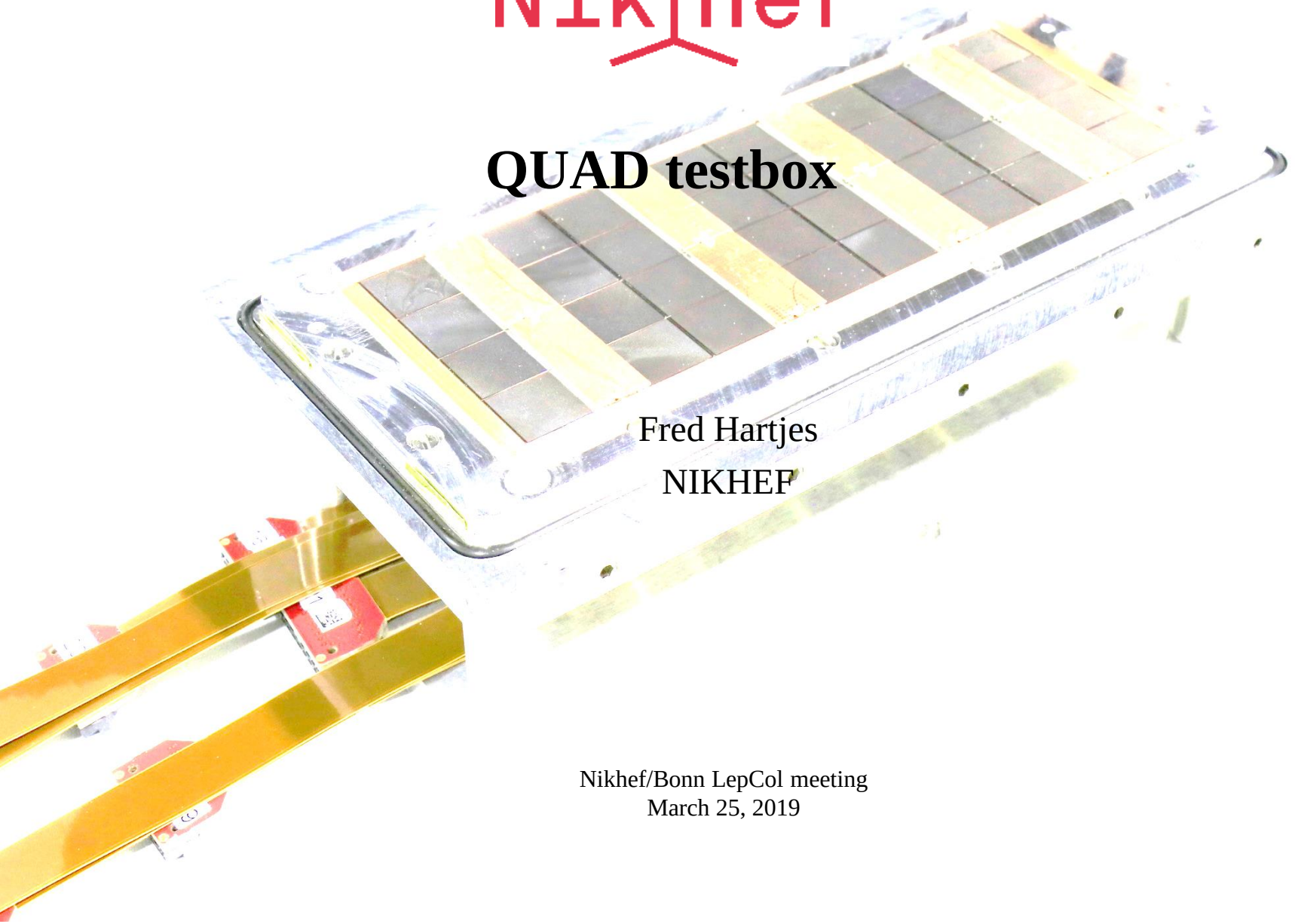


QUAD testbox

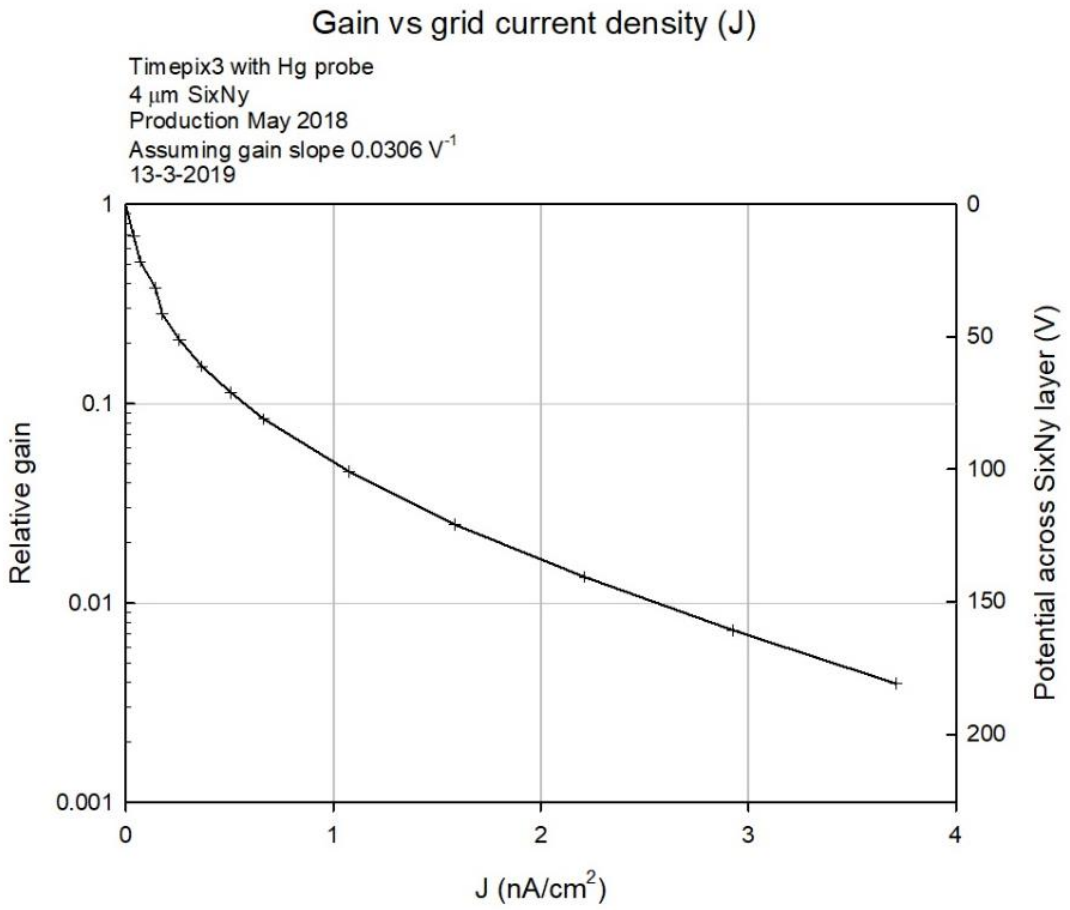
