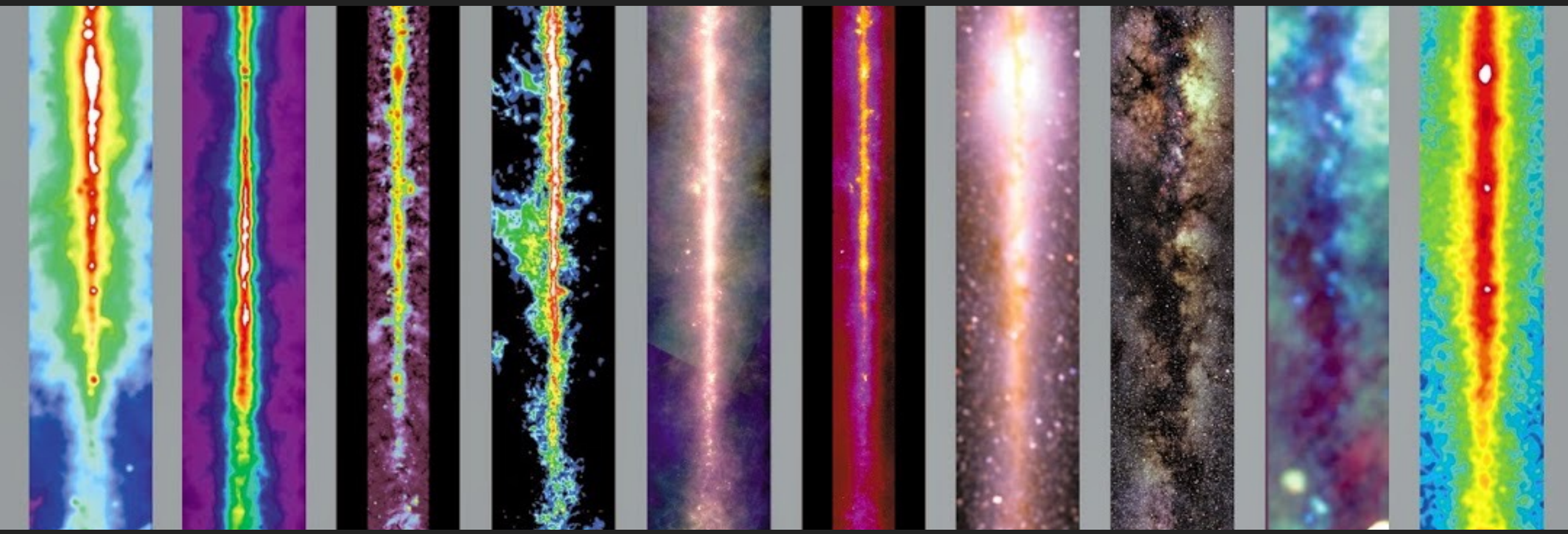


ALLE PIÙ ALTE ENERGIE…

GAMMA-RAY ASTROPHYSICS

Physics Torino Department of Excellence

INFN Istituto Nazionale di Fisica Nucleare

Fermi

UNITÀ DI LUNGHEZZA

Unità Astronomica (UA)

- "Distanza media tra Terra e Sole"
- Si ricava attraverso la misura del periodo: terza legge di Keplero

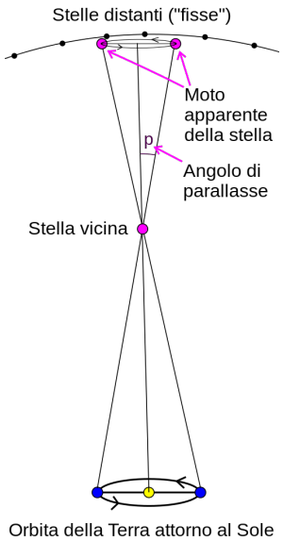
$$T^2 = \frac{4\pi^2\mu}{k}a^3 \qquad \mu = \frac{mm'}{m+m'} \qquad k = Gmm'$$

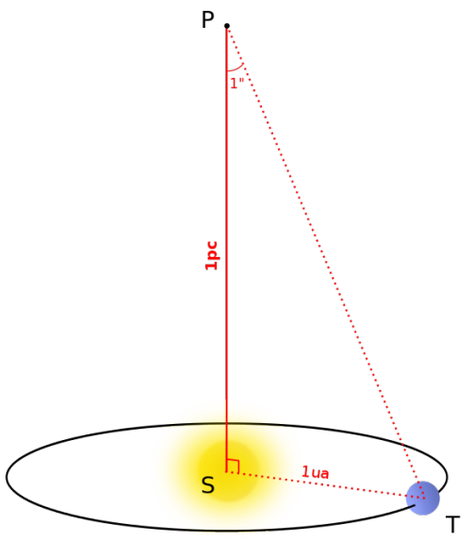
$$AU = 1.496 \cdot 10^{11} m$$

Parsec (pc)

- "Distanza di una stella con PARallasse annua di 1 SECondo d'arco"

$$pc = 3.086 \cdot 10^{16} m$$





Anno luce (al o ly)

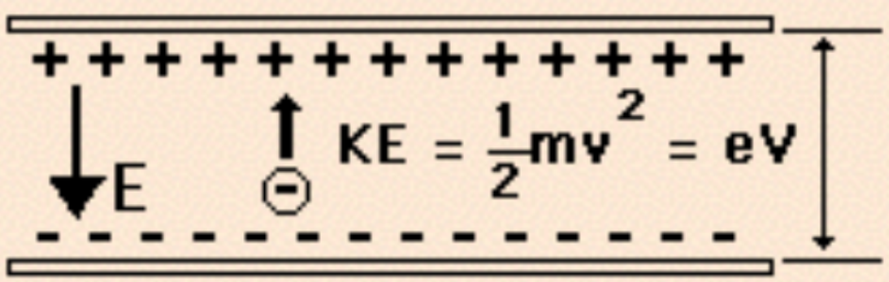
- "Distanza percorsa dalla luce in un anno"

$$al = 9.461 \cdot 10^{15} m$$

UNITÀ DI ENERGIA

Electron Volts

A convenient energy unit, particularly for atomic and nuclear processes, is the energy given to an electron by accelerating it through 1 volt of electric potential difference. The work done on the charge is given by the charge times the voltage difference, which in this case is:



$$E = qV = (1.6 \times 10^{-19}\ C)(1\ \frac{J}{C})$$

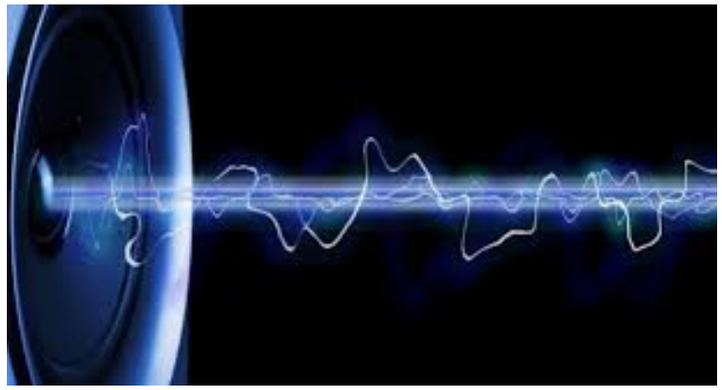
$$1 \text{ electron volt} = 1.6 \times 10^{-19}\ J$$

e = electron charge = 1.6×10^{-19} C
V = voltage

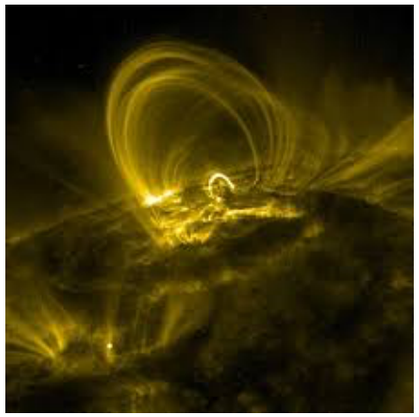
The abbreviation for electron volt is eV.

FENOMENI ONDULATORI

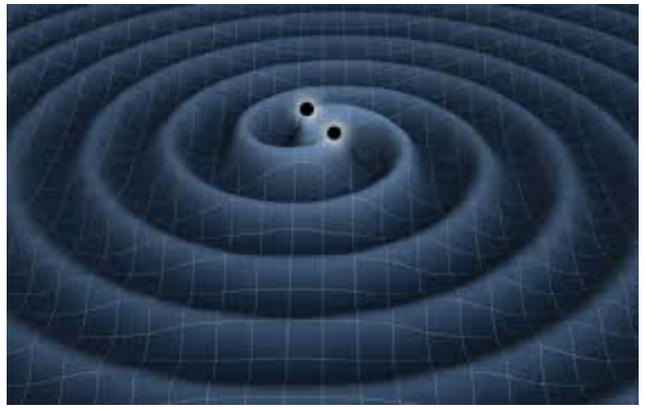
- Onde Meccaniche



- Onde elettromagnetiche

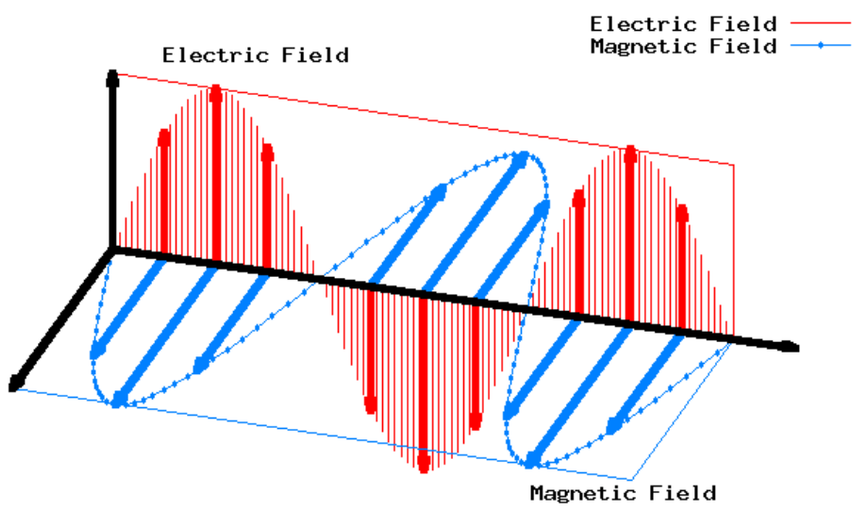


- Onde gravitazionali



FENOMENI ONDULATORI

- Onde elettromagnetiche



- Trasversali
- Prodotte da cariche elettriche
- Si propagano nel vuoto
- **Velocità di propagazione non dipendente dalla frequenza**

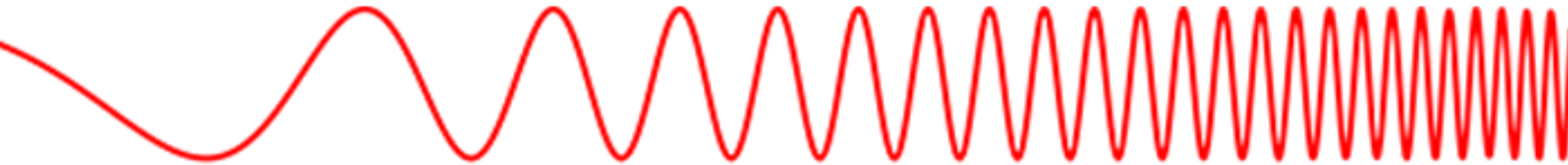
λ Lunghezza d'onda

ν Frequenza (inverso del periodo)

