

# INTERNATIONAL COLLABORATIONS

Ricardo Galvão

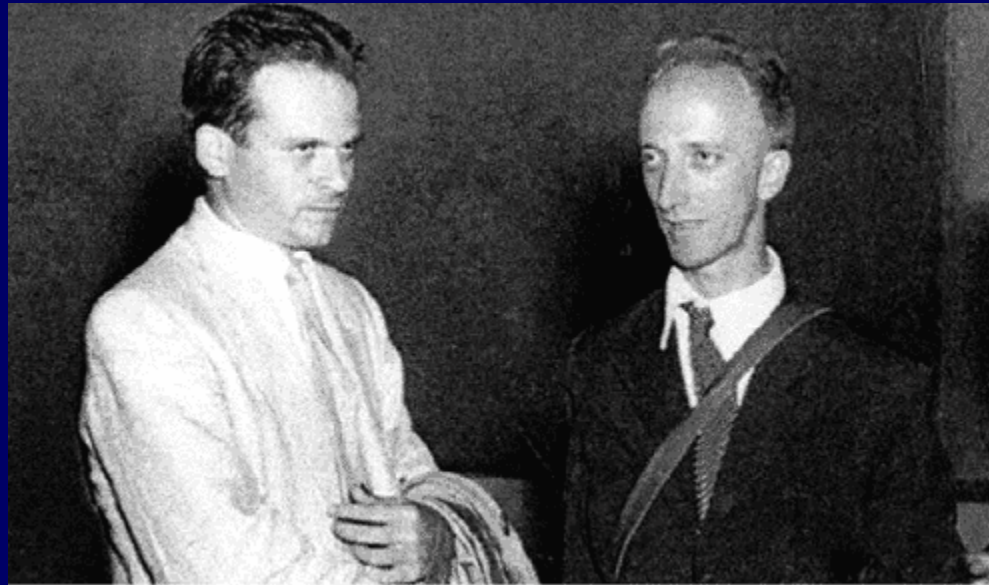
CENTRO BRASILEIRO DE PESQUISAS FÍSICAS

# History

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CBPF was founded in 1949 (15th January) by two eminent Brazilian physicists,

**Cesare Lattes and José Leite Lopes,**



Os dois jovens cientistas César Lattes (à esquerda) e José Leite Lopes, parceiros nos anos 50

as a private organization to carry out research in Physics.

# History

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**1949 – 1976: Private organization supported by donations, Federal Confederation of Industries, budget allocations from the House of Representatives, and research grants.**

**1976 on - Research Institute of the Federal Government (Ministry of Science and Technology).**

**In the fifties, CBPF played a crucial role on the formation of young scientists, consolidating Physics Research and contributing decisively for the creation of other research institutions in Brazil.**

**The presence of eminent international scientists, who came as visiting professors, played a crucial role on fostering the scientific vocation of young Brazilians and on establishing the international reputation of the institution.**

# History

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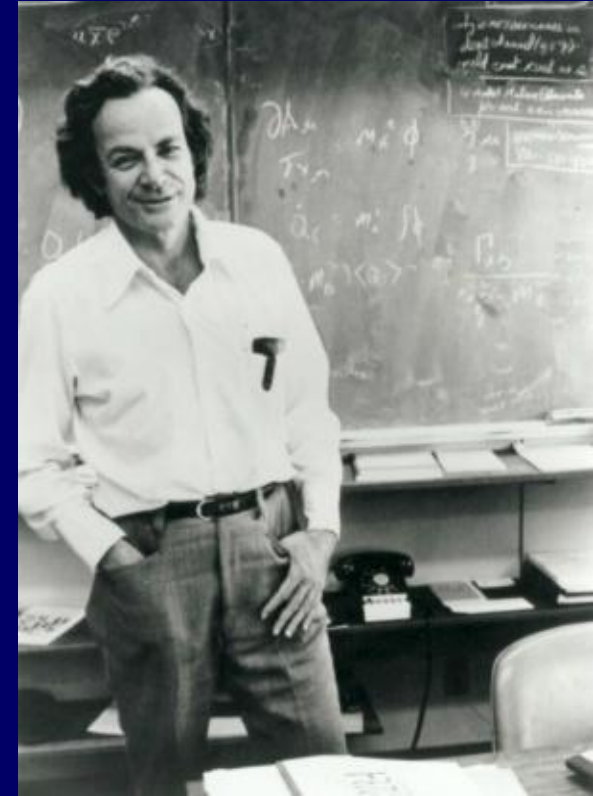


**Guido Beck**



Scanned at the American  
Institute of Physics

**Leon Rosenfeld**



**Richard Feynman**

# Research and Development

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- **Fundamental Research**

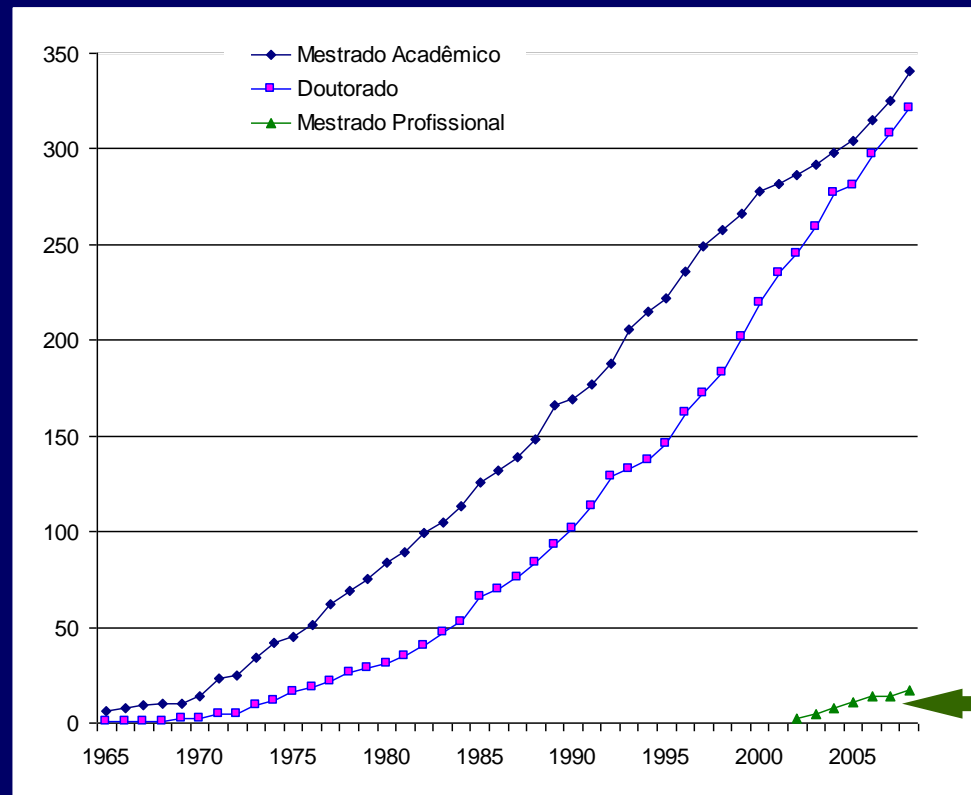
- Condensed Matter
- Physics of Biological Systems
- Statistical Physics and Complex Systems
- Dynamical Systems
- Cosmology, Gravitation and Relativistic Astrophysics
- High Energy Physics and Astroparticles
- Nuclear Physics and Astrophysics
- Field Theory and Mathematical Physics
- Quantum Computation

- **Applied Physics**

- Materials Science
- Biocompatible Materials
- Chemistry, Catalysis, and Environment
- Geology and Medicine
- Meteoritic
- Scientific Instrumentation / Computing
- Applied plasma physics

# Educational Programs

- First institution in Brazil to have a post-graduate course in Physics officially approved by the Ministry of Education.
- Over 600 students have obtained their higher scientific education in CBPF, with approximately 50% coming from outside Rio de Janeiro and many Latin-American countries.

