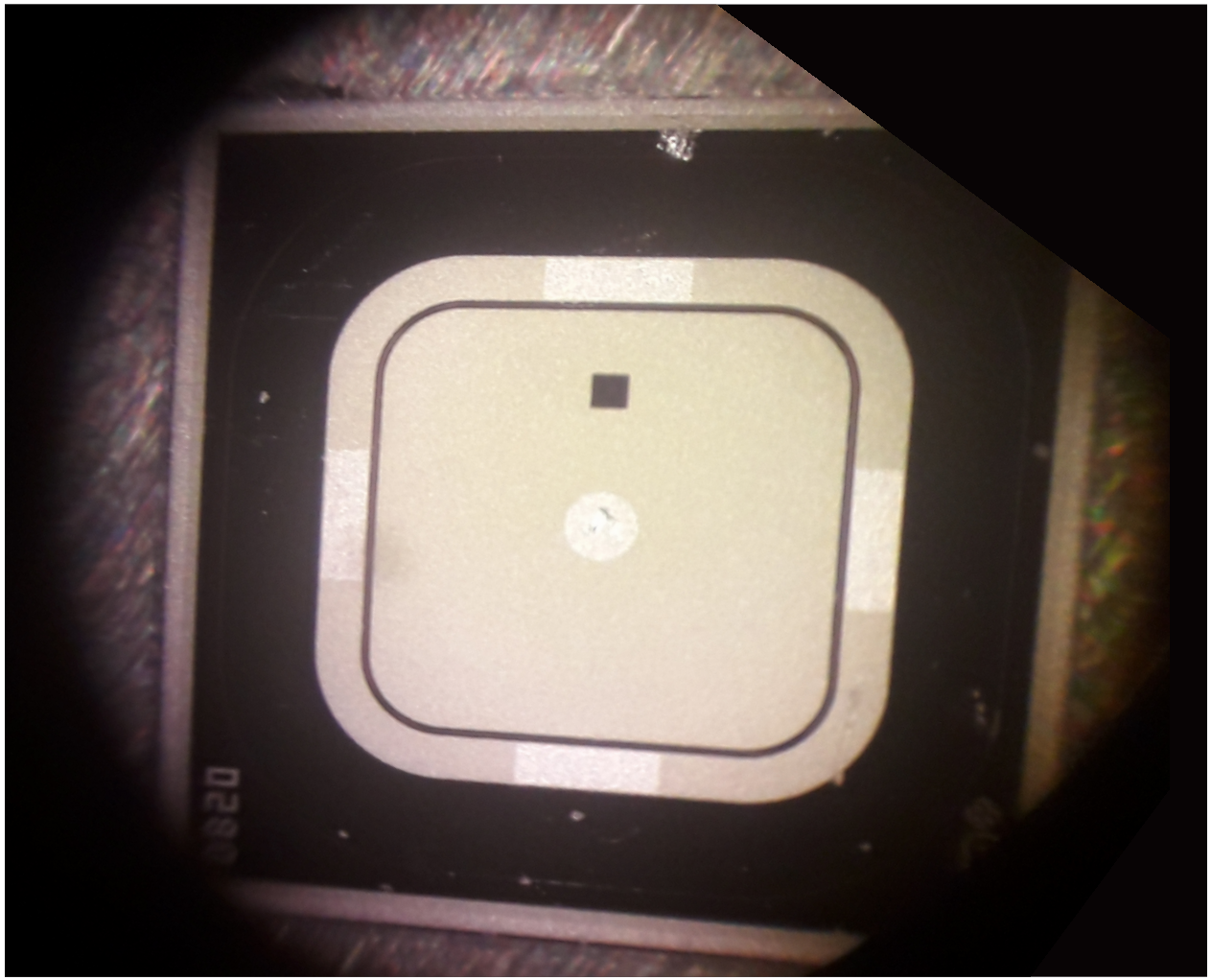
Timing resolution of the LGADs pads from a common AIDA2020 run produced at CNM

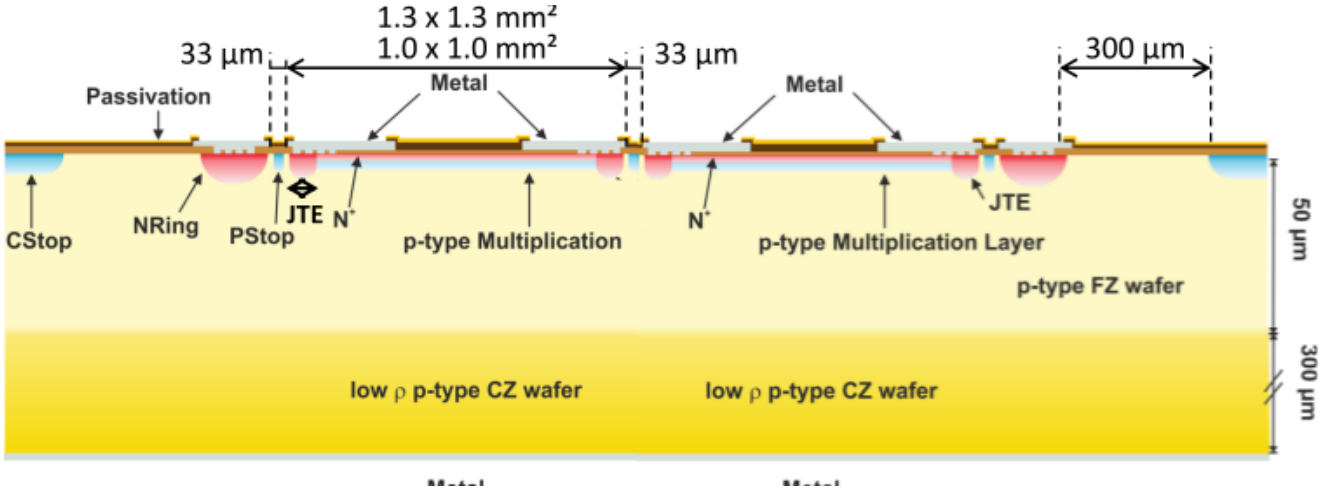


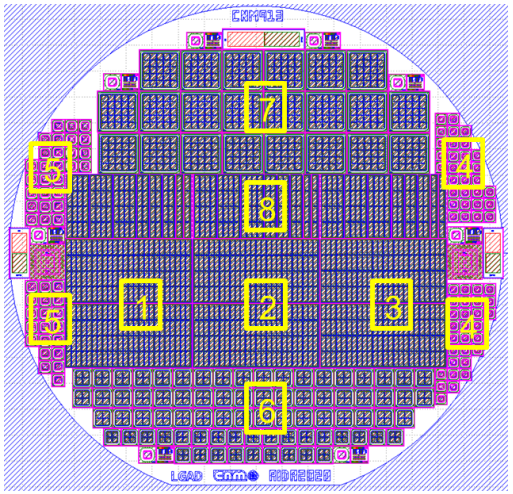
34th RD50 workshop (Lancaster)

Riccardo Del Burgo, A. Macchiolo, B. Kilminster, F. Canelli ,G. Pellegrini, I. Villa Alvarez, S. Hidalgo Villena

Structures

- The structures are from the AIDA-2020 run produced at CNM
- Single pads of two thickness: 50μm and 35 μm



