WP5 – Development of single-pulse detectors for experiments at FELBE and FLASH
overview and status

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WP - Overview

WP 5	**Beam monitor for single THz pulses at FLASH**
WP 5.1	Design of the Ge:Ga detector element
WP 5.2	Growth and characterization of Ge:Ga crystals
WP 5.3	Optical coupling
WP 5.4	Extension to 200 µm wavelength
WP 5.5	Integration into cryostat, characterisation, and calibration
WP 5.6	Implementation and test measurements at FLASH and for FT spectroscopy

Result: Detector successfully tested and implemented at FLASH.

WP 5.1 - Design of the Ge:Ga detector element

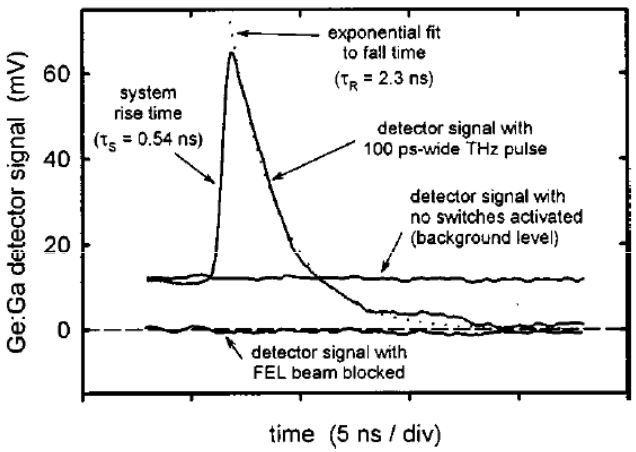


FIG. 4. Photoresponse of the Ge:Ga detector to 84 cm^{-1}, 100 ps wide THz pulses. The dotted line is an exponential fit to the fall time of the detector signal, giving a recombination time τ_R of 2.3 ns. The background THz level represents what the detector sees with no switches activated in the pulse slicer. The system rise time, τ_S, is measured to be 0.54 ns (10%-90%).

For design we consider

- Information from previous research on Ge detectors (Haller, Hegmann, Hübers)

