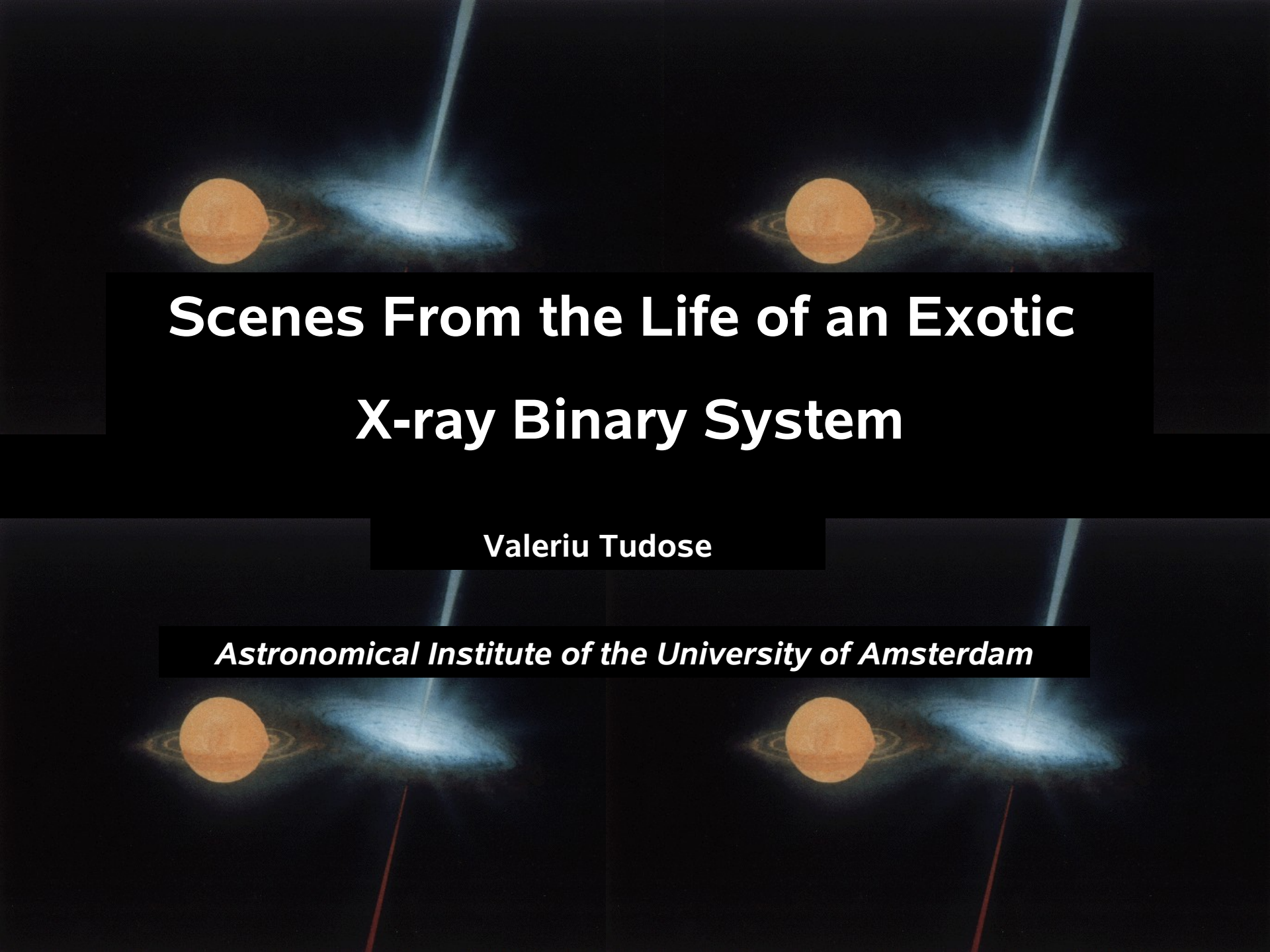

Scenes From the Life of an Exotic X-ray Binary System

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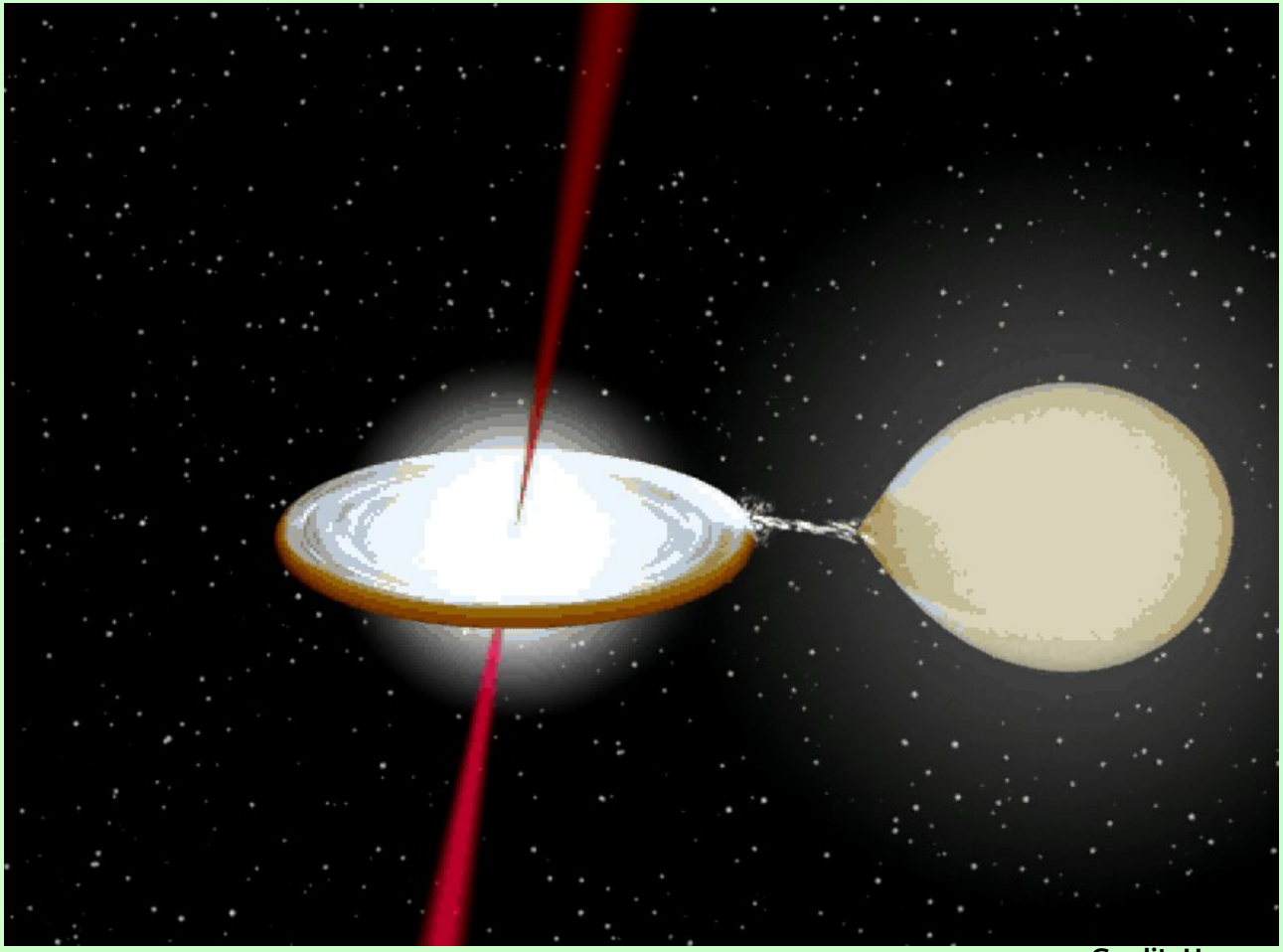
Summary

