Preliminary studies on 3D Diamond

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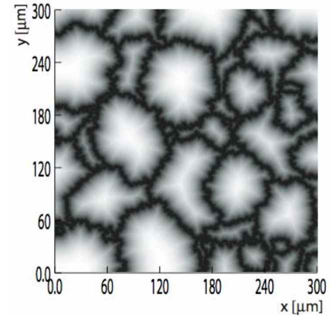
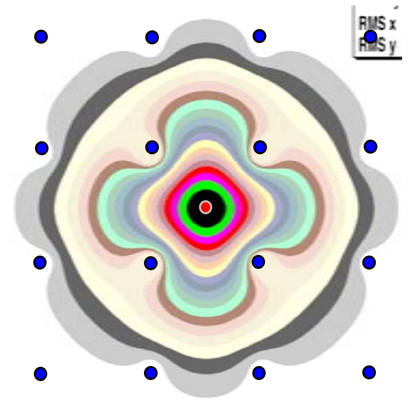
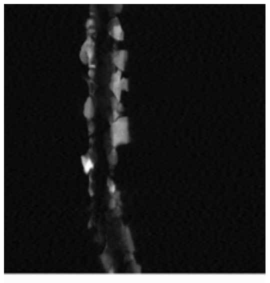
CARAT Workshop

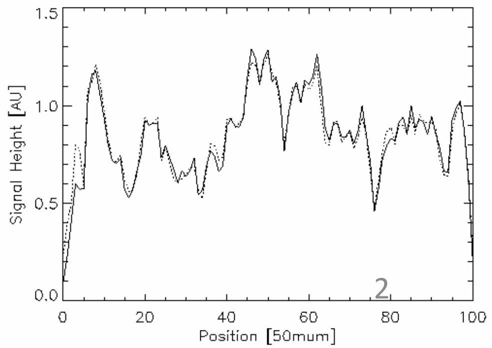
Research Interest

- 3D diamond detectors
  - Grain boundaries
  - Refined Modeling
  - Bulk electrodes
- Radiation Damage
- Spatially resolved measurements of charge transport
  - test beams



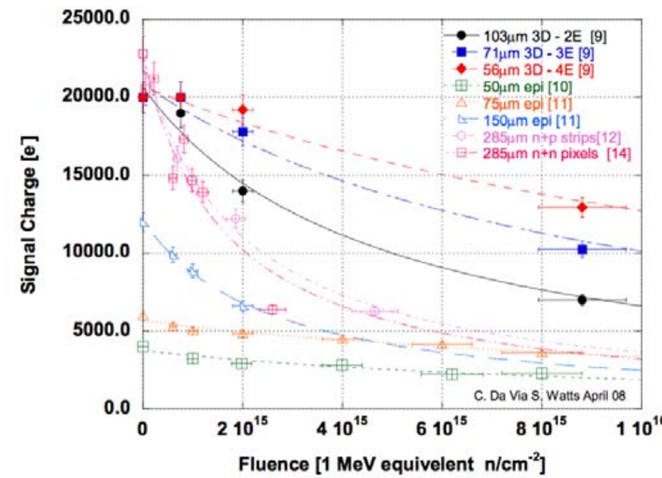


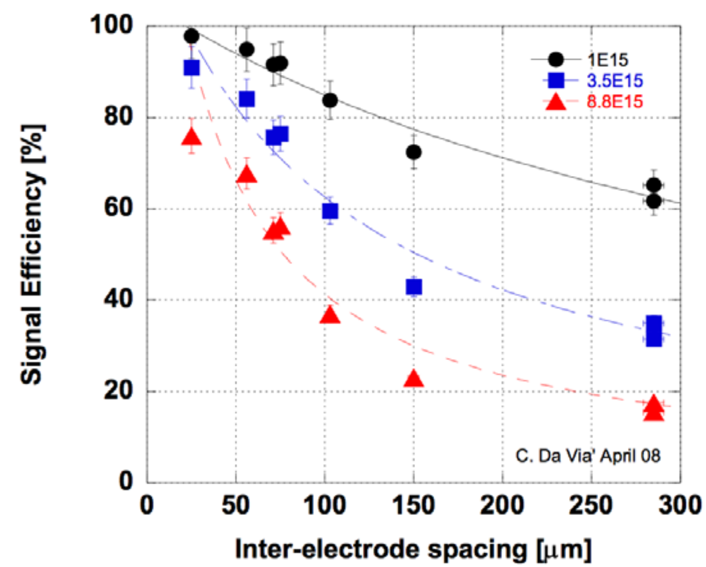


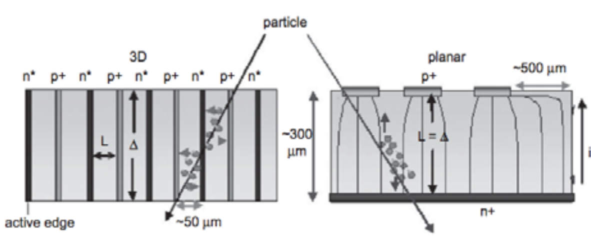


Why 3D?

- Silicon results show radiation hardness increases for 3D geometry.

