

*Tracking the Elusive:
50 Years of High Precision
Measurements with
Luigi Rolandi*

The start and end (?) of ALEPH

Roberto TENCHINI

SNS – 7 November 2025



I have known Gigi since 1977 ...
About half a century ago ...

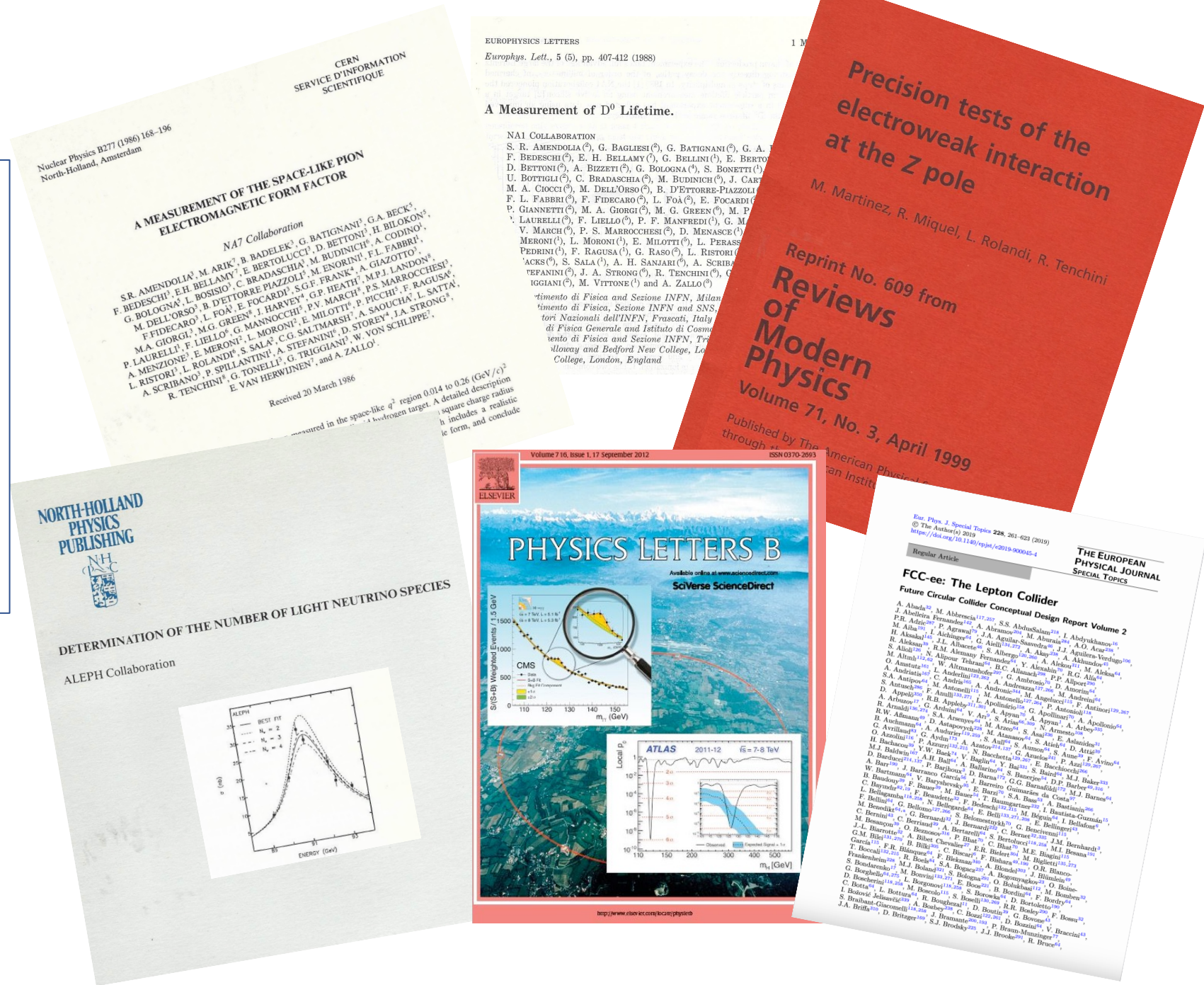
I met him for the first time when
he was “esercitatore” (assistant)
of FISICA IX (YES 9 !!!)
The physics course of Lorenzo Foà
at SNS

He was second year at
Perfezionamento SNS and he was
teaching students at SNS 1st year
“corso ordinario” how to solve
rather complex classical
mechanics problems
(well it was Fisica 9, not Fisica 1 !!)



Roberto 1977,
the year I met Gigi

I spent my entire physics career with Gigi and I share 96% of my publications with him
(source INSPIRE)



Skipping NA1, NA7, NA29, etc. already covered ... and coming to the start of ALEPH

Skipping also TPC construction (Francesco R.) and what has been covered already by Ramon

The first thing I remember from Gigi at LEP, not linked to the TPC ...





1985 : Toponium

MPI-PAE/PTh 85/85

December 1985

TOPONIUM PHYSICS AT LEP

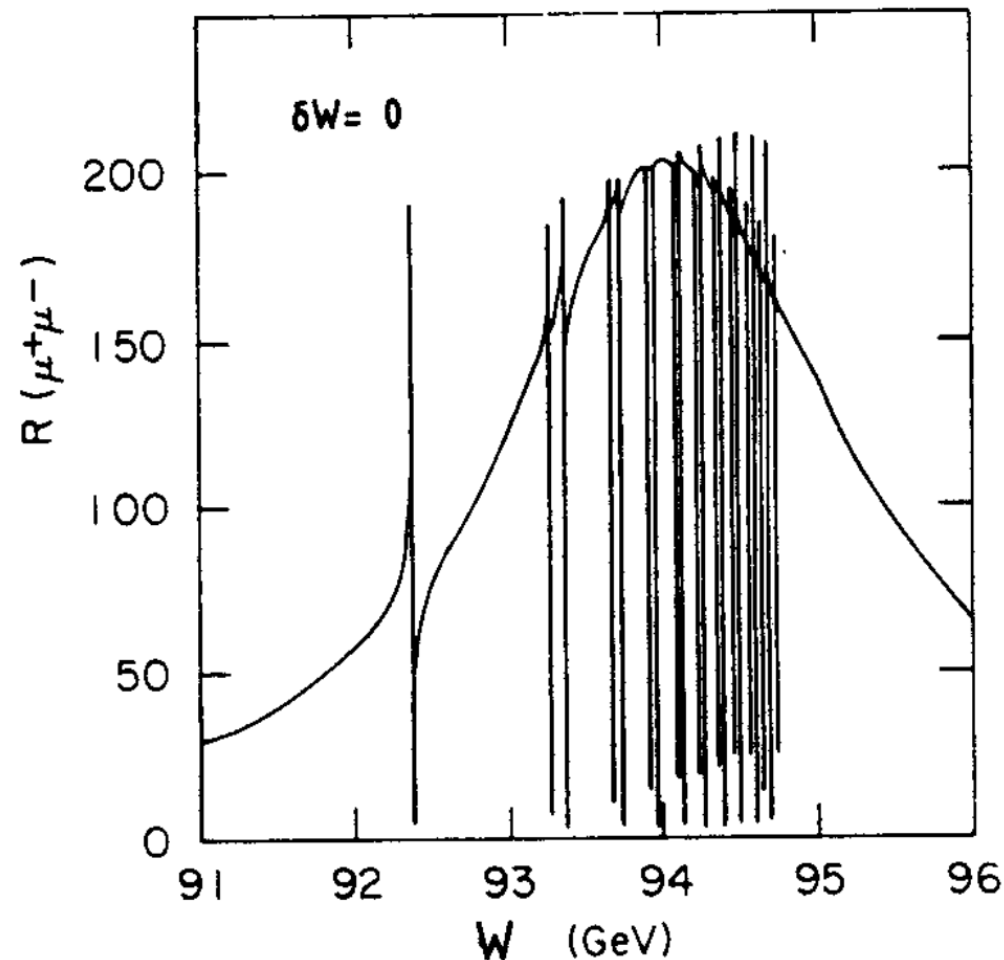
W. Buchmüller, A. Martin
CERN, Geneva, Switzerland

J.H. Kühn
Max-Planck-Institut für Physik und Astrophysik
8000 München, Fed.Rep.Germany

F. Richard, P. Roudeau
LAL, Orsay, France

G. Coignet
LAPP, Annecy, France

L. Rolandi
University of Trieste, Italy



Interference between the Z (94 GeV in this plot !) and toponium with top mass of 47 GeV

After 40 years ! Toponium at CMS ! (not θ but η_t)

OPEN ACCESS

IOP Publishing

Rep. Prog. Phys. **88** (2025) 087801 (25pp)

