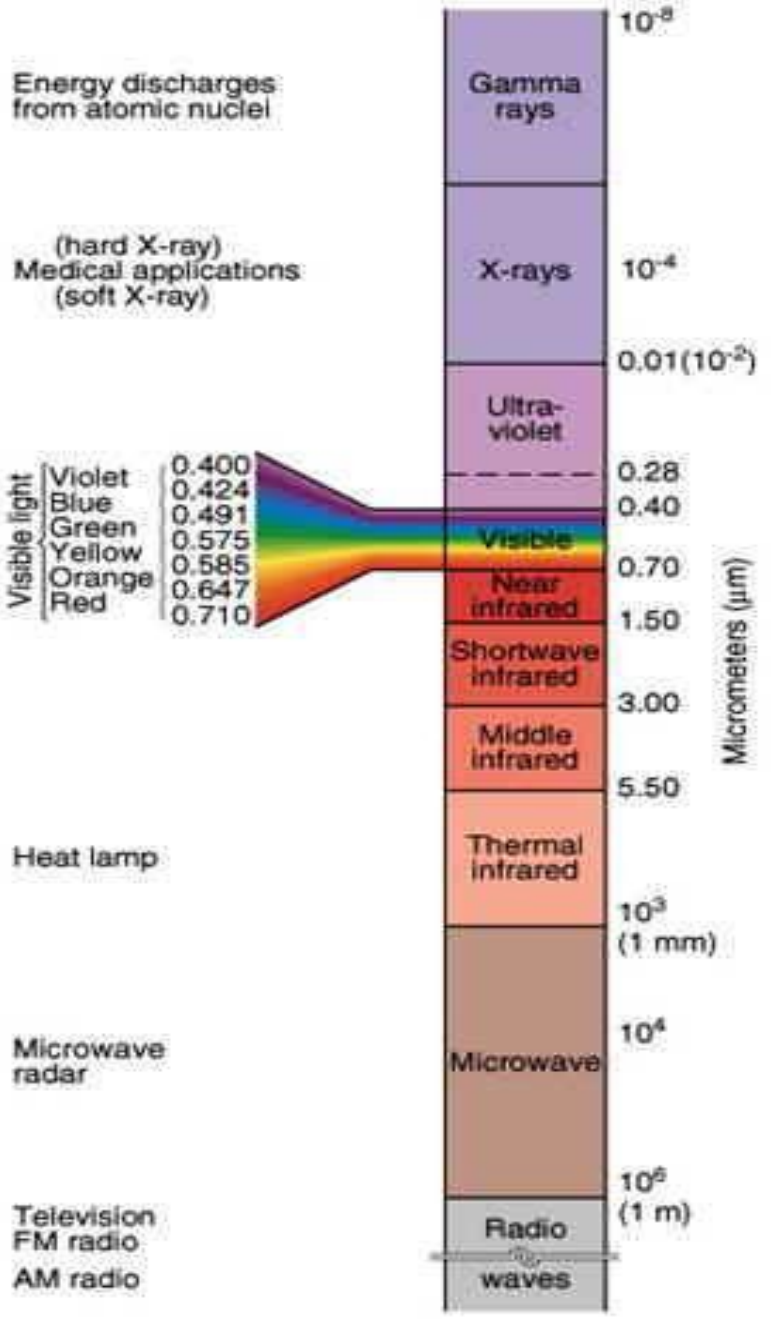
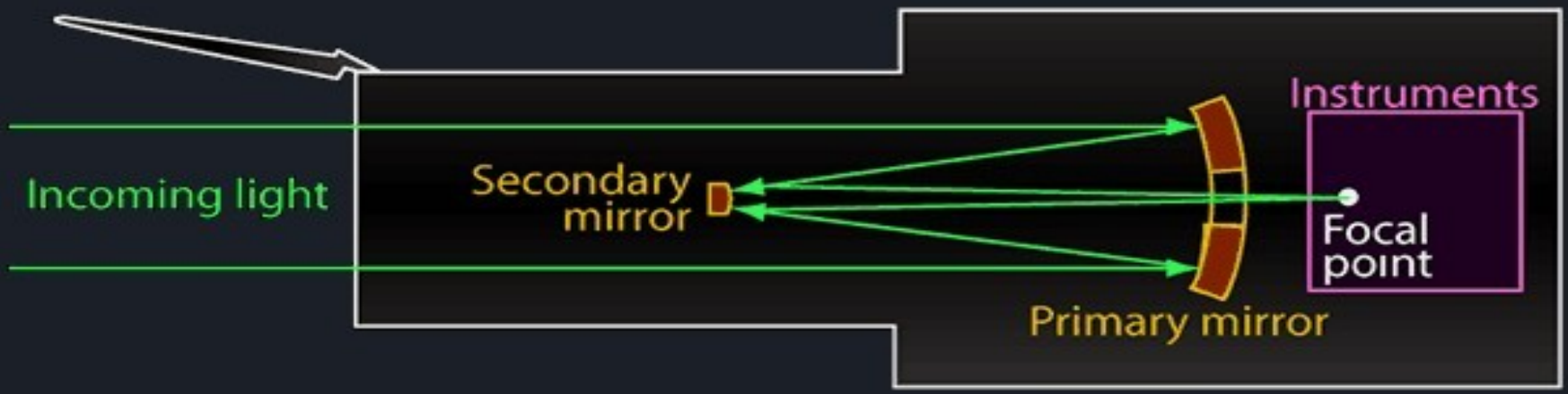
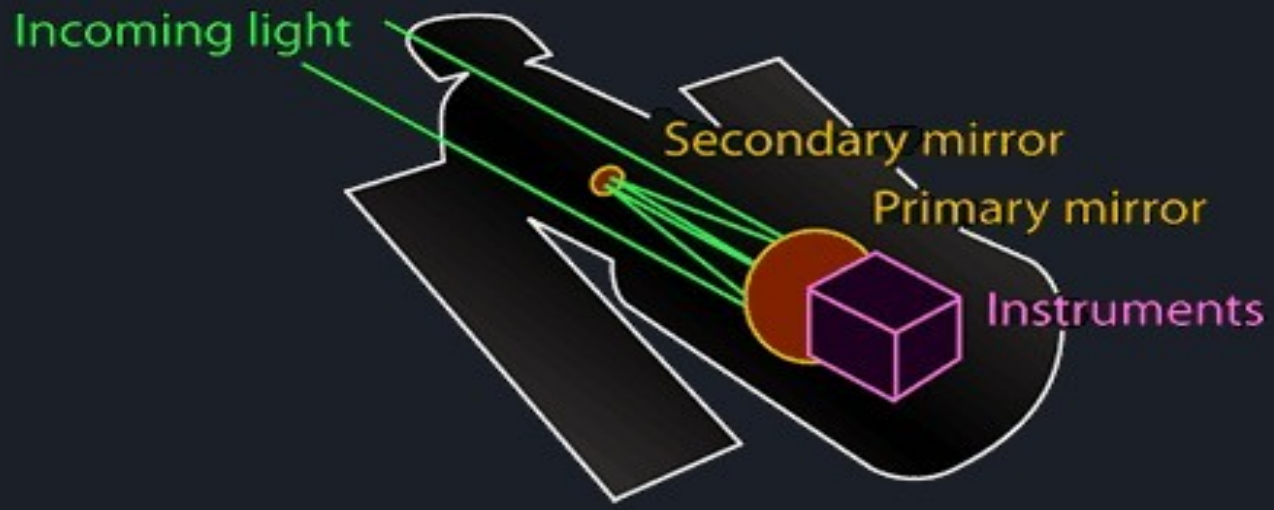
Astronomical instruments


Energy discharges from atomic nuclei
Gamma rays
10^{-5}
(hard X-ray)
Medical applications
(soft X-ray)
X-rays
10^{-4}
0.01(10^{-2})
Ultra-violet
0.28
0.40
Visible light
Violet
Blue
Green
Yellow
Orange
Red
0.400
0.424
0.491
0.575
0.585
0.647
0.710
Visible
0.70
Near infrared
1.50
Shortwave infrared
3.00
Middle infrared
5.50
Micrometers (μm)
Heat lamp
Thermal infrared
10^{3}
(1 mm)
Microwave radar
Microwave
10^{4}
10^{5}
(1 m)
Television
FM radio
AM radio
Radio waves

Optical telescopes





When light strikes the concave primary mirror of the Hubble Space Telescope, it is reflected to the convex secondary mirror, then back through a hole in the center of the primary mirror. There, the light comes to the focal point and passes to one of Hubble's instruments. Telescopes of this design are called Cassegrain telescopes, after the person who designed the first one.

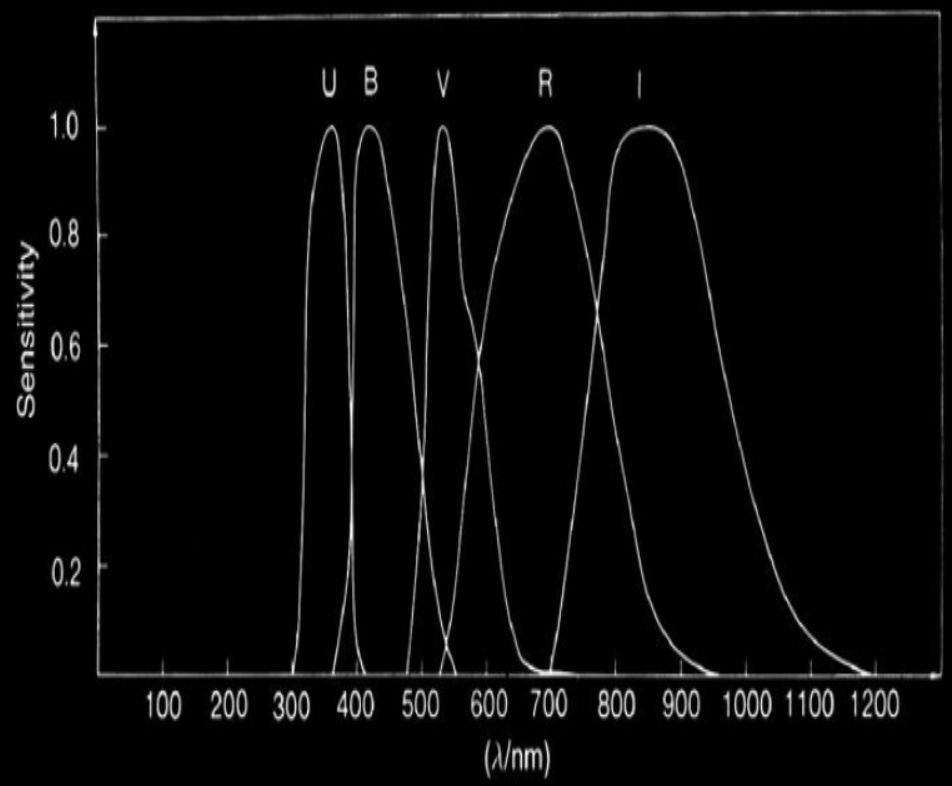
Fluxes in the optical and near infrared bands : Magnitudes

Apparent Magnitude :

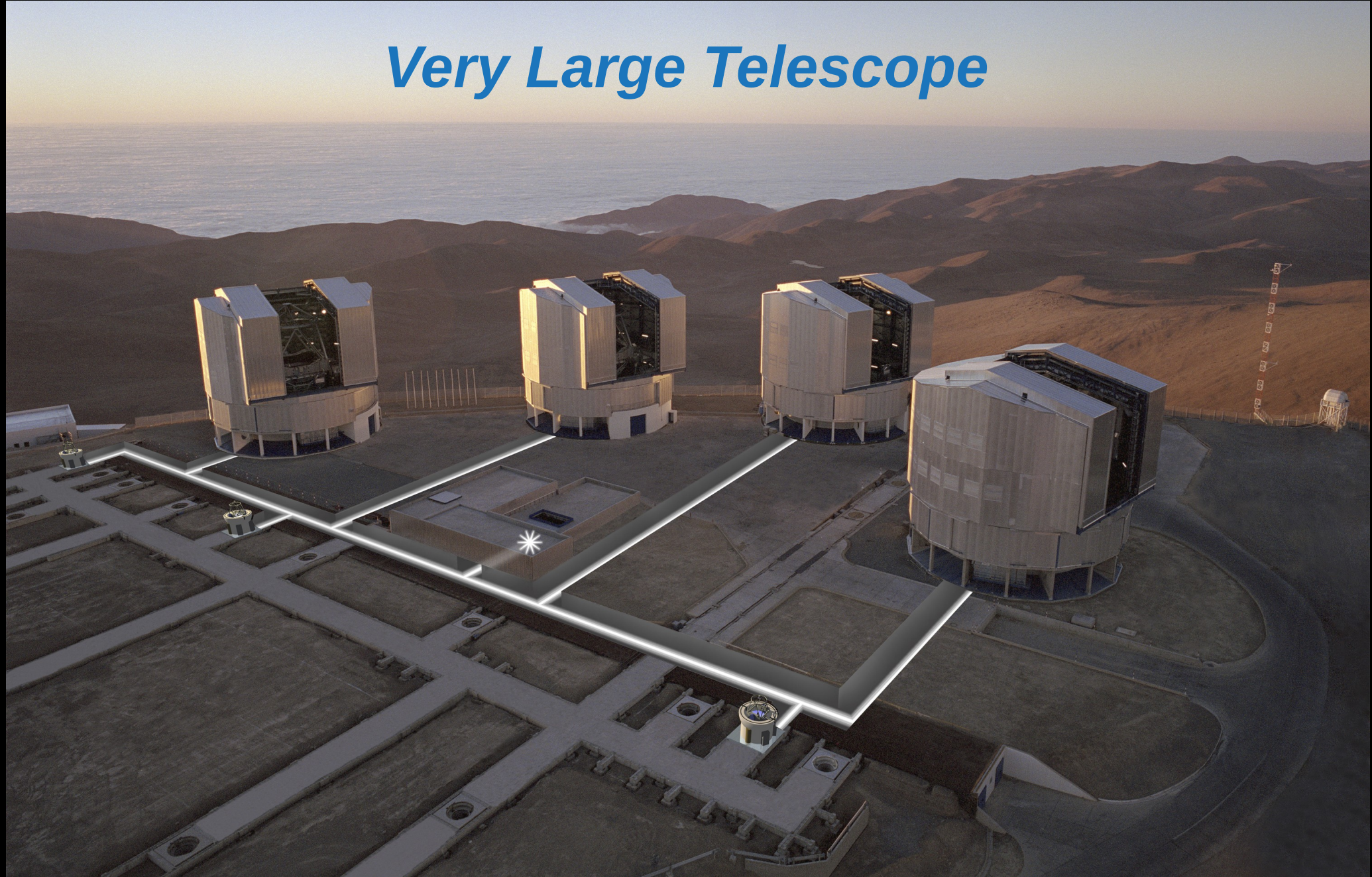
$$m - m_0 = -2.5\ Log_{10}(F/F_0)$$

Absolute Magnitude :

