First silicon sensor measurements at Tokyo and future plans

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Setting up ecal silicon sensor measurement system

First step towards future mass-testing QC system

Sensor understanding and development

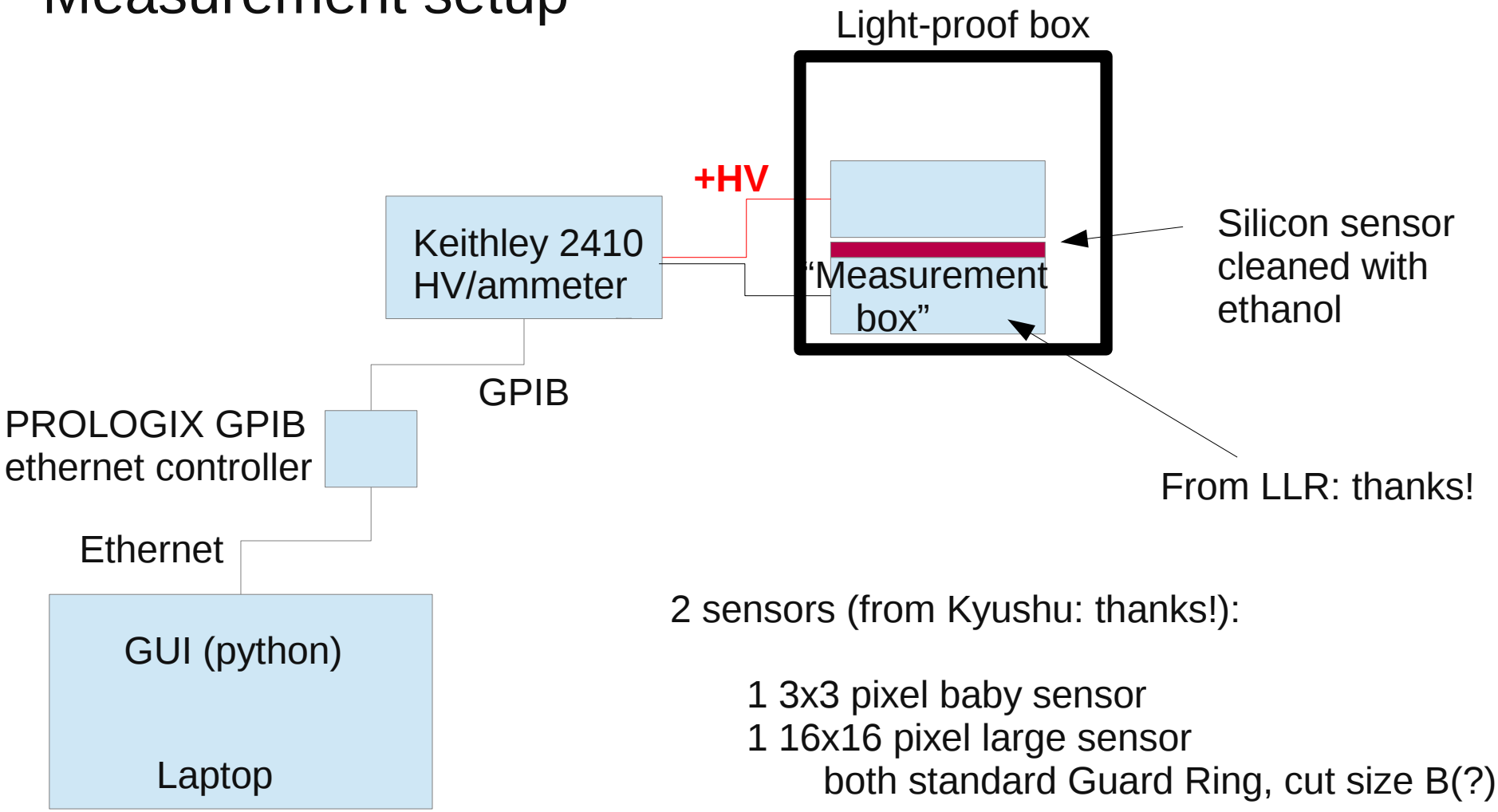
Measure and understand radiation effects

Exercise and develop system
making I-V measurements

- transient currents after HV turn-on

- current near breakdown

Measurement setup



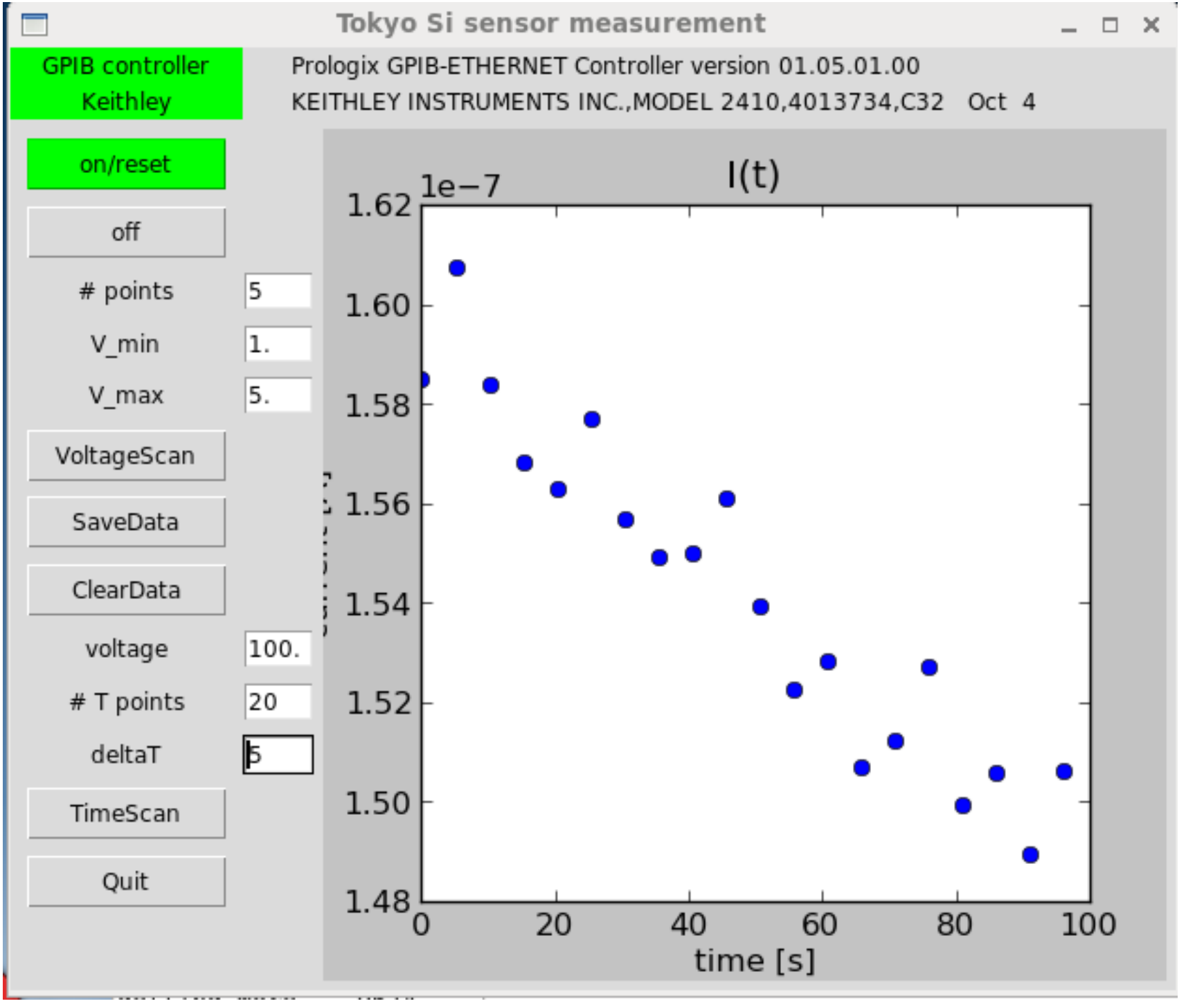
2 sensors (from Kyushu: thanks!):

1 3x3 pixel baby sensor
1 16x16 pixel large sensor
both standard Guard Ring, cut size B(?)

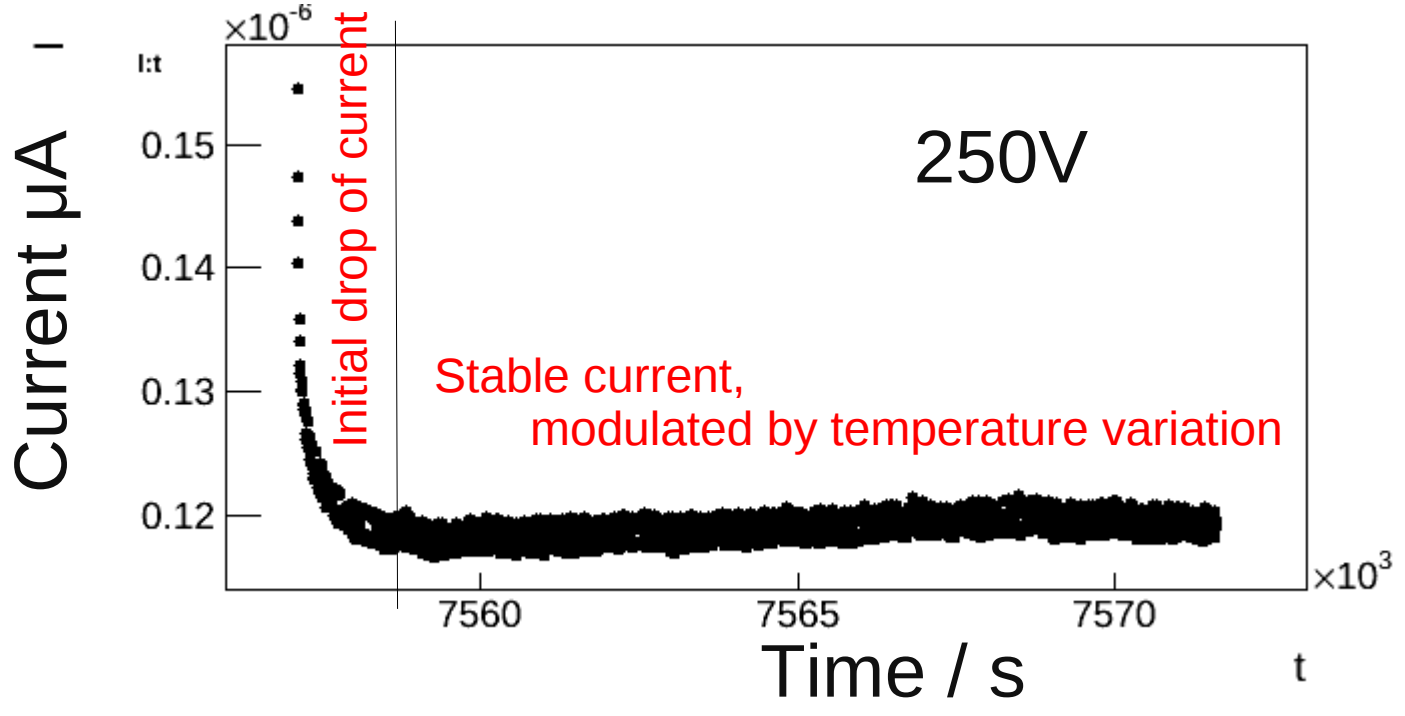
All measurements with all pixels connected in parallel

