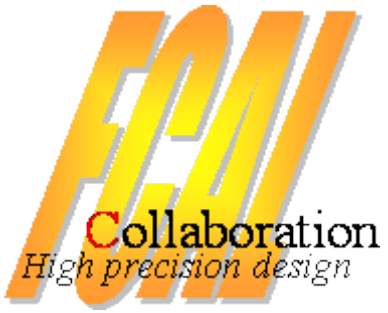


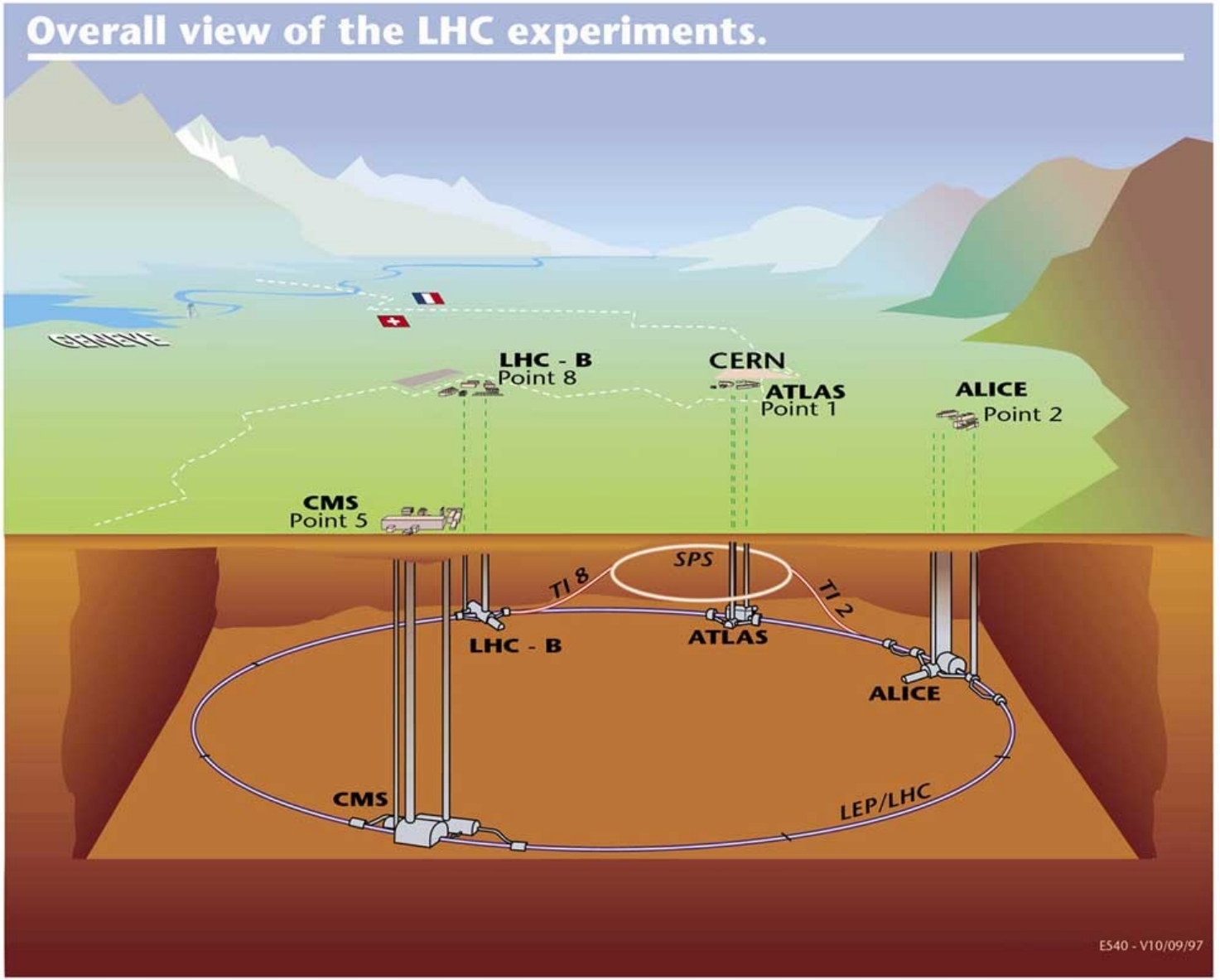
The CMS Beam Conditions and Radiation Monitoring System

(Principles, Hardware & Software)