- Spectral range for different dopants

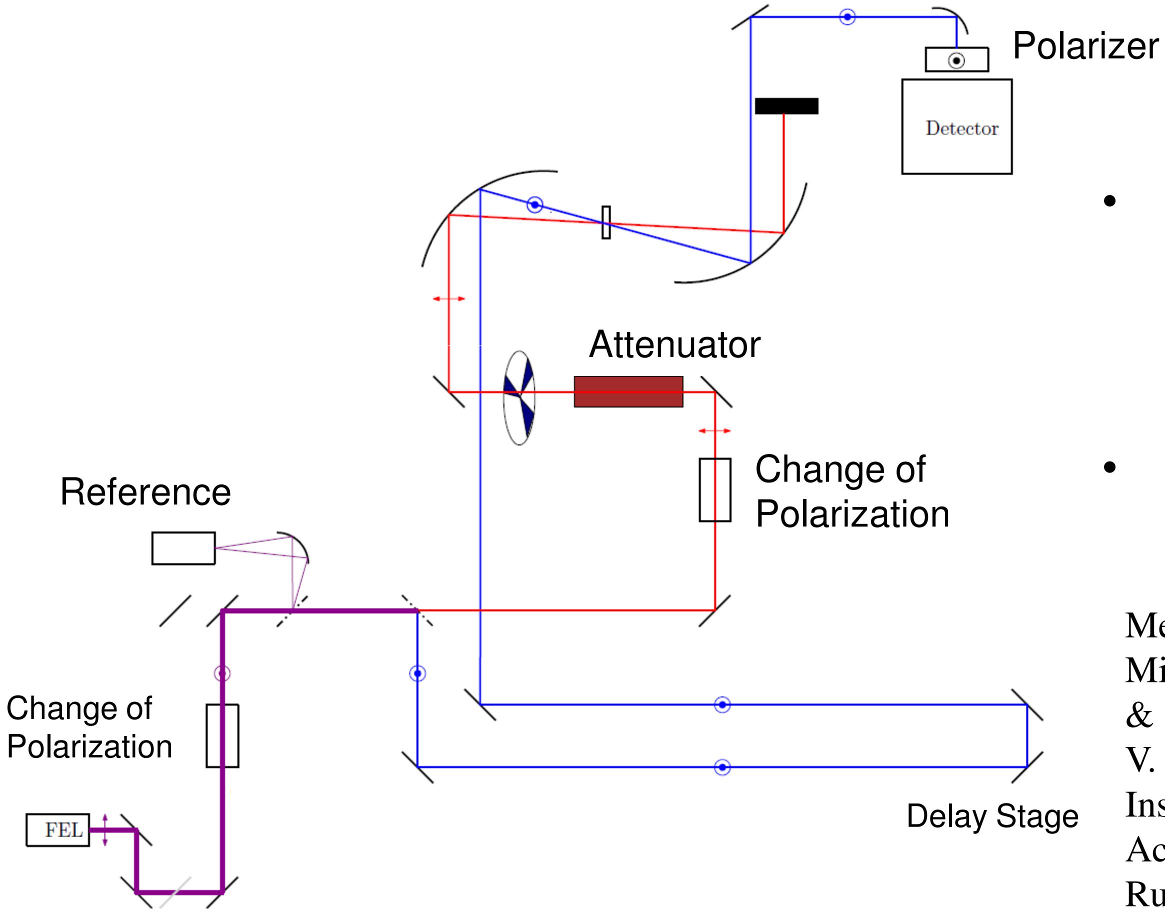
- Stress

- Time domain Photoconductivity

- Ohmic Contacting and Bias

Hegmann et al. (2000). Time-resolved photoresponse of a gallium-doped germanium photoconductor using a variable pulse-width terahertz source. *Applied Physics Letters*, *76*(3), 262. doi:10.1063/1.125741

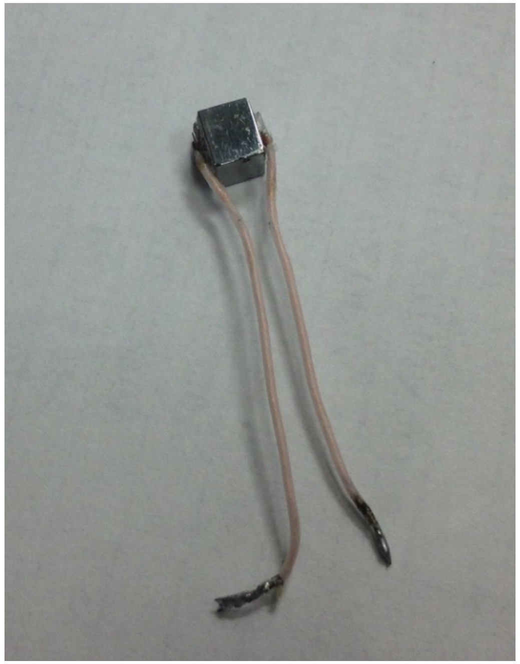
WP 5.1 - Design of the Ge:Ga detector element



- Pump probe measurement of photoinduced transmission in Ge:Ga and Ge:Sb to determine the free electron relaxation rates
- **Fundamental limit** in time resolution given by relaxation time (VB/CB to GS) ~ 1 ns (results to be published)

Measurements at FELBE with S. Winnerl, M. Mittendorf et al.
&
V. N. Shastin and R. Kh. Zhukavin
Institute for Physics of Microstructures, Russian Academy of Sciences, Nizhny Novgorod, Russia

WP 5.2 - Growth and characterization of Ge:Ga crystals



- Possibilites of crystal growth in the IKZ Berlin (Ge:Ga, Ge:Sb, Ge:As)
  - Obtained Samples:

