First measurements on apsel5T_TC

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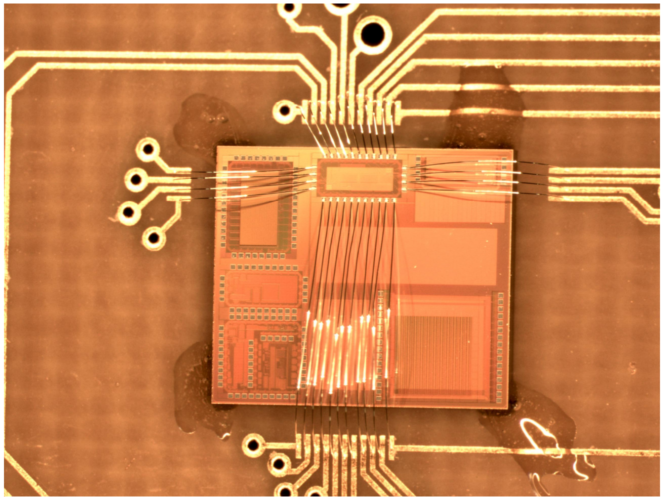
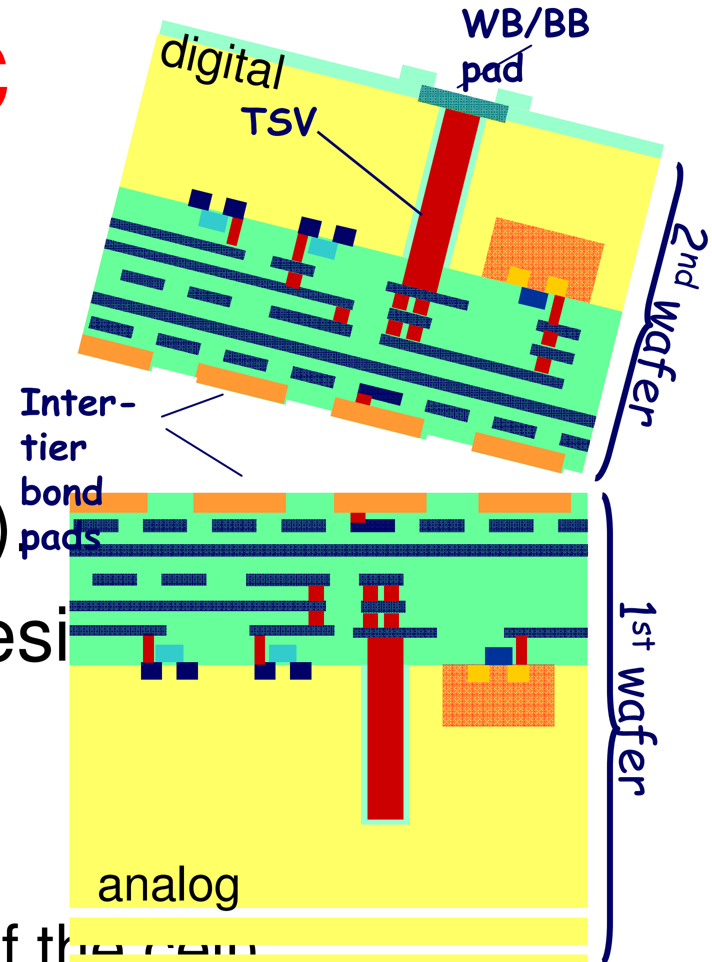


SuperB - Meeting LNF – 4/4/2011 – SVT parallel session

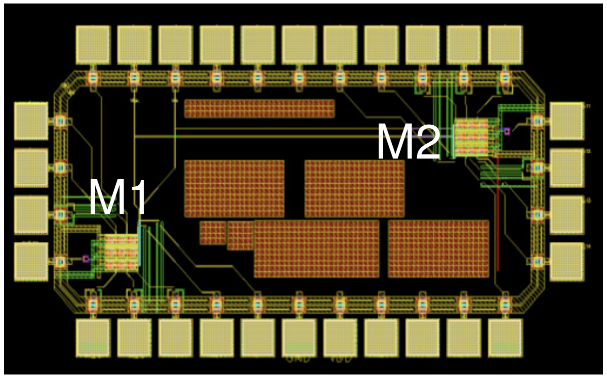
Apsel5T_TC

- With more than 1 year delay, Tezzaron/Chartered delivered the first chips of the pilot run, in the 2D version (300 um-thick "analog" tier)
- The PA output pads of the 3D-desi structures in the 2D wafers were metalized (i.e. bondable):
  - A partial (i.e. only the analog part of th test has been possible, so far …

