Universität Karlsruhe (TH)

Beam-monitors based on diamond-strip-detectors

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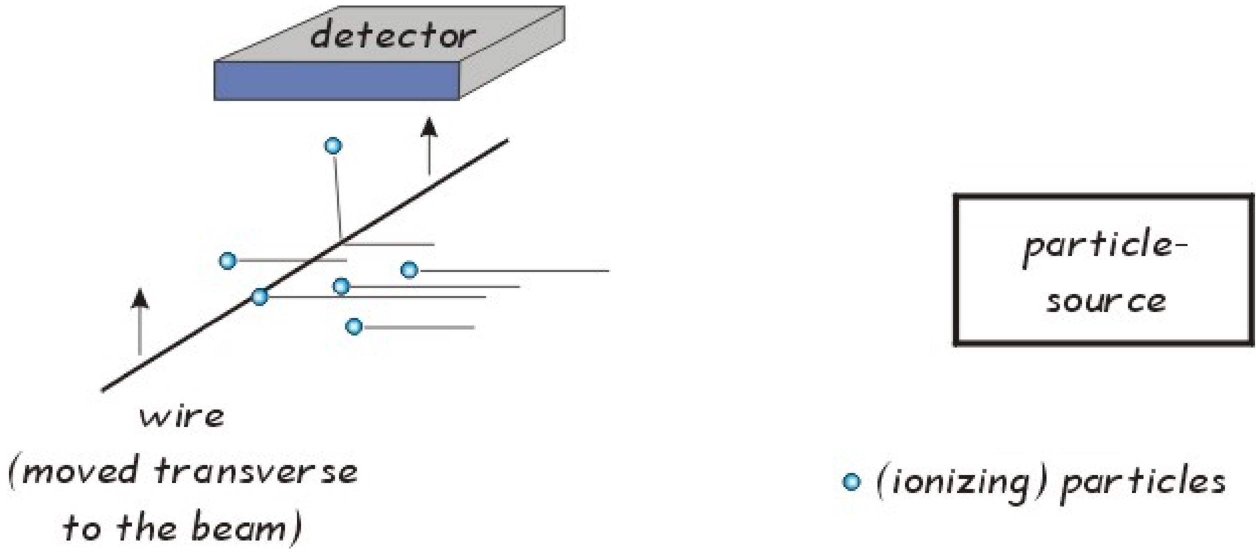
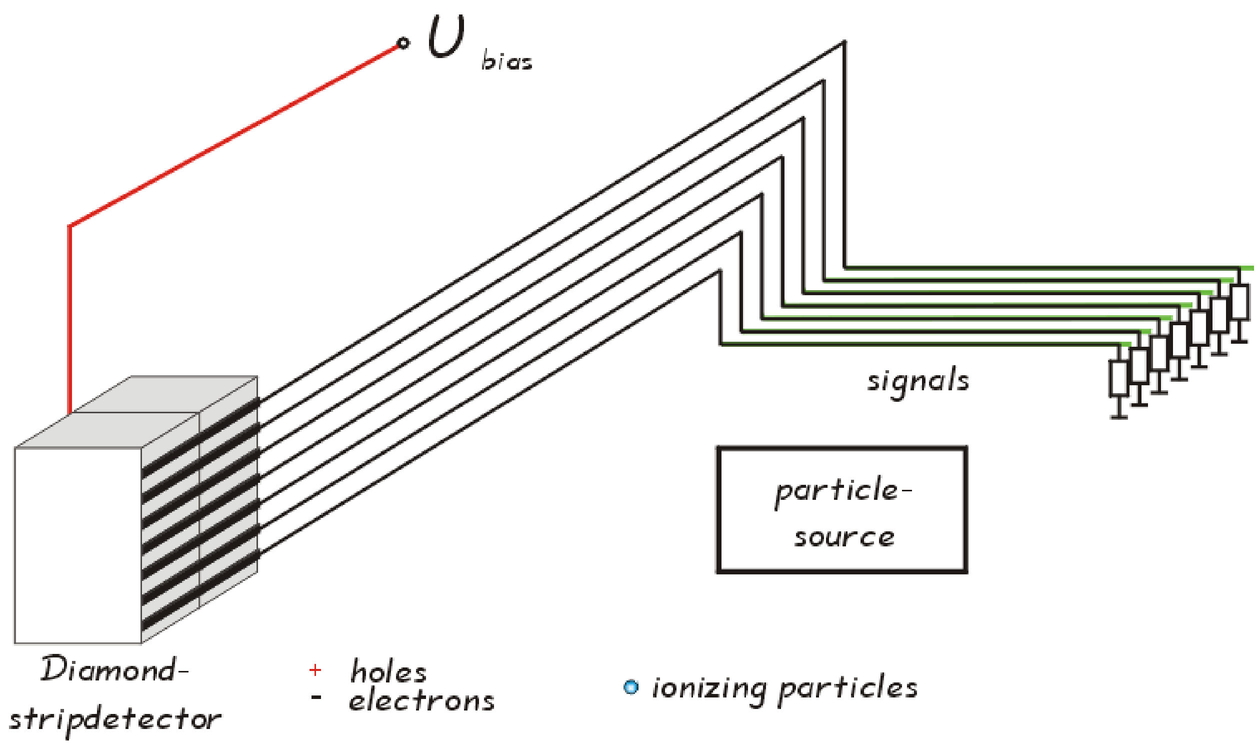
Beam-monitoring with wire-scanners



A very thin wire is moved through the beam. From the number of particles scattered into the detector, one can calculate the intensity of the beam at the postion of the wire.

