An analytic shaper for AToM chip

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1 Introduction

We tried to fit AToM pre production shaper with the function:[1]

$$y(t) = p_0 \left(\frac{t}{\delta t}\right)^2 \left(1 - \frac{t}{\delta t}\right) \exp\left(-p_1 \frac{t}{\delta t}\right) \tag{1}$$

where δt is the ToT at zero threshold and p_0 and p_1 are the fit results. In general p_0, p_1 and δt depend on injected charge q_{inj} . This dependence has been parametrized with the following linear functions:

$$\begin{aligned}
p_0 &= \begin{cases} q_{inj} \cdot p_{0b} & \text{if } q_{inj} < p_{0a} \\ p_{0a} \cdot p_{0b} - p_{0a} \cdot p_{0c} + q_{inj} \cdot p_{0c} & \text{otherwise} \end{cases} \\
p_1 &= \begin{cases} p_{1b} + q_{inj} \cdot p_{1c} & \text{if } q_{inj} < p_{1a} \\ p_{1b} + p_{1a} \cdot p_{1c} - p_{1a} \cdot p_{1d} + q_{inj} \cdot p_{1d} & \text{otherwise} \end{cases} \\
\delta t &= \begin{cases} p_{2b} + q_{inj} \cdot p_{2c} & \text{if } q_{inj} < p_{2a} \\ p_{2b} + p_{2a} \cdot p_{2c} - p_{2a} \cdot p_{2d} + q_{inj} \cdot p_{2d} & \text{otherwise} \end{cases}
\end{aligned} \tag{2}$$

At very large input charges ToT reaches a plateau. In the following the value of q_{inj} for which ToT gets its maximum will be indicated as q_{inj}^{SAT}. It is a good approximation to retain the parameters p_0, p_1 and δt as constants for $q_{inj} > q_{inj}^{SAT}$.

2 Results

Examples of shaper fit with equation 1 are shown in figures 1 and 2. Figure 3 shows p_0, p_1 and δt as a function of q_{inj}. Table 1 reports the values of p_{ij} at 100, 200, 300 and 400 ns peaking time. Figure 4 shows the analytic shaper at different injected charges. Figure 5 reports the ToT curves obtained from equation 1.

[1] Only negative lobe has been considered in the fit. More parameters should be introduced in equation 1 in order to make it work also for the positive lobe: since this is not important for ToT calculation, it wasn't taken into account in this report.

Time	Parameter	p_{ia}	p_{ib}	p_{ic}	p_{id}	q_{inj}^{SAT} [fC]
100 ns	p_0	12.6	-8.1	-7.2		
	p_1	15.8	4.1	-0.102	0.019	
	δt	12.3	292	-0.9	8.8	80
200 ns	p_0	14.6	-7.3	-18.4		
	p_1	12.0	3.3	-0.050	0.068	
	δt	12.1	492	0.6	17.1	80
300 ns	p_0	16.7	-9.1	-20.2		
	p_1	18.4	3.8	0.030	0.054	
	δt	16.6	683	6.4	23.1	55
400 ns	p_0	15.4	-7.9	-17.7		
	p_1	11.7	3.4	0.030	0.044	
	δt	15.4	828	8.4	29.0	45

Table 1: Parameters mean values. p_{ij} values permit to find out p_0, p_1 and δt for all values of q_{inj} through equations 2. Parameter p_0 is expressed in [V], δt is in [ns] and q_{inj} is in [fC].

Time	Parameter	δp_{ia}	δp_{ib}	δp_{ic}	δp_{id}
100 ns	p_0	5.3	1.1	1.3	
	p_1	0.8	0.1	0.007	0.003
	δt	0.2	3	0.3	0.6
200 ns	p_0	0.4	0.4	2.2	
	p_1	0.3	0.1	0.003	0.004
	δt	0.6	7	1.2	0.9
300 ns	p_0	0.4	0.6	2.5	
	p_1	2.8	0.1	0.010	0.007
	δt	0.7	8	0.8	1.0
400 ns	p_0	1.1	0.6	3.1	
	p_1	6.7	0.3	0.030	0.006
	δt	0.4	10	0.9	1.2

Table 2: Parameters dispersions. These values have been found from the fits of six channels (two channels for three chips).