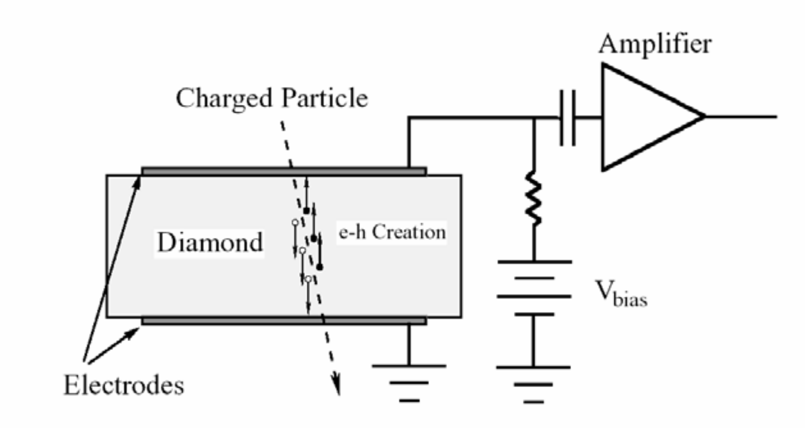


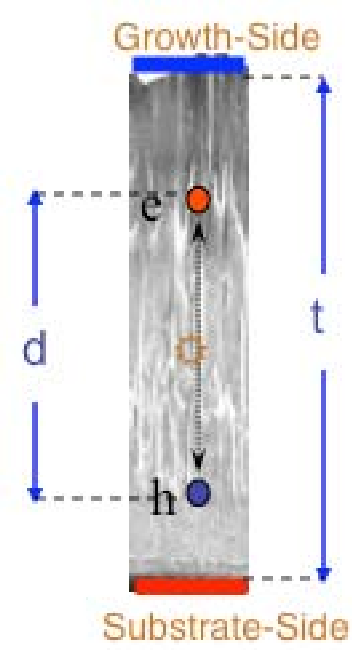


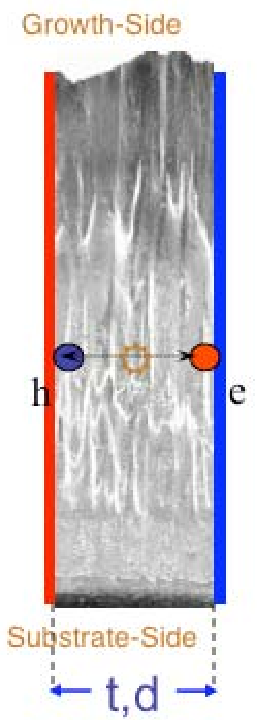


Diamonds at Diamond

- Beamtime 2010
  - Alexander Oh (PI), Cinzia Da Via, Mahfuza Ahmed, Thorsten Wengler, Steven Watts
- Use 15 keV photons to create charge in a diamond detector.
- Two field configurations
- Device is $1 \times 1 \times 3\ mm^3$





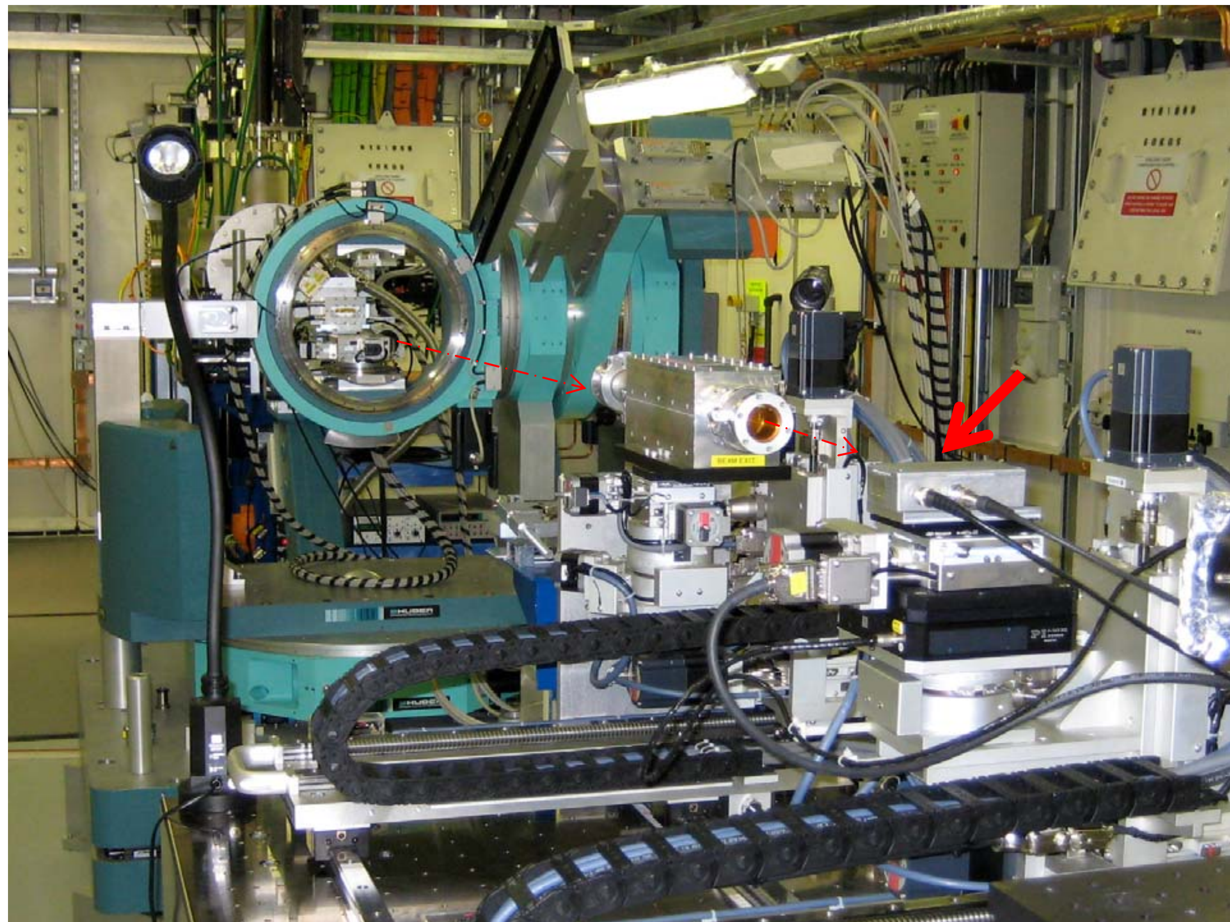


Samples & Data

- Samples provided by DDL
- “dot” electrodes
- Samples investigated
  - pCVD 1mm x 1mm x 3mm, Top Bottom Electrodes
  - pCVD 1mm x 1mm x 3mm, Left Right Electrodes
  - sCVD 1mm x 1mm x 2mm
- Data taken:
  - line scans at different voltages, both polarities
  - full scan, fixed field, both polarities
  - the above for beam parallel and orthogonal to electric field
- pCVD unfortunately excessive leakage current.