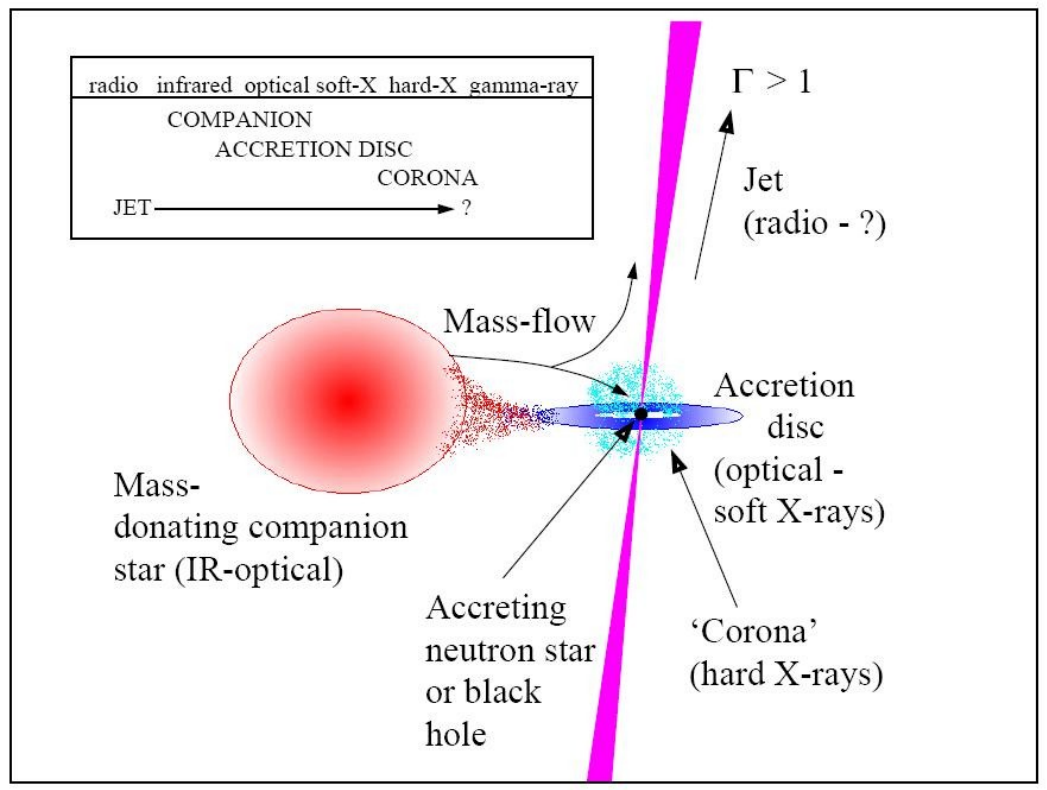
- X-ray binary systems (definition, radiation mechanisms)
- Instruments (radio telescopes, X-ray satellite)
- Circinus X-1 – radio view (morphology, polarization, spectral index)
- Circinux X-1 – radio/X-ray comparison (luminosities, QPOs)

X-ray binary = system containing a stellar-mass compact object accreting matter from a companion star



Credit: Haynes

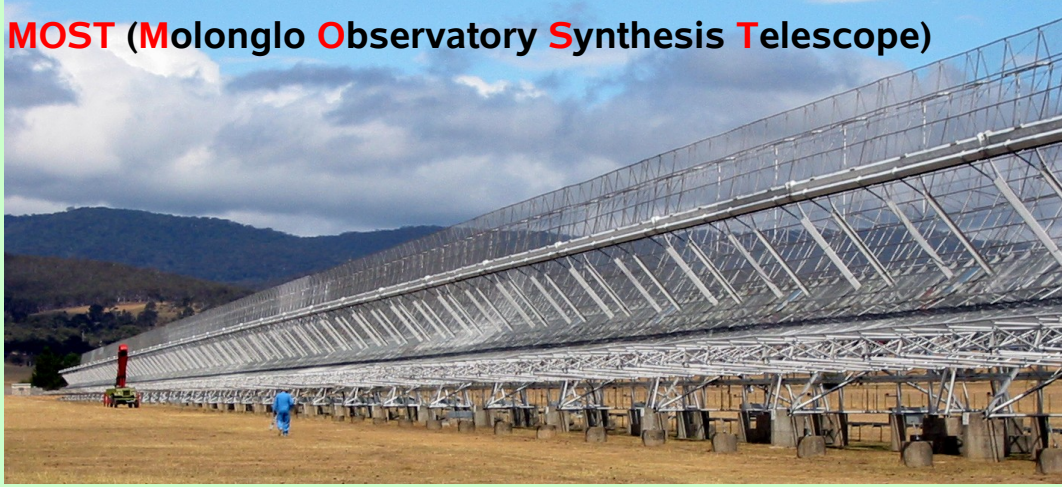
Radiation from X-ray binaries



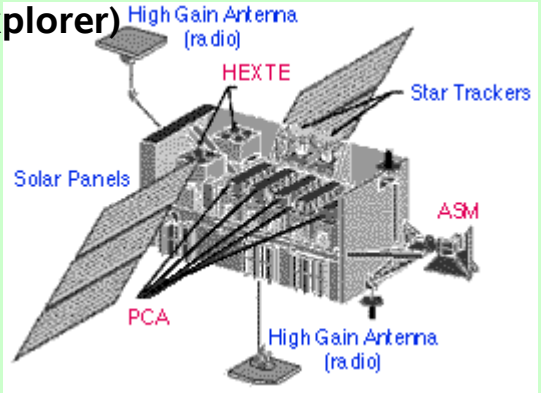
Fender & Maccarone, 2004, A&SSL 304, 205

ATCA (Australia Telescope Compact Array)

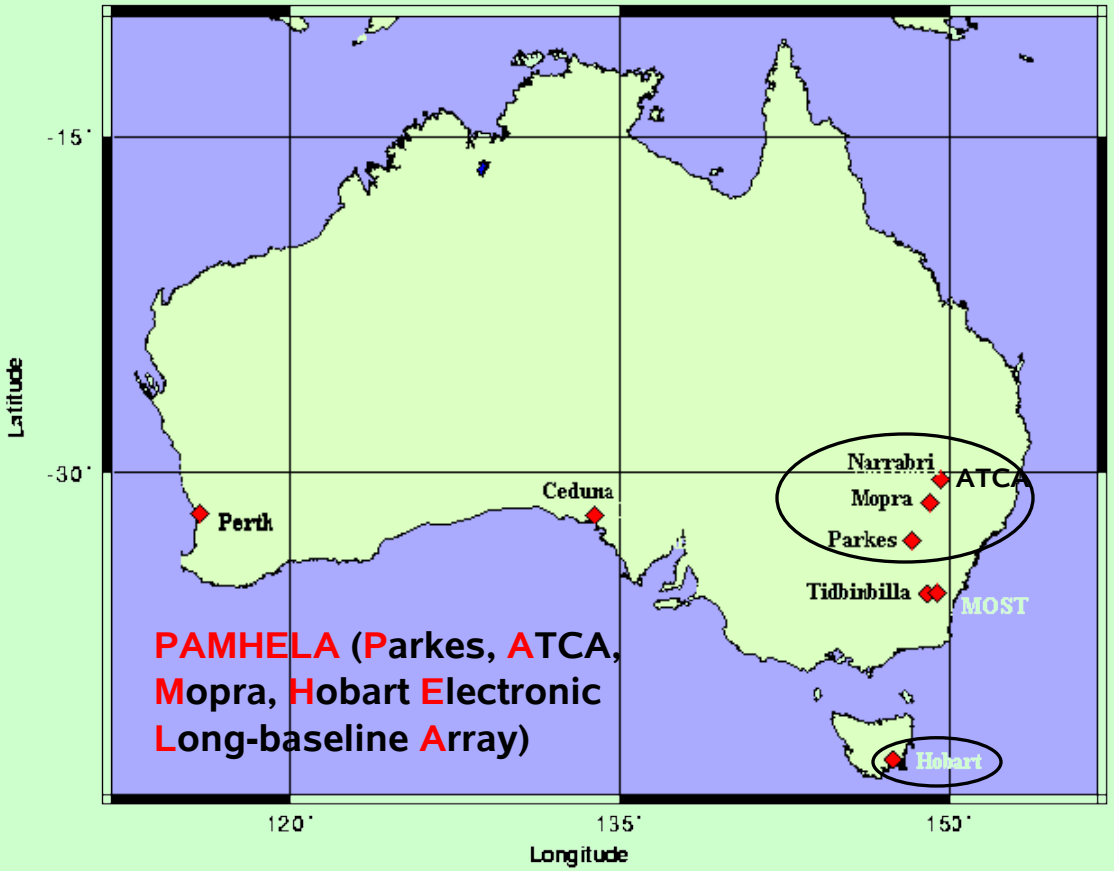
MOST (Molonglo Observatory Synthesis Telescope)



RXTE (Rossi X-ray Timing Explorer)