Reports on Progress in Physics

<https://doi.org/10.1088/1361-6633/adf7d3>

Observation of a pseudoscalar excess at the top quark pair production threshold

The CMS Collaboration

CERN, Geneva, Switzerland

E-mail: cms-publication-committee-chair@cern.ch

Received 28 March 2025, revised 23 July 2025

Accepted for publication 5 August 2025

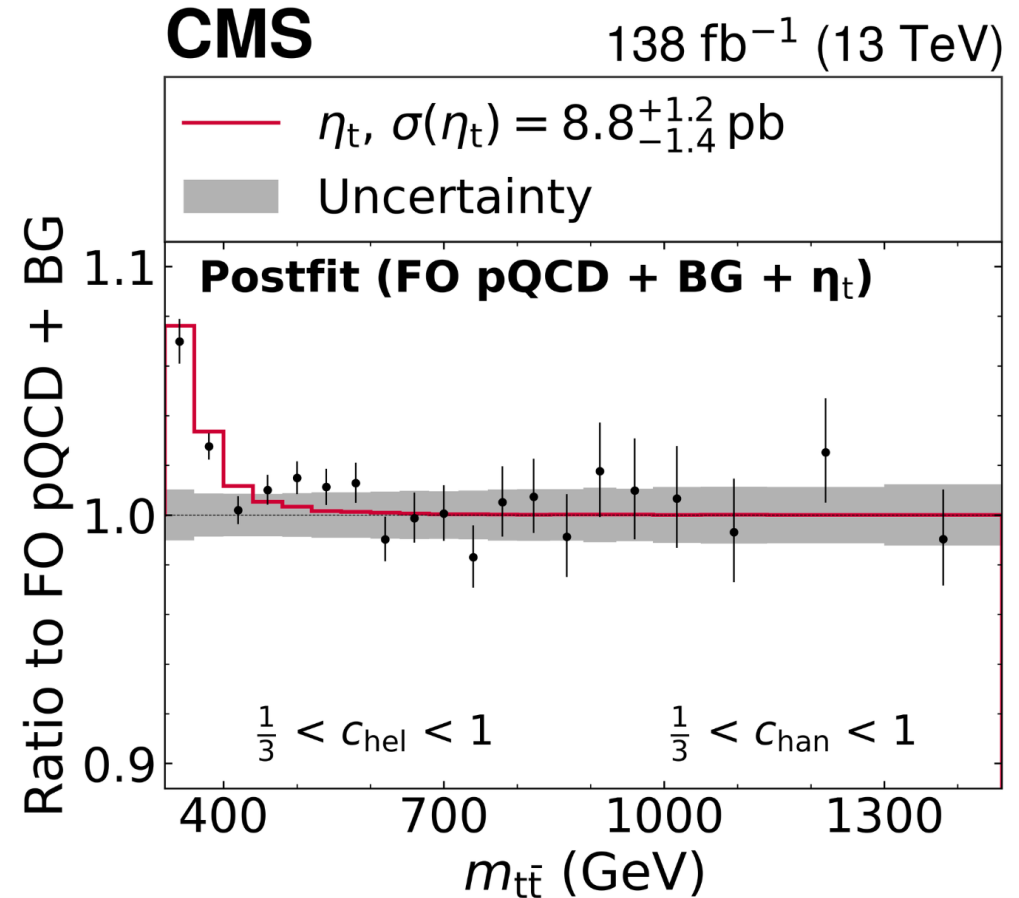
Published 22 August 2025

Corresponding editor: Dr Lorna Brigham



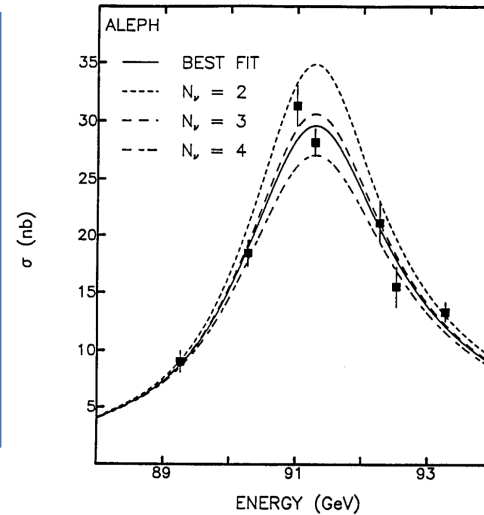
Abstract

A search for resonances in top quark pair ($t\bar{t}$) production in final states with two charged leptons and multiple jets is presented, based on proton–proton collision data collected by the CMS experiment at the CERN LHC at $\sqrt{s} = 13$ TeV, corresponding to 138 fb^{-1} . The analysis explores the invariant mass of the $t\bar{t}$ system and two angular observables that provide direct access to the correlation of top quark and antiquark spins. A significant excess of events is observed near the kinematic $t\bar{t}$ threshold compared to the non-resonant production predicted by fixed-order perturbative quantum chromodynamics (pQCD). The observed enhancement is consistent with the production of a color-singlet pseudoscalar ($^1S_0^{[1]}$) quasi-bound toponium state, as predicted by non-relativistic quantum chromodynamics. Using a simplified model for $^1S_0^{[1]}$ toponium, the cross section of the excess above the pQCD prediction is measured to be $8.8^{+1.2}_{-1.4} \text{ pb}$.



The N_ν race: LEP vs SLC

Aleph:	$N = 3.27 \pm 0.30$
Delphi:	$N = 2.40 \pm 0.64$
Opal:	$N = 3.12 \pm 0.42$
L3:	$N = 3.42 \pm 0.48$



Mark II 91.17 ± 0.18 $N_\nu = 2.7 \pm 0.7$

Ioanna Videau about Gigi: “You stayed awake for something like 50 hours because it was absolutely crucial for you to see the first Z in Aleph.”



Physics Letters B

Volume 231, Issue 4, 16 November 1989, Pages 519-529



Determination of the number of light neutrino species

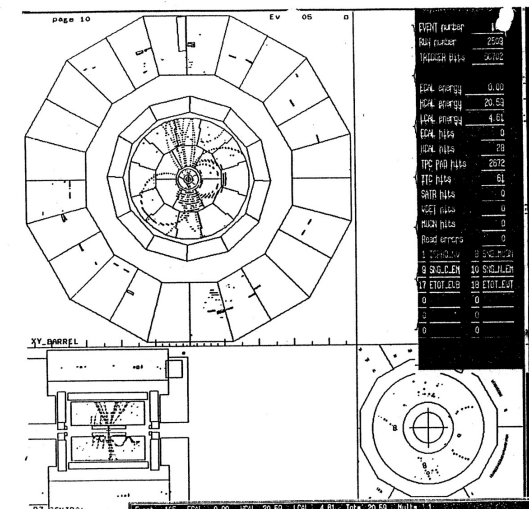
ALEPH Collaboration, D. DeCamp, B. Deschizeaux, J.-P. Lees, M.-N. Minard, J.M. Crespo, M. Delfino, E. Fernandez¹, M. Martinez, R. Miquel, M.L. Mir, S. Orteu, A. Pacheco, J.A. Perlas, E. Tubau, M.G. Catanesi, M. de Palma, A. Farilla, G. Iaselli, G. Maggi...G. Zobernig

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[https://doi.org/10.1016/0370-2693\(89\)90704-1](https://doi.org/10.1016/0370-2693(89)90704-1)

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Tau physics: polarizzazione, branching ratios, etc

Gigi Rolandi first convener of tau physics in ALEPH (with M. Davier and C. Geweniger)

OPEAN ORGANIZATION FOR NUCLEAR RESEARCH (CERN)

CERN-EP/2001-027
March 2, 2001

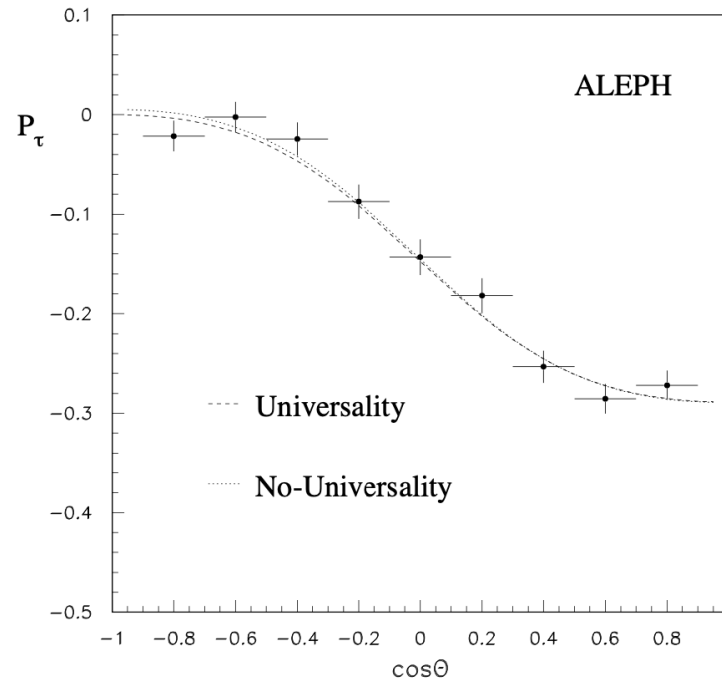
Branching Ratios and Spectral Functions of τ Decays: Final ALEPH Measurements and Physics Implications

The ALEPH Collaboration¹

Abstract

The full LEP-1 data set collected with the ALEPH detector at the Z pole during 1991-1995 is analysed in order to measure the τ decay branching fractions. The analysis follows the global method used in the published study based on 1991-1993 data, but several improvements are introduced, especially concerning the treatment of photons and π^0 's. Extensive systematic studies are performed, in order to match the large statistics of the data sample corresponding to over 300 000 measured and identified τ decays. Branching fractions are obtained for the two leptonic channels and eleven hadronic channels defined by their respective numbers of charged particles and π^0 's. Using previously published ALEPH results on final states with charged and neutral kaons, corrections are applied to the hadronic channels to derive branching ratios for exclusive final states without kaons. Thus the analyses of the full LEP-1 ALEPH data are combined to yield a complete description of τ decays, encompassing 22 non-strange and 11 strange hadronic modes. Some physics implications of the results are given, in particular related to universality in the leptonic charged weak current, isospin invariance in a_1 decays, and the separation of vector and axial-vector components of the total hadronic rate. Finally, spectral functions are determined for the dominant hadronic modes and updates are given for several analyses. These include: tests of isospin invariance between the weak charged and electromagnetic hadronic currents, fits of the ρ resonance lineshape, and a QCD analysis of the nonstrange hadronic decays using spectral moments, yielding the value $\alpha_s(m_\tau^2) = 0.340 \pm 0.005_{\text{exp}} \pm 0.014_{\text{th}}$. The evolution to the Z mass scale yields $\alpha_s(M_Z^2) = 0.1209 \pm 0.0018$. This value agrees well with the direct determination from the Z width and provides the most accurate test to date of asymptotic freedom in the QCD gauge theory.

(Submitted to Physics Reports)



**He did personally
precise measurements
of tau cross sections ...
... at the end of ALEPH
referee of the main tau
papers**

Measurement of the Tau Polarisation at LEP

The ALEPH collaboration*

Abstract

The polarisation of τ 's produced in Z decay is measured using 160 pb^{-1} of data accumulated at LEP by the ALEPH detector between 1990 and 1995. The variation of the polarisation with polar angle yields the two parameters $\mathcal{A}_e = 0.1504 \pm 0.0068$ and $\mathcal{A}_\tau = 0.1451 \pm 0.0059$ which are consistent with the hypothesis of e - τ universality. Assuming universality, the value $\mathcal{A}_{e-\tau} = 0.1474 \pm 0.0045$ is obtained from which the effective weak mixing angle $\sin^2 \theta_W^{\text{eff}} = 0.23147 \pm 0.00057$ is derived.

To be submitted to The European Physical Journal C

*See next pages for the list of authors.

Tau, Energy Flow (*Particle Flow*) and everything else

ALEPH was just the ideal apparatus for tau physics at the time;

- Excellent tracking (TPC)
- High granularity e.m. calorimeter
- VDET for tau lifetime

Tracks and calorimeters were combined for the very first time with an algorithm, called Energy Flow at the time and nowadays known as *Particle Flow*

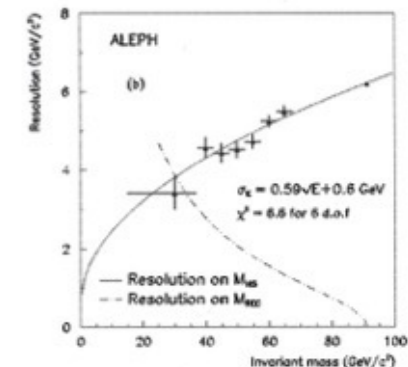
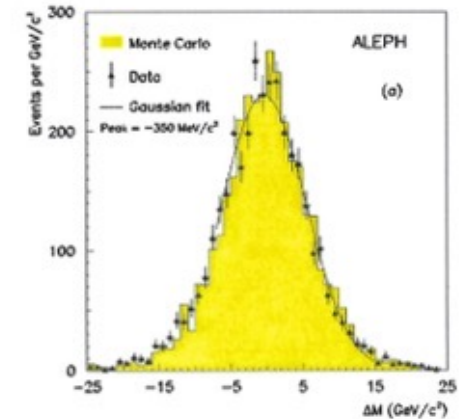
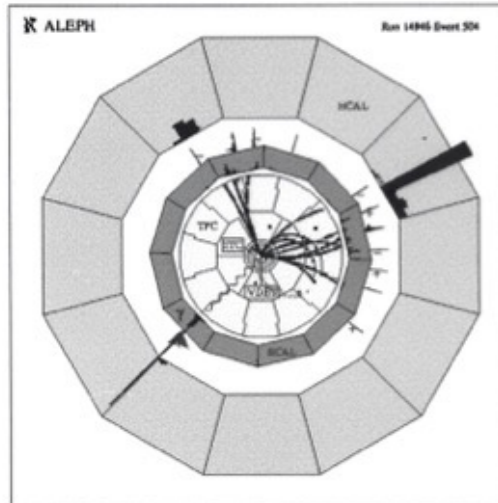
Used for many and eventually all Aleph measurements

Gerri Ganis, [Patrick Janot](#)

Related work on reconstruction:
Giuseppe Bagliesi, Vincent Bertin, Alain Bonissent, R.T.

