Real Time Histogramming Unit (RHU) Hardware and Commissioning Results

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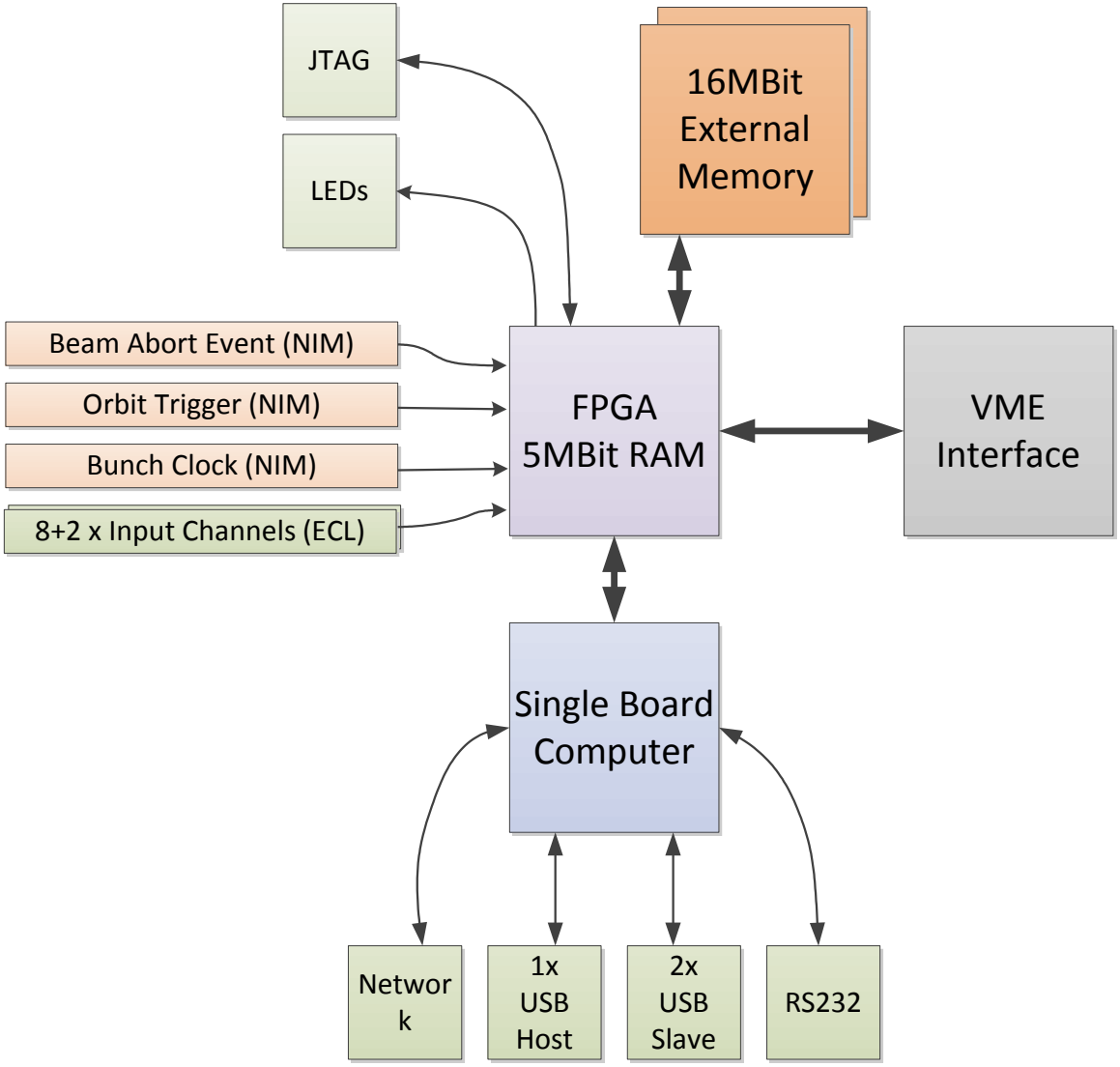
Overview

- RHU Hardware Rev.1
- Setup and Commissioning 2012
- RHU DAQ Software
- RHU Hardware Rev.2
- Proposal for „Lumi Nibble Control“
- Outlook 2013

Hardware Rev.1 (2012)

