A Real-time Histogramming Unit for Luminosity Measurement of each Bunch Crossing at CMS

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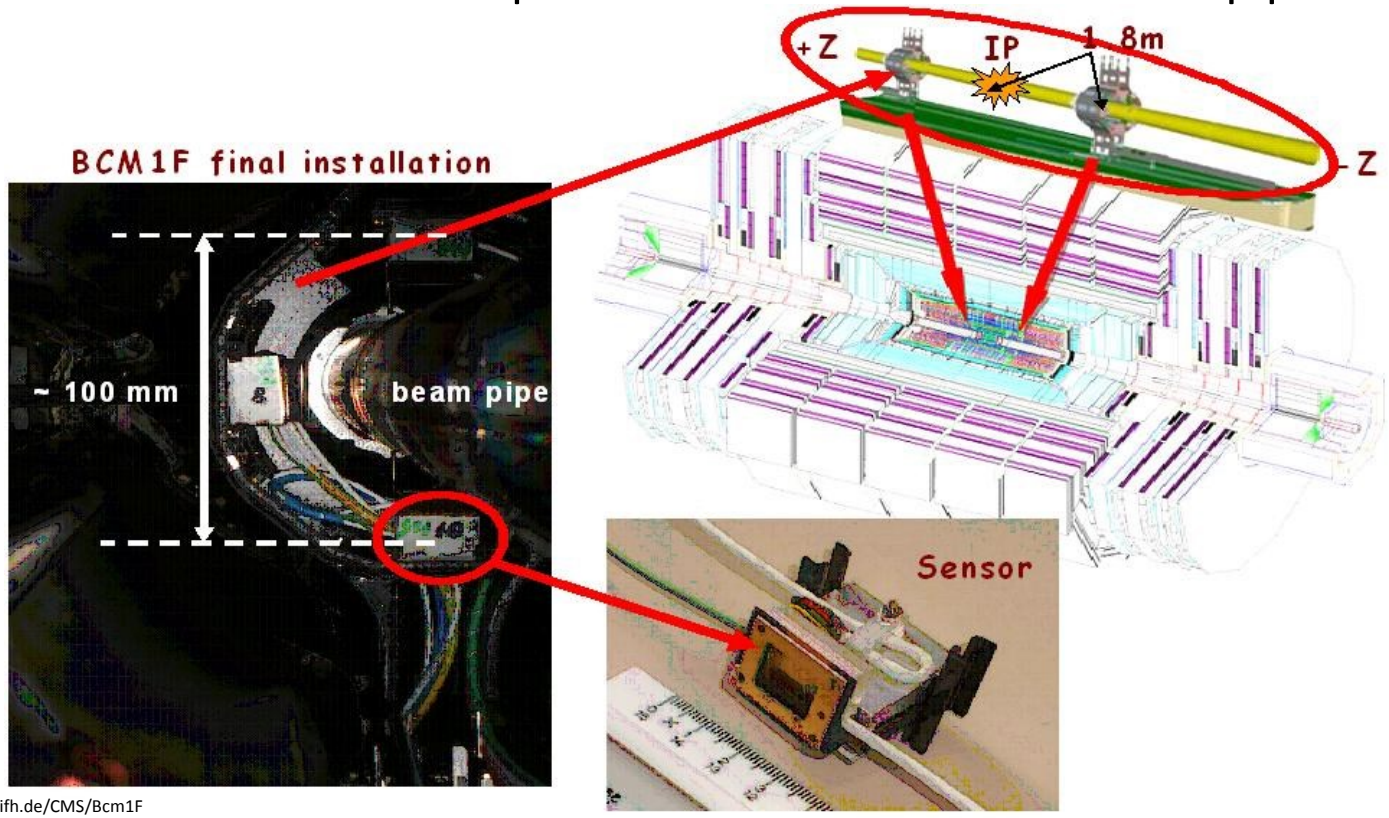
Overview

- BCM1F detector and setup
- Hardware rev.1
- Hardware rev.2
- DAQ software
- Outlook

BCM1F Detector

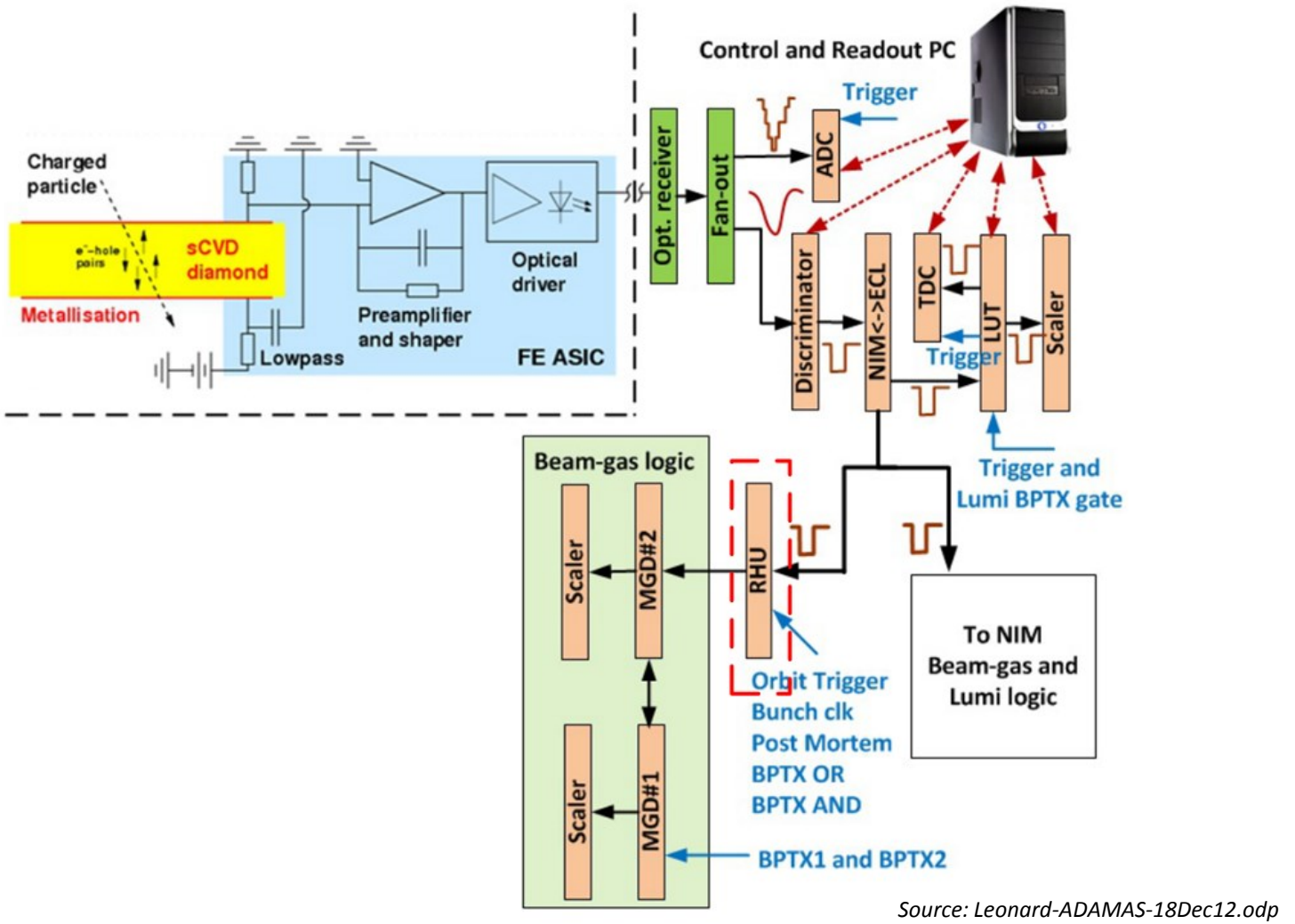
BCM1F, a subsystem of the CMS Beam Condition Monitor System

