Status at IMB-CNM-CSIC

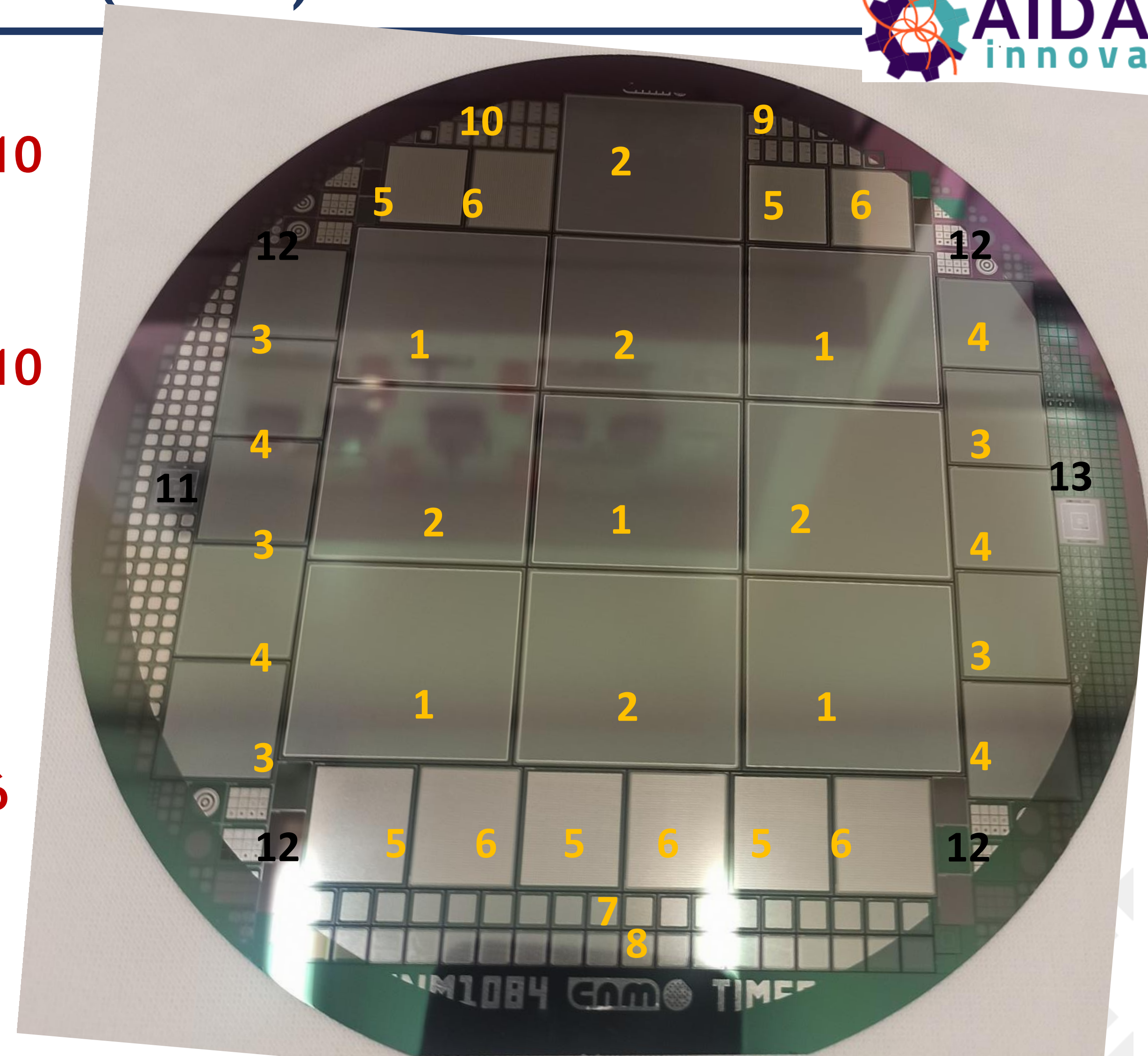
3rd meeting, Catania 18-21 MARCH 2024

Current Status of the CNM AidaInnova Runs

Run	Description	Clean Room Step
15543	150 mm **Timepix4 PiN**, Si (300 µm), 6PN1. **AidaInnova WP3**	Production Completed (Waiting for UBM)
16421	100 mm **Timepix3 Trench iLGAD**, Epitaxial wafers, 4iLG3. **Engineering Run**. **RD50**. **AidaInnova WP6**	Production Completed (Electrical Characterization)
	100 mm **Timepix3 Trench iLGAD**, Si-Si wafers, 4iLG3. **Engineering Run**. **RD50**. **AidaInnova WP6**	Production Completed (Electrical Characterization)
-	100 mm **Timepix4 Trench iLGAD**, Epitaxial and Si-Si wafers, 4iLG3. **AidaInnova WP6**	Mask arrived CNM1202 Mask Set
16069	100 mm **3D-DS Timing**, Si (285 µm), 240 µm depth columns, 10 µm columns diameter. **RD50**	Production Completed (test beam)
-	100 mm 3D timing 285um thick wafers **AidaInnova WP6**	Mask design

Timepix4. PiN (6PN1)

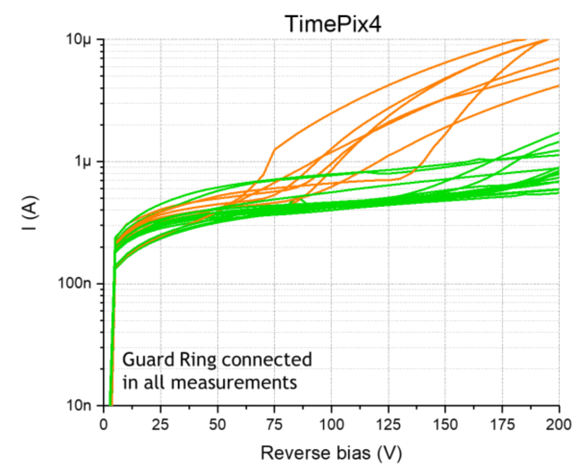
- Designed Structures
  - **Timepix4** (55x55 µm pitch, 512x448 pixels): **10**
    - Passivation Opening for Bump Pad 20 µm
    - A-type: 1 Guard Ring **(1)**
    - B-type: 4 Guard Rings **(2)**
  - **Timepix3** (55x55 µm pitch, 256x256 pixels): **10**
    - Passivation Opening for Bump Pad 20 µm
    - A-type : 1 Guard Ring **(3)**
    - B-type : 4 Guard Rings **(4)**
  - **TDCpix** (300x300 µm pitch, 40x45 pixels): **10**
    - Passivation Opening for Bump Pad 20 µm
    - A-type : 1 Guard Ring **(5)**
    - B-type : 4 Guard Rings **(6)**
  - **UZH-PSI** (100x100 µm pitch, 30x30 pixels): **36**
    - Passivation Opening for Bump Pad 12 µm
    - A-type : 1 Guard Ring **(7)**
    - B-type : 4 Guard Rings **(8)**
  - **Strips** (80 µm pitch, 20 strips): **22**
    - A-type : 1 Guard Ring **(9)**
    - B-type : 4 Guard Rings **(10)**

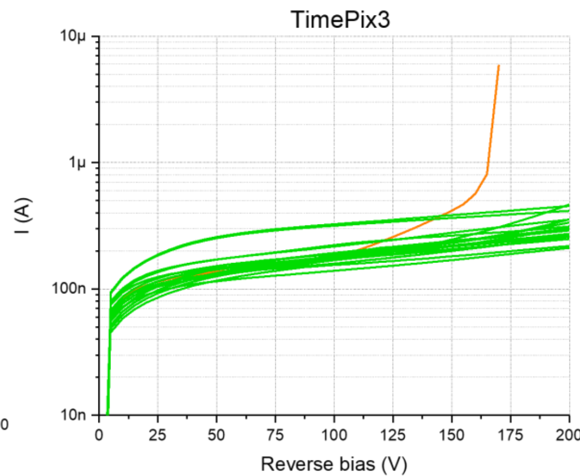


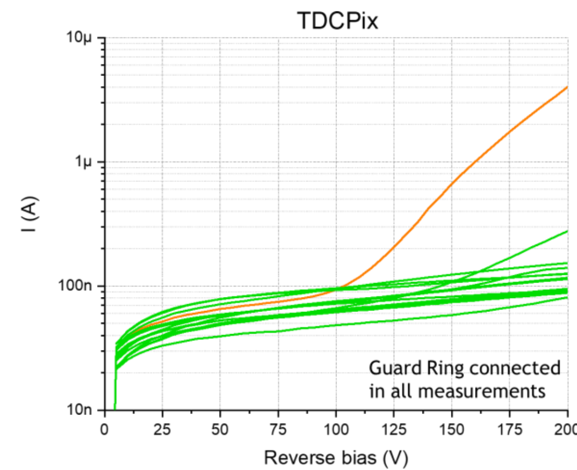
New run with iLGAD to start soon, see next slides

