Timing resolution on an irradiated 3D silicon pixel detector

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Outline

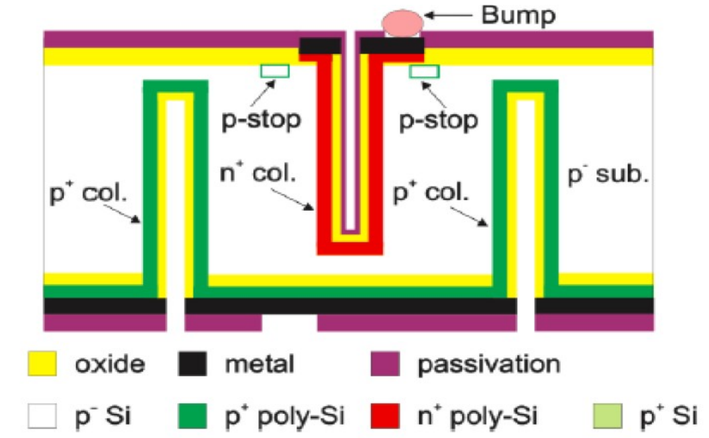
- 3D Pixel Sensor CNM Production
- Experimental Setup
- 3D Time resolution before and after irradiation for 285μm thick sensor at −20°C

3D Pixel Sensor – CNM production

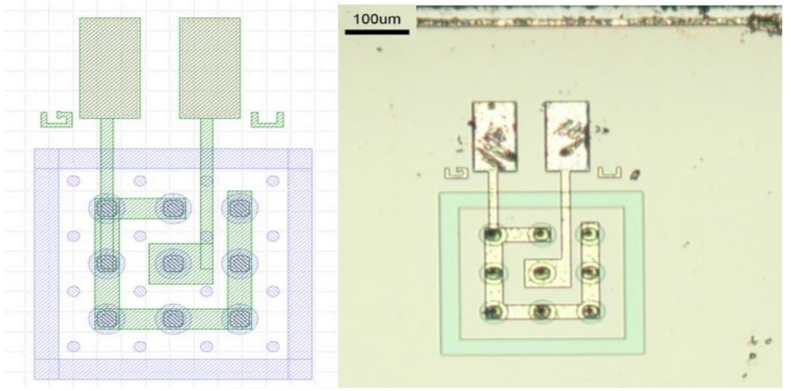
Features:

- thickness: 285µm
- cell size: 50x50 μm^2
- p-type bulk resistivity: ~5kΩcm
- diameter holes: 8-10 µm

