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THE MEERKAT REVOLUTION

RADIO JETS IN X-RAY BINARIES: TOWARDS THE SKA

The Fifth National Workshop on the SKA Project
24-28 November 2025, Bologna

MeerKAT

A precursor of the SKA - Inaugurated in 2018

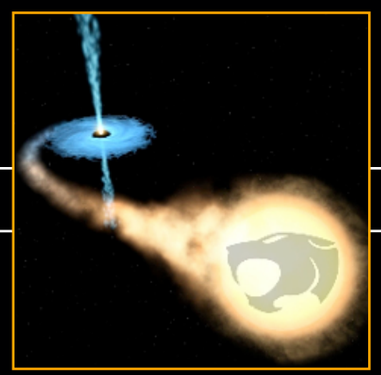
64 (+14 as MeerKAT+) 13.5 m dishes - multi-frequency (GHz) receivers

Radio

2018

MeerKAT comes online

ThunderKAT



XRBs, CVs, GRBs, SNe

2022

BowKAT

Large scale jet structures

2023

JetKAT

High-res jet monitoring

X-KAT

BH and NS XRBs

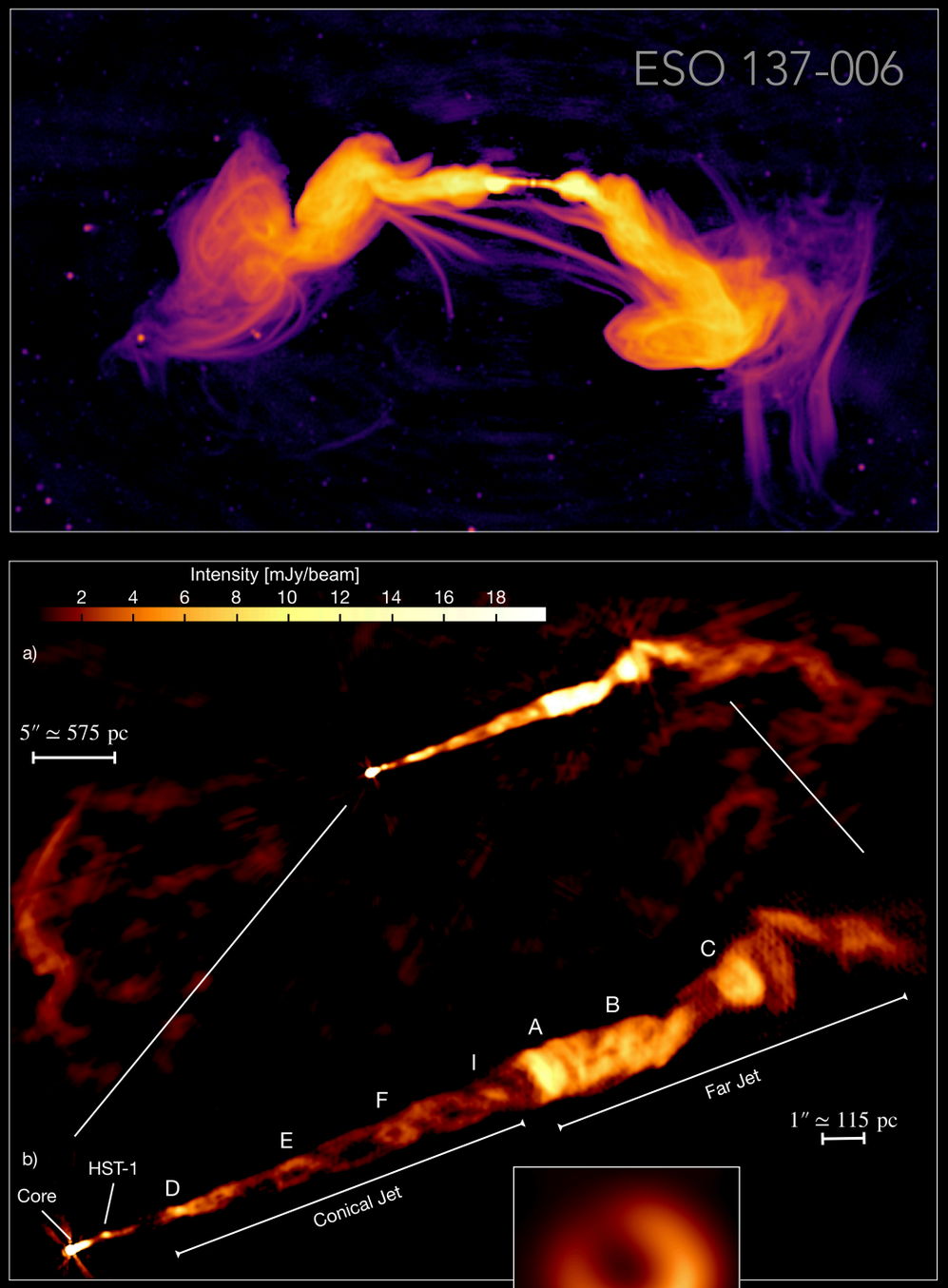
X-rays

2018

SwiftKAT

… as long as possible

Amazing detailed jets



MeerKAT - ESO 137-006

VLA - M87

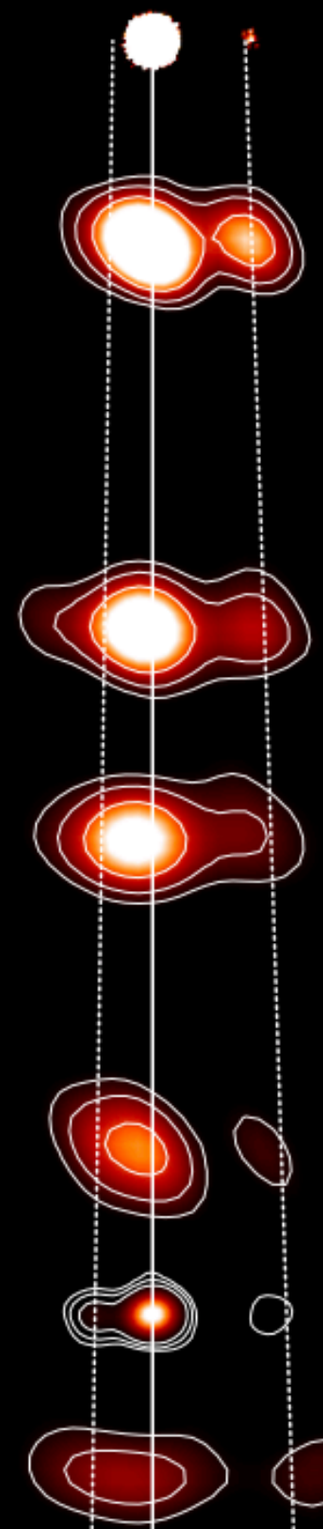
EHT - M87

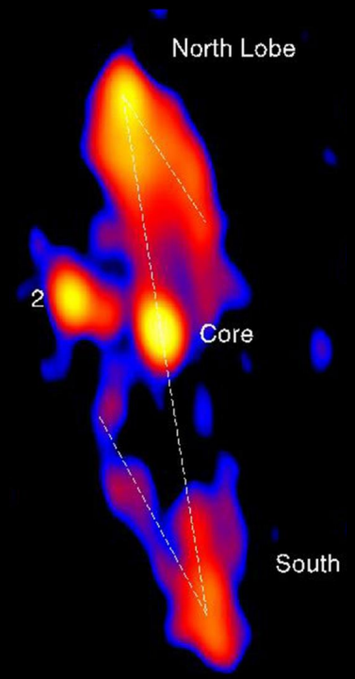
Super-massive black holes

X-ray binaries

Mostly moving blobs

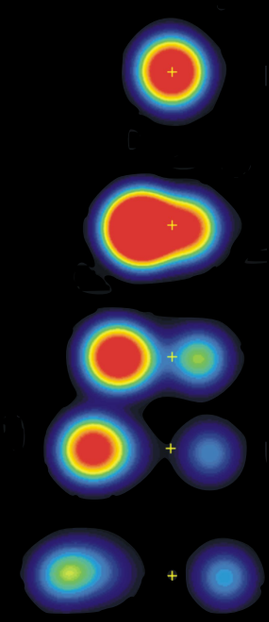
(in a complex ISM)





