LARGE AND SMALL SCIENCE

by

Alberto Santoro

Laboratório de Cosmologia e Física Experimental de Altas Energias

LAFEX/CBPF/CNPQ[1]

Brazil

Abstract: An international concern about the relationship among scientists of several branches, becomes a "tension" in last recent years. In our point of view the words "small" and "big" or "large" used recently in many papers, comments and newspapers, are not appropriated to distinguish or identify a certain scientific area. We present an option and we complement the discussion with Latin America information about the development of science, mainly Physics.

EPS Conference on "Large Facilities in Physics" Lausanne 12-14 September 1994

[1] In the appendix we give the definitions of all abreviatures used in this text.

I --Introduction

We can approach the subject of small and large Science in several ways. We have to take into account the different points of views. We will start from general views and after we will specify the subject inside the Latin America environment. What means "small?" and "Big?" Does it mean less money for the "small" and more to the "Big?" Does it mean small device and Big devices? "Big" is more important, "small" less relevant? Paying attention to the papers of Professor V.F.Weisskopf, on this subject is important.[2]

All these questions raise far from naive considerations. Many young physicists start the discussion with one of these points. We cannot say that these points are the dividing line between the so called "small and big science," or in Professor Weisskopf's epistemology, Terrestrial and Cosmic Sciences. [3] If we would like to understand what is the line dividing the two types of Sciences we need to define a set of parameters. I do not believe that applied and not applied science is a good divisor. Application is a question of time also.

The number of physicists per experiment could be a parameter. The need for new technologies is another one. In a current HEP experiment there are hundreds of physicists, and needs to develop lots of new technologies. Such experiments result impossibly without intense work from hundreds of physicists and technicians.

The concerns of many of our colleagues in HEP and mainly outside HEP, come from:

- Number of authors per paper. Questions like, What was "your contribution in one specific paper?" . The result of your thesis will be published? . How many papers will be produced with it? All questions seek comparison between our activities and theoretical physics

---

[2]V.F.Weisskopf-The development of science during this century.

-CERN-93/06 (1993)

[3]V.F.Weisskopf- "Endangered support of basic science"

Scientific American. May (1994).

or small physics activities. Many advisory committees, trying to establish rules for promotions, find themselves comparing papers of one author with papers of a hundred of authors.

Other questions come to the individual, mainly to young physicists. Are you, well integrated?

Can you exercise your creativity inside your big group? . These questions are of a psychological nature, similar to those striking a young person who decides to go from a small village to a big metropolis.

High Energy Physics calls for a different way to do science. The "social parameters" are different from small sciences. Nevertheless, it is certainly not the disaster presented sometime in the press.

The major question, in my view, is: Are we convinced that we do have to know nature any better? . Do we have to continue to probe more deeply the structure of matter? If yes! , Then we have to face the difficulties and efforts needed to build our devices. We have to pay attention to the values of the parameters that we work with, like 10^{-23} seg., 10^{-18} m., hundreds of terabytes, access to computers on line for thousands of physicists at same time, very big cryogenic facilities to reach low temperature, high vacuum, and so on.

Let me now assume the perspective of someone that, contrary to developed countries, belongs to a minority, someone that tries to survive as a "big science" worker inside a vast community of "small science" workers. More precisely, I will consider first the example of Brazil, and then expand to Latin America. I have called attention to the fact that each country in Latin America has a different reality and would be a mistake if we simplify and consequently make reductions and general conclusions.

II -- Historical Summary of HEP in Brazil[4]

---

[4] a) J.Leite Lopes - O Desnvolvimento da Ciência e os Povos do Terceiro Mundo,pag.95 -Edited by Paz e Terra.

It seems to me that, before we go to the main subject of Latin America, we should provide some historical milestones of Brazilian Physics[5]. Physics in Brazil was first introduced in the Technical courses of engineering created at the end of the last century.

