Annealing Studies with Irradiated p-Type Strip sensors

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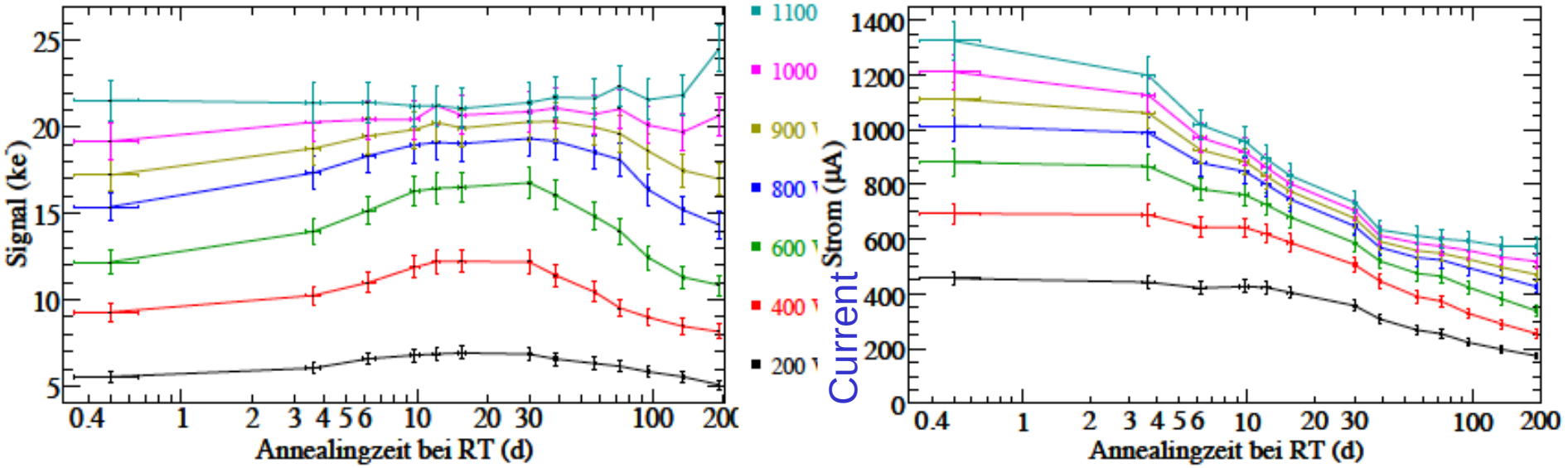
Study carried out by Adrian Driewer as part of his Diploma thesis

Ingredients

- Sensors
  - Miniature n-in-p strips, 320µm thick, made by Hamamatsu
  - Part of “ATLAS 07” production
  - Irradiated to 1.1×10^{15} N_{eq} in Karlsruhe
  - V_{fd} about 1000V
- Annealing study
  - 3 Sensors at 3 annealing temperatures (Room Temperature, 40° C, 60° C)
  - Many annealing steps
  - After each step
    - take IV-curve (normalise to 20° C)
    - measure CCE (using ALIBAVA system with 90Sr-source) at different V_{bias} from 200V to 1100V

Signal and Current

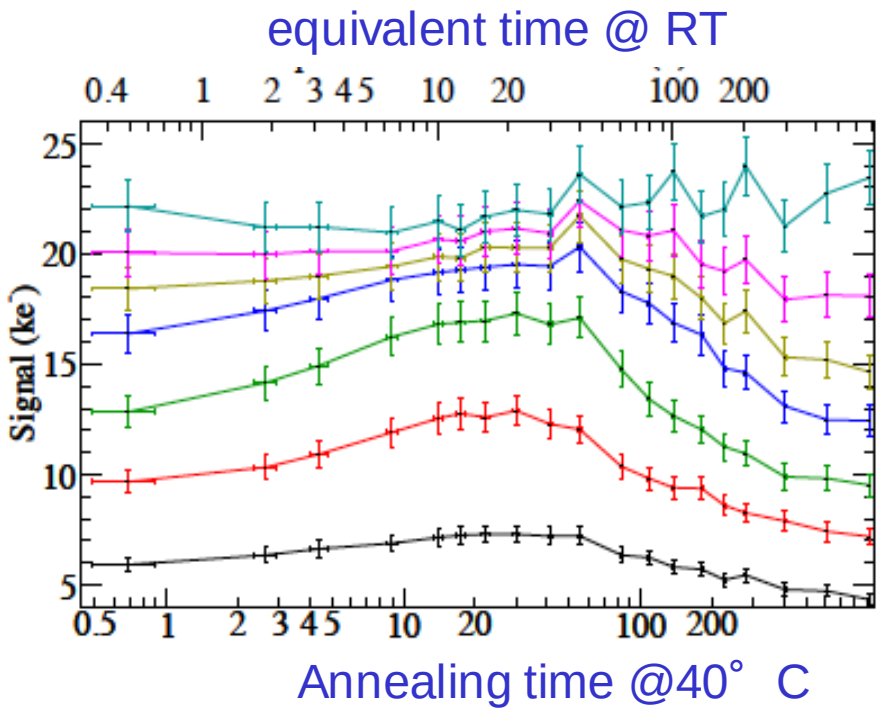
- Annealing at Room Temperature (RT)
- Beneficial annealing, followed by reverse annealing (esp. at lower V_{bias})
- Charge multiplication at highest V_{bias}

