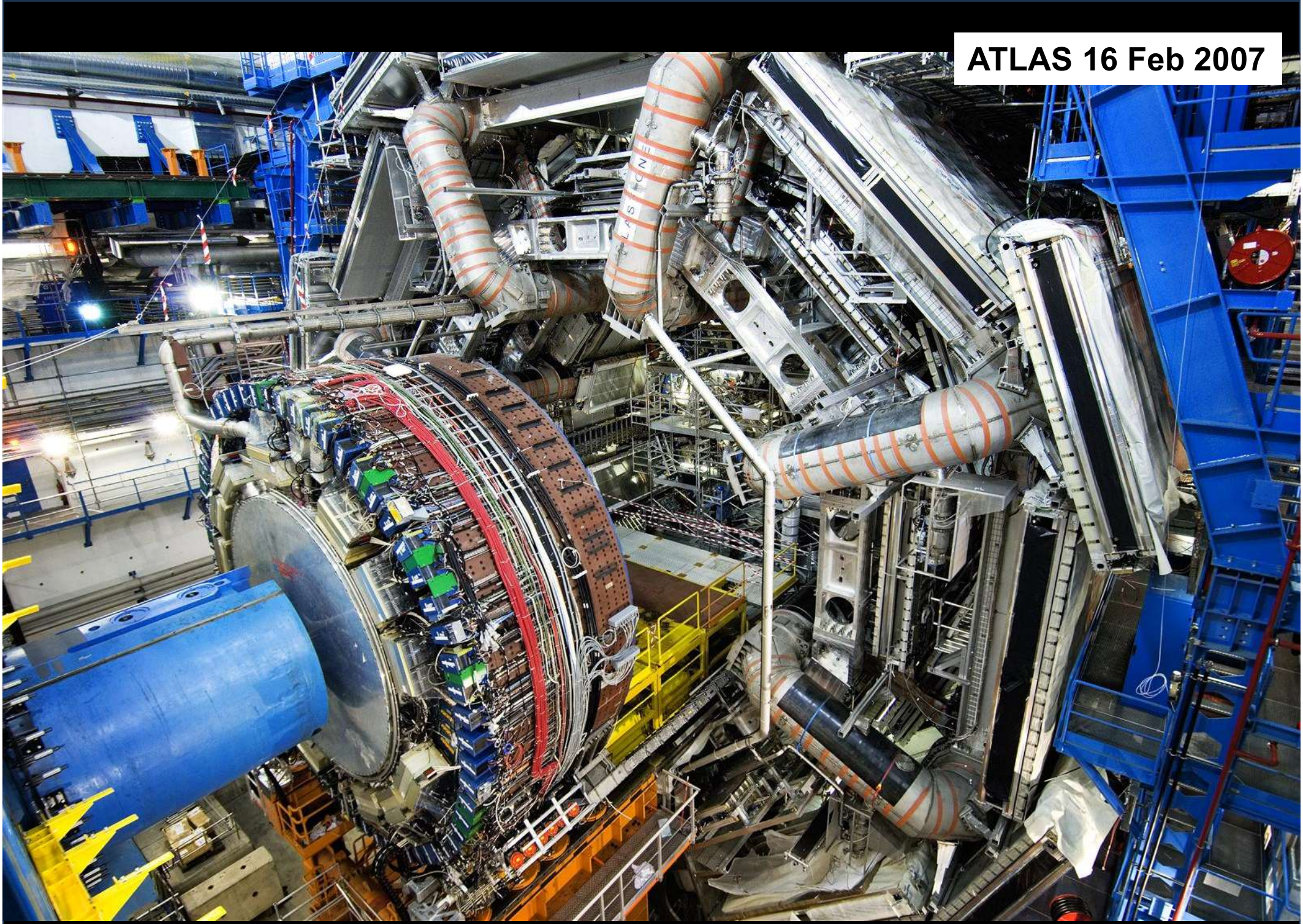
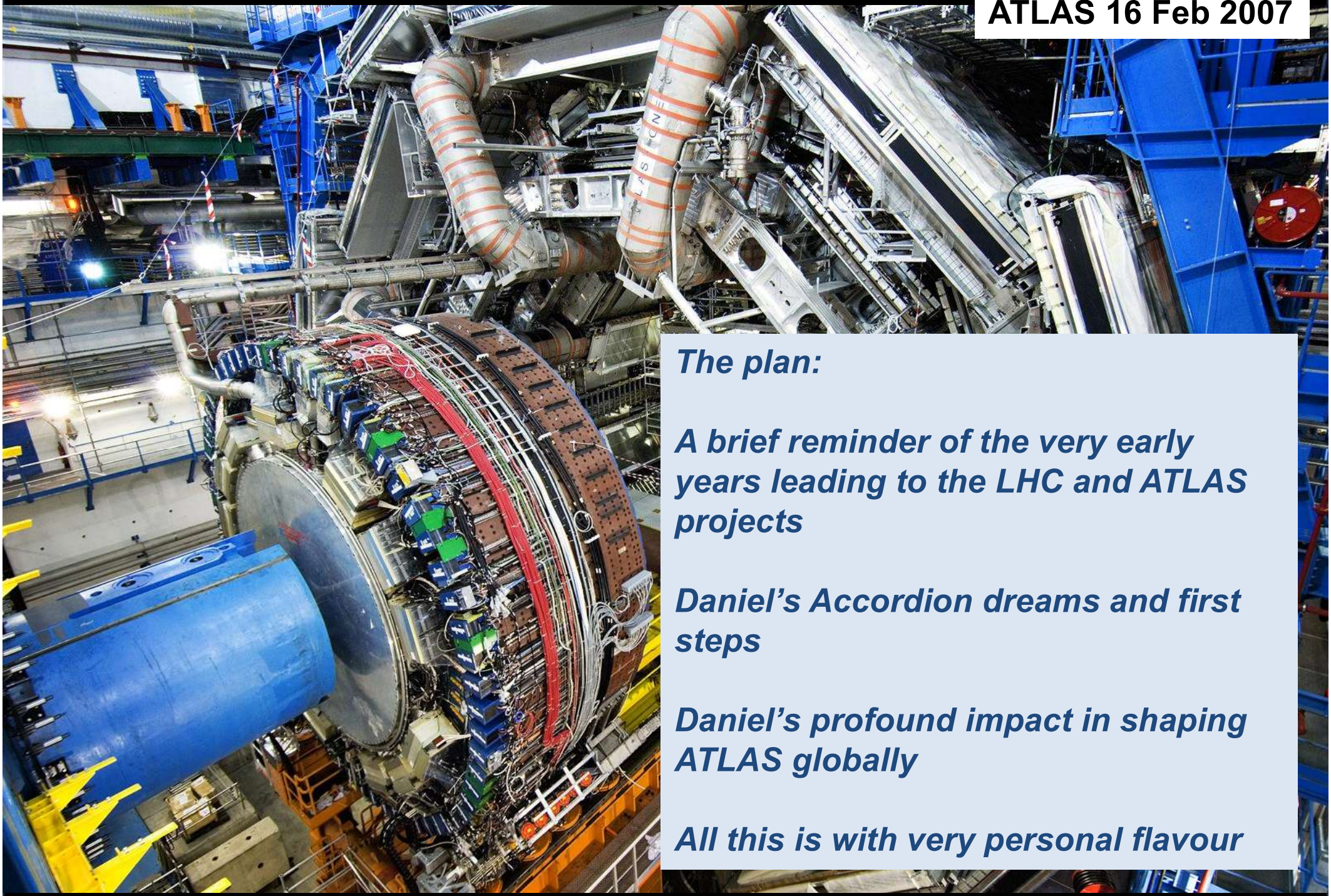
Daniel Fournier, Prix André Lagarrigue 2023

Daniel Fournier's Impact on ATLAS, the Early Years

Peter Jenni, CERN and
Albert-Ludwigs-Universität Freiburg
IJCLab, Orsay, 6 December 2023



Daniel Fournier, Prix Lagarrigue



The plan:

A brief reminder of the very early years leading to the LHC and ATLAS projects

Daniel's Accordion dreams and first steps

Daniel's profound impact in shaping ATLAS globally

All this is with very personal flavour

How the LHC came to be …

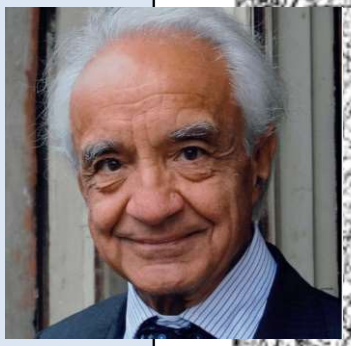
Some very early key dates

1977 The community talked about the LEP project, and it was already mentioned that a new tunnel could also house a hadron collider in the far future

1979 LEP White Book:

ECFA-LEP Working Group 1979 chaired by A Zichichi

‘Tunnel with 27 km circumference and a diameter of 5 m, with a view to the replacement of LEP at the end of its activities by a proton-proton Collider using cryogenic magnets’



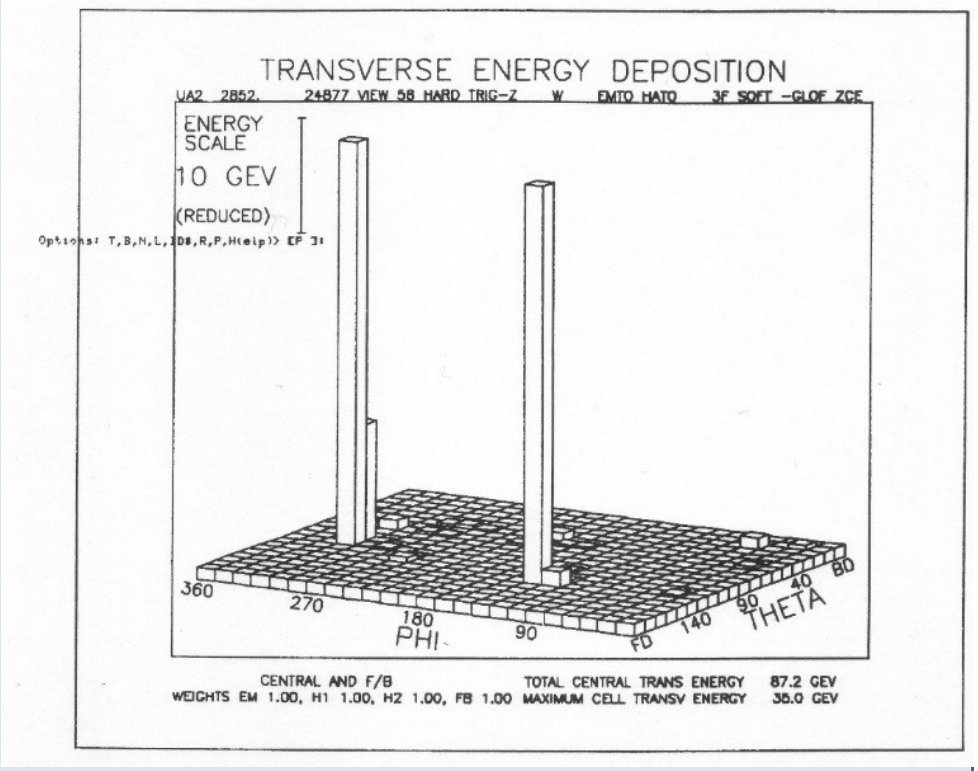
1981 LEP was approved with a large and long (27 km) ring tunnel

Herwig Schopper
CERN DG 1981 - 1988

1983 The early 1980s were crucial

The real belief that a 'dirty' hadron collider can actually do great discovery physics came from UA1 and UA2 with their W and Z boson discoveries at CERN

Louis Fayard will talk about that this afternoon



A very early Z → ee online display from one of the detectors (UA2)

1984 For the community it all started with the CERN - ECFA Workshop in Lausanne on the feasibility of a hadron collider in the future LEP tunnel

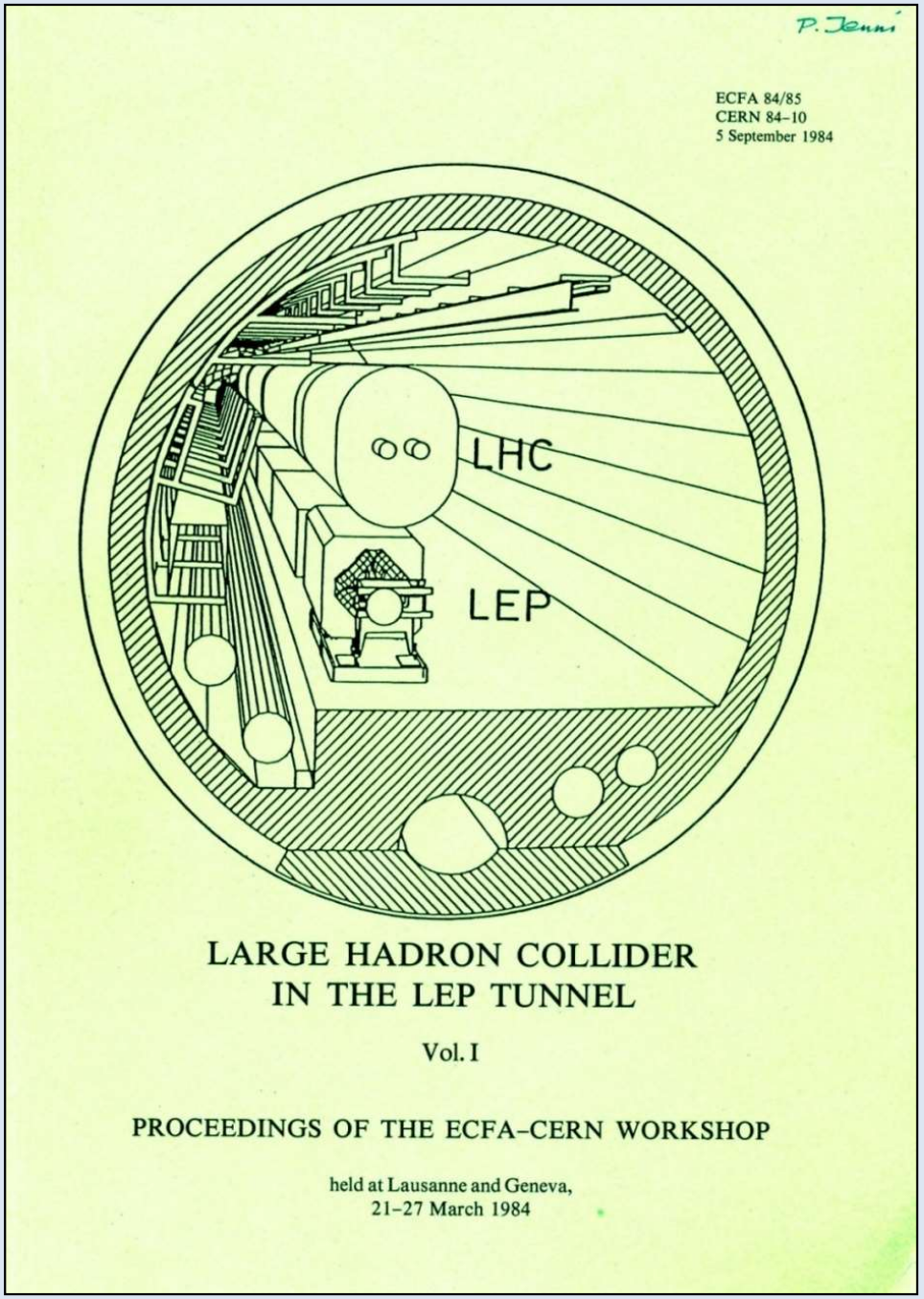
Giorgio Brianti was leading the LHC machine studies until 1993

Daniel was at this workshop, but we did not yet interact as far as I remember …

1986 LAA R&D on new detector technologies started, later followed by the DRDC

1987 La Thuile Workshop

Many LHC colleagues were already involved in this WS set up by Carlo Rubbia as part of the Long Range Planning Committee



La Thuile 7 – 13 January 1987
(Carlo Rubbia's Long Range Planning Committee)

