CMS Group
BCM1F Detector's DAQ System (RHUDAQ)
Data Storage Software

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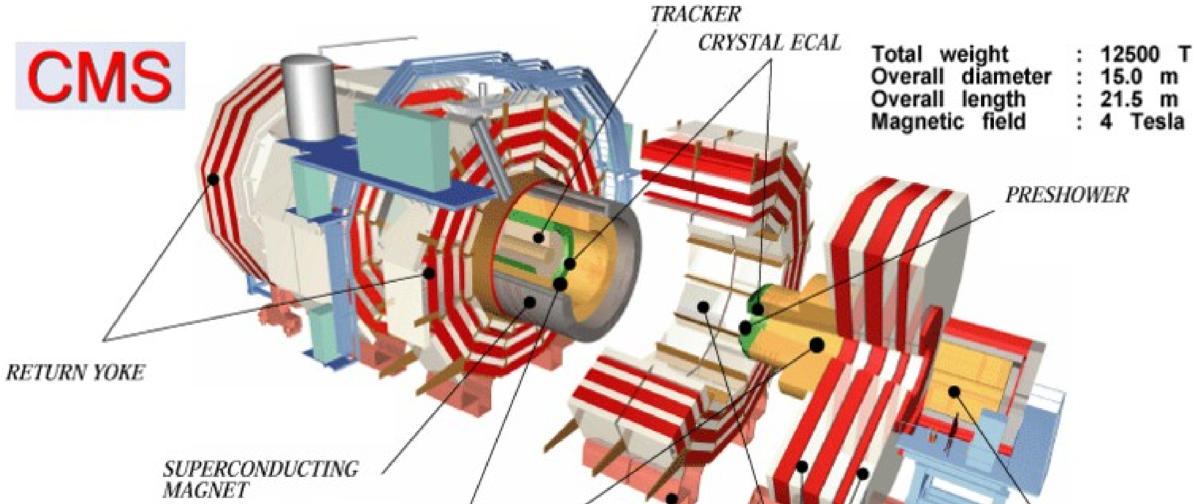
Head Supervisor: Wolfgang Lohmann

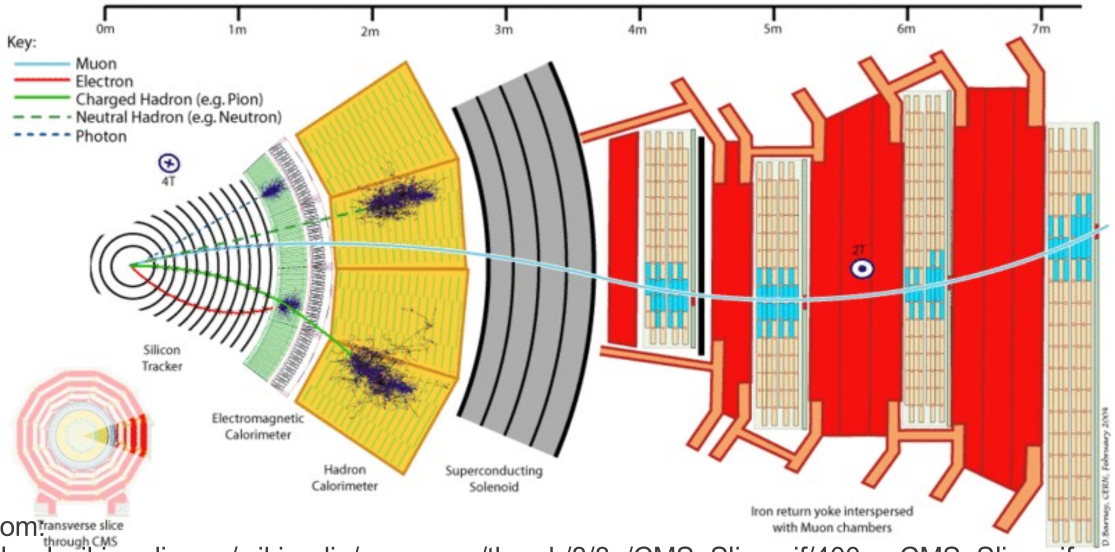
Supervisor: Marek Penno

CMS Detector

- CMS Detector is a multi Purpose detector
- CMS detector is radiated. In addition the LHC beam is Highly Energetic which can cause serious harm.
- For this reason there are various detector in CMS and for beam monitoring and protection.
- The one we are interested is BCM1F



