A Low-cost Multi-channel Analogue Signal Generator

Felix Müller, Klaus Schmitt, Wei Shen, Rainer Stamen

Kirchhoff Institute for Physics, University of Heidelberg

Introduction

The presented low-cost signal generator provides up to 12 independent analogue signals.

It consists of a standard PC hosting a commercial multi-monitor graphics card that acts as source for the analogue signals. The graphics card is controlled by a dedicated software package running on the same machine. An external device was developed as part of the signal generator, being an example of how to condition the signal.

A possible application, the emulation of analogue signals of the ATLAS calorimeter trigger inputs for the Level-1 PreProcessor test rig, is shown.

Concept

The signal generator consists of three building blocks:
- Programming of the digital signal
- Generating analogue signal
- Conditioning of the signal to a specific application
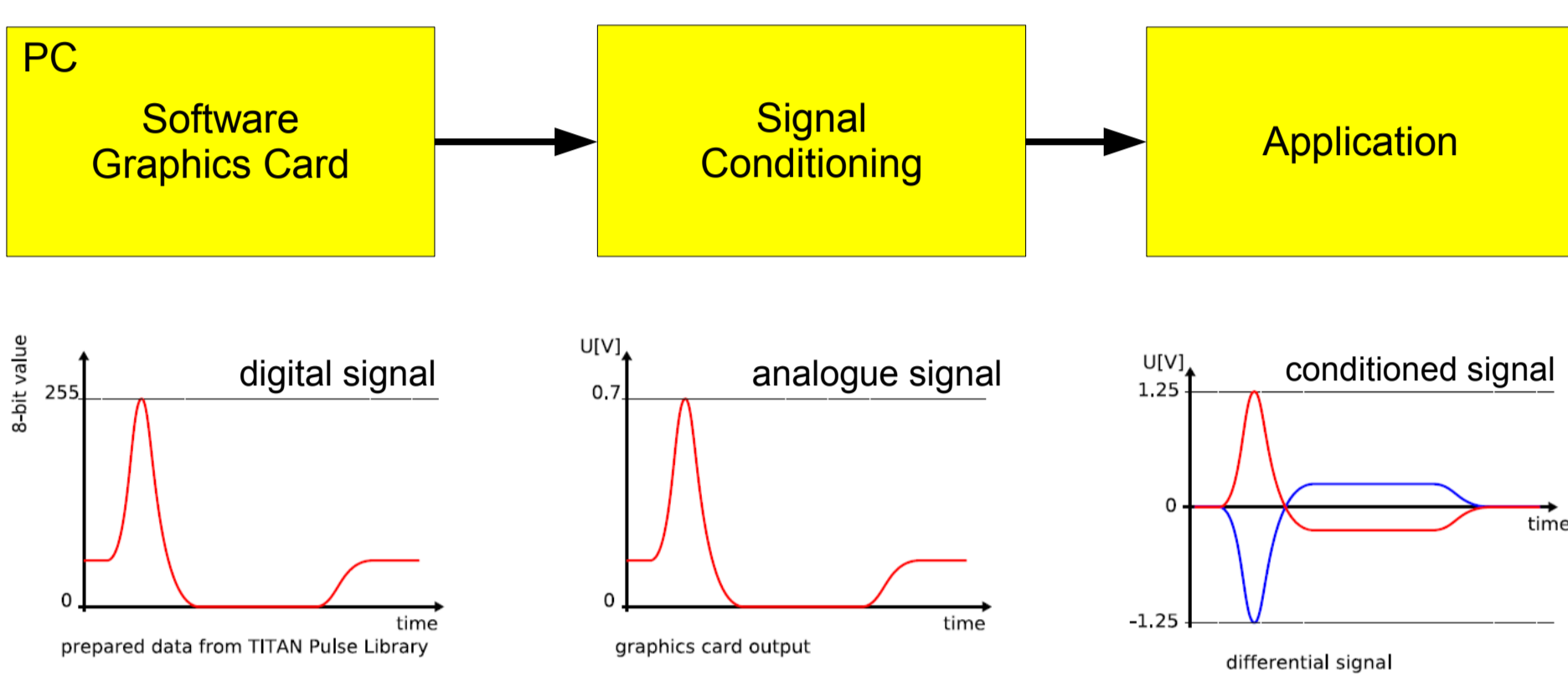

Graphics Cards as Signal Source

- Each color channel as independent signal source.
- Unipolar signal with 8-bit voltage resolution.
- Time resolution ("pixel clock") of up to 5ns.
- Sufficient to represent an analogue signal for systems operated at a lower speed, like e.g. many 40MHz systems at the LHC.

