# Calorimeter First Level Trigger Processor and Studies after the Upgrade at ZEUS

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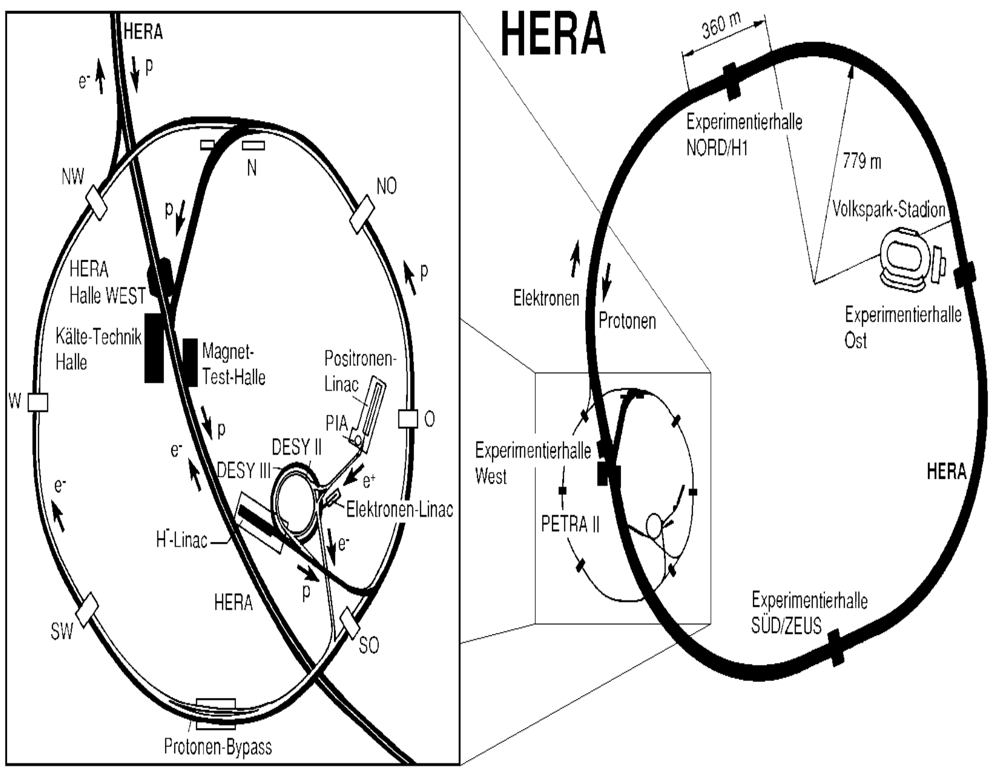
- Introduction To HERA & ZEUS
- The ZEUS Trigger System &The Calorimeter First Level Trigger
- The Calorimeter First Level Trigger Processor (CFLTP)
- Global Tracking Trigger Study
- Beauty Production at HERA II

