High Energy Astrophysics: the role of optical and infrared large telescopes

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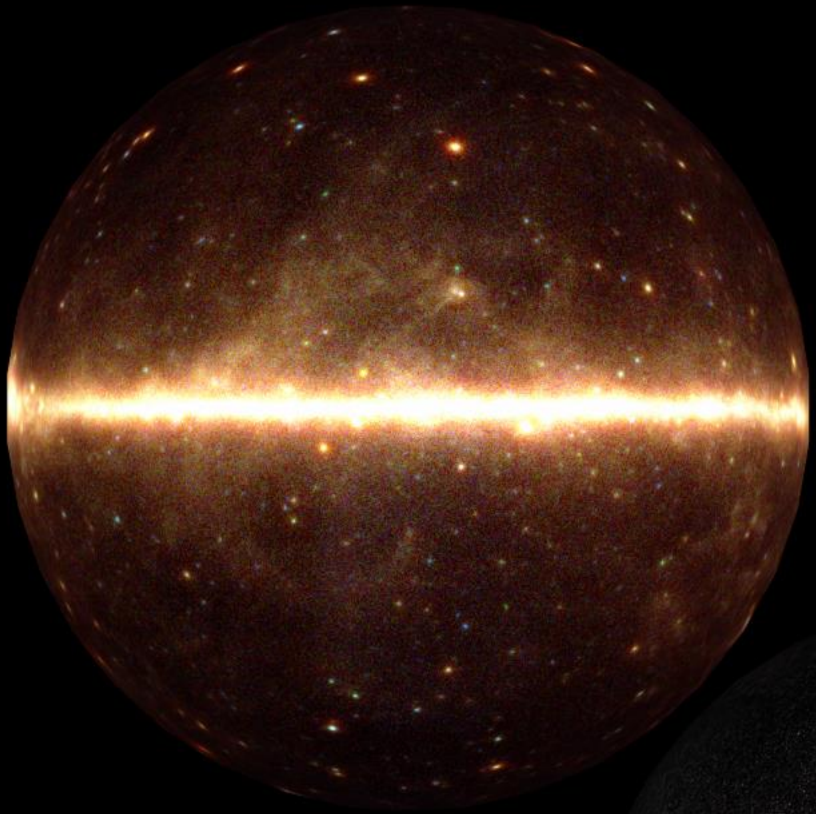
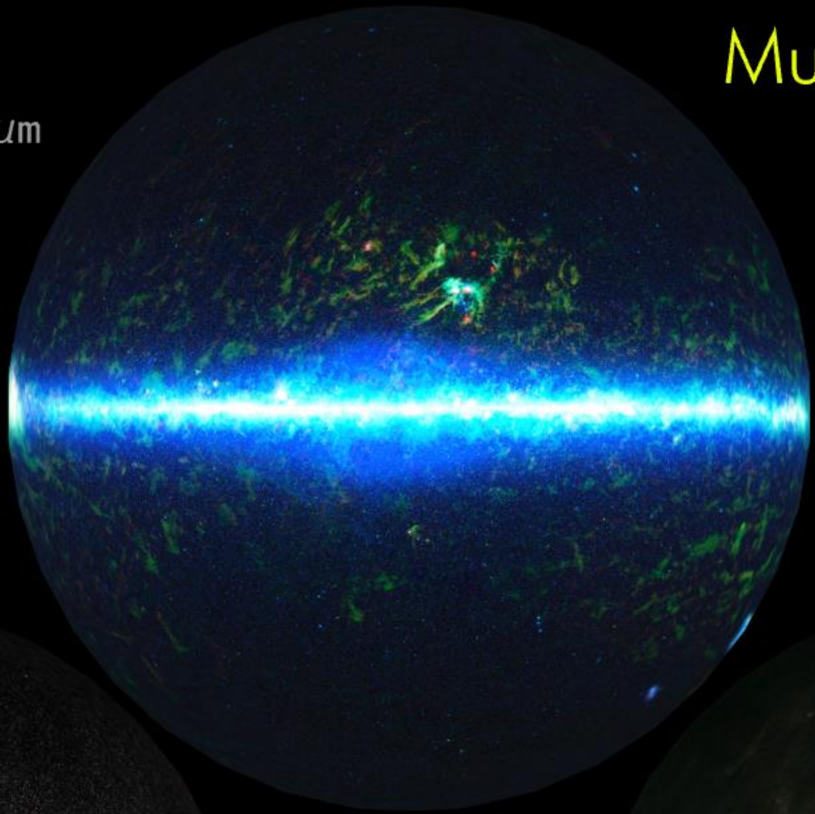
Gran Telescopio Canarias