Room (usually) air-conditioned

GUI written in python



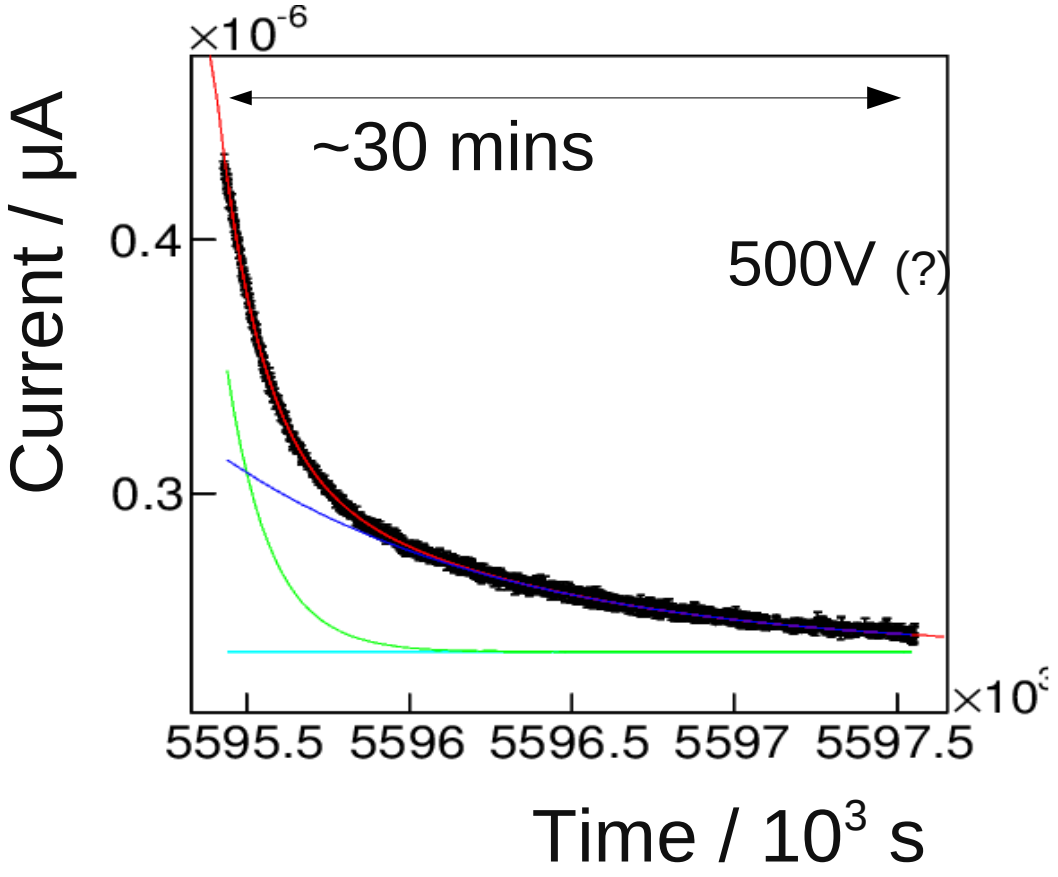
Transient current behaviour



~4 hours

Large sensor

Look at initial current drop



Initial drop off is nicely fitted by 2 exponential components with different time constants

What are properties of this transient behaviour?

Time constants, normalisation ?

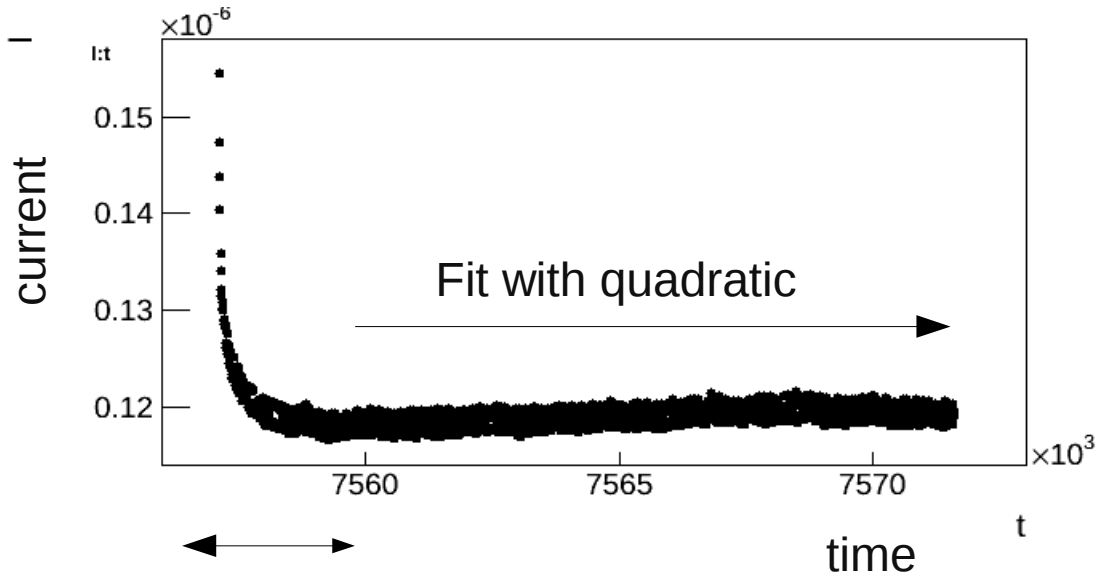
Does it depend on HV?

Does it recover after turning off HV? How quickly?

Understand the physical mechanism

Measurement procedure

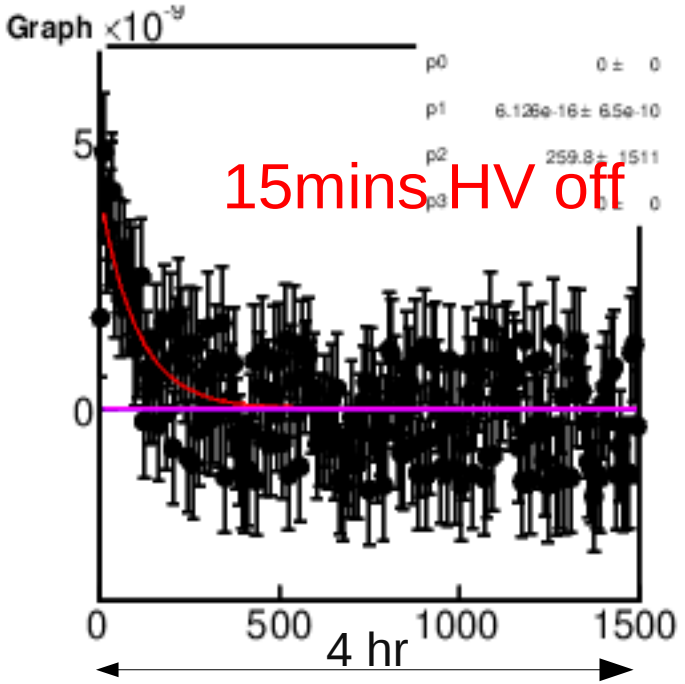
HV on for 4 hours
HV off for 10 seconds
HV on for 4 hours
HV off for 30 seconds
HV on for 4 hours
HV off for 3 minutes
.....
HV on for 4 hours
HV off for 1 hour
.....
HV off for 10 hours
HV on for 4 hours

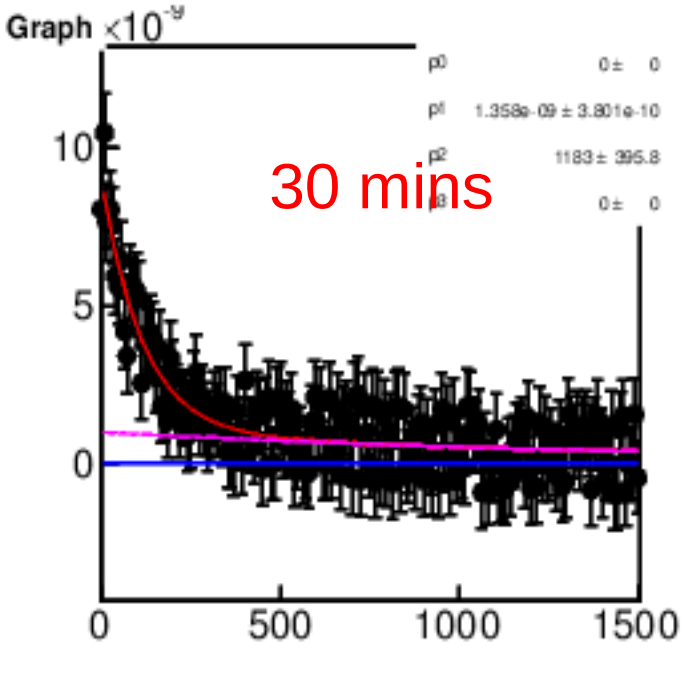


Subtract extrapolated quadratic

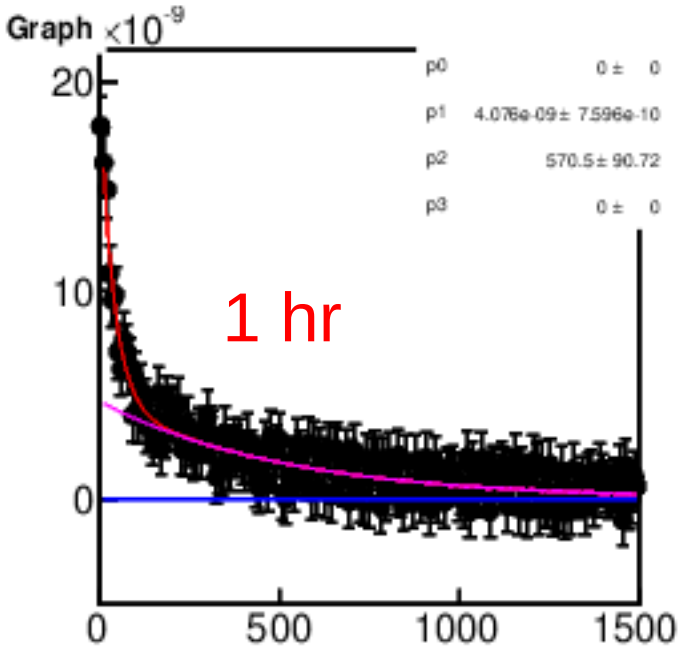
This subtracts “intrinsic” leakage current to isolate transient effects

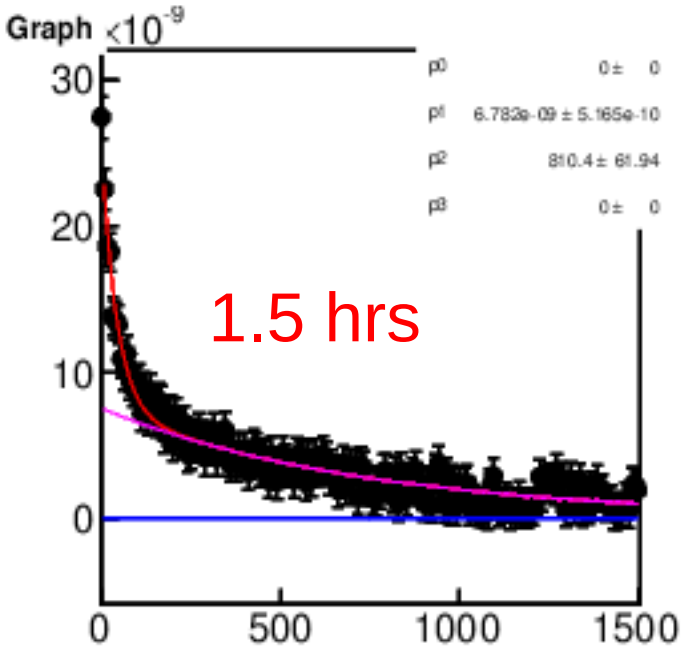
Also a “poor man's” temperature correction





