Charge Collection/Timing Setup at Jožef Stefan Institute

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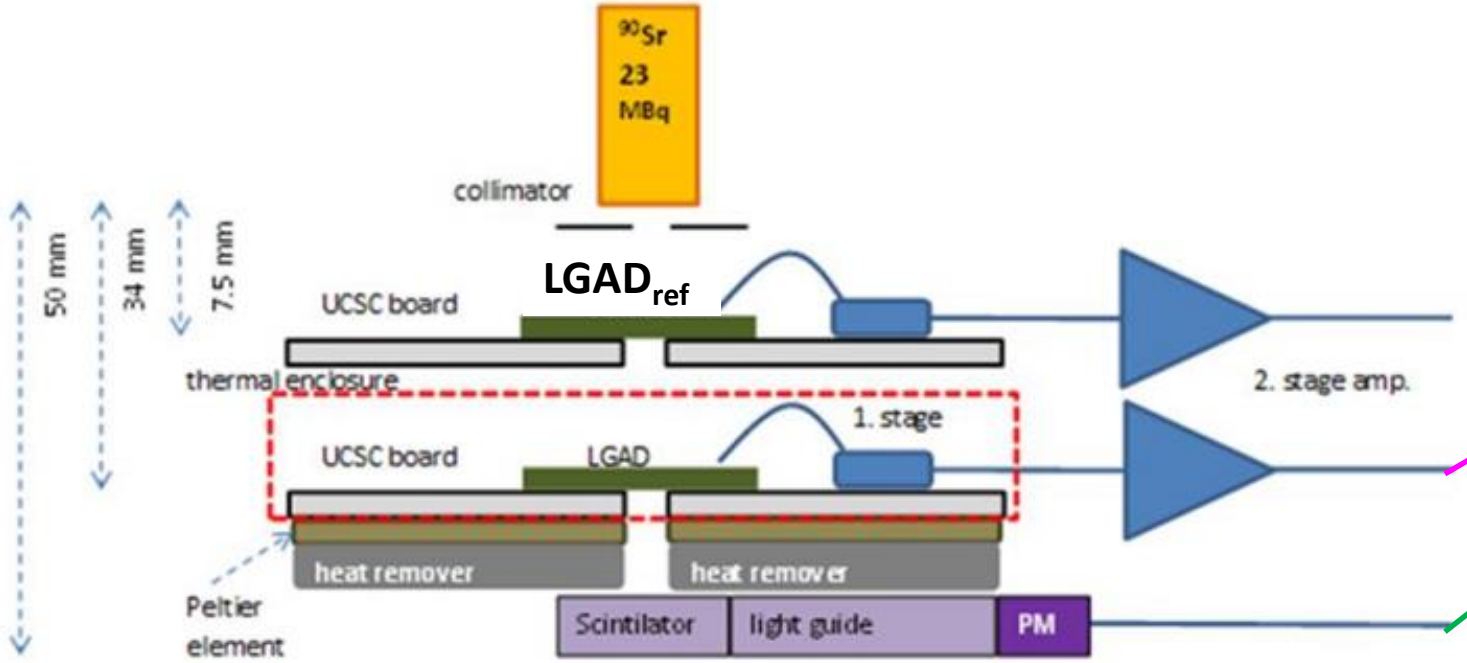
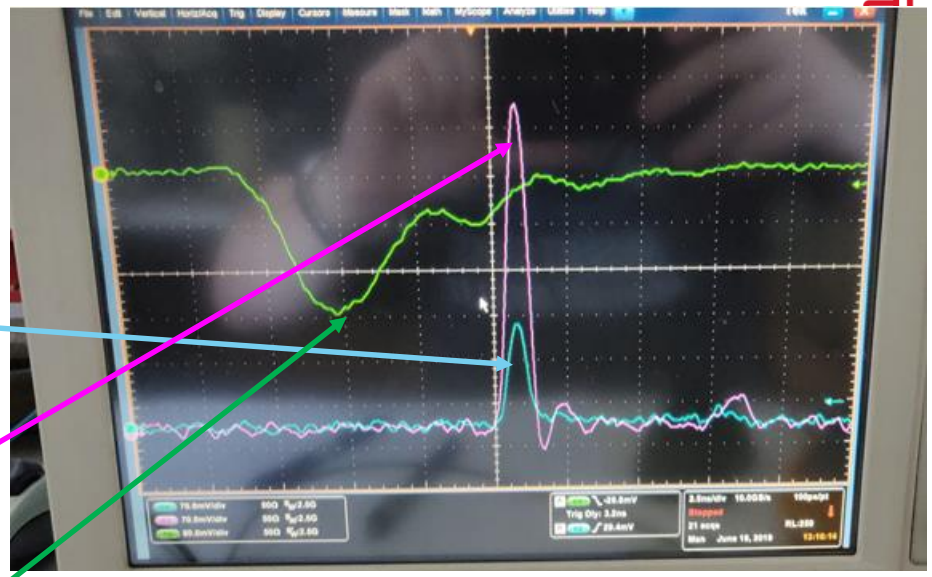
Hardware





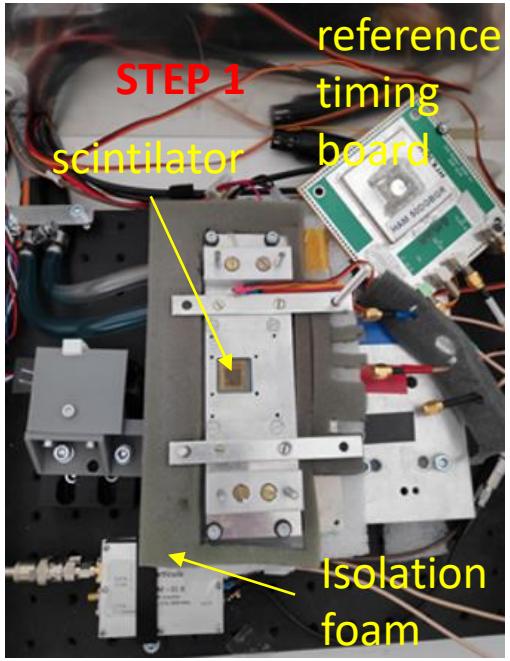
Electronics chain:

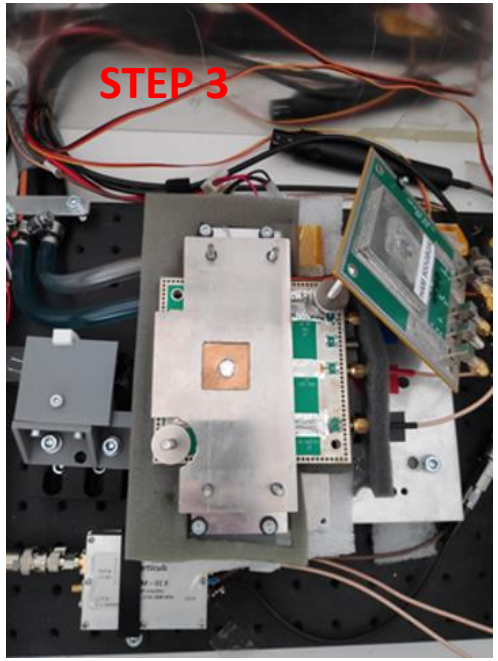
- UCSC boards (Elgoline production; distributed to many institutes) – 470 Ω (cut-off 3GHz) transimpedance amplifier
- Second stage amplification Particulars AM-02B (35 dB – signals fit in linear range; high amplification)
- Oscilloscope is a fast 2.5 GHz 40GS/s Tektronix, no BWL applied
- Keithely 237 is used as a power source for DUT
- Plastic scintillator coupled to HPK-PM – active area of around 0.5 cm^2

