

Thin LGADs characterization using Ion Beam Induced Charge (IBIC) and Time-resolved IBIC at the Centro Nacional de Aceleradores.

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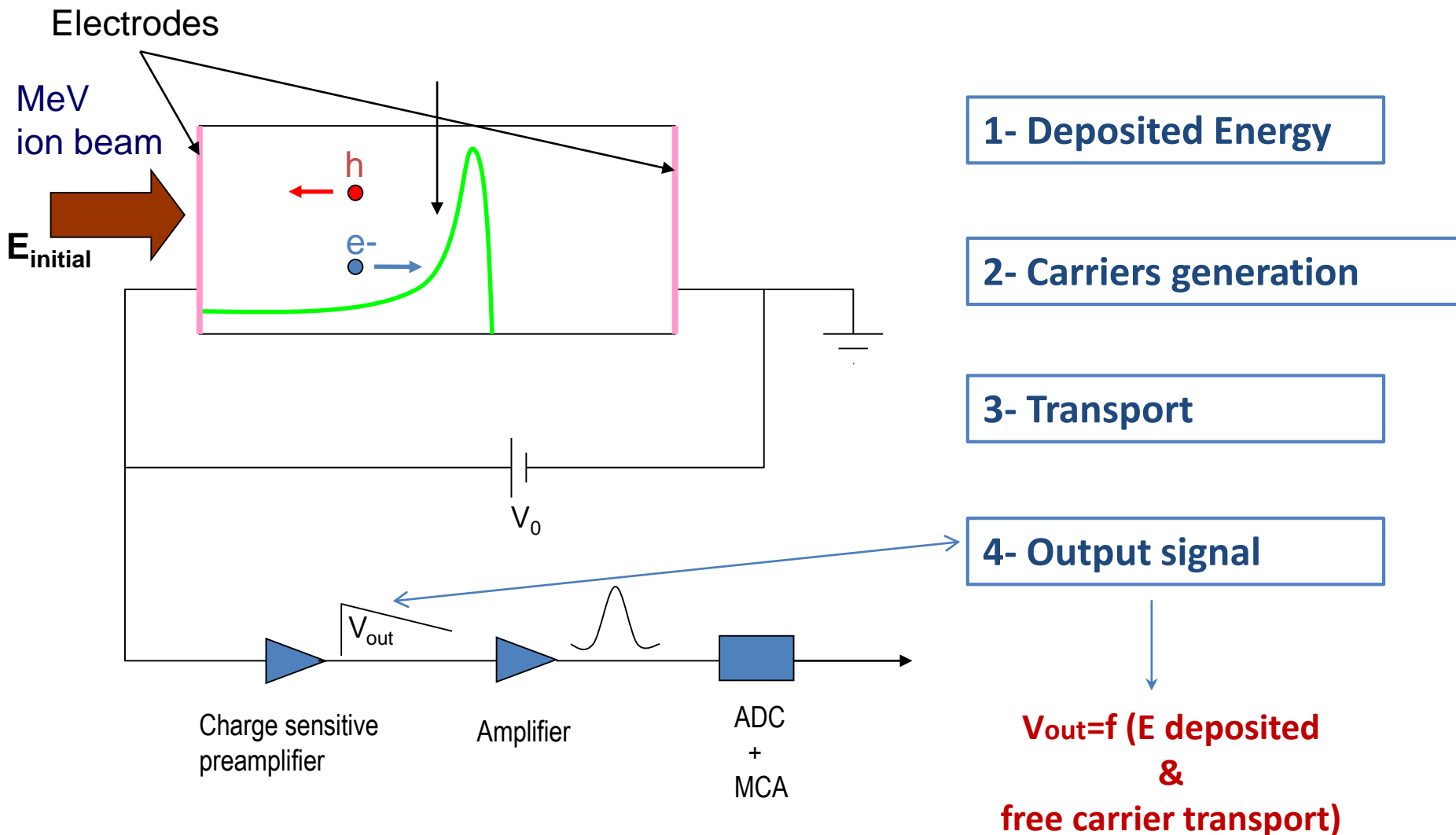
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⁴ Instituto de Microelectrónica de Barcelona (IMB-CNM, CSIC)

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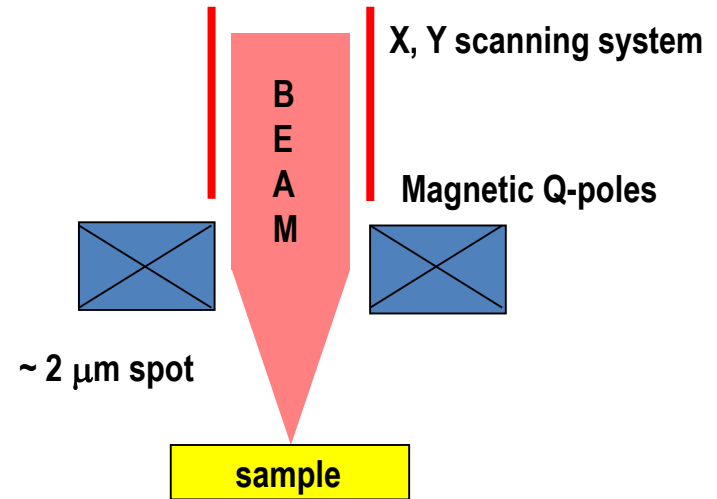
What is Ion Beam Induced Charge?



Same electronic chain as used in nuclear spectroscopy

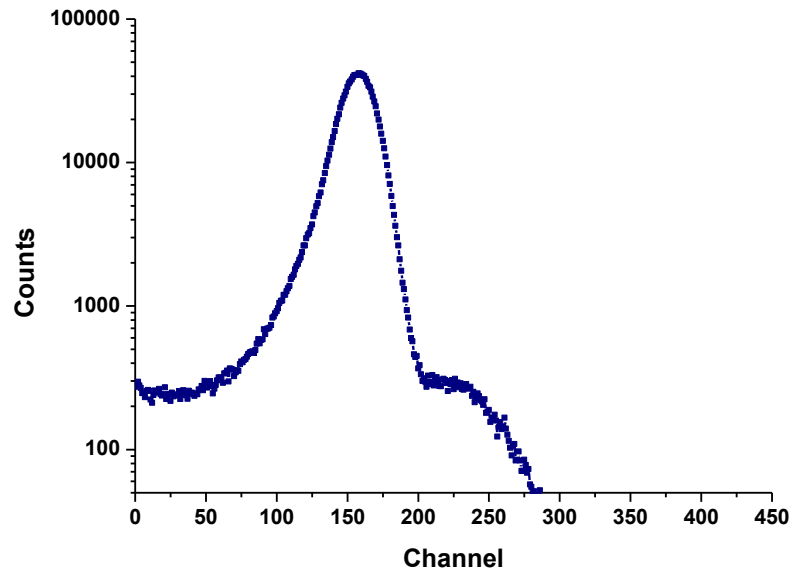
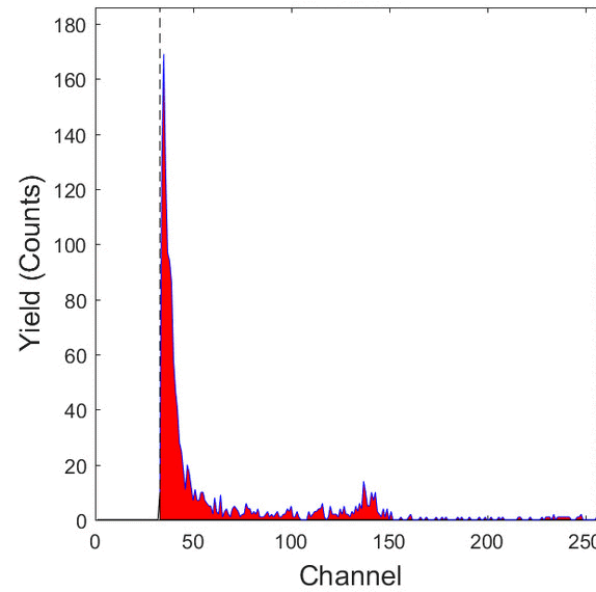
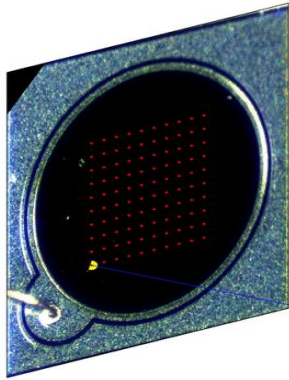
What is Ion Beam Induced Charge?