1 line on the screen ~10 µs of signal — blanking space for synchronisation (~ 20% in total)
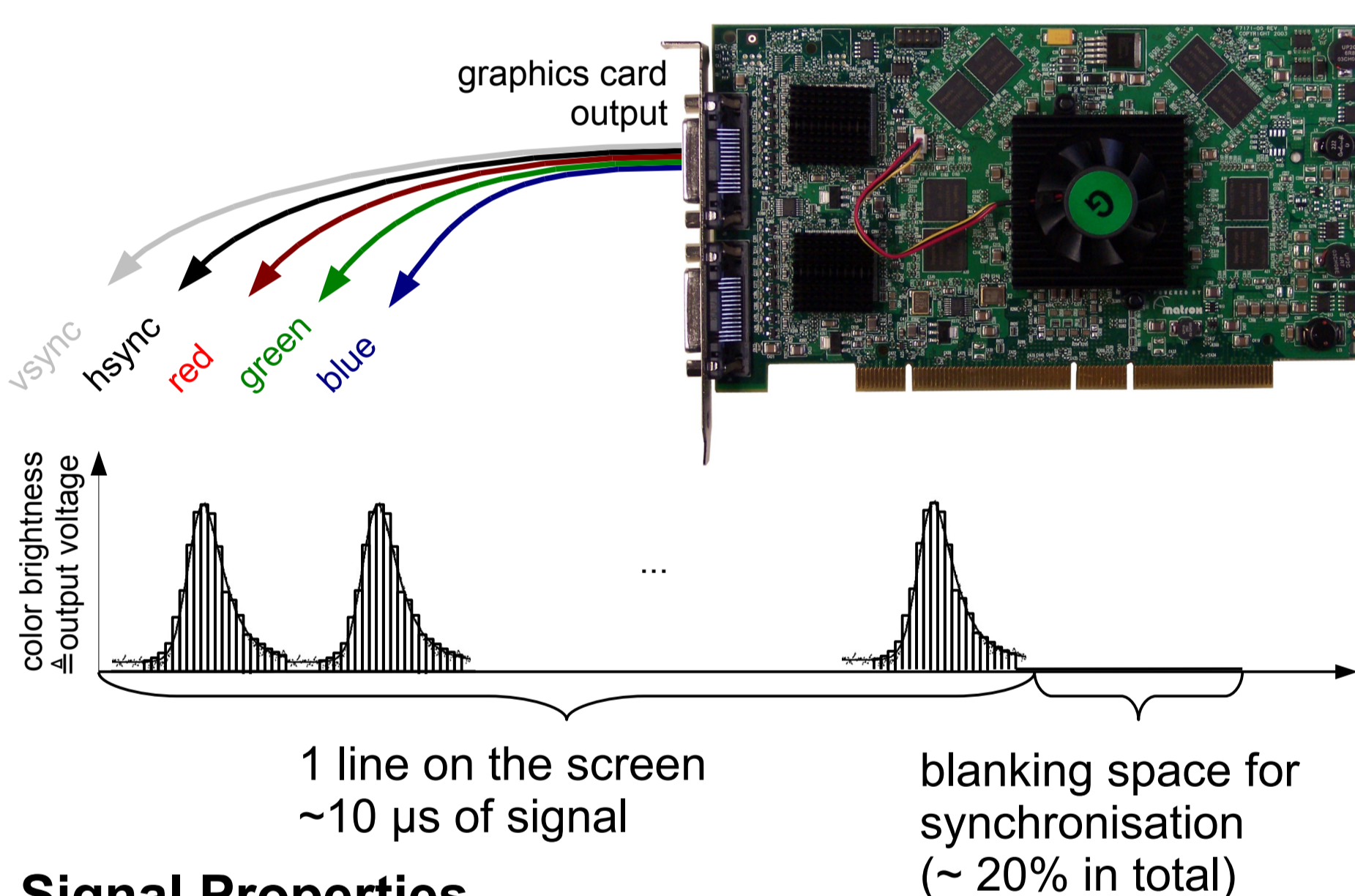
Signal Properties

Voltage resolution — 8-bit, [0, 0.7] V
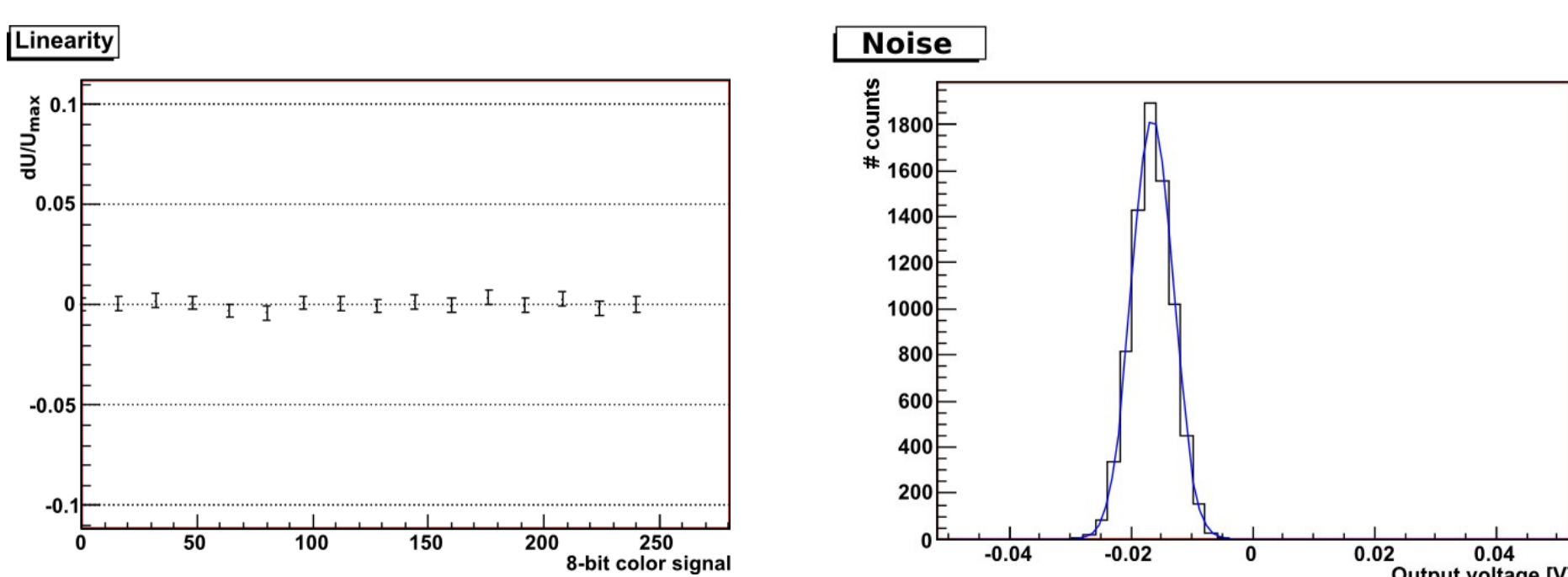Sampling rate — ~ 200 MHz