$$\boxed{\begin{aligned} \lambda\nu &= c \\ E &= h\nu \end{aligned}}$$

$$c \approx 3 \cdot 10^8 m/s$$

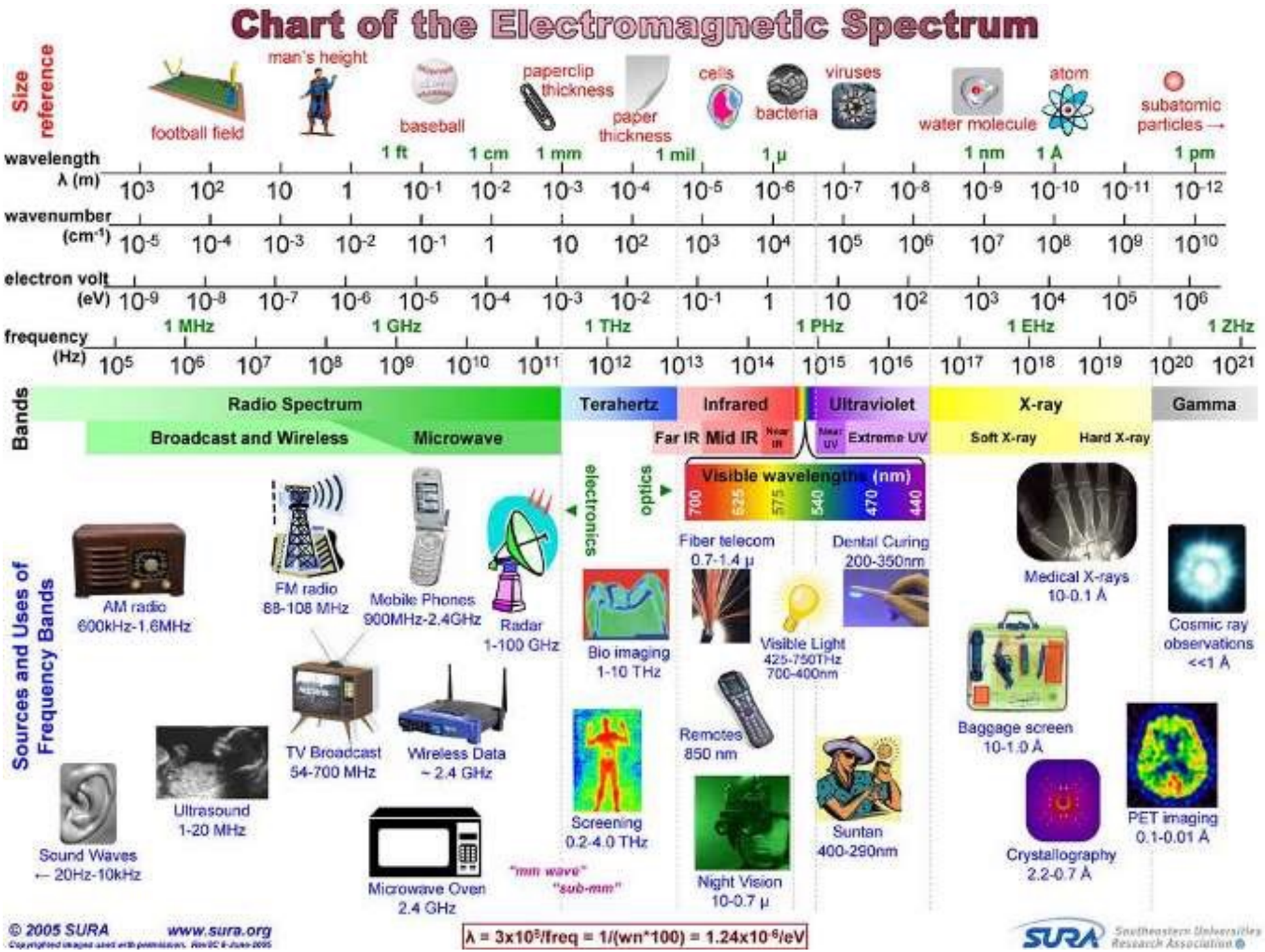
$$h \approx 6.626 \cdot 10^{-34} Js$$



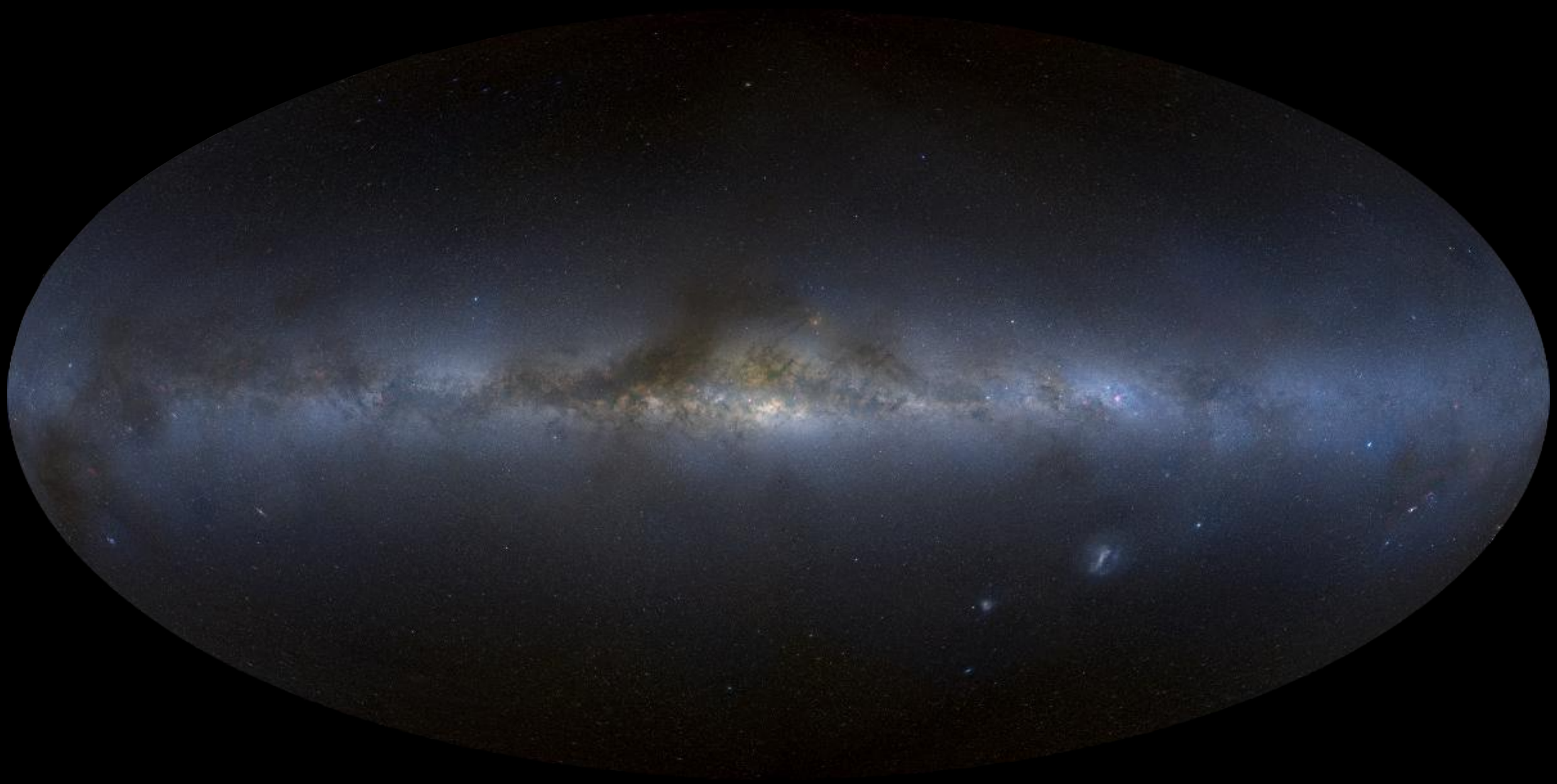
APPROFONDIAMO…

LO SPETTRO ELETTROMAGNETICO

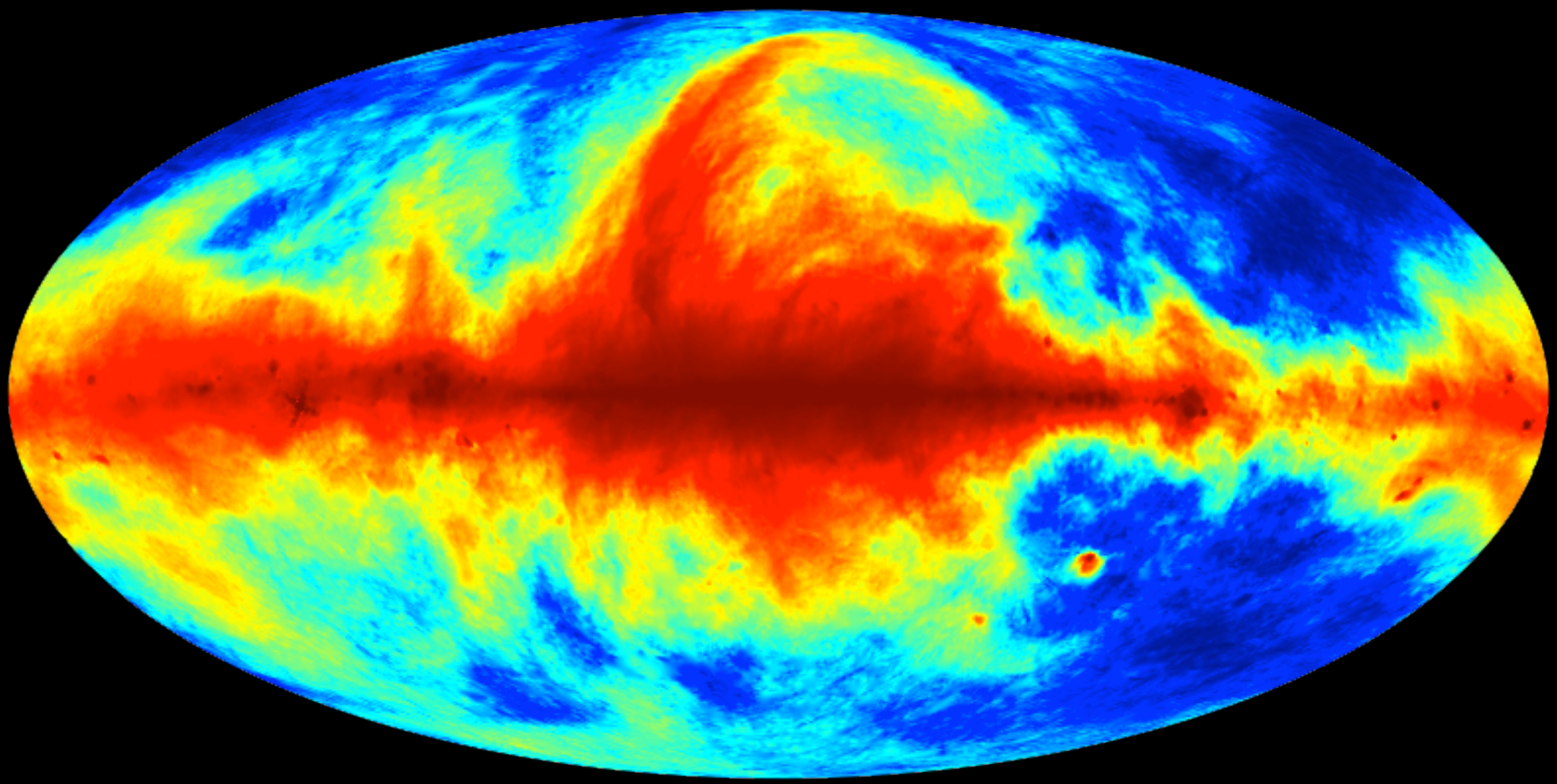
LO SPETTRO ELETTROMAGNETICO



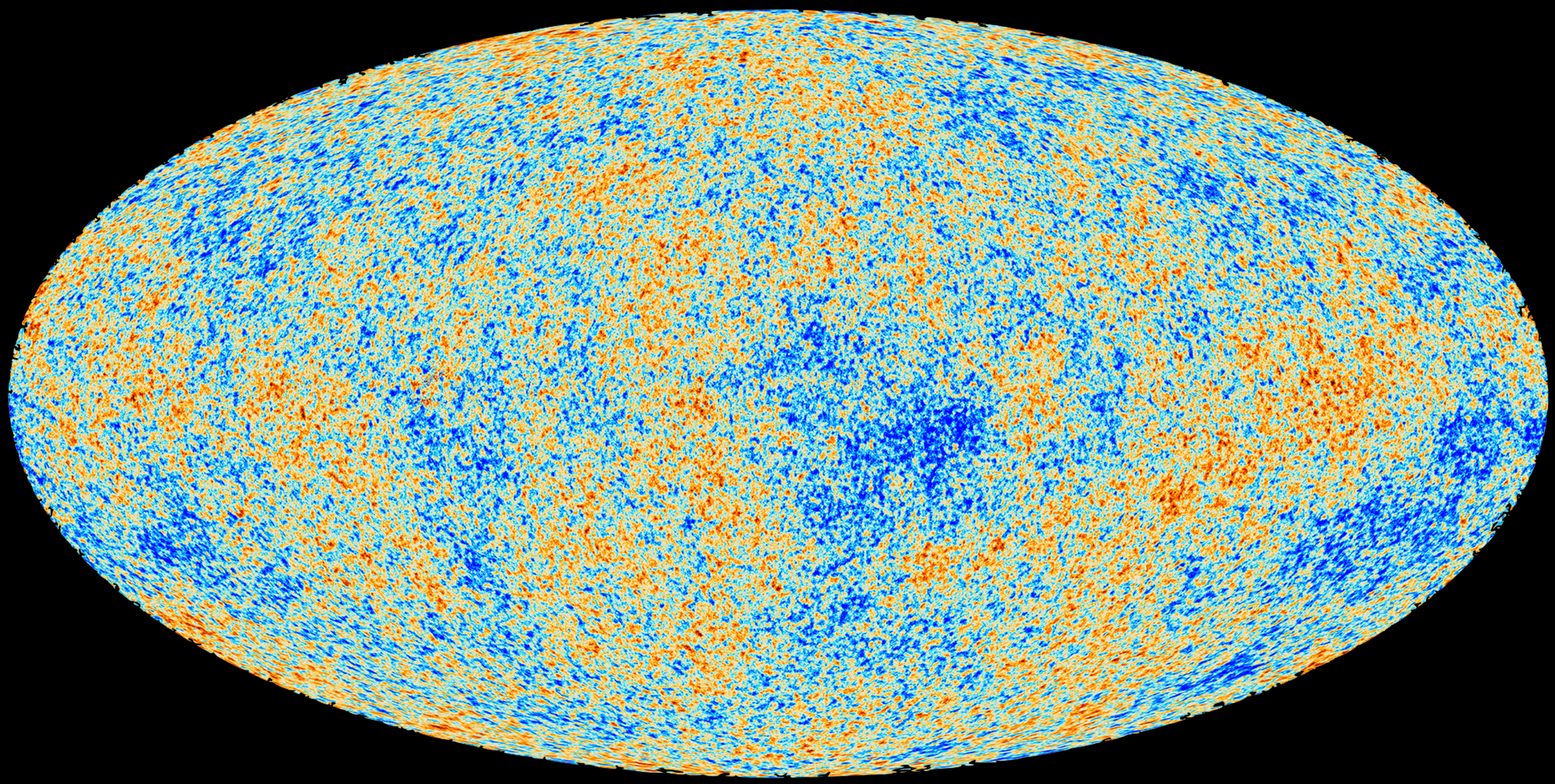
VISIBILE



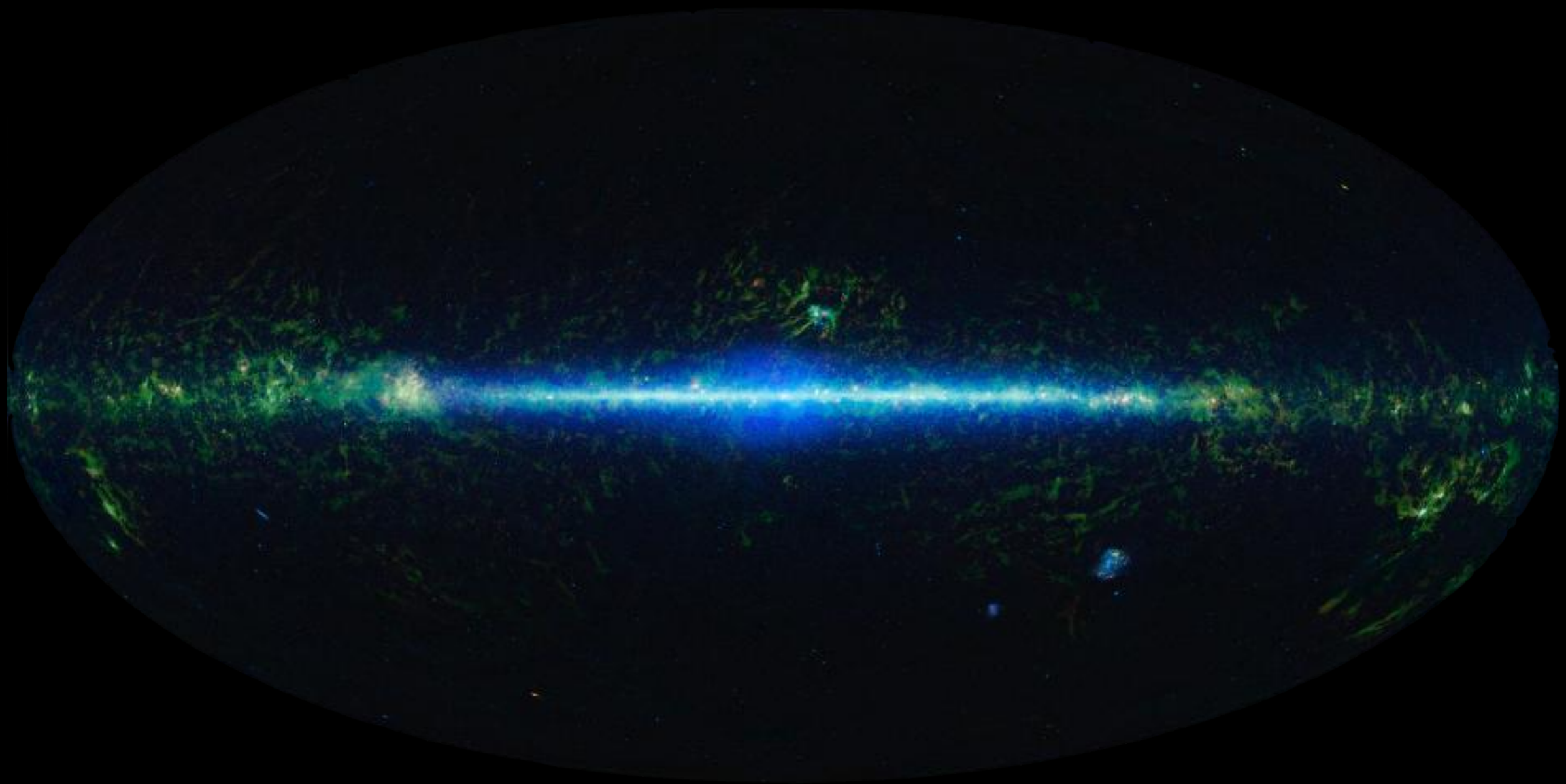
RADIO