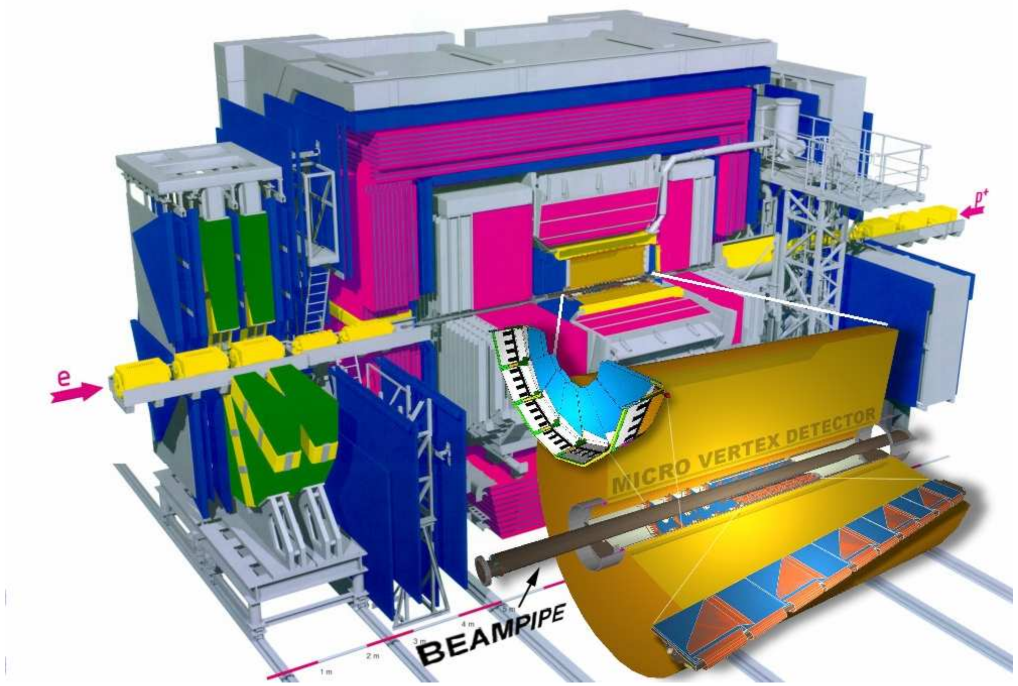
# HERA



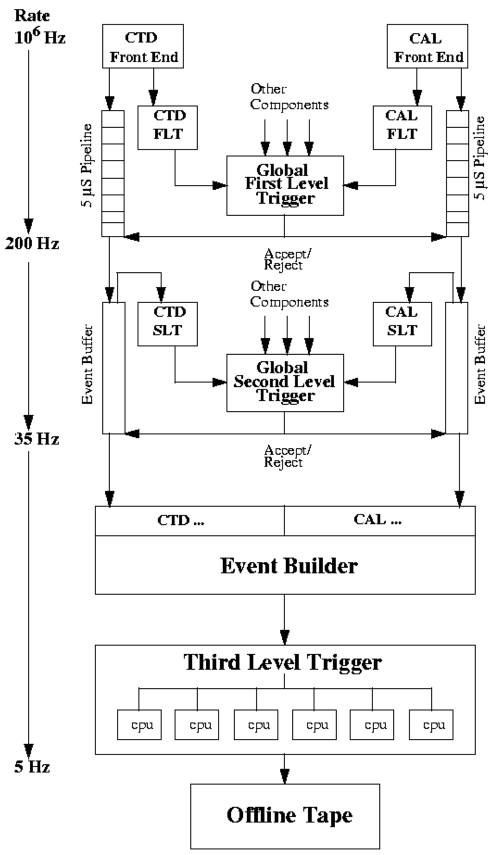

- HERA is the main $ep$ accelerator ring in Deutsches Elektronen-Synchrotron (DESY)
- It is $6.3\ km$ in circumference
- It collides positron/electrons at 27.5 GeV and protons of 920 GeV
- ZEUS can be found in the South Hall

# ZEUS

- ZEUS is a generic multipurpose detector designed to measure $ep$ collisions
- It has been going through a major upgrade for the past one and a half years
- Major improvements are a new Micro-Vertex Detector (MVD), Straw Tube Tracker (STT), and a new Luminosity Monitor (LUMI)
- These will allow for higher precision measurements of analyses such as in Heavy Flavours and make tests on Quantum Chronodynamics (QCD) with new data in the HERA II running phase

