Search and Analysis of the "Double-Hit" events in the study (γ, f) reactions

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A new phenomenon [1-3], characterized by nearly **collinear emission of three fragments**, with at least one possessing magic nucleon numbers termed **Collinear Cluster Tripartition**.

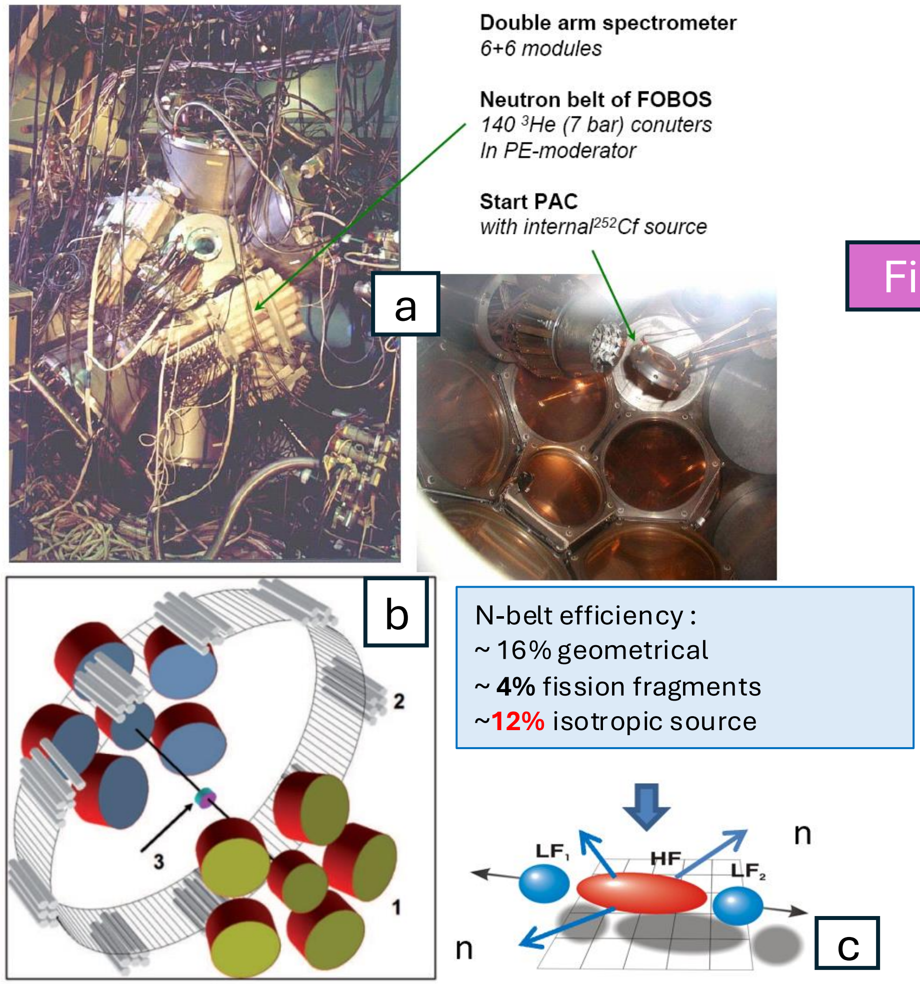
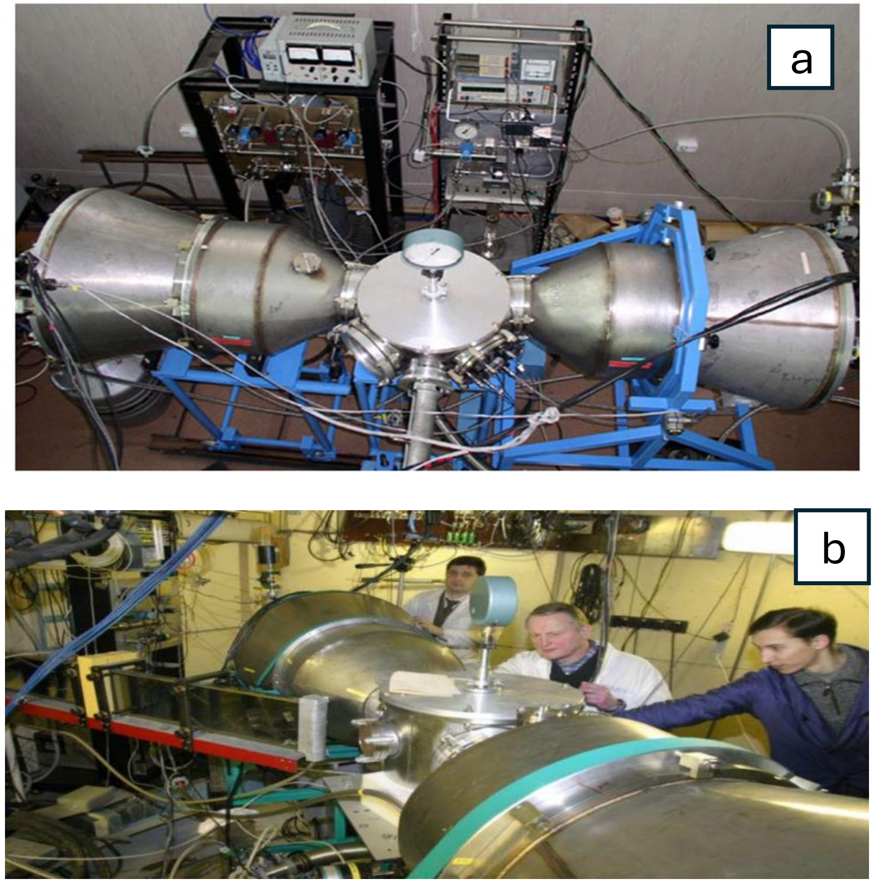


