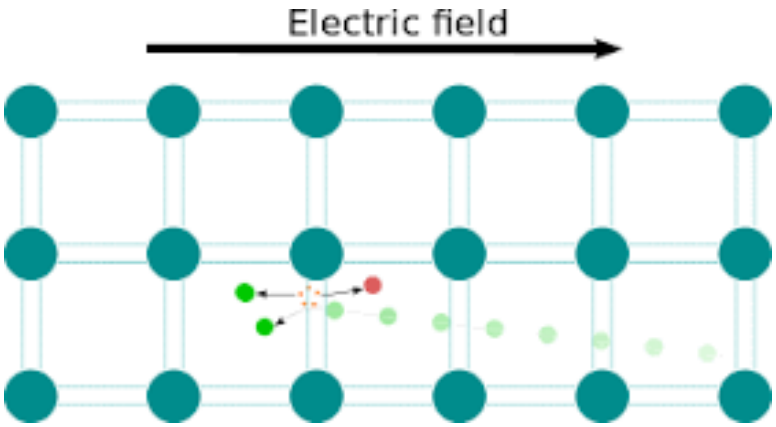
Signal amplification in segmented silicon sensors: strip-LGAD and I-LGAD



RD50 Workshop, Torino, June 6th, 2016

Iván Vila
Instituto de Física de Cantabria (CSIC-UC)

Instituto de Física de Cantabria

CSIC Consejo Superior de Investigaciones Científicas

UC Universidad de Cantabria

The Team

M. Fernández, J. González, R. Jaramillo, D. Moya, R. Palomo[(1)], I. Vila.

Instituto de Física de Cantabria(CSIC-UC)

[(1)] **Universidad de Sevilla**

M. Moll, S. Otero.

CERN

S. Hidalgo, G. Pellegrini, David Quirion, M. Carulla

IMB-CNM (CSIC)

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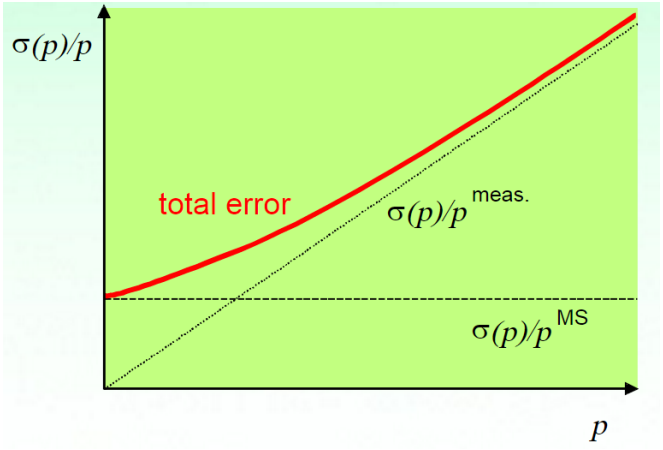
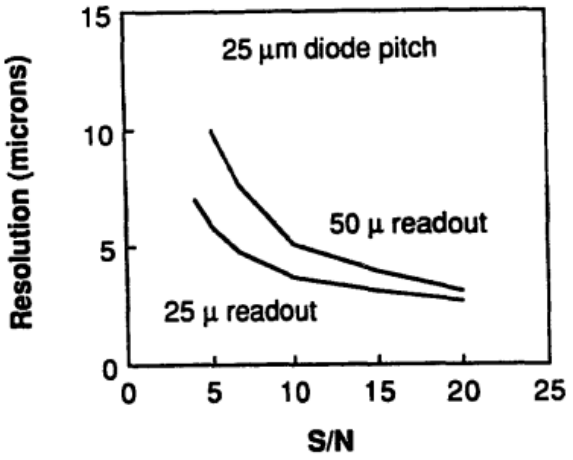
Outline

- Motivation: microstrips with integrated gain for tracking.
- Gain determination: Transient Currents from electron injection.
- Device description: strip LGAD (n-in-p) and Inverse LGAD (p-in-p)
- Preliminary results.
- Summary and outlook.

Motivation for a strip detector with integrated signal gain

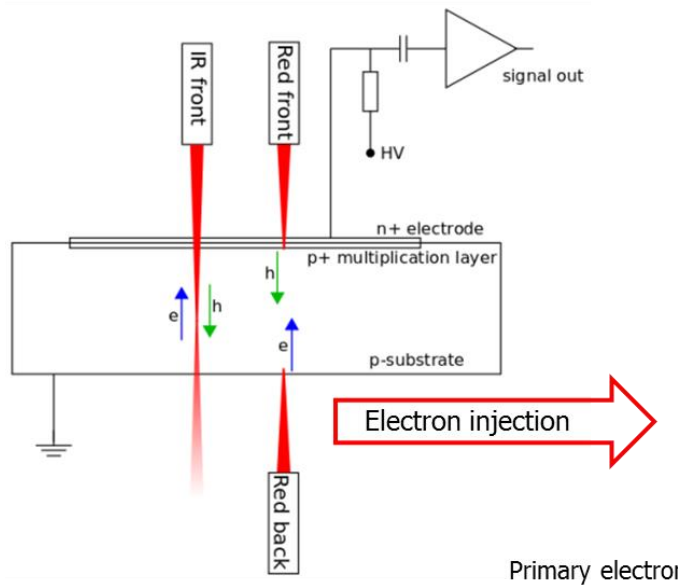
- Integrated signal amplification increases the Signal-to-Noise ratio increasing the tracking resolution:
  - Thinner detectors (reduction of the **multiple scattering**)
  - Improved **intrinsic hit resolution**.



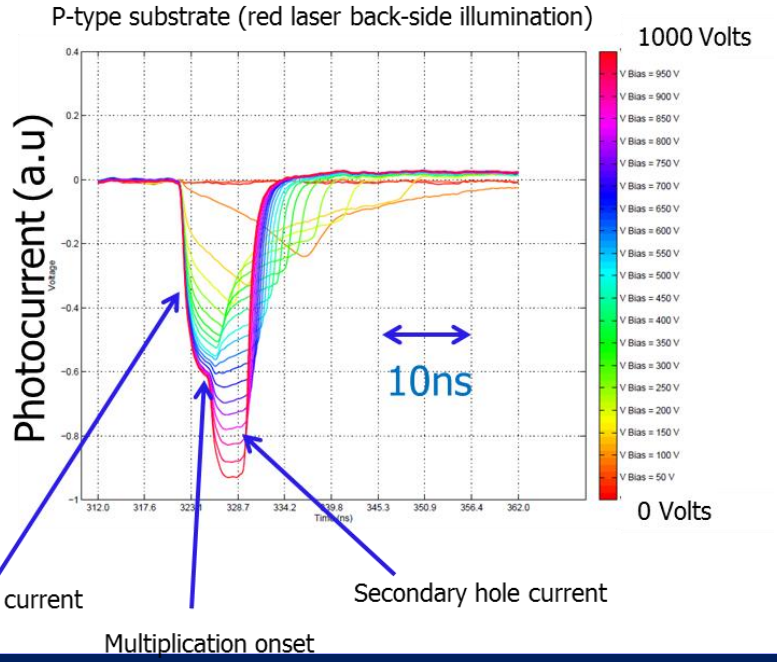


Methodology: Signal amplification footprint

- Distinct signature of signal amplification.
- Injections of electron into the anode: resulting transient current is a sequential contribution of primary electrons reaching the amplification layer and secondary holes drifting towards the anode.

