AGH UNIVERSITY OF SCIENCE AND TECHNOLOGY

CLIC oriented

Triggerless readout with time and amplitude reconstruction

Szymon Kulis

Faculty of Physics and Applied Computer Science

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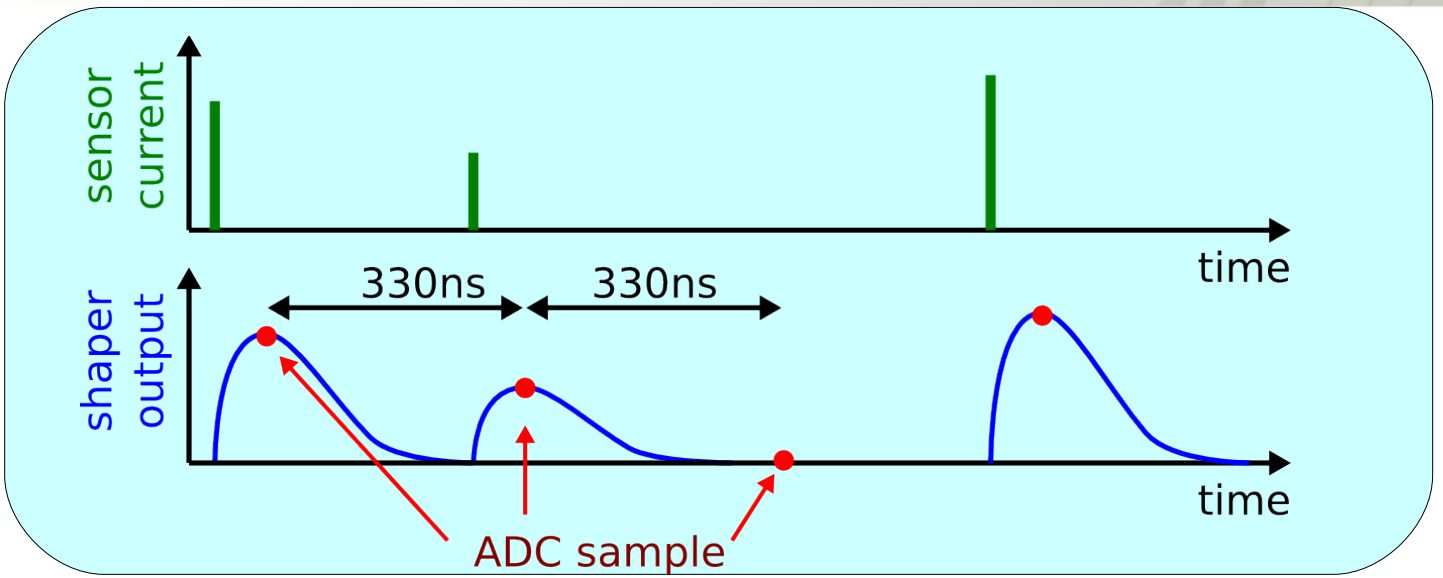
Agenda

- Motivation
- Deconvolution idea
- Test setup
- First results
  - With pulse generator
  - With radioactive source
- Towards CLIC & conclusions

