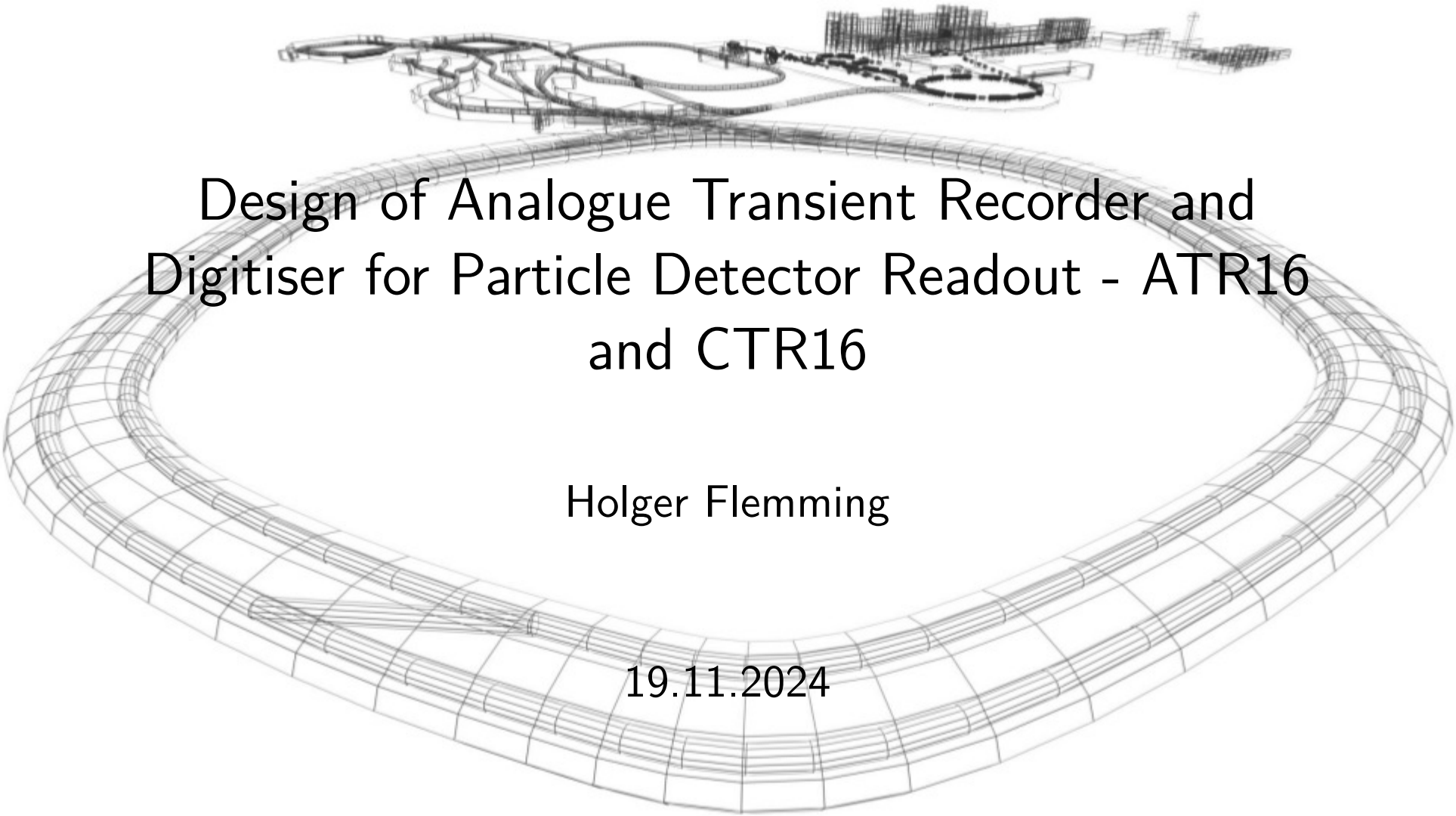


Design of Analogue Transient Recorder and Digitiser for Particle Detector Readout - ATR16 and CTR16

Holger Flemming

19.11.2024

Outline

Motivation

PANDA Barrel EMC

Motivation for ATR16

- Reduction of cable cross section.
- Reduction of analogue pic-up.

