CBPF, Astroparticles
South America and all that

Ronald Cintra Shellard
CBPF – Rio de Janeiro
CBPF – R&D Areas

- High energy physics and astroparticle
- Cosmology and gravitation
- Materials science, nanoscience and nanotechnology
- Biophysics
- Quantum information
- Statistical mechanics and complex systems (Tsallis statistics)
Origin per state of students who graduated at CBPF

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<th>ESTADO</th>
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<td>RIO GRANDE DO NORTE</td>
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<td>ESPÍRITO SANTO</td>
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<td>MINAS GERAIS</td>
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<td>RIO DE JANEIRO</td>
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<td>SÃO PAULO</td>
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Origin of students who graduated at CBPF
Schools and Conferences

- IV Workshop da Network for Bioengineering
- Advanced School on Experimental Physics
- Workshop “NMR applied to Petrophysics”
- CTA Consortium
- 16ª Brazilian School of Cosmology and Gravitation
- VI Quantum Information School and Workshop
- Brazil Norway November Conference on Oil and Gas
- Workshop Surface Science Rio (WS2Rio)
- CBPF Python Summer Camp
- HEP Network meeting
- ...

ICISE-CBPF, July 2019
Mural - Grafite da Ciência

Projeto cultural de divulgação da ciência e de revitalização do espaço público

ICISE-CBPF, July 2019
http://www.science-graffiti.cbpf.br/index.html
http://www.science-graffiti.cbpf.br/index.html
Some Science:

- Pierre Auger Observatory
- CTA
- LATTES/SWGO
FLUORESCENCE DETECTORS
$E^3(E) \times (\text{eV}^2 \text{km}^{-2} \text{sr}^{-1} \text{yr}^{-1})$

$\log(E/\text{eV})$

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$\sigma_{\text{inel}}$ vs. $E$

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$\sigma_{\text{inel}}$ vs. $\sqrt{s}$

---

$E^3(E) \times (\text{eV}^2 \text{km}^{-2} \text{sr}^{-1} \text{yr}^{-1})$

$\log(E/\text{eV})$

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$\log(E/\text{eV})$

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$\sigma_{\text{inel}}$ vs. $E$

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$\log(E/\text{eV})$

---

$\sigma_{\text{inel}}$ vs. $E$

---

$\sigma_{\text{inel}}$ vs. $\sqrt{s}$

---
RESULTS: $X_{max}$
Measure gamma-rays

Cosmic Rays

Gamma-rays
How can you detect gamma rays?

- Go to space and setup a particle detector, so you can detect pair conversion – *Fermi-LAT*

- Look at the sky with a large mirror and detect the Cherenkov light generated by the air shower (IACT) – *HESS, MAGIC, VERITAS*

- Detect the air shower directly with a particle detector – *MILAGRO, ARGO-YBJ, HAWC*
FERMI-LAT
Gamma rays – IACT Ground observatories (high energies)

**MAGIC**
La Palma, Canary Islands

**HESS**
- HESS-1: 4×12m tels
- HESS-2: +28m tel.
  Completed mid-2012
Namíbia

**Veritas**
Arizona
<table>
<thead>
<tr>
<th>Quantity</th>
<th>Fermi-LAT</th>
<th>IACTs</th>
<th>EAS</th>
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<tbody>
<tr>
<td>Energy range</td>
<td>20 MeV–200 GeV</td>
<td>100 GeV–50 TeV</td>
<td>400 GeV–100 TeV</td>
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<tr>
<td>Energy res.</td>
<td>5-10%</td>
<td>15-20%</td>
<td>~ 50%</td>
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<tr>
<td>Duty Cycle</td>
<td>80%</td>
<td>15%</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td>FoV</td>
<td>$4\pi/5$</td>
<td>5 deg $\times$ 5 deg</td>
<td>$4\pi/6$</td>
</tr>
<tr>
<td>PSF</td>
<td>0.1 deg</td>
<td>0.07 deg</td>
<td>0.5 deg</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>1% Crab (1 GeV)</td>
<td>1% Crab (0.5 TeV)</td>
<td>0.5 Crab (5 TeV)</td>
</tr>
</tbody>
</table>

The map shows the locations of various gamma-ray observatories:
- **VERITAS**
- **HAWC**
- **ARGO-YBJ**
- **LHAASO**
- **CTA North**
- **CTA South**
- **MAGIC**

- **In operation**
- **Planned**
CHERENKOV TELESCOPE ARRAY - CTA

4 North
4 South

LST

15 North
25 South

MST

70 South

SST

S. Funk

ICISE-CBPF, July 2019
Canary Islands
Acceleration of cosmic particles

• How they are accelerated?
• How they propagate?

Exploring Extremes environments

• Environment nearby neutron stars and Black holes
• Environment at relativistic jets, winds, flares
• Environment at cosmic voids

Frontier Physics – beyond SM

• The nature of black matter, its distribution
• Photon “speed” at high energies
• New particles (axions, p.ex.)?
Large Array Telescope for Tracking Energetic Sources
LATTES Objectives

- **Build a gamma ray detector operating 24/7, field of view of** $2\pi/3$ rad$^2$
- **Low energy sensitivity** $\sim 100$ GeV
- **Altitude above 5,000m**
- **Capability to detect transients**
- **South America (interesting objets)**
  - Non thermal process in theUniverso
  - Transients
  - Extreme objets: SNR, AGN, GRB
LATTES (Altitude?)

LATTES/HAWC ~ 2-3
R.L. gain ~ 2.5

ICISE-CBPF, July 2019
Why LATTES: Present situation

There are no large field of view experiment to:

- Monitor the Center of the Galaxy
- Exploit the 100 GeV range
Base design – Conceptual Design

CESAR

Calorimeter Electromagnetic for Studying AiR gammas
Water Cherenkov detector
Measure the shower energy with good resolution

MARTA

Muon Array Rpcs for Tagging Airshowers
Particle counter based on RPC technology
(RPC -- Resistive Plate Chamber)
Temporal resolution ~ 1 ns
• Thin slab of lead (Pb)
  - 5.6 mm (one radiation length)
• Resistive Plate Chambers (RPC)
  - 2 RPC per station
  - Each RPC with 4X4 reading pads
• Water Cherenkov Detector (WCD)
  - 2 PMT (diameter 15 cm)
  - Dimension: 1.5 m X 3 m X 0.5 m
LATTES core array

20000 m²
The shared concept for the future observatory is as follows:
- A gamma-ray observatory based on ground-level particle detection, with close to 100% duty cycle and order steradian field of view.
- Located in South America at a latitude -30 to -10 degrees.
- At an altitude of 4.4km or higher.
- Covering an energy range from 100s of GeV to 100s of TeV.
- Based primarily on water Cherenkov detector units.
- With a high fill-factor core detector with area considerably larger than HAWC and significantly better sensitivity, with a low density outer array.
- With the possibility of extensions and/or enhancements.
- Modular and scalable.
- Targeting a cost of €40-50M.
- Organised as a collaboration, constructing the instrument and exploiting the scientific data together.
- With all data becoming publically available after a proprietary period.
- With close scientific coordination with CTA, recognising the synergy and complementarity between these instruments.
FLARES (CRAB – April 2011)
An example: the Fermi Bubbles

Fermi data reveal giant gamma-ray bubbles

Credit: NASA/DOE/Fermi LAT/D. Finkbeiner et al.
No Conclusion

But a Beginning