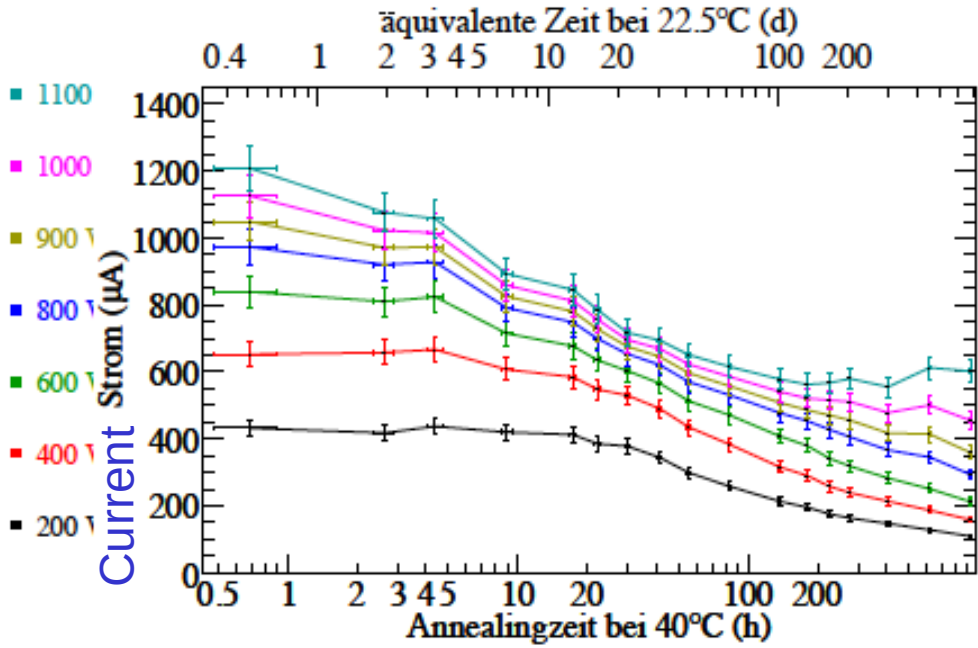


Annealing time

Signal and Current

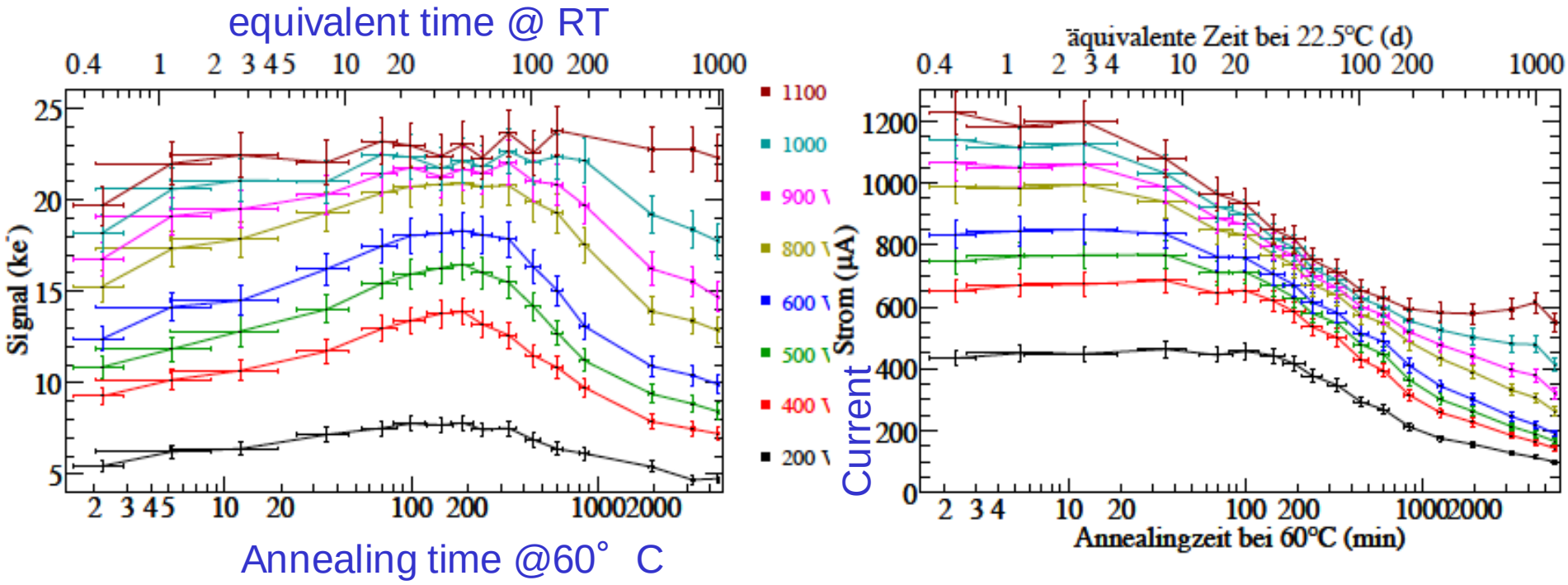
- **Accelerated annealing at 40° C (time scaled to RT using RD48 Model on this and following plots)**





