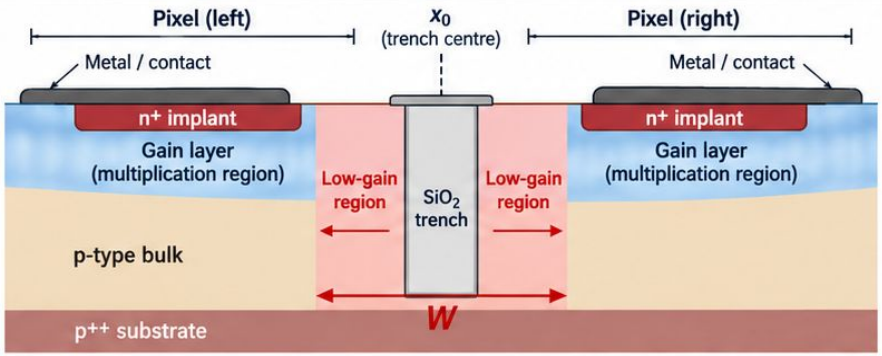
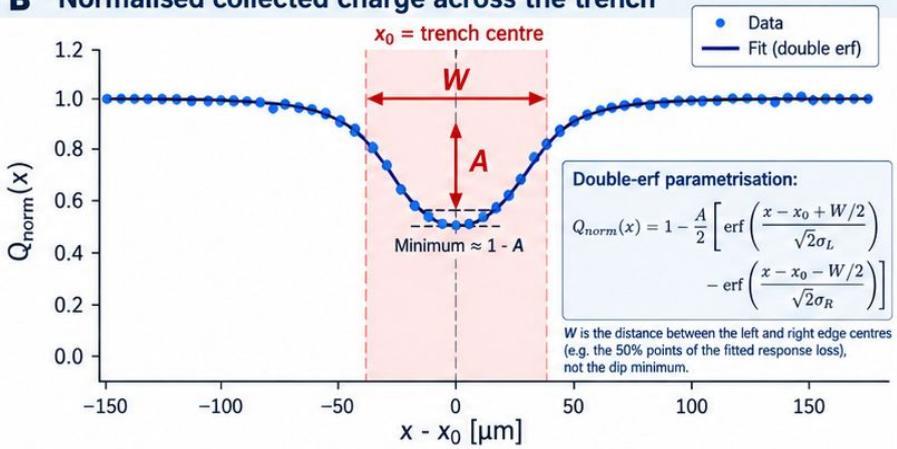
Conceptual parametrisation of TI-LGAD trench response

A TI-LGAD cross-section (two neighbouring pixels)

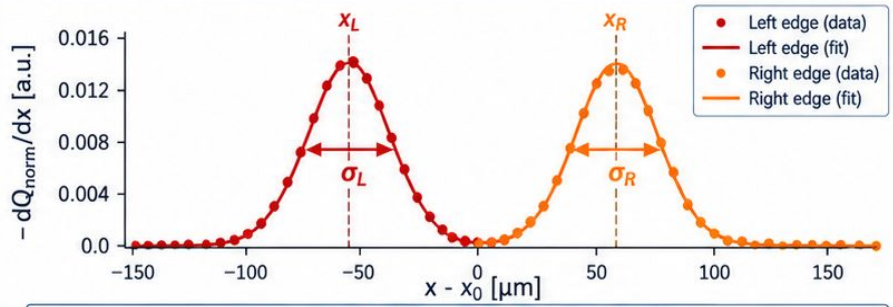


W is not the physical etched trench width only,
but the effective response-loss width extracted from the signal profile.

