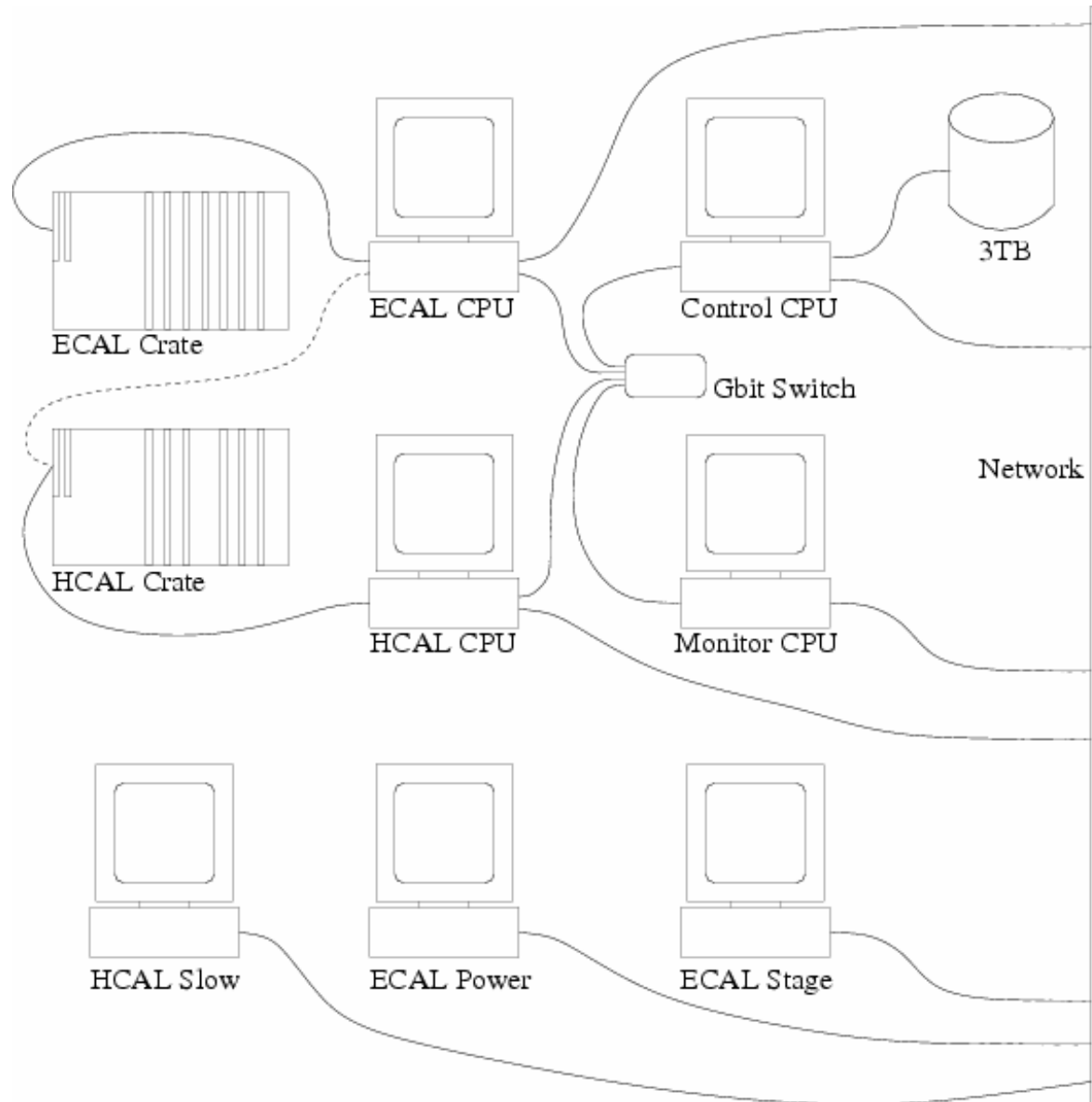

DAQ/Online:
Lessons from DESY run
Readiness for CERN beam test

Paul Dauncey

Imperial College London

DAQ hardware layout



DESY run: reminder of the dates...

