

The Erice International School of Subnuclear Physics



Pierre Darriulat
7 November, 2018
Bologna



In 1963, Bell, Blackett, Rabi, Weisskopf and Zichichi, signed the charter constitution of the Ettore Majorana Foundation and Centre for Scientific Culture (EMFCSC). Every year since then, authors of new discoveries or inventions come to Erice; 85 of them were awarded the Nobel Prize after their participation to EMFCSC activities and 49 were already Nobel laureates. These scientific world leaders teach students from all over the world who are eager to receive the latest knowledge directly from the mouth of its authors, just as was done in the University of Bologna more than nine centuries ago.

By 2015 over 120.000 scientists from 140 Nations have taken part in post-university activities to promote a Science without secrets and without borders.



Joint US-CERN-Japan-Russia School on Particle Accelerators
will hold a course on
Synchrotron Radiation & Free Electron Lasers
6-15 April 2011
Majorana Center for Scientific Culture, Erice, Sicily

This course will be of interest to designers, operators and users of synchrotron light sources and free electron lasers. The lectures will include both machine physics and technology plus scientific applications and experimental techniques.

Application deadline: 1 December 2010

Further information & application forms:
<http://www.cern.ch/schools/CAS>
or <http://uspas.fnal.gov>

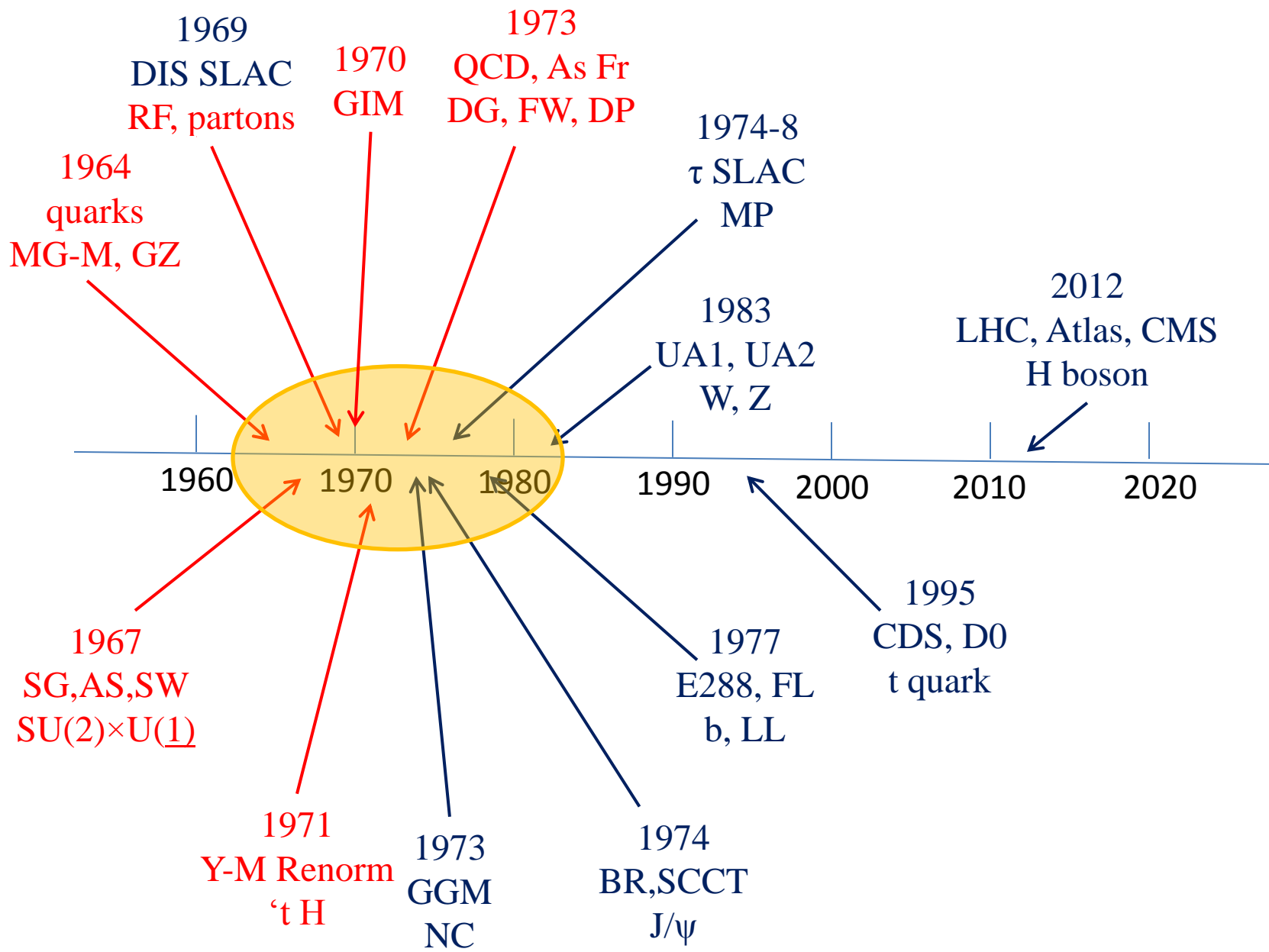
Photo: W. Barletta

The physics and the school
Where we stand today
The Erice spirit
Picture gallery

The physics and the school

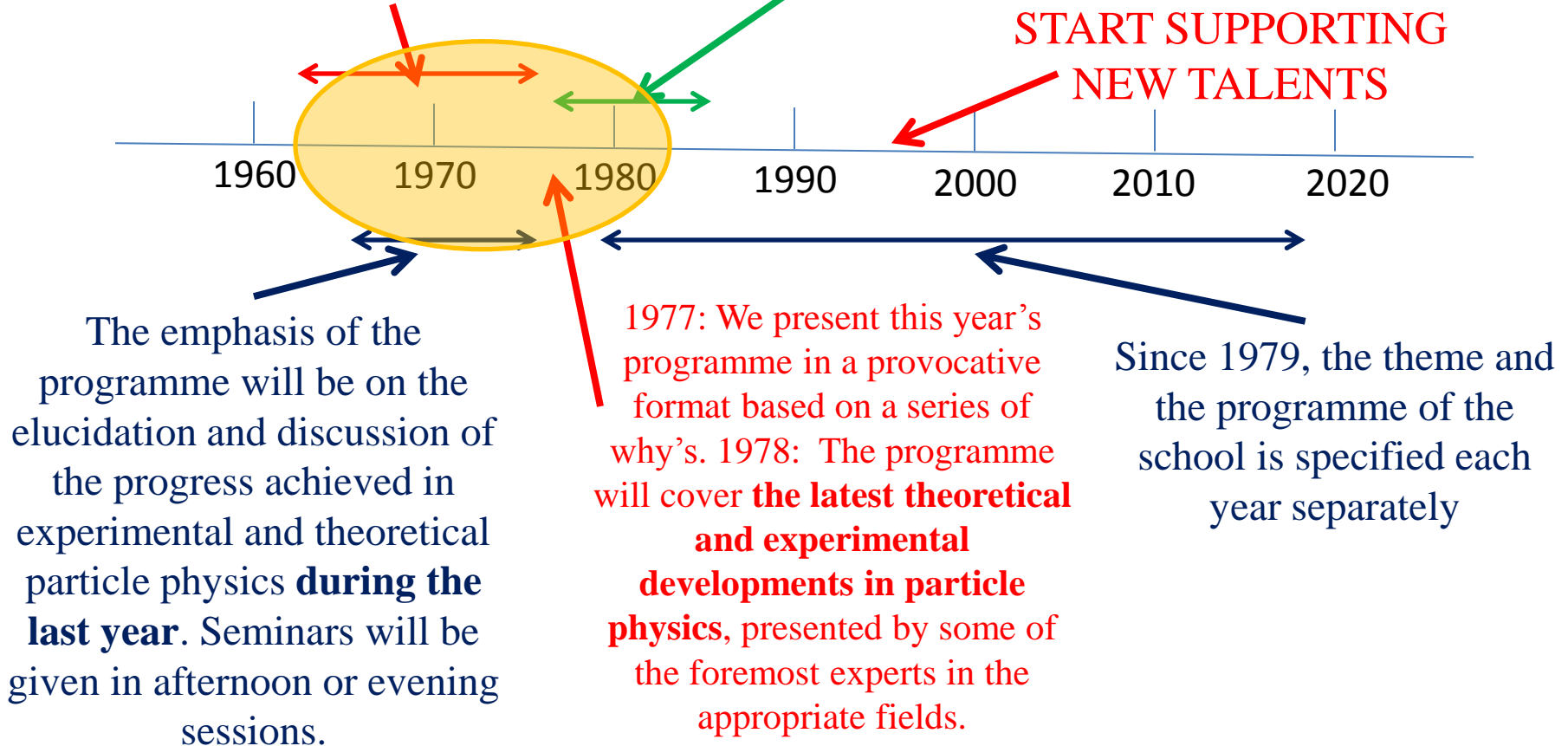
Soon after the creation of the school of subnuclear physics, the field entered an outstanding period of remarkable and rapid success. In less than two decades, the Standard Model of particle physics was constructed, based on group symmetries and gauge invariance.