MeerKAT - MAXI J1820+07

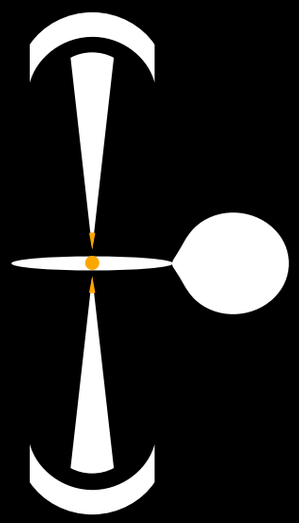
VLA - GRS 1758-258



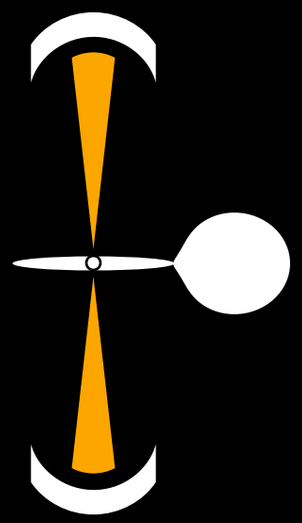
VLA - GRS 1915+105

JETS IN X-RAY BINARIES

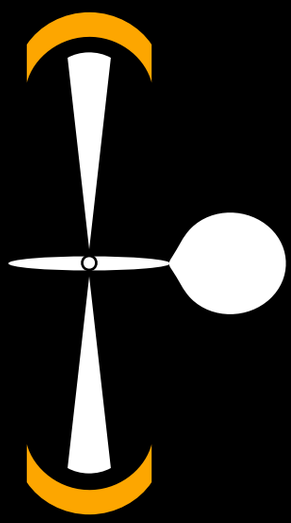
Core jets

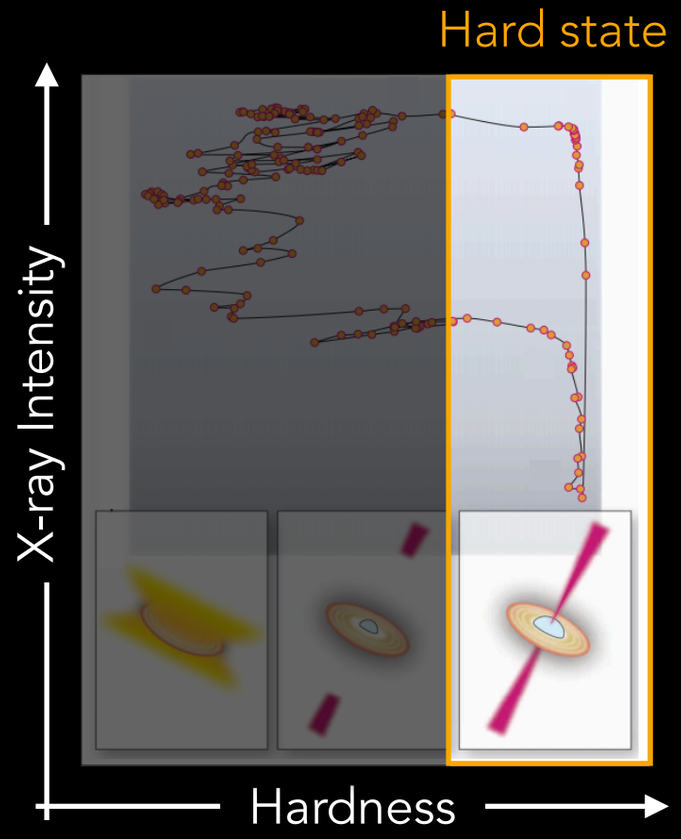


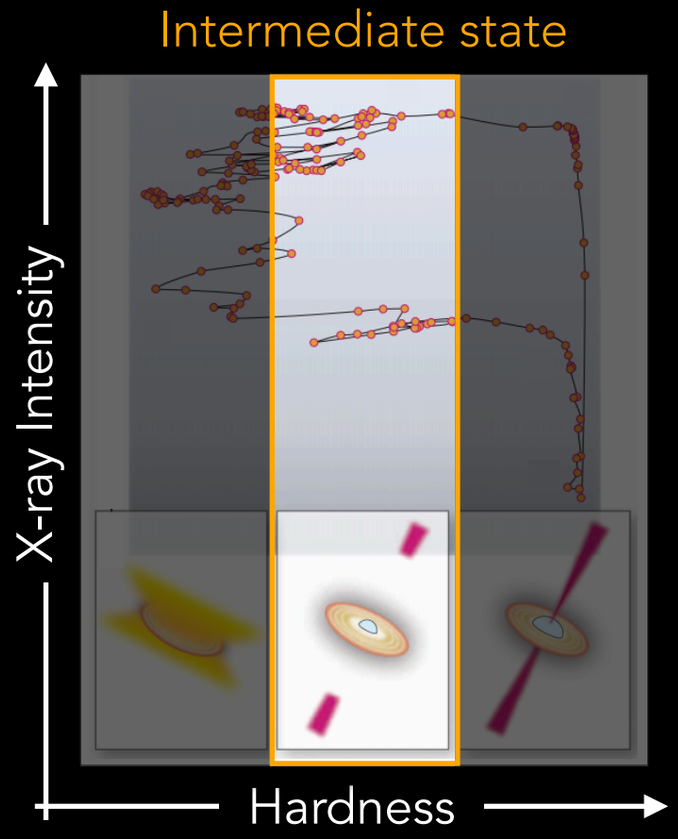
Transient jets

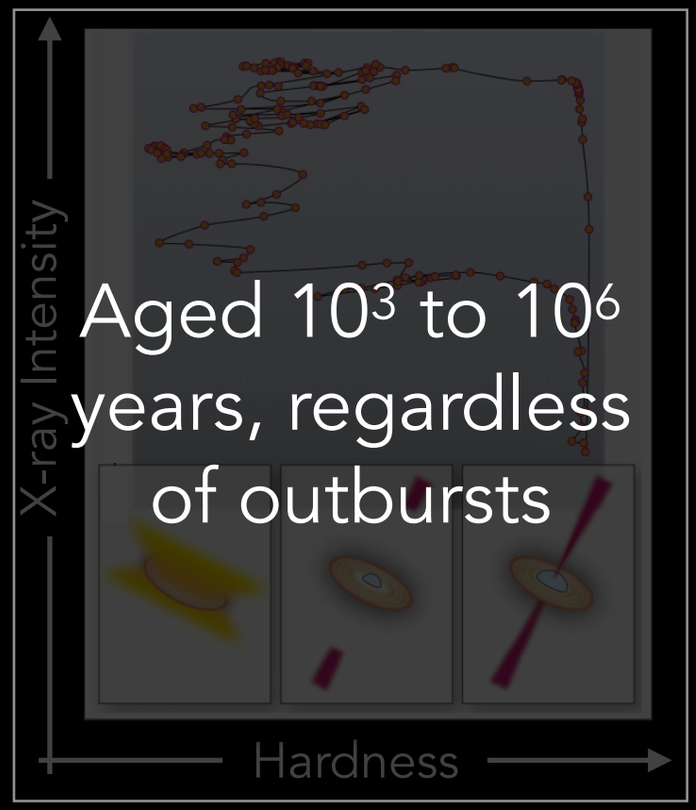


Large scale jet structures



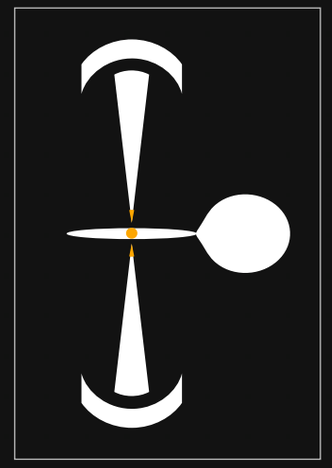






Fender & Belloni 2012

SAMPLING THE RADIO:X-RAY PLANE