- ECAL modules
 - Arrived on Mon 15 May
- Crate, trigger hardware installation
 - Started on Fri 12 May
 - Continued until Thu 18 May
- DAQ software setup
 - Started on Sat 20 May
 - Continued until Sun 21 May
- System stable from Mon 22 May onwards
 - I.e. one week after ECAL modules arrived
 - Ran until Wed 31 May
- Even after delay of one week, system not complete...

My main conclusion from the DESY run

- The run almost didn't happen
 - Many things were extremely marginal
 - A fortunate accident that it worked at the last minute
- IMHO, main cause was lack of an overall coordinator
 - No central setting of priorities
 - No fixed start time of hardware setup
 - ECAL packed up and not calibrated with cosmics after run
 - ECAL stage PC shipped back to Paris and not left for further tests
 - Late purchases of crate, cables, scintillators, etc.
- Everyone did what they thought was best
 - But need an objective view to decide what is most important

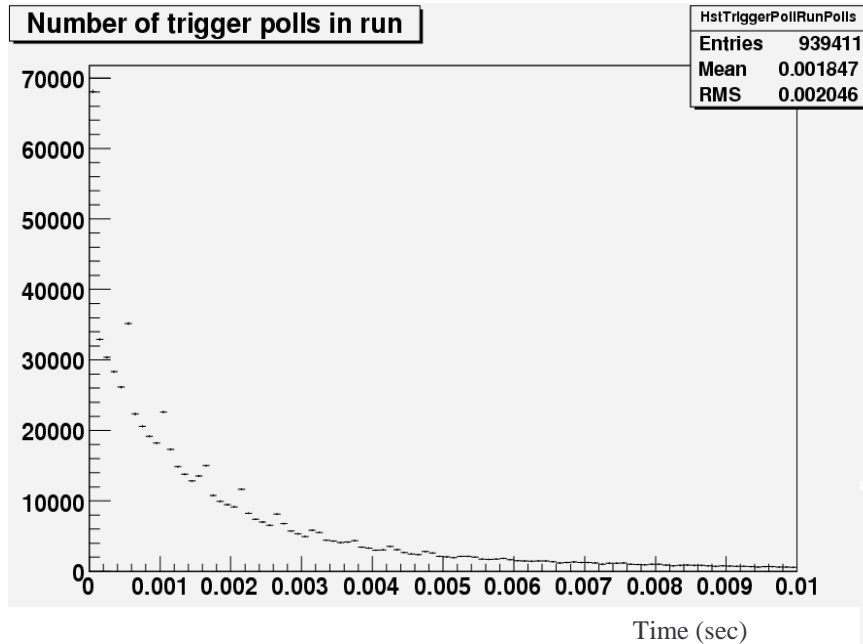
Issues from the DESY run (not complete)

- Hardware
 - New TDC (for CERN use) did not have chamber inputs
 - Single crate, not two crate system as will be used at CERN
 - Veto scintillator with analogue-only readout; cannot veto events with beam hits previous to trigger
 - Collimators not optimised
- Firmware
 - 500 event limit as no time to test newer firmware
- Software
 - New TDC not read out so no tracking data in CERN format
 - No spill-mode running
 - Some speed-ups not implemented