Fig. 1

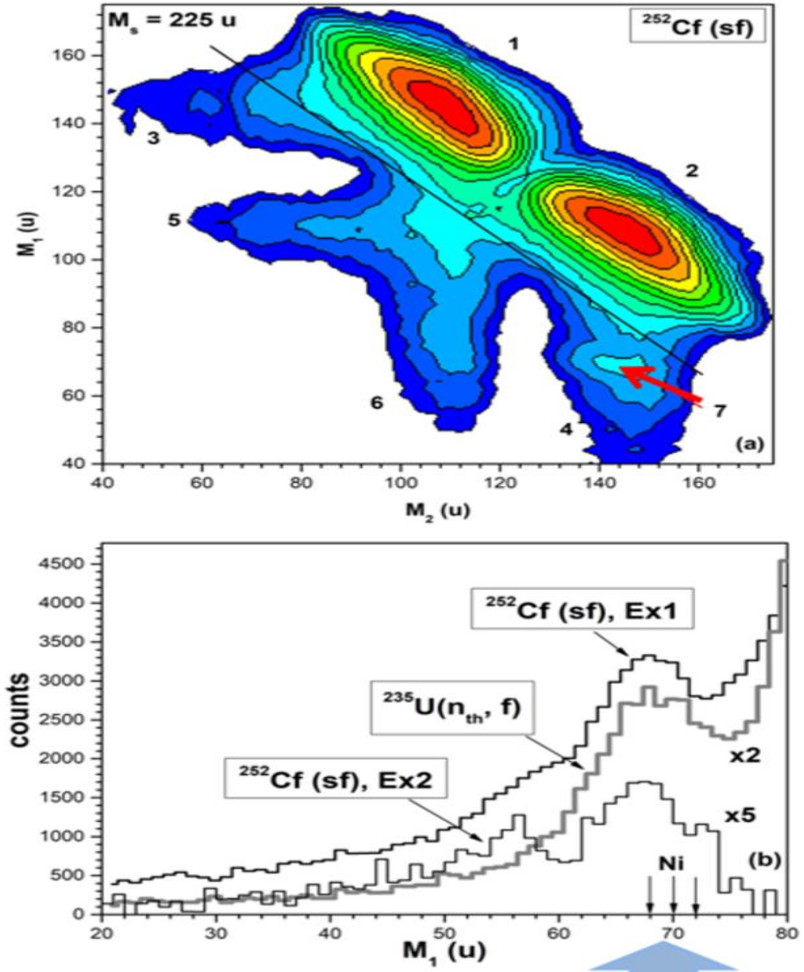


Mini-FOBOS setup at the IBR-2 beam

Fig. 2

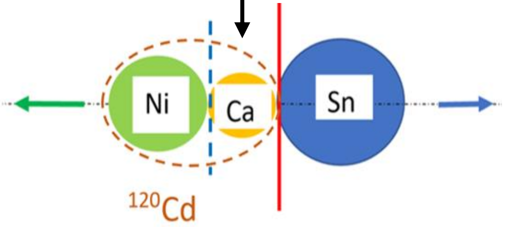
First observation of the FF break-up in the solid-state foil

Fig. 3



"Ni-bump"

Missing mass



FFs (**Ni & Sn**) were really detected in opposite arms due to the break-up of the light FF in the backing