$\Rightarrow$ Development of an power efficient integrated digitiser.

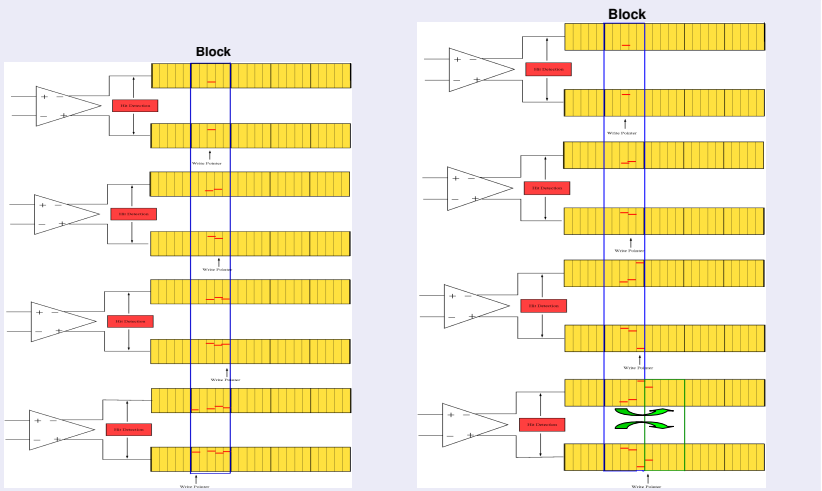
- Integrated circuit fitting to the readout concept and requirements of PANDA EMC
- Operated close to cold area of PWO crystals ($-25\,^{\circ}\mathrm{C}$).

The Transient Recorder ATR16 / CTR16

Concept

- Gaining physical quantities by transient recording and processing.
- Efficient ADC utilisation by analogue recording and triggering.

Analogue Sampling



Analogue Transient Recorder

- Continuously sampling of signal, storing in analogue memory.
- Switching to next memory block on trigger.
- Asynchronous readout of memory.