Let us give a list of important dates for the development of physics in Brazil and in particular for HEP.[6]

**1870 – Reorganization of the National Observatory.

**1874 -- "Central School" was transformed in the Polytechnic School of Rio de Janeiro by Viscount of Rio Branco.

**1893 – Creation of the Polytechnic School of São Paulo.

**1916 – The Brazilian Academy of Sciences was founded.

**30's -- Gleb Wataghin creates the Dept. Physics of FFCL-USP-S.Paulo and Bernhard Gross starts the solid state physics researches in Rio de Janeiro.

---

b) J.Leite Lopes - Ciencia e Desenvolvimento - Edited by EDUFF/PROED-UFF.

c) H.M.Nussenweig - Exodo de Cientistas : Suas causas e possiveis soluções, pag.109 -Ed. Paz e Terra.

d) J. Leite Lopes - A Física Nuclear no Brasil. pag.125 -Ed. Paz e Terra.

c) J.Leite Lopes Private communication.

[5] We would like to encourage the reader of this subject who would like to get much more details to read the references given here [3]. we will just give a list of important events do not be repeatitive in this text.

[6].a) Notes of the Logbook of CBPF/CNPq-Alvaro Difini - published in Jornal do Comercio 1955.

b) A Fisica do Brasil na próxima década -publishe by SBF 1990.

****40's** -- Formation of the first groups in Experimental and Theoretical physics. Mario Schemberg in São Paulo and Gross and Joaquim Costa Ribeiro in Rio de Janeiro represents the start of research groups. The younger generation, J.Leite Lopes, J.Tiomno, Elisa F.Pessoa formed a group of research and brought C.Lattes to Rio de Janeiro.

****1949** --CBPF is founded by J.Leite Lopes, J.Tiomno, Elisa F.Pessoa, C.Lattes and others with the support of the Admiral Alvaro Alberto.

****1951** -- Creation of the CNPq (Brazil's Research Council)

****50's** -- Installation of the two accelerators at University of São Paulo, a Betatron in 1951 of 25 Mev. of electron energy by the group of Marcelo Damy de Souza Santos. - this was the first accelerator installed in Brazil - and a Van der Graff in 1954 by the group of Prof. O. Sala. Nuclear Physics and Elementary Particle Physics developed at USP and CBPF were both the two domains and two geographic locals physics took place in Brazil. We will return to this point later.

****60's** -- FUNTEC -National Bank for Economic Development, was founded. This was very important for next developments in physics.

****1964** - A military government took the power in Brazil and in 1965 closed the doors of the University of Brasilia, aborting a program of R.Salmeron, J.Tiomno, E.Frota Pessoa, J.Leite Lopes, and many others for the development of High Energy Physics in Brazil. The whole institute of Physics, students, and Professors were expelled. In 1969 J.Tiomno, E.Frota Pessoa, J.Leite Lopes and others were forbidden to teach, to do the research, they were officially dismissed from the University and Research Centers that they founded. The consequences for High Energy Physics were disastrous. Certainly here is one of the most important causes of our retard in High Energy Physics in Brazil. It was about twenty years. Time sufficiently to build laboratories like Fermilab and CERN.

****70's** - FINEP starts the financial support for Science and Technology programs in Brazil. A new period of development of science was installed in Brazil. We start the decade with 190 Ph.D Physicists and in the beginning of 1980 we had about 600 Ph.D physicists. (See fig.1)

Let us go back to High Energy Physics.

In 1949, C.Lattes, J.Leite Lopes, J.Tiomno and others founded CBPF. In 1950 the "Symposium on New Research and Techniques in Physics" took place in Rio and São Paulo. This Symposium had attendees as Isidor J.Rabi, E.P.Wigner, S.De Benedetti, E.Segré, John and Leona Marshall, J.L.Anderson and so on. This symposium proposed for Particle Physics in Brazil. As we had two accelerators in São Paulo, I.J.Rabi suggested to build a High Energy (about 400 Mev) machine to be installed in Rio, similar to the one existing at Chicago University. The President of CNPq, Alvaro Alberto, took the initiative to start the project.[7] In 1952 The President of Brazil approved the proposal of Alvaro Alberto (President of CNPq). [8]The proposal was:

1. To buy a Cyclotron of 21".

2. To build a Synchrocyclotron similar to that of the Chicago University.

To accomplish this project, CNPq establishes a big program of Collaboration with University of Chicago. Many technicians come to Rio de Janeiro. Many researchers went to U.Chicago.

