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STÉPHANE CORBEL (AIM/ORN)

NEW RADIO OBSERVATORIES AND HIGH ENERGY TRANSIENTS

OUTLINE

- The transient high-energy (and radio) sky
- Stellar deaths, GRBs and TDEs
- NS-NS mergers and GWE
- XRB, a recent illustrative example with MeerKAT
- New observatories to come

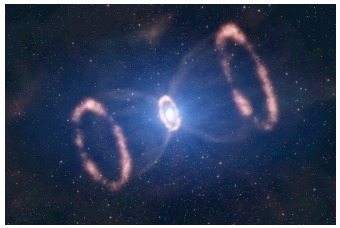
Some figures extracted from Miller-Jones (SKA/ngVLA conf.)

RADIO TRANSIENTS

- Exploring the extreme events in the Universe: brightest, fastest, hottest, densest, most massive, most magnetized, …. + the Unknown !
- Probing the Universe on cosmological distances.
- The various transients can be divided in two categories:
  - **Coherent** ($T_b > 10^{12}$ K), observed in beamformed data; short duration : **fast transients** (pulsars, FRB, RRATS,…).
  - **Incoherent** synchrotron from explosive events ($T_b < 10^{12}$ K), images, **slow transients.**

VARIABLE HIGH ENERGY TRANSIENTS

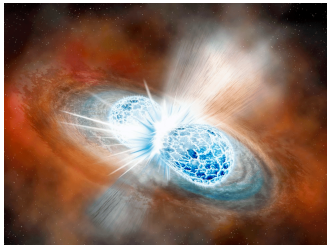
Black holes grows: accretion and mergers



Normal supernova

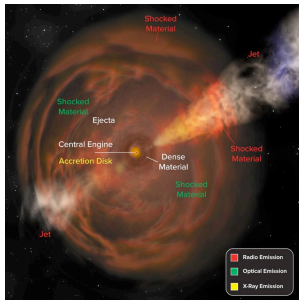
Gamma-ray burst (GRB)

Tidal disruption event (TDE)

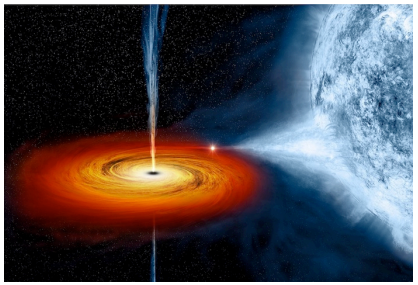


NS merger = GRB = GWE

Stellar deaths



Fast blue optical transient

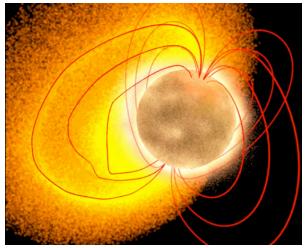


X-ray binaries = XRB

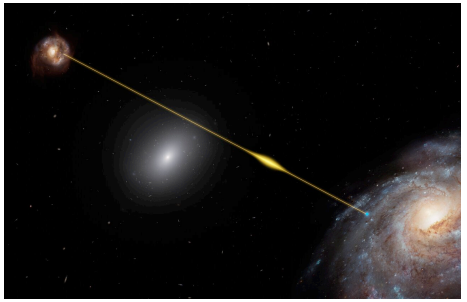
+ ?

Fast transients

Pulsars



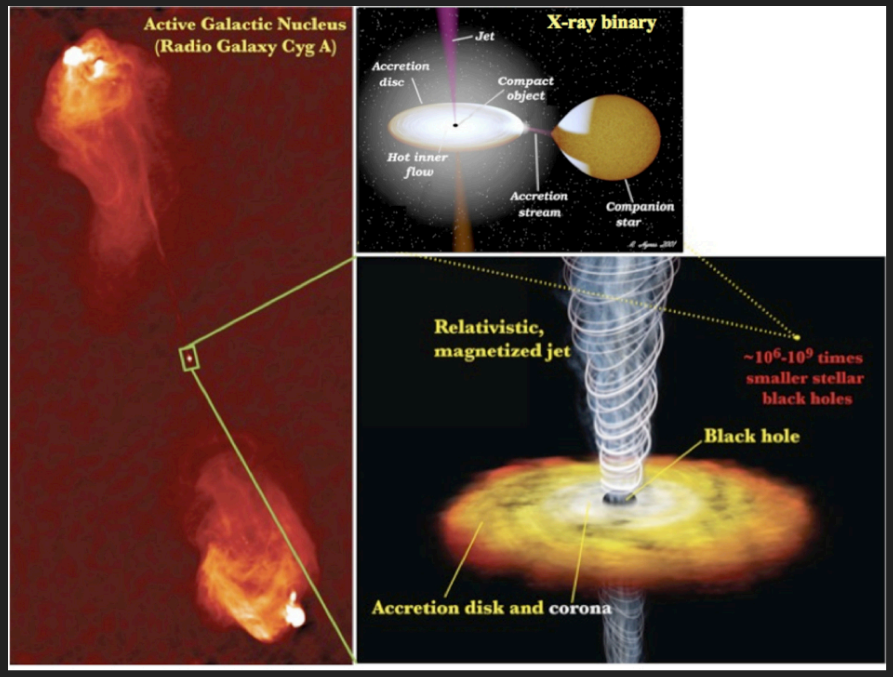
Magnetars



Fast Radio Burst (FRB)