250V
16x16 pix

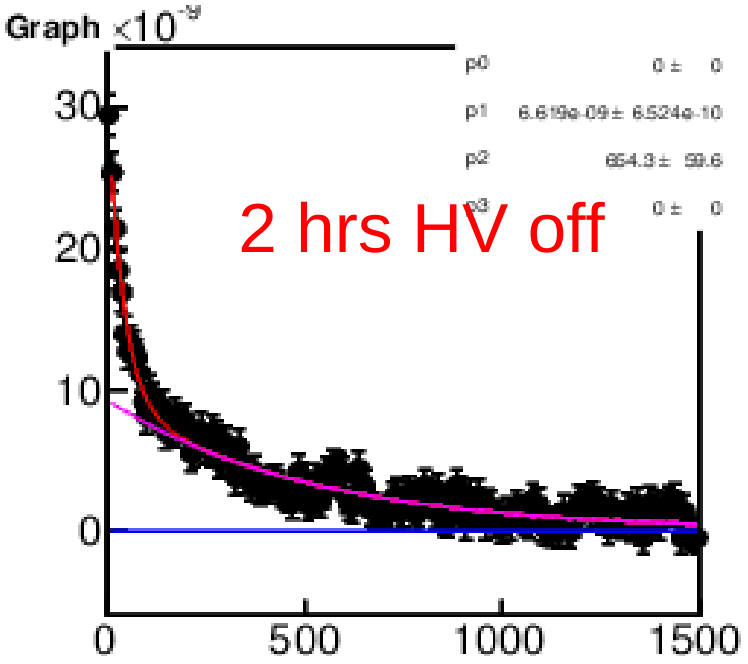


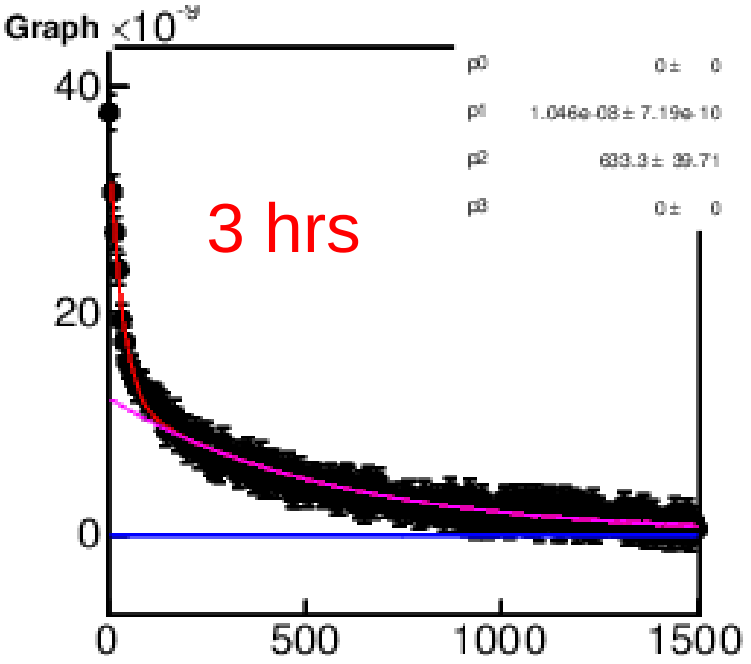


Fit each plot
2 exponentials

Subtracted current / nA

Time / s





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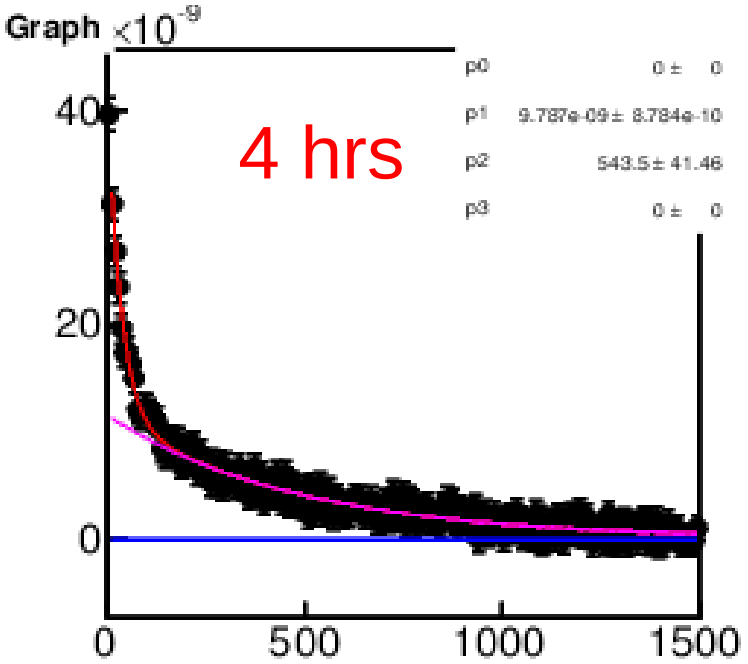
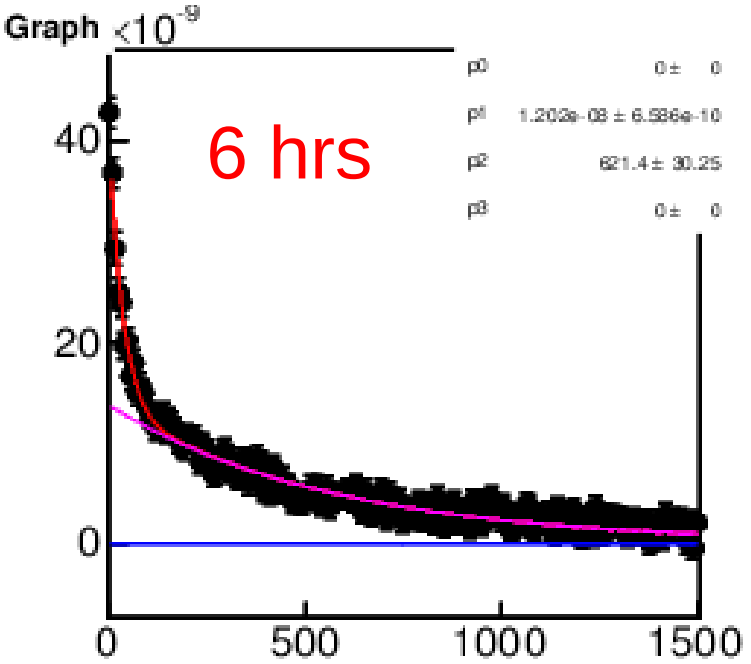
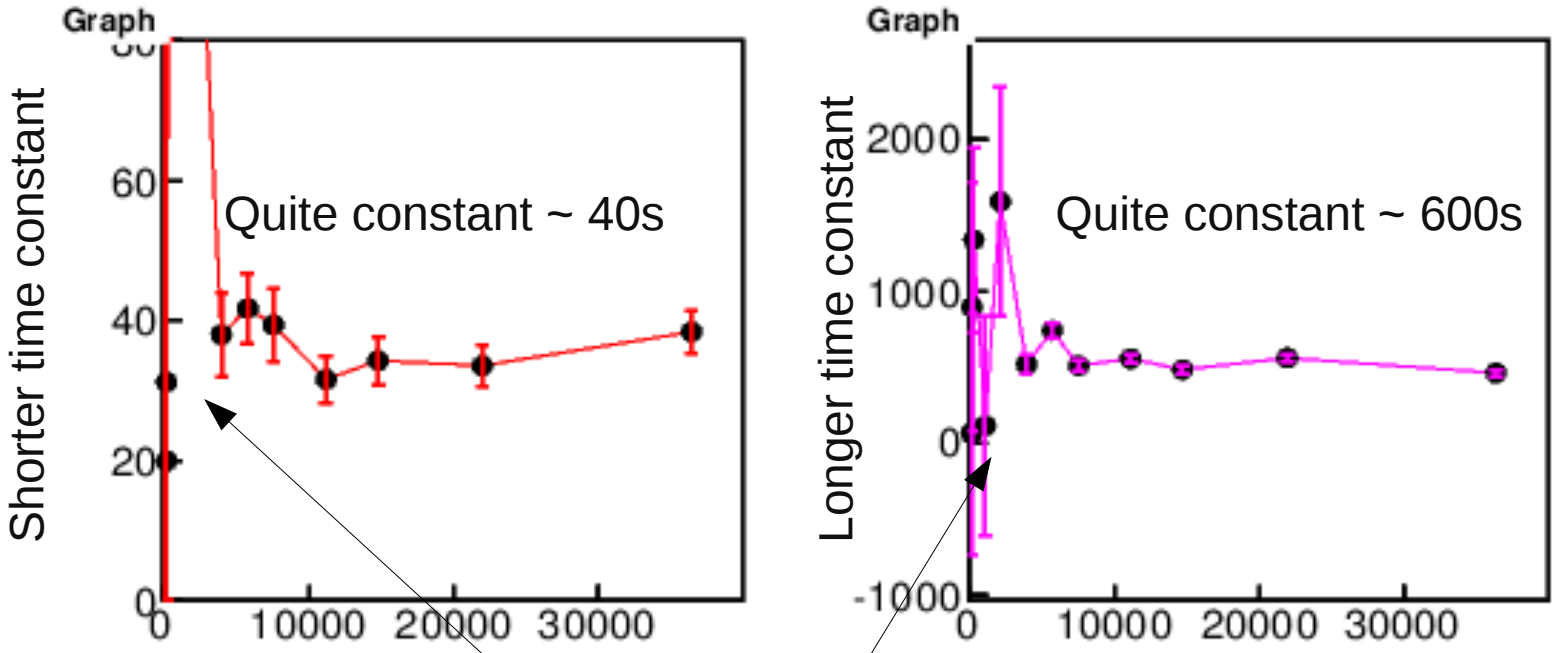