Diamonds at Diamond

- Beam-line at the Diamond Synchrotron Light Facility

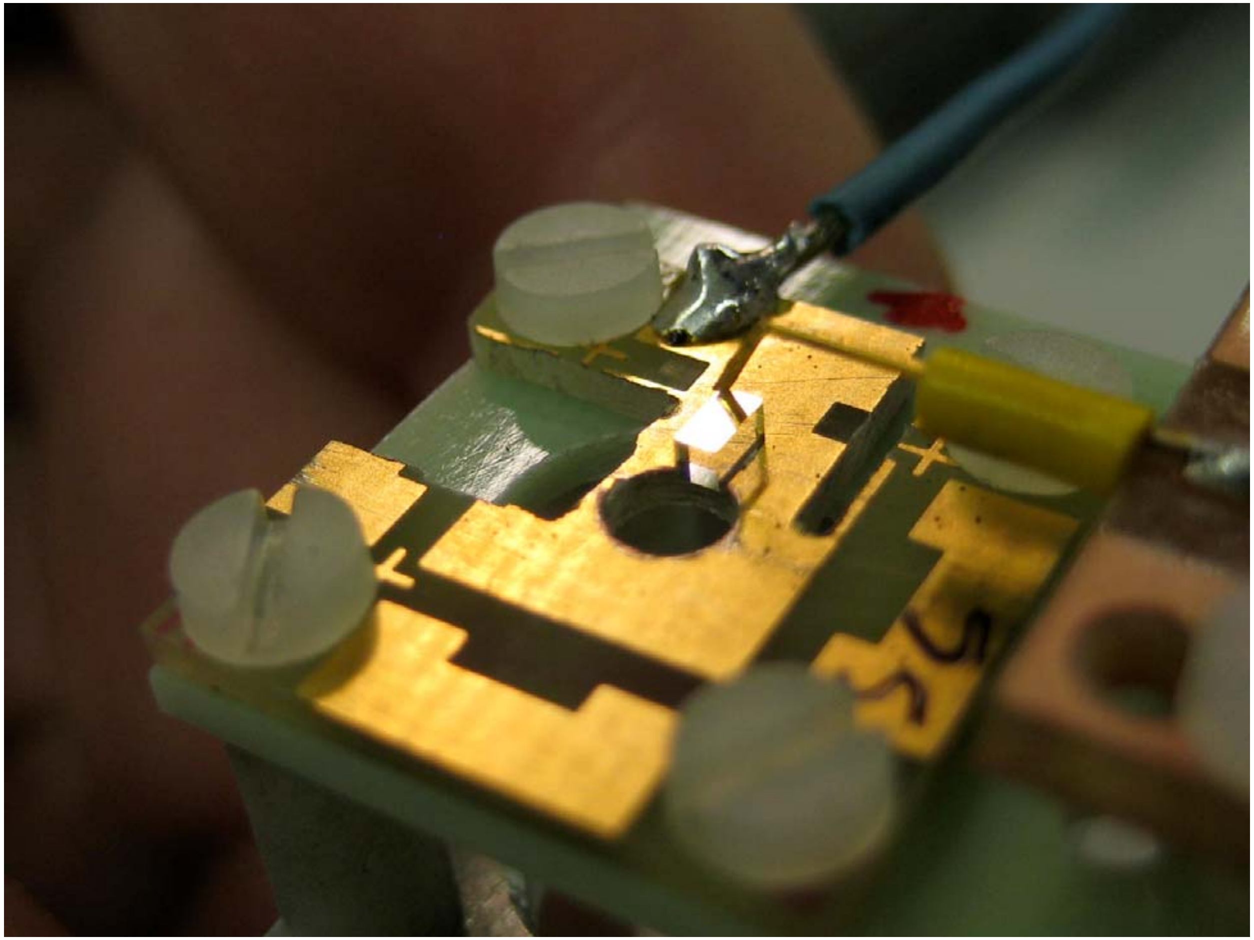


Beam Line

- Energy: 15 keV
- Absorption length ~3.5mm (total), ~18mm (photoelectric absorption)
- Beam focus: compound refractive lense
- Beam size: 4mum FWHM
- Flux: ~ 10^9 photons/s
- Very good Beam Line Support!
  - Technician
  - Beamline physicist
  - Fully working DAQ setup (plug & play)