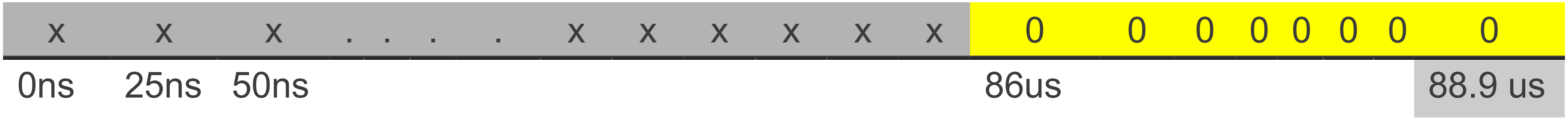
Taken from:
http://www.fnal.gov/pub/today/images11/CMS_all_sketch.jpg


0m
1m
2m
3m
4m
5m
6m
7m
Key:
Muon
Electron
Charged Hadron (e.g. Pion)
Neutral Hadron (e.g. Neutron)
Photon
4T
2T
Silicon Tracker
Electromagnetic Calorimeter
Hadron Calorimeter
Superconducting Solenoid
Iron return yoke interspersed with Muon chambers
Transverse slice through CMS
D Barney, CERN, February 2004

Taken from:
http://upload.wikimedia.org/wikipedia/commons/thumb/8/8a/CMS_Slice.gif/400px-CMS_Slice.gif

Bunch Structure

- At LHC beam line there are proton bunches that follow each other.
- At maximum performance the bunches will cross the same point with 25ns time difference.



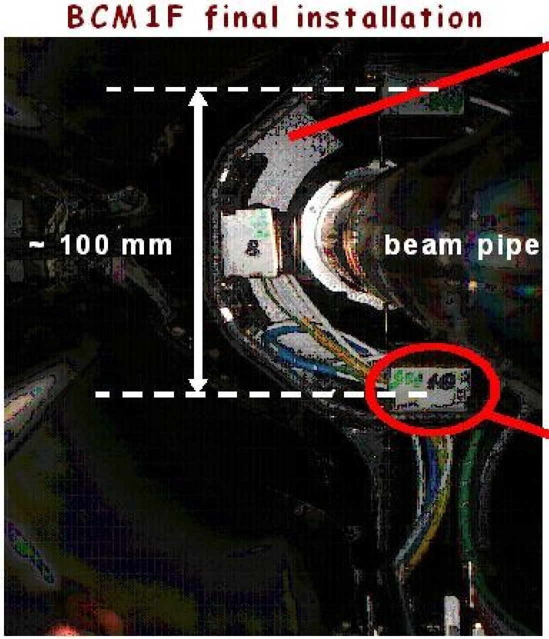
x x x . . . . x x x x x x 0 0 0 0 0 0 0 0

