Temperature control system for diamond characterization using ion beams

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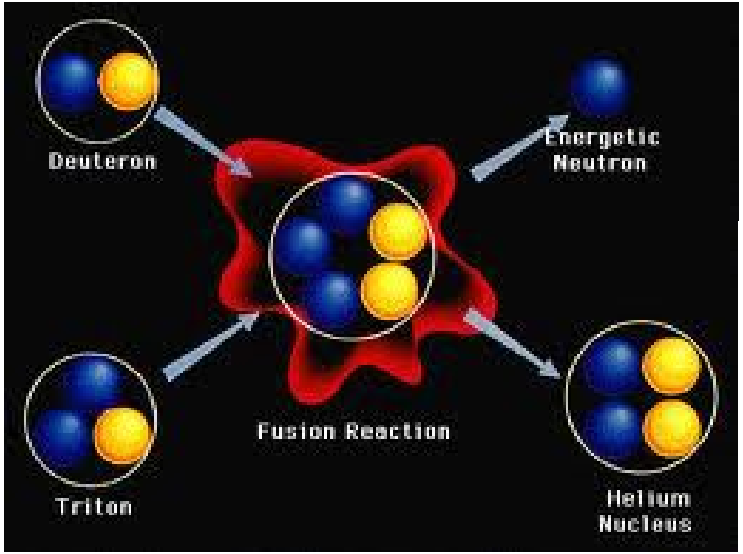
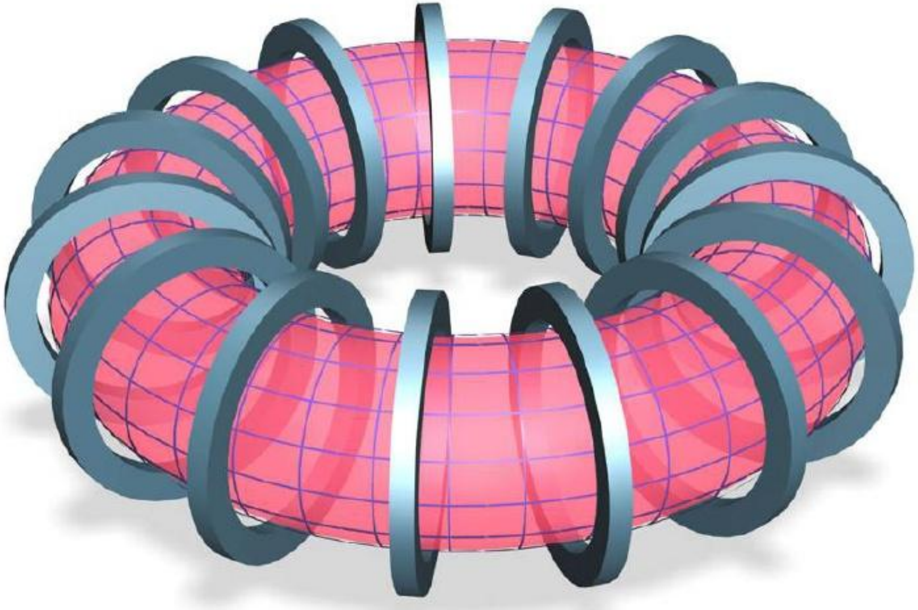
Outline

- Fusion - future power plants
- Design of temperature control system
- Using the system:
    - Ion Beam Induced Charge
    - Charge Transient Spectroscopy

