A new fluence monitoring device (AIDA - WP8)

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M.Glaser, M.Moll

CERN

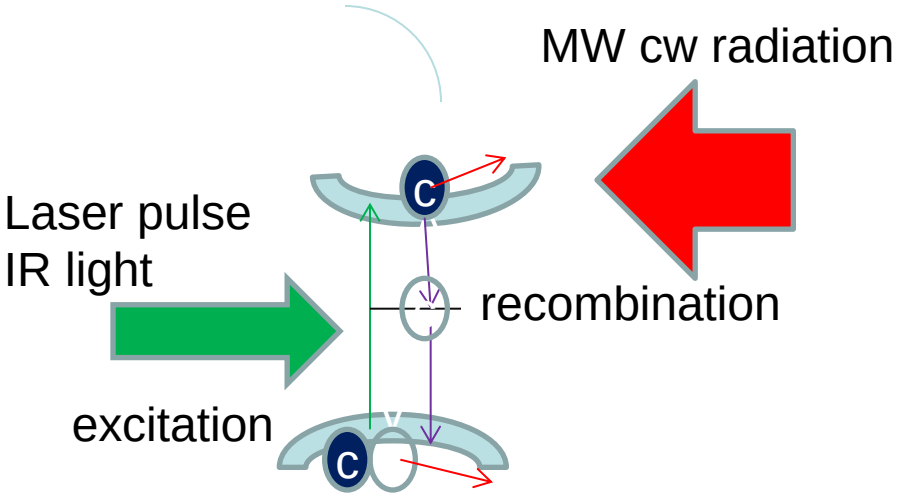
Outline:

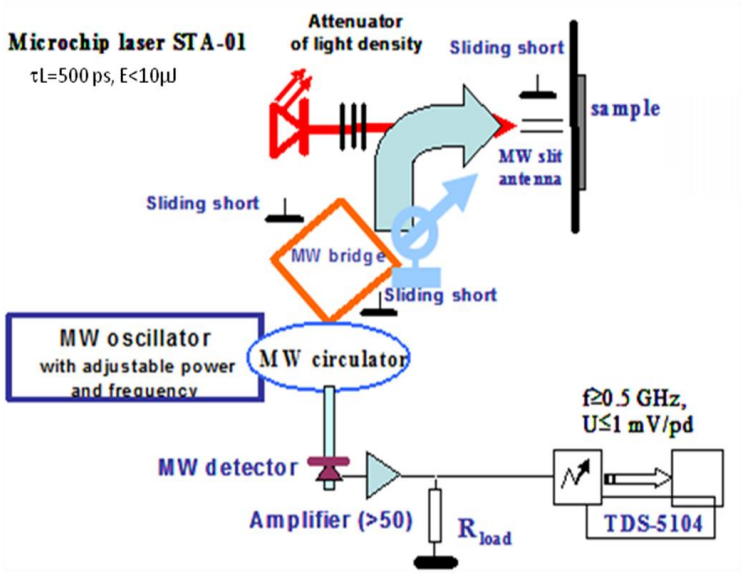
- WP8 task for VU
- test of the device for the remote measurement in the proton and neutron beam
- design and test of the device for radiation monitoring
- calibration of samples
- Conclusions

WP8 task for VU

– To **design** and **fabricate** an instrument for fluence monitoring (*hadrons*) based on free carrier lifetime control by microwave (absorption) probed photoconductivity transients

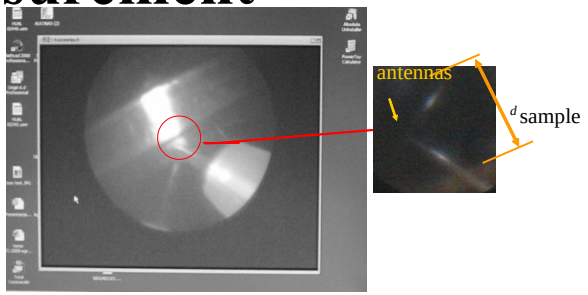
- to **calibrate** the samples and characteristics **under** different irradiation





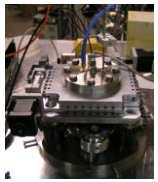
“The test of the device for the remote measurement”

E. Gaubas, A. Uleckas, J. Vaitkus, J. Raisanen, P. Tikkanen. *Instrumentation for the in situ control of carrier recombination characteristics during irradiation by protons*, Review of Scientific Instruments **81**, 053303 (2010).



