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EMC Feature-Extraction, Pulse detection

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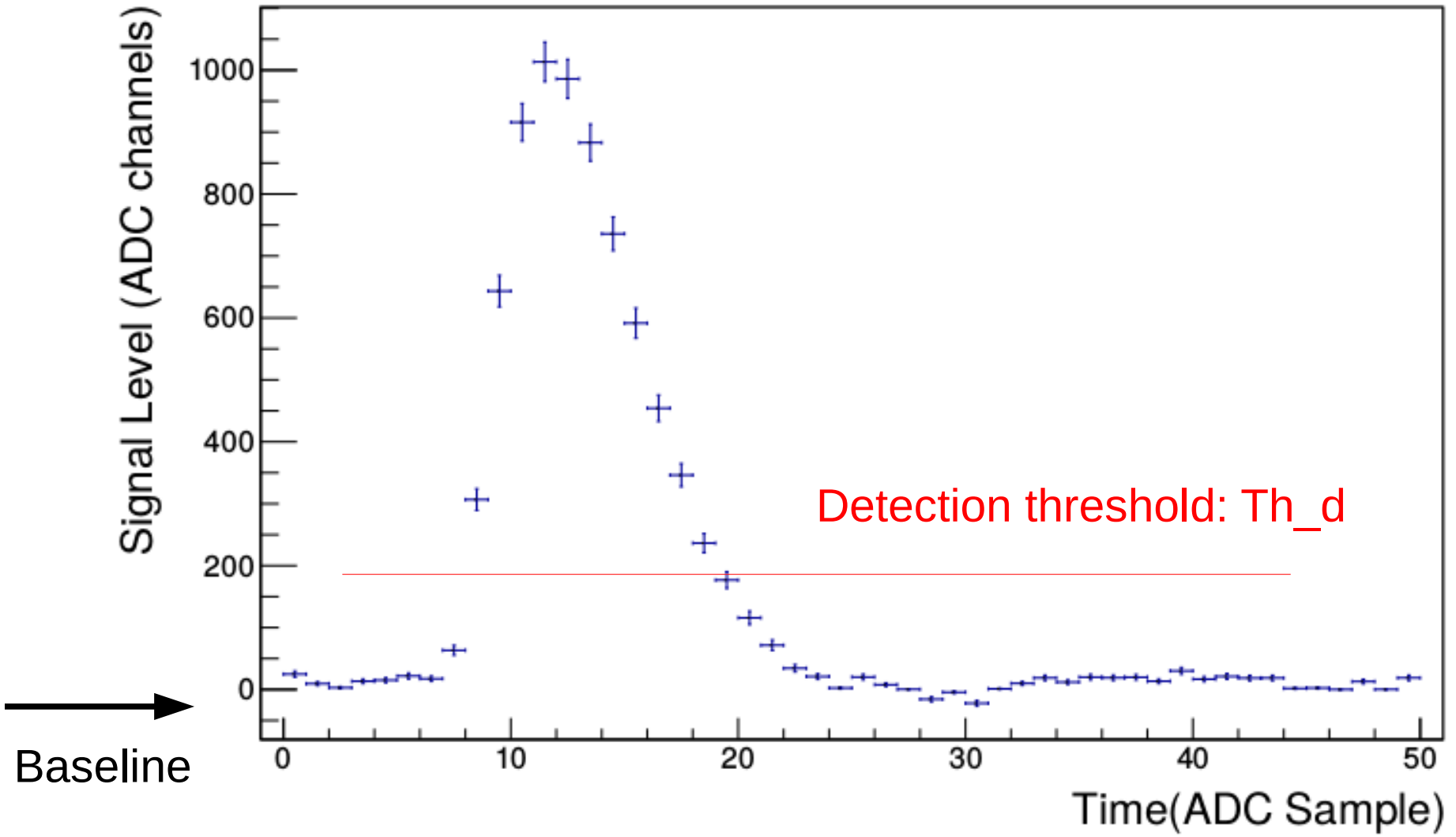
for the PANDA collaboration

