The LAA Project
Host Wenninger & Erik H.M. Heijne
What is LAA?
Preparations for Large Scientific Projects need often long lead times

The idea of the LAA project was to perform technology R&D as an independent research program with its own, independent funding.
Google Search: LAA - CERN

[PDF] The LAA Project and the consequences on LHC - Pontificia Academ... www.pas.va/content/dam/accademia/pdf/.../sv119-wenninger.pdf ▼ Diese Seite übersetzen von A. Zichichi - Ähnliche Artikel
To appreciate the importance of the LAA project for CERN we need to look back ... Group 2), chaired by Professor A. ZICHICHI, was handed over to the CERN.

Microelectronics at CERN: from infancy to maturity - CERN Courier
cerncourier.com/cws/article/cern/56223 ▼ Diese Seite übersetzen
24.02.2014 - The start of the LAA project in 1986 propelled electronics at CERN into the era of microelectronics, and laid crucial foundations for the success...

From the Preshower to the New Technologies for Supercolliders: In ...
https://books.google.ch/books?isbn=9812776389 ▼ Diese Seite übersetzen
Bjm H. Wilk - 2002 - Science
In particular, the first modern CAE stations and design tools for simulation (Verilog) have been introduced to CERN thanks to LAA. The importance of these...

22.06.2016 - The LAA Project was initiated by Prof. A. Zichichi, funded by the Italian government and implemented at CERN in 1986. 6/22/2016.

18.06.2017 - 18.06.2017. 18 June 2017 H. Wenninger. 5. It was a "chance for CERN" that Prof. A. Zichichi launched the special activity project LAA...

Archives of Directors of Research | CERN Scientific Information Service
library.cern/archives/CERN_archive/guide/.../isadresses ▼ Diese Seite übersetzen
In 1961, CERN created a Directorate to prepare, with the Director General, .... The LAA project (Lepton Asymmetry Analyser) was approved by CERN in 1986.
Google Search: LAA - CERN

The LAA project and the consequences on LHC - INSPIRE-HEP
inspirehep.net/record/1415333/references ➔ Diese Seite übersetzen
CERN Council document. Resolution on the LAA programme of activities, ... CERN Internal Reports (-1989), LAA Progress Report, CERN/EF 89-14 and ...

Zichichi, Antonino | TWAS
https://twas.org/directory/zichichi-antonino ➔ Diese Seite übersetzen
The great projects of European Physics (LEP and LAA at CERN, GRAN SASSO at INFN, HERA at DESY) are linked to his name, for his seminal contributions in ...

ALICE Collaboration | International Particle Physics Outreach Group
ippog.org/members/alice-collaboration ➔ Diese Seite übersetzen
After a two-year CERN fellowship with OPAL she remained at CERN working on detector development projects (LAA) and the L3 experiment. During the last 12 ...

A NEW GASEOUS DETECTOR FOR TRACKING: THE ... - Science Direct
https://www.sciencedirect.com/science/article/.../pdf?... ➔ Diese Seite übersetzen
von G Ambrosi - 1990 - Zitiert von: 3 - Ähnliche Artikel
Presented by G. Susinno I. Introduction. The “Large Area Devices” (LAD) Group of the. LAA project at CERN is devoted to R&D for muon detection at a future ...

Genesis of the LHC | Philosophical Transactions of the Royal Society ...
rsta.royalsocietypublishing.org/content/373/2032/20140037 ➔ Diese Seite übersetzen
von CL Smith - 2015 - Zitiert von: 3 - Ähnliche Artikel
24.11.2014 - The upshot was that the SPS was built at CERN and subsequently .... the so-called LAA Project, which were mostly used to support a range of ...

Fabio SAULI CERN, Geneva, Switzerland We are ... - Springer Link
von F Sauli - 1991 - Ähnliche Artikel
CERN, Geneva, Switzerland. THE MULTIDRIFT MODULE. We are developing as an LAA project a vertex detector designed to operate at the very high particle ...
Google Search: LAA - CERN

25 years of Microelectronics at CERN: from LAA to the LHC | EP ...
https://ep-news.web.cern.ch/.../25-years-microelectronics-cern-la... ▼ Diese Seite übersetzen
12.02.2014 - Last November, the success of the LAA R&D project that led to the development of microelectronics at CERN was celebrated. LAA was a ...

