Feature extraction for the shashlyk calorimeter

Markus Preston, Per-Erik Tegnér

Gratefully acknowledging the help from
Stefan Diehl and the JLU Gießen group

PANDA Collaboration Meeting, GSI, 2019-11-06

The PANDA electromagnetic calorimeters

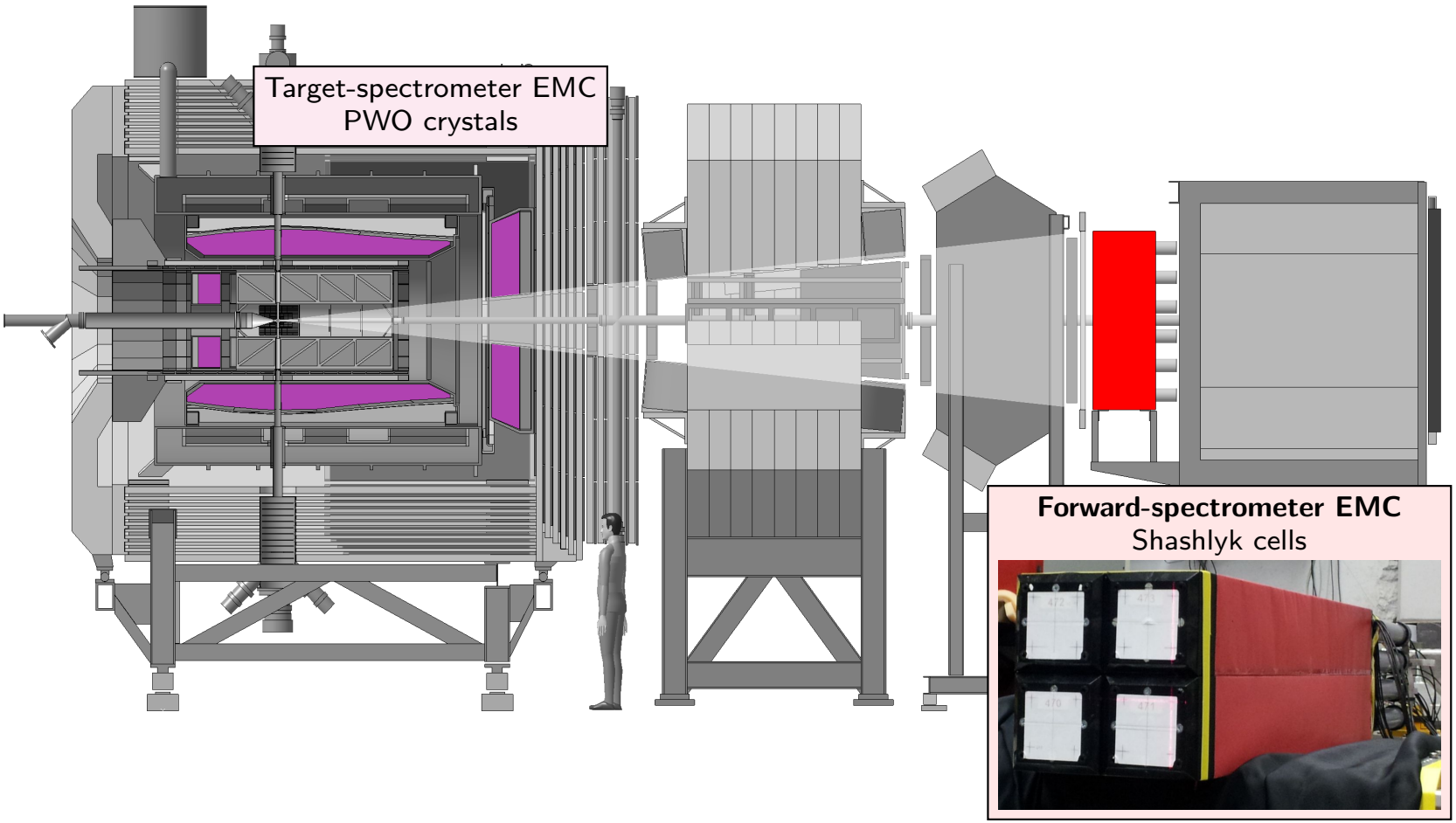
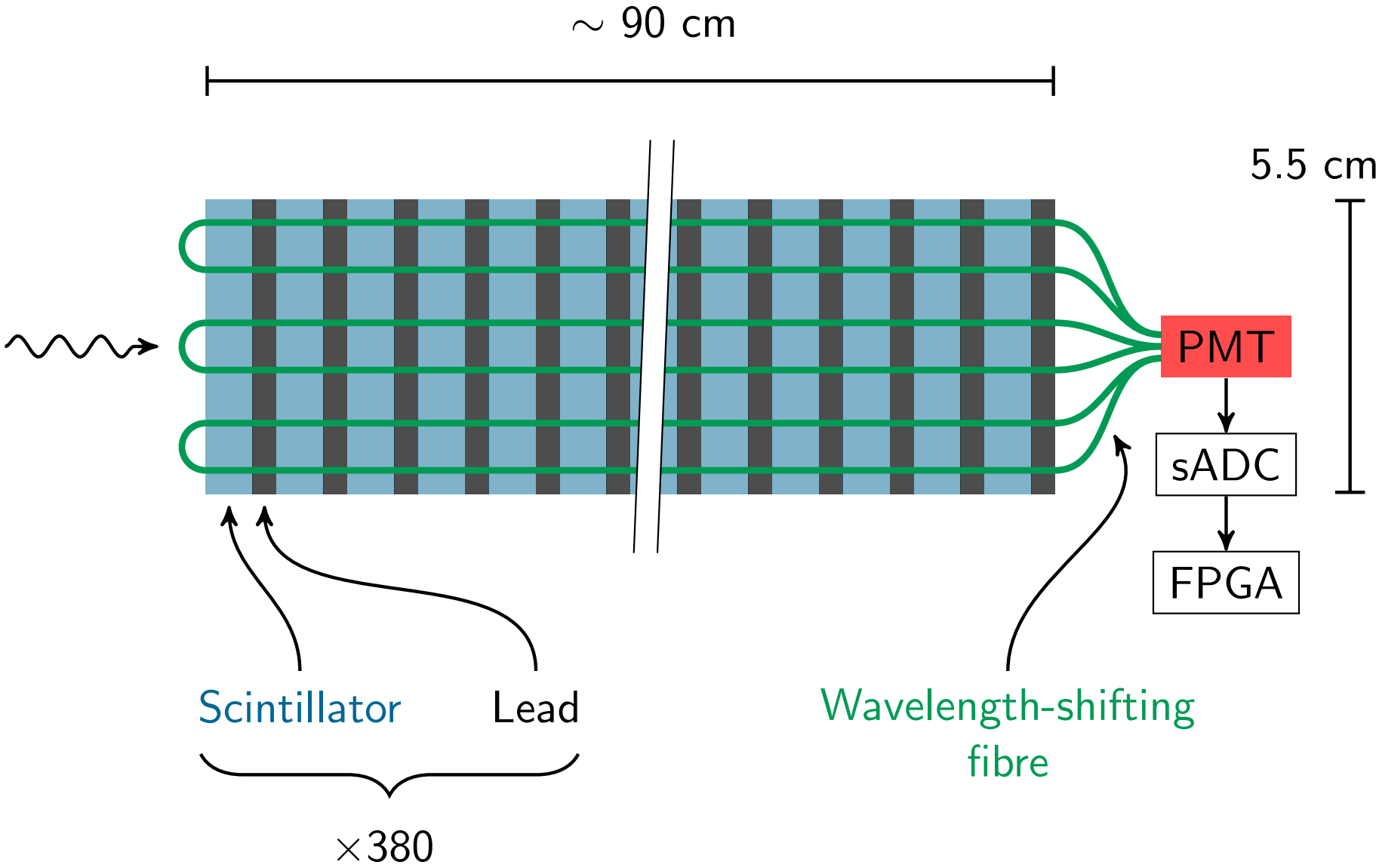


Figure adapted from https://panda.gsi.de/oldwww
Photo from S. Diehl, Ph.D. thesis, JLU Gießen (2016)