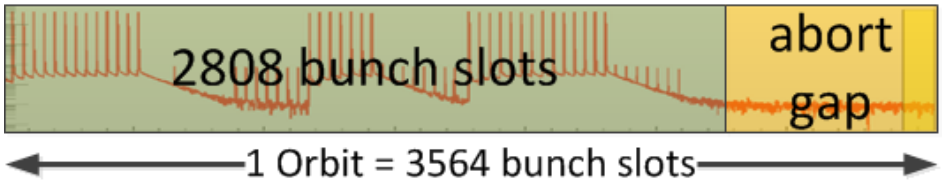
- RHU → Real Time Histogramming Unit
- FPGA based digital recorder
- 3x NIM Inputs for clock/control
- 12x ECL Inputs for input data
- VME Interface (not used yet)
- System On Board Embedded Linux System, RISC CPU 400MHz
- Ethernet Readout
- 5MBit RAM in FPGA
- 16MBit external RAM (3.2GBit/s)

RHU Schematic



RHU Features

- 8 input channels with Histogramming
  - 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
  - Max. 5839ms meas. period



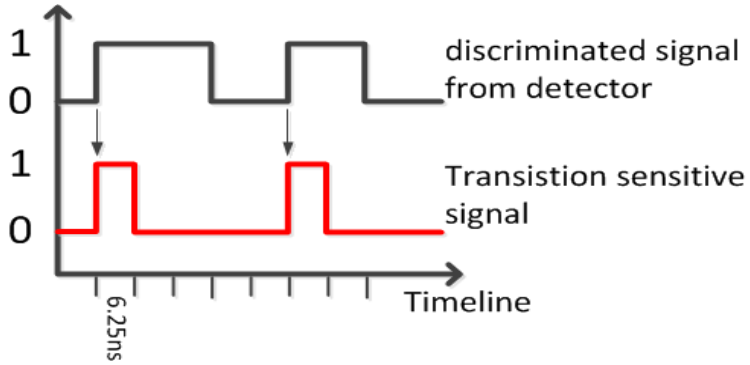
- No deadtime (double buffering histograms)
- Continuous Postmortem Ring Buffer
- Configurable # of Orbits for Histogramming

RHU Features

- Configurable delay for Orbit Trigger
- Readout and Control via Network
- Configurable Sampling Mode: Edge/Level

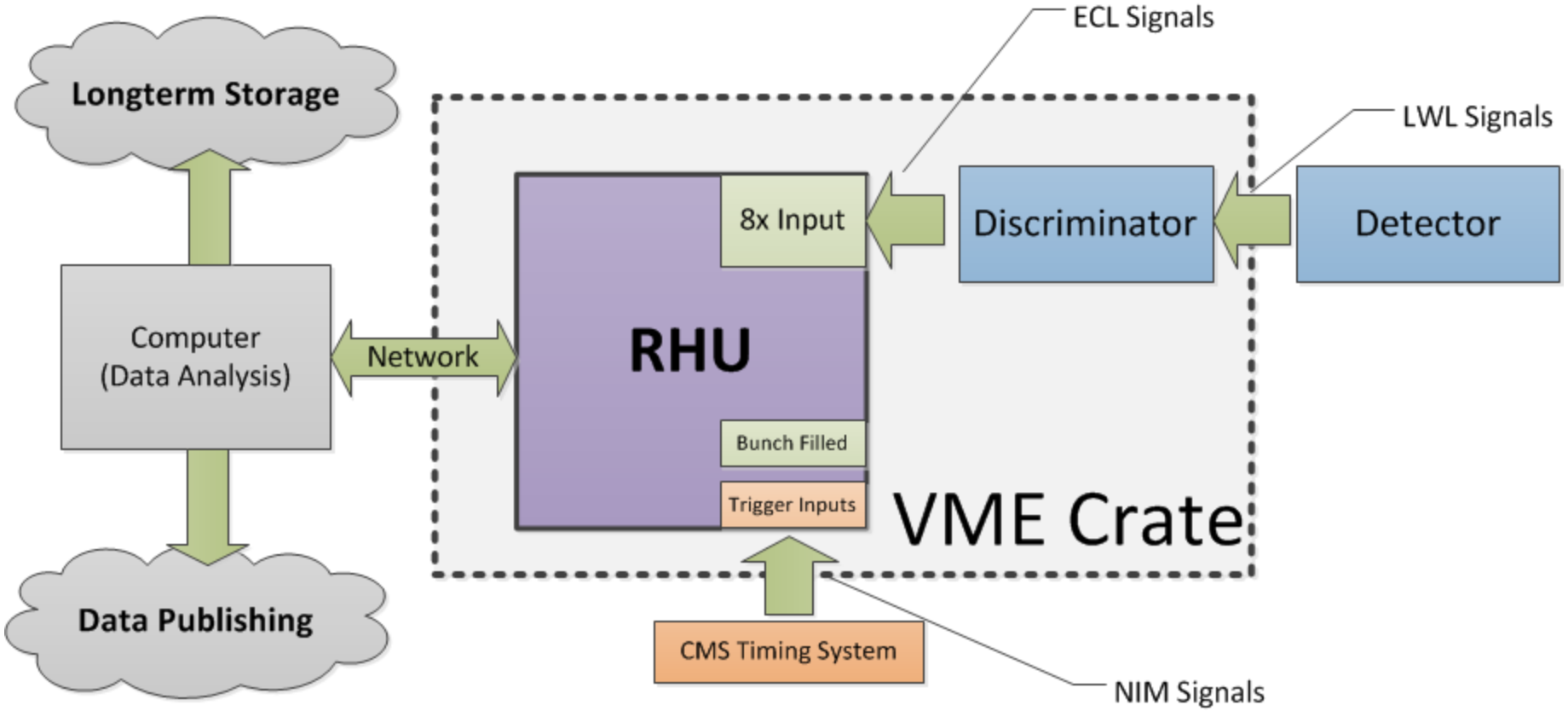
LEVEL Trigger Mode:

