Timing resolution on a 3D silicon pixel detector

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Outline

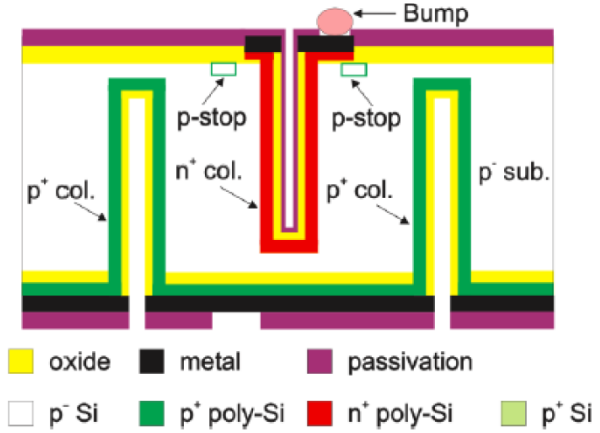
- 3D Pixel Sensor CNM Production
- Experimental Setup
- 3D Time resolution before and after irradiation

3D Pixel Sensor – CNM production

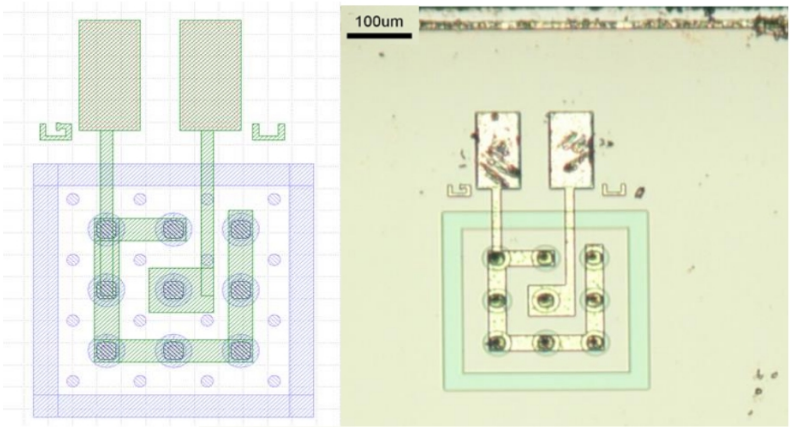
Features:

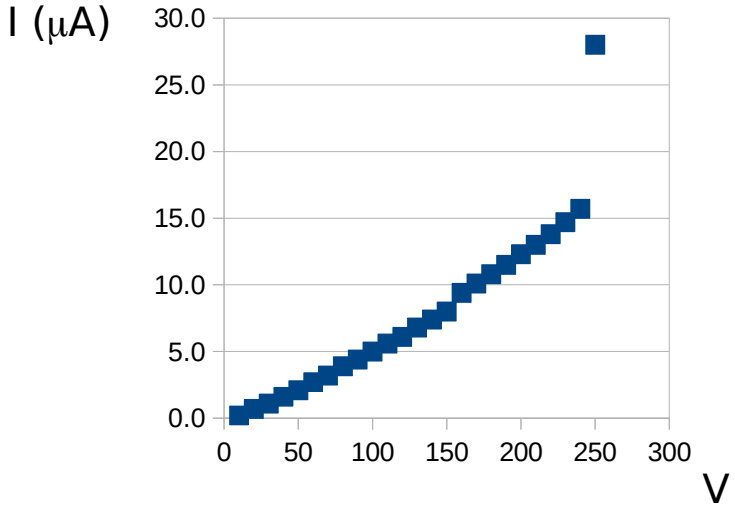
- thickness: 300 µm
- cell size: 50x50 µm^2
- p-type bulk resistivity: ~5kΩcm
- diameter holes: 8-10 µm

