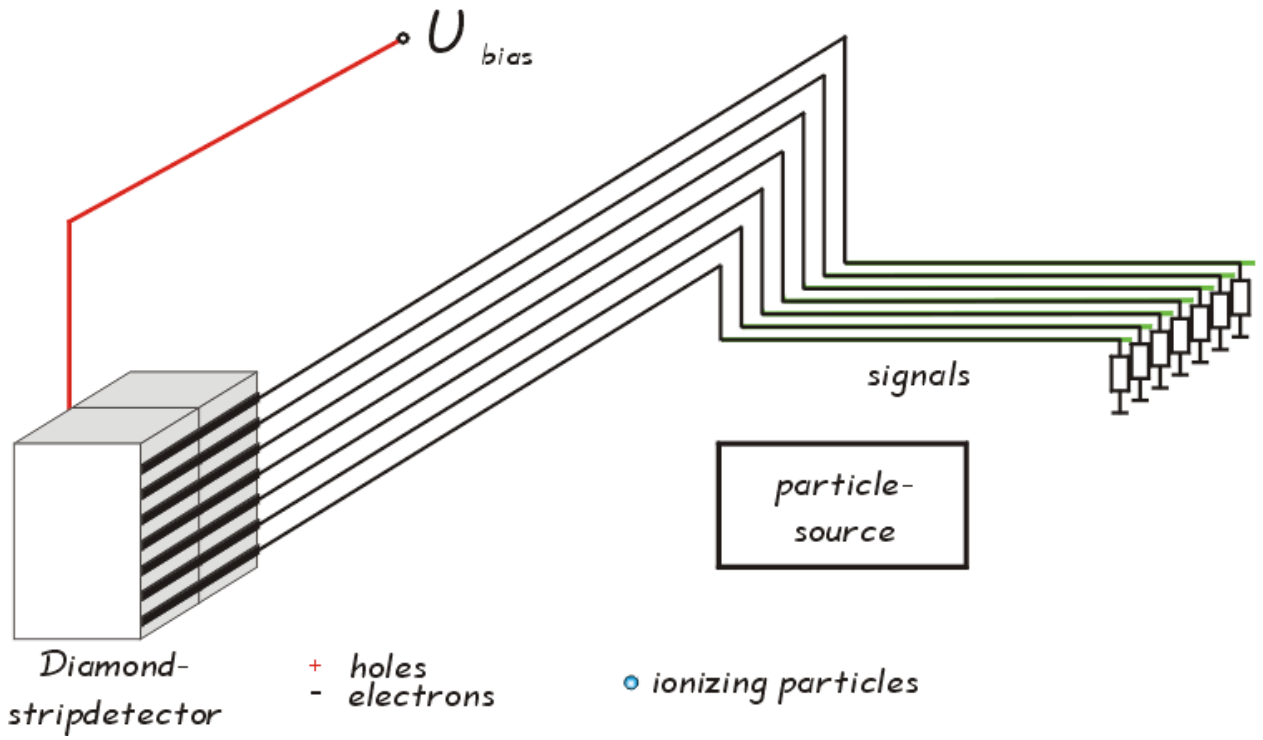
Universität Karlsruhe (TH)

