Results from the 1999 H8 beam tests of SCT prototypes

- Introduction
- Results efficiency-noise
- Results timing study
- Summary of results

Pepe Bernabeu, Rachel Challis, Szymon Gadomski, Jan Kaplon,

Carlos Lacasta, Gareth Moorhead, Peter Philips, Javier Sánchez,

Marcel Vos

Email: Marcel.Vos@ific.uv.es

Results submitted as ID Internal Note
ATL-COM-INDET-2000-002
draft available http://ific.uv.es/˜vos/

Modules

All modules under test were fully bonded to 12 cm of 325 μm thick, barrel type, $p^{+}n$ Hamamatsu detectors.

- ABC1 : 6 CAFE/P + ABC on LBL Beryllia hybrid
- CGNT1: 6 ABCD2NT on Oslo Alumina hybrid
- CGT1 : 6 ABCD2T on Oslo Alumina hybrid

Data

Threshold Scans for Edge Sensing Circuit ON/OFF and 80 and 240 V bias voltage $\rightarrow$

Affects the charge collection time in the Silicon:

$$T = \frac{d^2}{\mu V_{bias}}$$

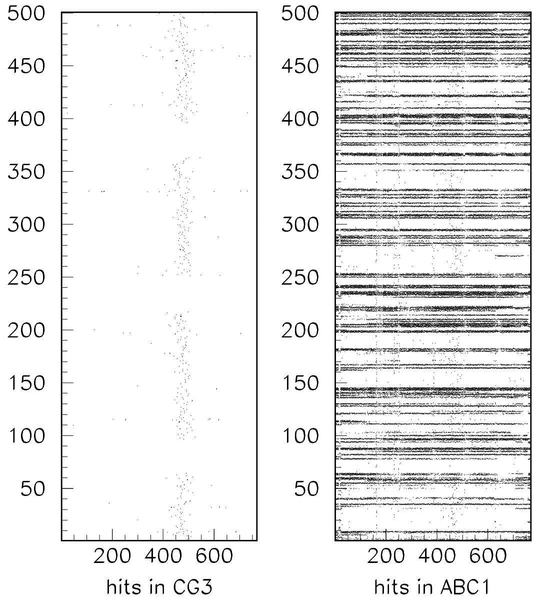
80 Volt: 27 ns

240 Volt: 9 ns

reference module CG3

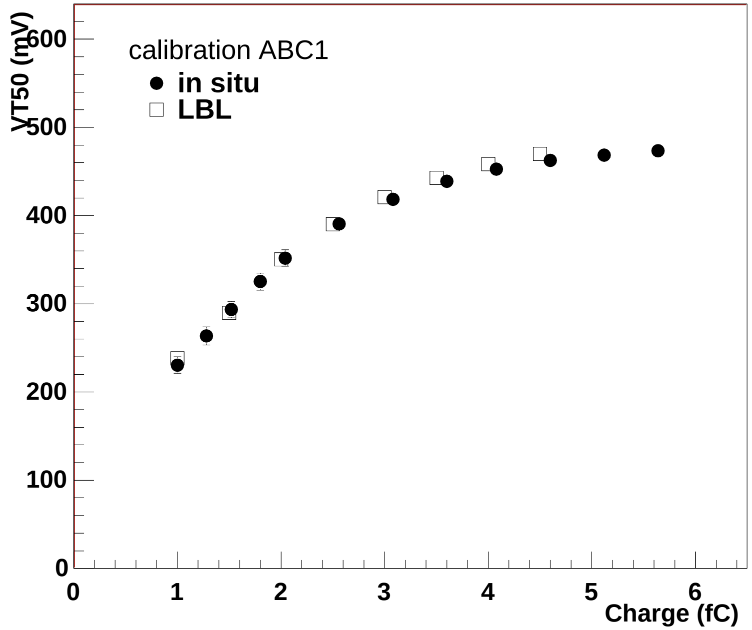
- 'old' ABCD module, bonded to 6 cm
- kept at fixed bias and threshold → high efficiency
- detection of residual inefficiencies