Time constants of 2 exponentials as function of how long HV was off

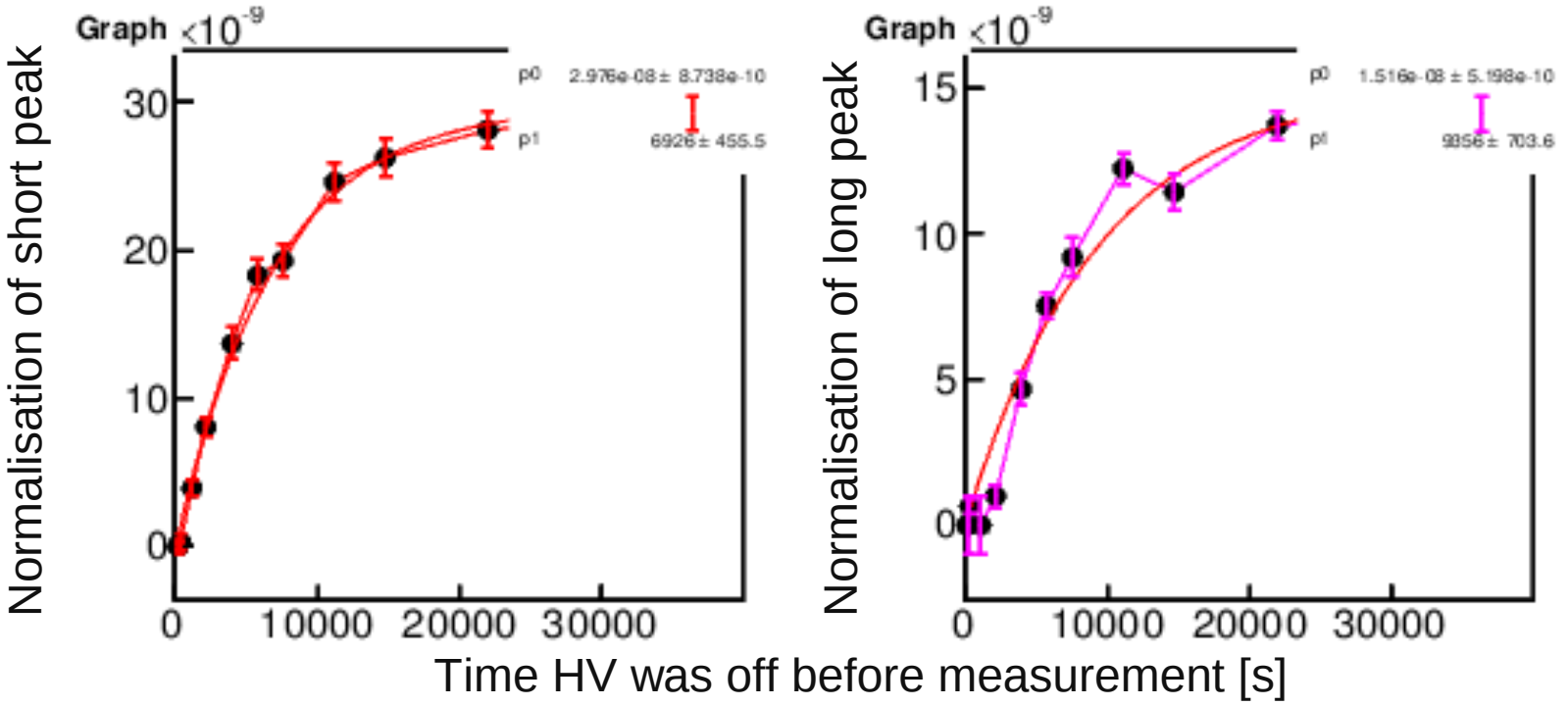
250V
16x16 pix



Fitting not always stable for short off-times

Normalisation of exponential components

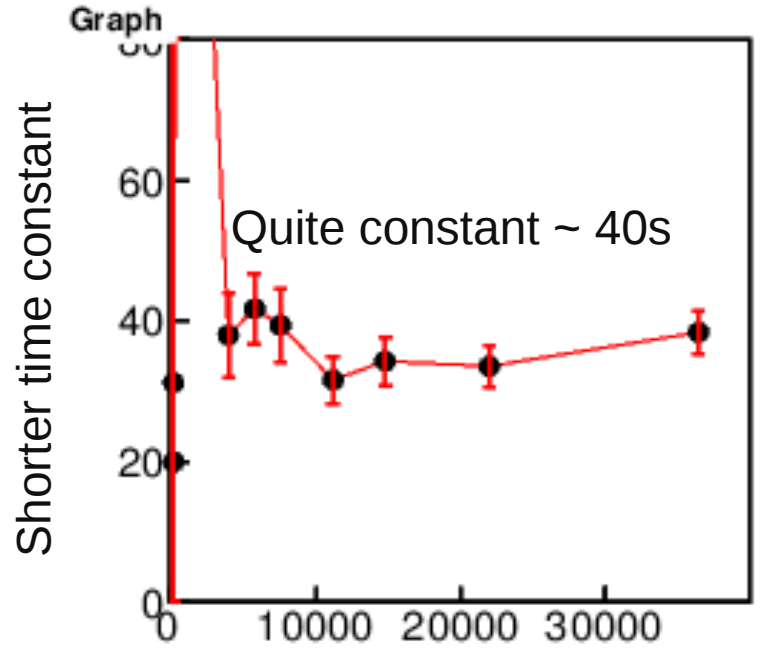
250V
16x16 pix

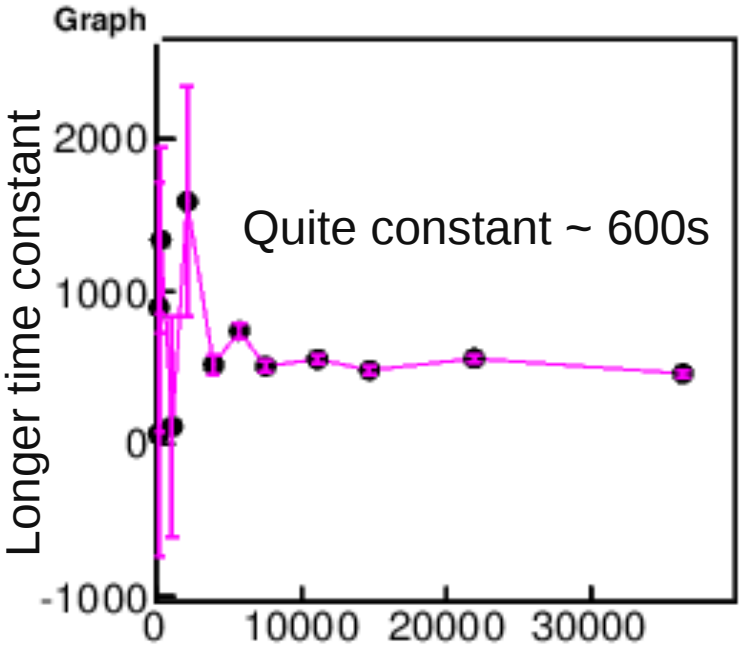


Nicely fitted by A*(1 – exp(-t/τ))

Time constants: ~ 1.9 h ~2.7 h

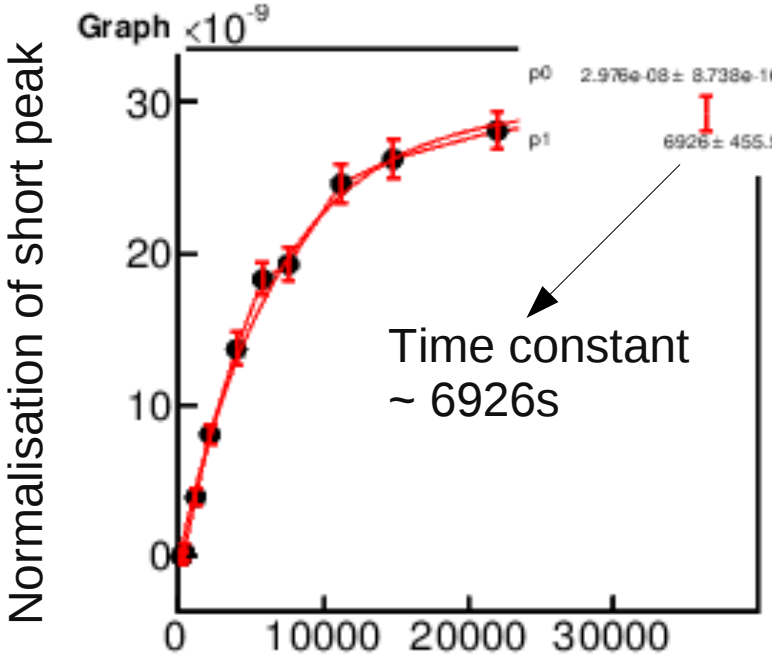
This is something like a “recovery time” when HV is off

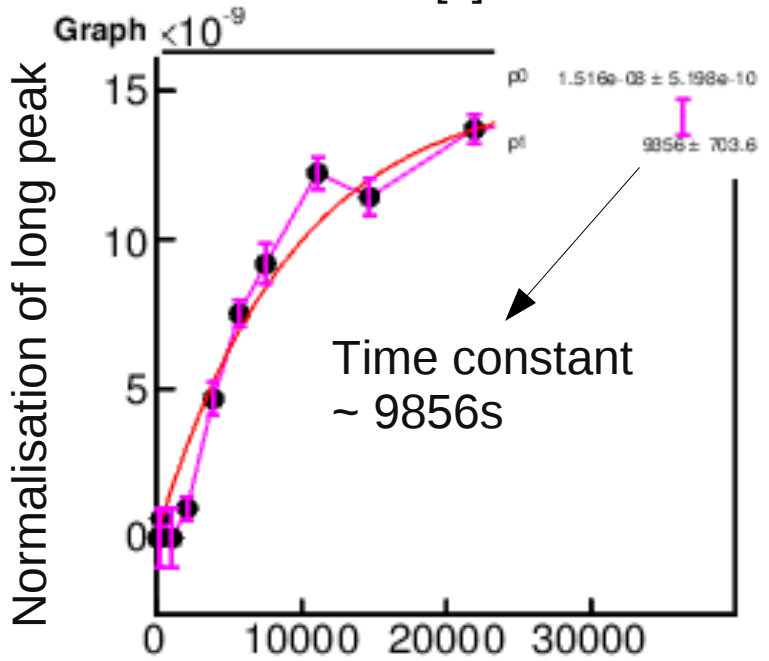




250V
16x16 pix

Time HV was off before measurement [s]

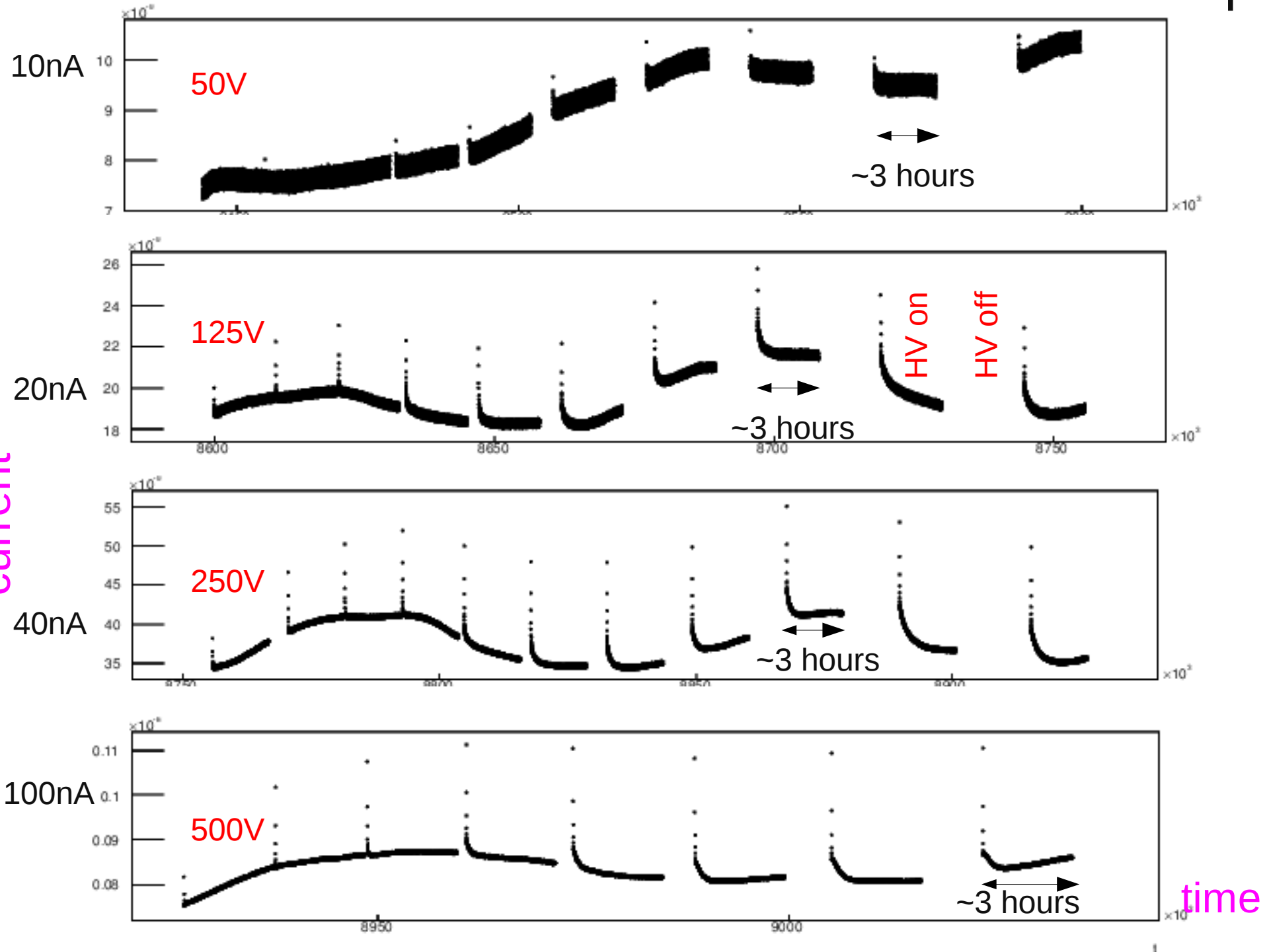




Time HV was off before measurement [s]

How about different voltages?