M. Ohlerich
for the FCAL group

Technisches Seminar DESY Zeuthen

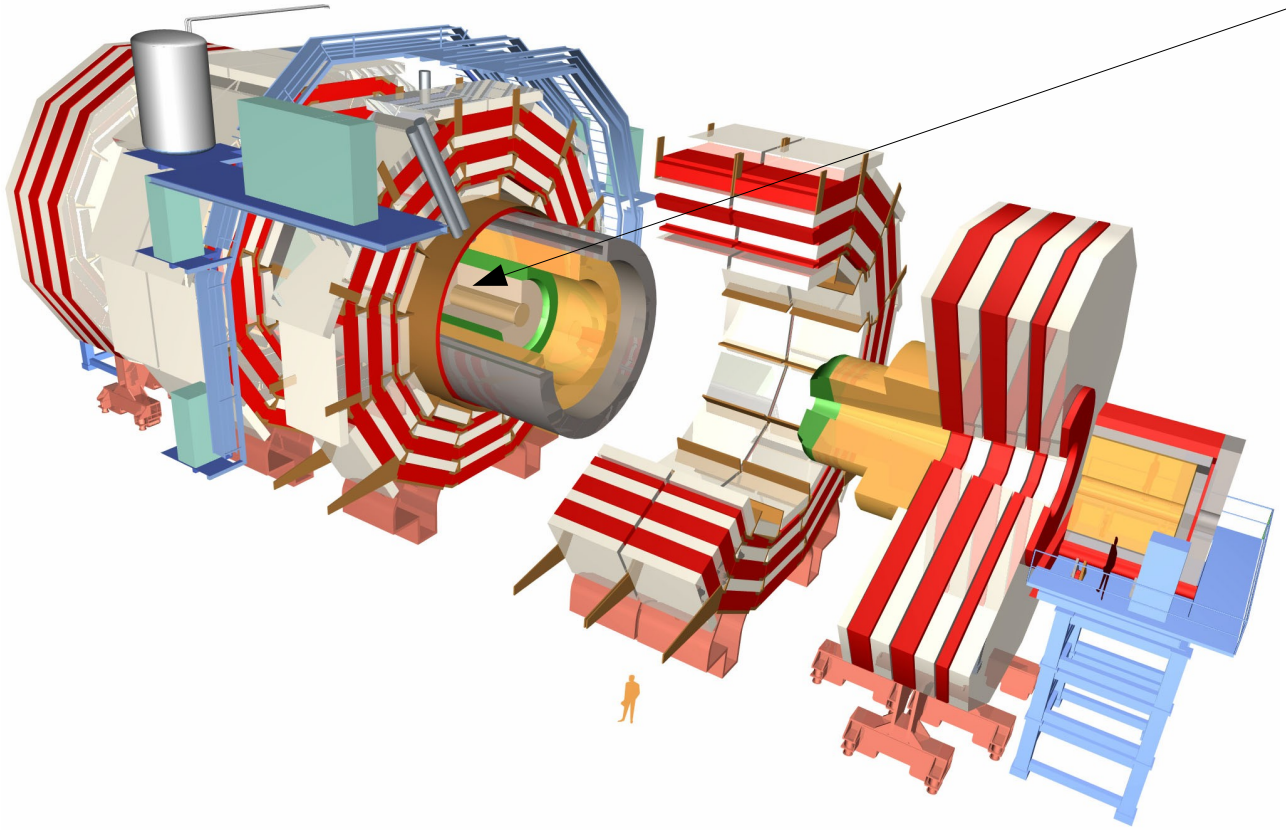
Introduction



CMS Detector

Proton bunch

Collisions



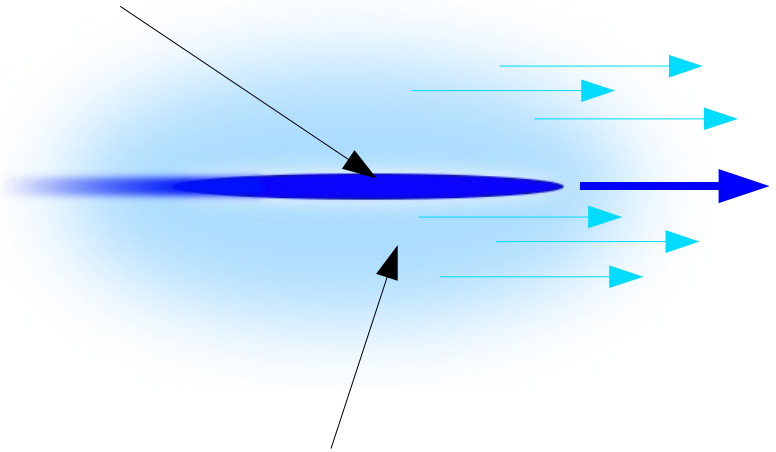
Proton bunch

Collision → Detector signals → Filter → Interesting Event

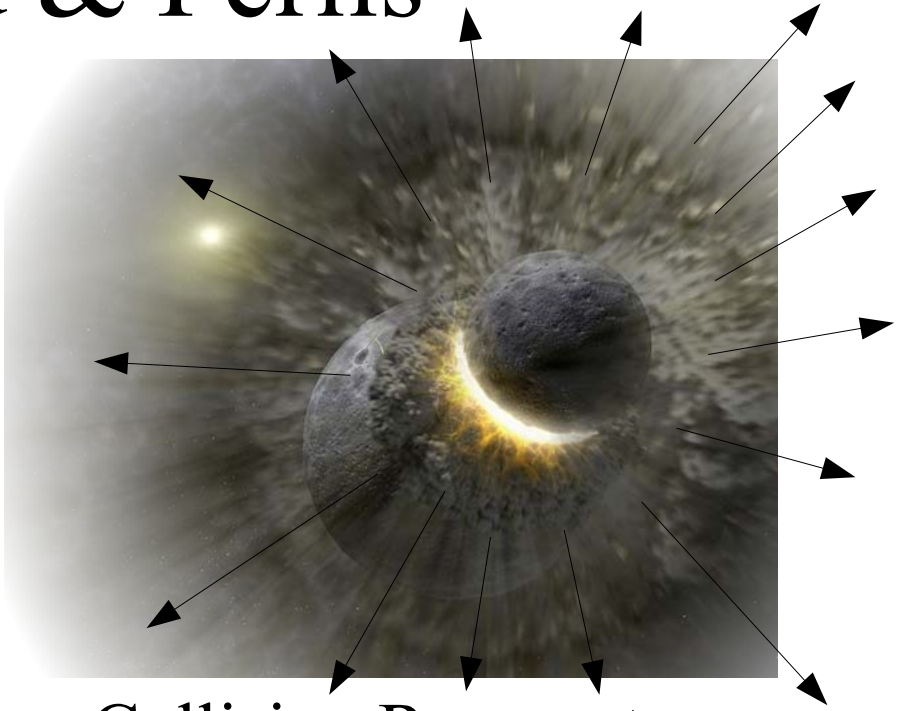
Detector = sensitive and expensive device