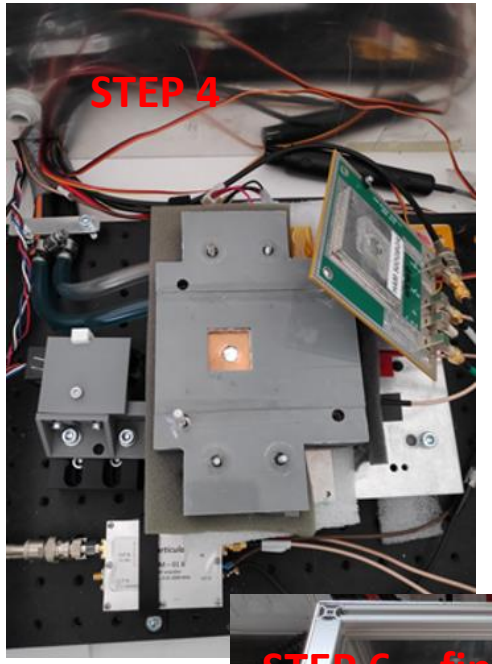
Triggering of the readout:

- **(Sci+PM) AND (LGAD$_{ref}$) in coincidence**

Assembly and cooling



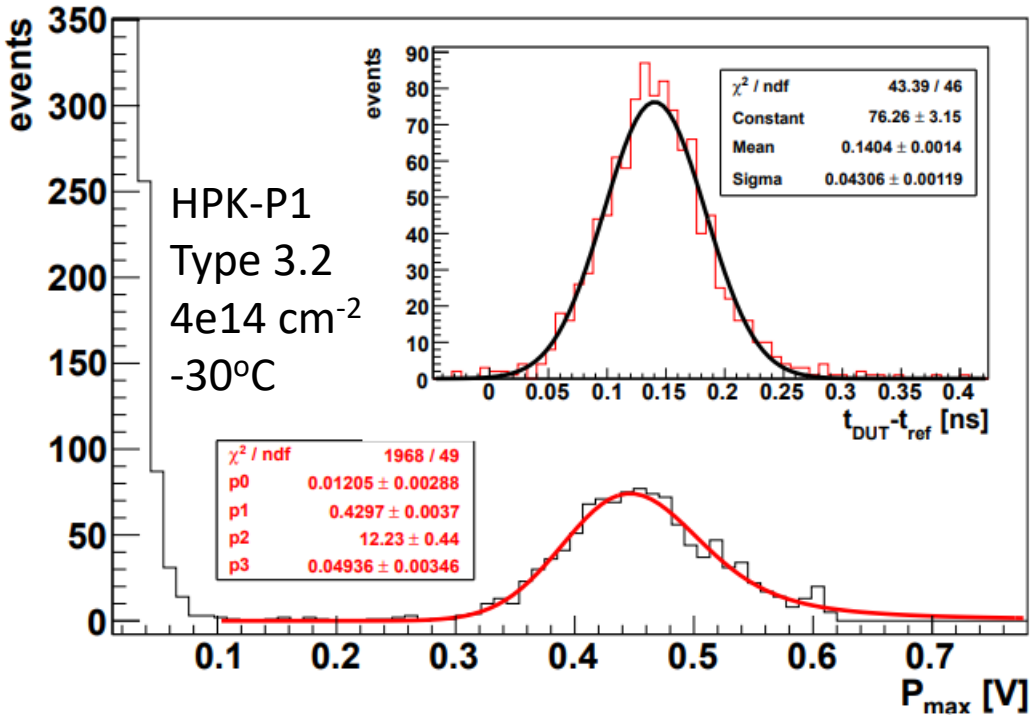


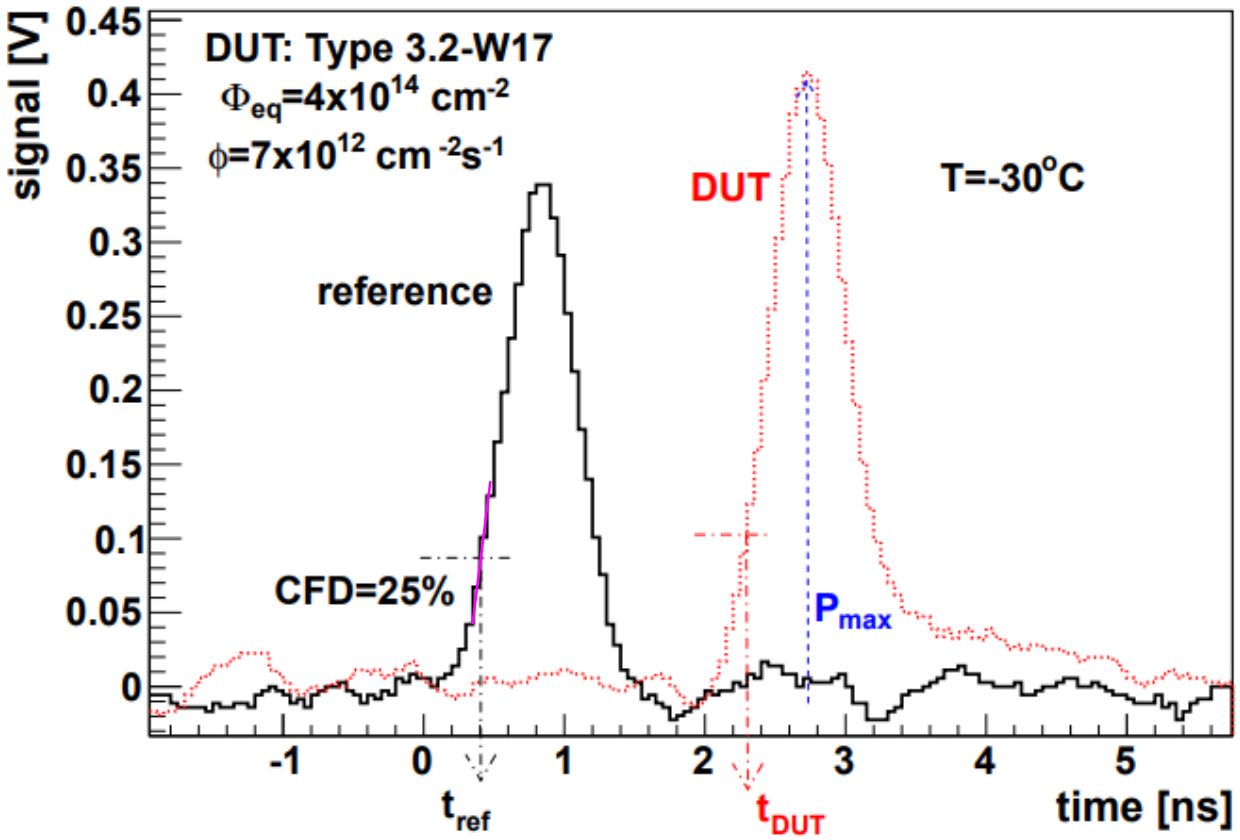


- There are six steps to assemble the setup (5-10 min work)
- Cooling – Julabo chiller with Peltier system; T<-30°C can be achieved. Pt-100 is mounted next to the sensor – probably some offset, but always stable - Particulars T-controller is used
- The system/box is flushed with dry air to keep the dew point well below operation point
- Benefits of such assembly:
  - small cold mass – quick warm/cold cycle
  - Compactness – table top setup
  - any kind of source can be used