'Oscillation' ABC1

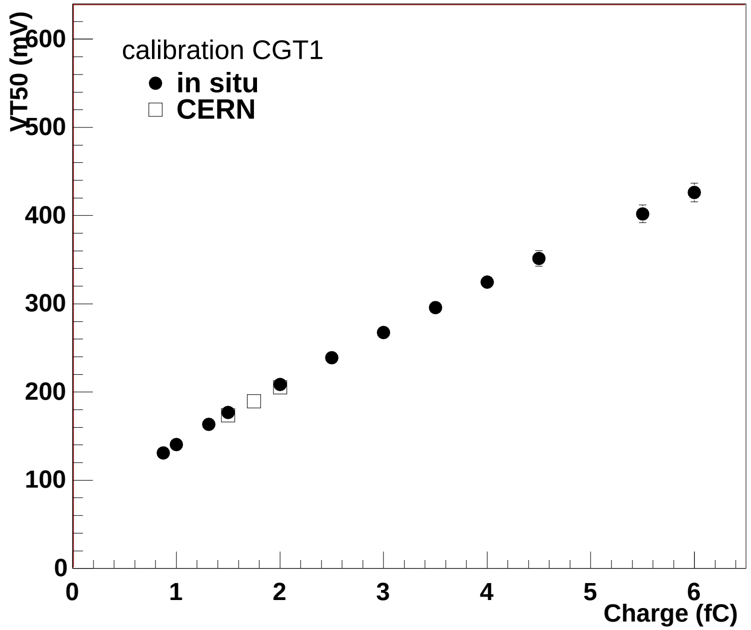


Calibration

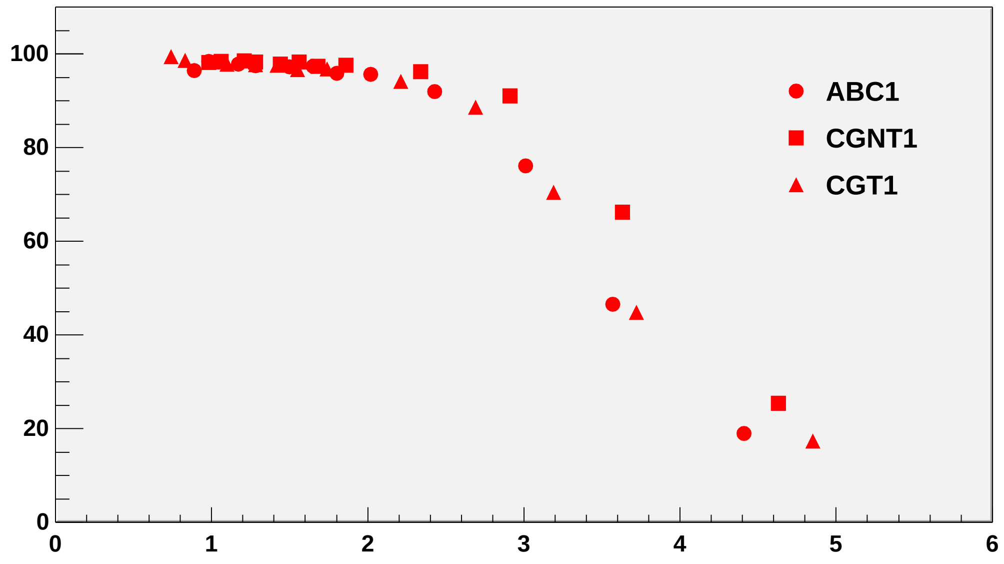
ABC1



CGT1

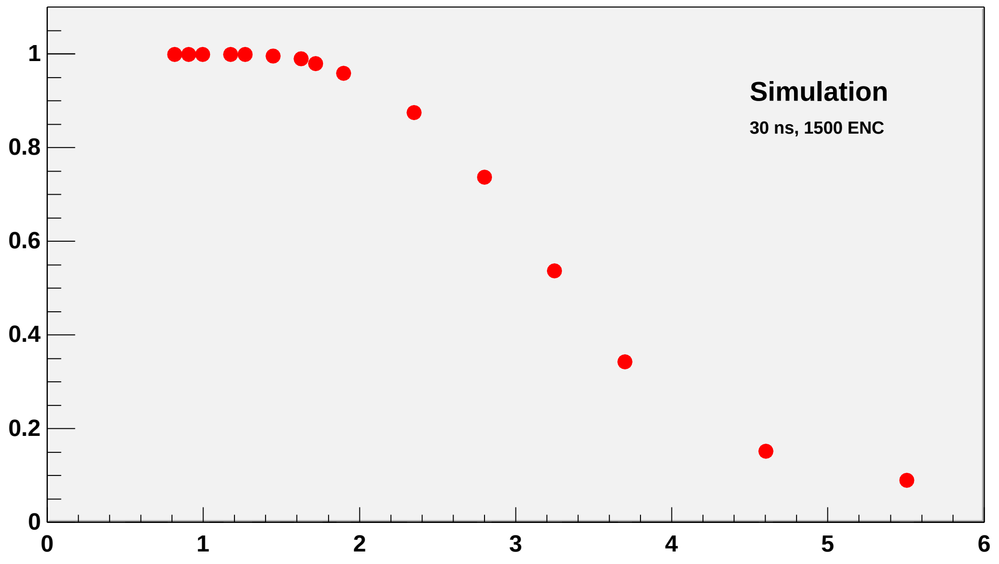


Efficiency versus threshold, edge ON, 240 V



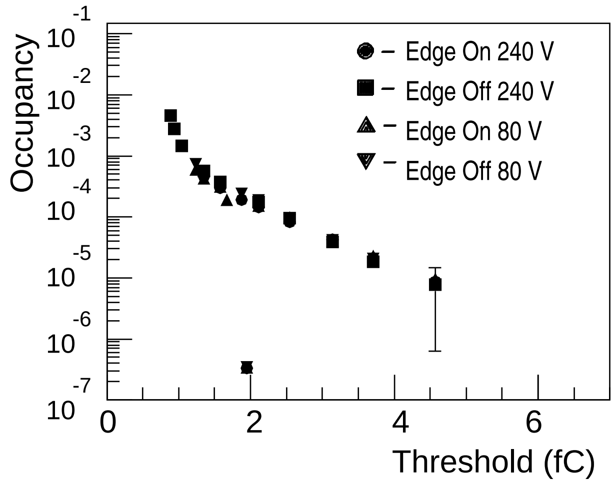
- Compare binary information to telescope prediction
- Only central time bin considered
- Narrow TDC interval for each threshold

Efficiency versus threshold, edge ON, 240 V

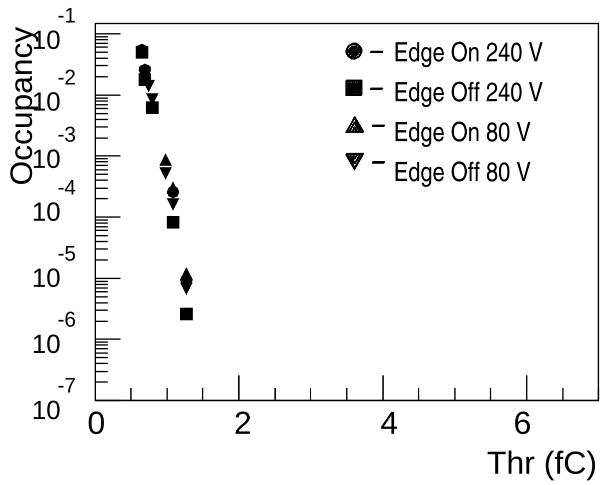


- Landau charge distribution + noise
- Inefficiency due to timing taken into account
- No ballistic deficit