Fred Hartjes

NIKHEF

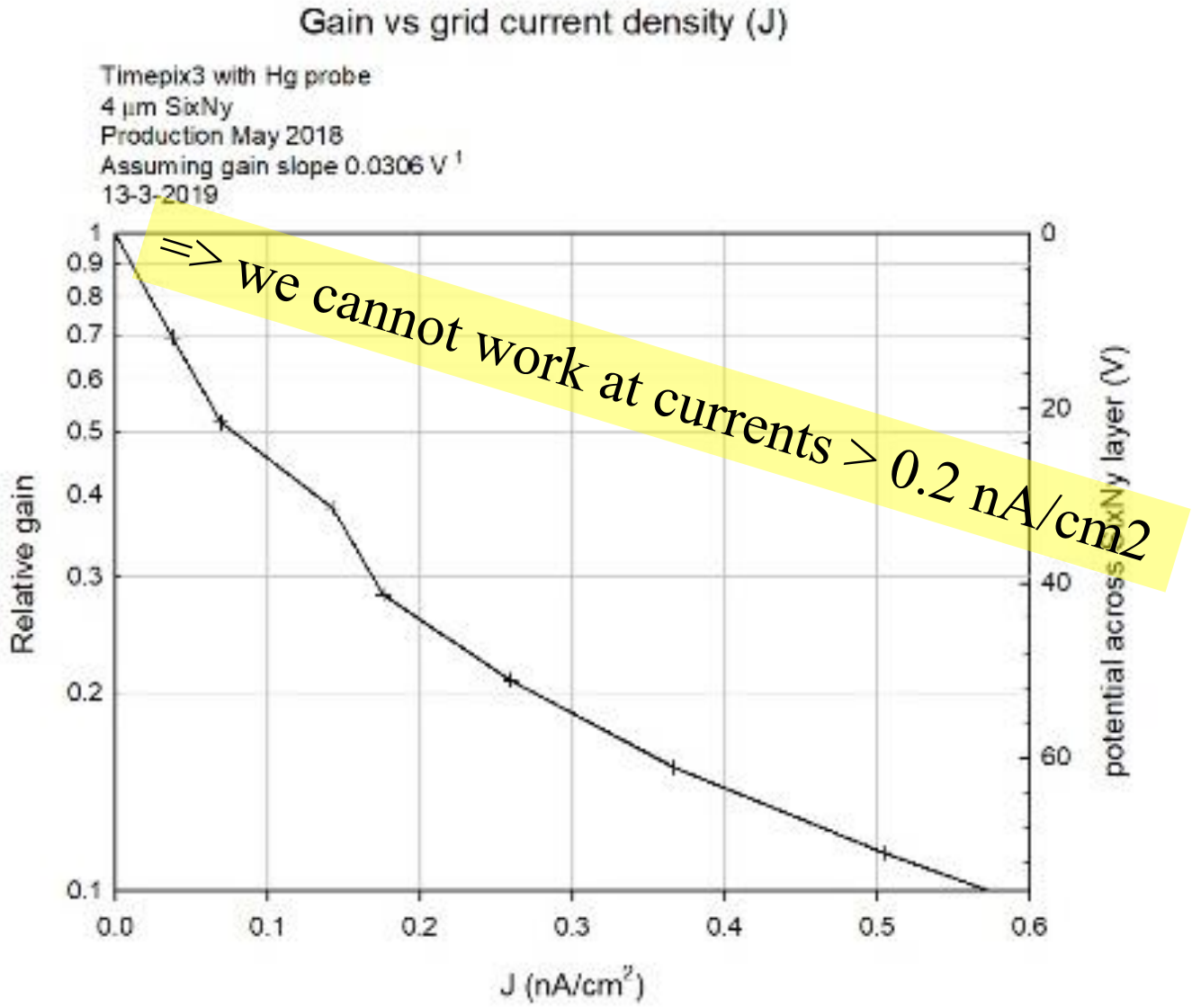
Nikhef/Bonn LepCol meeting
March 25, 2019