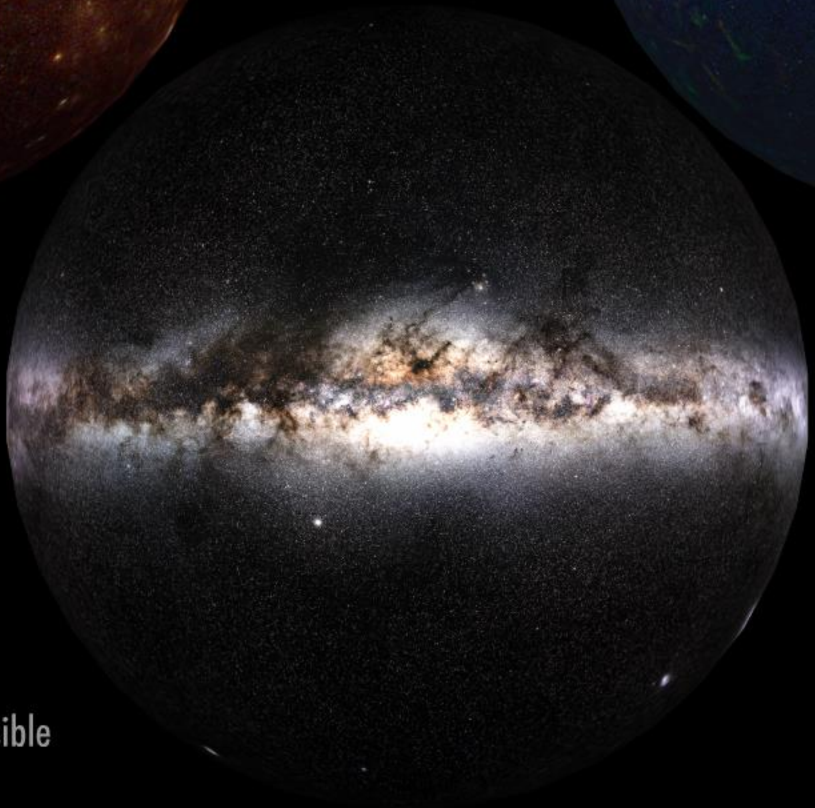
Multi-wavelength sky



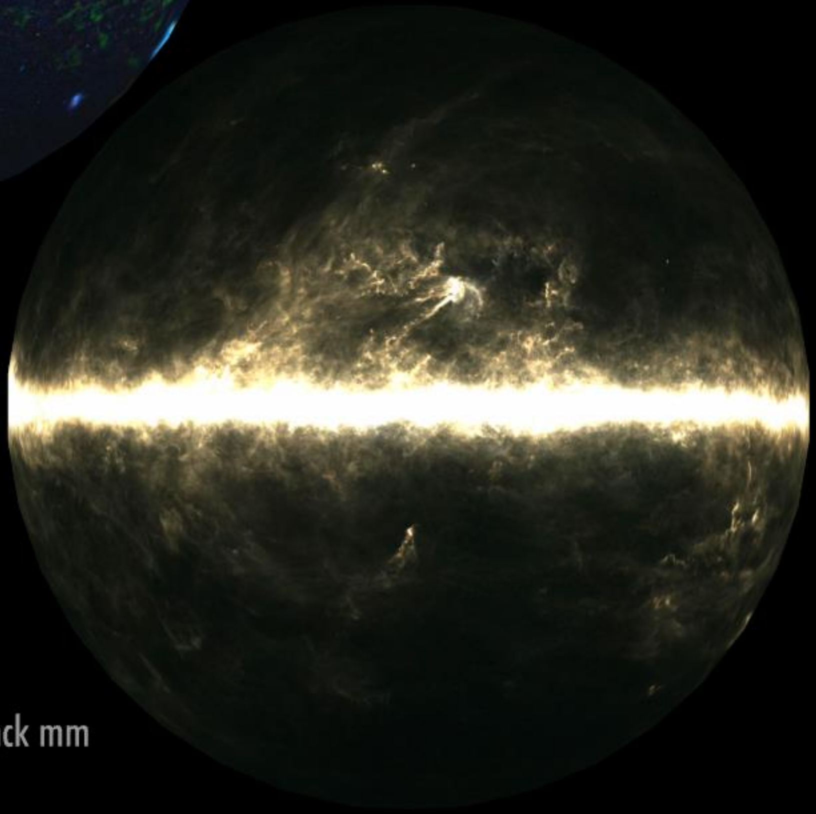
FERMI gamma-rays

WISE μm



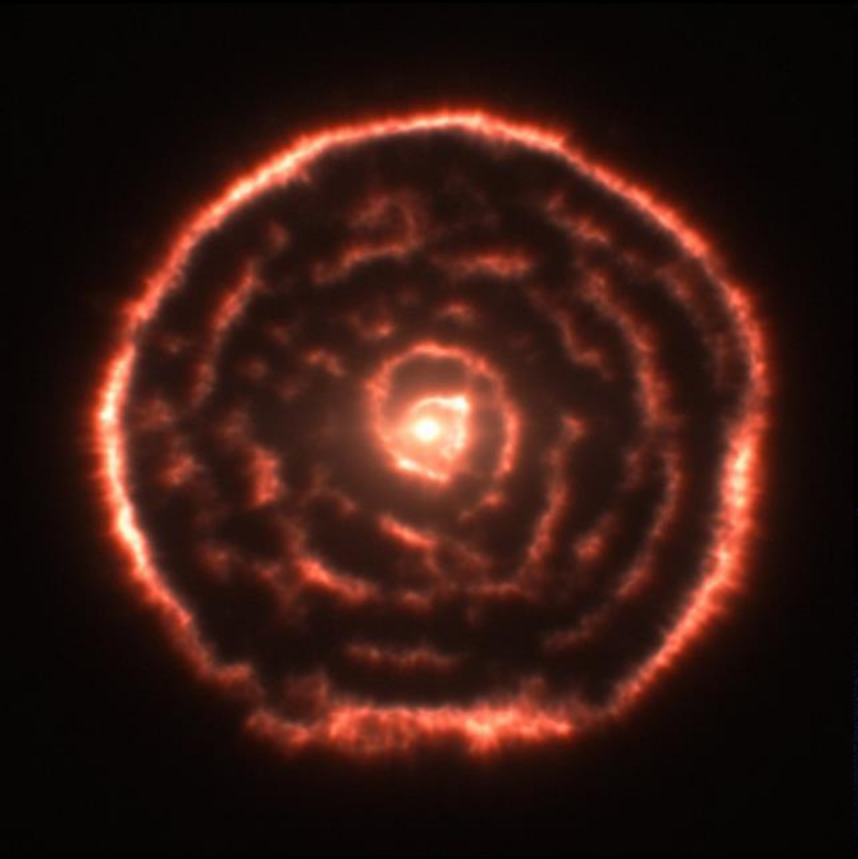


ESO visible



Planck mm

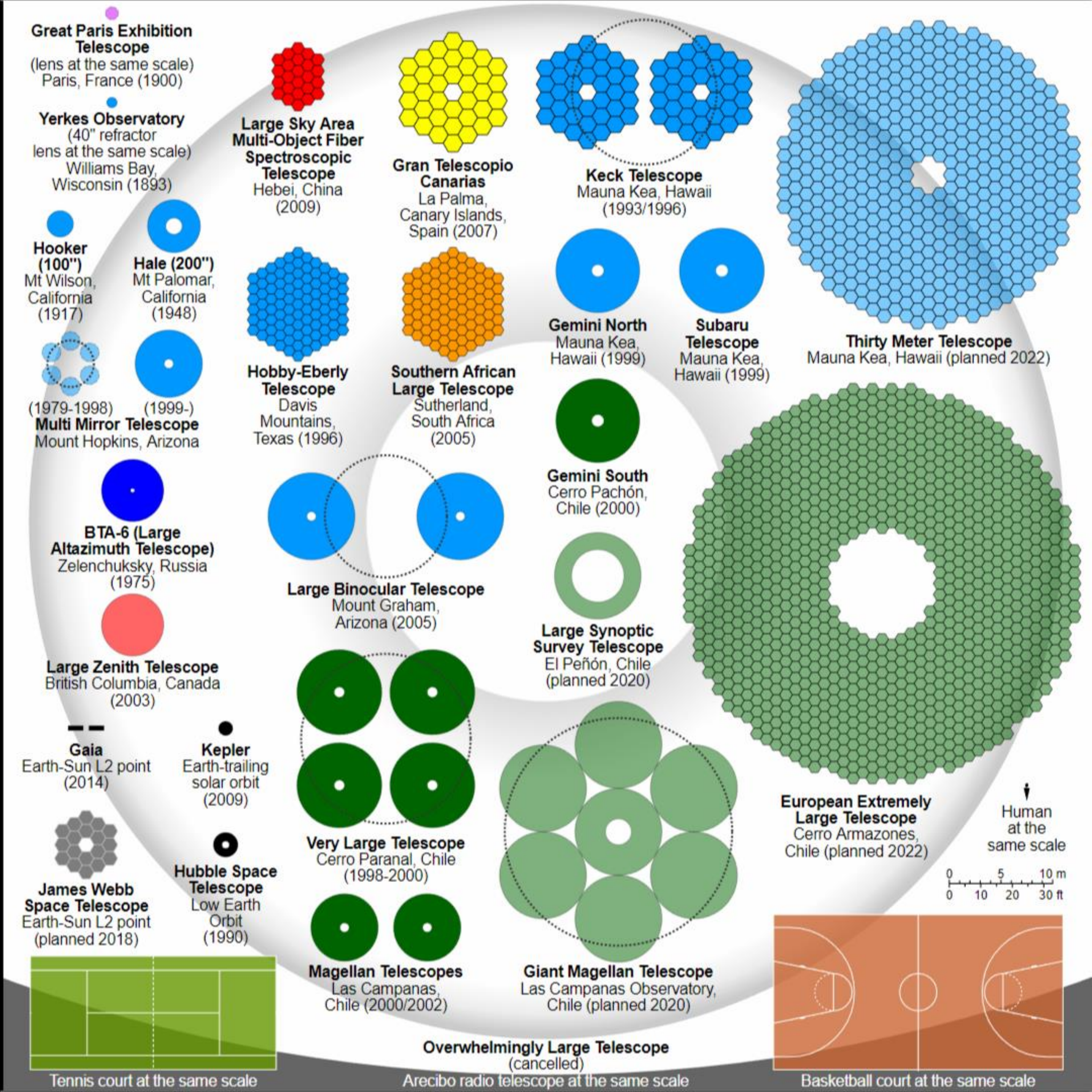
Multi-wavelength sky



Large optical/IR telescopes

- 8-10 m diameter
- Diffraction limit (~lambda/D,
e.g. 25 mas for 10m tel at 1 μm)
- Multiplexing (fibres)
- Stability
- Large WV coverage and resolution

- Interferometry (mas)



Mismatching eyes

Large differences in observing techniques at different wavelengths:

- sensitivity
- field of view
- spatial resolution
- temporal resolution
- response time
- technology
- reduction and analysis methods