ABC1



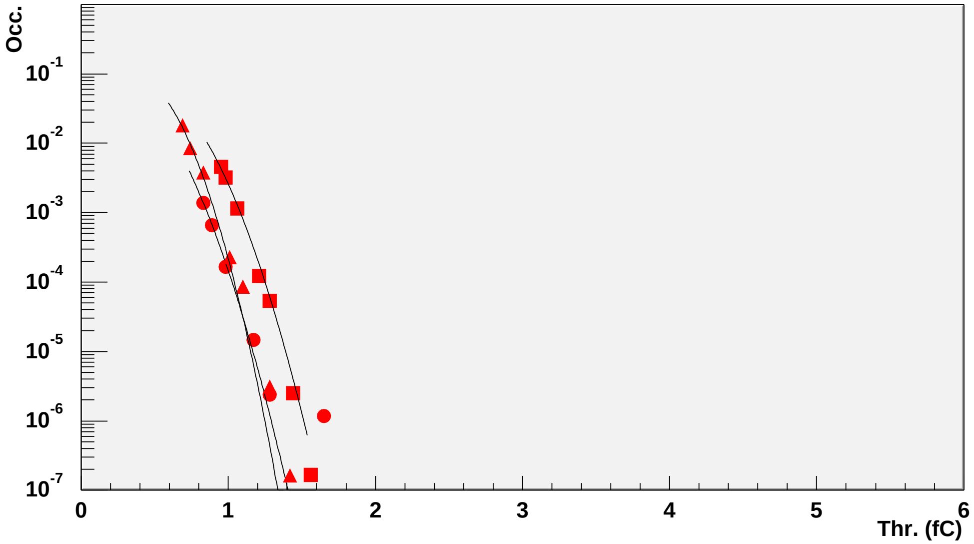
CGT1



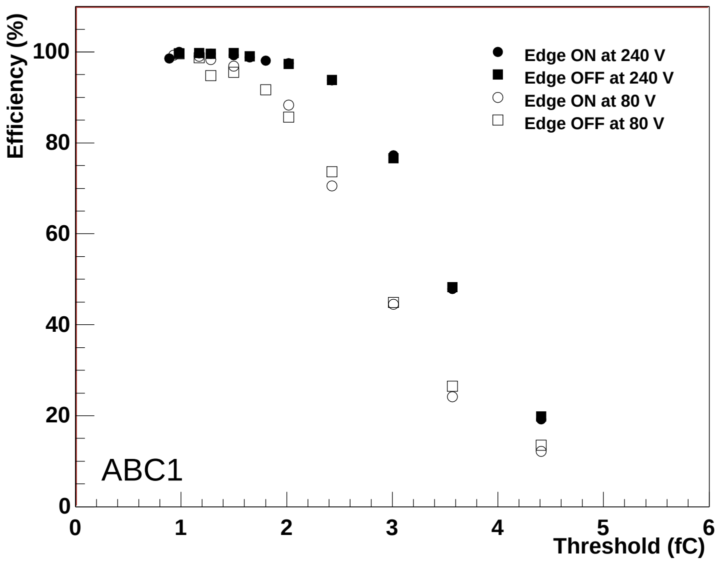
Noise occupancy versus threshold

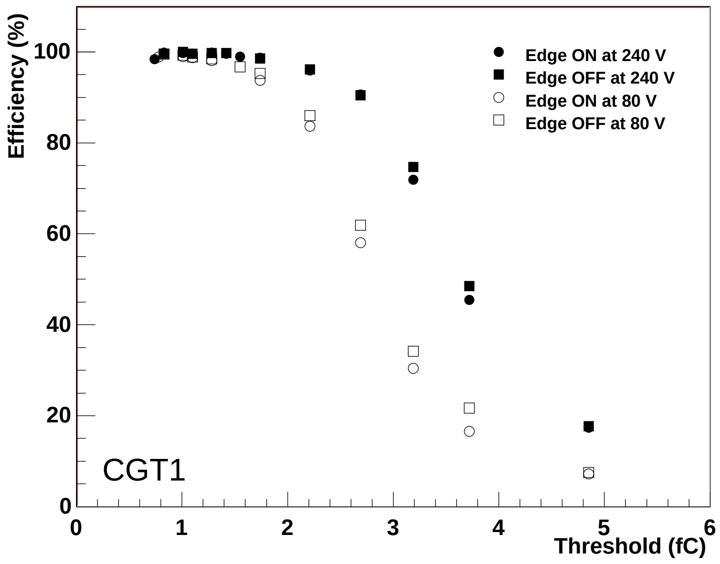
after bad channel rejection

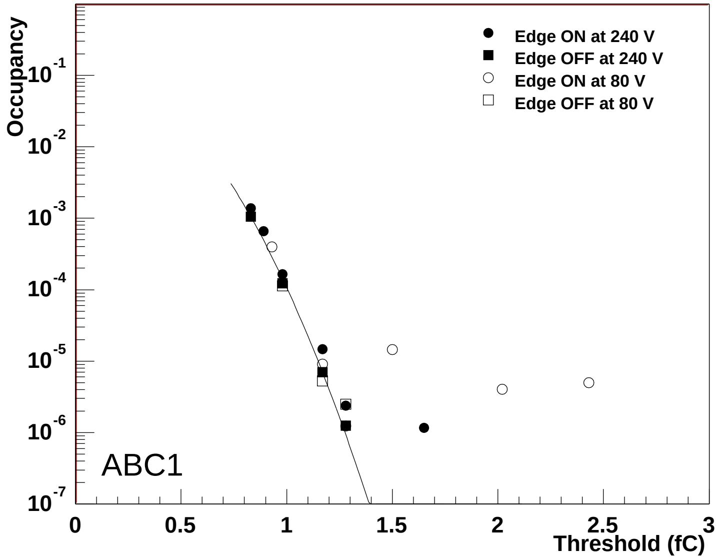
edge ON, 240 Volt

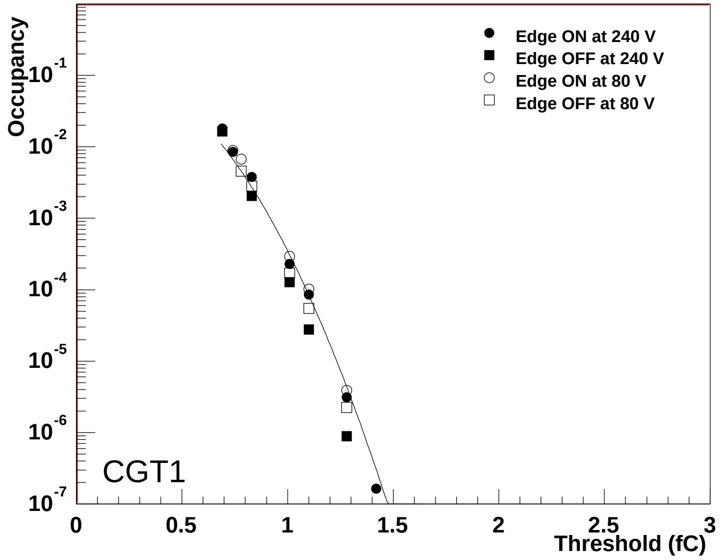


Testbeam 99


Efficiency (%)
100
80
60
40
20
0
0
1
2
3
4
5
6
Threshold (fC)
Edge ON at 240 V
Edge OFF at 240 V
Edge ON at 80 V
Edge OFF at 80 V
ABC1

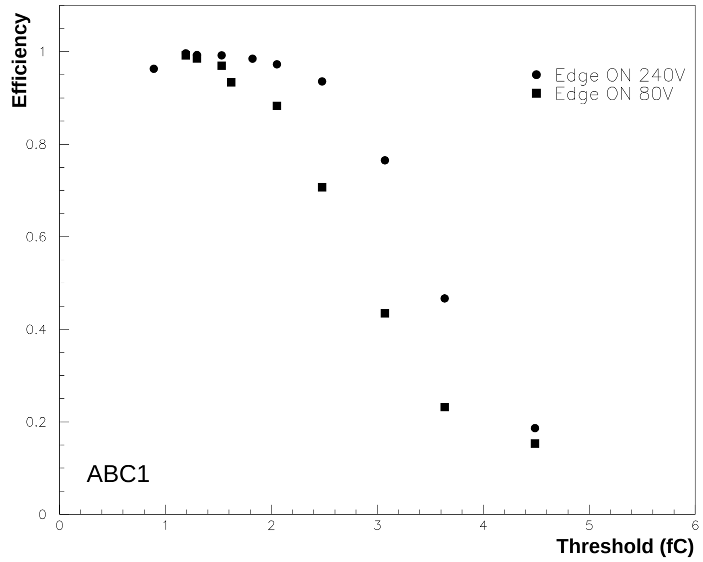

Efficiency (%)