Detector structure

Side view of cell



Aim of this work

- Find an FPGA triggering/feature extraction algorithm, optimised with respect to:
  - Pulse identification (triggering)
  - Energy resolution
  - Time resolution
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- How?
  - We have developed a Monte Carlo model of a 4×4 prototype (starting with Geant4). *Talk at June 2019 CM.*
  - Use the Monte Carlo model to generate pulses with known underlying energy, time and pile-up information. Evaluate performance of feature-extraction algorithms. **This talk.**

Recap of June presentation

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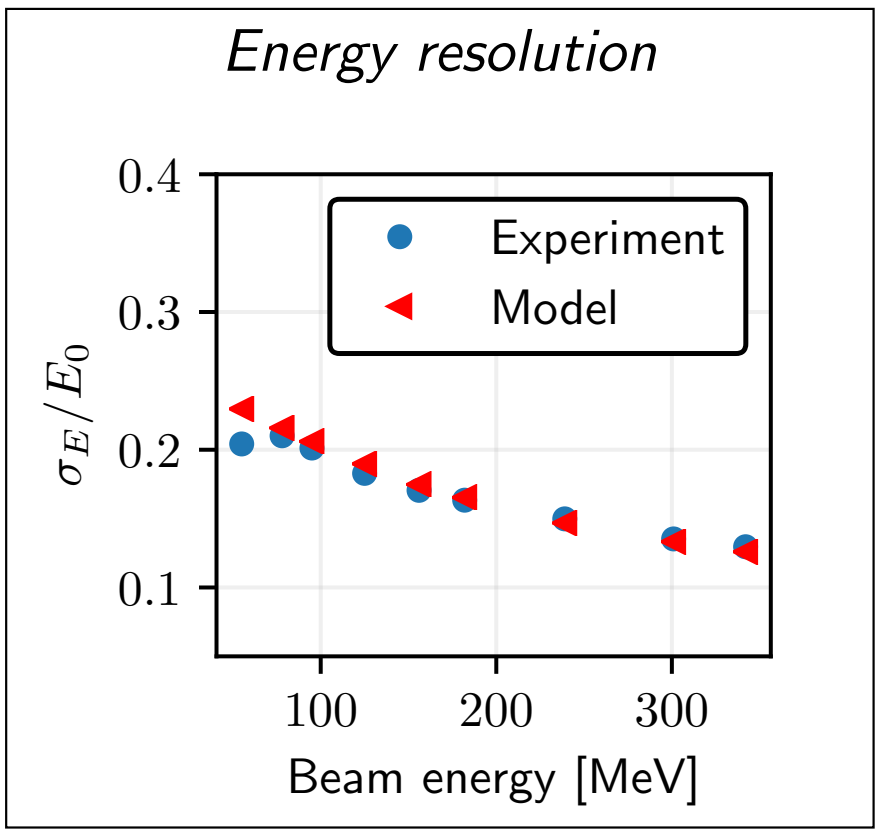

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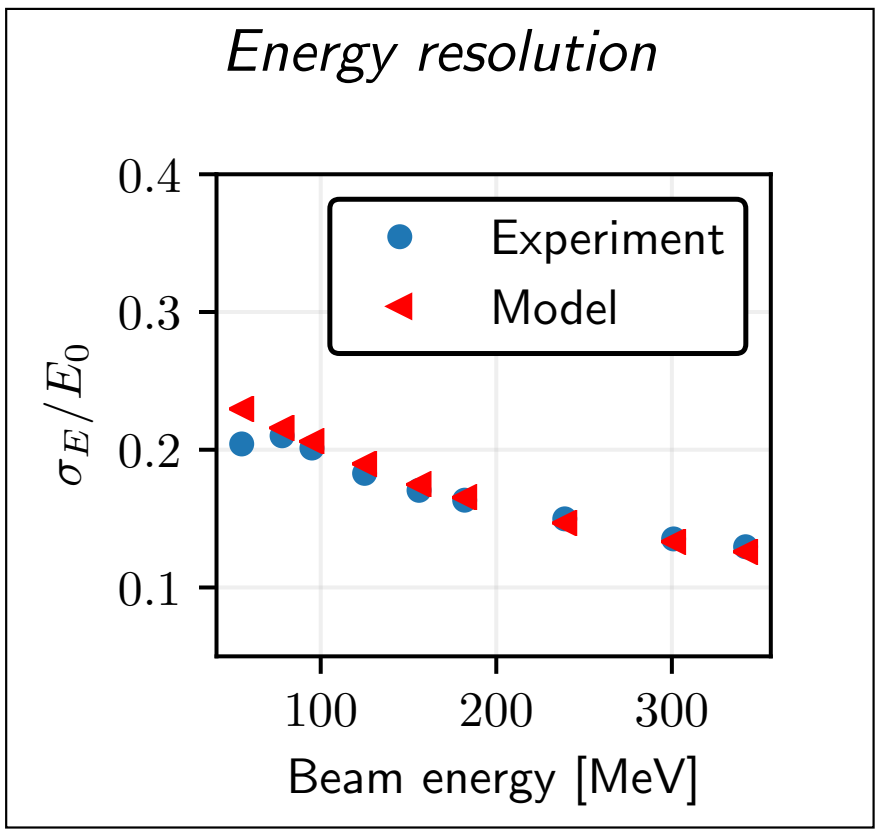
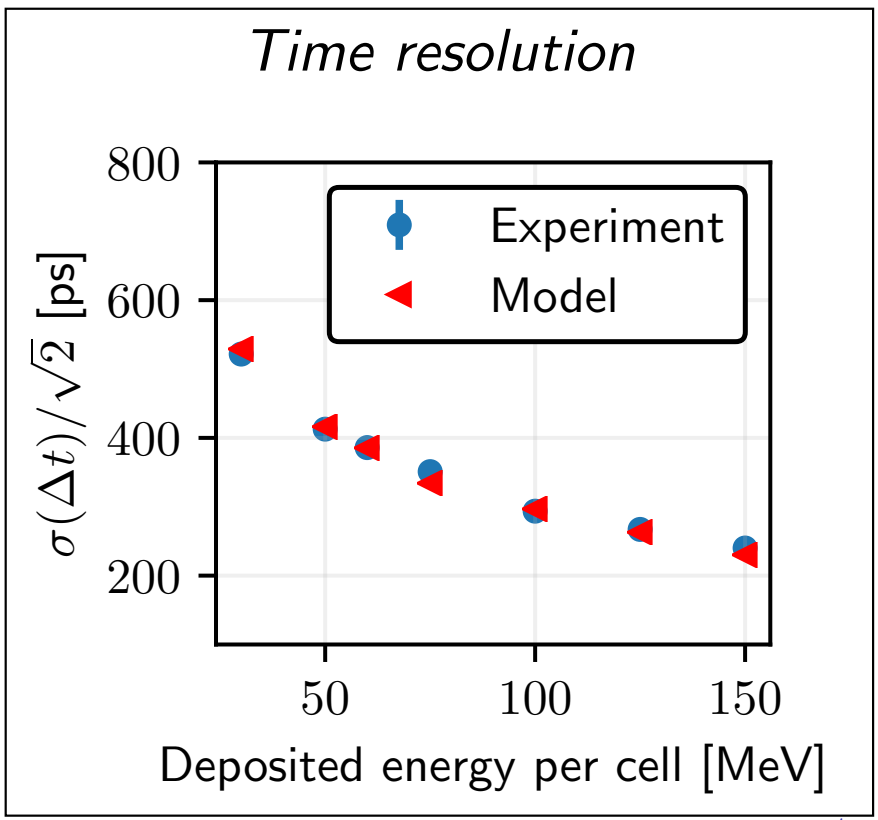
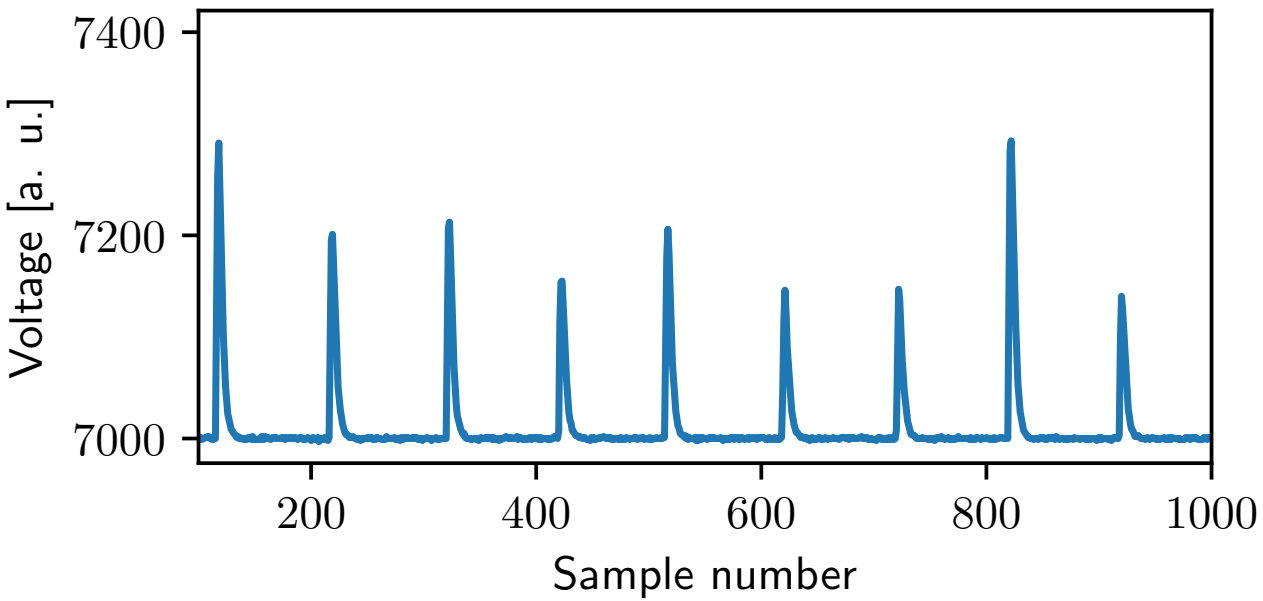