MW-PCT measurement setup – Helsinki tandem type proton accelerator





VUTEG-3

① ② ③ Accelerator laboratory

Visual control system

STA-01 laser driver

Attenuator

Telescope system

FC adapter

Microchip laser

Fiber line

Irradiation chamber

3-D positioning system

VC

Probes

circulator

MW waveguide

MW oscillator

MW bridge

15 m

Sample

beam

MW waveguide line

MW coax

Cold finger

T

Amplifier

TDS5104

Controller for steppers

PC-NB

MW detector

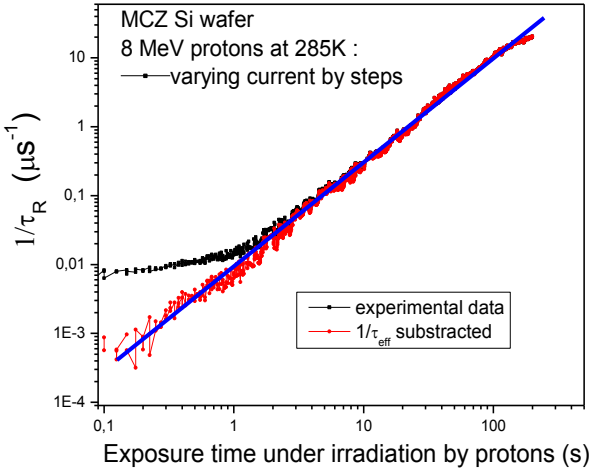
PC-NB for control of experiments

Coaxial lines

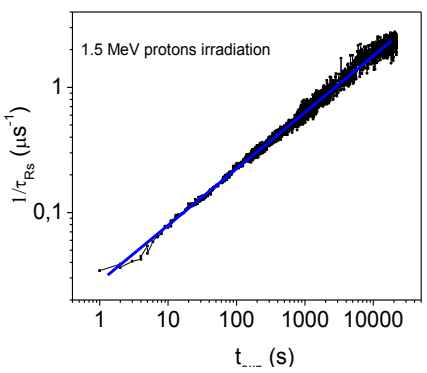
UTP

LAN

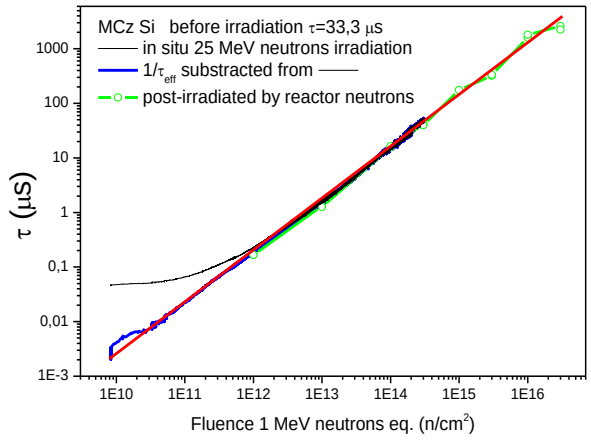
15 m.!



MW-PCT in situ – Vilnius tandem type accelerator



T. Ceponis, E. Gaubas, V. Kalendra, A. Uleckas, J. Vaitkus, K. Zilinskas, V. Kovalevskij, M. Gaspariunas, and V. Remeikis, JINST (Journal of INSTrumentation), **6** (2011) P09002.

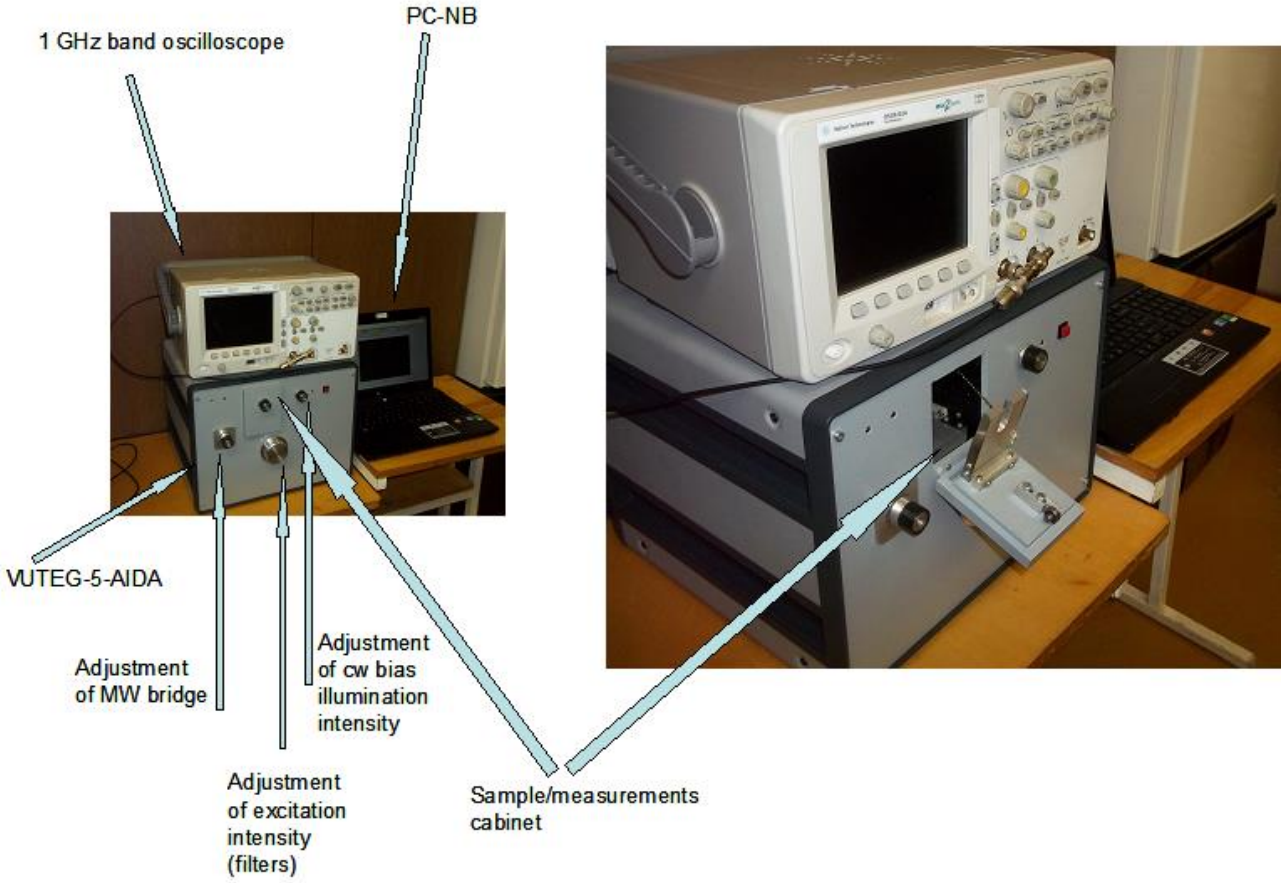


E. Gaubas, T. Ceponis, A. Jasiunas, A. Uleckas, J. Vaitkus, E. Cortina, and O. Militaru. Correlated evolution of barrier capacitance charging, generation, and drift currents and of carrier lifetime in Si during 25 MeV neutrons Irradiation. Appl. Phys.Lett. 101, 232104 (2012)