Nuclear microprobe



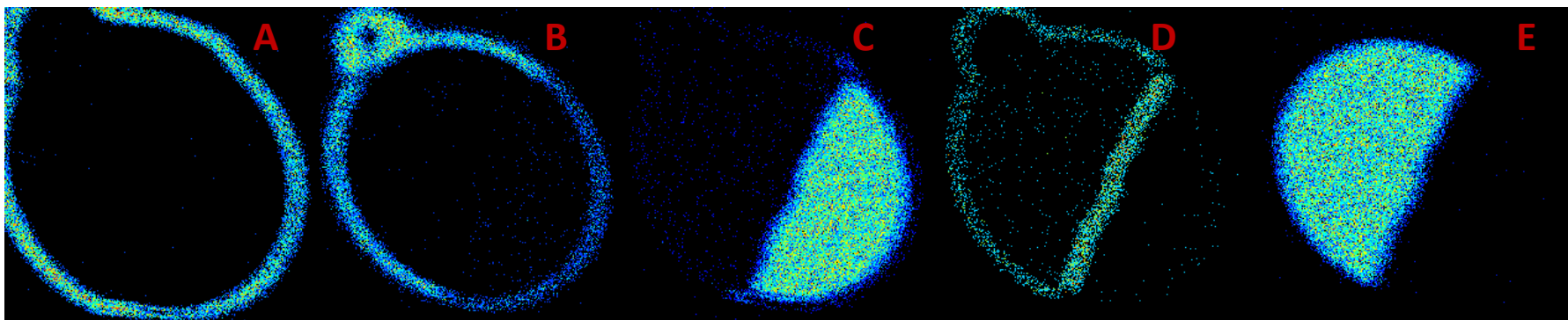
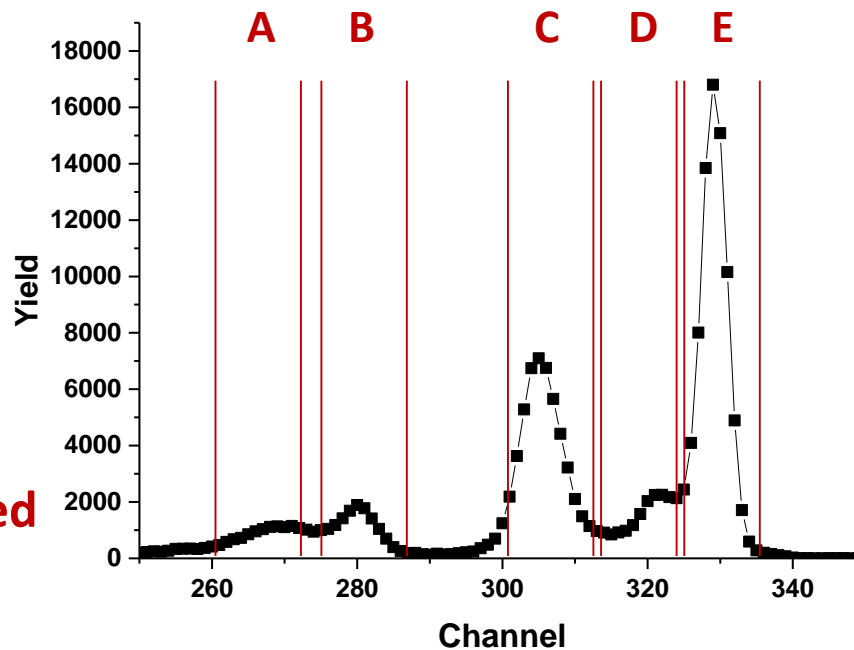
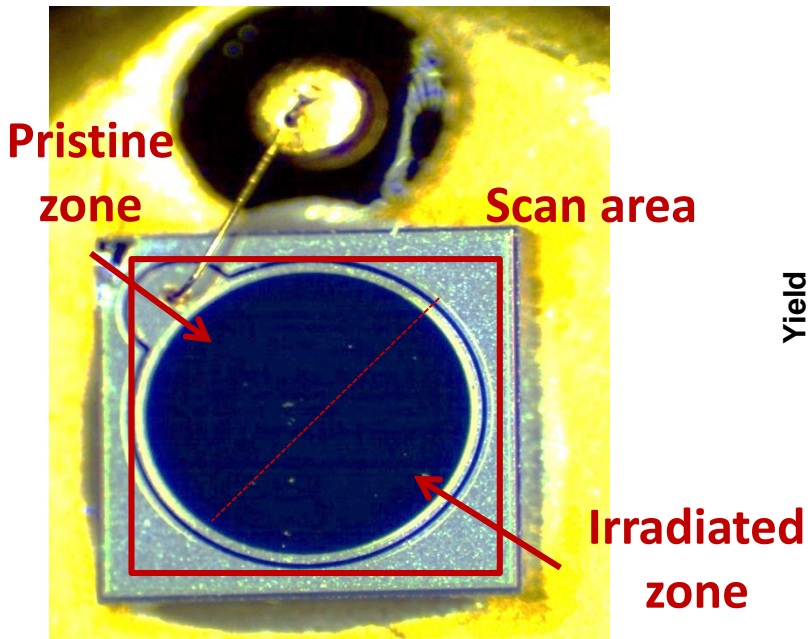
- Ion beam current: **nA to few pps** (micrometric slits)
- Scanning system: **few mm^2**
- Synchronous signal acquisition system with scanning: **mappings**

What is Ion Beam Induced Charge?



Sum spectrum from the whole scan
Channel \sim Q generated \sim E measured

What is Ion Beam Induced Charge?



RD50 Proposal

Thin LGADs characterization using Ion Beam Induced Charge (IBIC) and Time resolved IBIC at the Centro Nacional de Aceleradores.