CERN 87-07
Vol. I
4 June 1987

ORGANISATION EUROPÉENNE POUR LA RECHERCH
CERN EUROPEAN ORGANIZATION FOR NUCLEA

PROCEEDINGS OF THE
WORKSHOP ON
PHYSICS AT FUTURE ACCELERATORS

La Thuile (Italy) and Geneva (Switzerland)
7 – 13 January 1987

Vol. I

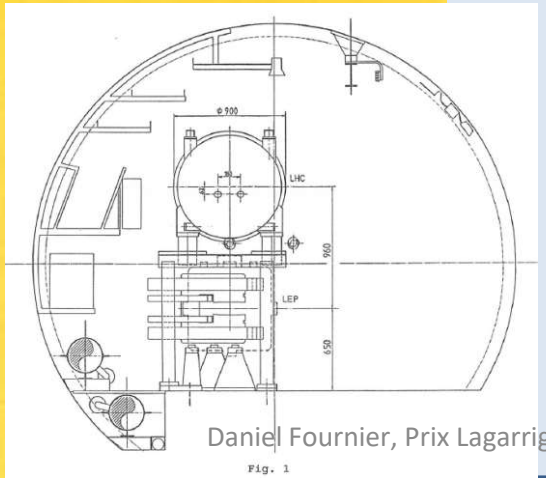
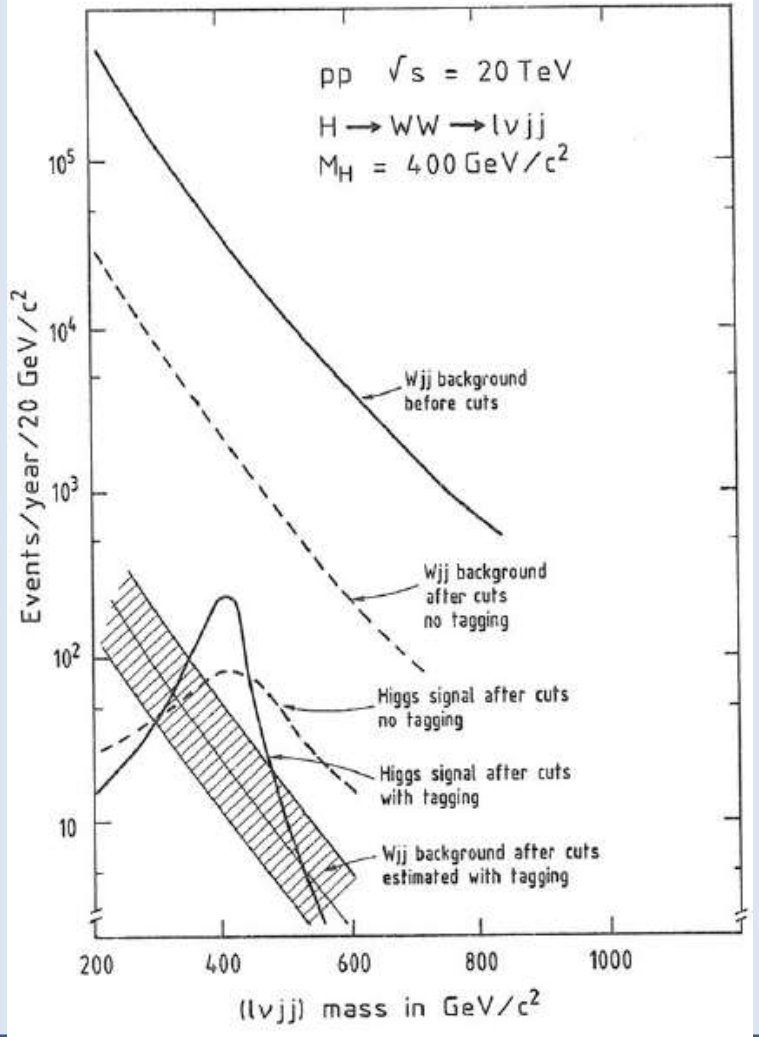


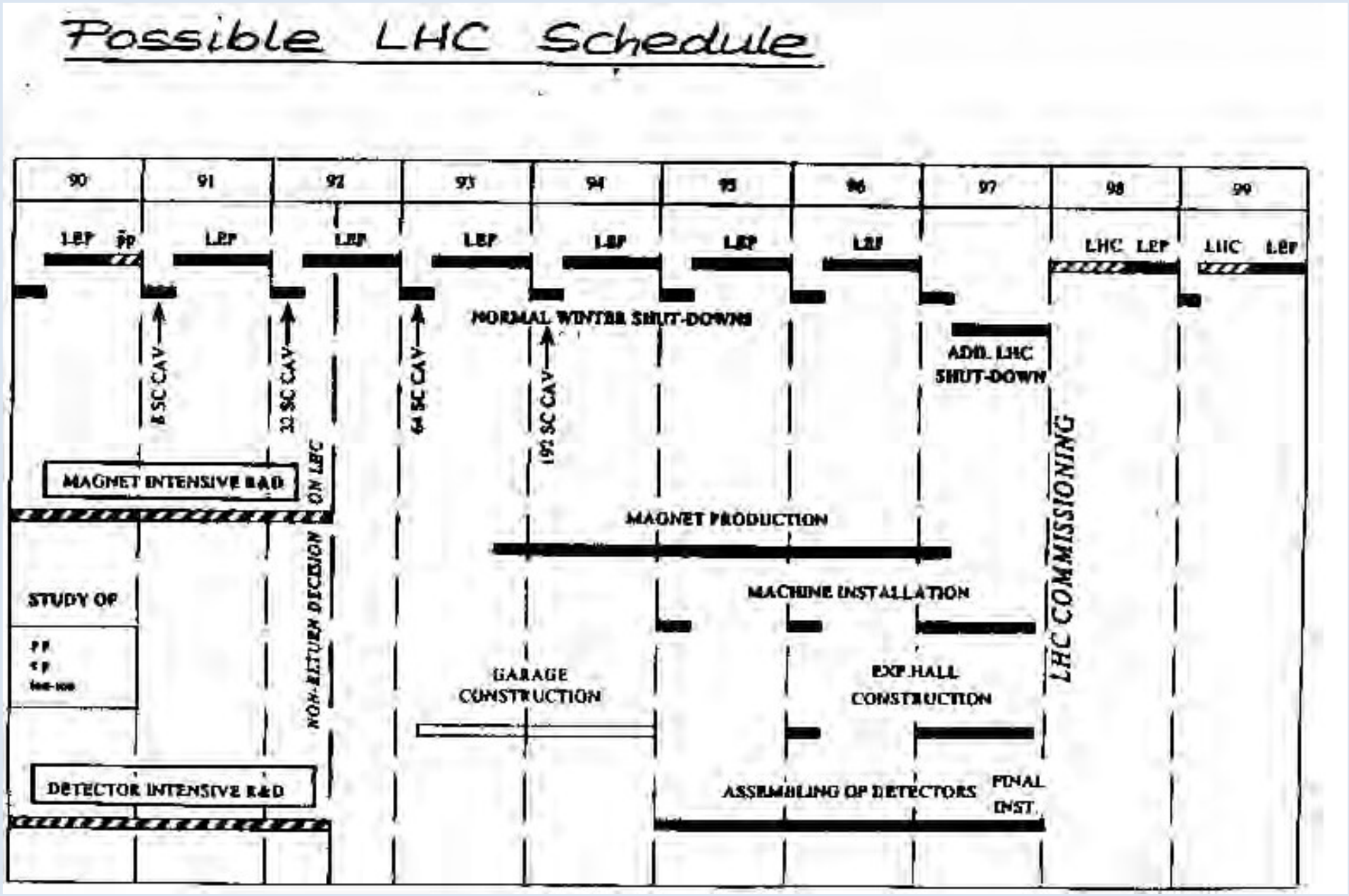
Fig. 1

Collider parameters

Machine		$\sqrt{s}$ (TeV)	L ($cm^{-2} s^{-1}$)
LHC	pp	16	$10^{33} \rightarrow 10^{34}$
	ep	1.3	10^{32}
		1.8	10^{31}
CLIC	e^+e^-	2	$10^{33} \rightarrow 10^{34}$



From an early talk about the LHC, it must have been around 1986/7 …



1989 ECFA Study Week in Barcelona for LHC instrumentation
(forming of first proto-Collaboration)

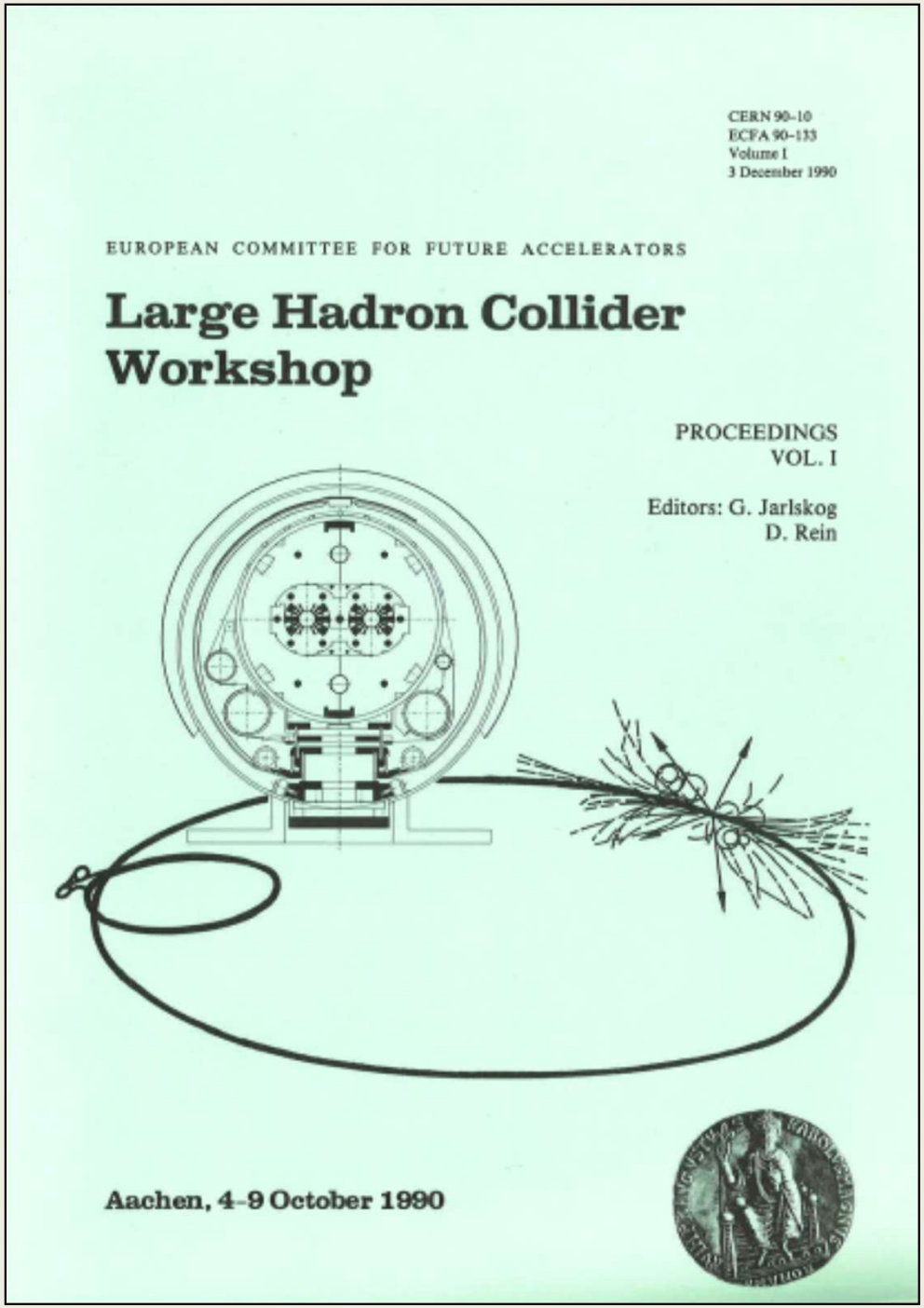
1990 Large Hadron Collider Workshop Aachen (CERN - ECFA)

Daniel was convener for Liquid Argon Calorimetry working group

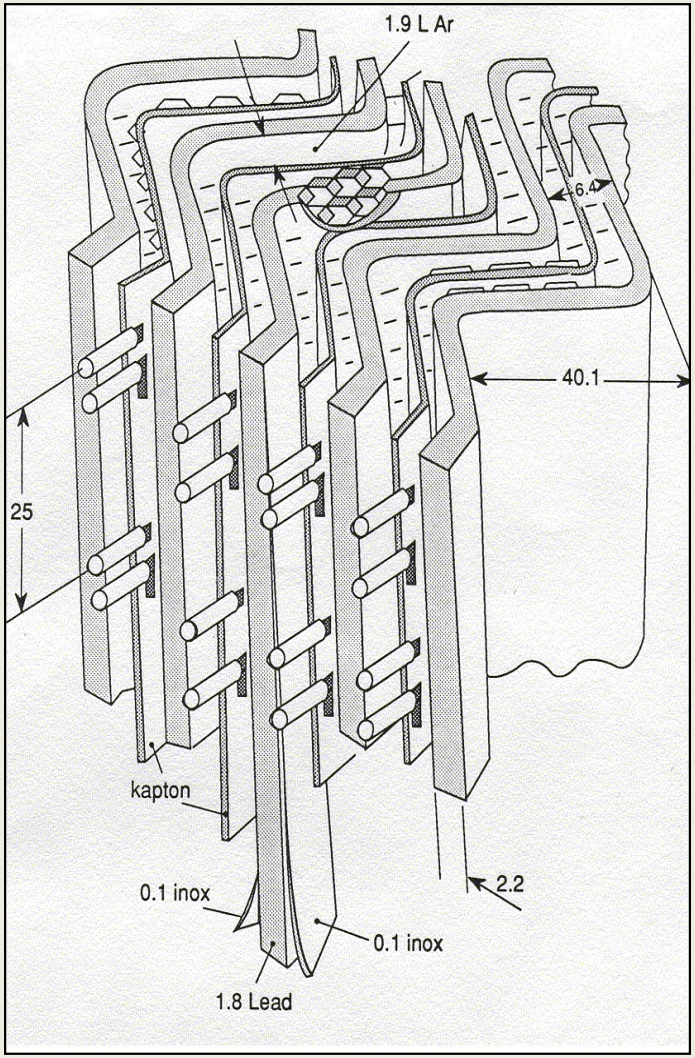
LIQUID ARGON CALORIMETRY

Convener: D. Fournier
LAL Orsay and PPE Division – CERN, Geneva

1992 CERN – ECFA meeting 'Towards the LHC Experimental Programme' in Evian



Our friendship and collaboration started in the late 1980s with Daniel's brilliant idea of how to make a LAr EM calorimeter for LHC



The UA2 CERN group was happy to be Daniel's co-host at CERN for a couple of years during that time

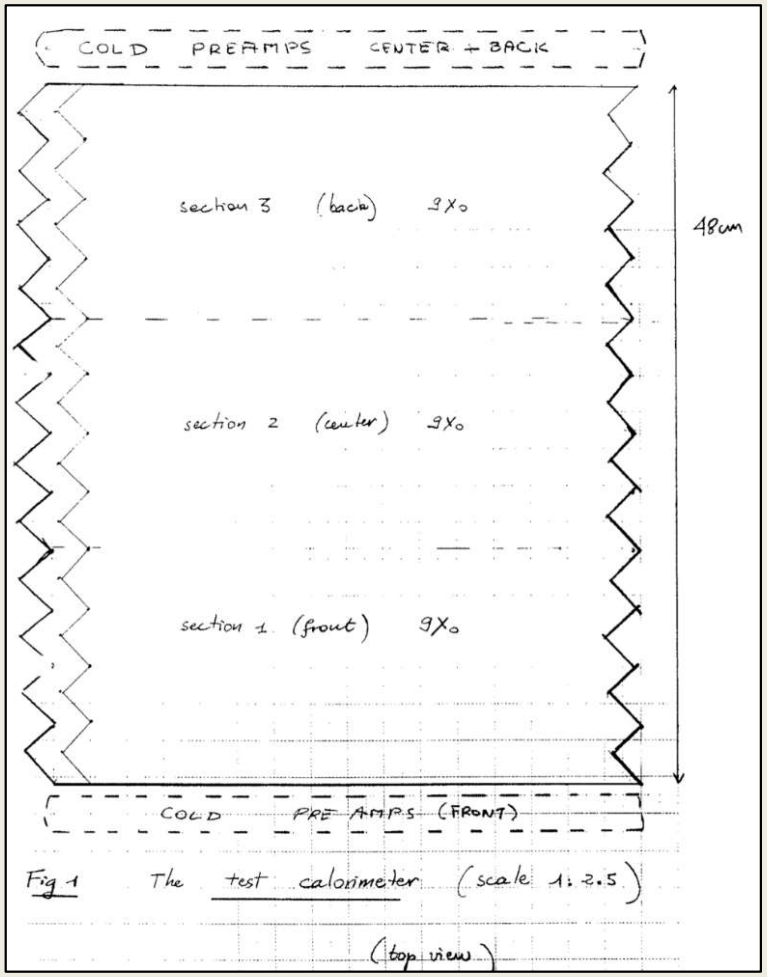
The famous LAr Accordion EM Calorimeter of ATLAS was born during that time!