Continous signal length: — ~10 µs
Total signal length: — ~10 ms
Minimal frequency: — ~100 Hz ("monitor frequency")
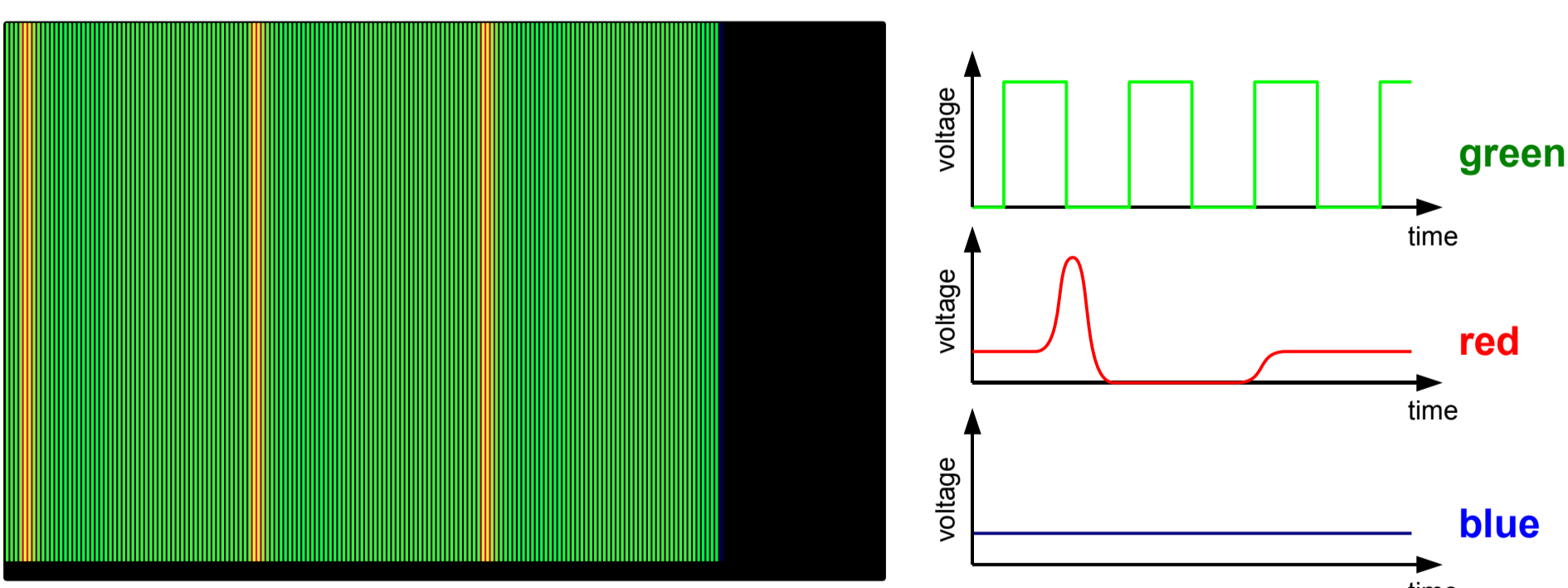
- 3 signals (rgb) merged into 1 fixed image.
- 12 independent signals with 4-head graphics cards.
- Simple programming: display image at full screen.

### Electric Properties
(Matrox Millenium G400)

- Linearity within 1% deviation over voltage range.
- Noise measurement ΔU = 3.4 mV.
- Constant offset up to 20mV.

