Status of x-ray calibration efforts

Different methods and results

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Motivation

- Some groups use our x-ray tube to irradiate their chips, sensors, semiconductor structures,...
- Calibration was done couple of years ago, we wanted to refresh calibration and crosscheck our data with an alternative method

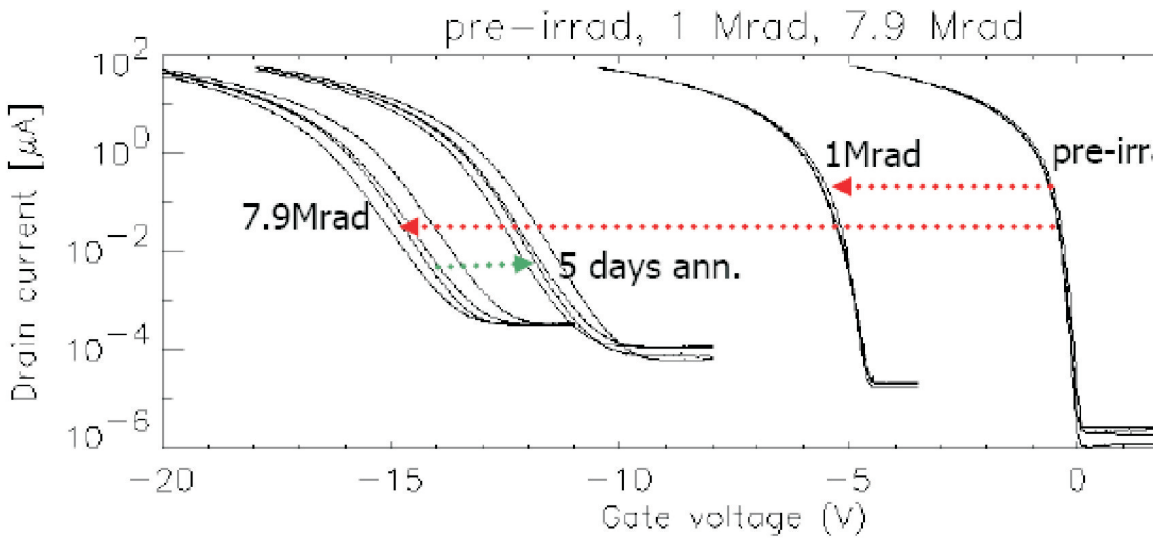


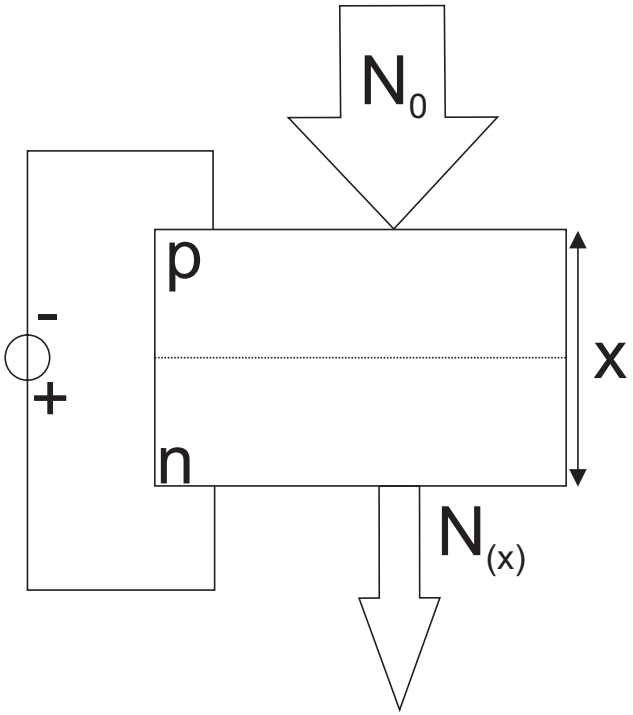
Figure: Measurement done by MPI Halbleiterlabor

Measurement with Diode I

- Silicon Diode is totally depleted
- γ's are absorbed via the photoelectric effect