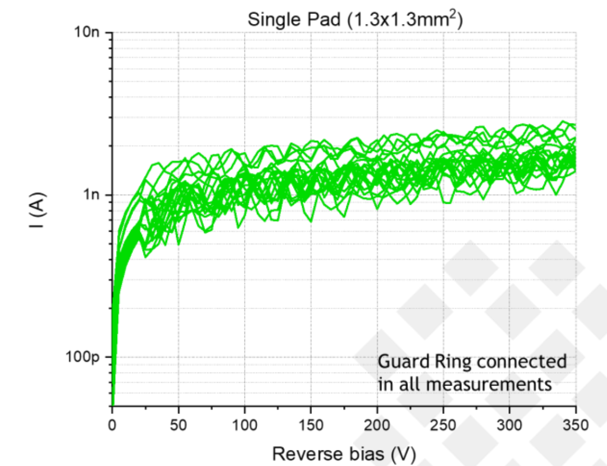
Current Status

- Detectors measured with temporary metal.
- Very good yield .
- Detectors ready since January 2023, waiting for UBM and flip chipping to be done by Aidainnova partners



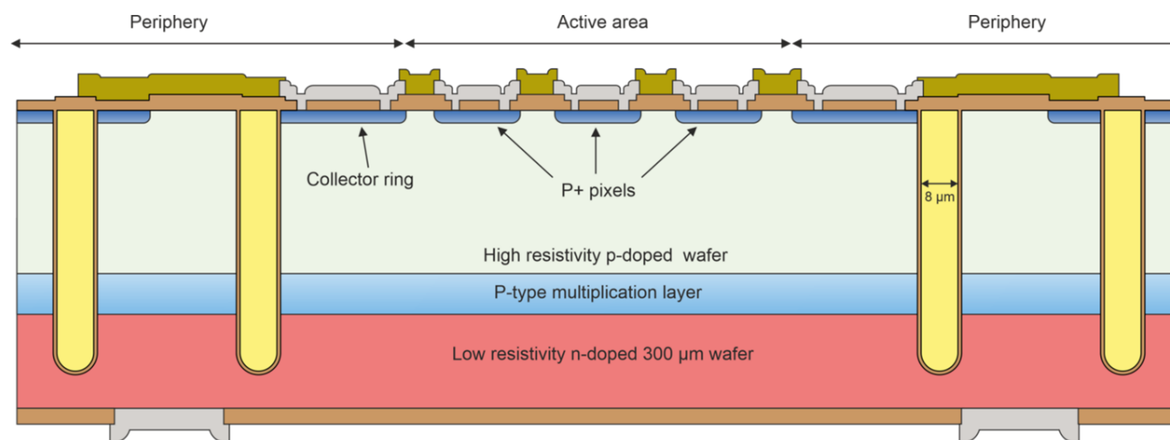




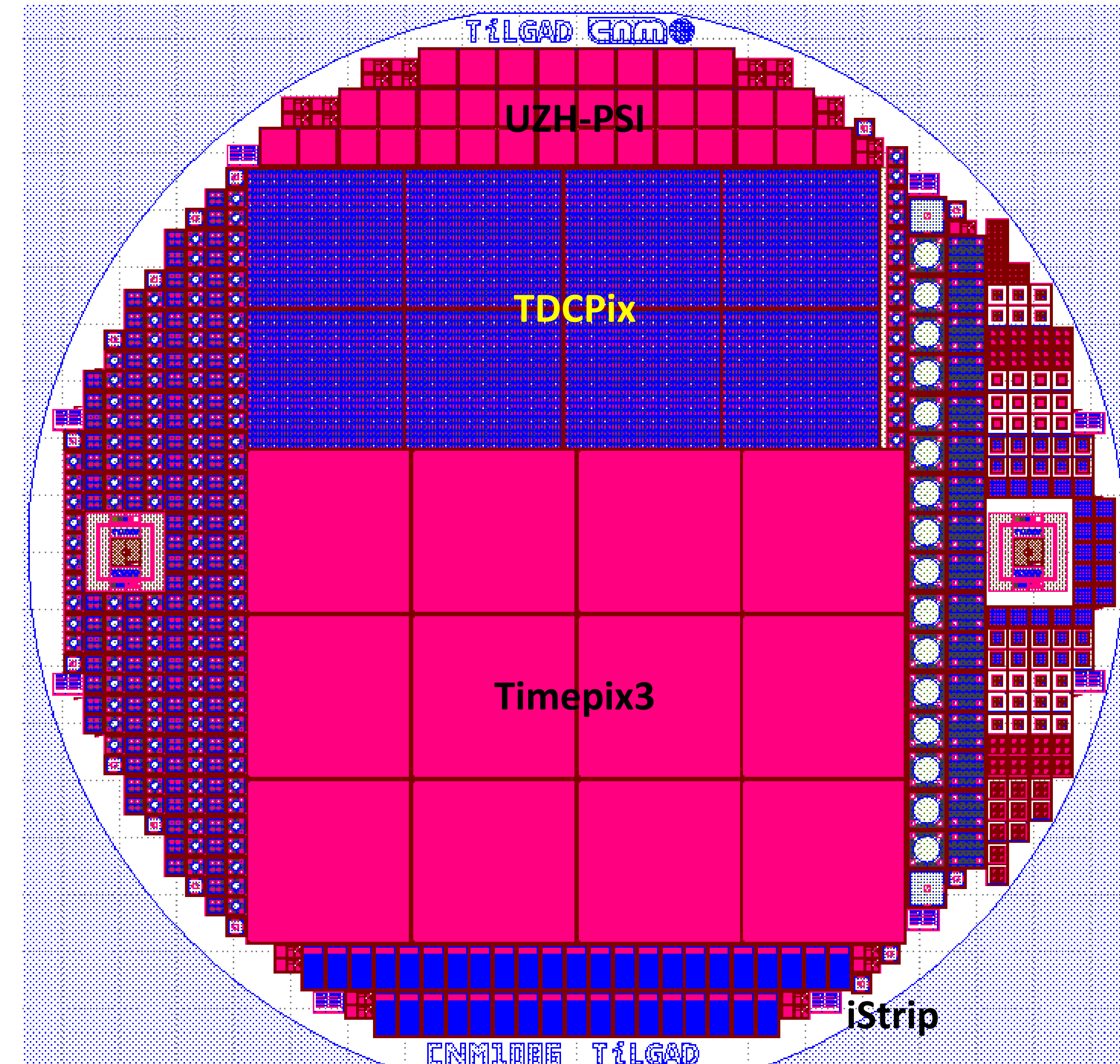


iLGAD Third Generation (4iLG3). Engineering Run 16421

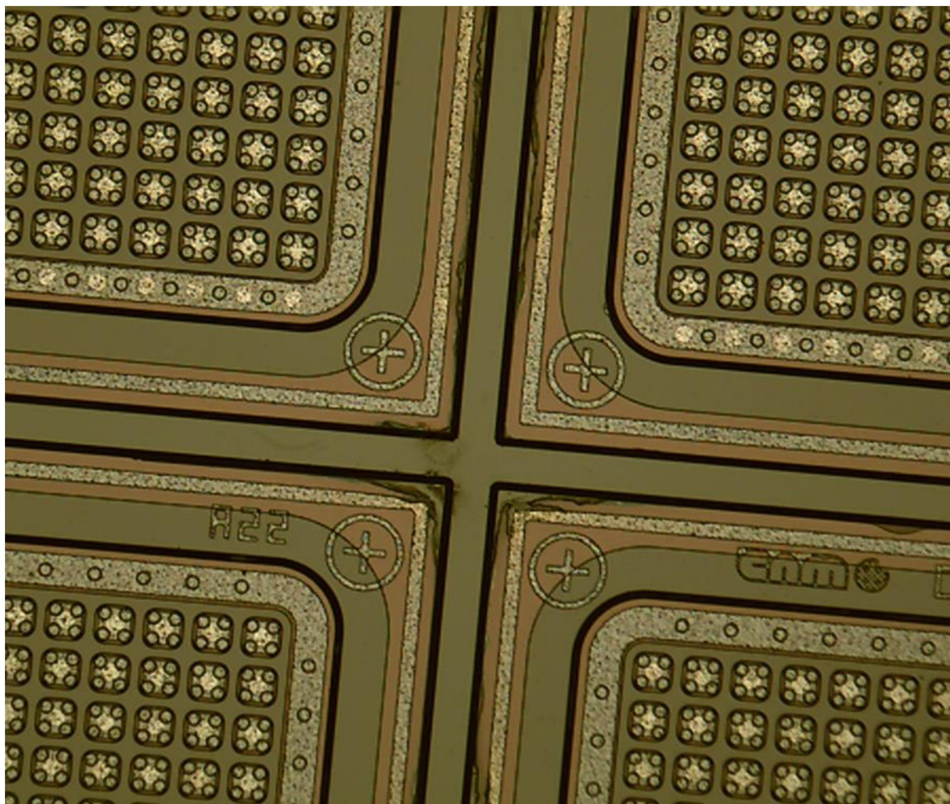
- **Run16421: 6 Wafers**, 100 mm, CNM1086 Mask Set
  - **3 wafers: Epitaxial Wafers** (50/515 µm)
  - **3 wafers: Si-Si Wafers** (50/350 µm)
- **TimePix3.** 55x55 µm pitch, 256x256 pixels: **12 devices**
- **TDCPix.** 300x300 µm pitch, 40x45 pixels: **8 devices**
- **UZH-PSI.** 100x100 µm pitch, 30x30 pixels: **36 devices**
- **iStrip.** 80 µm pitch, 20 strips: **40 devices**
- **Pad and Nikhef Test Devices** to fill the gaps