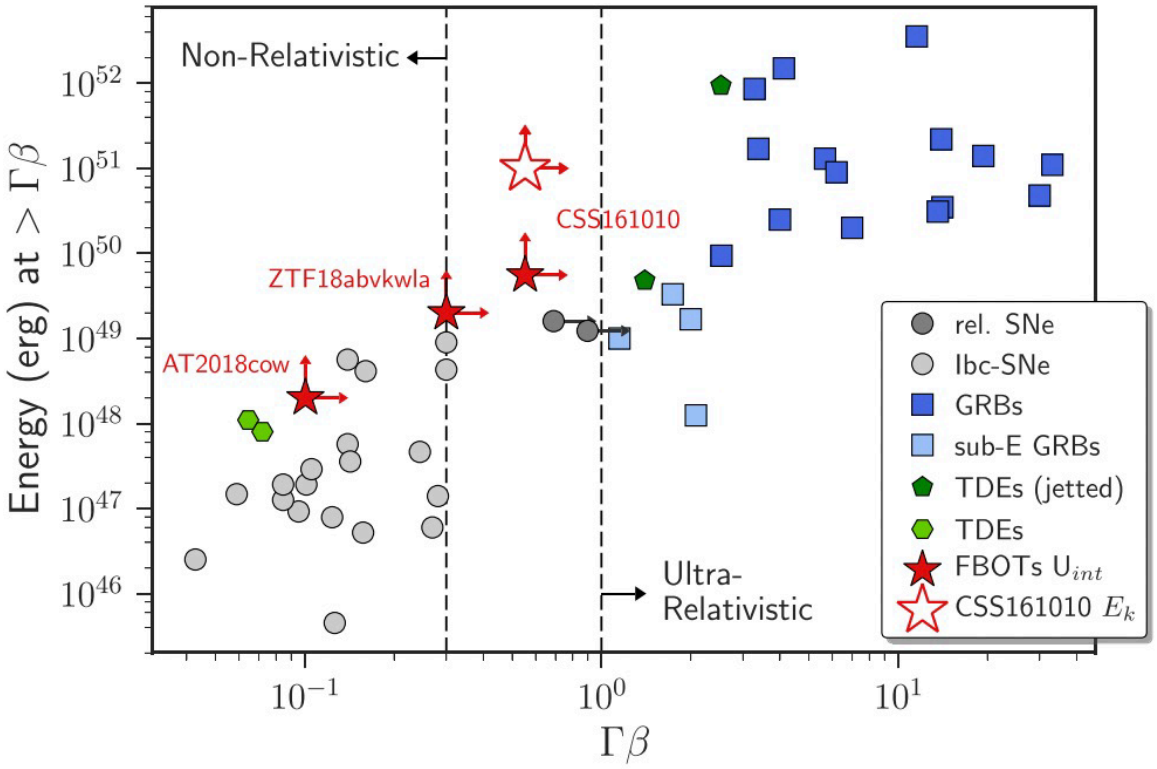
RADIO X-RAY SYNERGIES

- Accretion processes (X-ray emission) ubiquitously associated with relativistic outflows (radio emission)
- The X-rays probe the rate and conditions in the accreting matter, the radio traces the kinetic feedback to the local environment