Destructive Measurements with Diamonds in a Lead Ion Beam

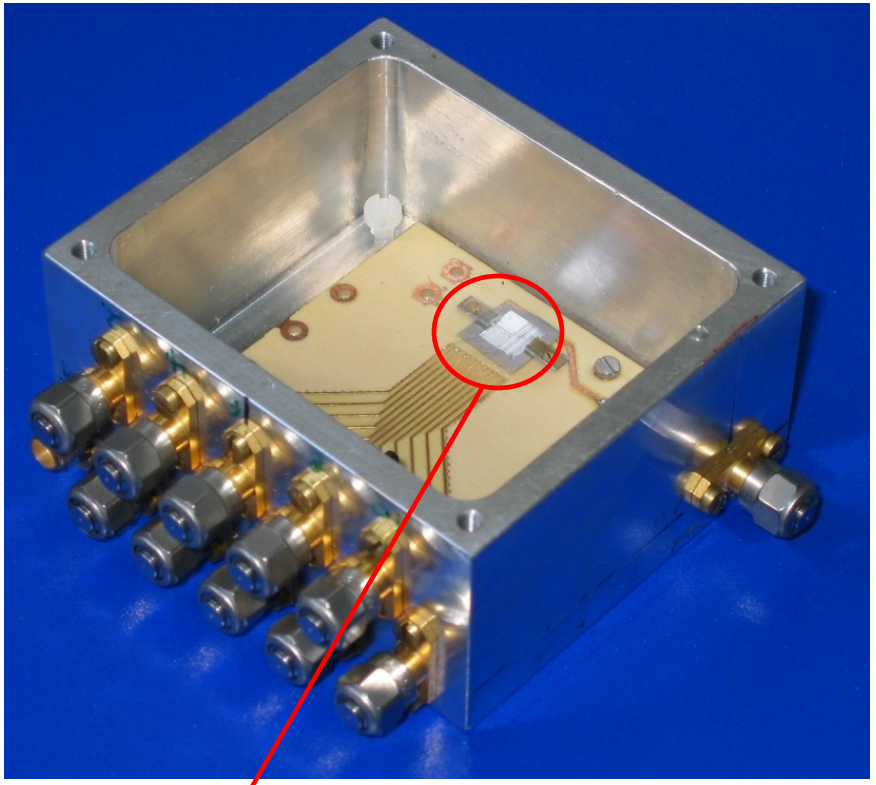
J. Bol, E. Berdermann, W. de Boer, S. Müller,
M. Pomorski

Beam-monitoring with strip-detectors



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

The strip detector



Detector and housing

- Size: ~ 1 x 1 cm^2
- Thickness: ~ 80 µm
- pCVD diamond
- Aluminum metalization (low Z ! low dE/dx)
- Strips of varying width