Beam-monitoring with strip-detectors



- High transversal and longitudinal resolution
- Measurement on single bunches of charged particles

Why diamond?

- Radiation hardness: (M.Bruzzi for RD42)

  -decrease of ~15% of CCE after 10^{15}protons/cm^2,

  -decrease of dark current with fluence
- Thermal conductivity:

  ~ 20 W/cmK (5 times higher than in copper)
- Fast signals

  electron-mobility: 2200 cm^2/Vs (Si: 1400 cm^2/Vs)

  hole-mobility : 1800 cm^2/Vs (Si: 450 cm^2/Vs)

Why is diamond radiation hard?

Since the bandgap (~ **5.5eV**) is very large, traps can be filled permanently. Thus they are not available for recombination or excitation processes any more.

⇒ The charge collection efficiency stays high.

⇒ The leakage current does not increase very much.

Requirements for diamond at TESLA

Size and charge of bunches at the end of the linac according to the TESLA - Technical Design Report: (Desy 2001 – 011, ECFA 2001 - 209)

$2 \cdot 10^{10}$ electrons,

$E = 250$GeV,

$\sigma_x = 60\mu m$, $\sigma_y = 3\mu m$.

Model calculation: $\Rightarrow$ $\boldsymbol{\phi \approx 1{,}4 \cdot 10^{16}\ e^-/cm^2}$

$\Rightarrow$ $\boldsymbol{\Delta T \approx 1600\ K}$

Metallisation with aluminum

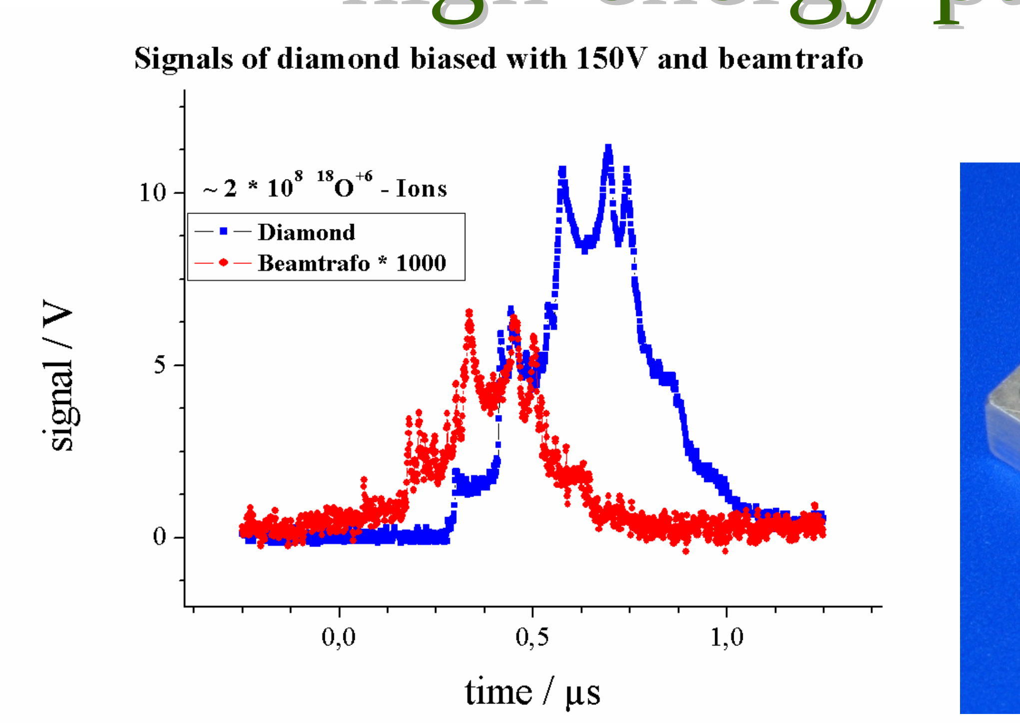
Why metallisation with aluminum?