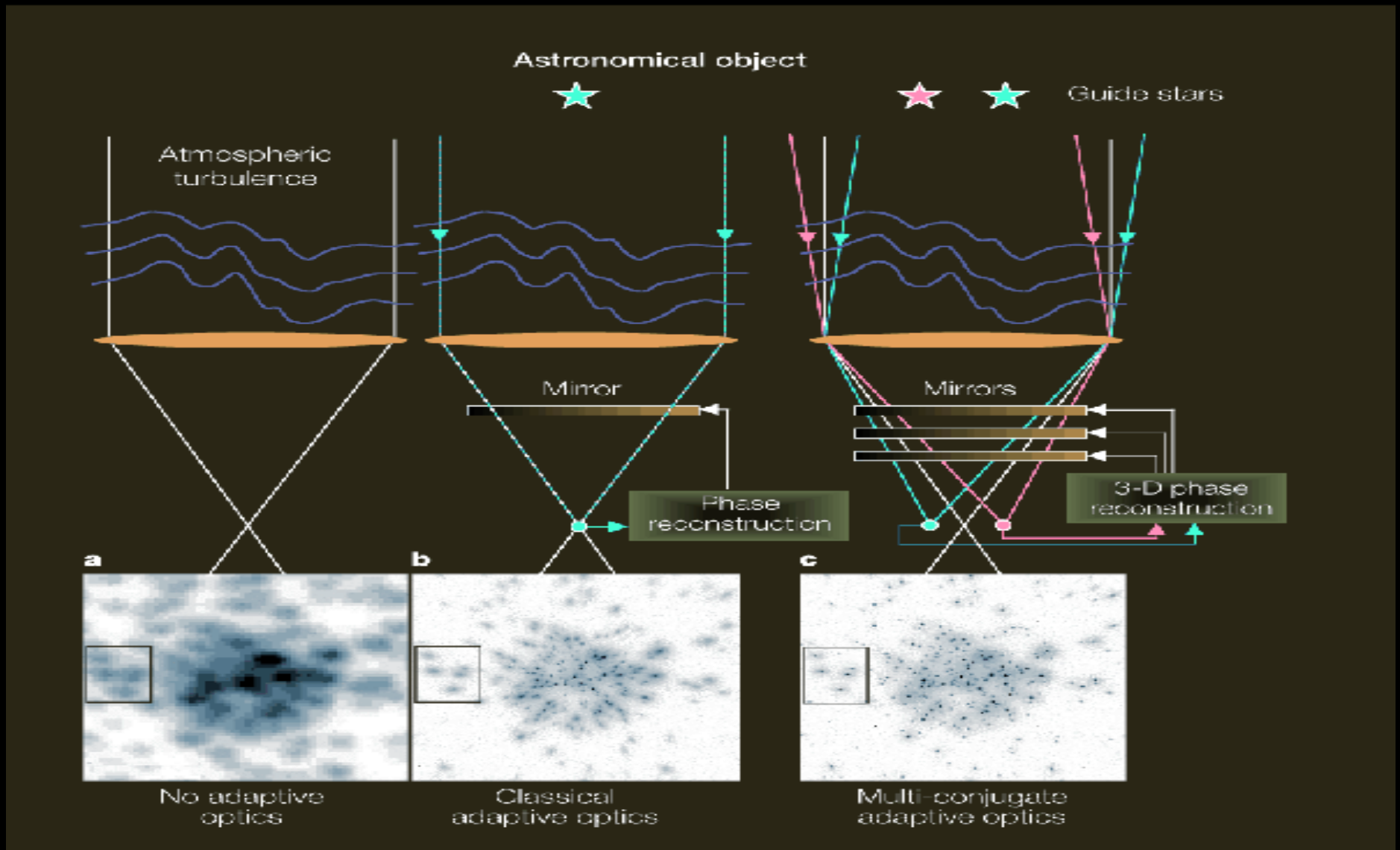
$$M = m - 5\ Log\frac{D}{10\ pc}$$



Very Large Telescope

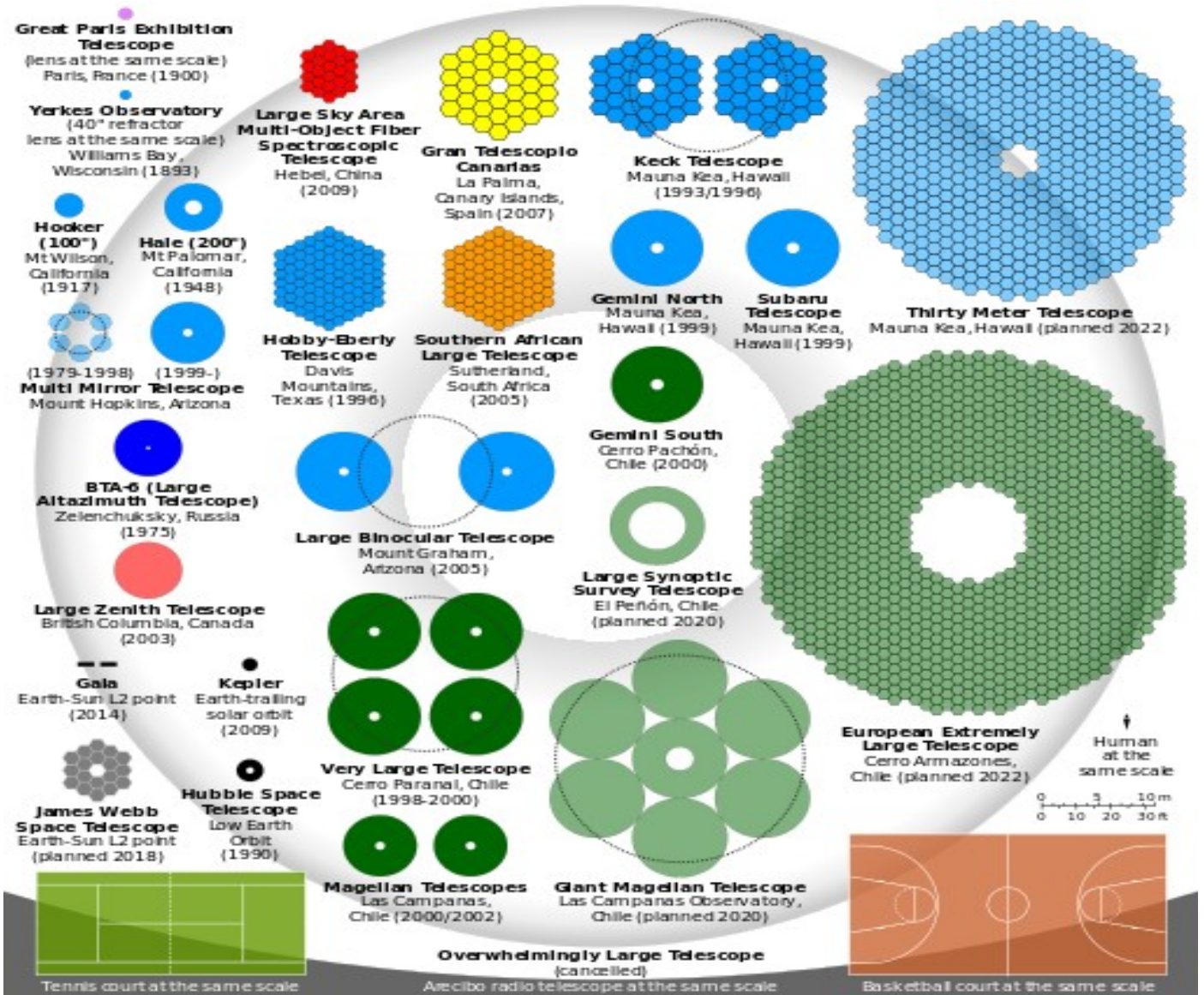


Adaptive optics

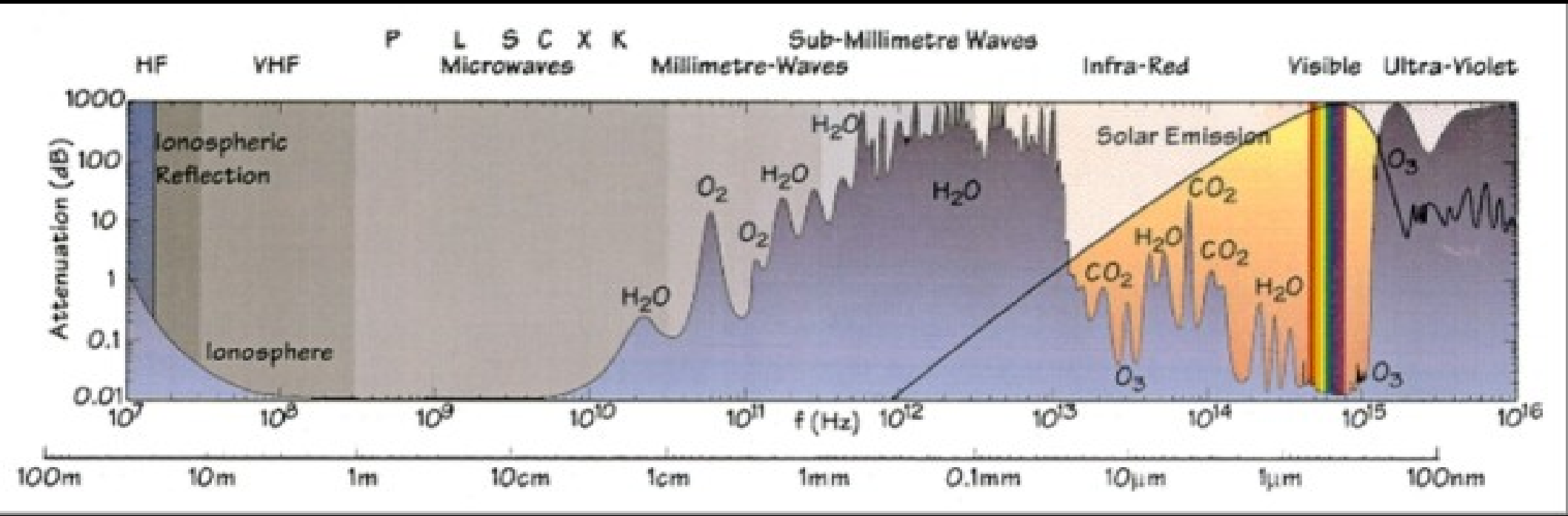


Extremely Large Telescope

Astronomical Mirrors



Atmosphere transparency




SOFIA
STRATOSPHERIC OBSERVATORY
FOR INFRARED ASTRONOMY
NASA
DLR
N747NA

OBSERVATORIO NOBEYAMA
1.350 mts. de altitud
Japón

VERY LARGE ARRAY (VLA)
2.124 mts. de altitud
EE.UU.

OBSERVATORIO LA SILLA
2.40 mts. de altitud
Chile

VERY LARGE TELESCOPE (VLT)
2.635 mts. de altitud
Chile

OBSERVATORIO KECK
4.145 mts. de altitud
EE.UU.

OBSERVATORIO ALMA
5.000 mts. de altitud
Chile

ALMA as an Interferometer

66 antennas working as one radiotelescope.

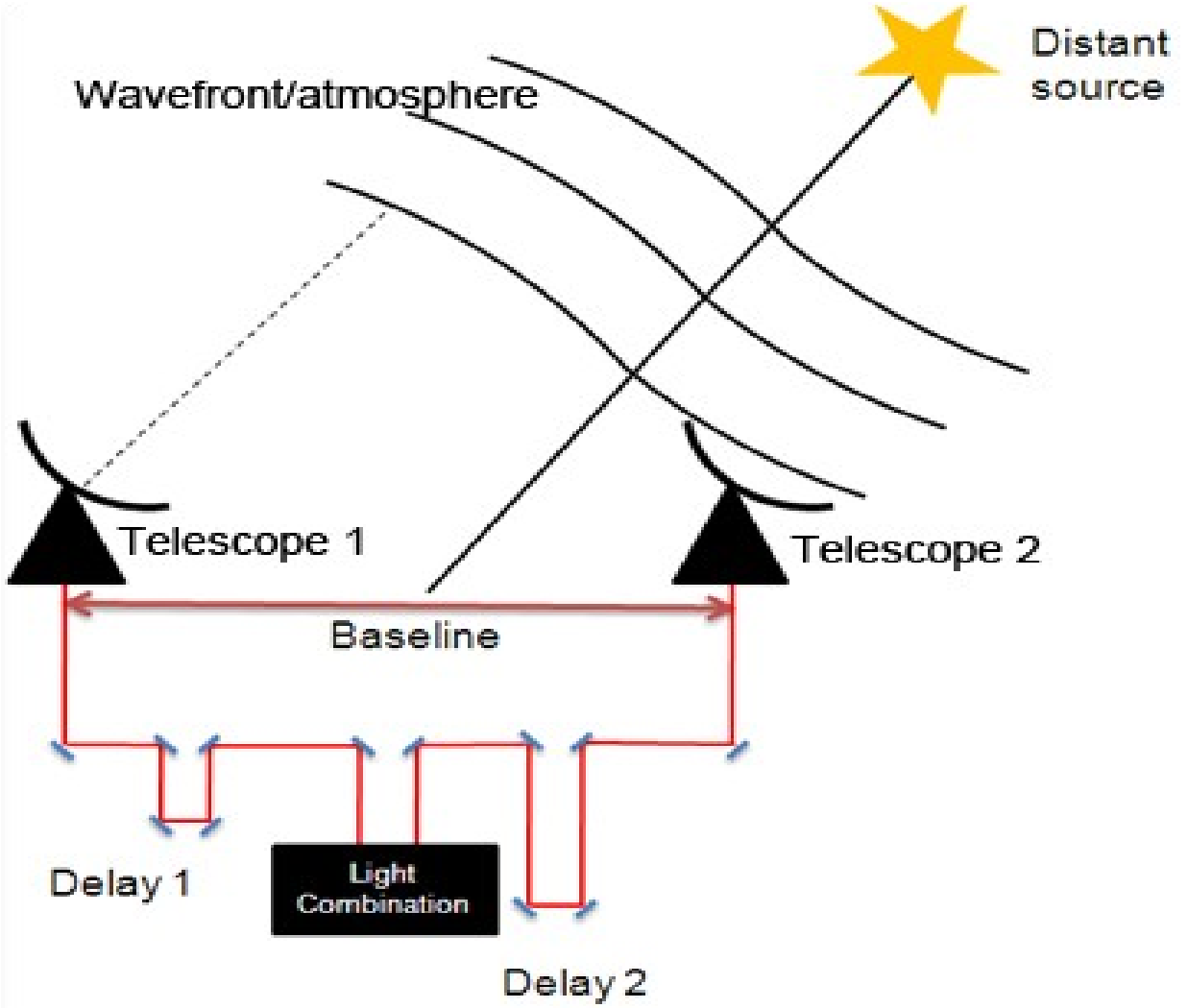
Is as if we had a 15km radiotelescope.

