Comparitive Irradiation Test of an Oxygenated and a Non-Oxygenated Silicon Microstrip Detector

I.Abt
MPI München
isa@mppmu.mpg.de

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Radiation hardness of the HERA-B double-sided Silicon Strip Detectors
C.Bauer et al. To be published in NIM

Content of this Talk

- Detector Design
- Irradiation Setup
- S/N
- IV curves
- Depletion Voltages
- Charge Collection
- Charge Devision
- Evolution
- Concluding Remarks

The Silicon Detectors

The detector design is driven by the HERA-B requirements

high track density

↳ **50 micron readout pitch**

required act. area 5cm · 7cm

↳ **55 and 52 micron pitch**

required stereo angle

↳ **2.5 degree rotation**

high and inhomog. radiation

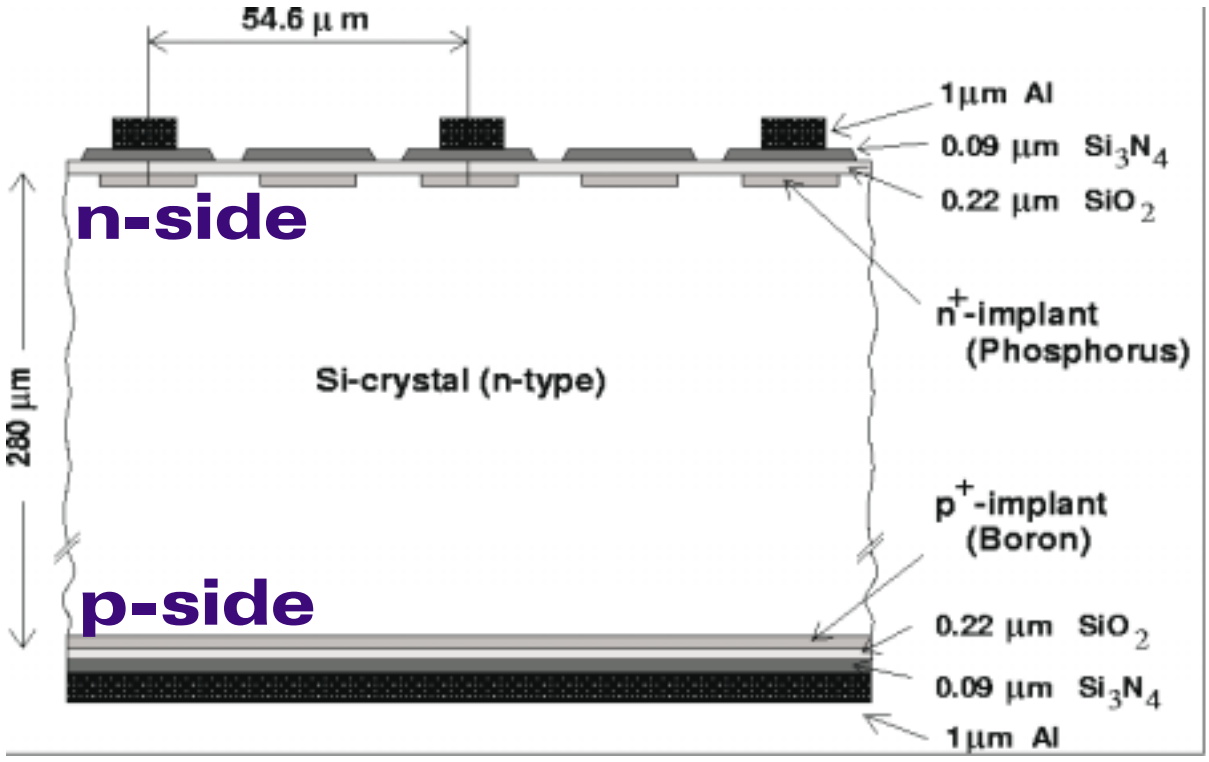
↳ **polysilicon biasing**

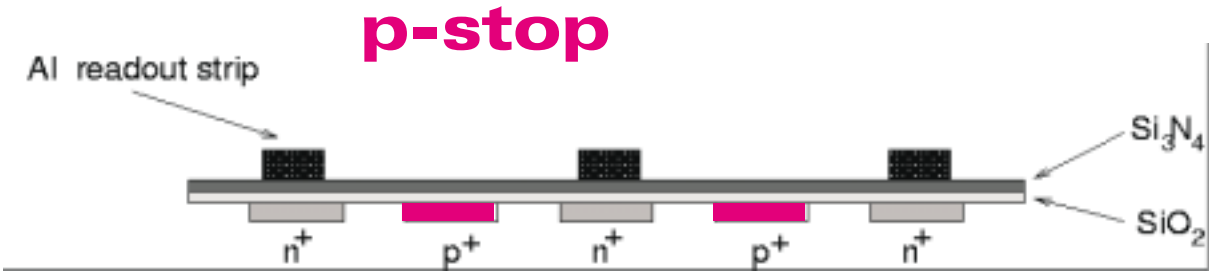
↳ **multiple guard rings**

↳ **burst protection**

↳ **intermediate strips**

Silicon Technology

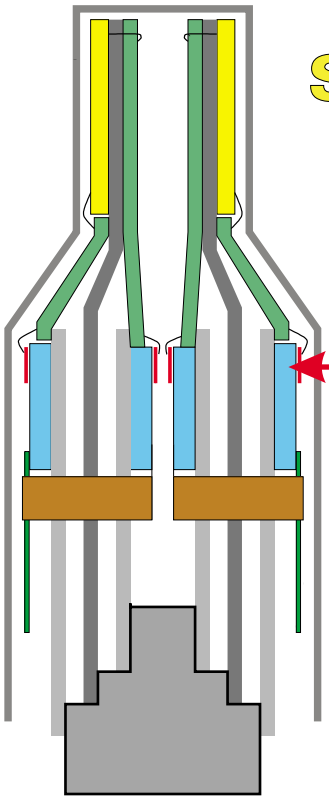




For this test we used 2 detectors from SINTEF with p-stop technology.

One normal detector 10^{16}, one oxygenated $2 \times 10^{17}/cm^3$.

Module Design



Silicon Detectors

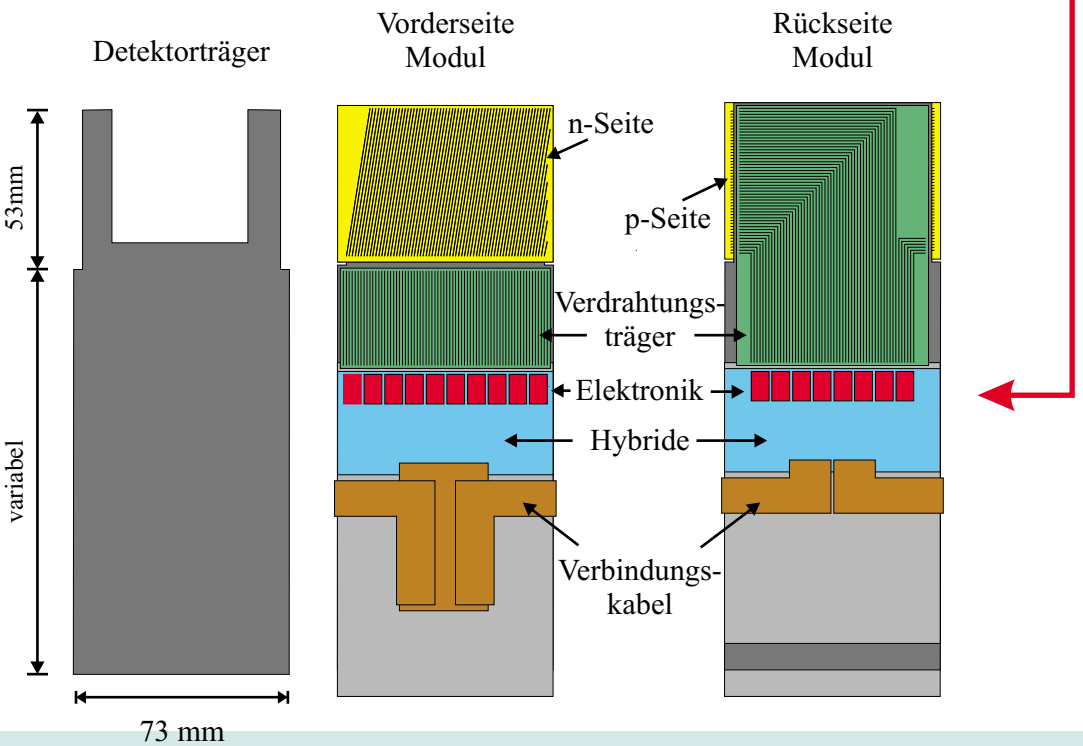
Kapton Flex-Jumpers

Bent Carbon Fibre

Ceramics Hybrids

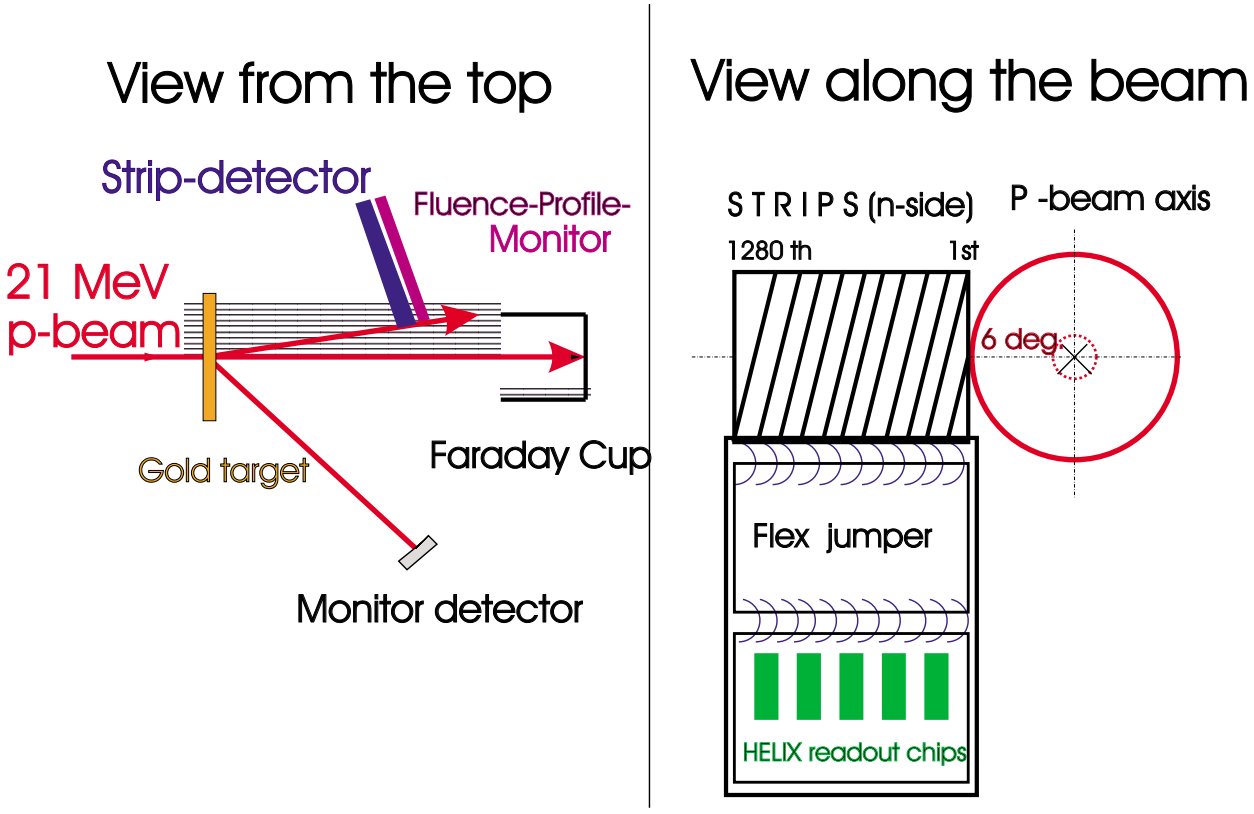
Read out with HELIX 2.2

50 ns shaping time



Irradiation Setup

Irradiation was done with 21 MeV protons scattered from 50micron gold foil.