- designed for fast flux monitoring measuring bunch-by-bunch both beam halo and collision products
- located inside the CMS pixel detector close to the beam-pipe



Source: https://znwiki3.ifh.de/CMS/Bcm1F

Setup at BCM1F



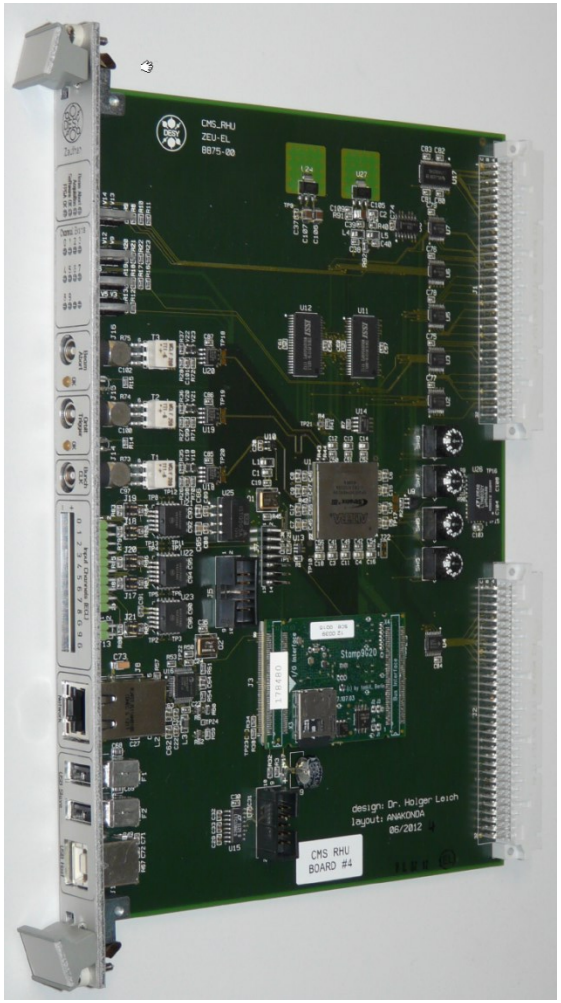
Source: Leonard-ADAMAS-18Dec12.odp

RHU Hardware Revision 1

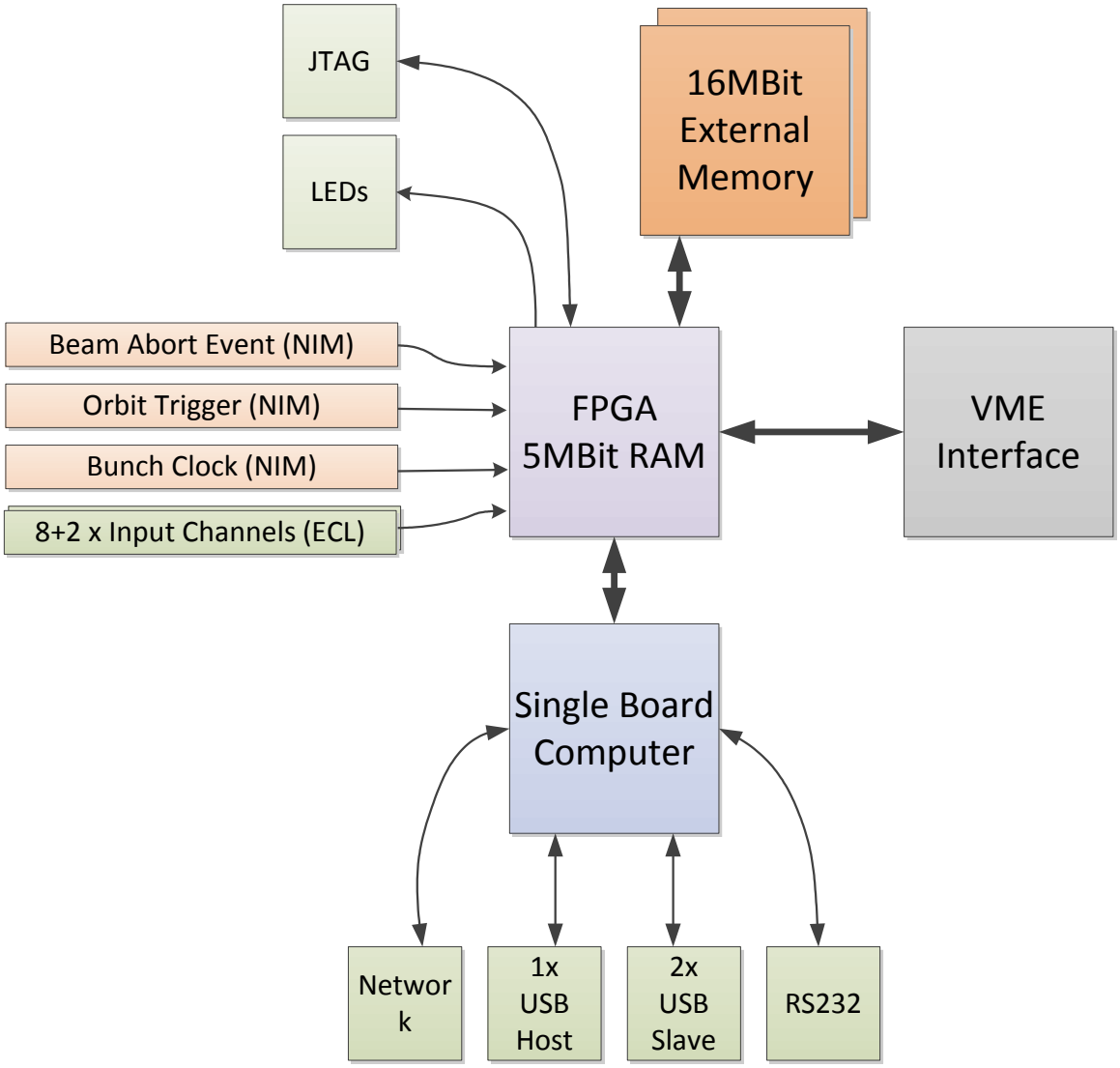
(finished development 2012)