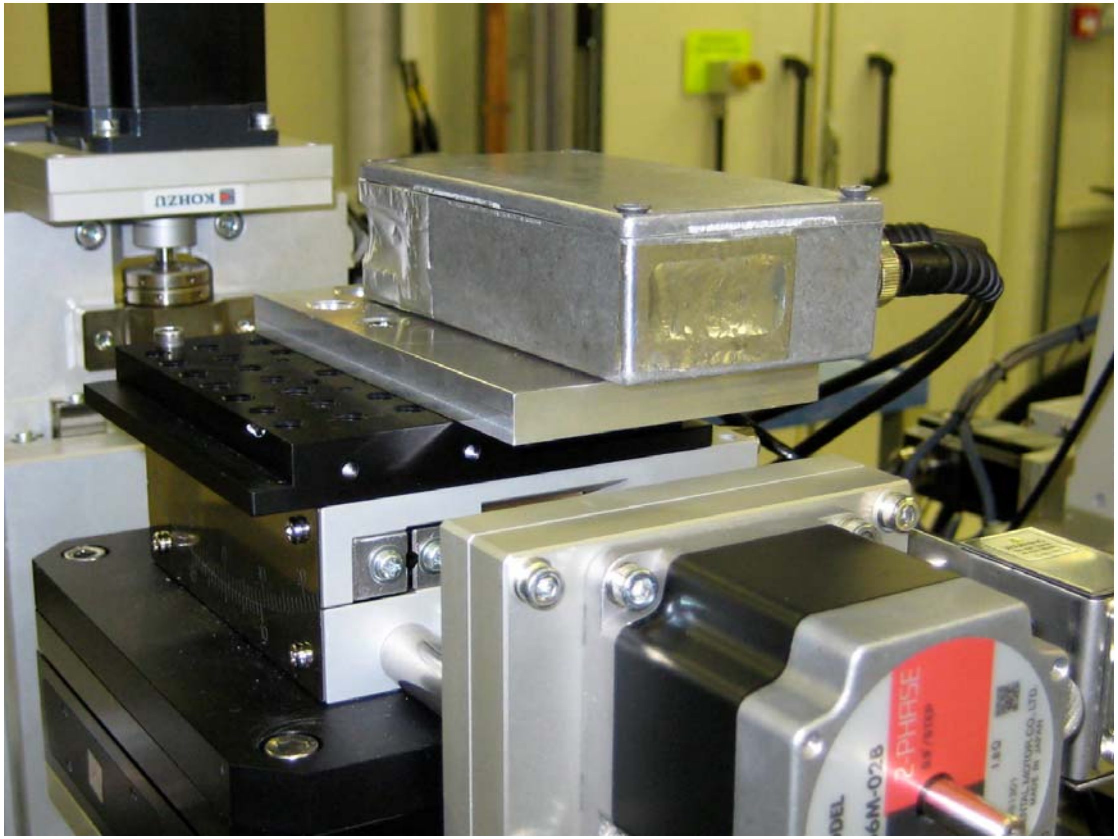
Diamonds at Diamond

- Single Crystal Diamond sample glued to the test PCB



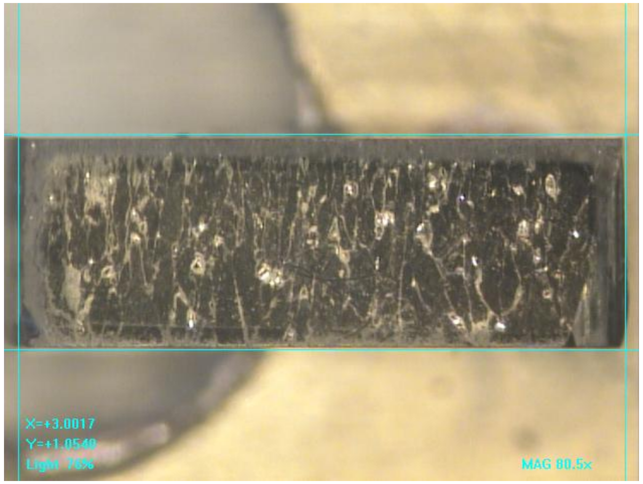
Diamonds at Diamond

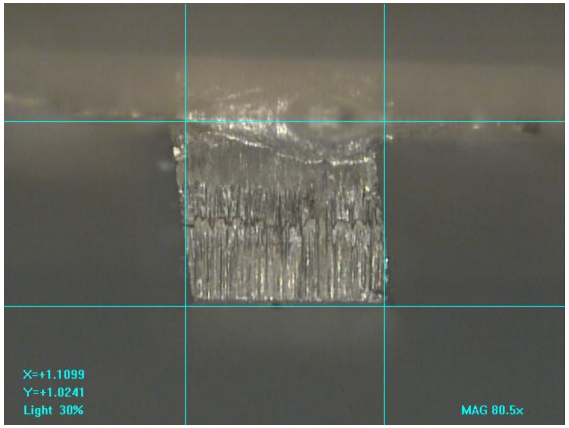
- Simple set-up
- Experimental table can move in theta, phi, x, y, z.
- Automatic scans via DAQ system.

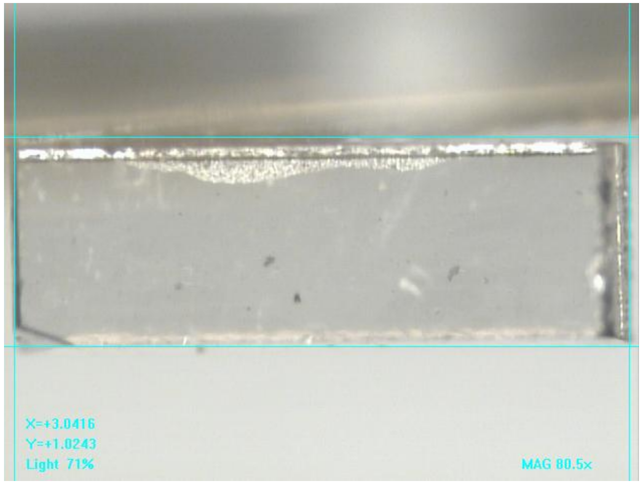


Diamonds at Diamond

- Poly-crystalline diamond samples



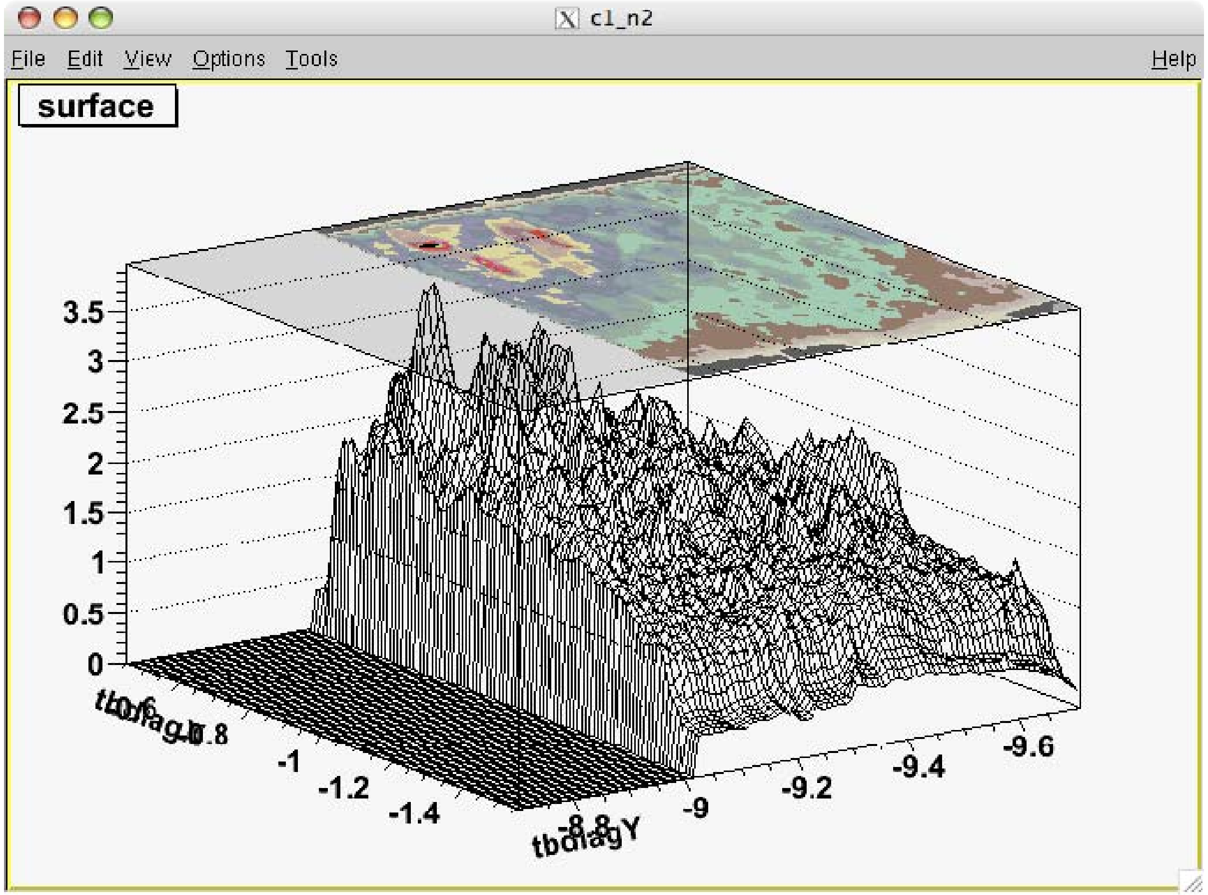




Results

- Surface scan with 10mum step size.
- Charge collected laterally across grain boundaries.