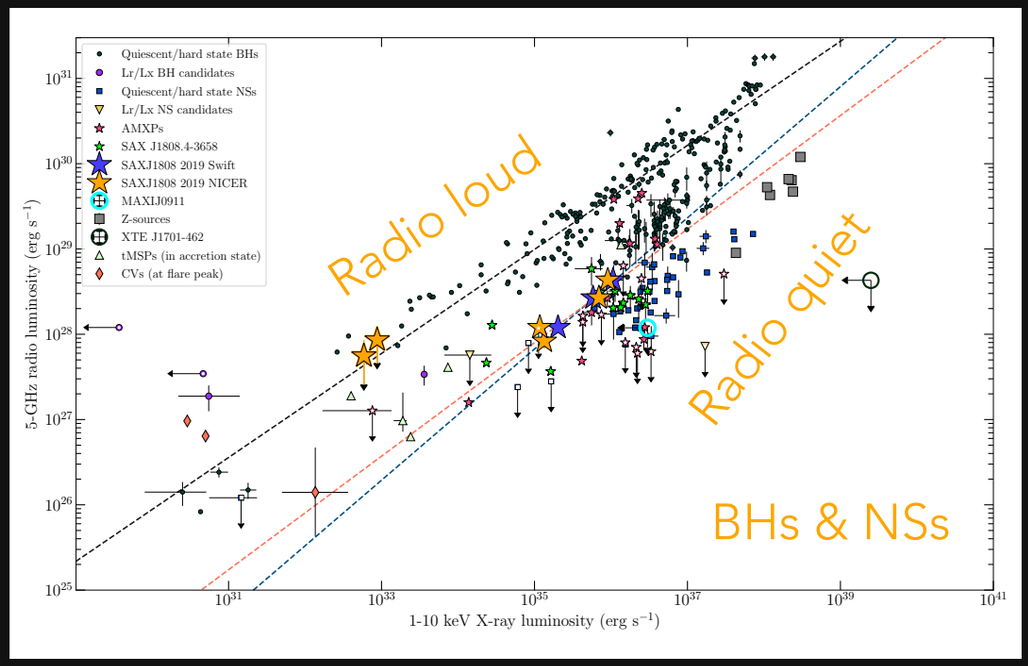
MeerKAT sample:

now > 1200 points

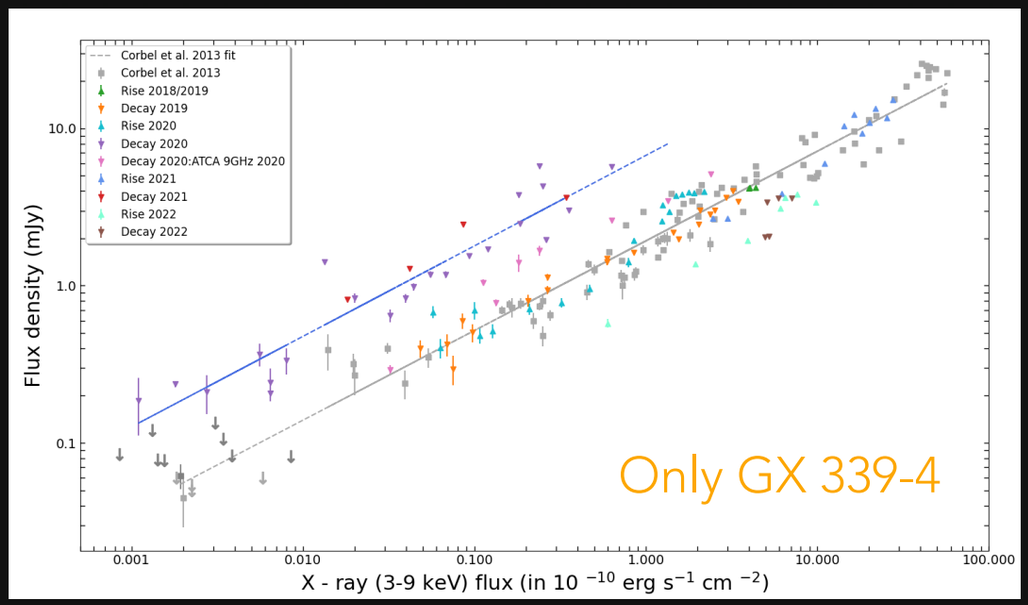
Previously ~400 points

Radio-quiet sources are very common

Parallel tracks from the same source



Gaseallahwe et al. 2022

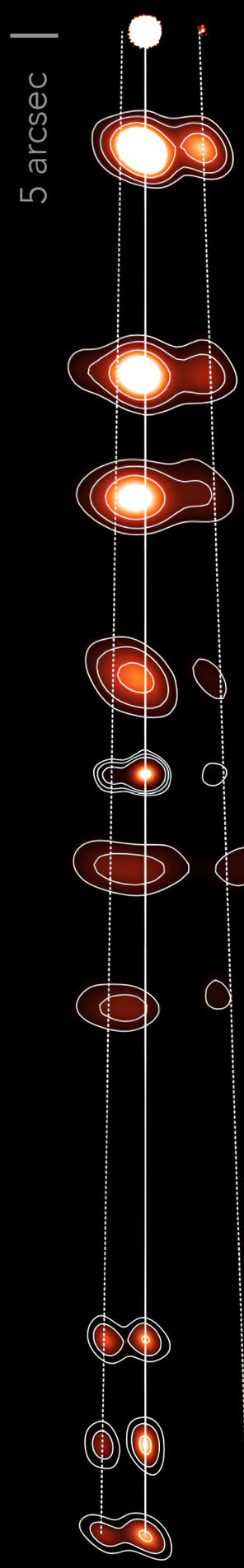


Tremou et al. 2024

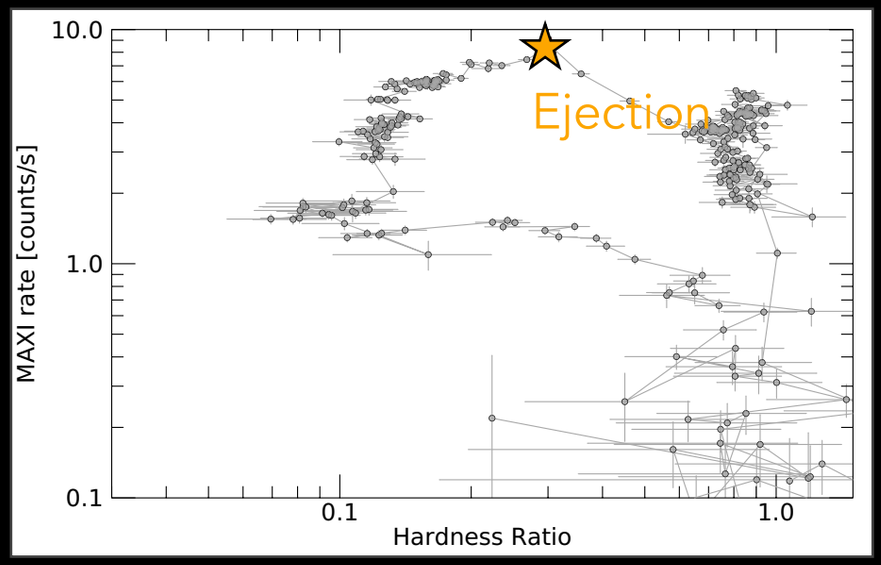
A brief history of how MeerKAT accidentally revolutionised the field of XRBs: the discovery of large-scale transient jets