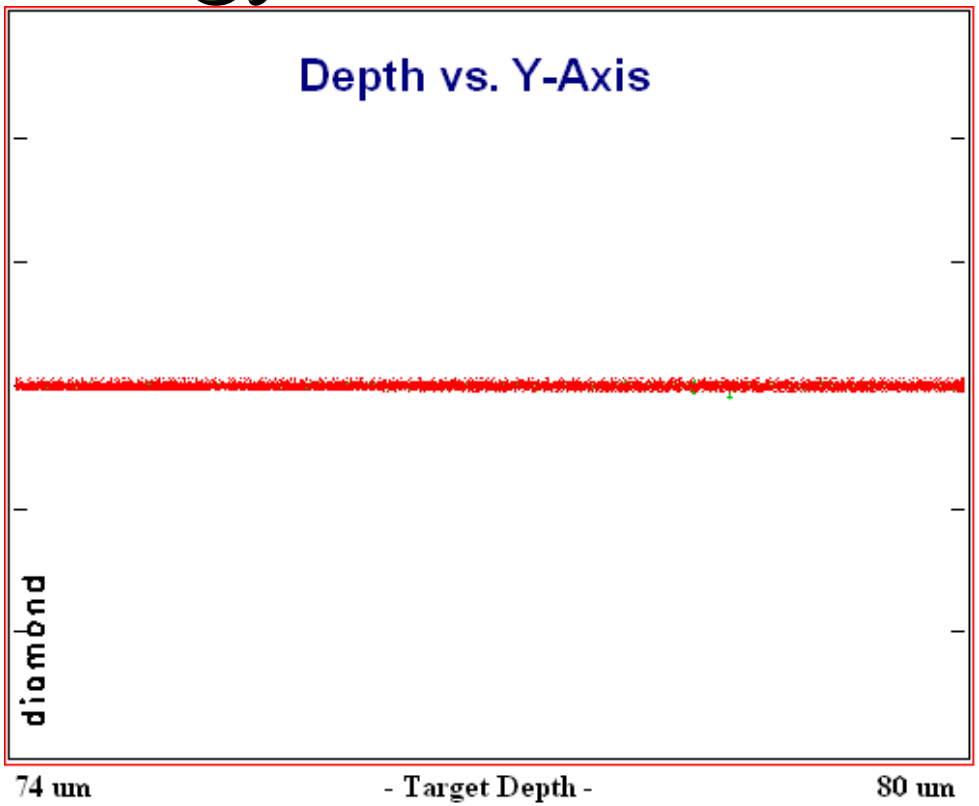
Beam Conditions

- Bunches of lead ions
- 67 elementary charges per ion
- Lateral dimensions: ~ 1000 µm £ 400 µm
- Bunch length ~ 1 µs
- Kinetic energy 400 Mev / amu (~ 83 GeV)
- Up to 5 ¢10^9 lead ions per bunch

)4 ¢ 10^{20} eV / bunch ¼ 660 J (!660 MW)

Fools calculation: If the beam is stopped in the diamond it´s heated up by ~ 45 000 °C.