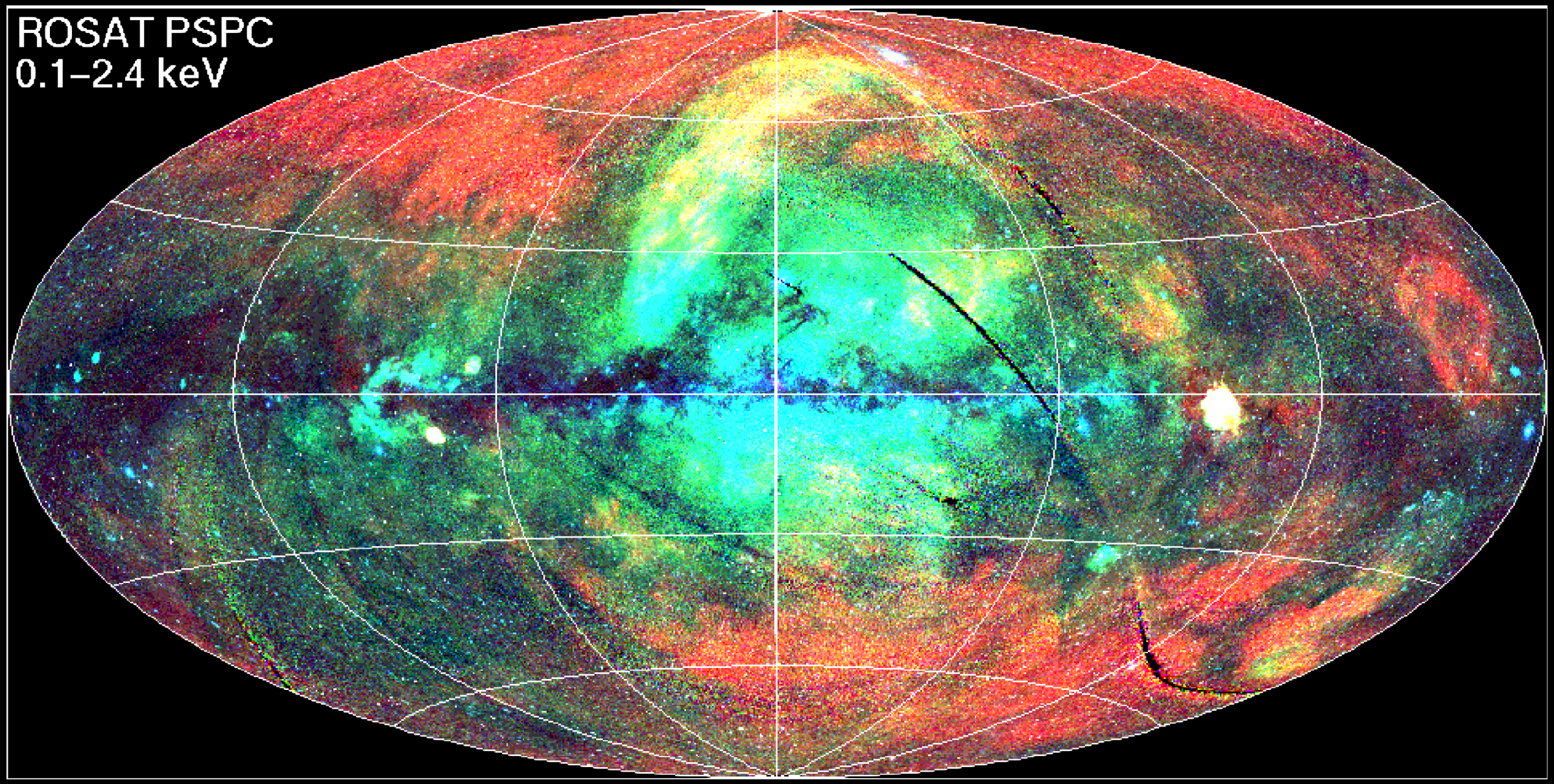
MICROONDE



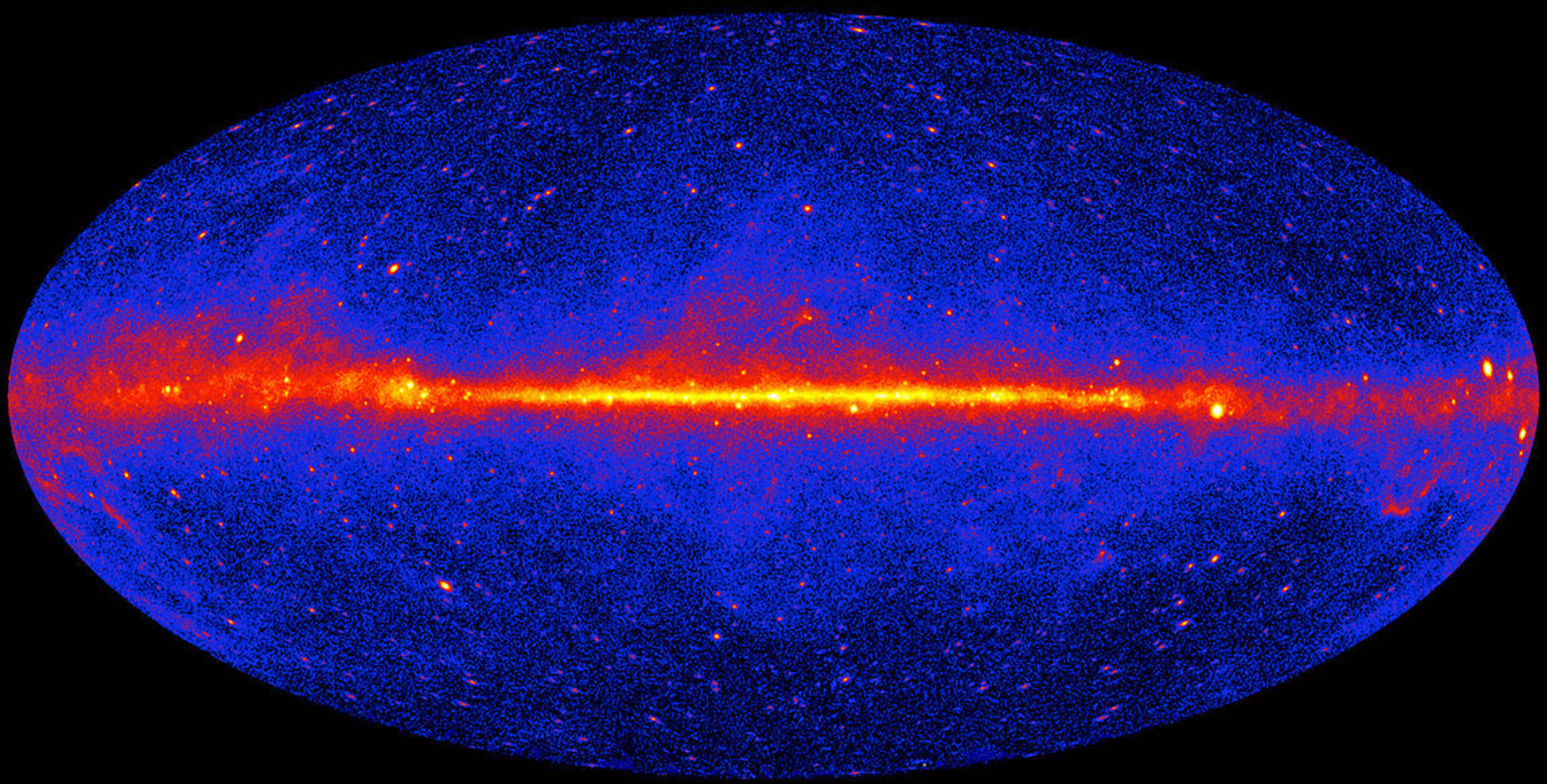
INFRA-ROSSO



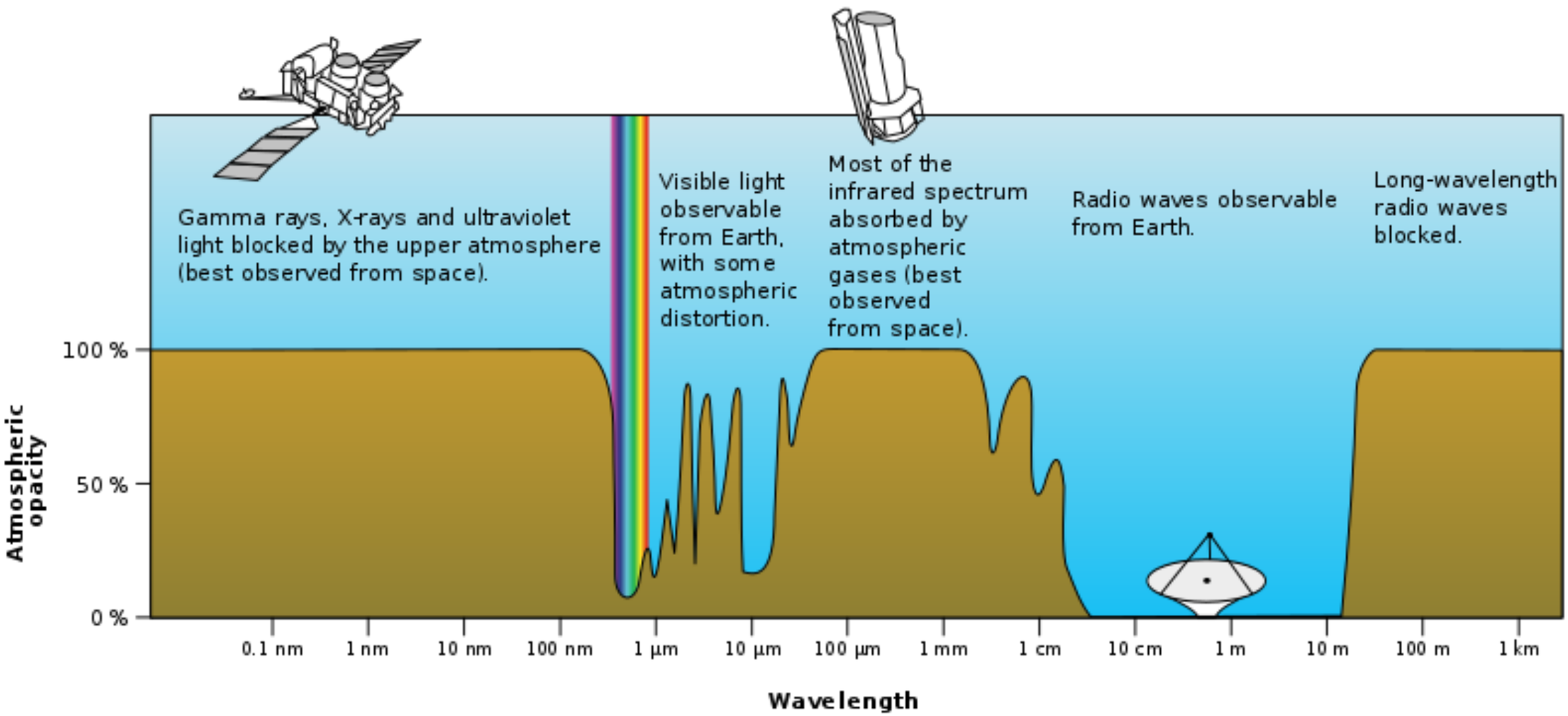
RAGGI X



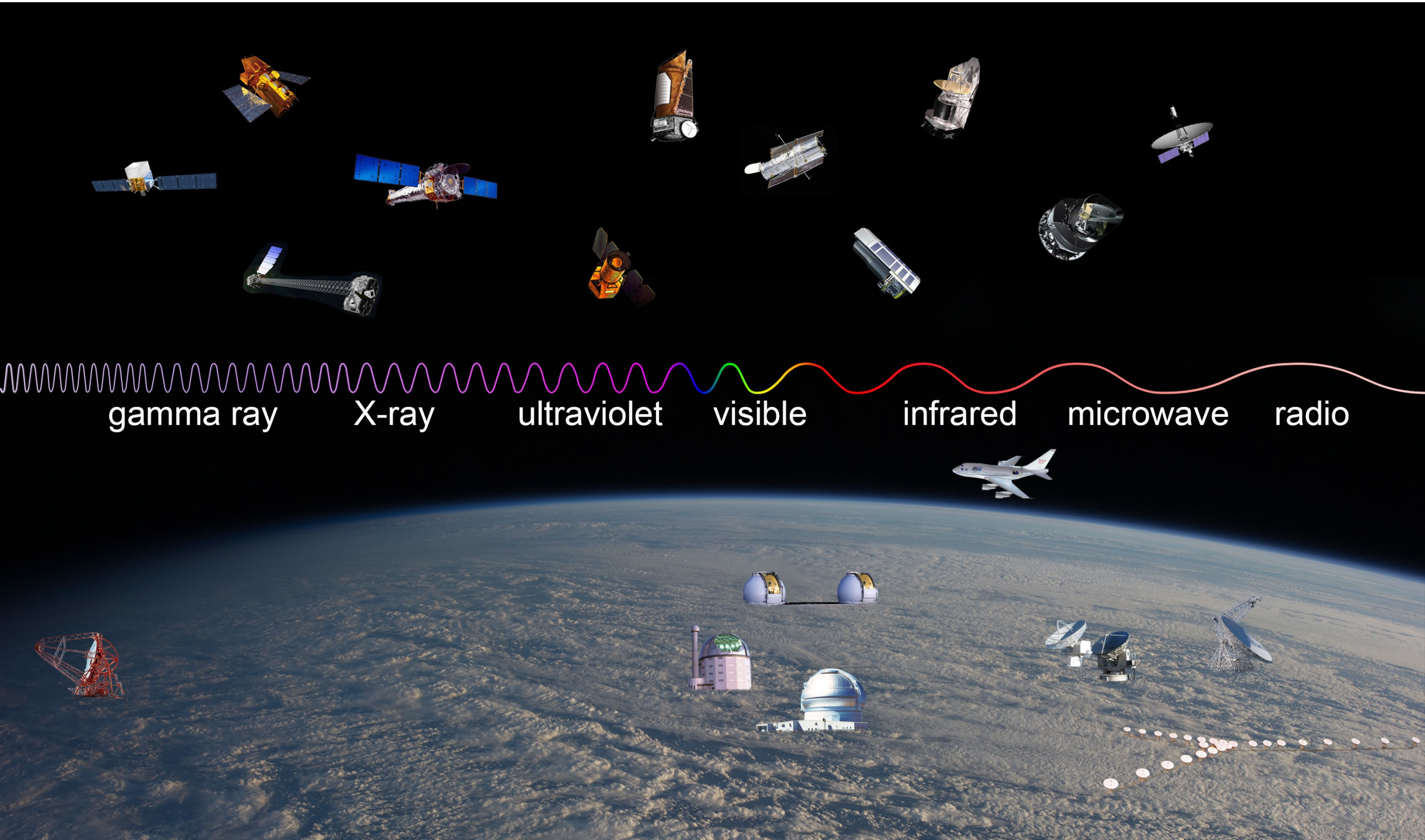
RAGGI GAMMA



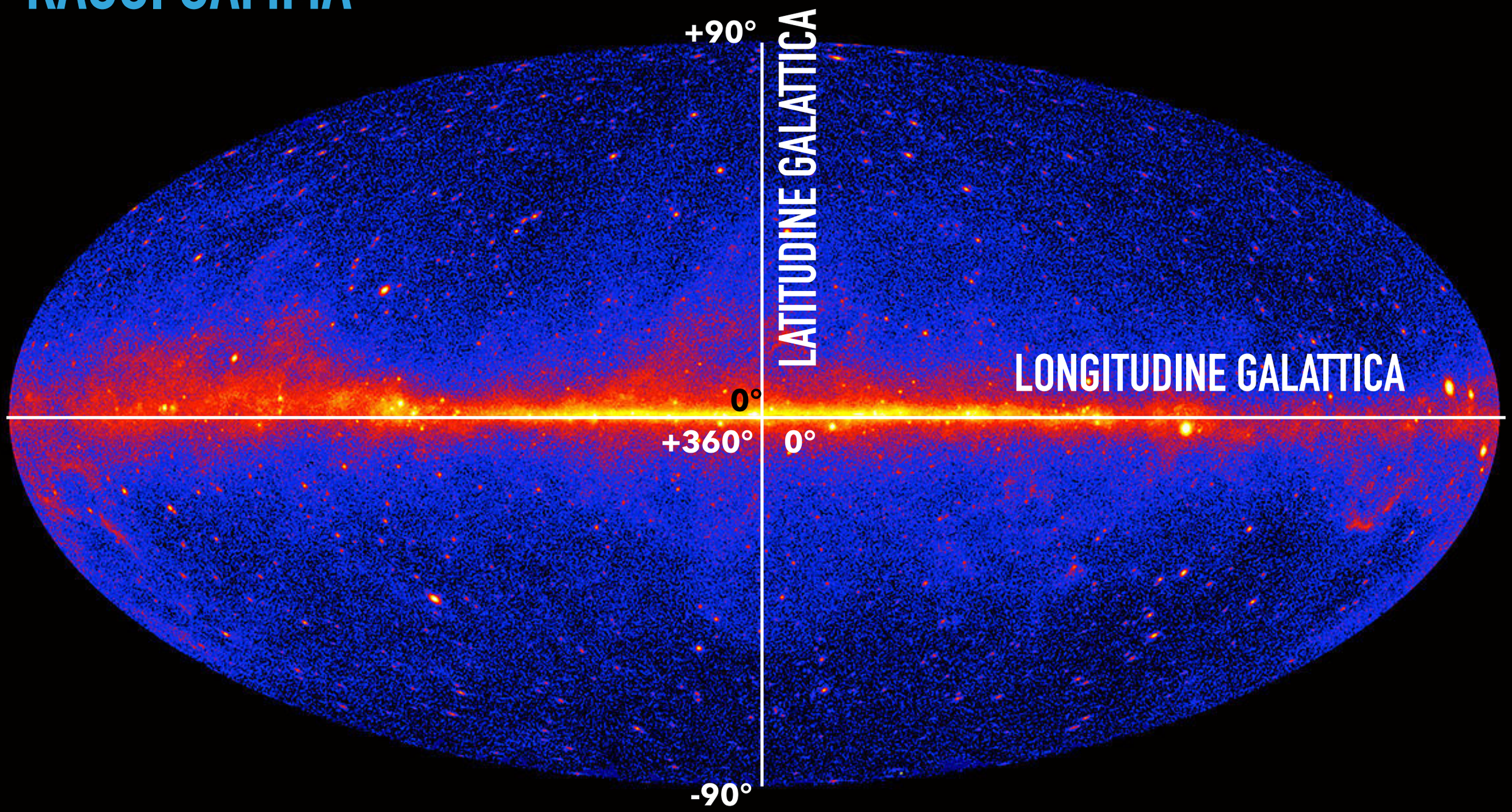
L'ATMOSFERA E LE ONDE ELETTROMAGNETICHE



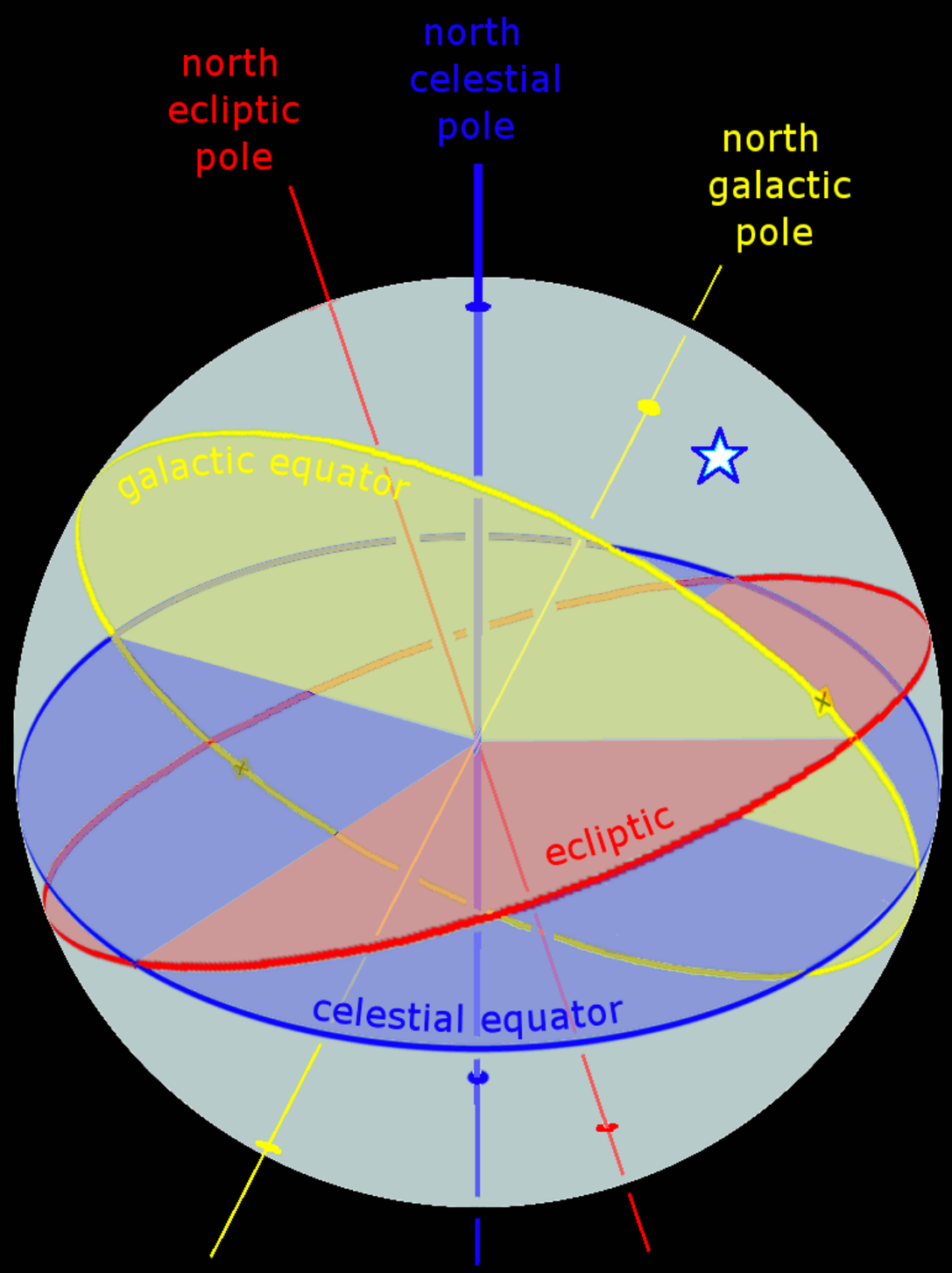
COME RIVELARE LA RADIAZIONE ELETTROMAGNETICA



RAGGI GAMMA



GUARDARE L'UNIVERSO CON OCCHI DIVERSI



Gal. Center:

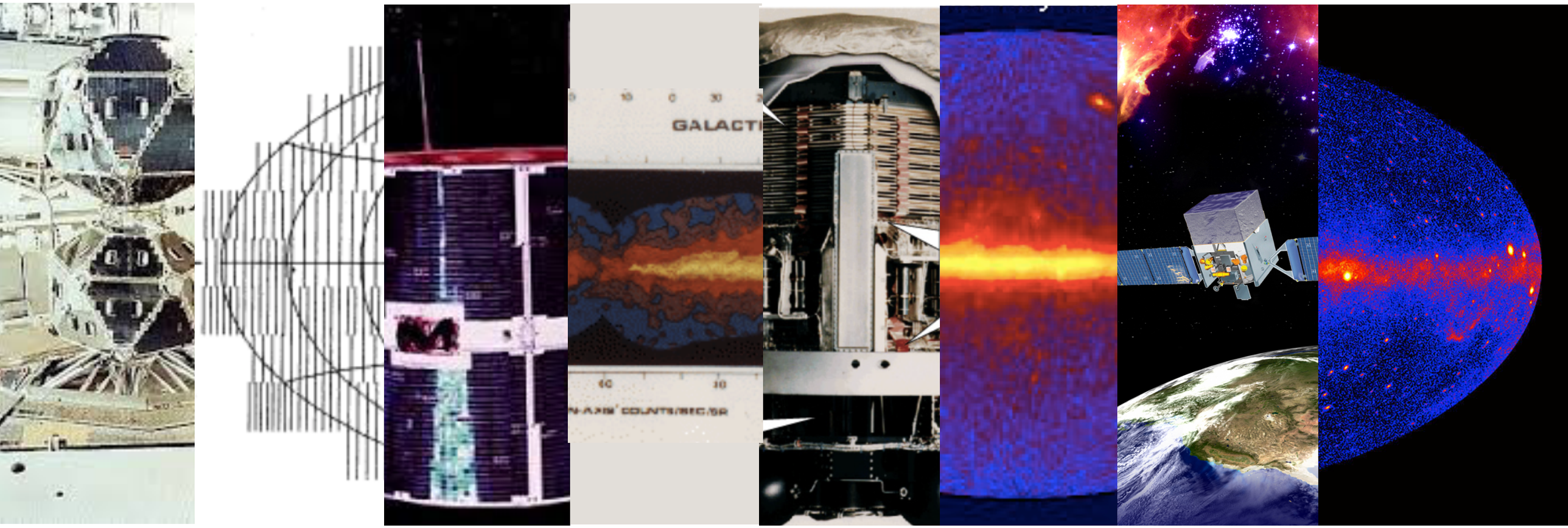
(0.0, 0.0) deg

(−25.29, 235.47) deg

(−5.27, 239.02) deg

COORDINATE GALATTICHE

COORDINATE CELESTI

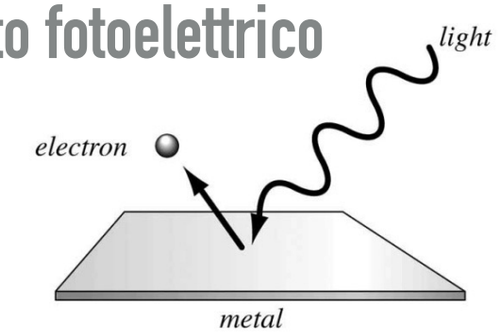


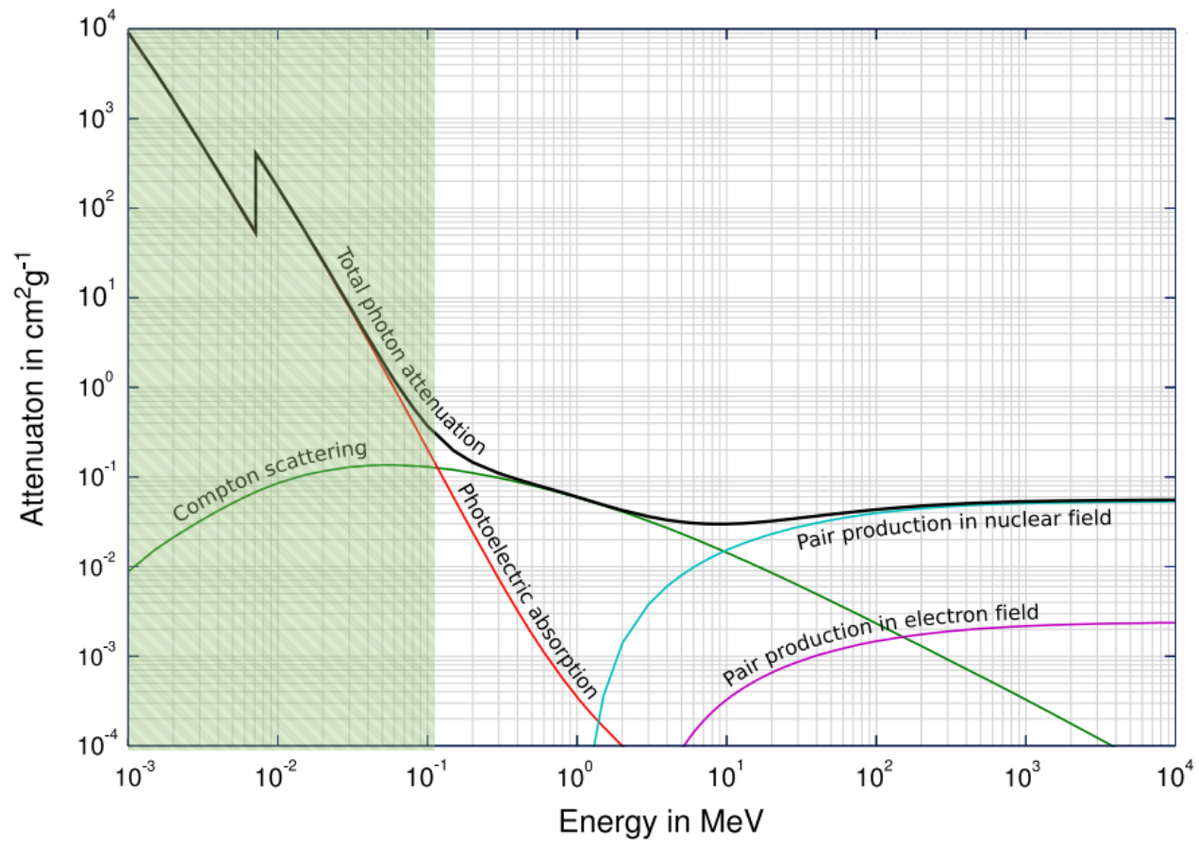
COME OSSERVARE…

STORIA, STRUMENTI E METODI DI RIVELAZIONE

RIPASSO INTERAZIONE FOTONE - MATERIA

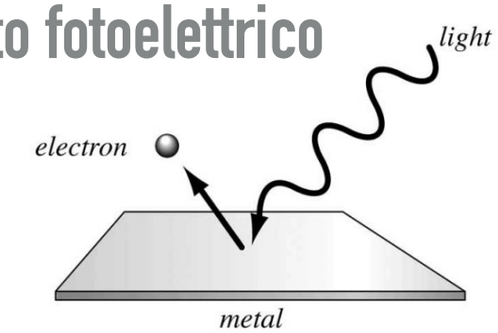
Effetto fotoelettrico



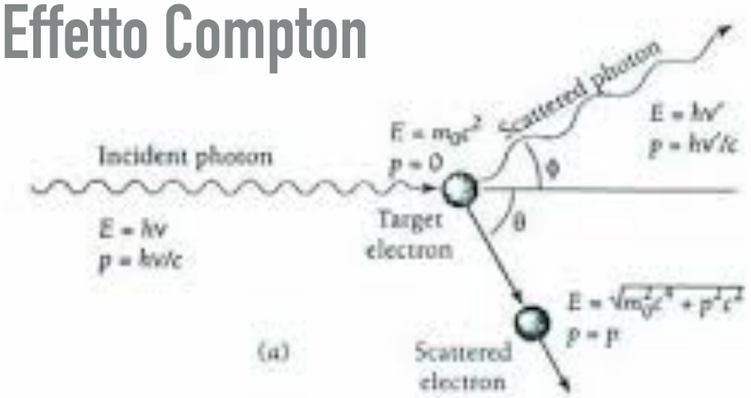


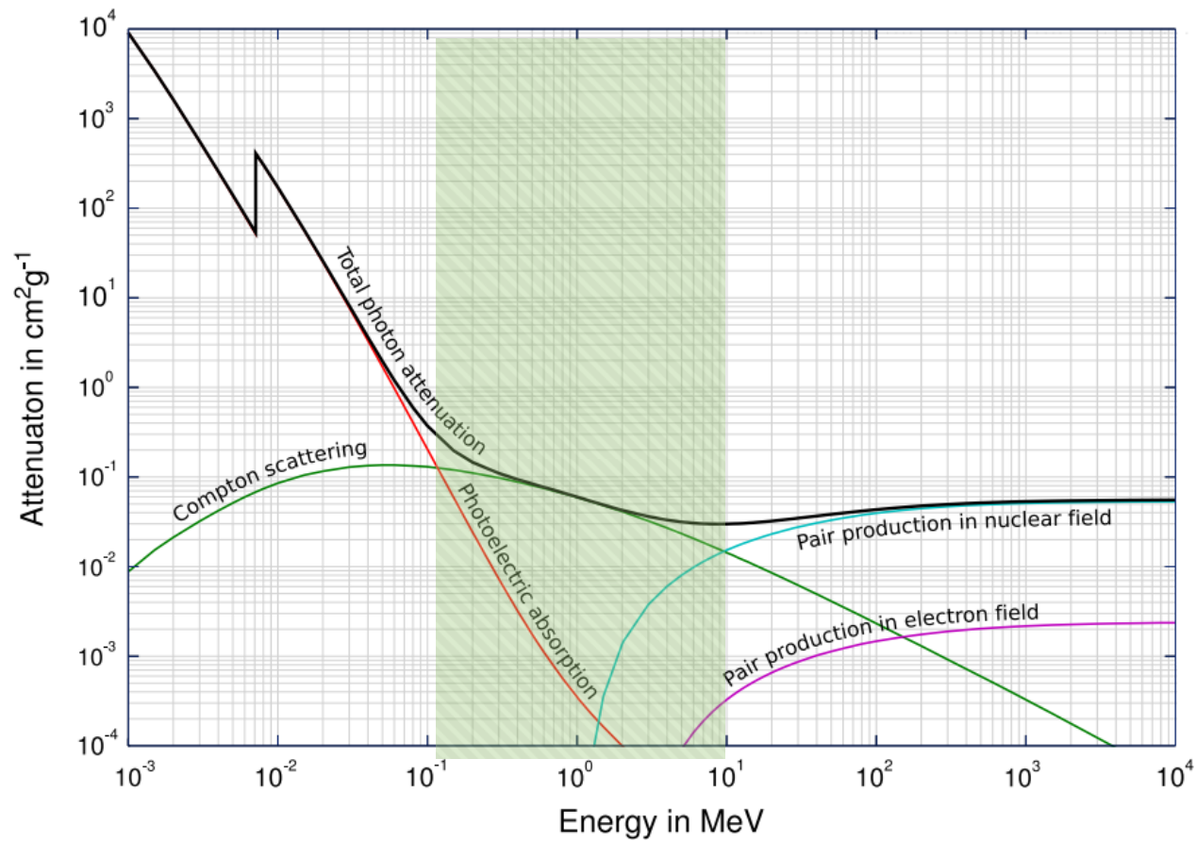
RIPASSO INTERAZIONE FOTONE - MATERIA

Effetto fotoelettrico



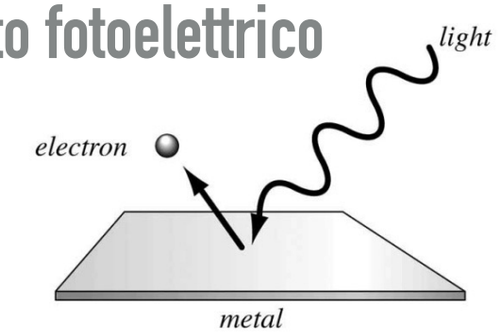
Effetto Compton



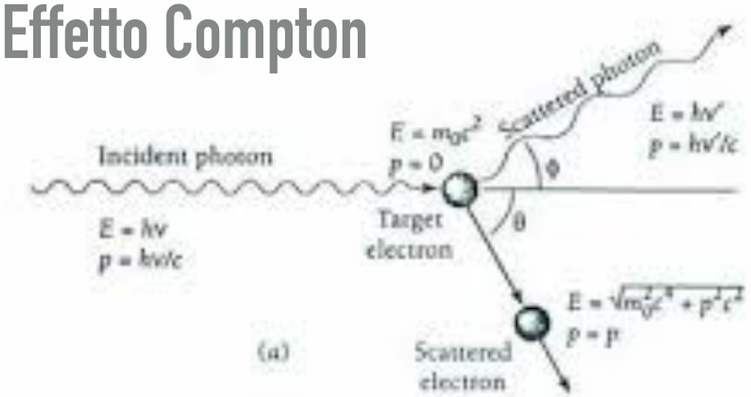


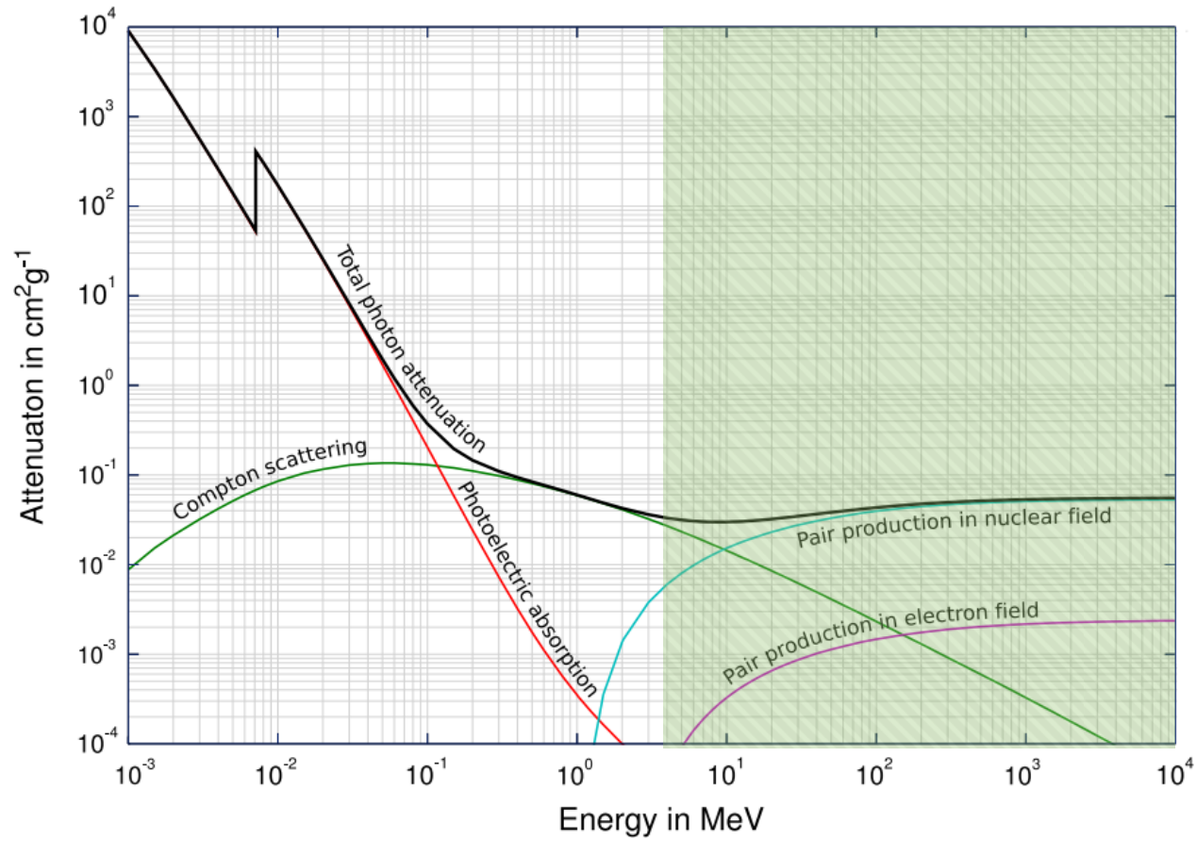
RIPASSO INTERAZIONE FOTONE - MATERIA

Effetto fotoelettrico

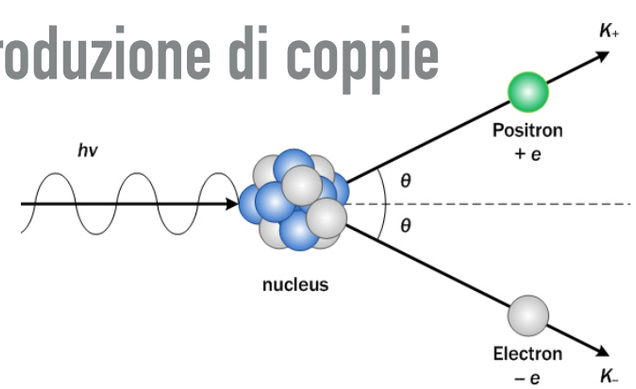


Effetto Compton





Produzione di coppie



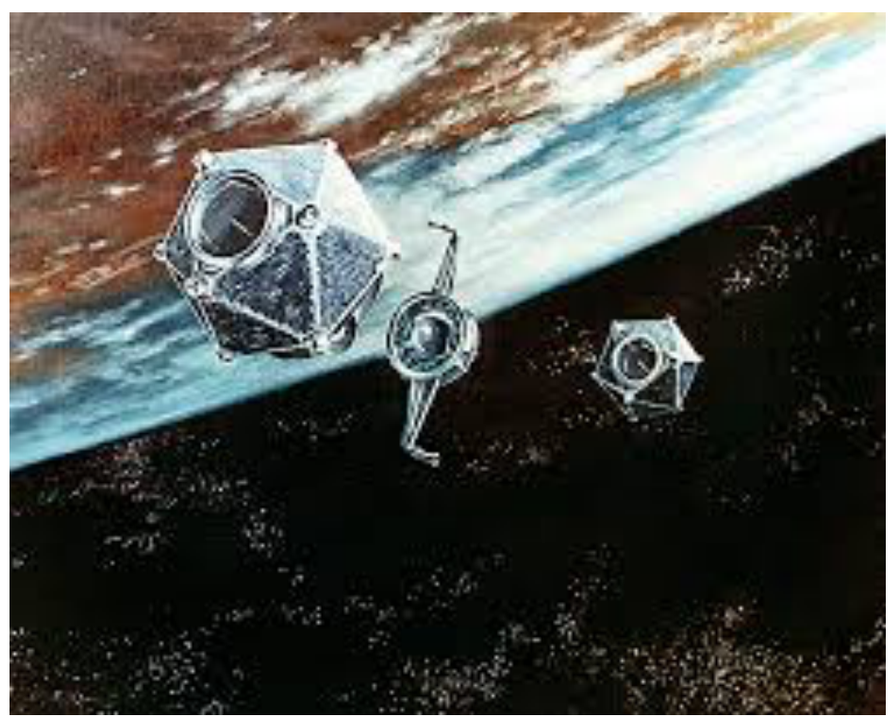
