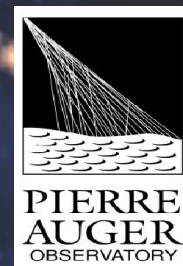




# O que são raios cósmicos ?

Vitor de Souza



# #ShutDownAcademia

# #ShutDownSTEM

10 June 2020



**STRIKE FOR  
BLACK LIVES**

**IFSE**



Universidade Federal do ABC



**ICTP  
SAIFR**



**UFPR**  
UNIVERSIDADE FEDERAL DO PARANÁ



EEL-USP

**UFRN**



Conselho Nacional de Desenvolvimento Científico e Tecnológico



**CAPES**



**FAPESP**



Instituto de Física Gleb Wataghin



**UFRJ**



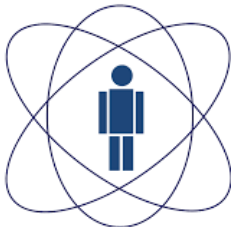
**UEFS**

UNIVERSIDADE ESTADUAL DE FEIRA DE SANTANA



**uff**

Universidade Federal Fluminense



**CBPF**



**ORBITAL**  
ENGENHARIA



**ITeDA**



MAX-PLANCK-GESELLSCHAFT



THE UNIVERSITY OF CALIFORNIA  
LET THERE BE LIGHT  
UCLA



**DESY**

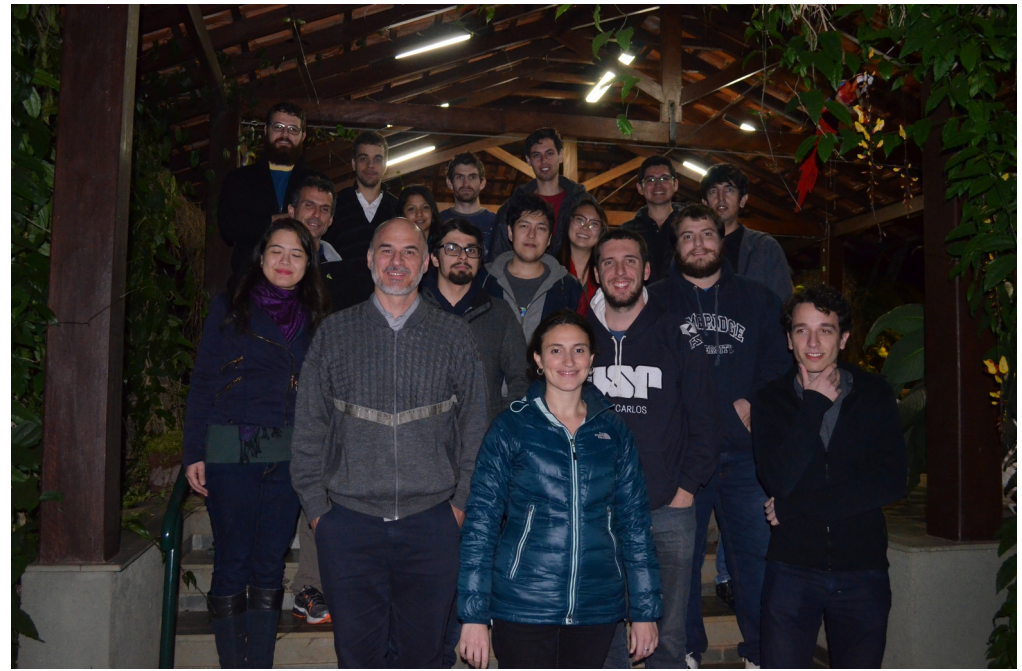
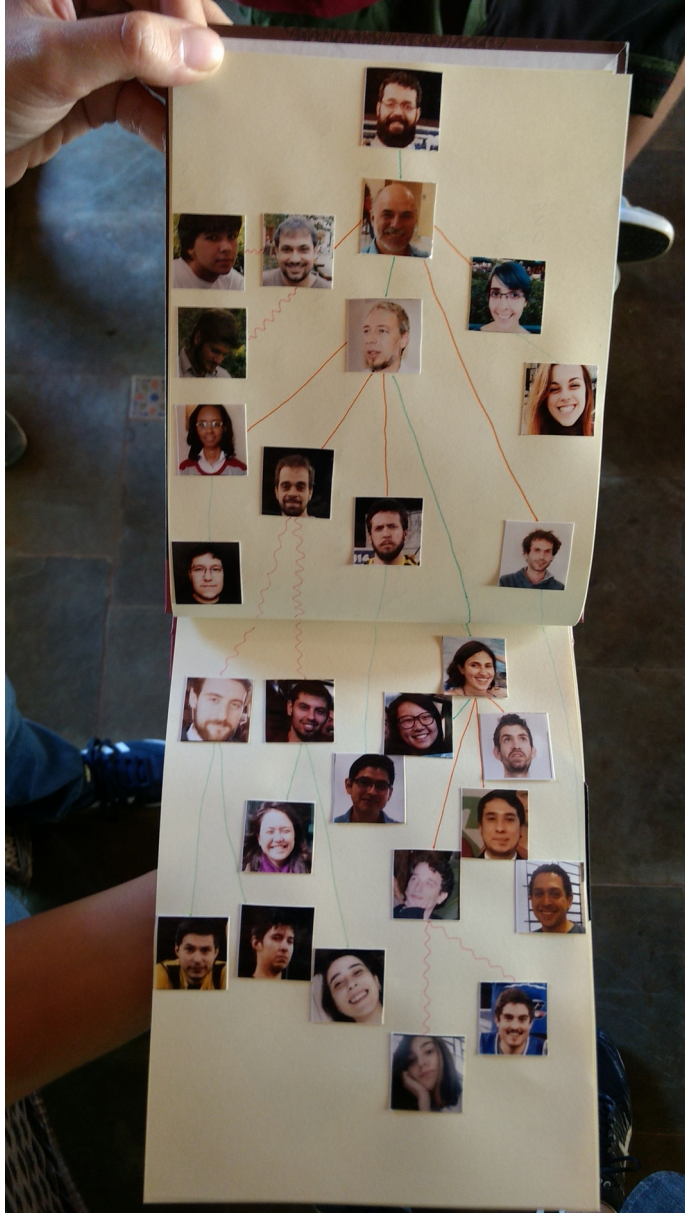


**LIP**



KIT  
Karlsruher Institut für Technologie

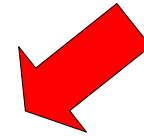
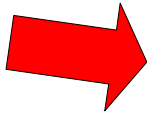
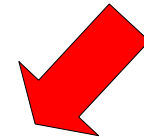
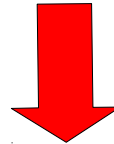
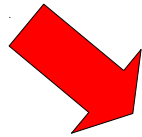
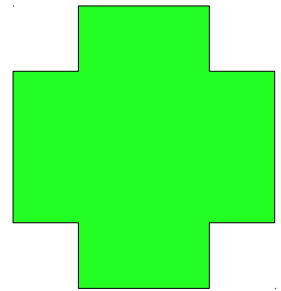
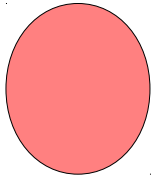
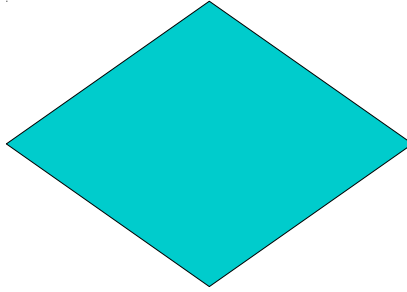
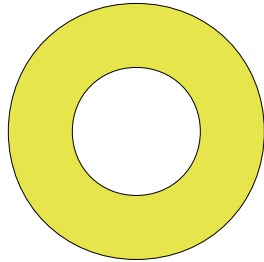
**IFSE  
UST**



**OBRIGADO !**



Se algo me atinge ...



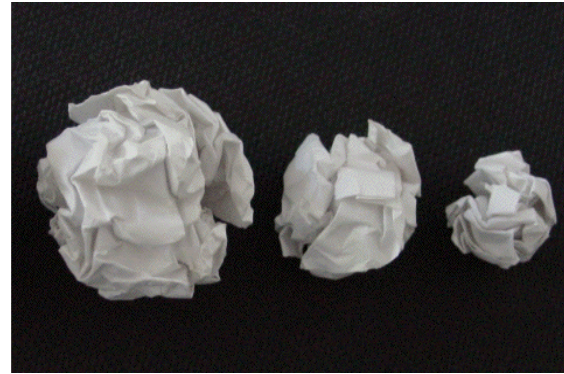
Se algo me atinge ... Eu quero saber o que é !



Se algo me atinge ... Eu quero saber o que é !

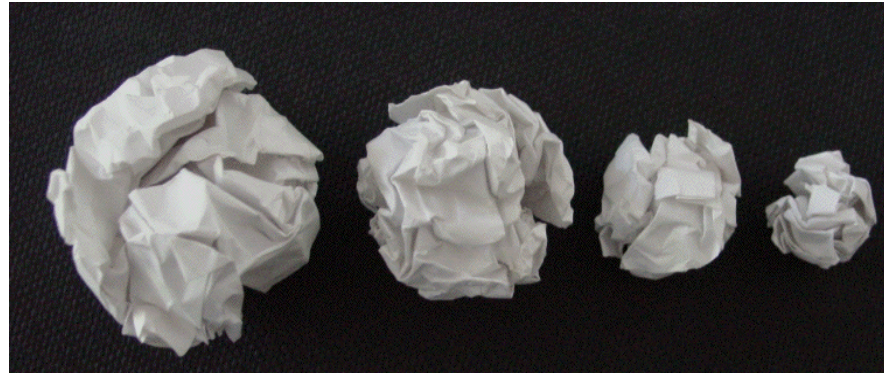


Se algo me atinge ... Eu quero saber o que é !





Se algo me atinge ... Eu quero saber o que é !



Se algo me atinge ... Eu quero saber o que é !



Se algo me atinge ...

Eu quero saber:

O QUE ?

Se algo me atinge ... Eu quero saber quem jogou !



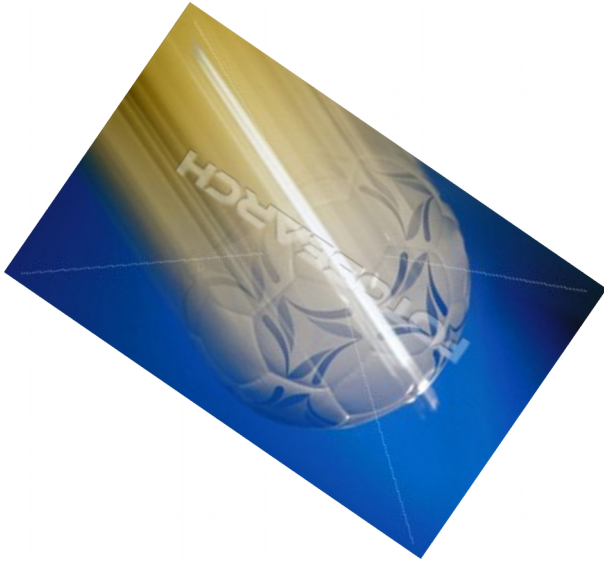
Se algo me atinge ...

Eu quero saber:

O QUE ?

QUEM ?

Se algo me atinge ... Eu quero saber a **velocidade** !



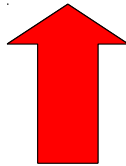
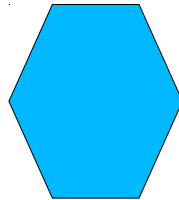
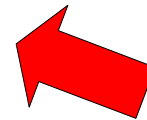
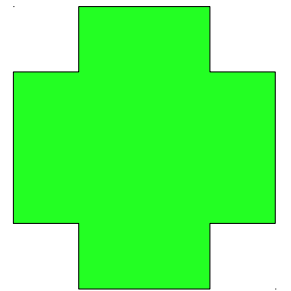
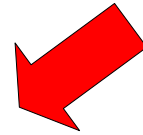
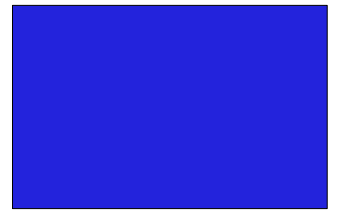
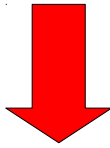
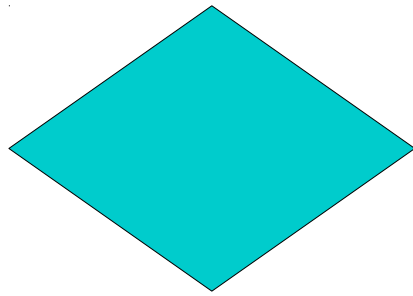
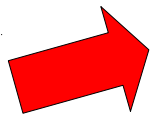
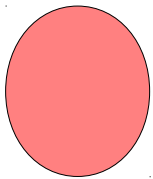
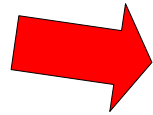
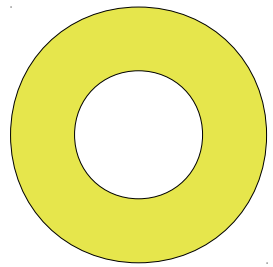
Se algo me atinge ...

Eu quero saber:

O QUE ?

QUEM ?

VELOCIDADE ?





Se algo me atinge ...

Eu quero saber:

O QUE ?

QUEM ?

VELOCIDADE ?

Se algo me atinge ...

Eu quero saber:

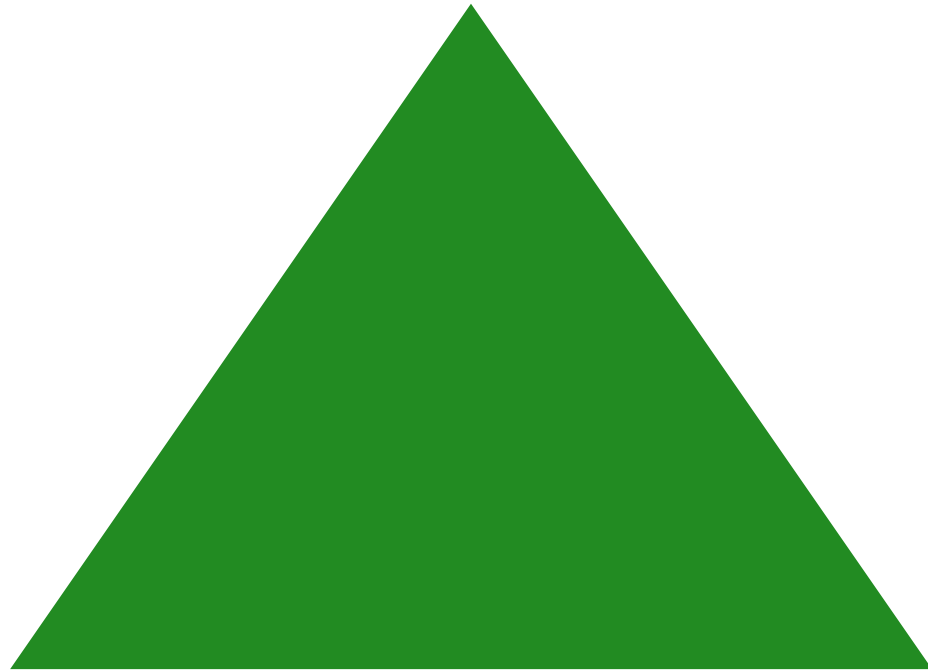
O QUE ?

QUEM ?

ENERGIA ?

