# SCUBA-2 Photometry of X-ray Binary Jets

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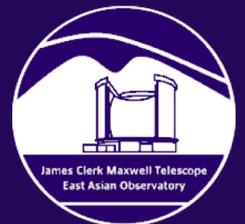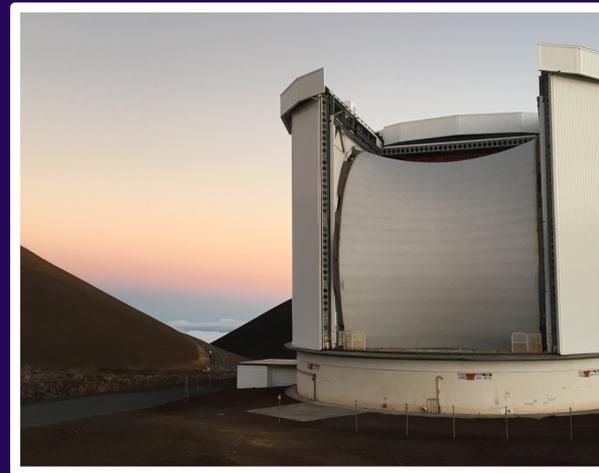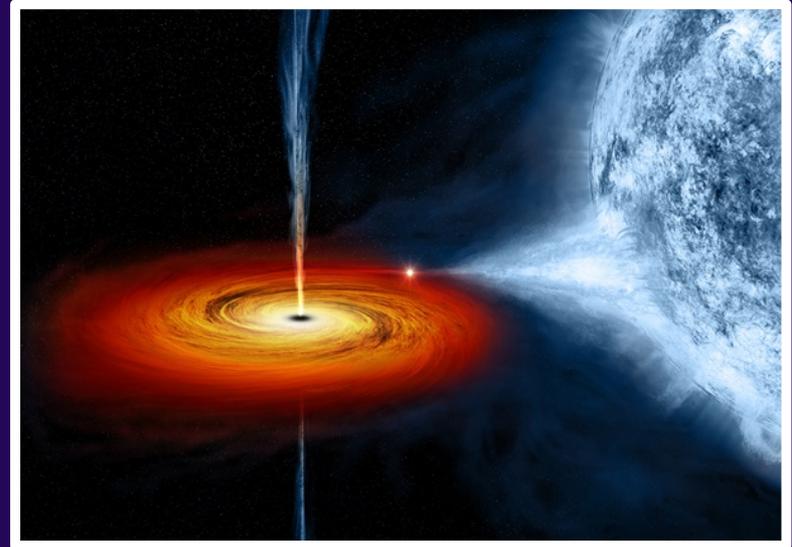
Relativistic Jets Launched From Black Holes