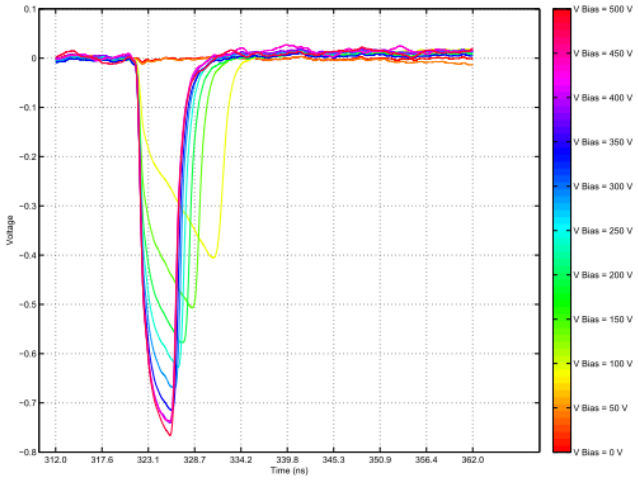


Electron injection

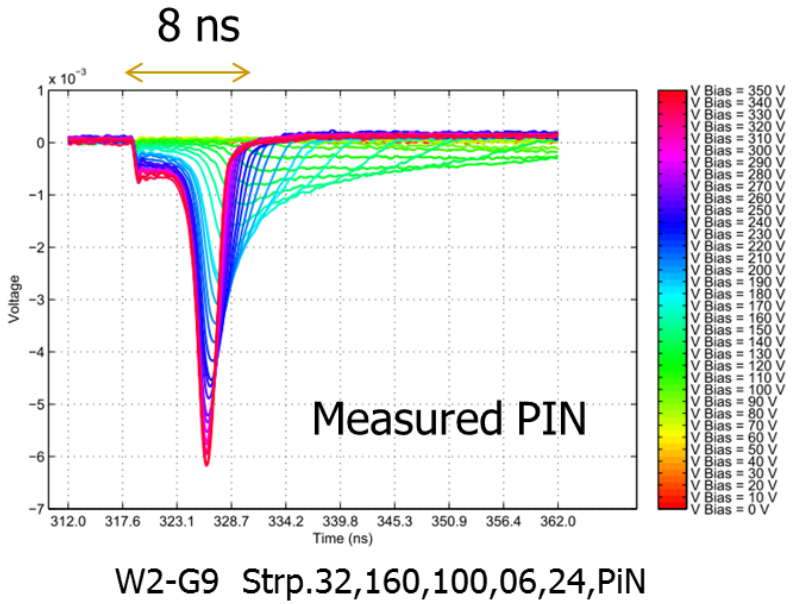


Transient currents: pad vs microstrips

– Transient current waveform shape dominated by weighting field (peaked at the collecting electrode):



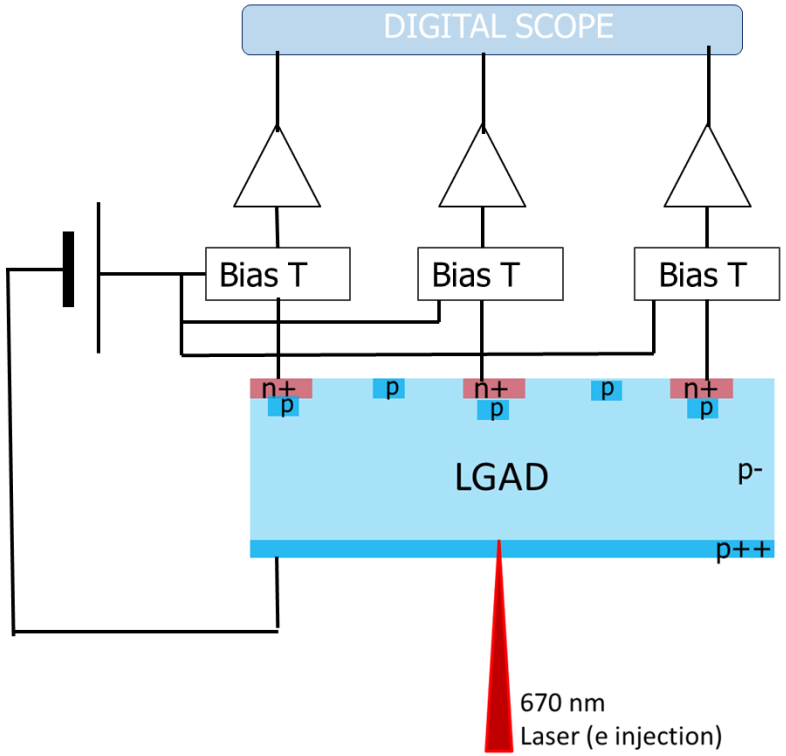
Pad like diode



microstrip diode

Multi-channel TCT on DC strips.

– All Strip LGAD (r#7859) and I-LGAD (r#8533) manufactured as DC mini sensors (biasing through decoupling capacitor).