$$N(x) = N_0 e^{-\sigma(E)\rho x}$$

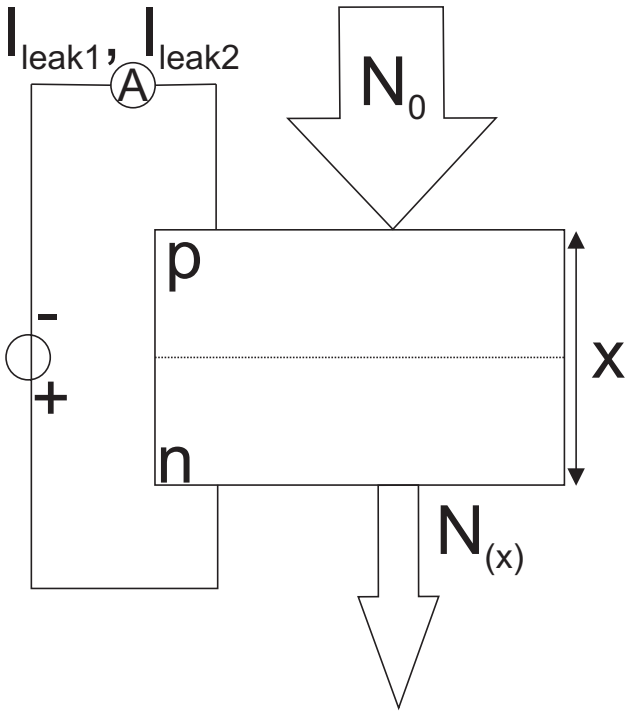
σ = mass attentuation coefficient, ρ = density



- Absorbed γ's create electron/hole pairs
- Every electron/hole pair represents 3.6 eV

Measurement with Diode II

- Leakage Current rises due to irradiation
- $I_{Leak} \Rightarrow$ electron/hole pairs per sec. $\Rightarrow$ Power deposited in Si-diode
- With mass of irradiated volume and power being absorbed in material $\Rightarrow$ Dose rate deposited in material



Measurement with Diode III

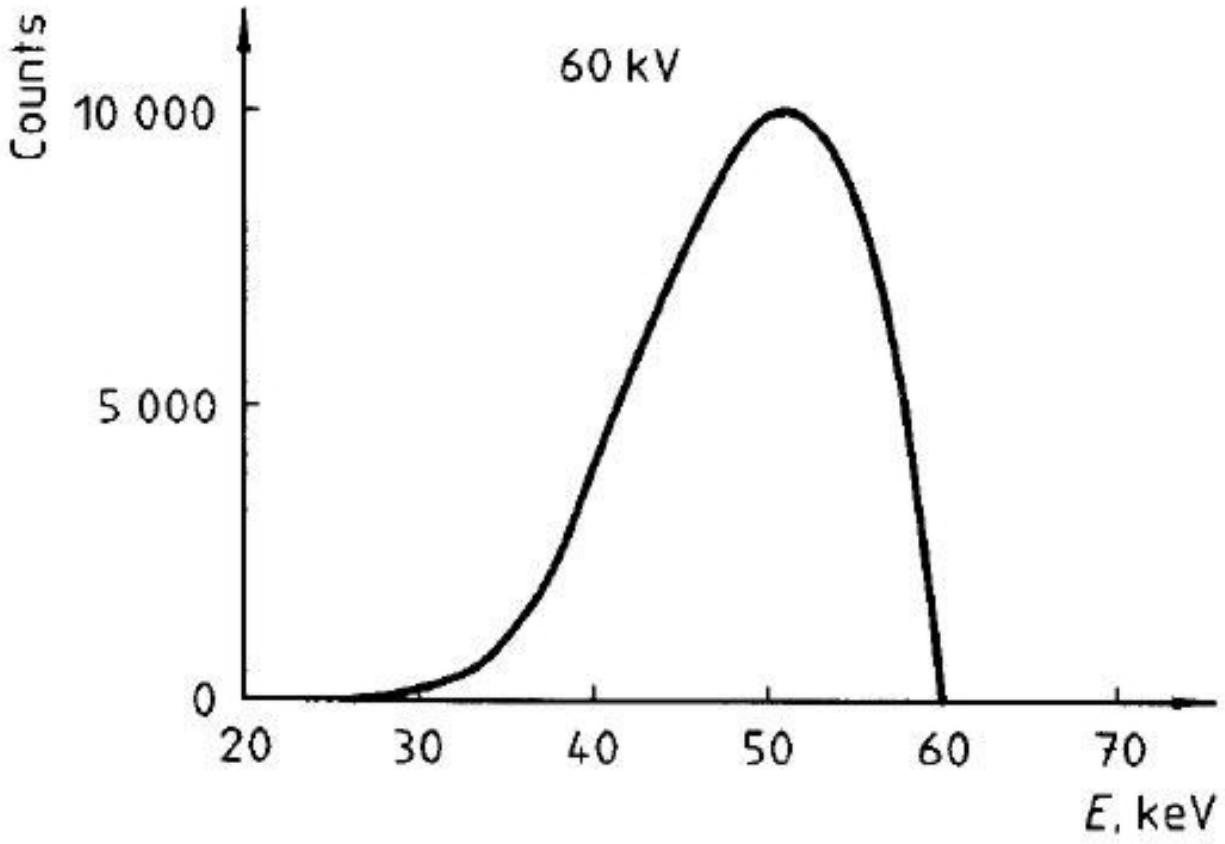
- At 60 kV, 20 mA and 155 mm distance, we have a doserate of $\frac{D}{t} = 66.6 \frac{krd}{h}$ in 300 μm Si
- Also the smaller the distance, the higher the dose rate $\frac{D}{t} \propto \frac{1}{r^2} + const.$
- To determine the energy deposited on surfaces the energy spectrum is required