Energy Flow Performance studied with data

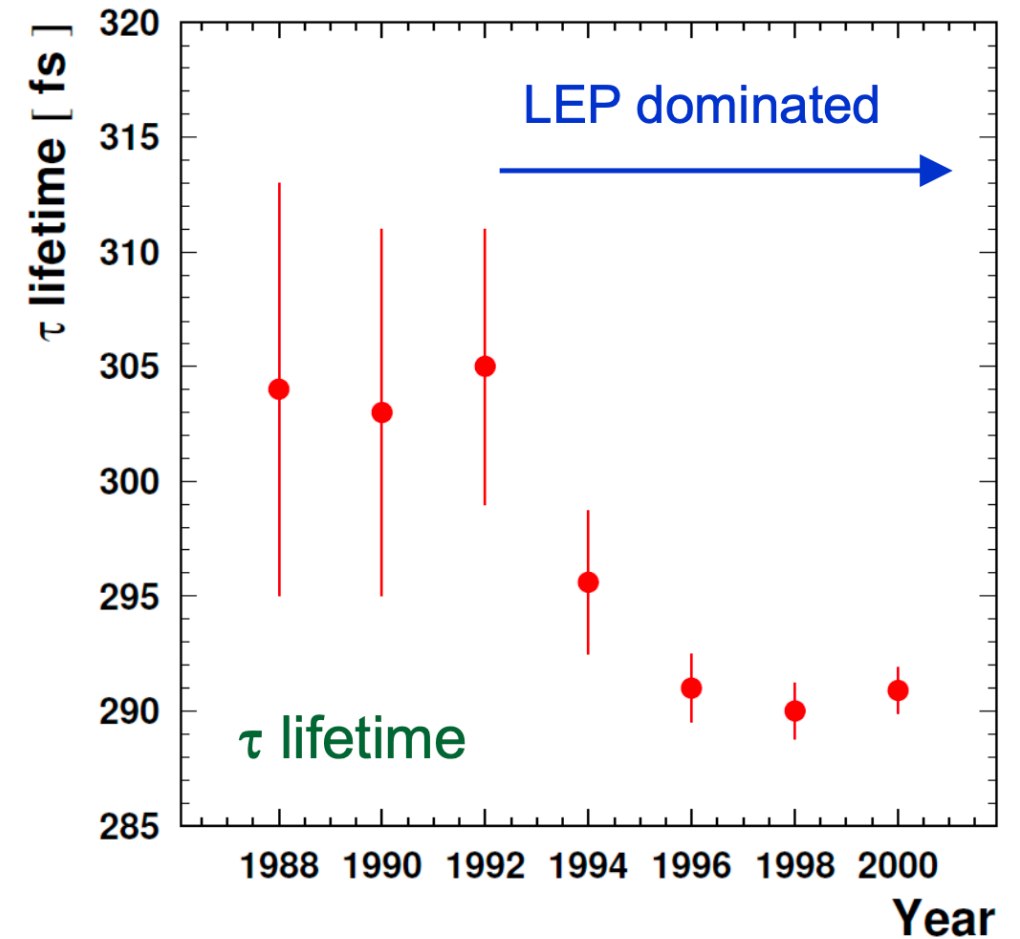
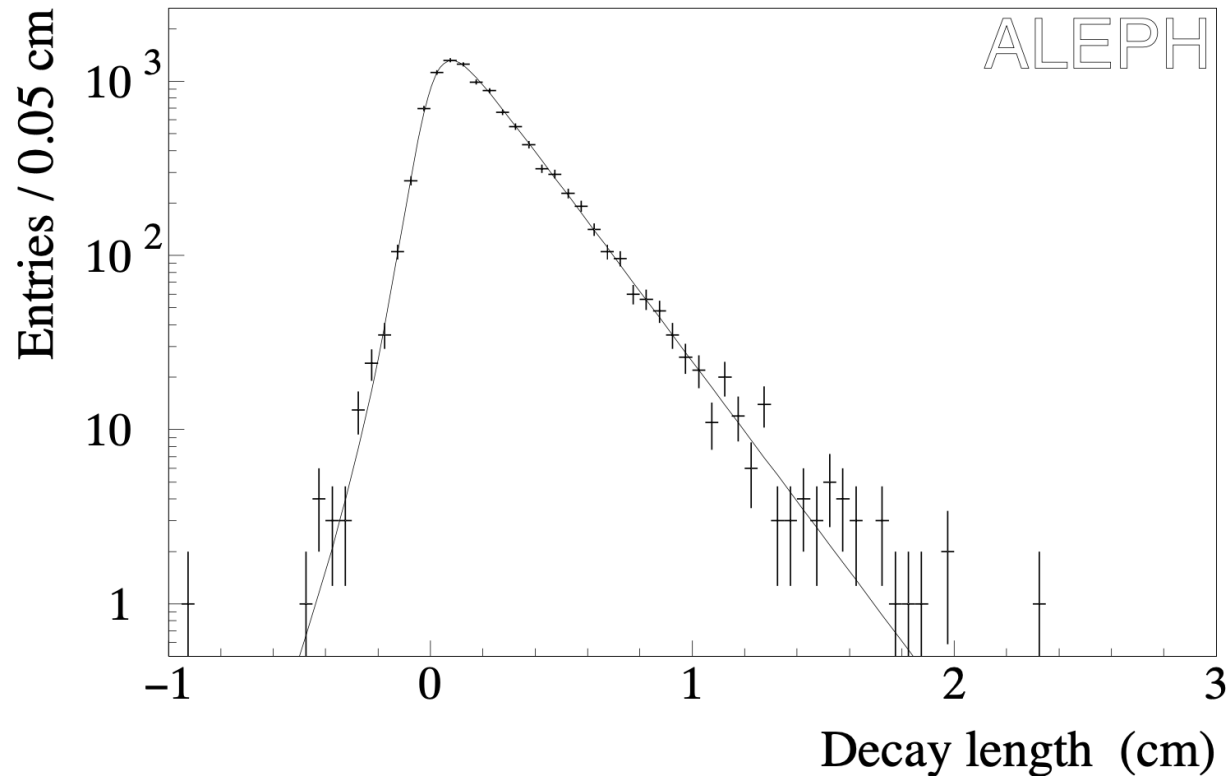
Tool: radiative events



(Gigi was spokesperson in this period)

Tau lifetime

Francesco Fidecaro, Isidoro Ferrante,
Alberto Lusiani, Alberto Messineo,
Andrea Sciabà
Steve Wasserbaech



Molte tecniche utilizzate : impact parameter sum(MIPS) method, the impact parameter difference (IPD) method, and the decay length (DL) method , 3-D method

(Gigi was spokesperson in this period)

Neutrino tau mass limit

Fabio Cerutti, Luca Passalacqua

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN PPE/95.03
13 January 1995

An upper limit for the τ neutrino mass
from $\tau \rightarrow 5\pi(\pi^0)\nu_\tau$ decays.

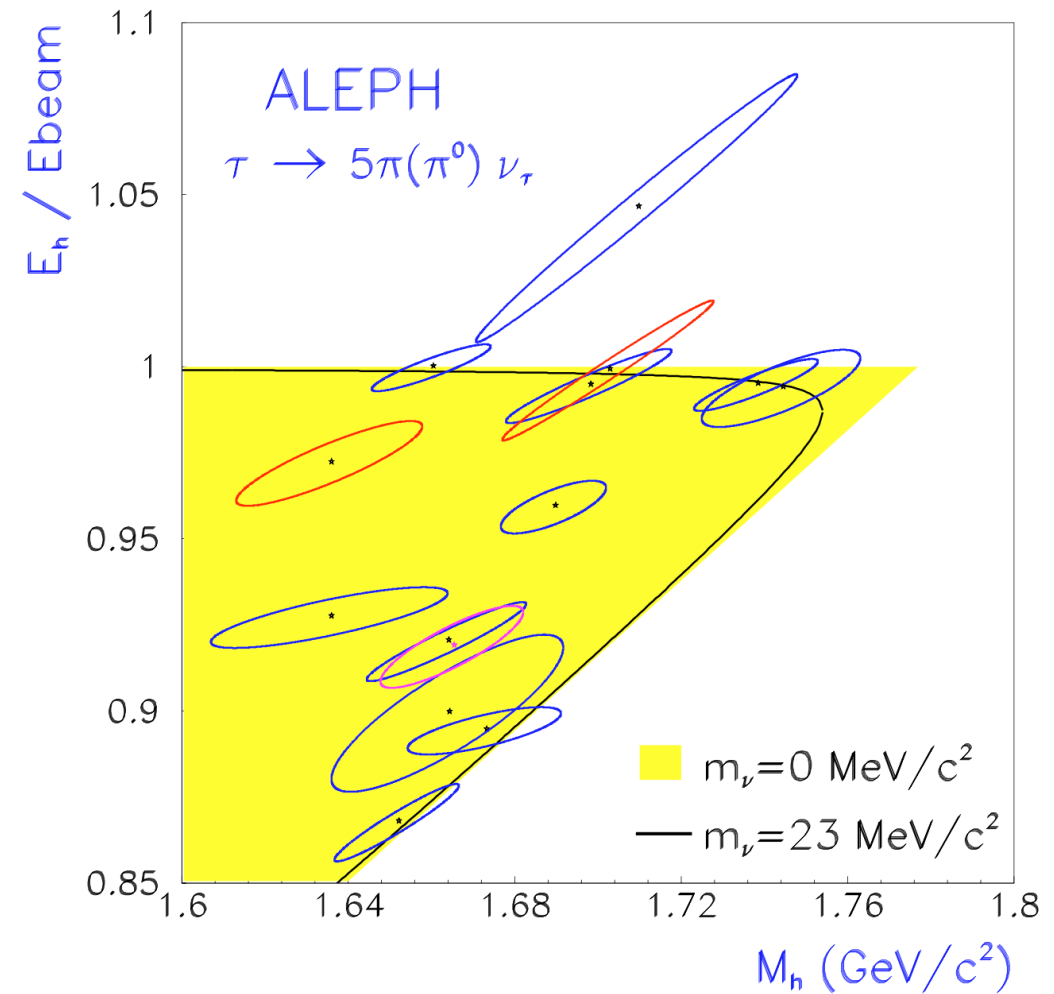
The ALEPH Collaboration*

Abstract

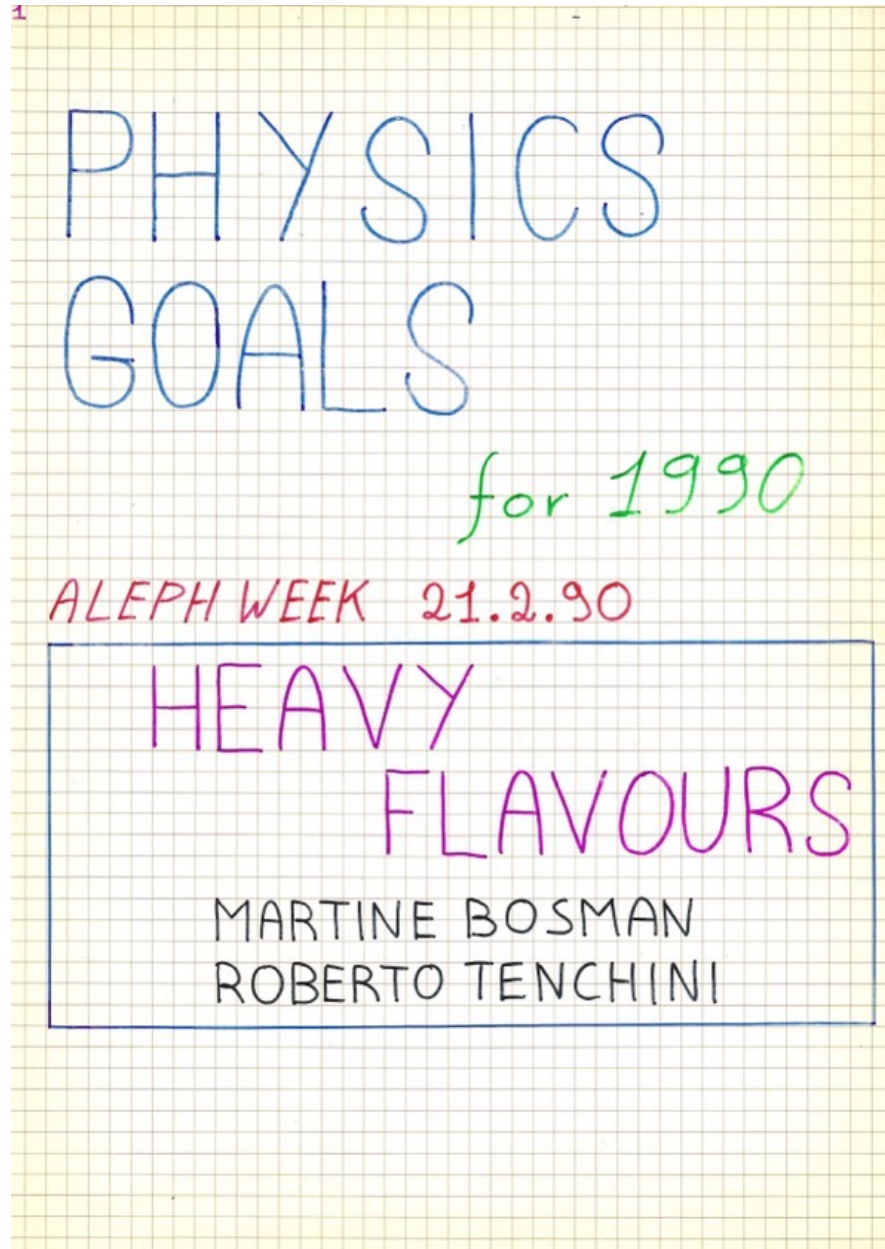
From a sample of 152,000 τ decays collected by the ALEPH detector at LEP an upper limit of 24 MeV at 95% CL on the τ neutrino mass has been determined. The limit is obtained using a two dimensional likelihood fit of the visible energy and the invariant mass distribution of 25 $\tau \rightarrow 5\pi(\pi^0)\nu_\tau$ events.