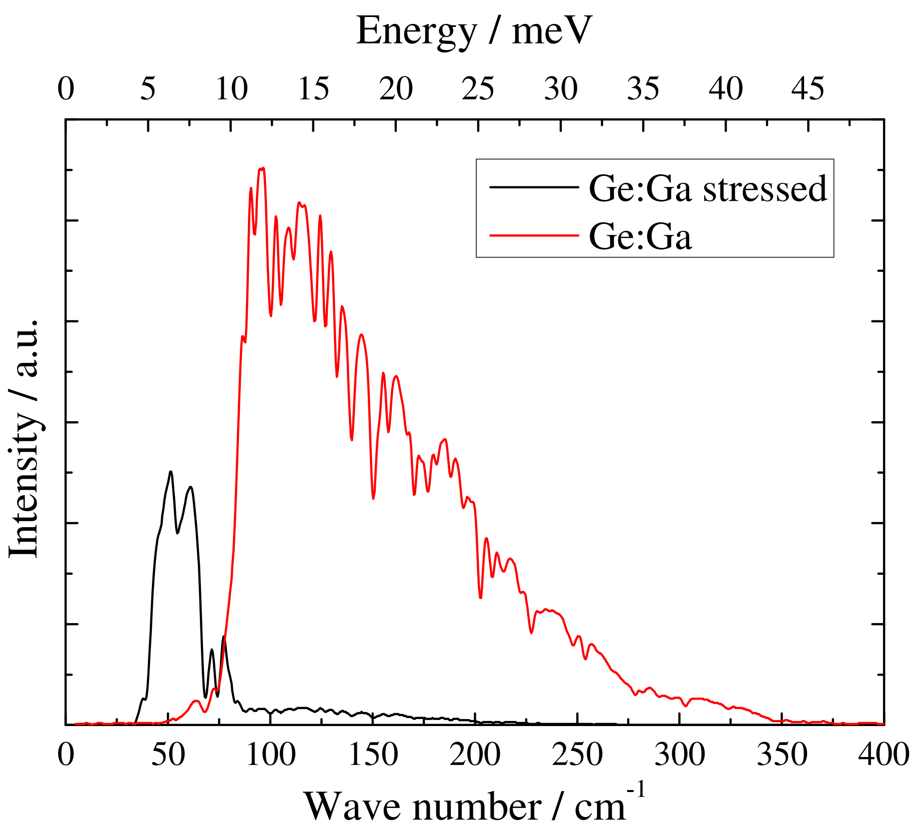
    Ge:Ga (7.93×10^{13} cm^{-3} , 2.11×10^{14} cm^{-3}, ~2×10^{15} cm^{-3})

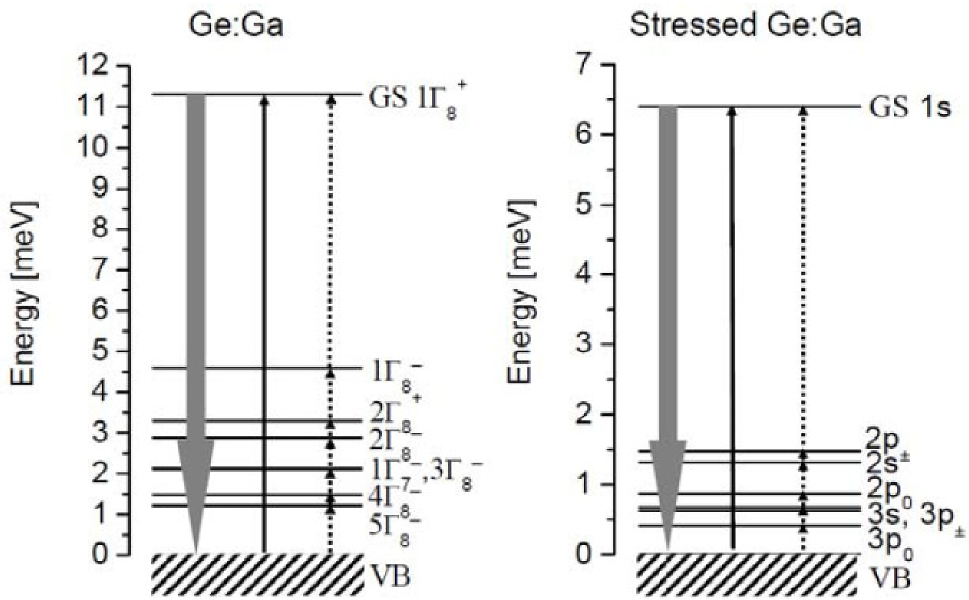
    Ge:Sb (~2.5×10^{12} cm^{-3}, ~6.3×10^{13} cm^{-3}, ~9×10^{14} cm^{-3})

