

**ABDUS SALAM'S LEGACY  
IN OCCASION OF ICTP'S 50<sup>TH</sup> ANNIVERSARY CONFERENCE**

**WITH ABDUS SALAM  
AT  
IMPERIAL COLLEGE**

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The scientific career of Abdus and mine started with the strong support of the same great man: Lord Patrick M.S. Blackett, Great Admiral of the British Navy and Nobel for his discovery of the simultaneous production of antielectron-electron pairs.

Thanks to a series of happy coincidences in 1955 I became the youngest member of his group: the most powerful experimental physics group in the world.

Abdus came after me and it is on this occasion that Professor Blackett expressed his view on the basic difference between Experimental Physics and Theoretical Physics.

This statement is at the entrance  
of the Blackett Institute in Erice:

*«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.»*

Abdus was convinced that a theoretical physicist must know what new technologies can be developed in order to allow new experiments. Experimental and theoretical approaches to understand the Logic of Nature must go together.

Abdus and I became close friends, as reported in three papers: “*The Abdus Salam Dream*” [1], “*Abdus Salam Beyond ICTP and the Electroweak Forces*” [2] and “*Frontiers in Physics*” [3].

Here I would like to recall a few episodes about Abdus Salam as physicist and friend.

On April of this year I have been at Imperial College for the Celebration of the Blackett Physics Institute in a Ceremony organized by Mike Duff.

Some of the memories given here will also be in the volume dedicated to Blackett “*My Testimony on Lord Patrick M.S. Blackett. A Lesson for the Future of our Science*” [4].

The study of strange particles produced in the cosmic radiation were in conflict with the Fundamental Law based on the fact that fermions and bosons in Lorentz Space-Time had to be iso-fermions and iso-bosons. Fermi was convinced that the new “charge” called “*strangeness*” had many problems.

The most important being that the new heavy mesons, called  $\theta$ , had only positive strange charge, the negative one being given to “baryons”.

The first example of pair production of heavy meson with positive and negative values for “*strangeness*”, allowed me to become the “pupil” of Blackett [4].

Abdus arrived after me and became the “theoretical pupil” of the Blackett group.

This is how I met him.



When Leon Lederman invited me to join his group at the first European accelerator, the CERN SC, to attempt the high precision measurement of the anomalous magnetic moment of the muon, Abdus was the only theorist interested in understanding why this quantity was not infinite as it should have been, if the muon was coupled to the Fermi weak interactions.

And when I first attempted to measure the proton stability at CERN in Geneva – not in an underground laboratory – but using a powerful new electronic-logic circuit able to select the forbidden process

$$p \rightarrow \pi \rightarrow \mu \rightarrow e,$$

Abdus was the only theoretical physicist interested in the experiment.

Baryon number conservation was – at that time – sacred.

The first limit  
obtained at CERN on  
 $\tau_p$   
and the interest of Abdus  
in this new frontier of physics,  
were the starting points  
of the Gran Sasso project,  
now the most powerful  
underground laboratory  
in the world.

Abdus was coming from Pakistan, I was coming from Sicily, both felt as being from forgotten areas and both of us were hoping to be able – one day – to contribute in helping those fellows from forgotten areas to take part in the fascinating challenge of understanding the Fundamental Laws of Nature.

When the ICTP was finally established he called me to express his great happiness and satisfaction.

It was one of the major objectives of his life.

But this is not all.  
I cannot ignore Erice.  
There was a strong opposition  
when, in 1962,  
the first School in Subnuclear Physics  
was proposed to be held in Erice:  
a totally forgotten corner of Sicily.  
The idea was to establish a Centre  
where the role of the old University  
could be implemented.  
This might appear a paradox nowadays.

The University was invented 900 years ago in one of the most developed areas of Europe, Bologna, in order to avoid waiting ten years before the books were available.

Medicine, Astronomy and Law were topics under investigation by few specialists.

Instead of waiting for them to write a book (printing still had to be invented), why not invite them to give lectures? Now there are instant books, why worry? Because human knowledge has exploded since Galilei.

Four hundred years ago he discovered the first Fundamental Laws of Nature. And this has produced an exponential growth in the human knowledge which has changed the primary role of the Universities.

Nowadays, their task is mainly pedagogical and therefore there is a gap which needs to be filled. New institutions, were needed. One for the Industrialized Countries, the Ettore Majorana Centre for Scientific Culture (EMCSC), and the other for Developing Countries, ICTP, having the role of the old University. These initiatives had Blackett as their strongest supporter.

Let me bring back a few memories  
of the fine times we had with our tutor:

P.M.S. Blackett.

I joined his cosmic ray group

and this is how

– as said before –

I first met Abdus.

Professor Blackett

was very proud of Abdus.