ESE - EP Department newsletter - CERN
https://ep-news.web.cern.ch/supporting-groups/ese ▼ Diese Seite übersetzen
by Francis Anghinolfi and Federico Faccio (EP-ESE). RADECS (RADiation ... 25 years of Microelectronics at CERN: from LAA to the LHC. by Panos Charitos.

Microelectronics at CERN: from infancy to maturity | CERN
https://home.cern/about/.../microelectronics-cern-infancy-maturit... ▼ Diese Seite übersetzen
04.03.2014 - The start of the LAA project at CERN in 1986 – proposed by physicist Antonino Zichichi and financed by the Italian government – led directly to ...

[PDF] * CERN LAA for new detectors
The LAA project under Antonino. Zichichi formally set up last year at. CERN (see September 1987 issue, page 11) is an intensive pro gramme to develop new ...
The LAA Project

by

A. Zichichi
CERN – Geneva
Switzerland

Geneva, 14 July 1987

Abstract.
A comprehensive R & D project to study new experimental techniques for the next step in multiTeV hadron collider physics is described.

(to be published in ICFA - INSTRUMENTATION BULLETIN)
Unlike all previous CERN projects
(PS, BOOSTER, BEBC, ISR, SPS)
**LEP approval** was obtained under the condition
to stay within the CERN budget level.

No extra project budget was assigned for
this major European scientific infrastructure project!
This required to set priorities:

CERN facilities and many experiments had to be closed to free resources for LEP construction and for the proton-antiproton SPS collider experiments

and in addition staff had to be reduced to provide resources
CERN staff reduction to provide resources for the Tunnel infrastructure

Very expensive “early retirement” program
Considering the status of Detector Developments in the 1980th and the challenges for the planning of LHC collider experiments

R&D project activities funded by the LAA proposal introduced by A. Zichichi helped CERN in the right period
LAA was the first special program at CERN dedicated to prepare the future beyond the ongoing CERN Large Electron-Positron Collider (LEP) construction program 1980 to 1989.
LAA funds allowed to hire dedicated staff (physicists, engineers, technicians) and form collaborations supported by LAA to prepare the future beyond LEP.

Some 40 staff and 80 unpaid scientists worked together for over 6 years.

LAA activities are published in over 350 papers.

After 6 years the LAA program of activities was extended by CERN Council.

Following the LEP start during the 1990th the CERN DRDC complemented the LAA program.
Antonio Zichichi, initiator of the LAA &
Erik Heijne & Alessandro Marchioro
two of the founding members of The CERN microelectronics group
presented the history of the group and discussed some important milestones over the years.
The first proposal for research in micro-electronics and silicon detectors in the framework of the LAA project was made in 1986 and was approved by the CERN Council meeting in December 1986.
The impact of LAA on the LHC Detectors has been outlined in the books... and many 100 publications in scientific journals.
Following the example of the LAA project

R&D initiatives became more and more independent research programs with independent funding

First at CERN with the Detector R&D and its own Committee (DRDC)

Later with several EU funded R&D projects and recently with the initiative of a new CERN Program
To prepare the LHC future physicists and engineers have begun to define CERN’s R&D program on new experiment technologies from 2020 onwards.
The time is ripe to think about how industry can be involved in joint R&D efforts.

Detector improvements envisioned for the 2020s and beyond include better electronic readout, modelling, simulation tools, and better computational techniques for reconstructing the recorded information.

Increased timing accuracy to mitigate event pile-up in very-high-luminosity environments will almost certainly have an impact on the development of all classes of detectors, whether silicon, gas or photo-detectors.
The challenges of HL-LHC and future colliders places tough requirements on readout electronics and fast data links, while advances in data processing and storage are important. Workshop participants discussed special infrastructures and facilities needed to test chips under realistic conditions, presenting options for advanced materials, design tools, production technologies, which could change how detectors are built and boost their performance.

R&D into magnet design for future colliders also requires progress in superconducting materials and cables to meet strict strength and cost requirements.
Before looking further into the 2020\textsuperscript{th}:

let us for a moment look back to CERN in the years 1980 and before prior to the Collider (LEP / LHC) period:
The CERN Control Center, where scientists analyze data from some of the laboratory’s projects.