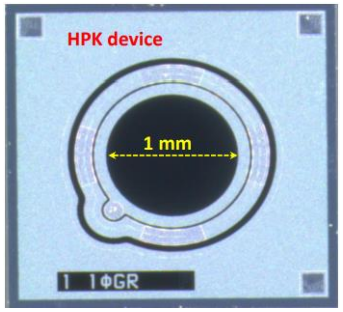
DAQ

- Reference detector is HPK-50D detector (G~40)
- P_{max} is sampled within 1 ns window (also integral can be used – very little difference)
- CFD of 25% is used – line fit around +/- 2 bins and then t_{ref} and t_{DUT} is determined

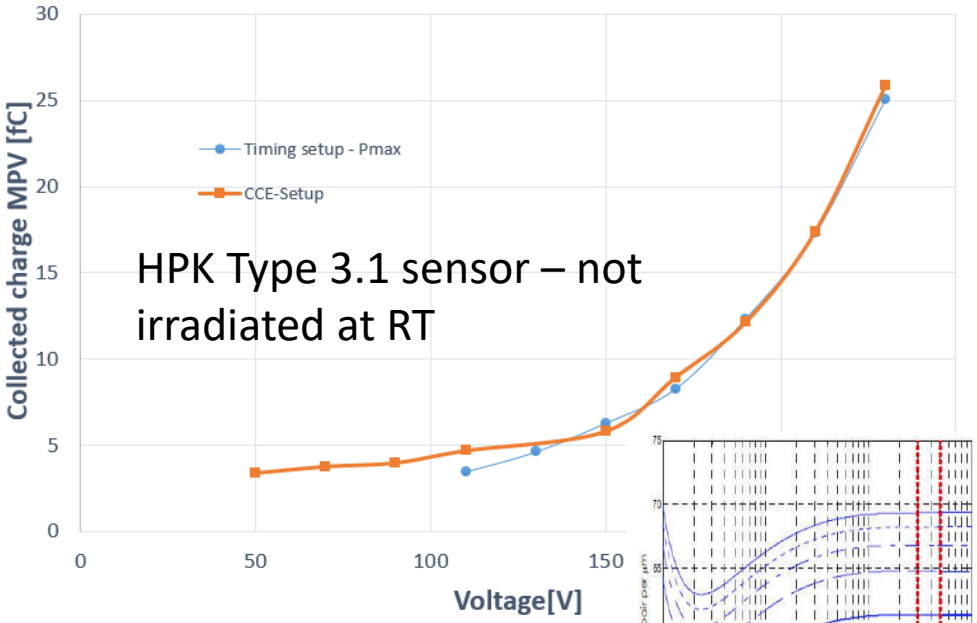


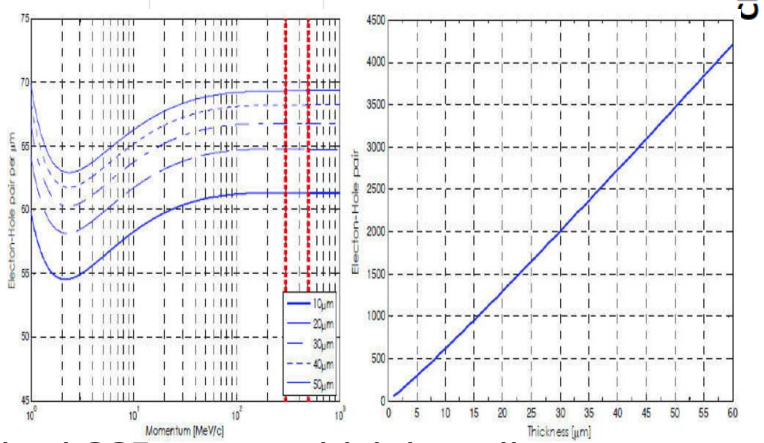


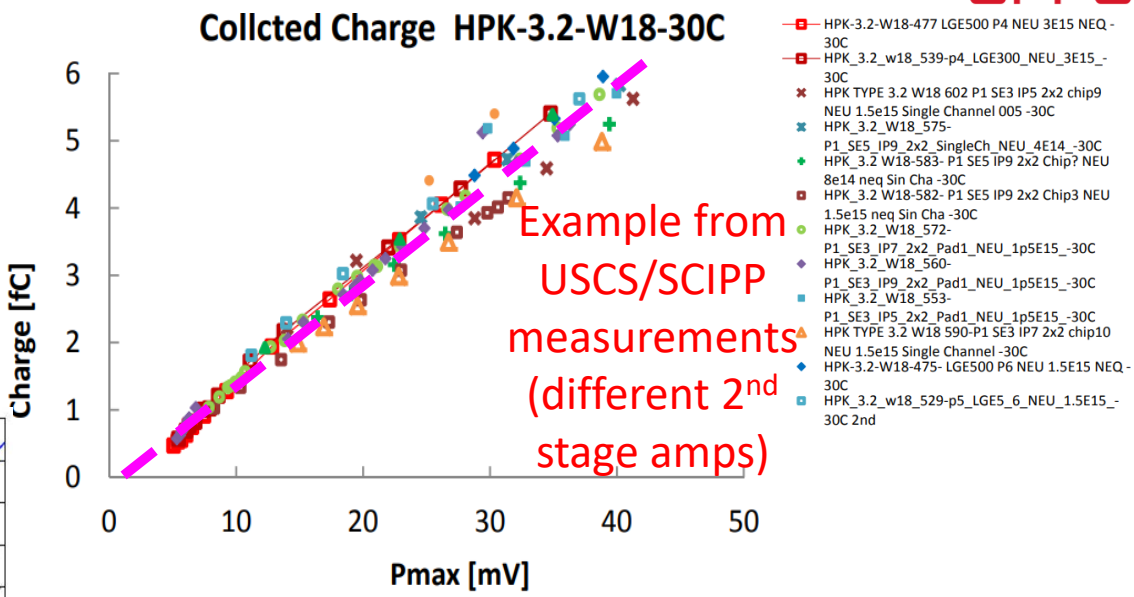
- Trigger: 70 mV the on reference and PM within limited time window (depends on cables)
- Spectrum is fit with convolution of Landau and Gaussian function. The integral of L*G is used to determine the fraction of "3 hit triggers" – real events – 1.3x1.3 mm^2 pads give 30-35% 3 hits.
- 2500-5000 triggers are usually taken at voltage point