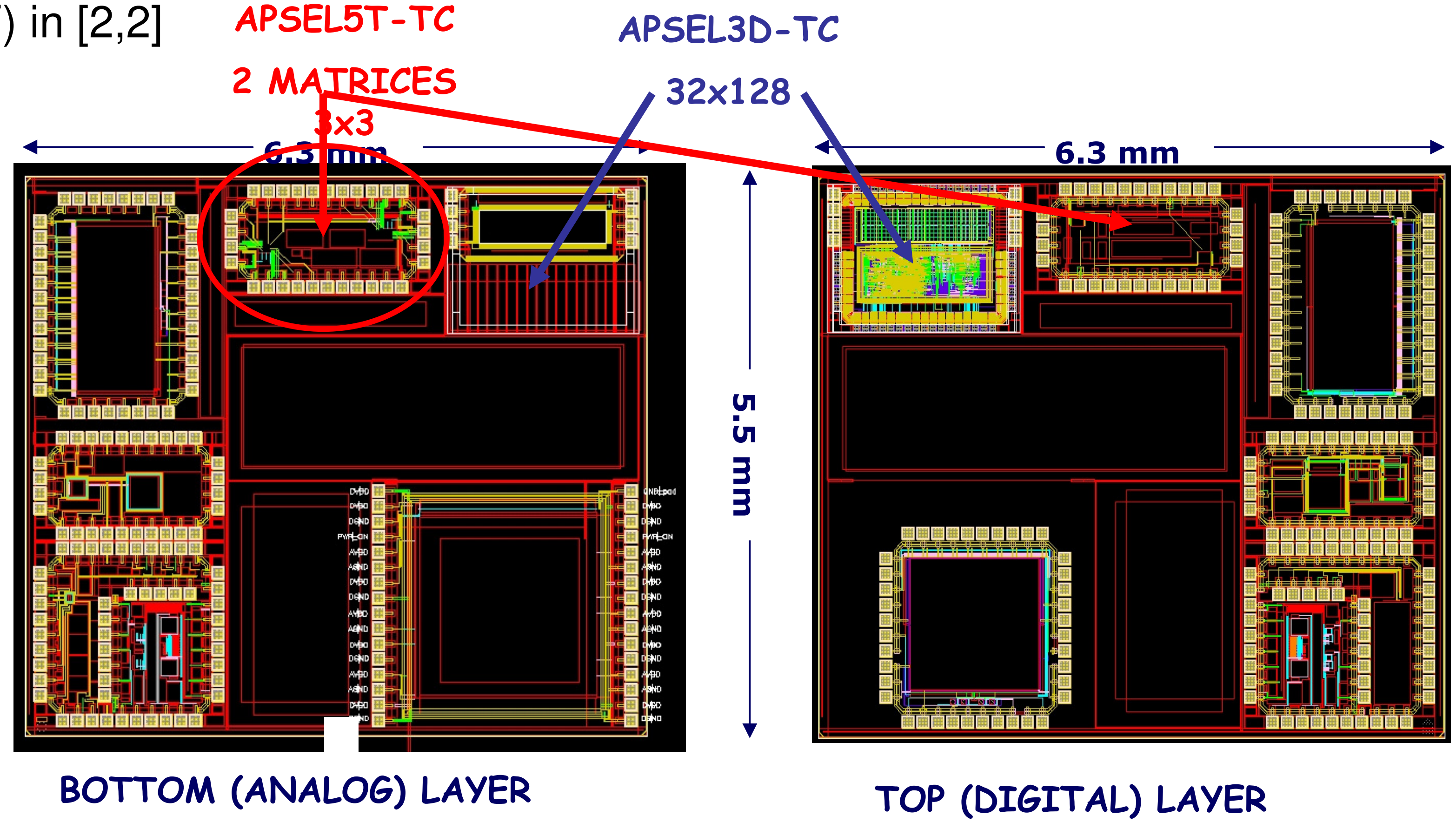


- Goals: test the matrices to characterize the new V.I. technology:
  - compare the FE performances to what expected from design (noise, Gain, G-dispersion, …)

Apsel5T_TC:



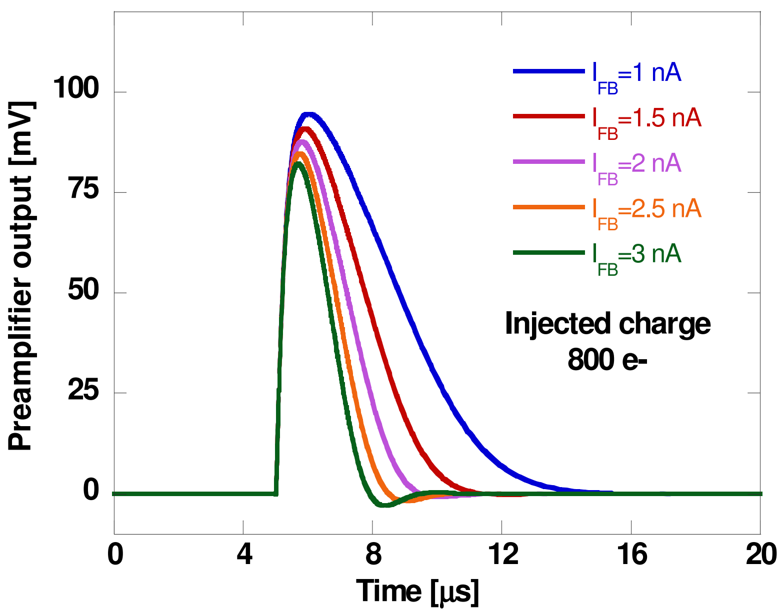
- The charge-collecting electrode is implemented by a deep-N-well extended over the 40um cell
- The M2 matrix differs from M1 in using enclosed layout transistors as input devices of the analog FE more robust against rad. damage (expected no difference in performance@0 dose)
- Shaper-less output and V_{fbk} may be tuned to modify the PA output
- C_{inj}(60fF) in [2,2]

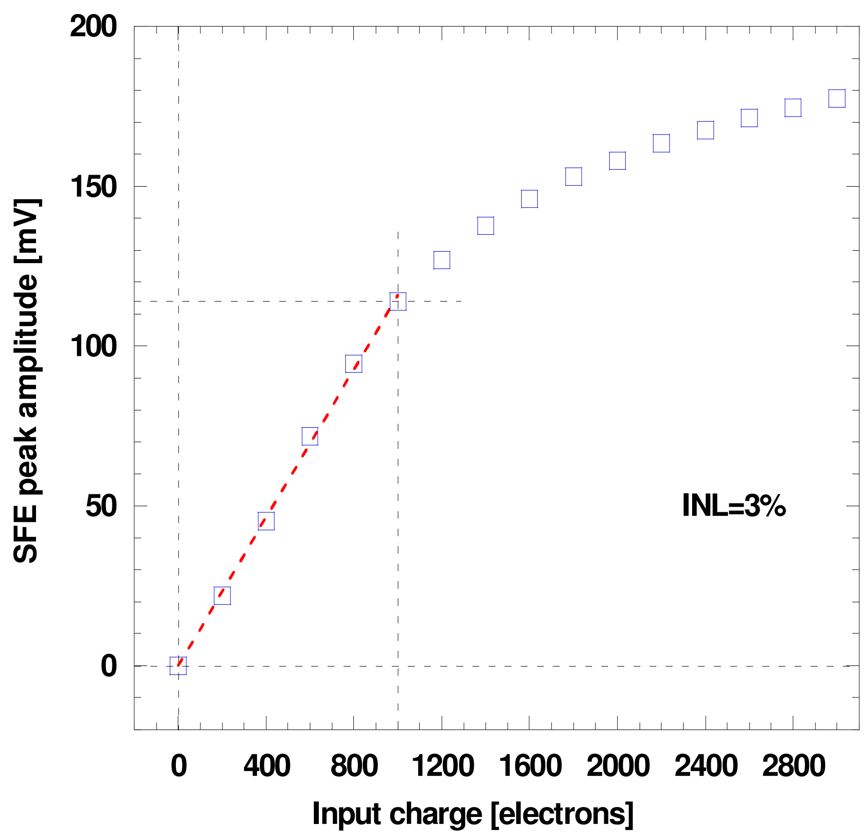


Analog FE

Main design features and simulation results

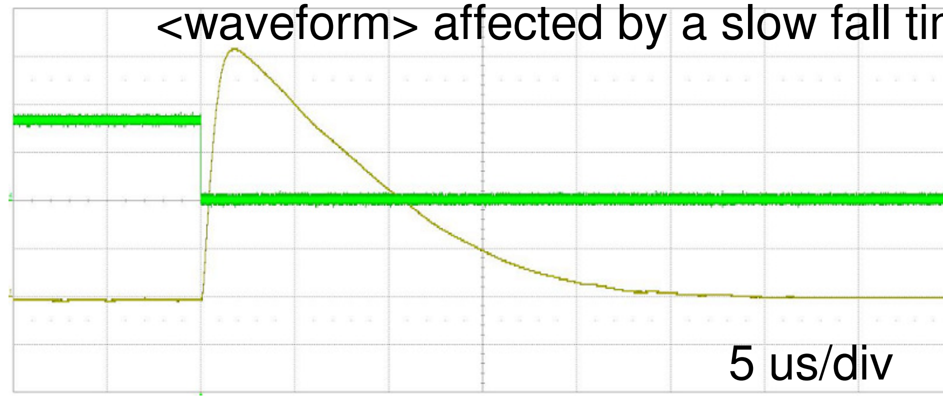
- W/L=30/0.3
- I_D=20 µA, power dissipation=35 µW
- C_D=250 fF
- ~1 µs peaking time
- Charge sensitivity (G_Q): 750 mV/fC
- Equivalent noise charge (ENC): 33 e-
- Threshold dispersion (ΔQ_t): 40 e- (34 e- from the SFE, 22 e- from the discriminator)

