

# **RESULTS FROM LVD-OPERA COMBINED ANALYSIS: A TIME-SHIFT IN THE OPERA SET-UP**

A. Zichichi

**Gran Sasso, 28 marzo 2012**

# **Determination of a time-shift in the OPERA set-up using high energy horizontal muons in the LVD and OPERA detectors**

A. Zichichi and A. Ereditato on behalf of LVD-OPERA Collaboration

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The purpose of this work is to report the measurement of a time-shift in the OPERA set-up in a totally independent way from TOF measurements of CNGS neutrino events and without the need of knowing the distance between the two laboratories, CERN and LNGS, where the neutrinos are produced and detected, respectively.

The LVD and OPERA experiments are both installed in the same laboratory: LNGS.

Indeed, the OPERA-LVD direction lies along the so-called “Teramo anomaly”, a region in the Gran Sasso massif where LVD has established, many years ago, the existence of an anomaly in the mountain structure, which exhibits a low *m. w. e.* thickness for horizontal directions.

The “abundant” high-energy horizontal muons (nearly 100 per year) going through LVD and OPERA exist because of this anomaly in the mountain orography.

How did we discover  
this  
**ANOMALY**  
?

# Our 1<sup>st</sup> reference paper

- [1] LVD Internal Note, 1997 and A. Zichichi for LVD group, *Unexpected results from the Gran Sasso Lab*, EPS Conf., September 1997-Erice, Highlights of Subnuclear Physics; presented also at the conference Ten Years LVD Celebration LNGS-2002.



**An example of  
HOW TO AVOID  
BIG-MISTAKES**

# **Search for Galactic Center Supernovae (SN)**

**Why?** Because from Keplero -  
Galilei last **Supernova (SN)** there are  
4 centuries.

The rate of SN per Galaxy per century is **3**.

$(3 \times 4) = 12 \Leftarrow$  This is the number of missing SN.

How can this be explained?

**Answer:** the **light** emitted by **SN** is what we observe. But the centre of our Galaxy is with enormous light emission. **Conclusion:** the centre of our Galaxy has to be observed by **neutrino-emission-effects**.

Notice that all Supernovae known so far are all in a galactic-space where the density of Stars is  $\simeq 5\%$  of the total number.

The highest density being at the core of the Galaxy.

Therefore:

$$\begin{aligned} & 5 \times 10^{-2} \times 3 \times / \text{Galaxy} / \text{Century} = \\ & = 1.5 \times 10^{-1} = 15\% / \text{Galaxy} / \text{Century} \\ & \text{of the total rate.} \end{aligned}$$



The rate of optically detectable SN is not  
 $3 / \text{Galaxy} / \text{Year}$ .

Therefore the number of missing SN in 4 centuries is not 12 but  $12 \times 5\% = 0,6$ .

The number of missing SN would be 12 if the telescopes for neutrinos from SN were active during the past 4 centuries.

**But** it is since

1992

that we have

**the LVD telescope**

for the observation of SN-neutrino being active.

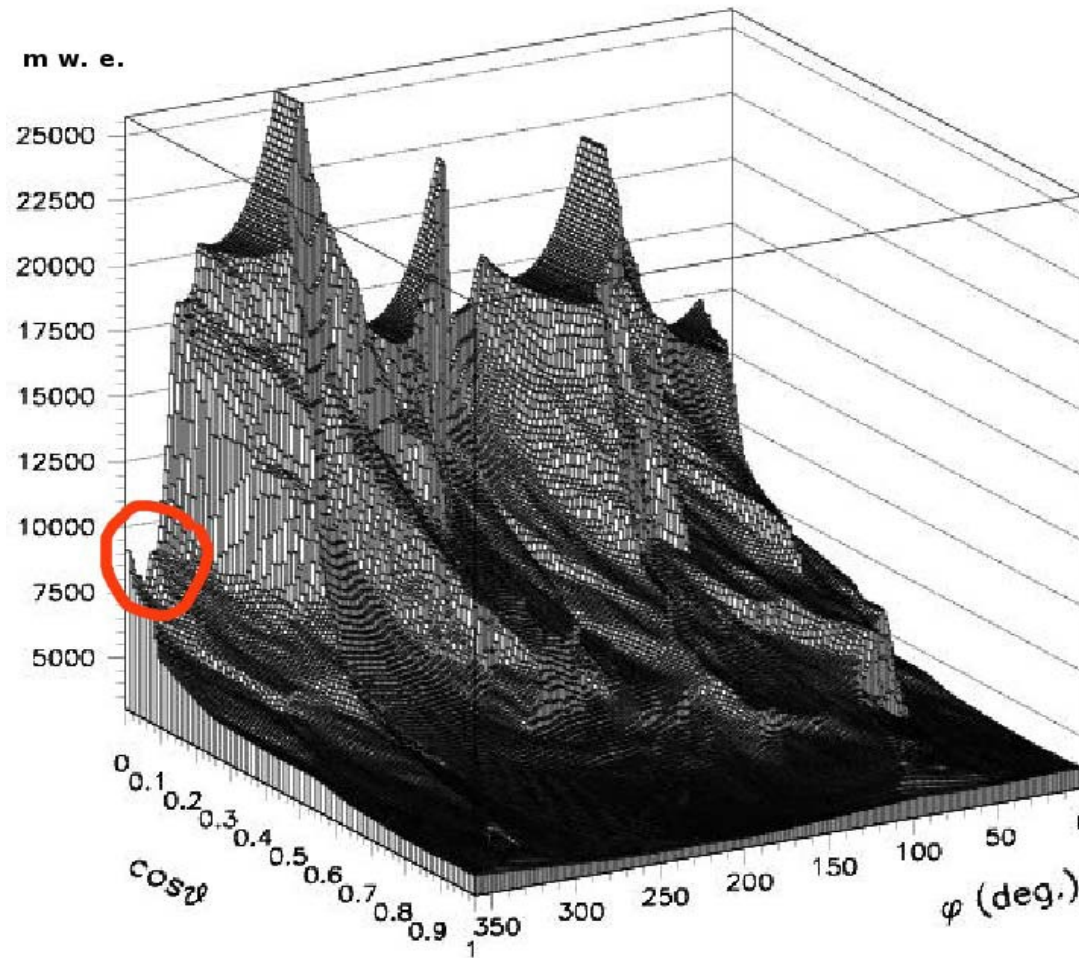
Therefore the number of missing SN is

$$\frac{20}{30} \simeq 0,67.$$

If we are lucky we should observe with LVD a SN in the next years to come.

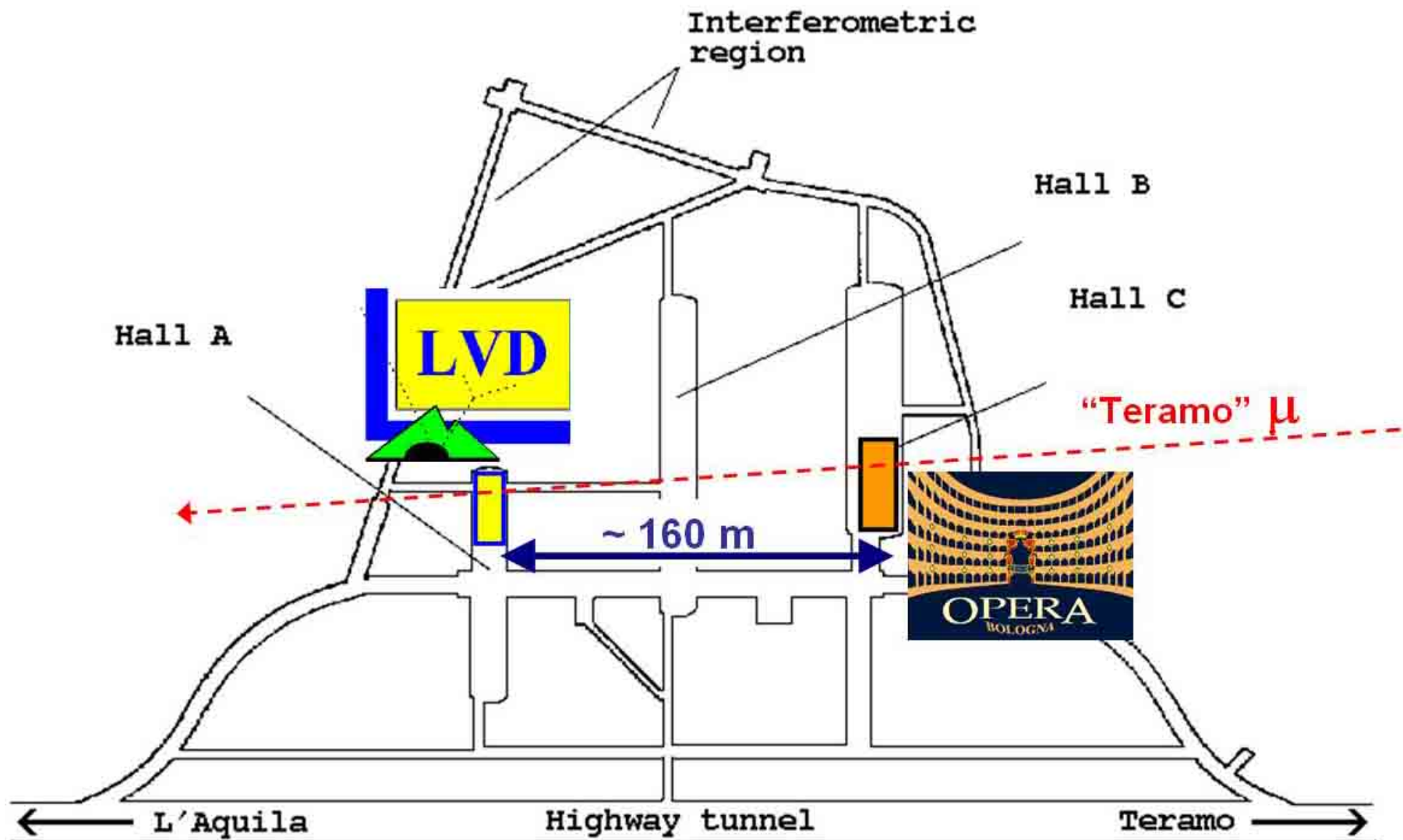
Let us look at the centre of our Galaxy.

**Results:** the “Teramo anomaly”  
(high-energy muon flux)  $\simeq 100$  per  
year.



*Fig. 12. Map of the slant depth of the Gran Sasso mountain (in m. w. e.) as a function of the arrival direction:  $\theta$  and  $\phi$  are respectively the zenith and azimuth angle. The red circle indicates the direction of the “Teramo valley”, where the mountain profile exhibits an “anomaly” in the m. w. e. for horizontal directions.*

A sketch of the LNGS map with the position of LVD and OPERA experiments is shown in Figure 11.

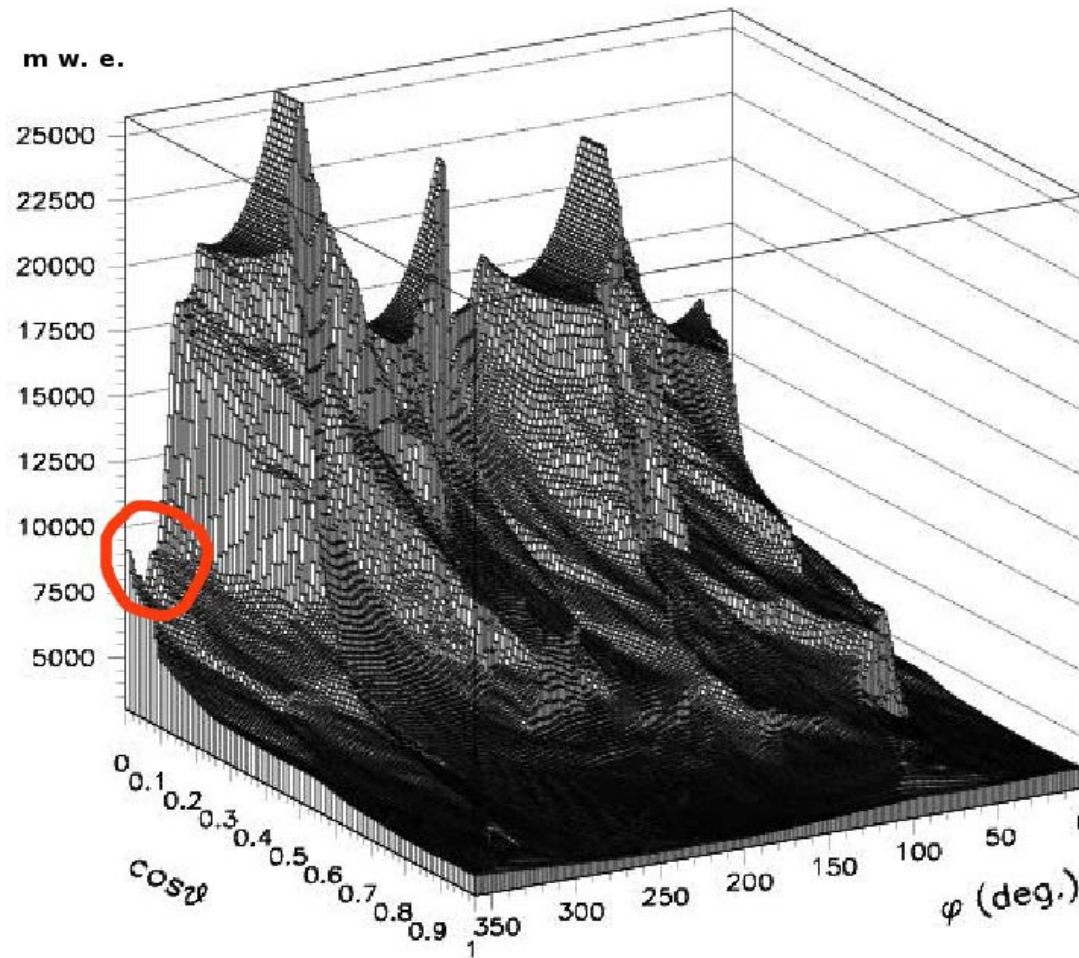


*Fig. 11. Sketch of the LNGS map with the position of the LVD and OPERA experiments.*

Indeed, the OPERA-LVD direction lies along the anomaly in the mountain profile observed in 1997 [1] when searching for neutrino events from the center of the Galaxy.

The anomaly is due to the non-uniform depth of the rock structure in the horizontal direction towards the city of Teramo, thus called “Teramo anomaly”. This is due to a large decrease in *m. w. e.* of the mountain rock structure, as indicated in Figure 12 by the red circle.



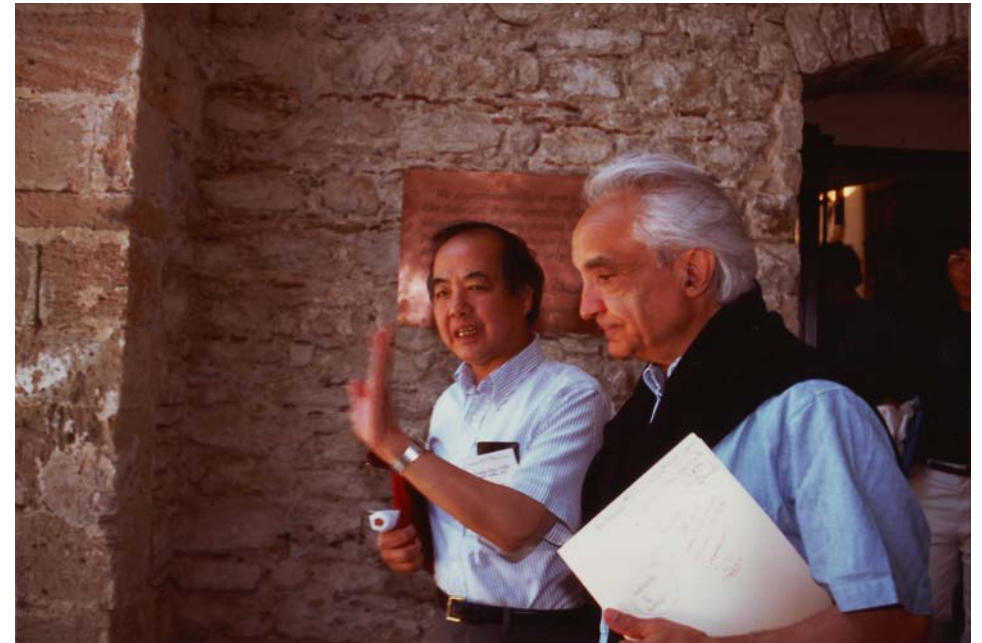
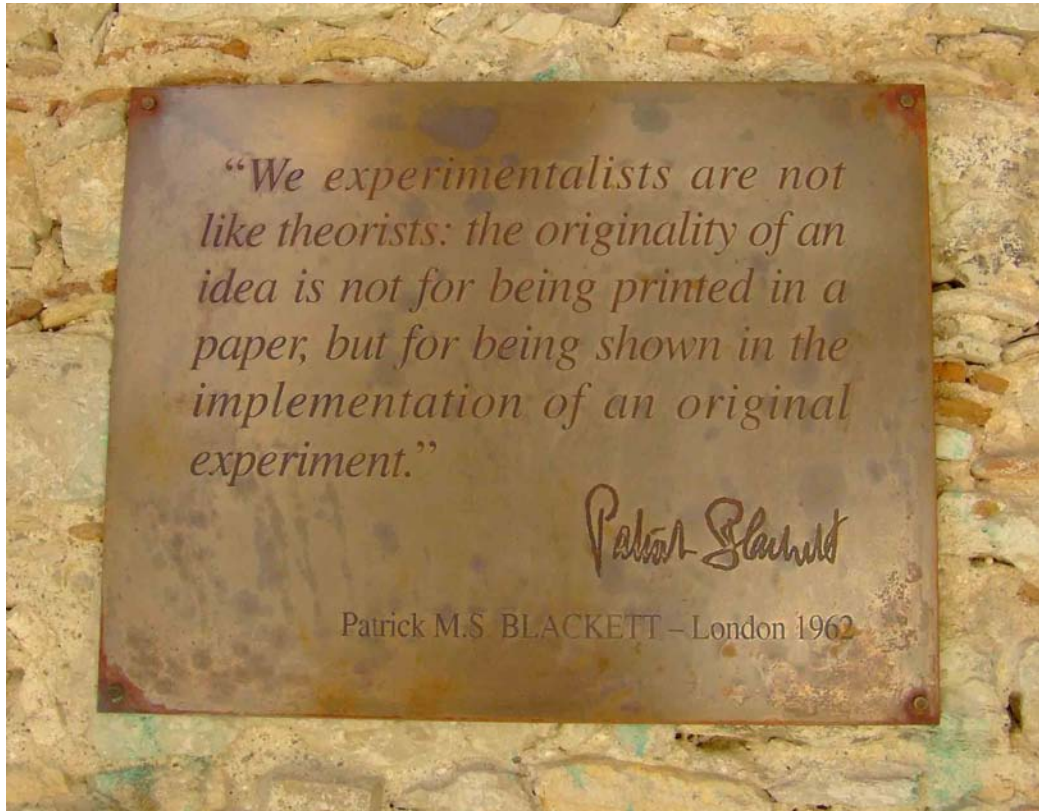


*Fig. 12. Map of the slant depth of the Gran Sasso mountain (in m. w. e.) as a function of the arrival direction:  $\theta$  and  $\phi$  are respectively the zenith and azimuth angle. The red circle indicates the direction of the “Teramo valley”, where the mountain profile exhibits an “anomaly” in the m. w. e. for horizontal directions.*

**Recall: P.M.S. Blackett Statement:**

*«We experimentalists are not like theorists: the originality of an idea is not for being printed in a paper, but for being shown in the implementation of an original experiment».*

*Patrick M.S. Blackett – London 1962*



publish a paper  $\Rightarrow$  Model

- “we experimentalist are not like theorists”

make real an experiment

- a) **Theorist**  $\Rightarrow$  if the **model** is not corroborated by an experimental result: nothing happens.
- b) **Experimentalist**  $\Rightarrow$  if the experimental result is not corroborated by (at least) another experimental result: the experimental physicist **loses his reputation**.

