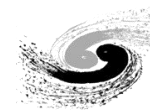


Data-taking Test with ^{55}Fe Radiation on COFFEE3

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2026.07.07

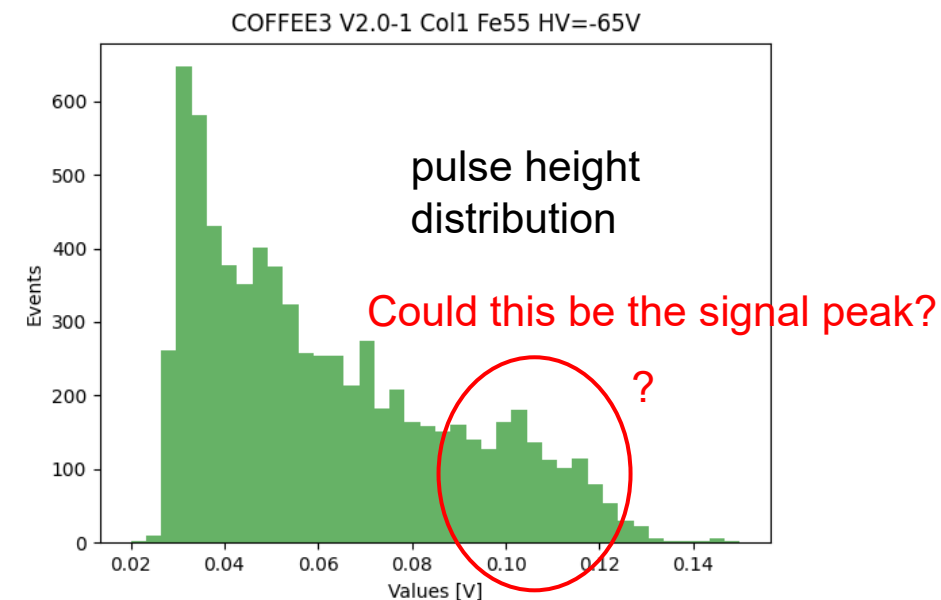
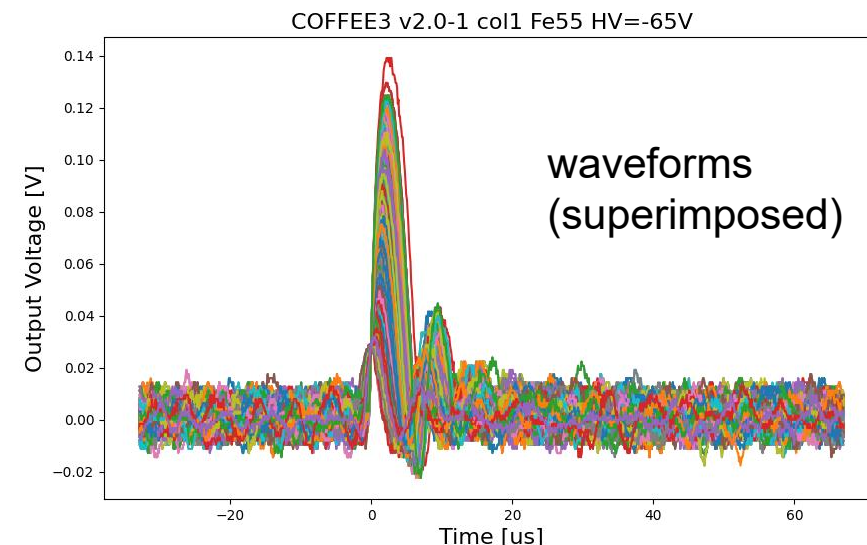


- Verify the digital response of the COFFEE3 chip to real radiation.
 - The **beam test during May 2026** has confirmed the **analogue & digital response** to charged particle beam.
 - Using ^{55}Fe for detailed information about performance.

