

# THE LAA PROJECT AND THE CONSEQUENCES ON LHC

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The International Symposium on “Subnuclear Physics: Past, Present and Future”, held at the Pontifical Academy of Sciences from 30 October to 2 November 2011, provided an excellent occasion to highlight the achievements of an important project at CERN: **the LAA project**.

The LAA project was initiated by Prof. A. Zichichi and implemented at CERN in 1986 as „another CERN program of activities“ <sup>1)</sup>. The goal of the project was to prove the feasibility of new detector technologies that could be used in future multi-TeV hadron colliders.

To appreciate the importance of the LAA project for CERN we need to look back to the 1980<sup>th</sup>, when CERN envisaged to enter the era of lepton collider physics. Indeed, in April 1980, a progress report, published by the ECFA – LEP Working Group<sup>2)</sup>, chaired by Professor A ZICHICHI, was handed over to the CERN Management.

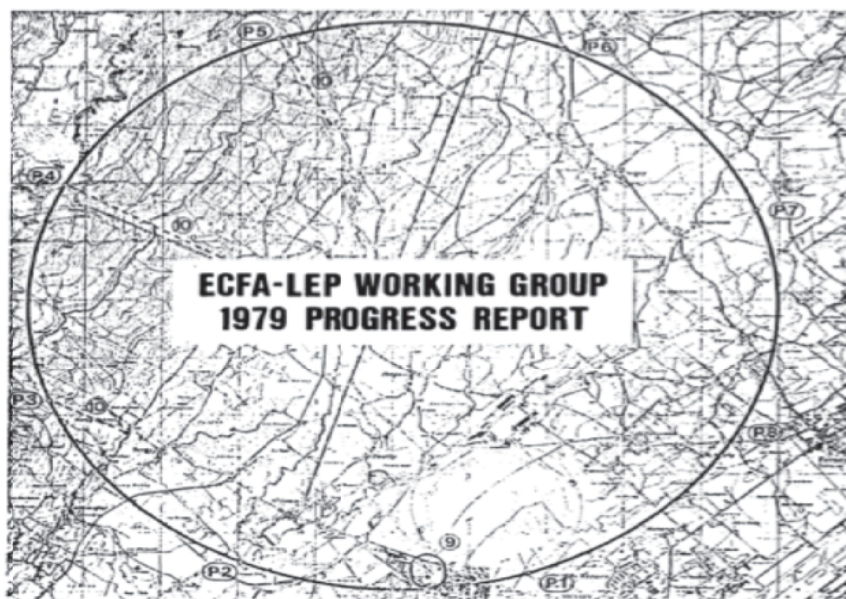
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ECFA EUROPEAN COMMITTEE FOR FUTURE ACCELERATORS



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In this Report it was recommended to construct a 27 km accelerator ring-tunnel adjacent to CERN between the French Jura and Geneva airport (see cover-page of the ECFA report above).

This tunnel infrastructure paved the way for 50 years of world-class subnuclear physics experiments by allowing to install high performance colliders, first LEP then LHC.

Within its constant funding levels from 1980 to 1989, CERN's resources were mainly dedicated to the SPS proton-antiproton program and to the LEP project. Not much was left for other activities: the ISR experiments, all bubble chambers and many fixed target experiments had to be closed down to free resources for LEP construction.

It was at that time when Prof. Zichichi proposed to CERN the LAA project permitting to invest in the future beyond LEP. The project allowed the recruitment of 40 staff-members (technicians-engineers-physicists) dedicated to research, innovation and development. The LAA project was open to all physicists and engineers and in the end over 80 scientists worked for LAA. The project was presented in an open meeting at CERN in June 1987 and subsequently to CERN's Research Board.

All aspects of an LHC detector layout were considered in the project and, in view of the demands of the collider, special attention was paid to hermeticity, radiation hardness, rate capability, and momentum resolution of the detector assemblies. The LAA Project consisted of sub-projects (*High precision tracking, calorimetry, large area muon detection devices, leading particle detection, data acquisition and analysis*).