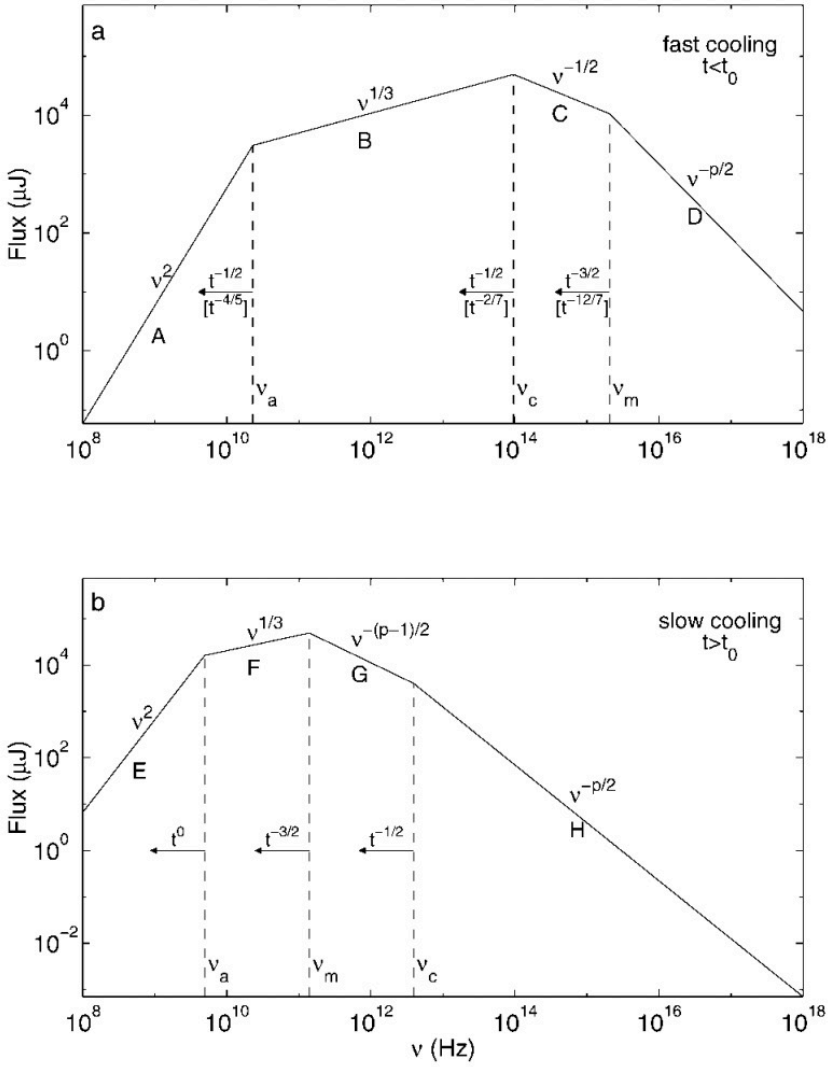


A WIDE VARIETY OF EXPLOSIONS

Sari et al. 1998

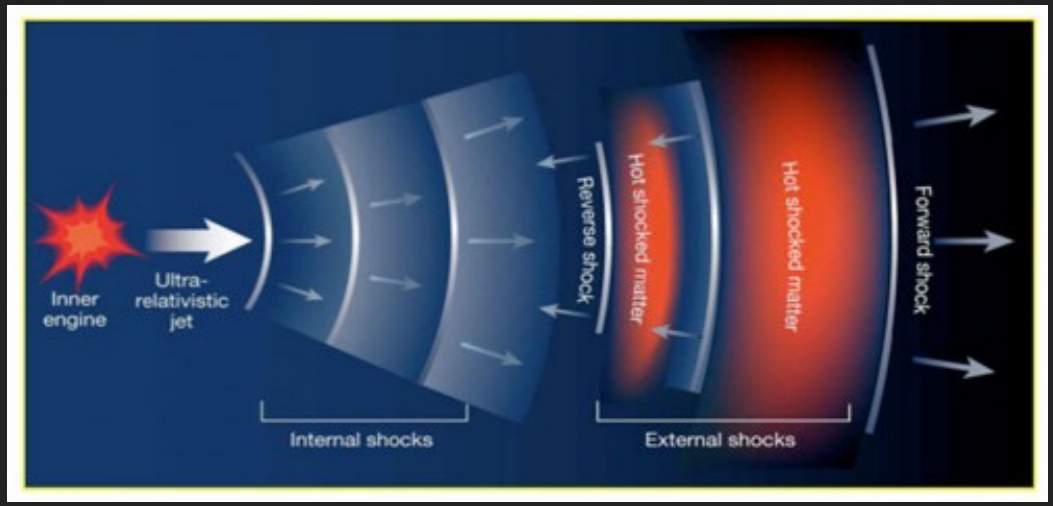


Coppejans et al. 2020



GRBs: ULTRARELATIVISTIC OUTFLOWS

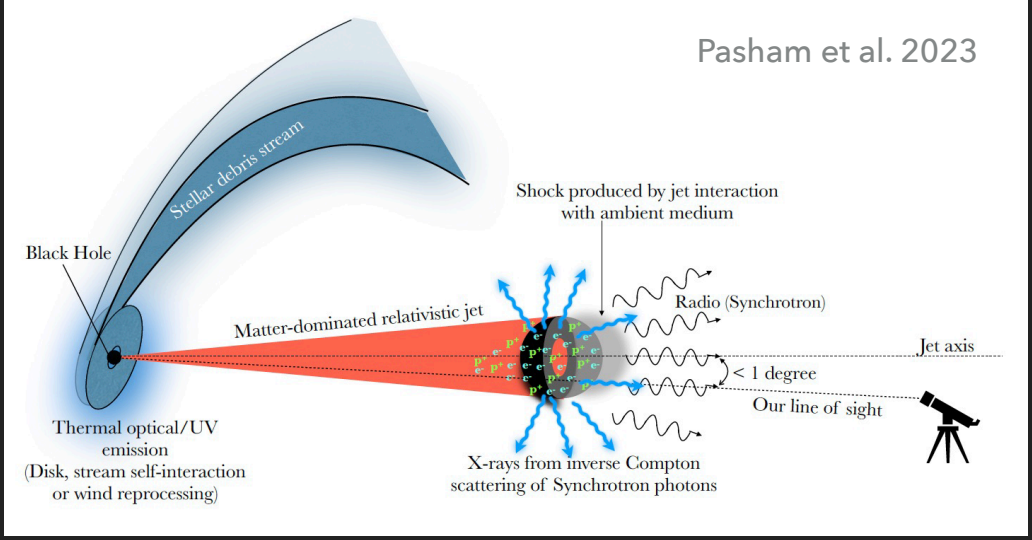
- Forward shock probes
  - Circumburst density
  - Total burst energy
  - Jet collimation
- Reverse shock probes:
  - Jet Lorentz factor
  - Jet composition
  - Jet magnetization

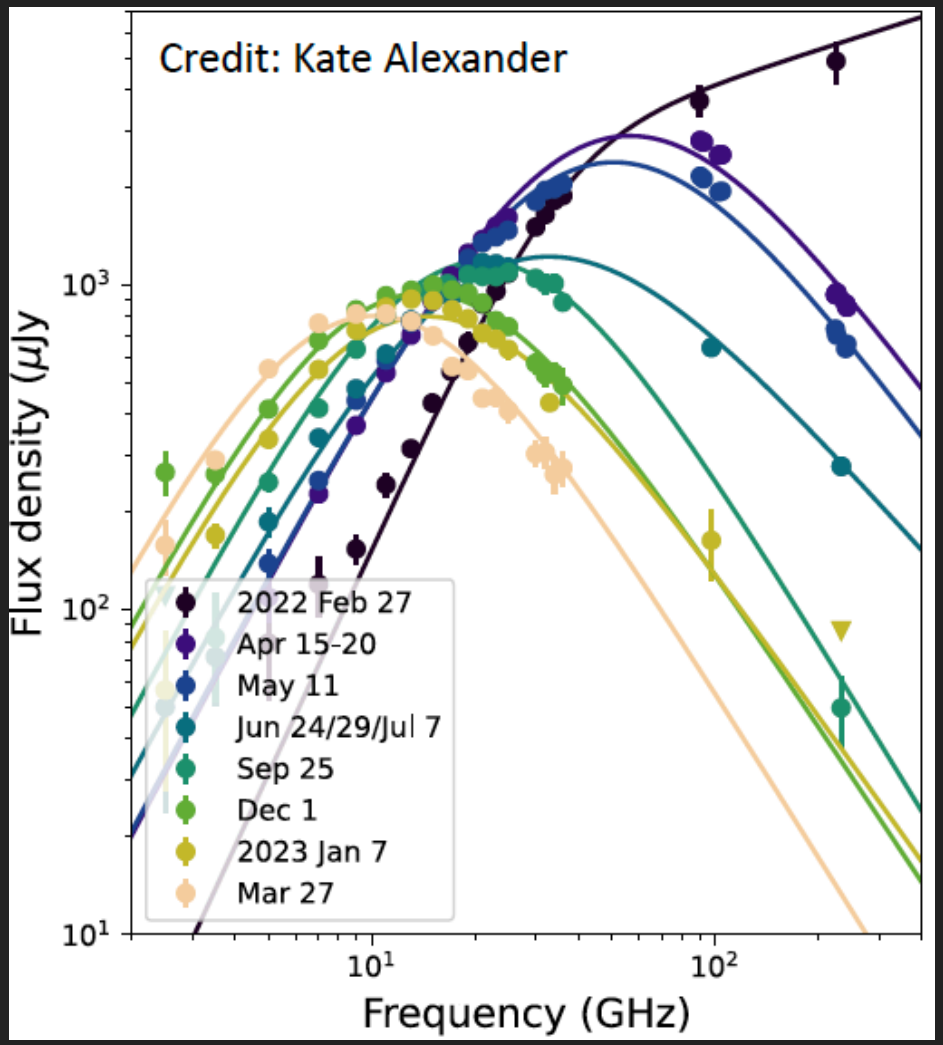


- Distant GRBs probe the first BHs
  - z= 9.4 (possibly 11)

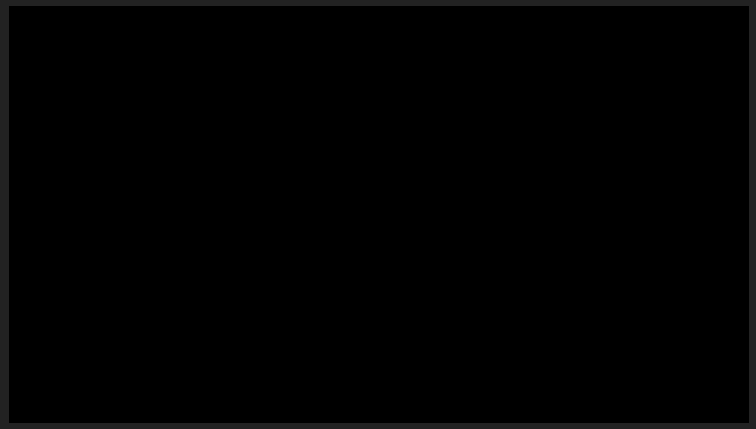
JETTED TDEs: HOW DO SMBHs LAUNCH JETS ?

- Jetted TDEs are rare – few percent
  - Visible out to z>1
  - Probe density profiles at pc scales
  - Accretion history
  - Spatial association with a HE neutrino (Stein et al 2021) ?