Energy loss and Radiation Damage

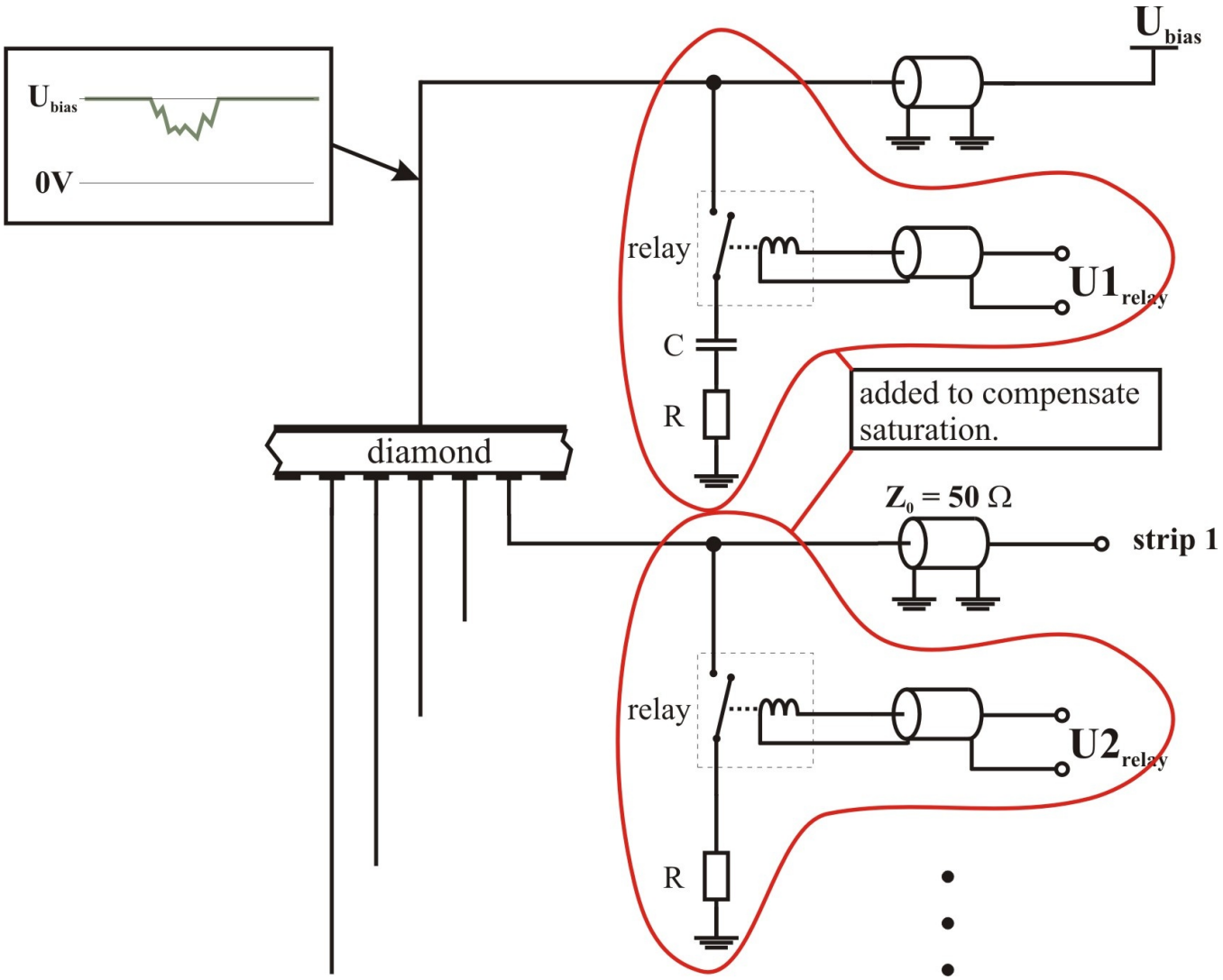


83.1 GeV lead ions in diamond

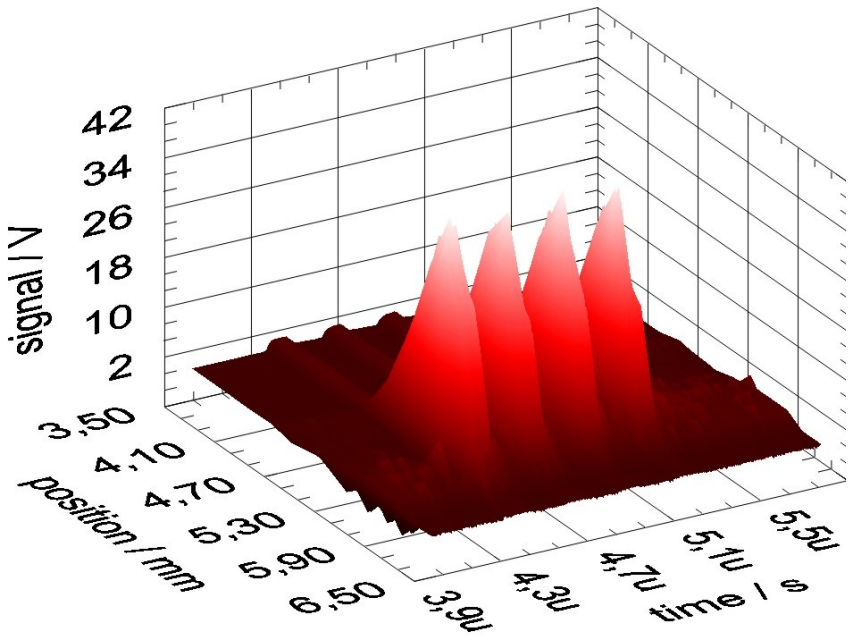
Stopped ions create highest lattice damage.
Range of 83 GeV lead ions in diamond: ~ 9 mm

