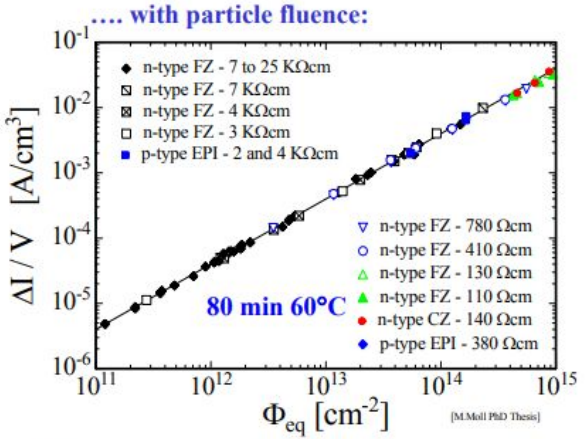
Overview

- InP devices irradiated in Ljubljana:
  - 1E13-1E16 / 1 MeV n eq
- Radiation hardness of a material (to hadrons) can be summarized by the damage parameter **alpha**
  - aka **current related damage rate**
  - Invariant to doping, thickness, impurities
  - Proportional to fluence
- Accurate measurement requires two conditions
  - Constant ambient temperature
  - Known effective volume



- **Damage parameter α (slope in figure)**

$$\alpha = \frac{\Delta I}{V \cdot \Phi_{eq}}$$

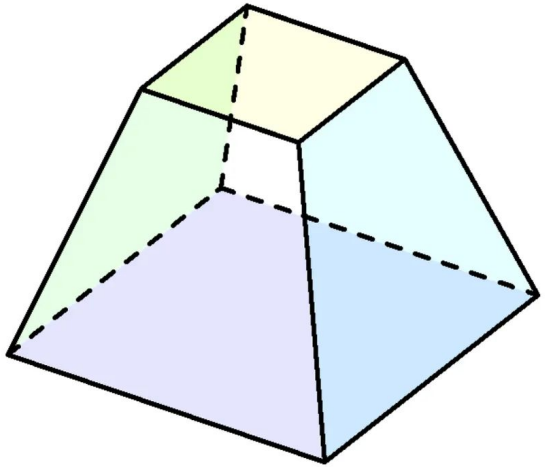
Leakage current per unit volume and particle fluence

- **α is constant over several orders of fluence and independent of impurity concentration in Si**
  - ⇨ **can be used for fluence measurement**

https://indico.cern.ch/event/46820/attachments/951707/1350470/081202-Helsinki-Moll-final.pdf

Caveat: Two Conditions Not Fulfilled

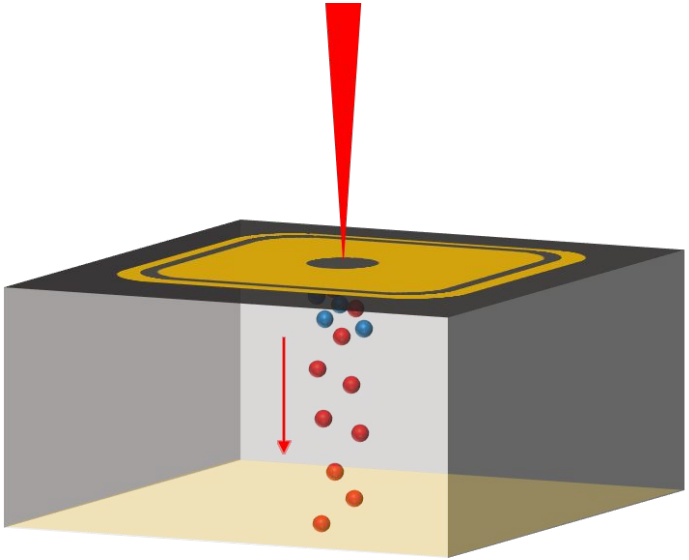
- Effective volume not constrained
  - **Floating guard ring**
    - Standard IV station does not have multiple channels to measure guard ring and central pad separately
  - Effective volume spreads beyond under central pad
  - Effective volume estimated as frustrum



- Temperature not held constant
  - Temperature not held constant/measured + measurements taken on different days
  - Leakage current temperature dependence will spread values
- Presented will be preliminary estimation of alpha