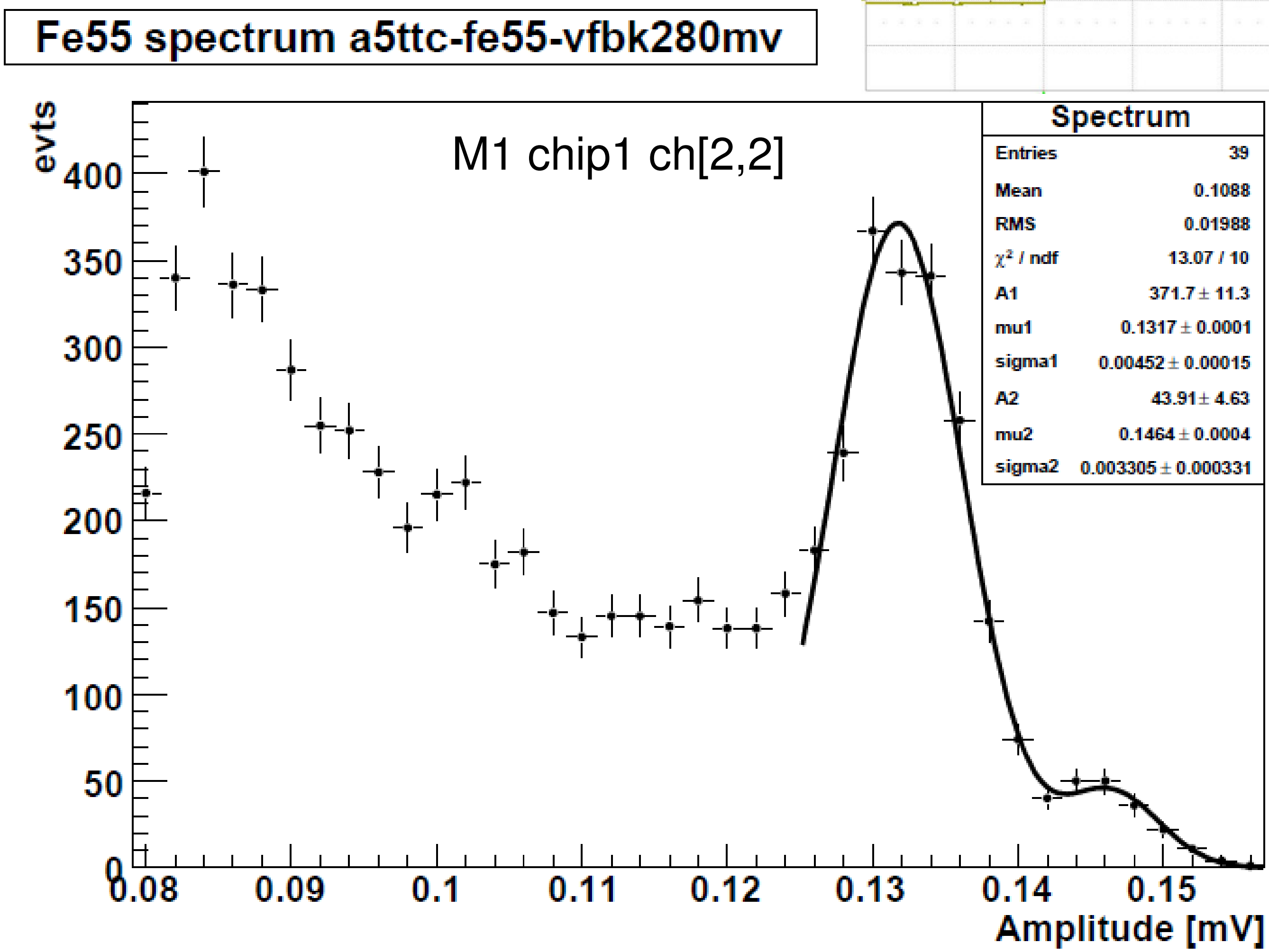




The “first” (Chip 1) Fe55 Spectrum

T_{DAQ}~4h V_{fbk}=280 mV
(from workpoint simulation)



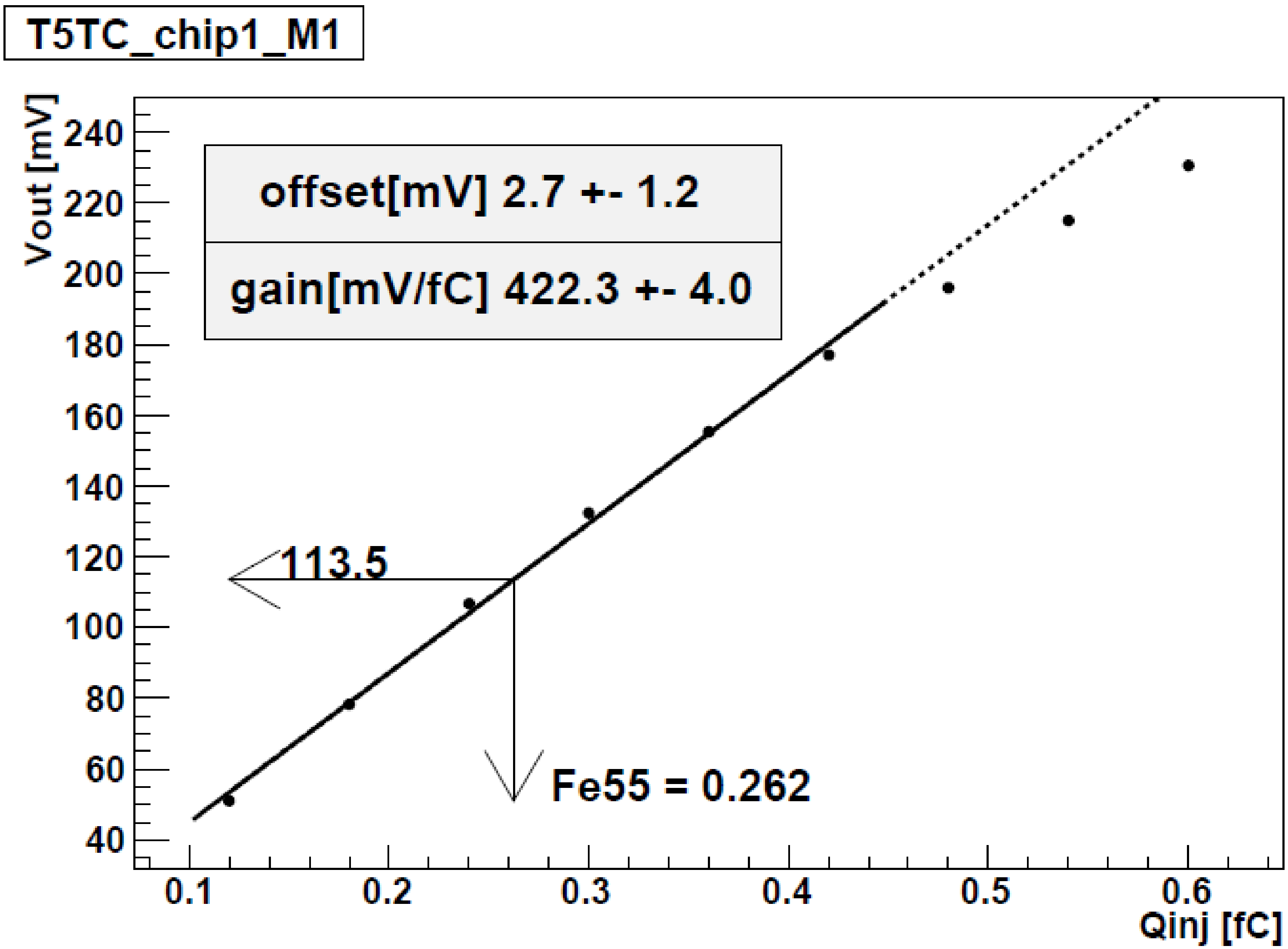


2Gaussian FIT:
μ_1=132 mV
G[mV/fC]~500
RMS noise~4 mV
ENC~50 e-
μ_2=146 mV

The low noise allows disentangling the 2nd peak
(5.90 e 6.49 keV far 164e-~3ENC)