6 kpc

Radio galaxy Cen A

Credit: NRAO

6 pc

Cygnus X-1
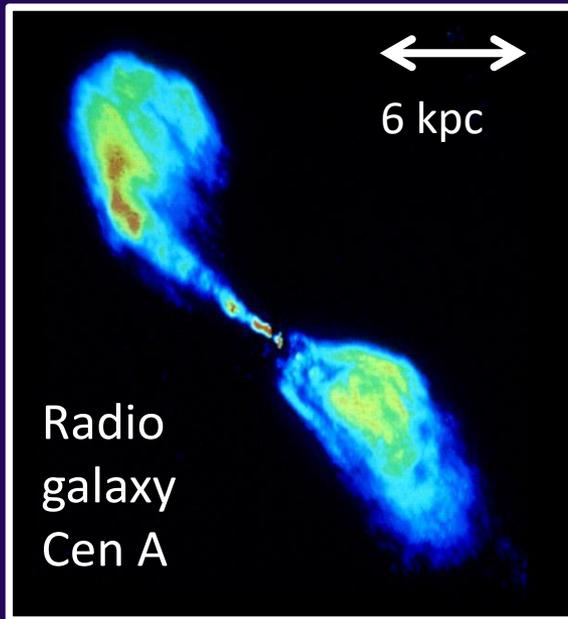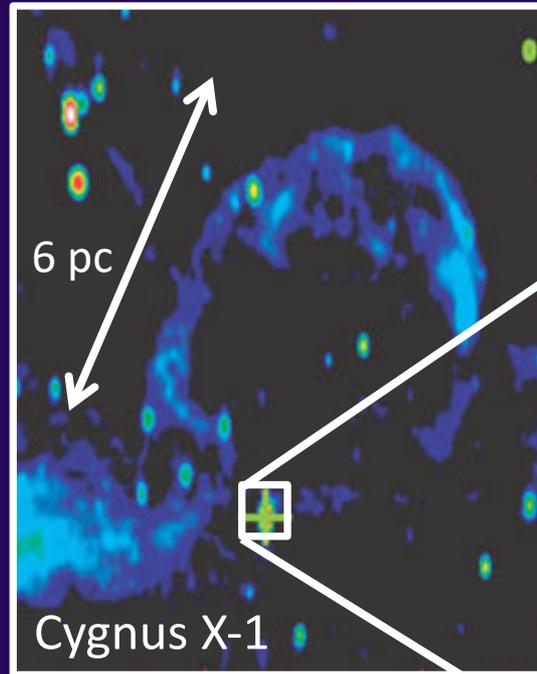
Credit: Gallo et al. 2005

Credit: J. Miller-Jones

18 AU