Simultaneous read out

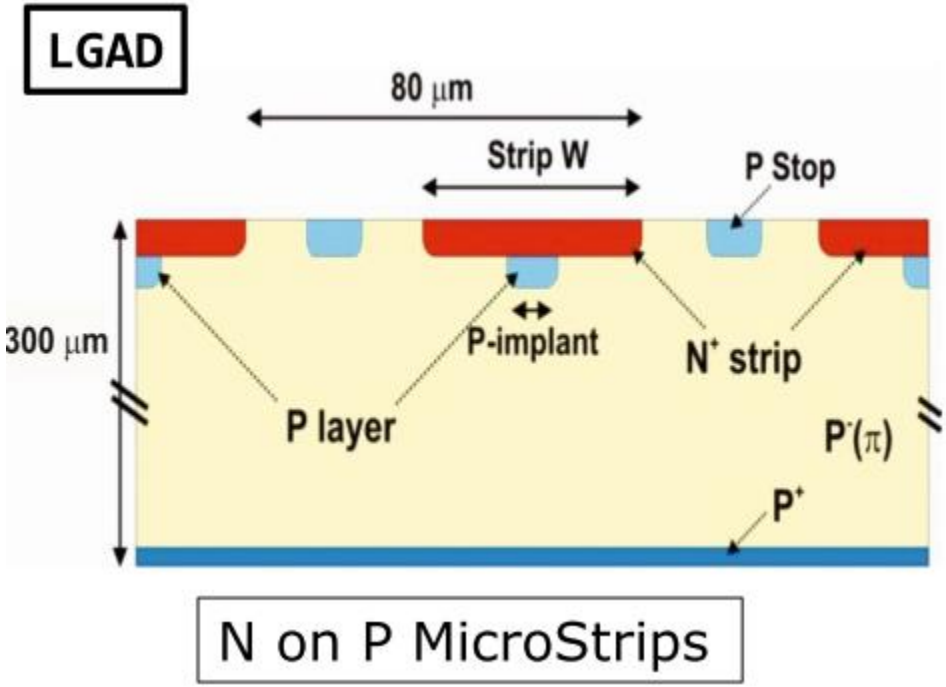
of up to three strips

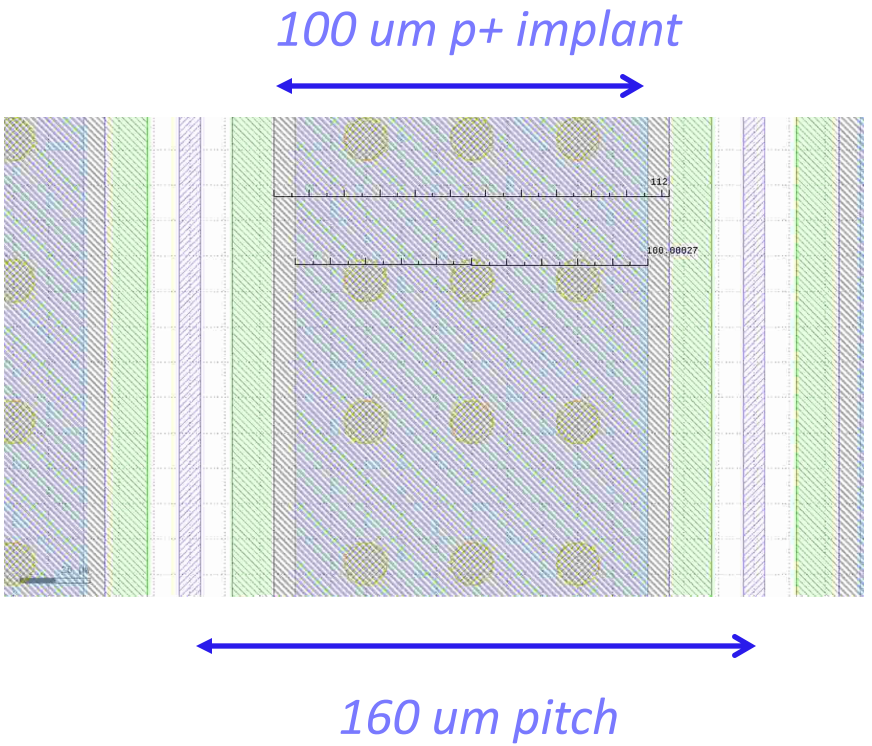
Electron injection

(red laser back-side

illumination)

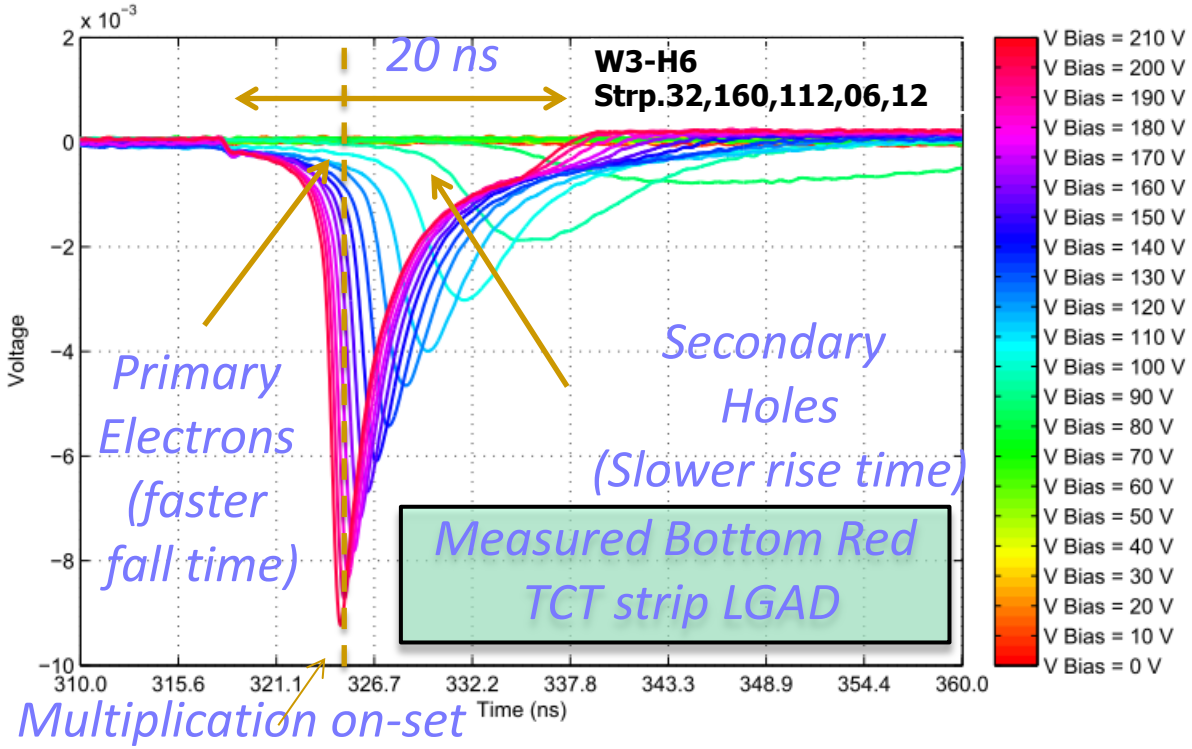
Strip LGAD Characterization (r#7859)