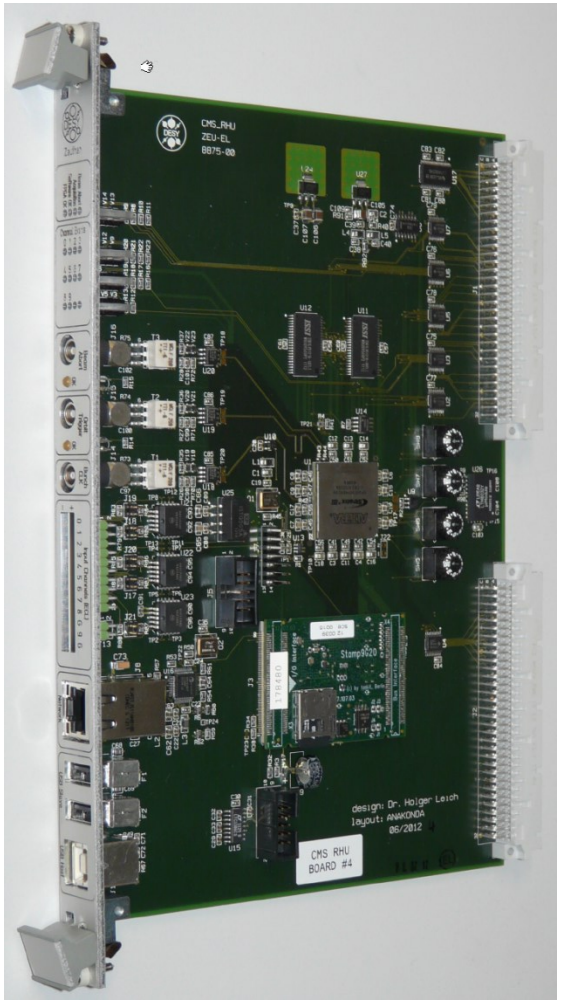
RHU Hardware Rev.1

- RHU → Real Time Histogramming Unit
- FPGA based digital recorder
- 3x NIM inputs for clock/control
- 12x ECL inputs for input data
- VME interface (not used)
- Embedded Linux System
- Readout via ethernet
- 5MBit RAM in FPGA
- 16MBit external RAM (3.2GBit/s)



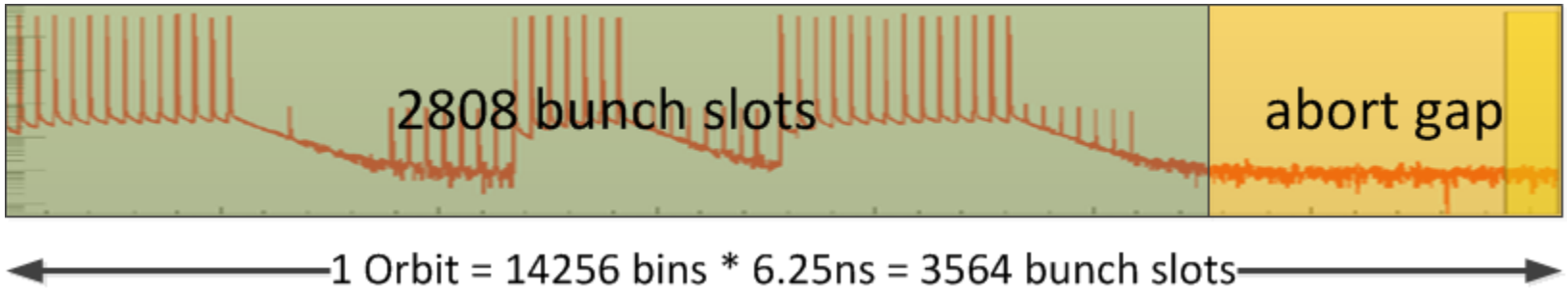
RHU Schematic Rev.1





RHU Features

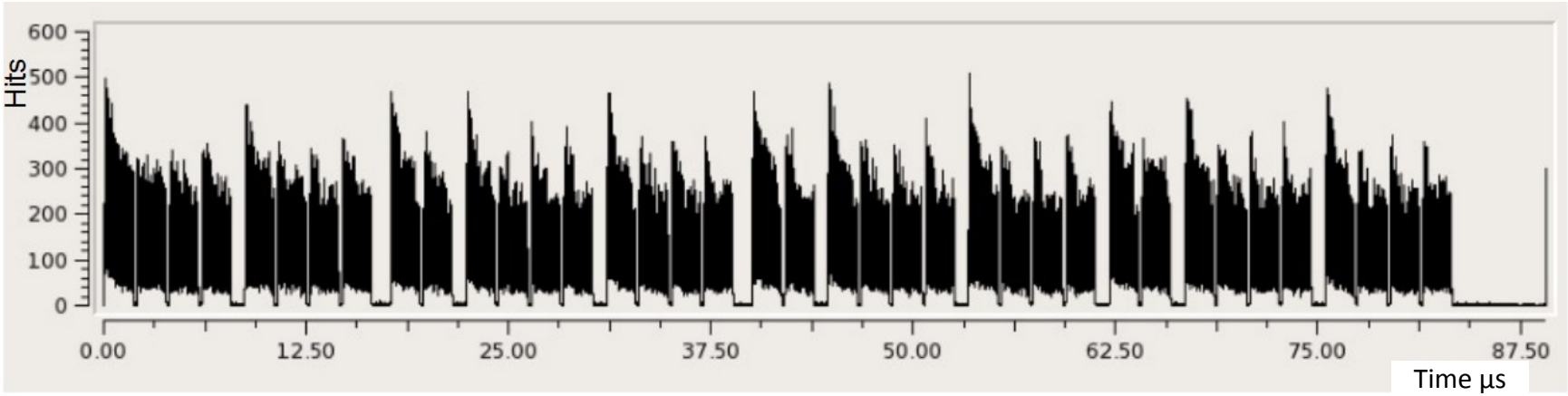
- 8 input channels with orbit histograms
  - Internal 320MHz sampling rate: two samples get „OR-ed“ and stored into one bin
  - → result is 160MHz sampling rate
- Histograms:
  - 6.25ns per bin, 14256 bins/orbit
- No deadtime (via double buffering)
- Continuous postmortem ring buffer
- Configurable # of orbits for histogramming