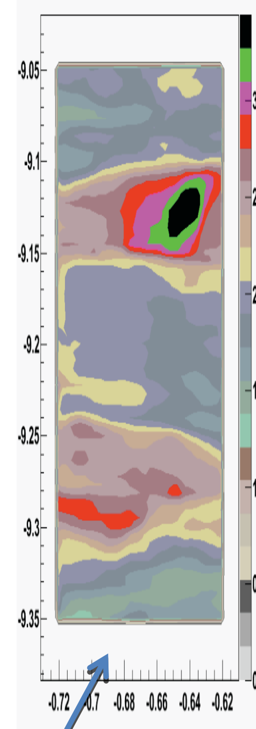
- Collected lots of data to analyse!
- First preliminary findings:

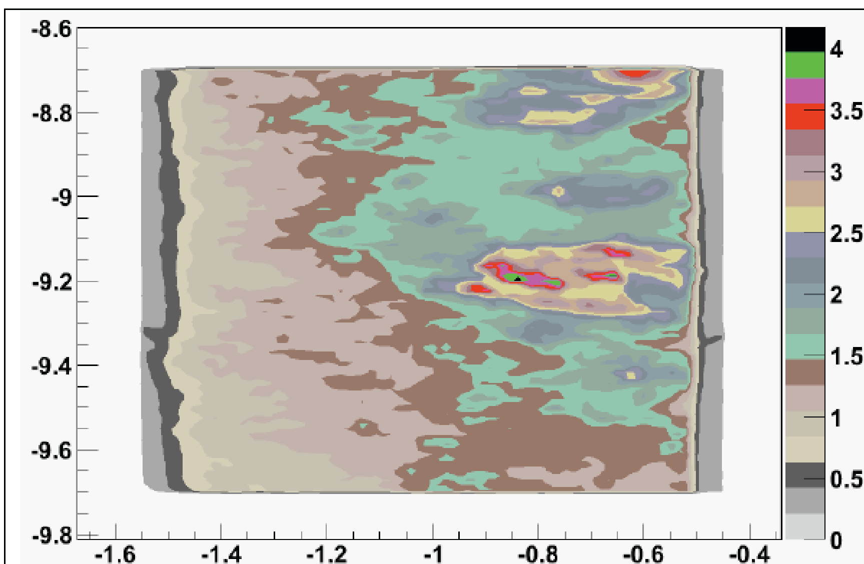


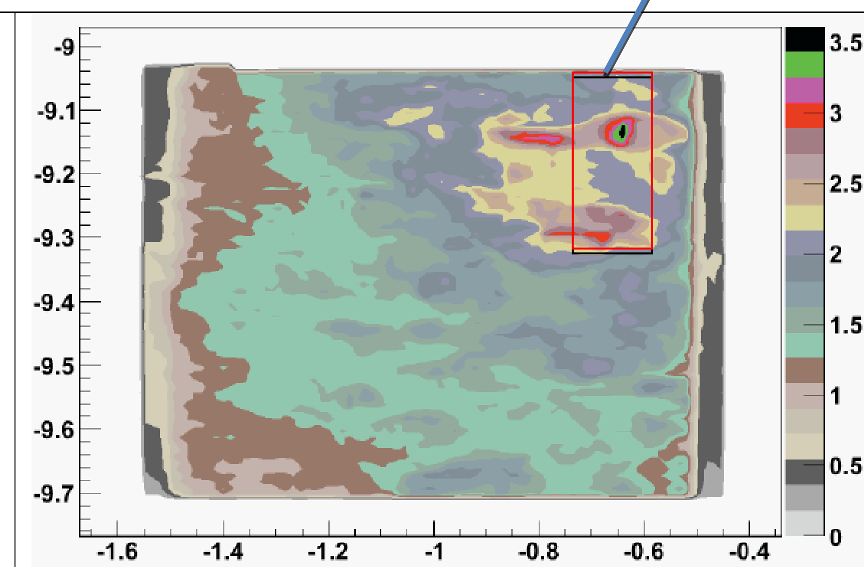
Results

- Area scans for pCVD-LR, E parallel
- Field E=1kV/cm
- Negative and positive field