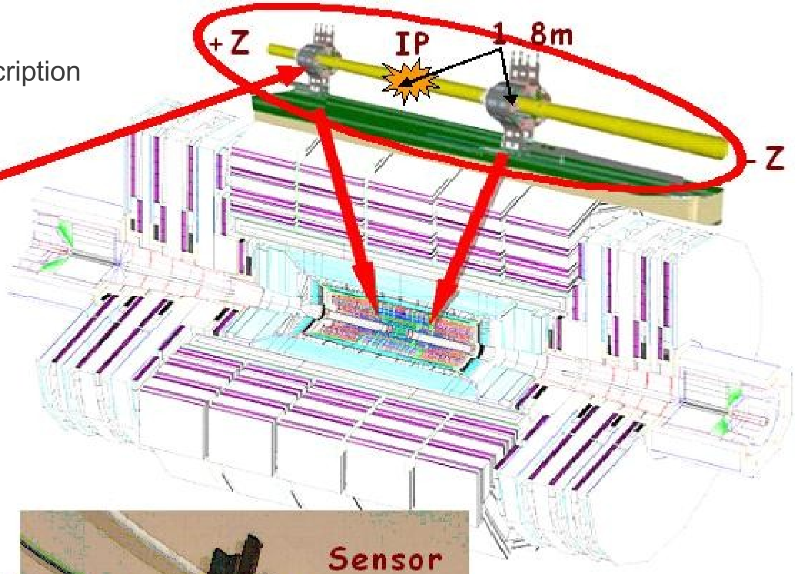
0ns 25ns 50ns 86us 88.9 us

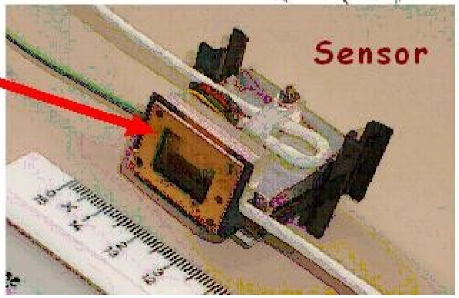
- The period of a single orbit is 88.9 us
- In LHC there is a beam abort gap which is a location without any beams.
- This is needed for the beam termination magnets to work.
- Each bunches have a beam halo which is particles that moves outside the beam line.