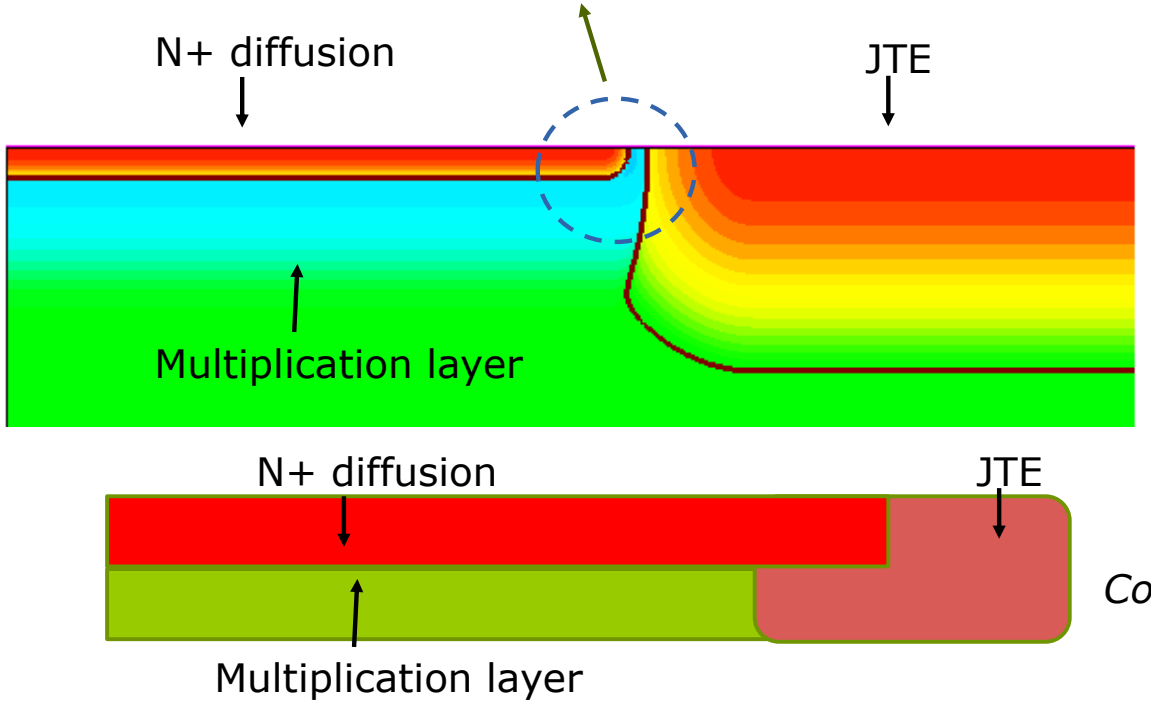


Two RD targets:

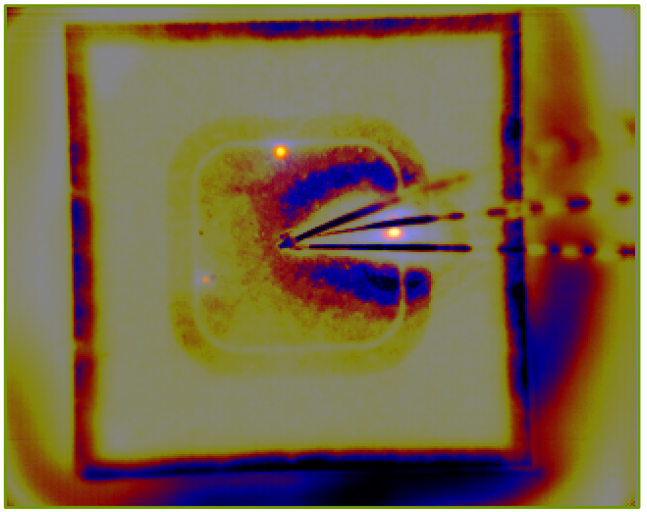
- Increase the radiation tolerance by reducing the active thickness up to 35um (mitigation of double-junction induced gain reduction)
- Increase the gain fill factor by reducing the width of JTE of the LGADs (reducing the inter-pad no-gain area)

High leakage current mechanism

- High current due to a mistake in the N+ mask level design
- 0.5 µm gap between N+ and JTE



Location of hot spots @ V_{AC} = 20 V



Amplitude image superimposed to average image

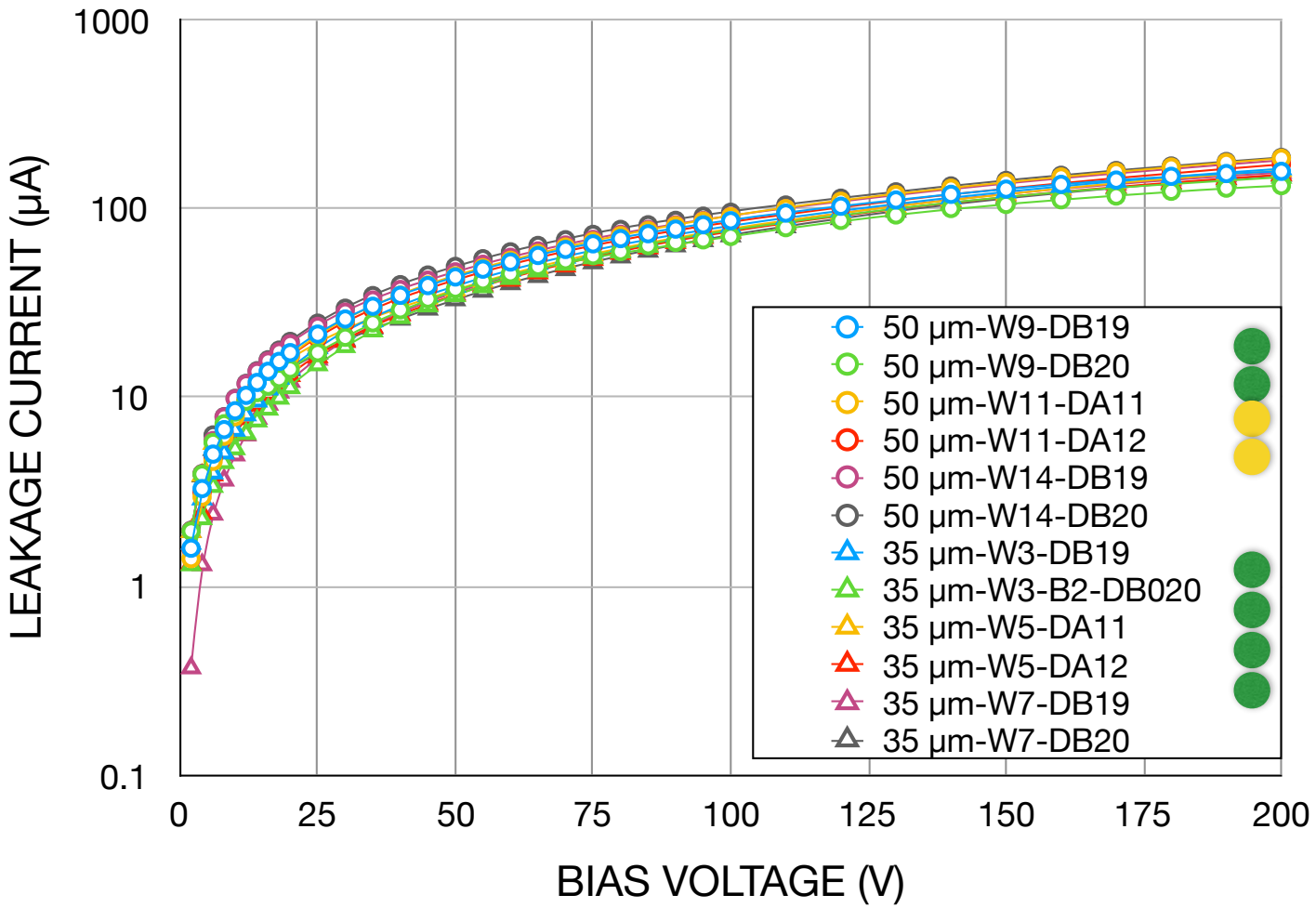
Current is not generated in the bulk, all other parameters (gain, breakdown voltage, capacitance, depletion voltage of the multiplication layer, surface current etc.) are OK