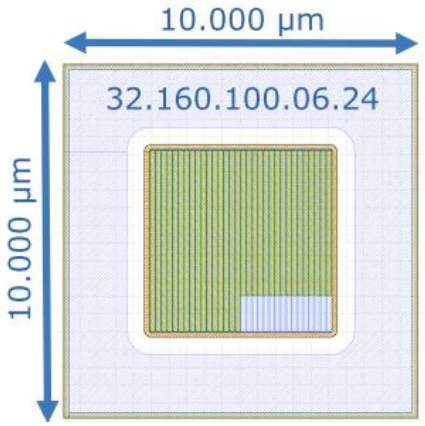


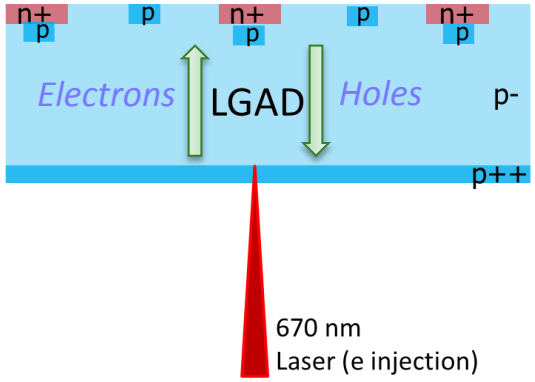


LGAD strip: electron injection

- Signal gain observed:
  - Wider TCT pulses wrt to PIN
  - Charge increases vs HV
- Strip current waveform shows clear sequential electron and hole drift