RHU Features

- Configurable delay for orbit trigger
- Readout and control via network
- Postmortem buffer for > 50 Orbits

Realtime Histogram Data of one channel over several orbits



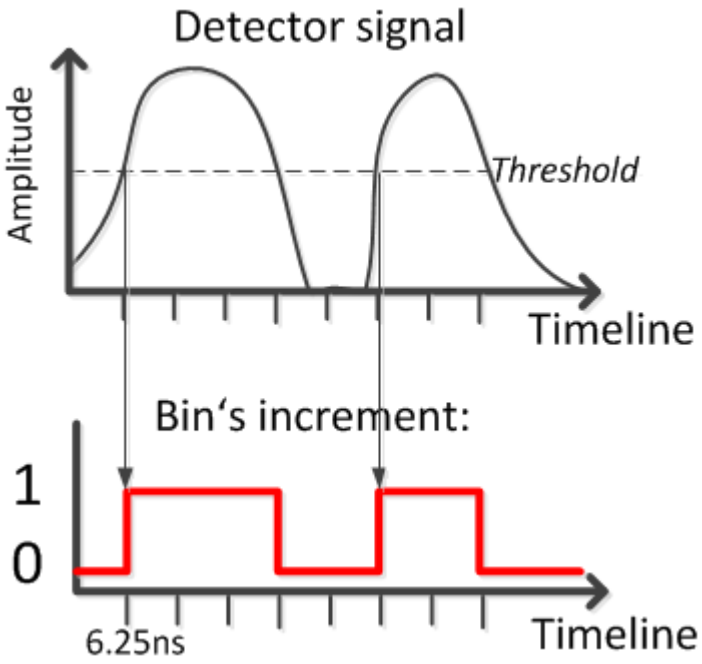
Source: Leonard-ADAMAS-18Dec12.odp

RHU Operation Modes

When the detector signal is above the threshold, the discriminator creates a logical ‚1‘ at the RHU input channel. Two modes of sampling exist:

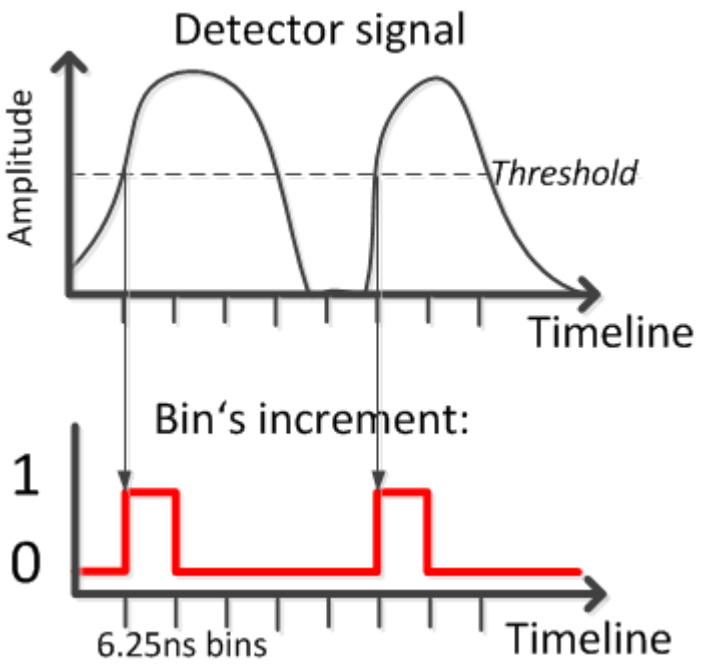
Level-Triggered Mode

- Consecutive bin‘s are incremented by 1 for each orbit



Edge-Triggered Mode

- Only one bin is incremented by 1, when the detector signal is above the threshold



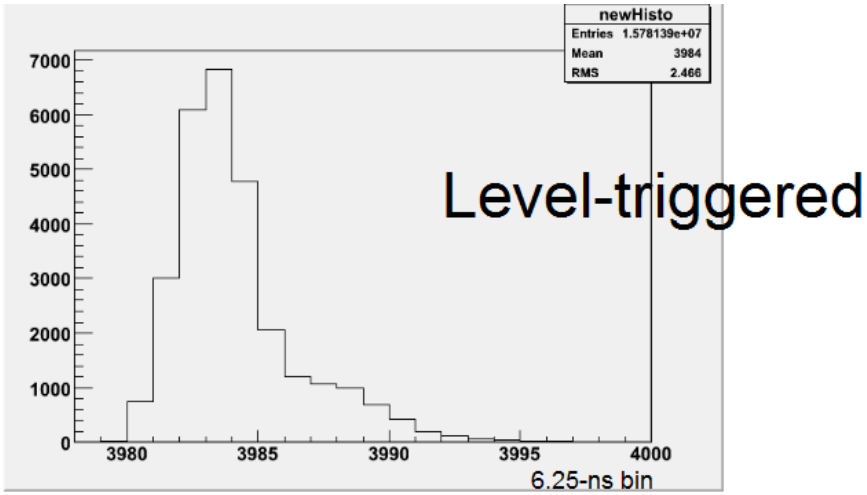
RHU Operation Modes

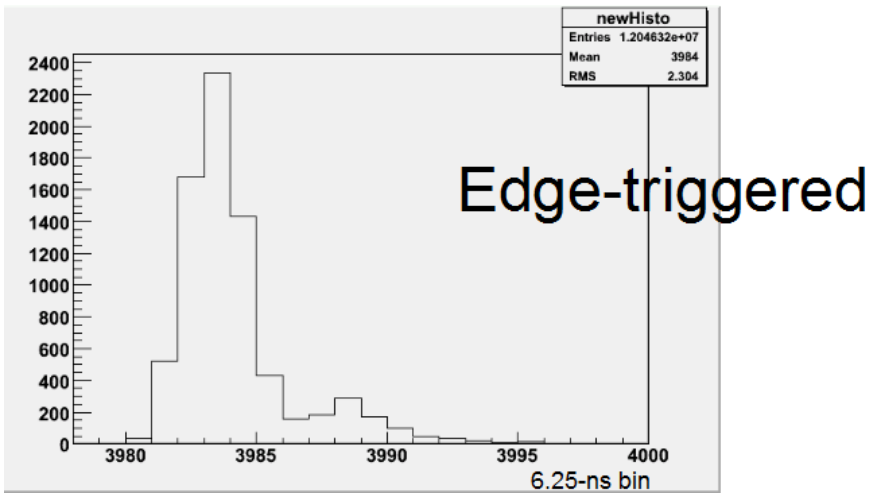
Level-Triggered Mode

- Used when interessted in Time over Threshold
- Increases event-count per bin
- Number of real events is hidden
- Time distribution is blured