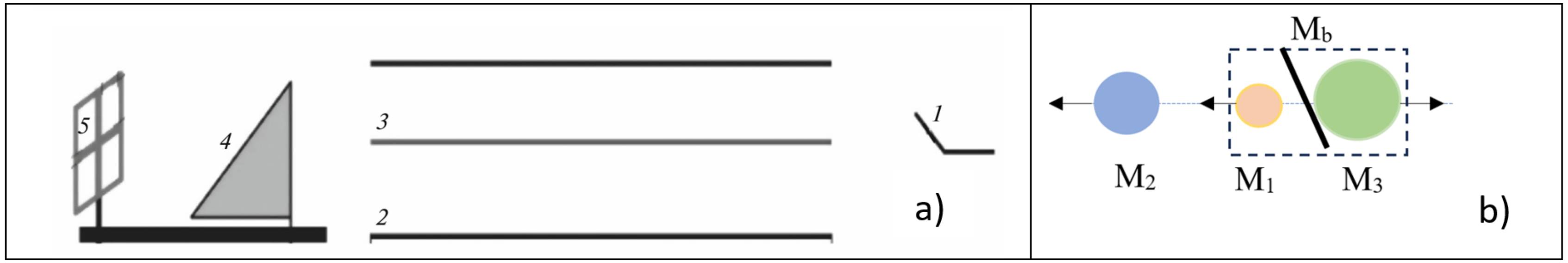
Methodological challenge:
Detection of two nearly collinear FFs from the rare decay mode.
Double Hit realised!