A few highlights from the KATs

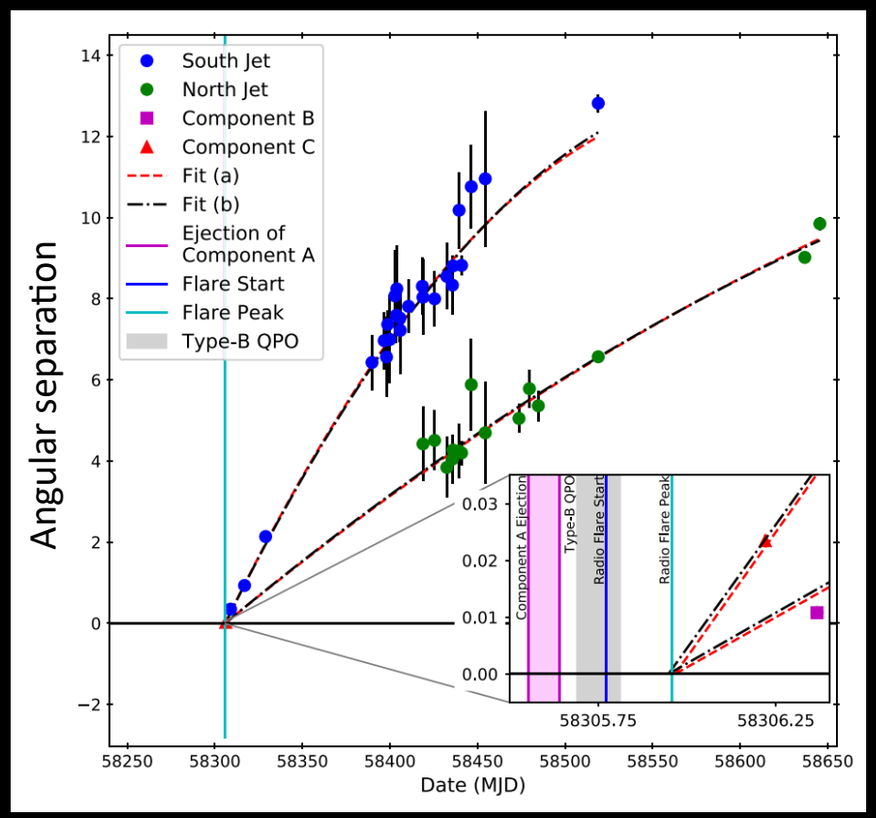
TRACING BLACK HOLE TRANSIENT JETS



Bright et al. 2020



Wood et al. 2021



MAXI J1820+070

The first large scale jets from an XRB

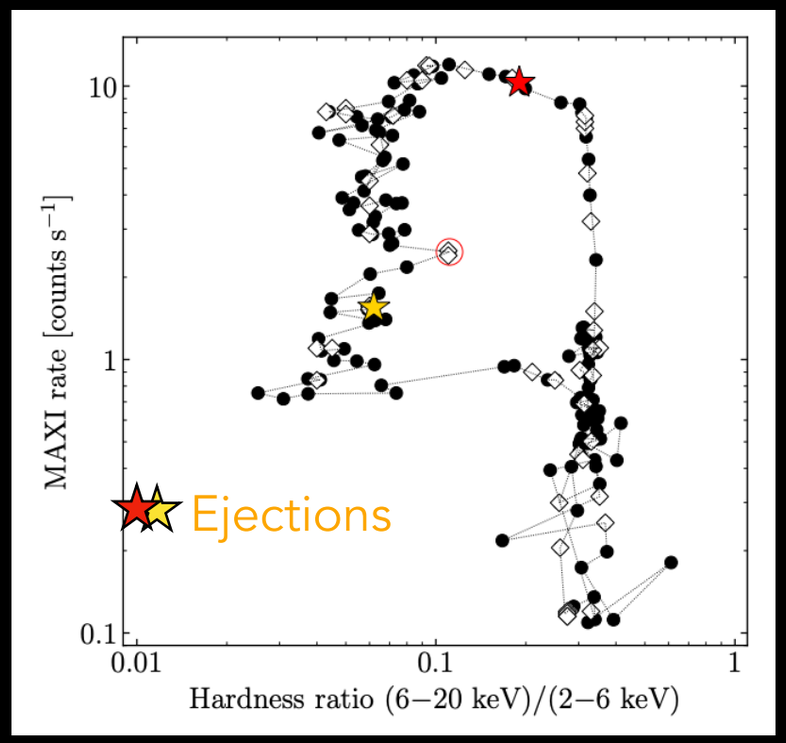
Slow jets tracked for over a year to a separation of ~12″ (~parsec), launched at accretion state change

Fast jest launched at peak of radio flare (Γ~2)