Schematic Cross Section

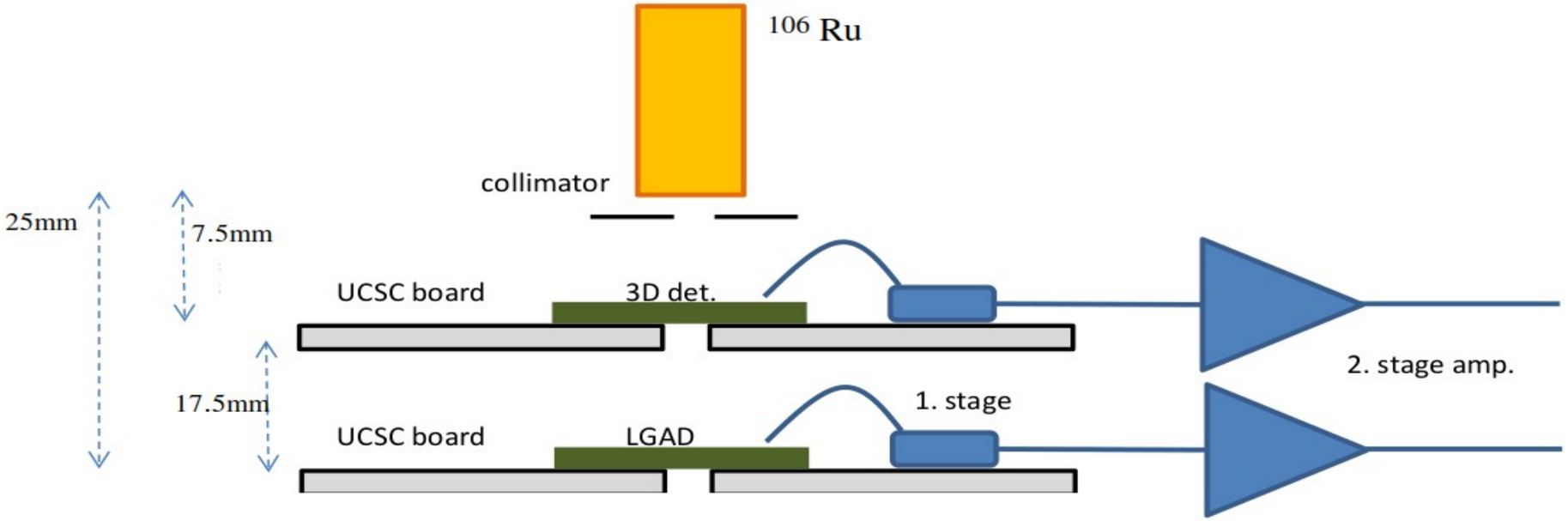


Design of a single cell structure



arXiv:1901.02538

Experimental Setup

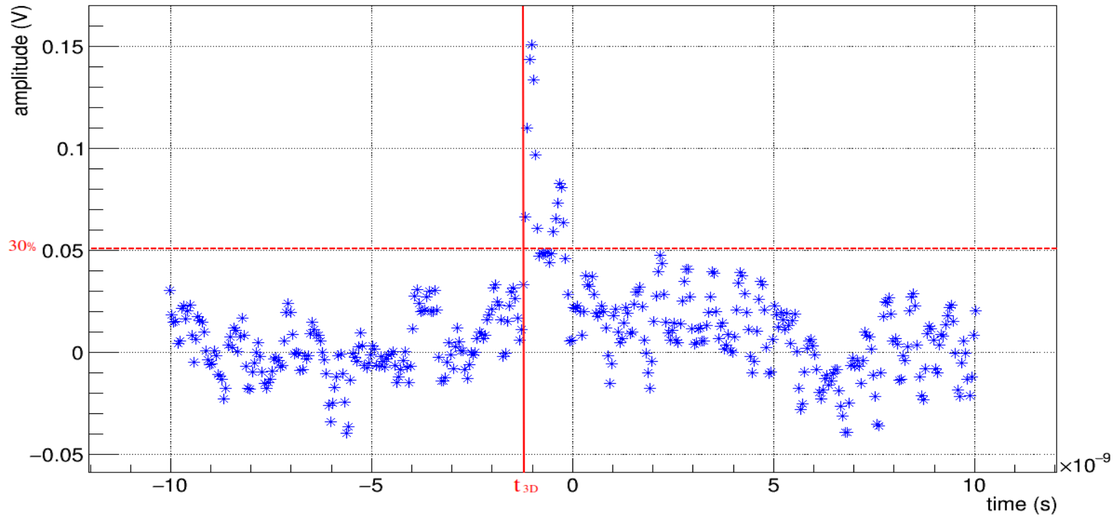


Signals in coincidence are analyzed

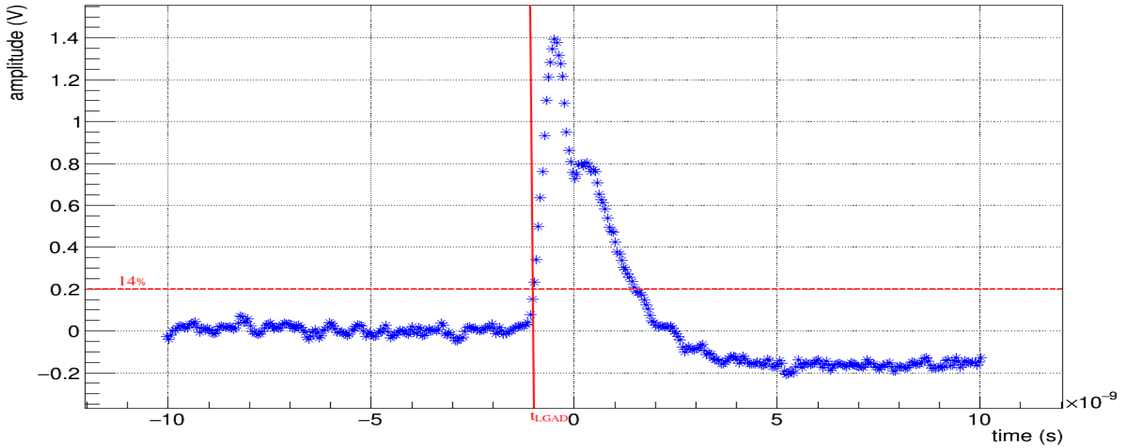
Source: ^{106}Ru
Board: Preamplified UCSC
LGAD: HPK50C - high gain 50 um thick (1 mm diameter)
Time resolution 39 ps (20°C) and 36 ps (-20°C)
2.stage amp: 4GHz
Readout: Waverunner 8404M oscilloscope 4GHz