**Whether the COFFEE3 is able to produce signal peak of ^{55}Fe
with the same configuration as the beam test?**

- ❑ Single-pixel (C1R0) test with ^{55}Fe .
- ❑ Using rising edge of **CSA waveform** as trigger on oscilloscope.
- ❑ Observed:
 - Events rate increased significantly when exposed to ^{55}Fe .
 - Backgrounds are significant.
 - Peak structure is almost discernable.

❑ Now we perform a new test using digital readouts.

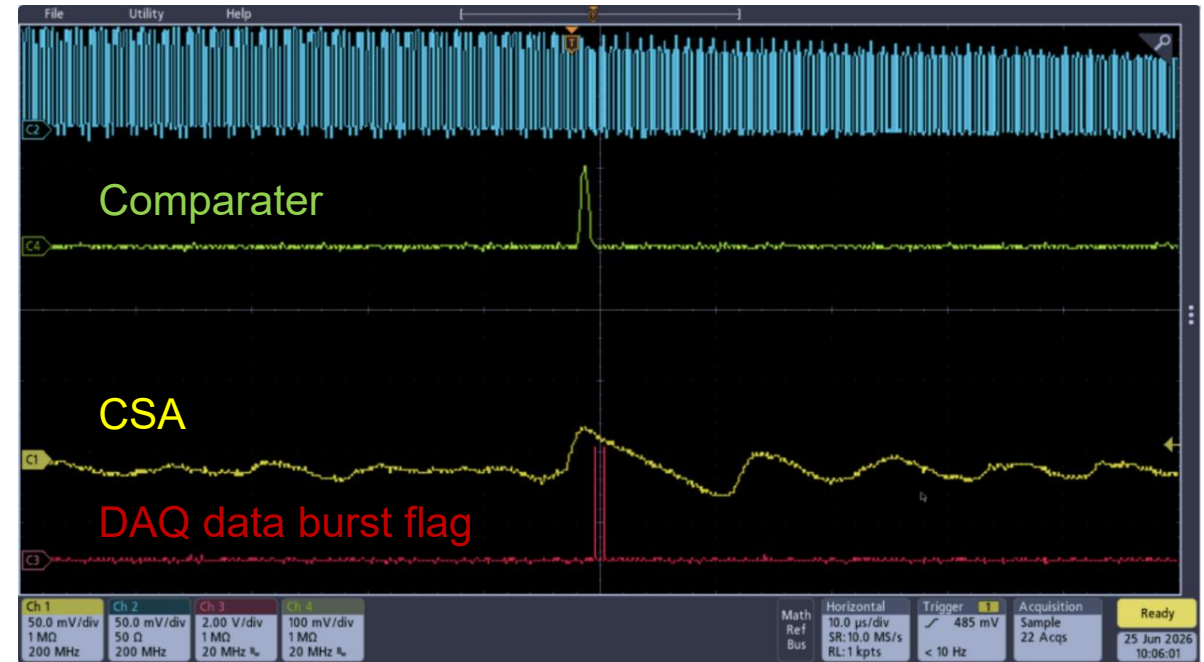


- ❑ Replicate all configurations used during beam test.
- ❑ Single pixel C1R0 was unmasked. Other pixels were all masked.

B1	0.9 V
B2	0.6 V
B3	0.65 V
B4	0.31 V
IB1	0.5 V
IB2	0.2 V
COM_bias	0.8 V
CLAMP	0.85 V
Th	0.81 V
HV	- 65 V
FCLK	320 MHz

The lowest comparater
threshold where no digital
readouts observed in 10 min.

Fast preliminary test using charge-injection.