**E N E R G I A**

$$E^2 = p^2 c^2 + m^2 c^4$$



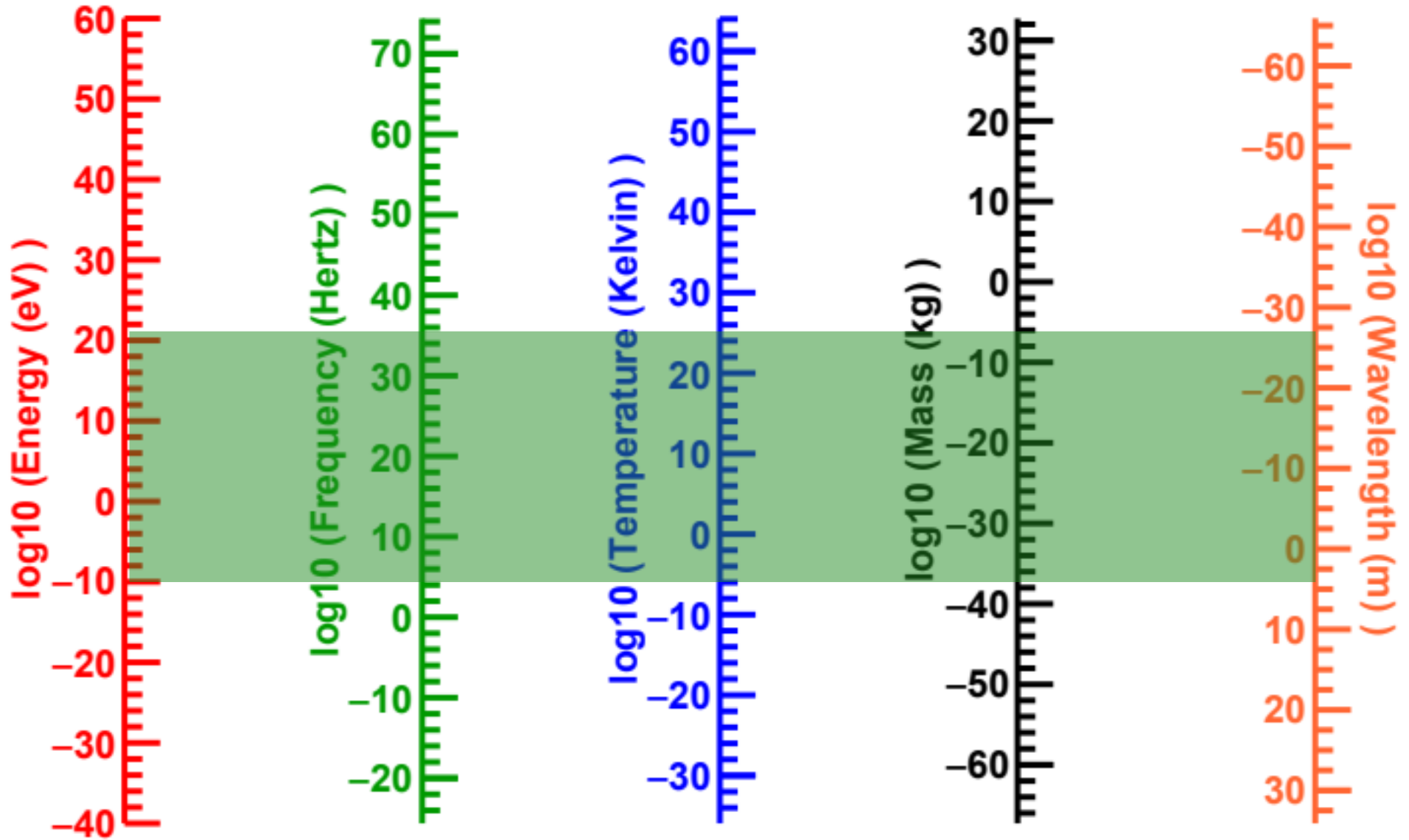
$$E \propto kT$$

$$E = h\nu = \frac{hc}{\lambda}$$

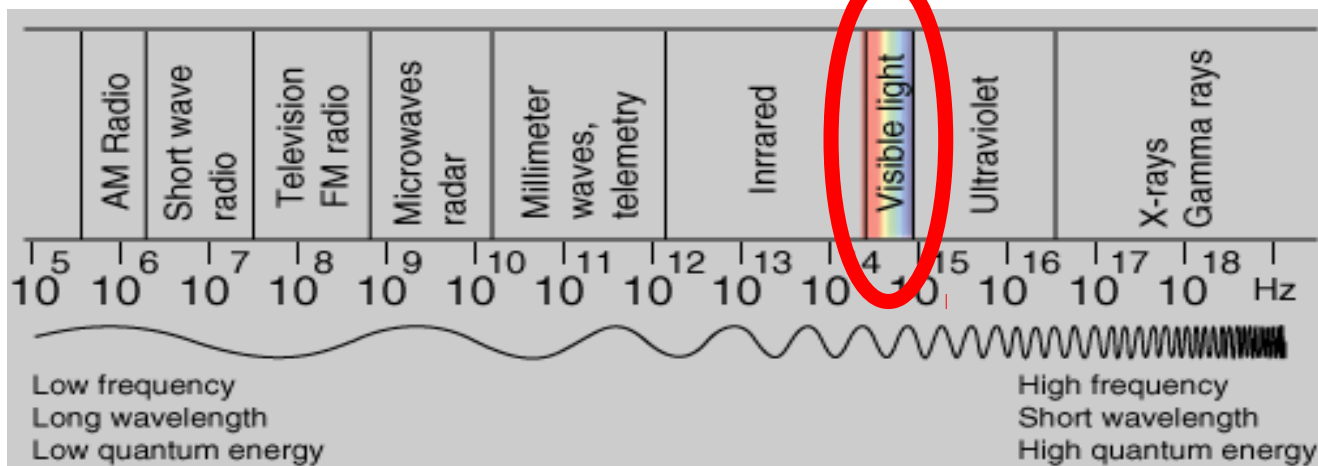


$1 \text{ eV} = 1.6 \times 10^{-19} \text{ Joule}$

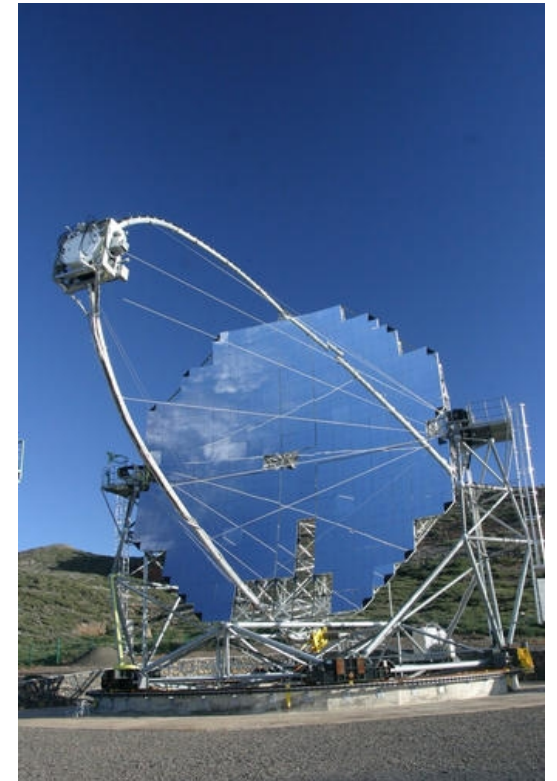
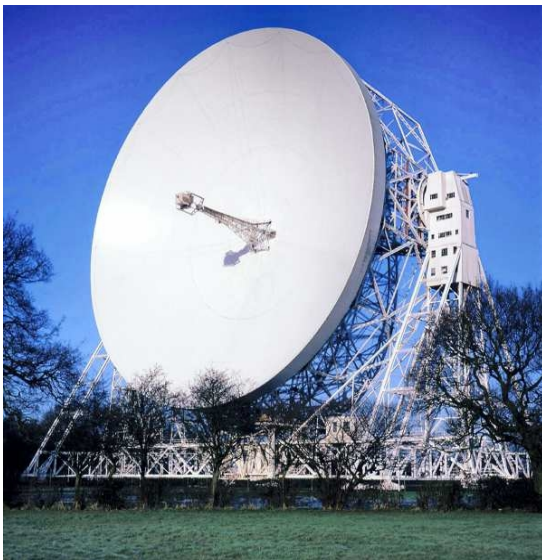
# Mensageiros extraterrestres



# Olhando pro céu com o nosso olho:



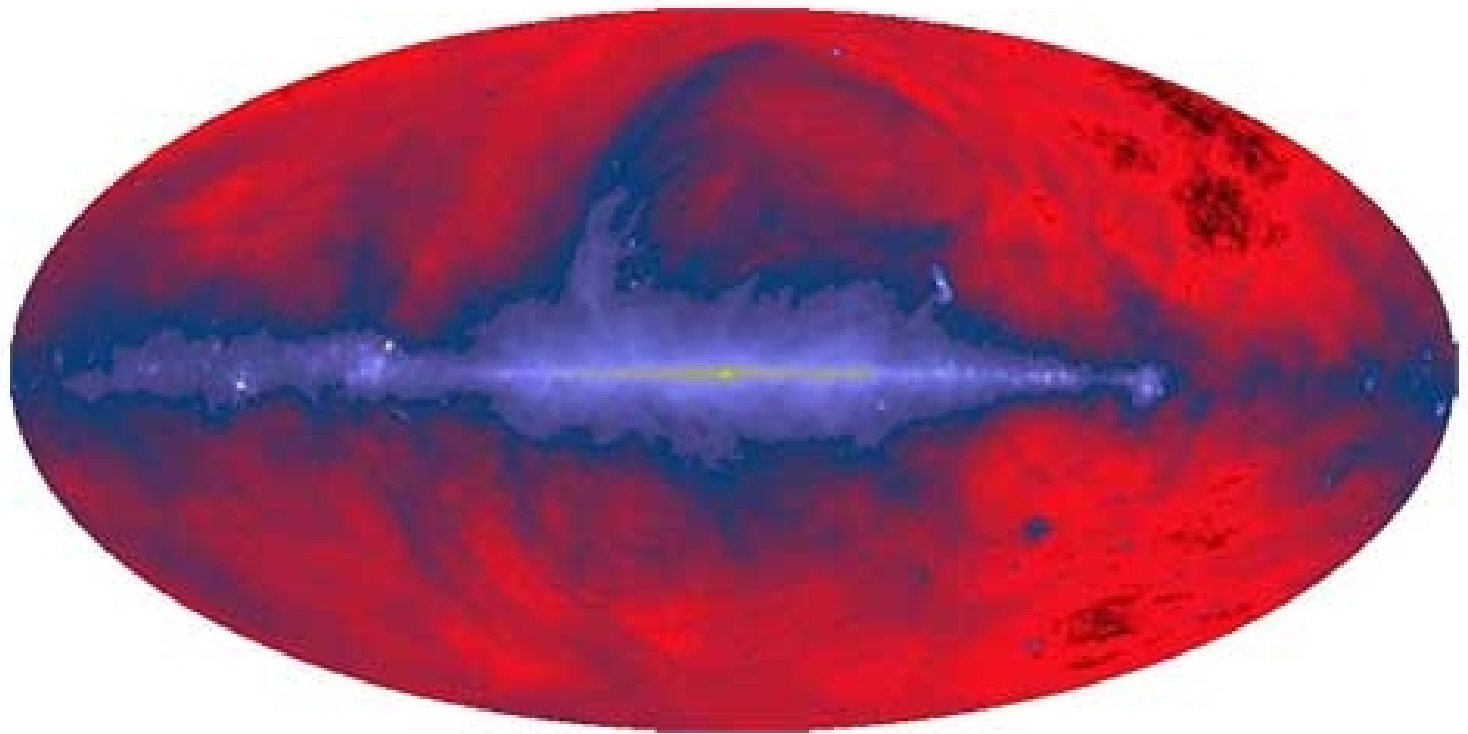
# Olhando para o céu com instrumentos:





# Ondas de Rádio

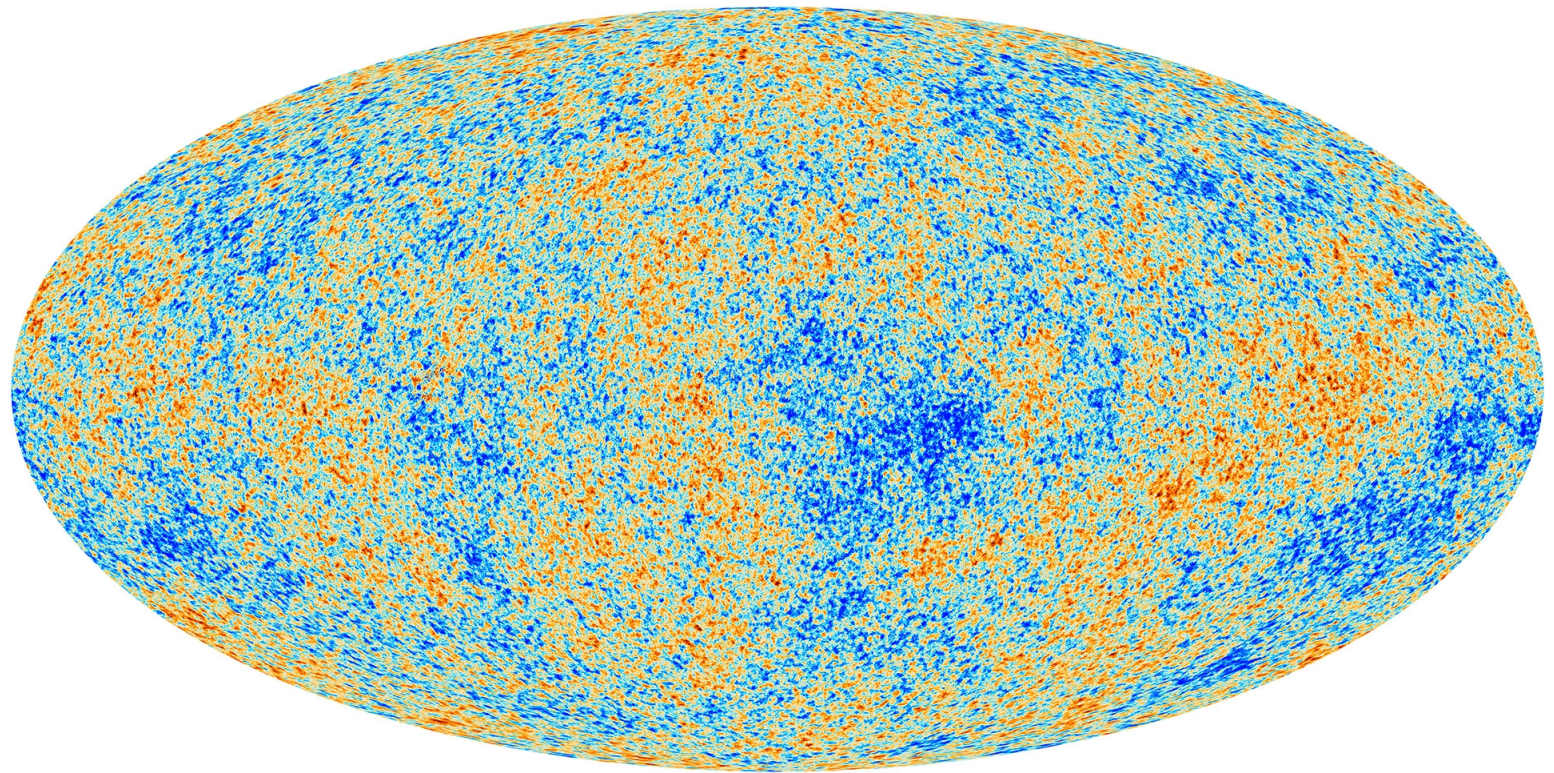
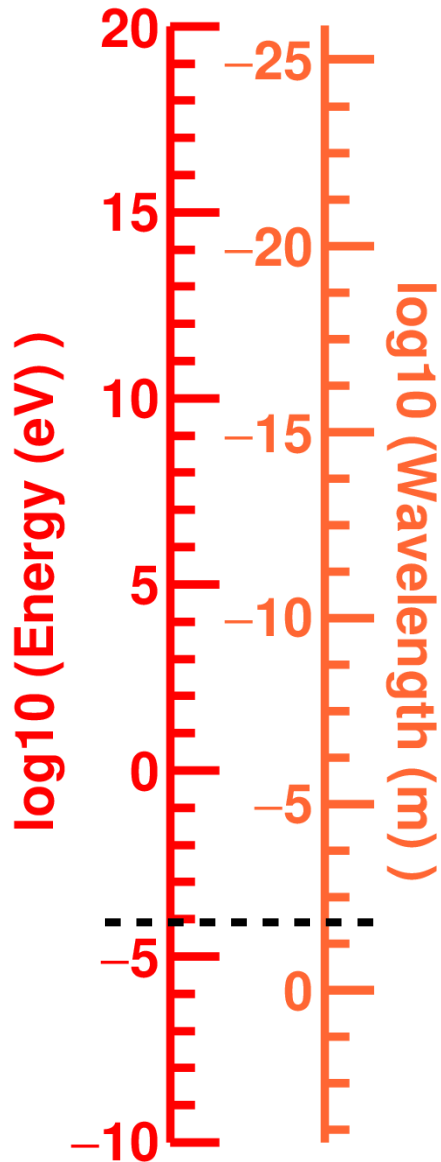
$$E \sim 10^{-6} \text{ eV} \Leftrightarrow \lambda \sim 1 \text{ m}$$





# Radiação C3smica de Fundo

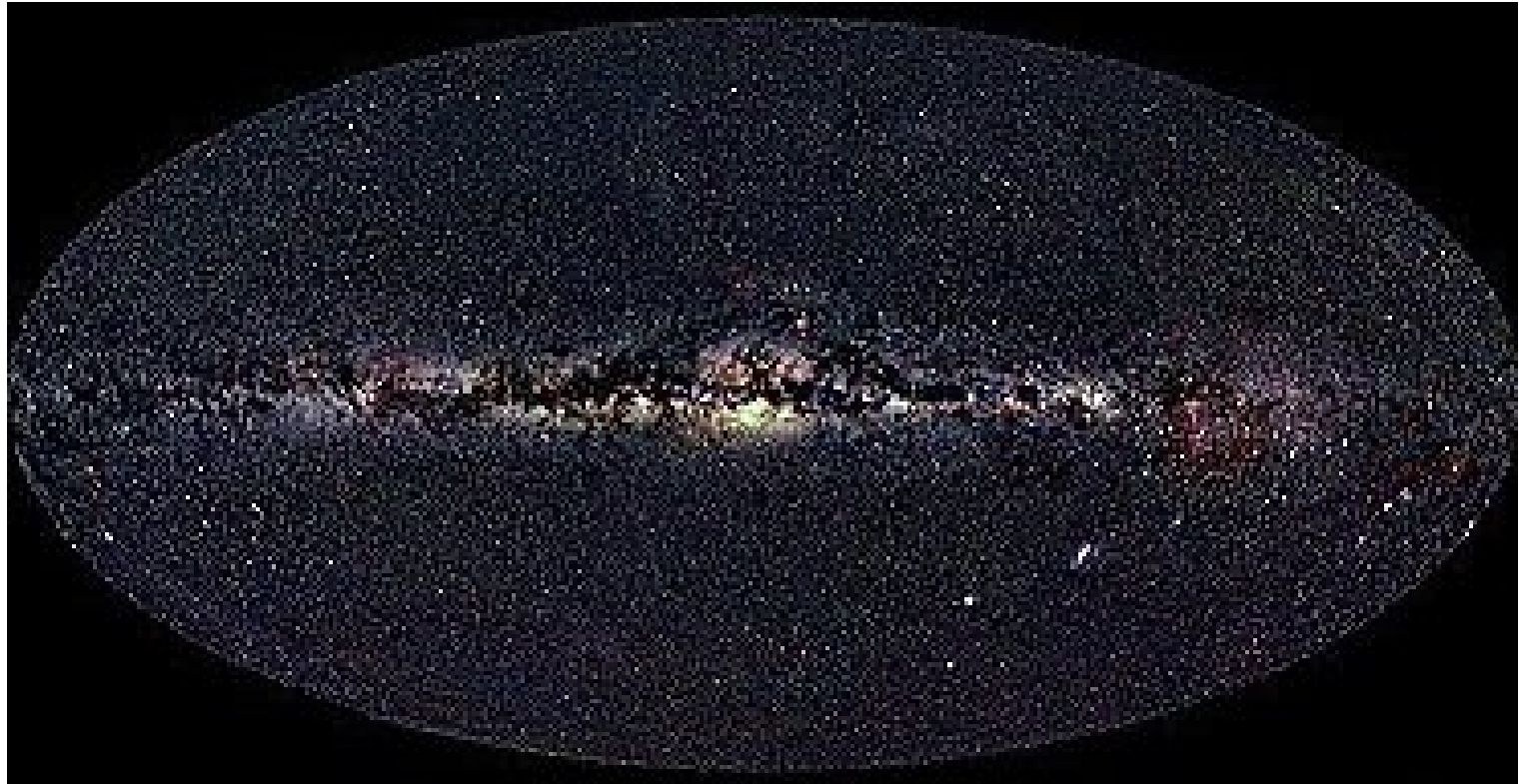
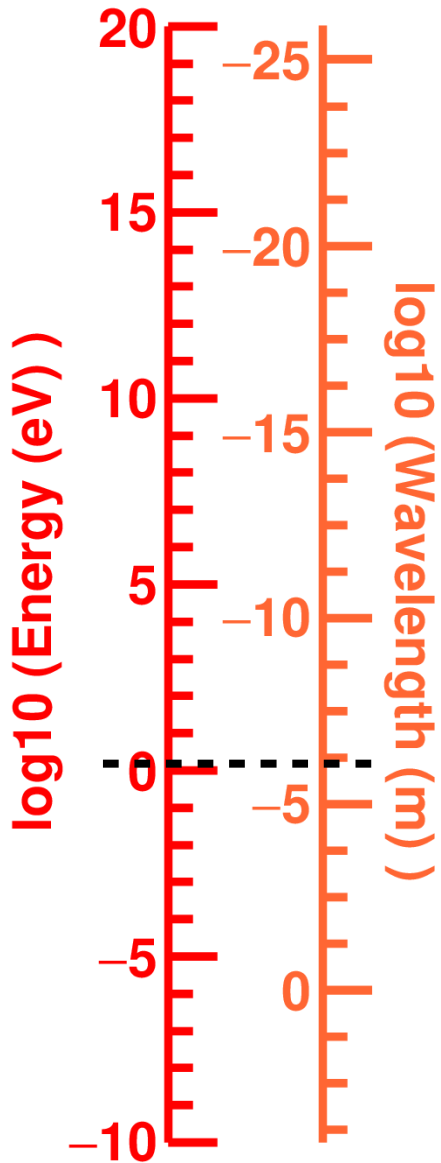
$$E \sim 10^{-4} \text{ eV} \Leftrightarrow \lambda \sim 10^{-2} \text{ m}$$