Once he told me that  
this young Pakistani physicist  
was really extraordinary.



I remember his lectures  
about the unification of the  
Weak and the Electromagnetic Interactions  
at Imperial College,  
when no one was speaking about these topics.  
When he knew that  
he had been awarded the Nobel Prize,  
for the electroweak unification  
together with  
Shelly Glashow and Steven Weinberg,  
he asked me if I did remember  
what I am now going to recall here.

Abdus was coming to visit me in my Lab at CERN in Geneva and one day he could not find me: I was inside the 6-metres-long magnet. He was among the very few theorists interested in the problem that the muon magnetic “anomaly”<sup>(\*)</sup> should not diverge.

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(\*) To measure the value of the magnetic “anomaly” was – at that time – a very difficult experimental task. It was necessary to “store” an intense muon beam in a magnetic field in order to “rotate” its magnetic moment as many times as possible. I started to work with a small magnet, called “*Liverpool*” in order to study how to build high precision magnetic fields. This is how came the invention of a new technology, hundreds of time less expensive and hundreds of time faster than all known technologies: the so-called “*shimming*” technology. This allowed the construction of the biggest magnet of the world: the “flat” 6-metres-long magnet. I was spending days and nights inside this big magnet in order to build the very high-precision fields needed to capture, store and eject the muons.

The electroweak interactions were needed.

Abdus was on the way to visit the “Pope” of theoretical physics: Wolfgang Pauli in Zurich.

Abdus was very enthusiastic on the way towards Zurich, but when he came back he was very depressed.

Pauli didn't encourage him to spend his time thinking about the unification of the electromagnetic and the weak interactions.

It was simply a waste of time.

In spite of this, he went on and in fact, after a few years, as I said before, he gave a series of seminars exactly on this “waste of time” topic.

Nowadays we speak about Grand Unification as given for granted.

In the late fifties the idea that the fundamental forces of nature had to be unified was in the mind of a very few:

Abdus was the leader of these few.

Thanks to his friendship I had the privilege to learn new theoretical concepts before anyone else.

And thanks to his support, projects like the Erice Centre and the Gran Sasso Laboratory could become real: Abdus is not only the ICTP and the electroweak unification as reported in [2].

On many occasions Abdus invited me to give lectures at ICTP and in the evenings for the public of Trieste to let people know what was going on in the *Ivory towers*.

When I think of life and of its challenges, of the physics community and of its achievements, Abdus Salam is a formidable example of how all of us should be: the young generations of physicists should follow his devotion to physics, to society and his extraordinary sense for human solidarity.

Let me recall the interest of Abdus in a new technology for experimental physics: the TOF technology. The Time Of Flight (TOF) has played a vital role in Subnuclear Physics [5].

Here are  
few examples  
which attracted Abdus interest  
during the many years  
of our friendship:

i)

the discovery of nuclear antimatter [6, 7, 8];  
[Abdus called Dirac to give him the good news  
(S-matrix dominance and CP violation  
did not allow the  $(\bar{d})$  not to be there);  
Dirac invited me home for dinner  
and this is how the  
Erice Seminars on Planetary Emergencies  
started to exist [7] ];



ii)

the discovery of  
the time-like structure  
of the proton [9, 10];

iii)

the search for the third lepton HL at CERN [10, 11] and at Frascati [12] many years before the Kobayashi and Maskawa [13] proposal for the existence of three families, in order to explain the origin of CP violation. Also many years before the SLAC discovery [14] which did not use the HL symbol but the Greek letter  $\tau$  despite it's use during many years for the  $(\theta-\tau)$  puzzle. This is why the Heavy Lepton (HL) is now called  $\tau$  ;