Fusion on Earth



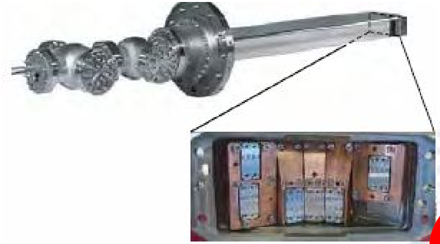
TOKAMAK

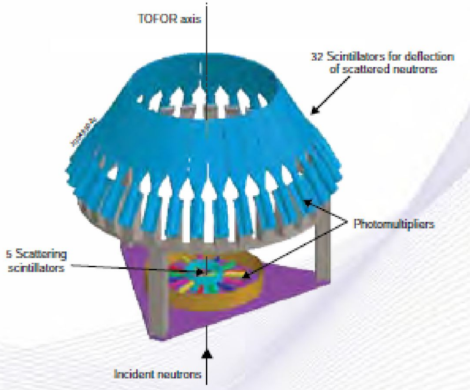


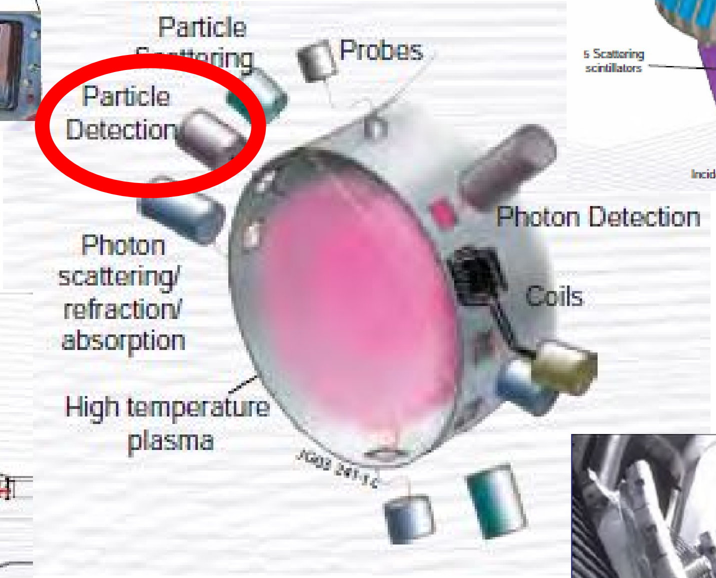
150 million degrees

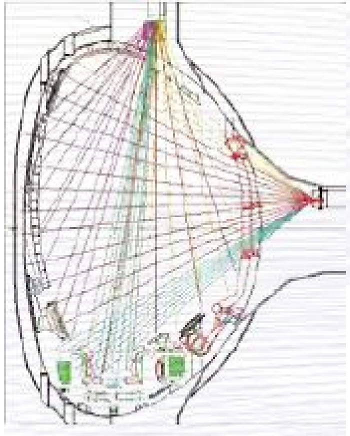

iter
TOKAMAK
&PLANT SYSTEMS

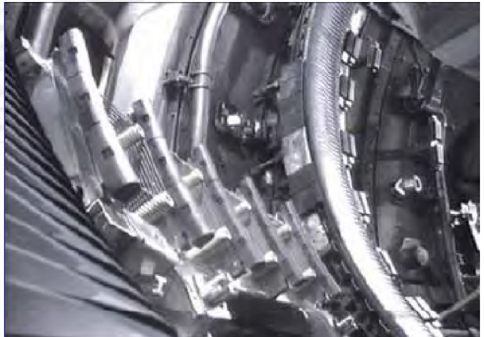