Sat3elite Planck

# Luz Visível

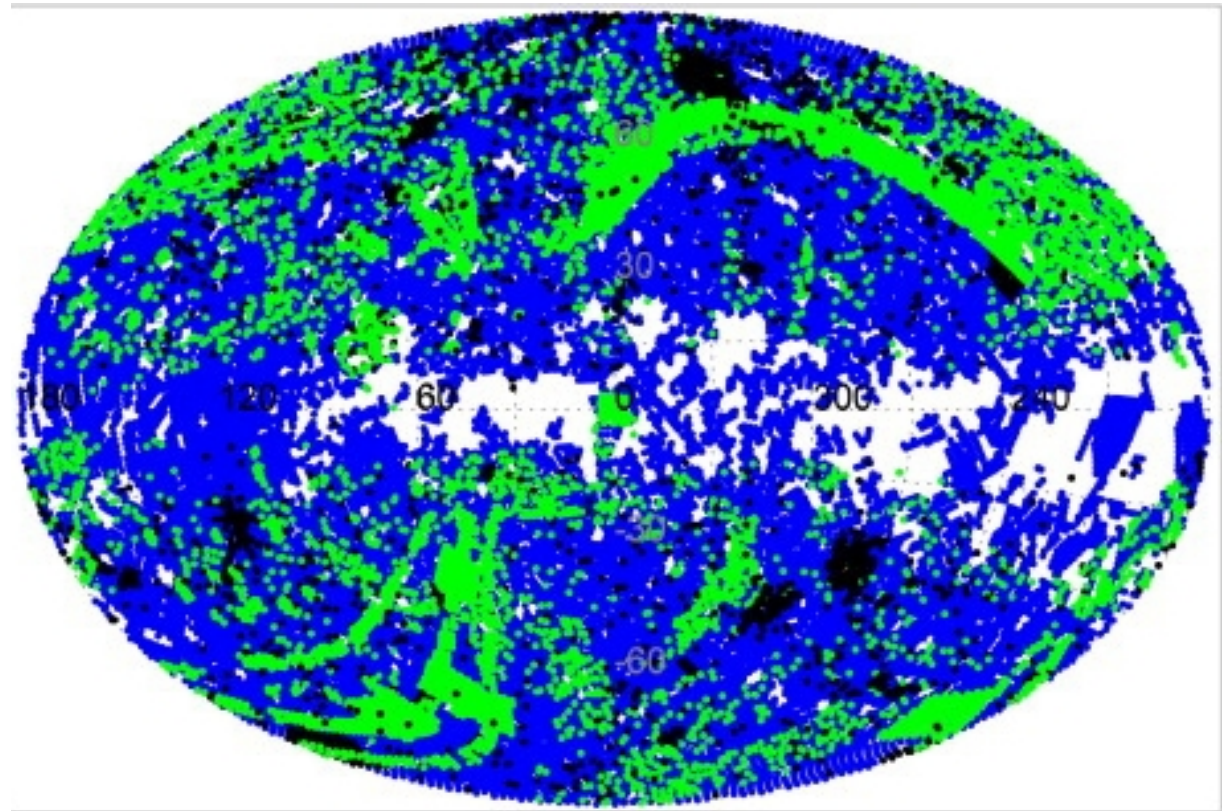
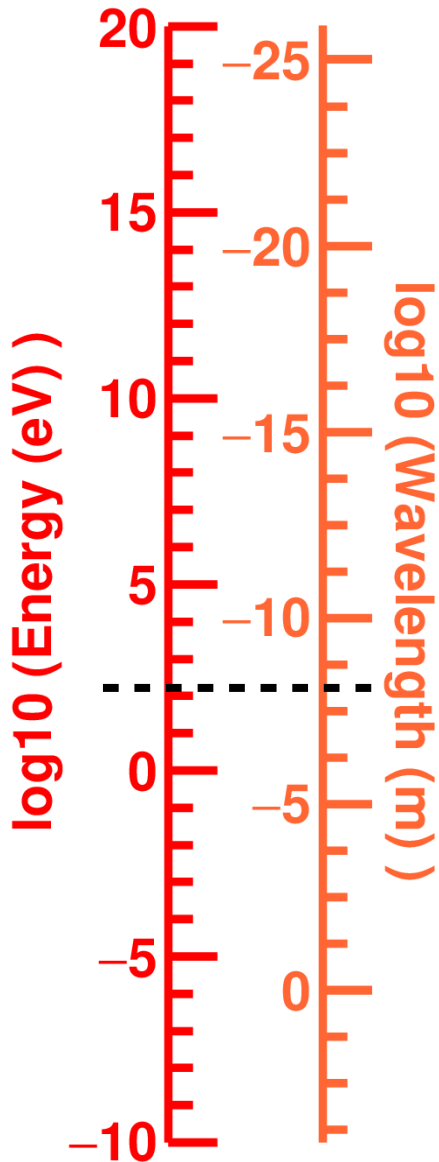
$$E \sim 1 \text{ eV} \Leftrightarrow \lambda \sim 10^{-6} \text{ m}$$



por Axel Melinger

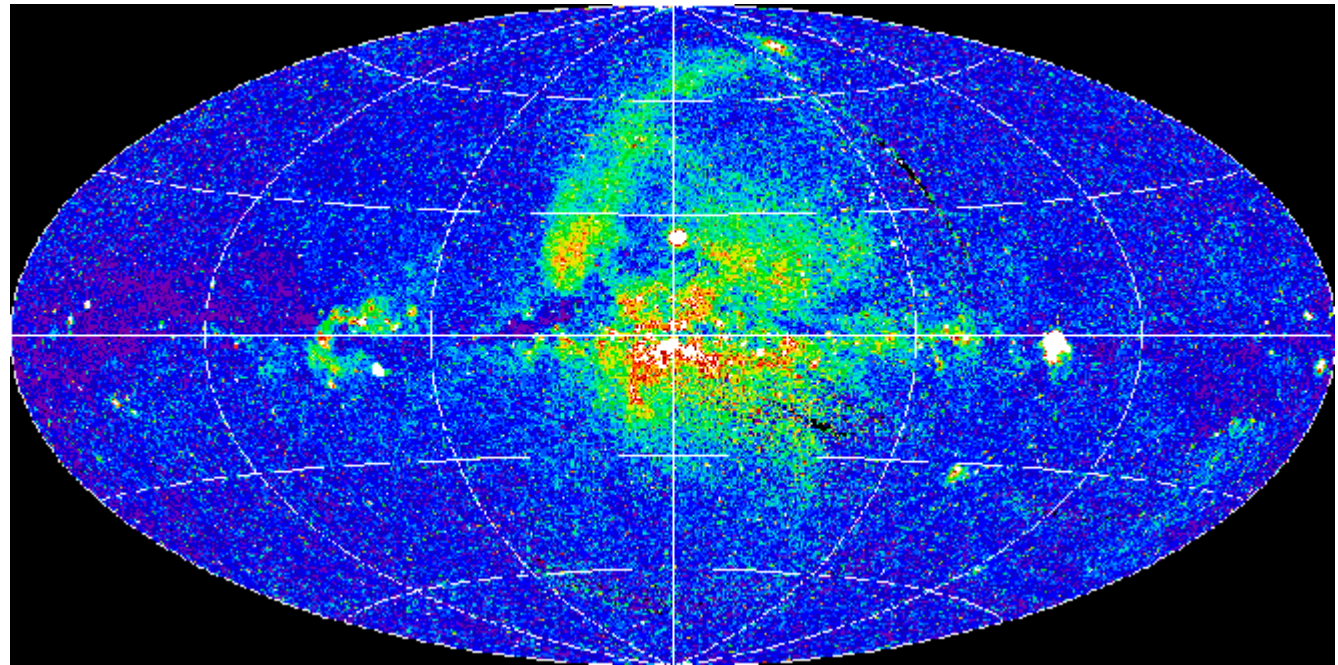
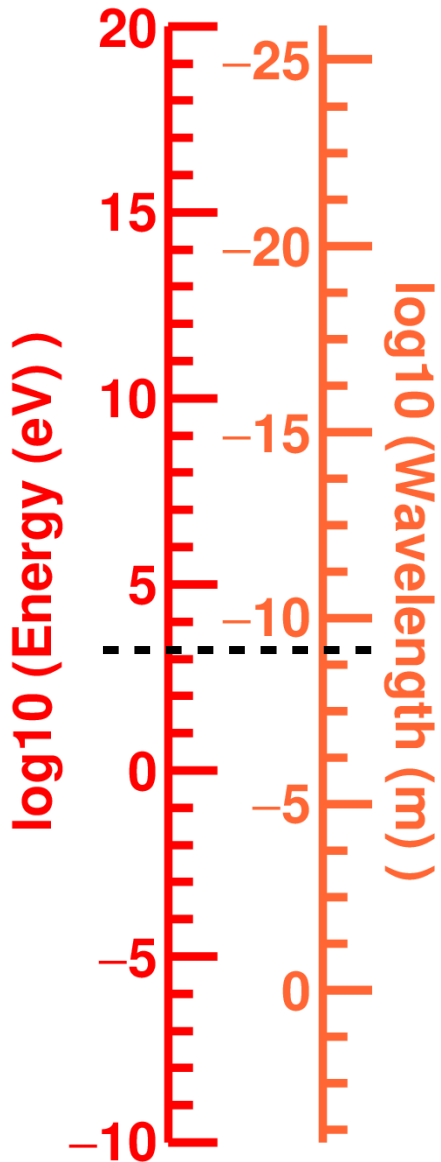
# Ultravioleta

$$E \sim 100 \text{ eV} \Leftrightarrow \lambda \sim 10^{-8} \text{ m}$$



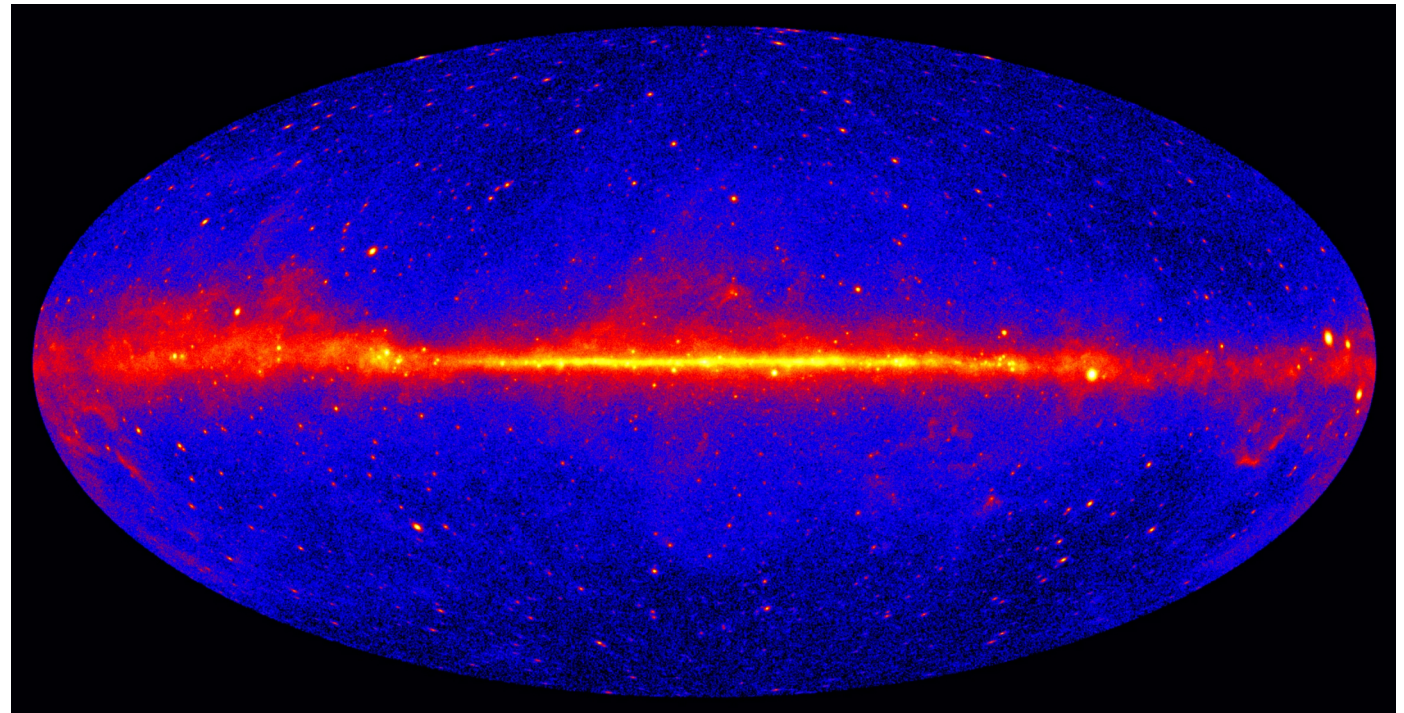
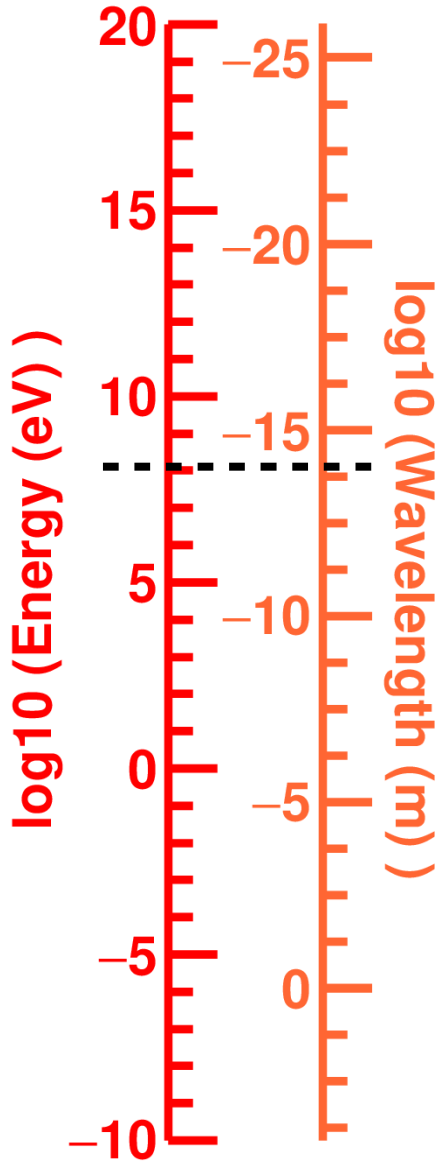
# Raio-X

$$E \sim 1500 \text{ eV} \Leftrightarrow \lambda \sim 10^{-9} \text{ m}$$



# Raios Gama

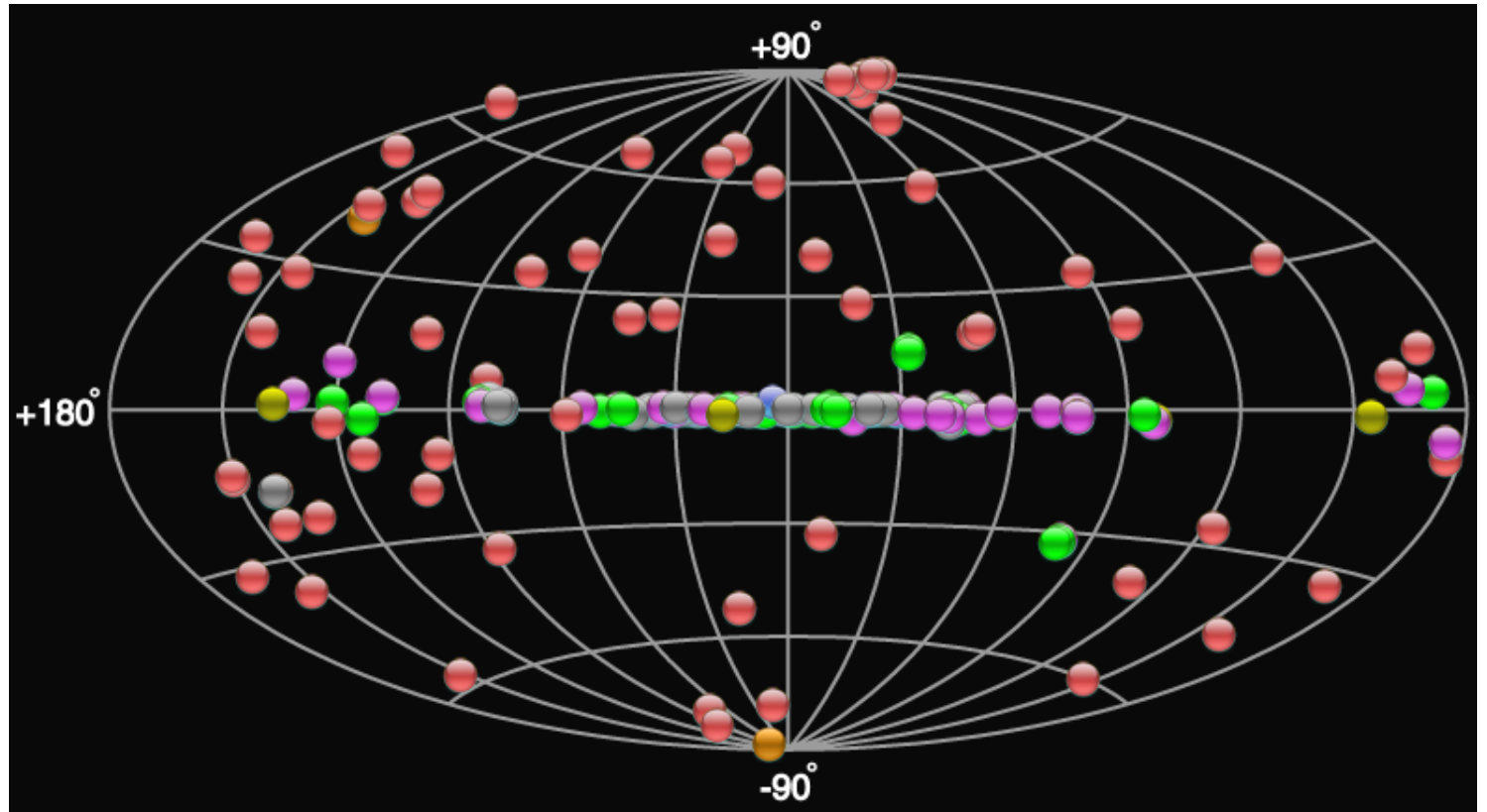
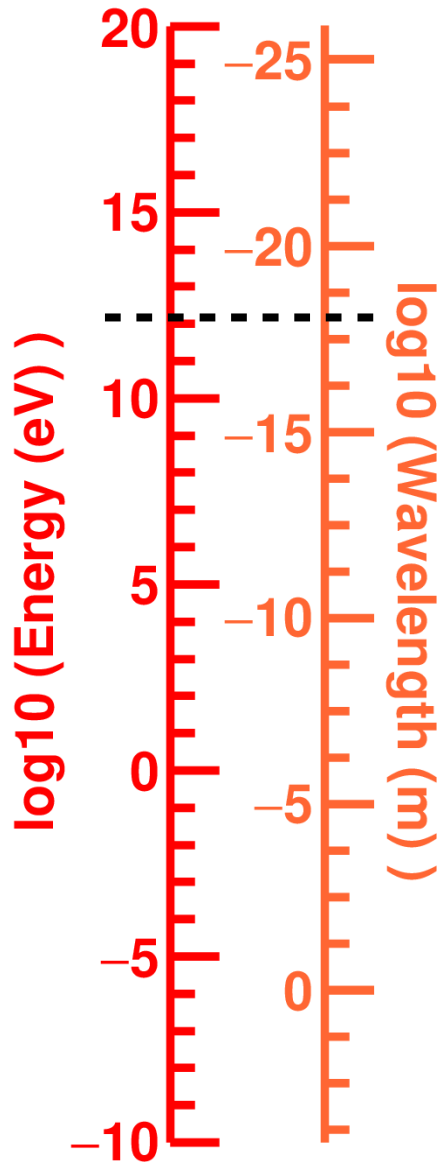
$$E > 10^8 \text{ eV} \Leftrightarrow \lambda < 10^{-14} \text{ m}$$



