Data Acquisition for BCM1F

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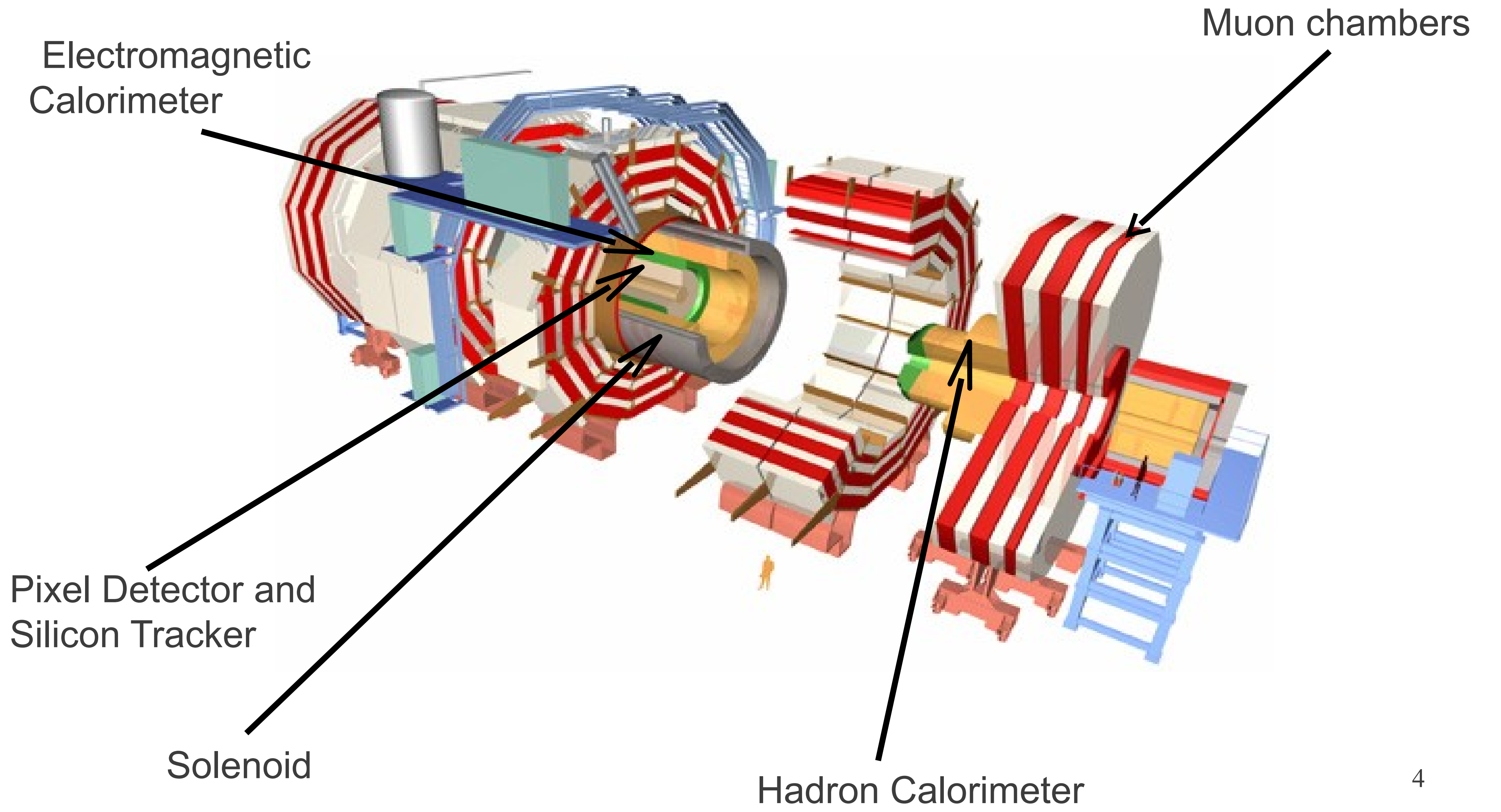
Outline

1. Introduction

1.1 Compact Muon Solenoid CMS

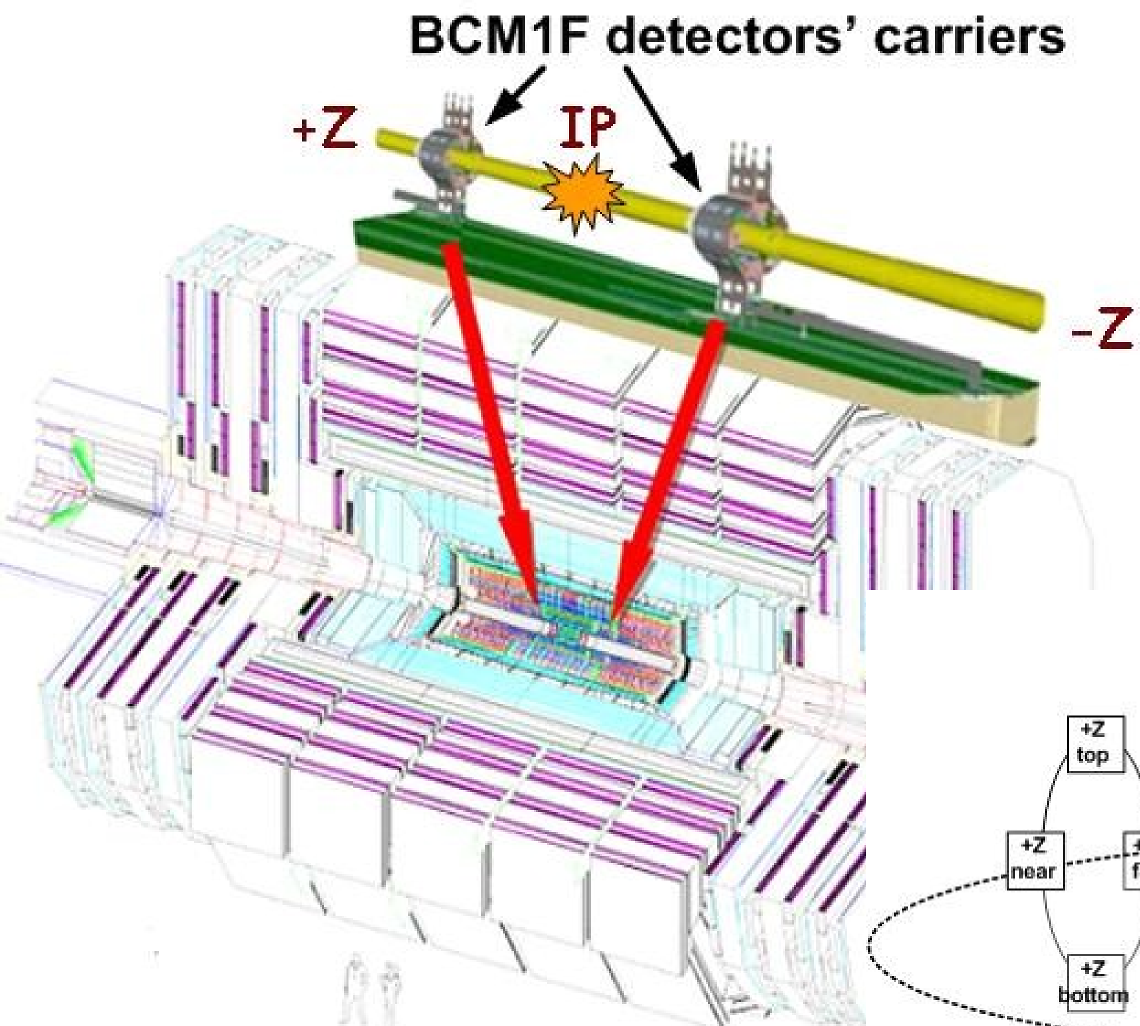
1.2 Fast Beam Condition Monitoring BCM1F

2.1 Compact Muon Solenoid (CMS)



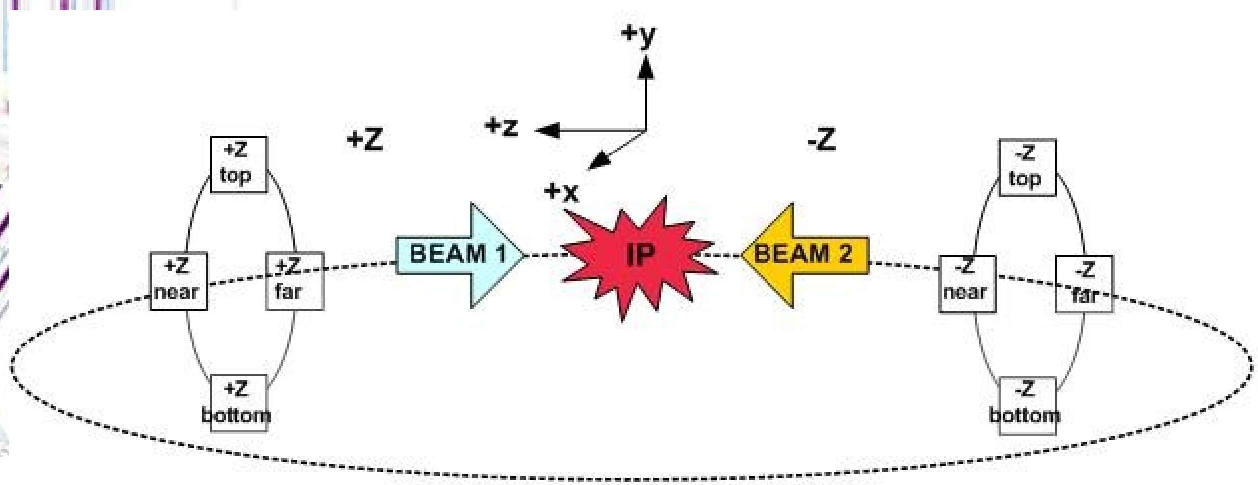
2.3 Fast Beam Conditions Monitor (BCM1F)