Background & Perils

Proton bunch

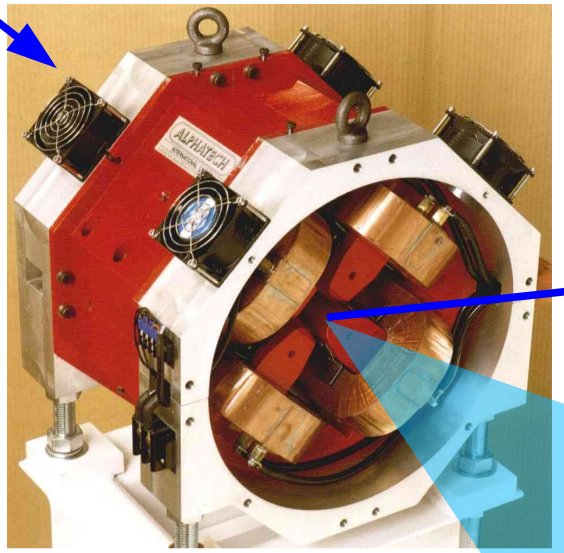


Beam Halo



Collision Remnants

Beam control



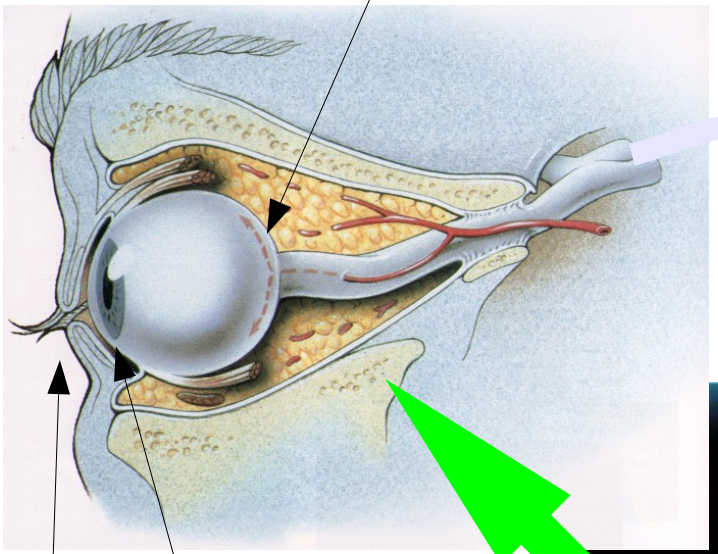
mis-steering

focusing

Detector has to be protected! → Monitor Beam Conditions

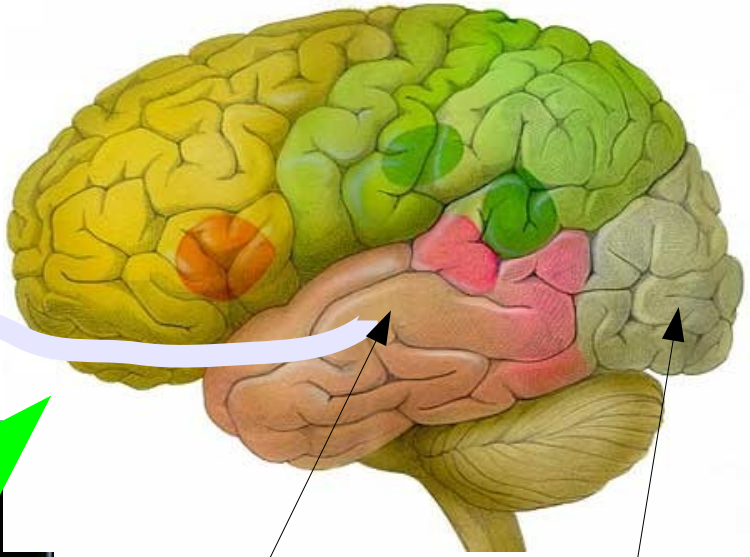
Analogy

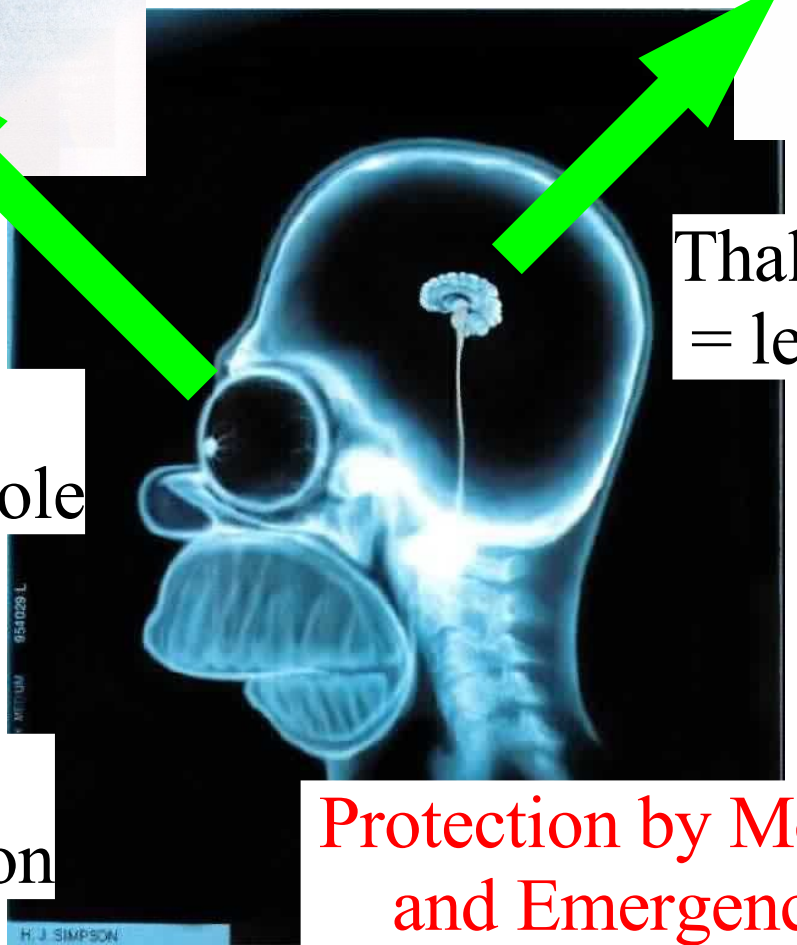
Detector = Retina
= level 1 trigger
= radiation monitor