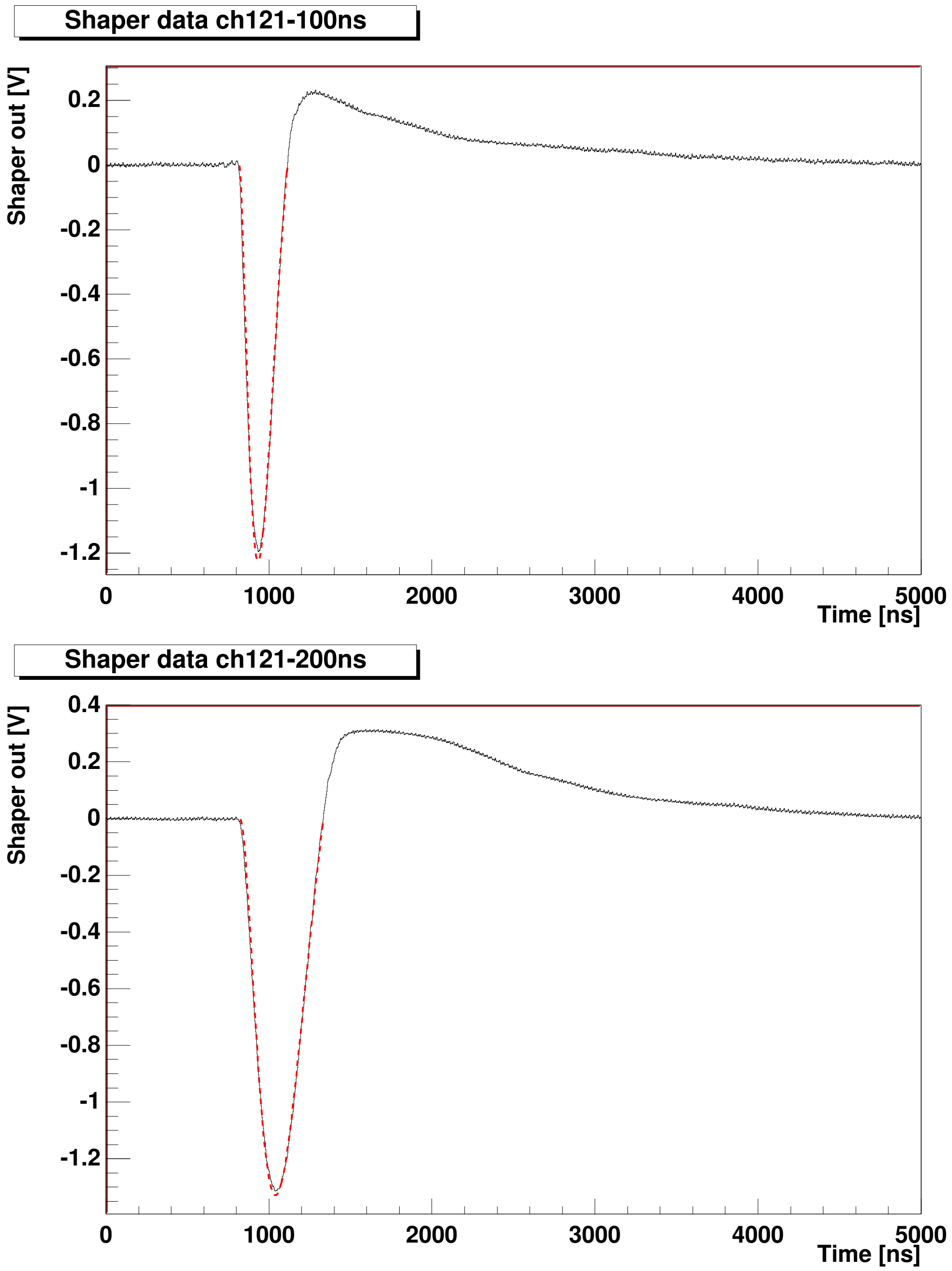

Figure 1: Shaper fit at 100 and 200 ns peaking time (injected charge is 6 fC).