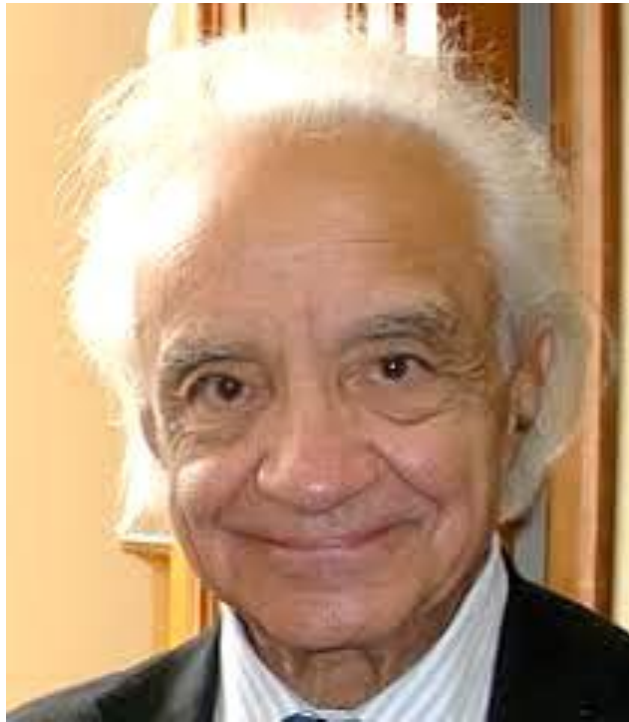
The development of the school matches tightly that of the field.



The school is devoted to those physicists who are interested in having a much deeper theoretical understanding of the field of physics in which they are working. In order to exploit to the fullest extent the material presented at the school, three lectures will be given in the morning and at least two hours of the afternoon will be dedicated to clearing up in free, informal discussions the topics of the morning lectures.

In spite of the spectacular results obtained in recent times subnuclear physics is far from reaching the asymptotic limit of a field without a future. This is testified by the large number of problems which open up at a rate at least comparable with that of new results.



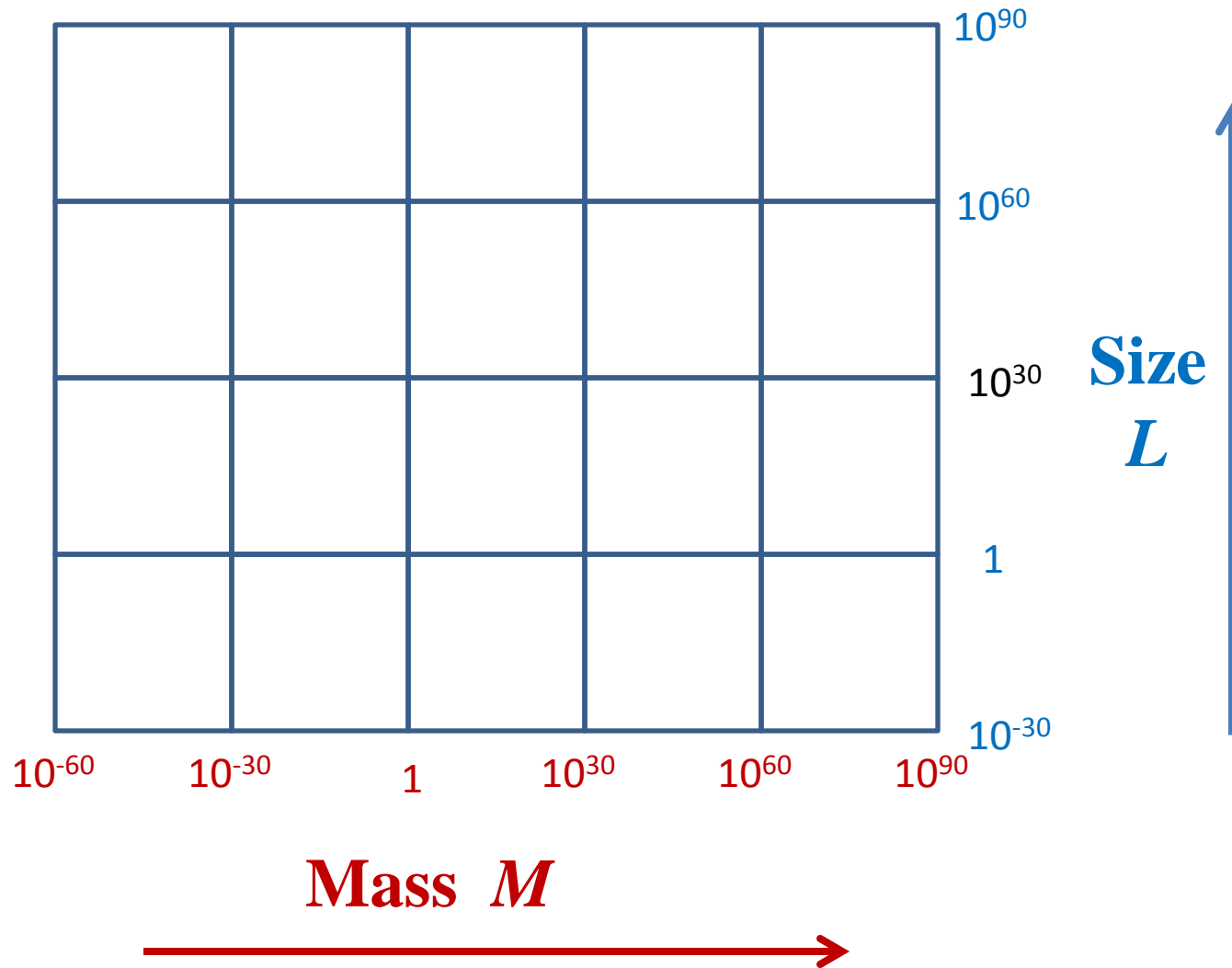


The school directors:
Antonino Zichichi
Gerardus 't Hooft
Gabriele Veneziano
Guido Altarelli