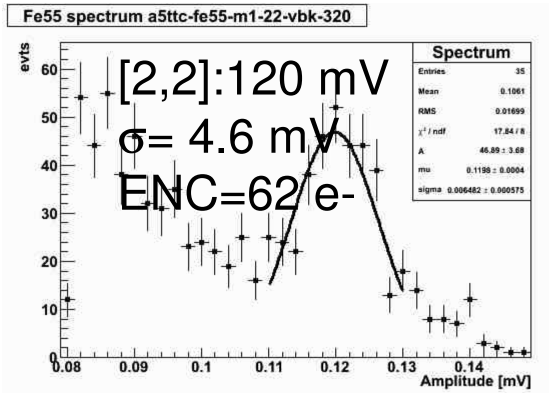
The “first” (Chip1) Gain with C_{inj}=60 fF

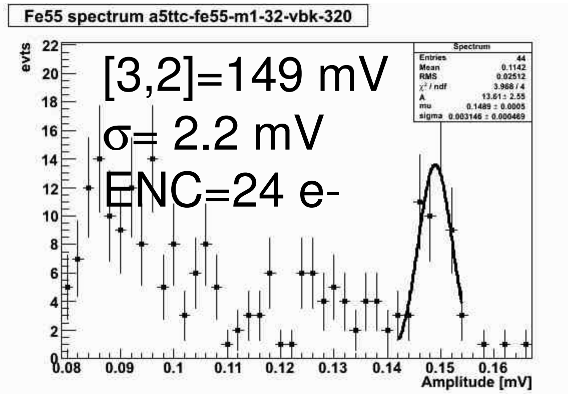
(Set V_{fbk}= 320 mV → waveform shape closer to simulation)

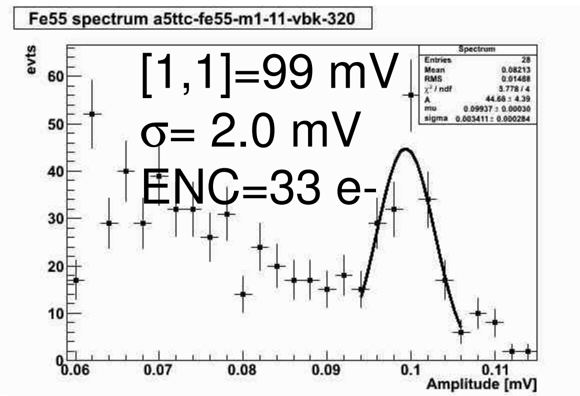


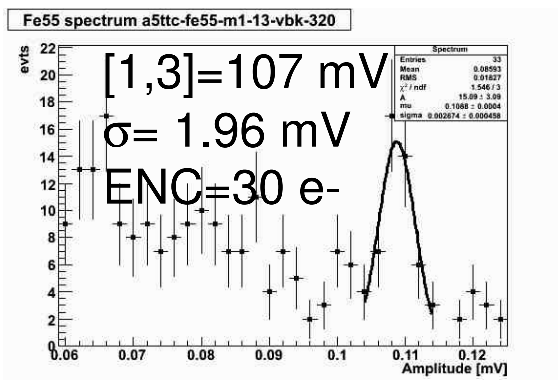
Chip1: first hints of gain/noise dispersion…

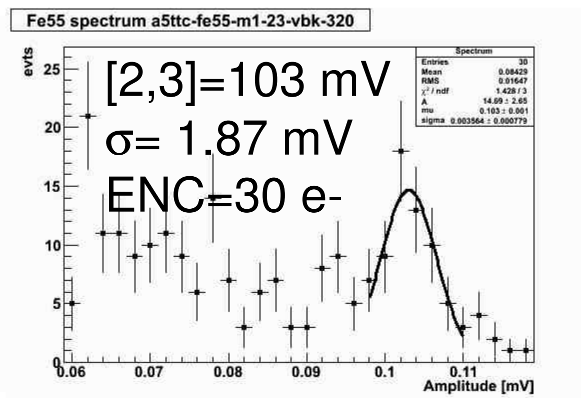
(Set V_{fbk}= 320 mV → waveform shape closer to simulation)











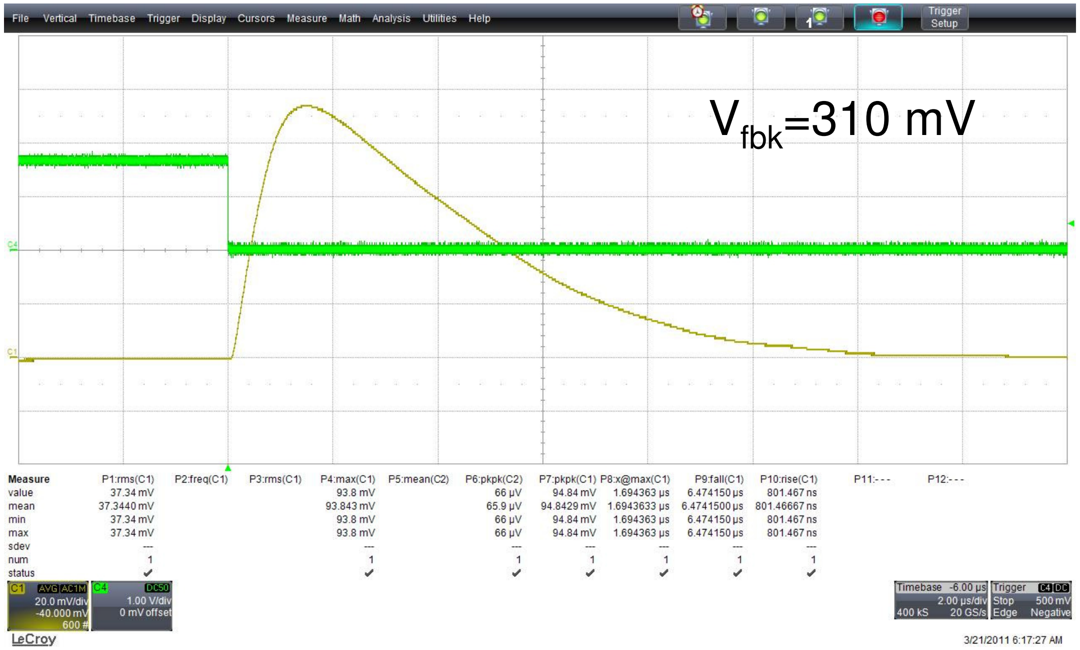
Even if the stat. is low → <peak> = 116 mV → <Gain>= 442 mV/fC