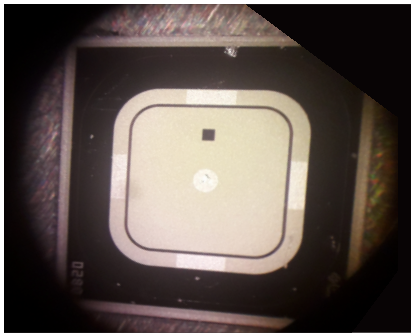
Structures tested (2)

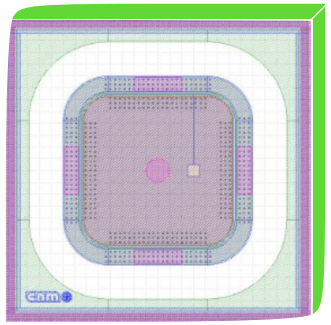
- ✓ 50 μm low gain
- ✗ 50 μm medium gain
- ✓ 35 μm low gain
- ✓ 35 μm medium gain
- 🕒 35 μm high gain
- 🕒 50 μm high gain

- All test at room temperature
- IV curves
- Timing resolution with Sr-90 source

IV curves

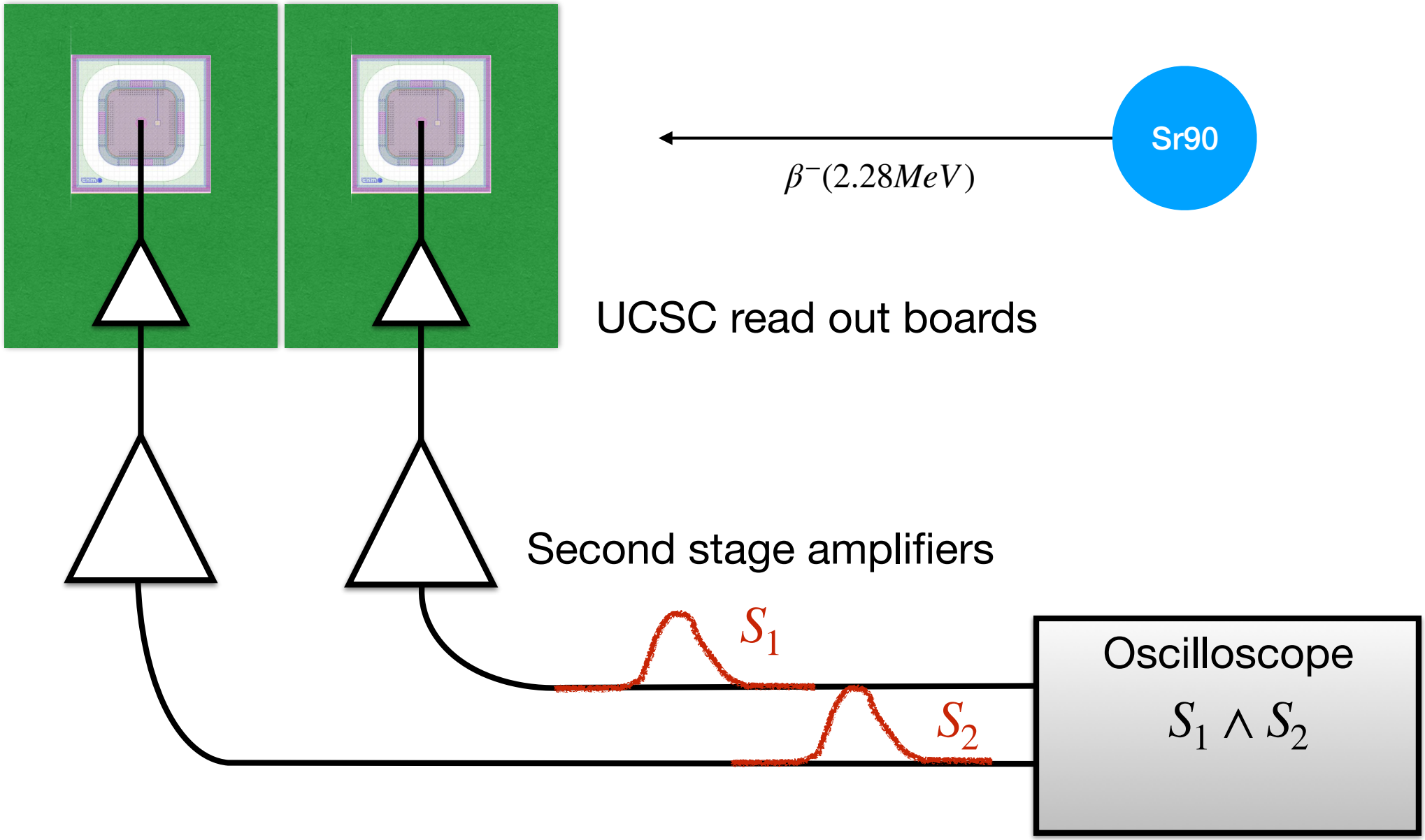




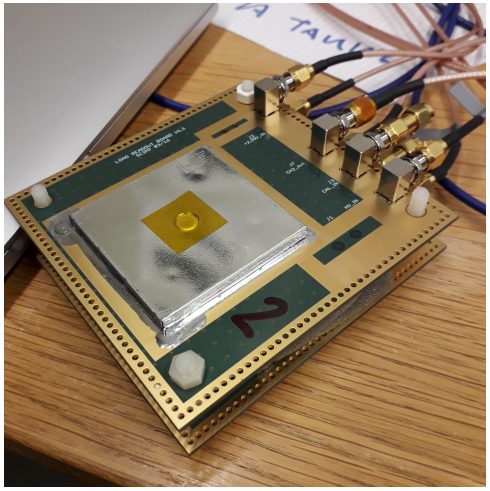


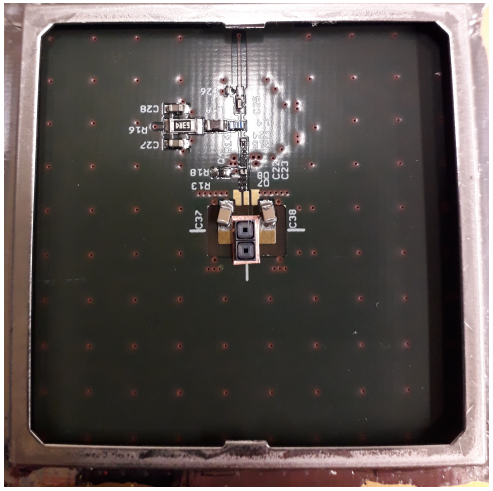
IV curves are quite similar and we do not really see a big spread. The high leakage current problem is common to all the structures (not present in PIN).