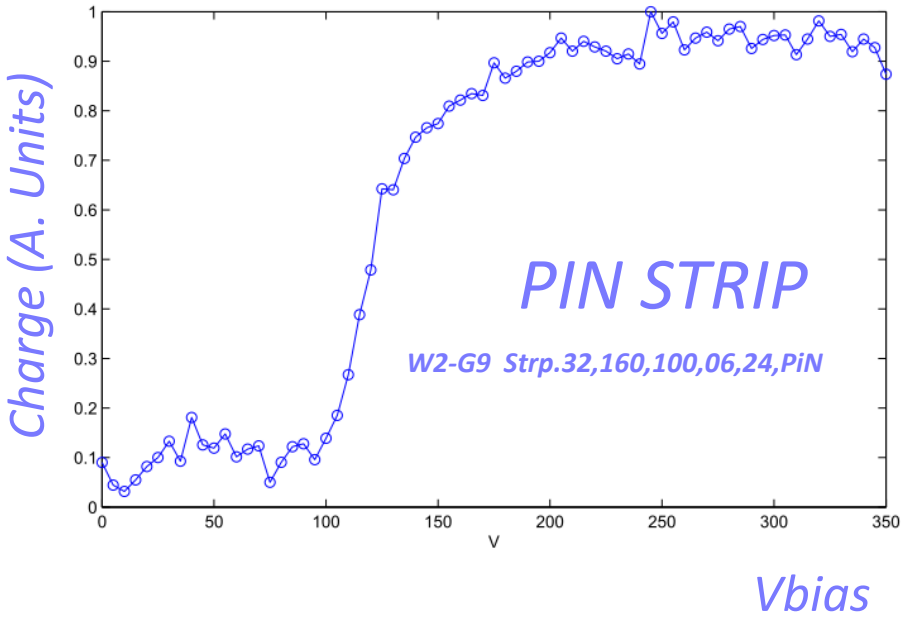


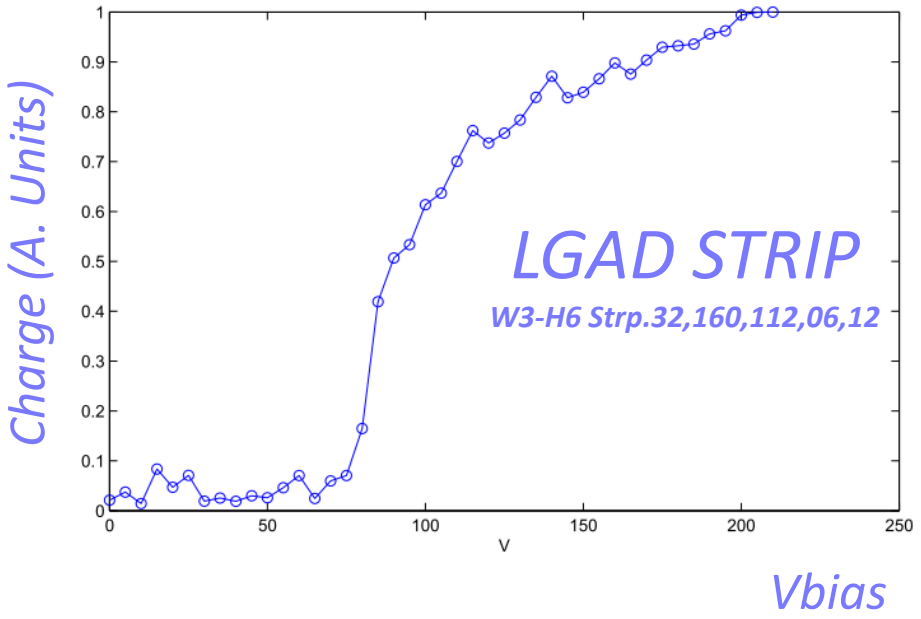




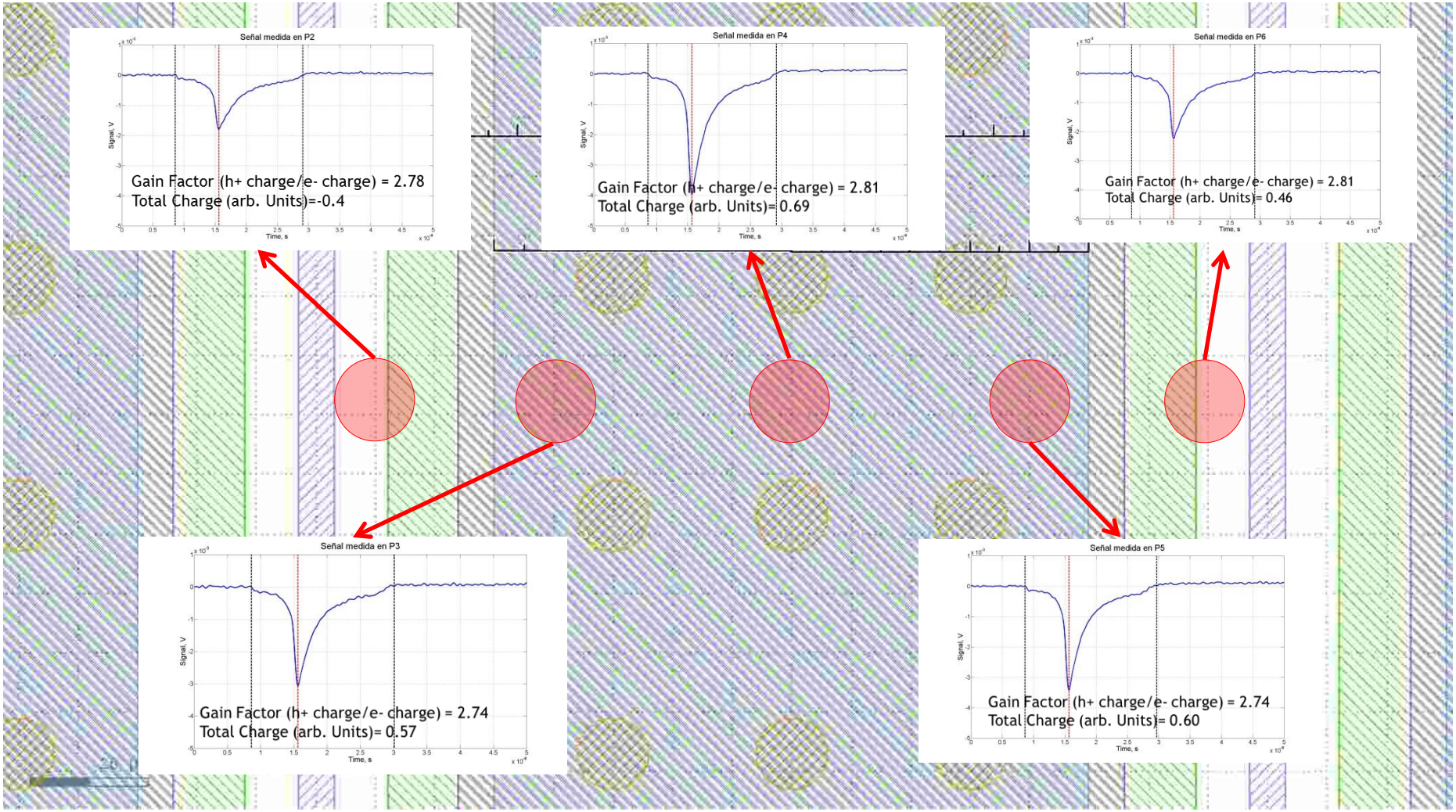
LGAD Strip: Signal vs V_{bias}

– Red laser, bottom TCT, electron injection (Integrated current transient curves)



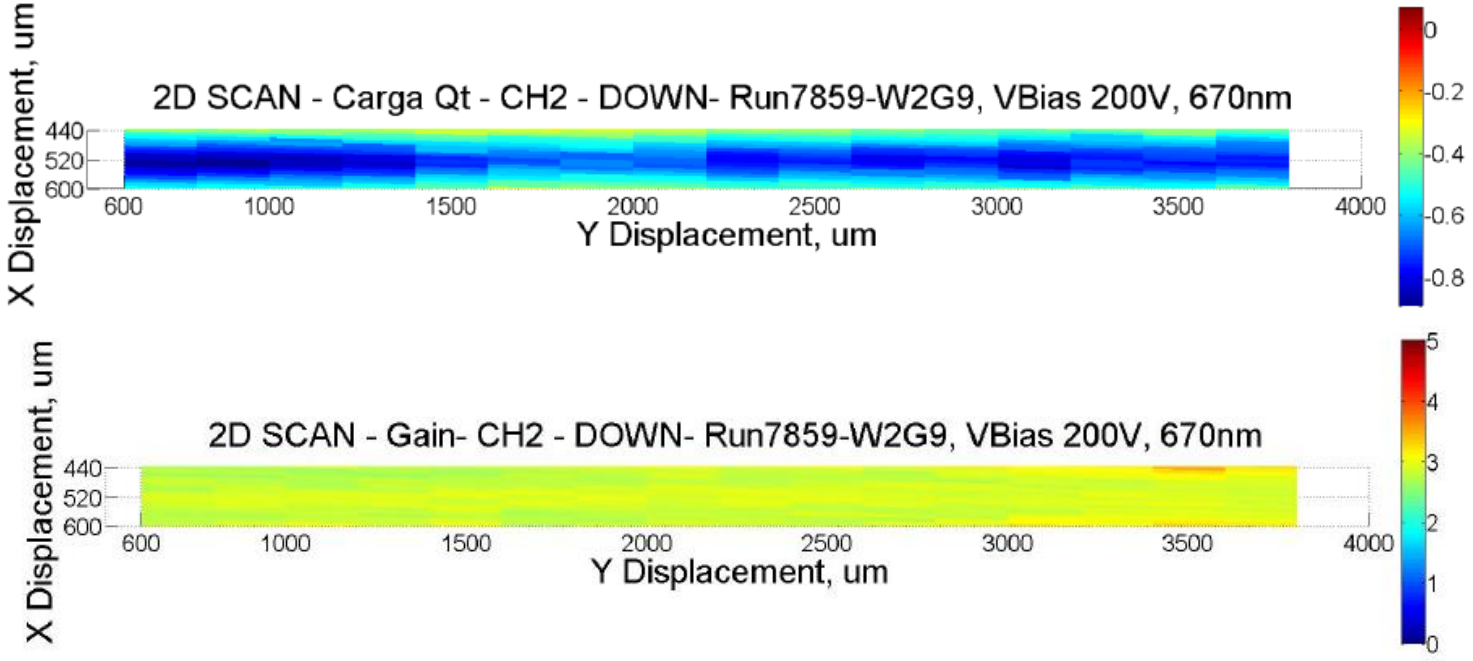


Strip LGAD: Gain Factor Uniformity:



Strip LGAD: Mapping the strip gain (1)