EDGE Trigger Mode:

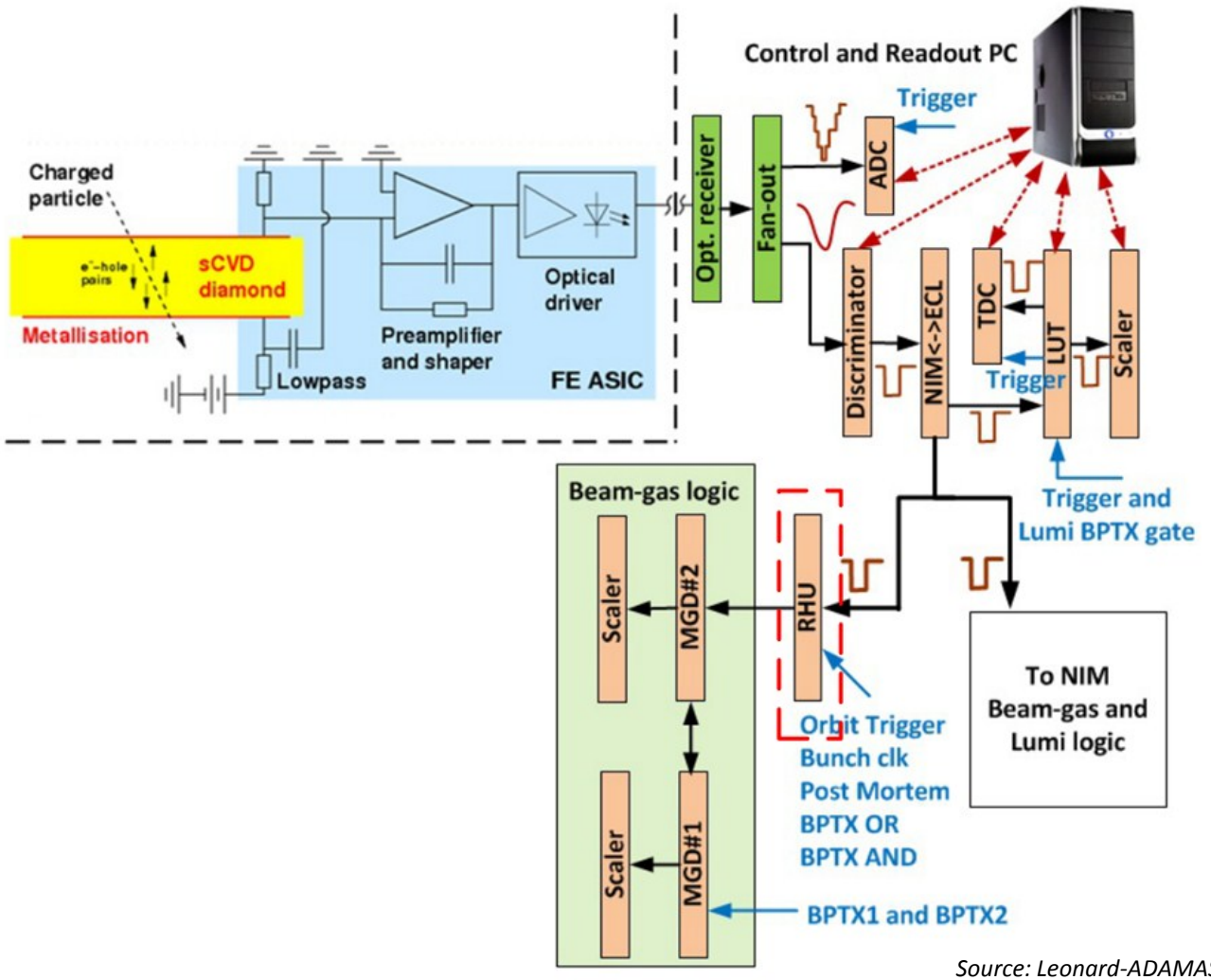


- Postmortem Buffer for > 50 Orbits

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

Setup at BCM1F

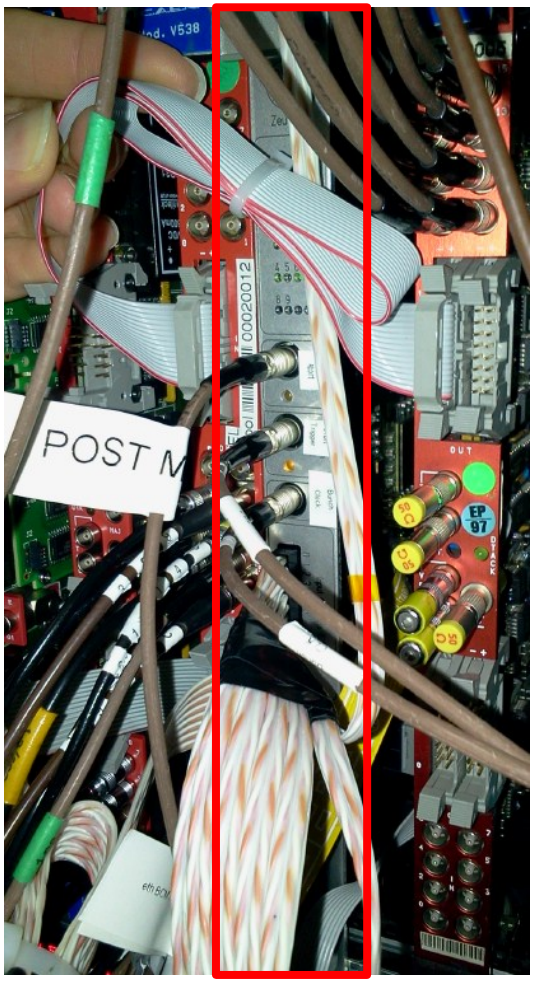


Source: Leonard-ADAMAS-18Dec12.odp

RHU Commissioning 2012

- 1 Device installed at CMS
- 1 Device installed at Prevessin
- Data taken since 4Q 2012 stored in ROOT files
- Data send via SSH Tunnels to DAQ Software at DESY Zeuthen
- DAQ Software also installed at computer at CMS but no data recording yet.