How interferometry works

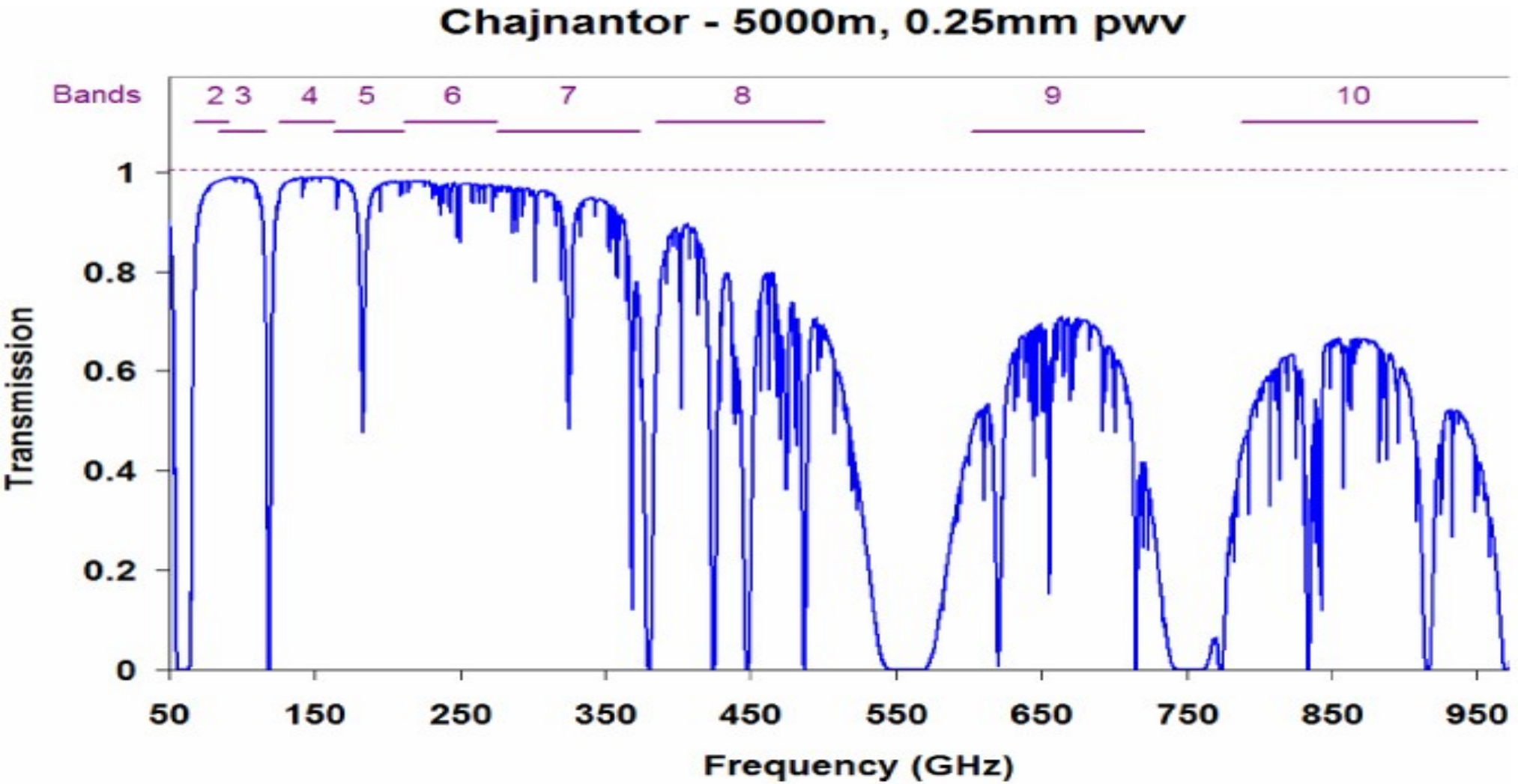
-

-

How interferometry works



ALMA bands


Chajnantor - 5000m, 0.25mm pwv
Bands
2 3
4
5
6
7
8
9
10
Transmission
1
0.8
0.6
0.4
0.2
0
50
150
250
350
450
550
650
750
850
950
Frequency (GHz)

Main molecules per band

ALMA Band	Frequency (GHz)	Main Lines
1	31 - 45	
2	67 - 90	
3	84 - 116	CO(1-0)
4	125 - 163	H_2O
5	163 - 211	
6	211 - 275	CO (2-1)
7	275 - 373	CO (3-2), [CII] z=5
8	385 - 500	CO (4-3), [CII] z=3
9	602 - 720	CO (6-5), [CII] z=2
10	787 - 950	CO (7-6), CO (8-7)

Quick Picker

- [x] CO v = 0
- [x] ^{13}CO v = 0
- [x] C^{17}O
- [x] C^{18}O
- [ ] CH_3OH v_t = 0
- [x] H_2CO
- [ ] HCN v = 0
- [ ] HNC v = 0
- [ ] H^{13}CN v = 0
- [ ] HC^{15}N v = 0
- [ ] DCN v = 0
- [ ] HCO^+ v = 0
- [x] CS
- [ ] H^{13}CO$^+$
- [x] NH_3
- [ ] C I
- [ ] C II
- [ ] O I
- [ ] O III
- [ ] N II
- [ ] H_2O v = 0
- [ ] HDO
- [x] SiO v = 0

splatalogue

database for astronomical spectroscopy

Search:

Telescope Bands: Any / ALMA Band 3 (84–116 GHz) / ALMA Band 4 (125–163 GHz) / ALMA Band 5 (163–211 GHz)

Redshift:

Energy Range: Min Max (E_L (cm^{-1}) / E_L (K))

Frequency Range: Frequency Unit: GHz

Min Max

+ Frequency − Frequency

Search

Astronomical Filters

(Double click to unselect)

- Top 20 list
- Planetary Atmosphere
- Hot Cores
- Dark Clouds
- Diffuse Clouds
- Comets
- AGB/PPN/PN
- Extragalactic

Scan to Mobile Splat

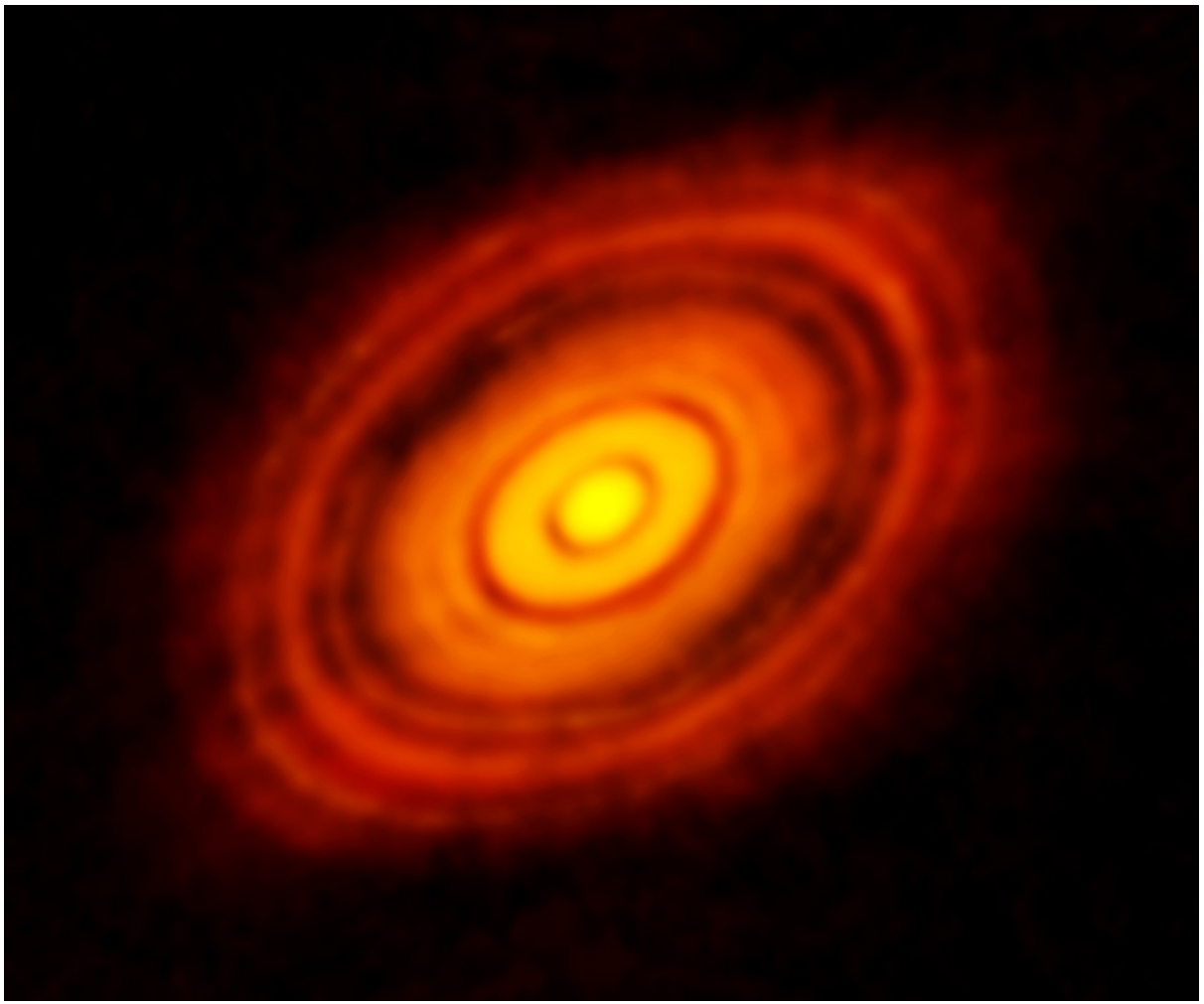
Found 15 lines in ALMA Band 3 (84-116 GHz), showing 1 - 15
Click on the chemical formula below for more information about that species.

	Species	Chemical Name	Ordered Freq (GHz) (rest frame, redshifted)	Resolved QNs	CDMS/JPL Intensity	Lovas/AST Intensity	E_L (cm^{-1})	E_L (K)	Linelist
1	H_2CO	Formaldehyde	85.31068, 85.31068	50(6,44)-50(6,45)	-11.01730		3390.2754	4877.8220	CDMS
2	SiO v = 0	Silicon Monoxide	86.84696, 86.84696	2- 1	-2.48320	1.5	1.4485	2.0841	CDMS
3	H_2CO	Formaldehyde	89.56506, 89.56506	13(2,11)-13(2,12)	-4.78500		253.2493	364.3672	CDMS
4	H_2CO	Formaldehyde	89.93780, 89.93780	45(2,43)-44(4,40)	-10.82770		2564.5250	3689.7582	CDMS
5	H_2CO	Formaldehyde	95.93231, 95.93231	31(4,27)-31(4,28)	-6.77550		1338.2468	1925.4276	CDMS
6	CS v = 0	Carbon Monosulfide	97.98095, 97.98095	2 - 1	0.00000	6.94	1.6340	2.3509	SLAIM
7	H_2CO	Formaldehyde	100.51110, 100.51110	22(3,19)-22(3,20)	-5.00180		689.1894	991.5841	CDMS
8	H_2CO	Formaldehyde	101.33299, 101.33299	6(1, 5)- 6(1, 6)	-4.04410	<0.1	57.4804	82.7010	CDMS
9	H_2CO	Formaldehyde	104.15793, 104.15793	41(5,36)-41(5,37)	-8.16510		2298.5855	3307.1328	CDMS
10	H_2CO	Formaldehyde	104.93181, 104.93181	51(6,45)-51(6,46)	-11.11150		3514.0612	5055.9211	CDMS
11	C^{18}O	Carbon Monoxide	109.78218, 109.78218	1- 0	0.00000	2.1	0.0000	0.0000	SLAIM
12	^{13}CO v = 0	Carbon Monoxide	110.20135, 110.20135	1-0	-5.06620	9.3	0.0000	0.0000	CDMS
13	H_2CO	Formaldehyde	110.93421, 110.93421	21(3,18)-22(1,21)	-6.30110		634.5972	913.0386	CDMS
14	C^{17}O	Carbon Monoxide	112.35928, 112.35928	J= 1- 0	0.00000	0.20	0.0000	0.0000	SLAIM
15	CO v = 0	Carbon Monoxide	115.27120, 115.27120	1- 0	0.00000	60.0	0.0000	0.0000	SLAIM

Found 15 lines in ALMA Band 3 (84-116 GHz), showing 1 - 15

ALMA discoveries

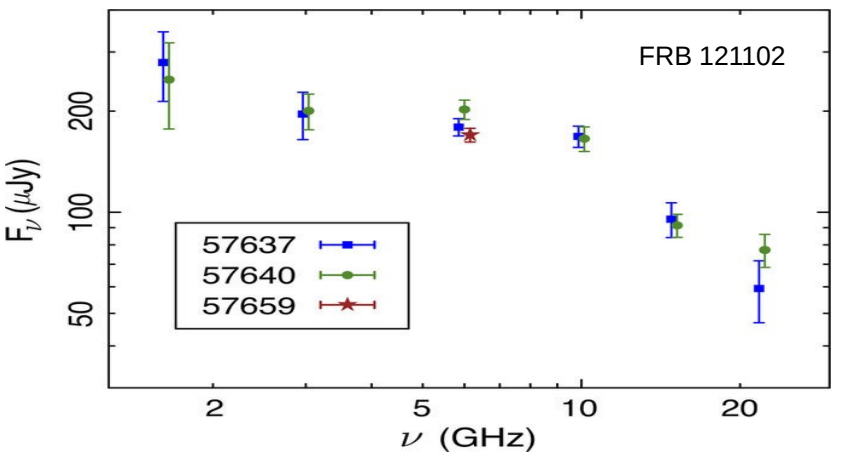
- The sharpest image ever taken by ALMA. It shows the protoplanetary disc surrounding the young star HL Tauri. These new ALMA observations reveal substructures within the disc that have never been seen before and even show the possible positions of planets forming in the dark patches within the system.