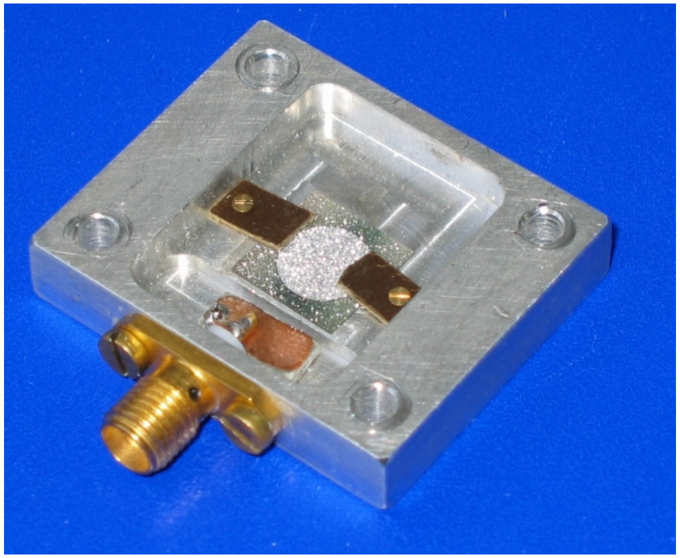
- Aluminum has a low density and a small Z. Thus the energy loss of ionizing particles is small and comparable to the energy loss in diamond.

  $\Rightarrow$ small thermal stress during irradiation

- It was proven that aluminium has good electrical and mechanical contact to the diamond, even after interaction with high intensity heavy-ion-beams.

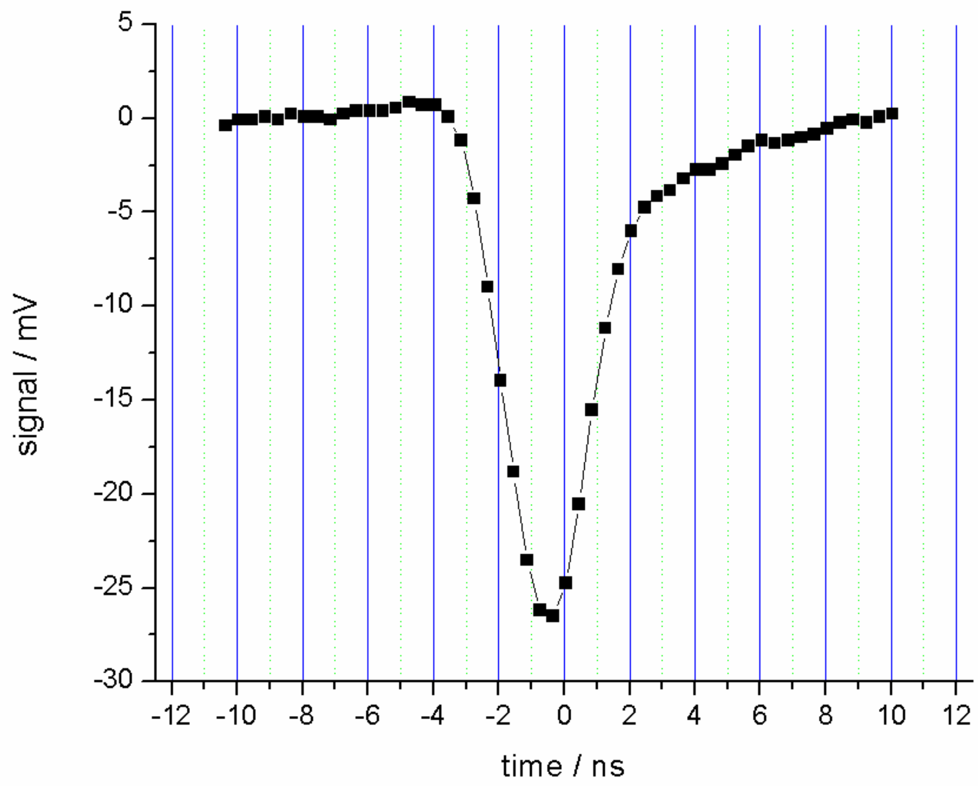
First results with bunches of high-energy particles





Pulses measured with O^{6+}-ions at GSI („Gesellschaft für Schwerionenforschung“) in Darmstadt. A 250µm diamond with a 7mm circular pad was used for this measurement