Charging up studies

- At substantial grid current a voltage drop will occur across the 4 um SixNy layer
  - => reduction amplification field
  - => reduction of gas gain
- Measurement with Hg probe
- Gain drop calculated from voltage vs gain measurement for T2K gas
- Very strong effect
  - At 3 nA/cm2 gain less than < 1%

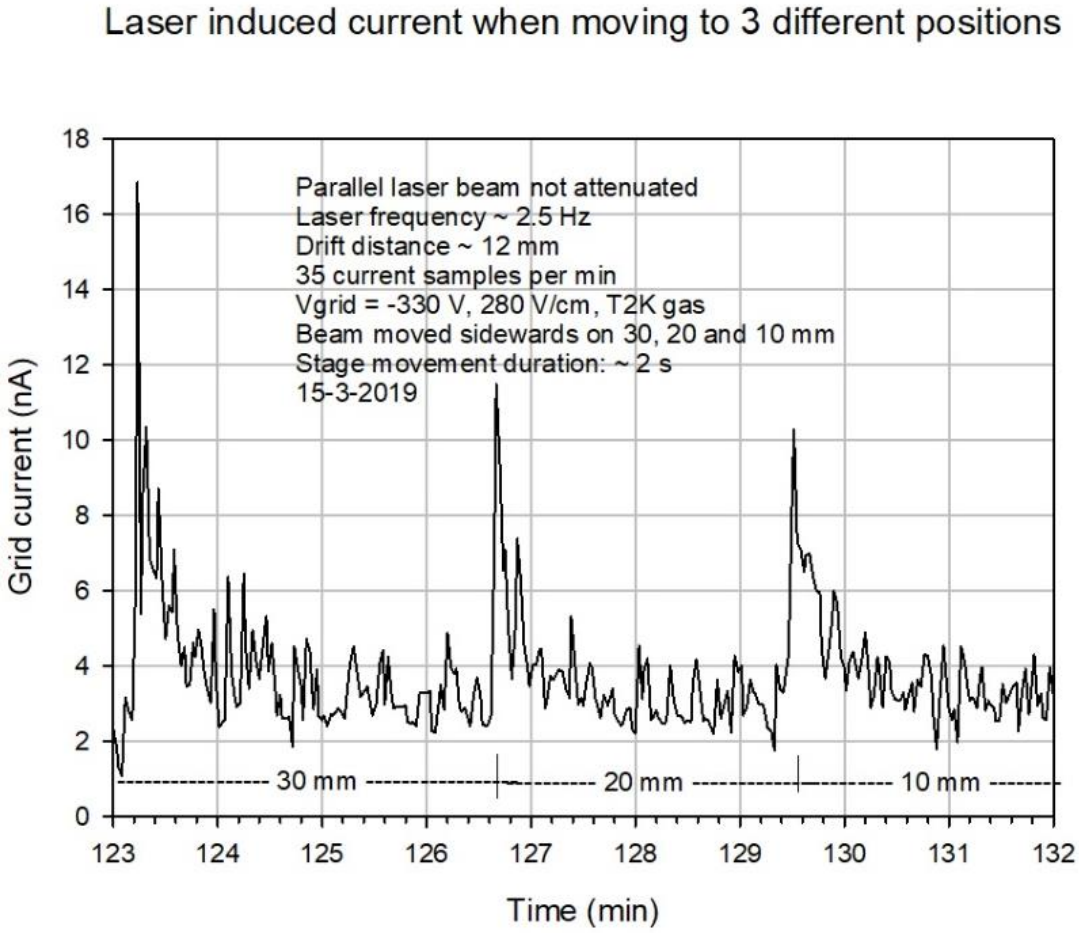