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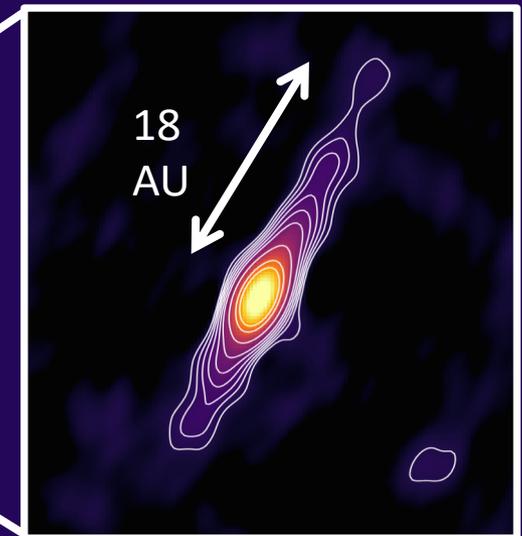
Black Hole X-ray Binaries
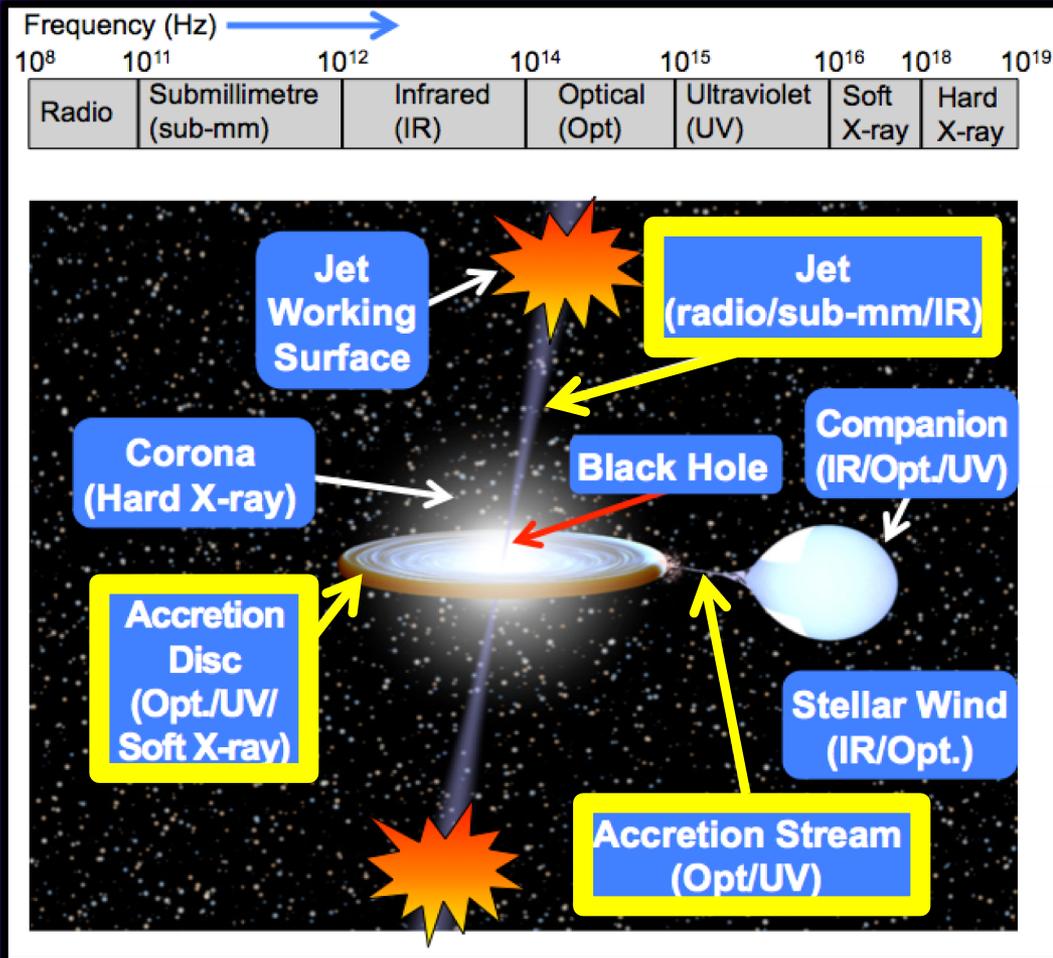
- Black hole accreting matter from a companion star

