

# SPADIC

Self Triggered Pulse Amplification and Digitization ASIC



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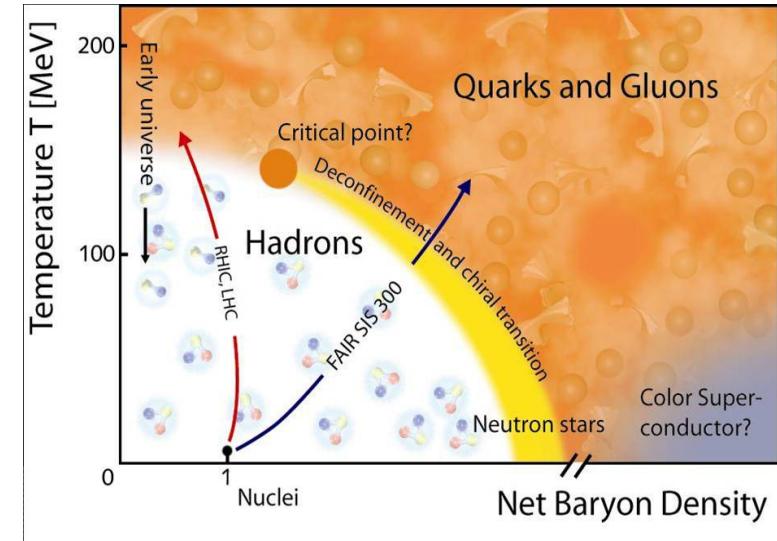
<http://spadic.uni-hd.de>

ANSiP-2011

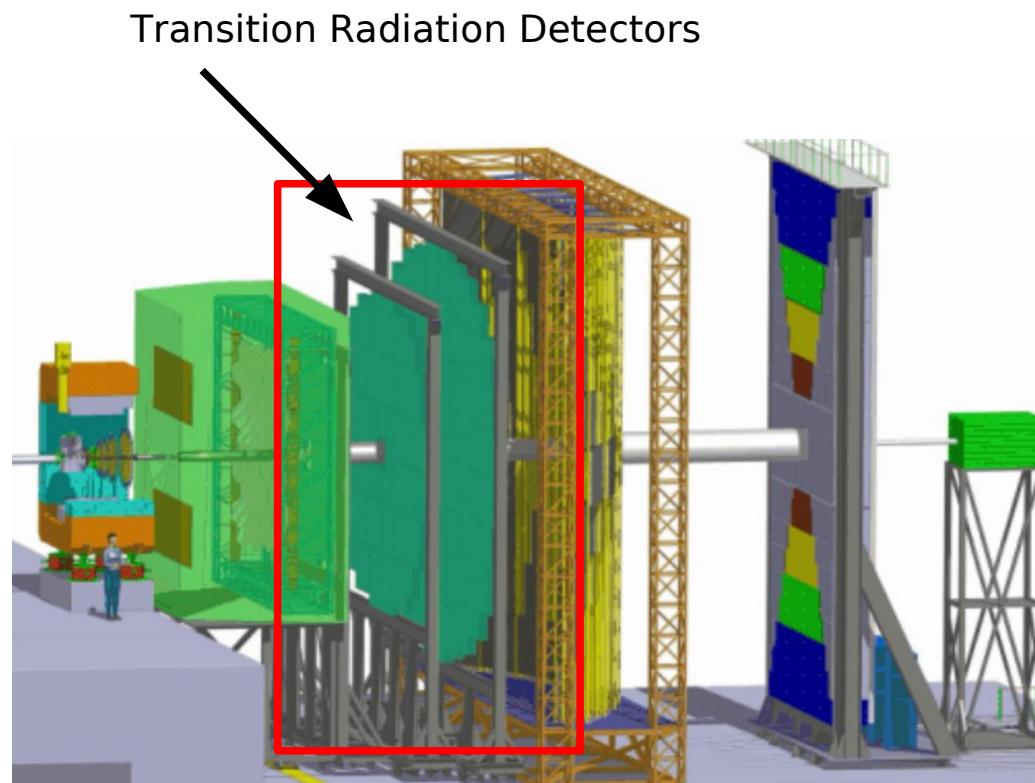
# SPADIC – Overview

# The CBM Experiment

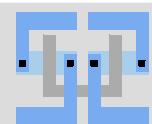
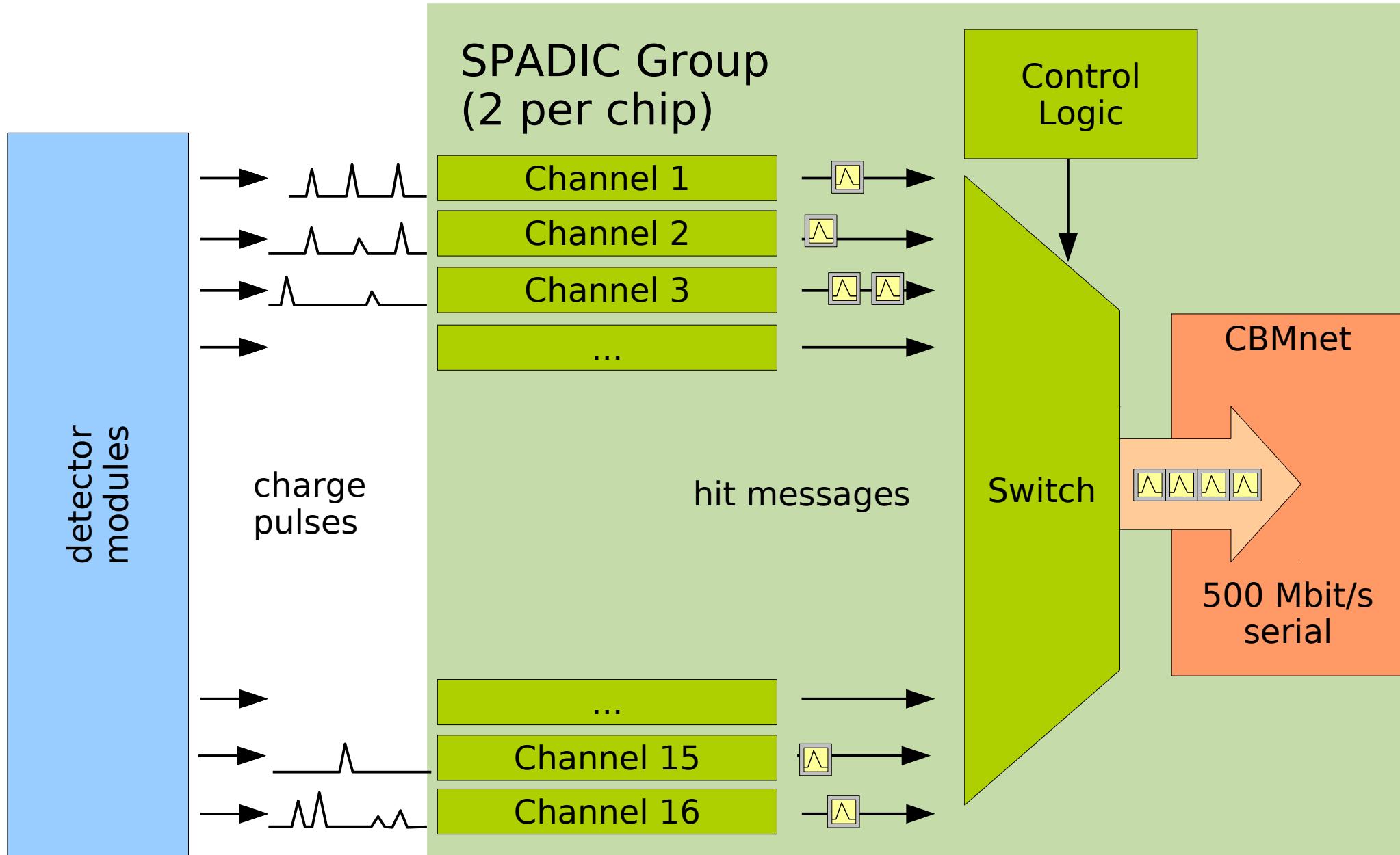
- FAIR: new accelerator at GSI
- CBM: Compressed Baryonic Matter
- fixed-target experiment at FAIR
- collide heavy ions
- explore QCD phase diagram at high baryon densities