3D Waveform and analysis – σ_{3D}

3D Waveform

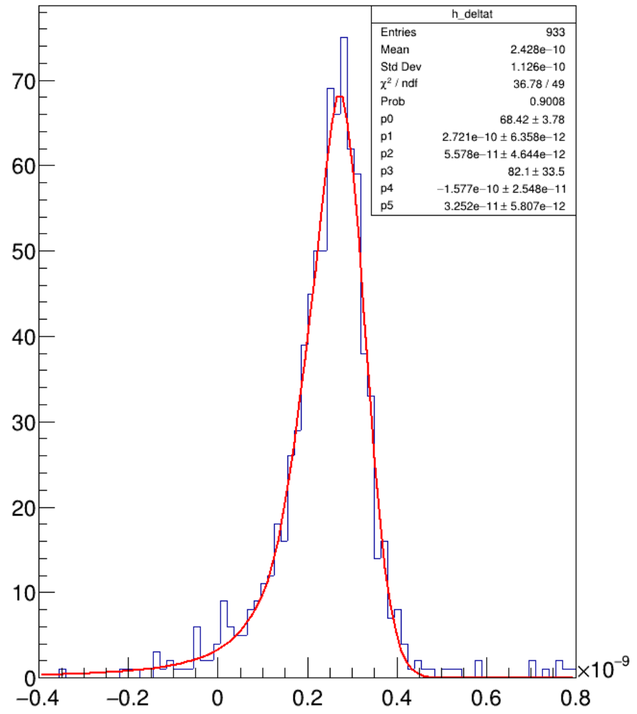


LGAD Waveform



CFD method

$\Delta t = t^*_{LGAD} - t^*_{3D}$



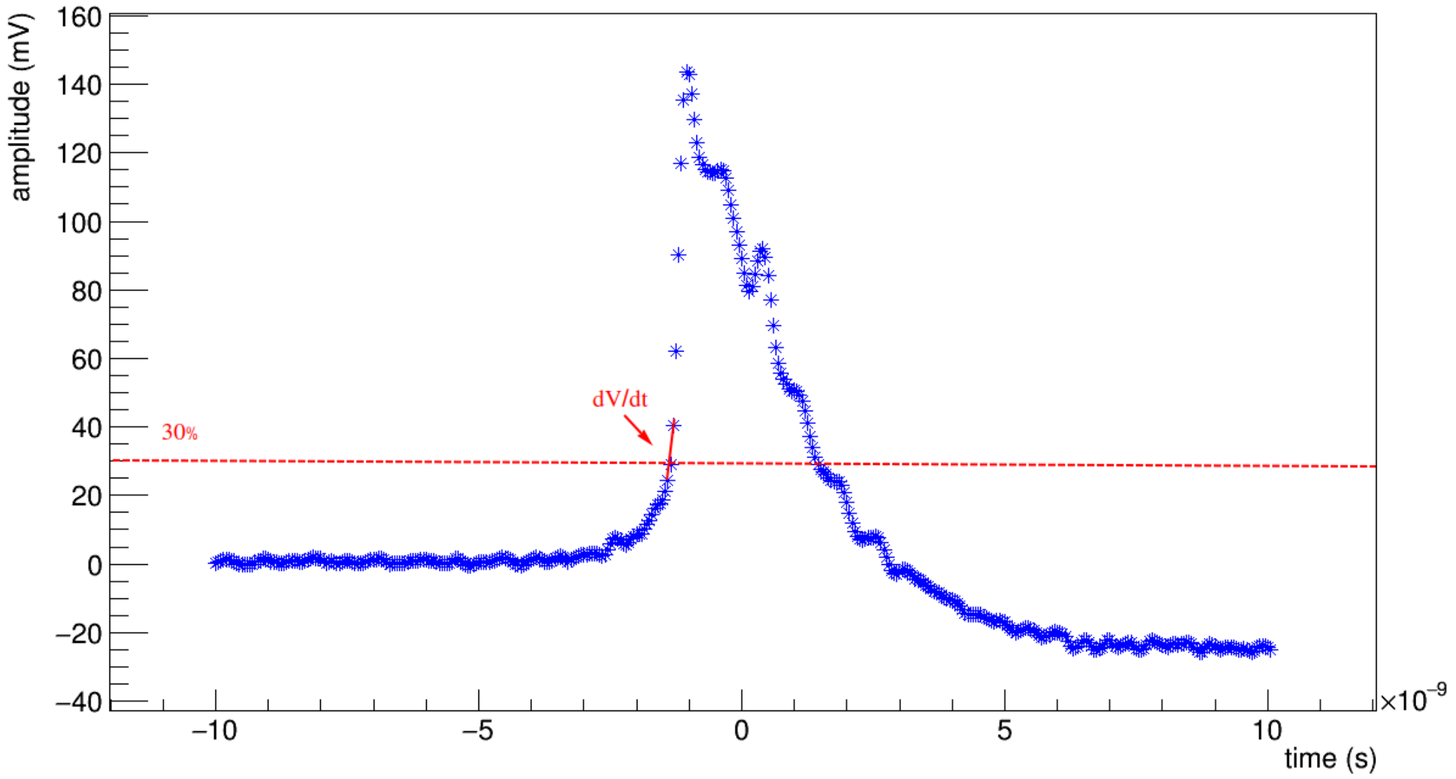
Fit on Δt to obtain: $\sigma_t = (\sigma^2_{LGAD} + \sigma^2_{3D})^{1/2}$