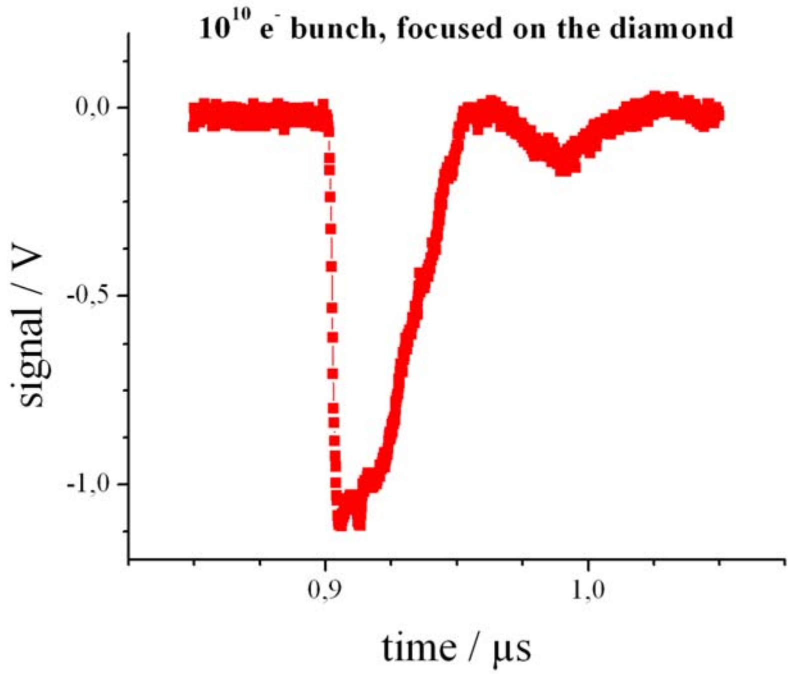
Fast signals



This signal was taken at the proton - cyclotron of the FZK (ForschungsZentrum Karlsruhe), where a pulse is delivered every 38 ns.

Unfortunately it could not be verified up to now whether the pulse is shaped like this or if the bandwidth of the readout (cables and scope) was limiting.

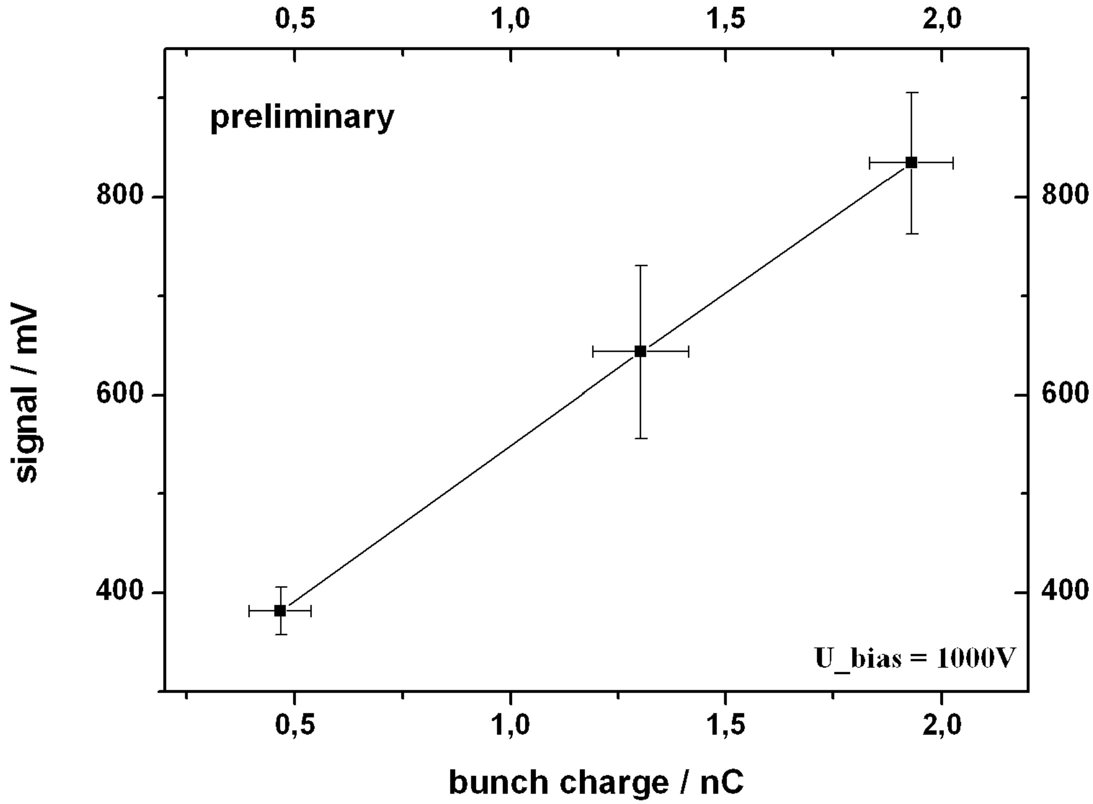
Signls from electron-bunches at TTF



Typical signal of a diamond generated by an electron bunch at the Tesla Test Facility. The diamond was 250µm thick with a circular aluminium pad of 7mm in diameter.