Pulse Detection: Threshold

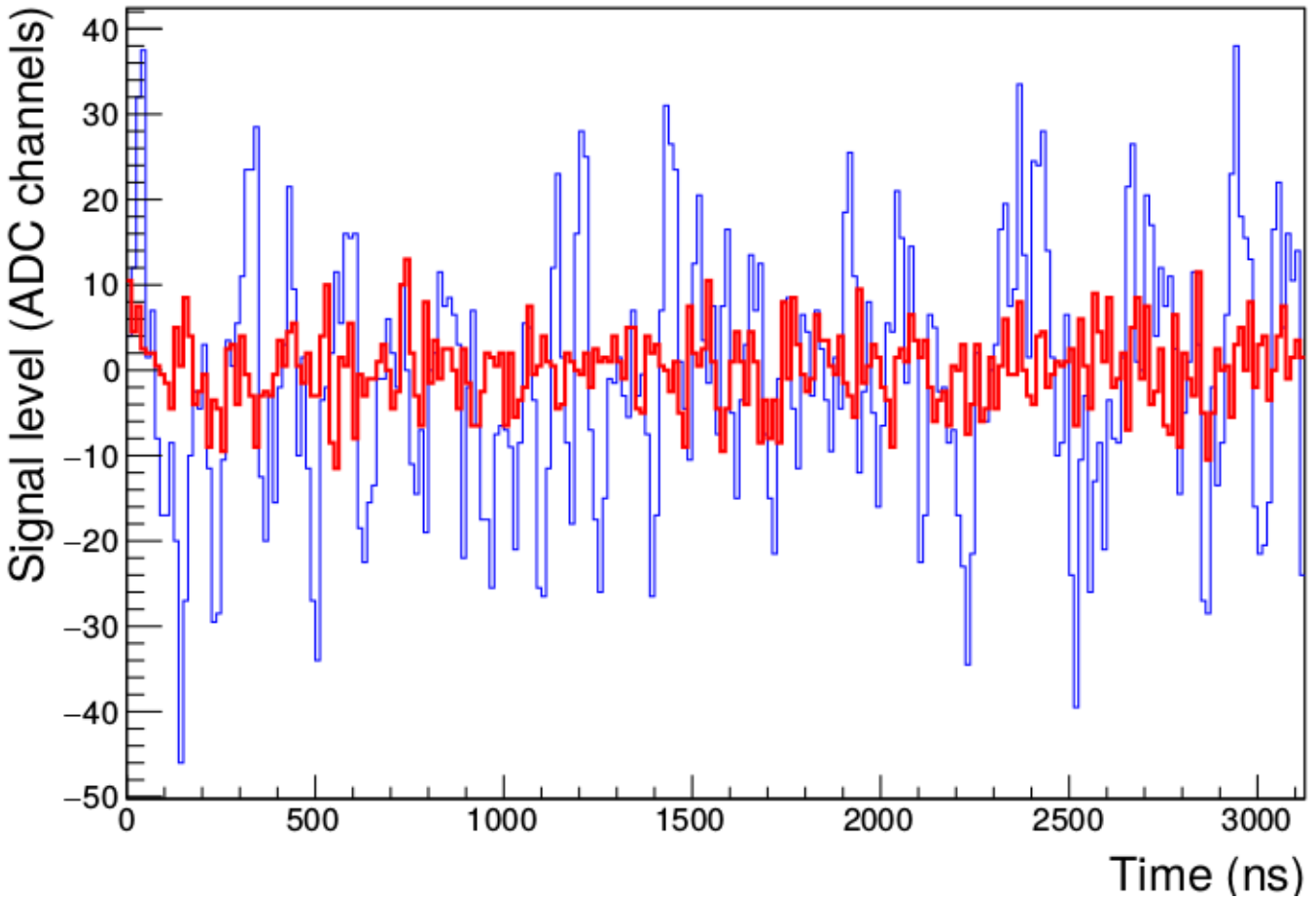
ADC samples after base-line subtraction



Straight-forward pulse detection: Threshold crossing

False pulse-detection rate depends on the noise level as...

Noise Level



ADC with LNP preamp.