σ(Gain)/<Gain>~20/116~18%

<ENC>= 36 e- σ(ENC)=15 e-

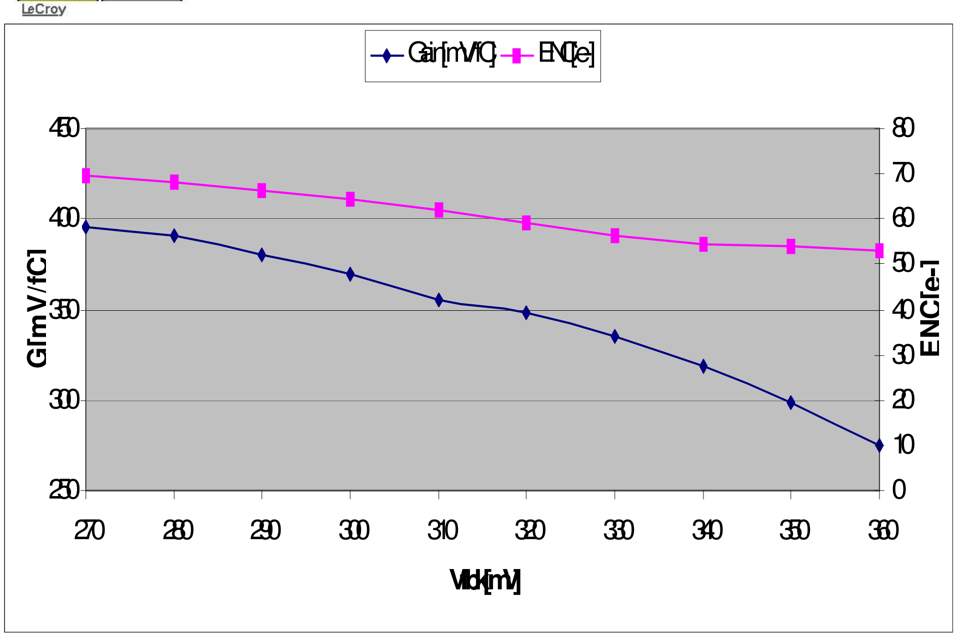
It's not surprising …
(apsel5T-ST)

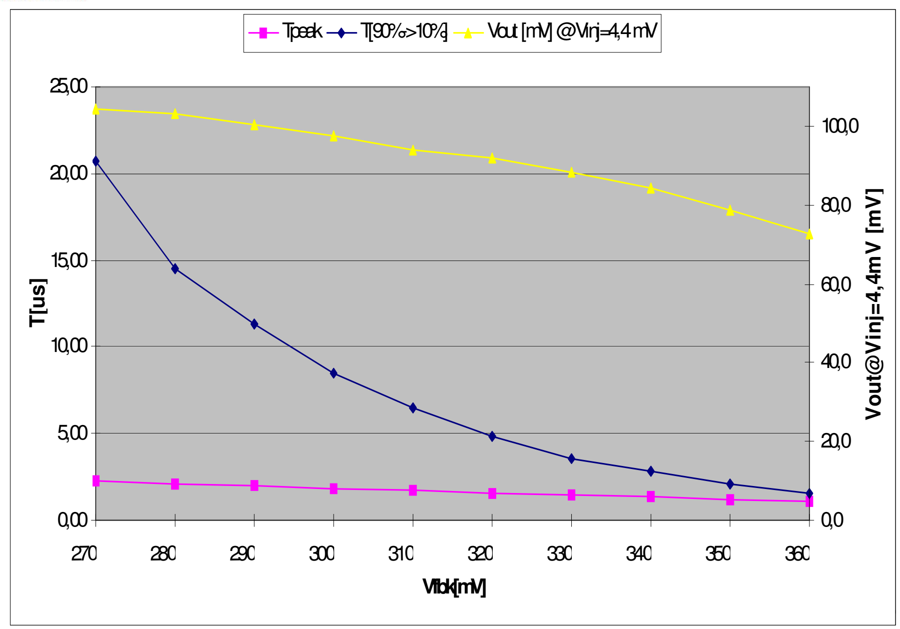
Chip4 Waveform study: shape vs. V_{fbk}



Inject a V-step (4.4 mV) into the (nominal 60 fF) Cinj:

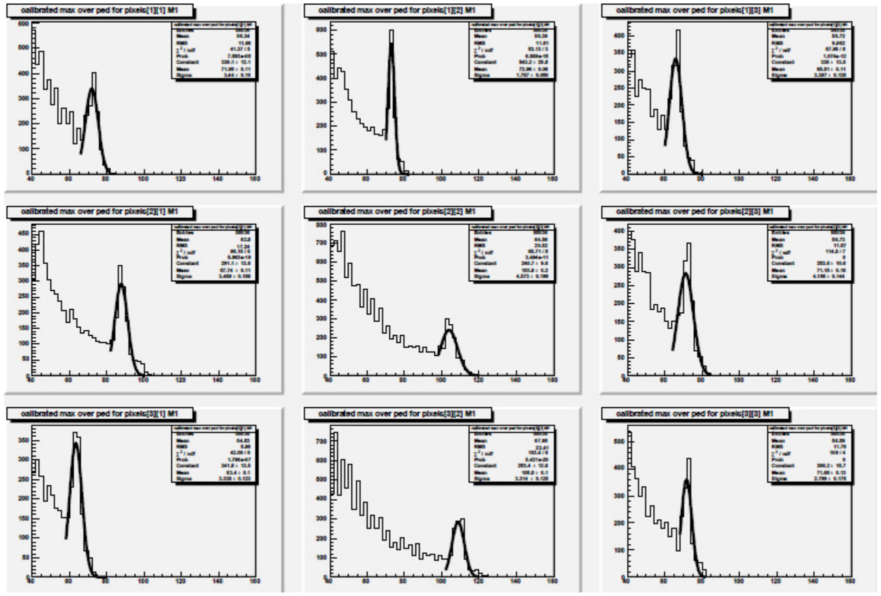
- Measure RMS noise
- Average out the noise to measure the waveforms:
  - Max V_{out} →Gain
  - T_{peak}
  - Fall time $T_{90\%\rightarrow 10\%}$
- Calculate ENC(e-) (with Cinj-Gain)





Chip 4: Fe55 Spectra

Matrix M1



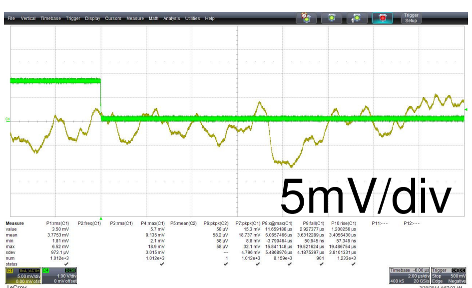
(Set V_{fbk}=310 mV)

Pixel Fe55 peak[mV]