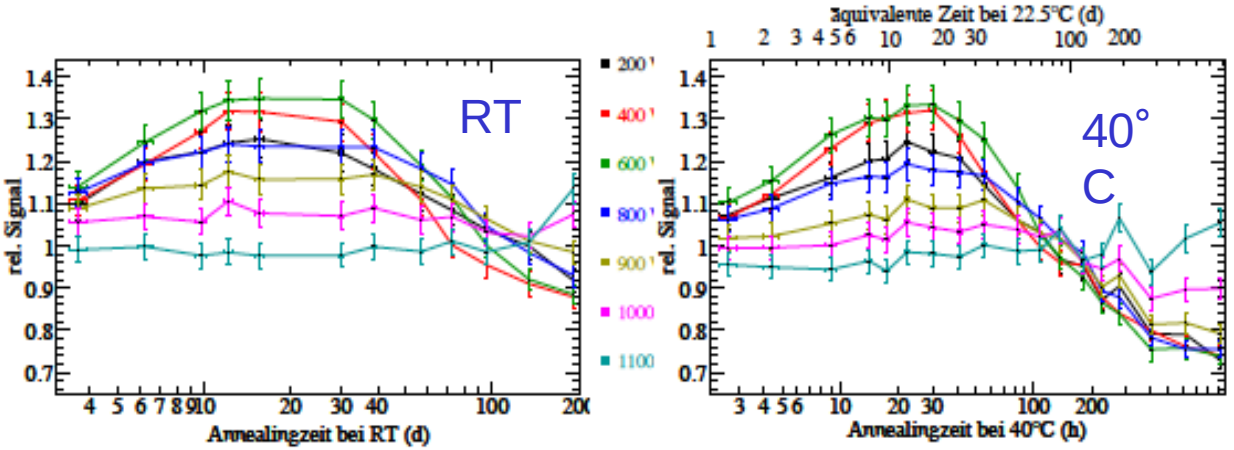
Signal and Current

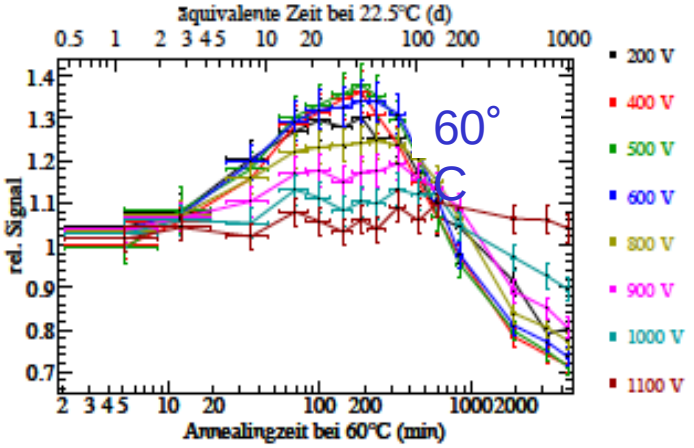
- **Accelerated annealing at 60° C**



Relative signal

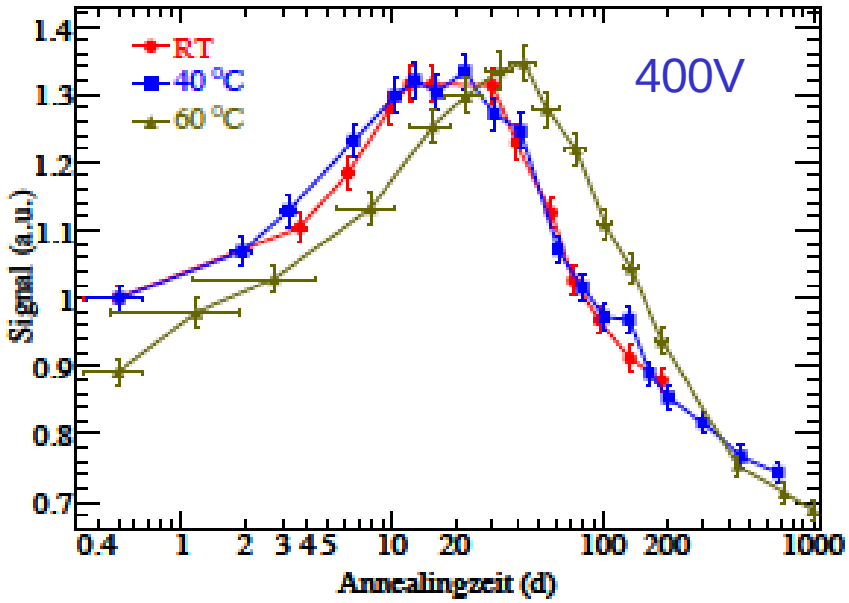
- Signal normalised to pre-annealing signal
  - N.B.: different time ranges in plots
- Beneficial and reverse annealing visible
- Higher bias voltages are less affected by annealing

