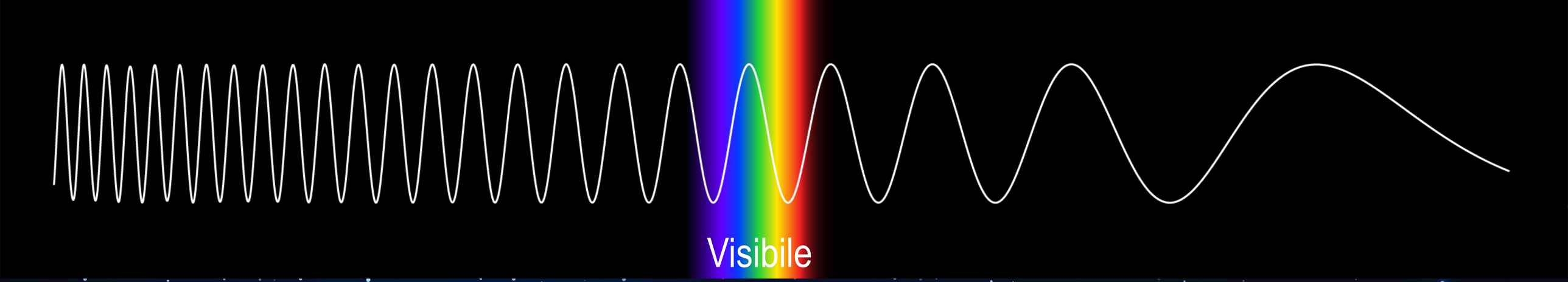
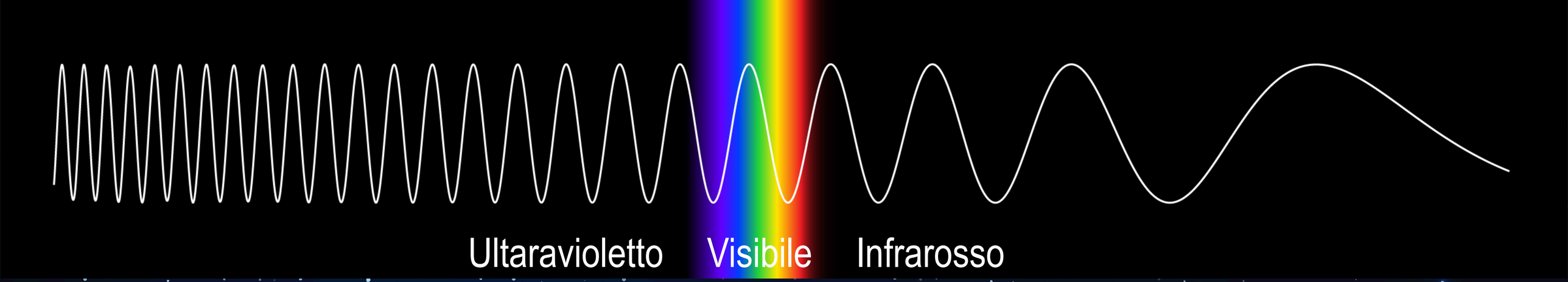
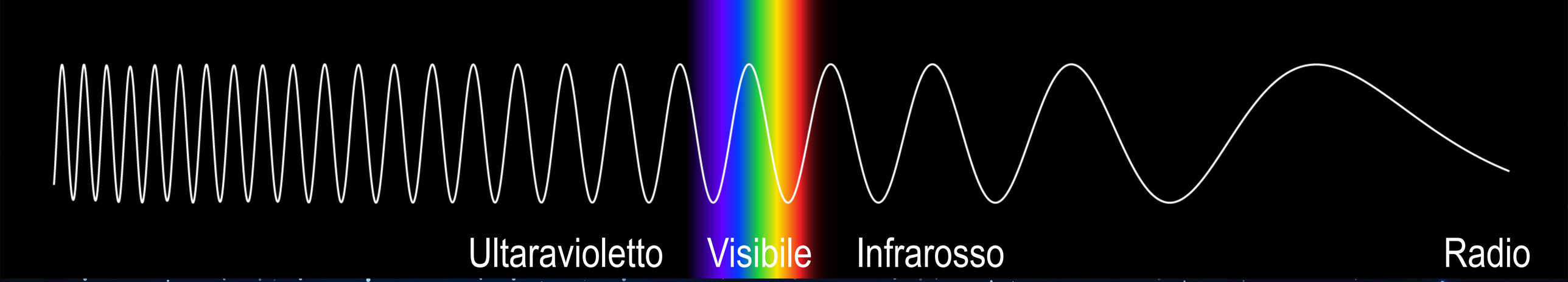
Attività in Astrofisica delle Alte Energie

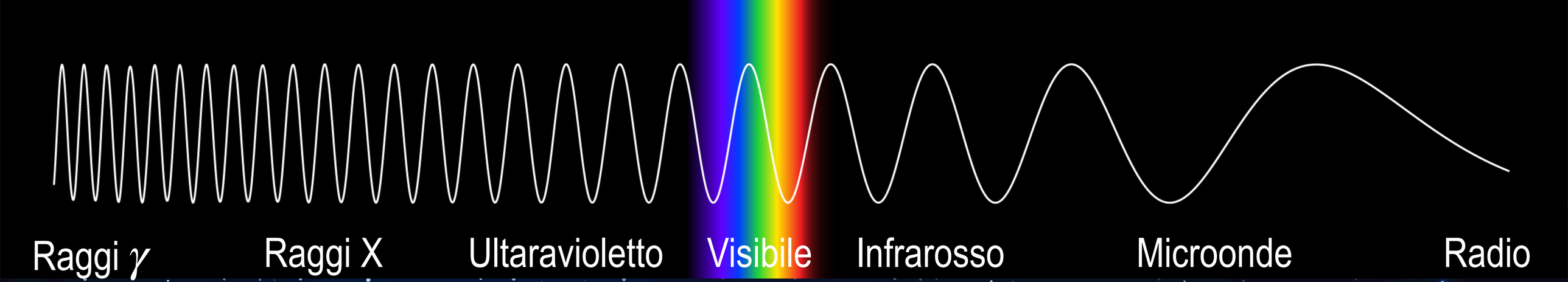
14 Aprile 2022

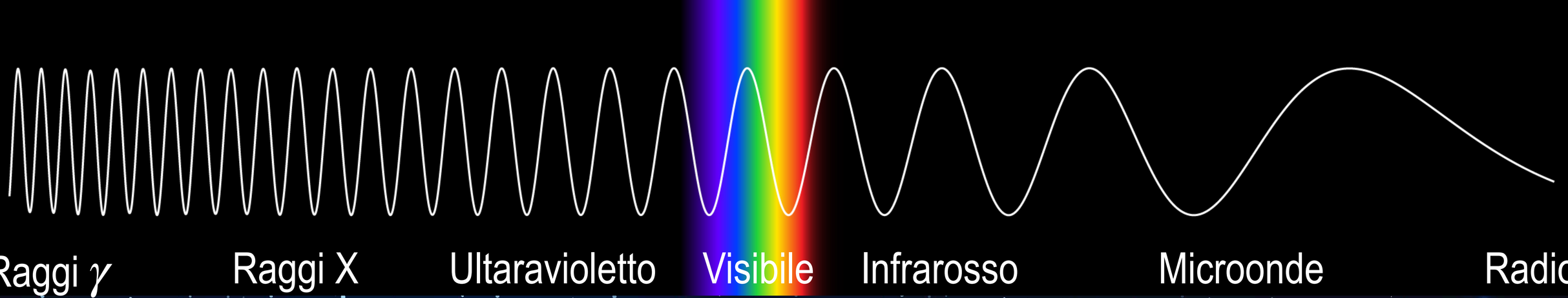
S. Cutini - INFN PG
S. Germani - UniPG


Visibile


Ultaravioletto
Visibile
Infrarosso

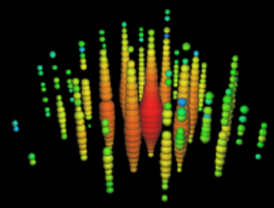

Ultaravioletto
Visibile
Infrarosso
Radio


Raggi γ
Raggi X
Ultaravioletto
Visibile
Infrarosso
Microonde
Radio



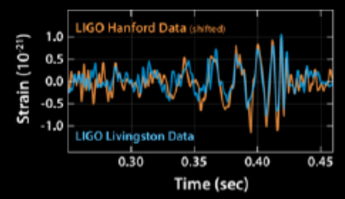


Photons



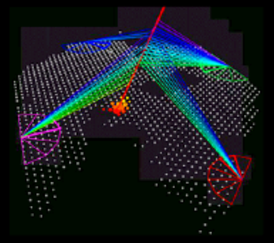
TeV-PeV Neutrinos

IceCube (2013)

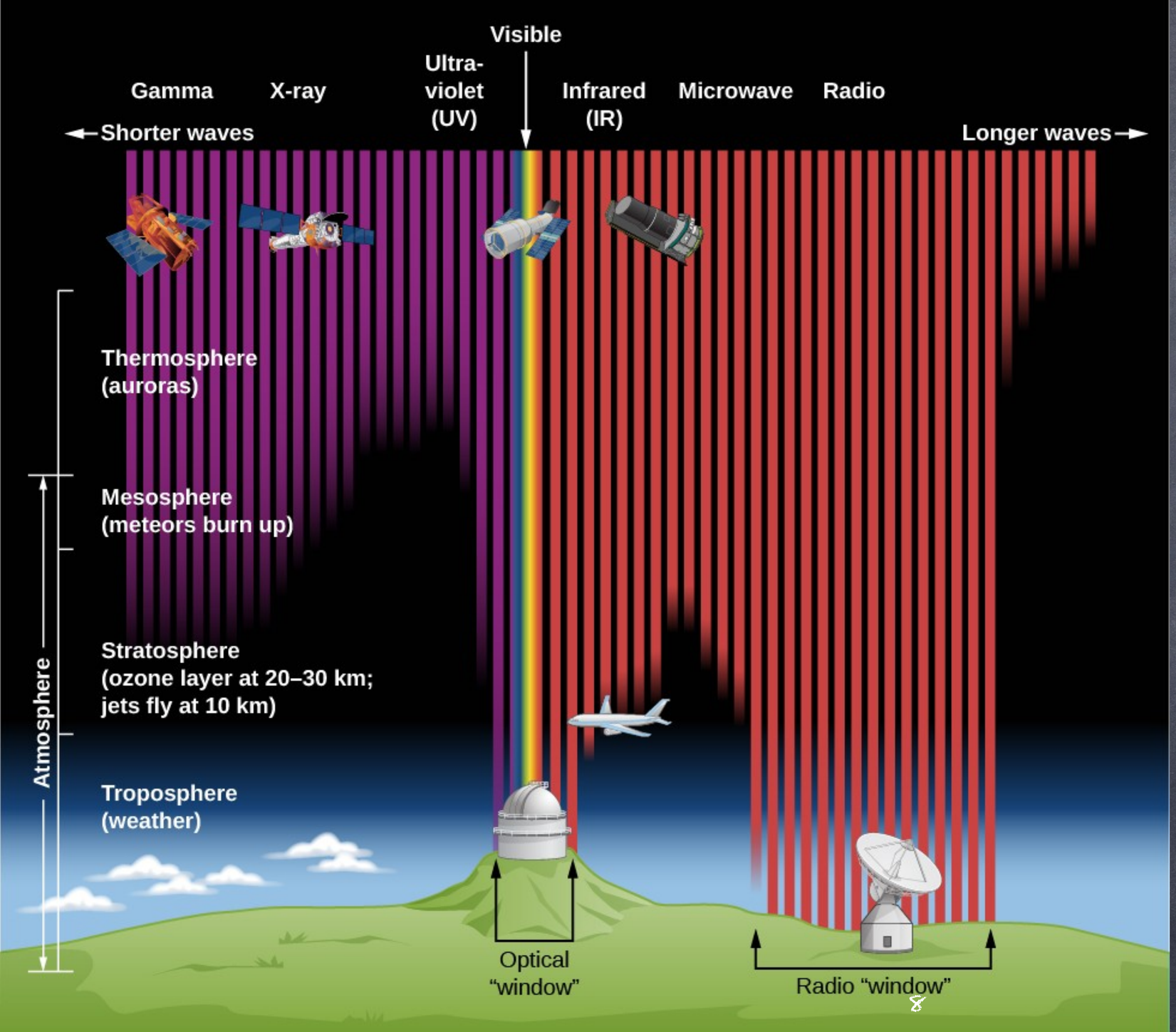


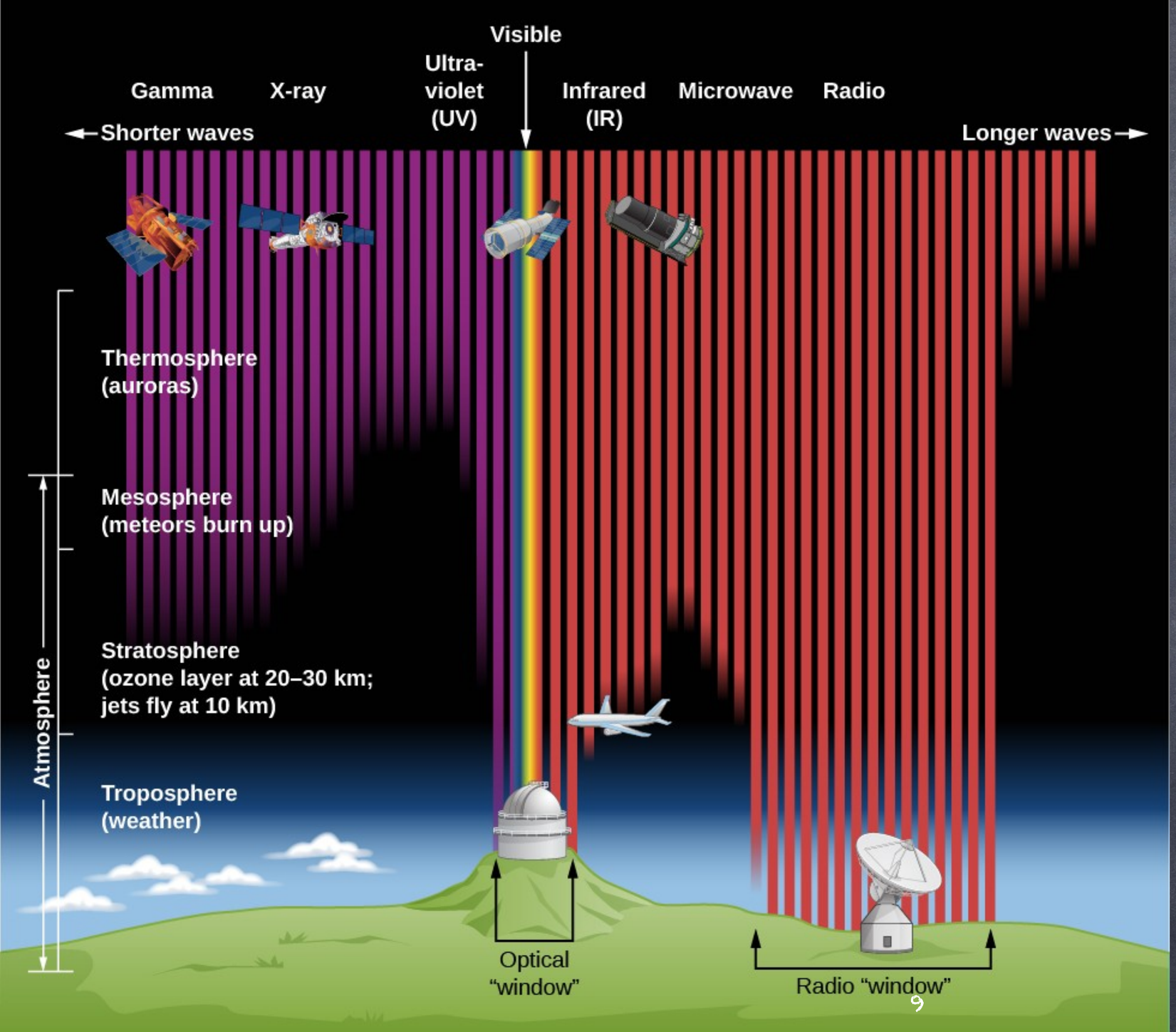
Gravitational waves

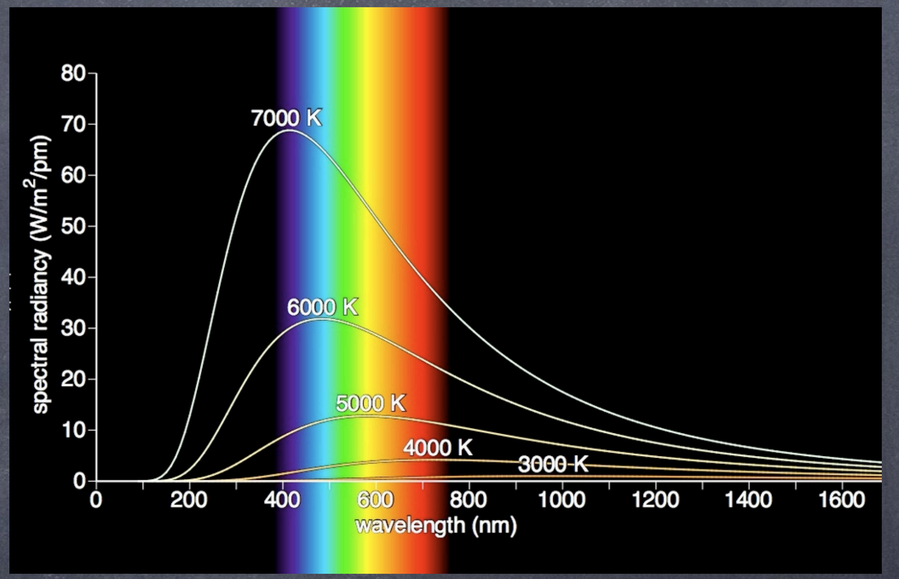
LIGO (2016)

