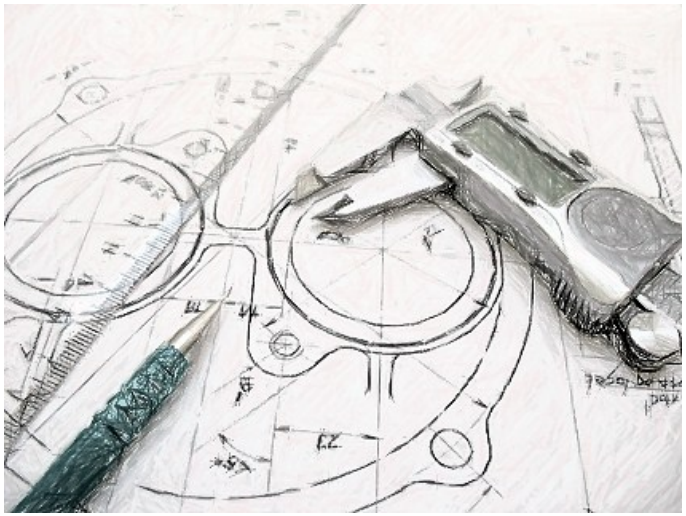
Arrival Time Histogramming Unit.

Requirements and concept



Marek Penno
Dr. Holger Leich

Workshop on Fast Beam Conditions Monitoring at DESY Zeuthen
2012/02/01

HELMHOLTZ ASSOCIATION

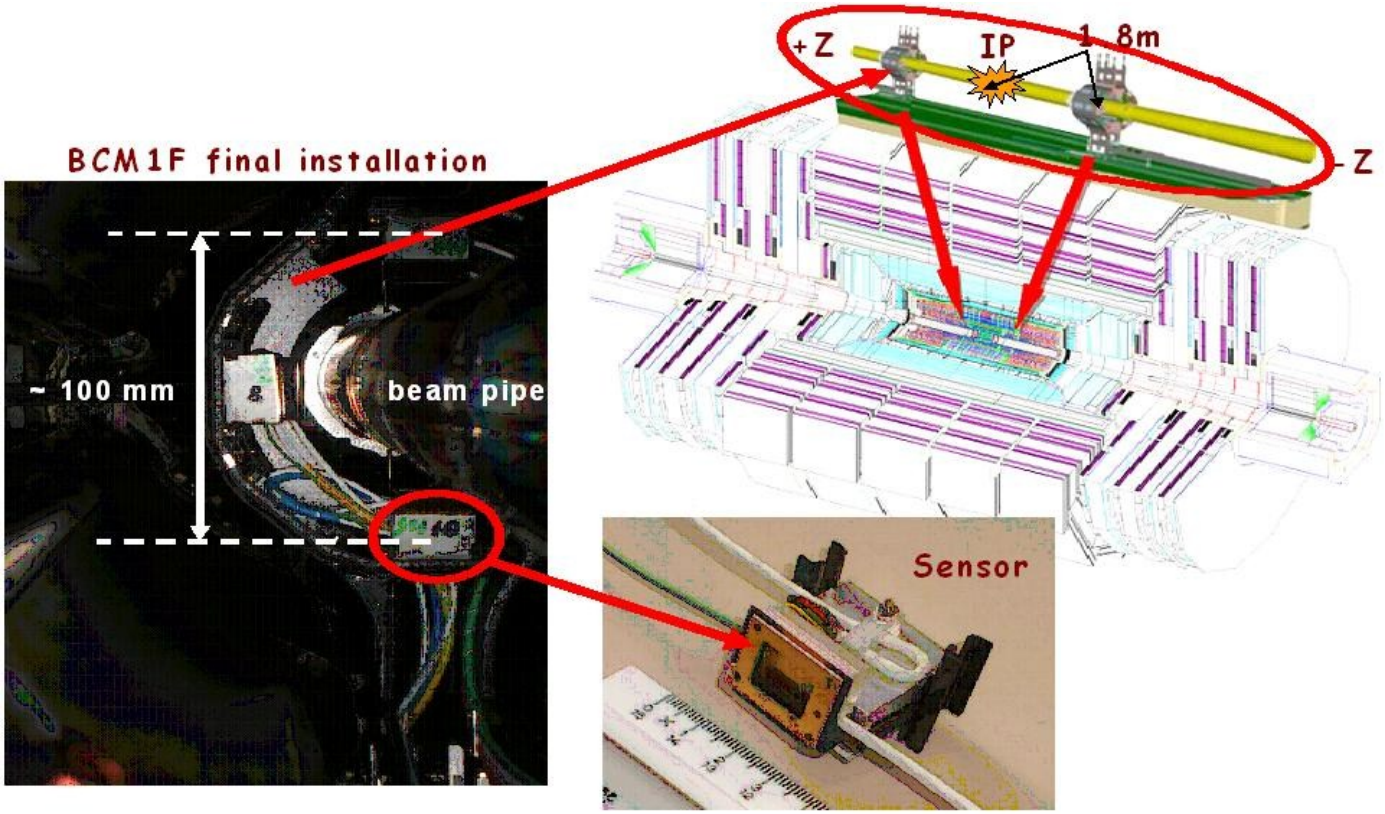
DESY

Outline.

- **Objective**
  - **Detector Subsystem BMCF1**
  - **Provide Histogram and Postmortem Data**
- Requirements