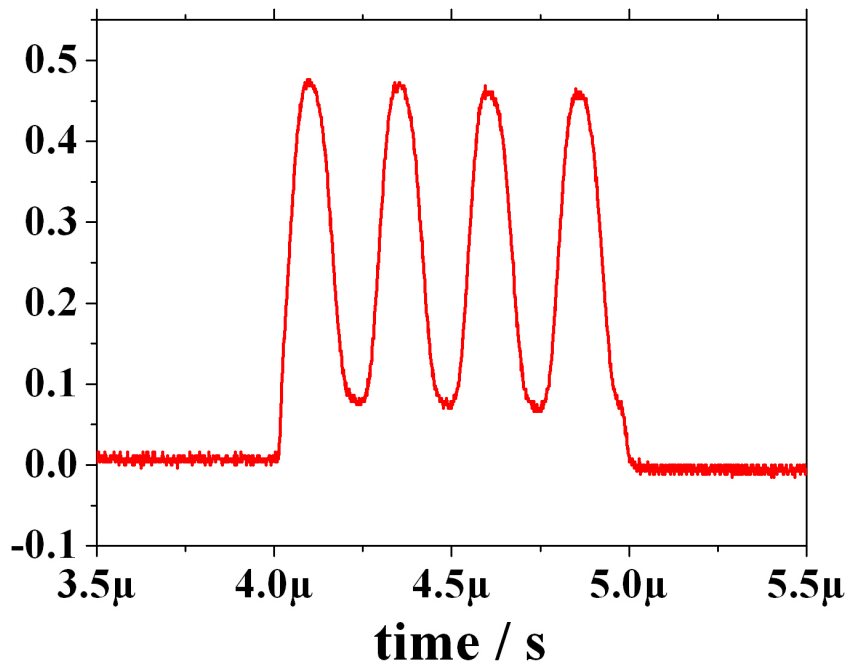
Red: Tracks of lead ions
Green: Displaced carbon atoms

Readout


U bias
0V
U bias
relay
U1 relay
C
R
added to compensate saturation.
diamond
Z0 = 50 Ω
strip 1
relay
U2 relay
R