- Particle detector with ns time resolution for monitoring and protection
- Measure beam halo and collision products



Design:

- 2 planes
- 4 sCVD diamond sensors
- Sensor volume is $5x5x0.465mm^3$
- Distance between IP and sensor is 1.8m

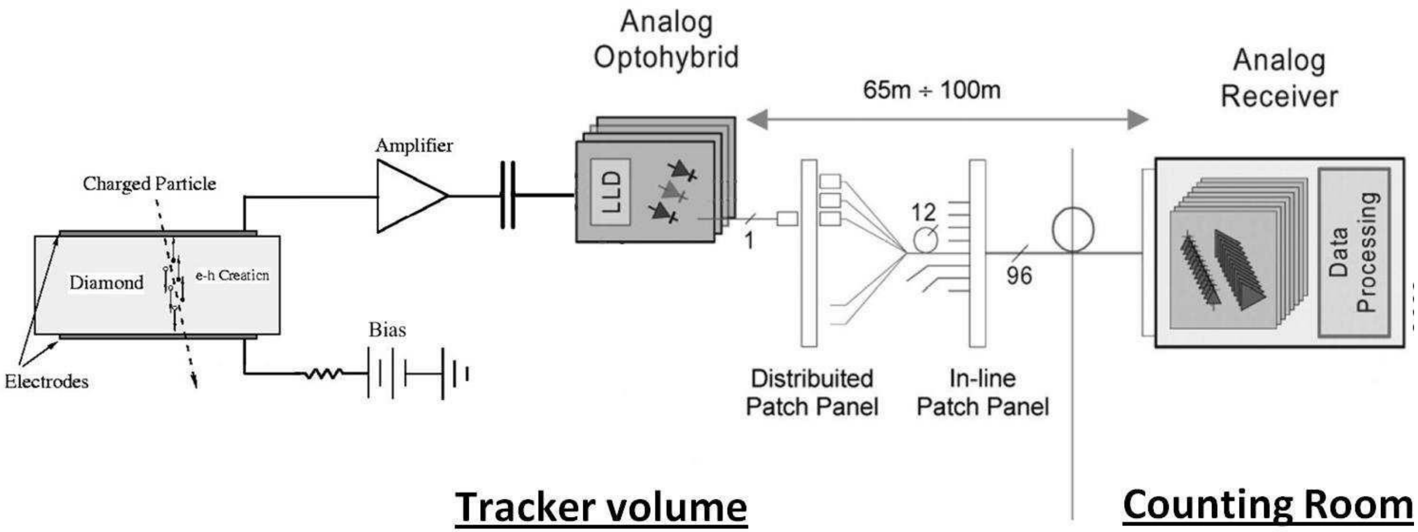


2. Readout System

2.1 Back-End Part

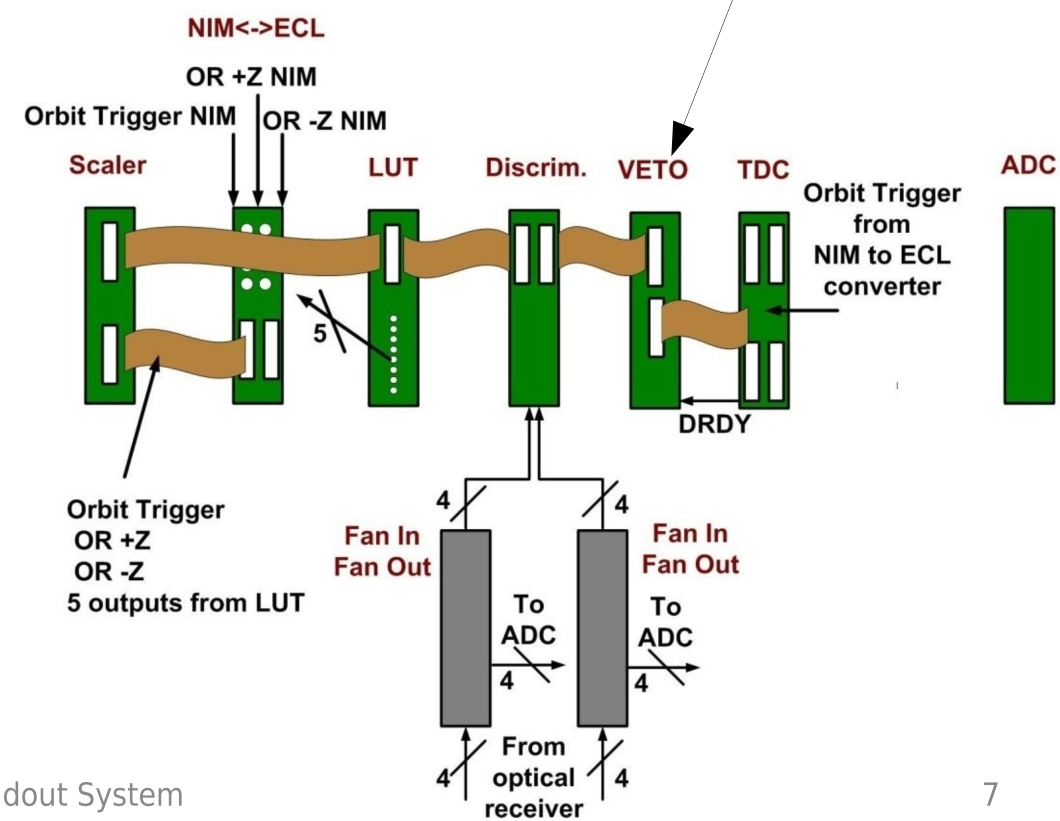
2.2 Modules for the Readout

2.1 Back-End Part



Veto module is not installed in the setup at Prevessin → no need so far

- Each sensor is connected to a radiation hard pre-amplifier
- Conversion to optical signal
- Transmission to counting room



2.2 Modules for the Readout

Module	Task
Discriminator	Discriminate signals/ noise
Time-to-Digital Converter (TDC)	Time information/ measurements
Look-Up Table (LUT)	Programmable board -> Veto signal, Register
Veto	Vetoing incoming signals
Scaler	Counting Hits
Analog-to-Digital Converter (ADC)	Obtain the signal spectra

A similar setup of the back-end part was installed in the laboratory at Prevessin

3. Time to Digital Converter TDC

3.1 Introduction

3.2 Storing Data

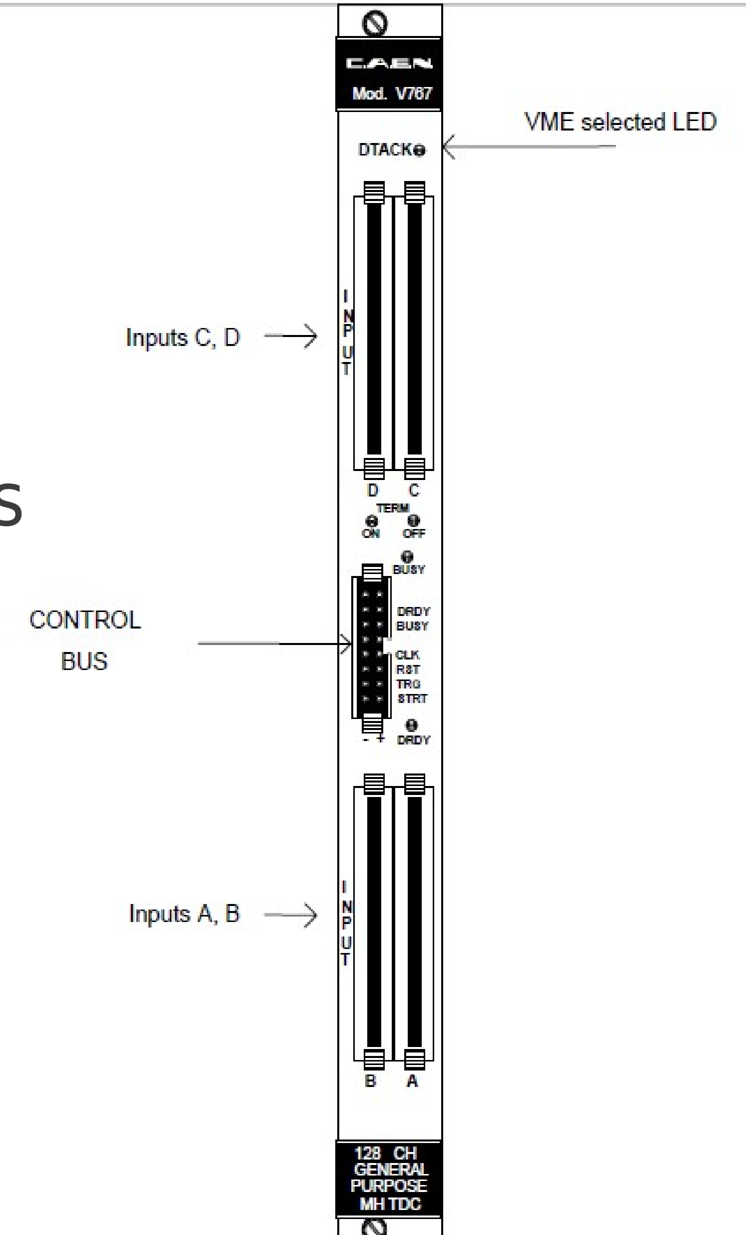
3.3 Readout Modes

3.4 Veto Module

3.5 Implementation of Ring Buffer

3.1 Introduction

- has 4 TDC chips, each contains 32 channels
- Information goes to "output buffer"
- The control and readout of data of the board is done with C++ programs