- Hardware Concept
- Summary

Objective.

- **BCMF1**, 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



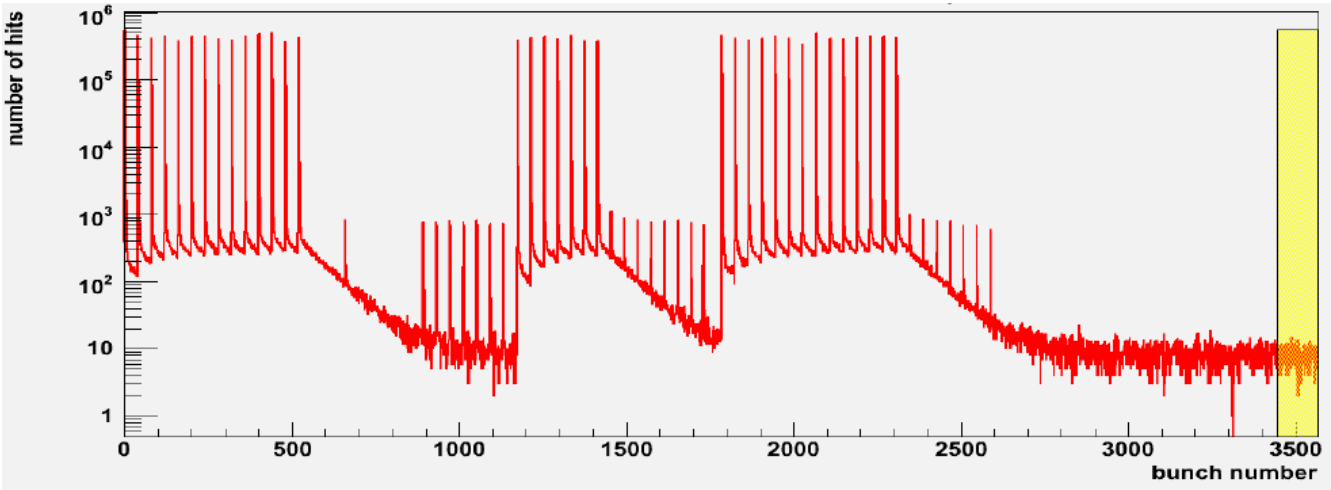
Source: https://znwiki3.ifh.de/CMS/Bcm1F

Objective Goals.

- Extend existing DAQ system
- Provide continuous beam particle distribution in real time
- Provide post-mortem data after beam abort

Objective – Reconstruct Particle Distribution.