Schematic Cross Section



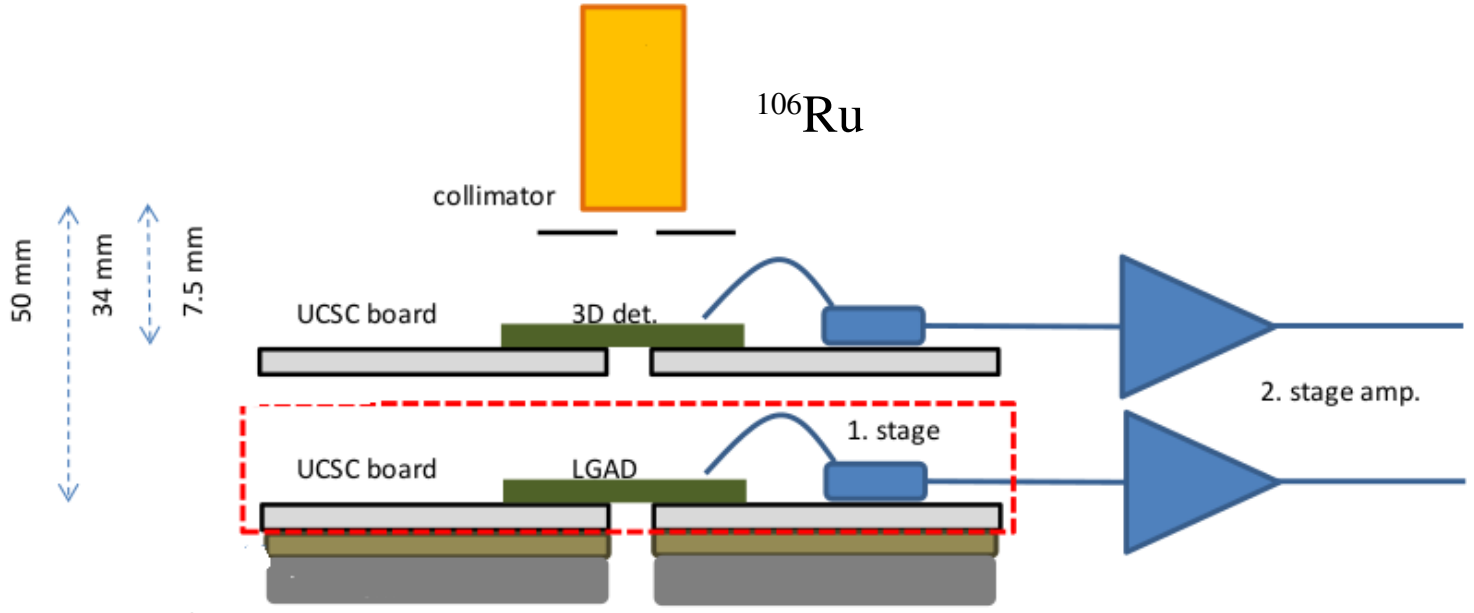
Design of a single cell structure





arXiv:1901.02538

Experimental Setup



Signals in coincidence are analyzed

Source: ^{106}Ru

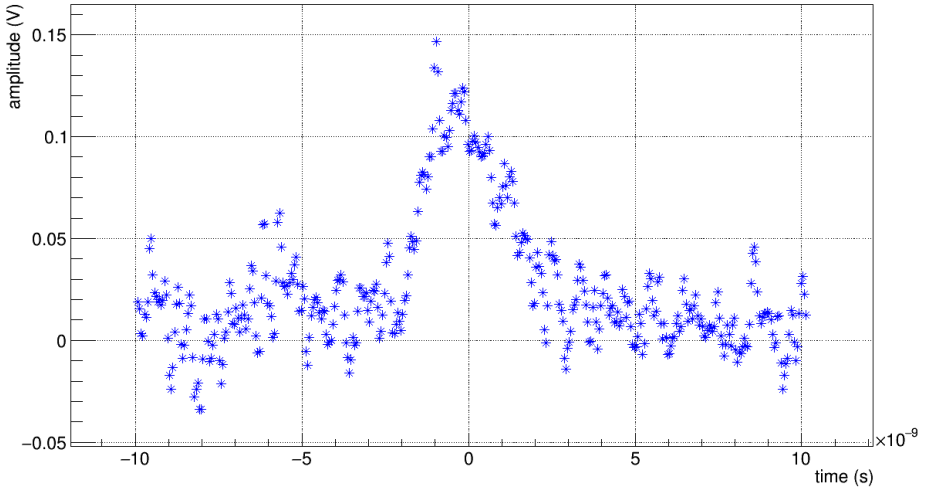
Board: Preamplified UCSC

LGAD: HPK50C - high gain 50 um thick (1 mm diameter)

Time resolution 39 ps (20°C) and 36 ps (-20°C)