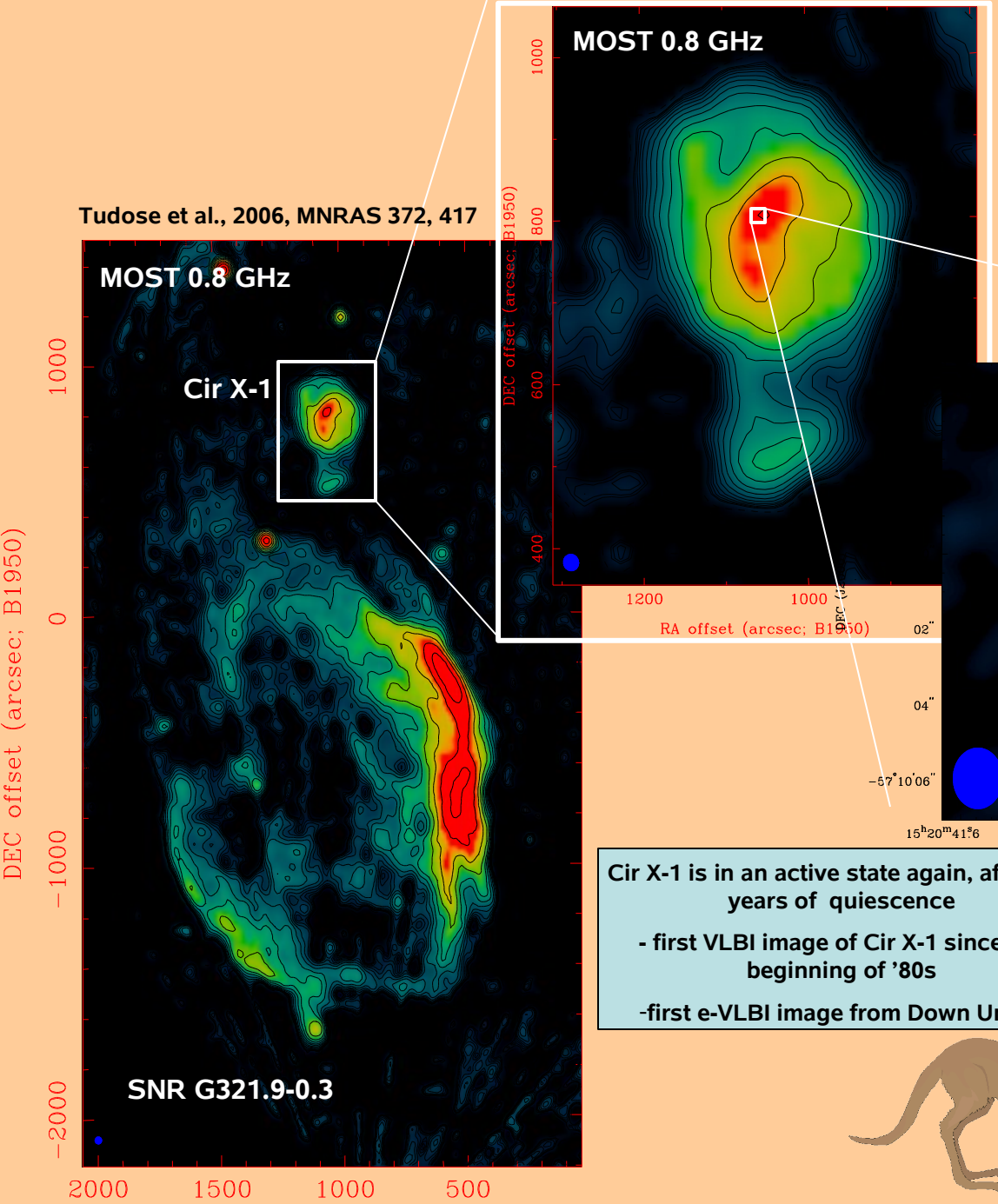
VLBI Telescopes Within Australia



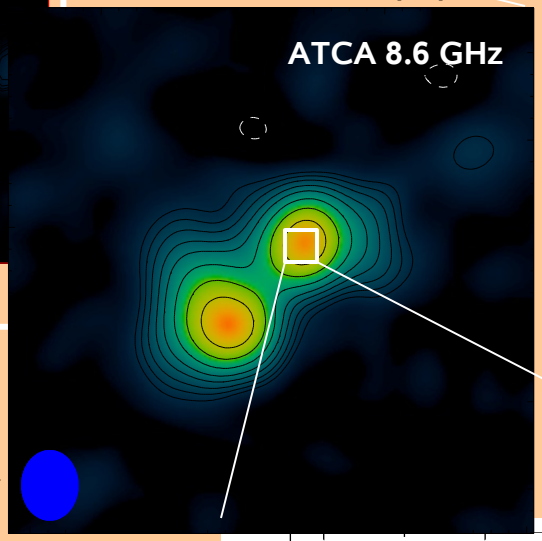
PAMHELA (Parkes, ATCA, Mopra, Hobart Electronic Long-baseline Array)

Circinus X-1

Tudose et al., 2006, MNRAS 372, 417



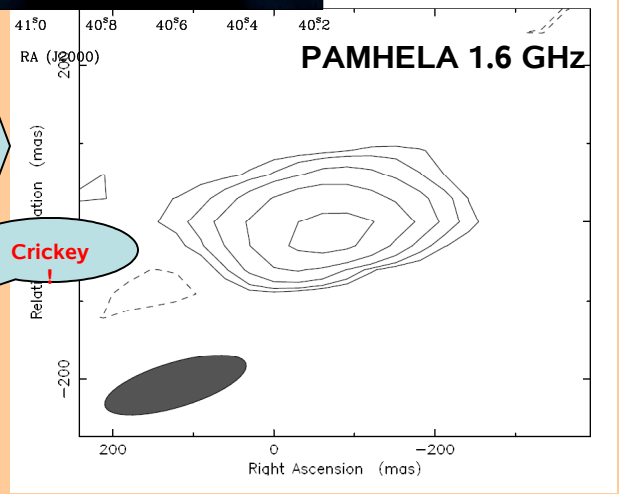
Tudose et al., in preparation



Cir X-1 is in an active state again, after ~25 years of quiescence

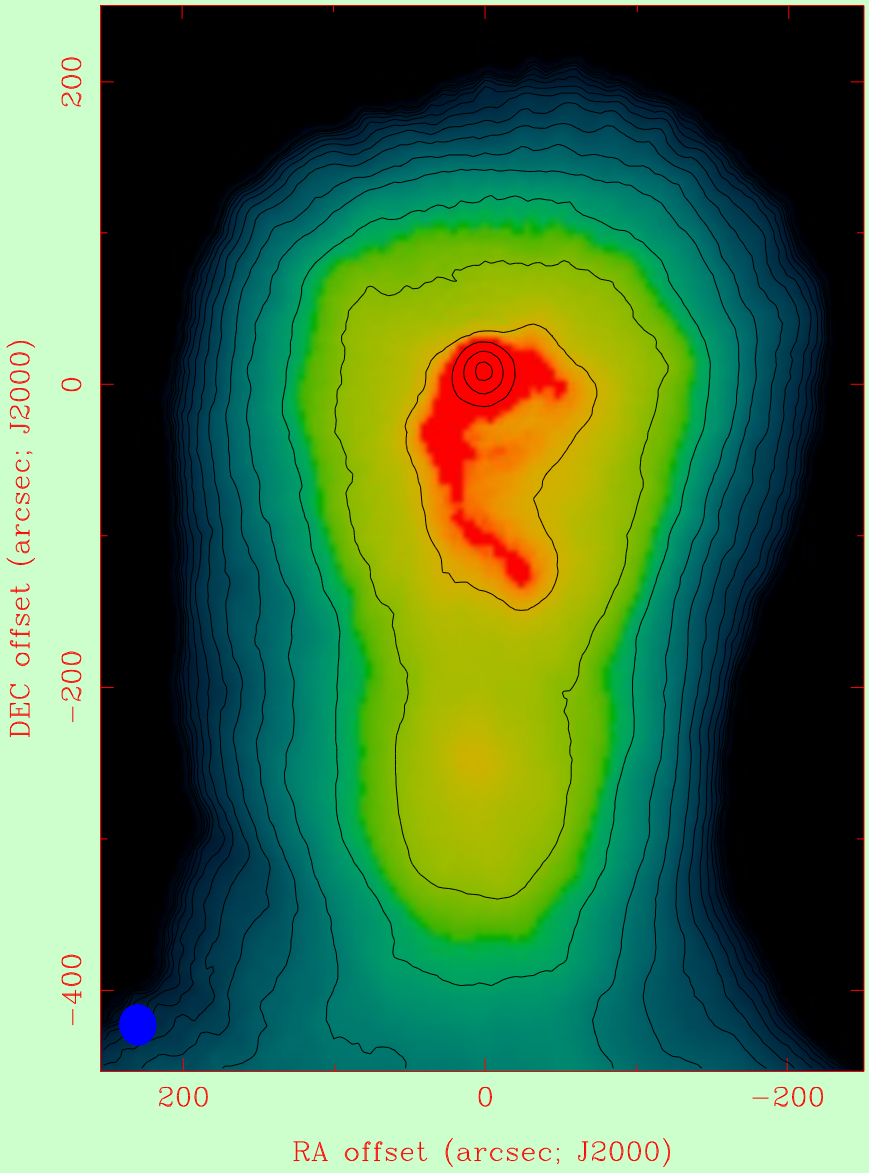
- first VLBI image of Cir X-1 since the beginning of '80s