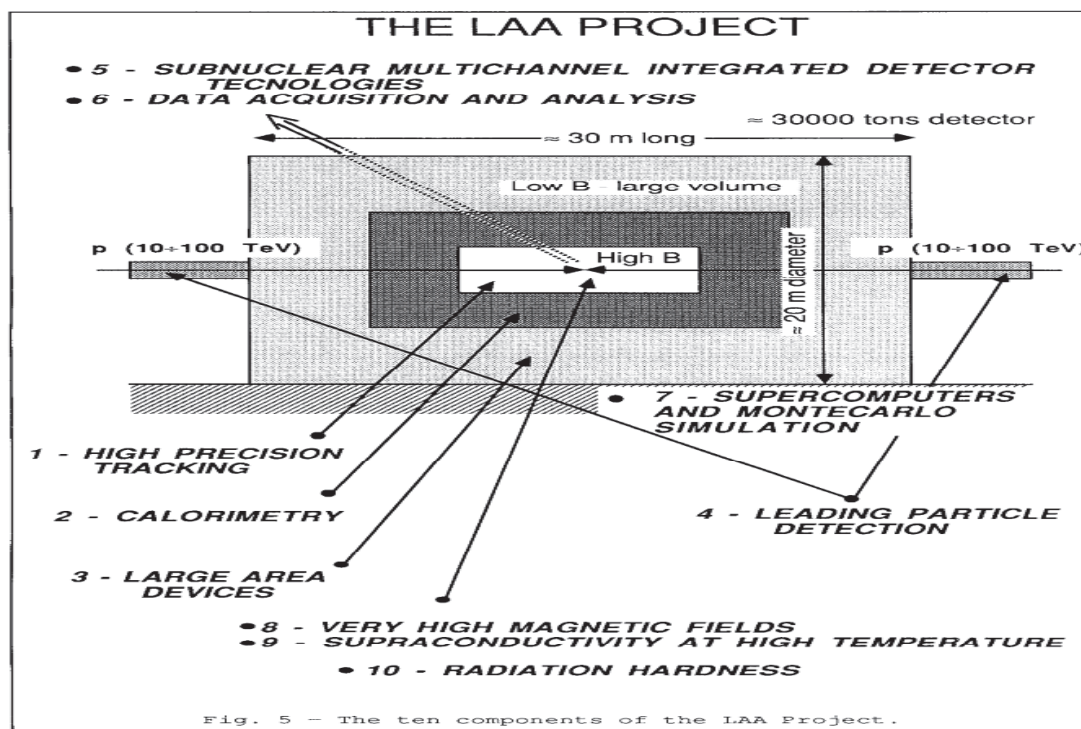


Figure 2: the ten components of the LAA project.

Main achievements are described in CERN reports<sup>3)</sup> and highlighted in a book with the title: “From the Preshower to the New Technologies for Supercolliders“, dedicated to Antonino Zichichi<sup>4)</sup>.

Although some detector solutions adopted for the LHC experiments were finally different from those developed during the R&D phase, the LAA work had a great influence and measurable impact on the design of the actual LHC detectors. The LAA R&D started 10 years before technical choices were approved for LHC detectors and over 20 years before LHC detector operation started for physics. Technical solution adopted by collaborations, clearly depended also on factors such as specific know-how and competences existing in those Institutes, which took the responsibility to build and finance the detector components.

Nevertheless, the LAA technologies had an impact on LHC: examples are the spaghetti electromagnetic calorimeter, multi-drift chambers, scintillation fiber trackers, micro-strip detectors, precision tracking and read-out electronics, IPSA tube (Imaging Silicon Pixel Array), silicon pixels detectors, CMOS chips and ASIC/VLSI chip detector read-out. In addition engineers, physicists, technicians, recruited for the LAA activities, helped LHC experiments and participate in the experiments still today.

I present below a specific example to demonstrate the importance of the LAA project for CERN in preparation for the Large Hadron Collider experiments:

Example: MICRO-ELECTRONICS, a technology strengthened at CERN thanks to the resources of the LAA project which allowed to built-up the know-how within the CERN Experimental Facility Division with the recruitment of trained electronic engineers. LAA allowed to finance experts staff, hardware & software tools, which were essential for the development and design of microelectronics, silicon strip and pixel detectors.