Inhomogenous irradiation from 0 to 3 x 10^{14} m.i.p.s equivalent.

detectors biased with 140 V cooled to 10 C

Measurements

Irradiation — **Sept. 2000**

S/N ^{106}**Ru** — **after 3 weeks at room temp.**

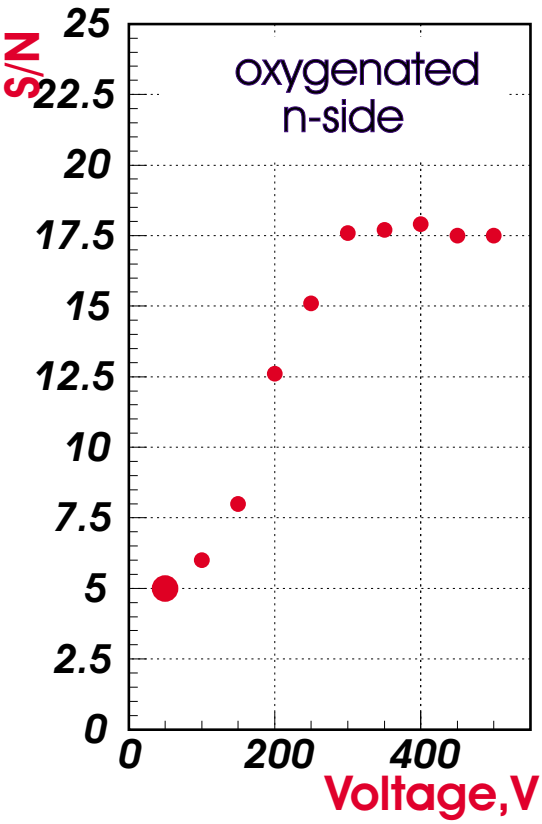
IV — **after 8 months at 20 Celsius**

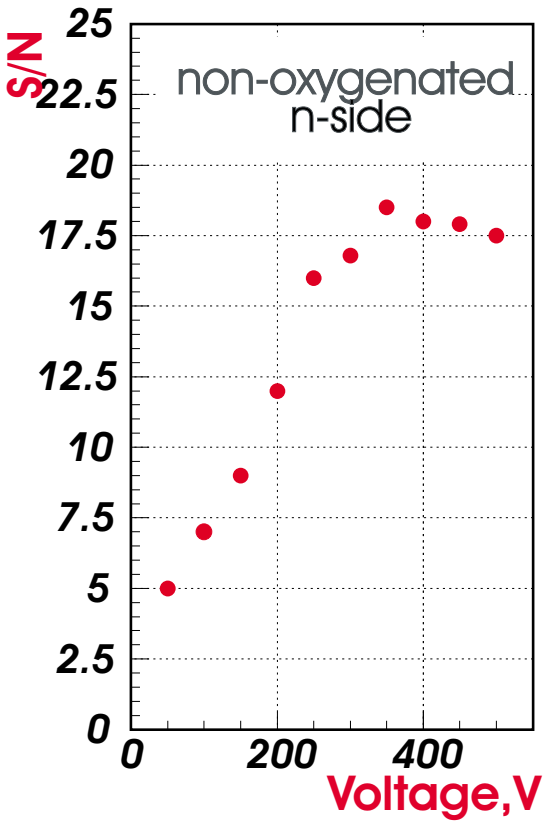
Depletion Voltage
Charge Collection
Charge Devision } **LASER**

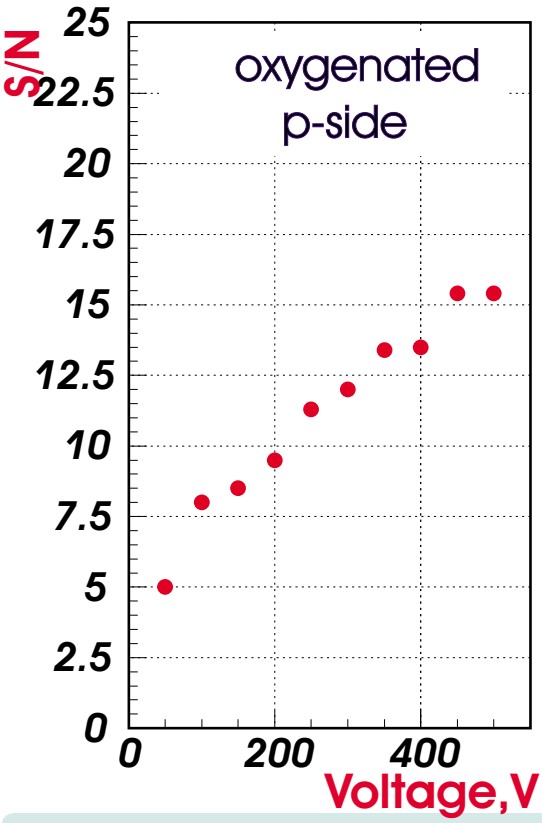
plus 6 months at 8 Celsius

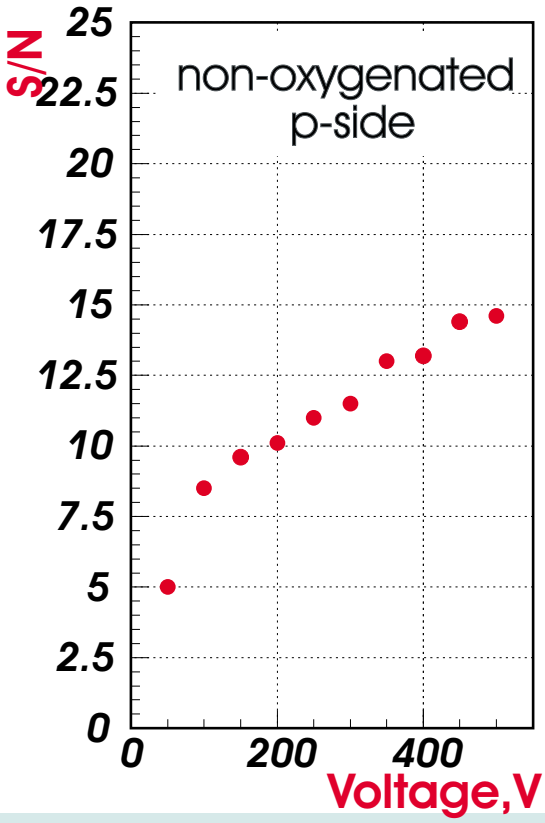
Depletion Voltage
Charge Collection } **LASER**

Signal to Noise









$> 2 \times 10^{14}$

Signal to Noise

Both detectors were at 10 C fully operational after 3 weeks at room temperature.

Some localized noise problems at high temperatures:

> 400 Volts oxygenated

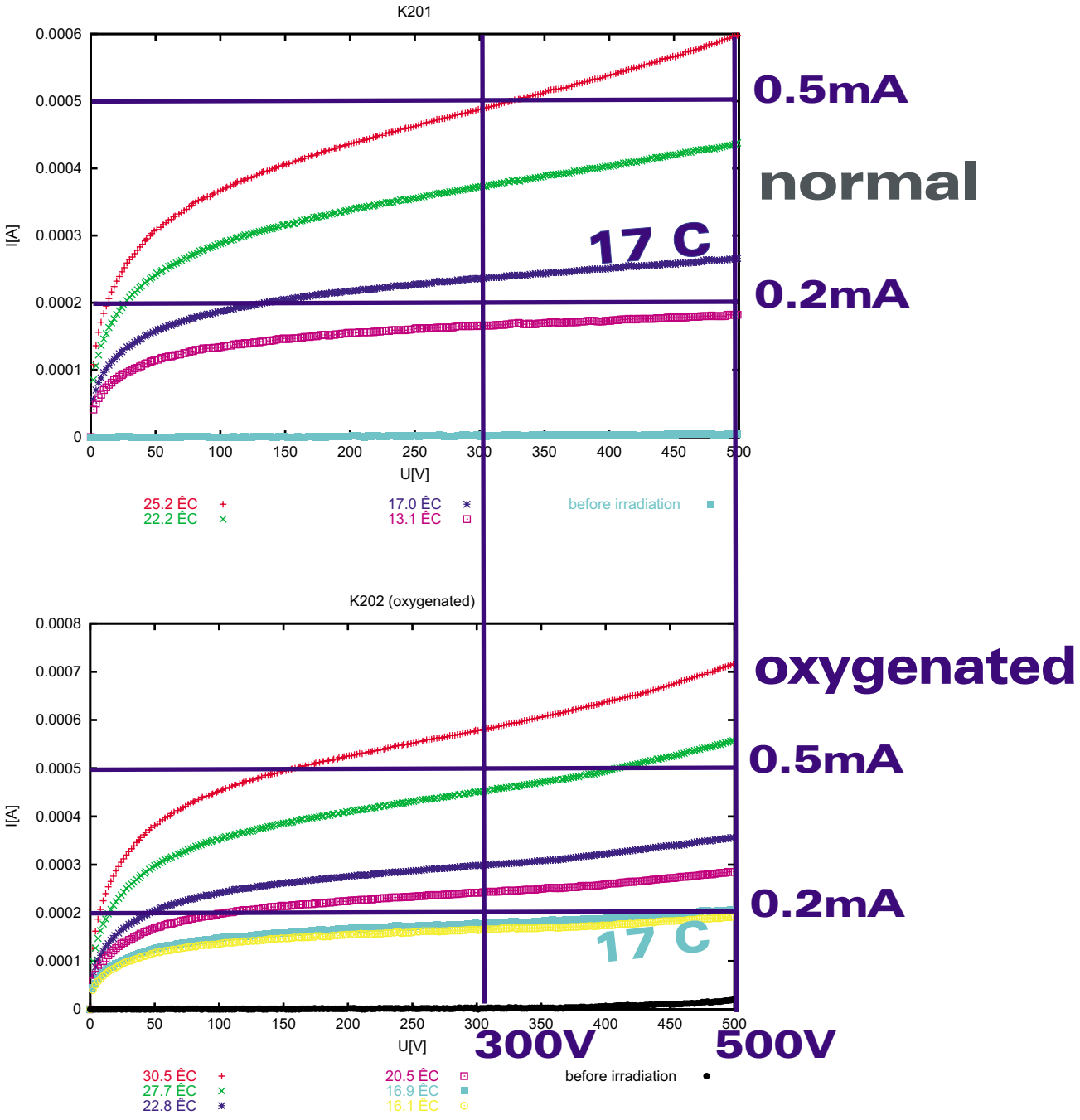
> 500 Volts normal detector

No significant difference in S/N between oxygenated and normal detector.

n-side:	S/N	22	17
p-side:	S/N	16	15

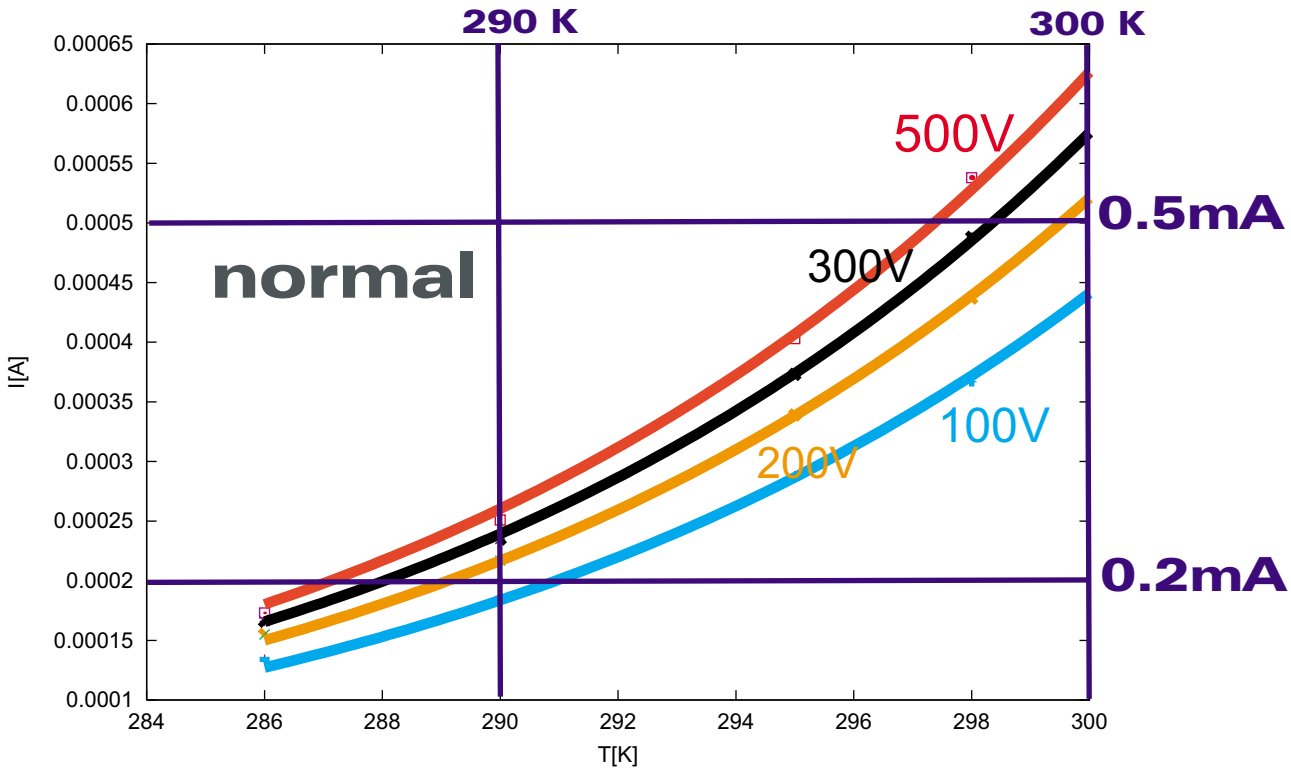
The difference between n– and p-side is due to geometry.