- Rapidly evolve through bright outburst periods on timescales of days to months

- Emit across the electromagnetic spectrum

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Outburst and Jet Behaviour

High State
(>0.5 L_{edd})

Intermediate
States
(~ 0.3 L_{edd})

Compact Jet

Soft
State

Hard State
(<0.1 L_{edd})

Jet Ejecta

Luminosity

Hardness

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James Clerk Maxwell Telescope
East Asian Observatory
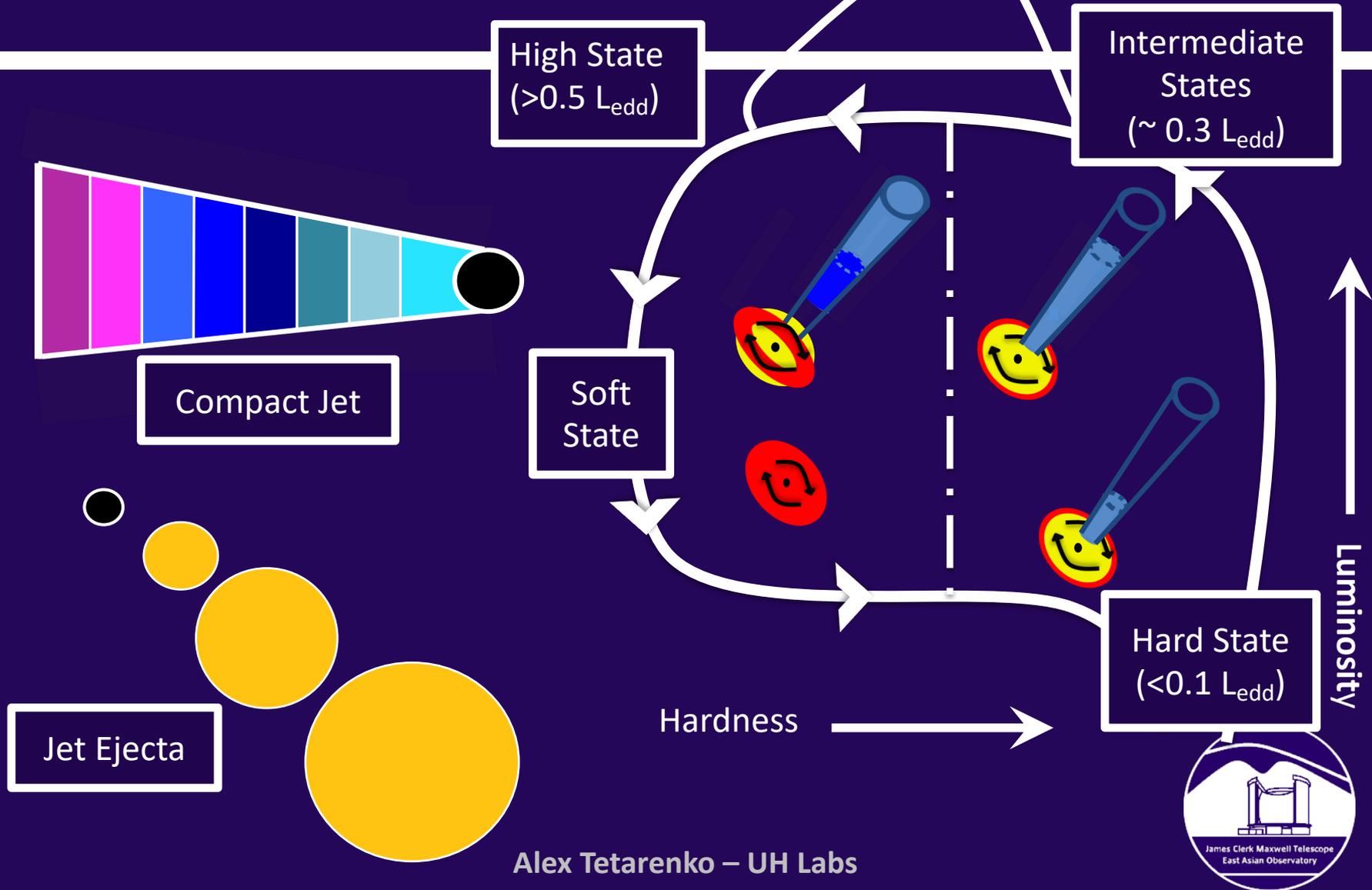
Hard State Compact Jets
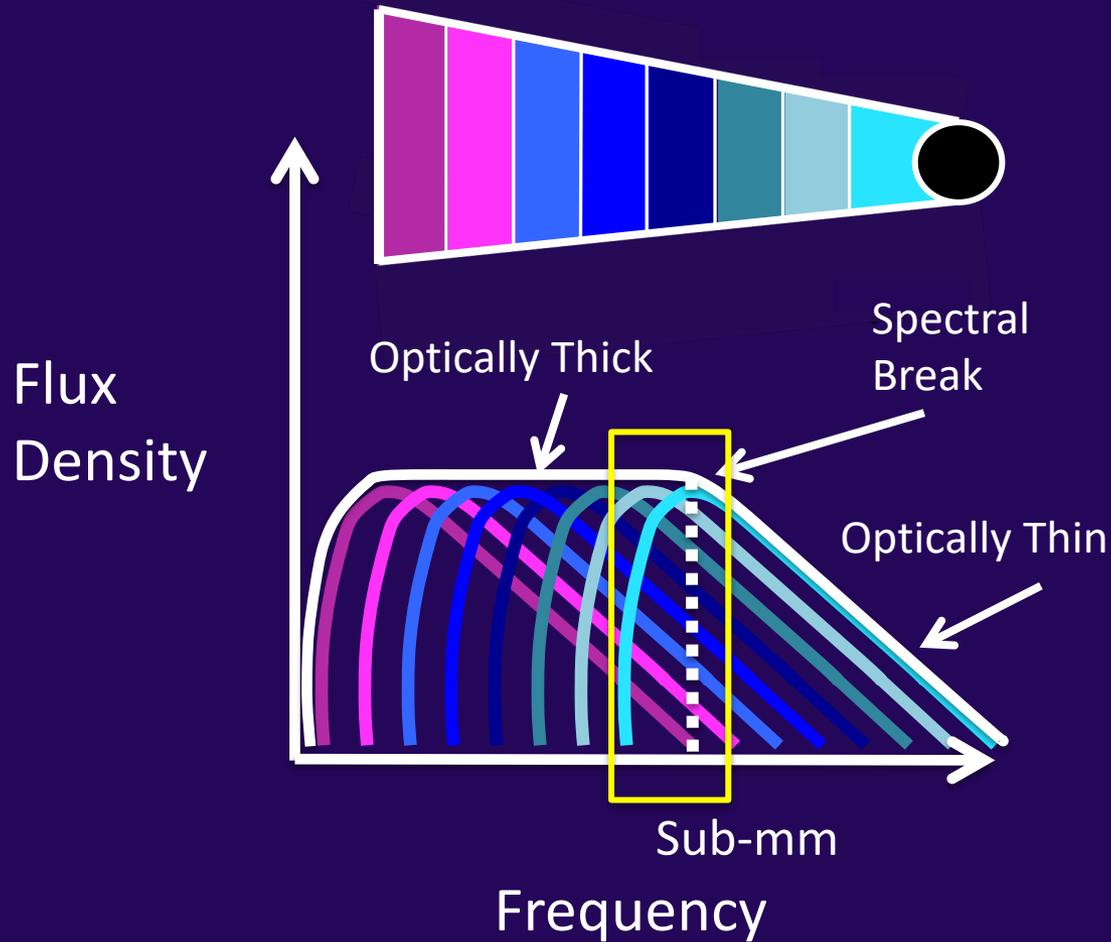
Broad-band Spectrum