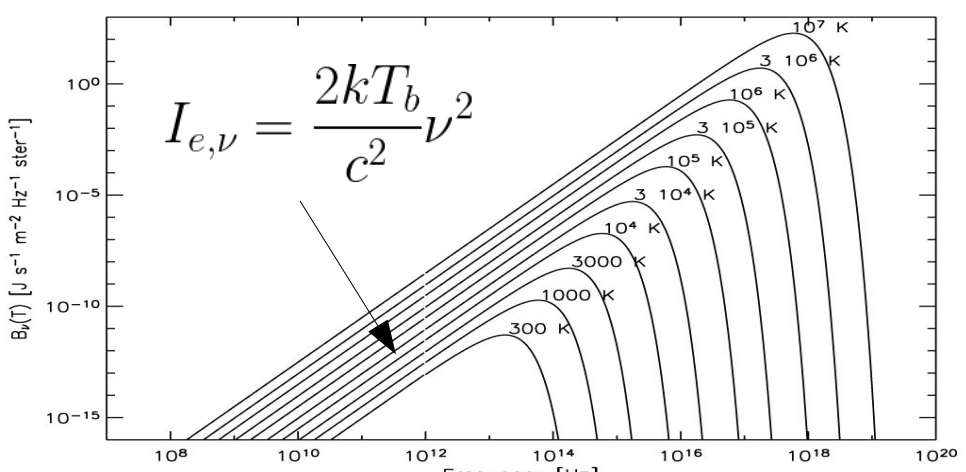
Fluxes in the Radio band

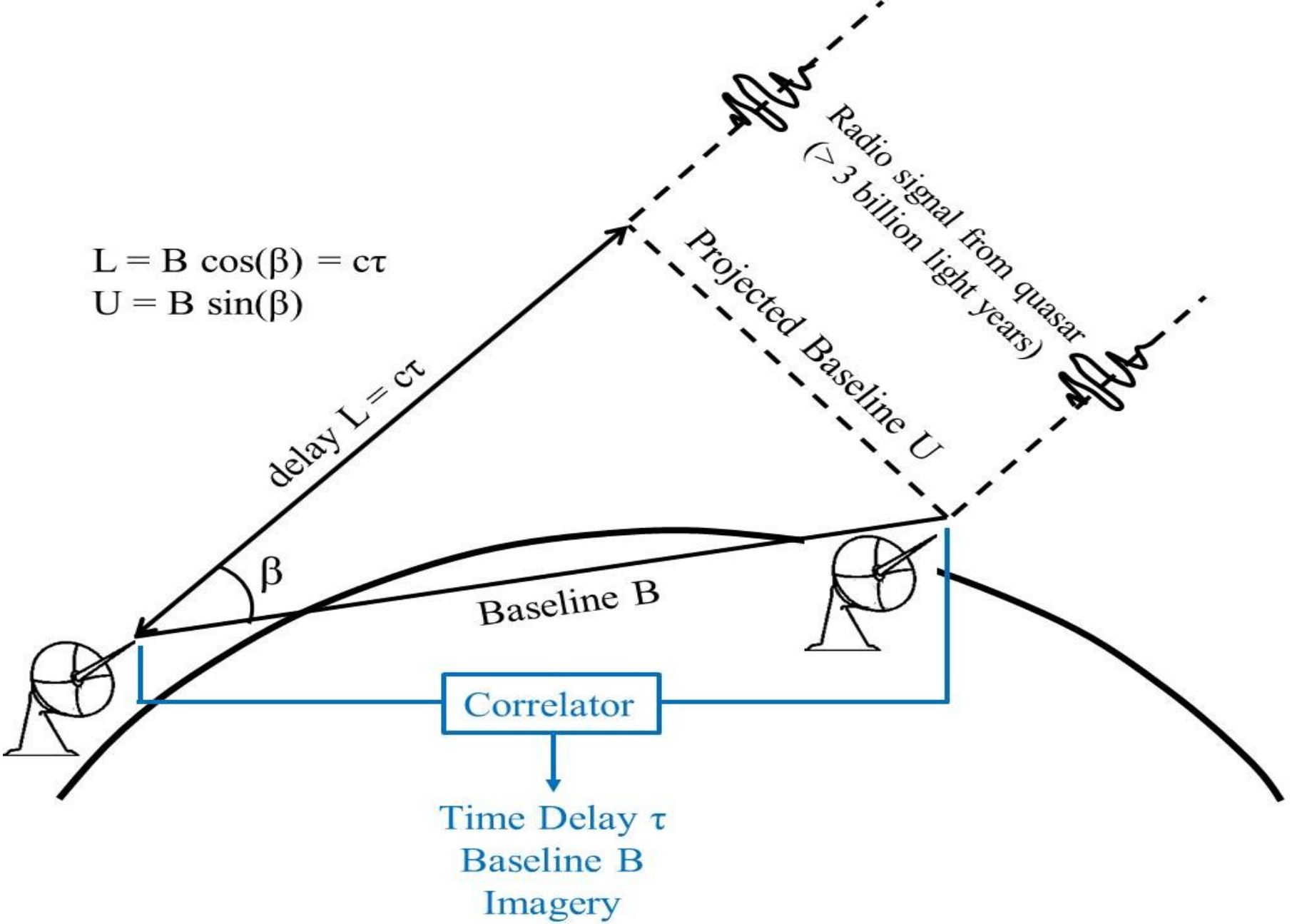
$$1\ Jy = 10^{-23}\ \mathrm{erg\ cm^{-2}s^{-1}Hz^{-1}}$$

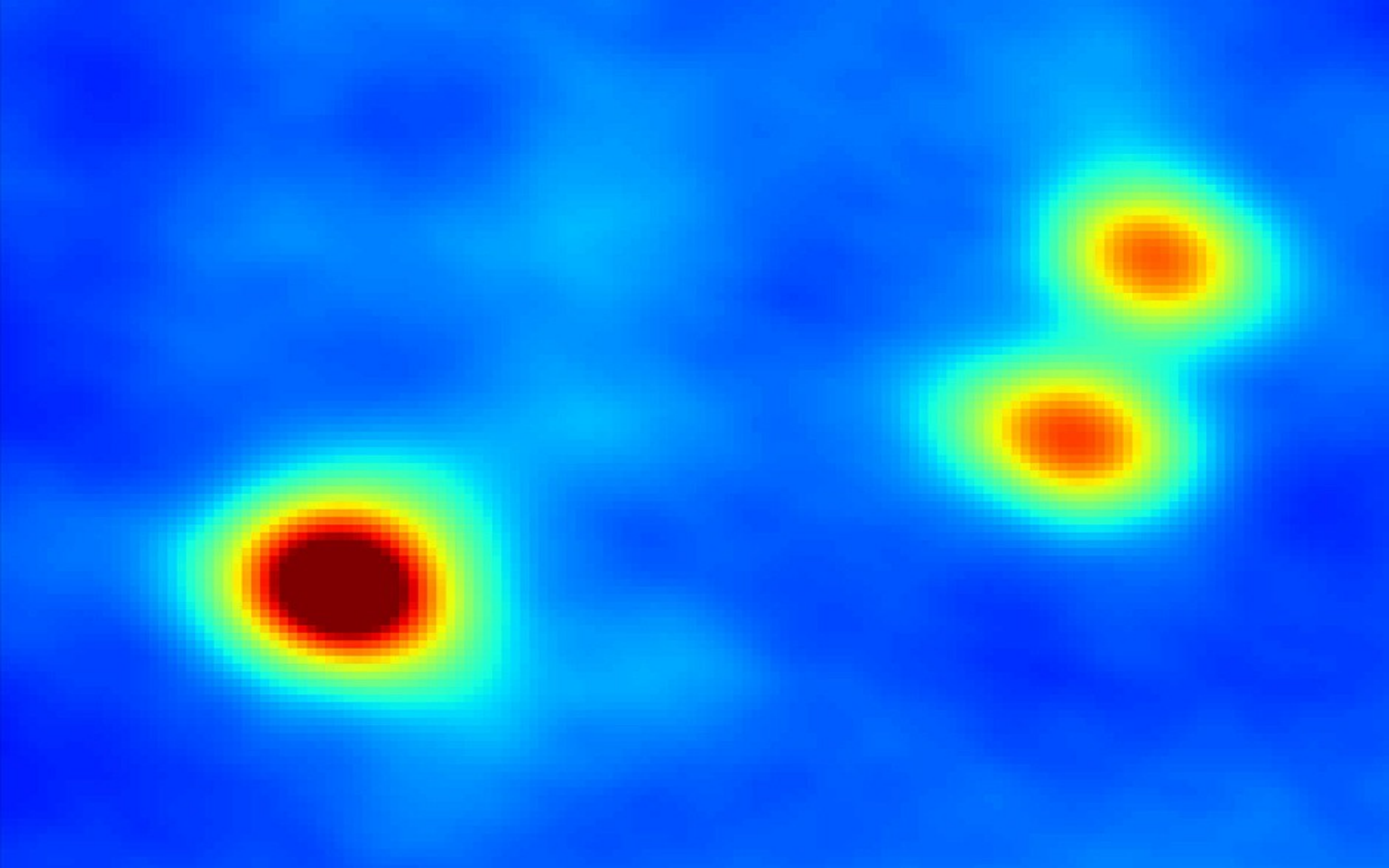
Nature volume 541, pages 58–61 (2017)

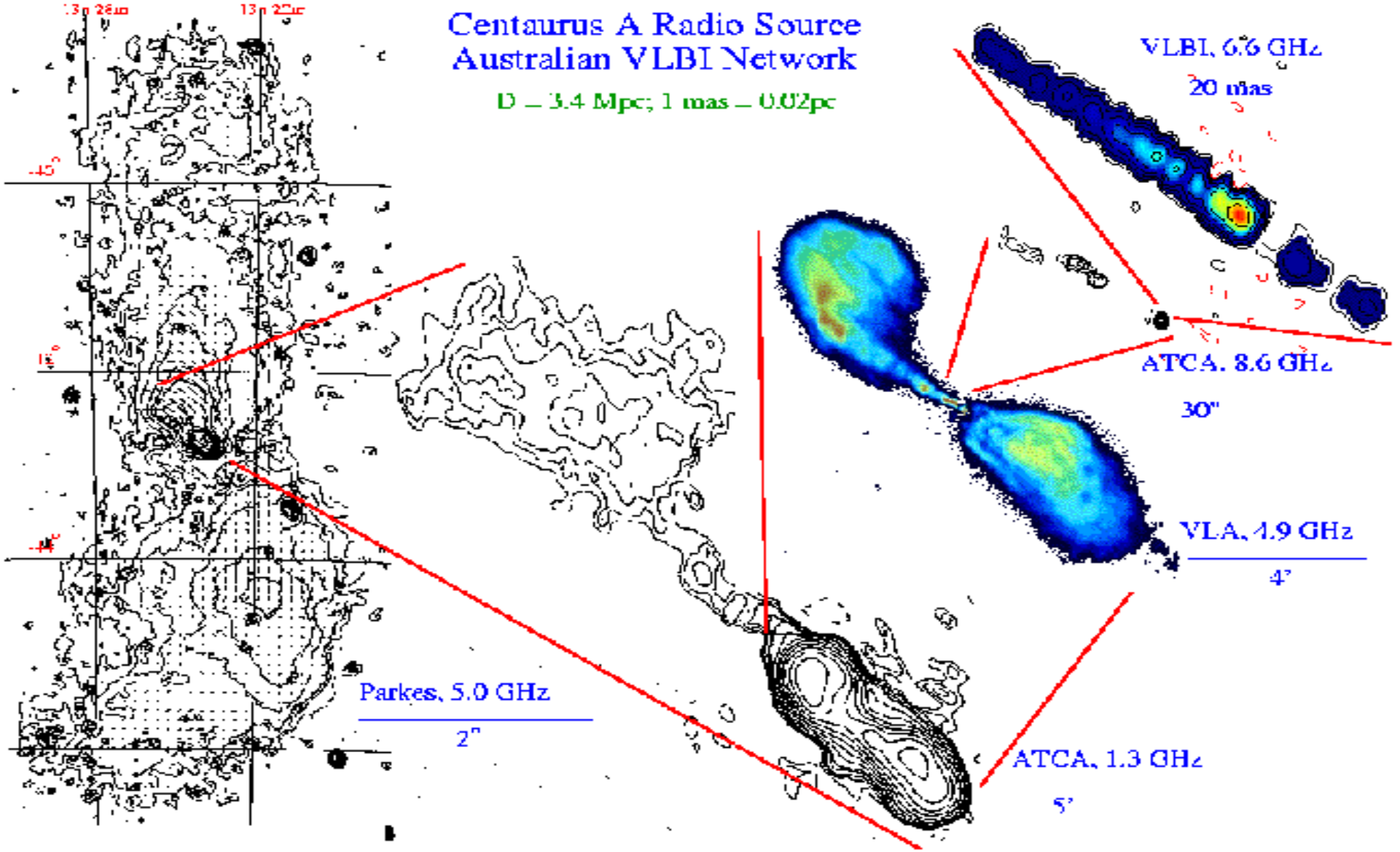


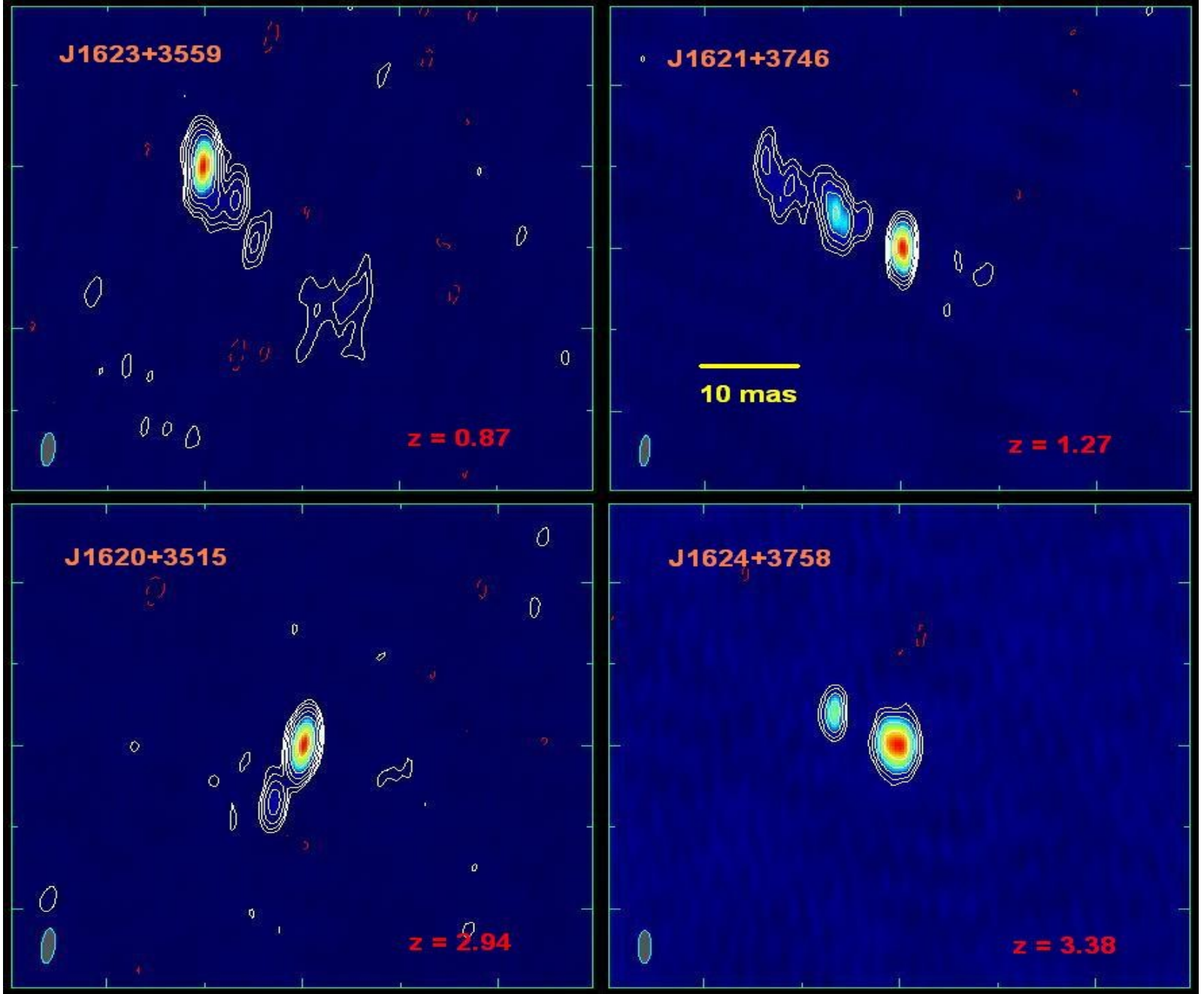
$$I_{e,\nu} = I_\nu h\nu = \frac{2h\nu^3}{c^2}\frac{1}{e^{\frac{h\nu}{kT_b}} - 1} \quad \left[\frac{erg}{cm^2 s\ sr Hz}\right]$$