Calibration of the system - charge



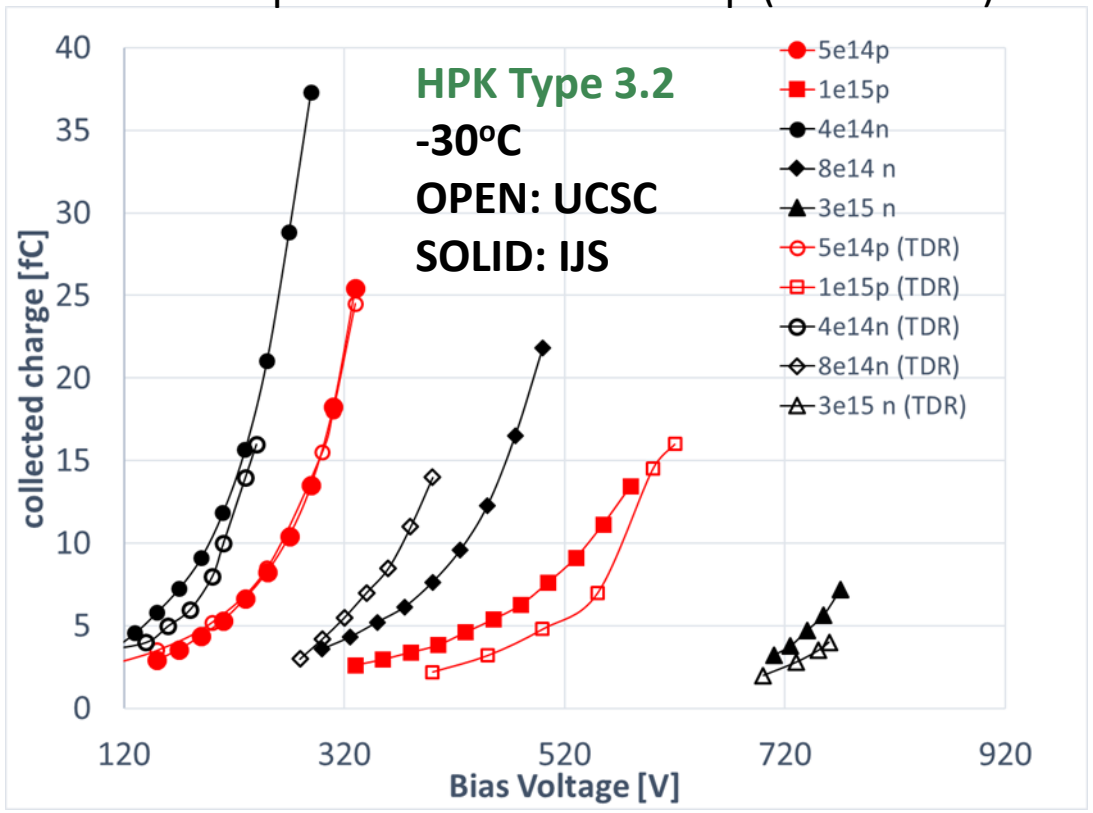


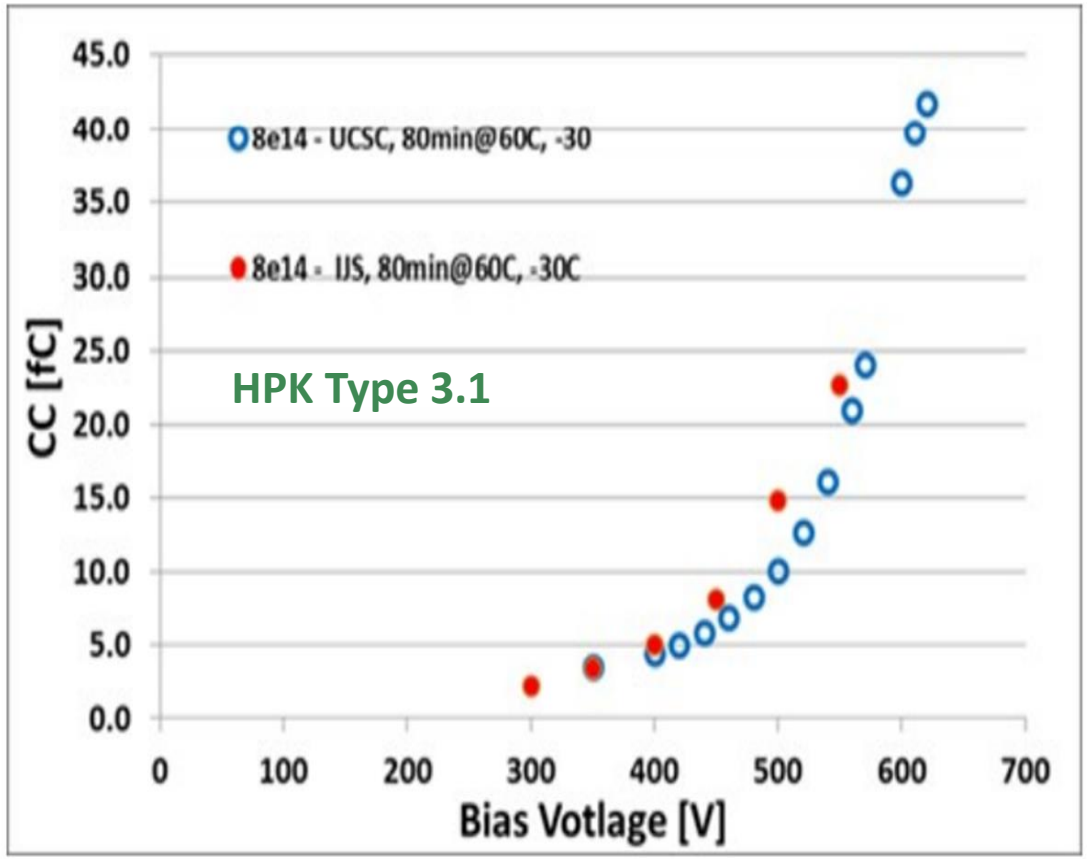


- Calibration done using our standard CCE setup, which is well calibrated by mip signals and ^{241}Am 60 keV photons
- At lower voltages slight disagreement probably due to slower signals and P_{max} deviates from integrated charge
- Using calibrated setup we get 1 V=80 fC
- assuming Q_{MPV}=3400 e for 50 µm we get the good agreement also with charge collection measurements with thicker 3D sensors in the same setup (see https://indico.cern.ch/event/754063/contributions/3222647/attachments/1759823/2855093/GK-RD50-Timing3D.pdf)
- We use different boards. Signal checked with the same sensors and found within peak-to-peak of 15%.

Cross-calibration of measurements

Comparison with UCSC setup (HGTD-TDR)