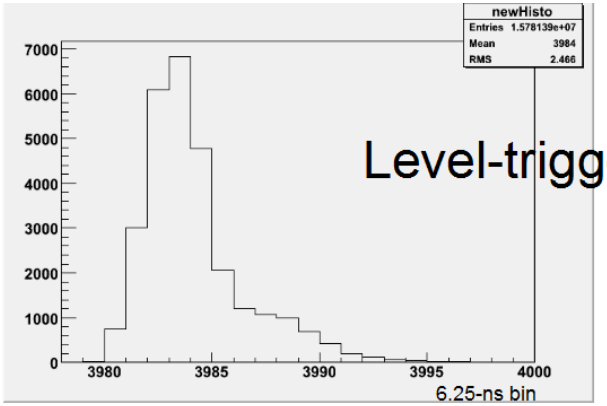
RHU Commissioning 2012

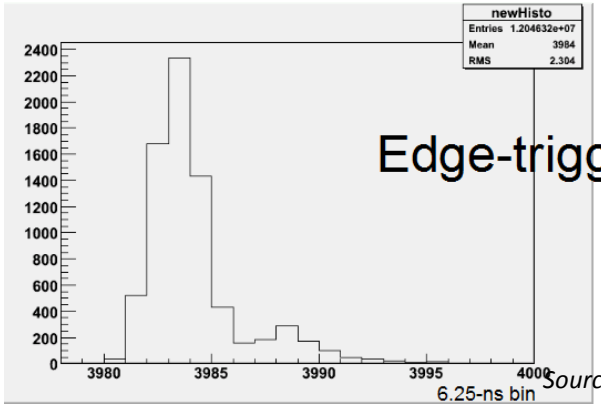


- Electrical corrections at the board made by the SMD workshop at CERN
- Mechanical correction of front panel made by mechanical workshop at CERN
- Made special 10-channel signal cable and installed it to intercept existing signal path at the crate
- Verified all input-signals via scope
- Some Firmware / Software adaptions

RHU Validation

- RHU Device validated in Edge and Level Trigger Mode
- Postmortem Function still to be tested