$\sigma^2_{wf} \approx \sigma^2_{3D} - \sigma^2_{j,3D}$

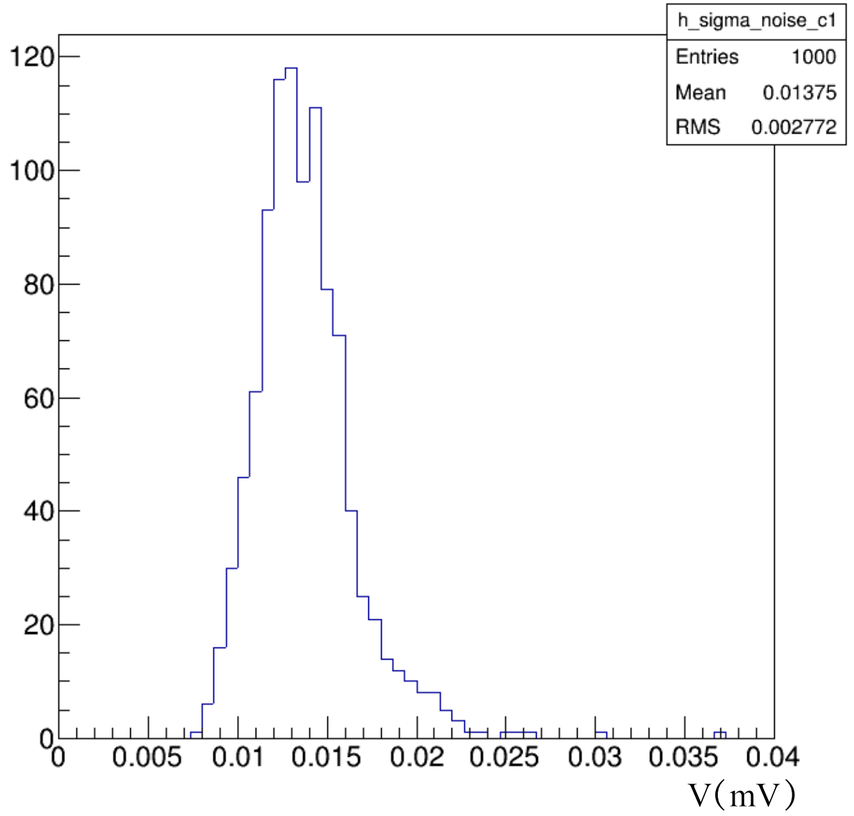
3D Waveform and analysis – σ_j

$$\sigma^2_{wf} \approx \sigma^2_{3D} - \sigma^2_{j,3D}$$

1000 averaged waveforms



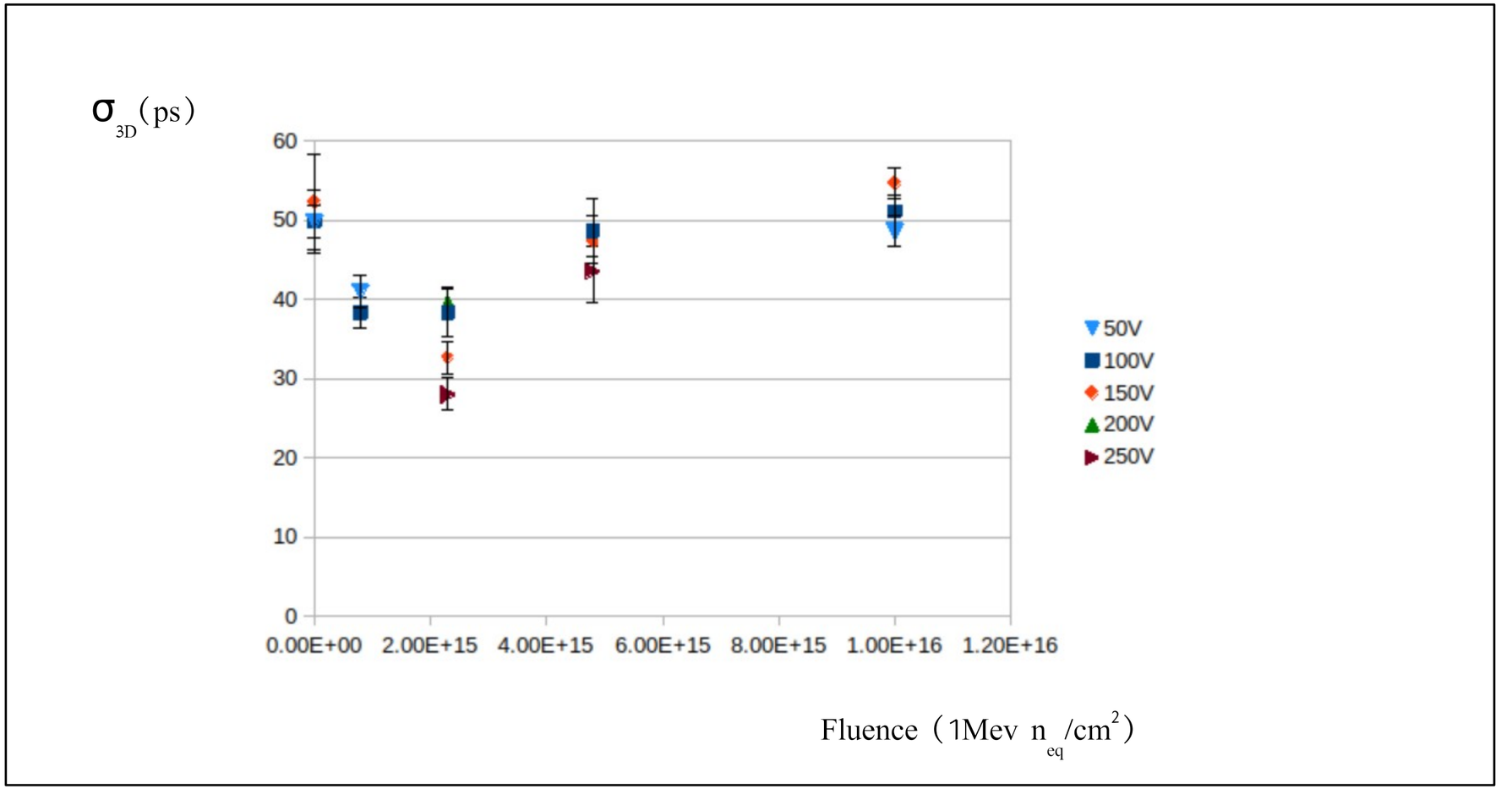
RMS of the noise



3D time resolution at -20°C VS fluence

Annealed 60 min at 80°C

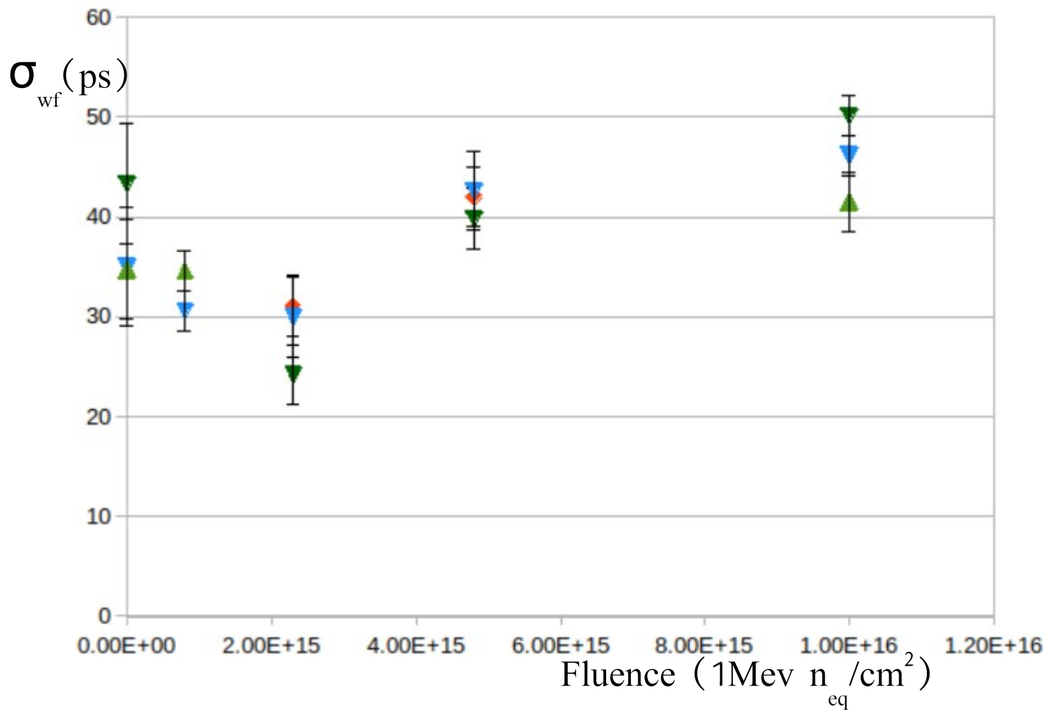
Irradiated at $8x10^{14}$ 1Mev n_{eq}/cm^2 - $2.3x10^{15}$ 1Mev n_{eq}/cm^2 – $4.8x10^{15}$ 1Mev n_{eq}/cm^2 – $1.0x10^{16}$ 1Mev n_{eq}/cm^2 at Ljubjiana