IV Curves



After 8 month storage at 20 C the oxygenated detector draws a little less curent.

IV Curves

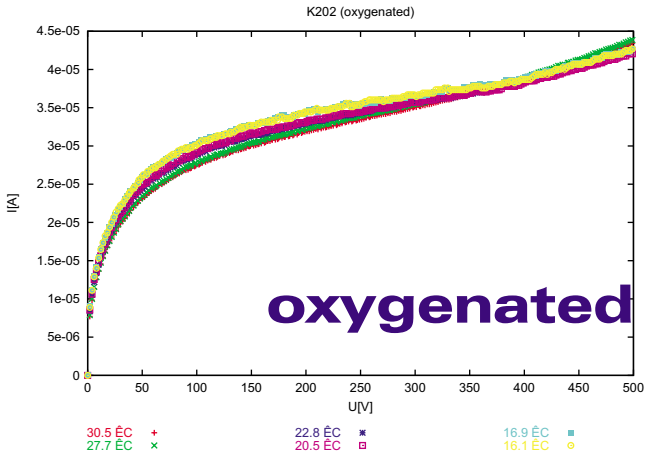


$$I_L = I_{L_{0K}} T^{\alpha} e^{E_{ion}/2kT}$$

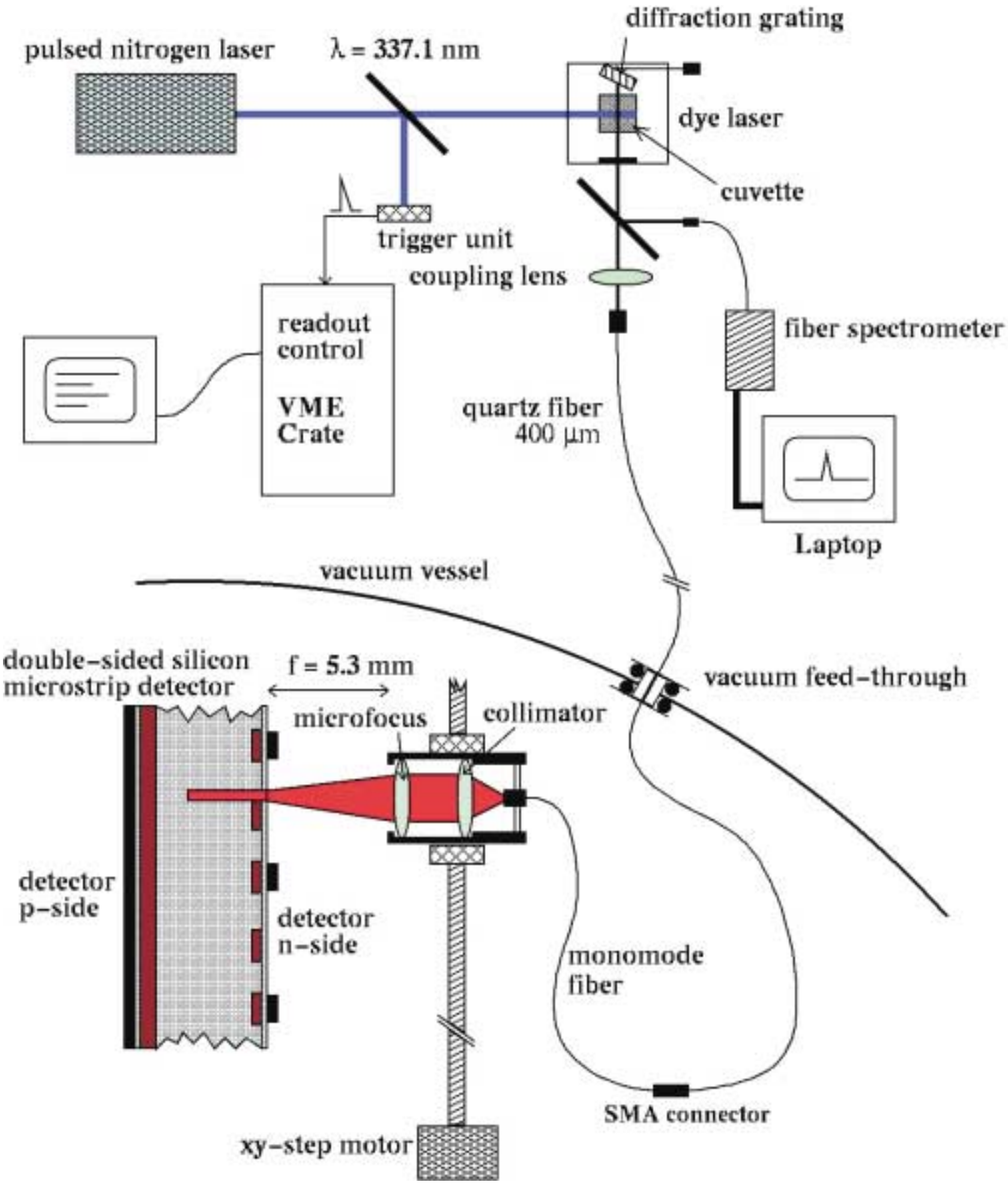
α seems to increase with bias voltage. An overall fit yields

α 3/2

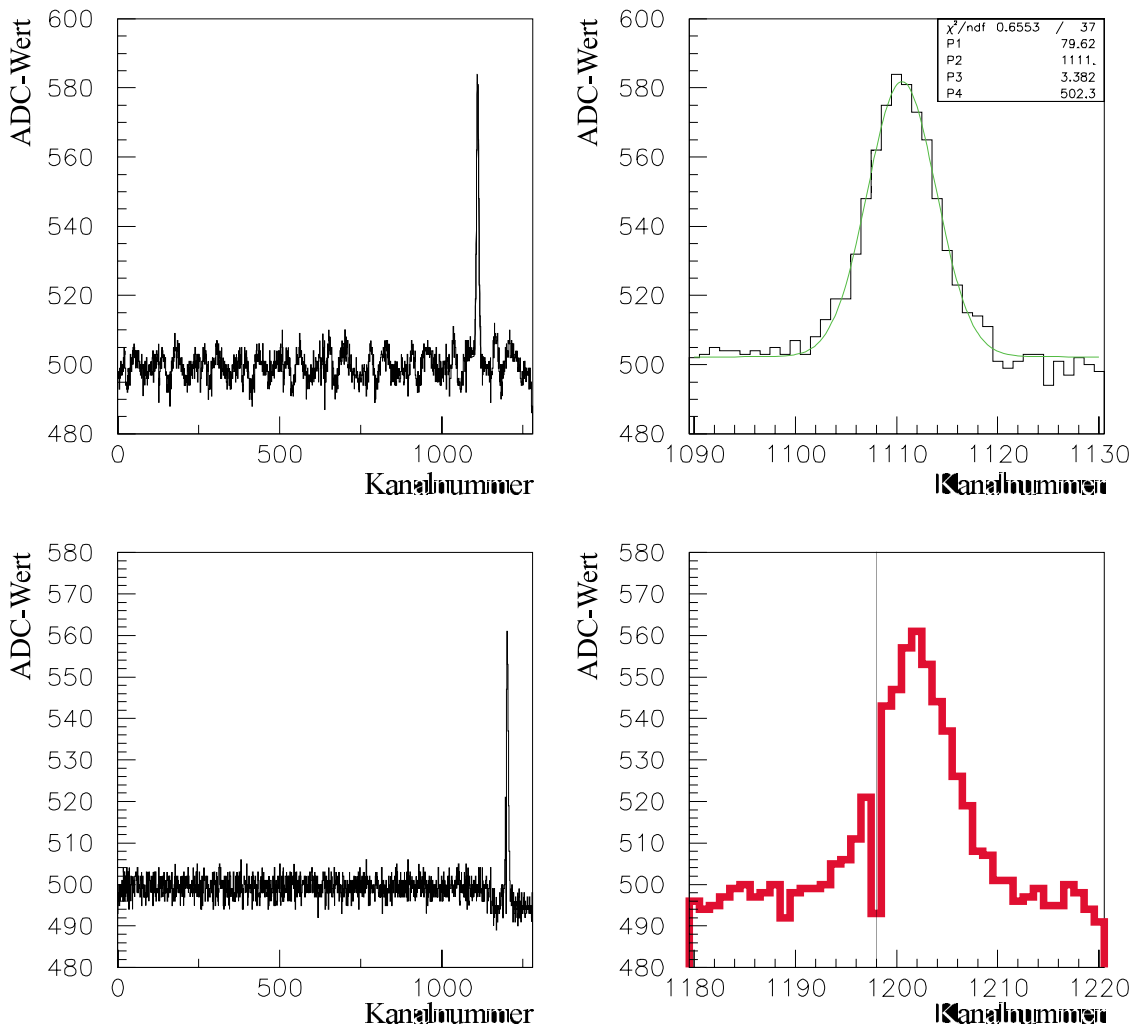
Both detectors show the same behaviour.