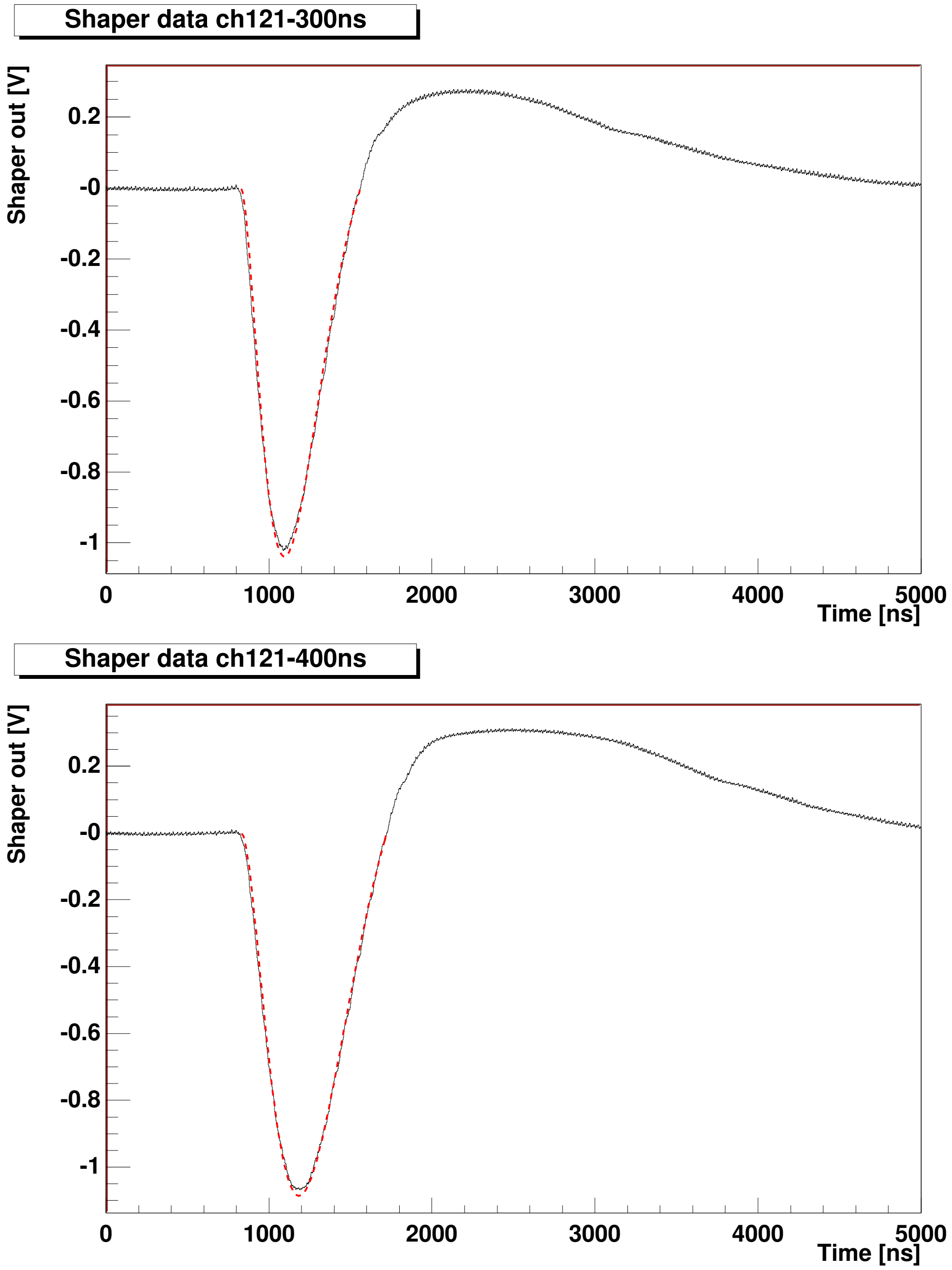

Figure 2: Shaper fit at 300 and 400 ns peaking time (injected charge is 6 fC).