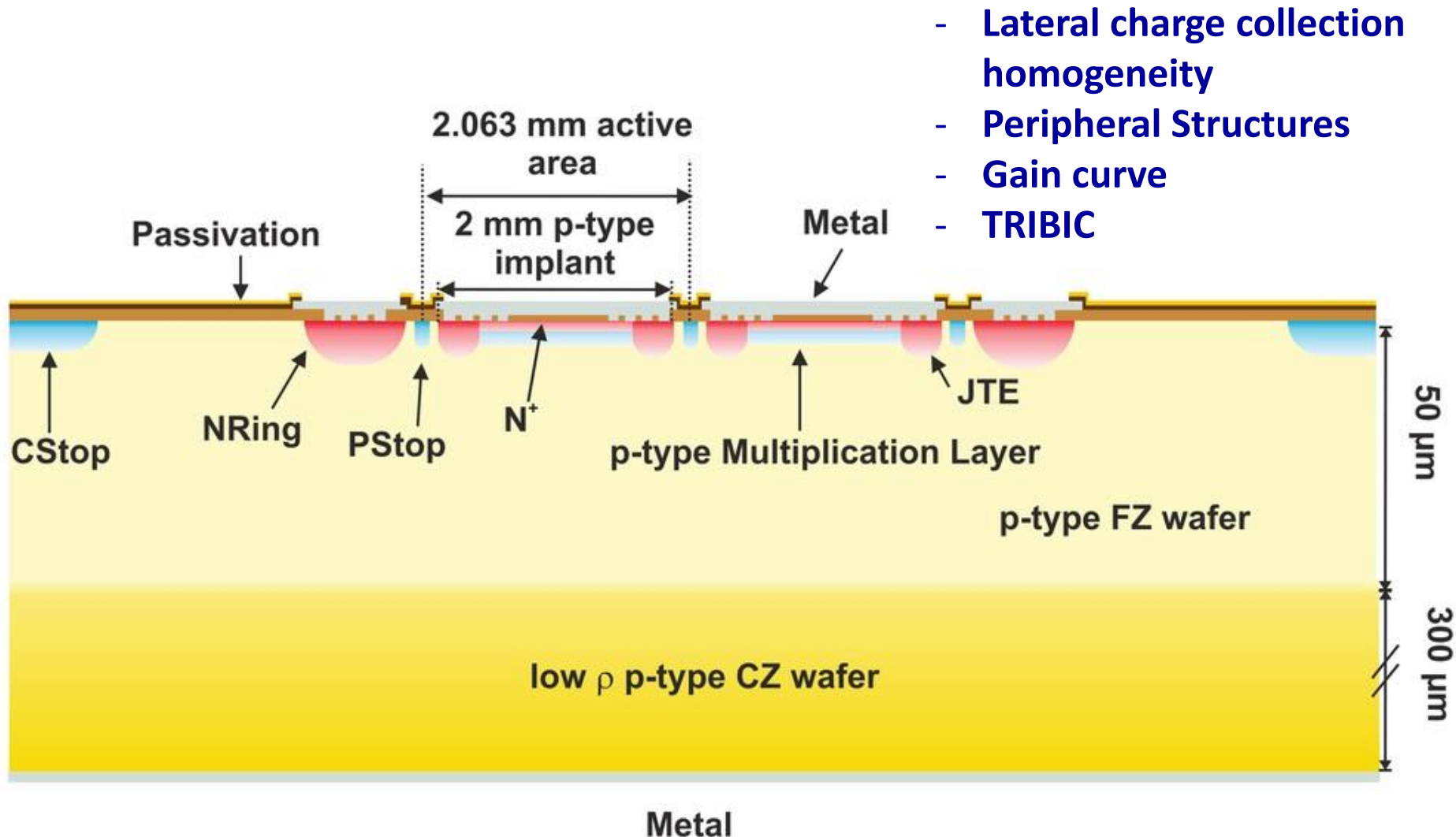
Contact person: *M^a Carmen Jiménez-Ramos*
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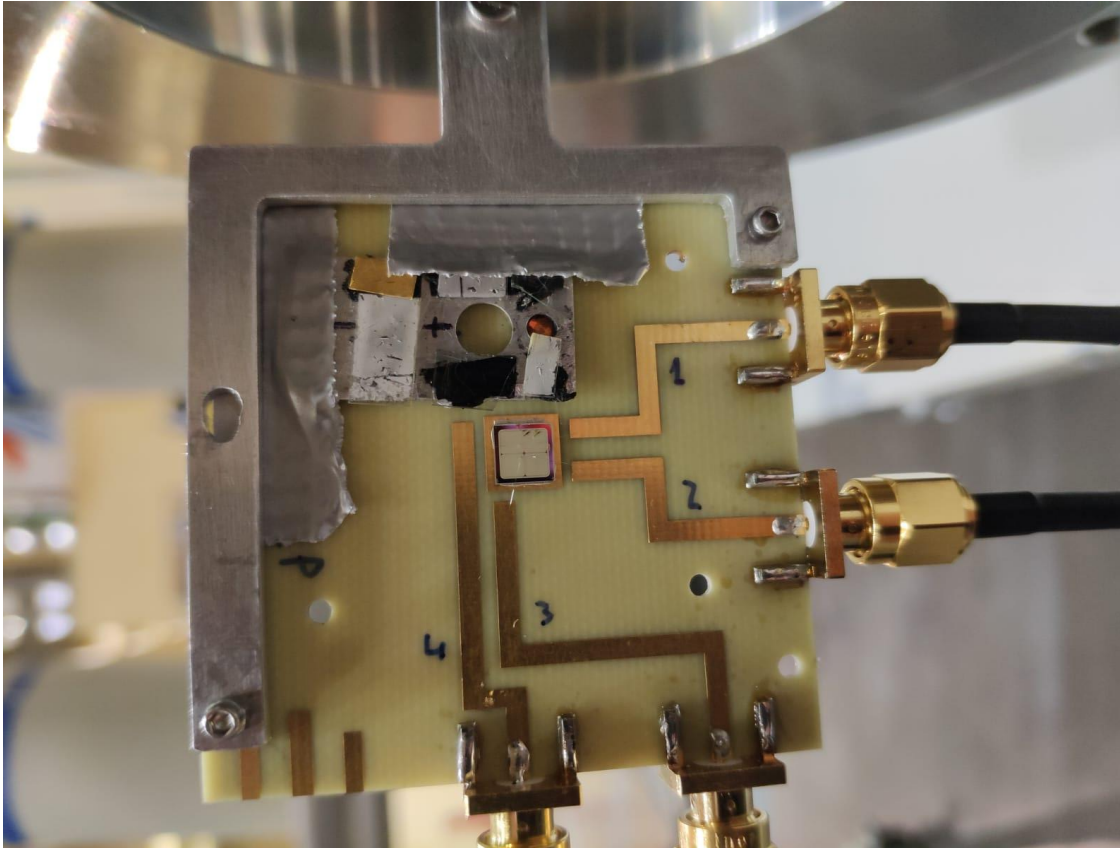
RD50 Institutes:

1. *Centro Nacional de Aceleradores, M^a Carmen Jiménez-Ramos; mcyj@us.es & Javier García López; fjgl@us.es*
2. *IFCA-Santander, Iván Vila, ivan.vila@csic.es*
3. *IMB-CNM, Salvador Hidalgo, Salvador.Hidalgo@csic.es*

Four sectors 50 μm LGAD fabricated by IMB-CNM

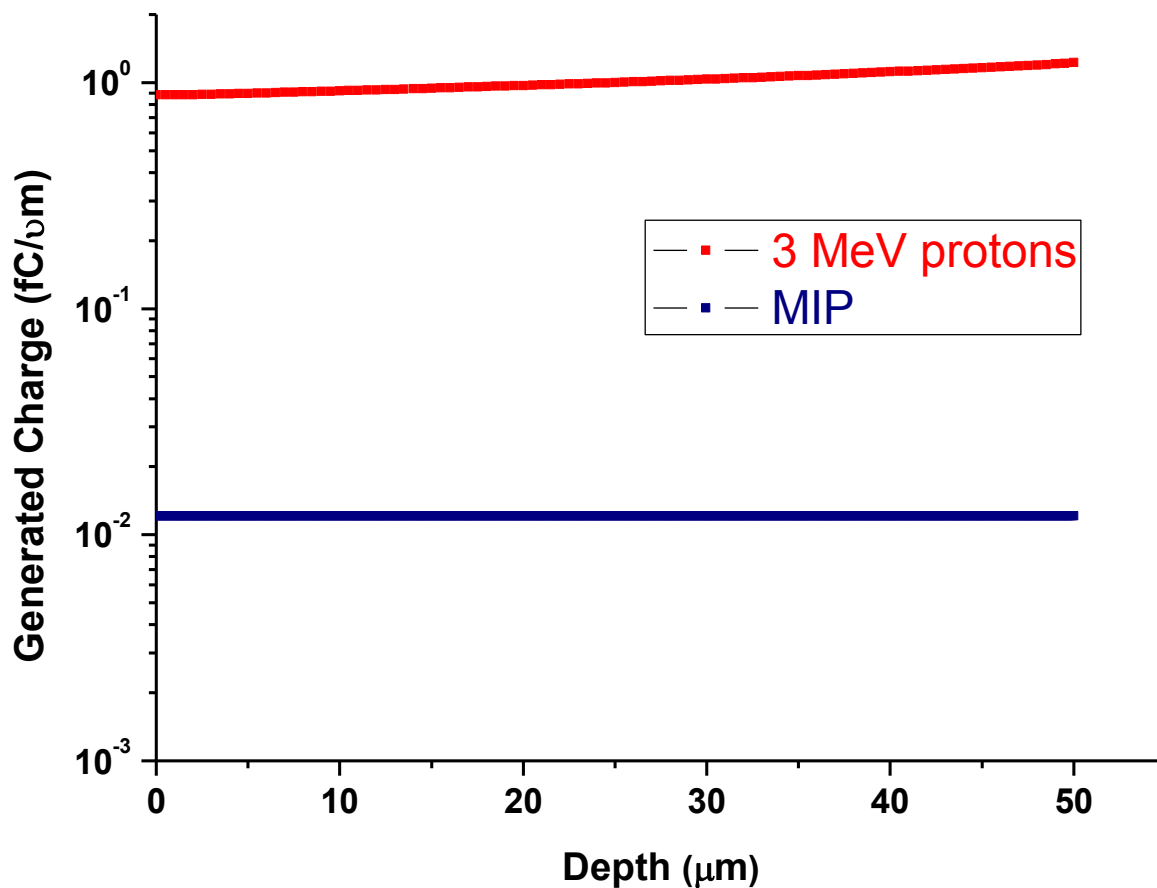


Four sectors 50 μm LGAD assembly by IFCA



- Bonding and electrical characterization by IFCA/CERN
- Dedicated PCB for laser and IBIC measurements