Same curve zoomed in



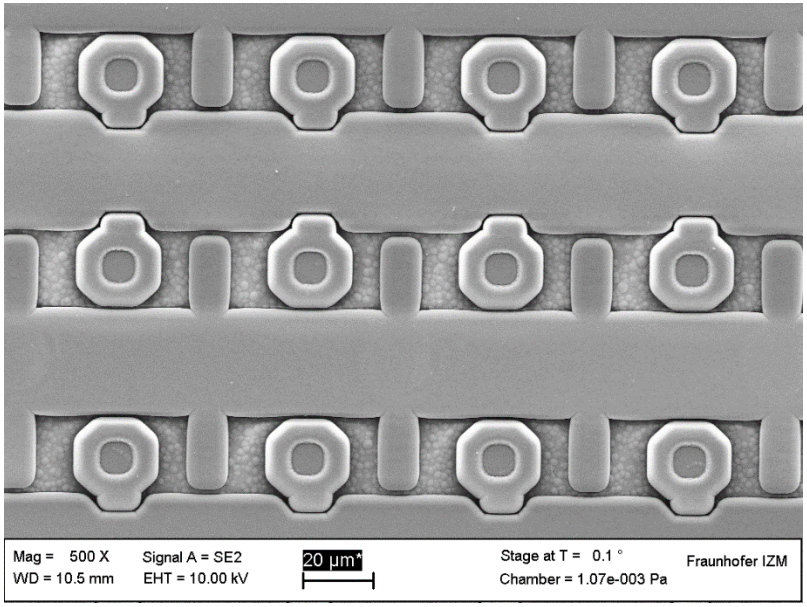
Reality is not that bad: laser ionization

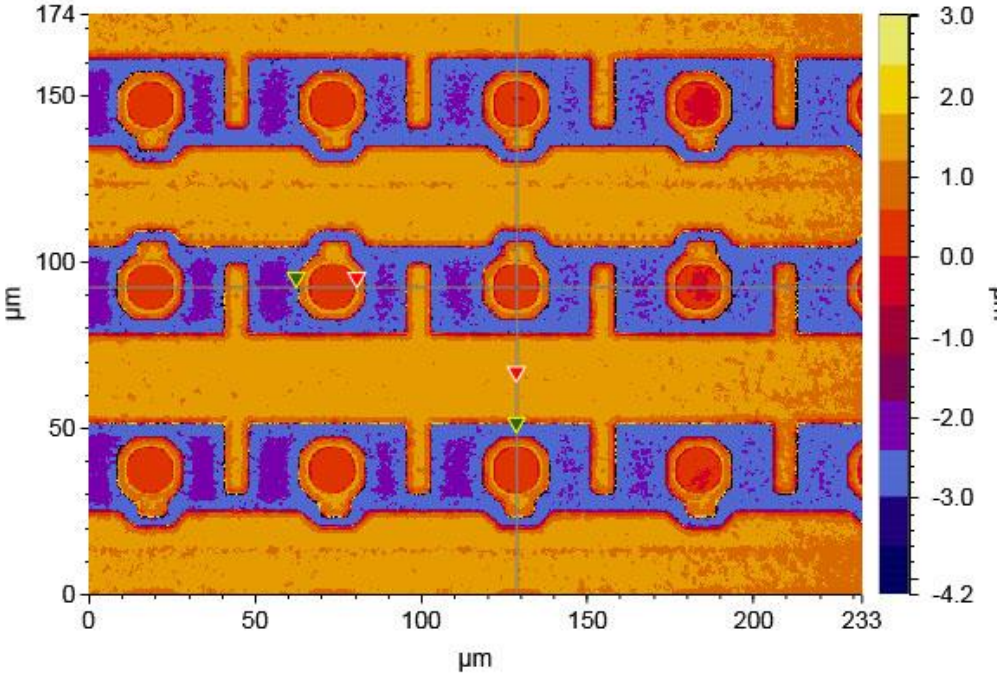
- In testbox induced current by UV laser
  - 2.5 Hz
  - Vgrid = 330 V, T2K gas
  - Drift distance ~ 8 mm
  - Active surface covered ~ 1 cm2
- Effect is there, but much smaller than expected
- Steady current of **3 nA/cm2**