- Reconstruct particle distribution in the accelerator ring
  - Monitor the discriminated signals (events) from the detectors of BCM1F
  - Monitor detector events in respect to LHC bunch clock and orbit clock
  - Acquire time of the orbit trigger and the time of the detector events
  - → Reconstruct the distribution of particles in the accelerator ring
  - Example Data from the existing DAQ System, TDC Modules:



Source: Elena Castro, FSP CMS Workshop, Beam Condition Data Analysis with BCM1F

Outline.

- Objective
- **Requirements**
  - **Interfaces**
  - **Acquisition**
- Hardware Concept
- Summary

Requirements – Interface for data acquisition.

- 8 detector input channels
  - ECL Type, optional 120 Ohm Termination, common ground
  - Sample Rate: 6.25ns
- supplementary input channel “Bunch filled”
  - Sample Rate: <= 25ns
- supplementary reserve input channel
  - Sample Rate: <= 25ns
- Orbit Trigger input
  - NIM, 50Ohm termination
- Bunch Clock input
  - NIM, 50Ohm termination
- Beam abort input signal
  - NIM, 50 Ohm termination

Requirements – Further Interfaces.

- VME Slave
  - Communication with VME Controller, access the control registers
- Network
  - Communication with DAQ System, transfer of acquired data
- USB Slave
  - Optional communication with DAQ System
- RS322
  - Administrative Interface
- JTAG
  - Programming Interface

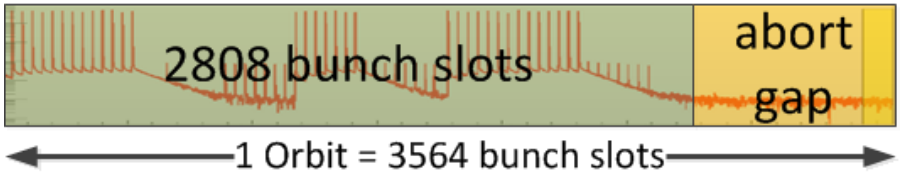
Requirements – Data Acquisition.

- Post Mortem Data
  - Filled continuously with event data from the detector inputs
  - Organized as ring buffer → outdated data being overwritten
  - Acquisition is stopped at beam abort event
  - Postmortem Data contains detector event data of the last 50 orbits
  - Software reads out post mortem data on beam abort

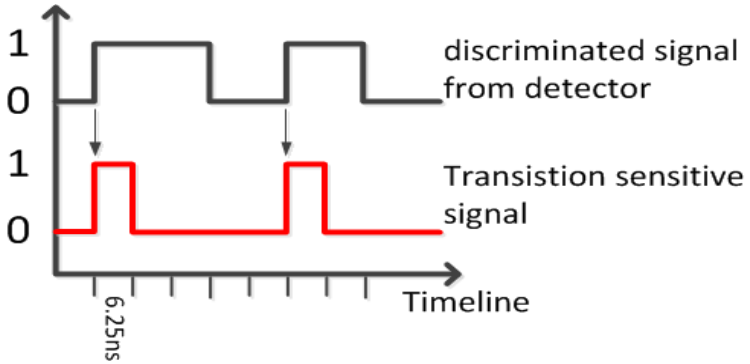
Requirements – Data Acquisition.

Histogram Data

- For each channel (8 detector + 2 supplementary)
- Statistical overview of count of events in respect to N orbits
- Sample Rate: 6.25ns = 160 MHz = 4 times bunch clock (40 MHz)
- Each orbit: 3564 bunch timeslots → 14256 bins in histogram per channel
- → Monitor all possible bunches and the "***abortion gap***"