Charge generated across the detector



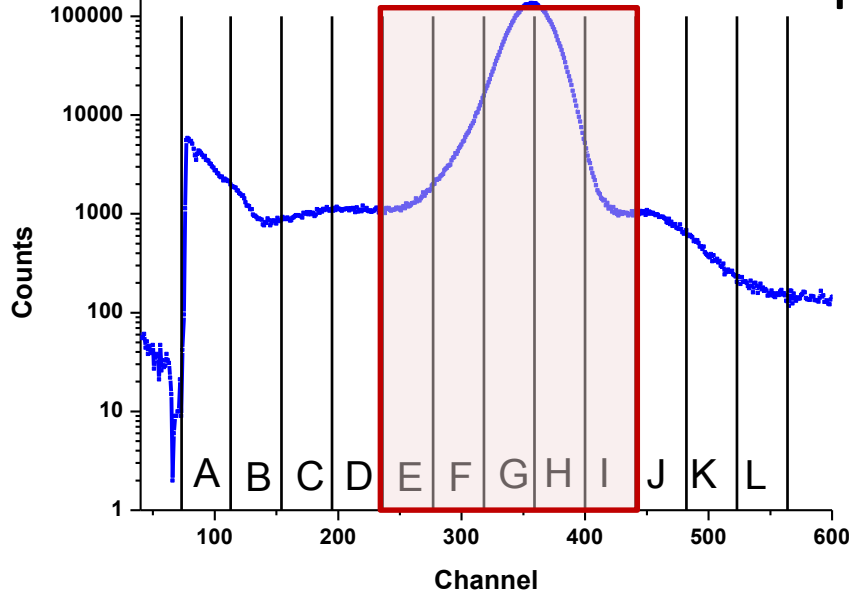
Total charge in 50 μm:

- 3 MeV protons → 50fC

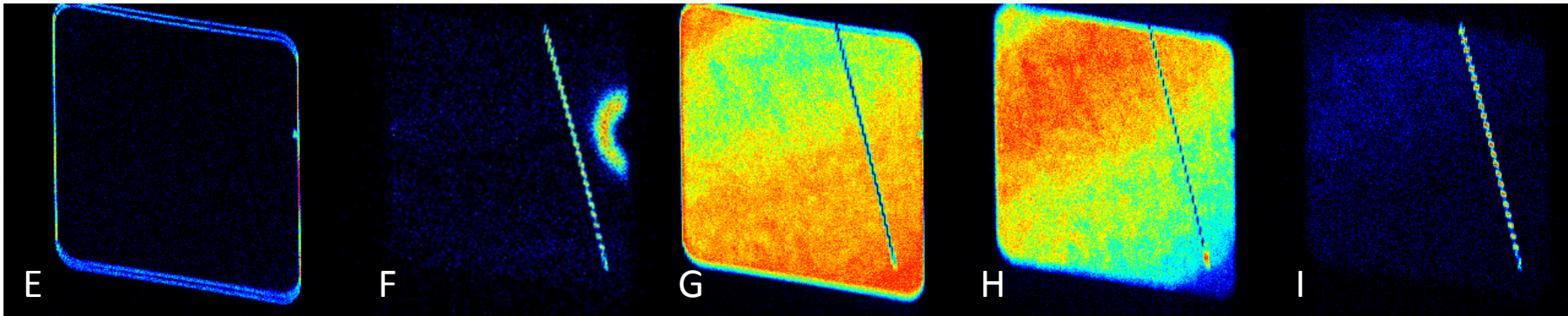
- MIP → 0,6 fC

Charge Collection homogeneity

LGAD W4-B231 #3: 3 MeV protons & +90V; 2.5*2.5 mm²

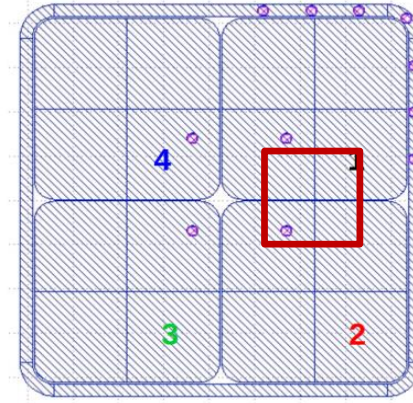
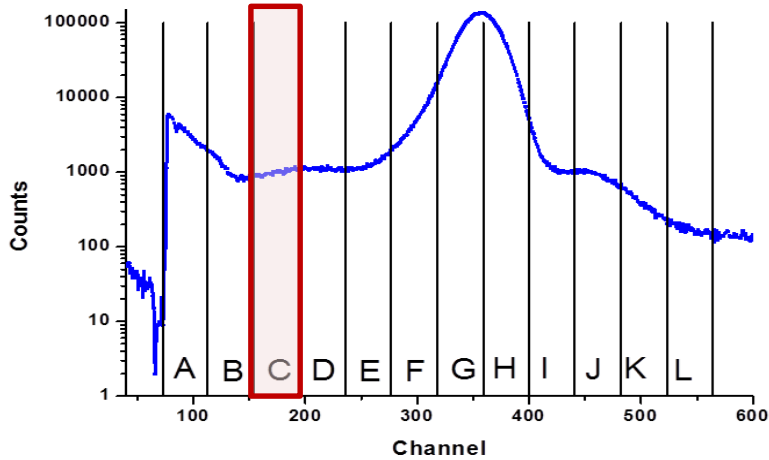


- Lateral charge collection is not homogeneous (<10%)
- Peripheral Structures are observed
- A defect is seen (red circle)
- The wire bonding is well resolved

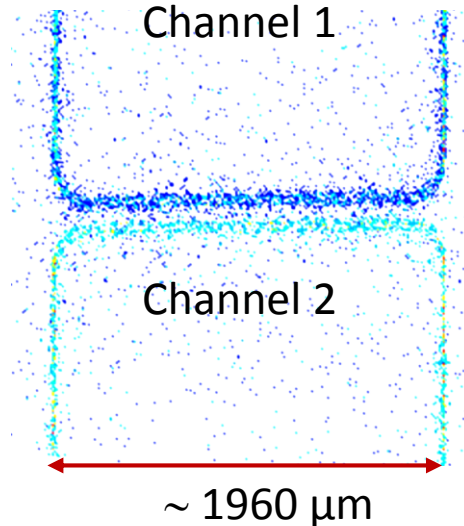
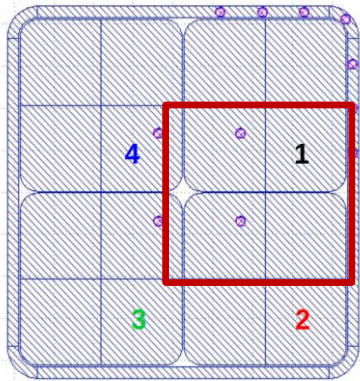


The color intensity is related to the number of counts in each position and the maps are related to the different energy windows