- ^{55}Fe data-taking: about 12 h 55 min.
- noise data-taking: about 10 h 5 min.
- In digital data, we have only Time Over Threshold (TOT) value to account for CSA pulse height.
- number of events:

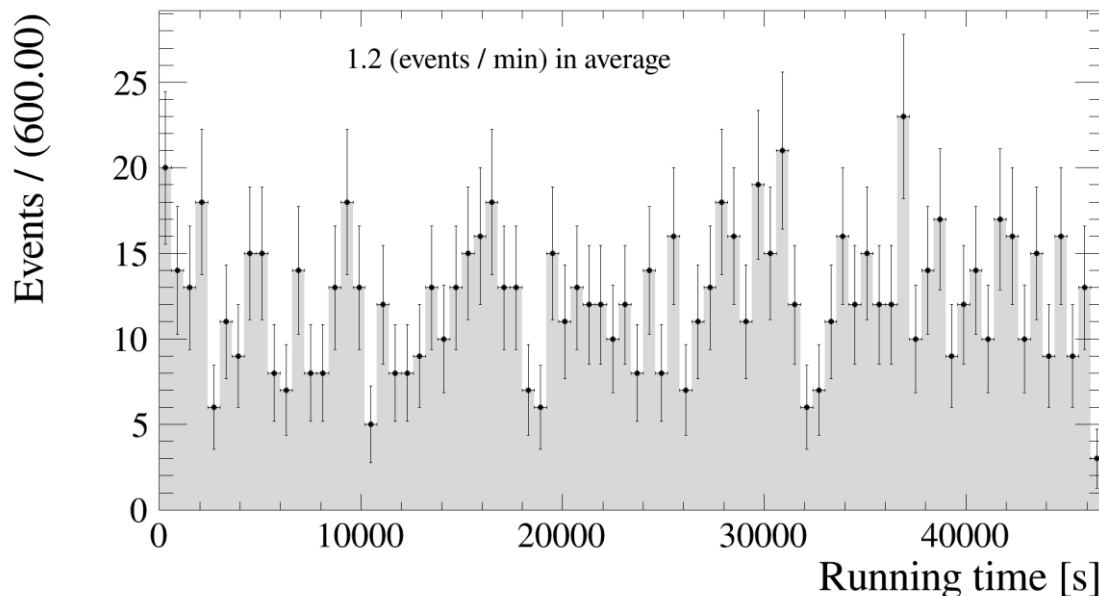
	full data		require TOT > 0	
	events	number of multiple events *	events	number of multiple events
^{55}Fe data-taking	958	104(2) 118(3)	797	27(2)
noise data-taking	4619	721 (2 - 40)	3538	692 (2 - 29)

* Consecutive events with their timestamp differences of less than 5 μs between any two adjacent events, and consisting of two or more events, are marked as a group of **multiple events**. The measured average counting rate is about 1.2 min^{-1} , corresponding to a Poisson probability of approximately 1×10^{-7} for a double-event formed by real signals.