fosters global/coordinated collaboration

Gran Telescopio Canarias

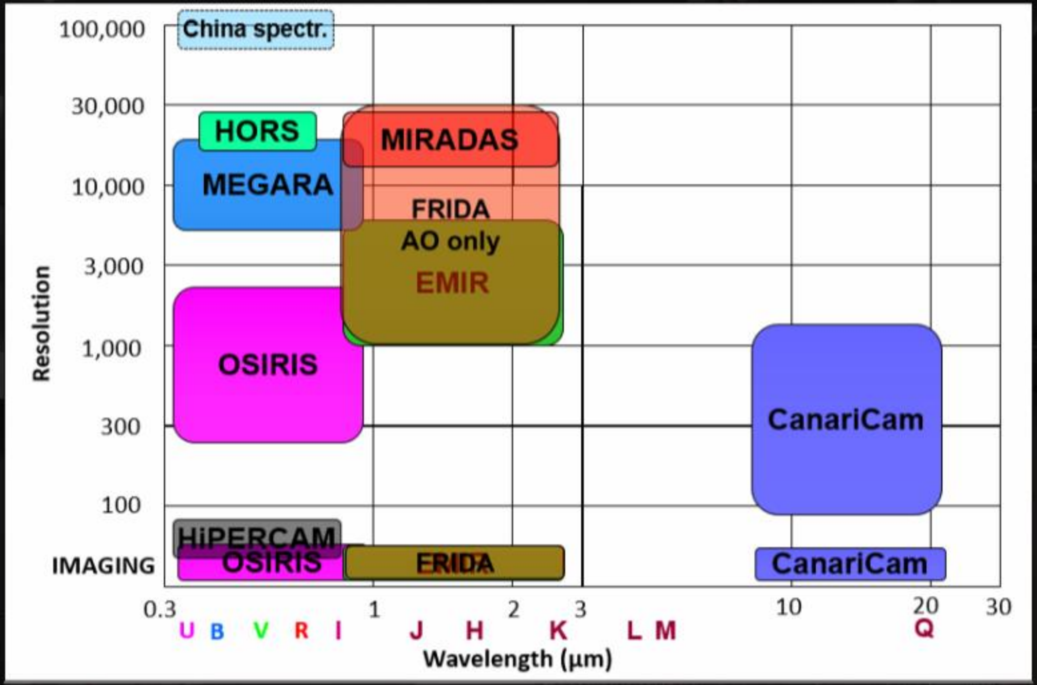
GTC telescope is an IAC initiative.
Funded by Spain, México, and Univ. of Florida.
Started scientific operations in 2009.

10.4 m alt-azimuthal , Ritchey-Chrétien
Effective focal length 169.9 m (1.21 arcsec/mm)
Unvignetted f.o.v. 20 arcmin (Nasmyth)

M1: 36 hexagonal aluminium-coated Zerodur segments
Active-optics control
M2: Aluminium-coated beryllium, provides
alignment, chopping, tip-tilt AO

Excellent image quality fitting site conditions

Versatile instrumentation & operation mode



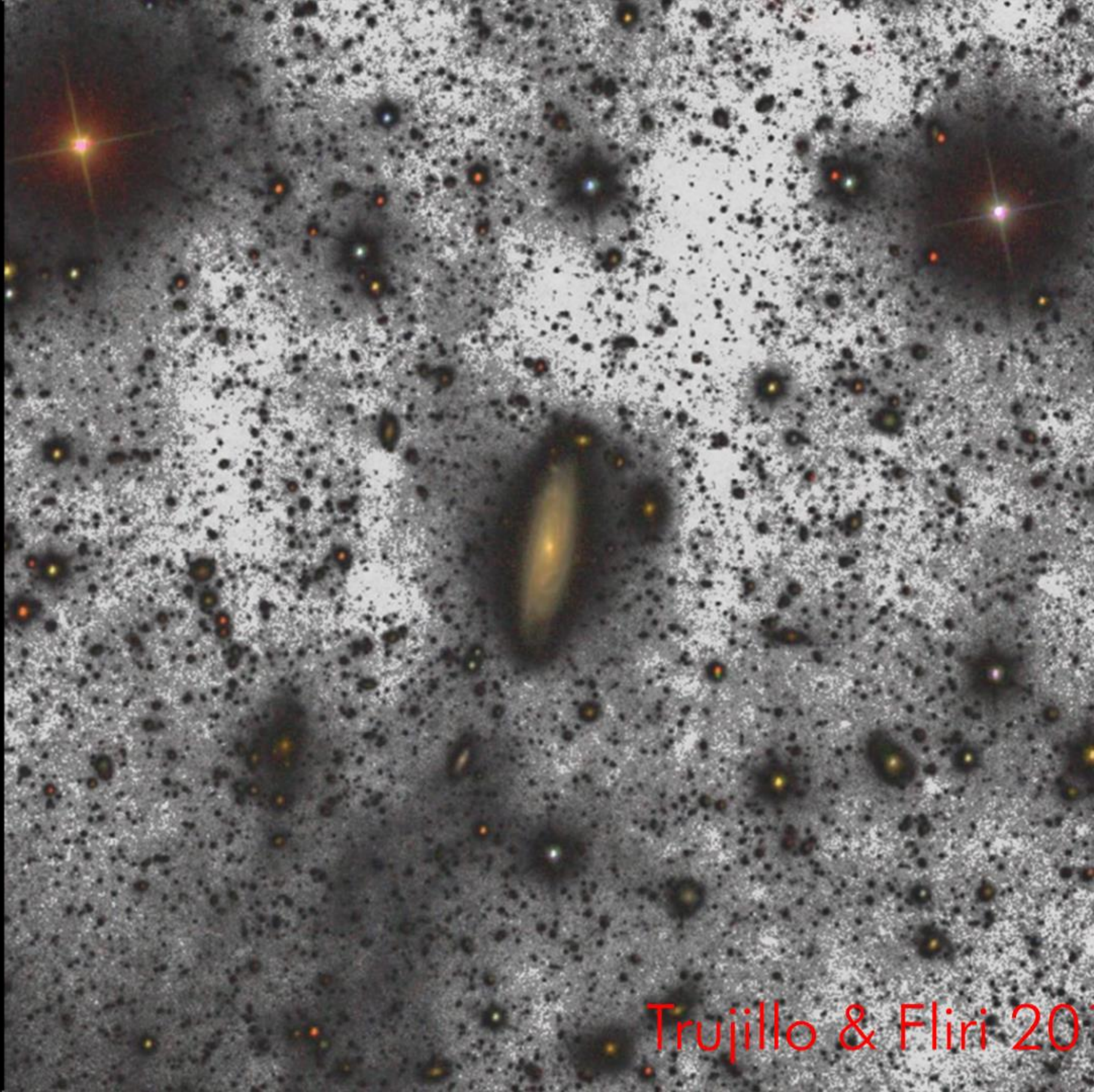
Service/queue observation mode, suited for ToOs and transients

HE astrophysics with optical/IR large telescopes

Map and study thermal Universe in fine details.
Insights into non-thermal processes.

(identify) and characterize sources:
- nature
- distance
- physico-chemical properties:
masses, densities, dynamics, shocks, magnetic fields, ...
- environment (evolution)

Relatively slow response time & small f.ov., require mediation by dedicated smaller telescopes to follow-up rapid transients

