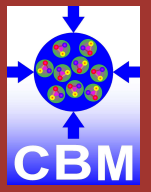
UNIVERSITÄT HEIDELBERG



SPADIC
Self triggered Pulse Amplification and Digitization asIC

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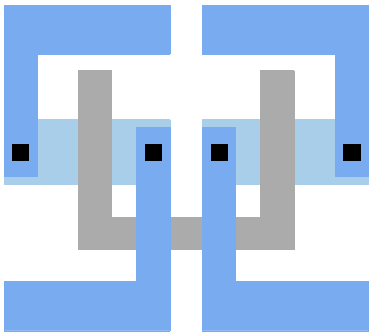
Self Triggered Pulse Amplification and Digitization ASIC



T. Armbruster, P. Fischer, M. Krieger, I. Peric

michael.krieger@ziti.uni-heidelberg.de

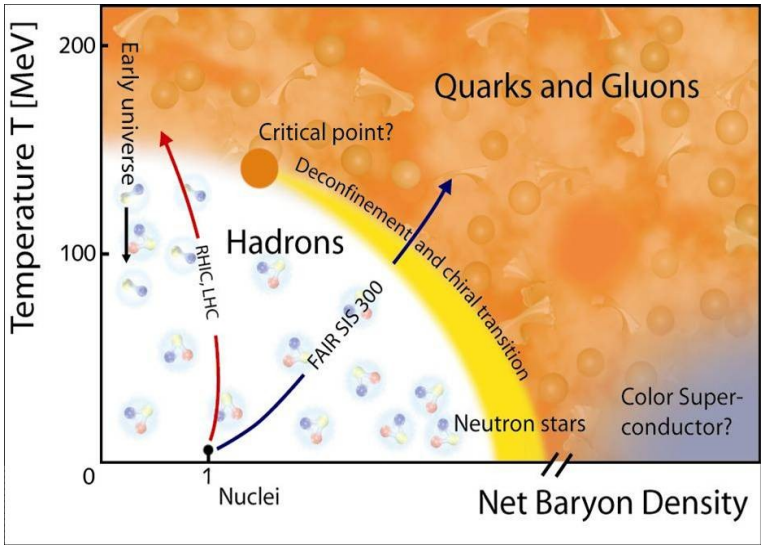
http://spadic.uni-hd.de

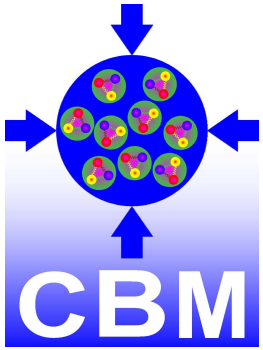
ANSiP-2011

SPADIC – Overview

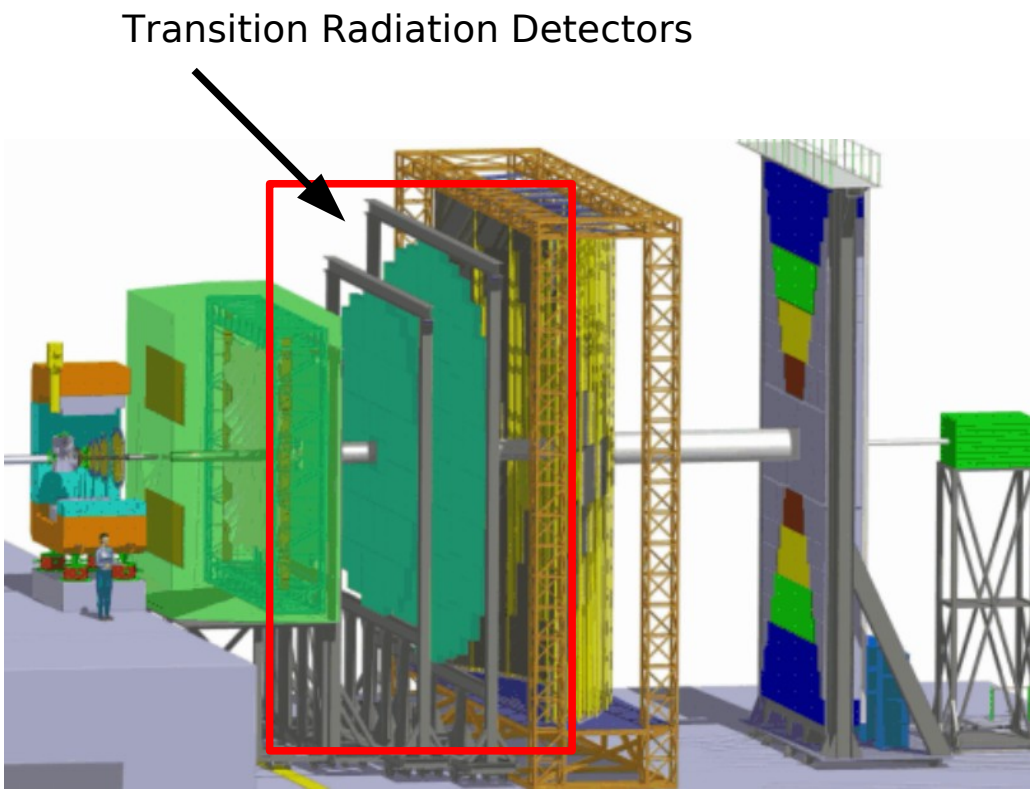
The CBM Experiment

- FAIR: new accelerator at GSI
- CBM: Compressed Baryonic Matter
- fixed-target experiment at FAIR
- collide heavy ions
- explore QCD phase diagram
  at high baryon densities