(To be submitted to Physics Letters B)

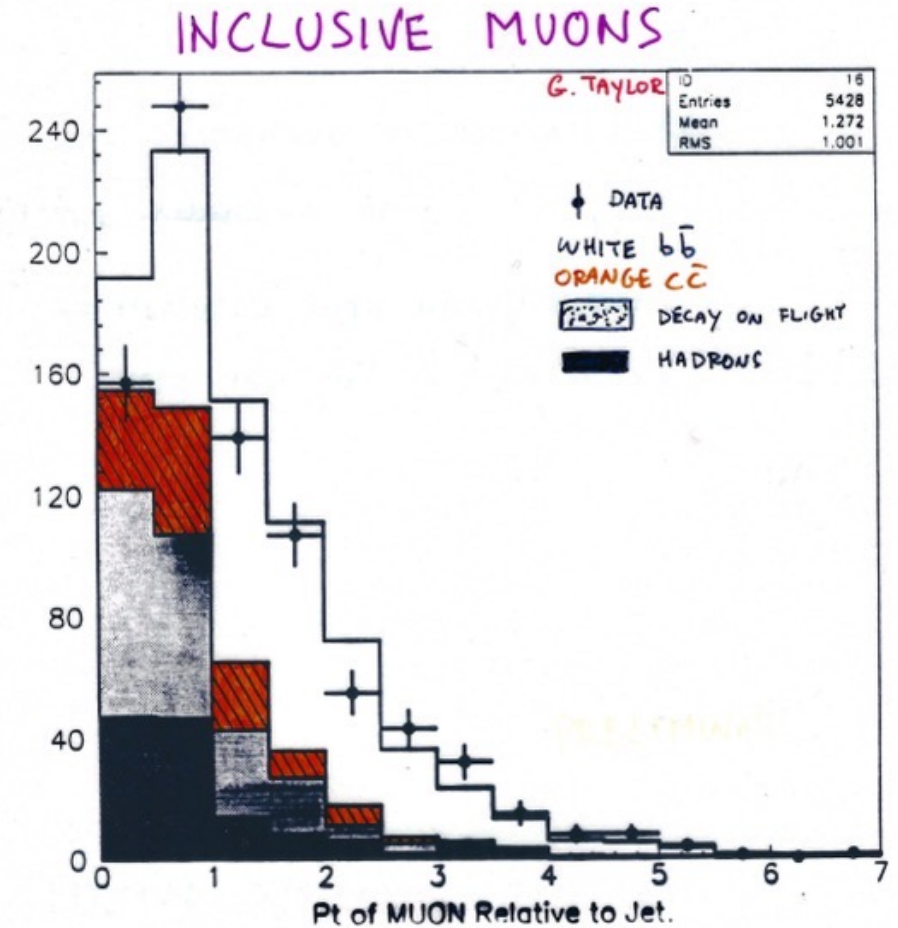
*See the following pages for the list of authors.



Heavy Quarks before VDET

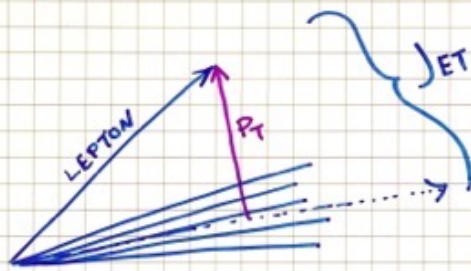


I remember presenting these slides during a “Gigi meeting”, then called Tuesday meeting and the Thursday meeting



4

- P_T definition



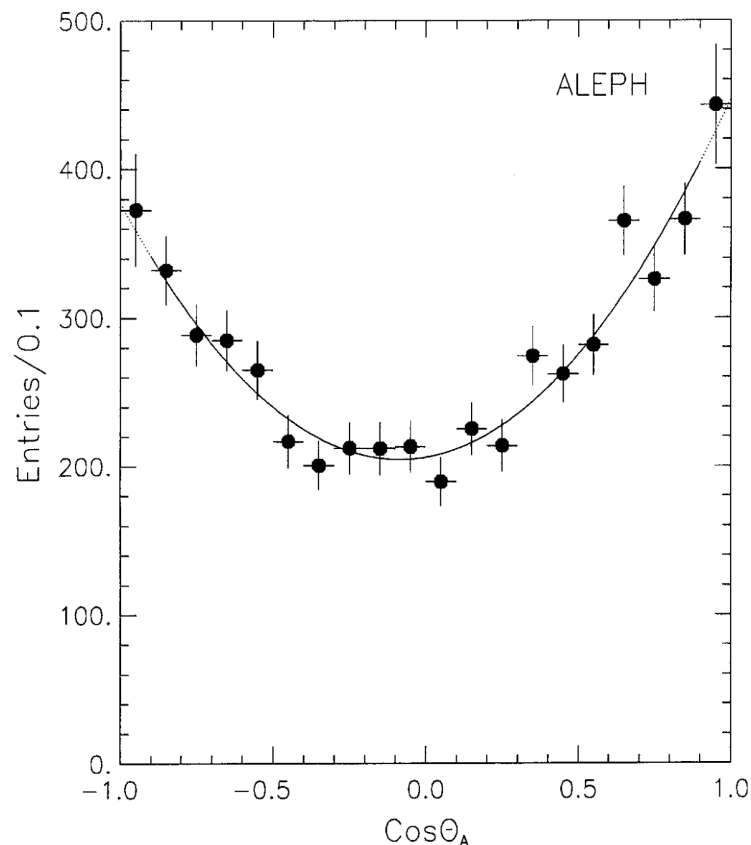
- $$\begin{cases} P_{LEPTON} > 3 \text{ GeV}/c \\ P_T > 1.3 \text{ GeV}/c \end{cases}$$

INCLUDENDO IL LEPTONE

ESCLUDENDO IL LEPTONE

- ALGORITMO PER i JET : SI AGGIUNGONO PARTICELLE FINO A QUANDO $M_{INV} < M_{CUT} \sim M_b$

- Important use of Energy Flow (now known as Particle Flow) for jet direction



EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-PPE/91-71
22 April 1991

Measurement of the Forward-Backward Asymmetry in $Z \rightarrow b\bar{b}$ and $Z \rightarrow c\bar{c}$

The ALEPH Collaboration

Abstract

From a sample of 150 000 hadronic Z decays collected with the ALEPH detector at LEP, events containing prompt leptons are used to measure the forward-backward asymmetries for the channels $Z \rightarrow b\bar{b}$ and $Z \rightarrow c\bar{c}$, giving the results $A_{FB}^b = 0.126 \pm 0.028 \pm 0.012$ and $A_{FB}^c = 0.064 \pm 0.039 \pm 0.030$. These asymmetries correspond to the value of effective electroweak mixing angle at the Z mass $\sin^2 \theta_W(m_Z^2) = 0.2262 \pm 0.0053$.

(Submitted to Physics Letters B)

Duccio Abbaneo, Franco Ligabue, Fabrizio Palla, R.T. Vivek Sharma

*See the following pages for the list of authors.

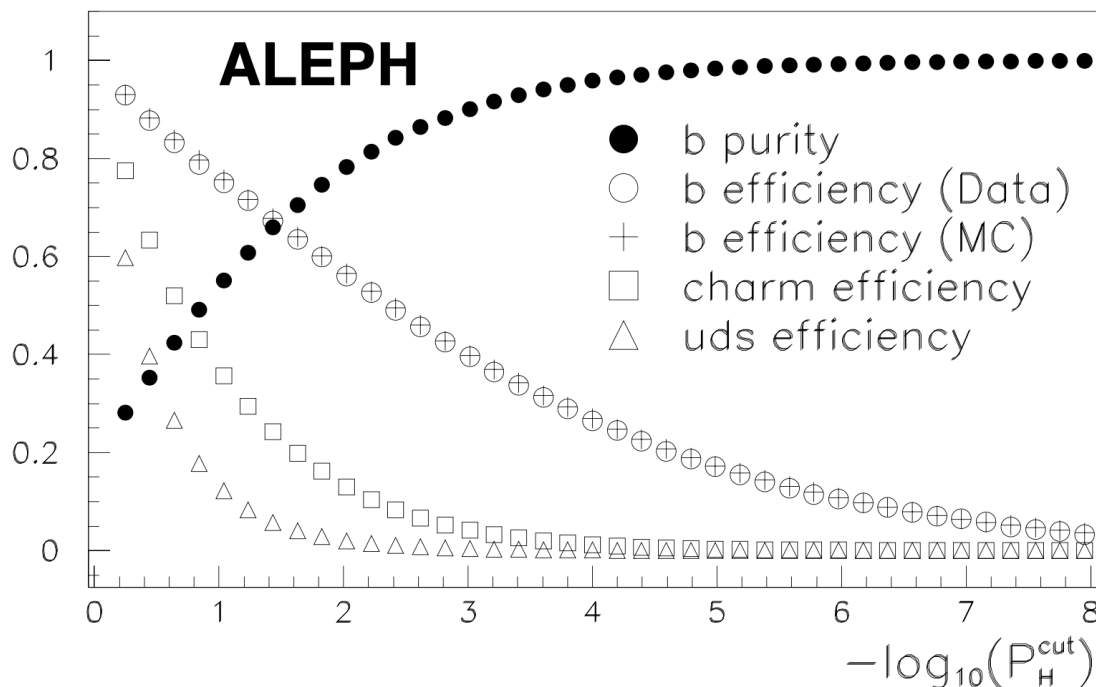
I remember presenting these slides during a “Gigi meeting”, then called Tuesday meeting and the Thursday meeting

Precise measurement of R_b and long saga

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

(Gigi was spokesperson in this period and he asked Duccio and myself to referee the paper, well I didn't complete the refereeing ... :-)