ADC with open input

Assuming threshold at 3σ of the noise level

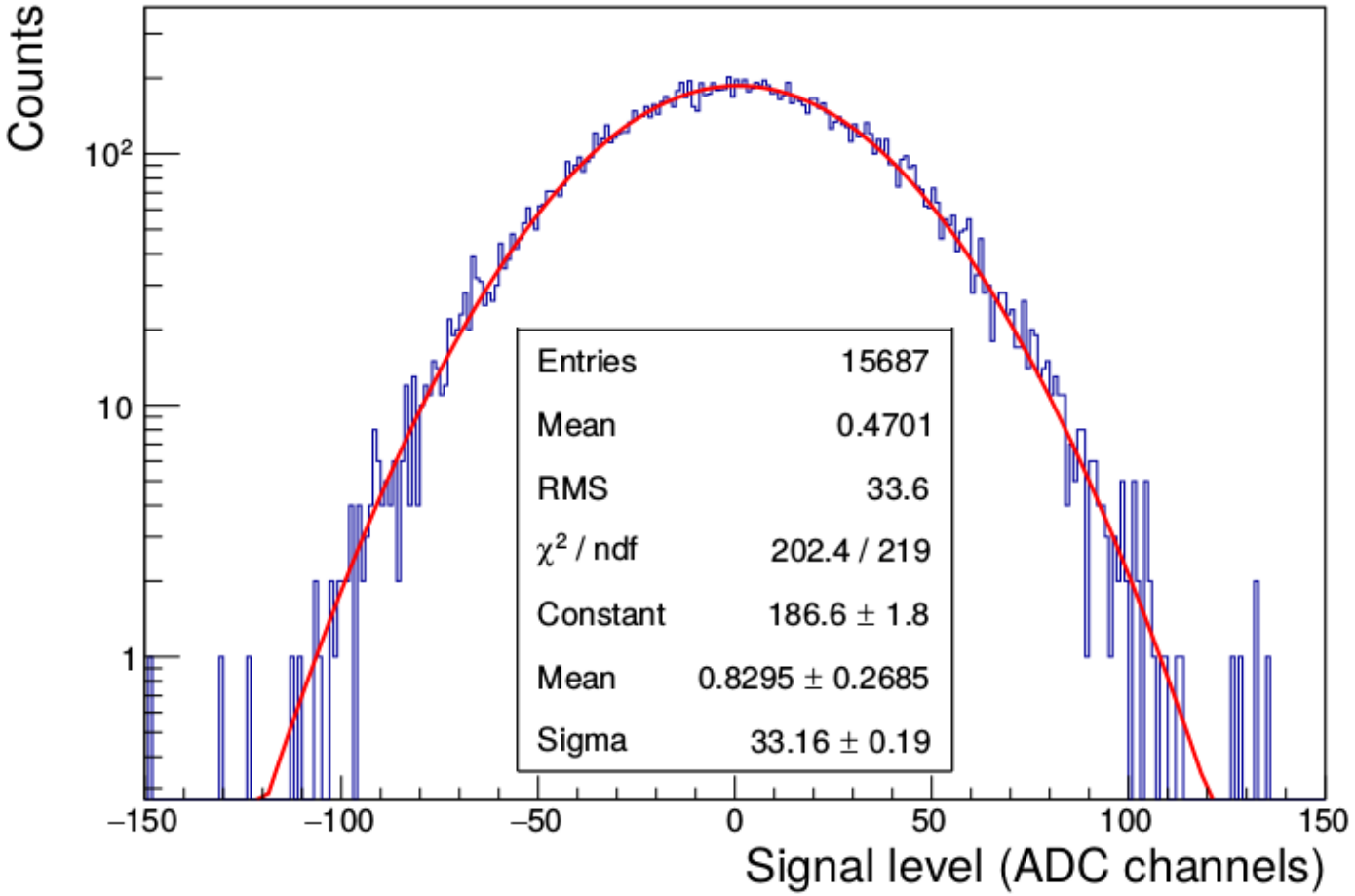
… rate = sampling_frequency * 0.0013

= 100 kHz

(80 MHz sampling rate)