    Ge:As (6×10^{15} cm^{-3})

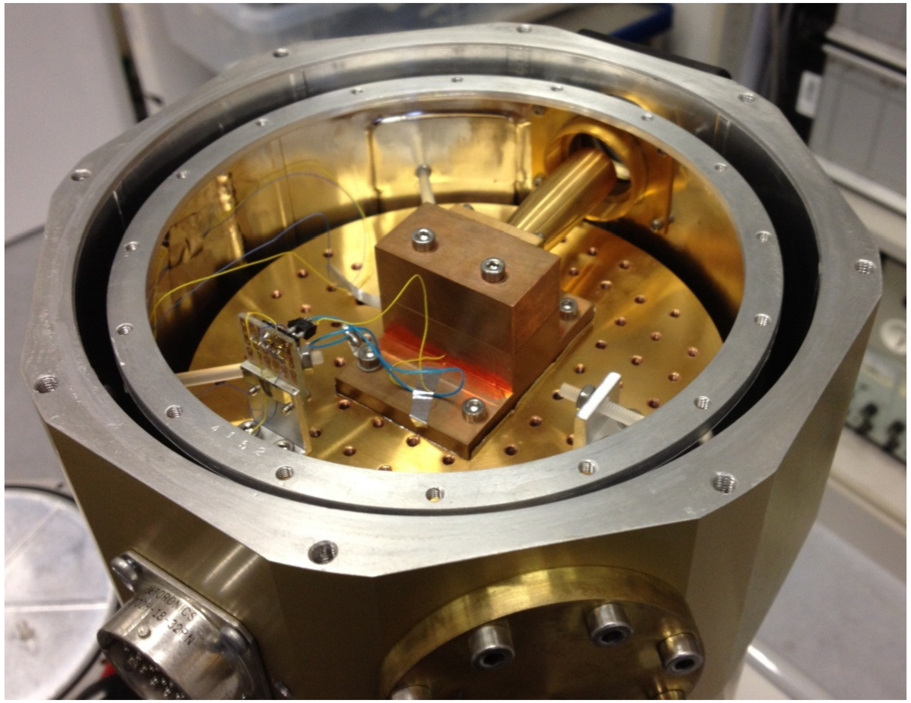
- other material already purchased (Ge:As ingot, Russia)
- NTD?