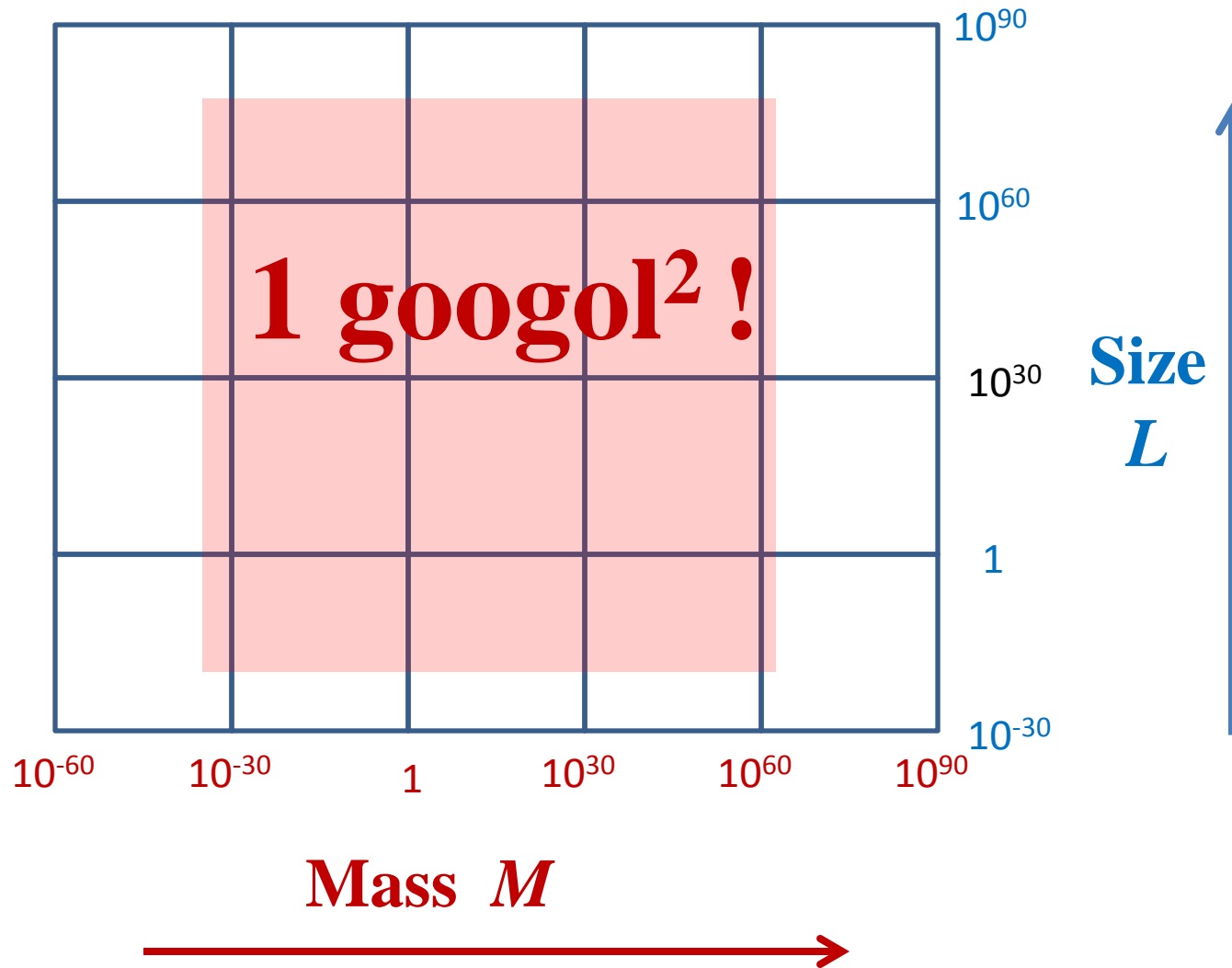


Where we stand today

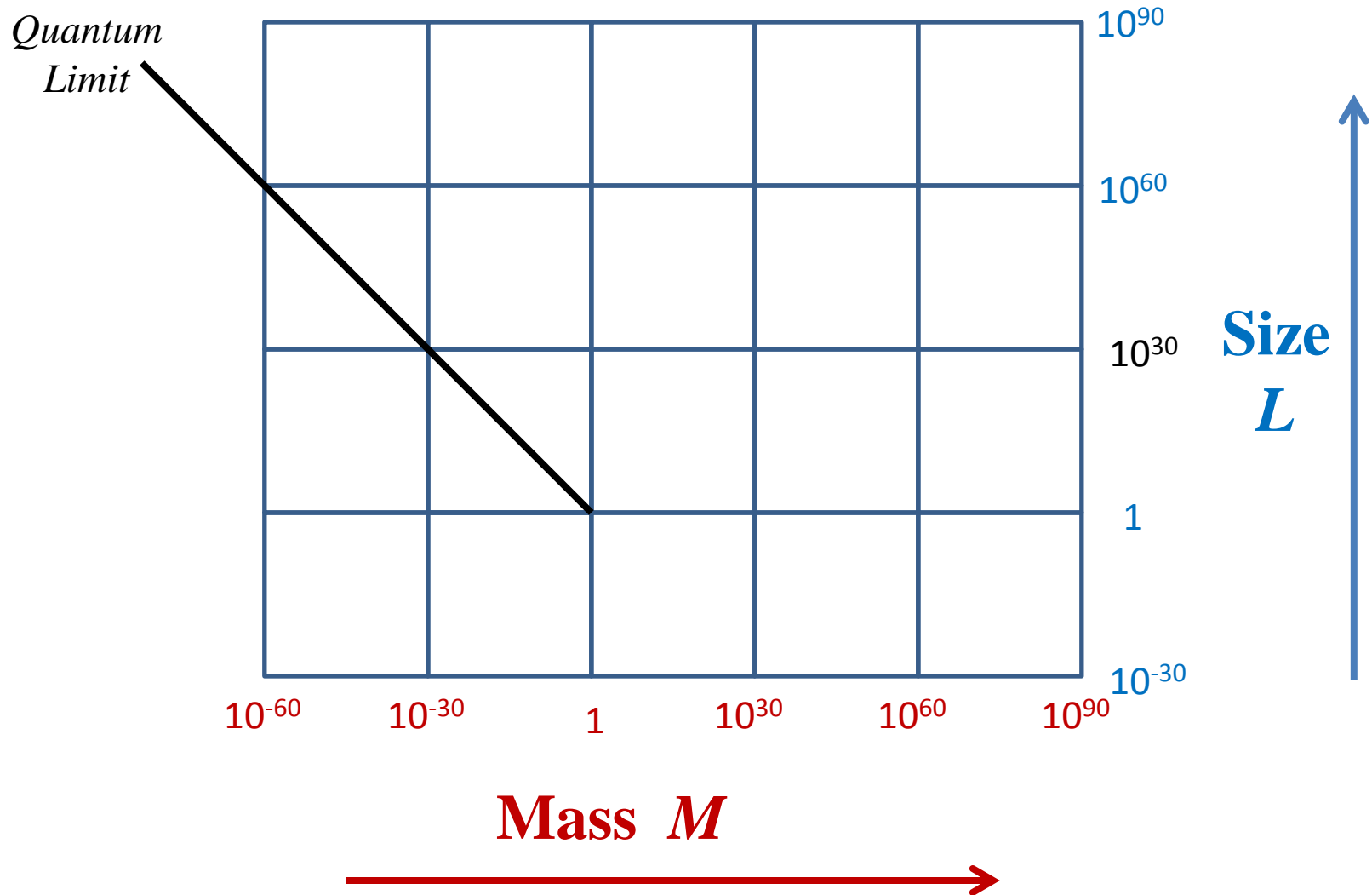
Natural units: $\hbar=c=G=1$



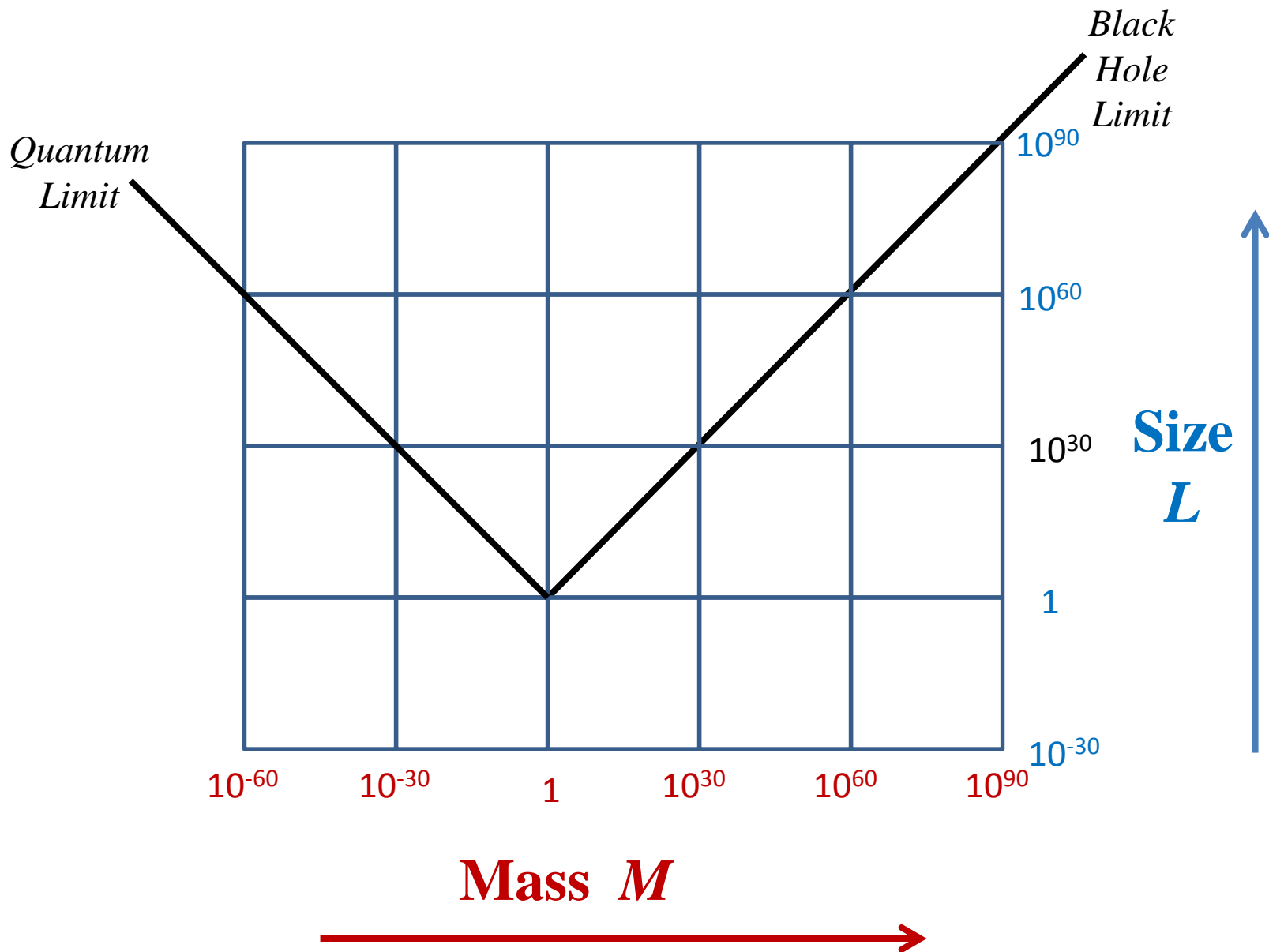
Natural units: $\hbar=c=G=1$



Quantum limit: $ML > 1$ ($\hbar c \sim 200 \text{ MeV fm}$)