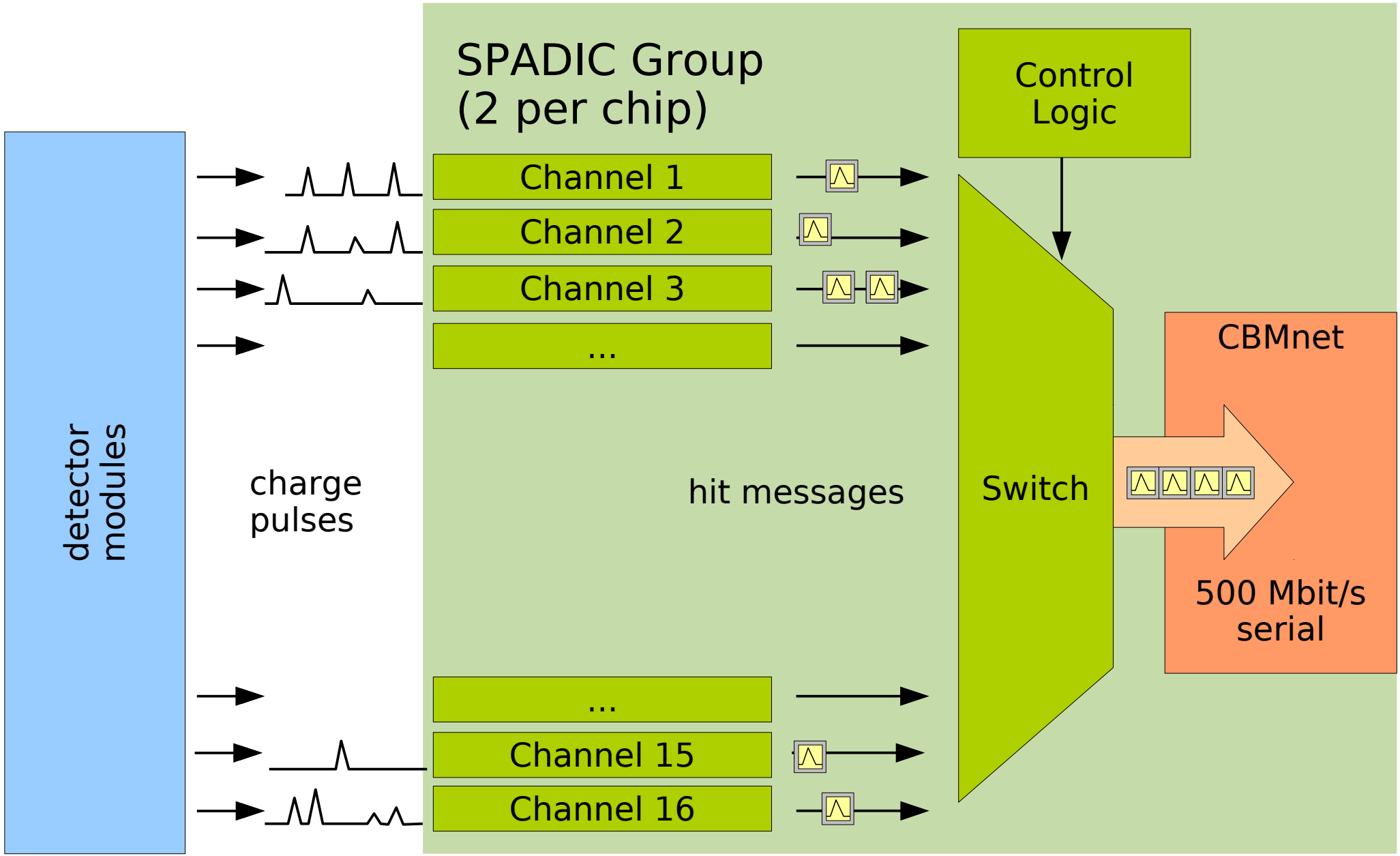




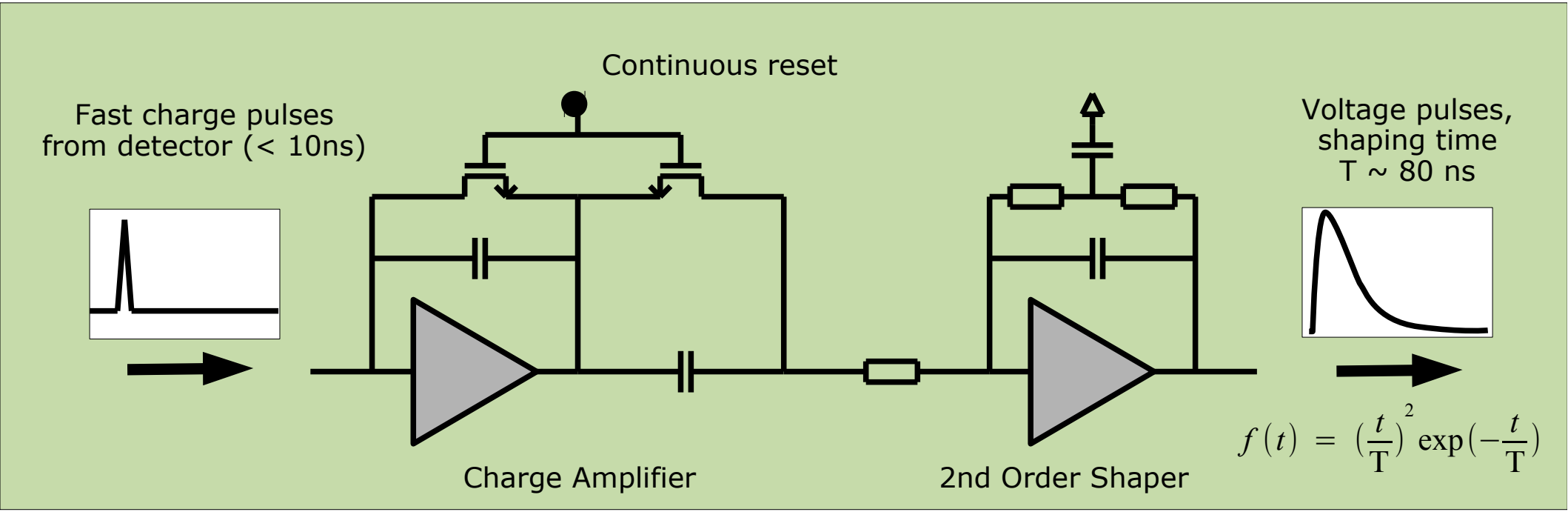
- **S**elf-Triggered **P**ulse **A**mplification and **D**igitization AS**IC**
- Readout of CBM transition radiation detectors (TRD)
- On-Chip:
  - Amplification/Shaping
  - Digitization
  - Signal Processing
  - Hit Detection
  - Message Building
  - Serial Output Interface