B Normalised collected charge across the trench

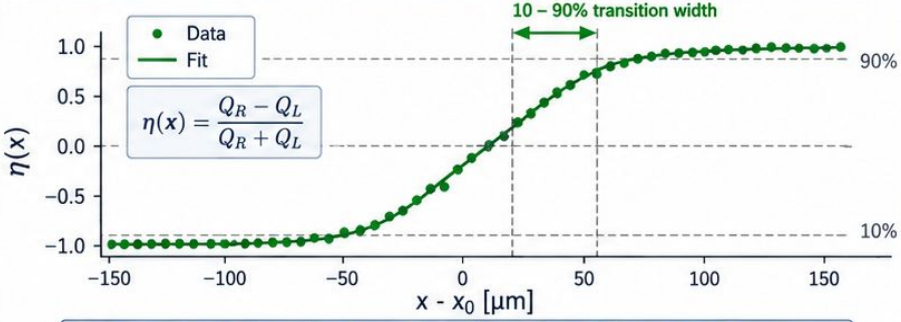


C Edge response and extraction of σ



σ_L and σ_R quantify edge broadening / transition sharpness;
they are extracted from the fitted left and right edges, even when the central response shows a dip.

D Charge-sharing across the trench



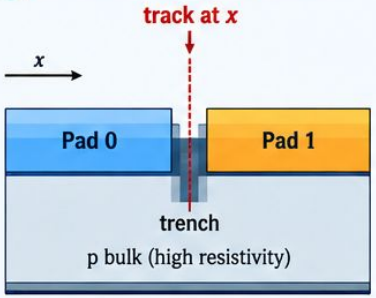
η provides an independent charge-sharing observable complementarty to $Q_{norm}(x)$.

Parameter summary

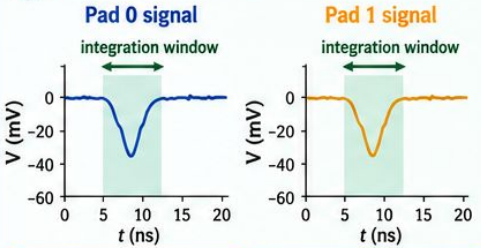
x_0 : trench centre from the fit / symmetry point | *W* : effective trench-affected width | *A* : relative charge-loss amplitude
σ_L, σ_R : edge-transition widths | $\eta(x)$: charge-sharing observable | **Applicable to both test beam and TCT scans**

A From detector signals to normalised total response

1 Geometry and track position



2 Signals from both pads



$$Q_L(x) = \int_{t_1}^{t_2} V_L(t)\,dt \qquad Q_R(x) = \int_{t_1}^{t_2} V_R(t)\,dt$$

3 Normalisation and total response

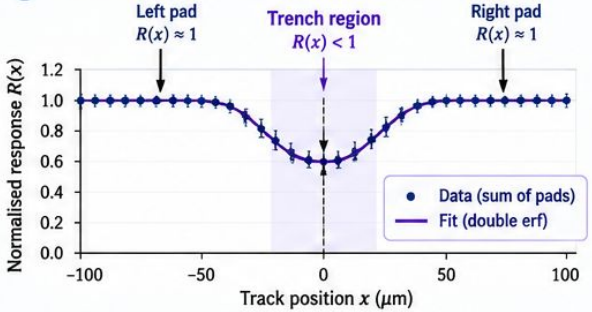
Each pad is normalised to its own bulk response (far from the trench):

$$q_L(x) = \frac{Q_L(x)}{Q_{L,\text{bulk}}} \qquad q_R(x) = \frac{Q_R(x)}{Q_{R,\text{bulk}}}$$

Total (charge-sharing independent) normalised response:

$$R(x) = q_L(x) + q_R(x)$$

4 Measured behaviour (typical example)



Response deficit:

$$D(x) = 1 - R(x)$$

- $R(x) \approx 1$ away from trench (full response)
- Dip at trench due to incomplete charge collection
- Charge sharing alone would give $R(x) \approx 1$ (no dip)