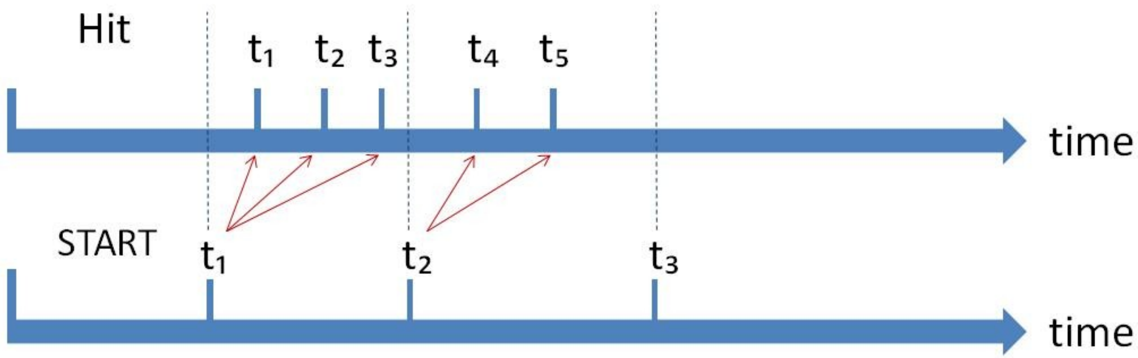


Parameters:

- Double hit resolution: 10ns
- time resolution: 0.8ns

3.2 Storing Data

- The TDC makes the time measurements of Hits

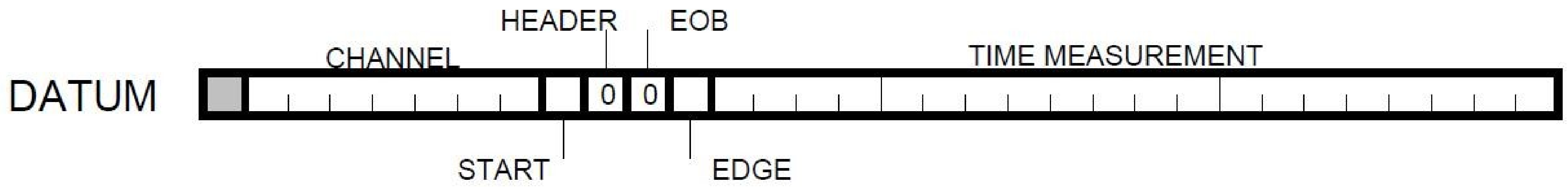


- Order of the time measurements:

This acquisition mode called:
continuous storage mode

Datum number	Signal
1	Start time 1
2	Hit time 1
3	Hit time 2
4	Hit time 3
5	Start time 2
6	Hit time 4
7	Hit time 5

- The signals will be stored in a output buffer
- The output buffer contains of 32k words
- Each word is 32 bit long



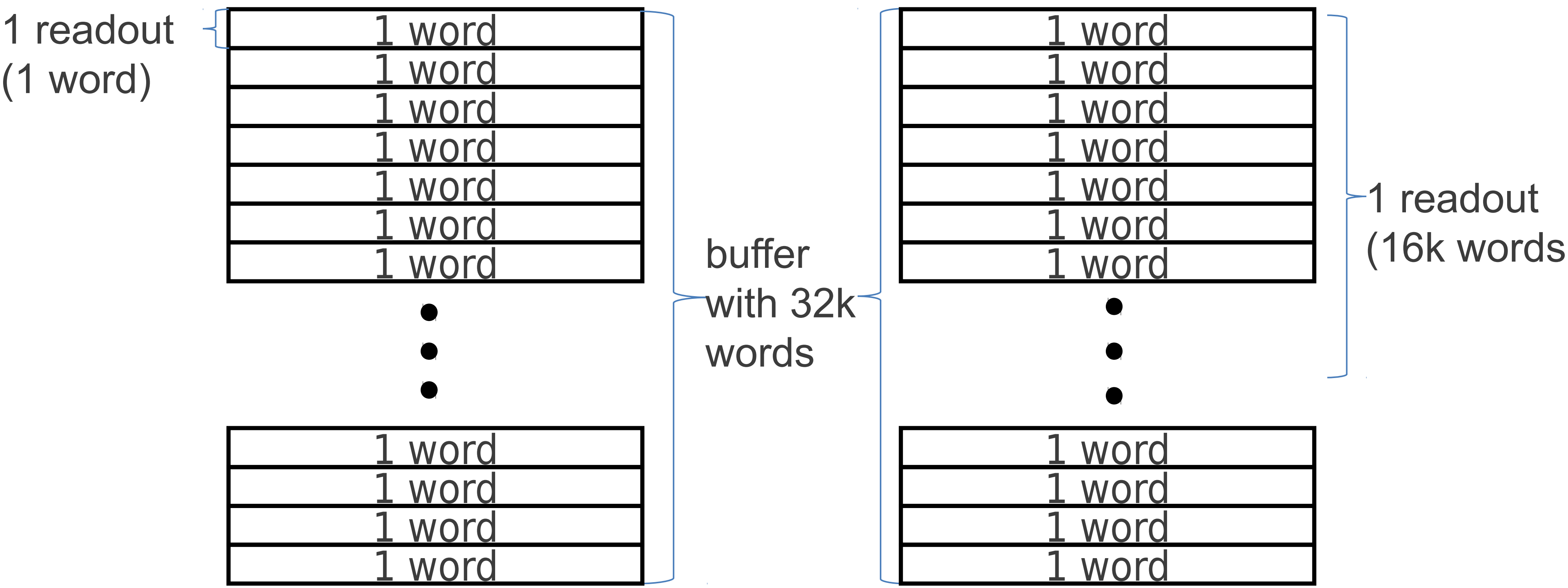
- The output buffer can be read out in 2 different ways:

Single Memory Access (SMA)

Block Transfer (BLT)