Plasma Diagnostics







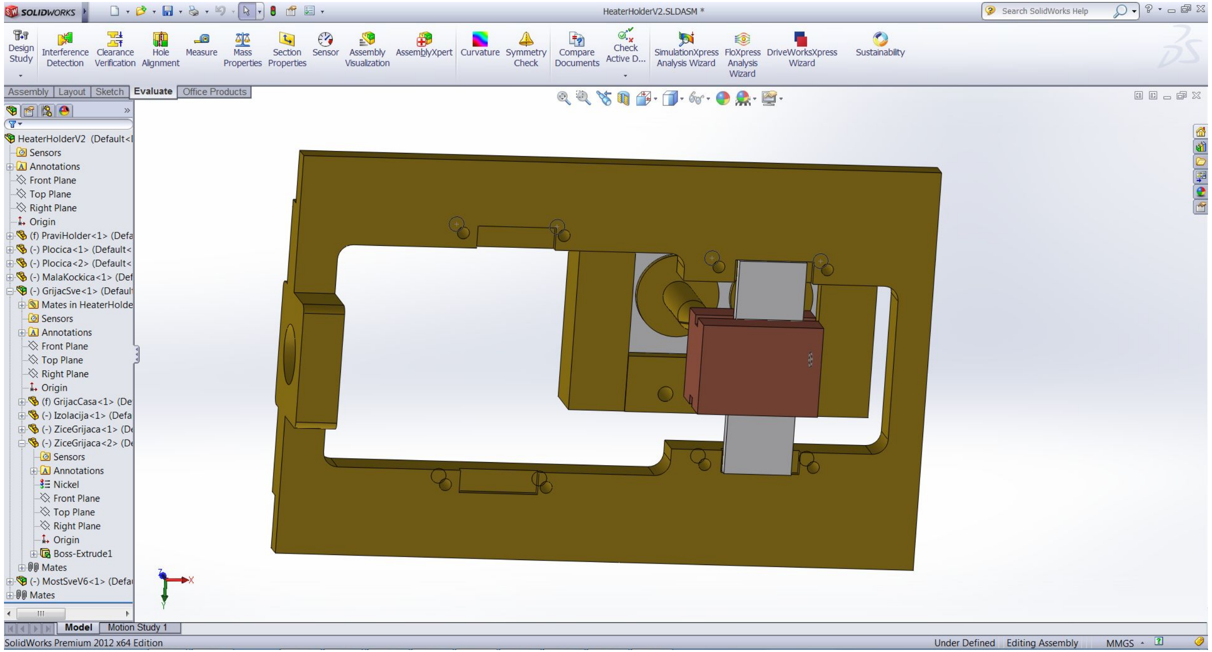




Task

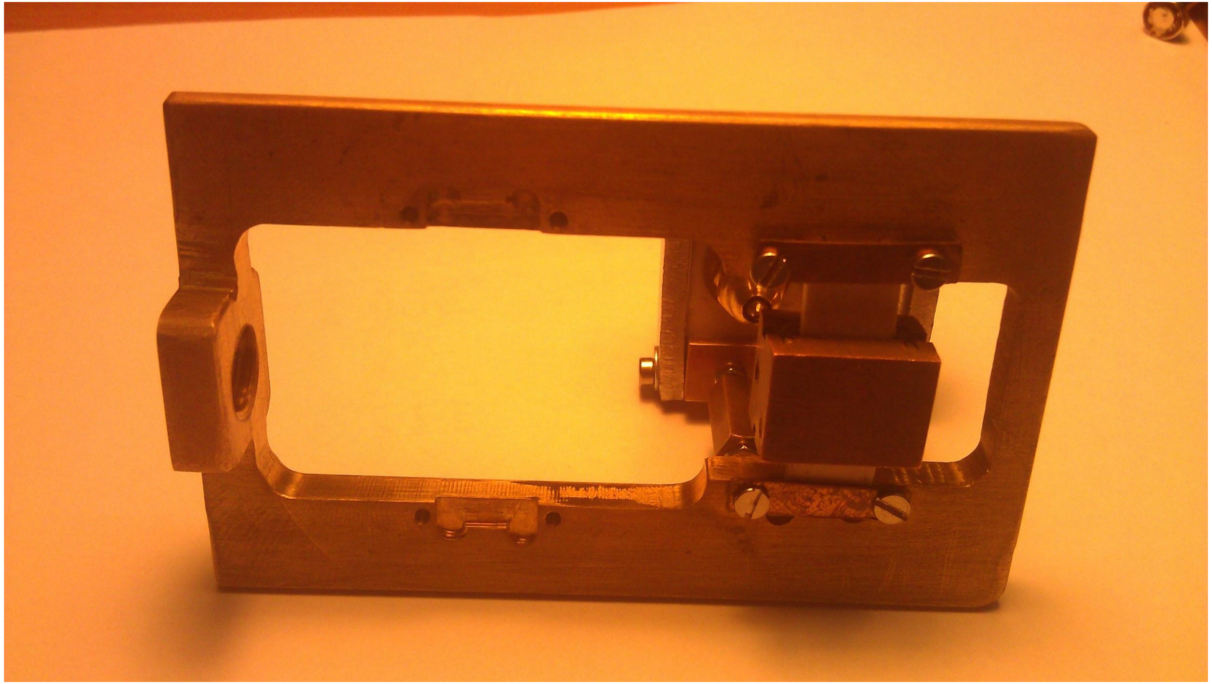
- How to test particle detectors on different temperatures?
- Design and construct a system for
  sample characterization using ion beams
  in the temperature range of -100 °C to +600 °C.