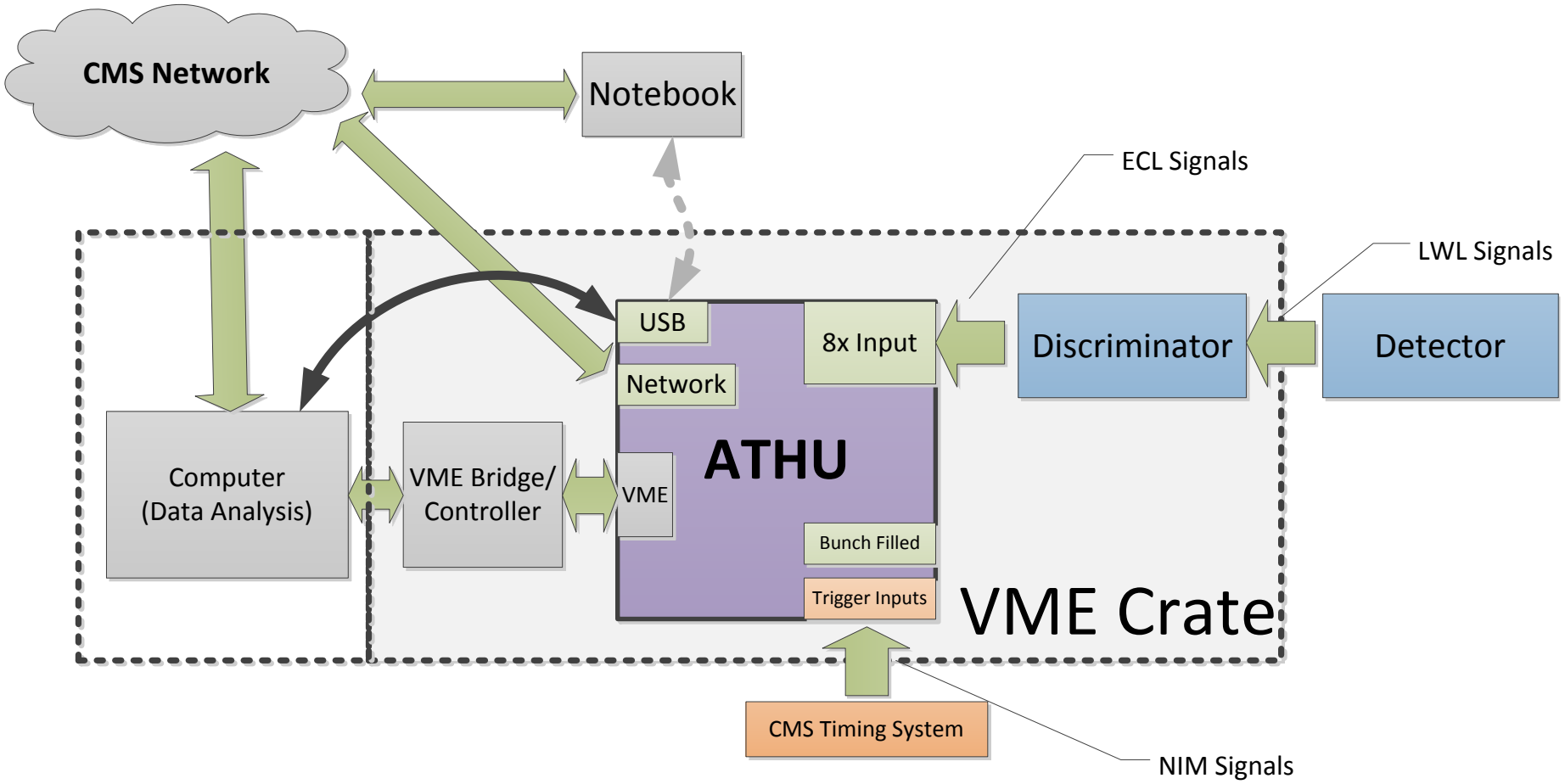
- Bin's width: 16 Bit → 65535 orbits = 5839.1ms timespan
- Double Buffered System: continuous data acquisition → no information loss
- Transition sensitive sampling or synchronous sampling:



Outline

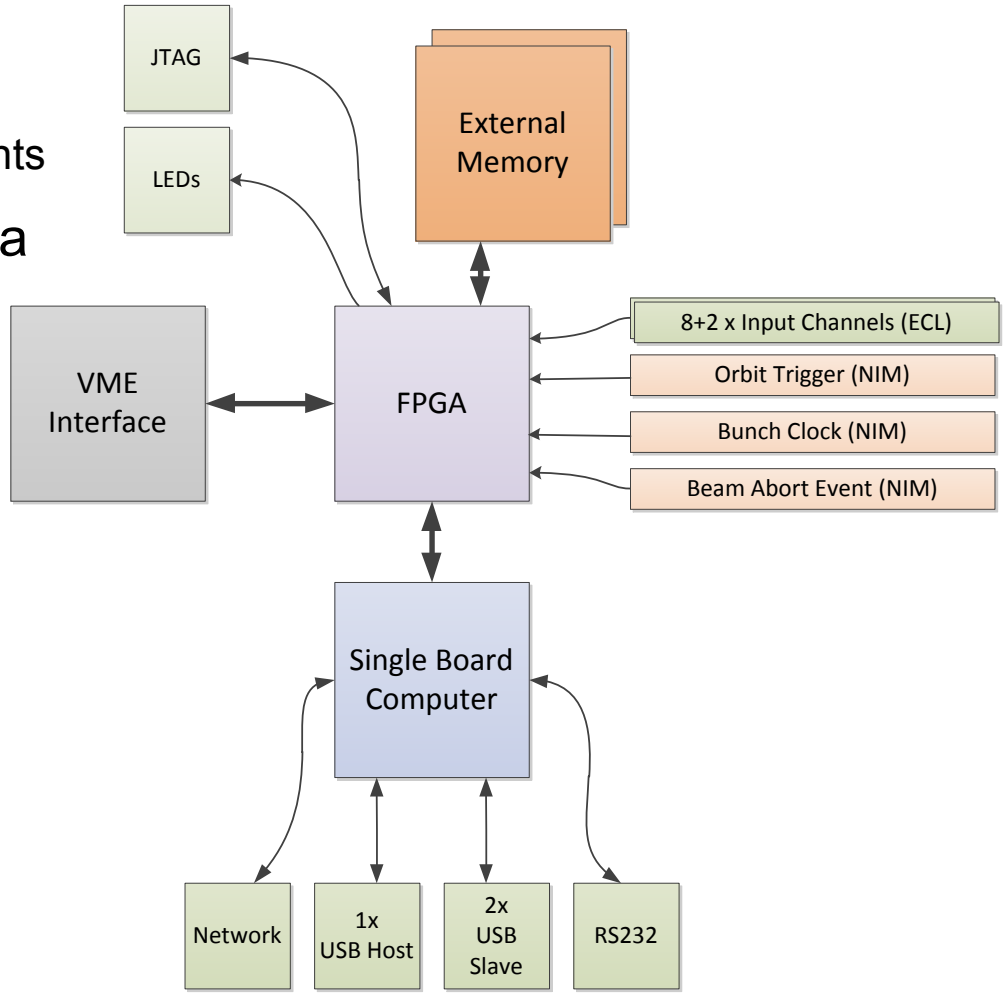
- Objective
- Requirements
- **Hardware Concept**
- Summary