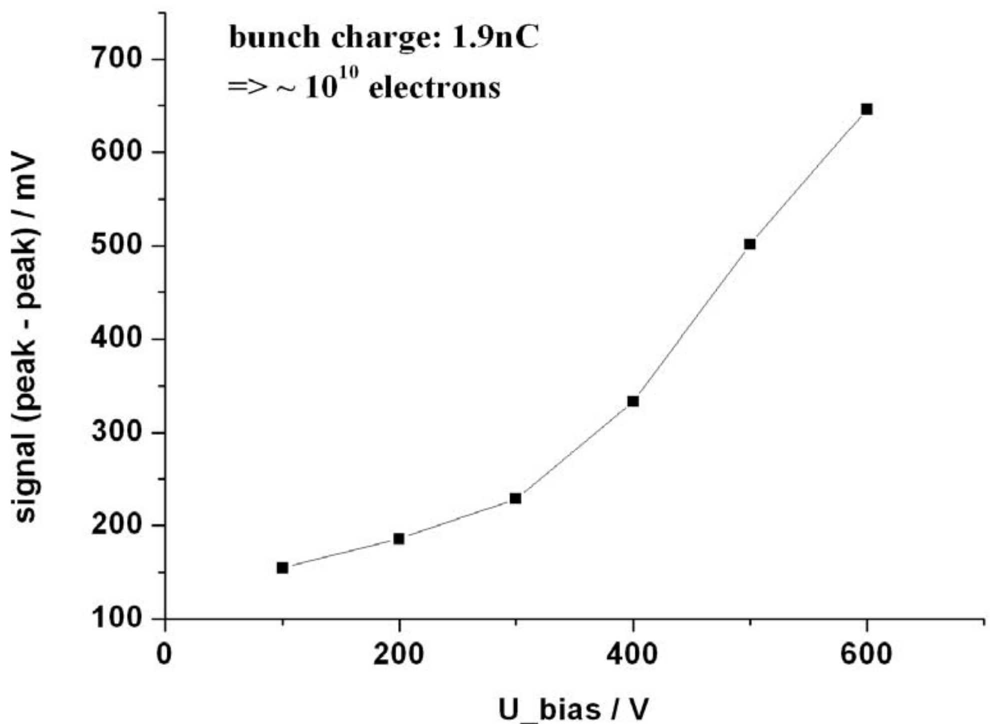
(TESLA: TeV superconducting linear accelerator)

Linearity of signals at TTF



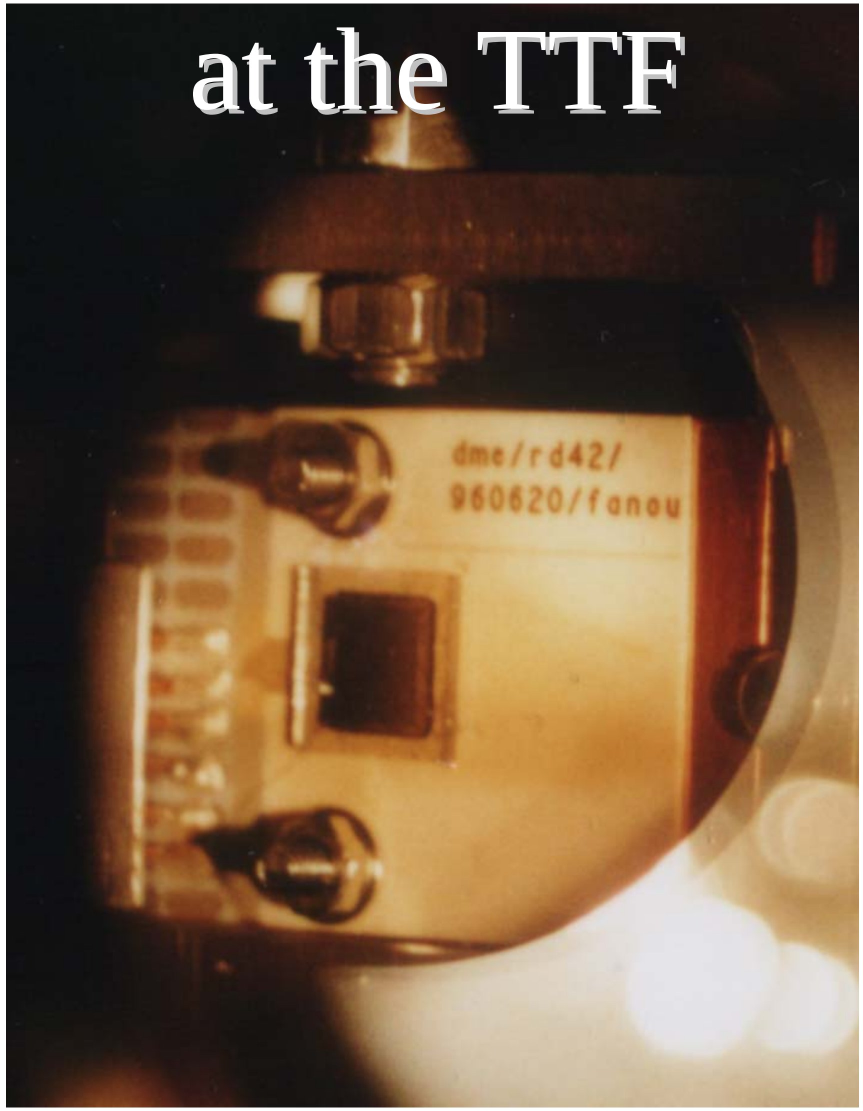
Signals were measured with an RD42 strip-detector. The thickness was approximately 1100µm.