- Originates from superposition of many synchrotron components along jet axis

- Jet properties encoded within exact spectral shape

- Key observables: spectral indices, location of spectral break
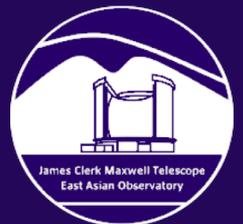
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Jet Spectral Breaks

- Location evolves as accretion properties change during outburst

- Evolution contrary to simple jet models

- Correlates with X-ray photon index

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$$\log \nu_b = -3.4\Gamma + 18.8$$

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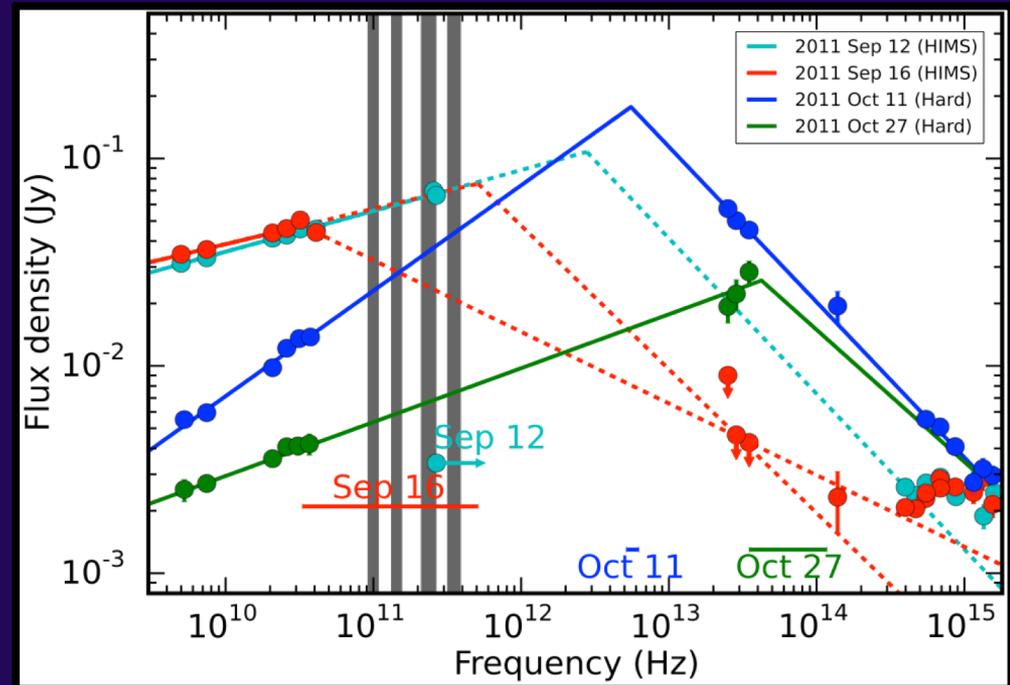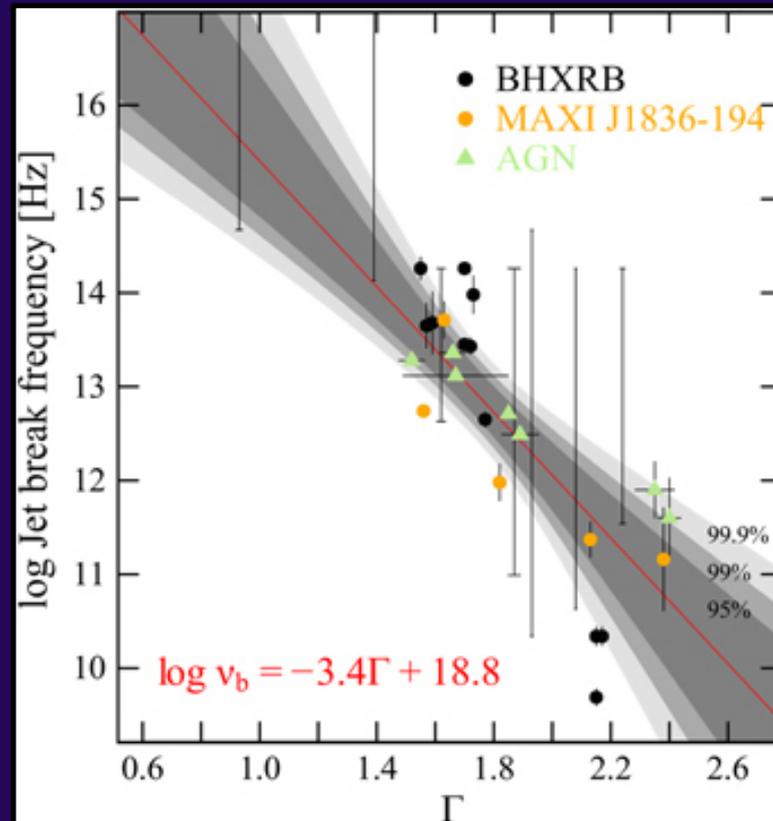
Relativistic Jet Simulations

