

## High-energy astrophysics in the multi-messenger era

### Main topics:

High-energy astroparticle physics – Open questions  
– Instruments – Data analysis – Possible near future  
discoveries

### Target participants:

Postdocs and final year PhD students

### First workshop:

Erlangen – Germany, 8th - 12th May 2023

### Second workshop:

São Carlos - Brazil, TBD 2024

Application deadline: Jan 13th 2023

### Open for applications:

For registration and more information:  
<https://indico.ecap.work/event/44/>



### Coordination group:

Stefan Funk, Vitor de  
Souza, Aion Viana, Edivaldo  
Moura Santos, Christopher  
van Eldik, Alison Mitchell,  
David Berge, Jim Hinton,  
Karl Mannheim, Carola  
Dobrigkeit, Chinellato,  
Farinaldo da Silva Queiroz,  
and Manuela Vecchi.

# Activities in São Paulo

Vitor de Souza



Jointly funded by





# History background

## BRAZIL

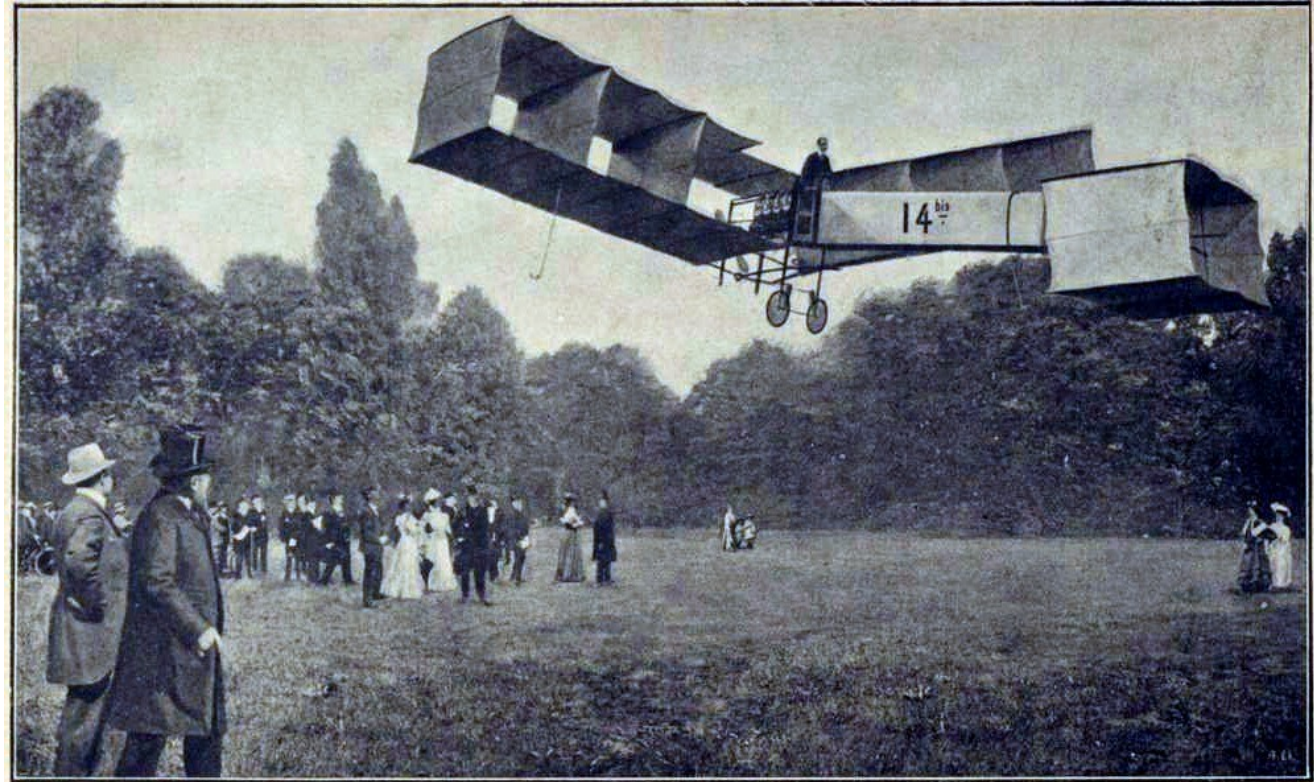
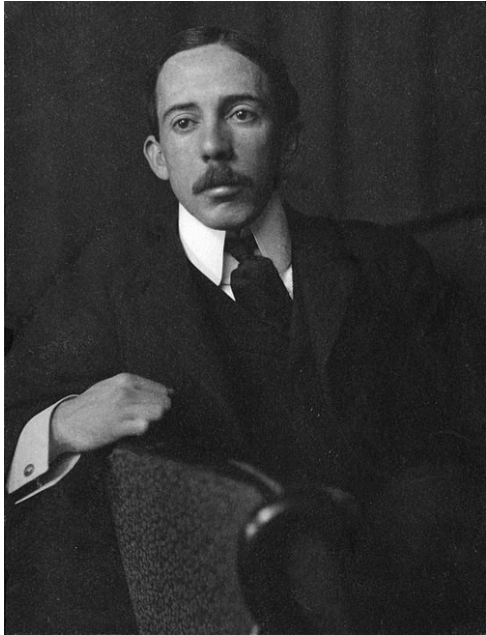
- 1500 taken by Portugal
- 1822 independent from Portugal
- 1888 official end of slavery
- 1889 became a republic
- ~1910 first universities

## STATE OF SÃO PAULO

- Until 1900:
  - the pathway to the countryside
  - coffee plantations
- ~ 1930 Industrialization
- 1934 USP is founded
- 1962 FAPESP is founded



# 1906 - First Brazilian Scientific Contribution to the World



**M. SANTOS DUMONT'S FIRST SUCCESS WITH A FLYING MACHINE.**

M. Santos Dumont, after several preliminary trials in Paris on November 12th, when his flying machine had flown 75, 128, and 142 yards, decided to return to his starting point by going against the wind. For thirty yards the motor ran along the ground, then suddenly it rose to a height of about five yards, and appearing like a great white bird, it soared half-way down the course. M. Santos Dumont, startled by some spectators in his way, twisted his rudder quickly, and the machine came heavily to the ground, damaging one of its wings. The experiment, however, was a triumph, for actual flight was achieved; and it seems as though it were only a matter of time for the conquest of the air to be accomplished. The 235 yards were traversed in twenty-one seconds.



# First Brazilian Scientific International Collaboration



Movie

# Fazenda São Carlos do Pinhal

Cultural visit  
for the  
Brazilian  
edition of this  
workshop



# Physics in Brazil started with **astroparticle physics**



- 1933 **Bernard Gross** arrives in Rio de Janeiro
  - Students: Joaquim Costa Ribeiro, Plínio Sussekind Rocha, Armando Dias Tavares, Francisco Oliveira Castro, **Sérgio Mascarenhas**, **Yvonne Mascarenhas**, E. Rodrigues e Guilherme Leal Ferreira.
- 1934 **Gleb Wataghin** arrives in São Paulo - USP:
  - Students: **César Lattes**, José Leite Lopes, Oscar Sala, **Mário Schenberg**, Roberto Salmeron, Marcelo Damy de Souza Santos e Jayme Tiomno, Paulus Aulus Pompéia





# Bernard Gross

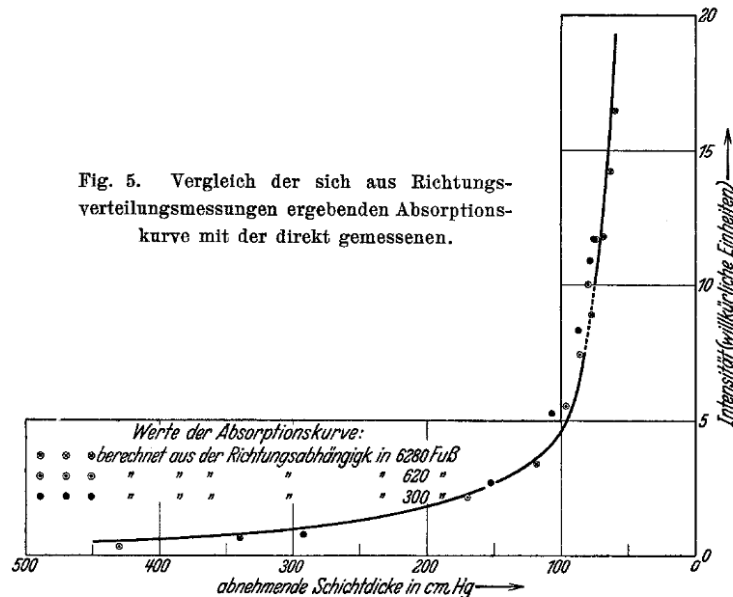
Z. Physik 83, 214–221 (1933)

## Zur Absorption der Ultrastrahlung.

Von B. Gross in Stuttgart.

Mit 5 Abbildungen. (Eingegangen am 6. April 1933.)

Es wird eine einfache Beziehung mitgeteilt, welche gestattet, aus dem experimentell gegebenen Intensitätsverlauf einer allseitig einfallenden Strahlung den Verlauf für senkrechten Einfall zu bestimmen. Das Verfahren wird auf die Absorptionskurve der Ultrastrahlung in der Atmosphäre angewendet.



## Extensive Air Showers

Peter Grieder

### B.5 Gross Transformation

The Gross transformation allows to transform the *altitude dependence* of the rate of air showers to the *zenith angle distribution* (Gross, 1933). Moreover, it permits to calculate the vertical intensity  $R_V(X, \theta = 0)$  of air showers per unit solid angle at an atmospheric depth  $X$  in terms of the measured rate of all showers  $R(X)$  at this depth. The Gross transformation can be written in different forms; it is frequently expressed as (Galbraith, 1958; Allkofer, 1975)

$$R_V(X, \theta = 0) = \frac{1}{2\pi} \left( (n + 1)R(X) - X \frac{\partial R(X)}{\partial X} \right) [\text{m}^{-2}\text{s}^{-1}] \quad (\text{B.13})$$

where

$$n = 2(\gamma - 1) + (k\gamma) - \kappa .$$

$\gamma$  is the exponent of the *density spectrum*,  $\kappa$  is the exponent of the *decoherence rate*,  $R$ , i.e.,  $R \propto d^{-\kappa}$ , determined empirically,  $k$  is related to the counter geometry and response, and  $d$  is the counter separation (Galbraith, 1958; Allkofer, 1975, Khristiansen, 1980).

