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Genesis of a workshop

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Abstract: The LHC Electronics Review Board was created in 1994 to advise the LHC experiments Committee LHCC on rationalization measures in the fields of design, manufacture and operation of electronic systems for LHC experiments. To this end, the LERB found appropriate to launch a series of topical workshops in order to allow for open discussions on the issues at stake. This paper recalls related events and decisions that occurred between 1985 and the approval of the LHC in 1995. The LERB terms of reference and the outcome of the first workshop are presented.

Keywords: Analogue electronic circuits; Radiation-hard electronics; Data acquisition concepts; Digital electronic circuits

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Contents

2015 JINST 10 C11007

1 From LAA to LHC approval

To begin with I would like to thank the organizers of this 21^{st} workshop for inviting me to remind some of today's participants, and tell the others, about the genesis of this series of meetings.

I cannot limit my report to the year following the approval of the LHC by CERN Council on 12 December 1994. In fact, it has been a long process which began in 1986 when A. Zichichi launched the LAA project on CERN site [1]. Most HEP laboratories and institutions were then involved in the preparation of LEP experiments, in addition to running the fixed target and ppbar experiments, not to speak of large detectors at other laboratories such as DESY. Thus little was left for funding R&D activities at a time when major changes were taking place in computer aided engineering tools, integrated circuit technologies, and manufacturing processes. Worse, meager recruitments had taken place since 1975 for advanced electronic design in experiments at CERN.

In addition to the recruitment of new staff literate in micro-electronics, the LAA fostered pioneering work in the use of CMOS for the development of pixel detectors and read-out chips for strip detectors [2]. Affordable processes through IMEC or, later Europchip/Europractice EU programs, allowed for the manufacture of early demonstrator chips in 1.2 micron CMOS technologies. At the same time, cheap PC based electronic CAD tools were upgraded to workstation based integrated CAD-CAE-CAM software.

Such was the scene when C. Rubbia took over from H. Schopper as Director General in 1989. Three directors assisted him in the management of the Research Sector at CERN: P. Darriulat for the fixed target and LEP programs, W. Hoogland for the R&D activities and J. Thresher for the computing. It took them a year to agree on a reorganization of the CERN research sector that would prevent the absorption of most of staff resources by LEP experiments. Despite a LEP overspending which accounted for a good 10% of CERN yearly budget, 90 MCHF were set aside to fund an R&D program aiming at the assessment of the performance of detectors likely to meet physics requirements at future energies and luminosities.

The Detector R&D committee DRDC was created in July 1990 [3] under the chairmanship of E. Iarocci to recommend and monitor R&D projects which, for some of them, were a mere continuation of LAA ones. DRDC met from September 1990 until January 1995. A non exhaustive list of electronics related activities follows:

- RD-2 Project to evaluate the feasibility of a tracking and/or pre-shower detector preceding the calorimeter of an LHC apparatus.

- RD-8 Radiation-hard, fast charged particle detectors using industry standard, semi-insulating GaAs substrate wafers.
- RD-9 A demonstrator analog signal processing circuit in a radiation hard SOI-CMOS.
- RD-12 Readout system test benches.
- RD-13 A scalable data taking system at a test beam for LHC.
- RD-16 FERMI: a digital front-end and readout micro-system for calorimetry at LHC.
- RD-19 Development of hybrid and monolithic silicon micropattern detectors.
- RD-20 Development of high resolution silicon strip detectors for experiments at LHC.
- RD-23 project: optoelectronic analogue signal transfer for LHC detectors.
- RD-24 SCI, Scalable Coherent Interface.
- RD-29 DMILL technology ("Durci Mixte sur Isolant Logico-Linéaire"), a new rad-hard analog-digital technology especially designed to fulfil very rad-hard, mixed analog-digital microelectronics VLSI technology.
- RD-31 NEBULAS: high performance data-driven event building architectures based on asynchronous self-routing packet-switching networks.

The Large Hadron Collider Committee LHCC was created two years later on 2 October 1992 under the chairmanship of J.J. Aubert [4]. Several proposals for experiments at LHC were submitted assuming that the new machine would be approved shortly and run by 1999. The competition was the Superconducting Super Collider SSC (the "Desertron", 20TeV) in Dallas, Texas; construction had started in 1990 in Waxahachie. The approval of the LHC by CERN Council was yet unclear and the community had to wait until SSC funding was cancelled by the DOE in October 1993 (a quarter of the tunnel had already been dug!) to see the redirection of existing resources worldwide (U.S.A., Japan and others) towards the CERN based Large Hadron Collider proposal.

Signs of likely approval were confirmed by the CERN Council with the appointment of C. Llewellyn-Smith as new Director General in 1994. L. Foà and H. Wenninger were appointed as directors for the CERN Research Sector. The challenge was political, technical and financial. LHCC had to deal with all aspects of the project: physics, machine, detector technology, experiments and costs. Political aspects were left to CERN directorate, Finance Committee and Council.