In the following a few historical pictures and plots recall the very early years…

Daniel Fournier 5 January 1990

An approach to high granularity, fast Liq Ar calorimetry using an 'accordeon' structure

The proposed test calorimeter



D.Fournier 5-jan-90

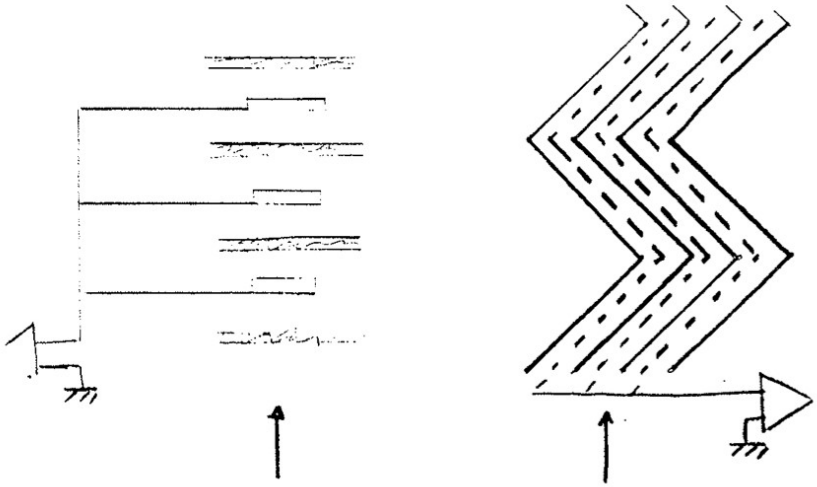
An approach to high granularity,fast Liq Ar calorimetry

using an "accordeon" structure

1)BASIC IDEA

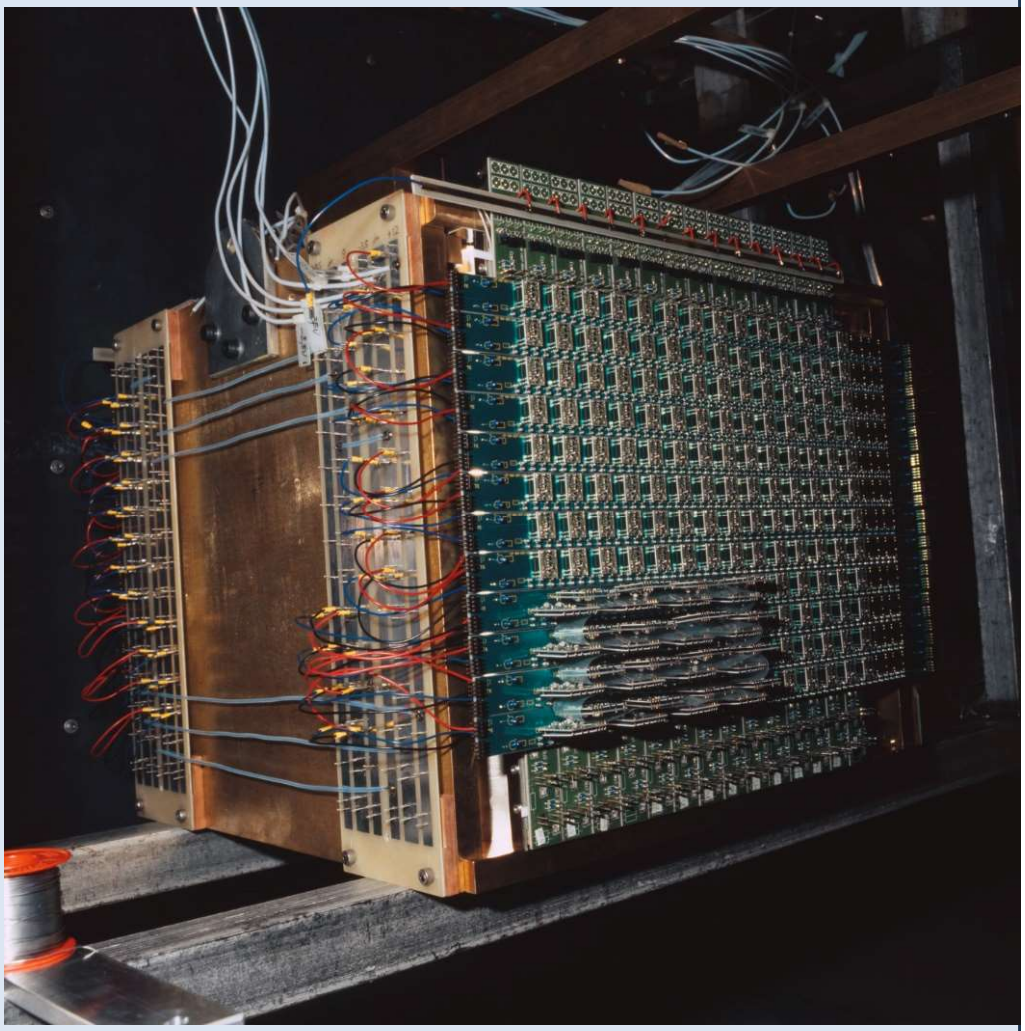
In the conventionnal approach of liquid argon calorimetry parallel electrodes are connected in parallel(or in serie in the ES transformer approach) to form a tower. Instead one consider here a scheme in which the converter plates and electrodes are at +- 45 degrees ,thus making an "automatic" connection of the elements forming a tower.

In this situation the incident particle makes an angle of 45 degrees with the converter plates.To first order resolution similar to the standard case is recovered by choosing converter plates thinner by sqrt(2).



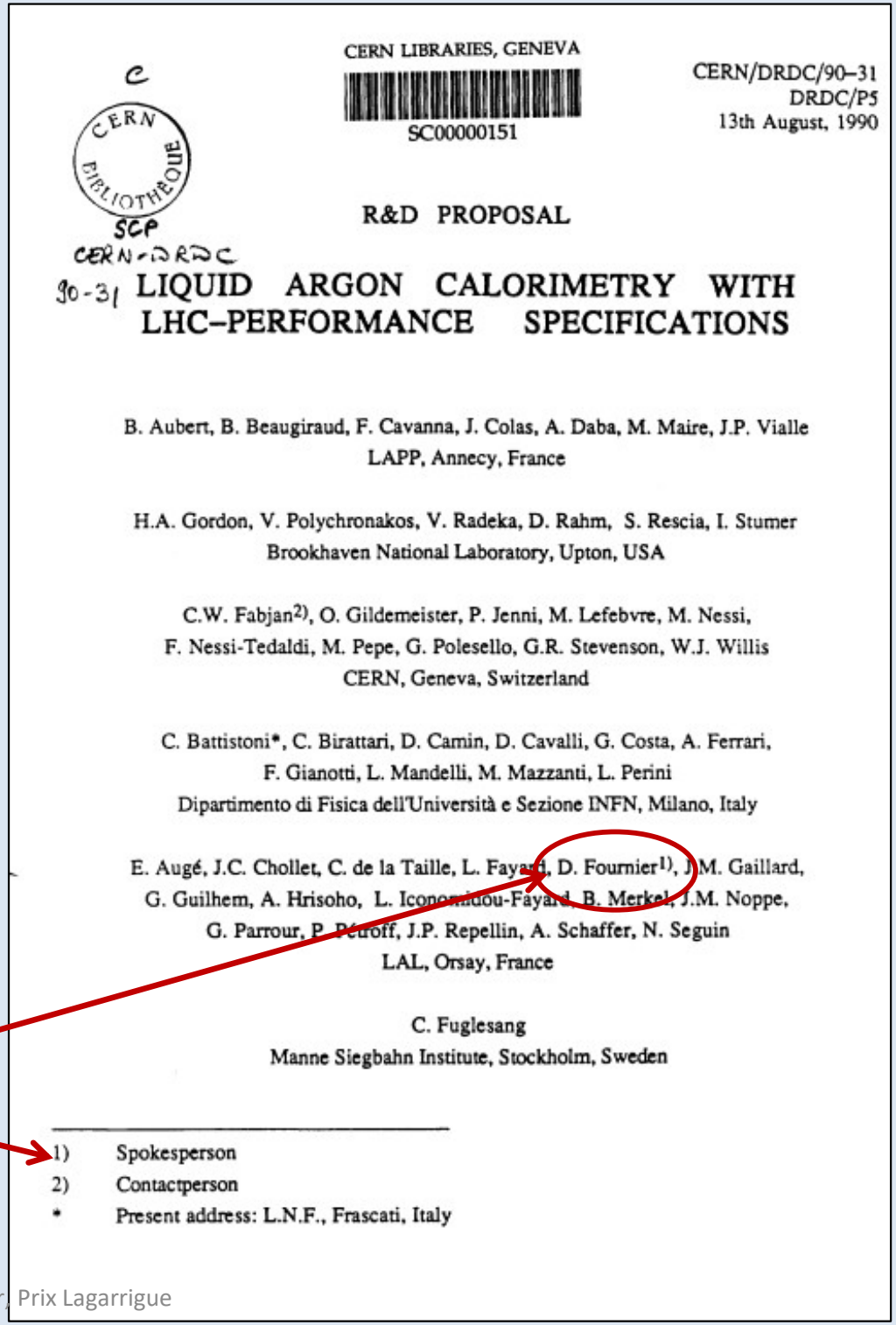
First prototype built in the very early 1990s when Daniel was at CERN for a couple of exciting years …

3 July 1990



10 July 1990

Daniel presented the concept and first results at the famous LHC Workshop in Aachen 4-9 October 1990 (as an 'R&D Proposal'), which then became later known as the highly successful RD3 project after it was approved by the new LHC detector R&D committee (DRDC).



CERN/DRDC/90–31
DRDC/P5
13th August, 1990

R&D PROPOSAL

LIQUID ARGON CALORIMETRY WITH LHC–PERFORMANCE SPECIFICATIONS

B. Aubert, B. Beaugiraud, F. Cavanna, J. Colas, A. Daba, M. Maire, J.P. Vialle
LAPP, Annecy, France

H.A. Gordon, V. Polychronakos, V. Radeka, D. Rahm, S. Rescia, I. Stumer
Brookhaven National Laboratory, Upton, USA

C.W. Fabjan[2)], O. Gildemeister, P. Jenni, M. Lefebvre, M. Nessi,
F. Nessi-Tedaldi, M. Pepe, G. Polesello, G.R. Stevenson, W.J. Willis
CERN, Geneva, Switzerland

C. Battistoni*, C. Birattari, D. Camin, D. Cavalli, G. Costa, A. Ferrari,
F. Gianotti, L. Mandelli, M. Mazzanti, L. Perini
Dipartimento di Fisica dell'Università e Sezione INFN, Milano, Italy

E. Augé, J.C. Chollet, C. de la Taille, L. Fayard, D. Fournier[1)], J.M. Gaillard,
G. Guilhem, A. Hrisoho, L. Iconomidou-Fayard, B. Merkel, J.M. Noppe,
G. Parrour, P. Petroff, J.P. Repellin, A. Schaffer, N. Seguin
LAL, Orsay, France

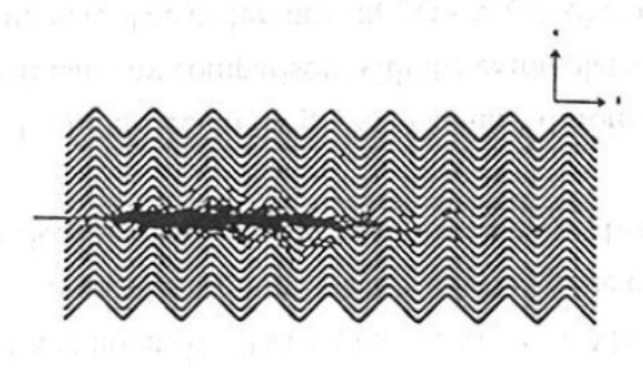
C. Fuglesang
Manne Siegbahn Institute, Stockholm, Sweden

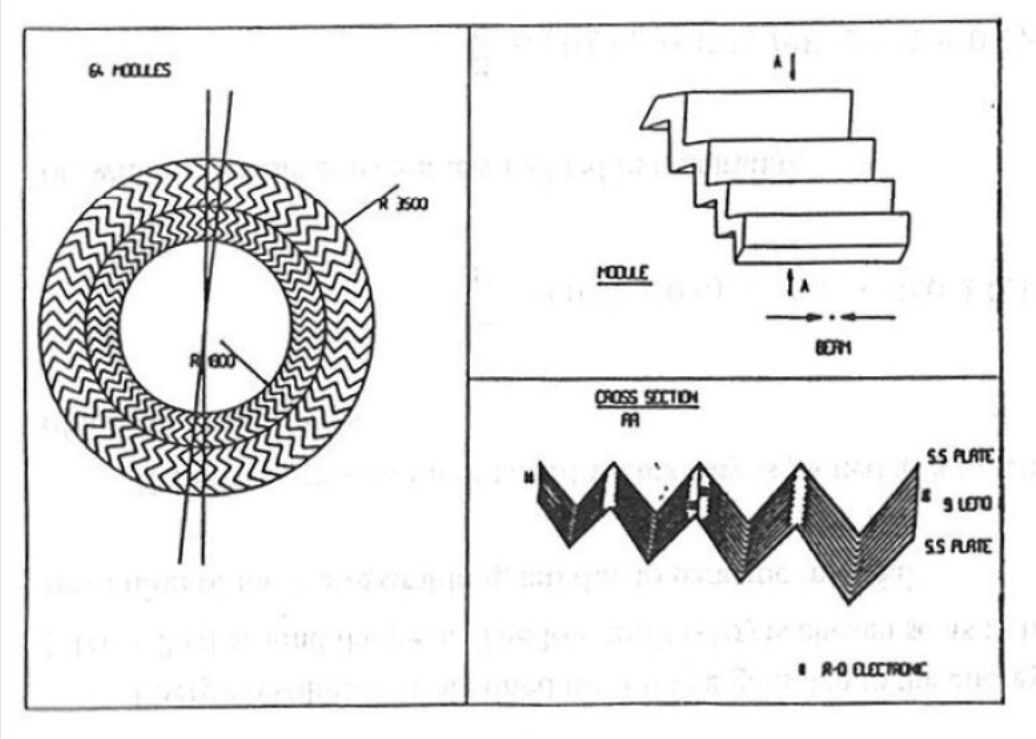
1) Spokesperson
2) Contactperson
* Present address: L.N.F., Frascati, Italy

Of course, Daniel was the Spokesperson of RD3

The community at large became familiar with ‘Accordion’ at that time

From the Aachen proceedings: the concept, and result of the first prototype:





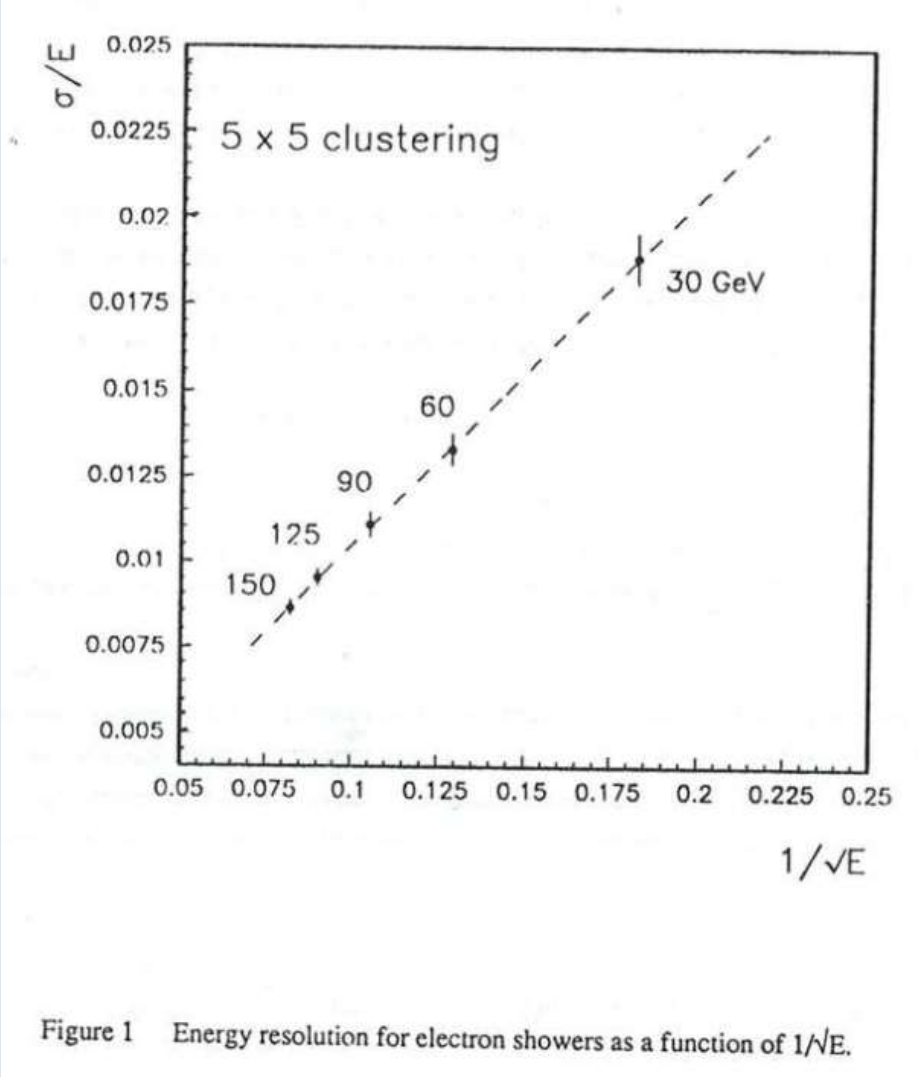


Figure 1 Energy resolution for electron showers as a function of $1/\sqrt{E}$.

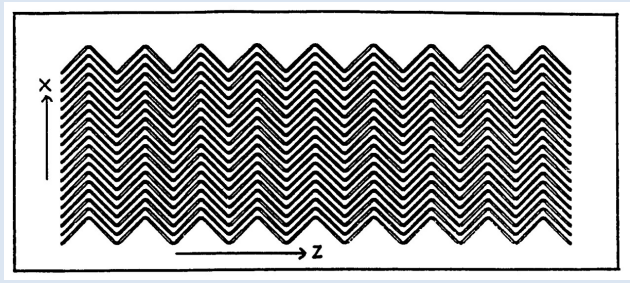
CAL–NO–002 24 May 1990

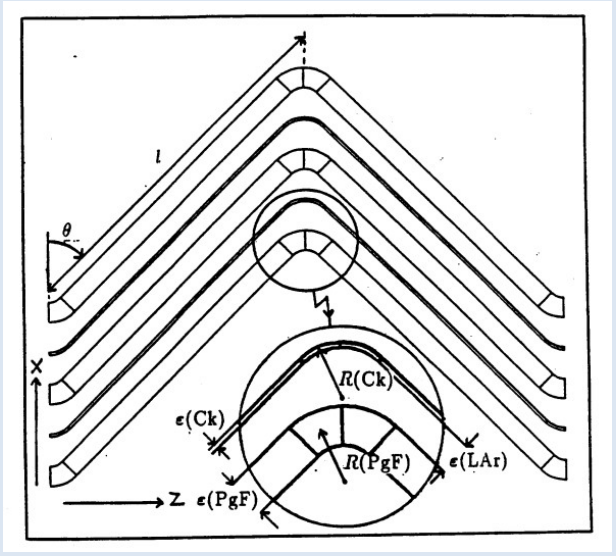
To: LAr Accordion Group

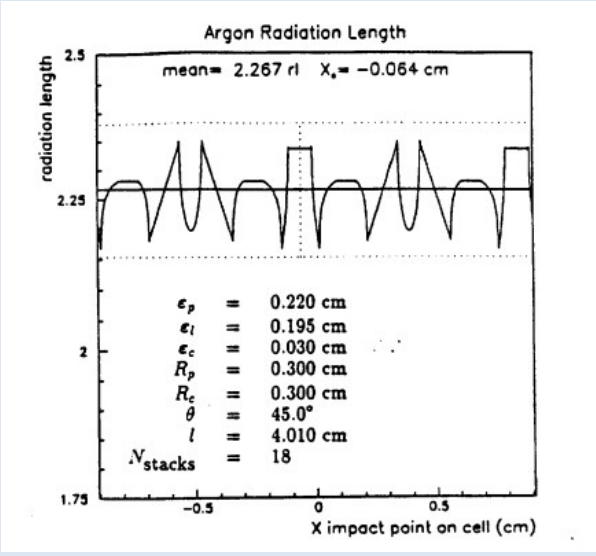
From: Michel Lefebvre, Monica Pepe, Giacomo Polesello

Subject: LAr Accordion Calorimeter Simulation

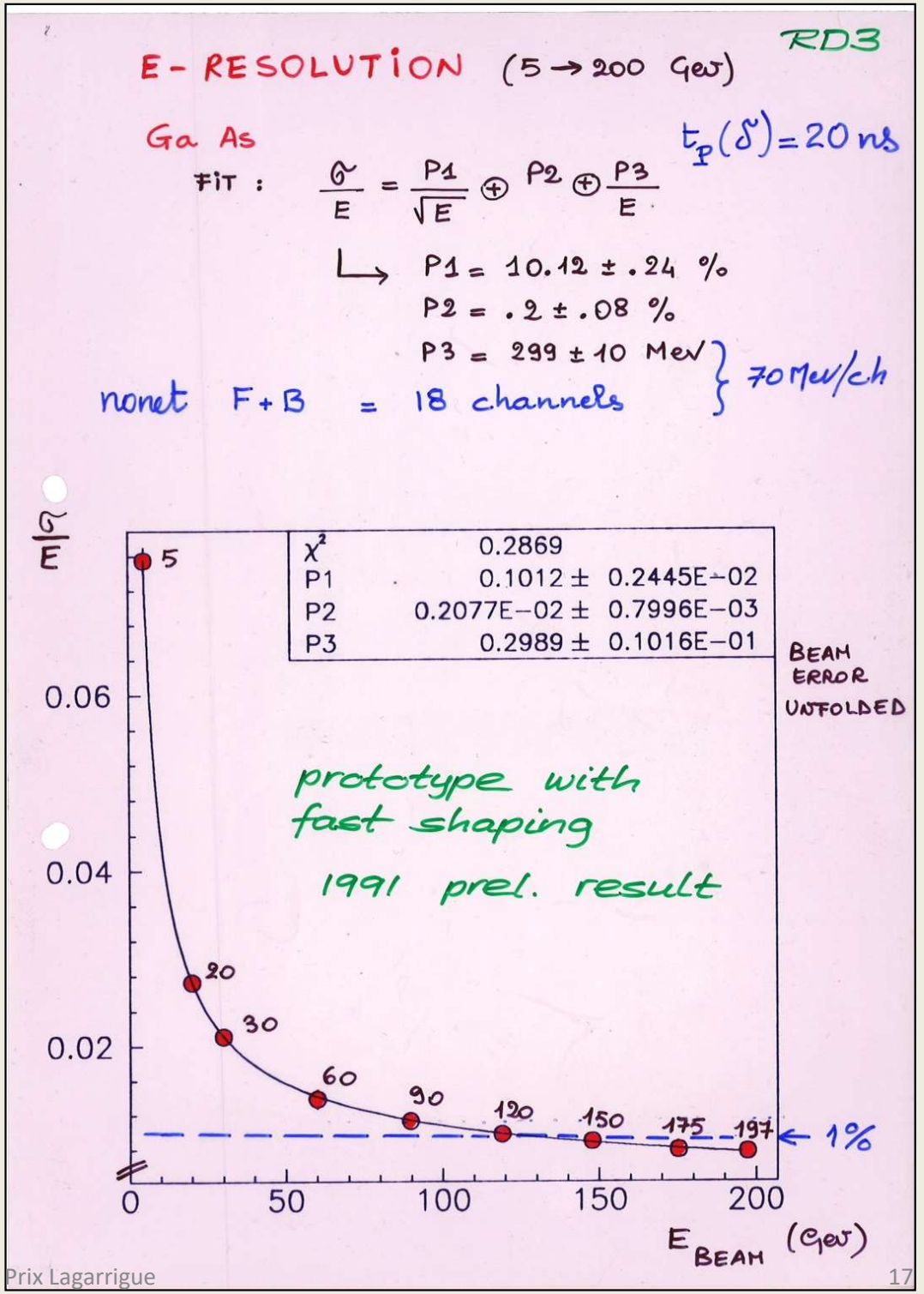
This note is a report on a Monte Carlo study of a LAr calorimeter with accordion design. Optimum geometrical parameters are obtained for the construction of a prototype.



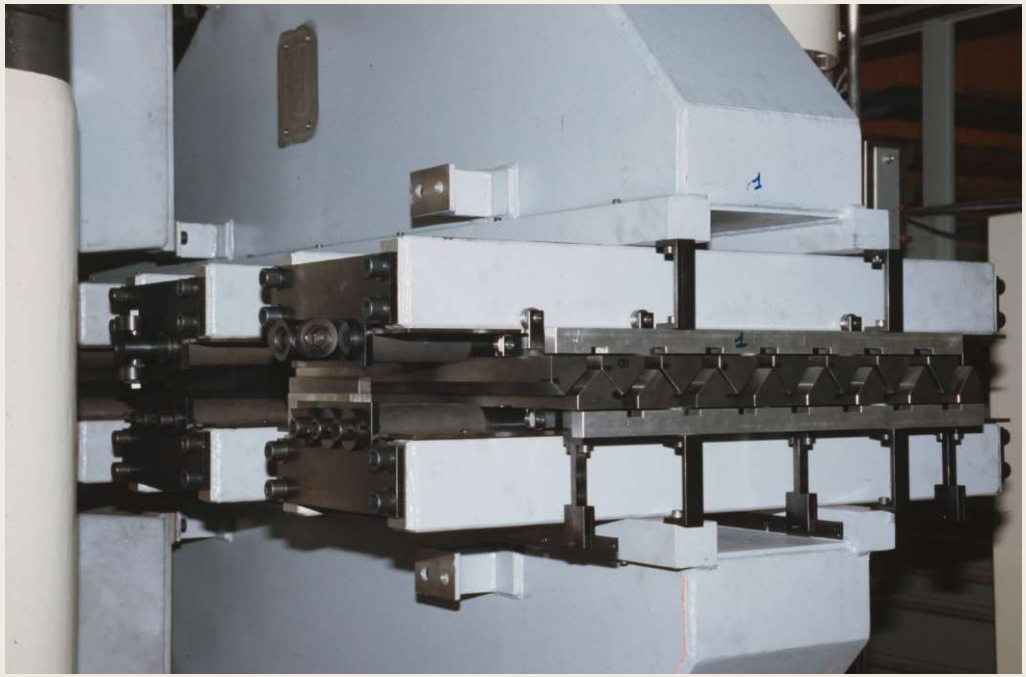




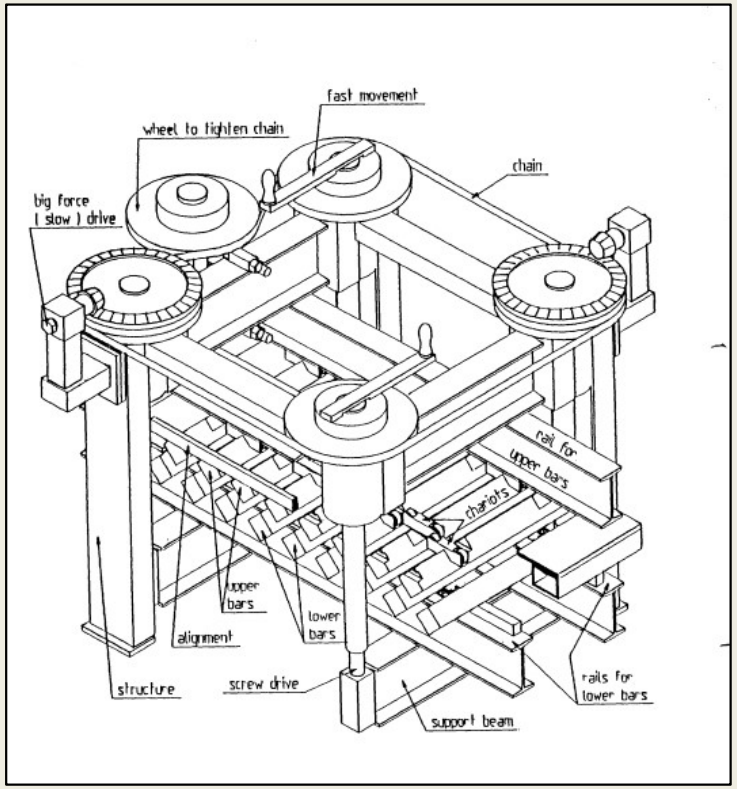
Test beam results obtained with the prototype equipped with fast electronics



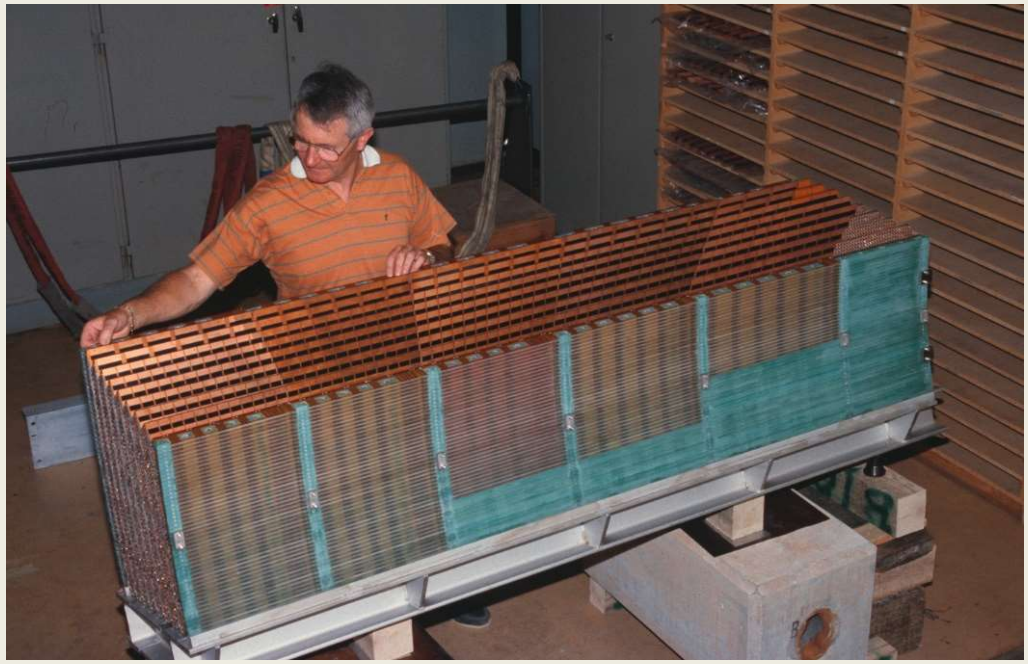
(Note the historic document with the handwriting of Daniel, Fabiola and PJ…)