# Physical Review

- Search for “Brazil”
- Time order
- Until 1960 most of the papers are on cosmic rays

PR

1 citation

## Remarks on the Theory of Protons and Neutrons

G. Wataghin

Phys. Rev. **48**, 284 (1935) - Published 1 August 1935

PDF

HTML

PR

1 citation

## On the Latitude Effect of the Soft Component of Cosmic Rays

Bernhard Gross

Phys. Rev. **53**, 607 (1938) - Published 1 April 1938

PDF

HTML

PR

## A Remark on the Latitude Effect of Cosmic Rays

B. Gross

Phys. Rev. **55**, 112 (1939) - Published 1 January 1939

PDF

HTML

PR

11 citations

## $\beta$ -Ray Selection Rules and the Meson Theory

Mario Schönberg

Phys. Rev. **56**, 612 (1939) - Published 15 September 1939

PDF

HTML

PR

6 citations

## On Explosion Showers

Gleb Wataghin

Phys. Rev. **56**, 1245 (1939) - Published 15 December 1939

PDF

HTML

PR

21 citations

## Simultaneous Penetrating Particles in the Cosmic Radiation

G. Wataghin, M. D. de Souza Santos, and P. A. Pompeia

Phys. Rev. **57**, 61 (1940) - Published 1 January 1940

PDF

HTML

# The meson pion discovery

- **César Lattes**
  - student of Gleb Wataghin at USP
  - **Exchange program with Bristol/UK:**
    - his work improves the emulsions
    - detects the meson pion in cosmic radiation
    - the mediator of the strong interactions according to Yukawa's theory
  - Go to Berkeley/USA
    - detect pions in accelerators



## OBSERVATIONS ON THE TRACKS OF SLOW MESONS IN PHOTOGRAPHIC EMULSIONS

By C. M. G. LATTES, DR. G. P. S. OCCHIALINI

AND

DR. C. F. POWELL

H. H. Wills Physical Laboratory, University of Bristol

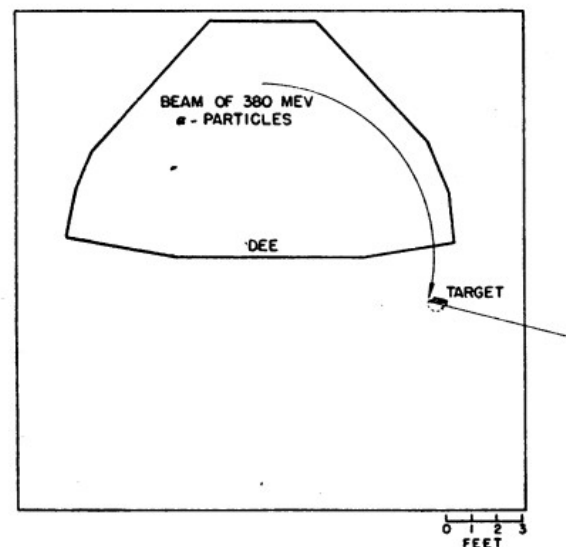
### Part 2: Origin of the Slow Mesons

IN Part 1 of the present article\*, we showed that two types of mesons exist, and it was suggested that the heavier,  $\pi$ -mesons, decay to produce the lighter,  $\mu$ -mesons. In this second part, we discuss the origin of the slow mesons observed in photographic emulsions, and their relation to the mesons forming the penetrating component of the cosmic rays, of which evidence is provided by experiments with Wilson chambers and counters. We also give photomicrographs which show that some slow mesons, ejected from nuclei during 'explosive disintegrations', can enter nuclei and produce a second disintegration.

Eugene Gardner and César Lattes

### Production of Mesons by the 184-Inch Berkeley Cyclotron

We have observed tracks which we believe to be due to mesons in photographic plates placed near a target bombarded by 380-Mev alpha particles. The identification of the particles responsible for these tracks was first made on the basis of the appearance of the tracks.



# CIÊNCIA *para Todos*

ANO 1.º N. 9

SUPLEMENTO DE DIVULGAÇÃO CIENTÍFICA DE "A MANHÃ"

Rio, Domingo, 28-11-48

## CESAR LATTES DE REGRESSO AO BRASIL

Esperado na segunda semana de dezembro o famoso cientista brasileiro

### SINGULAR TAREFA



**REAJUSTAMENTO DOS PREÇOS DE VENDA DE CARBURANTES NACIONAIS**

**VAI AO NORTE, EM VIAGEM DE INSPEÇÃO, O MINISTRO DA MARINHA**

**SERÁ TRANSMITIDA HOJE A RESPOSTA DA FINLÂNDIA**

**FINAL**

**Os "comandos" em Catumbi**

## SENSACIONAL DESCOBERTA DE UM CIENTISTA BRASILEIRO

**ESTEVE EM TERESINA O PRESIDENTE DUTRA**



**A NOITE**

**QUERIAM DESTRUIR O "RAUL SOARES"**

**DE REVOLVER EM PUNHO ASSALTARAM A SEDE DO P. R. P.**



# César Lattes

- Founded two cosmic rays groups:
  - CBPF (1949)
  - UNICAMP (1967)
- Brazilian-Japan Collaboration



## Search Researchers (Simple Search)

[Advanced Search](#)

Search by:

Select the search mode ☒ Name ☐ Subject

Databases

☒ PhD ☐ Others (Graduate, Undergraduate and others)

Nationality:

☒ Brazilian ☒ Foreign

Country of birth:

All



# Scientific visit of the Brazilian edition



# HADRONIC INTERACTIONS OF HIGH ENERGY COSMIC-RAY OBSERVED BY EMULSION CHAMBERS

C.M.G. LATTES

*Instituto de Física Gleb Wataghin, Universidade Estadual de Campinas, Campinas, São Paulo, Brasil*

Y. FUJIMOTO and S. HASEGAWA

*Science and Engineering Research Laboratory, Waseda University, Shinjuku, Tokyo, Japan*

Received 14 March 1980

PHYSICS REPORTS 65, No.3 (1980) 151-229.

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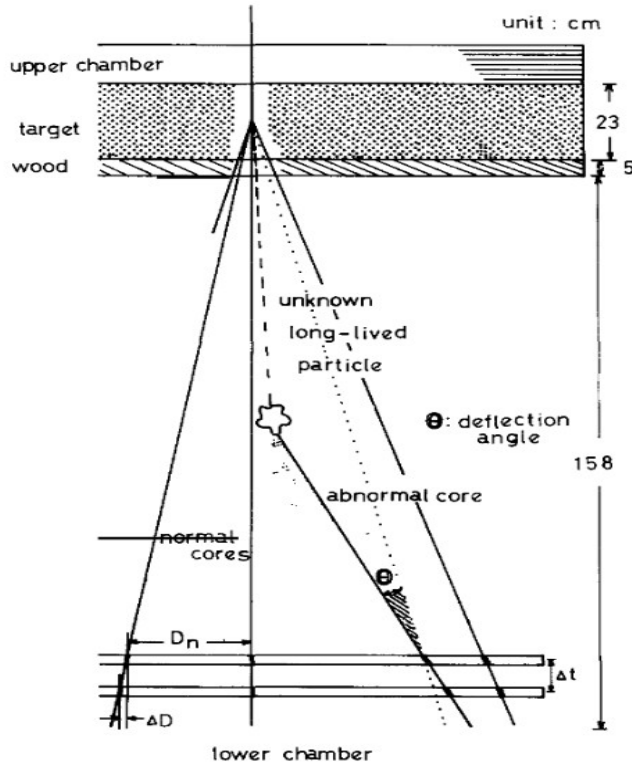
Physics ▾

Technology ▾

Community ▾

In focus

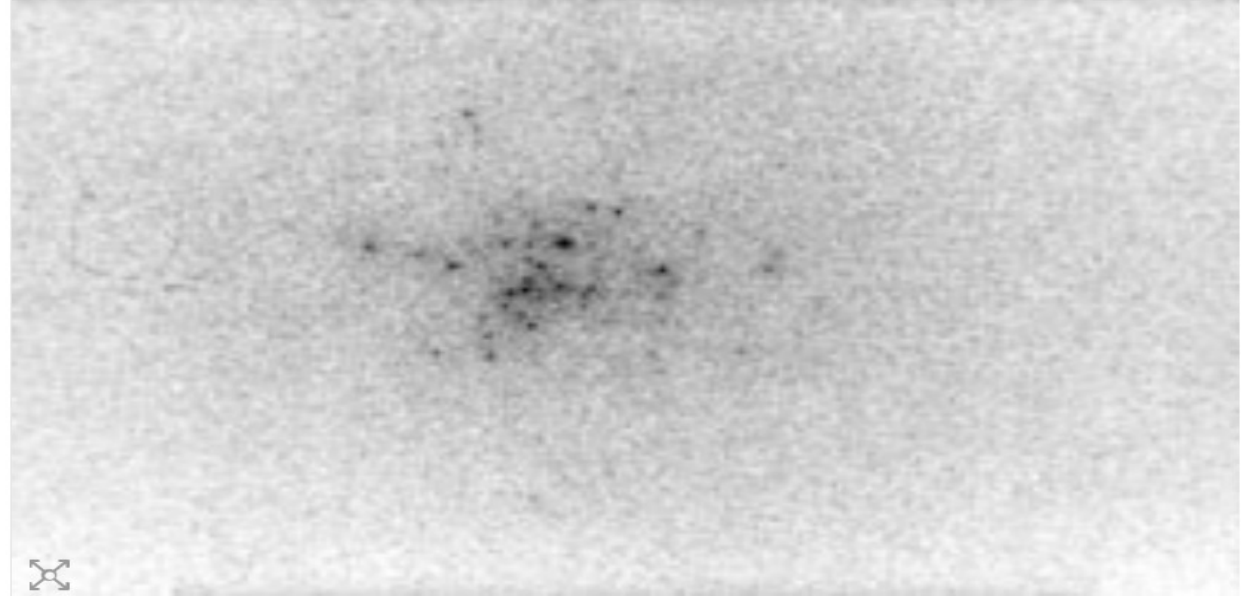
Magazine



FEATURE

## The mysteries of cosmic rays

29 January 1999



One of the mysterious “Centauro” events seen by the BrazilJapan collaboration operating X-ray emulsion chambers at an altitude of 5200 m on Mt Chacaltaya in the Bolivian Andes. Given the number of hadrons seen in the lower chamber (left) physicists are intrigued by the relative lack of corresponding electromagnetic effects in the upper chamber (right).