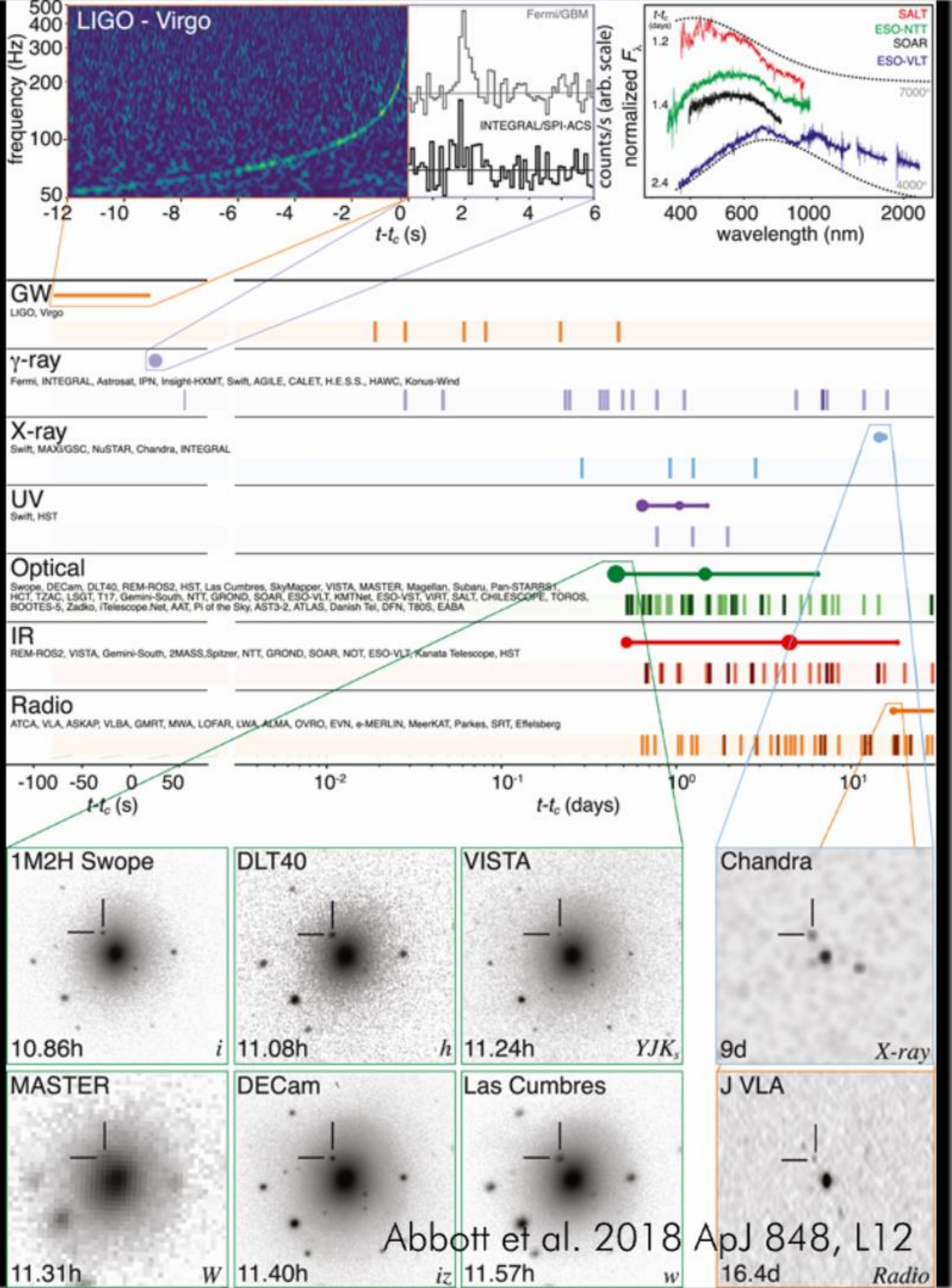


Gravitational waves

GW170817 paradigmatic example of MW and MM astrophysics by "global" collaboration

Optical observations provided:

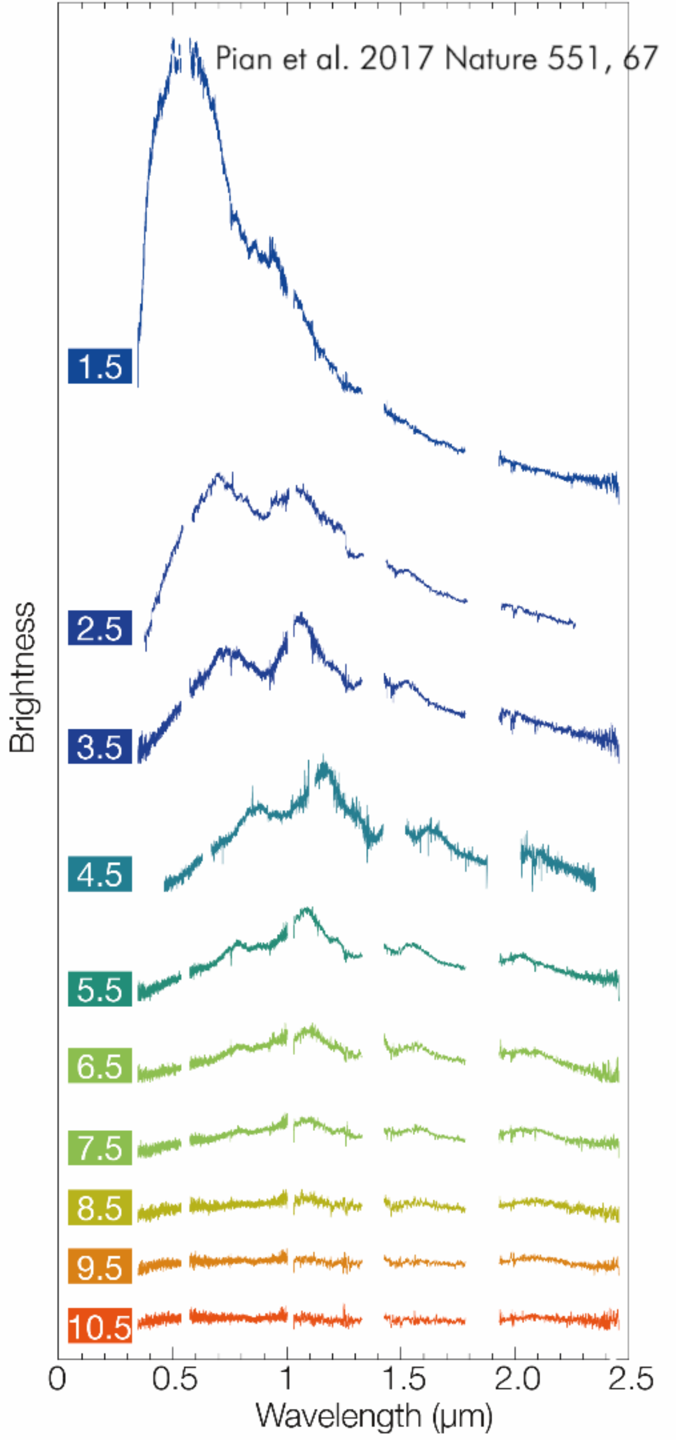
- precise location and distance (S0 galaxy NGC 4993)
- light curve (rapid luminosity decline & reddening)
- source environment (recent merger, old populaiton)
- spectrum (unprecedented, not SN)