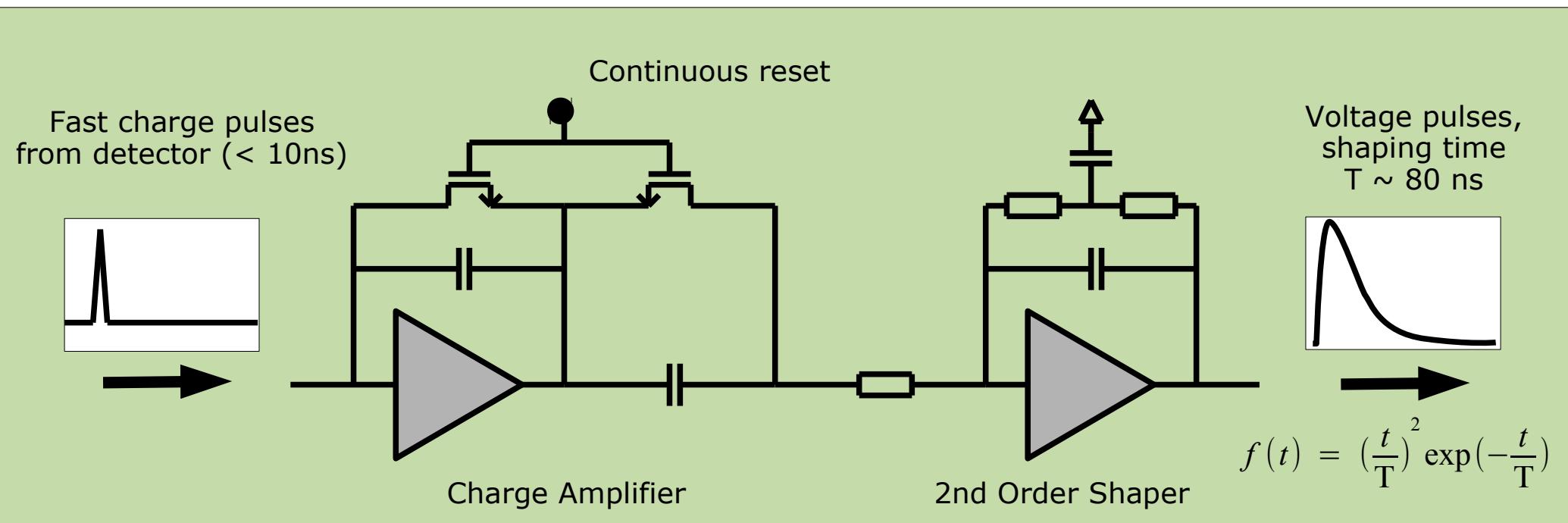
- **Self-Triggered Pulse Amplification and Digitization ASIC**
- Readout of CBM transition radiation detectors (TRD)
- On-Chip:
  - Amplification/Shaping
  - Digitization
  - Signal Processing
  - Hit Detection
  - Message Building
  - Serial Output Interface