Credit Leslye Davis/The New York Times
Figure 21: The set-up able to detect simultaneously (e+e−), (μ+μ−) and (μ±e±) final states from (βp) annihilation.
CERN collider programs (ISR, pbarp, LEP, LHC)
we now prepare next steps towards HE-LHC / FCC / ELOISATRON
LAA technology R&D for the Large Hadron Collider programme

Detecting particles

Accelerating particle beams

Higgs

Large-scale computing (Grid)

Courtesy: Manjit Dosanjh
Accelerator R&D
A. Zichichi proposed a very large superconducting accelerator which he called ELOISATRON (ELN) and launched the R&D on superconducting cables and magnets starting with HERA (DESY) and LHC (CERN).
SC Magnet Developments

Slide from FermiLab

1980’s

TeV, 76 mm
4.5 T, 4.2 K

SSC, 50 mm
6.6 T, 4.3 K

1990

HERA 5.3 T

2010’s

LHC, 60 mm
11 T, 1.9 K

2020-30’s?

FCC, 43 mm
16 T, 4.5 K

See Thomas Taylor talk
SUPERCOLLIDERS AND SUPERDETECTORS

ELOISATRON
Main Ring: 100TeV, 300–400km

EDITORS: W. A. BARLETTA AND H. LEUTZ

World Scientific

SUPERCONDUCTING MATERIALS FOR HIGH ENERGY COLLIDERS

in memory of T. Ypsilantis

EDITORS
L. CIFARELLI AND L. MARITATO

World Scientific
Copyrighted Material
Detector R&D
and
Electronics
Figure 21: The set-up able to detect simultaneously $(e^+e^-)$, $(\mu^+\mu^-)$ and $(\mu^\pm e^\mp)$ final states from $(\bar{p}p)$ annihilation.
ARRAY OF THIN ANODE WIRES BETWEEN TWO CATHODES

LARGE MWPC
SPLIT FIELD MAGNET DETECTOR (CERN ISR, 1972)

Cylindrical geometry is not the only one able to generate strong electric field:

- Parallel plate
- Strip
- Hole
- Groove
GEM: 50 μm METAL-CLAD POLYMER FOIL WITH ~ 100 HOLES / mm²

ELECTRONS
PREAMPLIFICATION AND
TRANSFER:

F. Sauli, Nucl. Instr. and Meth. A386(1997)531
The GEM consists of a thin, metal-clad polymer foil, chemically pierced by a high density of holes. With a potential difference between the two electrodes, electrons released by radiation in the gas on one side of the structure drift into the holes, multiply and transfer to a collection region.


Georges Charpak – a true man of science

In a Micromegas detector, the gas volume is divided in two by a metallic micro-mesh placed between 25 μm and 150 μm of the readout electrode. This allows for a high gain $10^4$ and a fast signal 100 ns.

http://cerncourier.com/cws/article/cern/44361
Nov 30, 2010 by Ioannis Giomataris, CEA-Saclay.
Looking at developments of detectors in particular on the latest Gas Electron Multiplier (GEM) and the Micro Mesh Gas Detector activities, Fabio Sauli describes this developments last year at this school.
This year we will learn about another development strongly supported within the LAA project

The silicon strip and pixel detector R&D

Erik Heijne will describe this developments at this school.
Early examples

Hybrid pixel devices, with a read-out chip “bump bonded” to the detector, were used in WA97 in the mid-1990s.

By 2002, CERN had developed a bump-bonded 8000-channel pixel for the ALICE silicon-pixel detector at the LHC.
A new type of resistive plate chamber: The multigap RPC

Author links open overlay panel E.Cerron Zeballos\textsuperscript{ab} I.Crotty\textsuperscript{a} D.Hatzifotiadou\textsuperscript{ab}
J.lamas Valverde\textsuperscript{abc} S.Neupane\textsuperscript{ab}
M.C.S Williams\textsuperscript{a} A.Zichichi\textsuperscript{da}