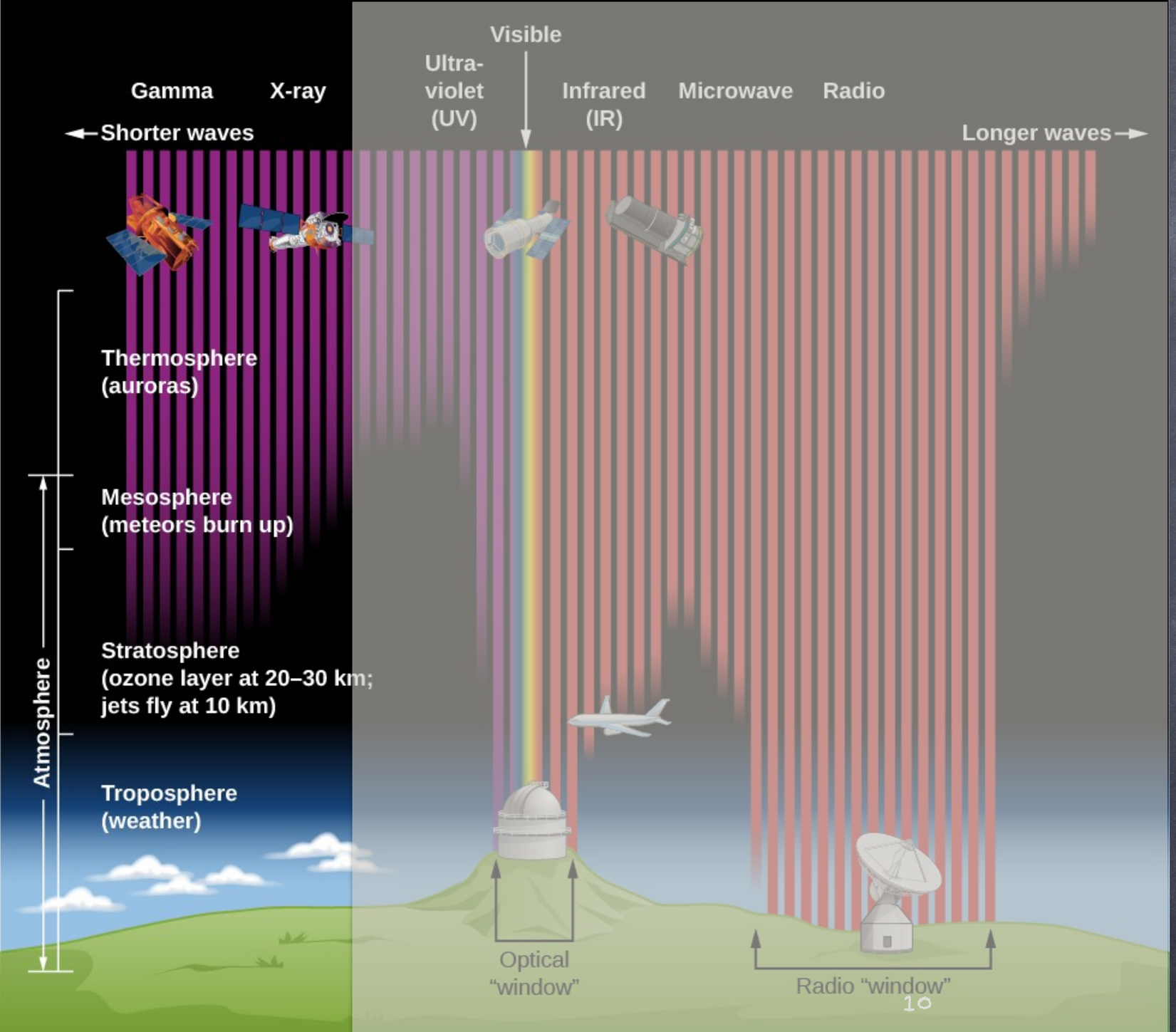


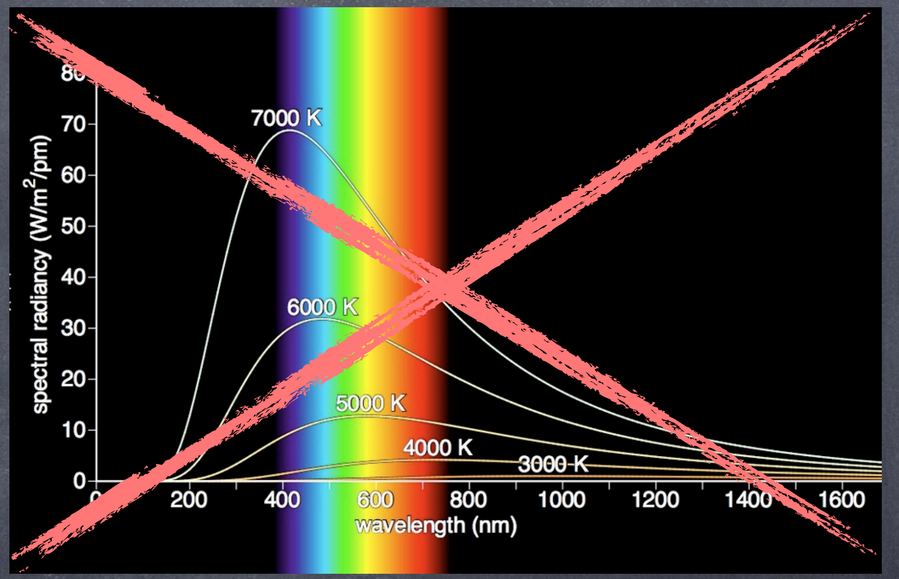
Cosmic rays

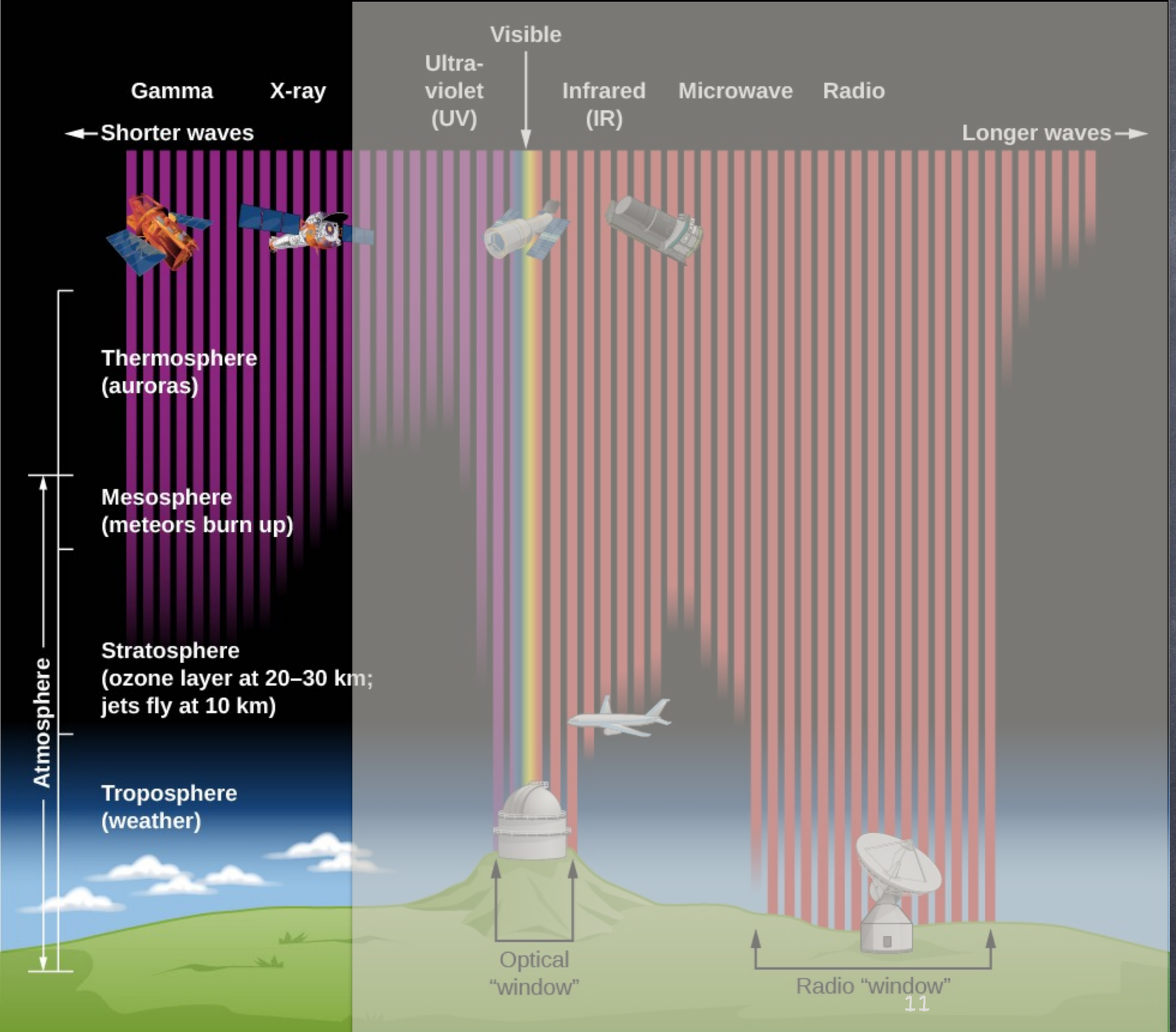

Visible
Ultra-violet (UV)
Gamma
X-ray
Infrared (IR)
Microwave
Radio
Shorter waves
Longer waves
Thermosphere (auroras)
Mesosphere (meteors burn up)
Stratosphere (ozone layer at 20–30 km; jets fly at 10 km)
Troposphere (weather)
Atmosphere
Optical "window"
Radio "window"

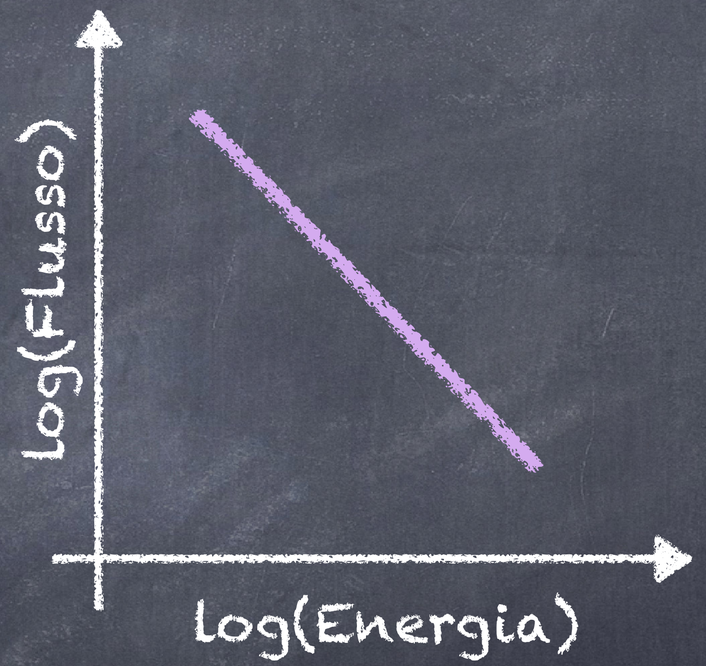

Visible
Ultra-violet (UV)
Gamma
X-ray
Infrared (IR)
Microwave
Radio
Shorter waves
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Troposphere (weather)
Atmosphere
Optical "window"
Radio "window"


spectral radiancy (W/m²/pm)
wavelength (nm)
7000 K
6000 K
5000 K
4000 K
3000 K
0
10
20
30
40
50
60
70
80
200
400
600
800
1000
1200
1400
1600


Visible
Ultra-violet (UV)
Infrared (IR)
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6000 K
5000 K
4000 K
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spectral radiancy (W/m²/pm)
wavelength (nm)
0
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1600


Gamma
X-ray
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Optical "window"
Radio "window"

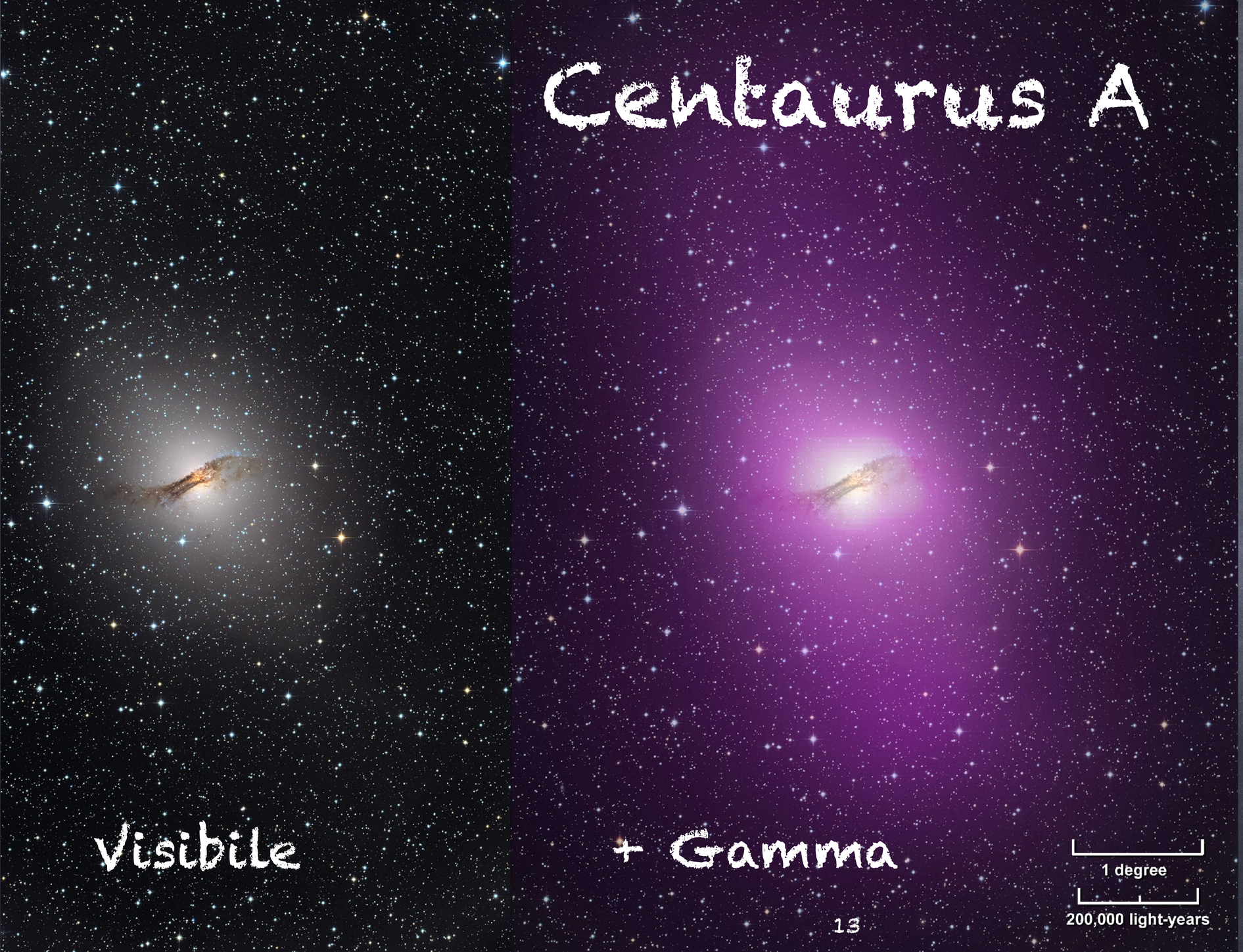

log(Flusso)
log(Energia)

Centaurus A

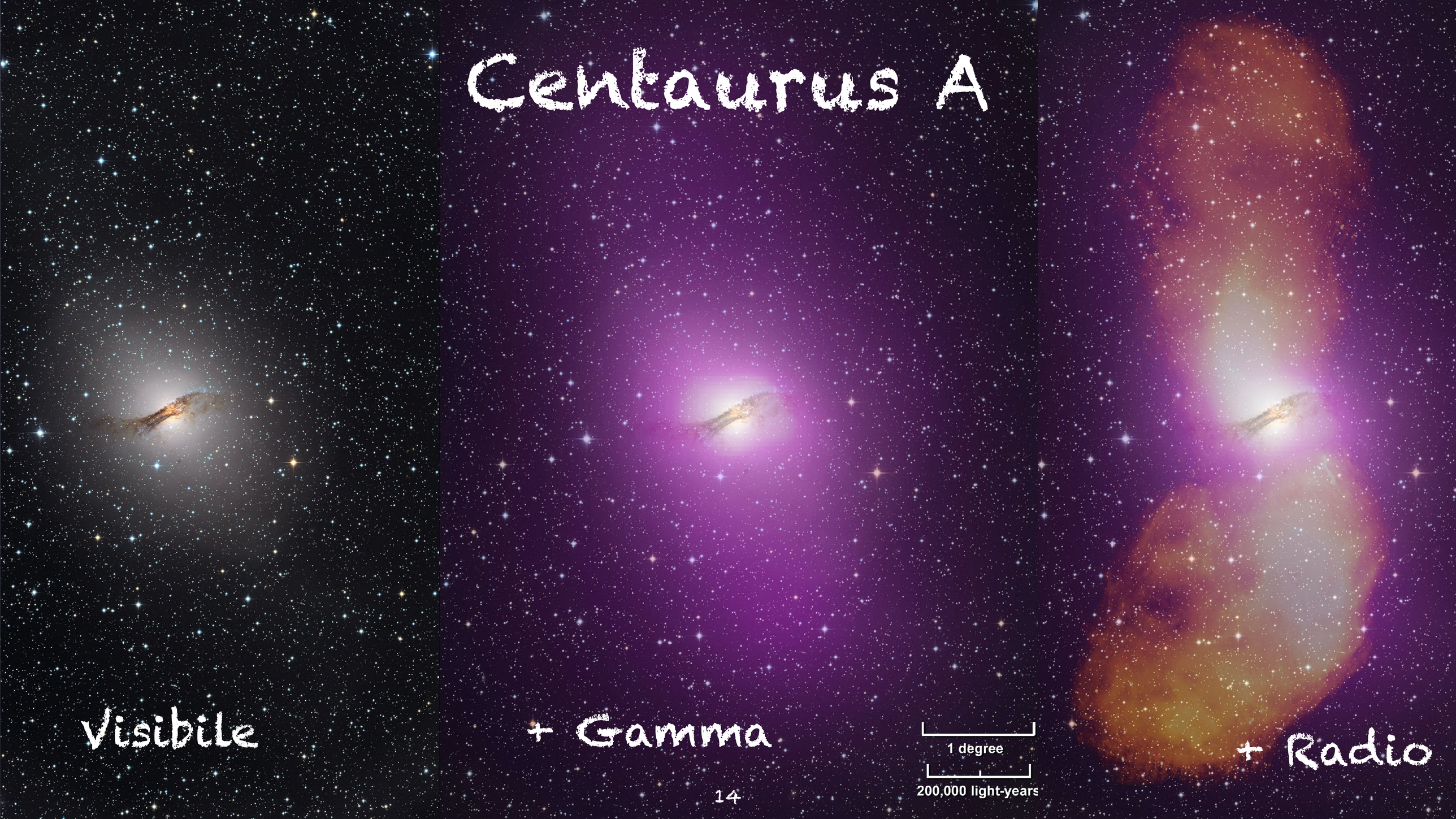


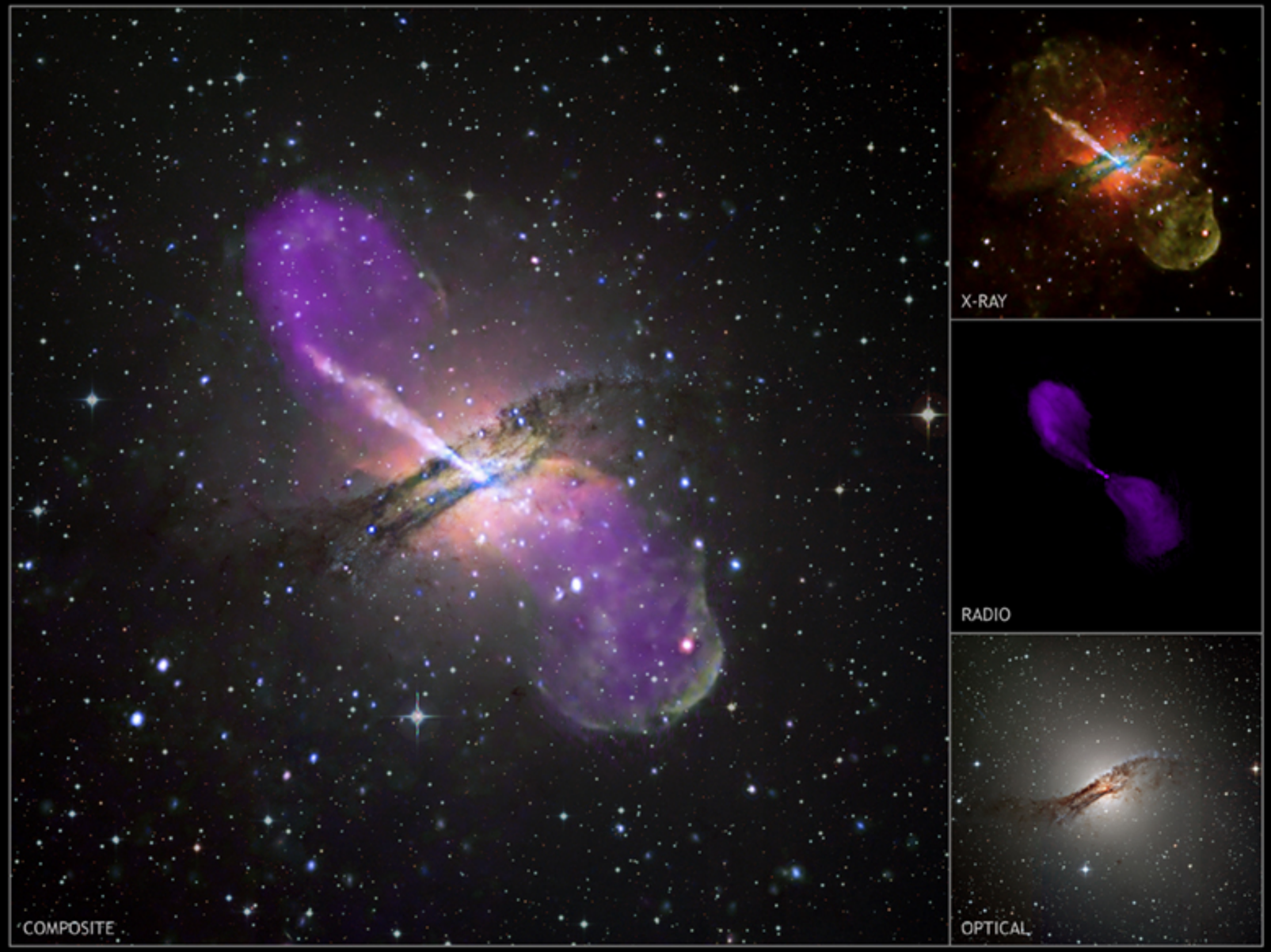
Visibile

Centaurus A



Centaurus A

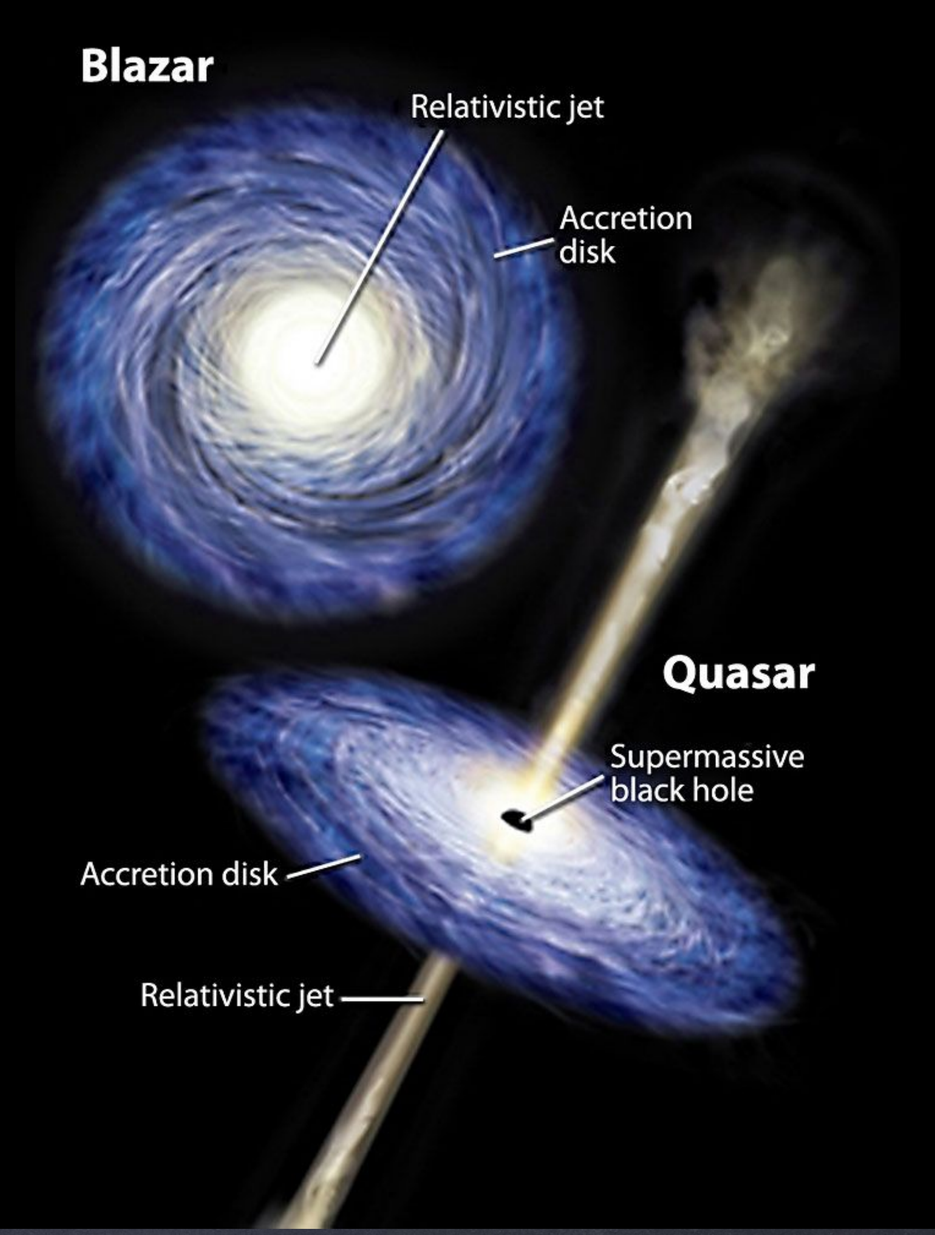



COMPOSITE

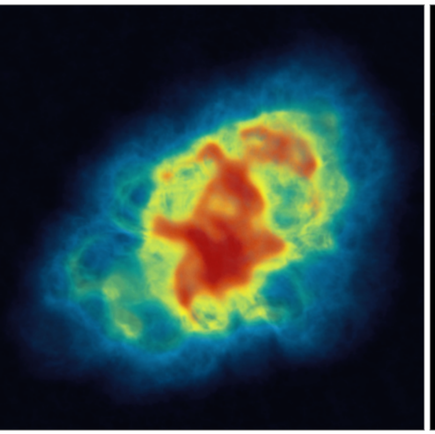
X-RAY

RADIO

OPTICAL


Blazar
Relativistic jet
Accretion disk
Quasar
Supermassive black hole
Accretion disk
Relativistic jet