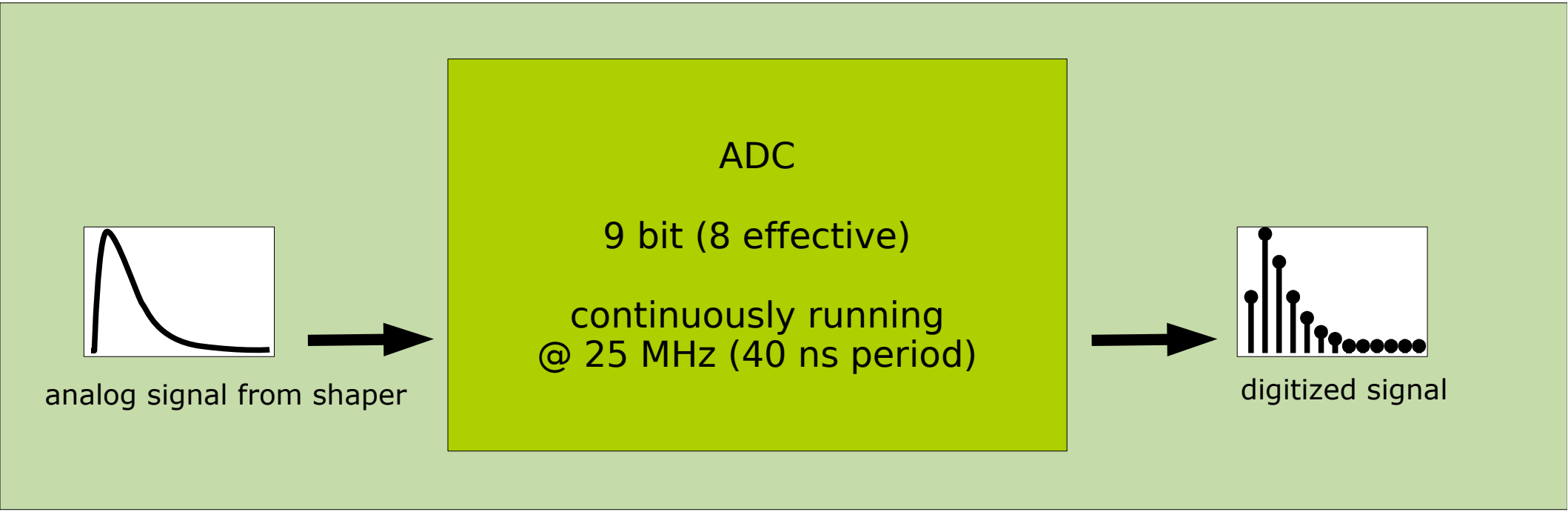
SPADIC – Architecture



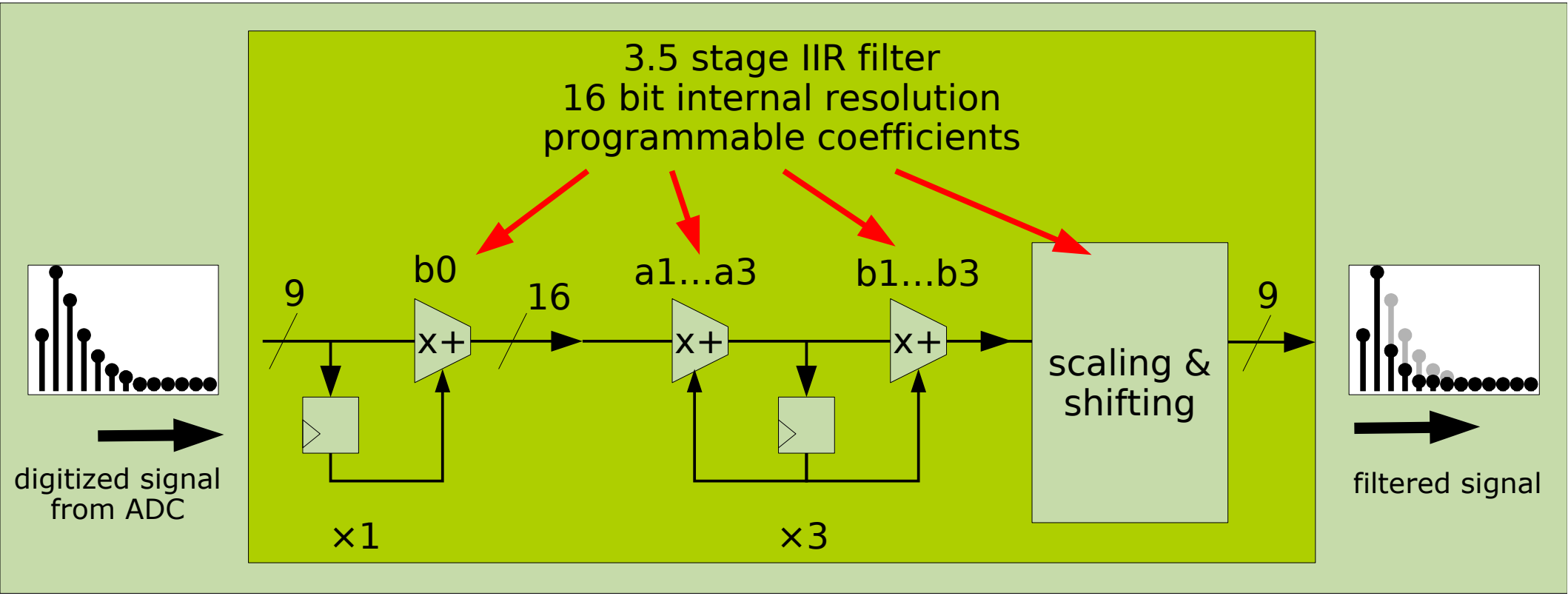
Step 1: Amplification + Shaping



Step 2: Digitization

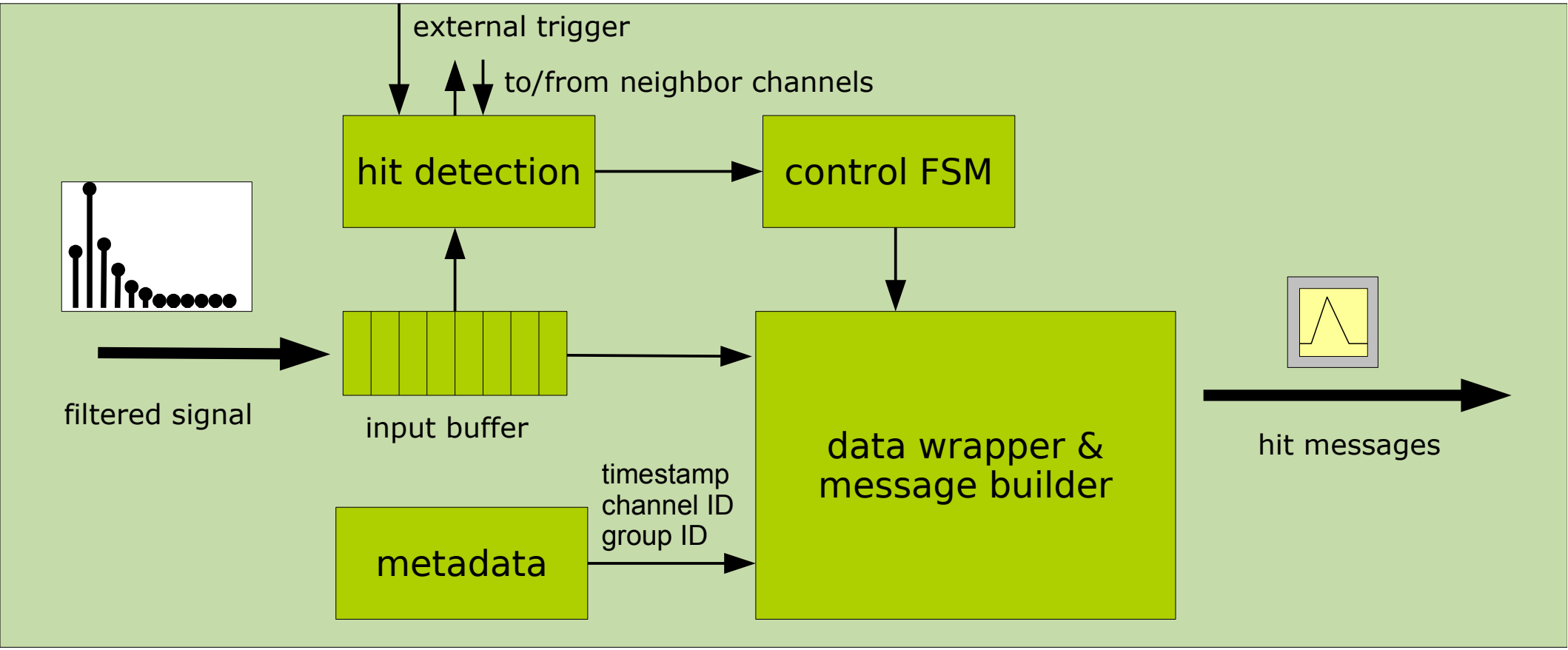


Step 3: Digital Signal Processing



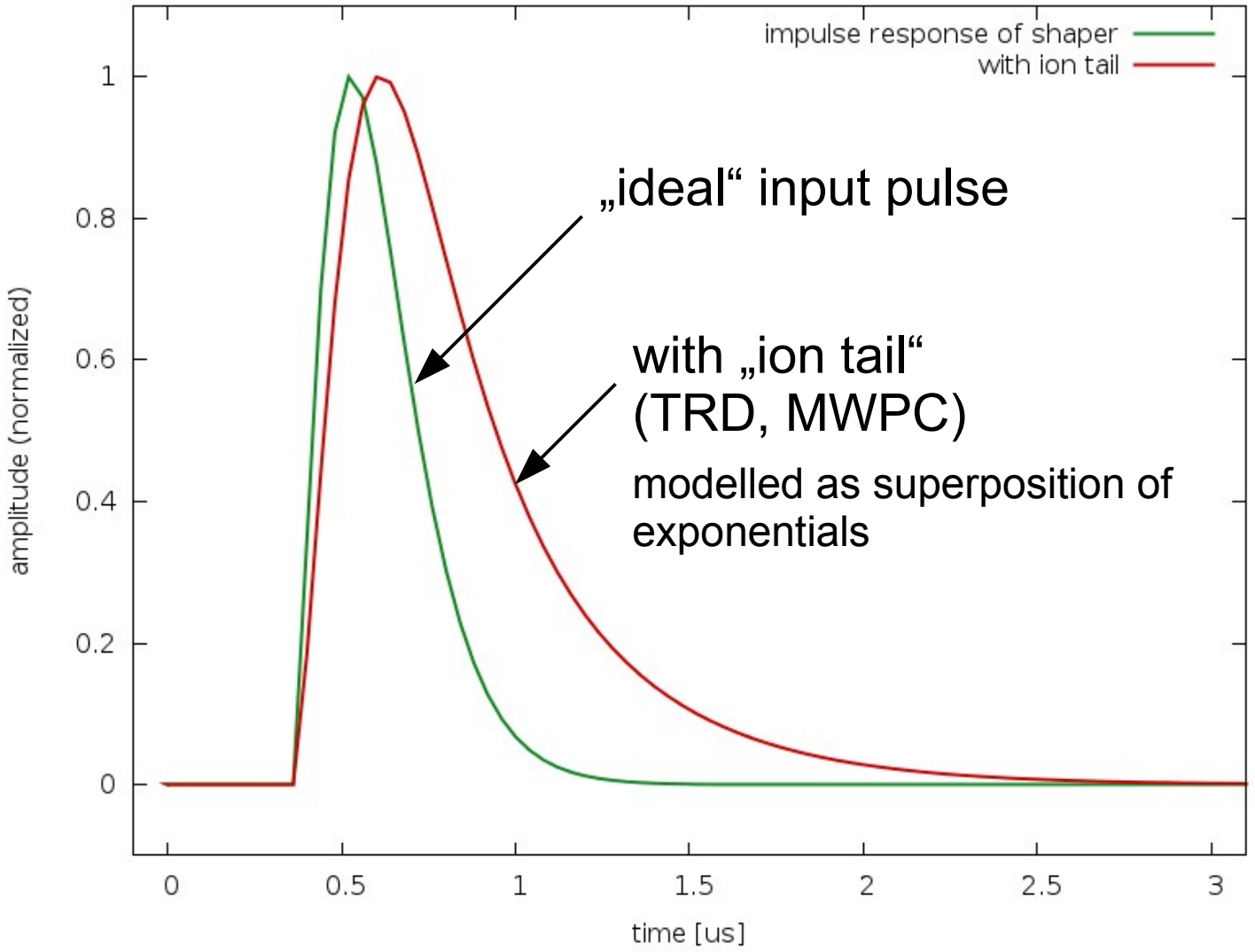
$$H(z)=\left(\left(1+b_0 z^{-1}\right)\frac{\left(1+b_1 z^{-1}\right)}{\left(1-a_1 z^{-1}\right)}\frac{\left(1+b_2 z^{-1}\right)}{\left(1-a_2 z^{-1}\right)}\frac{\left(1+b_3 z^{-1}\right)}{\left(1-a_3 z^{-1}\right)}\right)$$