What we learned

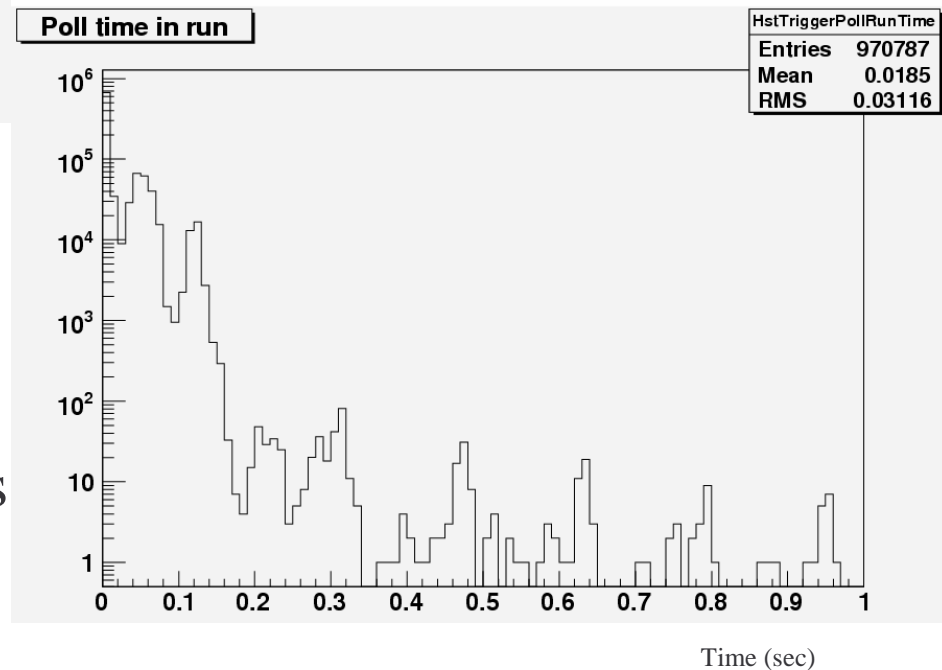
- Hardware takes at least one week to assemble
 - Main delay seems to be getting a reliable trigger
 - Saturates my time so no software work possible in parallel
- Once system is ready, it is reasonably stable
 - 3 runs out of ~180 in stable period ended abnormally
- All 3 due to loss of socket connection to ECAL stage PC
 - Only socket not going through the local hub
 - Could be bug at either end or external network glitch
 - This is why ECAL stage PC was shipped back from Paris

Data rates at DESY



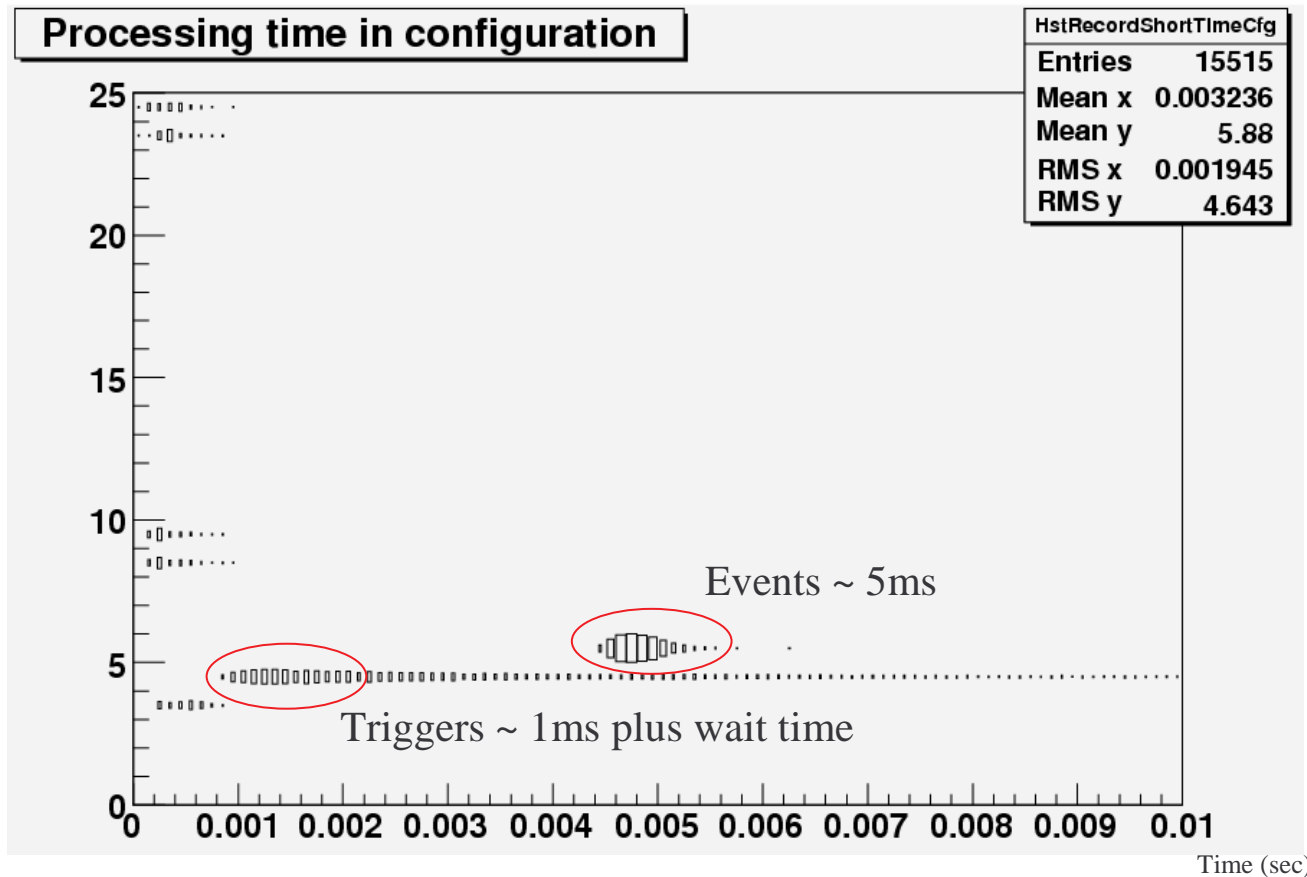
- Mean time to trigger $\sim 1.8\text{ms}$
- Implies beam intensity $\sim 540\text{Hz}$

