A Fast Track Trigger with High Resolution for H1

H1 Collaboration Proposal 750

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Queen Mary and Westfield College of the University of London
and the Rutherford Appleton Laboratory

with

RWTH Aachen (I and III Institutes), Humboldt University Berlin, Universities of Brussels, Cracow and Dortmund, CEA Saclay, DESY-Hamburg, DESY-Zeuthen, Universities of Hamburg (I and II Institutes) and Heidelberg, MPI Heidelberg, Universities of Kiel, Košice and Lund, CPPM-Marseille, ITEP Moscow,
LPI Moscow, MPI Munich, LAL Orsay, Ecole Polytechnique, Universities of Paris VI and Paris VII, Institute of Physics, Czech Academy of Sciences, Prague, Nuclear Center, Charles University of Prague, University of Rome, PSI-Villigen, University of Wuppertal, ETH Zürich and University of Zürich.

The proposal is to build a Fast Track Trigger (FTT) for implementation in H1 after the luminosity upgrade in 2000. This trigger is aimed at enhancing the trigger efficiency for exclusive physics in the absence of any high p_t particles, with the intention of making precision measurements of rare processes and fully exploiting the high luminosity at HERA. It represents one of the most ambitious attempts to reconstruct tracks with high precision down to low p_t in the real time environment necessary for triggering purposes in high multiplicity events at a collider. Furthermore, extremely high selectivity will be achieved by enabling combinations of tracks and triggering on the basis of invariant mass calculations.

The main thrust of the first round of physics at HERA has been concerned with the new kinematic regions of low x proton structure, real and virtual photon structure and the structure of hadronic interactions. The present luminosity at HERA, close to the original design value, has made possible precision studies of many inclusive aspects of such physics. Notable has been the measurement of parton densities at low x in the proton where the partonic system has the highest density so far observed. As yet, no conclusive evidence has been found for any anomalous behaviour; improving precision will allow detailed studies of regions in which small discrepancies with respect to Standard Model predictions have been observed. The partonic structure of the photon has been probed with a precision and kinematic scope which, for real photons, is similar to that achieved at LEP and which, for virtual photons, far exceeds that of LEP. The QCD structure of hadronic interactions in which there is no hard scale has been probed for the first time and, as a result, new tests of QCD made and new insight into the QCD dynamics of the bulk of hadronic interactions obtained.

The luminosity upgrade at HERA is motivated primarily by physics at the highest Q^2 and p_t^2 scales and the need to explore possible anomalies, including, *inter alia*, the two standard deviation excess above Standard Model expectation of the number of neutral current events at the highest Q^2 and $x \approx 0.4$ and the unexpectedly large number of events in which there is an isolated lepton with large p_t along with substantial missing p_t. However, measurements of exclusive processes at lower Q^2 in the kinematic region of low Bjorken-x, such as heavy flavour production, still suffer from a lack of data and hence precision. A major step forward in such physics, including the possible observation of new QCD phenomena in this region of high parton density, would come from the ability to select such processes efficiently at trigger levels 1, 2 and 3 (L1, 2.3 μs, L2, 25 μs, and L3, 800 μs). Suitable triggers can be achieved by exploitation of the topological and kinematic features of the events of interest. H1 is already implementing a substantial improvement in the topological discrimination of its liquid argon calorimeter triggering by improving the spatial resolution of triggers at L1 and L2 and full exploitation of such topological and kinematic properties will be possible with the addition of the proposed Fast Track Trigger, as described in the attached Proposal to the DESY PRC and the addendum thereto.

The UK groups wish to take charge of the design and construction of the L1 part of the FTT, illustrated in the figure below. As outlined in the attached documents, the aim is to have track information from the CJC with which to make basic selections at L1, full track based selections at L2 and kinematic selection at L3 (the latter in around 100 μs). The L1 system digitises the analogue signals from the drift chamber, carries out in parallel the "Q/t" analysis, performs local track segment finding in fast FPGA arrays and the L1 trigger logic within 2.3 μs, before distributing the segment information appropriately for the later track linking and fitting in the L2 system.