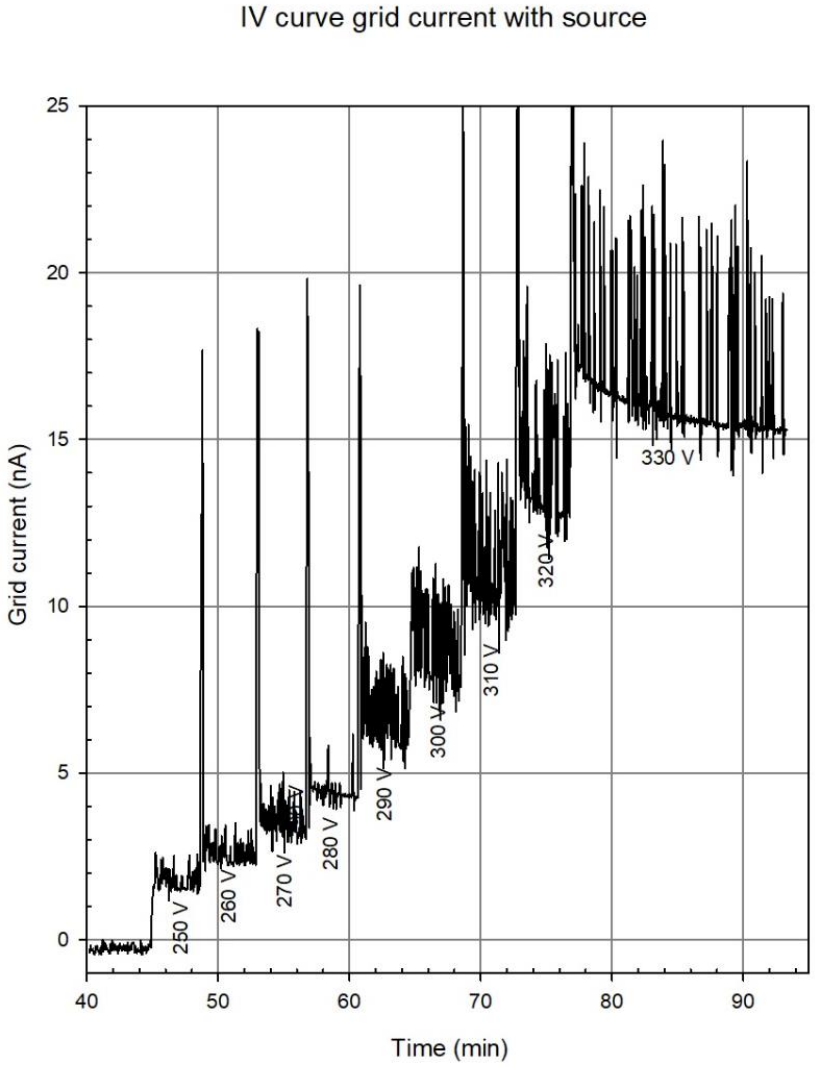
Geometry

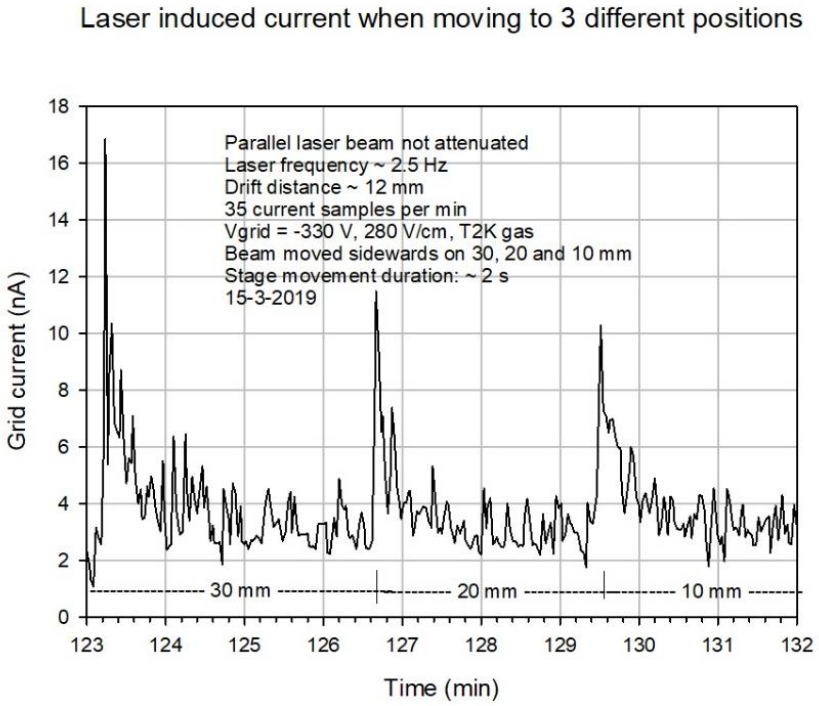
- Pads lay in well ~ 3 um under surrounding material
- Pads diam 14 um + ~ 3 um edge => cover ~ 8% of the surface
- Time constants of charging up vary
  - Above pad surface: ~ 120 pF capacity
    - ~ 1 min for $\Delta V = 10 – 20$ V (low rate)
    - 15 s for $\Delta V = 50$ V
    - 4 s for $\Delta V = 100$ V (very high rate)
  - Outside pad surface: ~ 800 pF capacity
    - 5 – 20 min, for less high rates much longer