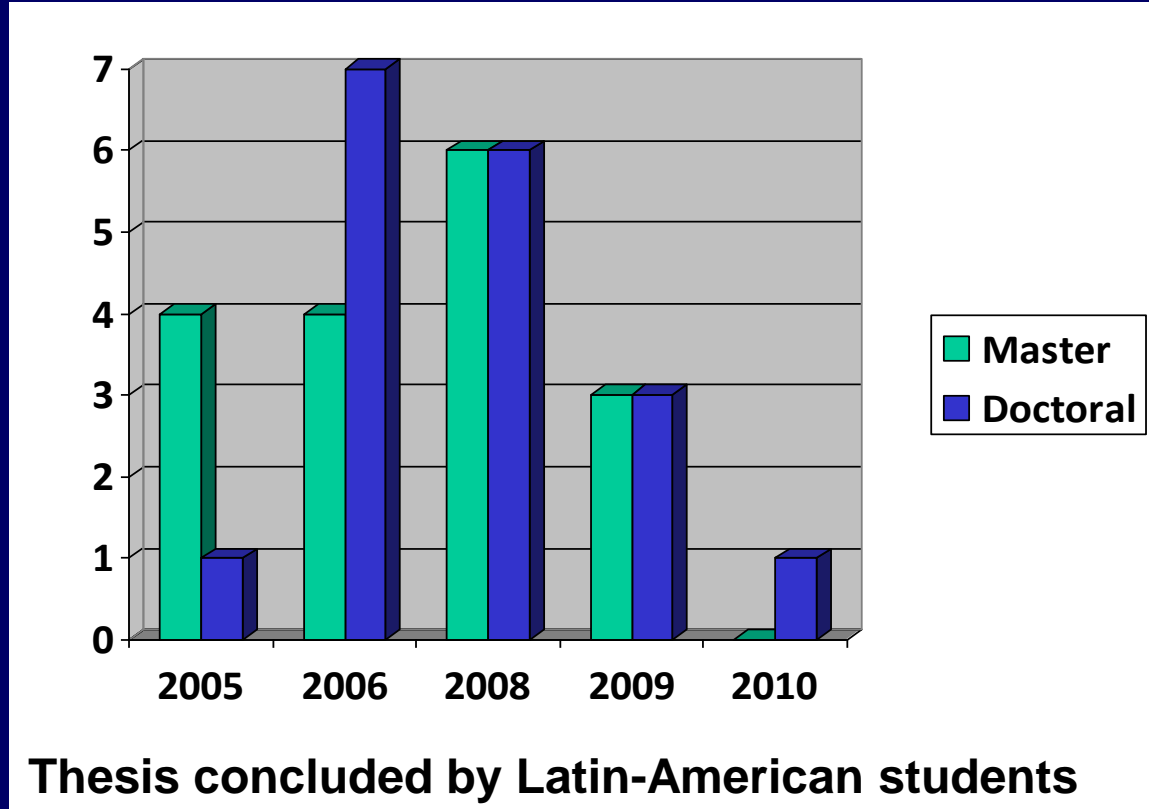


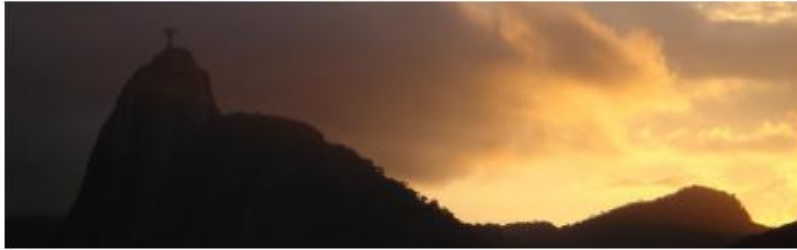
# International Collaboration in Scientific Education

First Semester 2010

Doctoral Students: 65; 15 from Latin - American countries

Master Students: 42; 12 from Latin - American countries





Observation of the  
Metal-Insulator Transition  
in Yb fcc metal  
under High Pressures

Carsten Enderlein

Berlin, August 31, 2006

# Diplomarbeit

zur Erlangung des akademischen Grades

Diplomphysiker

an der

FU Berlin

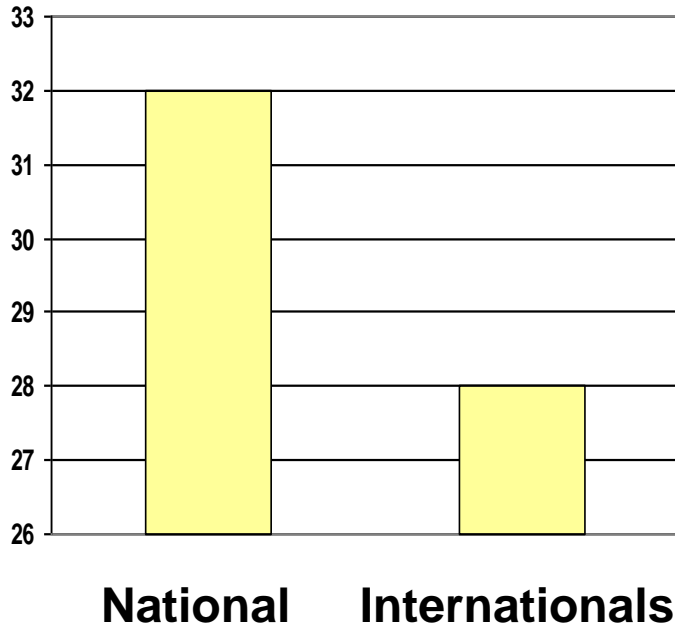
Fachbereich Physik

Thema: Observation of the Metal-Insulator Transition in  
Yb fcc Metal under High Pressures

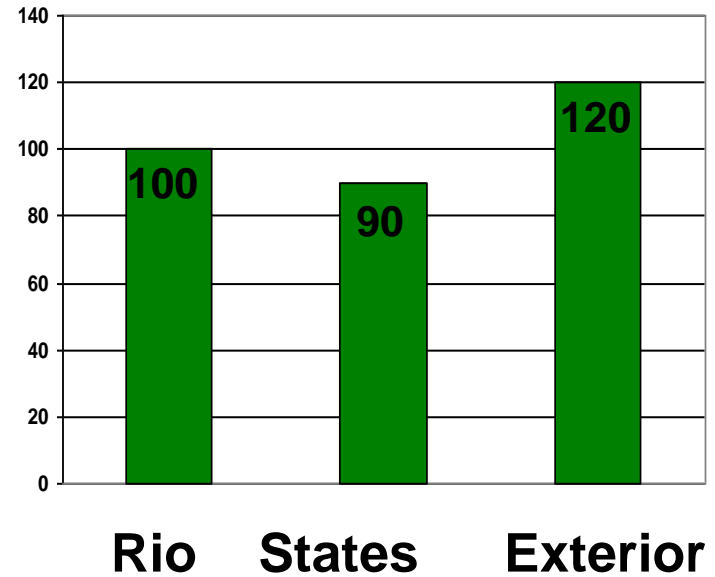
Diplomand: Carsten Enderlein  
Hans-Wieck-Str.9  
27356 Rotenburg - Wümme  
Carsten\_E@hotmail.com  
Tel. 0177-7 88 20 99