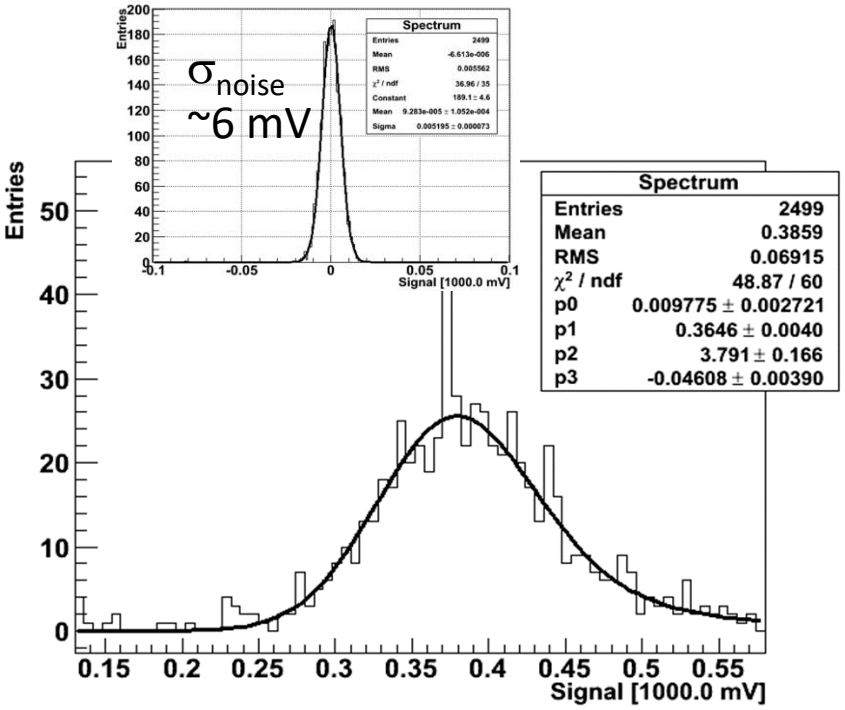


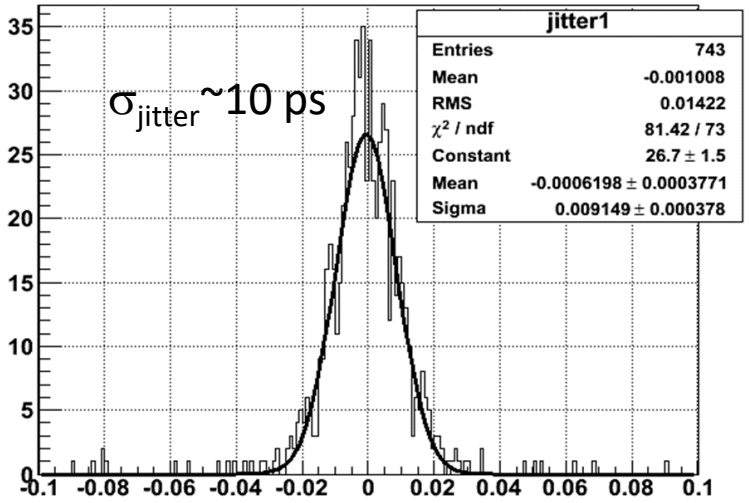


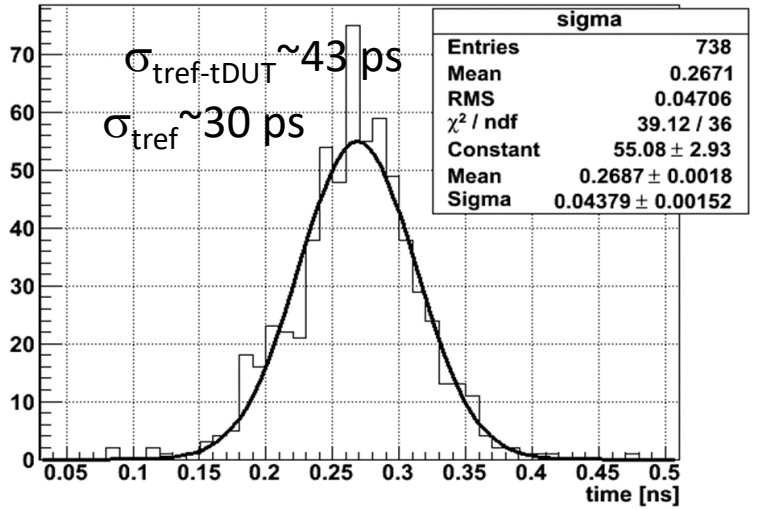
- We consider the agreement satisfactory – note that uncertainty in fluence has larger impact for LGADs than for standard detectors due to very high sensitivity of charge collection on V_{gl} .

Calibration of the system - timing

- Reference detector is HPK-50D detector:
  - Biased to 300 V – although not cooled, but at lower temperature than the environment
  - The time resolution of the reference detector was checked/determined with two equivalent detectors and was determined to be around **30 ps**
- Sensitivity of timing was also checked for thinner detectors for sanity check.
- 35 μm HPK Type 1.2 detector gives time resolution of ~20 ps in agreement with expectations (see the backup slide) – we may use it in the future as reference detector