WP 5.4 - Extension to 200 µm wavelength

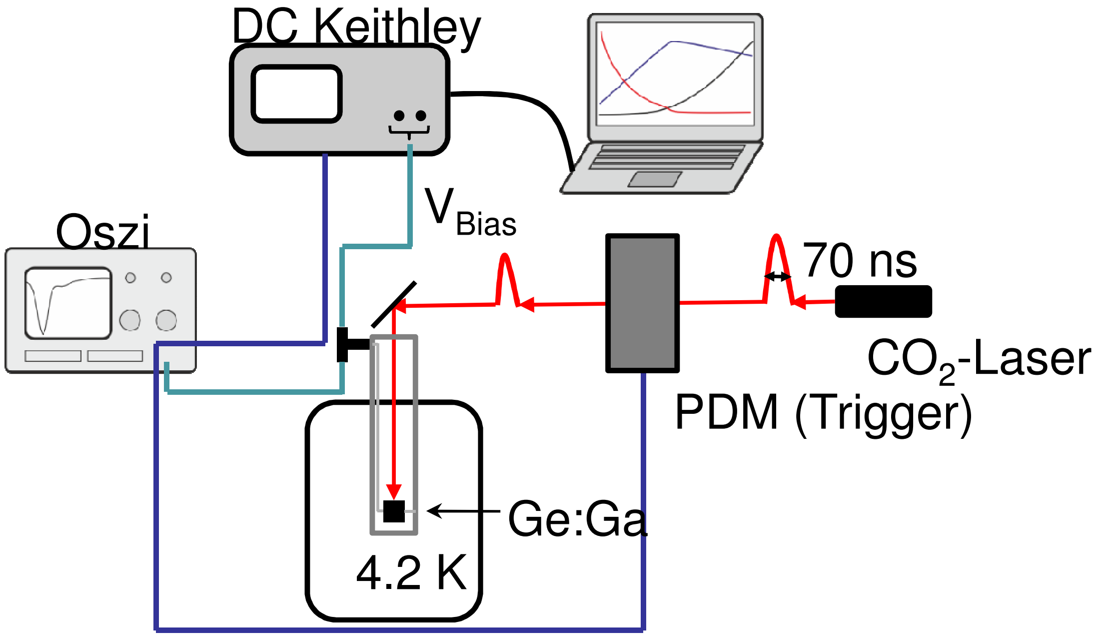


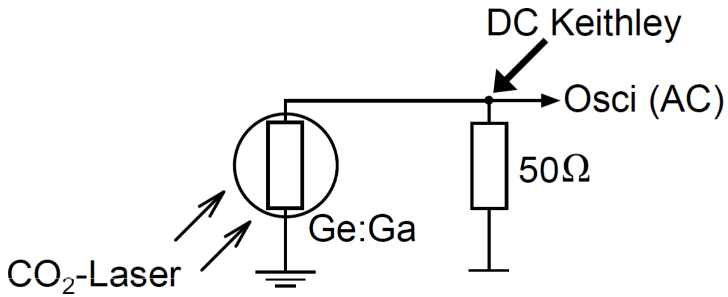


WP 5.5 - Integration into cryostat, characterisation, and calibration



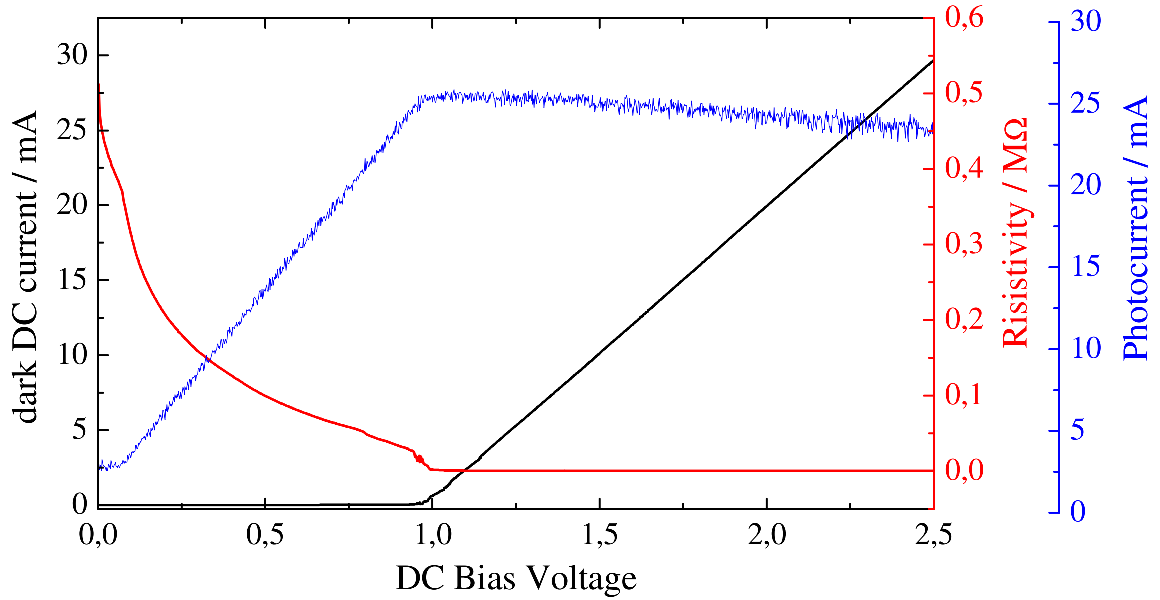
WP 5.5 - Integration into cryostat, characterisation, and calibration