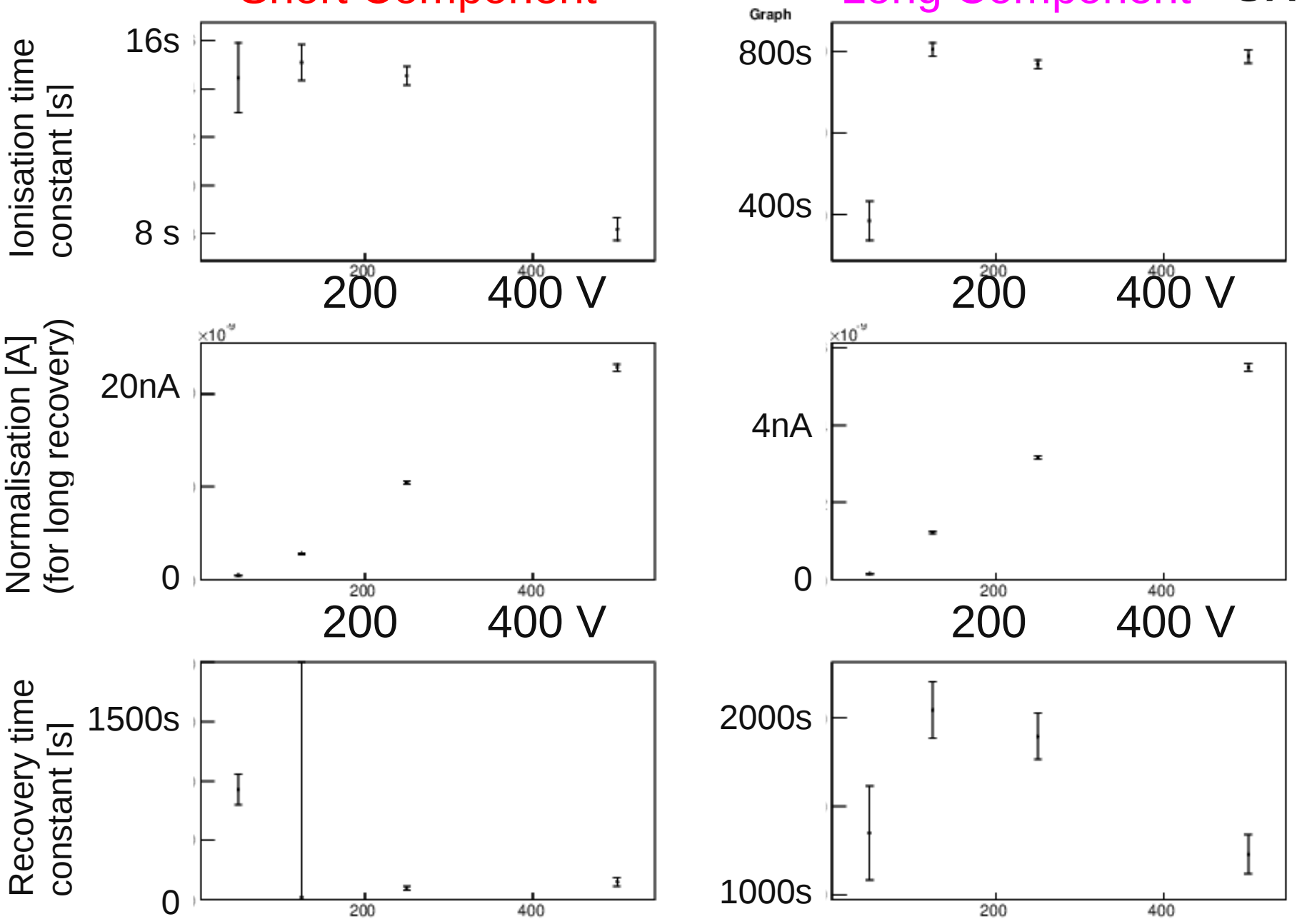
3x3 pix



3x3 pix

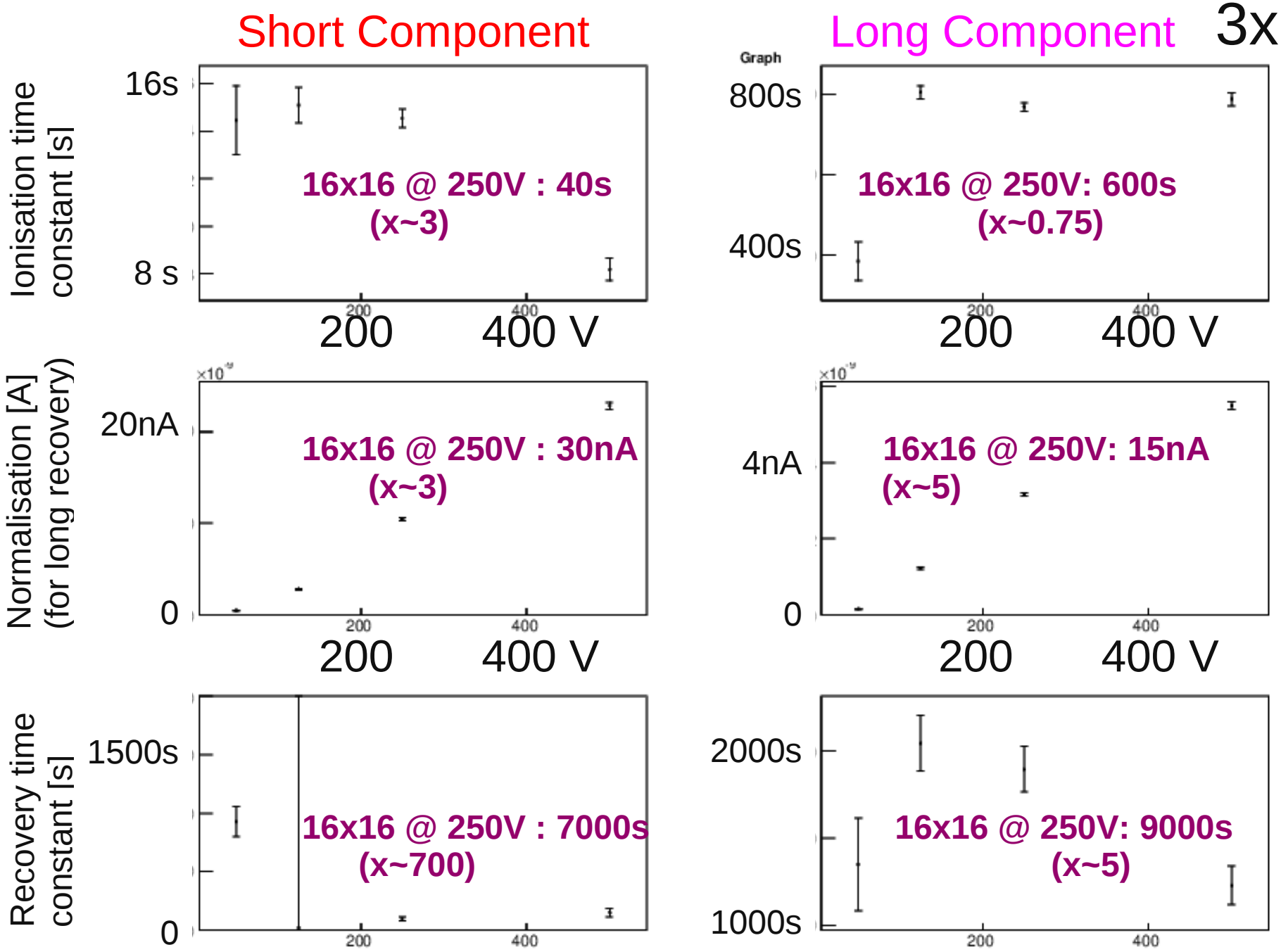
Short Component

Long Component



Mostly consistent picture -> check fit quality of “strange” points

3x3 pix



16x16 vs. 3X3 : no direct scaling with area (x30),
maybe with edge length (x5), recovery times very different

my previous interpretation

Energy states in bandgap due to traps in silicon volume
- Ionised by HV
- Typical recombination time
  - (could estimate energy by temperature dep)
  - (trap state density from total charge)

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(very preliminary) new guess

Seems to be related to sensor edge
- rather than “bulk” property

Want to test more sensors
- same and different GR designs, cut widths
- temperature dependence
  - to further understand behaviour

Your suggestions very welcome..

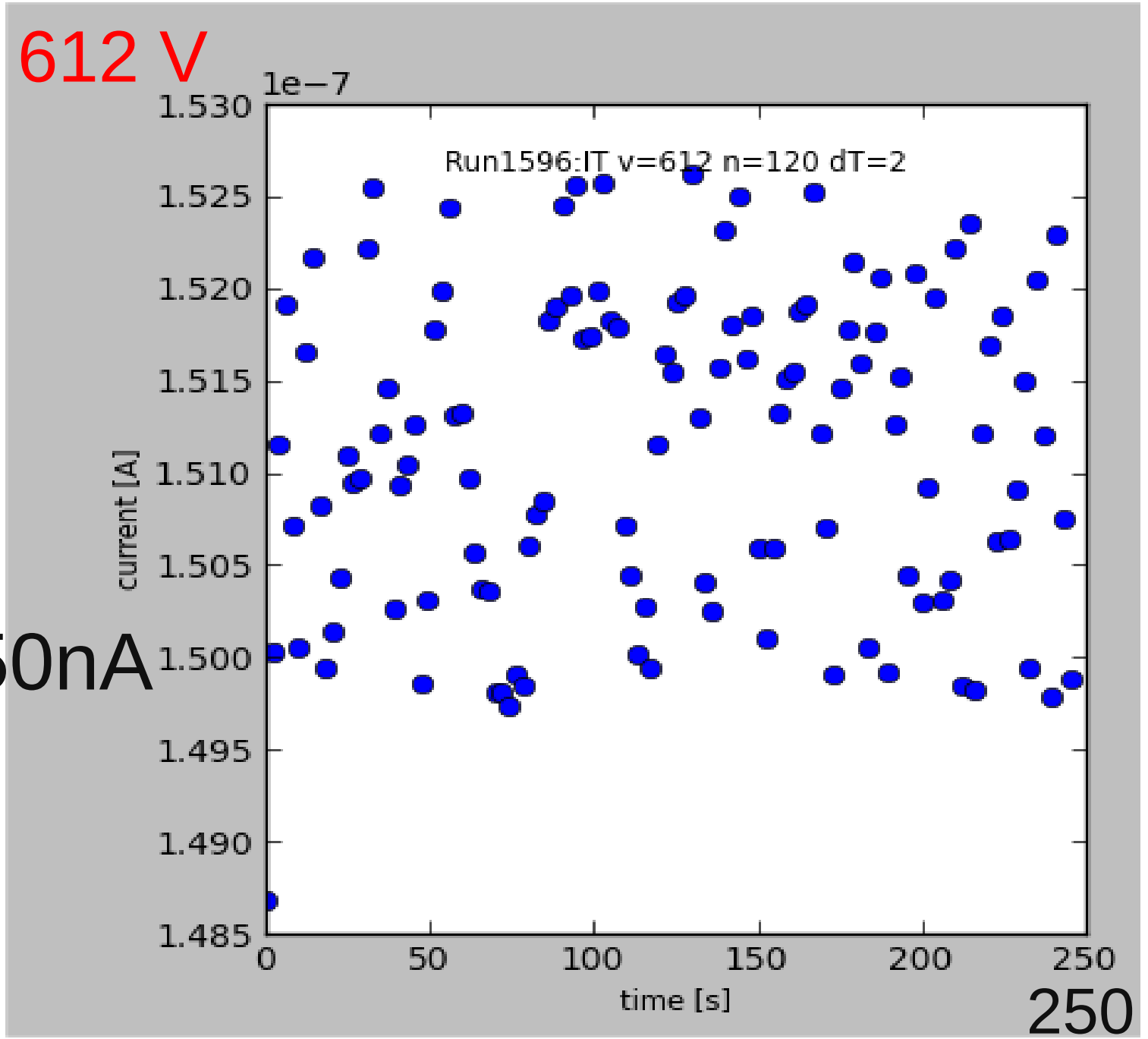
Current near breakdown

Some behaviour I noticed,
but have not really investigated further

Measurement procedure:

99 measure ~4 minutes current @ fixed V
increase by 5V
If not breakdown {goto 99}