CERN-PPE/97-018
11 February 1997

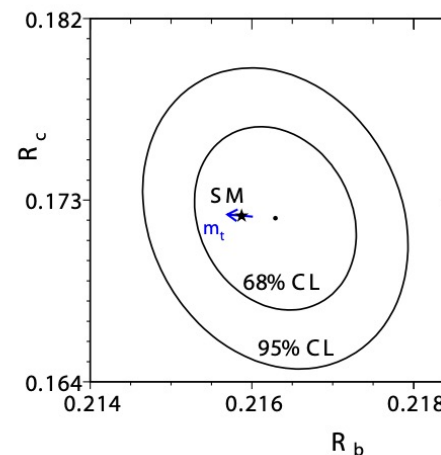


Dave Brown

Fabrizio Palla, Jack Steinberger

A Measurement of R_b using Mutually Exclusive Tags

The ALEPH collaboration



Abstract

five mutually exclusive hemisphere tags has been performed
3P1 statistics. Three tags are designed to select the decay of
e remaining two select Z^0 decays to c and light quarks, and
ging efficiencies. The result, $R_b = 0.2159 \pm 0.0009(\text{stat}) \pm$
t with the electroweak theory prediction of 0.2158 ± 0.0003 .

be submitted to Physics Letters B)

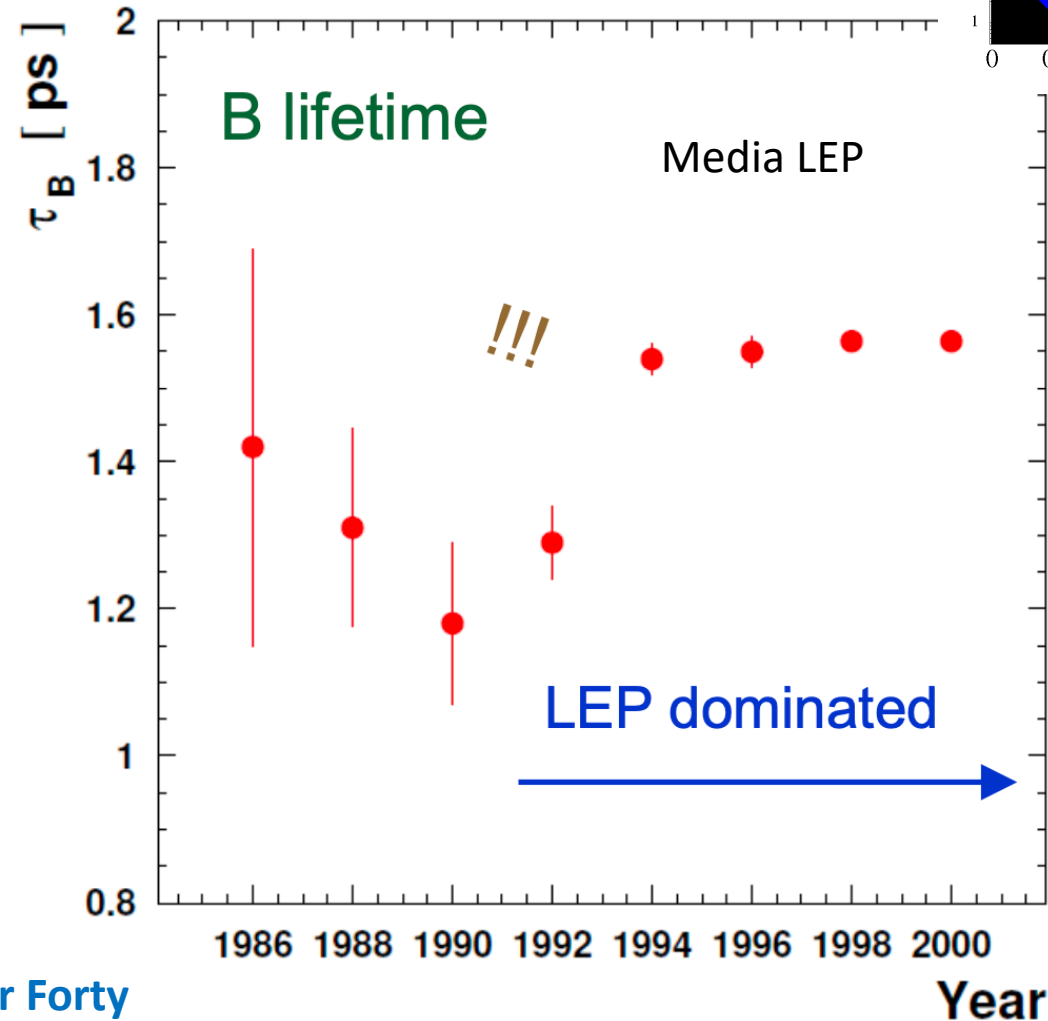
B lifetime (finally the right one) (discussed at Gigi meetings)

ALEPH

- PHYSICS MOTIVATION. IN THE SPECTATOR QUARK MODEL, EXPECTED TO BE A GOOD APPROXIMATION FOR B HADRONS,
$$\tau_B \approx \frac{1}{5} \frac{1}{|V_{cb}|^2} \left(\frac{m_\mu}{m_b} \right)^5 \tau_\mu$$
 τ_B IS RELATED TO FUNDAMENTAL QUANTITIES
- TECHNIQUE. MEASUREMENT OF THE LEPTON IMPACT PARAMETER IN A B ENHANCED SAMPLE OBTAINED BY LEPTON TAGGING. SAME FITTING PROCEDURE ADOPTED FOR THE MARK II MEASUREMENT AT 29 GeV [R.A. ONG, SLAC-320 (1987)]
- USE TRACKING CHAMBERS [ITC+TPC]. IN FUTURE INCLUDE THE SILICON VERTEX DETECTOR.

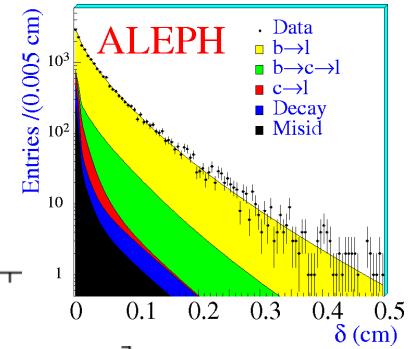
INCLUSIVE
B LIFETIME

46



Roger Forty

Roberto Dell'Orso, Lorenzo Moneta, Cristina Vannini



Λ_b discovery

(Gigi was spokesperson in this period)

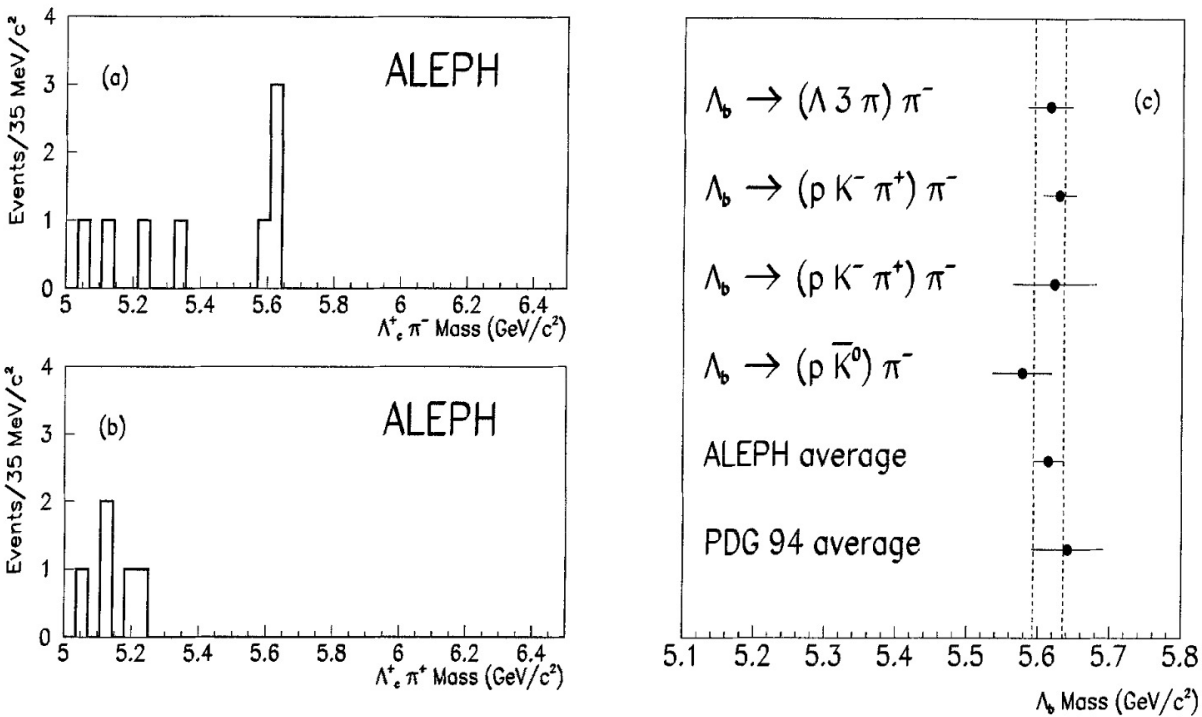
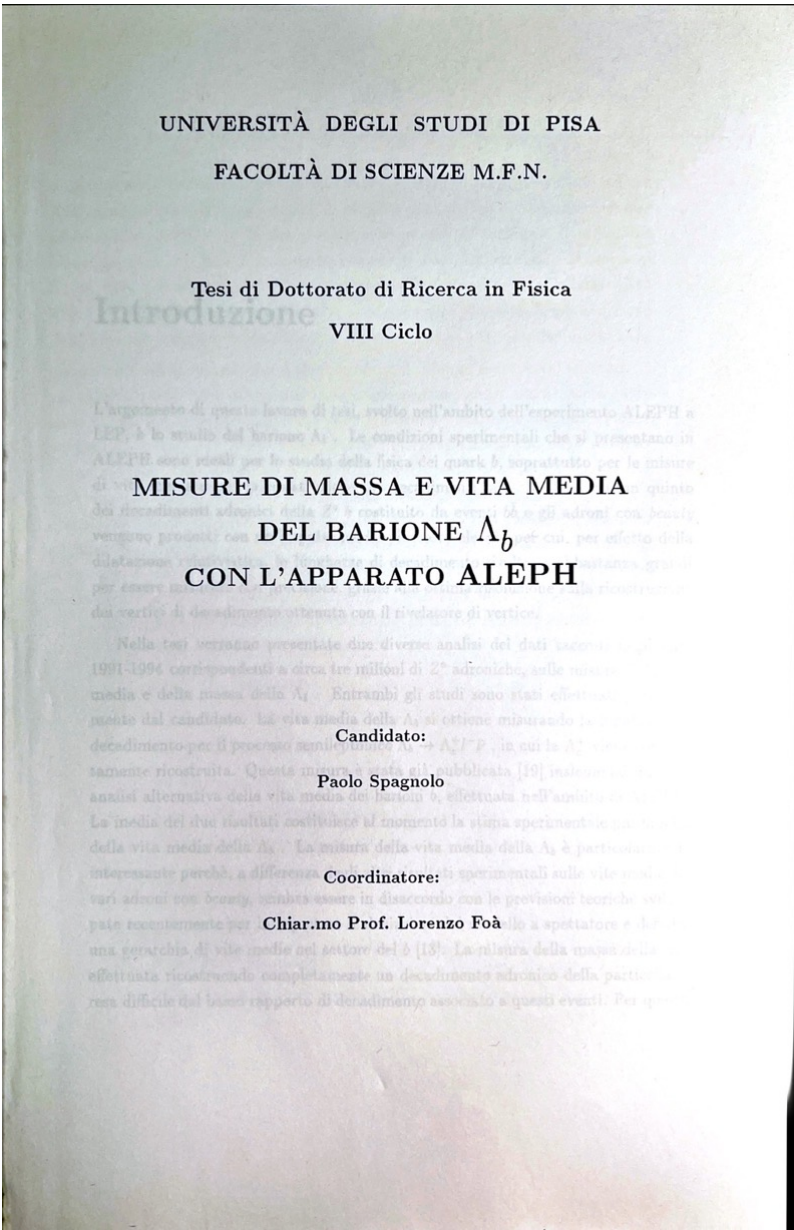


Fig. 1. (a) $\Lambda_c \pi$ invariant mass distribution for the right-sign combinations and (b) wrong-sign combinations. (c) Λ_b invariant masses for the four selected candidates. Also shown are the average value and the PDG 94 world average. The dotted lines indicate the $\pm 1\sigma$ values around the ALEPH average measurement.