- Spill structure visible but spills could be empty



Data rates (cont)

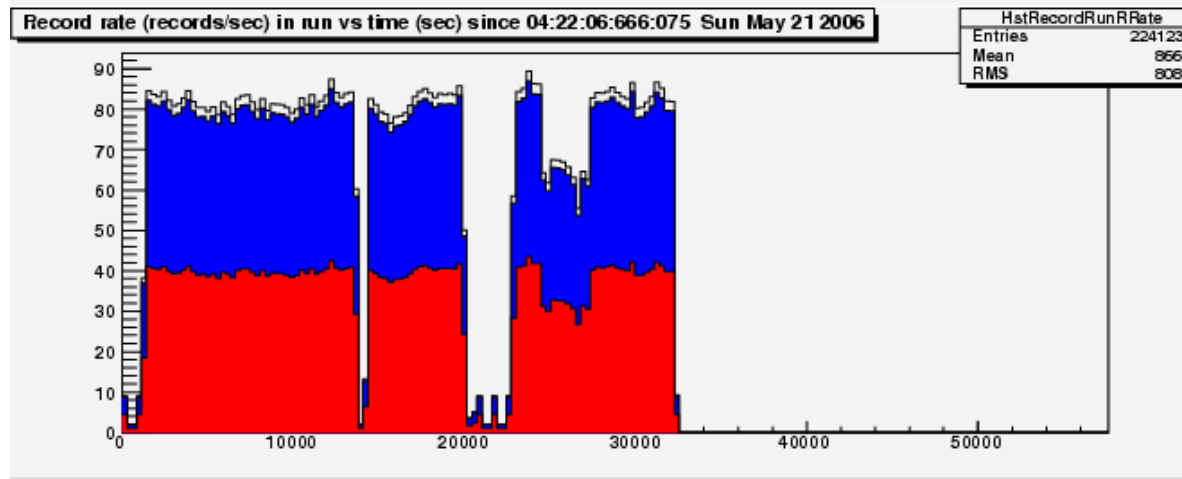
- Trigger processing is done separately from event readout



- Total average time for trigger wait and processing ~3ms
- Total average time for whole processing ~8ms