612 V

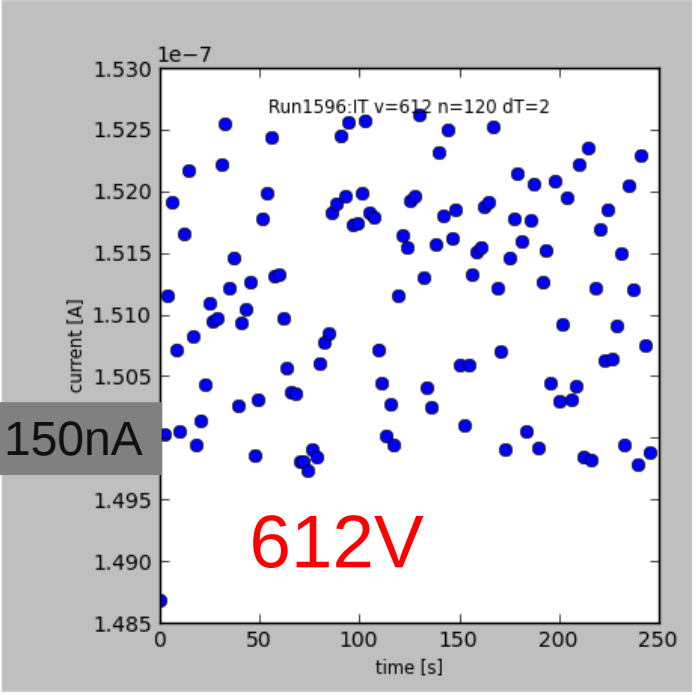


150nA

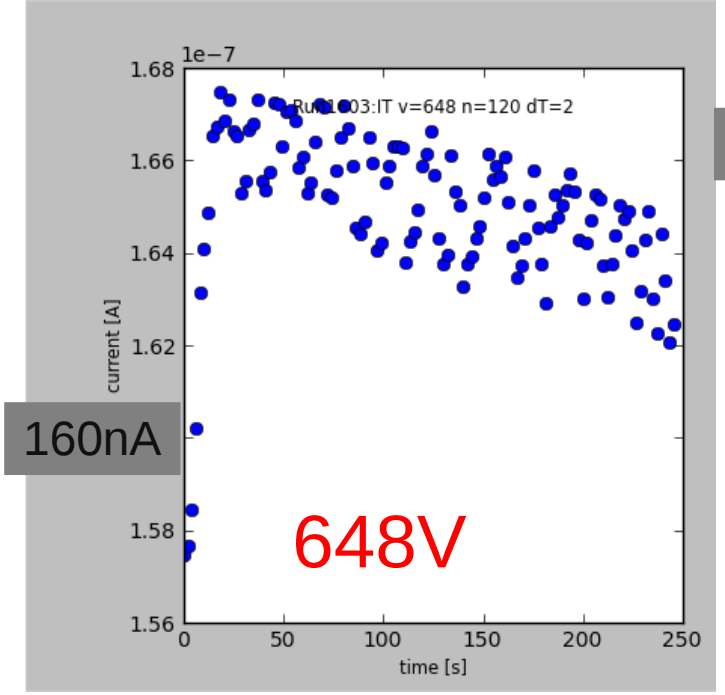
+/- <1% noise

250 s

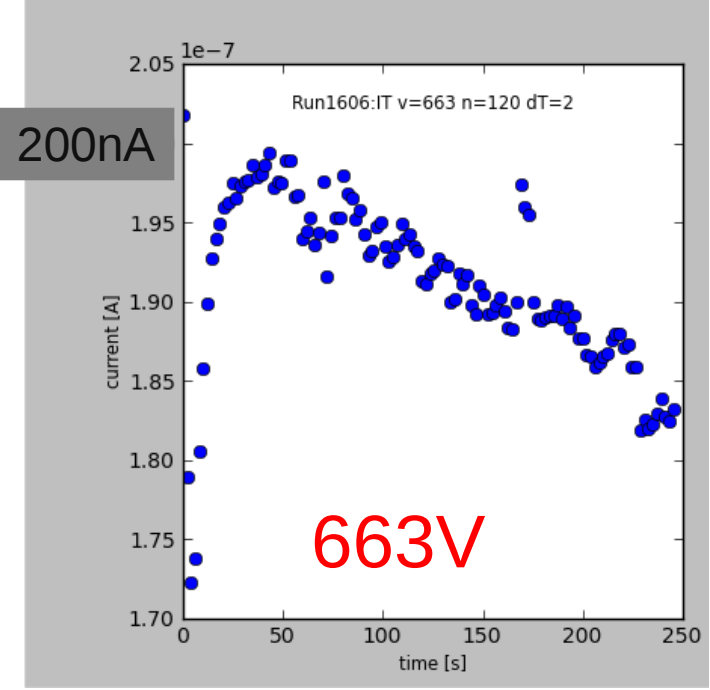
150nA

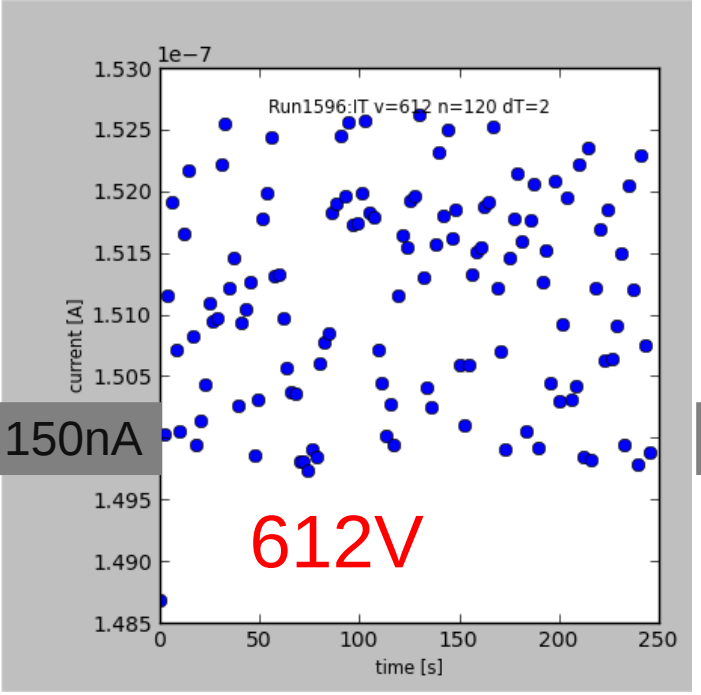


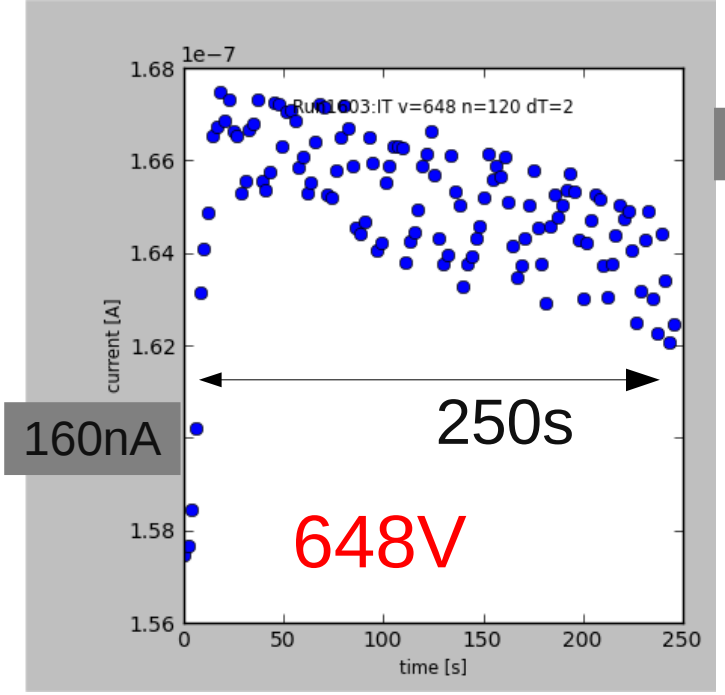
160nA

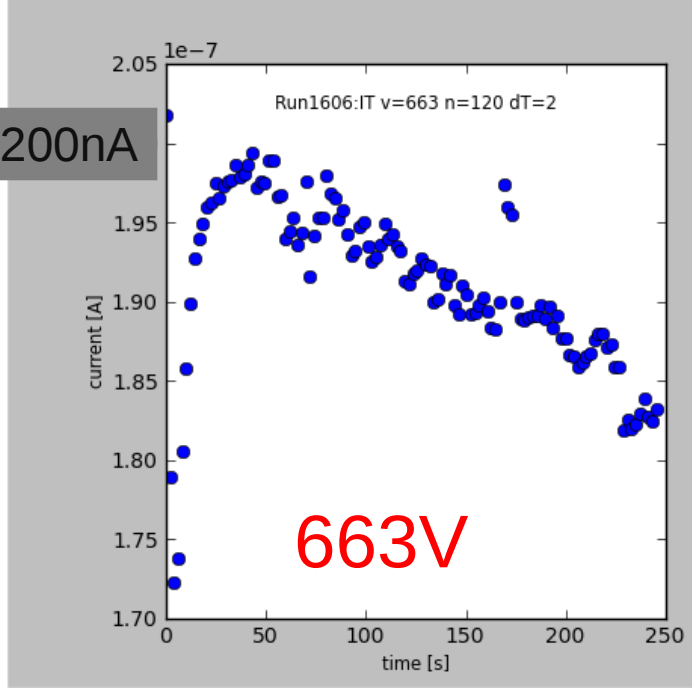


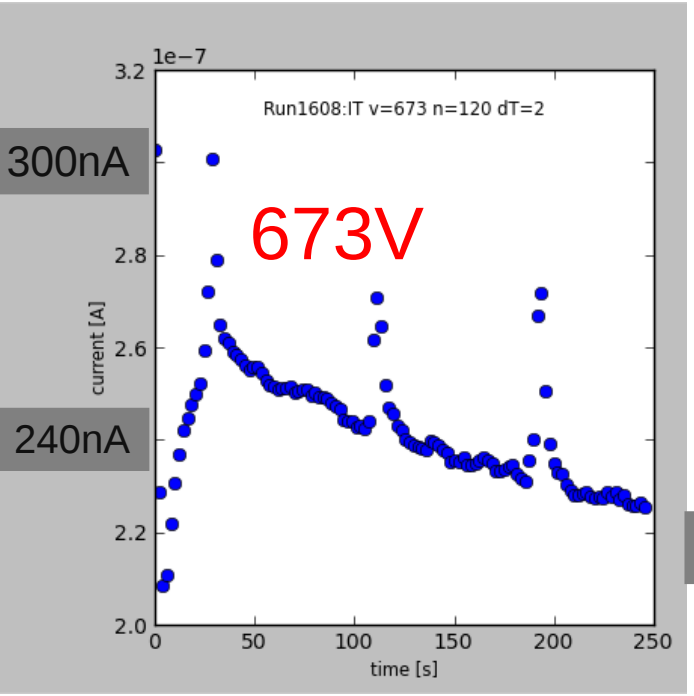
200nA

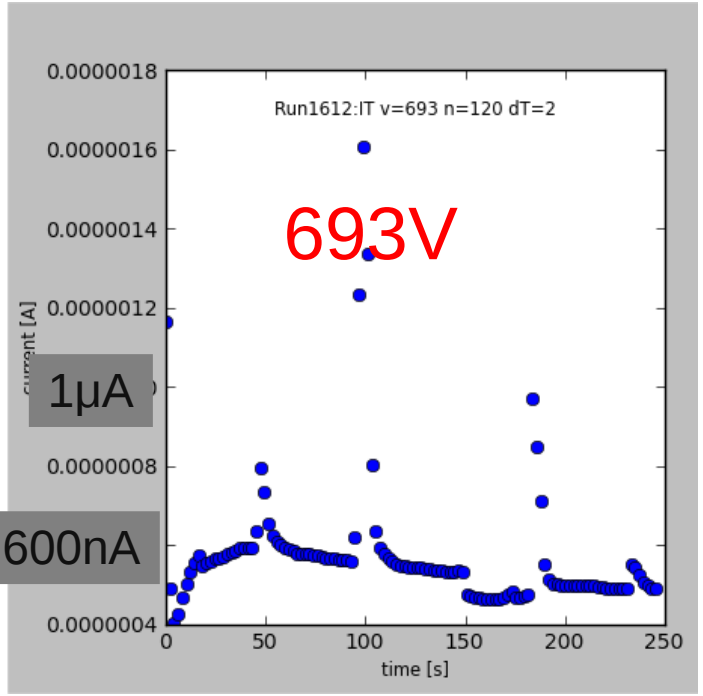


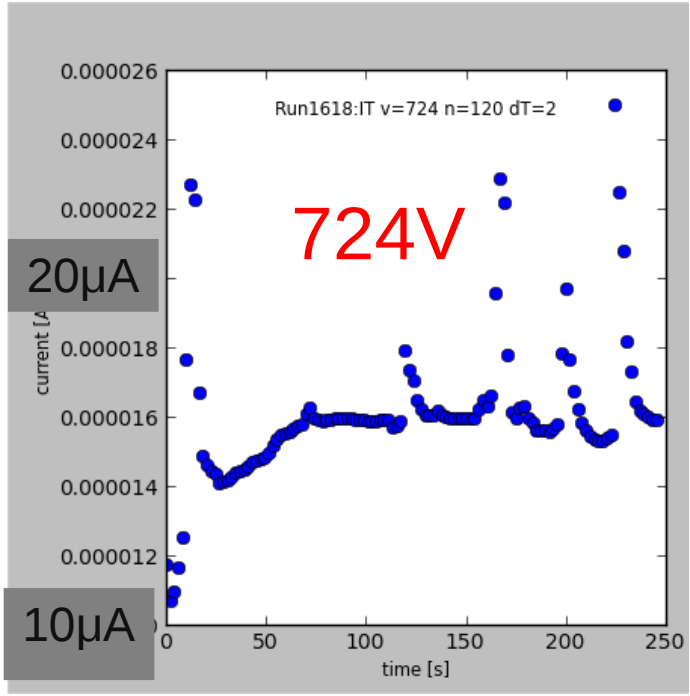








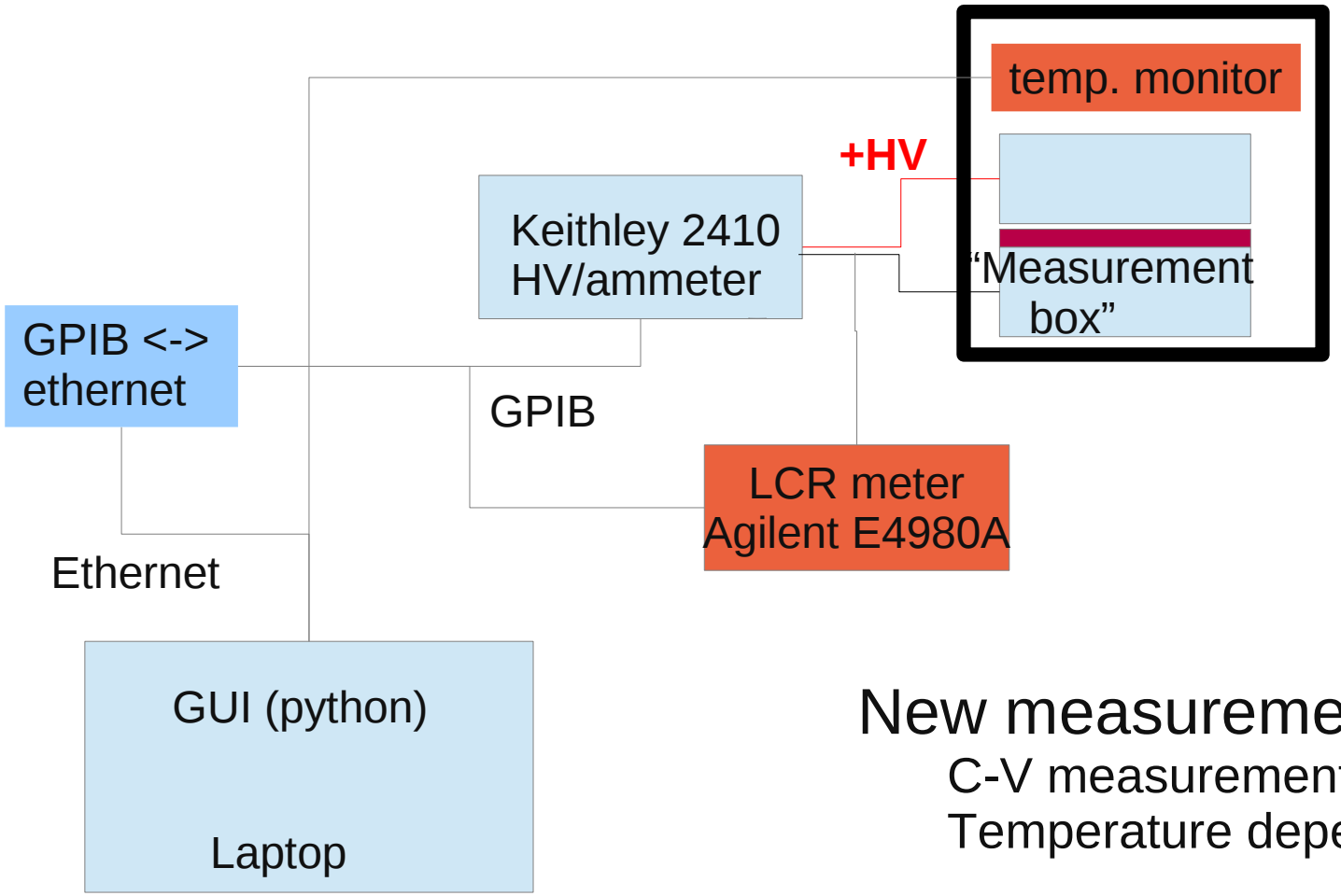




Maybe interesting to understand breakdown behaviour...?

I > 25μA @ V>729

Upgrades to measurement setup now underway



New measurements planned:

C-V measurement
Temperature dependence/corrections

Single pixel measurements

before and after radiation (neutron/gamma) exposure