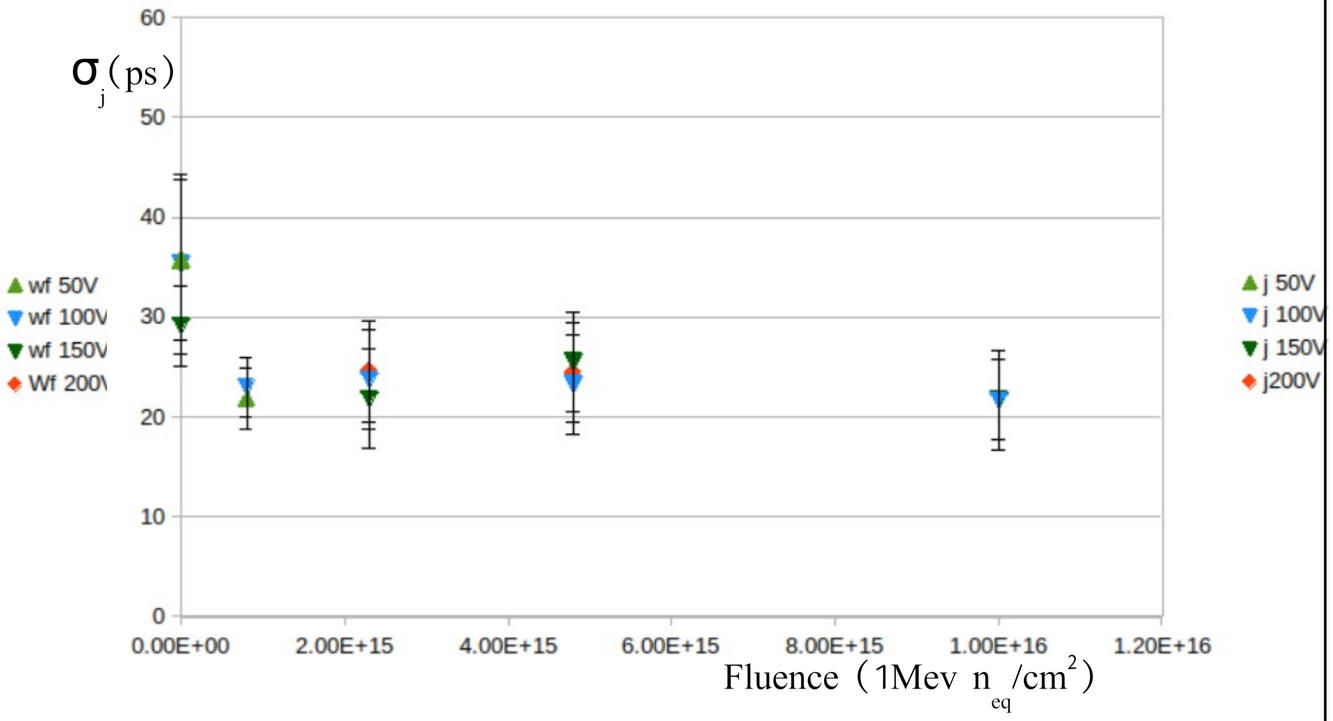


Weighting field and jitter at -20°C VS fluence

Annealed 60 min at 80°C

Irradiated at $8x10^{14}$ 1Mev n_{eq}/cm^2 - $2.3x10^{15}$ 1Mev n_{eq}/cm^2 – $4.8x10^{15}$ 1Mev n_{eq}/cm^2 - $1.0x10^{16}$ 1Mev n_{eq}/cm^2 at Ljubjiana