Evaluating feature extraction — method

1. Generate well-separated signals



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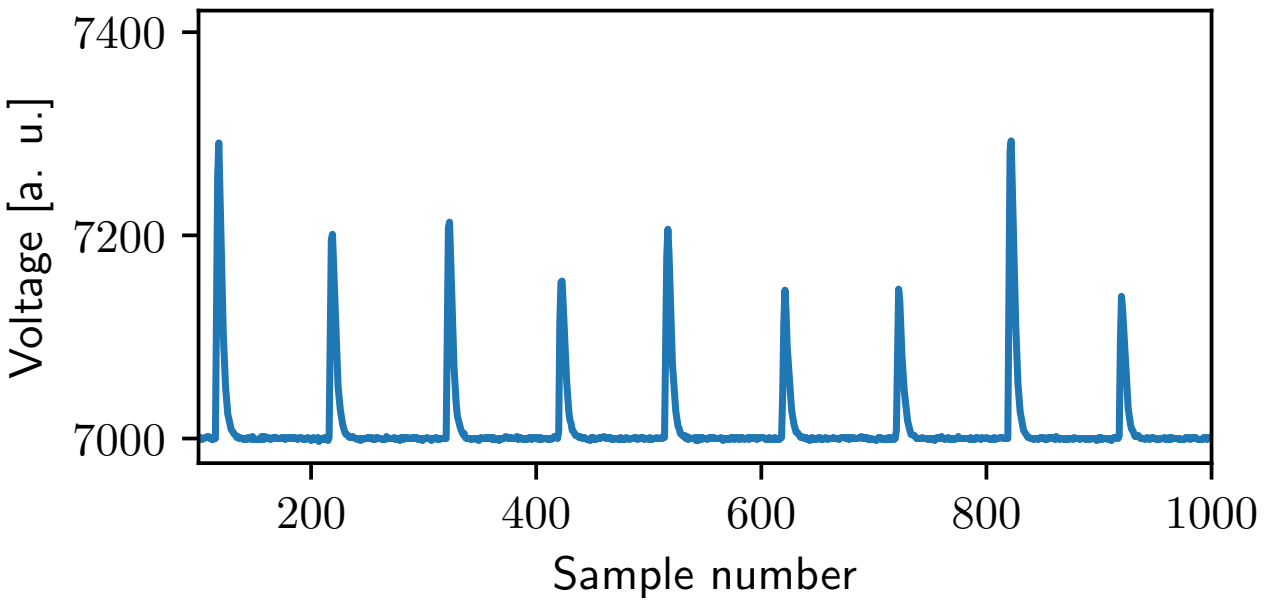

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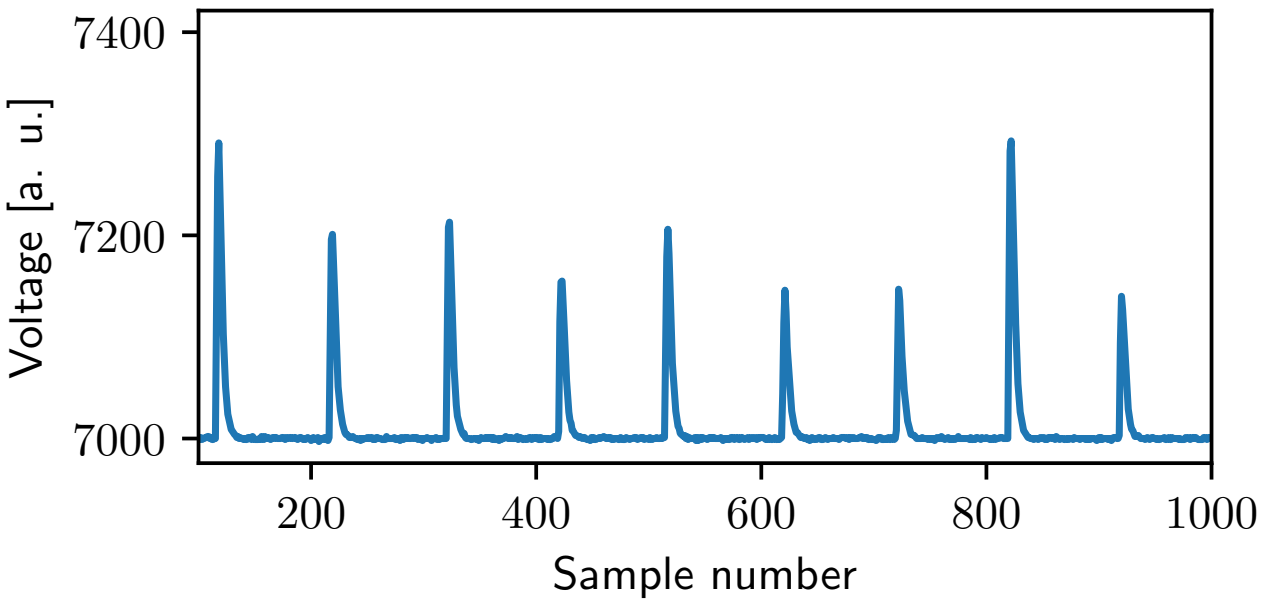