# Explanation of the Centauro events

Acce:

Exotic models are no longer required to explain the Centauro events

V. Kopenkin and Y. Fujimoto

Phys. Rev. D **73**, 082001 – Published 13 April 2006

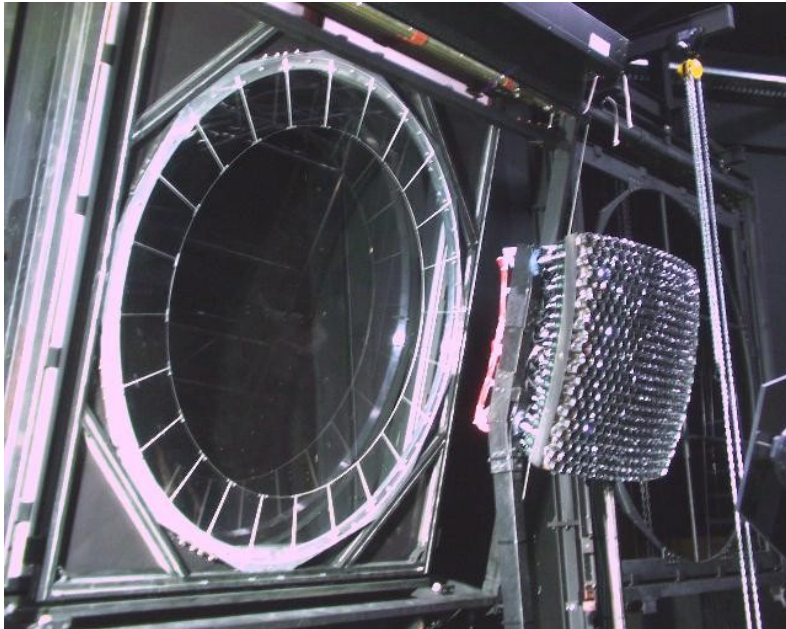
Solution to the Centauro puzzle

V. Kopenkin, Y. Fujimoto, and T. Sinzi

Phys. Rev. D **68**, 052007 – Published 30 September 2003

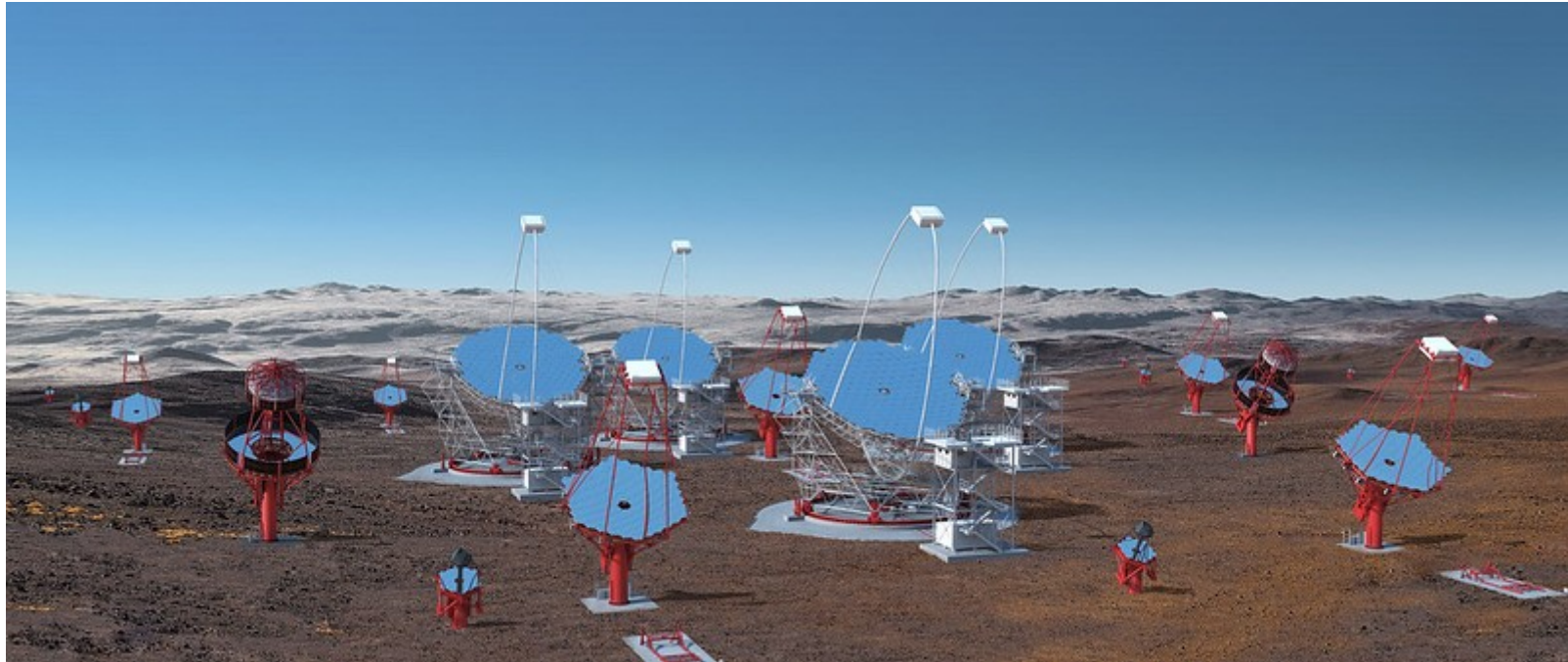
# Since 1990 Pierre Auger Observatory

- Transition to new generations: people and experiments
- CBPF + UNICAMP leads the Brazilian participation
- Full support of FAPESP



# Since 2010 CTA

- Transition completed
- USP leads the Brazilian participation
- Full support of FAPESP





# Instrumentation: MST Camera Support Structure

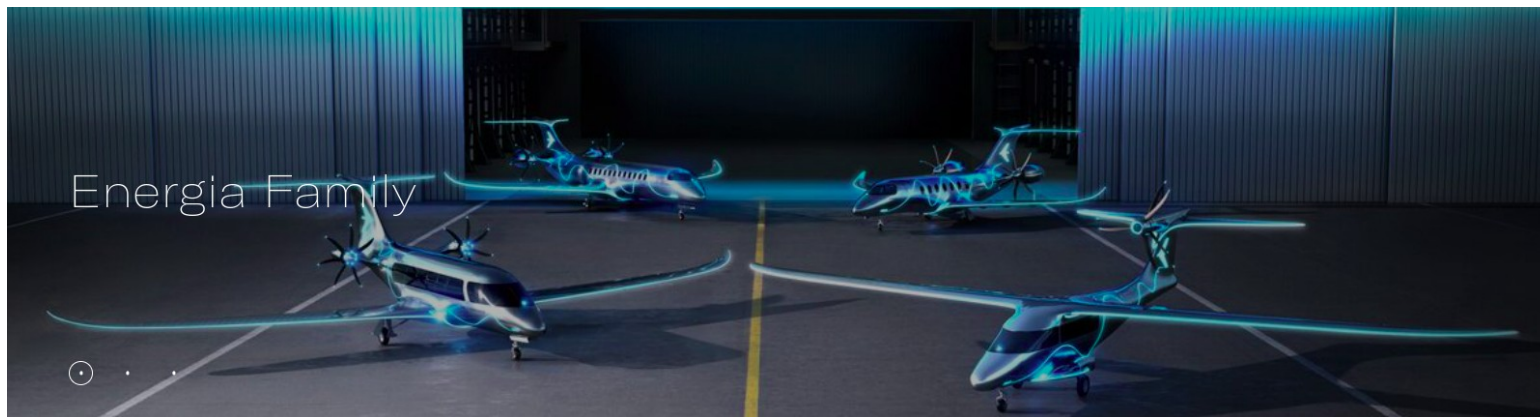
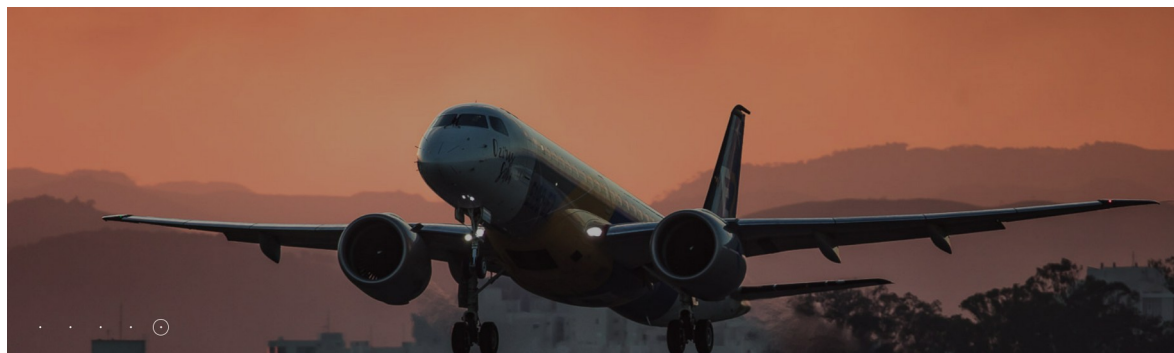
100% Brazilian  
Project  
Analysis  
Prototype  
Verification  
Re-project  
Final product  
2 prototypes  
already  
constructed,  
delivered and  
approved



**Patent of positioning  
system**

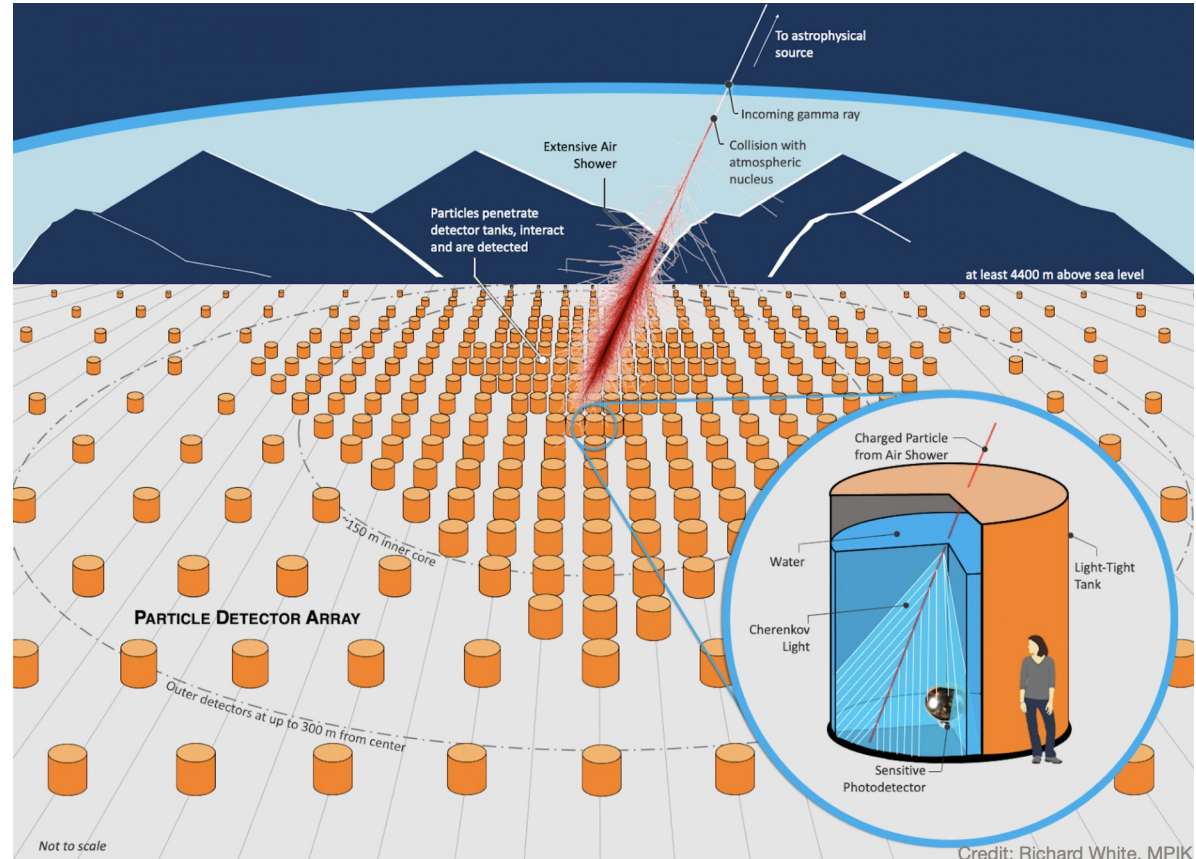
**Budget approved for 10  
structures to be build in the  
next two years.**