Conoscere tali meccanismi è importante per capire come rivelare la radiazione gamma!!

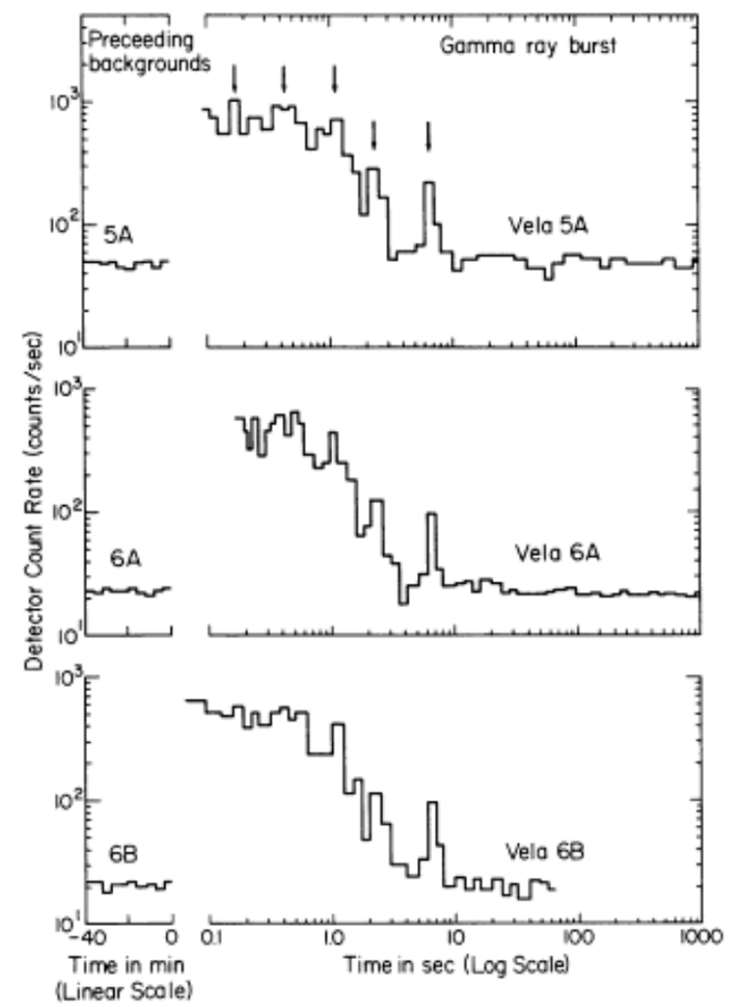
QUINDI, ANDIAMO NELLO SPAZIO…

Vela satellites

Costruiti per monitorare test nucleari in atmosfera

1967 prima detection di un fenomeno transiente (Gamma Ray Burst)

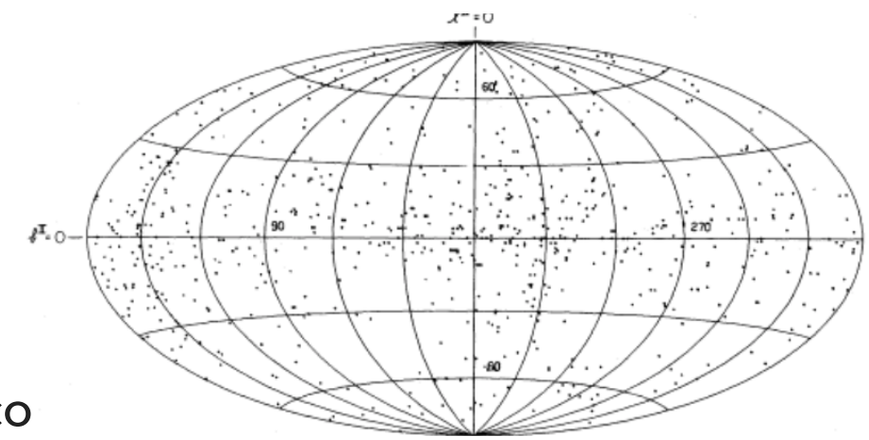




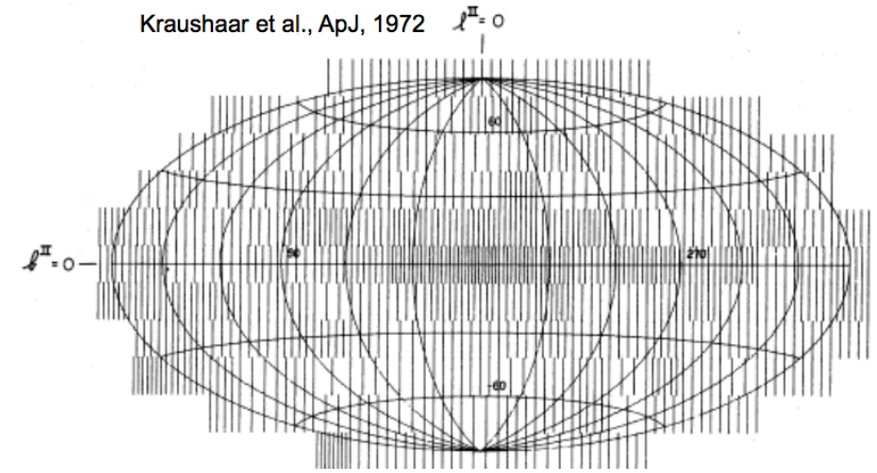
QUINDI, ANDIAMO NELLO SPAZIO…

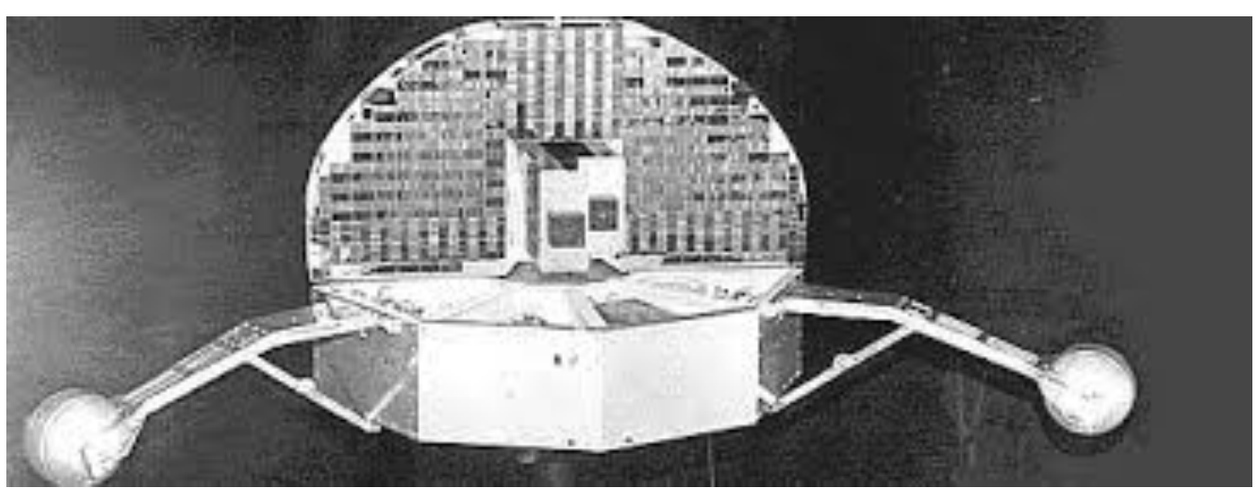
Orbiting Solar Observatory (OSO-3)

- 9 satelliti lanciati nel 1967
- Rivelano 621 raggi gamma sopra i 50 MeV
- No detection di sorgenti, ma emissione dal piano galattico



Kraushaar et al., ApJ, 1972

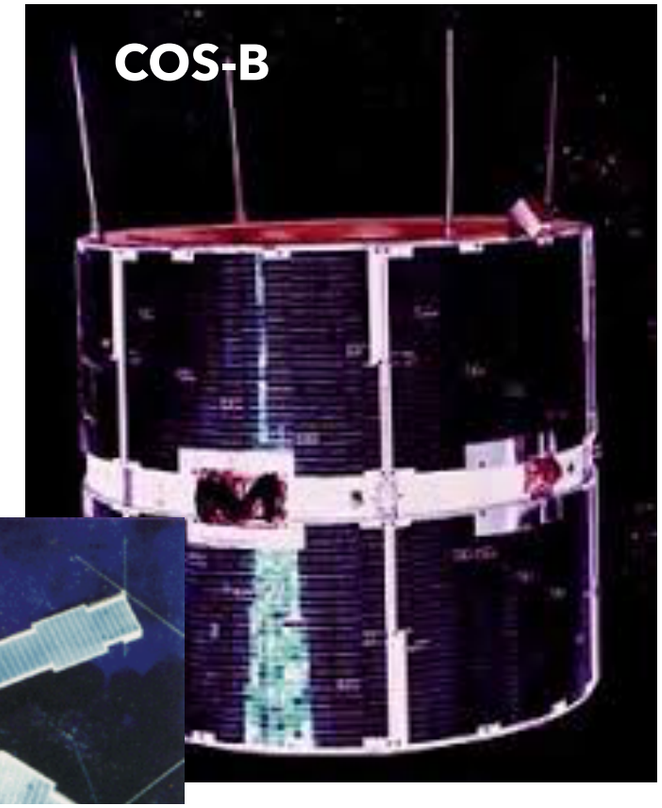




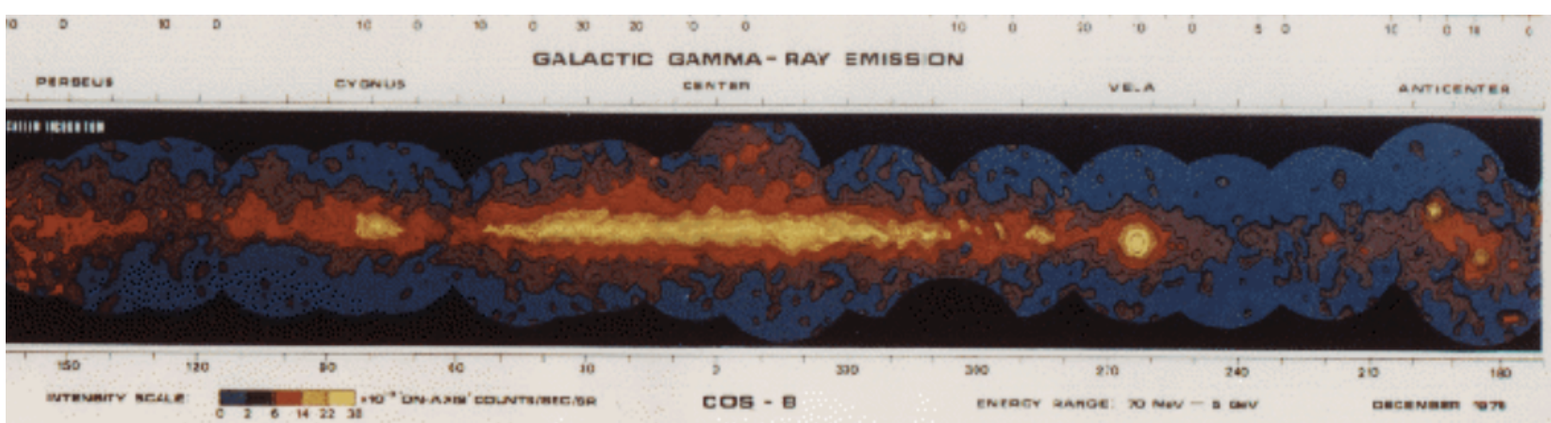
ALLE PIÙ ALTE ENERGIE

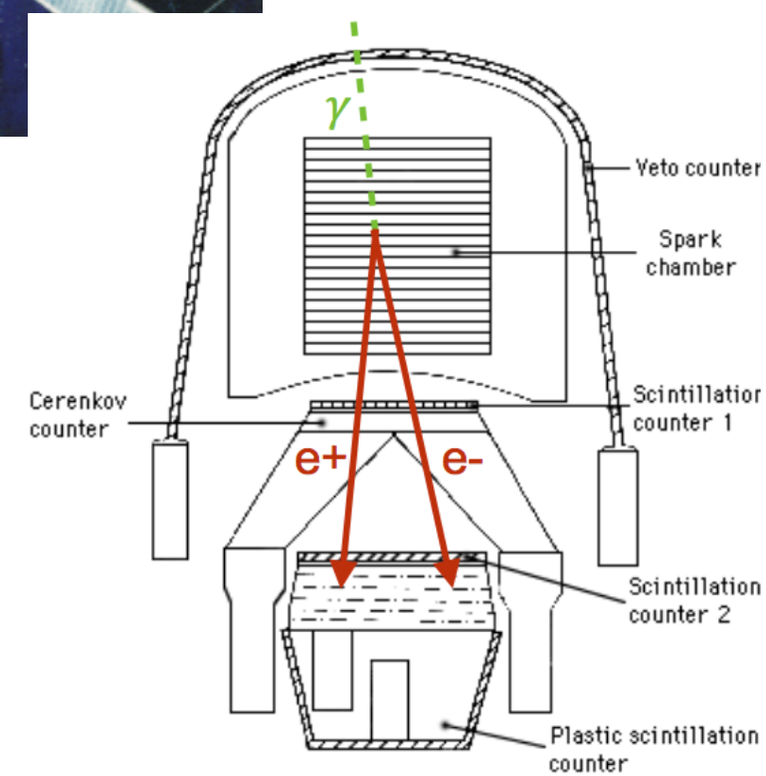
QUINDI, ANDIAMO NELLO SPAZIO…

COS-B (ESA) and SAS-2 (NASA)