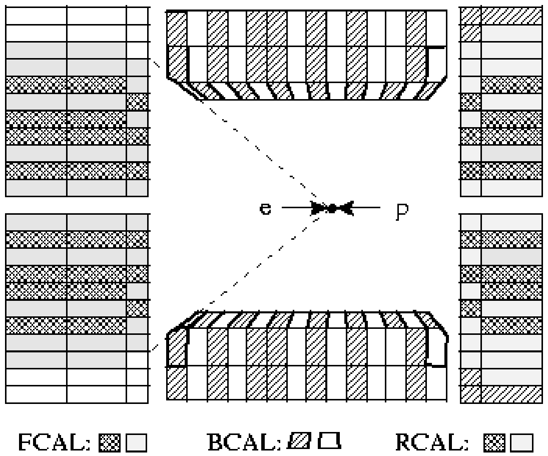


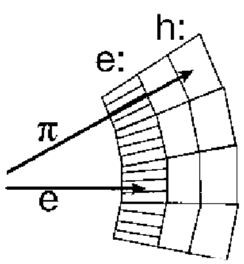
# The ZEUS Trigger System

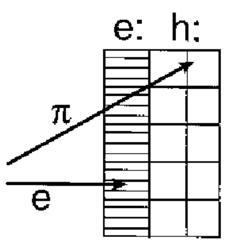



- ZEUS has adopted a three level trigger system
- HERA's bunch crossing rate is every 96 $ns$ which corresponds to a rate of $10\ MHz$
- The background rate is about $10\ kHz$
- The rate of actual interesting $e^{\pm}p$ interactions is at about $5\ Hz$
- As the input rates for each trigger stage decrease the complexity of algorithms and time each stage has to perform then increases

# The Calorimeter First Level Trigger

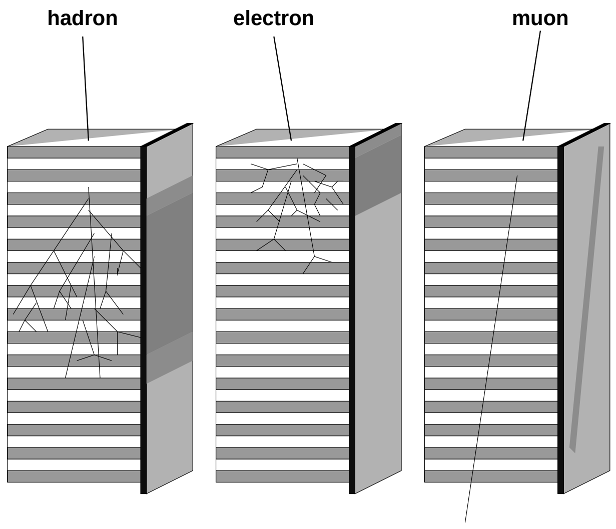


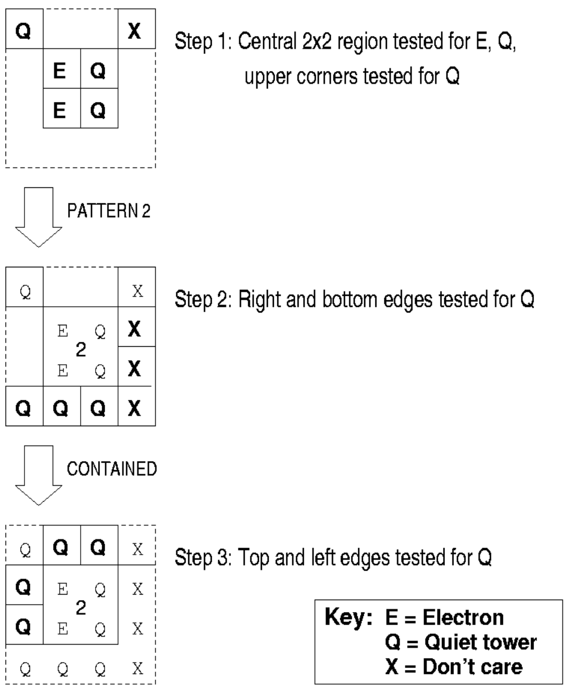

- Sums regional energy quantities in the Calorimeter
- $2.2\ \mu\ s$ to complete its decision
- Calorimeter geometry, effects the summation procedure
- Non-projective FCAL and RCAL result in special tower arrangements to compensate
- Computes 5 Gigabytes of data per second the passes its information to the Calorimeter First Level Trigger Processor

# The Calorimeter



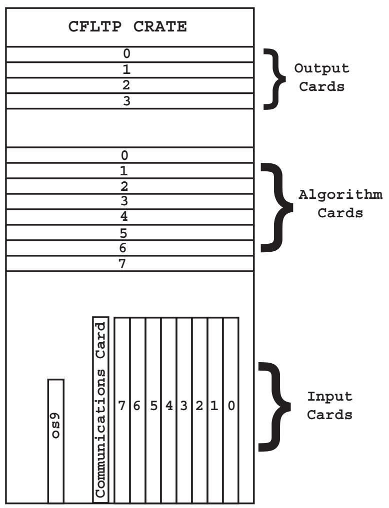

- The ZEUS Calorimeter is a Compensating Uranium Calorimeter
- The response of the Calorimeter to electromagnetic showers and hadronic showers are the same
- The Calorimeter covers 99.7% of the possible $4\pi$ solid angle
- The calibration of the absolute energy scale is 1%
- How does the Calorimeter First Level Trigger know when it sees e.g. an electron?