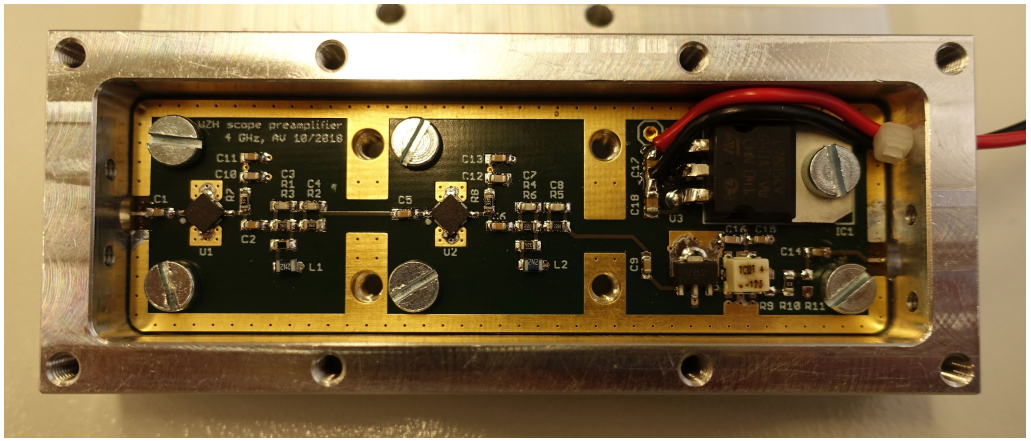
Timing setup



Timing setup (2)





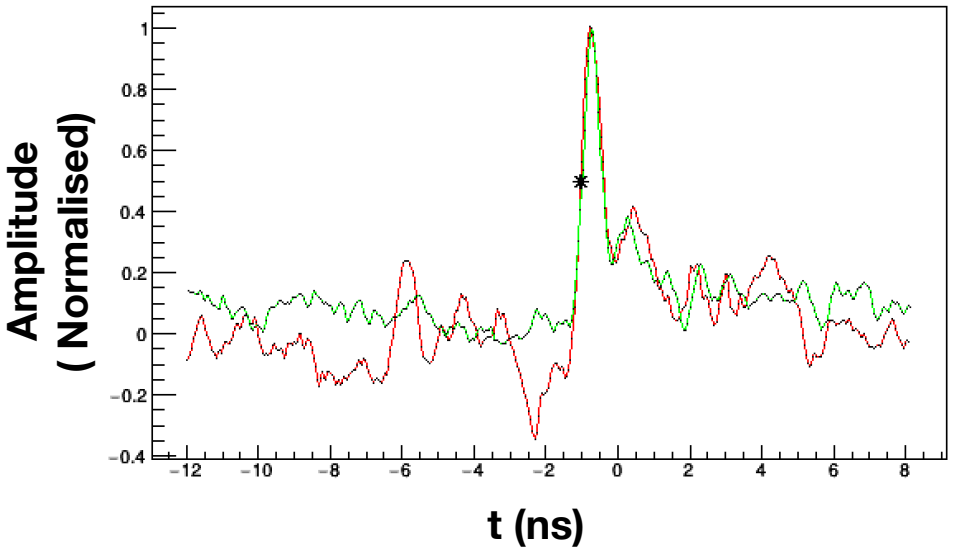


UCSC RO

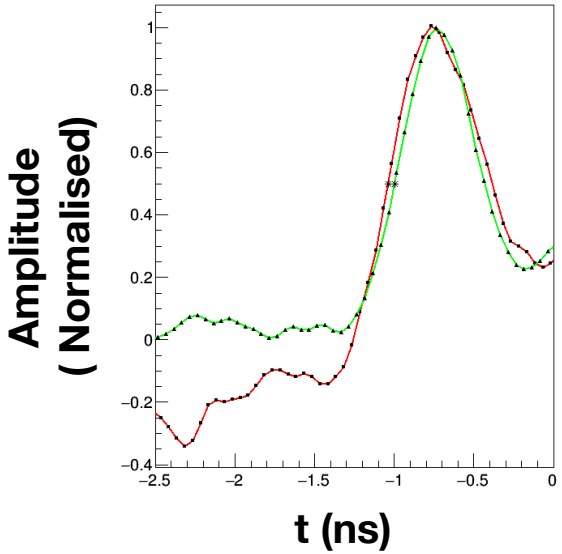
Sensor

Second stage amplifier

W3 35 µm LGAD @ 170 V



zoom



Timing measurement

CFD with different configurations:

- baseline removal event by event
- fixed baseline removal
- no baseline removal and amplitude computed between maximum and first minimum

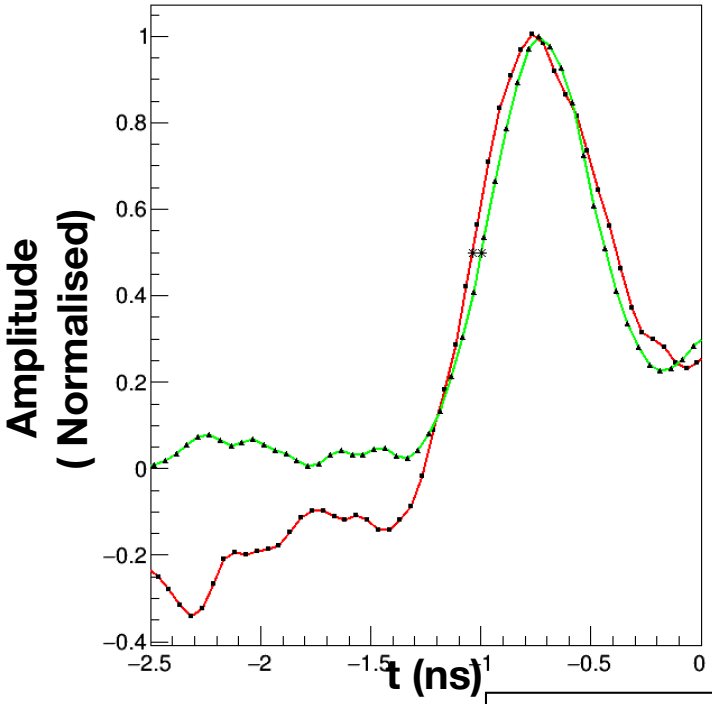
No significant difference observed using the 3 methods