fine scan
2mum
step size





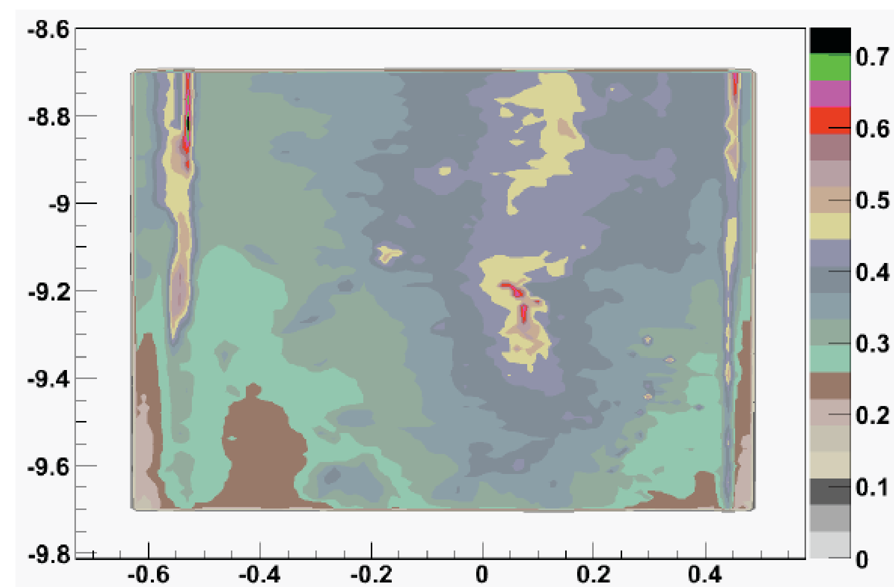


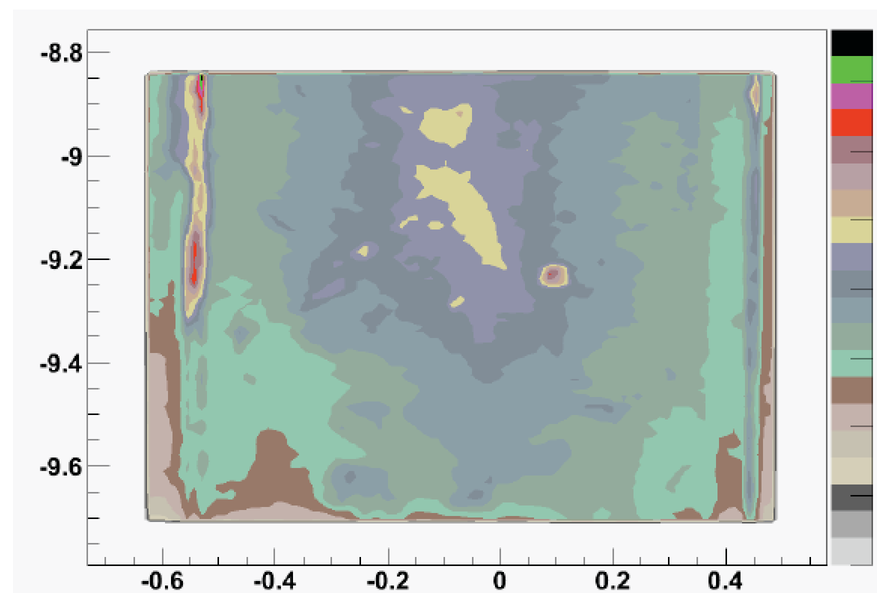
positive field

negative field

Results

- Area scans for pCVD-LR, E orthogonal
- Field E=1kV/cm
- Negative and positive field



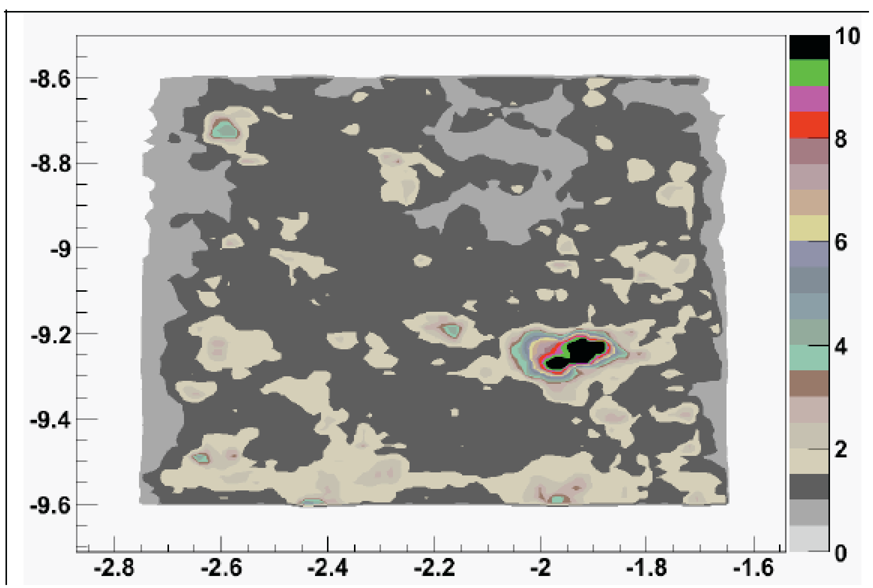


positive field

negative field

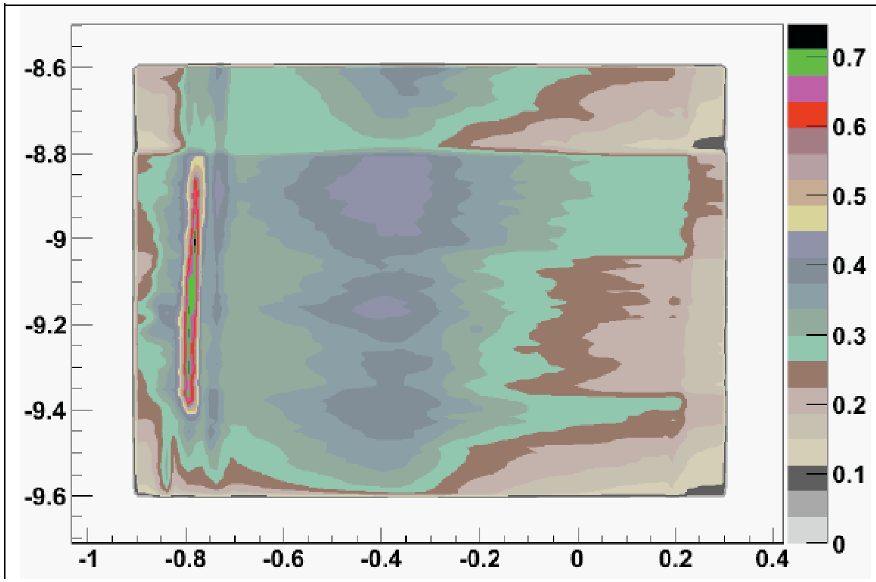
Results

- Area scans for pCVD-TB, E parallel
- Field E=0.5kV/cm
- Negative field

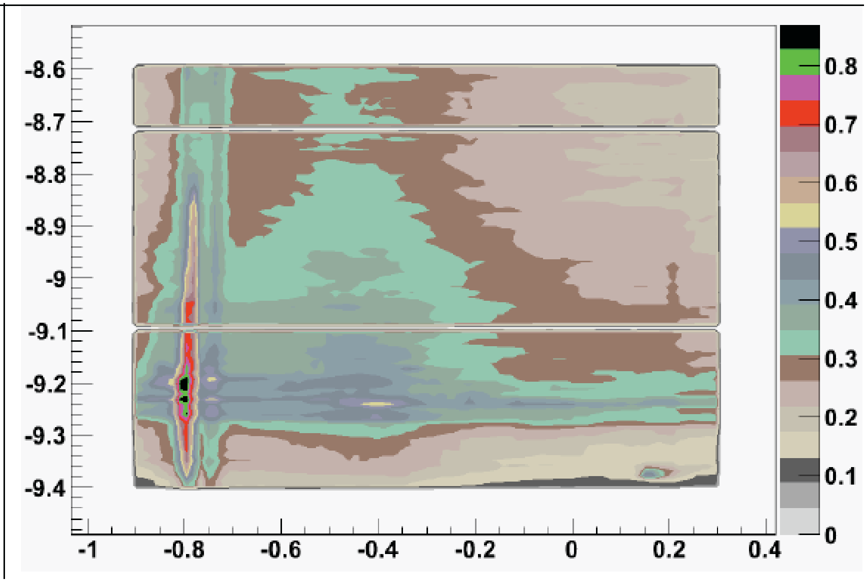


Results

- Area scans for pCVD-TB, E ortogonal
- Field E=0.5kV/cm
- Negative and positive field