Mechanical design and manufacturing



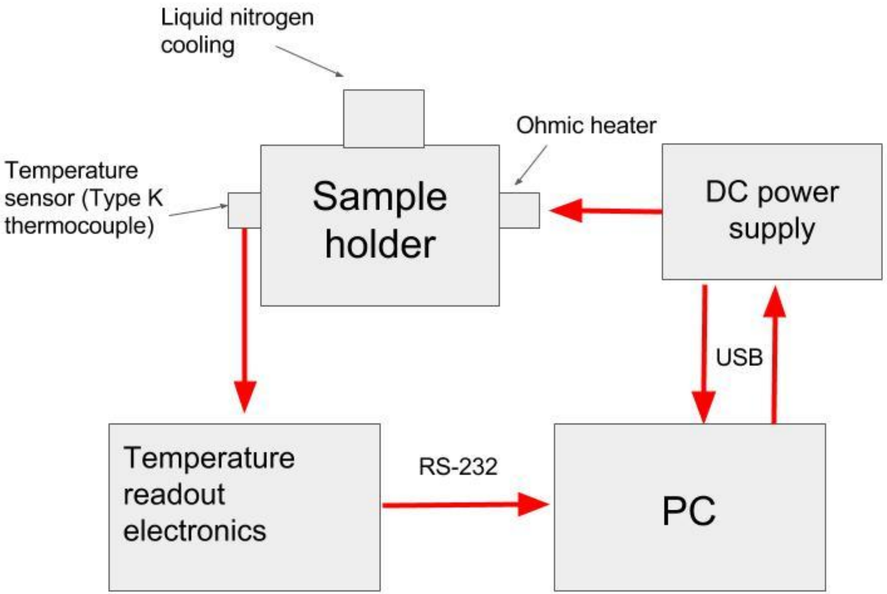
- 3D CAD model using Solidworks

Mechanical design and manufacturing



- In house manufacturing

Computer controlled heating and cooling:

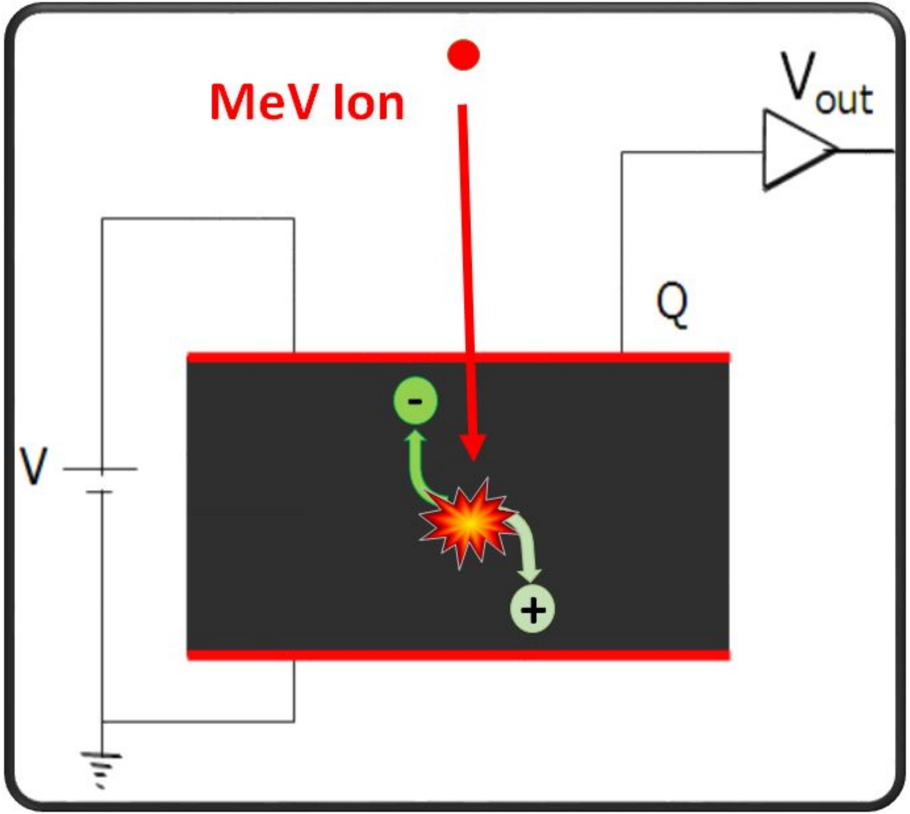


- Homemade python temperature control software

Tested capabilities

● Temperature range:	-120 °C to +650 °C
● Temperature stability:	better than ± 0.5 °C (for heating part)
● Vacuum level after heating:	better than 10^{-5} mbar
● Chamber temperature:	less than 50°C
● Electromagnetic noise:	not seen in electrical measurements