2 December 1991



RD3 2 m prototype under construction



27 August 1992

1989 – 1992: The first ‘proto-collaborations’ started working on ‘coherent’ detector concept ideas

In September 1989, at the ECFA Study Week, some old and new friends, including Jean-Paul Repellin from LAL, started the EAGLE proto-collaboration

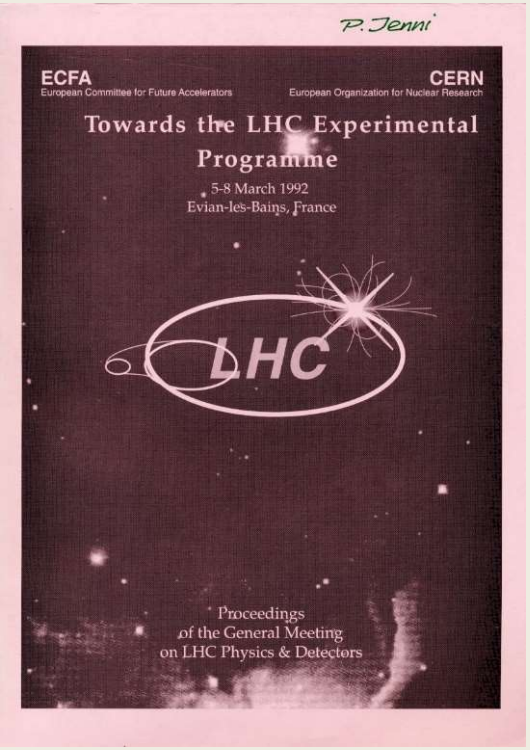
ECFA STUDY WEEK
on Instrumentation Technology for
High-Luminosity Hadron Colliders

ECFA/CERN/CICYT/EEC Workshop
held at
Universitat Autonoma de Barcelona, Bellaterra, Barcelona, Spain
14–21 September 1989

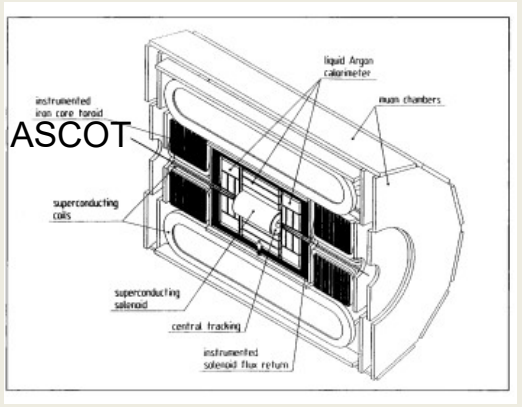
March 1992:

Evian-les-Bains LHC Conference

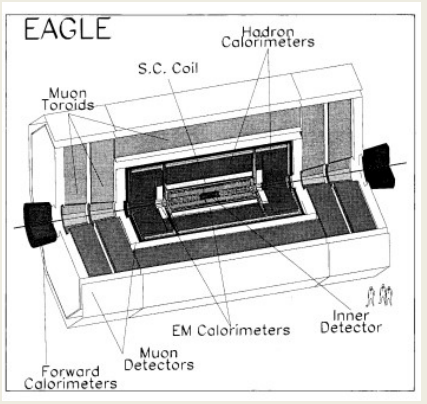
ASCOT and EAGLE both presented detector concepts with a toroid magnet configuration for the muon spectrometer at the Evian meeting



From their Expressions of Interest



ASCOT with a superconducting air-core barrel and warm iron end cap toroids



EAGLE with warm iron barrel and end cap toroids

The birth of ATLAS

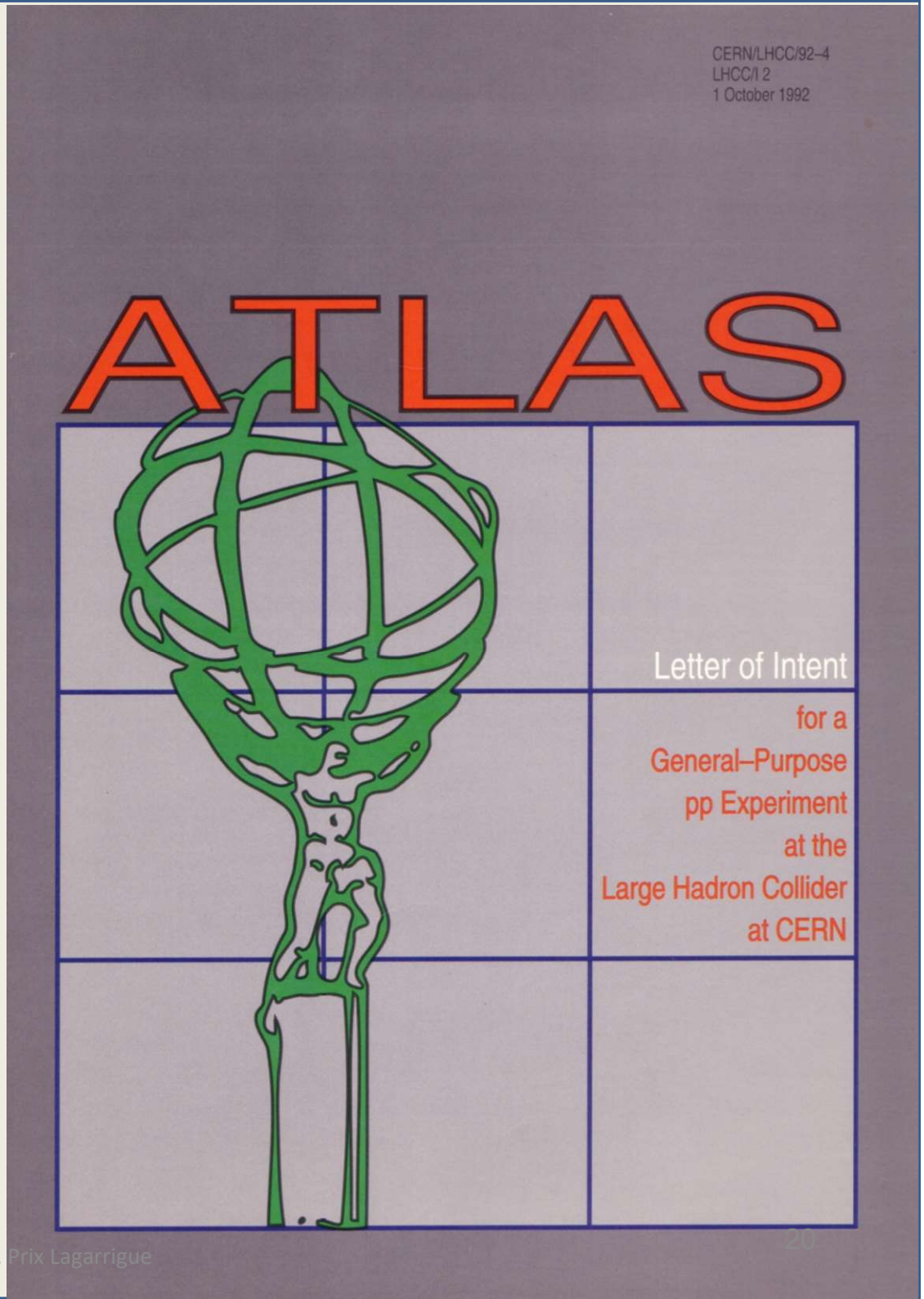
March 1992 – Summer 1992

Merging of two proto-collaborations, ASCOT and EAGLE

September 1992: Decision on the name taken in vote at the Collaboration Board based on many names suggested by Collaboration members

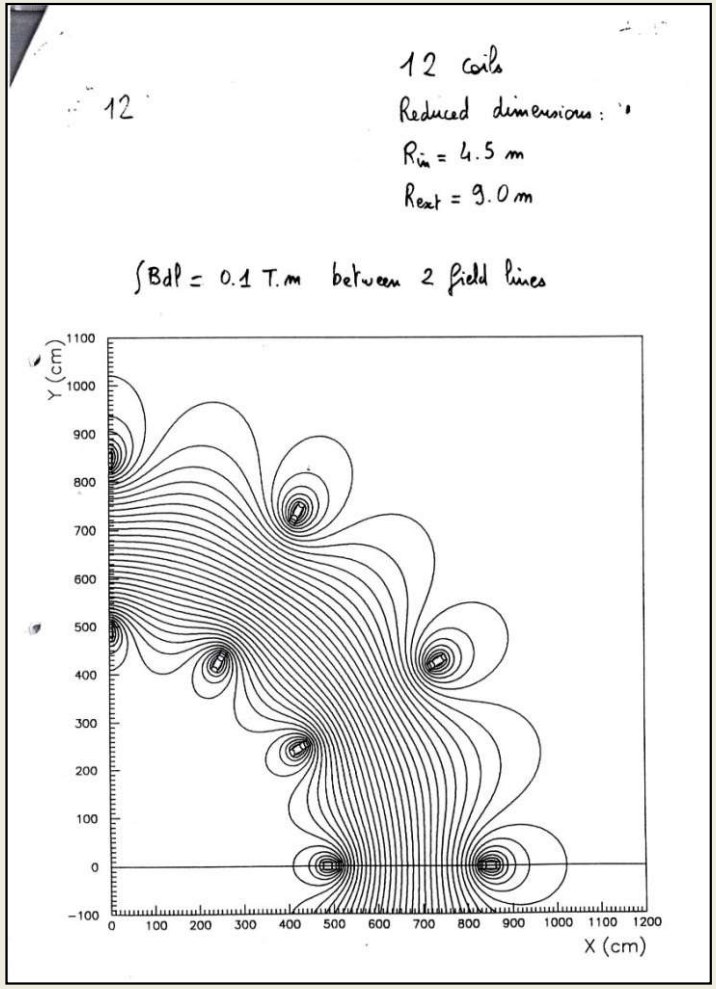
***1st October 1992* :**
ATLAS LoI submitted to the LHCC

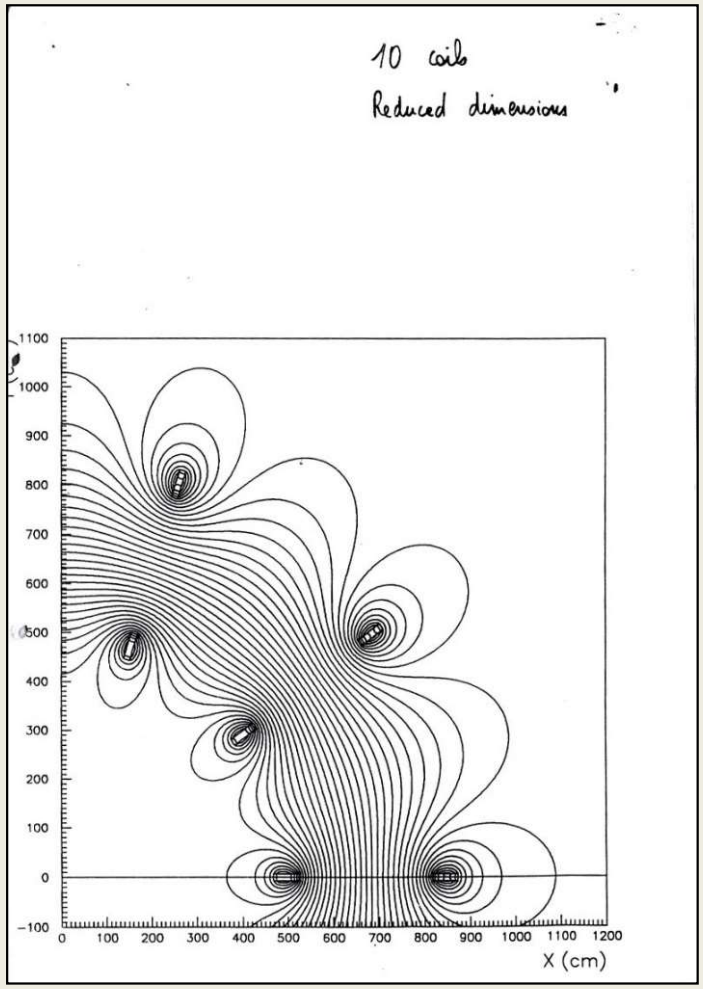
'Official birth of the ATLAS Collaboration'

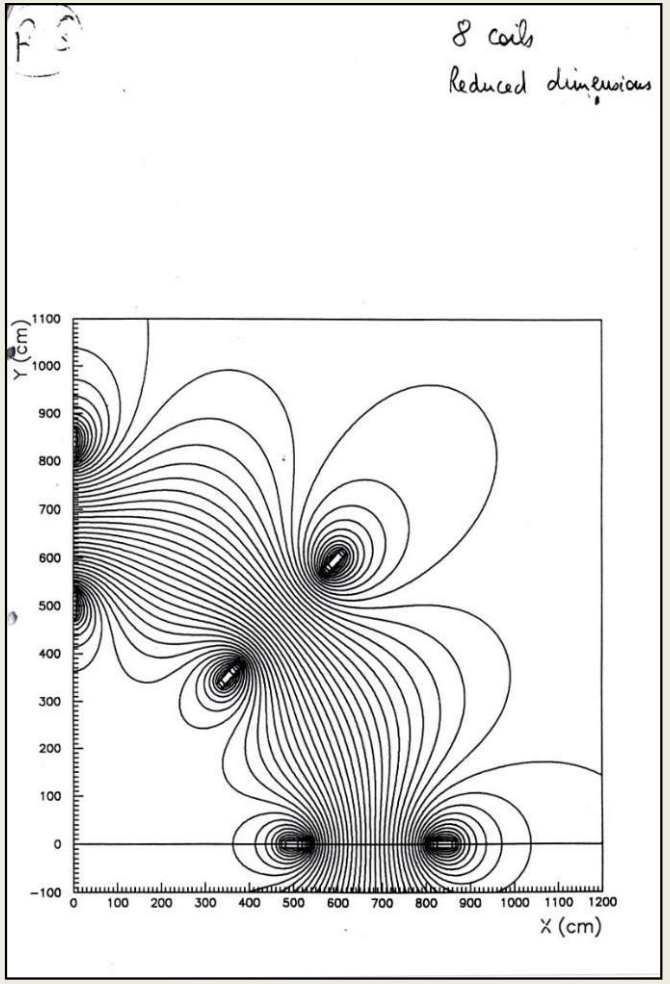


First reaction of the LHCC to the LoI in December 1992: It was well received, but a long saga started for ATLAS about costs and funding …

One of many ingredients… reduced number of coils from 12 to 8 in the toroid system







The LoI included various options for most of the detector subsystems, and in intense years choices had to be made

Daniel Fournier was very active and constructive in this process

Calorimeter Panel 1993

The panel met on seven occasions occupying 10 days during March to July 1993.

1.1 The Panel Membership

The panel consists of five independent members - T Akesson, J D Dowell (Chairman), N N Ellis, P R Norton and R Voss; six experts - D Fournier, B Mansoulie (Accordion); H Oberlack, P Schacht (TGT); M Nessi, F Vazeille (Scintillator Tiles); and the two spokesmen F Dydak, P Jenni (ex-officio).