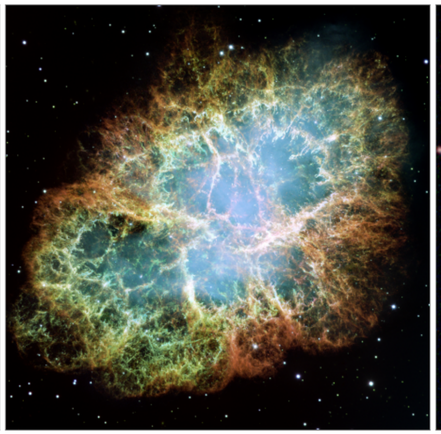
CRAB NEBULA



RADIO



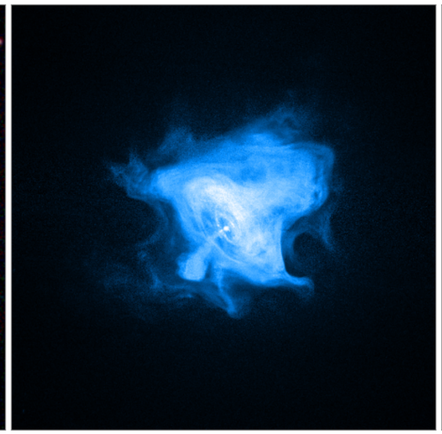
INFRARED



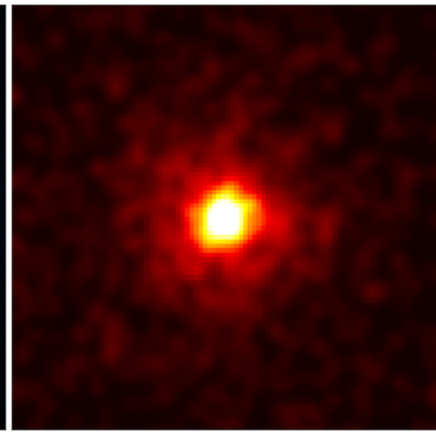
VISIBLE LIGHT



ULTRAVIOLET

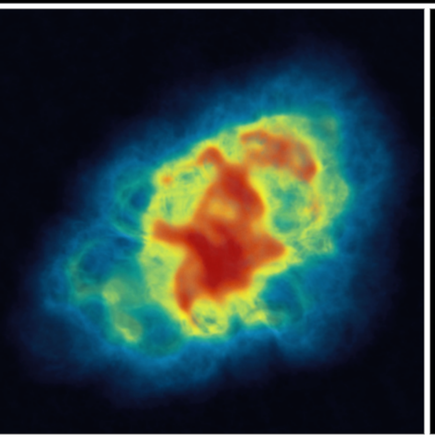


X-RAYS



GAMMA RAYS

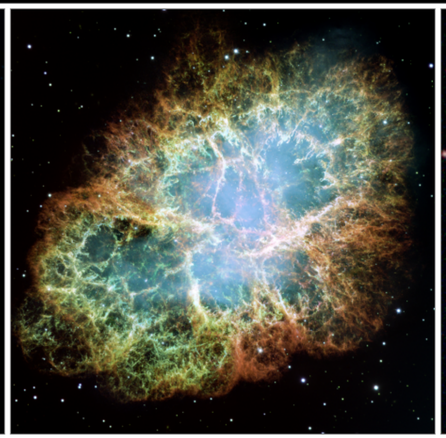
CRAB NEBULA



RADIO



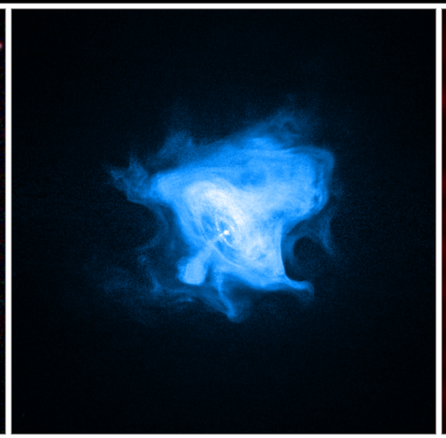
INFRARED



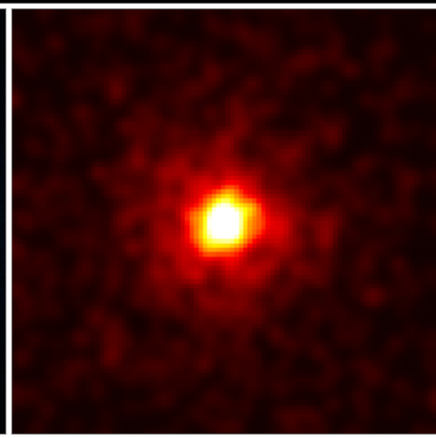
VISIBLE LIGHT



ULTRAVIOLET



X-RAYS

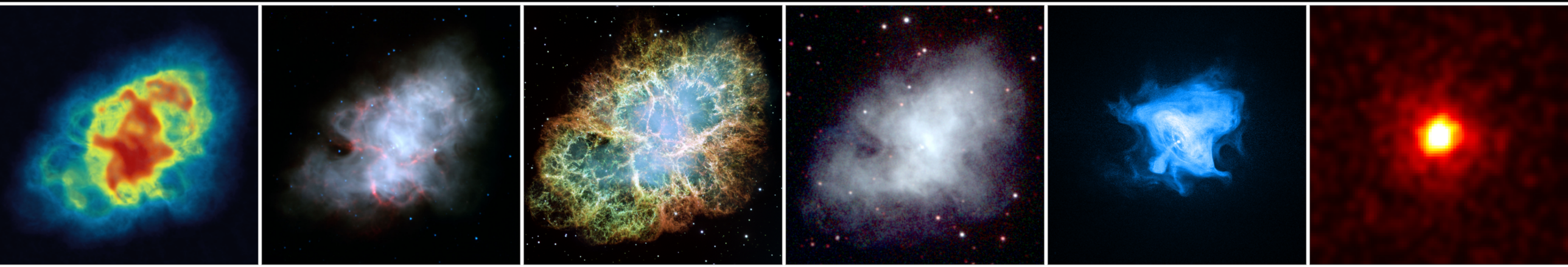


GAMMA RAYS



Resto di Supernova

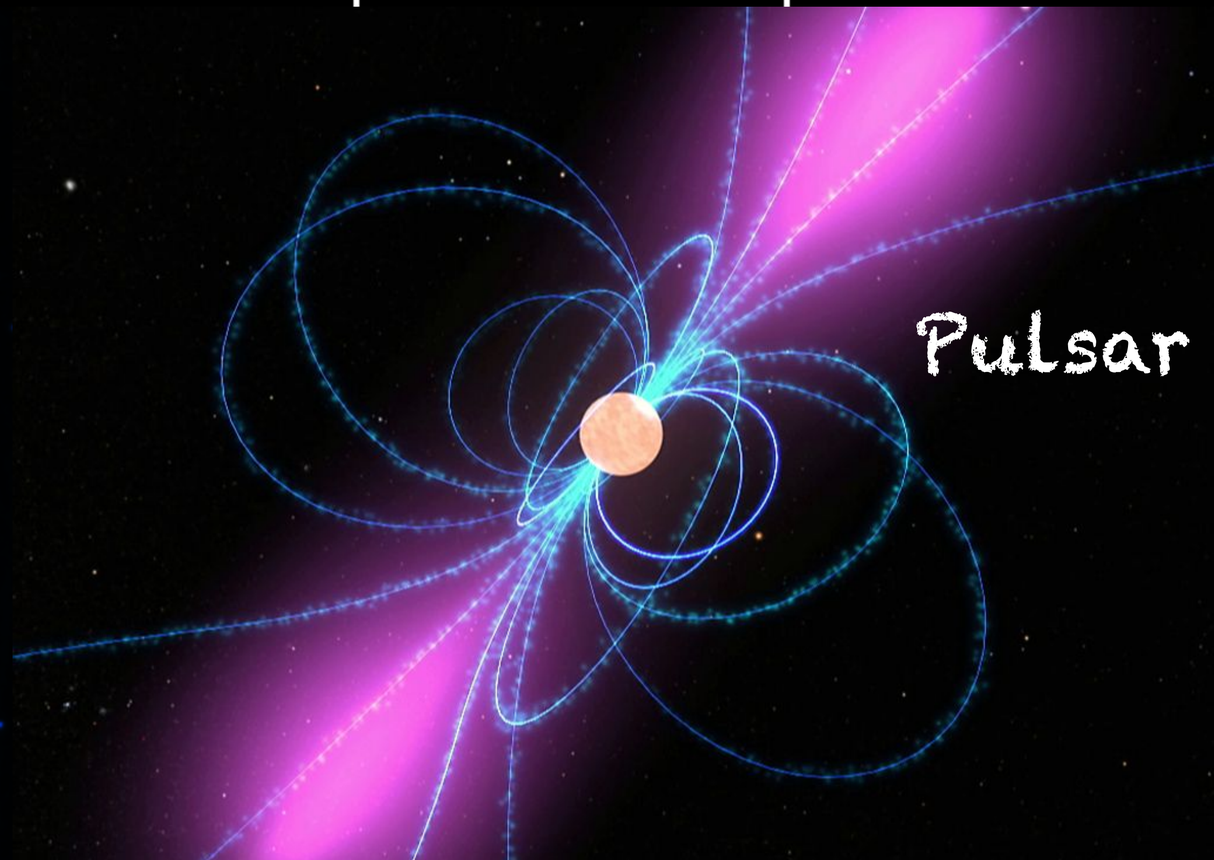
CRAB NEBULA



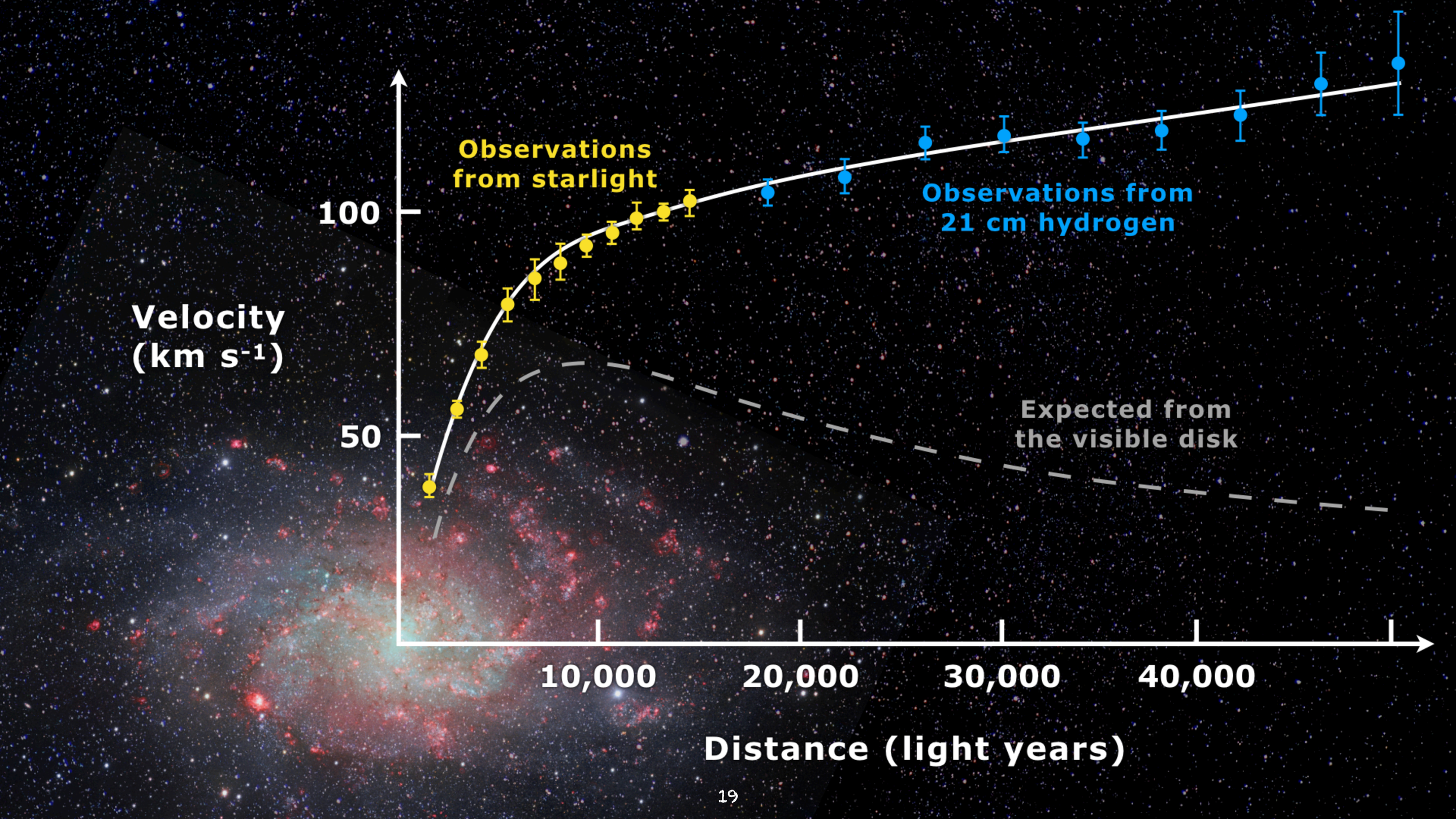
RADIO	INFRARED	VISIBLE LIGHT	ULTRAVIOLET	X-RAYS	GAMMA RAYS

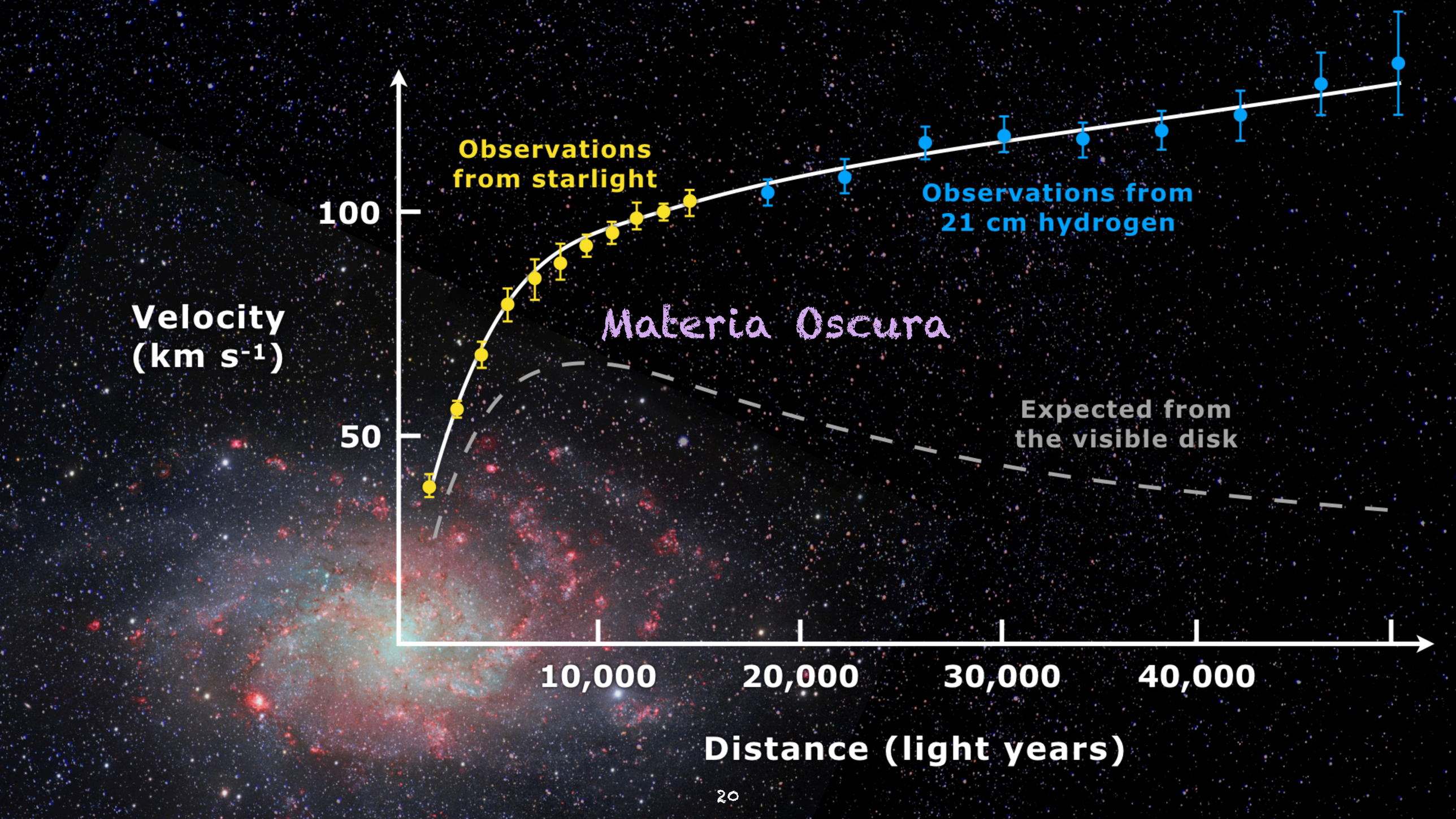


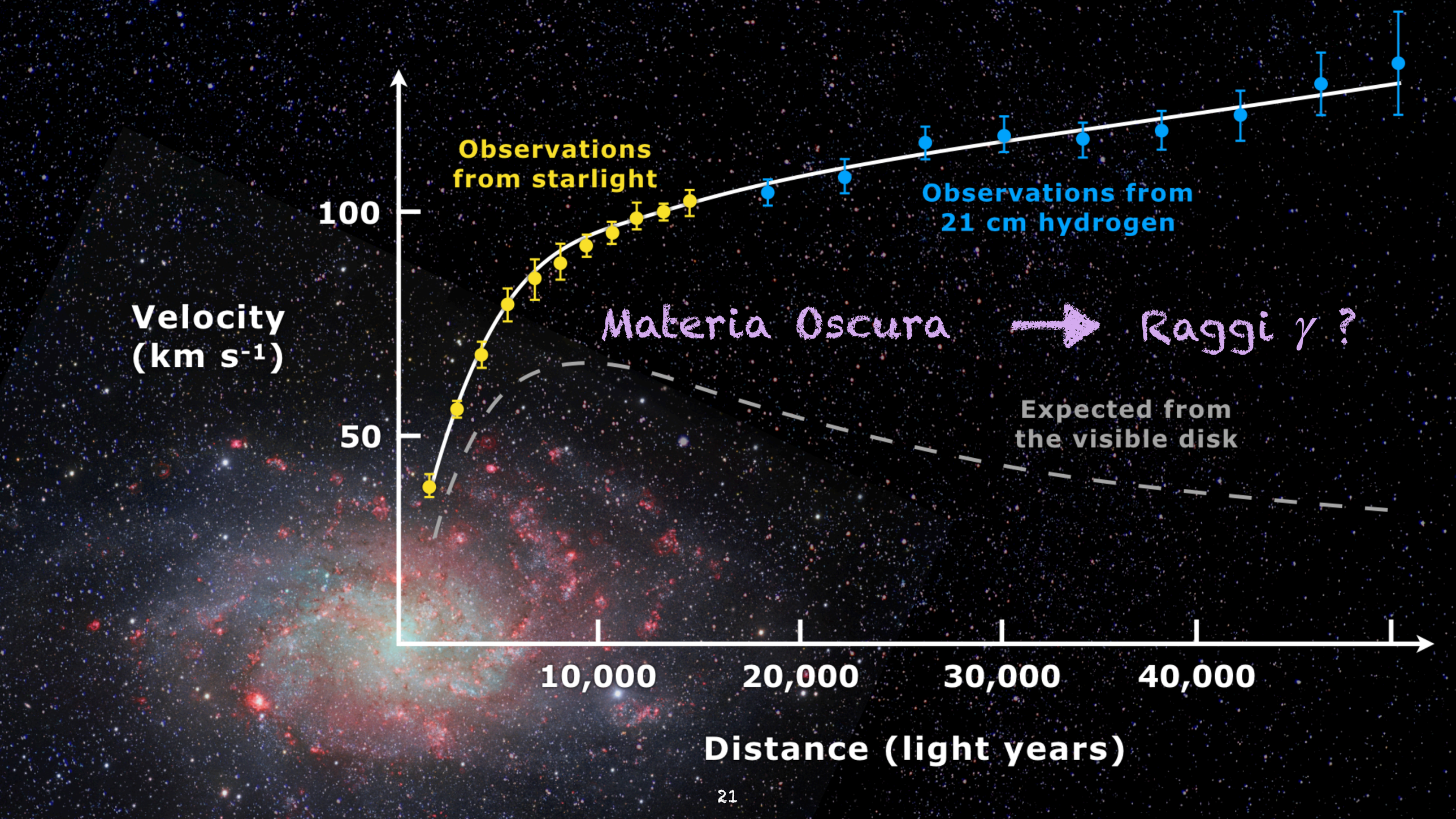
Resto di Supernova



Pulsar

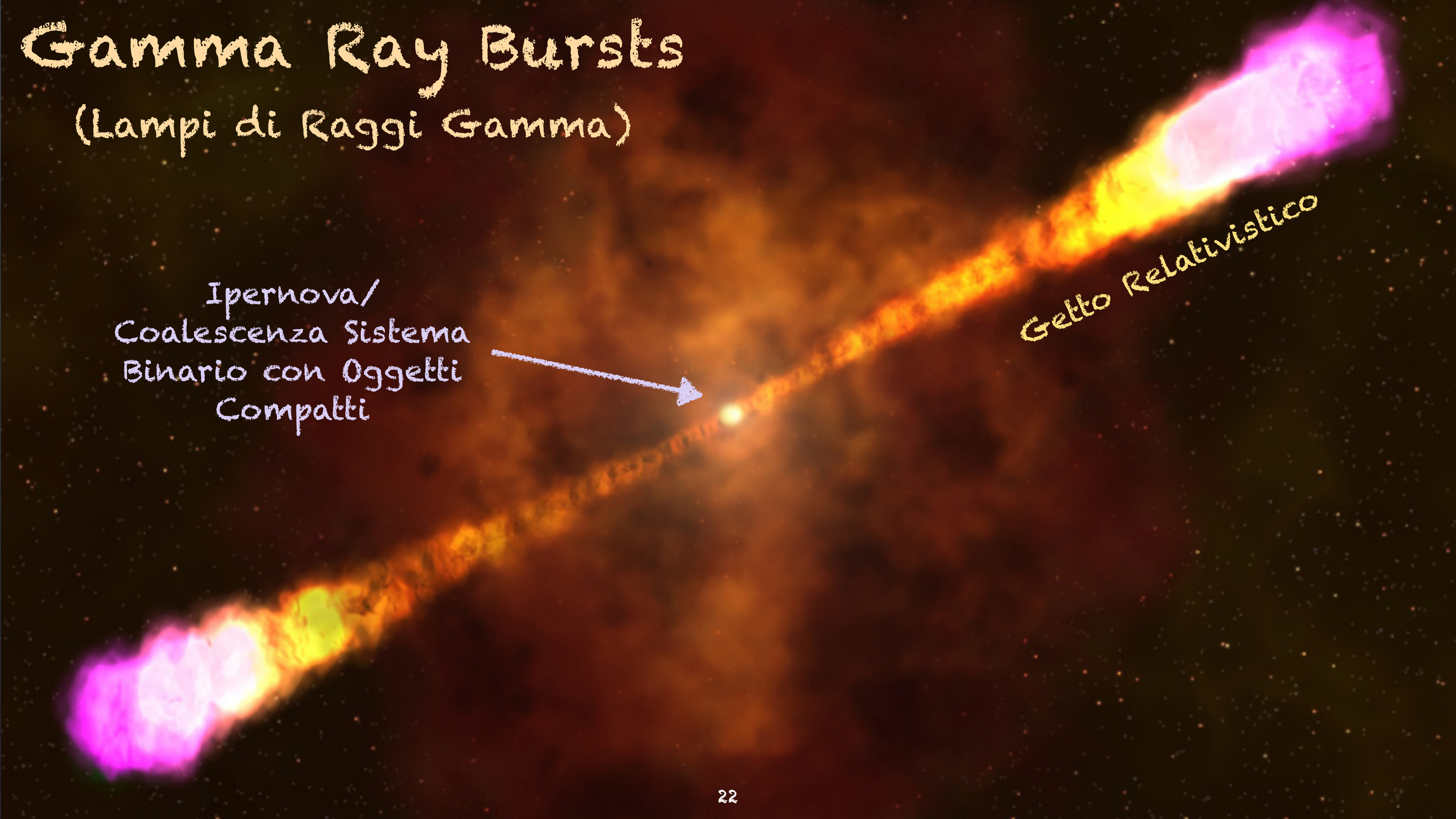

Observations
from starlight
Observations from
21 cm hydrogen
Expected from
the visible disk
Velocity
(km s-1)
100
50
10,000
20,000
30,000
40,000
Distance (light years)