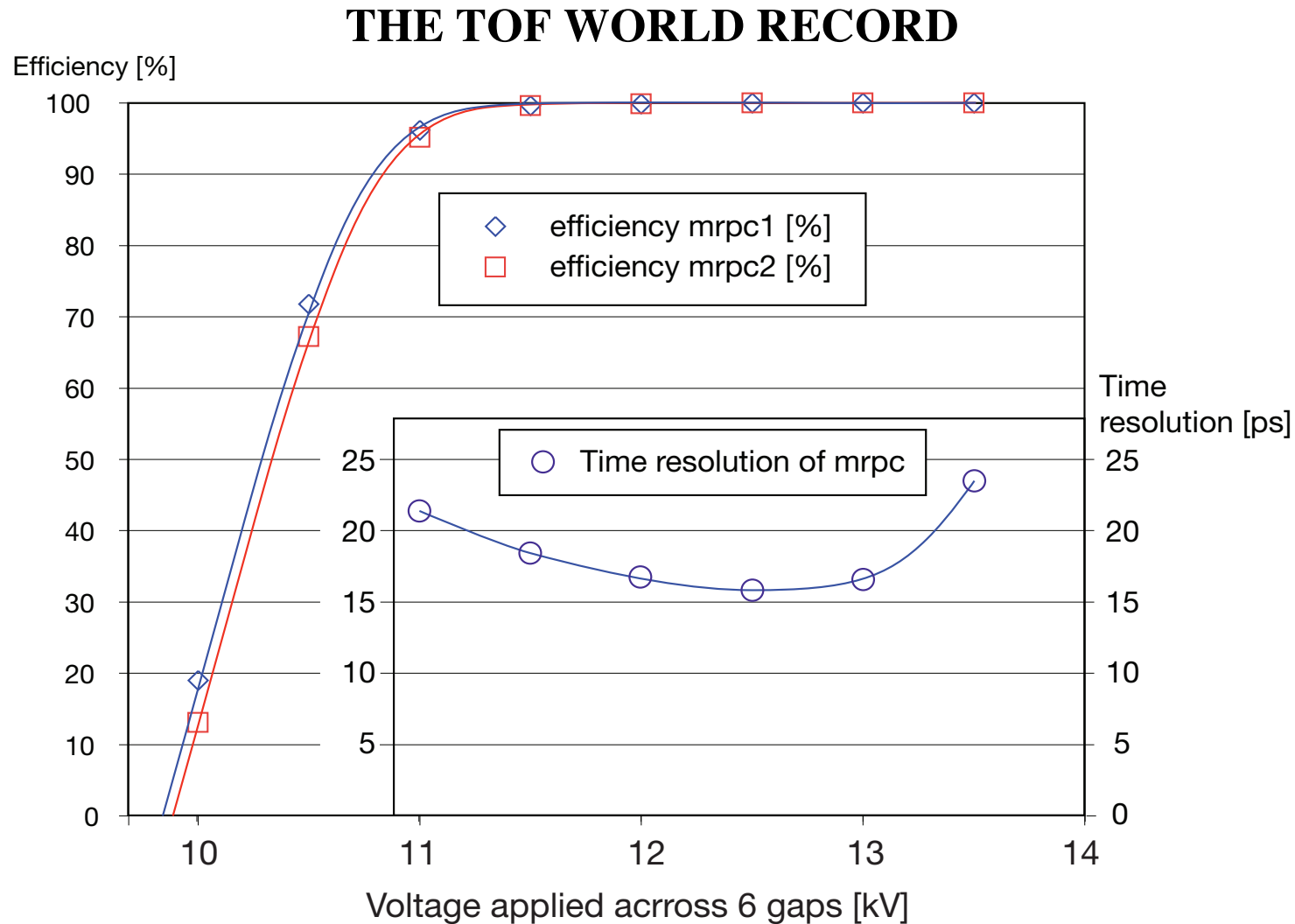
iv)

the high precision search  
for fractionally charged particles  
in high energy  
strong and weak interactions [15];

v)

the discovery of  
the Effective Energy in QCD [16].

The impressive series  
of  
technological developments  
on  
TOF  
has been going  
on during  
the last decade.



**Figure 1:** These results are the proof that highly segmented TOF arrays with high precision timing can be built. This world record was achieved thanks to the LAA Project – the largest project for the invention of subnuclear technologies – that have allowed CERN to build remarkably powerful instruments and detectors, as demonstrated by the very recent discovery of “God’s particle”.

**I would like to close my contribution  
with the data reported in Figure 1  
on the time resolution  
obtained using two MRPCs  
(Multigap Resistive Plate Chamber) [17, 18]  
at CERN.**

**The TOF resolution is 16ps:  
a World Record.**

**On behalf of all members  
of my group  
I dedicate to the memory  
of the great physicist  
Abdus Salam  
this  
World Record.**



## REFERENCES

- [1] *The Abdus Salam Dream*  
A. Zichichi, CERN/LAA/93-32/a, 21 October 1993. Invited Lecture given at the "Salamfest", in honour of Abdus Salam, ICTP, Trieste, Italy, 8-12 March 1993.
- [2] *Abdus Salam Beyond ICTP and the Electroweak Forces*  
A. Zichichi, CERN/LAA/95-18, September 1995.
- [3] *Frontiers in Physics*  
A. Zichichi, CERN/LAA/93-32, 2 November 1993. Invited Lecture given at the X Anniversary Celebration of the Third World Academy of Sciences, ICTP, Trieste, Italy, 1-4 November 1993.
- [4] *My Testimony on Lord Patrick M.S. Blackett. A Lesson for the Future of our Science*  
A. Zichichi, World Scientific, to be published.
- [5] “*Subnuclear Physics - The first fifty years*”  
A. Zichichi. O. Barnabei, P. Pupillo and F. Roversi Monaco (eds), a joint publication by University and Academy of Sciences of Bologna, Italy (1998); World Scientific Series in 20th Century Physics, Vol. 24 (2000).
- [6] *Experimental Observation of Antideuteron Production*  
T. Massam, Th. Muller, B. Righini, M. Schneegans, and A. Zichichi, *Nuovo Cimento* 39, 10 (1965).
- [7] *The Discovery of Nuclear Antimatter*  
L. Maiani and R.A. Ricci (eds), Conference Proceedings 53, Italian Physical Society, Bologna, Italy (1995); see also A. Zichichi in “*Subnuclear Physics - The first fifty years*”, O. Barnabei, P. Pupillo and F. Roversi Monaco (eds), a joint publication by University and Academy of Sciences of Bologna, Italy (1998); World Scientific Series in 20th Century Physics, Vol. 24 (2000).

