CERN/DRDC 91–48
DRDC/M14
28 October 1991

MEMORANDUM

To: E. Iarocci, Chairman of the DRDC, Members of the DRDC

FIRST-LEVEL TRIGGER SYSTEMS FOR LHC EXPERIMENTS

N. Ellis, J. Garvey, R. Staley, A. Watson

School of Physics and Space Research, University of Birmingham, UK

E. Eisenhandler

Queen Mary and Westfield College, London, UK

V. Perera, S. Quinton

Rutherford Appleton Laboratory, Chilton, Didcot, Oxon, UK

In this note we express an intention to form a collaboration which would submit to the DRDC, within the next few months, a proposal to study first-level trigger systems for the LHC. We are at present carrying out a programme of R&D on calorimeter first-level triggers for the LHC, funded by the UK Science and Engineering Research Council. We feel that there is a strong need for broader based R&D over the whole range of first-level triggers and intend to initiate such an activity. This would include triggers for high-p_T electrons, photons, muons and jets, and for large missing transverse energy. It would also address general issues relating to the overall first-level trigger system.

Our ongoing R&D programme for the design of first-level calorimeter triggers is based on a pipelined, digital trigger processor. Signals from the calorimeter are grouped into trigger cells (granularity about $\Delta\eta \times \Delta\phi = 0.1 \times 0.1$ for the electromagnetic calorimeter). Analogue summation is made within each trigger cell and digitisation of the summed signal is performed every 15 ns (8-bit ADCs appear to be sufficient). Look-up tables are used to apply calibration constants and to convert the value for each trigger cell to transverse energy. The data are then fed into a pipelined trigger processor which searches for high-E_T electromagnetic clusters (electrons or photons) and jets, and for large missing transverse energy. An isolation requirement can, optionally, be applied to the electromagnetic clusters. The trigger processor is pipelined in 15 ns steps and the total processing time should be less than 500 ns.

The most challenging part of such a trigger processor, and the part which forms its basic building block, is the electromagnetic cluster-finding logic. We have concentrated our efforts here, and have designed an ASIC which will perform this function. The trigger algorithms which are being implemented in the ASIC were chosen on the basis physics simulation studies performed within our group. Simulation work is essential in order to choose the granularity of the trigger cells, the range and resolution of the the ADCs and to find good algorithms for cluster-finding and isolation.

A small prototype processor for electron triggers incorporating these ASICs, and therefore operating at the full 15ns clock speed required for the LHC, will be completed at the beginning of 1992. The prototype trigger module will take inputs from 36 ADC channels, corresponding to an area of 6 x 6 electromagnetic trigger cells. We plan to build sufficient fast ADC channels to test this trigger using signals from the liquid argon calorimeter of RD3 in a beam test at CERN towards the end of 1992.

Our current R&D project on first-level calorimeter triggers [1] and our involvement in various working groups on triggering and data acquisition for the LHC [2] have made us aware of a wide range of problems in the area of first-level triggering which must be addressed. We need to extend the work to cover more general issues of first-level triggering at the LHC. This will clearly require an increased level of intellectual effort and financial support.

We wish to undertake a comprehensive study of first-level triggers for the LHC. This would cover all relevant physics signatures (electrons, photons, muons, jets, missing transverse energy). The R&D would not be restricted to calorimeter trigger processors, but would include muon trigger systems as well. It would also consider the overall organisation of the first-level

trigger system and its interaction with other parts of the experiment. Some examples of more general issues which would be addressed are given below:

- The problem of uniquely identifying of the beam crossing responsible for the trigger.
- The interaction between different parts of the first-level trigger system.
- The interaction between the first and second-level trigger systems.
- The problem of synchronizing the large first-level processor system, which must be pipelined in 15 ns steps, and which might be distributed over a large area.
- The study of where best to locate the trigger electronics.
- The question of inter-connection between processing units (especially important in the context of two-dimensional cluster finding algorithms).

It is clear to us that we do not have the resources within our groups to handle all of these problems by ourselves. However, we could provide the nucleus of an R&D collaboration and we hope to find collaborators from other European institutes and industry.

In conclusion, this memorandum is to inform the Committee of our present considerations on first-level triggering for LHC. We hope to form a collaboration of people interested in making a comprehensive study of first-level triggers for LHC experiments and to submit a proposal to the DRDC within the next few months.

References

[1] N. Ellis and J. Garvey, A digital solution to first level triggering using calorimetry at the LHC. *Proc. ECFA Large Hadron Collider workshop, Aachen, Germany,* 1990, pp. 80–83. CERN report 90–10 (vol III), eds. G. Jarlskog and D. Rein.

[2] S. Cittolin, N. Ellis and L. Mapelli, Signal processing, triggering and data acquisition. *Proc. ECFA Large Hadron Collider workshop, Aachen, Germany,* 1990, pp. 504–538. CERN report 90–10 (vol I), eds. G. Jarlskog and D. Rein.