Edge-Triggered Mode

- Used when interessed in the exact number of events
- gives clean statistical time distribution of events
- Reduces event-count per bins

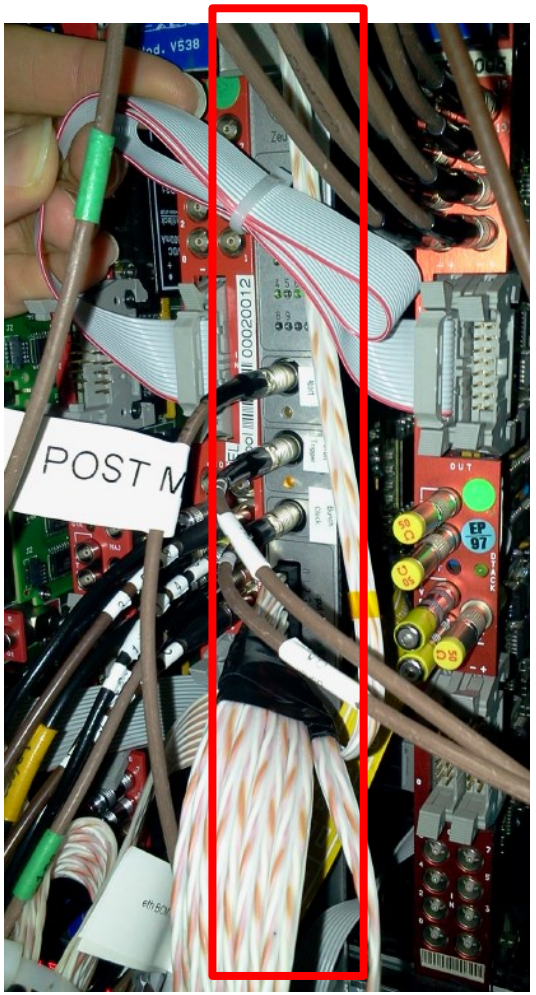




Source: Leonard-BRM-RHUplans-12Feb13.odp

RHU Commissioning 2012

- 1 Device installed for CMS experiment and validated
- 1 Device installed for LHC Beam Background measurements, in Prevessin

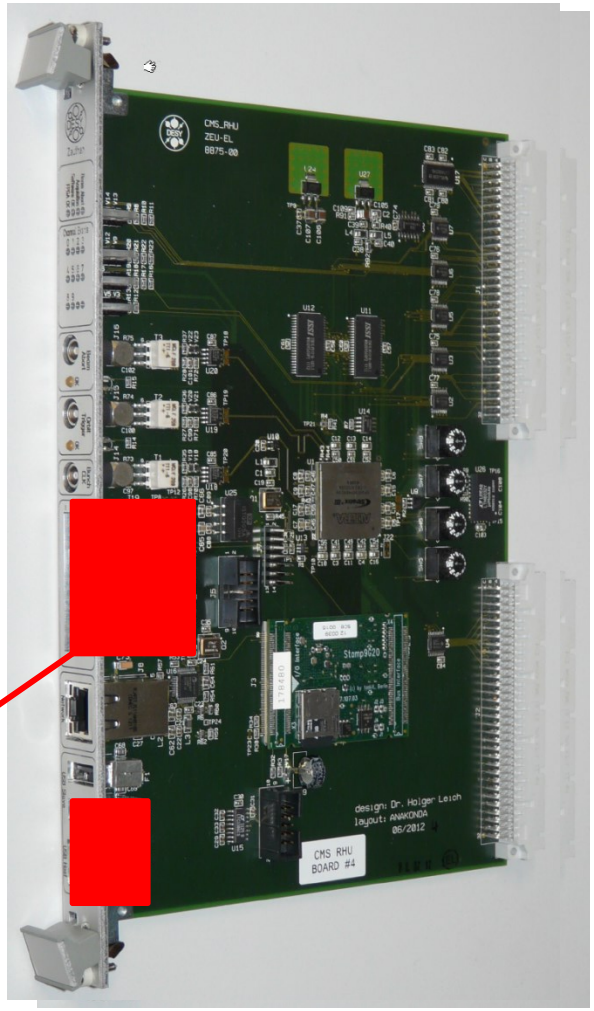


RHU Hardware Revision 2

(ongoing development 2013/2014)

Hardware Rev.2 (2013)

- Use mezzanine card for signal inputs
  - use CAEN V1495 mezzanine cards
  - extensible with customized cards
- Add interface for the TTC timing system
  - decoding events in FPGA
  - support for synchronized luminosity DAQ
- Removed USB host and one USB slave connector
- Removed FPGA flash memory → Boot FPGA via microcontroller
- Add reset switch for SBC
- Improve software and firmware stability



32x LVDS/ECL input channels

8 NIM/TTL in/out channels

32 LVDS input channels

Source: CAEN

Hardware Rev.2 (2013)