Peripheral Structures

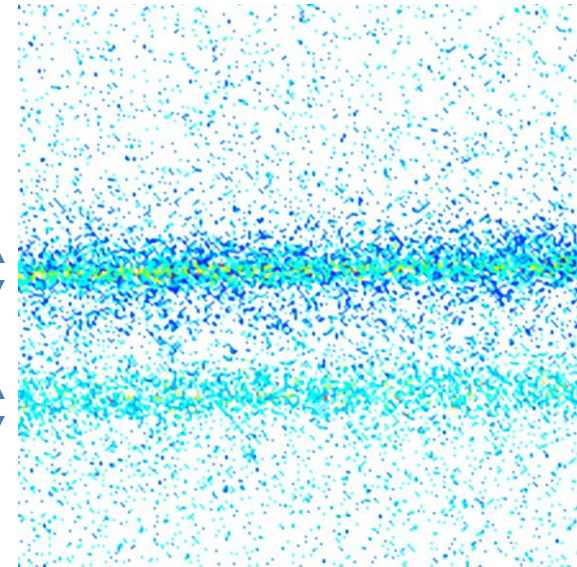


Signals from channel 1 & 2



~ 20 μm

~ 20 μm

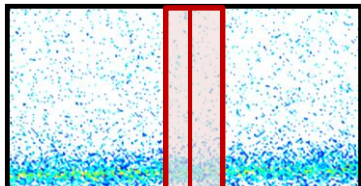


V1 = V2 = +90V

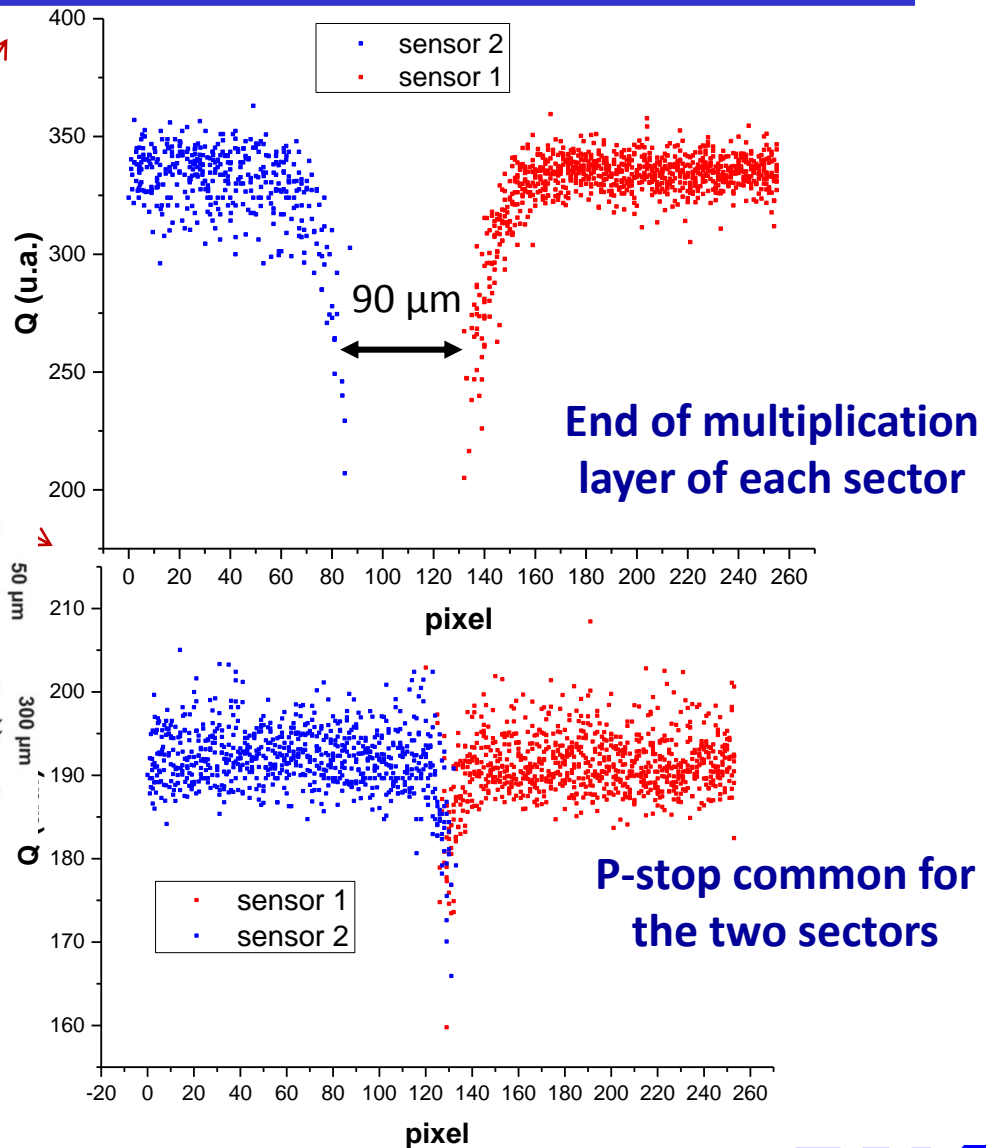
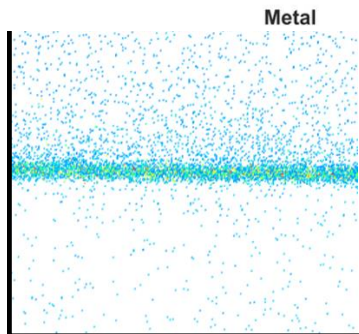
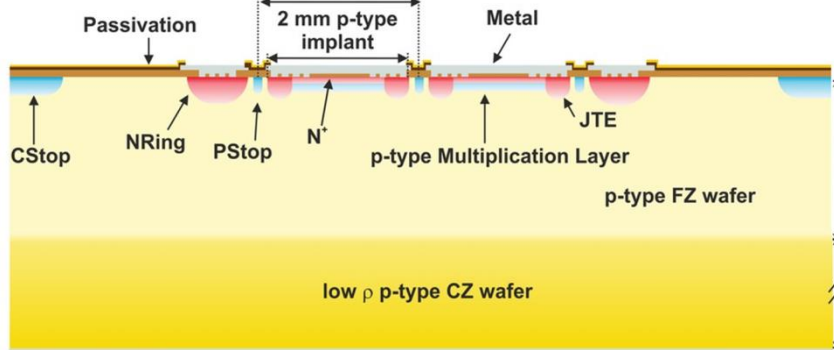
Peripheral Structures: LGAD vs PIN

LGAD

One structure for each sector with a CCE value lower than 50%.