Fermi-LAT

# Raios Gama TeV

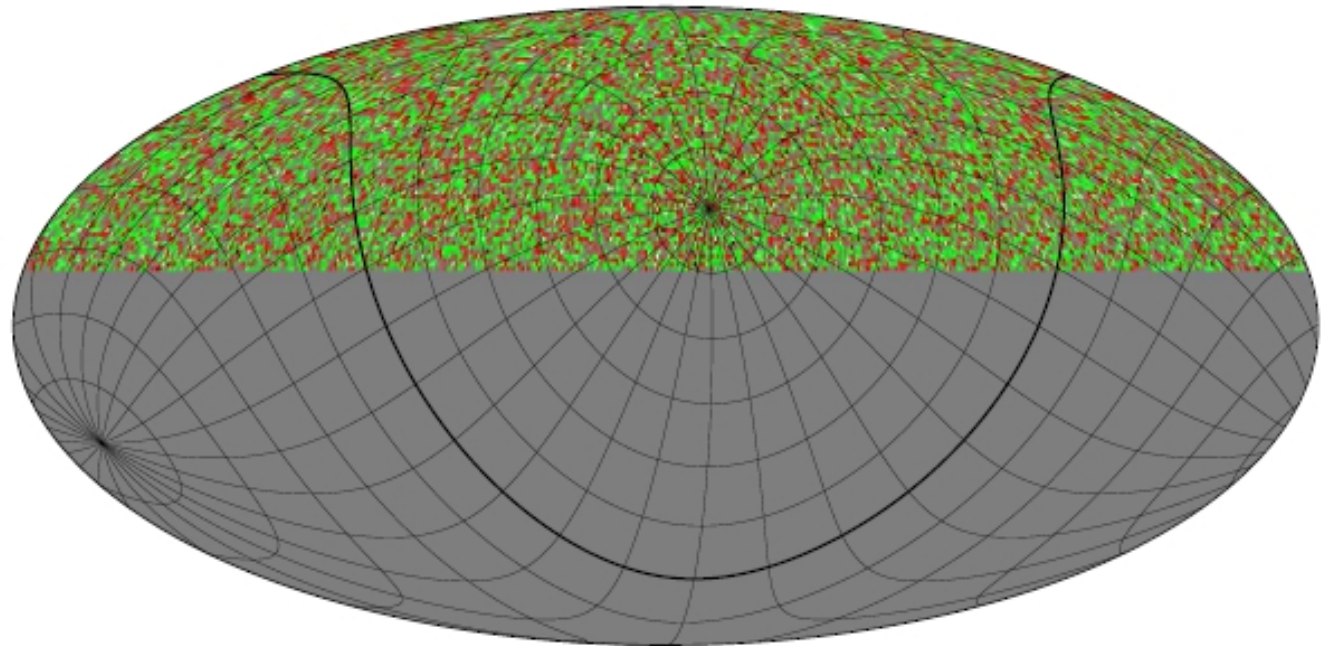
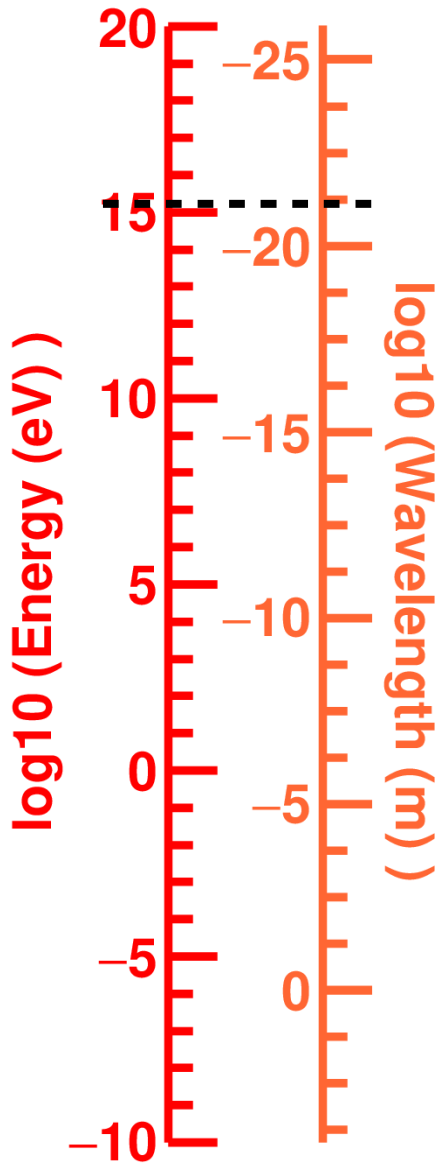
$$E > 10^{12} \text{ eV} \Leftrightarrow \lambda < 10^{-17} \text{ m}$$





# Partículas Carregadas

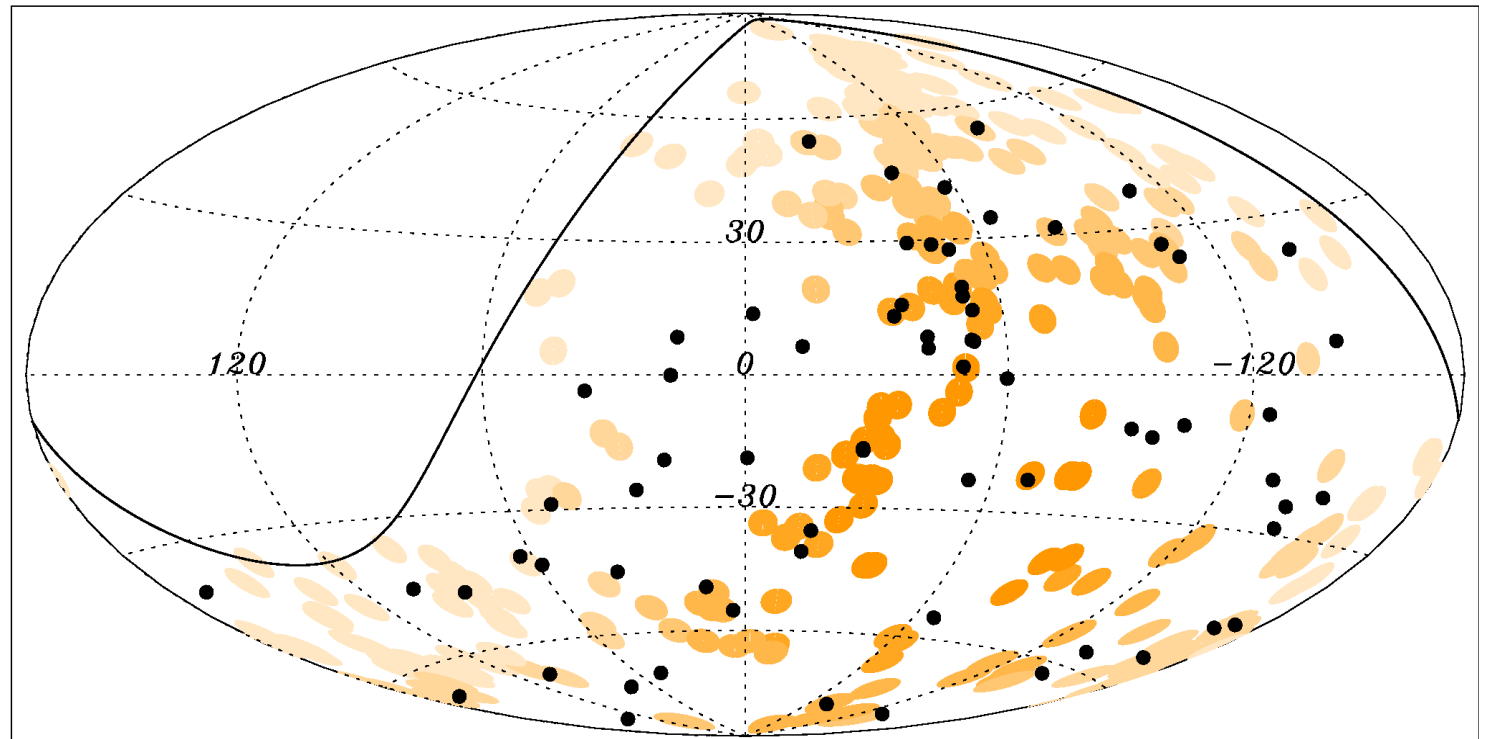
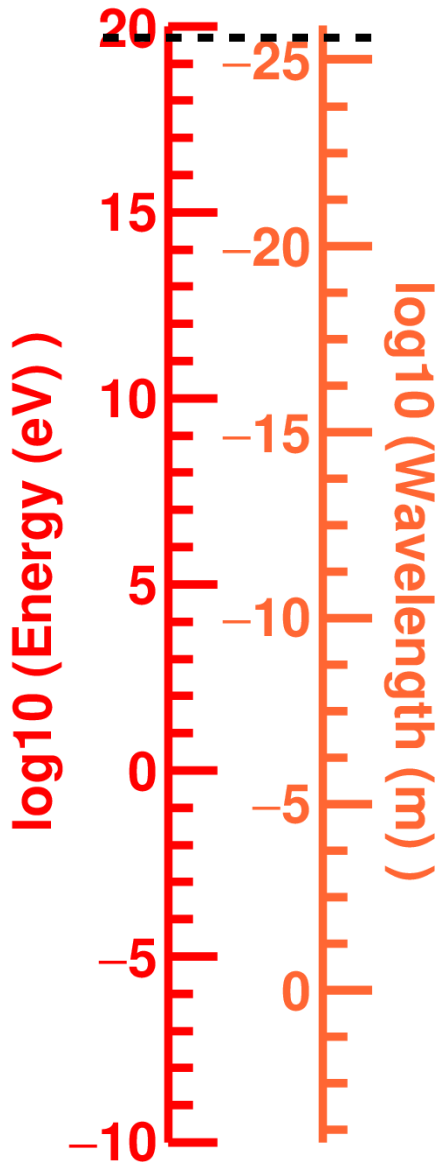
$$E > 10^{15} \text{ eV} \Leftrightarrow \lambda < 10^{-21} \text{ m}$$



KASCADE

# Partículas Carregadas

$$E > 10^{19} \text{ eV} \Leftrightarrow \lambda < 10^{-25} \text{ m}$$

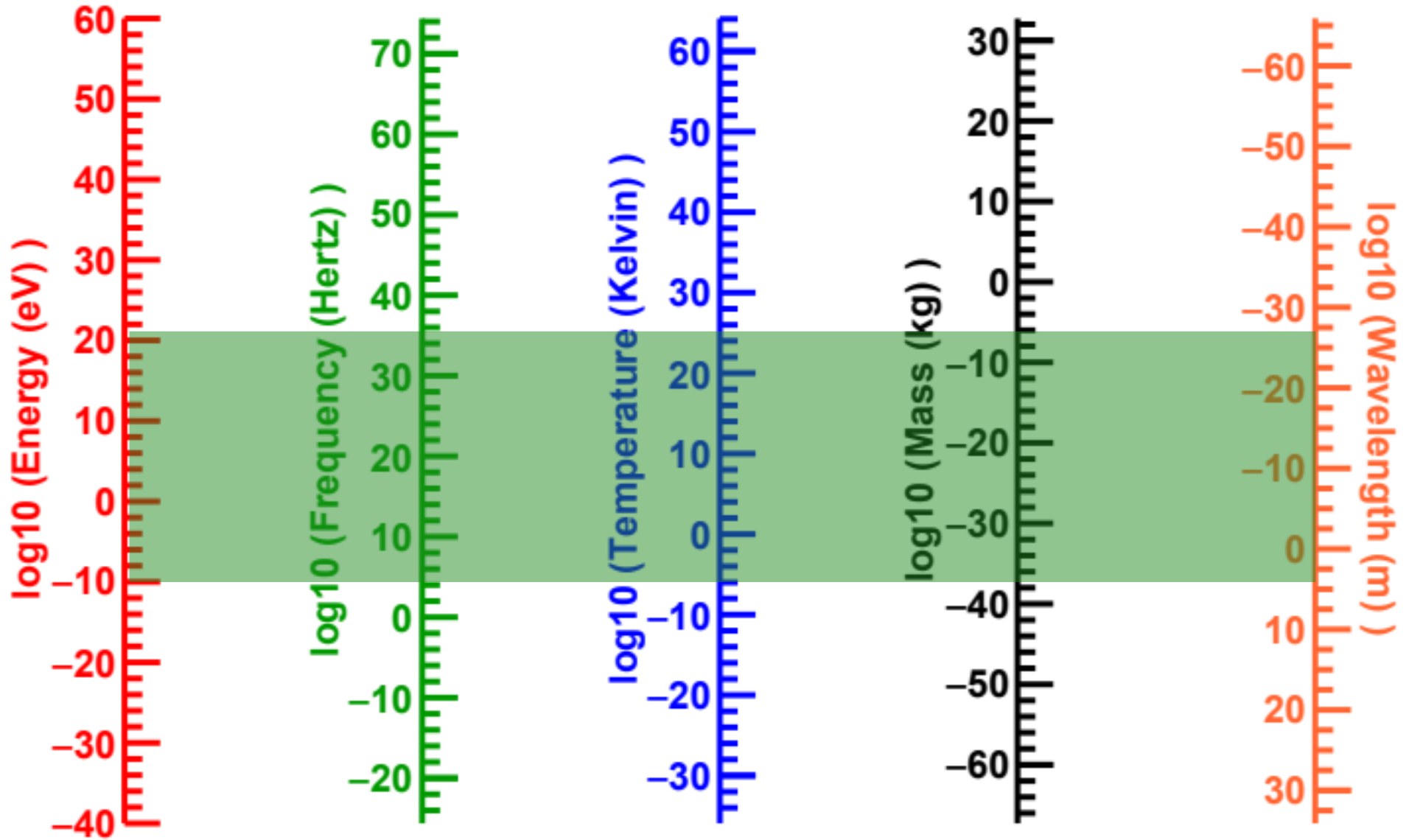


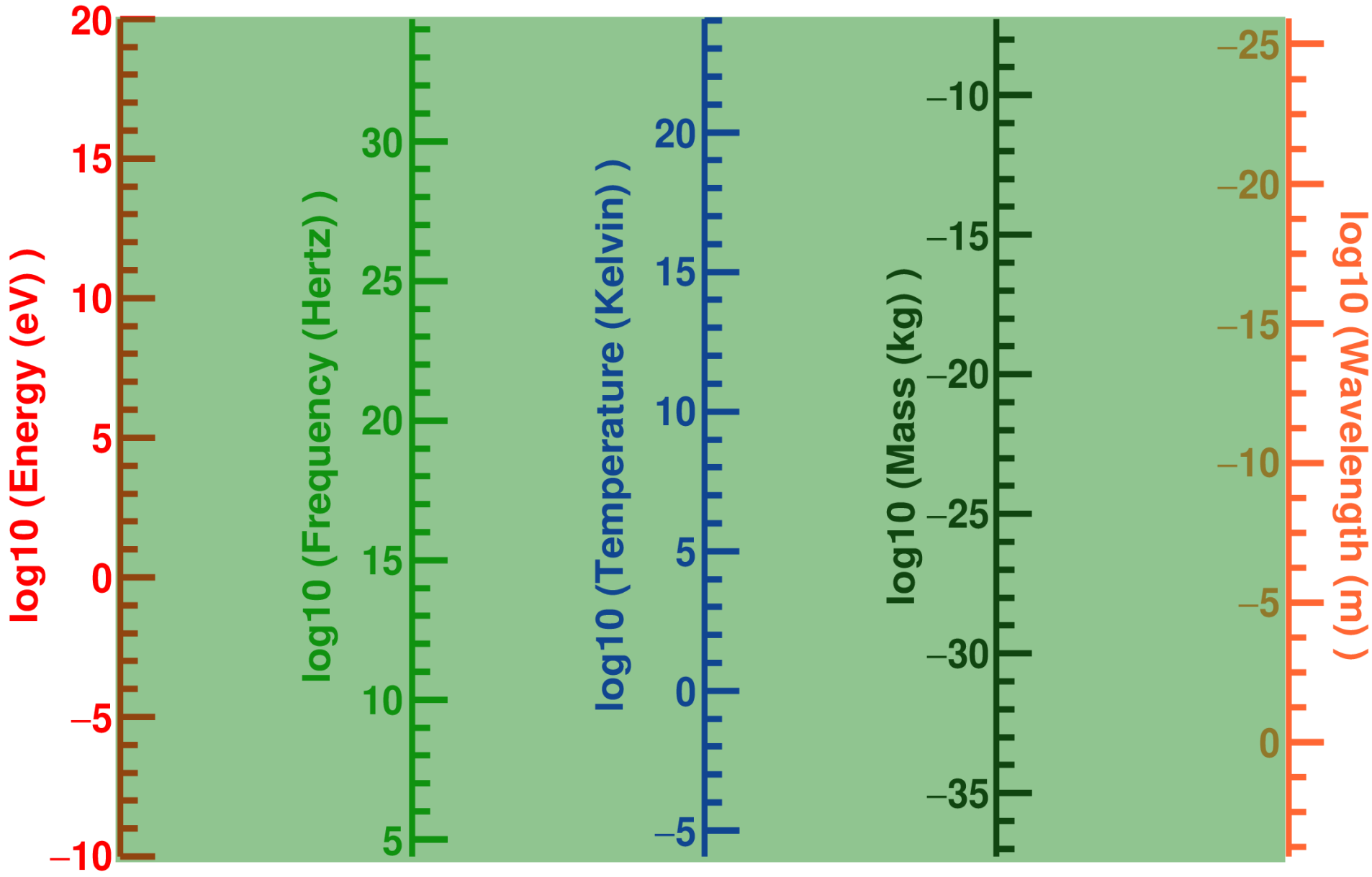
Raios cósmicos EeV =  $E > 10^{18} \text{ eV}$