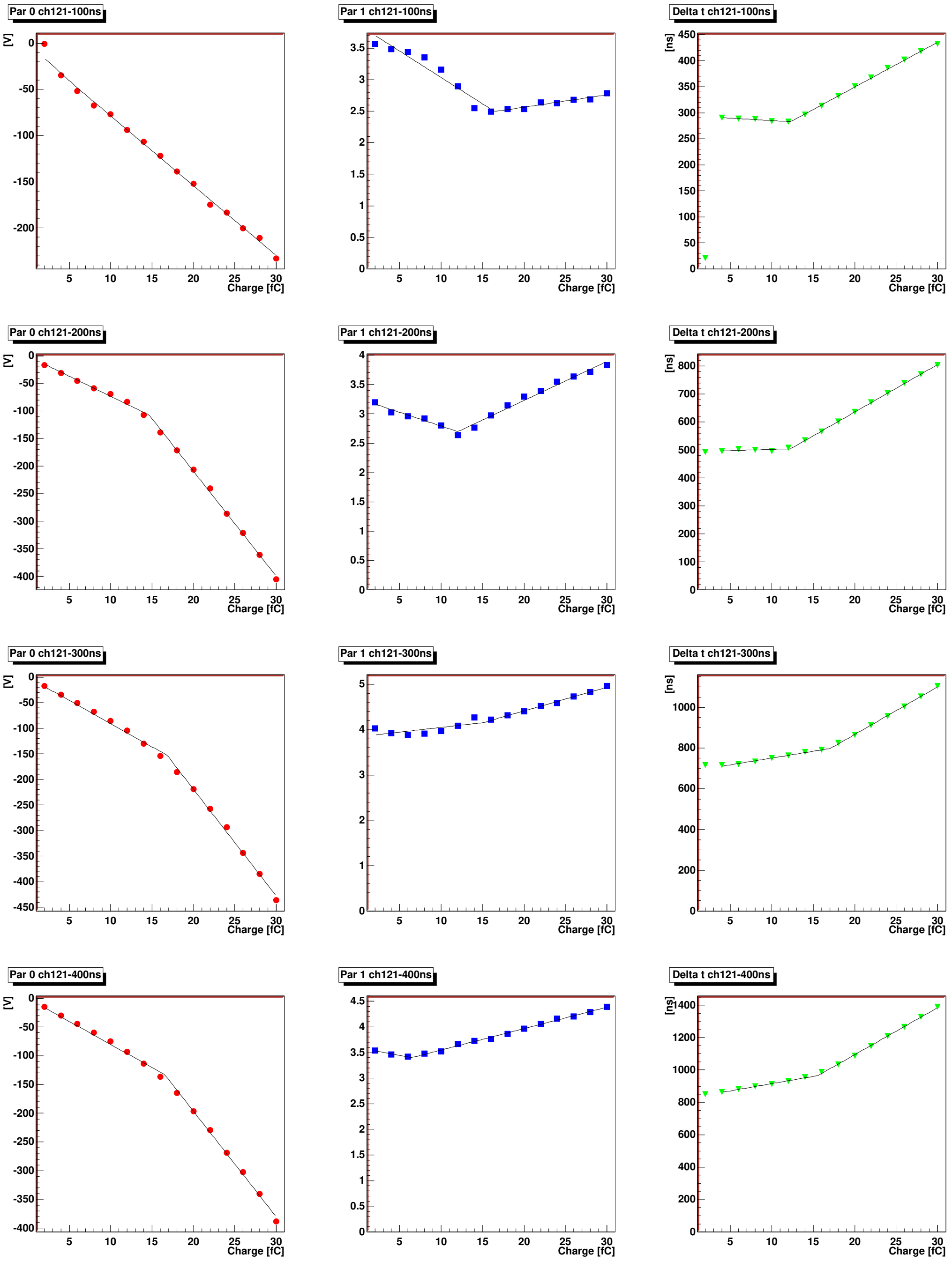

Figure 3: Parameter values as a function of injected charge.