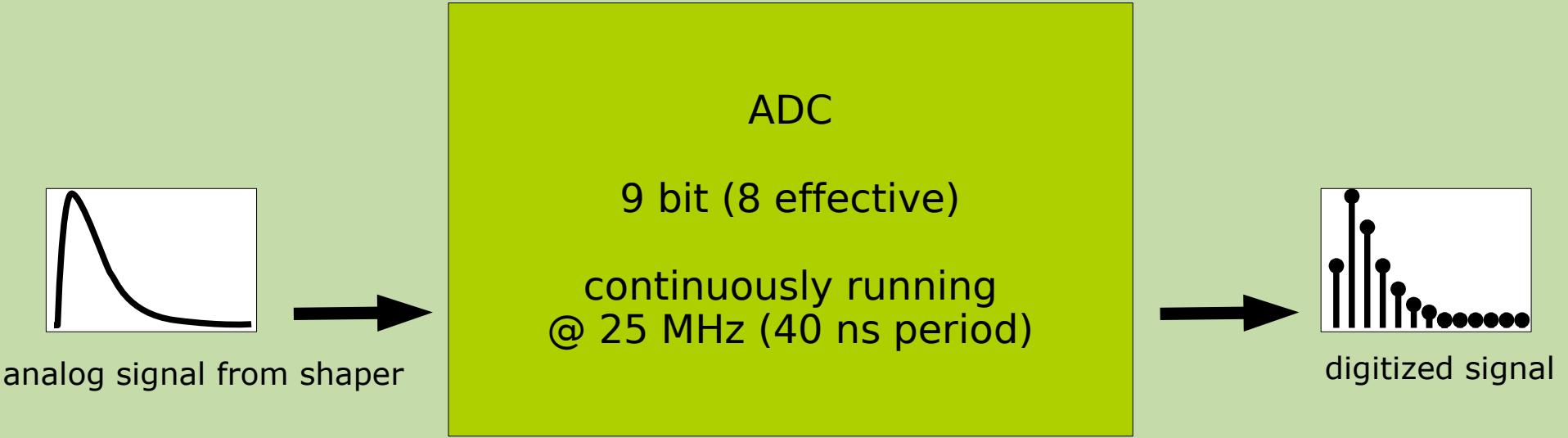
# SPADIC – Architecture



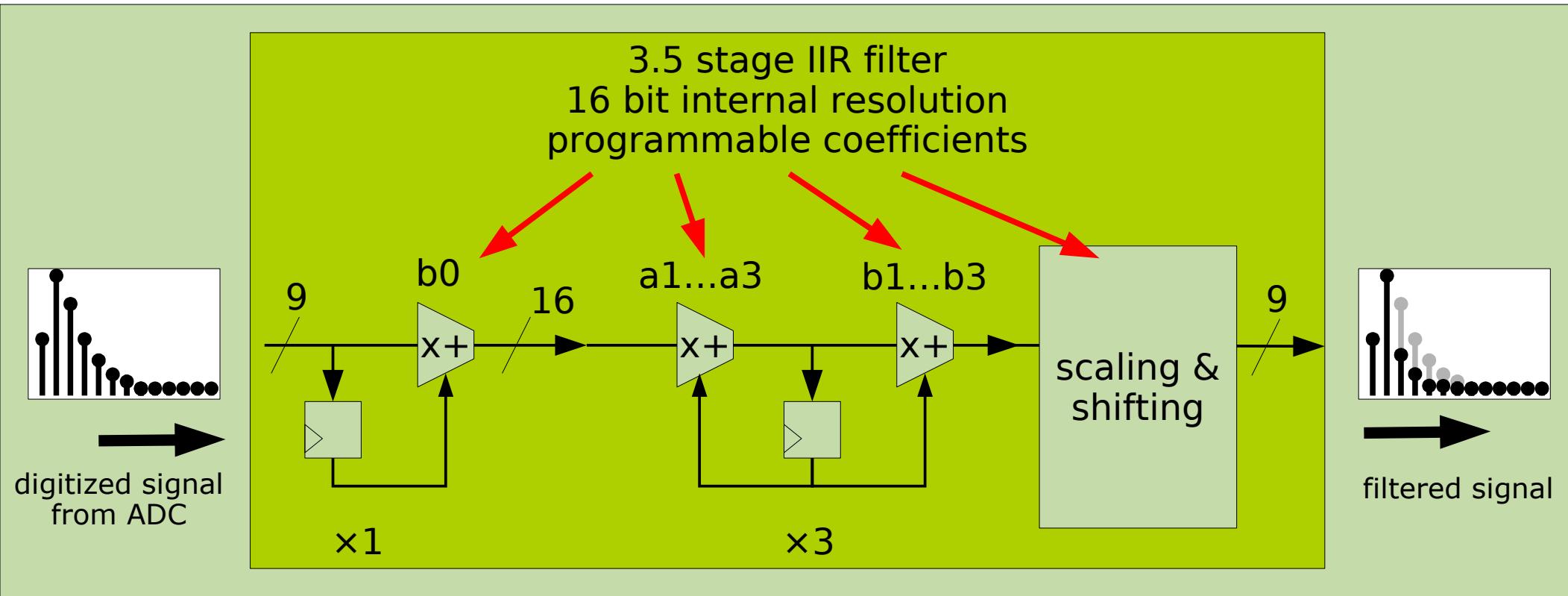
## Step 1: Amplification + Shaping



## Step 2: Digitization

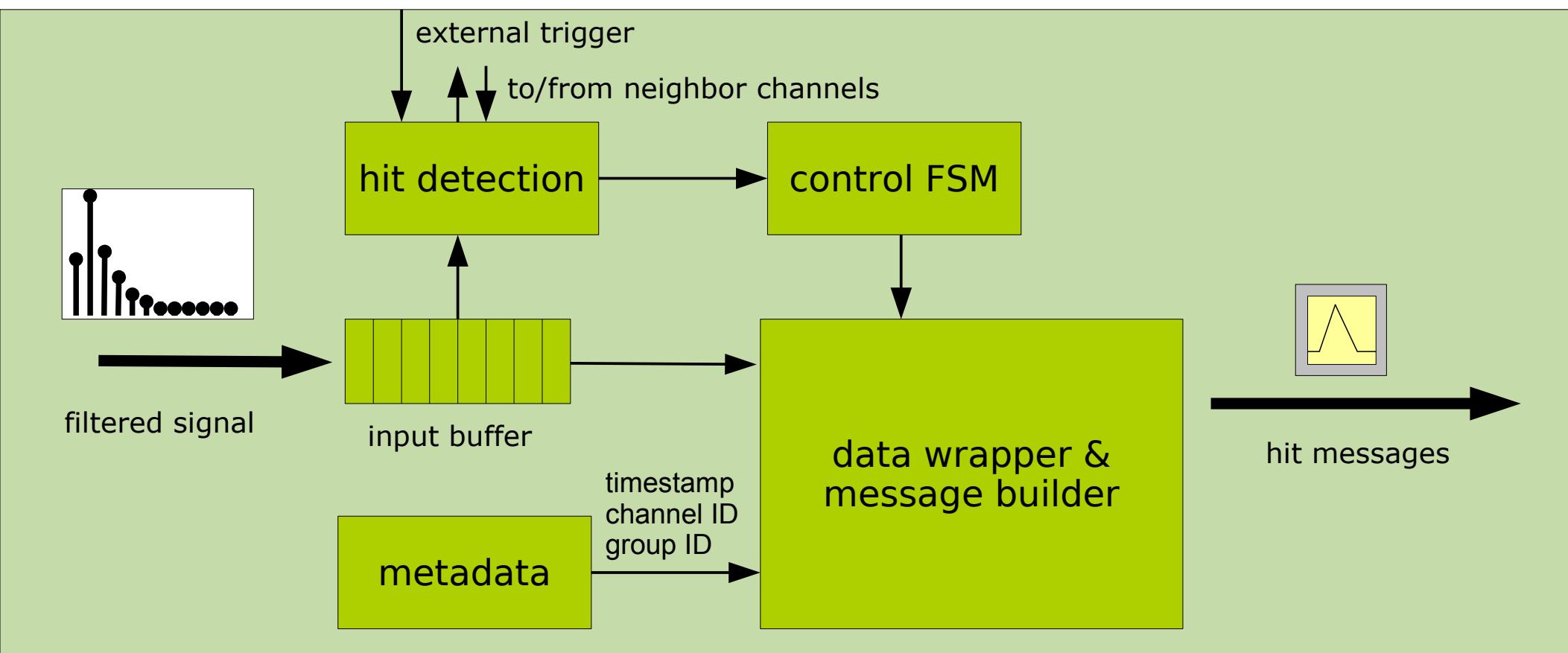


## Step 3: Digital Signal Processing



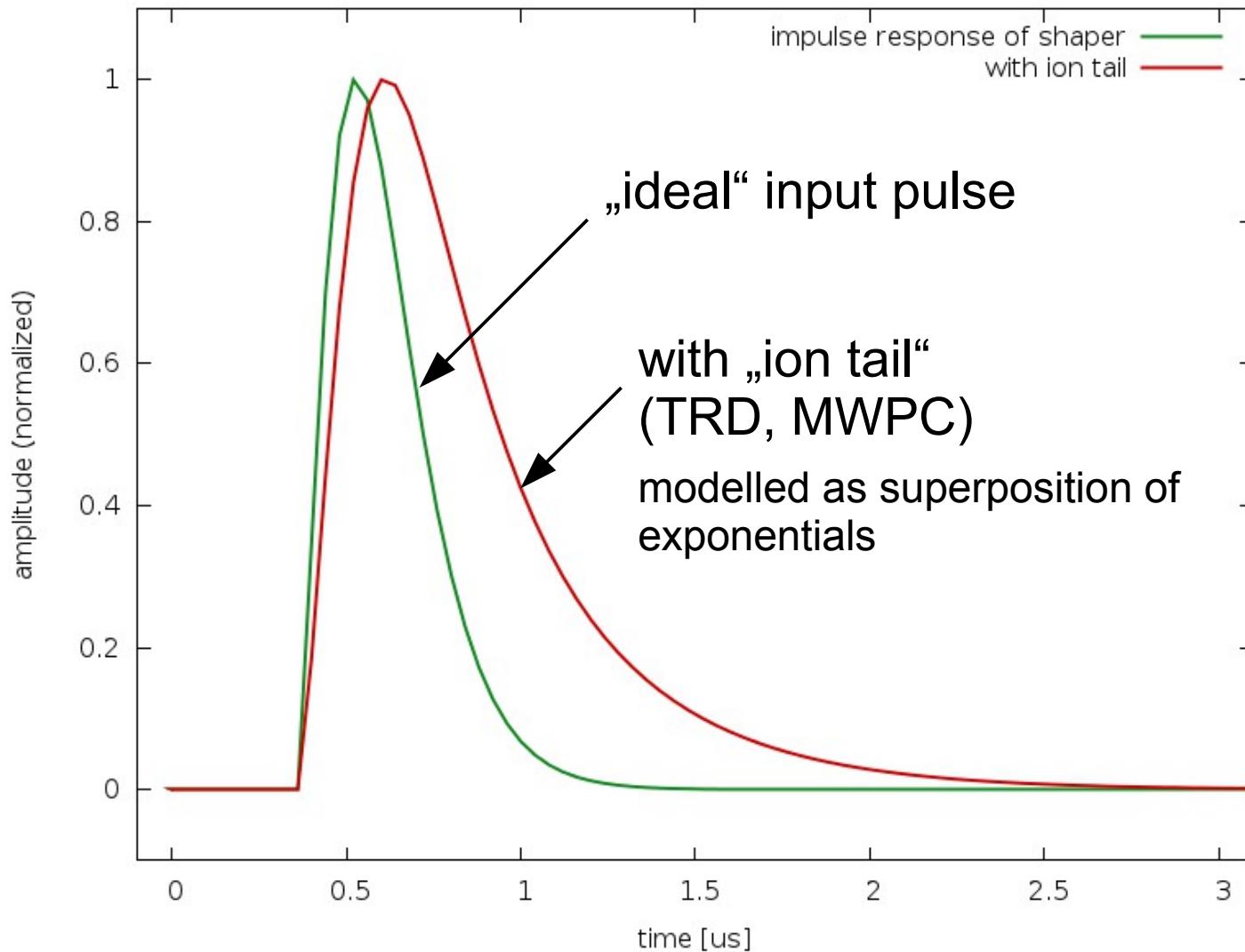
$$H(z) = ((1+b_0 z^{-1}) \frac{(1+b_1 z^{-1})(1+b_2 z^{-1})(1+b_3 z^{-1})}{(1-a_1 z^{-1})(1-a_2 z^{-1})(1-a_3 z^{-1})})$$

