



INFN
BARI-PERUGIA-ROMA-TORINO-TRIESTE

8TH FERMI MASTERCLASS

HUNTING FOR GAMMA-RAY BURSTS

28 MARZO 2025 // DALLE 9:30 ALLE 17

DIPARTIMENTO INTERATENEO DI FISICA "M. MERLIN"
VIA E. ORABONA 4, BARI
AULA MULTIMEDIALE // PRIMO PIANO

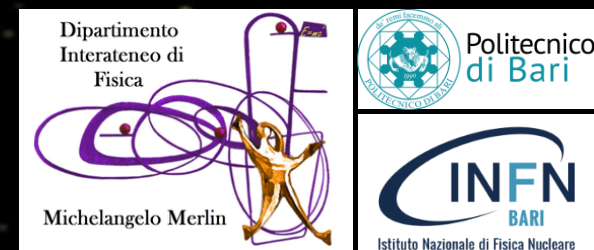
[HTTPS://AGENDA.INFN.IT/E/FERMI_MASTERCLASS](https://agenda.infn.it/e/fermi_masterclass)

Picture Credit: NASA's Goddard Space Flight Center Conceptual Image Lab

Gamma-Ray Bursts: I lampi di raggi gamma

Prof.ssa Elisabetta Bissaldi

Dipartimento Interateneo di Fisica "M. Merlin"
Politecnico & INFN Bari – elisabetta.bissaldi@ba.infn.it

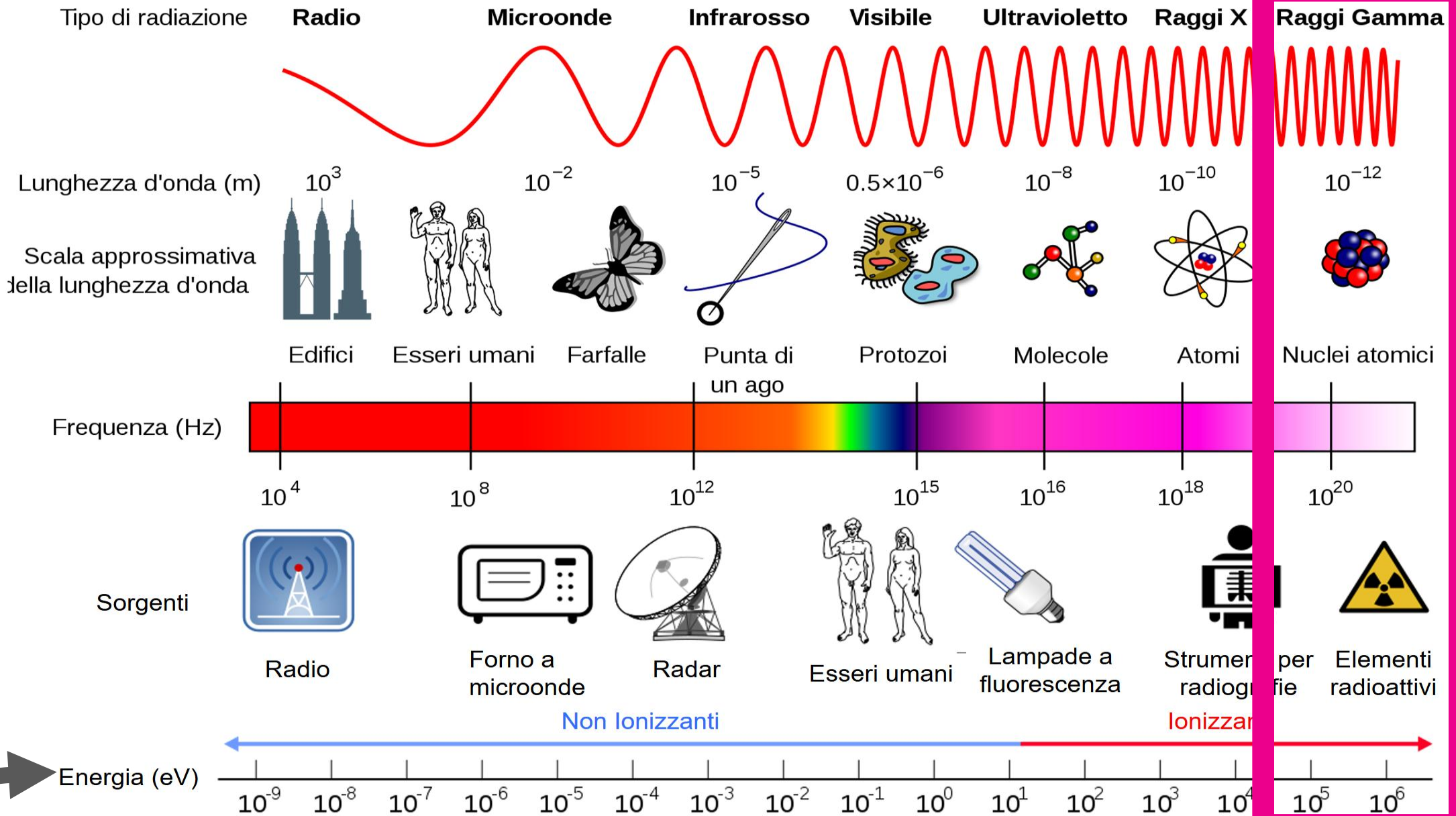


Dipartimento Interateneo di Fisica

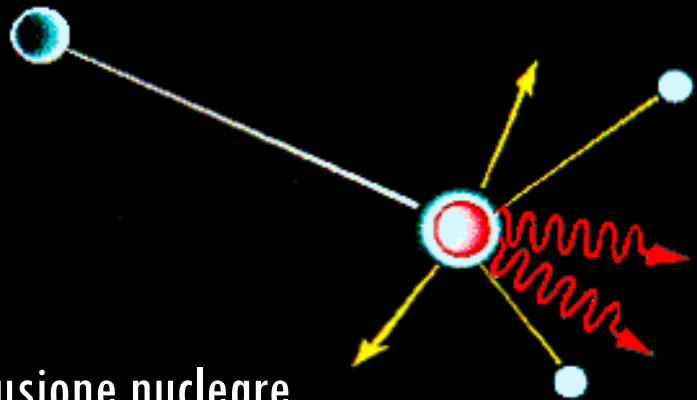
Politecnico di Bari

Michelangelo Merlin

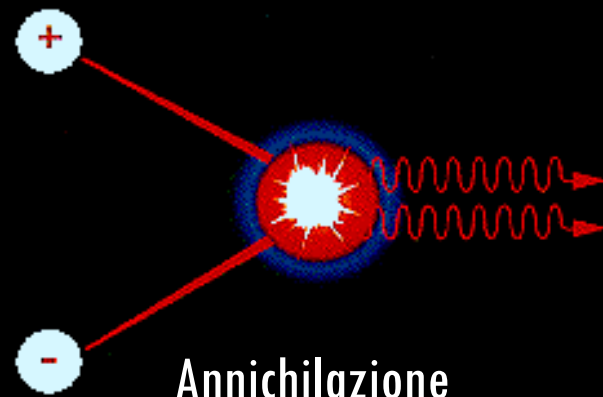
INFN BARI
Istituto Nazionale di Fisica Nucleare



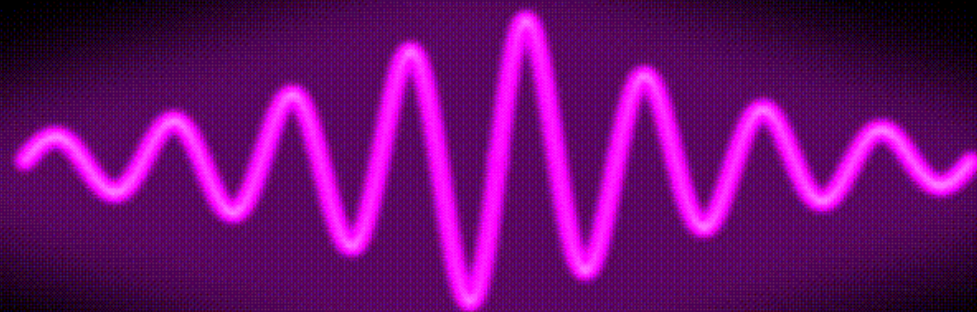
Un elettronvolt (eV) è un'unità di misura dell'energia molto usata in ambito atomico e subatomico



Fusione nucleare

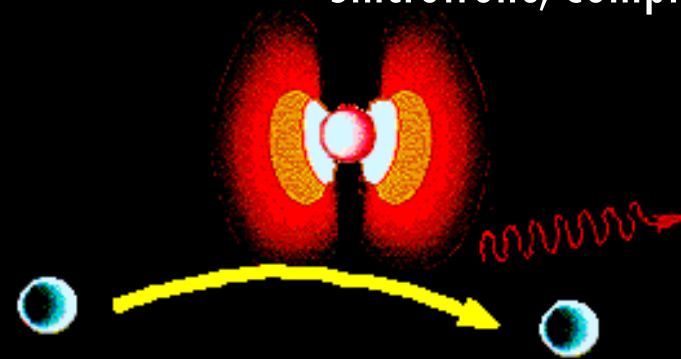


Annichilazione
elettrone-positrone

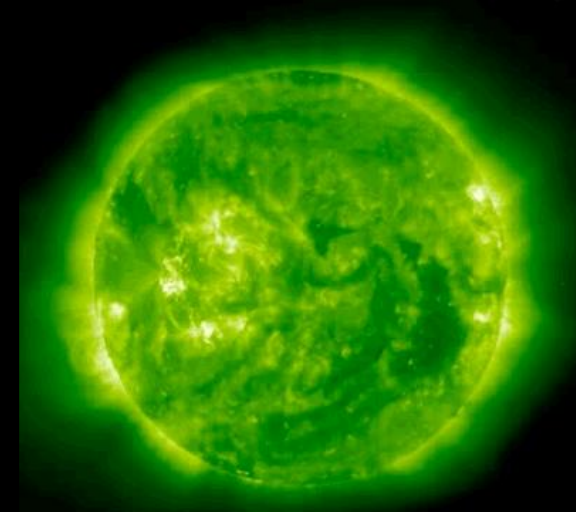
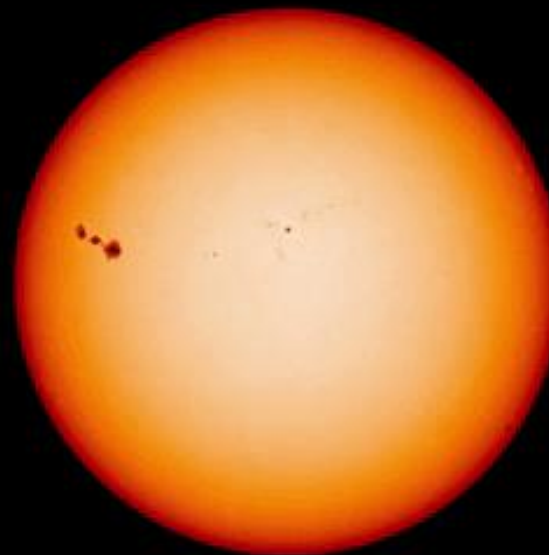
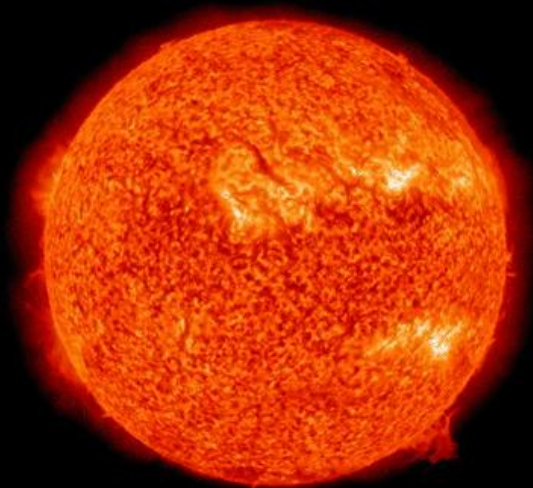


Decadimenti nucleari gamma

Accelerazione di particelle
cariche (Bremsstrahlung,
Sincrotrone, Compton)



La stella più vicina: Il nostro Sole



2003/10/21 00:00:10

SDO/AIA 304 2011-06-07 02:23:33 UT

HMI Dopplergram Surface movement Photosphere	HMI Magnetogram Magnetic field polarity Photosphere	visibile	4,500 K

Fotosfera

6,000 K	10,000 K	50,000 K	600,000 K	1 MK

Cromosfera

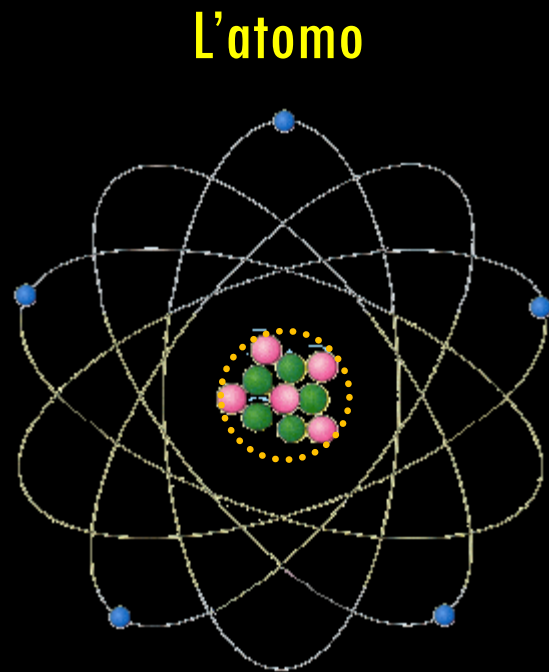
Corona

Regioni attive

2 MK	2,5 MK	6 MK	10 MK

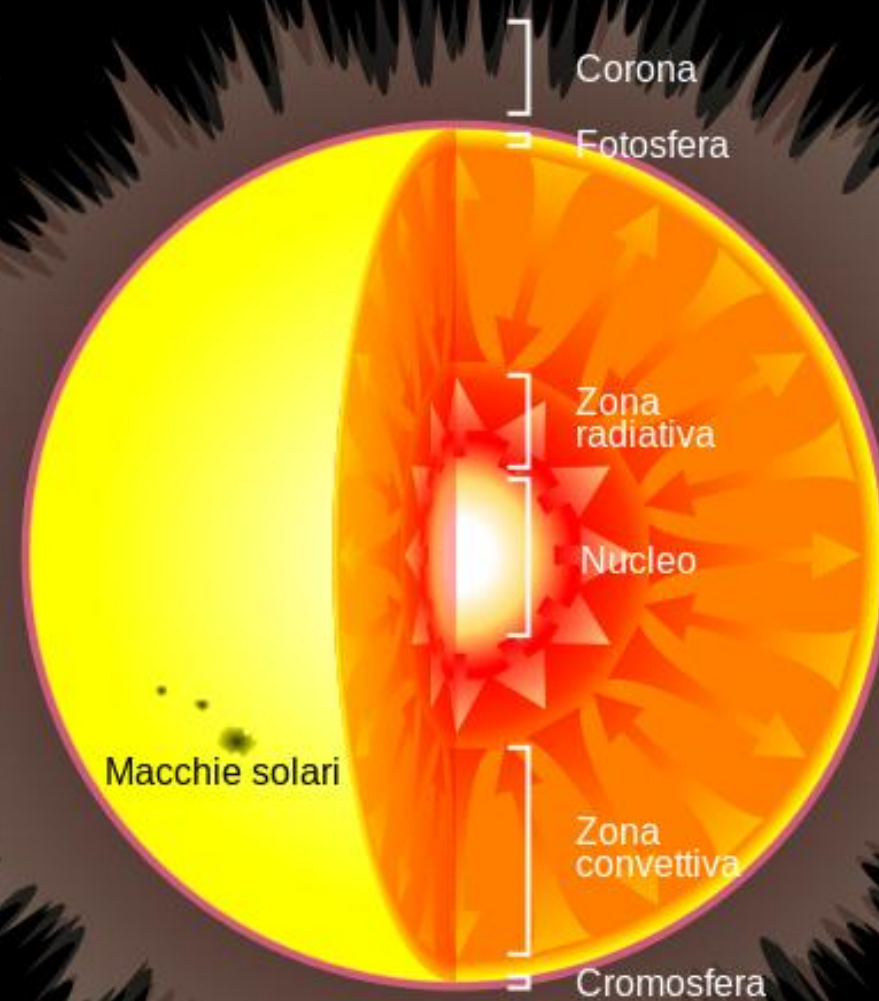
Regioni «flaring»