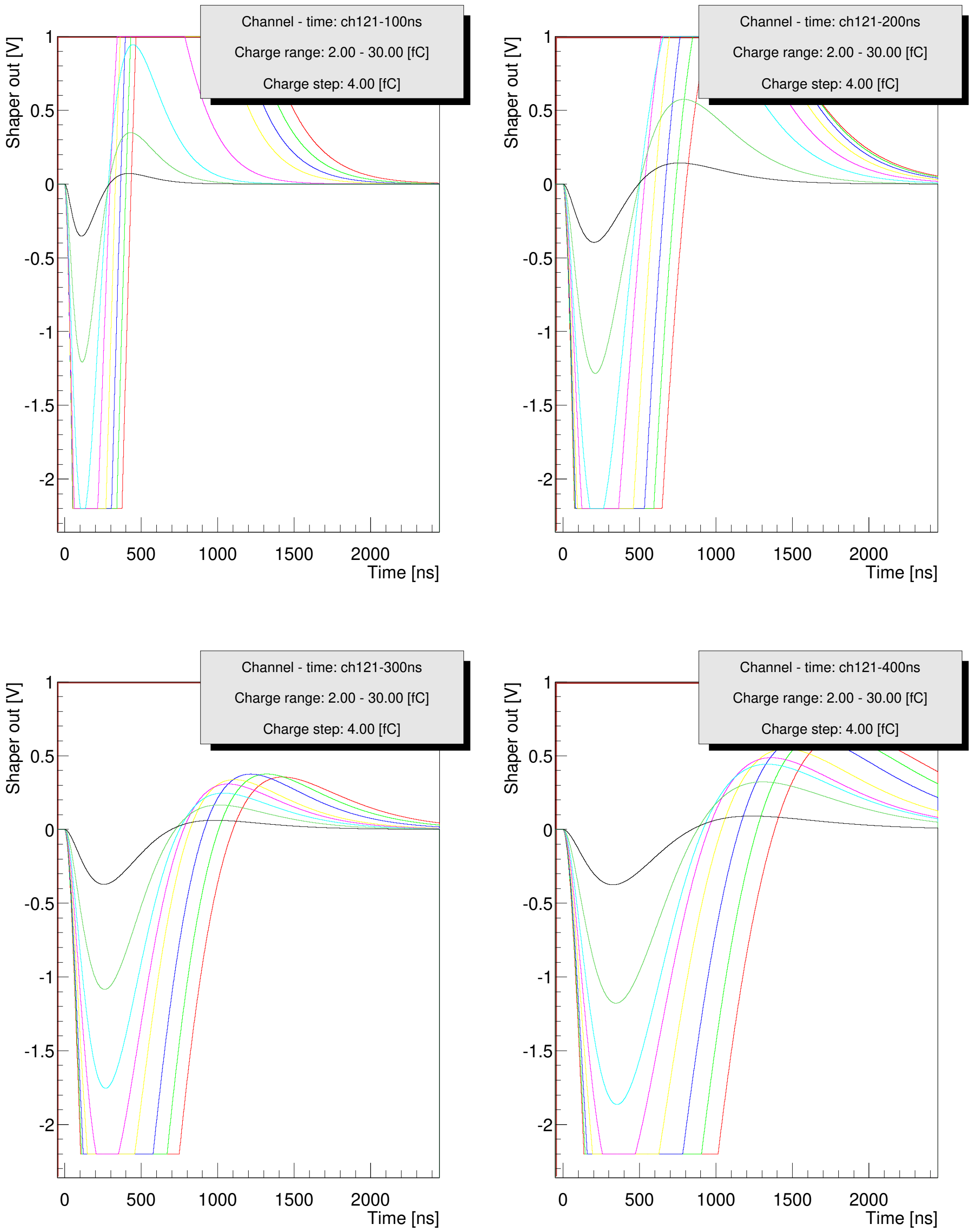

Figure 4: Shapers obtained from equation 1 at 100, 200, 300 and 400 ns peaking time.