Gian Musolino, Paolo Spagnolo

B_s discovery(*)

(discussed at Gigi meetings)

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-PPE/93-97
16 June 1993

Vivek Sharma

First Measurement of the B_S Meson Mass

The ALEPH Collaboration

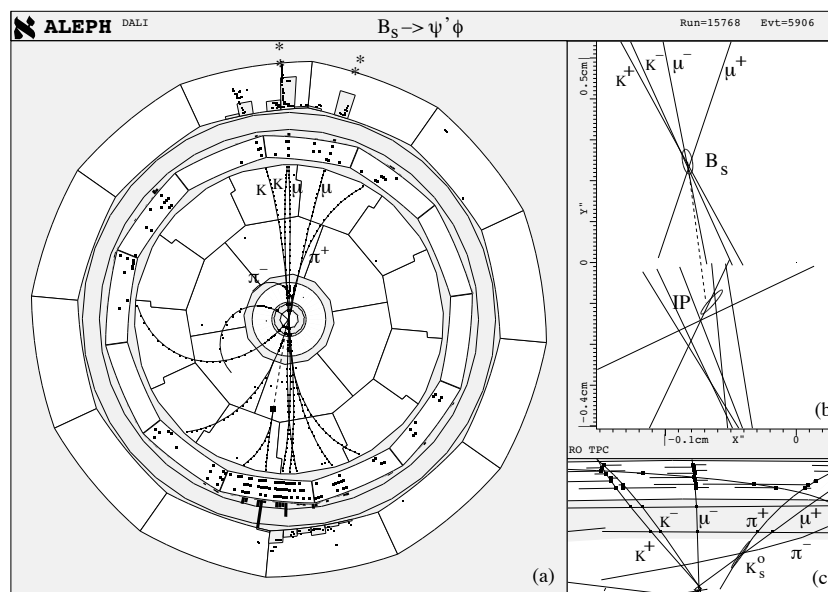
Abstract

In a sample of about 1.1 million hadronic Z decays recorded with the ALEPH detector during the 1990-1992 running of LEP, two unambiguous B_S meson candidates were observed. From these events the mass of the B_S meson has been measured to be $5.3686 \pm 0.0056(stat.) \pm 0.0015(syst.)$ GeV.

(Submitted to Physics Letters B)

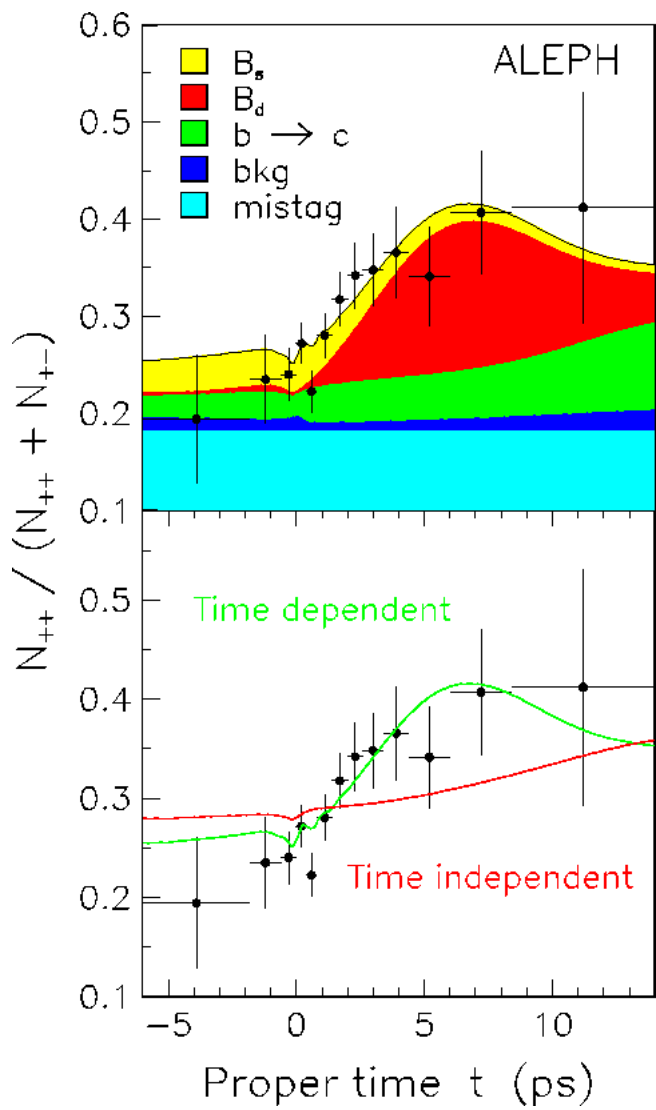
*See the following pages for the list of authors.

Figure 1: (a) A fisheye $r\phi$ view of the $B_s \rightarrow \psi'\phi$ event. The tracks forming the B_s meson are appropriately labeled. (b) A closeup view of the event near the interaction point. The error ellipses on the interaction point (IP) and the B_s vertex are 3σ . (c) A fisheye view of the event near the inner tracking chambers in the $r-\phi$ dimensions. The track coordinates recorded in the VDFT and the TTC are shown. All tracks forming the B_s traverse a single silicon wafer in the inner and outer layer of the VDFT minimizing mass measurement errors from possible internal misalignment in the VDFT. The K_S^0 decay daughters are labeled as π^+ and π^- . The vertex error ellipse is 3σ . The π^- track has momentum of 0.27 GeV and curls inside the TTC in the magnetic field of 1.5 T and has no coordinates in the TTC.

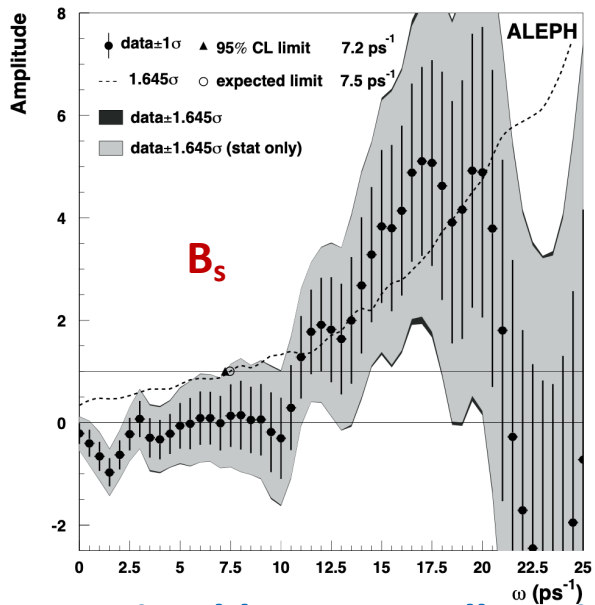


(*) disputed with Delphi

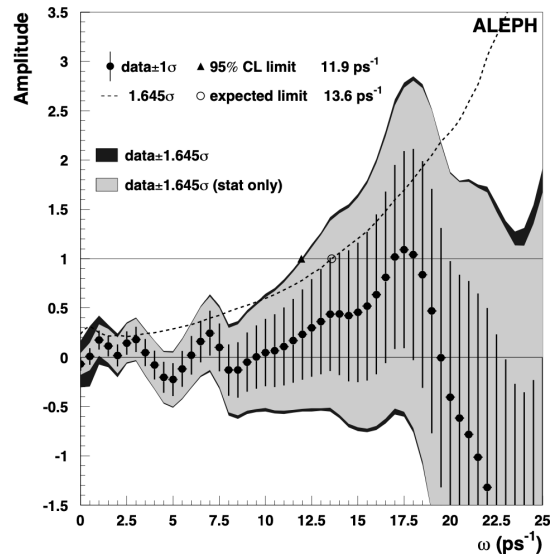
Oscillations: first measurement of time evolution



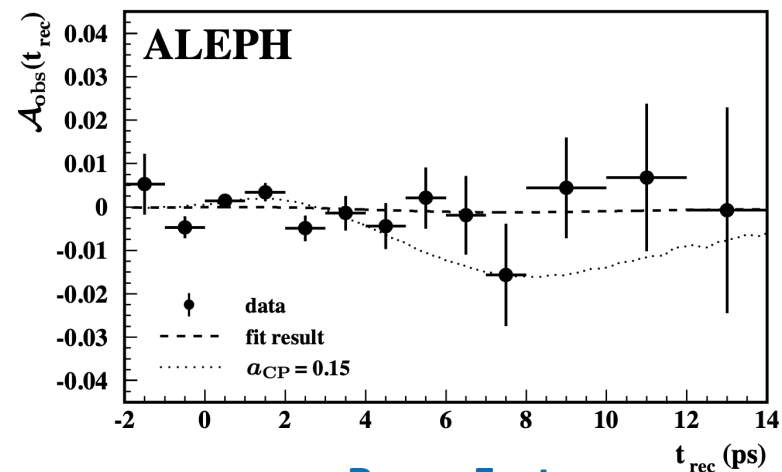
Roger Forty



Duccio Abbaneo, Gaelle Boix



(discussed at Gigi meetings)



Roger Forty

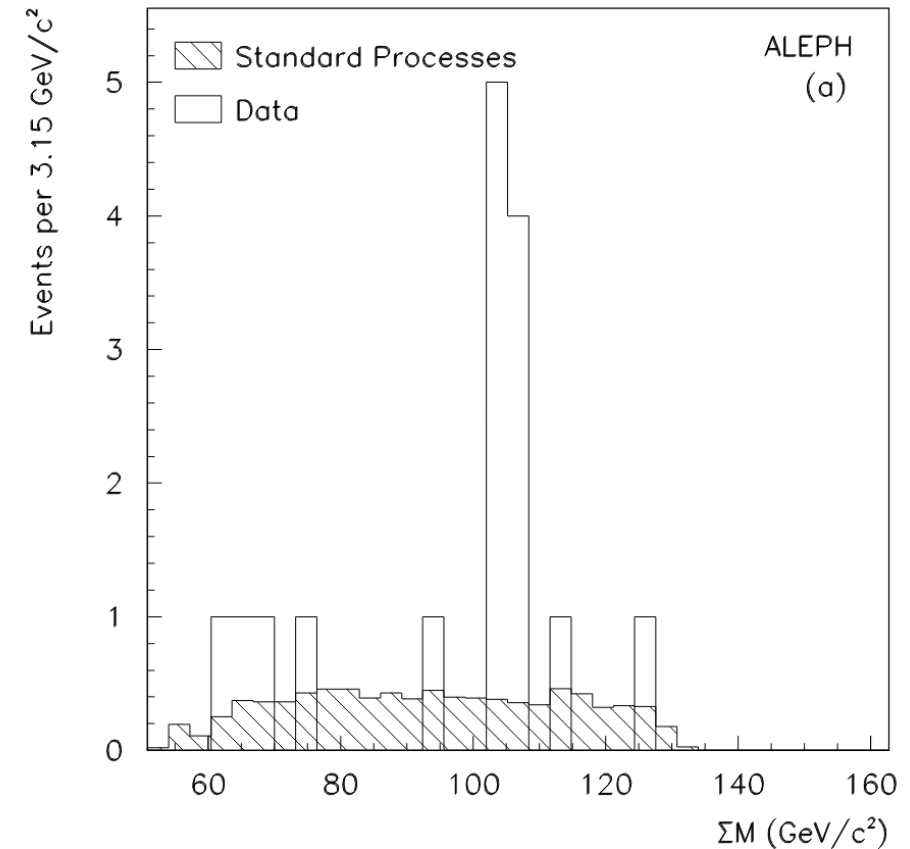
time-independent part (χ)
Duccio Abbaneo e Concezio Bozzi

The 4 jets saga (130 and 136 c.o.m. energy)

From Patrick Janot: the four-jet peak' (an excess of events in the 130–136 GeV data of 1995) arose from a search for hA pair production with no b -tagging possibilities: the new Aleph vertex detector for LEP2 had just been installed and was neither aligned nor entirely ready.