“Design and fabrication of the device for the radiation monitoring and proton beam profiling”

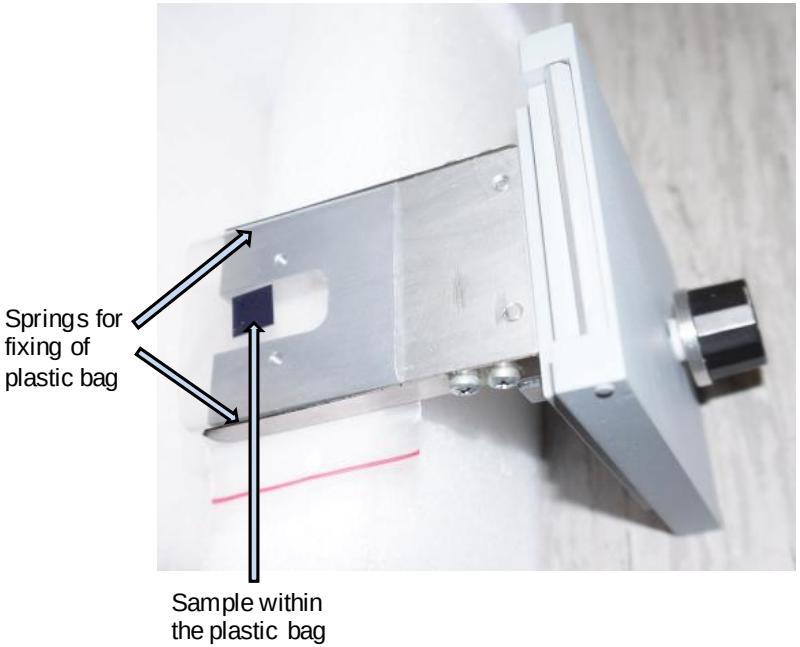
User guide
for manipulations
with dosimeter VUTEG-5-AIDA

2014 Vilnius

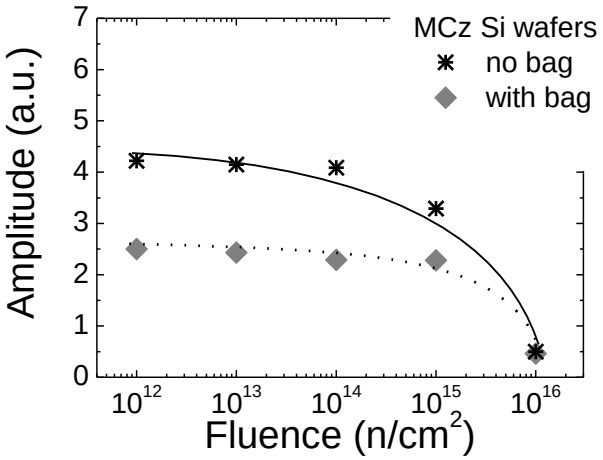


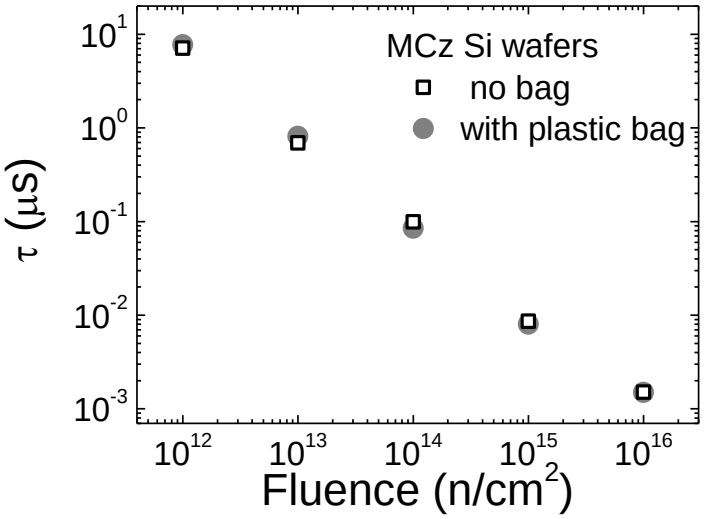
General view of the instrument VUTEG-5-AIDA with sample compartment C1 devoted to rapid fluence monitoring of Si samples of dimensions 10×10 mm^2 placed in plastic bags.