3.3 Readout Modes

Single Memory Access | **Block Transfer**



Address each cell and readout word

Address one cell and readout a block

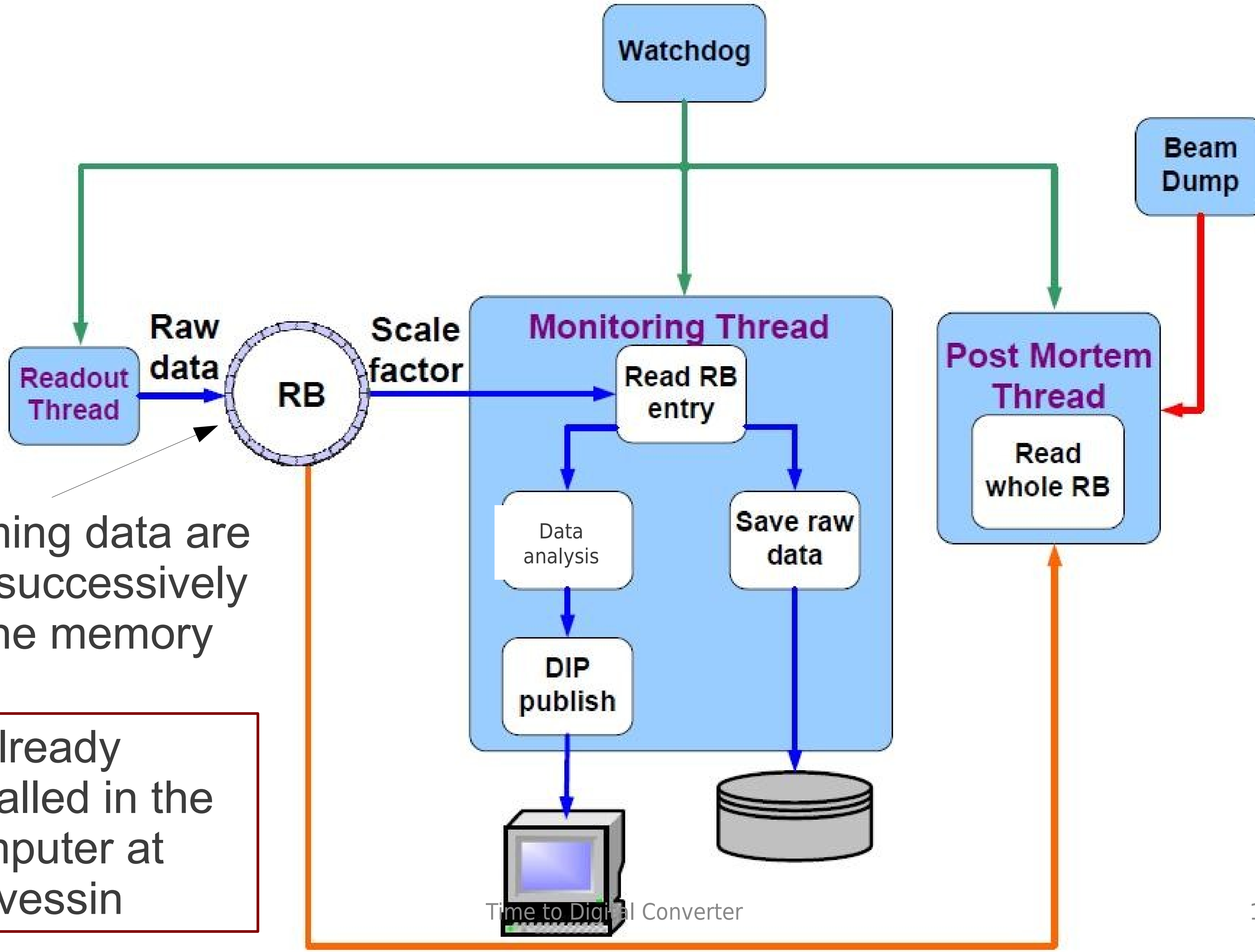
Comparison of SMA and BLT

- The time for the readout with BLT is faster than with SMA

Readout	Time for readout (16k)
Single Memory Access	229 ms
Block Transfer	3.7 ms

- For DAQ we concentrate on BLT

3.4 Implementation of Ring Buffer



Incoming data are filled successively into the memory

Is already installed in the computer at Prevessin

Programs:

C++ class

1. Readout.c: reads the raw data from TDC and writes it to the Ring Buffer
2. Analysis.c: picks up a block from Ring Buffer and writes them to a root file
3. PostMortem.c: in case of beam abort the TDC stops and the data in the Ring Buffer will be not overwritten

The last 10sec before beam abort can be inspected

3.5 Veto Module

- Blocking Hits
- Hits will be not stored in the TDC while we read out the buffer
- In case of high luminosity it prevents a buffer overflow
- No need for Prevessin because Hit rate is low

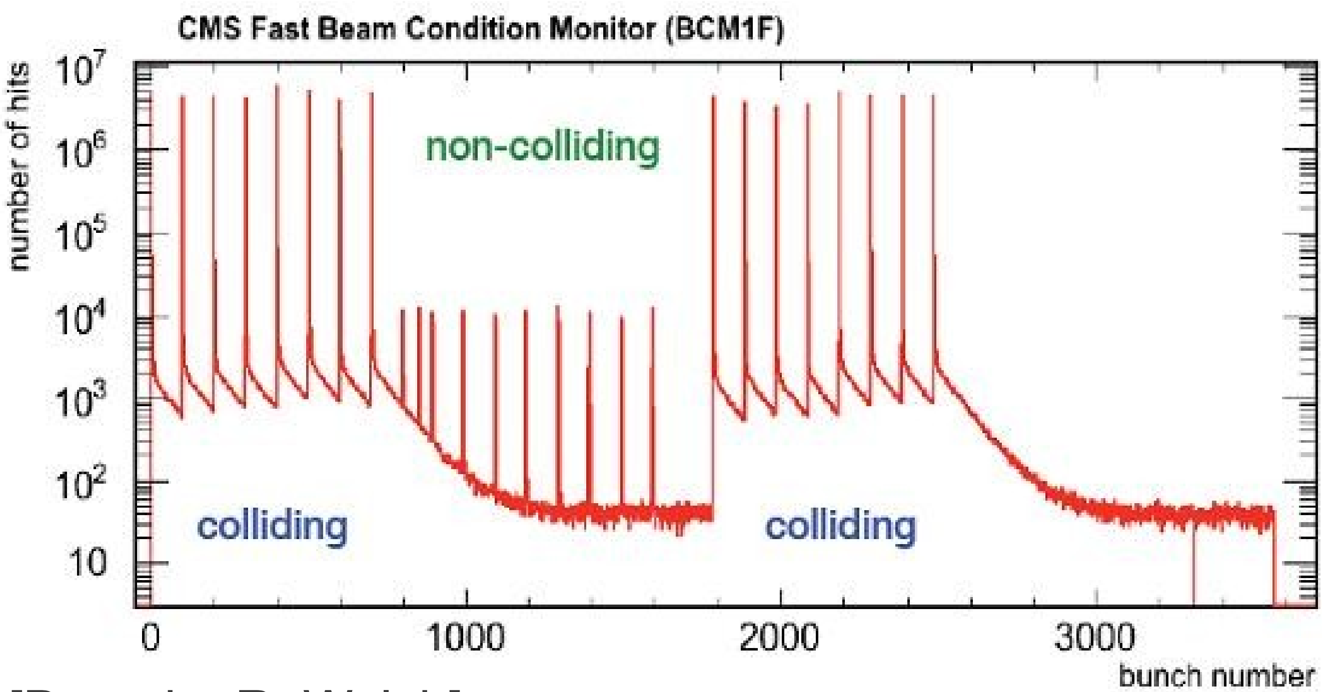
4. TDC Measurements in CMS

4.1 Bunch Identification

4.2 Time of Flight

4.1 Bunch Identification

Bunch identification:



[Done by R. Walsh]

Colliding bunches have tails:

- collision products (neutrons, positrons,...) that decay
- lifetime: 2μs

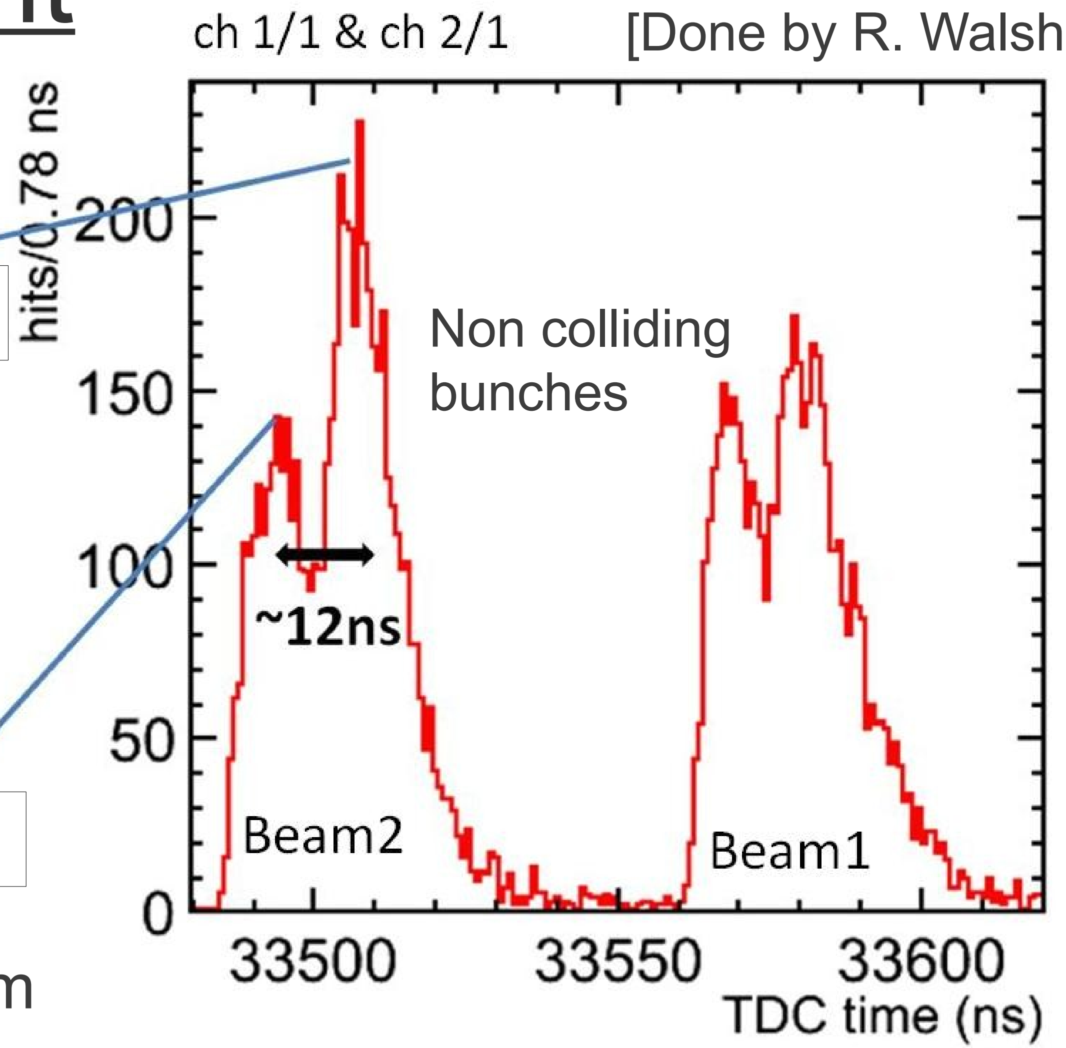
$$\text{bunch number} = \frac{t_{TDC} - \overbrace{6290\,ns}^{\text{Time offset}}}{24.95\,ns} + 1$$

4.2 Time of Flight

[Done by R. Walsh]

CH: -Z Top

CH: +Z Top



BCM1F is optimized to separate beam halo from each direction!