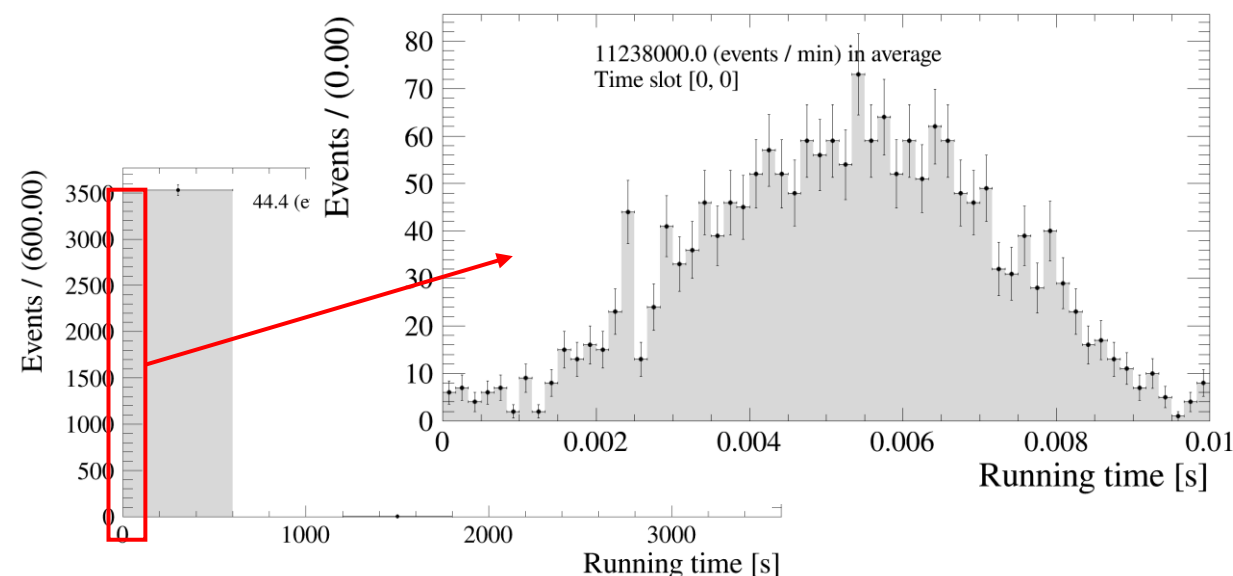
□ Timestamp distribution of events (require TOT > 0)

- The timestamp distribution of ^{55}Fe data sample is **almost uniform**, with average event rate of 1.2 / min.
- Much most of the events in noise data sample are **recored in less than 0.01 s**.