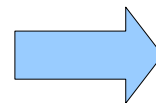
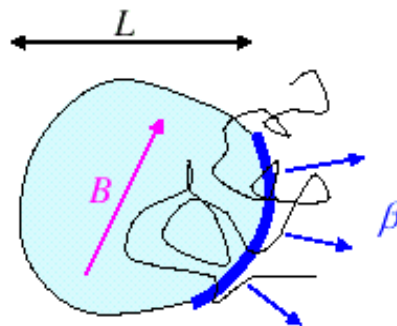
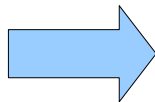


# SWGO

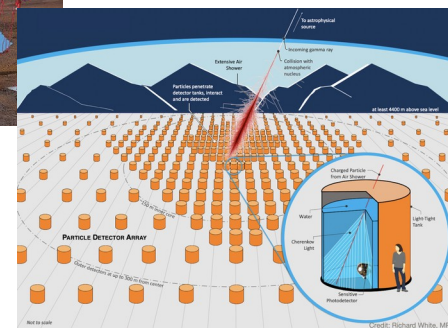
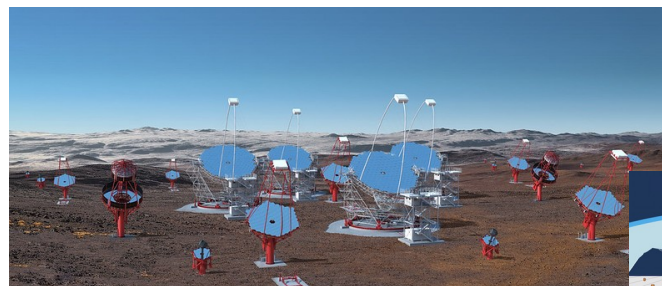
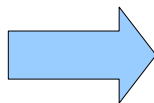
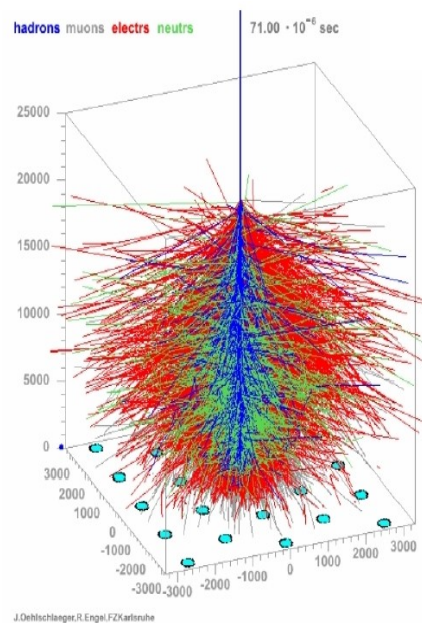
- Future
- CBPF leadership



Where do we stand today ?



# ATMOSPHERE



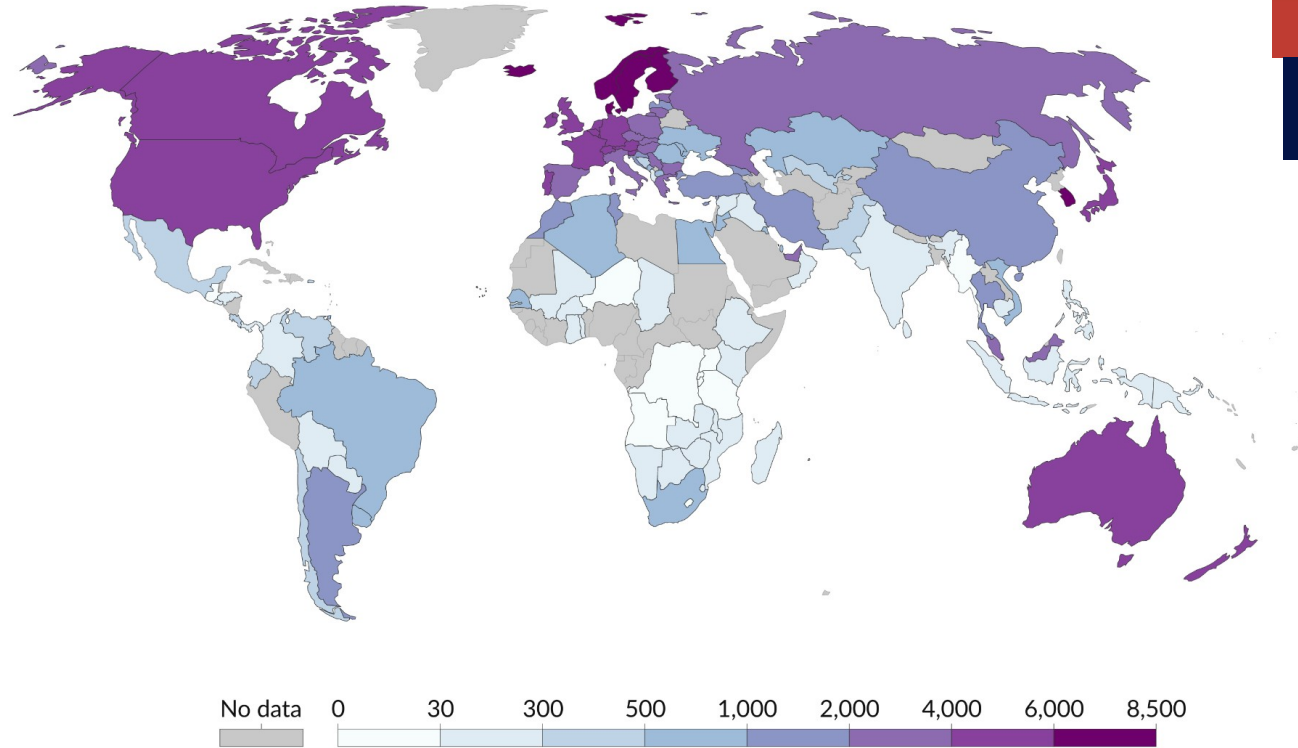


**Santos Dumont**  
é capaz de realizar até  
**5,1 QUATRILHÕES**  
de operações matemáticas por segundo.



# Researchers in R&D per million people, 2018

Researchers in Research & Development (R&D) are professionals engaged in the conception or creation of new knowledge, products, processes, methods, or systems and in the management of the projects concerned. Postgraduate PhD students engaged in R&D are included.



Our World  
in Data

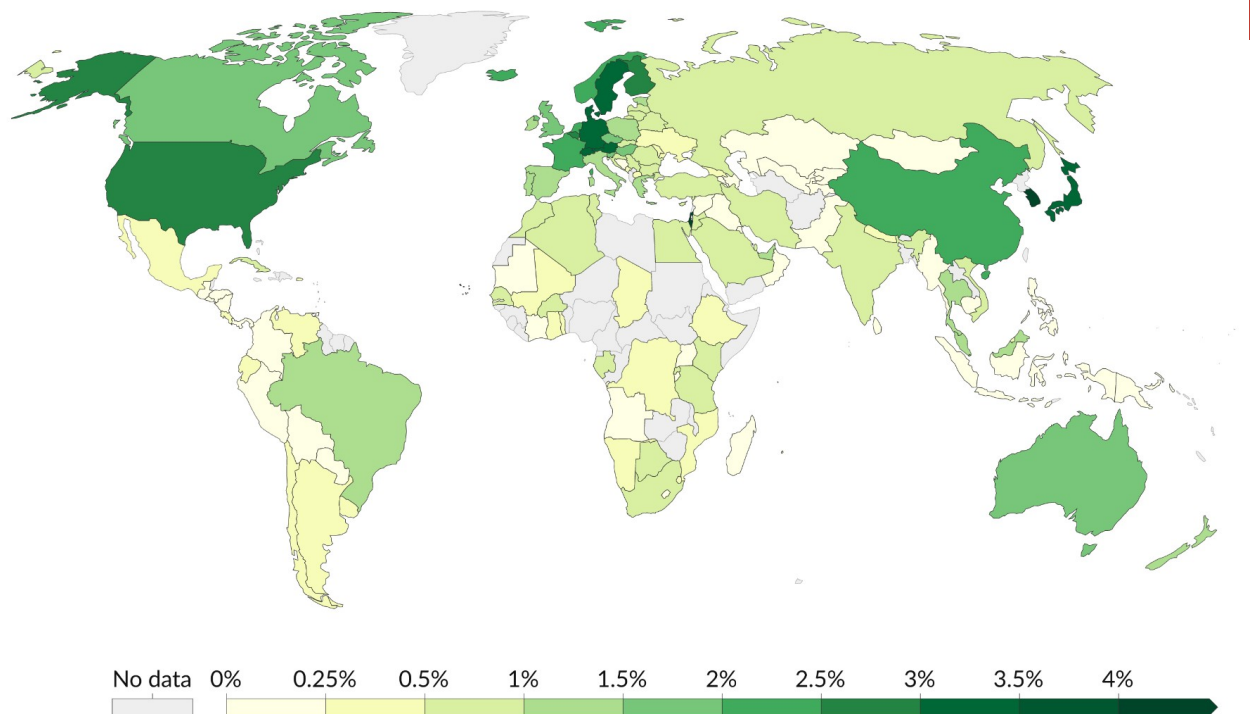
OXFORD  
MARTIN  
SCHOOL

UNIVERSITY OF  
OXFORD

GC  
DL

# Spending on research and development as share of GDP, 2019

Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.