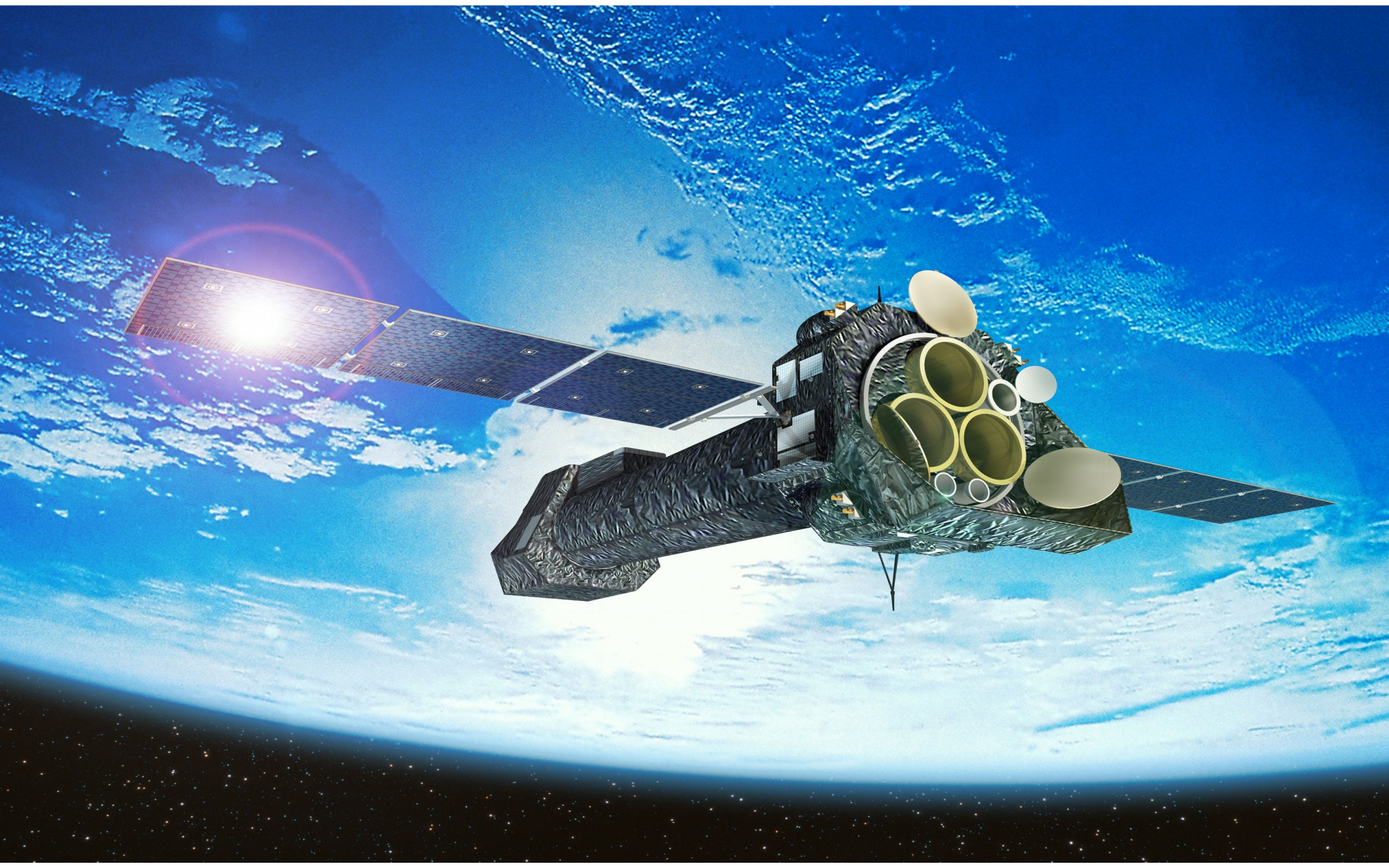


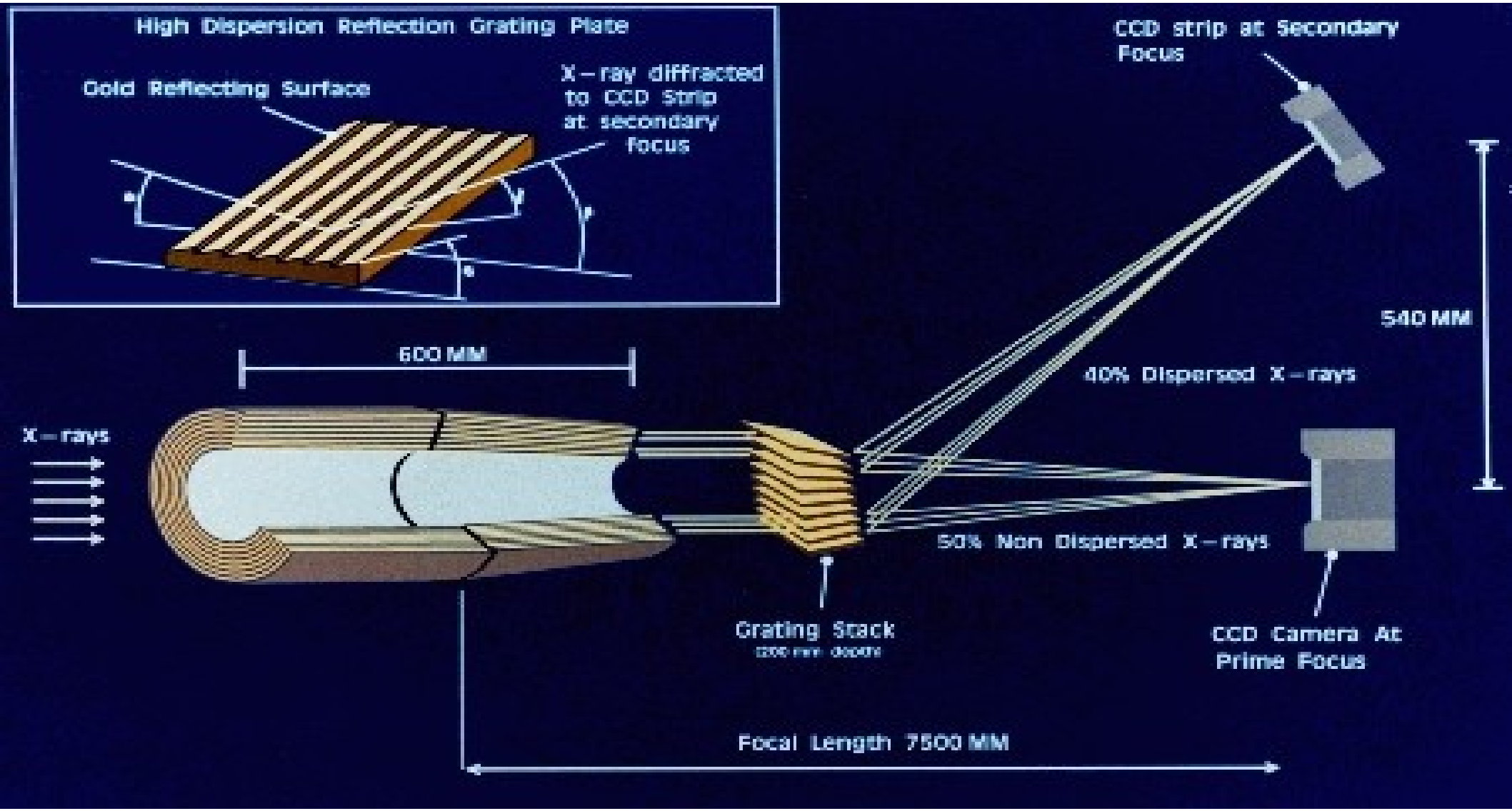

L = B cos(β) = cτ
U = B sin(β)
Radio signal from quasar
(> 3 billion light years)
Projected Baseline U
delay L = cτ
β
Baseline B
Correlator
Time Delay τ
Baseline B
Imagery




Centaurus A Radio Source
Australian VLBI Network
D = 3.4 Mpc; 1 mas = 0.02pc
VLBI, 6.6 GHz
20 mas
ATCA, 8.6 GHz
30"
VLA, 4.9 GHz
4'
Parkes, 5.0 GHz
2°
ATCA, 1.3 GHz
5'

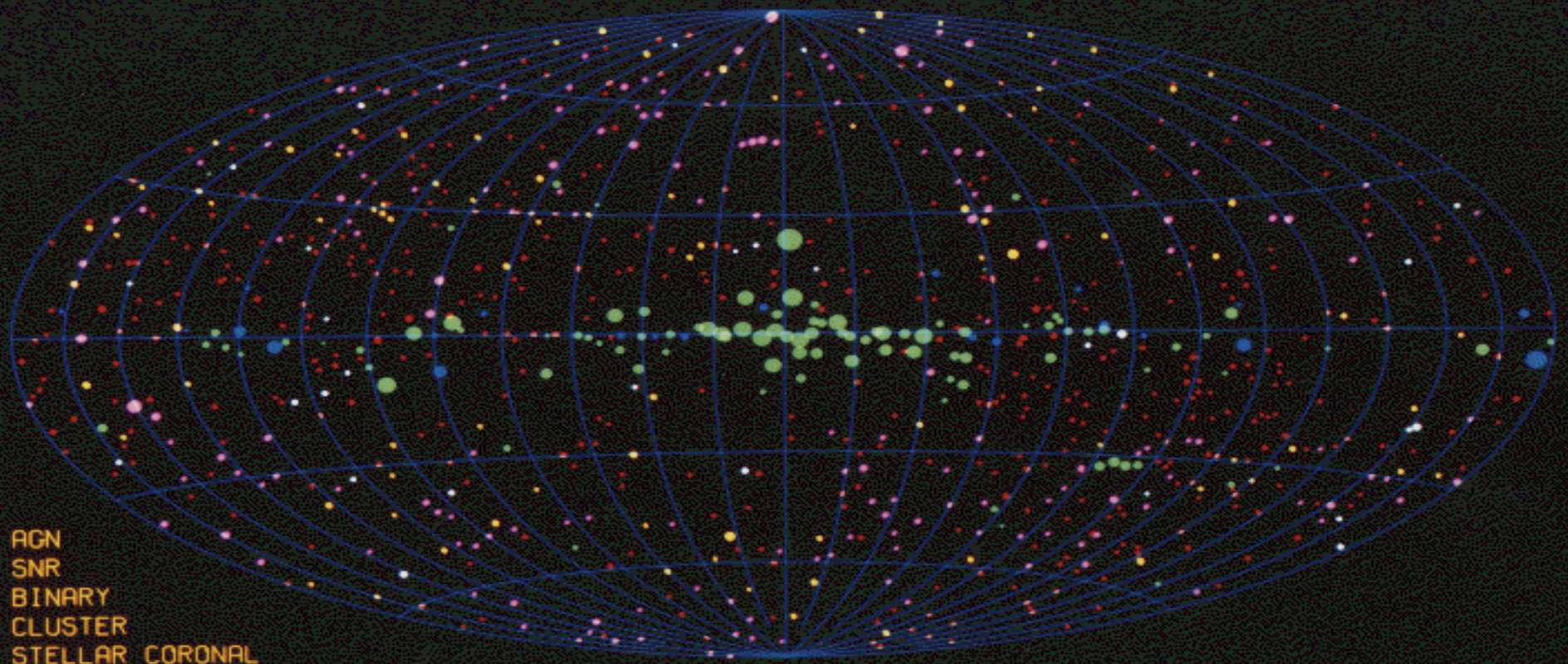

J1623+3559
z = 0.87
J1621+3746
10 mas
z = 1.27
J1620+3515
z = 2.94
J1624+3758
z = 3.38

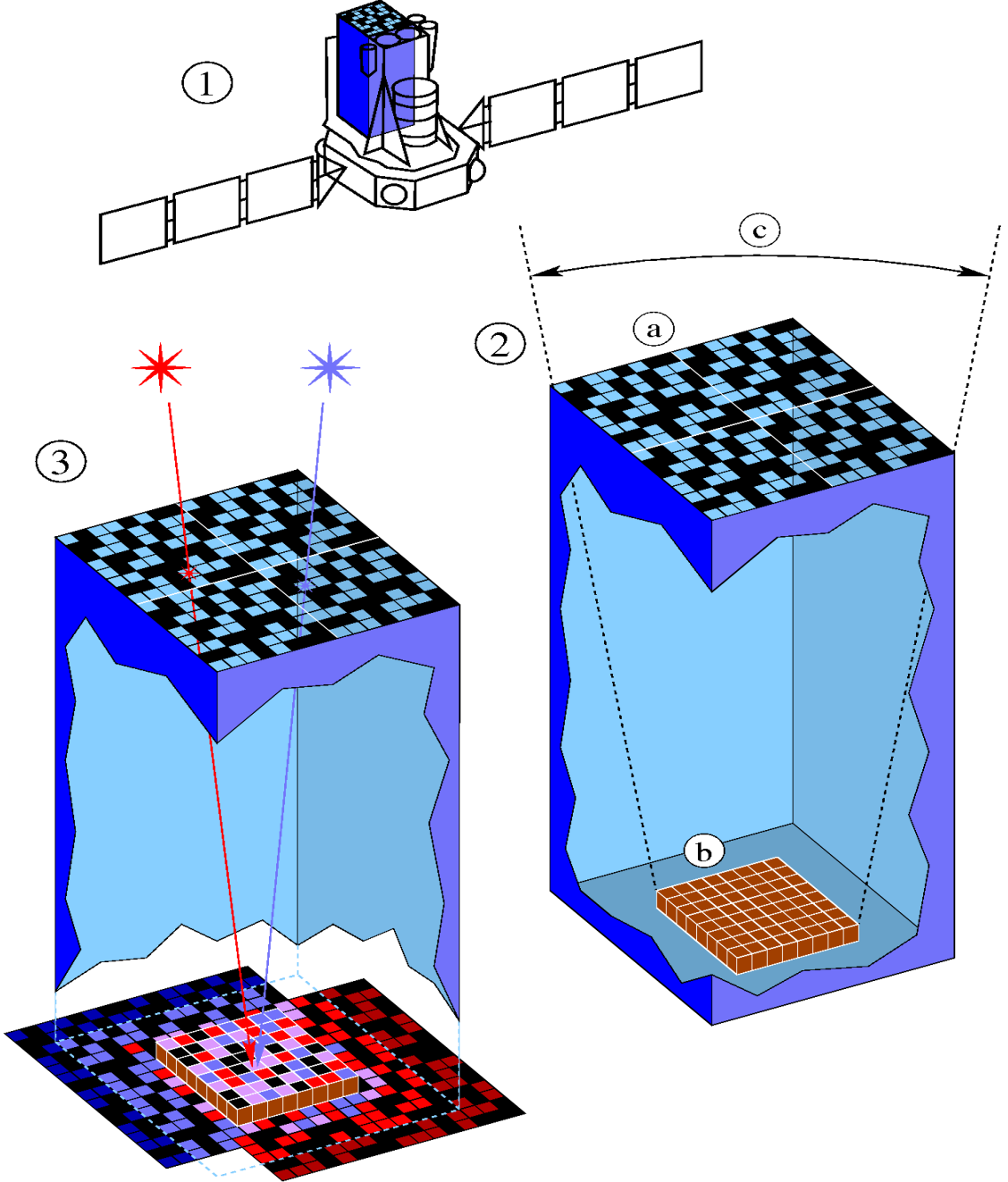



High Dispersion Reflection Grating Plate
Gold Reflecting Surface
X-ray diffracted to CCD Strip at secondary Focus
CCD strip at Secondary Focus
540 MM
600 MM
40% Dispersed X-rays
X-rays
50% Non Dispersed X-rays
Grating Stack
CCD Camera At Prime Focus
Focal Length 7500 MM