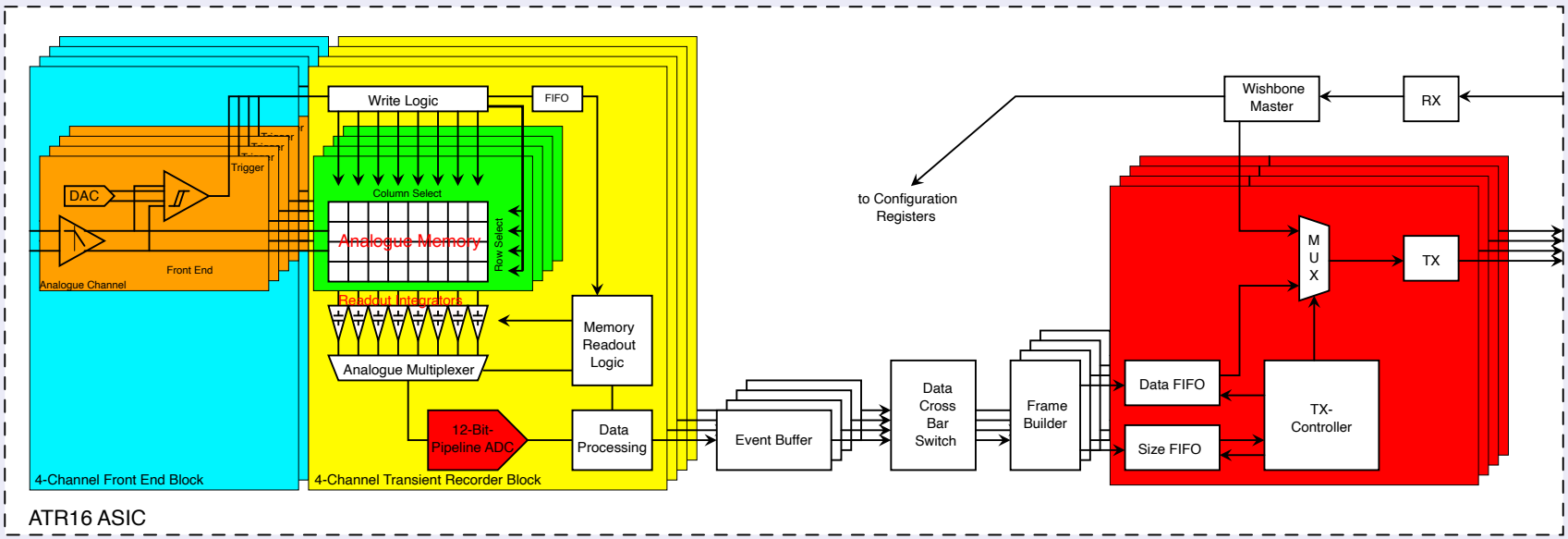
The Transient Recorder ATR16 / CTR16

Architecture

- 16 channel analogue transient recorder organised in four block with four channels each.
  - Input buffer for external preamplifier or integrated charge sensitive amplifier.
  - Analogue memory 4 rows by 16 columns for each channel.
  - One 12 bit ADC for each block.
  - Data processing (calibration, feature extraction) for each block.
- Event buffer with trigger selector $\Rightarrow$ Triggered and self-triggered operation.
- Four serial links with 500 Mbit/s each.
- More details in [Flemming et al., 2022a, Flemming and Noll, 2023].

The Transient Recorder ATR16 / CTR16

Block diagram



The Transient Recorder ATR16 / CTR16

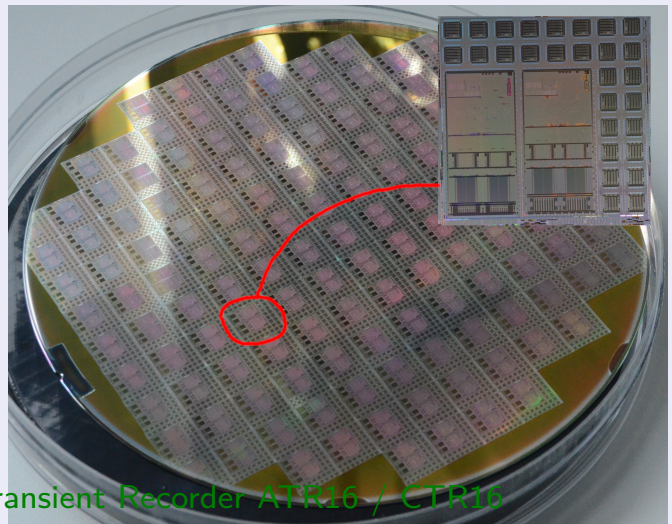
2 Variants of Transient Recorder

- Two variants with different front ends:
- ATR16
  - Input buffer for external pre-amps[Flemming et al., 2022b].
  - PANDA EMC
- CTR16
  - Integrated charge sensitive amplifier[Wieczorek et al., 2022, Rocco et al., 2022].
  - Originally PANDA GEM
  - SFRS GEM-TPC