Our World  
in Data

OXFORD  
MARTIN  
SCHOOL

UNIVERSITY OF  
OXFORD

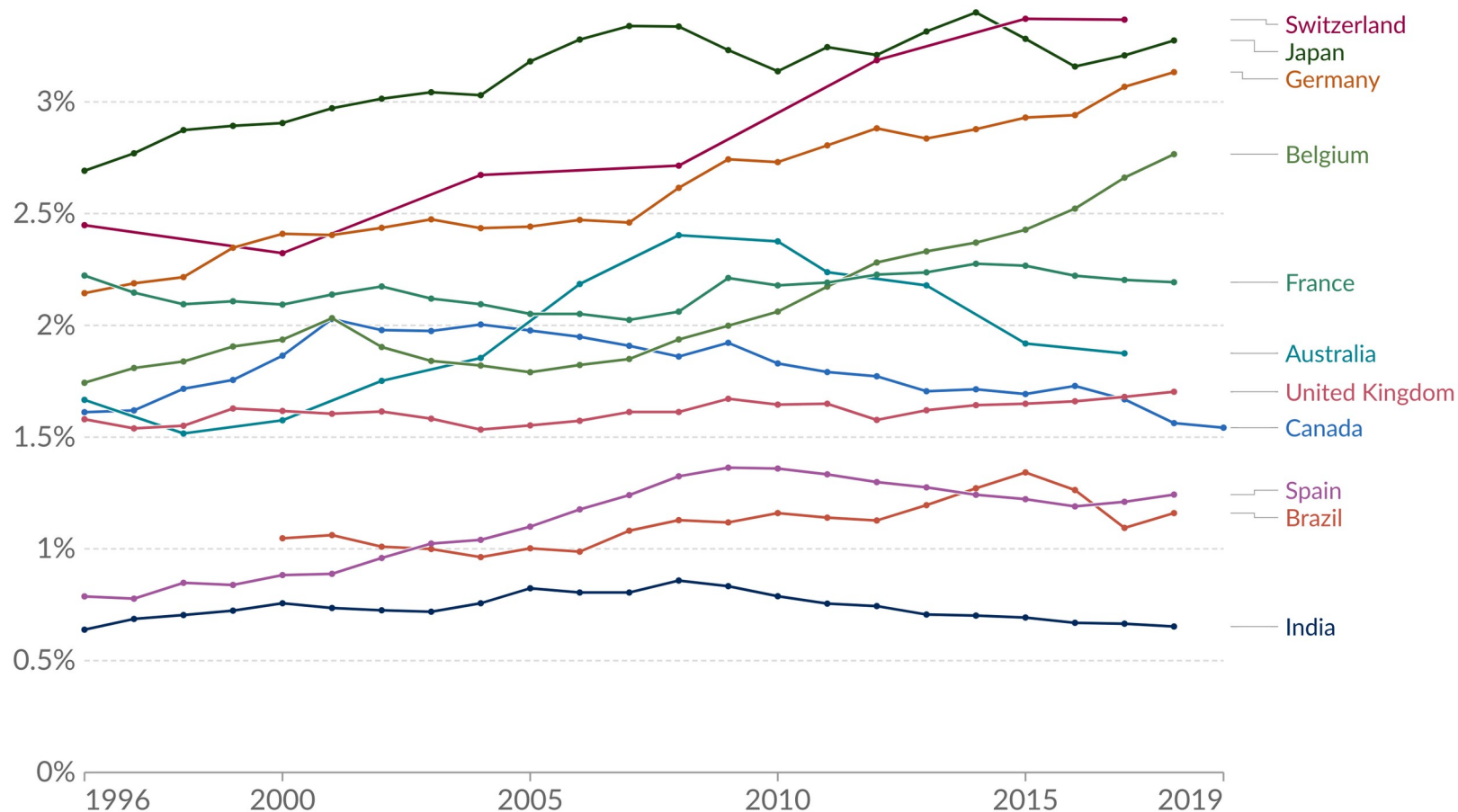
GC  
DL

Source: UNESCO (via World Bank)

[OurWorldInData.org/talent-is-everywhere-opportunity-is-not](https://OurWorldInData.org/talent-is-everywhere-opportunity-is-not) • CC BY

# Research & development spending as a share of GDP

Includes basic research, applied research, and experimental development.



Source: UNESCO (via World Bank)

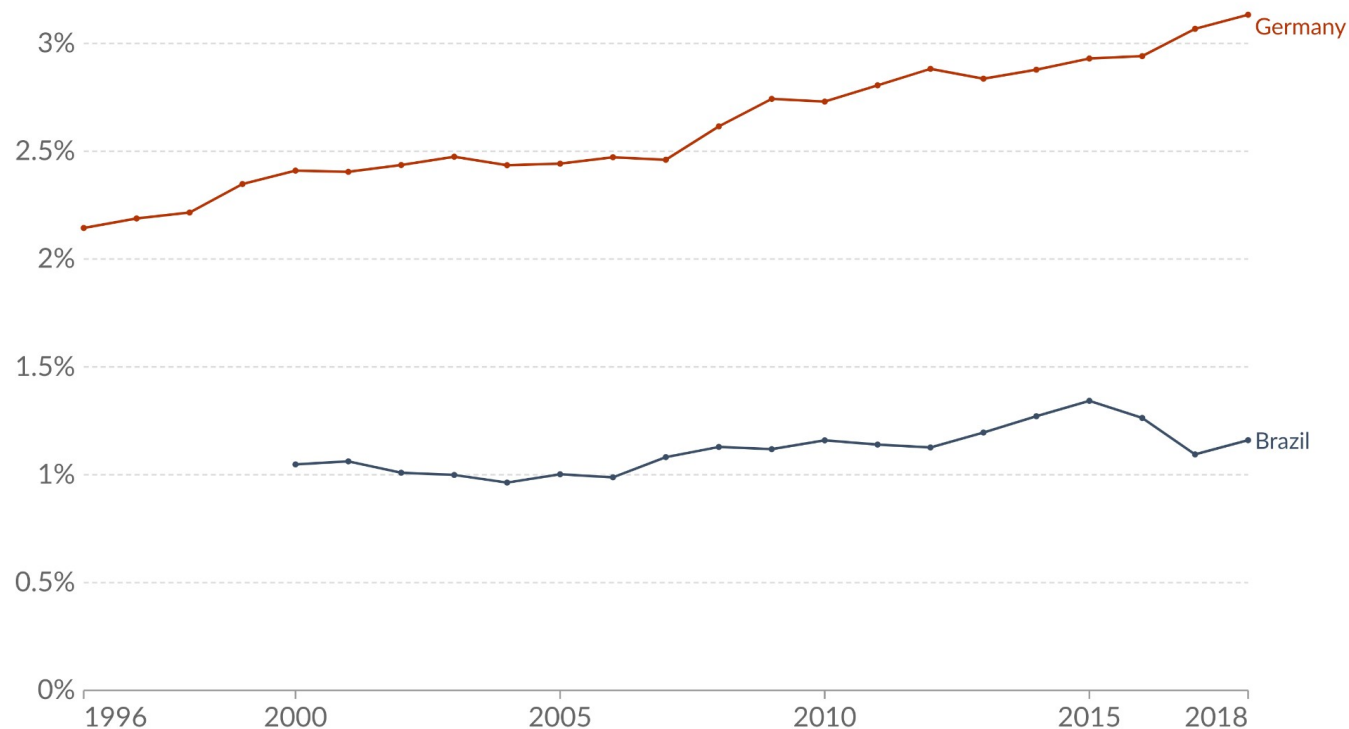
Note: Spending includes current and capital expenditures (public and private) on research.

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## Spending on research and development as share of GDP, 1996 to 2018

Expenditures for research and development are current and capital expenditures (both public and private) on creative work undertaken systematically to increase knowledge, including knowledge of humanity, culture, and society, and the use of knowledge for new applications. R&D covers basic research, applied research, and experimental development.

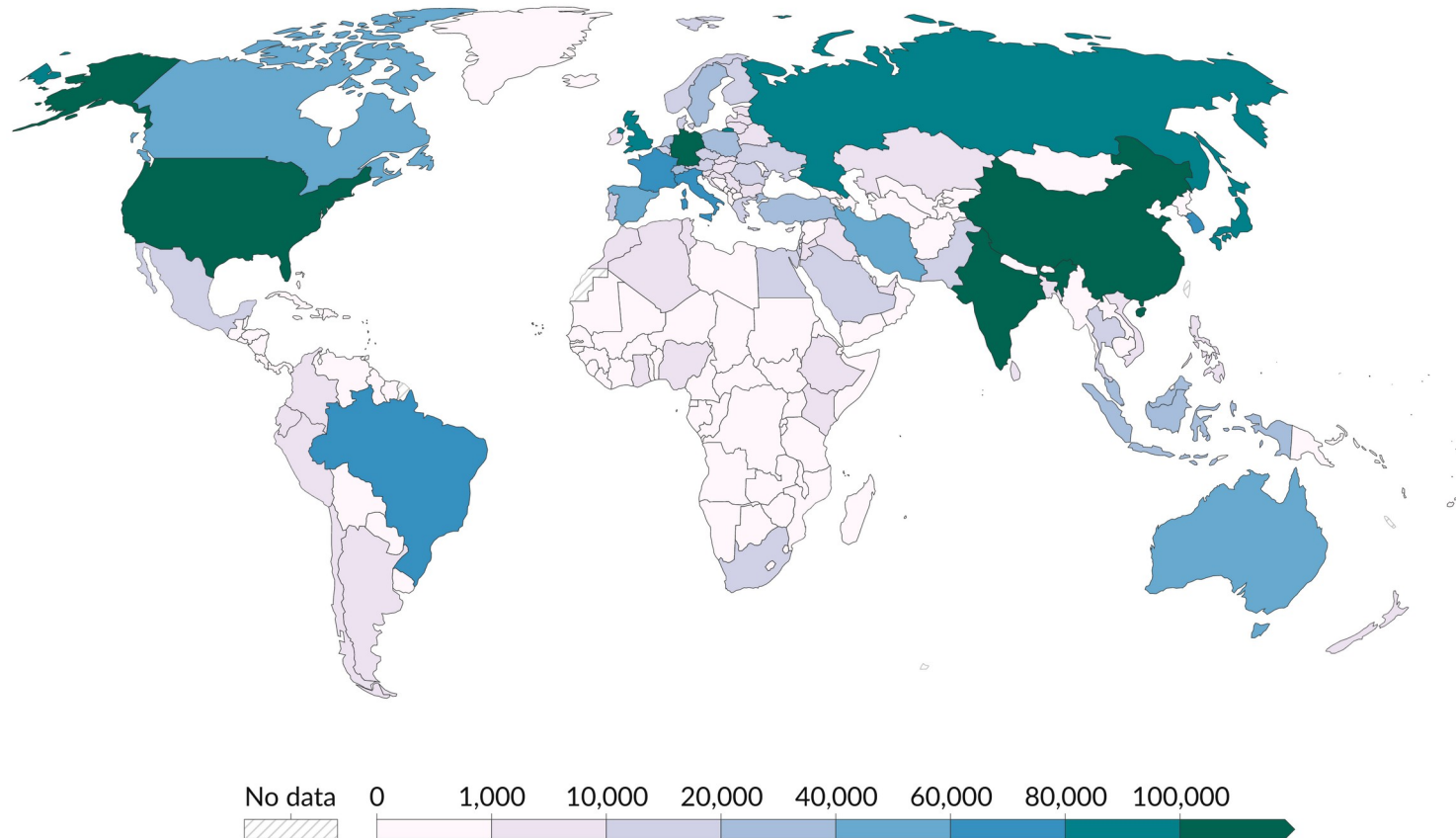


Source: UNESCO (via World Bank)