BCM1F Detector

Taken from: https://znwiki3.ifh.de/CMS/Bcm1Fdescription



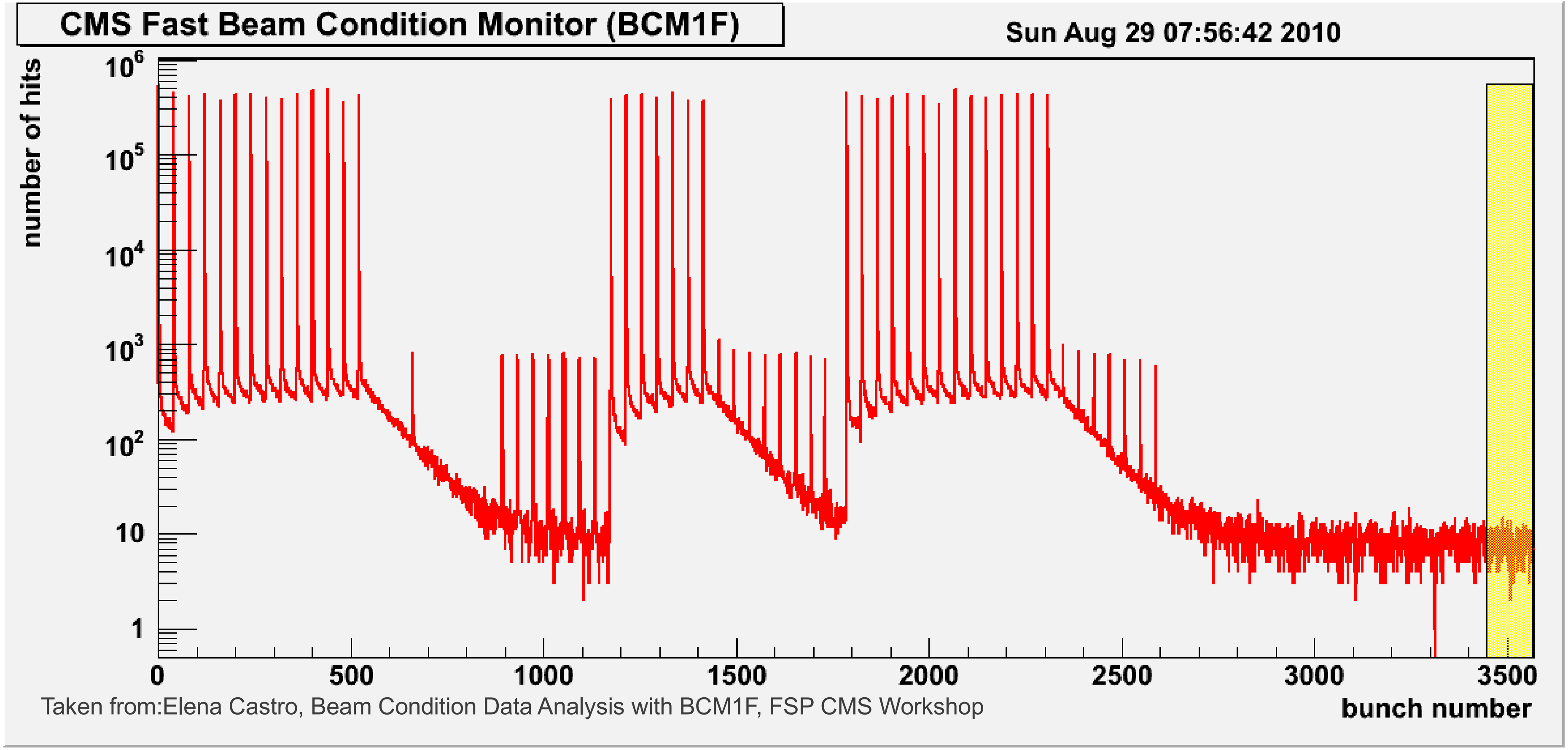




- First Run at August/2010
- After Glow Effect was discovered by the detector

- Detector made out of diamond. Similar to a diamond filled capacitor (Diamond Ionization Chamber)
- Located inside the CMS pixel detector on the beam line.
- Detects particle Hits on the detector.
- Designed for fast flux monitoring measuring bunch-by-bunch both beam halo and collision products

Sample Histogram



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

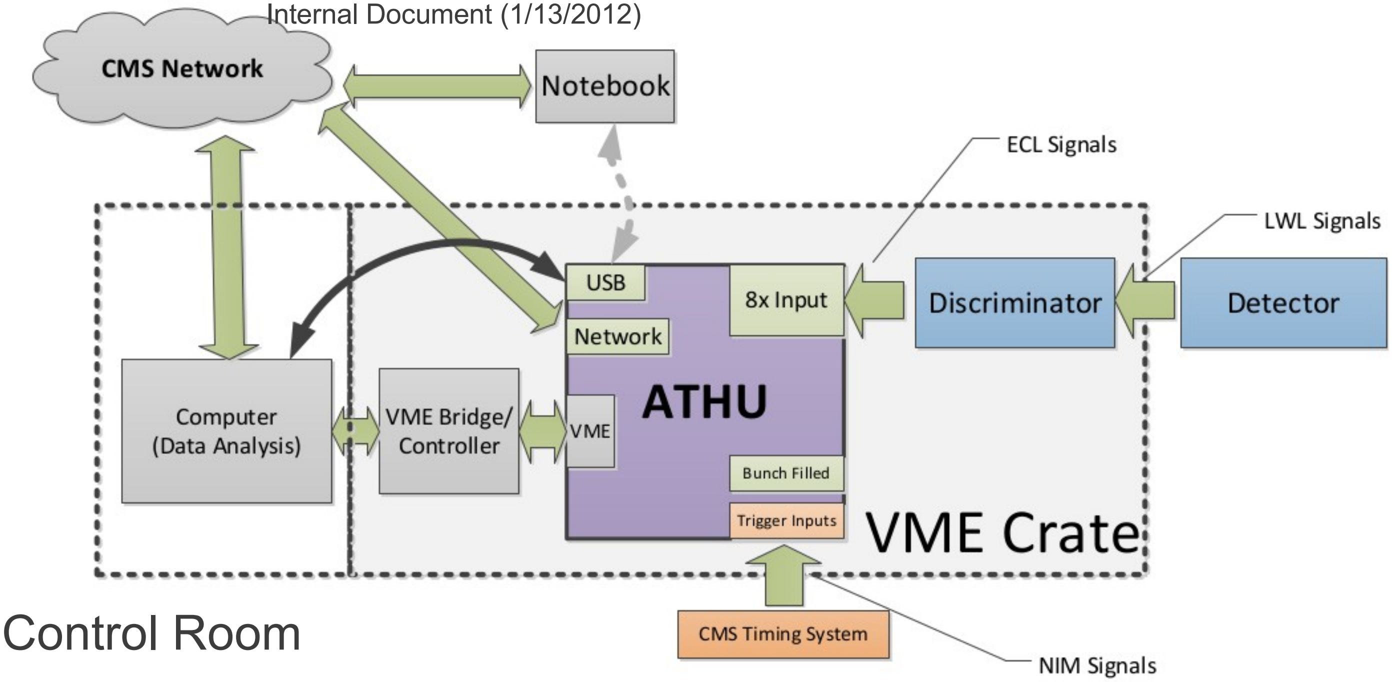
- All peaks are Bunches.
- High peaks are colliding bunches, low peaks are non-colliding.
- The end yellow region is dead time. (Beam is not completely filled)