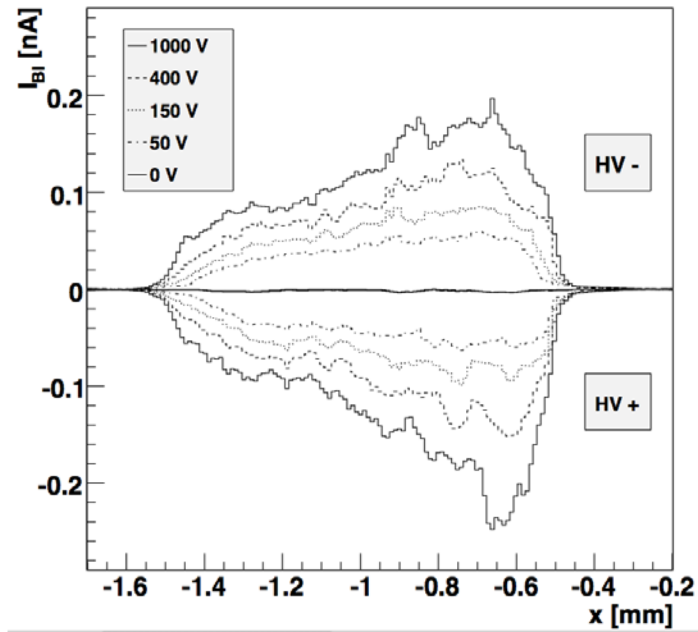
positive field

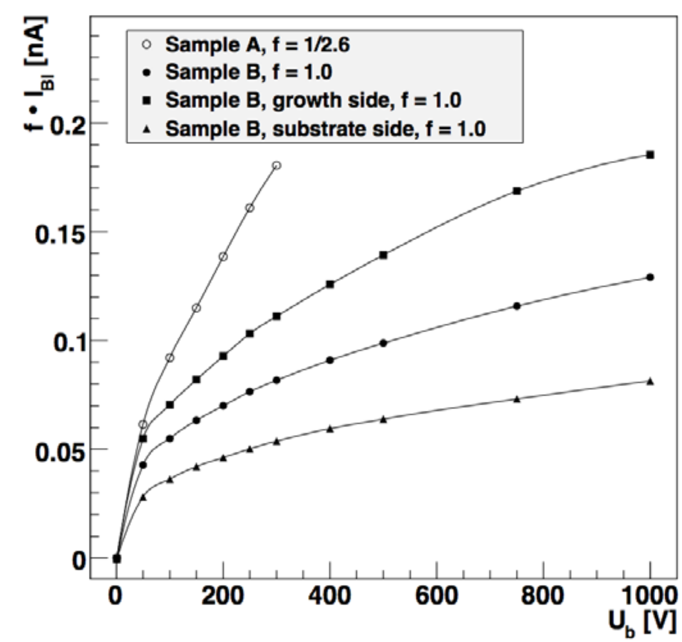


negaitve field

Results

- Response along a line for different voltages for sample B.
- Comparison of sample A and sample B.
  - 40% - 70% less signal for sample B.
- Grain boundaries seem to have a detrimental effect on charge collection.

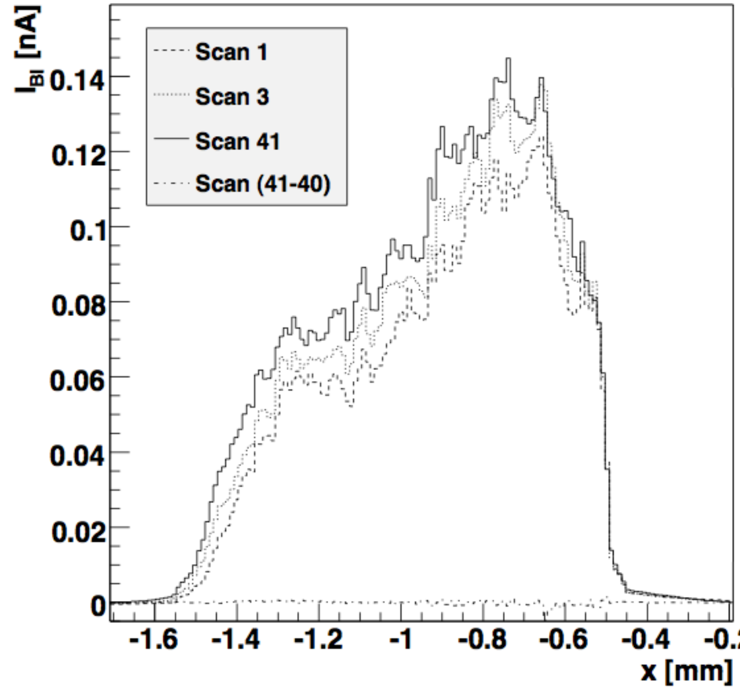


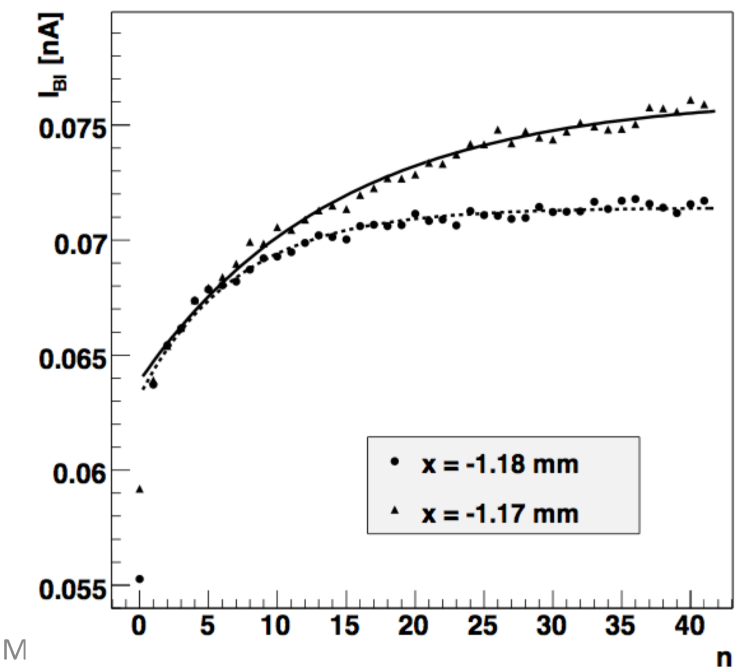


Results

- Multiple line scans to measure the pumping behavior spatially resolved.
- Is the priming uniform?
- Extract priming parameters as a function of position.