As approved by the Collaboration Board on 10 September 1993

7 Recommendations

The following recommendations are made by the independent members of the panel:

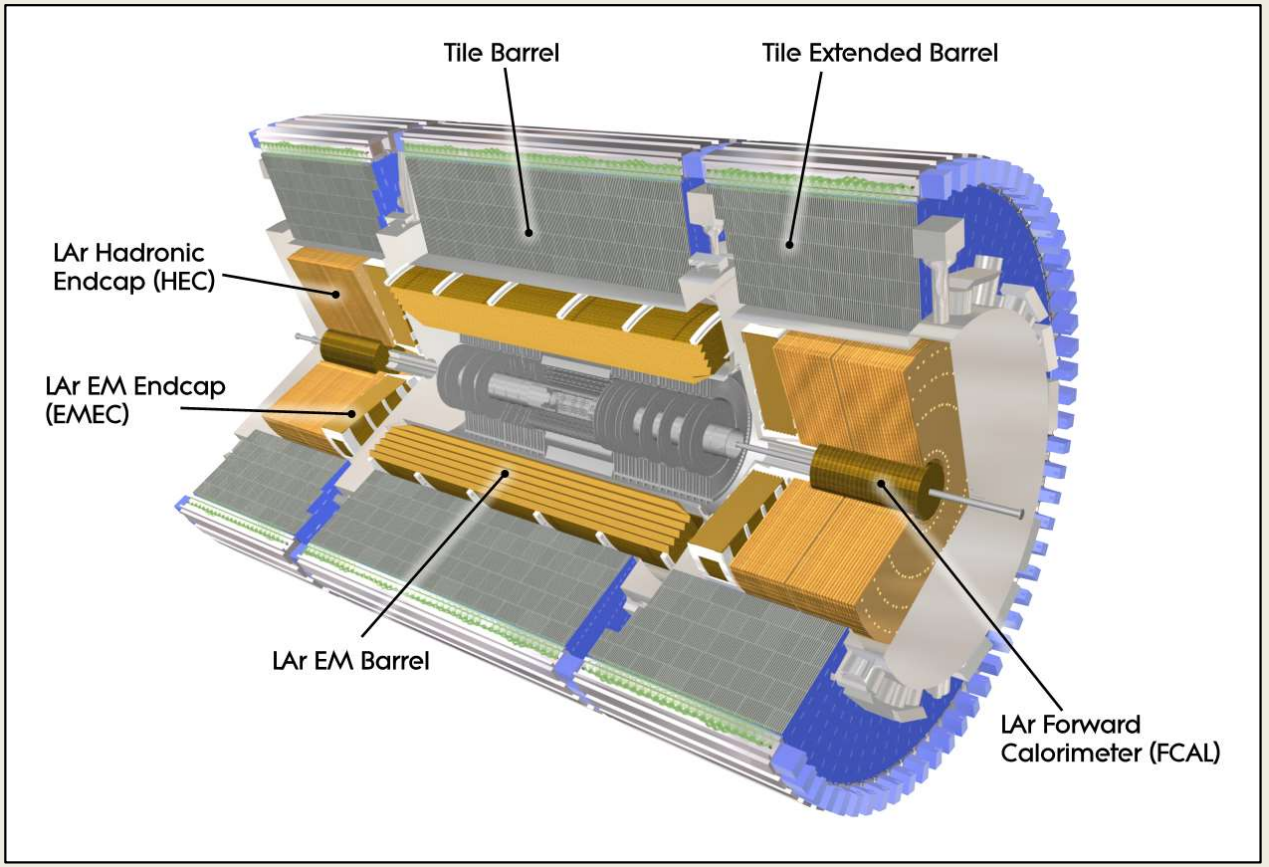
i) The ATLAS calorimeter should have an extended hadronic barrel calorimeter with liquid argon end plugs.

ii) The hadronic barrel calorimeter should be based on scintillating tiles only, including the extended barrel, subject to confirmation of the required performance in beam tests and Monte Carlo simulations.

iii) The baseline option for the electromagnetic end plugs should be the 'Spanish Fan' version of the accordion calorimeter, subject to the satisfactory demonstration of a prototype and the achievement of a constant term in the energy resolution of 0.5%.

Forward Calorimeter Panel 1994

It took one more year to select the technology for the forward calorimeter



1.1 The Panel Membership

The panel consists of 11 independent members - T Akesson, J D Dowell, (Chairman), N N Ellis, D Fournier, B Mansoulie, M Nessi, P Norton, H Oberlack, P Schacht, F Vazeille and R Voss; 4 experts - V Khovansky (liquid argon and liquid scintillator); S Denisov, A Vorobiev and A Zaitsev (high pressure gas); and the two spokespersons F Dydak, P Jenni (ex-officio).

The panel therefore recommends the integrated forward calorimeter as the choice for the Technical Proposal. Because of its intimate relation to the endcap calorimeter, it is further recommended that the work should be included in the overall liquid argon calorimetry organisation.

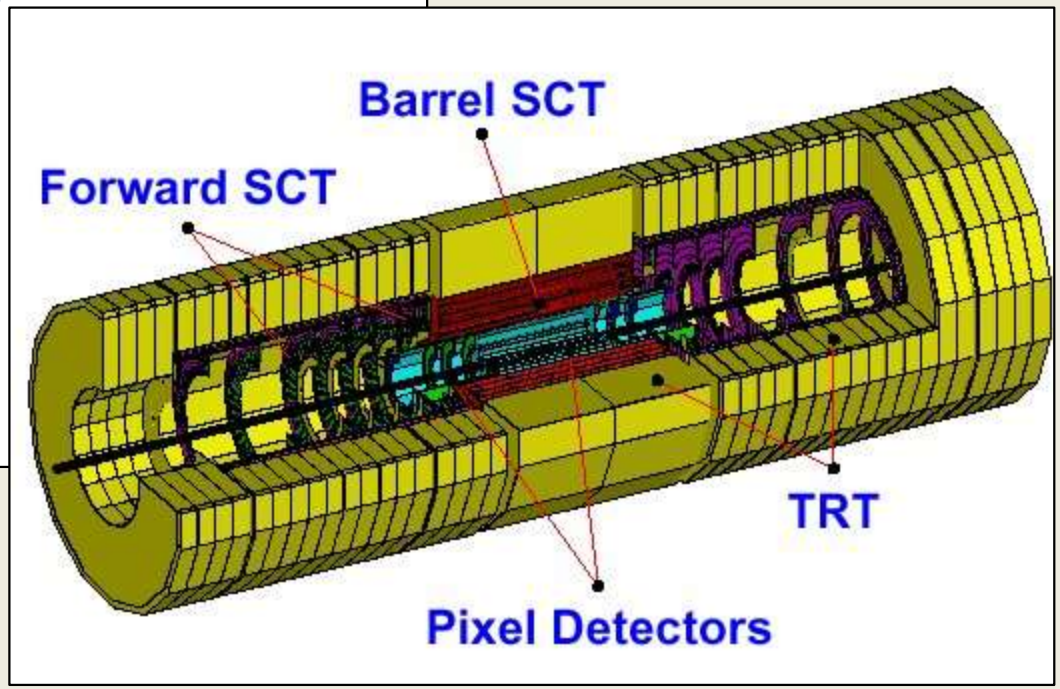
(26 Aug 1994)

Inner Detector Review Panel 1995

Daniel Fournier made decisive contributions to other systems, shaping the ATLAS detector well beyond the calorimetry

He chaired the Inner Detector Review Panel, in fact guiding the very diverse community of tracking experts, to arrive at a consensus

The baseline concept of the ATLAS tracking detector was approved by the Collaboration Board on 29 September 1995, which noted:



2. The CB chairman thanked Daniel Fournier, chairman of the Inner Detector Review Panel, and the panel members for their strong commitment and excellent work. The recommendation, which was reached unanimously by the Panel, was presented by Daniel Fournier in the Plenary meeting. The recommendation is:

But again, we were too expensive!

→ Act two of cost reduction:
the famous 'Pilcher' Task Force
for global descoping

A major ingredient was:

'Reduction of detector dimensions and magnetic fields, leading to an adequate safety margin in the cavern size'

Daniel, as LAr Project Leader, was not directly a member of the task force, but gave invaluable constructive input for arriving at a balanced overall detector

ATLAS Internal Note
Gen-No-014
24th November 1995

Report of the Global Descoping Task Force

Abstract

The work and recommendations of the ATLAS Global Descoping Task Force are presented. The revised configuration is believed to be one which retains good integrated physics performance of the detector and reduces the cost by 24.8 MCHF.

1

But again, we were too expensive!

→ Act two of cost reduction:
the famous 'Pilcher' Task Force
for global descoping

A major ingredient was:

'Reduction of detector dimensions and magnetic fields, leading to an adequate safety margin in the cavern size'

HOWEVER, AS WE SEE NOW WITH THE BENEFIT OF HINDSIGHT:

It was crucial to resist as much as possible to major descoping of specific detector systems, like for example the granularity of the calorimeters

Thanks to this ATLAS can exploit now with - at the time - unforeseen advanced analysis methods a lot of physics well beyond the initial dreams …

ATLAS Internal Note
Gen-No-014
24th November 1995

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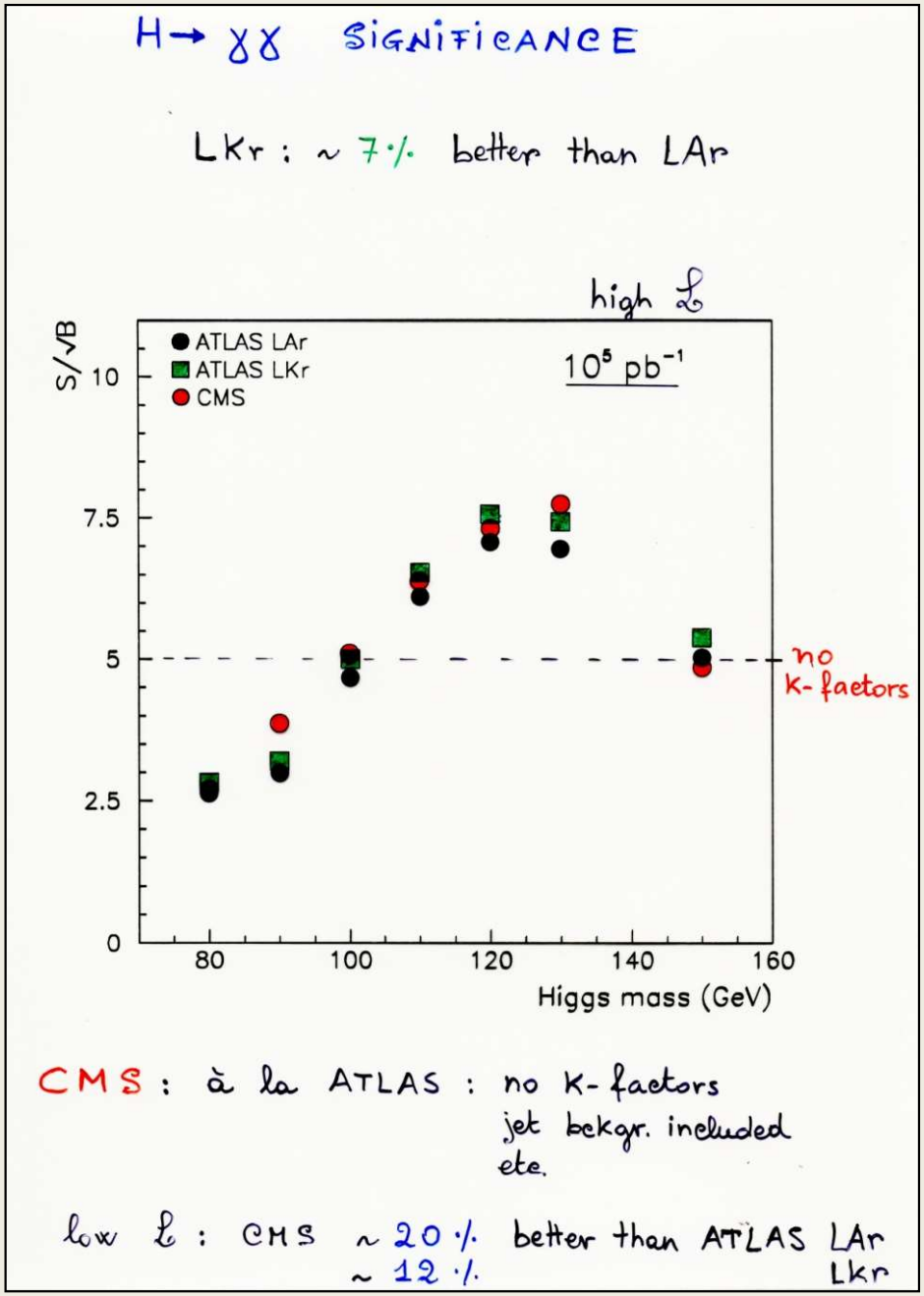
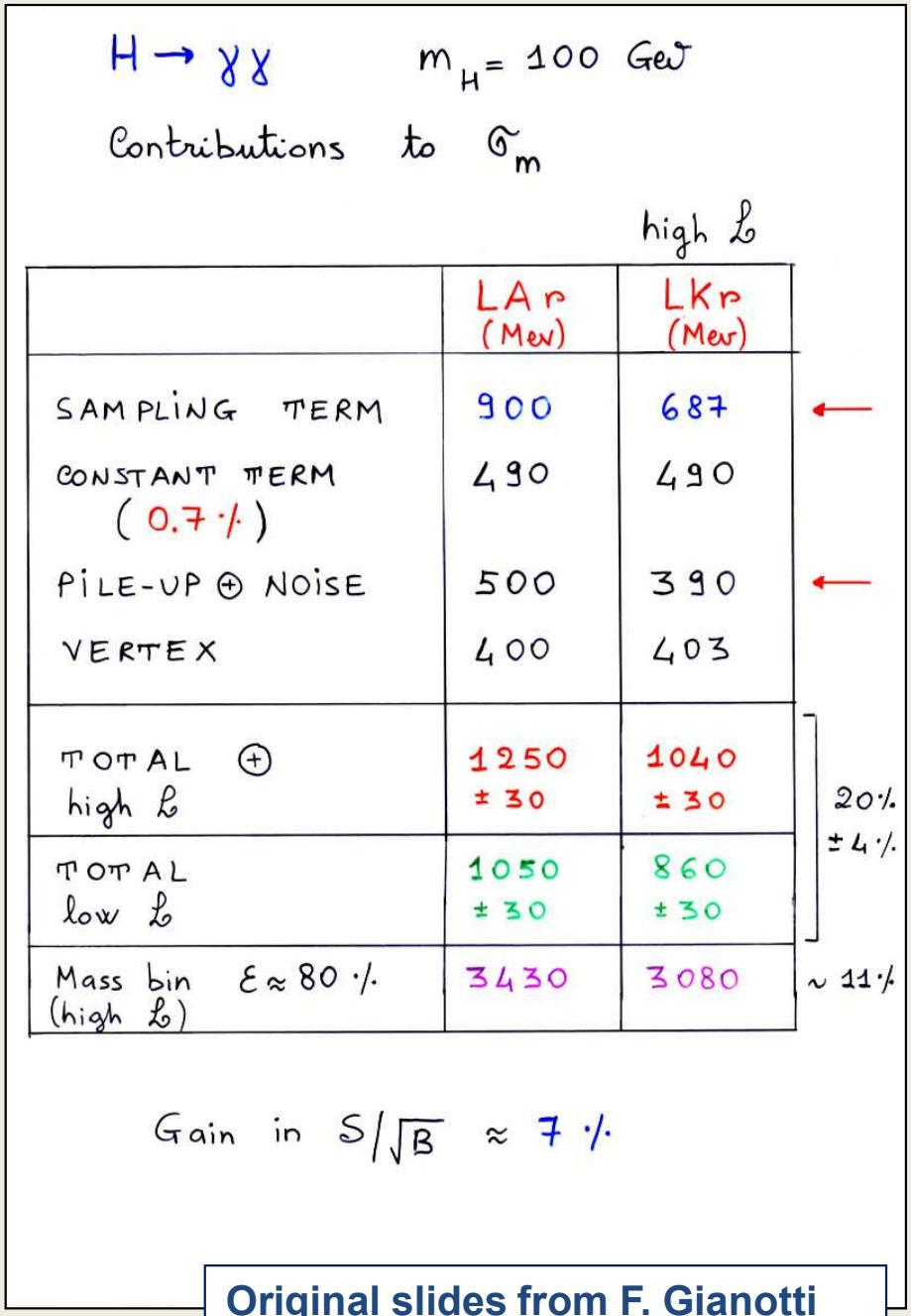
Abstract

The work and recommendations of the ATLAS Global Descoping Task Force are presented. The revised configuration is believed to be one which retains good integrated physics performance of the detector and reduces the cost by 24.8 MCHF.