Recall: I.I. Rabi about new ideas.

## **I.I. Rabi - 1972**

*«Physics needs new ideas. But to have a new idea is a very difficult task: it does not mean to write a few lines in a paper. If you want to be the father of a new idea, you should fully devote your intellectual energy to understand all details and to work out the best way in order to put the new idea under experimental test.*

*This can take years of work. You should not give up. If you believe that your new idea is a good one, you should work hard and never be afraid to reach the point where a new-comer can, with little effort, find the result you have been working, for so many years, to get.*

*The new-comer can never take away from you the privilege of having been the first to open a new field with your intelligence, imagination and hard work. Do not be afraid to encourage others to pursue your dream. If it becomes real, the community will never forget that you have been the first to open the field.»*



## RABI - 1972

*Physics needs new ideas. But to have a new idea is a very difficult task: it does not mean to write a few lines in a paper. If you want to be the father of a new idea, you should fully devote your intellectual energy to understand all details and to work out the best way in order to put the new idea under experimental test.*

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*I. S. Rabi*

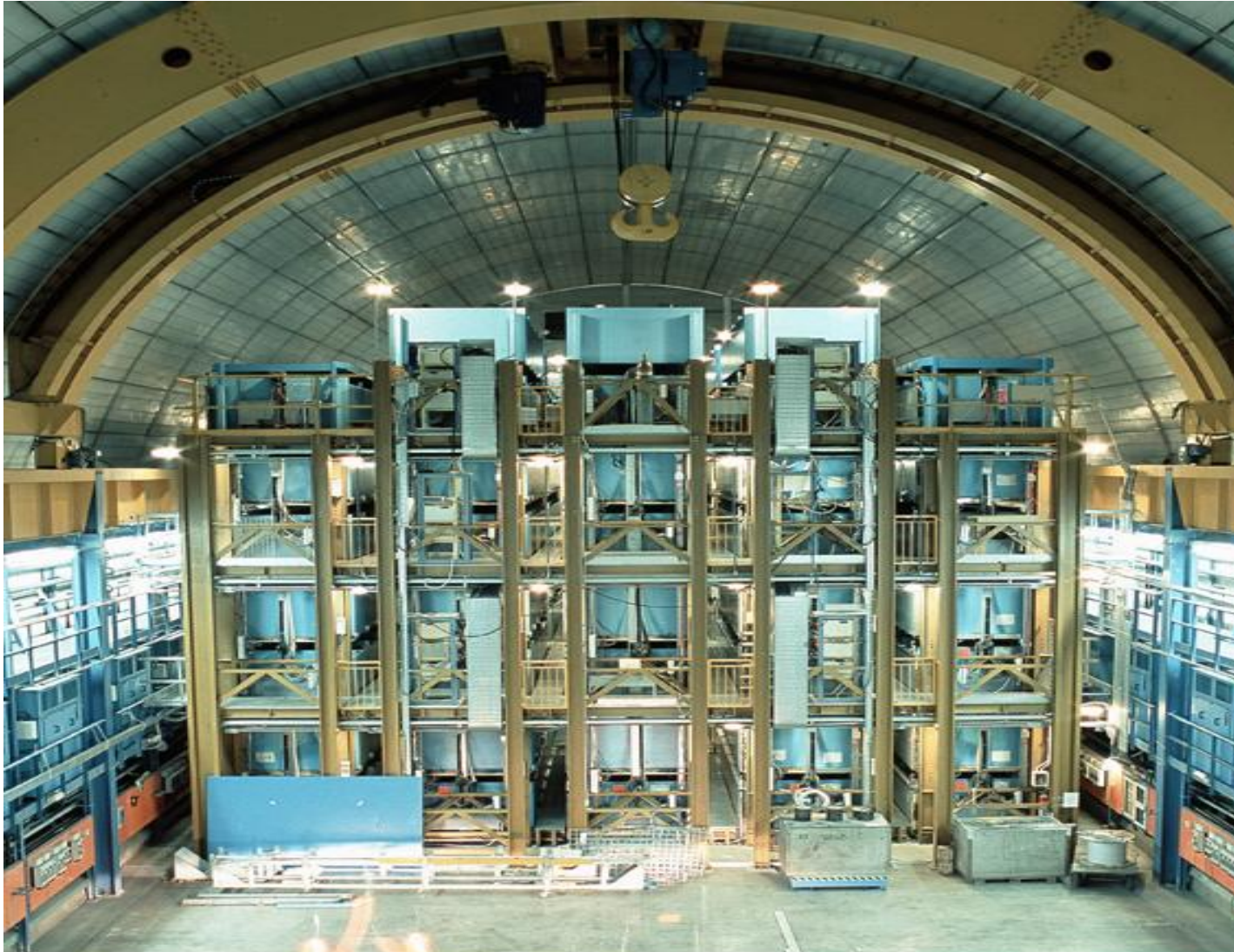




**• AND NOW**  
**LVD-OPERA RESULTS**  
**BASED ON**  
**AN EFFECTIVE COLLABORATION.**

## **2. The LVD detector**

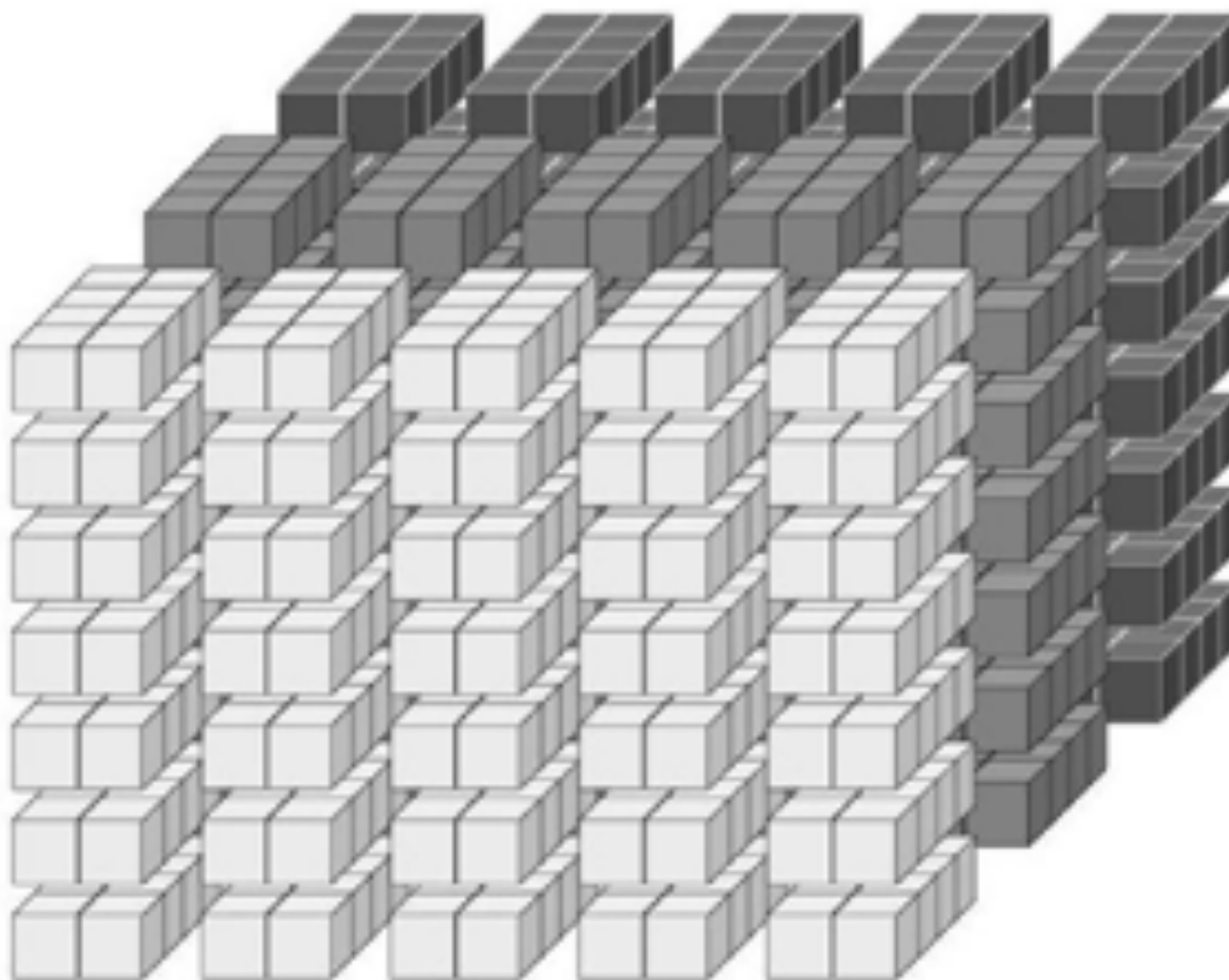
The Large Volume Detector (LVD) [4] (Figure 1) is located in Hall A of the INFN underground Gran Sasso National Laboratory at an average depth of 3600 *m. w. e.* The LVD main purpose is to detect and study neutrino bursts from galactic gravitational stellar core collapses.



*Fig. 1. Photograph of the LVD detector in the Hall A of the underground Gran Sasso Labs.*

The experiment started taking data in June 1992 and has continued without interruptions until now.

The detector, schematically shown in Figure 2, consists of an array of 840 liquid scintillator counters,  $1.5 \text{ m}^3$  each, arranged in a compact and modular geometry: 8 counters are assembled in a module called “portatank”; 35 portatanks (5 columns  $\times$  7 levels) form a “tower”; the whole detector consists of three identical towers that have independent power supply, trigger and data acquisition systems.



*Fig. 2. Schematic view of the LVD apparatus.*

The external dimensions of the active volume are  $13 \times 23 \times 10 \text{ m}^3$ . The liquid scintillator (density  $\rho = 0.8 \text{ g/cm}^3$ ) is  $\text{C}_n\text{H}_{2n}$  with  $\langle n \rangle = 9.6$  doped with 1 g/l of PPO (scintillation activator) and 0.03 g/l of POPOP (wavelength shifter).



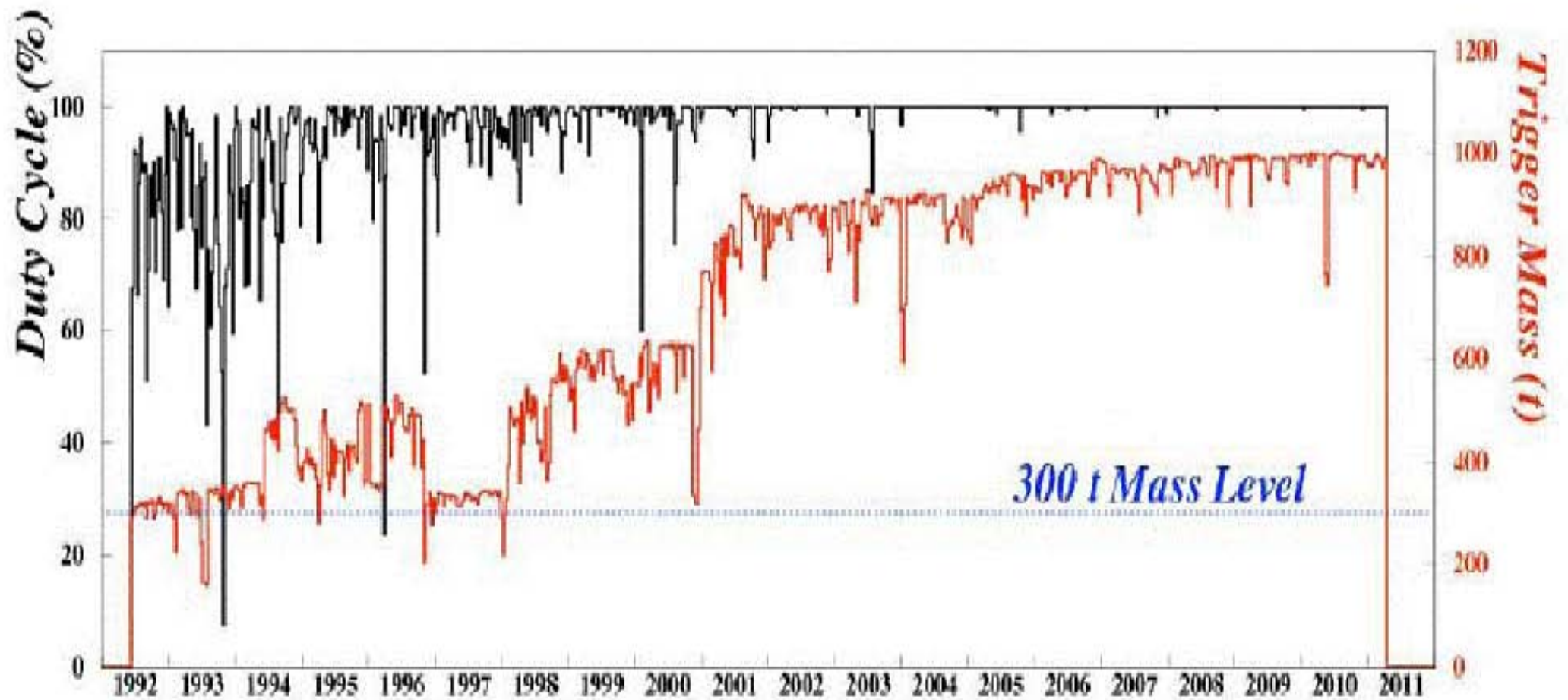
The total active scintillator mass is  $M = 1000$  t. Each LVD counter is viewed from the top by three 15 cm diameter photomultipliers (FEU49 or FEU125).

The main reaction that is detected by LVD is the inverse beta decay ( $\bar{\nu}_e + p \rightarrow n + e^+$ ), which gives two signals: a prompt one due to the  $e^+$  followed by the signal from the neutron capture reaction ( $n + p \rightarrow d + \gamma$ ) with mean capture time of about 185  $\mu\text{s}$  and  $E_\gamma = 2.2 \text{ MeV}$ .

The modularity of the apparatus allows for calibration, maintenance and repair interventions without major negative interference with data taking and detector sensitivity.

Figure 3 shows the duty cycle and the trigger active mass of LVD from June 1992 to March 2011.

From 2001 the experiment has been in very stable conditions with duty cycle  $> 99\%$  and slightly increasing active mass.



*Fig. 3. LVD duty cycle and active mass in the period June 1992 – March 2011.*

The minimum trigger mass of 300 t, corresponding to less than one “tower”, at which LVD can monitor the whole Galaxy for gravitational core collapses is also shown (blue).

### **3. The OPERA detector**

OPERA is a hybrid experiment with electronic detectors and nuclear emulsions located in Hall C of the underground Gran Sasso Laboratory [5]. The main physics goal of the experiment is to observe neutrino flavor oscillations through the appearance of  $\nu_\tau$  neutrinos in the  $\nu_\mu$  CNGS beam.



The detector design was optimized to identify the  $\tau$  lepton via the topological observation of its decay: this requires a target mass of more than a kton to maximize the neutrino interaction probability and a micrometric resolution to detect the  $\tau$  decay.

$$\tau \equiv HL$$

$$\nu_\tau \equiv \nu_{HL}$$

proposed and searched at CERN with  
 PAMPLEP (Proton Antiproton  
 Annihilation into Lepton Pairs) ( $p\bar{p}$ )  
 and in Frascati with ( $e^+e^-$ ).

The CNGS beam was in the Gran  
 Sasso Project (1979) to study  
 oscillations between the second  $\nu_\mu$   
 and  $\nu_{HL}$ .