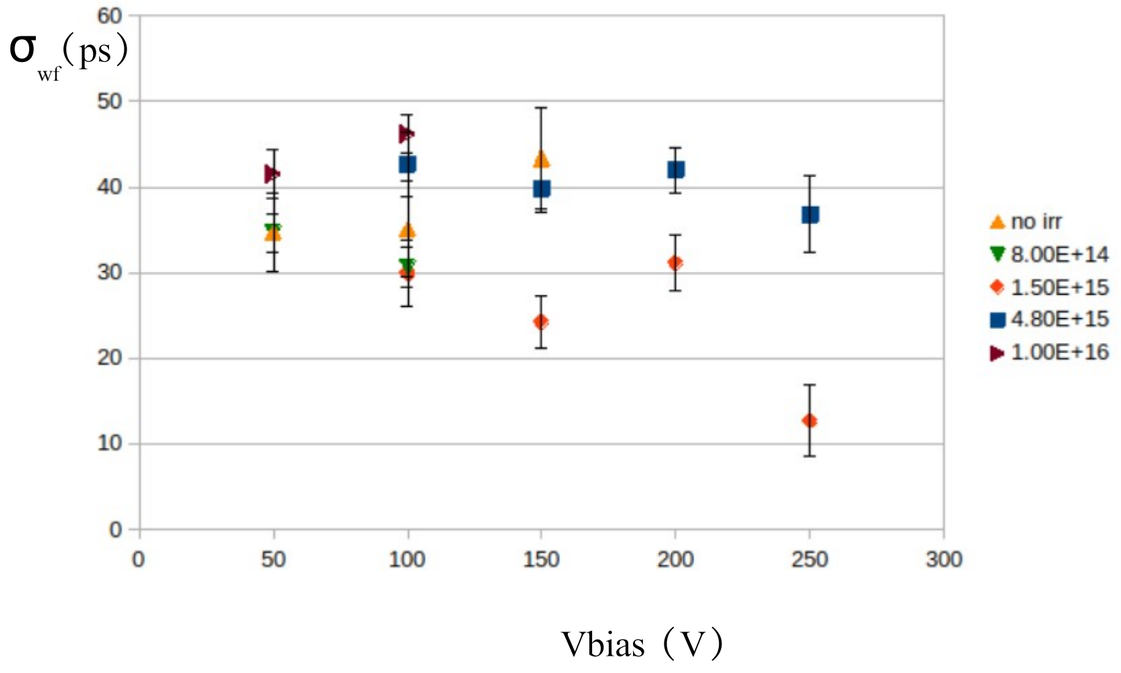


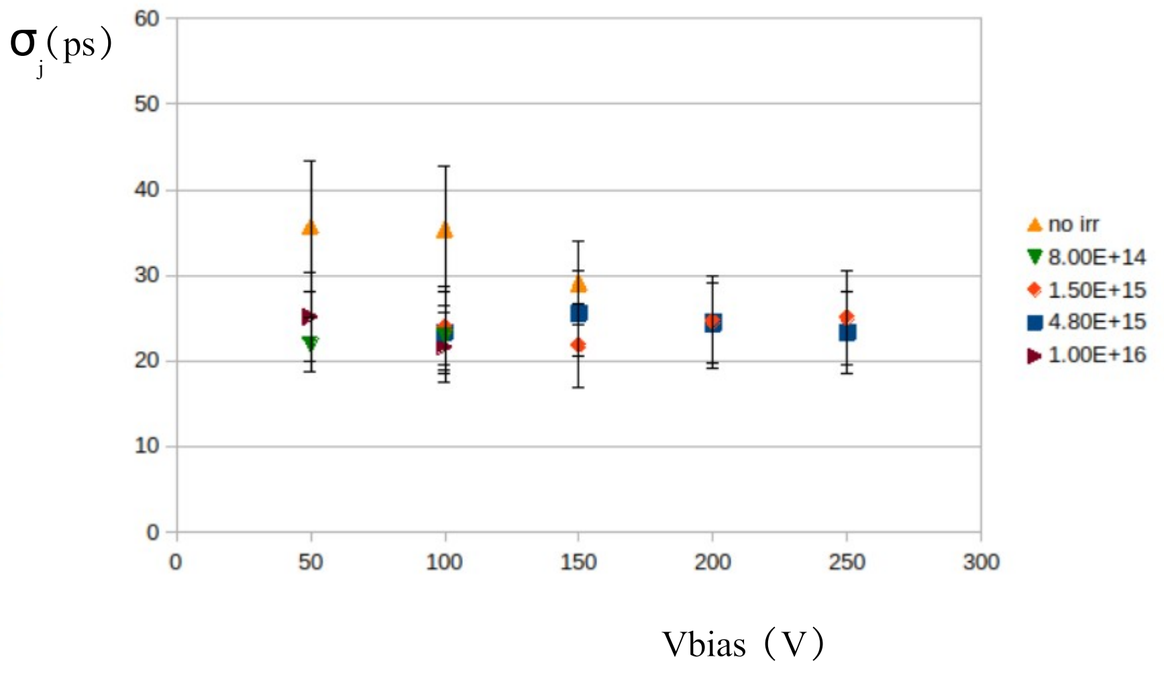


Weighting field and jitter contribution at -20°C VS Bias voltage

Annealed 60 min at 80°C

Irradiated at $8x10^{14}$ 1Mev n_{eq}/cm^2 - $2.3x10^{15}$ 1Mev n_{eq}/cm^2 – $4.8x10^{15}$ 1Mev n_{eq}/cm^2 - $1.0x10^{16}$ 1Mev n_{eq}/cm^2 at Ljubjiana