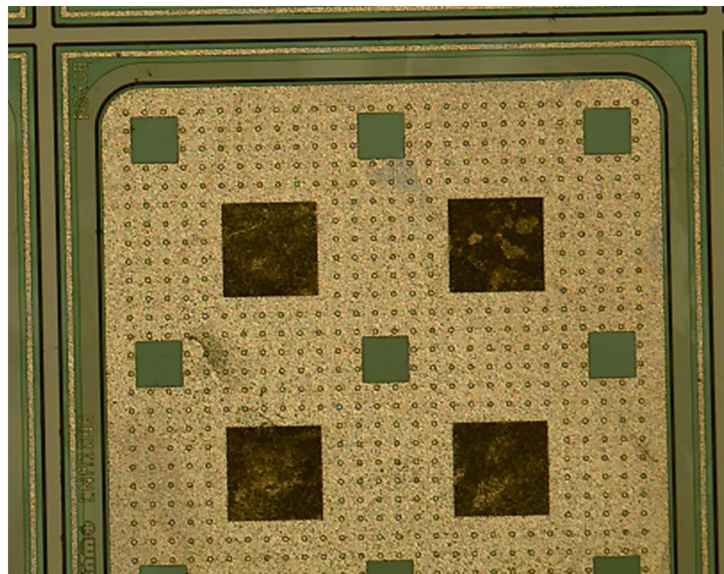


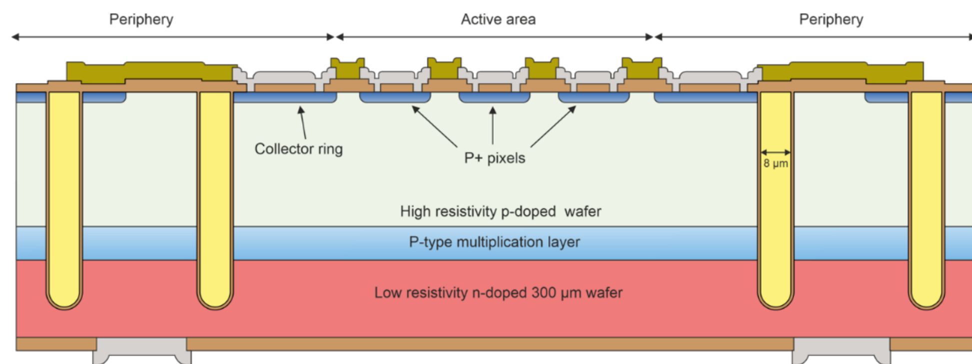
Wafer Layout

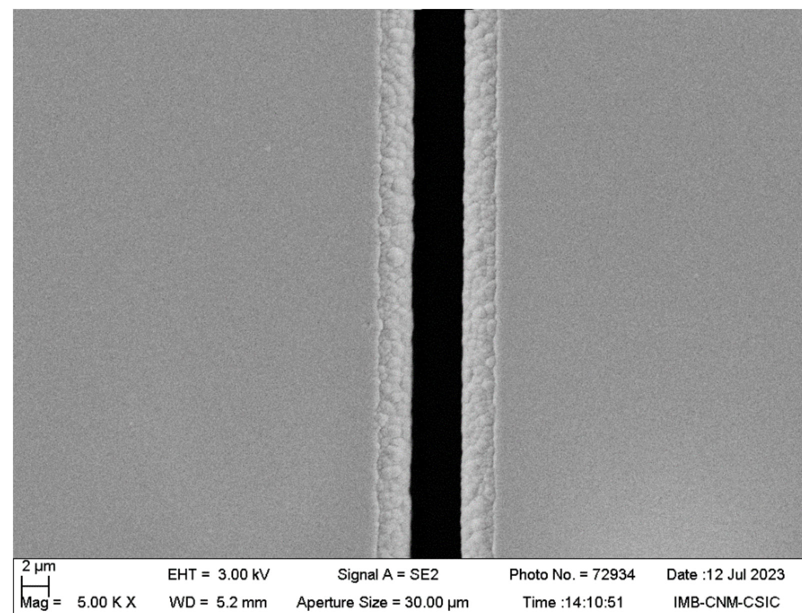


iLGAD Third Generation (4iLG3). Engineering Run 16421









iLGAD - SEN EPI

High Resistivity P type substrate (Boron)

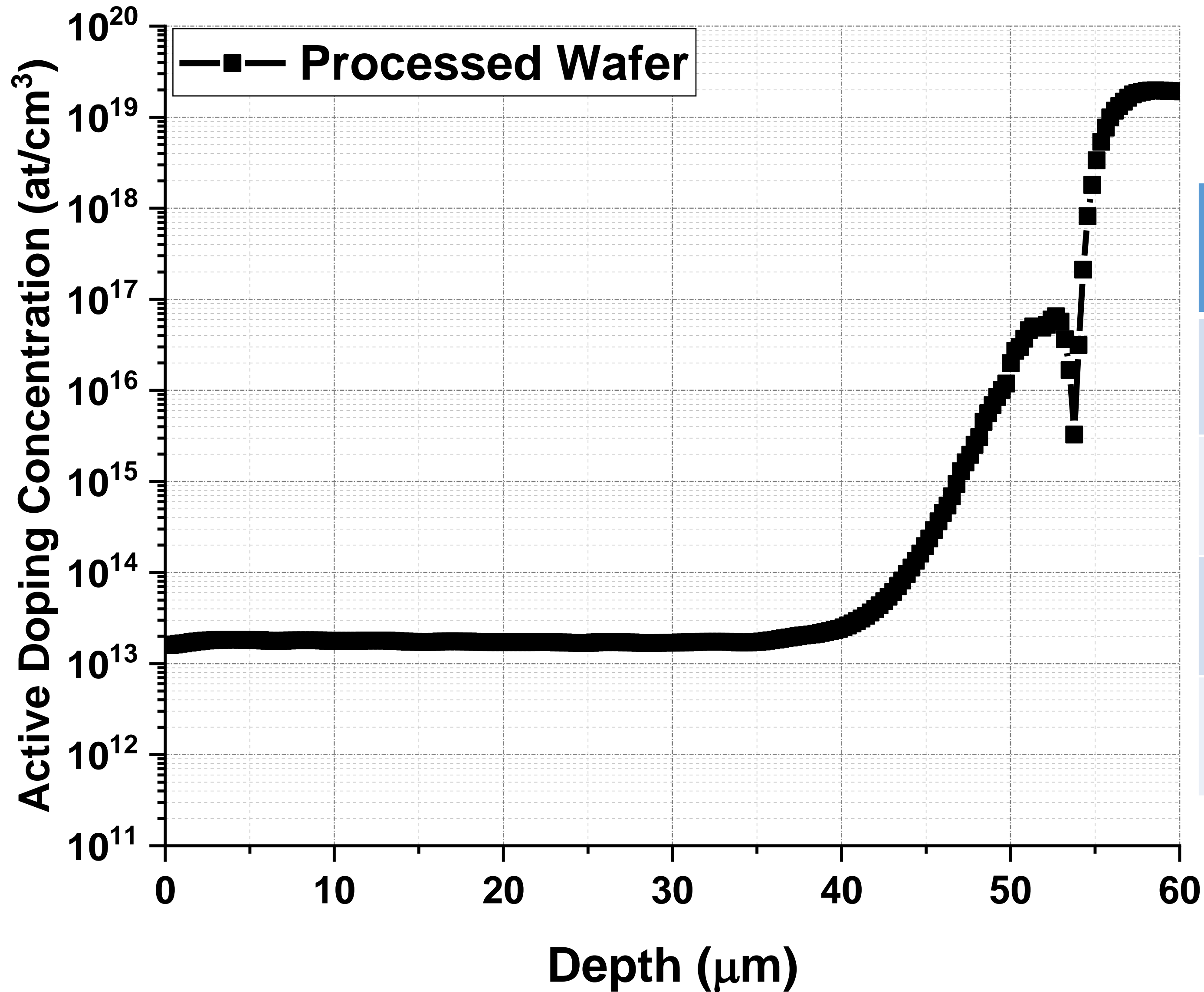
Expitaxial P type multiplication layer (Boron)

Low resistivity N type epitaxial layer (Arsenic)

Epitaxial Layer	Resistivity (Ohm.cm)	Doping Concentr. (1/cm^3)	Thickness (um)
HR P-type (substrate)	> 1000	< 1e13	45-55
P-type mult	0.39-0.53	3e16-4.8e16	2.7-3.3
LR N-type	0.0015-0.005	1e19-1e20	440-480