B Parametrisation with a double error function

1 Fitting function

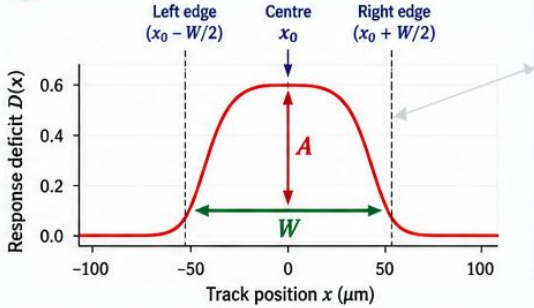
The response deficit $D(x)$ is described by a double error function:

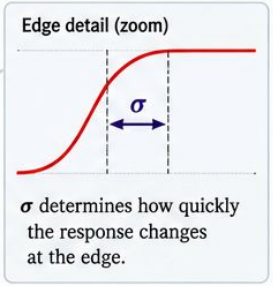
$$D(x) = 1 - R(x) = \frac{A}{2}\left[\operatorname{erf}\left(\frac{x-(x_0 - W/2)}{\sqrt{2}\sigma}\right) - \operatorname{erf}\left(\frac{x-(x_0 + W/2)}{\sqrt{2}\sigma}\right)\right]$$

2 Meaning of the parameters

x_0	–	centre of the response deficit (trench position)
A	–	depth of the response deficit (maximum loss, $0 \le A \le 1$)
W	=	effective width of the affected region (distance between midpoints)
σ	=	transition sharpness (controls the edge slope)

3 Visual meaning of W and σ





σ determines how quickly the response changes at the edge.

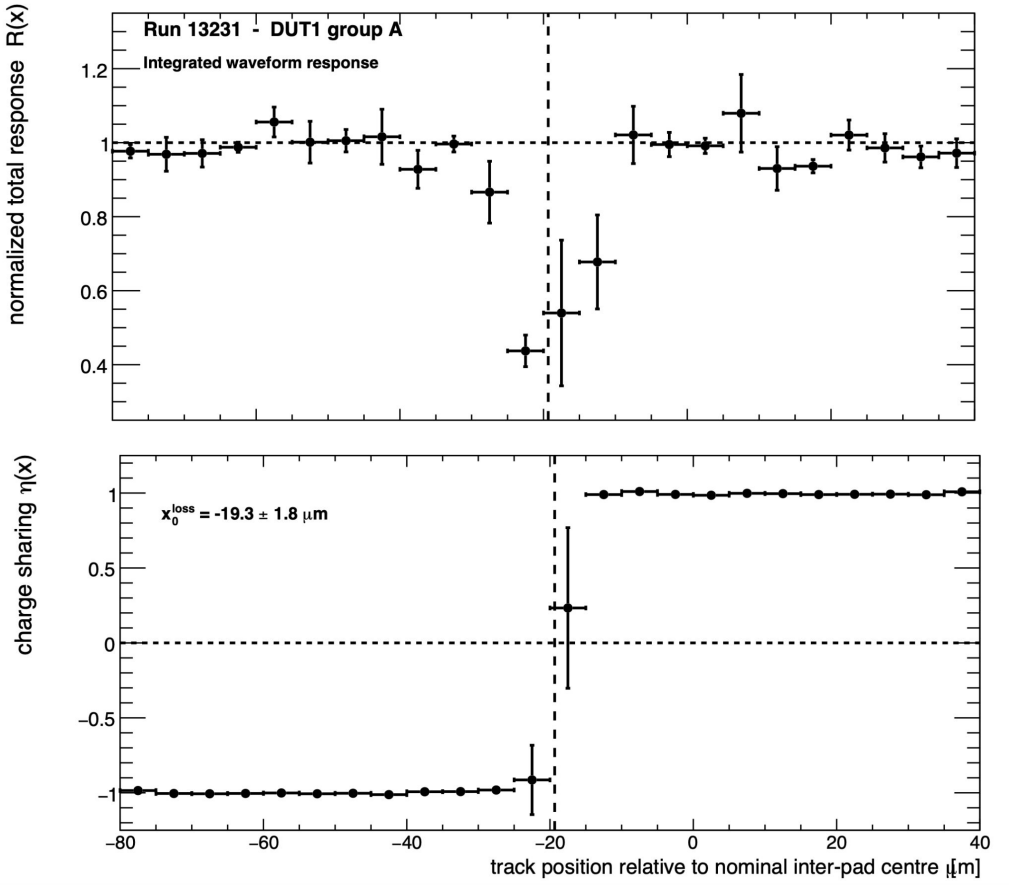
4 Figure of merit

Integrated response loss (area of the deficit):

