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 μm²
- p-type bulk resistivity: ~5kΩcm
- diameter holes: 8~10 μm
Signals in coincidence are analyzed

Source: $^{106}\text{Ru}$
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

\[ \Delta t = t_{\text{LGAD}}^* - t_{\text{3D}}^* \]

\[ \sigma_t = \left( \sigma_{\text{LGAD}}^2 + \sigma_{\text{3D}}^2 \right)^{1/2} \]

\[ \sigma_{\text{wf}}^2 \approx \sigma_{\text{3D}}^2 - \sigma_{\text{j,3D}}^2 \]
3D Time resolution measurement and simulation

Sim. And previous measurements

Measurements 2019

arXiv:1901.02538
3D time resolution before and after neutron irradiation at 20°C and -20°C

Annealed 60 min at 80°C
Irradiated at 8x10^{14} \text{n}_{eq} at Ljubjiana

![Graphs showing 3D time resolution before and after neutron irradiation at 20°C and -20°C]
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 measurement.

Next step:

• Redo the measurements increasing the radiation dose.
Backup
### Jitter $\sigma_{j,3D}$

\[
\sigma_{j,3D}^2 = \sigma_{j,3D}^2 + \sigma_{tw}^2 \\
\sigma_{tw}^2 \sim \sigma_{wf}^2 \\
\sigma_{wf}^2 \approx \sigma_{3D}^2 - \sigma_{j,3D}^2 \\
\sigma_{j,3D}^2 = \frac{N}{(dV/dt)}
\]

<table>
<thead>
<tr>
<th></th>
<th>CFD(%)</th>
<th>$N$ (mV)</th>
<th>dV/dt (mV/ps)</th>
<th>$\sigma_{j,3D}$ (ps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 V</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 °C</td>
<td>30</td>
<td>16±3</td>
<td>4,2±0,3</td>
<td>38±8</td>
</tr>
<tr>
<td>-20 °C</td>
<td>40</td>
<td>16±3</td>
<td>3,9±0,2</td>
<td>41±8</td>
</tr>
</tbody>
</table>
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 $t_{\text{MAX}}$
4) Landau fit (11 pt.) on the waveform rising
5) Extrapolation of $t_{\text{LGAD}}$
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 $t_{\text{MAX}}$
4) Linear fit (2 pt.) with the first point which crosses the threshold and the previous one
5) Extrapolation of $t_3^{\text{D}}$