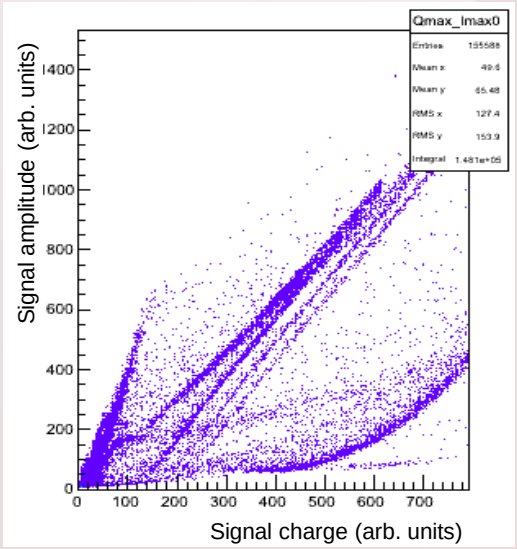
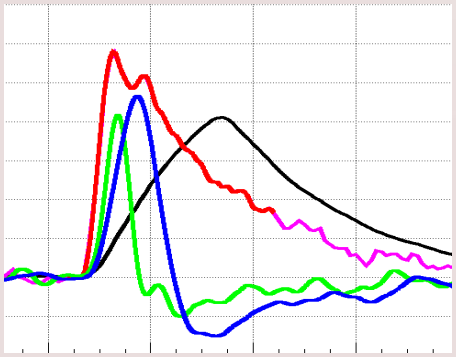
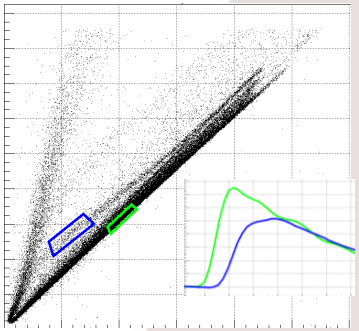
GASPARD: ELEMENTS OF SIGNAL PROCESSING

Oct. 29, 2012
GASPARD-HYDE-TRACE meeting
Oct. 29-31, 2012
University of Padova, Italy

Proposal for the signal processing studies for GASPARD, from the preliminary analysis of the data of the October, 2012 beam test data at ALTO (Orsay, France).







Unité mixte de recherche
CNRS-IN2P3
Université Paris-Sud

91406 Orsay cedex
Tél. : +33 1 69 15 73 40
Fax : +33 1 69 15 64 70
http://ipnweb.in2p3.fr

SITUATION

Requirements

About 10^4 channels on which to perform particle identification by pulse shape analysis (PSD – pulse shape discrimination)

Integration/mechanics: density on the PCB

Integration/power: low-power budget (per channel)

Integration/cooling: related to the absorbed power, but also to the operation in vacuum

Data flux: real-time processing → don't save all the traces

Existing solutions

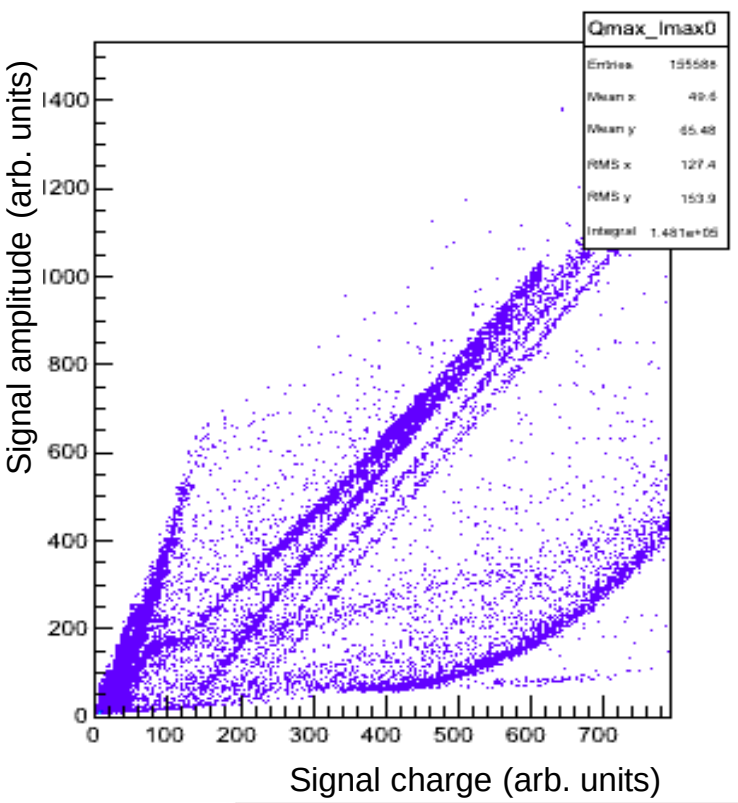
FAZIA: Digitization: 100 MSPS, 14 bits; rise time evaluation with dCFDs (20% and 70% « empirically determined ») (S. Carboni et al., NIMA 2012, doi:10.1016/j.nima.2011.10.061)