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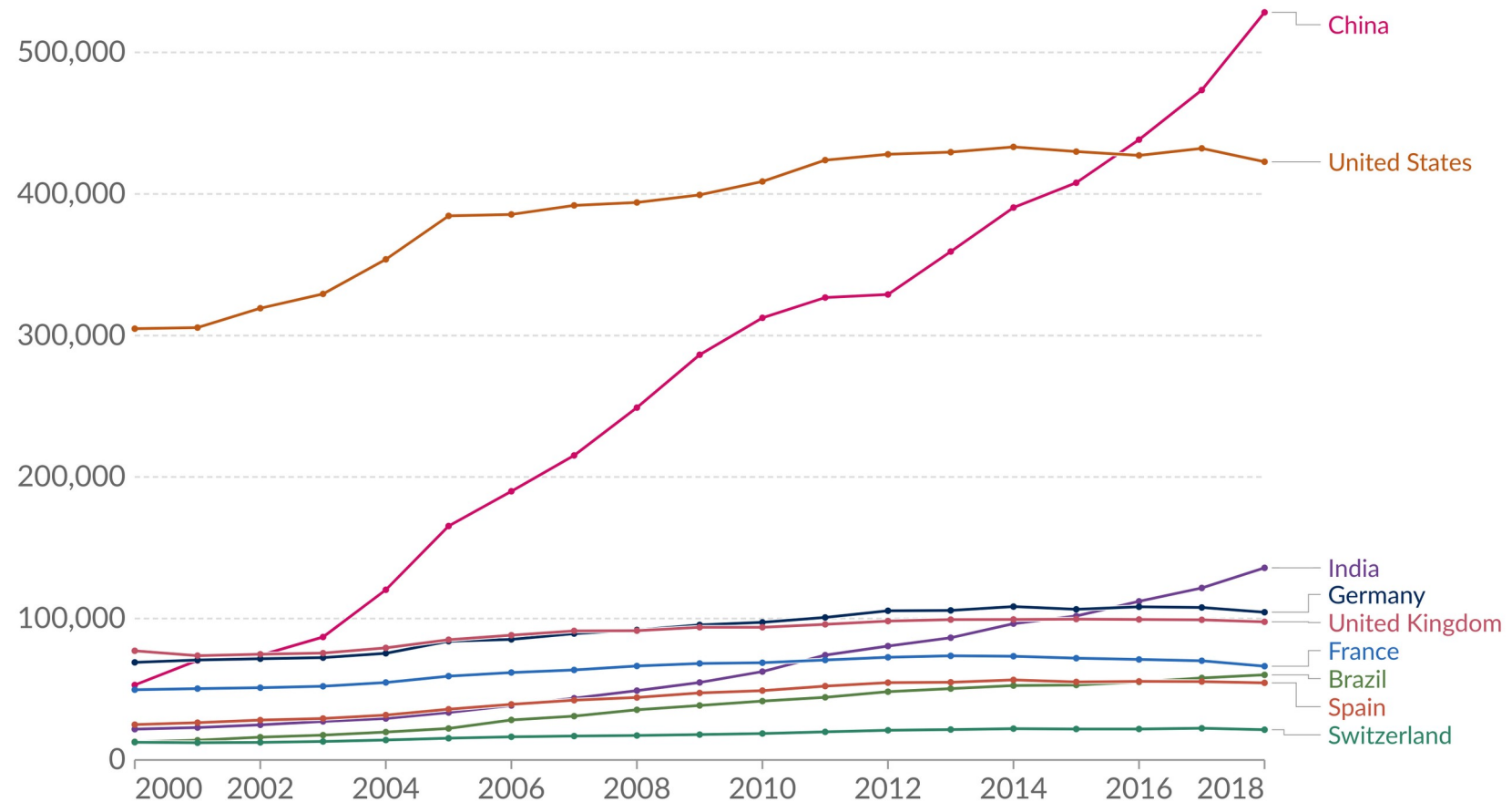
# Scientific and technical journal articles, 2018

This is counted by the country of the author's institution. Includes scientific articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.



# Scientific and technical journal articles, 2000 to 2018

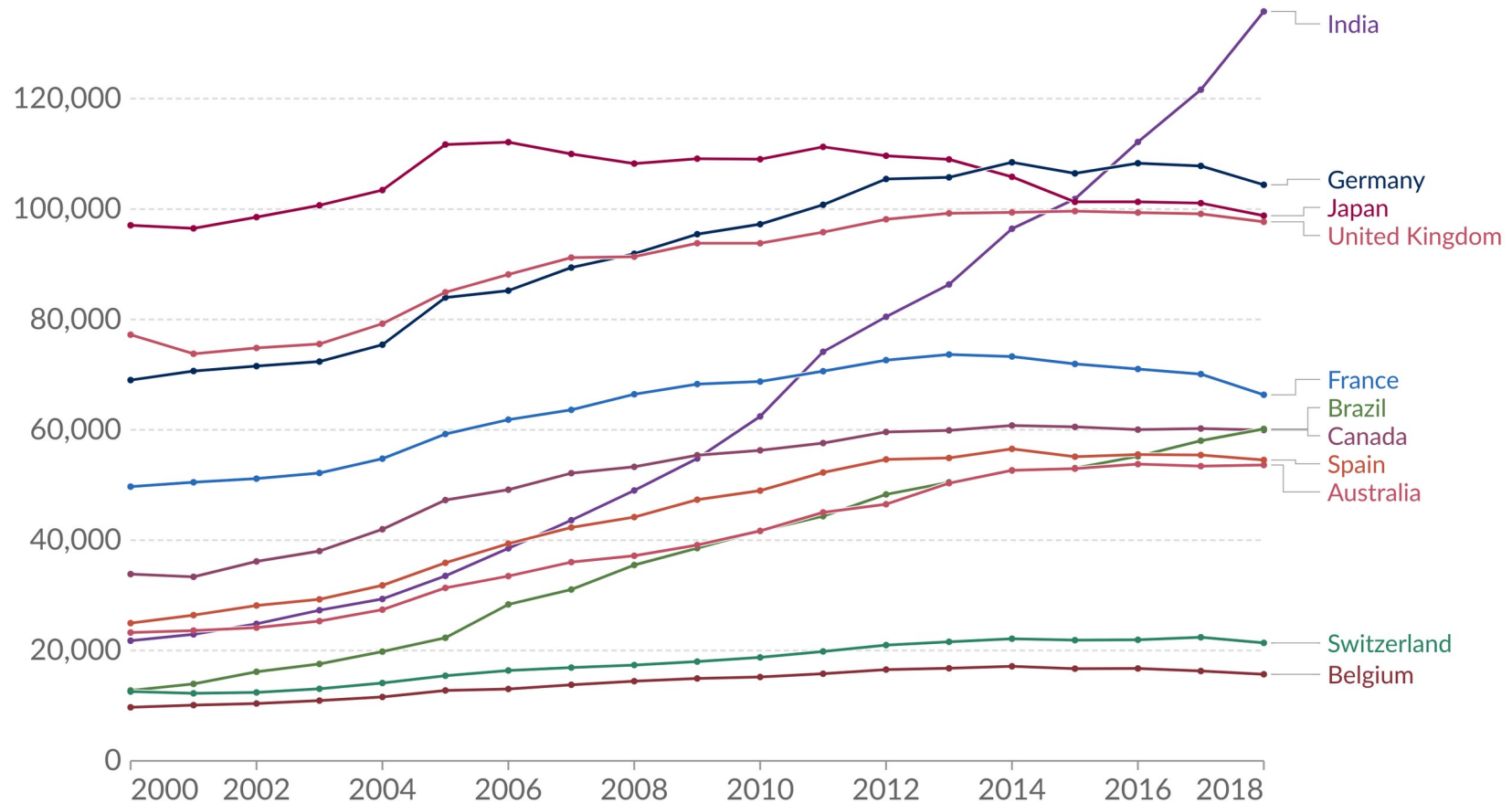
This is counted by the country of the author's institution. Includes scientific articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.