Software Package

A software package was developed to program and produce the signals:
- Create and modify basic pulse shapes.
- Import external data (e.g. from oscilloscope).
- Merge three signals into a fixed image.
- Drive the graphics card.
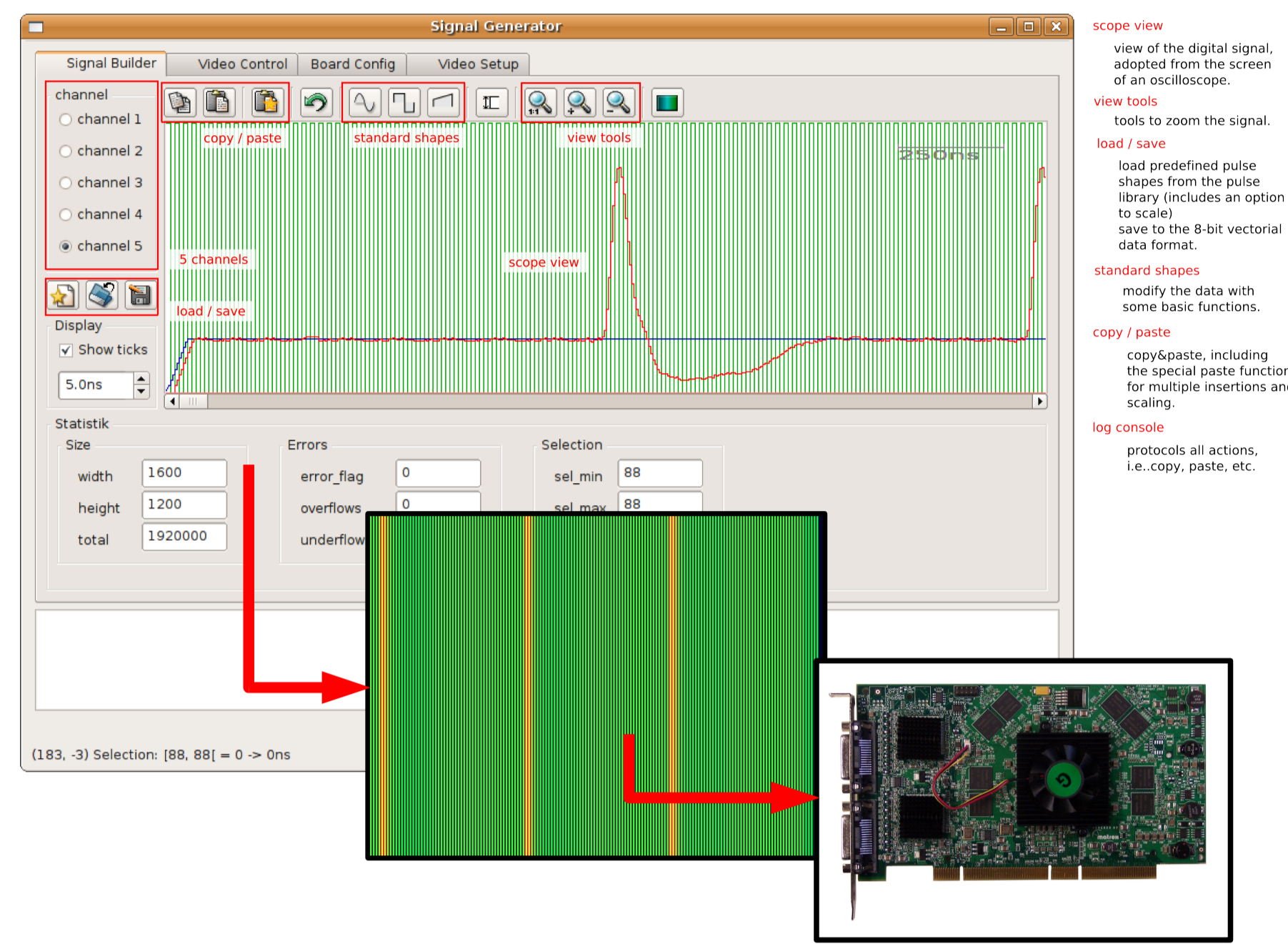
Signal Conditioning