-first e-VLBI image from Down Under

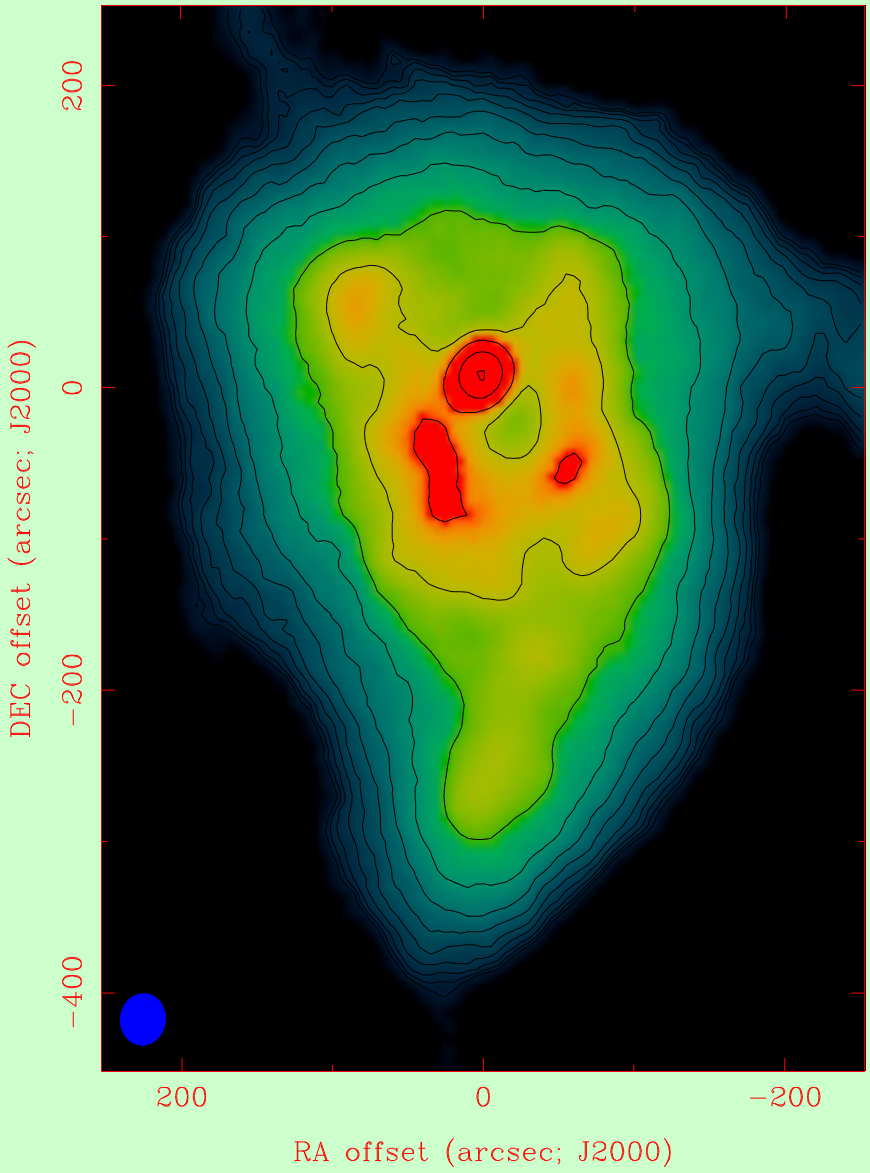


Phillips et al., submitted to MNRAS

ATCA, 1.4 GHz

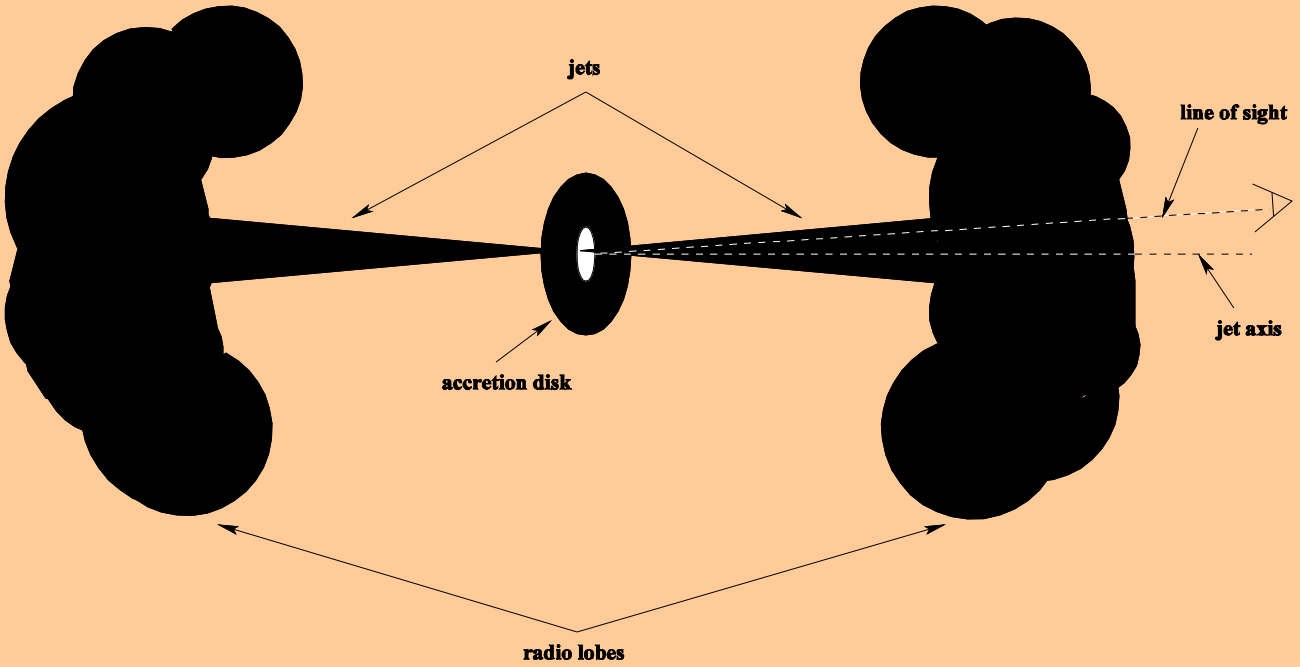


ATCA, 2.5 GHz

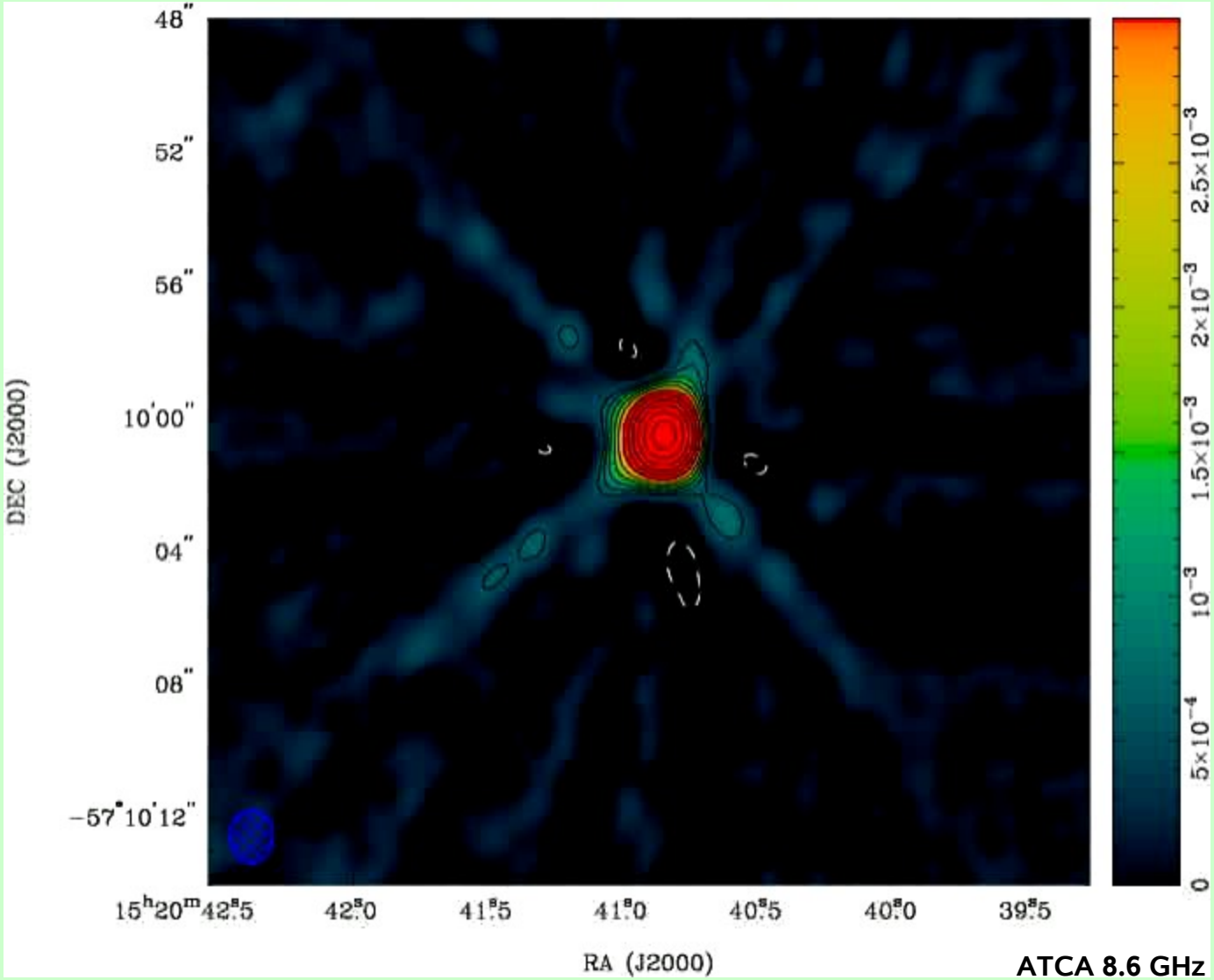


Tudose et al., 2006, MNRAS 372, 417

The possible geometry of the Cir X-1 system



Radio evolution of Cir X-1 between 1996 - 2006

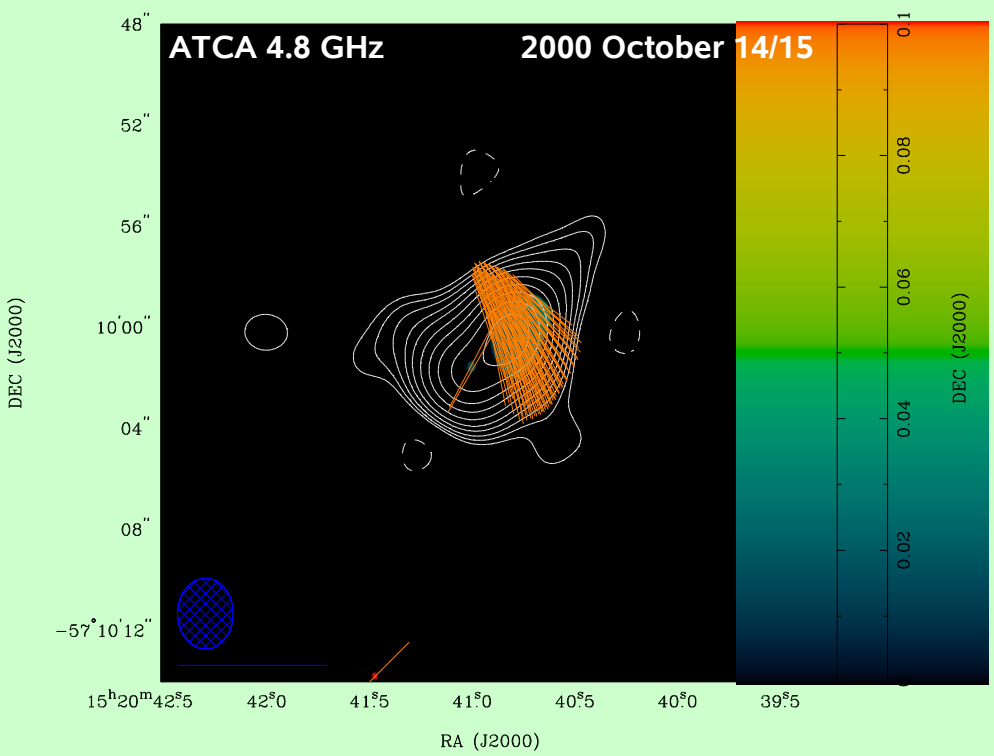


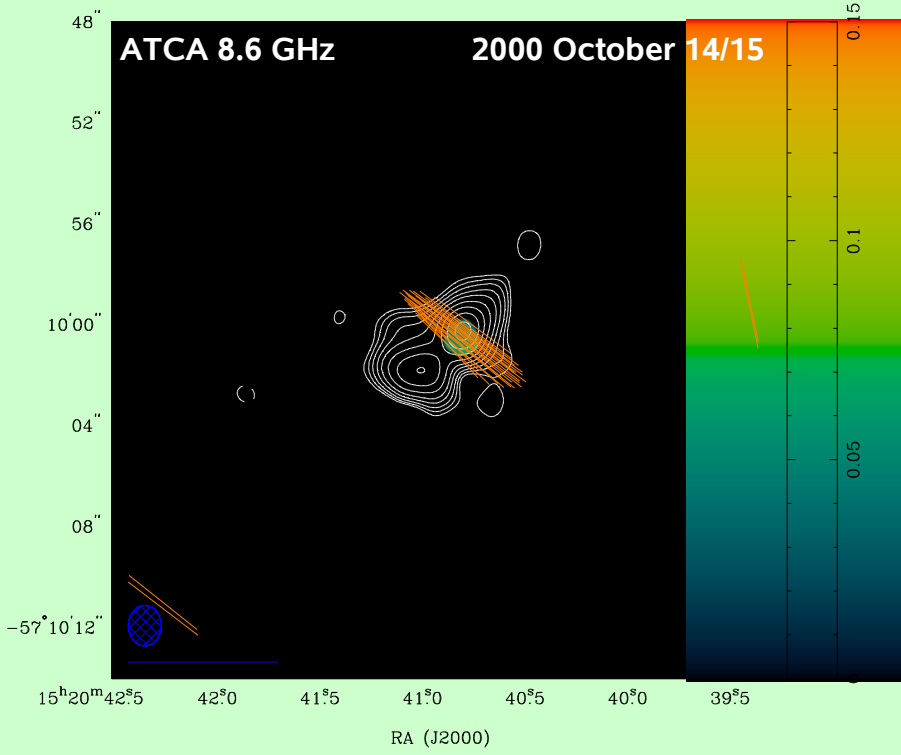
