Update on the upcoming test beam and the ongoing analysis of TI-LGADs

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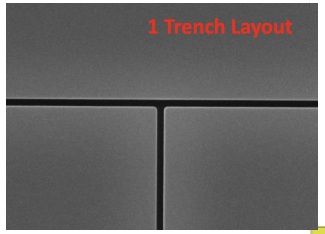
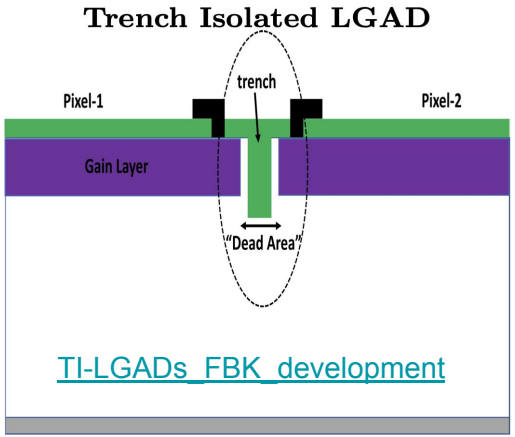
Introduction: Trench Isolated - LGADs: Solution?

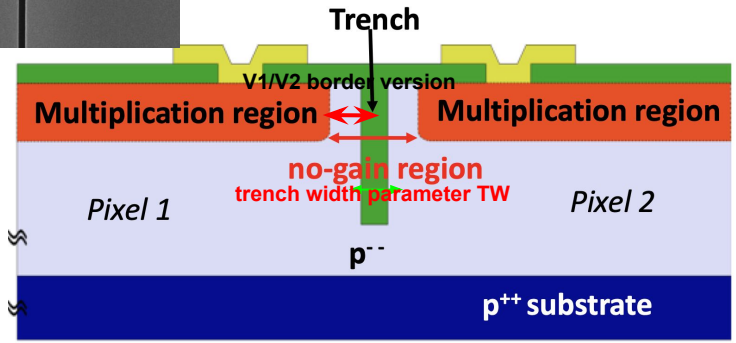
- New LGAD technology:
  The trench replaces JTE (Junction Termination Extension) & p-stop
  Trenches → Drift/diffusion barrier
  - Carbon co-implantation in the gain layer
- Solution considered for Phase 3 in the LHC experiments in the timing layer

(preventing charge carriers (electrons/holes) from drifting)

- Dead region is significantly reduced
- The trenches are < 1μm wide and few microns deep
- Smaller gain-loss region is expected
- Trenches of etched dielectric material, filled with SiO_2

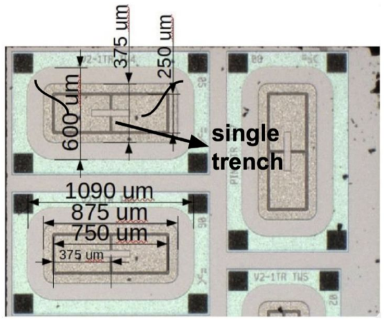






Samples characterized at SPS test beams

- Variations in trench depth (Dx) and trench width (TWx)
- **375 µm × 250 µm pixel pitch**
  - Fabricated @ FBK wafers: 2, 5 and 9
  - Trench width parameters TW5, TW1/2/3; TW4/6
  - Border version V1 and V2: distance between center of trench to the edge of the gain layer
  - Fluences: 0E15, 1.5E15 and 2.5E15 n_{eq}/cm^2
- Single-trench TI-LGAD devices



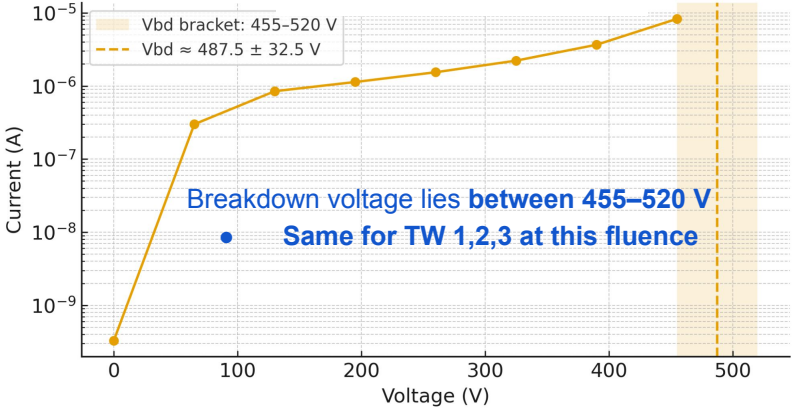
Measured in October 2024 and April 2025 testbeam
V2 border version