An external device was developed to condition the output signal to the voltage levels for a specific task:
- Input: up to 6 monitor outputs
- Calibrate for gain and offset
- Dedicated channel to apply a global offset
  → **allow negative signals**
- Flexible fan-out, depending on input configuration
- Amplification to a specified voltage range
- Output: 16 differential signals (configurable fan-out)
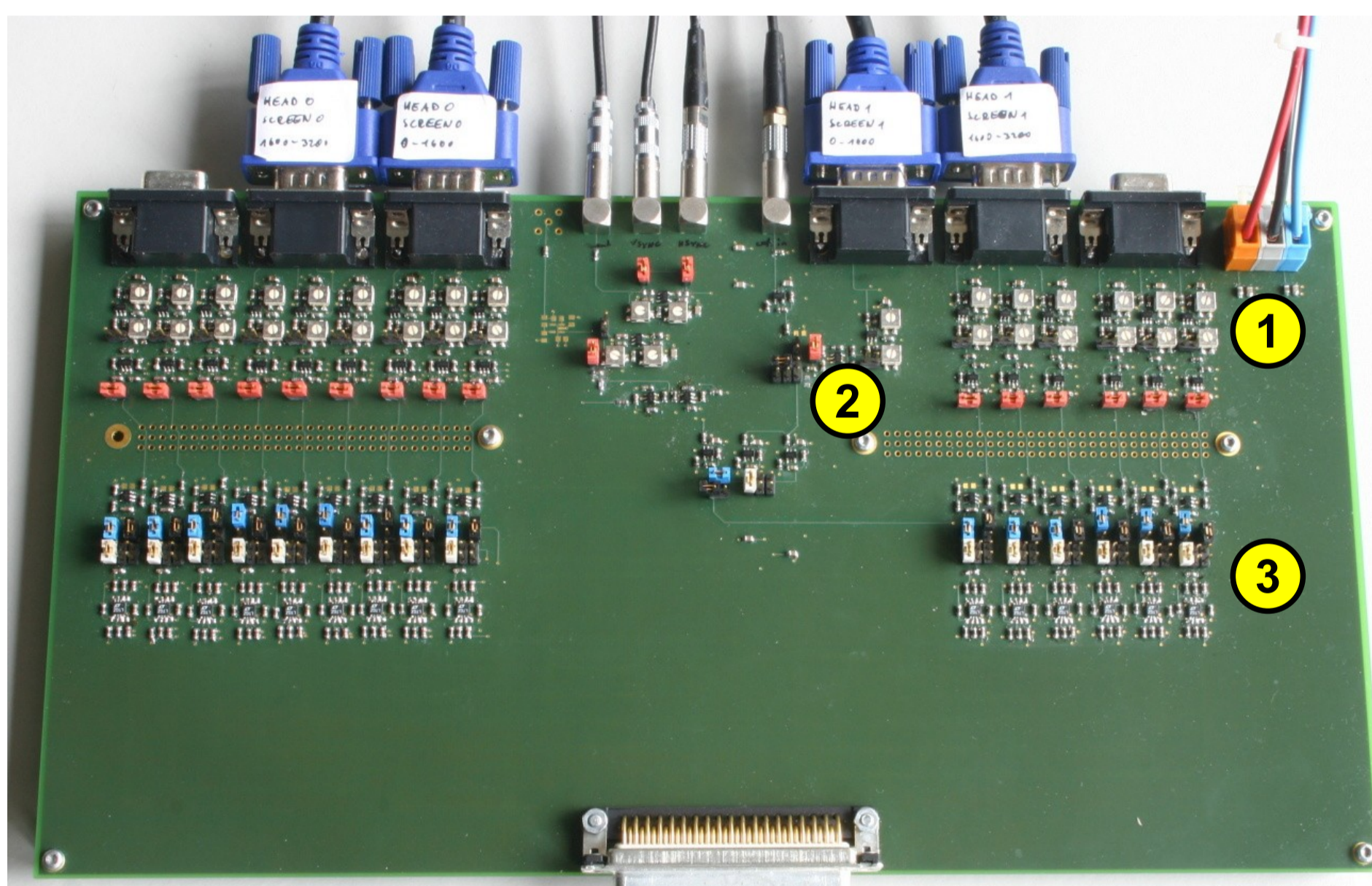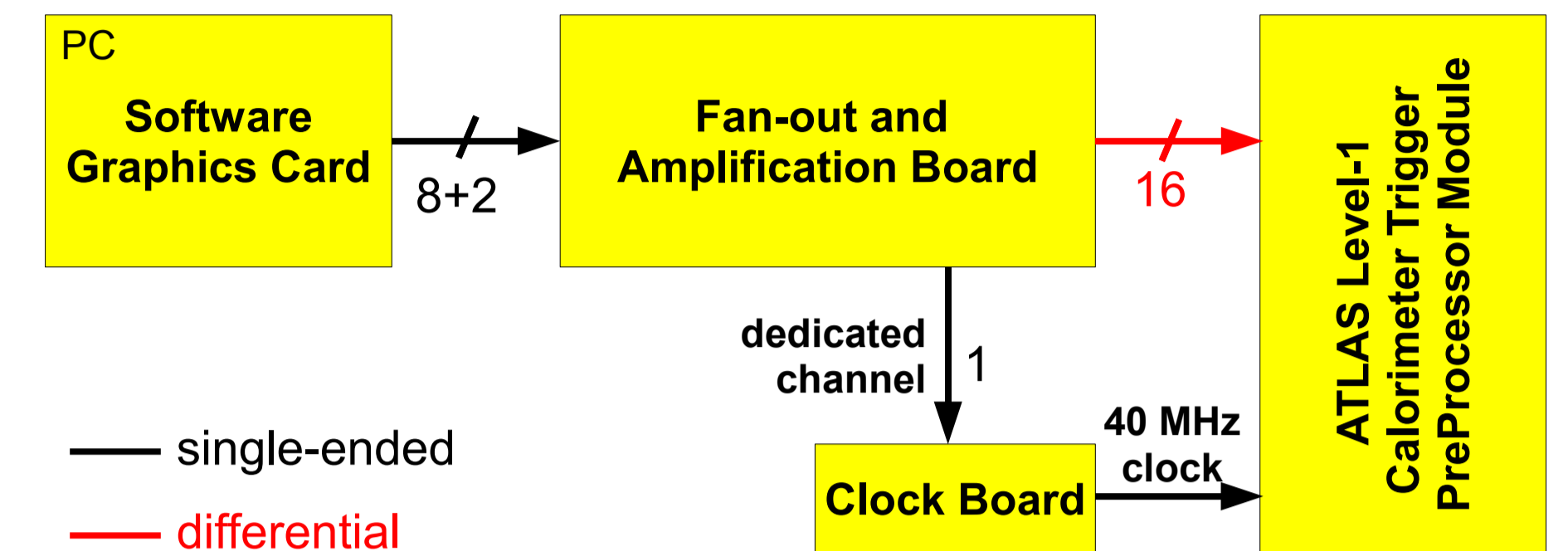