The results of test



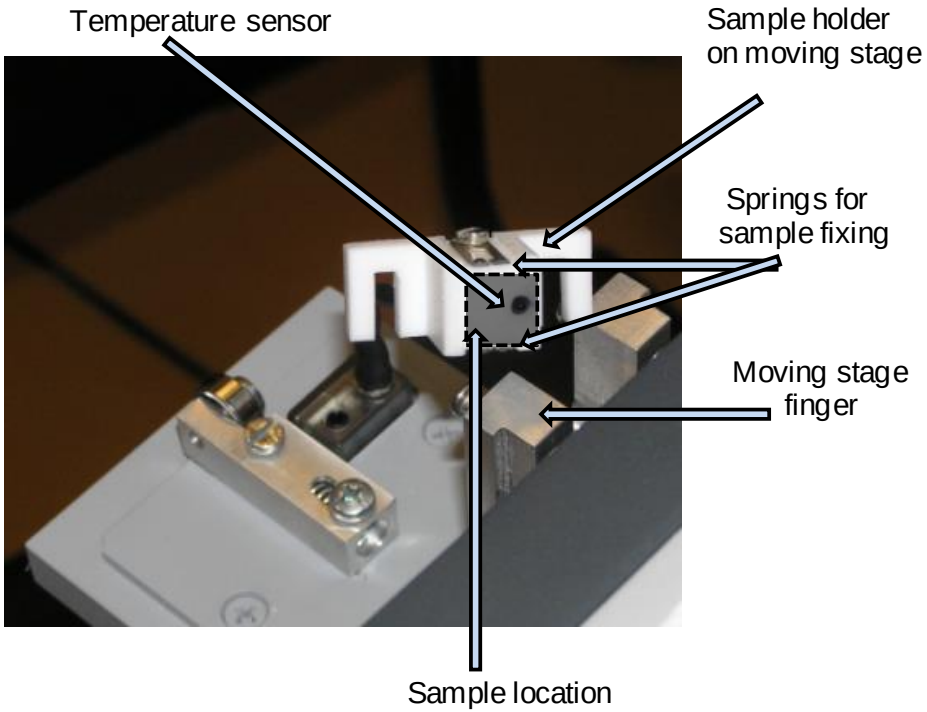
Sample compartment C1 for dosimetry of samples in plastic bags.



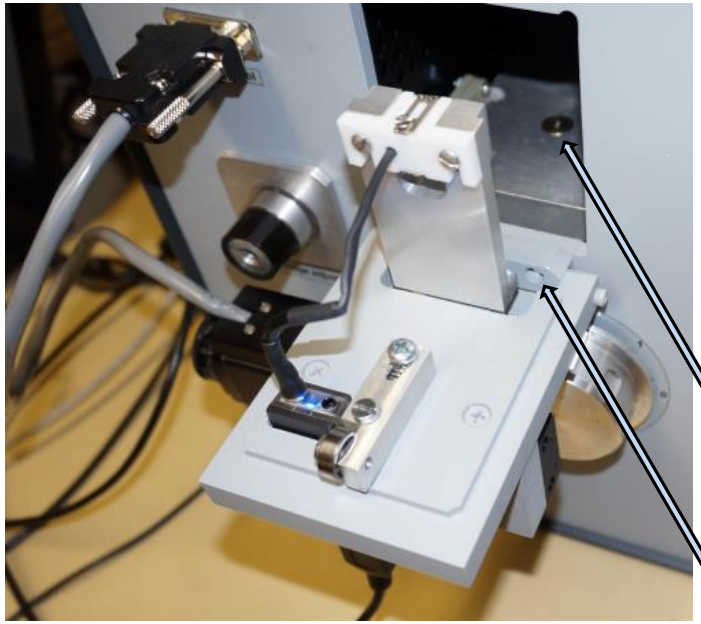


- Samples being in plastic (polythene) bag were irradiated and tested.
- MW-PCD signal amplitude is reduced due to excitation light scattering.
- Lifetime values are not perturbed due to bag.