Time over a variable threshold on the current signal (time over a constant fraction treshold – ToCFT): already tested on the feb. 2012 run: good separation p-t-d vs alpha

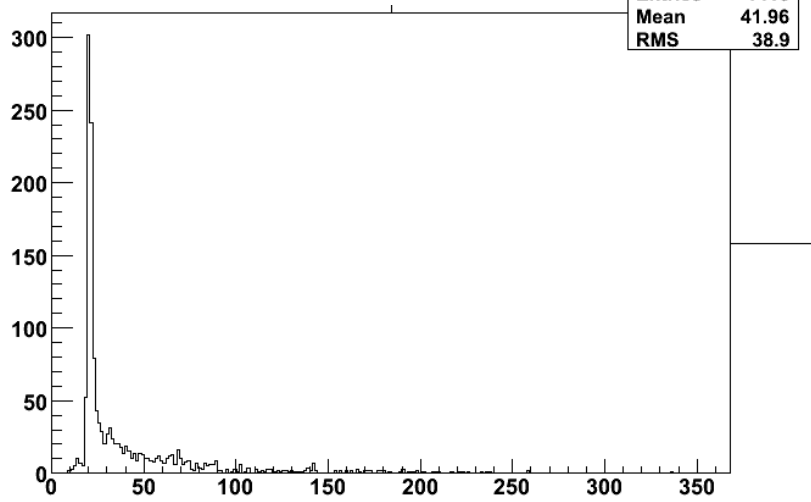
Interpolation for Q vs I (J. Dueñas et al., NIMA (2012), doi: 10.1016/j.nima.2012.02.032)

"Old" analog method(shaping, differentiation, time measurement at zero cross-over)