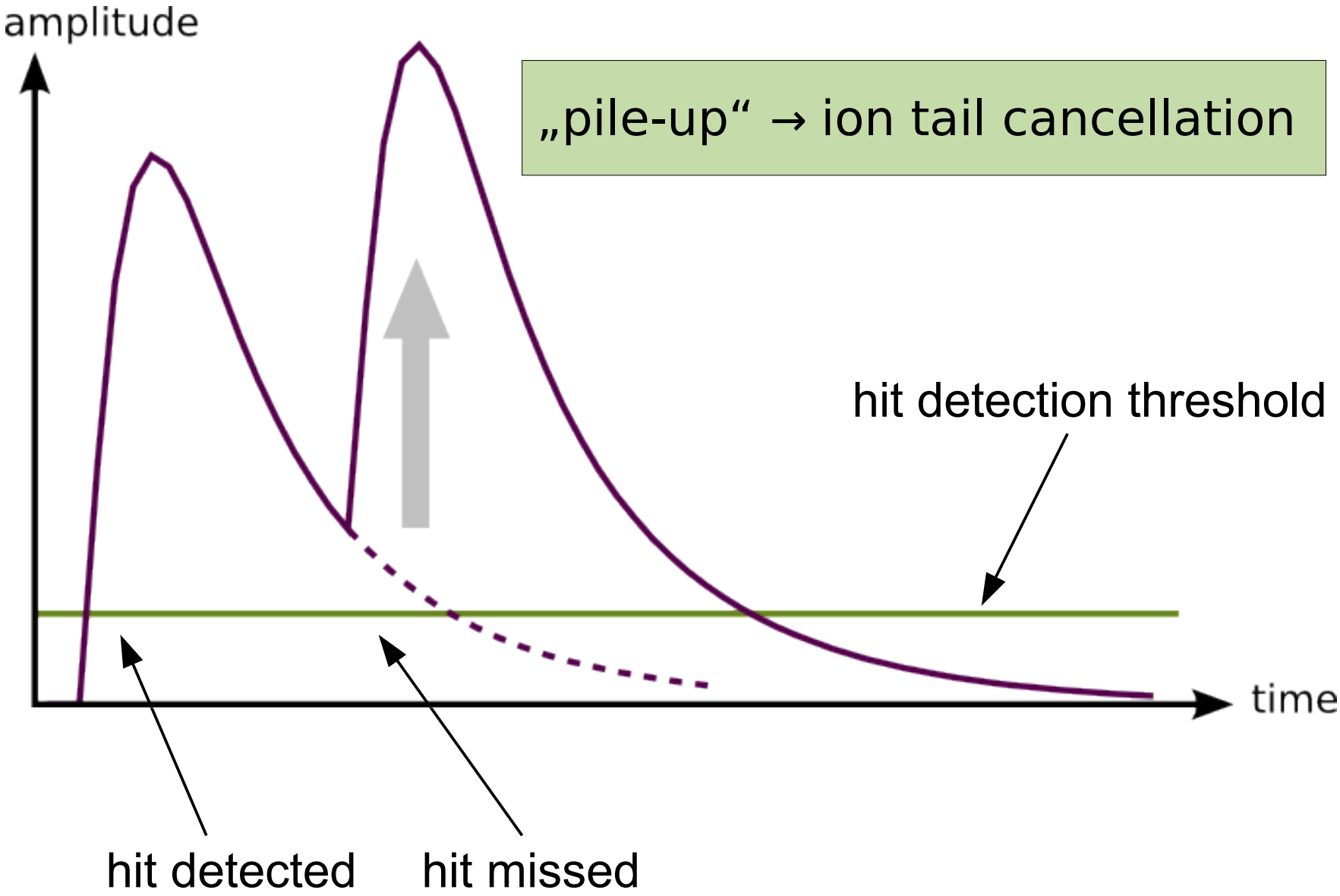
Step 4: Hit Detection & Message Building (simplified)



SPADIC - Digital Signal Processing

shaper output:

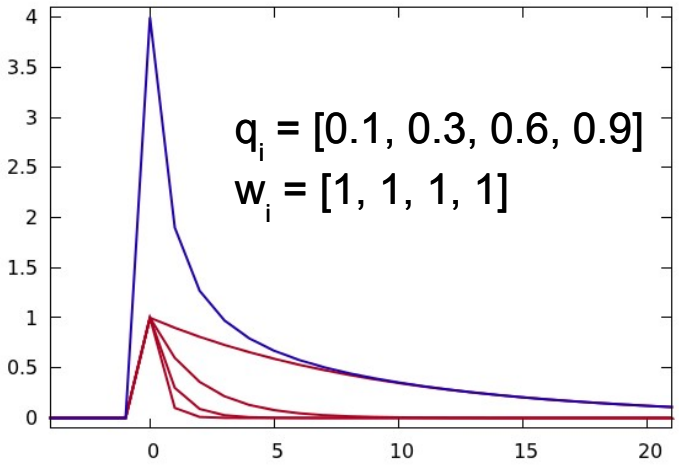


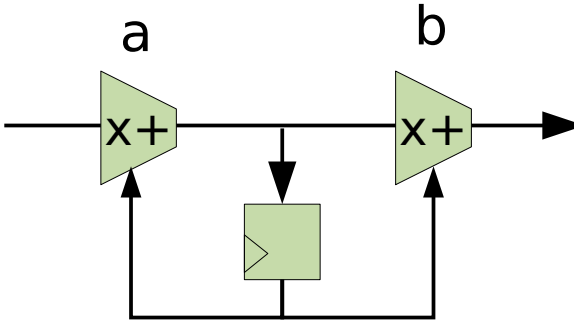

amplitude
„pile-up“ → ion tail cancellation
hit detection threshold
time
hit detected
hit missed

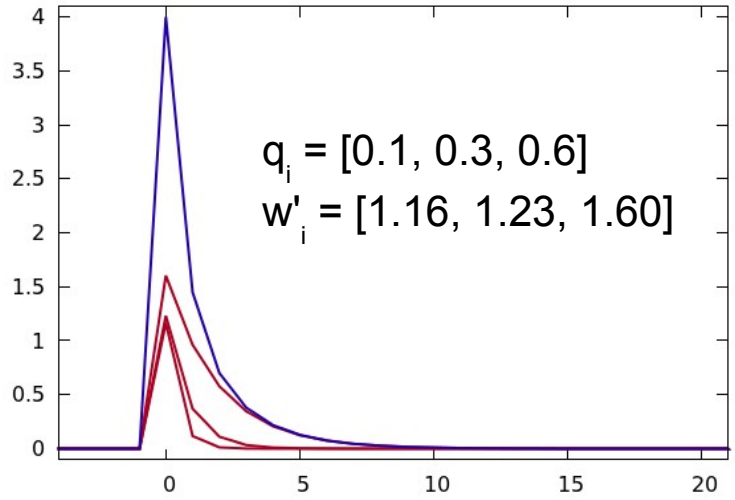
Ion Tail Cancellation

- charge pulse modelled as superposition of exponentials:

$$x[n] = w_0 q_0^n + w_1 q_1^n + w_2 q_2^n + w_3 q_3^n$$



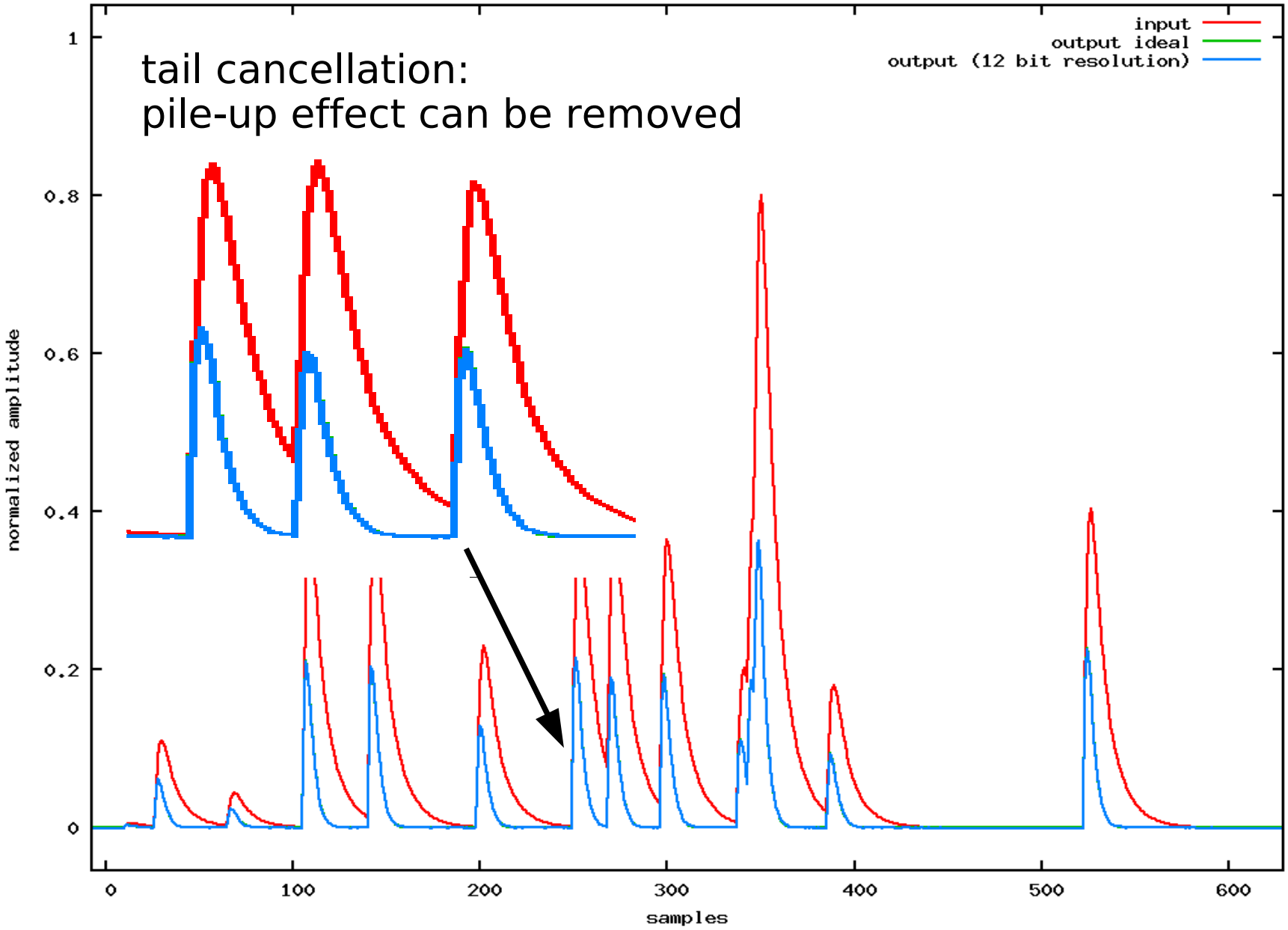


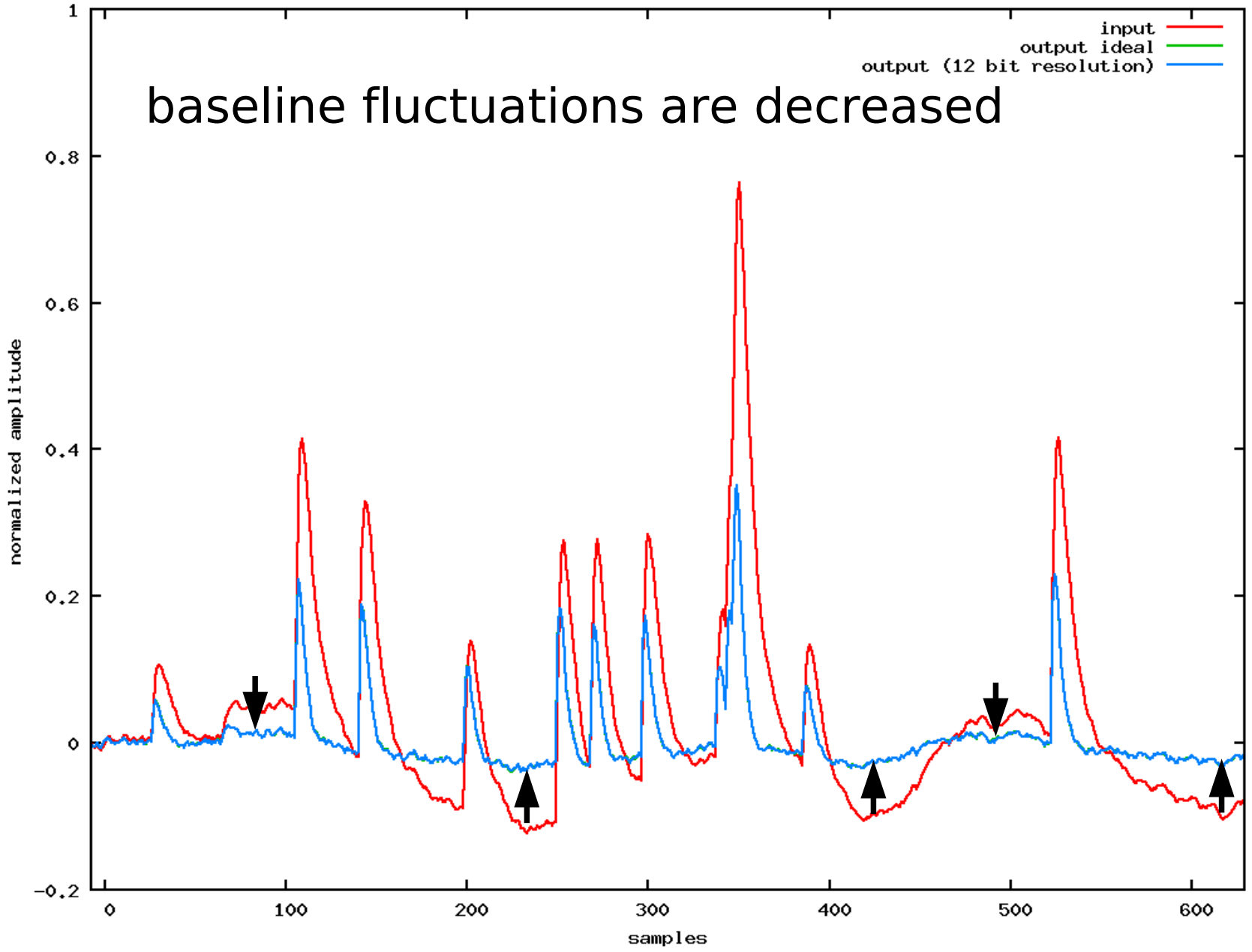


$b = -0.9$
$a = 0.78$

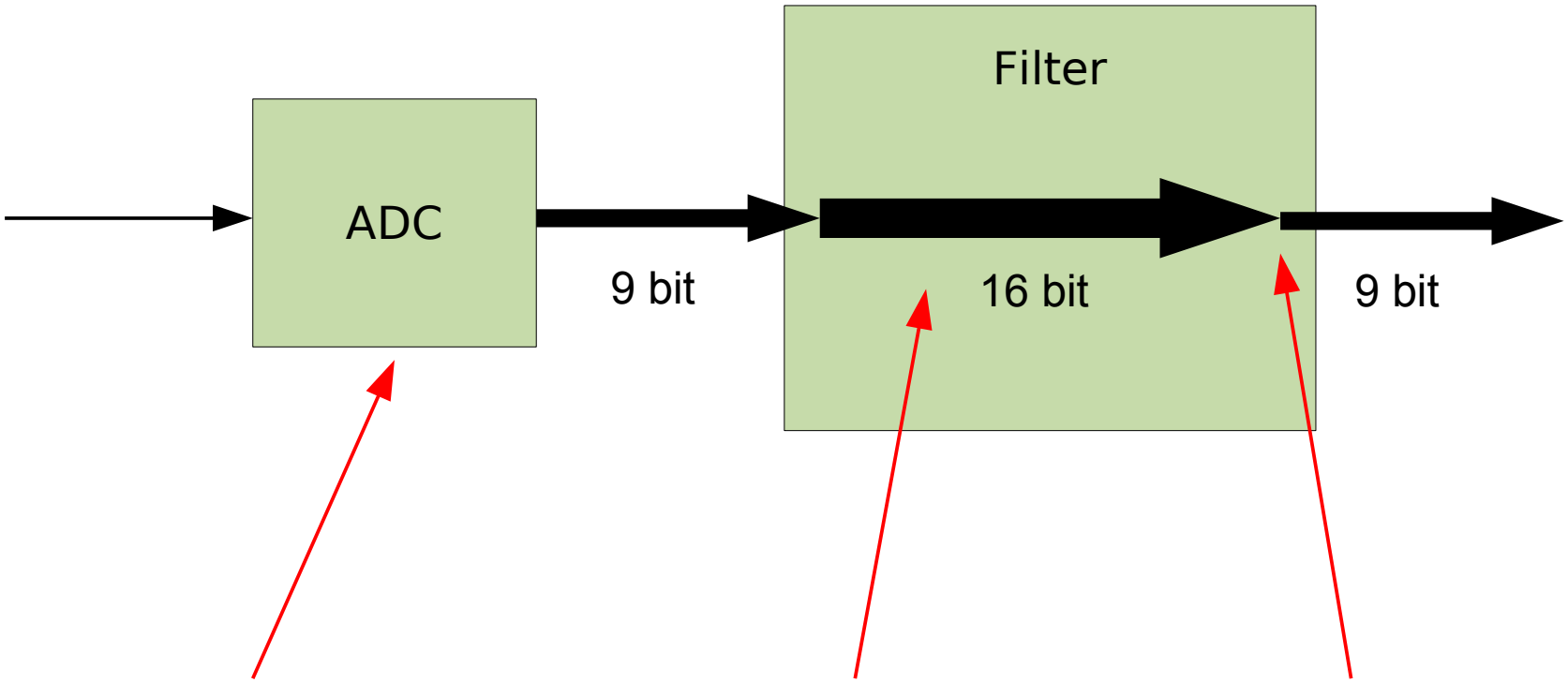
$$y[n] = w'_0 q_0^n + w'_1 q_1^n + w'_2 q_2^n + w'_3 q_3^n$$