Wafer	Wafer type	Boron Dose for multiplication layer (1/cm^2)	Boron Energy for multiplication layer (keV)	Comments
4	Epitaxial	NA	NA	APDs obtained instead of LGADs. **Devices were irradiated @ JSI** with neutrons at fluences 8e13, 1e14, 2.5e14 & 5e14. Measurements ongoing.
5				
6				

iLGAD - SEN EPI



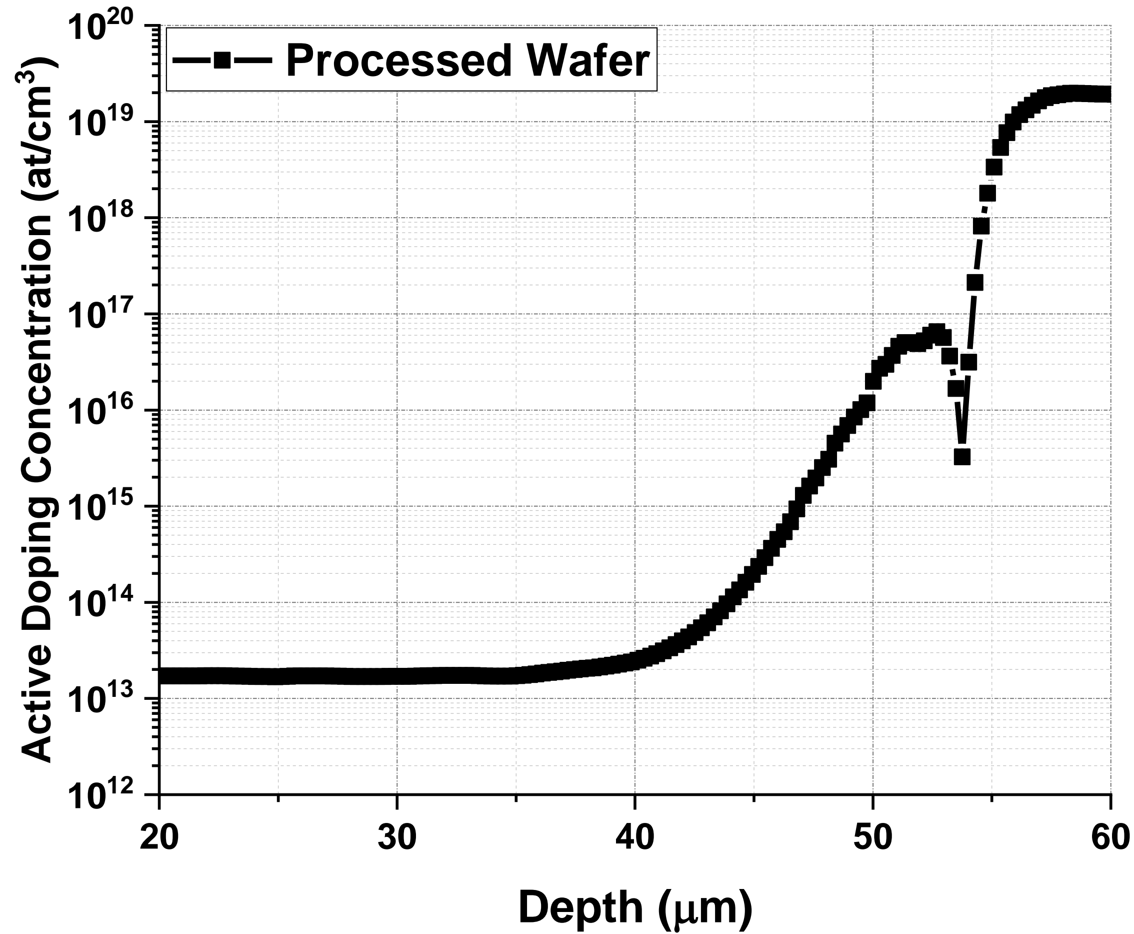
Epitaxial wafers specifications & SRP measurements @ CNM

Epitaxial Layer	Resistivity (Ohm.cm)	Doping Concentr. (at/cm^3)
HR P-type substrate (specifications)	> 1000	< 1e13
HR P-type substrate (Processed wafer)	**800±20**	**1.7±0.1 (1e13)**
P-type mult (specifications)	0.39-0.53	3-4.8 (1e16)
P-type mult (Processed wafer)	**0.40±0.09**	**4.7±1.2 (1e16)**

Thermal steps on processed wafers:
30min @ 1000°C
3h @ 1175°C

iLGAD - SEN EPI

Simulation with SRP profiles



W4
W5
W6
Keithley Limit
Simulation
20ºC
I (A)
Reverse bias (V)