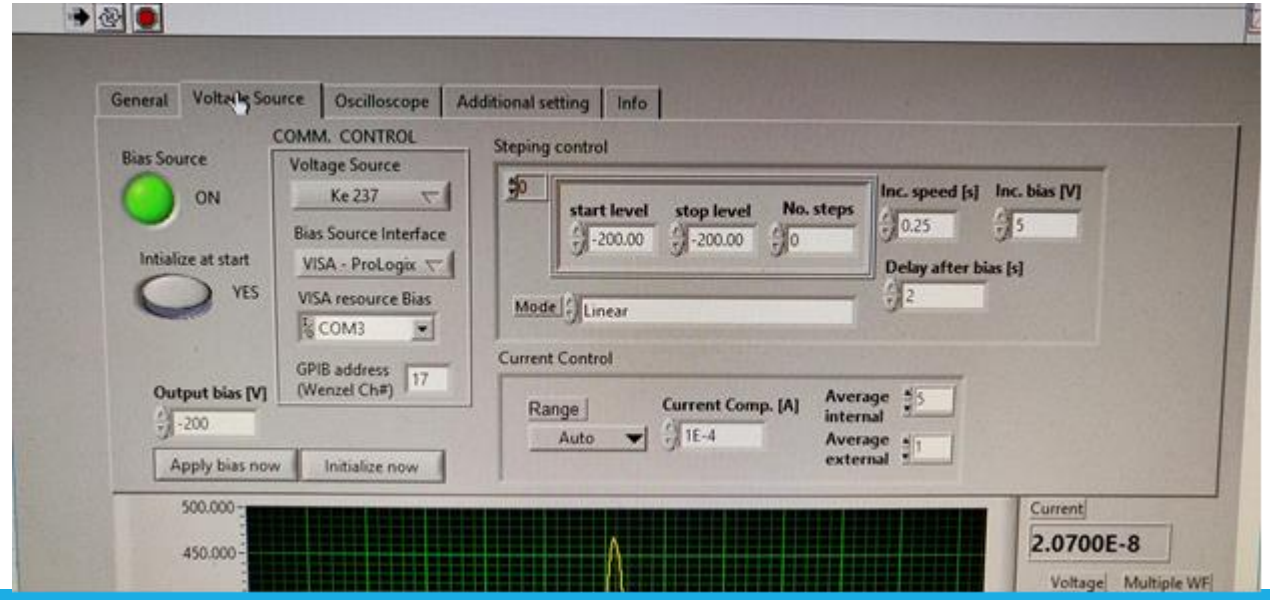






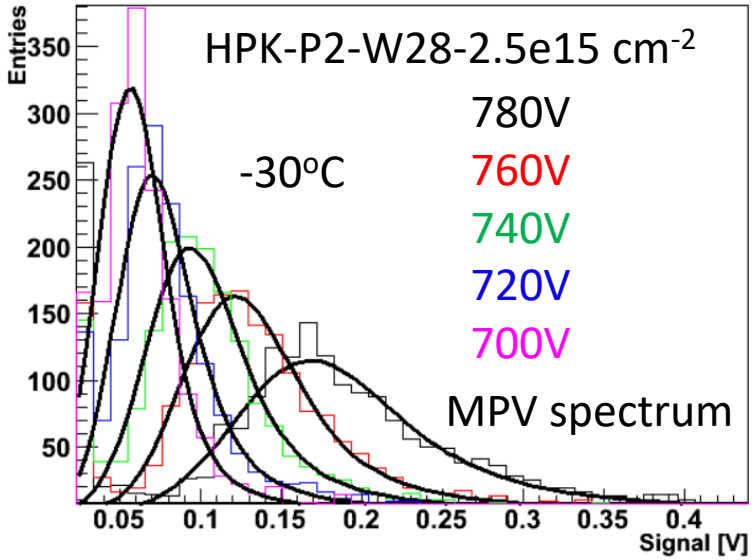
DAQ and Analysis Software

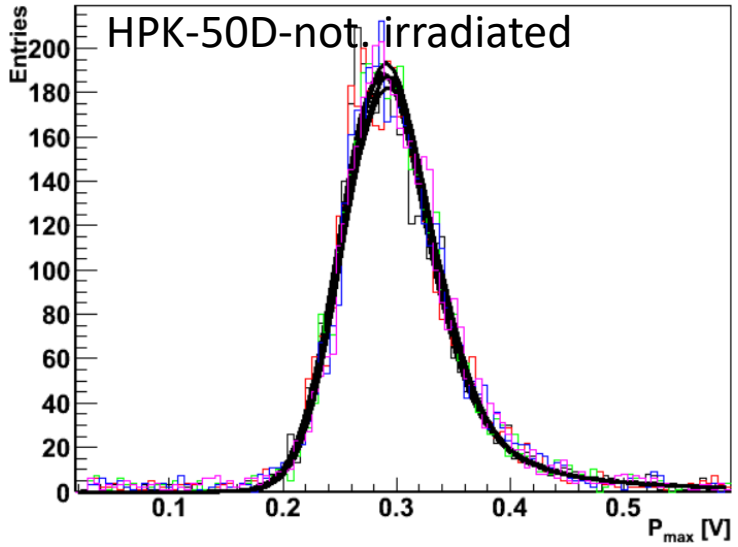
- LabView software – downloadable from http://www.particulars.si/downloads/CompactTCT-V3.0.zip , manuals http://www.particulars.si/downloads/ClassicalTCT-V2.0.pdf
- It is ready for many oscilloscopes and power supplies
- Data stored are waveforms in binary format that can be read with ROOT (TCTAnalyse.dll)
- Analysis is done with in ROOT using a set of macros - no filtering is done apart from baseline subtraction
- DAQ rate in our setup is ~10 s^{-1}



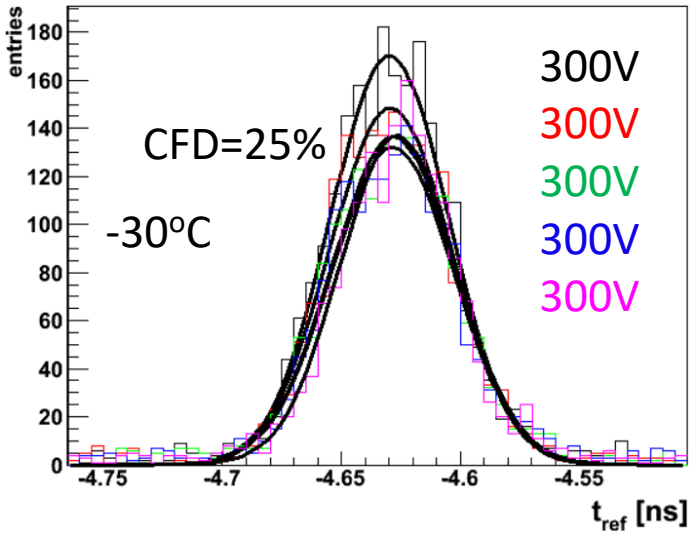
Note: in our in order to ensure what you store to disk is coming from the same event "Single" should be ON

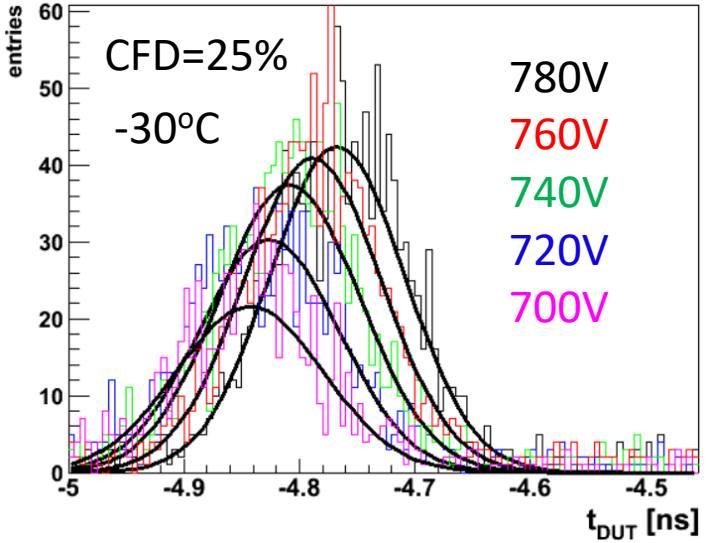
Analysis procedure – HPK-P2(W28) at 2.5e15 cm^{-2}

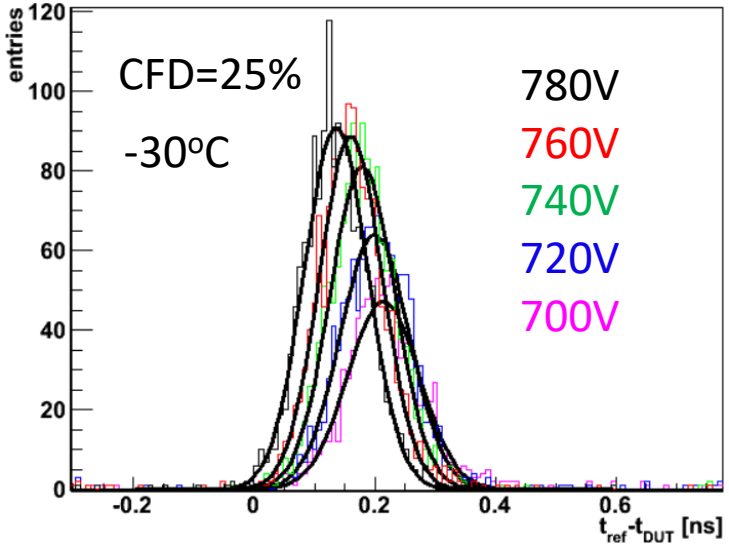




- We only analyse events that are larger than 30 mV and only those voltages where the L*G can be clearly fit with visible peak in the spectrum
- Reference detector is always checked in the analysis to make sure 30 ps reference timing is achieved.
- There are several control plots to scrutinize the analysis.
- See A. Howard's talk on more information about these sensors.