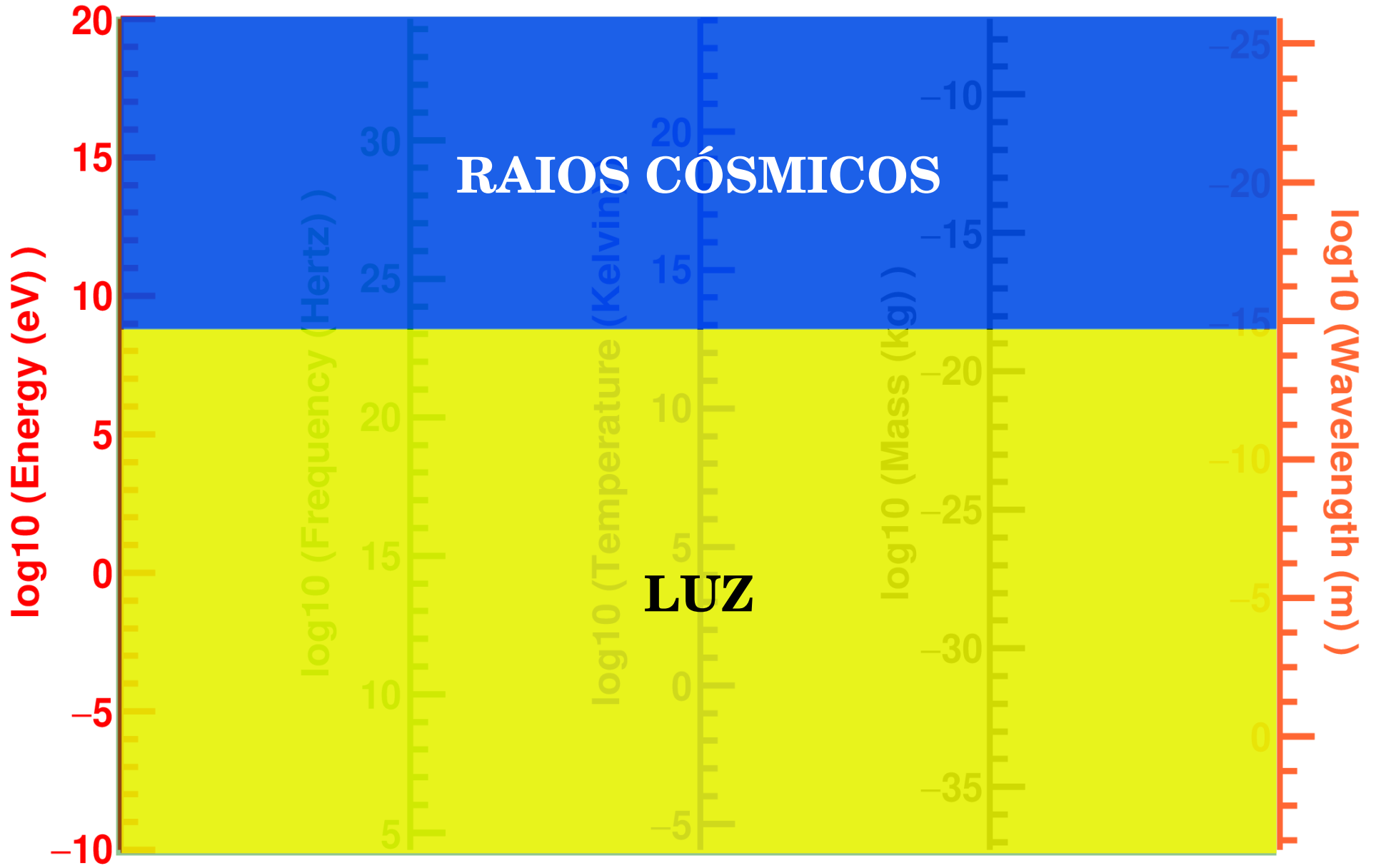
Observatório Pierre Auger

$$1 \text{ eV} = 1.6 \times 10^{-19} \text{ Joule}$$

# Mensageiros extraterrestres











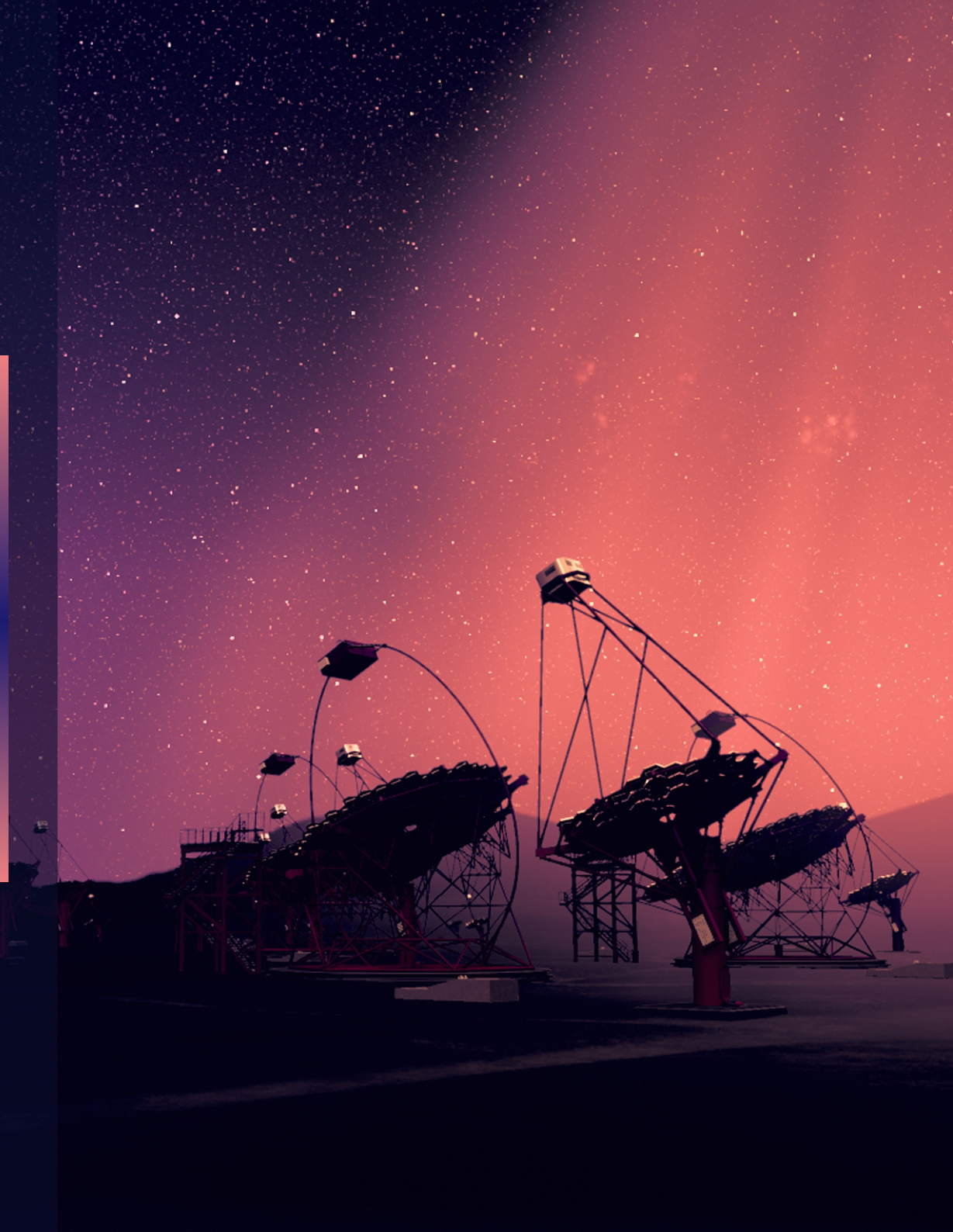
# RAiOs!

mensageiros do cosmos

O QUE ?

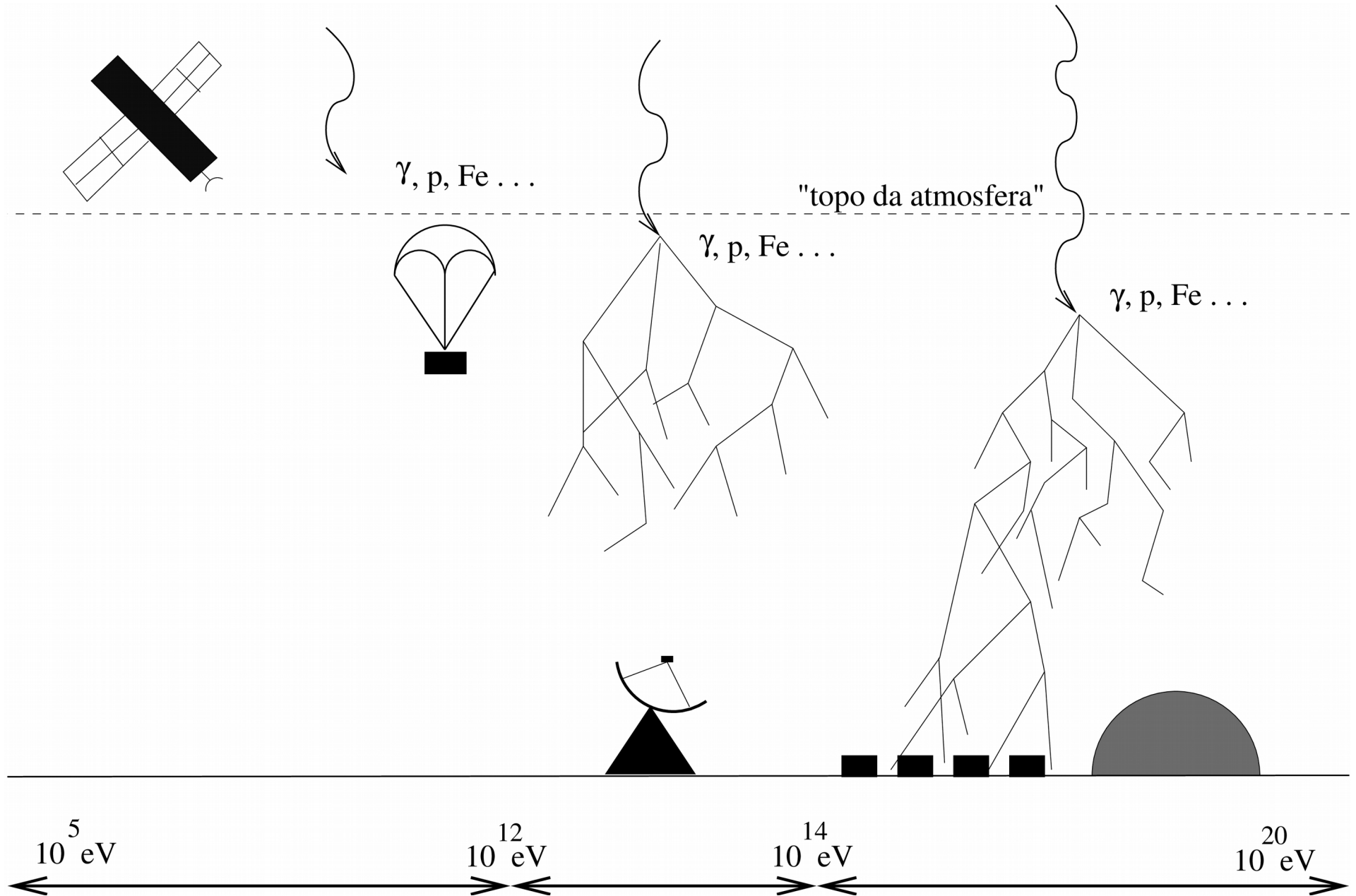
QUEM ?

ENERGIA ?

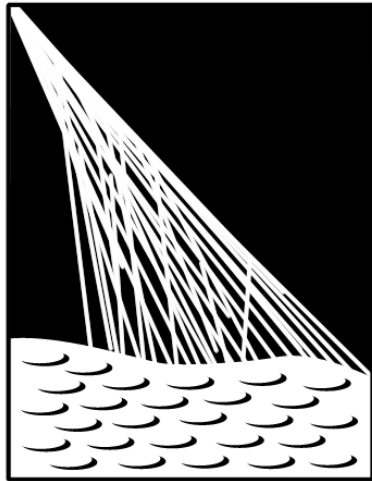




# Astrofísica de Partículas - Experimentos



# Experimentos em que participamos



PIERRE  
AUGER  
OBSERVATORY

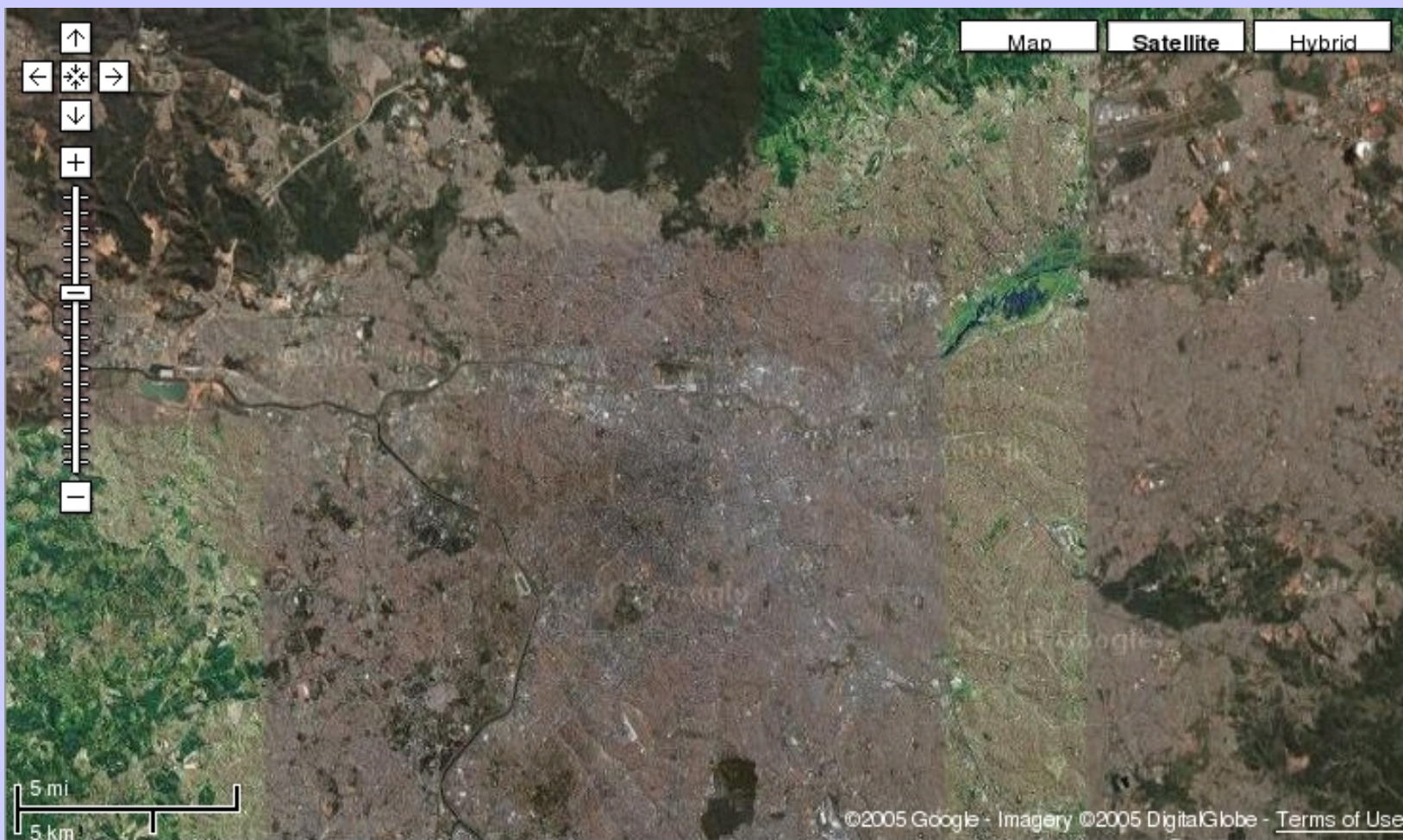
Partícula  
carregadas



Raios gama

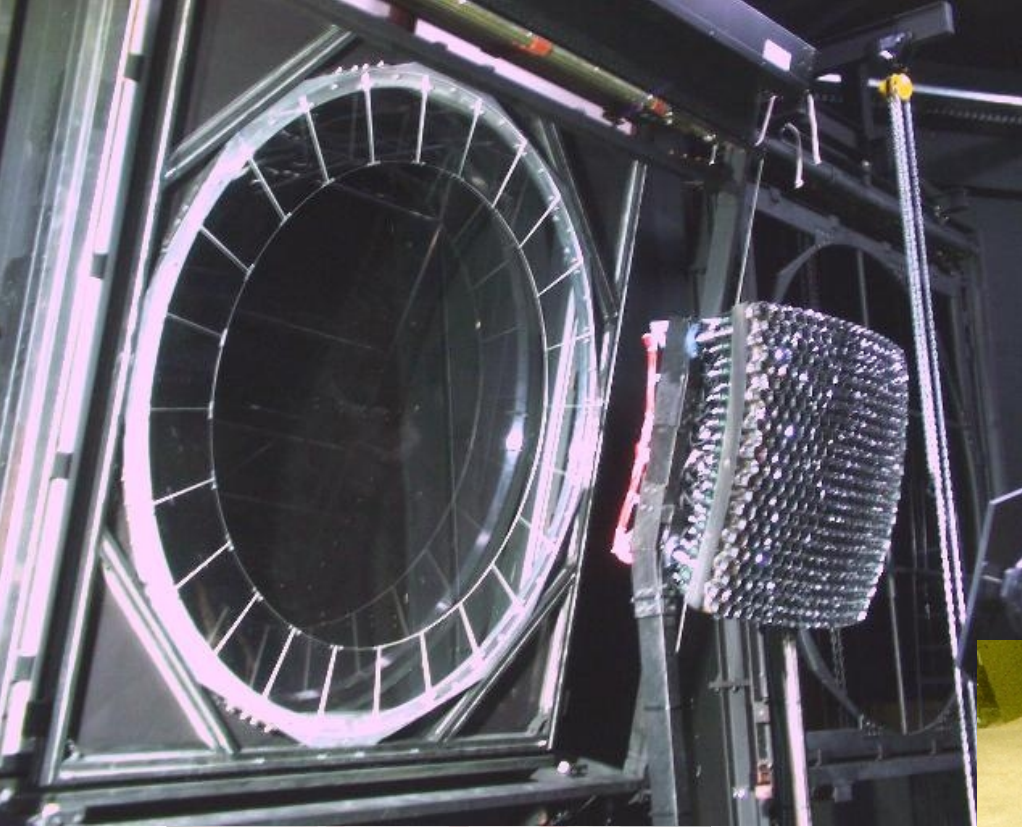
<https://www.auger.org/index.php/gallery/videos>