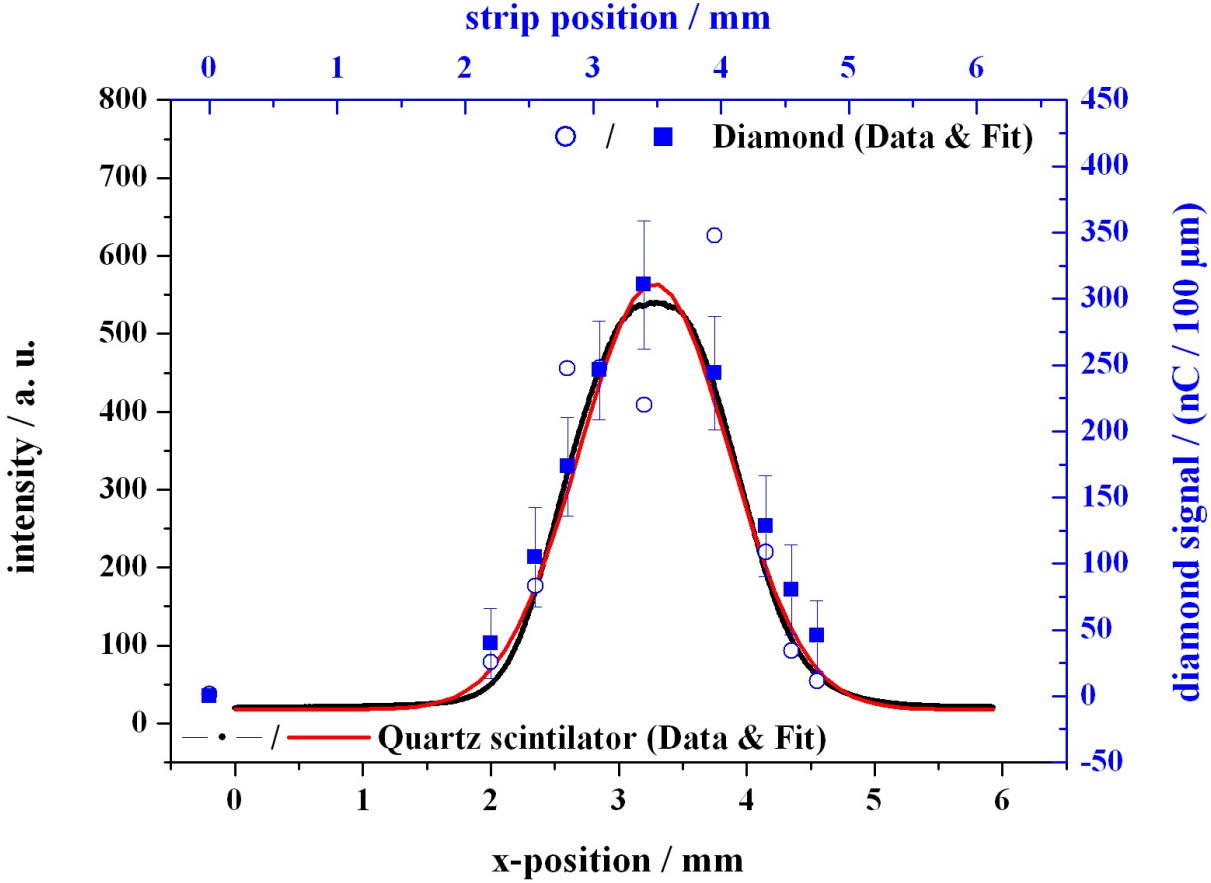
Results





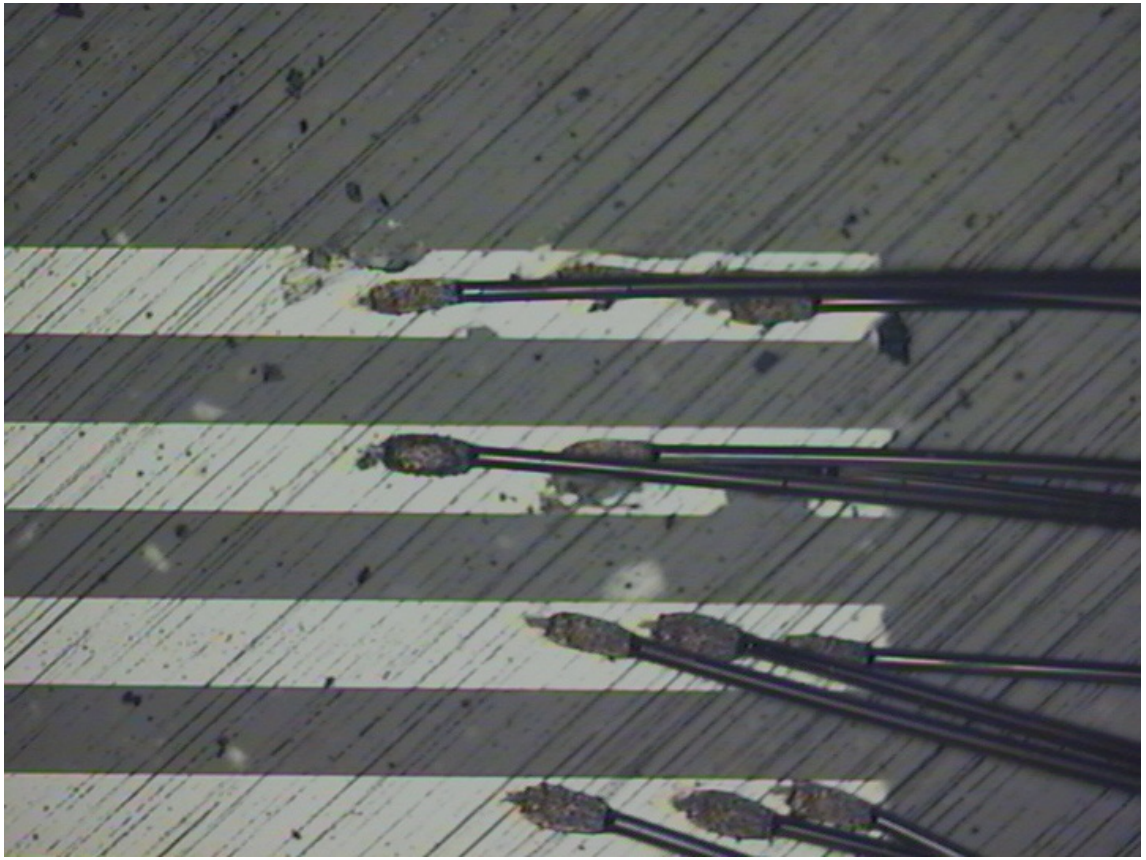
Good longitudinal (time) resolution in the measured signals compared to signal of a Rogowski coil.