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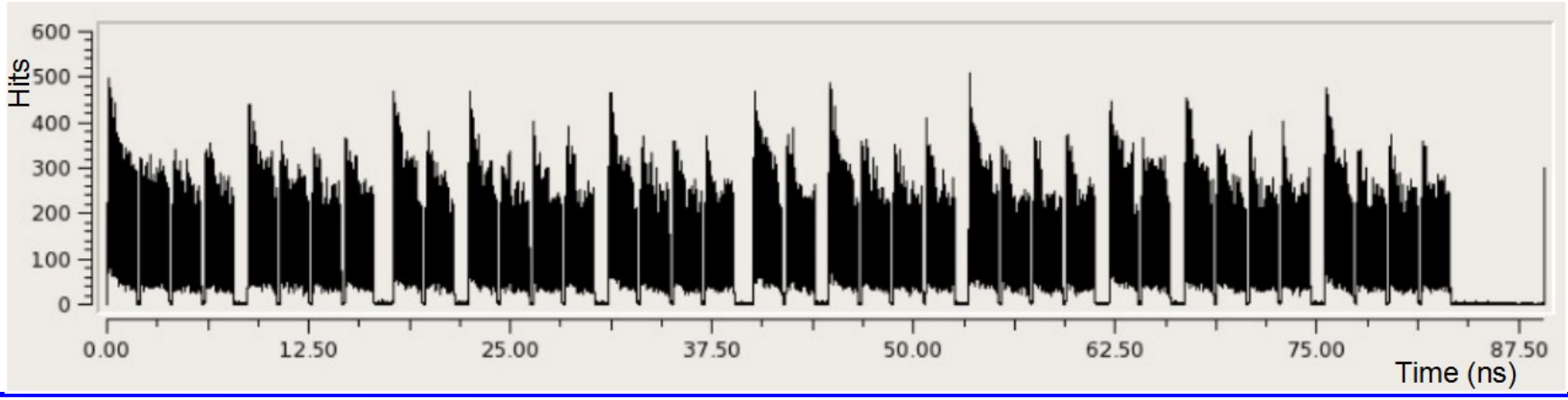