# Observatório Auger



50 km

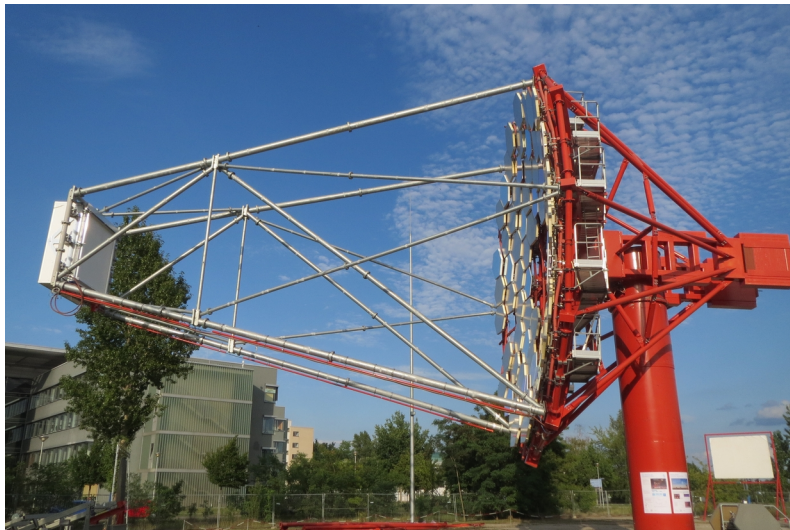
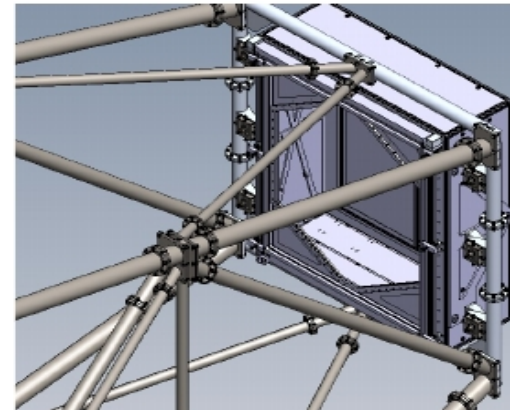
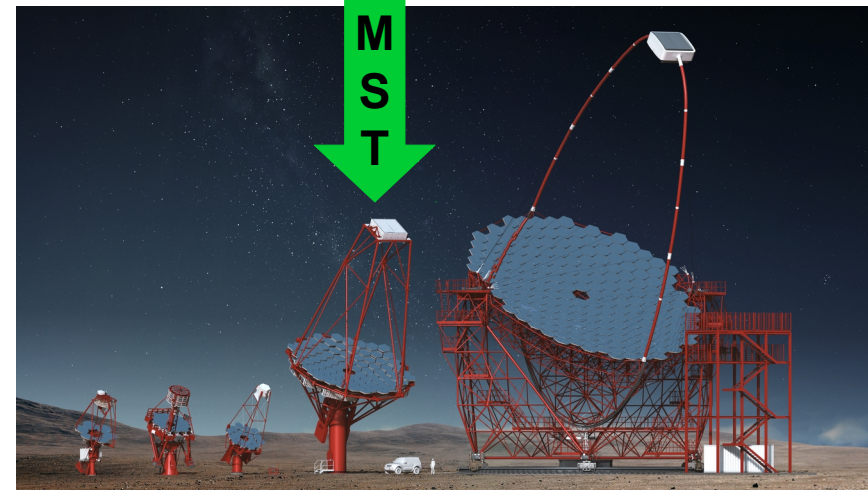
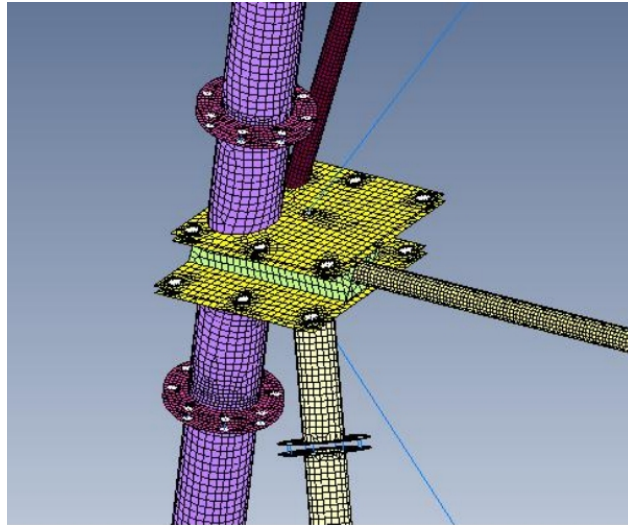
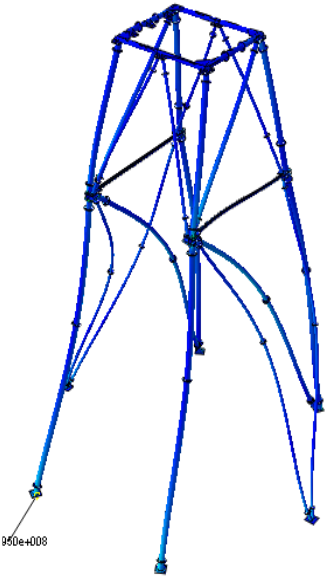
60 km



**PROJETO, CONSTRUÇÃO E INSTALAÇÃO  
DAS ESTRUTURAS  
DO TELESCÓPIOS DE FLUORESCÊNCIA.**

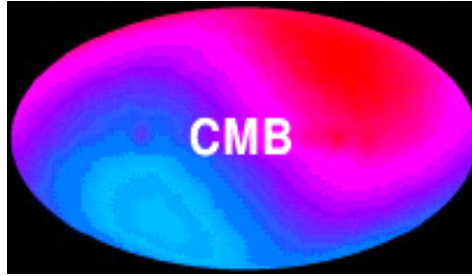
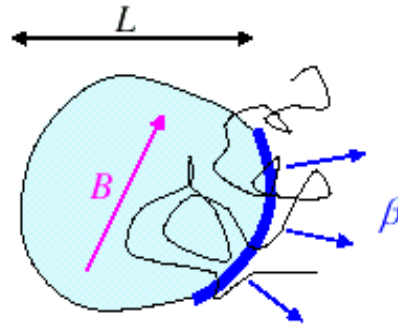
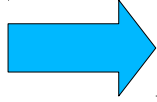
<https://www.cta-observatory.org/outreach-education/multimedia/>

# Construindo Telescópios no Brasil

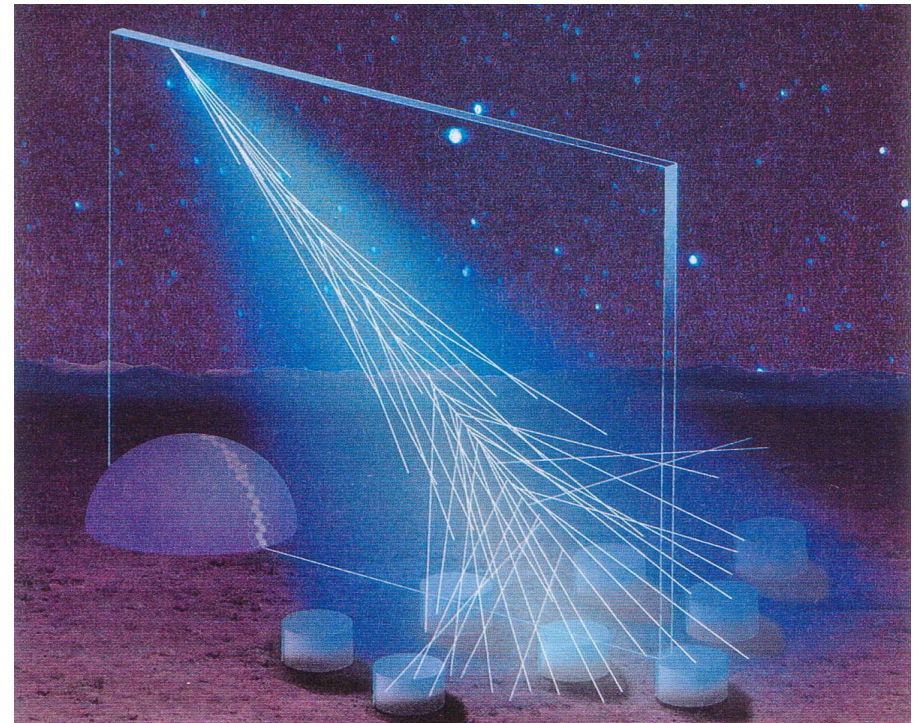
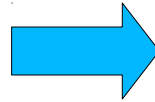
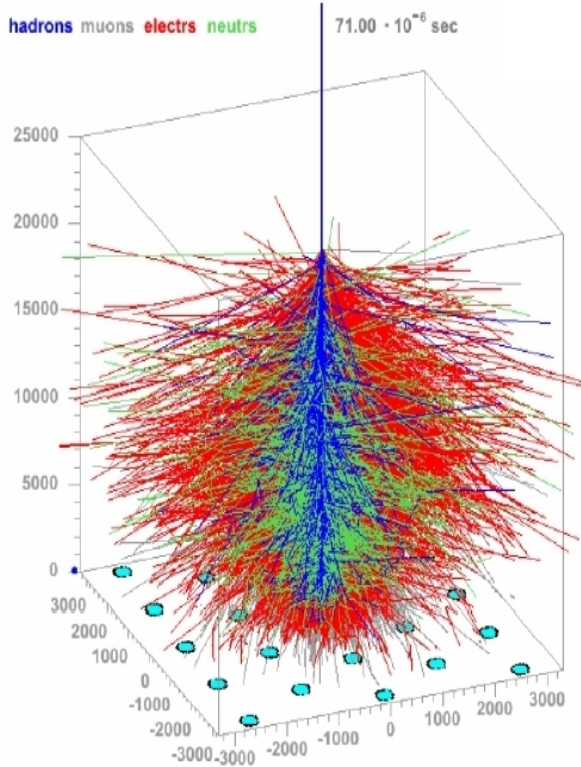


IFSC

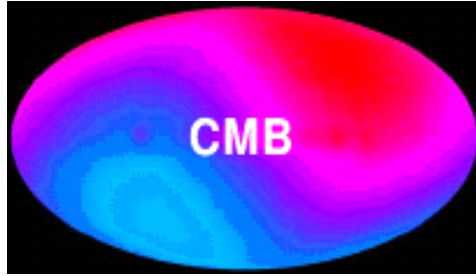
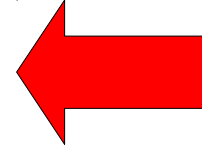
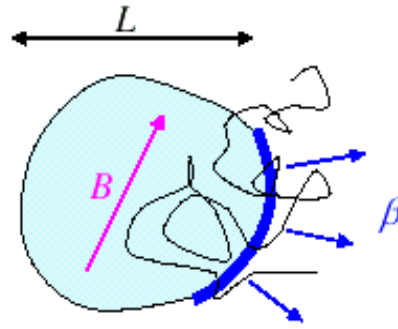
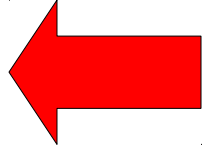




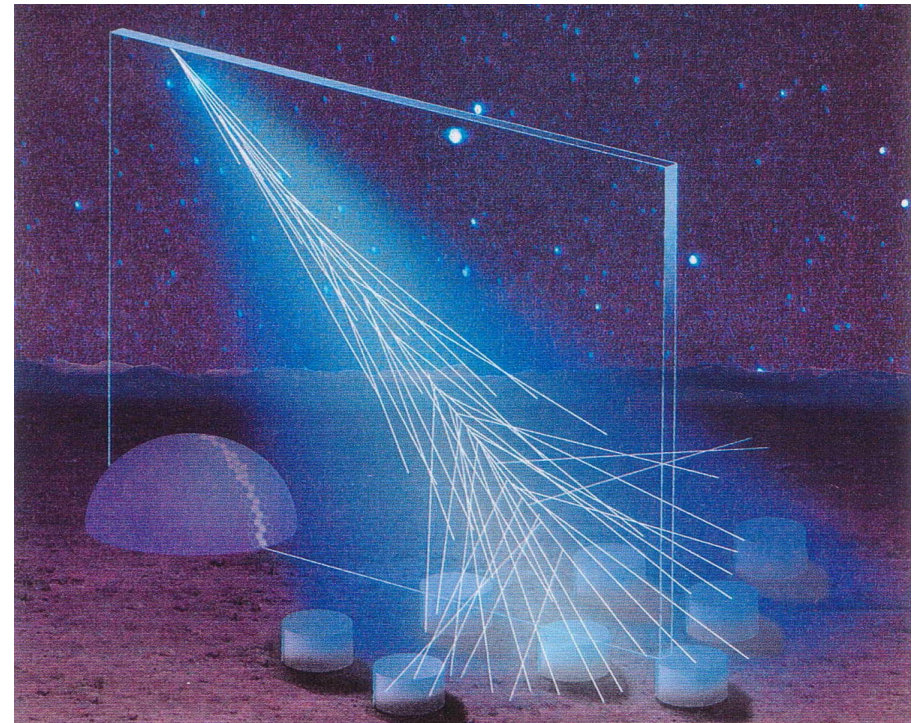
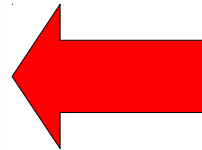
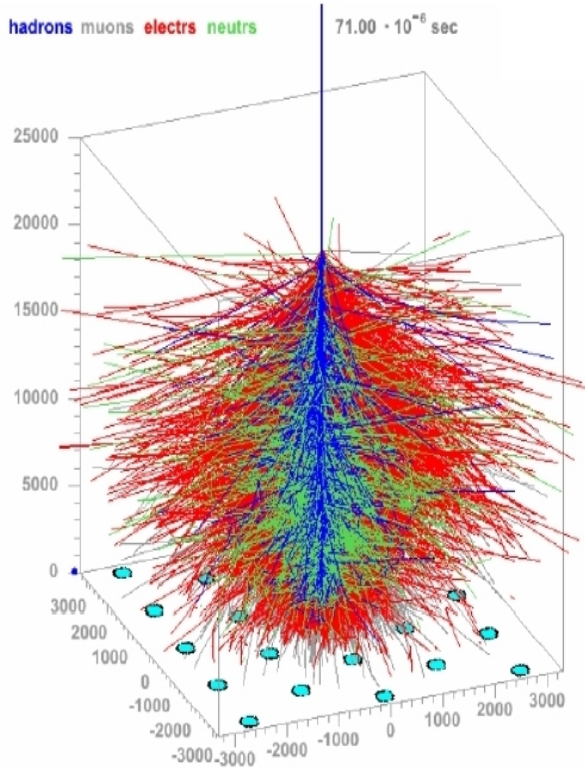
A  
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A  
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R  
A



# RAIOS!

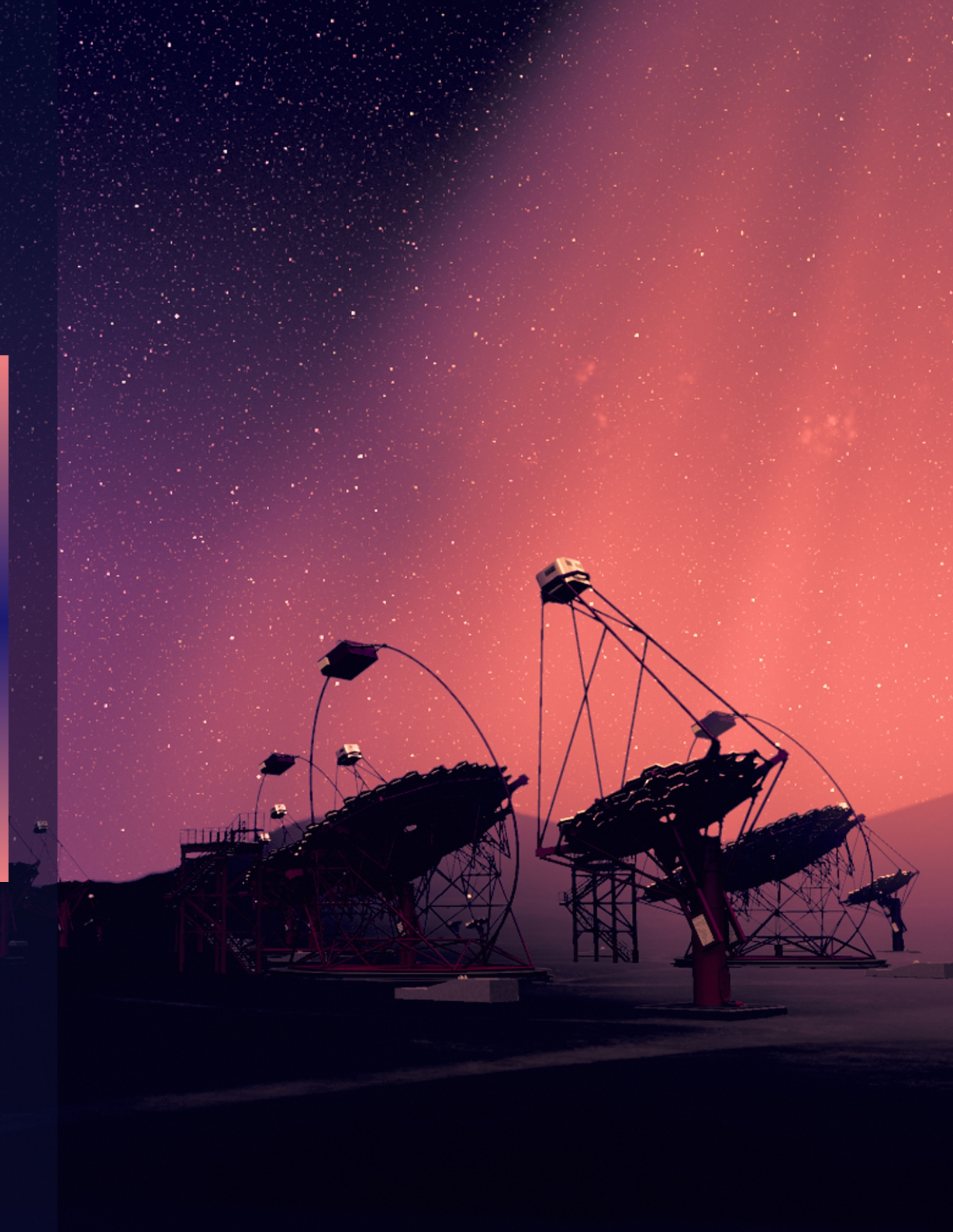
mensageiros do cosmos



O QUE ?

QUEM ?

ENERGIA ?