La nucleosintesi stellare



Protone
Neutrone
Nucleo
Elettrone

Vento solare



Corona

Fotosfera

Zona
radiativa

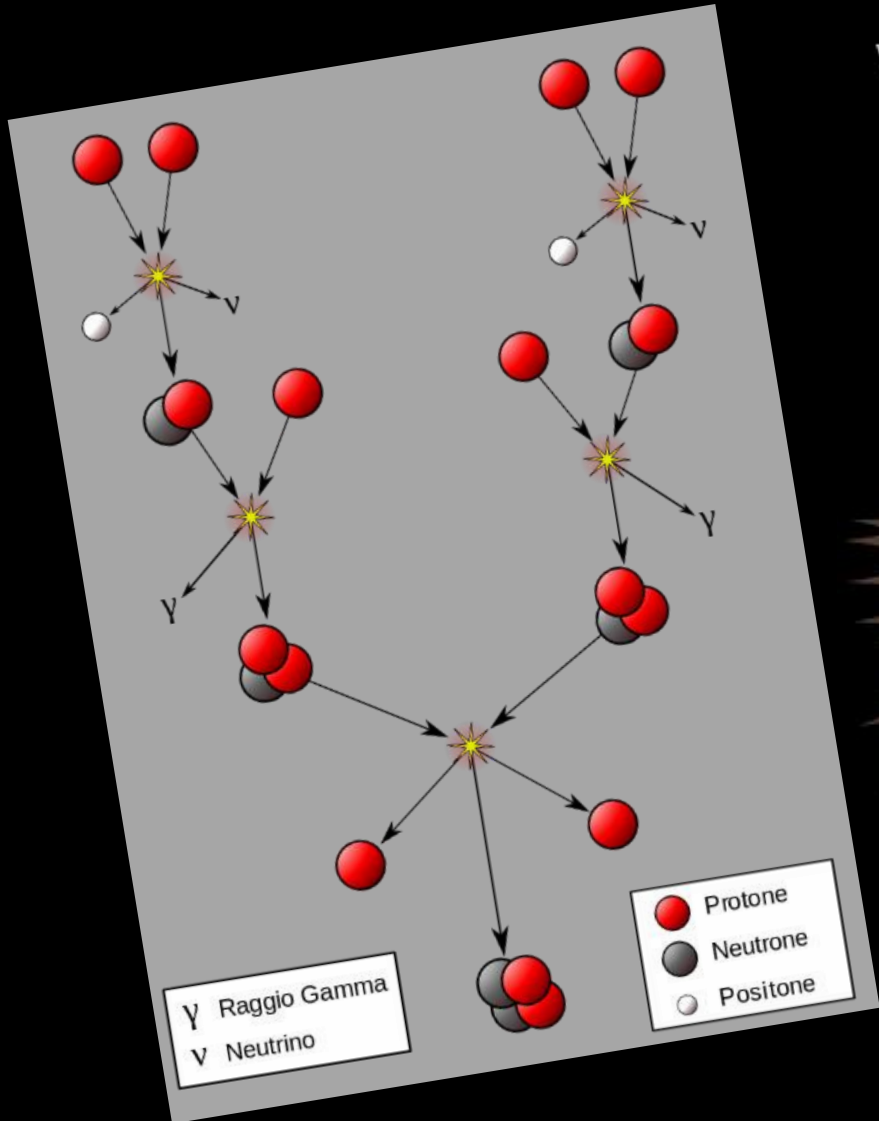
Nucleo

Zona
convettiva

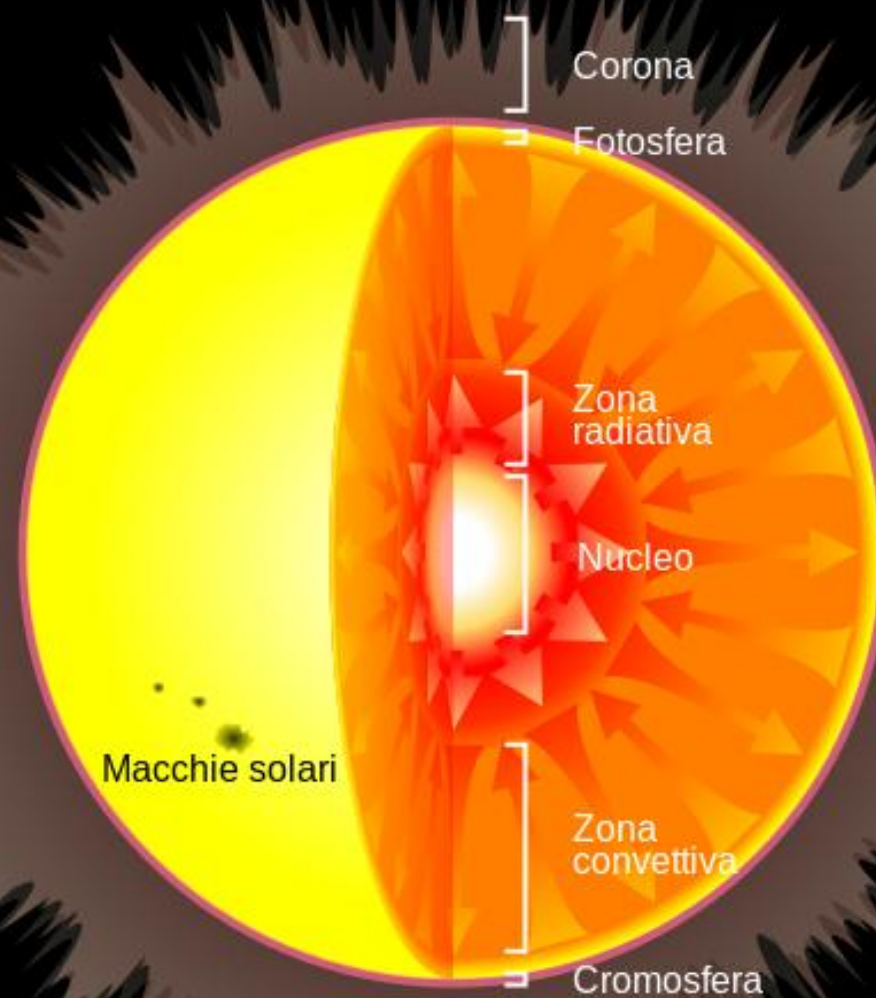
Cromosfera

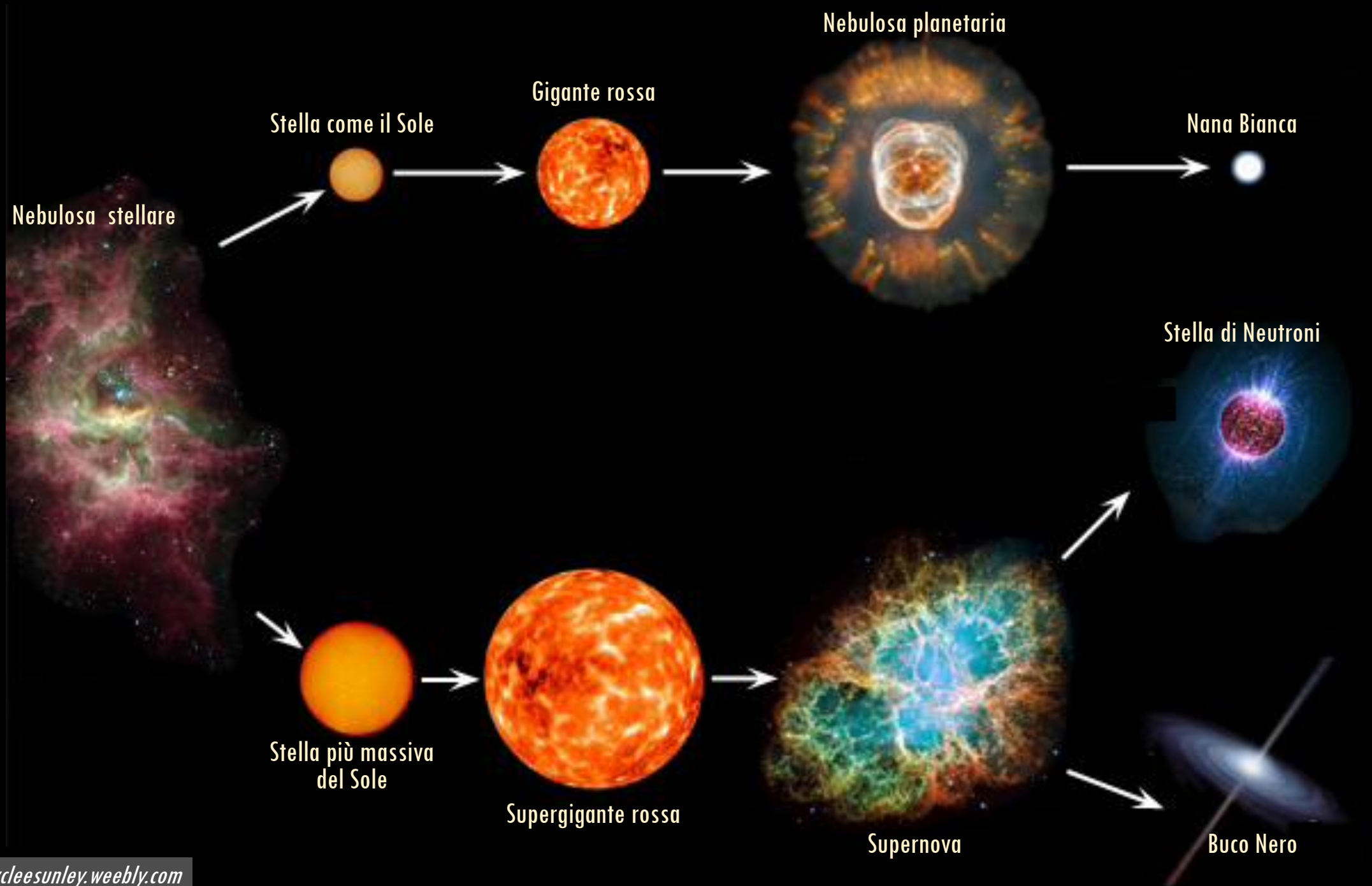
Macchie solari

La nucleosintesi stellare

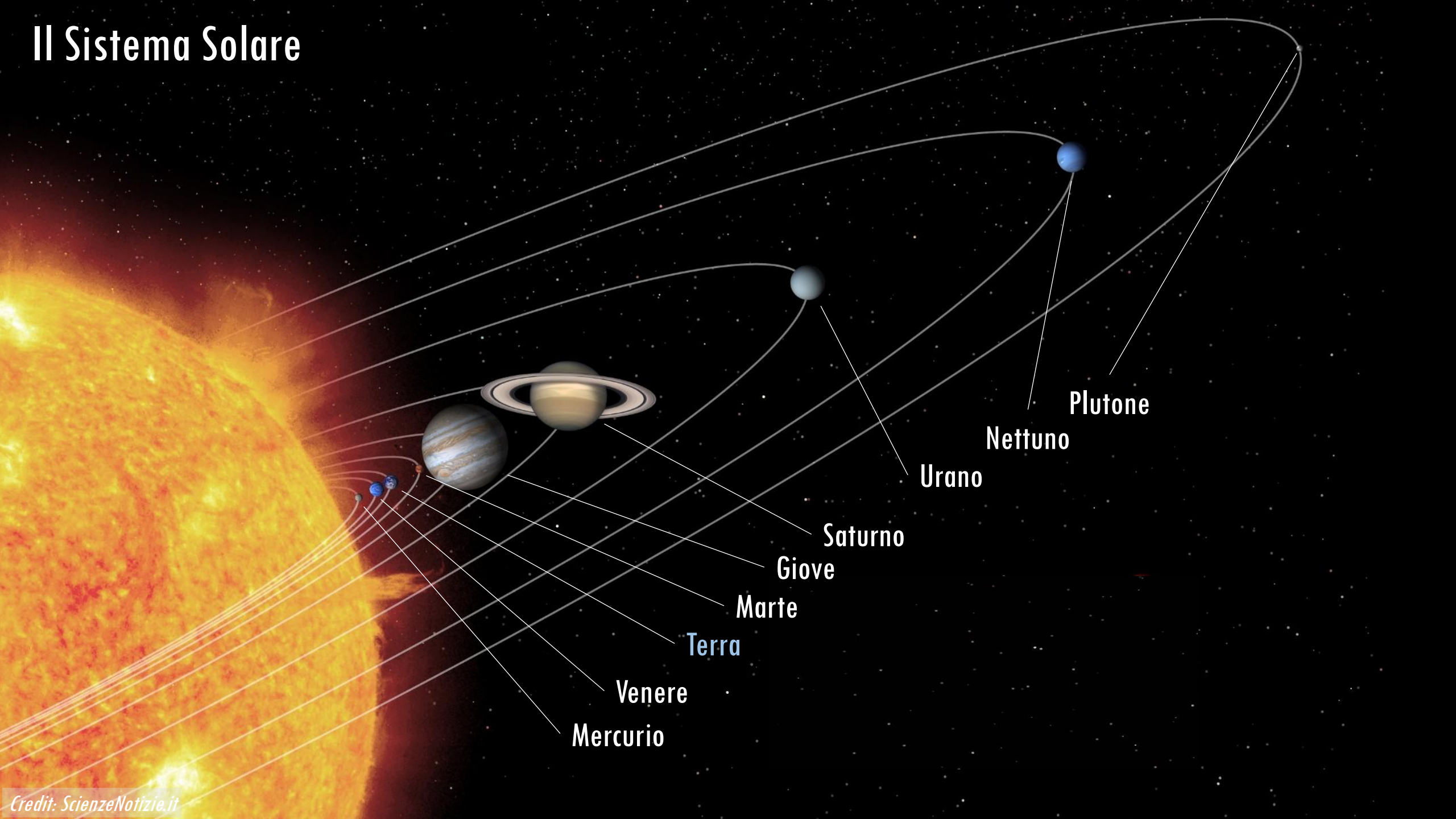


Vento solare





Il Sistema Solare



Mercurio

Venere

Terra

Marte

Giove

Saturno

Urano

Nettuno

Plutone

Le distanze in Astronomia

- Lunghezza di un'aula:
- Lunghezza di un campo da calcio:
- Lunghezza del Dipartimento Interateneo di Fisica:
- Distanza dal Dipartimento alla Stazione di Bari Centrale:
- Distanza Bari – Trani:
- Distanza Bari – Roma:
- Distanza Bari – Sydney:
- Diametro della Terra:
- E dalla Terra alla Luna?



~10 m

~100 m

~150 m

~2.2 km

~55 km

~450 km

~16000 km

~12700 km



1,3 s

Le distanze in Astronomia

Nuove unità di misura

L'Unità Astronomica:

1 AU = ~150 milioni di km

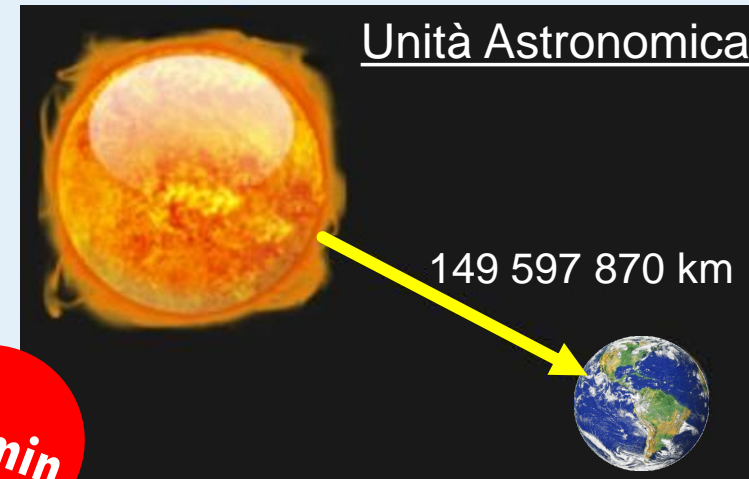
L'Anno Luce:

1 ly = ~ 9500 miliardi di km

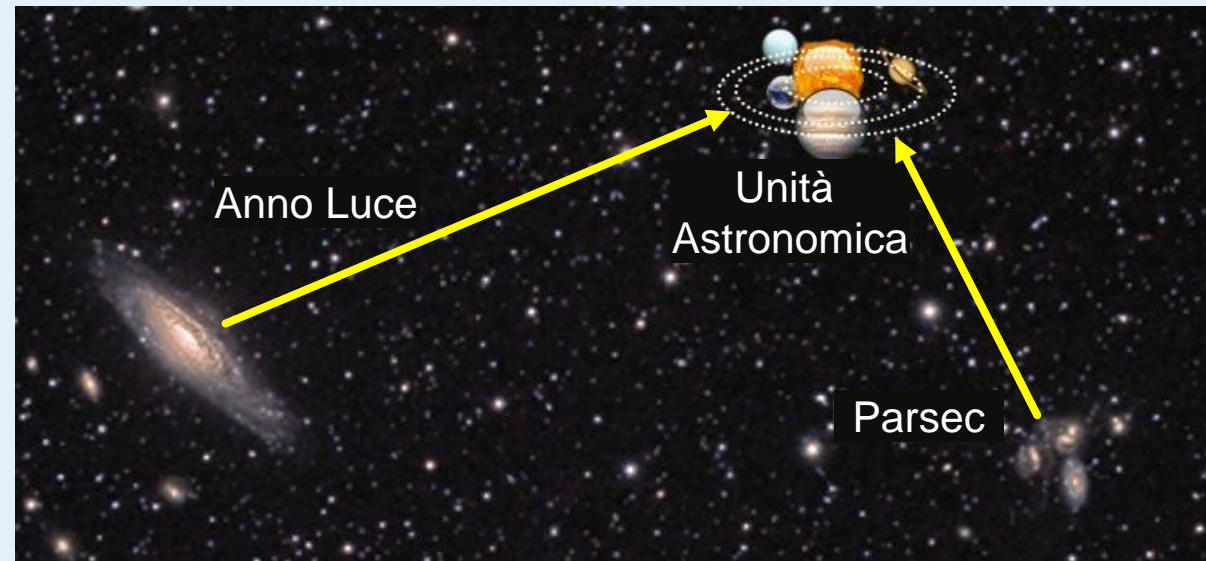
→ Ricordando che
 $v_{\text{luce}} = 300000 \text{ km/s}$

Il Parsec:

1 pc = ~31000 miliardi di km

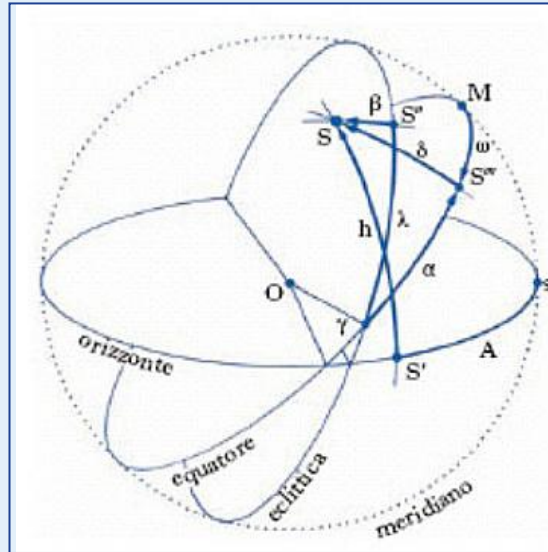


8,3min



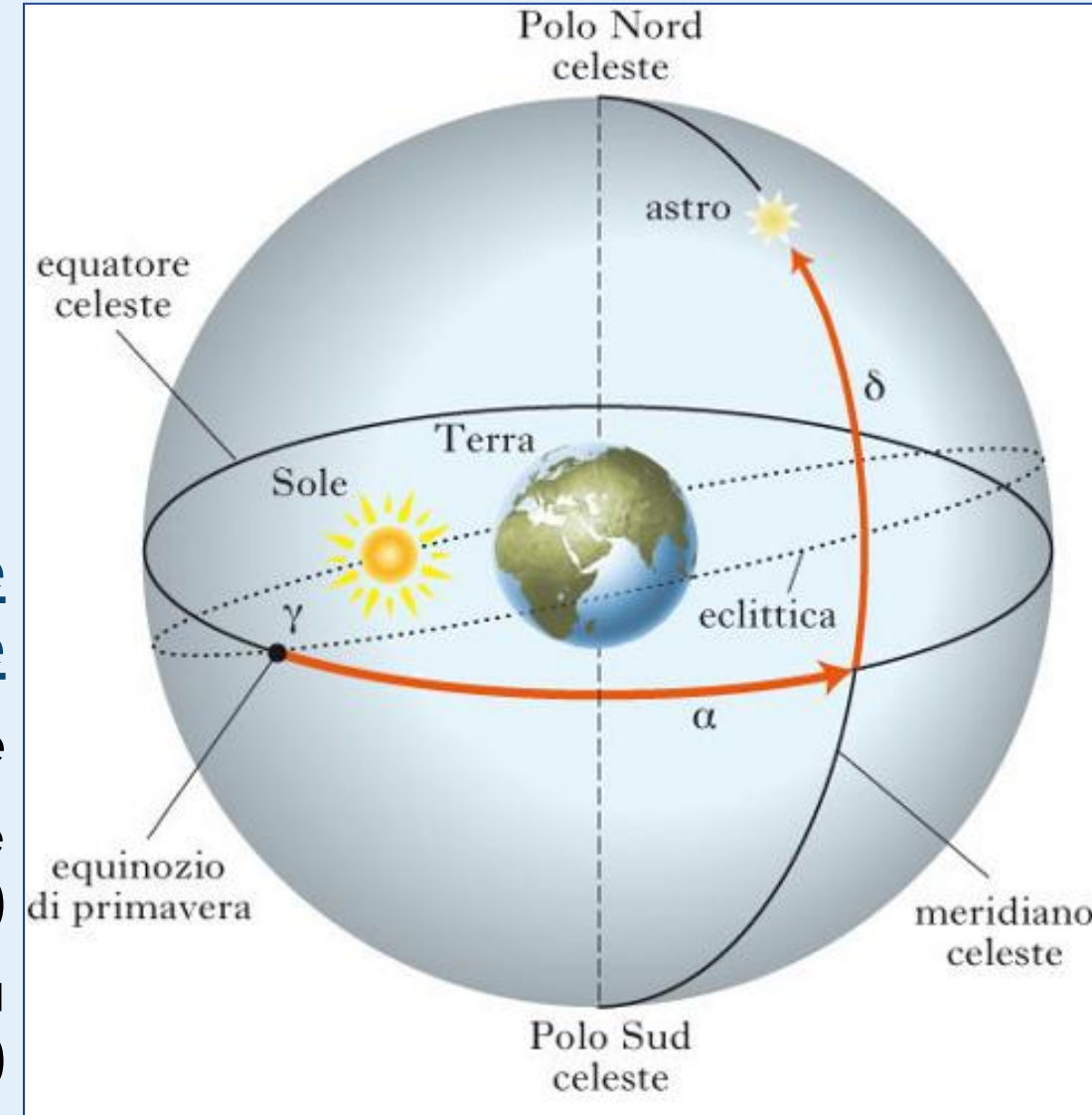
Diversi sistemi di coordinate astronomiche

1. Orizzontale
2. Equatoriale
3. Eclitticale



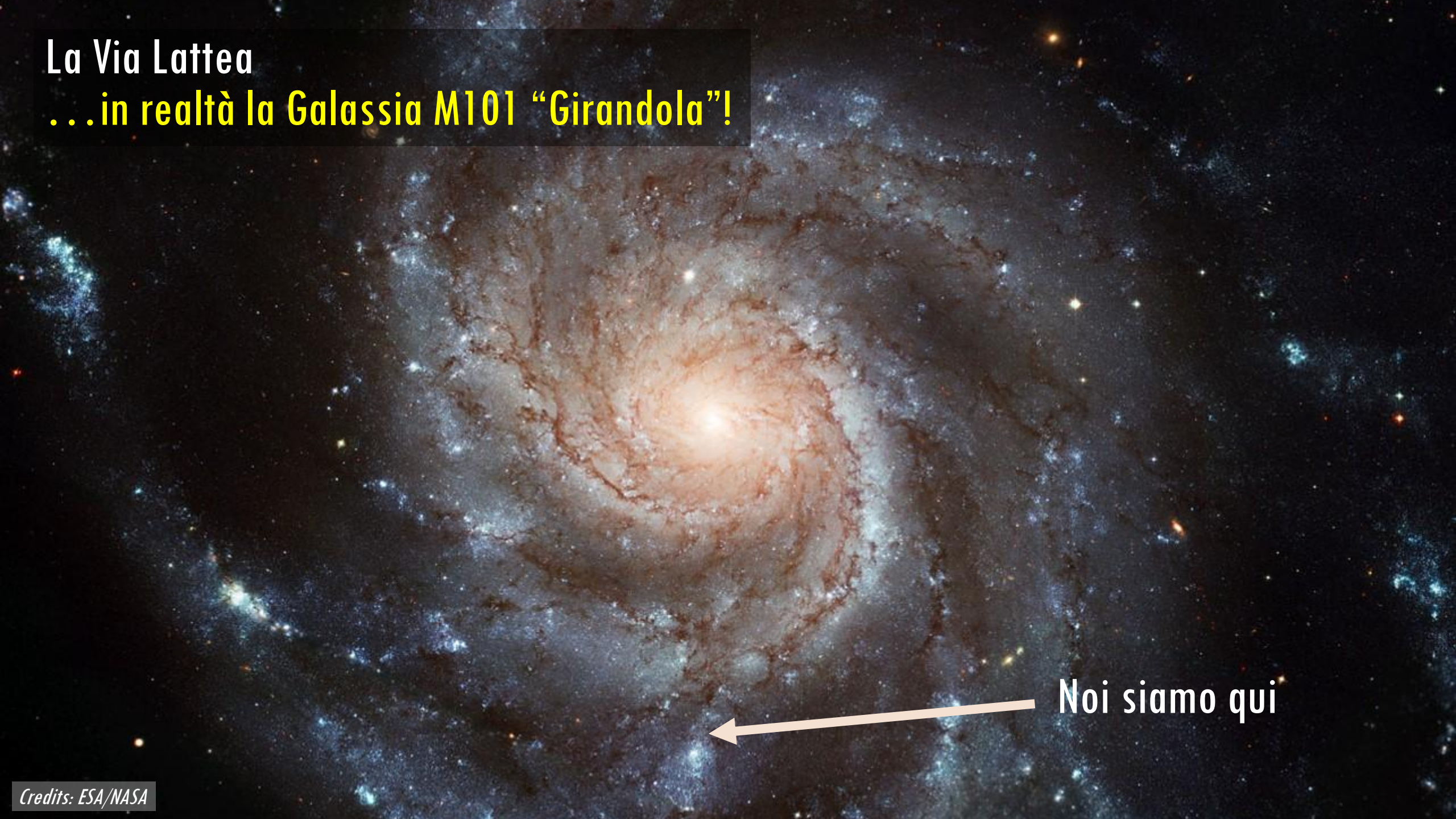
Sistema di coordinate equatoriali assolute

- Cerchio base è l'**equatore celeste**
 - L'ascissa sferica è l'**ascensione retta α (RA)**
 - L'ordinata sferica è la **declinazione δ (Dec)**



La Via Lattea

...in realtà la Galassia M101 "Girandola"!



Noi siamo qui

La Via Lattea

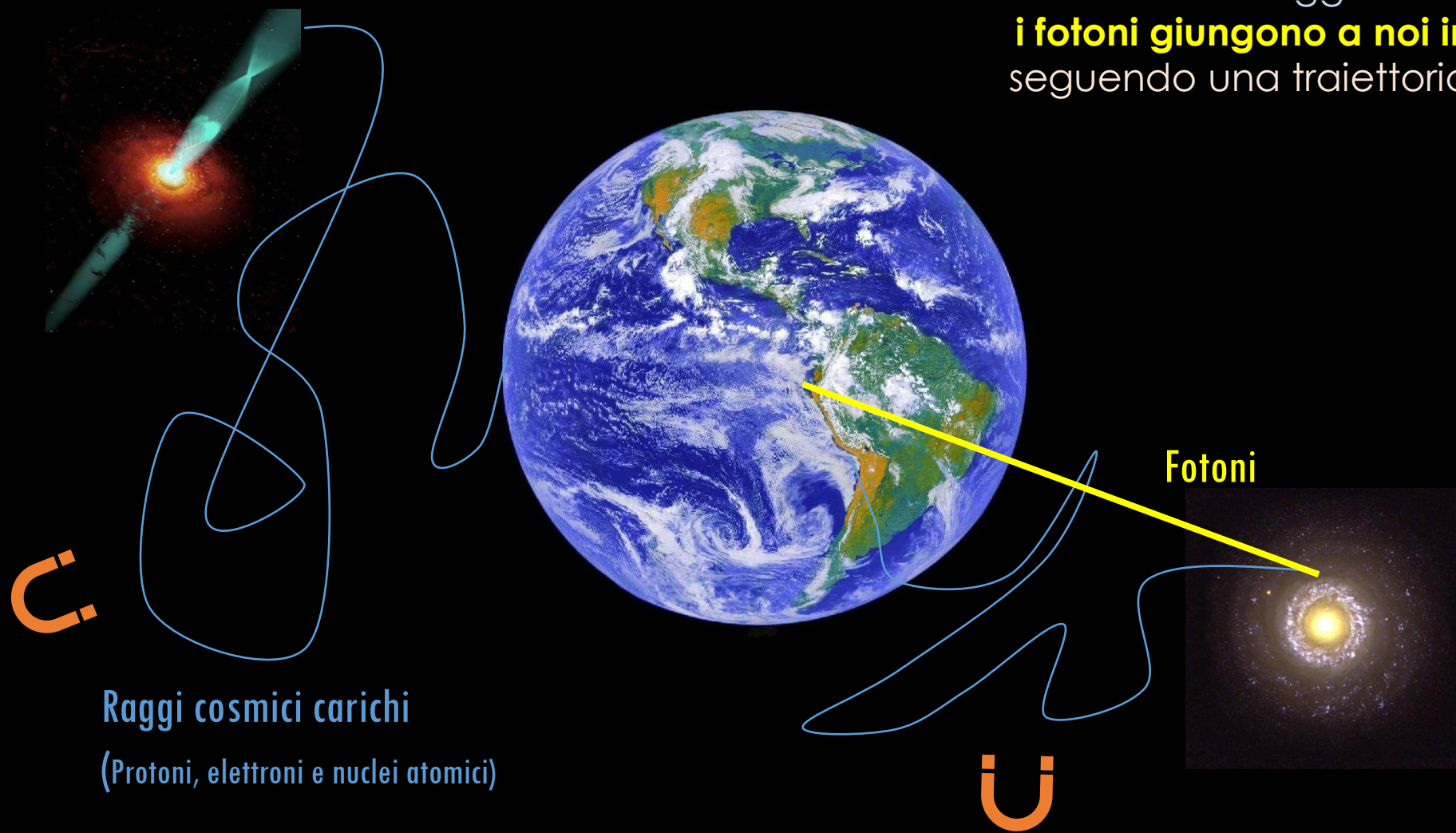
Very Large Area Telescope (VLT)

European Southern Observatory, Paranal, Chile



Propagazione di fotoni e raggi cosmici nella Via Lattea

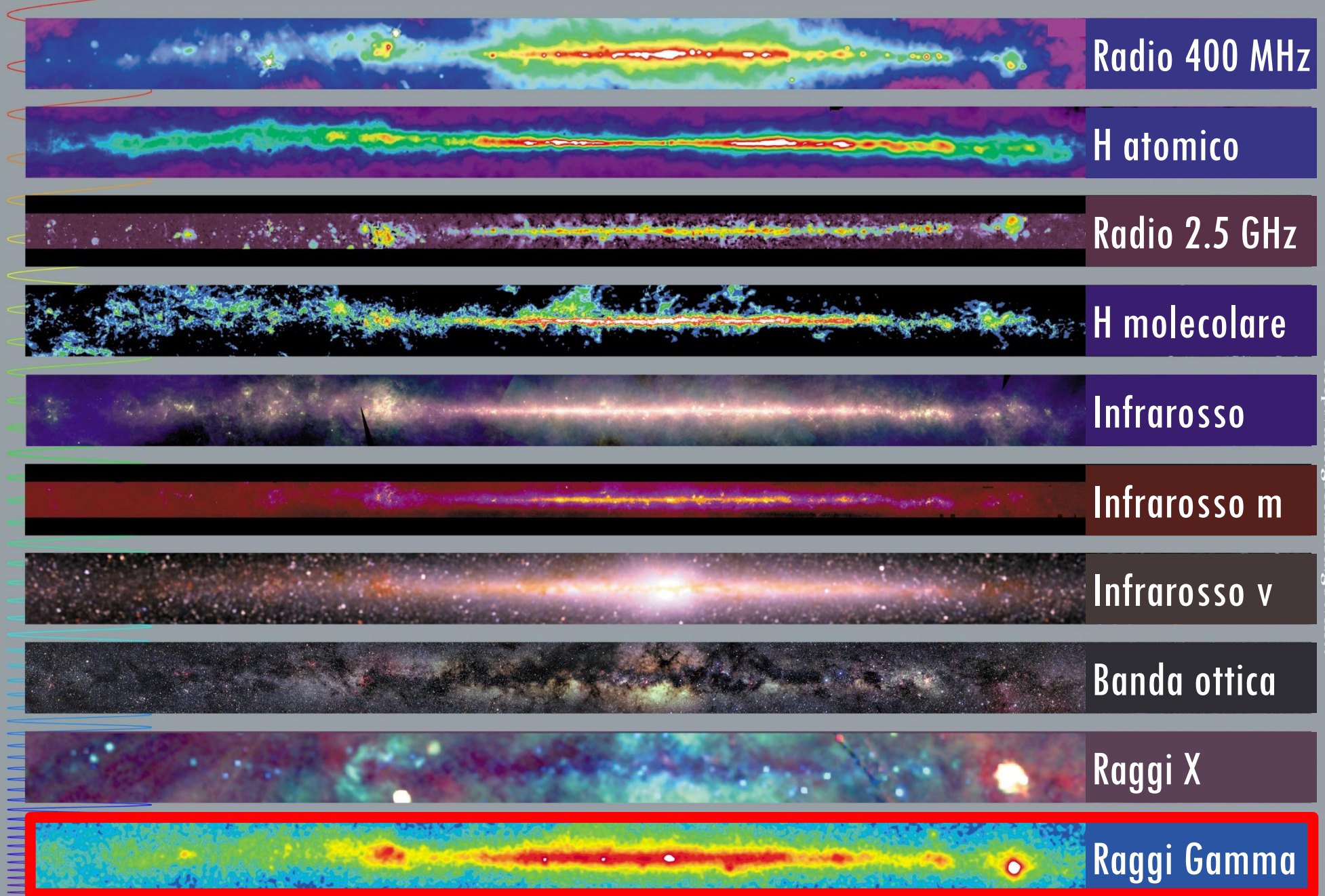
Mentre i campi magnetici nello Spazio deviano i raggi cosmici carichi, **i fotoni giungono a noi indisturbati**, seguendo una traiettoria rettilinea,



La Via Lattea

Gaia Early third Data Release (EDR3 2020)

UN MILIARDO E 800 MILIONI di stelle mappate...!!!!