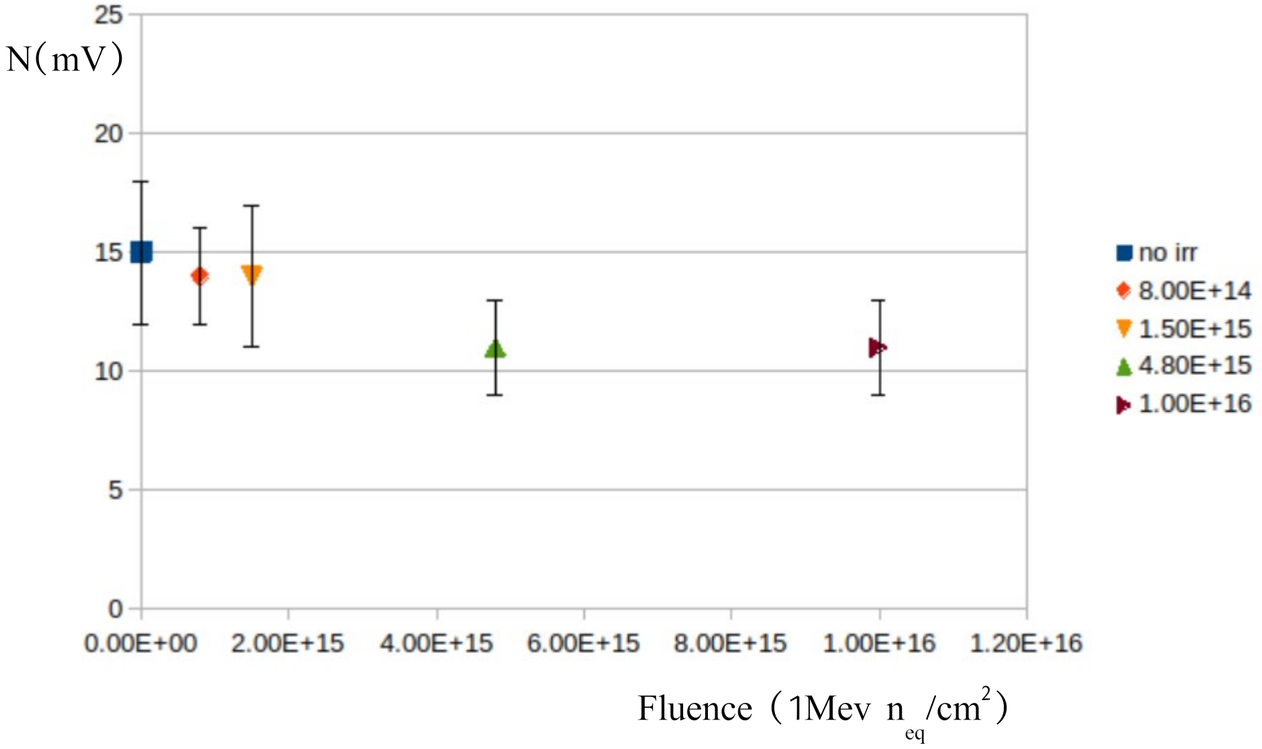


Conclusions

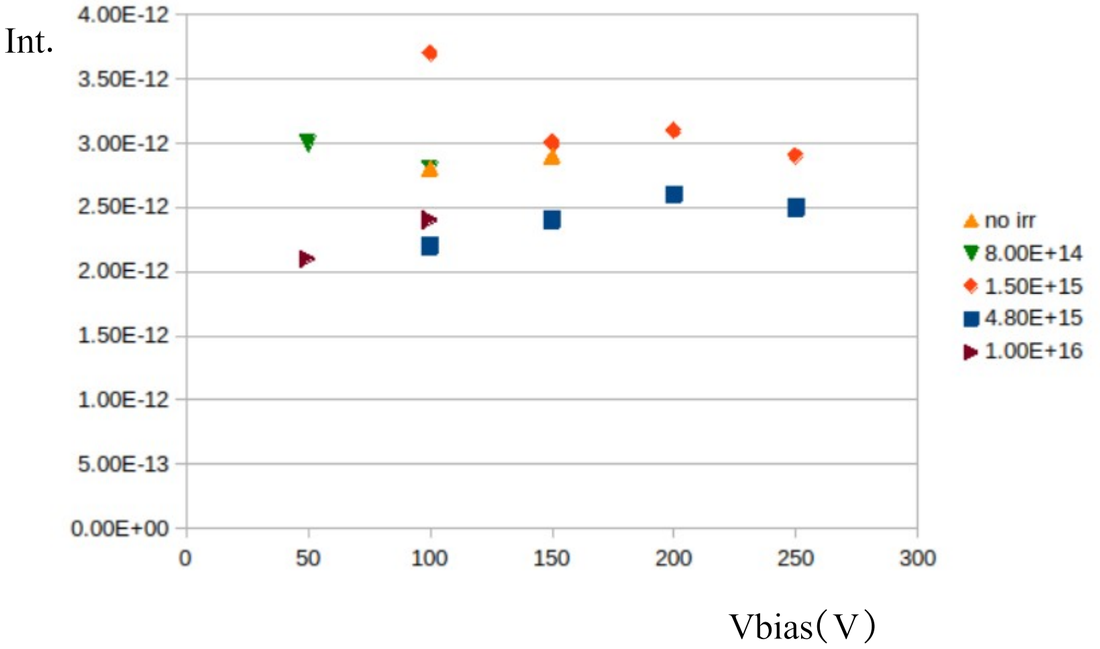
- We have reported data for 3D detector with thickness of 285 μm at 50,100,150,200,250 V_B at −20°C before and after n irradiation of $8x10^{14}$ 1MeV n_{eq}/cm^2 $-2.3x10^{15}$ 1Mev n_{eq}/cm^2 - $4.8x10^{15}$ 1Mev n_{eq}/cm^2 $-1.0x10^{16}$ 1Mev n_{eq}/cm^2
- Total time resolution of 50 ps, better resolution for intermediate fluences $8x10^{14}$ 1MeV n_{eq}/cm^2 $-2.3x10^{15}$ 1Mev n_{eq}/cm^2
- Behaviour of temporal resolution as a function of fluence attributable to weighting field contribute
- No remarkable difference for Vbias, for the last radiation dose it looks a bit better for 50V than for 100V