The compartment for proton beam profiling

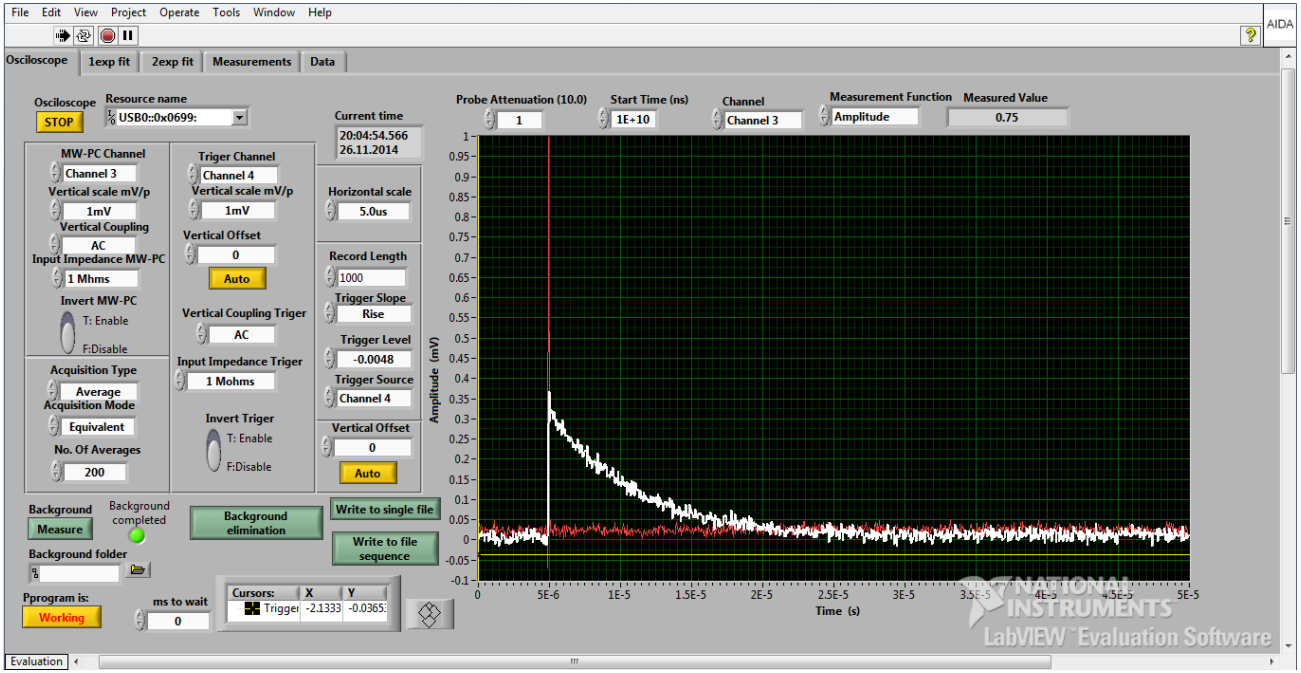


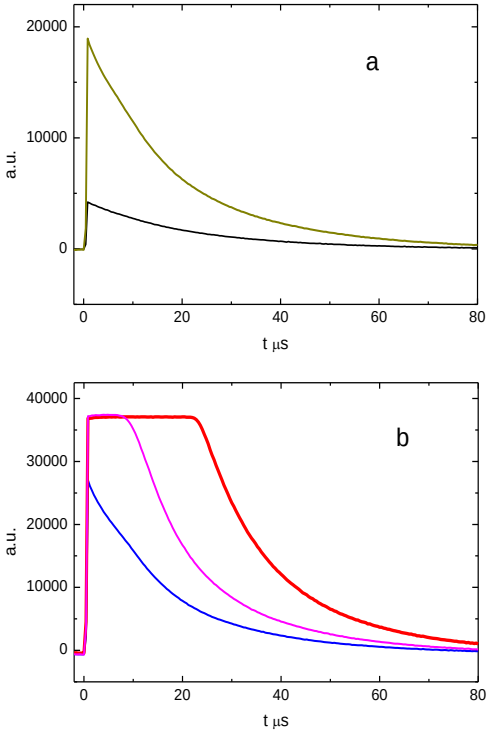
a- The spring-supported sample compartment C2 with mounted humidity-temperature sensor.



b- Fixing of the compartment C2 f

Signal control to define the device working regime



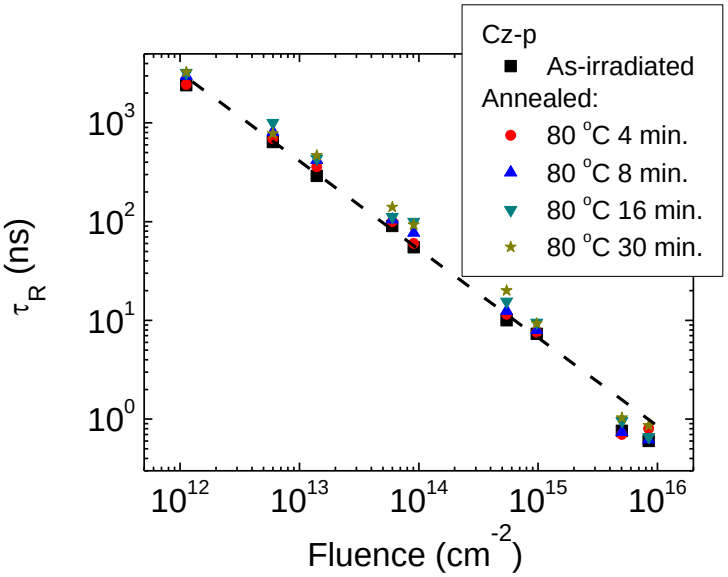


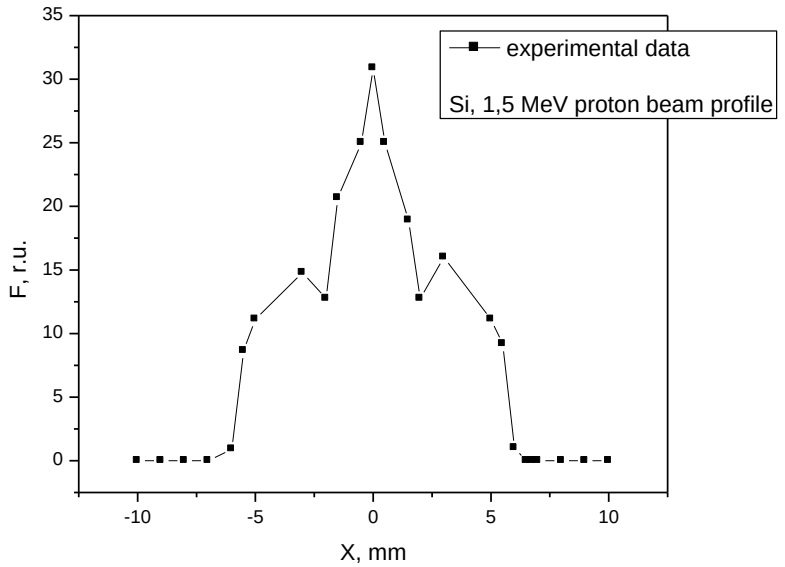
The main view of the window for oscilloscope control.

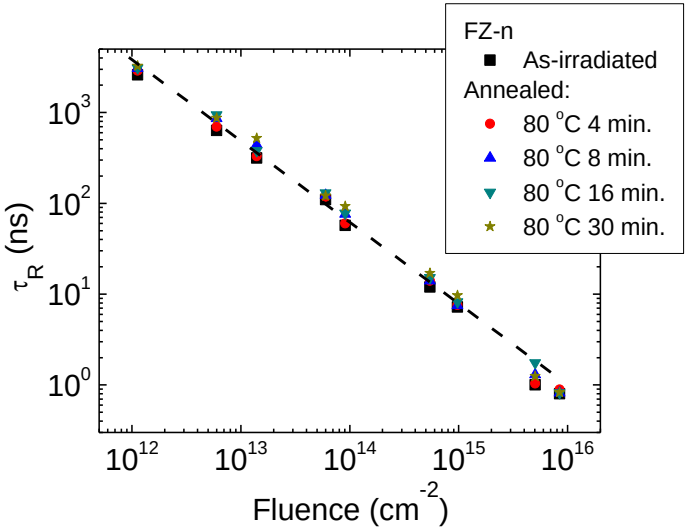
a- The concave MW-PC transients measured using appropriate regimes and suitable for further analysis.