\textsuperscript{a} LAA project, CERN, Geneva, Switzerland
\textsuperscript{b} World Laboratory, Lausanne, Switzerland
\textsuperscript{c} University Louis Pasteur, Strasbourg, France
\textsuperscript{d} University of Bologna and INFN, Bologna, Italy

LAA MRPC for ALICE TOF and the EEE Project

• [https://videos.cern.ch/record/2262028](https://videos.cern.ch/record/2262028)
and there are more projects

LAA - AMS (TOF) - ALICE (TOF) - EEE (MRPC) - QGCW

See also talks by Luisa Ciffarelli (EEE), Crispin Williams (TOF)
Microelectronics at CERN: from infancy to maturity

The LAA project propelled electronics at CERN into the era of microelectronics.

Two decades of microelectronics at CERN enabled by the LAA project.
Early examples

In 1988, the AMPLEX multiplexed read-out chip used in UA2

HERMETIC PAD DETECTORS UA2

~5 mm THICK CILINDER
ONLY POSSIBLE with "AMPLEX" CHIP
DESIGN Pierre Jarron

1986 - 1988 FIRST Si DETECTOR in COLLIDER
FIRST operating Si DETECTOR with IC CHIP READOUT

16 CHANNELS COLLABORATION IMEC LEUVEN

DETECTOR CYLINDER CURRENTLY IN U. DORTMUND by Claus Gößling
Let us for a moment look back to the development of electronics
Integrated Circuits

Micro Sim to Standard Sim

Nano Sim Card + Nano to Micro + Micro Sim Adapter = Standard Sim Card
CERN has often been the incubator for the development of innovative technologies but very few people know about the capacitive touch screens invented for the consoles of the SPS Control Room in 1973. The inventor, Bent Stumpe, who also developed the CERN tracker ball and the computer-programmable knob.
semiconductors – transistors - micro (nano) - electronics, FinFet devices

Courtesy: CERN library and copy rights
Technology development at CERN from analogue to digital

http://cerncourier.com/cws/article/cern/56223

- Developed at CERN under LAA project
  
  LAA collaborative R&D activity to study new detection techniques for the next generation of hadron-colliders that would reach the scale of TeVs (1986). The project had a huge impact in the LHC electronics.

- Front-end electronics ALICE TOF detector
  
  Used for time-of-flight measurements for particle vertex reconstruction in the ALICE experiment of the LHC collider.

- NINO32 channels version, NINO board

![NINO](image.png)

- pico-second (64ch) being developed
- The R&D in TOF PET is increasing exponentially
NINO: an ultra-fast and low-power front-end amplifier/discriminator ASIC designed for the multigap resistive plate chamber

F. Anghinolfi\textsuperscript{a}, P. Jarron\textsuperscript{a}, A.N. Martemiyanov\textsuperscript{b}, E. Usenko\textsuperscript{c}, H. Wenninger\textsuperscript{a}, M.C.S. Williams\textsuperscript{d,*}, A. Zichichi\textsuperscript{d,e}

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\textsuperscript{b}Institute for Theoretical and Experimental Physics, Moscow, Russia
\textsuperscript{c}Institute for High Energy Physics, Protvino, Russia
\textsuperscript{d}Sezione INFN, Bologna, Italy
\textsuperscript{e}Dipartimento di Fisica dell'Università, Bologna, Italy

Available online 28 July 2004

Abstract

For the full exploitation of the excellent timing properties of the Multigap Resistive Plate Chamber (MRPC), front-end electronics with special characteristics are needed. These are (a) differential input, to profit from the differential signal from the MRPC (b) a fast amplifier with less than 1 ns peaking time and (c) input charge measurement by Time-Over-Threshold for slewing correction. An 8-channel amplifier and discriminator chip has been developed to match these requirements. This is the NINO ASIC, fabricated with 0.25 $\mu$m CMOS technology. The power requirement at 40 mW/channel is low. Results on the performance of the MRPCs using the NINO ASIC are presented. Typical time resolution $\sigma$ of the MRPC system is in the 50 ps range, with an efficiency of 99.9\%.