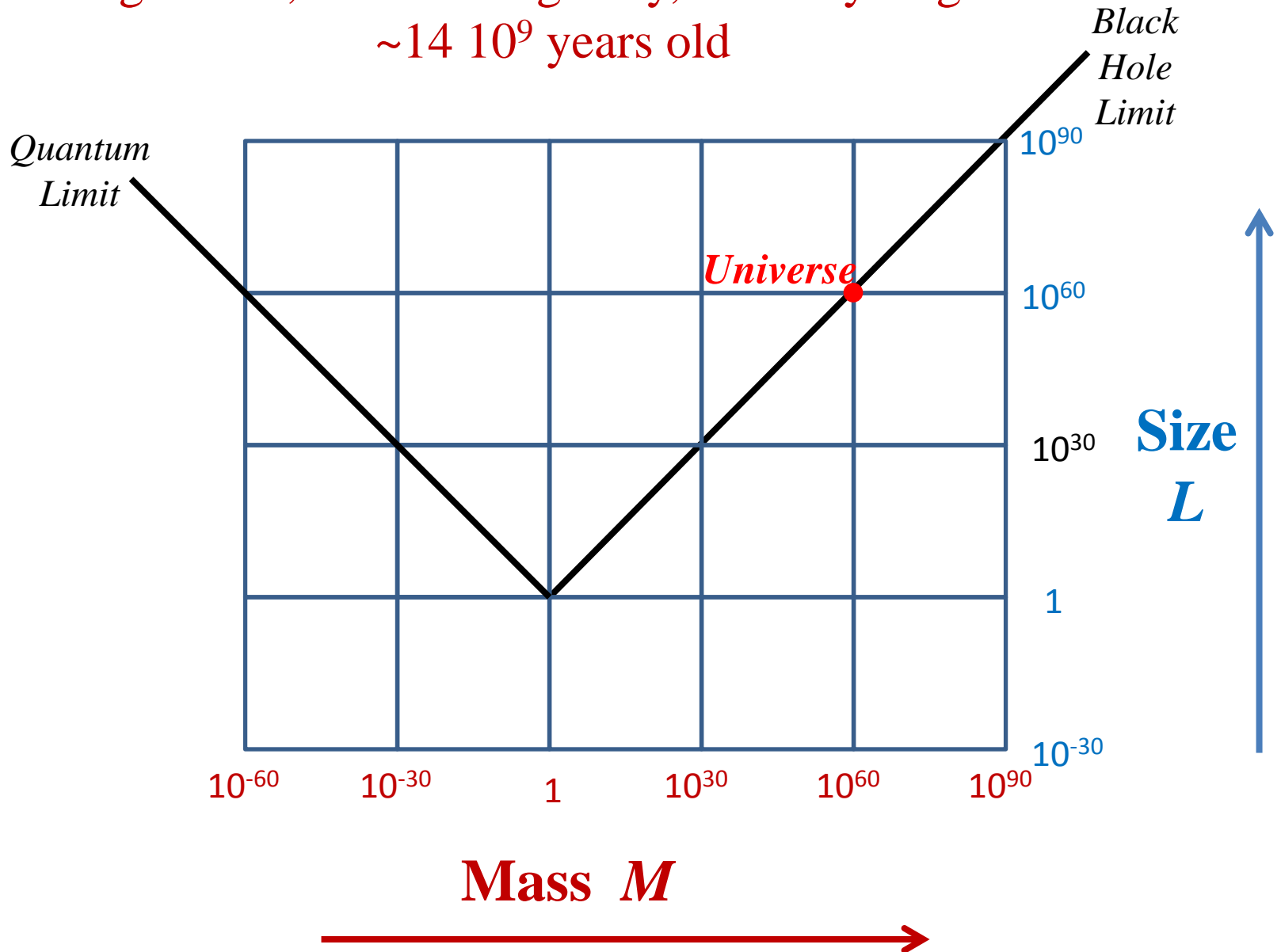


Black Hole limit: $L/M > 1$ ($G/c^2 \sim 1.5 \text{ km}/M_{\text{sun}}$)

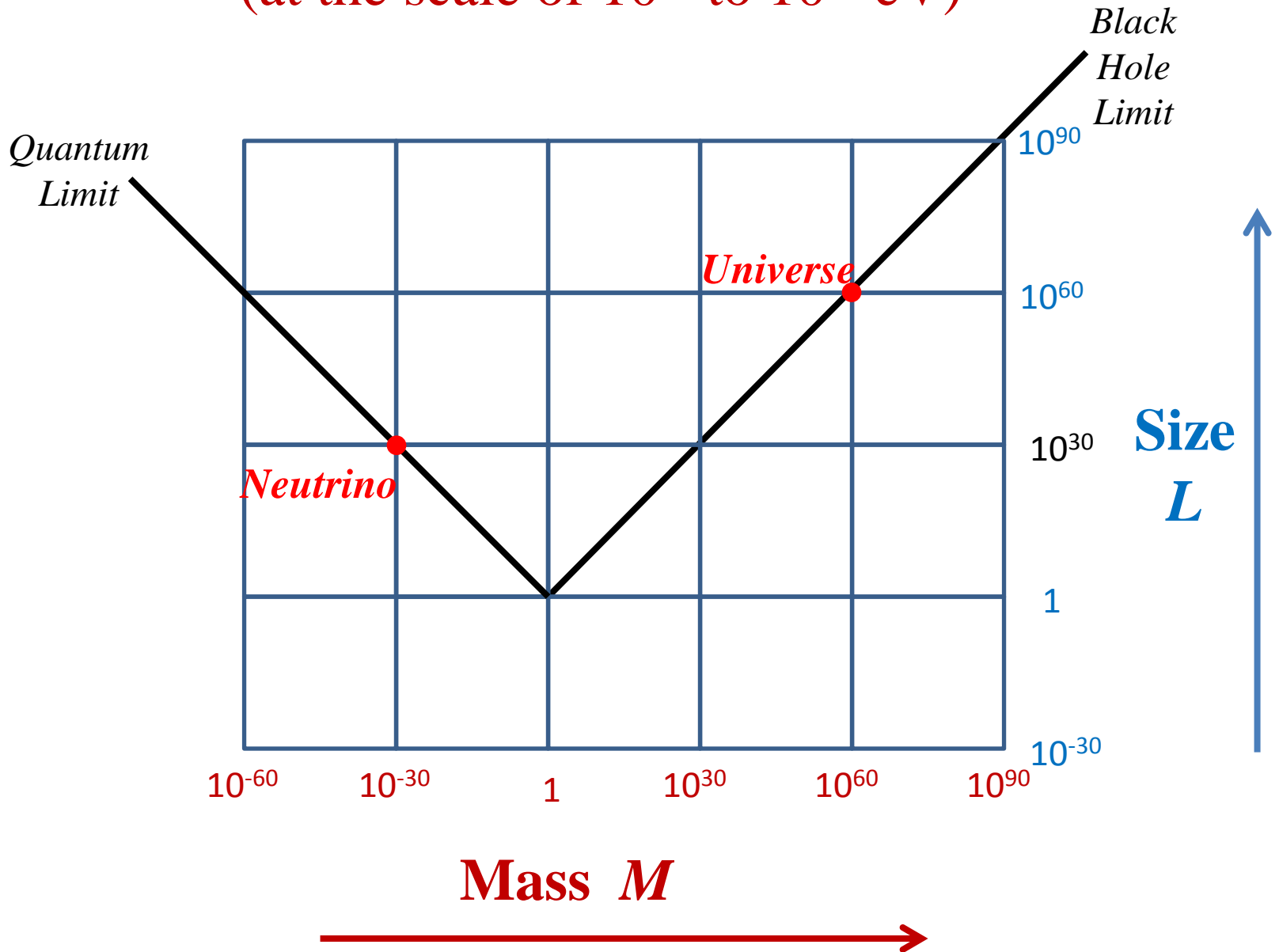


Universe: $L \sim M > \sim 10^{60}$

$\sim 10^{11}$ galaxies, $\sim 10^{11}$ stars/galaxy, $\sim 10^{57}$ hydrogen/star
 $\sim 14 \cdot 10^9$ years old