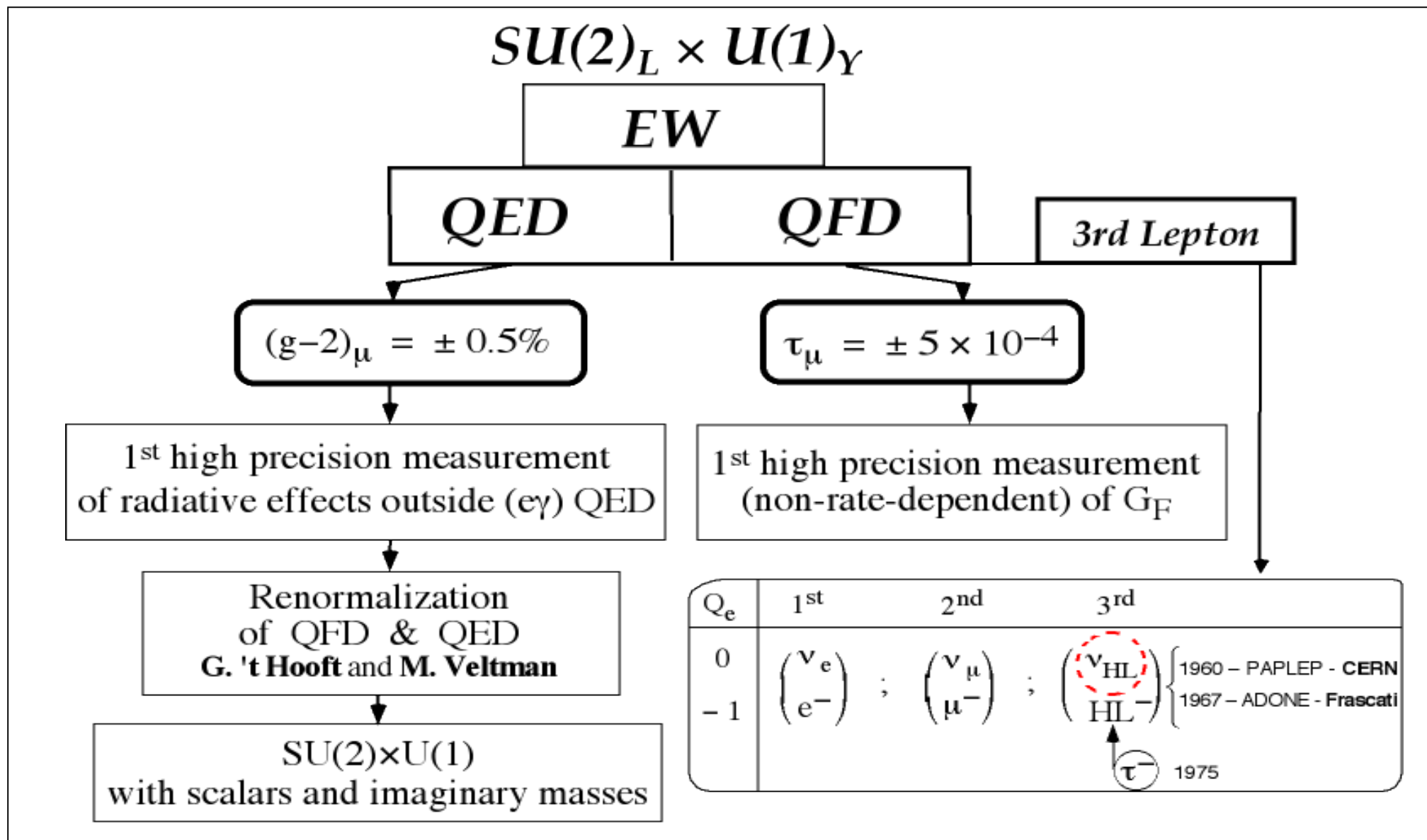


Figure 33

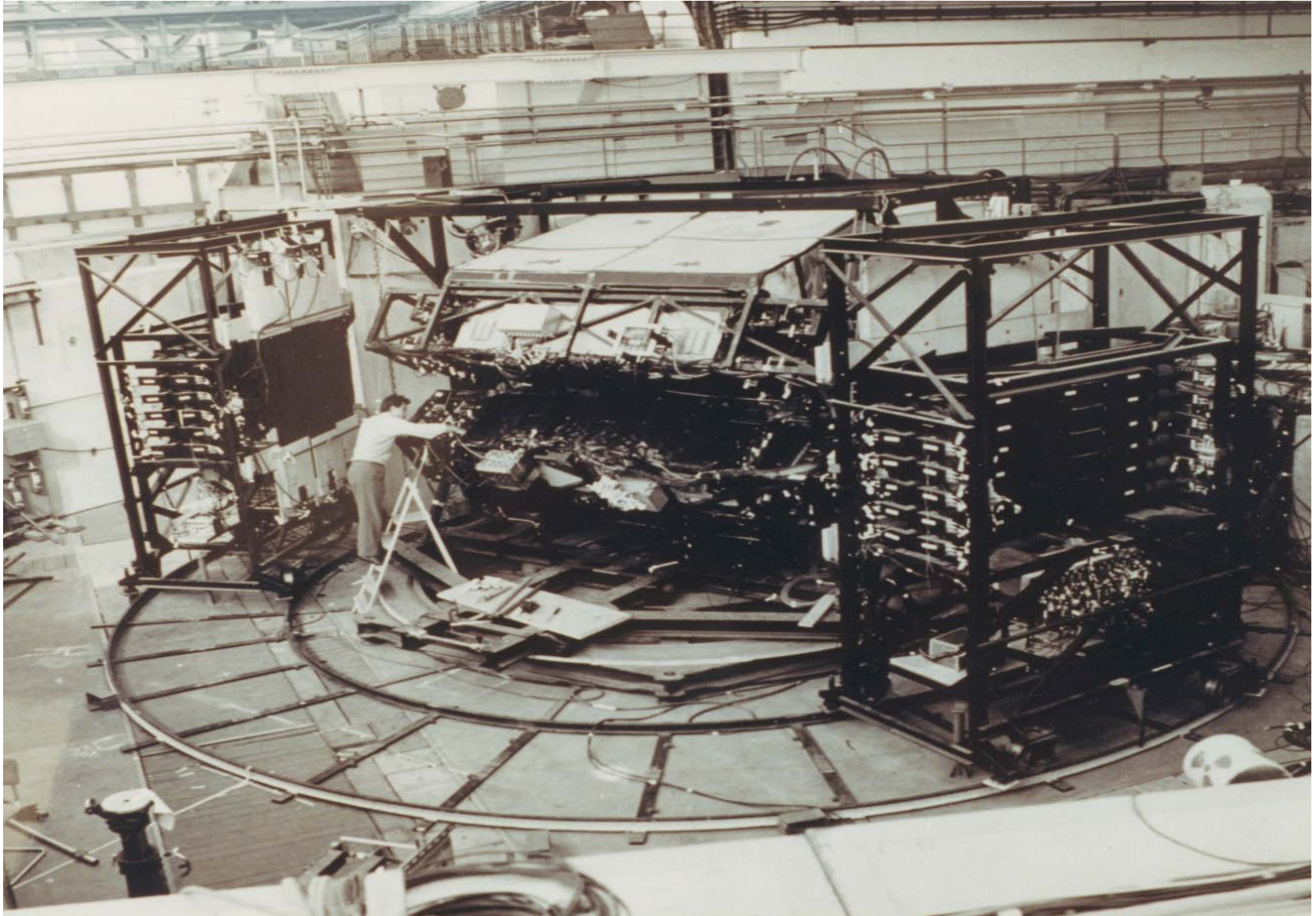


Figure 3: The PAMPLE experimental set-up at CERN.

The

$\tau - \theta$   
puzzle

discovered by Richard Dalitz  
was ignored.





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AND TO ENRICO FERMI, THE "ITALIAN NAVIGATOR", FATHER OF THE WEAK FORCES

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- World Federation of Scientists • World Laboratory

**PROGRAMME AND LECTURERS**

HOMAGE TO RICHARD H. DALITZ

Figure 42



World Scientific Series in 20th Century Physics – Vol. 20

*The*  
**ORIGIN**  
*of the* **THIRD**  
**FAMILY**

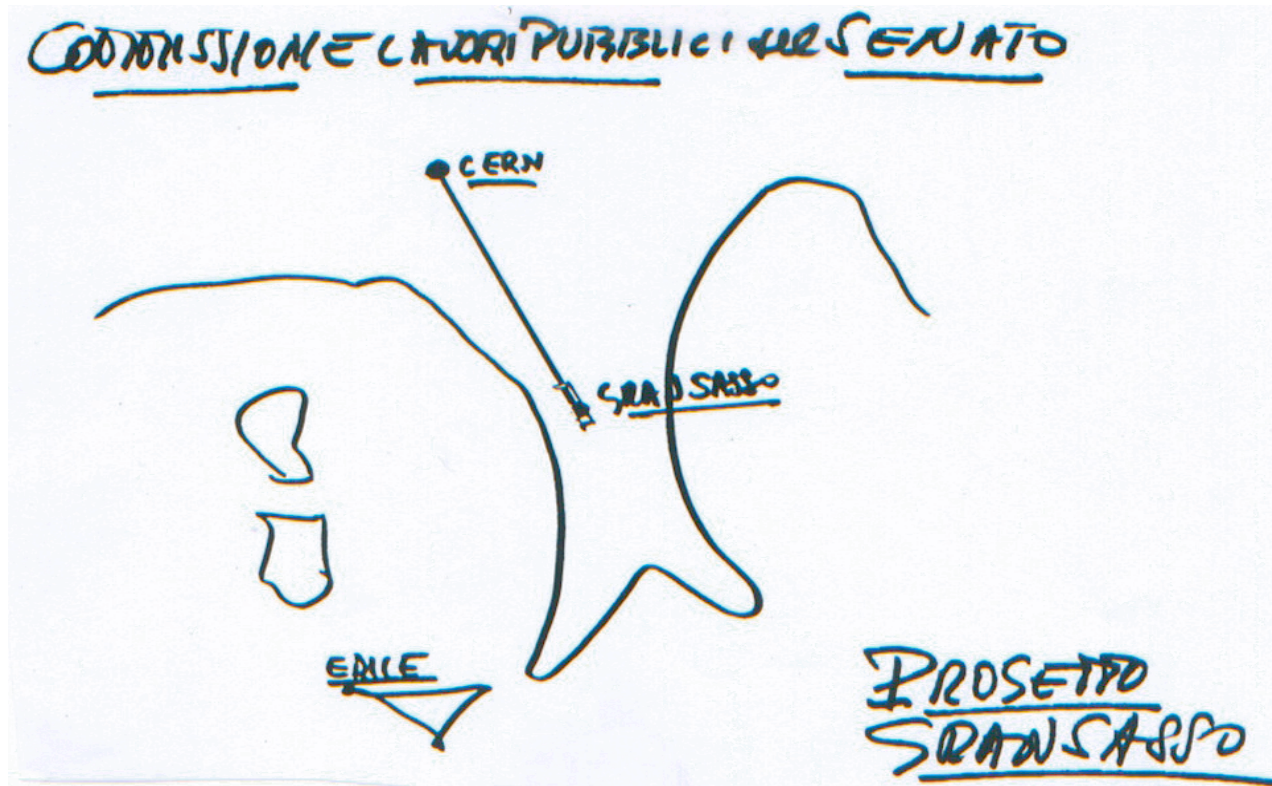
IN HONOUR OF A. ZICHICHI ON THE XXX ANNIVERSARY OF THE  
PROPOSAL TO SEARCH FOR THE THIRD LEPTON AT ADONE

**C.S. Wu, T.D. Lee, N. Cabibbo,  
V.F. Weisskopf, S.C.C. Ting, C. Villi,  
M. Conversi, A. Petermann,  
B.H. Wiik and G. Wolf**

*Edited by*  
**O. Barnabei, L. Maiani, R.A. Ricci and F. Roversi Monaco**

World Scientific





Handwritten notes from the presentation by A. Zichichi to the Commission on Public Works of the Senate in a Session convened on short notice by the President of the Senate to discuss the proposal for Project Gran Sasso (1979).

To summarize, the scientific aims of the "Gran Sasso" laboratory are the study of:

- 1) nuclear stability;
- 2) neutrino astrophysics;
- 3) new cosmic phenomenology;
- 4) neutrino oscillations;
- 5) biologically active matter;
- 6) ground stability.

Not only  
 $\tau_p \neq \infty$

Reproduction of page 13 of the original project [10].

Figure 10



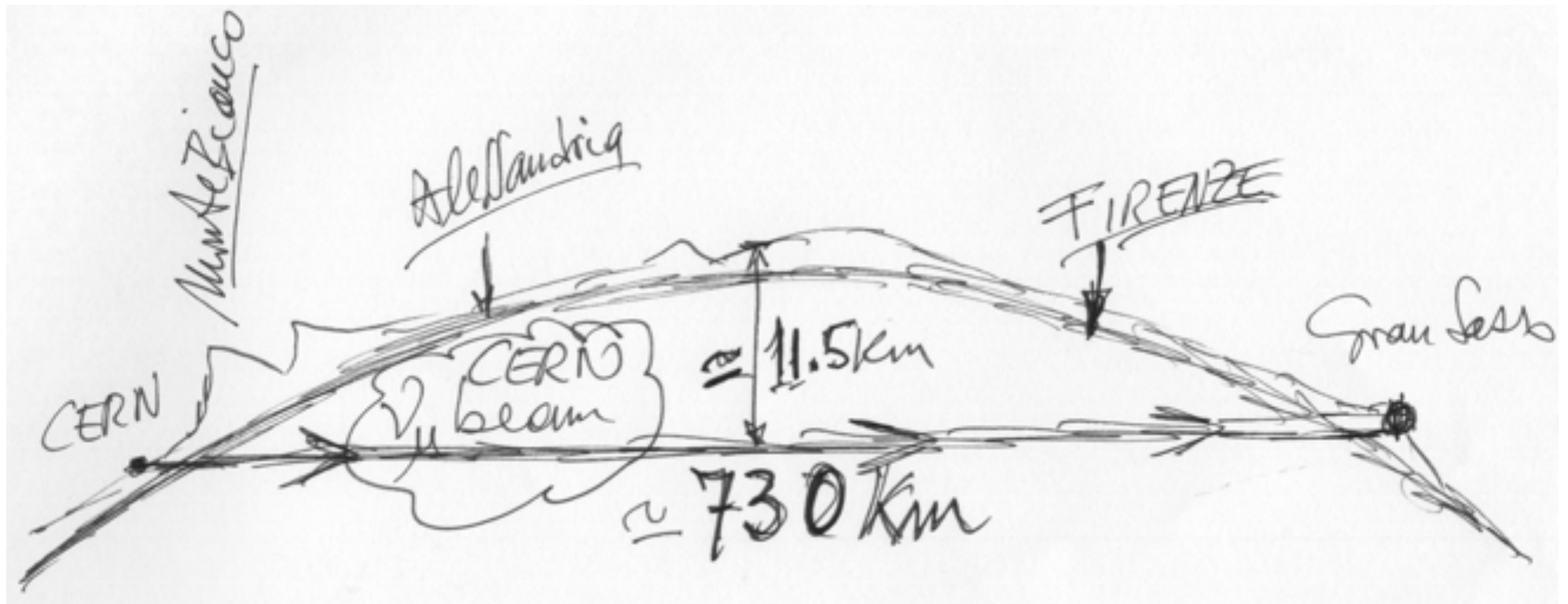


Figure 11

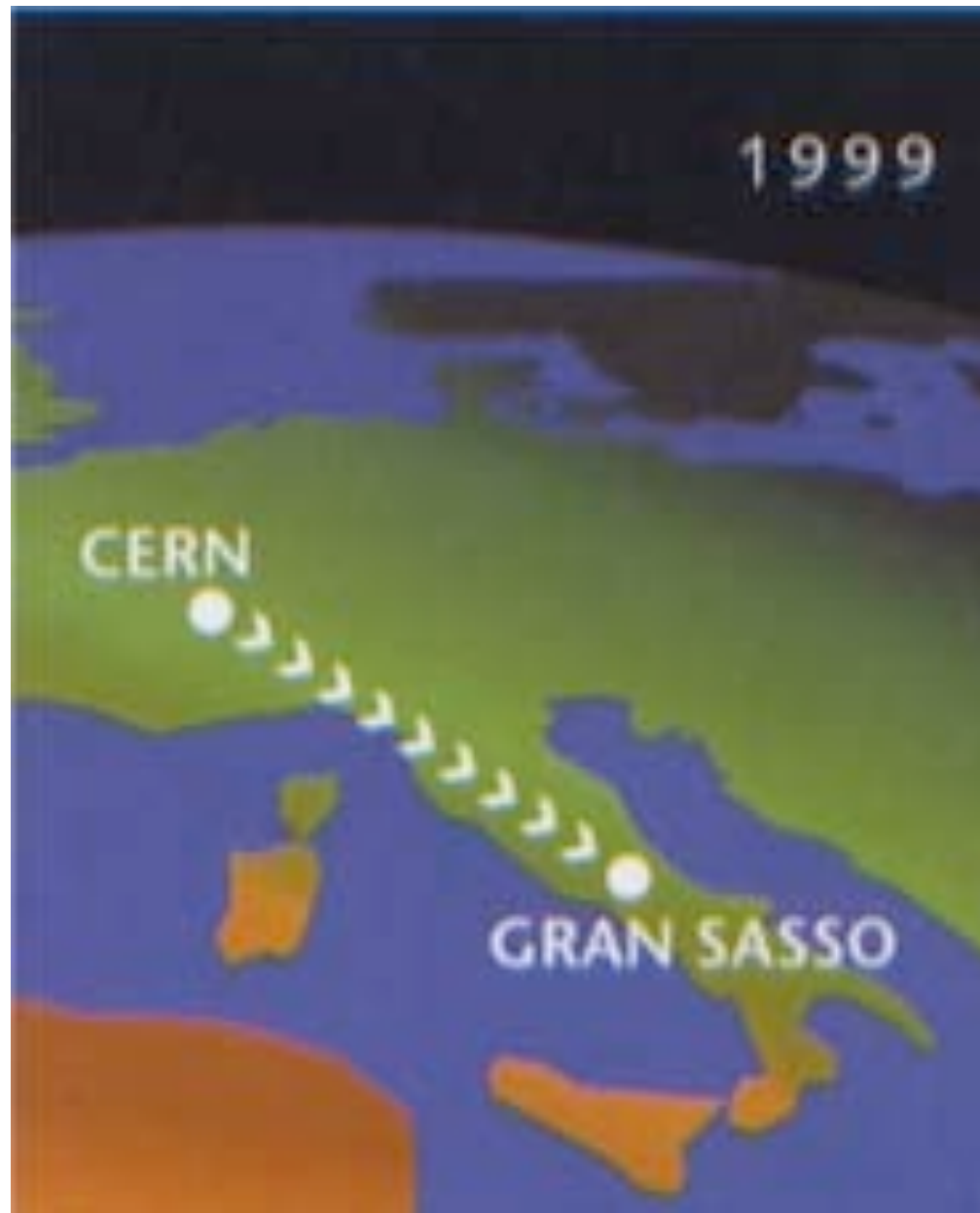


Figure 12

To summarize, the scientific aims of the "Gran Sasso" laboratory are the study of:

- 1) nuclear stability;
- 2) neutrino astrophysics;
- 3) new cosmic phenomenology;
- 4) neutrino oscillations;
- 5) biologically active matter;
- 6) ground stability.

Not only  
 $\tau_p \neq \infty$

Figure 13: Reproduction of page 13 of the original project [10].

## 2. THE BASIC CHARACTERISTICS OF THE LAB.

The range of scientific perspectives opened up by the Gran Sasso Laboratory goes far beyond the measurement of the proton lifetime, as shown in Fig. 1.1.

These *scientific perspectives* depend on the *basic features* of the Gran Sasso Laboratory, which are:

- 1) very low noise due to local radioactivity;
- 2) neither too deep, nor too shallow underground;
- 3) orientation towards the most powerful (artificial) source of neutrinos and other unknowns (Fig. 2.1);
- 4) link with a laboratory at the top of the Gran Sasso, which allows time coincidences to be made (Fig. 2.2);
- 5) instrumentation which uses the most advanced technologies.