100
80
60
40
20
0
0
1
2
3
4
5
6
Threshold (fC)
Edge ON at 240 V
Edge OFF at 240 V
Edge ON at 80 V
Edge OFF at 80 V
CGT1

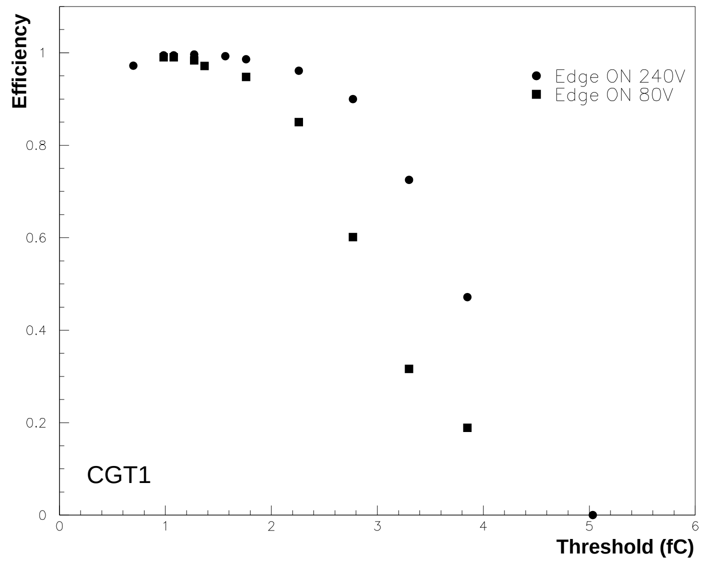

Occupancy
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
0
0.5
1
1.5
2
2.5
3
Threshold (fC)
Edge ON at 240 V
Edge OFF at 240 V
Edge ON at 80 V
Edge OFF at 80 V
ABC1


Occupancy
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
0
0.5
1
1.5
2
2.5
3
Threshold (fC)
Edge ON at 240 V
Edge OFF at 240 V
Edge ON at 80 V
Edge OFF at 80 V
CGT1