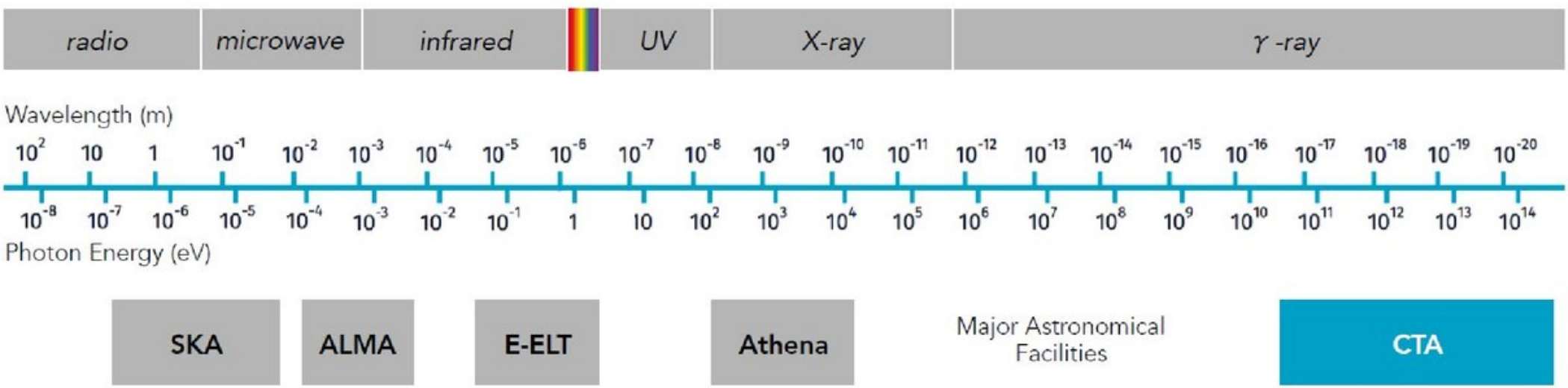
HEAO A-1 ALL-SKY X-RAY CATALOG

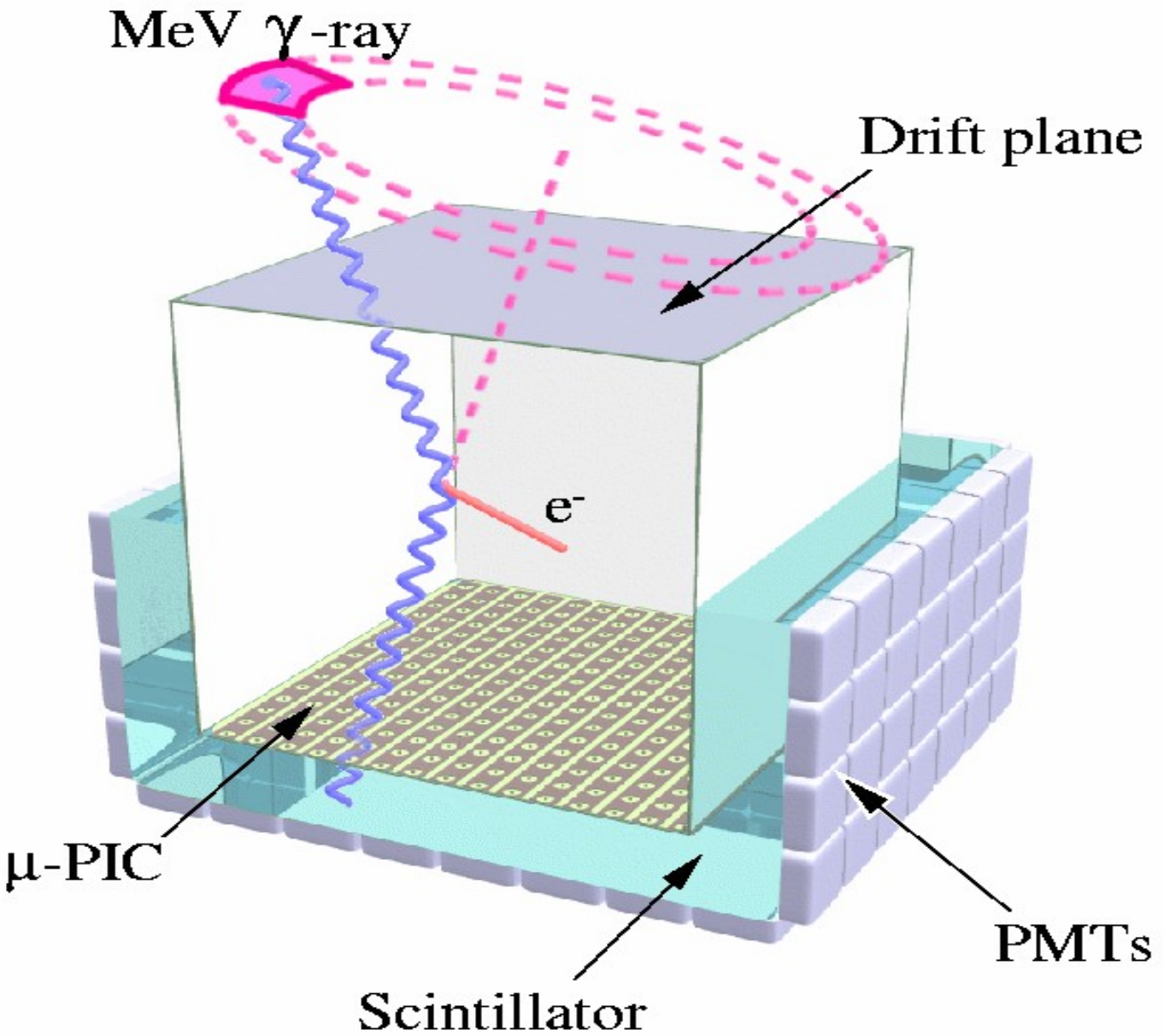
NAVAL RESEARCH LABORATORY

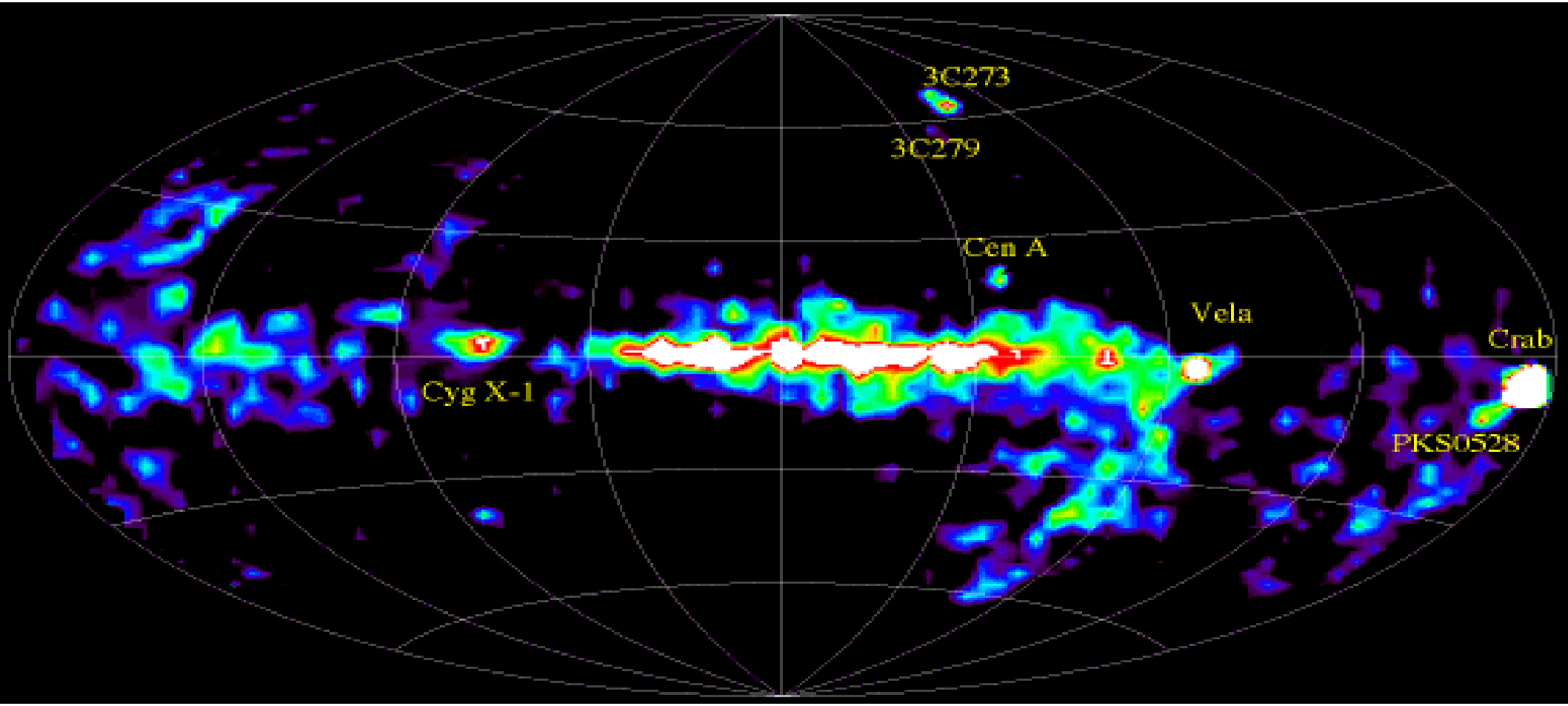


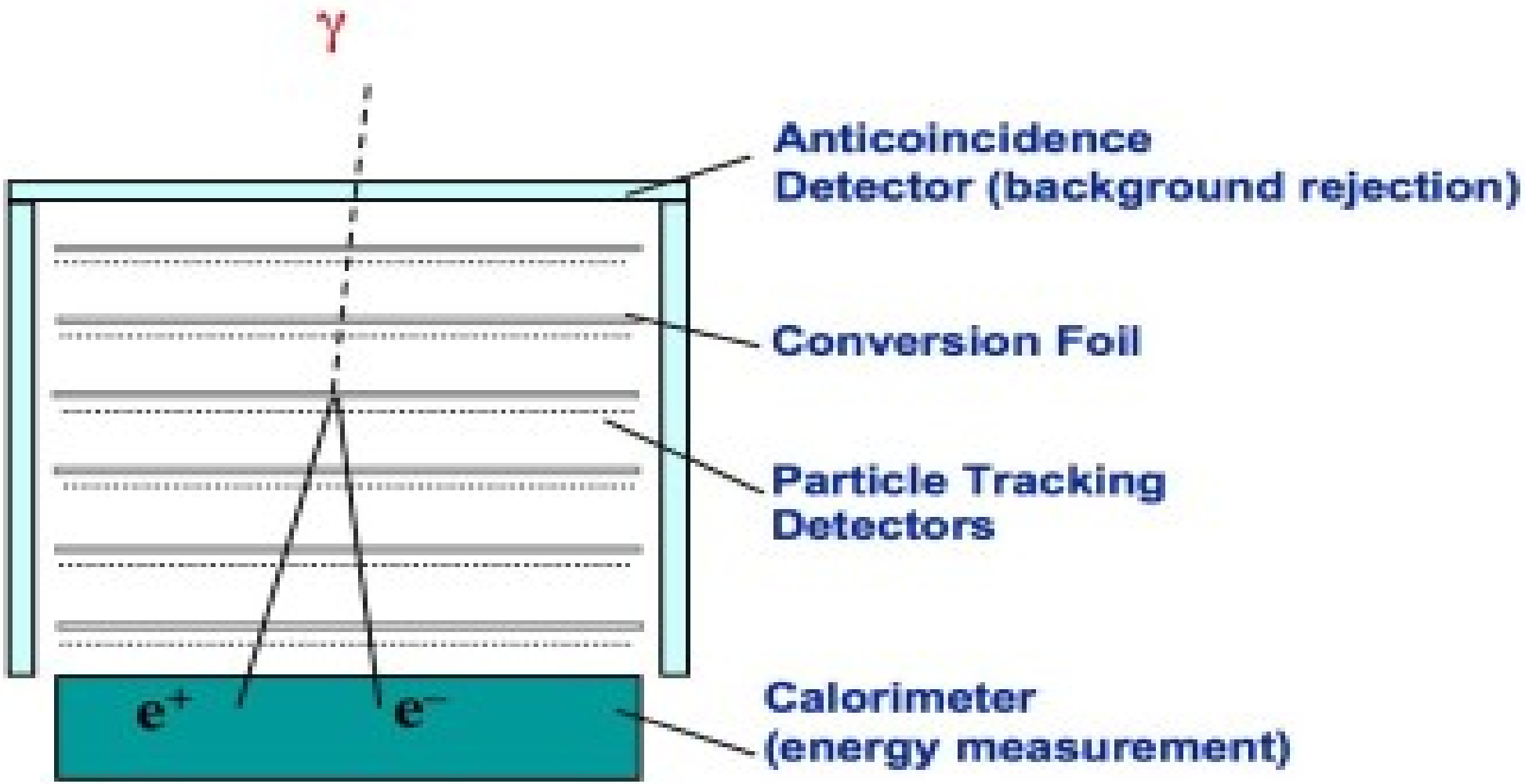

1
2
3
a
b
c

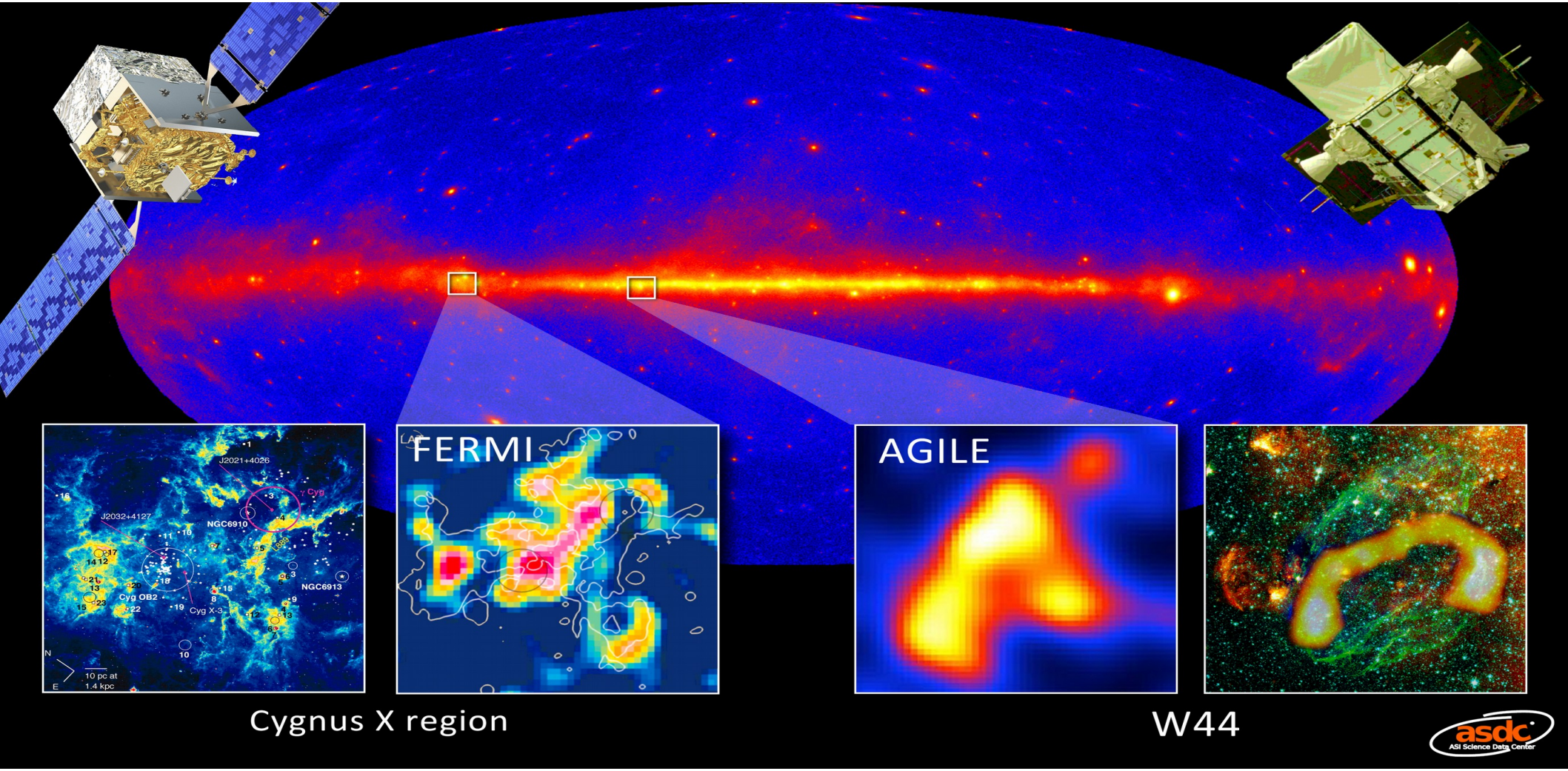
Astronomical bands




MeV γ-ray
Drift plane
e-
μ-PIC
Scintillator
PMTs


3C273
3C279
Cen A
Vela
Crab
Cyg X-1
PKS0528

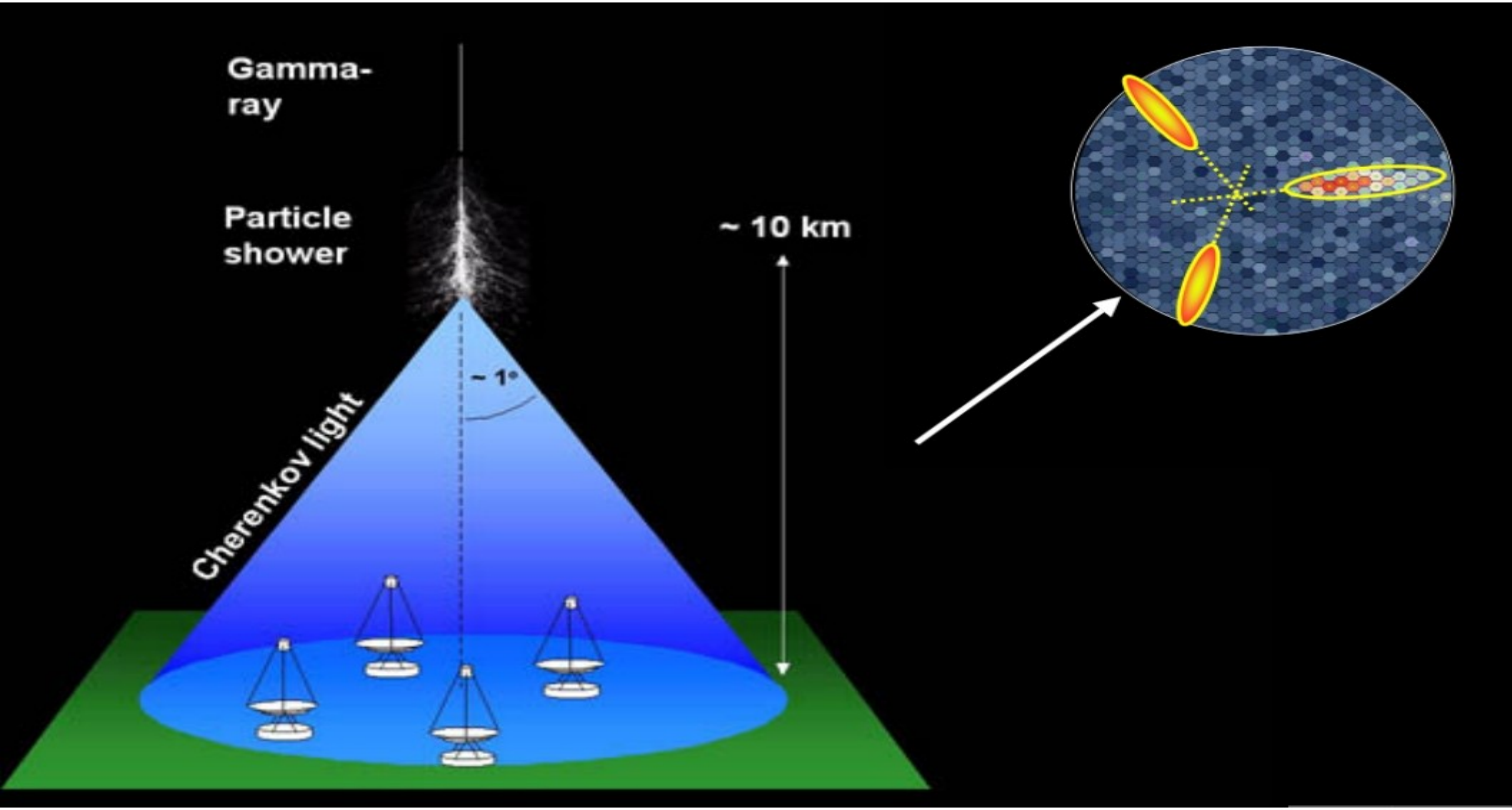

γ
Anticoincidence
Detector (background rejection)
Conversion Foil
Particle Tracking
Detectors
e+
e−
Calorimeter
(energy measurement)