Movie of 41 epochs of observations, made at unequal time intervals in the last 10 years

Polarization of the radio emission from Cir X-1

When detected, the orientation of the electric vector polarization angle (EVPA) in the jet is along the axis, suggesting the presence of shocks

The typical fractional linear polarization is of the order of a few percents



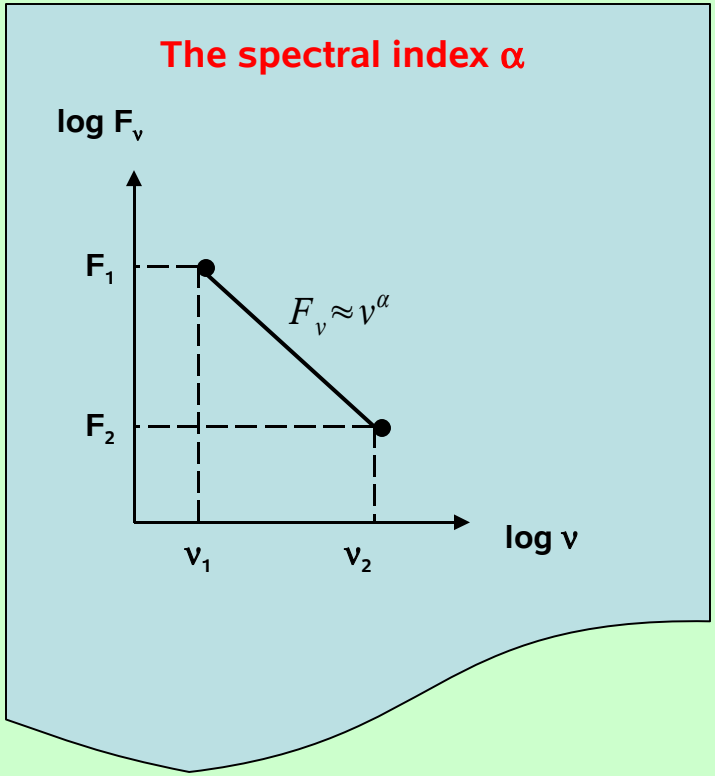


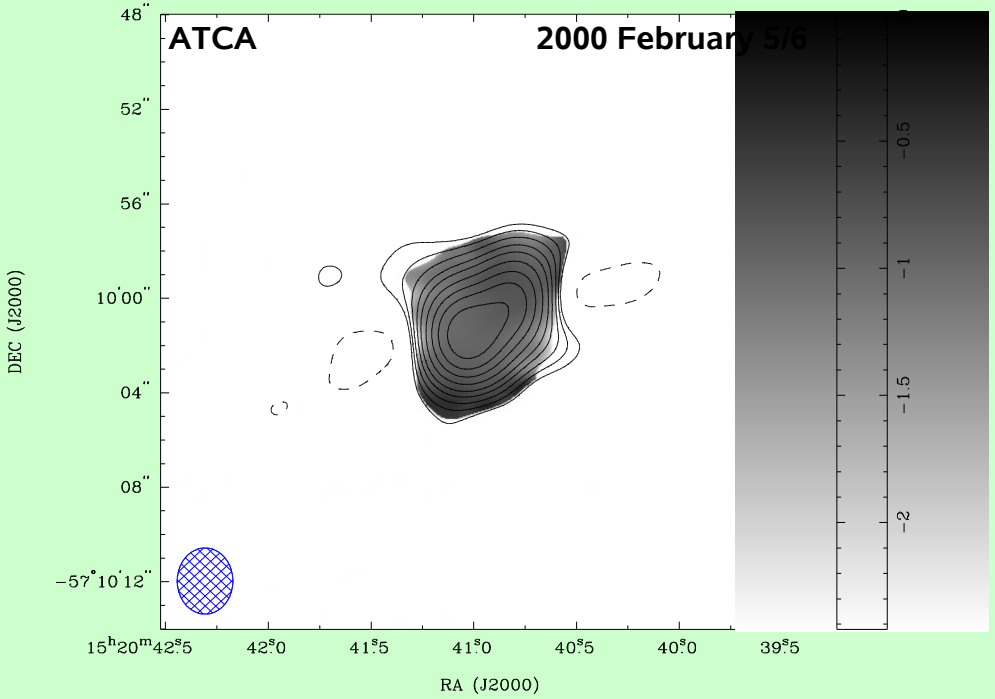
Orientation of the EVPAs and the fractional linear polarization.