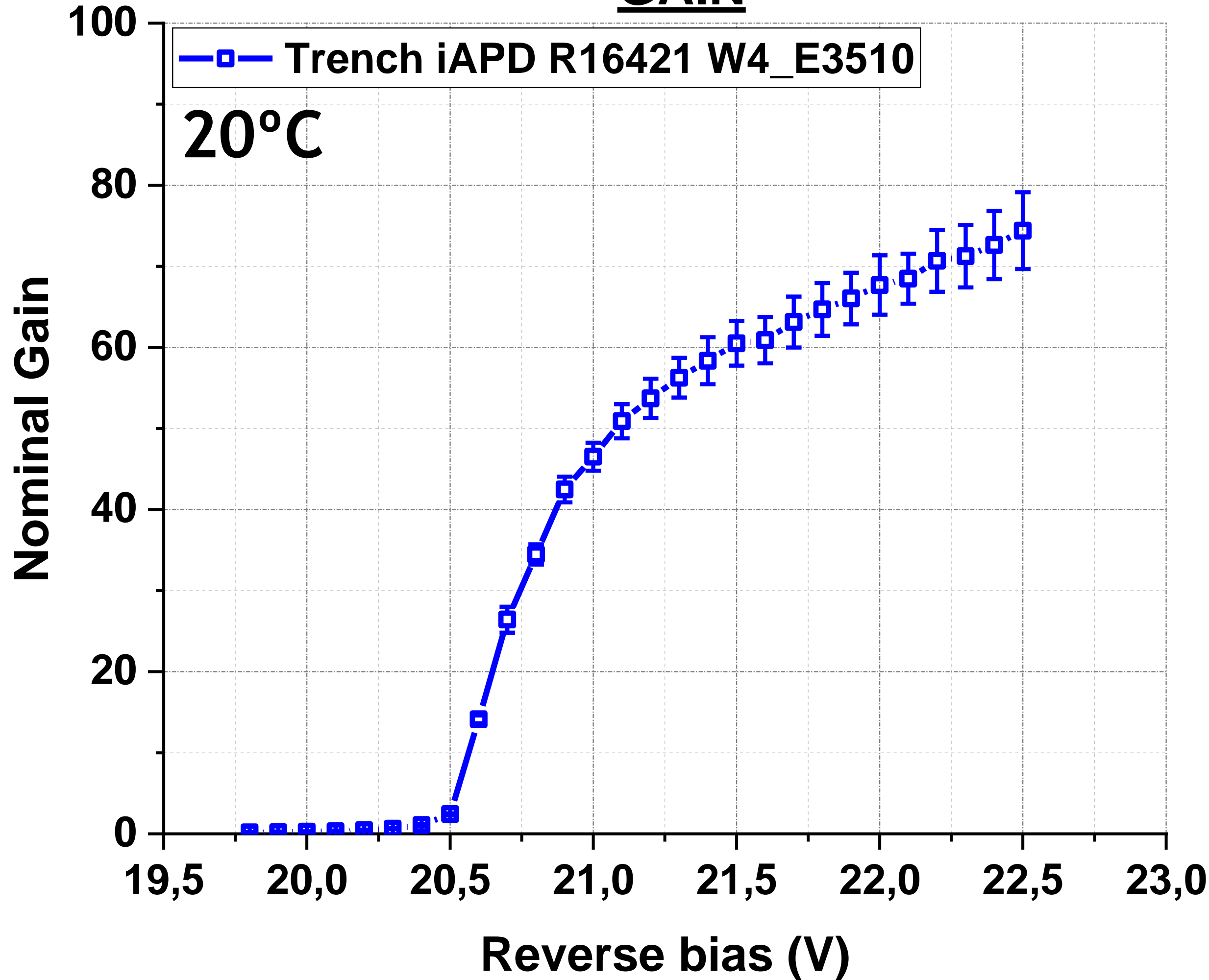
We have APDs instead of LGADs

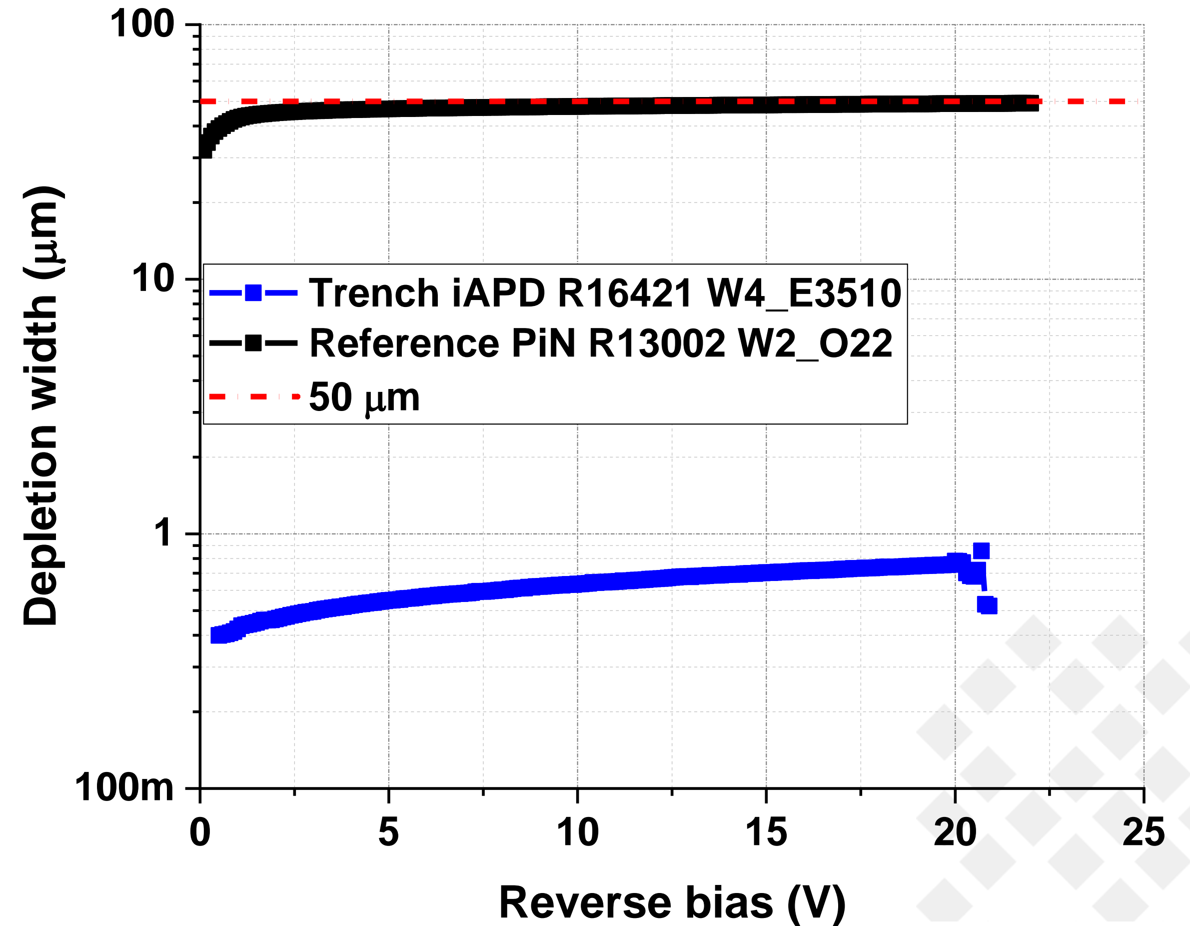
1.5mm single pad devices

iLGAD – SEN EPI

1064 nm TCT IR Light, **10000 waveforms per V point**
Max intensity of the laser, 1kHz

GAIN



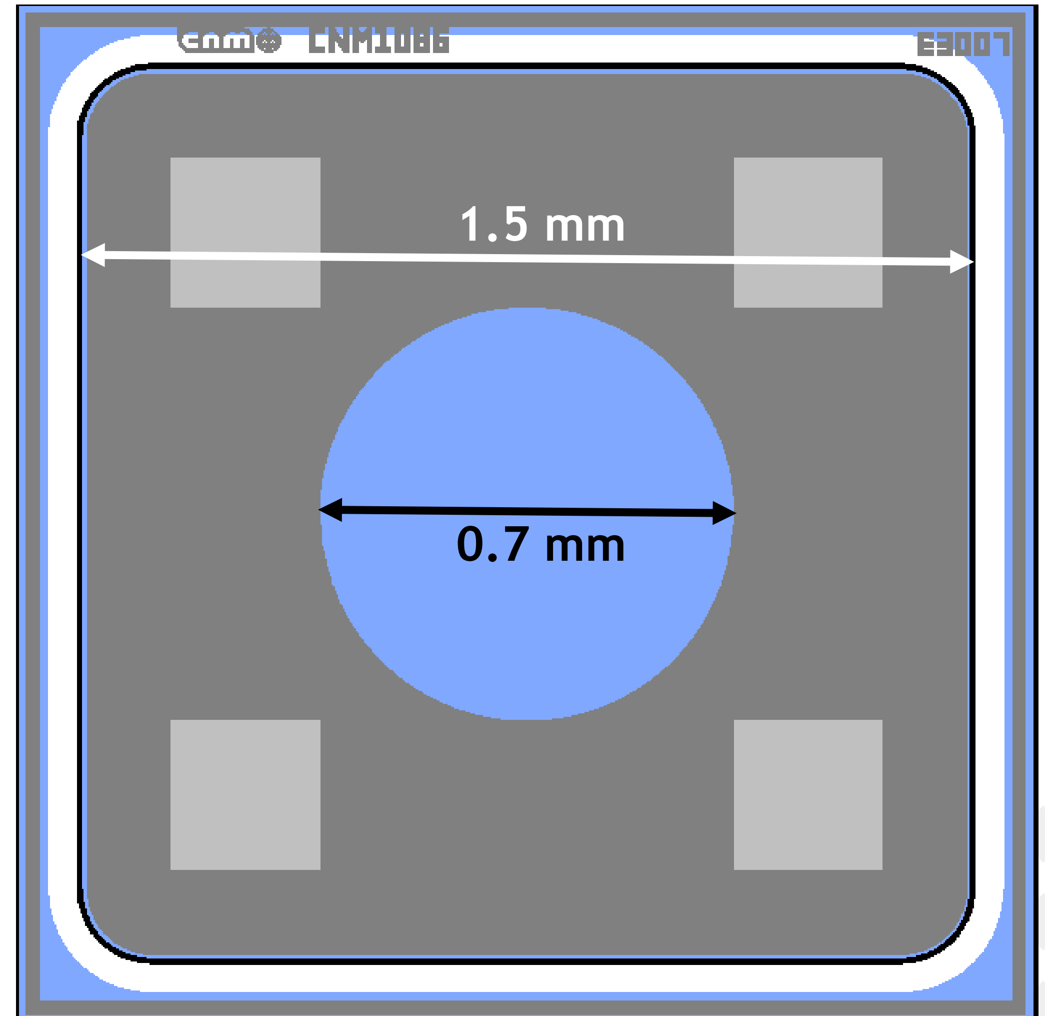


iLGAD - SEN EPI

Peak 2DScan

1064 nm TCT IR Light, 20.5 V, 20ºC
Max intensity of the laser, 1kHz

y position [µm]: 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000
x position [µm]: 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000
Color scale: 0, 5, 10, 15, 20, 25



iLGAD - SEN EPI irradiations

-30ºC , 8e13 1MeV n_{eq}, Annealing = 2h @ 200ºC

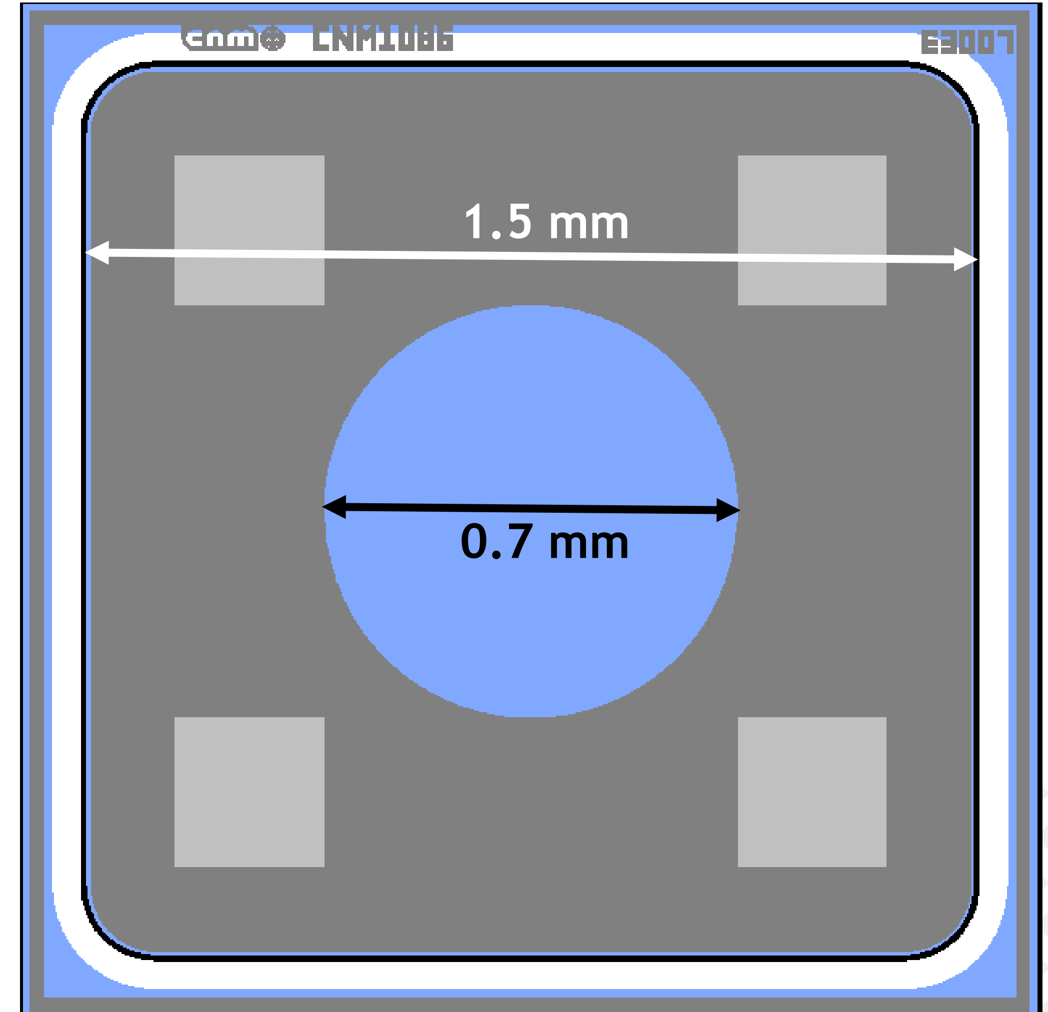
I (A)