Hardware Concept – ATHU Bird eye view

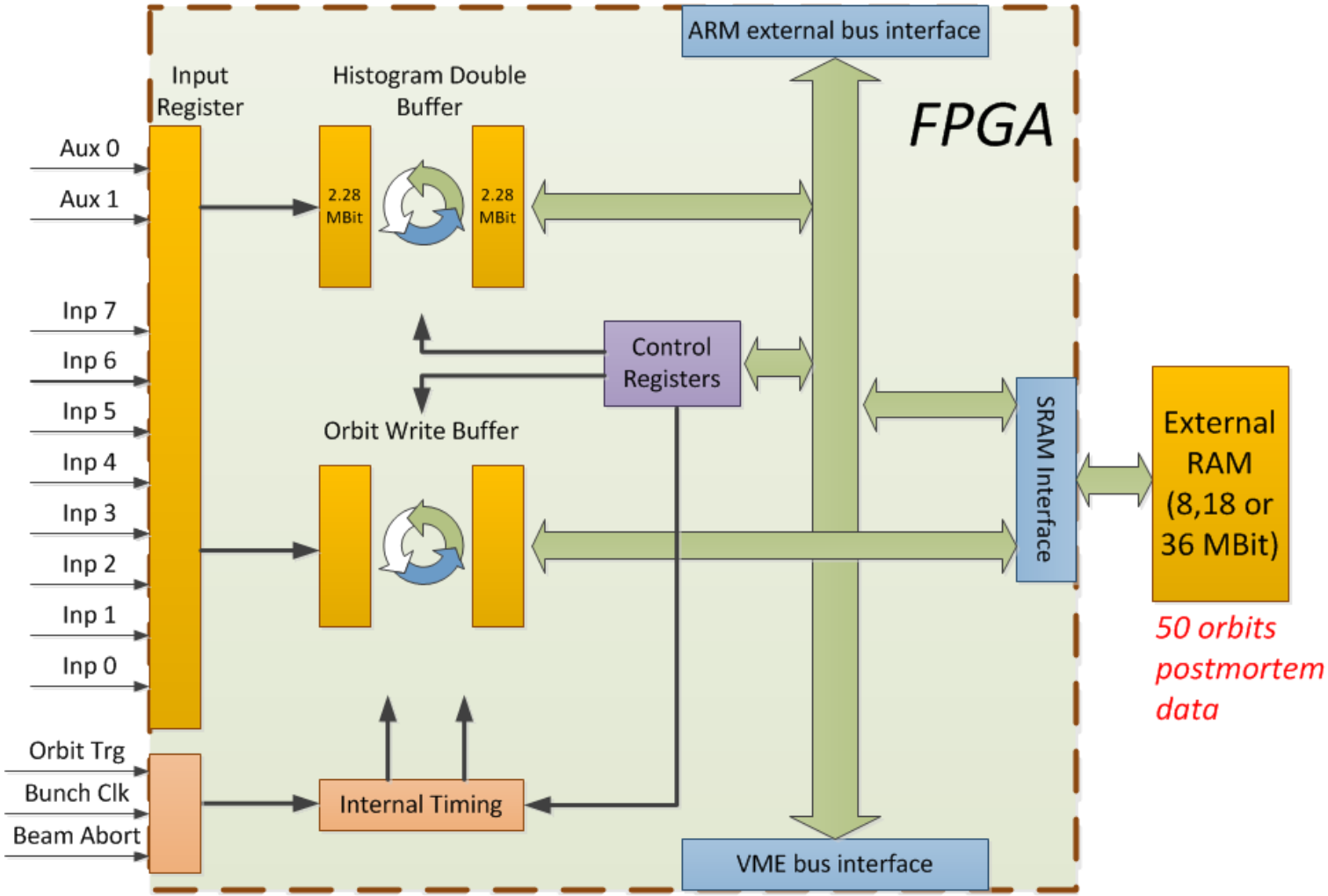


Hardware Concept – Block Schematic.

- Single FPGA solution
- Ext. RAM for post mortem data
  - Reduced FPGA memory requirements
- Int. FPGA ram for histogram data
  - Fast read and write requests with in 6.25ns
- Single Board Computer
  - Data readout
  - Acquisition control
  - Network communication