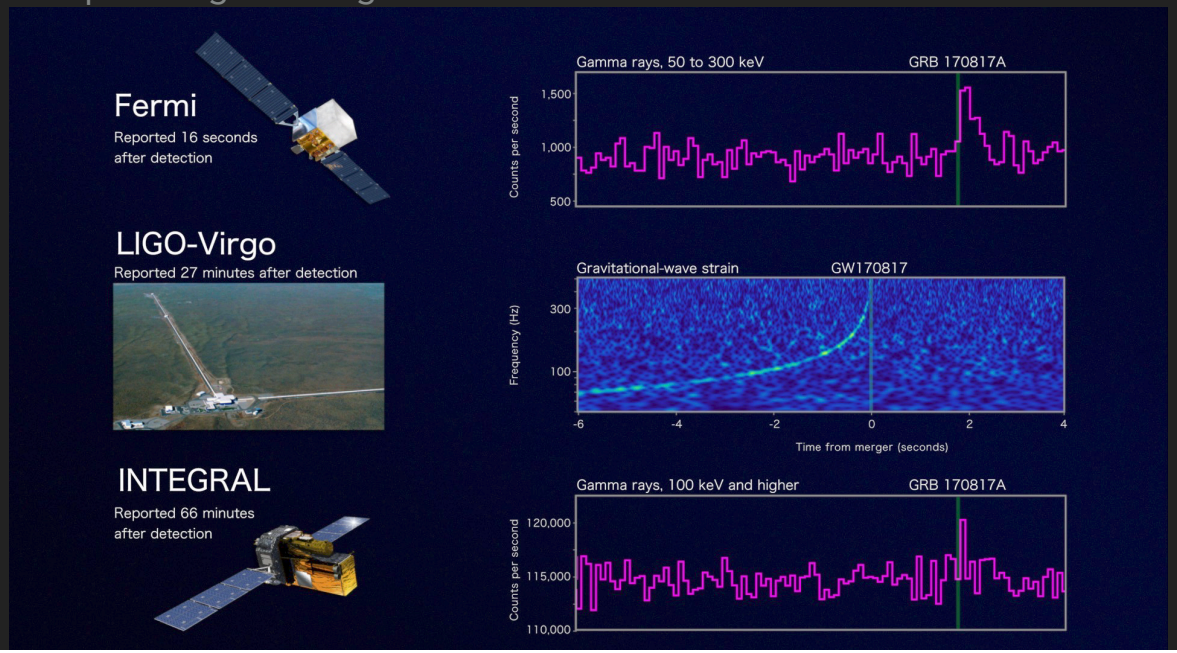


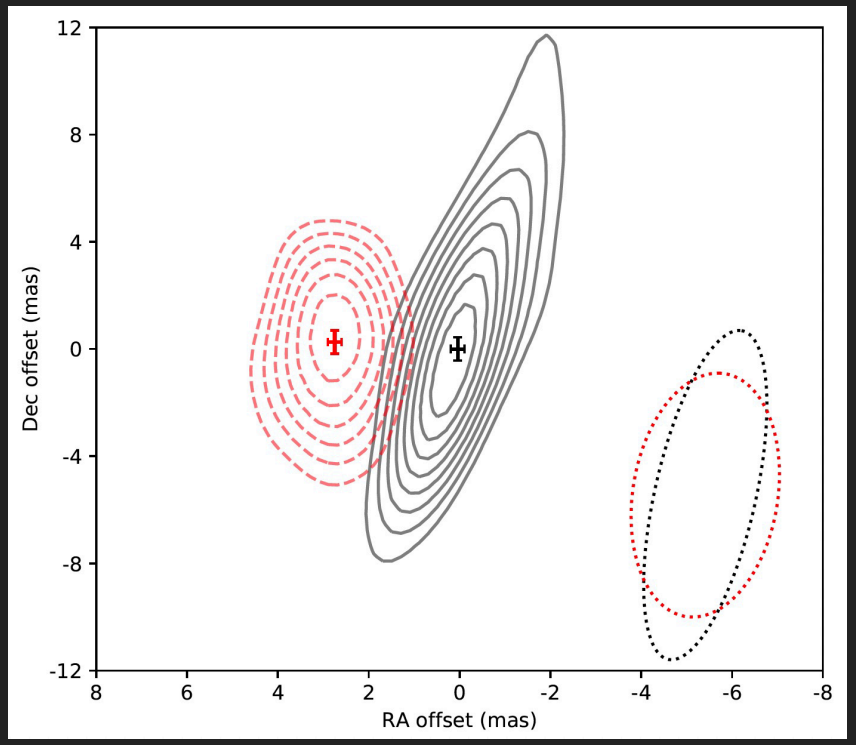
NEUTRON STAR MERGER EVENTS



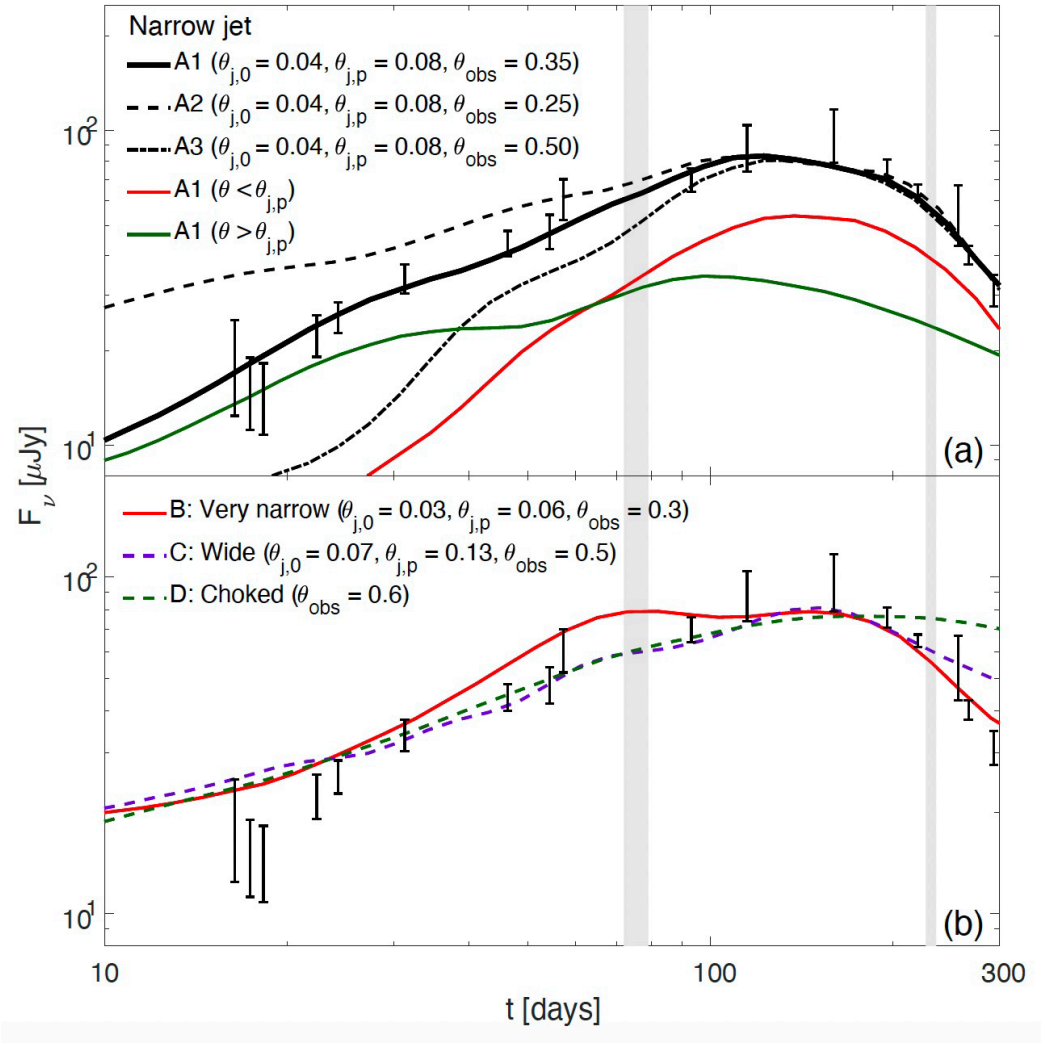
https://svs.gsfc.nasa.gov/12740

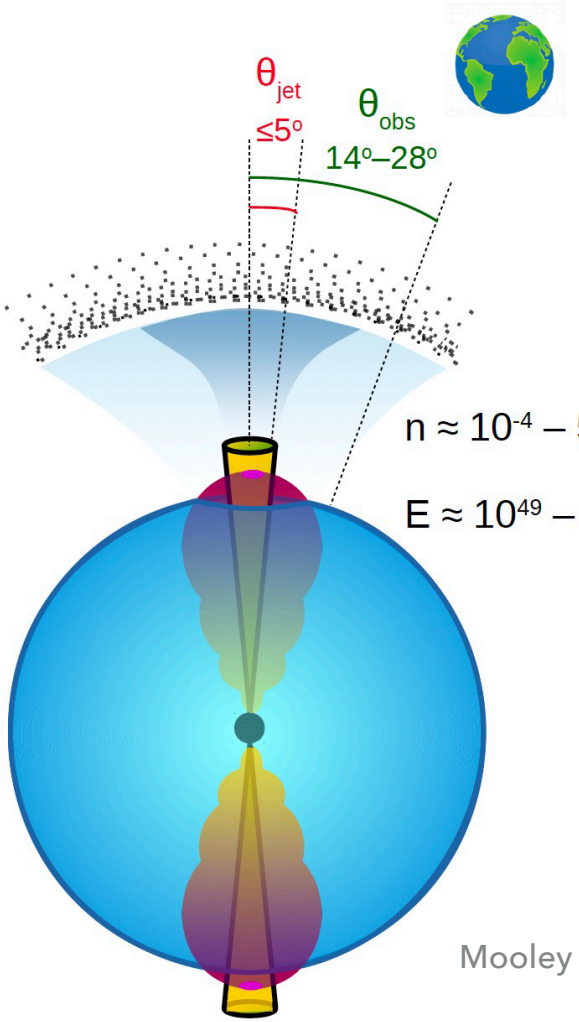
- Superluminal motion in GW170817
  - Astrometric shift over 165 days (Mooley et al. 2018)