# National and International Scientific Collaborations (last 5 years)



**Formal Collaborations**



**Visitors**

# National and International Involvement

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## Most Important International Agreements

- **Fermilab - USA**
- **CERN - Switzerland**
- **Pierre Auger – Multilateral**
- **Dark Energy Survey**
- **ICRA - Multilateral**
- **CLAF – Latin America**
- **CNRS - France**
- **TWAS – Trieste – Italy**
- **CAPES/DAAD – Univ. Tech. Munich**
- **CAPES/COFECUB**
- **University of Hawaii at Manoa**

# International Articulation

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- **Center of Excellence of “ The Third World Academy of Sciences” (TWAS).**  
*Associateship scheme for regular visits of the Third World Researchers - Since 1994*
- **Host of the Latin American Center for Physics (CLAF)**  
**Since 1963**
- **Brazilian Branch of “The International Center for Relativistic Astrophysics” (ICRA)**  
**Since 2000**
- **Headquarters of the National Network for High Energy Physics**  
*Coordinates HEP international collaborations of Brazilian Groups*

# Cosmology and Relativistic Astrophysics

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Brazil has signed a formal collaboration agreement with

**ICRANet**

**INTERNATIONAL CENTER FOR RELATIVISTIC  
ASTROPHYSICS NETWORK**

[Legislative Decree N<sup>o</sup> 292 (Diário Oficial da União 205 –  
24/10/2007)]

**CBPF is the Regional Office of ICRANet for South  
America**

**Doctoral and Post Doctoral Fellowships are offered  
for Latin American Students**

# Cosmology and Relativistic Astrophysics

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## ERASMUS MUNDUS ACTION 1 - Selection 2009 List of EMJD courses proposed for selection

**Reference:** 159735 -1-2009-1-FR-EMJD

**Title:** International Relativistic Astrophysics Doctorate Program

**Beneficiary organisation:** UNIVERSITE DE NICE - SOPHIA ANTIPOLIS

**Coordinator contact details:**

Mr Pierre COULLET

PRÉSIDENCE

Grand Château 28 avenue Valrose, BP2135

F-06103 NICE

Tel.: +33 492 076460 - e-mail: Pierre.COULLET@unice.fr

**Partners:**

SHANGHAI ASTRONOMICAL OBSERVATORY, China

FRÉE UNIVERSITY OF BERLIN, Germany

AEI - POTSDAM, Germany

TARTU OBSERVATORY, Estonia

STOCKHOLM UNIVERSTIY, Sweden

UNIVERSITY OF FERRARA, Italy

UNIVERSITY OF ROME - LA SAPIENZA, Italy

BRAZILIAN CENTRE FOR PHYSICS RESEARCH, Brazil

OBSERVATORY OF THE CÔTE D'AZUR, France

INDIAN CENTRE FOR SPACE PHYSICS, India

INTERNATIONAL CENTER FOR RELATIVISTIC ASTROPHYSICS NETWORK, Italy

UNIVERSITY OF SAVOY, France

# the International Relativistic Astrophysics Erasmus Mundus Joint Doctorate Program

The IRAP Ph.D. program, sponsored by Erasmus Mundus, is dedicated to the formation of scientists in the field of relativistic astrophysics. The successful scientific space missions by the European Space Agency (ESA), the Very Large telescope of the European Southern Observatory (ESO) in Chile, as well as the high-energy particle activities at CERN in Geneva have created the basis for a vigorous development of the field of relativistic astrophysics. This has become one of the most active fields of current research.

This program provides expertise in the most advanced topics of mathematical and theoretical physics, including relativistic field theories, in the context of astronomy, astrophysics and cosmology. This activity is necessarily international – no single university can cover this broad scientific scope.

The first three-year program cycle starts in 2010 at the University of Nice Sophia Antipolis. It benefits from the presence of the astrophysics research institute of the Observatoire de la Côte d'Azur. The coordination of the IRAP Ph.D. will take place at the Center of ICRANet at Villa Ratti, close to the university campus. The Freie Universität Berlin and the Einstein Institute in Potsdam contribute with teaching in relativistic field theories. The University of Savoie connects to the particle physics at CERN. The activities at the University of Rome, at Stockholm University and at ICRA and ICRANet offer teaching programs in all fields of relativistic astrophysics, including cosmology, the physics of gravitational collapse, gamma-ray bursts, and black hole physics. The University of Ferrara takes part with lectures and research in observational astronomy and development of space missions. In addition, the students can follow graduate courses at all the participating institutions.

Through ICRANet the extra-European connections with Brazil, China and India will be guaranteed: with China via the Shanghai Observatory of the Chinese Academy of Science, with India via the Indian Centre for Space Physics in Kolkata and with Brazil via the Rio de Janeiro branch of ICRANet.



- GENERAL RELATIVITY
- ADVANCED GENERAL RELATIVITY
- RELATIVISTIC FIELD THEORY
- PARTICLE PHYSICS APPLIED TO ASTROPHYSICS
- SINGULARITIES IN GENERAL RELATIVITY
- ROTATING AND ELECTROMAGNETIC BLACK HOLES
- GRAVITATIONAL WAVES
- BLACK HOLES AND FUNDAMENTAL PHYSICS

- ULTRA RELATIVISTIC ELECTRON POSITRON PLASMA
- RELATIVISTIC EFFECTS IN GAMMA RAY BURSTS SUPERNOVAE
- ULTRA HIGH ENERGY GAMMA RAY SOURCES
- FORMATION OF GALAXIES
- EXTRAGALACTIC ASTROPHYSICS
- LARGE SCALE STRUCTURE OF THE UNIVERSE
- NON-SINGULAR COSMOLOGY

- INTERNATIONAL CENTER FOR RELATIVISTIC ASTROPHYSICS (ICRANet) and UNIVERSITY OF ROMA LA SAPIENZA, ROME, ITALY  
Prof. Remo RUFFINI, IRAP PhD director (ruffini@icranet.it)
- UNIVERSITY OF SAVOIE, ANNECY, FRANCE  
Prof. Pascal CHARDONNET, Erasmus Mundus coordinator (chardonnet@lapp.in2p3.fr)
- INDIAN CENTRE FOR SPACE PHYSICS, KOLKATA, INDIA  
Prof. Sandip Kumar CHAKRABARTI (chakraba@bose.res.in)
- UNIVERSITY OF NICE-SOPHIA ANTIPOLIS, NICE, FRANCE  
Prof. Pierre COULLET (pierre.coulet@unice.fr)

- SHANGHAI ASTRONOMICAL OBSERVATORY, SHANGHAI, CHINA  
Prof. Yipeng JING (ypjing@shao.ac.cn)
- FREE UNIVERSITY OF BERLIN, BERLIN, GERMANY  
Prof. Hagen KLEINERT (hakei@gmx.de)
- ALBERT EINSTEIN INSTITUTE, POTSDAM, GERMANY  
Prof. Hermann NICOLAI (hermann.nicolai@aei.mpg.de)
- BRAZILIAN CENTRE FOR PHYSICS RESEARCH, RIO DE JANEIRO, BRAZIL  
Prof. Mario NOVELLO (novello@cbpf.br)
- STOCKHOLM UNIVERSITY, STOCKHOLM, SWEDEN



# HIGH ENERGY PHYSICS

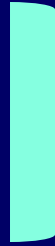
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- 1930's Some European scientists came to the University of São Paulo

Gleb Wataghin

G. Occhiallini

U. Camerini



work on cosmic rays

- 1940's

Cesare Lattes (student of Occhiallini)

Went to Bristol and, together with Occhiallini and C. Powell, discovered the pion.