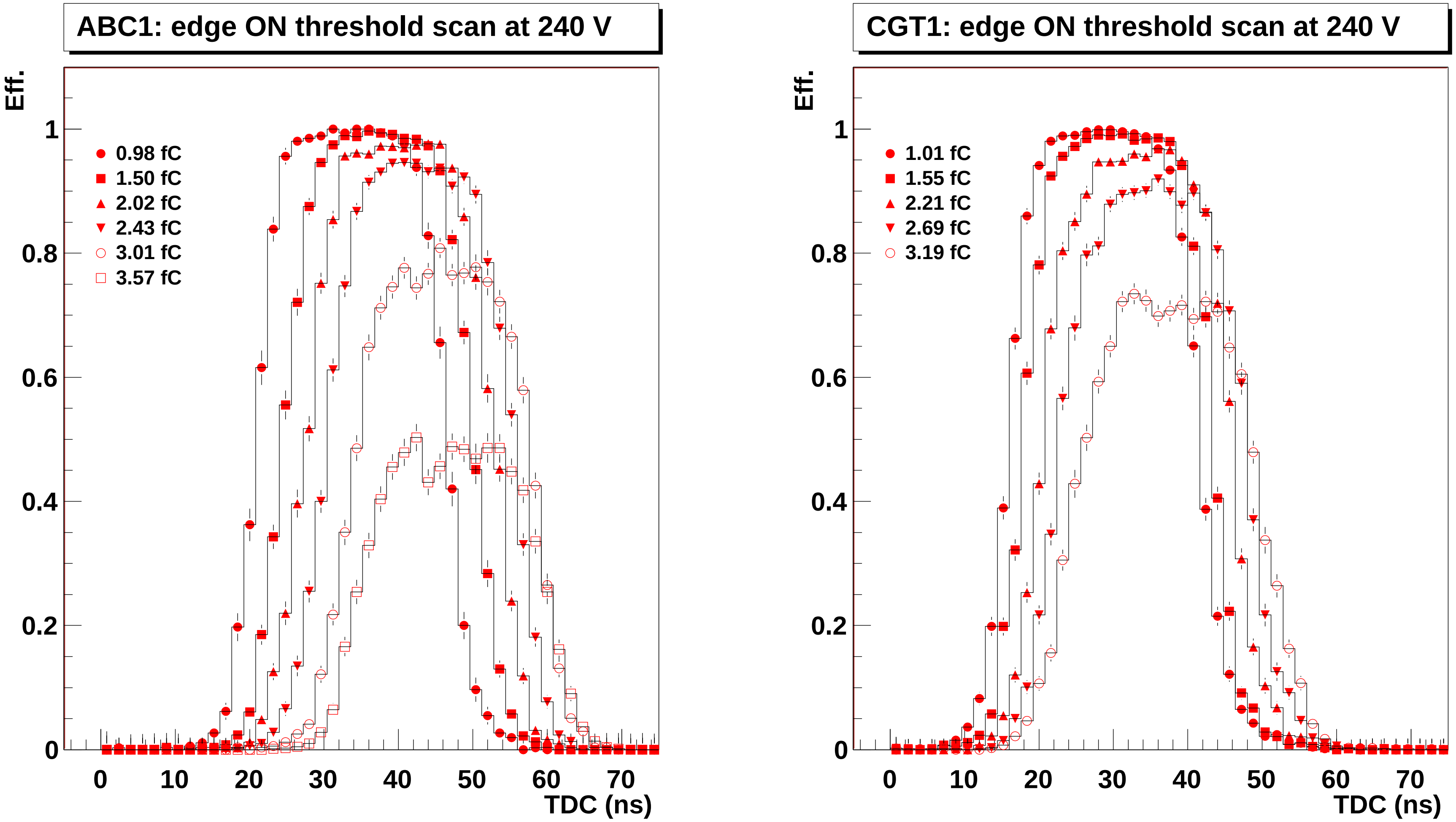
Binary only analysis

- Information from telescopes and TDC not used
- Tracks reconstructed from other binary modules + reference
- Inherently less sensitive to residual inefficiencies
- Fast $\rightarrow$ high intensity beams