Noise Level: Measurement

ADC samples after base-line subtraction

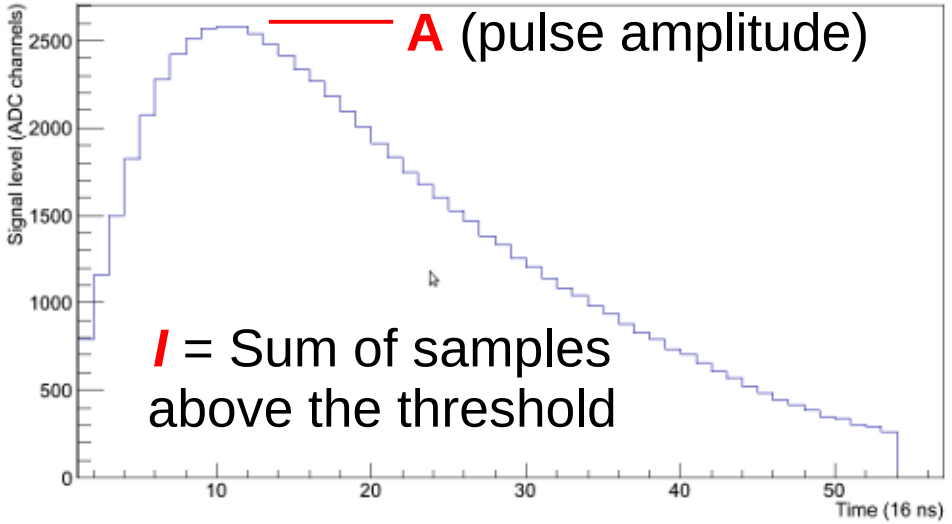


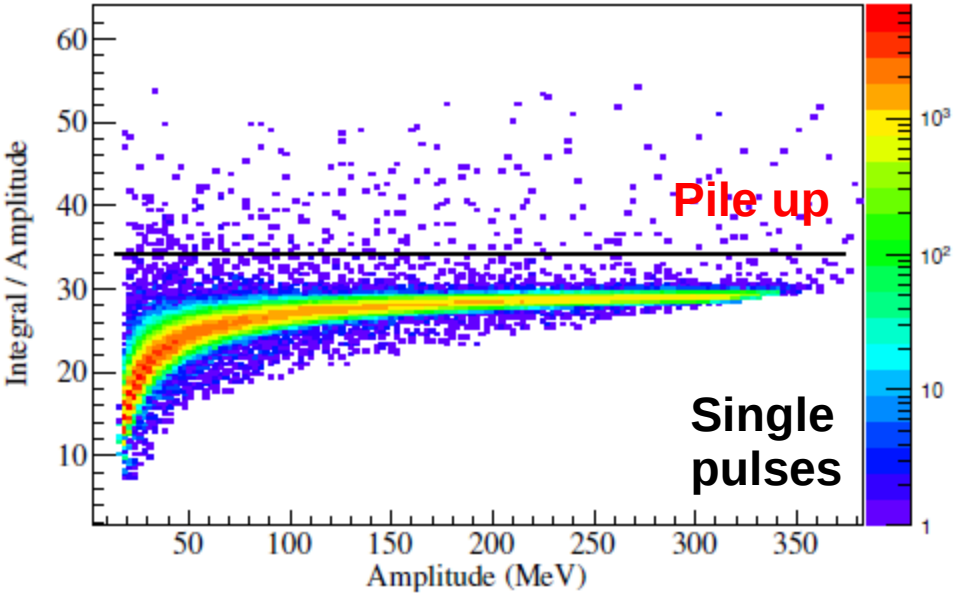
Straight-forward pulse detection: With threshold of **100** we should expect rate of 100 kHz

We should use information on pulse shape to suppress false hits...

Pulse Detection: Pulse

- Baseline of the signal is continuously subtracted
- Once signal crosses detection **threshold**, samples are collected in a buffer until signal drops below **threshold/4** (one pulse before detection threshold and one sample after end-of-signal threshold are included into the buffer)
- **Pulse is detected if:**
  - Number of samples in the buffer (waveform length) > **min_wf_length**
  - Number of samples in the buffer < **pileup_wf_length**
  - Ratio **Int/A** (pulse area over amplitude) > **min_IA**
  - Ratio **Int/A** (pulse area over amplitude) < **pileup_IA**





Pulse Detection: Pile-up

Pulse pile-up is detected if:

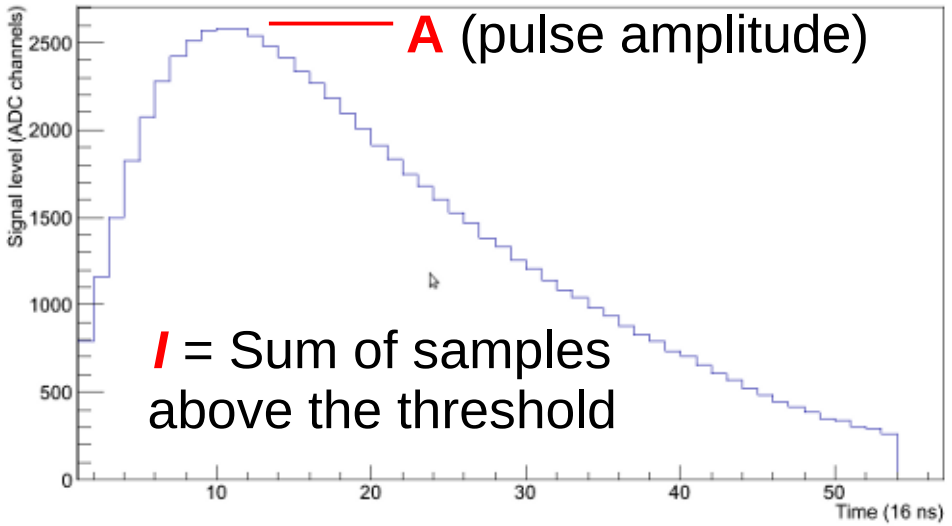
- Number of samples in the buffer > **pileup_wf_length**