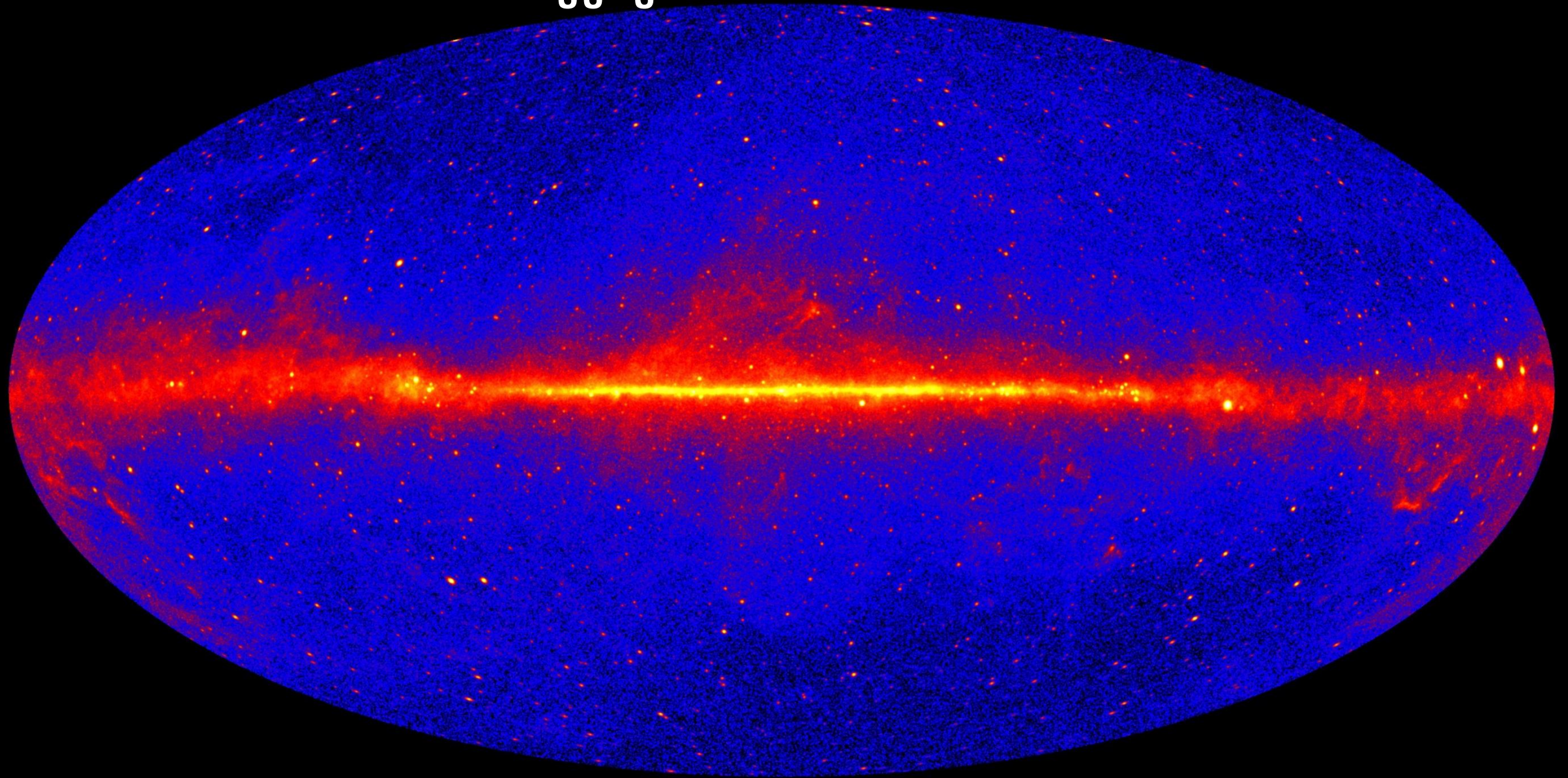


<http://adc.gsfc.nasa.gov/mw>

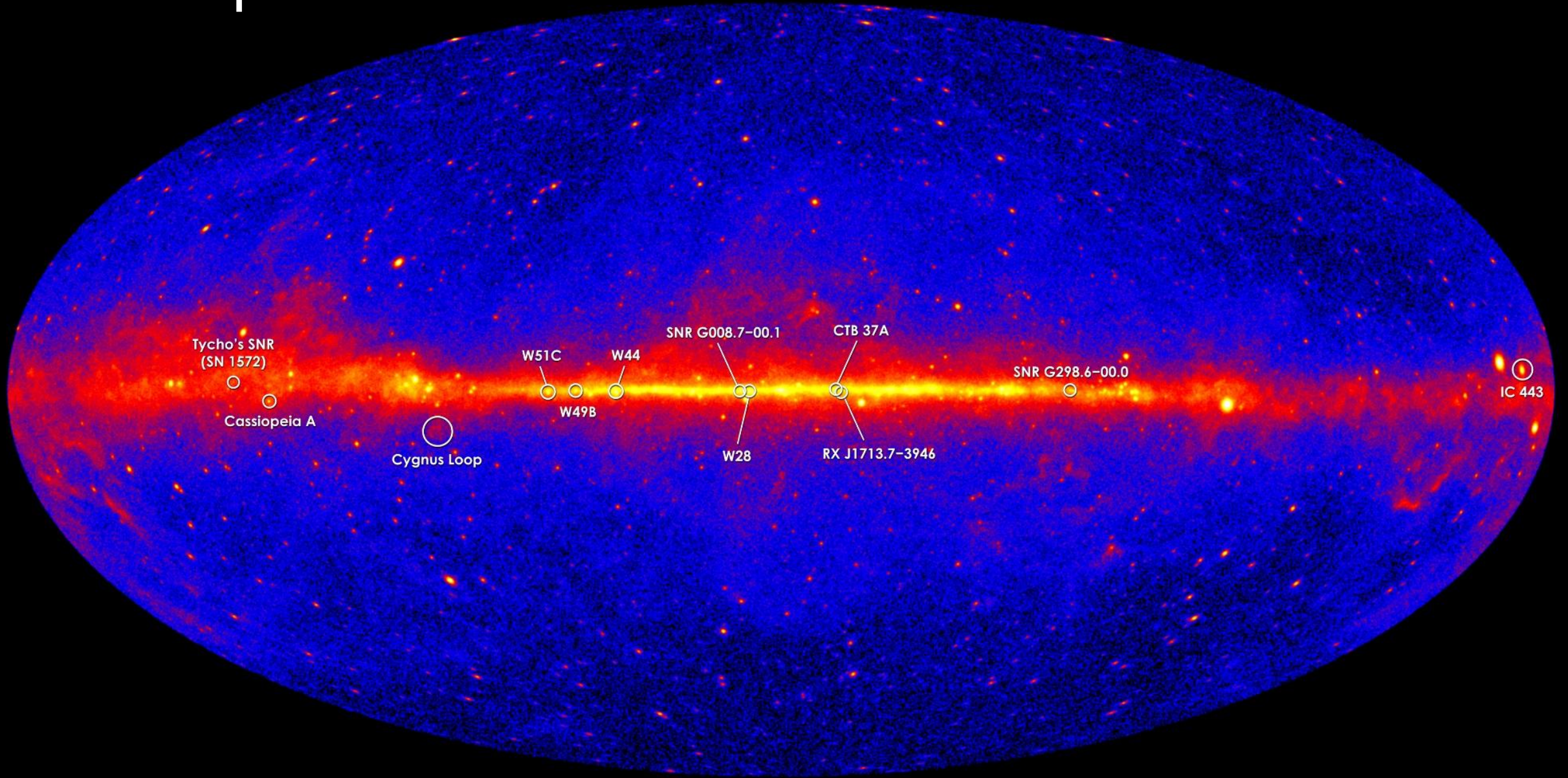


La Via Lattea vista a diverse frequenze

L'Universo osservato nei raggi gamma



I resti di Supernova



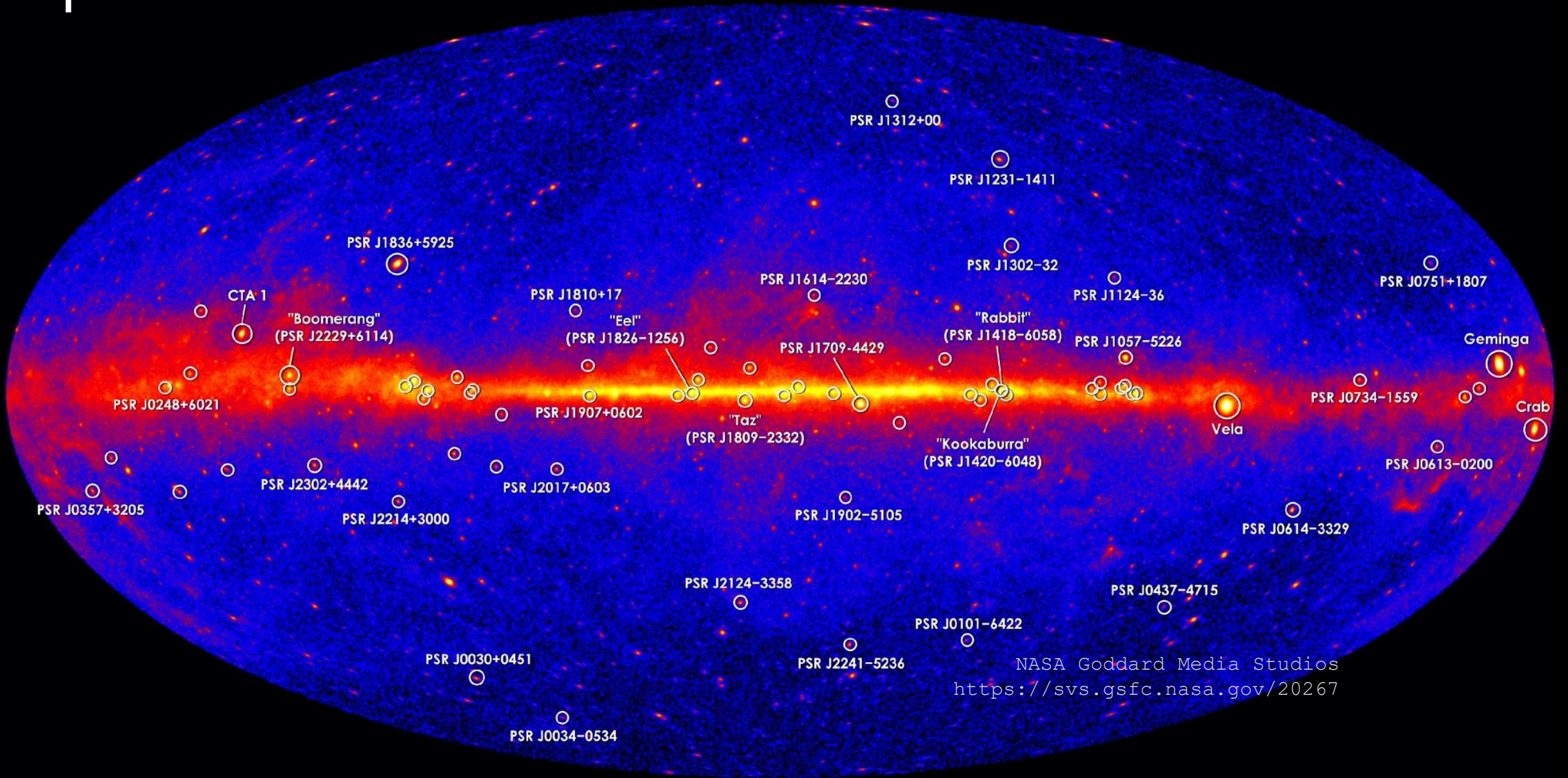
I resti di Supernova

Nebulosa del Granchio (M1)

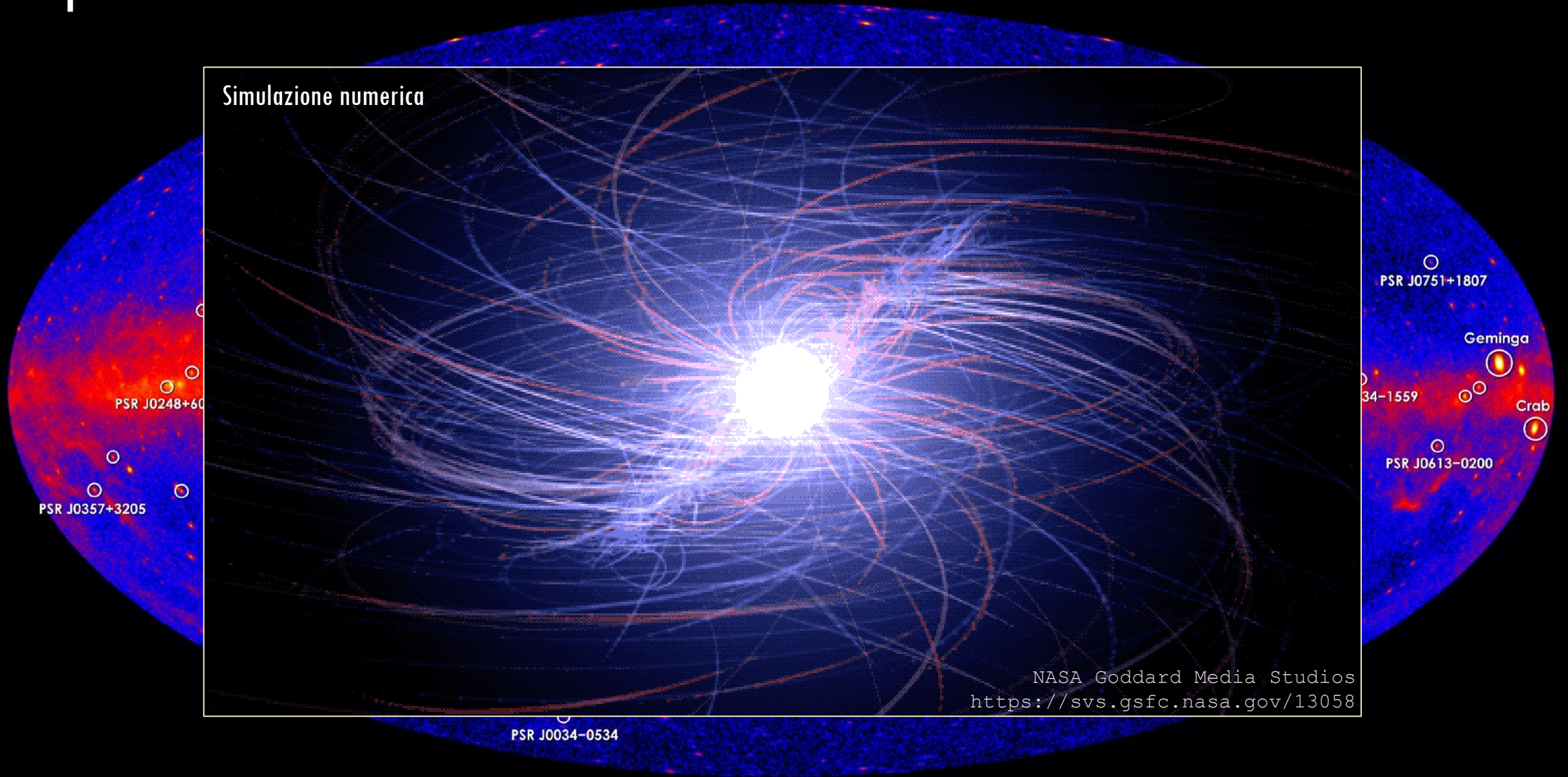


IC 443

Le pulsar

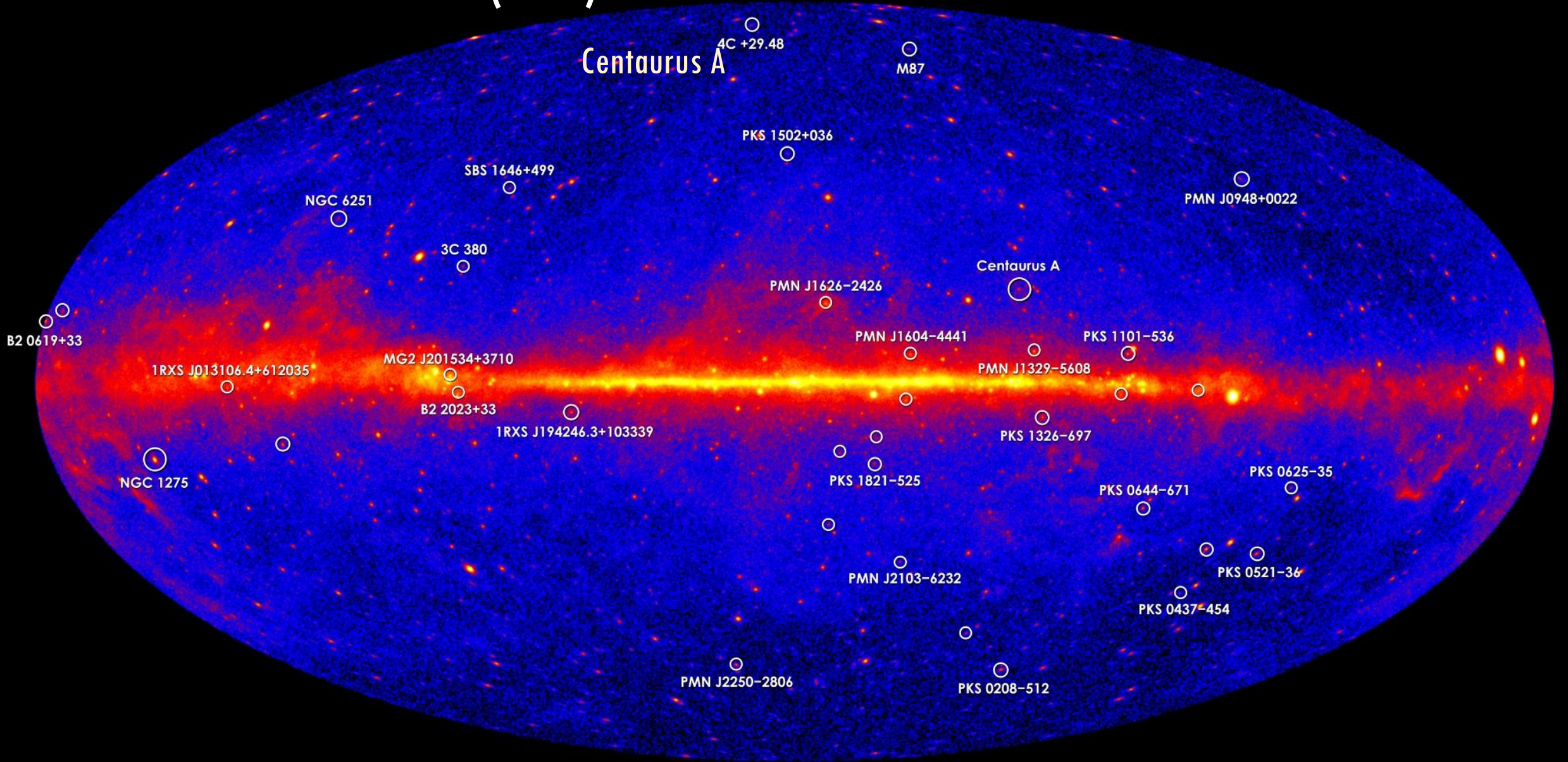


Le pulsar



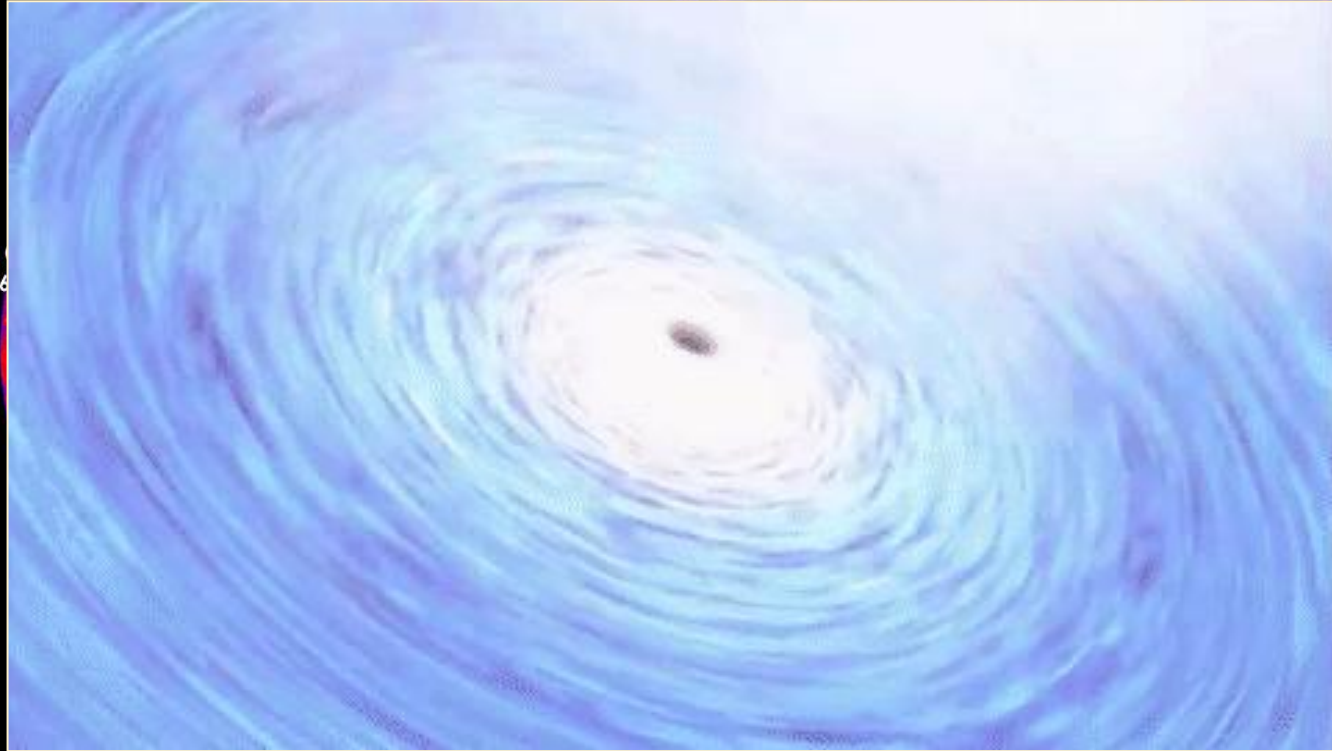
NASA Goddard Media Studios
<https://svs.gsfc.nasa.gov/13058>