The *low noise* level in terms of *natural radioactivity*, was proved before the excavation work started. The measurements of the cosmic ray flux and of the local rock radioactivity were first performed by one of my collaborators, - L. Federici<sup>3)</sup> - whom I want to pay tribute to, in this solemn occasion. These measurements demonstrated that over the length of one Km the cosmic ray flux was constant. This nice feature is due to the shape and structure of the mountain. The Gran Sasso rock radioactivity was so low that the term «laboratory of cosmic silence» could be coined.

Reproduction of page 111 of Ref. 15; Proceedings in honour of M. Conversi, a strong supporter of the Gran Sasso Project.

## REFERENCES

- [1<sup>a</sup>] *THE GRAN SASSO PROJECT*. A. Zichichi, Proceedings of the GUD-Workshop on “Physics and Astrophysics with a Multikiloton Modular Underground Track Detector”, Rome, Italy, 29-31 October 1981 (INFN, Frascati, 1982), 141.
- [1<sup>b</sup>] *THE GRAN SASSO PROJECT*. A. Zichichi, NFN/AE-82/1, 28 February 1982.
- [1<sup>c</sup>] *THE GRAN SASSO PROJECT*. A. Zichichi, Proceedings of the Workshop on “Science Underground”, Los Alamos, NM, USA, 27 September-1 October 1982 (AIP, New York, 1983), 52.
- [2] *THE GRAN SASSO LABORATORY*. A. Zichichi, Proceedings of the International Colloquium on “Matter Non-Conservation” - ICOMAN ‘83, Frascati, Italy, 17-21 January 1983 (INFN, Frascati, 1983), 3.
- [3] *THE GRAN SASSO LABORATORY AND THE ELOISATRON PROJECT*. A. Zichichi, “Old and New Forces of Nature” (Plenum Press, New York-London, 1988), 335.
- [4] *PERSPECTIVES OF UNDERGROUND PHYSICS: THE GRAN SASSO PROJECT*. A. Zichichi, Invited Plenary Lecture at the Symposium on “Present Trends, Concepts and Instruments of Particle Physics”, in honour of Marcello Conversi’s 70th birthday, Rome, Italy, 3-4 November 1987, *Conference Proceedings* Eds. G. Baroni, L. Maiani and G. Salvini (SIF, Bologna, 1988), Vol. 15, 107.

Figure 14



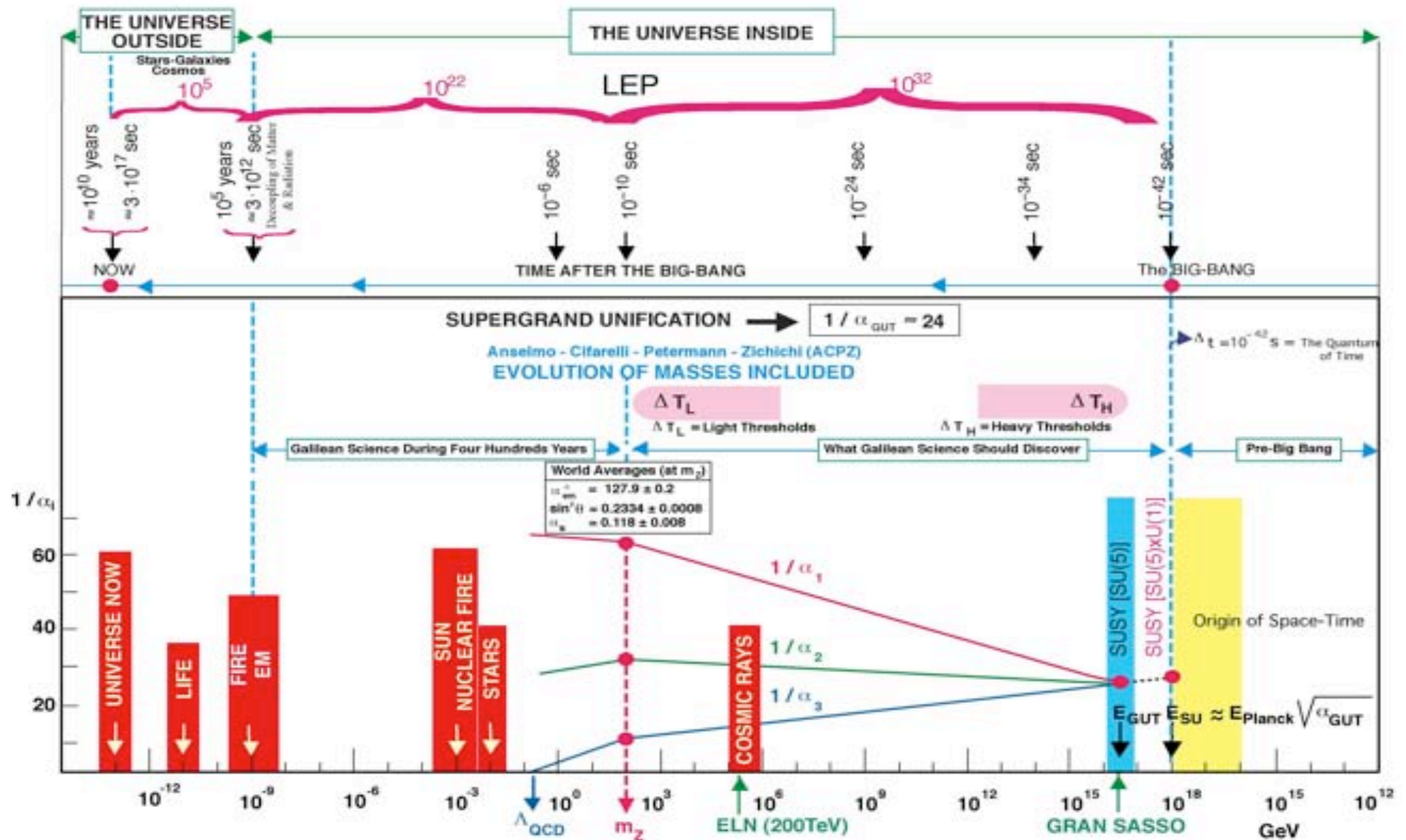


Figure 17

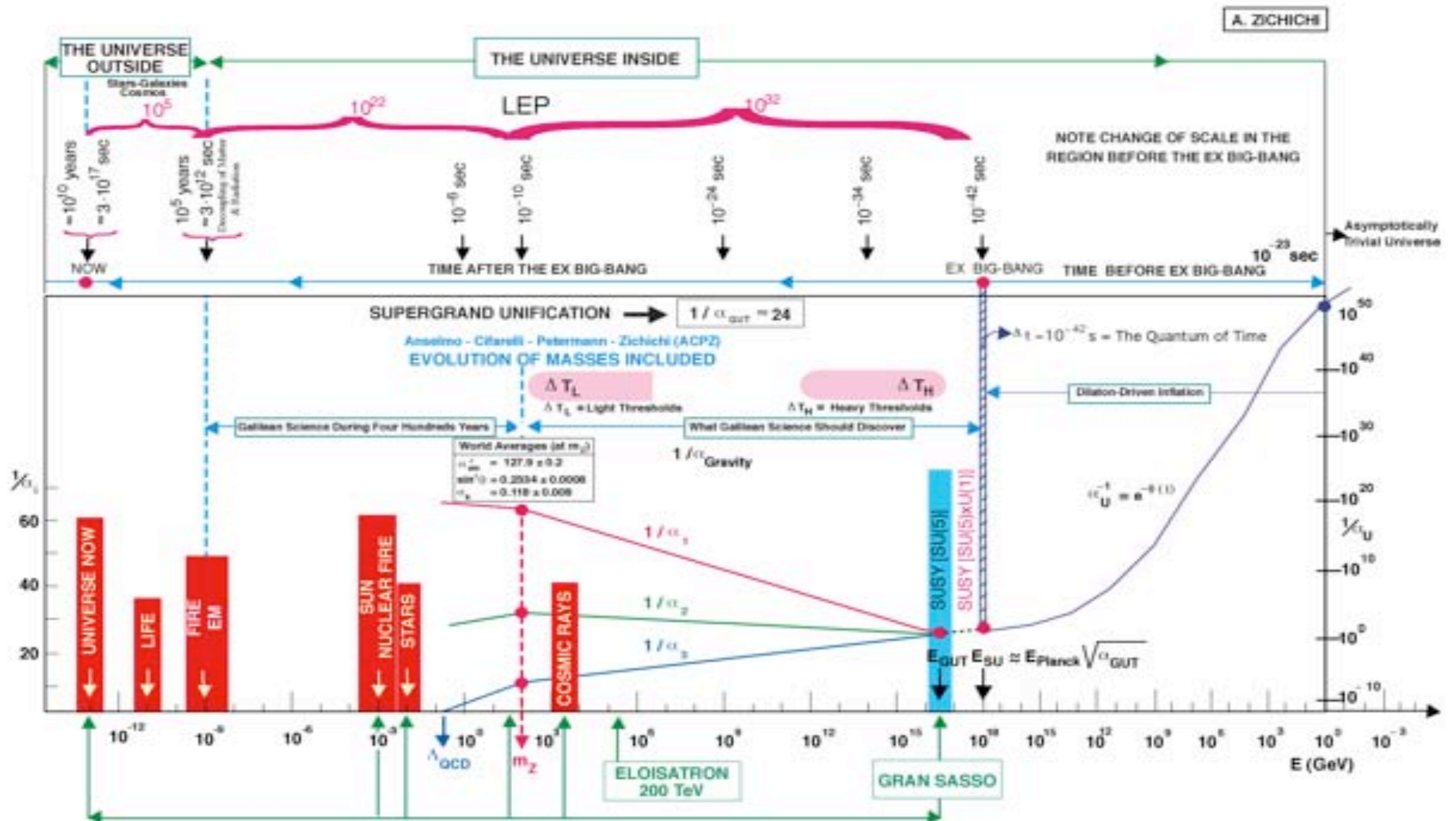


Figure 18: This picture shows the pre-Big Bang zone, which is at the centre of theoretical attention today.

## The Renormalization Group Equations

The lines result from calculations executed with a supercomputer using the following system of equations:

$$\mu \frac{d\alpha_i}{d\mu} = \frac{b_i}{2\pi} \alpha_i^2 + \sum_j \frac{b_{ij}}{8\pi^2} \alpha_j \alpha_i^2 .$$

This is a system of coupled non-linear differential equations (RGEs) that describes the Superworld, from the maximum level of Energy (Planck Scale) to our world.

Figure 19

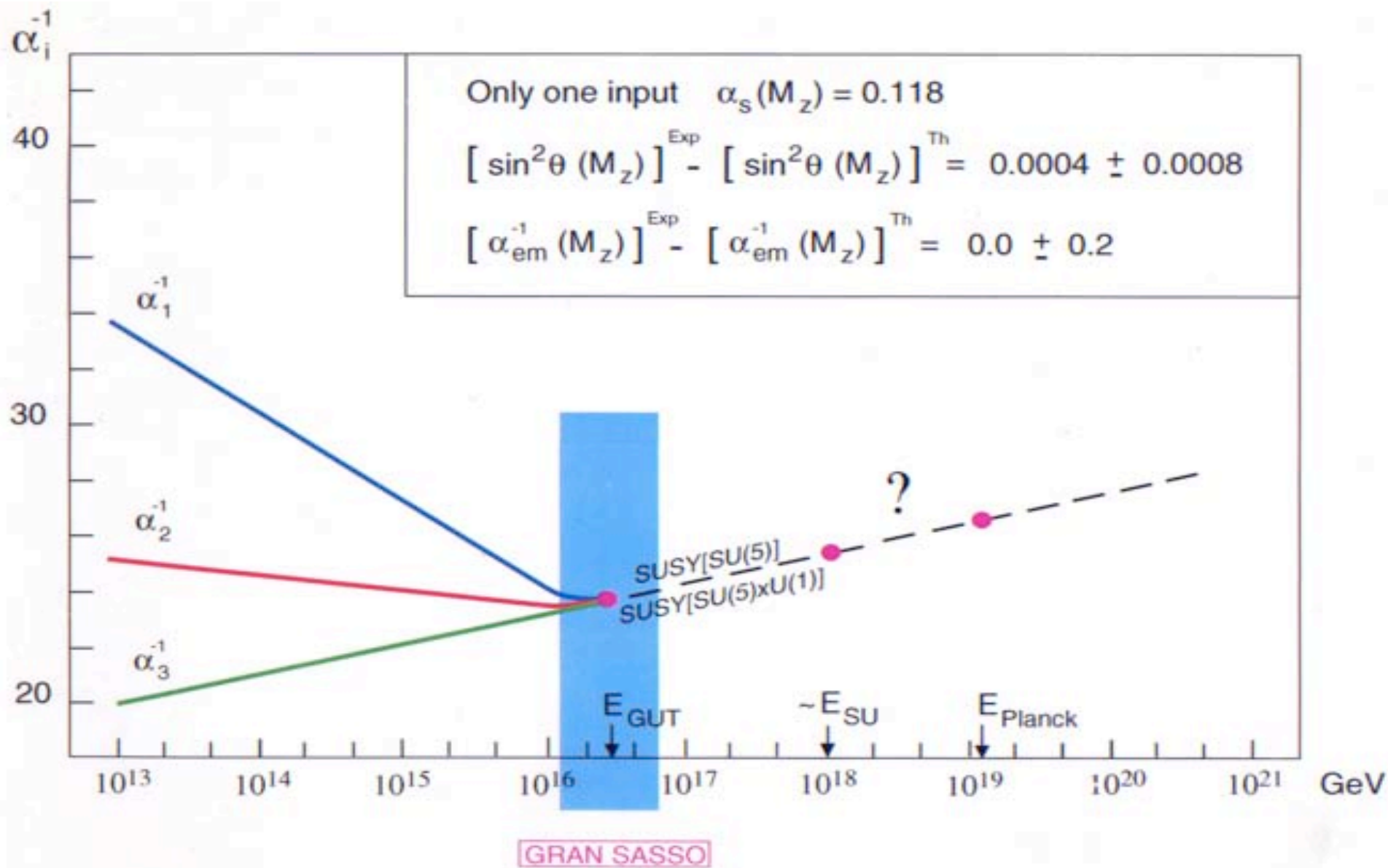


Figure 20



The time different between  
LVD and OPERA

$$\delta t = t_{LVD} - t_{OPERA}^*$$

In order to study the stability of the time difference  $\delta t$  versus calendar time, the data have been subdivided in different periods of the various solar years.

The year 2008 has been divided in three samples: before May, May-August, after August. For each period we look at the  $\delta t$  distribution, compute the mean and the RMS.

The results are shown in Figures 16 and 17 and summarized in Table 2. The total number of events, 306, is distributed into eight samples, each one covering a given calendar time period.

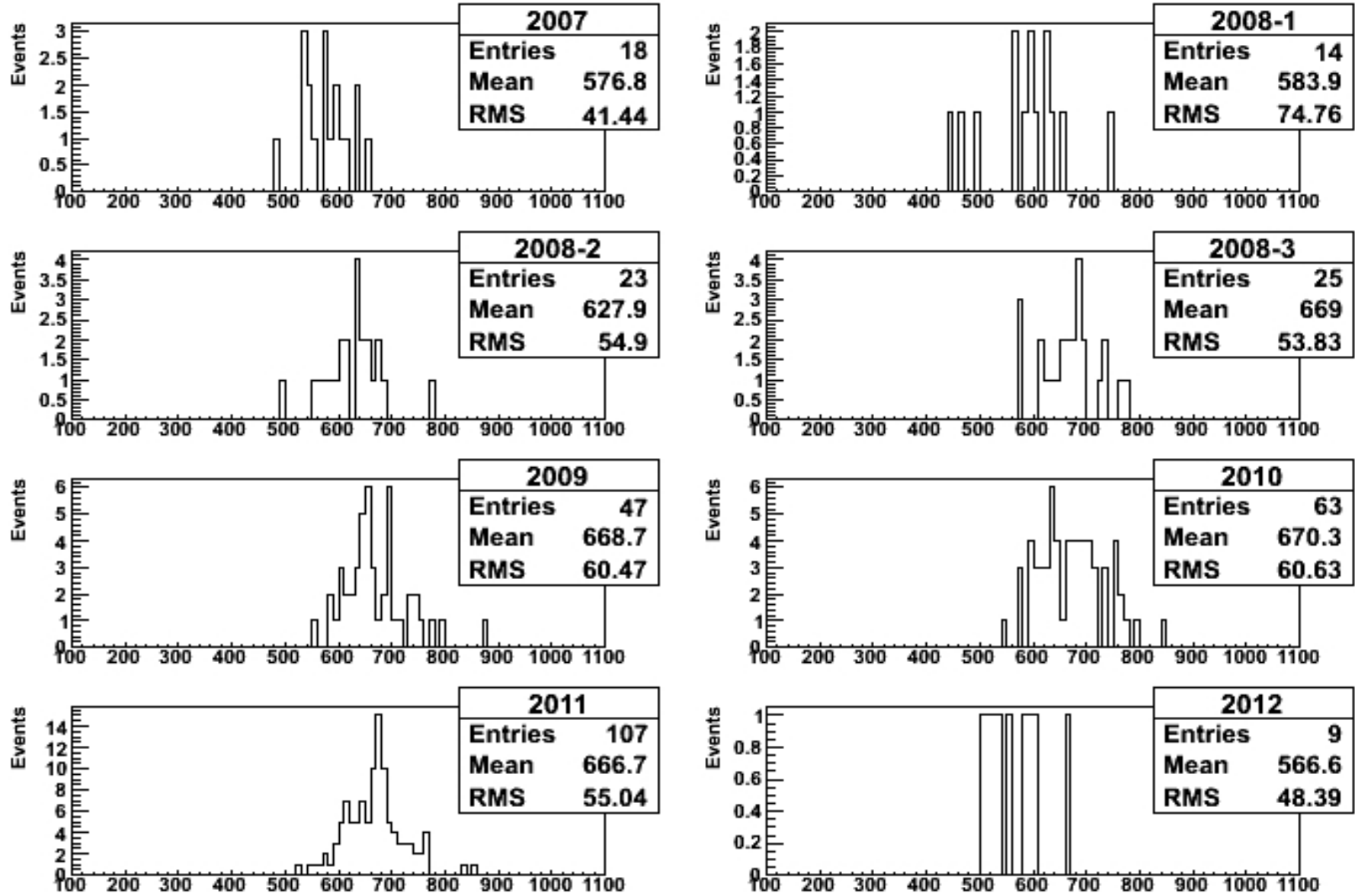


Fig. 16. Distribution of the  $\delta t = t_{LVD} - t_{OPERA}^*$  for each period of time.