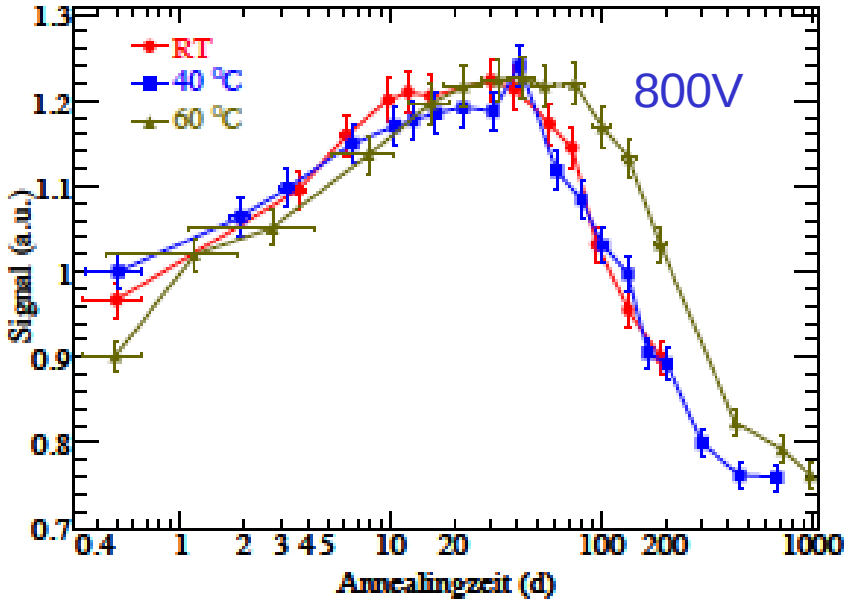




Scaling

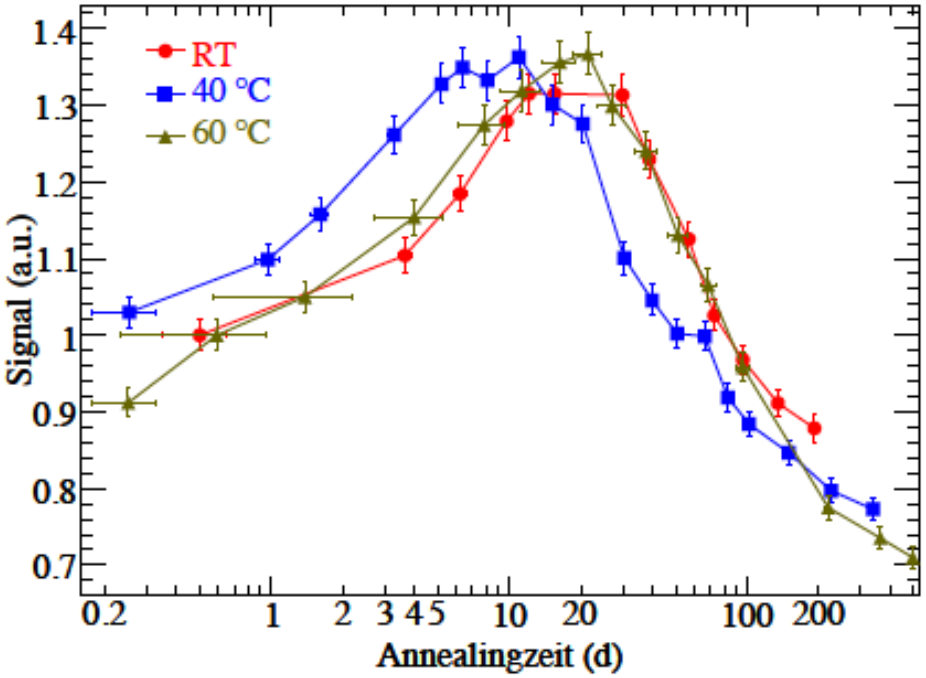
- Comparison of signal evolution for RT, 40° , 60°
- RD48 Model does not scale 60° data correctly to RT
- Annealing at 60° appears “too slow”