The New RHUDAQ

Old DAQ system

- Had a long dead-time, we were loosing data which means loss of luminosity
- The data storage and transfer was slow.
- Live data wasn't available

Taken from:
Holger Leich, Marek Penno, Concept Draft for Recording Histogramming Unit, Desy CMS Group Internal Document (1/13/2012)



New Features

- Live Monitoring at CMS Control Room
- Able to send histograms without dead-time.
- External PC's can receive the histograms and store it.

The Data Structure

- There are two Data Packets Sent by the hardware.
  - Fast/Slow Data
  - Postmortem Data
- Currently Fast Data is eight channels
- Slow Component of the Fast/Slow data is two channels
  - One of them stores orbit fill signal
  - The other is currently unused
- The Data Packages accumulate data using the library written by Marek Penno.
- Data is send over network and is received by a rhu system data provider. It publishes the data to a shared memory. The softwares are connecting to that shared memory and is notified via interprocess mechanism about new data

Fast/Slow Channel

Fast/Slow Data Packet Details

- TTimeStamp (Time Stamp's of each entry)
- Bool (valid/invalid signal)
- Unsigned long (unique orbit number)
- Unsigned short (number of obits contained)
- Unsigned short[14256/3564] (Fast/Slow Histogram Entries)

Postmortem Data

Postmortem Data Packet Details

- TTimeStamp (Time Stamp)
- Bool (Valid/invalid signal)
- unsigned char[50][1782] (Last 50 orbits BCM1F Data) (x8 for each Fast Channel)
- unsigned long (Unique Orbit Numbers for last 50 orbits) (x8 for each Fast Channel)
- Bool (valid signal for last 50 orbits) (x8 for each Fast Channel)
- 2 Fast Data Entries (Data Structure from Fast/Slow) (x8 for each Fast Channel)

RHUDAQ Storage Software

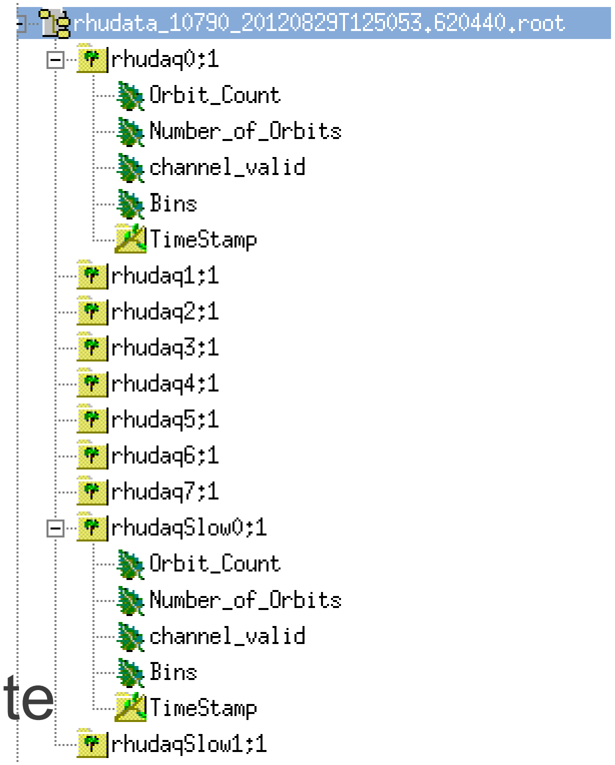
- There exists three Software Packages
  - rhuRootStore (Stores Fast/Slow Data)
  - PostMortemStore (Stores Postmortem Data)
  - DataProcess (Processes Stored Data)

