FEE-DD Simulations: Preliminary Analyze of first DOI measurement results

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Outline

- Motivation.
- Trials for evaluation of the sc. species / total species ratio.
- Summary and Outlook.
Functions used in calculations:

1) Noise distribution: Gaussian with \( x_N \) and \( w_N \) parameters
\[
f_i(x) = \frac{1}{w_N \cdot \sqrt{2\pi}} e^{-\frac{(x-x_N)^2}{2w_N^2}}
\]
Correction for a Gaussian noise jitter: \( f_2(x_i) = \sum_i f_i(x_i) \cdot \frac{1}{20} ; \) (1 bin has 0.02 ns)

2) Polycrystalline species description: Exponential function:
For \( x < x_{EX} \), \( f_3(x) = 0 \)
For \( x \geq x_{EX} \), \( f_3(x) = A_{EX} \cdot e^{-\frac{x-x_{EX}}{\tau_{EX}}} \); with \( A_{EX}, x_{EX} \) and \( \tau_{EX} \) parameters

3a) Single crystal species description by a pulse with parameters:
\( A_{SC} \) is the amplitude, \( x_{SC} \) the delay and \( w_{SC} \) the width of the pulse.
For \( x < x_{SC} \), \( f_4(x) = 0 \)
For \( x \geq x_{SC} \), \( f_4(x) = \frac{1}{w_{SC} \cdot \sqrt{2\pi}} e^{-\frac{(x-x_{SC})^2}{2w_{SC}^2}} \), \( \int_0^\infty f_1(x)dx = 1 \)
Correction for a Gaussian noise jitter: \( f_5(x_i) = \sum_i f_4(x_i) \cdot \frac{1}{20} ; \) (1 bin has 0.02 ns)

3b) Single crystal species description by a pulse which take into account the Bragg effect:
The width of the sc DD is \( d \sim 0.3 \) mm. The energy of \( \alpha \) particles is deposited in \( \sim 60 \) \( \mu \)m (0.8\( d \)). If we approximate the deposited energy by a linear dependence with the depth, we expect for the detected signal a rectangular shape till 0.8 of the carrier drift time and after then a linear decrease to 1/3 of the pulse amplitude. The 3a) correction is applied too for this case.
4) Correction for the Signal and Amplifier time constant ($\tau_S$ and $\tau_A$), convolution with the unity delta response of the FEE.

$$\tau_S = 0.43 \text{ pF} \cdot 50\Omega = 21.5 \text{ ps} \quad ; \quad \tau_A = \frac{1}{2 \cdot \pi \cdot 2.3\text{GHz}} = 70\text{ ps}$$

The Front End Electronics response to $Q_{COL}^{*}\delta(t)$ function is:

$$v_{out}(t) = Q_{COL} \cdot G_0 \cdot \frac{\tau_S}{\tau_S - \tau_A} \cdot (e^{-\frac{t}{\tau_S}} - e^{-\frac{t}{\tau_A}})$$

The response to unity $\delta(t)$ is: $v_{out,\delta}(t) = v_{out}(t) / Q_{COL}$.

The response to $i(t)$ function is:

$$v_p(t) = v_{out,\delta}(t) \otimes i(t) = \int_0^t v_{out,\delta}(u) \cdot i(t-u) \cdot du$$

Implementation: $i=1,n_{\text{date}}$ $k=1,i$

For $x < x_{\text{SC}}$, $f_7(x_i) = 0$

For $x \geq x_{\text{SC}}$, $f_7(x_i) = \sum_{i=1}^{j} f_6(x_k) \cdot \frac{\tau_S}{\tau_S - \tau_A} \cdot (e^{-\frac{x_i-x_{\text{SC}}}{\tau_S}} - e^{-\frac{x_i-x_{\text{SC}}}{\tau_A}})$

5) Correction of the amplifier noise which generate a Trigger jitter of the Scope.

Implementation: $i=1,n_{\text{date}}$ $k=-20,20$

$$f_8(x_i) = \sum_{-20}^{20} f_7(x_{i+k}) / 40$$

6) The final function applied to MINUIT program for error minimization:

$$f_{\text{cn}} = \sum_{1}^{n_{\text{date}}} (f_8(x_i) - v(x_i))^2$$
The MINUIT algorithm used to fit the experimental data with a set of analytical formulas need to set the initial value and limits of all parameters. In our case, there are used successive formulas, and the minimization process which have a few iterations, is time consuming.

We made a few trials and the results of the last three are described. The main result is the ratio of pc. species / total species which has a big dispersion (57% - 72% - 77%).

In order to increase the reconstruction accuracy, we must:
1. To modify the DD metallization mask to include a guard ring to avoid the DD edge signals. A collimator can prevent the edge signals too.
2. To connect all unused pad’s and guard ring to ground.
3. To identify on the Scope, by single sweeps, the main classes of signals.
4. To avoid changes of the Scope parameters in the time of registration.