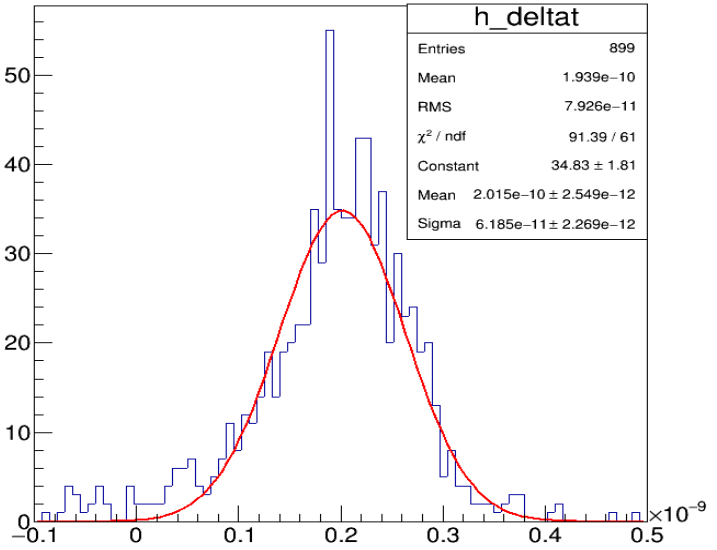
3D Waveform and analysis

3D Waveform



CFD method

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

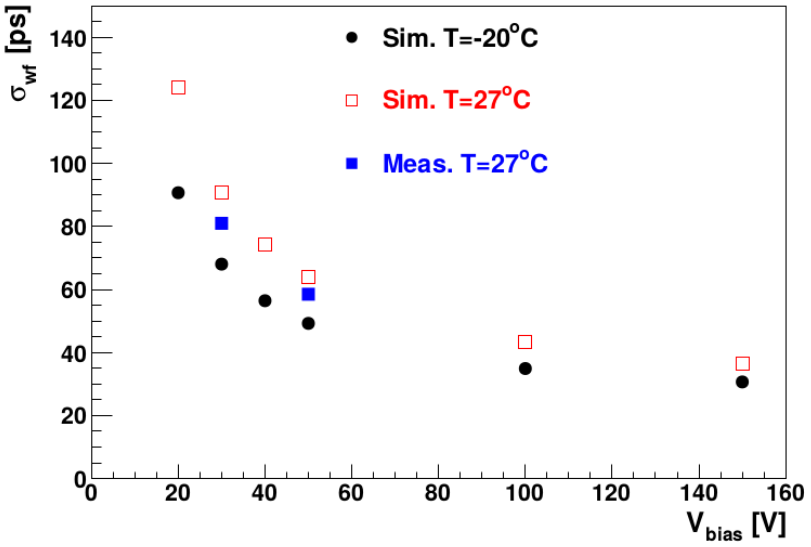


Fit on Δt to obtain: $\sigma_t = (\sigma^2_{LGAD} + \sigma^2_{3D})^{1/2}$