- anni '70: primi saltelli dedicati all'esportazione del cielo gamma
- Energy range: ~50 MeV – ~ 10 GeV
- Rivelazione tramite produzione di coppie



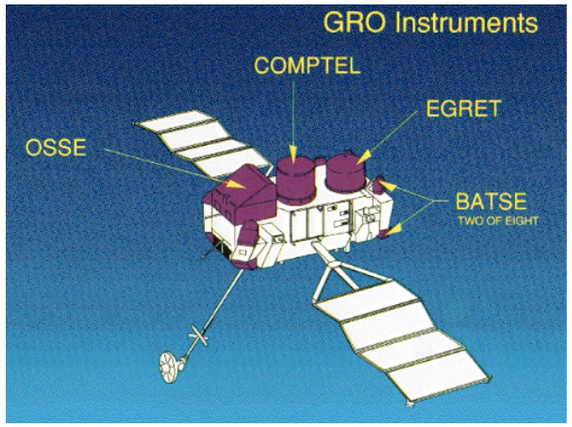


QUINDI, ANDIAMO NELLO SPAZIO…

Compton Gamma Ray Observatory (CGRO)

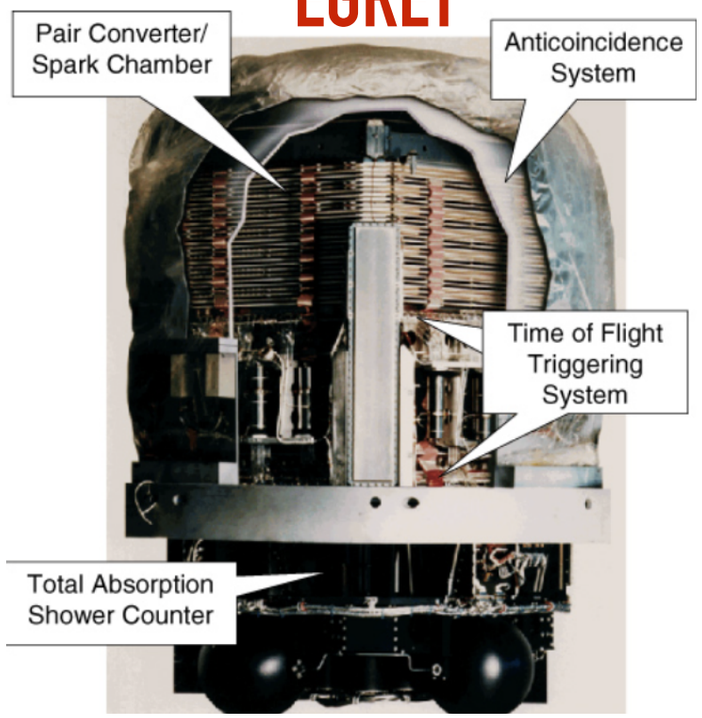
Uno di 4 esperimenti a bordo della missione NASA Compton Gamma Ray Observatory satellite

- BATSE - Gamma-ray transients 20 keV - 600 keV
- OSSE - Source spectrometer 50 keV - 10 MeV
- **COMPTEL - Sky survey 800 keV - 30 MeV**
- **EGRET - Rivela Gamma tra 30 MeV to 30 GeV**

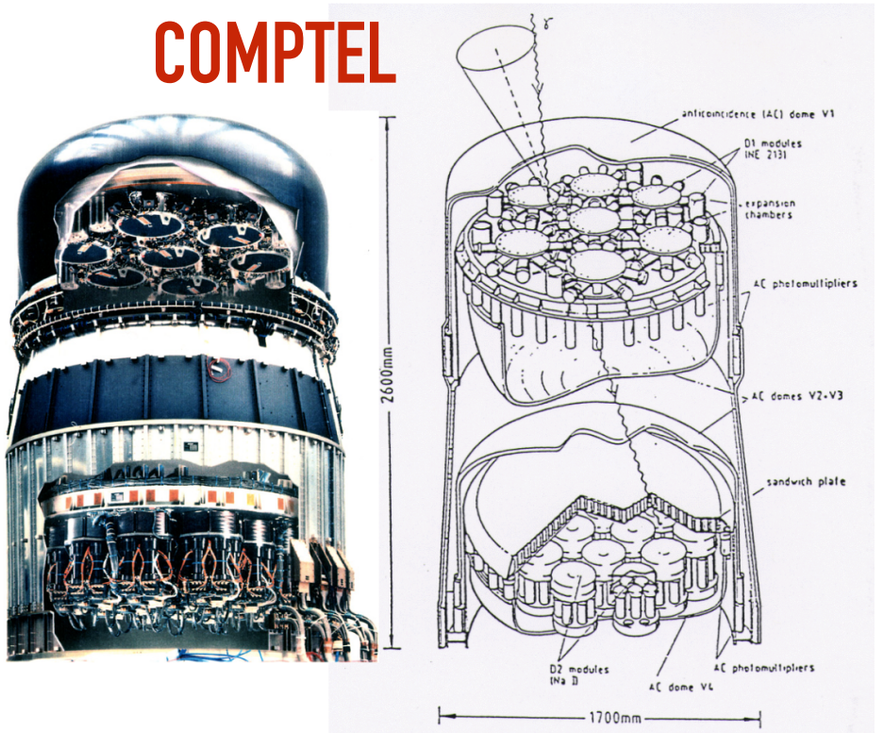


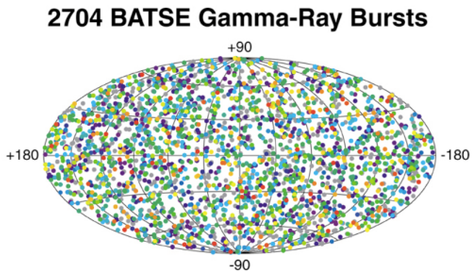
Diverse energie: diverse tecniche di rivelazione!

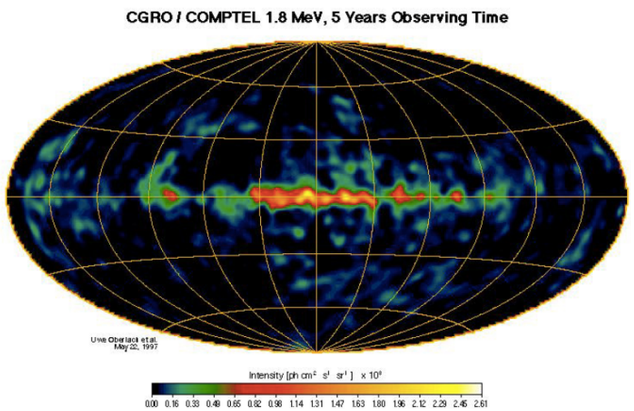
EGRET



COMPTEL







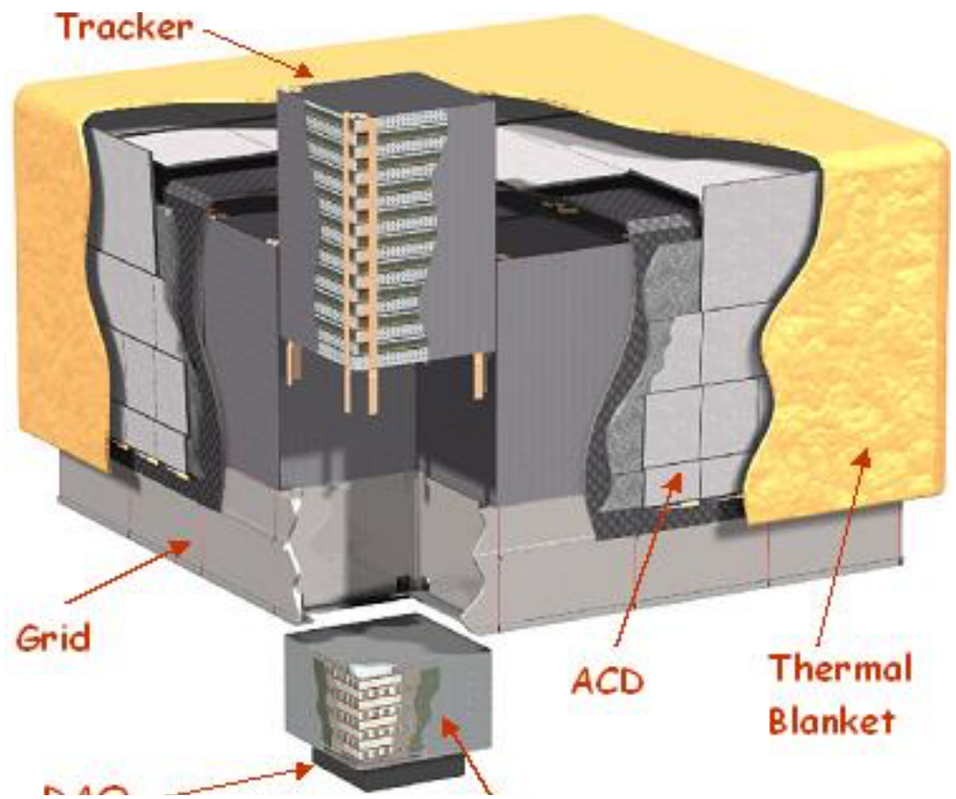
ALLE PIÙ ALTE ENERGIE

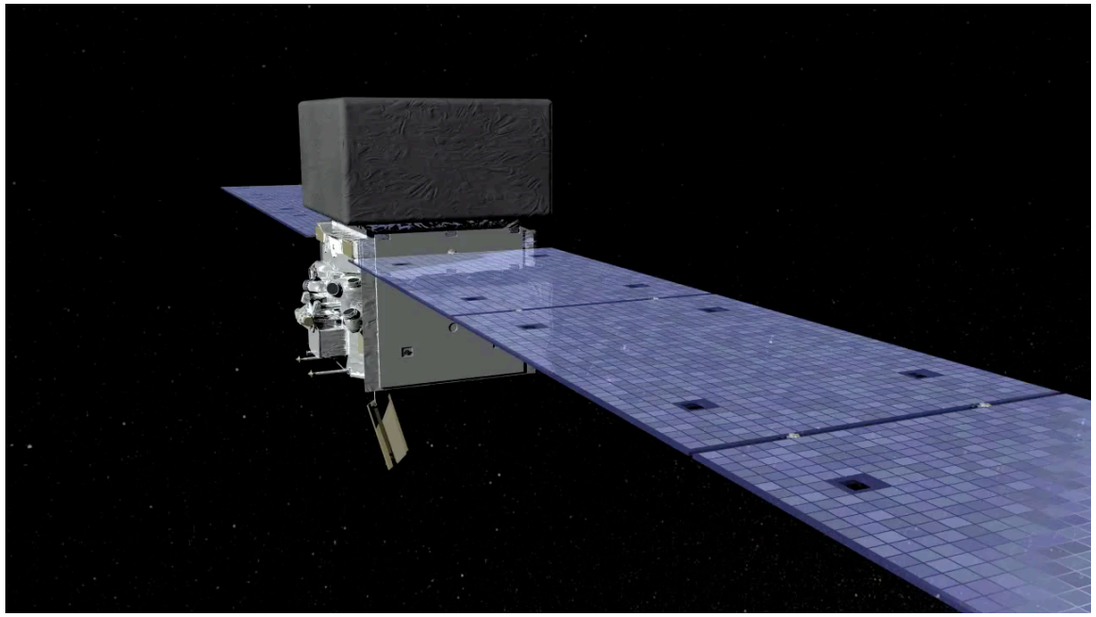
FERMI LARGE AREA TELESCOPE

Anti-coincidence detector (ACD)