1µ
100n
10n
1n
100p
10p

0
50
100
150
200
250

Reverse bias (V)

W4_E2709
W4_E2809
W4_E2909
W4_E3009
W4_E3109
W4_E3209



iLGAD SiSi

Wafer	Wafer type	Boron Dose for multiplication layer (1/cm²)	Boron Energy for multiplication layer (keV)	Comments
1	Si-Si	3.7e14	150	Diffusion @ 1175ºC for 3h (same as Epitaxial wafers 4, 5 & 6). **Preliminary IVs do not show APD behavior**. Fabrication about to finish (within 1 week). Measuremetns before passivation deposition
2		3.9e14		
3		4.1e14		

High Resistivity P type substrate (Boron)

P type multiplication layer (Boron)

Low resistivity N type wafer

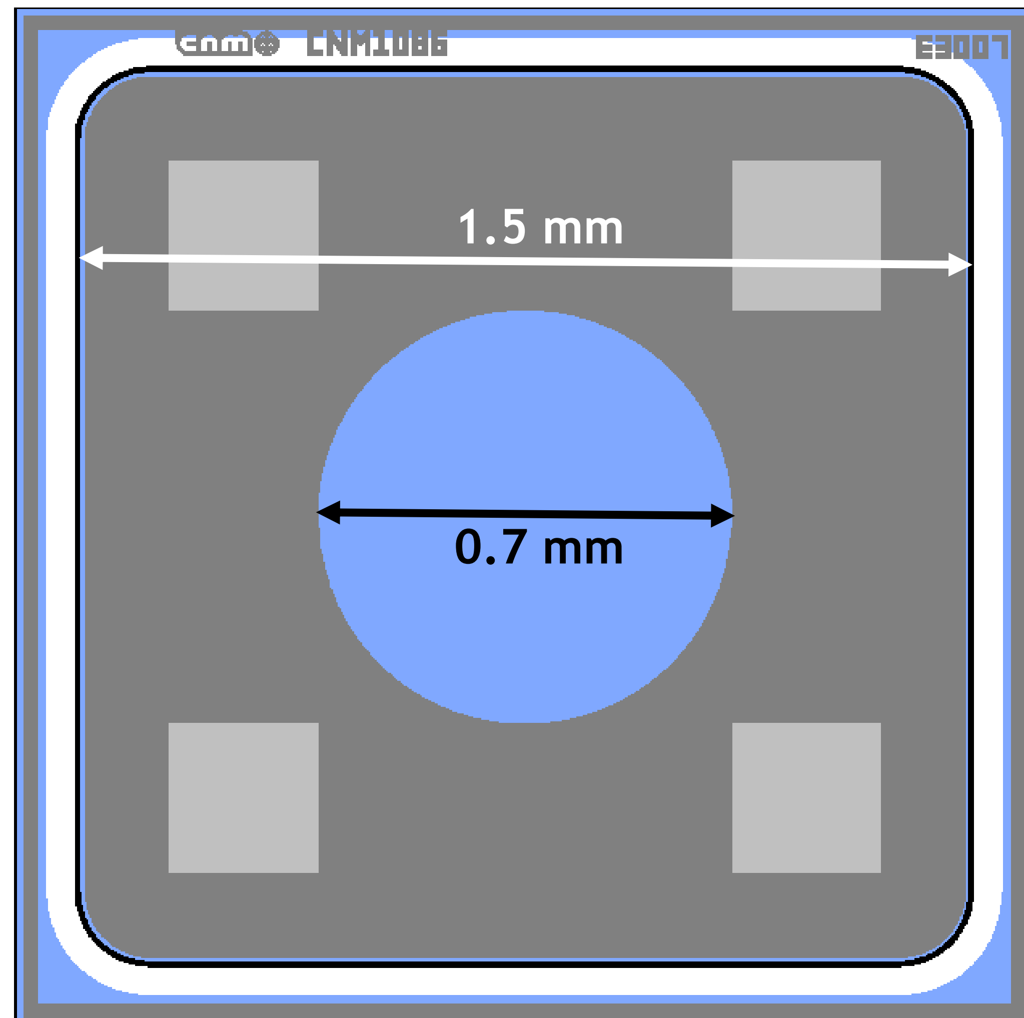
iLGAD SiSi

iLGADs on Si-Si Wafers - measured at clean room after metallization

I (A): 1µ, 100n, 10n, 1n, 100p

Reverse bias (V): 0, 25, 50, 75, 100, 125, 150, 175, 200

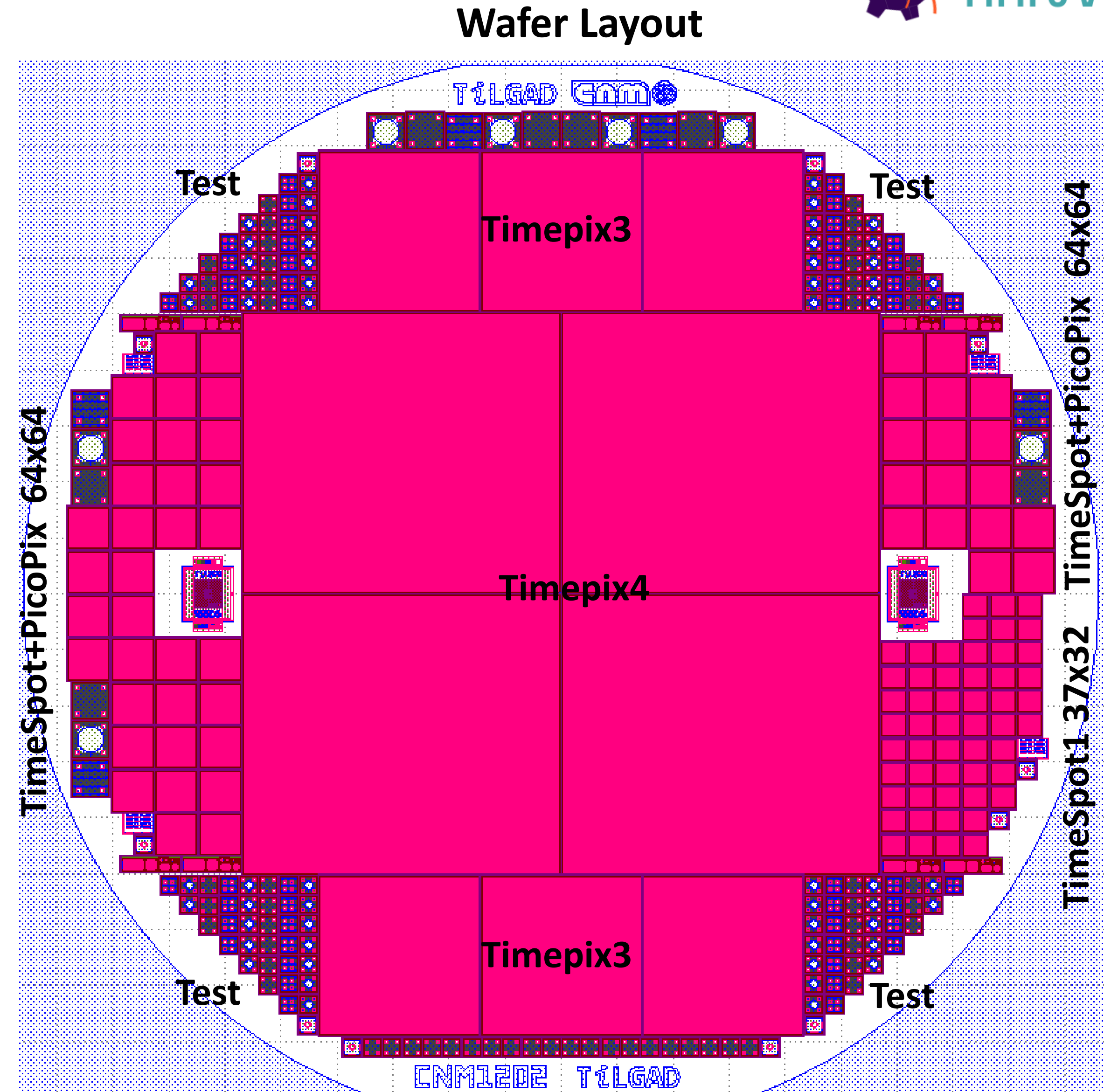
- W1_E2510
- W1_E2610
- W2_E2510
- W2_E2610
- W3_E2510
- W3_E2610