I Nuclei Galattici Attivi (AGN)



I Nuclei Galattici Attivi (AGN)

Rappresentazioni artistiche



4C +29.48

M87

PKS 1502+036

B2 06

J1

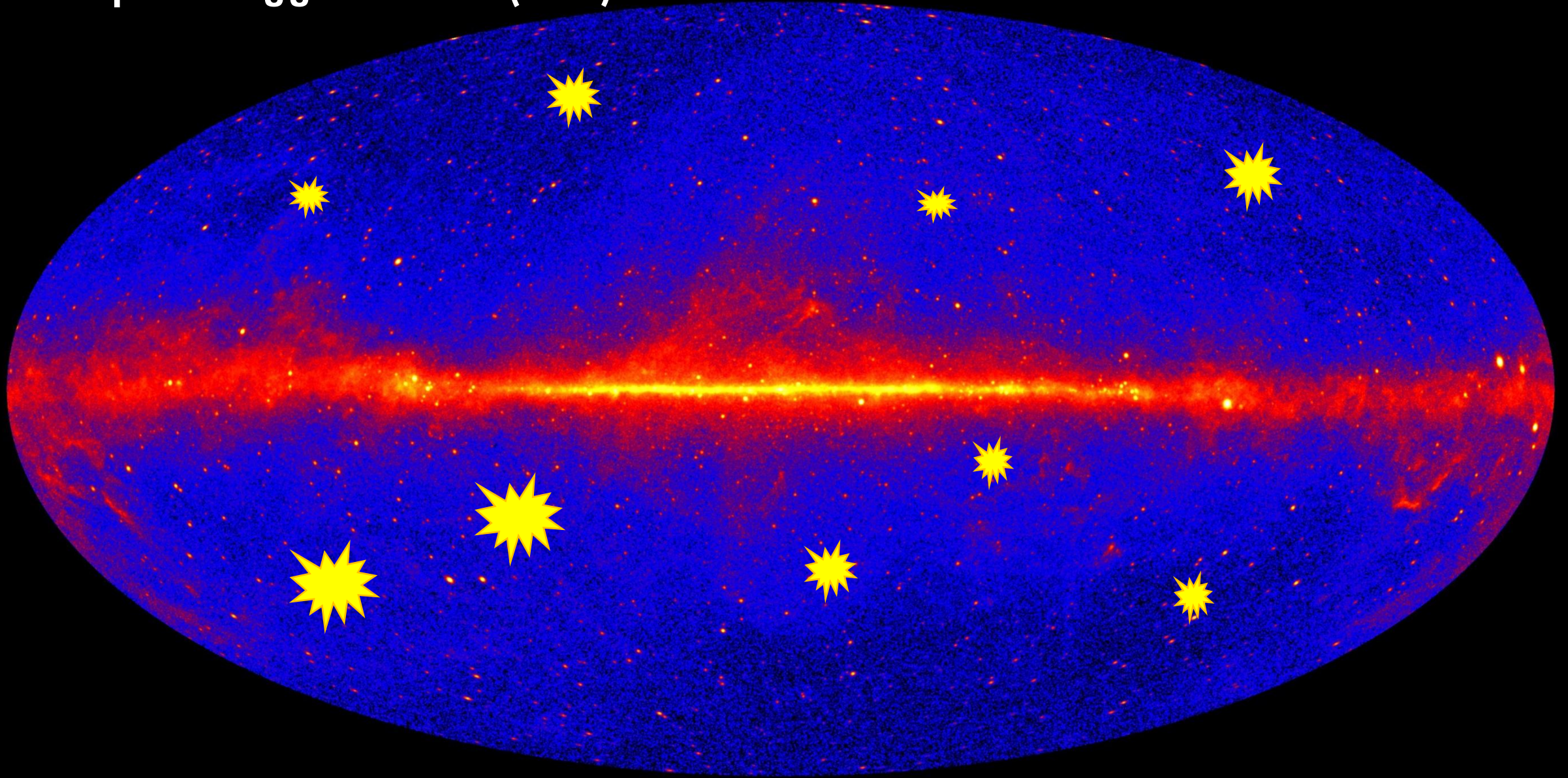
1-5

J21

PMN J2250-2806

PKS 0208-512

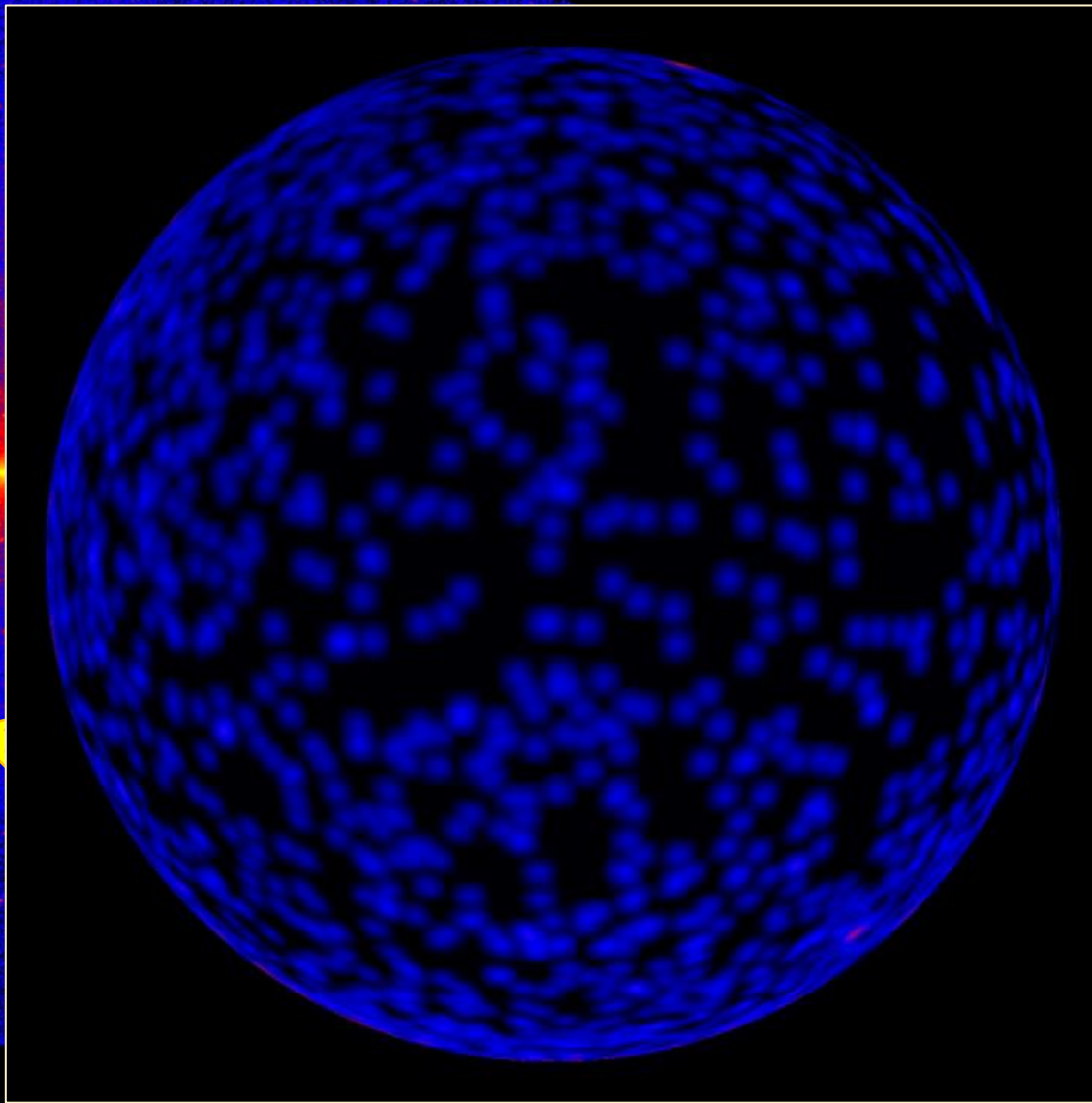
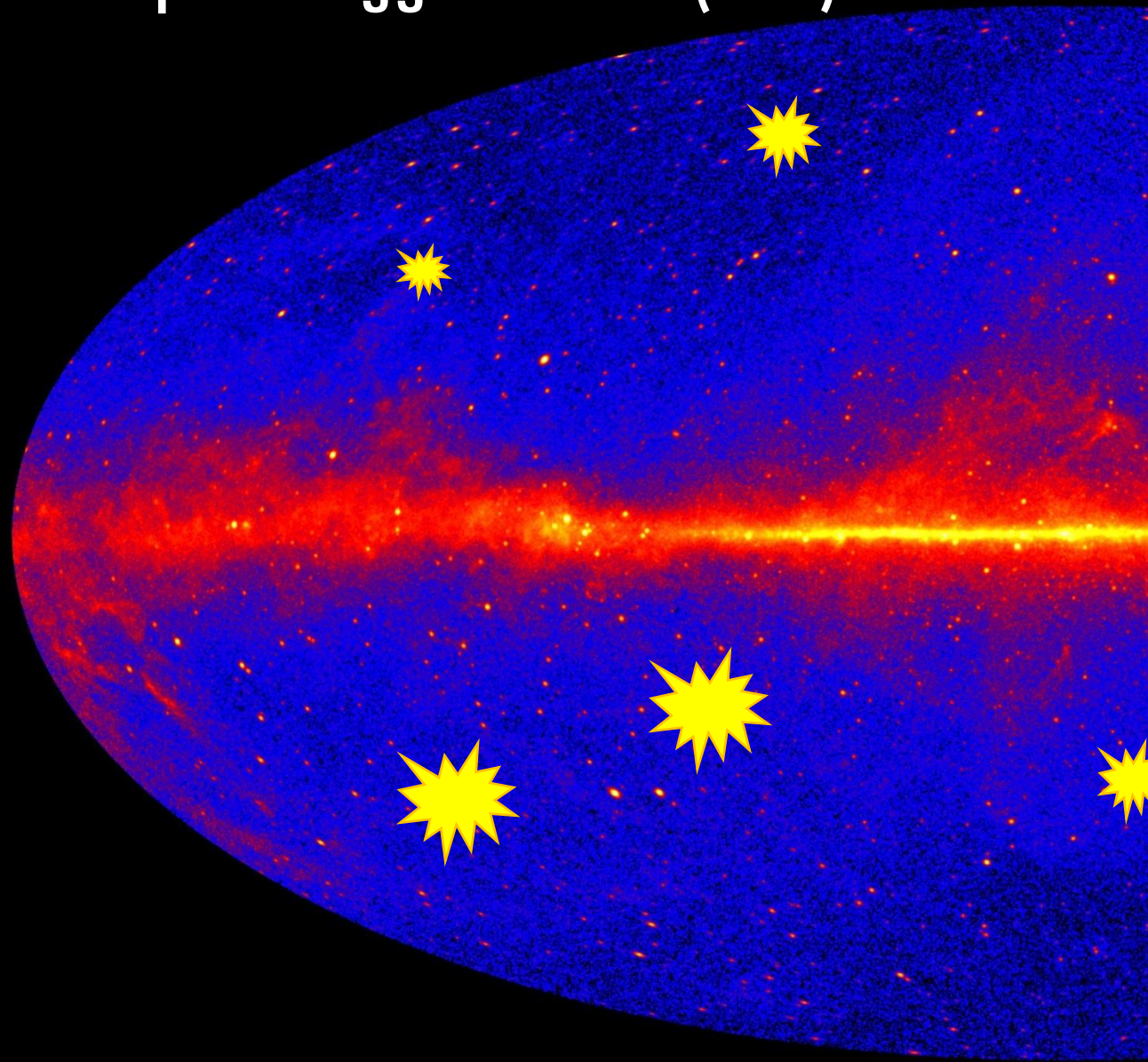
I Lampi di Raggi Gamma (GRB)



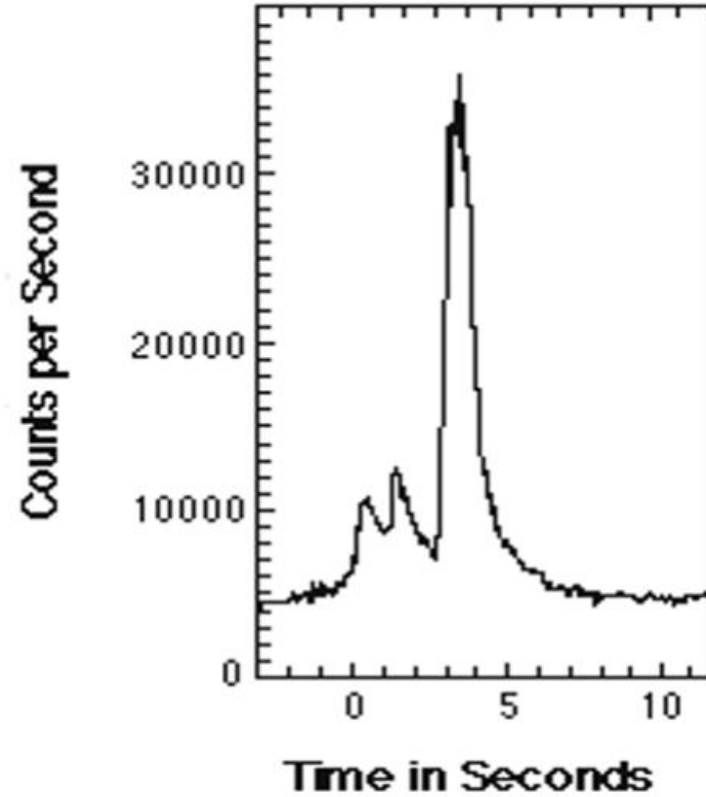
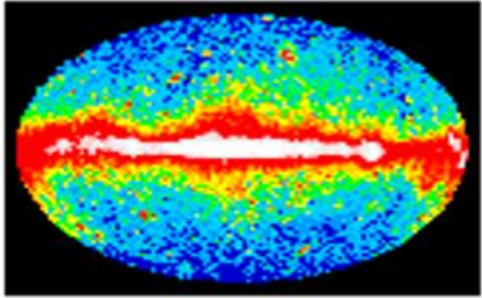
I Lampi di Raggi Gamma (GRB)

27 aprile 2013

GRB 130427A



Osservazioni di GRB nella storia

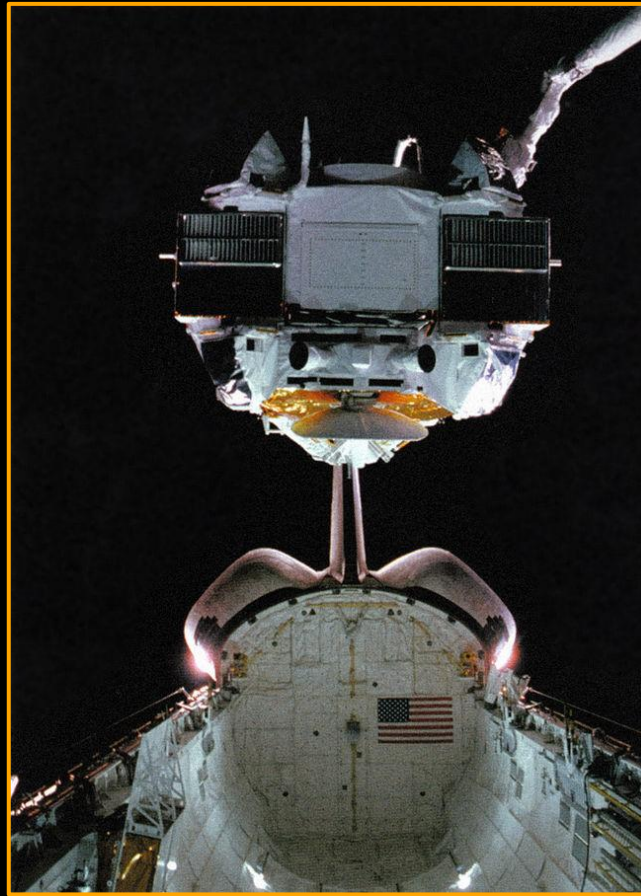
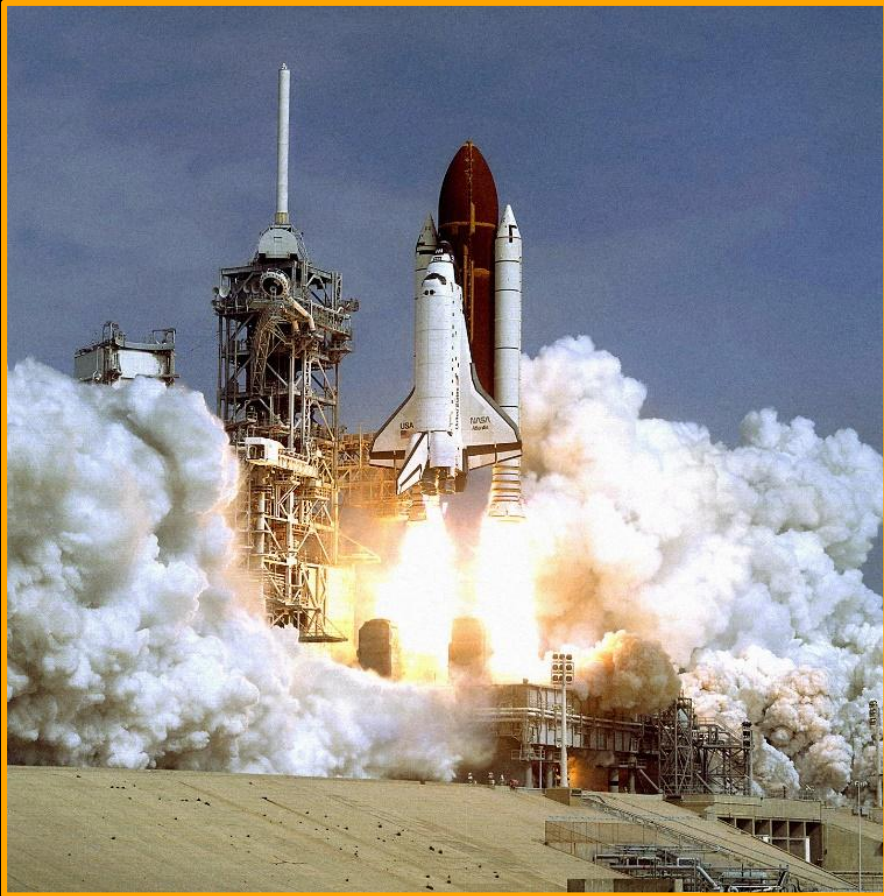