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

3D Time resolution measurement and simulation

Sim. And previous measurements



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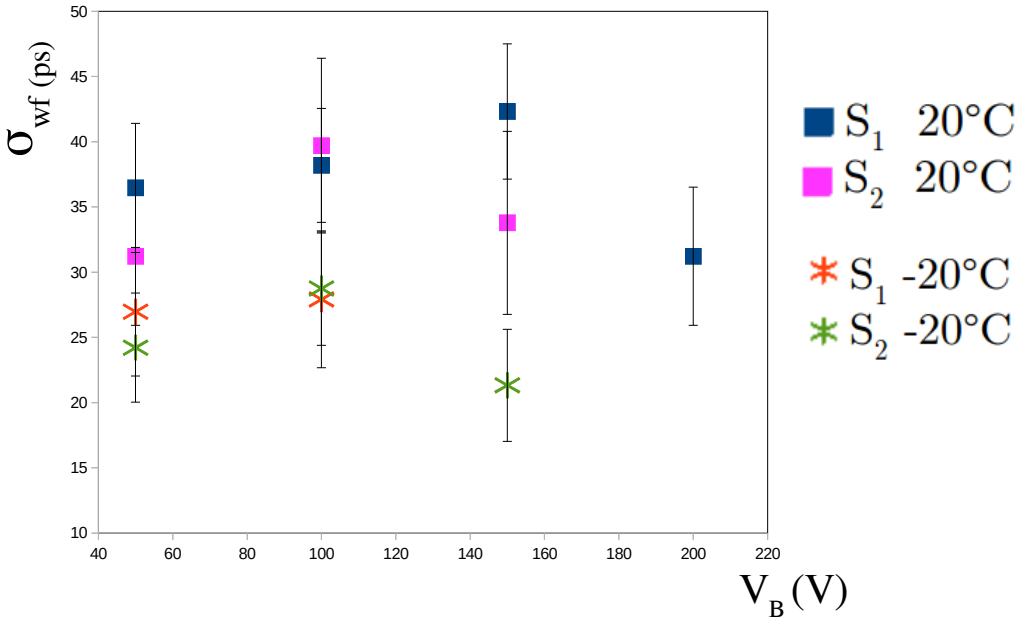
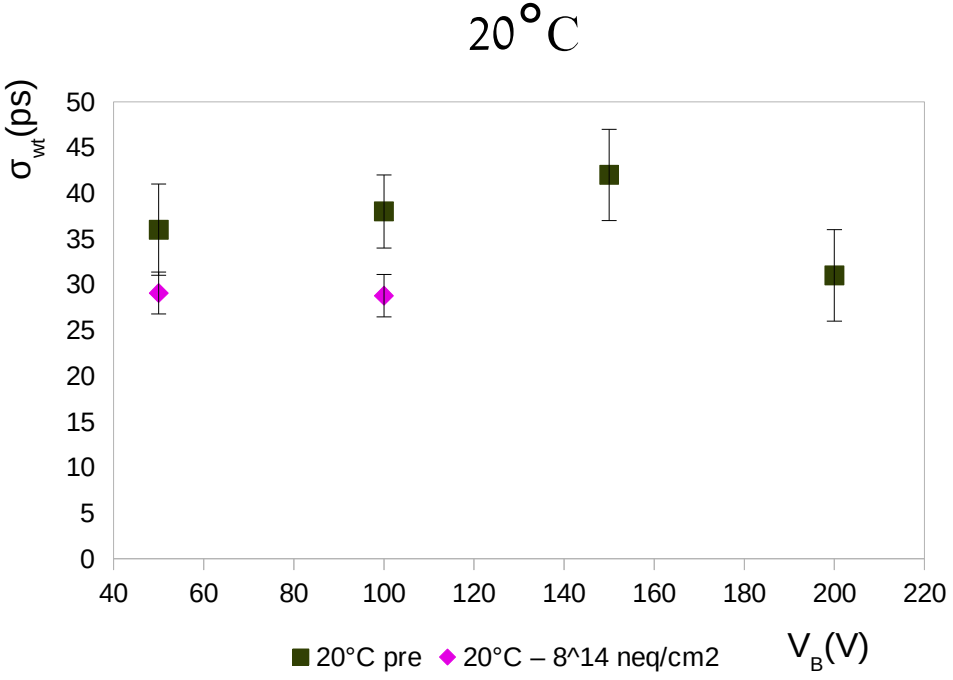
Measurements 2019