EXPERIMENT

Fig. 4

$$F = \frac{0.153 \cdot q \cdot V}{E_{lin} \cdot \left(\frac{R}{s}\right)}$$

Velocity **E**nergy **G**uide based **A**rray setup



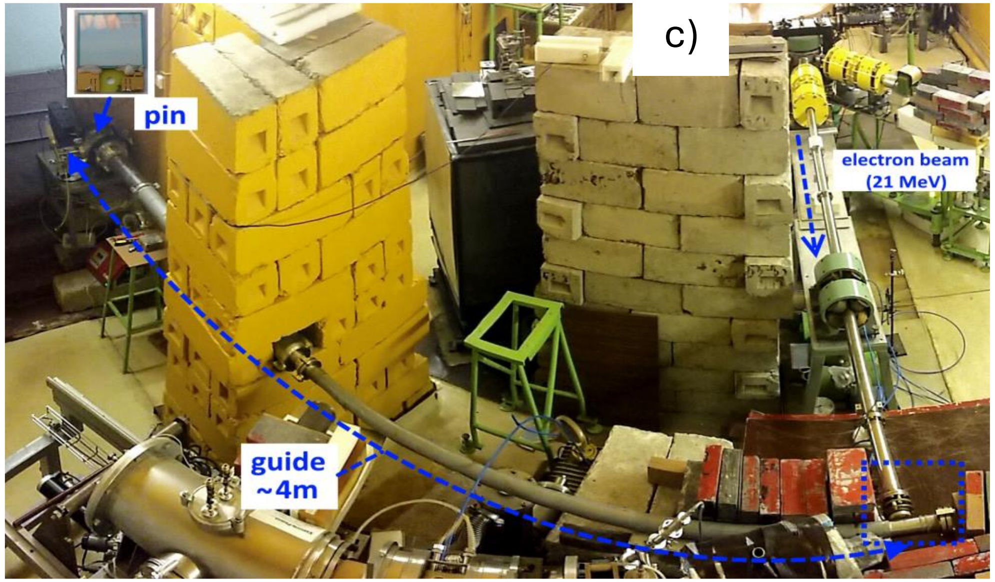


Fig. 5

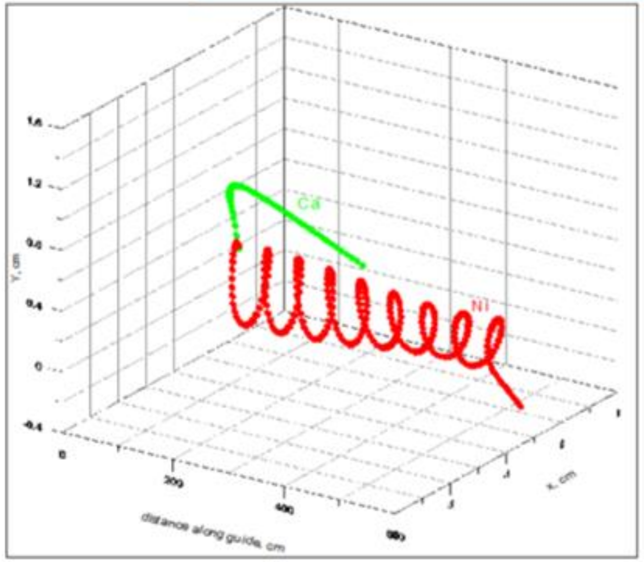


Fig.4: The target **(1)** of the **^{242}Pu isotope** is irradiated by gamma rays of bremsstrahlung radiation from the electron beam (20 MeV) of the MT-25 microtron. A fraction of the FF is captured by the field of the **EGS (Electrostatic Guide System)**, consisting of a **pipe (2) 4 m long** at zero potential and a **central conductor (3)**, to which a **voltage of –10 kV** is applied. At the output of the ESG there is a detection system consisting of a time stamp detector based on **microchannel plates (4)** and a matrix of **four PIN diodes (5)**. **b)- Kinematical scheme of ternary decay**. The target backing is represented by a tilted line.

Using the Double-Hit approach to detect fragment pairs from shape-isomer break-up