The resources necessary for the L1 system are summarised in the table below and amount to £260k and 4 staff years of effort from CLRC (along with effort from DESY and ETH Zürich to implement the L1 track segment finding and L1 trigger functionality). The total cost of the FTT project is some 2 MDM, with the design and construction of the L2 and L3 systems being the responsibility of our German and Swiss collaborators, who are funding this project at the level of 1.2 MDM.

We request that the Particle Physics Experiments Selection Panel agree to the provision of £260k and 4 staff years of effort from CLRC to support this proposal.

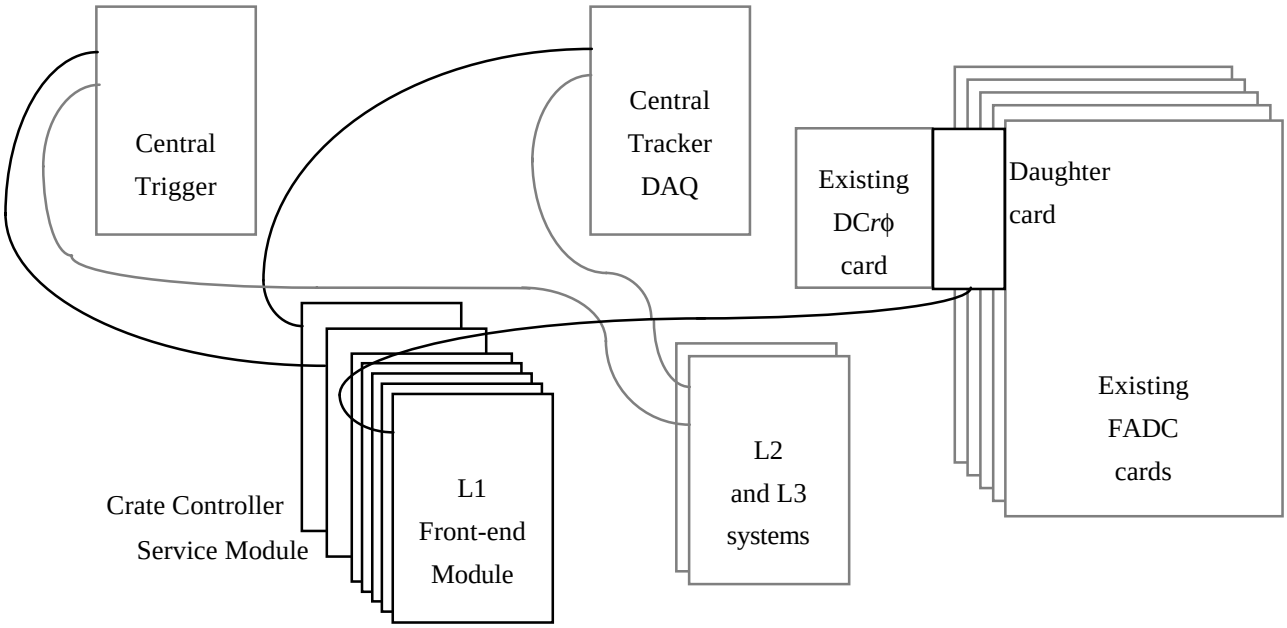

Figure - Sketch of proposed FTT hardware with L1 system (UK responsibility) highlighted.

Item	Quantity	Cost (£)	Effort (SY)	Source of effort
Analogue Dc$r\phi$ daughter card	150	30k	1	RAL*/Manchester
L1 Front-end Modules	30	135k	3+1	RAL*/RAL PPD
Coding track segment finding algorithm	-	-	2	DESY/Zürich
L1 crate control processor	2	10k	-	-
Control software and interfaces	-	-	1	RAL*/Manchester
L1 service module/trigger card	2	10k	2	Manchester/Birmingham
Crate (compact PCI)	2	20k	-	-
Cabling	various	10k	-	-
Workstation and interface	1	5k	-	-
Trigger algorithms and simulation	-	-	2.5	Birmingham/DESY
VAT @ 17.5%		40k		
Total		260k	4*+8.5	

Table - Cost of Fast Track Trigger L1 system excluding contingency (cost of Front-end Module dominated by underlying cost of large high-speed FPGA, £3k per module assuming 50% reduction compared to today's prices) and effort required to implement it.

* Effort requested from PPESP.