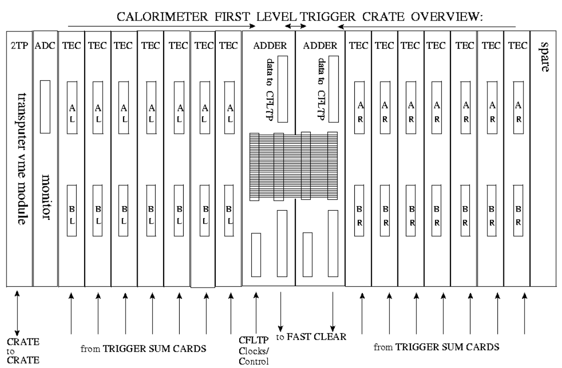
# The Calorimeter First Level Trigger




- It has three steps in which it needs to identify electrons within regions
- Six cells per region can be checked simultaneously
- If an electron straddles two regions the Calorimeter First Level Trigger Processor completes the Calculation
- Similar pattern recognition for $\mu$

# The Calorimeter First Level Trigger Processor




- Receives data from the 16 CFLT Regions
- Calculates Total energy, Transverse Energy, # of isolated leptons and compiles threshold information for the entire detector
- Calculates sub-regional "clusters"
- Ability to captures and examine $\sim 4\ K$ consecutive crossings
- Histograms all Input and Output Variables
- 4096 bits per crossing (every $96\ ns$)
- Computes 3 Gigabytes per second
- Has less then $2.2\ \mu s$ to complete its decision

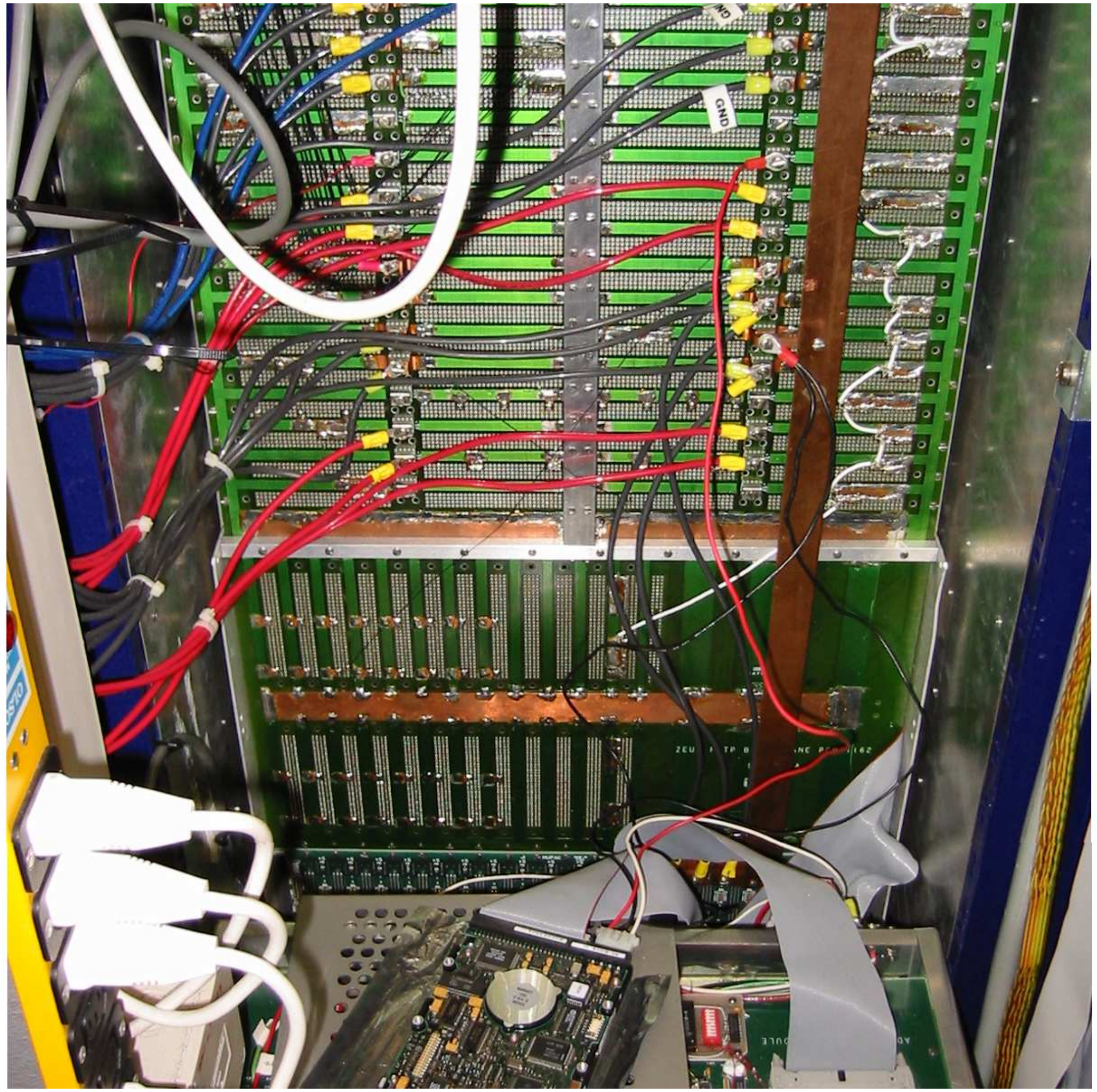
# The Calorimeter First Level Trigger Processor Problems