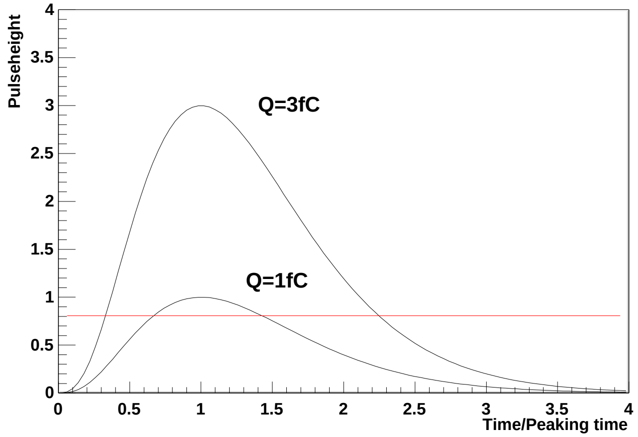


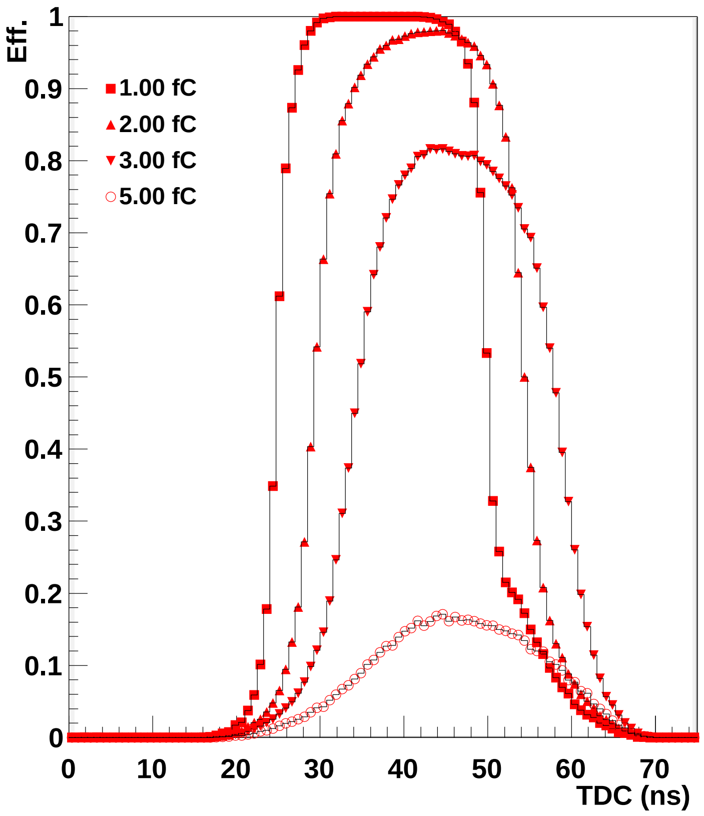
Timing Results: efficiency versus TDC



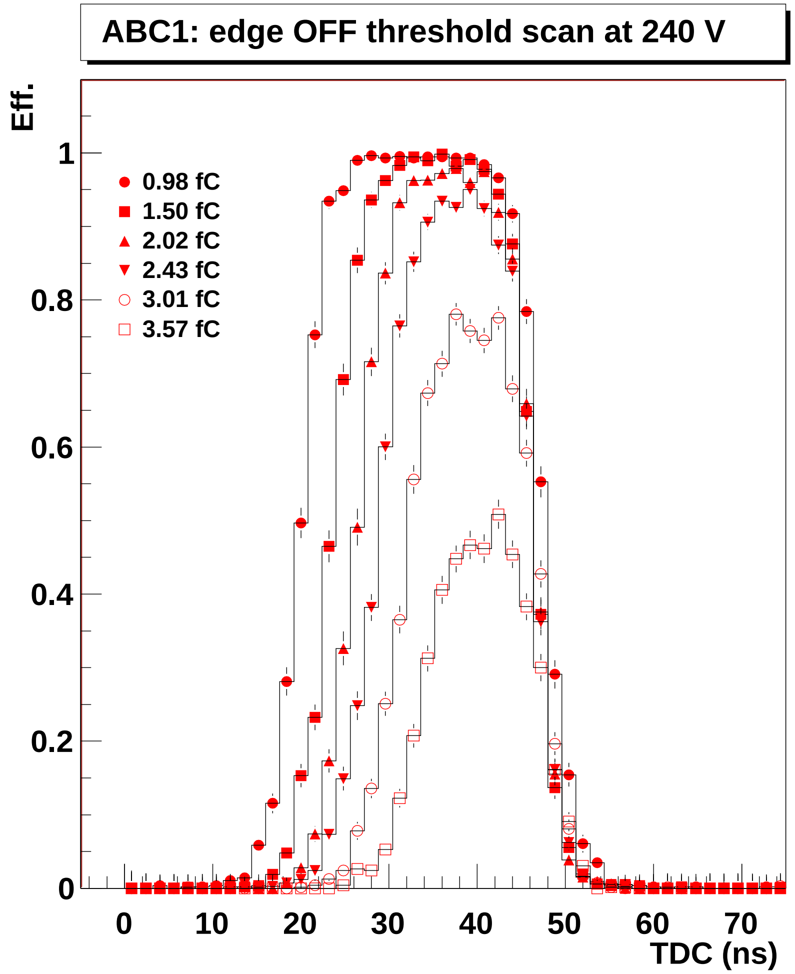
Monte Carlo Simulation

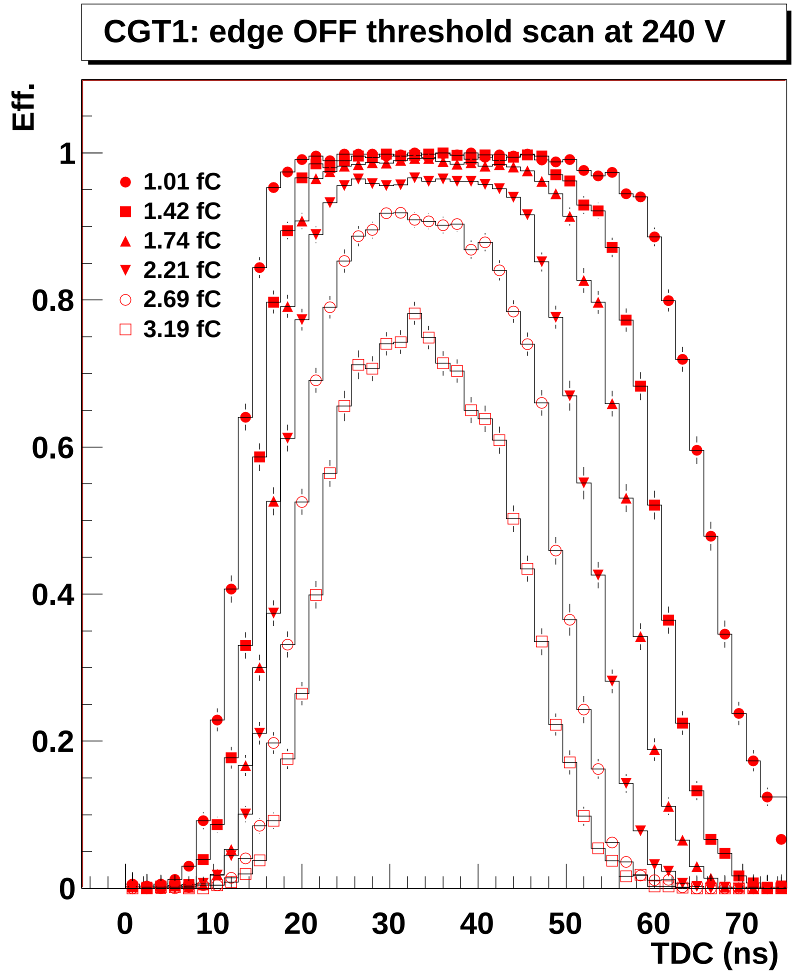
- Landau charge distribution
- Analysis equivalent to real data
- Shaper described as ideal third order CRRC
- Assuming δ function input pulse !!