Laser Teststand



Production Control



1280 + 1024 strips /module

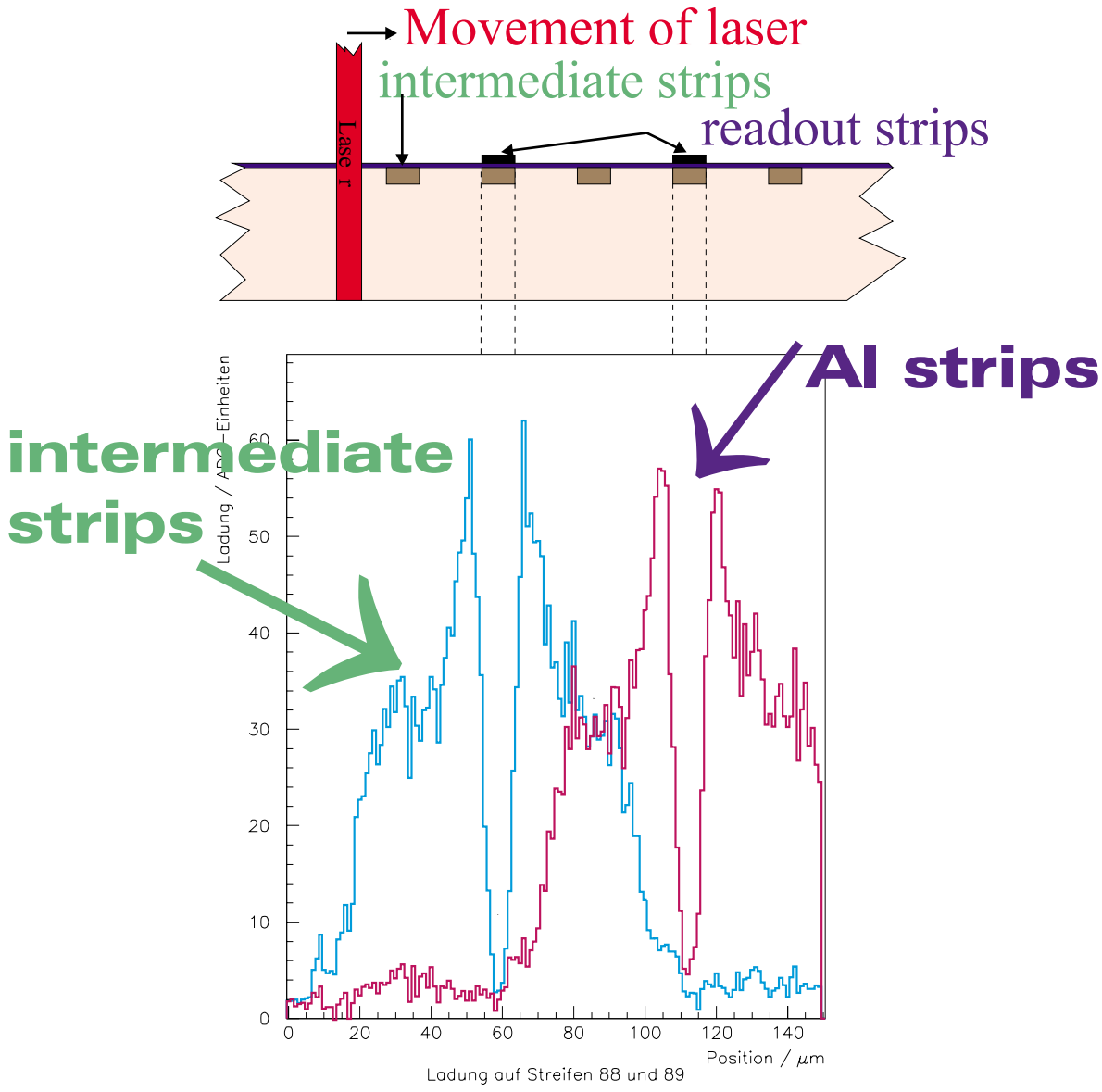
Typically 5 to 10 bad strips/side

Test takes <2hours/module

64 x 2324 = 148736 channels

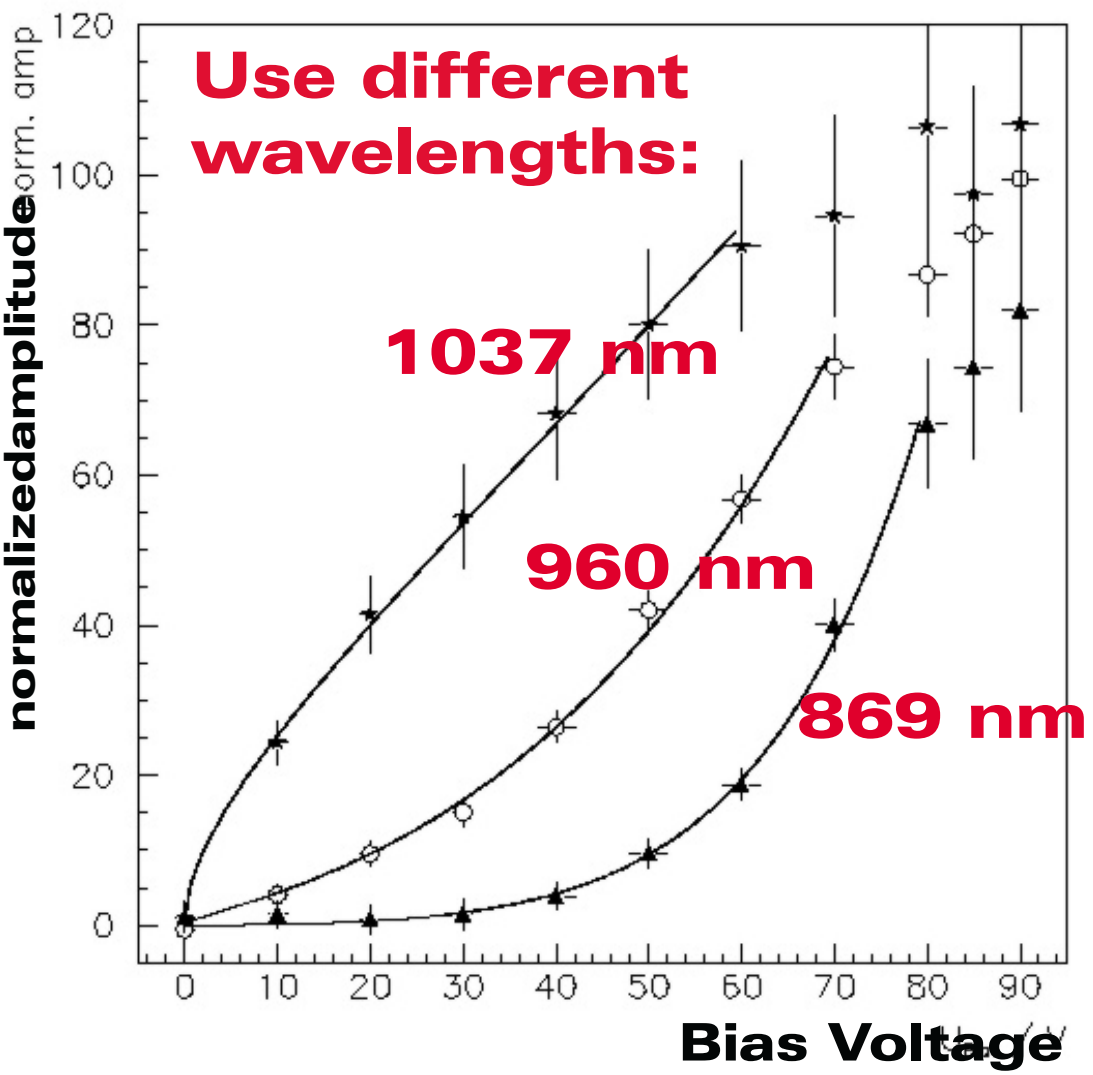
book-keeping is fun !

Eta-Functions



Measure eta-functions with infrared laser and correctly predict the response to minimum ionizing particles.

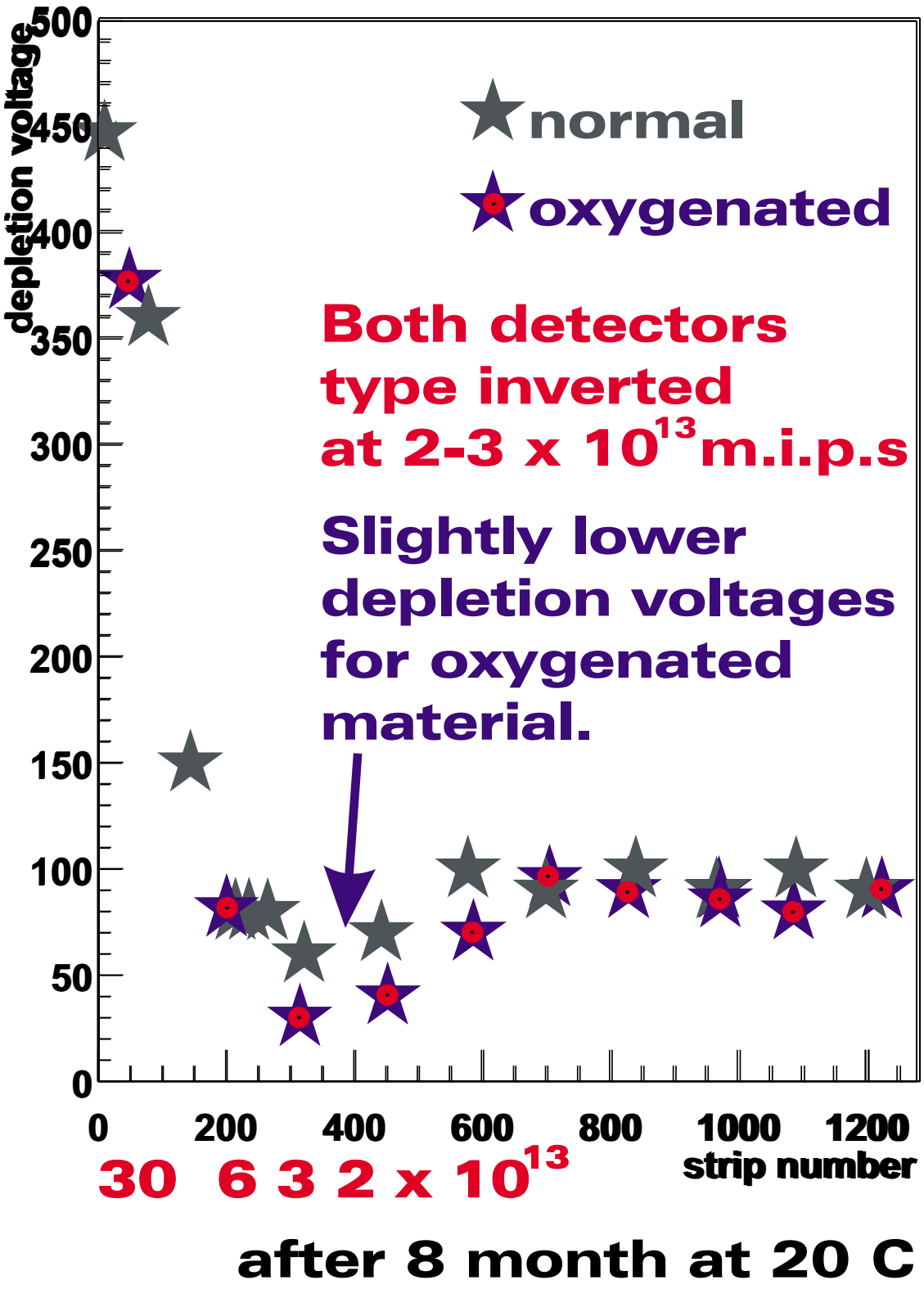
Probing Depletion Zone



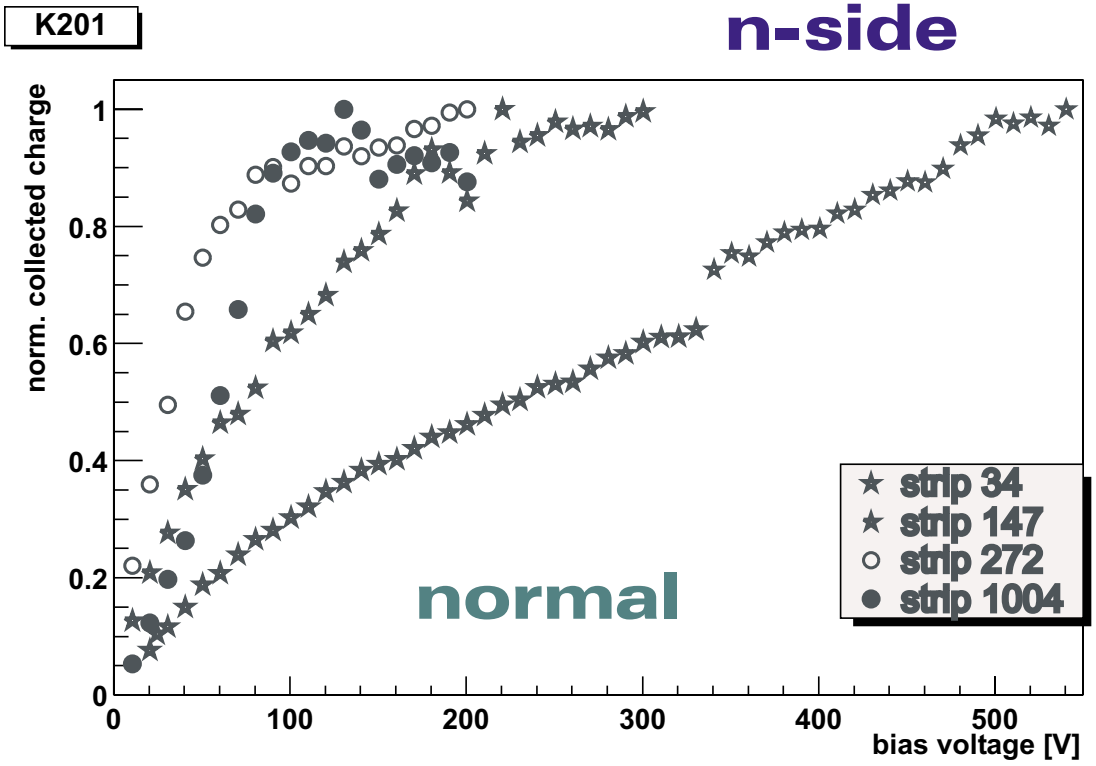
Depletion zone grows from p-side. The laser beam hits the n-side.

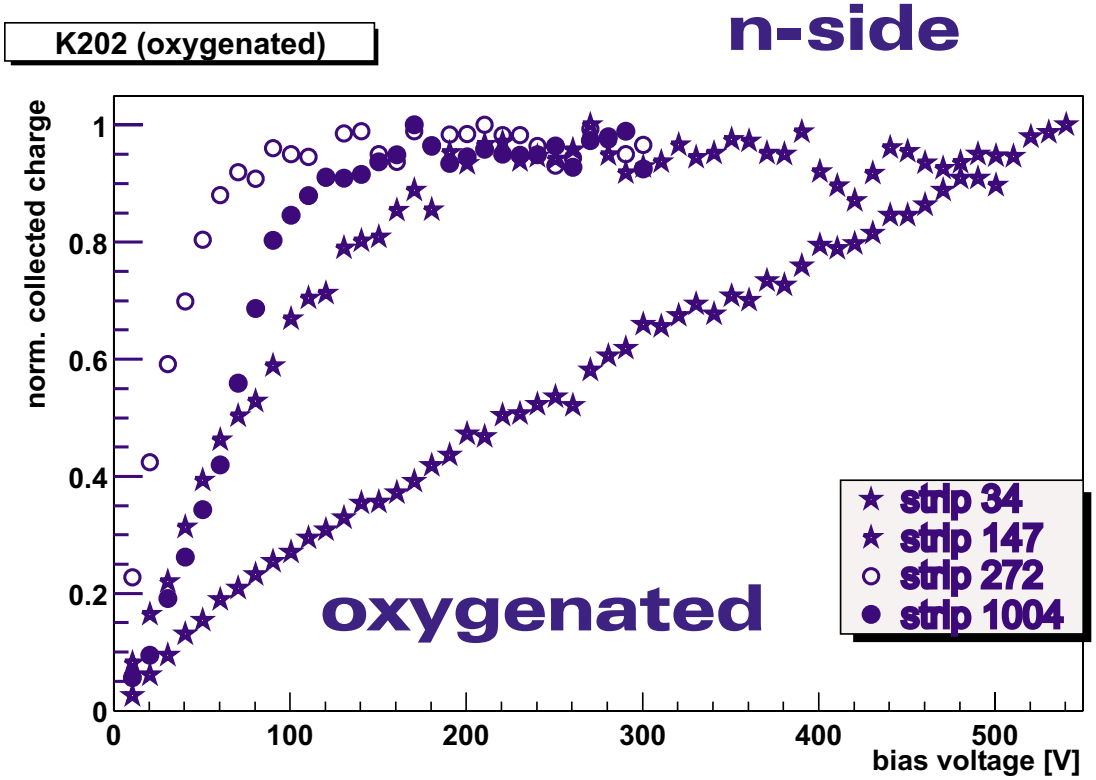
For low bias voltages the low wavelength beam does not reach the depletion zone.