Then went to Berkeley and with E. Gardner, showed that there were pions in the fragments of collisions in the cyclotron.

His achievements motivated the setting up of HEP research in Brazil.

Together with José Leite Lopes, creates the Brazilian Center for Physics Research - CBPF, with strong emphasis on HEP.

# HIGH ENERGY PHYSICS

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- 1950's

Roberto Salmeron, after working for three years in CBPF, goes to Manchester for the PhD work, and then becomes staff member of CERN.

- 1980's

CBPF participated officially in the NA22 collaboration, mainly through Ana Maria Endler.

- 1982

Leon Lederman visits many Latin American countries inviting participation in HEP experiments in FERMILAB.

Four Brazilian scientists work for two years in FERMILAB, starting the modern phase of HEP research in Brazil.

- 1995

Jim Cronin invited some Argentinean and Brazilian physicists to participate in the study group of what later became the AUGER Project.



# HIGH ENERGY PHYSICS- Current Situation

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## *Accelerator Physics*

|              |  |
|--------------|--|
| <b>Dzero</b> | <b>CBPF and UERJ ( ~ 10 PhDs)</b>                      |
| <b>ALICE</b> | <b>USP and UNICAMP ( ~ 8 PhDs)</b>                     |
| <b>ATLAS</b> | <b>UFRJ and USP ( ~ 9 PhDs)</b>                        |
| <b>CMS</b>   | <b>CBPF, UERJ , and UNESP ( ~ 15 PhDs)</b>             |
| <b>LHCb</b>  | <b>CBPF, PUC, and UFRJ ( ~ 14 PhDs)</b>                |
| <b>WLCG</b>  | <b>CBPF, UERJ, UNESP → 3 TER 2; establishing a ROC</b> |

## *Accelerator Physics – Neutrinos*

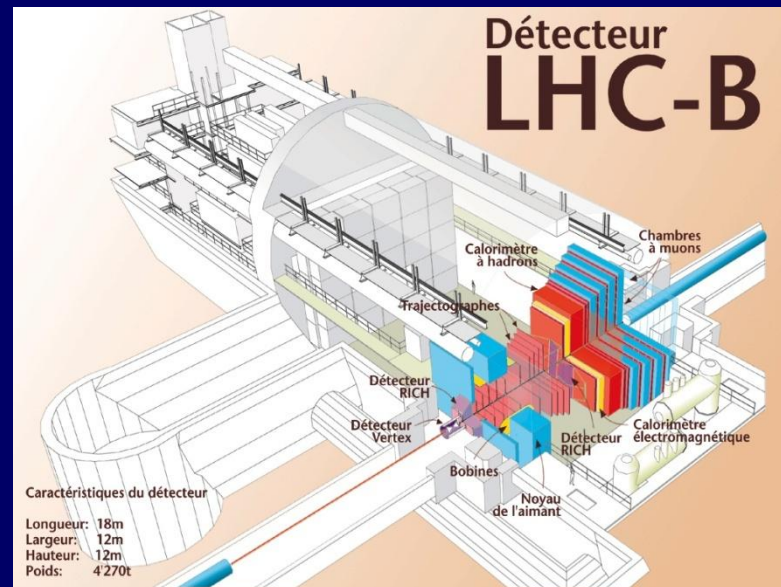
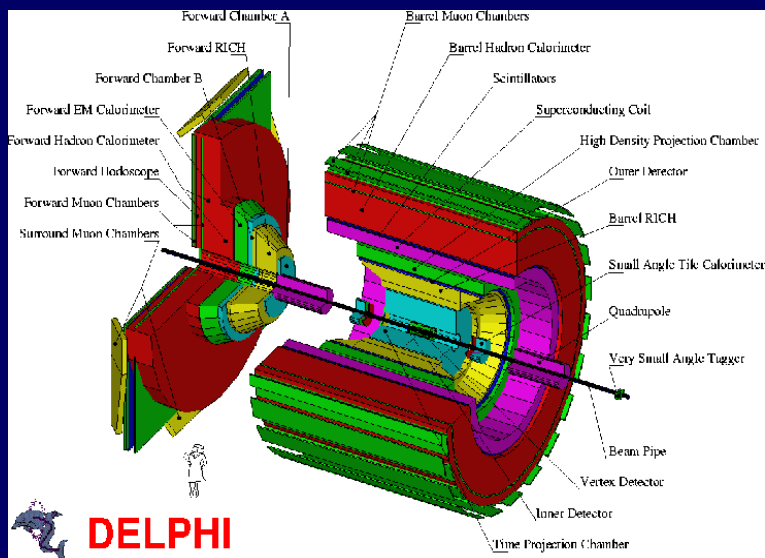
|                                  |
|----------------------------------|
| <b>USP and UNICAMP ( 3 PhDs)</b> |
| <b>MINERVA CBPF ( 2 PhDs)</b>    |

## *Non-Accelerator Physics*

|              |  |
|--------------|--|
| <b>AUGER</b> | <b>CBPF, UFRJ, UNICAMP, USP ( ~ 20 PhDs)</b> |
|--------------|--|