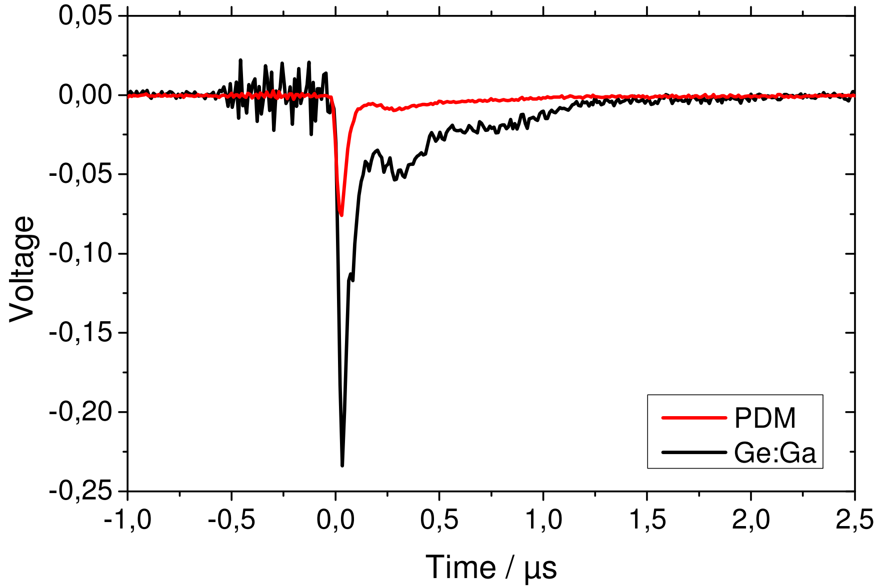
- Experimental setup to obtain information about temporal response on a CO_2 laser pulse
- Detector characteristics via Bias Sweep

WP 5.5 - Integration into cryostat, characterisation, and calibration

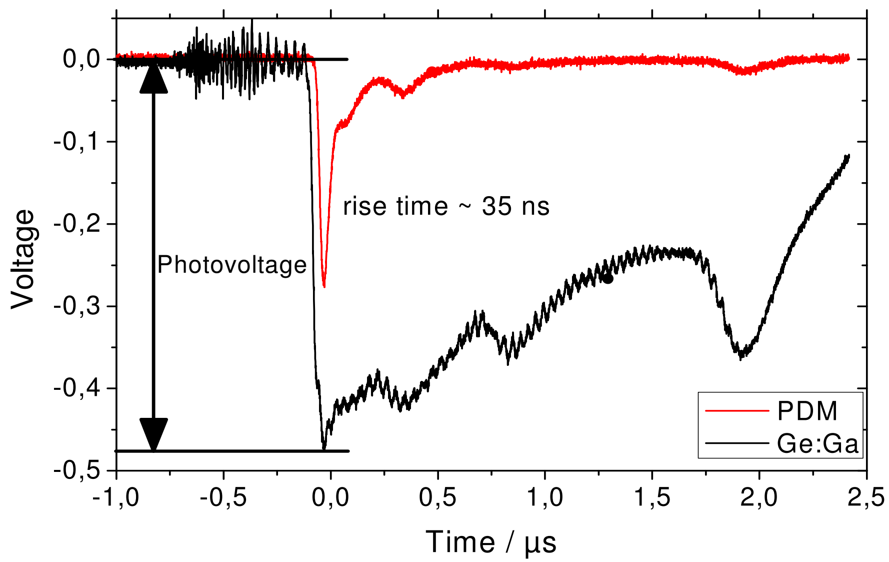


- Labview program written to measure (as a function of Bias Voltage)
  - resistivity of detector circuit
  - photocurrent during/after laser pulse & inbetween two pulses (dark current)