Depletion Profile



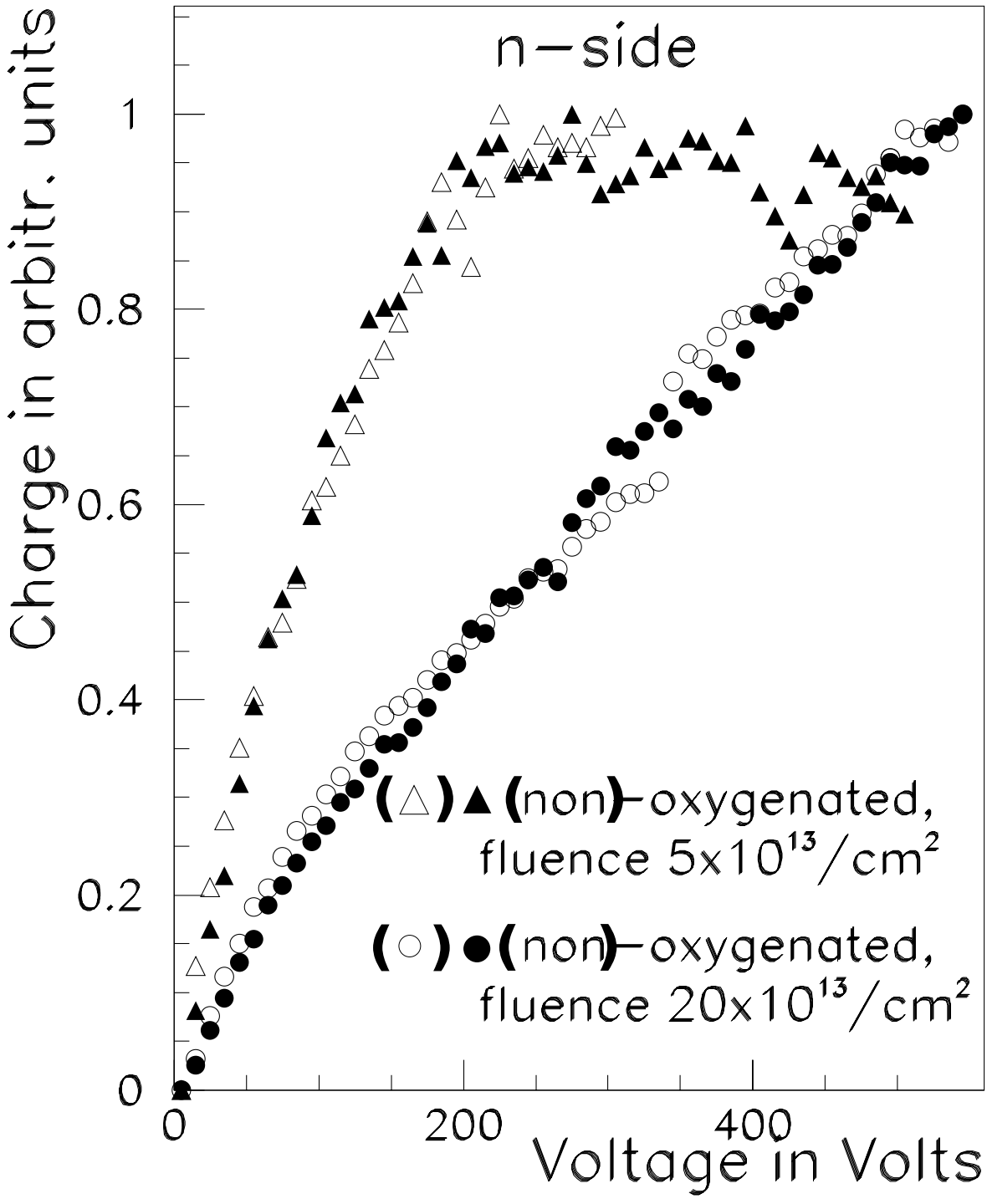
Charge Collection





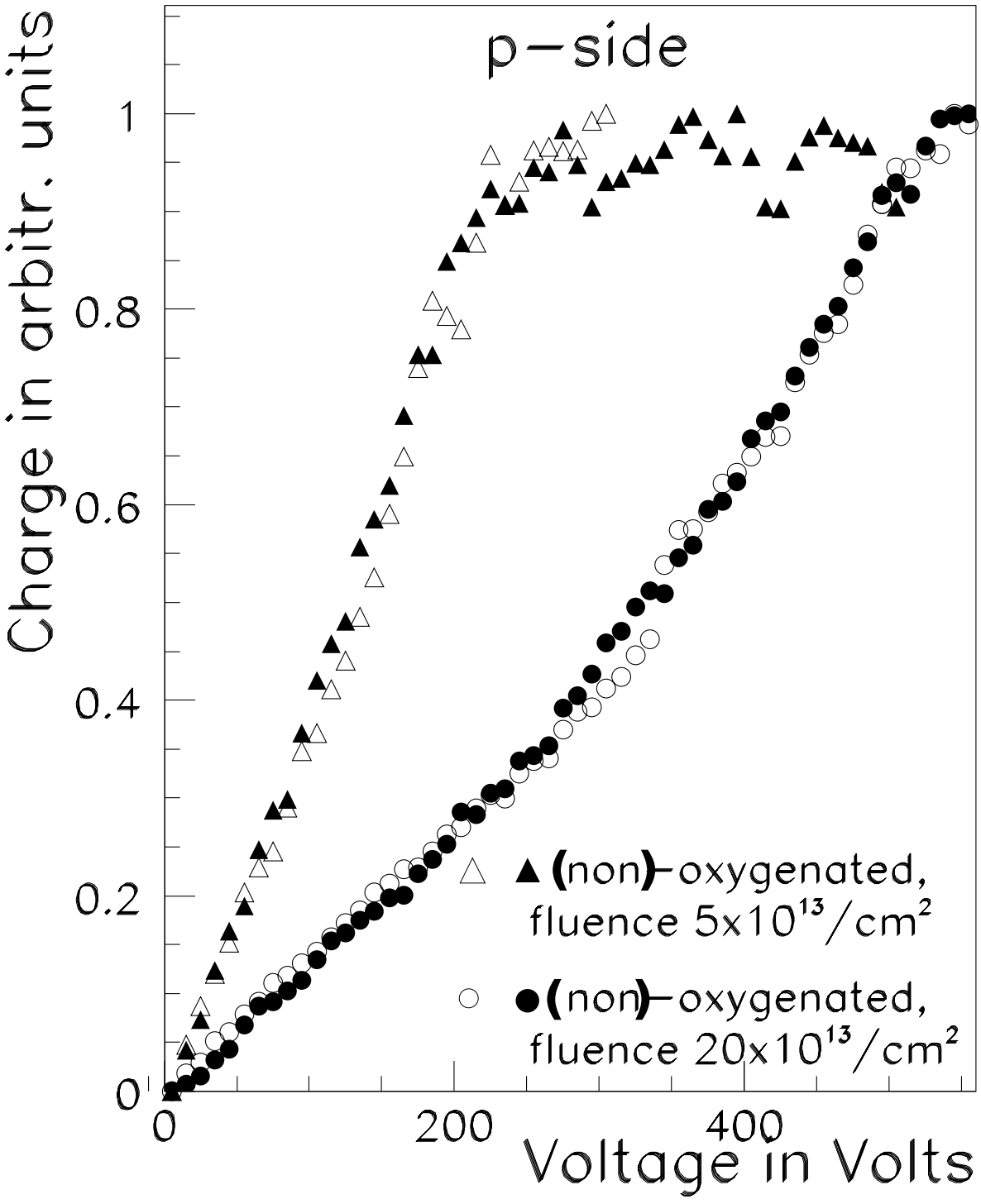
Laser 1050nm

Charge Collection



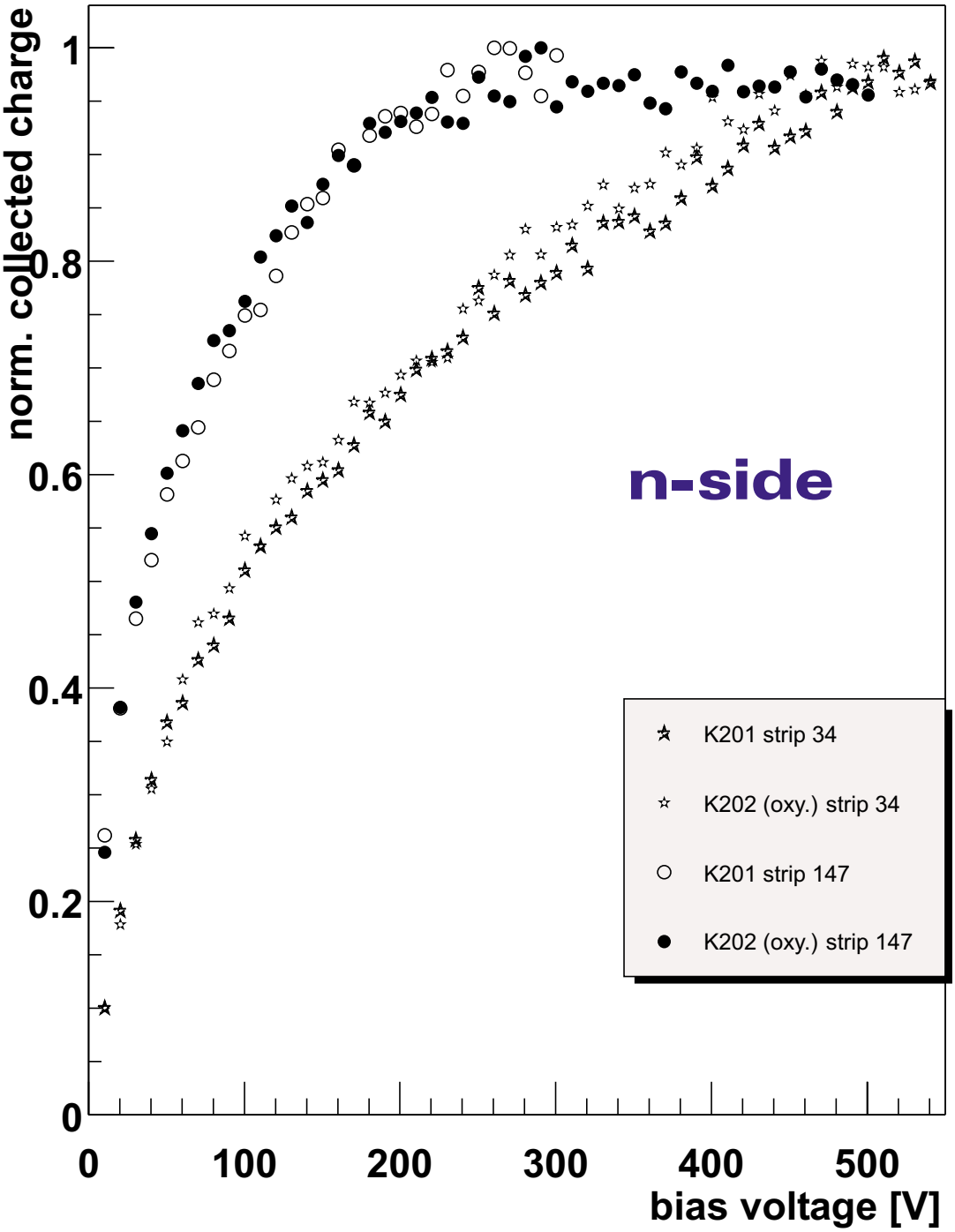
Laser 1050nm

Charge Collection