$$F = A \cdot W$$

- Single, design-independent number
- Quantifies the overall impact of the trench
- Can be compared across different TI-LGAD designs

Testing the concept for wafer 5 (I)



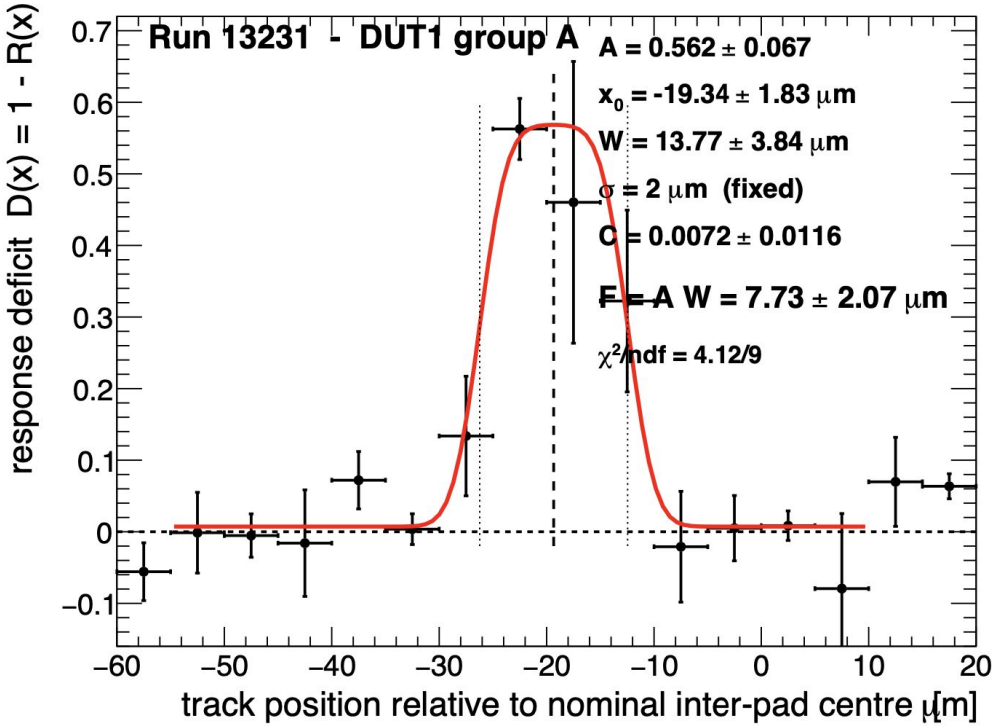
$$r_L(x) = \frac{S_L(x)}{S_{L,\text{bulk}}}, \qquad r_R(x) = \frac{S_R(x)}{S_{R,\text{bulk}}},$$

$$R(x) = r_L(x) + r_R(x)$$

$$\eta(x) = \frac{r_R(x) - r_L(x)}{r_R(x) + r_L(x)}$$

I normalize the integrated charge of each pad to its own bulk response. The sum R(x) tells me whether charge is actually lost, while η(x) tells me how the charge moves from one pad to the other.