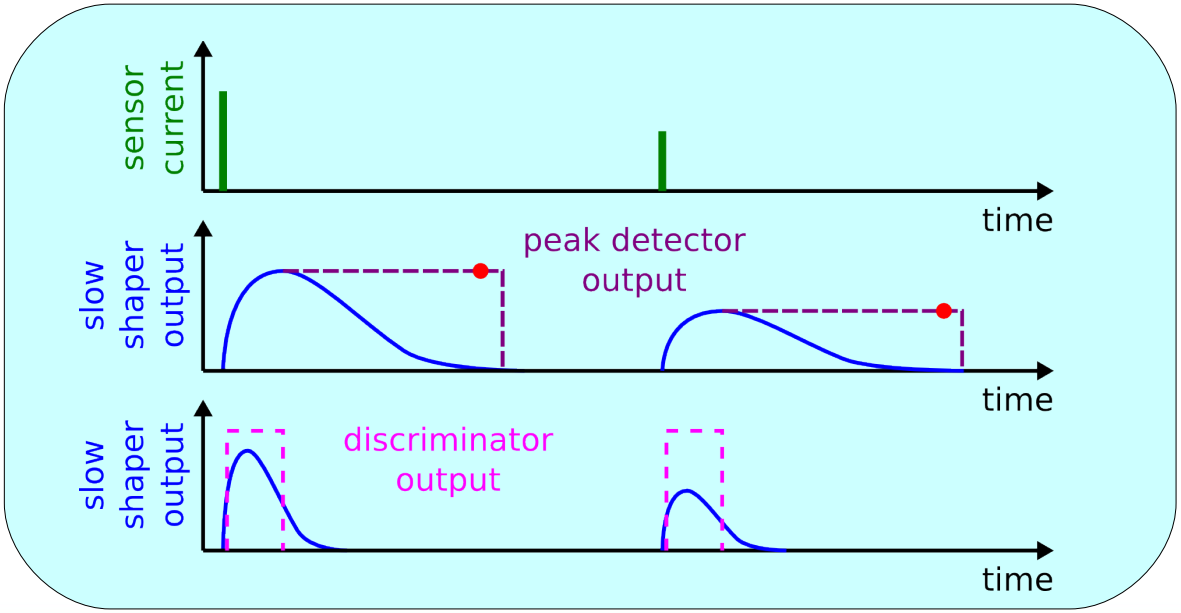
LumiCal(@ILC) readout scheme quick reminder



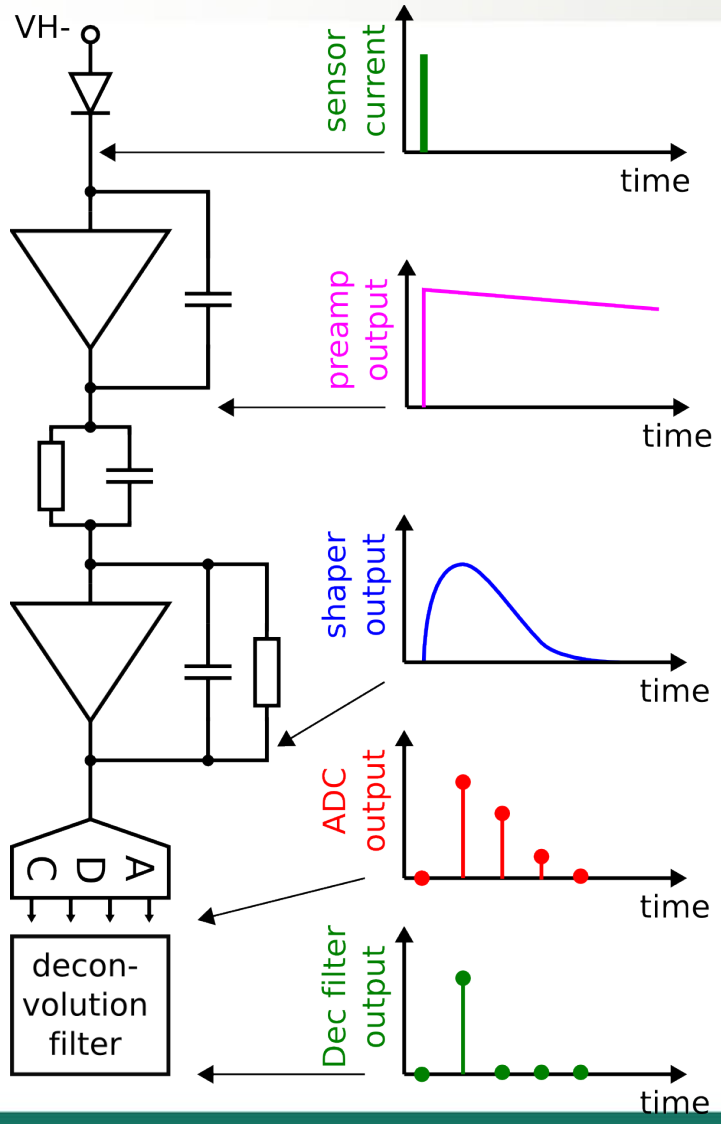
- Bunch crossing separation ~330ns
  - each hit is processed separately (pulse finishes before next beam crossing, if not we can try to correct it)
  - front-end output is digitalized every 330 ns to obtain energy deposition in given channel
- **Time taging** given by counting bunch crossings