Tudose et al., in preparation

The spectrum of Cir X-1

The typical spectral index α is between -0.5 and -1.0, suggesting the radiation mechanism is of synchrotron origin





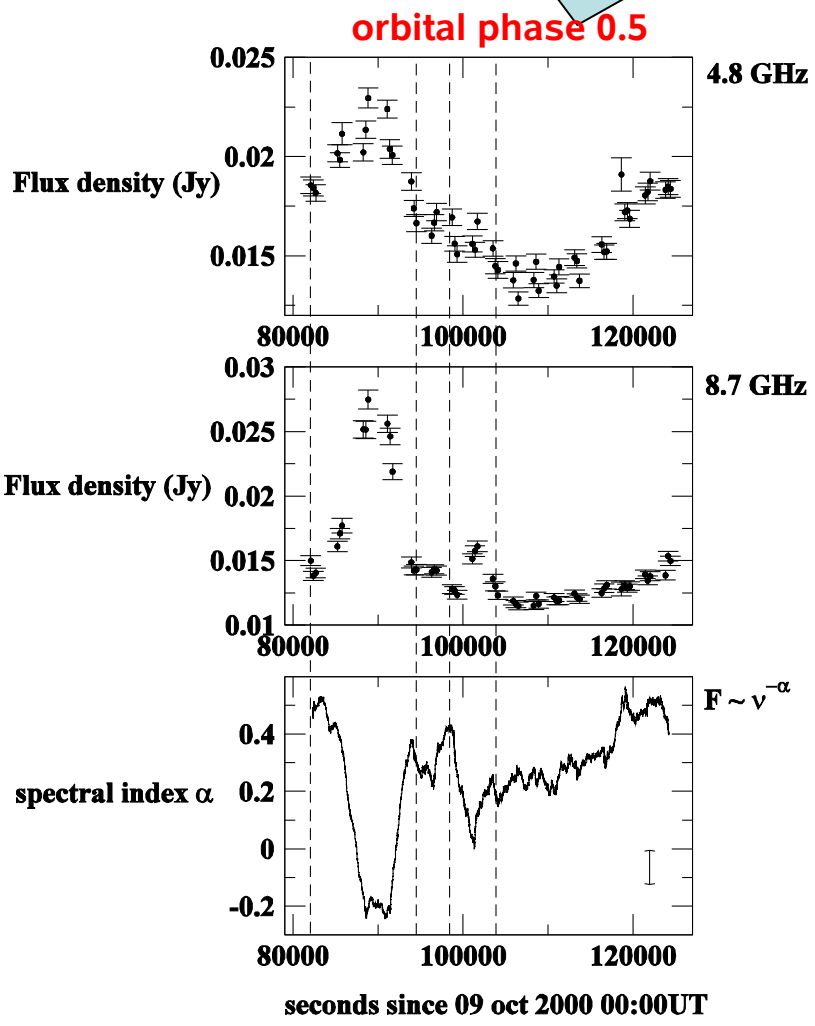
Spectral index map

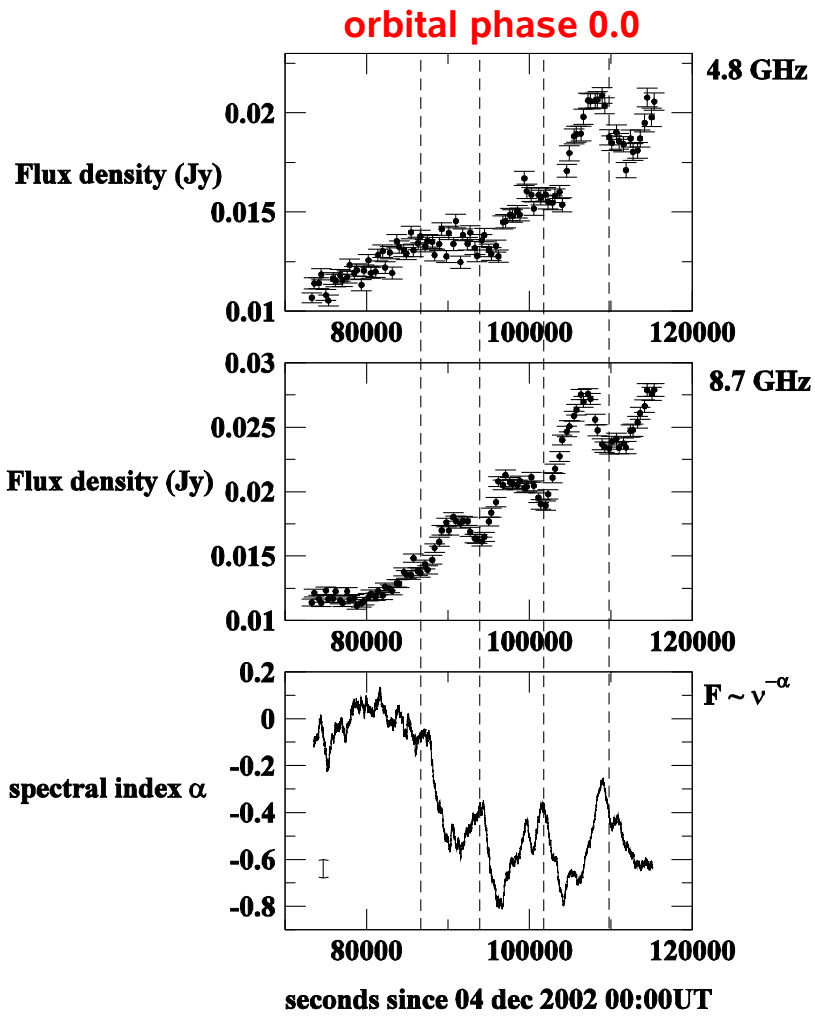
Tudose et al., in preparation

Radio flares

Flares at radio wavelengths occur periodically at orbital phase 0.0