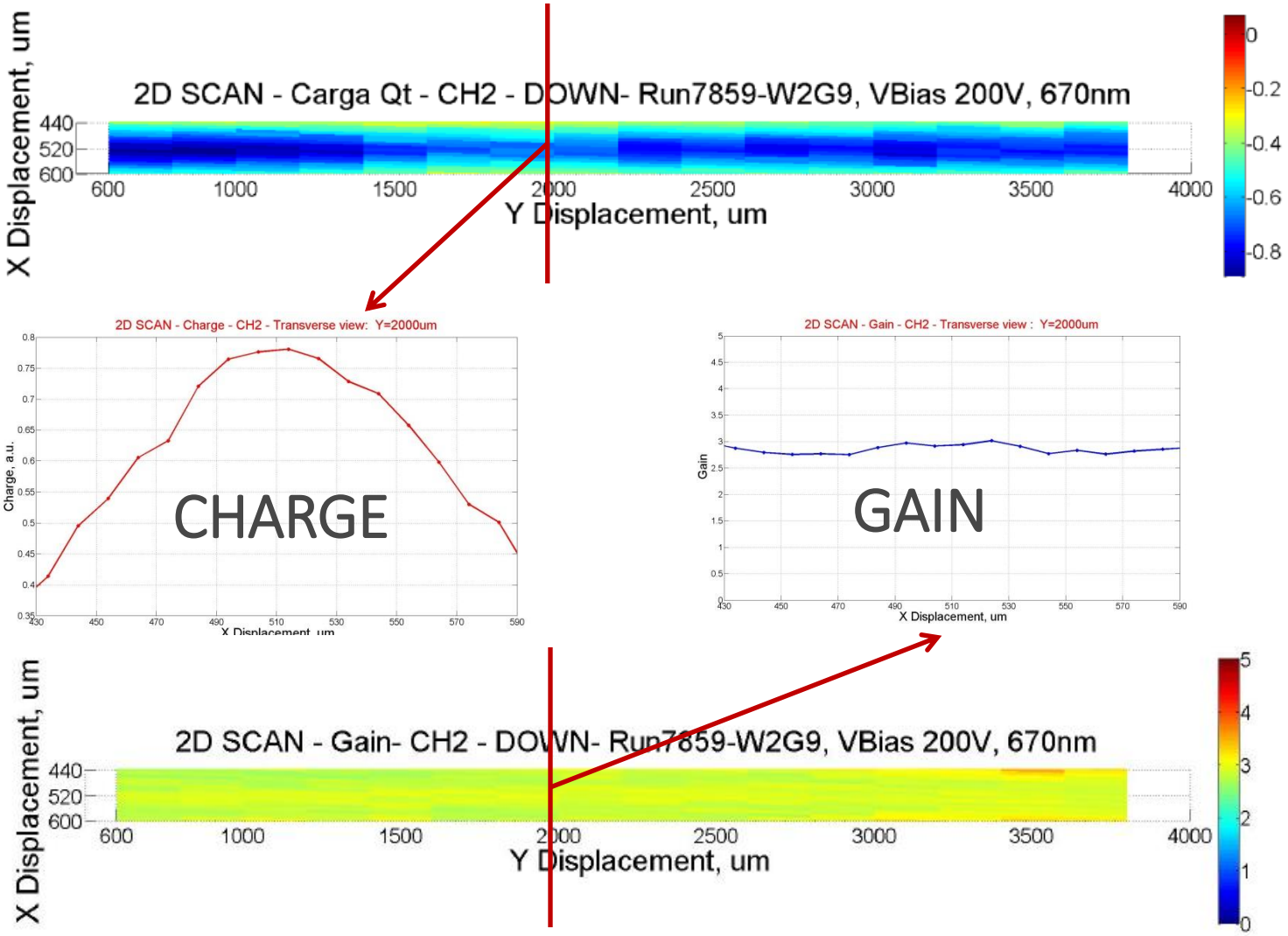
– Raster scan: electron injection into the anode at each point of the strip collecting charge back side area (+-80um around the strip center)



CHARGE MAP

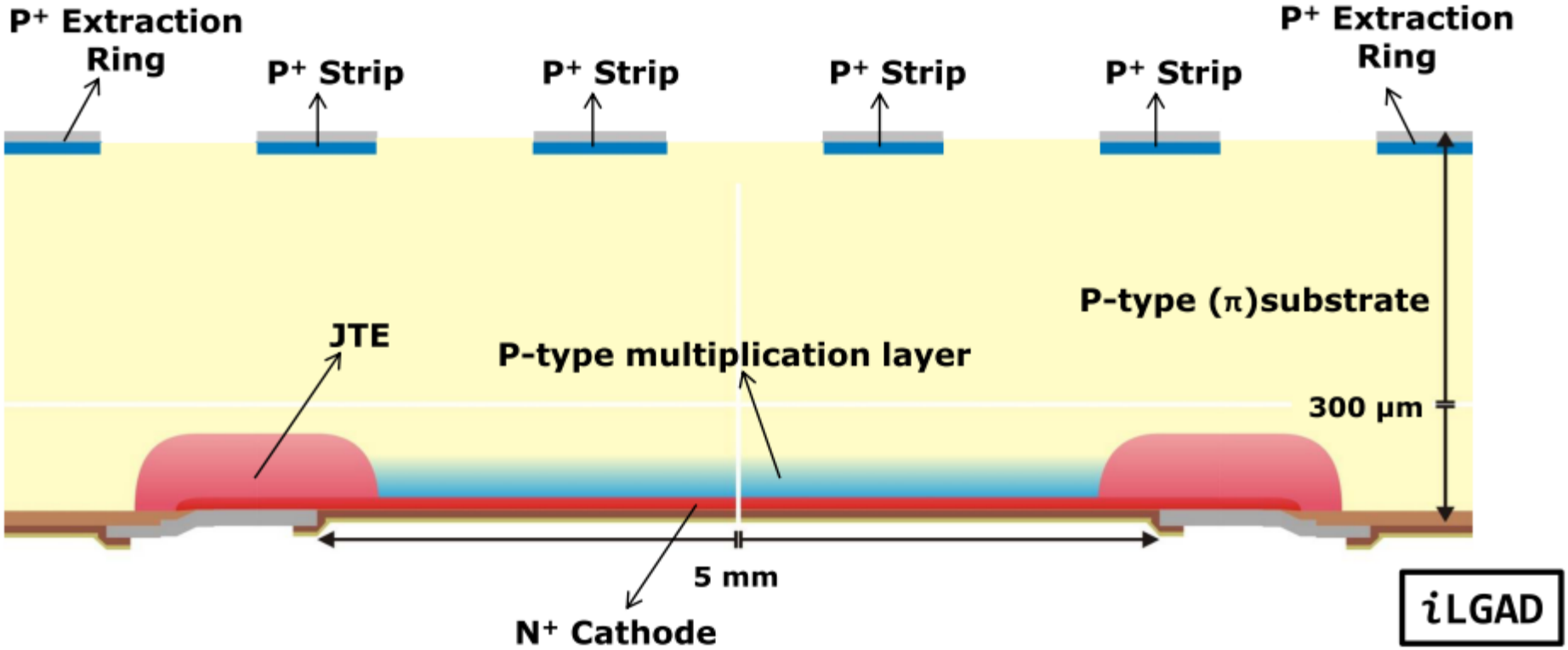
GAIN MAP

Strip LGAD: Mapping the strip gain (2)

