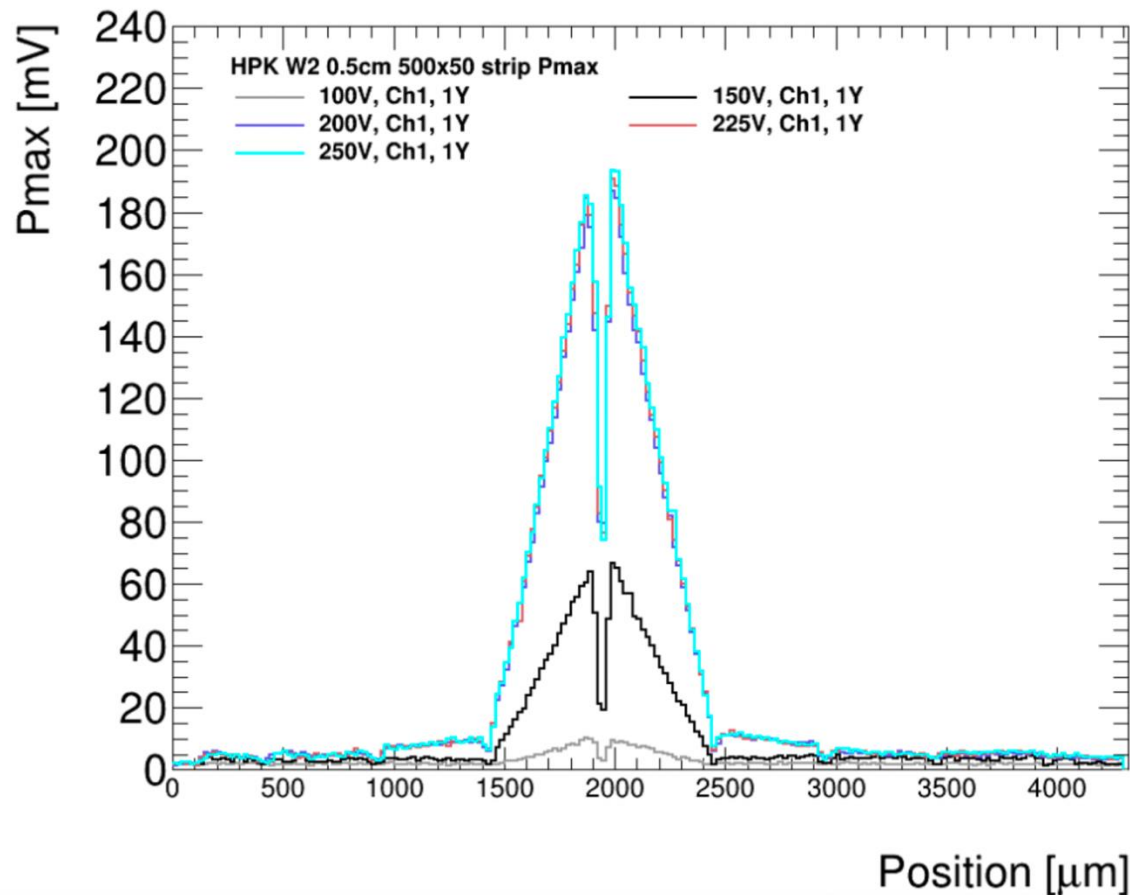
- Top: Before Irradiation
 - 2D scan taken with katana laser at **250V** (breakdown for non-irradiated sensor)
- Bottom: After $1e14\text{Neq}$
 - 2D scan taken with katana laser at **350V** (breakdown for irradiated sensor)
- Cooling setup was in place for these measurements
- Cut off wire bonds on non-irradiated sensor to increase voltage for irradiated sensor until breakdown
- Able to take measurements at multiple voltages to compare the sensors