First Iteration

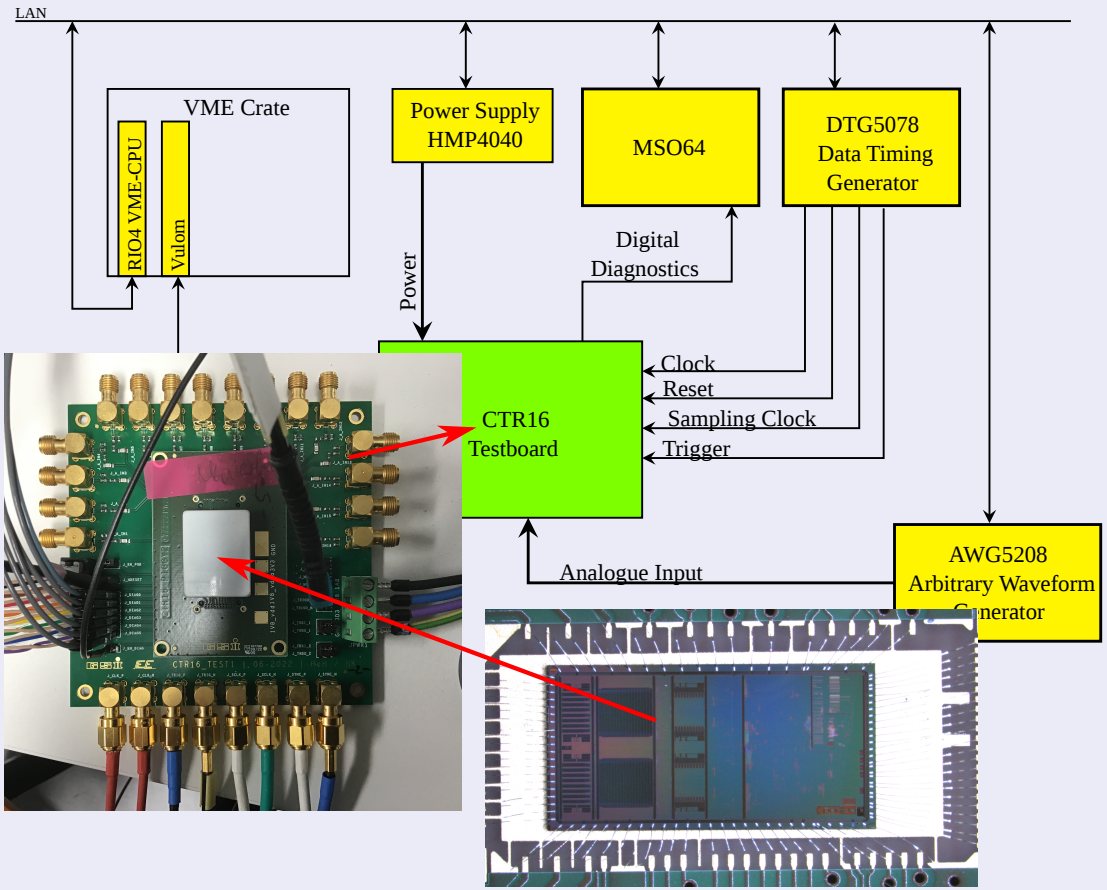
- Both ASICs realised in 180-nm-CMOS from UMC.
- First prototypes produced in 2021.

Production



CTR16 Tests and Measurements

CTR16 Test setup in ASIC Lab



CTR16 Tests and Measurement Summary

General Observations

- Reasonable power consumption ✓.
- Communication works ✓.

Front End

- Response to DAC settings ✓.
- Threshold scans ✓.
- Automatic threshold setting ✓.
- Baseline tracking for drift compensation ✓.

Transient Recording and Digitisation

- Transient data seen ✓.
- ADC calibration stable over hours ✓.

Data Transport

- Some minor issues in data transport Understood.
- Hang-up of crossbar switch Makes data taking with high statistics difficult.

CTR16 Tests and Measurements

Measurement Conclusion

- First iteration of CTR16 was extremely successful.
- Except for issue in cross bar switch complete complex logic for control, readout and data transport is operational. Minor bugs are understood.
- Issue in cross bar switch makes precise analogue characterisation with high statistics and data taking difficult.

Conclusion for ATR16

- ATR16 not yet tested
- Analogue memory readout and data acquisition back end are identical on ATR16 and CTR16.
- $\Rightarrow$ It is expected that issues in data transport affect ATR16 as well.

Outlook

Next Prototype Iteration

- Redesign of digital part in 2023.
  - Correction of all known bugs.
  - Cross bar switch redesigned from scratch considering all observations of first iteration.
- Wafer production in 2024.
- Wafer currently at dicing process.
- First results expected end of 2024 / beginning of 2025.

Thank you for your attention

Flemming, H., Deppe, H., and Wieczorek, P. (2022a). A family of transient recorder ASICs for detector readout. *Journal of Instrumentation*, 17(07):C07002.

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