 - Almost all events in ^{55}Fe data sample were induced by ^{55}Fe radiation.
 - The noise data sample is rather not representative.

^{55}Fe data sample

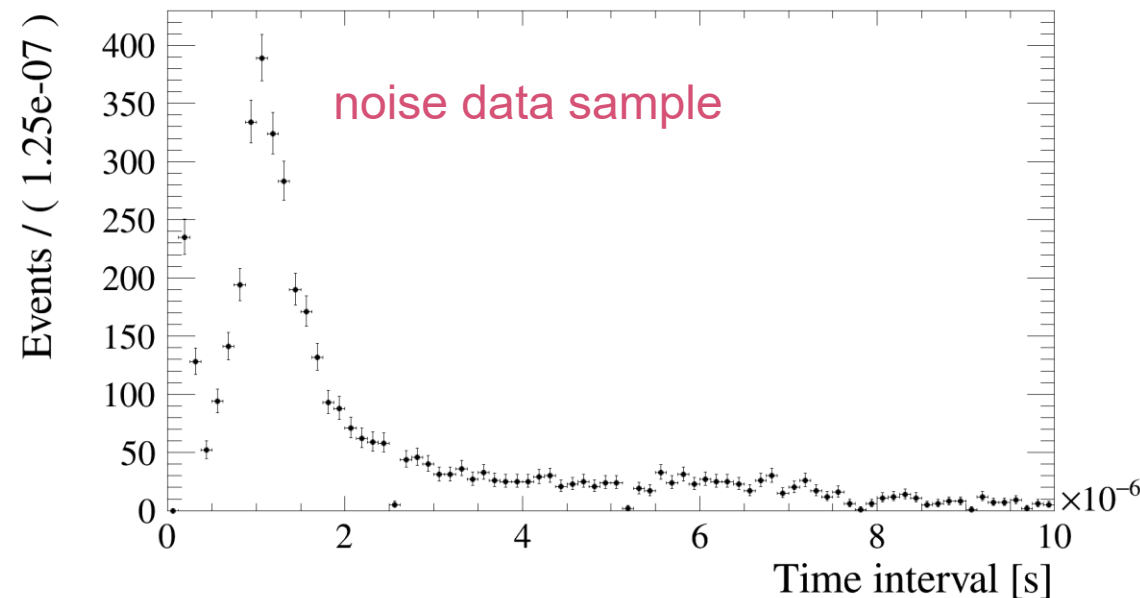
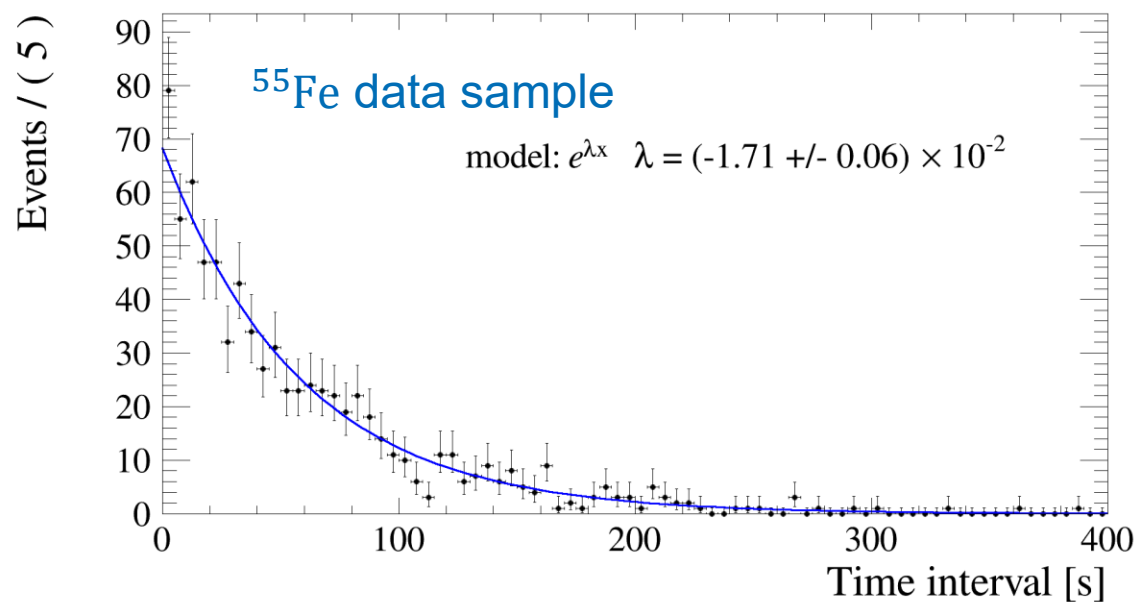