WP 5.5 - Integration into cryostat, characterisation, and calibration



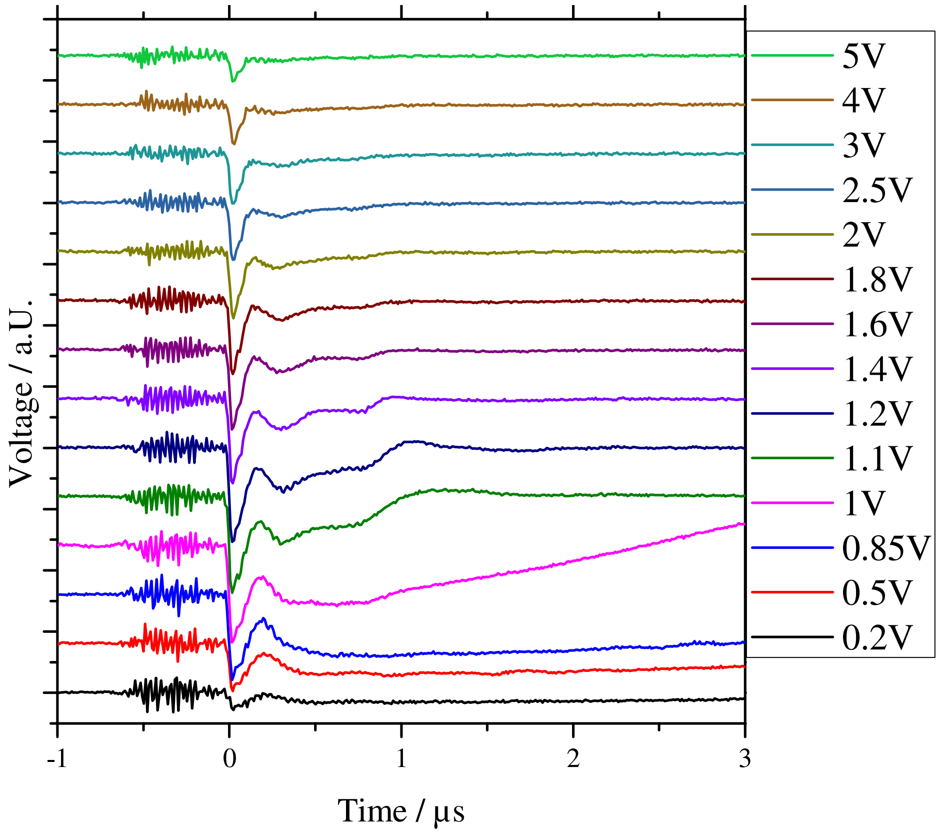
Temporal response with attenuation (480 µm mylar)