Spill structure at DESY

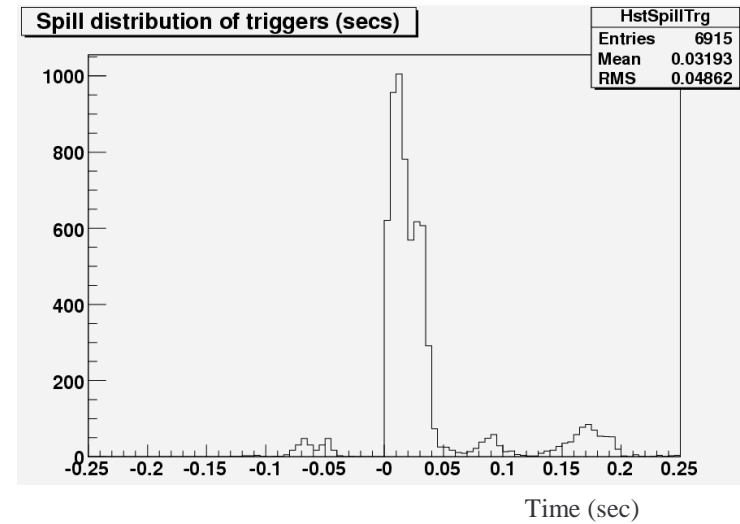
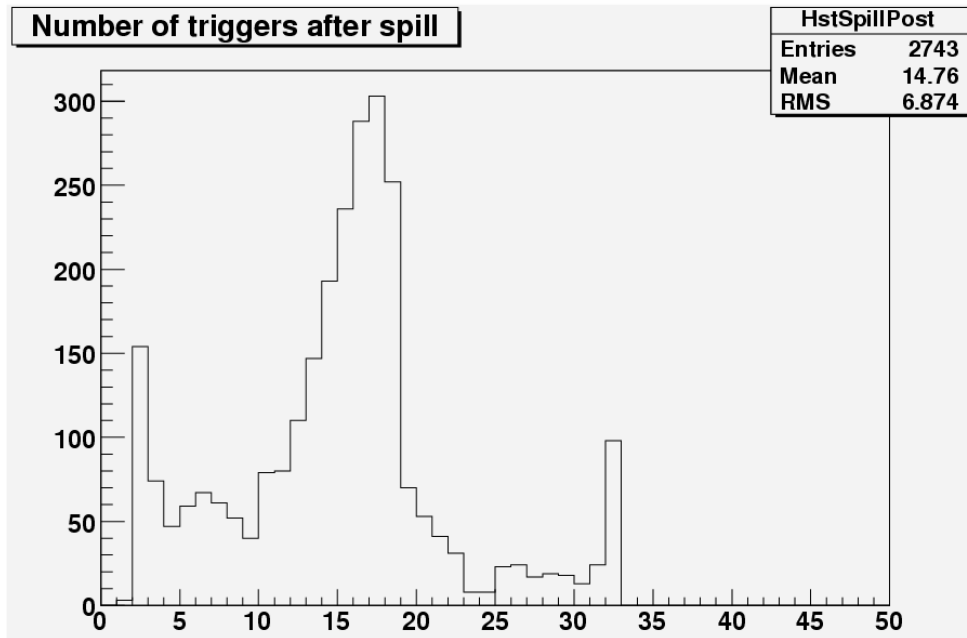
- So why only 40Hz rate at DESY?



- The DESY beam is not continuous
 - Has a spill structure which can change with machine settings
 - Usually 160ms period with beam for (usually) 40ms within this; 25%
- Only found this out after ECAL installation
 - Spill signal not wired into crate until the end of hardware setup
- Spill size completely different from CERN
 - 16.8 sec period, beam for 4.8 sec

Spill structure at DESY (cont)

- Trigger distribution shows spill time clearly
- Triggers outside spill also



- Number of triggers taken per spill looks sensible
 - 2.8ms per trigger, 40ms spill
 - Average of ~14 events expected
- Needed to tune rate
 - Too many taken would miss next spill
- No time to do this; spills ignored
 - Probably lost factor of 1.5 to 2 in event rate; 14 events/spill ~ 90Hz

Preparations for CERN

- Since end of ECAL run have tried to put together “CERN system”
 - Not yet achieved this
- Remaining issues:
 - Hardware setup; no solid trigger distribution
 - New TDC not yet proven
 - HCAL slow PC communication not yet stable
 - ECAL stage only just back at DESY
 - Not the final trigger scintillators (so no HOLD measurement)
- Also DAQ work to be done on
 - CRCs
 - Firmware
 - Software