    .

rhuRootStore

- This application stores the Fast/Slow Channel
- User specifies orbit amount of each histogram
- User specifies orbit amount of each file
- User specifies if her/she wants store invalid data

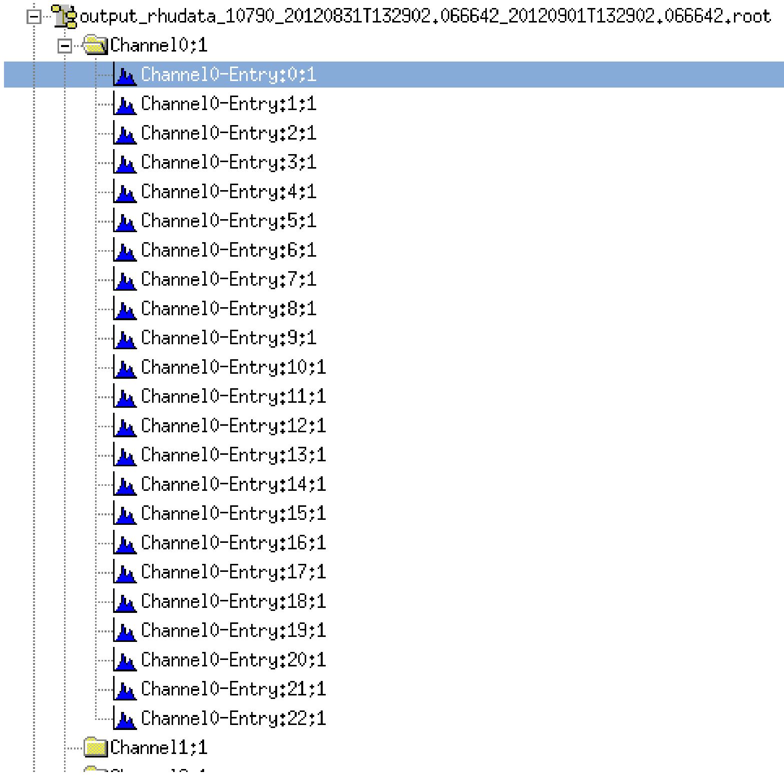
- Stores file in a TTree format
- File size varies a lot according to sampling rate
  - 30m/24h=15mb; 10s/24h = 2.1gb
- The data has to processed