iLGAD Timepix4 AidaInnova Run

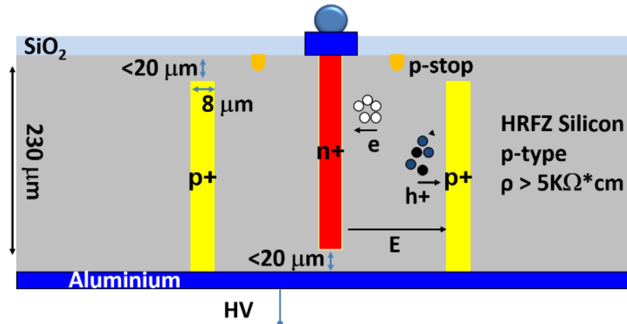
- **RunXxxxx: 6 Wafers**, 100 mm, CNM1202 Mask Set
  - **3 wafers**: **Epitaxial Wafers** (50/515 µm) (diffusion necessary)
  - **3 wafers**: **Si-Si Wafers** (50/350 µm)
- **TimePix4.** 55x55 µm pitch, 448x512 pixels: **4**
- **TimePix3.** 55x55 µm pitch, 256x256 pixels: **6**
- **TimeSpot1.** 55x55 µm pitch, 37x32 pixels: **53**
- **TimeSpot, PicoPix.** 55x55 µm pitch, 64x64 pixels: **51**
- **Test Devices** to fill the gaps (Pad, Pixels)
- **Taking into account the instructions received by e-mail. New ROCs, 55x55 µm, 64x64 pixels**
  - **24/05/2023.** Adriano Lei (2024, new **TimePix**)
  - **04/09/2023.** Martin van Beuzekom (**PicoPix**)
    - There will be a **65th row** directly adjacent to the pixel matrix for the connection of the innermost guard ring
- **Six months** are needed for its Production and Electrical Characterization. Mask already arrived.

Wafer Layout

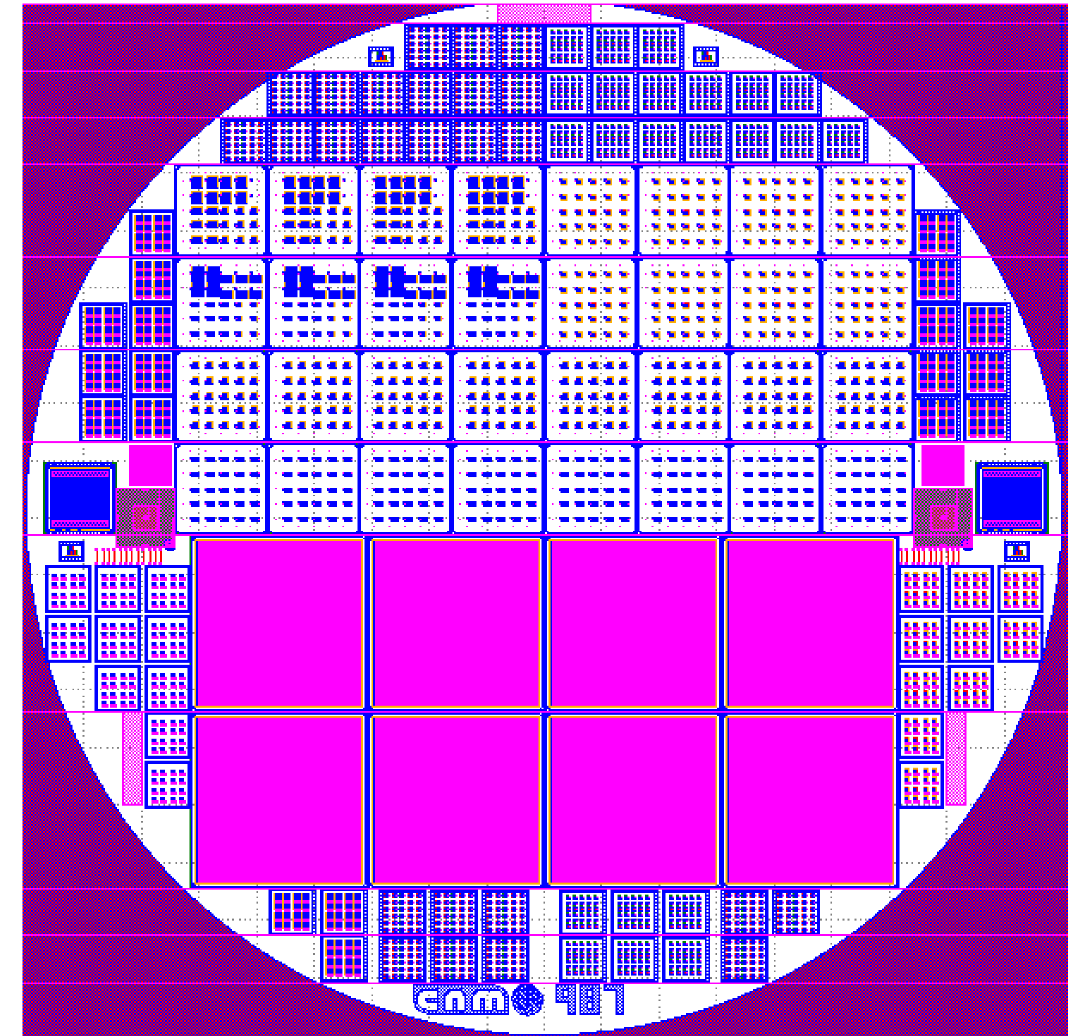


3D-DS Timing, Si (285 μm)

- Altiroc1
- Medipix3
- Test structures



- Fabrication on going
  - 285 μm thick Si wafers
  - 240 μm depth columns
  - 8-10 μm columns diameter
  - Double side technology
  - P-Stop isolation
  - Metal layer opening on the back