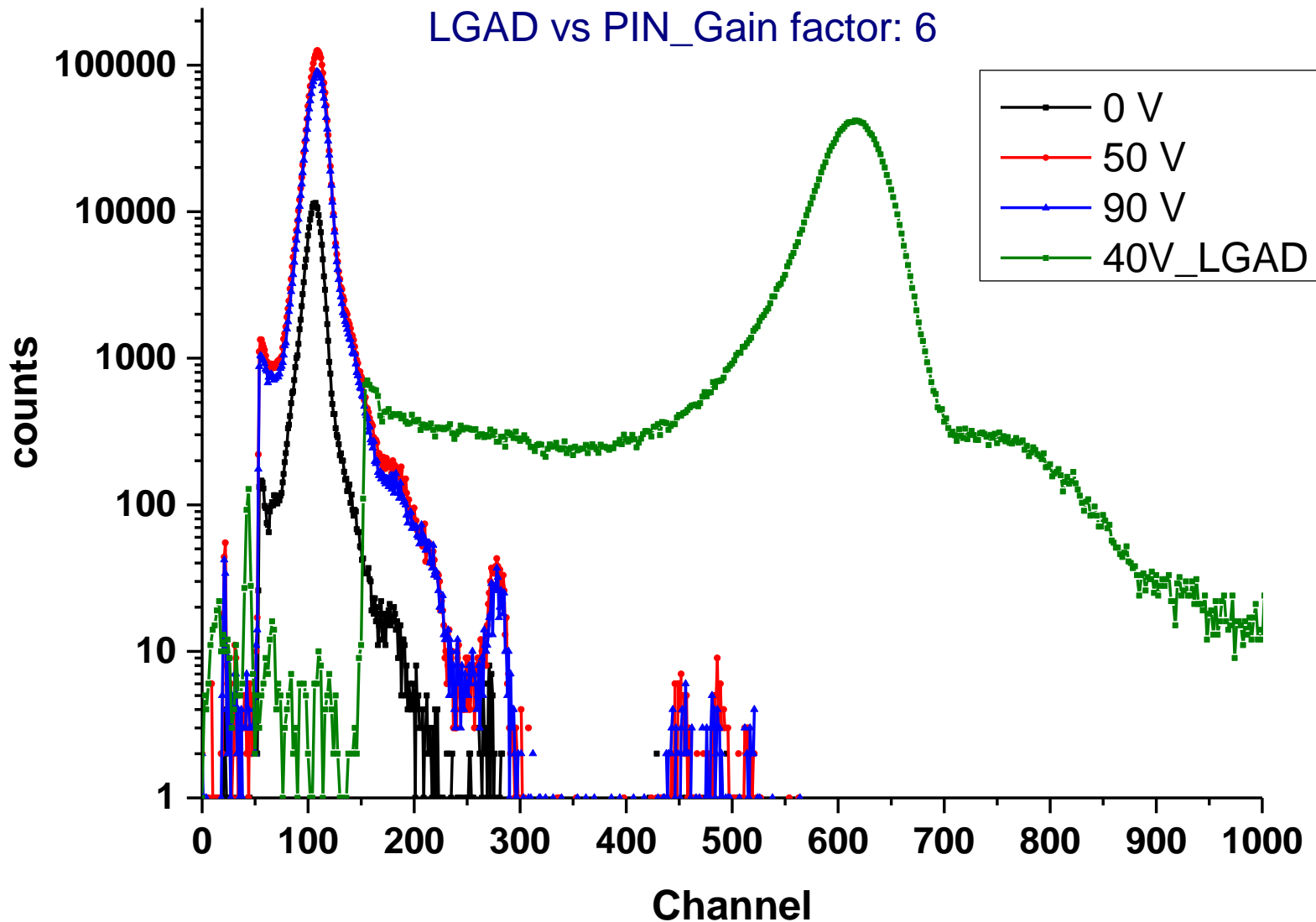


Analysis along the



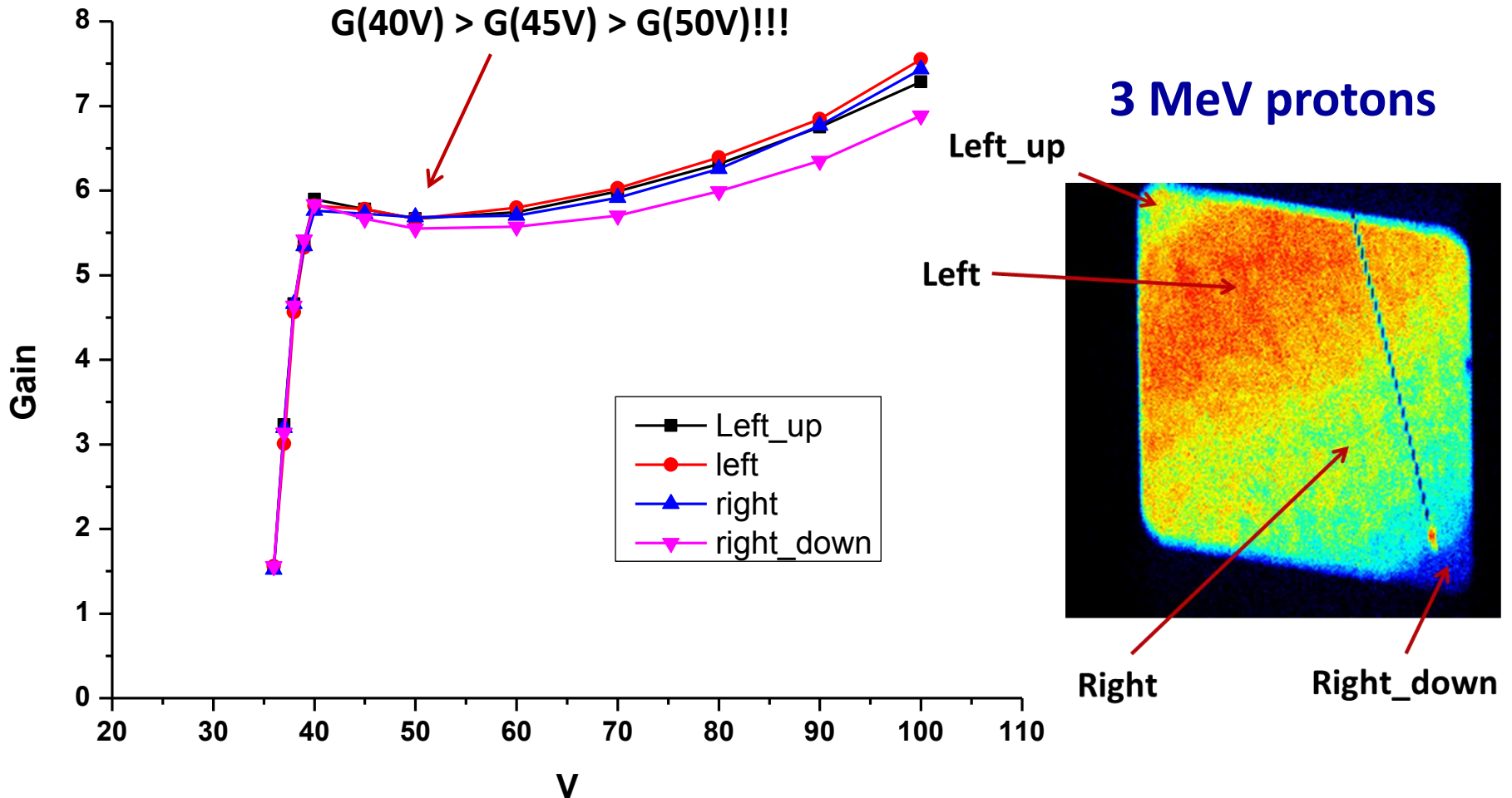
LGAD W4-B231 #3 vs W4-B232P #3

LGAD vs PIN_Gain factor: 6



Gain Curve

Gain vs Voltage for different positions within the sensor



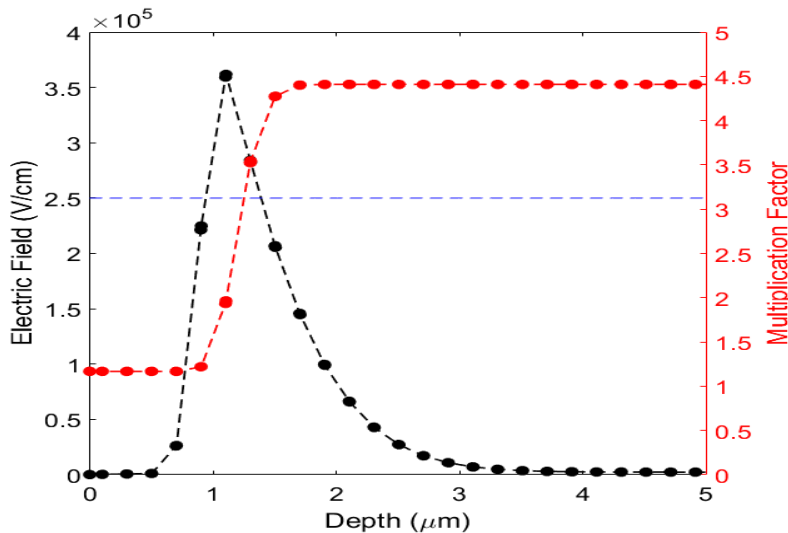
LGAD W4-B231: Gain calculations

Multiplication Factor

Y. Musienko et al., NIMA, 2000.

$$M(x) = \frac{e^{-\int_x^W (\alpha - \beta) dx'}}{1 - \int_0^W \alpha e^{-\int_{x'}^W (\alpha - \beta) dx''} dx'}$$

40 V

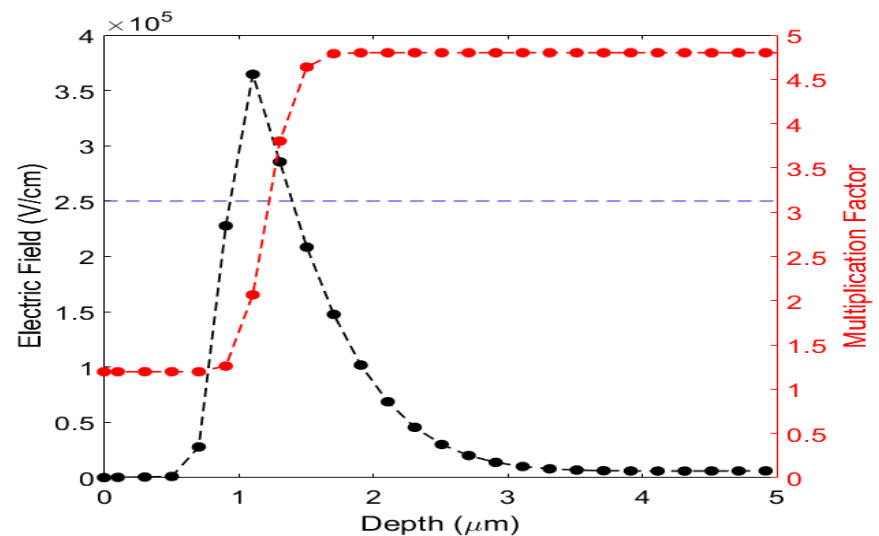


Ionization coefficients

$$\alpha(E) = 2300e^{-6.78\left(\frac{2 \cdot 10^5}{E[V/cm]} - 1\right)} \quad \text{electrons}$$

$$\beta(E) = 13e^{-13.2\left(\frac{2 \cdot 10^5}{E[V/cm]} - 1\right)} \quad \text{holes}$$