Fig. 6

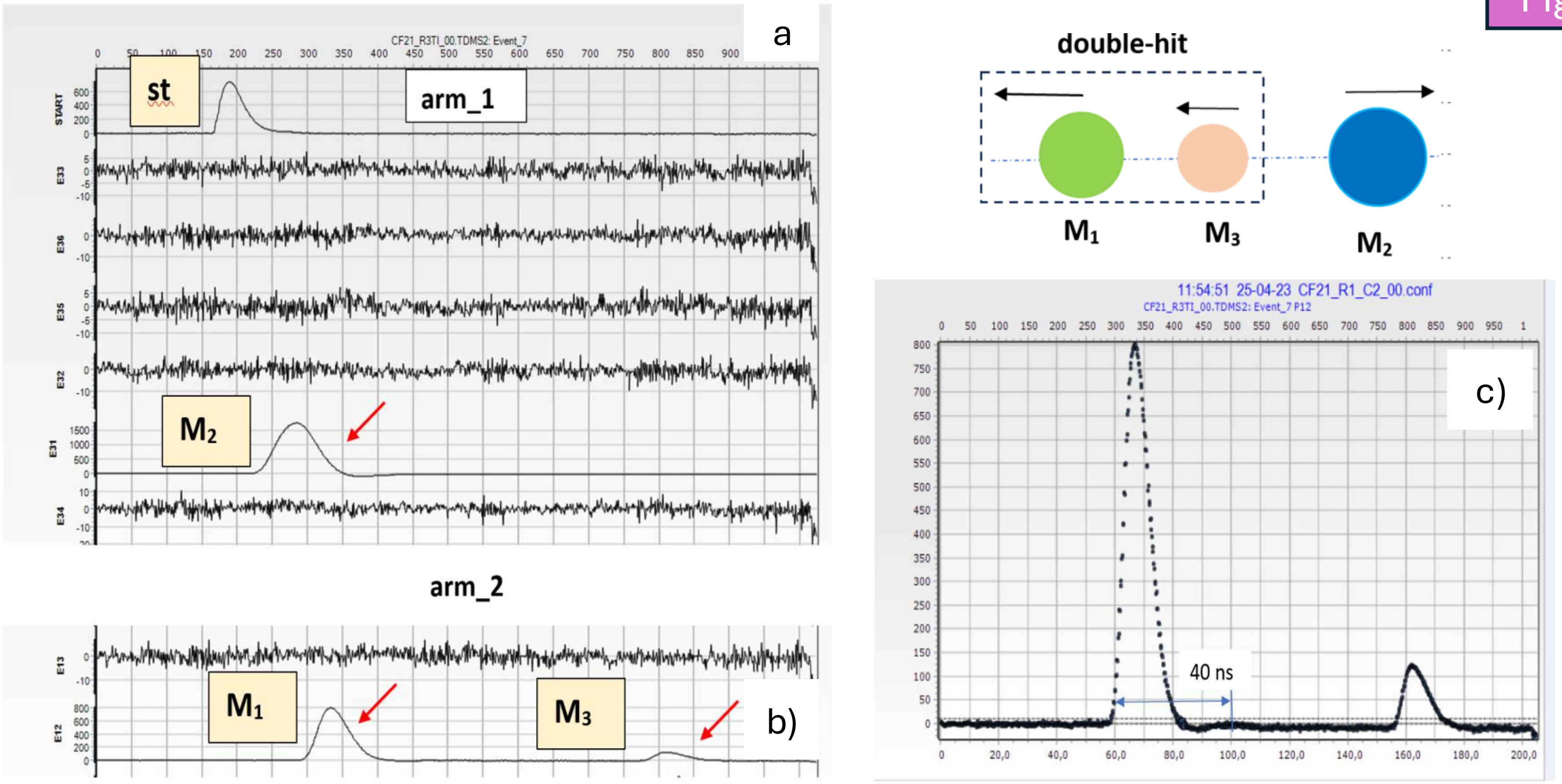


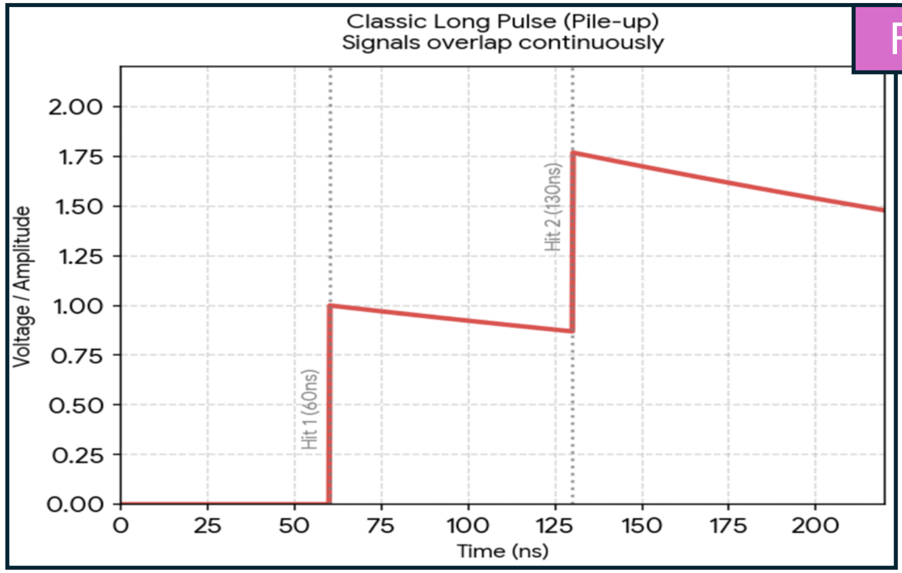
Fig. 6: a) Registered particles in arm 1, and arm 2 shown insert b). c) Registered Double hit signal from a PIN Diode.

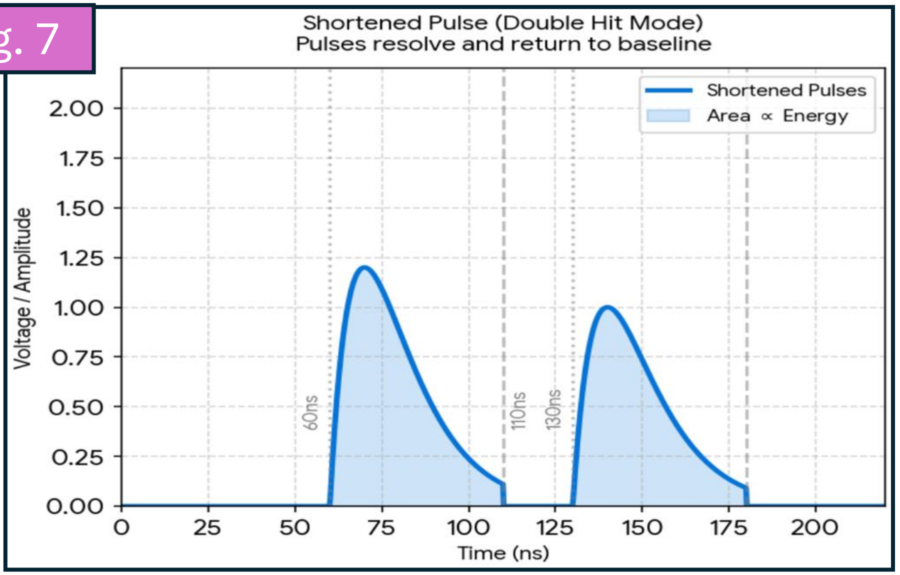
Double-Hit :

Two fragments are detected in the same PIN diode, during one registration gate of 200ns. The open angle between the fragments does not exceed 5^0 .

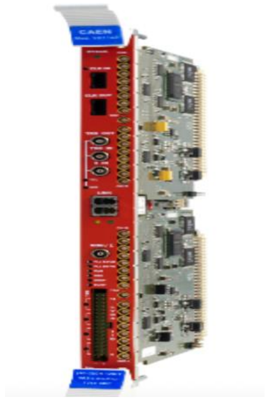
Energy spectrometry with PIN diodes: short waveforms