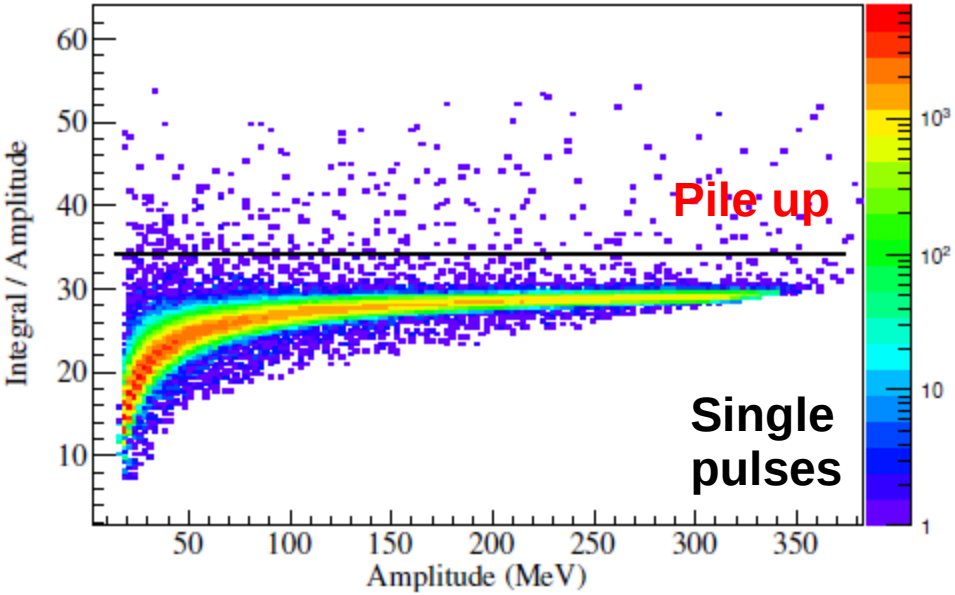
OR

- Ratio **Int/A** (pulse area over amplitude) > **pileup_IA**

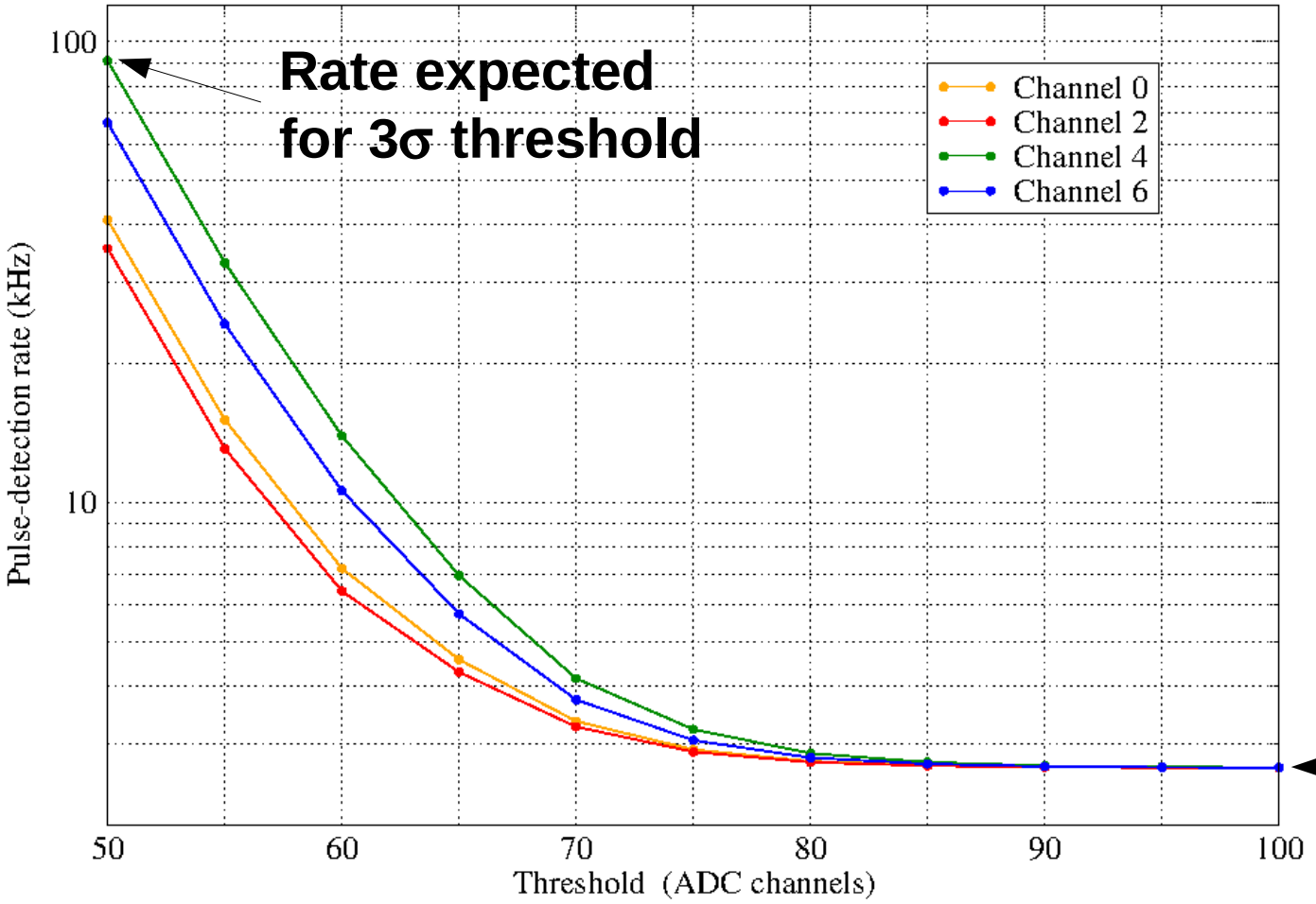
If pile-up is detected complete waveform is sent do EMC DC