80 V



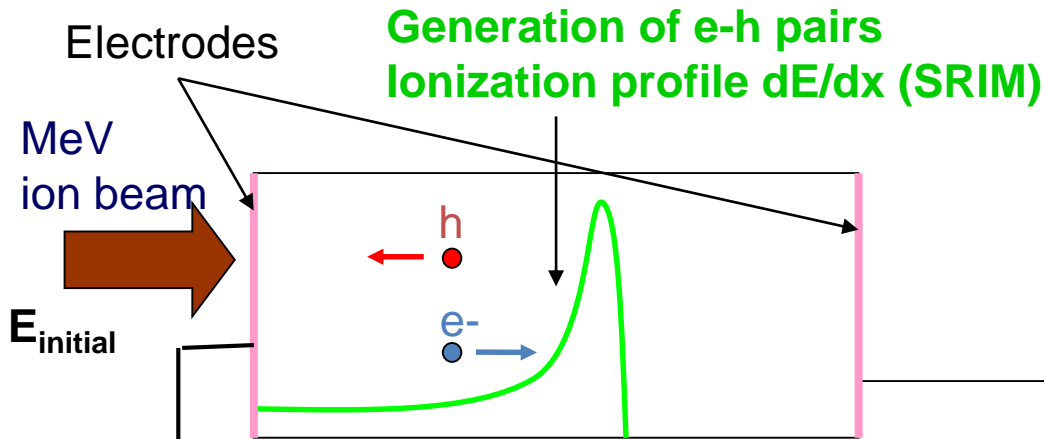
Absolute Gain (@40V) =

- Calculation: 4.4
- IBIC: 5.7

Gain (80V)/ Gain (40 V) =

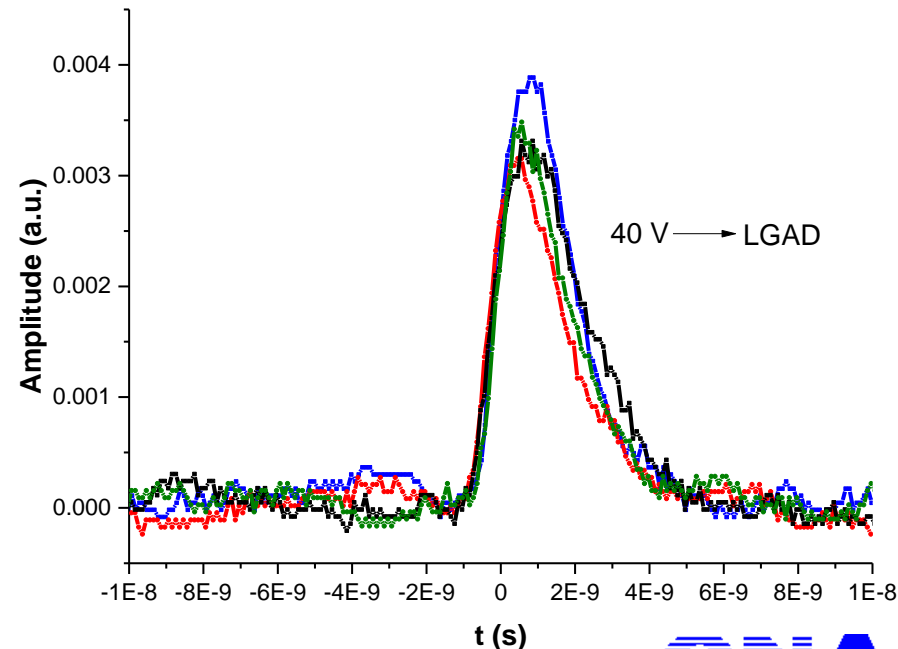
- Calculation: 1.09
- IBIC: 1.07

TRIBIC (preliminary measurements)



Transient signal
(TRIBIC)

- Without amplification stage between detector and scope
- Self-trigger: working in DAQ improvements
- External trigger system ongoing