Unfortunately, in 1954 the President of Brazil committed suicide and a big political crisis took place in Brazil, and one consequence was the end of the project.

It is important to call attention to this step of physics in Brazil and in particular of CBPF as one of the pioneer institute in Brazil, because this fact is in a certain way has been neglected and presented as failure of the CBPF staff and as a negative part of our history. This was the first serious tentative to establish a program a long term of High Energy Physics in Latin

---

[7]At this time, (1951,1952) R.Feynman took a sabbatical year at CBPF. In this period CBPF had many visitors like C.N.Yang,J.R.Oppenheimer,E.P.Wigner, L.Rosenfeld giving courses, seminars, and collaborating with the brazilian community.

[8]Memo #19, April 16,1952 and Presidency of Republic 46971/52

America. We remark that we were in the context of the International Collaboration but the institution was National.

In 1961 -1965-- Again, J.Tiomno, E.F.Pessoa, Roberto Salmeron founded the Institute of Physics of the University of Brasilia. I have commented above on its fate under the military regime.

1981 sees the start of a new project. Leon Lederman took the initiative to propose a Symposium in Mexico to discuss the development of the Experimental Physics, in Latin America with a focus in High Energy Physics. Leon's dream was a Pan-American Laboratory at Fermilab. The Brazilian participants of this Symposium, was J.Tiomno invited by the organizers, and a set of physicists sent by CNPq and Brazilian Physical Society, M.Nussensweig, F.Zawislak, and Fernando Souza Barros. R.Lobo was the director of CBPF, received the report from J.Tiomno about the Symposium. R.Lobo decided to start a new project at CBPF, and invited a set of Theoreticians to accept the challenge to build a group of HEP at CBPF.

Due to many difficulties the project starts two years later only. It was the proposal of Lederman offering four grants for two years that allowed the group to go to Fermilab and be trained in experimental physics.

The Pan-American Symposium was repeated in Several countries, the first in Mexico, twice in Brazil, once in Argentina , and the last one was held in Colombia.

Meanwhile, other initiatives came up (from CERN, by C.Rubbia; from INFN in Italy, by Giorgio Mathiae and Enrico Predazzi; from LIP-Lisbon Mariano Gago and so on...) expanding the collaborations, and now are two Brazilian groups involved with experiments at CERN.

Then, the consequences for these now more than ten years of activity of High Energy Physics, were felt in several universities. Brazilian groups of physicists/engineers/technicians are involved with detector technologies, computing and are helping other groups to develop their programs of researches. These programmes have involved several Brazilian institutions, in regional collaboration.

III - Last Ten Years of HEP in Latin-American

I have to apologize for incomplete information in these notes. It is possible that I am involuntarily missing important facts also, but I will try to correct later in a future publication.

The activities in HEP in Latin America can be seeing in two parts;

(1) Cosmic Ray Physics, with active groups mainly in Bolivia and Brazil. A Collaboration Brazil - Bolivia - Japan has been going on for many years. In Brazil we have some groups in UNICAMP (Campinas/Sao Paulo), UNESP (IFT/S.Paulo), UFF (Rio de Janeiro) CBPF (Rio de Janeiro) and USP (S. Paulo).

(2) Accelerator Physics, with Brazilian groups in USP (S. Paulo), UFRJ (Rio de Janeiro), PUC (Rio de Janeiro), UERJ (Rio de Janeiro), and CBPF (Rio de Janeiro).[9] We have also groups in Colombia and Mexico. Some activities are starting in Argentina, Bolivia, Peru and perhaps in other countries that I have no information about. Latin America has difficulties with the infrastructure such as networks.