New: if it amplitude **A < 2×threshold** and waveform is detected as pile-up, it is discarded (most probably it is noise and if it contains pulse it is too distorted to be useful)





Measurement with LED pulser



Noise level (sigma):

- Channel 0: 33.2
- Channel 2: 33.7
- Channel 4: 35.7
- Channel 6: 35.2

LED pulser rate
(~2.6 kHz)

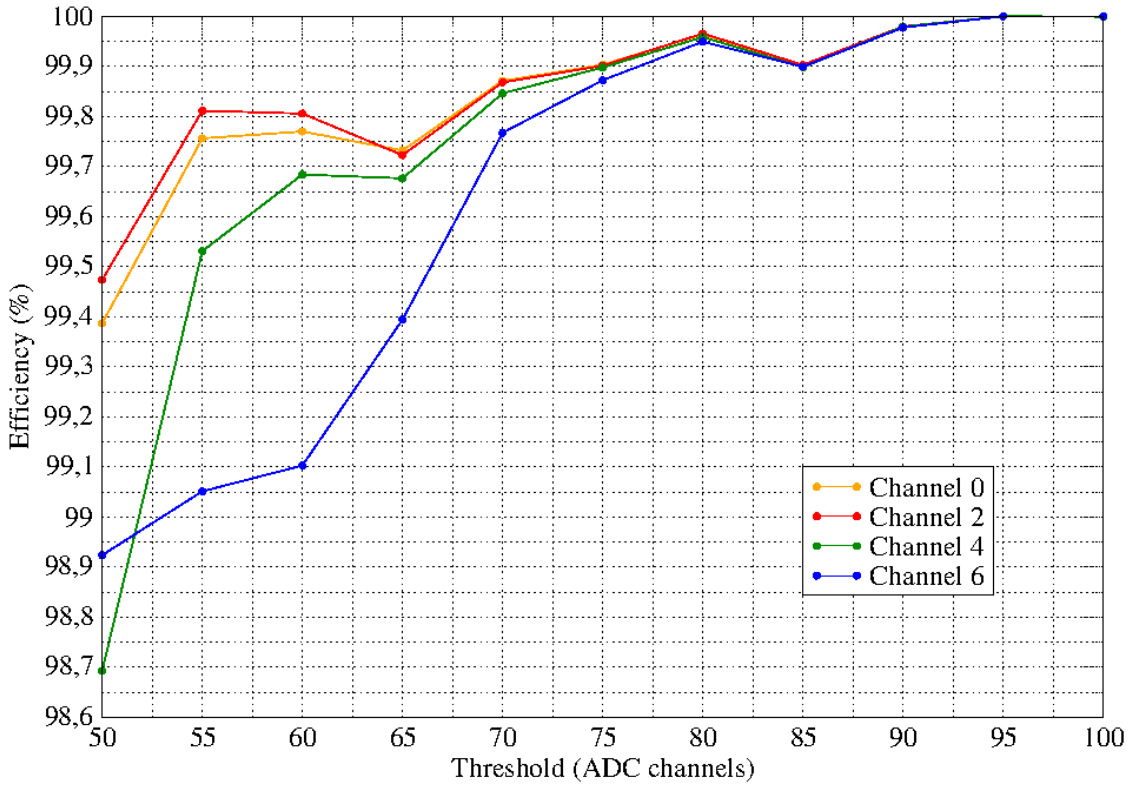
Performance of the “smart pulse detection”:

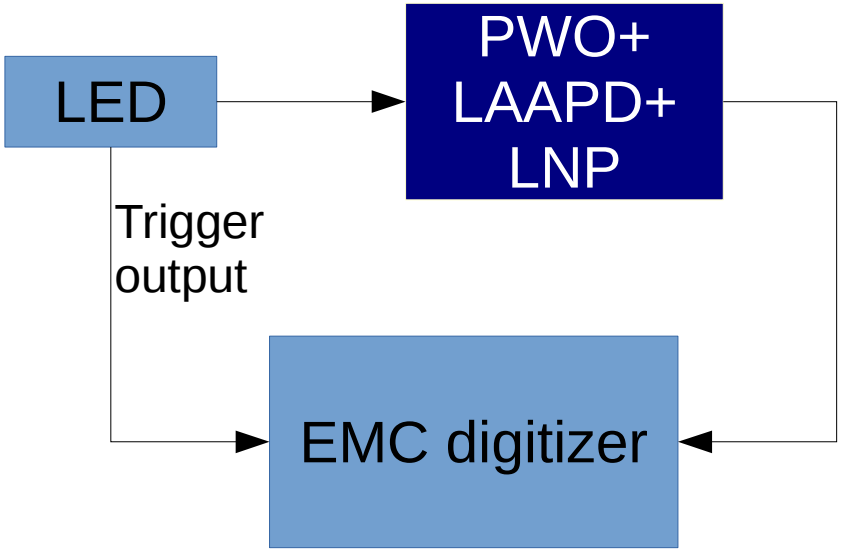
False hit-detection rate with threshold of 2 sigma only ~ 1 kHz

Do we lose any pulses due to the low threshold?