Backup - Analysis

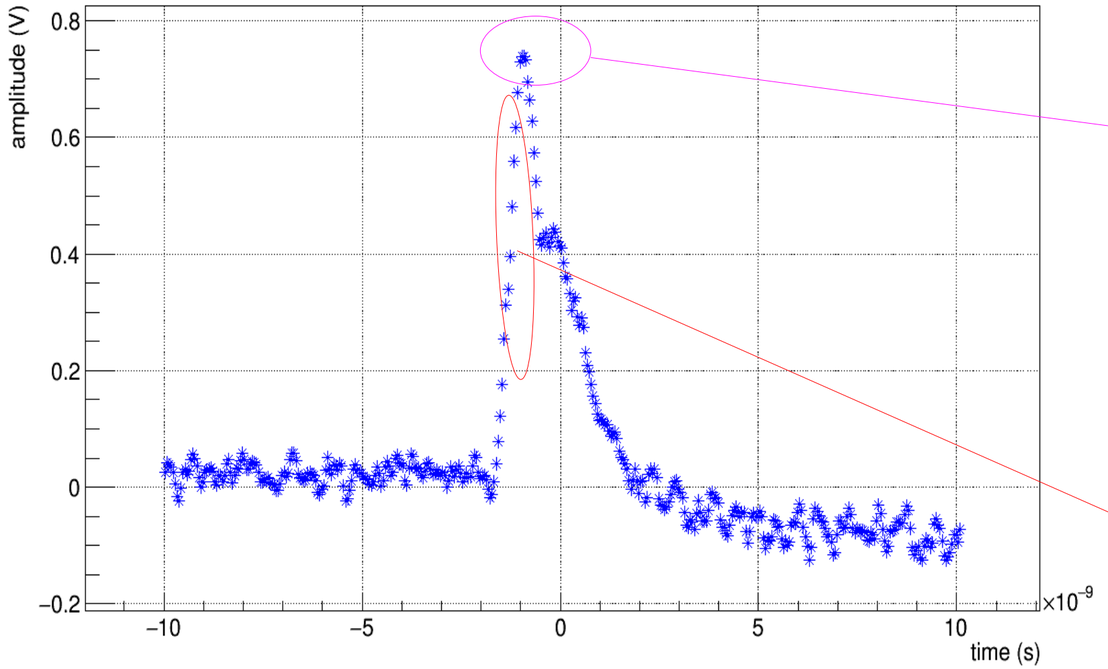
Noise



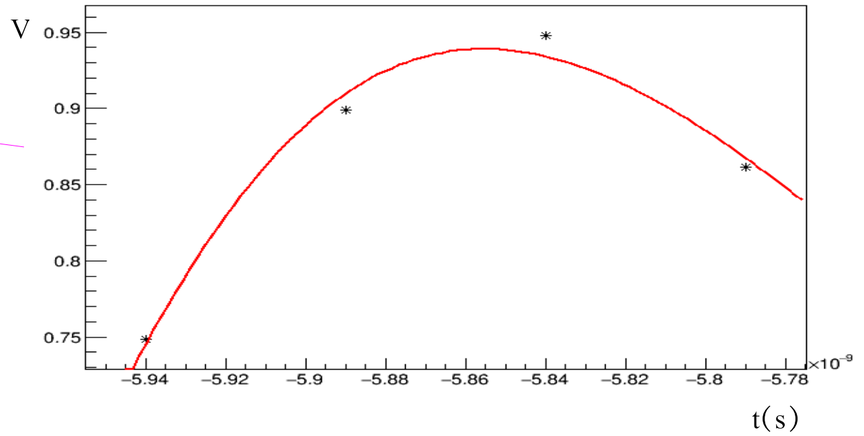
Charge Collection



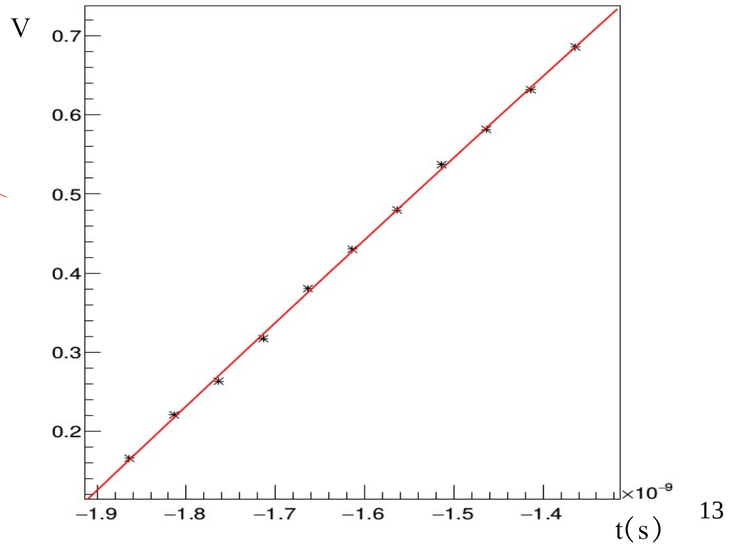
LGAD Waveform Analysis



3)

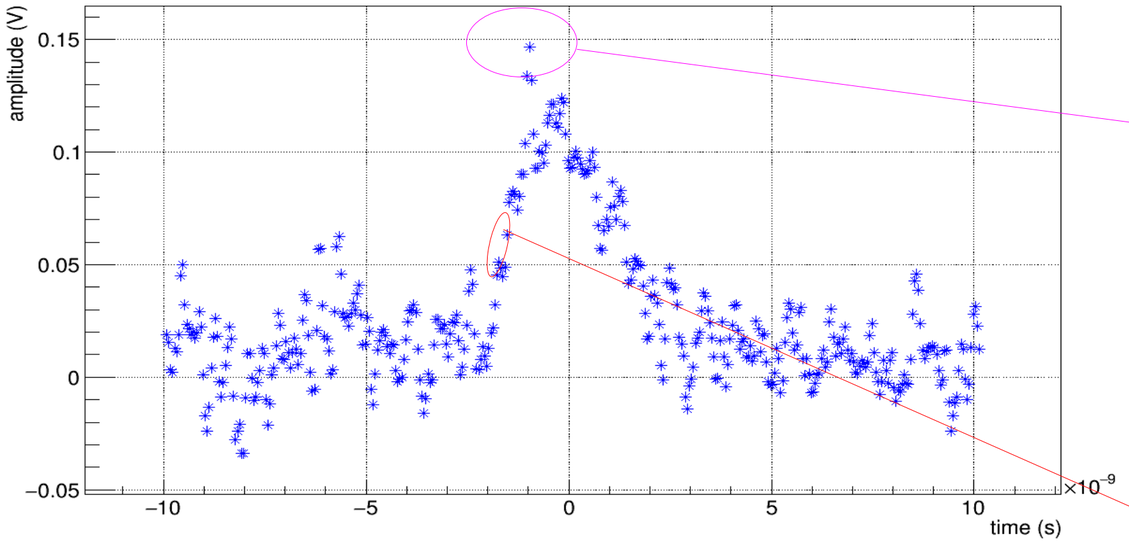


4)

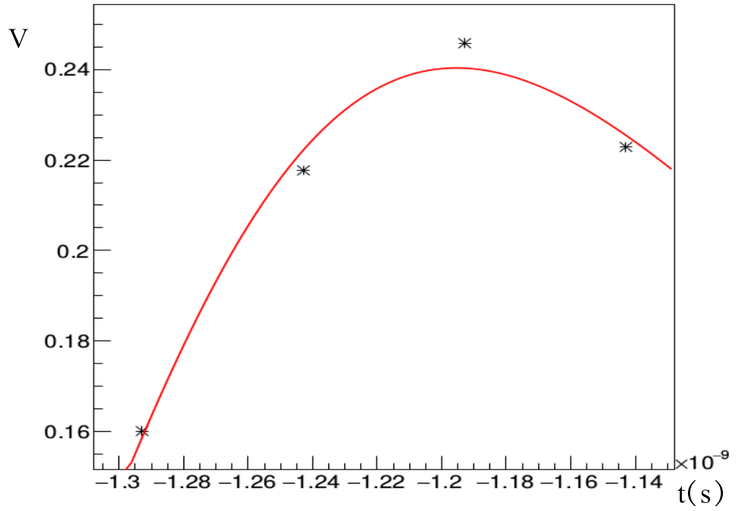


1) Noise estimation: gaus fit on the first 100 pt. (5 ns)
2) Offset correction
3) Landau fit around the maximum value in amplitude (4 pt.) and extrapolation of t_{MAX}
4) Landau fit (11 pt.) on the waveform rising
5) Extrapolation of t^{*}_{LGAD}

3D Waveform analysis



3)



1) Noise estimation: gaus fit on the first 100 pt. (5 ns)

2) Offset correction

3) Landau fit around the maximum value in amplitude (4 pt.)
and extrapolation of t_{MAX}

4) Linear fit (2 pt.) with the first point which crosses the threshold and the previous one

5) Extrapolation of t^{*}_{3D}

4)