Let me concentrate on HEP with Particle Accelerators and after the First Symposium led by Leon.

It was in Brazil where the biggest group of HEP took place. More exactly it occurred in LAFEX/CBPF/CNPq. In 1986 this group was limited to three members, and now has about sixty members but more than one hundred users of the same facilities. (See the table 1 to have an idea as Lafex people are distributed).

I will give below some facts to illustrate the development, of this group and for historical registration.

In the present, Lafex is a Laboratory totally dedicated to Cosmology and High Energy Physics. LAFEX has regional collaborations with UFRJ, UERJ, CEFET, and PUC. These are Federal and State Universities and CEFET is a Federal School of Engineering and Technical School. Beyond these institutions of Rio de Janeiro, many other institutions have

---

[9]At CBPF we have two groups. LAFEX-Laboratorio de Cosmologia e Fisica Experimental de Altas Energias and the Departamento de Fisica Nuclear e Altas Energias.

used our facilities, like USP (S. Paulo and S.Carlos), UFF, COPPE, U.Para, LNCC, UFRGS and so on. Also due to our expertise in Computing, and Networks for HEP, we have helped institutions like, CEPEL, private and commercial institutions, and so on. Also, inside CBPF we have contributed with modern equipment and knowhow for our colleagues.

The internal organization of LAFEX is in four divisions; The Experimental Physics Division, with different groups participating in international collaborations. The Theoretical Physics Division, where Cosmology, and HEP Phenomenology are developed; The Associated Technologies Division, where the support of engineering for HEP is developed. And an Academic Activities Division that concentrates the scientific orientation for Master and Ph.D Thesis, technical stages, courses, seminars, workshops and Summer Schools.

The group of LAFEX, has

19 Ph.D, (8 experimentalists and 11 theoreticians), 19 M.Sc., 9 M.Sc. Students and 17 Ph.D. students, 4 engineers and 5 administrative. Beyond that LAFEX has visitors, and local collaborators as was shown in table 1.

The number of papers published since the beginning of the group is 492 (1970-1993). The number of Thesis oriented by the group is 56 for the same period. Experimental HEP activities started in 1981 and certainly the support of many physicists like J.Tiomno, J.L.Lopes, R.Salmeron, R.Lobo, R.P.Muniz, M.Nussenzweig and other's Brazilian scientists and politicians, (R.Archer, a former Minister of Science and Technology and President J.Sarney, both supported our initiatives), were very important since the beginning. But without the collaboration of Fermilab would be impossible to achieve in the present status of the laboratory (L.Lederman, R.Rubinstein, T.Nash, J.Appel, J.People, are those among other having helped continuously the formation of Lafex).

IV-Small and Big Science in Latin America

In Latin American we have no Large Facilities for HEP. We have no high energy accelerators. Nevertheless, we have many accelerators for "small" physics or Terrestrial Sciences; Four in S.Paulo, one in Rio, one in Rio Grande do Sul. The latest device being built

for Terrestrial science in Brazil, it is an accelerator to produce Synchrotron Light. In Argentina we have also the Tandar working for Nuclear Physics.

Beyond accelerators, we have an international facility in Chile for Astrophysics, and other facilities in INPE/CNPq, in S.Paulo, are being used by Brazilian community.

The Terrestrial sciences dominate completely the science in Latin America. Most important is Condensed Matter that has only in Brazil about one thousand of physicists.

We would like to say finally that:

1. In the discussion of this round table, it was clear for me that "small"science does not exist. This is called for some small and local experiments in condensed matter mainly. Nevertheless, globally the sizes are the same. The only difference in report to HEP for example, is that in HEP the physics imposed to work concentrated. It was not demonstrated up today that is possible to get the same results in physics by another way.