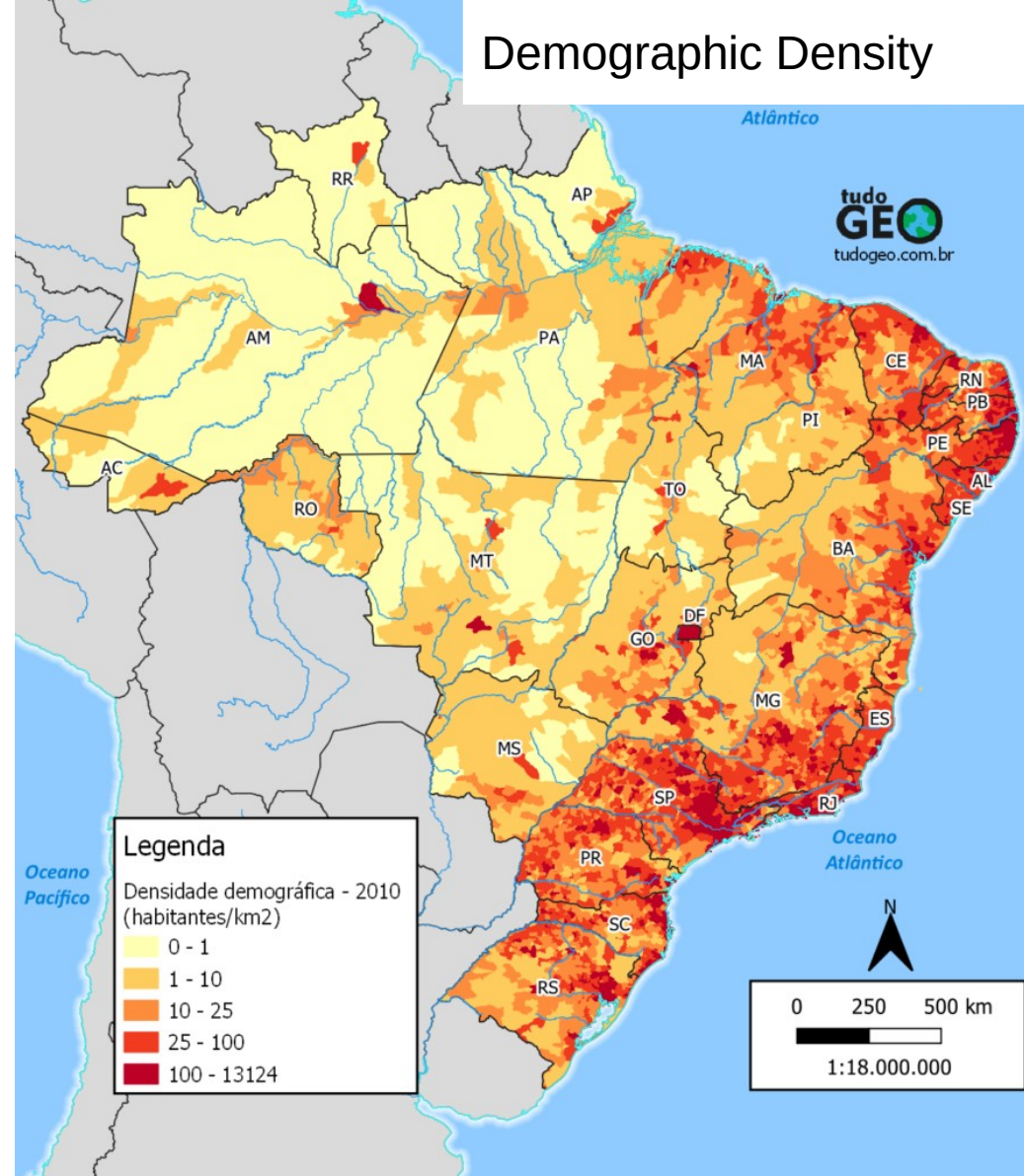


# Scientific and technical journal articles, 2000 to 2018

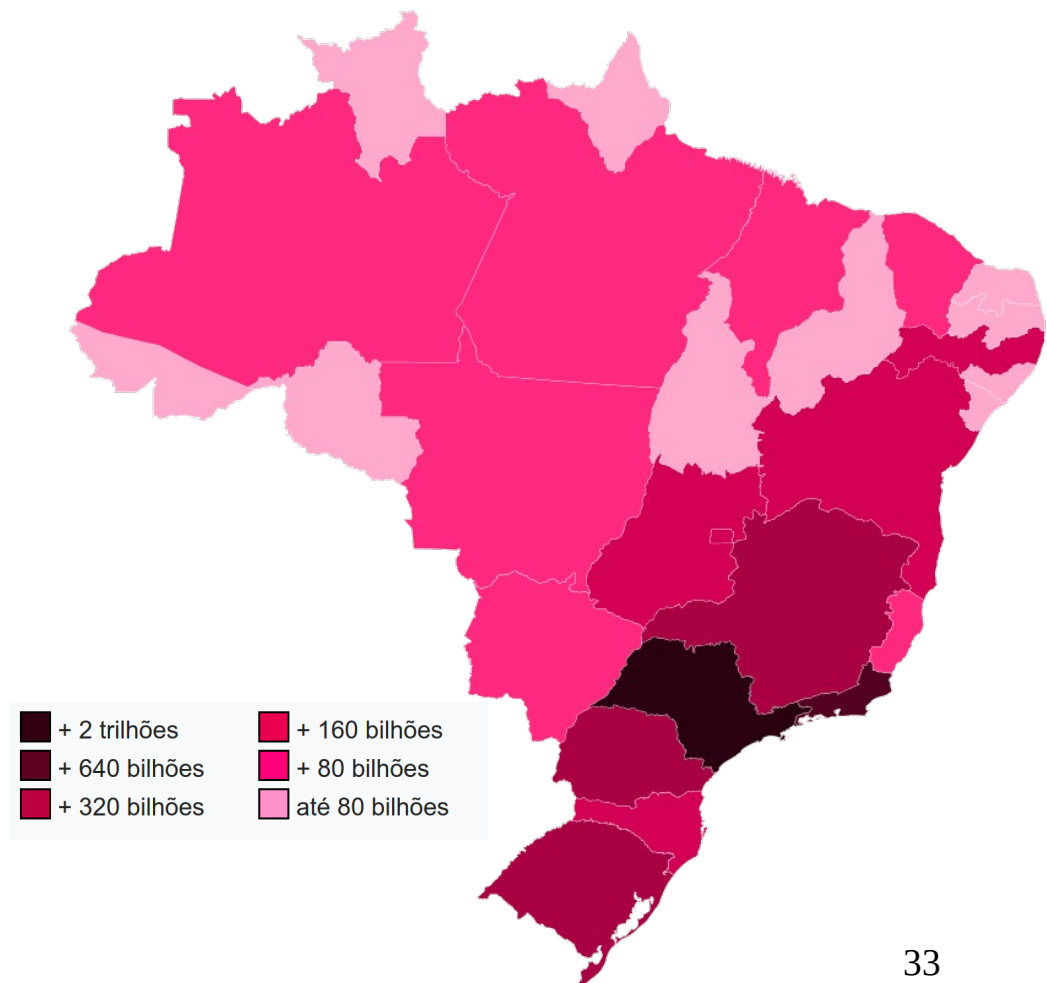
This is counted by the country of the author's institution. Includes scientific articles published in the following fields: physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.



## Demographic Density



## Gross Domestic Product



# State of São Paulo


<b>Area</b> <sup>[2]</sup>	
• <b>Total</b>	248,219.5 km <sup>2</sup> (95,838.1 sq mi)
• <b>Rank</b>	12th
<b>Population</b> (2023) <sup>[4][5]</sup>	
• <b>Total</b>	46,649,132
• <b>Estimate</b> (2022)	46,004,000 <sup>[3]</sup>
• <b>Rank</b>	1st
• <b>Density</b>	183.46/km <sup>2</sup> (475.2/sq mi)
• <b>Rank</b>	3rd
<b>Demonym</b>	Paulista
<b>GDP (PPP)</b>	
• <b>Year</b>	2020
• <b>Total</b>	US\$1.287 trillion <sup>[6]</sup> (1st)
• <b>Per capita</b>	US\$28,723 <sup>[6]</sup> (2nd)
<b>GDP (nominal)</b>	
• <b>Year</b>	2023
• <b>Total</b>	US\$721.06 billion <sup>[6]</sup> (1st)
• <b>Per capita</b>	US\$15,457 <sup>[6]</sup> (2nd)

# Free State of Bavaria

<b>Area</b>	
• <b>Total</b>	70,550.19 km <sup>2</sup> (27,239.58 sq mi)
<b>Population</b> (2019-12-31) <sup>[1]</sup>	
• <b>Total</b>	13,124,737
• <b>Density</b>	186/km <sup>2</sup> (480/sq mi)
<b>Demonym</b>	Bavarian
<b>Time zone</b>	UTC+1 (CET)
• <b>Summer (DST)</b>	UTC+2 (CEST)
<b>ISO 3166 code</b>	DE-BY
<b>GRP (nominal)</b>	€633 billion (2019) <sup>[2]</sup>
<b>GRP per capita</b>	€48,000 (2019)

WIKIPEDIA

# Universities in São Paulo

- Three majors Universities kept by the State of São Paulo
  - USP
  - UNICAMP
  - UNESP

10% of the VAT paid in the State
- Three major Universities kept by the Federal Government
  - UFABC
  - UFSCar
  - UNIFESP



# USP



<b>Motto in English</b>	"Through knowledge you will conquer"
<b>Type</b>	Public university
<b>Established</b>	25 January 1934; 89 years ago <sup>[a]</sup>
<b>Budget</b>	R\$ 7,500,000,000 <sup>[2]</sup>
<b>Rector</b>	Carlos Gilberto Carlotti Junior
<b>Academic staff</b>	5,383 <sup>[1]</sup>
<b>Administrative staff</b>	13,368 <sup>[1]</sup>
<b>Students</b>	97,325 <sup>[1]</sup>
<b>Undergraduates</b>	59,097 <sup>[1]</sup>
<b>Postgraduates</b>	29,295 <sup>[1]</sup>

## University rankings

### Global – Overall

<b>ARWU</b> World <sup>[26]</sup>	101-150 (2020)
<b>CWUR</b> World <sup>[27]</sup>	103 (2020-2021)
<b>CWTS</b> World <sup>[28]</sup>	7 (2020)
<b>QS</b> World <sup>[29]</sup>	121 (2022)
<b>THE</b> World <sup>[30]</sup>	201-250 (2021)
<b>USNWR</b> Global <sup>[31]</sup>	115 (2022)
















### Regional – Overall

<b>QS</b> Latin America <sup>[32]</sup>	2 (2021)
<b>THE</b> Latin America <sup>[33]</sup>	2 (2020)
<b>USNWR</b> Latin America <sup>[34]</sup>	1 (2022)

- five hospitals
- 247 undergraduate programs
- 239 graduate programs
- 24 museums and galleries with half a million visitors a year
- two theaters and one cinema,
- TV channel
- two orchestras

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	University		P	P(top 10%)	PP(top 10%)	
1	Harvard Univ		35050	7247	20.7%	<div></div>
2	Zhejiang Univ		29091	3281	11.3%	<div></div>
3	Shanghai Jiao Tong Univ		28703	3024	10.5%	<div></div>
4	Univ Toronto		24260	3387	14.0%	<div></div>
5	Tsinghua Univ		22311	3221	14.4%	<div></div>
6	Huazhong Univ Sci & Technol		21654	2700	12.5%	<div></div>
7	Sichuan Univ		21566	1960	9.1%	<div></div>
8	Cent S Univ		20131	2255	11.2%	<div></div>
9	Peking Univ		19874	2272	11.4%	<div></div>
10	Sun Yat-sen Univ		19866	2150	10.8%	<div></div>
11	Univ Michigan		19609	2873	14.6%	<div></div>
12	Univ São Paulo		19552	1314	6.7%	<div></div>
13	Xi'an Jiaotong Univ		19478	2001	10.3%	<div></div>
14	Jilin Univ		19332	1533	7.9%	<div></div>
15	Fudan Univ		18366	1779	9.7%	<div></div>



# CWTS Leiden Ranking 2022

Start tour



List view



Chart view



Map view

## Time period, field, and region/country

Time period:

2017–2020



Field:

Physical sciences and engineering



Region/country:

World



Min. publication output:

100



## Indicators

Type of indicators:

Gender



Indicators:

A(MF), A(F), PA(F|MF)






Order by:

A(MF)





University			A(MF)	A(F)	PA(F   MF)				
1	Univ Tokyo		36578	2731	7.5%	<div><div></div></div>			
2	Univ Chinese Acad Sci		35623	7455	20.9%	<div><div></div></div>			
3	Lomonosov Moscow State Univ		29184	7012	24.0%	<div><div></div></div>			
4	Tsinghua Univ		26801	5118	19.1%	<div><div></div></div>			
5	Kyoto Univ		25149	1595	6.3%	<div><div></div></div>			
6	Karlsruhe Inst Technol		24723	3987	16.1%	<div><div></div></div>			
7	MIT		24285	4830	19.9%	<div><div></div></div>			
8	Univ Sci & Technol China		24139	3723	15.4%	<div><div></div></div>			
9	Univ Paris-Saclay		23924	5669	23.7%	<div><div></div></div>			
10	Zhejiang Univ		23455	3754	16.0%	<div><div></div></div>			

26	Stanford Univ		19516	3451	17.7%	<div><div></div></div>			
27	Imperial Coll London		19170	3566	18.6%	<div><div></div></div>			
28	Univ São Paulo		19160	5266	27.5%	<div><div></div></div>			
29	RWTH Aachen Univ		18994	2669	14.1%	<div><div></div></div>			
30	Cent S Univ		18941	3924	20.7%	<div><div></div></div>			
31	Harvard Univ		18822	4105	21.8%	<div><div></div></div>			
32	Univ Oxford		18120	3229	17.8%	<div><div></div></div>			

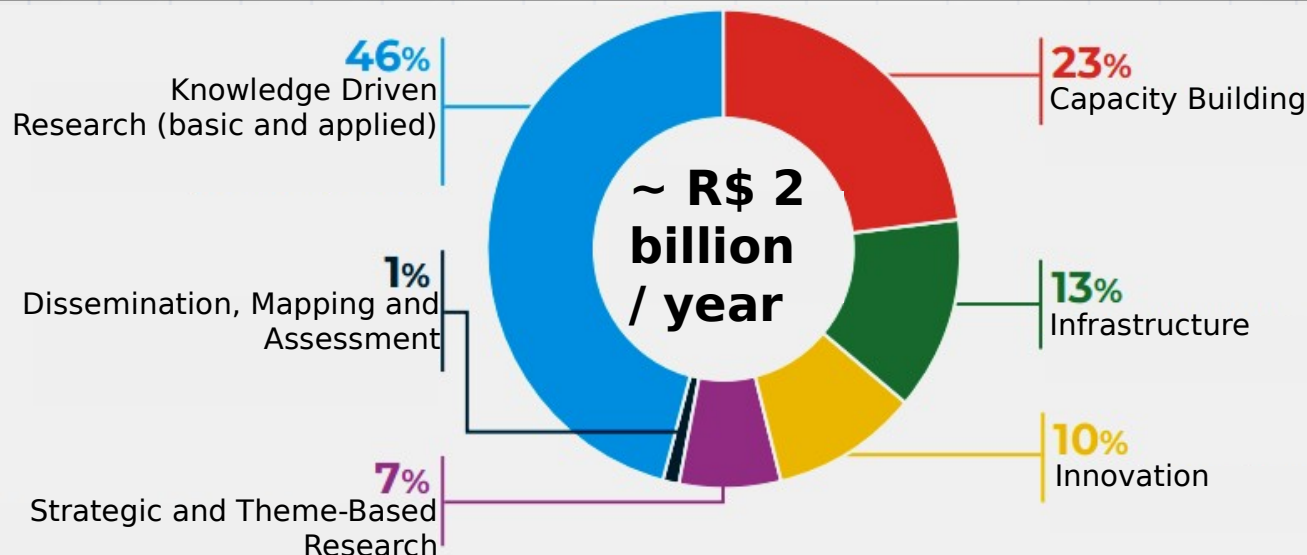
# The Foundation



Established in 1962, FAPESP is a **public foundation of the State of São Paulo** with the mission to support **research and innovation** in research institutions and enterprises in the State of São Paulo.