Voltage-scan at TTF

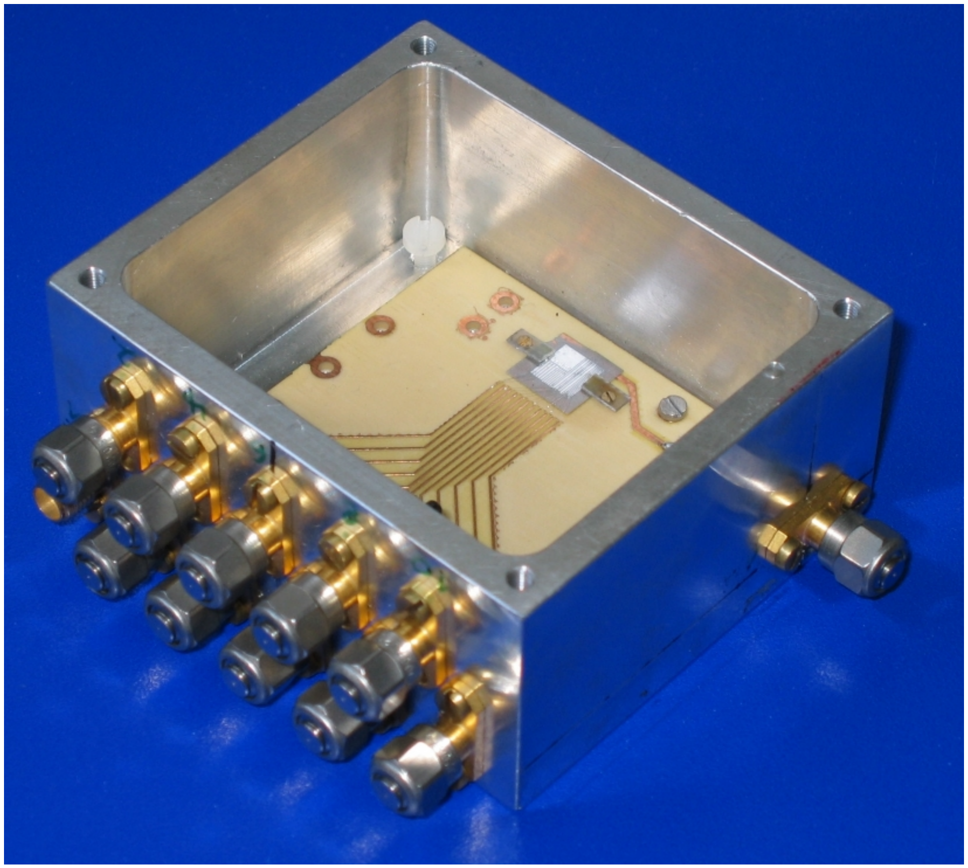


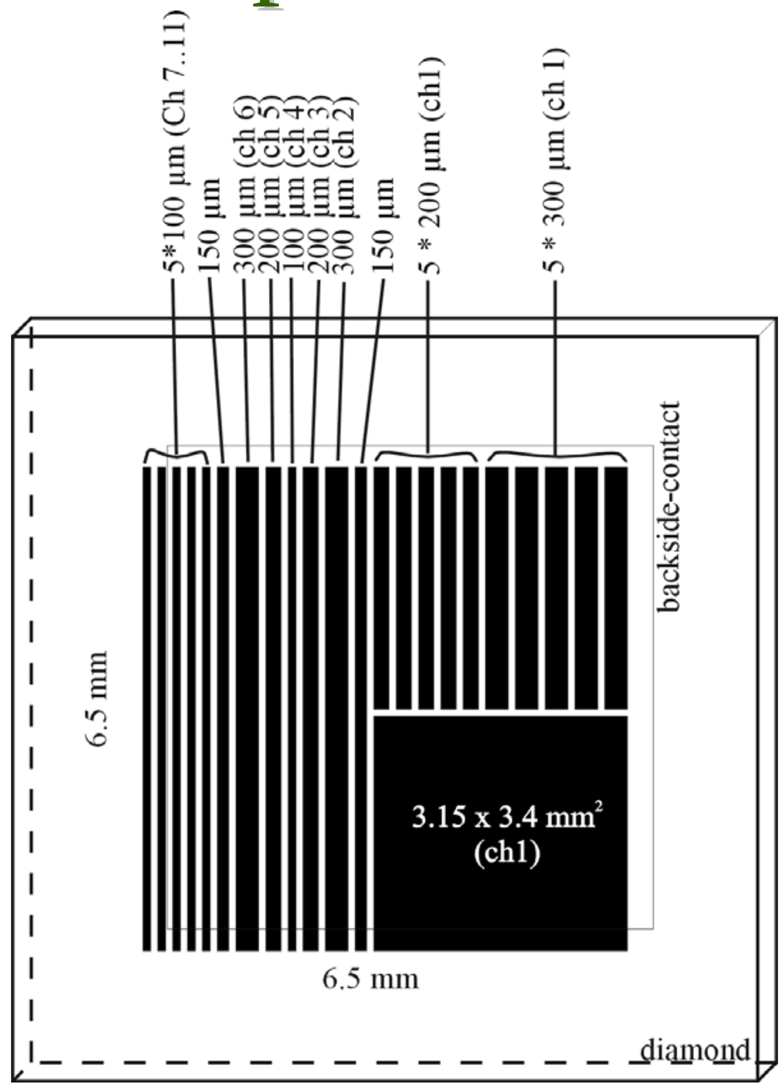
The RD42-strip-detector was used for this measurement. Unfortunately the highvoltage cables did not work properly with voltages higher than 600V.