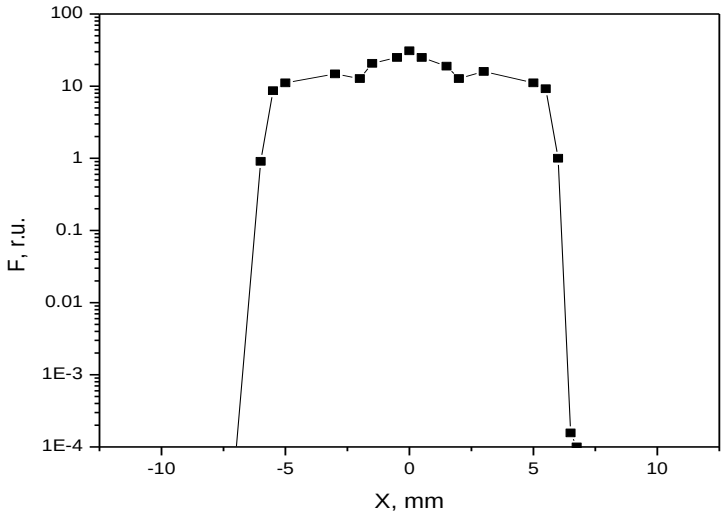
b - Typical waveforms of transients of the over-saturated amplitude with convex initial components obtained using too intensive excitation.

Tests


Cz-p
As-irradiated
Annealed:
80 °C 4 min.
80 °C 8 min.
80 °C 16 min.
80 °C 30 min.
τR (ns)
Fluence (cm-2)


experimental data
Si, 1,5 MeV proton beam profile
F, r.u.
X, mm


FZ-n
As-irradiated
Annealed:
80 °C 4 min.
80 °C 8 min.
80 °C 16 min.
80 °C 30 min.
τR (ns)
Fluence (cm-2)


F, r.u.
X, mm

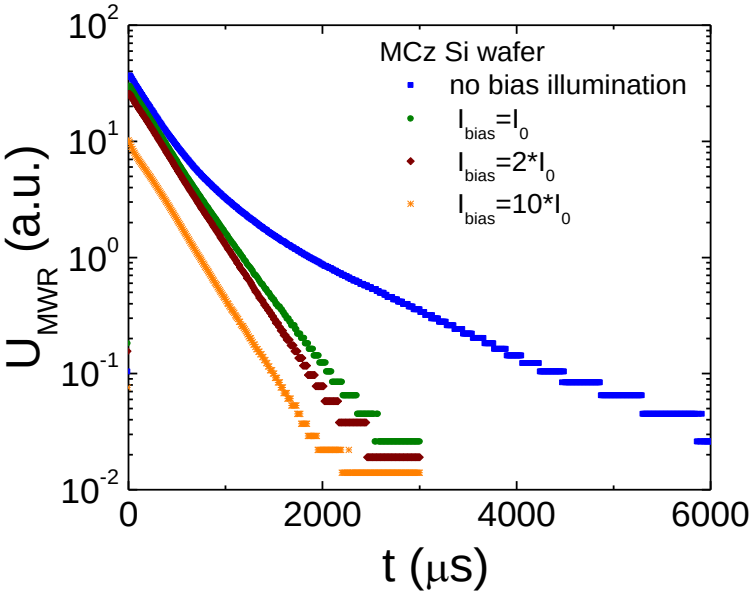
- Measurement regimes and MW-PCD transients

The method is based on direct control of carrier decay transients, registered by microwave probed photoconductivity technique. For non-irradiated samples recombination with trapping effect can be important, therefore CW bias illumination should be applied to extract recombination lifetime.

For hadrons irradiated samples recombination lifetime can be ascribed to extended radiation defects, while trapping centres are attributed to point radiation traps

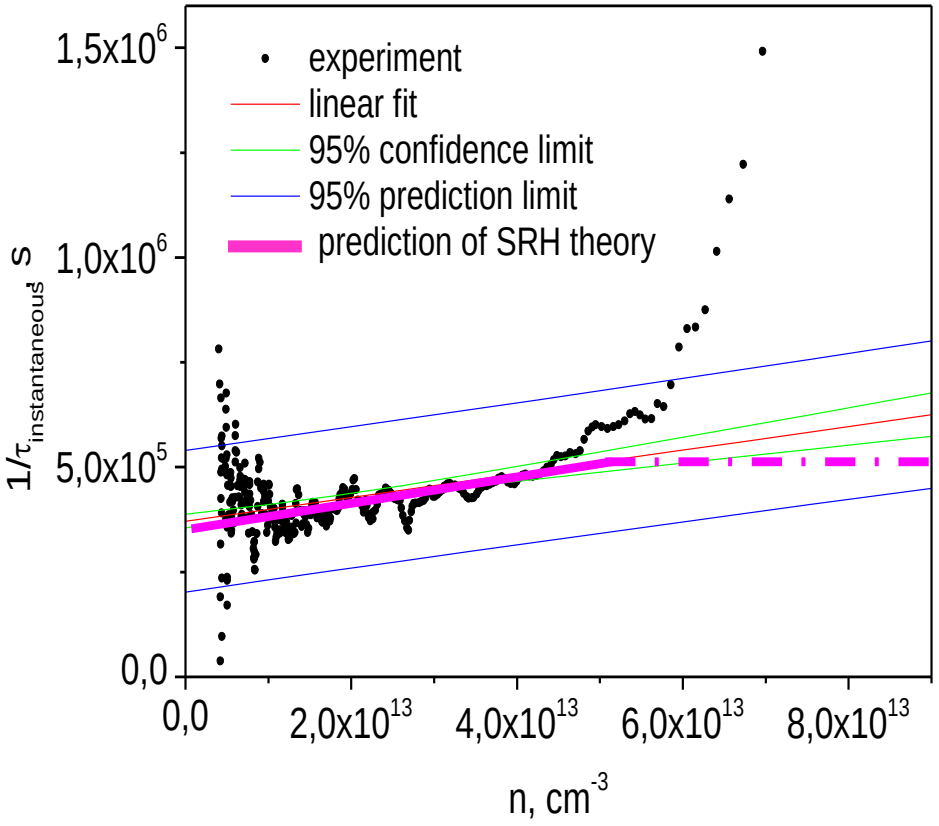
$$U(t) \sim n_{ex}(t=0) \exp(-t/\tau_R) \qquad U(t) \sim n_{ex}(t=0) \exp[-t/\tau_{i,tr}(t)]$$