Charge generation and collection

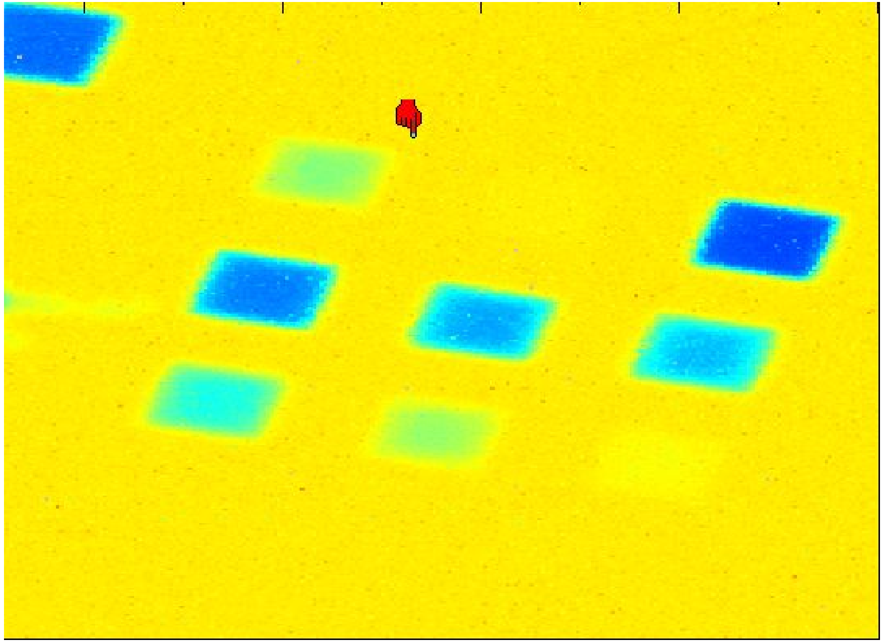


Collecting total charge

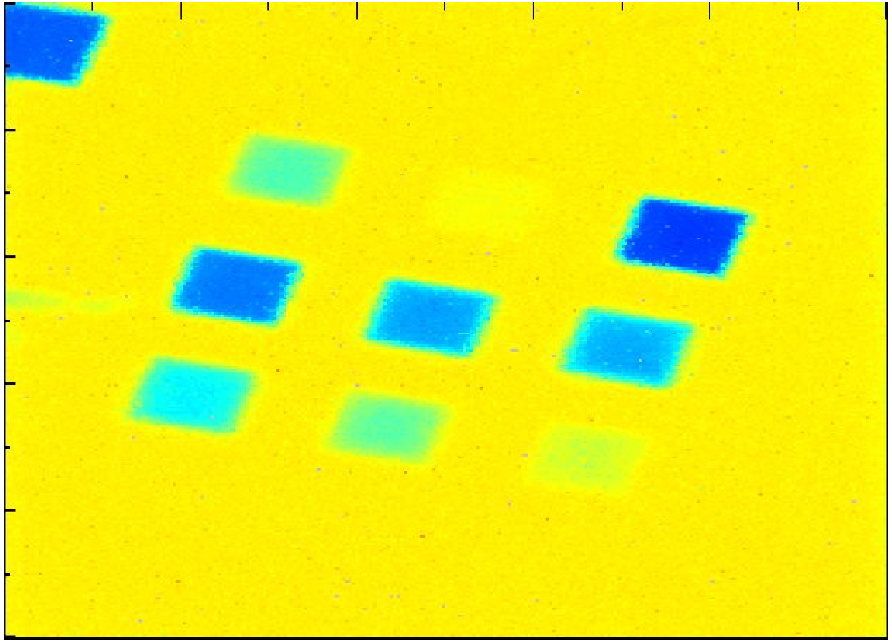
- 50 μm thick scCVD diamond detector from DDL