HPK W2 strip 0.5 cm, 500x50

Pmax at Multiple Voltages

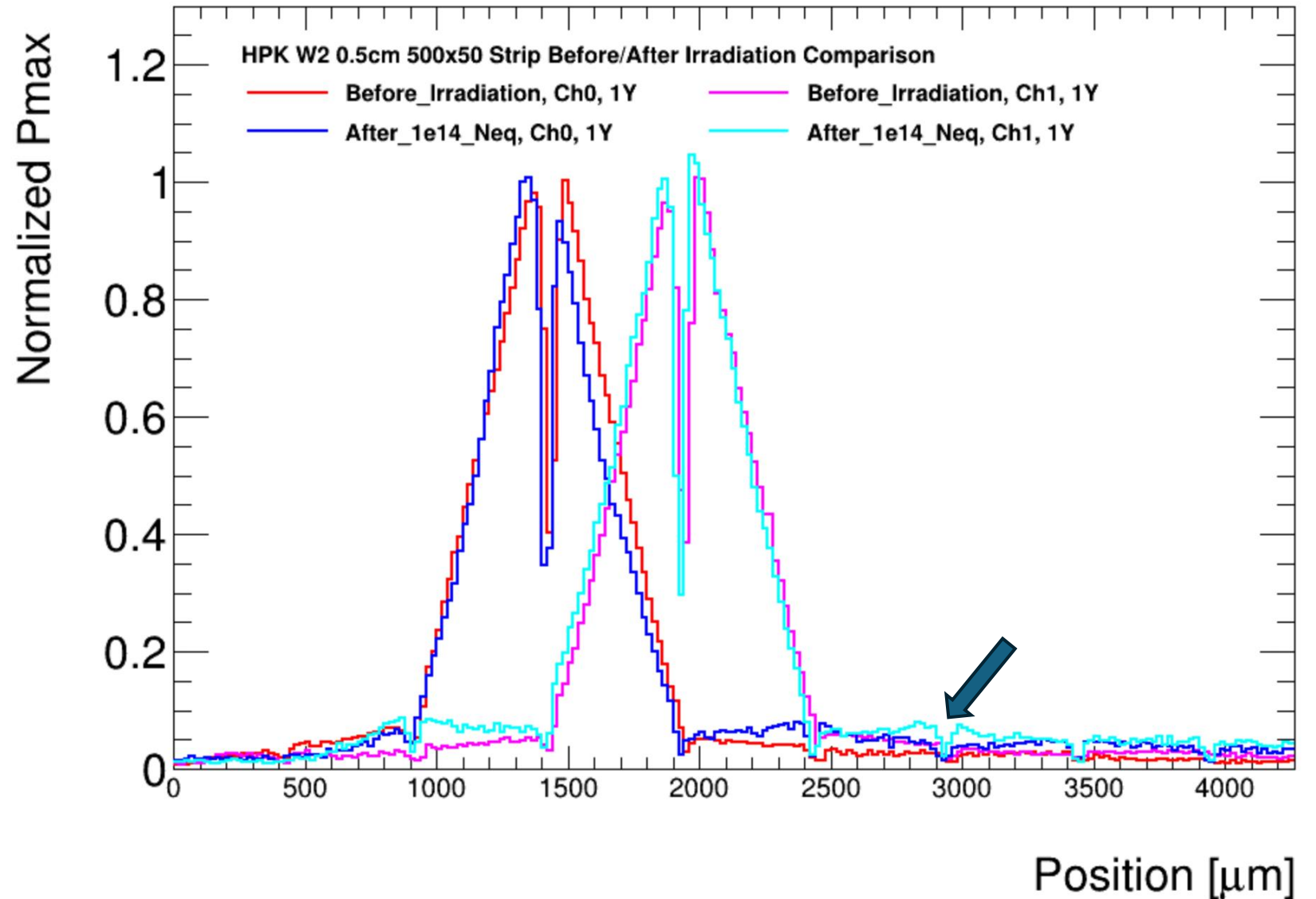
- Measured non-irradiated sensor from 100V to 250V, and irradiated 150V to 350V
- Pmax of both sensors increase with voltage until breakdown