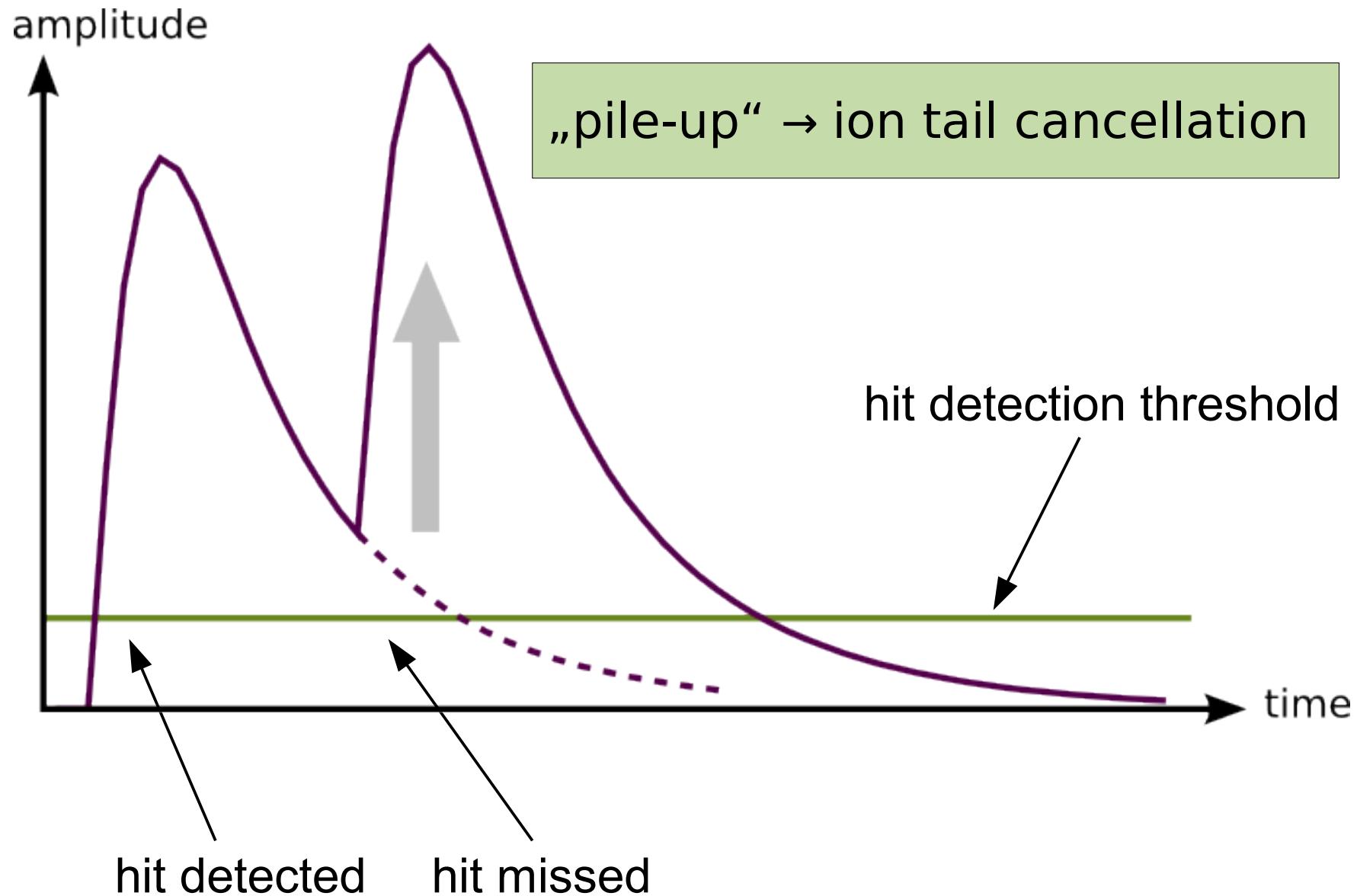
## Step 4: Hit Detection & Message Building (simplified)



# SPADIC - Digital Signal Processing

shaper output:

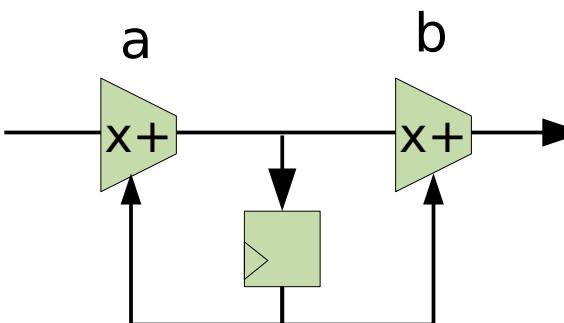
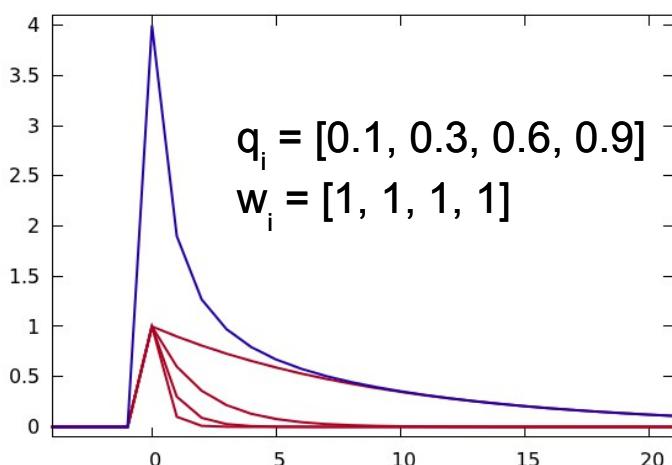




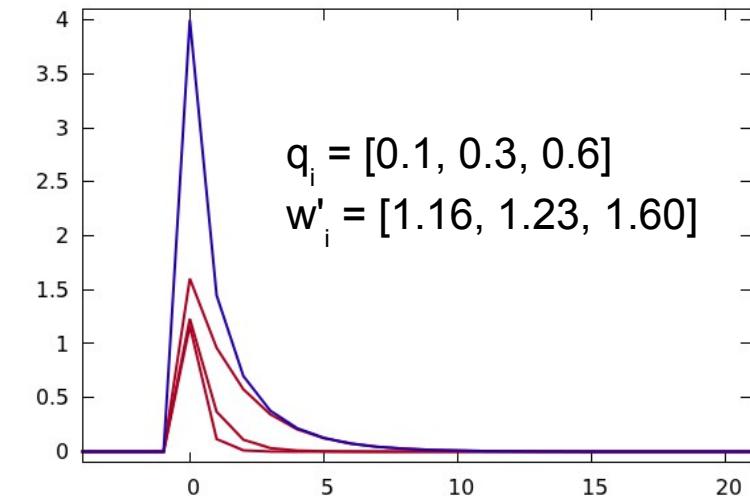
# Ion Tail Cancellation

- charge pulse modelled as superposition of exponentials:

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



$$\begin{aligned} b &= -0.9 \\ a &= 0.78 \end{aligned}$$

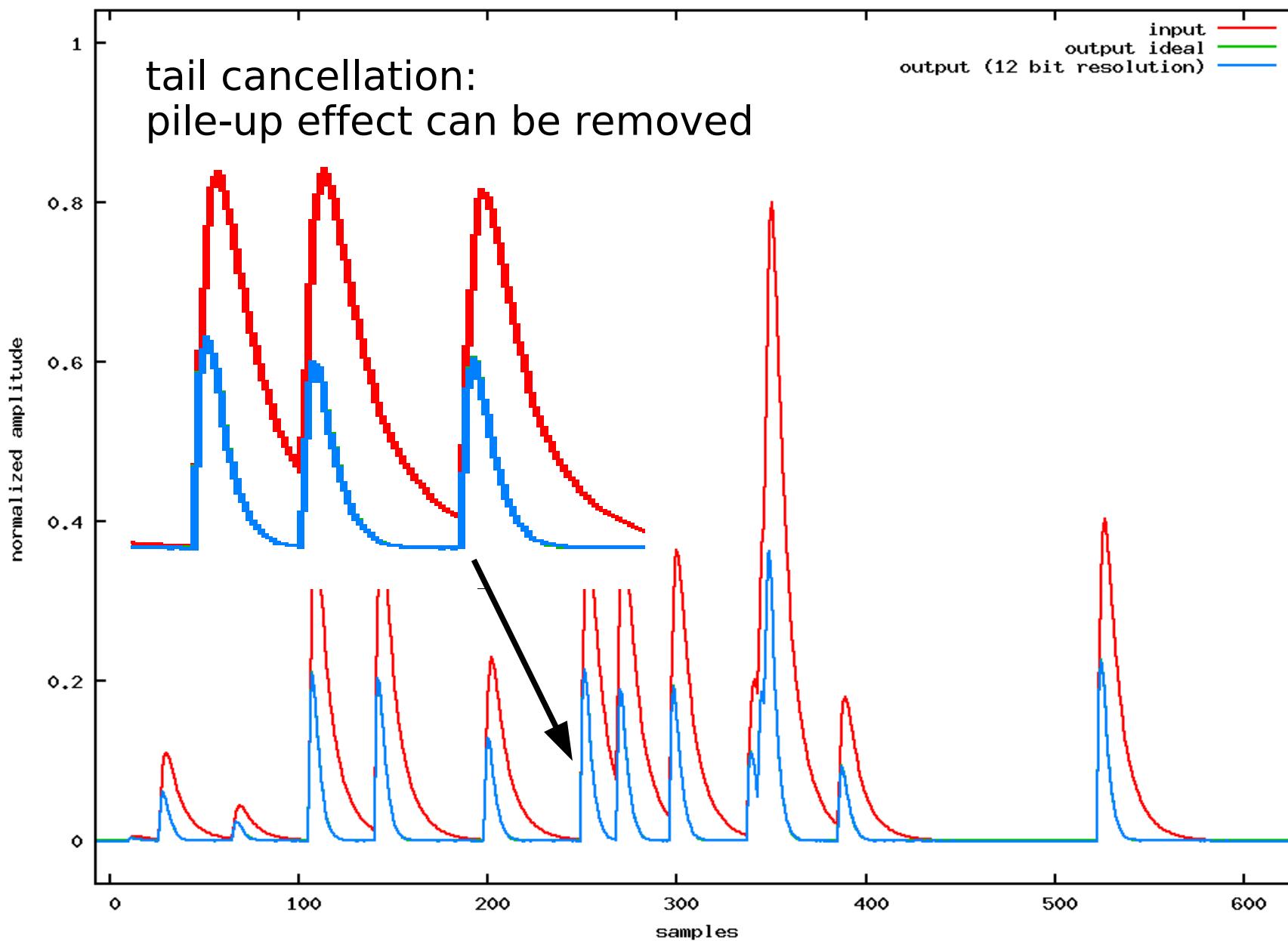


$$y[n] = w'_0 q'_0^n + w'_1 q'_1^n + w'_2 q'_2^n + w'_3 q'_3^n$$

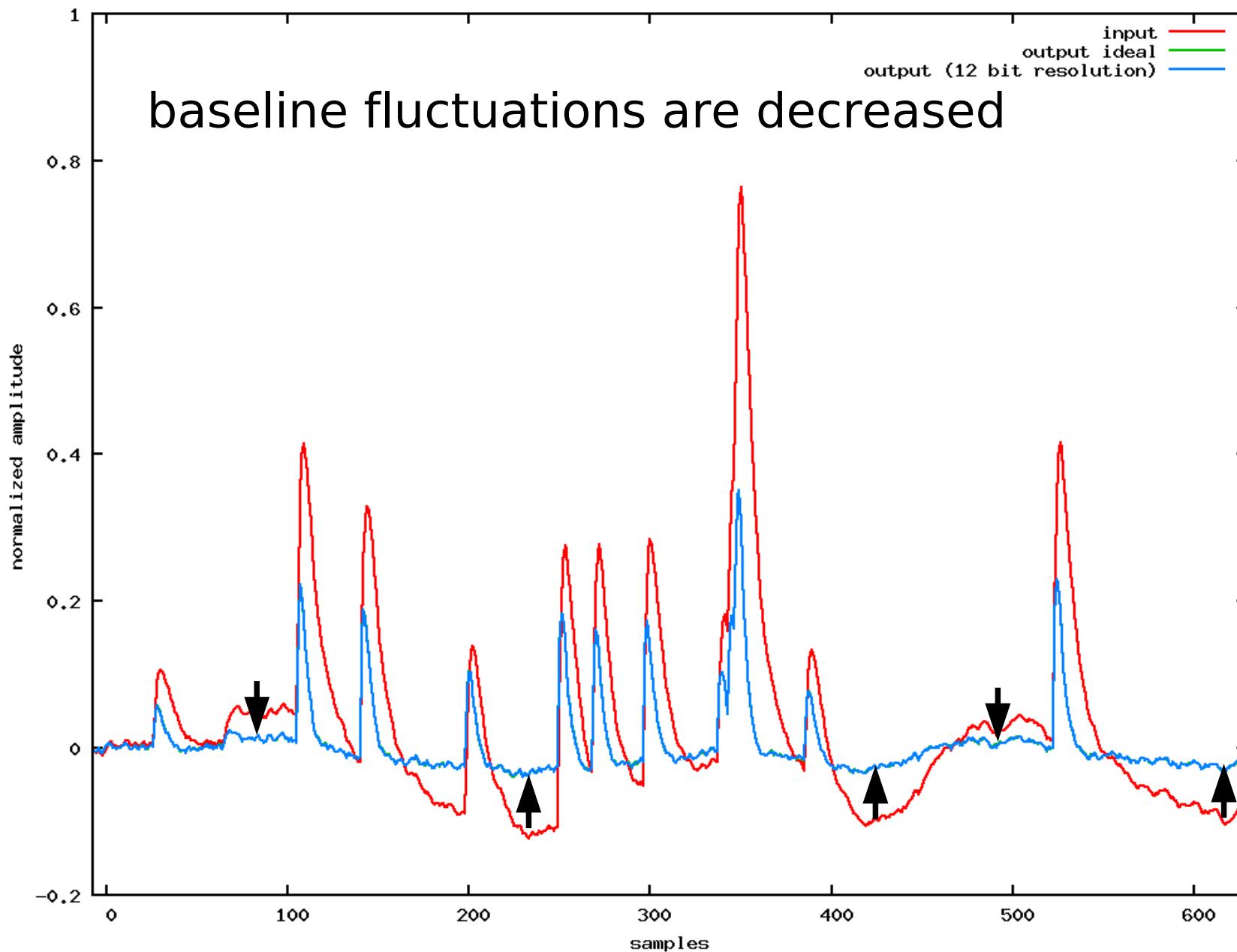
~~x~~

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

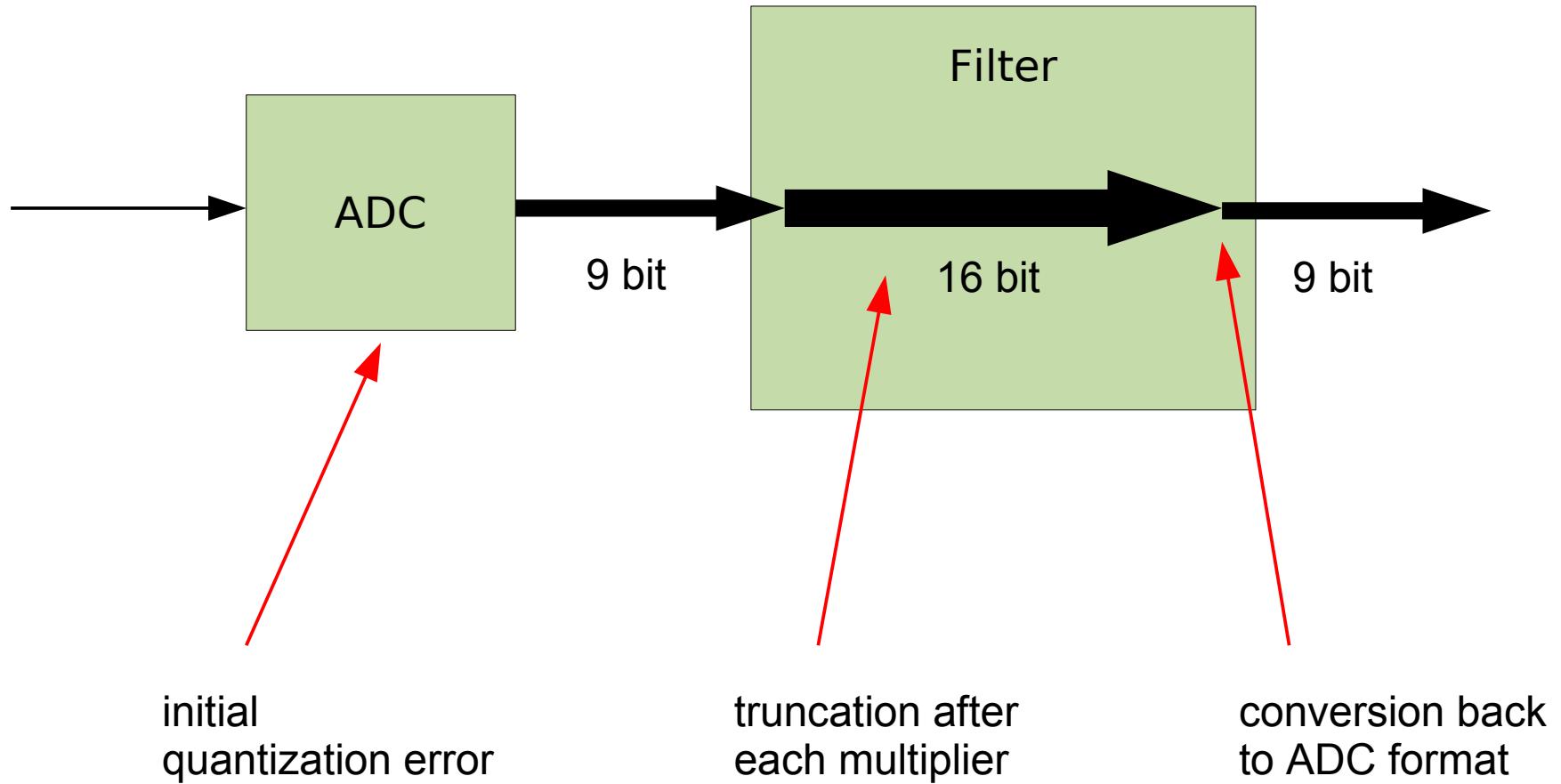