Summary

V-I measurement system working well

Measuring various properties of sensors
maybe not directly related to usual operation
but may help us to
better understand the sensors
and more robustly specify measurement procedure

System will be applied to radiation tests
and developed into more automatised measurement system

CERN/CLIC ECAL optimisation group

Relatively new group of (mostly) CLIC people looking at ecal optimisation

Conveners are John Marshall, Andre Sailer (if I remember correctly)

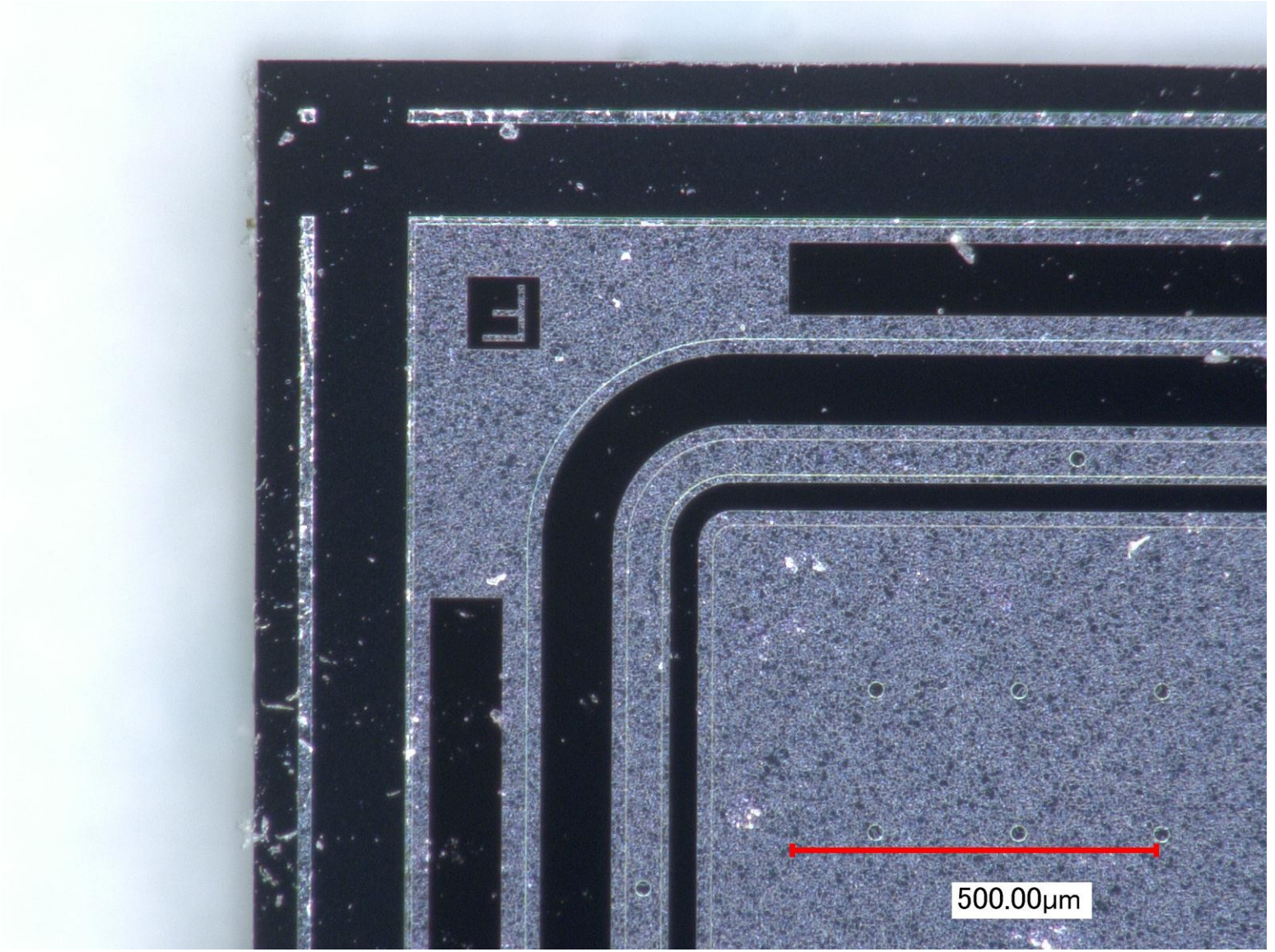
Meetings every ~2 weeks

Agendas and slides:
https://indico.cern.ch/categoryDisplay.py?categId=4379

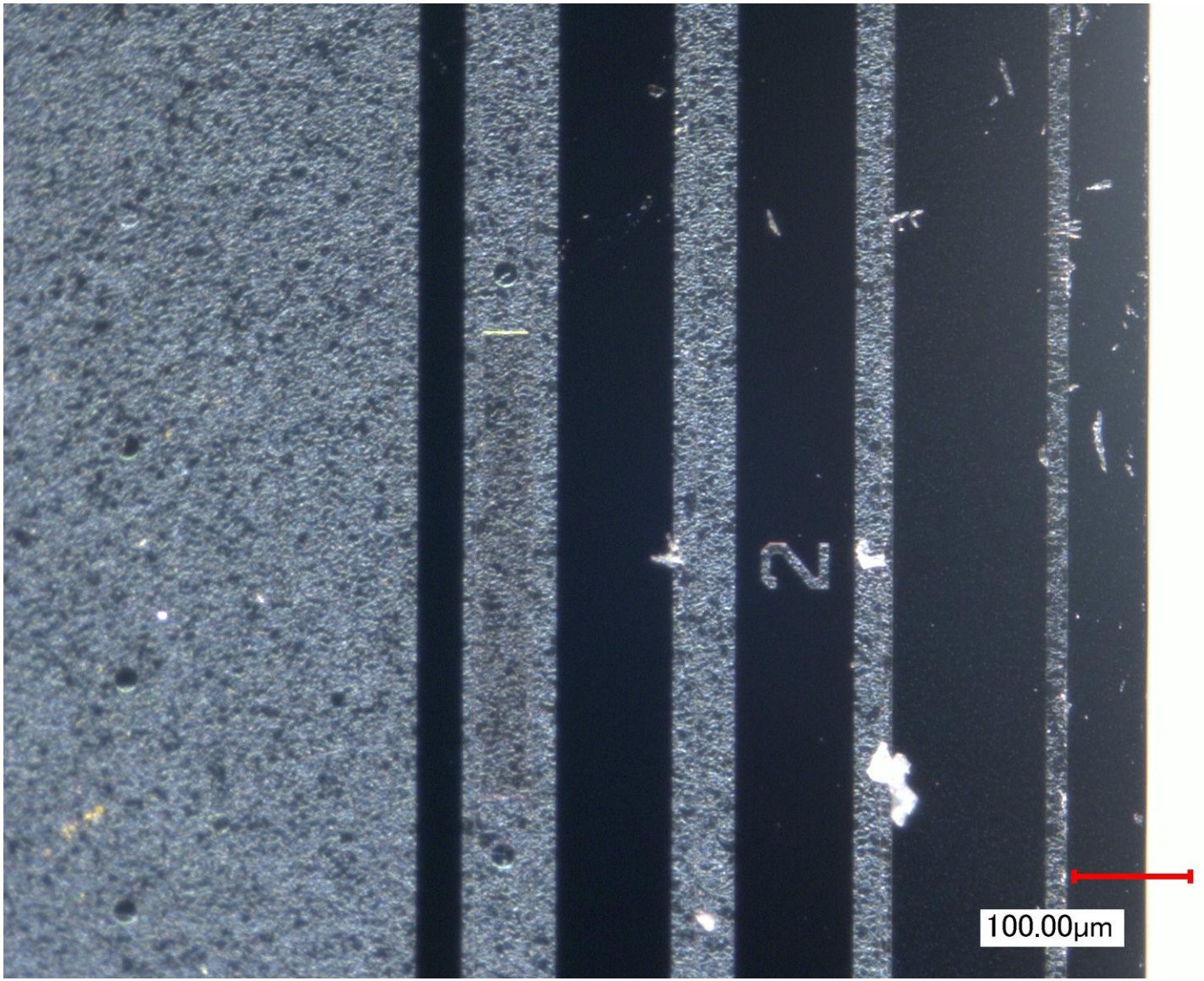
Seem to concentrating mostly on:

- Scintillator tiles
- Varying tile size with depth
- Calibration of PandoraPFA for Scintillator

Baby chip

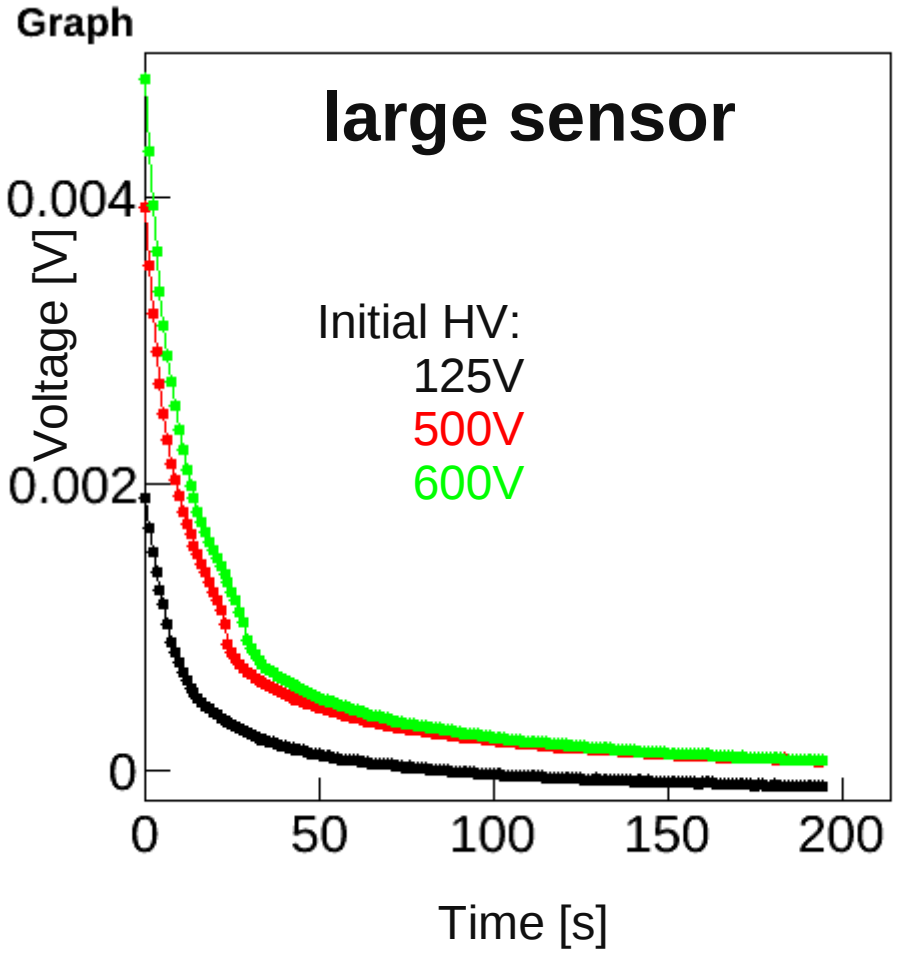


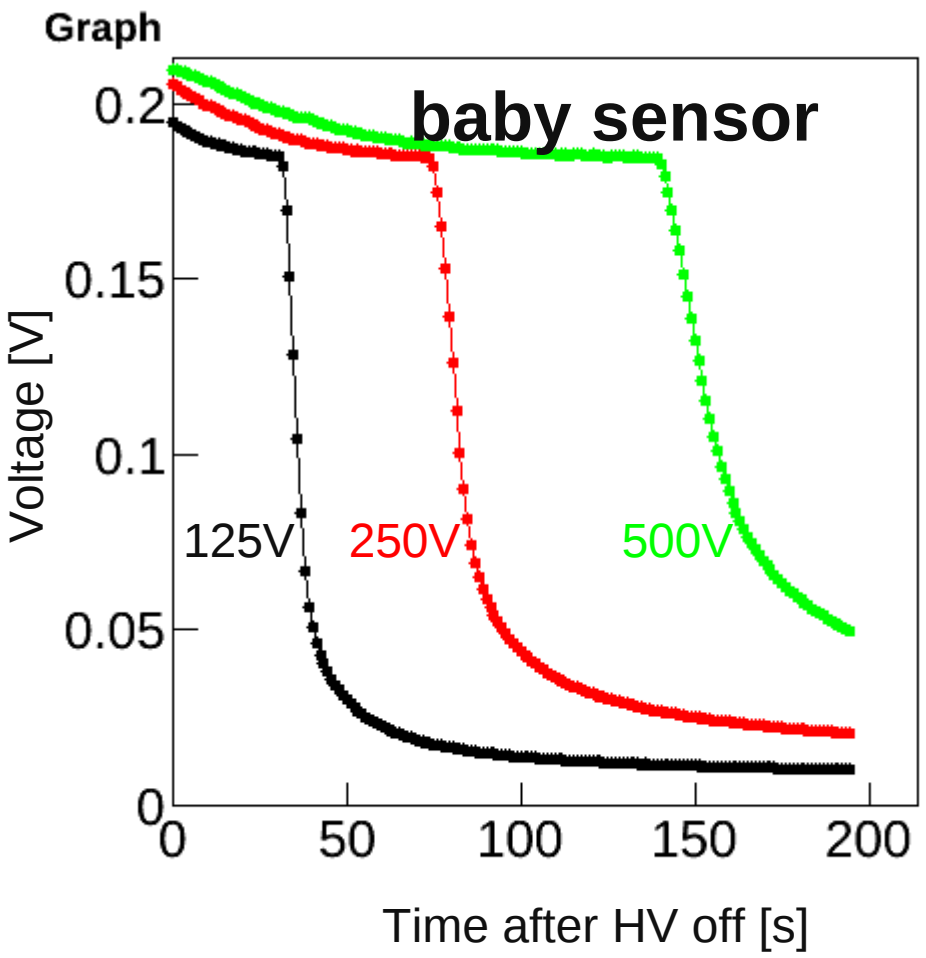
Baby chip



What happens after we turn off HV?

Measure voltage across diode as a function of time after turning off HV
(HV was on for ~3 hours)



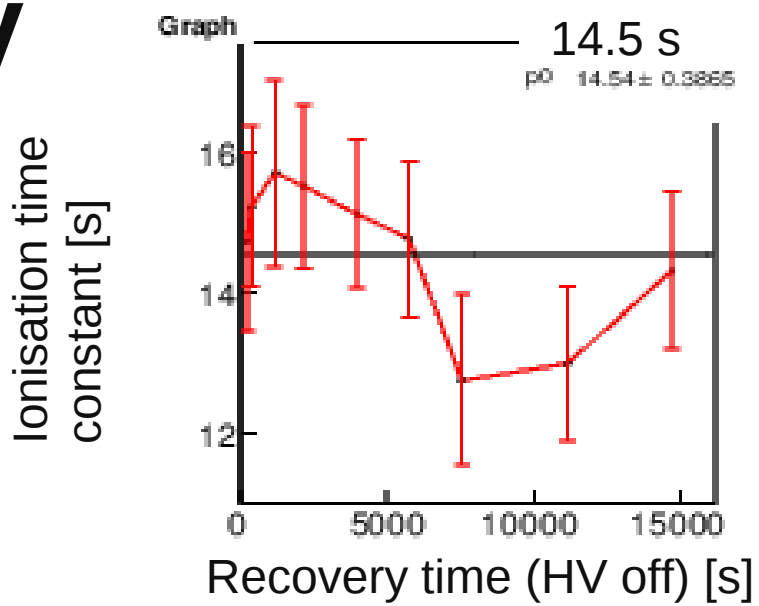


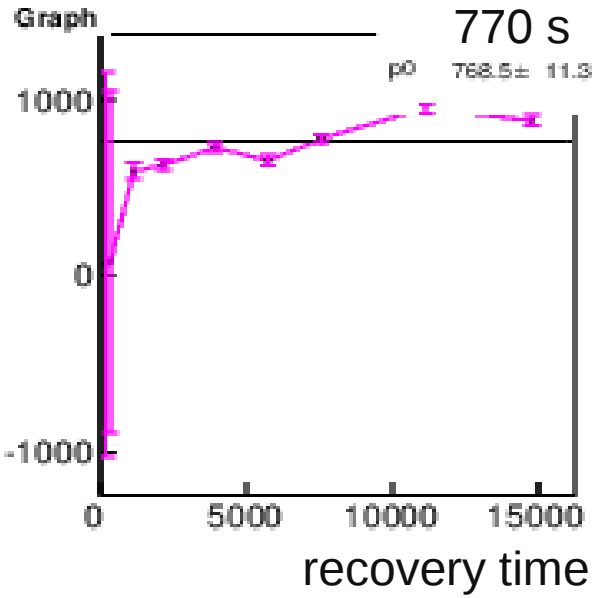
I don't understand this yet...

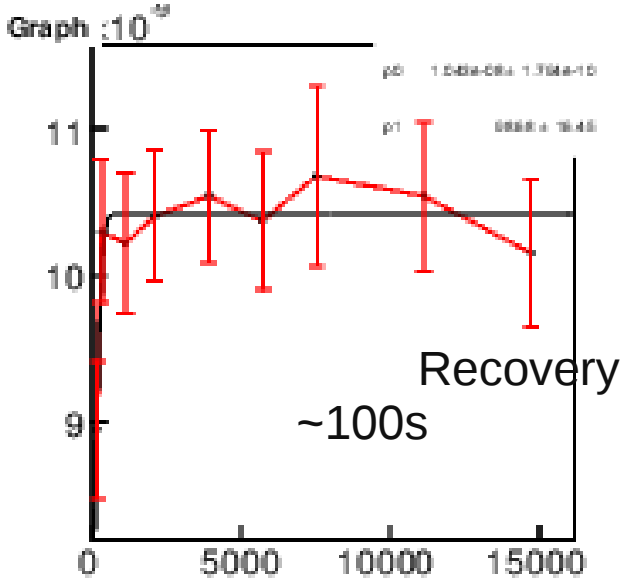
3x3 pix 250V

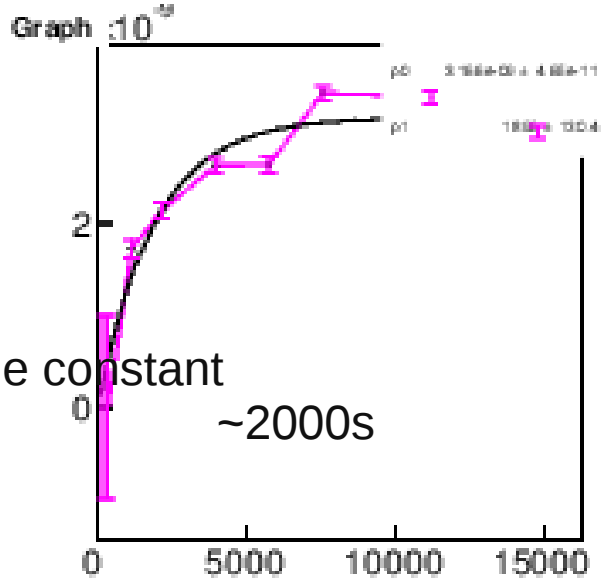
Fast exponential

Slow exponential









Recovery time constant

~100s

~2000s

Repeatedly scan V-I around breakdown, same 16x16 pixel sensor
fast measurement (<~1 hour) -> “stable” conditions