HPK W2 strip 0.5 cm, 500x50

Charge Sharing Comparison Before/After $1e14$ Neq Irradiation

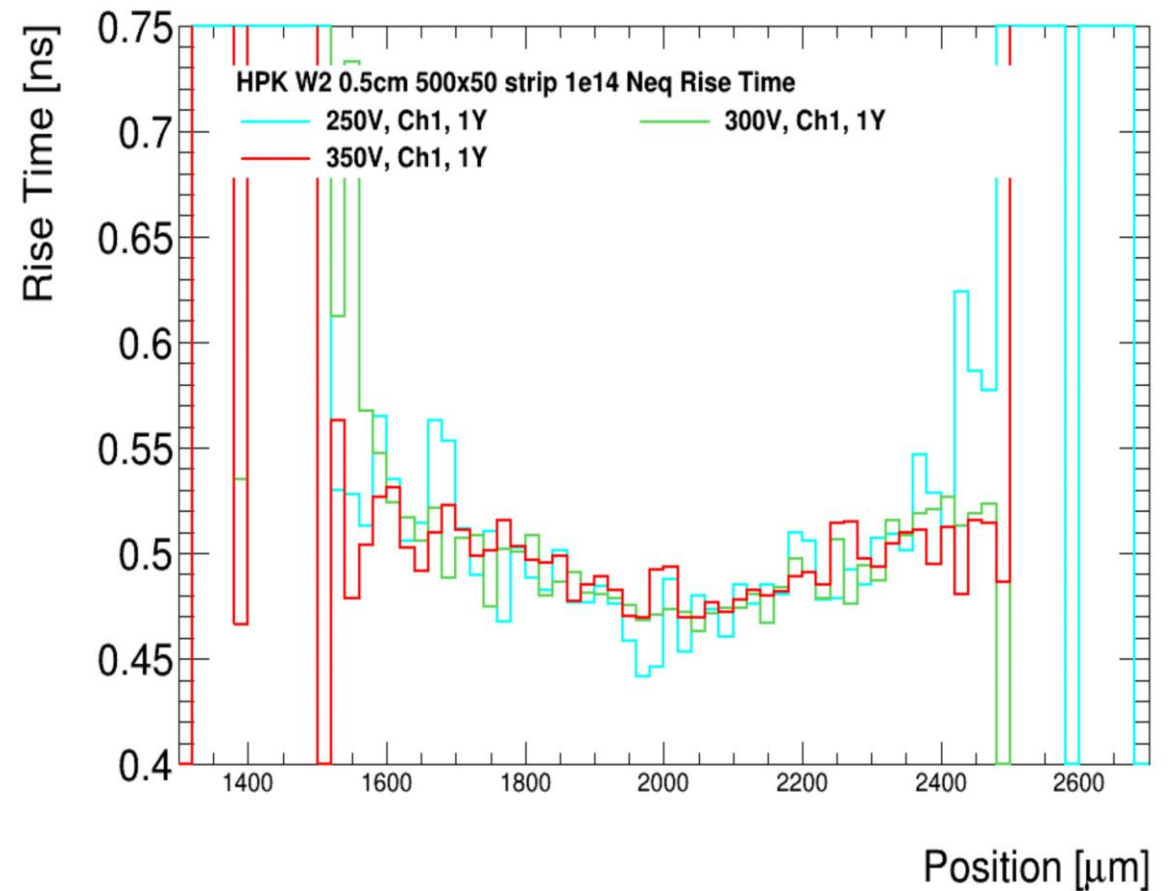
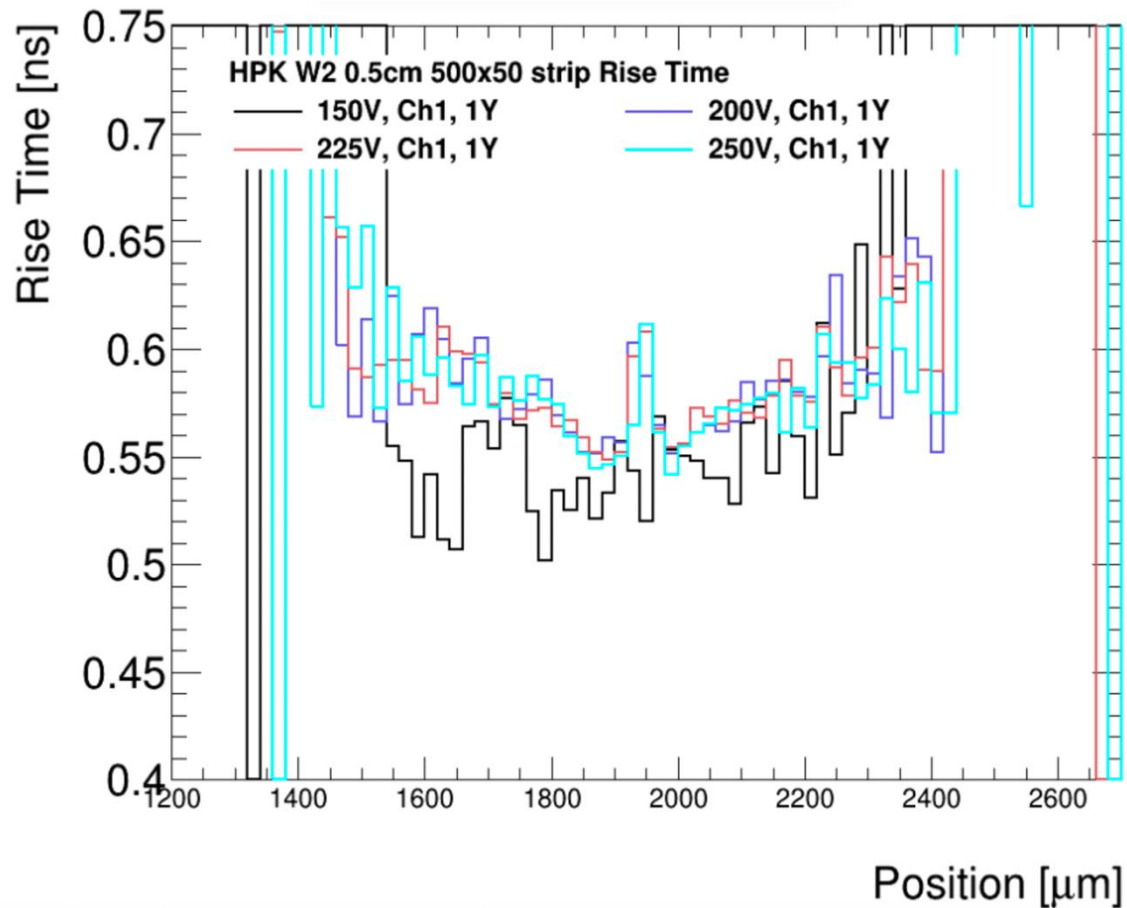
- Charge profile is nearly identical
- Discrepancy on the tail, where we observe a “bump” in the charge sharing after the first neighbor