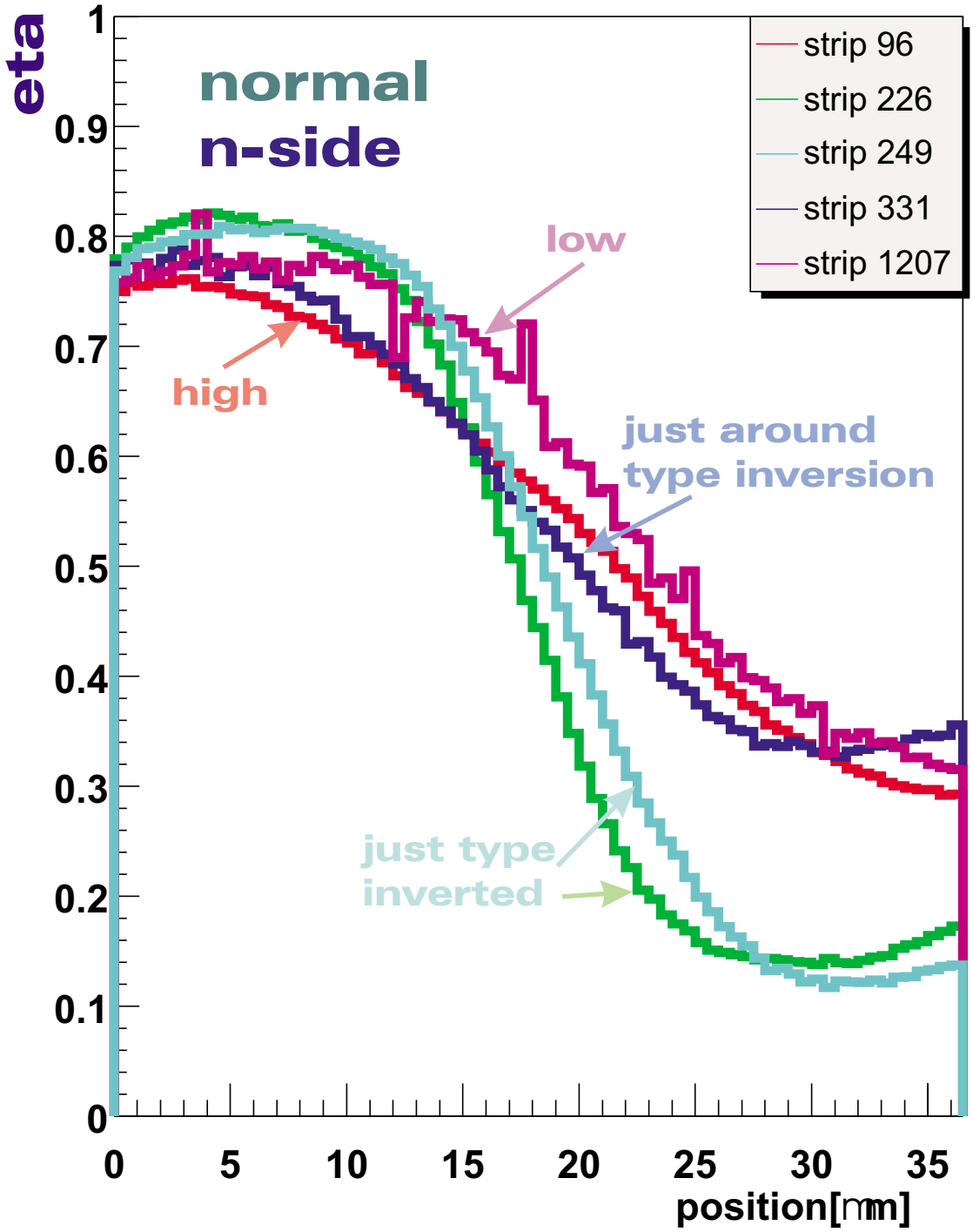
Laser 1050nm

Charge Collection



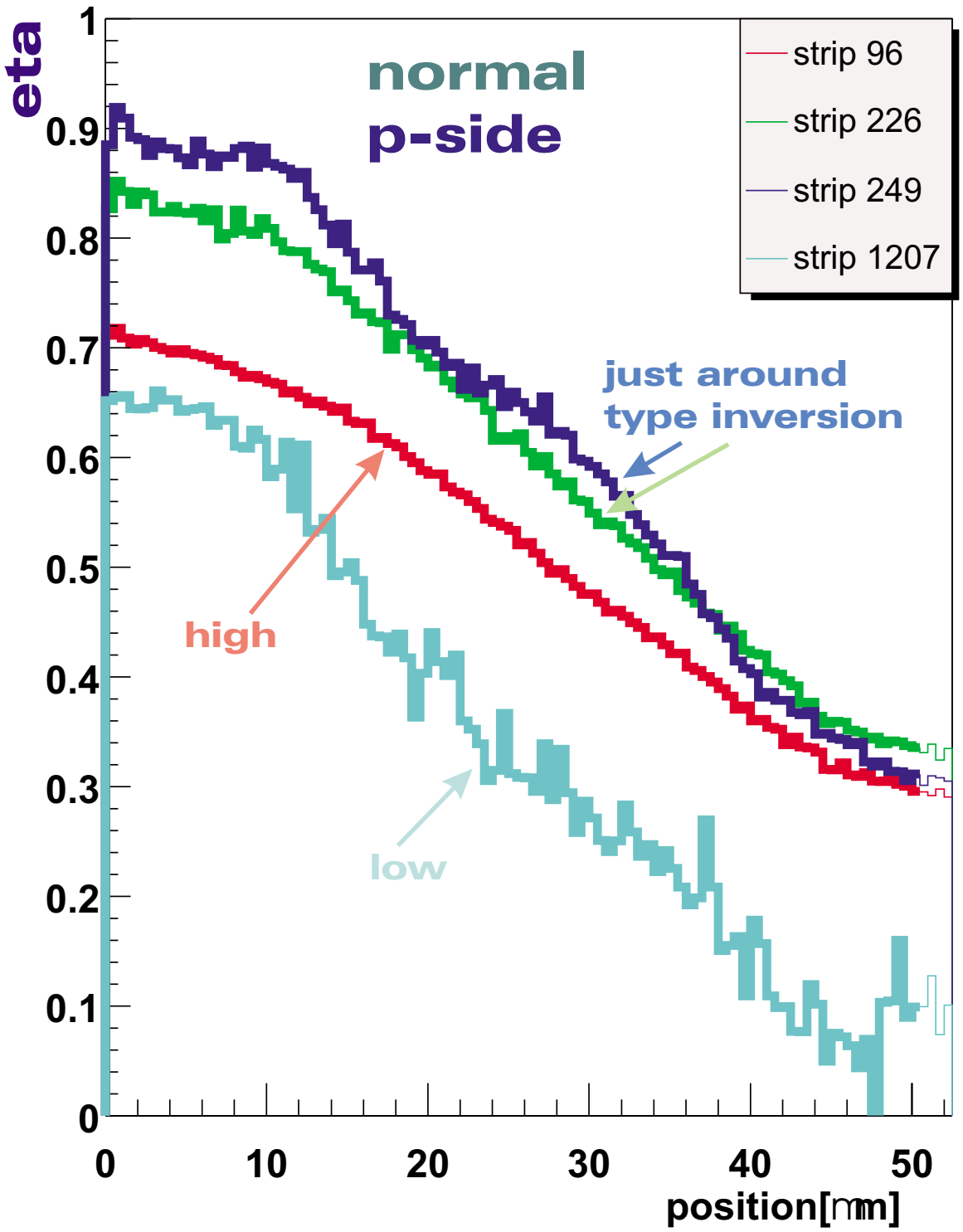
Laser 940nm

Eta Functions



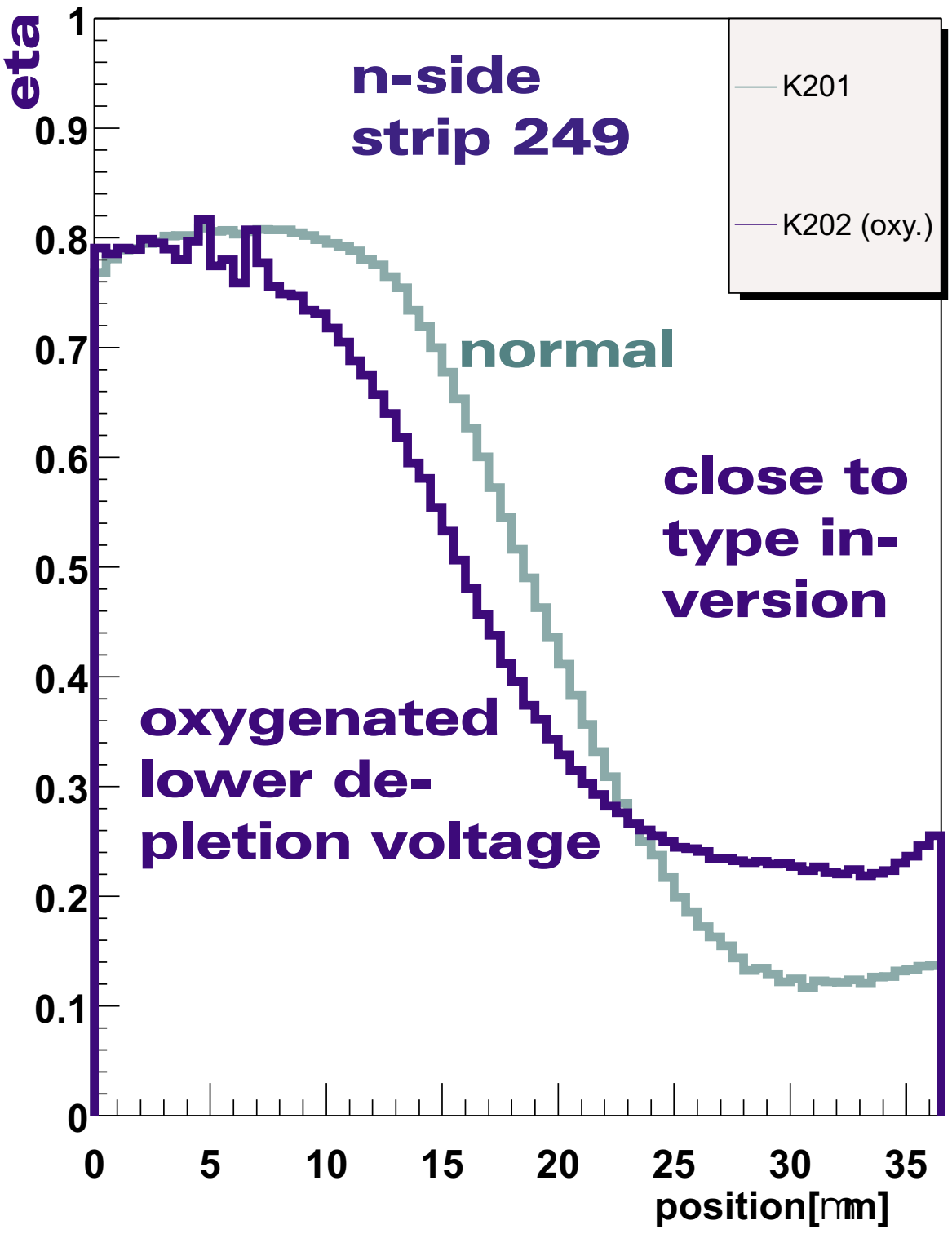
Before irradiation the eta-functions looked perfectly normal.