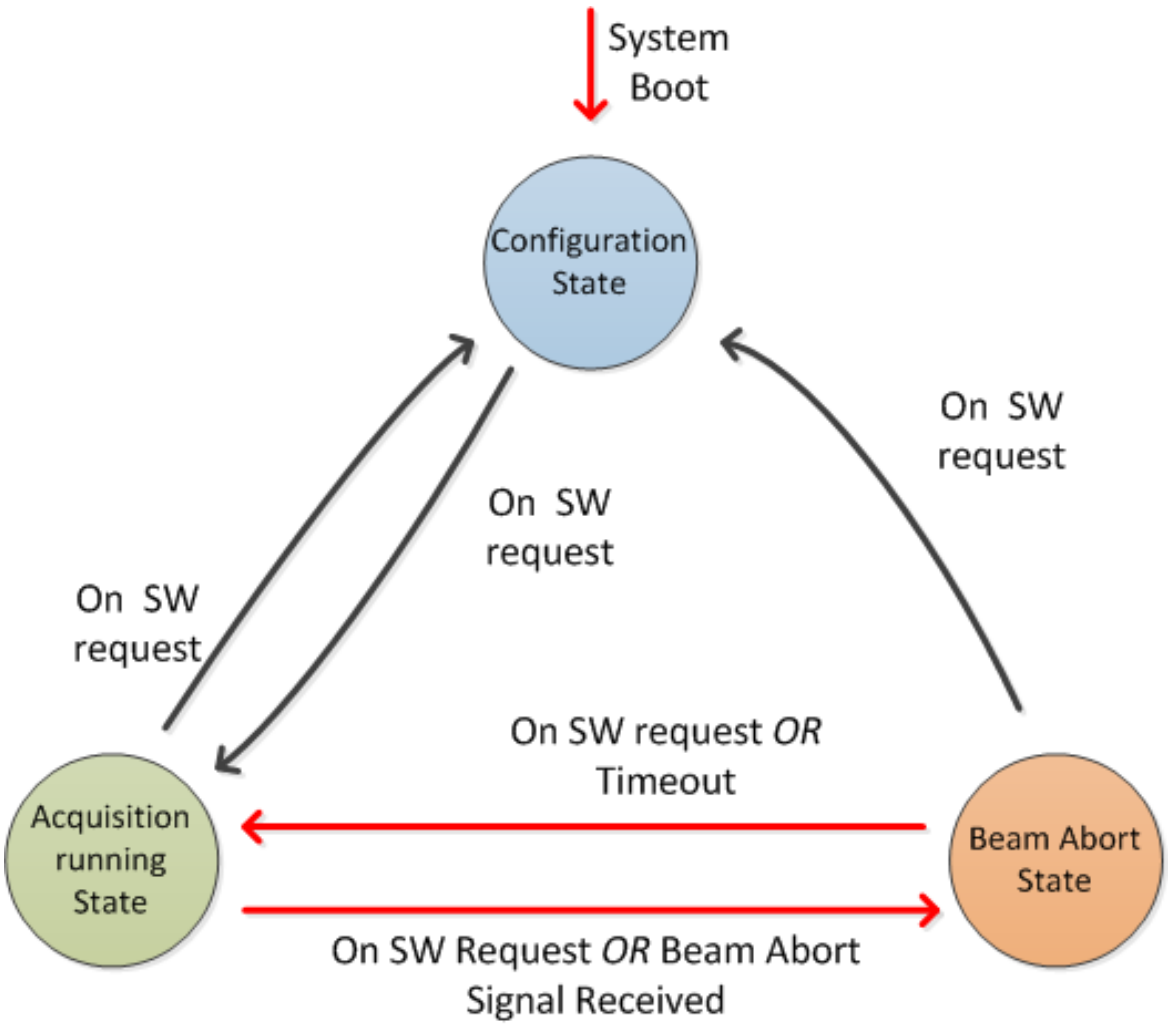
Hardware Concept – Detailed Implementation Schema.



Histogramming: 6.25 ns/bin, 14256 bins
Orbit acquisition: 6.25 ns/bin
Max. histogram timespan: 5.8 s

Hardware Concept – Operation States.