HPK W2 strip 0.5 cm, 500x50

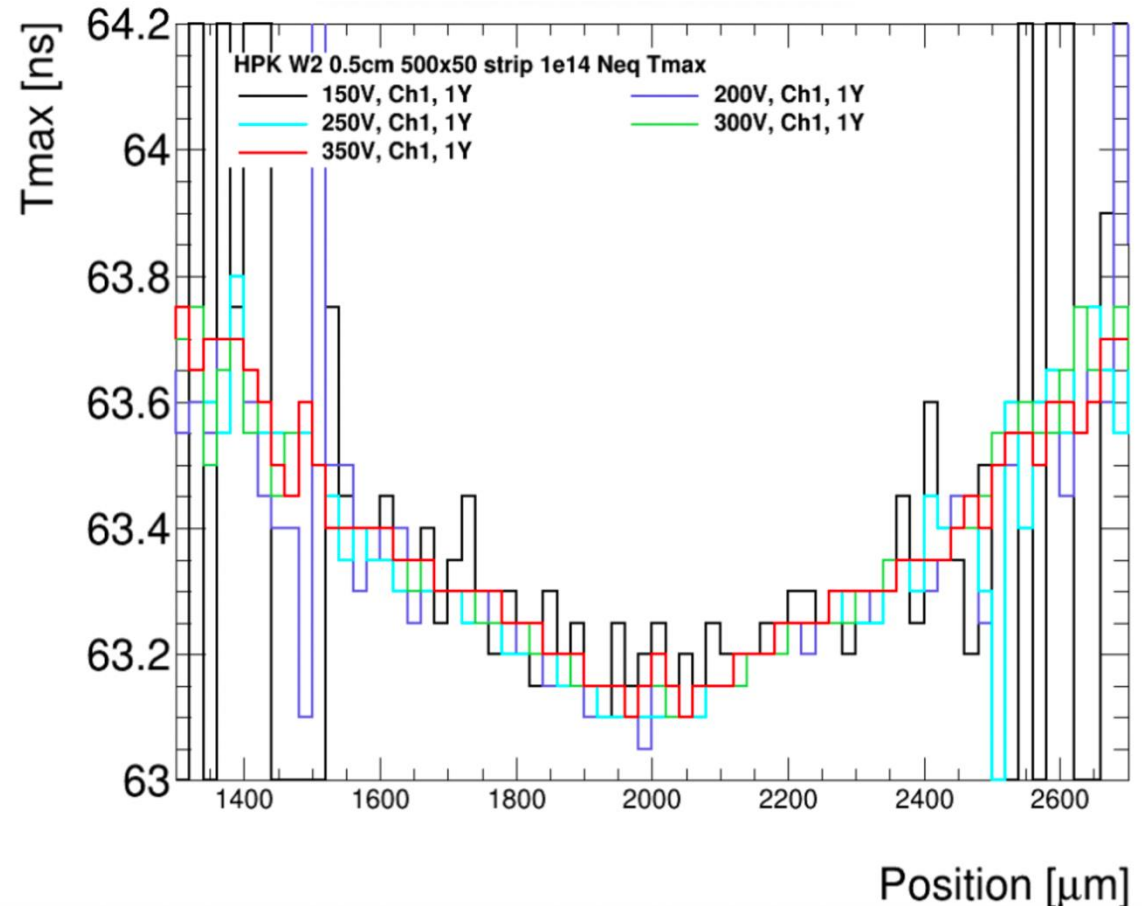
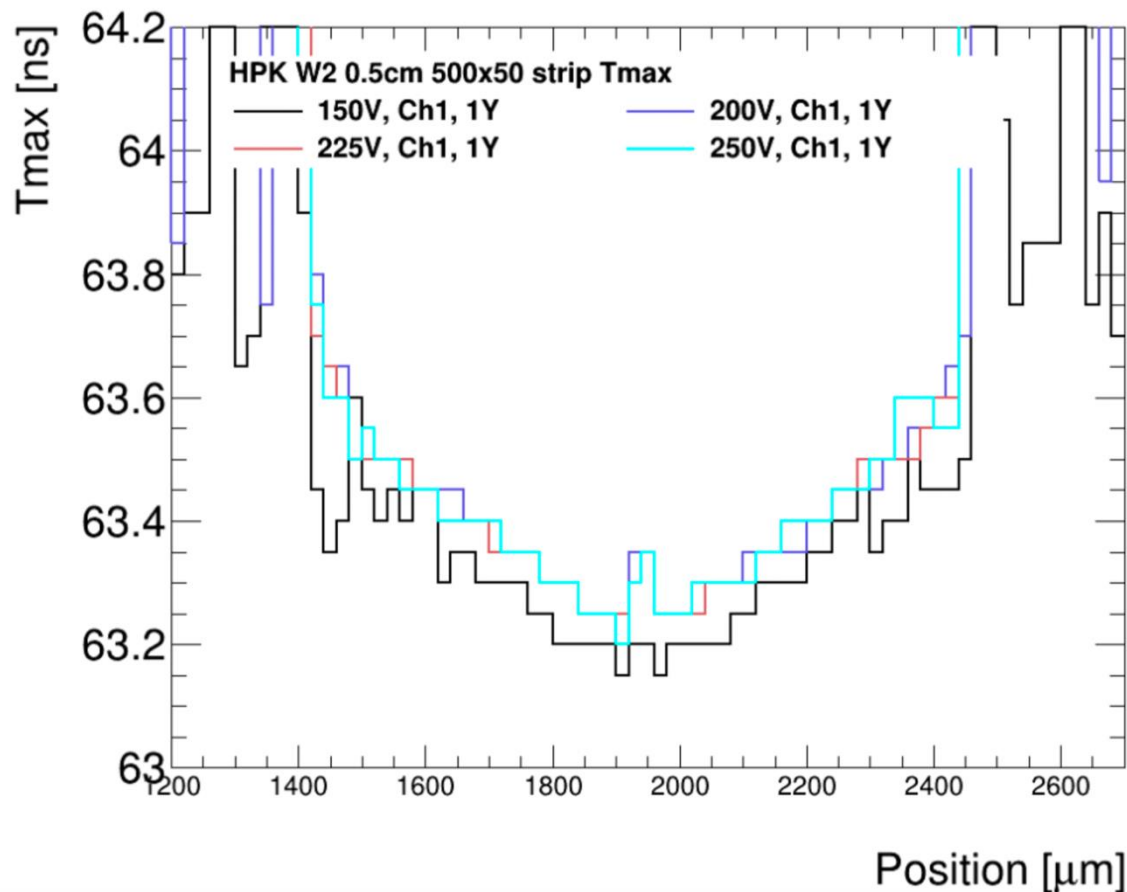
Rise Time at Multiple Voltages