# SPADIC - Digital Signal Processing



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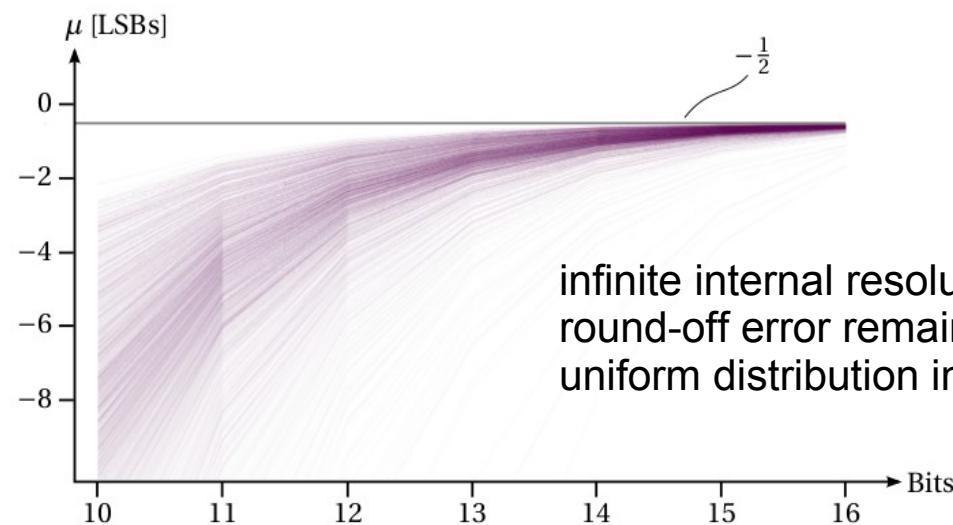
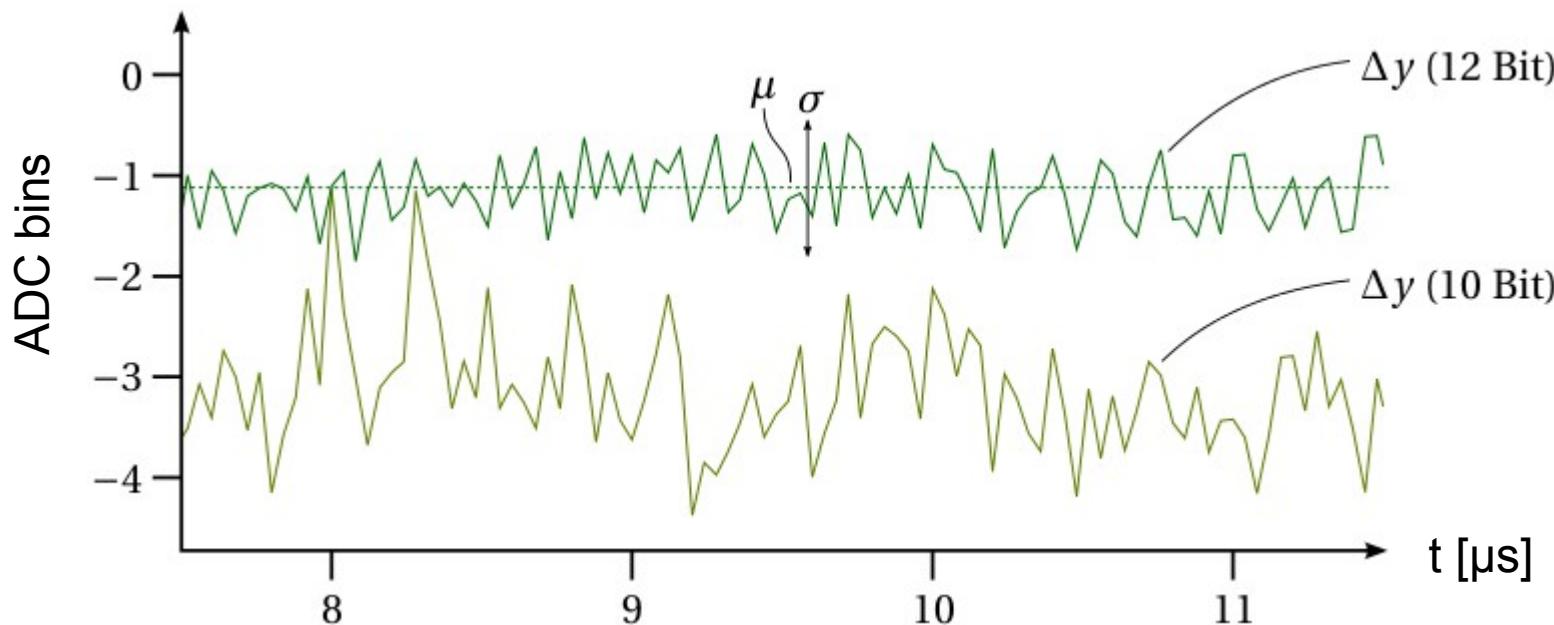


# Quantization Error - Sources

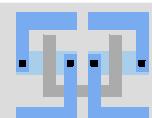
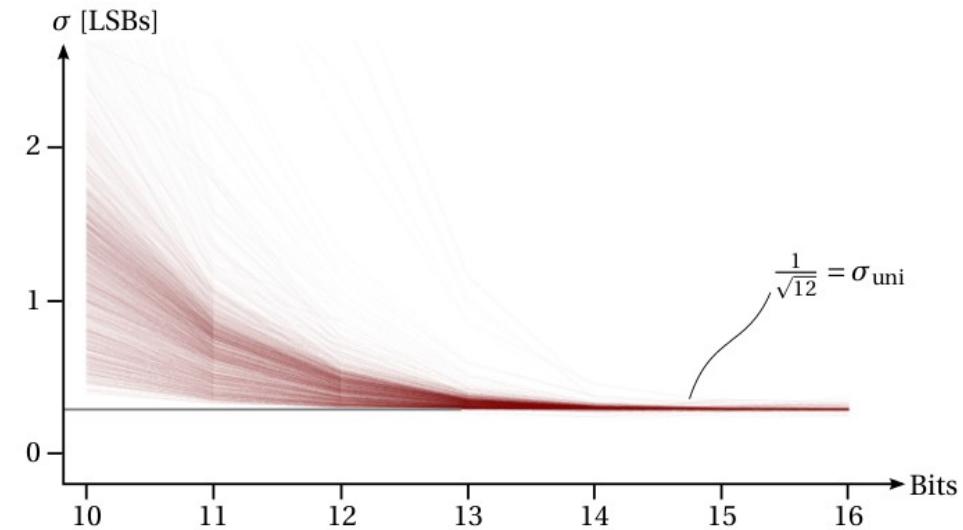


# Quantization Error (1)

quantization error introduced in the filter:

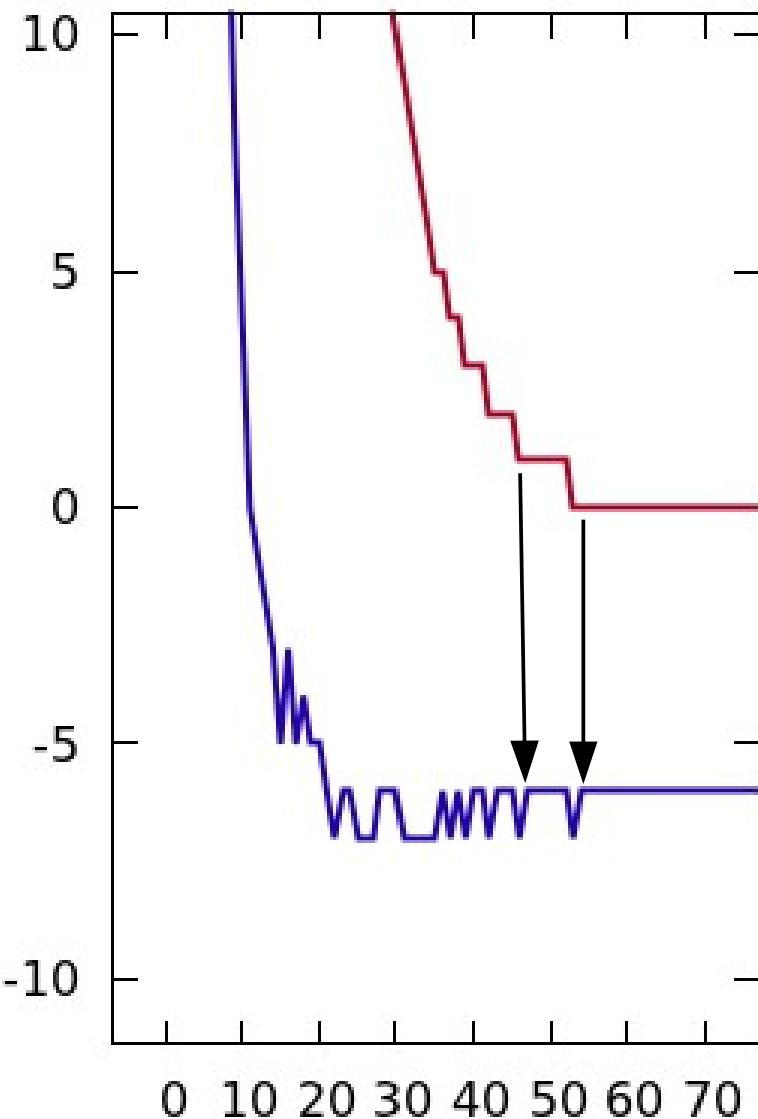


infinite internal resolution:  
round-off error remains  
uniform distribution in [-1,0]



## Quantization Error (2)

quantization error present before the filter:

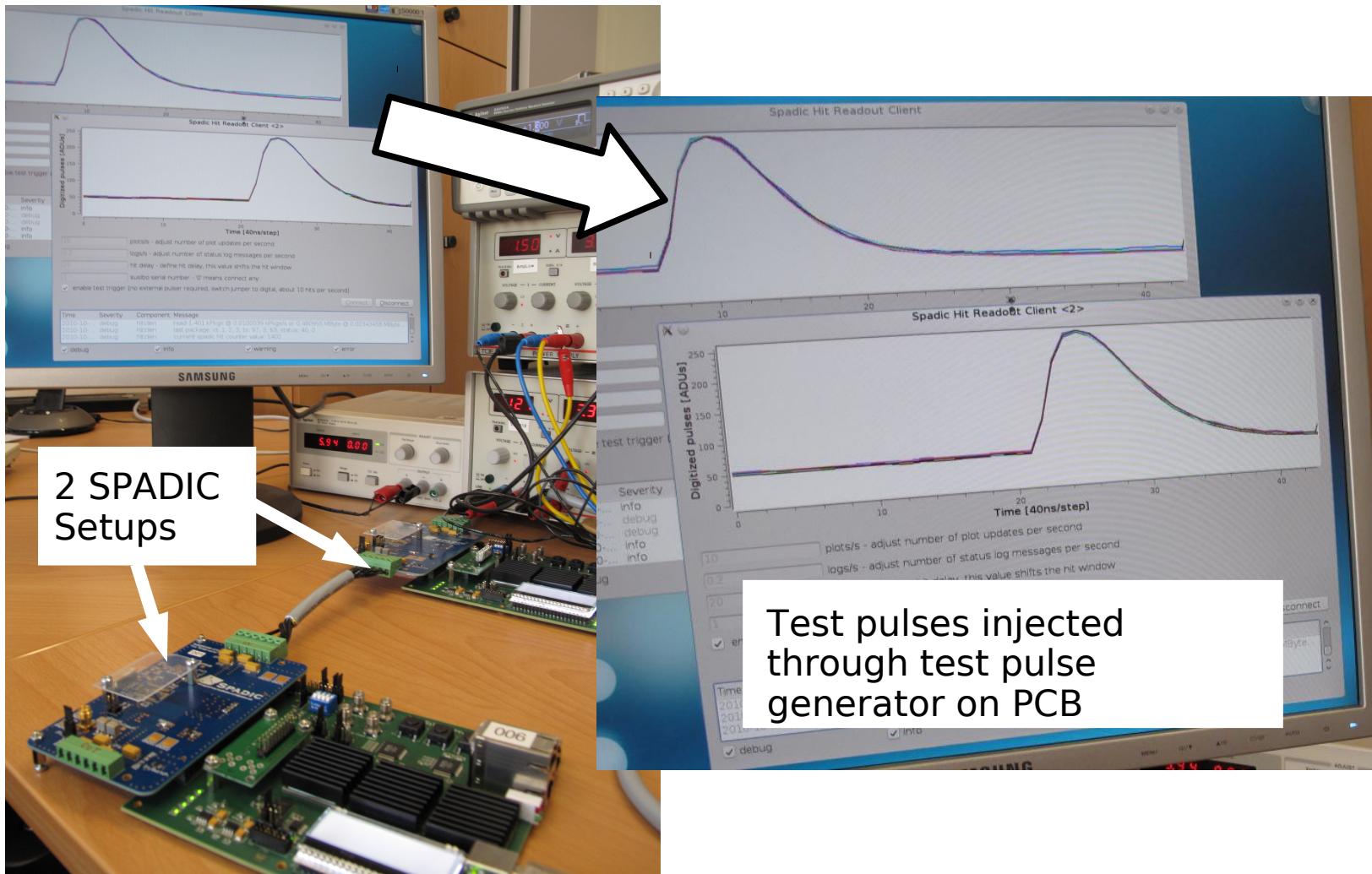


- high-frequency content in quantization error of ADC (sawtooth)
- limits use of filtering (high-pass)
- more detailed analysis needed