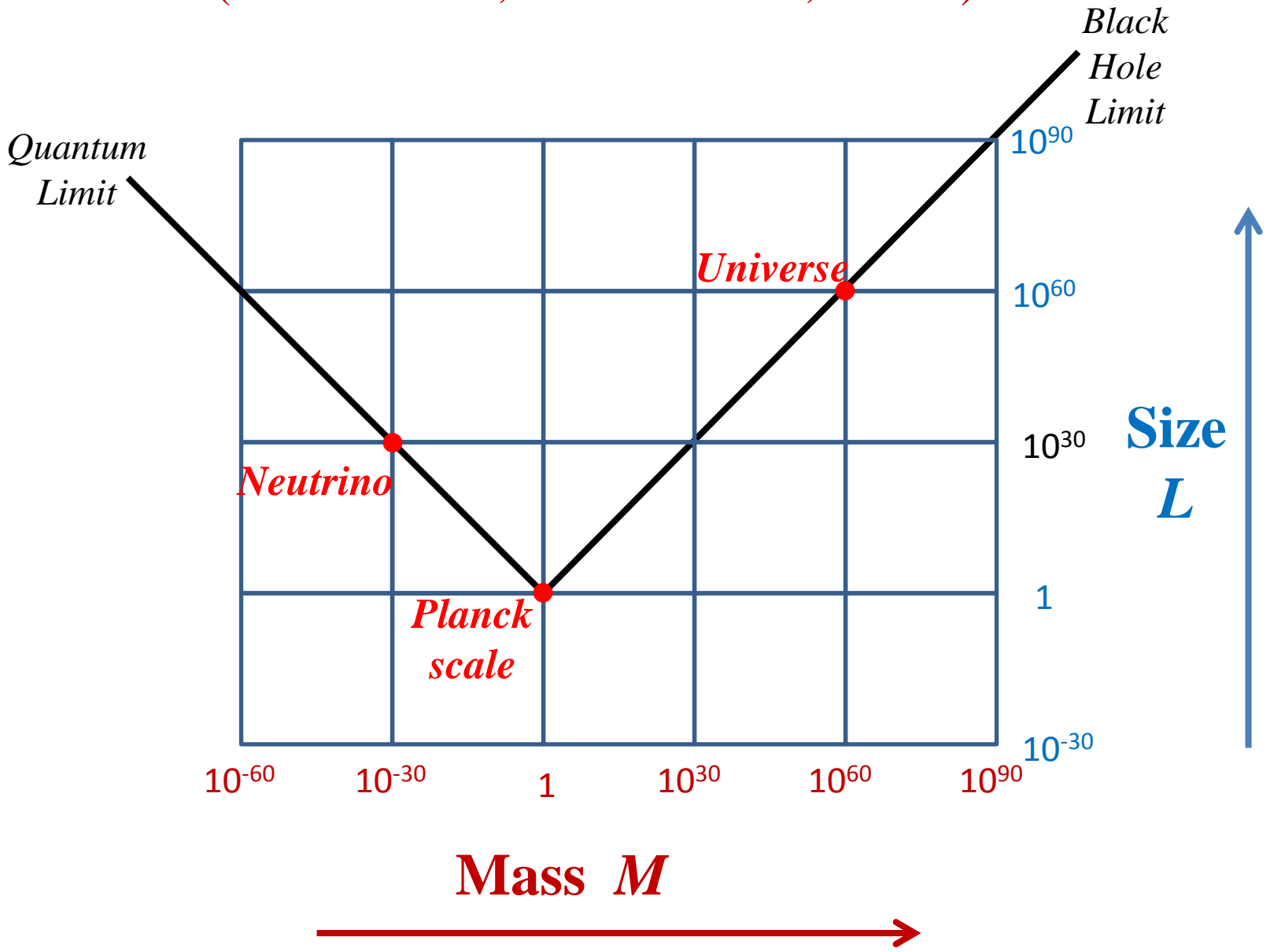


Neutrino: $M=1/L\sim 10^{-30}$
(at the scale of 10^{-2} to 10^{-1} eV)



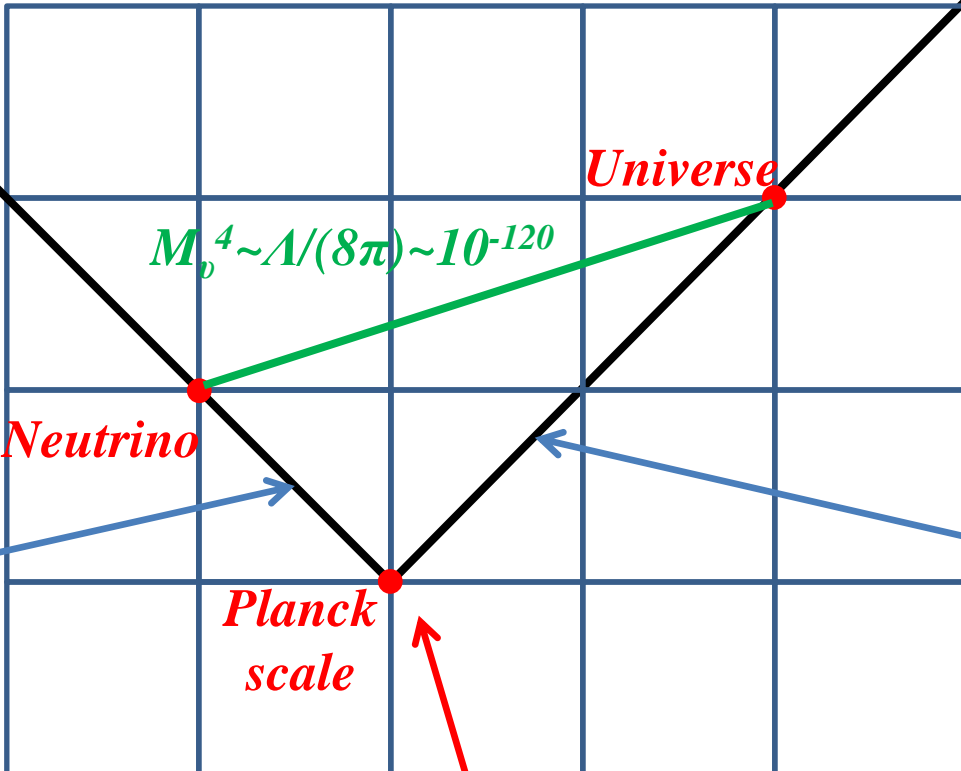
Planck Scale, $L=M=1$

($\sim 1.6 \cdot 10^{-33}$ cm, $\sim 1.2 \cdot 10^{19}$ GeV, 10^{-44} s)



*Quantum
Limit*

*Black
Hole
Limit*



$M_p^4 \sim \Lambda / (8\pi) \sim 10^{-120}$

Neutrino

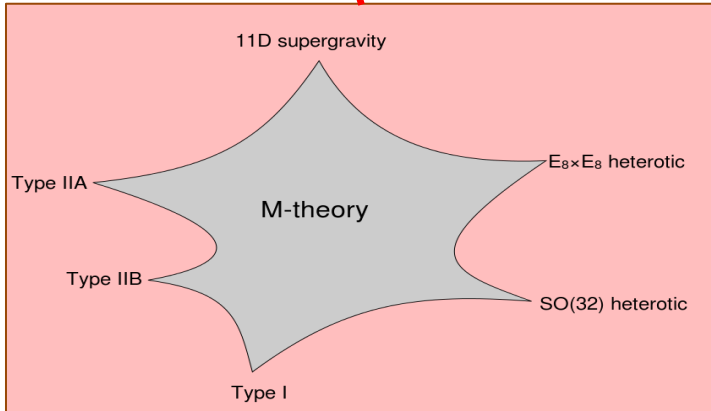
Universe

*Planck
scale*

**Why the Standard
Model?
Flavour symmetry
Grand Unification
Hierarchy
 $\Lambda = 8\pi m_\nu^4$**

**What is dark
energy?
What is dark
matter?
What is
inflation?**

10^{-60} 10^{-30} 1 10^{30} 10^{60} 10^{90}

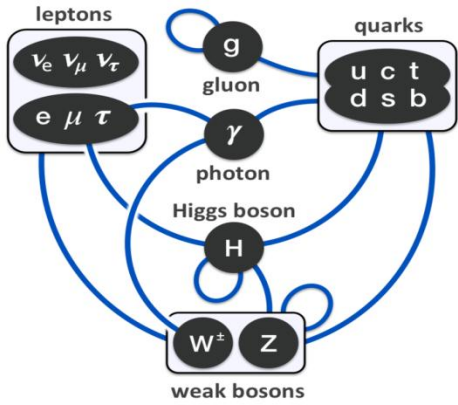


Why the Standard Model?