- A Diagnostic showed that there were problems with input rates from CFLT to GFLT could be explained by corrupted CFLT data in CFLT Region 1(FCAL). Tests showed that the problem was not in the latching of the data received from the CFLT regional trigger, but somewhere in the CFLTP in the data sent by the region to the algorithm cards

- Temporarily masked out the problem in the algorithm cards, but the fix could not survive the fact that the pattern of corrupted bits from Region 1 was not constant and varied during beam conditions

- A number of tests to localise where the problem occurred. Toggling all bits on the backplane, found Region 1 had a large number of pins (there are 128 per region!) that were not showing the expected signals, indicating no continuity between the Input Card output lines and the backplane. As the lines on the backplane are floating, random patterns could develop depending on external factors

# The Calorimeter First Level Trigger Processor Custom Backplane



# The Calorimeter First Level Trigger Processor

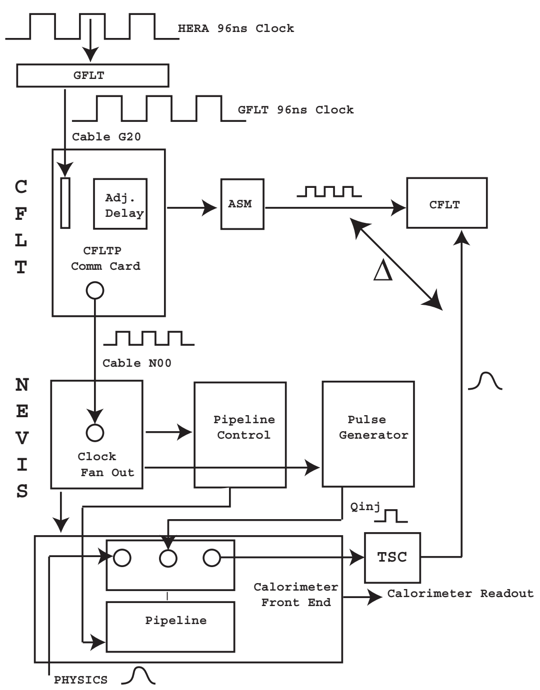
- With My colleagues from Argonne, we solved the problem together in the following way
  - Pushing the CFLTP backplane toward the card we could re-establish continuity and see all bits toggling.
  - The (temporary fix) consisted in gaining more room on the front of the crate to insert the Input Card in a controllable way and checking all signals once more at the end of this operation. This was successful. I am currently trying to arrange for a technician and an engineer to come from Argonne for a more educated look and a better fix

- Also 2 more Input cards were fixed and tested in the system!