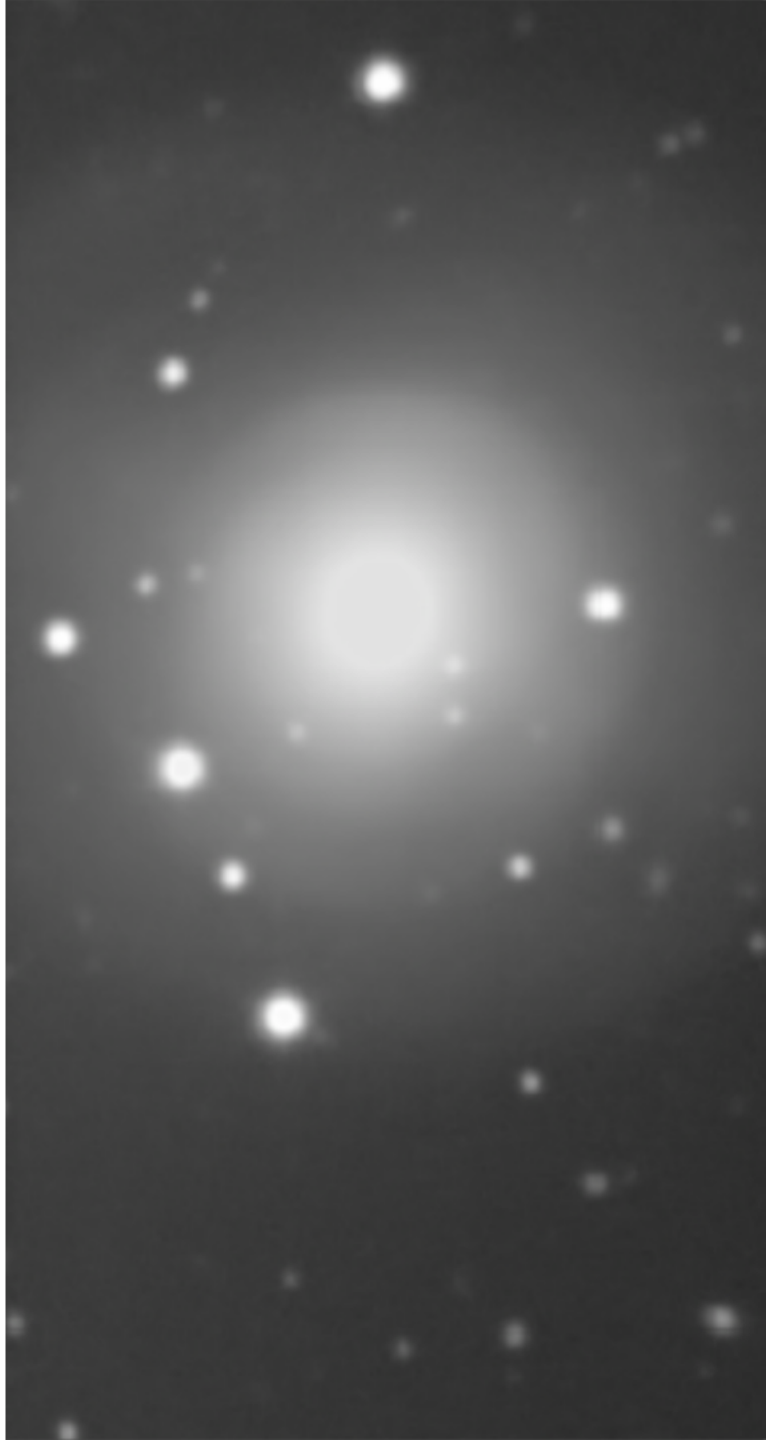


Abbott et al. 2018 ApJ 848, L12

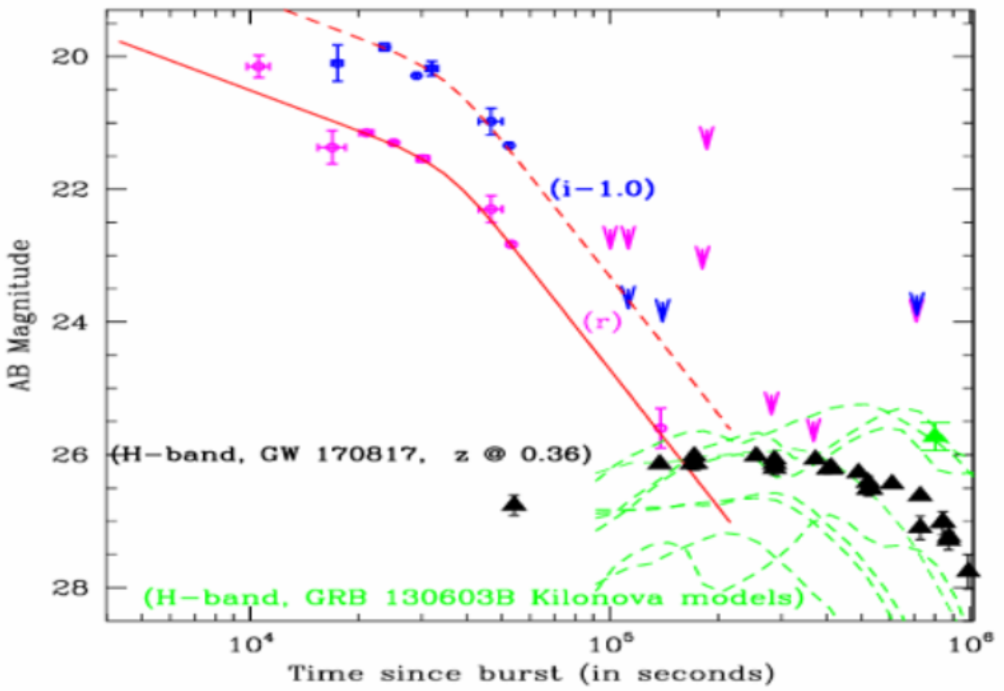
Gravitational waves

Rapid shift from optical to NIR and fading, and emergence of broad spectral features, revealing signatures of radioactive decay of r-process nucleosynthesis elements indicated consistency with "kilonova" models following merger of two neutron stars



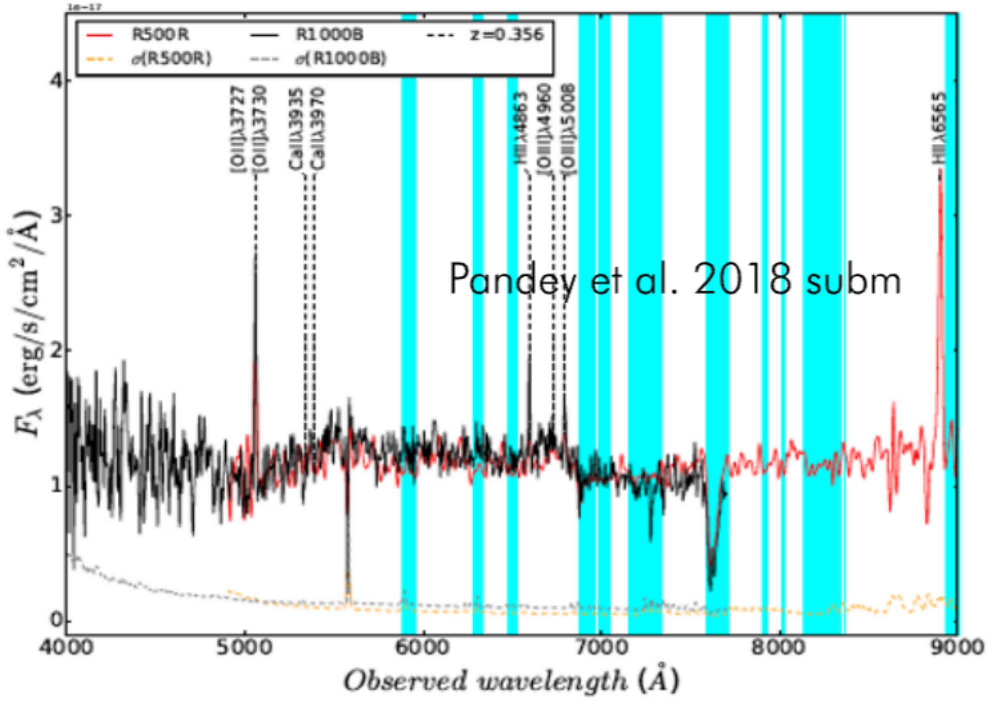


Kilonovae and (short) GRBs



Prior to GW170817, the most compelling evidence for kilonova was a faint near-infrared rebrightening in the afterglow of (short) GRB130606B (z = 0.356, Tanvir et al. 2013 Nature 500, 547).
GTC obtained its spectrum 8 hour after GRB event, revealing for the first time absorption features.

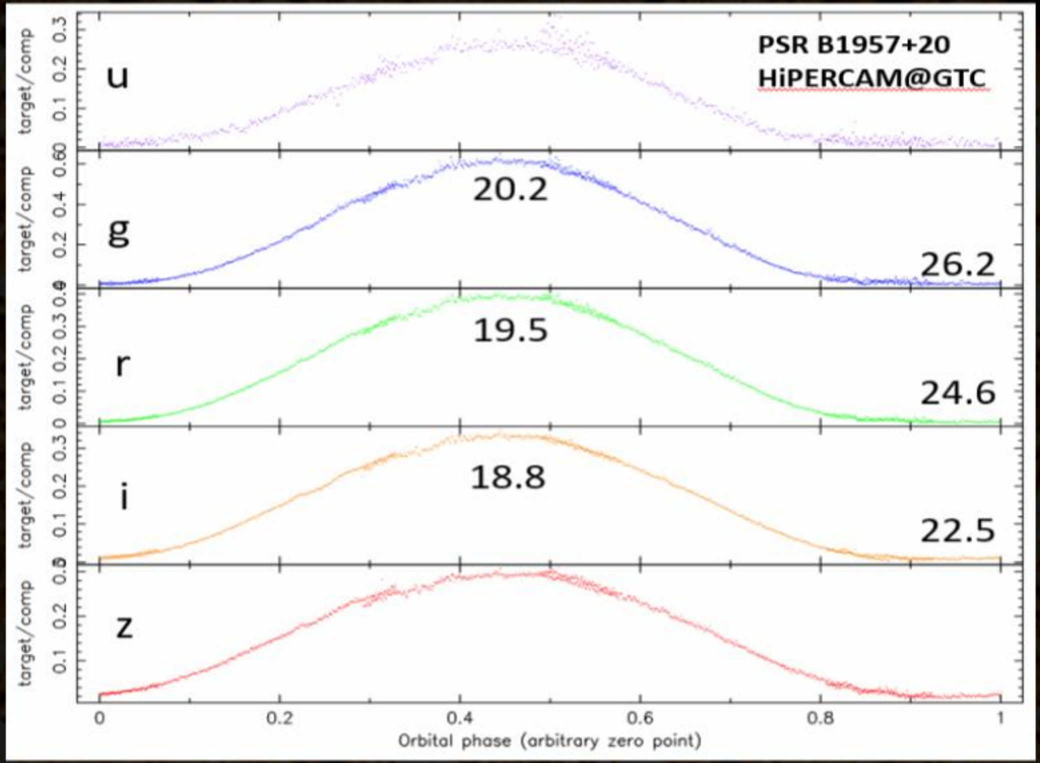
This provide new perspectives to study kilonovae, neutron star mergers, and r-processes.