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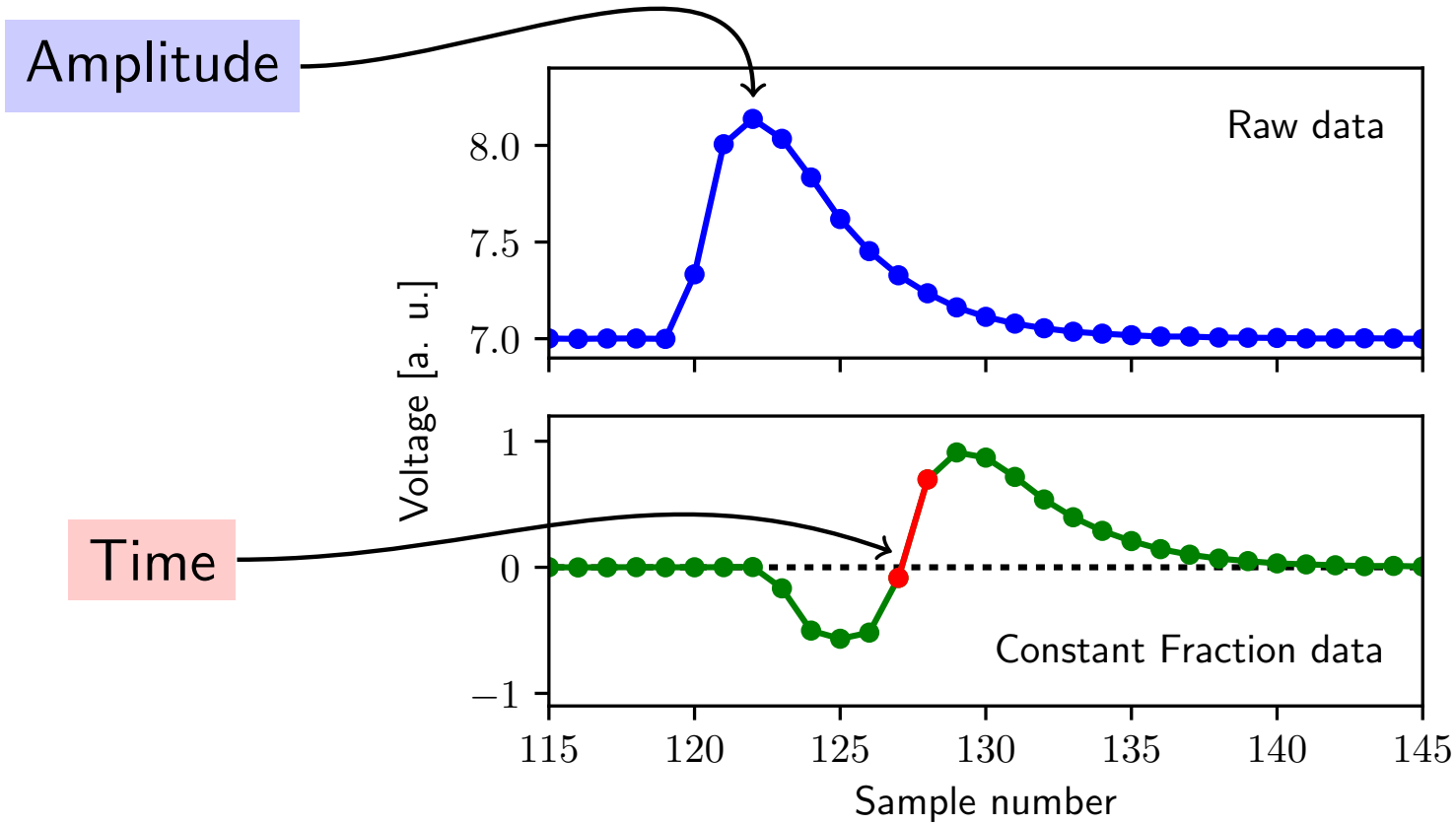
3. Evaluate algorithm performance

Existing algorithm

- Amplitude from highest sample in pulse
- Time from Constant Fraction method (linear interpolation)



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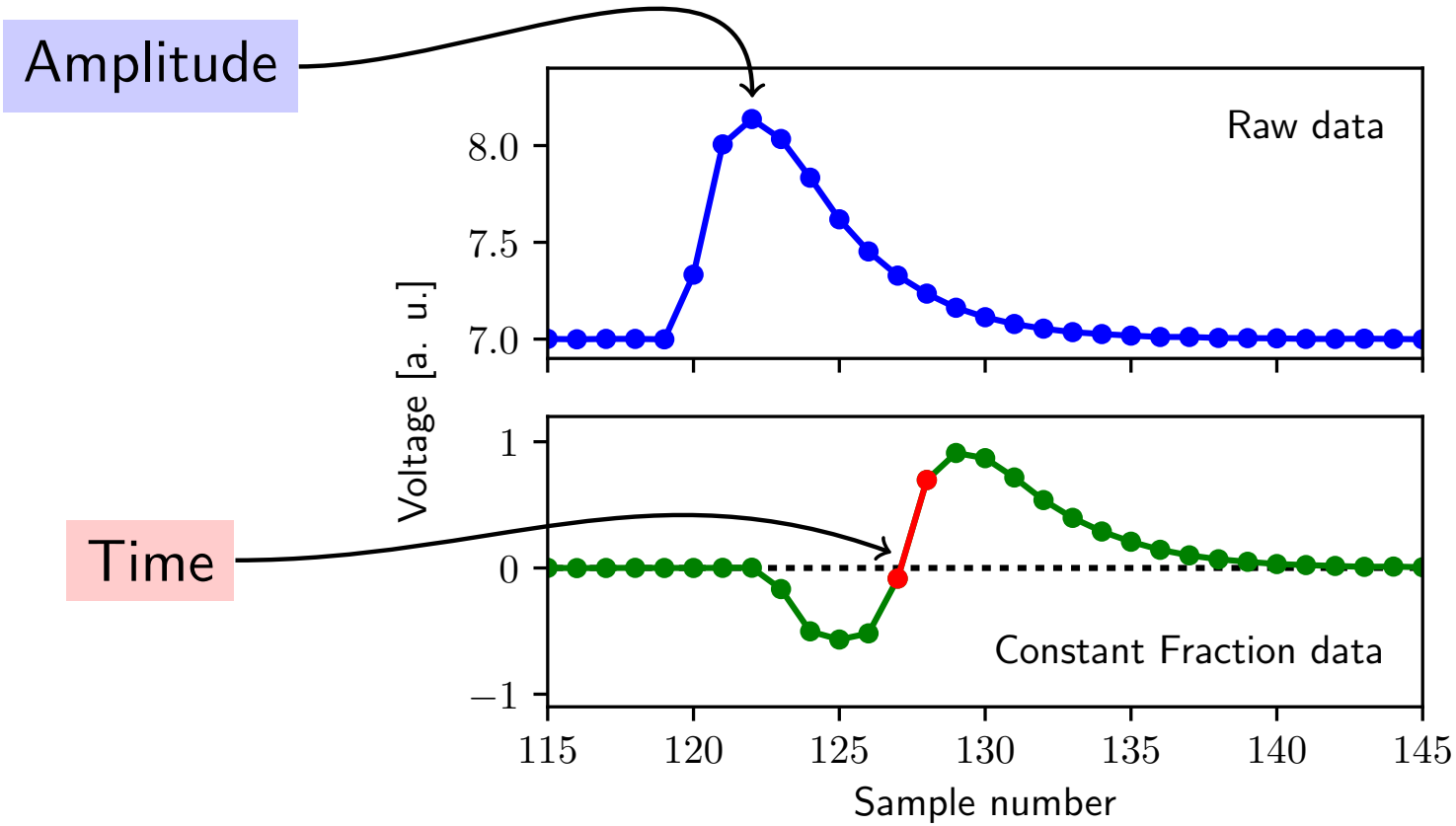

- Validity confirmed (analysis of 2014 testbeam data)
- Potential issues: (i) does not solve pile-up problem, (ii) relies on linear interpolation between two samples.

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- $A = \sum a_i S_i$
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- Sets of coefficients are fixed $\rightarrow$ calculated offline $\rightarrow$ FPGA implementation possible!

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- *Optimal filter* method has been refined to address (i) free-running trigger nature of PANDA, (ii) pile-up reconstruction