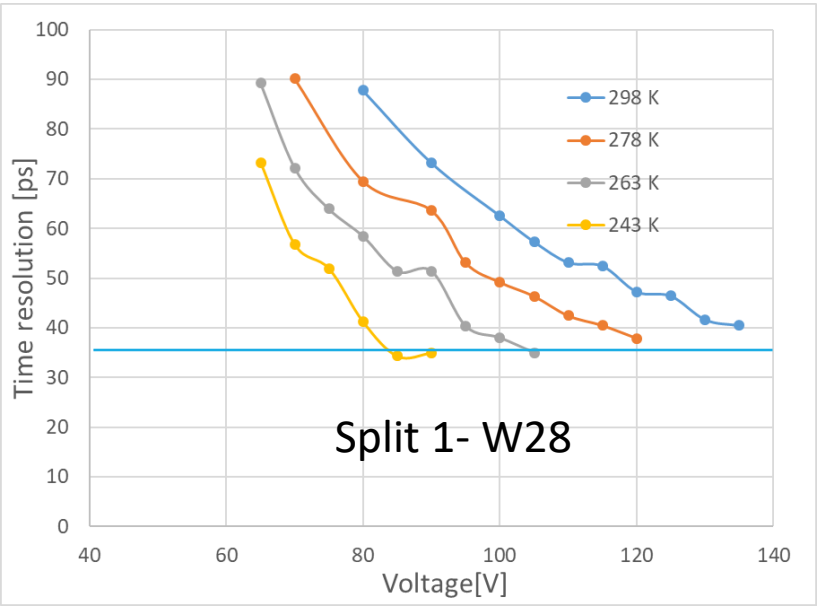


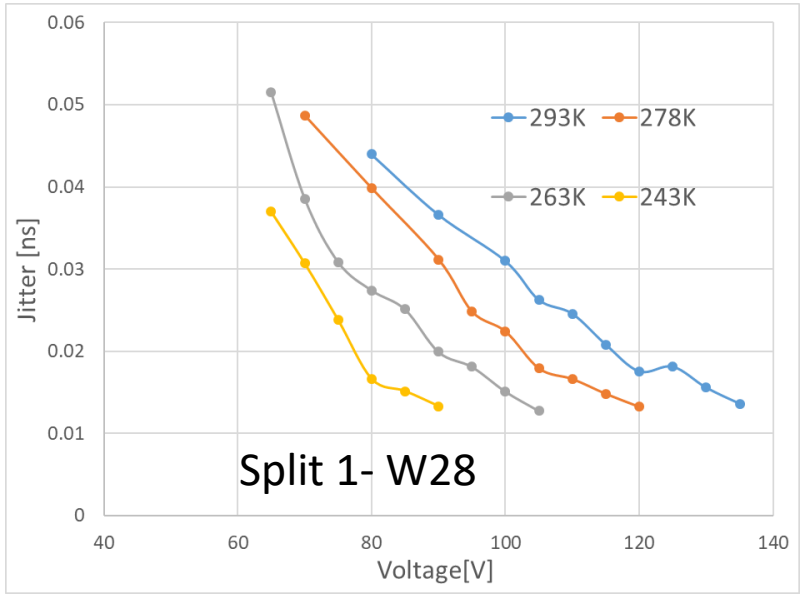


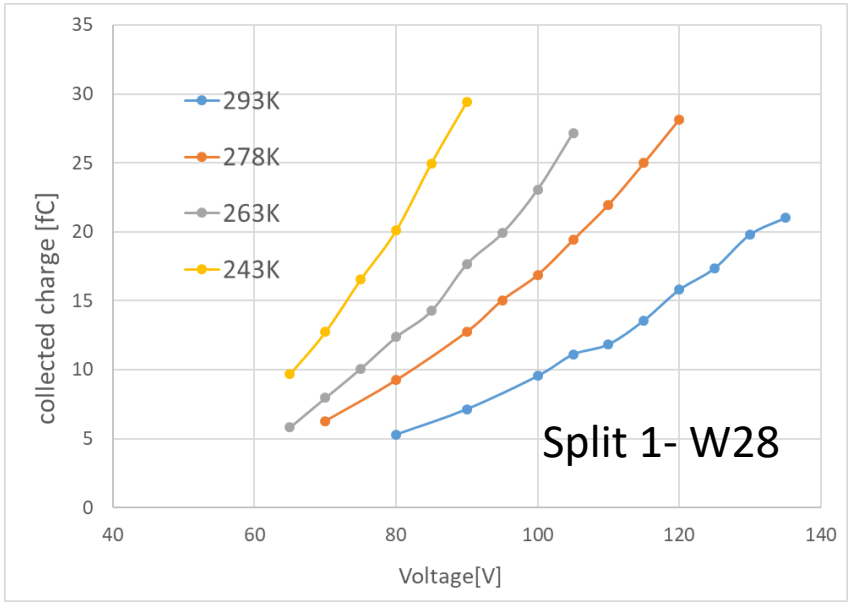


Thermal enclosure – nirr. HPK-P2 example

Remember: 0.5 fC ~ signal in PIN of 50 μm

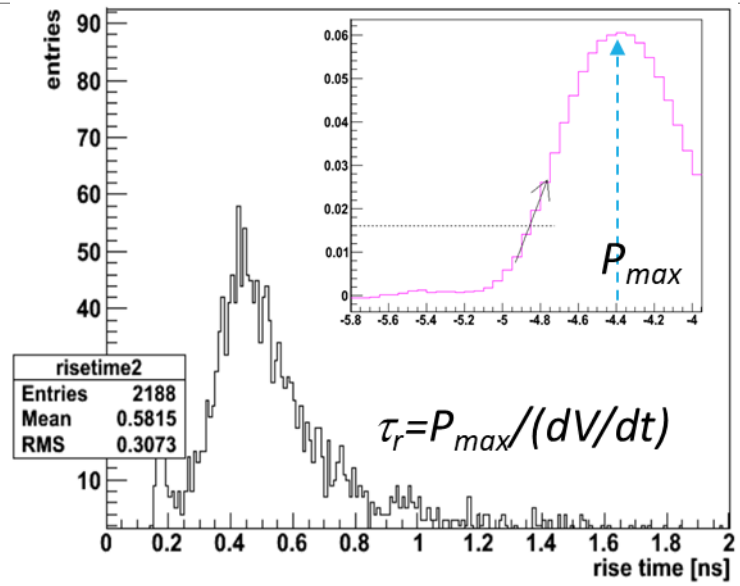


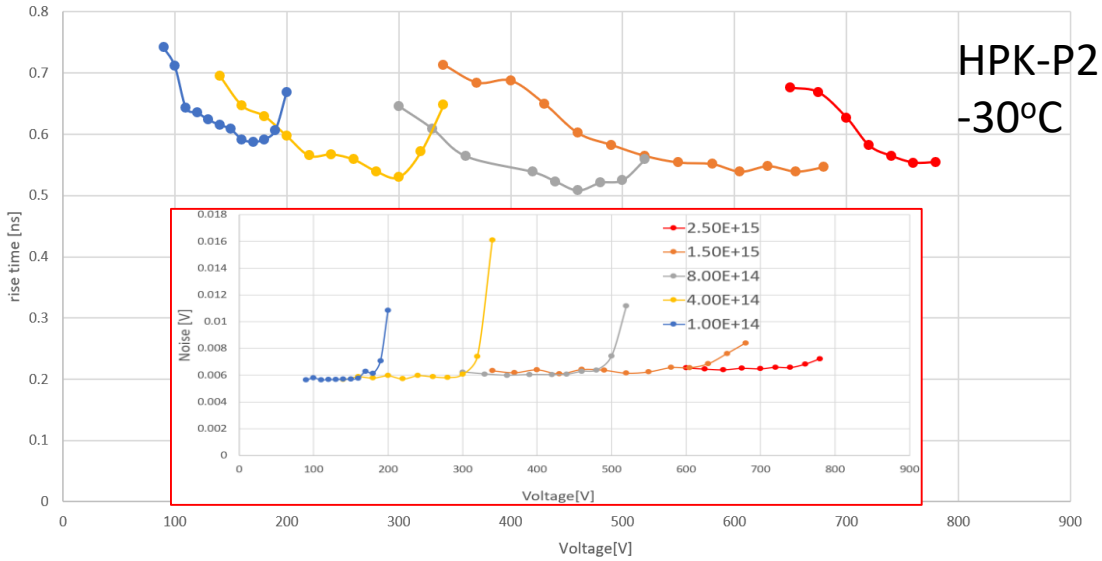


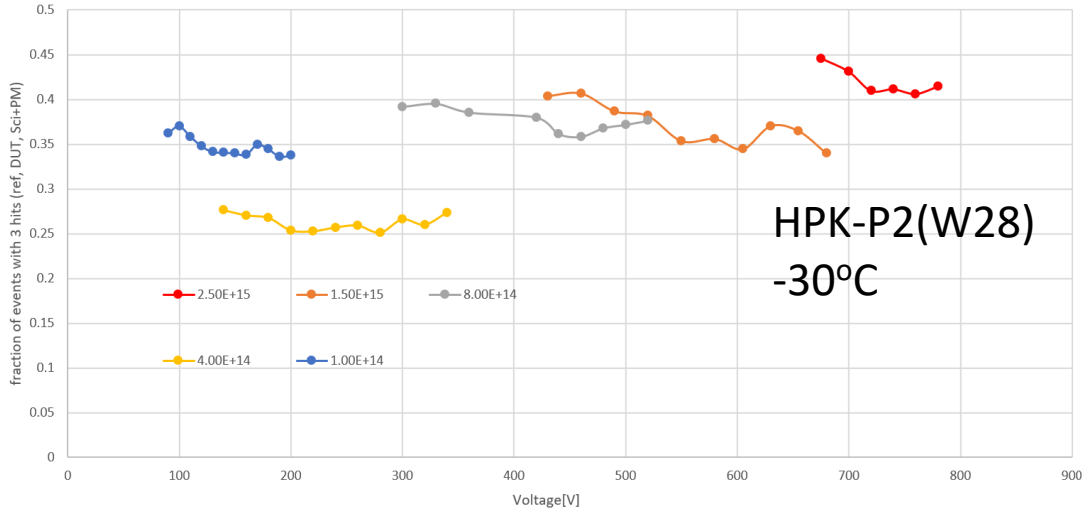


- HPK-W28 (V_{gl}=54, V_{fd}=61 V) -> just enough to reach the desired time resolution and has maximum gain
- Dew point is constantly monitored and kept well below the operation temperature