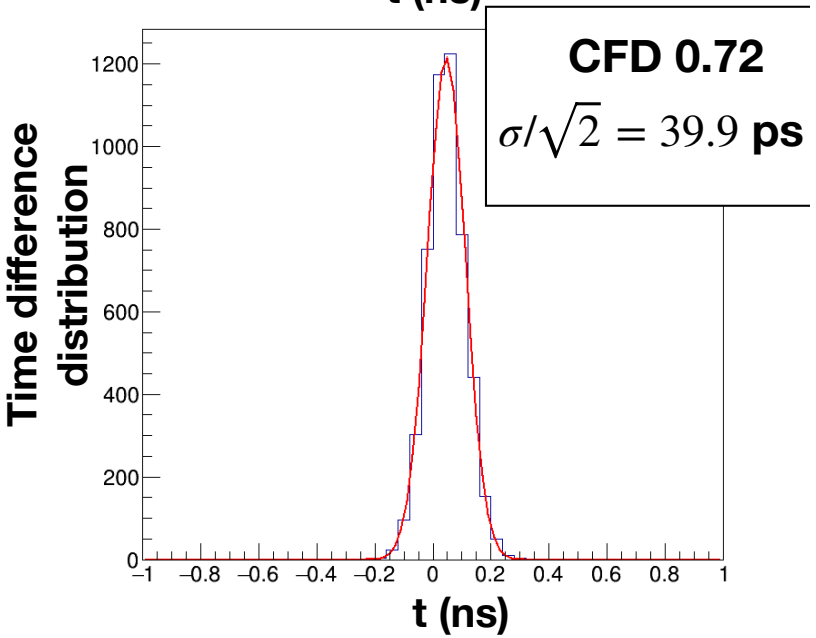
Basic quality cut on the waveform:

- risetime < 1 ns
- amplitude < (1.0) 1.4 V

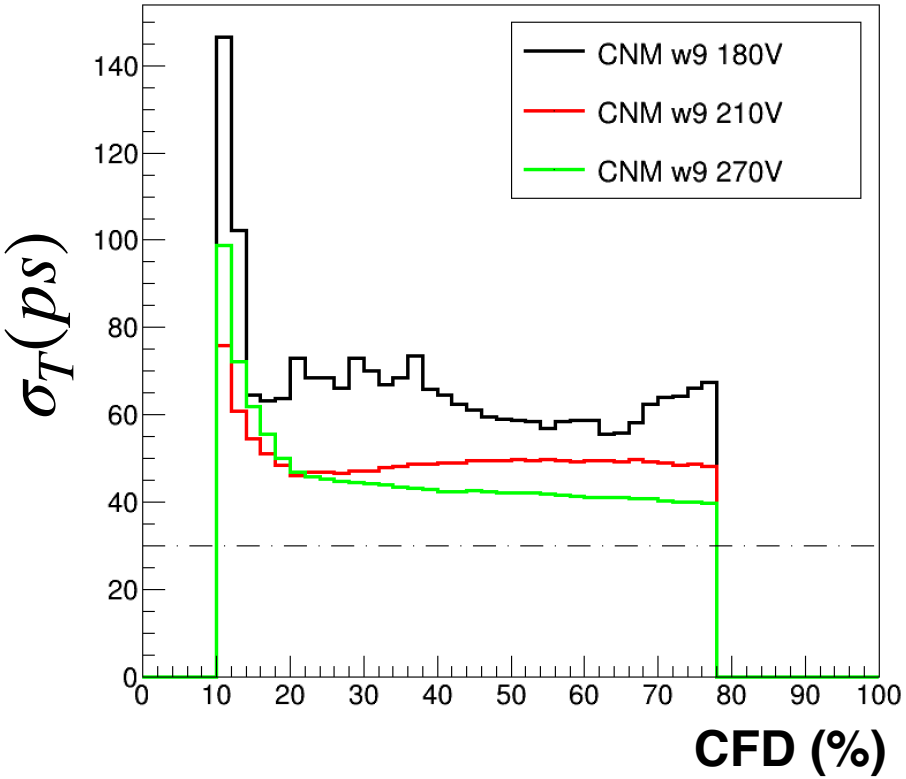
Test repeated for:

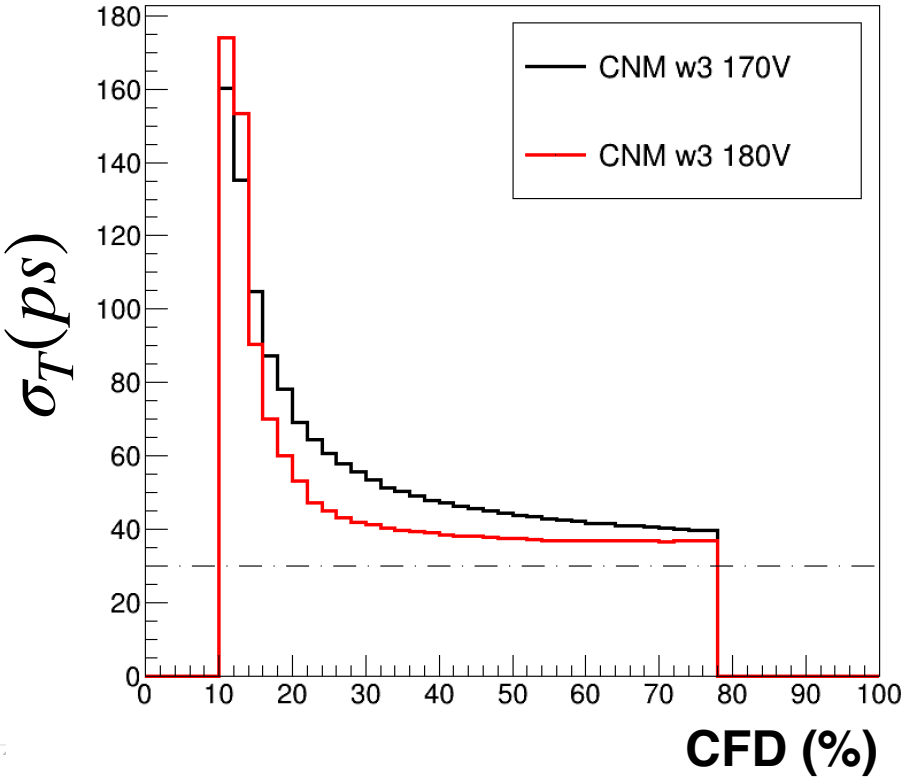
- different sensors
- as function of bias voltage





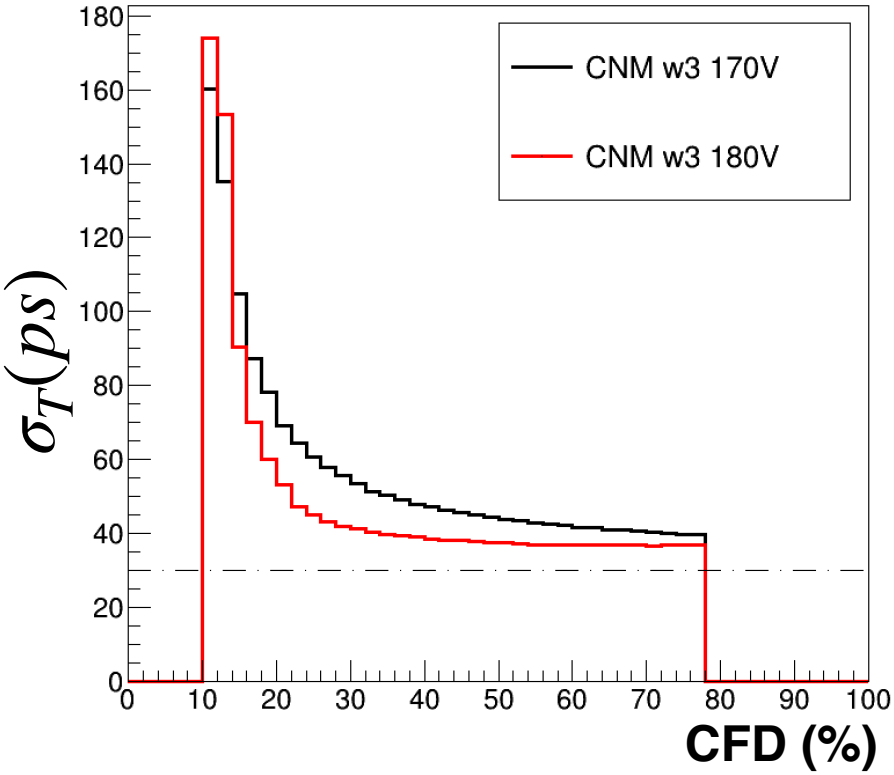
CNM W3 (35 μm, low gain)
CNM W9 (50 μm, low gain) @ 20°