Flavour symmetry

Grand Unification

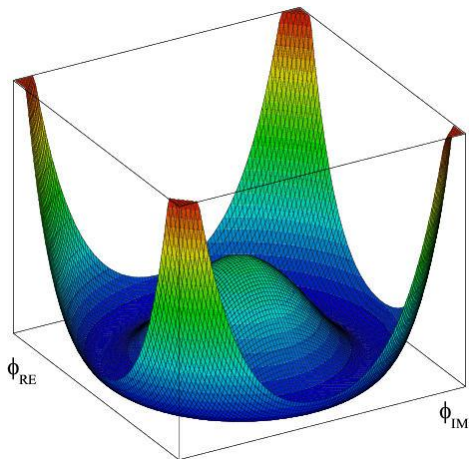
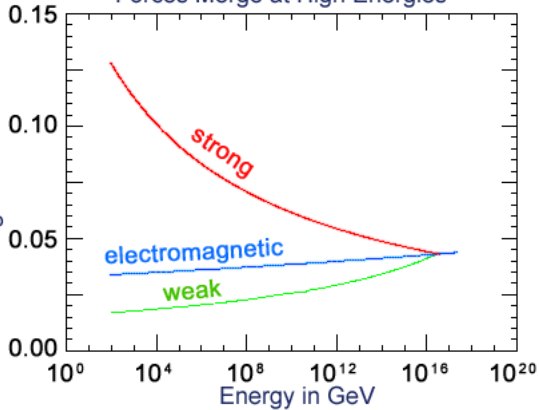
Hierarchy

$$\Lambda = 8\pi m_{\nu}^4$$


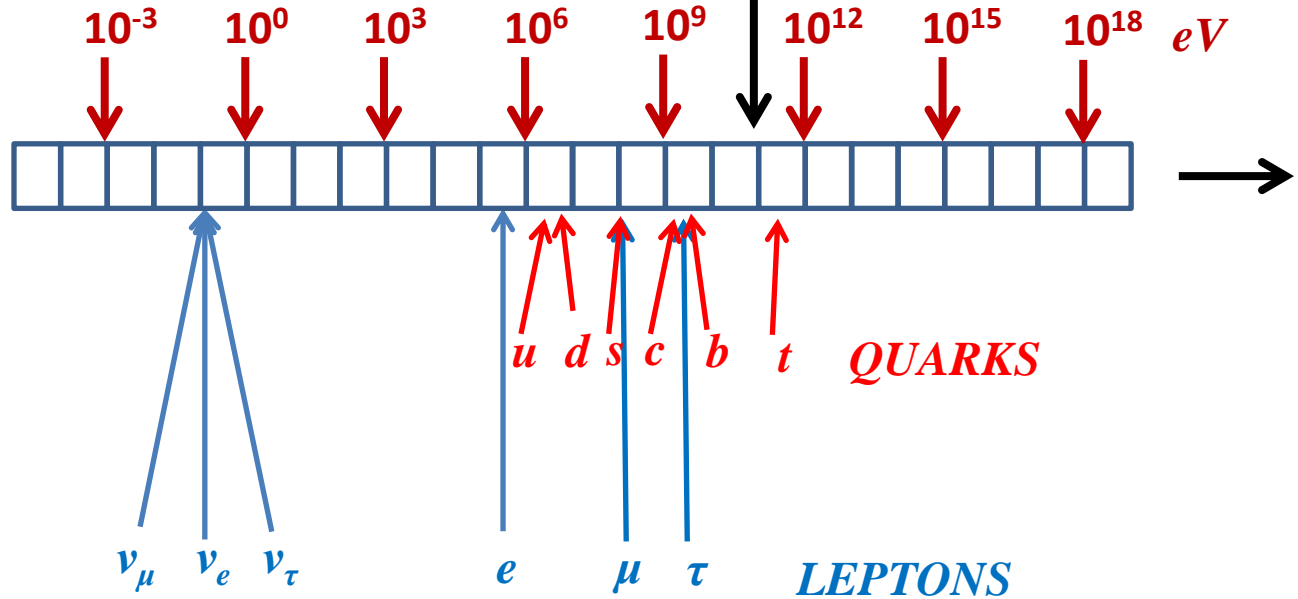
Standard Model of Elementary Particles

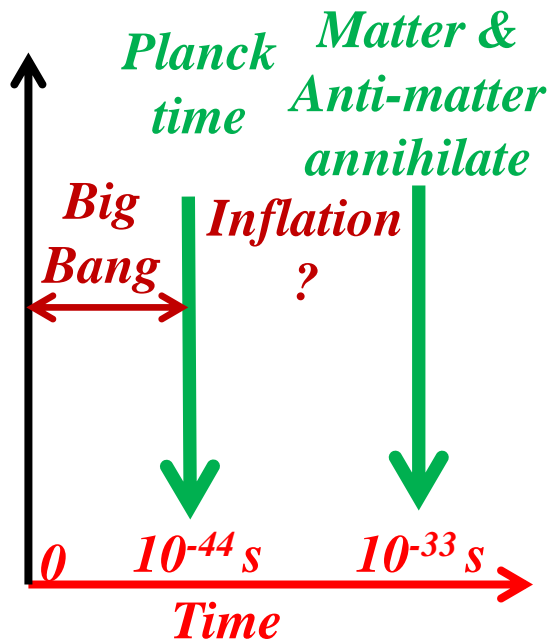
		three generations of matter (fermions)				
		I	II	III		
mass		$\approx 2.2 \text{ MeV}/c^2$	$\approx 1.28 \text{ GeV}/c^2$	$\approx 173.1 \text{ GeV}/c^2$	0	$\approx 125.09 \text{ GeV}/c^2$
charge		$2/3$	$2/3$	$2/3$	0	0
spin		$1/2$	$1/2$	$1/2$	1	0
	QUARKS	u up	c charm	t top	g gluon	H Higgs
		$\approx 4.7 \text{ MeV}/c^2$	$\approx 96 \text{ MeV}/c^2$	$\approx 4.18 \text{ GeV}/c^2$	0	
		$-1/3$	$-1/3$	$-1/3$	0	
		$1/2$	$1/2$	$1/2$	1	
		d down	s strange	b bottom	γ photon	
	LEPTONS	$\approx 0.511 \text{ MeV}/c^2$	$\approx 105.66 \text{ MeV}/c^2$	$\approx 1.7768 \text{ GeV}/c^2$	0	
		-1	-1	-1	0	
		$1/2$	$1/2$	$1/2$	1	
		e electron	μ muon	τ tau	Z Z boson	
		$< 2.2 \text{ eV}/c^2$	$< 1.7 \text{ MeV}/c^2$	$< 15.5 \text{ MeV}/c^2$	$\approx 80.39 \text{ GeV}/c^2$	
		0	$1/2$	$1/2$	± 1	
		ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	
						GAUGE BOSONS
						SCALAR BOSONS

Forces Merge at High Energies

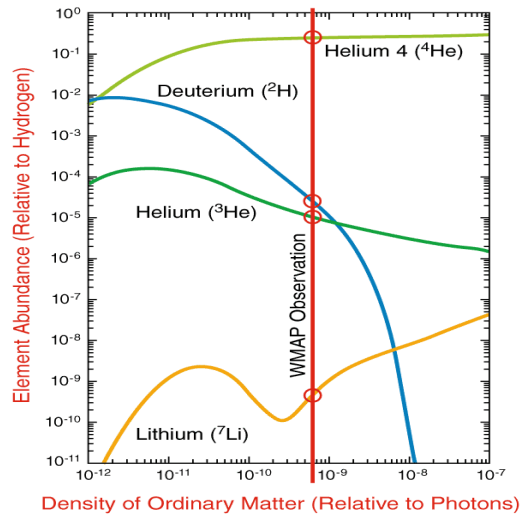
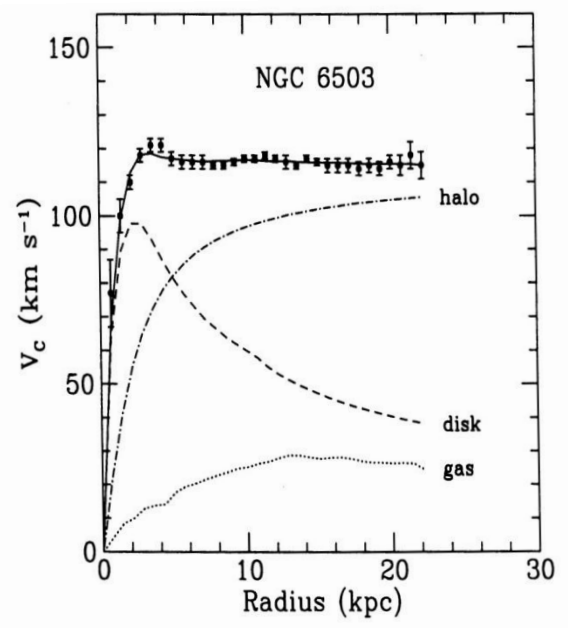
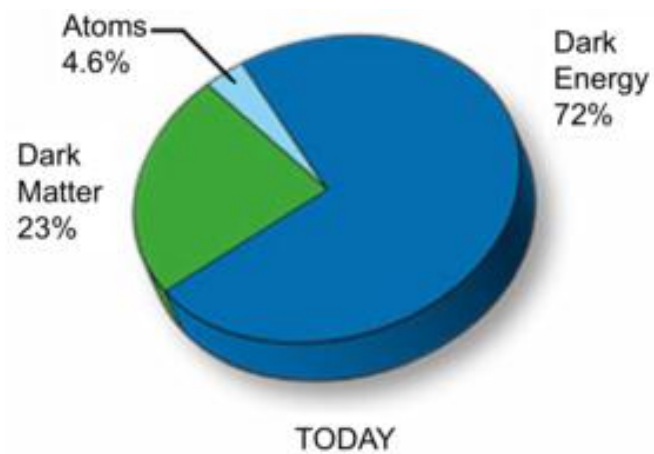