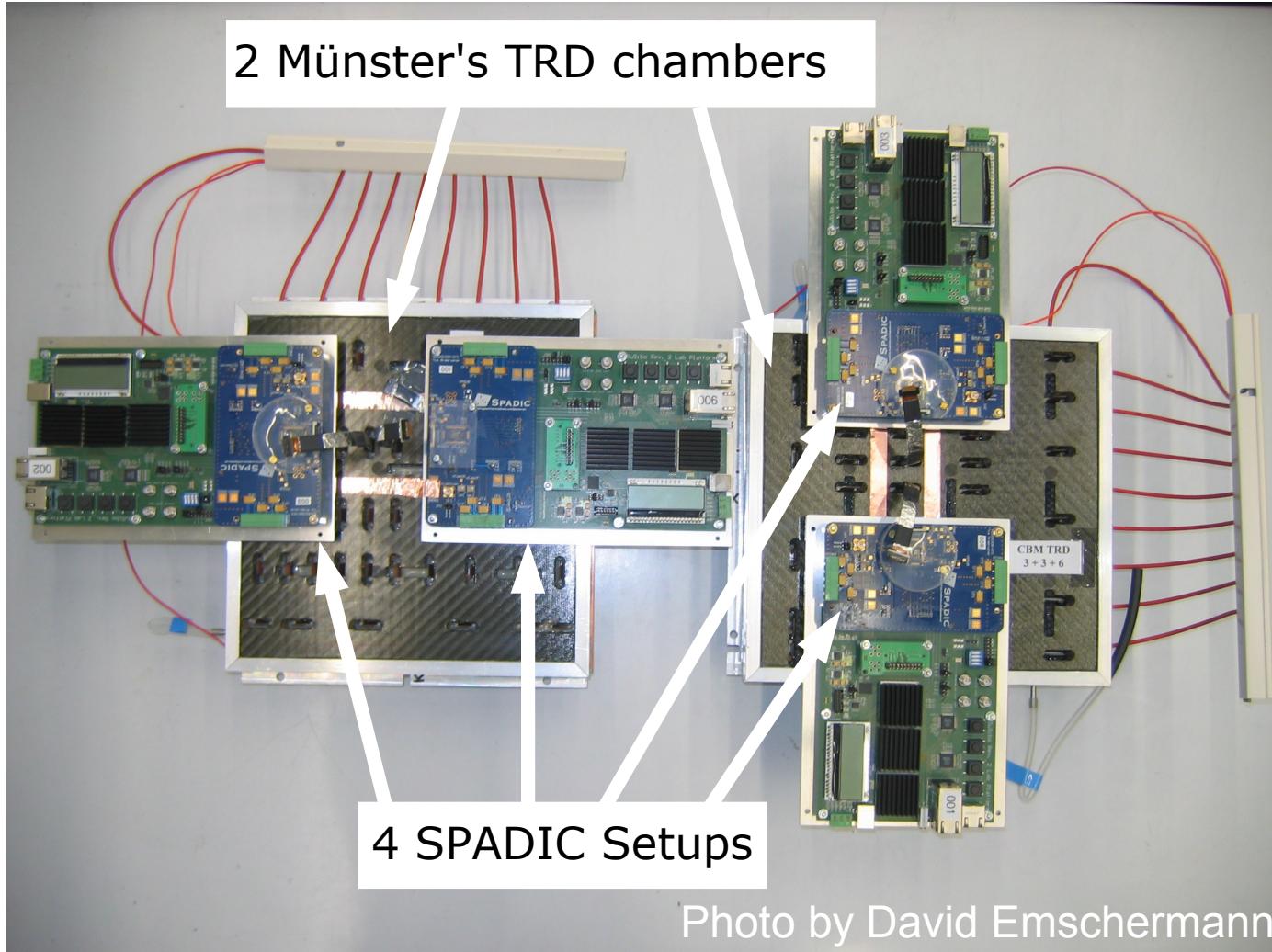
# Status

# Latest Prototype: SPADIC v0.3

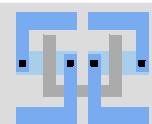
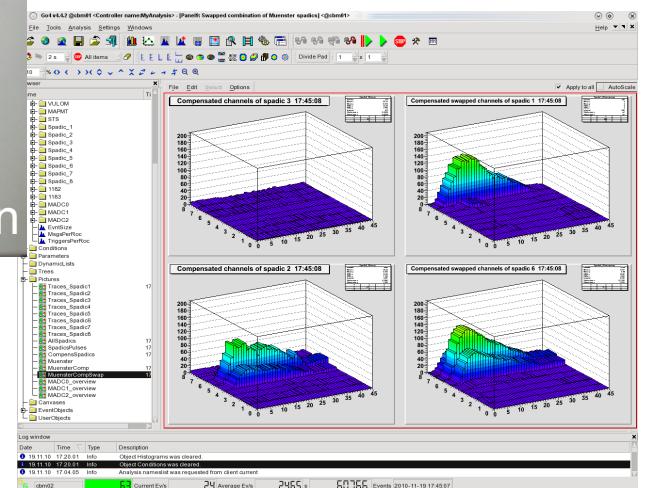
in the lab...



# Latest Prototype: SPADIC v0.3



...and at CERN, testbeam 2010

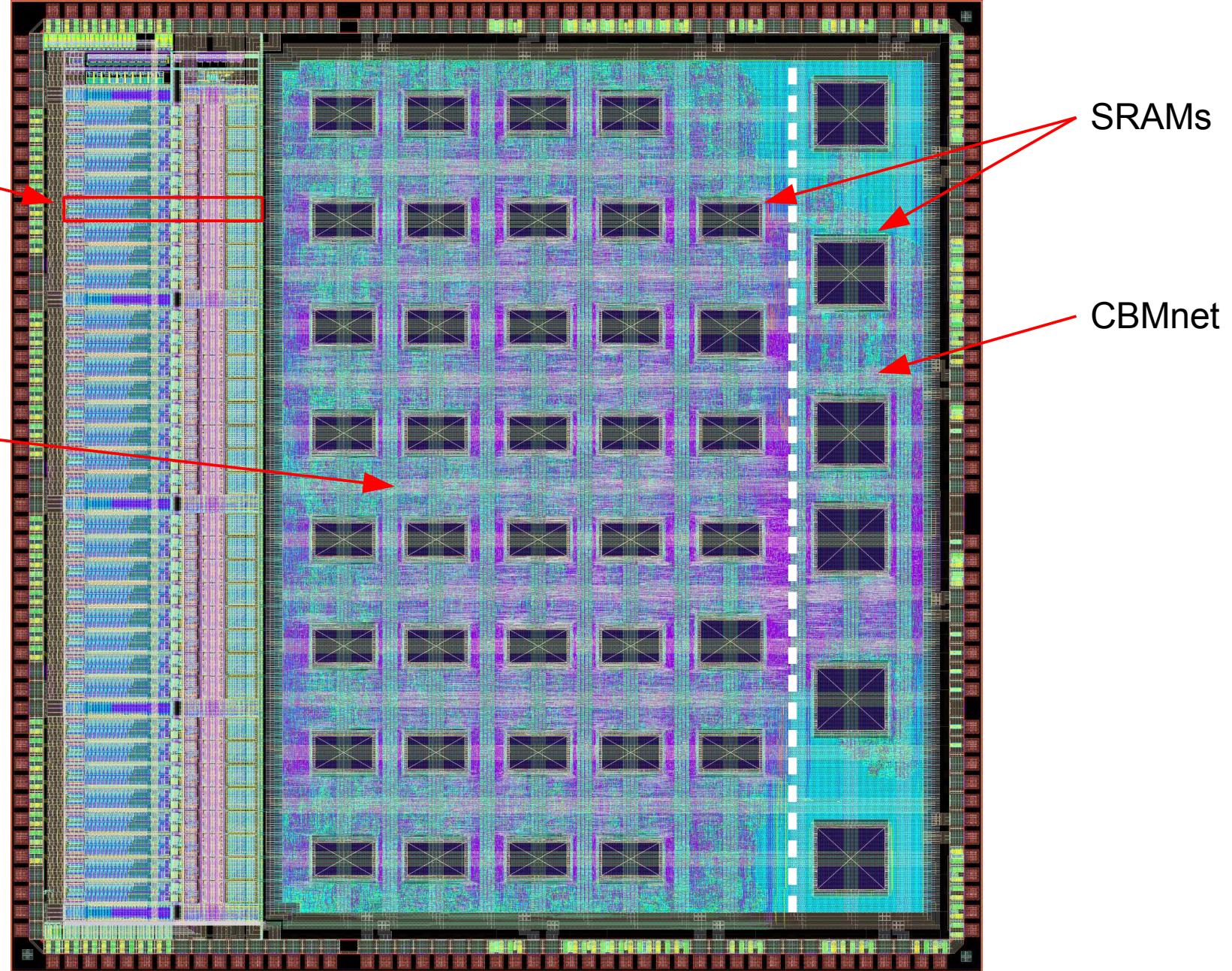


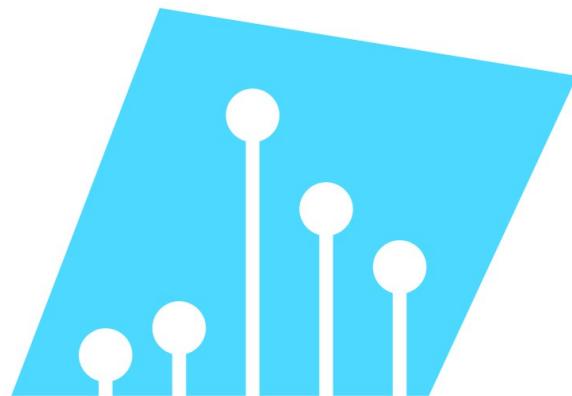
# SPADIC v1.0 Top-Level Layout

amplifier/shaper,  
ADC

digital part

submitted:  
November 2011  
UMC 180 nm  
 $5 \times 5 \text{ mm}^2$





# SPADIC

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