Efficiency of pulse detection

Hit-detection efficiency vs. threshold



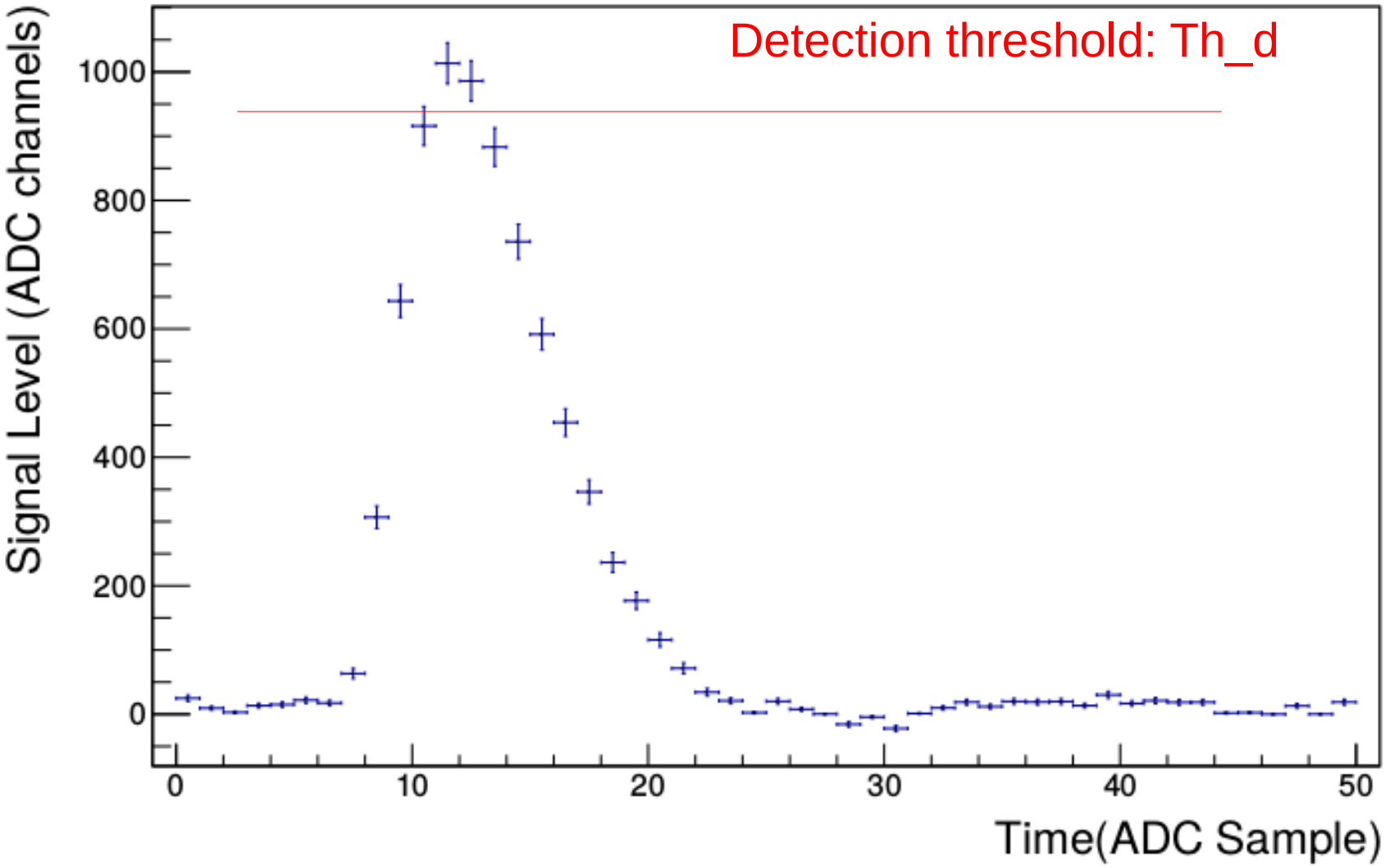


For pulses with amplitude well above the threshold efficiency does not suffer significantly from reduced threshold:

It is safe to set threshold at ~2σ

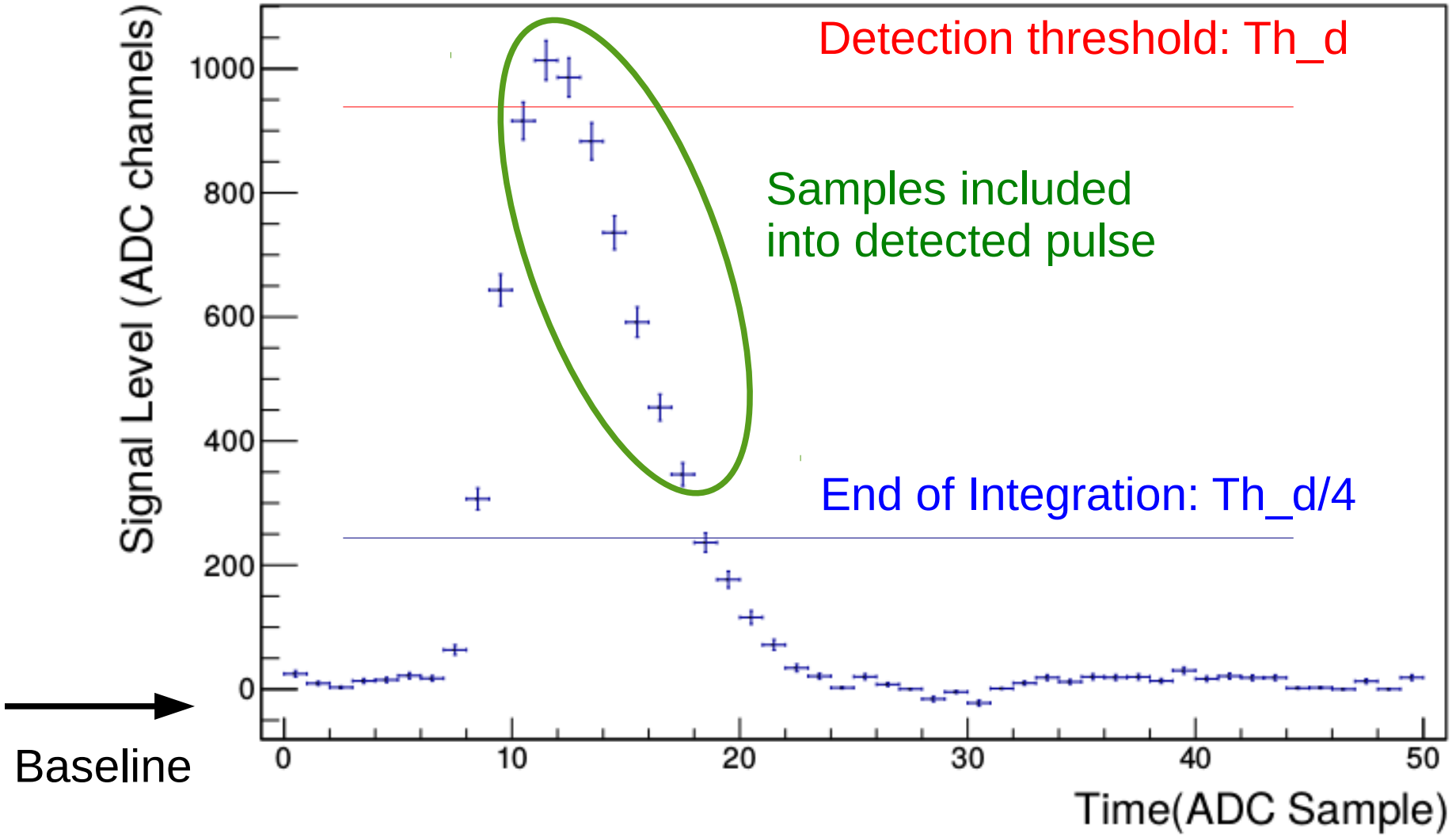
Pulse Detection: low amplitude

How requirement of the minimum pulse-width influence detection of pulses near threshold?



Pulse Detection: low amplitude

ADC samples after base-line subtraction



Pulses of proper shape will be properly detected close to the threshold

* **Efficiency depends on the pulse-shape (LNP, APFEL)**
* **For simulations use pulse-detection threshold 20% higher than in hardware...**

Summary

Threshold setting set at 2 sigma is yielding acceptable performance

Smart pulse-detection algorithm should detect properly pulses close to threshold (depends on the pulse shape)

The EMC readout is ready for non-expert operation and should be used by different groups to find possible bugs

Some parameters should be optimised for different amplifiers:

- Energy measurement by amplitude or integral?
- What is the best MWD filtering?
- Is pulse-shape stable enough to benefit from correction LUTs?
- What are the optimal hit-detection parameters
- Can “hits-combining” be used to decrease hit-detection thresholds?

Optimisations should be done using measurements with EMC prototypes and simulations (simulation root macro is provided)