- As observed by e.g. Gianluigi: scale factor appears too large

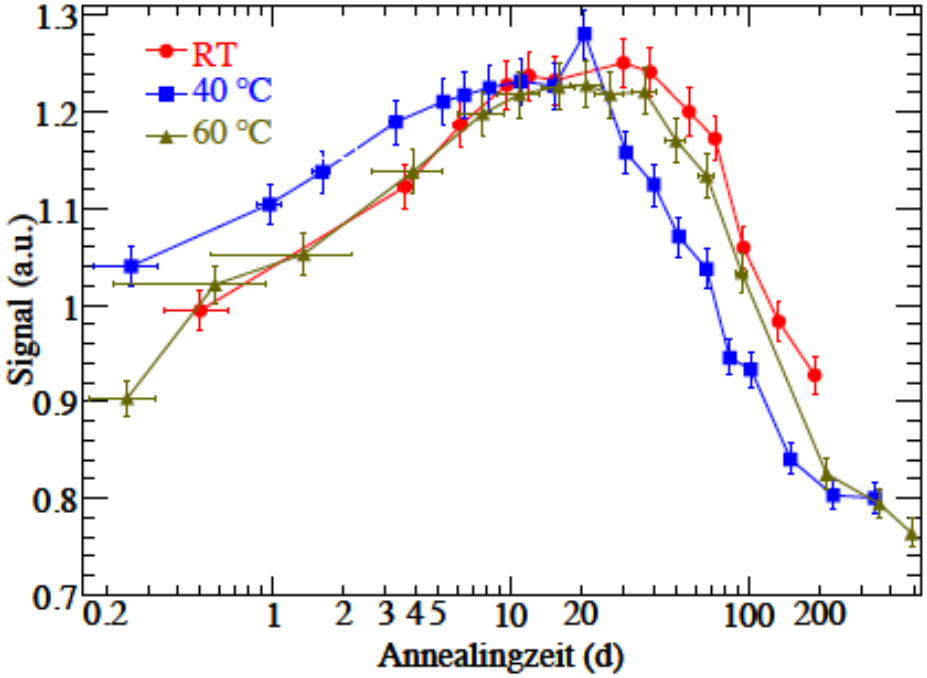




Scaling

- Signal comparison for RT, 40° , 60°
- As before, but scale factor reduced by ≈2
- Reasonable agreement between RT and 60° CCE data (as previously reported by G.C.)