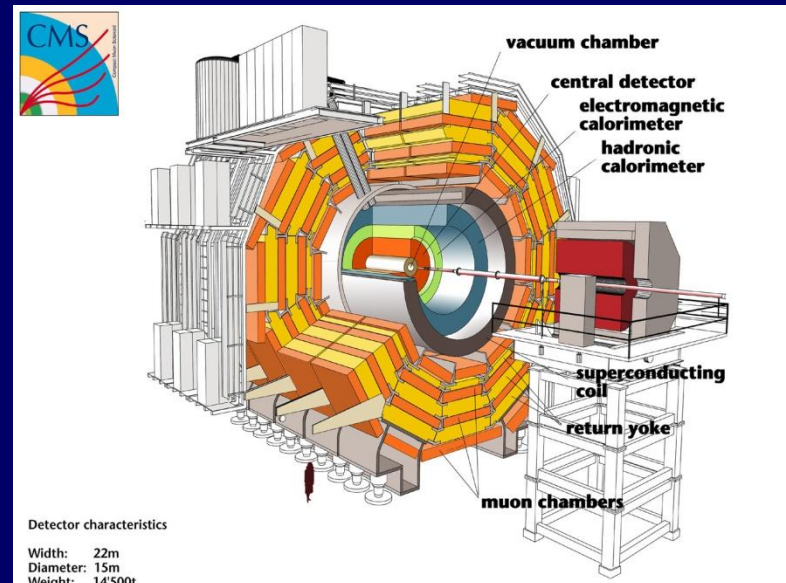
# HIGH ENERGY PHYSICS

## LEP (stopped in 2000)



## LHC – LHCb & CMS

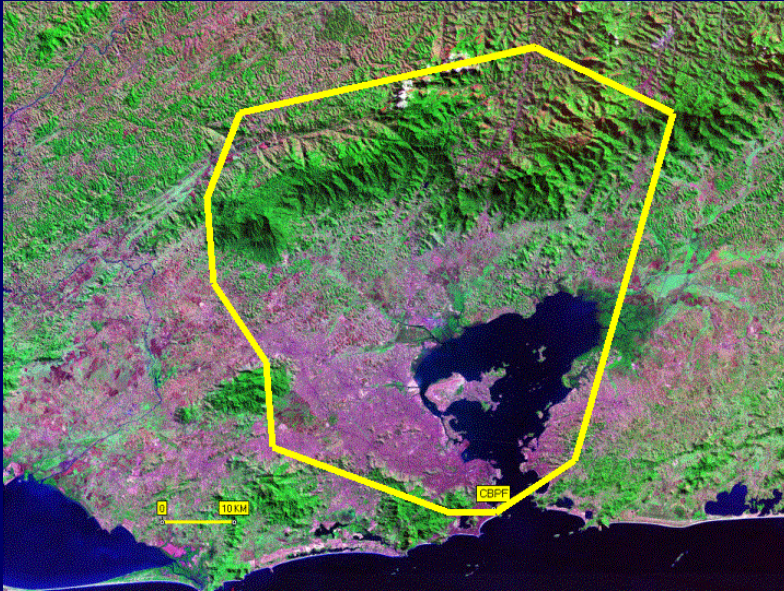
- GRID computing
- Electronics (triggers)
- Muon detectors
- Near beam detectors



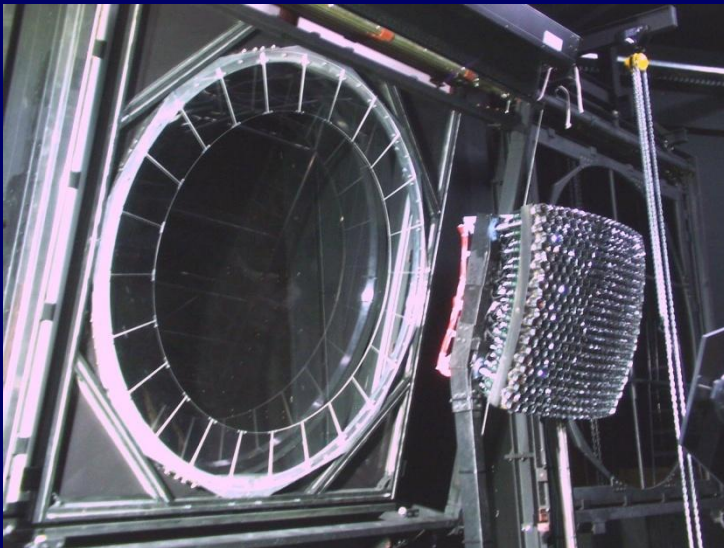
# HIGH ENERGY PHYSICS

## Pierre Auger Observatory

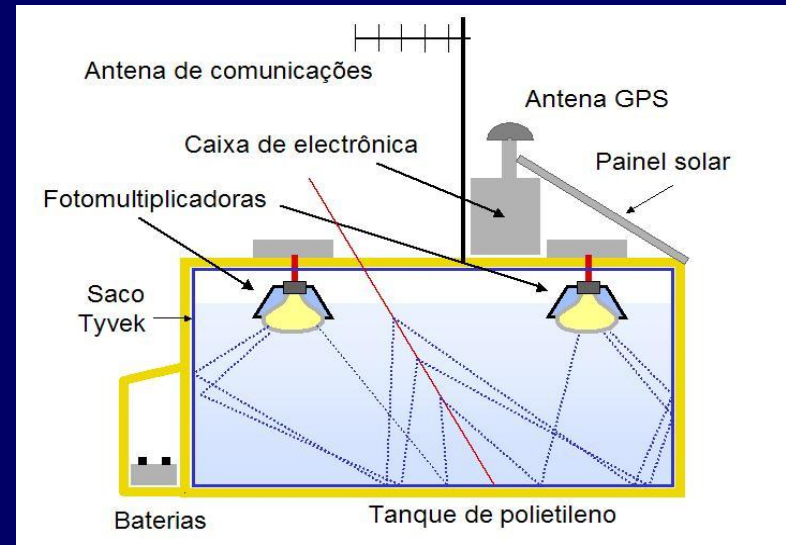
- Measure cosmic rays at ultra-high energies
- Involved in every aspect of the observatory
- Intense participation of Brazilian industry
- Finish construction this year (2007)
- Taking data since 2004
- Next step: Auger North, Colorado, USA



Fluorescence Detectors



Surface Detectors



# Angra Neutrino



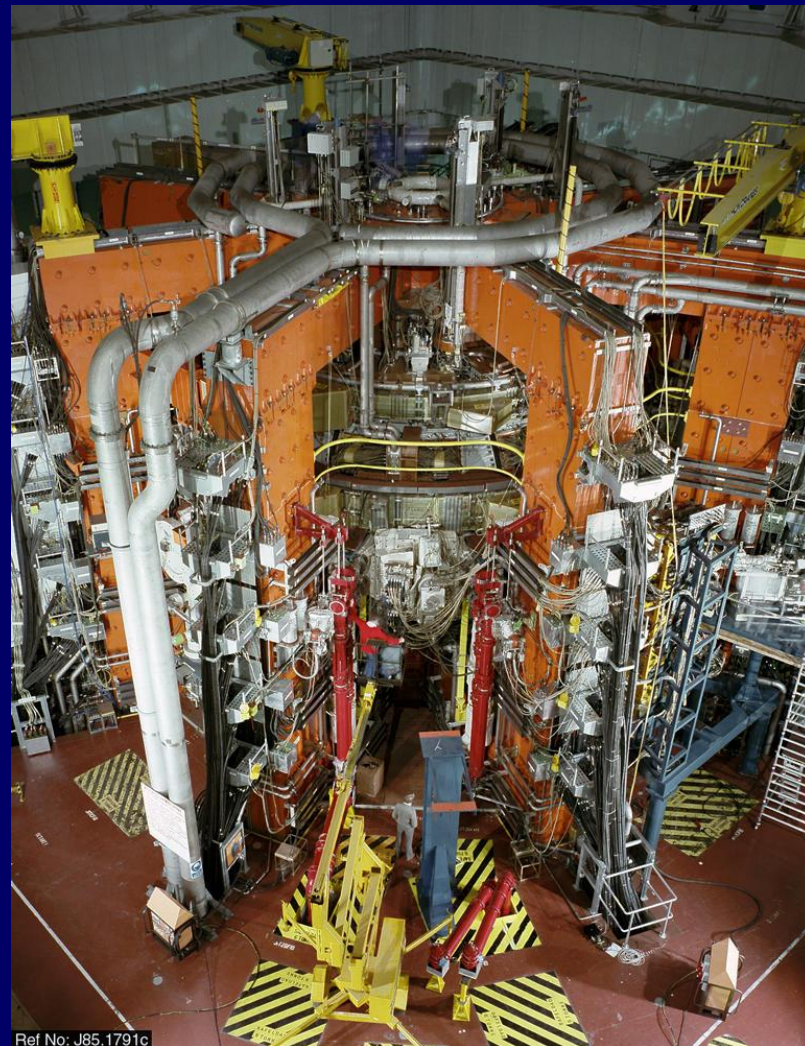
# FUSION ENERGY RESEARCH

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- **Brazil has established a National Fusion Research Network in 2007; CBPF acts as the Executive Secretariat of the Network.**