Eta Functions



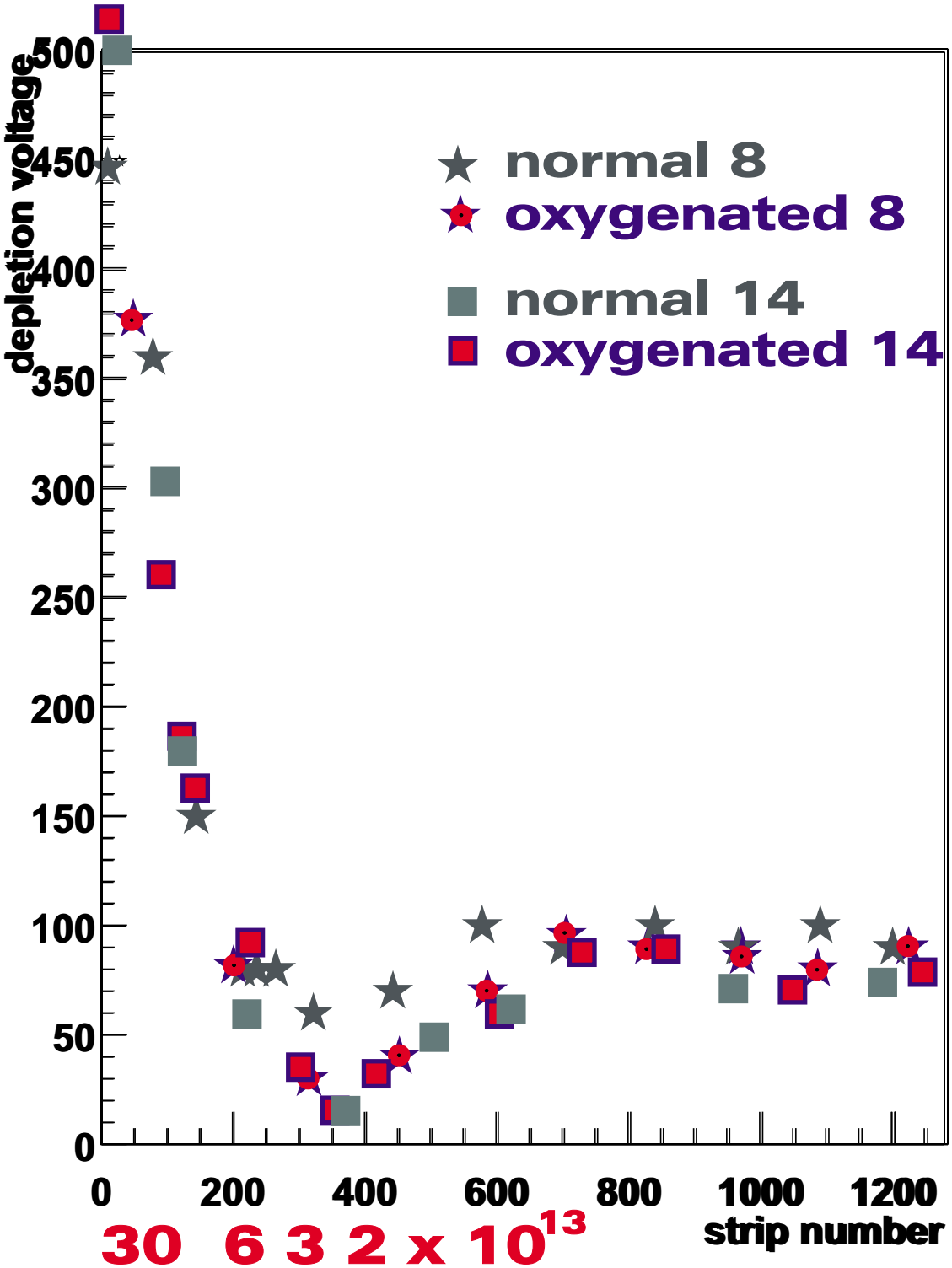
asymmetries also on p-side

Eta Functions



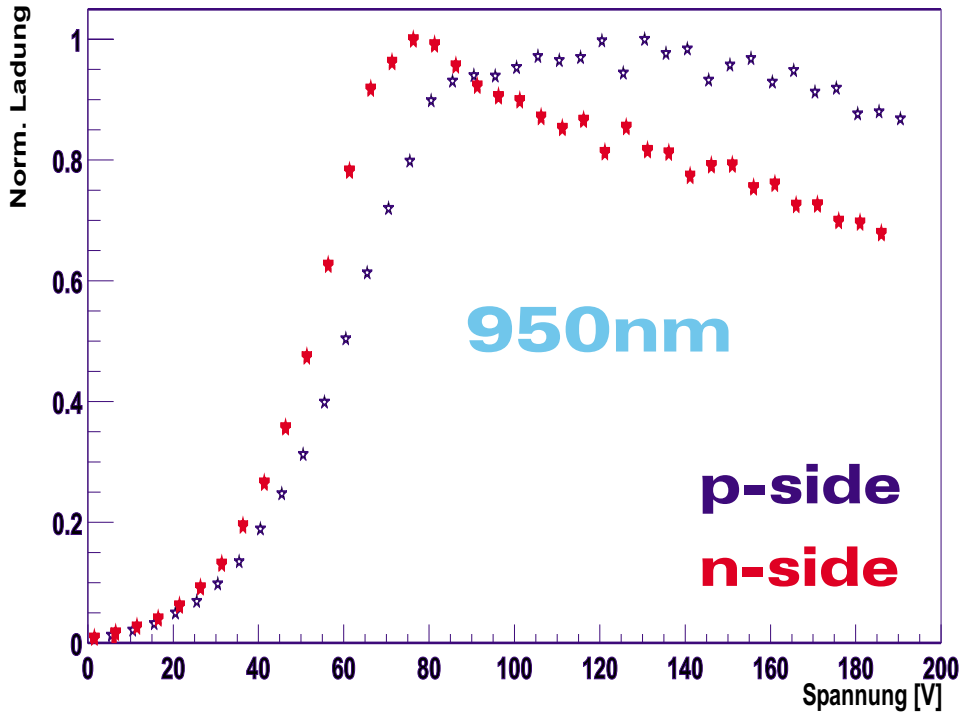
Both detectors are strange...