CERN tracking

- We can borrow CERN **delay wire chambers**
 - Got a **CAEN V767 TDC** out from CERN loan pool
 - 128 (!) channels, 800 μ s range, 0.75ns LSB, 32kword buffer
- TDC is complex and painful to use
 - Full setup takes 7 sec (!), including 2 sec wait after reset
 - Trigger is rounded to 25ns clock so need independent fiducial signal
 - Not yet proved reliable as no good trigger yet
- Is 32kword buffer sufficient for 2000 events?
 - Each event has header and end-of-buffer word
 - Also need to read out fiducial signal
 - Leaves average of 13 words per event
- Delay wire chambers have two channels/chamber
 - Requested four x-y planes = 16 channels
 - Buffer not sufficient to even store single hit/event, let alone noise
 - With four planes of chambers must borrow a second TDC

CRCs: from my talk at Montreal

- “Need to determine **exact size** of the problem
 - How many bad channels now exist? Must use a VFE PCB to be sure
 - Need **systematic test** of every FE connector input; **who** will do this?
 - If problems seen, need to check alternative FE connector
 - Also check if input is connected through to first stage of ADC circuit
- Adding **bridging wires** for broken traces can be done
 - Probably best for Adam to do this; need to be done in the UK
 - Do we **return boards** to the UK? Need to be sure enough left at DESY
 - Need **(realistic) schedule** for ECAL/AHCAL module delivery”
- Nothing has been done on this; no progress
- I got a realistic (? to what level?) module schedule yesterday

Firmware still to do

- Now have a version with 2000 event buffer
 - Solution found for the limitation on storage size within FPGA...
 - ...which has introduced a bug into the FE header data
 - This only shows up for disabled (unused) FEs before enabled FEs
 - Currently, engineer working on a fix; timescale unknown
 - Workaround would be to enable a few extra FEs so no gaps
- Very recently have a version allowing trigger and ADC data to be mixed within one (slot 12) CRC
 - Trigger event (history) data takes FE0
 - Without this change, other seven FEs are unusable
 - This version has not yet been tested at all