72	73	66
88	104	71
63	109	72

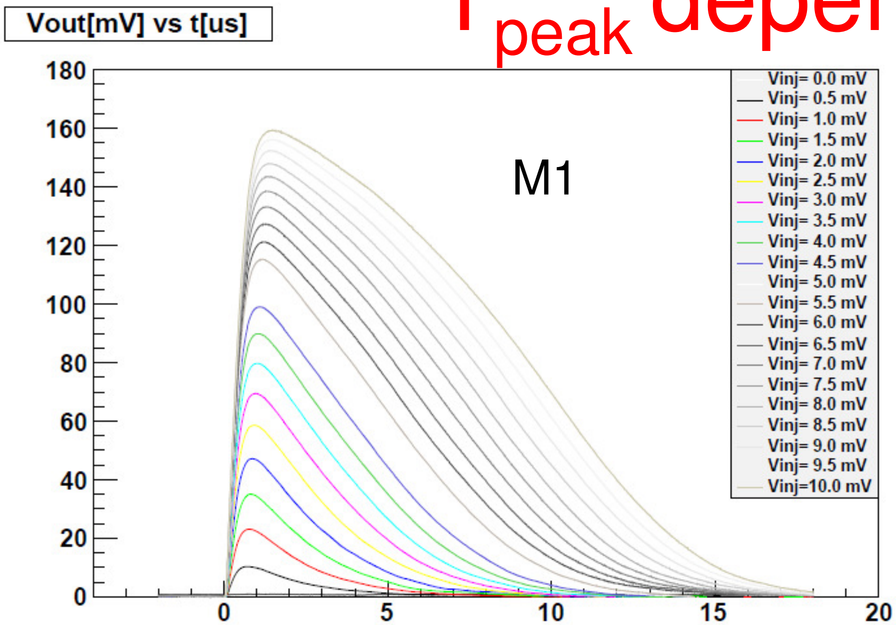
Pixel Noise RMS [mV]

2,29	1,77	1,86
2,01	3,79	1,94
1,81	2,09	1,80

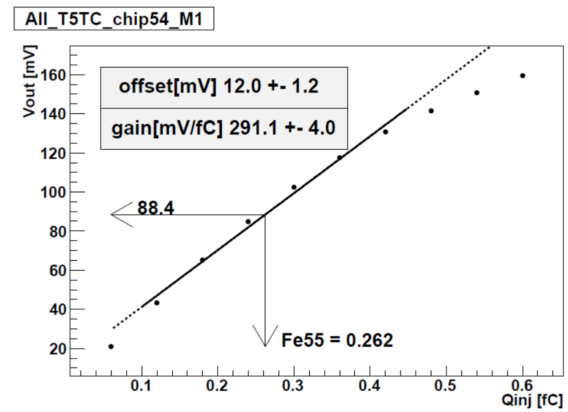


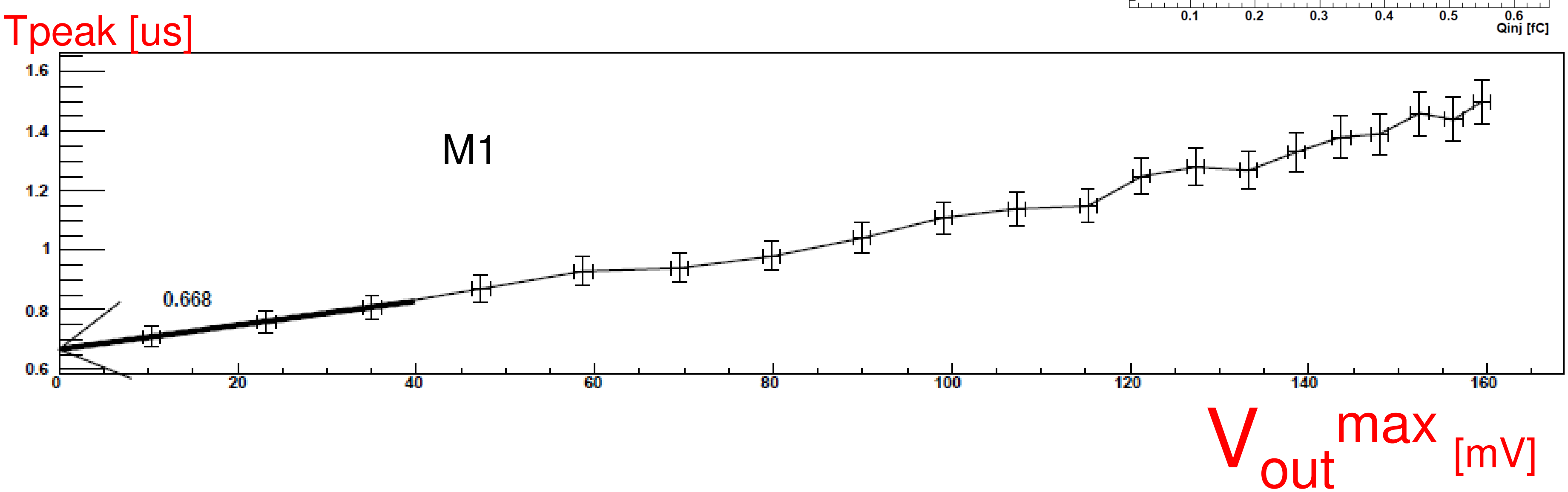
M	<μ> [mV]	<σ> [mV]	G [mV/fC]	ΔG/G [%]	<enc> [e-]
1	80 +- 17	3.4 +- 0.7	304	21	44
2	72 +- 14	2.9 +- 0.7	276	20	40

T_{peak} depends on V_{out}^{max}



The feature of shaper-less FE:
the peaking time depends on the output level.
V_{inj}=[0.5, 10] mV
←Averaged waveforms
of channel [2,2] M1





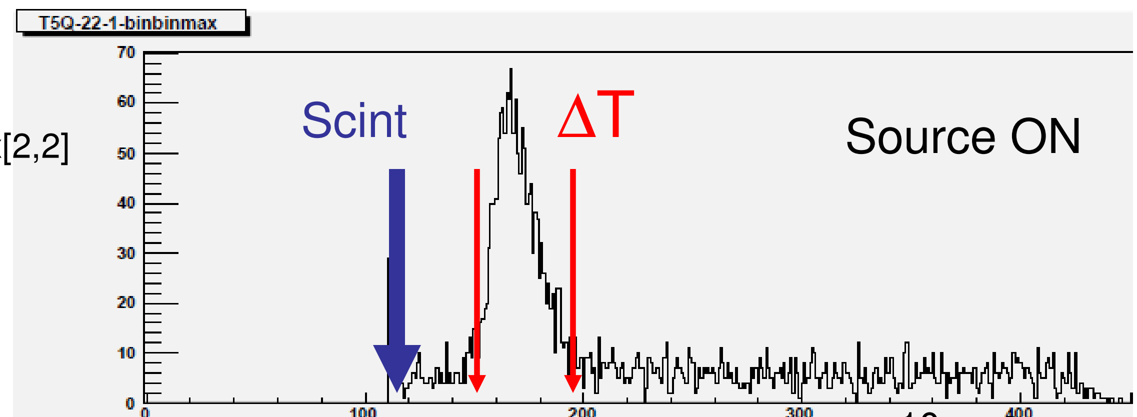
Sr-90 Spectrum (chip4)

Trigger: sgn[2,2]>5$\sigma_{[2,2]}$ within a 4μs window after the scintillator fires (100 kevts written).