- Broad-band observations needed to test and guide simulations

- Tie jet dynamics, plasma conditions to the jet spectral break
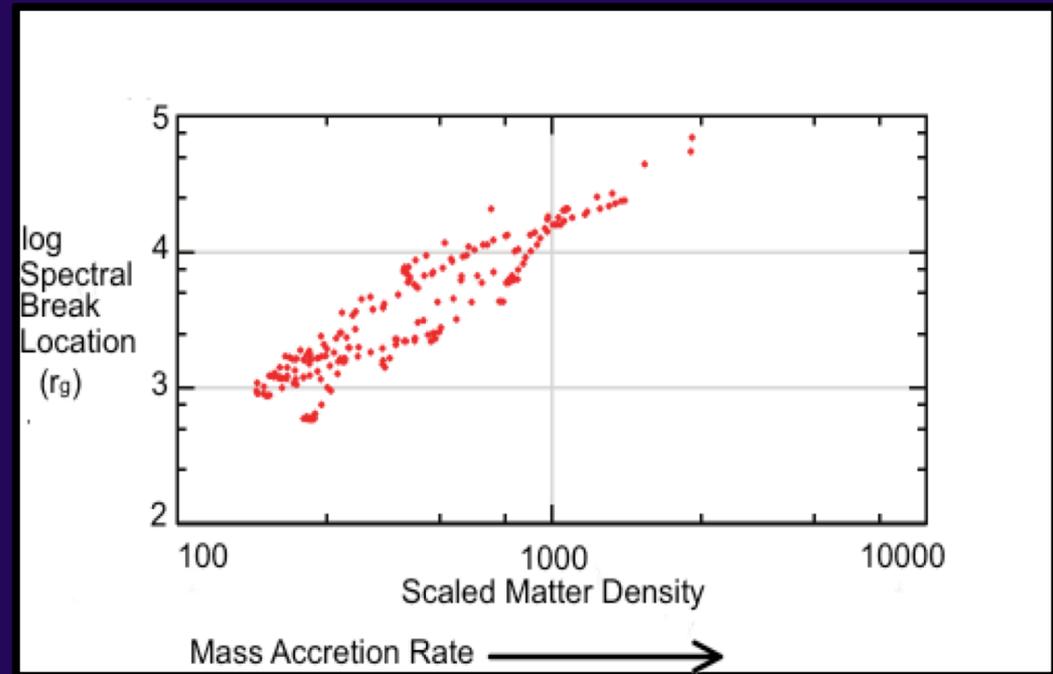
New solutions in agreement with observed spectral break evolution!

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(Sub)-Millimetre Frequencies

• Fill 2 order of magnitude gap in broad-band spectrum

• Uniquely probe jet emission close to compact object

• Need rapid response ToOs to obtain data of X-ray binaries.

ALMA

JCMT

NOEMA

SMA

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# Target Source: V404 Cygni

- Prolonged quiescent period of 26 yrs.