noise data sample



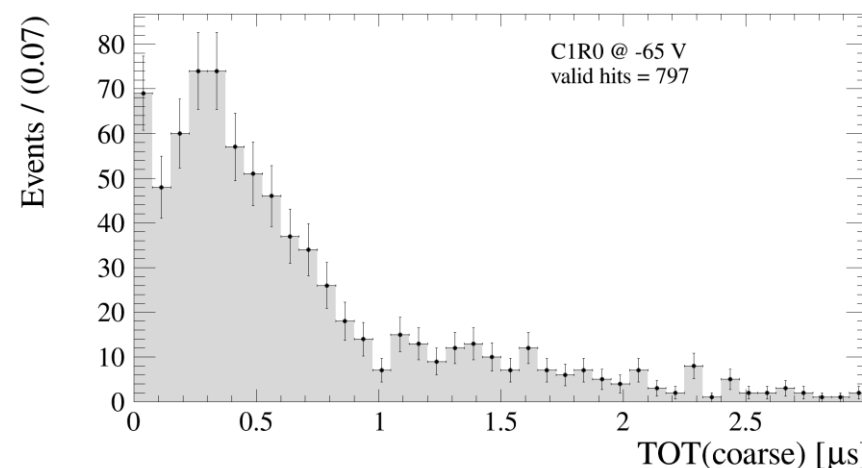
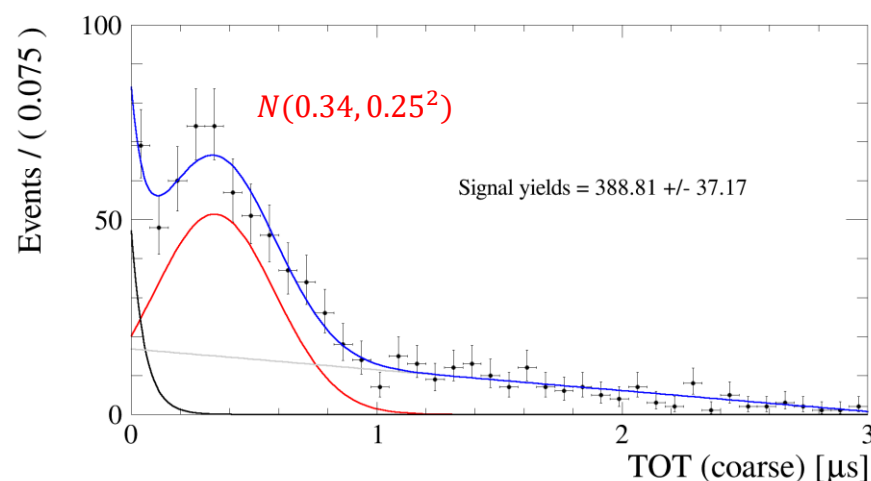
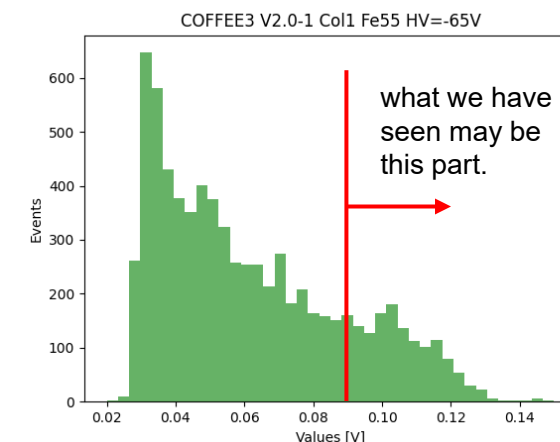
□ Time interval distribution of events (require TOT > 0)

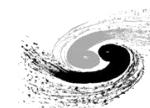
- For a radioactive decay source, the time interval between two consecutive events **should follow exponential distribution** $f(x) = \lambda e^{-\lambda t}$ ($x > 0$), where λ is the average event rate.
- For **^{55}Fe data sample**, the averaged event rate is $797/46500 \approx 0.017 \text{ s}^{-1}$, which is in good agreement with the fitting result on time interval distribution.
- For **noise data sample**, the time interval distribution shows a strange structure.



□ TOT distribution of events (require TOT > 0)

- Consider fitting the TOT distribution of ^{55}Fe data sample with Gaussian peak.
- PDF: noise on the left (exponential) + signal (Gaussian) + tail on the right (linear)
- Issues:
 - The component of **higher long tail** is necessary.
(may due to over magnification or other effects)
 - Exponential component representing the noise is necessary.
(may due to the Gaussian tail of electronic noise)





□ Statistics analysis:

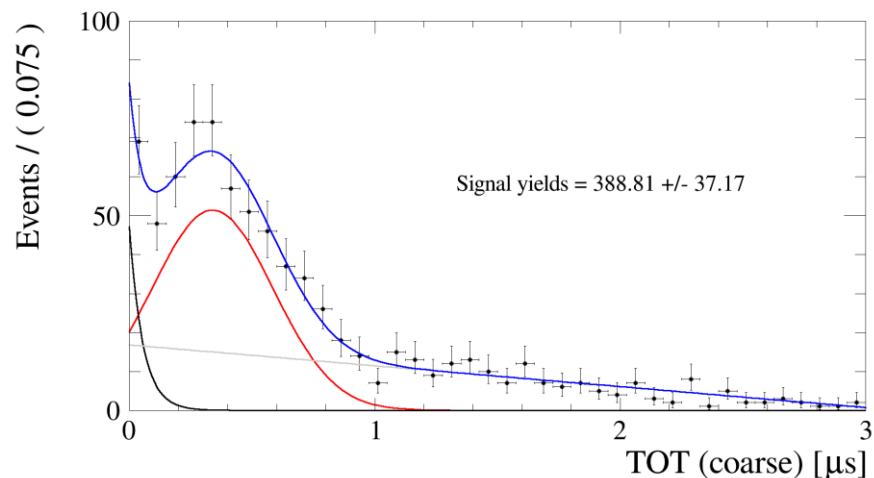
- Time related analysis shows that almost all events in ^{55}Fe data sample are signal, with the event rate of about 0.017 s^{-1} .
- TOT analysis shows that **the Gaussian peak is significant**, although the long tail on higher band is not yet well explained physically.