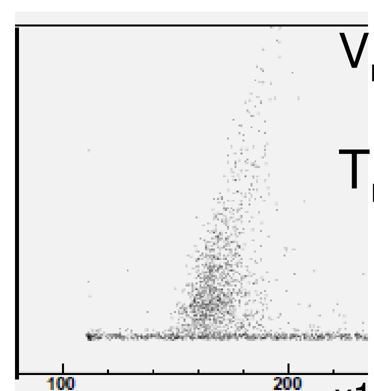
In the offline analysis, due to the T_{peak} dependance on V_{out}^{max},not to biased by positive noise oscillation and to sum the contribution of the other pixels to the cluster charge, we can apply 2 methods:

1. look for the max. signal V_{max}[i,j] in a shorter time window ΔT, request that V_{max}[2,2] > V_{max}[i,j] $_{i!=2,j!=2}$,find the $T_{max[2,2]}$ and sum-up the other 8 V_{max}[i,j] found within $T_{max[2,2]}$

$T_{max[2,2]}$



x10 ns

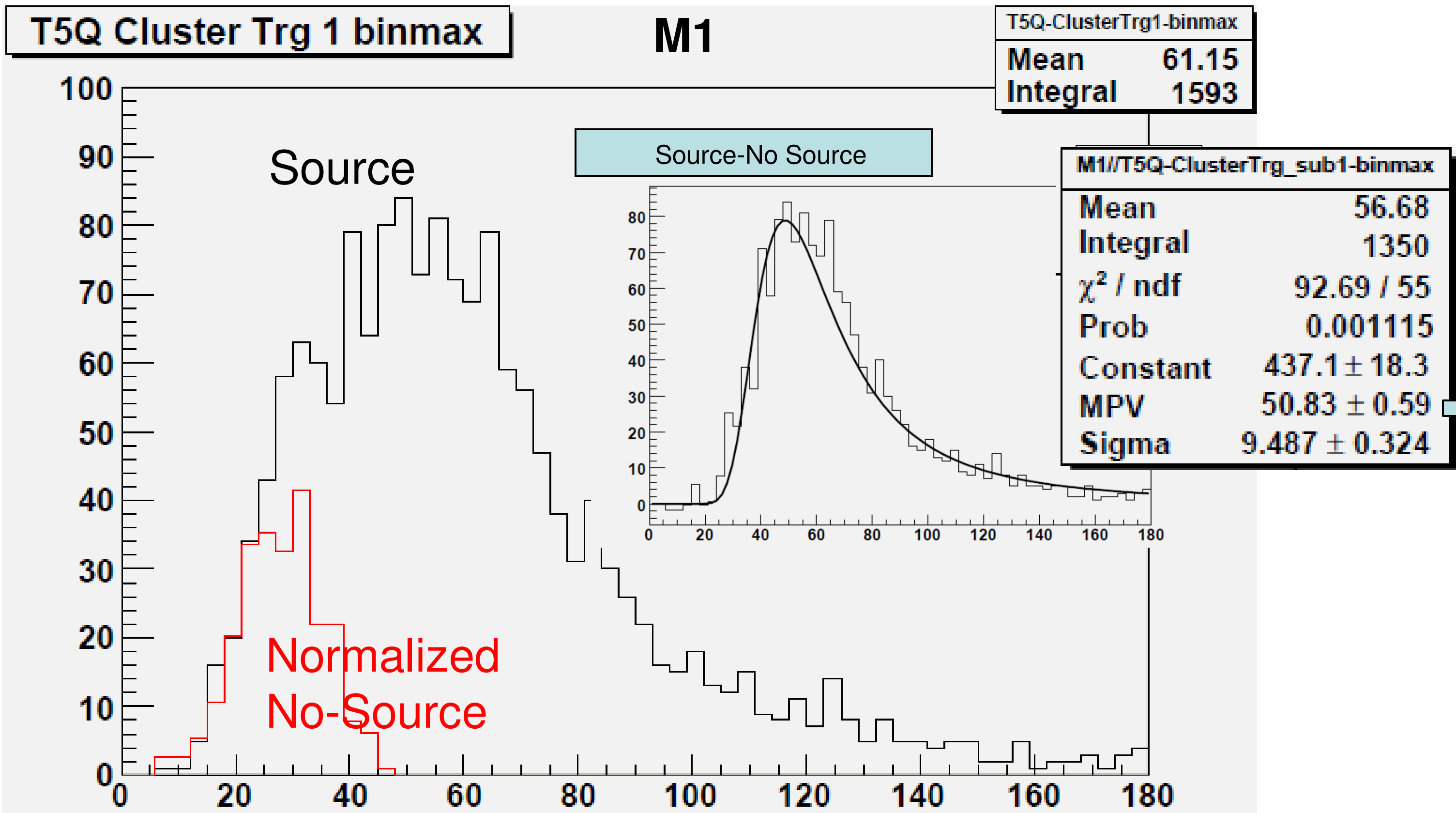


V_{max}[2,2] vs $T_{max[2,2]}$

x10 ns

2. fit the outputs with the (expected) waveforms (CPU time→ pre-select events:V_{max}[2,2]>V_{max}[i,j] $_{i!=2,j!=2}$) and then sum the fitted V_{max}[i,j] to give the cluster charge

Sr-90 Spectrum (method-1)