OFF AXIS STRUCTURED JETS





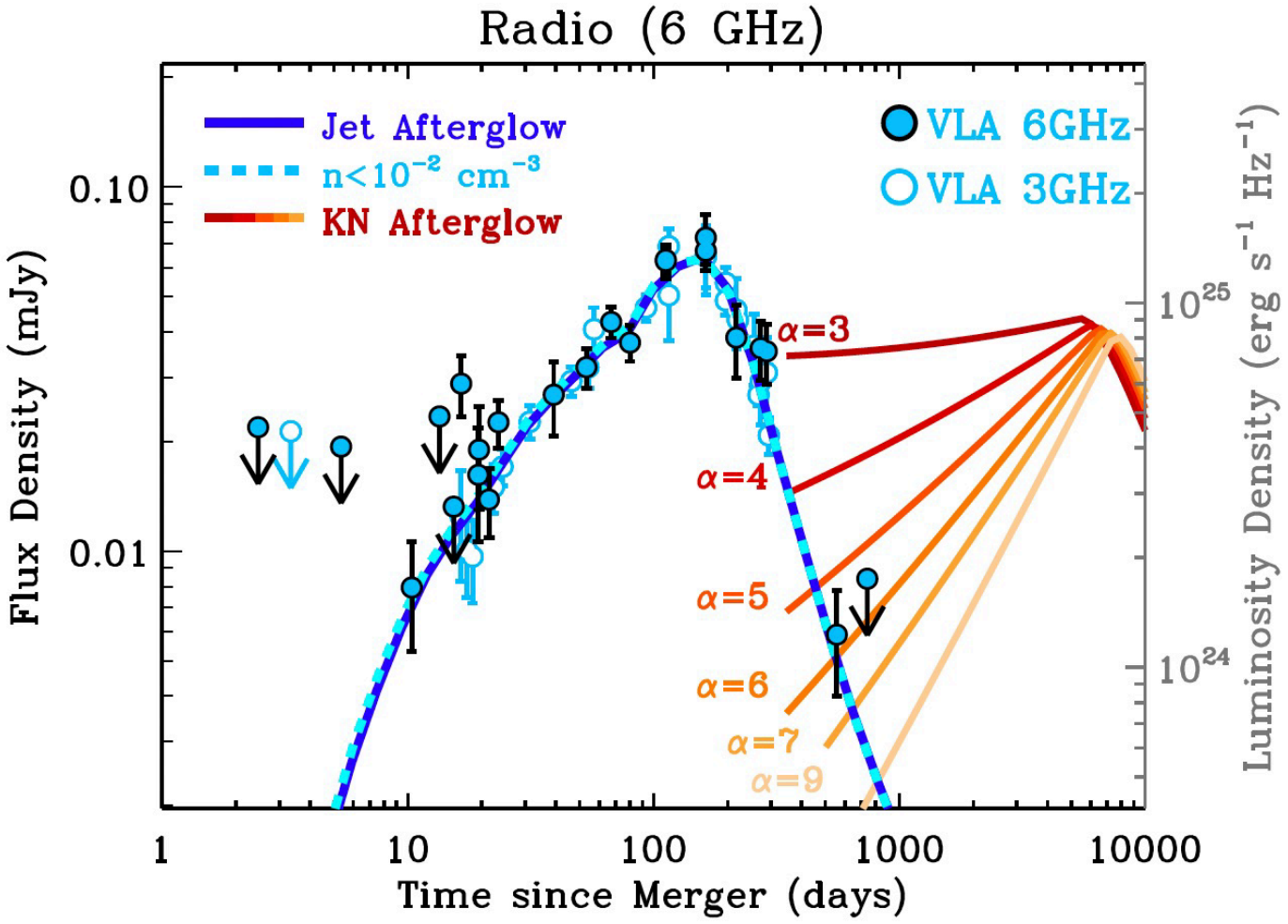
Mooley et al. (2018)

LONGER TIMESCALE MONITORING

- Remains consistent with structured jet viewed off-axis
- No evidence as yet for kilonova afterglow
  - Rules out shallow stratification indices $\alpha<6$:

    $E(\Gamma\beta) \propto (\Gamma\beta)^{-\alpha}$

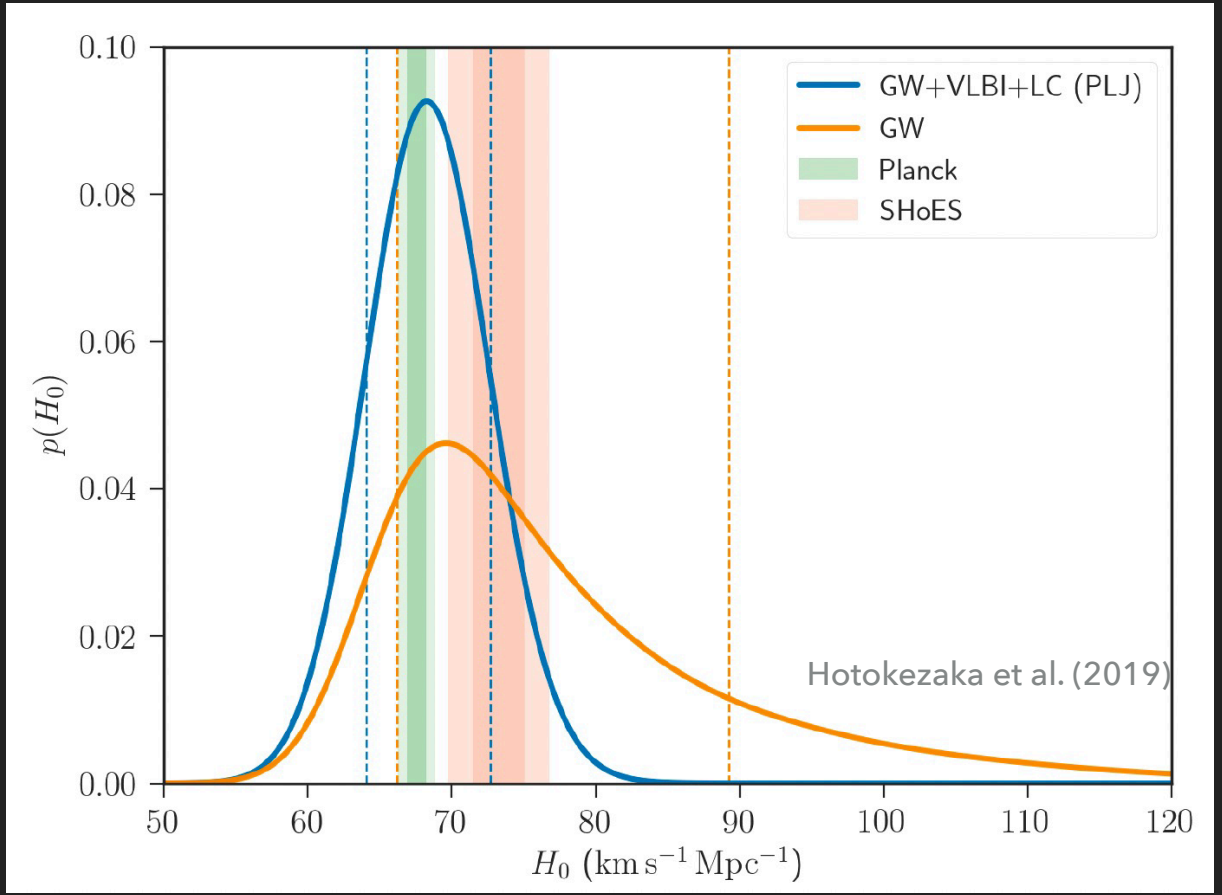
  - Depends on NS EOS



Hajela et al. (2019)

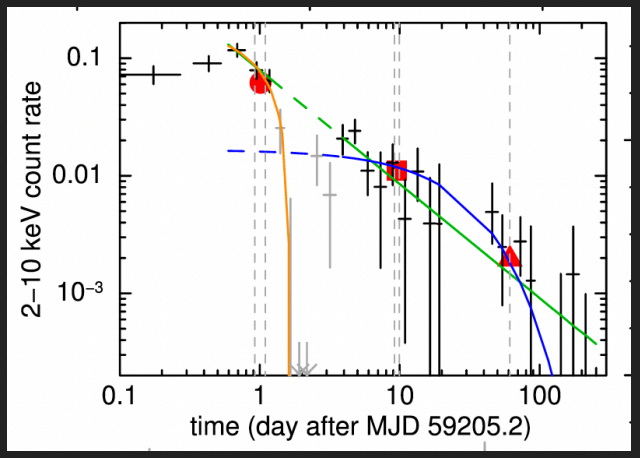
COSMOLOGY AND STANDARD SIRENS

- d_L from GW waveform
- z from EM data
- H_0 constraint limited by degeneracy in GW data
- Break using VLBI and light curve modeling
- 7% constraint on H_0
- 2% with 50-100 BNS

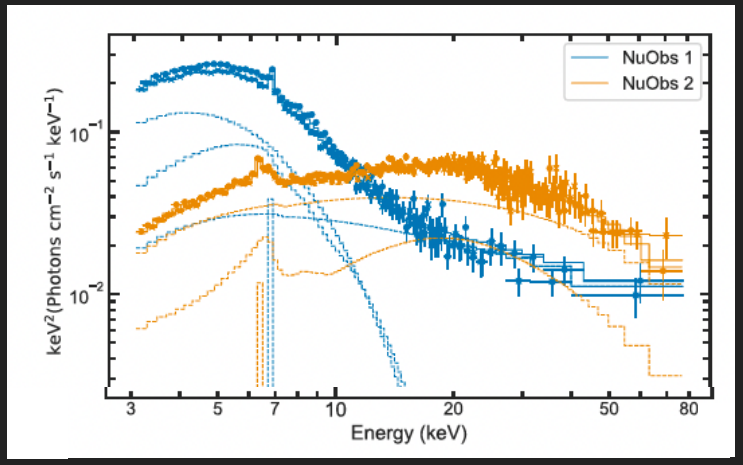


XRB: AN ILLUSTRATIVE EXAMPLE —> MAXI J1848-015

- X-ray binary, discovered in outburst in December 2020 by MAXI (Takagi et al. 20) (while the source was Sun-constrained for almost all other telescopes).