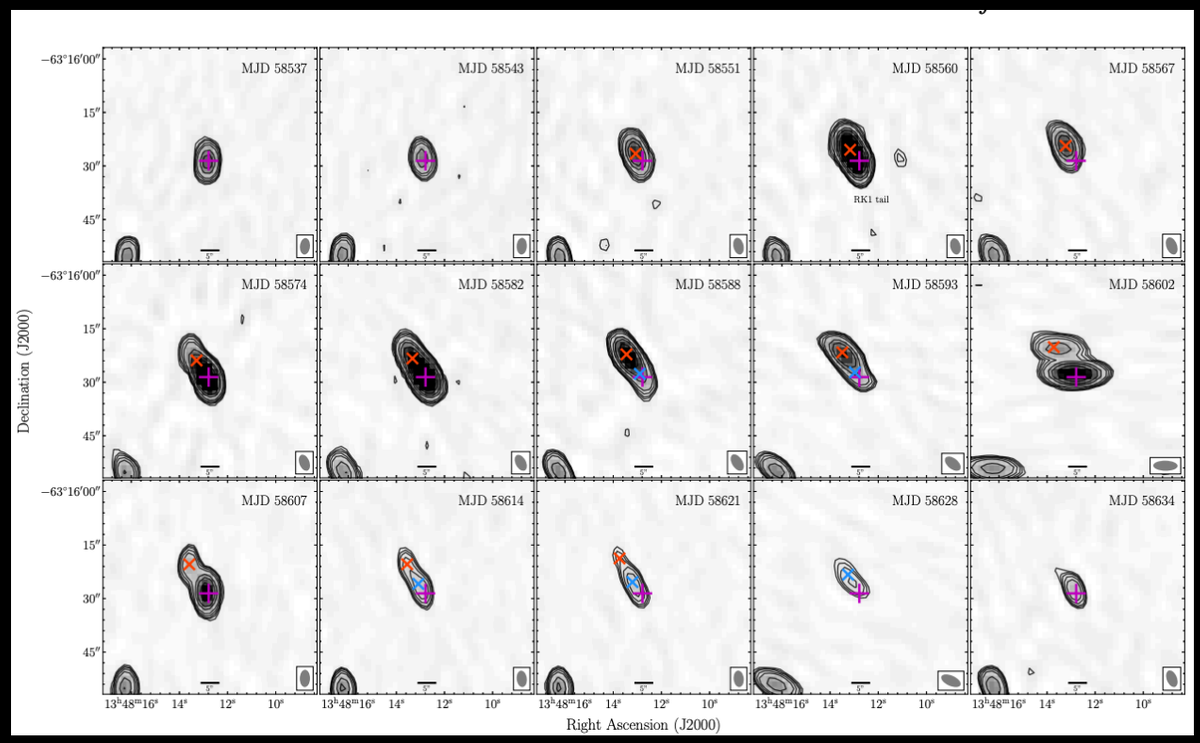
See Francesco Carotenuto's talk

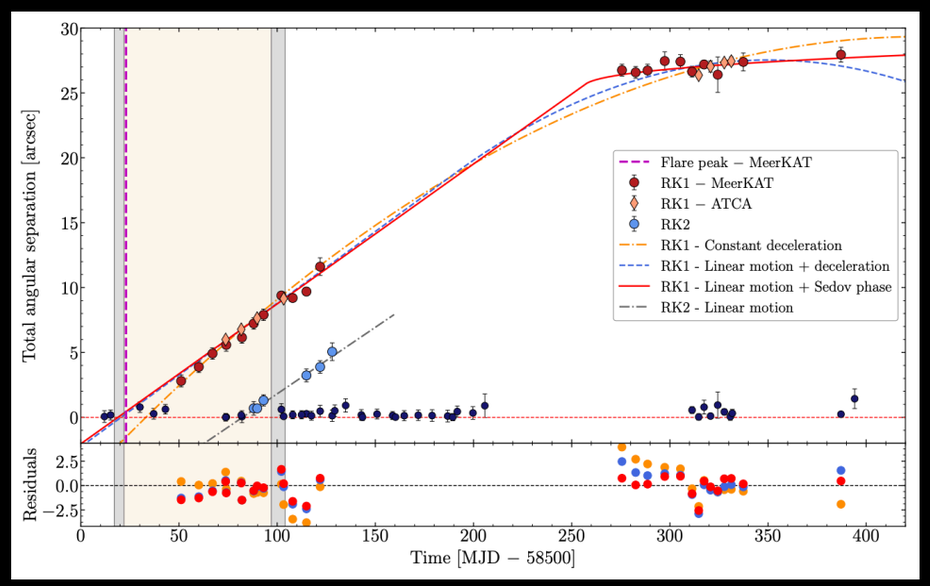
THE DECELERATING JETS FROM MAXI J1348−630

See Francesco Carotenuto's talk



Carotenuto et al. 2021a,b

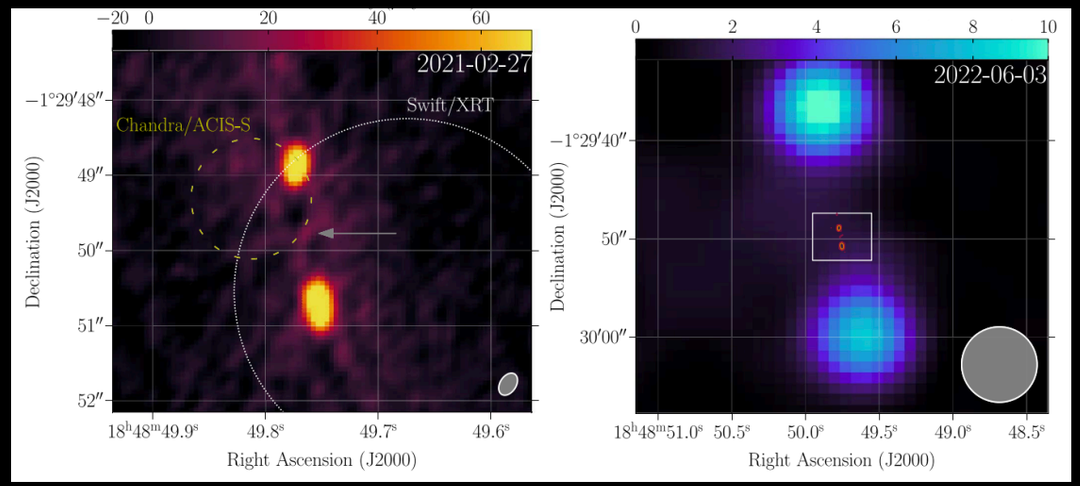




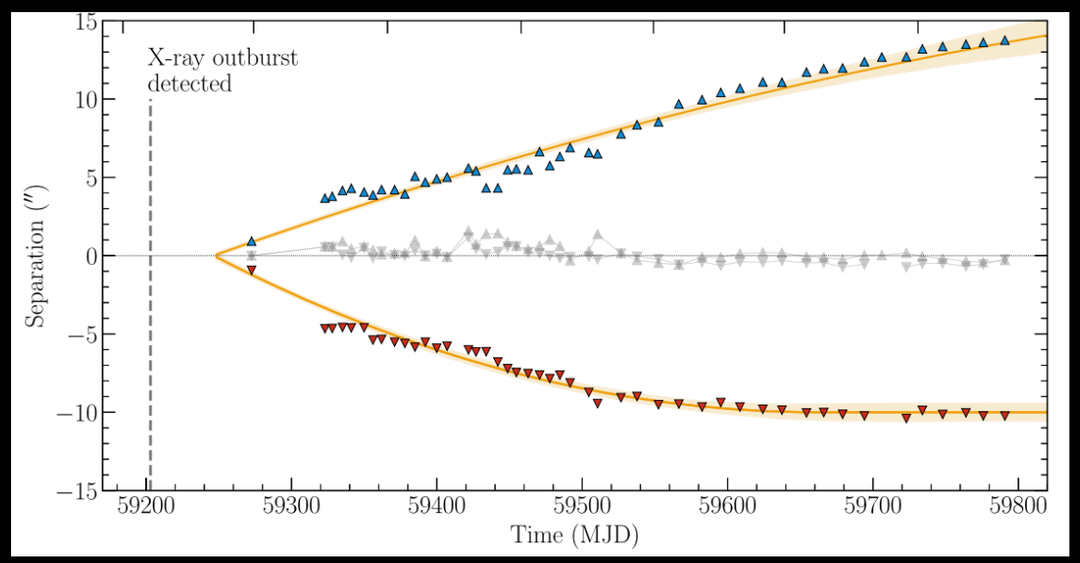
Large scale decelerating jets, expanding to ~30". The fastest jets from an XRB at that time (Γ>2)

