

# Analysis of few-ion decays in the ESR

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In the ESR the revolution frequency of particles is measured by means of Schottky noise FFT (Fast Fourier Transform). This frequency reflects the particle mass. If a decay occurs and the mass changes, the revolution frequency changes as well. The FFT of noise sampled in a pick-up over a certain time interval shows the frequencies of particles in the ring. One interesting information is the exact time of the decay signaled by the appearance of a new frequency in the subsequent FFT frames. Fig.1 shows the time

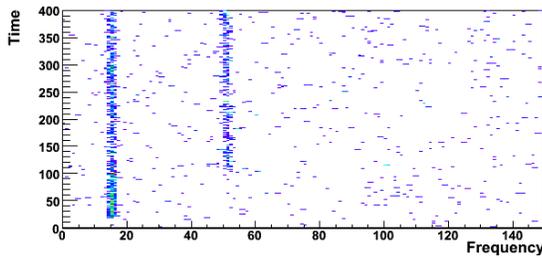


Figure 1: Single shot matrix with decay.

trace matrix of one shot generated from the raw data of a Sony/Tektronix Realtime Spectrum Analyser. It is built by lines of FFT frames of subsequent time intervals. One can easily see where the decay occurred.

Typically thousands of shots must be analyzed. Up to now the time trace matrices have been analyzed manually. To make the analysis reproducible and faster a program

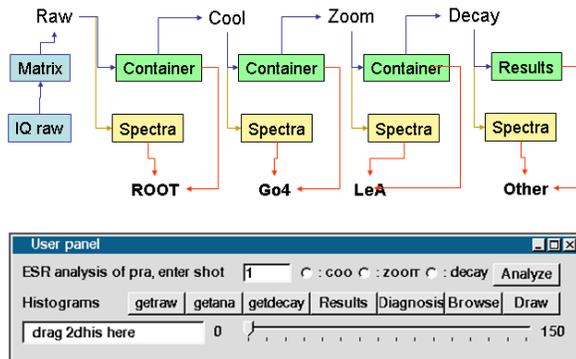


Figure 2: Analysis steps and Go4 control panel.

library has been developed to determine the decay times. The results of the manual analysis have been used as reference. The design of the software is shown in Fig. 2 as a chain of steps, each processing the output of the previous step.

Data storage, code and visualization are separated. The data of all shots of a run is stored in binary container files.

The access to one shot is done by index and therefore very fast. For more detailed analysis of single shots various spectra are stored in files. The analysis code is written as functions in plain C. ROOT macros are provided to convert matrices and spectra from the files into ROOT histograms for visualization. A control panel (Fig. 2) for convenient handling of a standard analysis is provided in the Go4 browser. It executes the same macros. Pictures for printing can easily be created. Once the raw files (IQ) have been converted into the first container (Raw step), the full analysis of one shot takes about 0.2 sec.

The primary data are the FFT frames where the existence of a particle should show up as a peak. It turned out, however, that there are fake peaks and missing peaks. Therefore one needs a filter on the quality of each FFT frame and then rule out the fakes and ignore the absentees. In the "no decay" time region the probability to find a peak is smaller than in the "decay" region, but also in the "decay" region there could be up to 8 subsequent missing decay peaks. A new method was introduced to describe this situation: the bonus system: To determine the first valid "real" decay

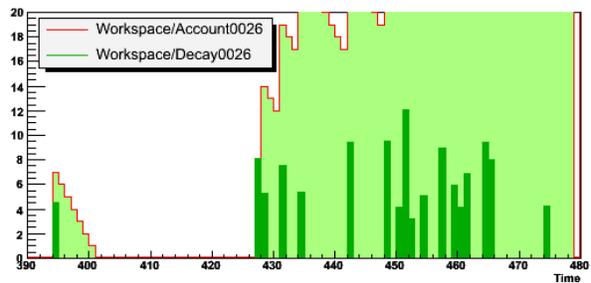


Figure 3: Account bonus mechanism.

peak which defines the decay time we must rule out fakes. We now step through the time frames and fill a confidence account spectrum, one bin per frame. A valid peak in the time frame adds a bonus (2-10) to the account (integer), a missing peak subtracts 1 if account > 0. Then the account is stored in the account spectrum bin. The time bin after the last zero in the account spectrum is the decay time. This method needs four lines of code!

The effect is that fake peaks are ignored if they are followed by n=bonus empty bins, but at the same time missing decay peaks are bridged. An account spectrum is shown in Fig. 3 together with valid frame peaks. One can easily see the mechanism (bonus 7). The proper bonus can be derived from the distribution of empty time bins in the decay track. The exact start of the track is not required for that!

The results of the software and the manual analysis agree in 75% of the shots ( $\pm 3$  frames).