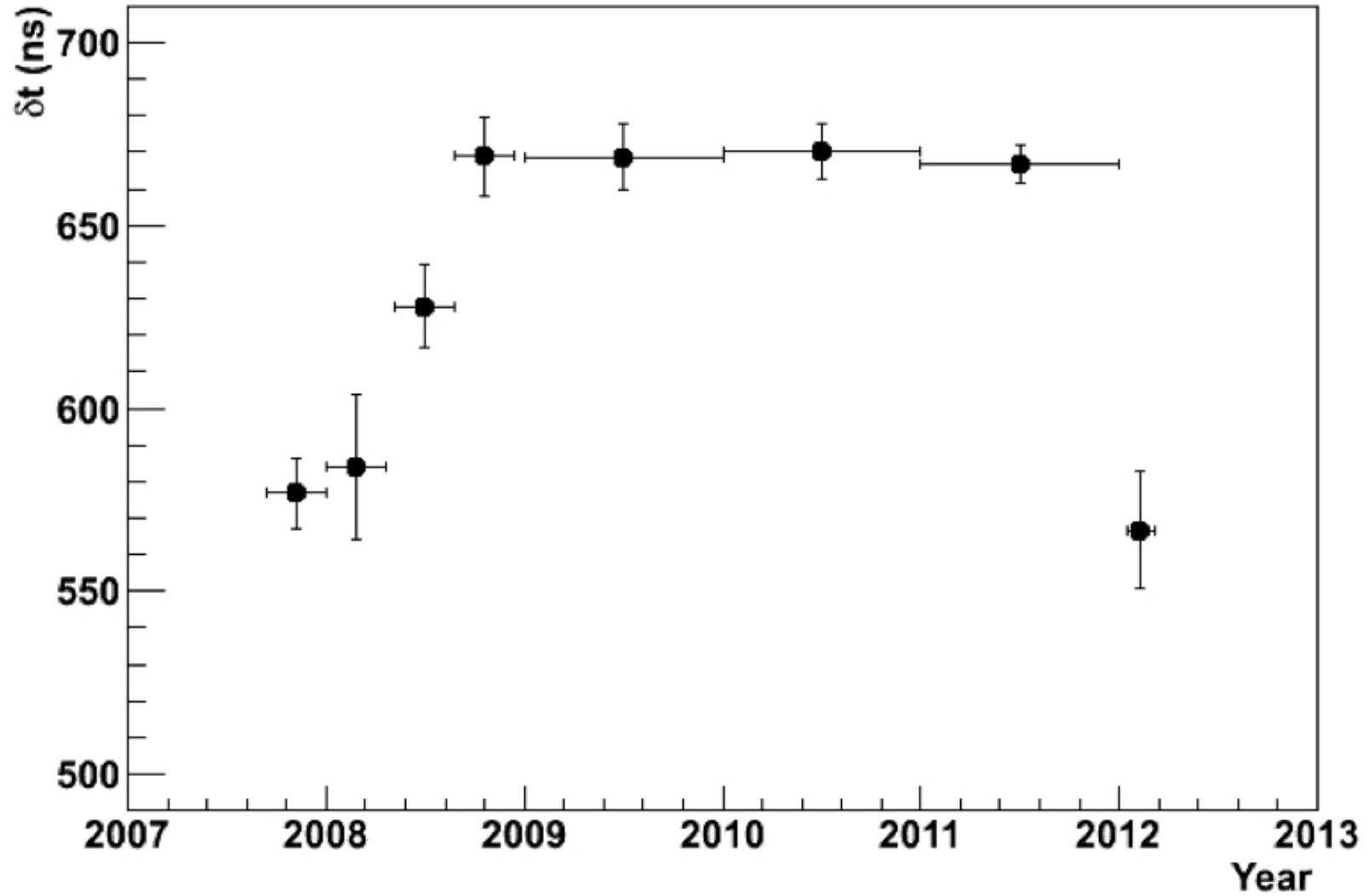


Fig. 17. Distribution of the  $\delta t = t_{LVD} - t_{OPERA}^*$  for corrected events. All the events of each year are grouped in one single point with the exception of year **2008** which is subdivided in three periods: before May, May-August, after August.

<b>TOTAL NUMBER OF EVENTS = 306</b>					
<b>Class</b>	<b>Year</b>	<b>Since</b>	<b>To</b>	<b>Nb. of events</b>	<b><math>\langle \delta t \rangle</math> (ns)</b>
A	2007	Aug	Dec	18	$577 \pm 10$
A	2008-1	Jan	Apr	14	$584 \pm 20$
A	2008-2	May	Aug	23	$628 \pm 11$
A	2012	Jan	Mar	9	$567 \pm 16$
B	2008-3	Sep	Dec	25	$669 \pm 11$
B	2009	Jun	Nov	47	$669 \pm 9$
B	2010	Jan	Dec	63	$670 \pm 8$
B	2011	Jan	Dec	107	$667 \pm 5$

*Table 2: Summary of the  $\delta t$  distribution in the various calendar time periods.*

Let us now group the results in two classes:

- class A: between August 2007 to August 2008 and from January to March 2012;
- class B: from August 2008 to December 2011.

.



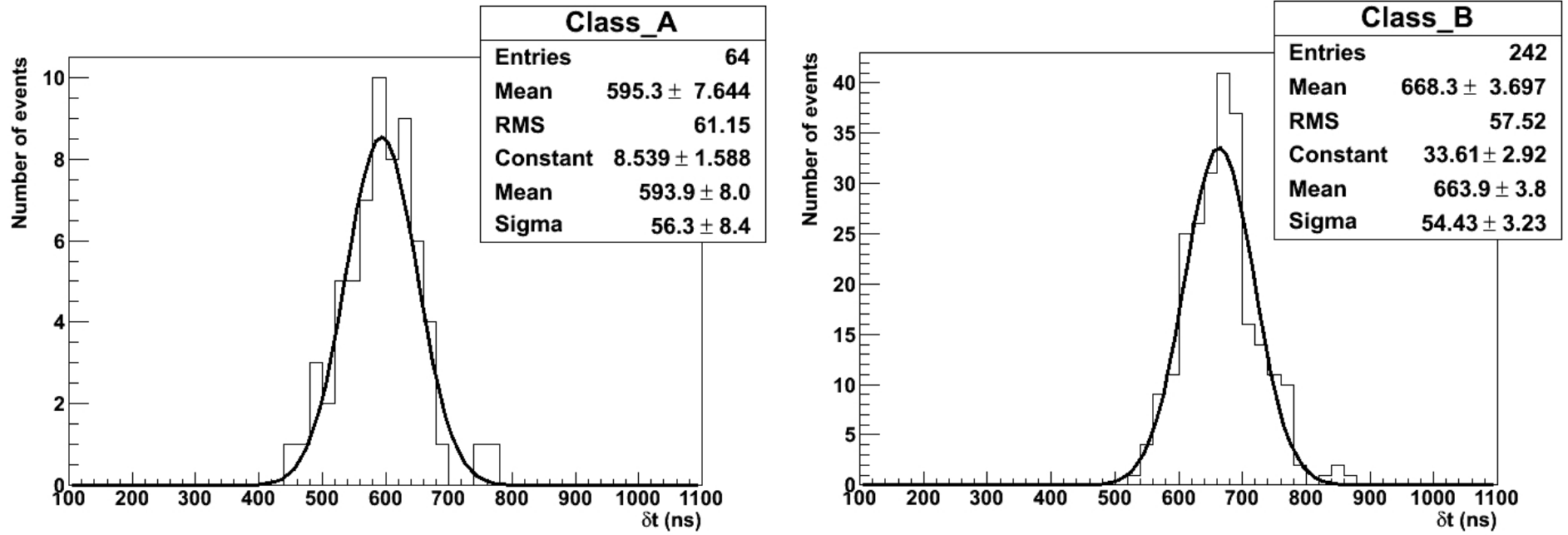
The two distributions for class A and B are reported in Figure 18.

We obtain for class A

$$\delta t = (595 \pm 8) \text{ ns},$$

while for class B

$$\delta t = (668 \pm 4) \text{ ns}.$$



*Fig. 18. Distribution of  $\delta t = t_{LVD} - t_{OPERA}^*$  for events of class A (left) and B (right).*

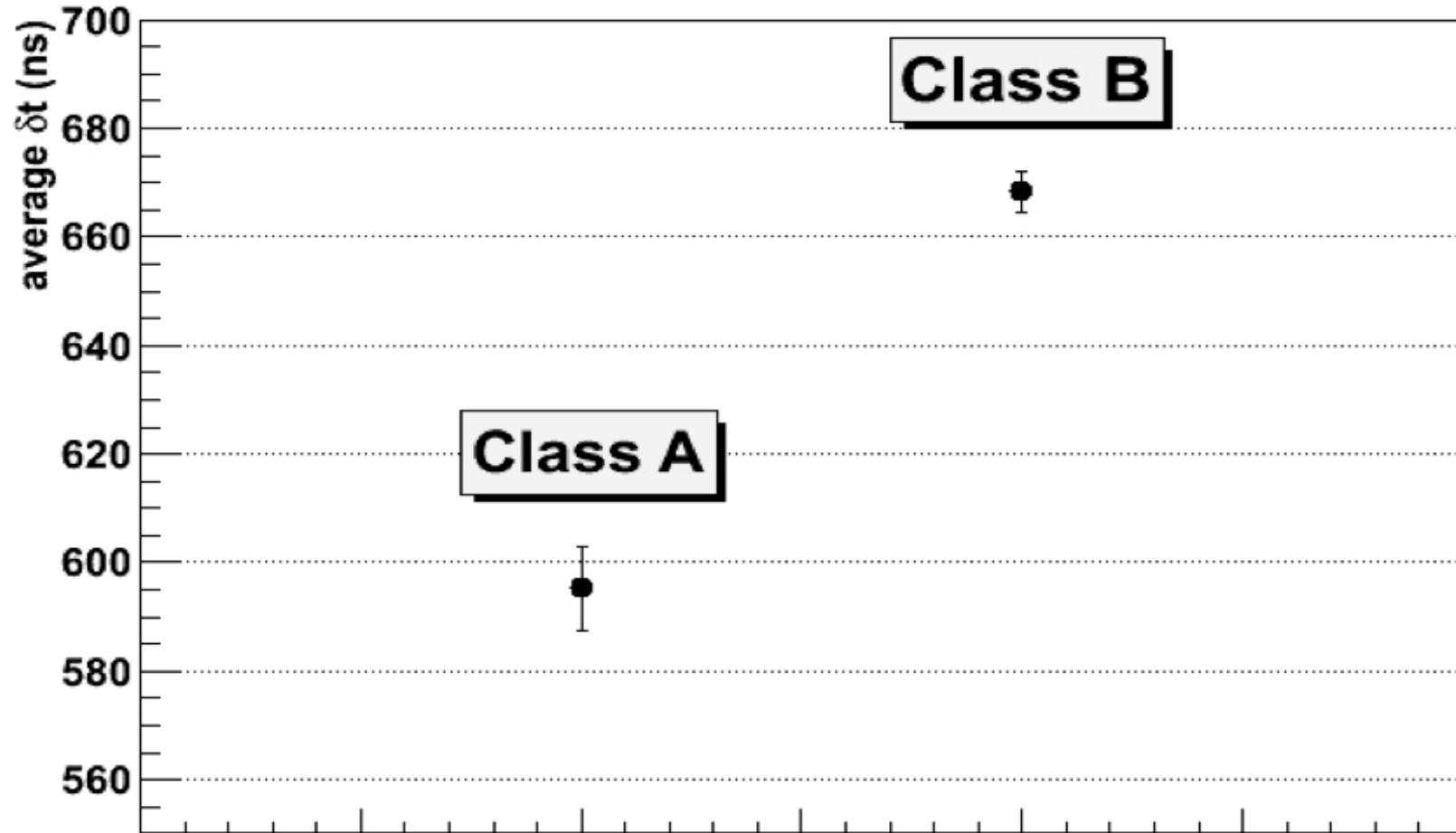
In Figure 19 we report  
the average value  
 $\langle \delta t \rangle$

for the two classes.

The resulting time difference between  
the average values in the two classes is

$$\Delta_{AB} = \langle \delta t_A \rangle - \langle \delta t_B \rangle = (-73 \pm 9) \text{ ns},$$

far from zero at 8-sigma level.



*Fig. 19. Average value of  $\delta t$  computed in each class of events. Class A are events in calendar time from August 2007 to August 2008 and from January 2012 to March 2012; Class B are from August 2008 to December 2011.*

We also note that now, after doing all the needed corrections, the two Gaussian distributions have a width compatible with the  $\sim 50$  ns time accuracy claimed by the experiments.

The stability in time of LVD shows that the OPERA detector has a negative time shift in the calendar period from August 2008 to December 2011 of the order of

$$\Delta_{AB} = (-73 \pm 9) \text{ ns}$$

compared with the calendar time from August 2007 to August 2008 and from January to March 2012 taken together.

## **7. Summary and conclusions**

Data from horizontal muons traversing the LVD and OPERA detectors cover a calendar time period from mid 2007 until 2012, for a total live time of about 1200 days.



In a time-window of 1  $\mu\text{s}$ , and excluding events in time with the CNGS beam spill, we found 306 events due to horizontal muons from the “Teramo anomaly”.

This sample has a time-difference ( $t_{LVD} - t_{OPERA}$ ) distribution peaked at 616 ns with an RMS of 74 ns.

The central value of the distribution has the following interpretation: the coincident events detected up to now are not multiple muons (one per each detector), but single muon events entering horizontally from the OPERA side and going through the LVD detector after 616 ns of flight.

Indeed, the OPERA-LVD direction lies along the so-called “Teramo anomaly”, where the mountain profile exhibits an anomaly in the *m. w. e.* depth in the horizontal direction. Visual inspection using the event displays of LVD and OPERA detectors confirms this anomaly discovered by LVD in 1997 [1].

The calendar time evolution of the time difference  $\delta t$  for various periods of data-taking is shown in Figure 17.

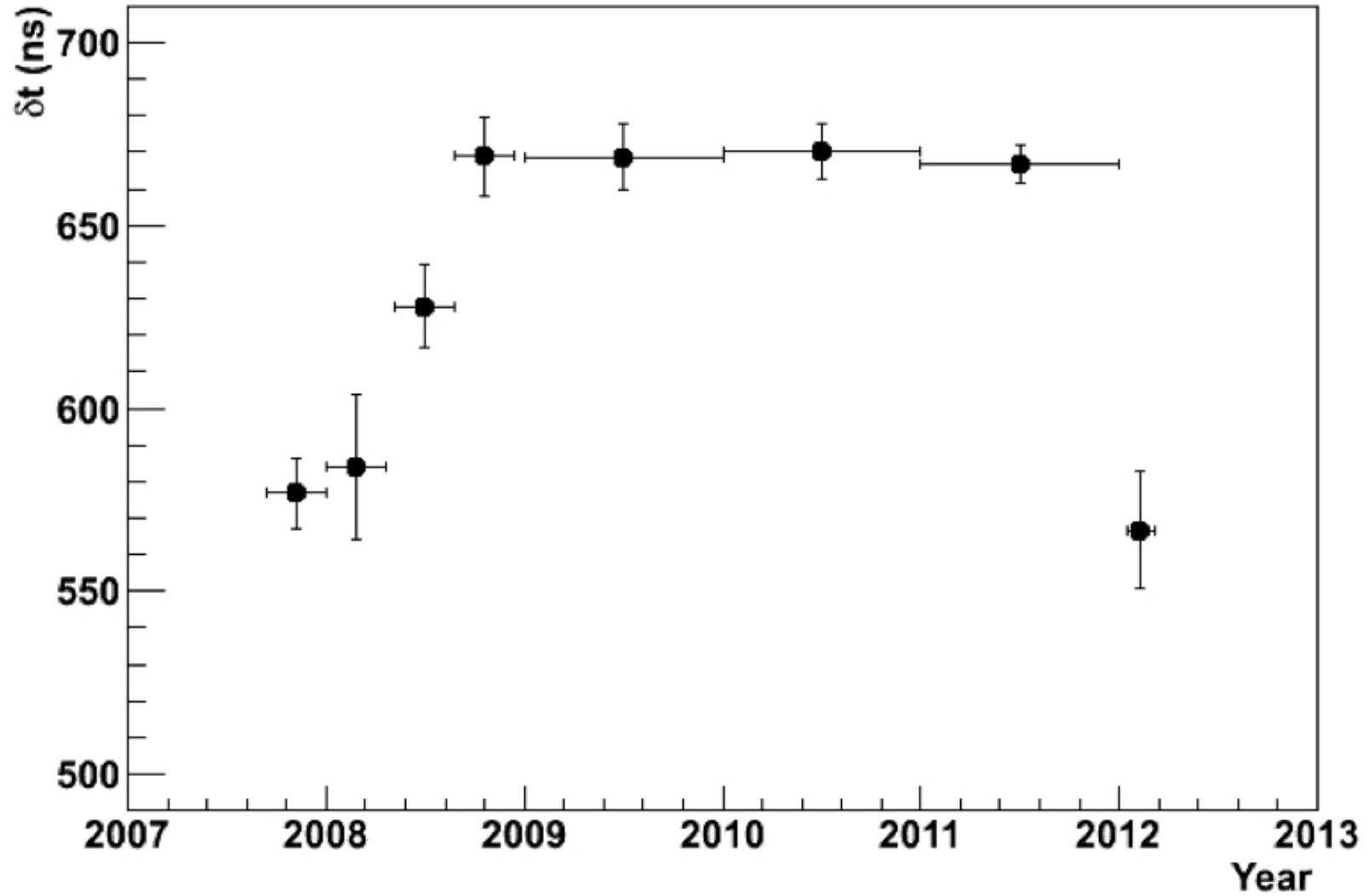


Fig. 17. Distribution of the  $\delta t = t_{LVD} - t_{OPERA}^*$  for corrected events. All the events of each year are grouped in one single point with the exception of year **2008** which is subdivided in three periods: before May, May-August, after August.

We see an evolution of the average value in each period, ranging

from  $\sim 580$  ns in 2007 up to  $\sim 670$  ns  
from May 2008 to the end of 2011;

then for the 9 events collected so far  
in 2012 it decreases again  
to  $\sim 570$  ns.

The observed variations are larger than the statistical uncertainty estimated for each period.