BIPOLAR JETS FROM MAXI J1848-015

The first example of a jetted black hole in a globular cluster



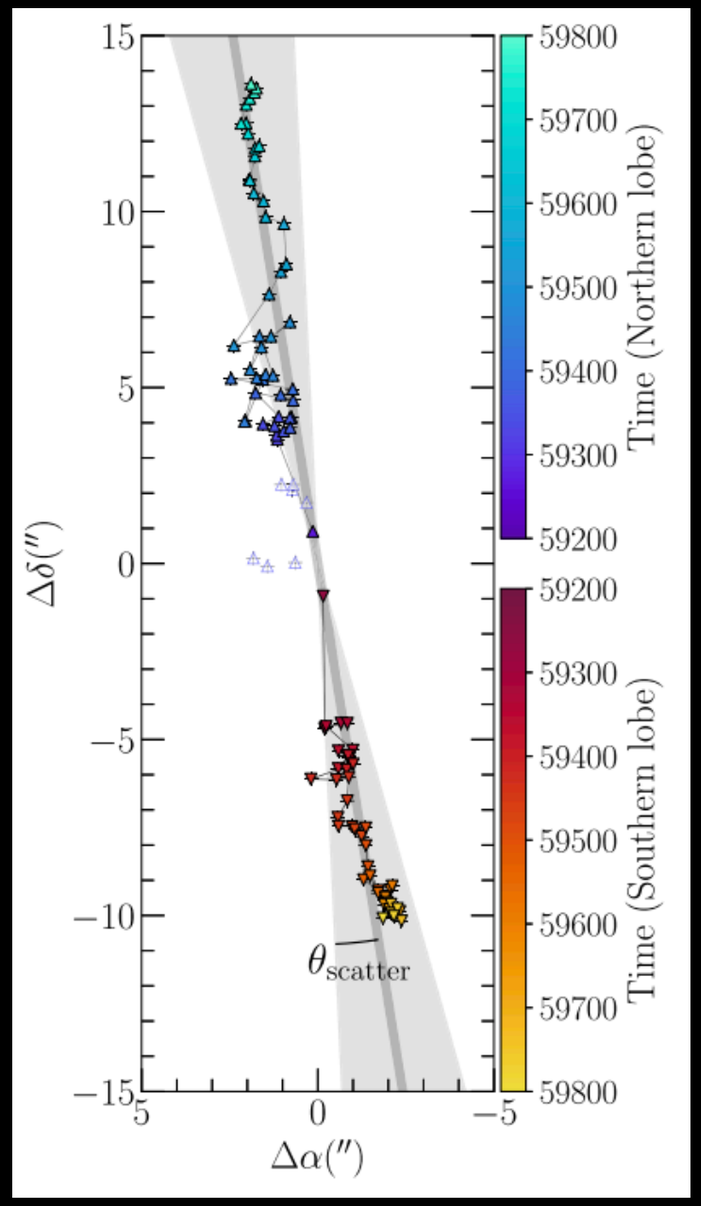
VLA data



South North

Bahramian et al. 2023

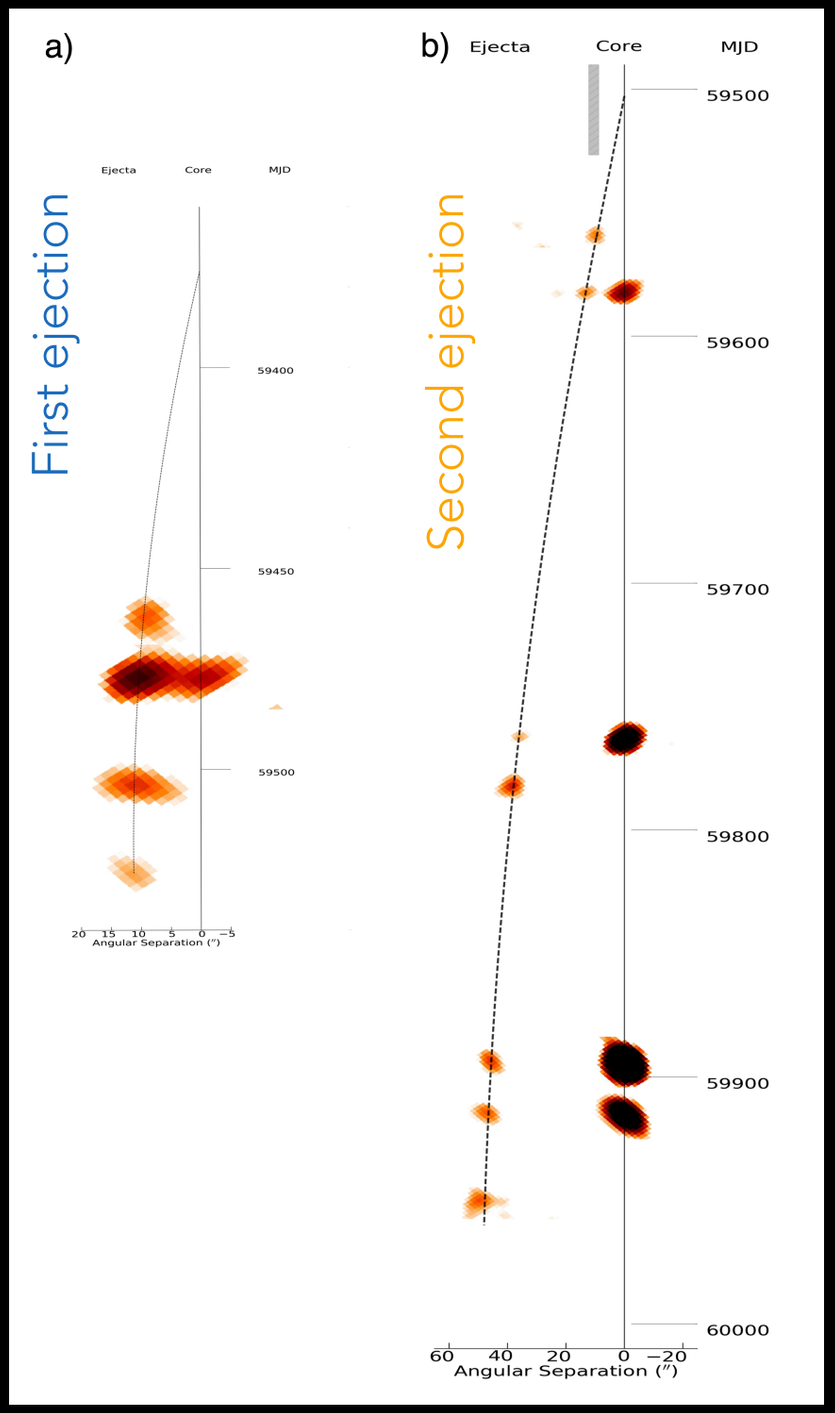
MeerKAT data



South (receding jet) North (approaching jet)

Bahramian et al. 2023

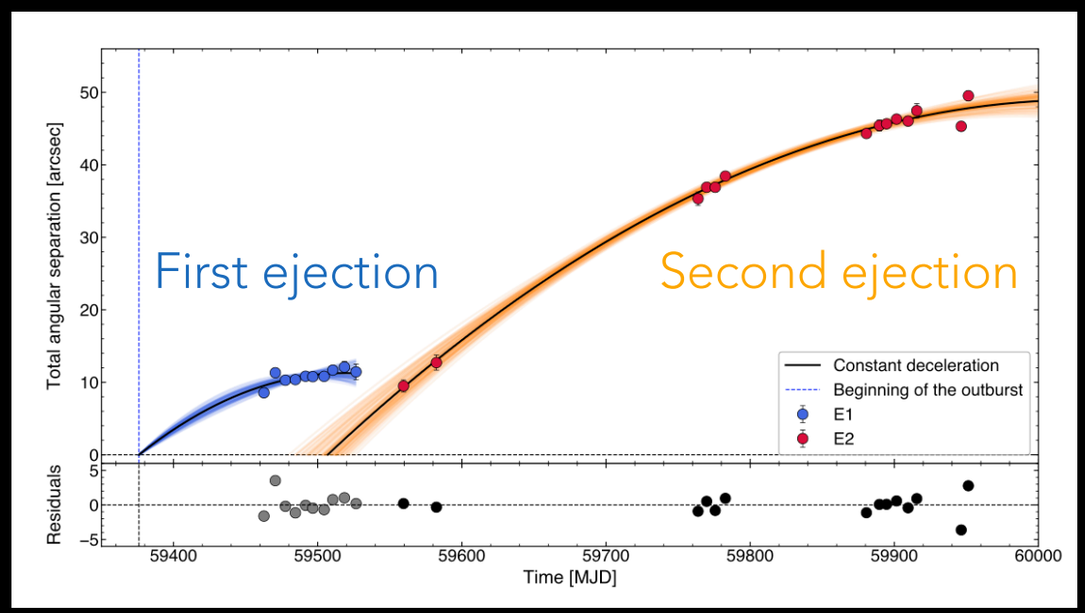
THE FASTEST JETS IN OUR GALAXY (FOR NOW): 4U 1543-47



Zhang et al. submitted (2025arXiv250411945Z)

Absolute minimum Lorentz factor is 5

Jets from BH XRBs may be as relativistic as AGN jets.



Thanks to MeerKAT

the XRB jets sample is now statistically significant

We have the first statistically robust results on the properties of jets from low mass XRBs

Fender & Motta 2025 (Nat.As.)