Calibration with thermoluminescent dosimeter (TLD)

- TLDs provided by Forschungszentrum Karlsruhe (FZK)
- TLD material emits light after exposure to radiation
- Calibration is done via heating the TLDs and counting emitting photons
- Absolute calibration is complex and requires known spectra
- TLDs of FZK are calibrated to "'N-60"' spectrum [1]

[1] N-60 spectrum is a specified spectra of the ISO-4037 standard

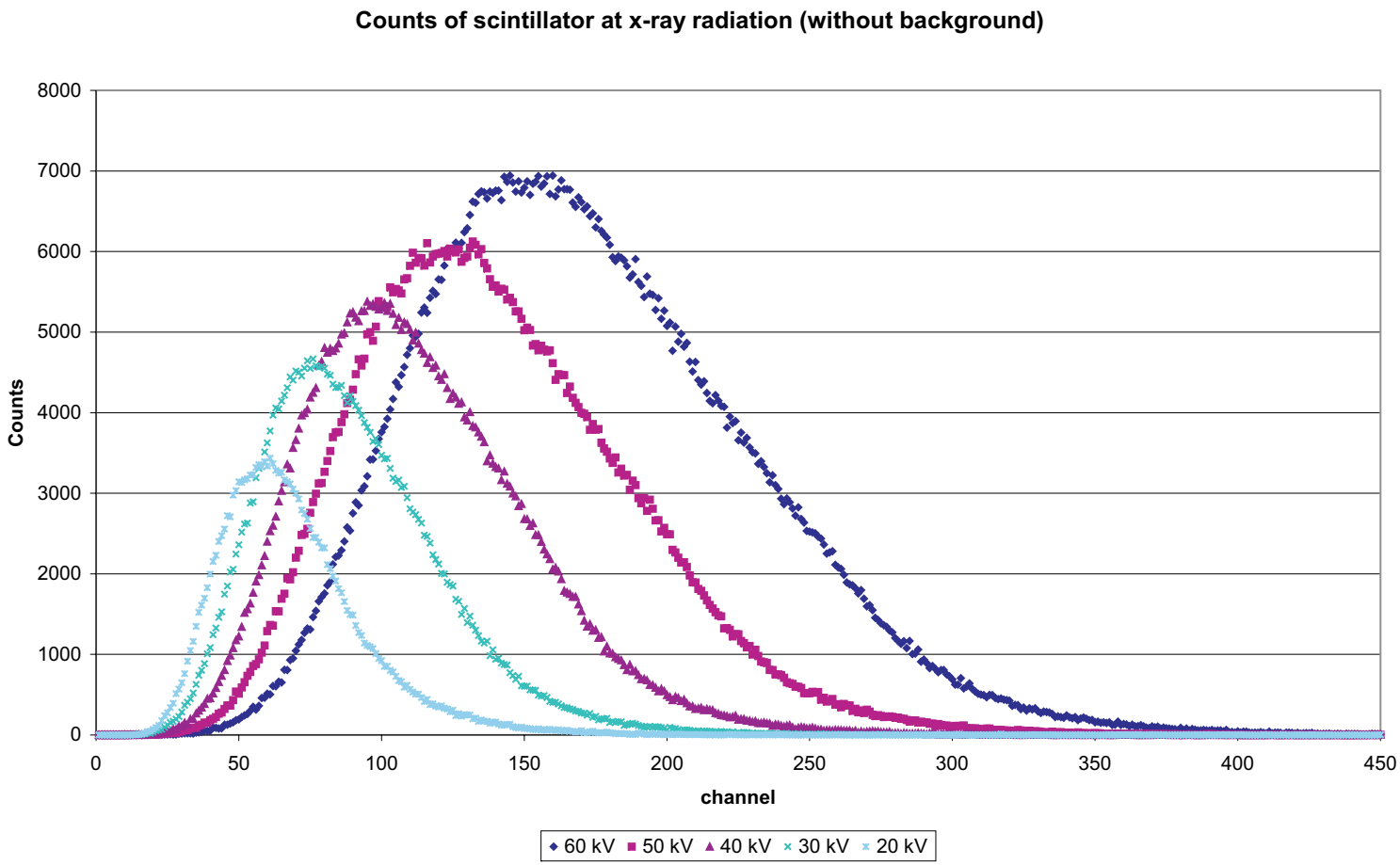
N-60 spectrum



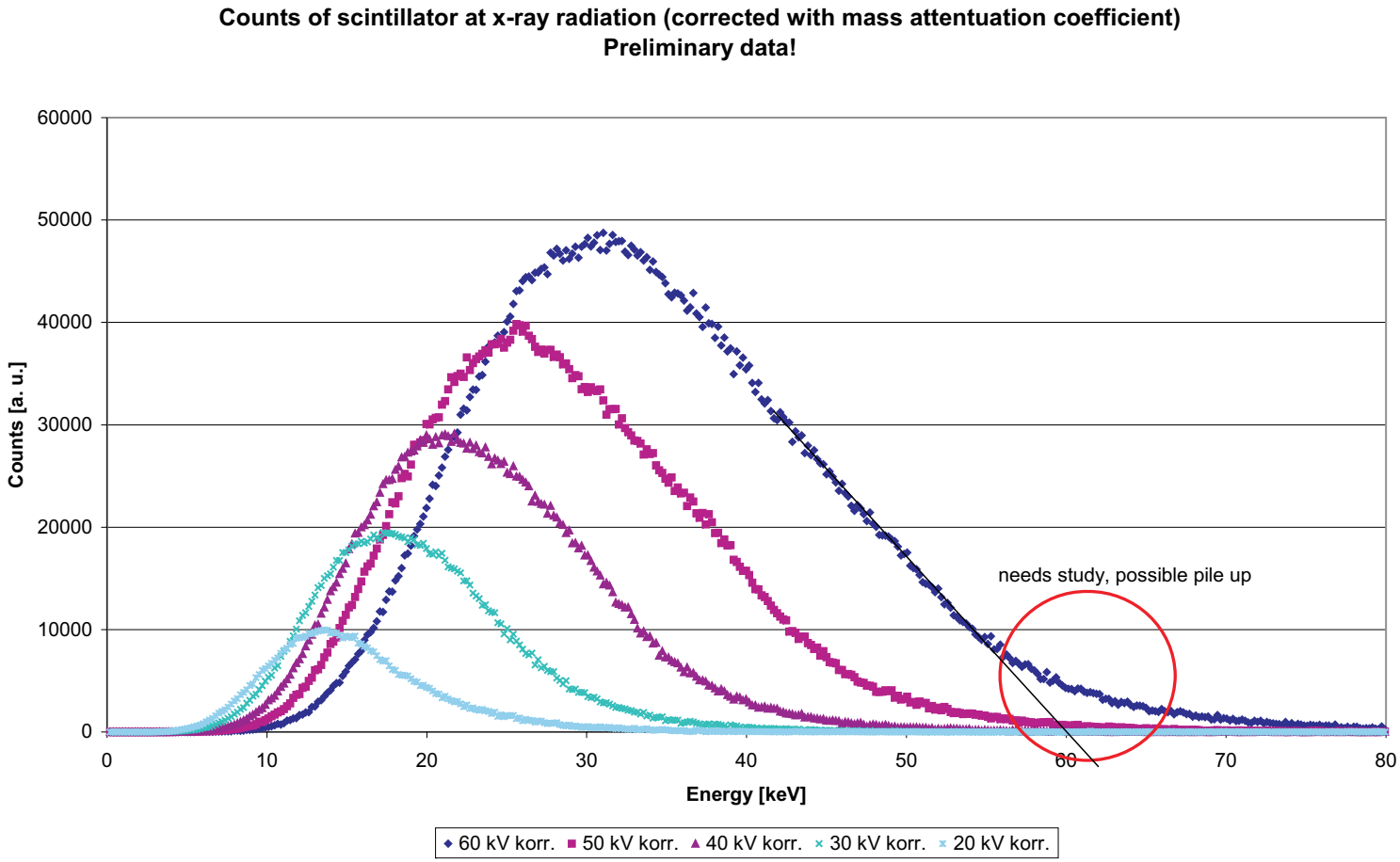
Measurement of x-ray spectra with scintillator

- Using a plastic scintillator "'Ne 102 A"' with photomultiplier
- Radioactive source with known γ peak needed to calibrate x-ray spectra, or calibration with maximum voltage of electron acceleration potential
- Results have to be combined with total mass attentuation coefficient for "'real"' spectra

Energy spectrum of scintillator



Energy spectrum of scintillator (corrected)



Conclusions and outlook

- Diode measurement redone, new dose rate coefficient aquired
- TLD measurement done by FZK, needs our spectra to determine actual dose rate
- Spectra themselves are useful for irradiation studies (how much energy is deposited in surface structures/SiO_2)