- **Last year, a formal scientific agreement on Fusion Energy Research was signed between the Federal Government and EURATOM**

- **Collaborative work is starting this year on JET and on the planning of an experiment for the National Fusion Laboratory**

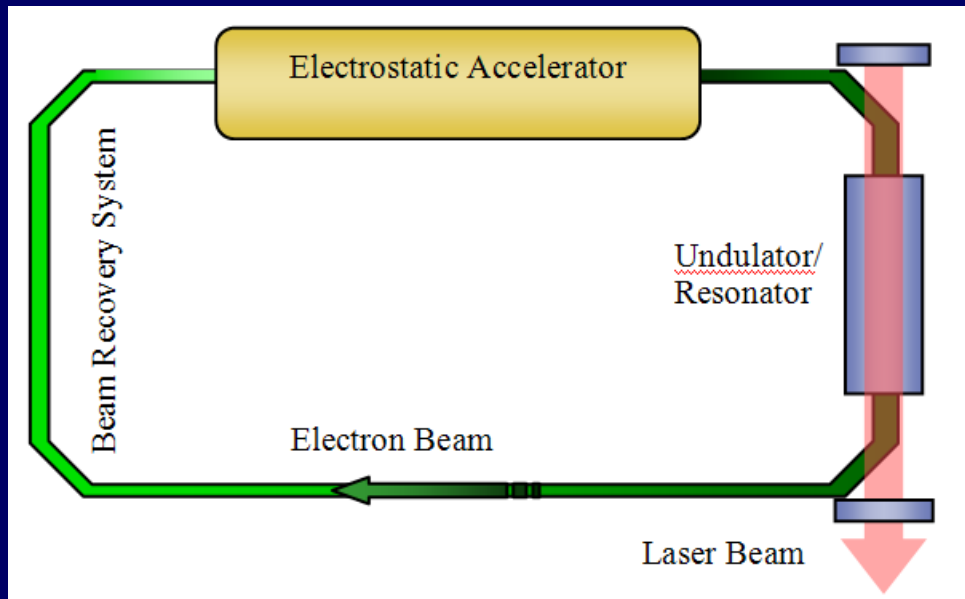


# Collaboration with University of Hawaii

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# Collaboration with University of Hawaii



## THz Free Electron Laser

(Prof. Luis Elías)

To be installed as an open Latin American Facility

### Collaborating Institutions

- ❖ Laboratório Nacional de Luz Sincrotron
- ❖ Universidad Nacional de Ingeniería (Peru)

| LEL THz               |                  |
|-----------------------|------------------|
| Frequency tunability  | 0.3-1.2 THz      |
| Pulse length          | 100 ns-CW        |
| Frequency homogeneity | 1 part in $10^8$ |
| Peak power            | 1000 W           |
| Average power         | < 1000 W         |

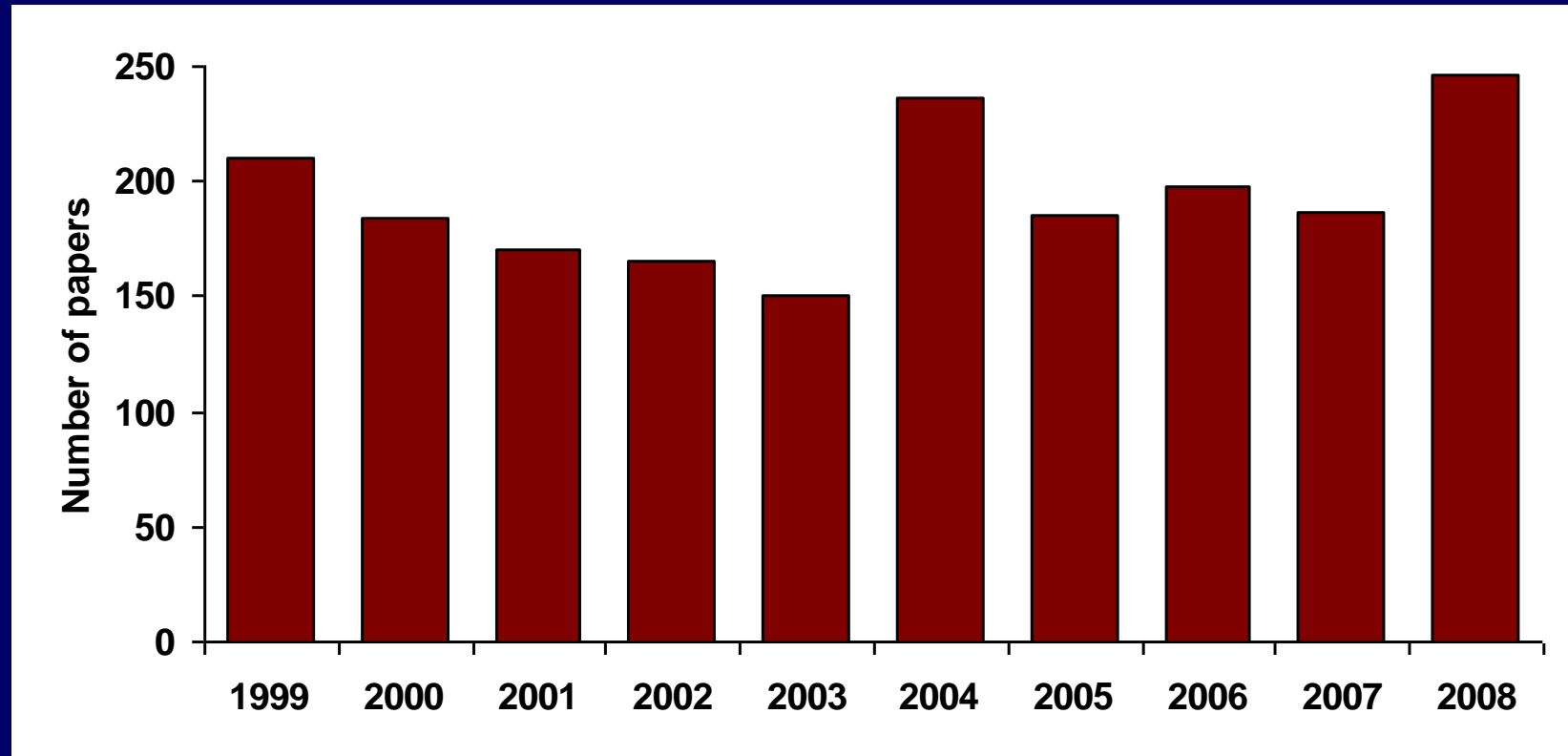
THANK YOU







# Scientific Production



*CBPF scientific production in Physics is one of the highest in Brazil. In spite of its small scientific staff, is in eighth place among the Brazilian institutions with the most quoted publications, in all areas of scientific research.*

# Non-Extensive Statistical Mechanics



Office for Outer Space Affairs  
United Nations Office at Vienna



## Non-extensive Statistical Mechanics

### Generalizing Boltzmann-Gibbs statistical mechanics



#### B.G. Statistics - A reminder.

- Entropy:  $S = -k \sum_i \rho_i \ln \rho_i$
- Constraints:  $\begin{cases} 1 = \sum_i \rho_i \\ U = \sum_i \rho_i \epsilon_i \end{cases}$
- Maximize the objective:  
 $J = -k \sum_i \rho_i \ln \rho_i + \alpha \sum_i \rho_i + \beta \sum_i \rho_i \epsilon_i$       $\frac{\partial J}{\partial \rho_j} = 0$
- Yields distribution:  
 $\rho_i = e^{-\beta \epsilon_i} / Z$      where  $Z = \sum_i e^{-\beta \epsilon_i}$



Postulate: [C. Tsallis J. Stat. Phys. 52 p479 (1988)]

Generalized entropy:

$$S_q = k \frac{1 - \sum_i \rho_i^q}{q-1} \quad q \in \mathfrak{R}$$

where  $q$  characterizes the extensivity of the statistics.