CLIC Motivation

- CLIC beam clock is too fast (BX separation ~0.5ns) for ILC front-end approach
- We need to find time and energy of event
- Classical approaches use preamplifier and two shapers:
  - Fast shaper + discriminator + TDC → time information
  - Slow shaper + peak detector + ADC → energy information

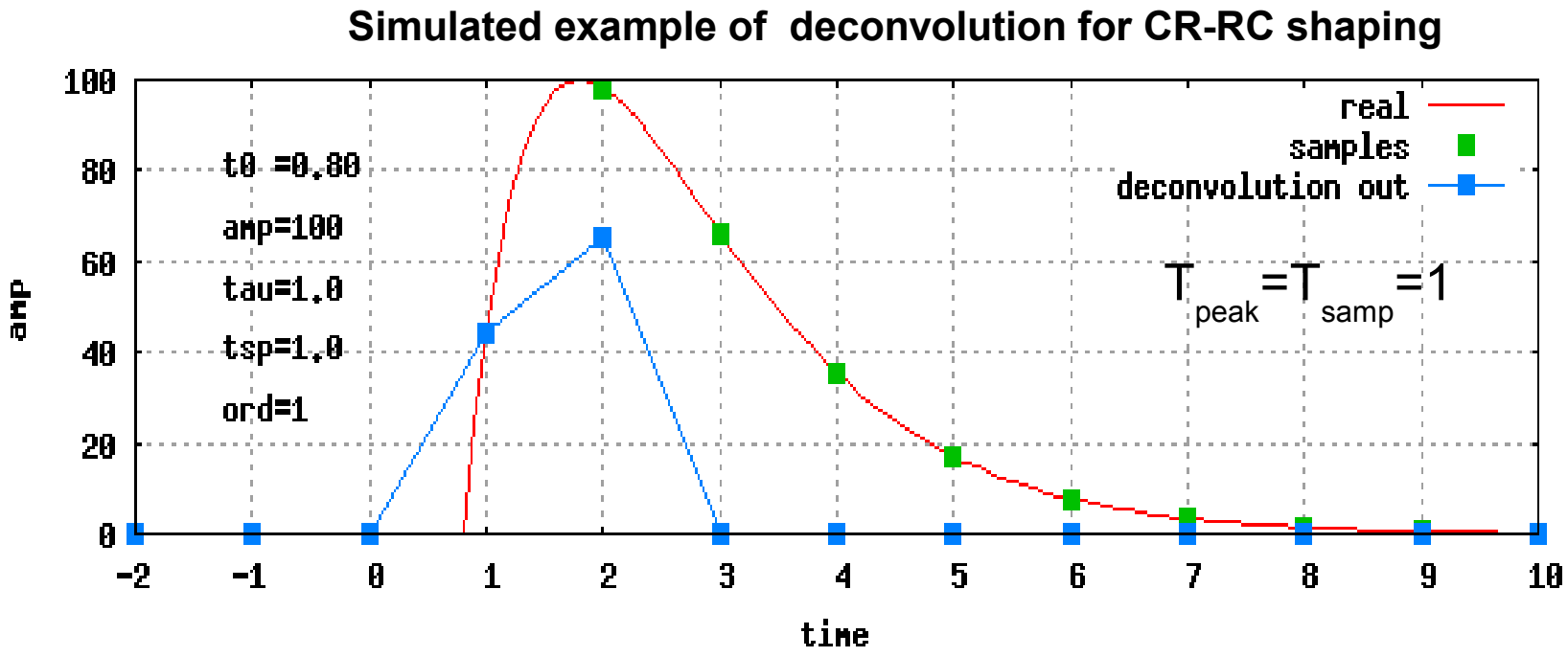


Deconvolution idea



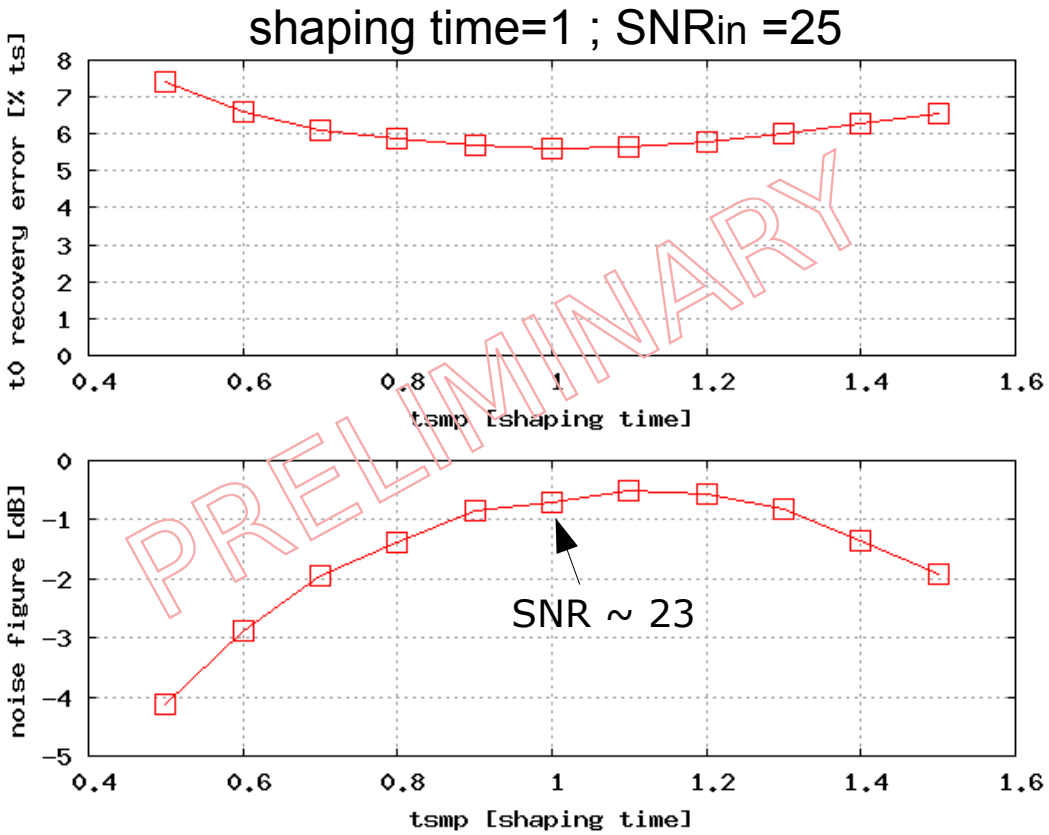
- Assumption : **fixed pulse shape at ADC input!!!**
- No external trigger needed
- Continuous sampling
- Deconvolution filter is quite simple
  → can be realized on-line in hardware (FPGA) or off-line

Deconvolution idea (cont.)



- If input pulse isn't synchronized with sampling clock (majority of events) one will have **2 non zero deconvolution samples per pulse**
- Amplitude info is obtained from the sum of 2 non zero samples (blue) and timing information from their ratio (both functions are non-linear and need lookup tables)

CR-RC deconvolution (MC simulations)