Optic nerve
= signal data line

Brain = CE & SE





Thalamus
= level 2 trigger

Lens
= final quadrupole

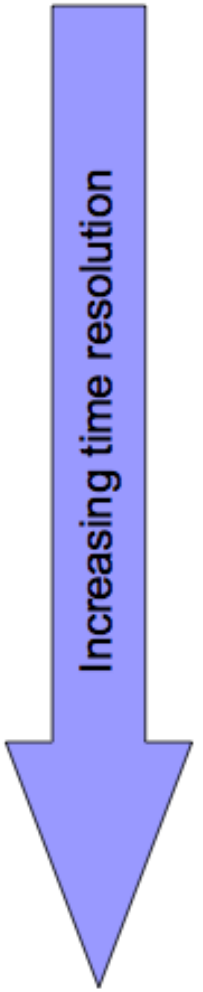
Visual cortex
= high level trigger

Eyelid & Pupil
= detector protection

Protection by Monitoring
and Emergency Shutdown

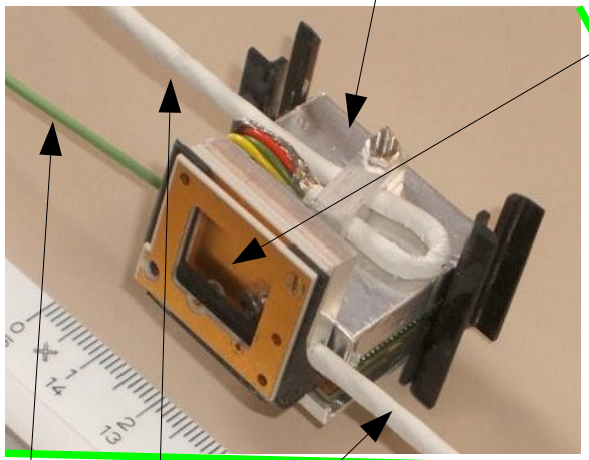
BRM

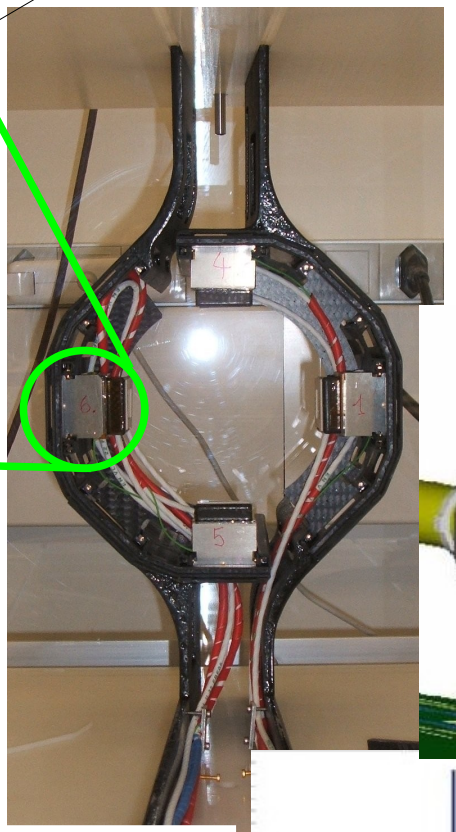
Subsystem	Location	Sampling time	Function	Readout + Interface
Passives TLD+Alanine	In CMS and UXC	Long term	Monitoring	---
RADMON	18 monitors Around CMS	1s	Monitoring	Standard LHC (FESA)
BCM2 Diamonds	At rear of HF 14.4m	40 us	Protection	Standard LHC (FESA)
BCM1L Diamonds	Pixel Volume 1.8m	Sub orbit ~ 5us	Protection	CMS + Standard LHC (FESA)
BSC Scintillator	Front of HF 10.9m	Bunch by bunch	Monitoring	CMS Standalone
BCM1F Diamonds	Pixel volume 1.8m	Bunch by bunch	Monitoring + protection	CMS Standalone

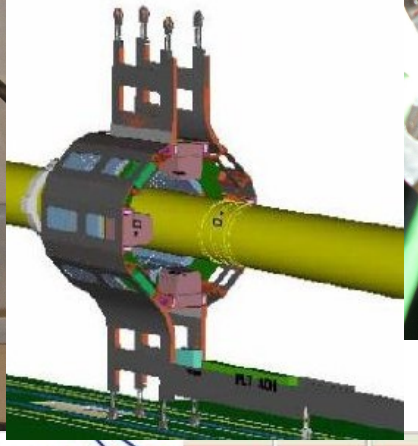


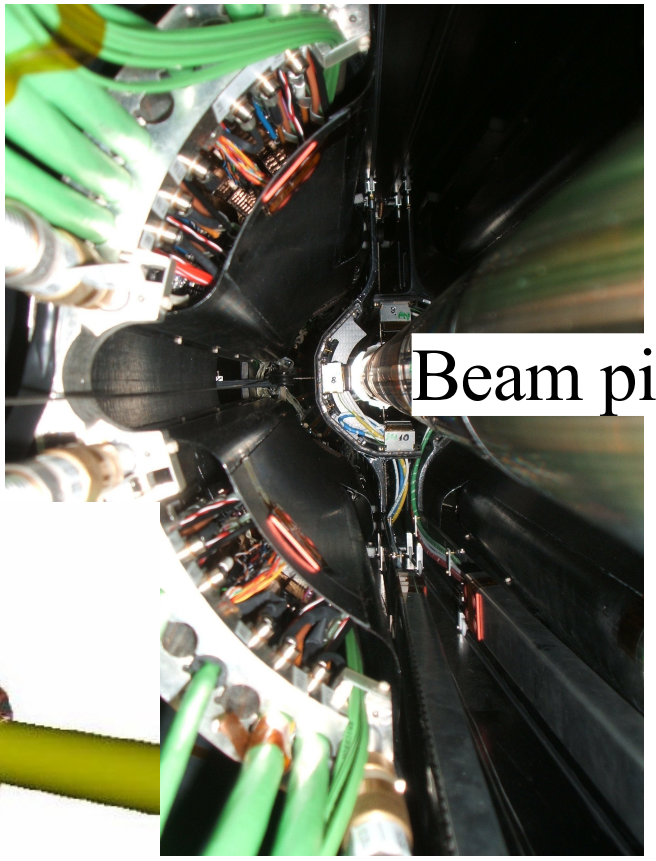
1 Orbit ~ 90 μs, Bunch Spacing ~ 25 ns

BCM1F (& BCM1L)