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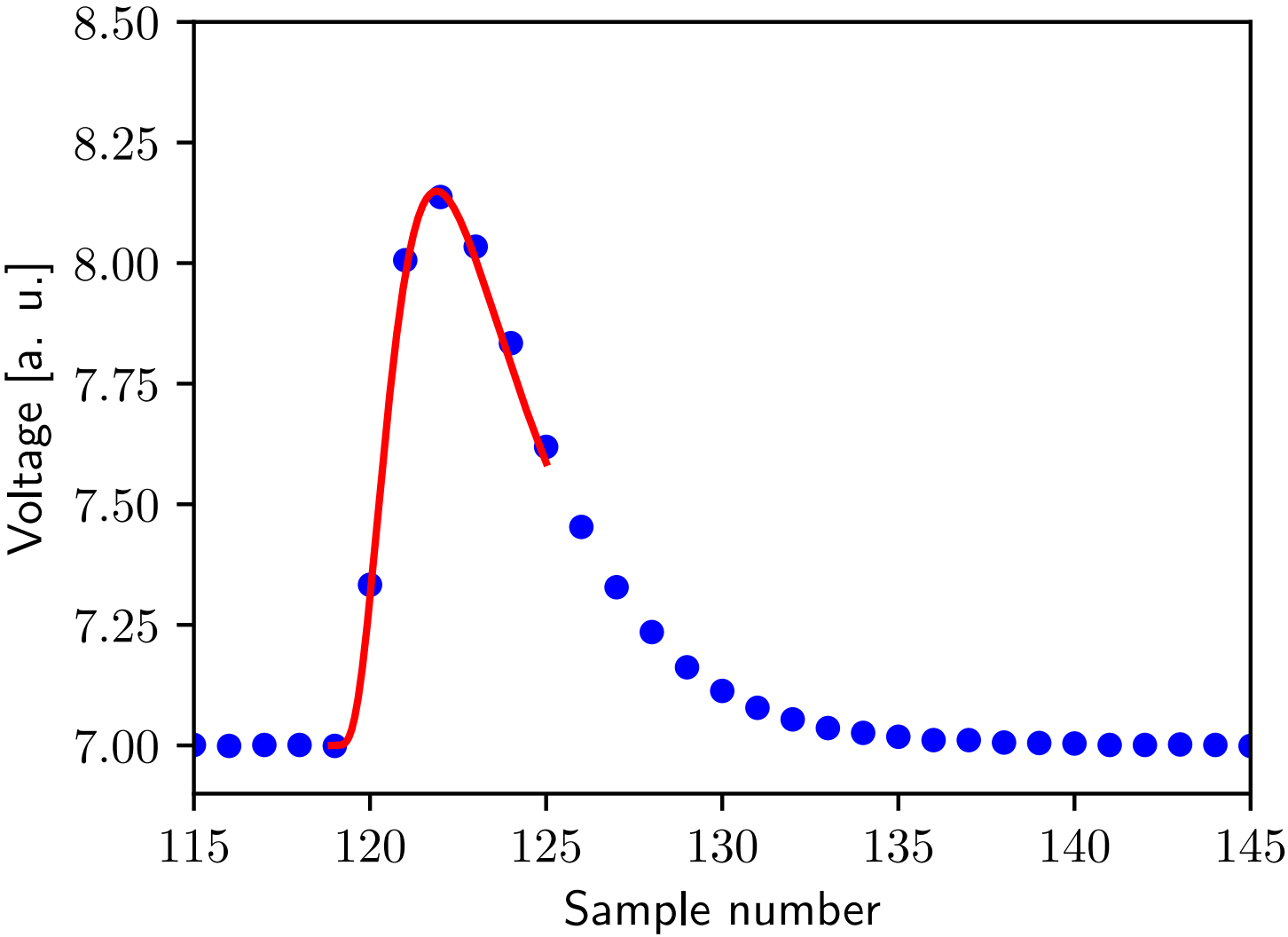
  2. Make pileup reconstruction/recovery possible.
     - Limit number of optimal filter coefficients to first part of pulse.
     - See later slides.

New algorithm — example



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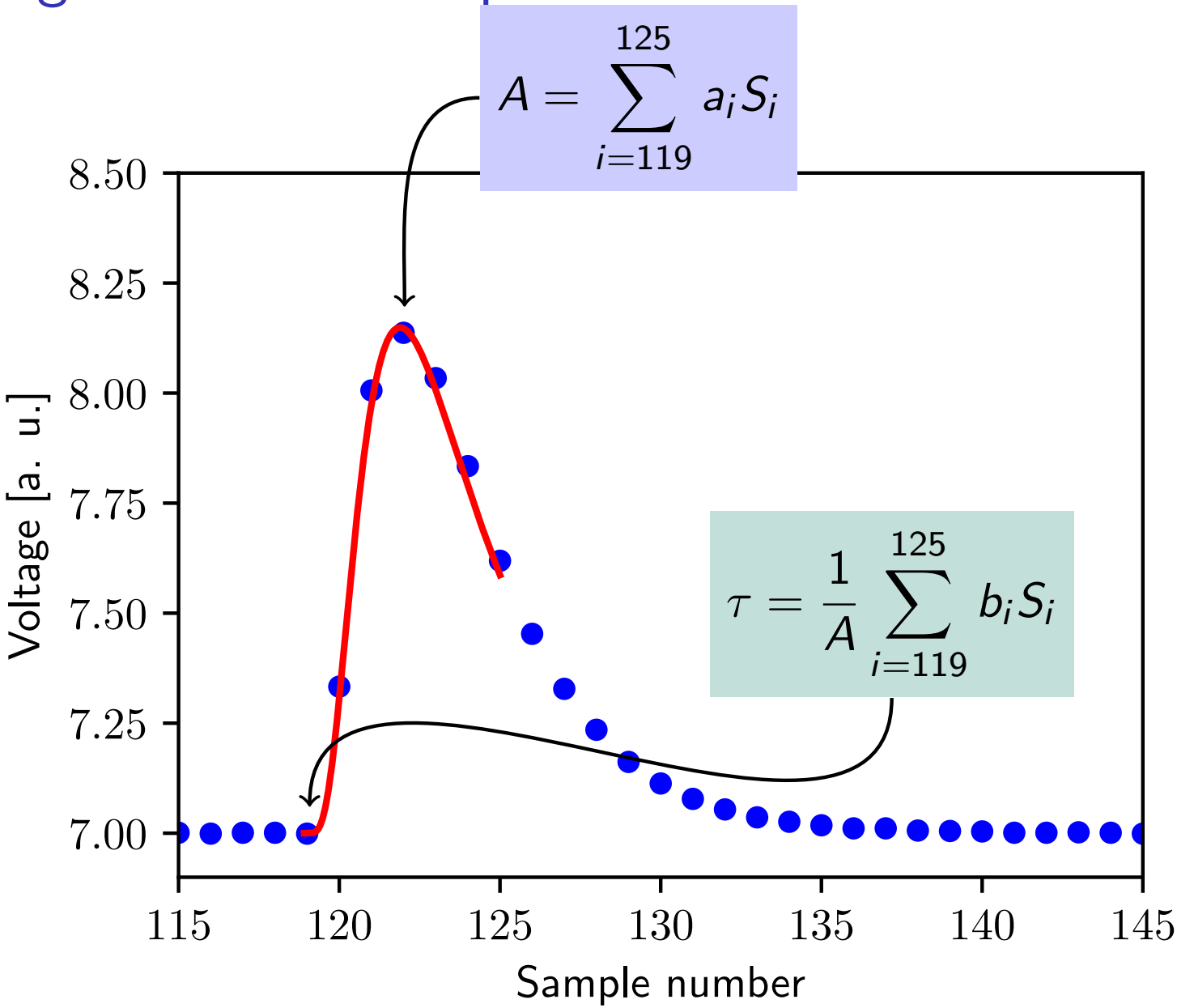
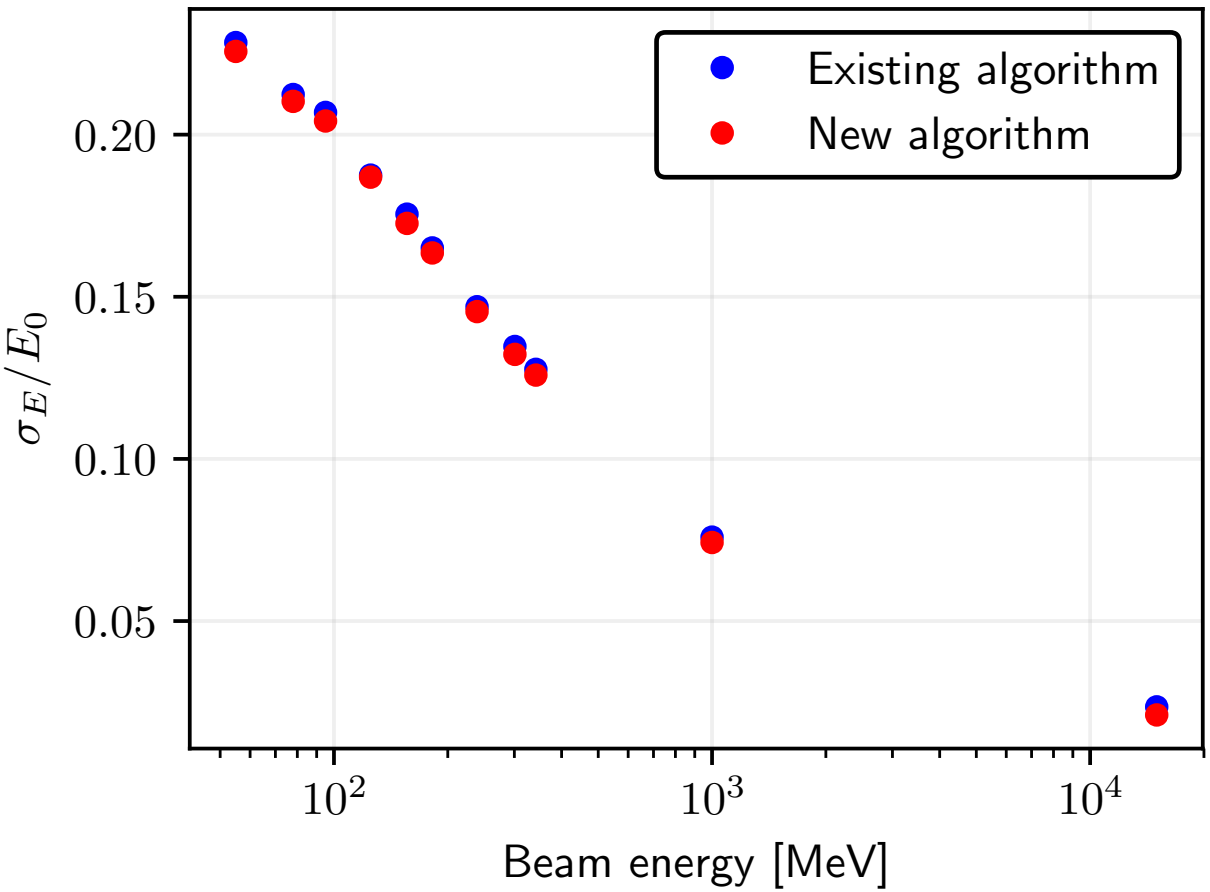