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32 LVDS input channels

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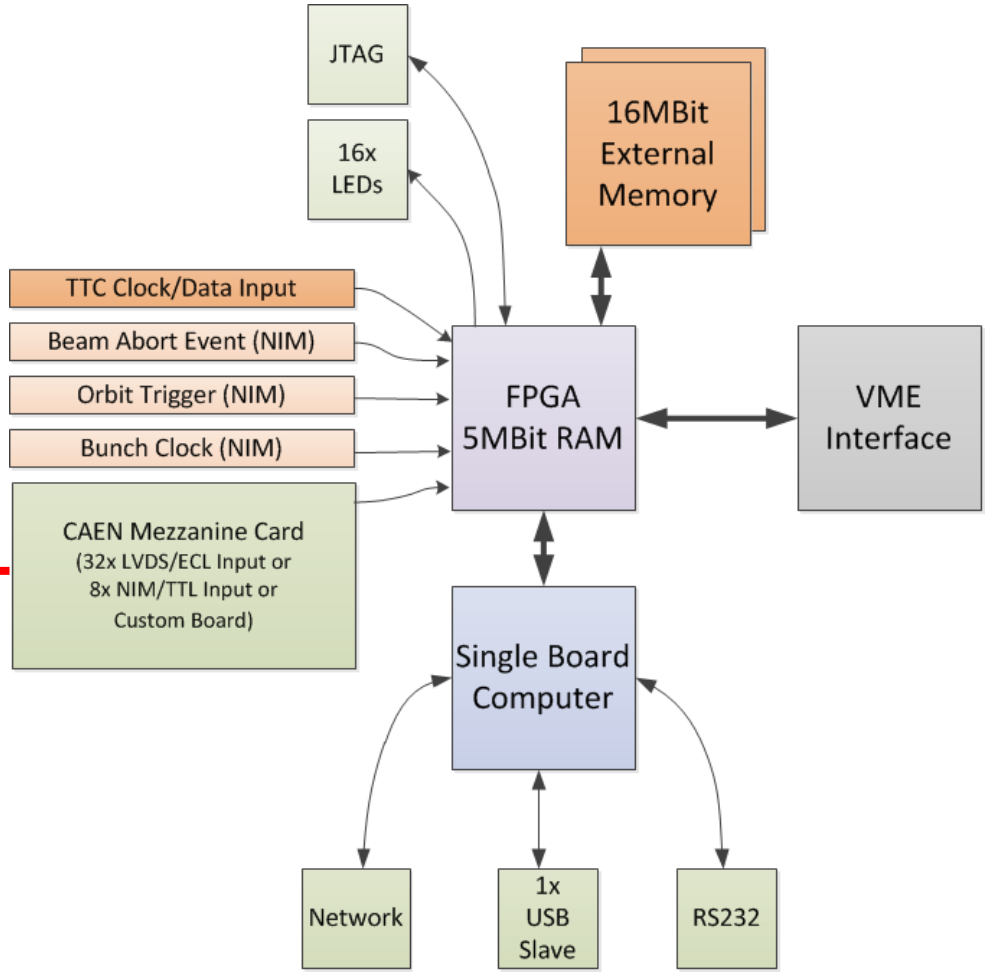
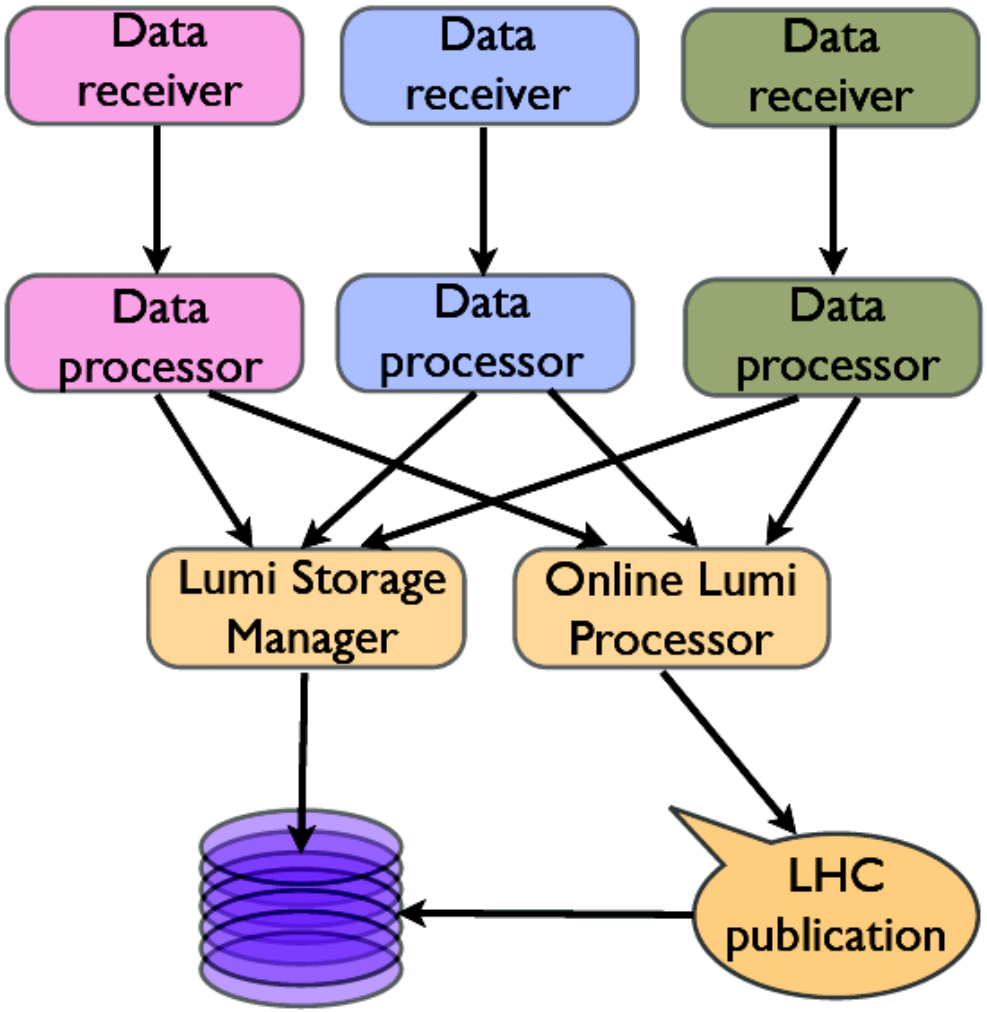