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PACS: 29.40.Cd; 84.30.+c; 84.30.Lq; 84.30.Qv

Keywords: Resistive plate chamber; ALICE; Time-of-flight; Fast amplifier; Discriminator; ASIC; CMOS technology

E. Heijne in his talk at the EPS-HEP 2017
<table>
<thead>
<tr>
<th>Year</th>
<th>Institute/Institution</th>
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<tbody>
<tr>
<td>2014</td>
<td>Beijing Normal University</td>
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<td></td>
<td>University of Glasgow</td>
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<td></td>
<td>University of Physics SAS, Slovakia</td>
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<td></td>
<td>IFINHH (Horia Hulubei National Institute of Physics and Nuclear Engineering), Romania</td>
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<td>2015</td>
<td>LIP, Portugal</td>
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<tr>
<td></td>
<td>Universitat Politecnica Catalunya</td>
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<td></td>
<td>INFN (Instituto Nazionale di Fisica Nucleare), Italy</td>
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<td>LPCCAEN, France</td>
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<td>VECC (Variable Energy Cyclotron) India</td>
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<td>University of Delhi, India</td>
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<td>2016</td>
<td>STFC, Rutherford Appleton Laboratory</td>
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<td>Stanford Medicine, Molecular Imaging Instrumentation Laboratory</td>
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<td>2017</td>
<td>Saha Institute of Nuclear Physics - India</td>
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NINO for PET/CT Imaging

- Development of a novel photo-detector readout technique for combined PET and CT

- NINO circuit is used as fast discriminator to get low jitter
- Output pulse width variation w. input charge permits to separate PET (511 keV) and CT (100 keV) events
- Thanks to FEDC05 and NINO CERN integrated circuits, system shows an energy resolution close to standard PMT techniques and low timing resolution (~ 1.2 ns FWHM).
ACES 2018 – Sixth Electronics Workshop for LHC Upgrades

24 Apr 2018, 07:30 → 26 Apr 2018,
Globe of Science and Innovation - 1st Floor (CERN)
Magnus Hansen (CERN), Philippe Farthouat (CERN)

https://indico.cern.ch/event/681247/timetable/?print=1&view=standard
Data handling
How much data are we talking?

- Big Data! 😊
- 2012, 15 PB
- 2017 estimates 50 PB, equivalent to a 12km high stack of DVDs
- CERN can only provide 20%-30% storage and CPU
An Early “Computer”

- Wim Klein
- Calculating the 73rd root of a 500 digit number took less than 3 minutes...
- Not the first CERN Computer! Two “female computers” were already working with mechanical calculators
apes being sent up from B513 basement
200+ press cuttings
150,000 visits to our website
50+ events, visits, lectures
100+ presentations
50+ news articles, press releases, case studies

CERN openlab Summer Students Programme

Seminars, training courses, academic training

Innovation and Knowledge Transfer

Joint R&D

Communication

Education

Management

Innovation & Entrepreneurship

Applications to cross-disciplinary research

Credit to Hannah Short
What next

Machine Learning for Physics Analysis at the LHC (Selected Topics)

Josh Bendavid (CERN)

Feb. 22, 2018
The LAA impact on technology R&D: from past to future.

GEM detectors

Silicon Pixel detectors

A GEM based time projection chamber with pixel readout
The silicon detector R&D

EPS HEP prize 2017

Erik H.M. Heijne
Robert Klanner
Gerhard Lutz
with

Erik H.M. Heijne

presenting the silicon story
Vision and Outlook: The Future of Particle Physics

Ian Shipsey
University of Oxford
Oxford, United Kingdom
E-mail: ian.shipsey@physics.ox.ac.uk

1.6 Instrumentation the Great Enabler

Instrumentation is the great enabler. “New directions in science are launched by new tools much more often than by new concepts. The effect of a concept-driven revolution is to explain old things in new ways. The effect of a tool-driven revolution is to discover new things that have to be explained” – Freeman Dyson. In our field, we detect & measure over 24 orders of magnitude in energy, from the CMSB to cosmic rays. We use a rich spectrum of technologies (Figure 16).
I am sure that the students here at the ISSP2018 listening to the talk by Erik Heijne will not be among those illustrated by “PHDCOMICS”
Figure 16: A selection of the detection technologies used in particle physics. (Original figure from Marcel Demarteau.) courtesy: Argonne Lab Division Director
Listen now to the next talk