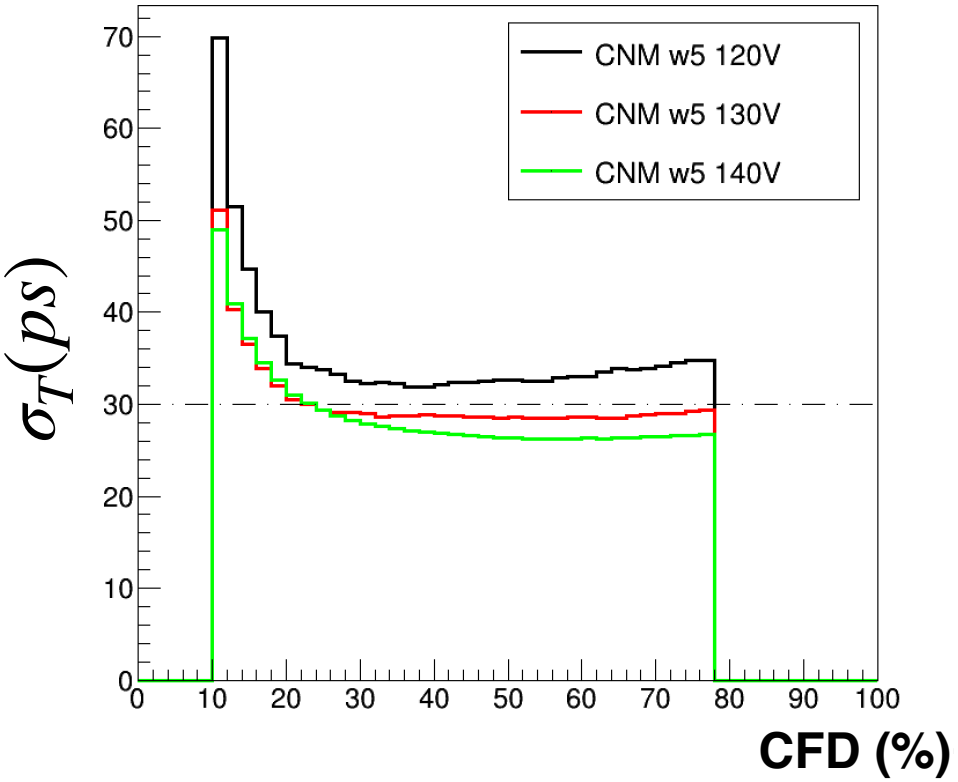




- Performances are quite similar
- The thinner sensors perform slightly better at lower voltage
- $W9\ \sigma_T = 40ps\,@\,260V, CFD = 0.5$
  $W3\ \sigma_T = 35ps\,@\,180V, CFD = 0.5$

CNM W3 (35 μm, low gain)
CNM W5 (35 μm, medium gain) @ 20°





- Medium gain sensors perform better
- Better S/N ratio help considerably
- $W5\ \sigma_T = 26ps @ 180V, CFD = 0.35$
- $W3\ \sigma_T = 35ps @ 140V, CFD = 0.5$

Conclusions & Future study

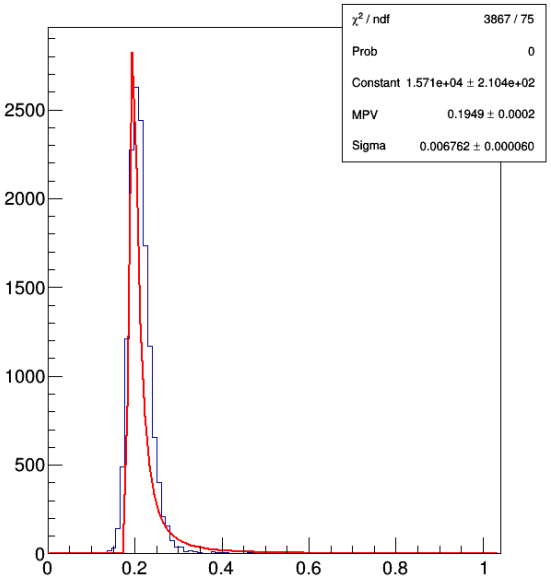
- Tested three couple of sensors:
- IV curves quite similar
- Time resolutions:
  - low gain 50 μm $W9\ \sigma_T = 40ps @ 260V, CFD = 0.5$
  - low gain 35 μm $W3\ \sigma_T = 35ps @ 140V, CFD = 0.5$
  - medium gain 35 μm $W5\ \sigma_T = 26ps @ 180V, CFD = 0.35$

- Studying characteristics as function of gain and temperature.
- Sensors irradiation

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654168

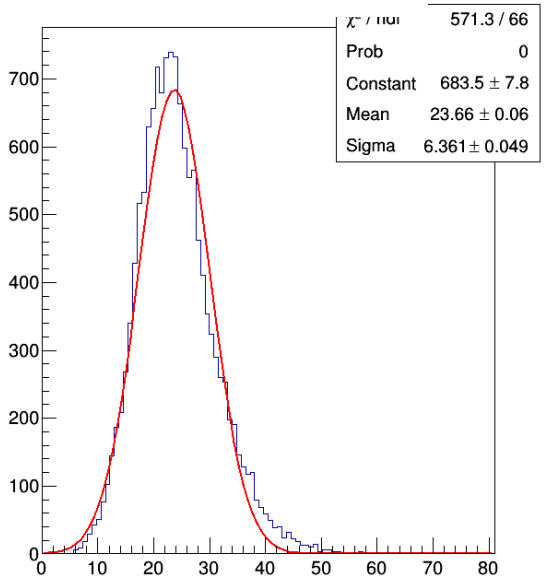
Risetime S/N and amplitude (W5 140V)

Risetime



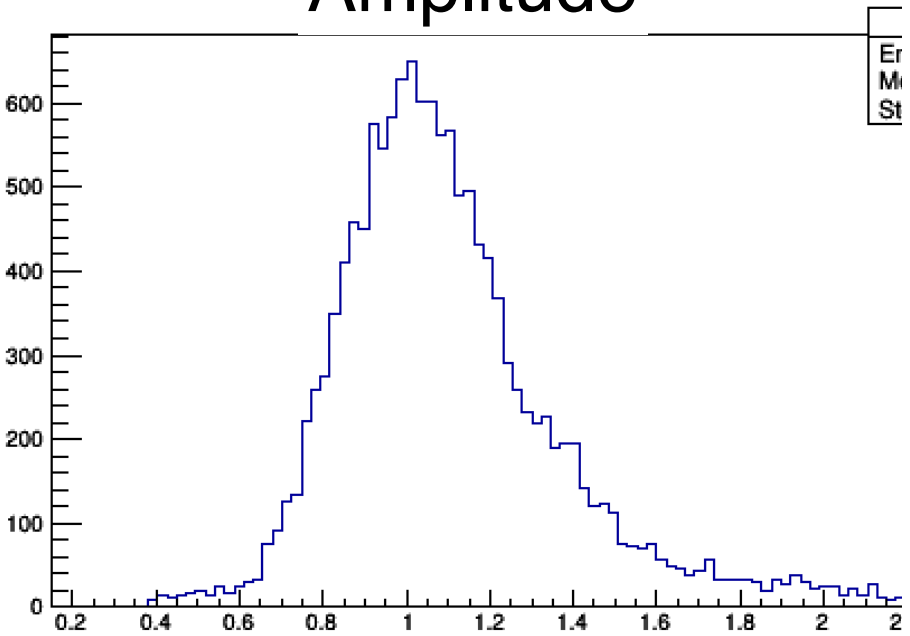
t(ns)