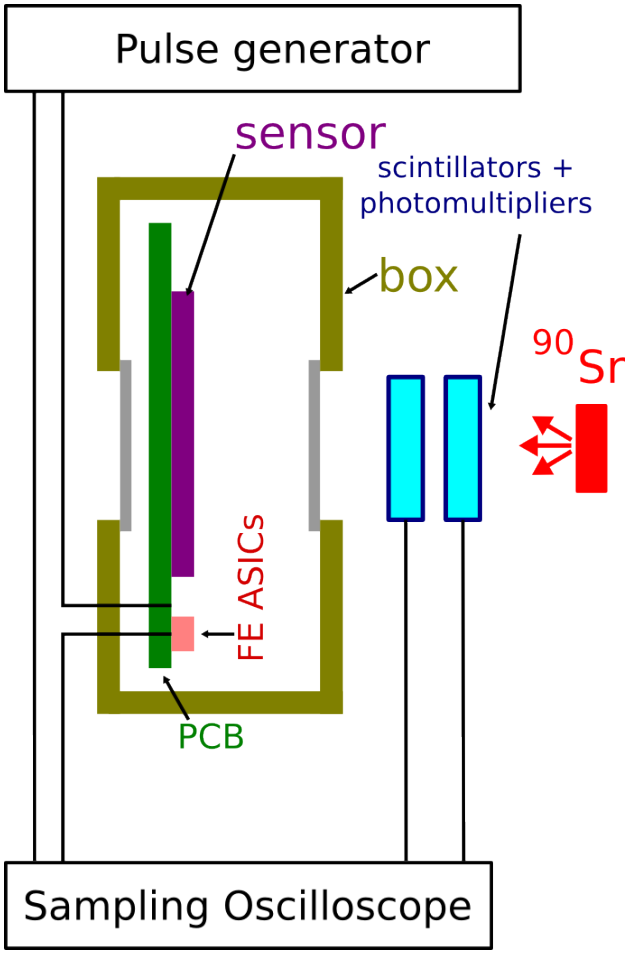


- Optimum sampling time to shaping time ratio ~=1
  → our case fsmp =1/60ns=~**16Msps**
- Time recovery error is a few % of sampling time
  → depends on SNR
  → our case: 3-4 ns for SNR=25
- S/N at the input transfers to the output

Noise Figure $$NF = 20\log_{10}\left(\frac{SNR_{in}}{SNR_{out}}\right)$$

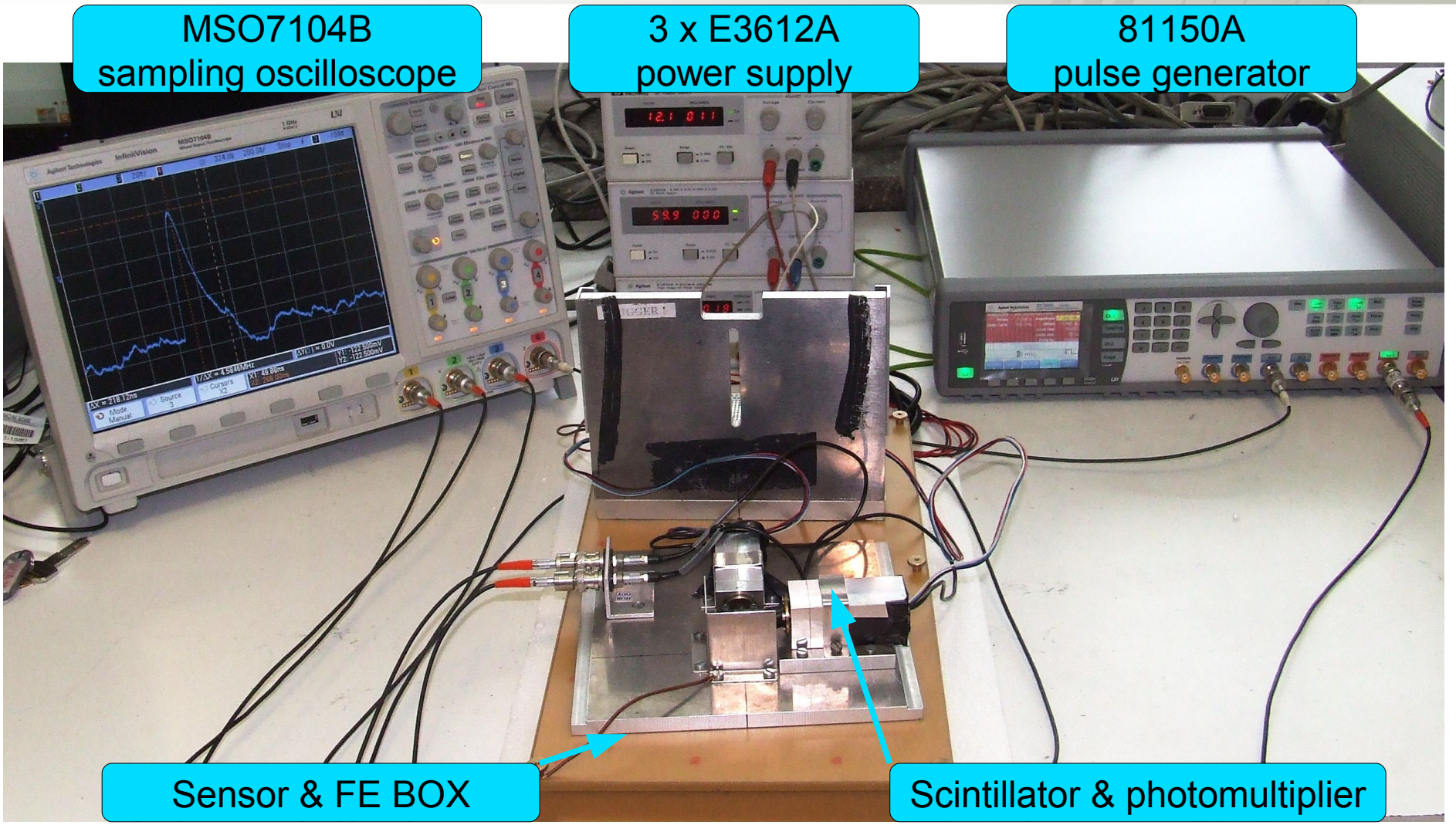
- NF = 0 → SNR doesn't change
- NF > 0 → SNR increases
- NF < 0 → SNR decreases