Signal Chain
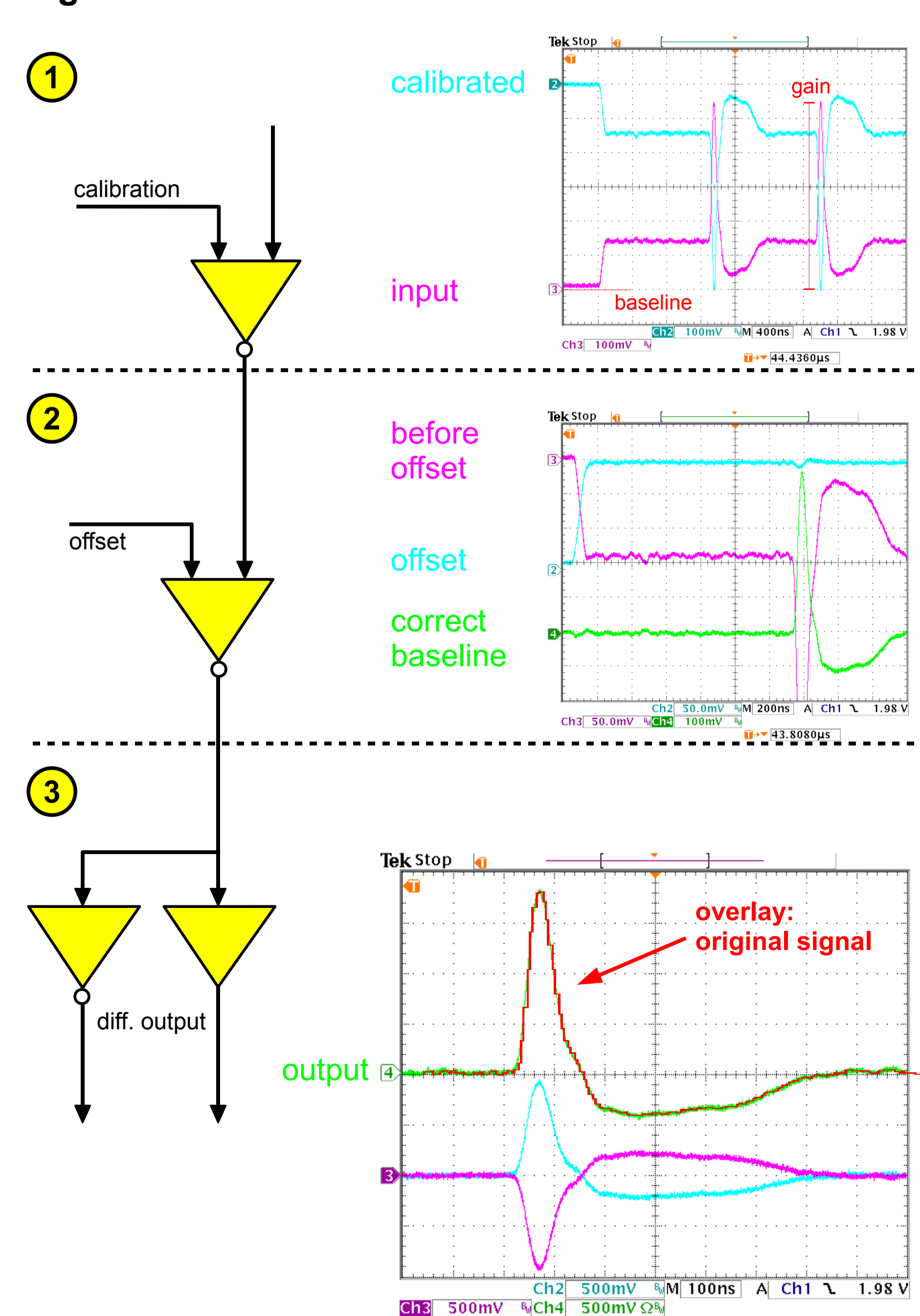
Application

Test Bed for the PreProcessor Module

The signal generator is used to emulate the analogue ATLAS Calorimeter Signals for the Level-1 Trigger.
- Setup with 8 independent channels that are fanned out and converted to 16 differential signals.
- Additional device to provide a continuous clock.