Note: For  $q=1$  regular B.G. Statistics is recovered.

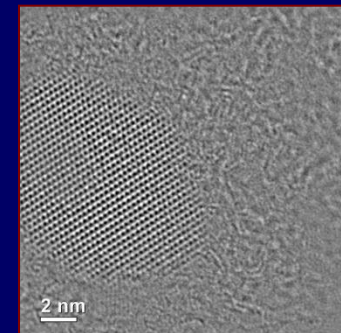
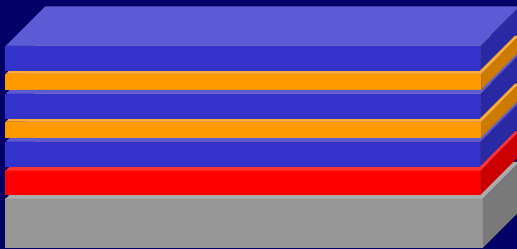
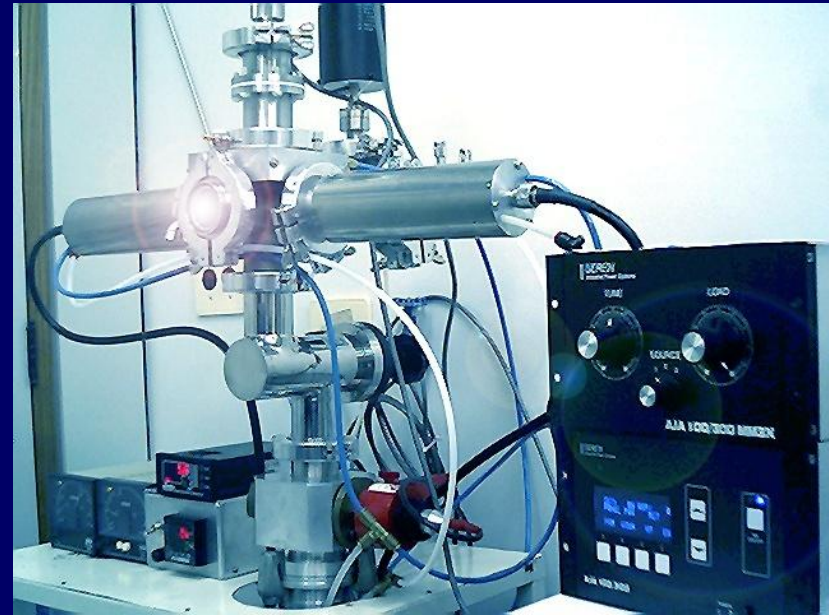
$$S_{q \rightarrow 1} \rightarrow -k \sum_i \rho_i \ln \rho_i$$

# Experimental Facilities

Magnetic multi-layers by RF sputtering



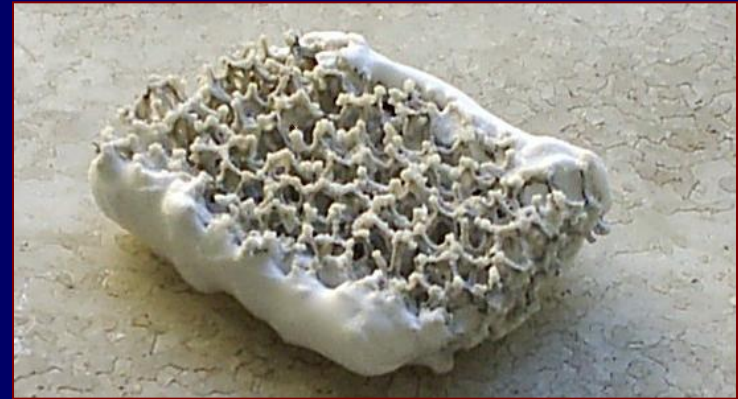
Nanostructured bio ceramic films by magnetron sputtering



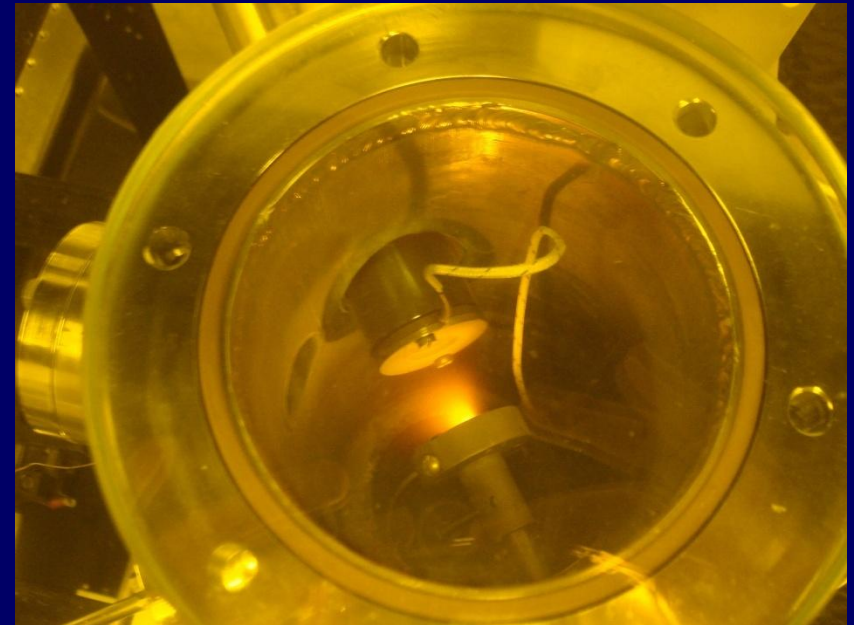
# Some Equipment and Experimental Developments

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## Bio materials for bio medical applications (Hydroxyapatite)