Distance of +Z and –Z is: 3.6 m

Protons travel with speed of light

$$t = \frac{s}{v} = \frac{3.6\text{m}}{3 \cdot 10^8 \frac{m}{s}} = 12\,ns$$

5. First Results with TDC at Prevessin

5.1 Location

5.2 Hit Rate

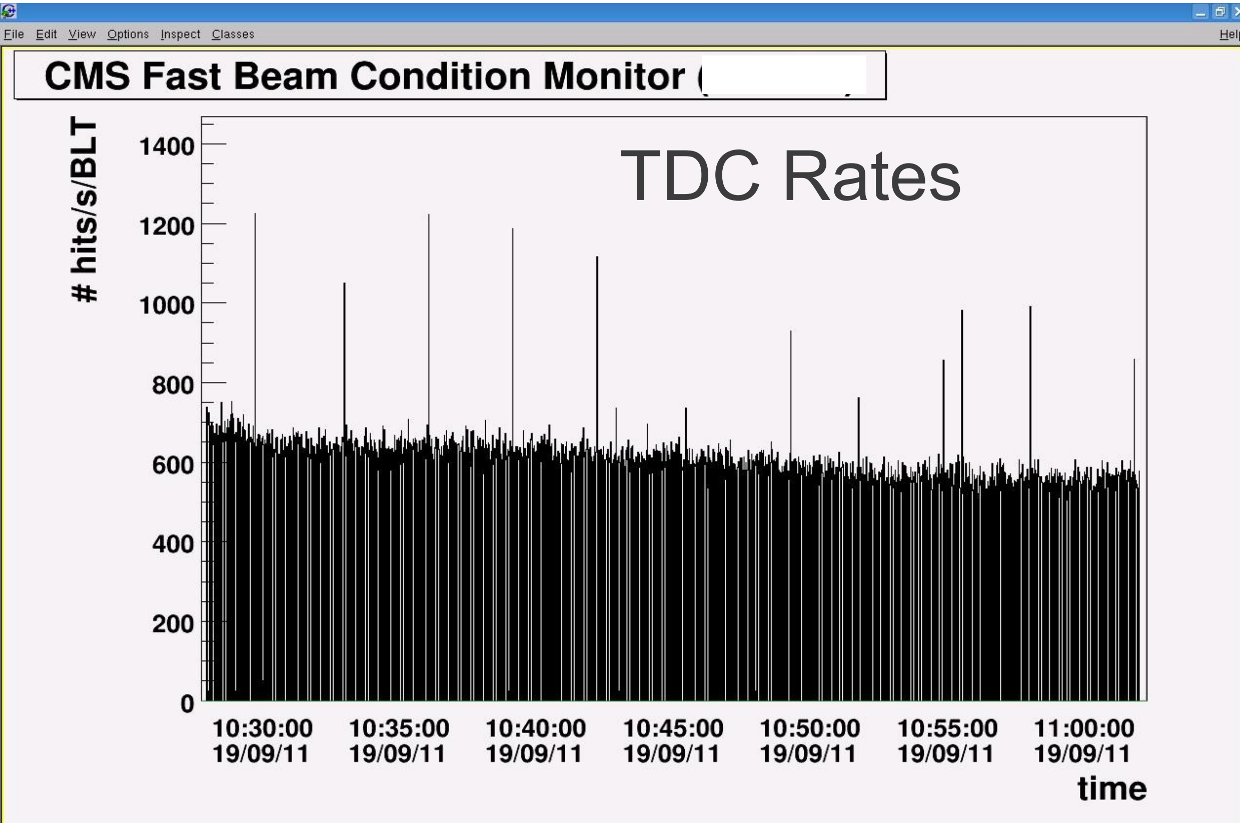
5.3 TDC Time Plot

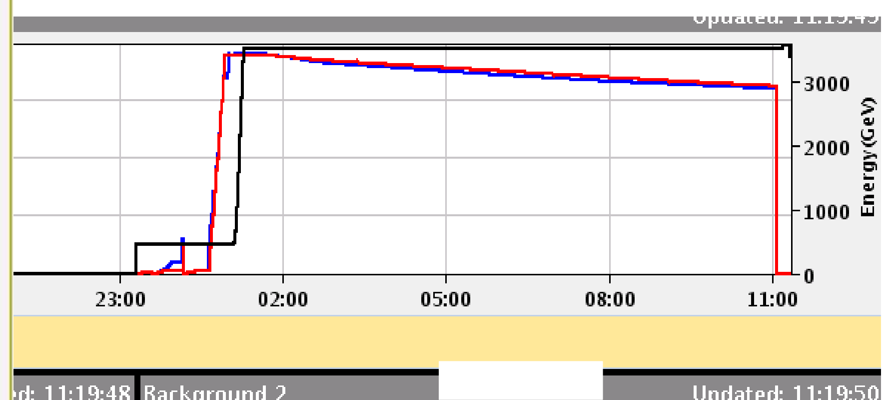
5.4 Scaler Rates

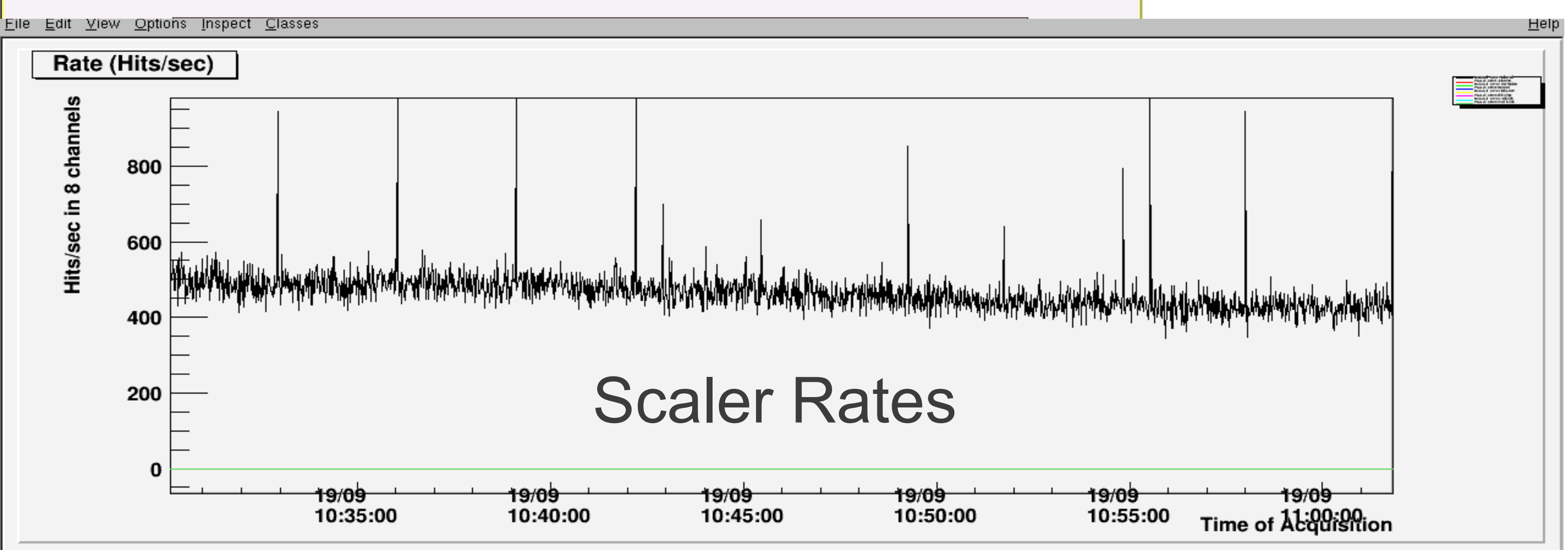
5.1 Location

- Located at P8 → LHCb
- Directly under beam pipe
- Below the vacuum chamber
- 20cm away from the centre of the beam
- Distance of IP and diamond: 70m