Results — energy resolution



Relative energy resolution of single cell determined by fitting Novosibirsk distribution to pulse-height (amplitude A) spectra.

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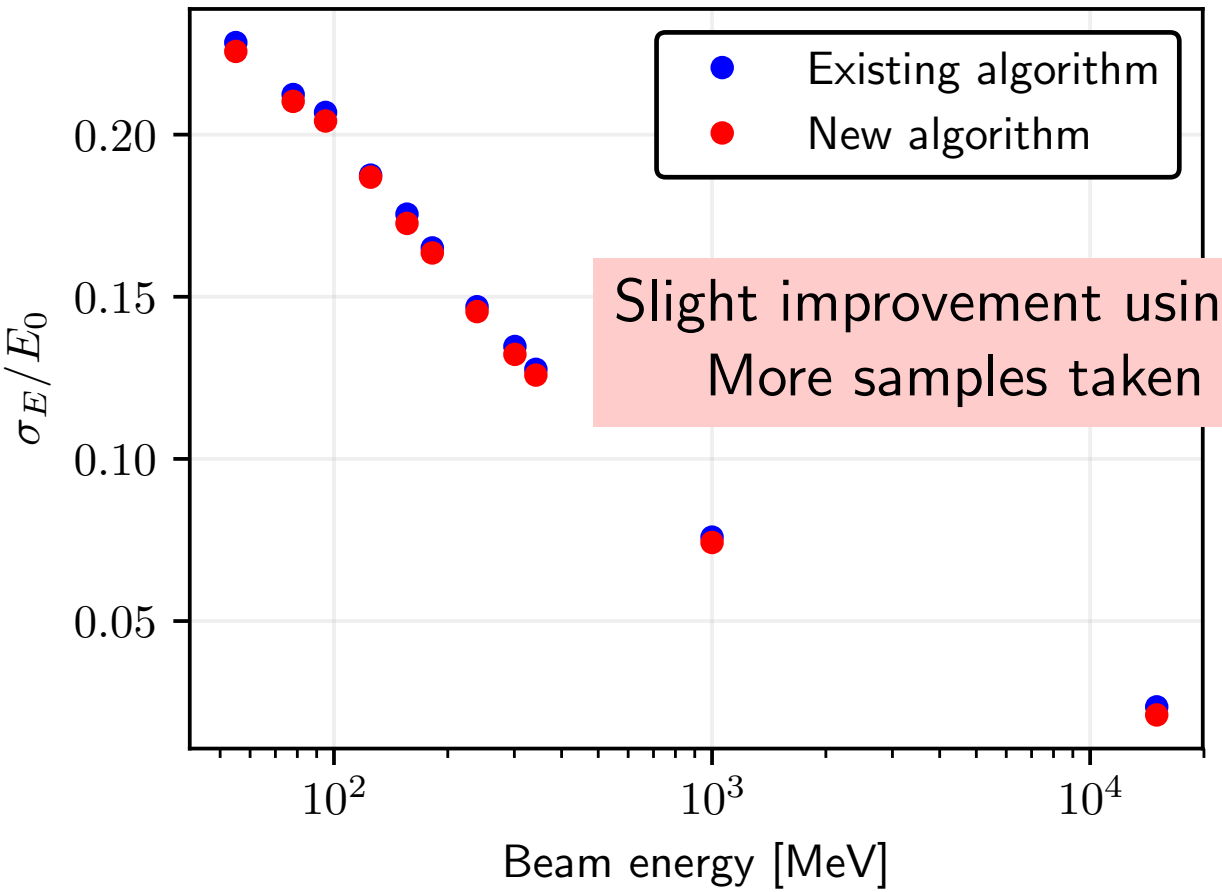

Slight improvement using new algorithm
More samples taken into account

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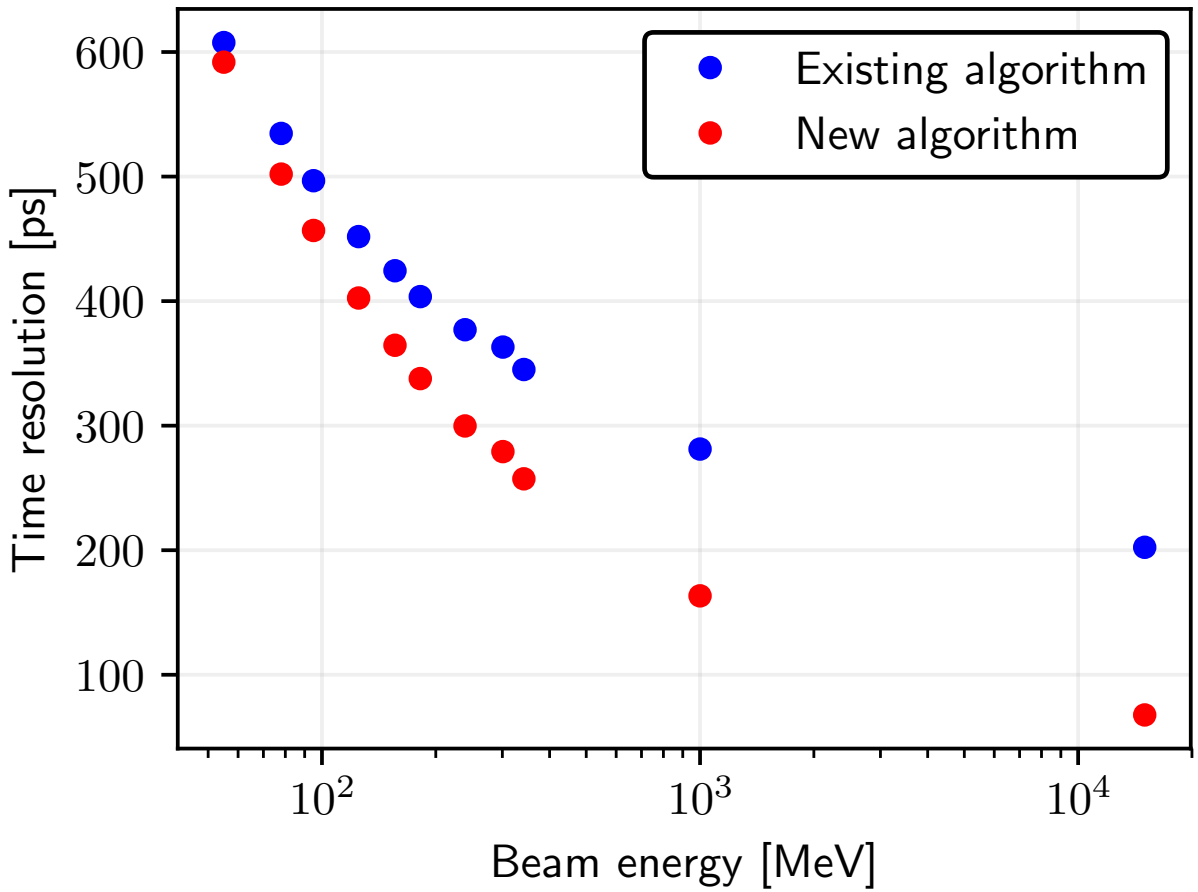

Time resolution determined from $\sigma(t - T_0)$.
T_0: time when photon hits front of detector.