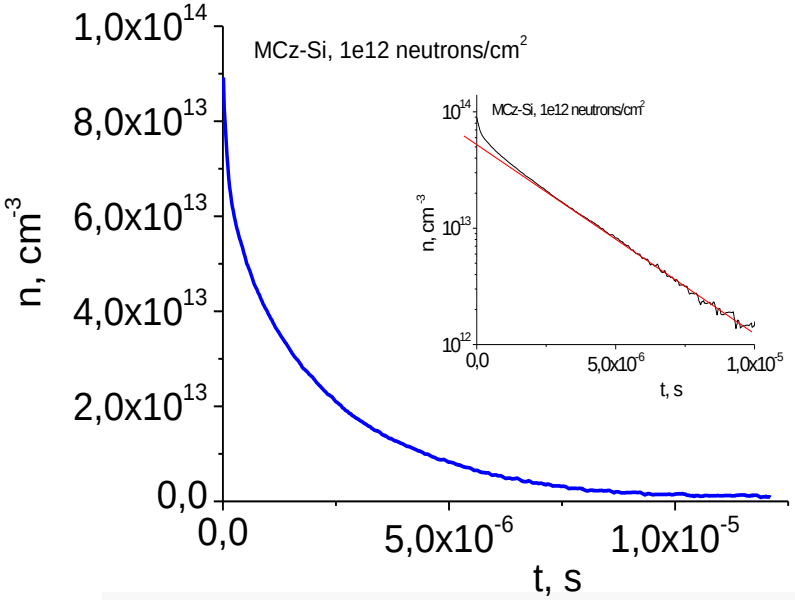
$$\tau_{i,tr}(t, n_{ex}(t)) \cong \tau_R [1 + (\tau_{sh,E}(t) / \tau_{sh,C}(t)]$$

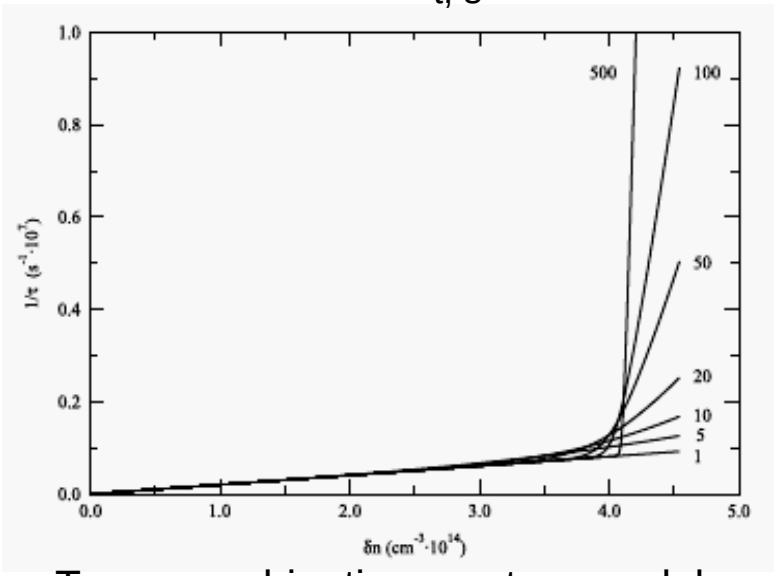


Does a Shockley–Read–Hall recombination model fit to the irradiated Si?

(It is incorporated into TCAD and fits very well to Si for microelectronics.)







Two recombination centers model
(Modified A.Rose model)