Grouping the time periods in two classes, as labelled in Table 2, we obtain for

class A an average value of

$$\Delta t (A) = (595 \pm 8) \text{ ns},$$

and for class B

$$\Delta t (B) = (668 \pm 4) \text{ ns}.$$

<b>TOTAL NUMBER OF EVENTS = 306</b>					
<b>Class</b>	<b>Year</b>	<b>Since</b>	<b>To</b>	<b>Nb. of events</b>	<b><math>\langle \delta t \rangle</math> (ns)</b>
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A	2008-2	May	Aug	23	$628 \pm 11$
A	2012	Jan	Mar	9	$567 \pm 16$
B	2008-3	Sep	Dec	25	$669 \pm 11$
B	2009	Jun	Nov	47	$669 \pm 9$
B	2010	Jan	Dec	63	$670 \pm 8$
B	2011	Jan	Dec	107	$667 \pm 5$

*Table 2: Summary of the  $\delta t$  distribution in the various calendar time periods.*

The time stability of LVD compared with that of the OPERA detector gives a time difference between the two classes

$$\Delta t (A - B) = (-73 \pm 9) \text{ ns.}$$

This corresponds to a negative time shift for OPERA in the calendar period from August 2008 to December 2011 of the same order of the excess leading to a neutrino velocity higher than the speed of light as reported by OPERA [7].

Recent checks of the OPERA experimental apparatus showed evidence for equipment malfunctionings [8].

A first one is related to the oscillator used to produce the event time-stamps, while the second one is linked to the connection of the optical fiber bringing the GPS signal to the OPERA master clock.

This allows to conclude that the quantitative effect of this malfunctioning is the negative time shift,  $\Delta t (A - B)$ , mentioned above.

This explains the previous OPERA finding [7] on the neutrino time of flight shorter by 60 ns over the speed of light.



The result of this joint analysis is the first quantitative measurement of the relative time stability between the two detectors and provides a check that is totally independent from the TOF measurements of CNGS neutrino events and from the effect presented in [8], pointing to the existence of a possible systematic effect in the OPERA neutrino velocity analysis.

If new experiments will be needed for the study of neutrino velocities they must be able to detect effects an order of magnitude smaller than the value of the OPERA systematic effect.

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- [4] M. Aglietta et al., Il Nuovo Cimento 105 (1992) 1793.
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- [6] R. Acquafredda et al. (OPERA Collaboration) *First events from the CNGS neutrino beam* New J. Phys. 8 (2006) 303.
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- [8] OPERA Internal Note 143, 2012, report to the SPSC and LNGS-SC, March 2012.
- [9] T. Brugiere, “Oscillations des neutrinos sur et hors faisceau: étude des performances du système d'acquisition d'OPERA” Ph. D. Thesis., Lyon, 2011.

# APPENDIX 1

UEEC –

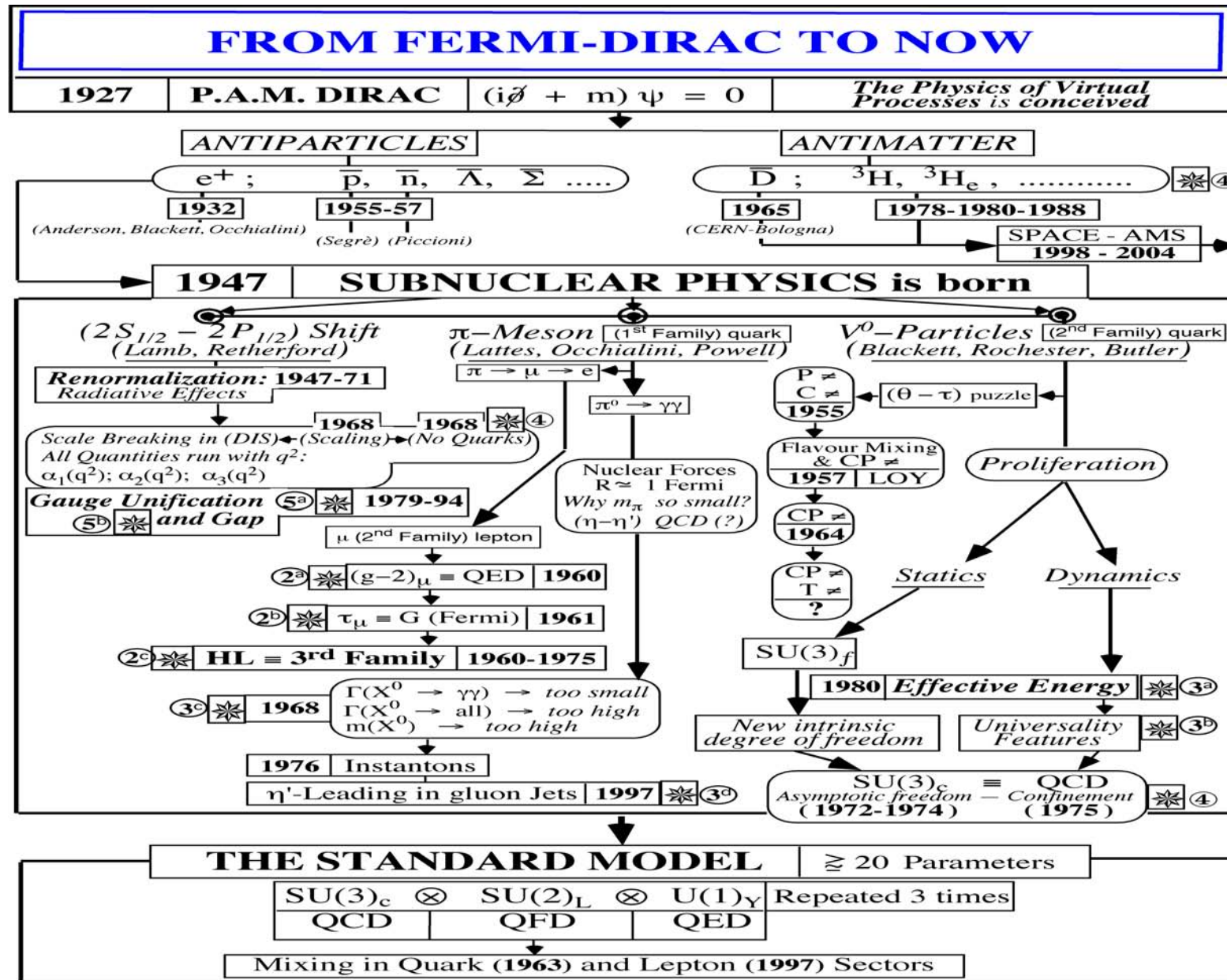
FROM GALILEI TO BLACKETT –

FERMI-DIRAC – SM&B

**‘UEEC’  
TOTALLY UNEXPECTED DISCOVERIES  
FROM GALILEO GALILEI TO SM&B**

<i>I</i>	Galileo Galilei	$F = mg$ .
<i>II</i>	Newton	$F = G \frac{m_1 \cdot m_2}{R_{12}^2}$
<i>III</i>	Maxwell discovered the unification of electricity, magnetism and optical phenomena, which allowed him to conclude that light is a vibration of the EM field.	
<i>IV</i>	Planck	$h \neq 0$ .
<i>V</i>	Lorentz discovered that space and time cannot be both real.	
<i>VI</i>	Einstein discovered the existence of time-like and space-like real worlds.	
<i>VII</i>	Rutherford discovered the nucleus.	
<i>VIII</i>	Dirac discovered his equation, which implies the existence of the antiworld.	
<i>IX</i>	Fermi discovered the weak forces.	
<i>X</i>	The ‘strange particles’ were discovered in the Blackett Lab.	

Figure 31



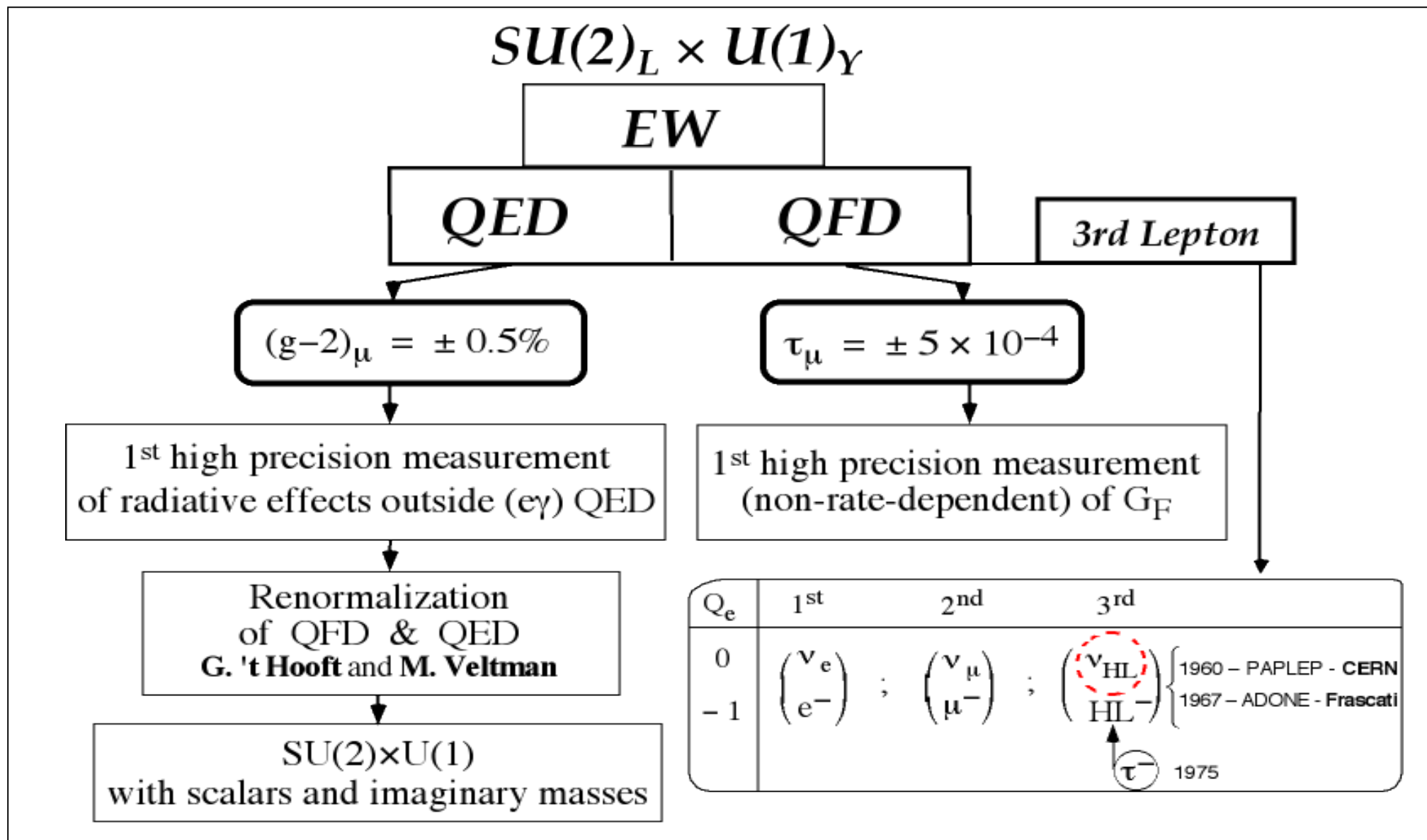


Figure 33

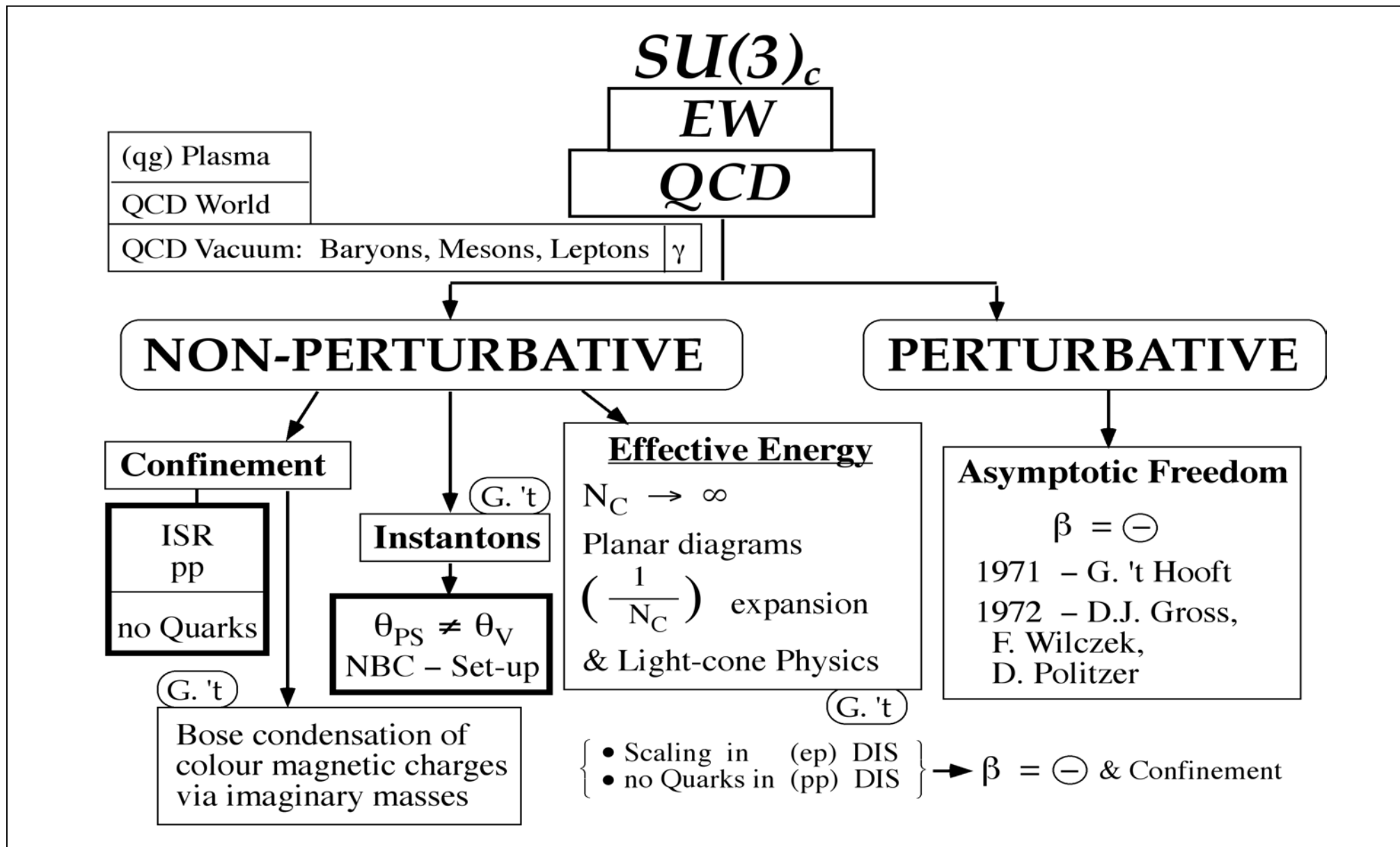


Figure 34



# SM&B

## THE STANDARD MODEL AND BEYOND

- ① RGEs ( $\alpha_i$  ( $i \equiv 1, 2, 3$ );  $m_j$  ( $j \equiv q, l, G, H$ )) :  $f(k^2)$ .
  - GUT ( $\alpha_{\text{GUT}} \equiv 1/24$ ) & GAP ( $10^{16} - 10^{18}$ ) GeV.
  - SUSY (to stabilize  $m_F/m_P \equiv 10^{-17}$ ).
  - RQST (to quantize Gravity).
- ② Gauge Principle (hidden and expanded dimensions).
  - How a Fundamental Force is generated: SU(3); SU(2); U(1) and Gravity.
- ③ The Physics of Imaginary Masses: SSB.
  - The Imaginary Mass in SU(2) $\times$ U(1) produces masses ( $m_{W^\pm}$ ;  $m_{Z^0}$ ;  $m_q$ ;  $m_l$ ), including  $m_\gamma = 0$ .
  - The Imaginary Mass in SU(5) $\Rightarrow$ SU(3) $\times$ SU(2) $\times$ U(1) or in any higher Symmetry Group (not containing U(1))  $\Rightarrow$  SU(3) $\times$ SU(2)  $\times$  U(1) produces Monopoles.
  - The Imaginary Mass in SU(3)<sub>c</sub> generates Confinement.
- ④ Flavour Mixings & CP  $\neq$ , T  $\neq$  .
  - No need for it but it is there.
- ⑤ Anomalies & Instantons.
  - Basic Features of all Non-Abelian Forces.

Note:	$q$	=	quark and squark;	$m_F$	=	Fermi mass scale;
	$l$	=	lepton and slepton;	$m_P$	=	Planck mass scale;
	G	=	Gauge boson and Gaugino;	$k$	=	quadrimomentum;
	H	=	Higgs and Shiggs;	C	=	Charge Conjugation;
	RGEs	=	Renormalization Group Equations;	P	=	Parity;
	GUT	=	Grand Unified Theory;	T	=	Time Reversal;
	SUSY	=	Supersymmetry;	$\neq$	=	Breakdown of Symmetry Operators.
	RQST	=	Relativistic Quantum String Theory;			
	SSB	=	Spontaneous Symmetry Breaking.			

The five basic steps in our understanding of nature. ① The renormalization group equations (RGEs) imply that the gauge couplings ( $\alpha_i$ ) and the masses ( $m_j$ ) all run with  $k^2$ . It is this running which allows GUT, suggests SUSY and produces the need for a non point-like description (RQST) of physics processes, thus opening the way to quantize gravity. ② All forces originate in the same way: the gauge principle. ③ Imaginary masses play a central role in describing nature. ④ The mass-eigenstates are mixed when the Fermi forces come in. ⑤ The abelian force QED has lost its role of being the guide for all fundamental forces. The non-abelian gauge forces dominate and have features which are not present in QED.