Image of the RD42 sripdetector at the TTF



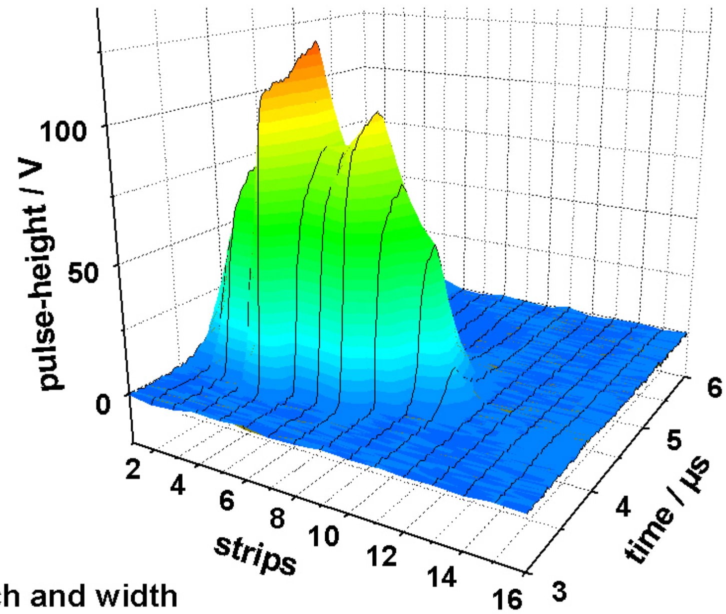
Measurements with a strip-detector



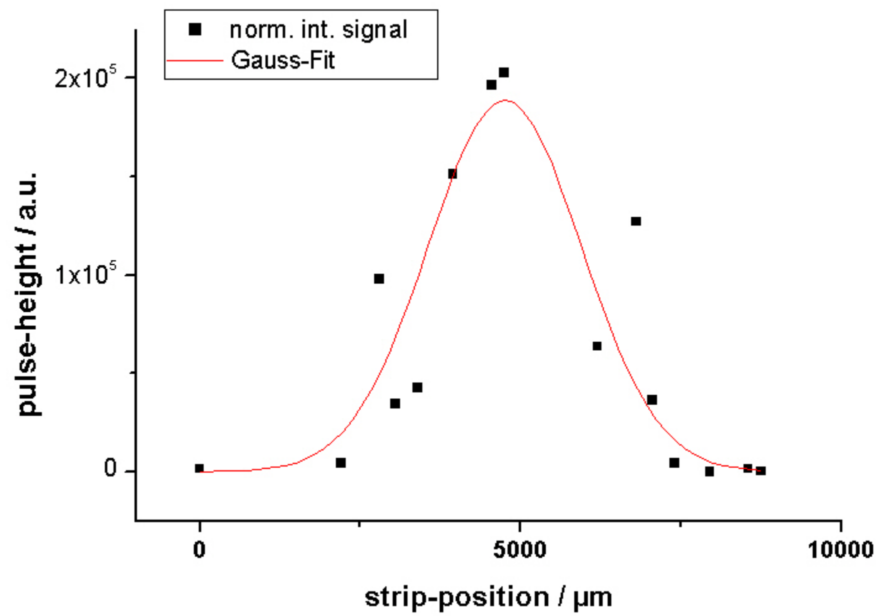


Measuring a bunch-profile

Pulse-shape measured at GSI Darmstadt with a few bunches of 10^9 Xe^{47+}-ions at an energy of 27.7 GeV



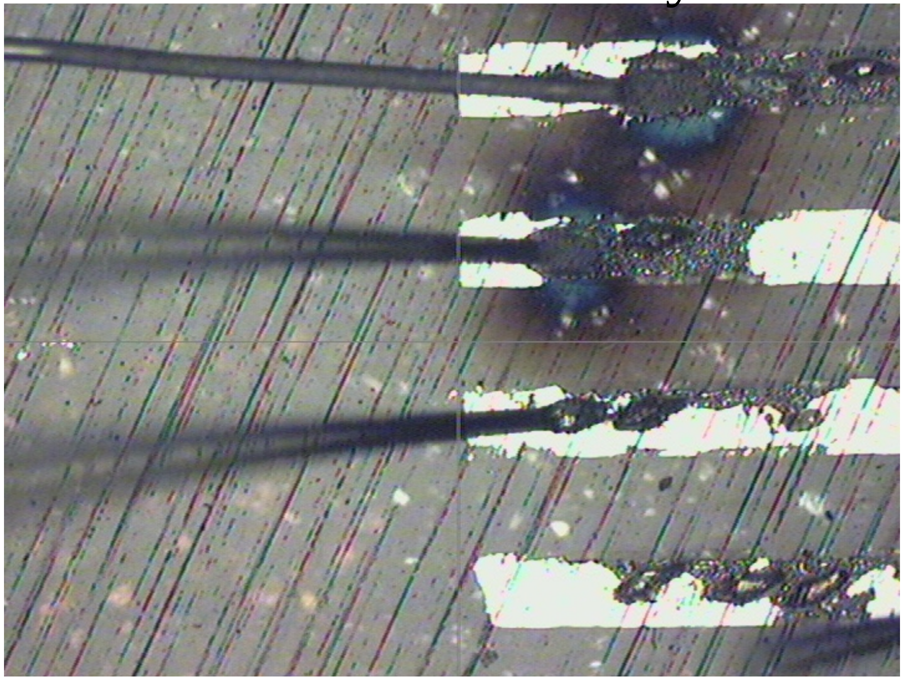
pitch and width of strips are not uniform