$$f(n) = a + b \cdot (1 - e^{-\frac{n}{c}})$$

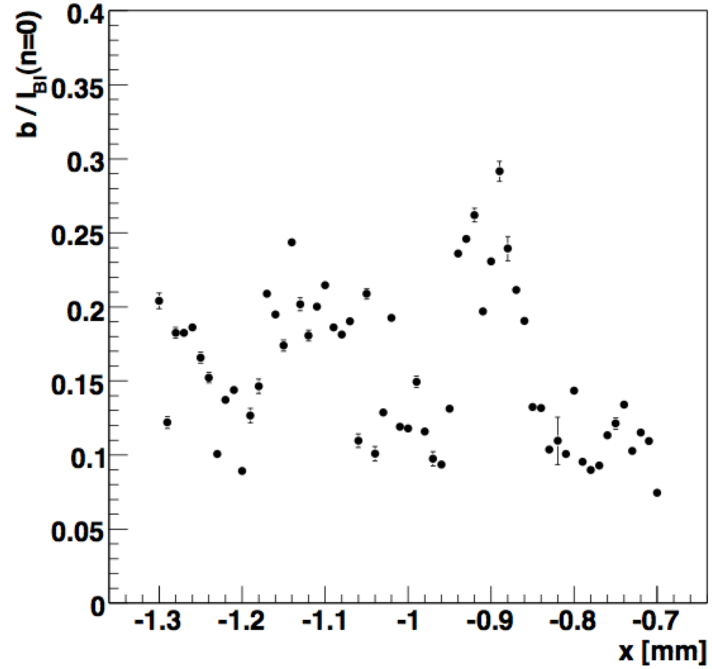


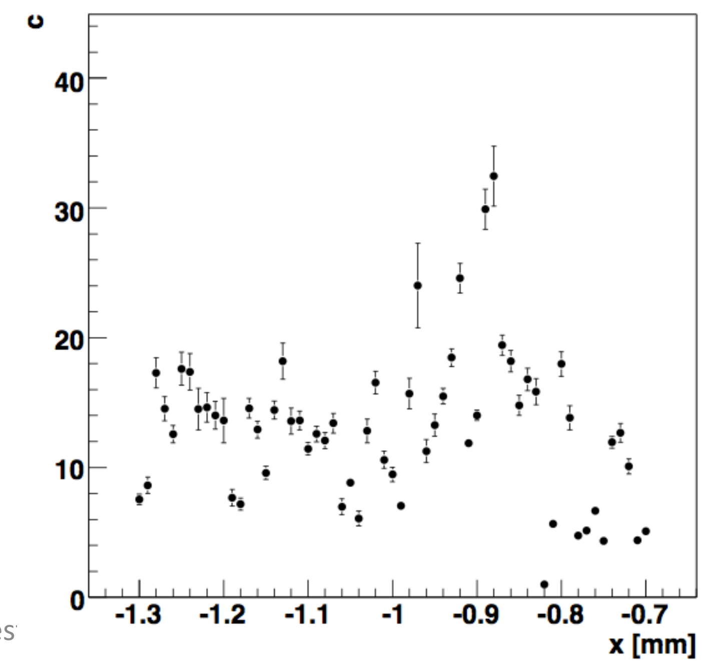


Results

- Large variations observed with position.
- No clear correlation of priming parameters and signal response

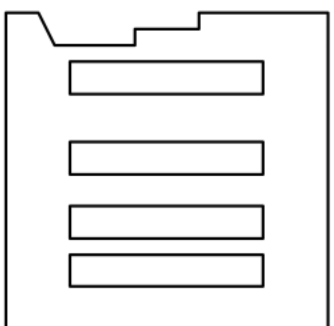
$$f(n) = a + b \cdot (1 - e^{-\frac{n}{c}})$$

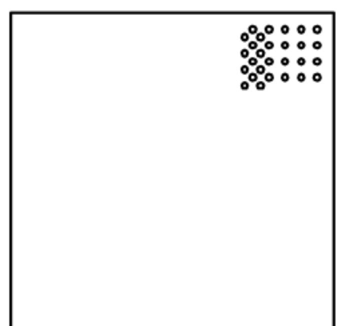


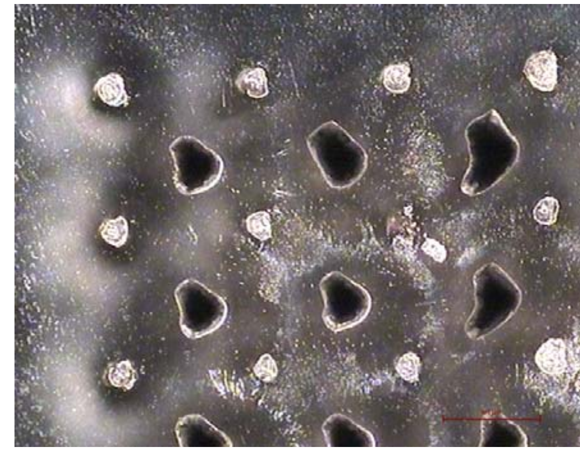


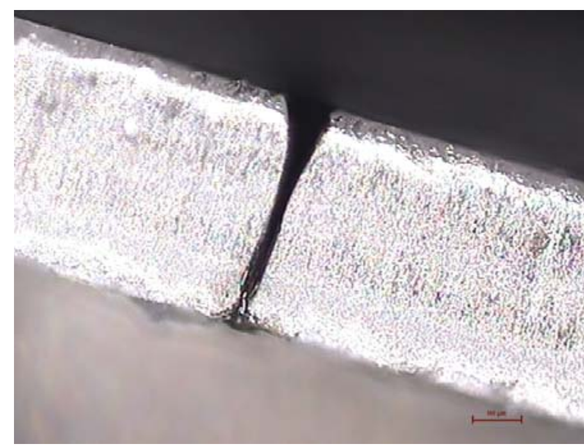
Outlook

- Analysis ongoing.
- Successfully applied for beam time in 2011
- Further investigations:
  - Angular scans
  - working sCVD
  - varying width samples
  - Graphite electrodes









Michal Pomorski