S/N



au

Amplitude

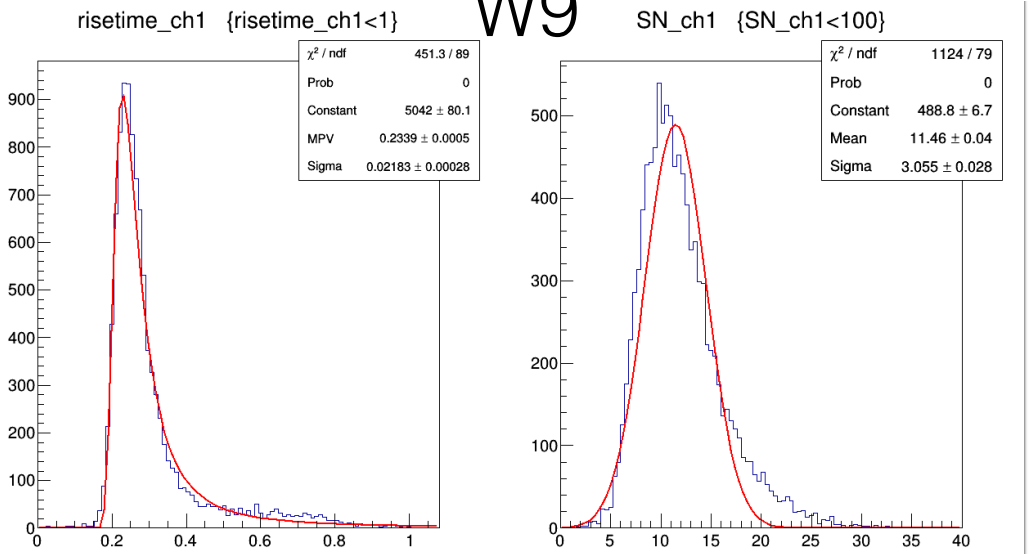


amplitude(V)

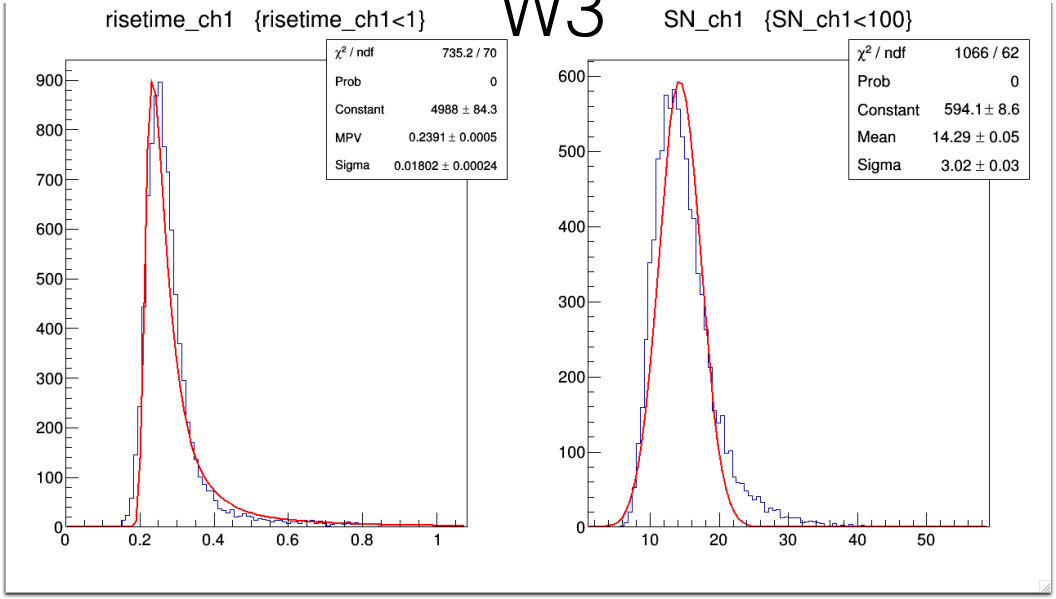
W5	rms (mV)		amplitude (mV)		rise time (ps)		S/N	
bias	ch1	ch2	ch1	ch2	ch1	ch2	ch1	ch2
120	24 (8)	27 (7)	623	650	200 (1)	215 (1)	27	28
130	26 (5)	28 (5)	820	850	197 (1)	212 (1)	28	32
140	47 (15)	35 (9)	1010	970	194 (1)	193 (1)	24	30

