Exploring the novel nLGAD concept

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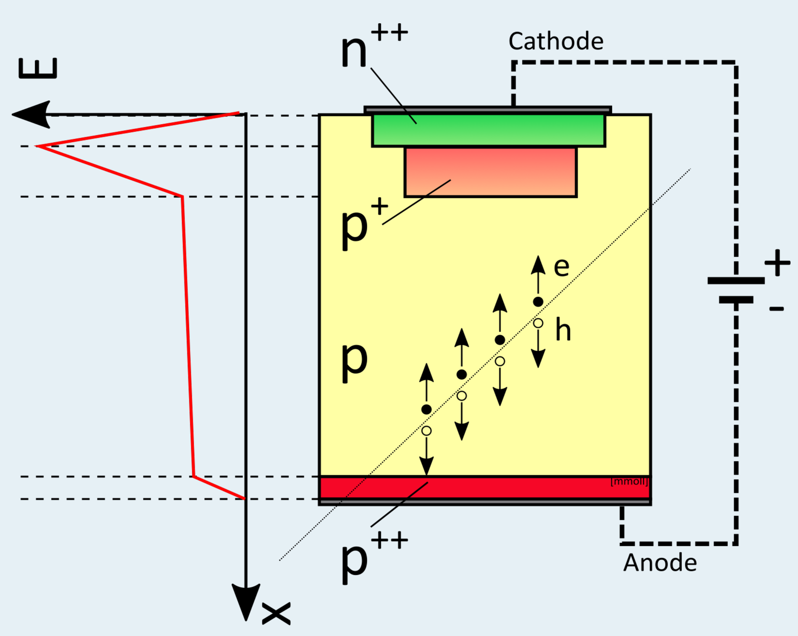
Low Gain Avalanche Detectors

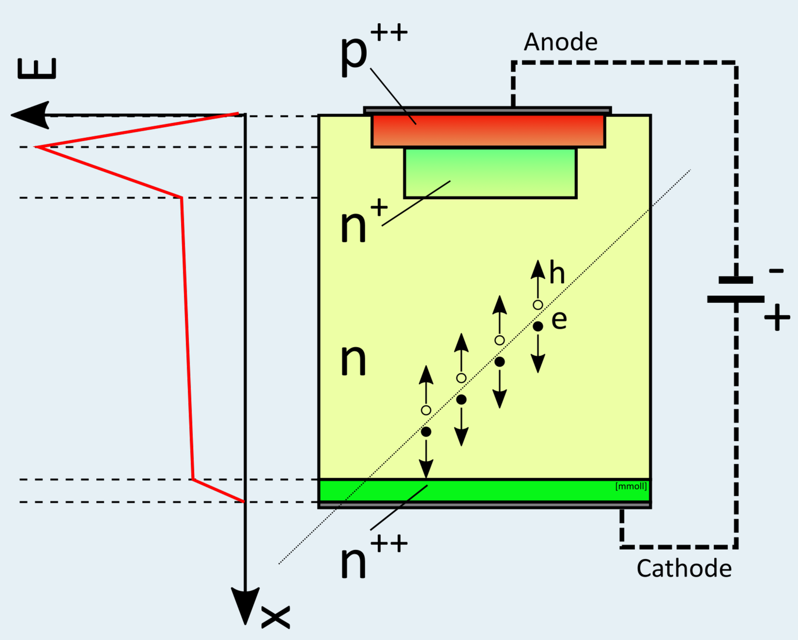
Semiconductor detectors with signal amplification: Gain layer creates strong electric field
→ avalanche multiplication → **good Signal-to-Noise ratio and timing capabilities**