- Near breakdown, the rise time is about the same for both sensors
- In general, the rise time of the irradiated sensor is lower than the non-irradiated



HPK W2 strip 0.5 cm, 500x50 Tmax at Multiple Voltages

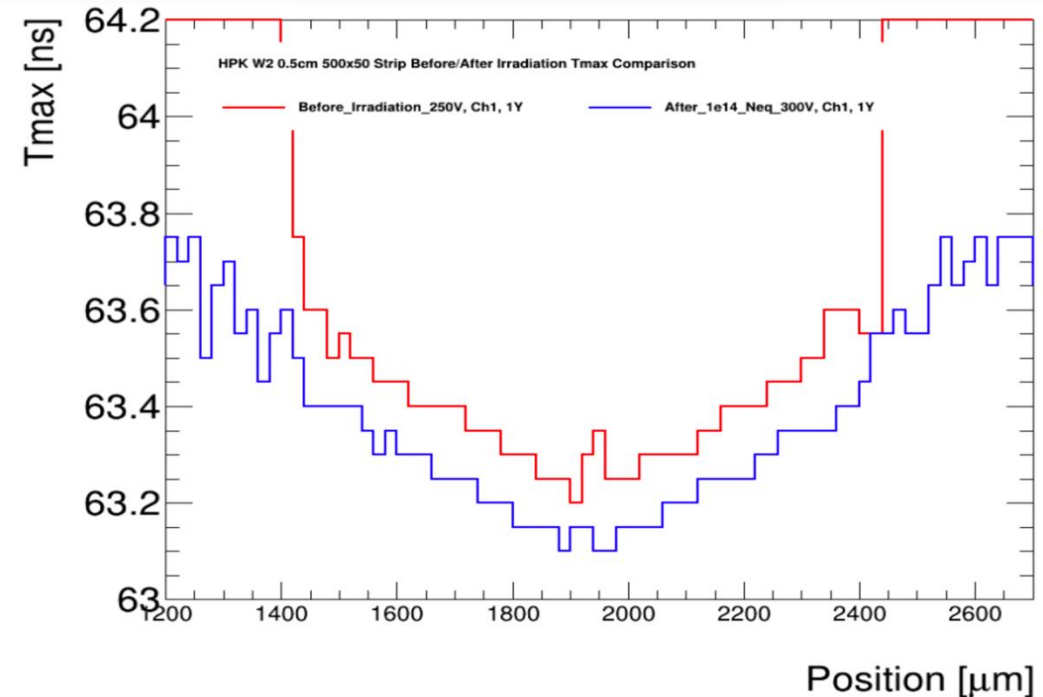
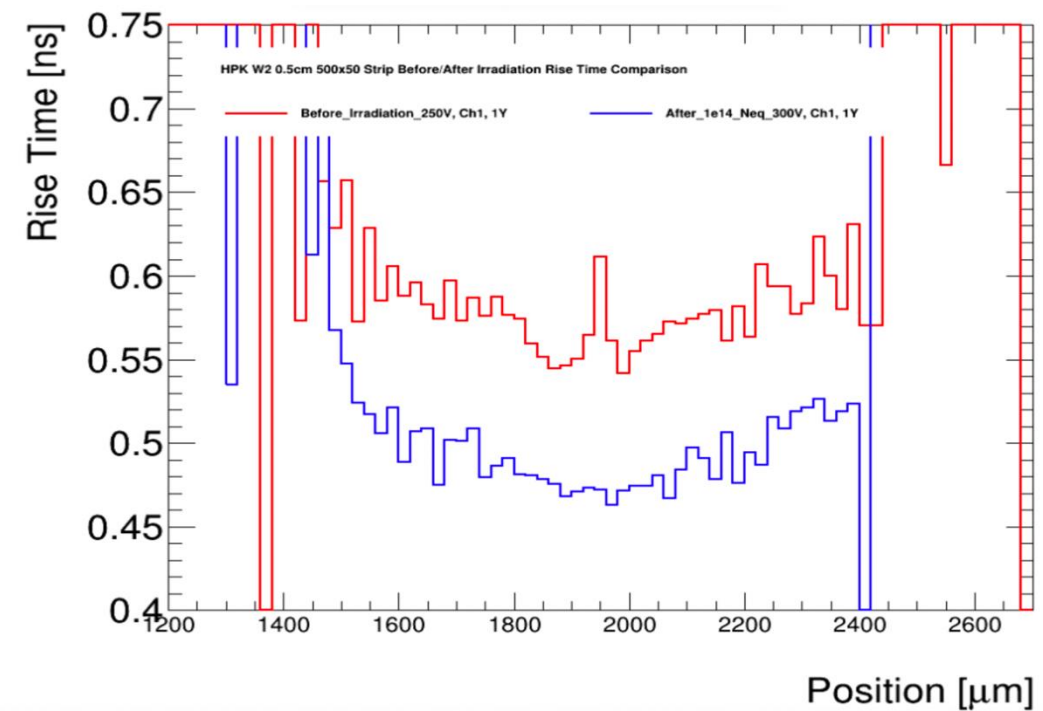
- Tmax of irradiated sensor is the same at all voltages, and appears to be lower than that of the non-irradiated sensor