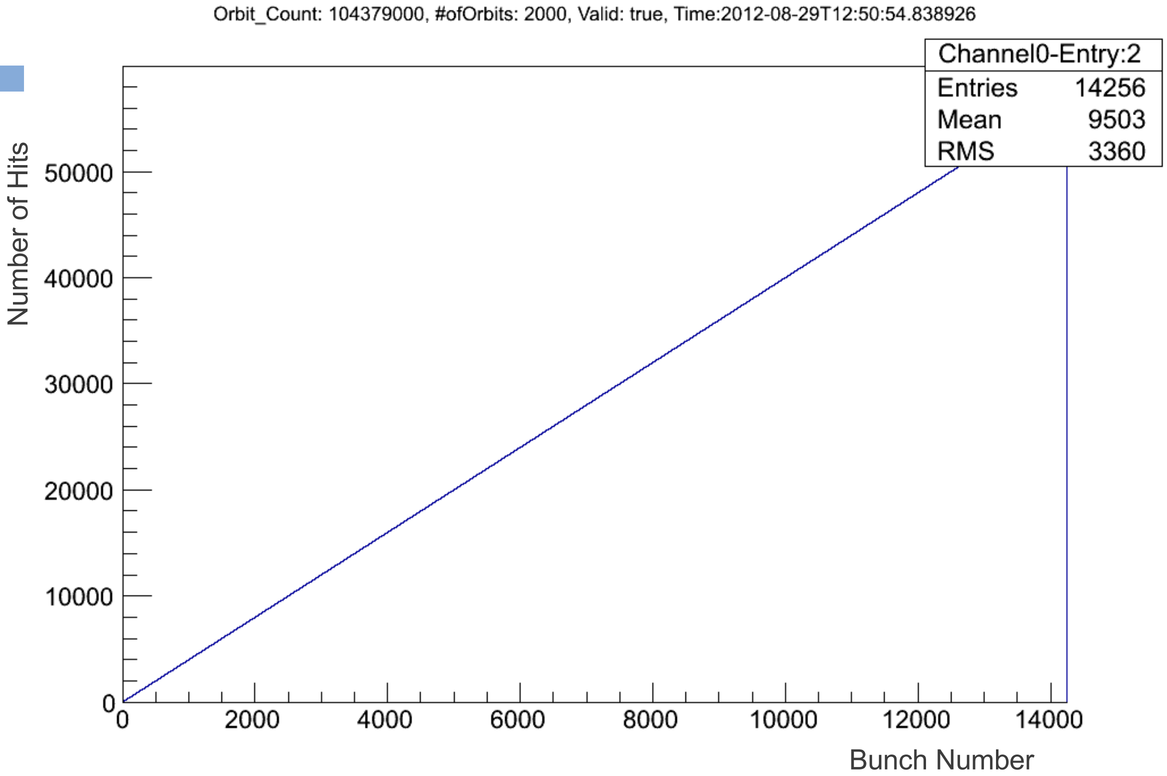
```
rhudata_10790_20120829T125053.620440.root
  rhudaq0;1
    Orbit_Count
    Number_of_Orbits
    channel_valid
    Bins
    TimeStamp
  rhudaq1;1
  rhudaq2;1
  rhudaq3;1
  rhudaq4;1
  rhudaq5;1
  rhudaq6;1
  rhudaq7;1
  rhudaqSlow0;1
    Orbit_Count
    Number_of_Orbits
    channel_valid
    Bins
    TimeStamp
  rhudaqSlow1;1
```

DataProcess

- This program process the data stored with rhuRootStore
- Takes in a time period and sampling rate and folder.
- Process the data in that time period.



```
⊟ output_rhudata_10790_20120831T132902.066642_20120901T132902.066642.root
   ⊟ Channel0;1
         Channel0-Entry;0;1
         Channel0-Entry;1;1
         Channel0-Entry;2;1
         Channel0-Entry;3;1
         Channel0-Entry;4;1
         Channel0-Entry;5;1
         Channel0-Entry;6;1
         Channel0-Entry;7;1
         Channel0-Entry;8;1
         Channel0-Entry;9;1
         Channel0-Entry;10;1
         Channel0-Entry;11;1
         Channel0-Entry;12;1
         Channel0-Entry;13;1
         Channel0-Entry;14;1
         Channel0-Entry;15;1
         Channel0-Entry;16;1
         Channel0-Entry;17;1
         Channel0-Entry;18;1
         Channel0-Entry;19;1
         Channel0-Entry;20;1
         Channel0-Entry;21;1
         Channel0-Entry;22;1
     Channel1;1
```