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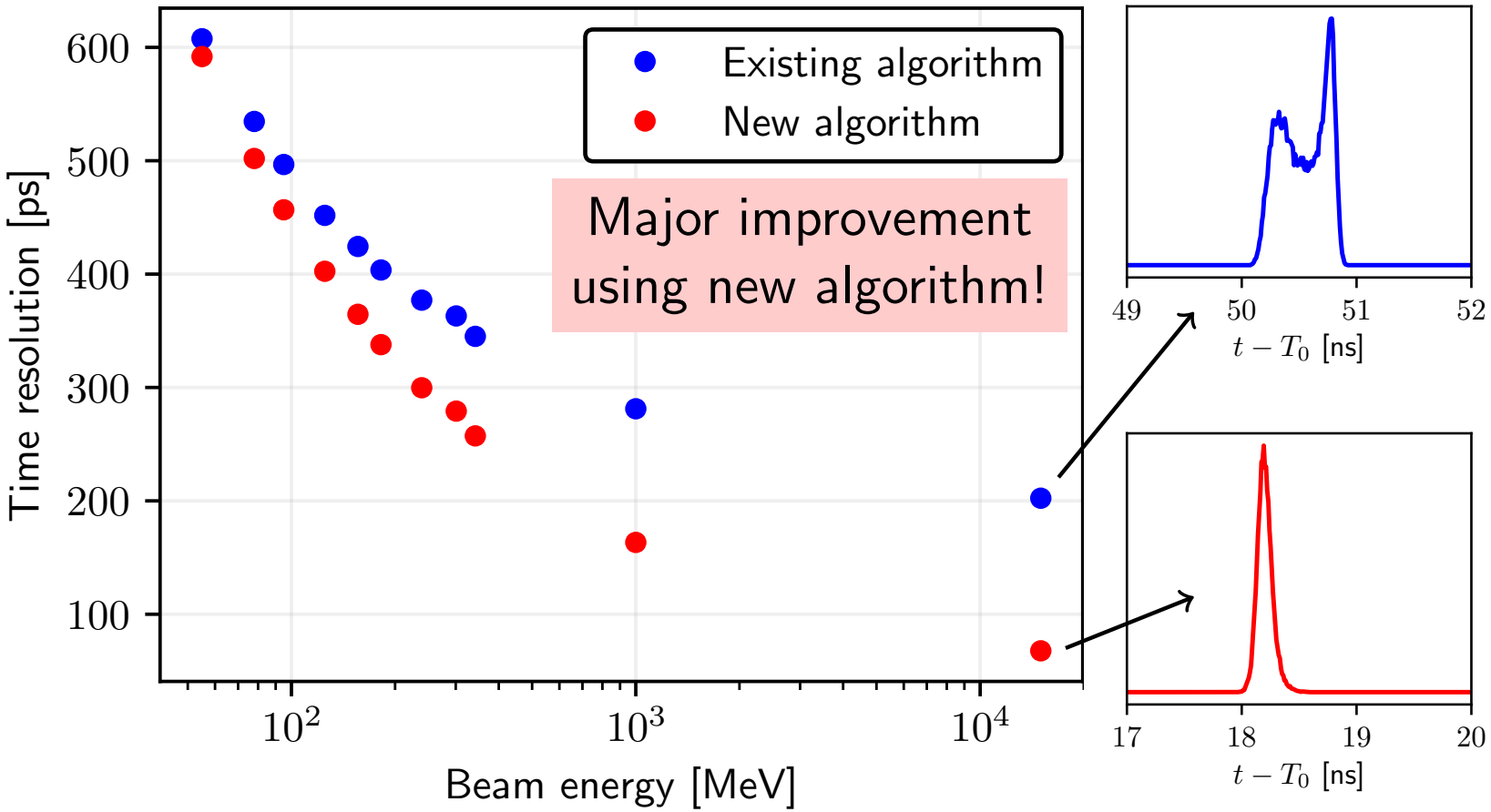

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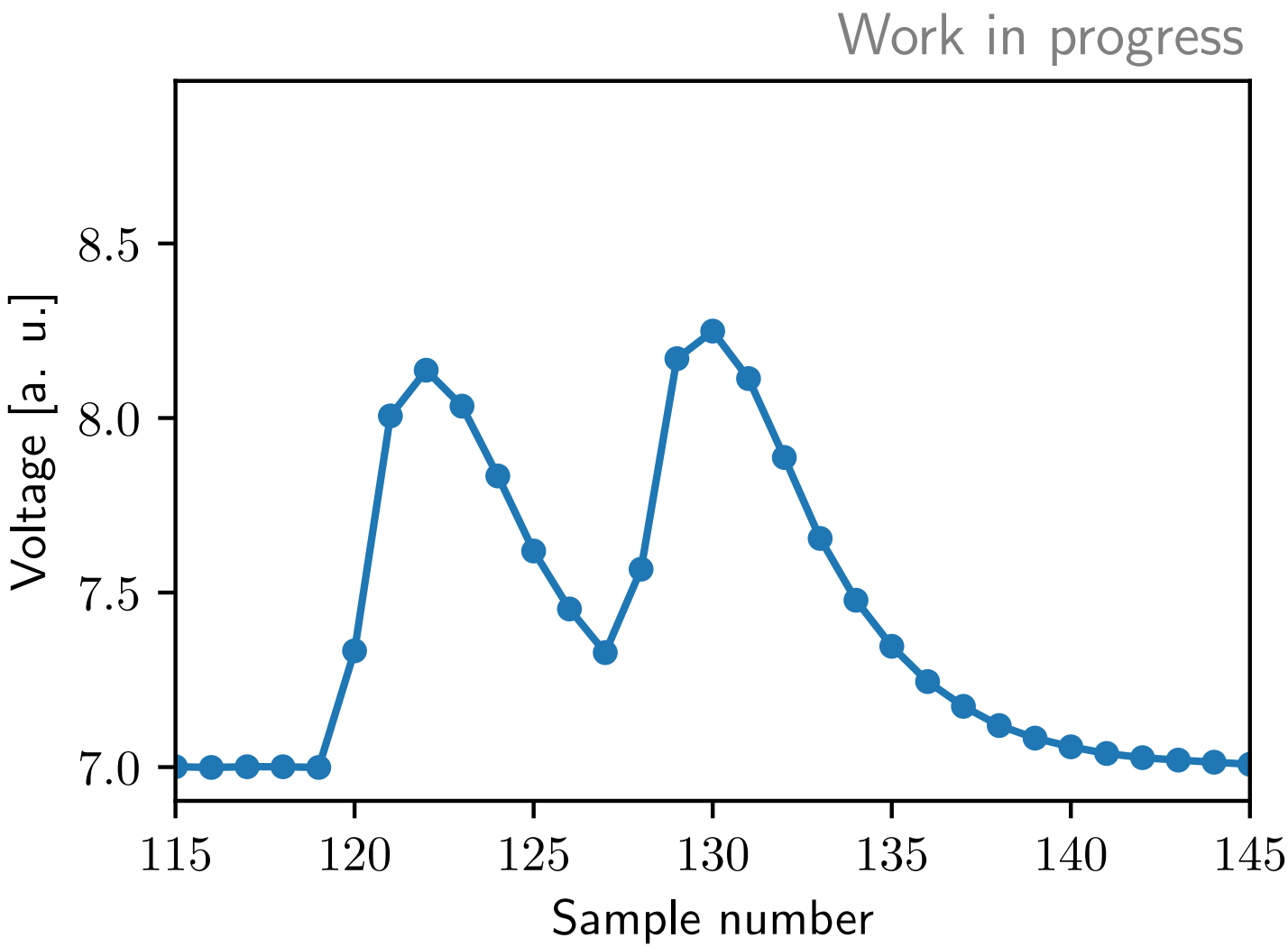