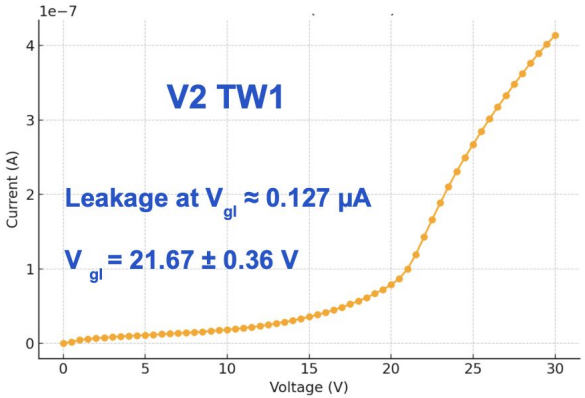
Measured in October 2025 testbeam
V1 and V2 border versions

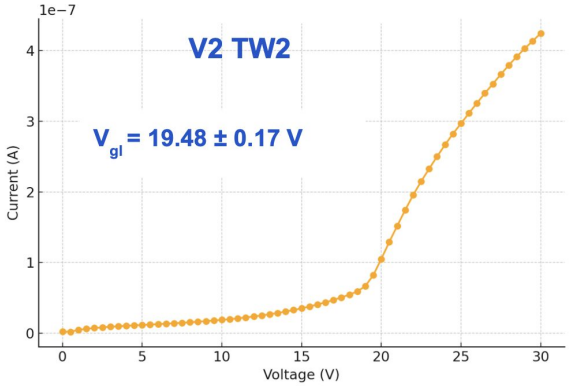
Wafer	Thickness	Carbon	Trench depth	Trench process
1	45	Y	D3	P2
2	45	Y	D2	P2
3	45	Y	D1	P2
4	45	Y	D1	P1
5	45	Y	D2	P1
6	45		D2	P2
7	45		D2	P2
8	45		D1	P1
9	55	Y	D3	P2
10	55	Y	D2	P2
11	55	Y	D2	P2
12	55		D2	P2

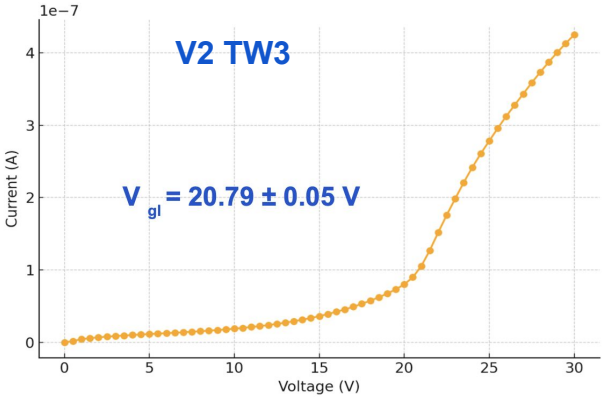
Wafer information provided by FBK:
https://zenodo.org/records/7515703

BEFORE, single pad: I–V Curve Validation of TI-LGAD after 1.5×10^{15} n_{eq}/cm^2 irradiation