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Postmortem Store

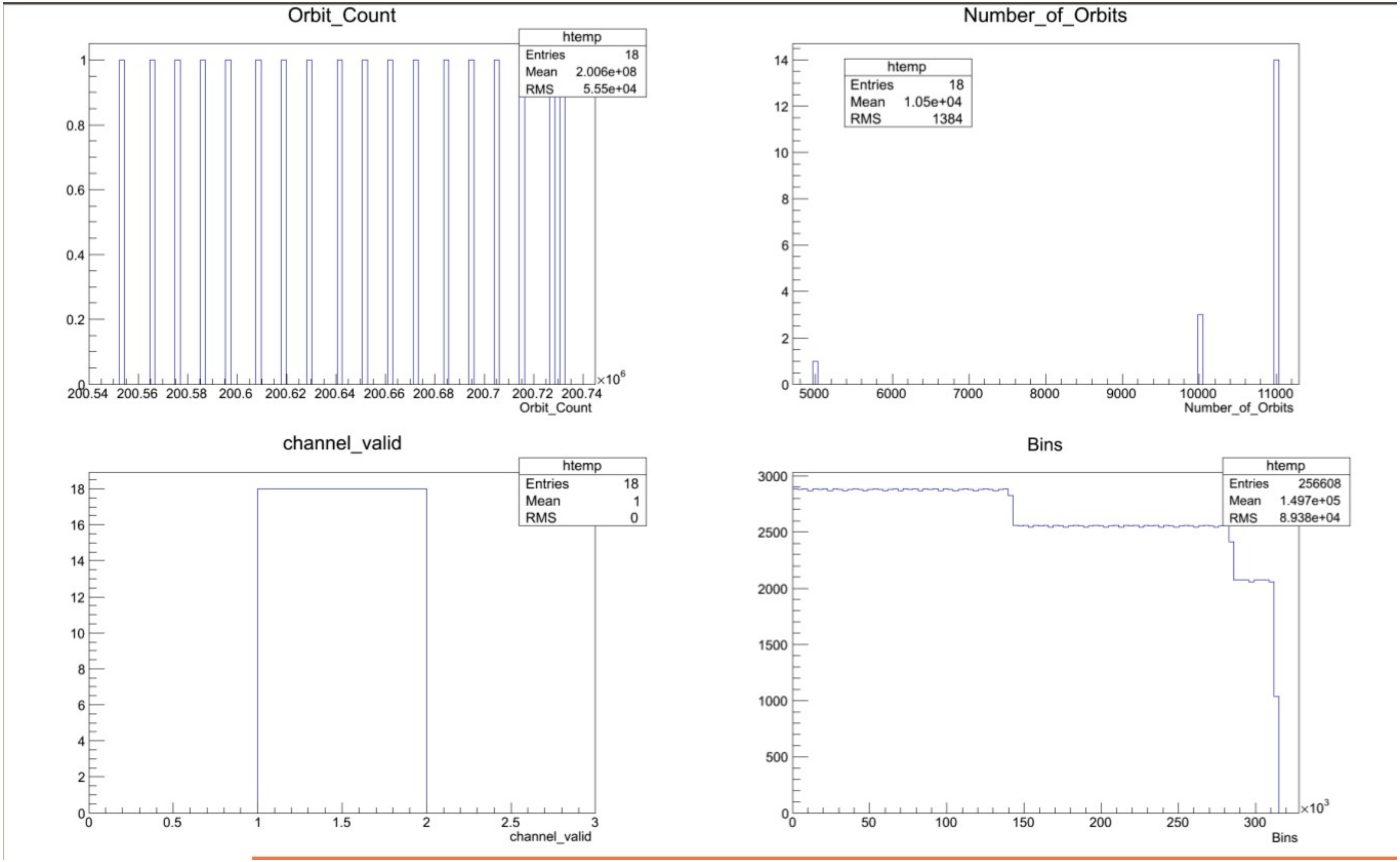
- Postmortem store stores the Postmortem Data
- Currently Postmortem data is not available and is not simulated
- Postmortem Store is in an experimental state.
- It will be tested when testing hardware is ready.

What is next

- All software and hardware will be tested on a Hardware simulation.
- If Hardware simulation is successful the system will be installed to the BCM1F DAQ system.
- I will be keeping support during all these stages, and later in the DAQ state.

Thank You for Your Patience.
Any Questions?

RhuRootStore (Detailed)


Orbit_Count
htemp
Entries 18
Mean 2.006e+08
RMS 5.55e+04
×10^6
Orbit_Count
Number_of_Orbits
htemp
Entries 18
Mean 1.05e+04
RMS 1384
Number_of_Orbits
channel_valid
htemp
Entries 18
Mean 1
RMS 0
channel_valid
Bins
htemp
Entries 256608
Mean 1.497e+05
RMS 8.938e+04
×10^3
Bins