— single-ended
— differential

PreProcessor requires 40 MHz clock (LHC bunch crossing frequency) synchronous to signals.
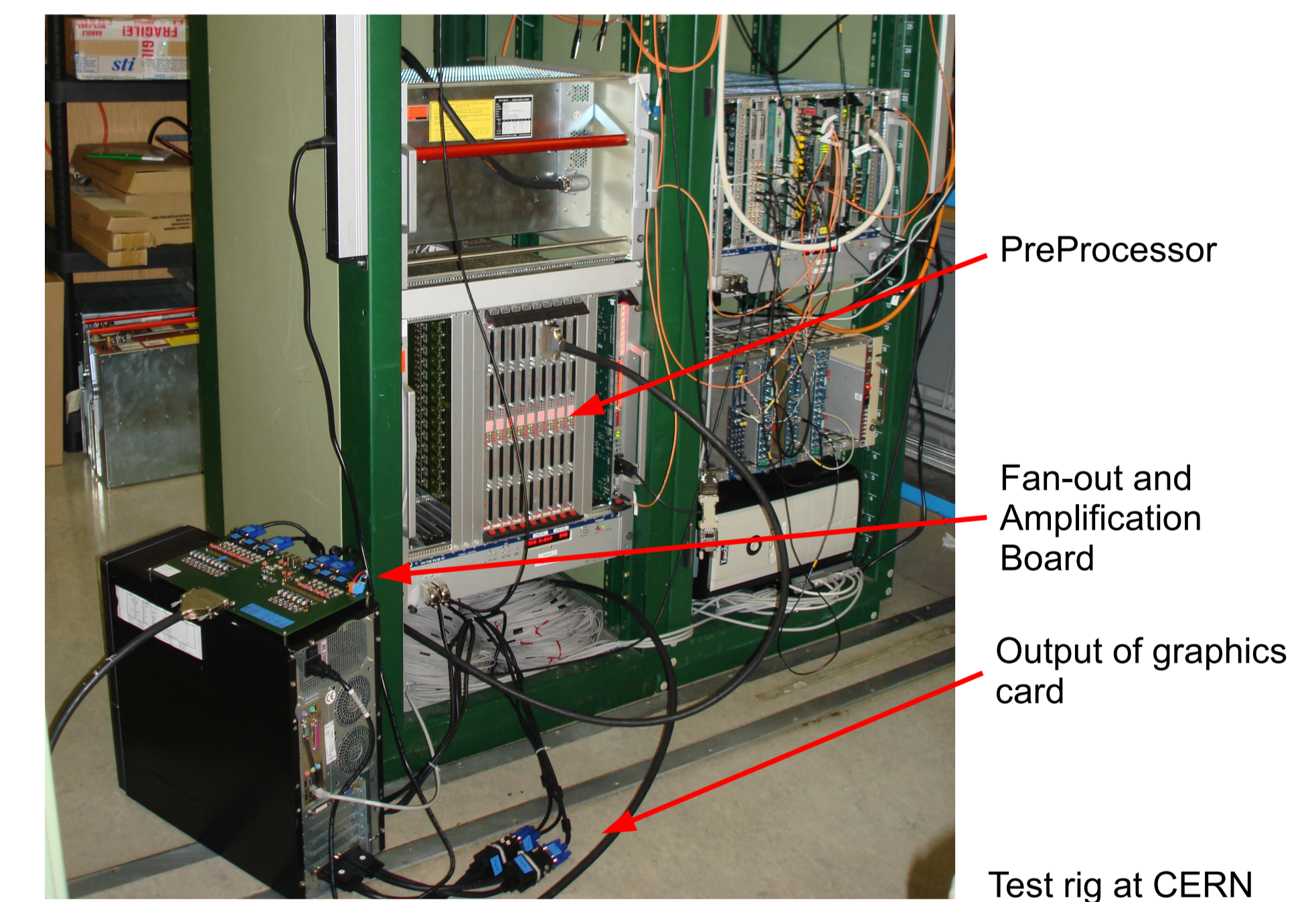
Clock Synchronisation Board
- Uses dedicated channel to synchronize internal clock to signal channels (PLL)
- Bridges horizontal and vertical blanking space.
→ synchronised and continuous 40 MHz clock.
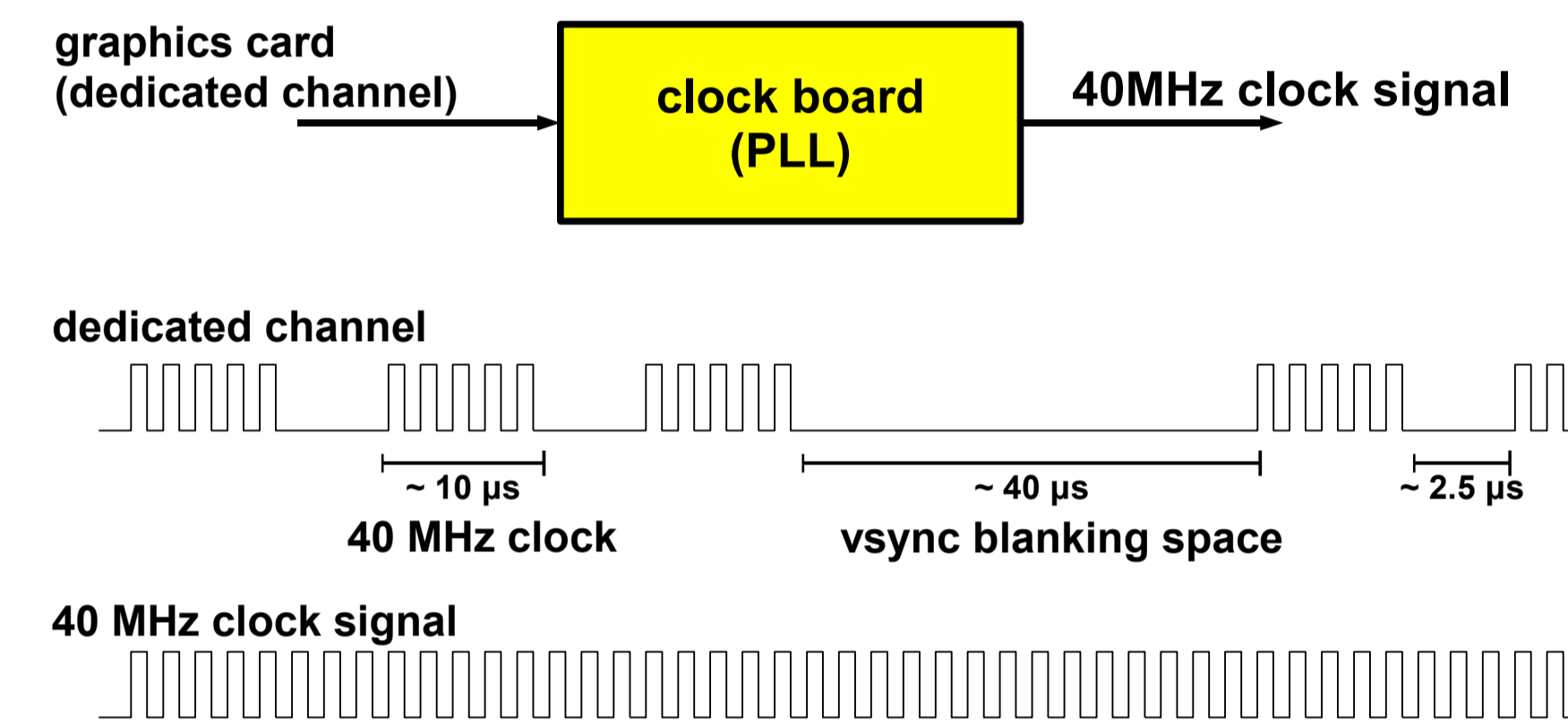
Setup