1

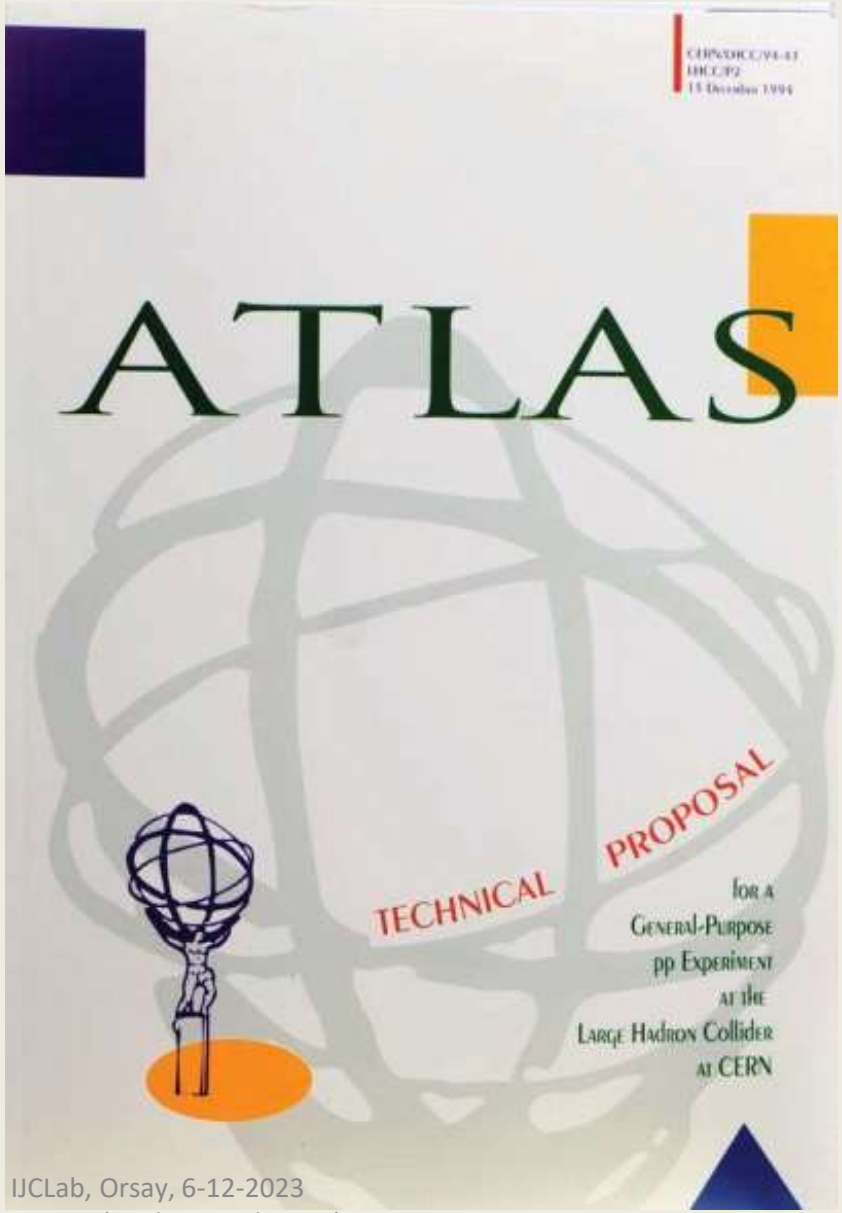
We had quite some intense discussions within the Collaboration and with the LHCC about performance issues in the 1990s, here as example on the EM resolution…



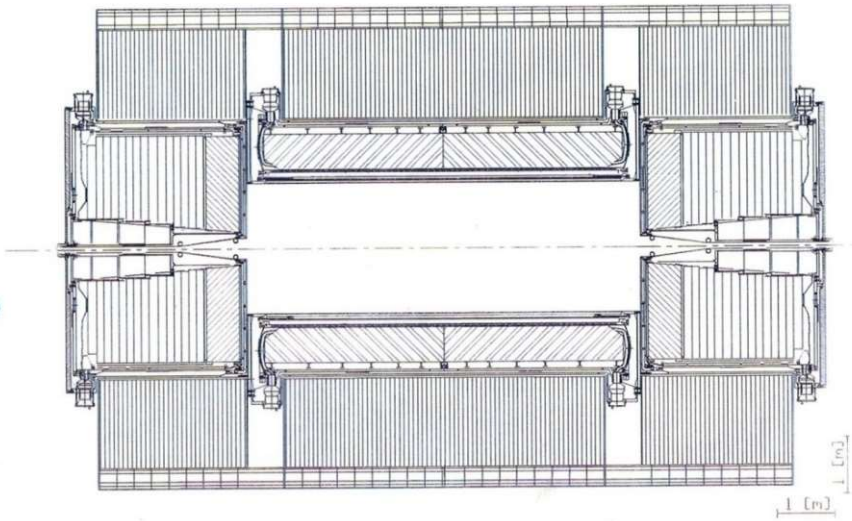


Original slides from F. Gianotti

Daniel presented the ATLAS Calorimetry TP at the LHCC on 19 January 1995



ATLAS calorimeter system

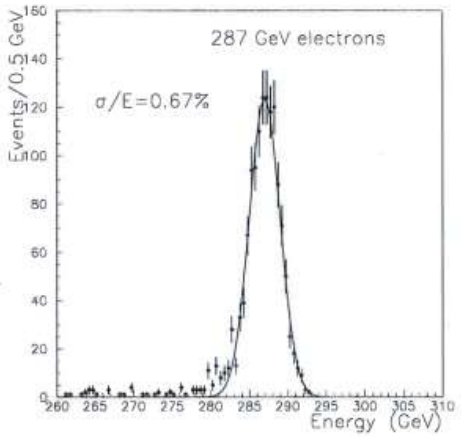


1. Outer dimension
   - $R_{out} = 4.23$ m
   - $\frac{1}{2} L_{out} = 6.70$ m
2. Solenoid and its return flux included
3. Cavity
   - $R_{in} = 1.15$ m
   - $\frac{1}{2} L_{in} = 3.45$ m
4. Weight
   - $W = 3500$ tons

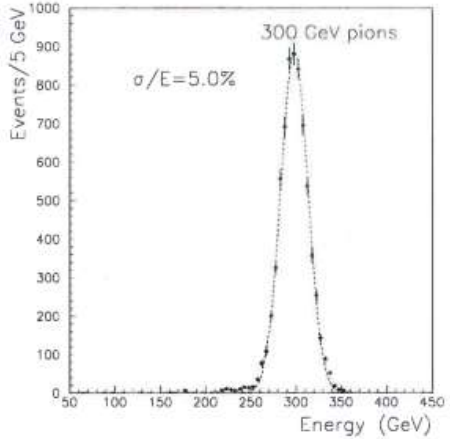
Two slides from the Daniel's calorimeter presentation (TP LHCC session)

Two Illustrative test beam results

- Electrons of 287 GeV in Liquid Argon Barrel prototype



- Pions of 300 GeV in combined Liquid Argon-Tile test



Conclusion

1. ATLAS Calorimeter system has a powerful physics potential
2. Understood from prototype results and detailed simulations
3. Still some choices to be made (barrel liquid, Electronics,...)
4. Team of about 50 labs capable of building it
5. Think construction can start very soon

The submission of the Technical Proposal was duly celebrated …

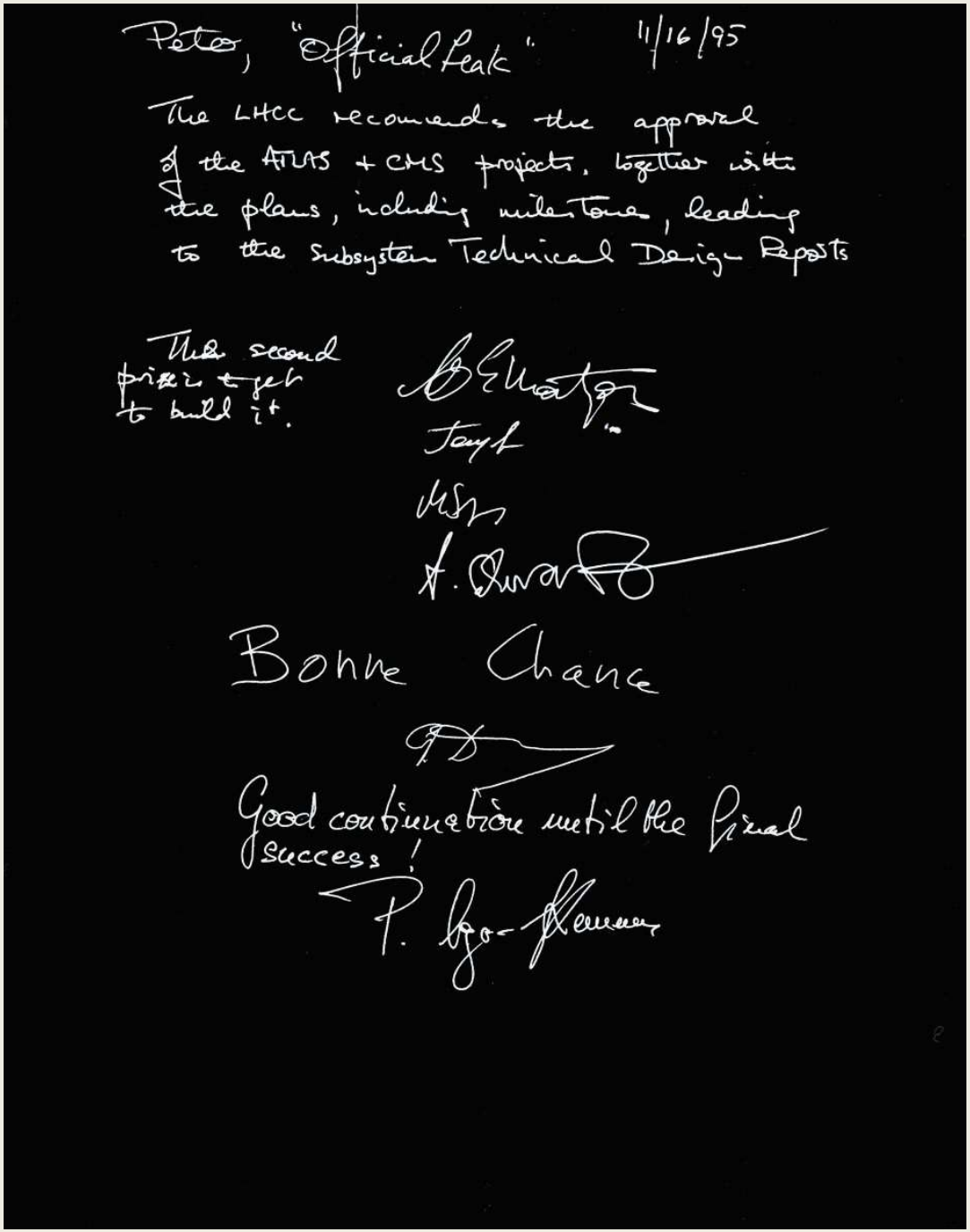
The Technical Proposal evaluations concluded by the end of 1995

It was a long way to convincing the LHC Experiment Committee (LHCC), but finally, on 16th November 1995, our referees were happy, and Hugh Montgomery, ATLAS main referee at that time, gave us the following 'official leak' from the committee…

ATLAS (and CMS) were invited then to work out Technical Design Reports for the various Sub-systems

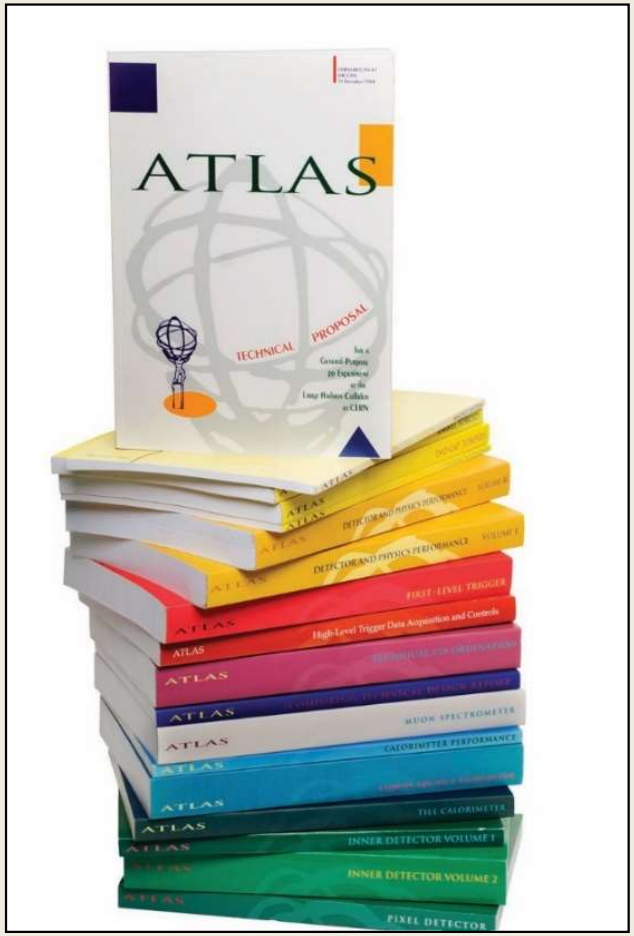
ATLAS: 17 volumes in total over the years !

TDR	Pages	Titles	Date
1	178	*Calorimeter Performance*	1996-12-15
2	606	*Liquid Argon Calorimeter*	1996-12-15
3	330	*Tile Calorimeter*	1996-12-15
4	256	*Inner Detector Vol 1*	1997-04-30
5	898	*Inner Detector Vol 2*	1997-04-30
6	101	*Magnet System*	1997-04-30
7	208	*Barrel Toroid*	1997-04-30
8	282	*End-Cap Toroids*	1997-04-30
9	85	*Central Solenoid*	1997-04-30
10	513	*Muon Spectrometer*	1997-05-31
11	317	*Pixel Detector*	1998-05-31
12	500	*First-Level Trigger*	1998-06-30
13	598	*Technical Coordination*	1999-01-31
14	458	*Detector and Physics Performance Vol 1*	1999-05-25
15	506	*Detector and Physics Performance Vol 2*	1999-05-25
16	370	*High-Level Trigger Data Acquisition and Controls*	2003-06-30
17	234	*Computing*	2005-03-18
Total	6440	pages	



The first three TDRs were about the calorimetry, and submitted on 15 December 1996

Daniel was of course centrally involved in that process



The formal construction approval was then given with the approval of the first TDRs

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
Laboratoire Européen pour la Physique des Particules
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Our Ref. DG/mnd/2540

Dr Peter Jenni
PPE Division
CERN

Geneva, 1st July 1997

Dear Peter,

Following the thorough discussion of the status of ATLAS and CMS by Council and its Committees two weeks ago, the way is now open for construction to begin. I am therefore pleased to inform you that I have decided to *i)* set the cost ceiling for ATLAS at 475 MCHF (1995 prices), and *ii)* approve the TDR of the ATLAS calorimeters on the following basis formulated by the LHCC and endorsed by the Research Board at its meeting on 12th June:

*"The LHCC **recommends general approval** of the ATLAS Calorimetry Technical Design Report describing design, performance, construction, and installation in 2004. The review **identified some concerns** in limited areas, which require resolution (LHCC 97–27). The LHCC considers that the schedules and milestones given in the TDR are reasonable, and these will be used by the committee to measure and regulate the future progress of the project."*

Yours sincerely,

Chris

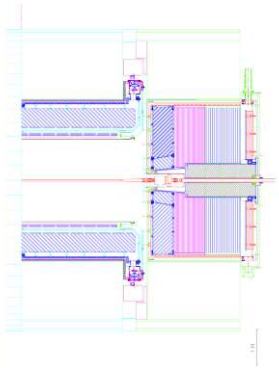
Chris Llewellyn Smith

cc: L Foà
E Iarocci

Here comes a little anecdote, told with an original slide from Fabiola Gianotti … (and I remember, it is a true story!)