Tracker-Converter

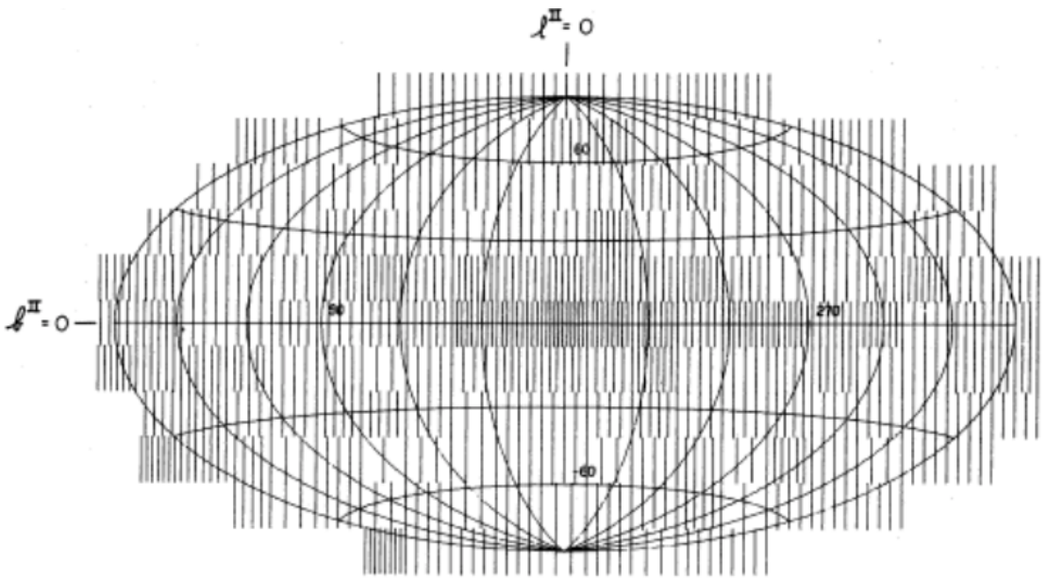
Calorimeter





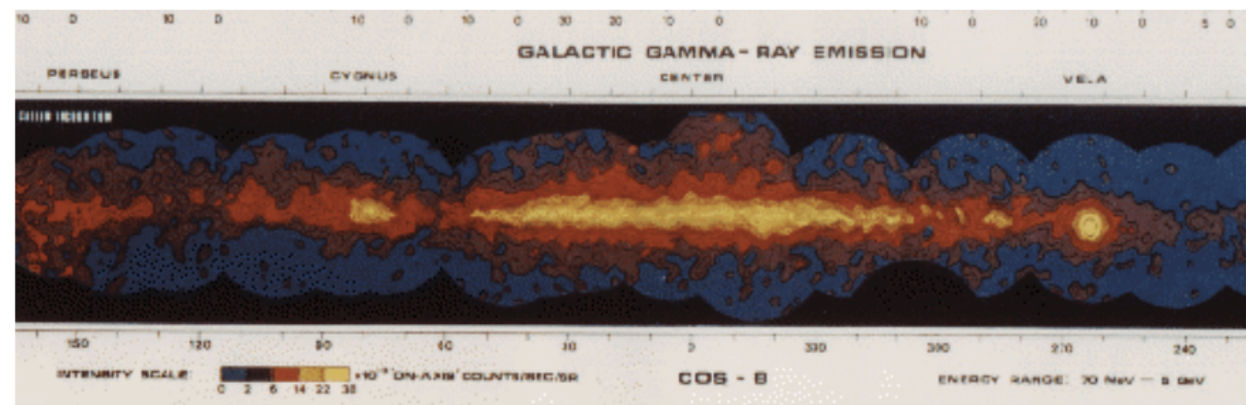
ALLE PIÙ ALTE ENERGIE

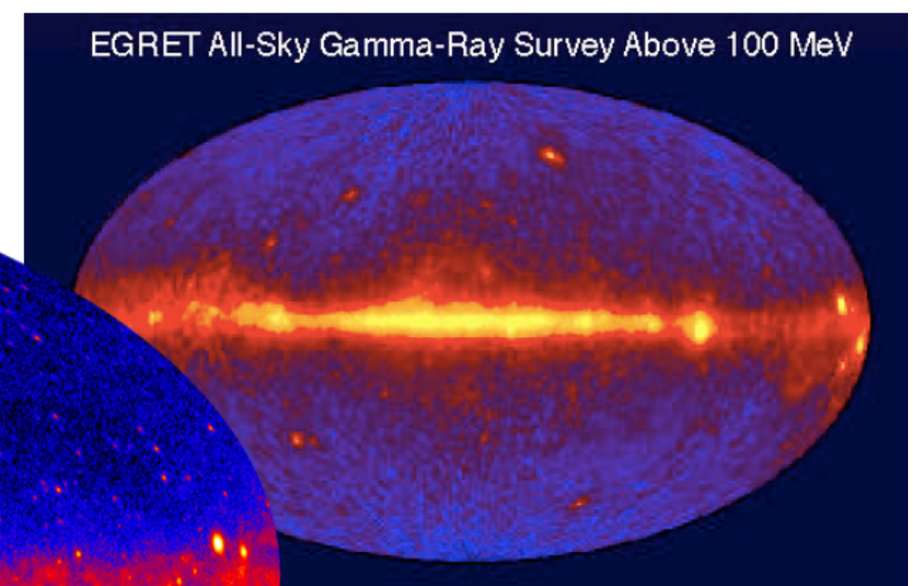
FERMI LARGE AREA TELESCOPE



1970

1980





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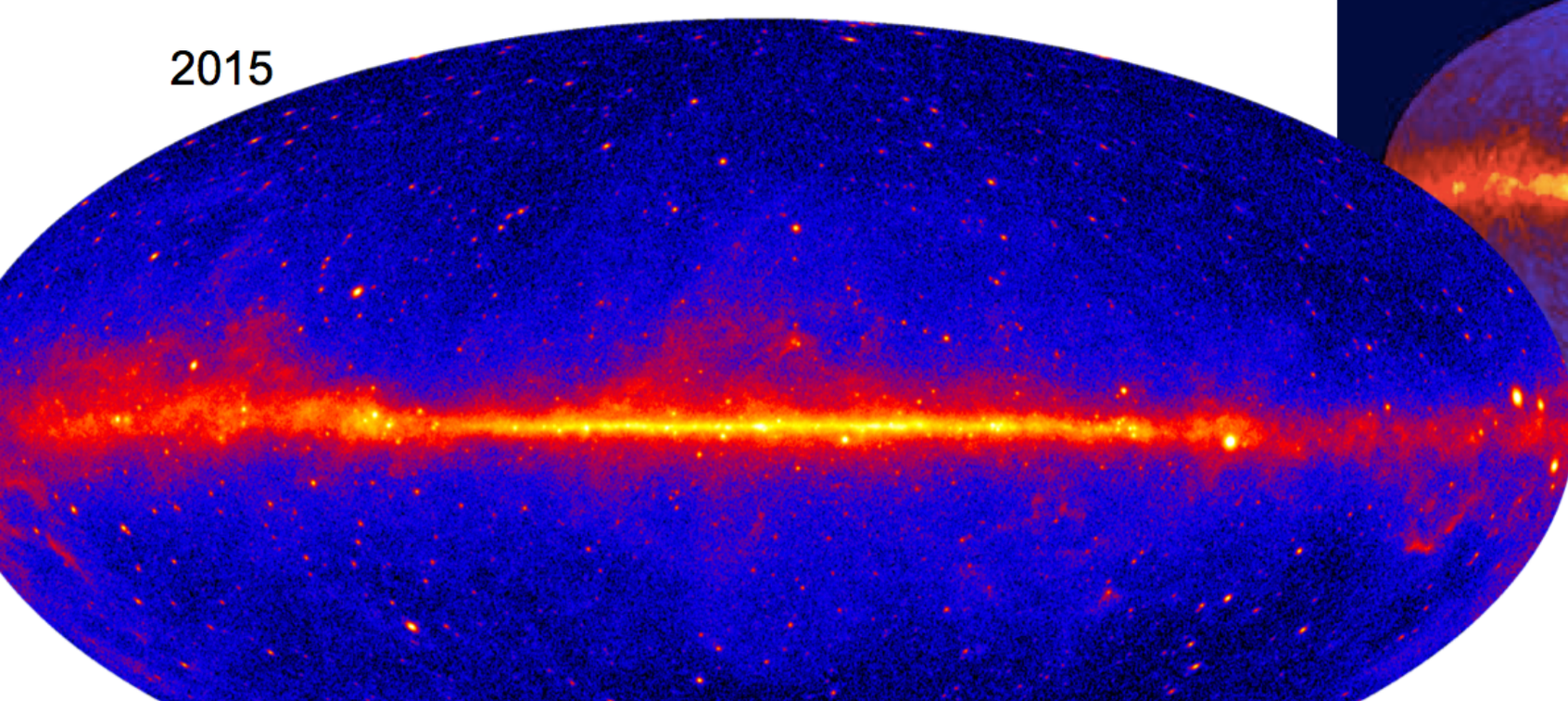
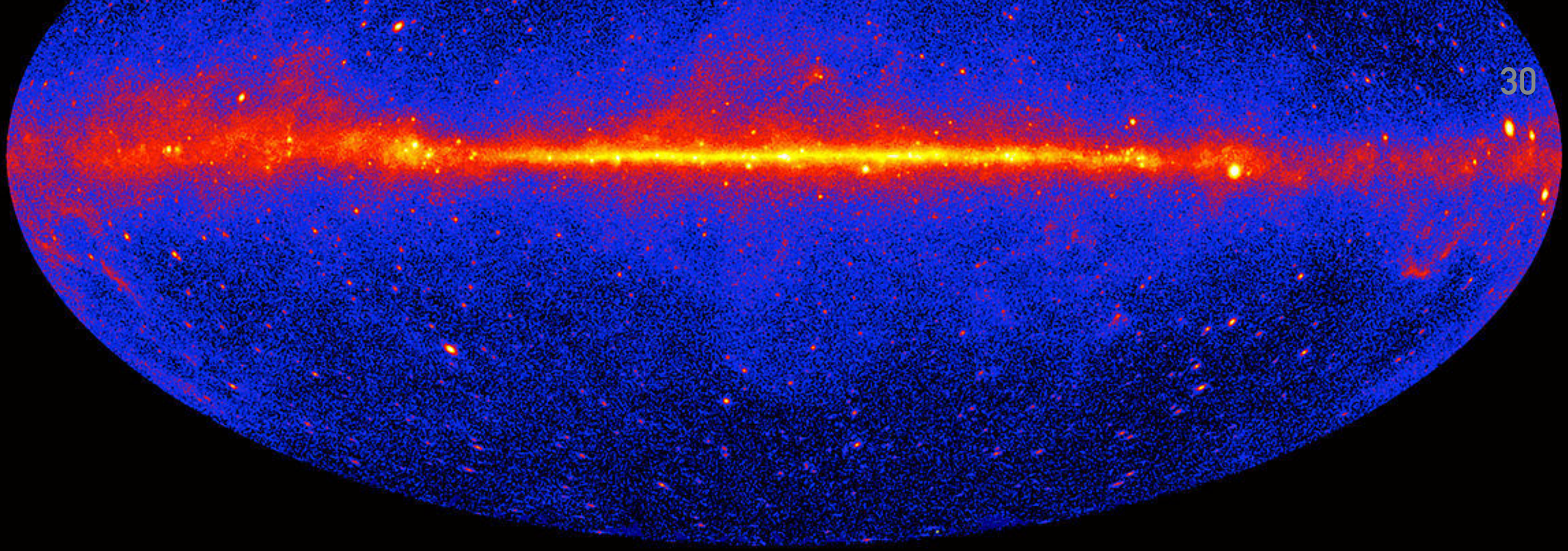




COSA OSSERVARE…

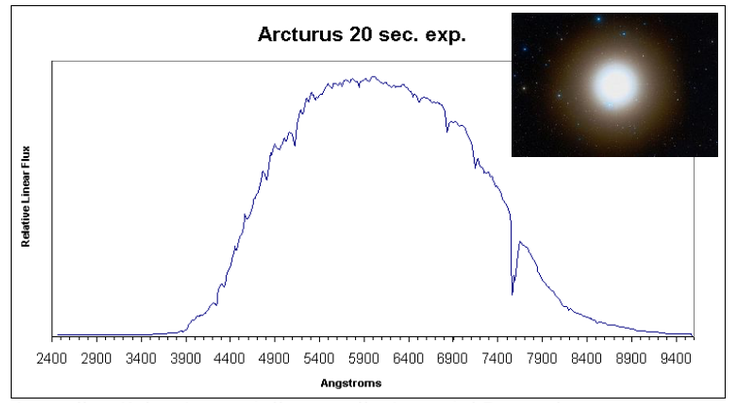
SORGENTI, DIFFUSO, FONDO EXTRAGALATTICO

ALLE PIÙ ALTE ENERGIE

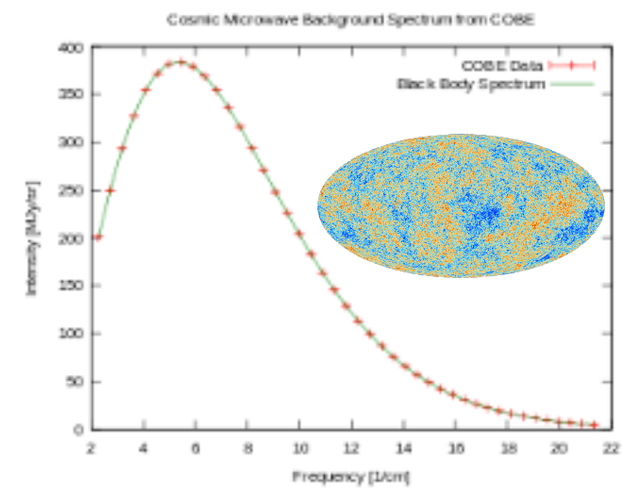
COSA SI OSSERVA NELLA BANDA GAMMA?

- Fenomeni Termici: sorgenti che emettono la radiazione sono in equilibrio termico

Dominano dal radio all'X

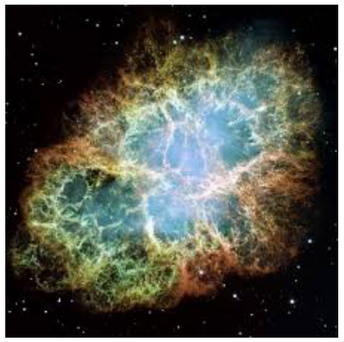


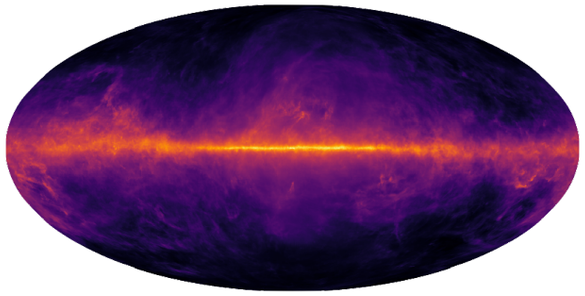
La stella più luminosa della costellazione del Boote, la quarta stella più brillante del cielo notturno osservabile dopo Sirio, Canopo e α Centauri

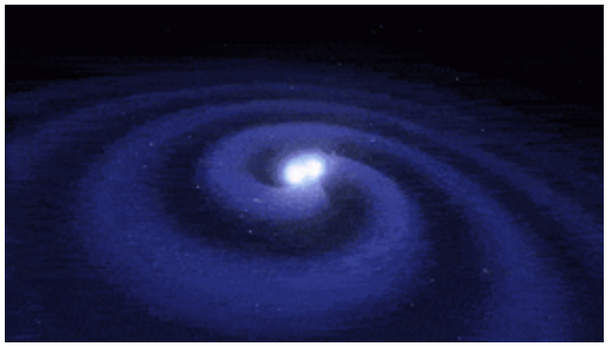


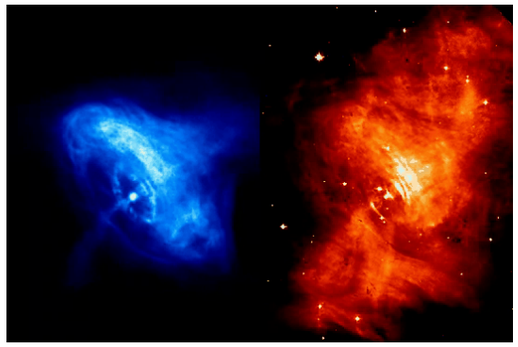
- L'astronomia gamma ci permette di osservare fenomeno NON TERMICI