E. Žasinas, J.V.Vaitkus/PhysicaB432(2014)45–52

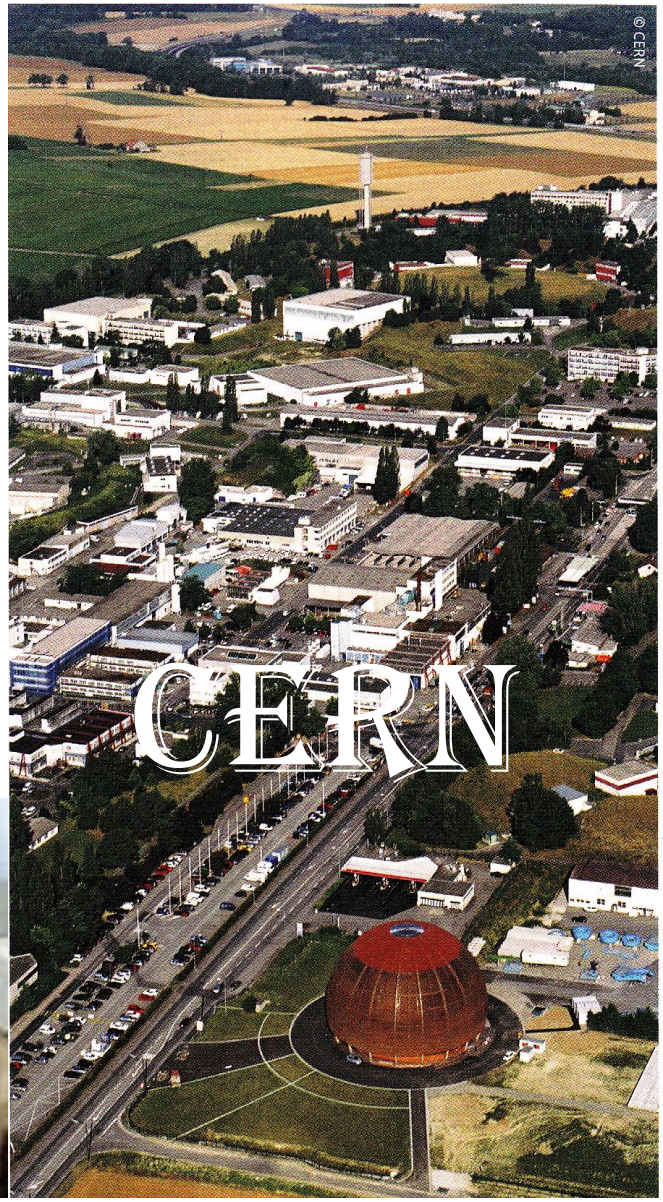
Conclusions:

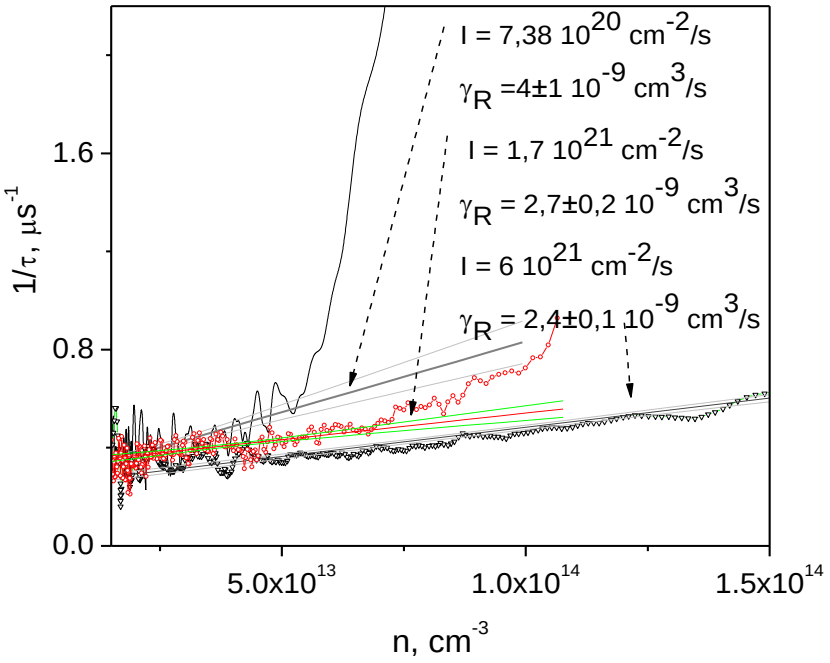
- The device for radiation monitoring is ready for work.
- The photoresponse dependence on proton and neutron fluence is calibrated but more statistics is necessary.
- The experimental data shows the SRH model is not consistent in irradiated Si.

Thanks to AIDA project that allowed to apply the results obtained by CERN RD50 collaboration
& to Lithuanian MITA agency and Lithuanian Academy of Science for a series of grants to contribute the AIDA project & Aida Transnational Access for irradiations in spalator (Louvain) and Triga reactor (Ljubljana)

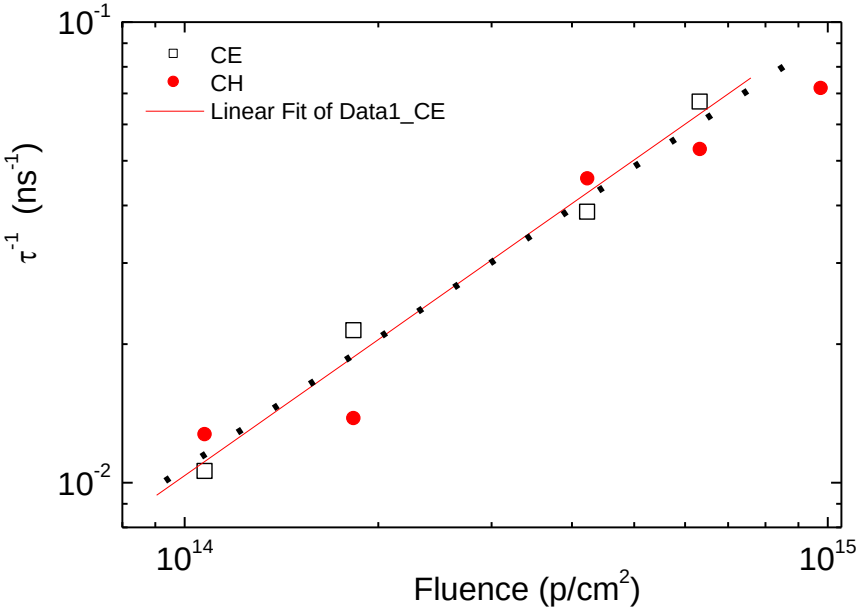
THANK YOU

FOR YOUR ATTENTION!





@ Rd50 2010



@ Rd50 2005
24 GeV protons