Software still to do

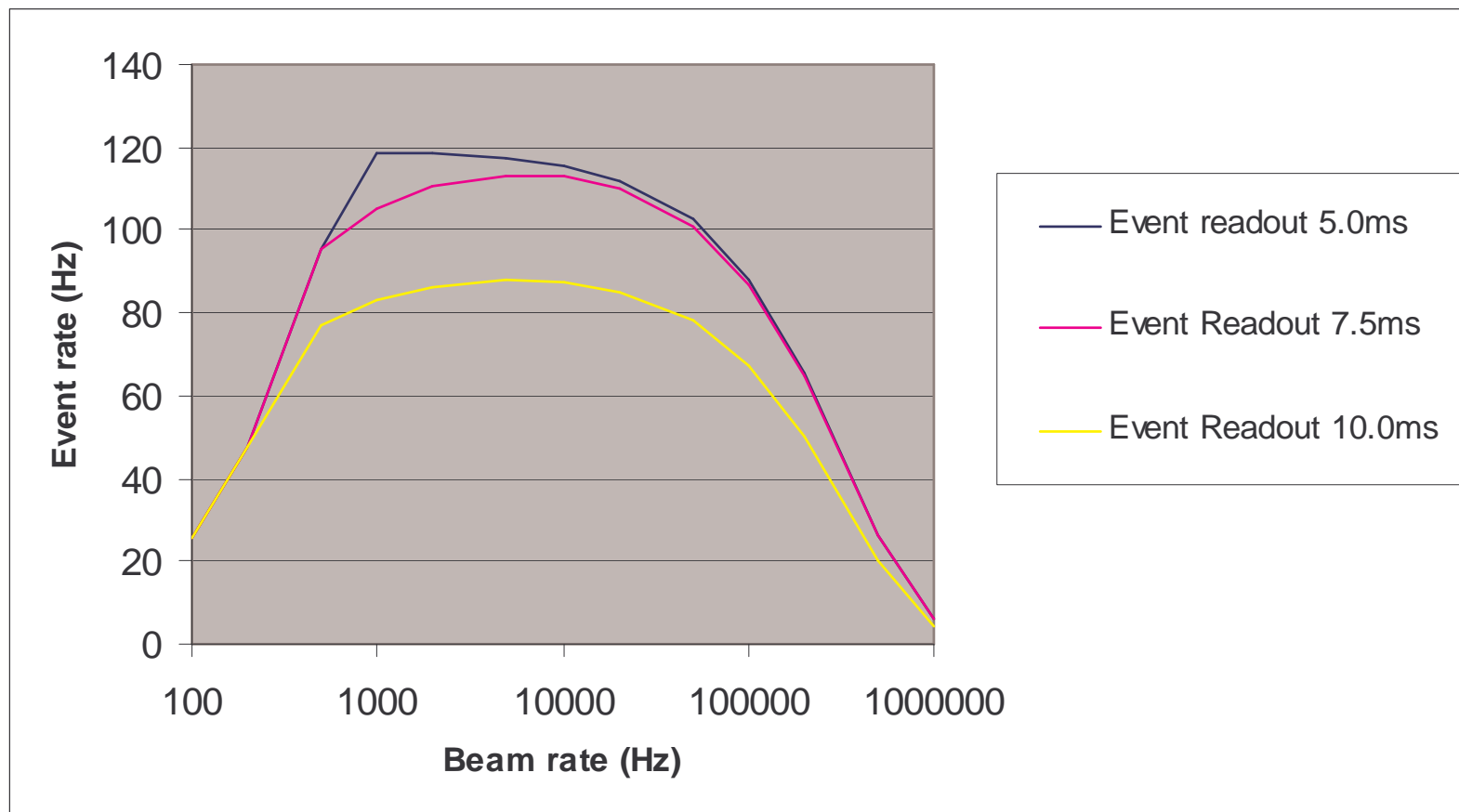
- Online monitoring speedup
 - Can limit run rate; mainly due to ROOT memory handling
 - Have rewritten several parts to use shared memory instead
- Trigger code reorganise
 - This is the part which is hacked around for different run types
 - Has organically grown (into a mess); no longer reliable
- ECAL slow PC interface
 - No work on this yet; plan is made but need to implement
- HCAL slow PC interface for CERN beam data
 - Mainly working but new data for beam energy, etc, at CERN
- Data integrity checking code
 - Need to be more sophisticated and check data structures more systematically
- Performance speed-ups
 - Read-ahead for events; need to predict when event readout will occur
 - Tune up for rate of scalar counter reads, histogram refresh rates, etc.
- Work with CERN spill timing structure
 - Fake timing in software
 - Tune parameters to optimise number of events taken