Results Part 2



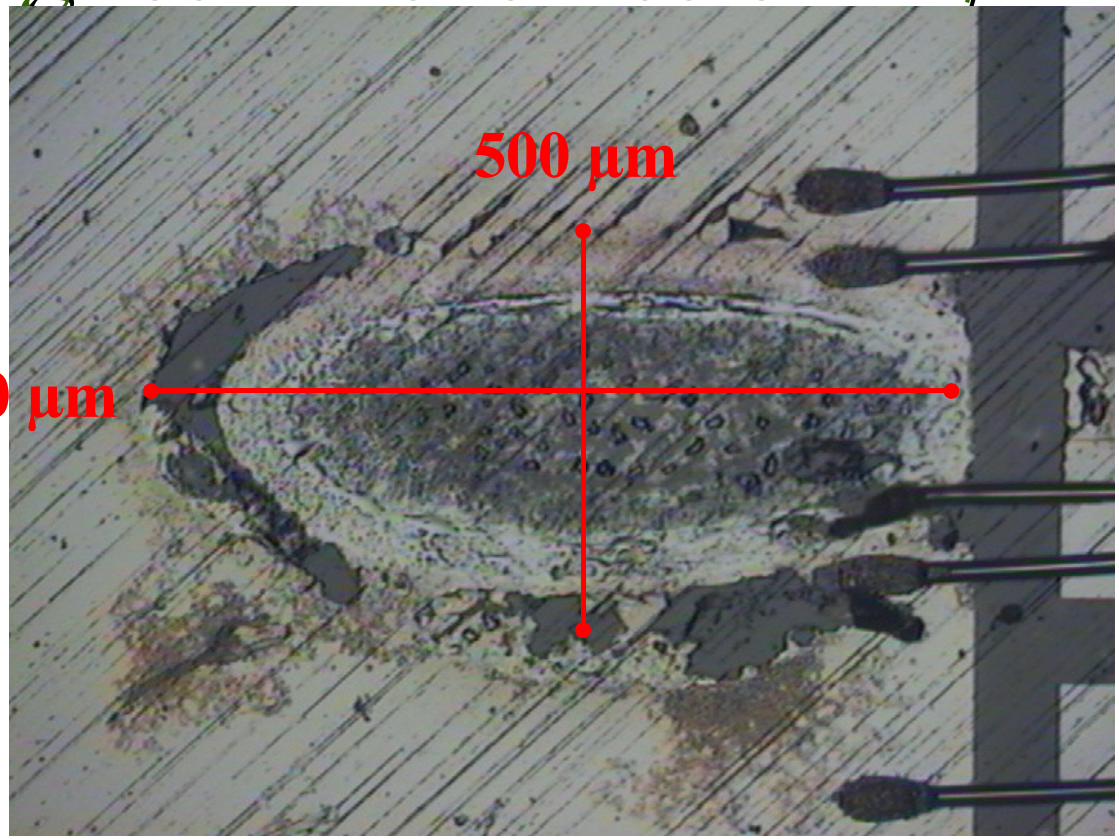
Good lateral resolution in comparison to a profile taken with a scintilator