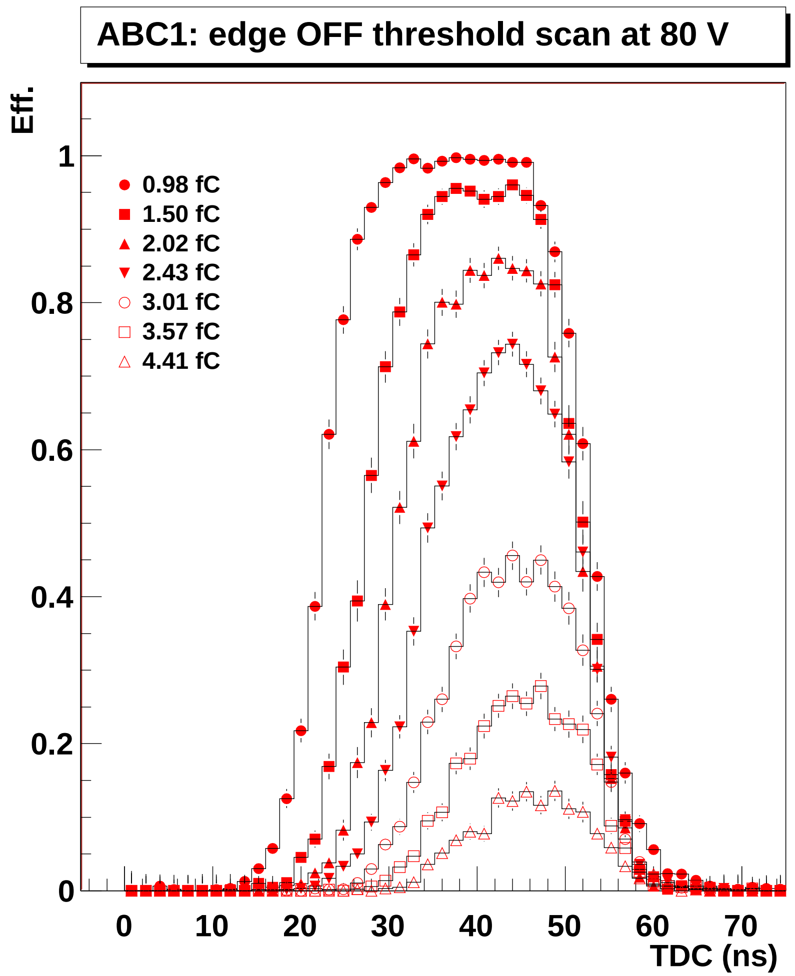


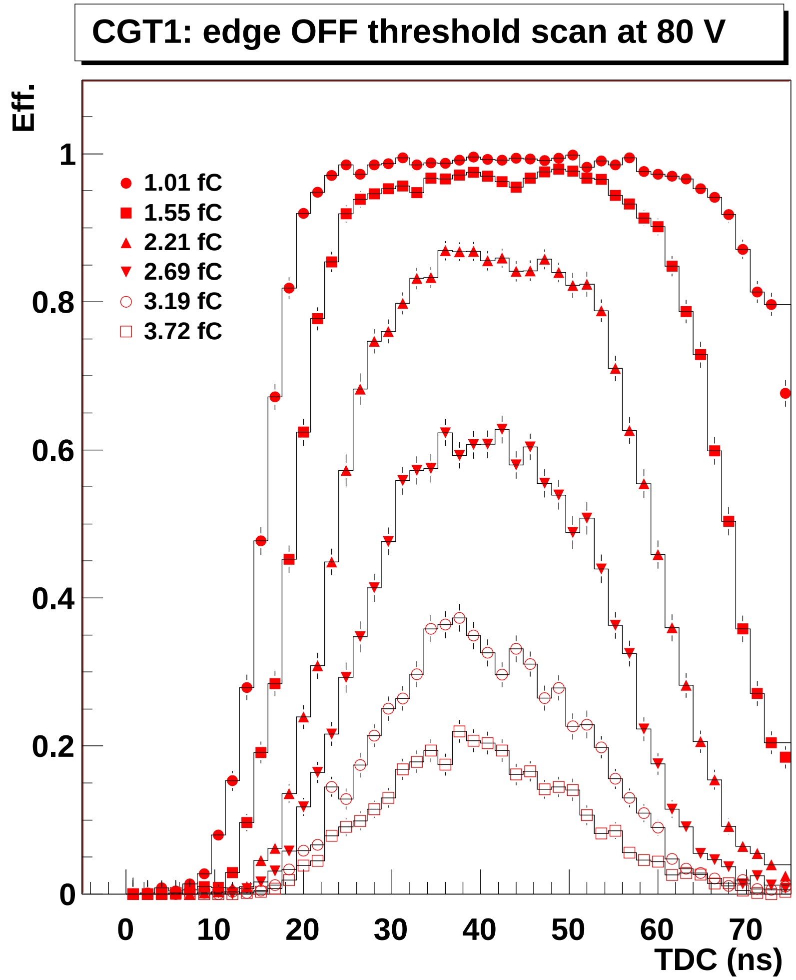
Timing Results: efficiency versus TDC



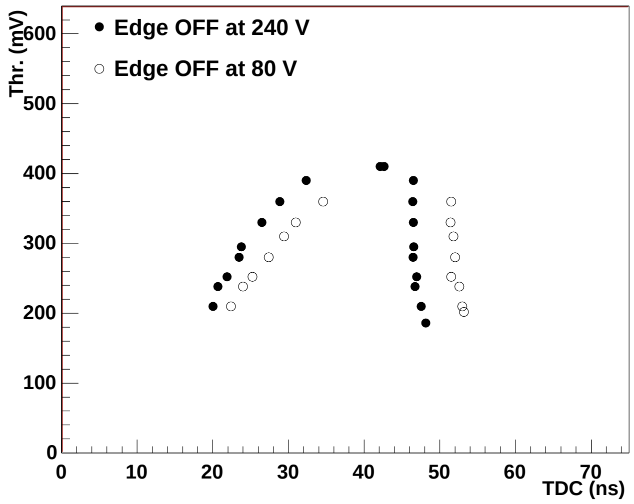


Timing Results: efficiency versus TDC

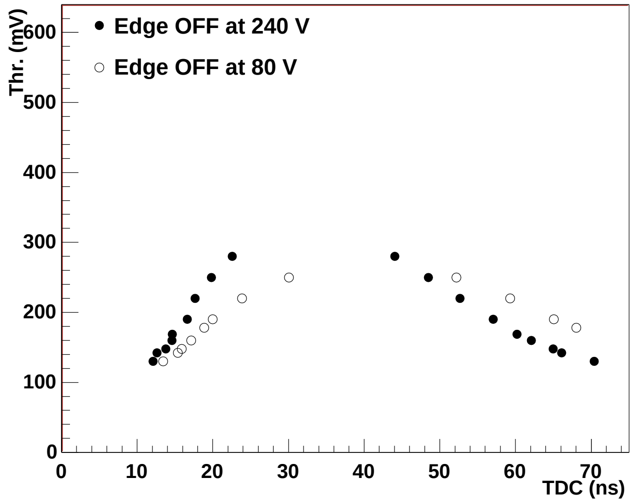




ABC1



CGT1



Ballistic deficit in $CRRC^3$ shapers:

Effective peaking time:

$$t_m = \frac{T}{1 - e^{-T/\tau}}$$

240 V: $t_m = 30$ ns

80 V: $t_m = 41$ ns

Amplitude loss (relative ballistic deficit):