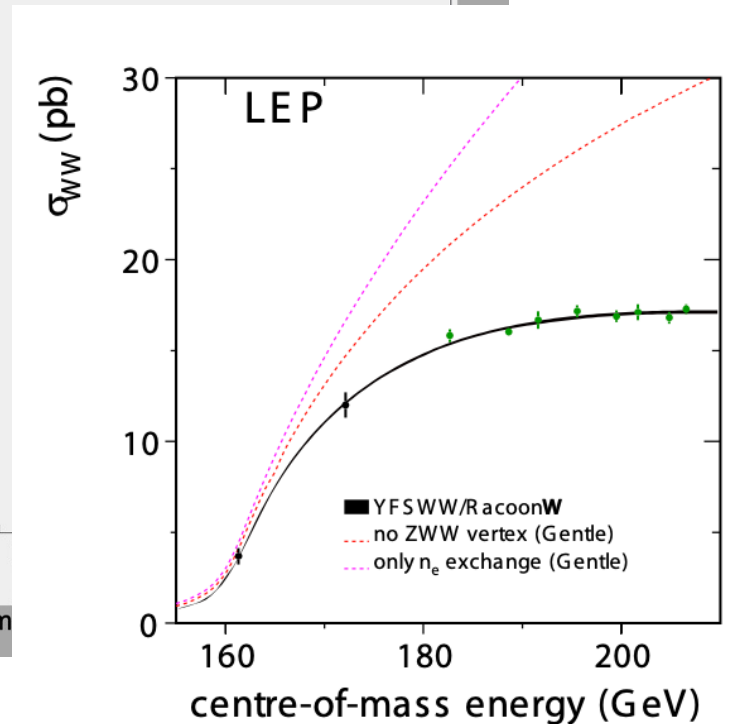
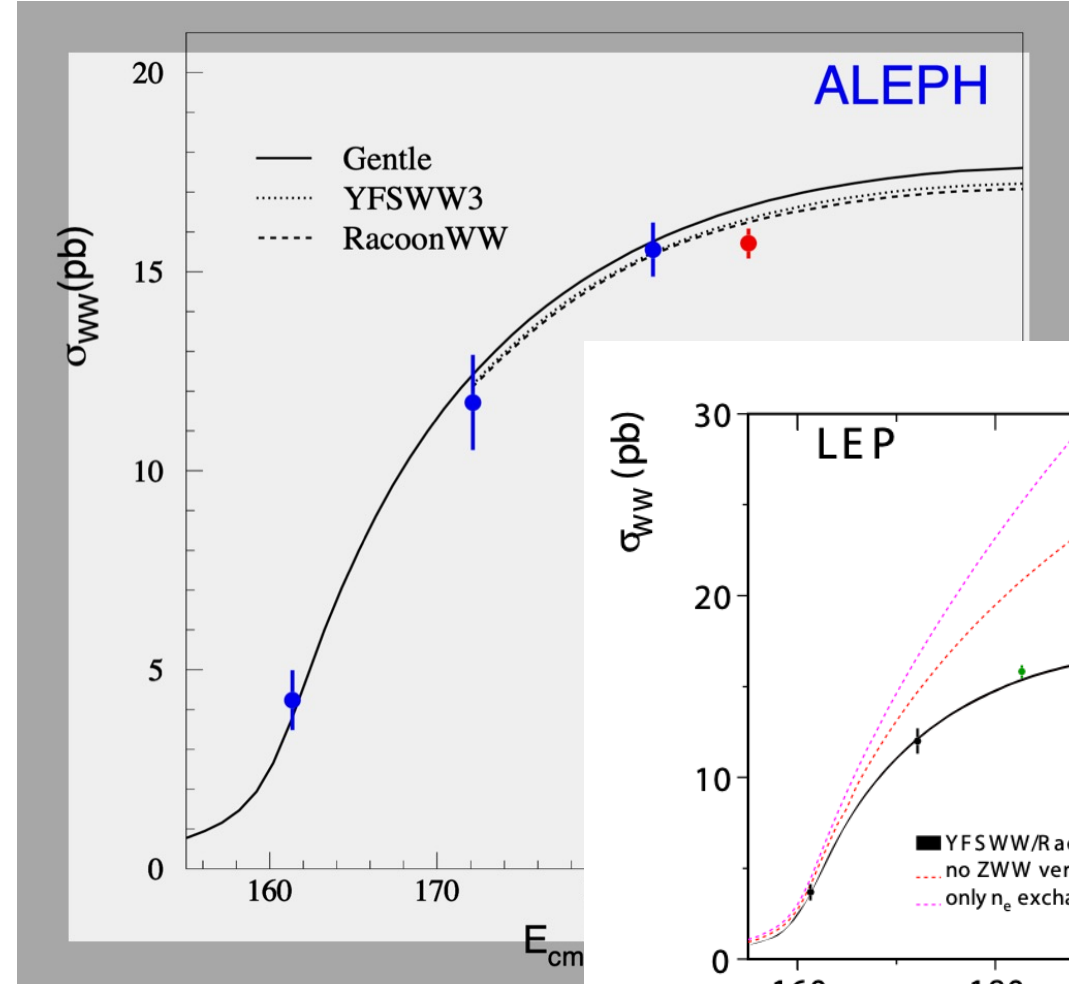
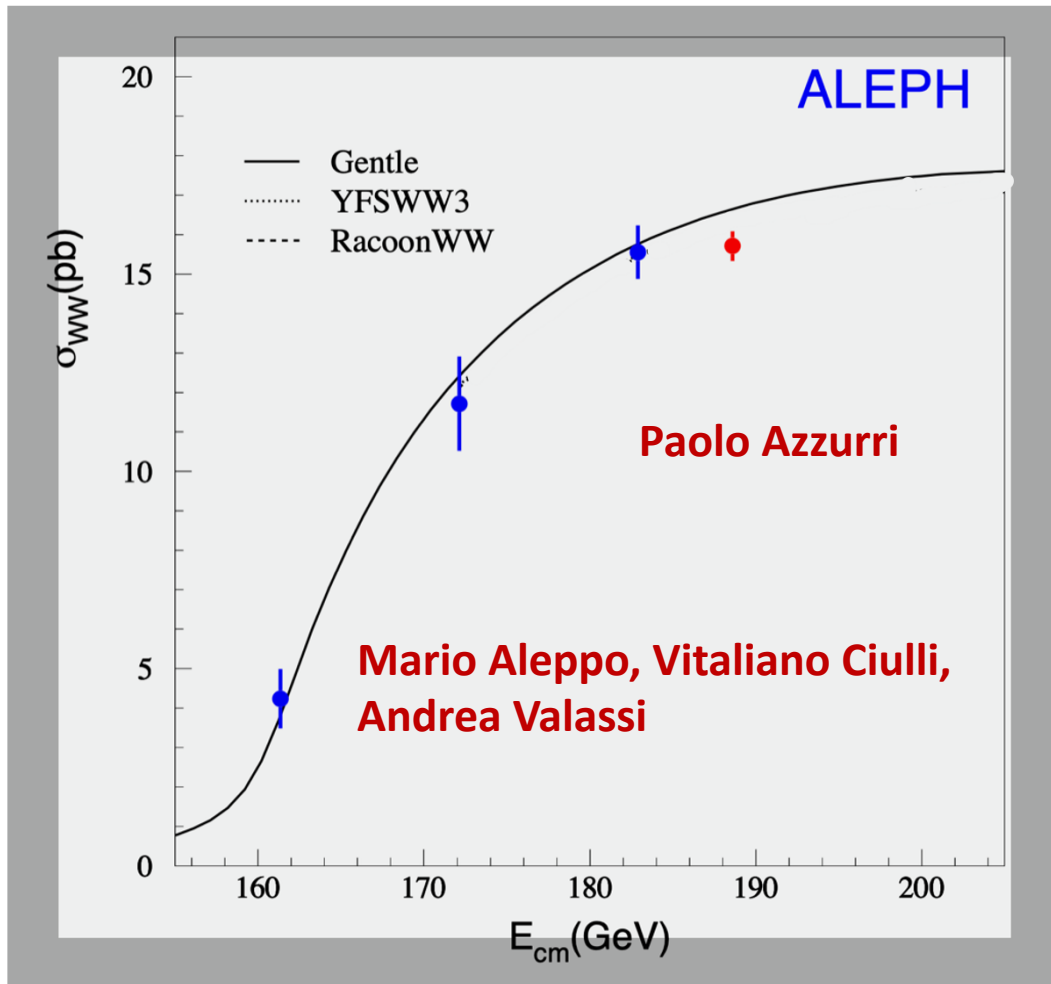
Clearly, the collaboration, led by Gigi Rolandi (who brilliantly mastered the situation), had learnt from the past (*) and managed to handle this situation much better. **We even succeeded in convincing the other three collaborations to run once again at 130 and 136 GeV. Eventually, 'we found no other explanations than a statistical fluctuation.'**

(*) he refers to the hA saga



LEP2 : surprise from WW cross section (and confession from theorists ... $O(\alpha)$ were missing)

(Gigi was spokesperson in this period)

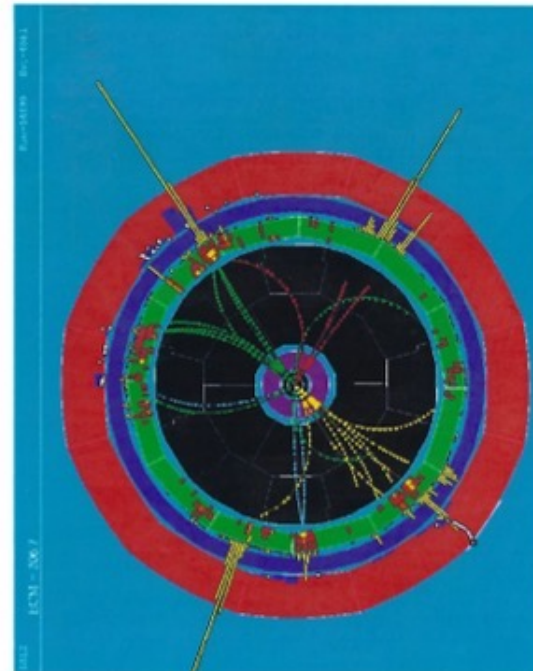
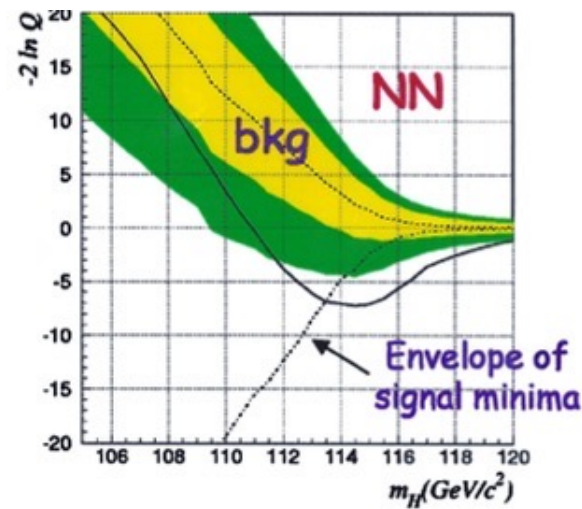


Higgs at 115 GeV ?