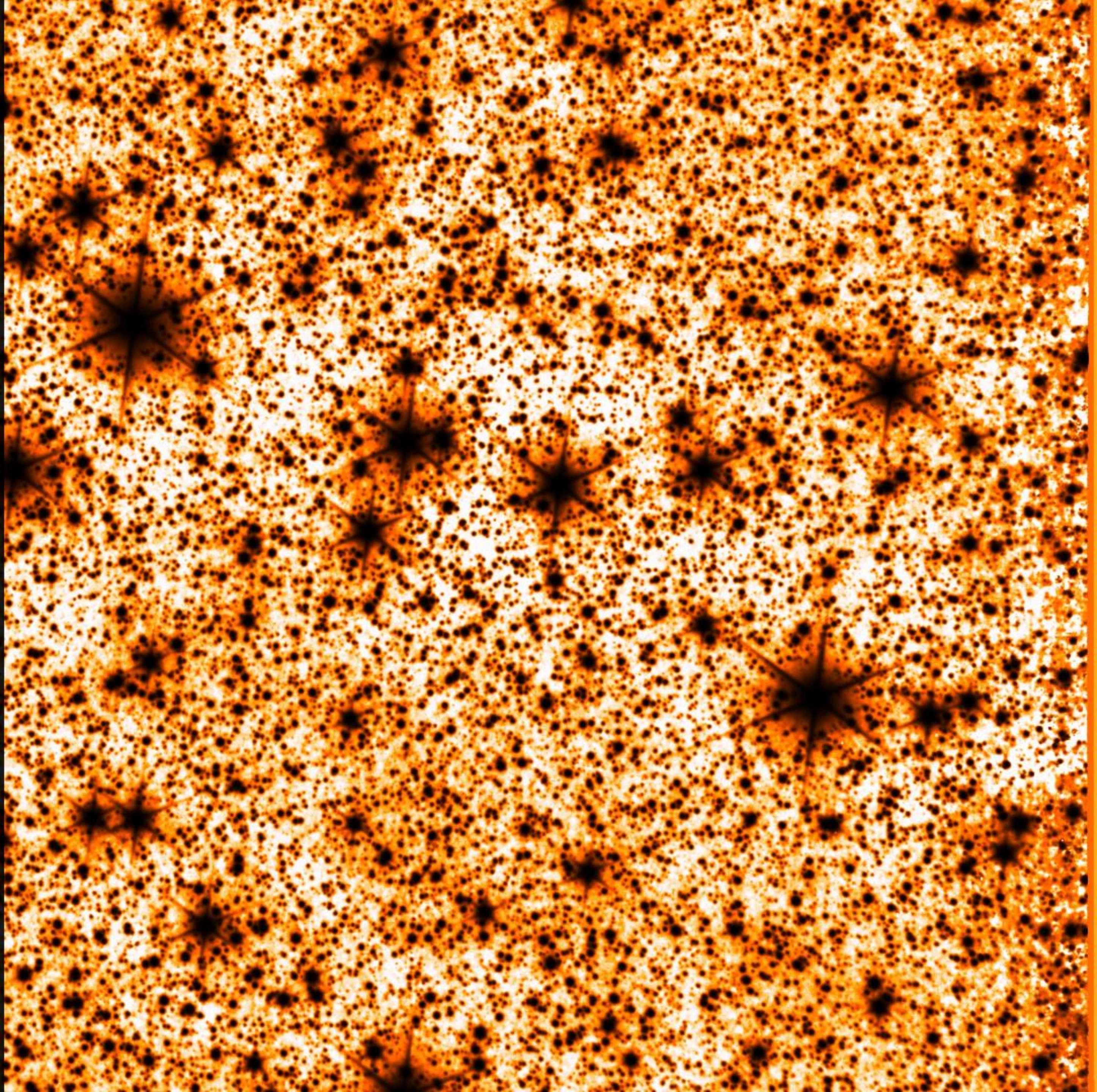
Pandey et al. 2018 subm

Pulsars

Isolated neutron stars optically faint (14 known)
EOS requires simultaneous mass & radius measurement (hardly possible), but can be indirectly probed by measuring maximum NS mass.
Binary millisecond pulsars are best candidates (accretion + dynamical mass + lightcurve modelling)



Breton et al. 2018, in preparation



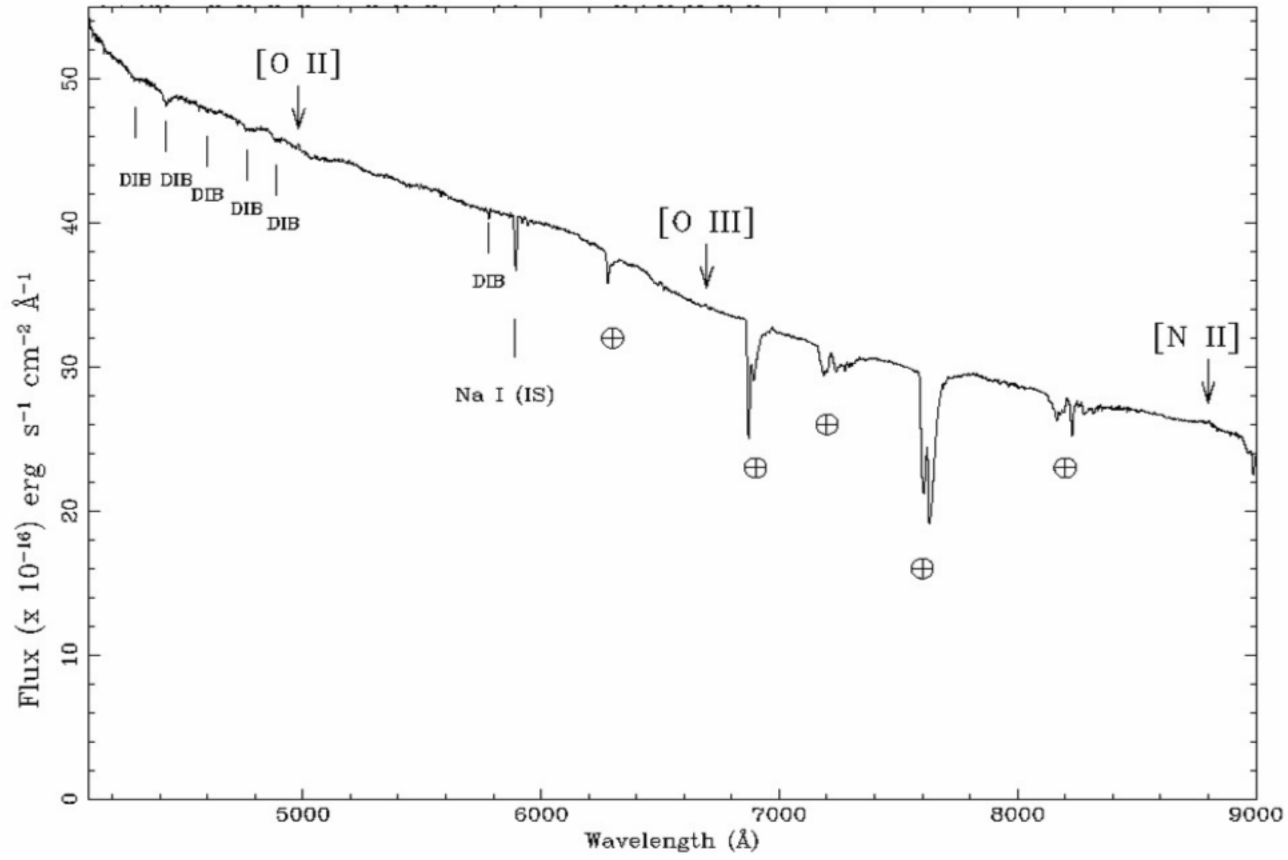
HE neutrinos

TXS 0506+056 is a HE Bl Lac-type blazar.
Detected as radio source (Arecibo 611 MHz survey, 1983)
tagged as possible blazar in 2000 from featureless optical spectrum
and adopted as BL Lac blazar using MW criteria in 2009.