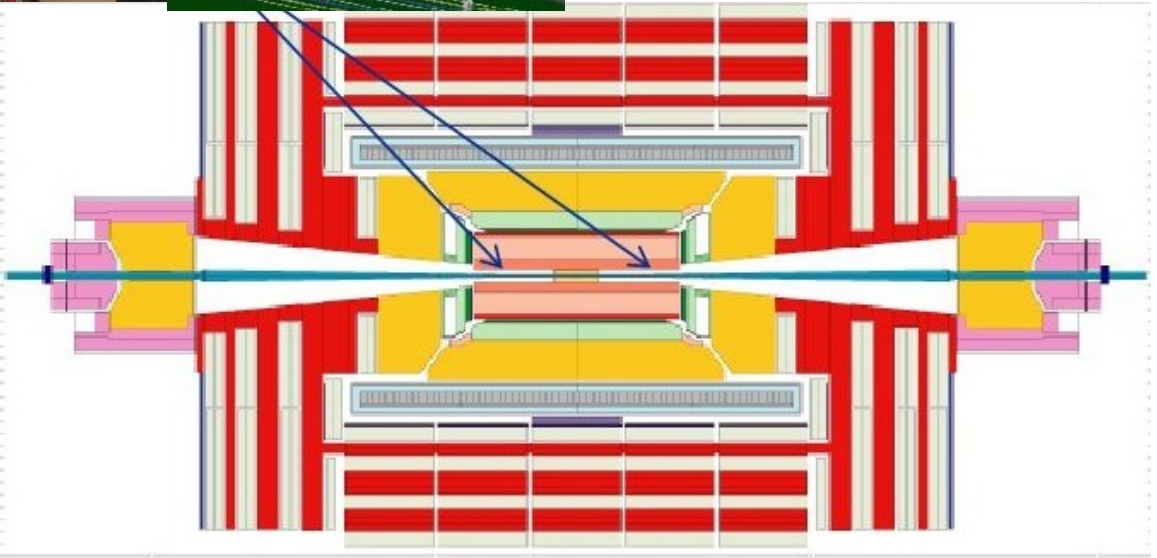


Beam pipe

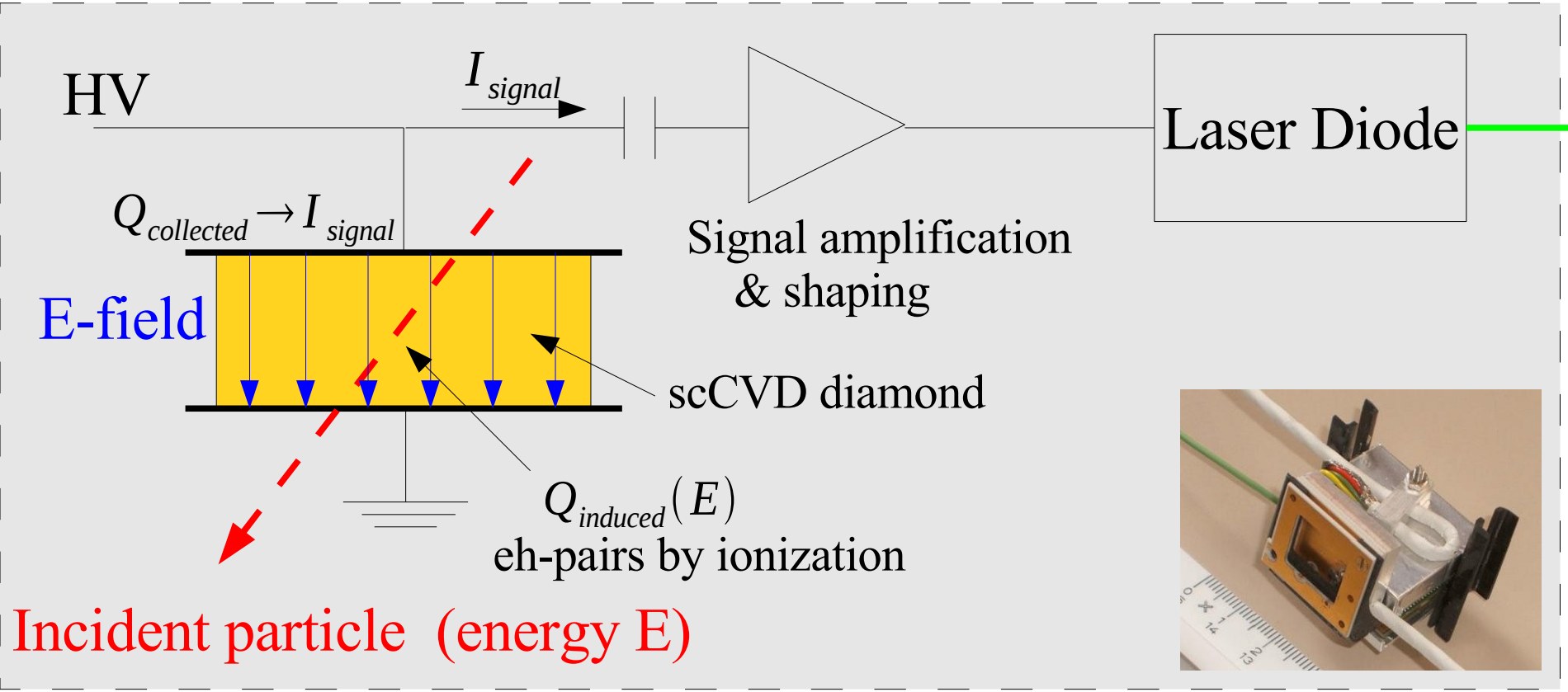
voltage supply

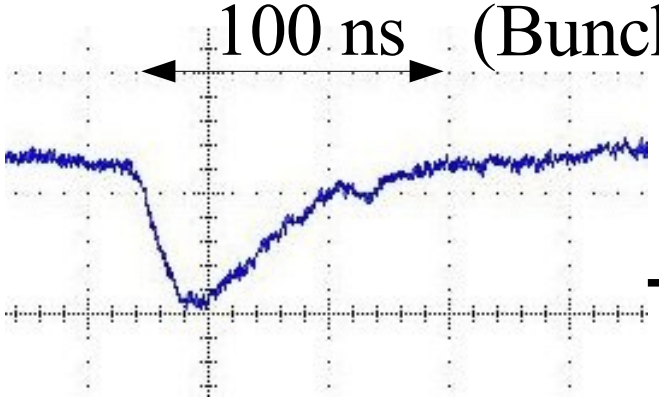
Optical Fiber

Assembled by W. Lange



BCM1F details + Readout Electronics





$Signal\ Area \propto Q_{collected}$

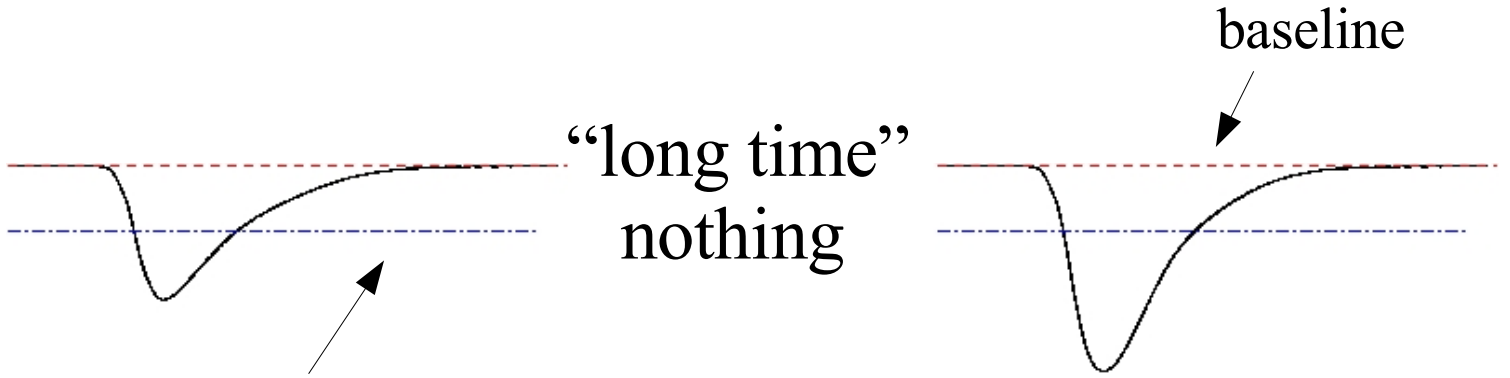
electrical signal

optical receiver

Monitoring Issues

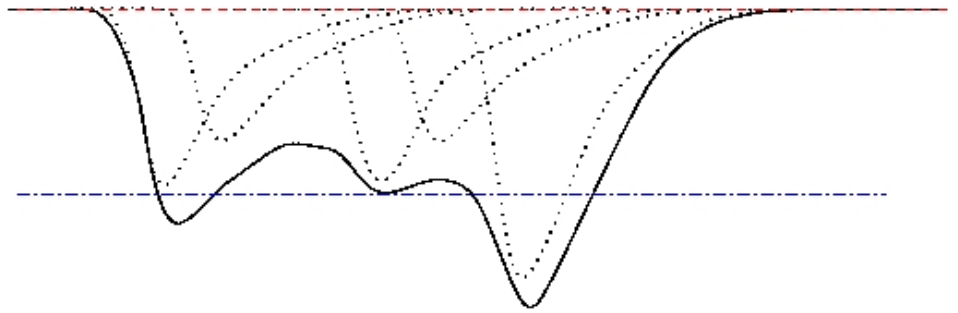
1. Monitoring Mode:

low signal rate



→ put threshold (discriminator) → Count Rate Monitor

(very) high signal rate



→ Level Monitor (~ Leakage Current Monitor)