- sum of weights remains constant
- trade slow parts for faster parts
- high-pass characteristic


tail cancellation:
pile-up effect can be removed
input
output ideal
output (12 bit resolution)
normalized amplitude
samples
0
0.2
0.4
0.6
0.8
1
0
100
200
300
400
500
600

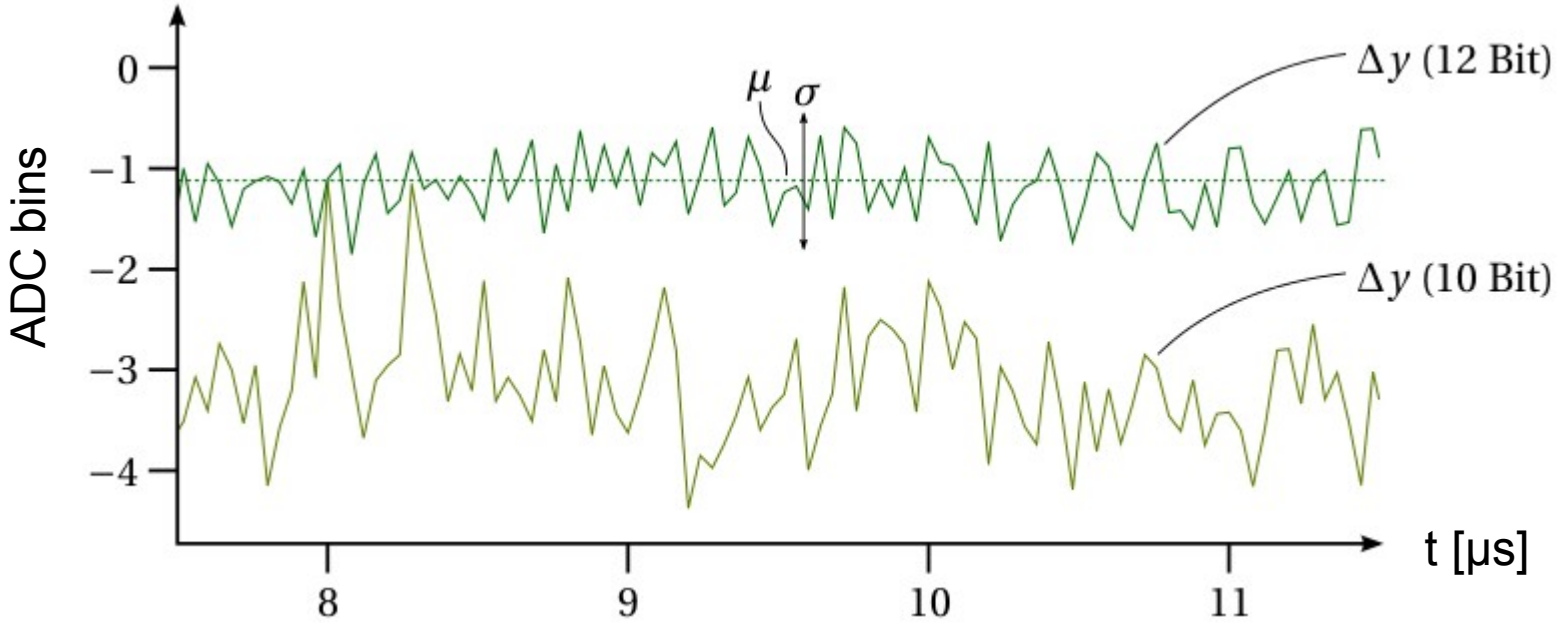

baseline fluctuations are decreased
input
output ideal
output (12 bit resolution)
normalized amplitude
samples
1
0.8
0.6
0.4
0.2
0
-0.2
0
100
200
300
400
500
600

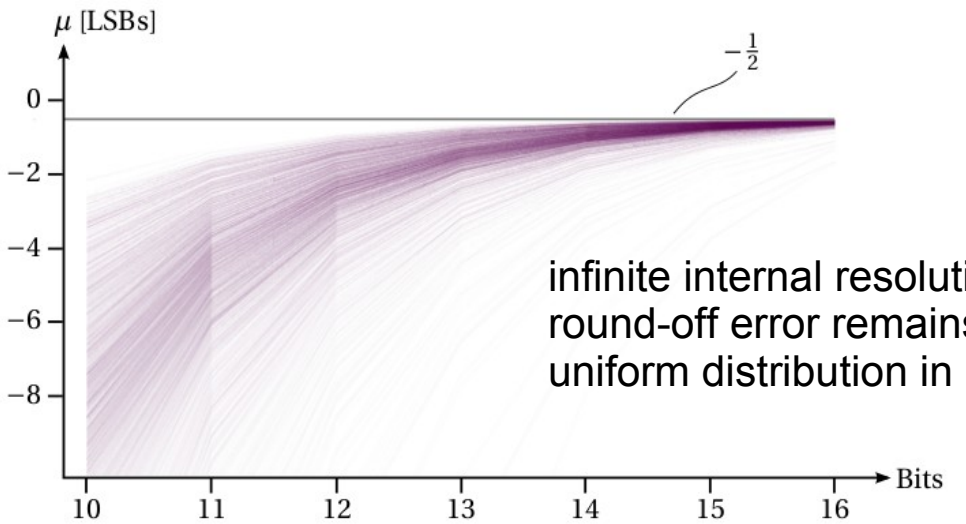
Quantization Error - Sources



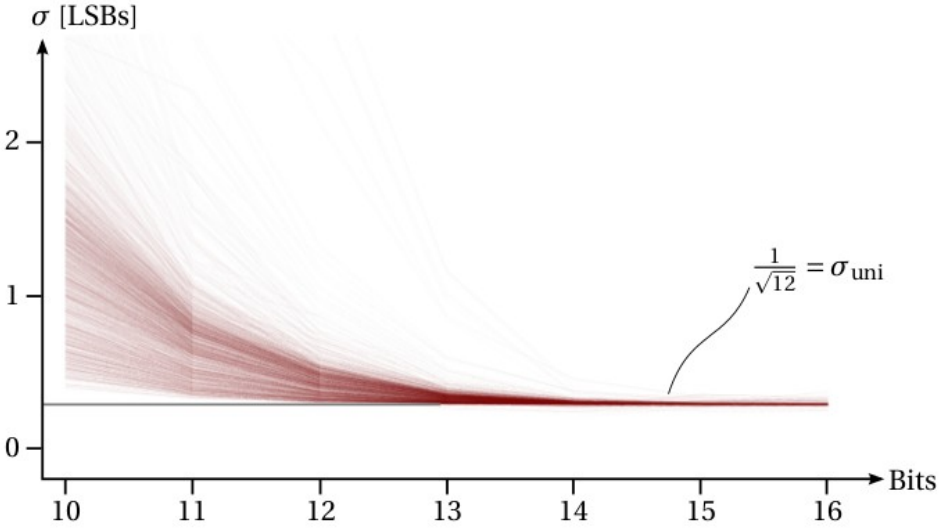
Quantization Error (1)

quantization error introduced in the filter:



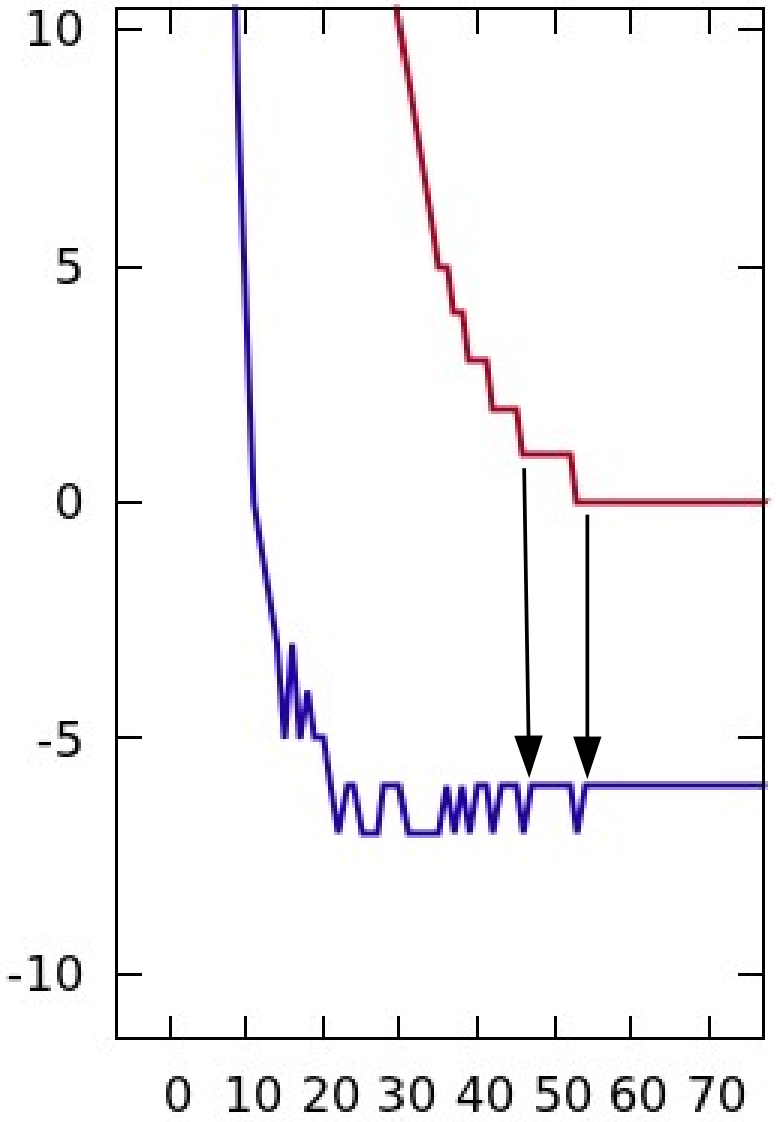


infinite internal resolution:
round-off error remains
uniform distribution in [-1,0]



Quantization Error (2)

quantization error present before the filter:

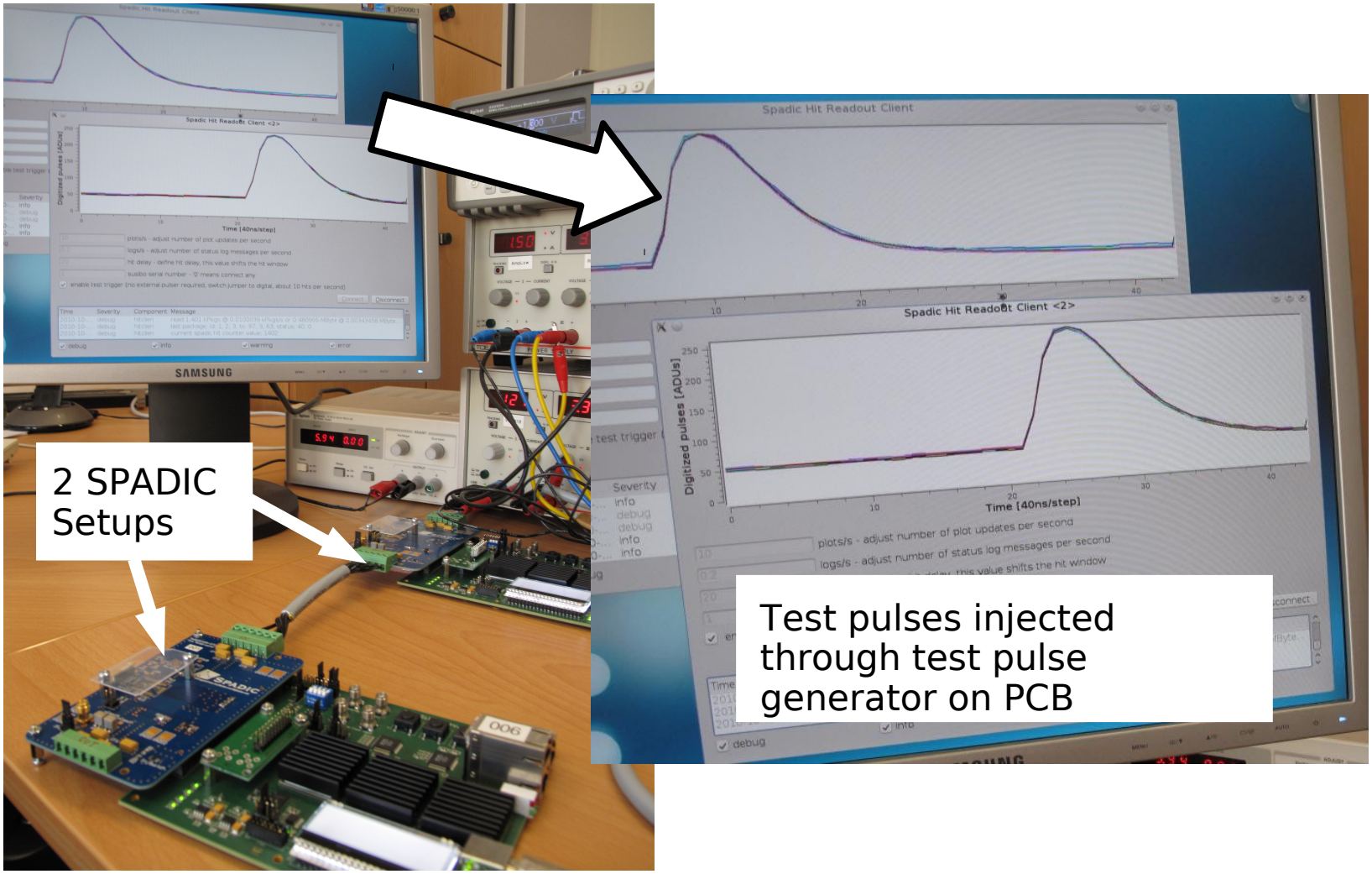


- high-frequency content in quantization error of ADC (sawtooth)
- limits use of filtering (high-pass)
- more detailed analysis needed