Sateliti Vela:

monitoraggio del rispetto del Trattato tra USA, UK e URSS del 1963 sul **bando parziale dei test nucleari**



Osservazioni di GRB nella storia



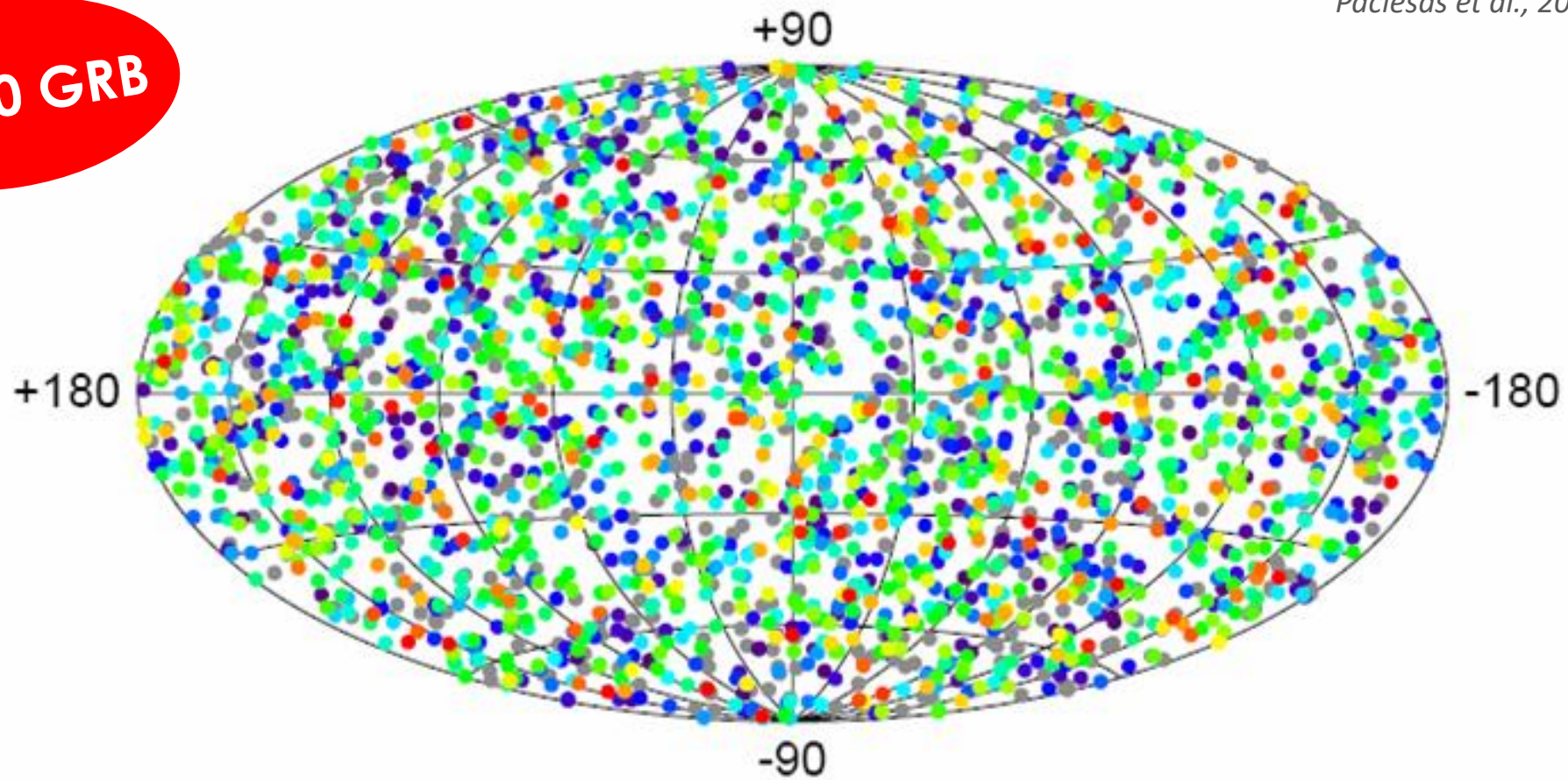
(Image Credit: NASA/MSFC)

Grande Osservatorio NASA (1991 — 2000) :
Compton Gamma Ray Observatory (CGRO)
Strumenti a bordo: BATSE — EGRET — OSSE — Comptel

Il primo grande catalogo dei GRB osservati da BATSE

Paciesas et al., 2000

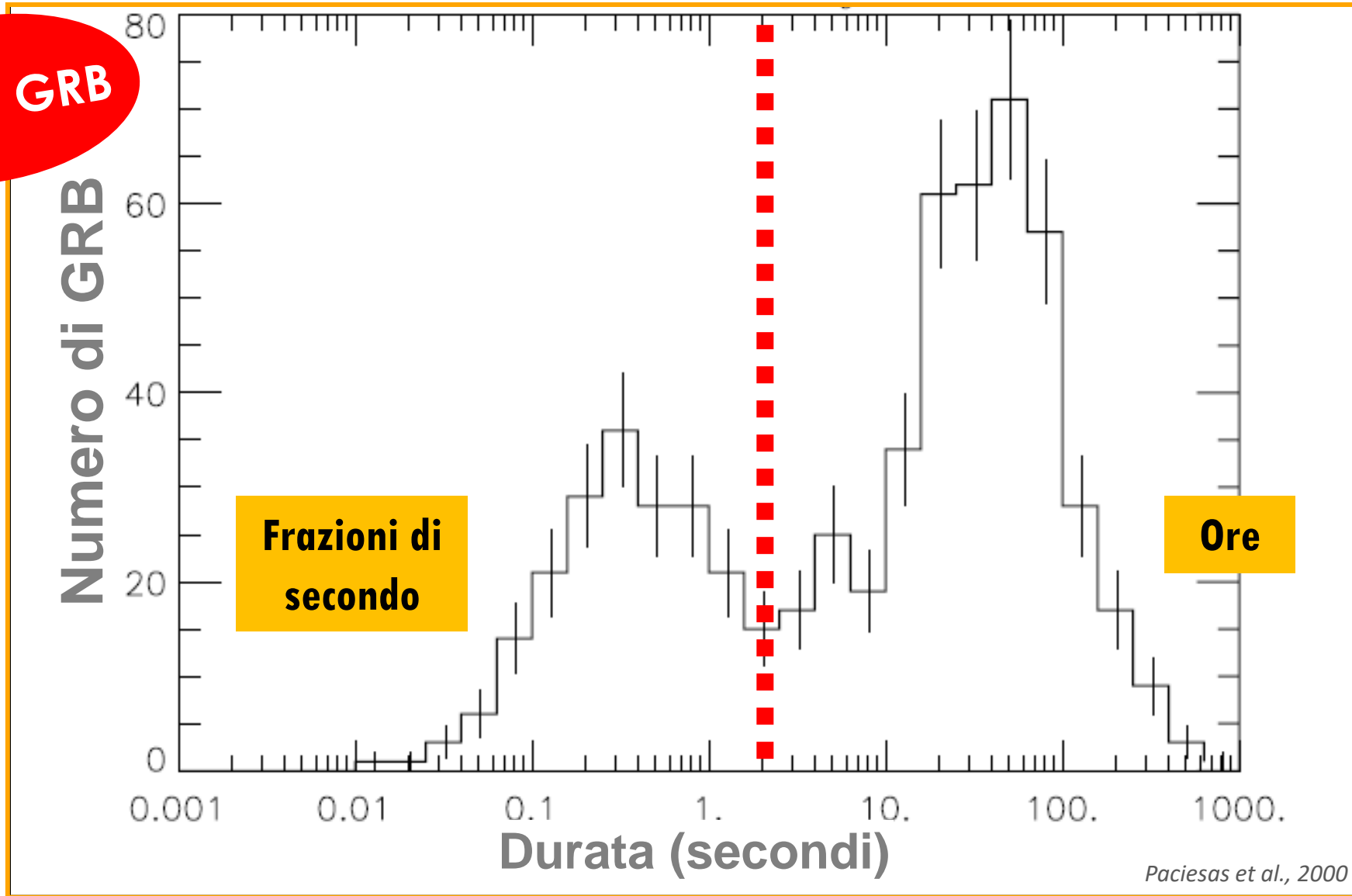
~3000 GRB



Flusso integrato in banda 50-300 keV (erg cm²)

Il primo grande catalogo dei GRB osservati da BATSE

~3000 GRB



Paciesas et al., 2000

GRB lunghi — Long GRB (Durata > 2 secondi)

Collasso di una singola stella supermassiva

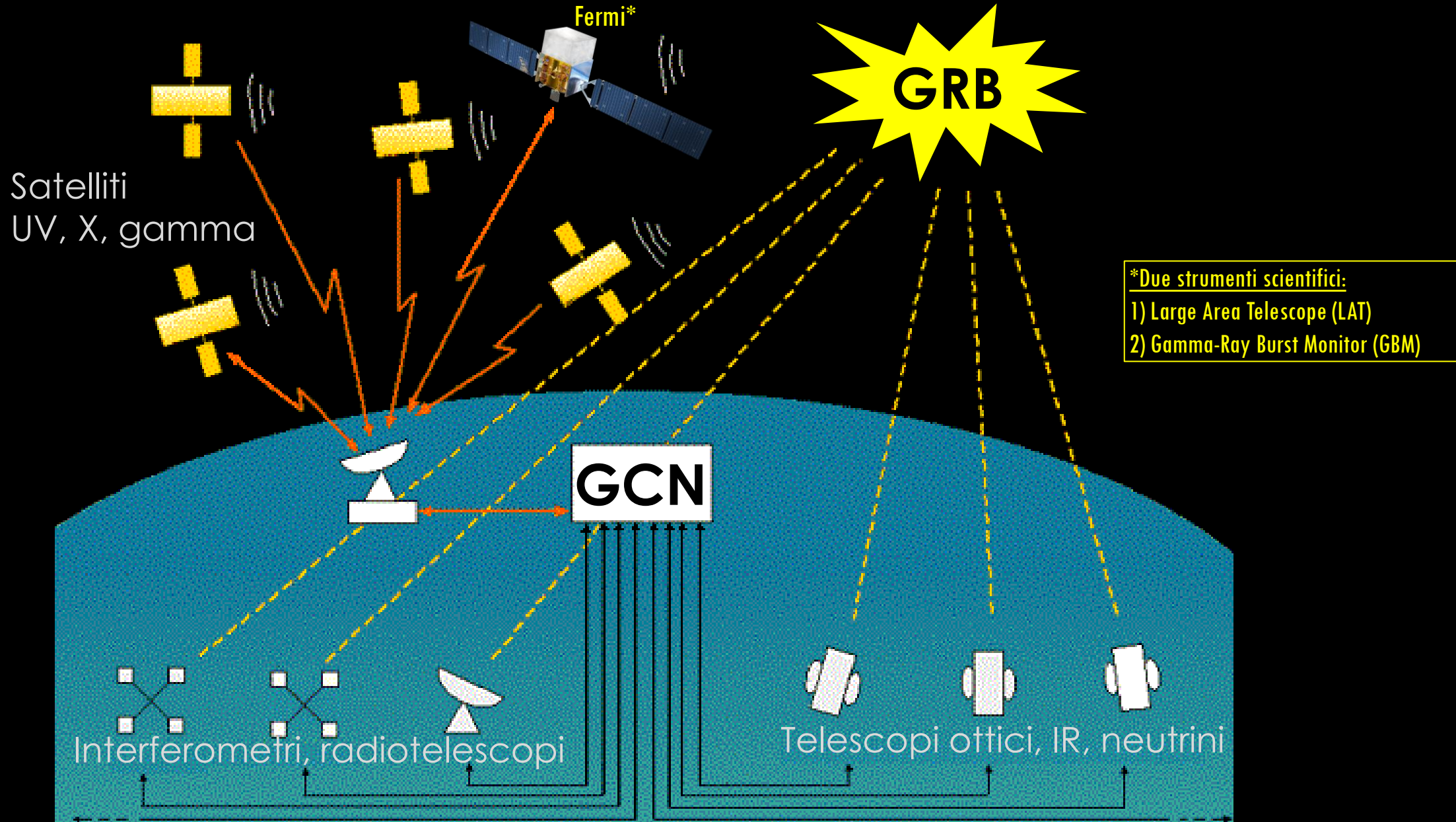


GRB brevi — Short GRB (Durata < 2 secondi)

Fusione di due stelle binarie compatte



Tutti a caccia di GRB — GRB Coordinate Network



L'emissione ritardata o «**afterglow**»

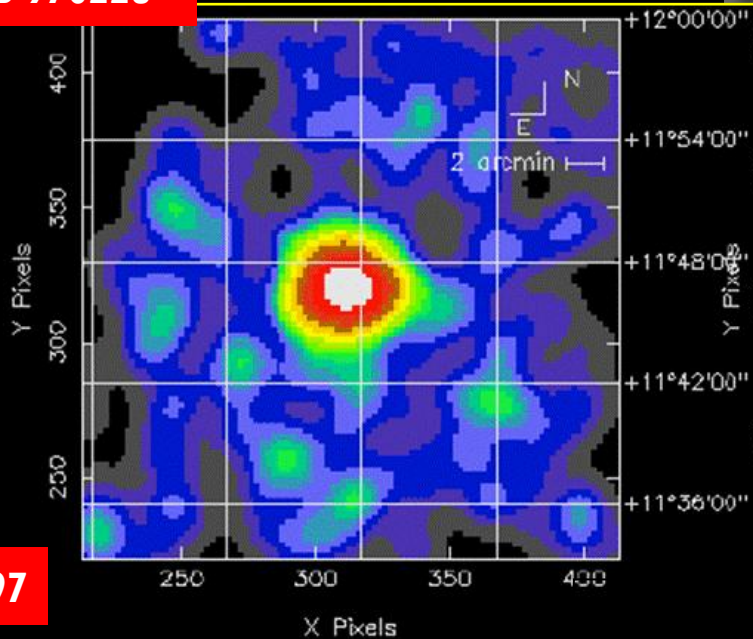
Osservata a partire dagli anni '90 ad altre lunghezze d'onda (ottico, radio, X, etc)