- The Comm Card was successfully integrated into the system and the CFLTP was ready for luminosity running in April!!!!

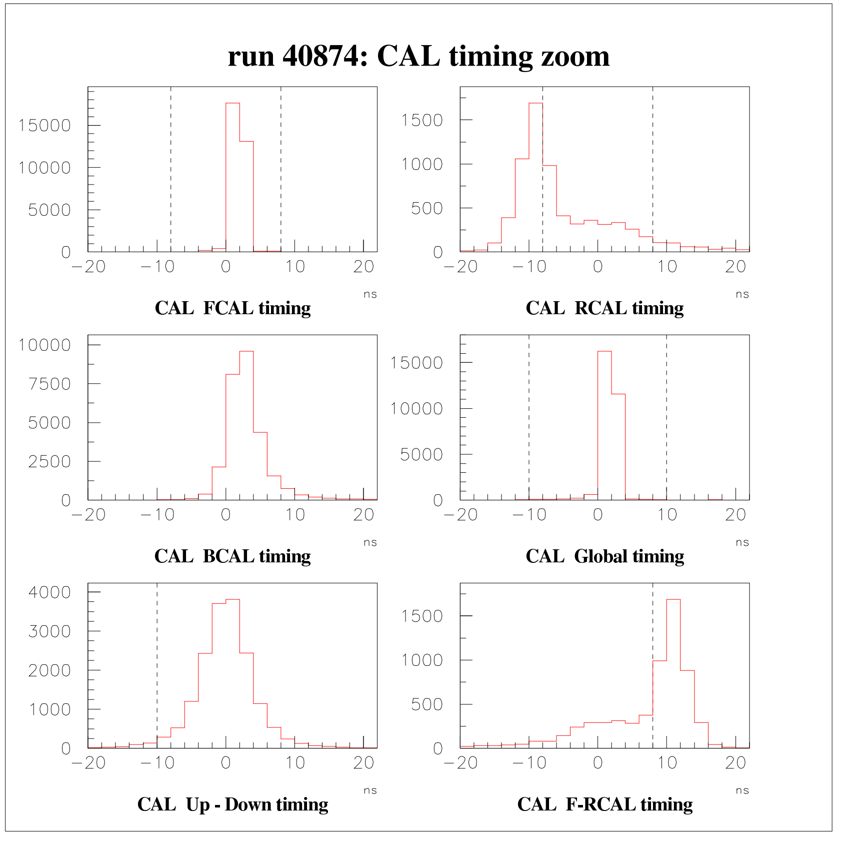
# The Calorimeter First Level Trigger Processor

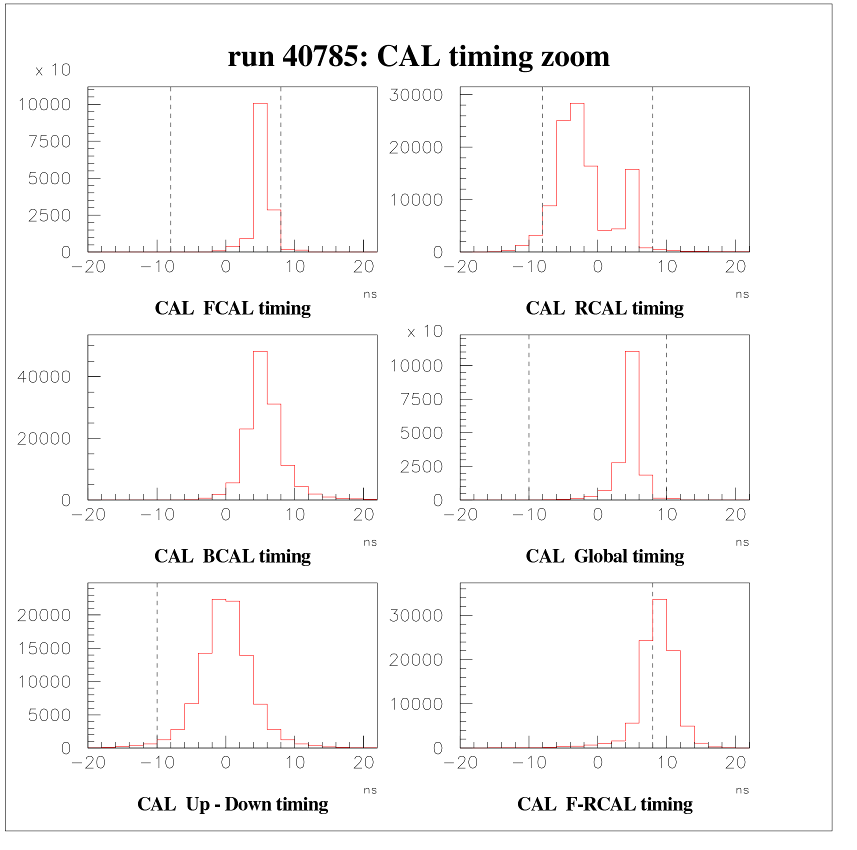
# The Calorimeter and Calorimeter First Level Trigger Timing calibration