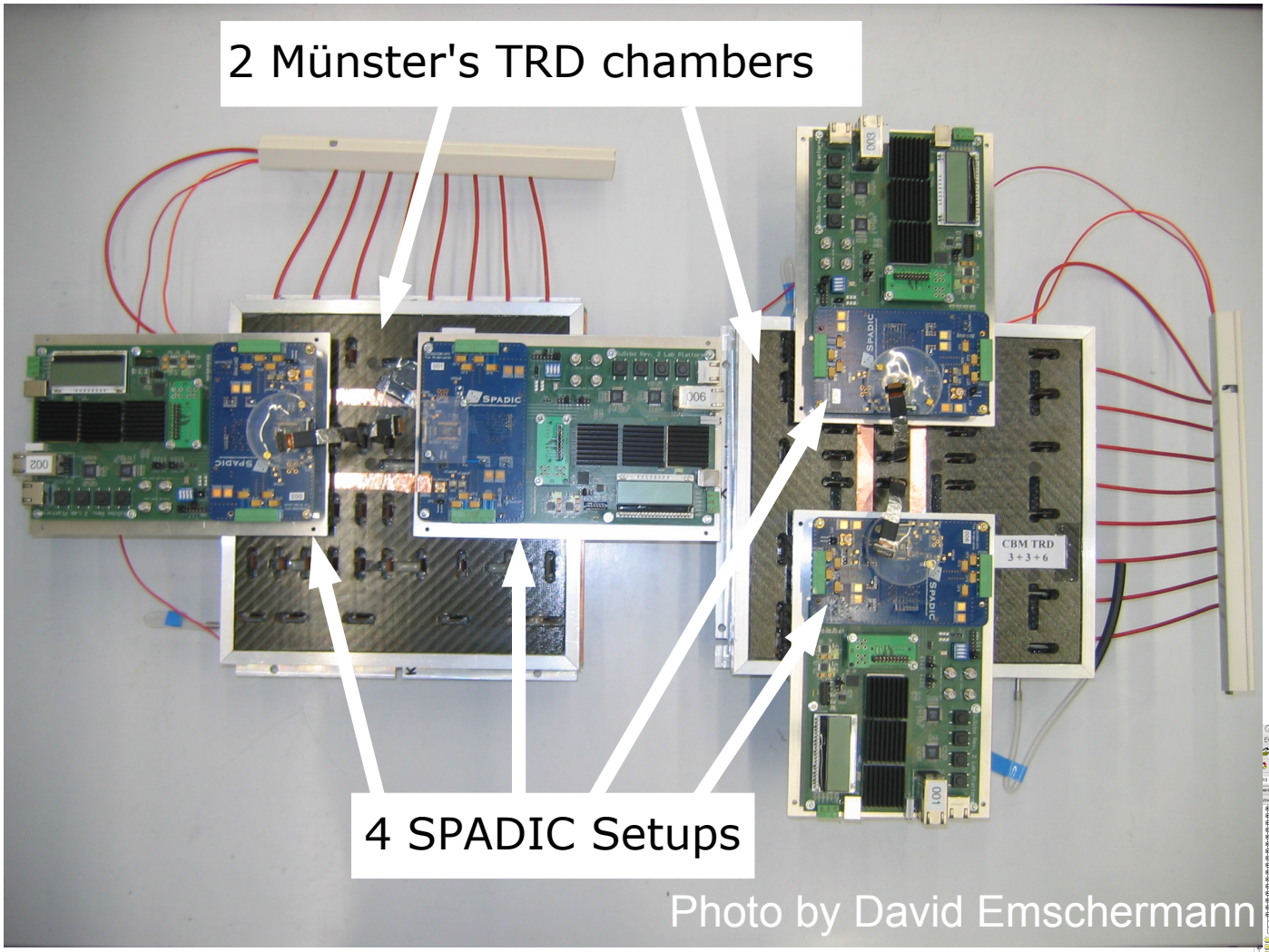
Status

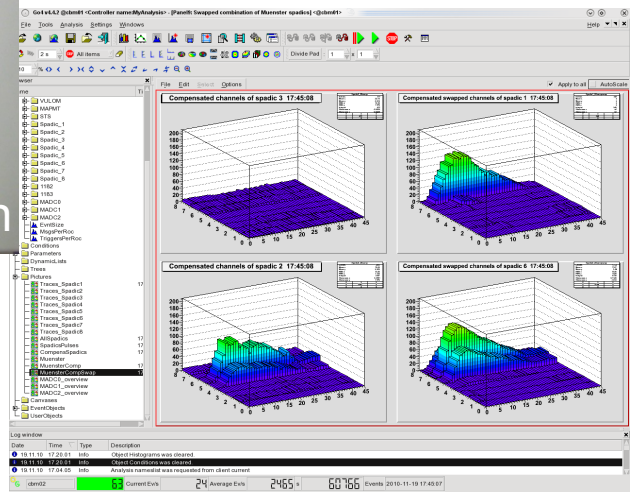
Latest Prototype: SPADIC v0.3

in the lab...



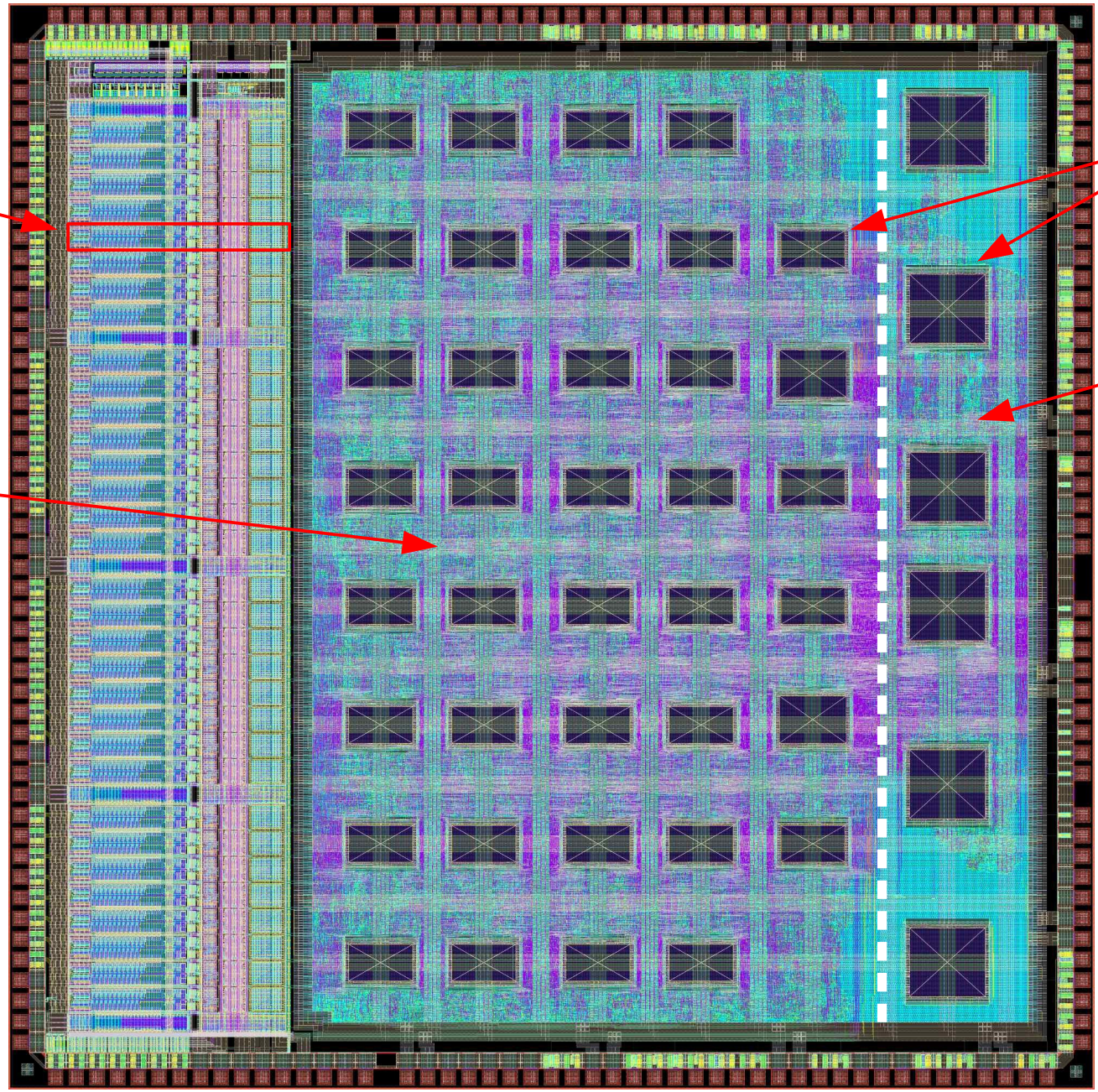
Latest Prototype: SPADIC v0.3



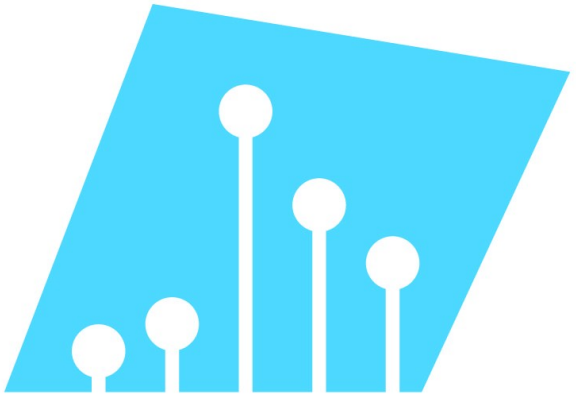


...and at CERN, testbeam 2010

SPADIC v1.0 Top-Level Layout



submitted:
November 2011
UMC 180 nm
5x5 mm²



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