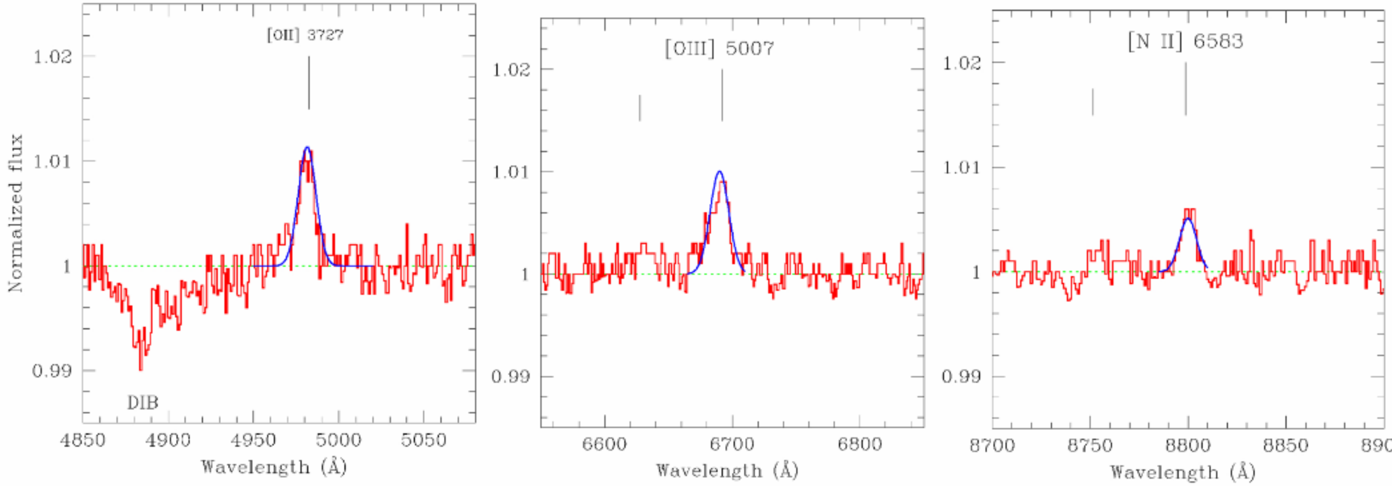
The path to identify TXS 0506+056 as likely source
of 290TeV IceCube-170922 neutrino was:
1) neutrino detection by IceCube
2) Consistent detection of flaring state of known
Gamma- and X-ray source TSX 0506+056
3) follow-up across entire EW spectrum.

Aaartsen et al. 2018, Science 361, 6398

GTC provided the blazar's redshift.

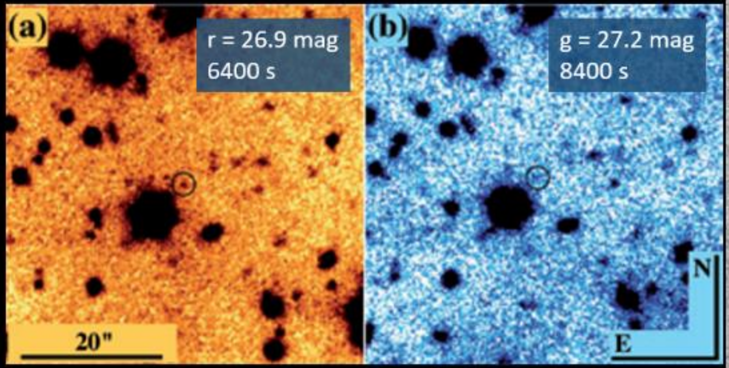


Paiano et al. 2018 ApJ 845, L32

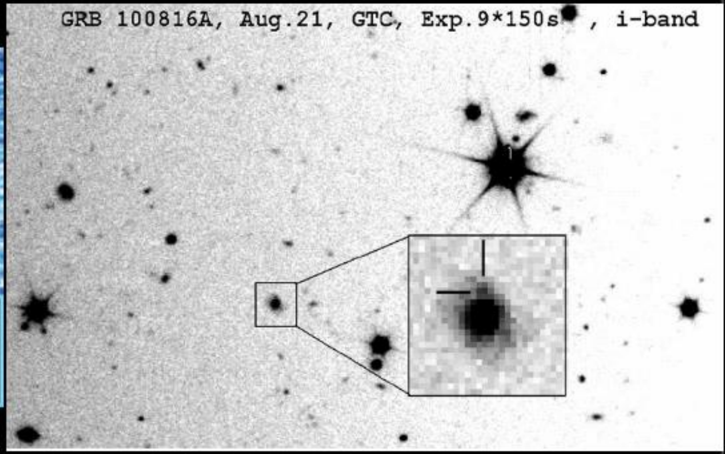


Gamma-Ray Bursts

Unusual GRB 101225A at z=0.33 from helium star/neutron star merger



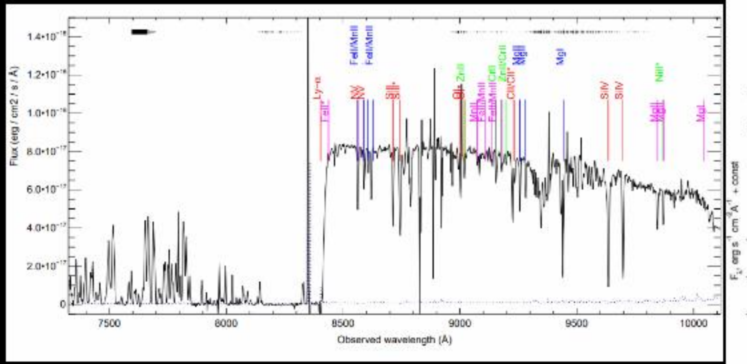
Thöne et al. 2011, Nature 480, 72



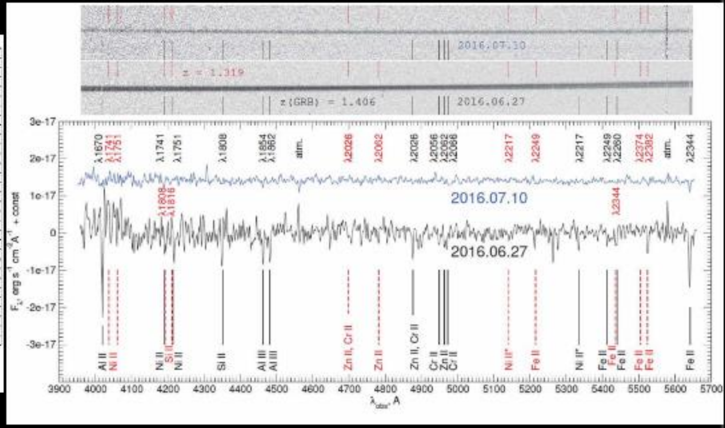
Gorosabel et al. 2010 (GRB 100816A)

High z allowed to measure ionisation degree of intergalactic medium between z=5 and 6, as well as and chemistry of host galaxy

Multiple bursts associated to transition from thermal to non-thermal radiation



Castro-Tirado et al. 2013 (z=5.9)



Zhang et al. 2018 Nature Astronomy 2, 69 (z=1.4)

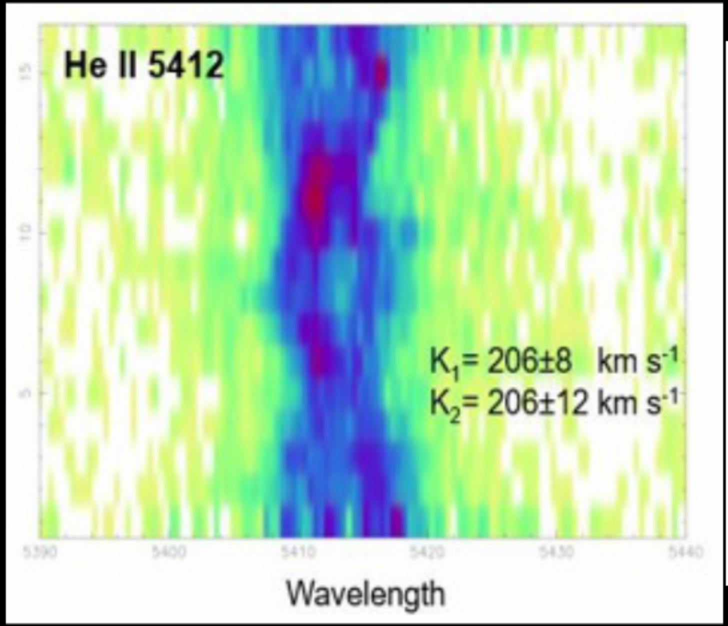
Black holes and compact binaries

SN Ia progenitors: Double-degenerate, super-Chandrasekhar nucleus of the planetary nebula Henize 2-428