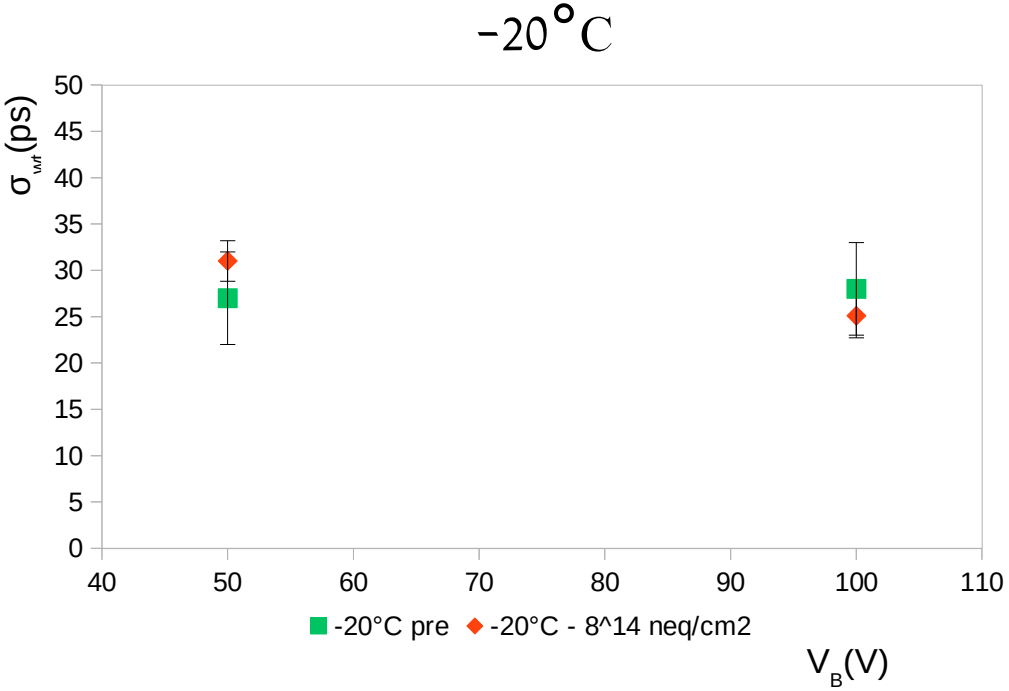


3D time resolution before and after neutron irradiation at 20°C and -20°C

Annealed 60 min at 80°C

Irradiated at 8×10^{14} n_{eq} at Ljubjiana





Conclusions

- We measured data for 3D detector at 50,100,150 V_B at 20°C and -20°C. At 100 V_B time resolution is around 40 ps for 20°C and 30 ps for -20°C
- After irradiation of $8x10^{14}$ n_{eq}/cm^2 the measurement is consistent with the pre-irradiated measurment.

Next step:

- Redo the measurments increasing the radiation dose

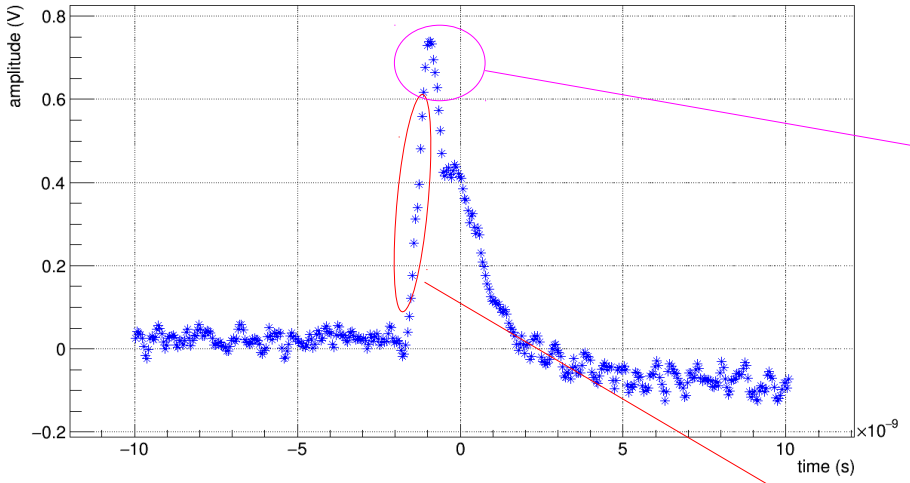
Backup

Jitter $\sigma_{j,3D}$

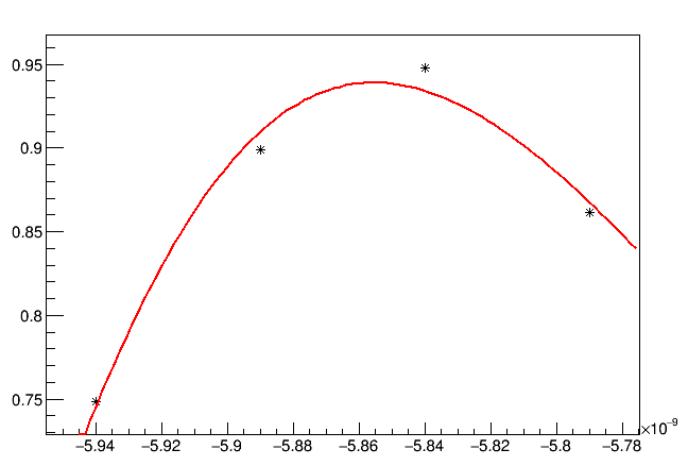
$\sigma^2_{3D}=\sigma^2_{j,3D}+\sigma^2_{tw}$ $\sigma^2_{tw}\sim\sigma^2_{wf}$ $\sigma^2_{wf}\approx\sigma^2_{3D}-\sigma^2_{j,3D}$ $\sigma^2_{j,3D}=N/(dV/dt)$