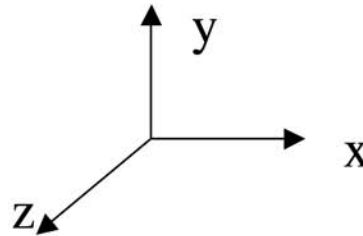
*Figure 35*

# OUR WORLD HAS FOUR SPACE-TIME DIMENSIONS

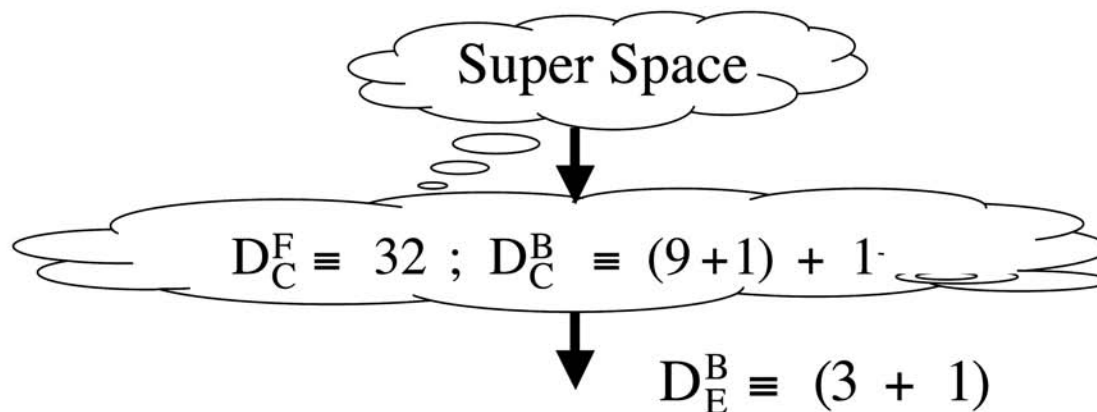
Three Space Dimensions

One Time Dimension

$$D_E^B \equiv (3 + 1) \equiv (\vec{x} ; it)$$



$$\left\{ \begin{array}{l} D^B \equiv \text{Bosonic Dimensions} \\ D^E \equiv \text{Expanded Dimensions} \end{array} \right\} \quad \left\{ \begin{array}{l} D^F \equiv \text{Fermionic Dimensions} \\ D^C \equiv \text{Compact Dimensions} \end{array} \right.$$



*THE SUPER SPACE HAS 43 DIMENSIONS*

Figure 36

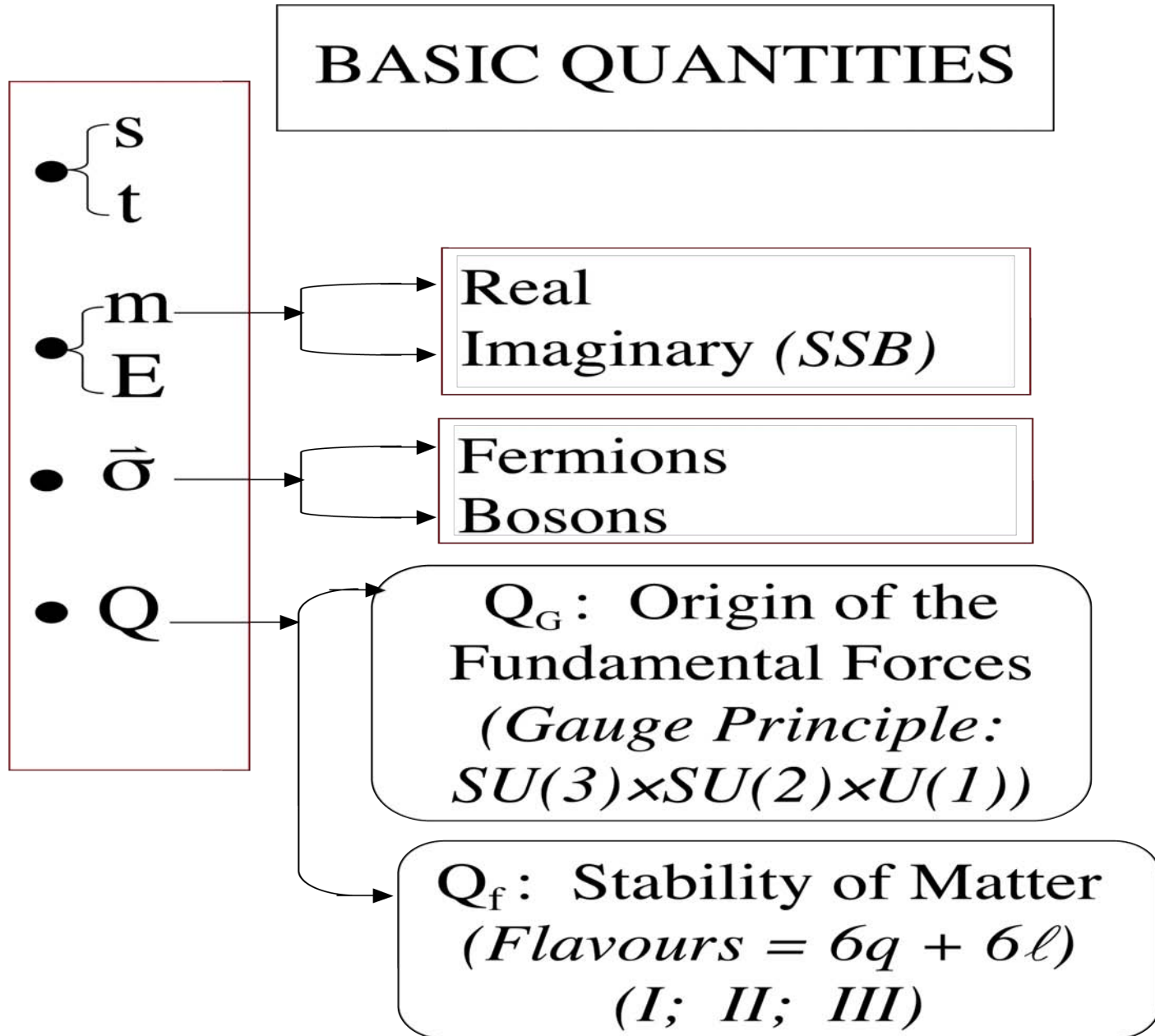


Figure 38

# SM&B

## THE STANDARD MODEL AND BEYOND

- ① RGEs ( $\alpha_i$  ( $i \equiv 1, 2, 3$ );  $m_j$  ( $j \equiv q, l, G, H$ )) :  $f(k^2)$ .
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  - SUSY (to stabilize  $m_F/m_P \equiv 10^{-17}$ ).
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  - The Imaginary Mass in SU(2) $\times$ U(1) produces masses ( $m_{W^\pm}$ ;  $m_{Z^0}$ ;  $m_q$ ;  $m_l$ ), including  $m_\gamma = 0$ .
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	G	=	Gauge boson and Gaugino;	$k$	=	quadrimomentum;
	H	=	Higgs and Shiggs;	C	=	Charge Conjugation;
	RGEs	=	Renormalization Group Equations;	P	=	Parity;
	GUT	=	Grand Unified Theory;	T	=	Time Reversal;
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	RQST	=	Relativistic Quantum String Theory;			
	SSB	=	Spontaneous Symmetry Breaking.			

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*Figure 39*

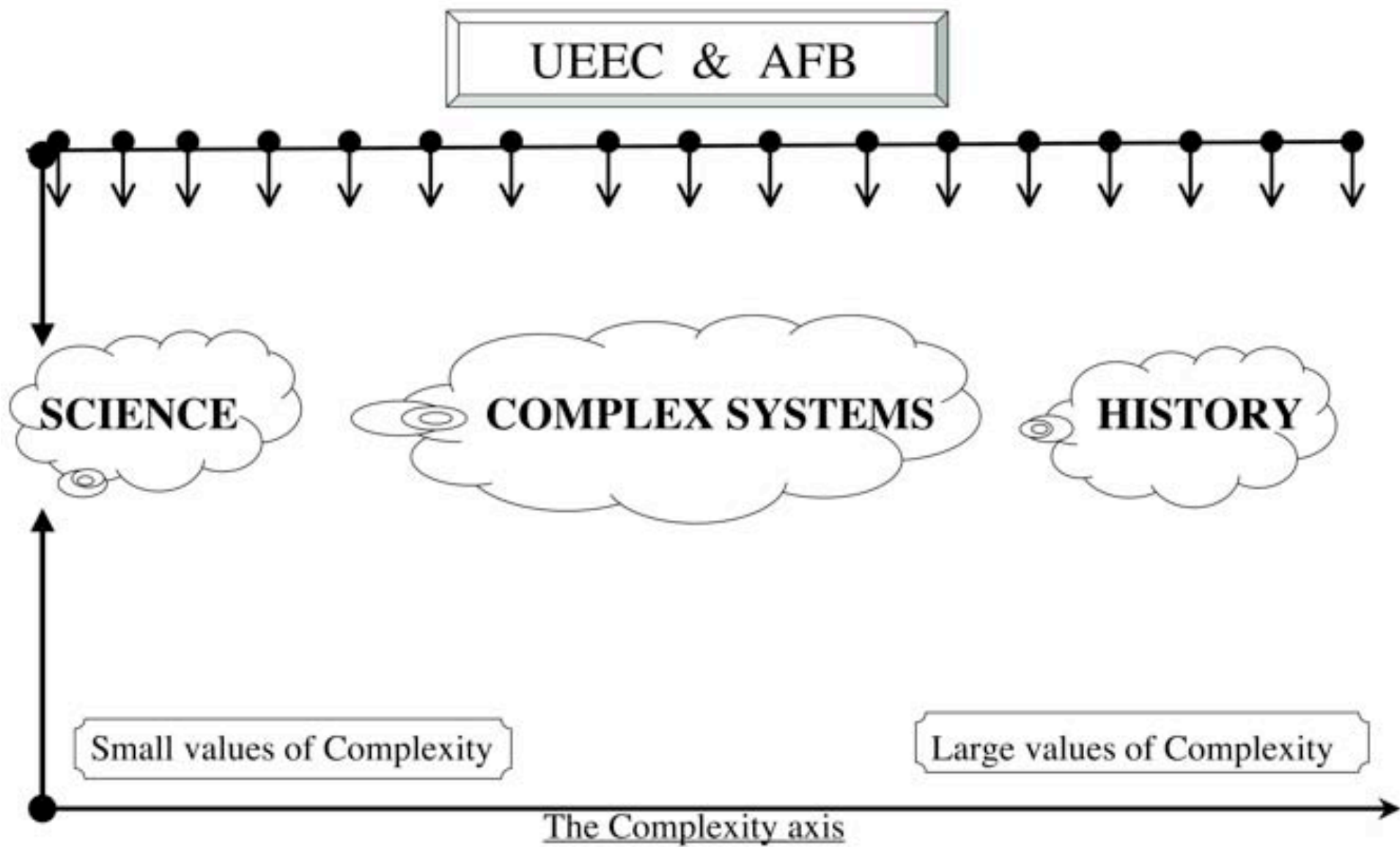


Figure 40

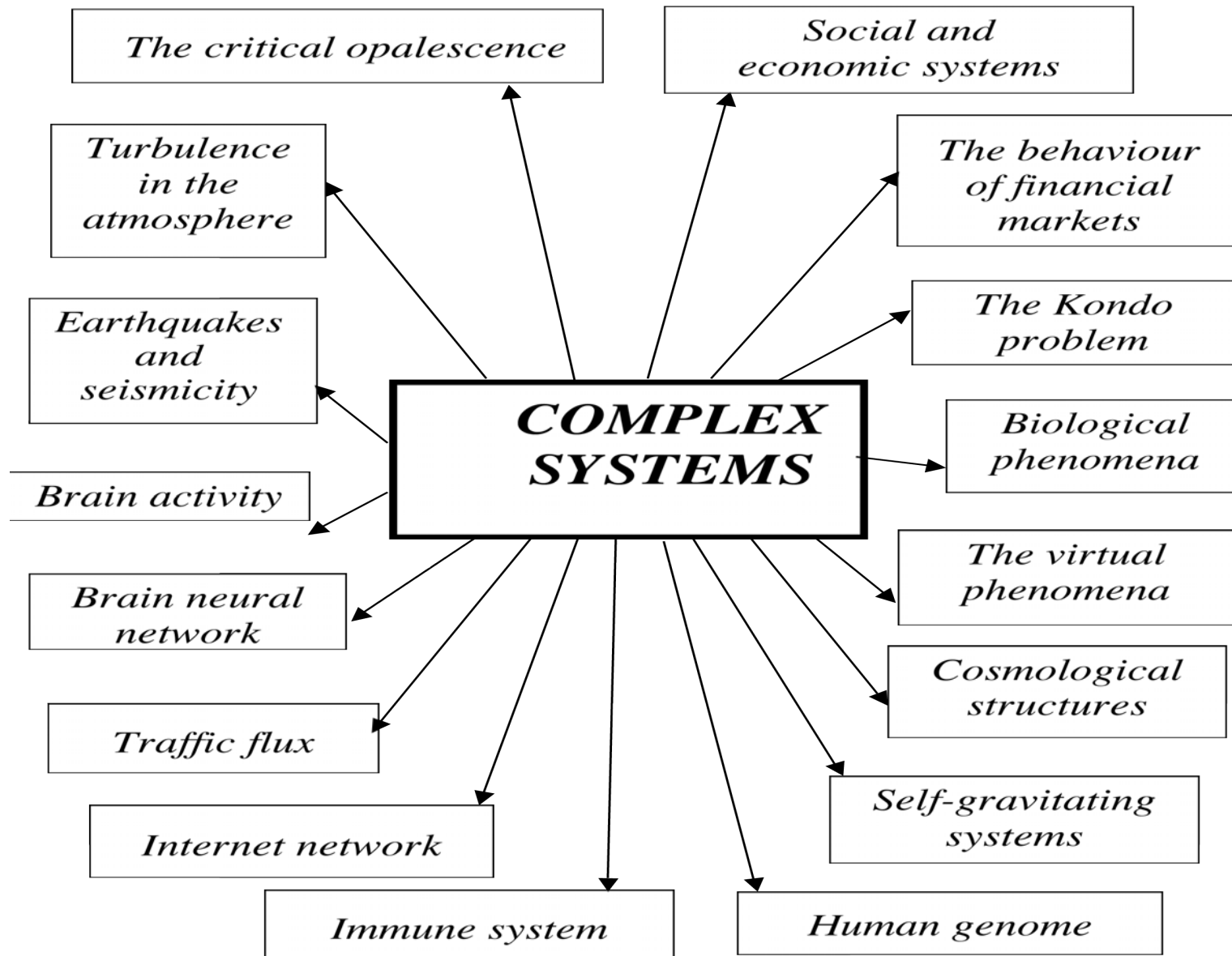


Figure 41





«ETTORE MAJORANA» FOUNDATION AND CENTRE FOR SCIENTIFIC CULTURE

TO PAY A PERMANENT TRIBUTE TO GALILEO GALILEI, FOUNDER OF MODERN SCIENCE  
AND TO ENRICO FERMI, THE "ITALIAN NAVIGATOR", FATHER OF THE WEAK FORCES