Luminosity DAQ

Luminosity DAQ

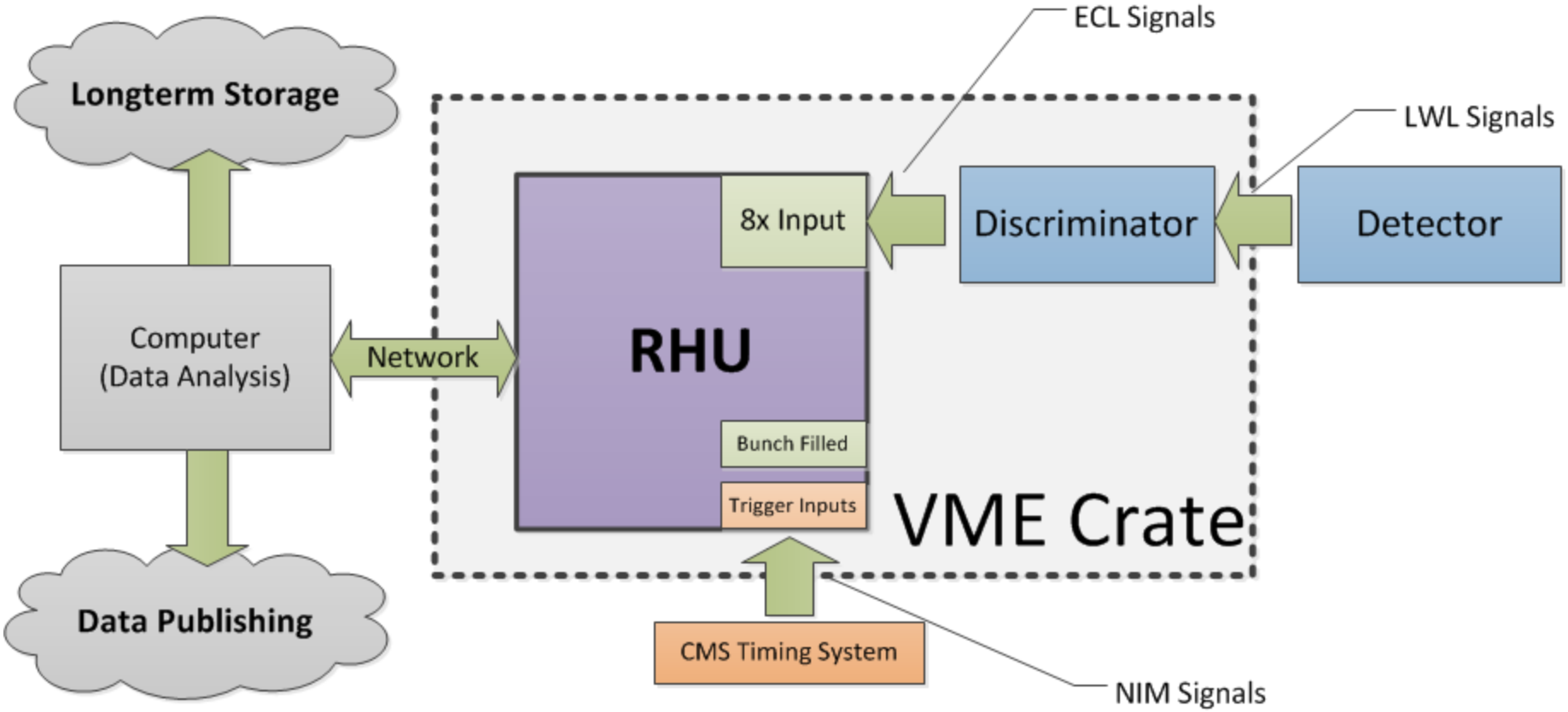
- DAQ dataflow for luminosity and beam background measurements is synchronized at CMS via TTC „short (broadcast) commands“
- Data of 4096 Orbits ≡ *1 Lumi Nibble*
- Lumi Nibbles are identified with ID‘s
- → Readout of RHU devices is synchronized
- → Data can be combined and correlated with other systems