Measured Currents of ~ 60 A



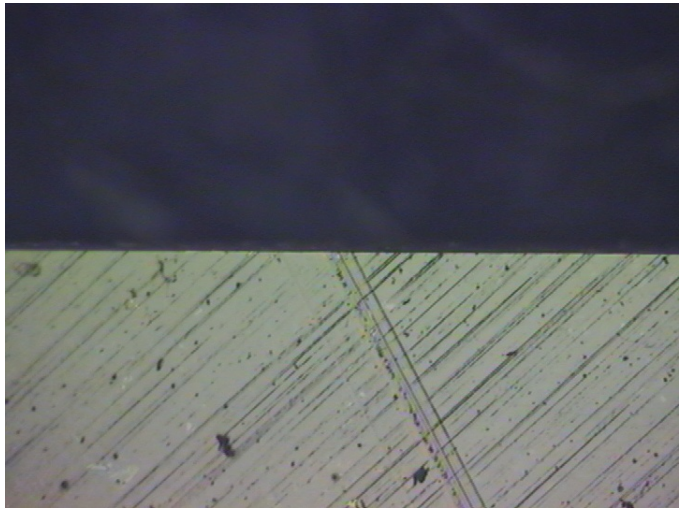
Three bonds on each strip prevented them from melting,
But they became black anyway.

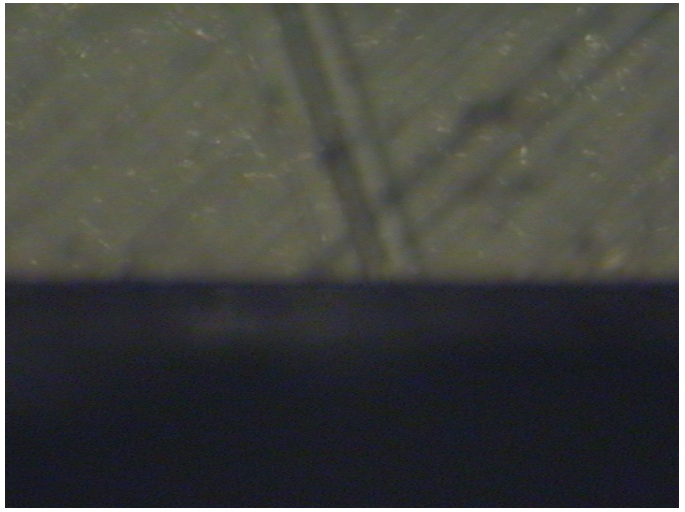
At highest intensities of 5 ¢ 10^9 ions



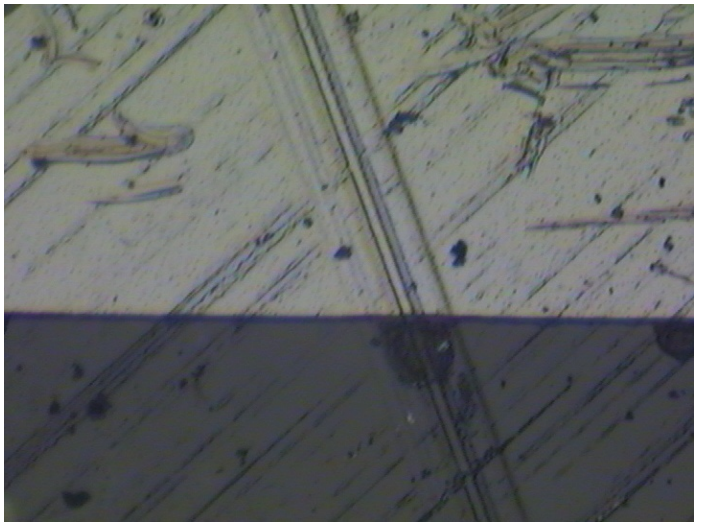
The aluminum metalization was damaged but still operational after several bunches of the highest intensity.
Bonds were molten when they got into the beam.

Cracks?





Something that looked like a crack by bare eye, ...



... could be verifyed to be a scratch under the microscope. (Which had been on the diamond right after the metallization.)

Conclusions

- Beam monitoring with diamond works well.
- pCVD diamond survived the bombardment.
- Several dozens bunches of 5 ¢ 10^9 Pb^{67+} ions: metalization with aluminum damaged but still operational.
- New technologie required for the electrodes??

  Low dE/dx metalization: Aluminum

  Other solutions for the Electrodes: Doping, Graphitization...