Inizio dello studio **MULTIFREQUENZA** dei GRB

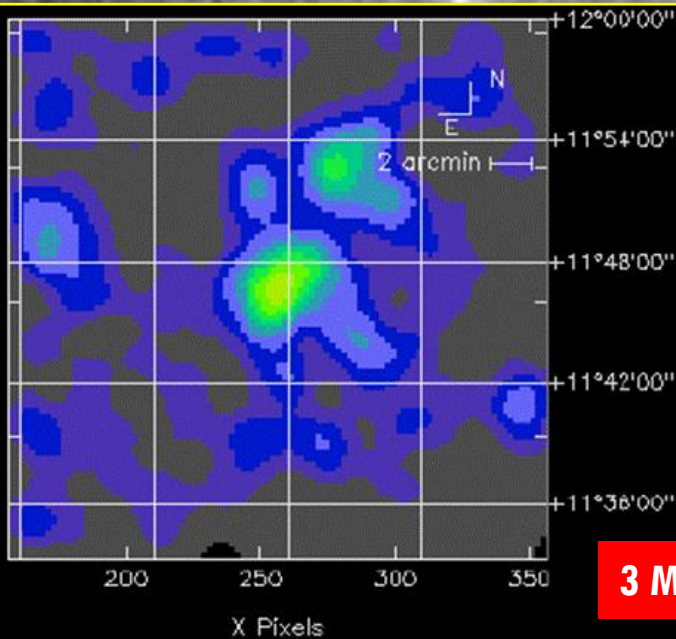


Credit: Pi of the Sky

GRB 970228



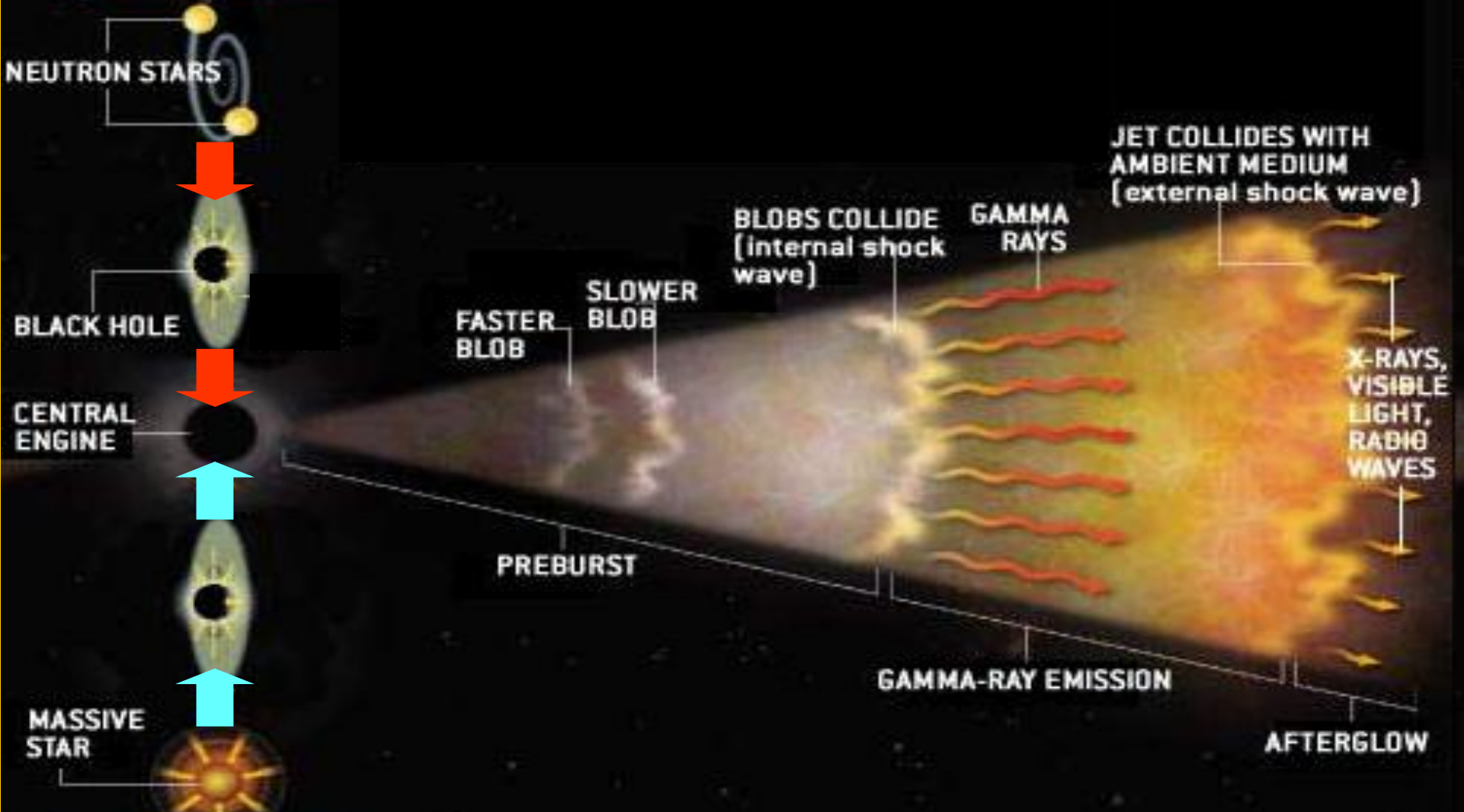
28 Feb 1997



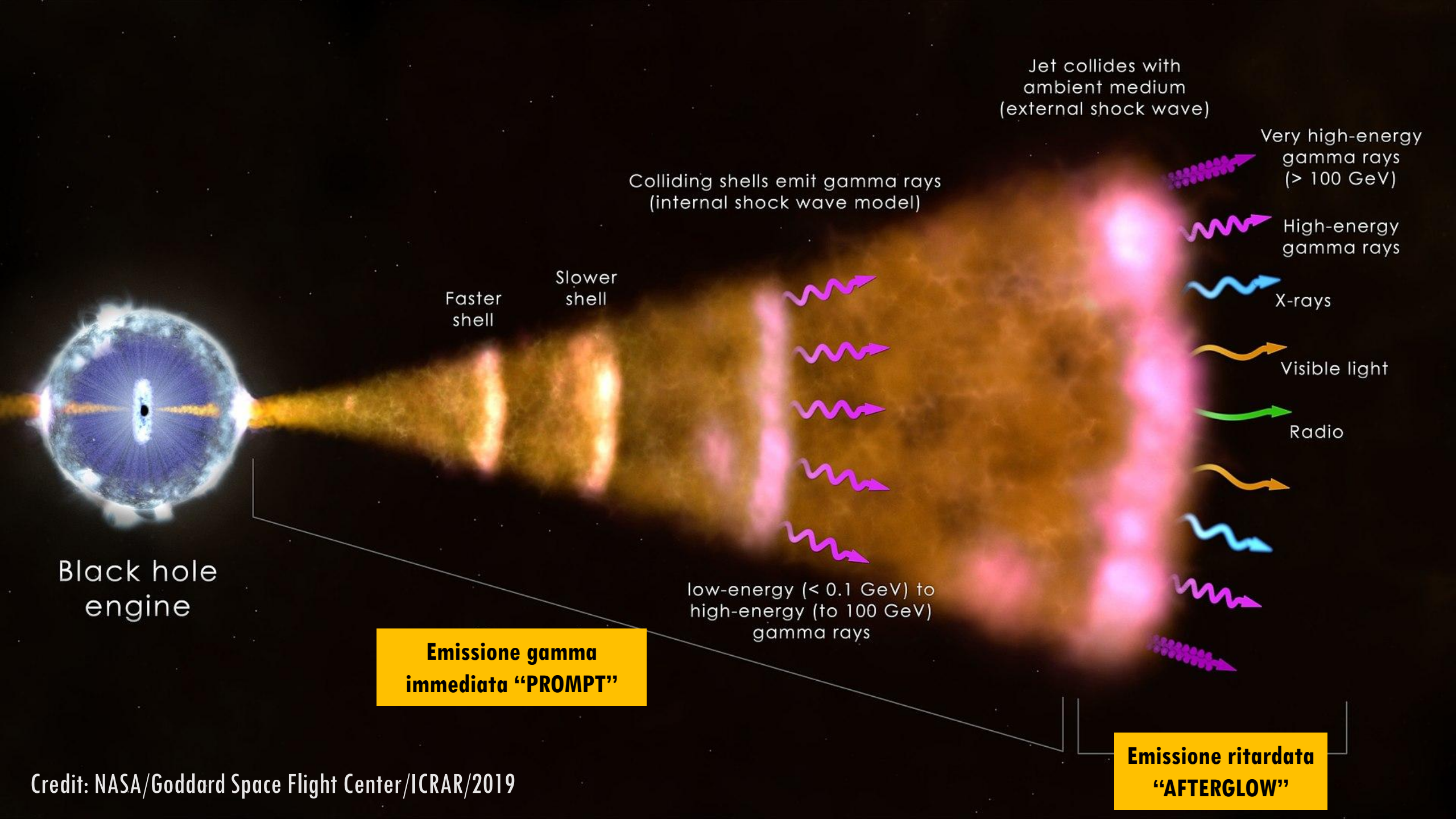
3 Mar 1997

Modello teorico «fireball»

FUSIONE DI STELLE DI NEUTRONI (GRB BREVI)



COLLASSO DI UNA STELLA MASSIVA (GRB LUNGI)



Black hole engine

Faster shell
Slower shell

Colliding shells emit gamma rays (internal shock wave model)

Jet collides with ambient medium (external shock wave)

Very high-energy gamma rays (> 100 GeV)

High-energy gamma rays

X-rays

Visible light

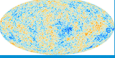





Radio

low-energy (< 0.1 GeV) to high-energy (to 100 GeV) gamma rays

Emissione gamma immediata "PROMPT"

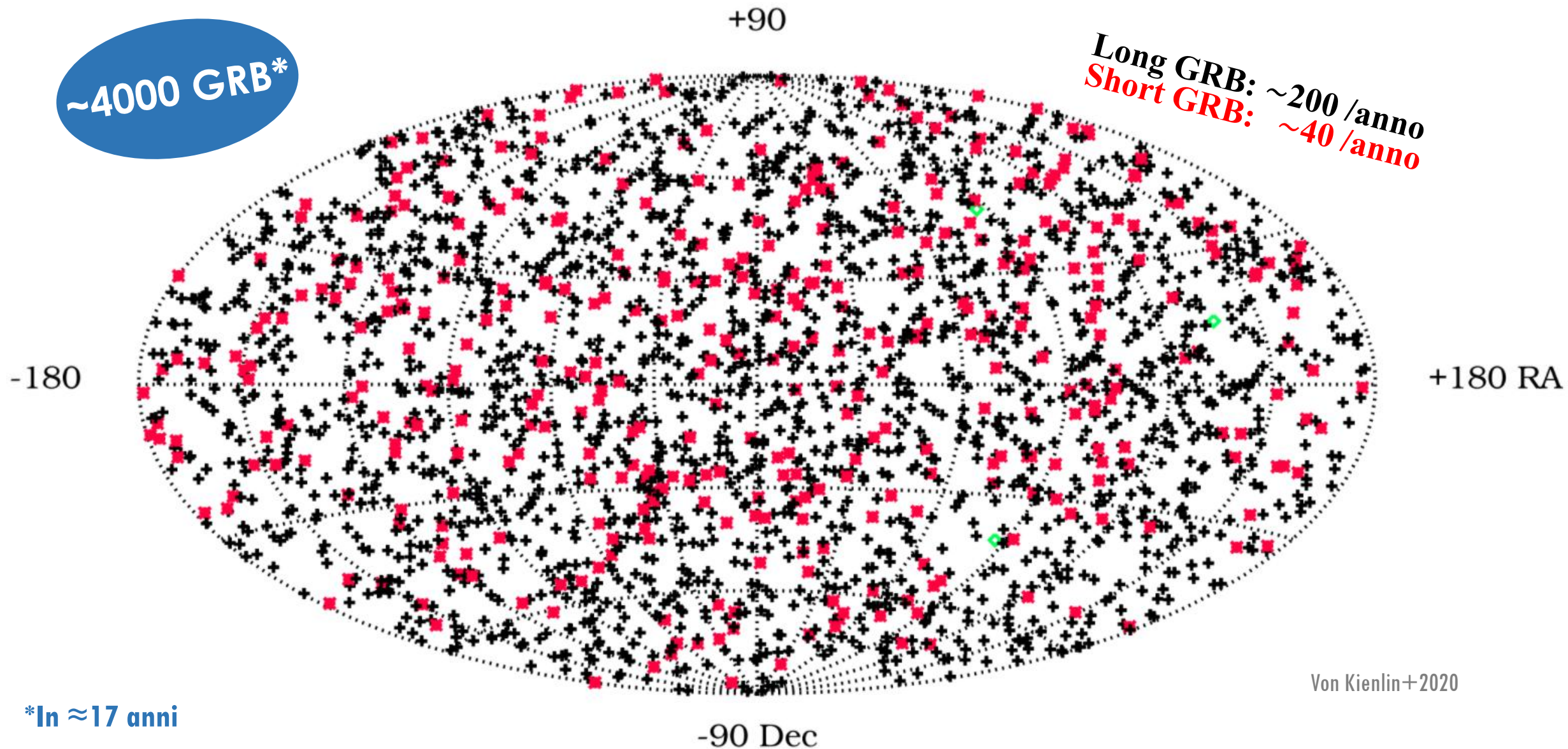
Emissione ritardata "AFTERGLOW"

L'origine degli elementi del Sistema Solare

1 H	big bang fusion 										cosmic ray fission 					2 He						
3 Li	4 Be	merging neutron stars 										exploding massive stars 					5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg	dying low mass stars 					exploding white dwarfs 					13 Al	14 Si	15 P	16 S	17 Cl	18 Ar					
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr					
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe					
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn					
87 Fr	88 Ra																					
			57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu					
			89 Ac	90 Th	91 Pa	92 U																