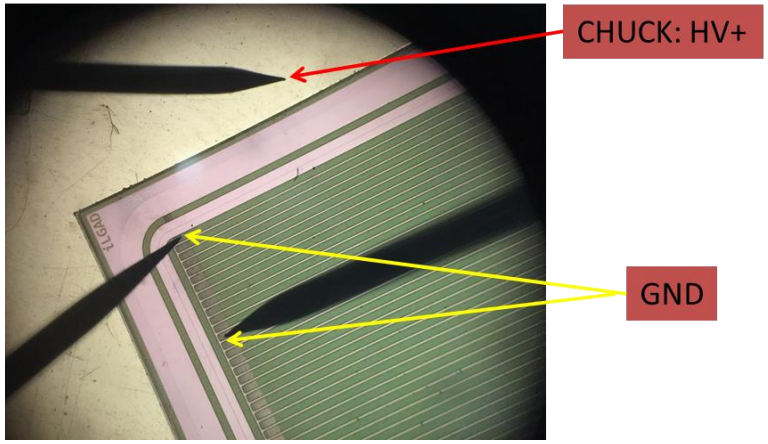


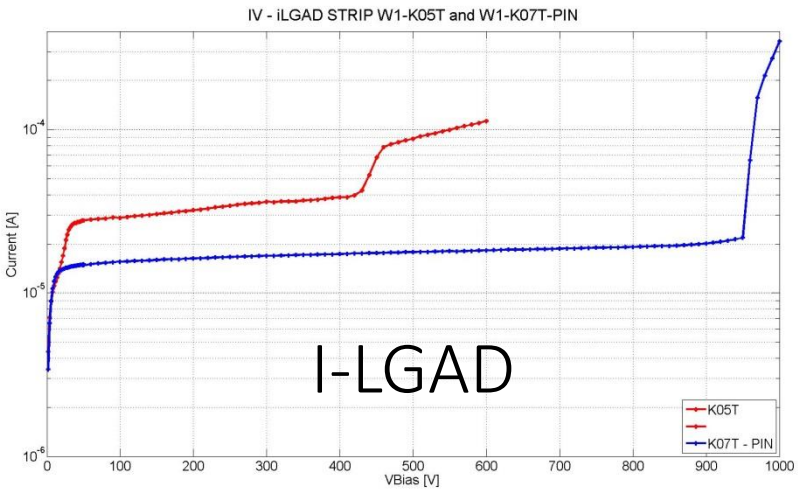
Inverse- LGAD

- P-in-P LGAD (See Mar Carulla talk in this workshop)
- W1-K037 STR.45.160.8000.06.12



I-LGAD: Electrical Characterization

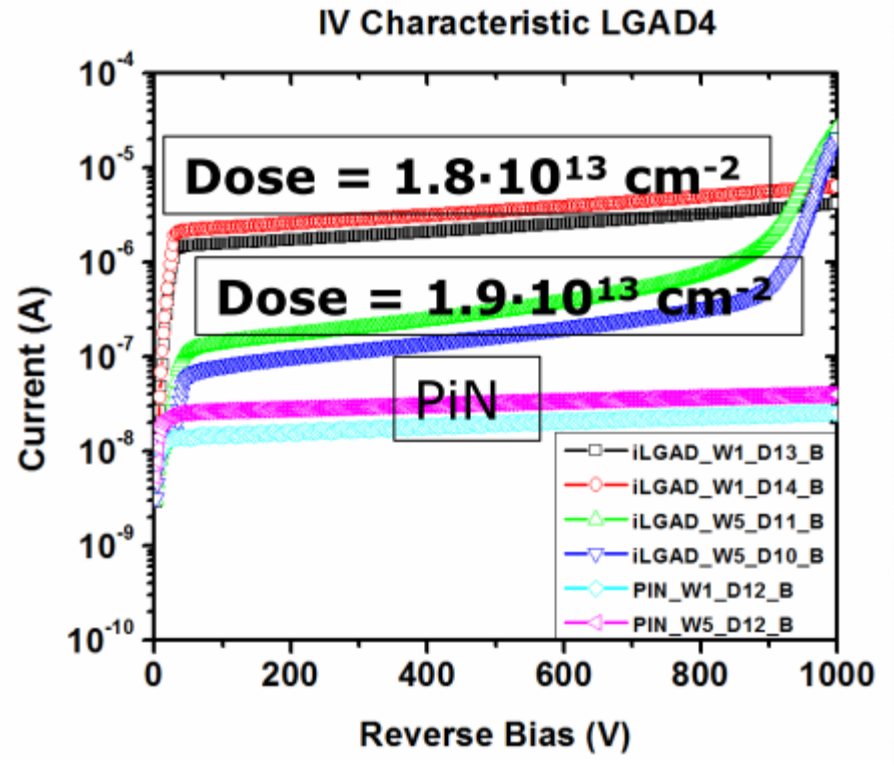




Current (A)

I-LGAD

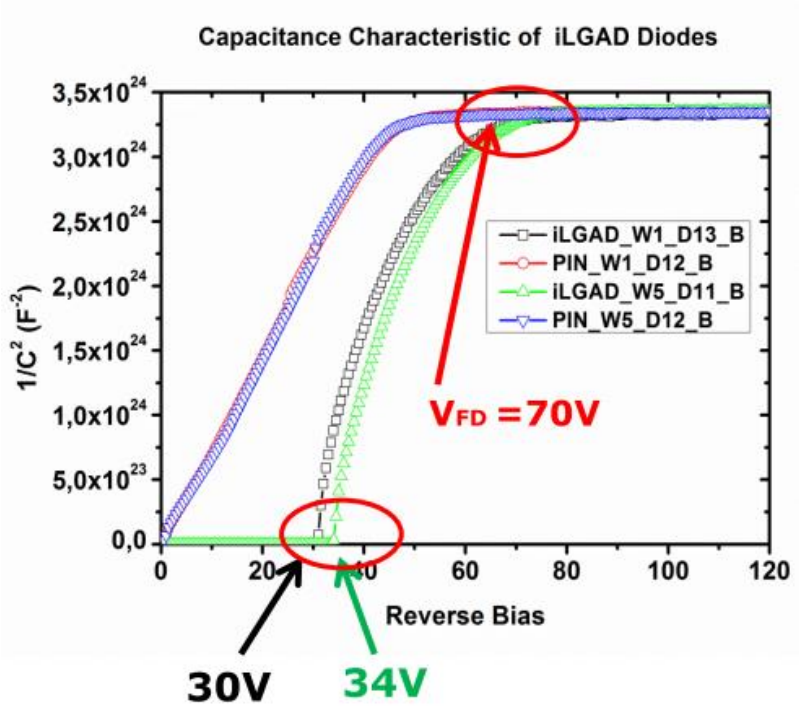
BIAS (Volts)