We've found evidence for a flare at orbital phase 0.5

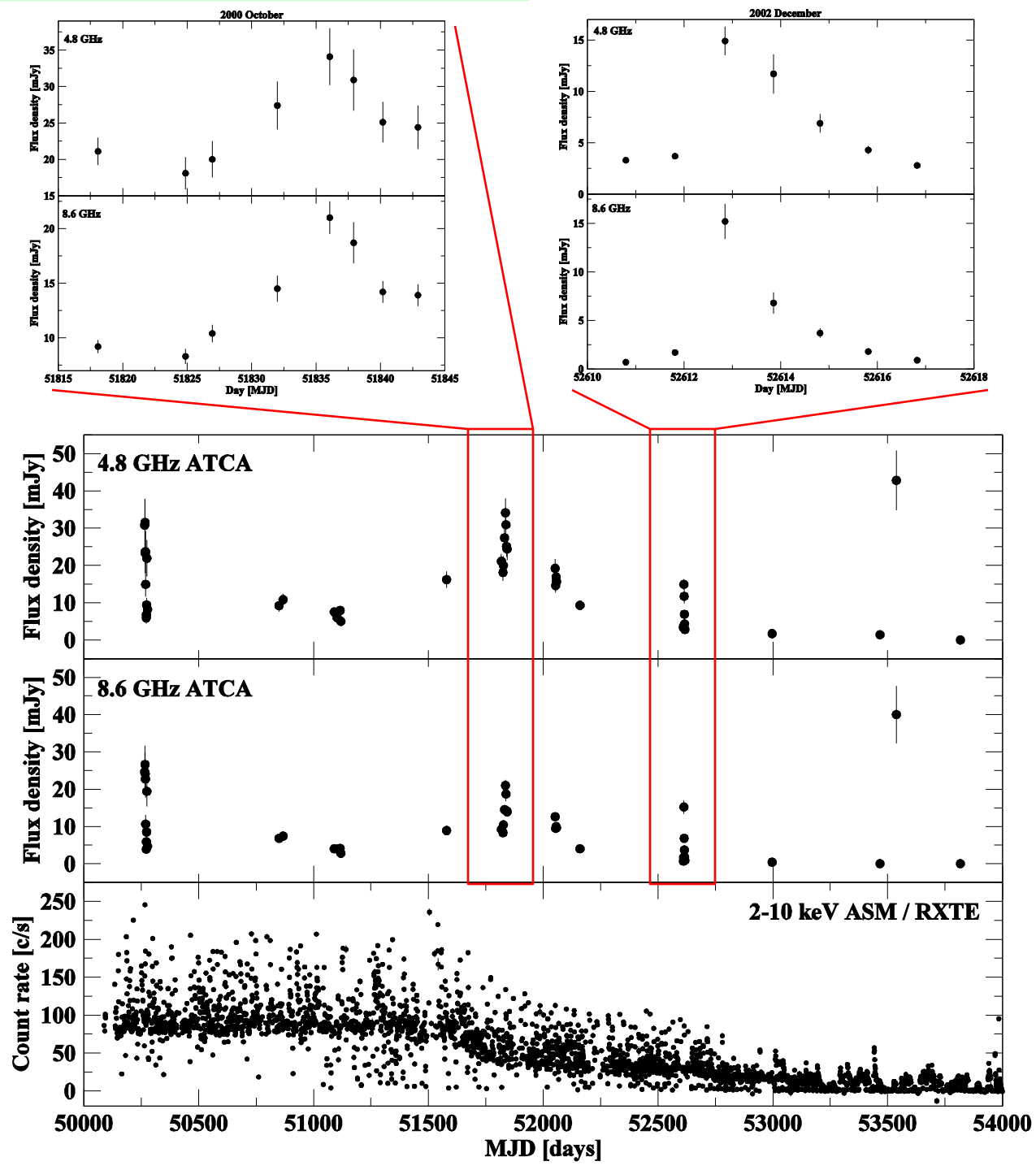




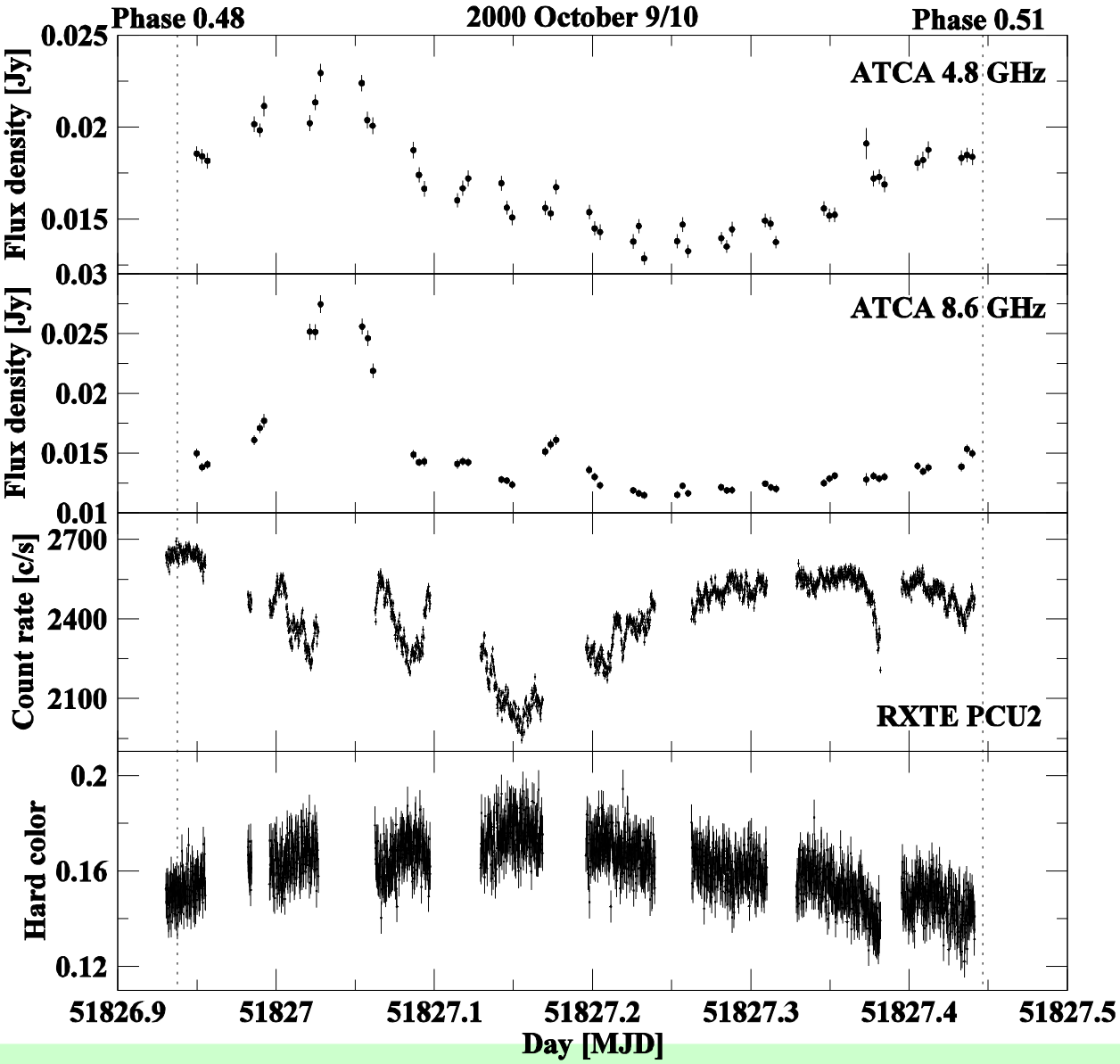
Tudose et al., 2006, PoS (MQW6) 098

Radio / X-ray

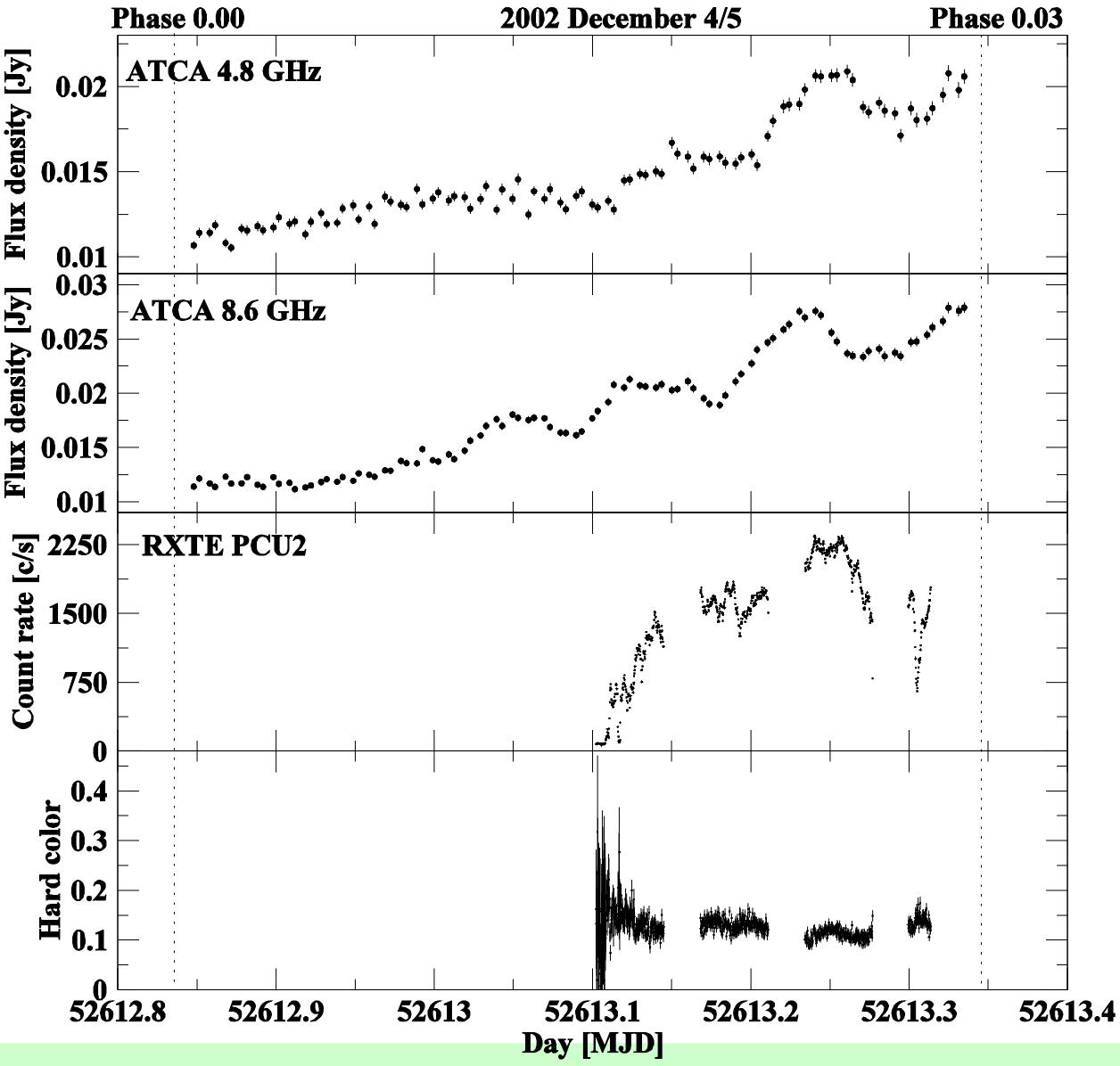
Out of 10 years of radio data, for 2000 October and 2002 December there is also simultaneous X-ray data