The traditional LGAD

Implemented as $n^{++}-p^{+}-p$

Showing outstanding performance when detecting high-energy charged particles





The novel nLGAD concept

Exchanging the conductivity type of all LGAD layers to $p^{++}-n^{+}-n$

Difference in multiplication mechanism for holes and electrons

Good option for HL-LHC and future detectors

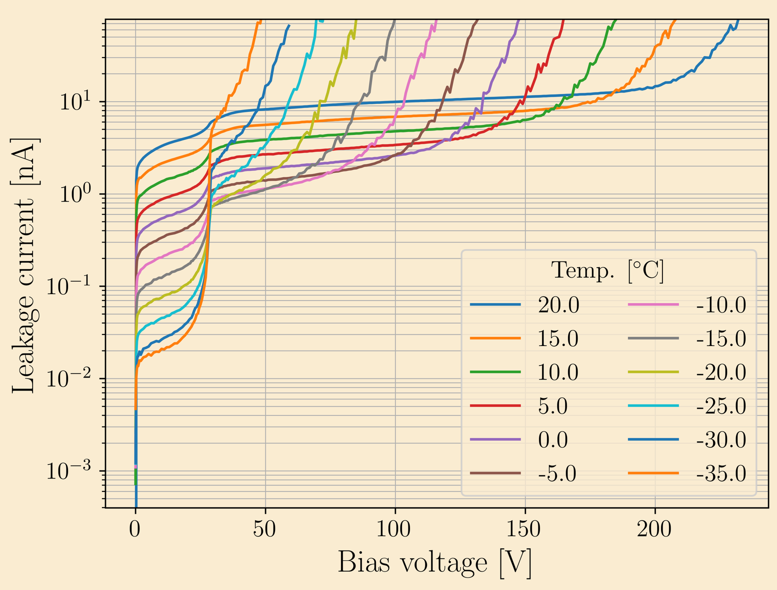
Detection performance is optimized for low penetrating particles

Characteristics

Of interest for high energy physics and R&D:
first ever tests in such a structure!

Impact ionization, donor removal ↔ acceptor removal (e.g.: relevant for compensated LGADs) and many more things to learn

- Thickness 275 µm
- Active area 1.3 mm x 1.3 mm
- Resistivity > 1 kΩcm

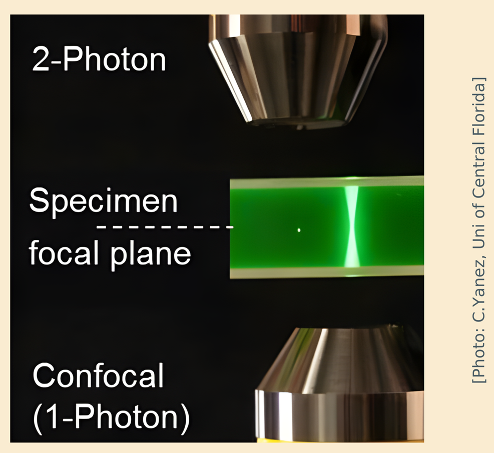


Exemplary IV characteristic: temperature dependence of the breakdown voltage indicates dependence of impact ionization in the n^{+} gain layer

TPA-TCT Measurements

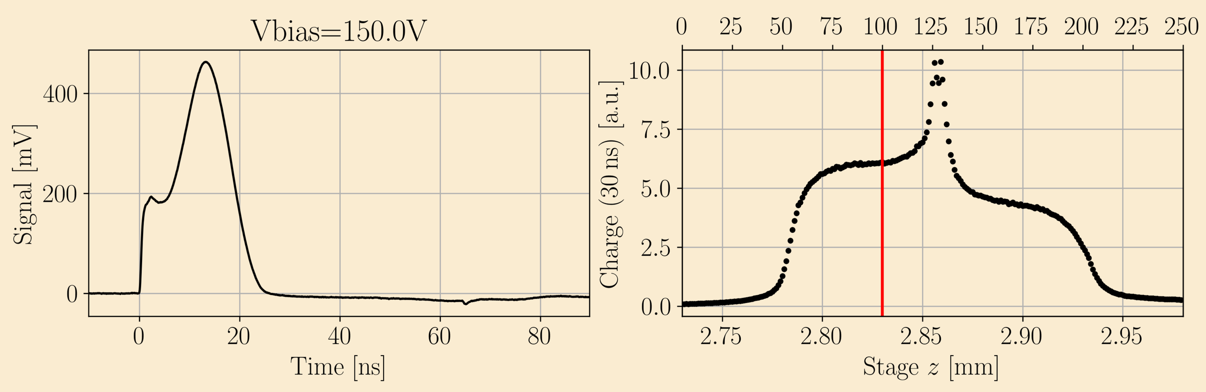
Working principle **T**wo **P**hoton **A**bsorption – **T**ransient **C**urrent **T**echnique:

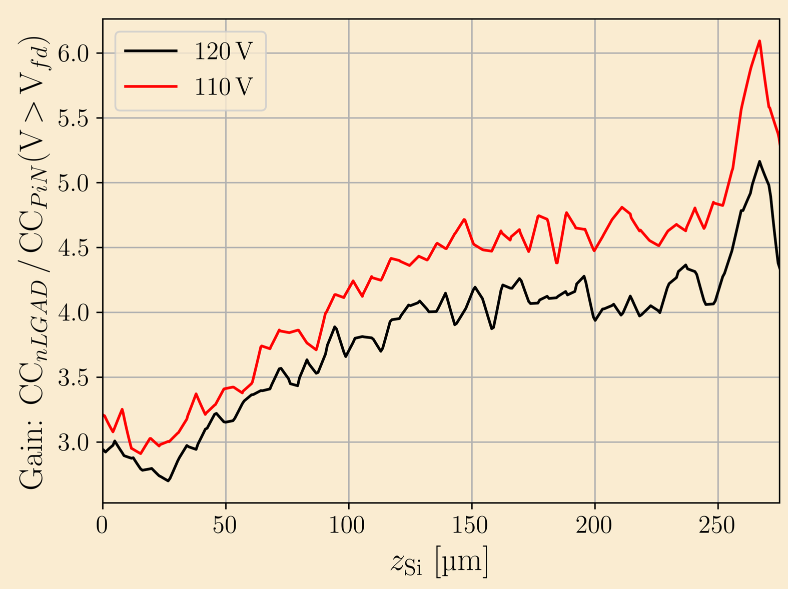
- Laser (λ = 1550 nm) induces generation of charge carriers
- 2 photons produce one electron-hole pair ($E_{photon} < E_{gap}$)
- Point-like energy deposition in focal point
- 3D spatial resolution (1 µm x 1 µm x 10 µm)



[Photo: C.Yanez, Uni of Central Florida]

TPA-TCT signal at the corresponding position of the charge profile (below) and nLGAD gain for two bias voltages (right).



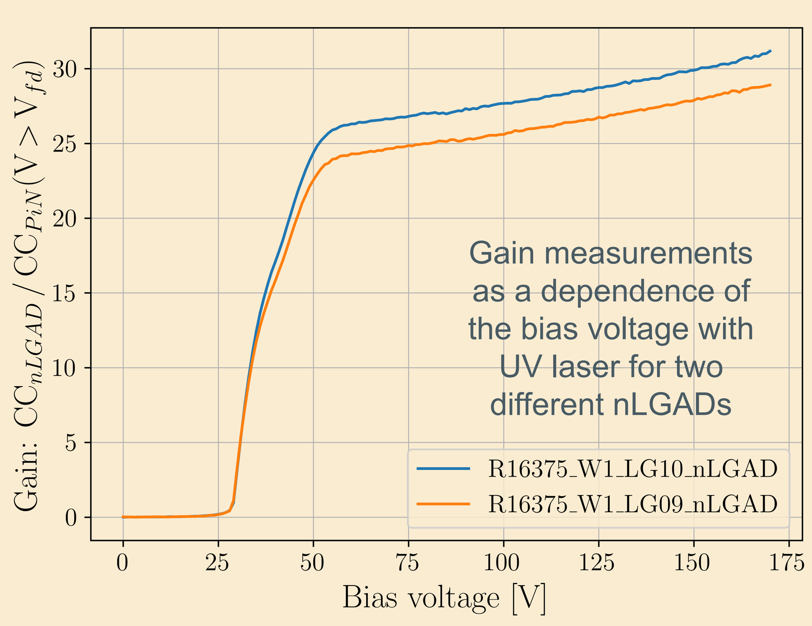


$$Gain[V] = \frac{CC_{LAGD}[V]}{CC_{PIN}[V \geq V_{FD}]}$$

TCT with UV Laser

Working principle SPA-TCT:

- UV laser (λ = 375 nm) at CERN-SSD TCT+ setup
- Single Photon Absorption (SPA-TCT): continuous energy deposition along beam ($E_{photon} \geq E_{gap}$)
- Gain measurements of nLGADs with Gain (UV) > Gain (Infrared, λ = 1064 nm) compared to traditional LGADs due to inverted conductivity type



Gain measurements as a dependence of the bias voltage with UV laser for two different nLGADs

Outlook & Acknowledgment

Future plans:

- Proton (IRRAD, CERN) and neutron (JSI, Ljubljana) irradiation
- Study donor removal (↔ acceptor removal for HEP applications)

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Sources: nLGAD publication

Gain measurements on NLGAD detectors (2023), *Jairo Villegas et al.*