HPK W2 strip 0.5 cm, 500x50

Rise Time and T_{max} Comparison Before/After 1e14Neq Irradiation

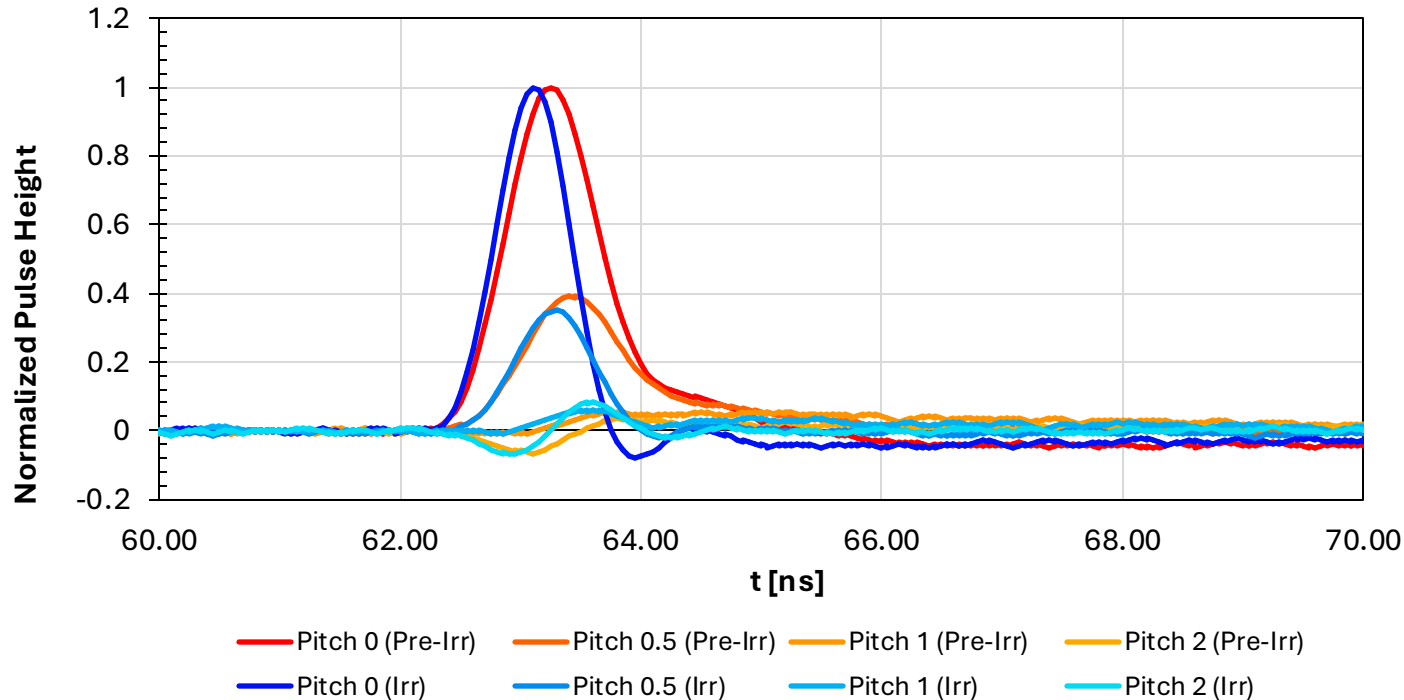
- Compared measurements of non-irradiated sensor at 250V with irradiated sensor at 300V
- Irradiated sensor has a lower rise time (~480 ps) than the non-irradiated counterpart (~560 ps)
- T_{max} of the two sensors also differs by about 80 ps, with the irradiated sensor having a lower T_{max}