(Threshold for Warning or Emergency Shutdown)

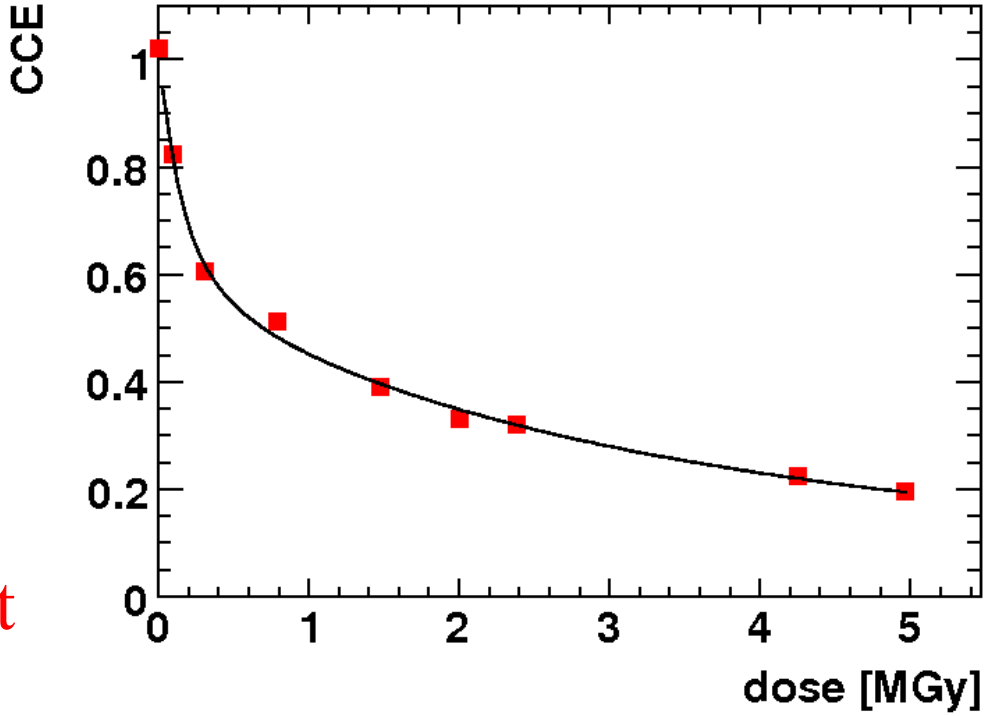
Monitoring Issues (2)

2. Detector Performance:

$$Q_{induced}(E) \geqslant Q_{collected}(dose)$$

$$CCE = \frac{Q_{collected}}{Q_{induced}}$$

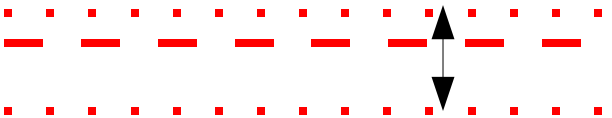
→ Calibration/Adjustment



2. Environment:

Thresholds depend on baseline

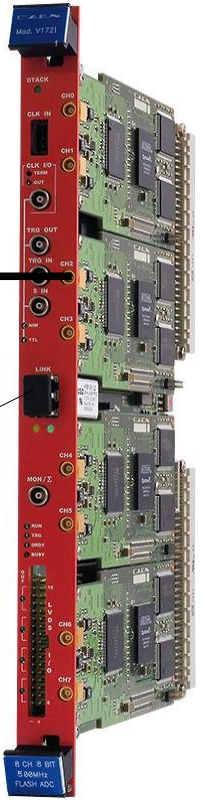
→ Baseline Monitor



Baseline Shift due to temperature, electronic noise, etc

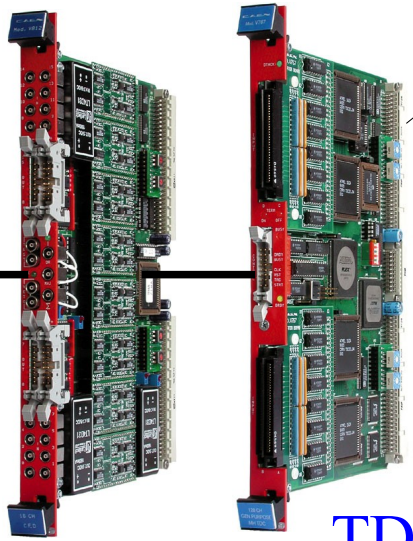
Digitization Electronics

optical receiver



ADC (Sampling)