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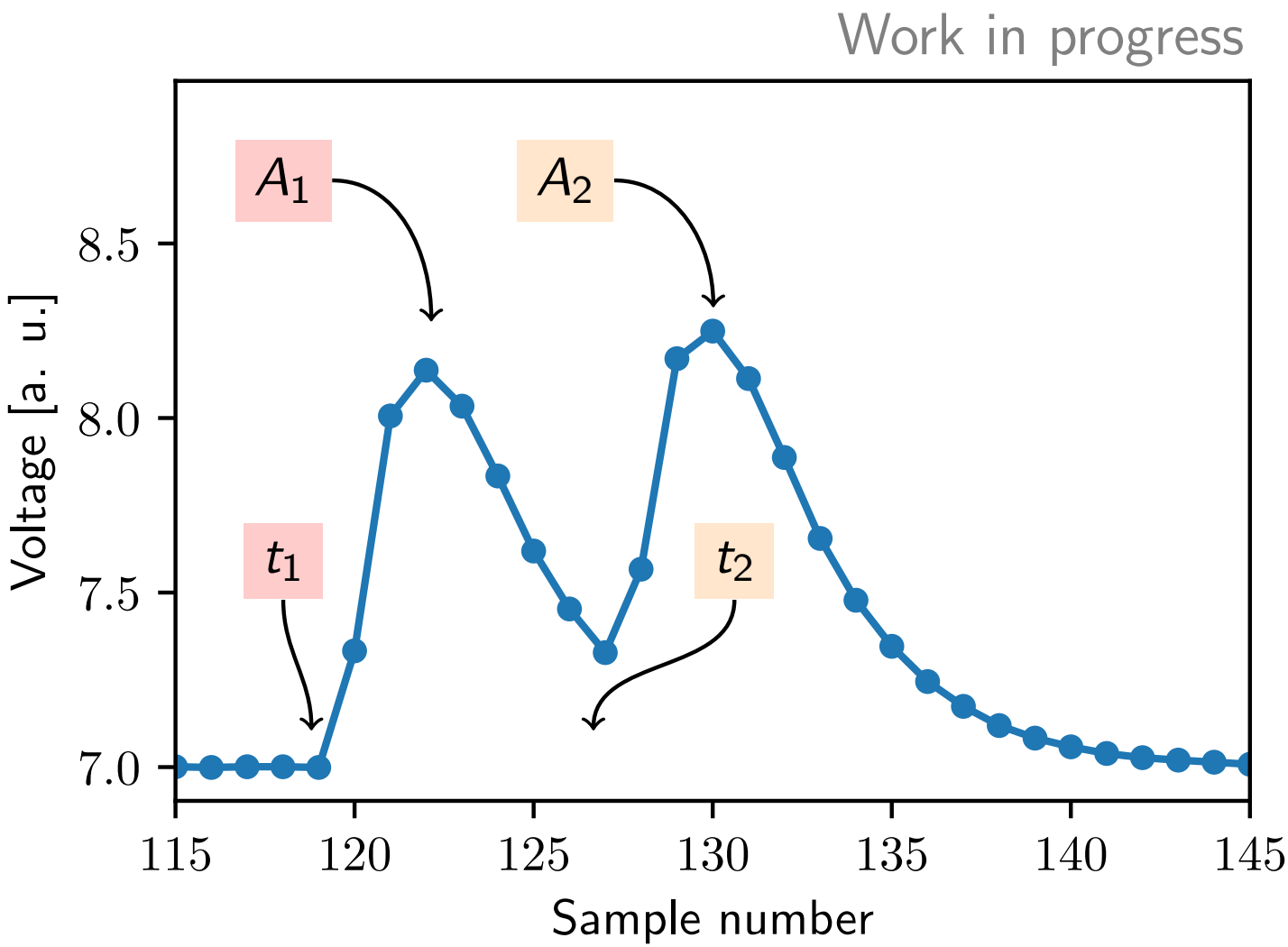
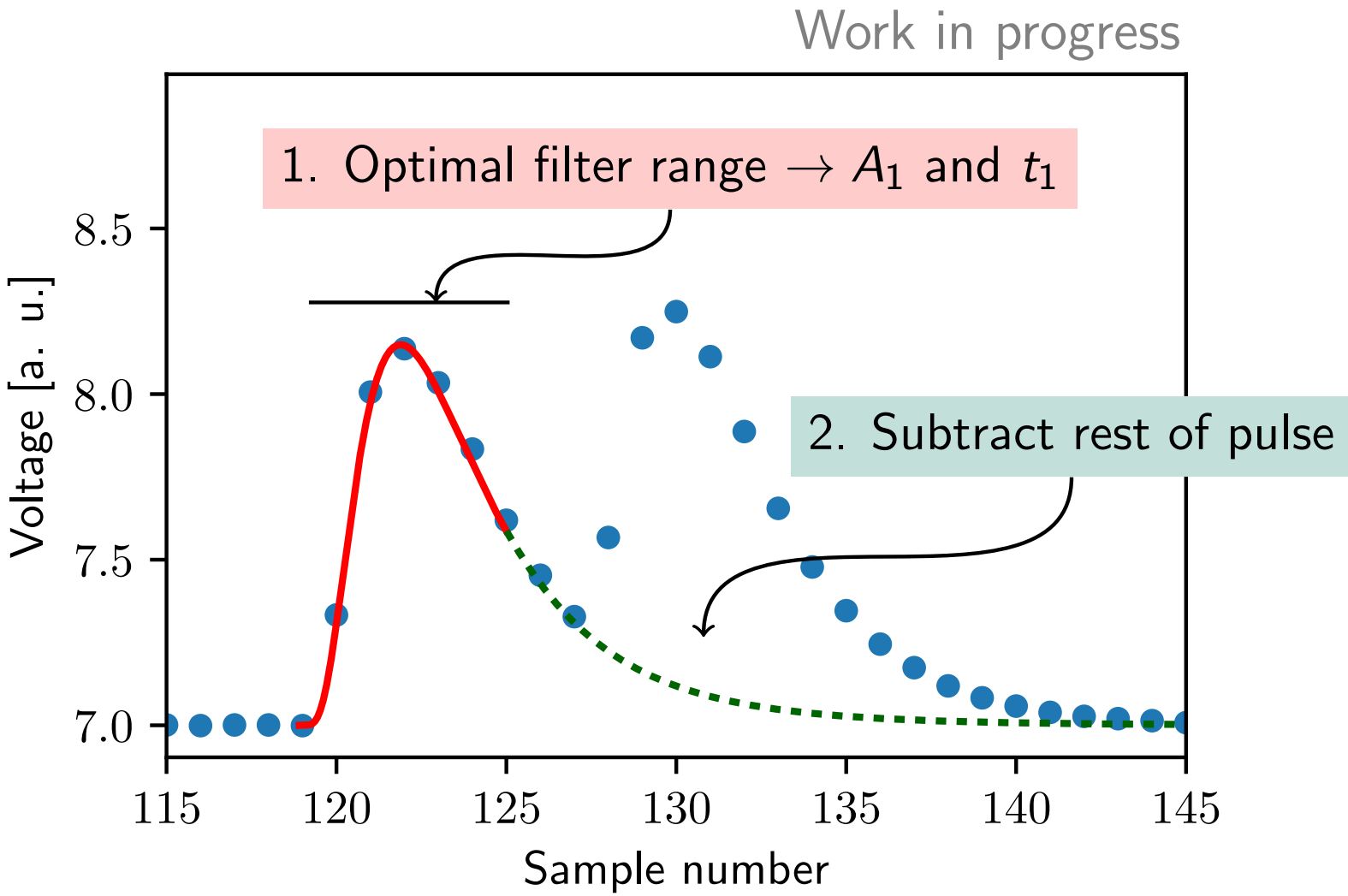


Pileup reconstruction



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- Based on method of *optimal filtering*
- Slight improvement in energy resolution
- Big improvement in time resolution (relative to linear Constant Fraction)
- Method can be used to reconstruct pile-up events
- Optimisations needed for final shashlyk digitiser hardware (e.g. different shaping time and sampling rate)

Thank you for your attention!