Control plots - usually not shown







- Upon saturation of the rise time and noise the time resolution depends only on amount of charge – we monitor all
- Monitoring the fraction of events (integral of L*G) assures no bias is introduced in analysis – we don't select only the event in the tail of the Landau curve.
- The alignment on 1 mm^2 scale can be a problem – fractions are around 1/3.
- Also jitter is monitored for each voltage.

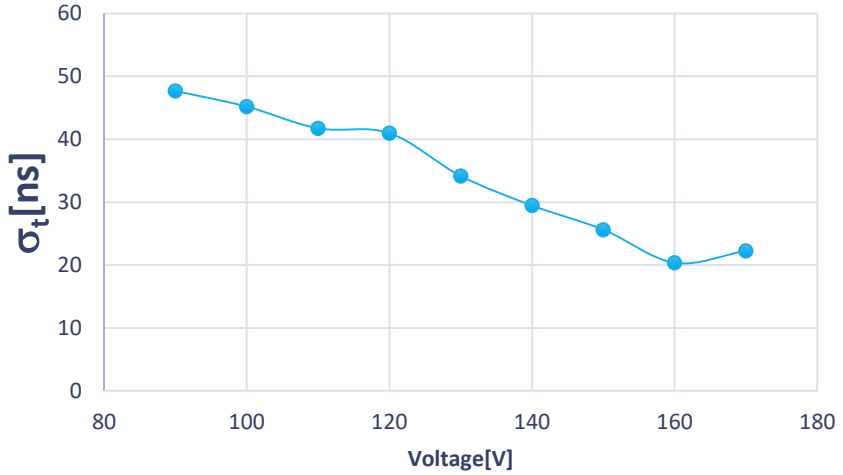
Final remarks

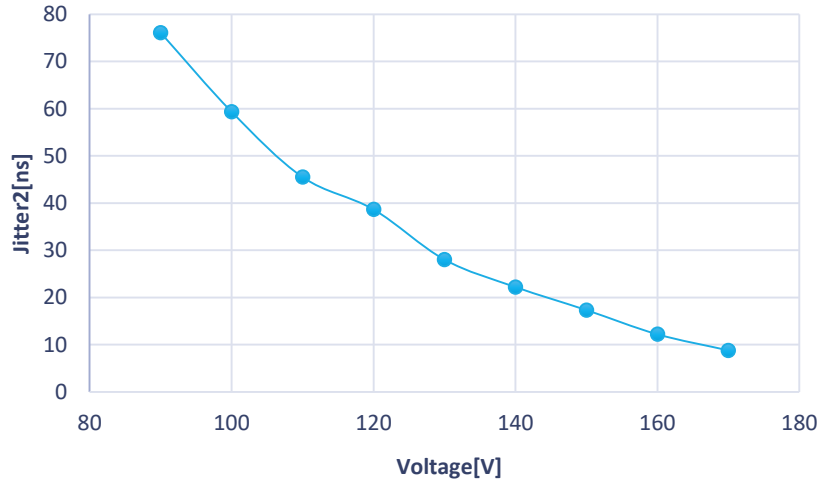
- Possible upgrade: scanning of the source over the sensor - to test different parts of the sensor
- 3D printer files for production of thermal enclosure as well as all the software is available
- If any other information about software/hardware is required please let me know

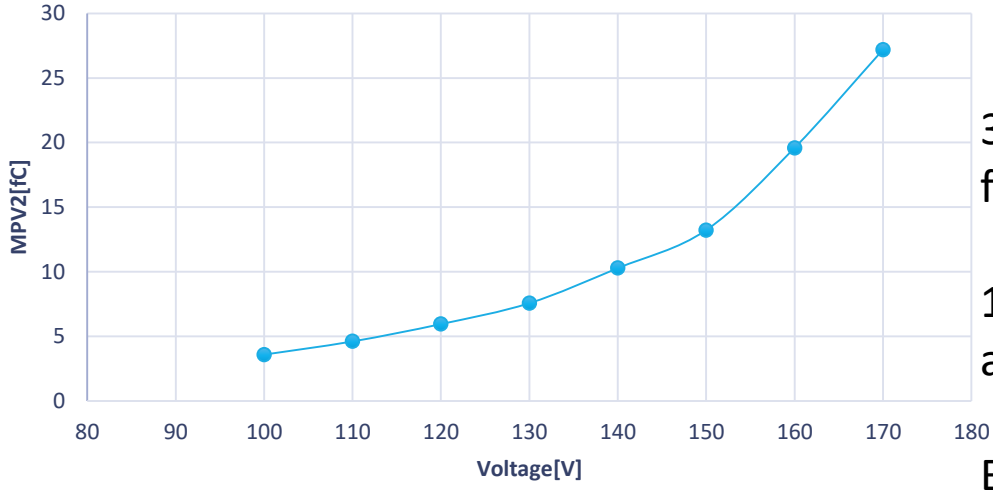
THANK YOU FOR YOUR ATTENTION!

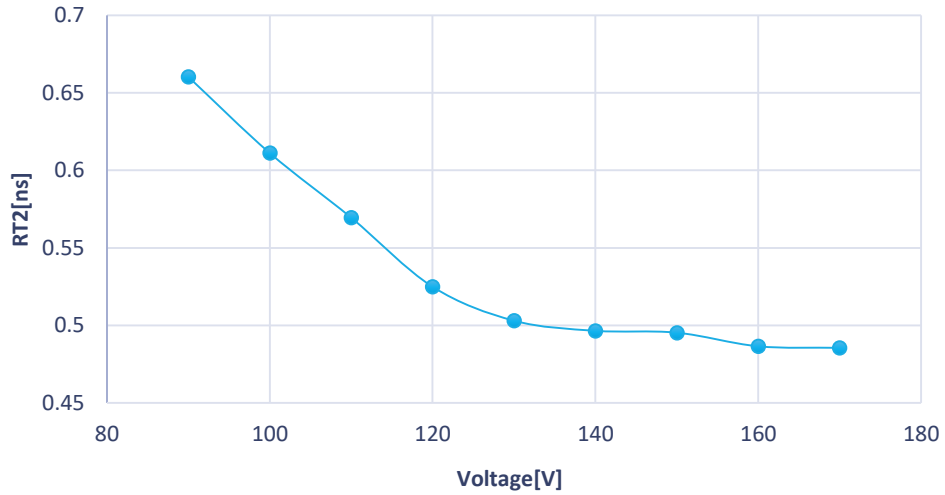
BACKUP SLIDES

TIME RESOLUTION OF THIN SENSORS









35 um thick LGAD for ATLAS – HGTD

15x15 arrays already done

Best achieved so far in out system was 18 ps