Measurement setup configuration *(diagram)*



- Digital sampling oscilloscope
  - Sampling 2Gsps (500ps)
  - 4 channels available
- Data taking "modes"
  - Pulse generator
    - Second channel gives information about time
      (measured channel to channel jitter < 100ps)
  - Radioactive source
    - Photomultiplier give information about time
      (measured PMT to PMT jitter ~ 500ps)

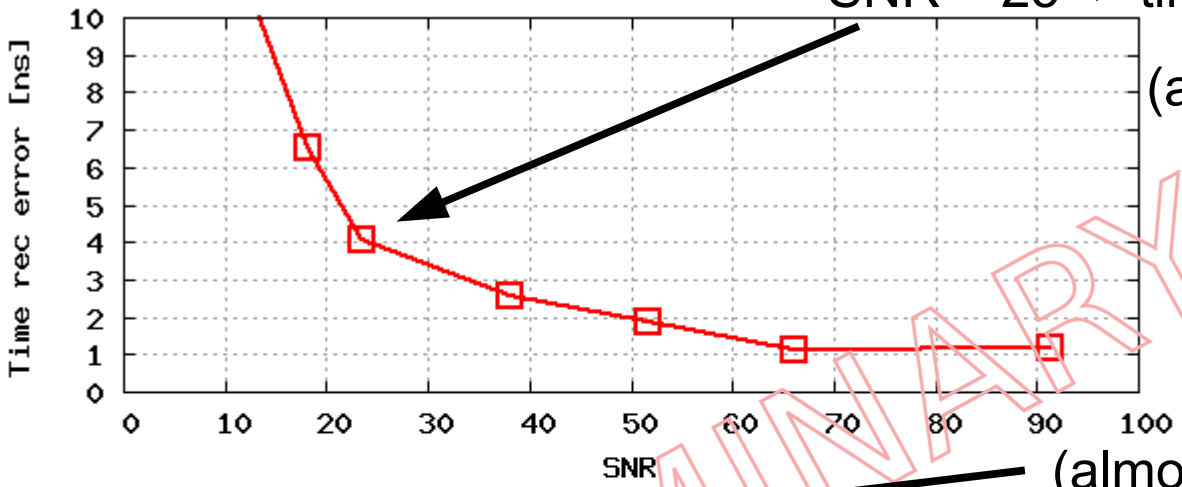
Measurement setup configuration *(photo)*



CR-RC Deconvolution - measurements (pulse generator)

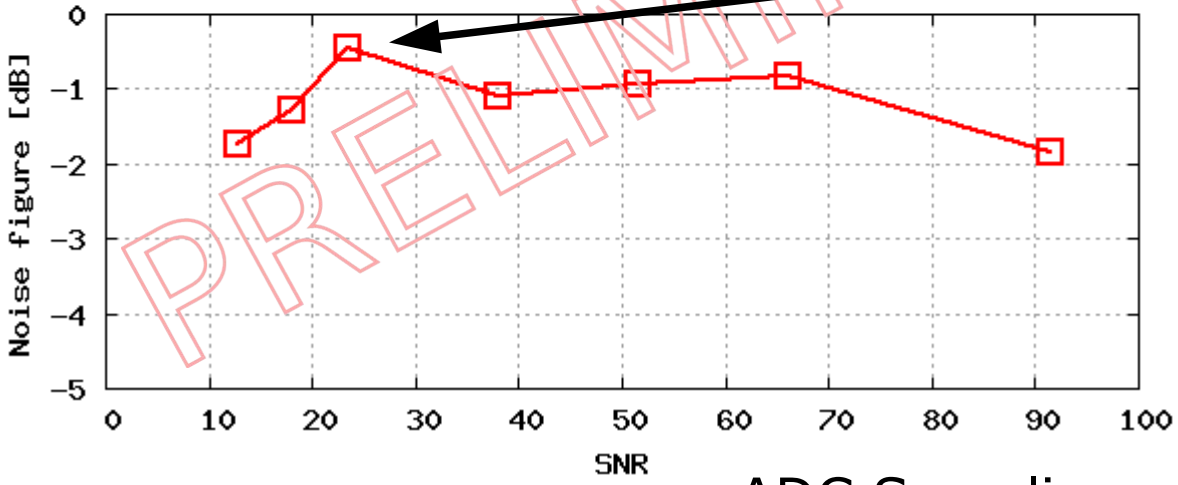
SNR ~ 25 -> time error ~ 4ns (6% tsmp)