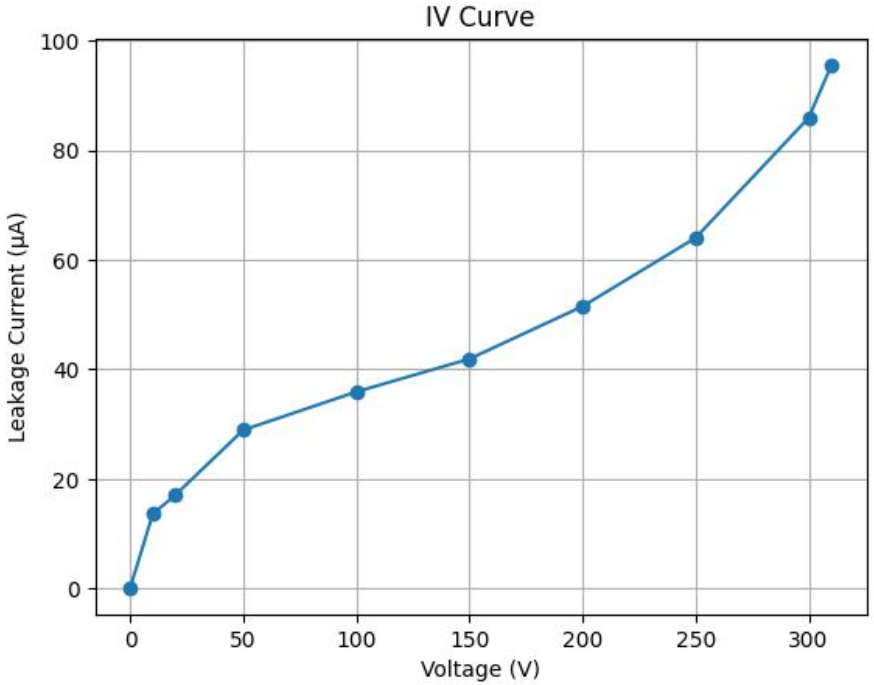








Both pads together: I–V Curve Validation of TI-LGAD after 1.5×10^{15} n_{eq}/cm^2 irradiation



Test beam overview -> preparations

Trench Depth	Trench parameter	Fluence (n_{eq}/cm^2)	Devices	Number of daughterboard	Chubut CH1,2	Chubut CH3,4	B
V1	TW5	2.50E+15	V1TW5 / V2TW5	1	V1TW5	V2TW5	
V1	TW5	2.50E+15	V1TW5 / V2TW5	2	V1TW5	V2TW5	
V1	TW5	2.50E+15	V1TW5 / V2TW5	3	V1TW5	V2TW5	
V1	TW5	2.50E+15	V1TW5 / V2TW5	4 @JSI	V1TW5	V2TW5	
					V1TW5	V2TW5	
V1	TW5	1.50E+15	V1TW5 / V2TW5	5	V1TW5	V2TW5	
V1	TW5	1.50E+15	V1TW5 / V2TW5	6	V1TW5	V2TW5	
V1	TW5	1.50E+15	V1TW5 / V2TW5	7 @JSI	V1TW5	V2TW5	
V2	TW 4/6/7	1.50E+15	Standard	8	V2TW4	V2TW6	
V2	TW 4/6/7	1.50E+15	Standard	9 @ JSI	V2TW4	V2TW6	
V2	TW 4/6/7	2.50E+15	Standard	10	V2TW4	V2TW7	
V2	TW 4/6/7	2.50E+15	Standard	11	V2TW4	V2TW6	
V2	TW 1/2/3	1.50E+15	Standard	12	V2TW1	V2TW3	
V2	TW 1/2/3	2.50E+15	Standard	13	V2TW1	V2TW2	
V2	TW 1/2/3	2.50E+15	Standard	14	V2TW1	V2TW3	
From previous test beam							
V2	TW 1/2/3	8.00E+14	Standard	15	V2TW1	V2TW2	
V2	TW 1/2/3	1.50E+15	Standard	16	V2TW1	V2TW2	
V1/2	TW 5	0.00E+00	V1TW5 / V2TW5	W9C	V2TW1	V2TW2	
AC-LGAD		0.00E+00					

DUT Overview

- **First batch:**
  - Samples → mounting, wire bonding, testing before TB → **Iskra**
- **W5 V1/V2 TW5** (standard 2 × 2 pixels)
  or **W5 V2 TW1/2/3 → 0E15 neq/cm^2** (Zurich + CERN maybe)
- **W5 V2 TW4/6 → 1.5E15 neq/cm^2**
  - Measurements at different sensor tilt angles together with the non-irradiated DUT (if time allows)
- **W5 V2 TW1/2 → 2.5E15 neq/cm^2**
- **W2 V2 TW1/2 → 2.5E15 neq/cm^2 (Marcos to check if there is one left at CERN and re-wirebond 3->2)**
  - Possibly different bias voltage points