Time Evolution

- Repeated measurement of signal spectra
  - Same sensor, same conditions, 7 days later
- Landau signal peak narrows with time (sensor stored cold)

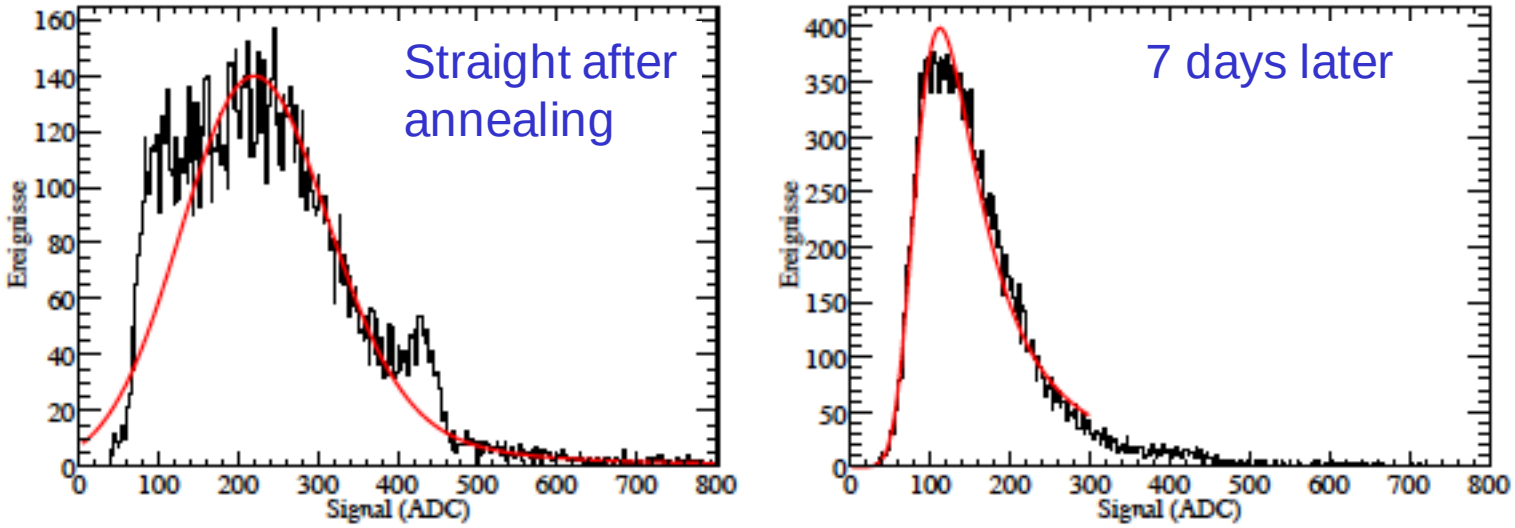


Abbildung 7.9: Signalspektrum von Messungen direkt nach der Wärmebehandlung (links) und 7 Tage später (rechts).

Time Evolution

- Sequence of IV and CCE measurements
  - sensor (annealed at 40° C) remaining in cold the 90Sr-system
- Charge multiplication effect fading with time
- Similar effect observed on other sensor