(agreement with simulation)



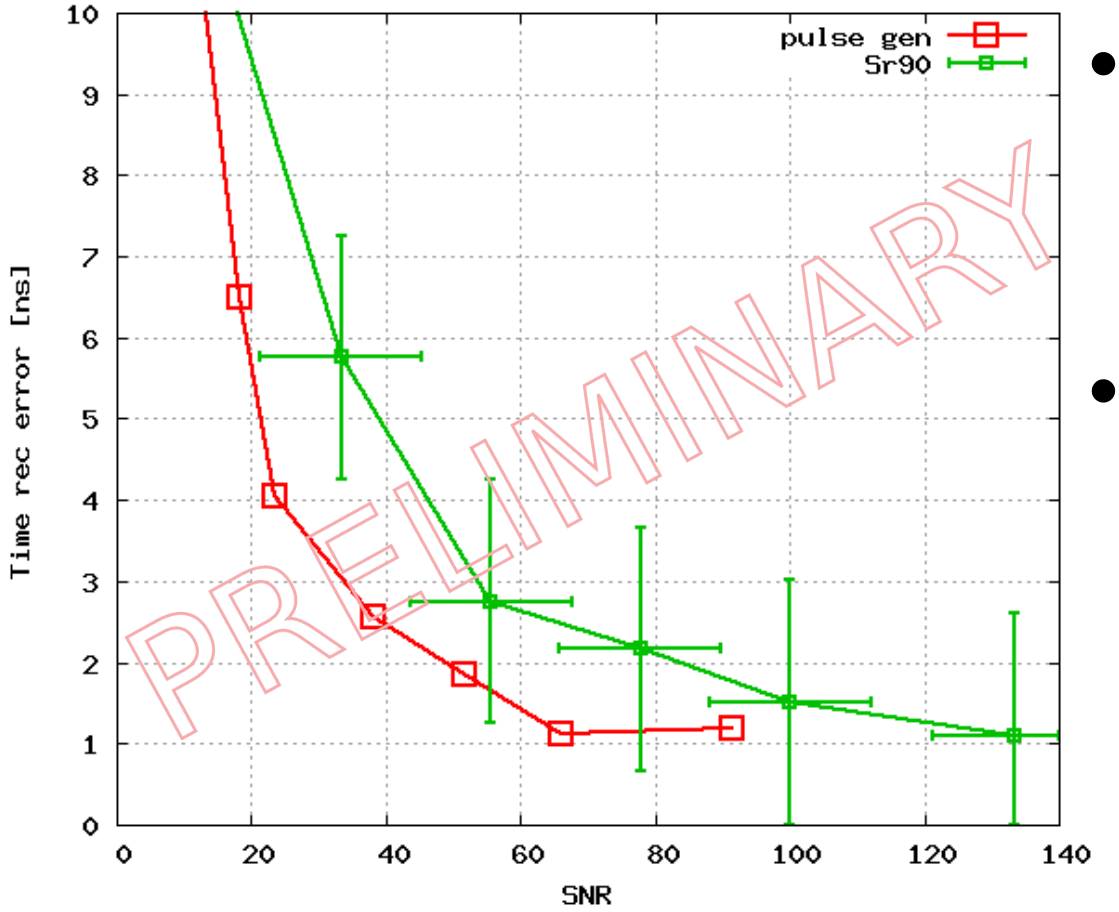
(almost) no degradation in SNR

SNR ~ 24



ADC Sampling ~ 16Msps (period 60 ns)