CERN-EP/2000-138
November 13, 2000

Observation of an Excess in the Search
for the Standard Model Higgs Boson at ALEPH

The ALEPH Collaboration *)



Physics Letters B 526 (2002) 191–205

PHYSICS LETTERS B

www.elsevier.com/locate/nucphys

Final results of the searches for neutral Higgs bosons in e^+e^-
collisions at \sqrt{s} up to 209 GeV

ALEPH Collaboration

A. Heister, S. Schael

Physikalisches Institut der RWTH-Aachen, D-52056 Aachen, Germany

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F. Martin, E. Merle, M.-N. Minard, B. Pietrzyk, B. Trocmé

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G. Boix, S. Bravo, M.P. Casado, M. Chmeissani, J.M. Crespo, E. Fernandez,
M. Fernandez-Bosman, Ll. Garrido¹⁵, E. Graugés, J. Lopez, M. Martinez, G. Merino,
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X. Huang, J. Lin, Q. Quyang T. Wang, Y. Xie, R. Xu, S. Xue, J. Zhang, L. Zhang,
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D. Abbaneo, P. Azzurri, T. Barklow³⁰, O. Buchmüller³⁰, M. Cattaneo, F. Cerutti,
B. Clerbaux, H. Drevermann, R.W. Forty, M. Frank, F. Gianotti, T.C. Greening²⁶,
J.B. Hansen, J. Harvey, D.E. Hutchcroft, P. Janot, B. Jost, M. Kado³¹, P. Maley,
P. Mato, A. Moutoussi, F. Ranjard, L. Rolandi, D. Schlatter, G. Sguazzoni, W. Tejessy,
F. Teubert, A. Valassi, I. Videau, J.J. Ward

European Laboratory for Particle Physics (CERN), CH-1211 Geneva 23, Switzerland

0370-2693/02/\$ – see front matter © 2002 Elsevier Science B.V. All rights reserved.
PII: S0370-2693(01)01487-3

End of ALEPH ??? We archived data for long-term analyses !!

arXiv:0712.0327v2 [hep-ph] 11 Feb 2008

Prepared typset in JHEP style – PAPER VERSION
ZU-TH 28/07, IPPP/07/91, ETHZ-IPP RP-2007-04, Edinburgh 2007-48

Guenther Dissertori

First determination of the strong coupling constant using NNLO predictions for hadronic event shapes in e^+e^- annihilations

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8093 Zurich, Switzerland
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A. Gehrmann–De Ridder
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EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

Paolo Spagnolo

Search for neutral Higgs bosons decaying into four taus at LEP2

The ALEPH Collaboration*)

Abstract
A search for the production and non-standard decay of a Higgs boson, h , into four taus through intermediate pseudoscalars, a , is conducted on 683 pb^{-1} of data collected by the ALEPH experiment at centre-of-mass energies from 183 to 209 GeV. No excess of events above background is observed, and exclusion limits are placed on the combined production cross section times branching ratio, $\xi^2 = \frac{\sigma(e^+e^- \rightarrow ah)}{\sigma(e^+e^- \rightarrow 2h)} \times B(h \rightarrow aa) \times B(a \rightarrow \tau^+\tau^-)^2$. For $m_h < 107\text{ GeV}/c^2$ and $4 < m_a < 10\text{ GeV}/c^2$, $\xi^2 > 1$ is excluded at the 95% confidence level.

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*) See next pages for the list of authors

ALEPH Open Data used a lot, last results arrived a few days ago
Marcello Maggi deserves a big thank for coodinating it

Statement on the use of Aleph data for long-term analyses.

The Aleph Collaboration

The data collected by the Aleph experiment in the years 1990-2000 have been archived to allow their use for physics analyses after the closure of the Collaboration. The archiving includes the last set of simulated events and the most updated version of the analysis software.

Limitations.

The available information is not sufficient to repeat all analyses, particularly when systematic effects play an important role as, for instance, for precision measurements in the electroweak sector. Examples of physics analyses that cannot be repeated on archived data are

- The measurement of the Z lineshape
- The measurement of the W mass
- The measurement of the tau polarization
- The measurement of leptons and quarks forward-backward asymmetry
- Most heavy flavour measurements, such as the measurement of R_b , of the CKM matrix elements, of B_d and B_s oscillations
- The searches for the Higgs boson
- Many searches in the Susy sector

Authorized Users.

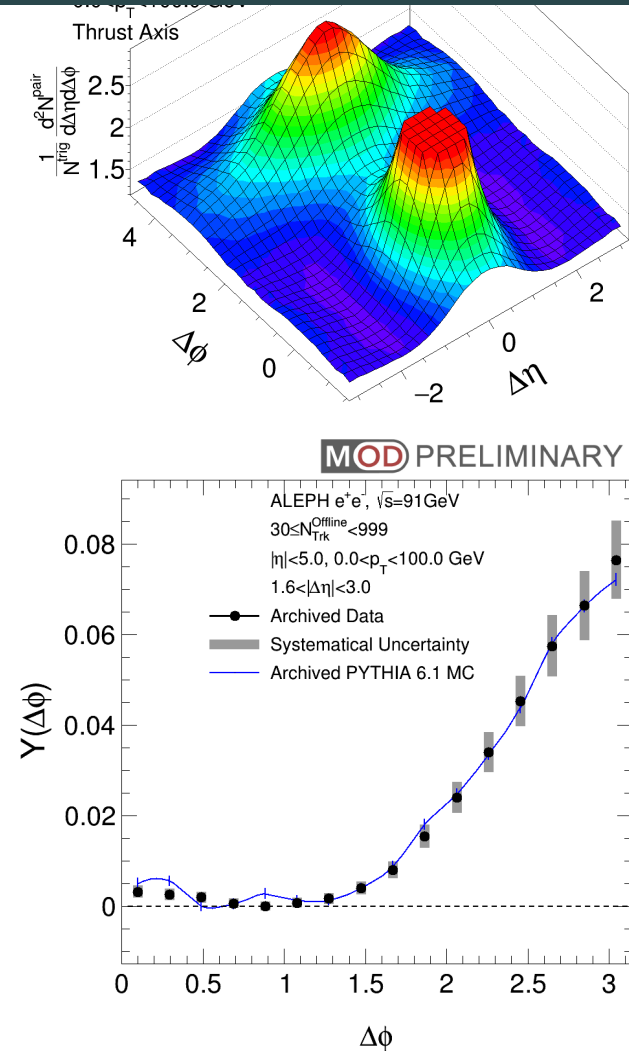
The use of archived Aleph data is authorized to former members of the Aleph Collaboration and their collaborators. The use of a subset of data for teaching and pedagogical purposes, under the guidance of former members of the Collaboration, is allowed.

Authorship.

The publication of results based on archived Aleph data is not allowed until 1 year after the official termination of the Collaboration, foreseen for the end of 2004. The authors of the analysis take full responsibility for the publication. Any figure, plot or table using Aleph data should contain the label “ALEPH Archived Data”. A reference to the present document “Statement on the use of Aleph data for long-term analyses” must be present in the publication.

Approved by the Aleph Steering Committee
CERN
4 December 2003

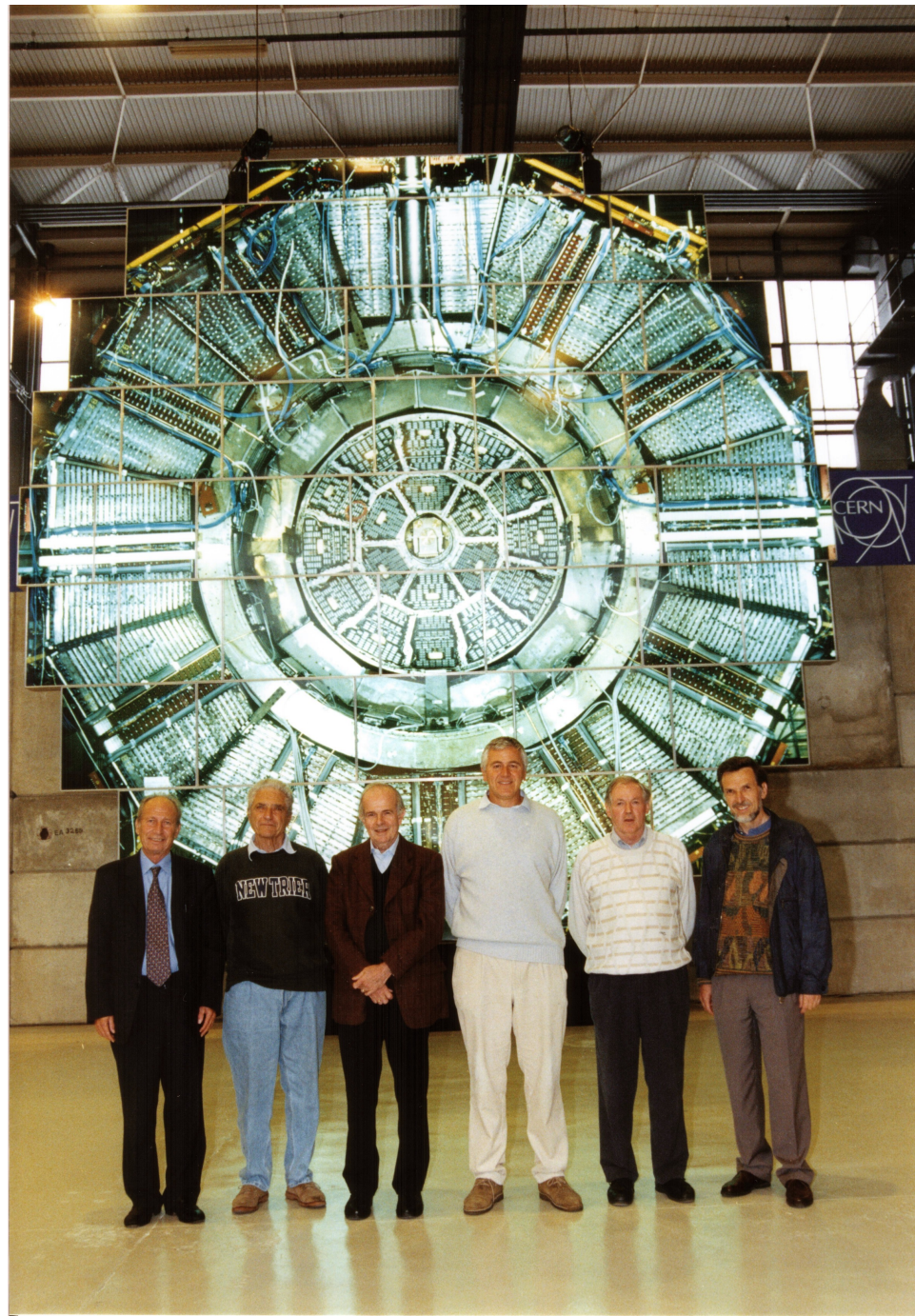
Two-Particle Correlation in e^+e^- Collisions at 91.2 GeV with ALEPH Archived Data



- The first two-particle correlation analysis in e^+e^- performed in bins of event multiplicity up to $N = 35 - 55$
 - No significant ridge signal is observed in beam axis analysis
- Thrust axis and jet region veto are employed to enhance the signal from soft radiations
- No evidence of the final state effect in the probed event multiplicity ranges:
 - An important reference of the ridge signal observed in pp, pA, dA and AA collisions

Gigi was CMS physics coordinator at the time of the CMS “ridge”, then checked with the ALEPH TPC !!

**It has been a
great honour
(and fun !) to
work with you
Gigi !**



**We live to learn
and I've
learned a lot
from you and
many other
great
colleagues !**

July 1996 at ALEPH party