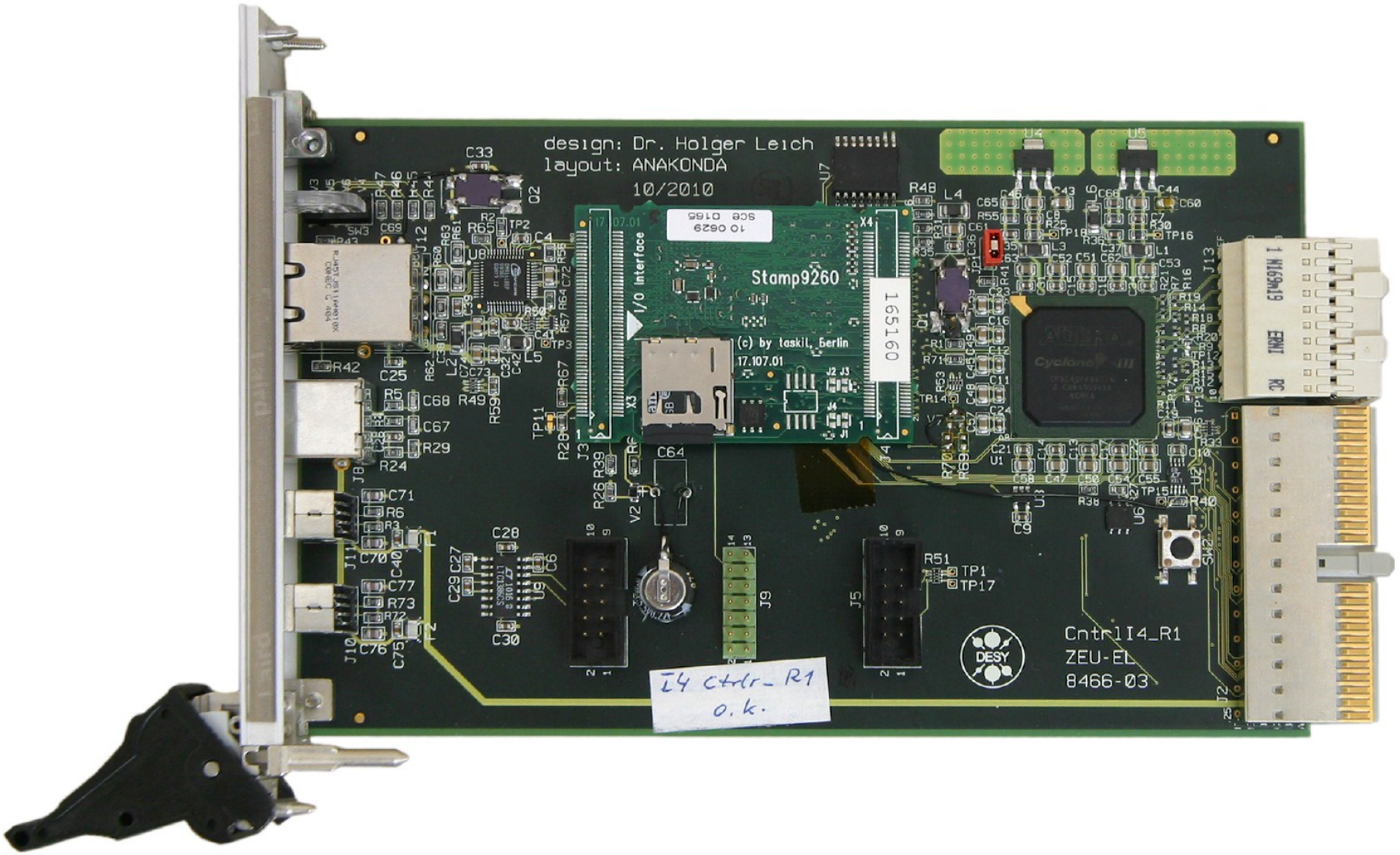
- Configuration
- Acquisition
- Postmortem Analysis



Summary.

- Concept of a VME Module
- Extending the existing DAQ system
- 10 Channel, Sample Resolution 6.25ns
- Continuous beam particle distribution in real time
  - Histogram function: 14256 Bins a 16 Bit per channel
  - Continuous data acquisition, no information loss
- Post-mortem data after beam abort
  - 50 orbits detector event data
- Communication via VME Bus, Network and USB

Example of SBC with FPGA



Single Board Computer

- CPU: AT91SAM9G20
- RAM: 128MB, FLASH: 512 MB,
- Static Memory Interface to FPGA (~ 20MB/sec)
- USB 2.0, Ethernet 10/100MBit, SD Card Drive as persistent Memory