Fig. 7





Fast ADC digitiser



VX1742
32+2
12 bit 5GS/s

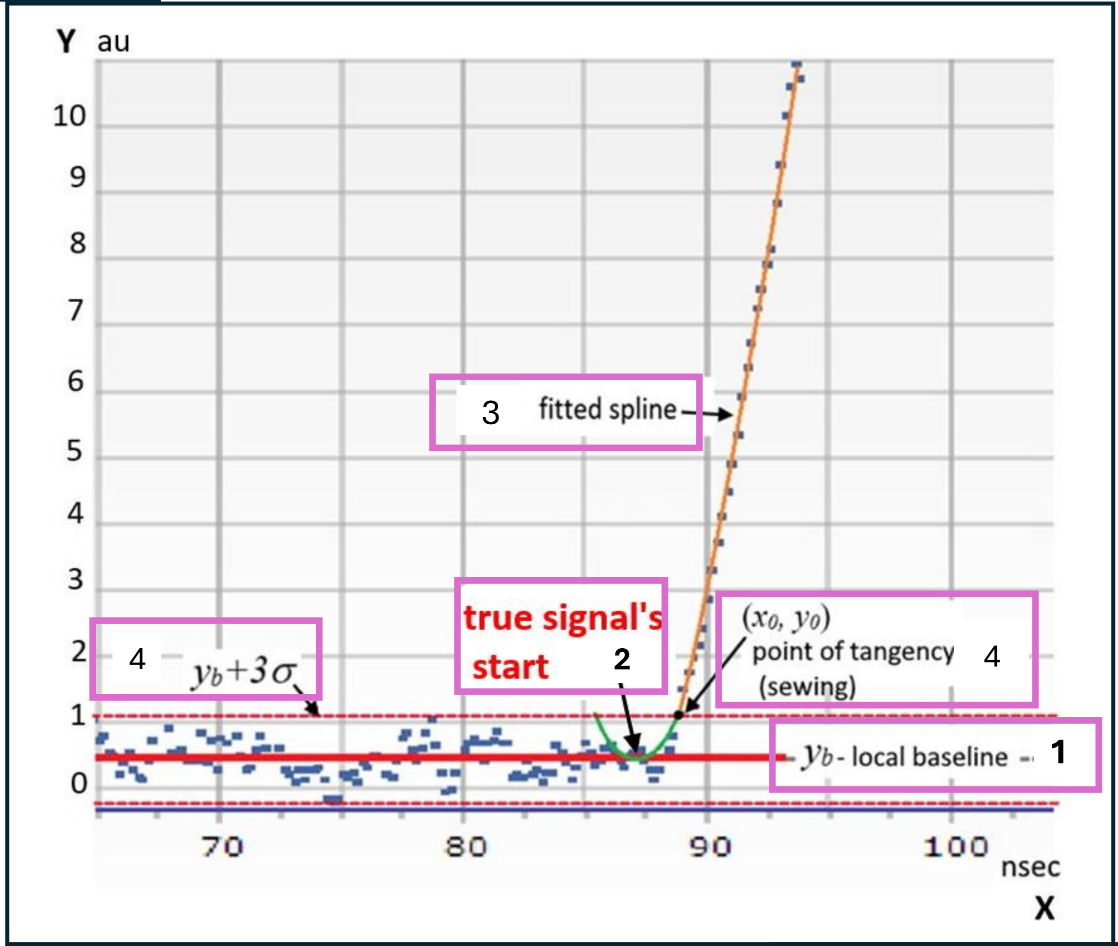
- **Traditional Method**: Particle energy (E) is measured by the total collected charge (Q). $Q \sim E = \int_{-\infty}^{\infty} i(t)dt$
- **The Problem**: Standard detector signals are slow, lasting tens of microseconds {s}. However, consecutive particles can hit the detector just nanoseconds {ns} apart, causing the signals to overlap (pile-up).
- **The Solution**: To separate these rapid "double hits," the pulses must be significantly shortened.
- **The Challenge**: Once shortened, the peak height (amplitude) no longer accurately represents the energy because it changes with the signal's shape.

Instead of peak height, use the **total area under the signal** (S)

$$S = \int_0^{\infty} i(r)dr \int_r^{\infty} h(t-r)dt = \int_0^{\infty} i(r)dr \int_0^{\infty} h(z)dz = C\int_0^{\infty} i(r)dr = Cq$$

Signal area is directly proportional to the particle's charge (q), making it a reliable linear measure of energy.