Observations
from starlight
Observations from
21 cm hydrogen
Materia Oscura
Expected from
the visible disk
Velocity
(km s-1)
100
50
10,000
20,000
30,000
40,000
Distance (light years)

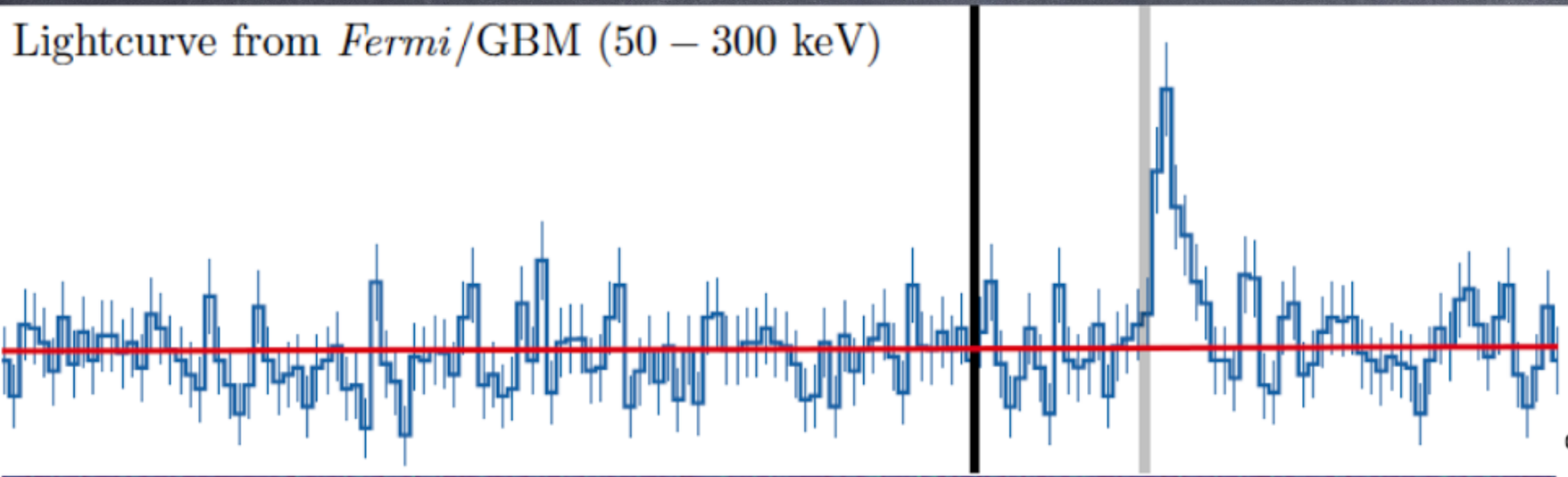

Observations
from starlight
Observations from
21 cm hydrogen
Materia Oscura → Raggi γ ?
Expected from
the visible disk
Velocity
(km s-1)
100
50
10,000
20,000
30,000
40,000
Distance (light years)

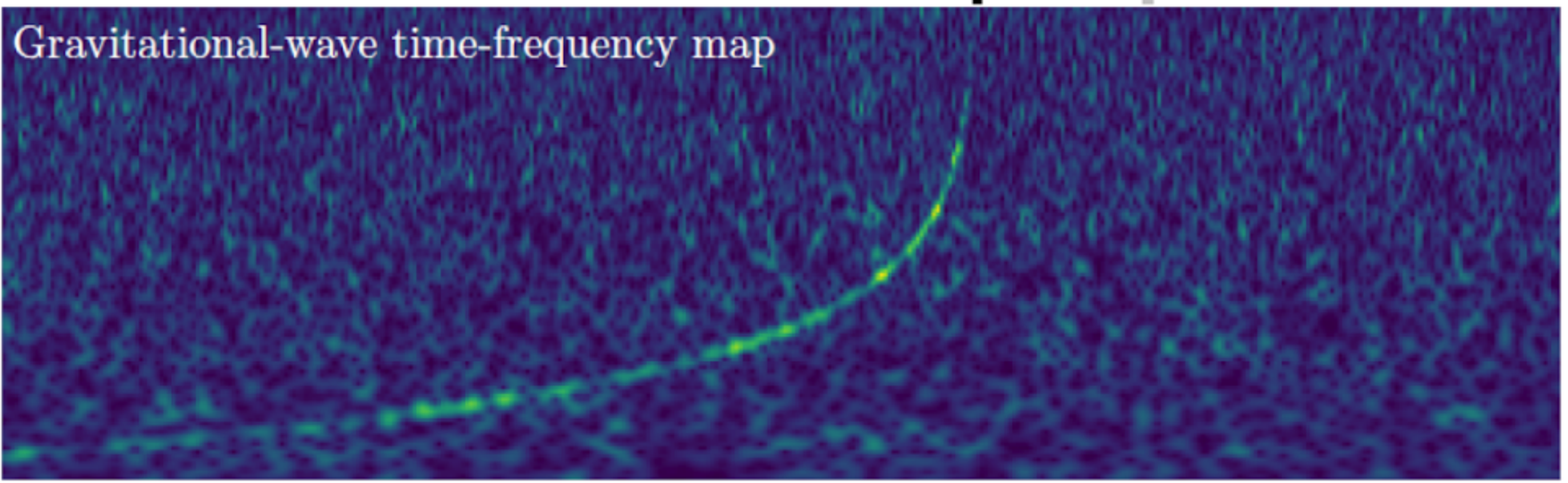
Gamma Ray Bursts

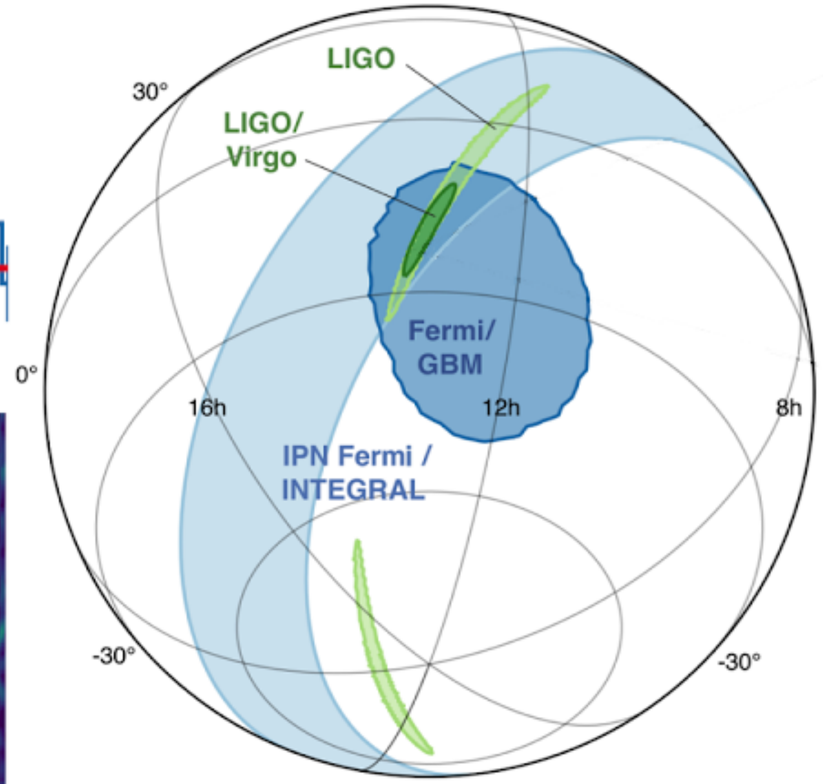
(Lampi di Raggi Gamma)



Astronomia Multimessaggero







Corso Astrofisica delle Alte Energie
E
Corso Astrofisica Multimessenger

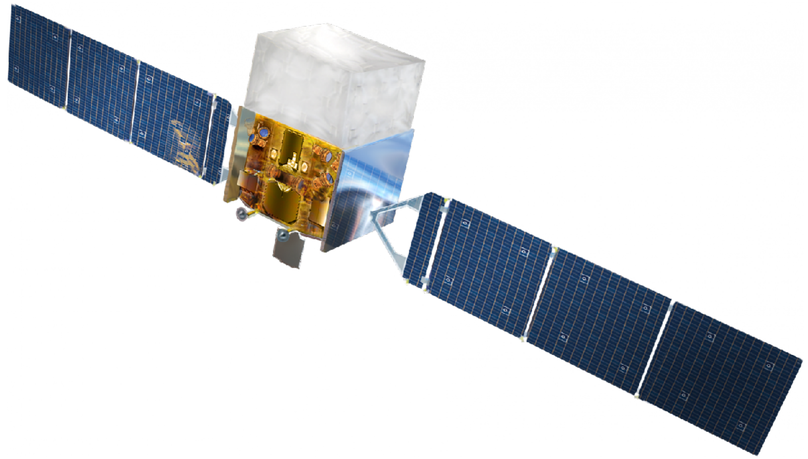
- Il cielo alle Alte Energie (X, MeV-GeV, TeV)
- Stelle e Galassie
- Plasmi Astrofisici e Processi Radiativi
  - Meccanismi di Produzione e Assorbimento di fotoni di alte energie
- Strumentazione per l'Astrofisica delle Alte Energie
  - X, MeV-GeV, TeV
- Sorgenti Galattiche
- Nuclei Galattici Attivi, Buchi Neri supermassicci
- Lampi di Raggi Gamma

Attività di Ricerca

INFN Istituto Nazionale di Fisica Nucleare

Fermi

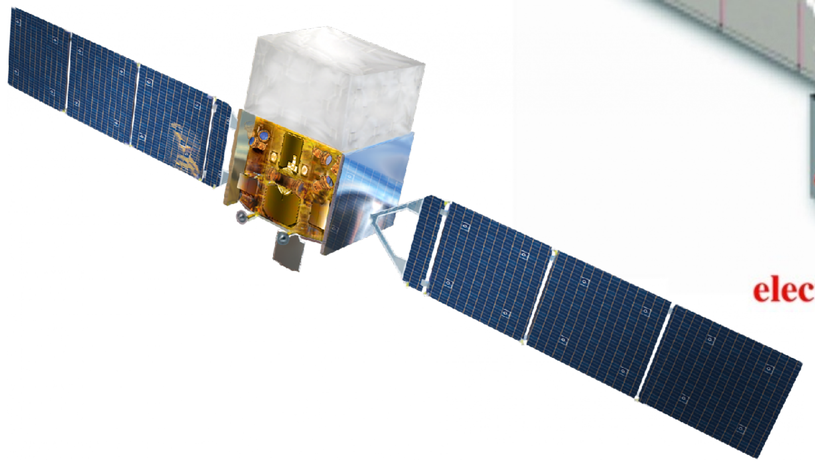
Gamma-ray
Space Telescope

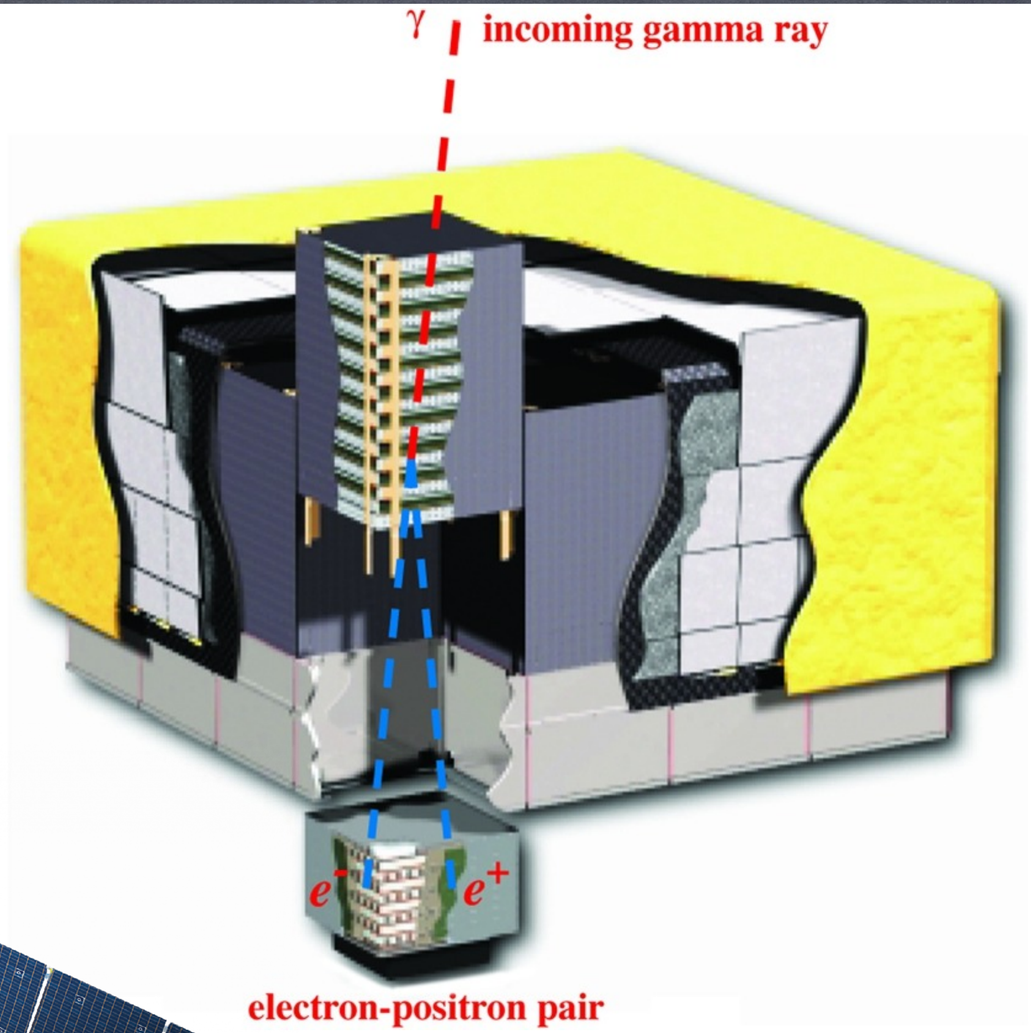


INFN Istituto Nazionale di Fisica Nucleare

Fermi

Gamma-ray
Space Telescope

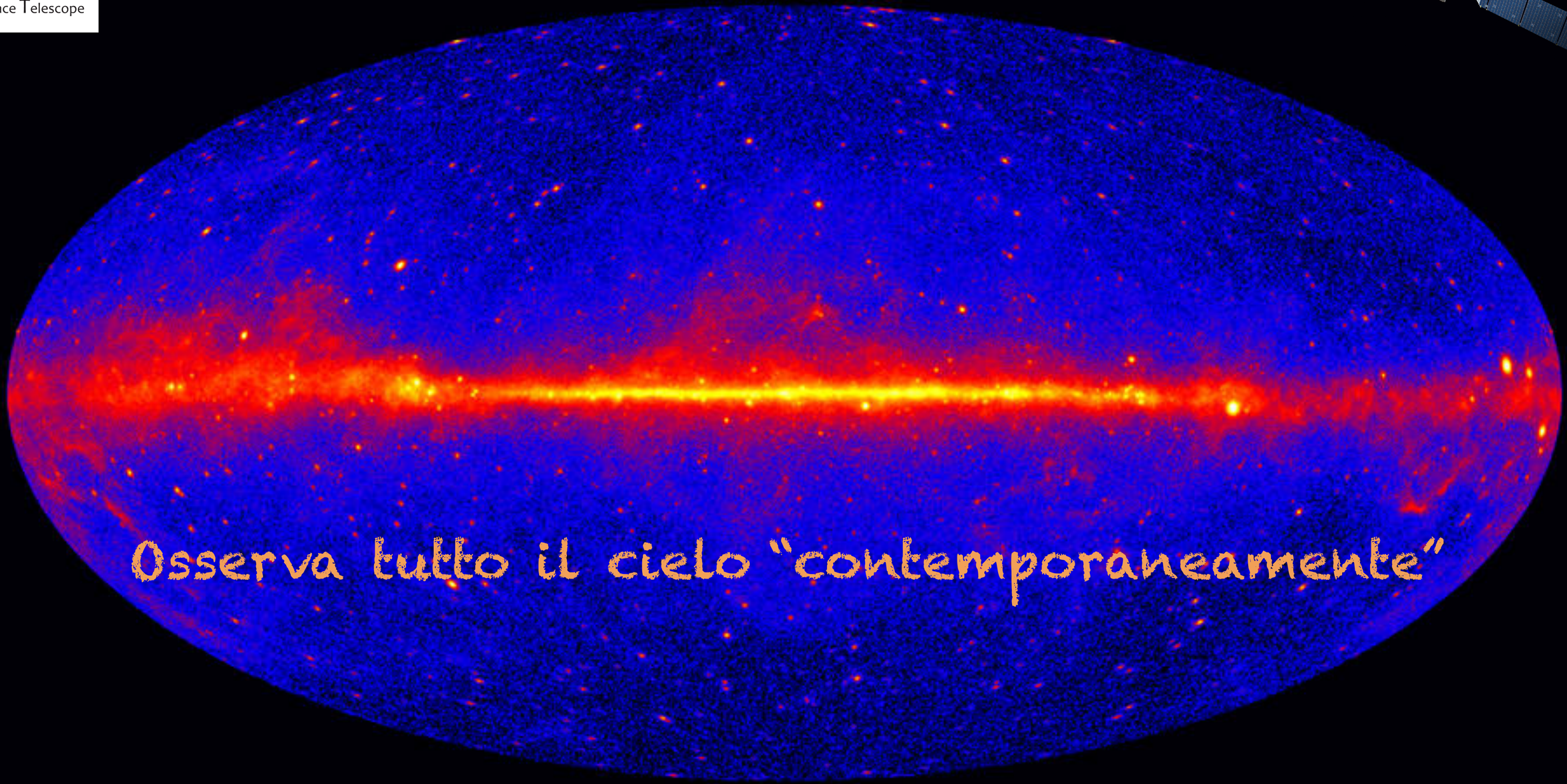




Fermi
Gamma-ray
Space Telescope

In orbita dal 2008

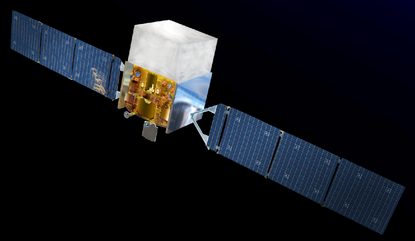




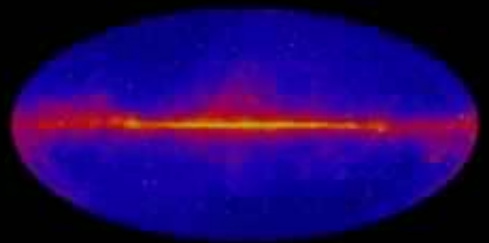
Osserva tutto il cielo "contemporaneamente"