The 3 Calorimeter TDRs (Liquid Argon, Tiles, Performance) were the first ones (out of a series of 15) submitted by ATLAS

Liquid Argon Calorimeter



Technical Design Report

Issue:	1
Revision:	0
Reference:	CERN/LHCC 96-41
Created:	15 December 1996
Last modified:	15 December 1996
Prepared By:	ATLAS LARG Unit

ATLAS
Liquid Argon Calorimeter

Technical Design Report
15 December 1996

1 Calorimeter overview

1.1 The Liquid Argon calorimeter in ATLAS

The calorimeter plays a central role in ATLAS. In the difficult environment of the LHC machine running at its full luminosity, the calorimeter is designed to trigger on and to provide precision measurements of electrons, photons, jets, and missing E_T.

The Liquid Argon sampling calorimeter technique with "accordion-shaped" electrodes is used for all electromagnetic calorimetry covering the pseudorapidity interval $|\eta| < 3.2$.

Original slide from Fabiola Gianotti

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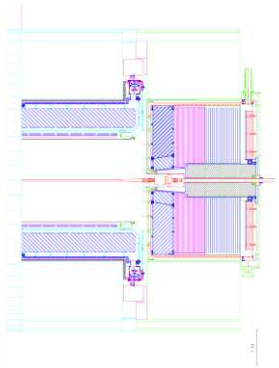
ATLAS

Liquid Argon Calorimeter



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Original slide from Fabiola Gianotti

The first version of this sentence (written by Daniel) was:
"The liquid-argon calorimeter is the masterpiece of ATLAS"
→ Peter Jenni, in his role as Spokesperson, managed to get it changed to "The calorimeter plays a central role in ATLAS" after long negotiations with Daniel

It was a long way to go from the paper reports to the real Calorimeter

A story that Bruno Mansoulié will tell

Just two pictures of two days I will never forget:

27 and 28 October 2004, the transport and lowering into the cavern of the completed LAr barrel calorimeter

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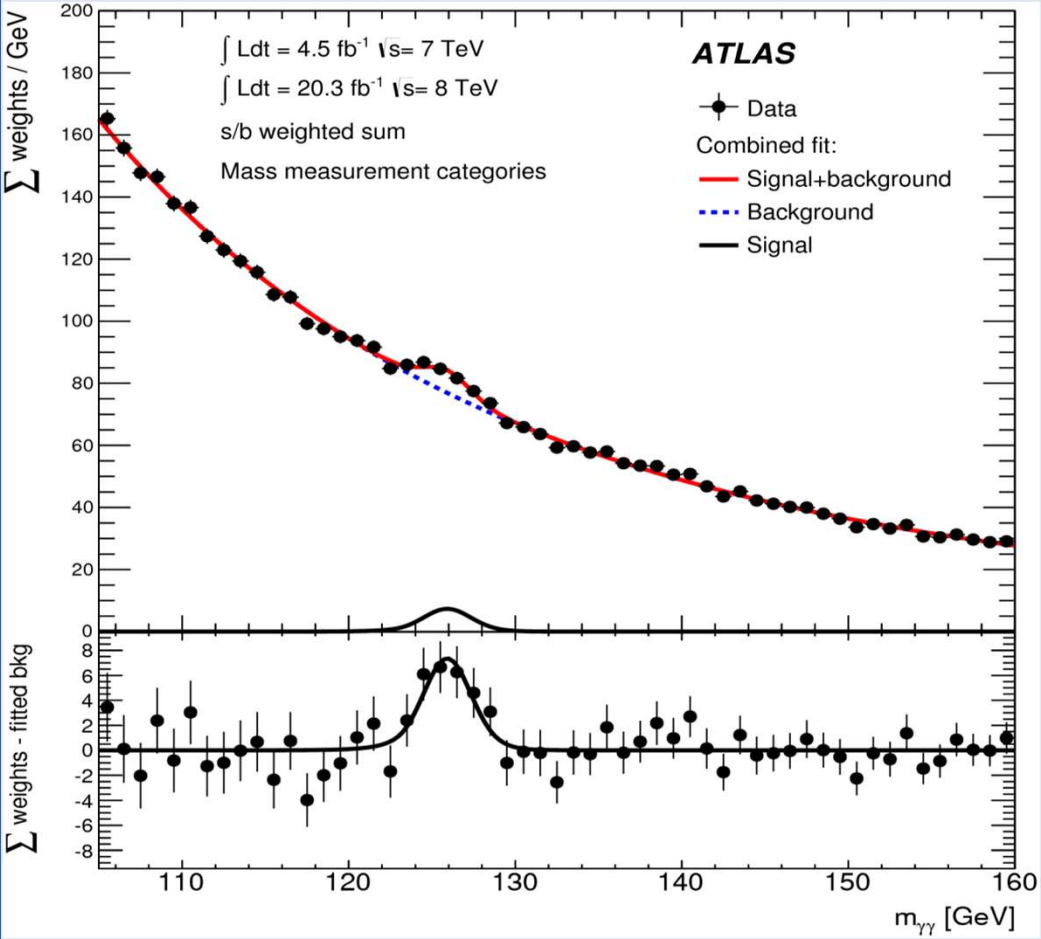
Formal ATLAS Leadership roles by Daniel related to the LAr calorimeter

LAr Project Leader 1994 – 2001

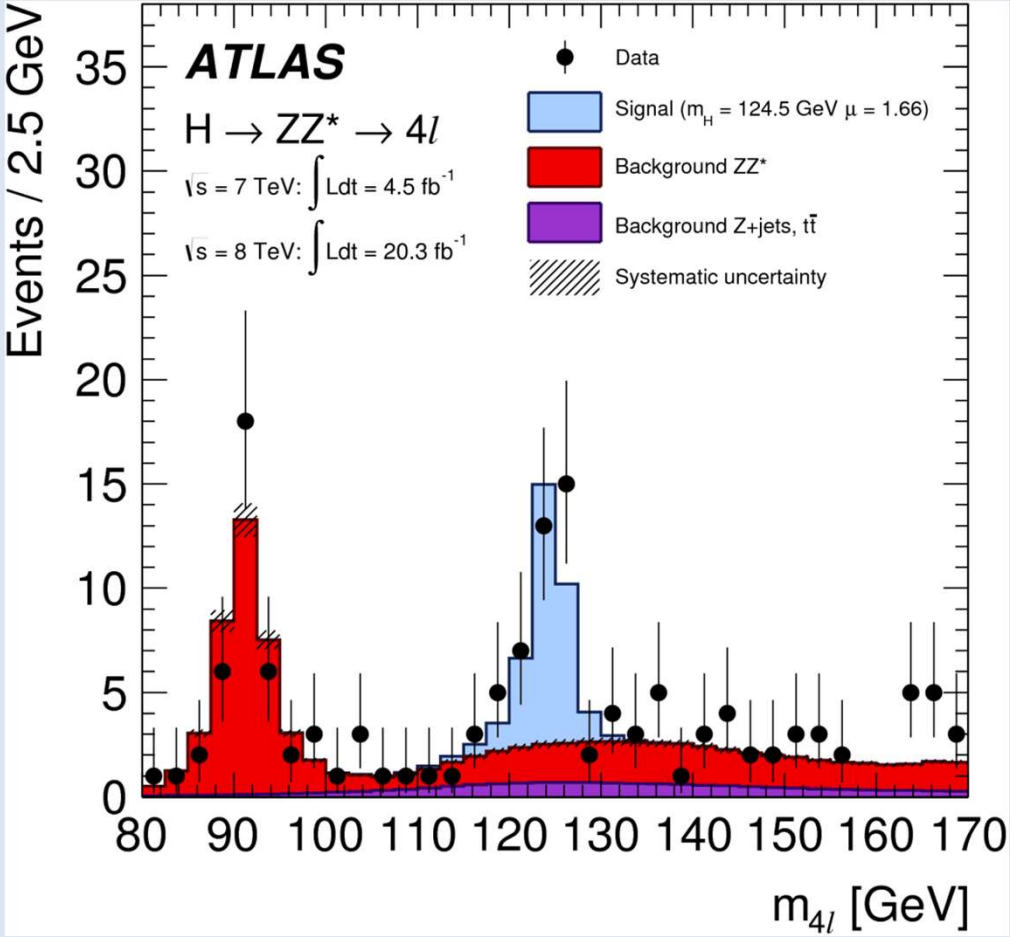
Executive Board 1994 – 2008

LHC Run-1 Higgs boson signal peaks ('Run-1 legacy')

H → γγ



H → ZZ(*) → 4l (4e, 4μ, 2e2μ)



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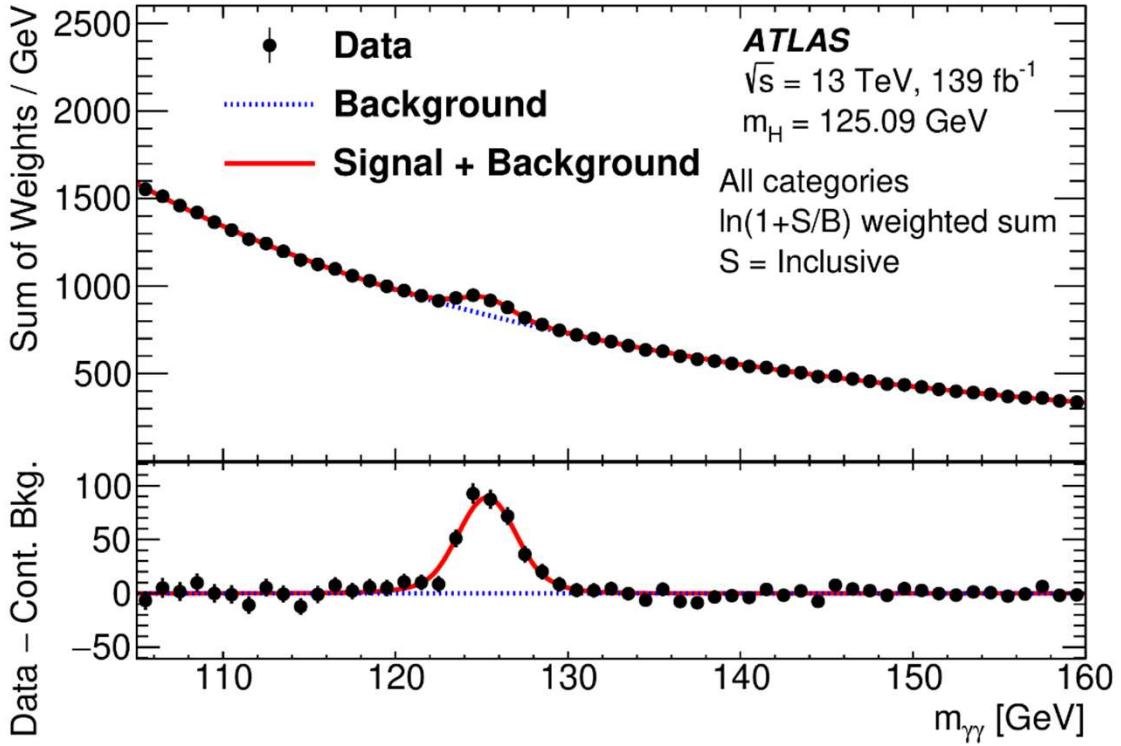
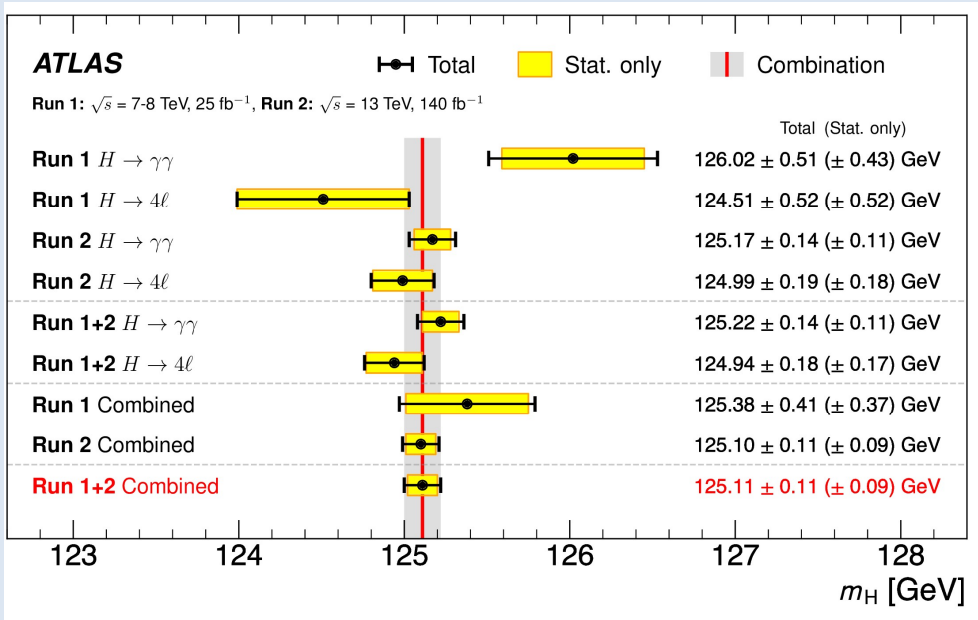
The LAr calorimeter continues to perform brilliantly, here the Run-2 results …

The full story that Jean Baptiste de Vivie will tell





JHEP 07 (2023) 088

Daniel Fournier has made since the very early, pioneering times a monumental impact on the ATLAS experiment

And, as we will hear, still does this today!

As a highly appreciated colleague he is at ease with the whole team that made ATLAS such a success, spanning from the technical staff to 'physics analyzers'

ATLAS owes him immense thanks!

And so do I, having had the joy of sharing very closely the early two decades of ATLAS

Cordial congratulations, Daniel, also in the name of the Collaboration, for this great and so well-deserved honour of receiving the prestigious Prix Lagarrigue 2023

Two pictures from 2003 and 2004
(Curtesy of Louis Fayard)

A message from Andreas Hoecker, ATLAS Collaboration Spokesperson:

I apologise that due to travel I am not able to join today's ceremony.

I hope Daniel is aware that he is a true hero for the next generation of ATLAS physicists, including myself. We are all very much aware that we owe the huge harvest of results and advances of particle physics since the inception of the LHC entirely the genius, dedication, energy and assertiveness of Daniel and other pioneers of the LHC and its experiments who made this project possible.

The liquid-argon calorimeter stands as the centerpiece of our fantastic ATLAS detector. Its excellent resolution, uniform and linear energy response, robustness, and stability under drastically changing beam conditions form the backbone of ATLAS physics and performance. Daniel will enjoy the latest Higgs to diphoton mass result with a systematic uncertainty of only 90 MeV. This achievement adds to the high-precision W mass measurement in the electron channel, which is both compatible and competitive with the muon channel.

Daniel's influence on the science we cherish extends far beyond the conception and construction of the liquid-argon calorimeter, encompassing his various roles at different levels in ATLAS, and his contributions to the CELLO and NA31 experiments. It is also reflected in the originality and rigor of his thinking, as well as his commitment to knowledge transmission. Although I didn't have the privilege of working under his direction, I can attest that whenever he made a comment in meetings or emails, we regarded it as a directive to think harder.

Daniel, I send you my most sincere congratulation on receiving the Prix Lagarrigue, and my admiration for your brilliant career.