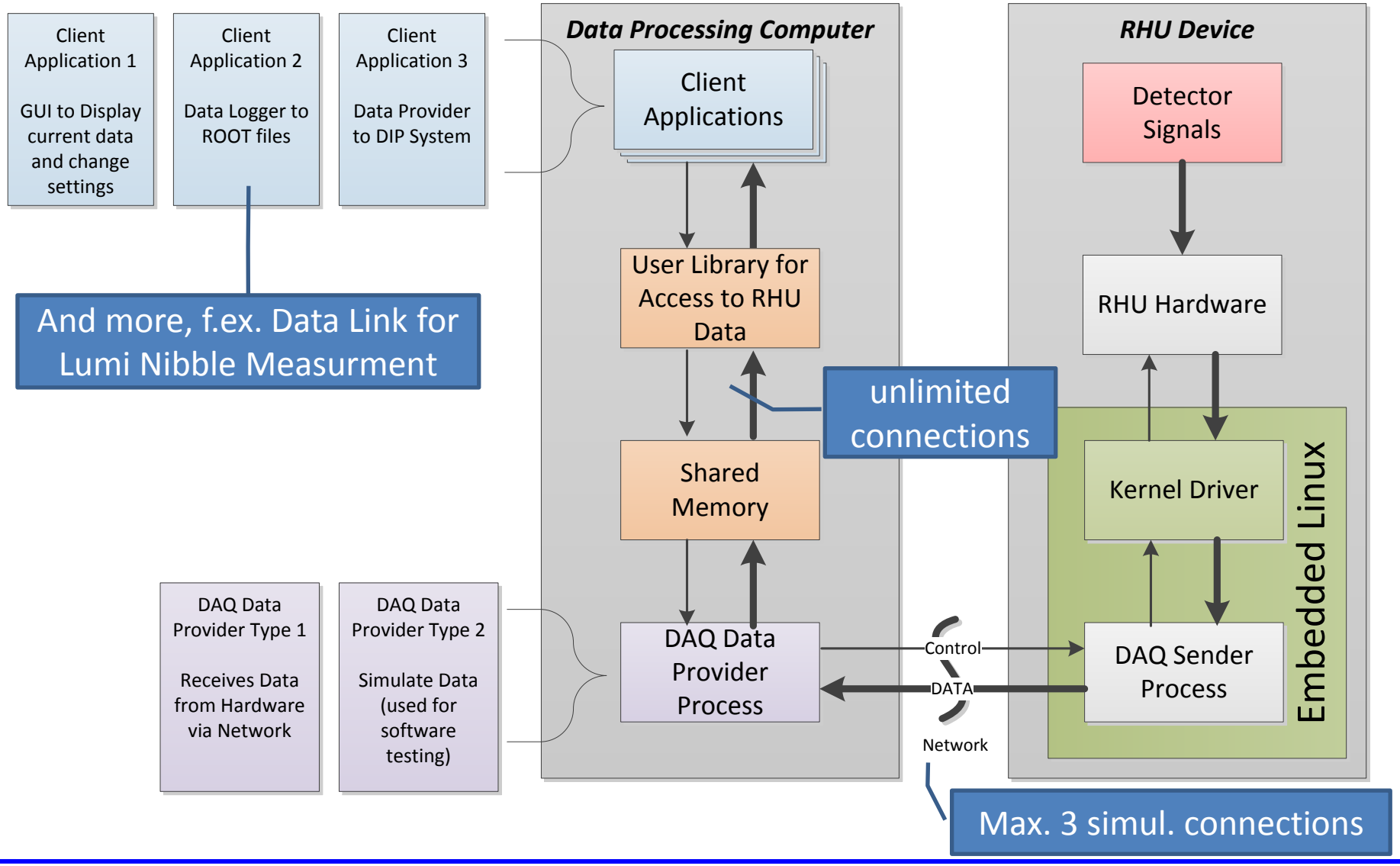
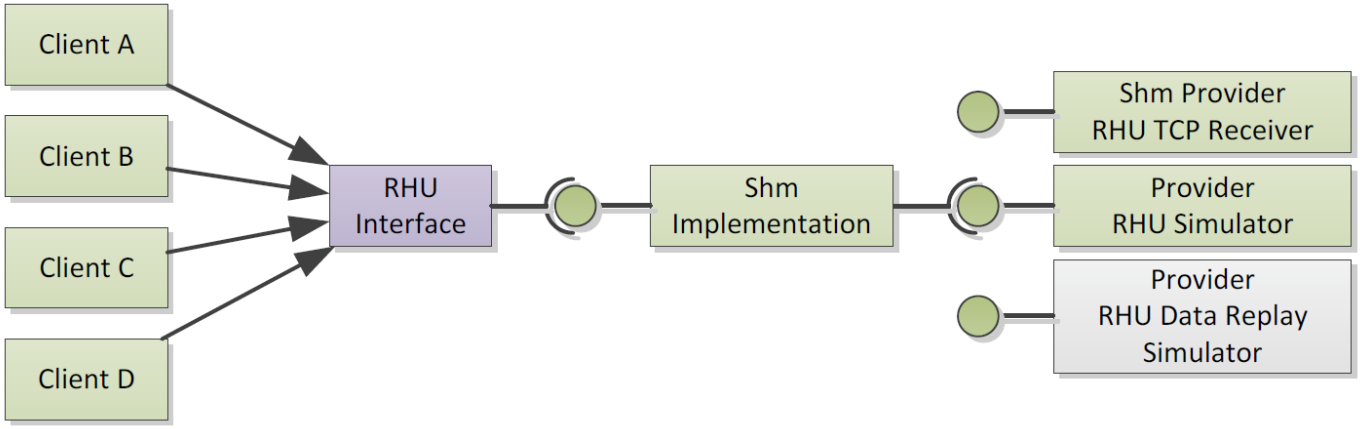