Fig. 8



Time pick-off algorithm for PIN diode signals generated by heavy ions across a wide mass range

Plasma delay effect (PDE):

Due to generation of plasma in a heavy ion track in the PIN diode

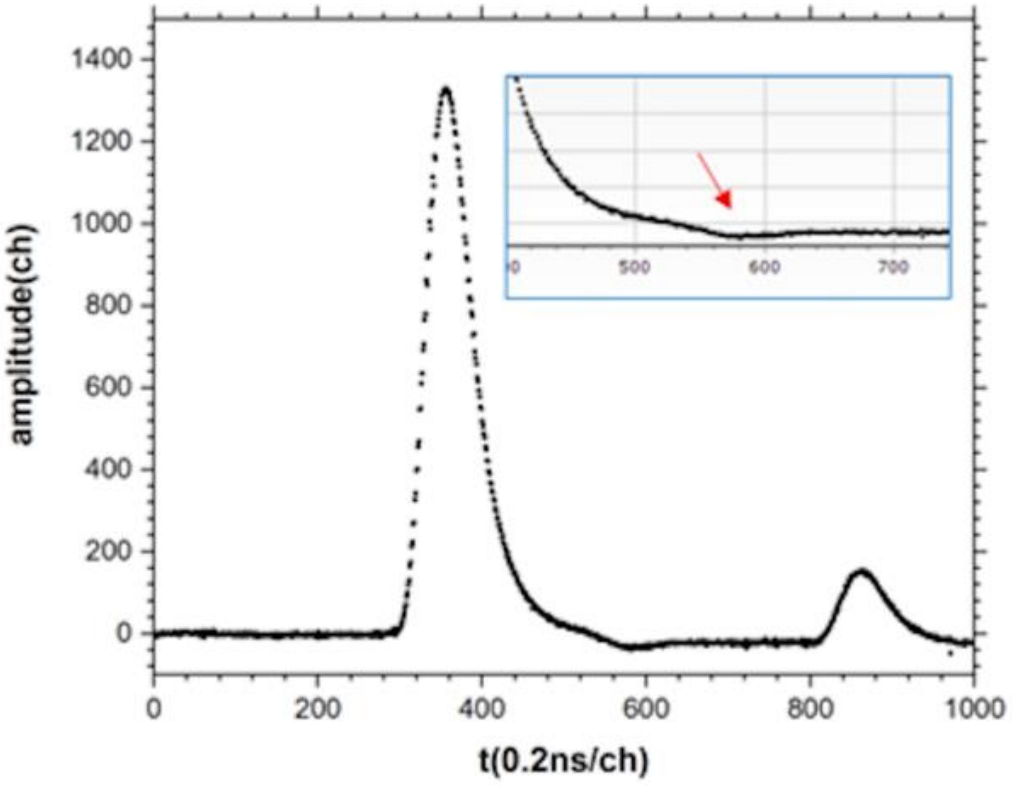
Slowly growing function of unknown form at the start of PIN diode signal

To account for PDE:

"Paraspline" method approximates the initial part that lies inside the "noise track" with parabolic function, whose vertex lies on the average of the noise. The Parabola is seamlessly sewed with a spline function that automatically approximates points above the noisy region.

Fig. 9

Presented with an issue of pile-up



Diagnosis

Sample of 40 waveforms

- Undershoot-to-Peak ratio ~0.023
- Undershoot-to-Peak DT ~50ns

Faulty electronics

Undershoot Restoration

- Main peak*0.023 = Compensation
- The width of the main kept
- This compensation filled in the undershoot region to return it to baseline.