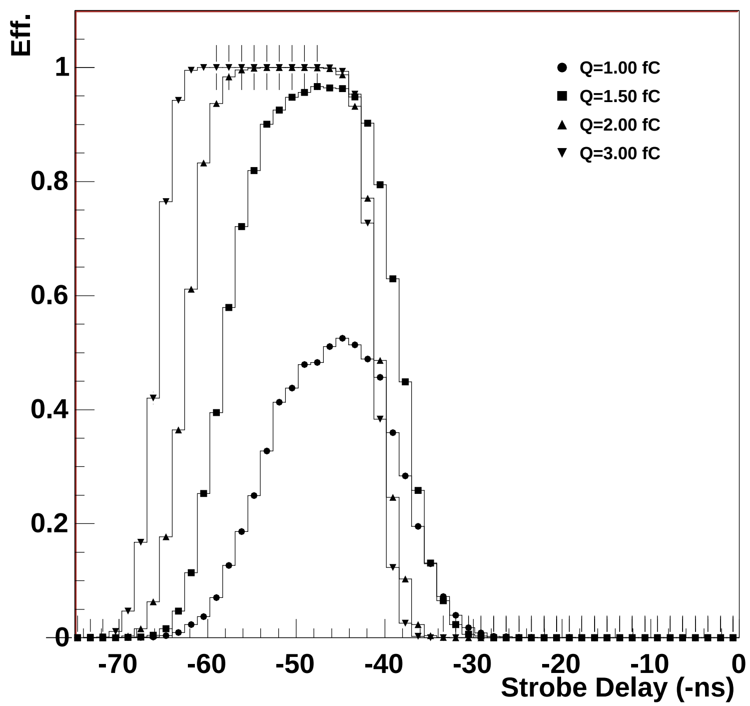
$$RBD \approx \frac{1}{8}\left(\frac{T}{\tau}\right)^2 \approx \frac{1}{8}\left(\frac{d^2}{\mu\tau V_{bias}}\right)^2$$

240 V: RBD = 1.6 %

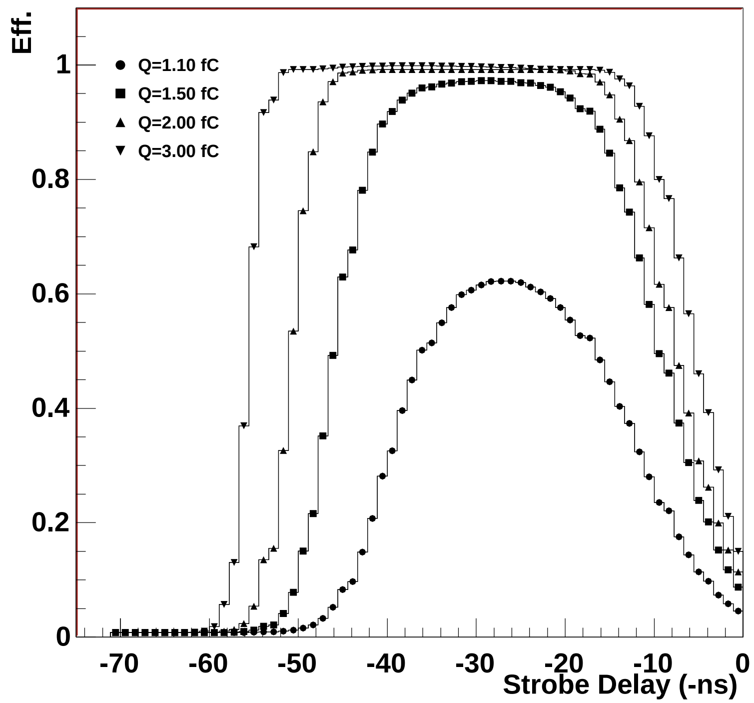
80 V: RBD = 15 %

Laboratory: efficiency versus strobe delay

CAFE/P+ABC



ABCD2T



- Varying charge at fixed threshold of 1 fC
- Negative strobe delay plotted

Summary of Results

- The residual inefficiencies are effectively removed by the introduction of a reference module
- A binary only analysis is certainly feasible and can provide a valuable cross check to the conventional analysis
- The three analysis find all half modules to provide a working range with efficiency $\pm 99\%$ and noise occupancy $< 10^{-4}$
- Spatial resolution $< 23\mu$
- Strong effect of detector bias seen in efficiency: ballistic deficit
- Pulse shape reconstruction using TDC and binary information from three time bins confirms ballistic deficit explanation

summary of efficiency and noise results

	data	*ABC1*	*CGNT1*	*CGT1*
efficiency (%)[a]	edge ON 240 V	99.5 ± 0.1	99.6 ± 0.1	99.1 ± 0.2
occupancy	edge ON 240 V	4.7×10^{-4}	4.3×10^{-4}	2.6×10^{-4}
efficiency (%)	edge ON 80 V	98.5 ± 0.2	99.6 ± 0.2	99.3 ± 0.2
occupancy	edge ON 80 V	5.9×10^{-4}	4.8×10^{-4}	3.1×10^{-4}
efficiency (%)	240 V	99.6 ± 0.4	99.8[b] ± 0.4	99.6 ± 0.4
efficiency (%)	80 V	98.6 ± 0.4	99.5[b] ± 0.4	97.3 ± 0.4
occupancy	all data	10^{-4}	10^{-4}[b]	2×10^{-4}
Noise fit (ENC)	all data	1560	1470	1250
efficiency (%)	edge ON 240 V	99.2[c]	99.3	99.4
efficiency (%)	edge ON 80 V	99.6[c]	99.2	99.0

[a] Efficiencies and noise of the entire first block evaluated at optimum efficiency/noise points ABC1: 1.35 fC (1.24 for 80 V), CGNT1: 1.30 fC, CGT1: 1.08 fC.

[b] Efficiency and noise of CGNT1 evaluated at 1.3 fC.

[c] Efficiency of ABC1 evaluated at 1.2 fC.