RHU Software Architecture



RHU Software Review

- Shared Memory Concept works
  - Client Software/Library is kept simple, data transportation details not exposed to clients
  - 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)
  - OpenEmbedded 2008 / Angstrom Distribution + Taskit Overlay (for Embedded Software Part)



RHU Software outlook

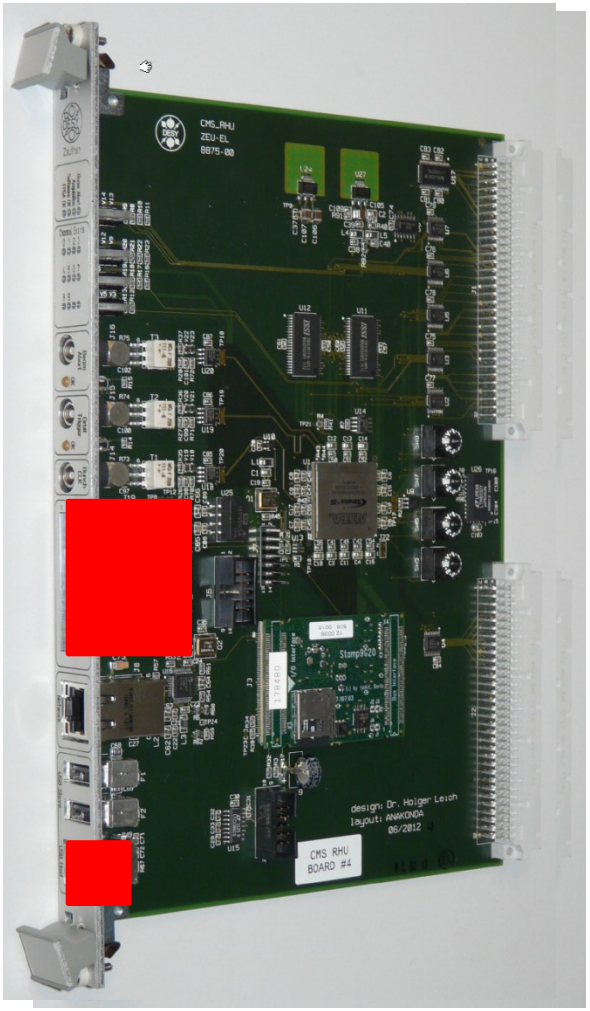
- Move RHU DAQ Software to CERN Network
  - Increase Performance and stabilize communication
  - Create Development Environment for future
- Provide RHU Development Environment at CERN
  - Need Scientific Linux > 4 on Target Machines
- Provide Post Mortem Readout Functionality
- Improve GUI usability and stability for better user experience
- Improve RHU Slow Control Protocol (remote configuration)
- Provide Documentation
- More Software thinkable
  - RHU data replay provider, replays history data
  - RHU DIP Server, distributes data to DIP clients
  - RHU Lumi Nibble Server, combines data of several RHU's
  - RHU Shared Library for ROOT Scripts
- But: Software Development Capacities limited

Hardware Rev.2 (2013)

- Experiences from installation and test run
- Room for improvement:
  - Other 8ch connector for easier installation
  - Additional signals needed for „lumi nibble control“
  - Improve software and firmware stability
- → Final Hardware Design

Hardware Rev.2 (2013)

- Fix optional ECL Termination
- Change 8ch ECL Input to Caen compatible connector
- Provide 4 ECL Inputs for control (f.ex. Lumi Nibble control)
- 1 ECL Output for future applications
  - WHY? Provide ability for fast decisions / reaction in real-time that are based on measured data
- Removed USB Host