- Well determined system parameters

- Low optical extinction

- Parallax distance

P_{orb} = 6.5 days

d=2.39 +/- 0.14 kpc

K0 sub-giant

M_{BH} = 7.15 +/- 0.35 $M_{\odot}$

i=60-80 degrees

E(B-V)=0.1

Credit: R. Hynes

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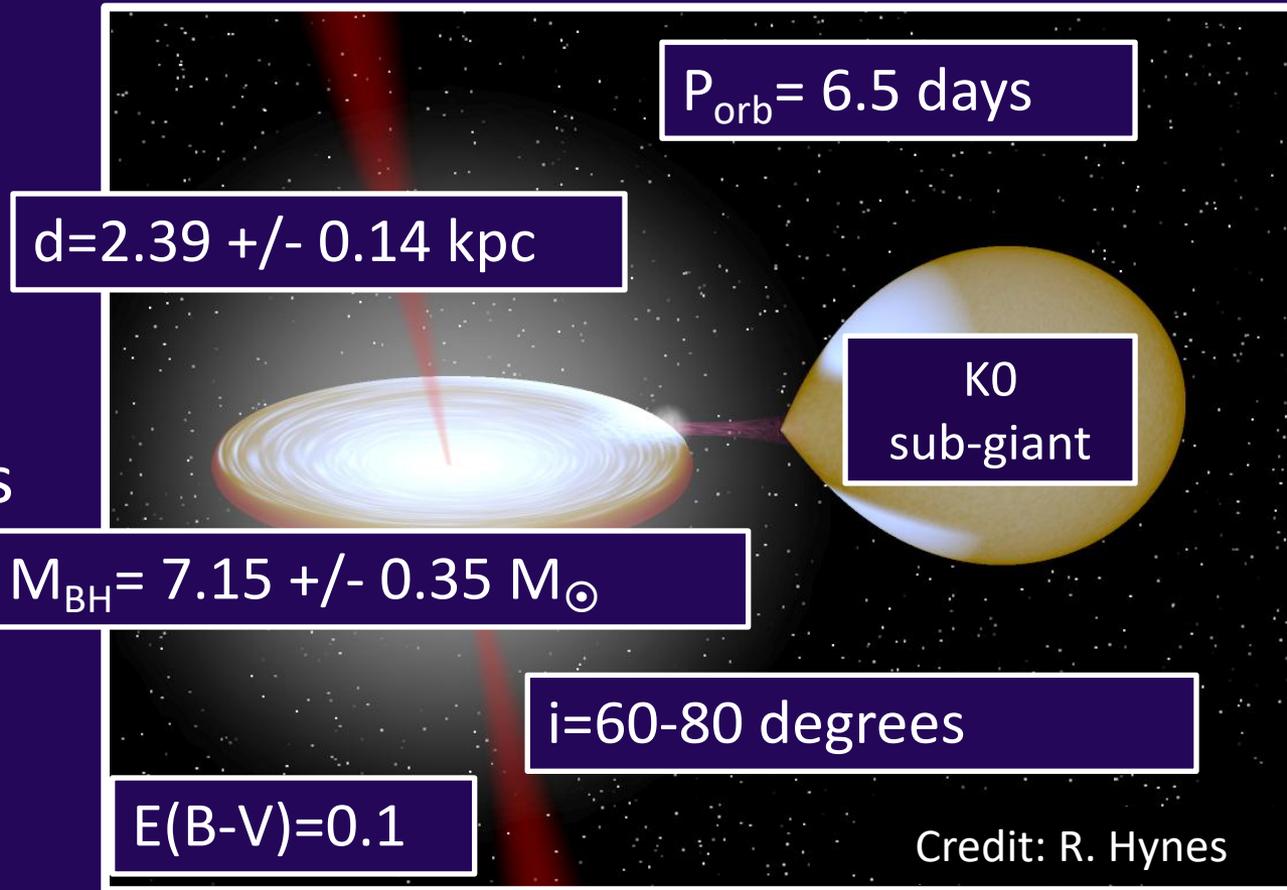
Lab Procedure

- Reduce a JCMT SCUBA-2 observation of V404 Cygni during the decay of its 2015 outburst.

- Combine your SCUBA-2 sub-mm measurement with other simultaneous multi-wavelength data to build a broad-band spectrum.

- Fit different emission models to your spectrum to deduce jet properties.

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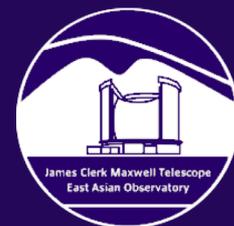
Additional Notes

- Follow the detailed procedure in the lab writeup for reducing your data.
- You will NEED to FIRST download the data!
- You will NEED to have the Starlink software installed on your machine.
- This lab involves some coding, don't freak out if you haven't done any coding before!
- All coding and analysis should be done in the jupyter notebook provided.

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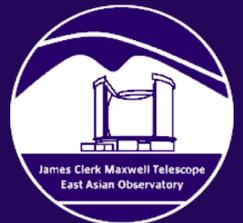
What do you need to hand in?

- Please email me your lab writeup and jupyter notebook

- Please use the subject line: UH Labs XRB Spectrum – [NAME]

- My email is: a.tetarenko@eaobservatory.org

- Questions? – Email me!

                    Thanks!