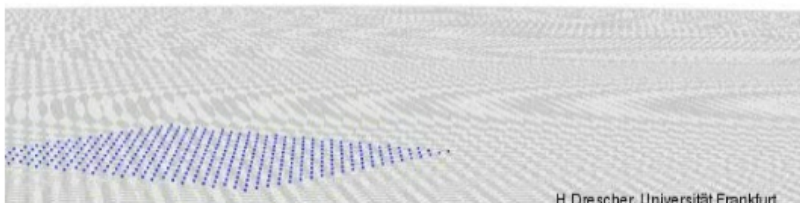


# Ferro

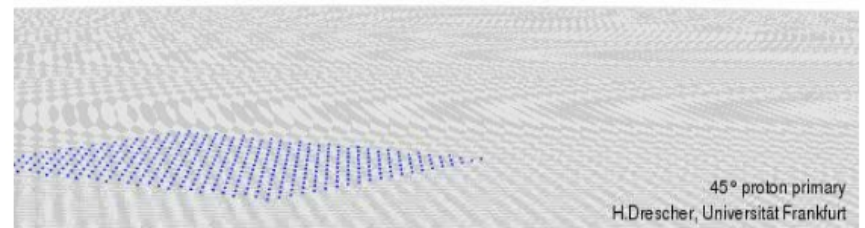


# Próton

time = -160  $\mu$ s



H. Drescher, Universität Frankfurt

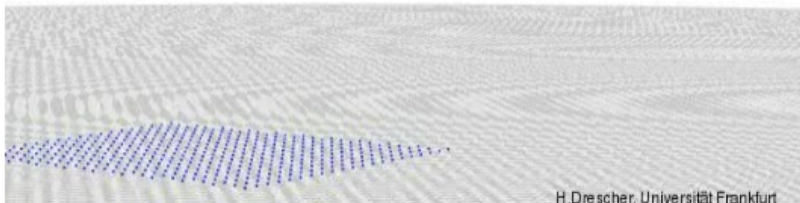


45° proton primary  
H. Drescher, Universität Frankfurt

# Ferro

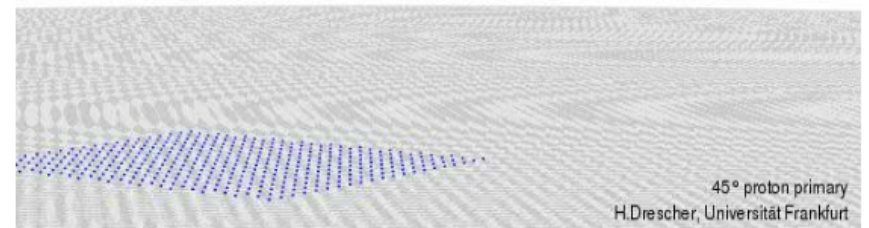


time = -106  $\mu$ s



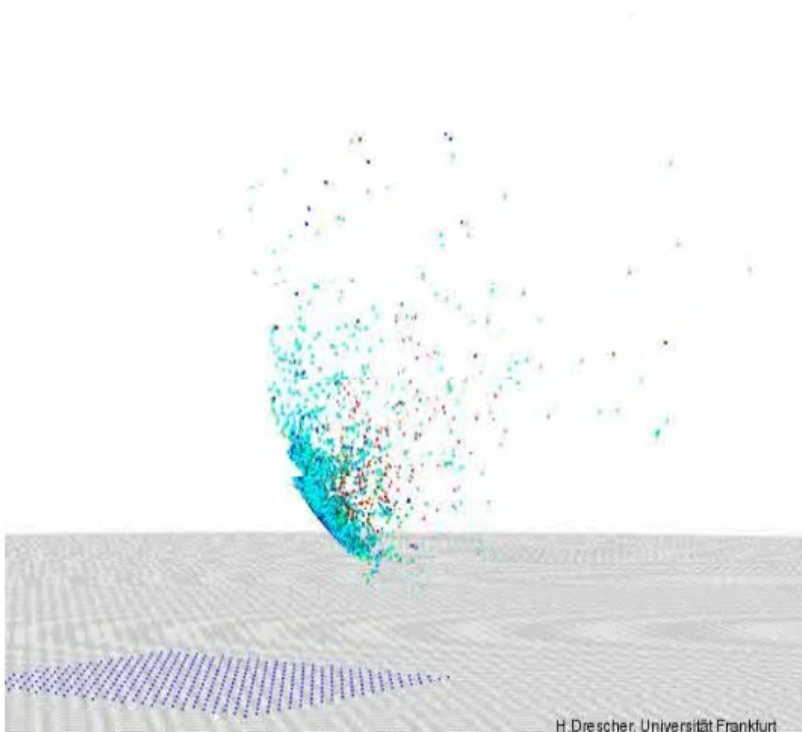
H. Drescher, Universität Frankfurt

# Próton



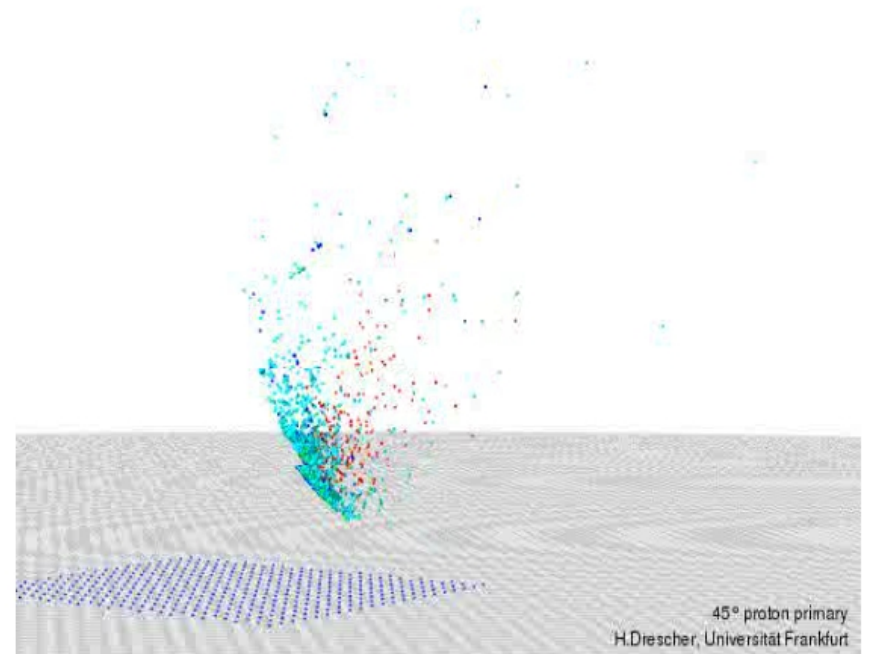
45° proton primary  
H. Drescher, Universität Frankfurt

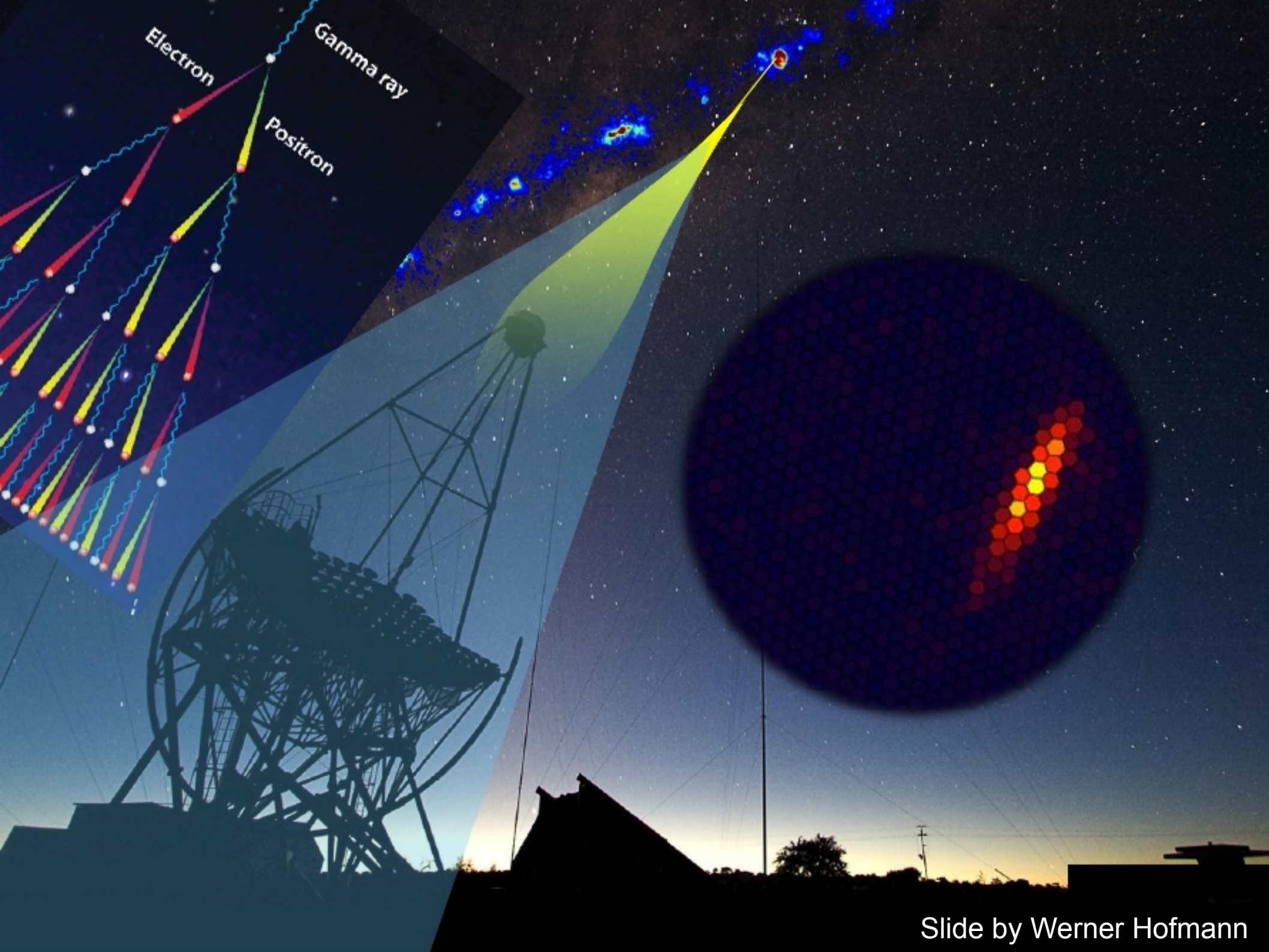
# Ferro



# Próton

time = 43  $\mu$ s



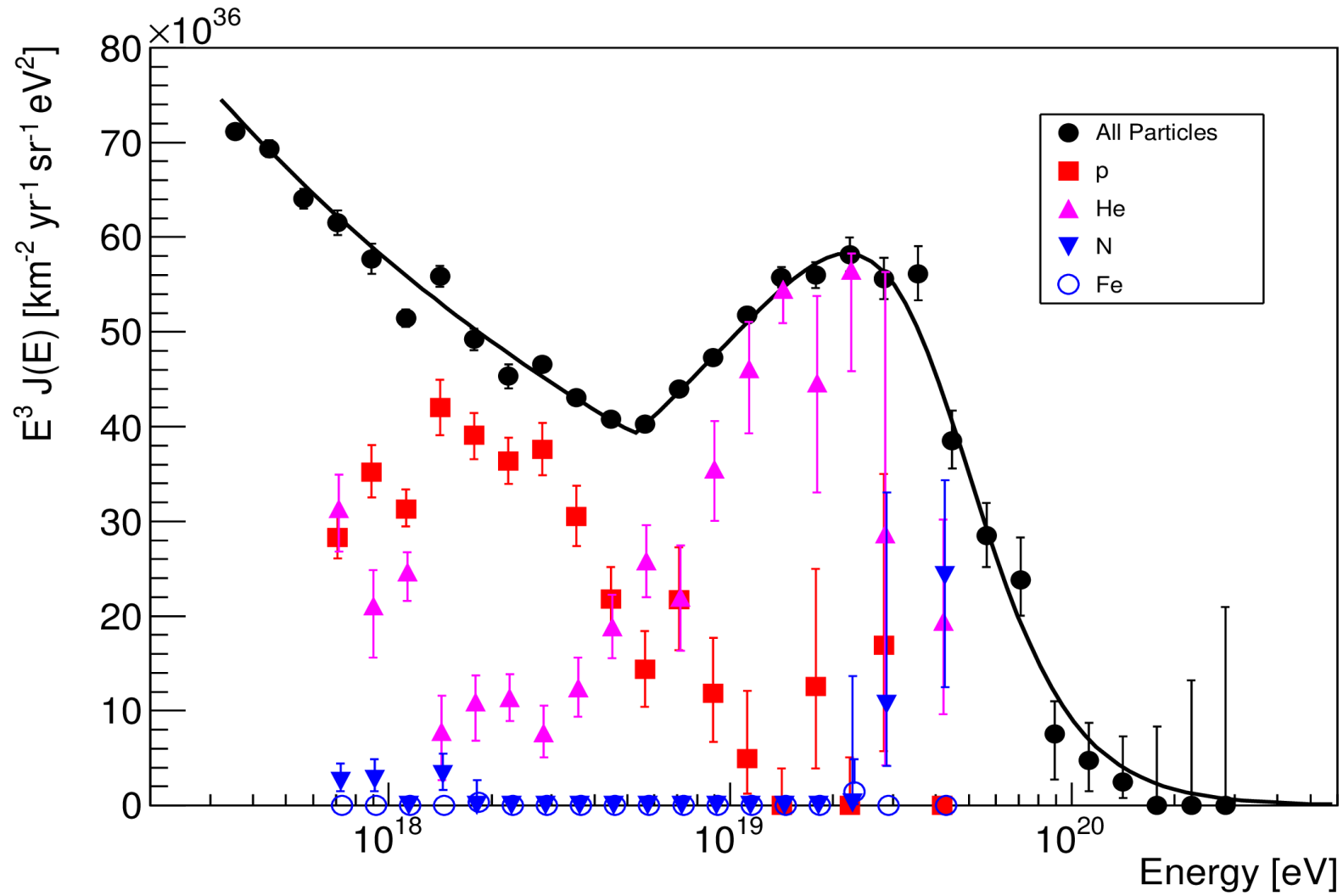


Electron

Gamma ray

Positron

# O que é ?



Massa intermediária !!

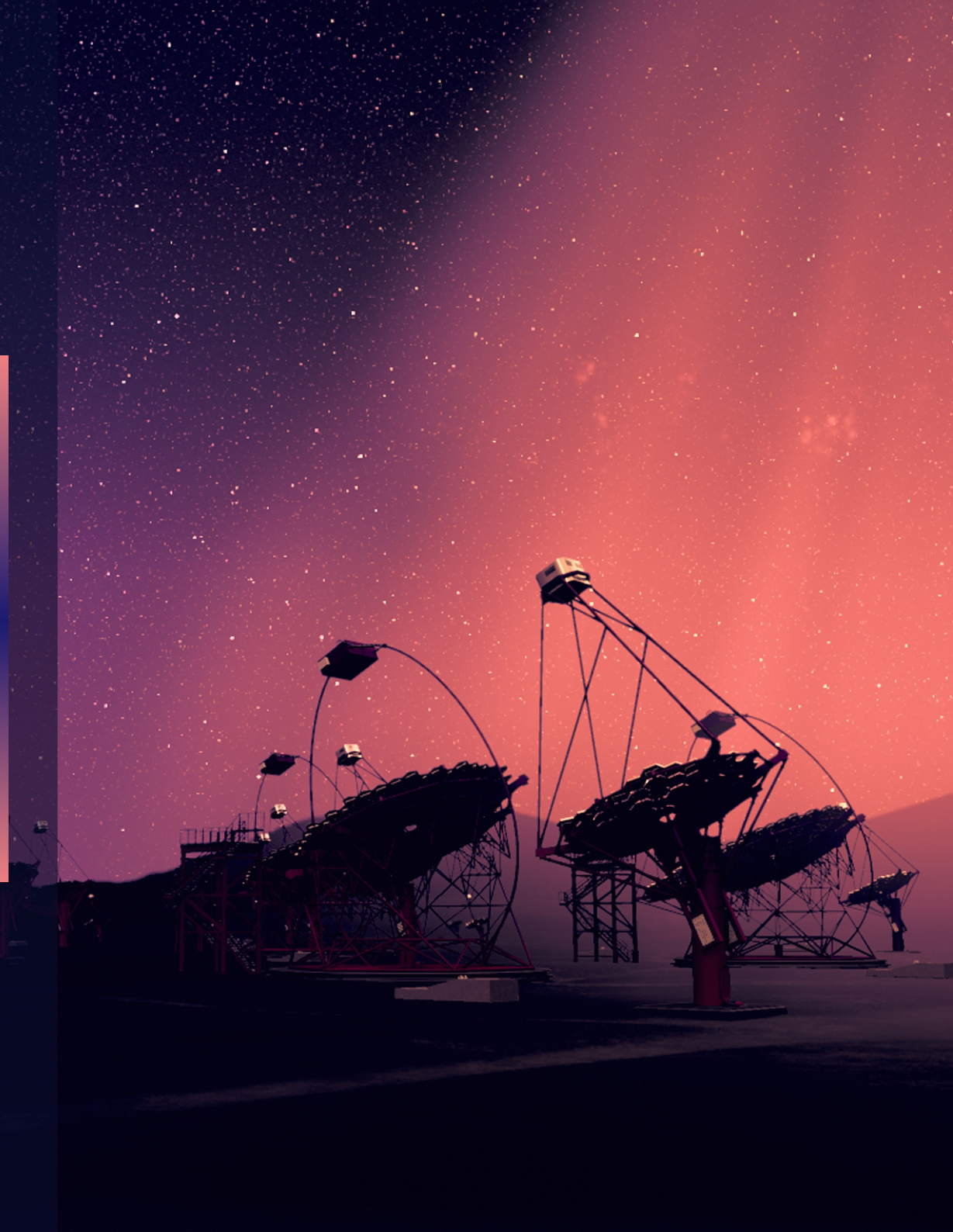
# RAIOS!

mensageiros do cosmos

O QUE ?

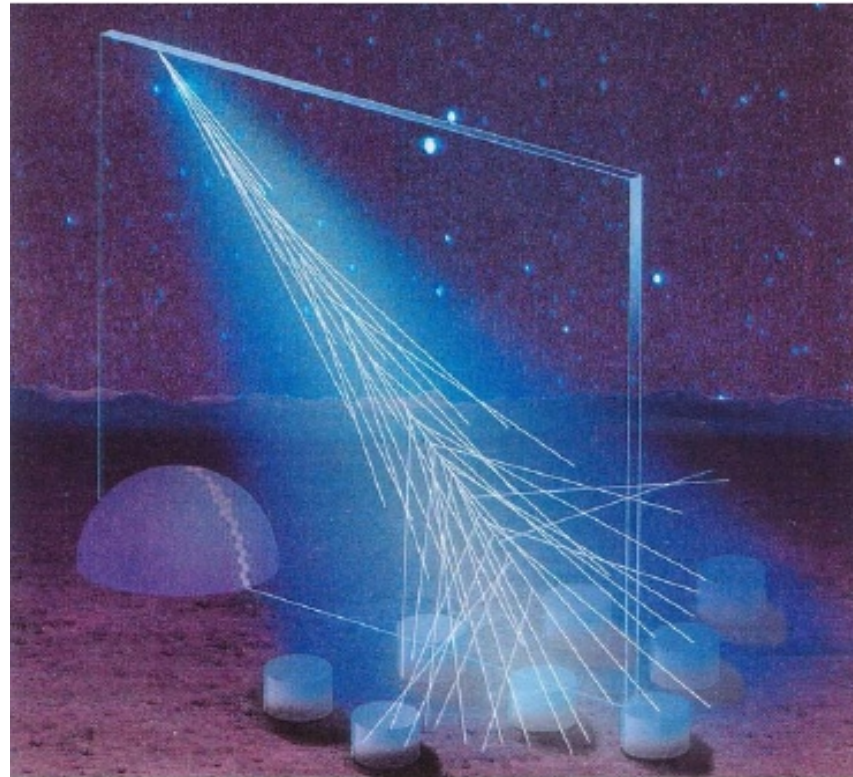
QUEM ?

→ ENERGIA ?