Fermi
Gamma-ray
Space Telescope

E > 50 GeV

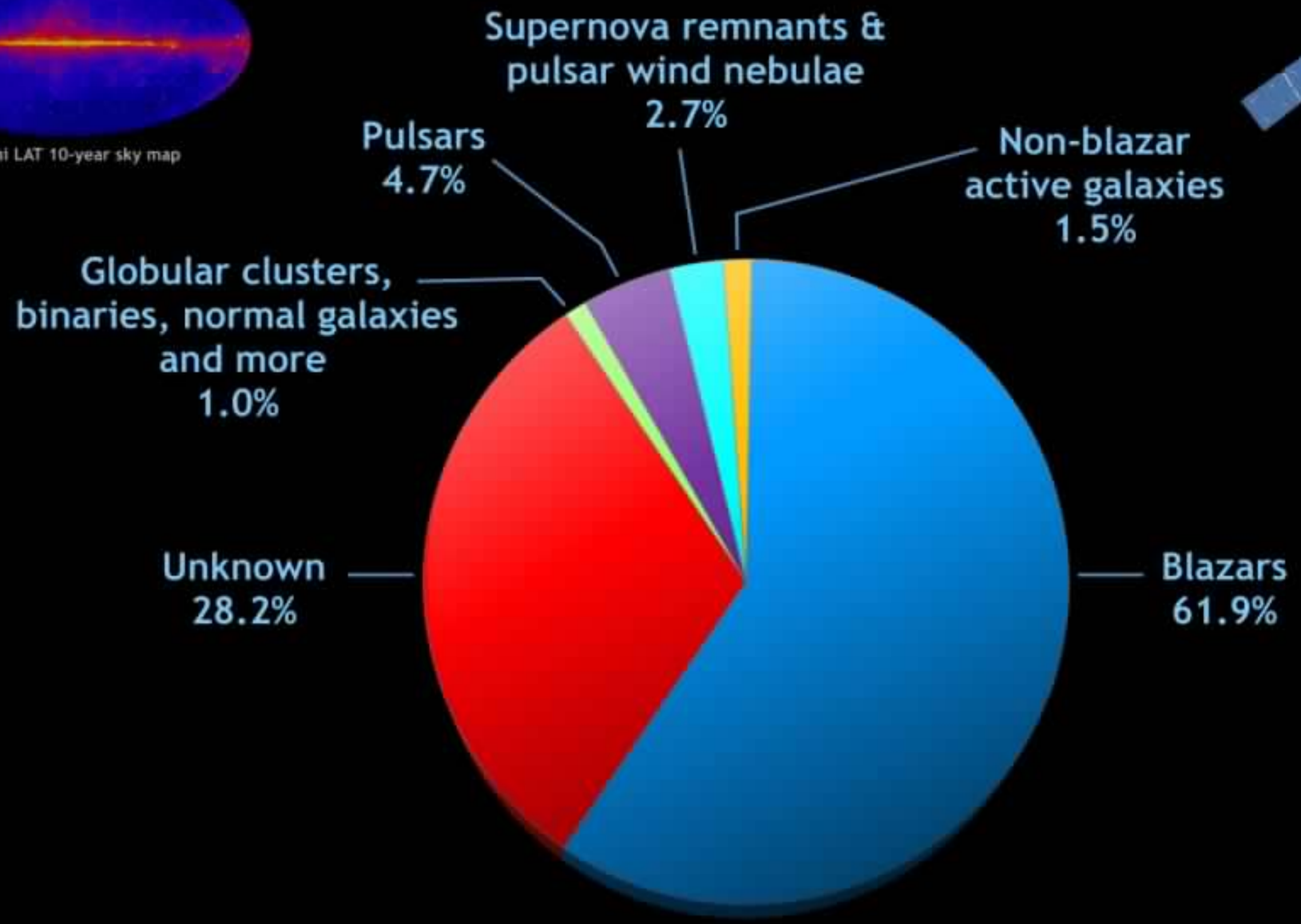


The Fourth Fermi LAT Catalog

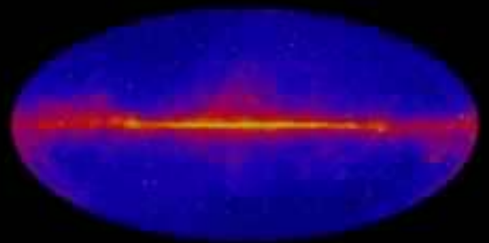


Fermi LAT 10-year sky map



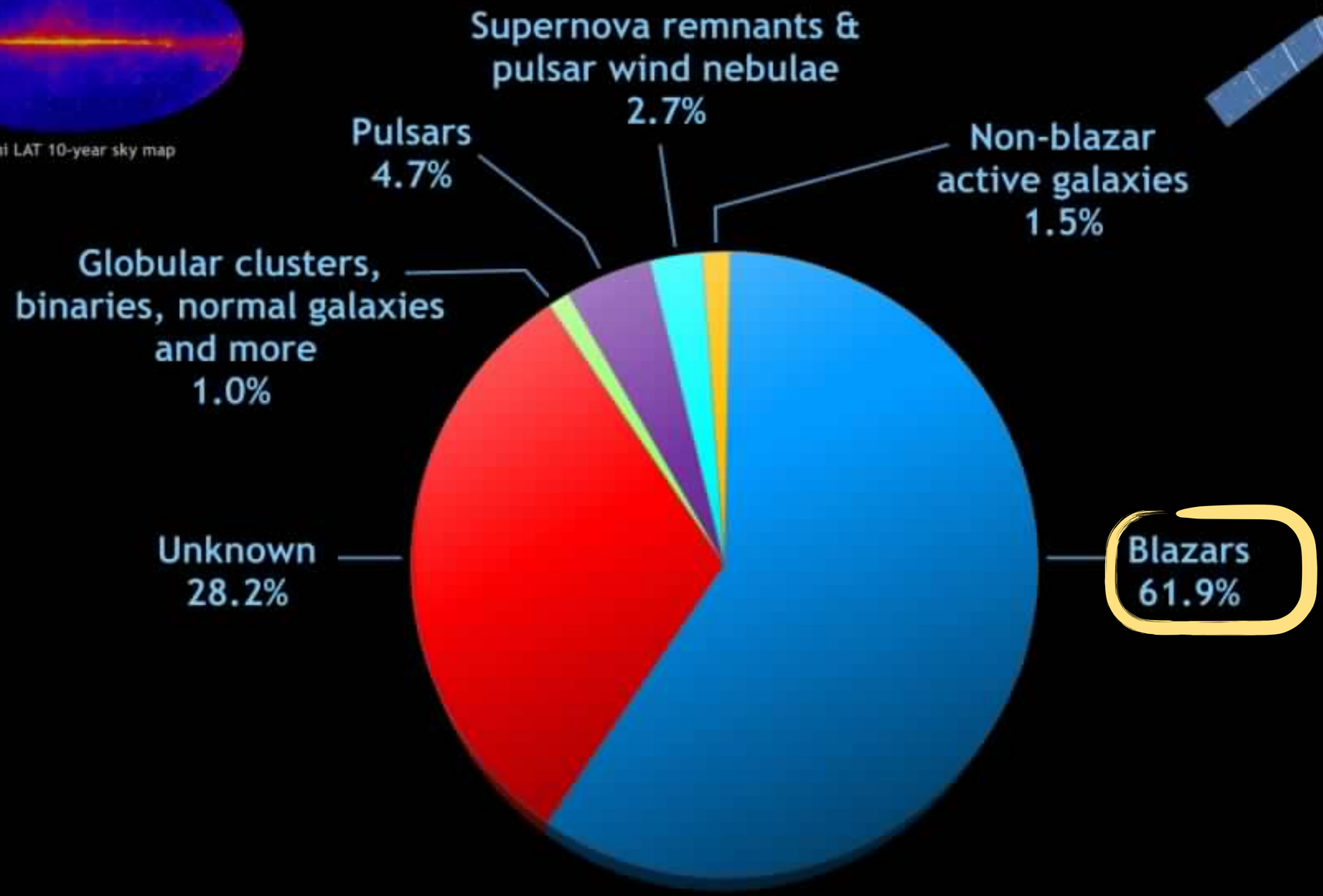


The Fourth Fermi LAT Catalog

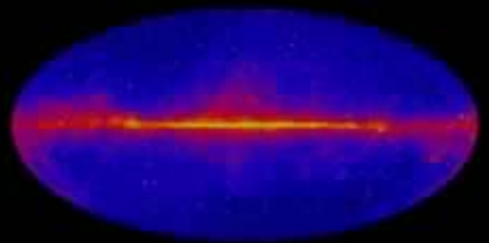


Fermi LAT 10-year sky map



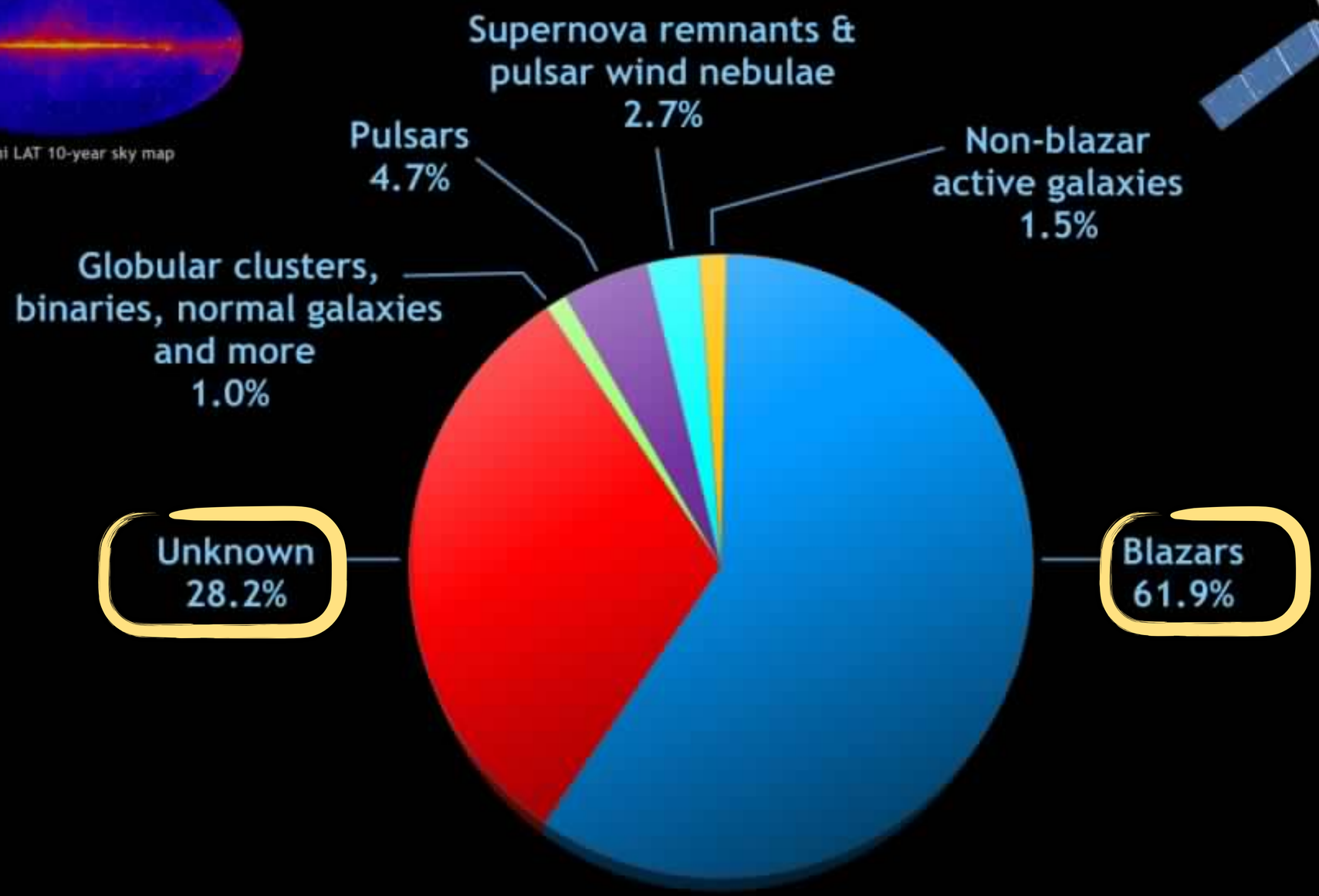


The Fourth Fermi LAT Catalog

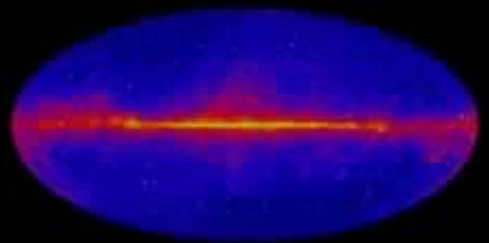


Fermi LAT 10-year sky map



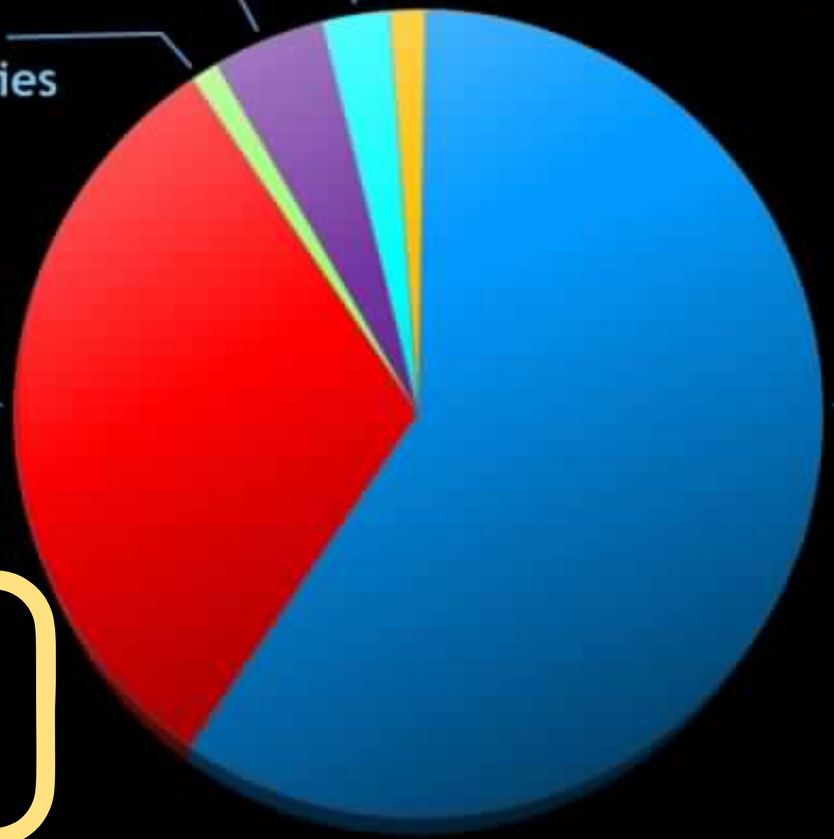


The Fourth Fermi LAT Catalog



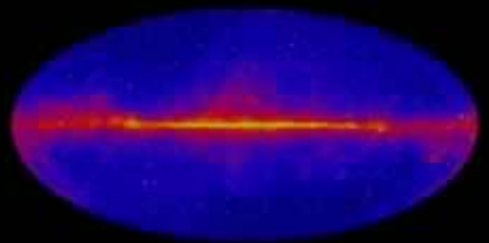
Fermi LAT 10-year sky map





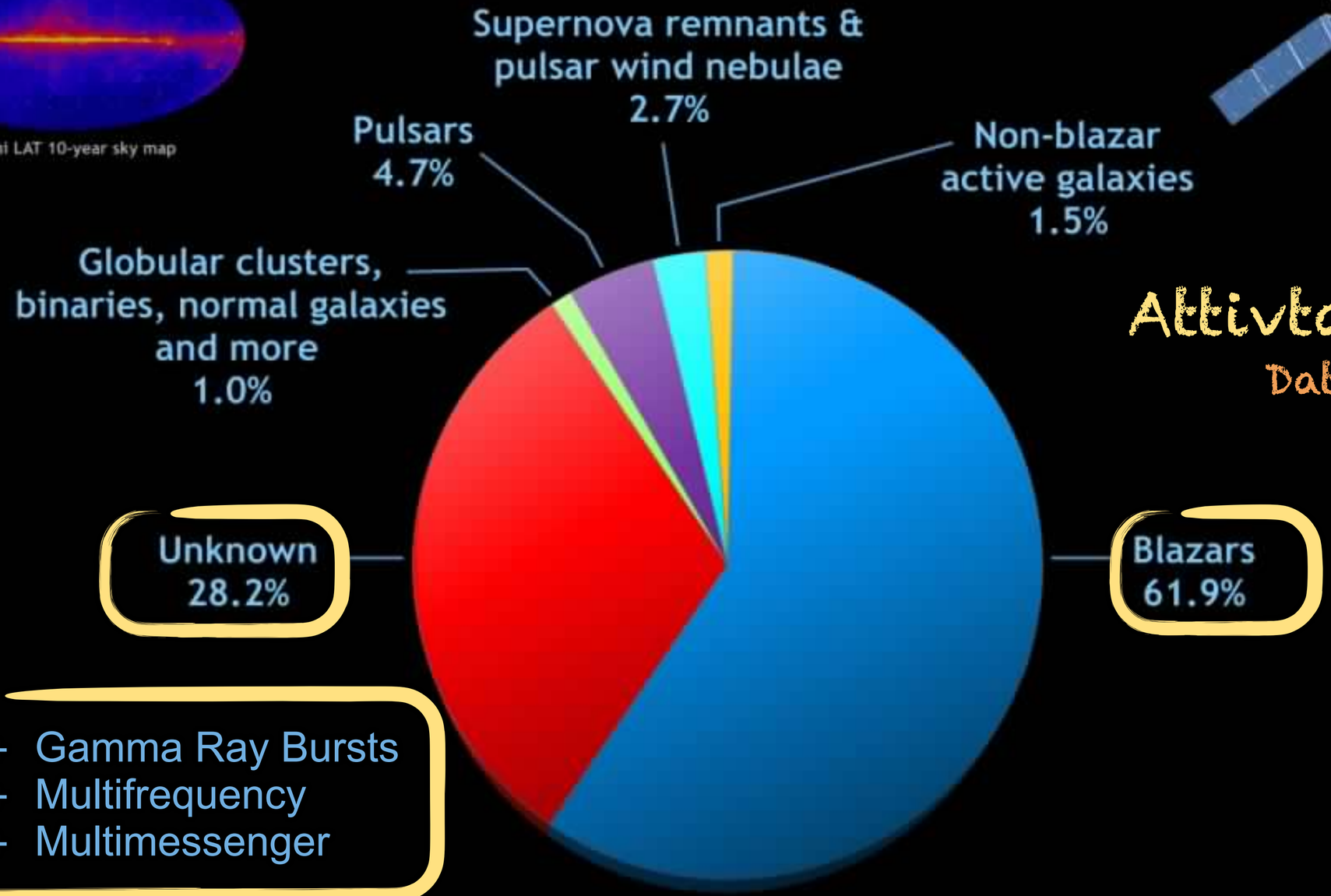
+ Gamma Ray Bursts
+ Multifrequency
+ Multimessenger

The Fourth Fermi LAT Catalog



Fermi LAT 10-year sky map

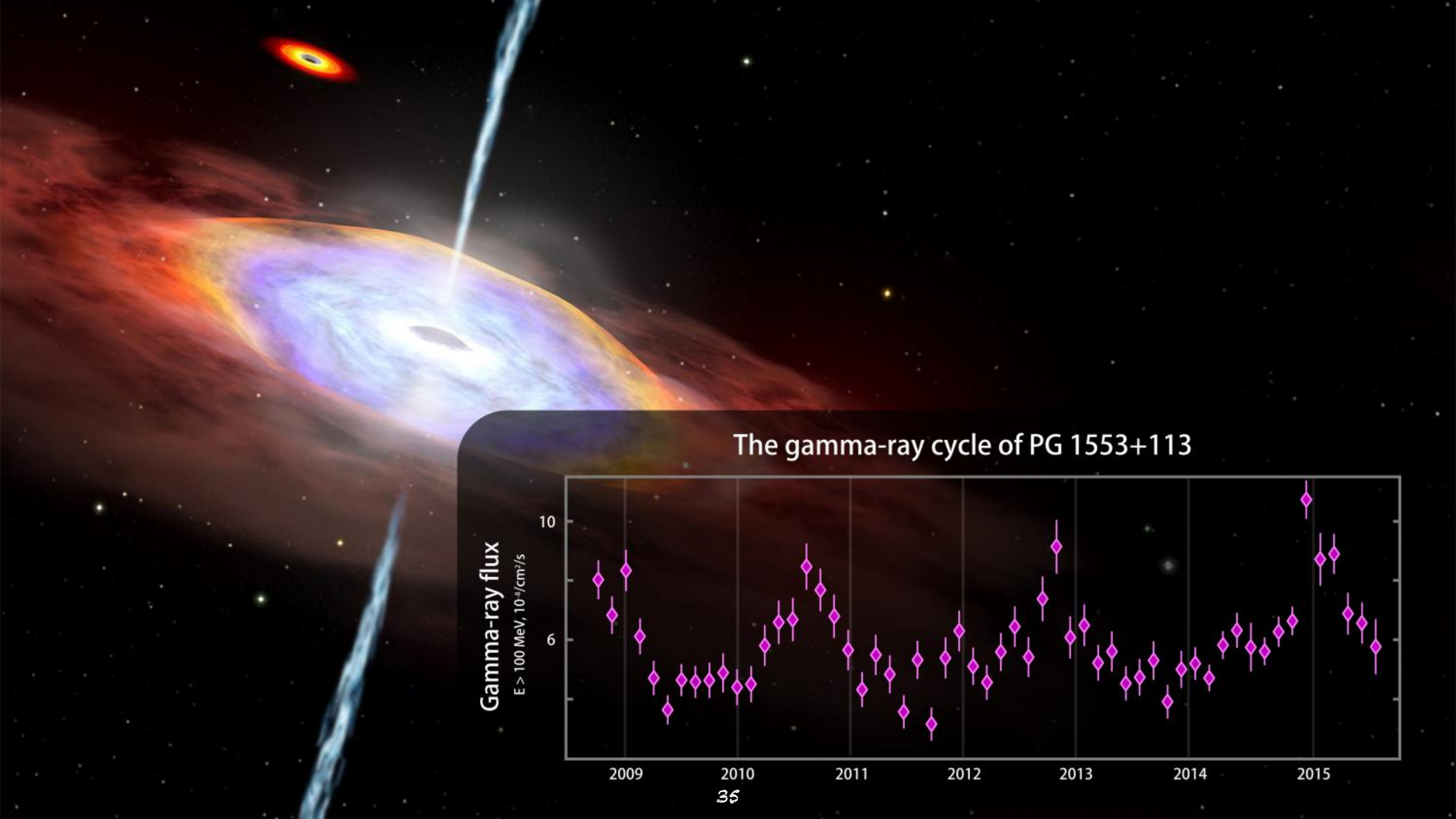




Attivta': Analisi Dati

Data Science / Machine Learning

+ Gamma Ray Bursts
+ Multifrequency
+ Multimessenger

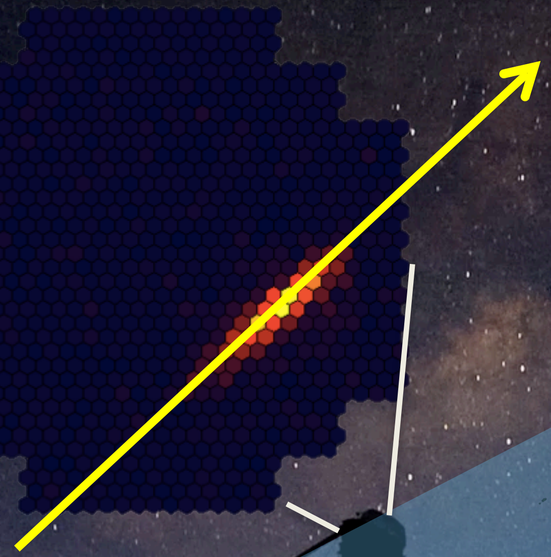

The gamma-ray cycle of PG 1553+113
Gamma-ray flux
E > 100 MeV, 10⁻⁸/cm²/s
10
6
2009
2010
2011
2012
2013
2014
2015