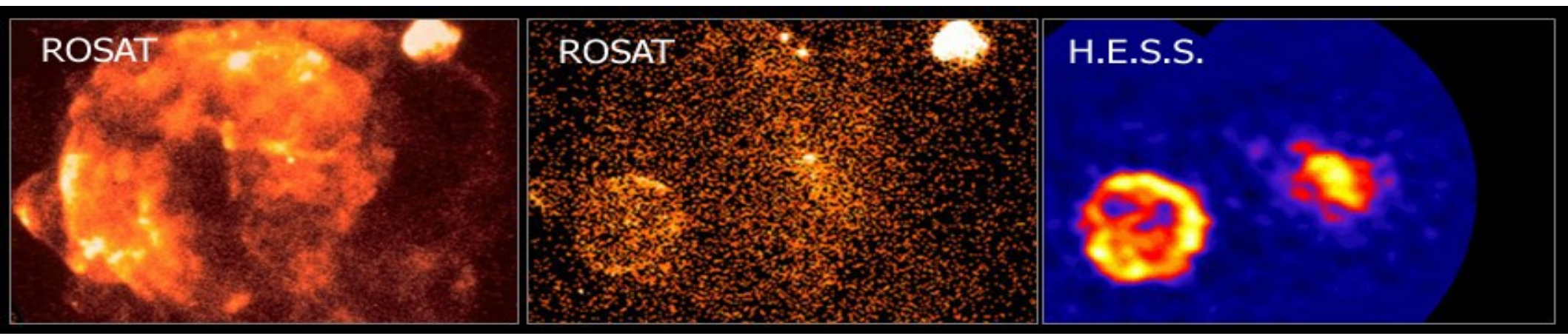


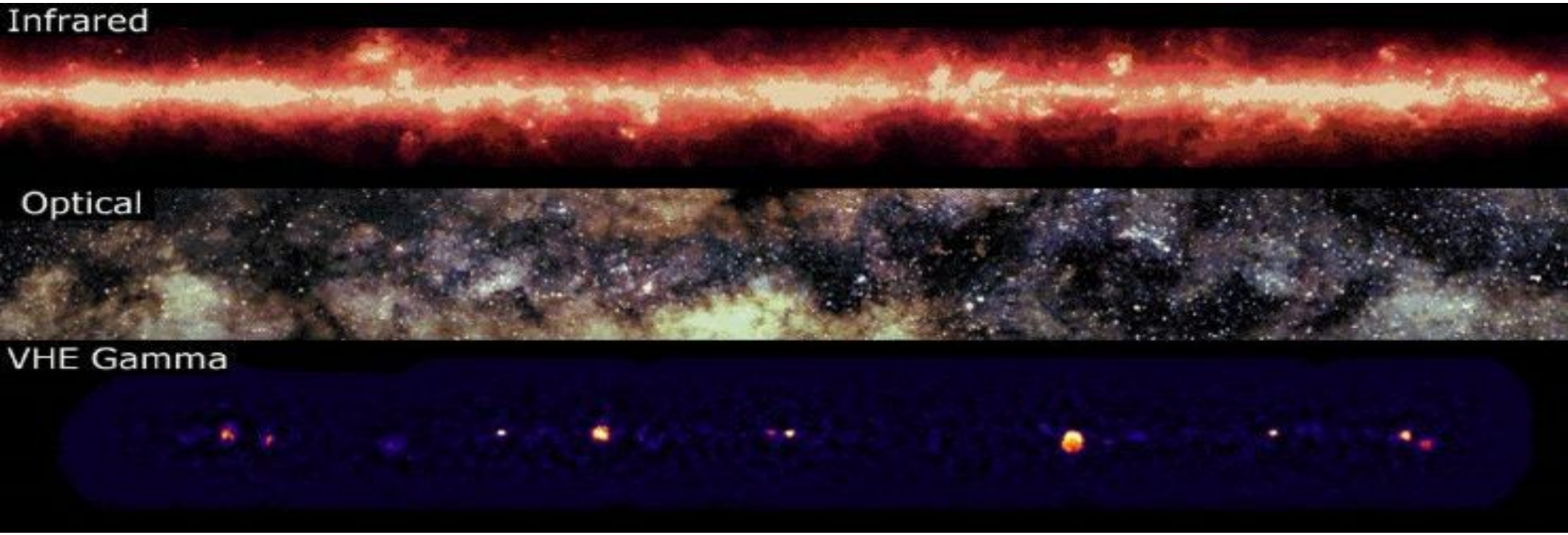
Cygnus X region

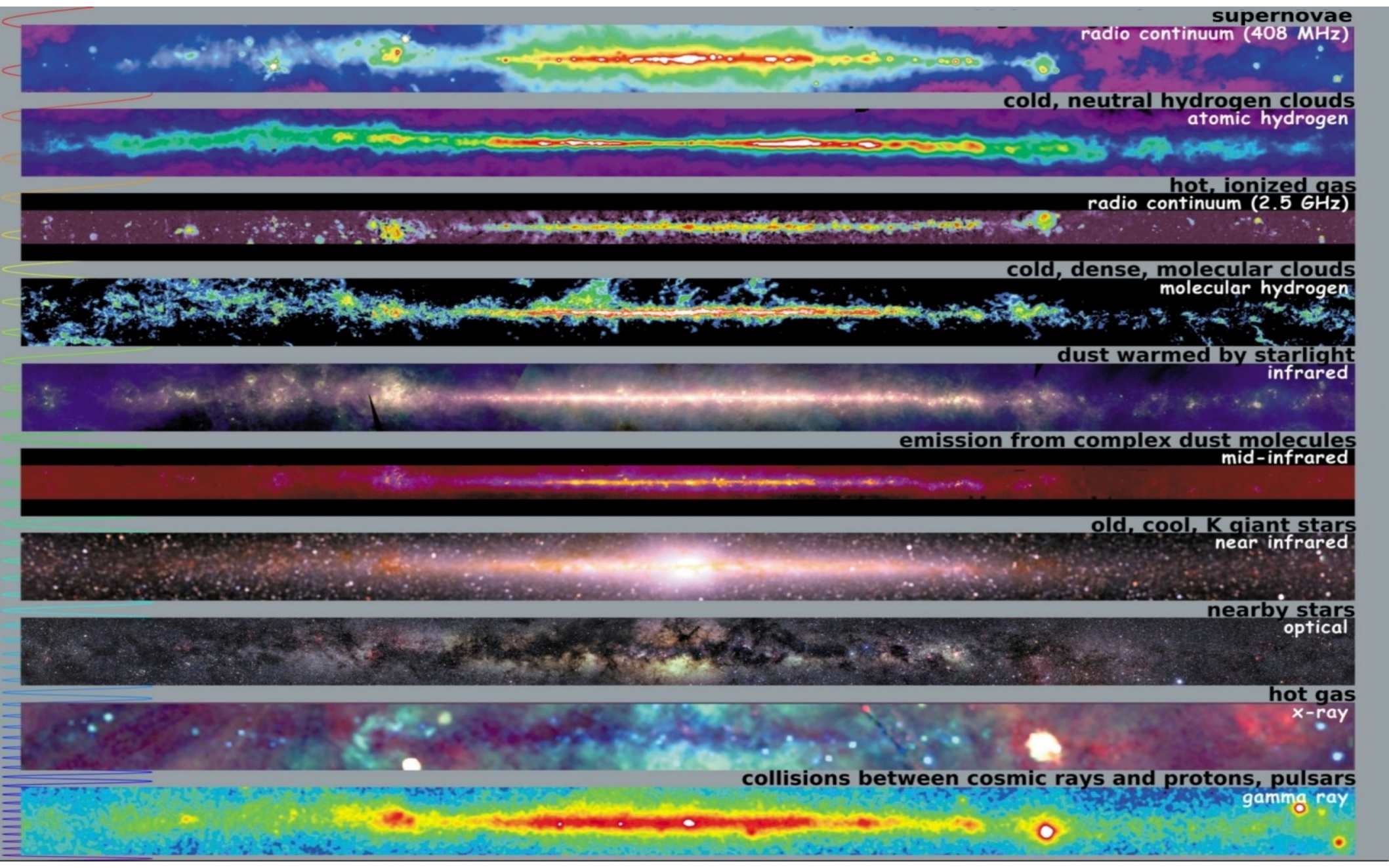
W44

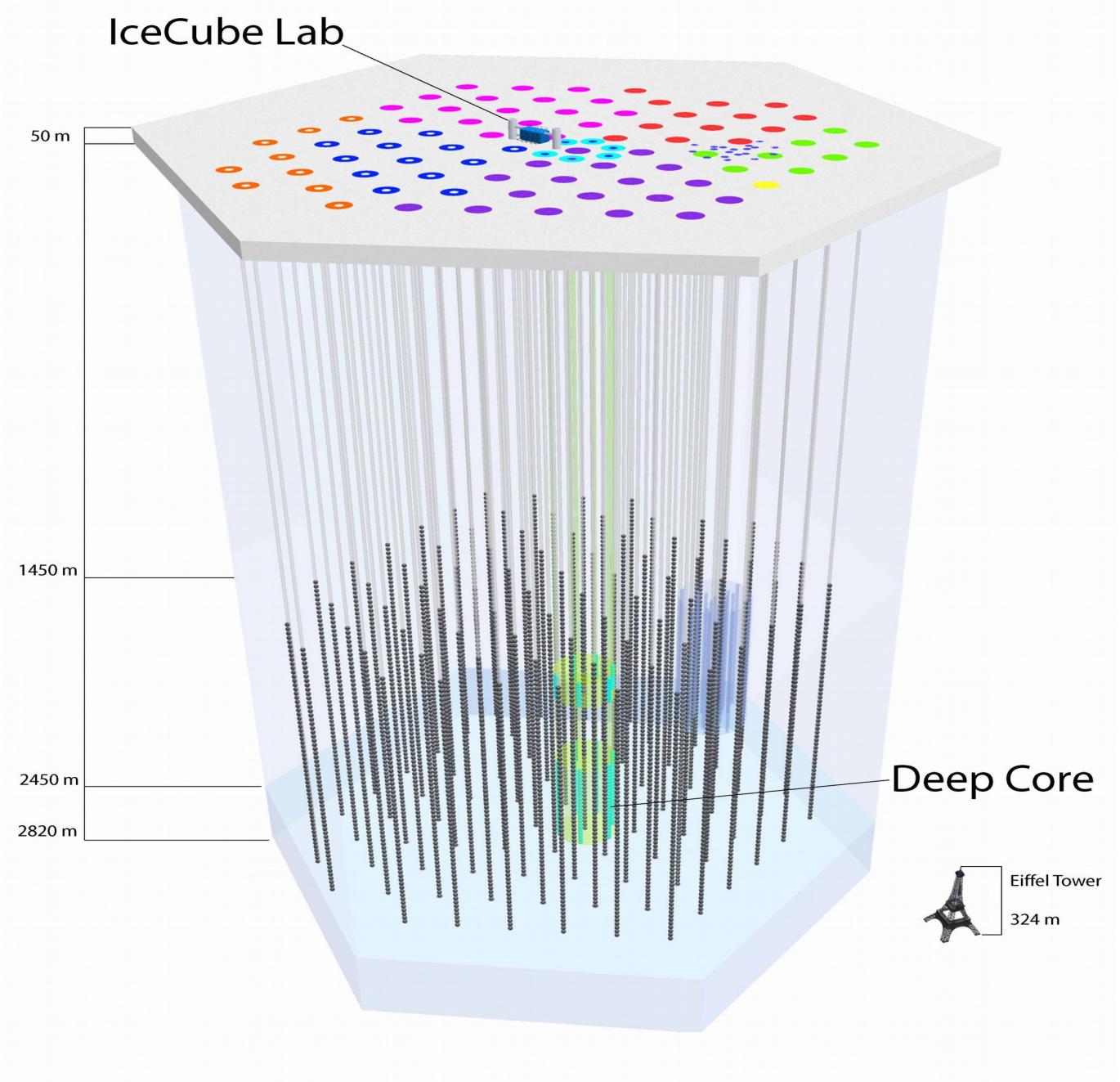
asdc
ASI Science Data Center

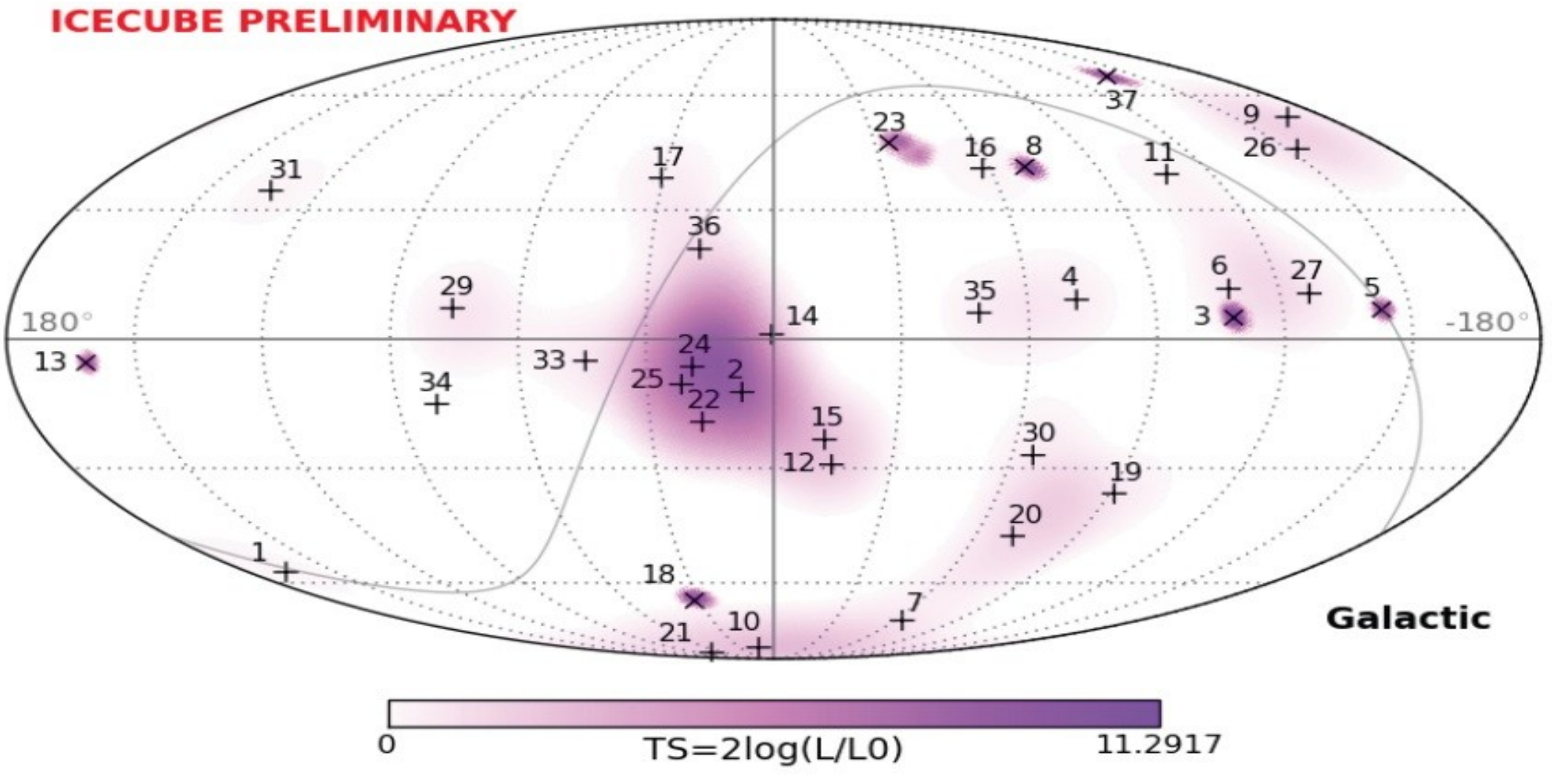

Gamma-ray
Particle shower
~ 10 km
~ 1°
Cherenkov light

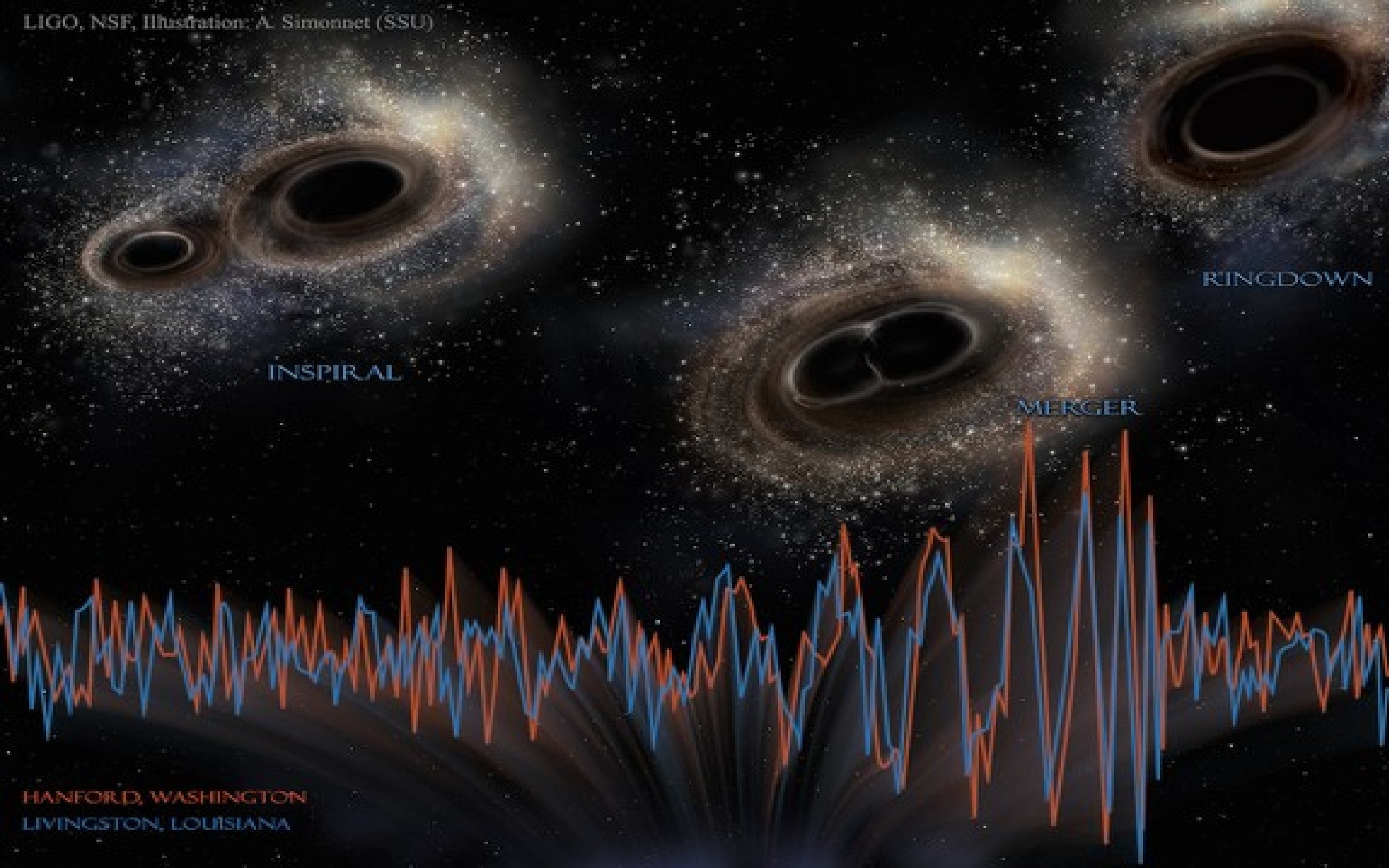

ROSAT
ROSAT
H.E.S.S.

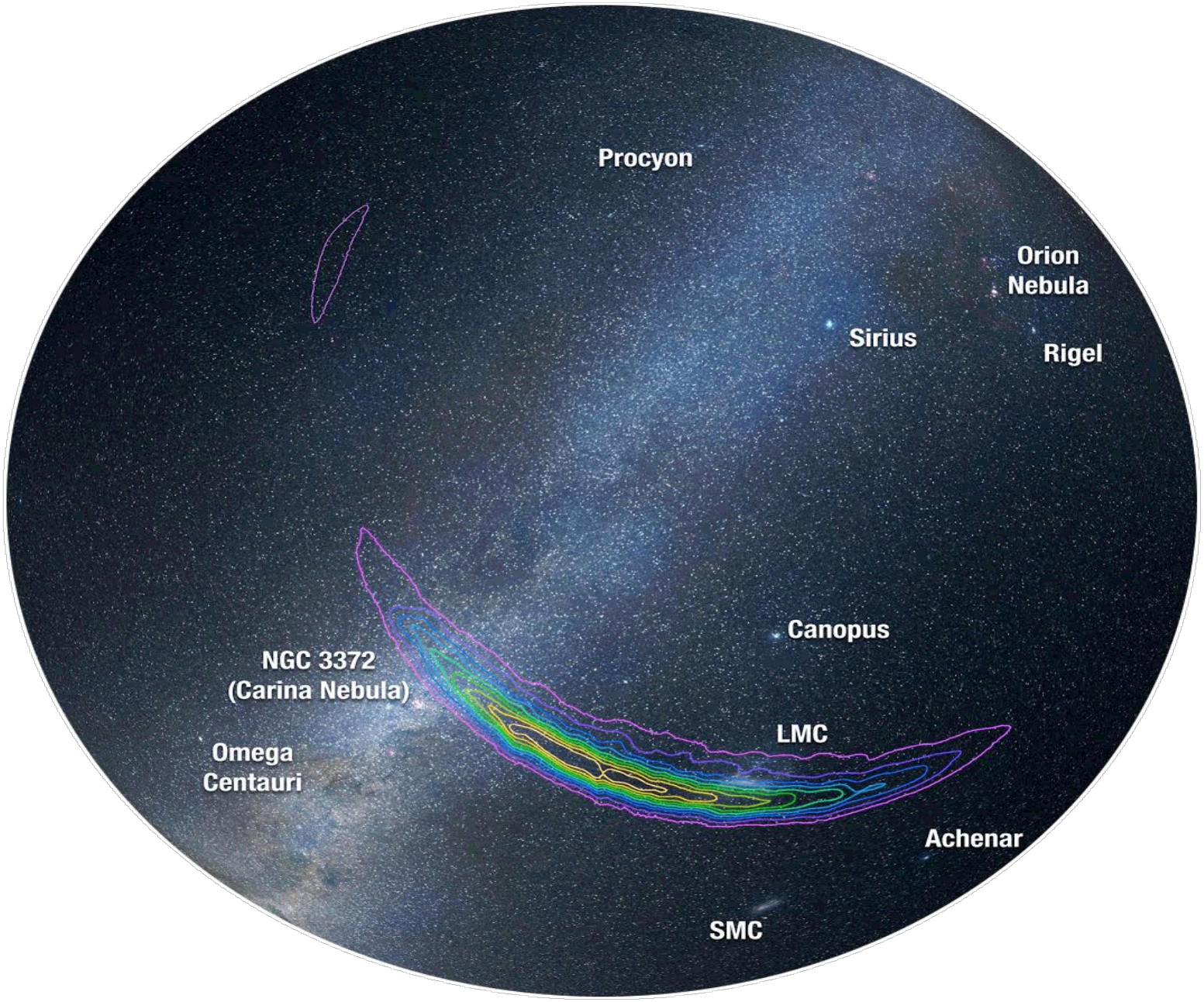

Infrared
Optical
VHE Gamma


supernovae
radio continuum (408 MHz)
cold, neutral hydrogen clouds
atomic hydrogen
hot, ionized gas
radio continuum (2.5 GHz)
cold, dense, molecular clouds
molecular hydrogen
dust warmed by starlight
infrared
emission from complex dust molecules
mid-infrared
old, cool, K giant stars
near infrared
nearby stars
optical
hot gas
x-ray
collisions between cosmic rays and protons, pulsars
gamma ray


IceCube Lab
50 m
1450 m
2450 m
2820 m
Deep Core
Eiffel Tower
324 m


ICECUBE PRELIMINARY
180°
-180°
Galactic
0
TS=2log(L/L0)
11.2917


LIGO, NSF, Illustration: A. Simonnet (SSU)
INSPIRAL
MERGER
RINGDOWN
HANFORD, WASHINGTON
LIVINGSTON, LOUISIANA


Procyon
Orion
Nebula
Sirius
Rigel
Canopus
NGC 3372
(Carina Nebula)
LMC
Omega
Centauri
Achenar
SMC