Fast Jets

> 0.7 c

Exclusively
from black holes

Propagate along the
same direction

Locked to the black hole
spin axis

Slow Jets

< 0.7 c

From both black holes and
neutron stars

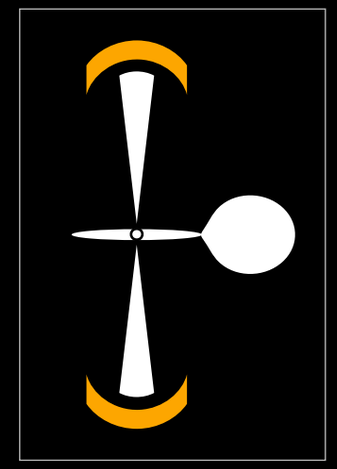
Slow jets can precess or
change angle

Launched from the
precessing disk

No correlation between jet speed and the spin

Fender & Motta 2025 (Nat.As)

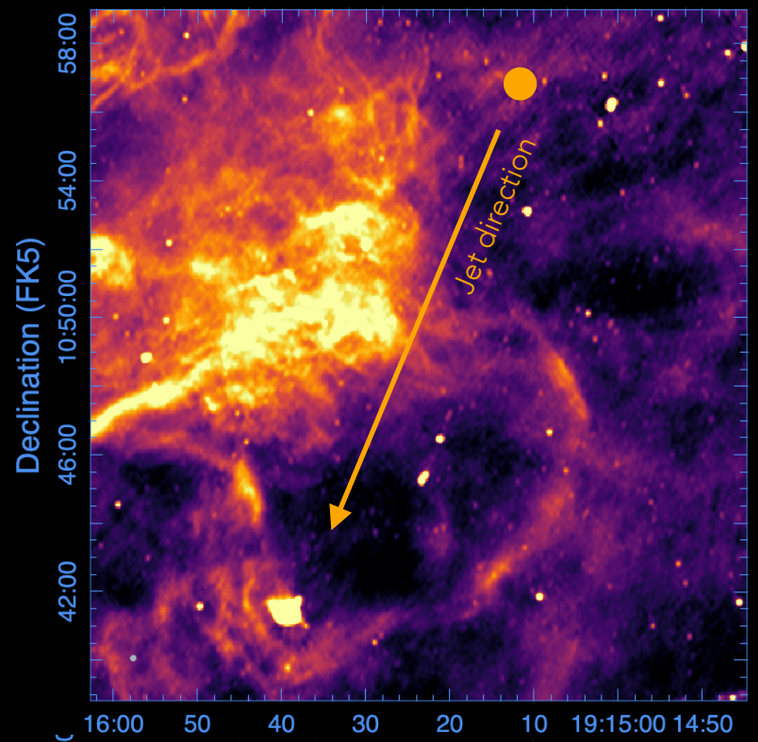
EXTENDED JET STRUCTURES



Jets from XRBs carve huge cavities (> pc) in the ISM, aged kyr to Myr

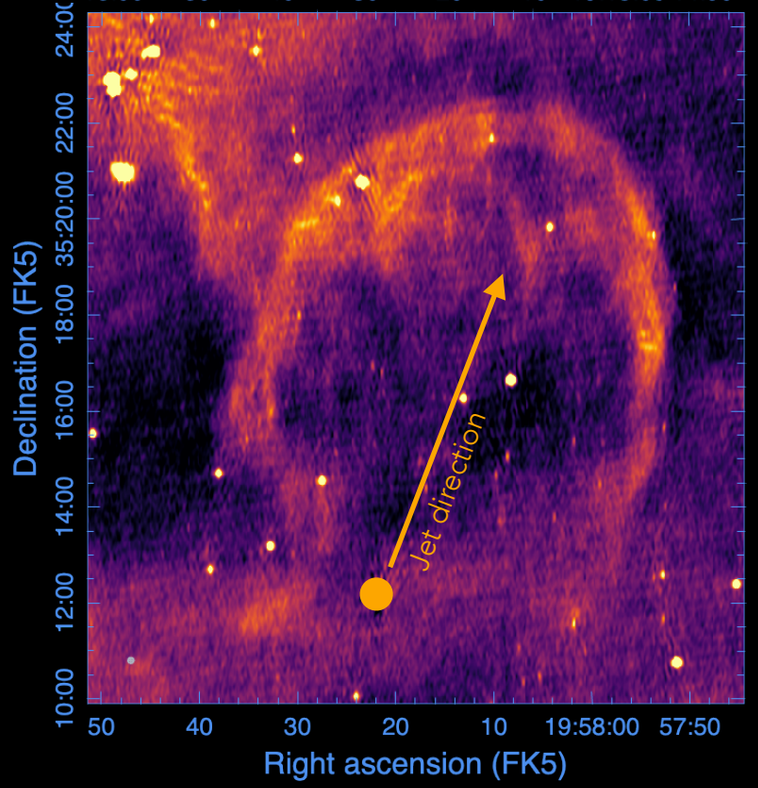
The energy transferred is comparable with the accretion energy ~ 10^{34} -10^{40} erg/s