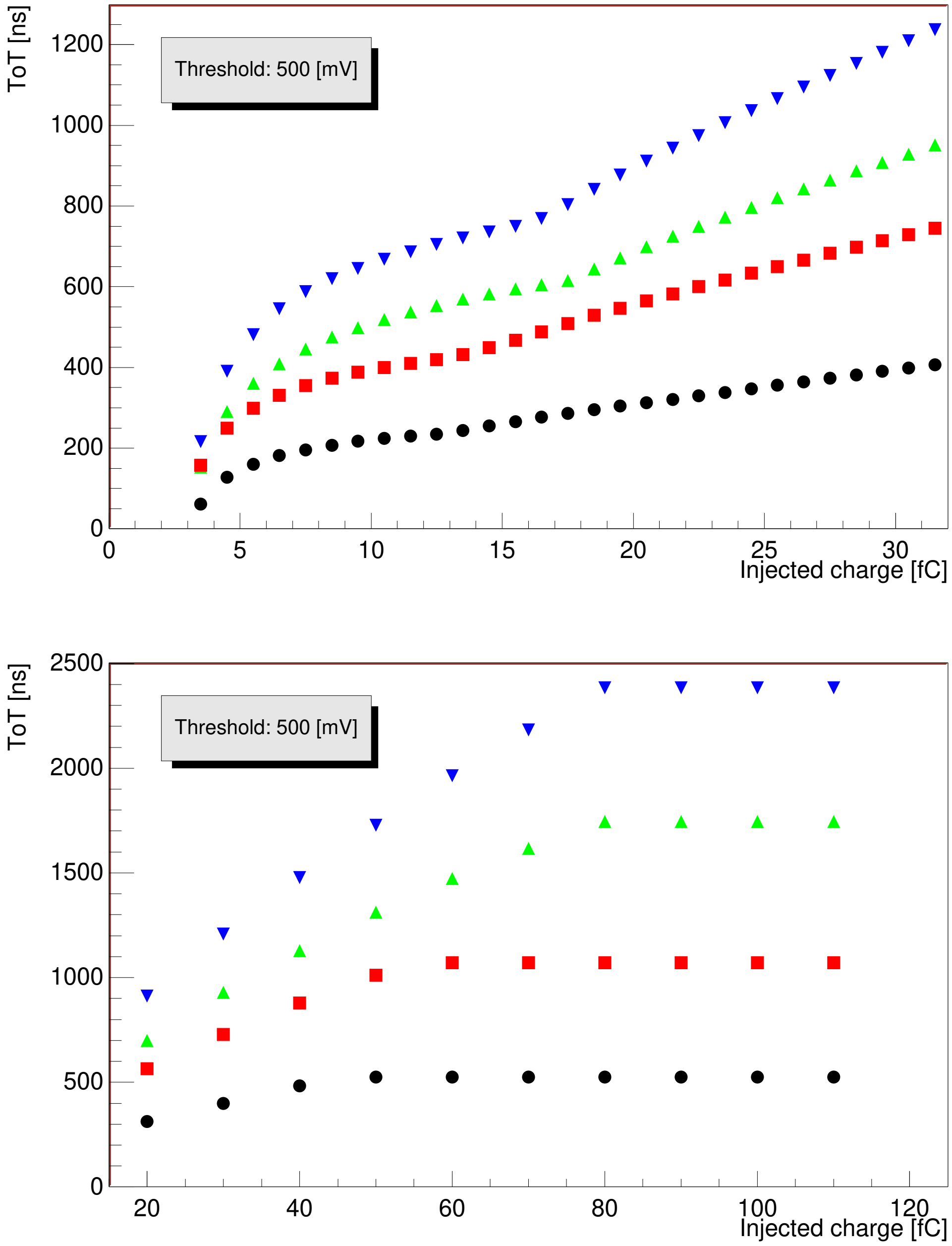

Figure 5: ToT curves obtained from equation 1 at 100, 200, 300 and 400 ns peaking time. Different input charge ranges are shown. Threshold is 500 mV.