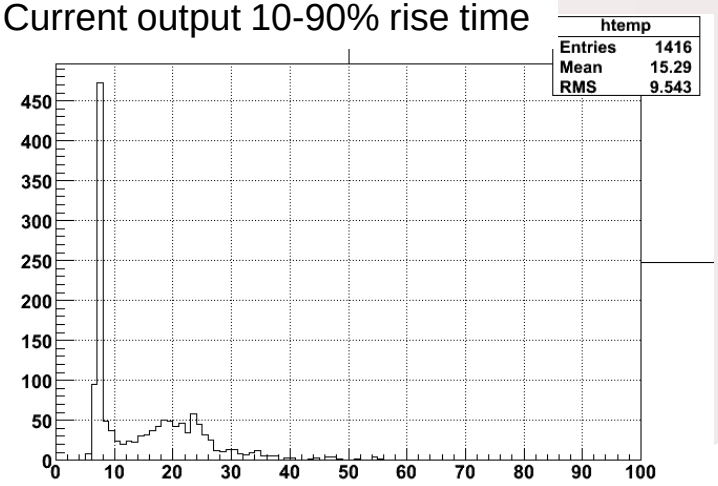
OCT. 2012 RUN: PRELIMINARY RESULTS



Charge output 20-70% rise time



Current output 10-90% rise time

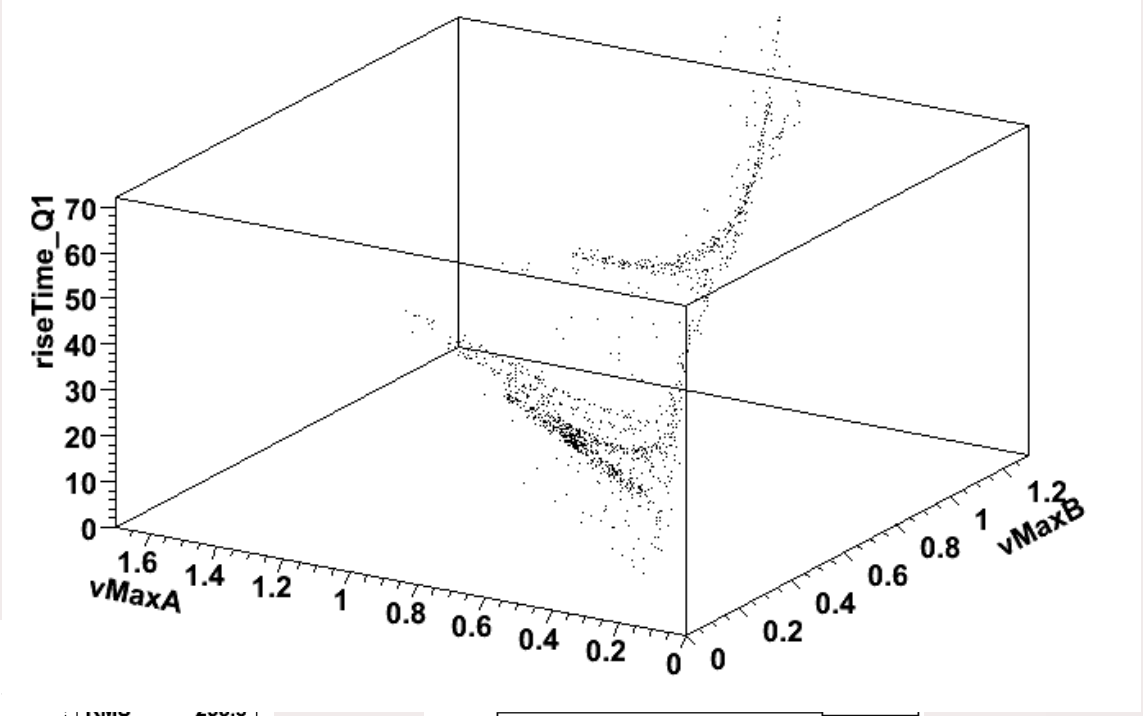


Detector biased from 250 to 300 V

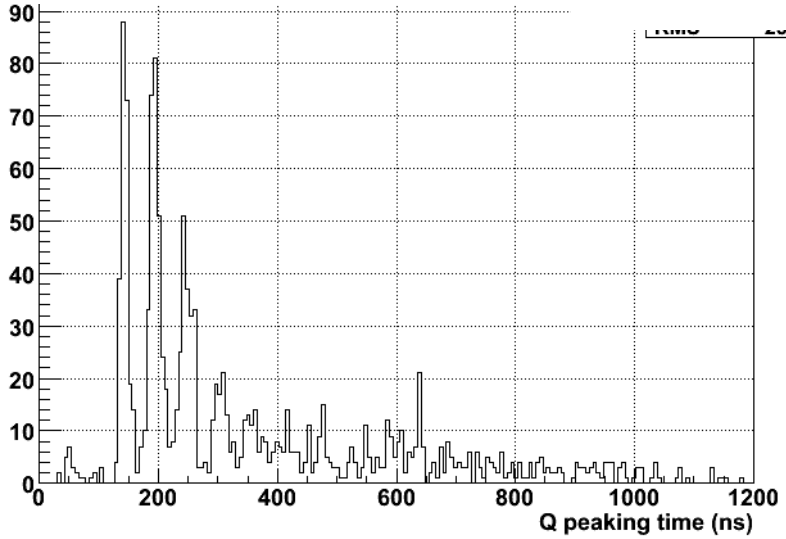
Preliminary analysis: good results at 275 V. Simple methods applied to strip P #1:

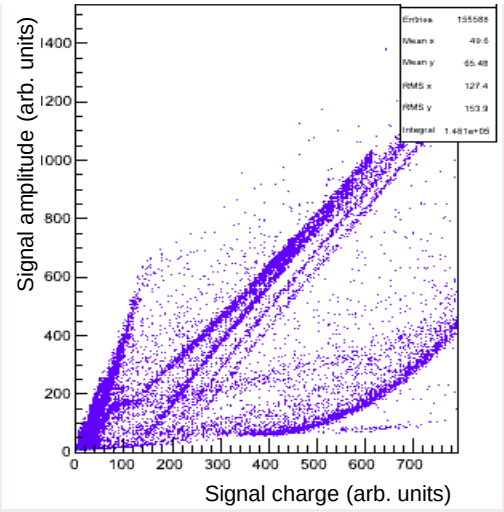
- Max(out_I) vs Max(out_Q)
- Peaking time / rise time (with leading edge discriminators)