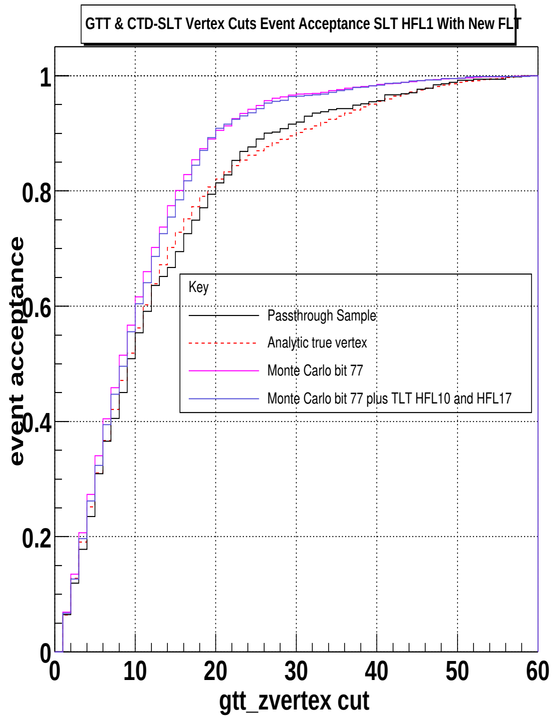

- Charge Injection ($Q_{inj}$) test pulses are used to perform a gain and timing calibration of both CAL and CFLT to tuning each individual channel towards the timing of when "real physics" events occur.
- Due to the hardware design of the CFLT there is only a certain timing window relative to the CAL which the CFLT can be calibrated in order to correctly integrate the charge and be at optimum efficiency
- Many changes in the way this GFLT measures its timing form HERA clock
- A re-calibration was done in order to find the optimum efficiency for the CFLT the shifting the CAL and CFLT simultaneously, not changing the relative delay between the CAL and CFLT $\Delta$
- A ZEUS Note 02-010 has been written explaining in detail the procedure followed

# The Calorimeter and Calorimeter First Level Trigger Timing calibration



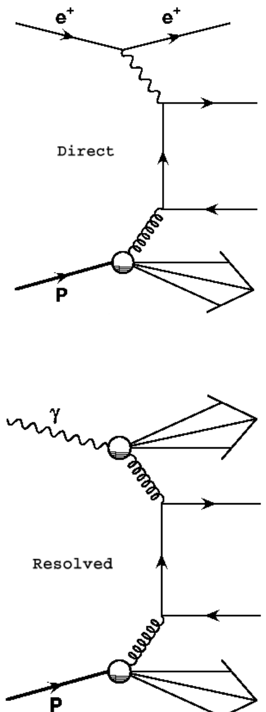



# The Global Tracking Trigger Study




- GTT is the new trigger joining in at the Second level trigger, joining the MVD, CTD, STT
- GTT vertex CUT $|Z| < 20\ cm$ and new FLT slot added to existing Dijet trigger slot
- Results in a 40% rate drop for this slot in MVD acceptance region
- Allows for Heavy Flavour Tagging at the Second Level and Third Level