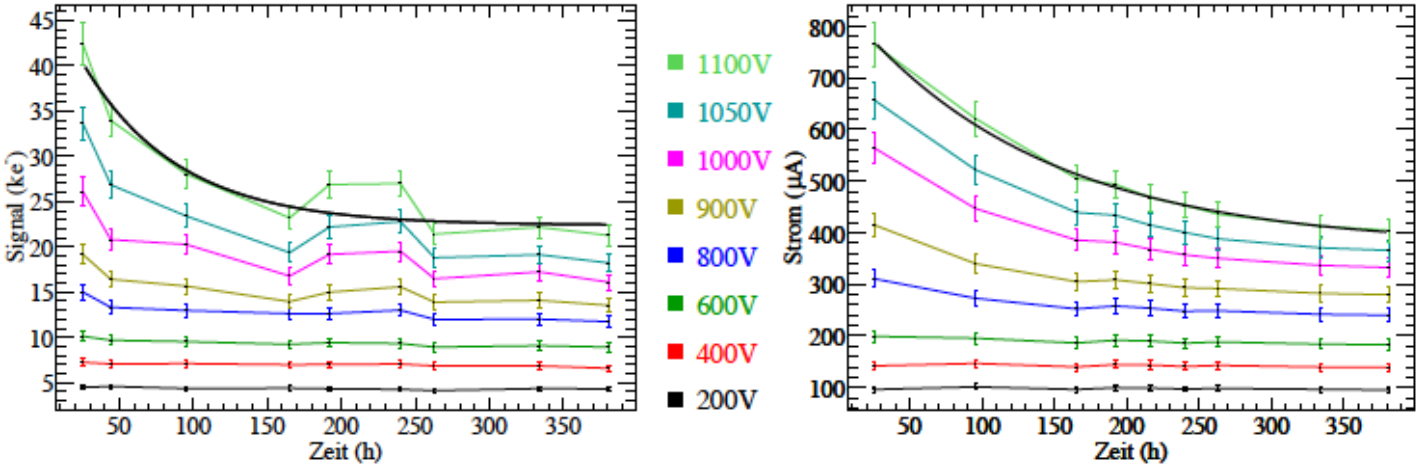


Abbildung 7.10: Zeitliche Entwicklung der Ladungssammlung (links) und des Leckstroms (rechts). Aus einer an die Kurve der höchsten Spannung angepasste Funktion eines exponentiellen Zerfalls erhält man für die Ladungssammlungseffizienz eine Zeitkonstante von $\tau_Q = (65 \pm 21)$ s und den Leckstrom $\tau_I = (134 \pm 35)$ s. Auch wenn die Fehler sehr groß sind, lassen diese Werte erahnen, dass die gesammelten Ladung etwa doppelt so schnell abnimmt.

Summary

- Annealing study performed on HPK P-type minis
- Evidence of charge multiplication at high bias
- Confirms existing results
- Scaling from 60° to RT needs modification

- **Signal and current seem to "decay away" over ≈2 weeks (?)**

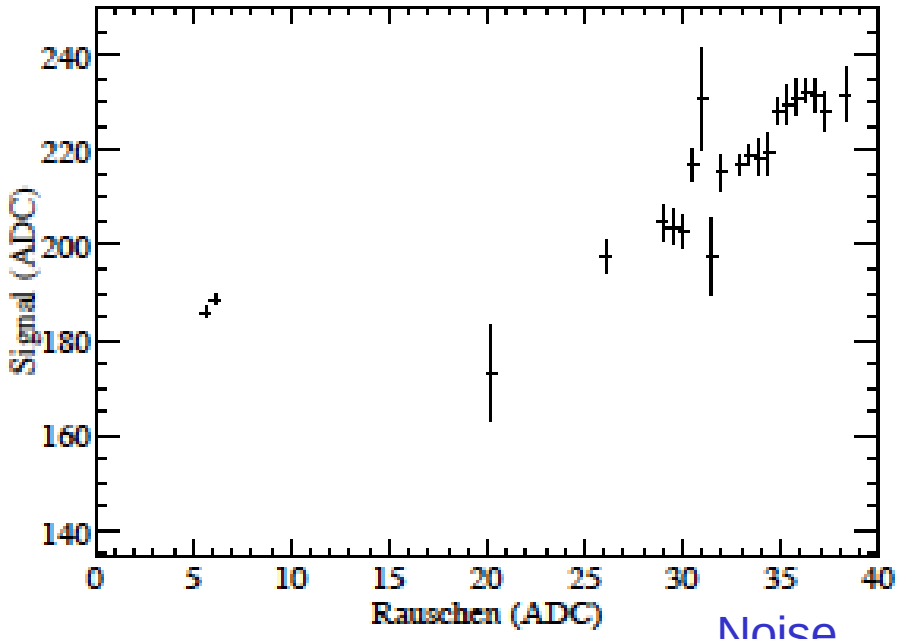
Advertisement: Freiburg is looking to recruit
- RA (postdoc) to work on Si and CdTe Detectors (EU Project)
- PhD student to work on Si detectors (ATLAS Tracker Upgrade)

Contact Ulrich.Parzefall@cern.ch for details and/or informal enquiries

Backup

Signal and Noise

- Charge multiplication occurring at high voltages
- Signal plots before averaged over all strips
- S/N plots not conclusive
- Grouping strips by noise level for 1100V run:
- Signal and noise are correlated
- **Higher signal from charge multiplication may "come at a price"**



Noise