GRS 1915+105 *"THE microquasar"*



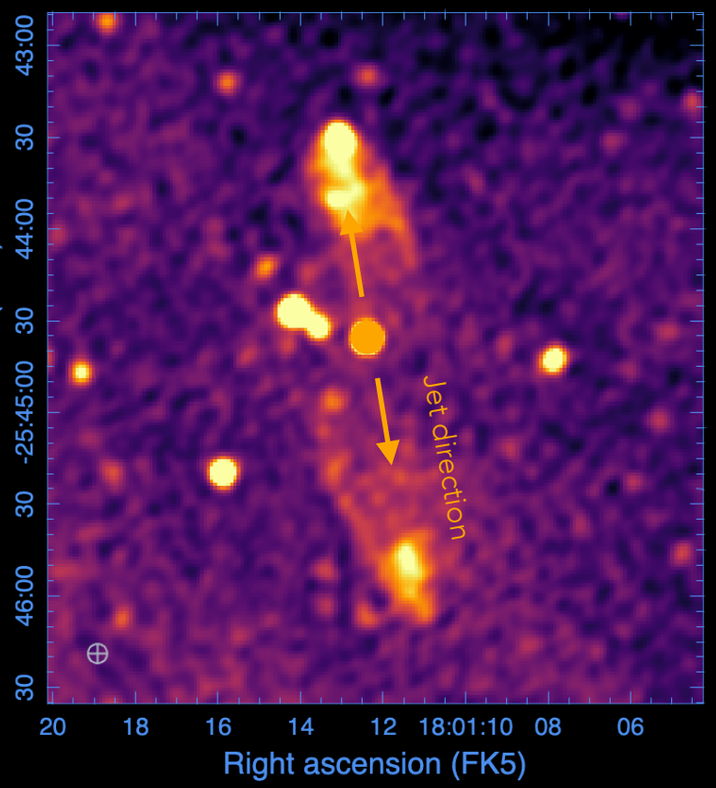
Motta, Atri et al. 2025

Cyg X-1



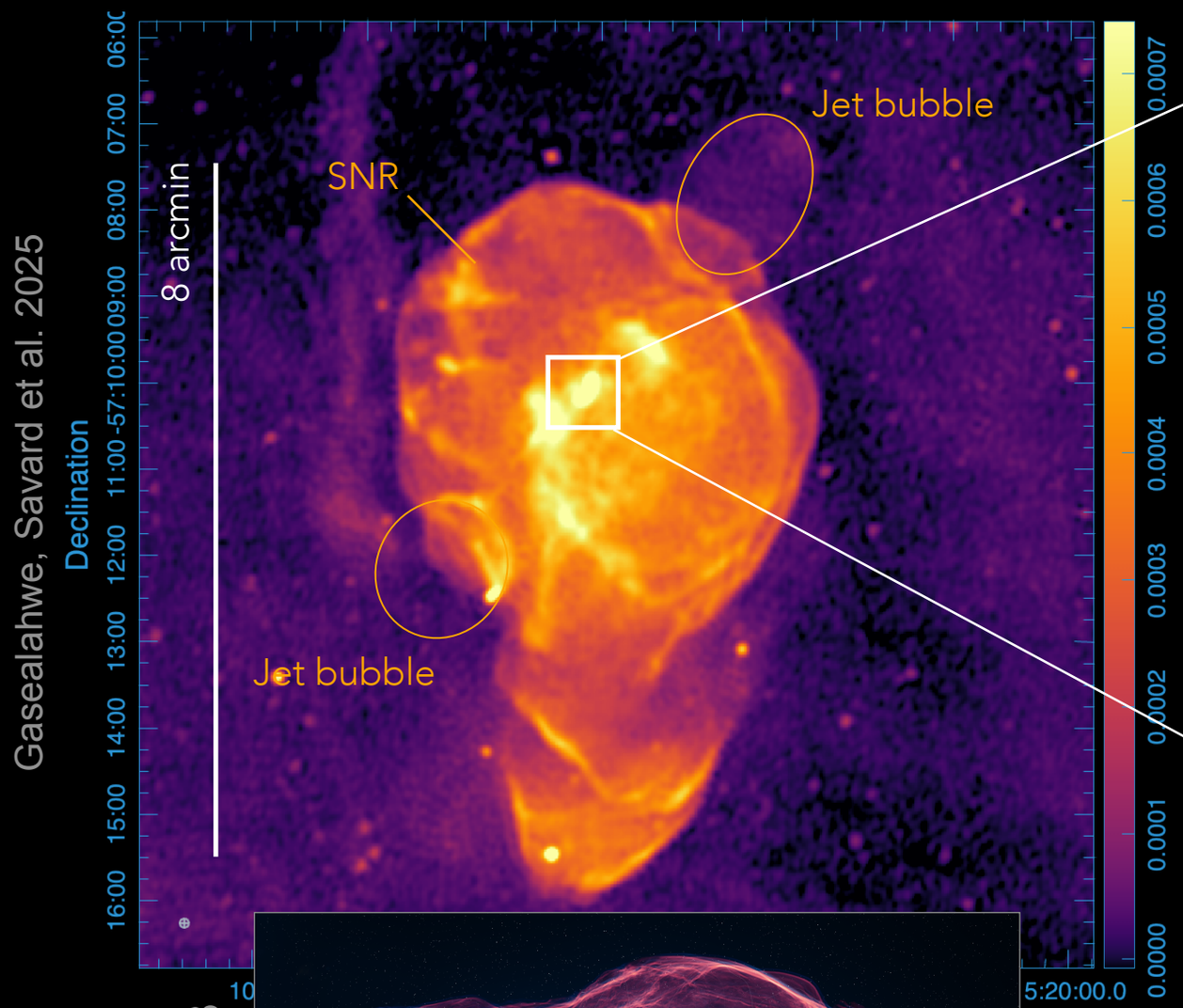
Atri, Motta et al. 2024

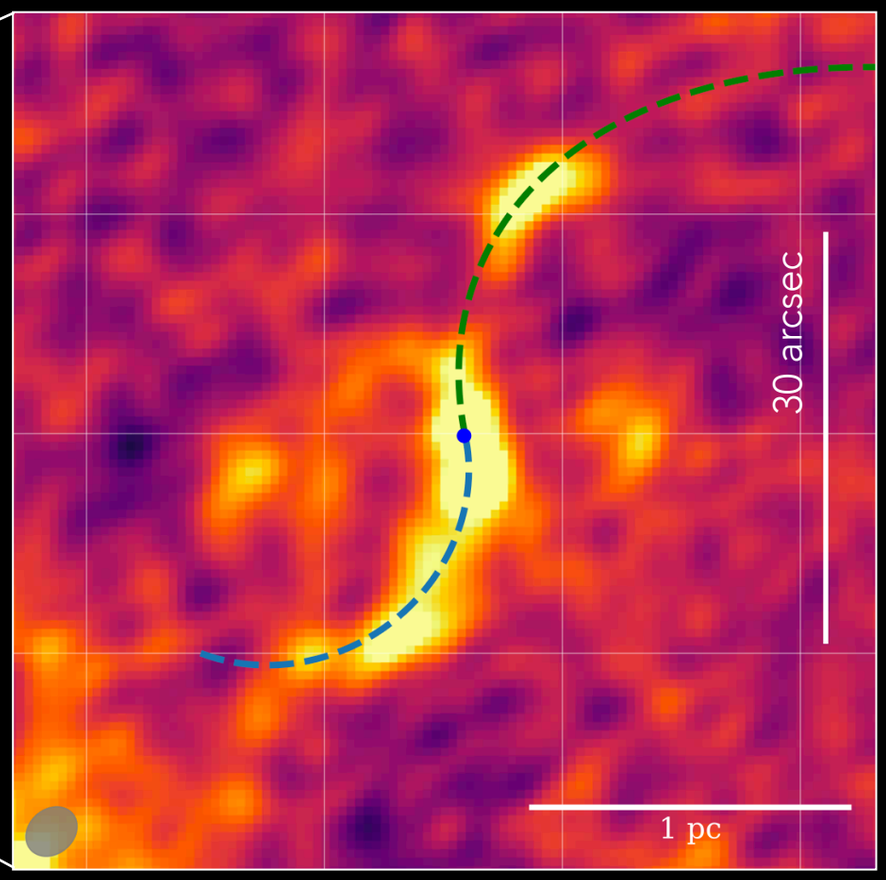
GRS 1758-258

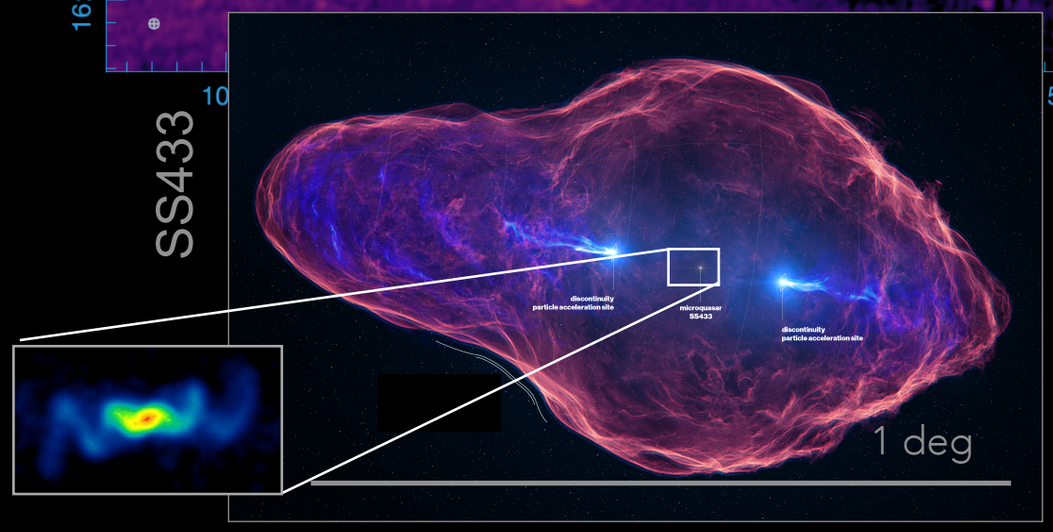


Mariani, Motta et al. 2025

EXTENDED JET STRUCTURES AROUND NEUTRON STARS







Cir X-1: a southern SS433

A jet-powered nebula and relativistic precessing jets

ALL WE DO WITH MEERKAT, WE'LL DO BETTER WITH THE SKA

SKA w.r.t. MeerKAT	*Transient jets*	*Large scale jet-ISM interaction regions*
Better angular resolution and surface brightness sensitivity	More events, form earlier times, including fainter one	Unveil a population currently below sensitivity threshold
Better uv-coverage and sub-arraying	Constrain size, probe variability and spectral info	Improved morphological information and spectral info
Improved survey speed and image fidelity	Many more transient events, better sampled in time	Population studies independent of outburst activity

If MeerKAT is amazing, SKA will be incredible

"... But an infrastructure almost never builds its legacy on the science cases defined before the instrument is built. It's always the unknown that defines it." - F. Zerbi

The SKA science will be great, especially the one we will discover on the way

Thanks