S/N and Risetime

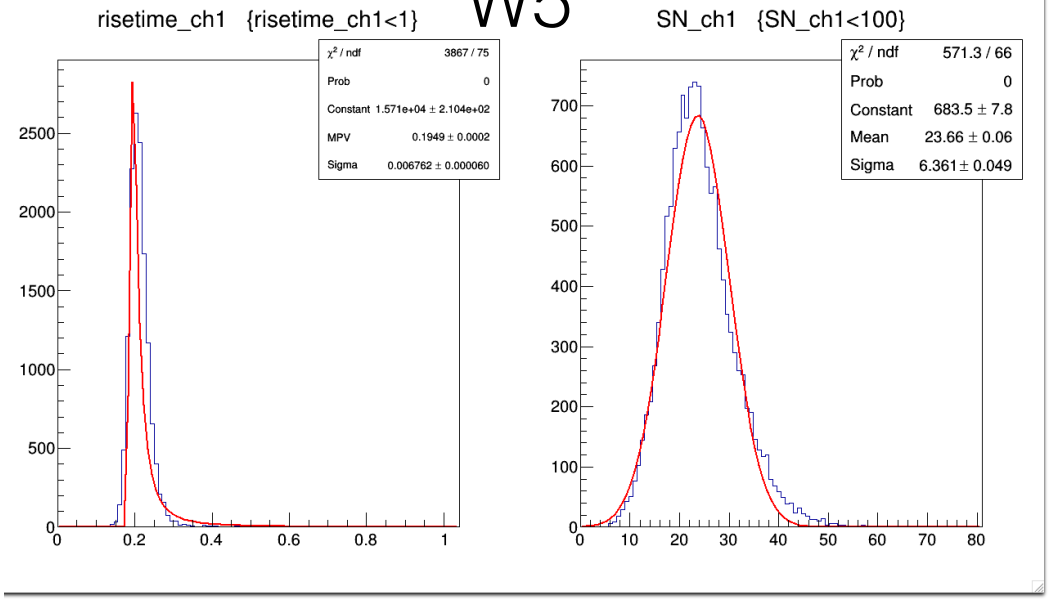
W9



W3



W5

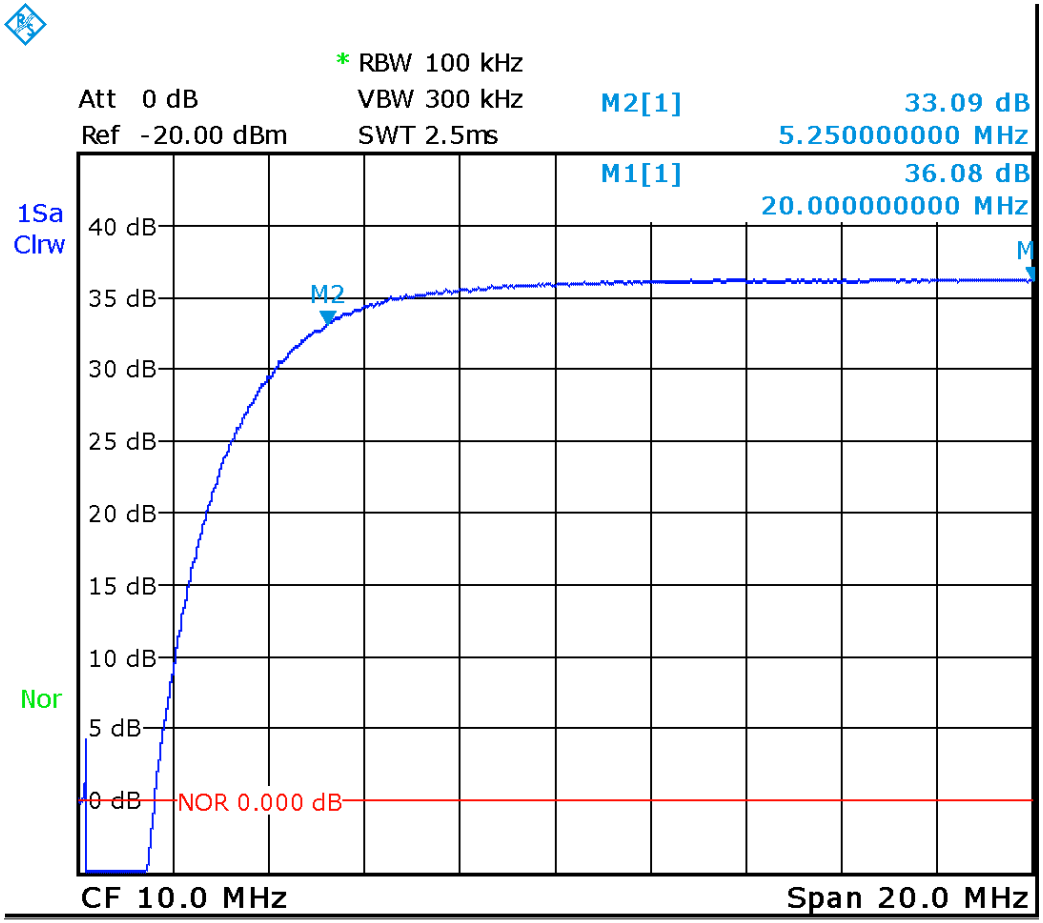


VS Bias voltage

W3	rms (mV)		amplitude (mV)		rise time (ps)		S/N	
bias	ch1	ch2	ch1	ch2	ch1	ch2	ch1	ch2
170	58 (13)	31 (6)	538	586	235 (69)	234 (5)	9.9	20
180	62 (13)	35 (7)	697	742	233 (4)	230 (4)	12	22

W5	rms (mV)		amplitude (mV)		rise time (ps)		S/N	
bias	ch1	ch2	ch1	ch2	ch1	ch2	ch1	ch2
120	24 (8)	27 (7)	623	650	200 (1)	215 (1)	27	28
130	26 (5)	28 (5)	820	850	197 (1)	212 (1)	31	32
140	47 (15)	35 (9)	1010	970	194 (1)	193 (1)	24	30

Second stage amplifier response



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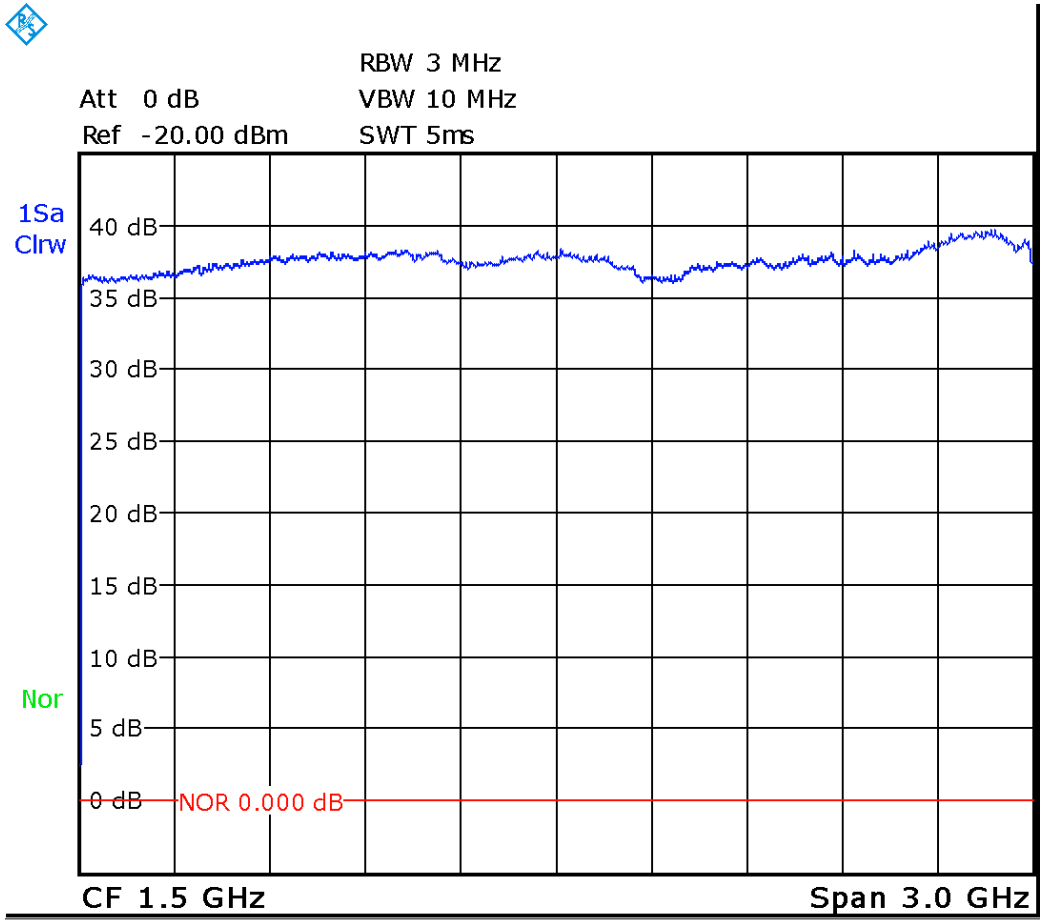

Date: 14.MAY.2019 12:28:01

3-stage amplifier with two Mini-Circuits LEE39 (low noise) followed by a GVA-82 (high dynamic range)