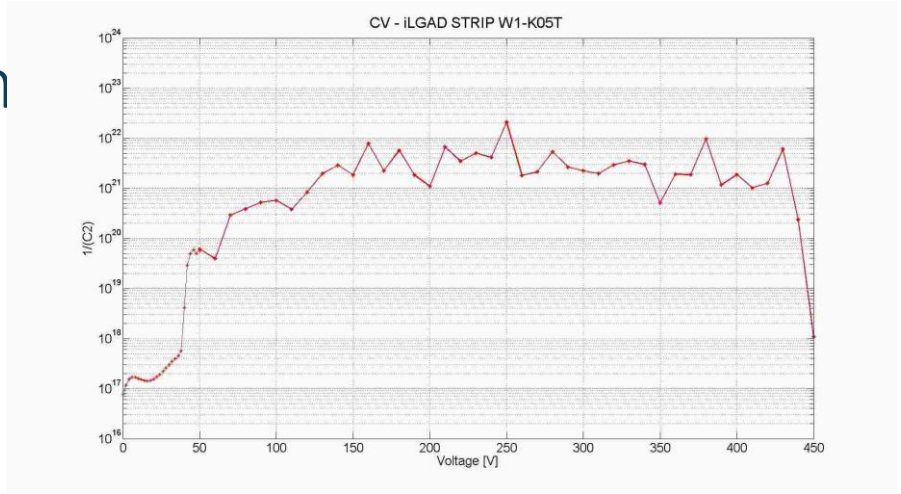


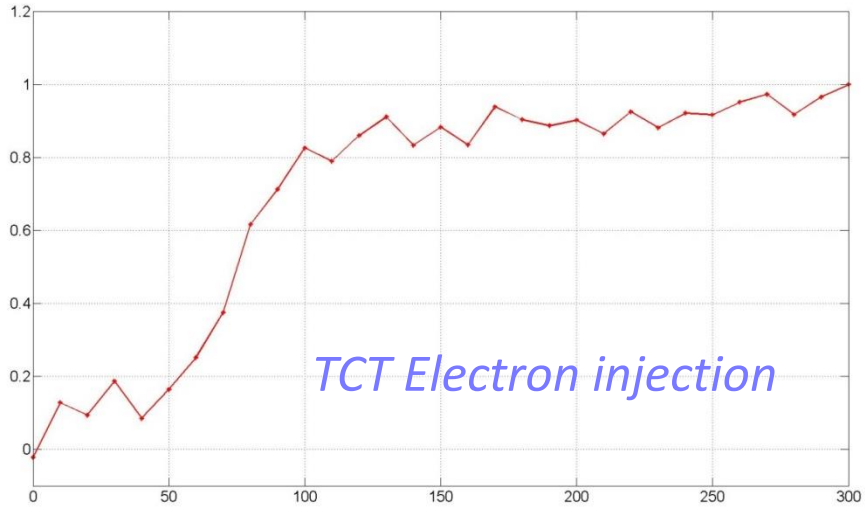
PAD DIODE

Inverse-LGAD: CV

– PADs vs I-LGAD depletion

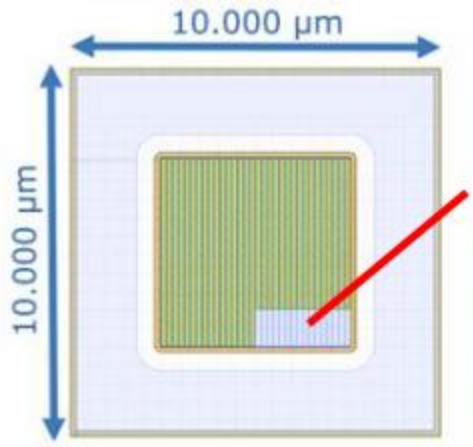






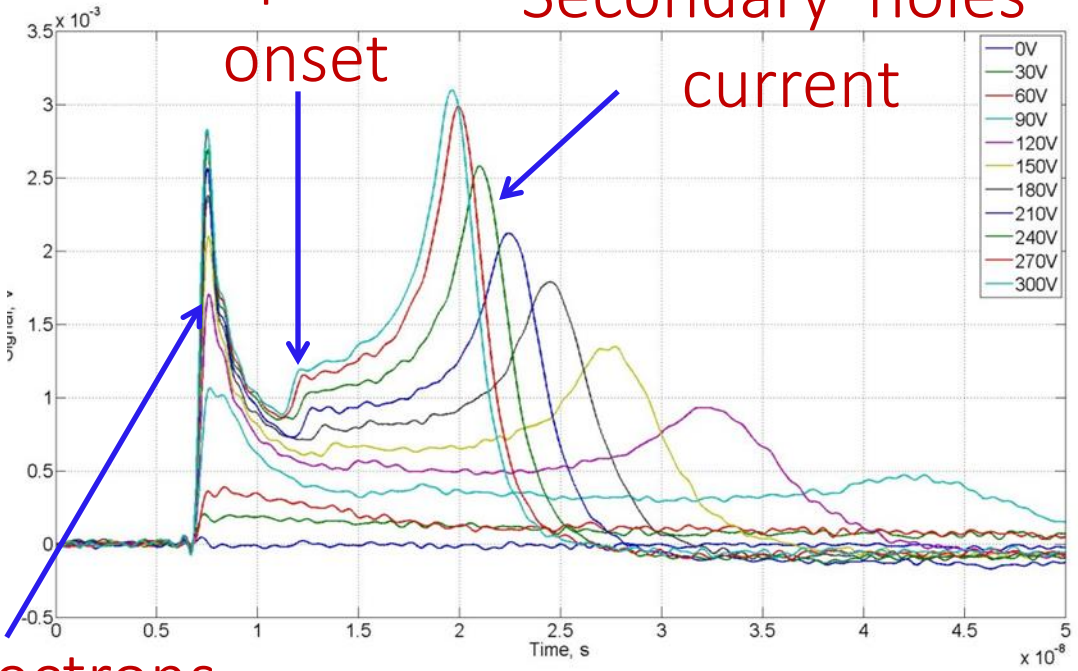
Inverse-LGAD: first observation of signal amplification

– Electron injection into the anode (FRONT SIDE !)



Multiplication onset

Secondary holes current



Primary electrons current

Time (ns)

Summary and Outlook

- Signal amplification observed both in n-in-p strip-LGADs and p-in-p strip LGADs (I-LGAD).
- Excellent gain uniformity for strip LGAD.
- Full biasing of the mini-sensors via AC fan-out.
- Complete characterization of mini-sensors different geometries (implant widths, pitch, etc).
- Test beam with Alivaba readout.

Grazie !