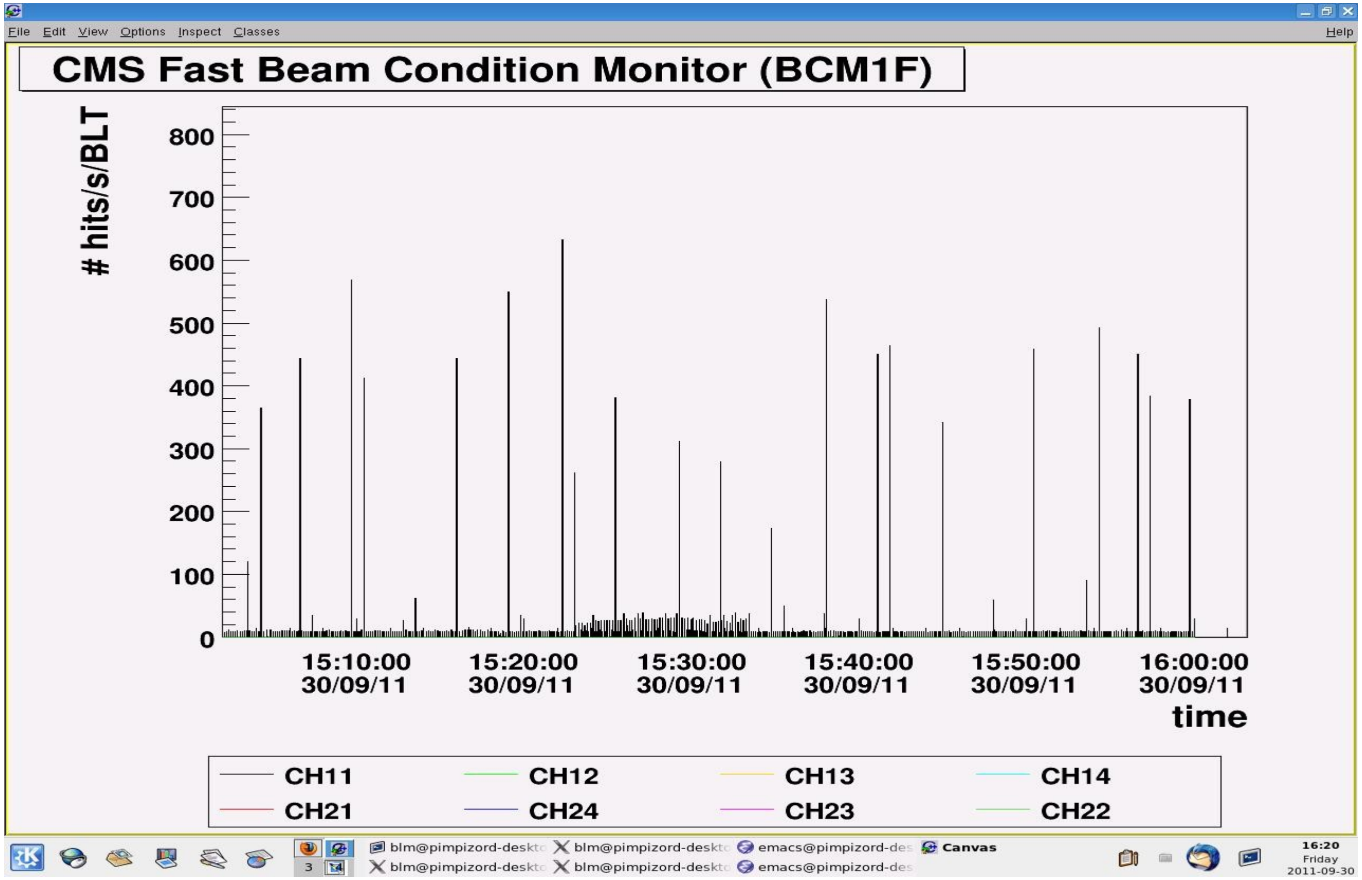
5.2 Hit Rate


File Edit View Options Inspect Classes
Help
CMS Fast Beam Condition Monitor (
TDC Rates
hits/s/BLT
1400
1200
1000
800
600
400
200
0
10:30:00 19/09/11
10:35:00 19/09/11
10:40:00 19/09/11
10:45:00 19/09/11
10:50:00 19/09/11
10:55:00 19/09/11
11:00:00 19/09/11
time

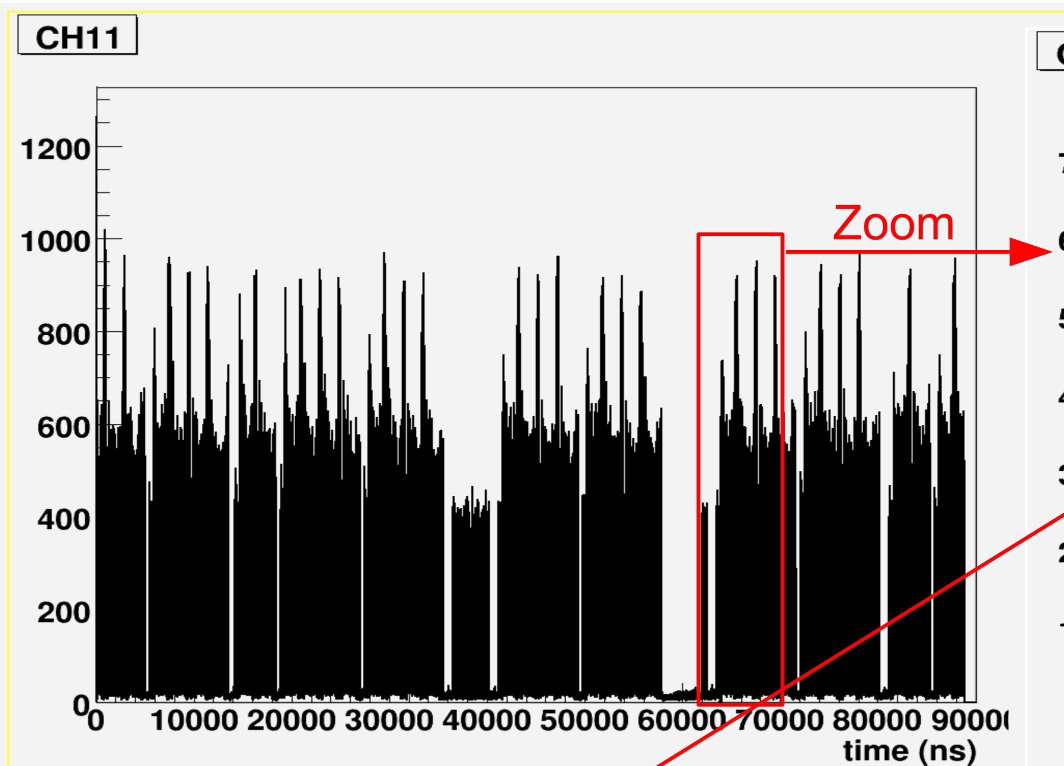

Energy(GeV)
3000
2000
1000
0
23:00
02:00
05:00
08:00
11:00
Background 2
Updated: 11:19:50

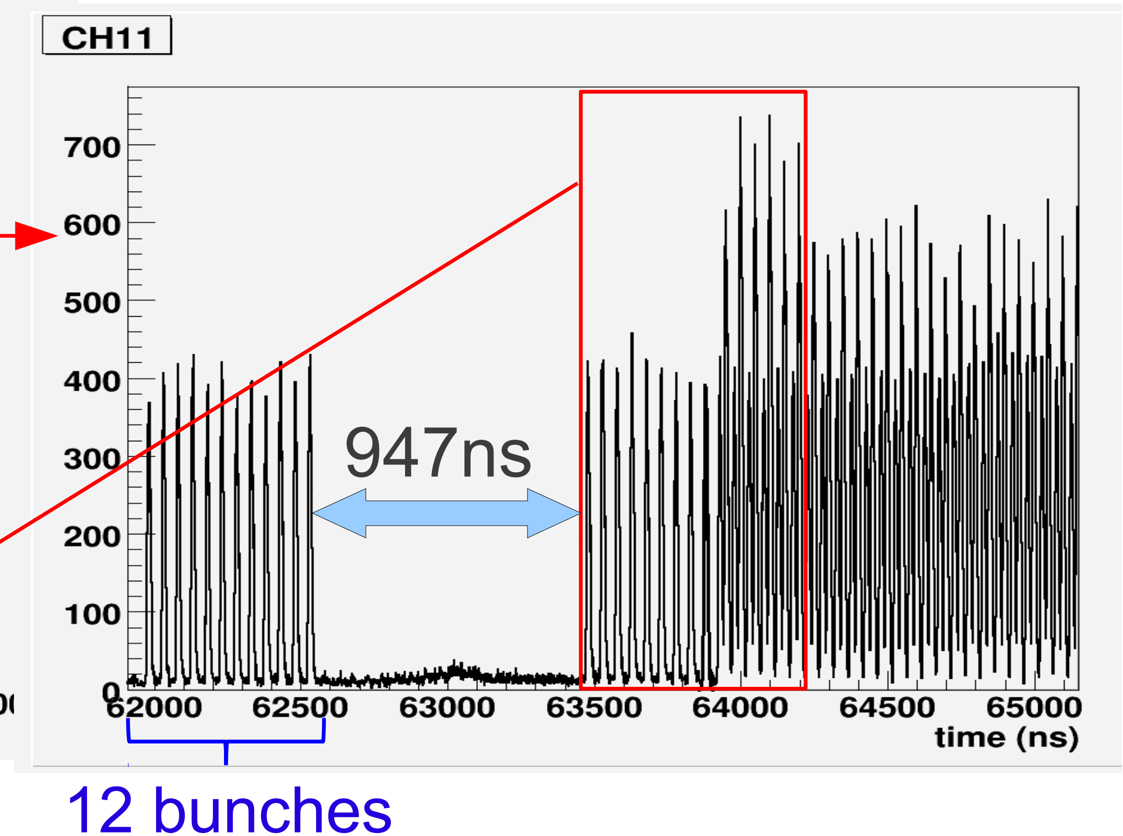

File Edit View Options Inspect Classes
Help
Rate (Hits/sec)
Hits/sec in 8 channels
800
600
400
200
0
Scaler Rates
19/09 10:35:00
19/09 10:40:00
19/09 10:45:00
19/09 10:50:00
19/09 10:55:00
19/09 11:00:00
Time of Acquisition