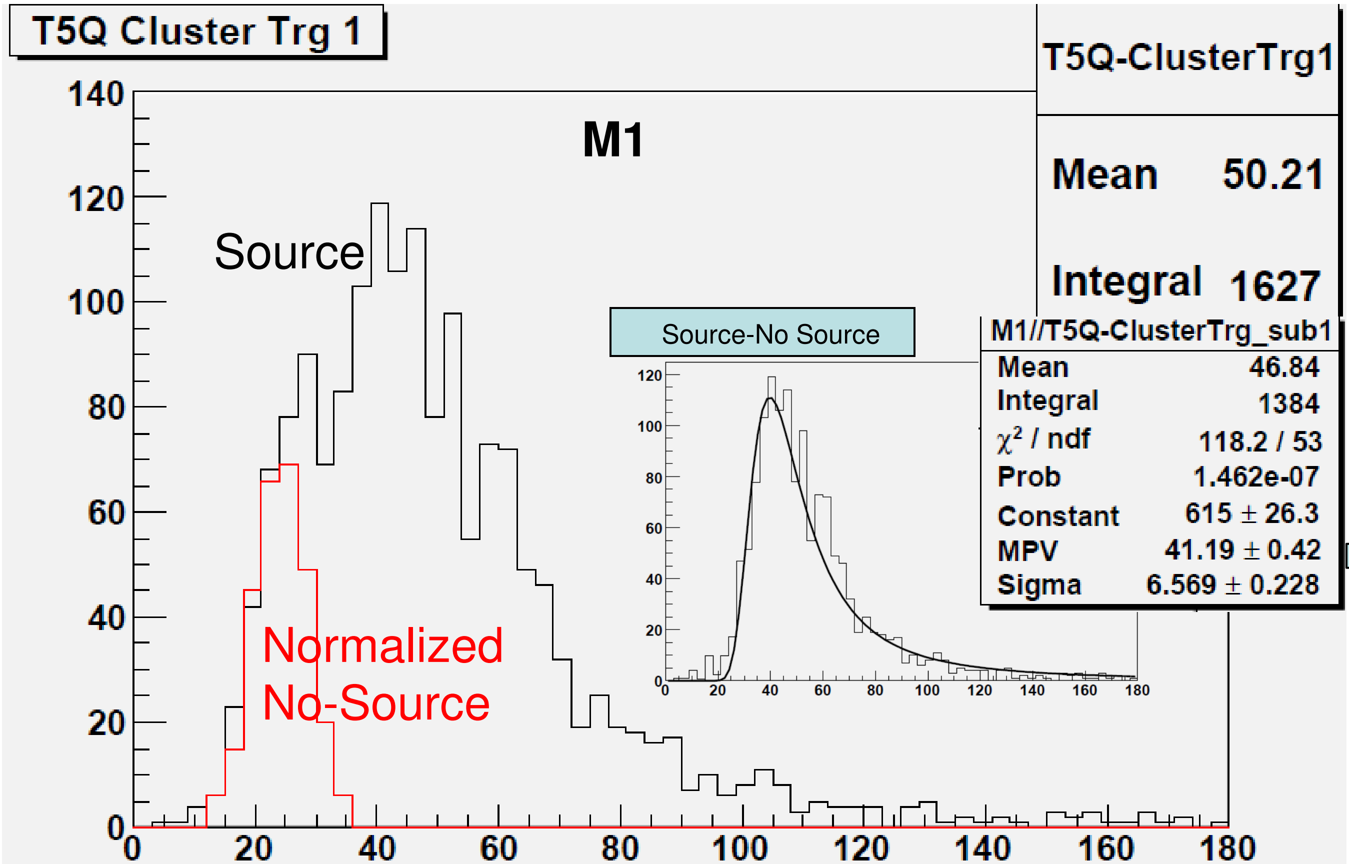
M1

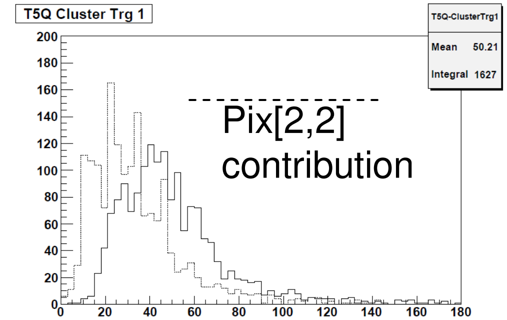
SGN=1046e-

The Source distribution contains true β (scintillator fired!) but not impinging on the matrix (the mechanical collimator lets them pass). To estimate them, the Normalized No-Source distribution is taken w/o source with a pulse at the average scintillator frequency, normalizing to the same DAQ time.

For **M2:** MPV= 39.3 mV ⟹ SGN=890e-

Sr-90 Spectrum (method-2)





M1
SGN=847e-

Hypothesis: all the channels of the matrix have the PA responding with a waveform-shape equal to that of the (injectable) central pixel.

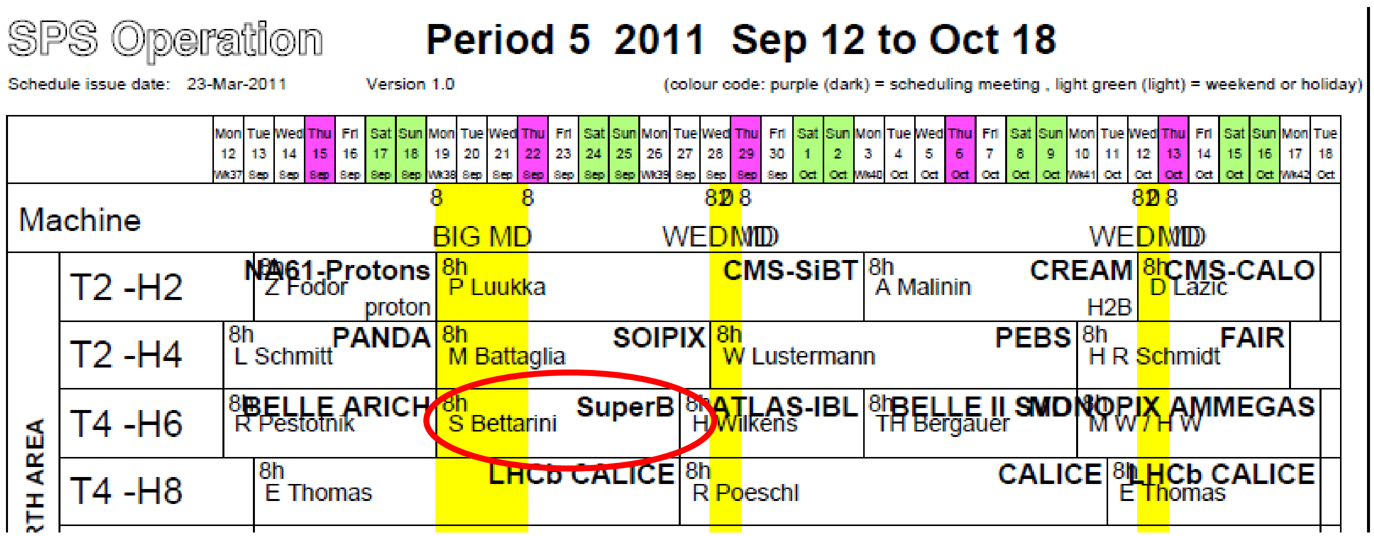
For **M2:** MPV= 26.0 mV ⇨ SGN=590e-

Some notes …

- The chip#4 is the best of a small (5 chips) production:
  - Chip 1: to be further investigated in PV (by Laser SCAN);
  - Chip 2: gain extremely low (PV)
  - Chip 3: M1-pixel[2,2] oscillates (RMS 12 mV)
  - Chip 5: M1:pixel[1,3] oscillates; 3 pixels of M2 are noisy.
- More stat. needed to judge quality and yield (assuming these single problems are not caused by u-bonding, almost “perfect” in the past productions).
- “A posteriori” (after closing the design) we realized that a shaper-less FE is not the most robust/performing design to test a new technology (apsel5T ST “docet”).
- The main contribution of the Q-cluster comes from the central pixel (request that in order to analyze clusters well-contained in the 3x3 matrix).
- The Q-cluster now doesn’t take into account the spread on the gain (sum the 9 output voltages instead of the 9 charges).
- To be confirmed the difference btw M1 and M2.
- The first 2 chips have been sent to PV to be tested under LASER scan.

Conclusions

- First encouraging test results on the apsel structures of the V.I. chips:
  – The process produced a working sensor (at least) at analog level
  – The noise and gain are "reasonable"
  – The electrode collects a charge from MIP of about 700e-
- An un-biased estimate of the charge collected by the cluster to be done in the September Test-Beam (SPS), with a pure sample of MIP tracks (telescope used) impinging on the matrix



- The OK flag for the submission of the 1st T.C. run→ test the digital part in the 2 tiers assembly (…coming soon).