Il catalogo dei GRB osservati da Fermi-GBM

~4000 GRB*

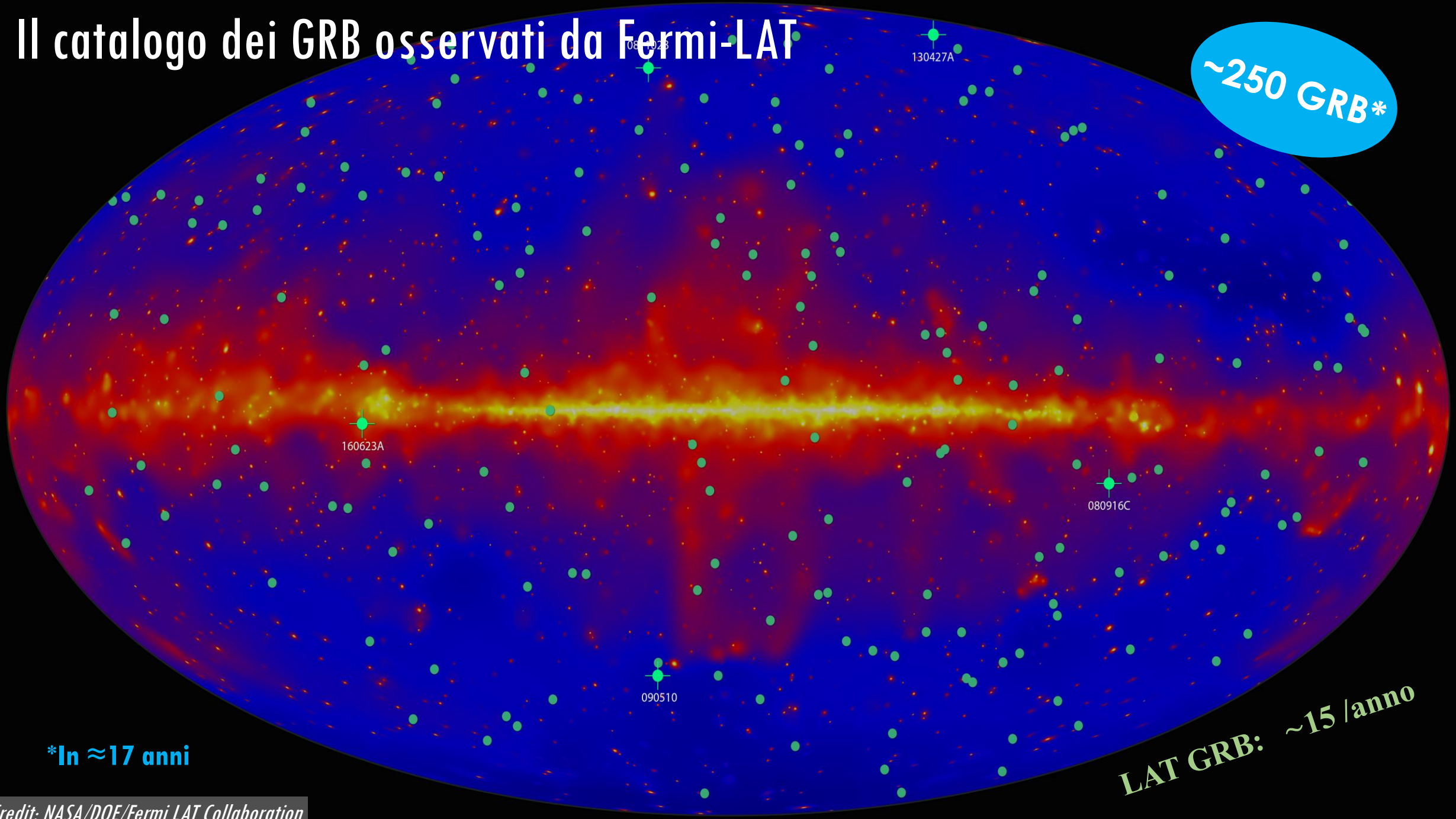


Von Kienlin+2020

*In ≈ 17 anni

Il catalogo dei GRB osservati da Fermi-LAT

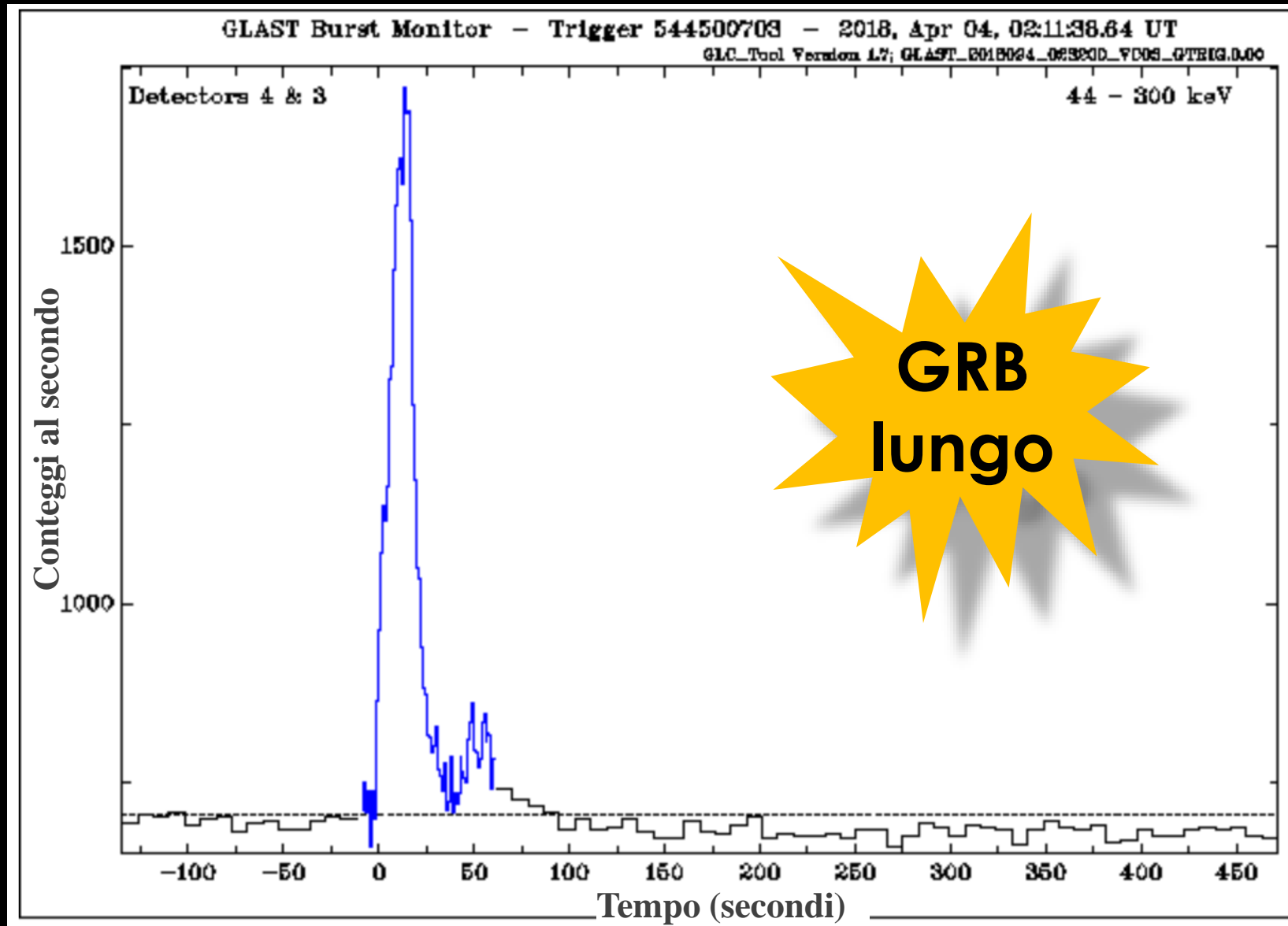
~250 GRB*



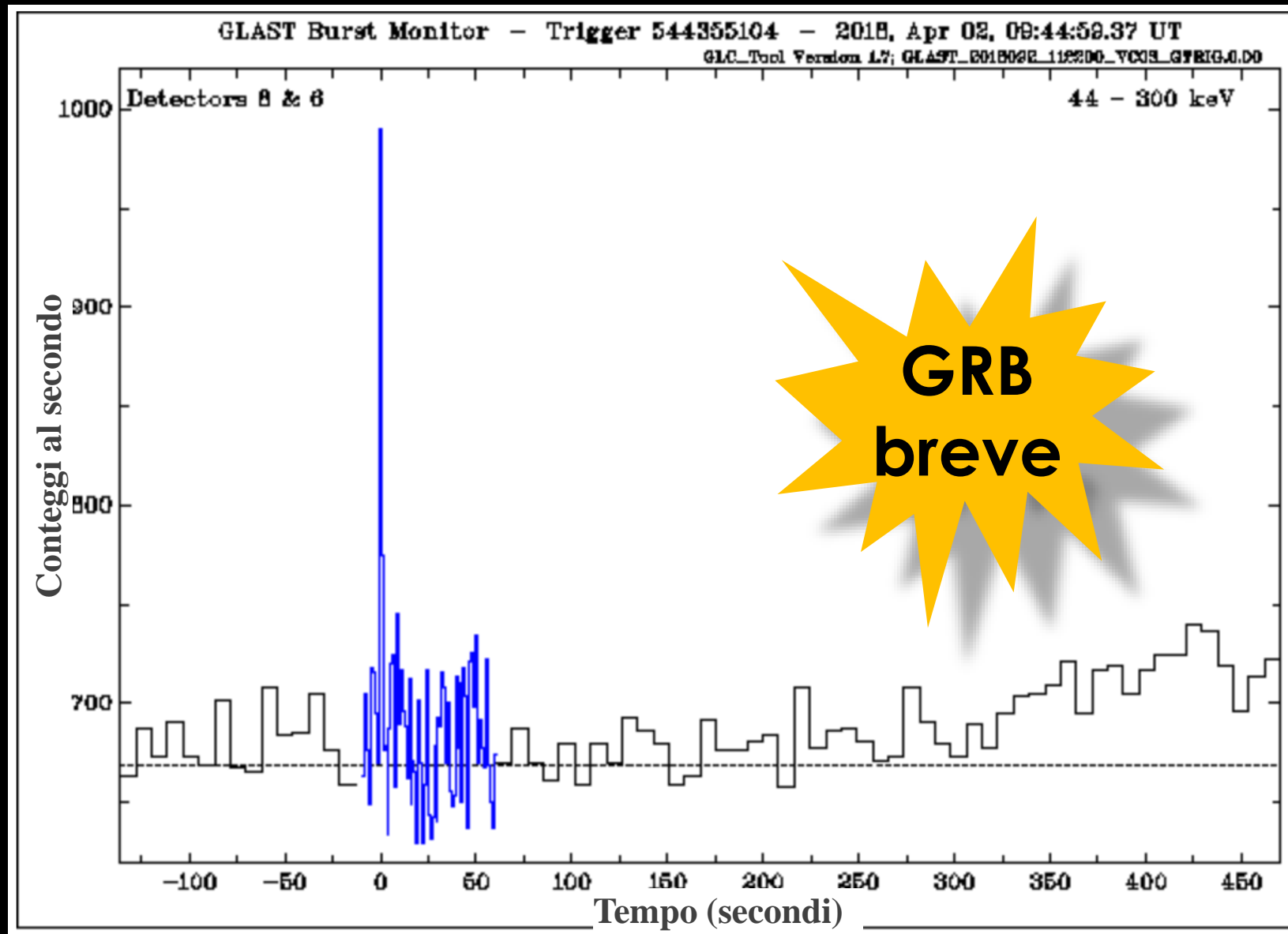
*In ≈ 17 anni

LAT GRB: ~ 15 /anno

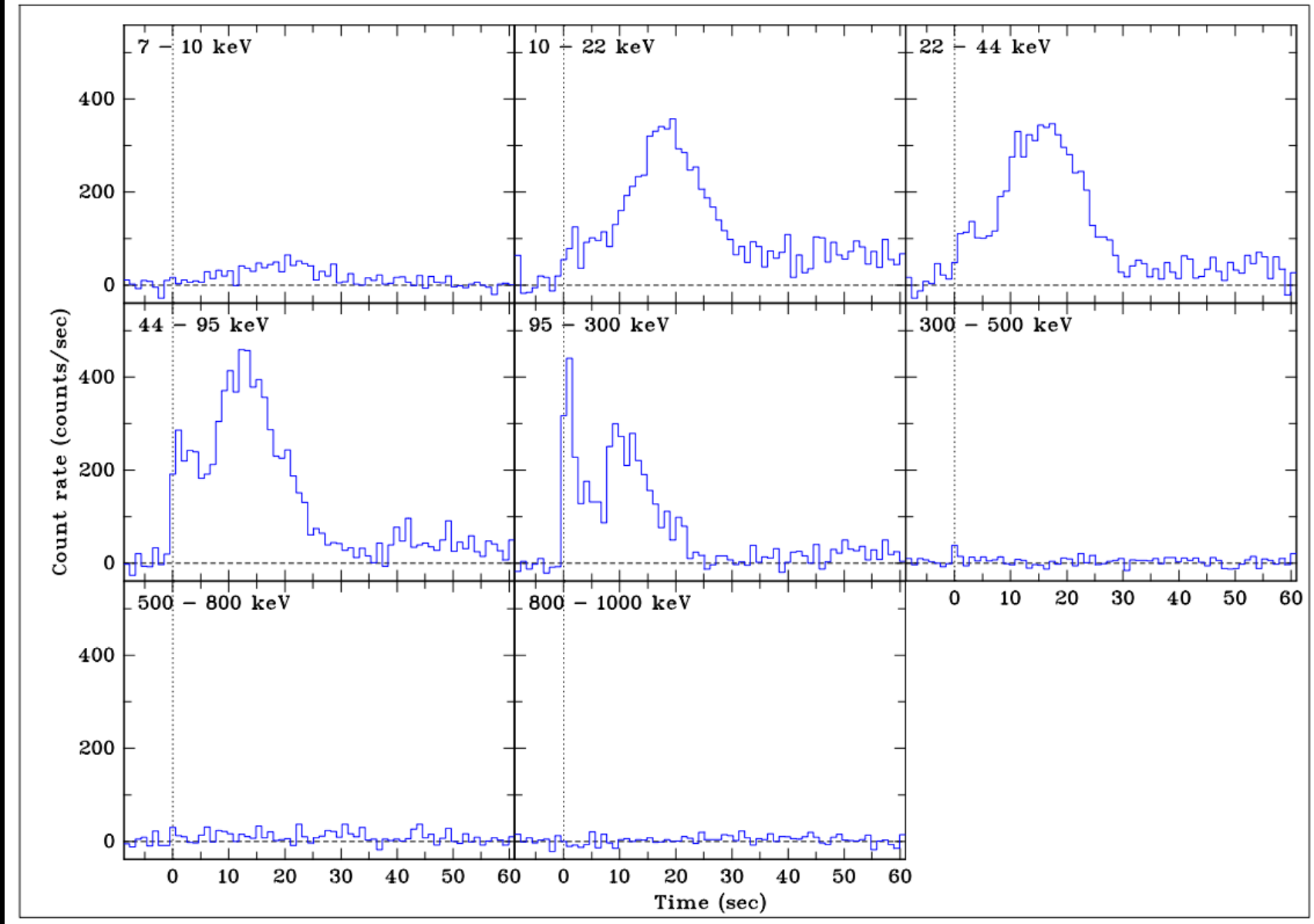
Come è fatto un GRB visto da Fermi-GBM?



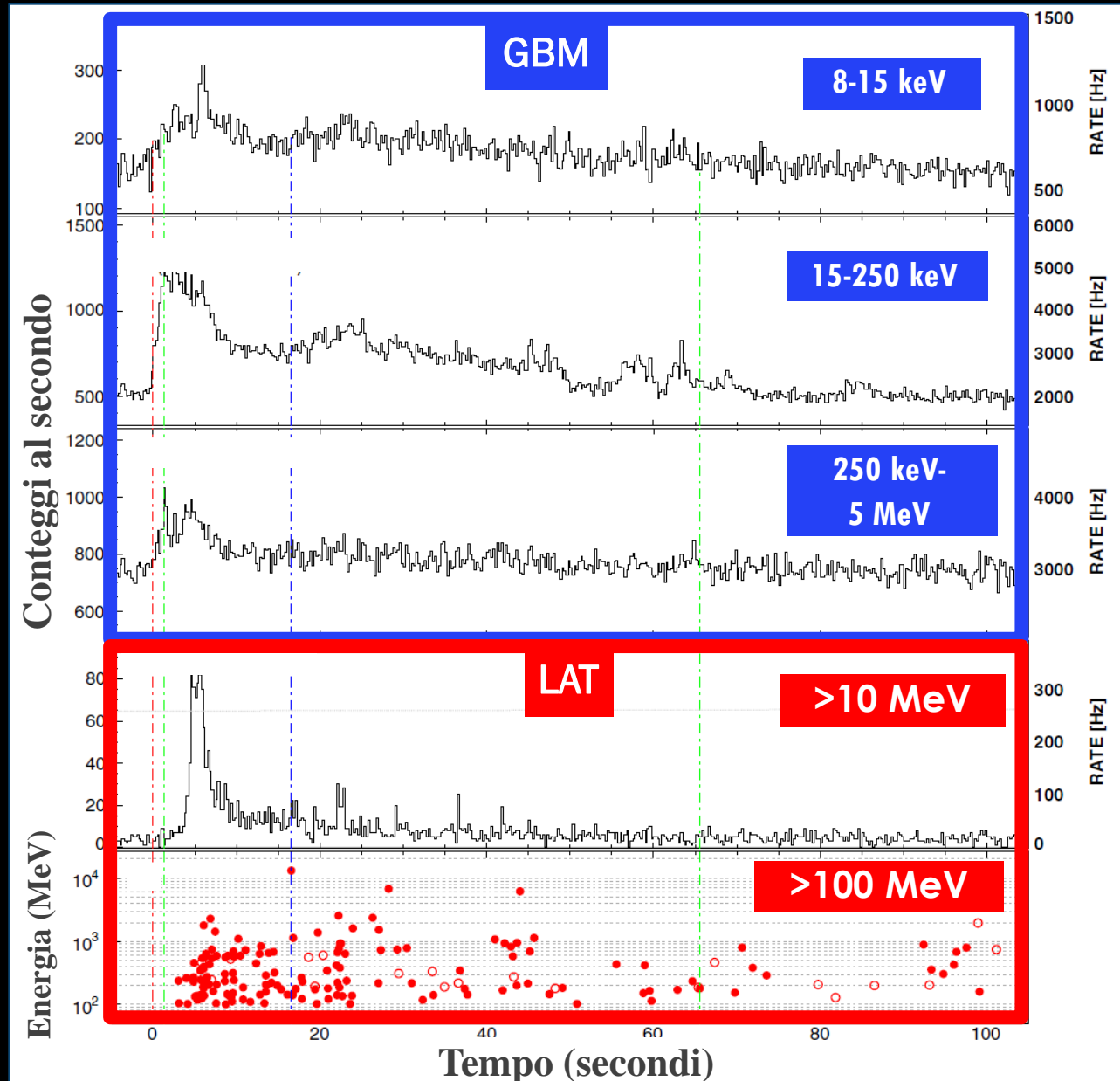
Come è fatto un GRB visto da Fermi-GBM?



La forma del GRB cambia al variare dell'energia!



GRB 080916C osservato sia da Fermi-GBM che da Fermi-LAT

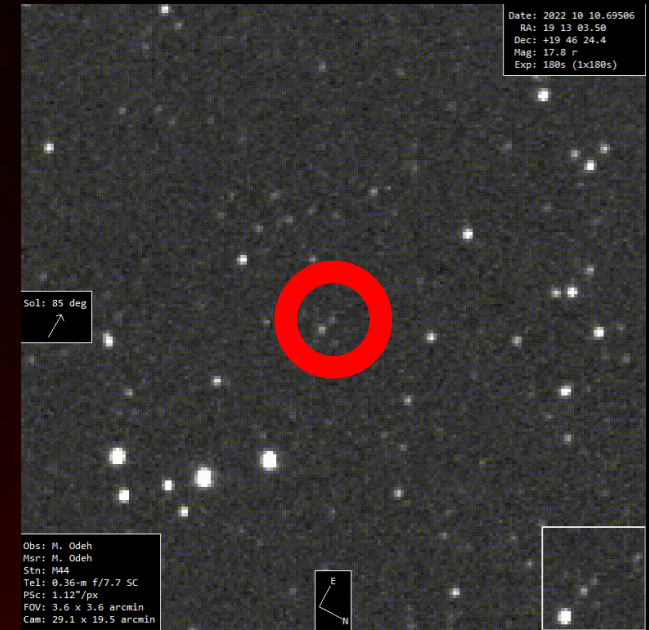
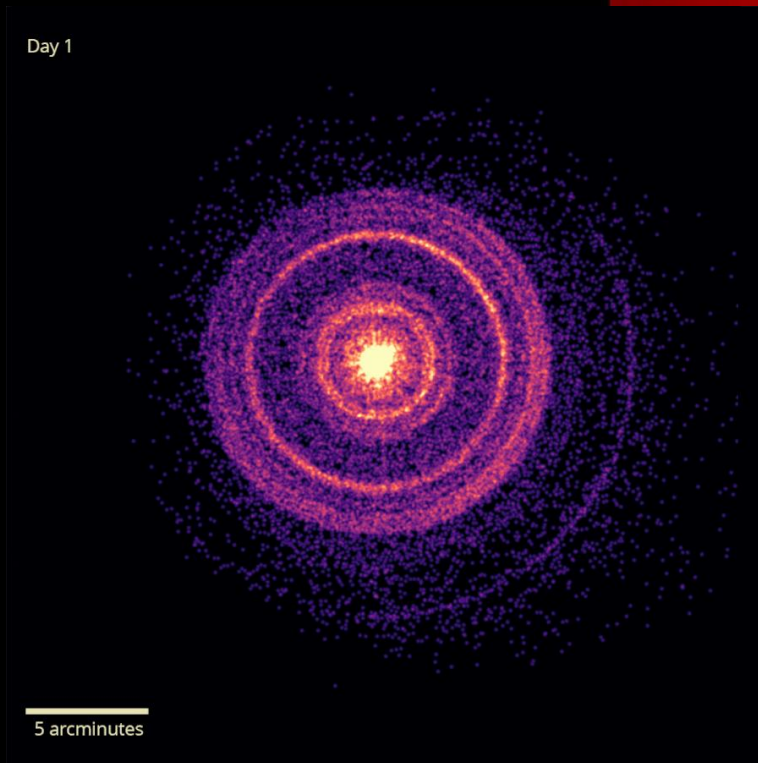


«BOAT» GRB 221009A

Brightest of All Times

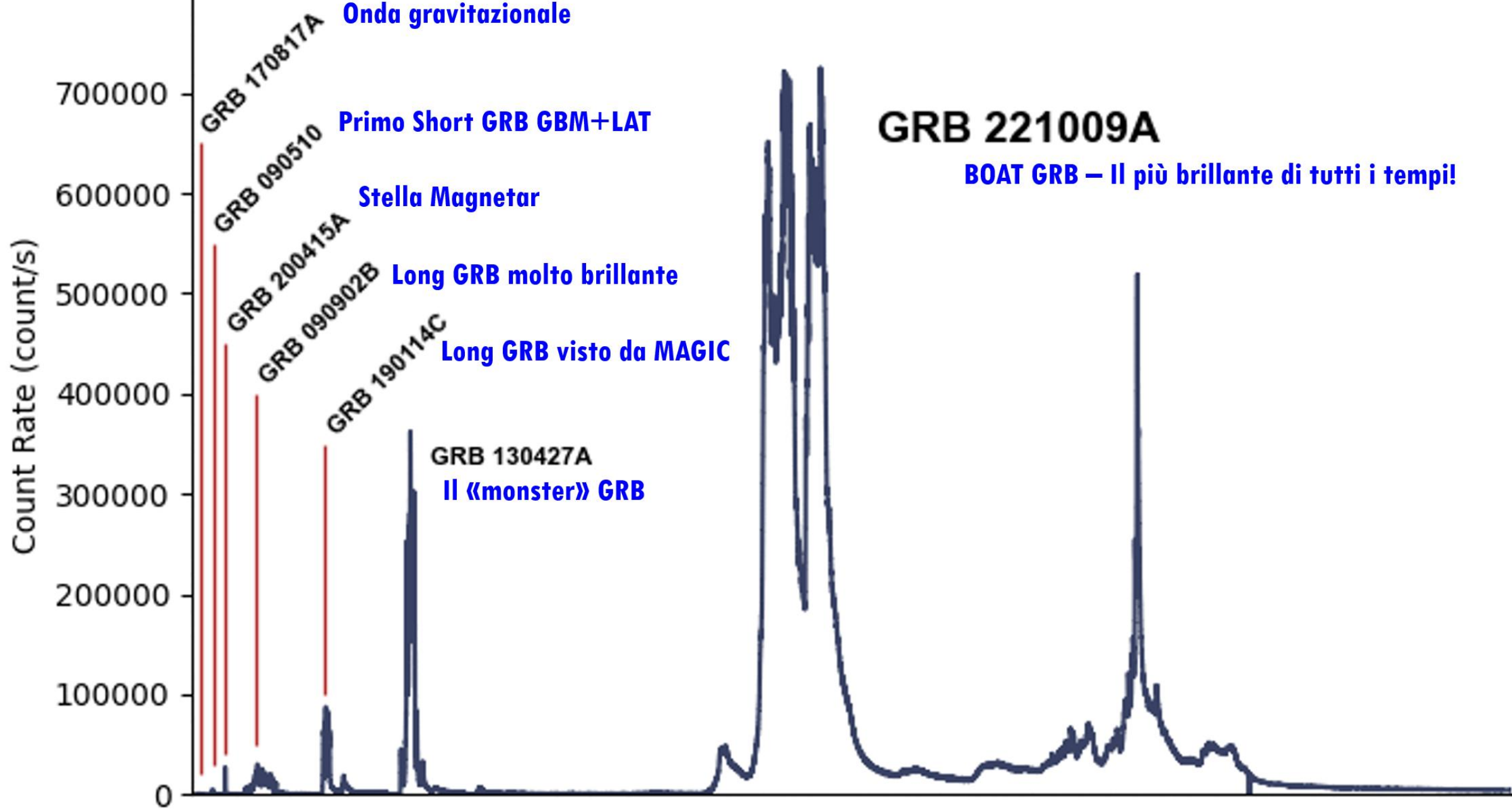
Astronomy Picture of the Day

15 Ottobre 2022

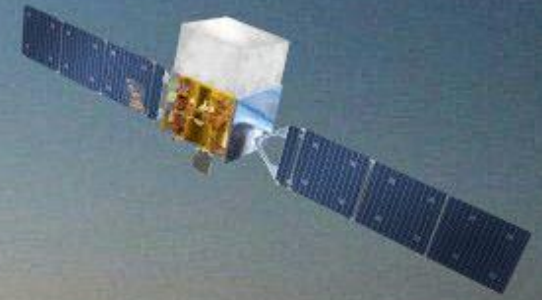


https://apod.nasa.gov/apod/ap221015.html?fbclid=IwAR0dtOruG18ZOg9a-AhjcLkfPfvsoK_C5Dvn-sjK7YpBQB5Pt_g_RShYsUE

Image Credit: NASA, DOE, Fermi LAT Collaboration, R.Pillera



Grazie per l'attenzione



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