Luminosity DAQ Architecture

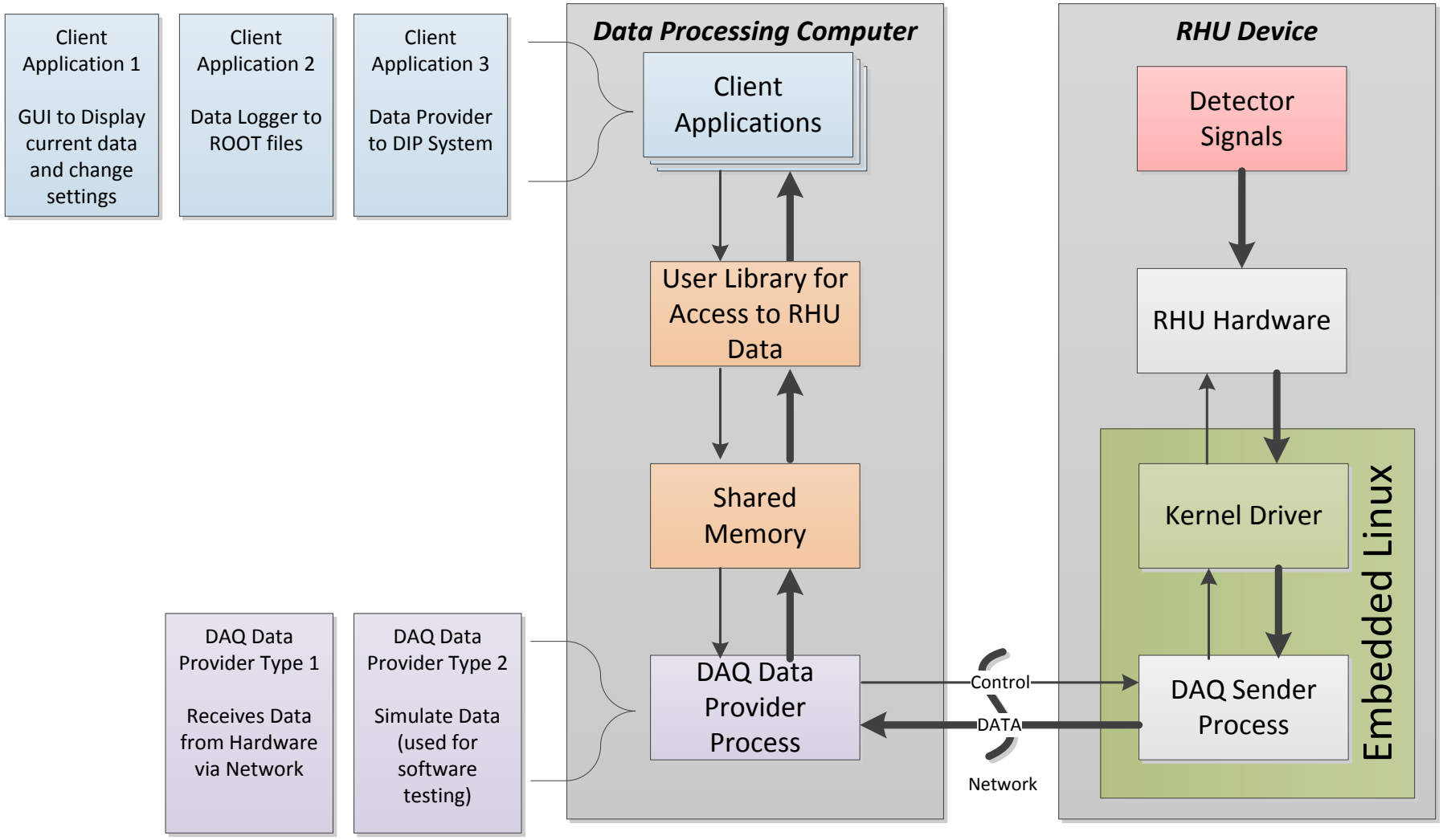


RHU DAQ Software

RHU Setup

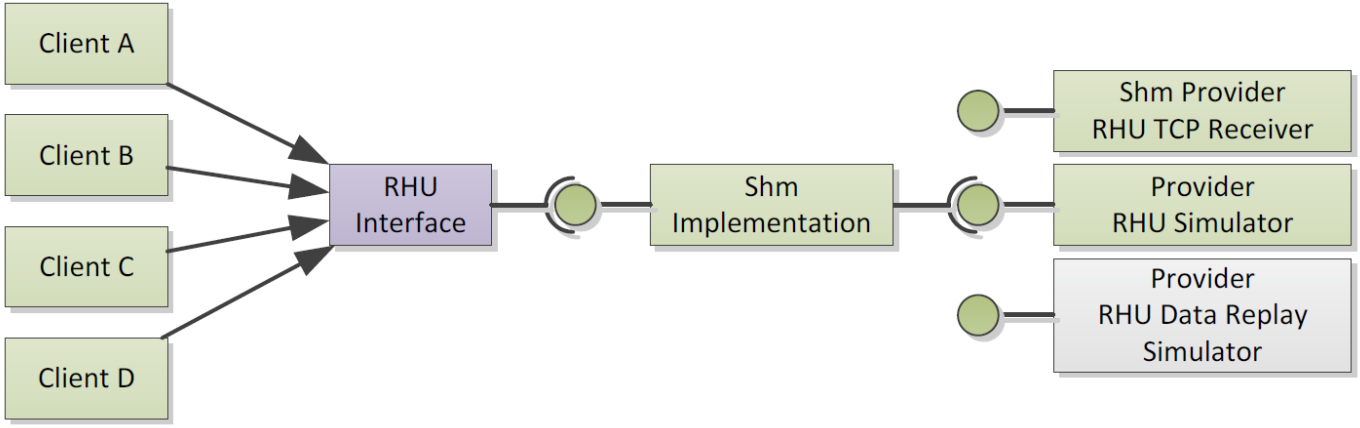

Longterm Storage
Computer
(Data Analysis)
Data Publishing
Network
RHU
8x Input
Bunch Filled
Trigger Inputs
VME Crate
ECL Signals
LWL Signals
Discriminator
Detector
CMS Timing System
NIM Signals

RHU Software Architecture



RHU Software

- Shared Memory Concept works
  - Client Software/Library is kept simple
  - Implementation Details hidden from Clients
  - RHU Data Connection can be reused without performance drop
  - RHU Data Provider can be changed between Simulator and Real-time-Receiver
- Current Software Dependencies:
  - ROOT Framework 5.x
  - Boost C++ Library >= 1.43 (needed in general)
  - QT4 & QWT (For GUI only)
  - DIP Library (for DIP Server only)



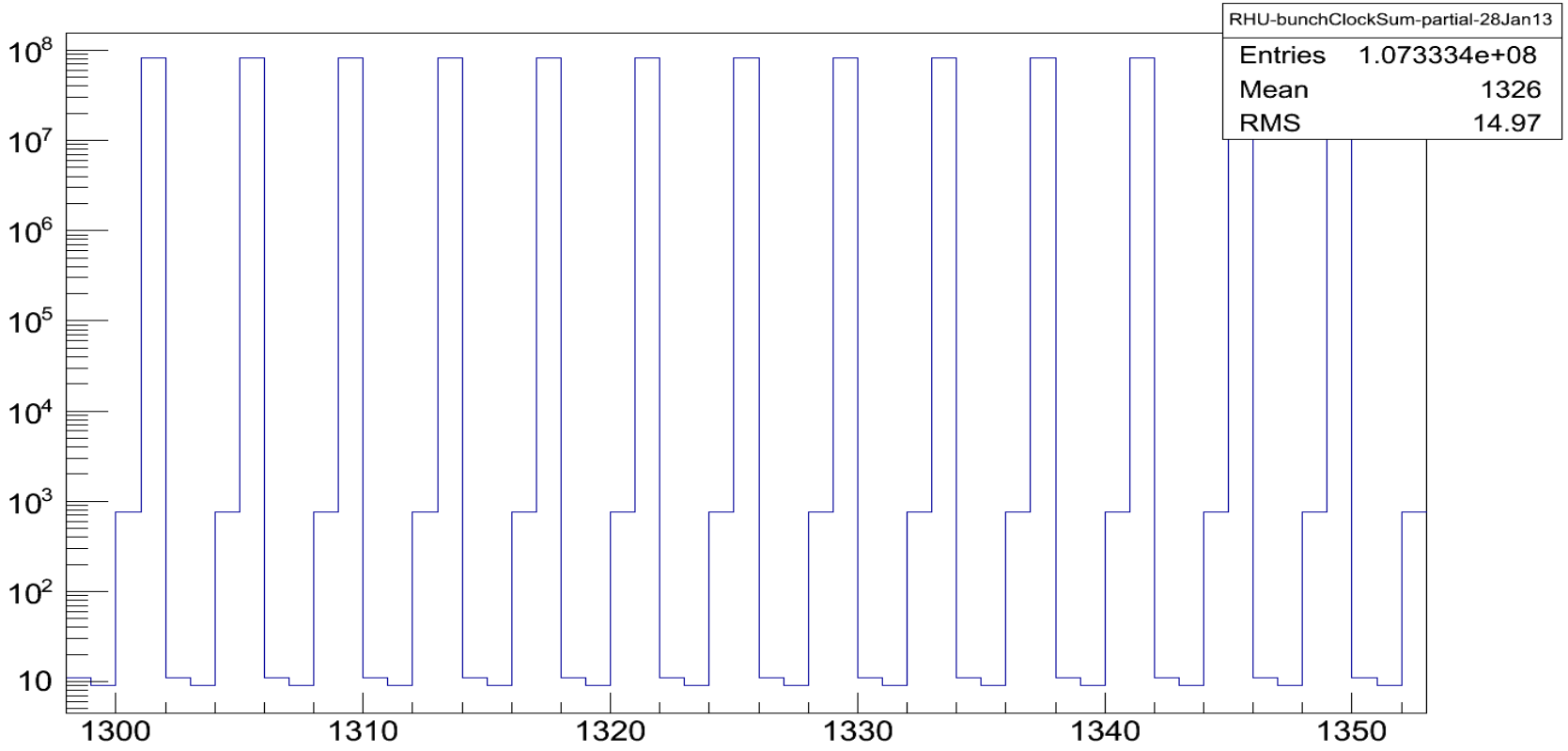
Outlook 2013/2014

- Production and test of 12 RHU devices rev.2
- RHU firmware extended for TTC and Luminosity DAQ synchronisation
- Test TTC interface and luminosity DAQ
- Adapt software to hardware changes
- Software documentation
- Install hardware and DAQ software at CMS

Thank you!

RHU with test input signal

- Using bunch clock as input signal



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