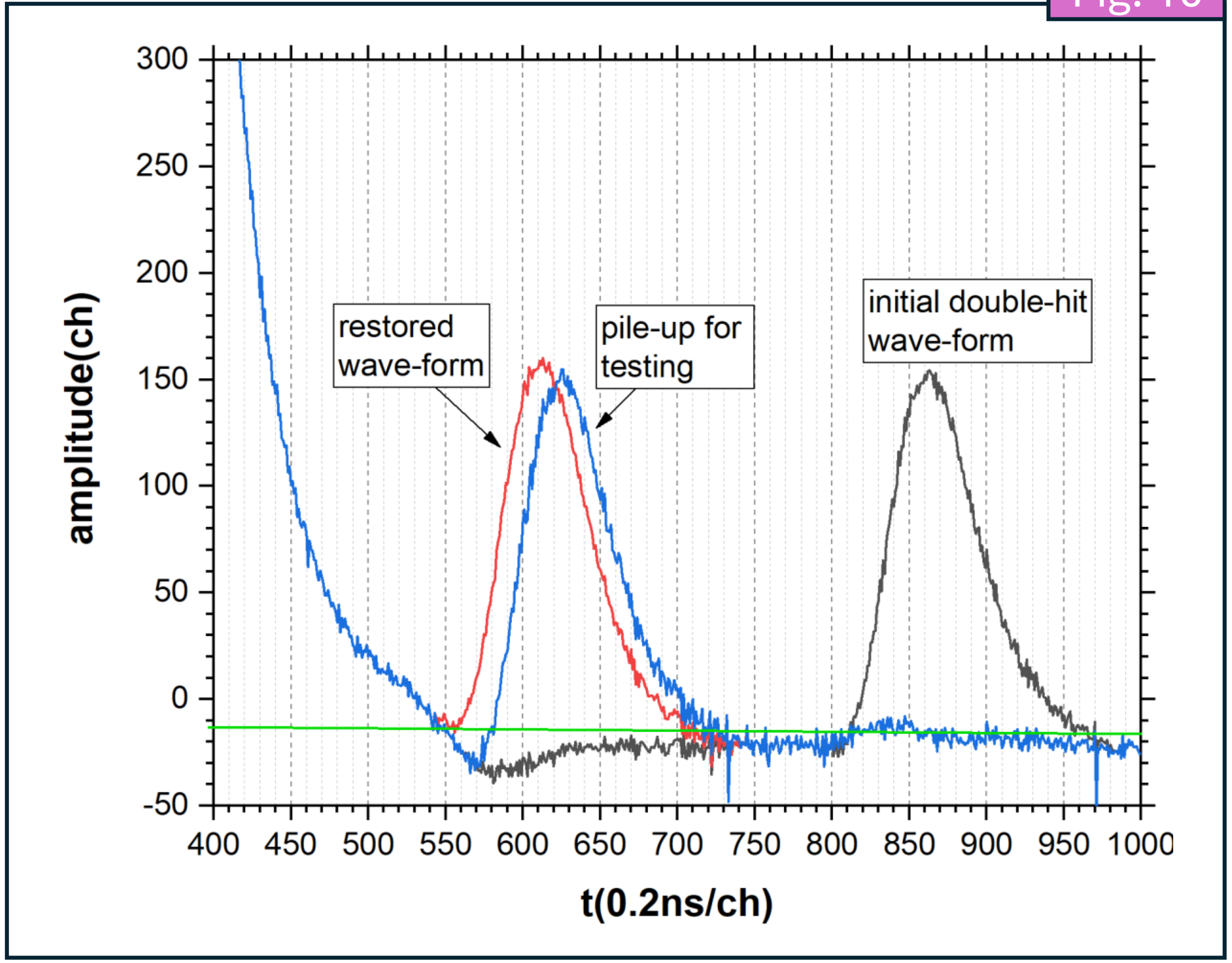
Restoring the pile-up wave-forms

"Initial double-hit" (black) uses a 100ns separation, 10-point baseline correction, and identifies time via linear fit intersection, representing 100% accuracy.

"Pile-up for testing" (blue) uses a 50ns separation, leaves the baseline uncorrected, compensates for undershoot, identifies time via linear fit intersection, and shows a 12.8% area error.

"Restored waveform" (red) uses 50ns separation with full baseline restoration, identifies time via linear fit intersection, reducing area distortion to 0.4% and timing error to under 1%.

Fig. 10



	DT, ns	S	ΔS	δS, %	t, ns	Δt, ns	Δt %
	100	12017	0	0	160.4	0	0
	50	11960	57	0.4	162	1.6	1
no corr.	50	10484	1533	12.8	153.8	6.6	4.1

Conclusion

The pile-up restoration algorithm ensures distortion-free data by subtracting the baseline using a 10-point adjacent mean from every bin. This results in a drastically reduced waveform area distortion, dropping from 12.8% (uncorrected blue) to just 0.4%, effectively mitigating severe 50 ns detector pile-up using the 0.023 (2.3%) correction factor.

It achieves exceptional precision, maintaining signal timing accuracy within a 1% margin of error, making it a robust solution for extreme radiation environments.

References

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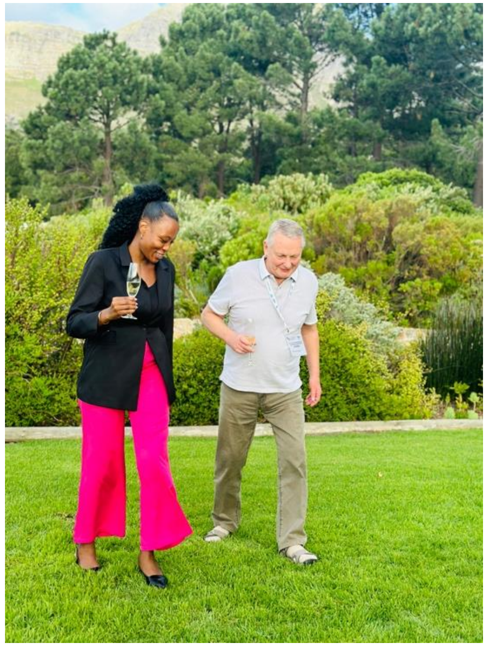

Thank you!