Test beam overview -> preparations

Hardware & Equipment

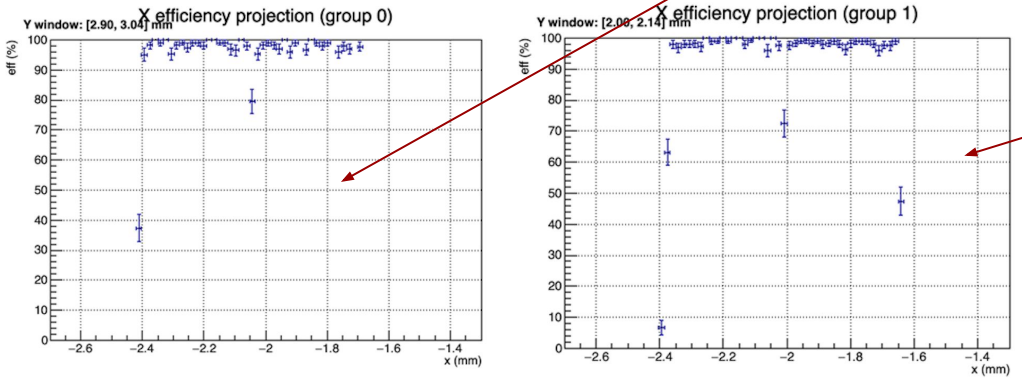
- 25 × 100 μm^2 CROC to be installed on Monday (Jordi + Antonio)
- 3 LV and 2 CAEN HV supplies (e-pool – done)
- Cables + splitter (Leena; splitter I/O (3) found at CERN)
- Irradiated wire-bonded samples already at CERN from previous test beams (to be checked)
- 2 telescope planes missing (telescope to be checked before TB starts) → Iskra + Marcos (next week at H6)
- Chubut boards (Leena + Iskra)
- Scopes → will use only one for triggering (CROC+scintillators) (have we ordered one?)
- 2 × 16+1 12 bit 5 GS/s CAEN digitizers
  - One already at CERN (JSI office)
  - One from Santander
- Cold box → same status as before
- 3D printing in progress for clamps + holders
- Newport nano-stages → provided by LHCb (Victor Coco)

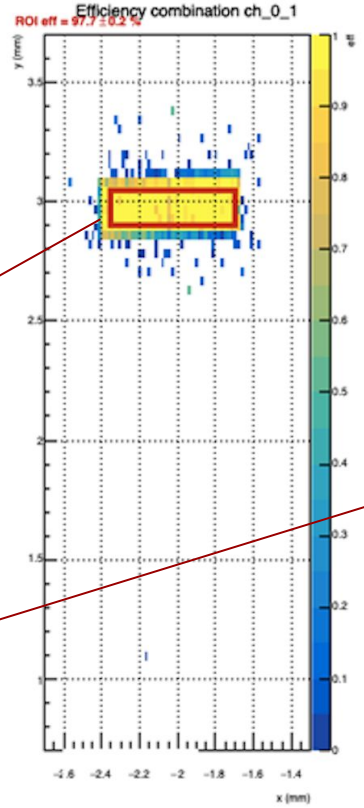
No telescope!
Action asap

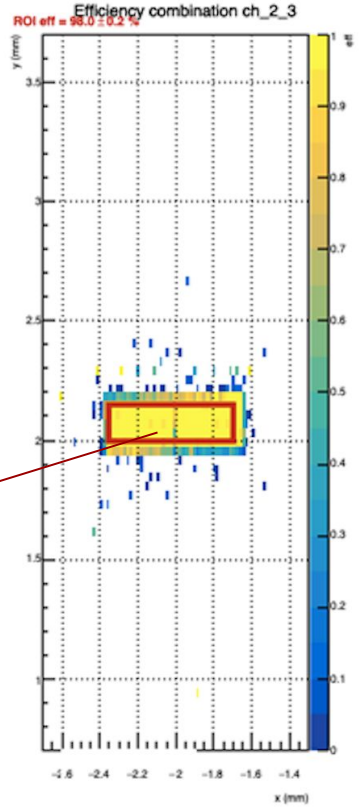
Run 607 – Strict TREF-Anchored Efficiency Analysis

Analysis settings:

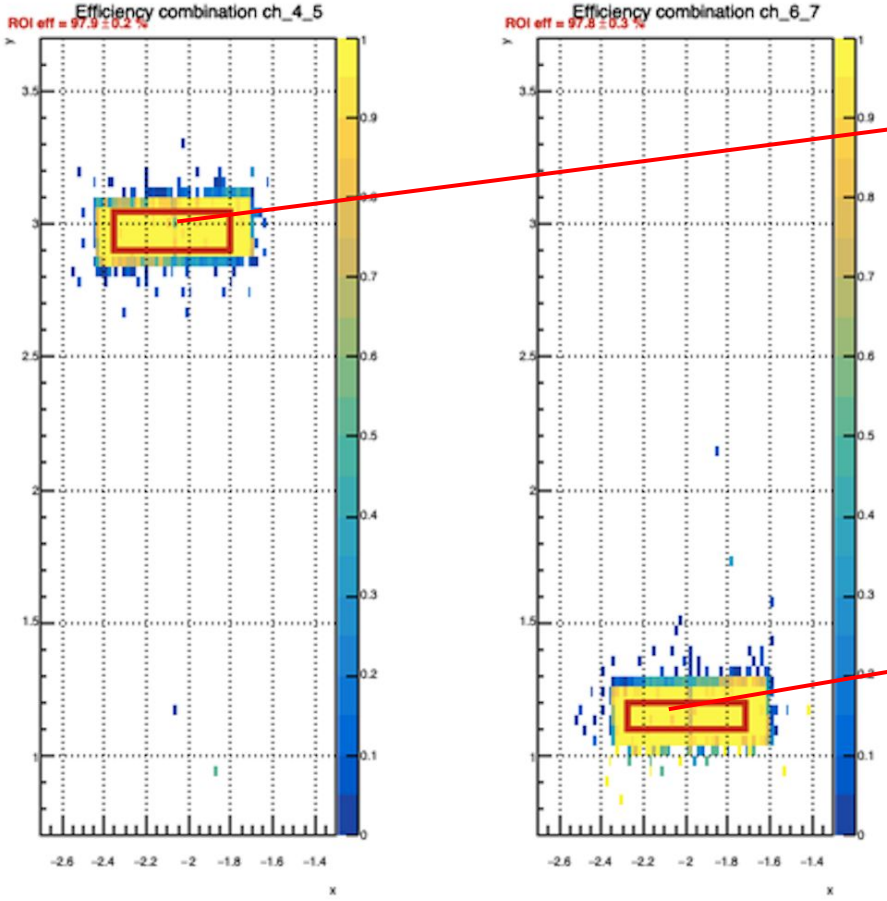
- Baseline subtraction on all channels
- TREF anchor from CFD50 on wf8/wf9
- Strict cuts:
  - (Design and performance of the Fermilab Constant Fraction Discriminator ASIC)
  - Using timing from both channels (Interaction position, time, and energy resolution in organic scintillator bars with dual-ende readout) -> averaging two time estimates
  - interpolated value between samples corresponding to 50% of the maximum value on the rising edge of the pulse