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**PROGRAMME AND LECTURERS**

HOMAGE TO RICHARD H. DALITZ

Figure 42

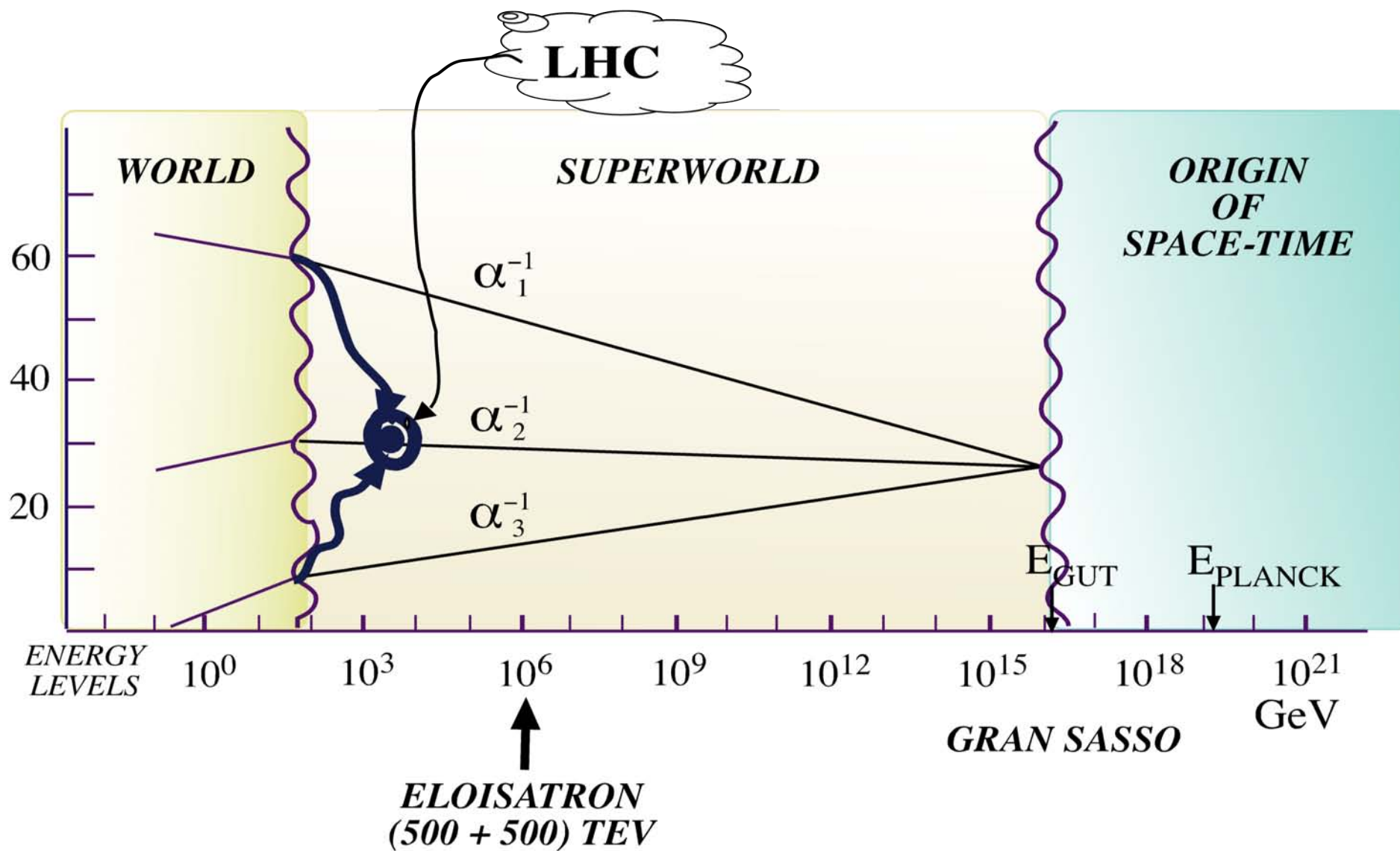


Figure 43



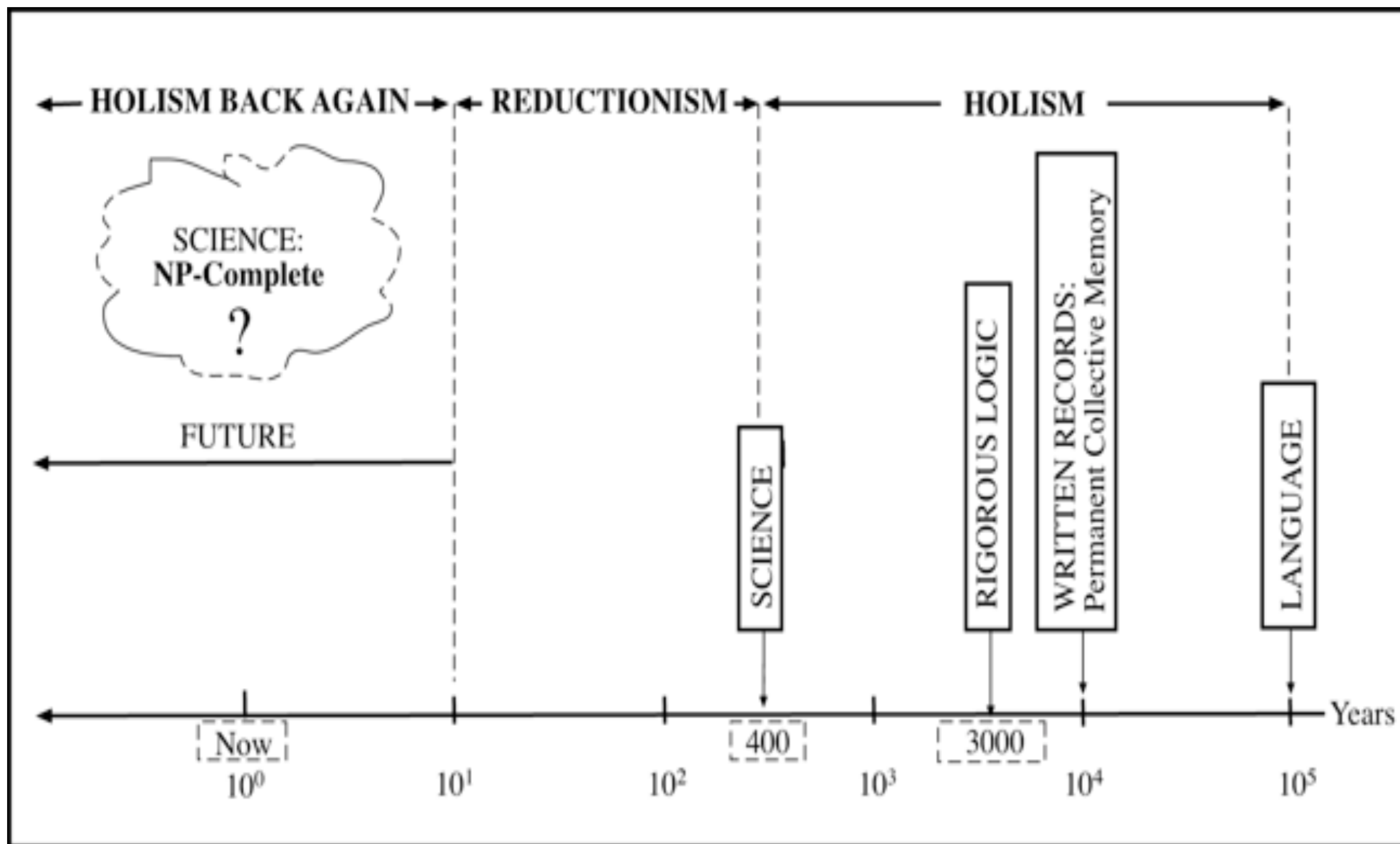


Figure 44

# APPENDIX 2

## SUPER LUMINAL NEUTRINOS – ETHICS AND IGNORANCE –

# **Super Luminal Neutrinos (SL $\nu$ )**

**23 Sept 2012**

Have produced confusion and proofs  
of lack of scientific knowledge

Let me recall Enrico Fermi:

*«Neither physics nor civilization  
could exist without memory».*

Enrico Fermi, Rome – 1930

*«Fellows who have never contributed to discoveries and inventions should never be considered physicists».*

Enrico Fermi, Chicago – 1950

# ETHICS IN SCIENCE

**1) Publication of a discovery. Discoveries must first be published in peer-review journals and only later given to the Media.**

**1965:  $\bar{d}$  (1<sup>st</sup> example of Nuclear Antimatter) CERN submitted to scientific journal (March). 3 month later  $\bar{d}$  “discovered” at BNL-USA and given to Media. Claim we are first, therefore this is USA discovery.**  
**30<sup>th</sup> anniversary celebration only CERN.**

Symposium in honour of Antonino Zichichi  
to celebrate the 30th anniversary of

## THE DISCOVERY OF NUCLEAR ANTIMATTER

Edited by L. Maiani and R. A. Ricci

IL NUOVO CIMENTO

VOL. XXXIX, N. 1

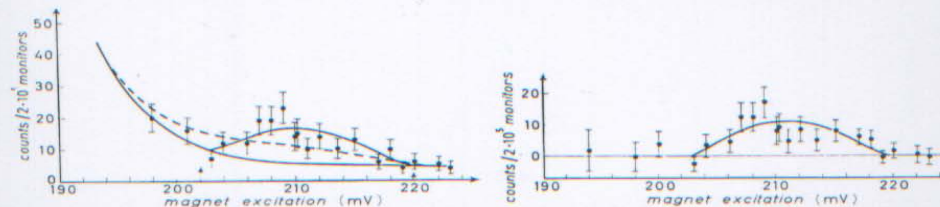
1° Settembre 1965

### Experimental Observation of Antideuteron Production.

T. MASSAM, TH. MULLER (\*), B. RIGHINI, M. SCHNEEGANS (\*) and A. ZICHICHI  
CERN - Geneva

(ricevuto il 13 Marzo 1965)

**Summary.** — The results of an experiment which show the existence of antideuterons in the production process proton-beryllium are reported.



*«I think that this discovery of antimatter was perhaps the  
biggest jump of all the big jumps in physics in our century»*

*Werner Heisenberg*



## **2) Reproducibility of a discovery.**

**1967:**  $S^0$  discovered in **USA** (the old version of the **God-particle** **announced** and **published**).

**Experiment:** repeated at CERN and proved to be wrong. The  $S^0$  does not exist.

### 3) **Origin of LNGS.**

i) **orientation** of the experimental Halls towards CERN: powerful source of  $\nu_\mu$  and other unknowns.

ii) **Powerful structure.** The Labs able to have gigantic set-ups like LVD; MACRO, OPERA, ICARUS, etc.

- **Origin** of this: PAMPLEP (Proton AntiProton into LEpton Pairs).

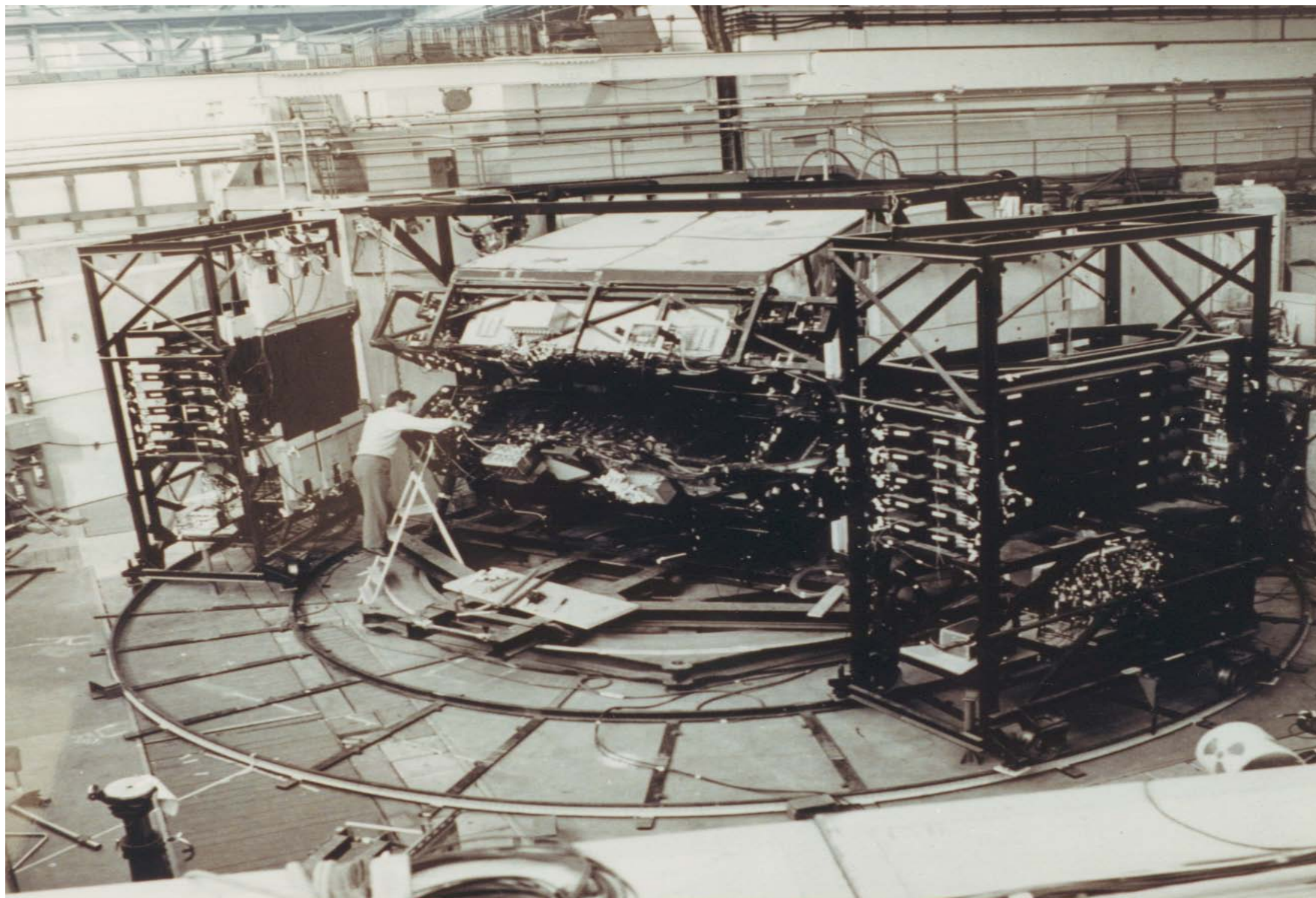


Figure 3: The PAPLEP experimental set-up at CERN (1960).



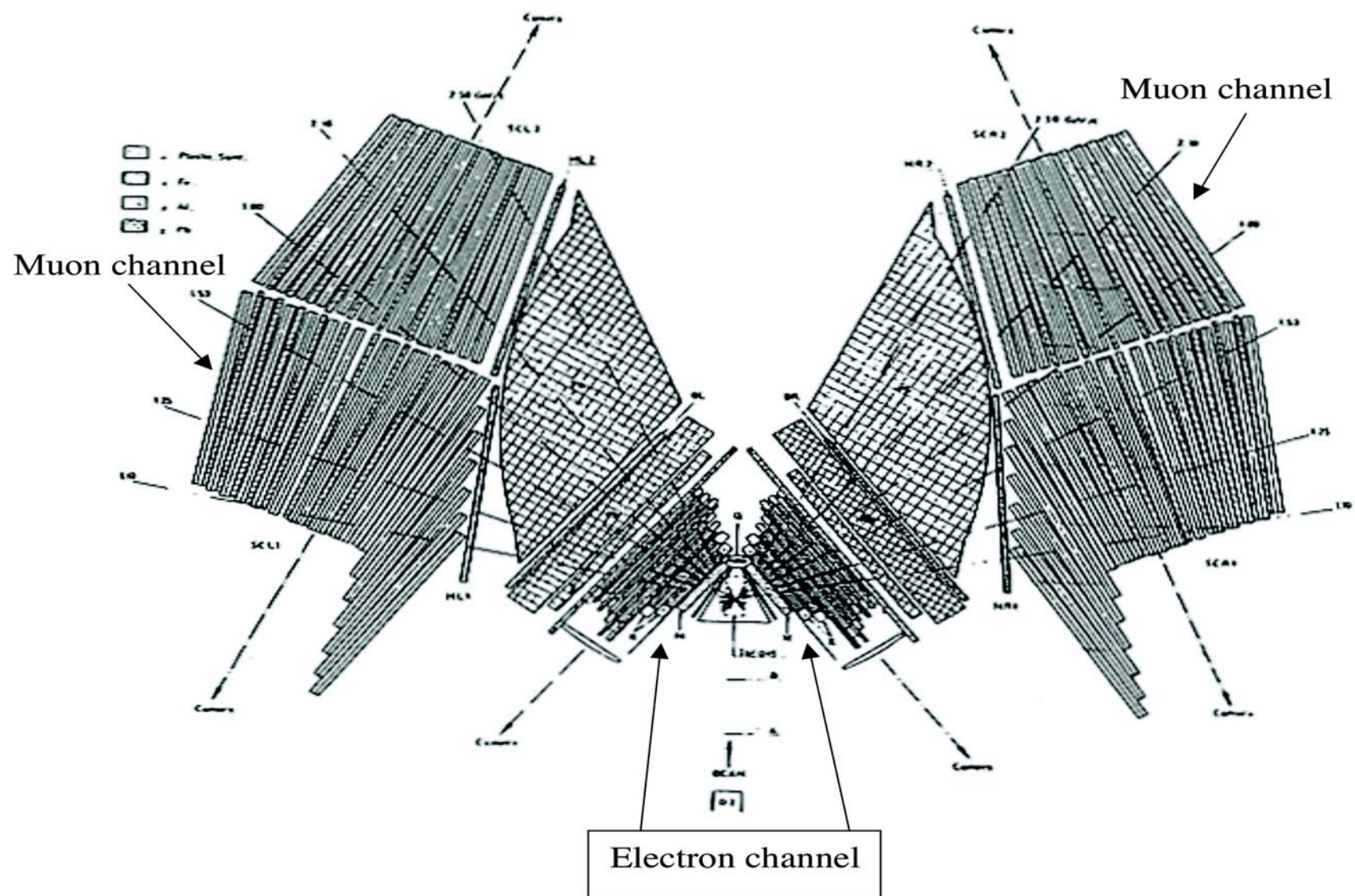


Figure 4: The diagram of the PAPLEP experimental set-up. The ‘electron channel’ indicates the electron detector; the ‘muon channel’ indicates the muon detector. For the scale, see figure 3.

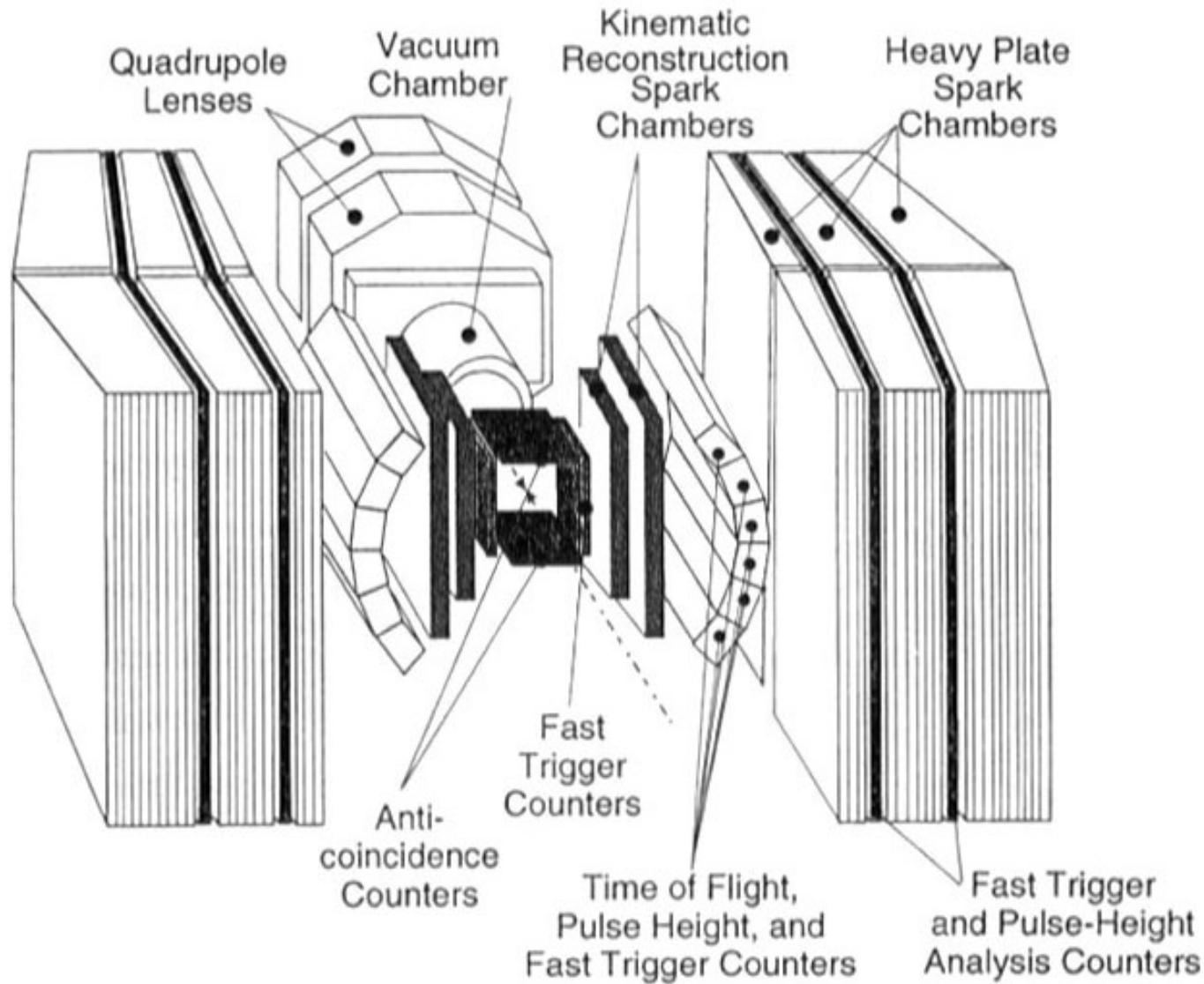


Figure 5: Perspective of the experimental set-up of the BCF (Bologna-CERN-Frascati) group, to search for acoplanar ( $e^\pm\mu^\mp$ ) pairs using the ADONE ( $e^+e^-$ ) collider at Frascati.

1<sup>st</sup> gigantic  
structure of the time (1960) at CERN  
and now  
ATLAS;  
CMS,  
ALICE.

# SLv: Culture of Confusion

# The causality principle



The **time sequence**: Past→Future ignoring all experiments done to check with high precision QED, the Wigner theorem, the J.S. Bell inequality and the fact that experiments have been implemented to study

$$\begin{array}{llll}
 q^2 & = & + & \text{(time-like)} \\
 q^2 & = & \text{zero} & \text{(light-like)} \\
 q^2 & = & - & \text{(space-like)}
 \end{array}
 \left. \vphantom{\begin{array}{l} \\ \\ \end{array}} \right\} \begin{array}{l} \mathbf{metric} \\ \\ q \equiv (i\vec{p}; E) \end{array}$$

# Examples:

- i) the discovery of the time-like structure of the proton EMFF;
- ii) the high precision experiments on the validity of QED, QFD and QCD.