Ion Beam Induced Charge

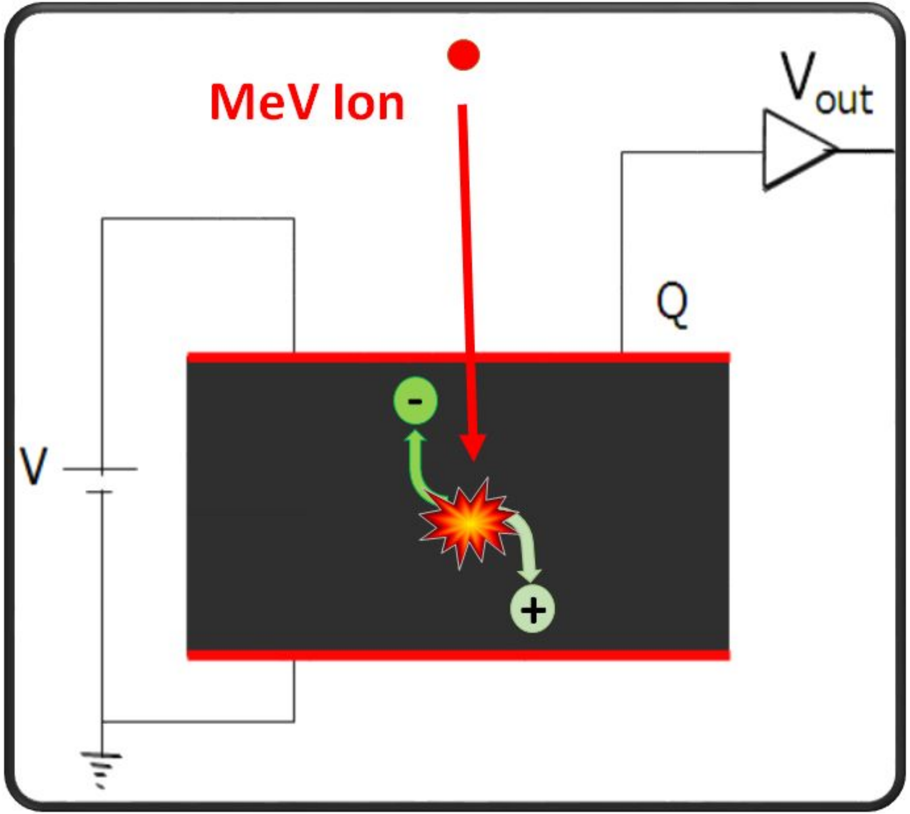
25 °C



250 °C



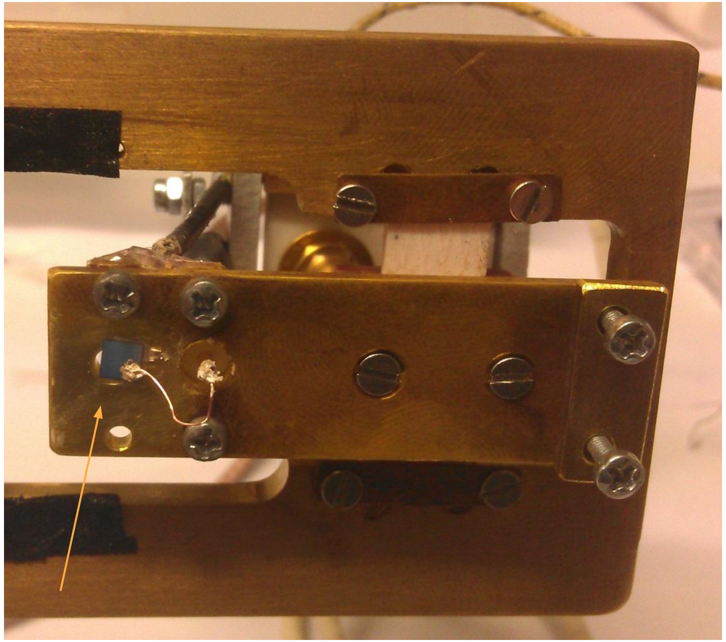
Charge generation and collection



Measuring transient current

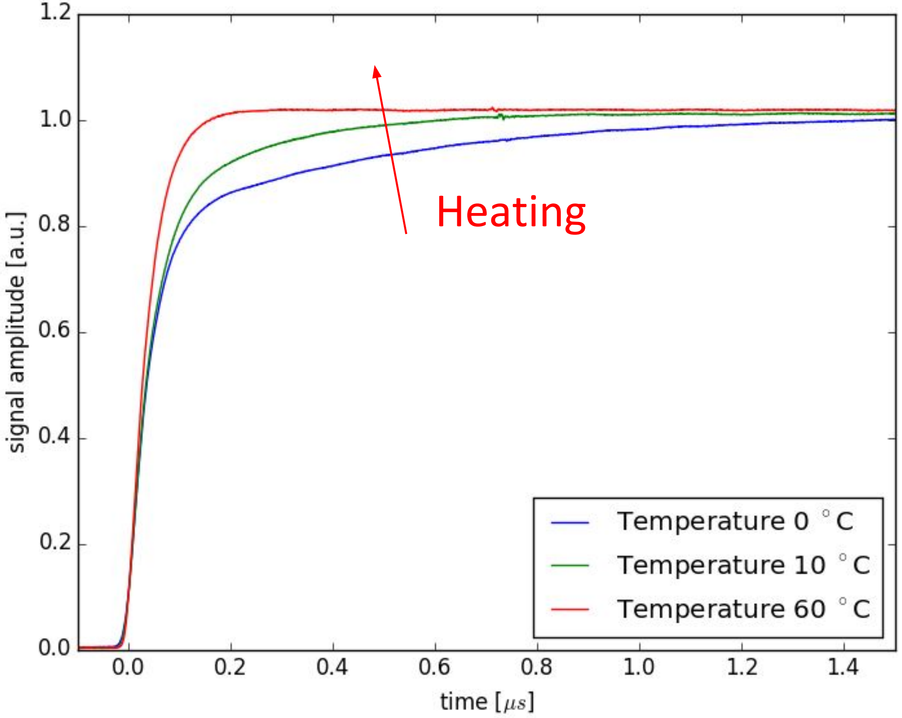
Charge transient spectroscopy (QTS) setup

- CoolFET preamplifier
- WaveMaster 8500A oscilloscope



NDT sample mounted on QTS setup

QTS trace analysis



$$A = A_0(1 - e^{-e_1 t})$$

$$e_1 \sim \sigma\, N_D e^{-\frac{\Delta E}{kT}}$$

- Traps in whole sample:
  - ΔE = 0.53 eV ±0.1 eV
  - $\sigma\ N_D$ is lower
  - Boron? Arsenic?
- Traps close to the edge:
  - ΔE = 0.43 eV ± 0.04eV
  - $\sigma\ N_D$ is higher
  - Boron? Arsenic?

Future plans

- Higher temperature electrical measurements
  - Different material for contacts (Tungsten…)
  - Mechanical connections instead of soldering
- Irradiation damage on high temperature

Thank you for your attention!