Testing the concept for wafer 5 (II)

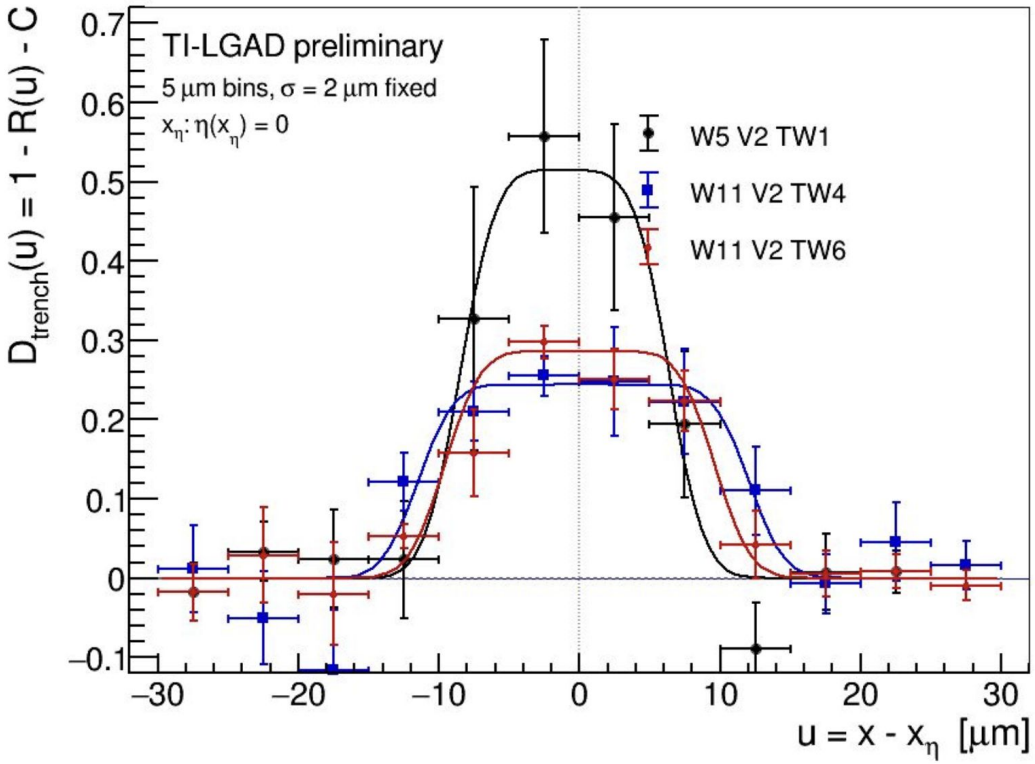


The baseline is consistent with zero, so this is a localized response deficit.
The fitted centre is x0=−19.3 μm, while the completely independent charge-sharing transition is around −19.7 μm

When I change the assumed edge smearing, A and W change substantially because they are correlated. But their product AW remains much more stable.

The double-erf fit gives F=7.73 μm, while directly integrating the measured response deficit gives about 7.8 μm. The agreement shows that AW is measuring the integrated response loss, rather than just being an arbitrary combination of fit parameters

Standardised TI-LGAD response-loss comparison



Common procedure

- Align each structure to the charge-sharing transition x_η:
  $\eta(x_\eta)=0$ $u=x-x_\eta$
- Same analysis for all structures: 5 μm bins,
  $|u|<30$ μm $\sigma=2$ μm
- The fitted response-loss centres are consistent with the charge-sharing centre:
  $u_0 \simeq 0$

$$F = AW = \int D_{\mathrm{trench}}(u)\, du$$

$$\begin{aligned} \mathrm{W5\ TW1}: &\quad 7.66 \pm 1.92\ \mu\mathrm{m} \\ \mathrm{W11\ TW4}: &\quad 5.85 \pm 1.13\ \mu\mathrm{m} \\ \mathrm{W11\ TW6}: &\quad 5.42 \pm 0.66\ \mu\mathrm{m} \end{aligned}$$

The fitted F=AW values are consistent with direct numerical integration, supporting F as a candidate common response-loss metric for TI-LGAD designs.