# Beauty Production in Photoproduction at HERA II



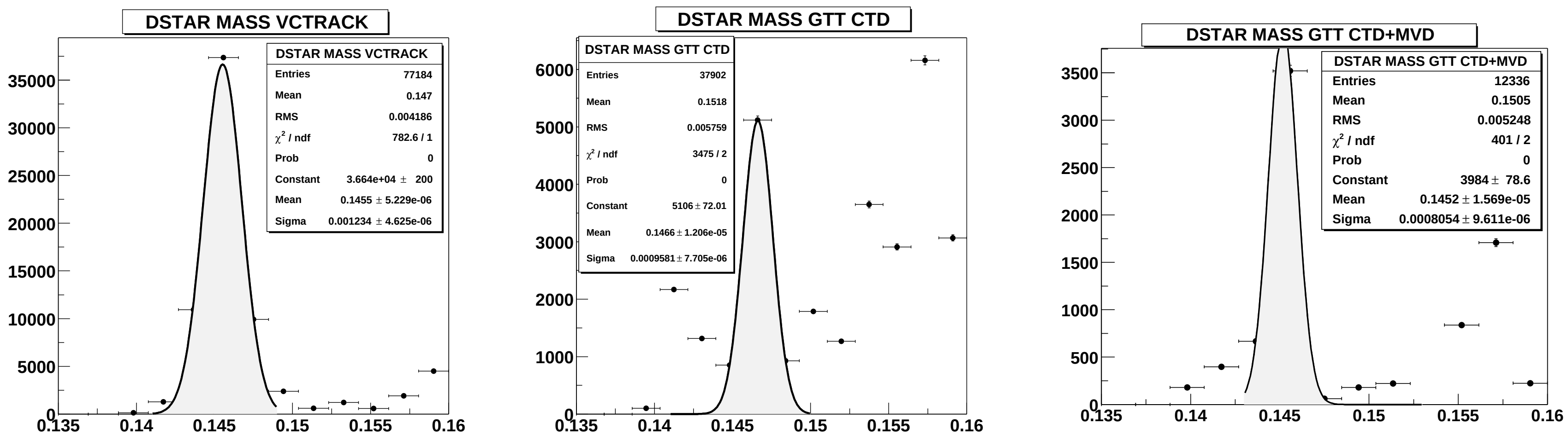
(a)

- The MVD will allow a higher precision measurement of beauty mesons/baryons
- Monte Carlo studies show that the MVD is sensitive to Decays of such heavy flavours and allow to identify them from their decay and fragmentation products
- The Decay channel understudy was $B^0 \rightarrow D^{*-}\pi^+$ where the $D^*$ decays; $D^{*-} \rightarrow \overline{D}^0\pi^-$ then to $\overline{D}^0 \rightarrow K^+\pi^-$
- This channel will be able to be fully reconstructed with a small background hence giving a clear signal for beauty
- $D^*$ candidates are within $0.143\ GeV \ \leq\ \Delta m\ \leq\ 0.148\ GeV$

# $D^*$ Tagging with the MVD

| Reconstruction Technique | Sigma (MeV) | efficiency |
|---|---|---|
| VCTRACK (offline) | 1 | 100% |
| GTT CTD–ONLY MODE | 1 (7) | 11% |
| GTT CTD+MVD MODE | 0.8 | 60%(40%) |

- Only a first glimpse at the power of the Global tracking trigger including the Micro-vertex detector.
- Feasibility study concluded for $100\ pb^{-1}$ 300 events should be present in the data



# SUMMARY AND FUTURE WORK

- I have been responsible for the past 5 months for the CFLTP. It is in good shape, know common errors can be found quickly and efficiently improvements to software and hardware fixes are being made
- GTT is looking very good, and will improve to be better then the offline reconstruction, ability to cut on mass peaks and such events online
- Studies for the measurement of beauty after the upgrade at ZEUS look very promising
- I look forward to my time on ZEUS and the new data taking period