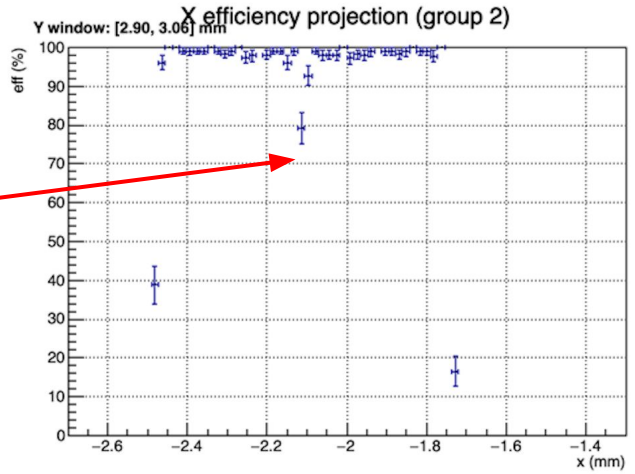


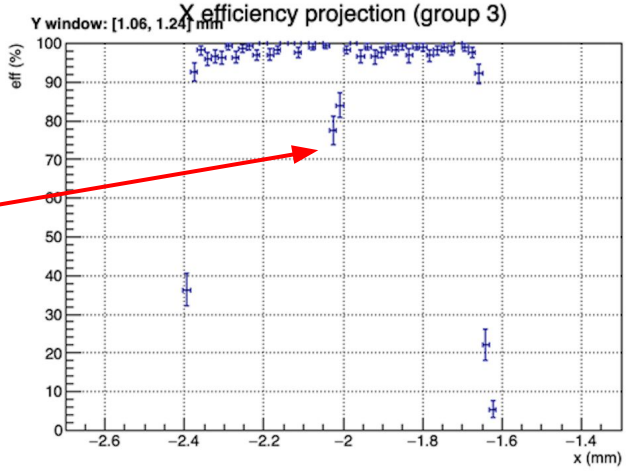




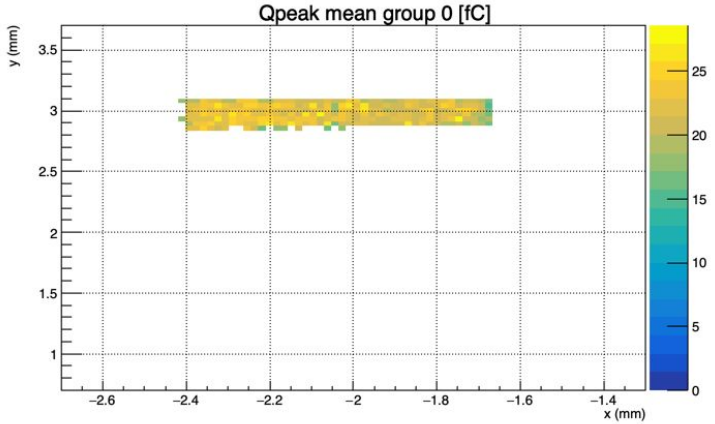
Irradiated structure to 1.5E15 neq/cm2 -> efficiencies

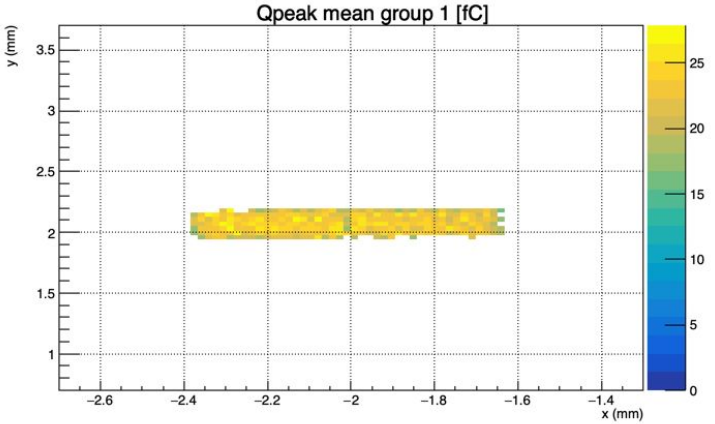


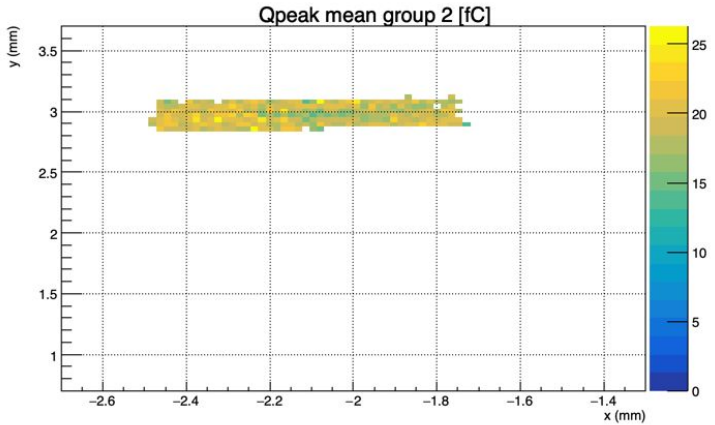


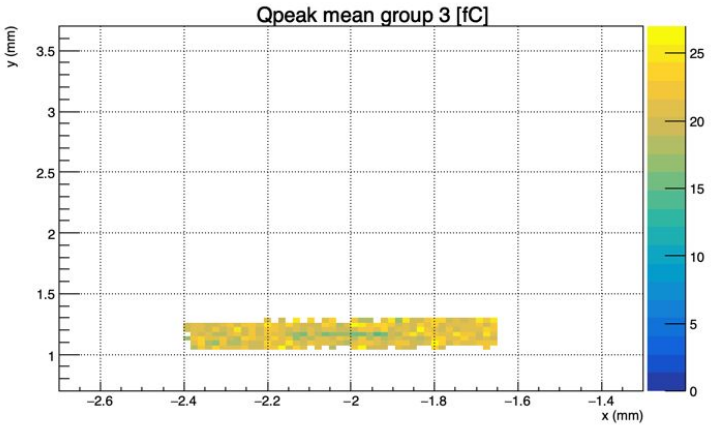


Track-based 2D maps of mean peak charge, show a uniform signal response across the active strips with typical values of about 20–27 fC









Per-bin timing resolution σt(x,y), obtained as the standard deviation of the centered time difference (preliminary)