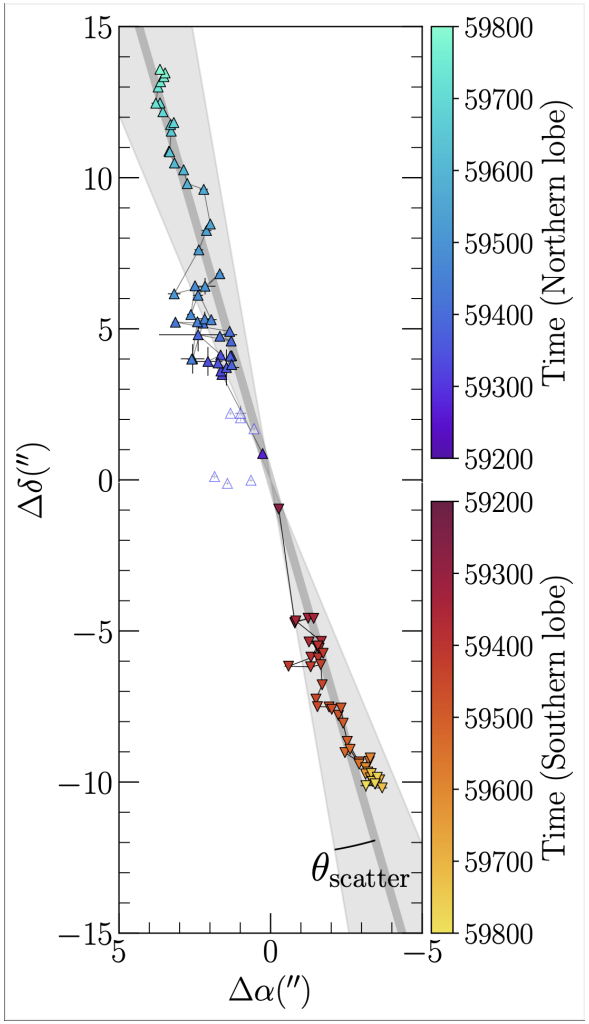


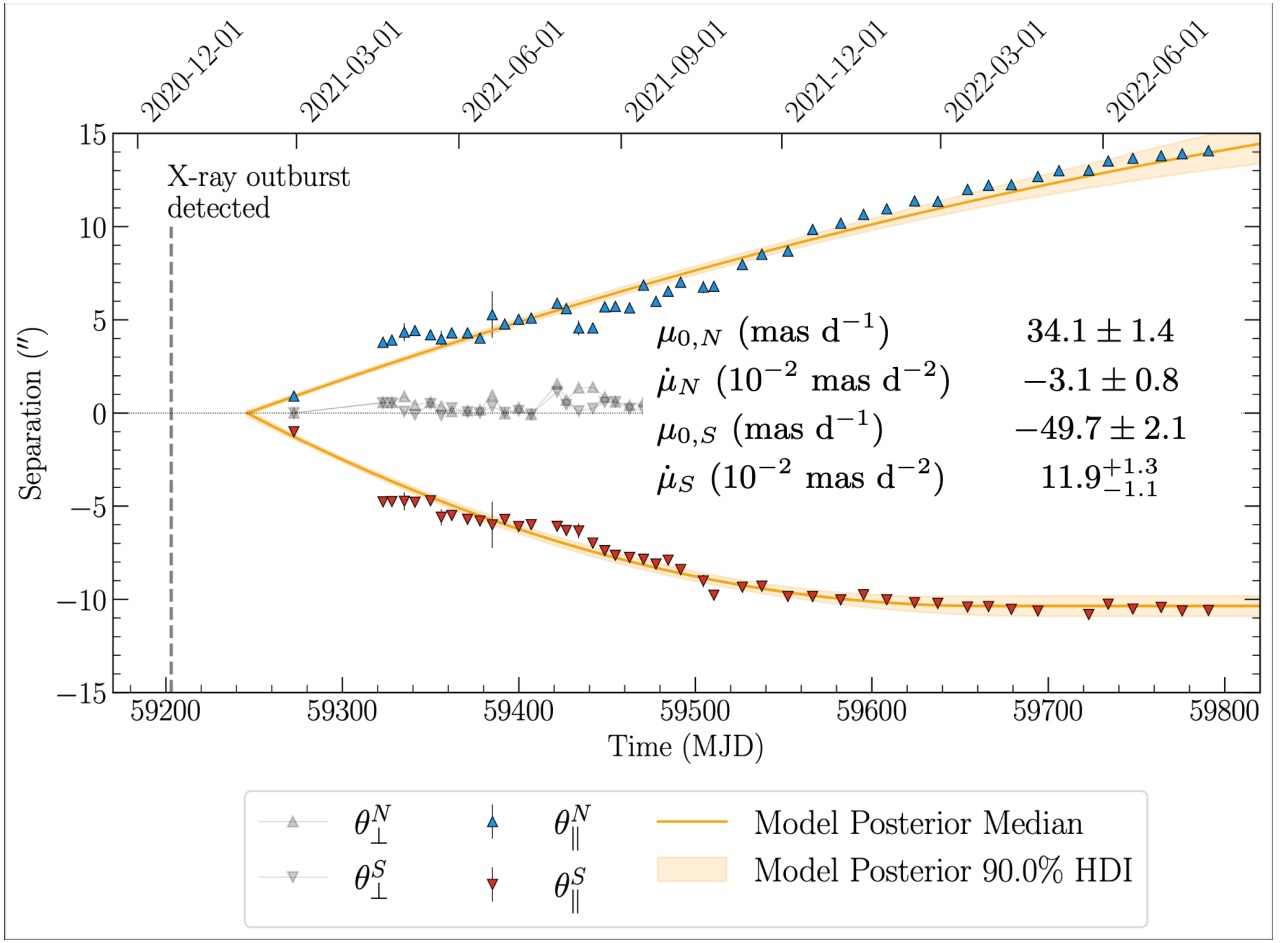
Pike et al. 2022



- NuSTAR observations (Pike et al. 2022) : State transition (soft, hard), relativistic reflection features, high spin (a = 0.967 +/- 0.013) –> A black hole candidate ?
- Early February 2021: Swift+Chandra follow-up -> located in the core of the cluster GLIMPSE-C01 but not coincident with any of the X-ray sources (e.g. Chakrabarty et al. 21).
- Short duration outburst. Radio counterpart (Tremou et al. 21) –> likely radio jets

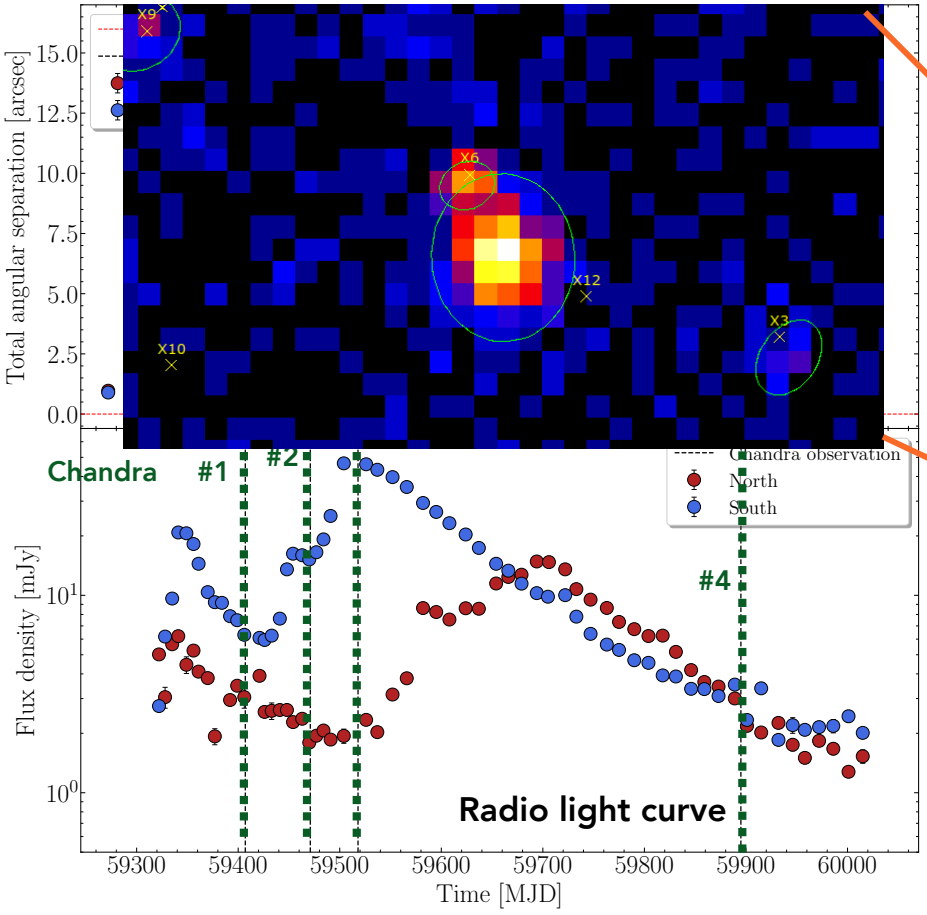
MODELLING THE JET PROPER MOTION





First relativistic jets detected from an XRB in a GC (Bahramian et al. 2023)