- 500 MB/s sampling
- 8 channels
- Ext./Int. Trigger
- Interval adjust.
- 16 MB (45 orbits)



Discriminator

- set thresholds
- output logical on/off

TDC

- output start trigger & hit time

Modes of Operation: Learning Mode

- ADC only

- Store on Orbit Clock (= ext. Trigger) 45 orbits (buffer full)

- Readout & Store/Treat Data online (½ sec dead time)

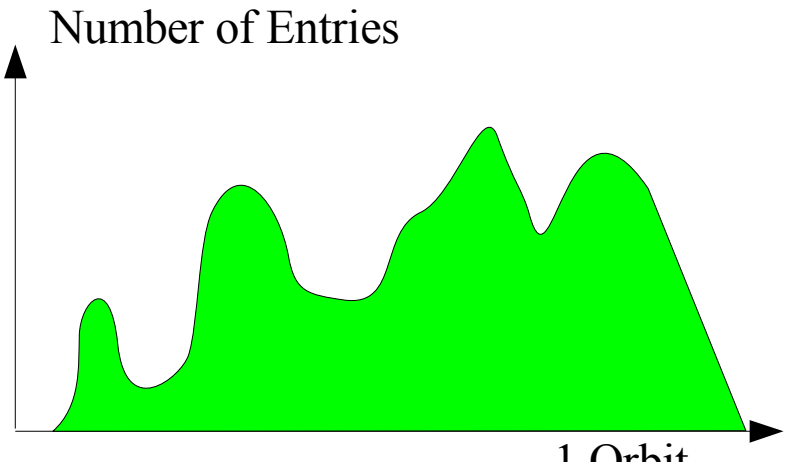
- Analyze Data offline / online (slow, Software)

- Useful ONLY at high Luminosity
  (11. Sept. low Luminosity → GBytes of baseline)

- Optimized – but not flexible

- Check for Bunch Filling
  and Bunch Timing

No Monitor !!



Modes of Operation: Maintenance Mode

- ADC only

- Use Self-Trigger / Ext. Trigger (flexible)

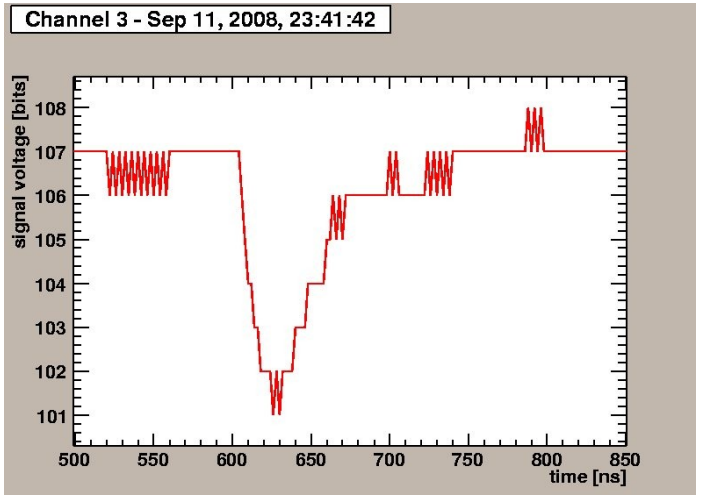
- Adjust Trigger and Acquisition Interval (e.g. few 100 ns)

- Readout & Store/Treat Data online (dead time much smaller)

- Analyze Data offline/SW (No precise Time Assignment)

- 11. Sept. OP Mode
  Useful for any signal rate
- For Sensor Performance /
  Baseline / Calibration

- Flexible – but not optimized

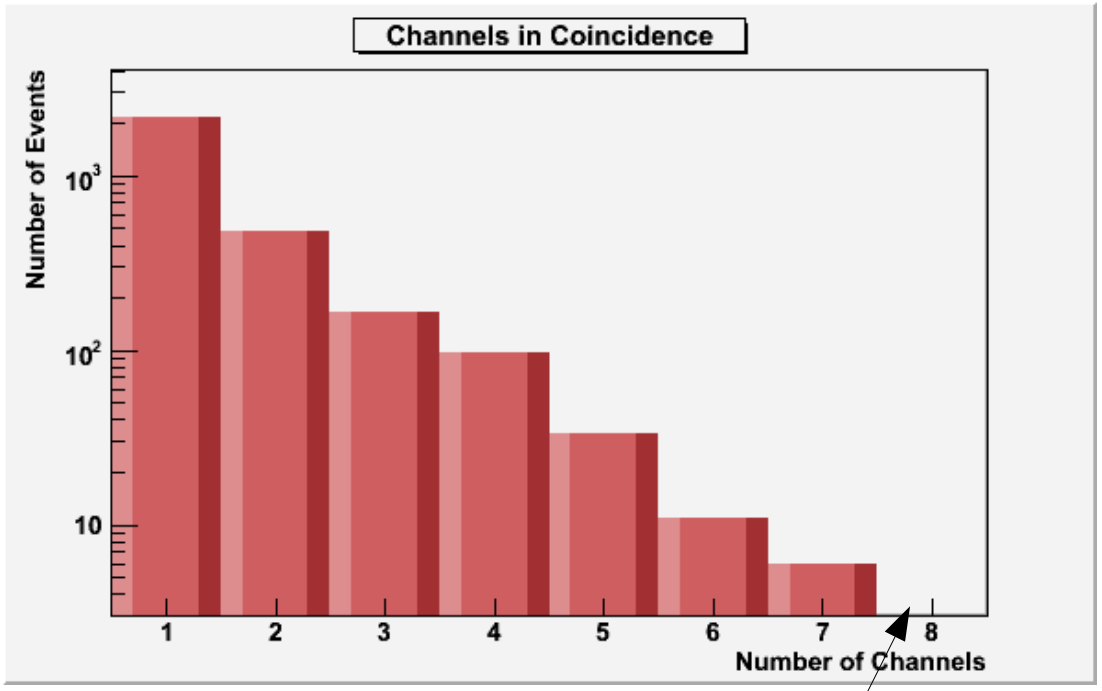


No Monitor !!