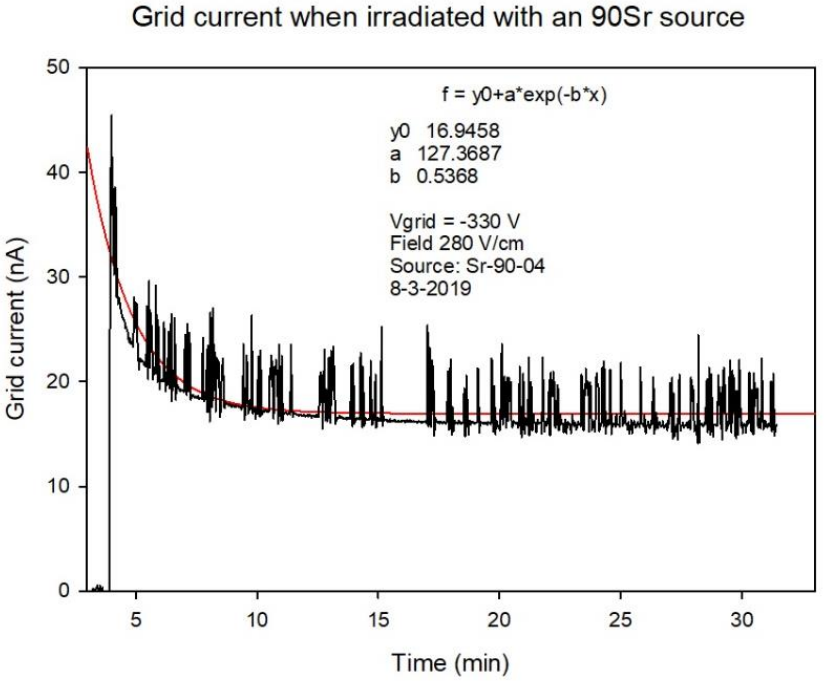




Short term and long term charging up

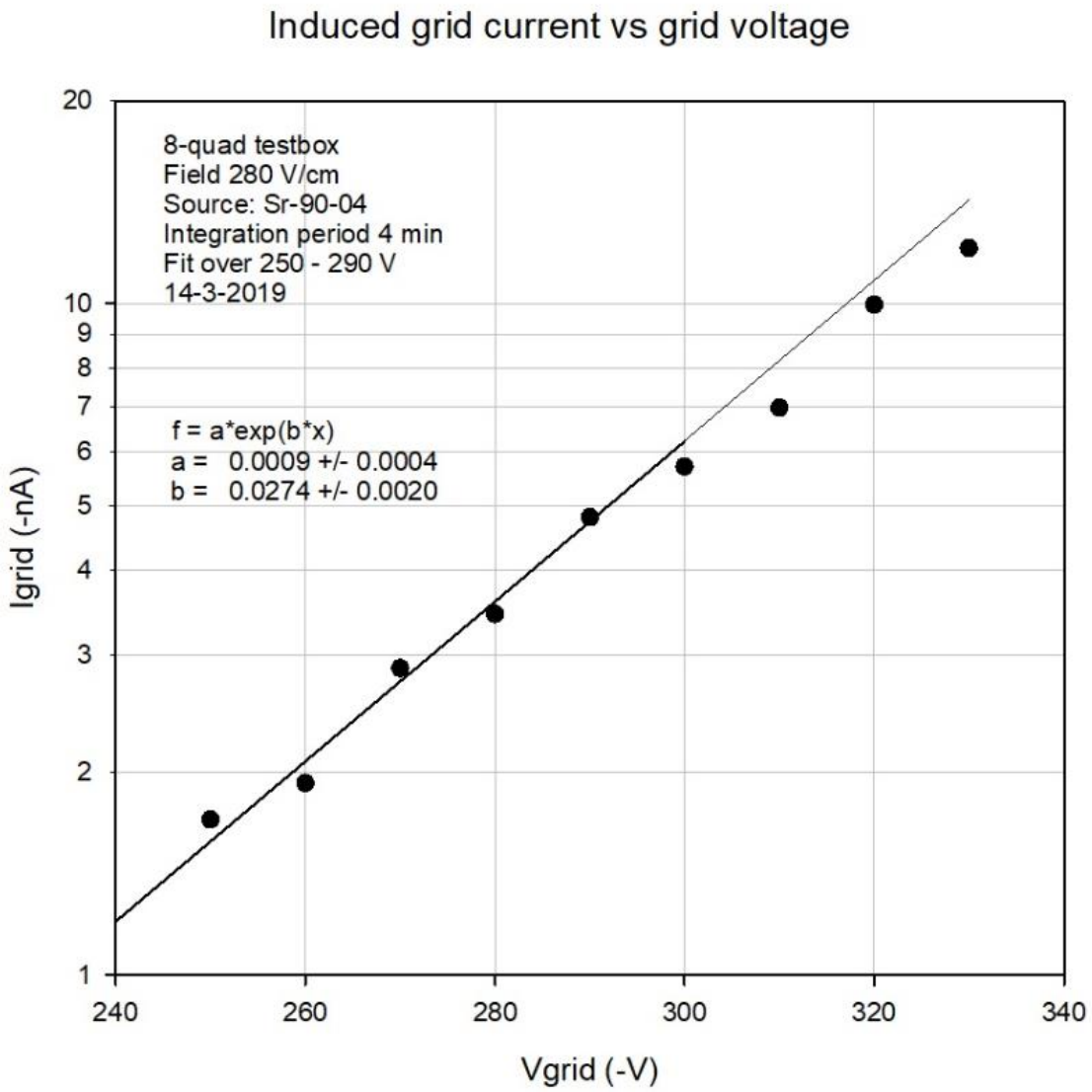






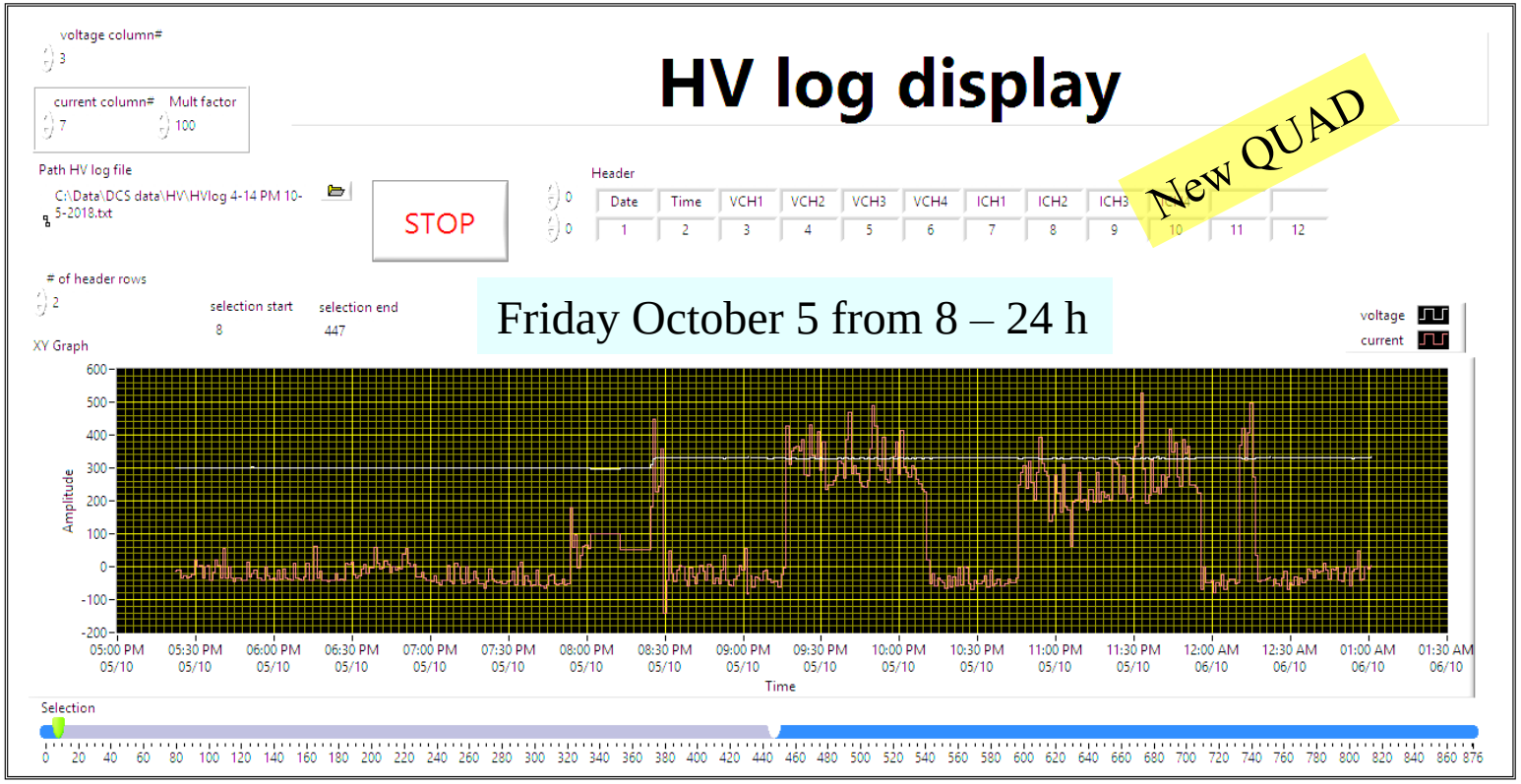
IV curve with source

- Quite small saturation effect
- Some 20 – 40 cm2 covered by source



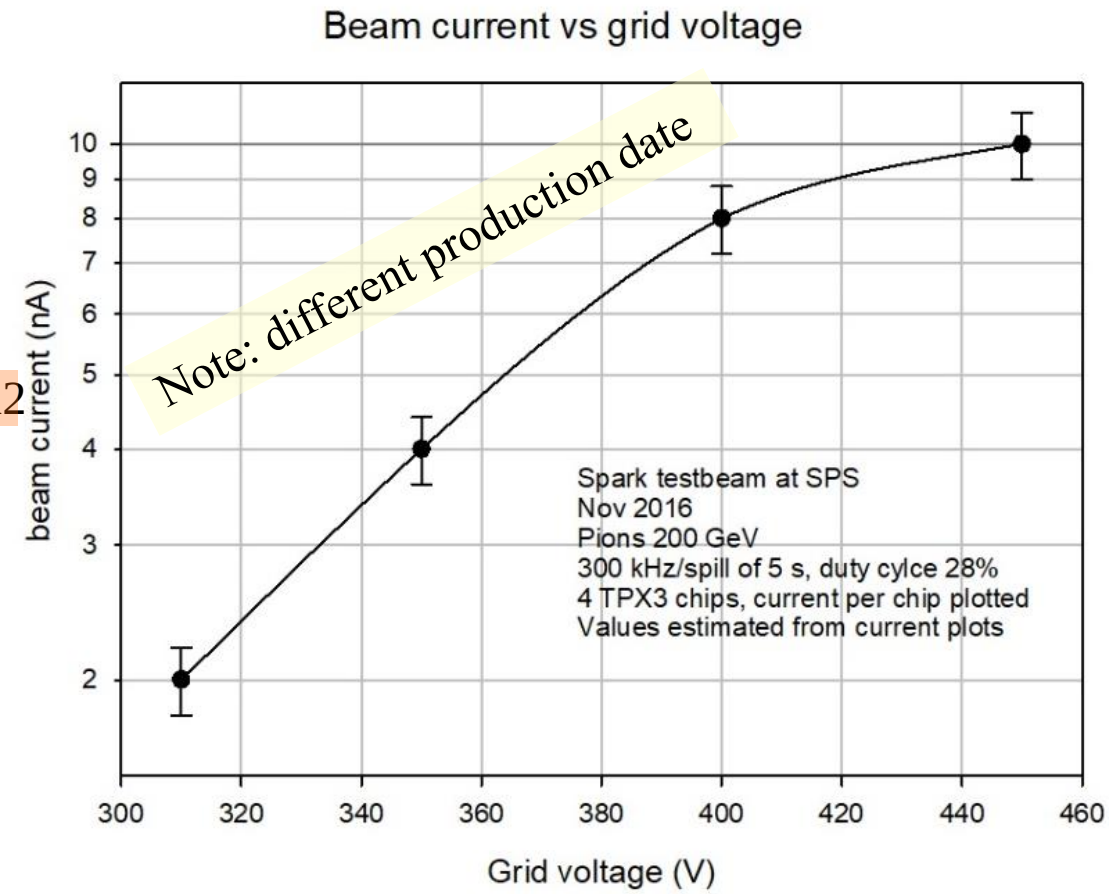
Last year's testbeam

- At Vgrid = -300 V beam current ~ 1 nA
- At Vgrid = -330 V beam current 3 nA
- Active surface covered ~ 2.5 cm2
- Note that log period is 1 min vs 1.7 s at laser measurements
  - => rapid decrease of beam current will not be not noticed
- **Long term effect not visible**



Spark testbeam 2016 at SPS

- High pion beam rate
  - 300 kHz during 5 s
  - 13 s idle
- Active surface covered ~1.2 cm2
- Signal limit ~ 8 nA



Conclusions

- Charging up is very complicated process with a convolution of a multitude of different time constants
  - Sufficient for a full PHD study
- Resistivity of the layer cannot be described by a single parameter
- Main dependencies
  - Resistivity curve of protection layer vs field
  - Grid current (combination of ionization rate and gain)
  - Chip geometry (pad size)
- Two main processes
  - Charging up **above** the pad (τ < 1 min)
  - Charging up **outside** the pad (τ = 5 - 20 min and higher)
- Charging up effects will always occur, even at very low rate
- Initial gain (no charging up) almost impossible to determine
- Until ~ 1 nA/cm2 not much decay of gain, in the 0 - 30% range
- Current limit for TPX3: ~ 8 nA/cm2
  - We should stay far away from this limit