2. There is no doubt that the Cosmic Sciences [10]can have a very important collaboration with Terrestrial Sciences.[7] HEP's needs for new materials, for its detectors, could be a motivation also for New Materials Sciences collaborate with big detector groups. Everybody needs computing. Nevertheless, we can have facilities as we have in LAFEX and serve our colleagues of Atomic Physics, Nuclear Physics, Technologies and Engineering, and so on. We can share electronics and develop small devices for them. Then, this could be a strategy for us: To share all our facilities. DESY is a good example. A more efficient uses of large facilities have to be pursued for new and current projects. More efficient means also collaboration among different existing sciences.

---

[10] An elegant name for our Science, High Energy Physics. Astrophysics.Astronomy and so on.

3. In the next future, it is well possible that big detectors perhaps become like big accelerators. I mean, we have a big facility for several groups to work in several branches of particle physics. Perhaps we have to think about new way of organizing ourselves in several collaborations defined by the subject, around one big detector.

4. International Collaboration must take into consideration the differences, not only cultural, but economical and the infrastructure in countries of Latin America. It is important if we want really to build a new Scientific World, to pay attention to this part of the world. I invite our colleagues of the called developed country world, to consider this challenge. We cannot survive alone. I also have doubt that you can survive without this important part of the world. If we really would like to have our collaboration, we have to develop facilities in this world. Internal and local facilities are also generators of a HEP culture and build future collaborators. A program like that is a real revolution just started by Leon Lederman.

5. Existing ideas[11] have be exploited to turn possible the participation of Latin America in these Large Facilities like CERN, FERMILAB, SLAC, BNL, and so on.

Acknowledgment. I would like to thank Professor Carlos Aguirre (President of the Academia Nacional de Ciencias de Bolivia) for invited me to represent him in this conference. His suggestions were very useful for this text. I would like to acknowledge also Professor J.Leite Lopes for provide me many documents about Physics in Brazil , to Prof. Arthur Kos Maciel for his suggestions and discussions about the subject of this text and to Prof.E.Predazzi to have allowed me concludes this notes in their institute

Appendices:

I -- List of Institutions cited in the text above.

I. FFCL - Faculdade de Filosofia Ciencias e Letras.

---

[11] A.Santoro - Possiveis Contribuições da Física de Altas Energias a Integração e Desenvolvimento do País. CBPF.-CS-003/93.

2. USP - Universidade de São Paulo.

3. CBPF - Centro Brasileiro de Pesquisas Físicas.

4. CNPq - Conselho Nacional do Desenvolvimento Cientifico e Tecnologico.

5. FUNTEC - Fundo de Ciencia e Tecnologia do Banco Nacional de Desenvolvimento Economico.

6. FINEP - Financiadora de Projetos em Ciencia e Tecnologia.

7. CERN - European Laboratory for Particle Physics.

8. UNICAMP - Universidade de Campinas.

9. UNESP - Universidade Estadual de São Paulo.

10. UFF - Universidade Federal Fluminense.

11. UERJ - Universidade do Estado do Rio de Janeiro.

12. UFRJ - Universidade Federal do Rio de Janeiro.

13. CEFET - Centro de tecnologia Celso Sukow.

14. COPPE - Coordenacao de Pos-graduação em Engenharia.

15. LNCC - Laboratório Nacional de Computação Cientifica.

16. UFRGS - Universidade Federal do Rio Grande do Sul.

17. CEPEL - Centro de Pesquisas da Eletrobras.

18. INPE - Instituto Nacional de Pesquisas Espaciais.

19. DESY - Deustsches Elektronen Synchrotron.

20. FERMILAB - Fermi National Accelerator Laboratory.

21. MCT - Ministério de Ciencia e Tecnologia.

22. IBICT - Instituto Brasileiro de Informação em Ciencia e Tecnologia.

23. SBF - Sociedade Brasileira de Física .

II - Bibliography used in the text

1. A Física do Brasil na próxima decada -published by SBF .1990

2. Relatório Estatistico 1993 published by MCT/CNPq/IBICT

3. Despesas Realizadas da União em Ciencia e Tecnologia 1980/92 - MCT/CNPq/IBICT.

4. J. Leite Lopes - Trinta anos de Física no Brasil : Evocações -CBPF-CS-004/84.

5. Notes of the Logbook of CBPF/CNPq -Alvaro Difini - published in Jornal do Comercio 1955.

6. A.F.S.Santoro - Possíveis Contribuições da Física de Altas Energias à Integração e Desenvolvimento do País. CBPF - CS-003/93