W, Z, H BOSONS



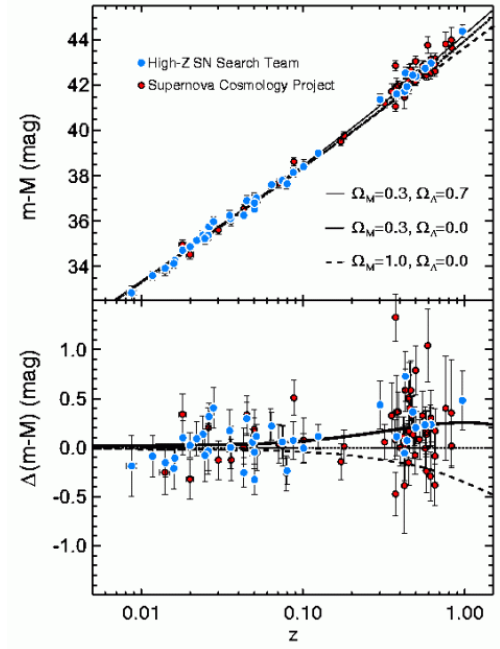
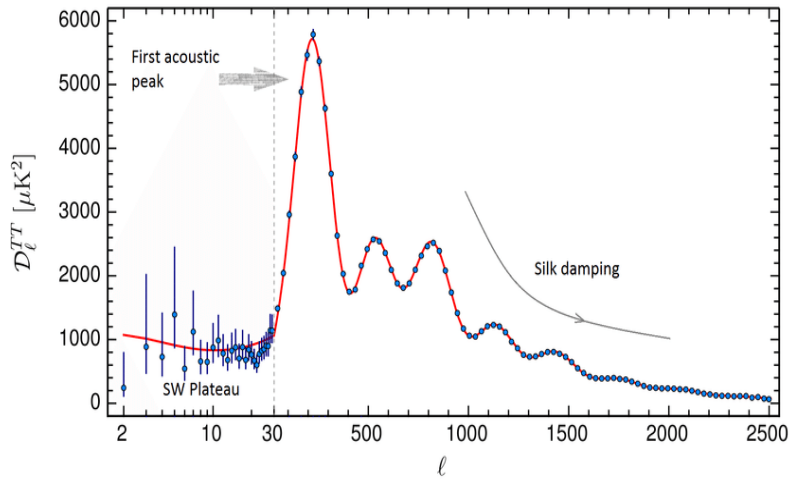


What is dark energy?
 What is dark matter?
 What is inflation?



NASA/WMAP Science Team WMAP 10/2007

Element Abundance graphs: (Sagevan, Encyclopedia of Astronomy and Astrophysics (Institute of Physics, December, 2000)



Physics at the Planck Scale

Heisenberg uncertainty relations prevent a wave packet of size D and mass M to contain a gravitation energy GM^2/D larger than $\hbar/(D/c)$, hence to have a mass in excess of

$$M_{\text{Planck}} = \sqrt{(\hbar c/G)} = 10^{19} \text{ GeV.}$$

New physics is required to describe the Planck scale.

For over three decades, research has followed the road of

Superstrings:

Supersymmetry relates fermions to bosons

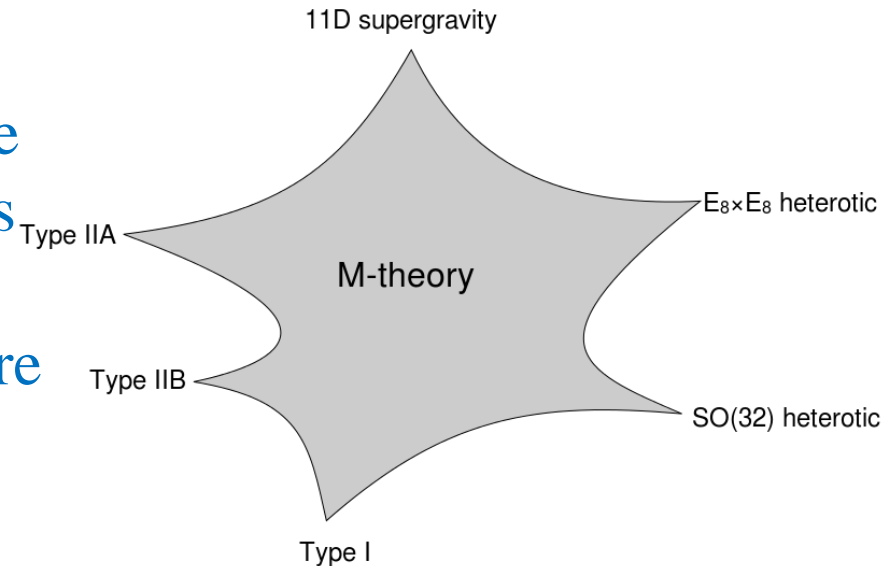
Strings, with sizes at the Planck length, and branes are the

basic 1-d and 2-d objects

9+1 dimensions, of which 6 are compactified

M-theory, in 10+1 dimensions,
unifies 11-D Supergravity with the five
consistent versions of String Theory as
limiting cases.

Different versions of String theories are
related by highly non trivial duality
relations



**Understanding physics at the Planck scale
is undoubtedly, and by far, the most puzzling
unanswered question of contemporary physics. Many
think that its answer will bring with it an answer to all
the other major questions of particle physics and
cosmology**

THEORY & PHENOMENOLOGY

The Black Holes Physics is a New Frontier

- G. 't HOOFT, Utrecht University, NL

Black Holes in String Theory

- S.D. MATHUR, Ohio State University, Columbus, OH, US

Status of Inflation

- A. GUTH, MIT, Cambridge, MA, US

Inflation and Neutrino Masses in NoScale Supergravity

- D. NANOPOULOS, Texas A&M University, College Station, TX, US

Updates on Brane Supersymmetry Breaking

- A. SAGNOTTI, Scuola Normale Pisa, IT

Thirty Years of Erice on the Brane

- M.J. DUFF, Imperial College London, UK

Gravity Amplitudes from Gauge

- Z. BERN, UCLA, Los Angeles, CA, US

Dark Matter and LHC

- H. FRITZSCH, Ludwig-Maximilians-Universitaet, Muenchen, DE;
Nanyang Technological University, Singapore, SG

Highlights in Supergravity

- S. FERRARA, CERN, Geneva, CH; LNF-INFN, Frascati, IT; UCLA, Los Angeles, CA, US
- P. VAN NIEUWENHUIZEN, State University of New York, Stony Brook, NY, US

The Early Universe as observed by Radio-Astronomy

- P. DARRIULAT, VATLY Laboratory, Hanoi, VN

Status of Neutrinos

- A. BETTINI, INFN & Padoa University, IT

QCD from its birth to its stubbornly unsolved problems

- A. DE RUJULA, CERN, Geneva, CH

The GAP between α_G and α_{GUT}

- A. ZICHICHI, CERN, Geneva, CH; University of Bologna & INFN, IT

Current schools naturally focus on physics at the Planck scale.

The extreme mathematical complexity of standard superstring theory and the experimental inaccessibility of the Planck Scale, together with the lack of encouraging signals, is causing a surge of different approaches based on the direct study of quantum size black holes without biasing influence of string prejudices.

The Erice spirit

The project for realizing a World Laboratory that is open to the best intellects, without racial, ideological, political, religious or geographical (East, West, North, South) barriers, is the fruit of a promise that the scientific community – led by Erice – has made for the sake of all those who love peace not only as a word, but also as something that they wish to construct day by day out of facts.

The scientists of Erice have given life to a new way of conceiving international scientific collaboration: without secrets and without frontiers. This is the Spirit of Erice.

As an indispensable part of this collaboration, the voluntary scientific service has the objective of developing all of the poor countries that are far below the scientific and technological levels of today's industrialized countries [by] realizing projects that would require enormous sums if it were not able to count on the work offered by thousands of scientists and specialists who ask nothing in terms of stipends or compensation for the work they put in. This voluntarism touches all levels, up to the highest, including protagonists of global prestige from Science, Technology and Medicine, among whom are many Nobel Laureates.

The Erice statement pleads for a free science without secret
and without borders.

“The choice between peace and war is not a scientific choice,
it is a cultural one. The culture of love produces peaceful
technology, the culture of hatred instruments of war.
Love and hatred have existed forever. It is [now] imperative
that the culture of love wins.”