Raggi Gamma e Raggi Cosmici di Altissima Energia




Telescopi Cerenkov

TELESCOPI CHERENKOV

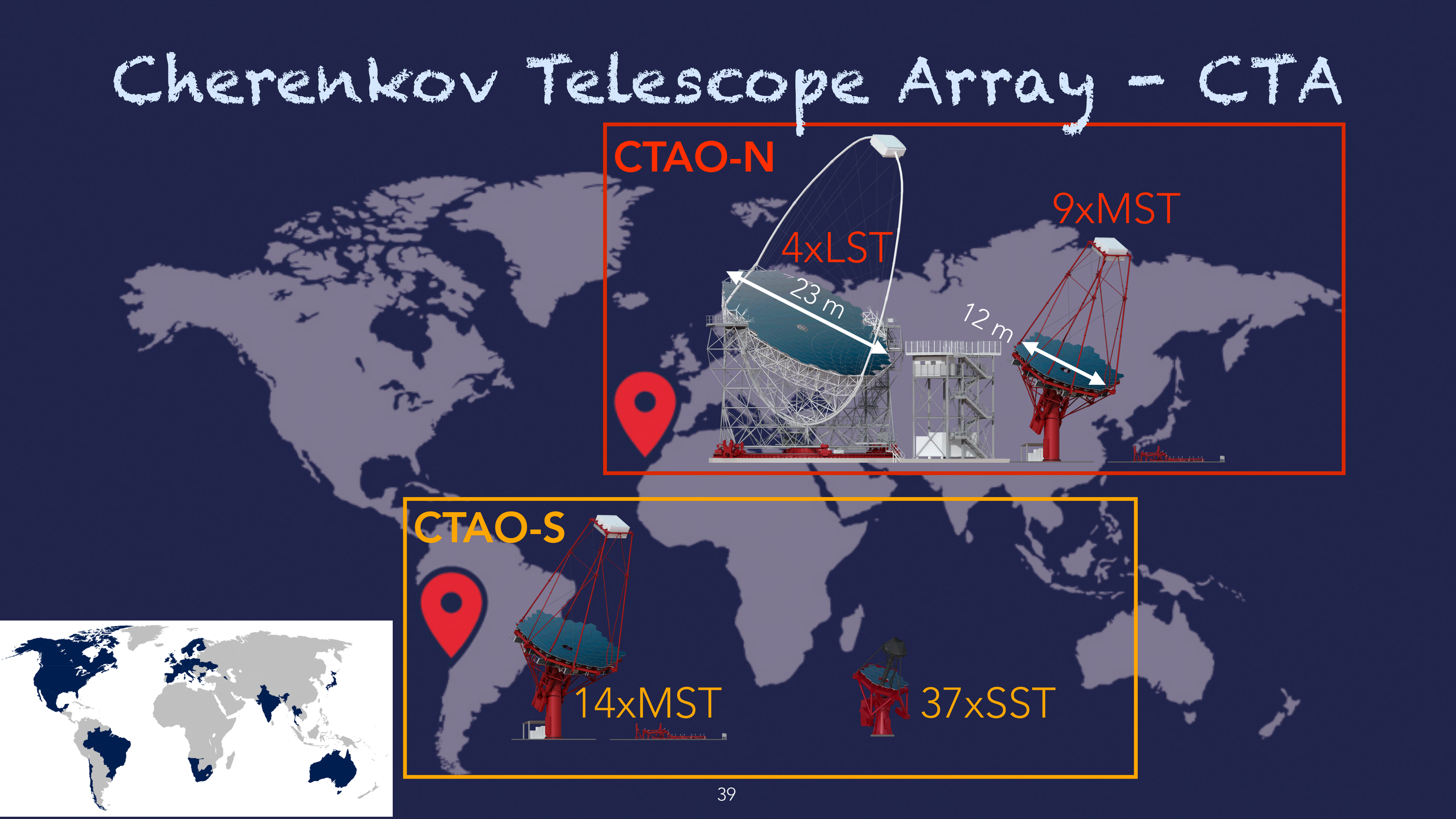


- Le particelle degli sciami viaggiano a velocità prossime a quelle della luce e superiore alla velocità con cui la luce attraversa l'atmosfera. Cherenkov trovò che in queste condizioni viene emesso un breve lampo di luce chiamata *luce Cherenkov*.
- La quantità totale di radiazione Cherenkov emessa da uno sciame è proporzionale all'energia del fotone che ha provocato lo sciame, *per questo motivo l'atmosfera si comporta come un calorimetro che permette di misurare l'energia delle particelle.*

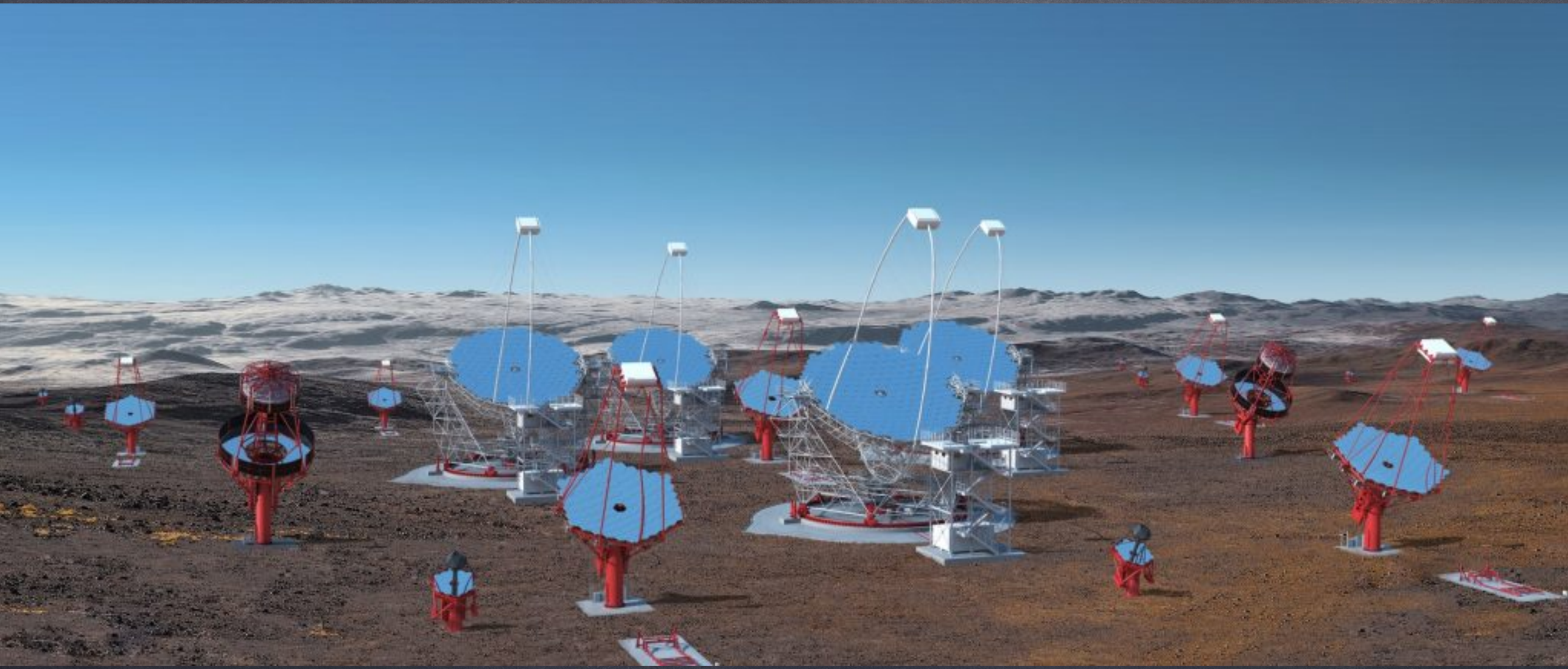
Difficoltà:

Radiazione Cherenkov
Debole (pochi fotoni per m^2)
di corta durata(some 10^{-9} seconds)
Separazione fotoni - particelle cariche.
Fondo Luminoso del cielo

Cherenkov Telescope Array - CTA



CTA



ASTRI



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NATIONAL INSTITUTE
FOR ASTROPHYSICS

ASTRI Mini Array

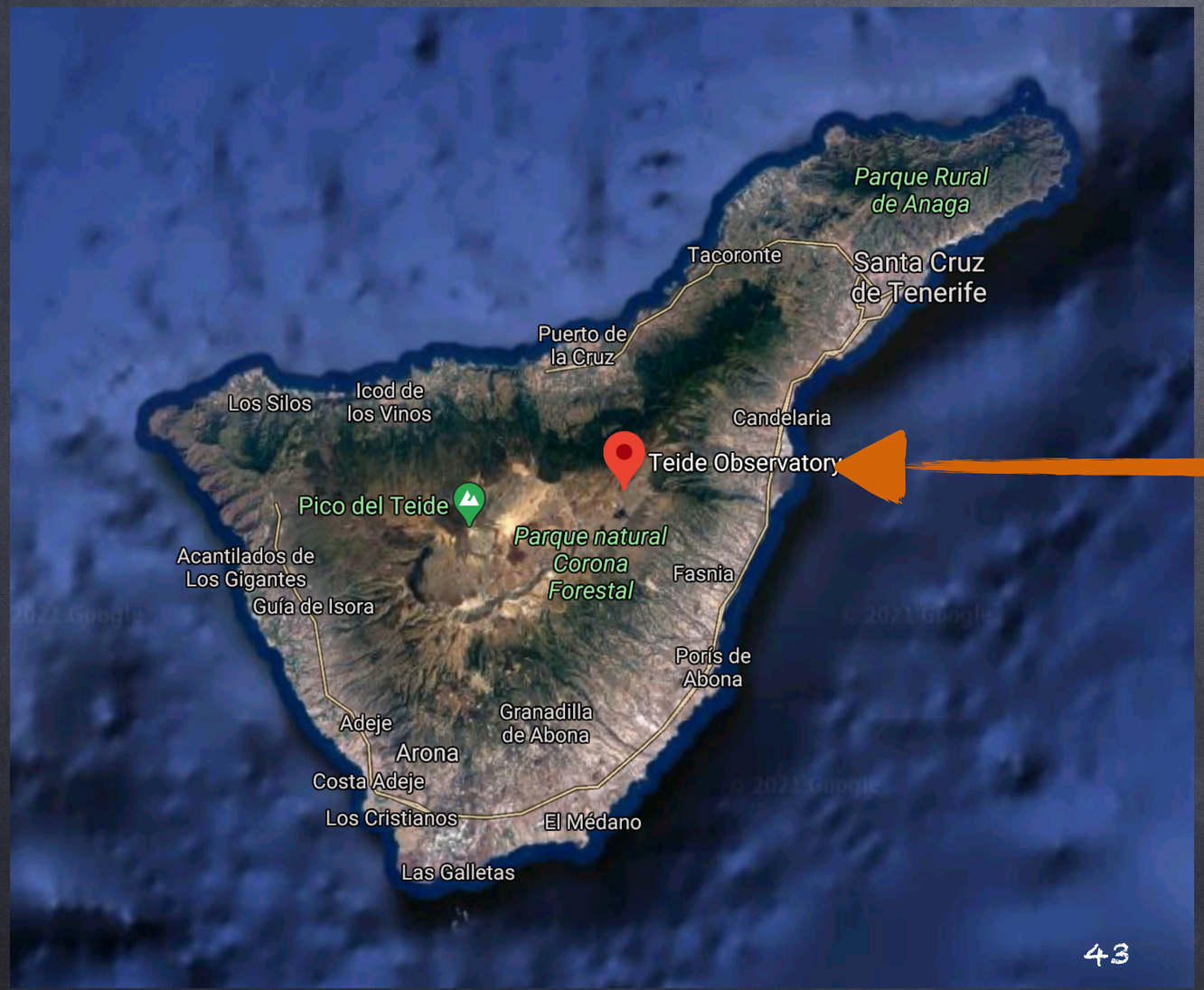
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ASTRI Mini Array

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NATIONAL INSTITUTE FOR ASTROPHYSICS