Beam rates at CERN

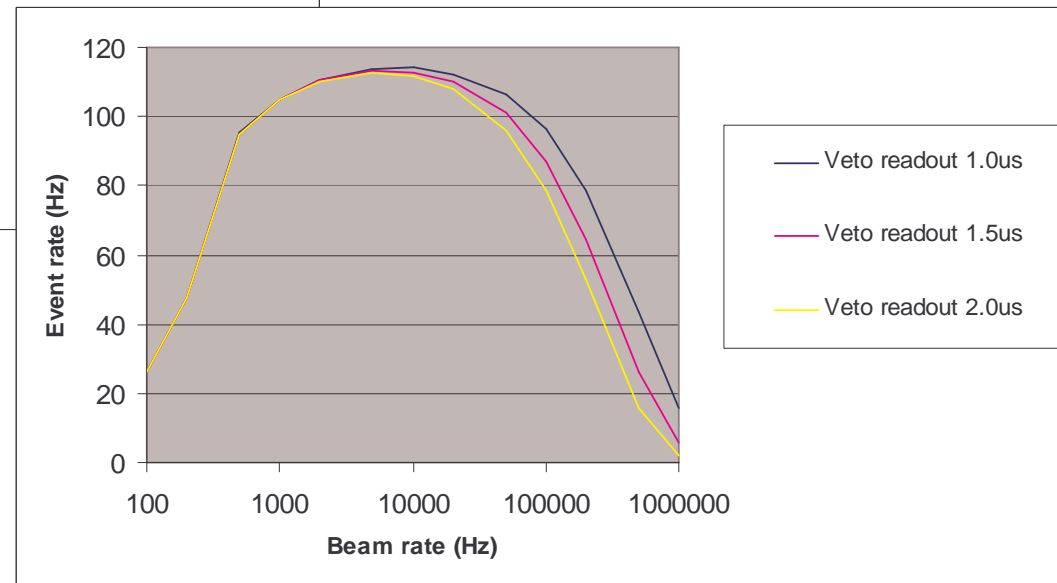
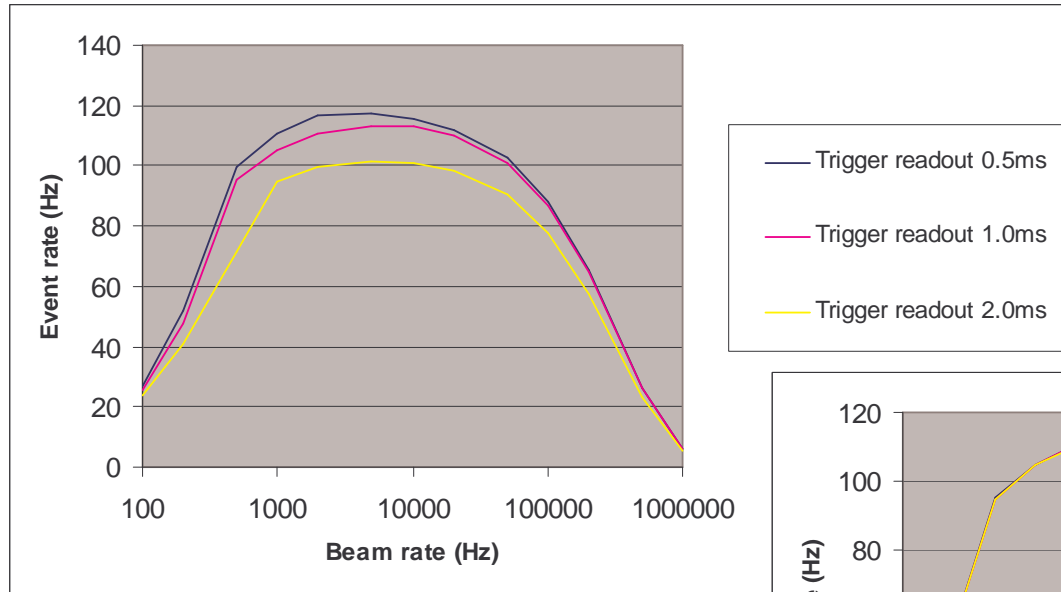
- If the changes get done in time...
- Time to take an event
 - Time waiting for a trigger = $1/r$, r = beam rate
 - Time processing trigger = t_t
 - Time reading out event = t_e
- Limits on events per spill
 - Maximum number of triggers in 4.8s spill = $4.8/(1/r + t_t)$
 - Maximum number of events in 16.8 spill period = $16.8(1/r + t_t + t_e)$
 - Maximum number of events in buffer = 2000
- High intensities give out-of-time hits
 - A hit within t_0 before trigger leaves energy
 - Probability of no out-of-time hit = $\exp(-t_0 r')$
 - r' is beam rate into whole calorimeter, not just trigger scintillator
 - Guesstimate $r' \sim 2r$?

Beam rates at CERN (cont)

- Some possible values
 - Times: $t_t = 1\text{ms}$, $t_e = 7.5\text{ms}$, $t_o = 1.5\mu\text{s}$
- Gives an indication of event rate as a function of beam intensity



Beam rates at CERN (cont)



- Optimal beam intensity is 3-10kHz in all cases
- Event readout most sensitive parameter but still hope to get 100Hz

Summary

- There is still a lot of work to be done
 - We will not have a reliable and efficient DAQ at CERN without this being completed
- Time has to be scheduled for all aspects of the installation
 - Including time for DAQ development
 - This is always the last thing to be prioritised...
 - ...but the first thing to be criticised
- Essential to appoint a coordinator to oversee this
 - Person has to be in place straight away