*The statement was written in Erice in August 1982 by Dirac, Kapitza
and Zichichi. It is signed by nearly 100'000.*

*It has attracted in the eighties the attention of world leaders such as
Deng Xiao Ping, Gorbachev, Reagan, Pierre Trudeau, Olof Palme and
Sandro Pertini.*

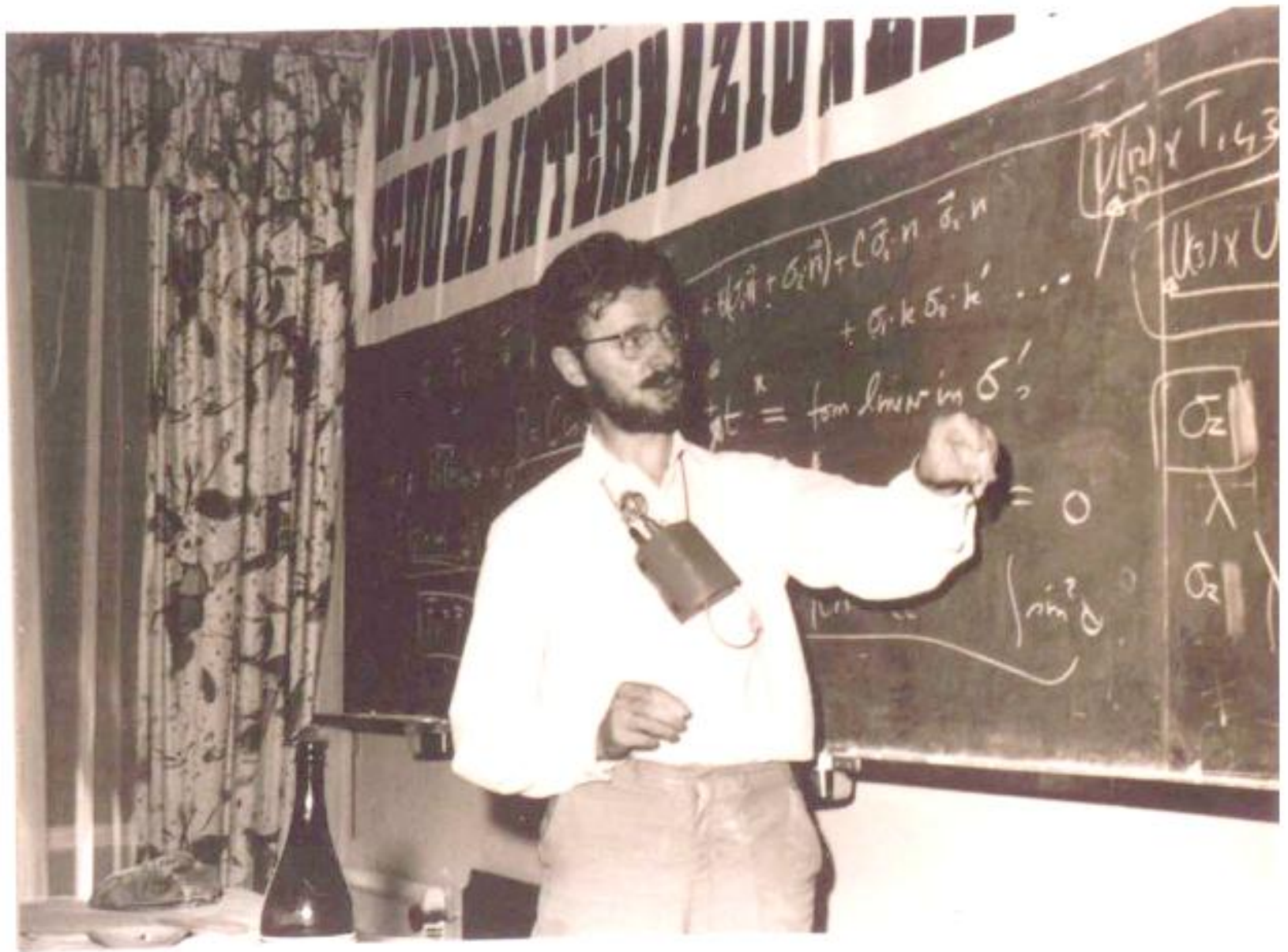
The International Seminars on Planetary Emergencies, Science for Peace the World over, have been analysing and discussing threats to the planet for over 50 sessions. In order to mitigate such threats, Professor Zichichi has launched the Project for Mankind for the 21st century.

The World Federation of Scientists and the World Laboratory have instituted a National Scholarship Programme for young graduates from developing and newly emergent countries to conduct scientific research activities in their own country under the supervision of the best and most experienced national scientists.

Picture Gallery



Victor F. Weisskopf with Antonino Zichichi (1960).



John Stewart Bell at Erice (1963) lecturing on Dirac and Majorana neutrinos.



Melvin Schwartz, Tsung Dao Lee, Antonino Zichichi and Isidor Isaac Rabi at Erice (1968).



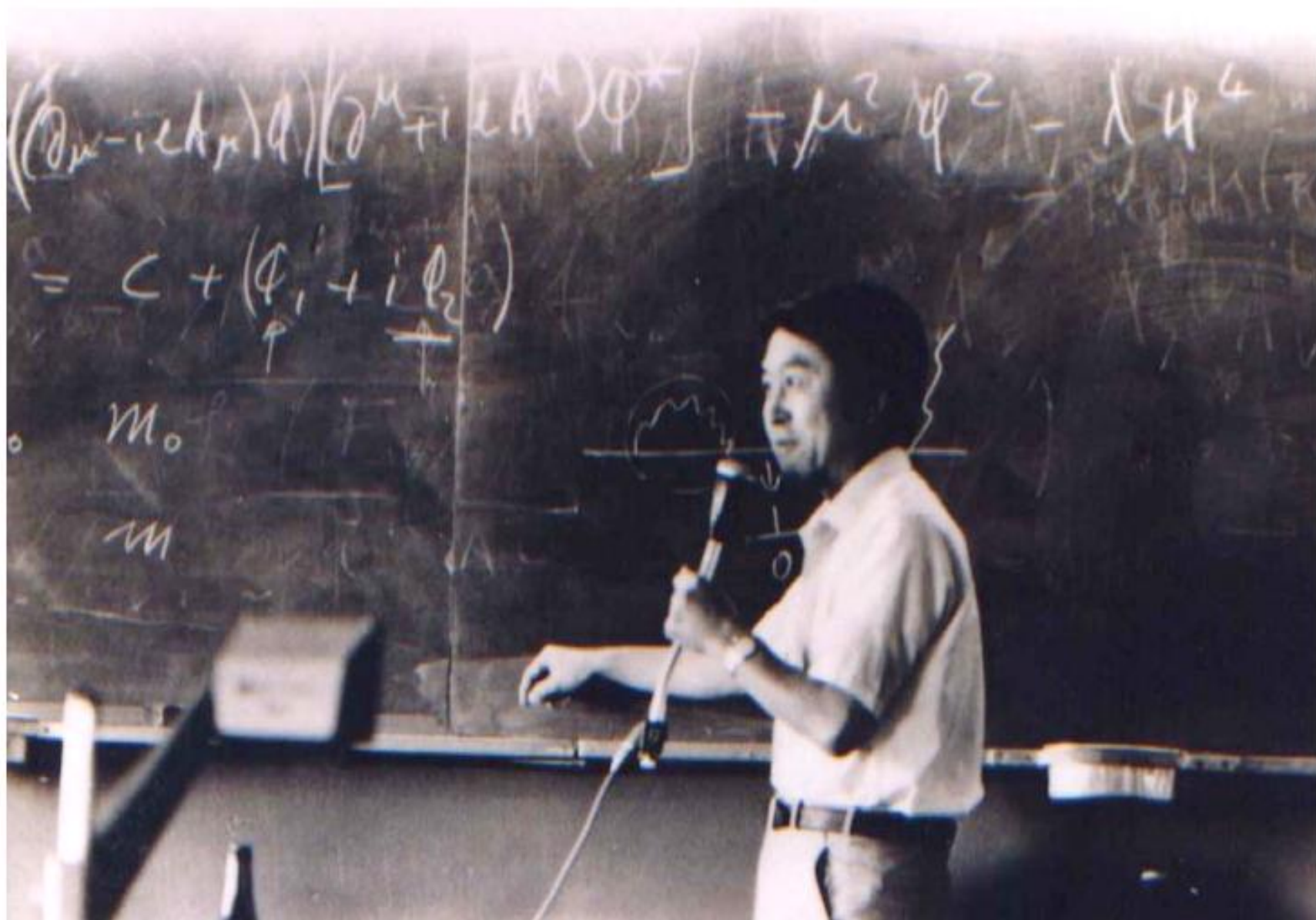
Bruno Zumino lecturing at Erice (1969) on the PCT theorem.



Victor F. Weisskopf lecturing at Erice (1970).



Giancarlo Wick at Erice (1971).



Yoichiro Nambu at Erice (1972).



Julian Schwinger at Erice during a discussion session devoted to Anomalies in Quantum Field Theory.



Laura Fermi at the Subnuclear Physics School in Erice (1975), lecturing on her recollections of Ettore Majorana.



John Stewart Bell at Erice (1975).



The father of Time Reversal Invariance, Professor Eugene Wigner (on the left) and Professor Paul Dirac (on the right), father of the equation which sparked the existence of 'annihilation' and of antimatter, with Antonino Zichichi at Erice (1982).



Sergio Ferrara lecturing at Erice (1988).



Julian Schwinger celebrating his 70th birthday in Erice during the 26th Subnuclear Physics School. From left: Sheldon Glashow, Mrs Manci Dirac, Sergio Ferrara, Michael Duff (1988).



2016: Best student prize awarded to X. Fan



Thank you
for your
attention



Thank you
for your
attention