9x



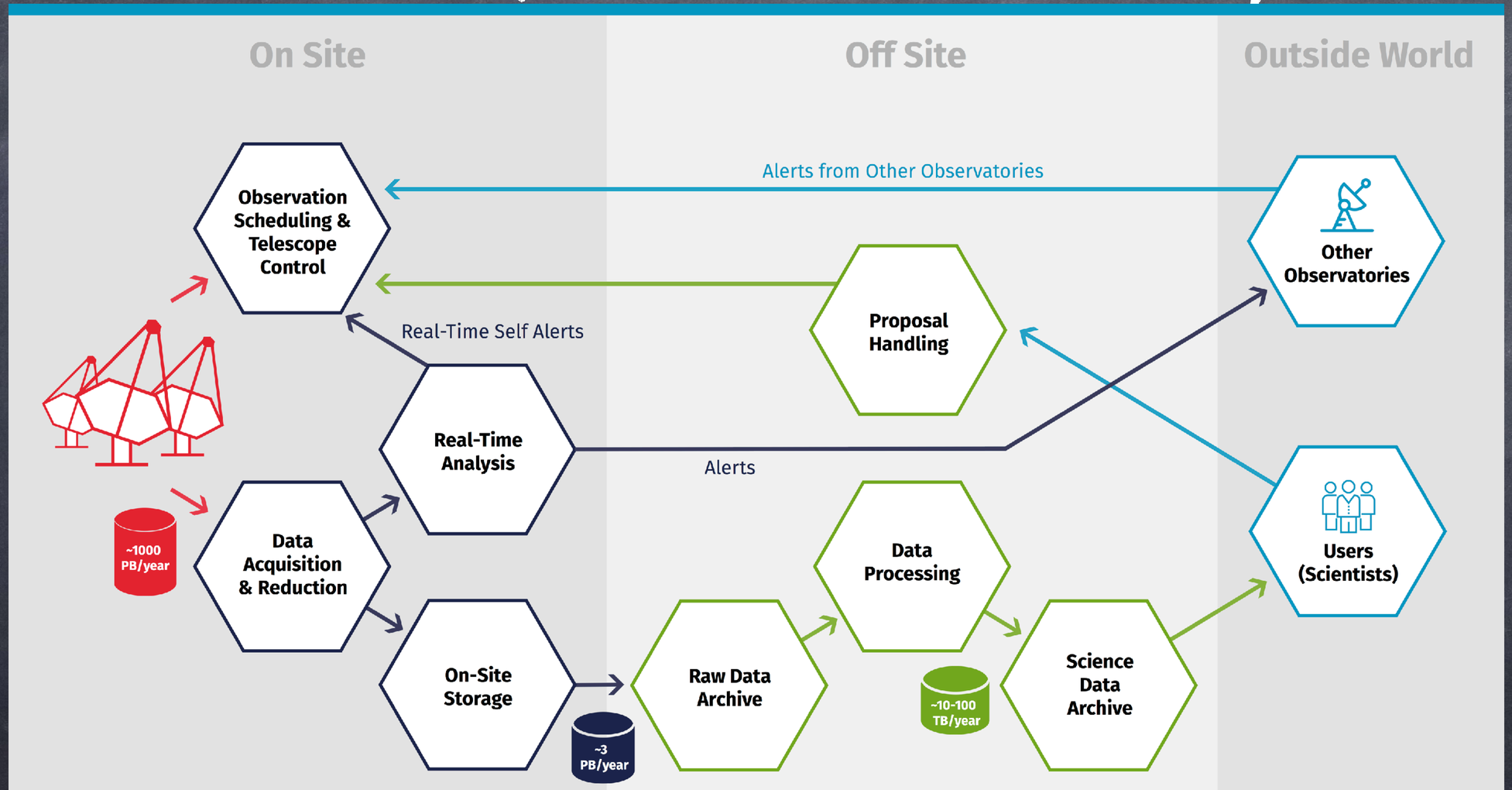
ASTRI Mini Array



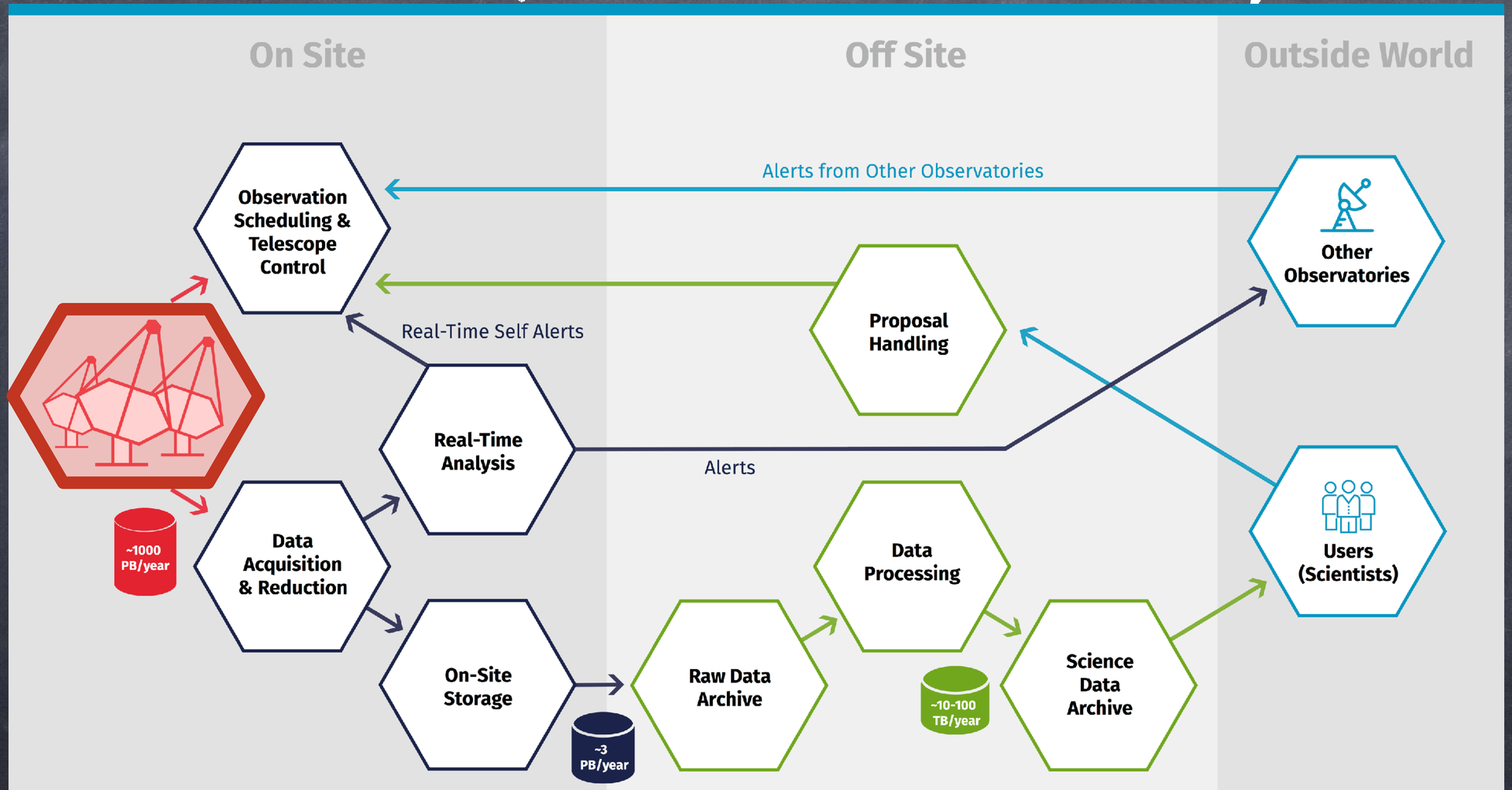
ASTRI Mini Array



CTA & ASTRI-Mini Array

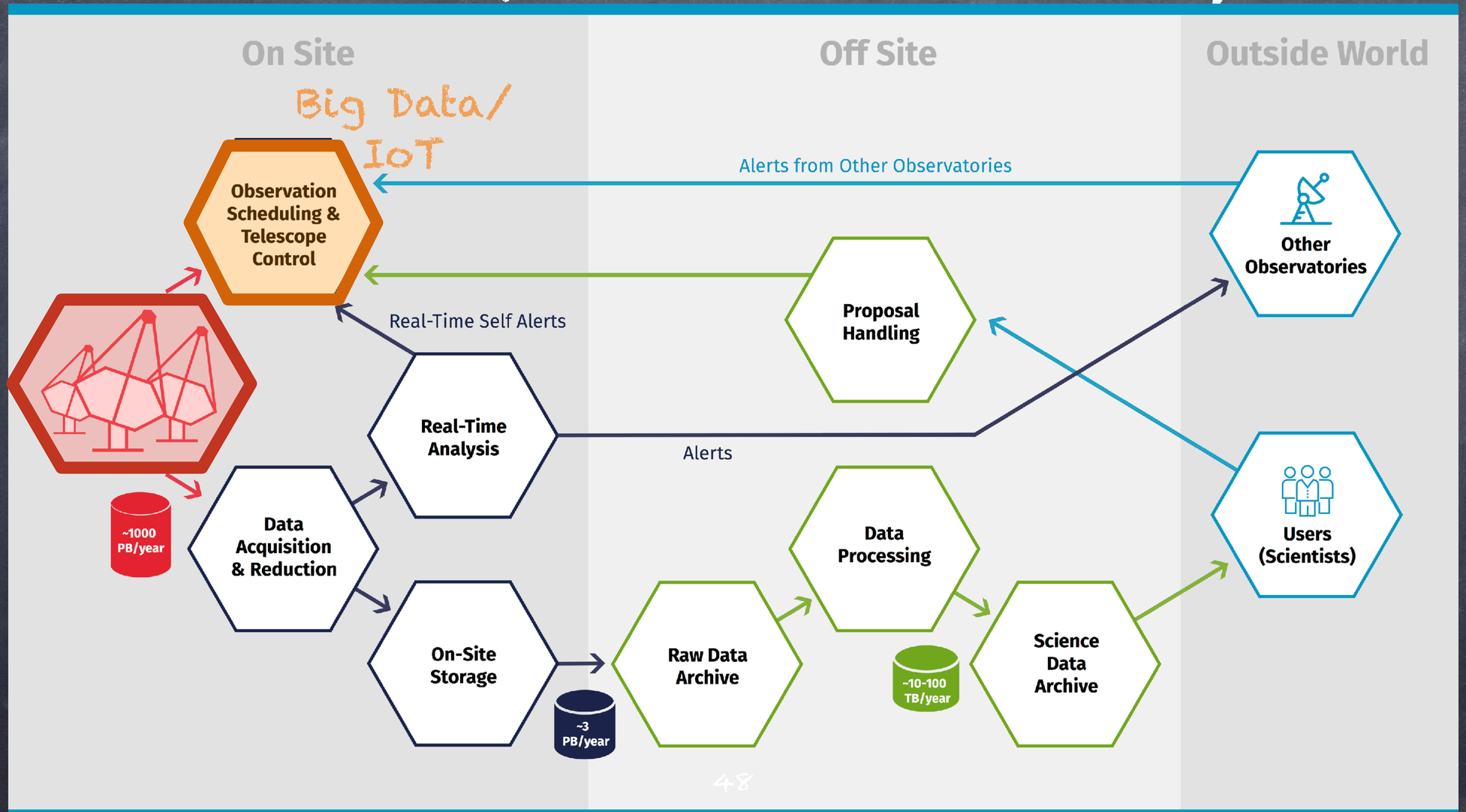


CTA & ASTRI-Mini Array



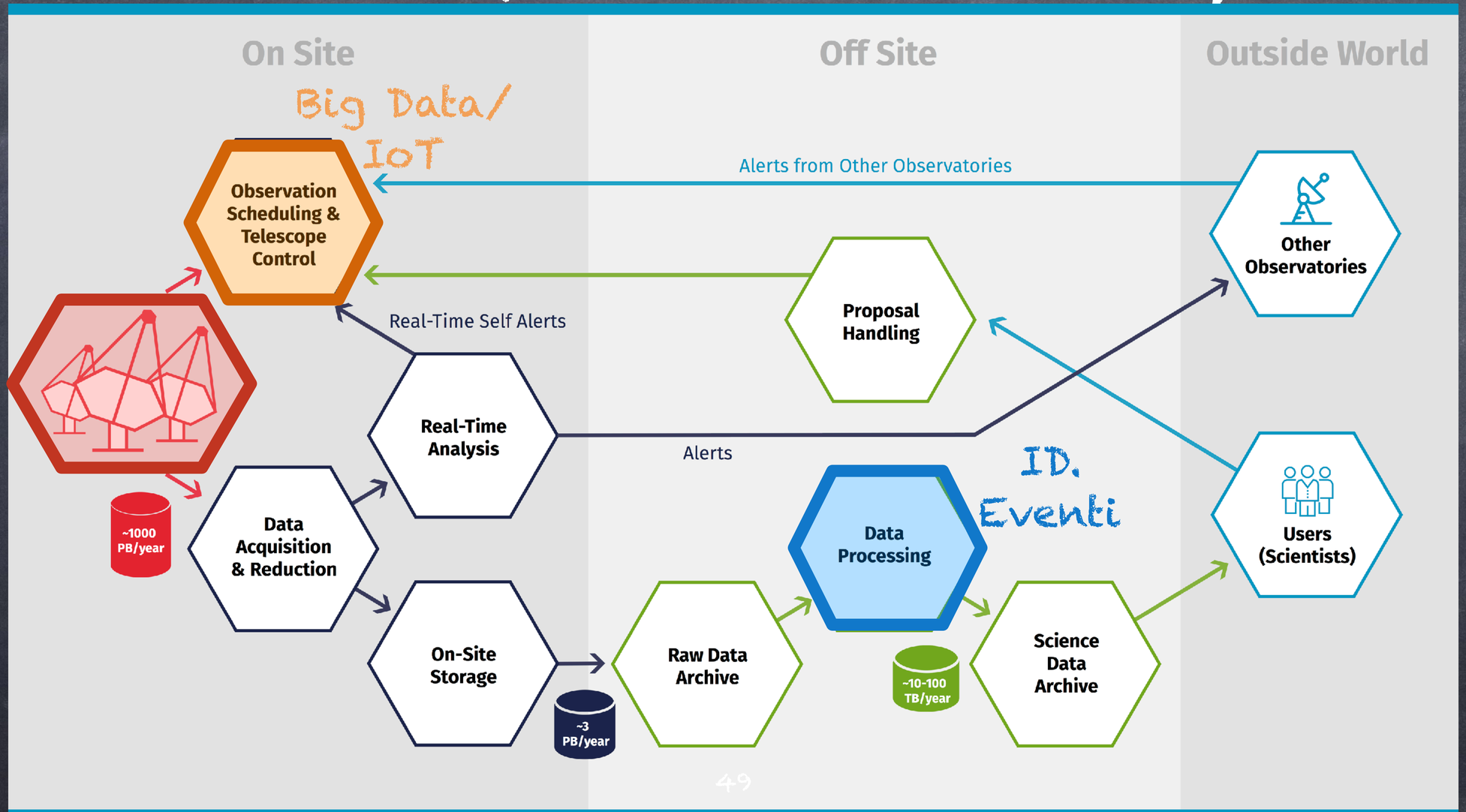
Sensori

CTA & ASTRI-Mini Array



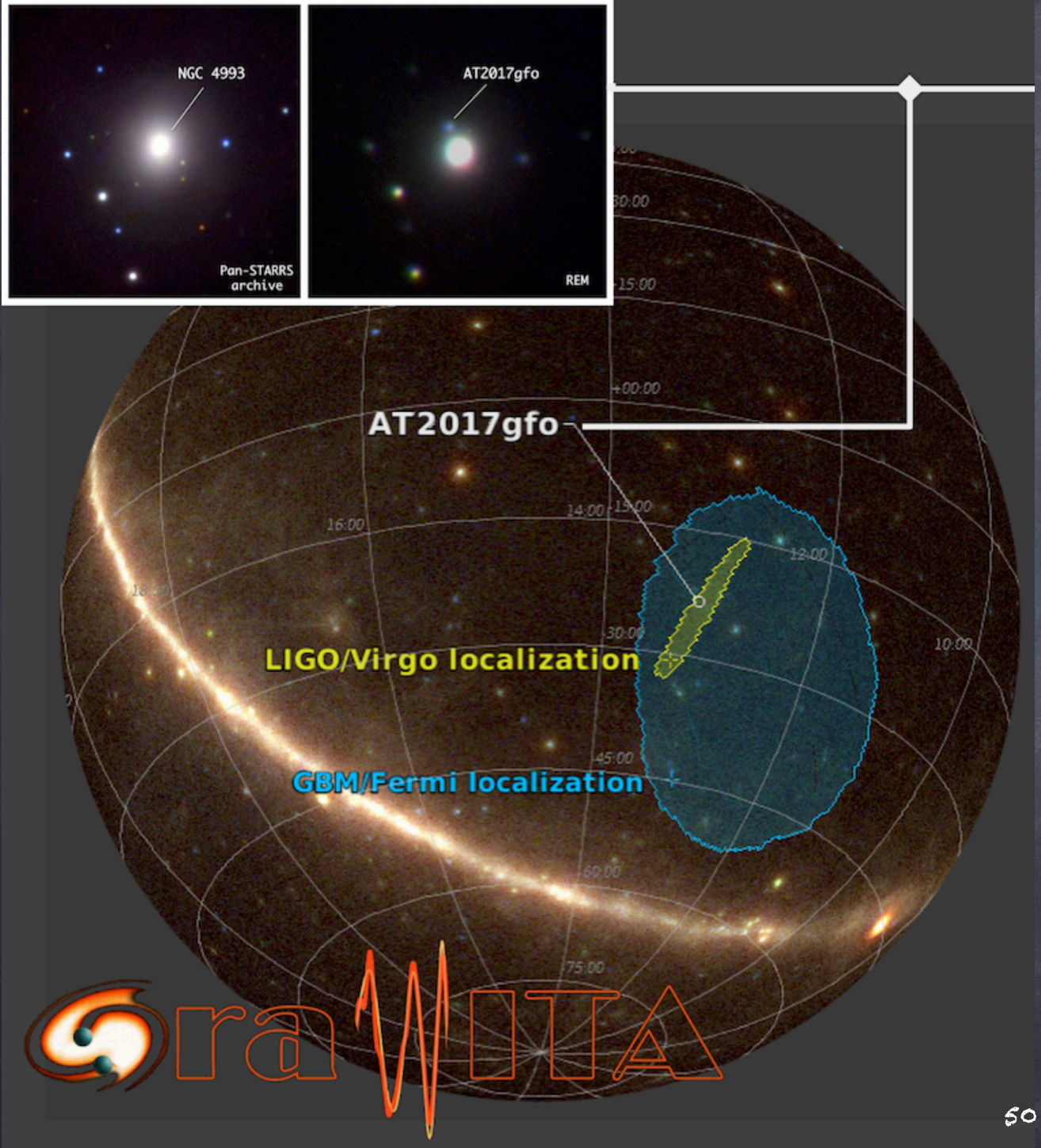
Sensori

CTA & ASTRI-Mini Array



Sensori

Follow Up Onde Gravitazionali



Osservatori e Telescopi si coordinano per cercare controparti elettromagnetiche

Osservatorio di Coloti





Attivita' in programma:

- Ripristino
- Remotizzazione
- Messa a punto analisi dati



Osservatorio di Coloti





Attivita' in programma:

- Ripristino
- Remotizzazione
- Messa a punto analisi dati

Scopo: inserimento in reti per follow-up Onde Graviatzionali



Attivta' di Tesi

Le possibilita' di Tesi collegate alle attivita' di Ricerca

Attivta' di Tesi

Le possibilita' di Tesi collegate alle attivita' di Ricerca

- Fermi
  - Analisi Dati / Machine Learning
  - Studio Buchi Neri / Processi Accrescimento

Attivta' di Tesi

Le possibilita' di Tesi collegate alle attivita' di Ricerca

- Fermi
  - Analisi Dati / Machine Learning
  - Studio Buchi Neri / Processi Accrescimento
- CTA / ASTRI
  - Identificazione Event Stereo
  - Studio/Caratterizzazione sensori SiPM

Attivta' di Tesi

Le possibilita' di Tesi collegate alle attivita' di Ricerca

- Fermi
  - Analisi Dati / Machine Learning
  - Studio Buchi Neri / Processi Accrescimento
- CTA / ASTRI
  - Identificazione Event Stereo
  - Studio/Caratterizzazione sensori SiPM
- Osservatorio di Coloti
  - Attivita' Hw/Sw per ripristino
  - Osservazione e analisi dati

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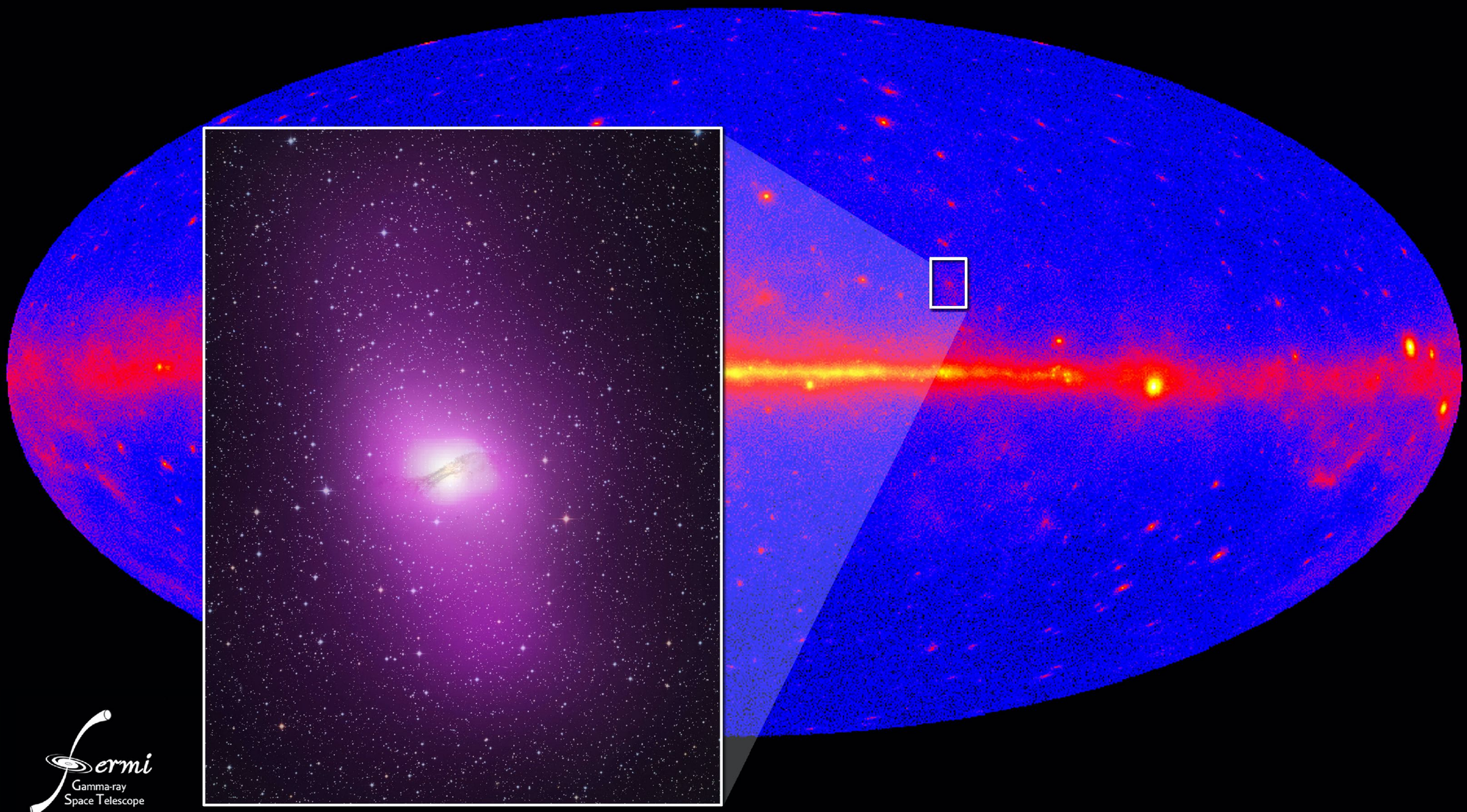
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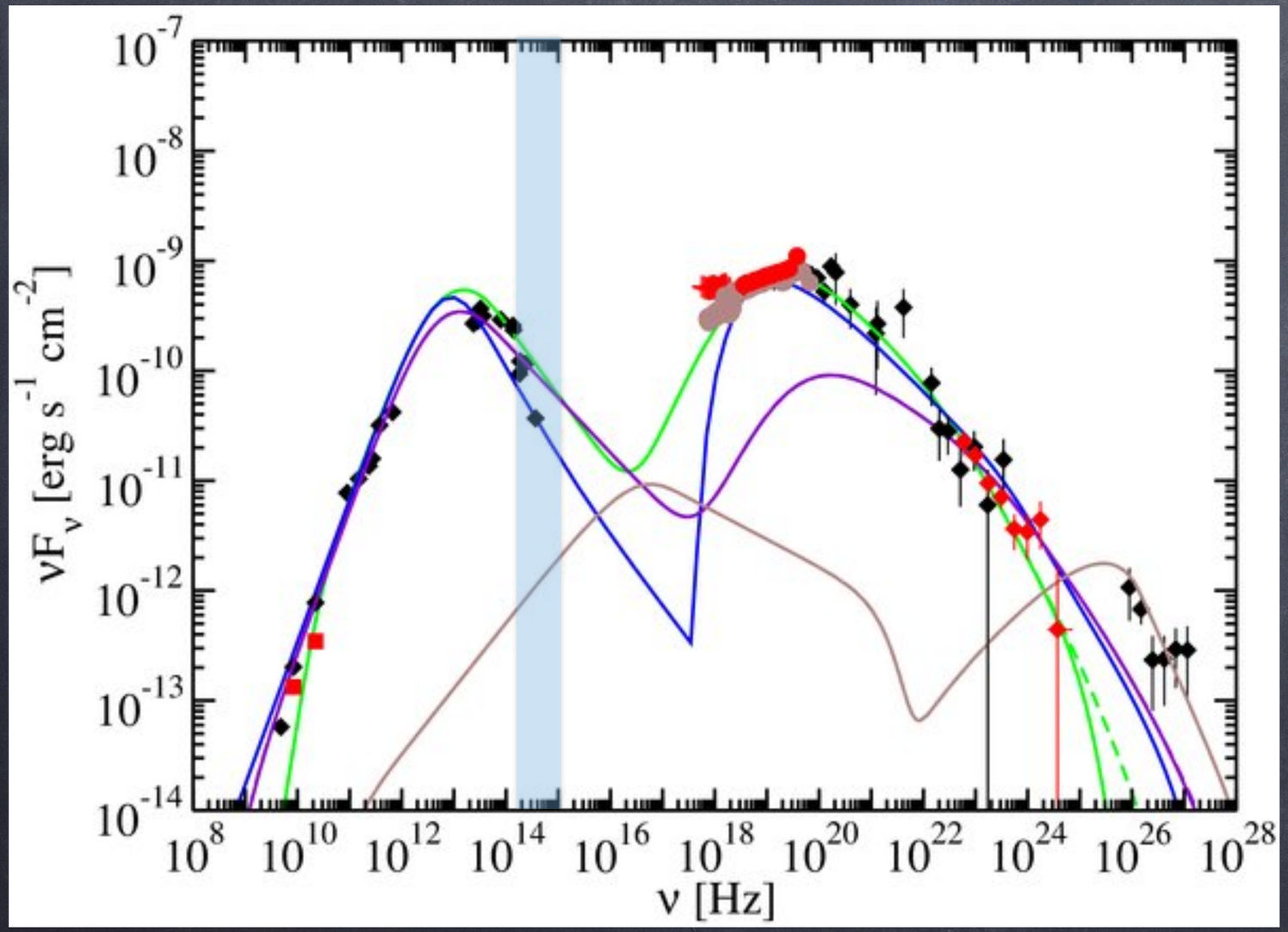
BACKUP

NASA’s Fermi telescope resolves radio galaxy Centaurus A



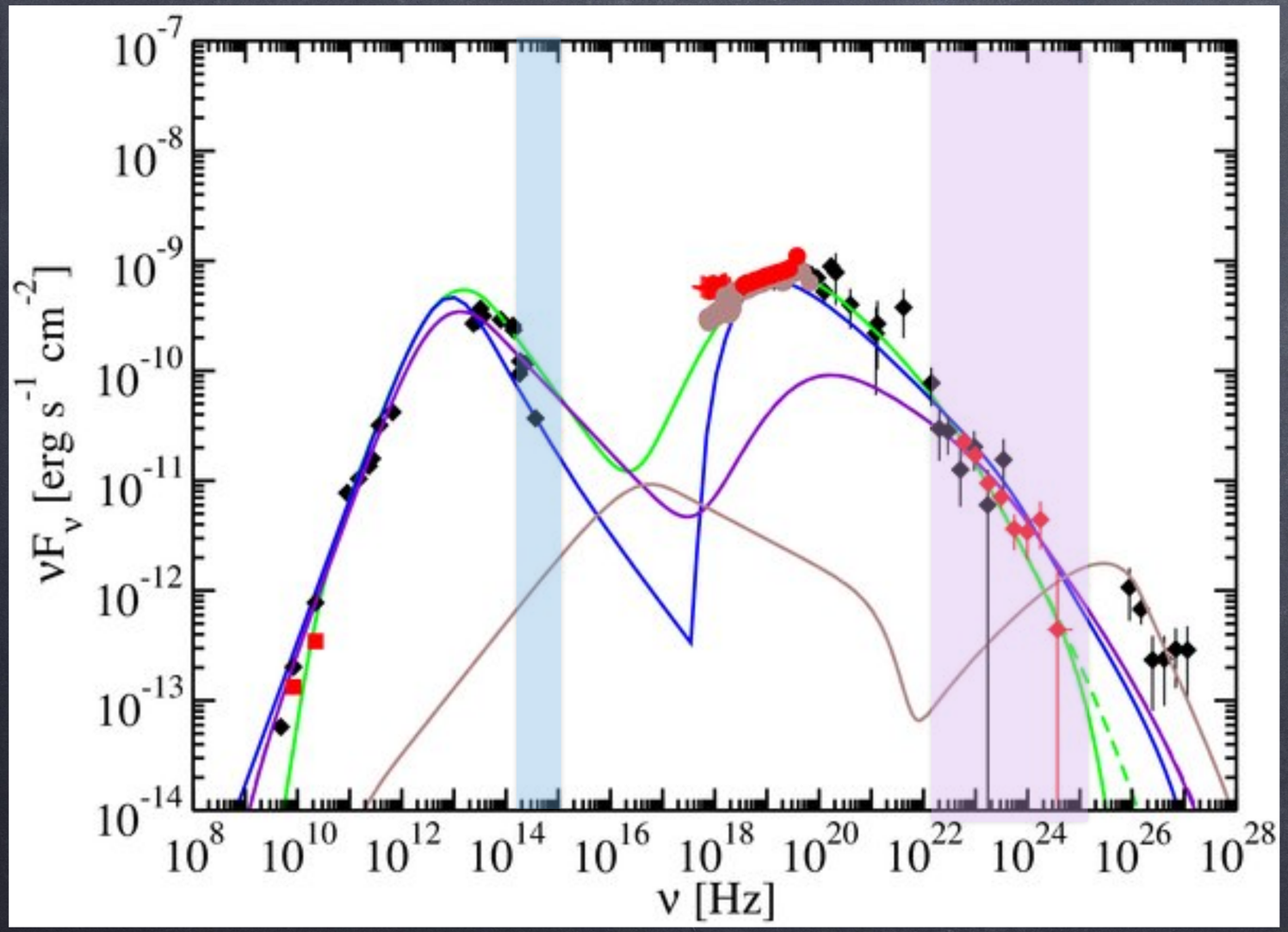
Fermi
Gamma-ray
Space Telescope

Centaurus A


10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
νF_ν [erg s^{-1} cm^{-2}]
10^{8} 10^{10} 10^{12} 10^{14} 10^{16} 10^{18} 10^{20} 10^{22} 10^{24} 10^{26} 10^{28}
ν [Hz]