New sample holder for IBIC at -20°C



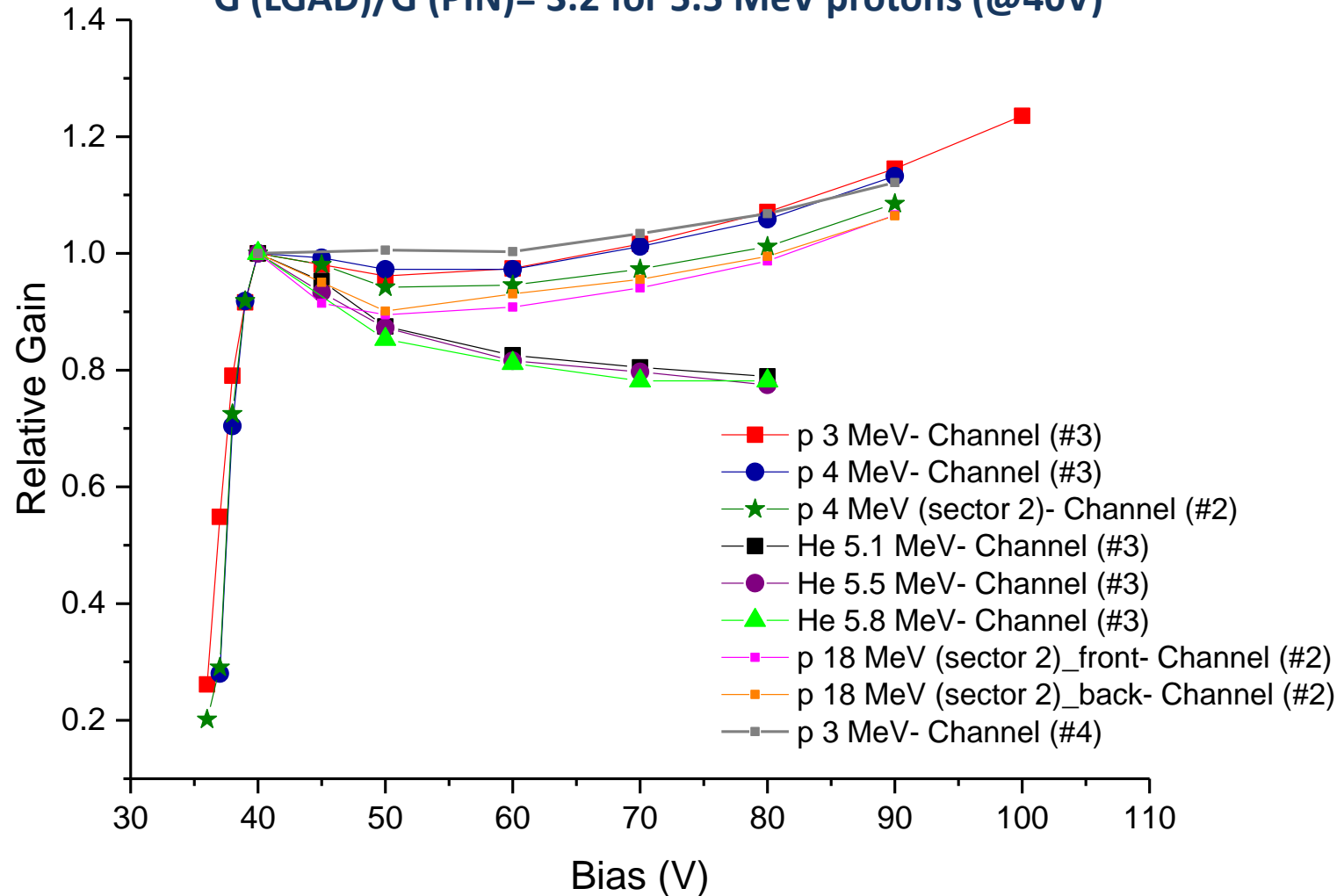
Thank you for your attention



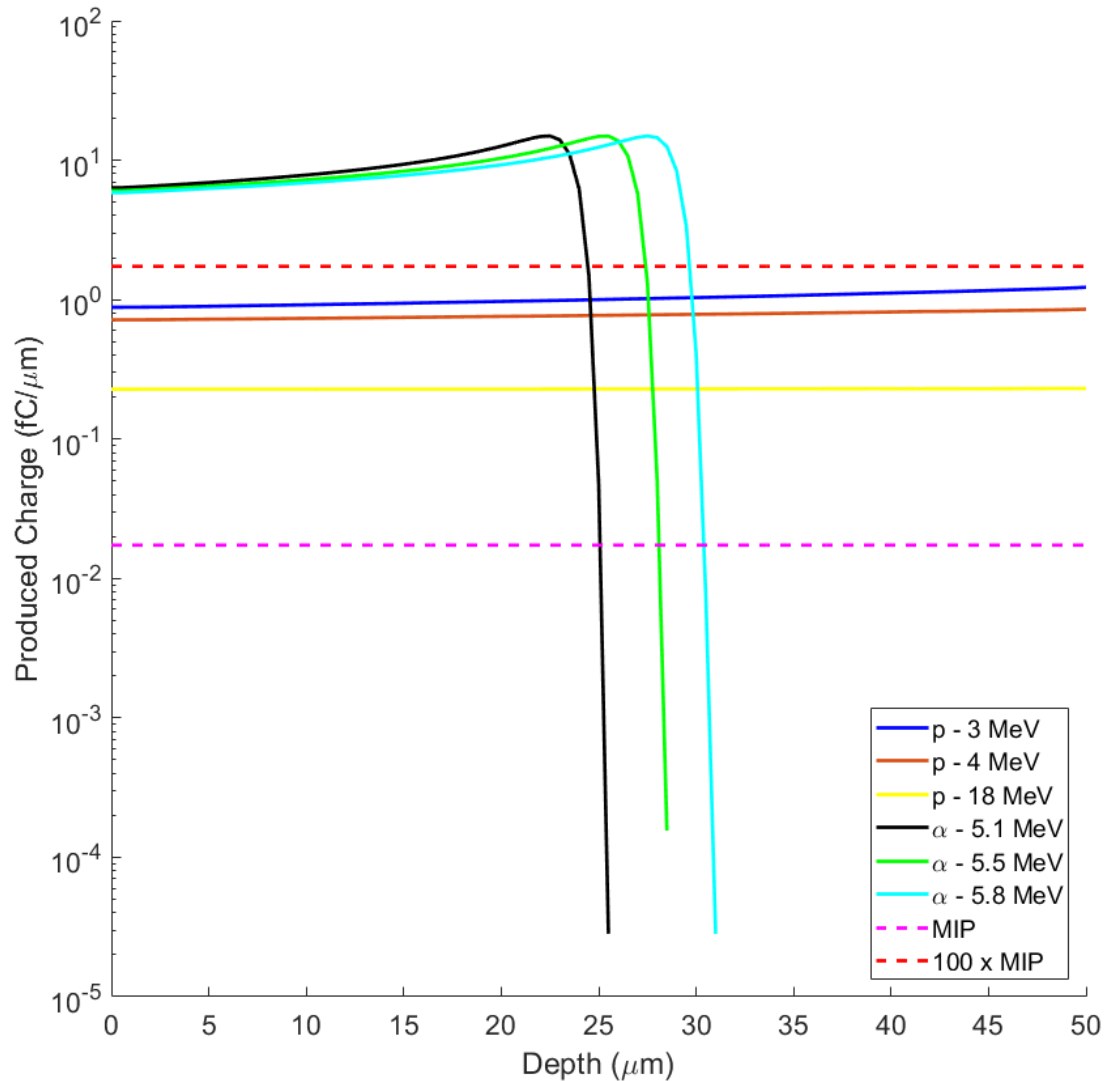
LGAD W4-B231: Gain Curve

$G(\text{LGAD})/G(\text{PIN}) = 5.8$ for 3 MeV protons (@40V)

$G(\text{LGAD})/G(\text{PIN}) = 3.2$ for 5.5 MeV protons (@40V)

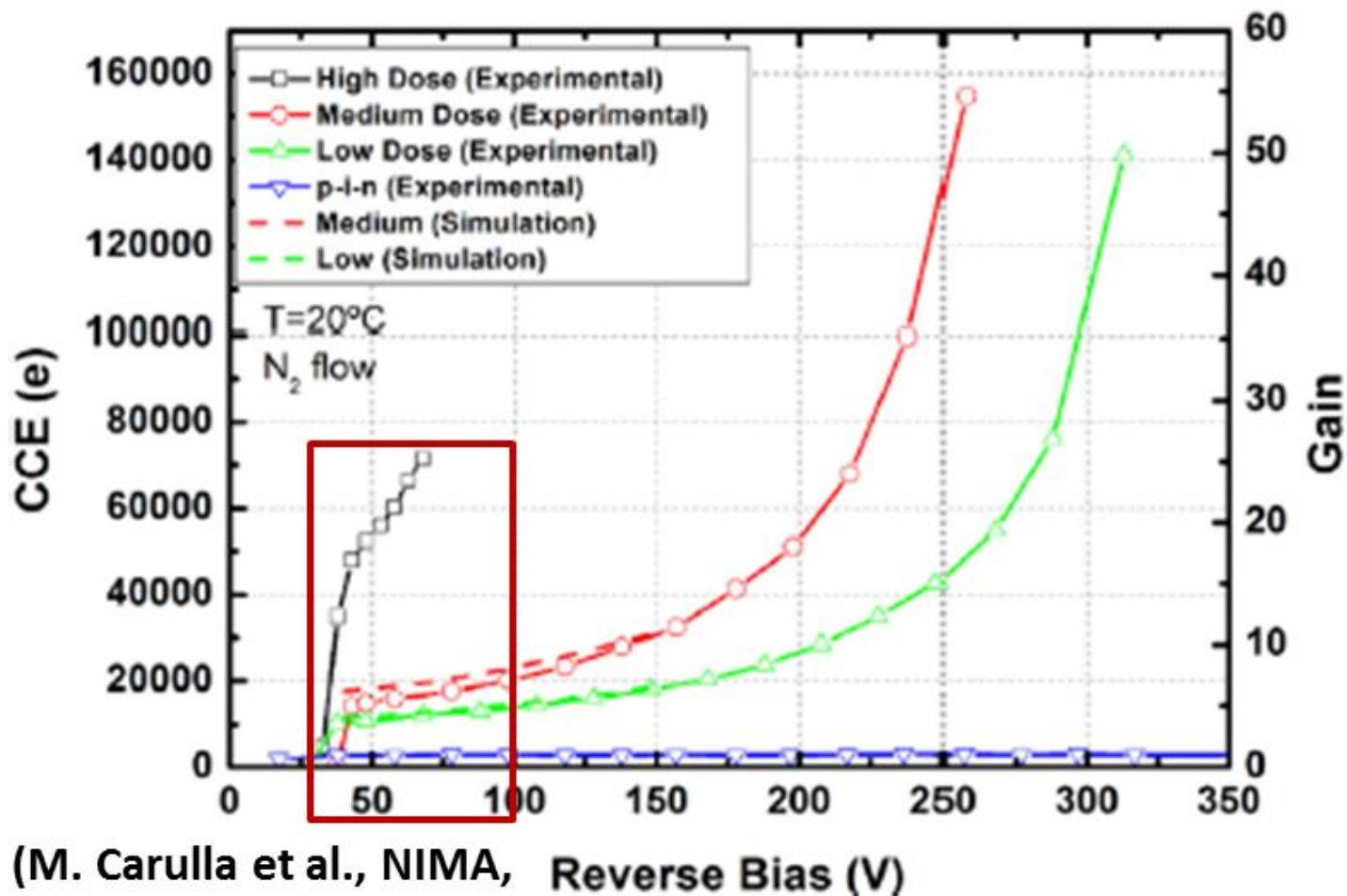


Generated charge profile



Sr-90 source

Charge collection



(M. Carulla et al., NIMA, Reverse Bias (V)
in press)

W4-B231 Pad Current