Signals were measured with a 4-channel-oscilloscope and so this profile was measured with a few bunches. Estimating the bunch-width results in a value, which is a little higher than the one estimated with a scintillator.

Sparks in the Argon Atmoshpere?

The diamond was placed in a box with an Argon atmosphere. When the pressure was decreased to a few mbar there were strange signals and after some time some of the strips did not give a signal any more. Measuring the resistance between the strip and these bonds after the beam-test we found that they lost contact...

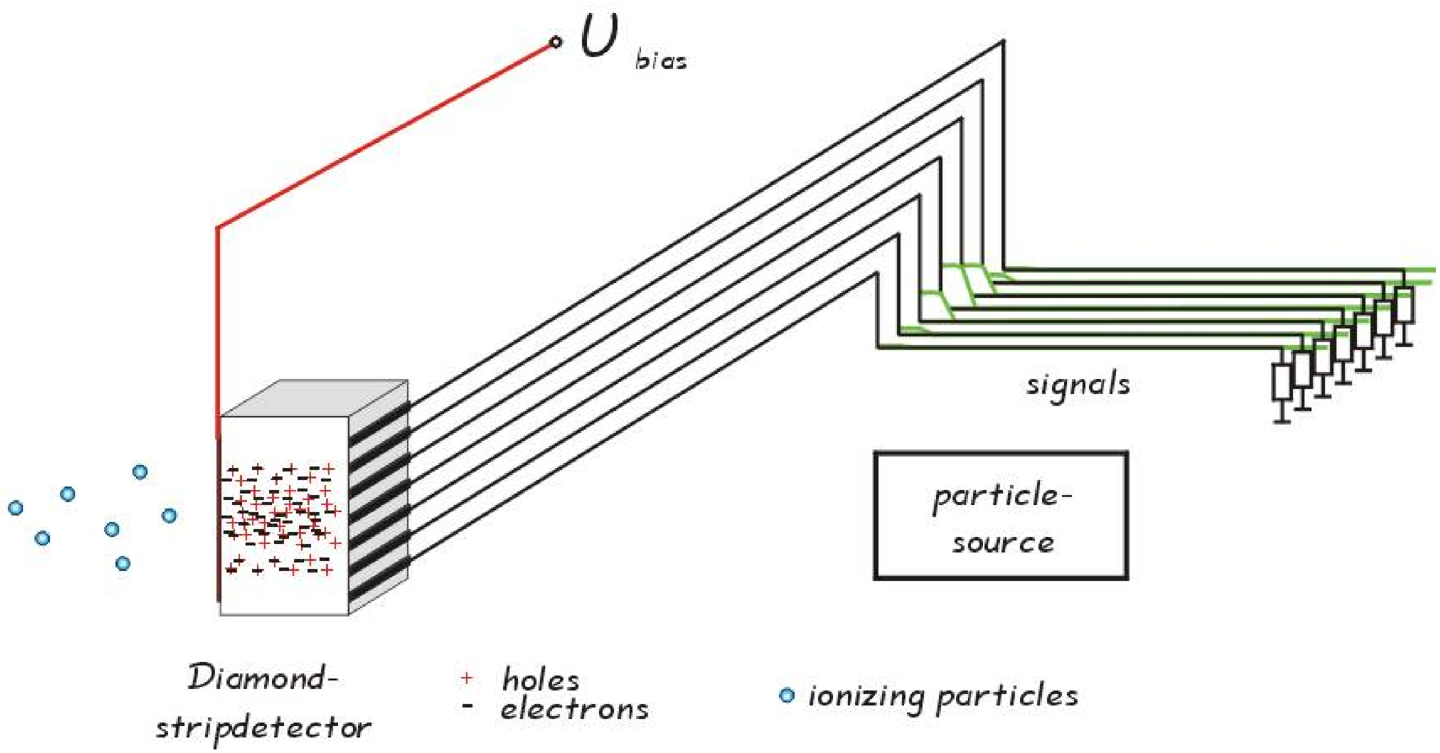


Outlook

stripdetectors:

The high density of ionizing particles induces a plasma of electrons and holes in the detector. With the next measurements it will be checked if this plasma spreads out and caused the measured bunch width to be wider than expected.

Beam-monitoring with strip-detectors



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