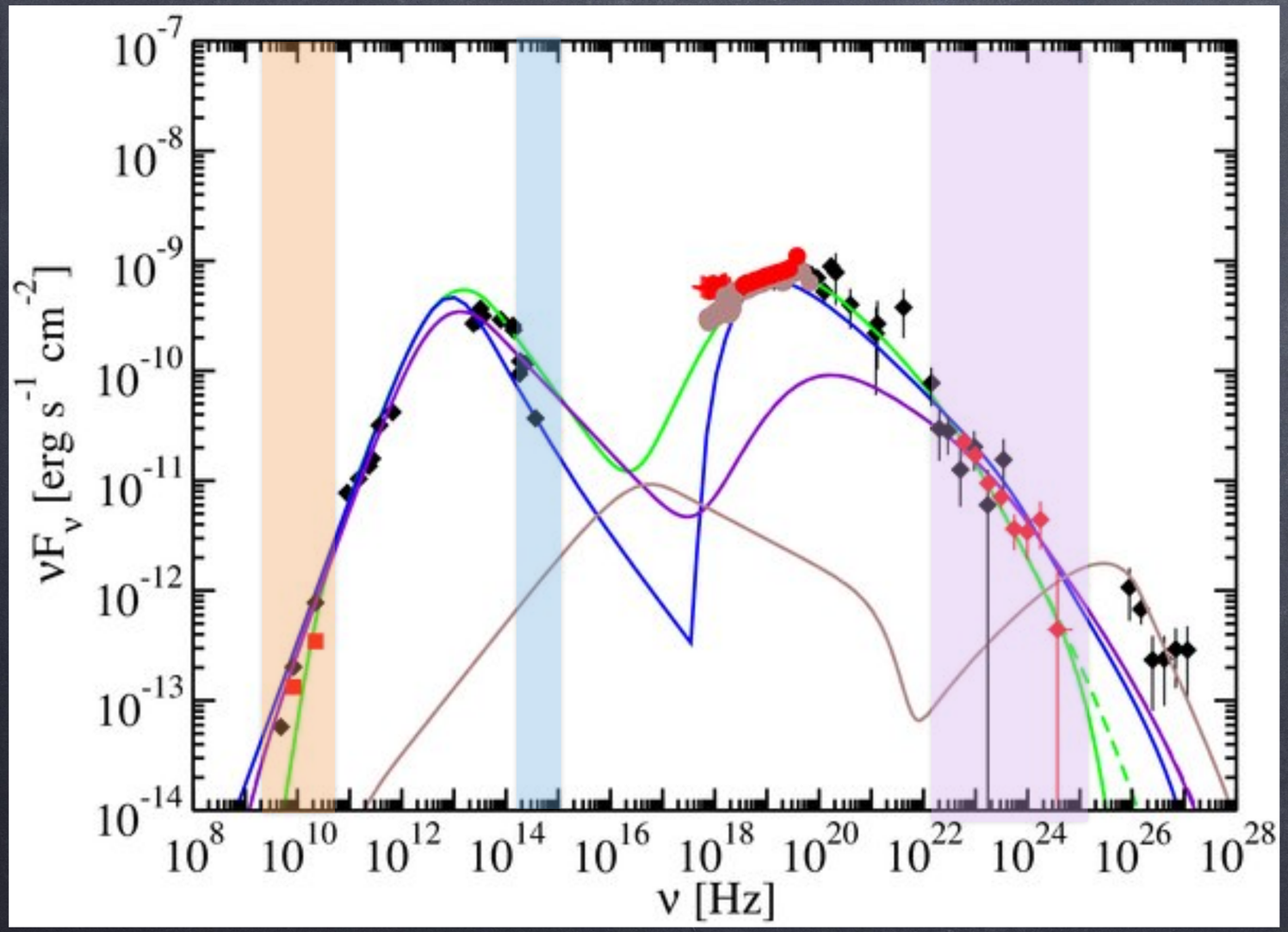


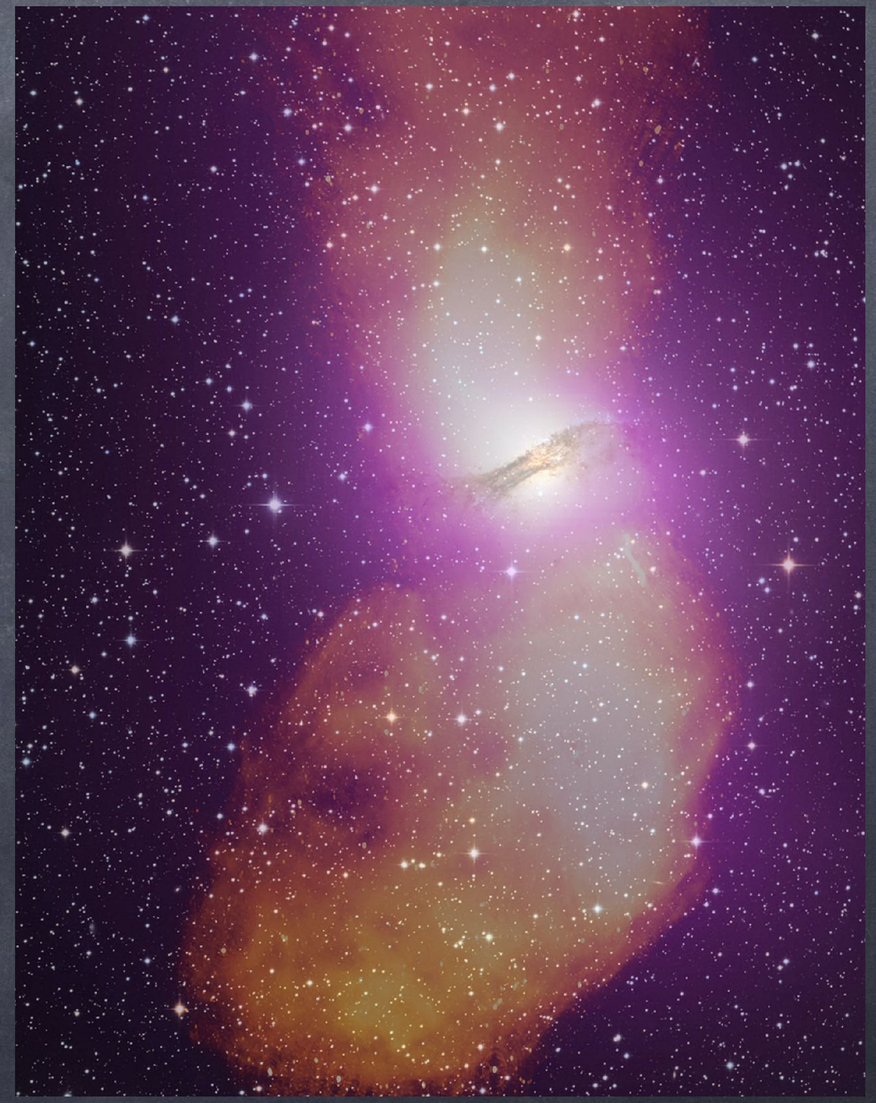
Centaurus A


10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
νF_ν [erg s^{-1} cm^{-2}]
10^{8} 10^{10} 10^{12} 10^{14} 10^{16} 10^{18} 10^{20} 10^{22} 10^{24} 10^{26} 10^{28}
ν [Hz]

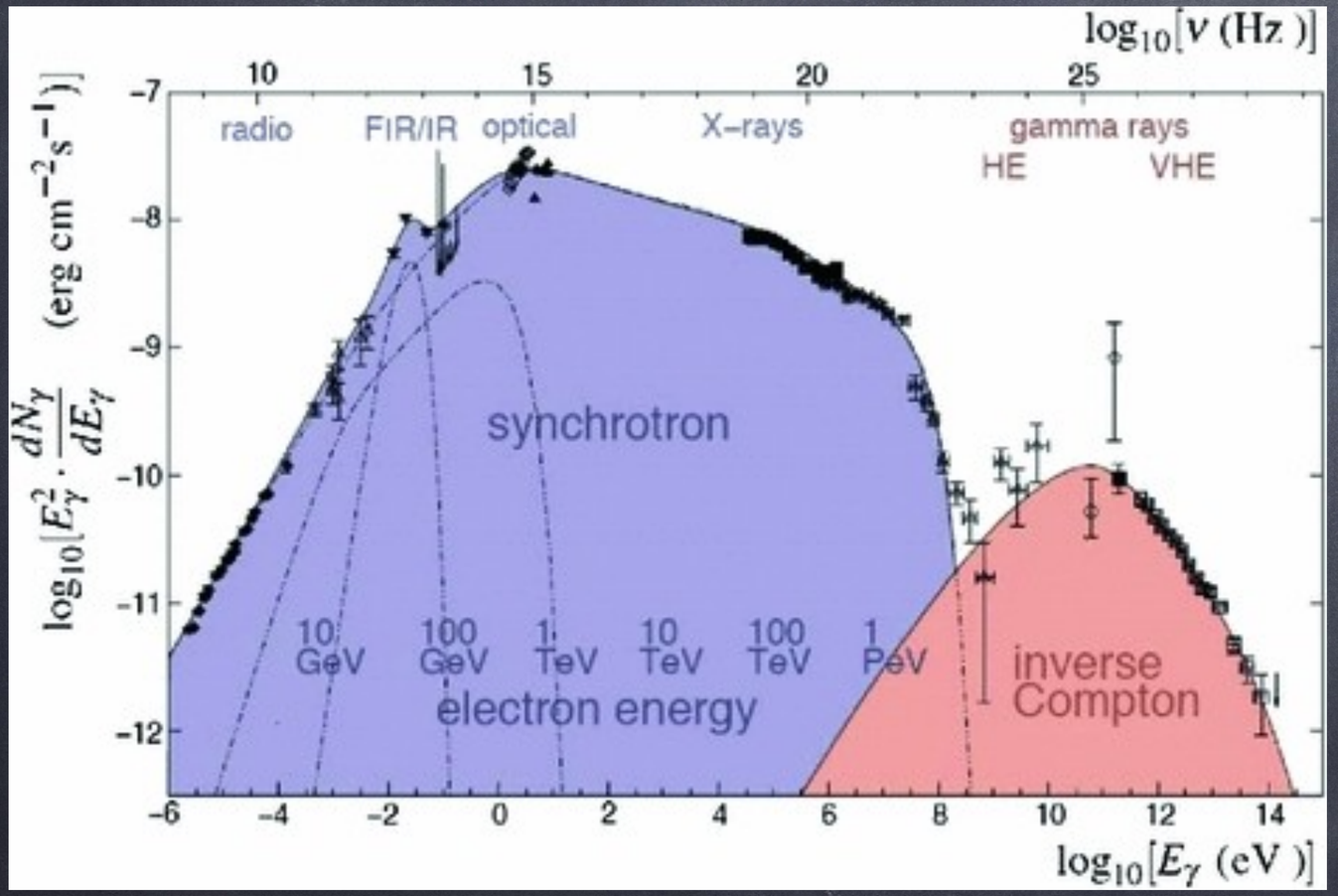


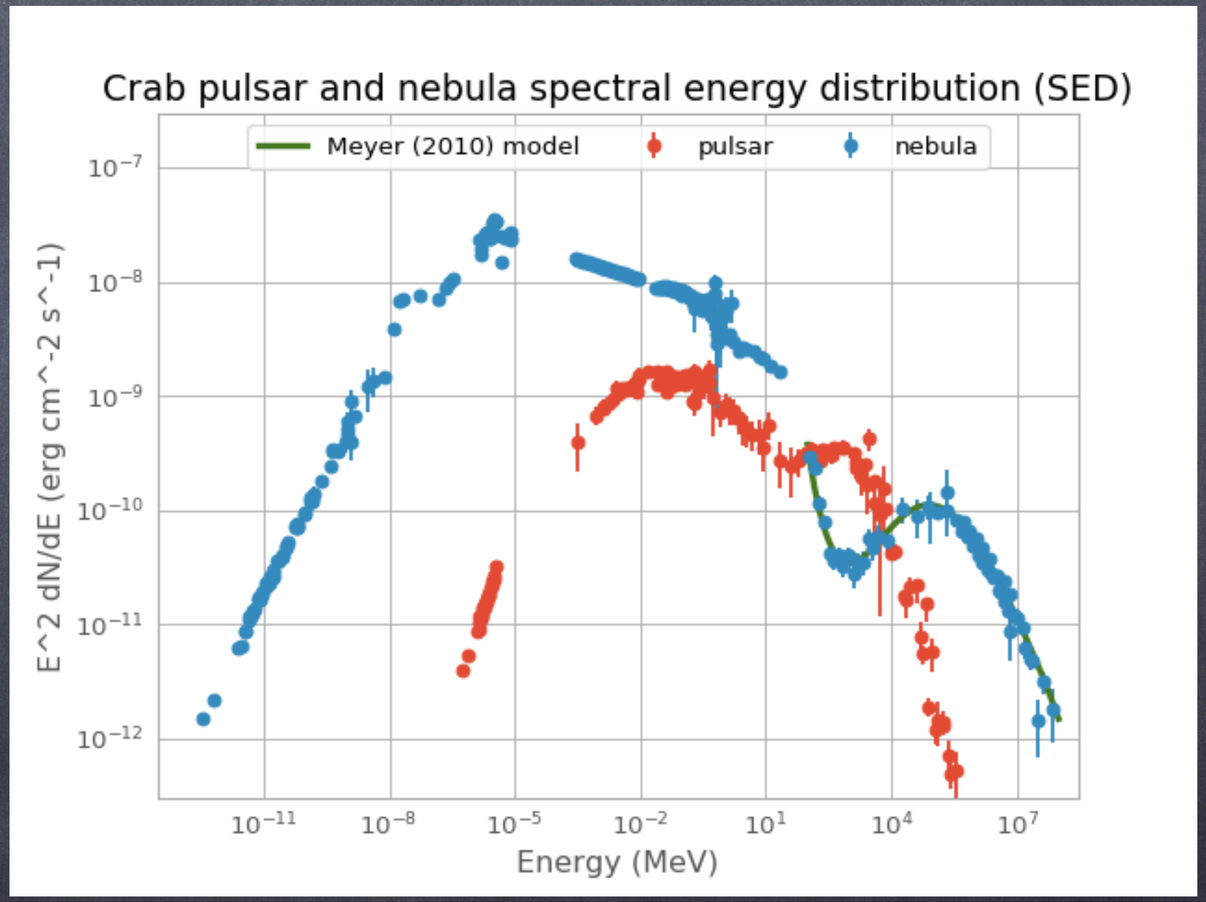
Centaurus A

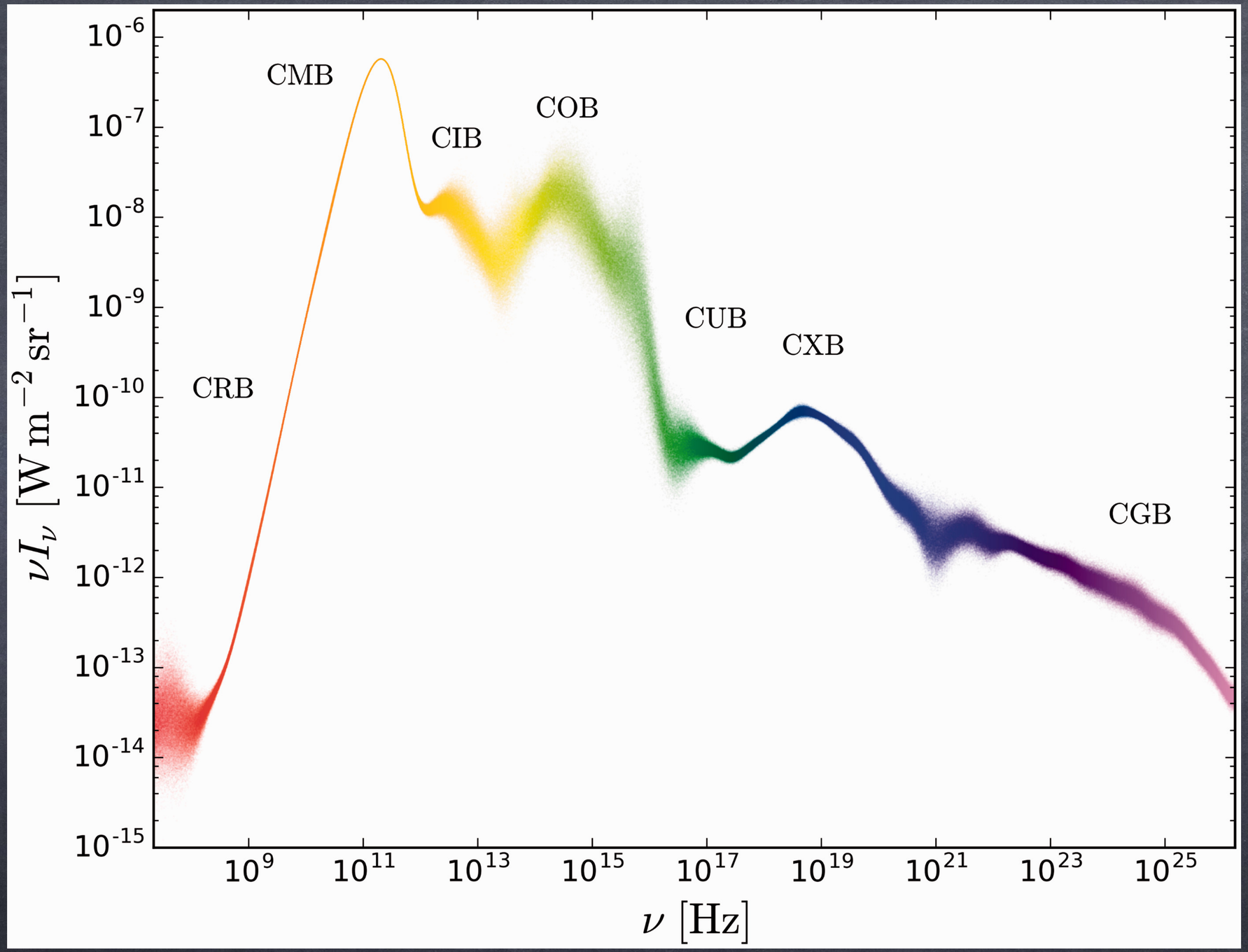

10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
νF_ν [erg s^{-1} cm^{-2}]
10^{8} 10^{10} 10^{12} 10^{14} 10^{16} 10^{18} 10^{20} 10^{22} 10^{24} 10^{26} 10^{28}
ν [Hz]

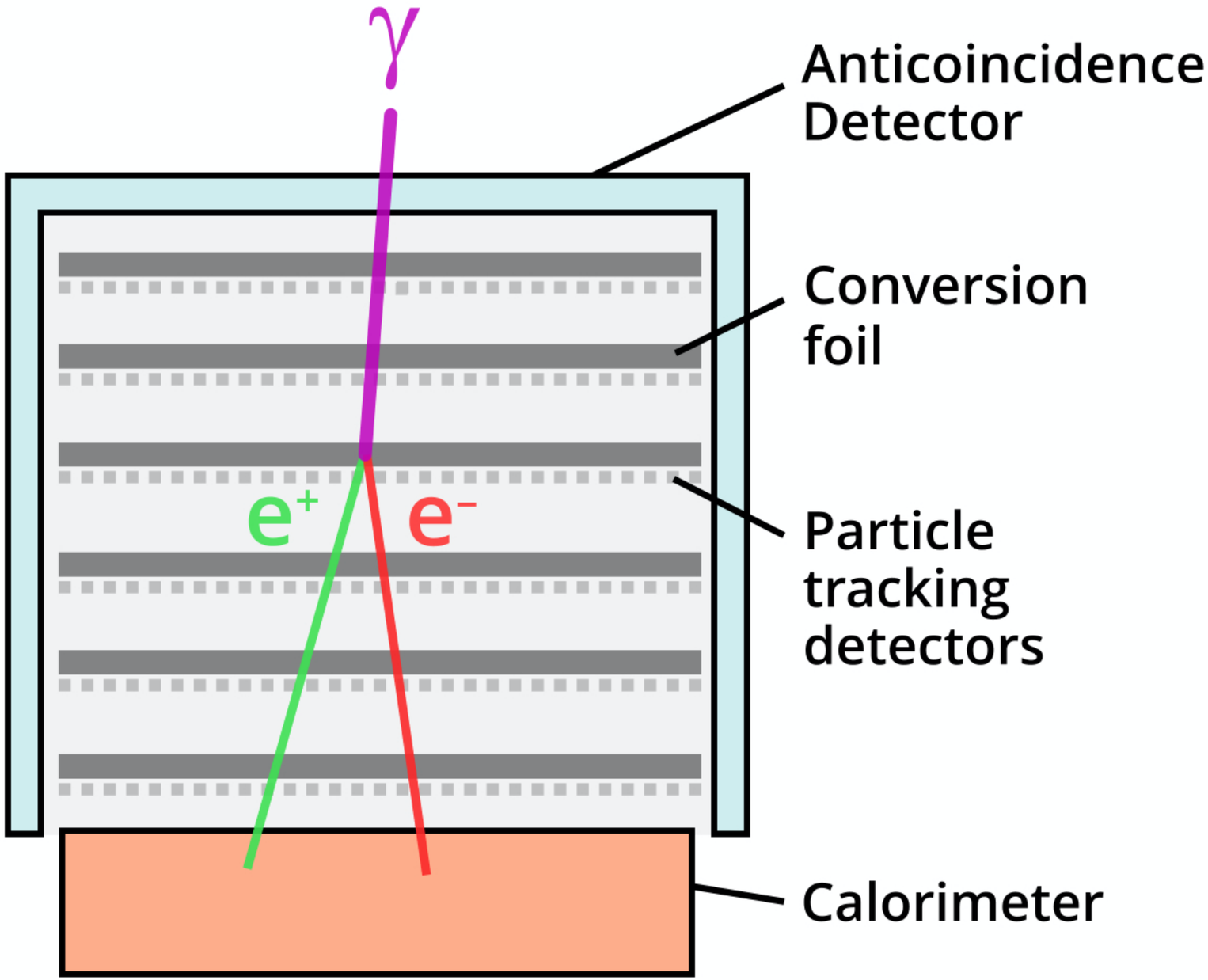


Crab Nebula


$\log_{10}[\nu\ (\mathrm{Hz})]$
10
15
20
25
radio
FIR/IR
optical
X-rays
gamma rays
HE
VHE
synchrotron
10 GeV
100 GeV
1 TeV
10 TeV
100 TeV
1 PeV
electron energy
inverse Compton
$\log_{10}[E_\gamma^2 \cdot \frac{dN_\gamma}{dE_\gamma}]$ (erg cm^{-2}s^{-1})
$\log_{10}[E_\gamma\ (\mathrm{eV})]$


Crab pulsar and nebula spectral energy distribution (SED)
Meyer (2010) model
pulsar
nebula
E^2 dN/dE (erg cm^-2 s^-1)
Energy (MeV)


CMB
CIB
COB
CUB
CXB
CGB
CRB
νI_ν [W m^{-2} sr^{-1}]
ν [Hz]
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10^{-15}
10^{9}
10^{11}
10^{13}
10^{15}
10^{17}
10^{19}
10^{21}
10^{23}
10^{25}


γ
Anticoincidence Detector
Conversion foil
e+
e−
Particle tracking detectors
Calorimeter


USAF
ULA
DELTA
GLAST
NASA





Telescopi Cerenkov