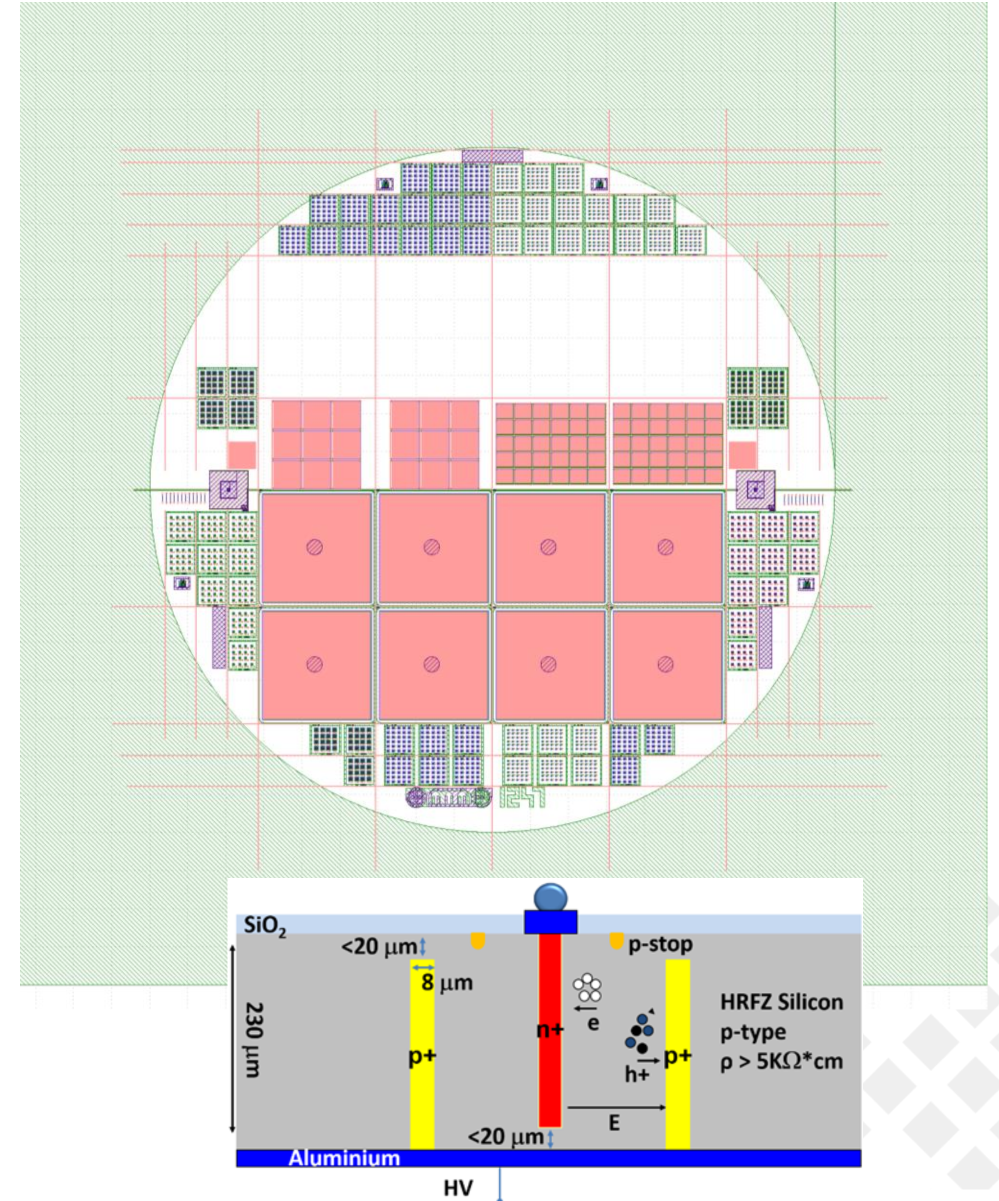


Detectors irradiated with neutrons at different fluences.

Tested in the Aidainnova testbeam, waiting for the analysis of the results but they look very promising.

3D-DS Timing, new mask design

- Decide if to move to **150mm** wafers for the 3D process (285um thick).
- This may delay the fabrication, never tried before although individual steps are ready .
- Try to reduce holes diameter (= increase aspect ratio). New equipment for 150mm wafers.
- **TimePix3.** 55x55 µm pitch, 256x256 pixels: **8**
- **TimeSpot1.** 55x55 µm pitch, 37x32 pixels: **60**
- **PicoPix.** 55x55 µm pitch, 64x64 pixels: **18**
- Different test structures
- Space for LHCb type test structures. To be designed and agreed.



Acknowledgement

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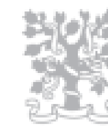
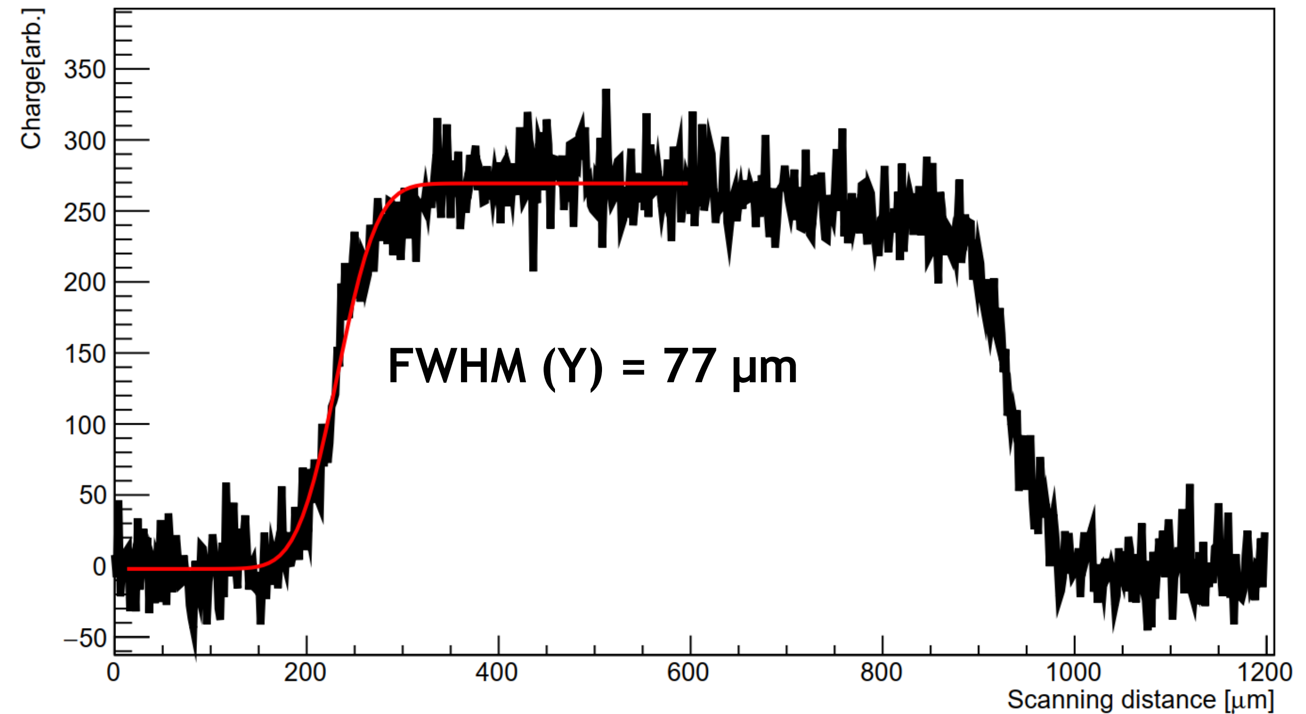


iLGAD – SEN EPI

Peak 2DScan

y position [µm]
2000
1800
1600
1400
1200
1000
800
600
400
200
200 400 600 800 1000 1200 1400 1600 1800 2000
x position [µm]
25
20
0
Charge[arb.]

1064 nm TCT IR Light, 20.5 V, 20ºC
Max intensity of the laser, 1kHz



iLGAD – SEN EPI

Peak 2DScan

y position [μm]

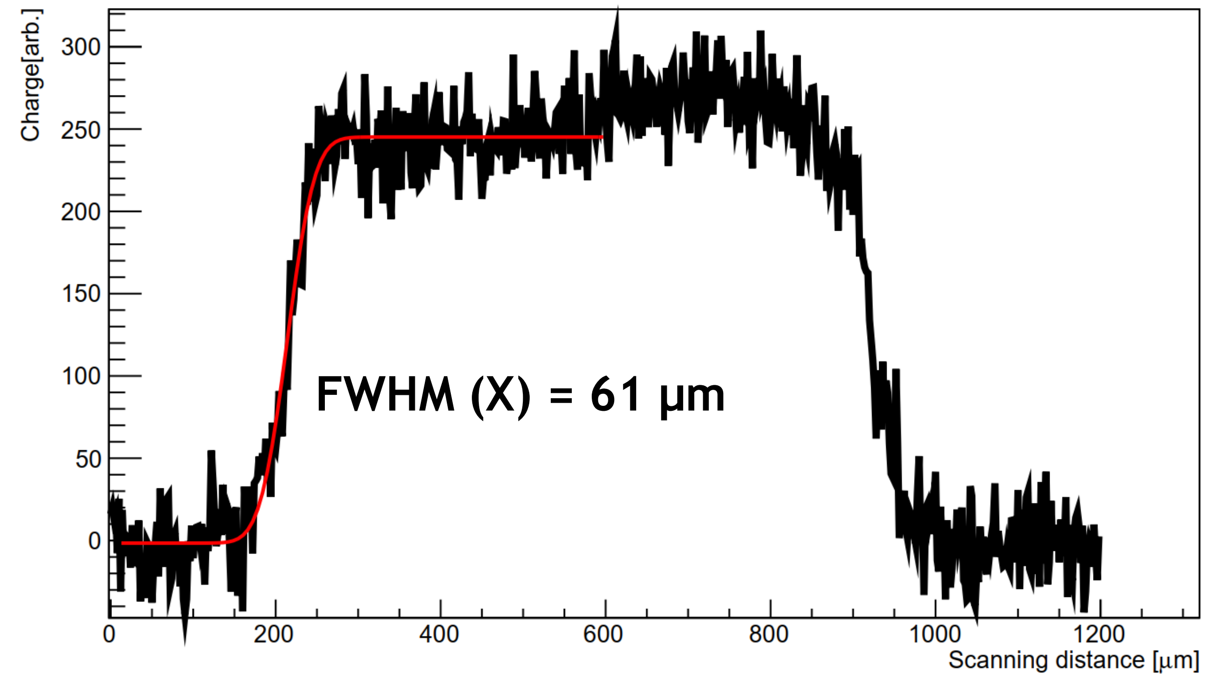
2000 1800 1600 1400 1200 1000 800 600 400 200

200 400 600 800 1000 1200 1400 1600 1800 2000

x position [μm]

0 5 10 15 20 25

1064 nm TCT IR Light, 20.5 V, 20ºC
Max intensity of the laser, 1kHz



iLGAD Third Generation (4iLG3). Engineering Run 16421