A recent article in the IEEE Solid-State Circuits Society News<sup>5)</sup>, published by Erik Heijne, physicist from CERN, outlines that the design of custom chips for silicon detector readout was started at SLAC in 1981 and in 1986 at CERN mainly thanks to the LAA project.

A first application of microelectronics tools at CERN was leading to the construction of a hermetic silicon detector for the UA2 collider experiment. The AMPLEX chip<sup>6)</sup>, developed by Pierre Jarron at CERN in collaboration with A. Gößling from the University of Dortmund, was used to read-out the silicon pad detectors signals.

Another more recent example is the so-called NINO chip<sup>7)</sup> for the ALICE Time-of-Flight ASIC front end. This chip is also interesting for medical applications of PET detectors, equipment developed for subnuclear physics experiments and now used in most hospitals.

A complete and detailed description of the LAA achievements has been published by the World Scientific Series in 20<sup>th</sup> Century Physics entitled: “SUBNUCLEAR PHYSICS the first 50 years Highlights from ERICE to ELN” , Antonino Zichichi<sup>8)</sup>.

From 1990 to 1996, the LAA project was complemented by a CERN Detector R&D program. LAA R&D groups participated in eight major proposals approved by the CERN DRDC<sup>9)</sup>. Activities of the LAA R&D have been published in more than 350 papers and journals.

A most recent achievement of LAA teams concern the development of the MPRC (MULTIGAP RESISTIVE PLATE CHAMBER) for the ALICE Time of Flight systems<sup>10)</sup>.

Furthermore, an educational spin-off program using LAA technology, initiated by Prof. A. Zichichi, has been implemented in schools all over Italy. The EEE (Extreme Energy Events) project<sup>11)</sup>, proposed by collaborator and team leader Crispin Williams, who is responsible for this R&D works, allows Italian pupils to construct themselves large area physics detectors to monitor cosmic ray showers and combine local results via Grid computing with schools in other locations.



Figure 3: Location of schools all over Italy where large area physics detectors have been installed to monitor cosmic ray showers as part of the *Extreme Energy Events* Project– to bring pupils in touch with real physics experiments

Future technological developments concentrate on an ambitious new project, which was proposed by Prof Zichichi at the International School of Subnuclear Physics at ERICE, the ISSP 2006<sup>12)</sup>.

The proposal is to probe a plasma of free quarks and gluons - the Quark–Gluon–Colored–World – produced in heavy ion collisions of extreme energies at LHC, by injecting beams of particles and photons to observe the different interaction results. The Quark–Gluon–Colored–World (QGCW) is expected to be totally different from our world made of QCD colorless baryons and mesons. The physics and details of this proposed project are outlined in a contribution by A. Zichichi to a conference in honour of MURRAY GELL-MANN'S 80th birthday <sup>13)</sup>.

The QGCW project aims at experiments to probe the quark gluon colored world. Figure 4 illustrates schematically the idea of the experiment.

We need timing and synchronization between: colliding heavy ions, forming the quark gluon colored world, and bombarding particle, simultaneously injected to probe the QGCW, and detectors, triggering on the emerging particles