CHANDRA/VLA CAMPAIGN

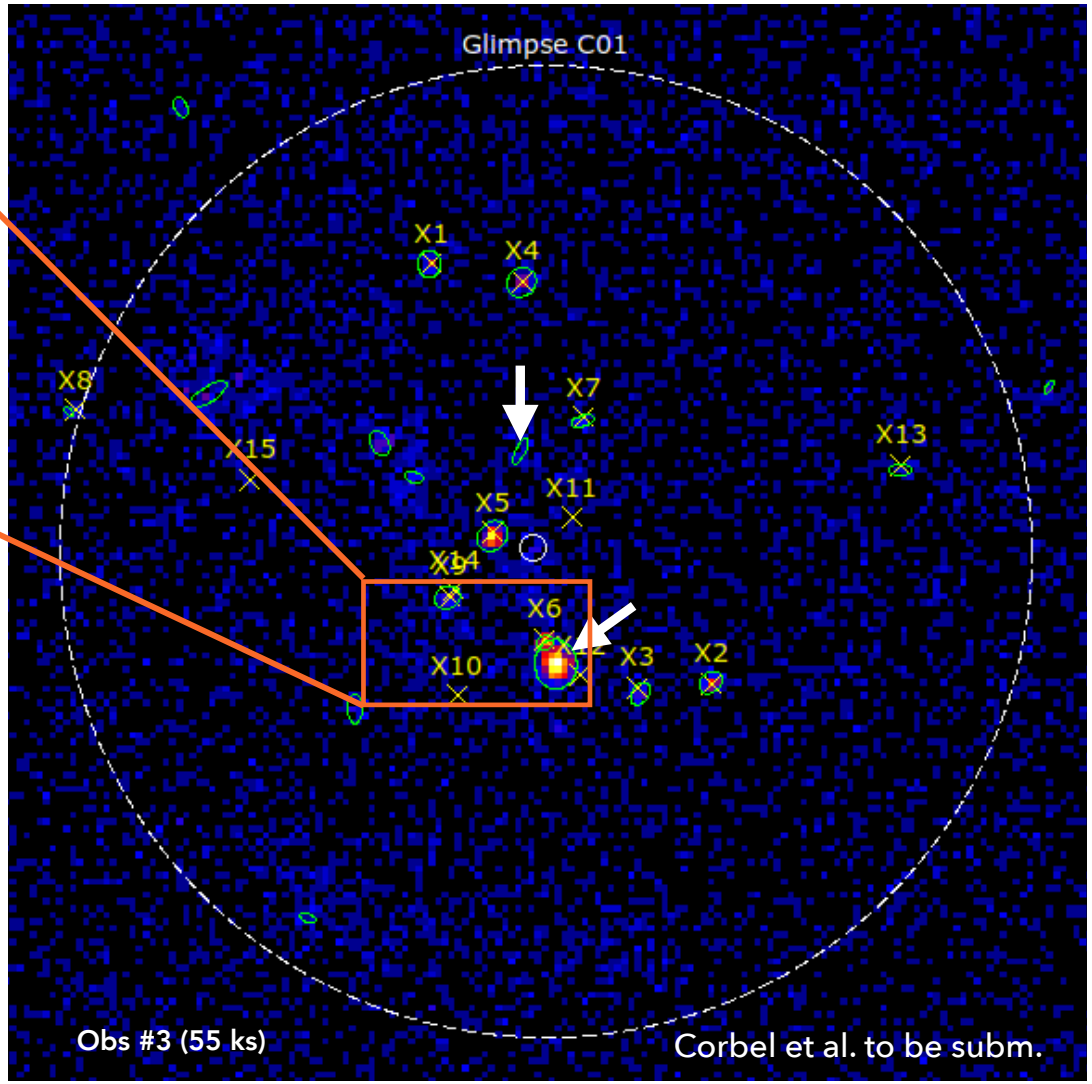


2021

2023

MeerKAT

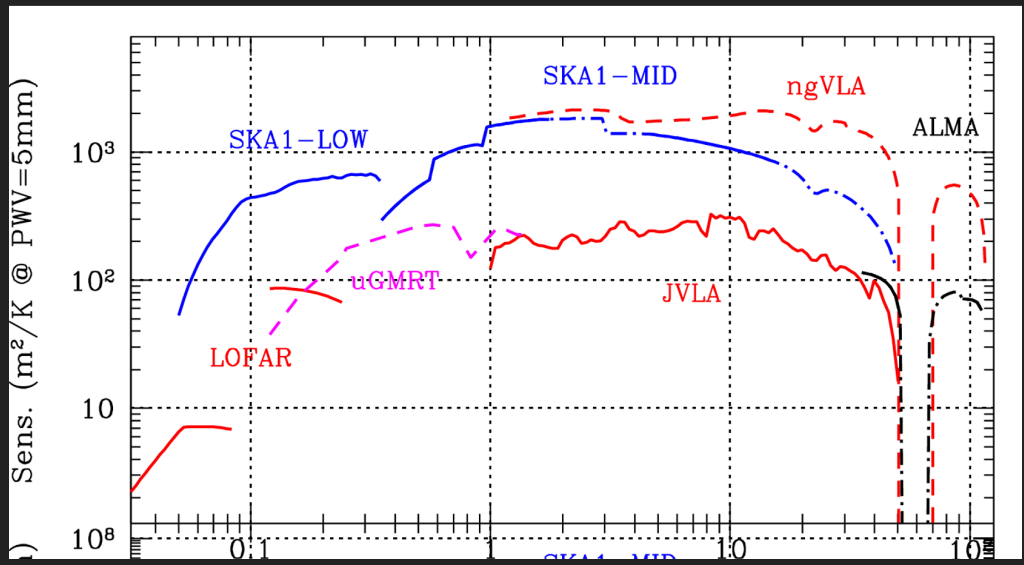
Tremou et al. (in prep.)



Corbel et al. to be subm.

NEW RADIO OBSERVATORIES

- Now available: NenuFAR, LOFAR, ATCA,MeerKAT, VLA, Noema, ALMA, … in term of increasing frequencies
- SKA in the near future (see talk by Chiara)
- But to not forget ngVLA (= SKA-High ?):
  - 10 x the sensitivity/resolution of the JVLA/ALMA
  - 1.2 - 116 GHz Frequency Coverage
  - 244 x 18m + 19 x 6m (for short baseline array)
  - Thermal imaging on milliarcsecond scales
  - Astro2020 identified the ngVLA as a high-priority large, ground- based facility whose construction should start this decade (> 2026) . Open sky policy.
- Future = Two hemisphere radio systems !
- + lots of synergies to explore for HE sources (Chandra, SVOM, CTA, …)




Questions ?