OCT. 2012 RUN: PRELIMINARY RESULTS (II)



Charge output peaking time





CONCLUSIONS: PLANS FOR THE ANALYSIS

Criteria

Particle peak resolution

Figure of Merit used in FAZIA

$$\frac{|\text{mean}(f_2) - \text{mean}(f_1)|}{\text{FWHM}(f_2) + \text{FWHM}(f_1)} \qquad \frac{|\text{mean}(f_2) - \text{mean}(f_1)|}{\max(\text{RMS}(f_2), \text{RMS}(f_1))}$$

Distance in worst standard deviation

Algorithm complexity / number of operations

Digital processing

Noise suppression (Butterworth, etc: IIR with a trade-off between accuracy/complexity)

Interpolation

Reduction of the sampling time + corresponding algorithm

Other methods

(because of the short signal length, it will be tricky/useless to apply moving window deconvolution method)

Analog processing simulations for a possible ASIC

Analog filter with its z-transform (IIR): peaking time / Zero Cross-Over (ZCO). Main issue: small slope for “heavy” particle (beyond He vs p-d-t).

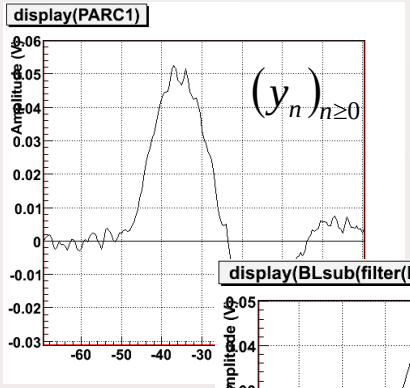
Time over fixed thresholds (ToTs)

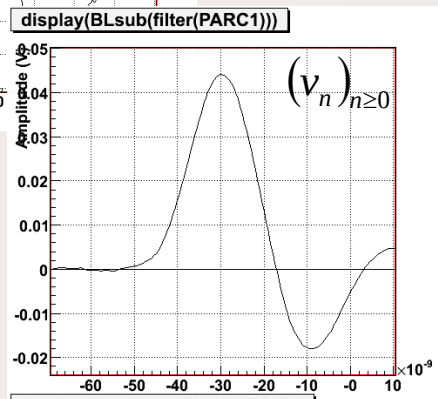
Optimum shaping(s) for peaking time

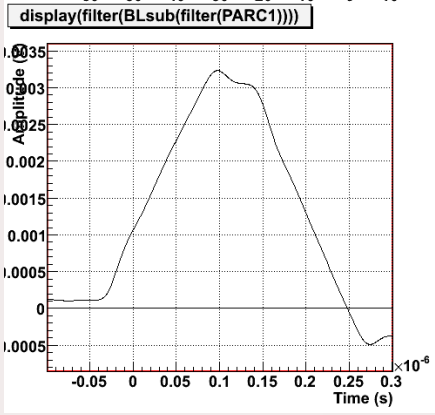
= try to implement a reduced number of analog outputs, to be hold in a analog memories (Switched Capacitor Array) for a multiplexed output (single line per chip)

APPENDIX: EXAMPLES OF IIR

IIR = Infinite Impulse Response filter







Mobile average $$v_n = v_{n-1} + \frac{1}{k}\left(y_n - y_{n-k}\right)$$ Much less operations!

Trapezoidal $$v_n = 2v_{n-1} - v_{n-2} + y_n - y_{n-k} - y_{n-k-m} + y_{n-2k-m}$$

Exponential moving window deconvolution * trapezoidal (« Jordanov »)

$$v_n = 2v_{n-1} - v_{n-2} + y_n - y_{n-k} - y_{n-k-m} + y_{n-2k-m} - \exp\left(-\frac{T}{\tau}\right)\left(y_{n-1} - y_{n-k-1} - y_{n-k-m-1} + y_{n-2k-m-1}\right)$$

T = sampling period, τ = exponential decay