HPK W2 strip 0.5 cm, 500x50

Normalized Pulses Comparison

HPK W2 0.5cm strip, 500x50, Normalized Pulses Before/After Irradiation

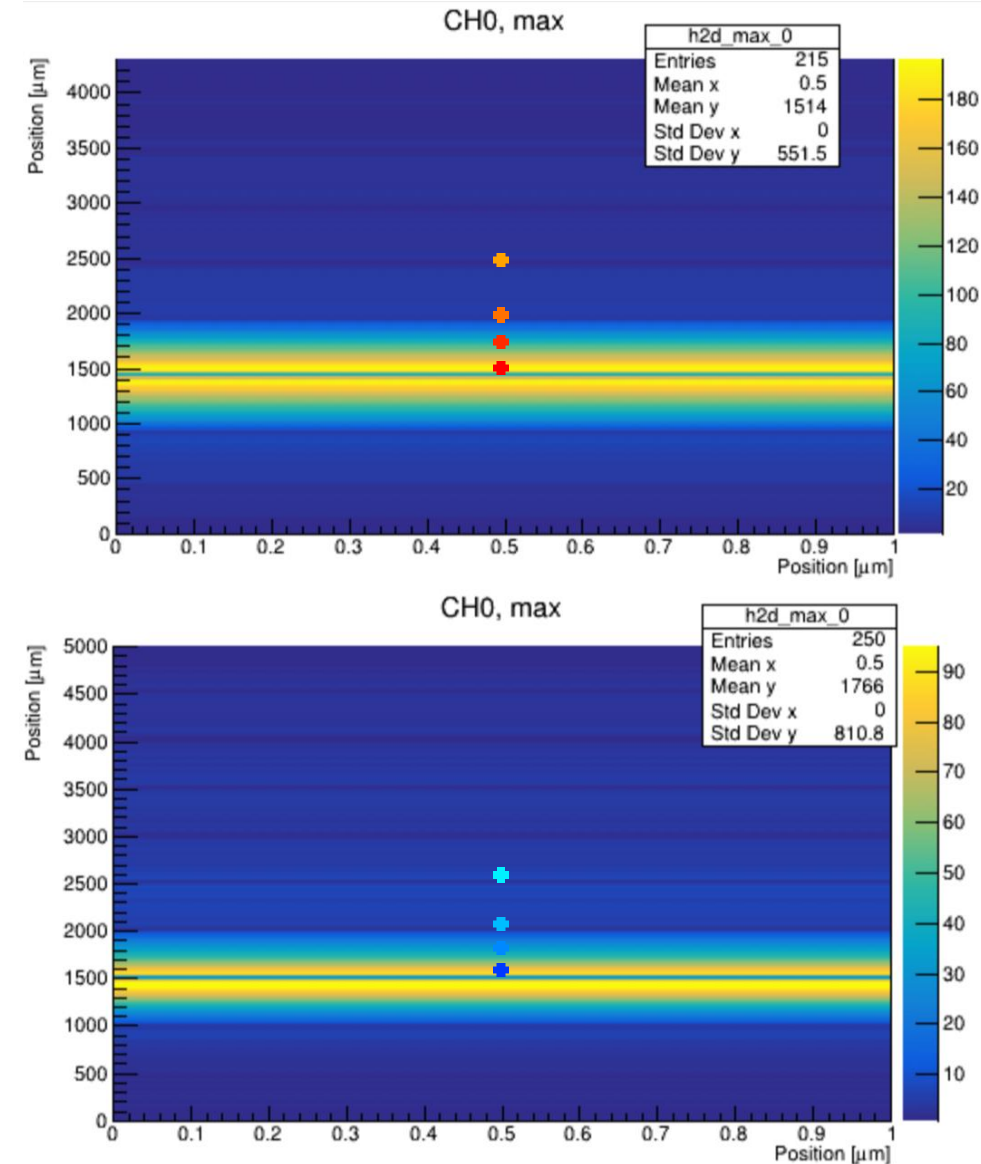


- Compared pulses at the main strip and two neighbors after, along with a pulse taken between the main strip and first neighbor for each sensor
- Irradiated sensor generally has a shorter pulse compared to the non-irradiated sensor