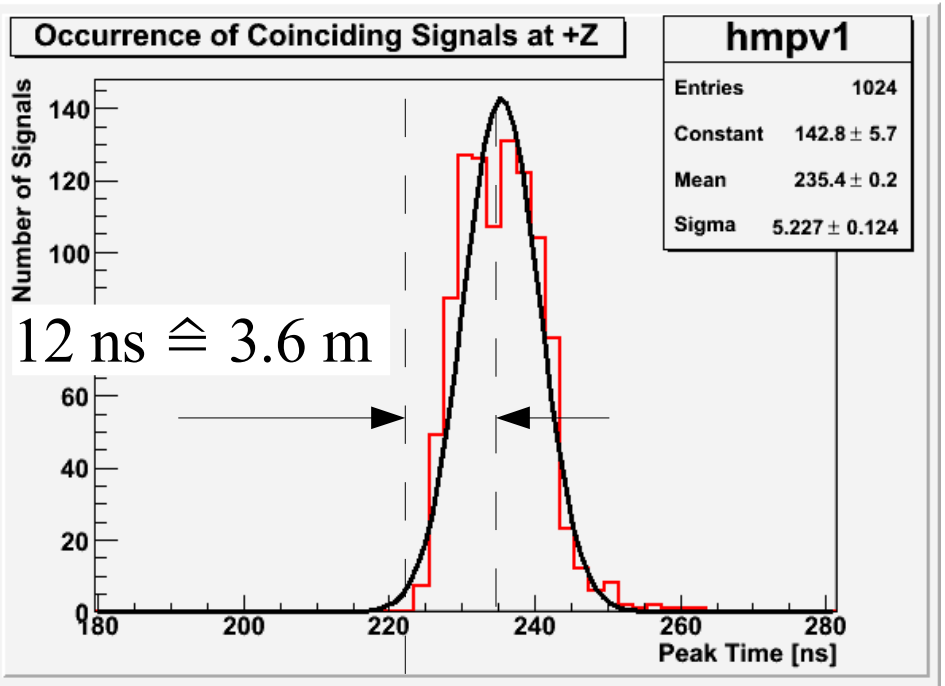
Ext. Trigger → BPTX

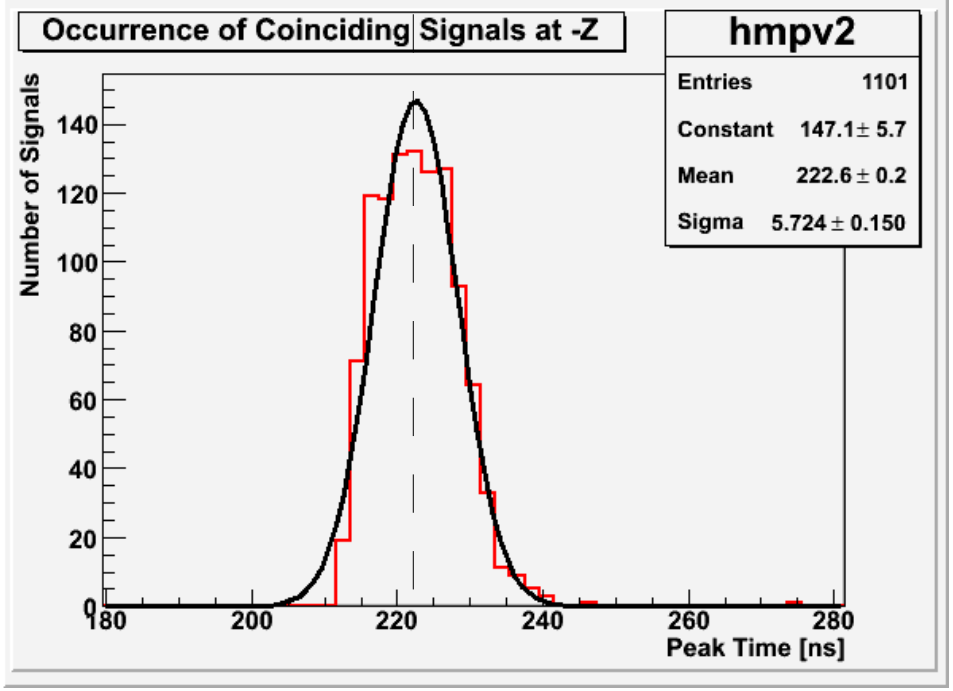
Data From 1st LHC Testrun

Offline Analysis:
Beam from one side, BPTX Trigger



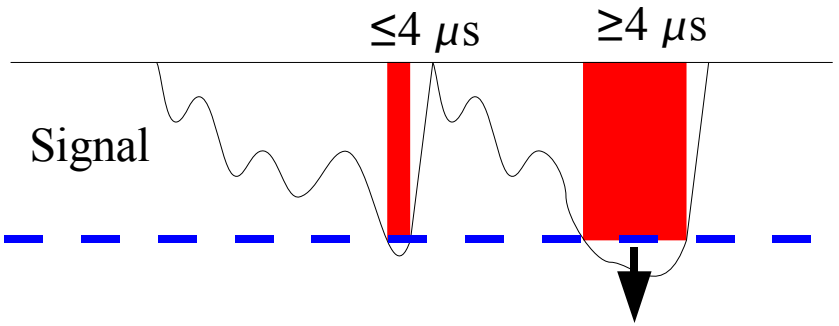
One channel had bad cable





Modes of Operation: Warning Mode

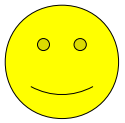
- ADC only
- Use Self-Trigger
- Store few orbits



Trigger = Time Reference

- Readout & Store Data offline
- Analyze Data offline/SW (post-mortem analysis)
- Permanent Monitoring, but NO online output for control !!
- For Level Monitor, internal Trigger → ext. Trigger out (to Control)
- fast, only hardware
- needs Baseline Monitoring for Trigger Thresholds

Modes of Operation: Count Rate Monitor

- ADC = Baseline Monitor & TDC Count Rate Monitor
- Discriminator Threshold adjusted w.r.t. Baseline
- TDC start trigger = Orbit clock (Time Reference)
- Readout & Store Data online (no dead time at low rates)
- Analyze Data online: Counting hits per Orbit, Timing Info
- Permanent Monitoring 
- Permanent Online Info for Control
- fast (no Software-based Under-Threshold discrimination)
- Works only, if no pile-up!

What is still to do ...

- DAQ Software for Monitoring Mode (TDC)
  → Elena Castro
- Data Analysis Software / User Interface Performance
  → Ringo Schmidt
- Publishing Routines (DIP)
  → both
- Test of the Software (This cannot be done often enough!)
  → volunteers

FCAL Group (on Testbeam Darmstadt)

Thanks to all DESY People!

Special Thanks to UCO ;)

Goodbye!

Also thanks to GIMP!