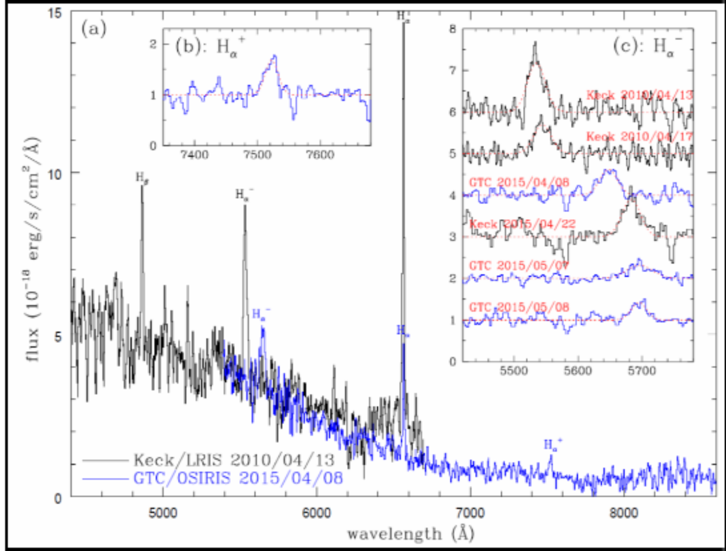
Microquasars: Relativistic baryonic jets from an ultraluminous supersoft X-ray source in M81

Black holes: Regulation of black-hole accretion by a disk wind during a violent outburst of V404 Cygni

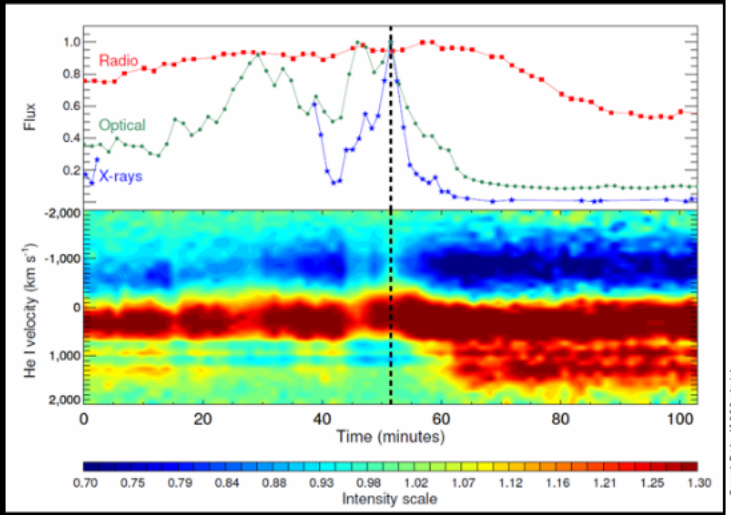
Black holes: Precise measurement of the magnetic field in the corona of the black hole binary V404 Cygni



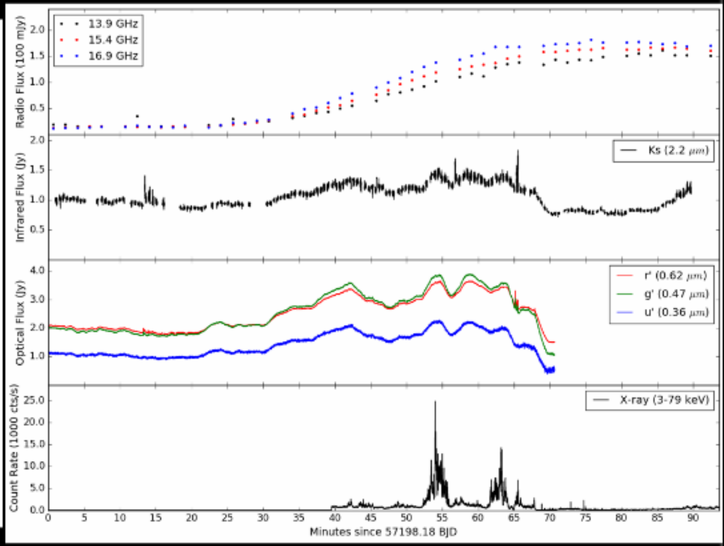
Santander-Garcia et al. 2015 Nature, 519, 63



Liu et al, 2015, Nature 528, 108



Muñoz-Darias et al. 2016, Nature, 534, 75

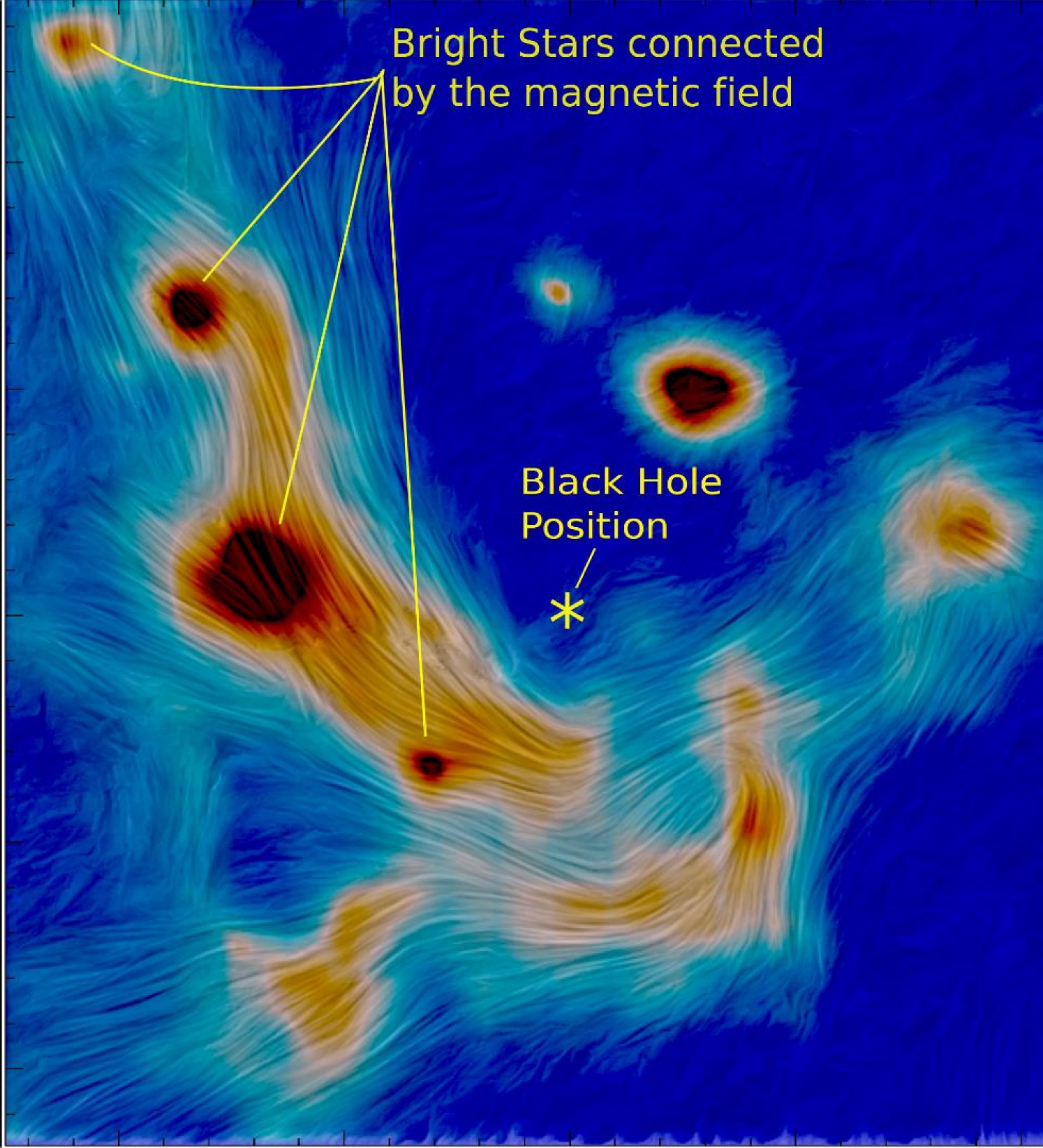


Dallilar et al. 2017, Science, 358, 1299

ISM magnetic field

Imaging polarimetry with CanariCam@GTC
at 10 μm allows measuring the magnetic field
in the central parsec of the Galaxy
using the polarization of dust grain emission
due to their alignment in presence of the field

Roche et al. 2018 MNRAS, 476, 235



Sinergies at ORM

ORM will soon have a powerful combination of Cherenkov and optical/IR telescopes

Opportunity for several years leadership

New projects will strengthen this potential, such as a 4m fully-robotic telescope under developed by Univ. Liverpool, IAC, and Univ.Oviedo

At GTC, we have also started an open process to define GTC instrumentation 2025+.
Concept papers to be submitted by Nov 2018.
Focus on time-domain, MW and MM astrophysics?