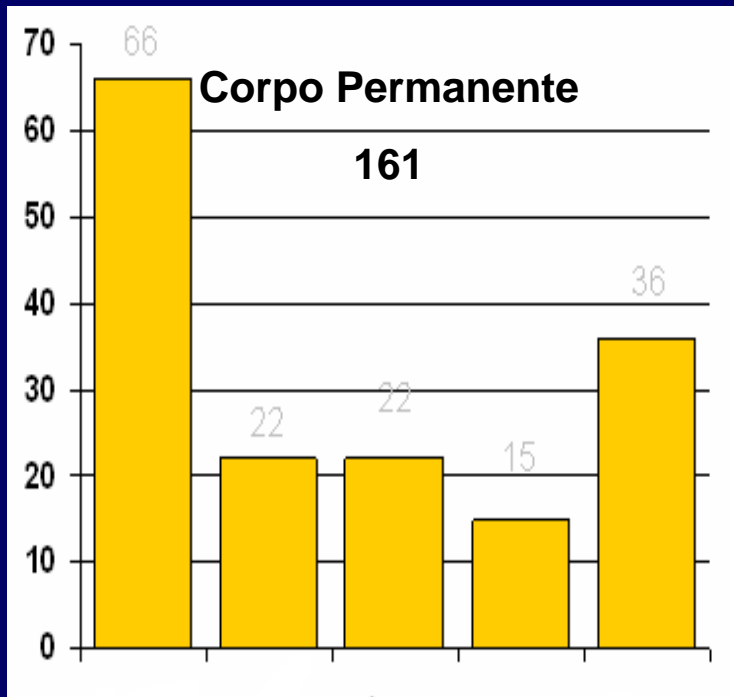
# Film Deposition by Laser Ablation



**Laser LITRON Nd:Yag**

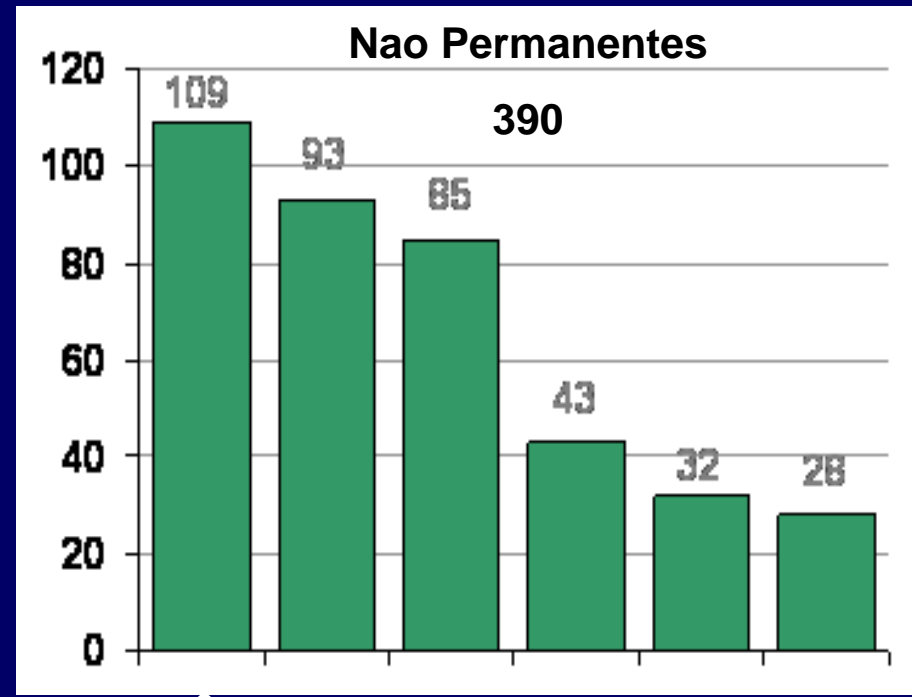
**Output energy: 650mJ (1064 nm); 350mJ (532nm)**

# Personnel



Pesquisadores  
Técnicos  
Tecnologistas  
Administrativo I  
Administrativo II

**Permanent staff**



Estudantes de Pós-Graduação  
Visitantes  
Estudantes de Graduação  
Pós-Doutores  
Estagiários  
Estudantes Secundários

**Temporary staff**

# Contribution to the establishment of other research groups

(last 10 years)

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## Rio de Janeiro

- Field Theory - UFRJ
- Field Theory - UCP
- Chemistry-Physics in Ecosystems - IQ/ UFF
- Eletronics - Biophysics Mic. - UFRJ
- Arqueometry / TL - IQ/ UFF
- Condensed Matter, Milling - UENF
- Dosimetry, Nuclear Engineering - COPPE/UFRJ

## Abroad

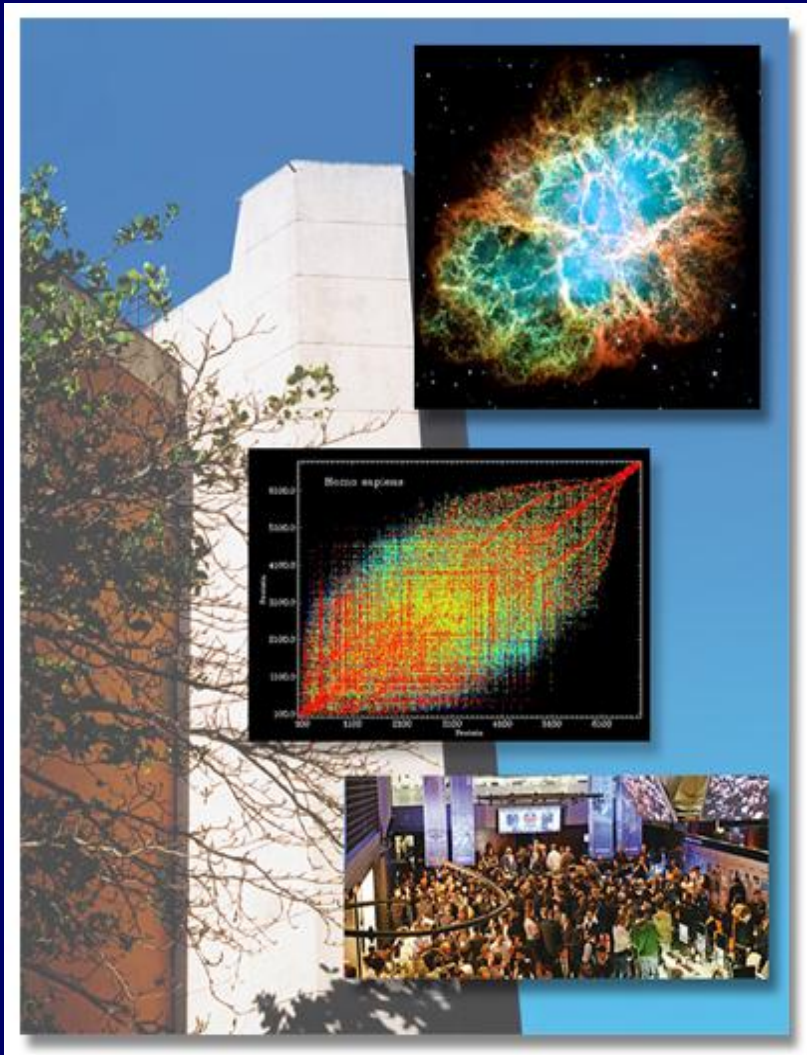
- Mössbauer - Thin Films - UNMSM - Peru
- Statistics - Univ. de Córdoba - Argentina

## In Brazil

- Statistics at UFRN
- Statistics at UFPE
- Statistics at UFViçosa
- Statistics at UFAL
- Statistics at U. E. de Maringá
- Cosmology at UFPB
- Cosmology at UFRN
- Cosmology at UFRGS
- Cosmology at E.F. de Itajubá
- Astrophysics at UFRN
- Field Theory at UFPB
- Field Theory at UFCE
- Field Theory at UFJF
- Condensed Matter at UFES



# COMPLEX SYSTEMS



**Head Institution of the  
National Institute  
for Complex  
Systems**

**Participants from  
18 institutions in Brazil**