RHU Firmware Outlook

- Implement „Lumi Nibble Control“
- Optional: Implement individual delay (3.125ns steps) configuration for each Input Signal
  - Idea: compensate for big differences in cable lengths (> 2m)
- Optional: Implement VME Interface
- But: No Firmware Engineer Capacity for „heavy changes“ available

Lumi Nibble Measurement

The Idea:

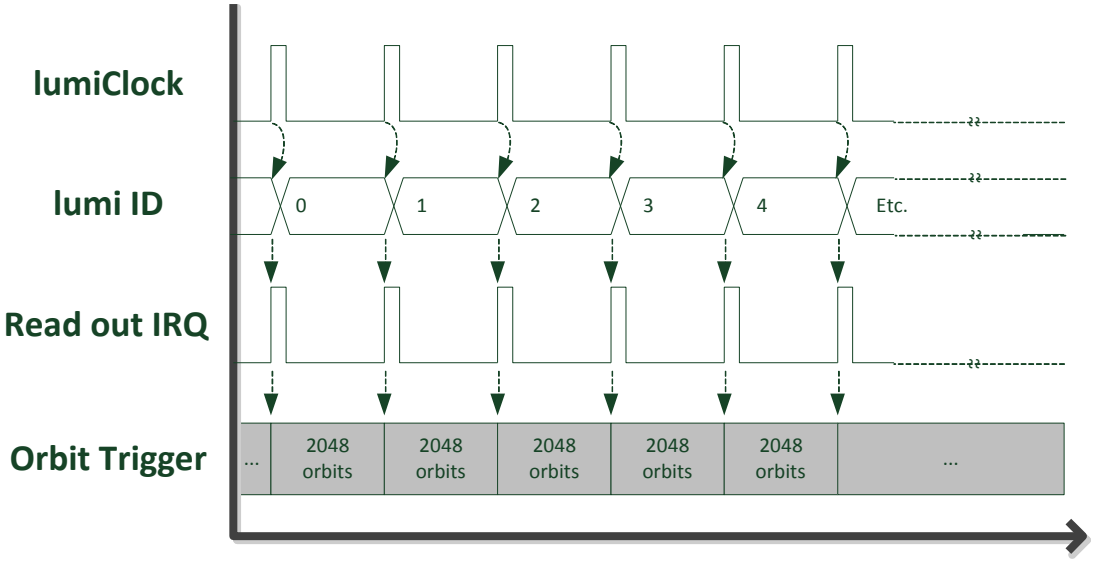
- Histogram of 2048 Orbits = *1 Lumi Nibble*
- Each Lumi Nibble has a *Lumi Nibble ID, is incremented for each nibble*
- → Data of *Lumi Nibbles* can be correlated of several systems
- Need for „Lumi Nibble Control“ to synchronize several RHU Devices and/or other systems that do Lumi Measurements

„Lumi Nibble Control“

- RHU Devices used in groups for f.ex. a 24 channel detector (3x 8 channel)
- Need for event/time-synchronization for the Lumi nibble measurement
- *Lumi Nibble* Information must be transferred in real-time → need for a hardware protocol
- *Lumi ID* should be transferred absolute/full to keep systems always synchronous
- RHU Rev.1 „prepared“ with 2 ECL inputs
- RHU Rev.2 „prepared“ with 4 ECL inputs

Proposal for Lumi Nibble Protocol

- 1 ECL Line for „Lumi Nibble Clock“
  - Each Clock Period → New *Lumi Nibble* starts/last data is send
- 1 ECL Line for asynchronous protocol
  - f.ex. RS232 like, 115Baud, (easy to implement)
  - Transfer of the absolute „Lumi Nibble Id“ before the next „Lumi Nibble Clock“



What‘s next in 2013?

- Production of 12 RHU Devices Rev.2 in 2013
- Agree to a „Lumi Nibble Concept“
- RHU Firmware extended with „Lumi Nibble Control“
- Postmortem Function Test
- Improve Software Stability
- Software Documentation
- Move DAQ Software to CERN Network

Long term planning

- Acquire Software/Firmware Engineering Capacity for the RHU Hardware Project to ensure long term support
  - Current Firmware Engineer at DESY is going to retire within next 2 years and is occupied with new projects until then
  - Current Software Engineer at DESY also occupied with new projects within next two years
- Its good to have an expert „nearby“

Thank you!