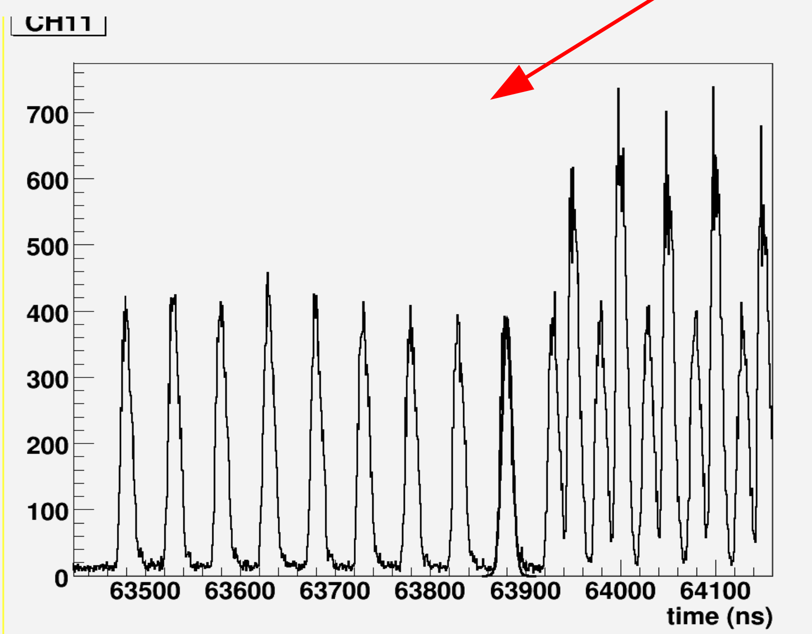
- Hit rate with Beam
- Several large peaks → appear also when there is no beam



5.3 TDC Time Plot



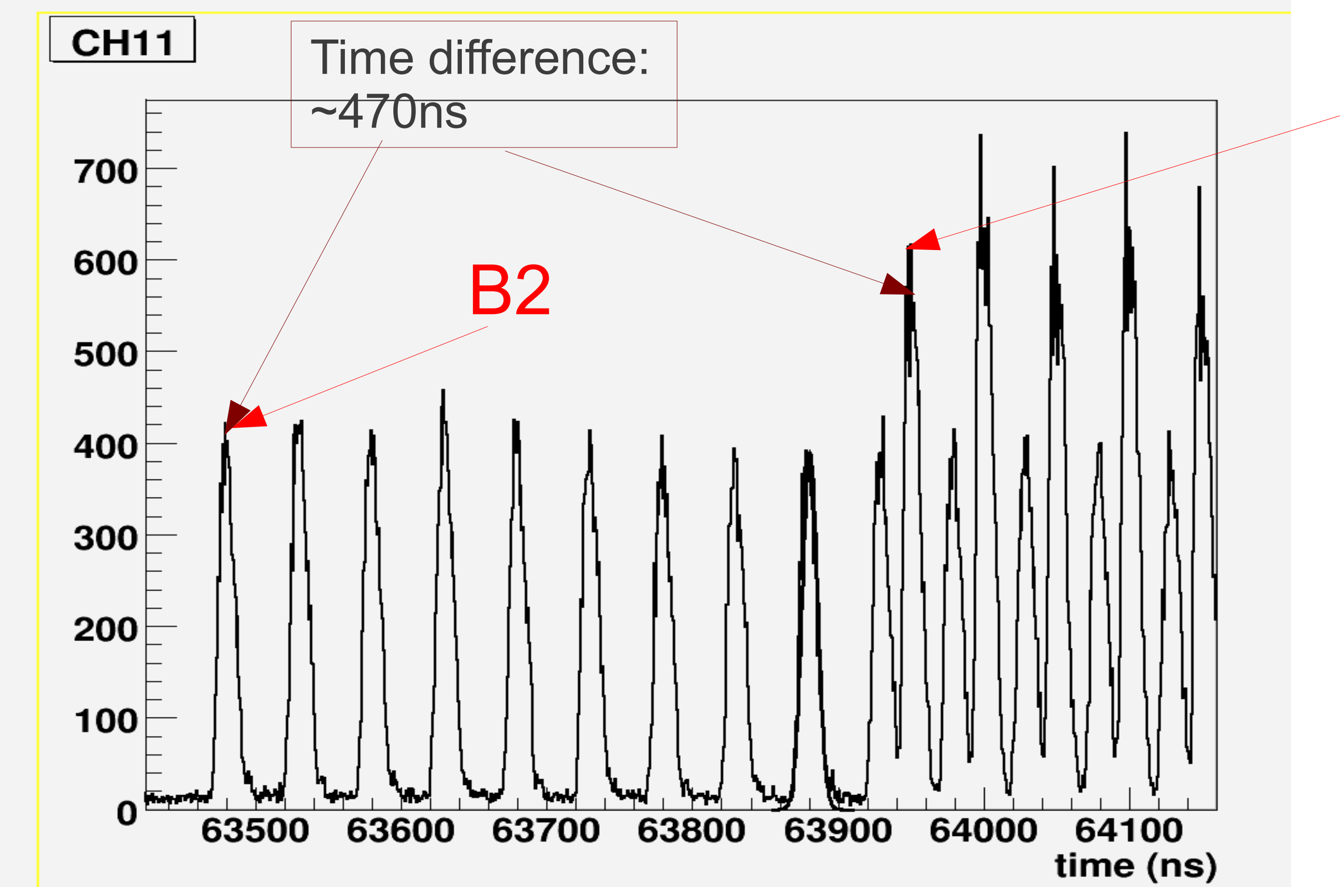




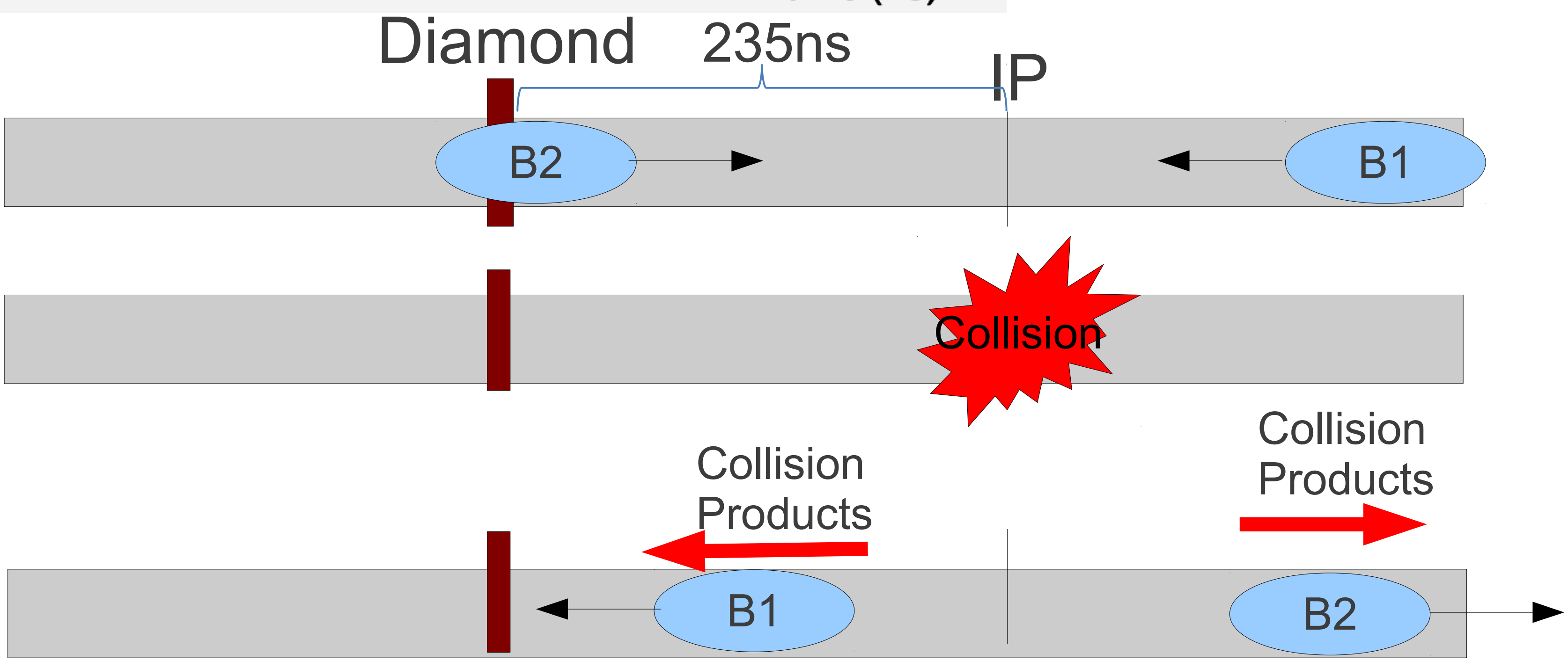
LHC fill scheme:
50ns_1380b+1small_1318_39_1296_144bpi