2 Auditing electronics and costs

The assumption was that machine and approved experiments would be operational by 2001, and that data taking might last for 20 years. Until the LEP era, access to detectors for maintenance and upgrades had been rather easy for little electronics was exposed to some, yet small, radiation levels. For years, thousands of kilometers of cables had been used to convey signals from the front-end preamplifier to the "counting rooms". Technology, cost, serviceability and lifetime had

2015 JINST 10 C11007

not been issues either for LEP experiments or for the UA-1 and UA-2 ones at the SPS ppbar collider. A sociological aspect was also that after successful operation of the four LEP experiments and extended operation of UA-2, many laboratories were eager to redirect their activities towards new challenging TeV pp physics. Everybody, including committee members, was involved and decisions were likely to be affected by conflicts of interest.

This led W. Hoogland and L. Foà to announce the formation of three audit committees (Review Boards): the LCRB for computing, the LDRB for detectors and the LERB for electronics. Status reports for R&D projects would be presented to these committees, which would report to the LHCC.

The LHC Electronics Review Board terms of reference were that LERB would recommend rationalization measures in the fields of design, manufacture and operation of electronic systems for LHC experiments. To this end, the Board would:

i) Review electronic contributions to the R&D effort;

ii) Review LHC technical proposals (electronics);

iii) Review activities within the approved programme of the laboratory, which may affect the decisions to be taken;

iv) Identify items of common interest in order to minimize variety of designs;

v) Identify the decision making centers in the experiments in order to contribute to the steering of the activity;

vi) Monitor resources.

As a result of this peer review, the Board would issue recommendations on the sharing of the design effort, the establishment of test procedures and documentation standards.

In the course of the design and construction of the experiments, the Board would monitor the actual implementation of its recommendations and contribute to the steering of the effort, taking into consideration the technological changes that would arise in the following decade.

LERB members were not chosen to represent LHC experiments. However, it was felt advisable that each experiment be represented by one member in order to make sure that the recommendations were well understood and that a follow-up took place.

In order to minimize the risk of conflict of interest, the LERB was comprised of 12 specialists from the participating states, well recognized for their achievements and having a position of authority in their home institute (or country).

It must be said that, given these boundary conditions, it took me as LERB Chairman a year of visits and discussions with the top management of the major participating institutes to put down a satisfactory (for all parties) list of members!

The LERB held its first meeting on 29 October 1994. In consideration of the variety of design options, the lack of accessibility to proven radiation-hard IC processes, the long-term serviceability needed and the necessary commitment of industry to selected manufacturing processes, it was agreed to meet once a year for a workshop in one of the participating states. To maximize participation, the Workshop would be organized before the long established IEEE Nuclear Science Symposium (early November in the U.S.A.).

2015 JINST 10 C11007

If the LERB was seen by some "prime donne" of electronic design as a way to impose a high level of standardization that would impair their freedom, the first workshop held in Lisbon, Portugal from 11 to 15 September 1995 taught the contrary.

Each of the six sessions was introduced by a review talk, followed by individual talks and concluded by an open discussion, thus highlighting areas of convergence and potential weaknesses. A record of the discussions was put down during the Workshop and sent to the members of the LHCC who thus got a factual view at the problems to come [5]. However, feasibility and costs were unclear for some of the proposed electronics, whilst LHCC was very much after a YES/NO answer from the LERB. This was especially the case for the radiation-hard processes to be used, optoelectronics and the large dynamic range architecture of the Analog-Digital-Converter of the calorimeters. Fortunately, most engineering teams converged towards proven solutions already investigated in the framework of the R&D program (e.g. silicon-strip and pixel detectors, muon detector trigger and readout electronics). If a negative recommendation was to be given, it had to be in the form of a cautiously worded statement like:

"The Board recognizes the impressive amount of work that has been carried out by the collaboration with the aim of developing a set of generic building blocks for 'xx'. The Board therefore recommends the formal conclusion of 'RD-yy' after the completion of existing commitments, to be accompanied by a transition of the generic developments into a focused project."

3 Conclusion

It was only a few months after this first workshop that the Director General announced on 1 February 1996 "that following discussions of the LHCC recommendations by the Research Board, he had formally approved ATLAS and CMS, and had written to the collaborations setting out the detailed conditions of approval."

Advising was no longer an issue and it is a year later, after the second workshop in Lake Balaton, Hungary, that the LERB was turned into a monitoring board chaired by Peter Sharp from RAL. Issues at stake were then:

- Radiation-tolerant electronics.
- Fiber-optic & copper readout links; the placement of electronics.
- Management of the electronics developments for LHC experiments.
- Services and system aspects e.g. cooling, power supplies, power distribution and regulation, grounding, shielding, etc.).
- Insufficient medium-scale system tests.

The road was paved for further workshops!

I cannot conclude without a reference to the excellent organization provided by our colleagues from LIP and IST in Lisbon in 1995. This has been the key to further workshops which were well regarded and to receiving adequate support from the management.

Portugal joined CERN some 30 years ago under the leadership of Prof. Jose Mariano-Gago (recently deceased). He and his colleagues were an important influence in the success of our programme. He will be much missed.

2015 JINST 10 C11007

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2015 JINST 10 C11007