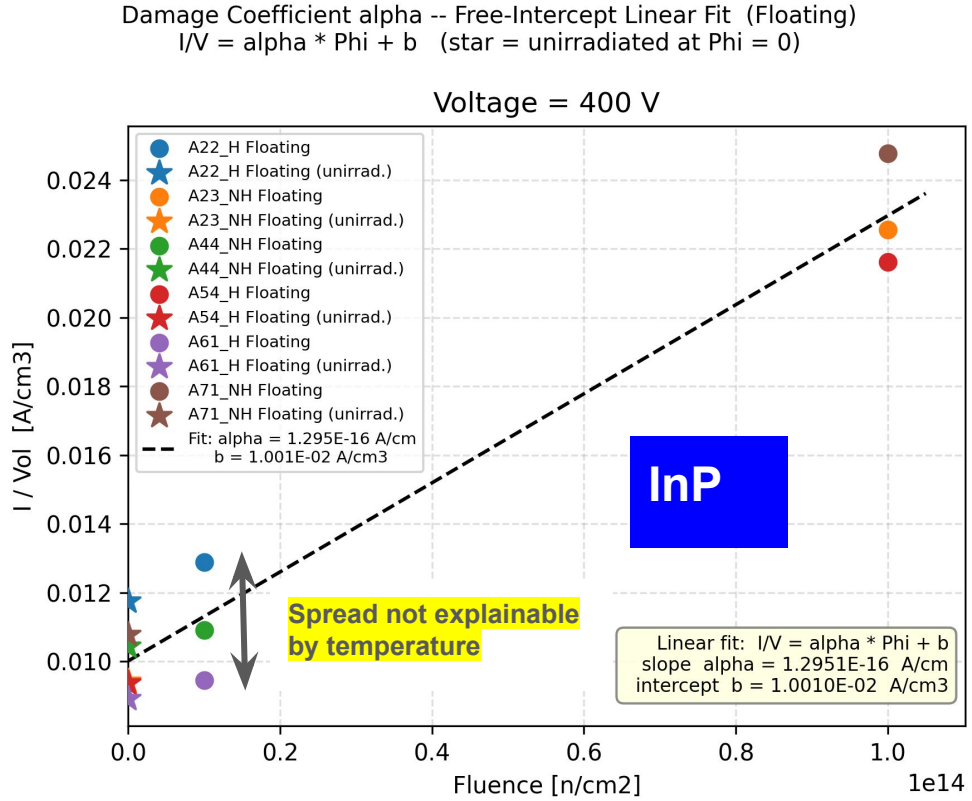
Caveat: No ‘Reverse Bias’ State

- Our devices are essentially asymmetric capacitors
  - Uniform doping
  - Single pad
  - No saturation current
- Alpha parameter assumes saturation current
  - Leakage current is dependent on choice of voltage for our devices
- Decision: choose characteristic voltage
  - Match to voltage shown in InP Paper
  - + 400 V on backside of device, central pad held at 0 V



Schematic by Jennifer Ott

Results



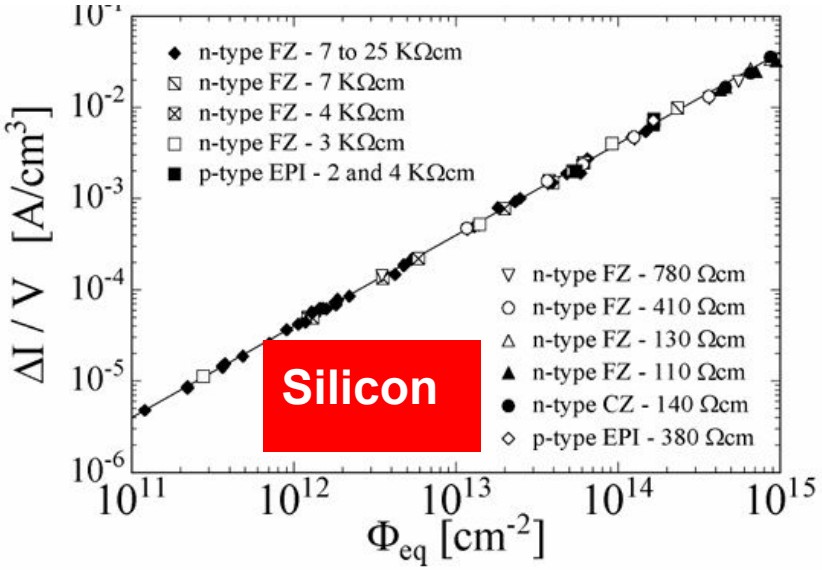


Figure 5.1: Fluence dependence of leakage current for silicon detectors produced by various process technologies from different silicon materials. The current was measured after a heat treatment for 80 min at 60°C $\{\alpha(80\,\text{min}, 60°\text{C}) = (3.99 \pm 0.03) \times 10^{-17}\text{A/cm}$; for details see Fig. 5.6$\}$.

Comparison with Silicon

- InP: 1.30E-16 A/cm | Silicon: 3.99E-17 A/cm
- Why this InP alpha derivation is a lower bound estimate
  - Electric field simulations from here in Thin Films showed our device geometry shows **electric field lines** curve inward
    - **Frustrum** is overestimation of volume → alpha parameter is underestimation
- Follow-Up:
  - For an accurate measurement, we may need temperature controlled measurements using the parameter analyzer (multi-channel for GR separation)

Electric Field Simulation Pictures Here, if slides are on Indico (couldn't find them)