- [8] *Are Matter and Antimatter Symmetric?*  
T.D. Lee, in Proceedings of the “Symposium to celebrate the 30th anniversary of the Discovery of Nuclear Antimatter”, L. Maiani and R.A. Ricci (eds), Conference Proceedings 53, page 1, Italian Physical Society, Bologna, Italy (1995).
- [9] *Search for the Time-Like Structure of the Proton*  
M. Conversi, T. Massam, Th. Muller and A. Zichichi, *Phys. Lett.* 5, 195 (1963).
- [10] *The Leptonic Annihilation Modes of the Proton-Antiproton System at  $6.8 \text{ (GeV/c)}^2$  Timelike Four-Momentum Transfer*  
M. Conversi, T. Massam, Th. Muller and A. Zichichi, *Nuovo Cimento* 40, 690 (1965).
- [11] 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  
*The Origin of the Third Family*, O. Barnabei, L. Maiani, R.A. Ricci and F. Roversi Monaco (eds), Academy of Sciences, Bologna University, INFN, SIF, Rome (1997); and World Scientific Series in 20th Century Physics, Vol. 20 (1998).
- [12] *A Proposal to Search for Leptonic Quarks and Heavy Leptons produced by ADONE*  
M. Bernardini, D. Bollini, E. Fiorentino, F. Mainardi, T. Massam, L. Monari, F. Palmonari and A. Zichichi, INFN/AE-67/3, 20 March 1967;  
*First Search for Sequential Heavy Leptons at ADONE*  
A. Zichichi, CERN-PPE/93-58 and CERN/LAA/93-18, 2 April 1993. Presented at the Symposium on “The  $\tau$  particle”, in honour of Martin Perl's 65th birthday, SLAC, Stanford, CA, USA, 24 July 1992.
- [13] *CP-Violation in the Renormalizable Theory of Weak Interaction*  
M. Kobayashi and T. Maskawa, *Prog. Theor. Phys.* 49, 652 (1973).

- [14] *Evidence for Anomalous lepton production in  $e^+e^-$  Annihilation*  
M.L. Perl et al., *Physical Review Letters* 35, 1489 (1975).
- [15] *Quark Search at the ISR*  
T. Massam and A. Zichichi, *CERN preprint*, June 1968;  
*Search for Fractionally Charged Particles Produced in Proton-Proton Collisions at the Highest ISR Energy*  
M. Basile, G. Cara Romeo, L. Cifarelli, P. Giusti, T. Massam, F. Palmonari, G. Valenti and A. Zichichi, *Nuovo Cimento* 40A, 41 (1977); and  
*A Search for quarks in the CERN SPS Neutrino Beam*  
M. Basile, G. Cara Romeo, L. Cifarelli, A. Contin, G. D'Alì, P. Giusti, T. Massam, F. Palmonari, G. Sartorelli, G. Valenti and A. Zichichi, *Nuovo Cimento* 45A, 281 (1978).
- [16] V.N. Gribov, G. 't Hooft, G. Veneziano and V.F. Weisskopf “*The Creation of Quantum ChromoDynamics and the Effective Energy*”, L.N. Lipatov (ed), a joint publication by the University and the Academy of Sciences of Bologna, Italy (1998); World Scientific Series in 20th Century Physics, Vol. 25 (2000).
- [17] *A New Type of Resistive Plate Chamber: The Multigap RPC*  
E. Cerron Zeballos, I. Crotty, D. Hatzifotiadou, J. Lamas Valverde, S. Neupane, M.C.S. Williams and A. Zichichi, *Nuclear Instruments and Methods* A374, 132 (1996).
- [18] *A 20ps Timing Device – A Multigap Resistive Plate Chamber with 24 Gas Gaps*  
S. An, Y.K. Jo, J.S. Kim, M.M. Kim, D. Hatzifotiadou, M.C.S. Williams, A. Zichichi and R. Zuyeuski, *Nuclear Instruments and Methods* A594, 39-43 (2008).



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