□ Issues:

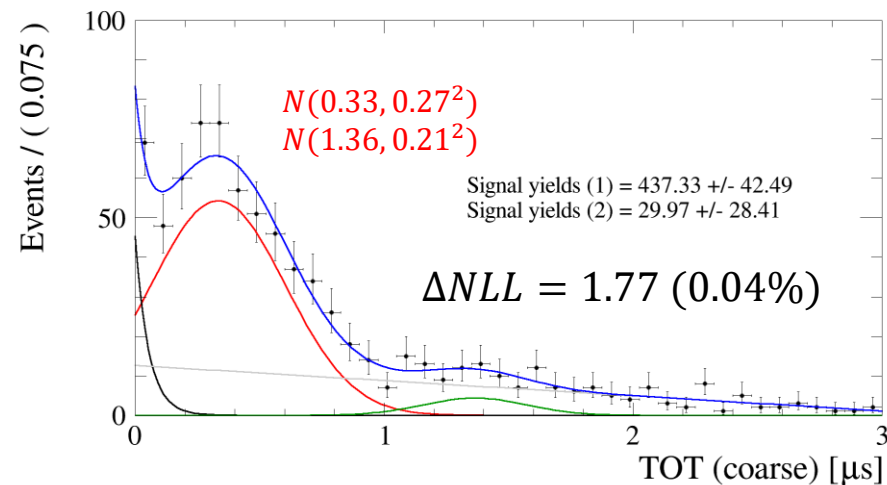
- Events with TOT = 0 account for a large fraction, and also the multiple events.

□ What's next

- Single-pixel test on other pixels.
- Simultaneous test on multiple pixels.



```
FVAL = -3952.30704520930976
Edm  = 3.94511923578427832e-07
Nfcn = 258
c0    = -0.917073 +/- 0.0534174 (limited)
c_noise = -18.3548 +/- 8.7395 (limited)
mean_fe_1 = 0.338227 +/- 0.0345017 (limited)
n_fe_1 = 388.81 +/- 36.831 (limited)
n_linear = 350.982 +/- 30.2639 (limited)
n_noise = 34.2073 +/- 18.1658 (limited)
sigma_fe_1 = 0.247335 +/- 0.0318374 (limited)
```



```
FVAL = -3954.08005438511418
Edm  = 4.46292108295257612e-07
Nfcn = 452
c0    = -0.839624 +/- 0.0922184 (limited)
c_noise = -18.7342 +/- 8.94244 (limited)
mean_fe_1 = 0.332811 +/- 0.0376904 (limited)
mean_fe_2 = 1.36385 +/- 0.107186 (limited)
n_fe_1 = 437.328 +/- 40.975 (limited)
n_fe_2 = 29.9703 +/- 16.9523 (limited)
n_linear = 274.483 +/- 34.7742 (limited)
n_noise = 32.2189 +/- 18.1786 (limited)
sigma_fe_1 = 0.270164 +/- 0.0356726 (limited)
sigma_fe_2 = 0.206689 +/- 0.0972372 (limited)
```