Analogue tests of the PreProcessor Modules take place in test rigs at CERN and Heidelberg.

Test rig at CERN

Measurement

The functionality of the signal generator was verified in a test setup with the PreProcessor Modules:
- Signal generator emulates calorimeter signals, taken from the TITAN pulse library.
- Continuous clock provided by Clock Synchronisation Board.
- PreProcessor digitizes the analogue signal.
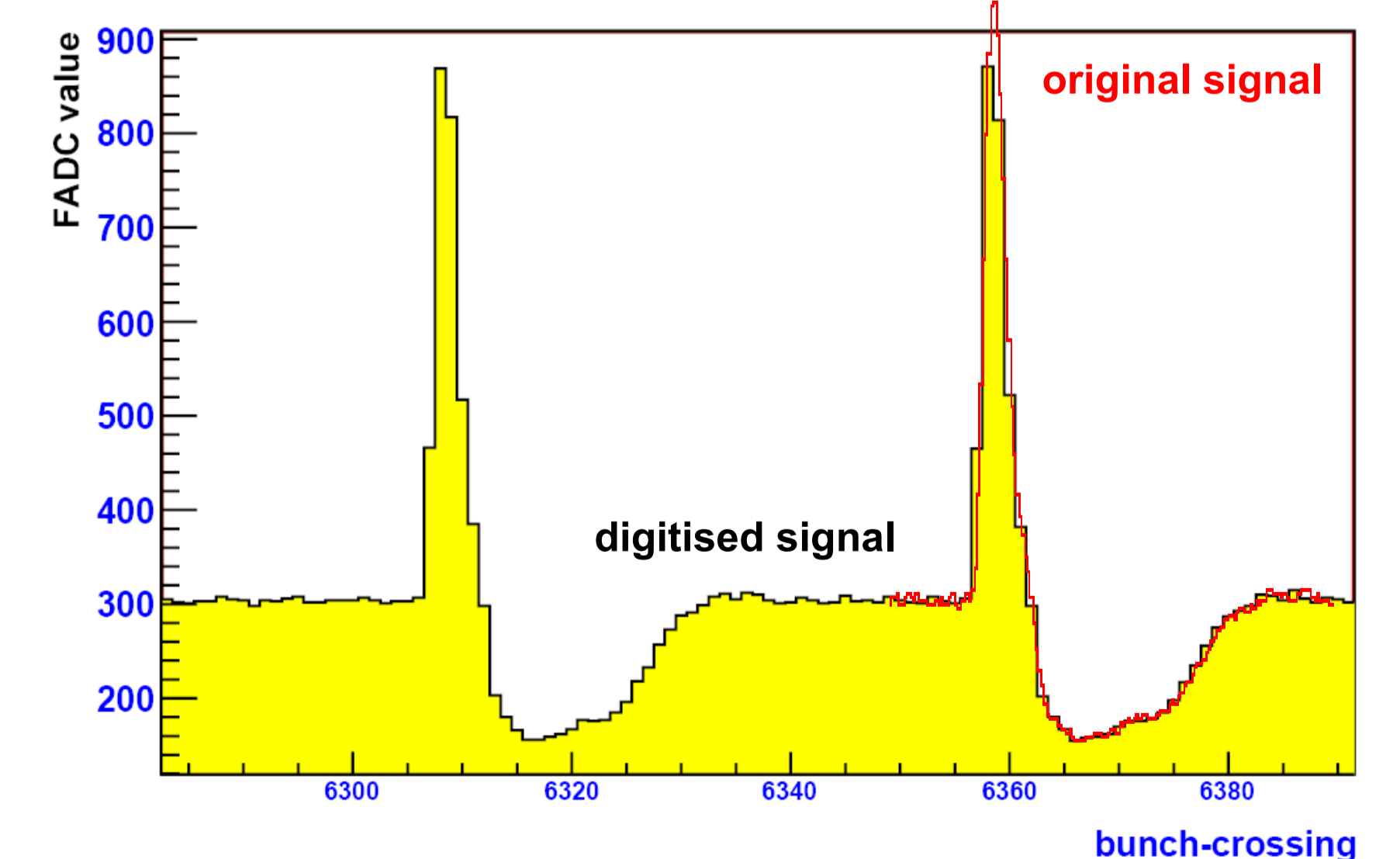
Summary

The presented signal generator is applicable in all fields with need for multiple analogue signals, as e.g. many systems at the LHC, where a blanking space is no drawback, or can be compensated as shown. The advantages are multiple, easily programmable signals with acceptable quality at very low expense.