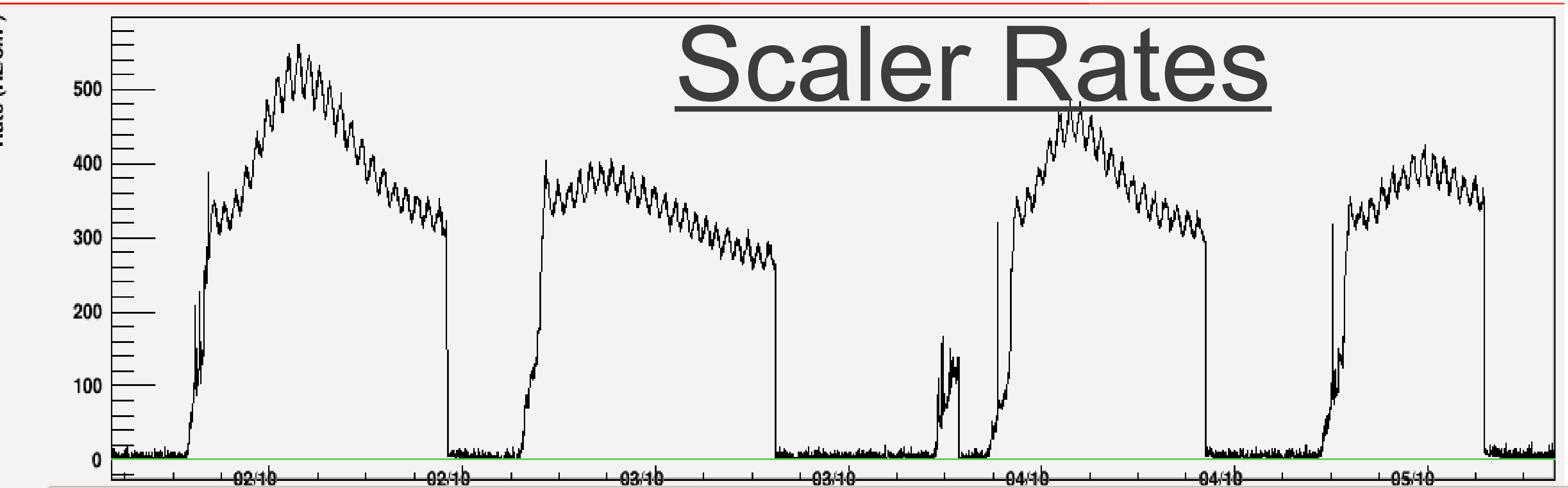
→ B1: 12 bunches, 1100ns difference to next bunch
→ B2: 12 bunches, 950ns difference to next bunch

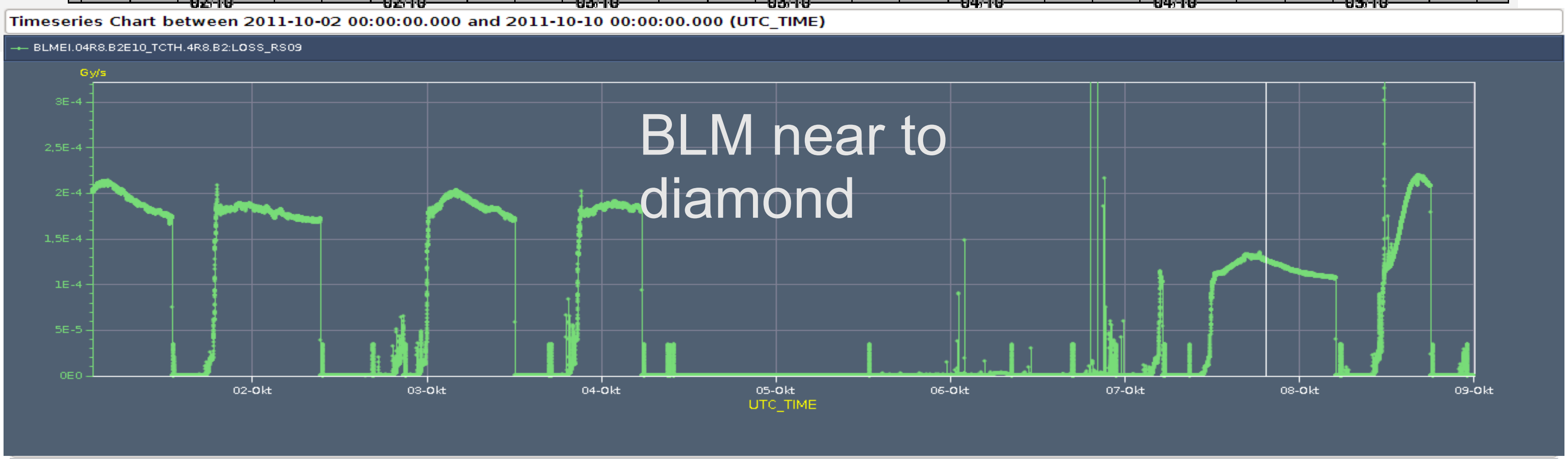
B1+collision products

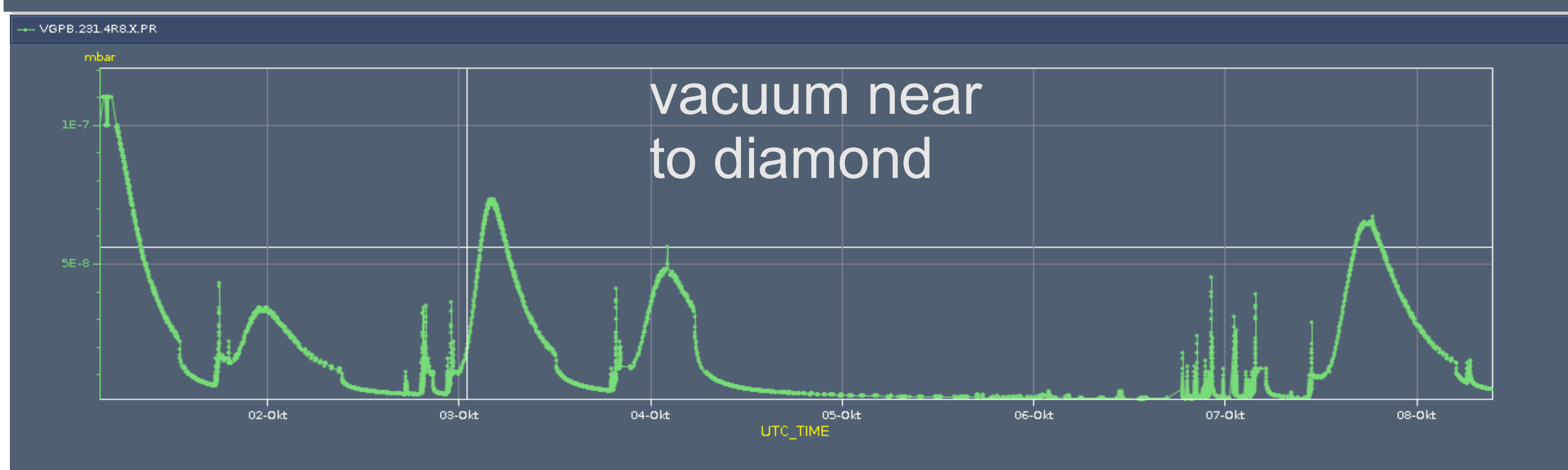


Distance between IP and diamond: 70m → 235ns




Scaler Rates
500
400
300
200
100
0
02/10
02/10
03/10
03/10
04/10
04/10
05/10


Timeseries Chart between 2011-10-02 00:00:00.000 and 2011-10-10 00:00:00.000 (UTC_TIME)
BLMEI.04R8.B2E10_TCTH.4R8.B2:LOSS_RS09
Gy/s
BLM near to diamond
3E-4
2,5E-4
2E-4
1,5E-4
1E-4
5E-5
0E0
02-Okt
03-Okt
04-Okt
05-Okt
06-Okt
07-Okt
08-Okt
09-Okt
UTC_TIME


VGPB.231.4R8X.PR
mbar
vacuum near to diamond
1E-7
5E-8
02-Okt
03-Okt
04-Okt
05-Okt
06-Okt
07-Okt
08-Okt
UTC_TIME

6. Conclusion

- All needed tools are installed
- DAQ for LHC is working
- 2nd diamond will be installed soon

Thank you for your attention!