Eventi catastrofici, repentini, estremamente energetici
= Gamma-rays



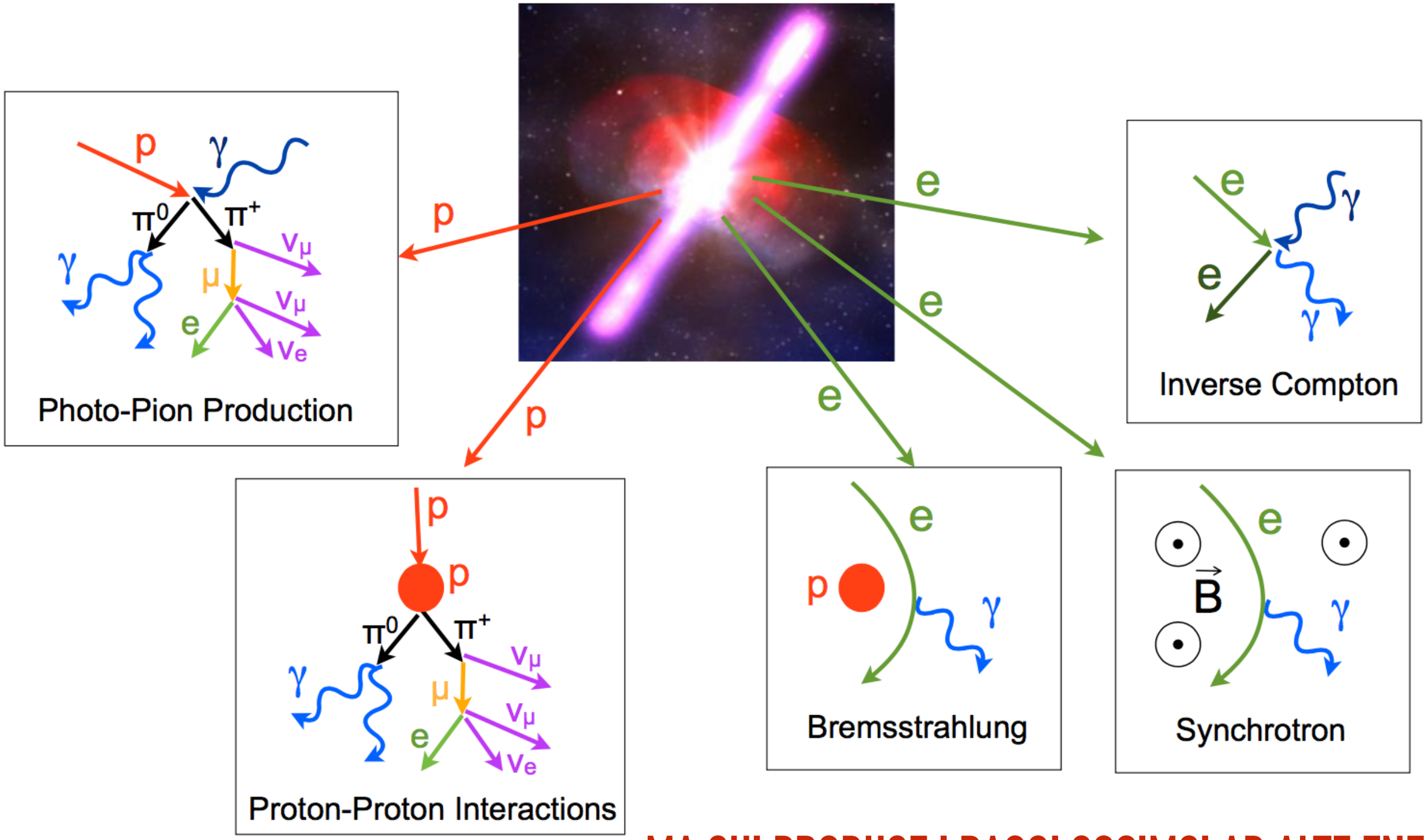






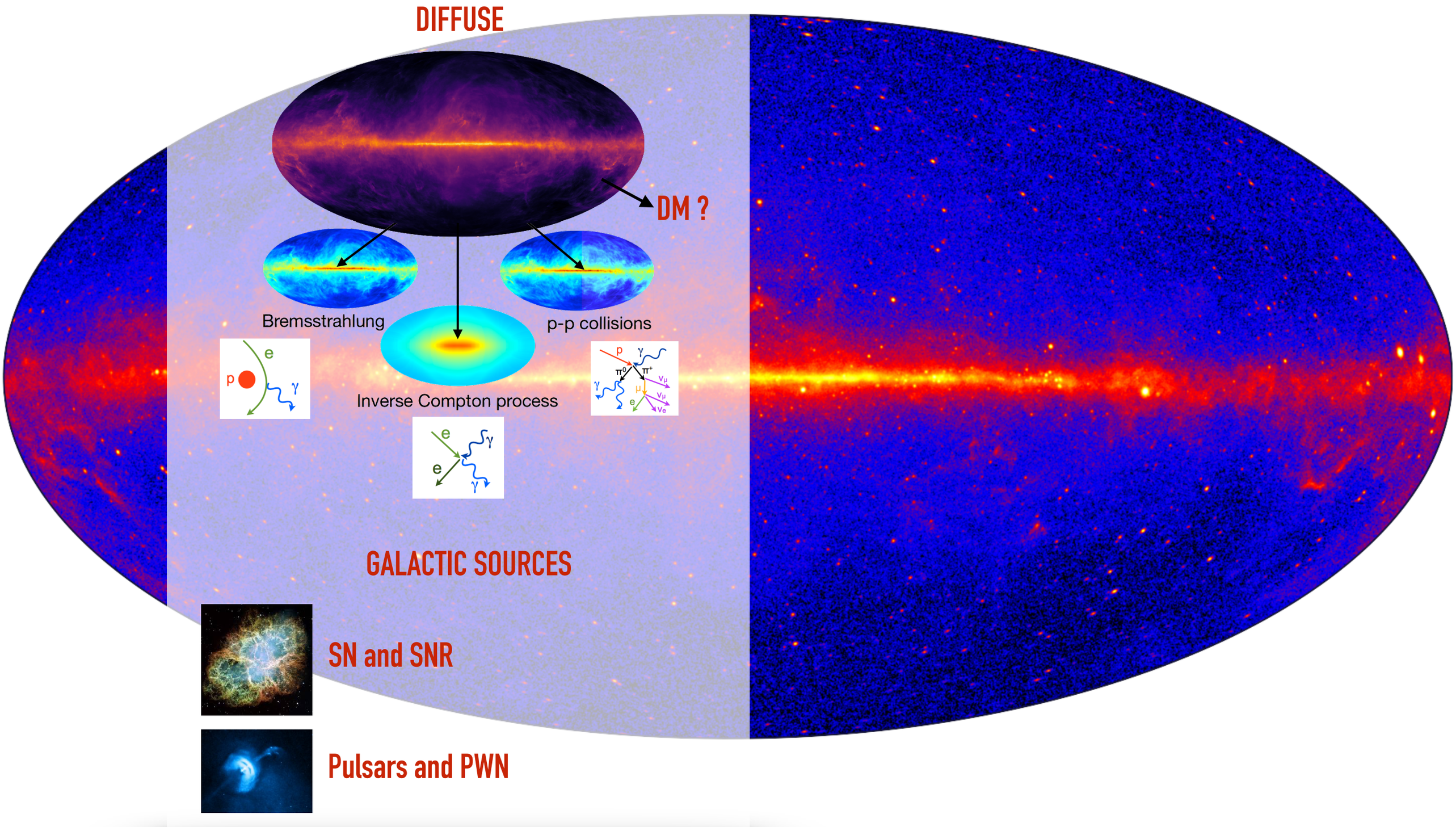
ALLE PIÙ ALTE ENERGIE

MECCANISMI DI PRODUZIONE DEI GAMMA



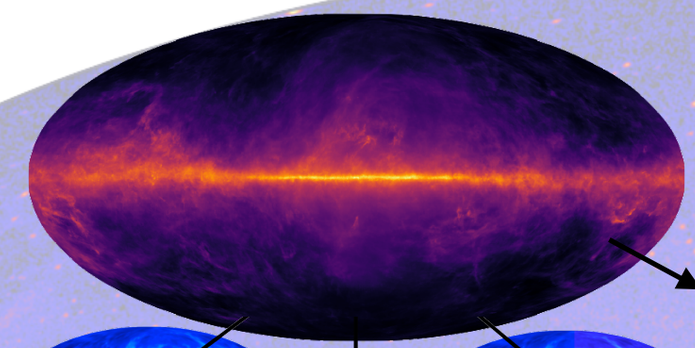
MA CHI PRODUCE I RAGGI COSIMCI AD ALTE ENERGIE?

GALACTIC EMISSION

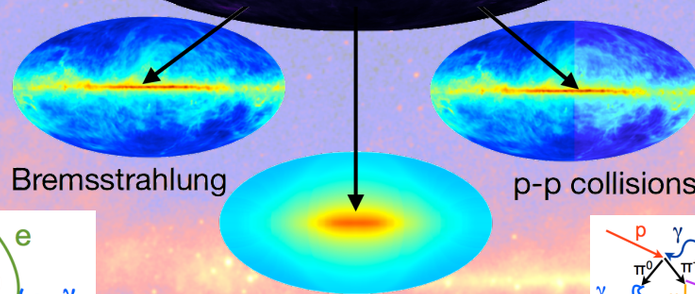


GALACTIC EMISSION

DIFFUSE

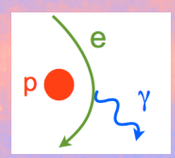


DM ?

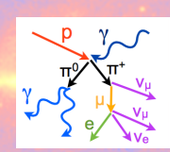


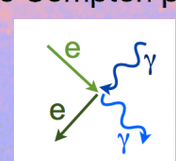
Bremsstrahlung

p-p collisions



Inverse Compton process



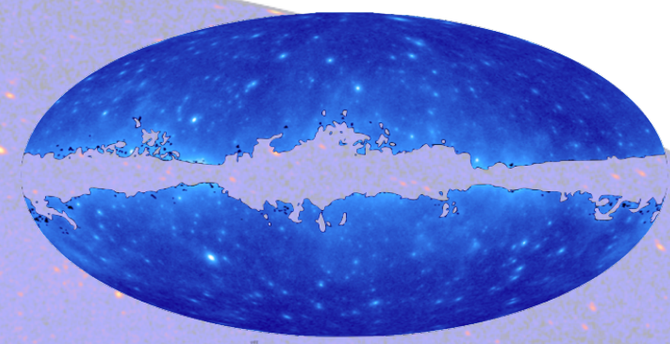


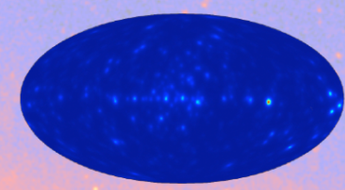
GALACTIC SOURCES

SN and SNR

Pulsars and PWN

EXTRA-GALACTIC EMISSION





RESOLVED EXTRAGALACTIC SOURCES

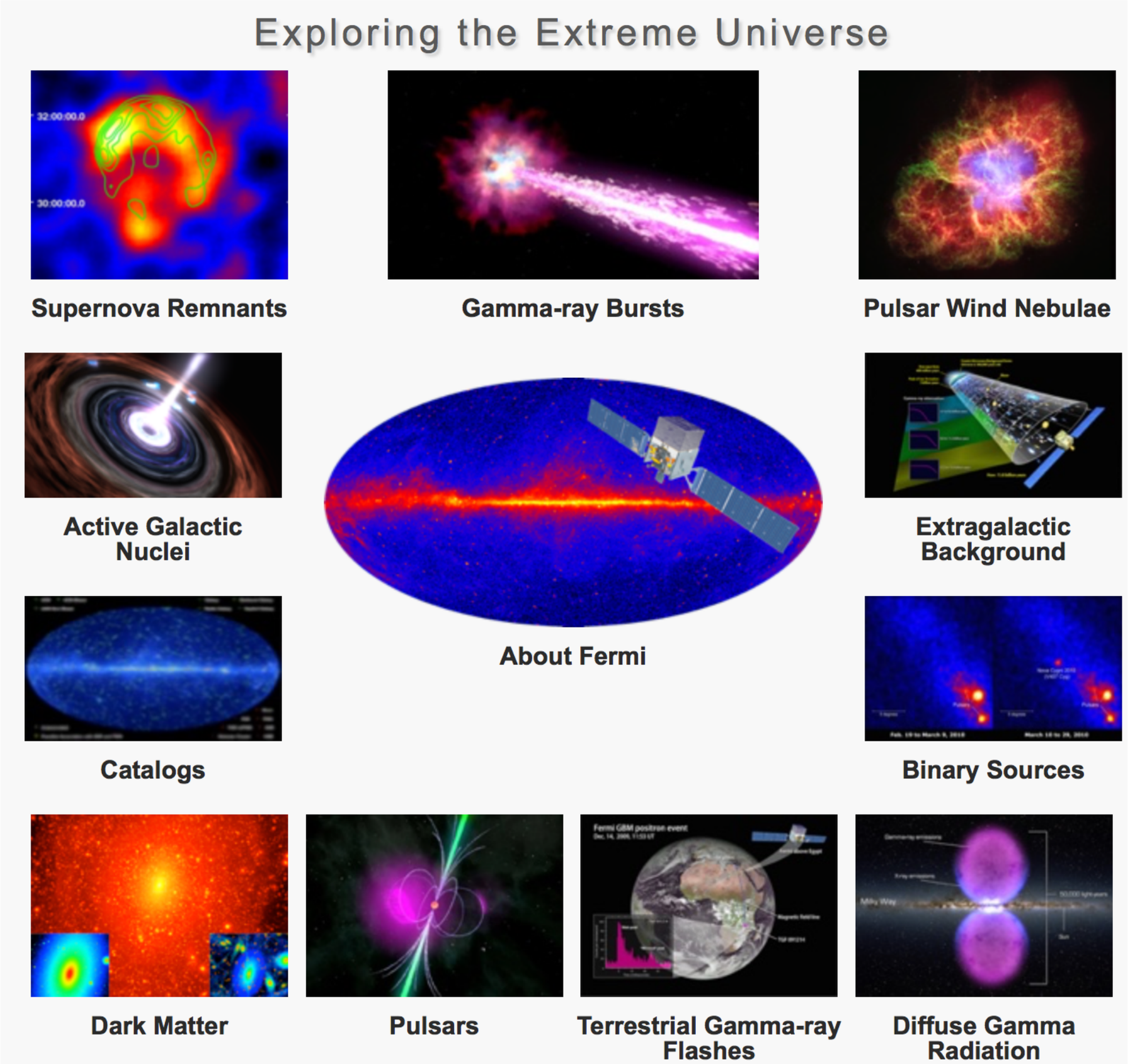
QUASI-ISOTROPIC EMISSION

SFG

AGN (Misaligned and Blazars)

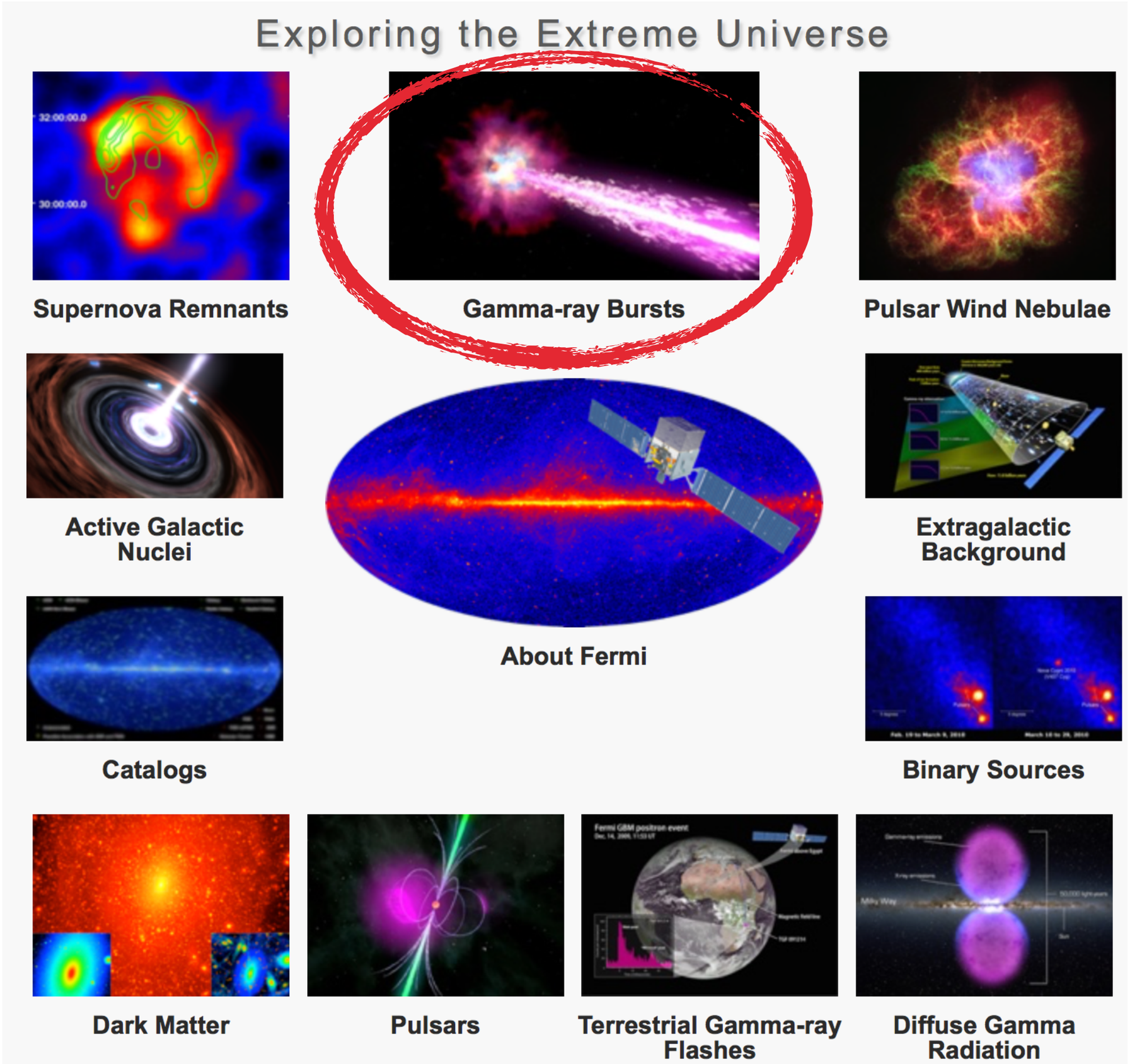
DM ? (see talk by Simone Ammazzalorso)

ALLE PIÙ ALTE ENERGIE



https://fermi.gsfc.nasa.gov/science/eteu/binaries/

ALLE PIÙ ALTE ENERGIE



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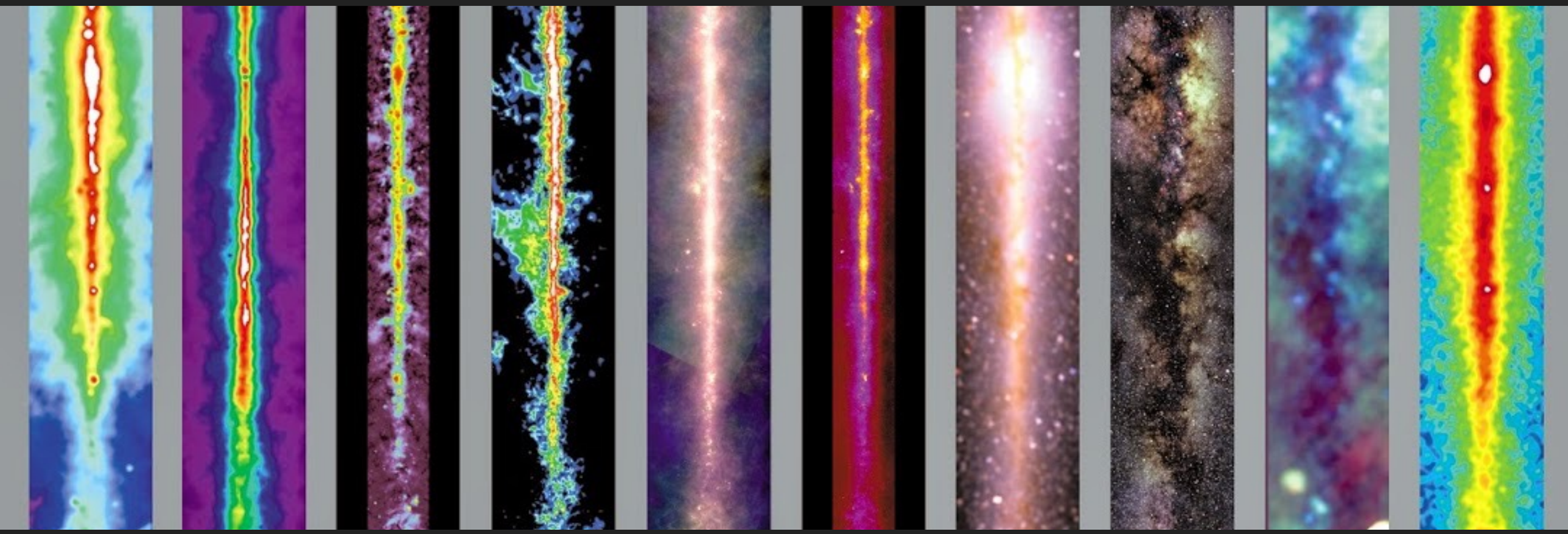

Physics Torino Department of Excellence

INFN Istituto Nazionale di Fisica Nucleare

Fermi