CR-RC Deconvolution – measurements (Strontium 90 source)

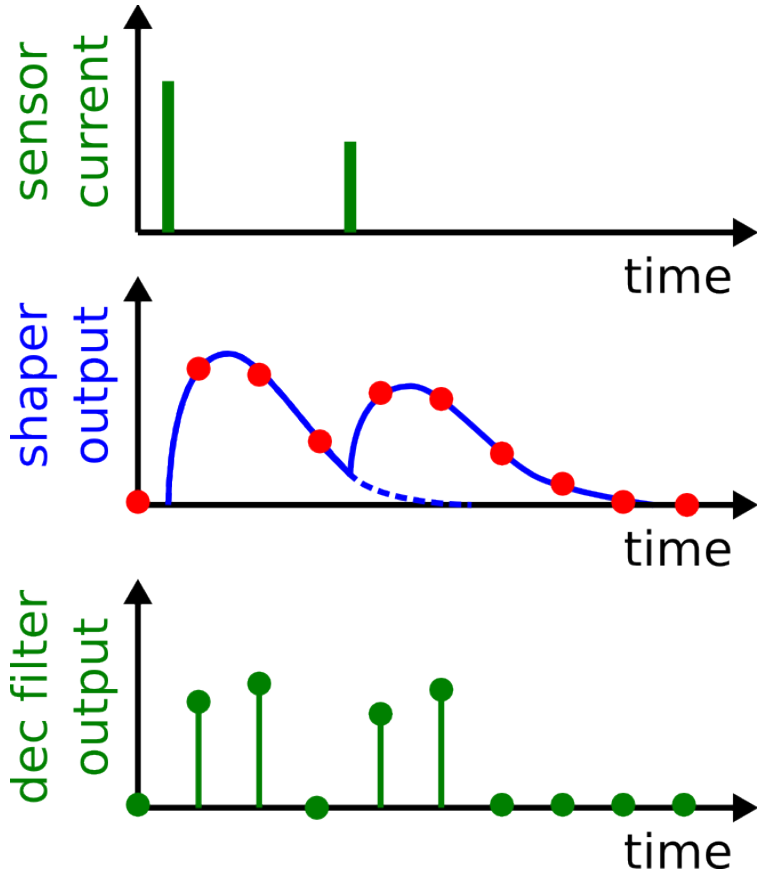


- Measurements with radioactive source just started
- Results slightly worse than with pulse generator, but some systematic errors may still be present (e.g. too weak field in the sensor resulting in non-delta pulse)

Deconvolution limitations

- Pulse shape at the shaper output has to be well known and independent of the charge deposition in the sensor

- Two pulses may be distinguished (pileup free) if they are distant 2-3 * Tsmp (>120 ns in case of LumiCal front-end)



Towards CLIC

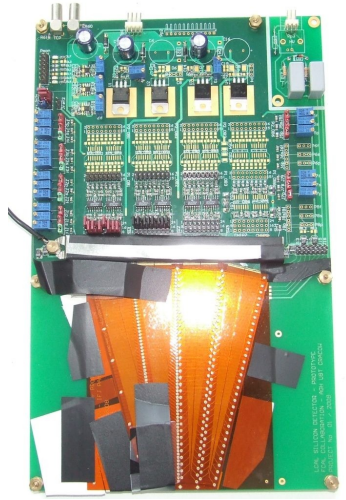
- To work out the solution for CLIC we need to know:
  - **Hit occupancy** (hits time structure per pad/layer)?
  - Signal dynamic range (MIP ... pC)? variable gain?
  - Sensor segmentation?
  - Limit on power consumption per channel?
  - Necessary **time resolution** per event?
  - Energy (amplitude) resolution (SNR)?

→ Knowing above specifications we can start FE design

- Maybe **other sub-detectors** may benefit from using such approach?
- We are going to continue work on this technology within **AIDA project**

Towards CLIC testbeam

- Testbeam feasibility
  - We have working LumiCal sensor+ front end chain
  - We are going to add our new scalable power and sampling frequency ADC (very soon, Lumical@ILC baseline plan)



- The above LumiCal based readout may be well used to verify/optimize triggerless readout at CLIC
- Shouldn't we try to verify this approach at CLIC testbeam?