Top: Non-Irradiated Sensor

Bottom: 1e14Neq Sensor

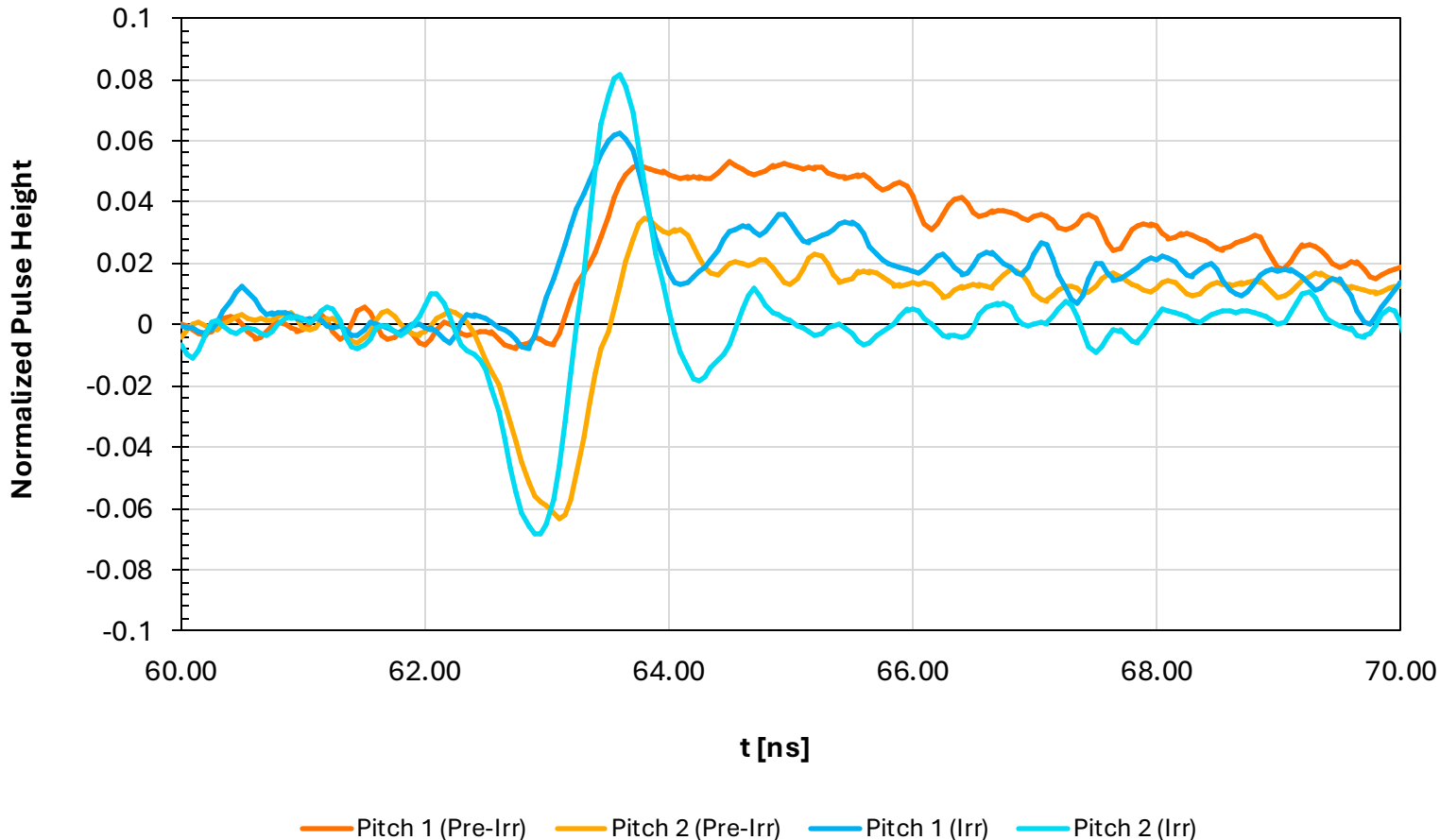
Colored symbols represent the locations that the plots were taken at



HPK W2 strip 0.5 cm, 500x50

Normalized Pulses Comparison (Zoomed In)

HPK W2 0.5cm strip, 500x50, Normalized Pulses Before/After Irradiation



- Comparing the waveforms at the first and second neighbors for each sensor
- Still see that the pulses on the irradiated sensor reach its peak faster than the non-irradiated sensor
- Shape of the pulse is also different
 - Non-irradiated: pulses rise, then fall steadily after the peak
 - Irradiated: distinct rise and fall once it reaches the peak

Conclusion

- Laser TCT measurements to directly compare a non-irradiated sensor and its counterpart at low irradiation
 - Pixels: Inhomogeneous distribution with neighboring pads
 - Strips: Lower Rise Time and T_{max} overall
- Main distribution of charge sharing profile is the same, but there's a deviation after the first neighbor where the irradiated sensor has a "bump"
- Irradiated sensor has a shorter pulse compared to the non-irradiated sensor, and pulse shape changes after the first neighbor as well
- Observations made from one set of measurements; will need to take additional direct comparisons with other sensors to check if the behavior is consistent