7. Estudos da SBF - A Física no Brasil.

8. J. Leite Lopes -O Desenvolvimento da Ciência e os Povos do Terceiro Mundo. -Edited by Paz e Terra.

9. J.Leite Lopes - Ciencia e Desenvolvimento. - Edited by EDUFF/PROED-UFF.

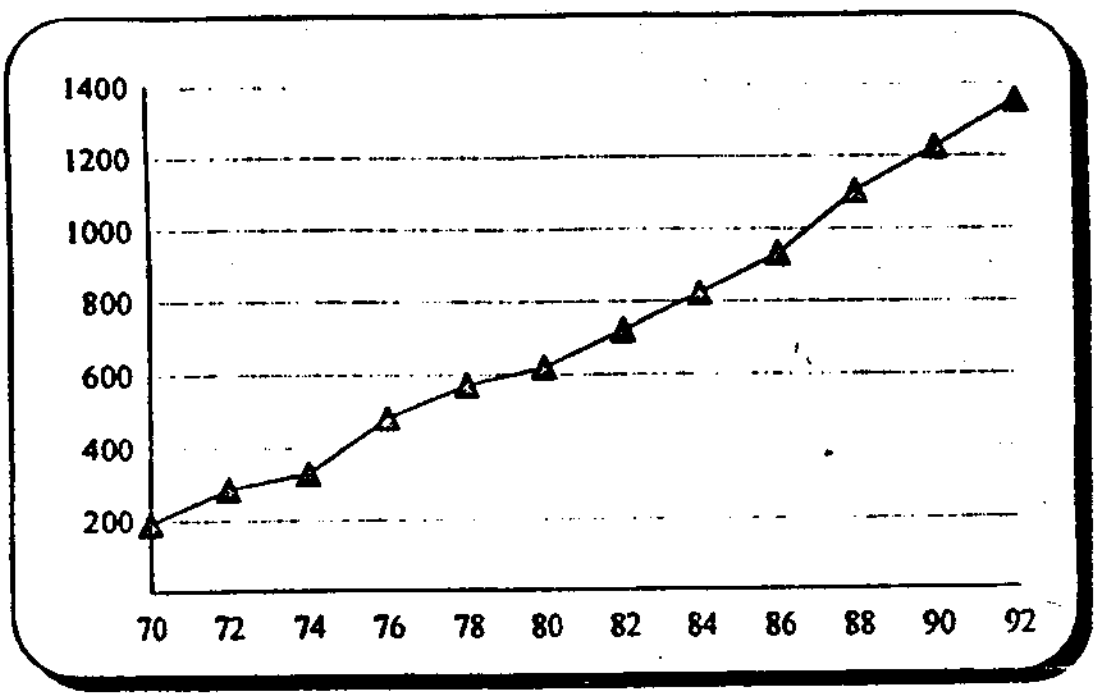

Fig. 1 - Number of Ph.D in Brazil - ref. 6 b)

Laboratório de Cosmologia e Física Experimental de Altas Energias LAFEX - 1994

	Experimentalists	Theoreticians	Total
Ph. D.	08	11	19
M. Sc.	08	11	19
Ph. D. Students	08	09	17
M. Sc. Students	03	06	09
Engineers			04
Administratives			05
Technicians			03
Fellowship holders			16
Published Papers(*)	287	205	492
Thesis(*)	16	40	56

Table 1. (Details about these data are available in the Annual Report of LAFEX).

(*) 1970/1993