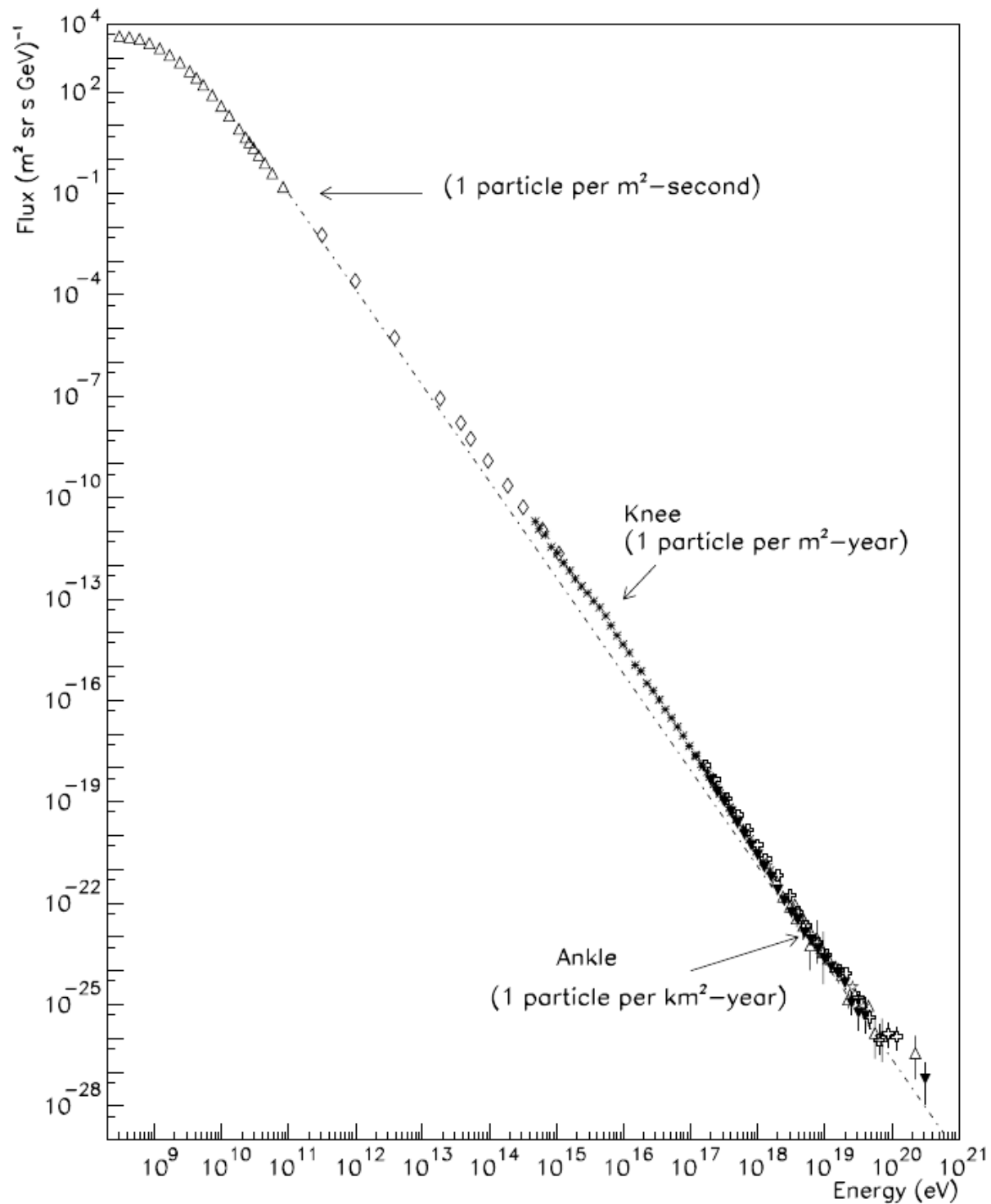




ENERGIA ?



Como determinar a energia ?



Compilation by J. Swordy

# RAIOS!

mensageiros do cosmos

O QUE ?

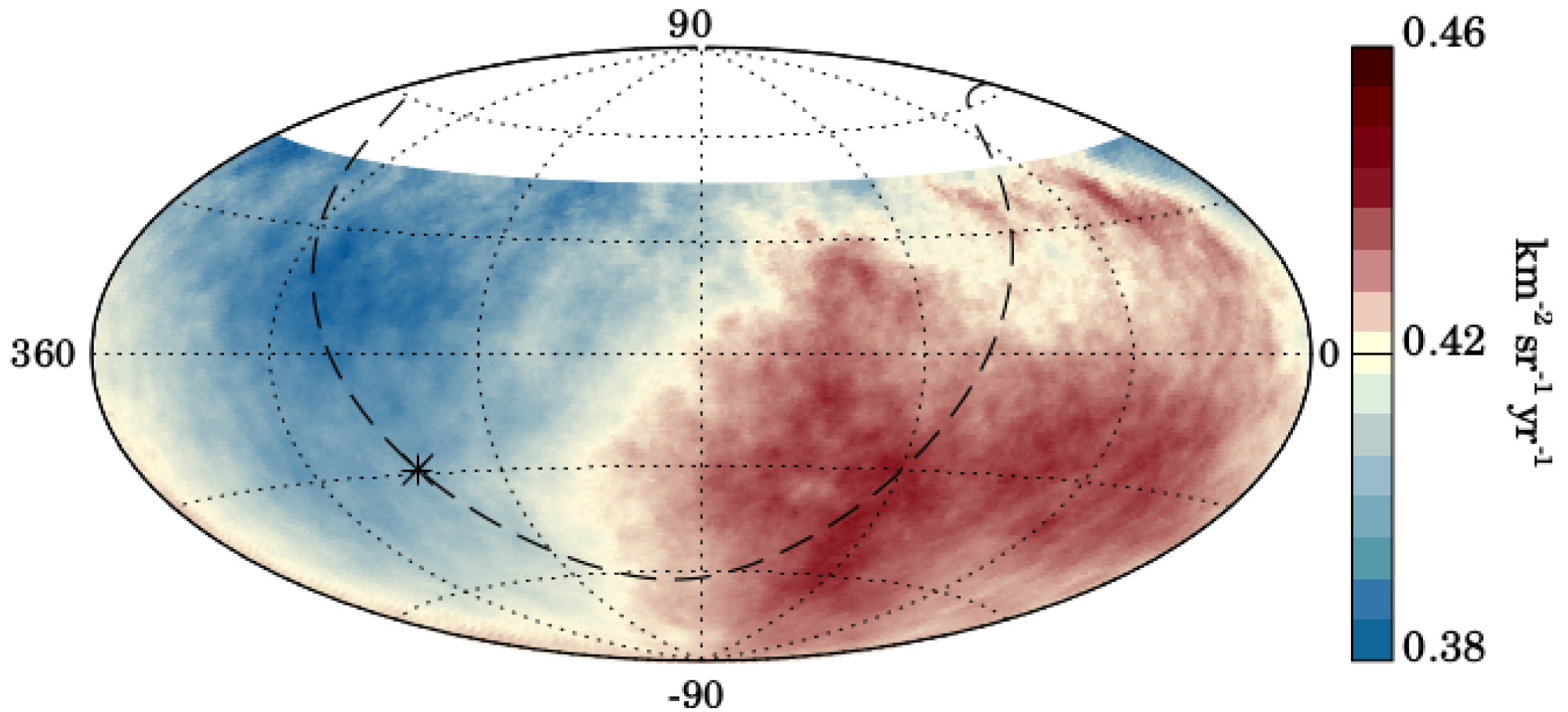


QUEM ?

ENERGIA ?



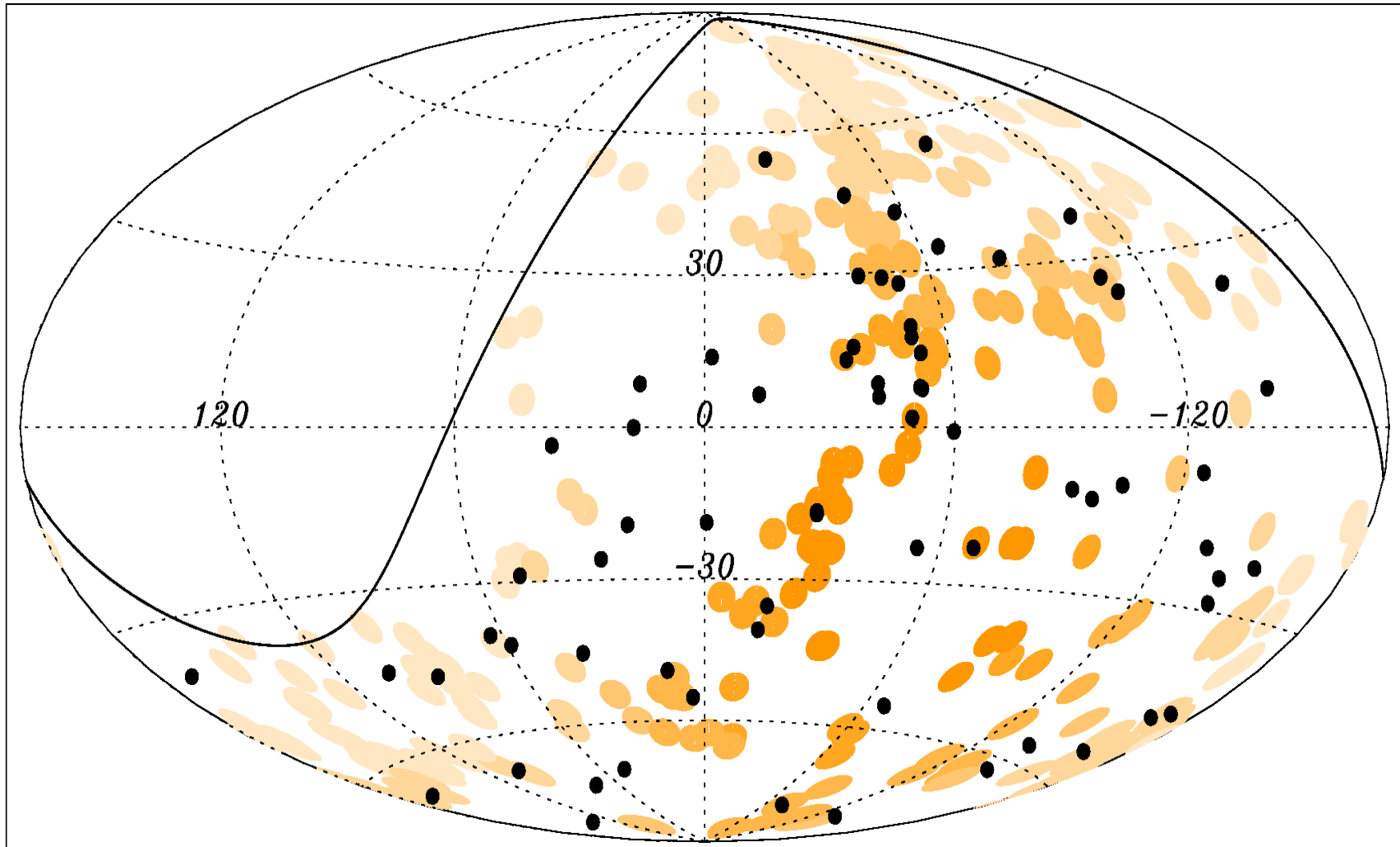
# Quem ?



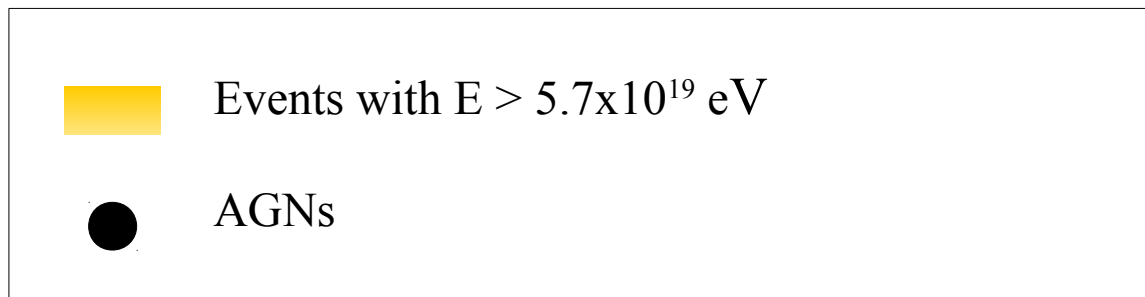
Equatorial coordinates - Hammer projection -  $E > 8 \text{ EeV}$

\* Galactic center

- - - Galactic plane



$$P = 3 \times 10^{-3}$$



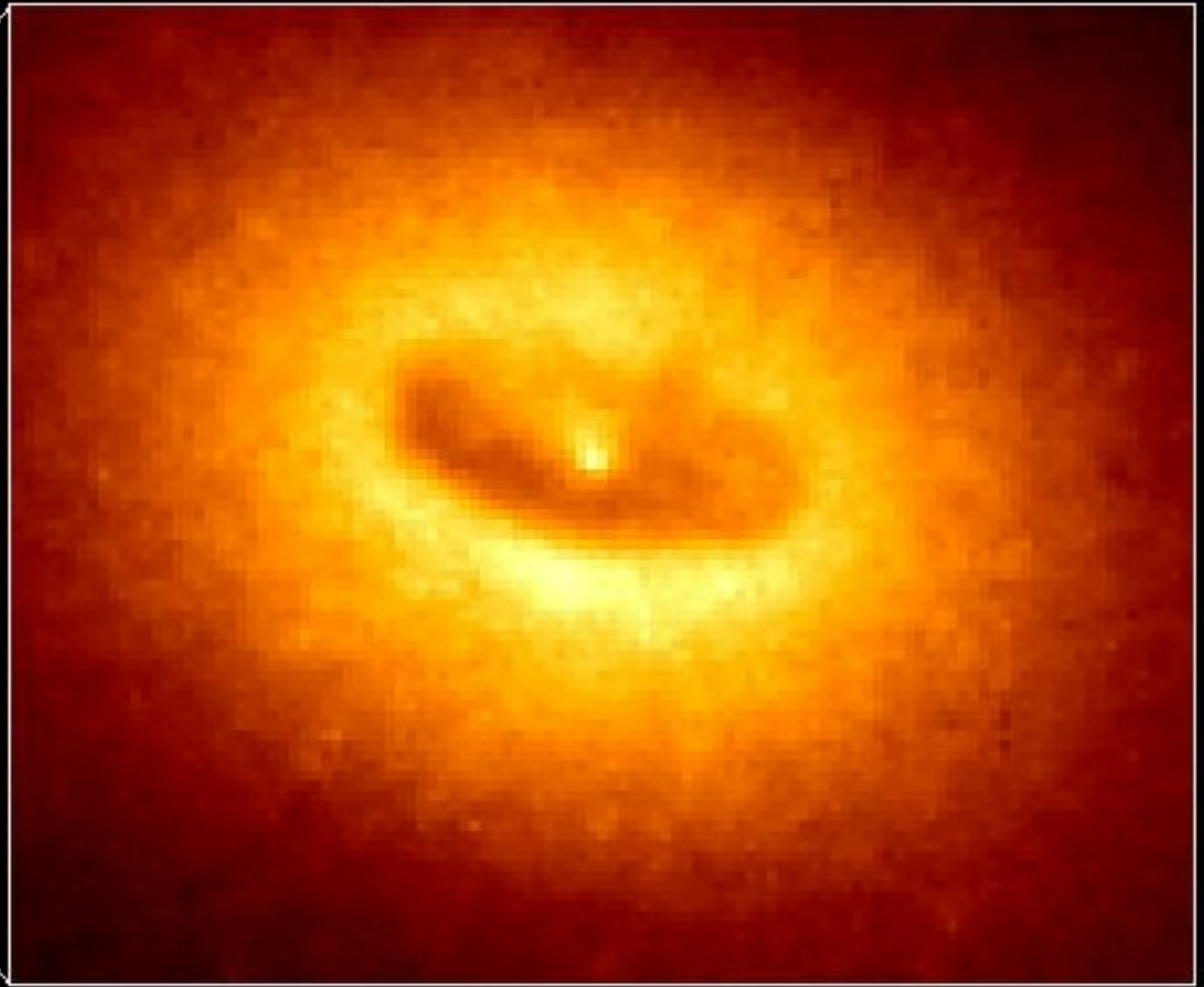
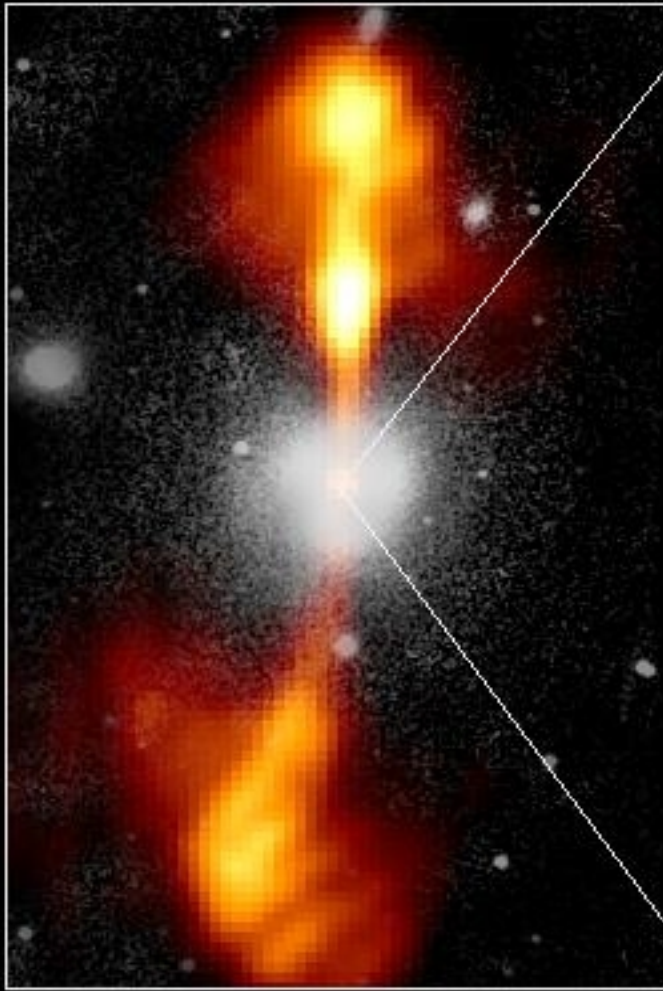
# Core of Galaxy NGC 4261

Hubble Space Telescope

Wide Field / Planetary Camera

Ground-Based Optical/Radio Image

HST Image of a Gas and Dust Disk



380 Arc Seconds  
88,000 LIGHTYEARS

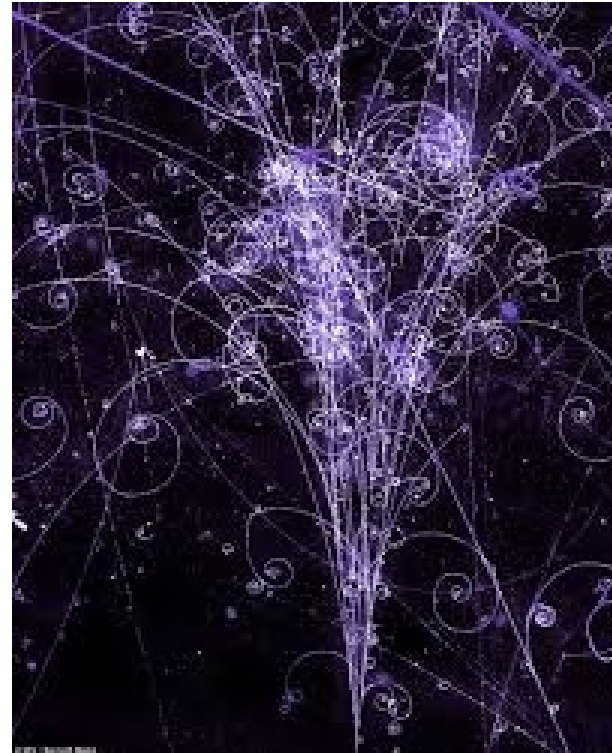
17 Arc Seconds  
400 LIGHTYEARS

# Raios C3smicos



Part3culas

Astro





# O que são raios cósmicos ?

Vitor de Souza