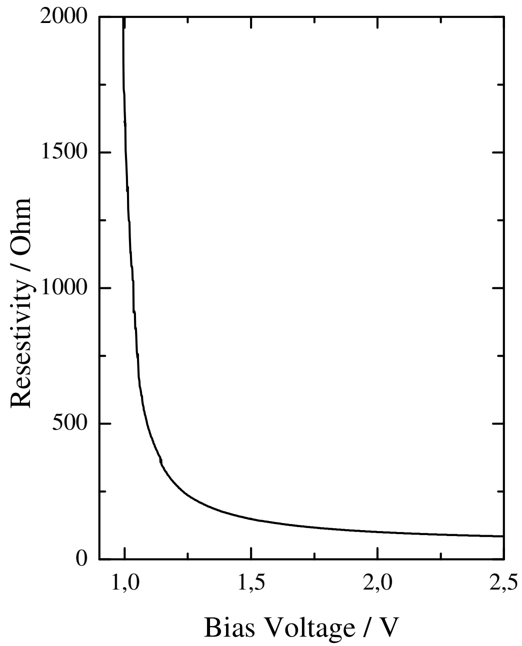


Temporal response without attenuation

- Too large intensity decreases temporal resolution

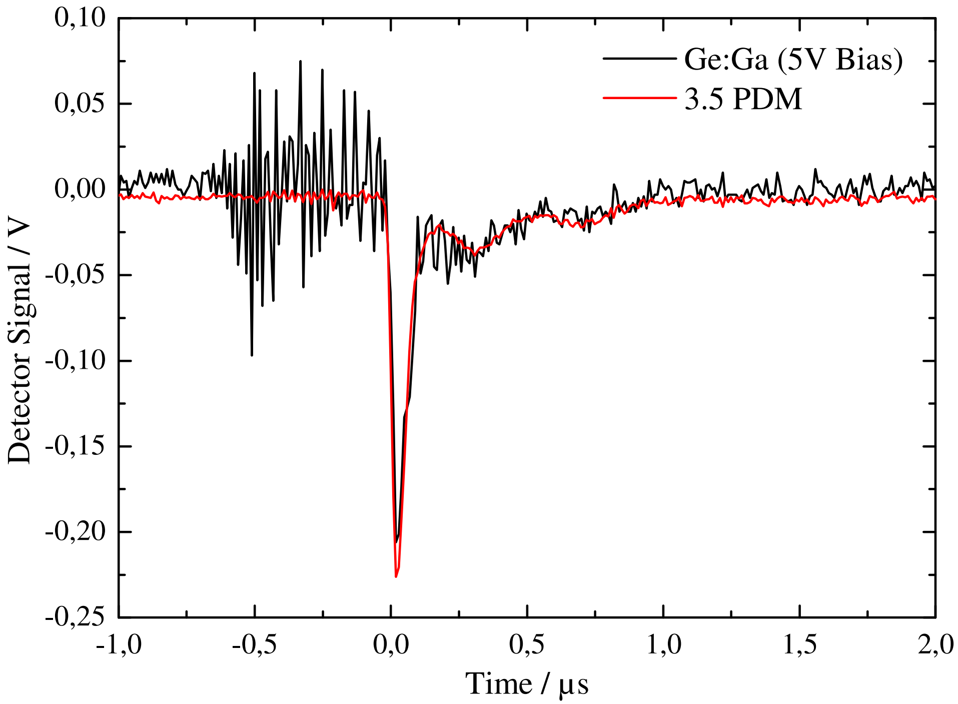
WP 5.5 - Integration into cryostat, characterisation, and calibration

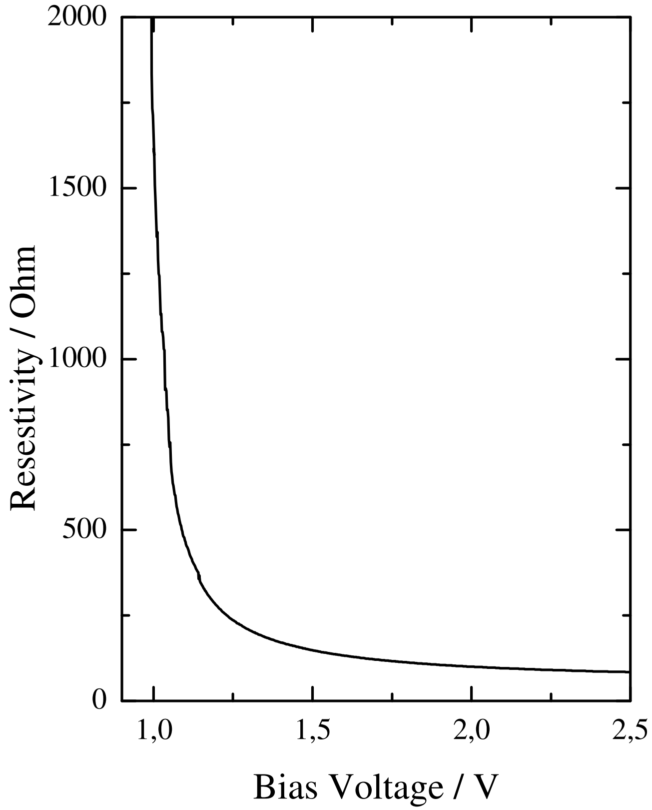




- The higher the Bias voltage the better the temporal response
- Electrical matching (resistivity during illumination) seems to be explanation

WP 5.5 - Integration into cryostat, characterisation, and calibration





- Highest Bias Voltage ($R_{Circuit}$ = 84 Ohm) reproduces peak perfectly
- But SNR decreased due to dark current

Milestone planning

Milestone planning

	1. Project year				2. Project year				3. Project year			
	1. Qt.	2. Qt.	3. Qt.	4. Qt.	1. Qt.	2. Qt.	3. Qt.	4. Qt.	1. Qt.	2. Qt.	3. Qt.	4. Qt.
Month	1-3	4-6	7-9	10-12	13-14	15-18	19-21	22-24	25-27	28-30	31-33	34-36
WP 5.1.1												
WP 5.1.2												
WP 5.1.3												
WP 5.1.4												
WP 5.1.5												
WP 5.1.6												

Vielen Dank für die Aufmerksamkeit!