50 V	CFD(%)	N (mV)	dV/dt (mV/ps)	$\sigma_{j,3D}$(ps)
20 °C	30	16±3	4,2±0,3	38±8
-20 °C	40	16±3	3,9±0,2	41±8

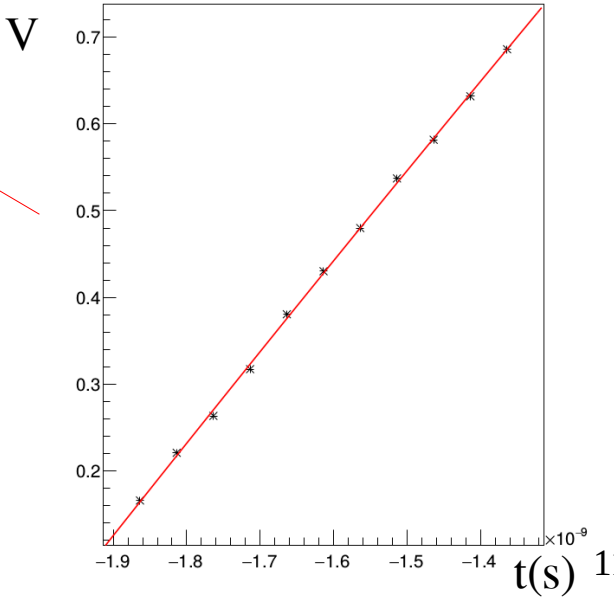
LGAD Waveform Analysis



3)



4)



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

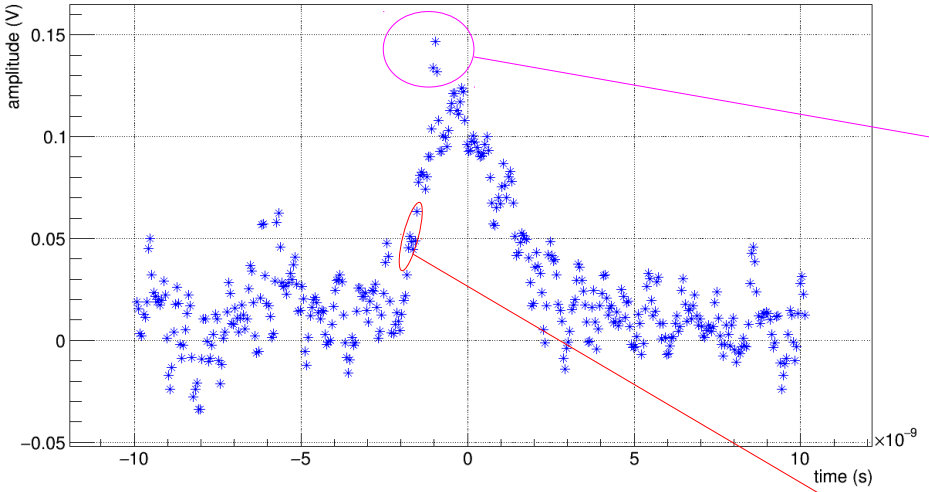
2) Offset correction

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

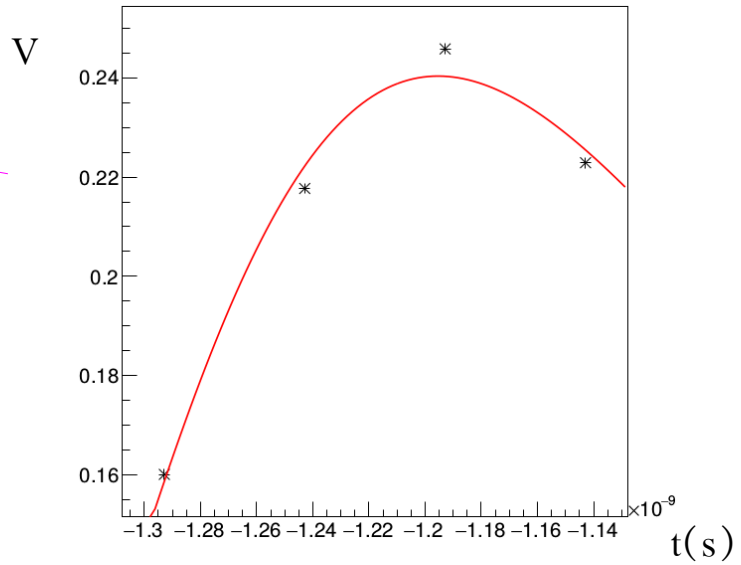
4) Landau fit (11 pt.) on the waveform rising

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)