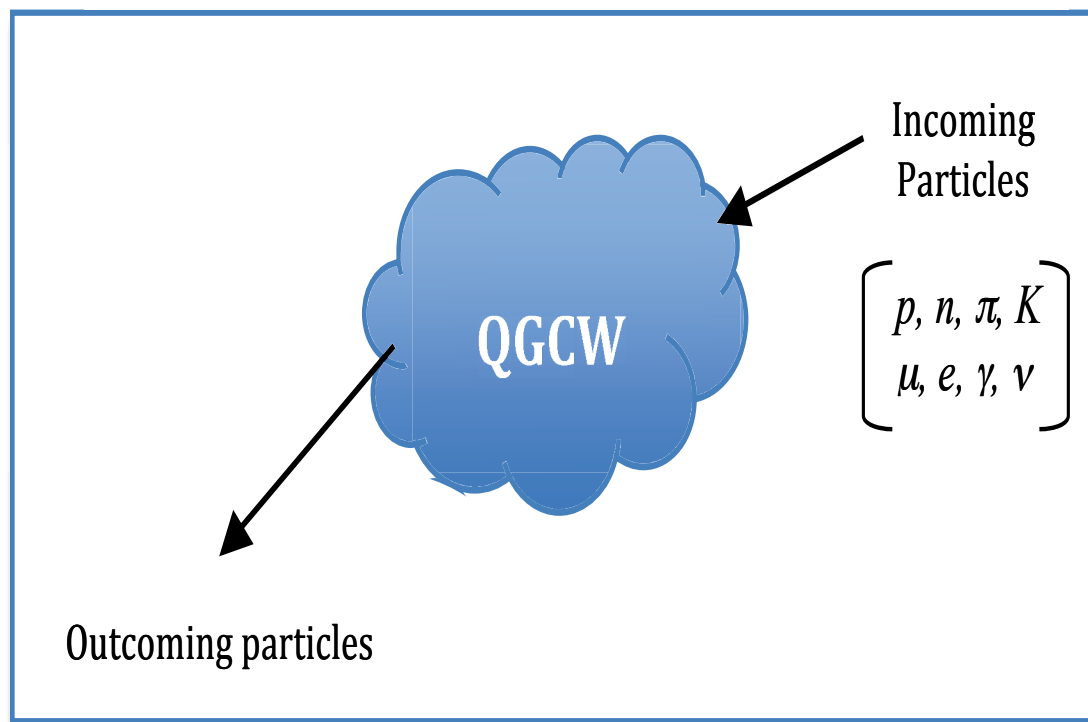


Figure 4: Schematic illustration of the way how to probe the QGCW

Advanced R&D has started all around Europe to prepare for the FAIR<sup>14)</sup> project at GSI<sup>15)</sup> and at CERN<sup>16)</sup> for the LHC upgrade program, and this R&D allows to chose eventually the suitable technology for the preparation of future experiments to explore the entirely new world of states formed by free quarks in the QGCW.

#### **Examples of R&D work proposed to prepare the future of the QGCW project:**

The “Bunch-phase Timing System (BuTiS)” for FAIR concentrates on research of thermal stability properties of optical fibers<sup>17)</sup>, which are essential to carrying control and monitor signals between complex accelerator equipment.

Also in the LHC tunnel optical fibers are used for fast signal transmission through large distances to synchronize the accelerators, to take measurements of the beams, and to send controls to the LHC. “Over the past 7 years, CERN has developed special optical fibers that can resist the radiation levels of the LHC<sup>18)</sup>”.

Intensive R&D on the detector to obtain an improvement of timing for the Time of Flight system using the MRPC combined with the NINO readout electronics<sup>19)</sup>.

Beams to inject probing particles into the heavy ion collision experiment pit 2 at LHC have to be studied in parallel with the LHC upgrade program. Included in this are the development of superconducting magnets for LHC and for FAIR<sup>20)</sup>.

In the past, focused R&D for specific experiments was performed in well defined laboratories, e.g.: for the UA, LEP and LHC experiments at CERN, for PETRA experiments at DESY, and for the future of FAIR experiments at GSI. This R&D works was in general reviewed by teams in the host laboratories. The LAA project belongs to this category of R&D programs.

Today, accelerator and detector development projects are often organized in large world-wide collaborations and funded by the EU Framework programs. This creates overheads and inefficiencies but also competition and challenges.

The QGCW project is ambitious but meets a lot of interest. “We do not know what will be the final outcome of all theoretical ideas intended to make predictions and of possible experiments to probe nature. What we know is that the world appears to be complex at every scale. Therefore we must expect a series of surprises that cannot be predicted.” (A.Zichichi, 2008). With this statement by A. Zichichi during his ERICE lectures in our minds, we are continuing to follow attentively the current efforts to find innovative ideas and develop technologies allowing to design such a challenging experiments for LHC in the future – which was and is still the spirit of the LAA project.

### *Acknowledgements*

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