Depletion Profile



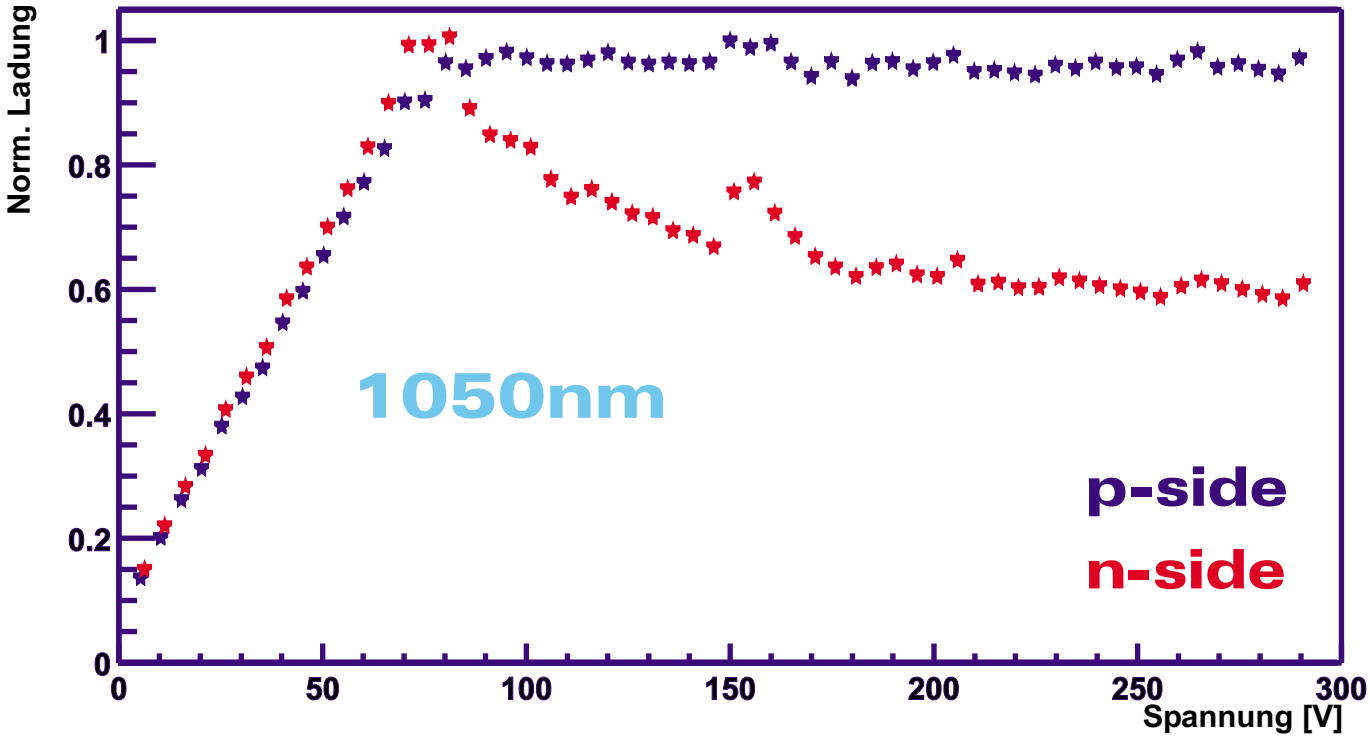
after 8+6 month at 20 /7°C

Charge Collection

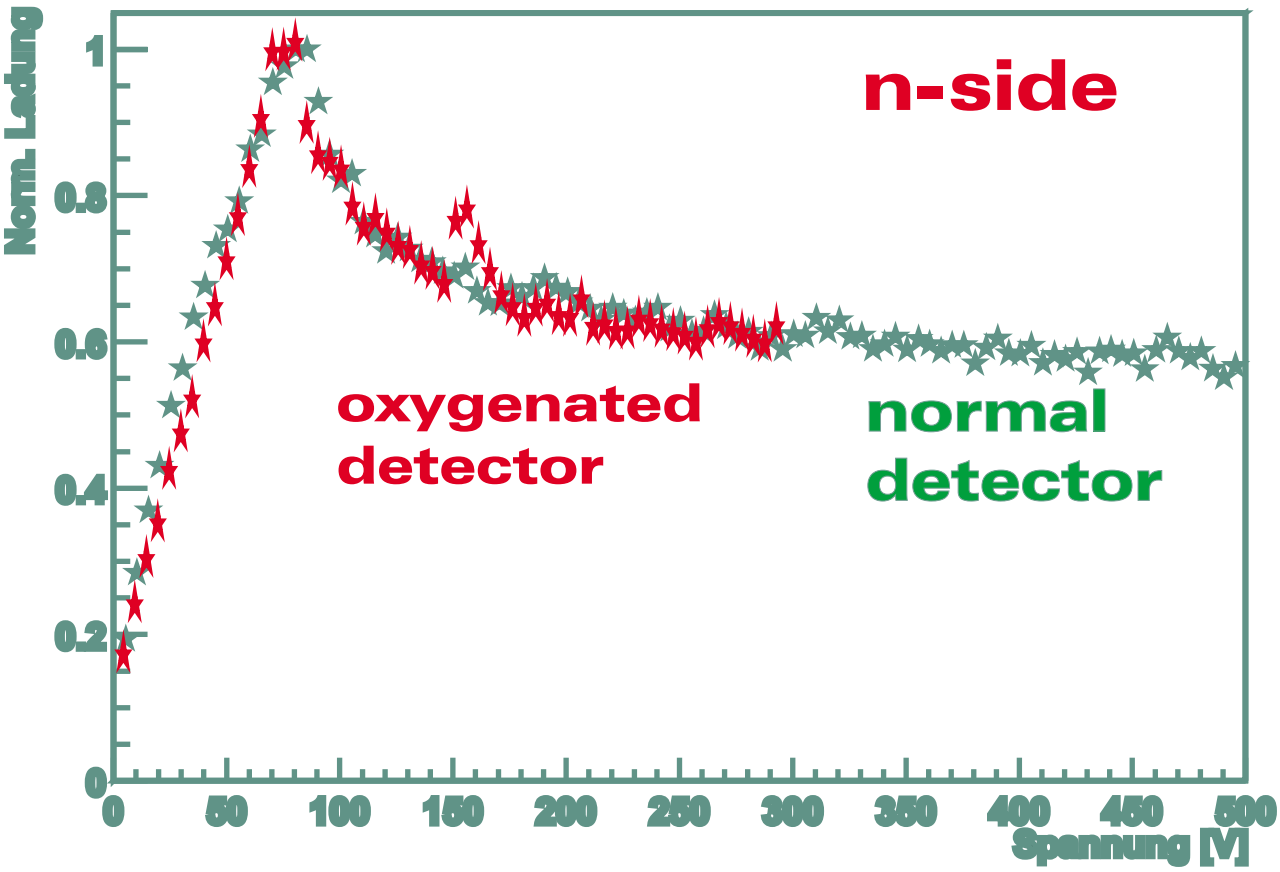


area of no irradiation

oxygenated detector



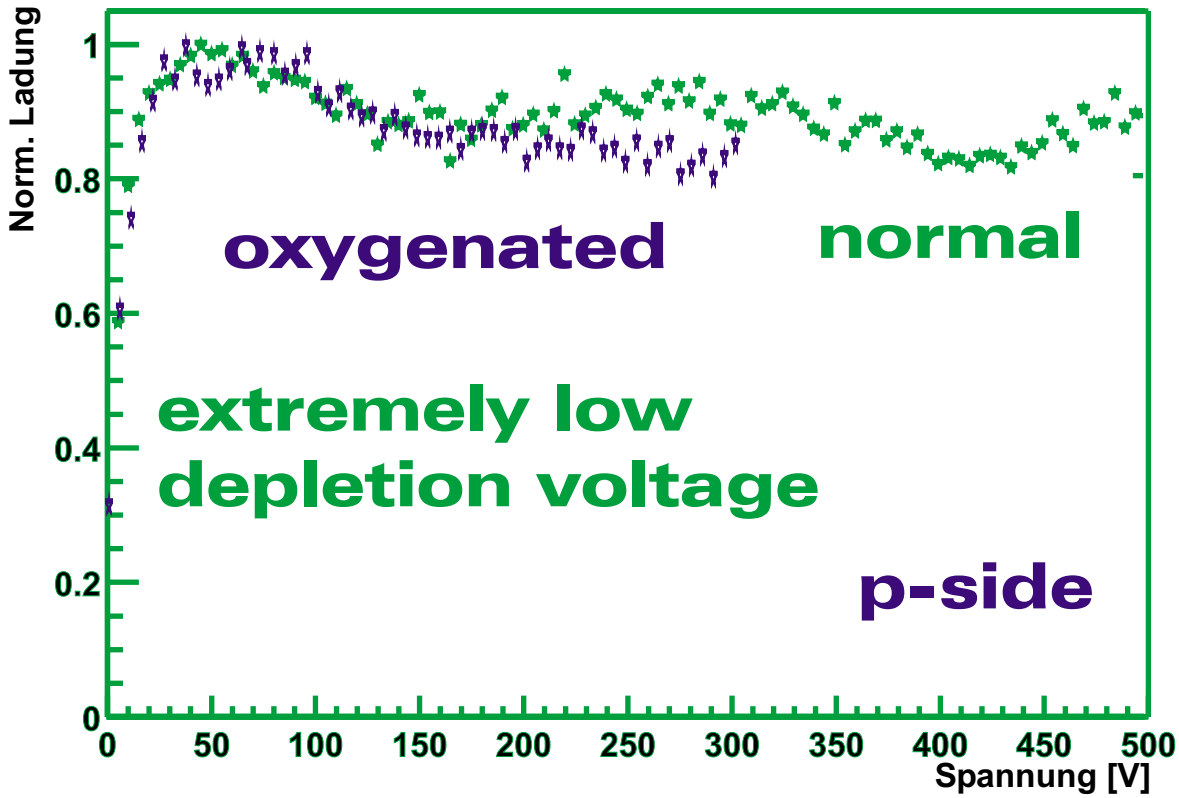
Charge Collection

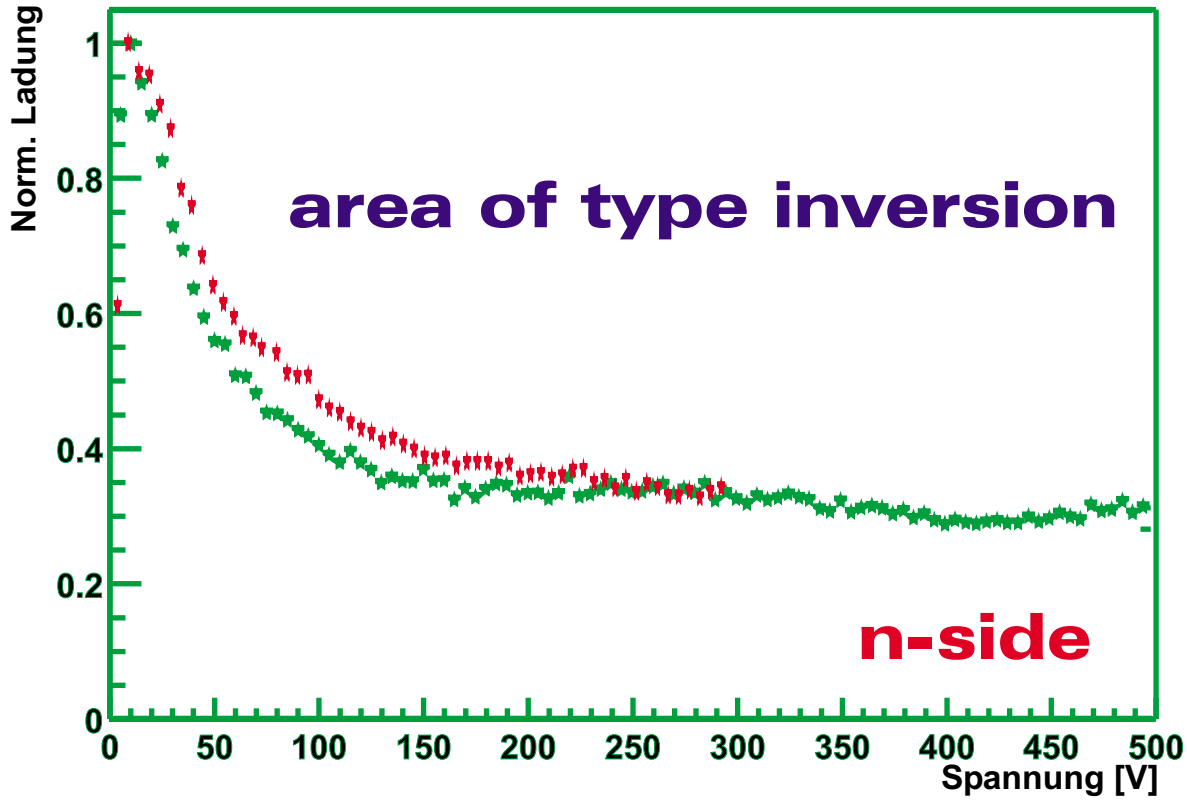


The normal detector isn't any better, but it is less temperamental.

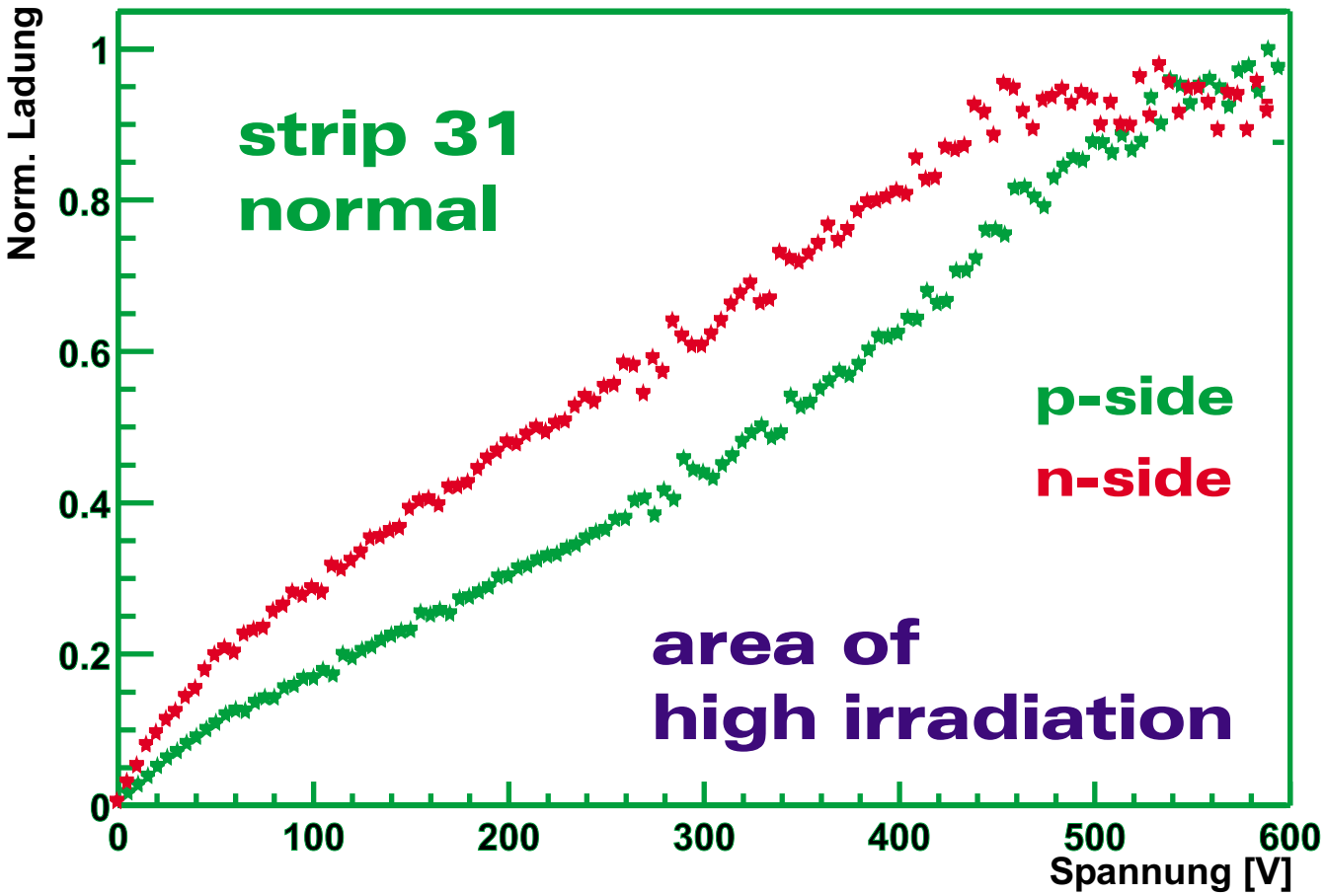
The oxygenated detector draws more current and sometimes breaks aorund 500 V and it has a serious noise problem in the area of highest irradiation.

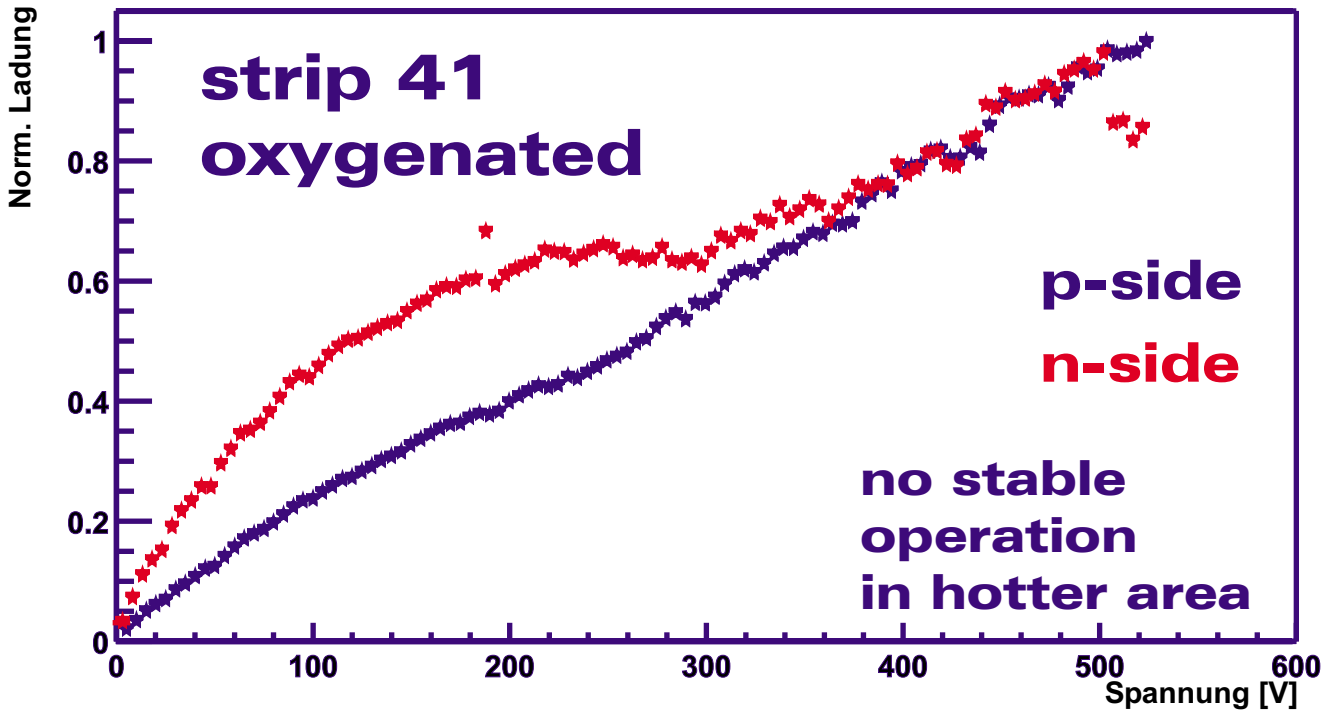
Charge Collection





Charge Collection





Conclusions

Two identical doubles sided detectors, one of them oxygenated, were inhomogenously irradiated in an identical setup.

Both detectors behave very much the same.
The oxygenated detector is a bit more temperamental.

Both detectors worked very nicely after 8 month storage.
Both detectors have problems with their n-sides after 14 month.

Silicon detectors are like men,
try to understand them and
you go crazy.....