Pile-up pulse analysis with fast sampling ADC techniques

Anton Roth

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I have developed a method, and it works.
Outline

1. Why has the method been developed?
2. How does the method work?
3. How do we know it works?
4. What is next?
A digitised preamplifier pile-up signal with a fast sampling ADC.
Pile-ups

Why has the method been developed?

How does the method work?

How do we know it works?

What’s next?

Digital

Analogue

A. Roth, Svenskt Kärnfysikermöte 2016. *Pile-up pulse analysis*
Why has the method been developed?

Possibilities with a digital electronics system:

- The amplitudes in pile-ups can be resolved
- Short-lived nuclei can be studied

And:

- Experimental data is available
How does the method work?
Filter and Time Extraction

A. Roth, Svenskt Kärnfysikermöte 2016. *Pile-up pulse analysis*
Filter and Time Extraction

Why has the method been developed? How does the method work? How do we know it works? What’s next?
Filter and Time Extraction

Zoomed in

Voltage (arb. unit.)

Channel

Why has the method been developed? How does the method work? How do we know it works? What's next?

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Filter and Time Extraction

Zoomed in

First derivative

Voltage (arb. unit.)

0 200 400 600 800

Channel 470 480 490 500 501 510 520

$\tau_{\text{rise}}$

$\tau_{\text{fall}}$

Change in voltage (arb. unit.)

0 50 100 150 200 250 300

Channel 470 480 490 500 510 520

A. Roth, Svenskt Kärnfysikermöte 2016. *Pile-up pulse analysis*
Moving Window Deconvolution

Preamplifier signal

Why has the method been developed? How does the method work? How do we know it works? What's next?

A. Roth, Svenskt Kärnfysikermöte 2016. *Pile-up pulse analysis*
Moving Window Deconvolution

Why has the method been developed? How does the method work? How do we know it works? What’s next?

Preamplifier signal

After deconvolution

A. Roth, Svenskt Kärnfysikermöte 2016. *Pile-up pulse analysis*
Moving Window Deconvolution

Preamplifier signal

After deconvolution

After differentiation

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Why has the method been developed? How does the method work? How do we know it works? What’s next?

Moving Window Deconvolution

Preamplifier signal

After deconvolution

After differentiation

After averaging

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Amplitude Extraction
An example

Digitised signal

Why has the method been developed? How does the method work? How do we know it works? What’s next?

A. Roth, Svenskt Kärnfysikermöte 2016. Pile-up pulse analysis
Amplitude Extraction

An example

Digitised signal

Deconvolved signal

A. Roth, Svenskt Kärnfysikermöte 2016. *Pile-up pulse analysis*
Amplitude Extraction

An example

Pulse 1

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Amplitude Extraction
An example

Pulse 2

Voltage (arb. unit)

Channel

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How do we know it works?
Why has the method been developed? How does the method work? How do we know it works? What’s next?

**Results**

$\alpha_1 - \alpha_2$-correlation spectra

<table>
<thead>
<tr>
<th>Energy of 1st alpha-particle (MeV/10 keV)</th>
<th>Counts</th>
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<tbody>
<tr>
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A. Roth, Svenskt Kärnfysikermöte 2016. *Pile-up pulse analysis*
Results

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A. Roth, Svenskt Kärnfysikermöte 2016. *Pile-up pulse analysis*
Results

$\alpha_1 - \alpha_2$-correlation spectra
# Results

Compiled results

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Results
Connection to decay paths

Source: Karlsruhe Nuclide Chart.
Results

Decay Level Scheme

Why has the method been developed?  How does the method work?  How do we know it works?  What's next?

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Why has the method been developed? How does the method work? How do we know it works? What’s next?

Results
Decay Level Scheme

This work
National Nuclear Data Center

$^{219}$Ra

$^{215}$Rn $\rightarrow$ $^{211}$Po

$E_{\alpha_1}$: 7.68(5) MeV
$E_{\alpha_1}$: 7.678(3) MeV

$E_{\alpha_1}$: 8.00(3) MeV
$E_{\alpha_1}$: 7.988(3) MeV

$\bar{T}_{1/2} = 2.0(1) \ \mu s$
$\bar{T}_{1/2} = 2.3(1) \ \mu s$

$E_{\alpha_2}$: 8.70(3) MeV
$E_{\alpha_2}$: 8.674(8) MeV

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Pile-up pulse analysis
Results

Decay Level Scheme

This work
National Nuclear Data Center

219Ra

316(1) keV
315.82(4) keV

$E_{\alpha_1}: 7.68(5)$ MeV
$E_{\alpha_1}: 7.678(3)$ MeV

G

215Rn

$E_{\alpha_1}: 8.00(3)$ MeV
$E_{\alpha_1}: 7.988(3)$ MeV

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$T_{1/2} = 2.0(1) \mu s$

211Po

$\bar{E}_{\alpha_2}: 8.70(3)$ MeV
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A. Roth, Svenskt Kärnfysikermöte 2016. *Pile-up pulse analysis*
Outlook

- Study the remaining eight (and possibly more) blobs for:
  - Better half-life measurements
  - New decay modes
  - Improved branching ratios
Experimental Techniques
Readout chain

- HV

\( R_1 \)

D

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Experimental Techniques
Readout chain

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Experimental Techniques
Analogue Pulse Processing

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A. Roth, Svenskt Kärnfysikermöte 2016. Pile-up pulse analysis
Experimental Techniques
Digital Pulse Processing

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A. Roth, Svenskt Kärnfysikermöte 2016. Pile-up pulse analysis
Experimental Techniques
Preamplifier trace
Amplitude Extraction

Deconvolution

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_Pile-up pulse analysis_
Why has the method been developed? How does the method work? How do we know it works? What’s next?

Amplitude Extraction
Deconvolution

Deconvolution - before

Deconvolution - new

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