- The Constitution of the State of São Paulo establishes that FAPESP is granted **1% of the state tax revenue**, which brings **autonomy and stability**.
- FAPESP selects projects through a **three-tier, peer-review process**.
- FAPESP funds **researchers from the State of São Paulo** with both scholarships and research grants in **all areas of knowledge**.

# Expenditures by type and disciplines



**19.880 applications**

**7.027 successful**

**21.233 ongoing grants**

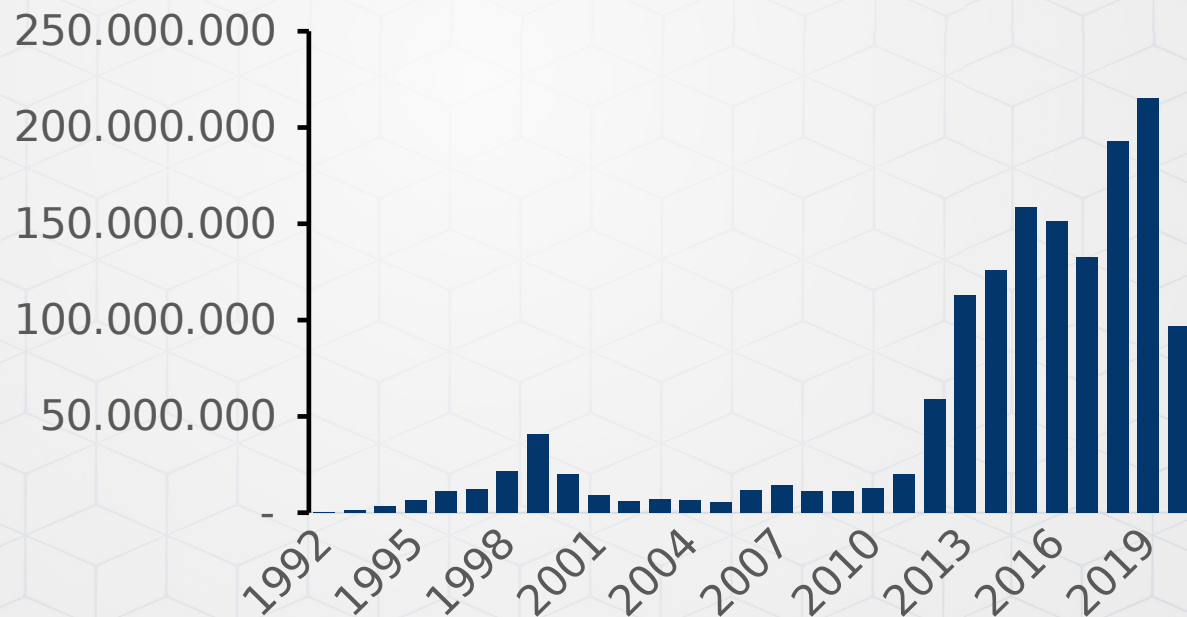




# INTERNATIONAL COLLABORATION STRATEGIES

- **Local grants and fellowships**
- **Joint calls for proposals** (different types and outreach)
- **Exchange of researchers** (SPRINT, Seed Fund, Visiting, Internships)
- **Collaborative activities** (Workshops, Seminars, Publications)
- **Multinational collaboration** (ERA-NET, Belmont Forum, T-AP, Horizon Europe)

FAPESP annual  
spending in  
projects involving  
international  
collaboration





# Global Research Council

Agência **FAPESP**

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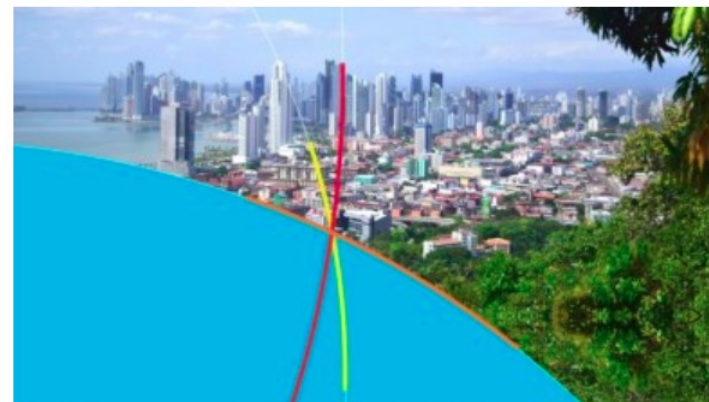


## FAPESP to host Executive Secretariat of Global Research Council from September

June 08, 2022

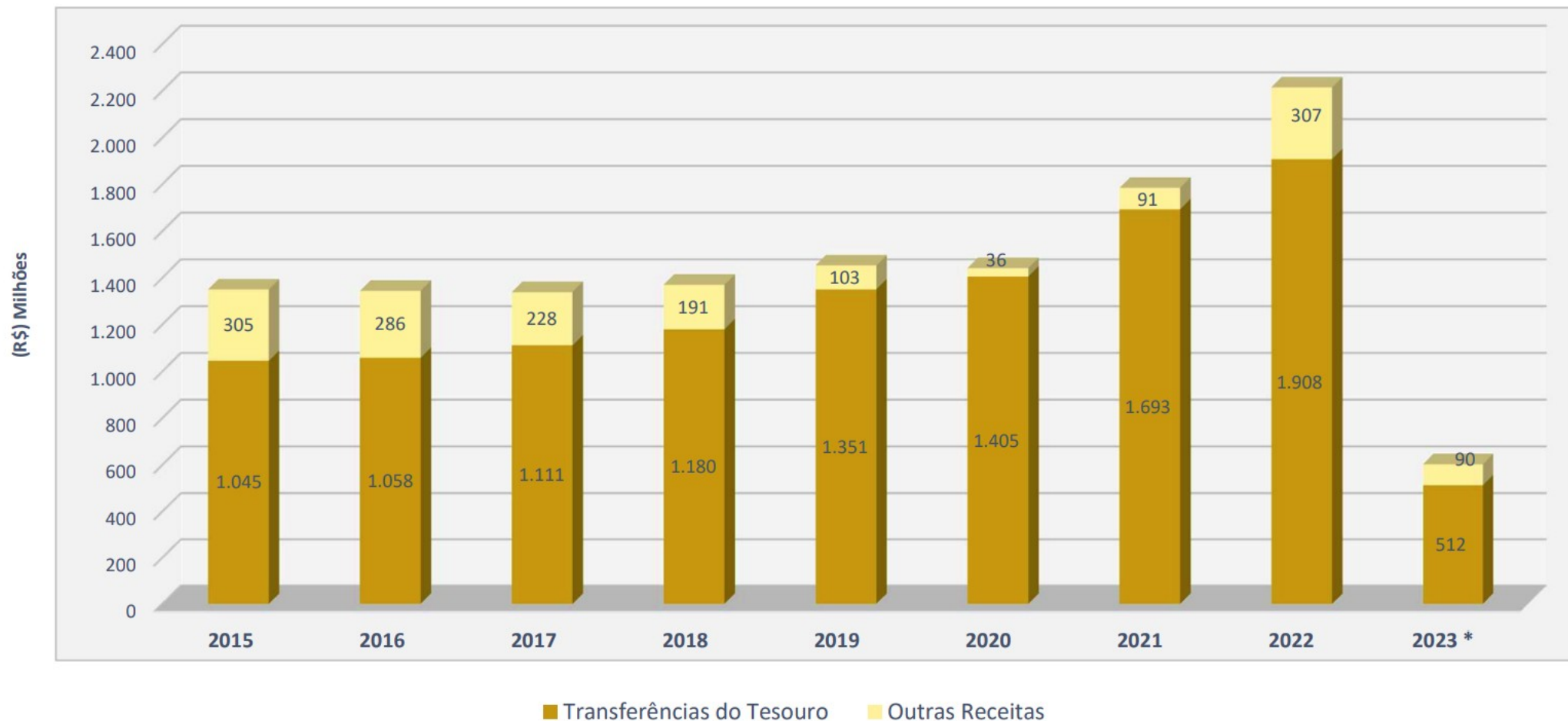


**Agência FAPESP** – As of September, FAPESP will host the Executive Secretariat of the Global Research Council ([GRC](#)), a virtual organization comprising the heads of more than 60 science and engineering funding agencies from countries on all continents. The announcement was made on May 31 on the first day of the GRC's Annual Meeting, which was held for four days in Panama. The GRC was established in 2012. Its first Executive Secretary was from the United States National Science Foundation (NSF), followed by representatives of the German Research Foundation (DFG) and United Kingdom Research and Innovation (UKRI).



The GRC is an association of more than 60 public research funding agencies on all continents. Its annual meeting took place in Panama on May 31-June 03, 2022. (photo: GRC)

**Gráfico I - Evolução Anual das Receitas**  
(em R\$ de 2015 a 2023\*)



# Pró-reitor da USP é nomeado diretor-científico da Fapesp

Márcio de Castro Silva Filho assume o novo cargo no final de abril



FAPESP NEW SCIENTIFIC  
DIRECTOR

- More support to young scientists
- International collaboration

# Opportunities in São Paulo

- **Post-Doc:**

- ▷ on demand or calls from large projects
- ▷ 24 + 12 months
- ▷ Grant
- ▷ Well paid (R\$ 8.479,20)
- ▷ Two open positions to work with us:
  - Sources
  - LIV

- **Young Researcher:**

- ▷ start your group
- ▷ 60 + 12 months
- ▷ PhD and post-doc fellowships
- ▷ 2 years experience
- ▷ Generous grant
- ▷ Very well paid (R\$ 9.634,20)



# Summary

- Enjoy the workshop
- This is just the start of a fruitfull collaboration
- It will be our pleasure to welcome you in 2024
- Consider Brazil / São Paulo for your next position