Singles in Eurogam

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1 Assumptions and definitions

I will assume that Eurogam will be built in VXI with a common deadtime over the whole system of 15μseconds to cover shaping time, conversion time and readout time. I will also assume that recovery time (i.e. time when it has returned as close to zero as required by the system accuracy specification) of the shaping amplifier is 10μseconds from the start of its input.

I will define two types of singles: 'true' singles and 'pseudo' singles. True singles means that every detectable event on a channel is collected in a 1-d histogram. This will be limited by either the physics of the reaction or the deadtime. Pseudo singles means that 1-d spectra are built up from multiparameter event data but the system is not allowed to collect any singles only events. The limit is the multiparameter event rate which will normally be defined by the fold used in the trigger's multiplicity check.

2 Which type of singles?

2.1 What's different?

The difference between the two types is that true singles counts at a higher rate per channel (10K plus background on each of 70 Ge channels) and has slightly different data. The difference in data will arise because pseudo singles will be biassed towards those parts of the array favoured by gamma rays from the reaction with a consequent higher inclusion rate in multi-parameter events while other parts of the array which detect low fold (e.g. doubles) or singles only events will be cut out of the singles spectra so detectors which are never involved in a large multiparameter event will never be histogrammed. I don't know whether or not this will be significant in physics terms. *Comments from physicists?*

2.2 Rates

The pseudo singles will histogram typically 3 or 4 different channels out of 70 for each collected event (assuming minimum fold of 3) at a rate of around 30KHz. Making the simplifying assumption that we can ignore directional bias in counting rates, we find that the total counting rate for true singles across the whole array is a factor of seven greater than that for pseudo singles.
True singles rate is $10K \times 70 = 700KHz$
Pseudo singles rate is $30K \times N = 100KHz$
(where N is fold, typically 3 or 4)

This means that the average rate per channel for pseudo singles (again ignoring directional bias) will be between 1 KHz and 1.5 KHz.

For setup with a source instead of beam the multiplicity in the trigger could be cut to 1 which would allow a pseudo singles rate over the whole array of up to 67 KHz, the limit imposed by deadtime. The common deadtime makes the system susceptible to the influence of background; I assume that using a source and no beam this is negligible anyway. I would guess that the strength of the source would limit counting rate in this case. *Comments from physicists?*

2.3 Quality of data

Background counts are random occurences which are completely uncorrelated with the reaction under investigation and arise from such effects as coulomb excitation of the target. True singles will collect good data and background indiscriminately, mixing the two at a rate governed by physics. The only exception would be when the background rate is several times the 10 KHz singles rate from the main interaction, in which case the rate is limited by deadtime.

Pseudo singles are part of a coincidence event and so should produce data virtually free from background contamination when run at folds of 3 and above.

3 Implementation

It is possible to design a system to collect either true singles or pseudo singles. Technically there is little difference in complexity between incrementing a histogramming memory for every pulse received in a Ge card (true singles) or incrementing a set of histogramming memories in a readout controller through which all multiparameter data pass.

The pseudo singles in the readout controller is slightly easier because the Ge cards are sensitive to noise (limits readout of histogram to time the card is not doing any analogue work) and board area is also limited by the need to include as many Ge channels as possible per card. The readout controller will be a much less crowded card and will be all digital (apart from possibly buffering the analogue sumbus for the trigger system) so noise problems are either removed or reduced. It is easier for the spectrum readout processor to get all spectra from one source per crate than to read many Ge cards although in either case a VME block transfer should be used to read 256 bytes at a time so as to minimize the effect of bus overheads like arbitration.

On the other hand it can be argued that true singles collected on the Ge cards will provide better information for diagnostics, giving a true picture of what the Ge detectors are seeing, including background.

4 Conclusions

It seems to me that pseudo singles with spectra built in the readout controller is the better of the two options because it supplies cleaner data than true singles with only a factor of 7 difference in rate, the actual rate still being over 1 KHz per channel. It is slightly easier to implement technically too.

The argument against it is that in the current version of the Ge electronics the shaping circuit will process pulses from the detector while the trigger and validation are being generated.

The effect of the trigger decision will be to either abort the event or allow the ADC to convert the shaped pulse. The amplifier has a fixed recovery time after peaking which is usually masked by the ADC conversion time, but is typically 10μseconds. When no trigger validates the input pulse the amplifier still requires this recovery time before it can accurately shape its next input, so it could be argued that once the pulse has been shaped that we might as well convert it and increment a local histogram while the amplifier is recovering. Incrementing a local histogram takes much less time than reading out an event because everything happens on the same card, typically in under 200 nanoseconds[1]. This gives true singles. Since there will be no trigger unless the detected pulse was part of a multiparameter event, the system will not be dead during this time, so if the count is caused by a random gamma ray and is quickly followed by a good event then the good event will not be affected.

Nevertheless it seems to me that on balance it is better not to add complexity to the Ge card and use board area to collect true singles on every channel even though this is possible with little or no effect on the throughput of multiparameter events[1] The advantages of collecting singles in one place (which has no board area problems) per crate and of having singles data without background seem to be the most important factors and point to the use of the pseudo singles method.

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[1] More recently it has been suggested that we use gated integrators instead of the semi-gaussian shaping amplifier and in this case it is no longer true that true singles incurs no time penalty; the penalty is the conversion time plus the update time which is over 5μs.

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