Soleri et al., in preparation



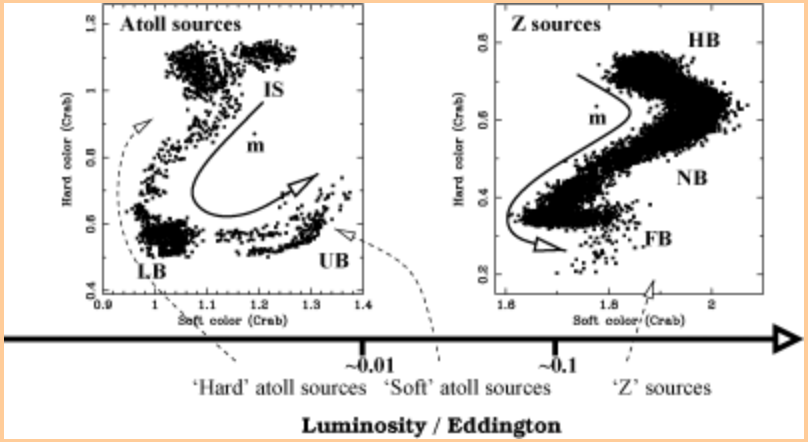
Soleri et al., in preparation



Soleri et al., in preparation

Classification of neutron star X-ray binaries

Migliari & Fender, 2006, MNRAS 366, 79



***Atoll sources*:**

IS – island state

LB – lower banana

UB – upper banana

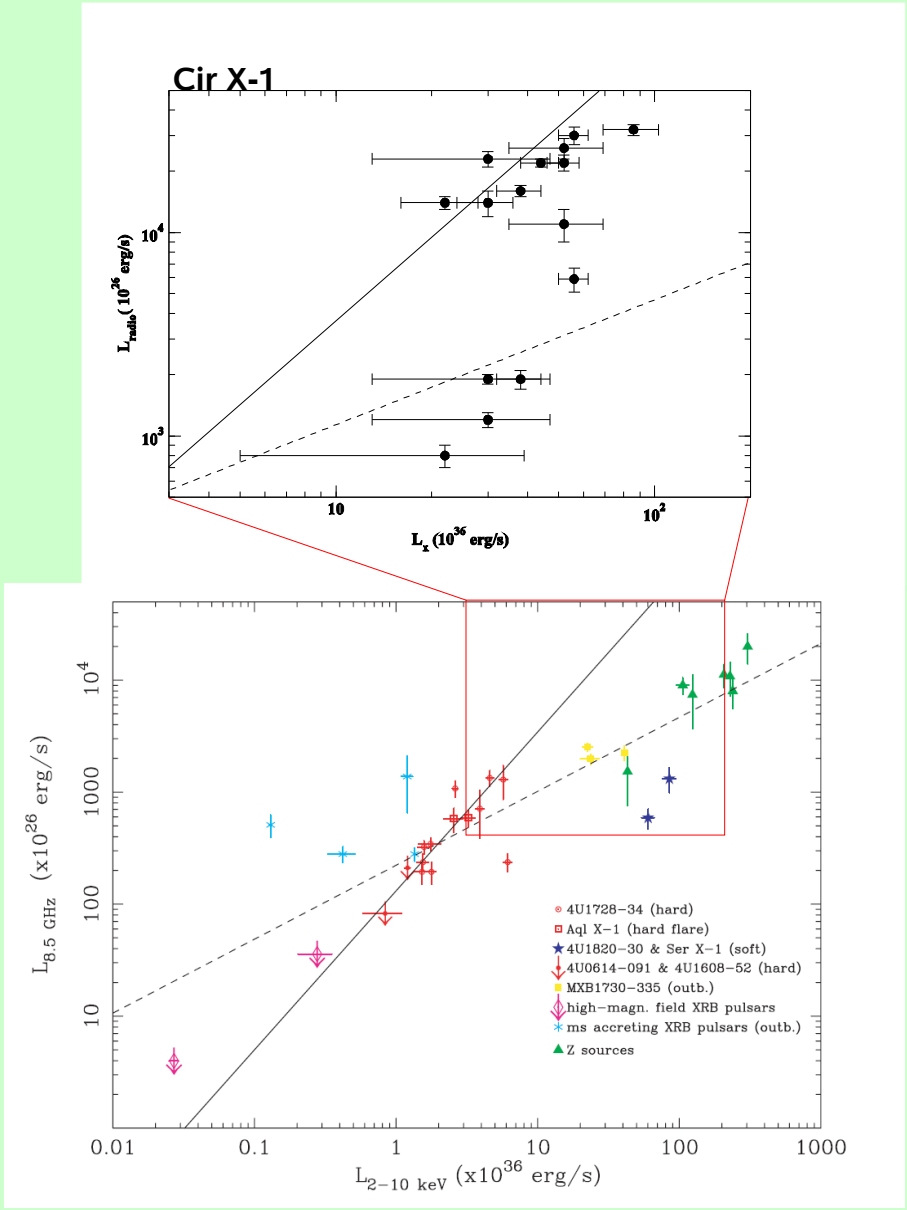
***Z sources*:**

HB – horizontal branch

NB – normal branch

FB – flaring branch

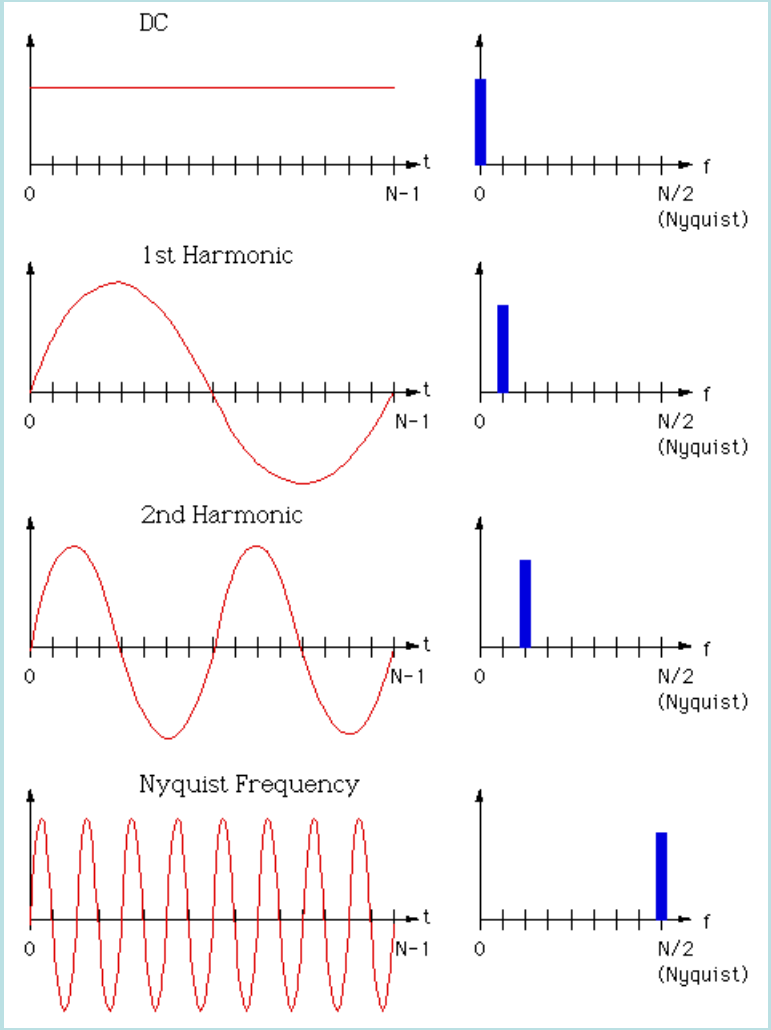
Radio and X-ray luminosities



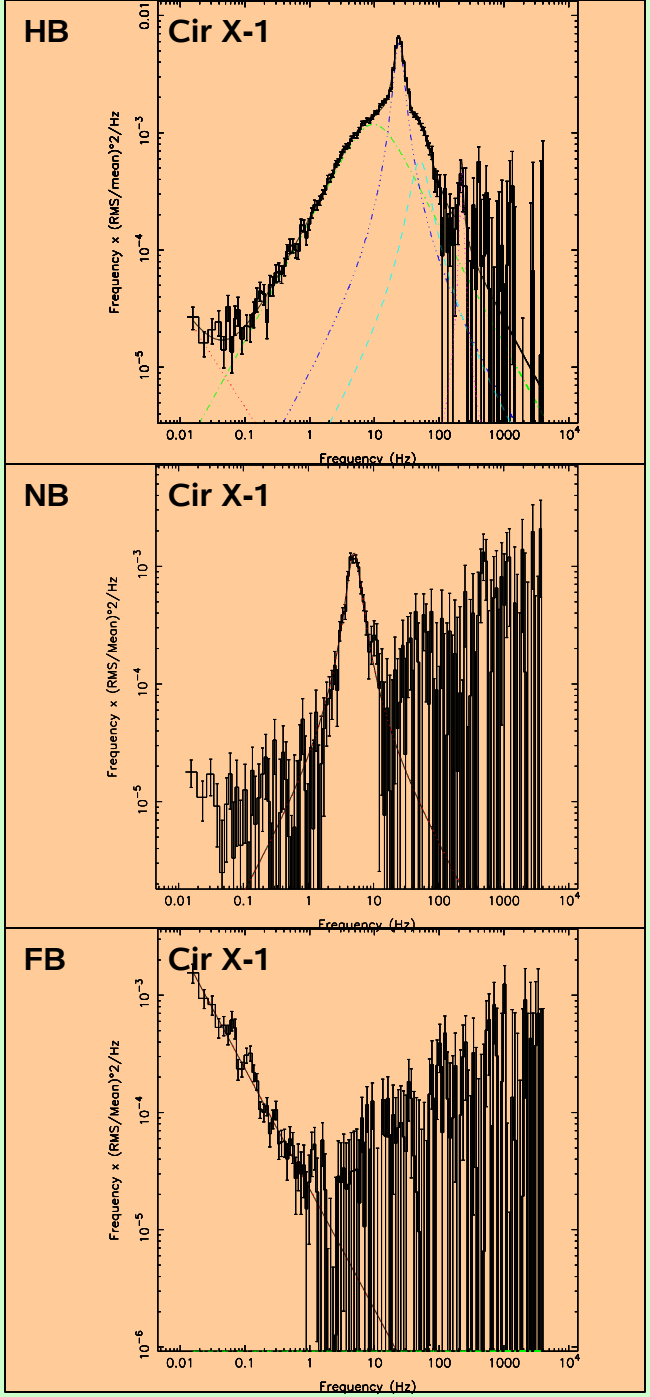
The radio luminosity (ATCA data at 8.6 GHz) vs. X-ray luminosity (ASM/RXTE data in 2-10 keV band) for Cir X-1 compared to the correlation in Migliari & Fender, 2006, MNRAS 366, 79 for neutron stars in hard state (solid line) and all the Atolls and Z sources in their sample (dashed line)

Tudose et al., 2006, PoS (MQW6) 098

Quasi-periodic oscillations (QPOs)

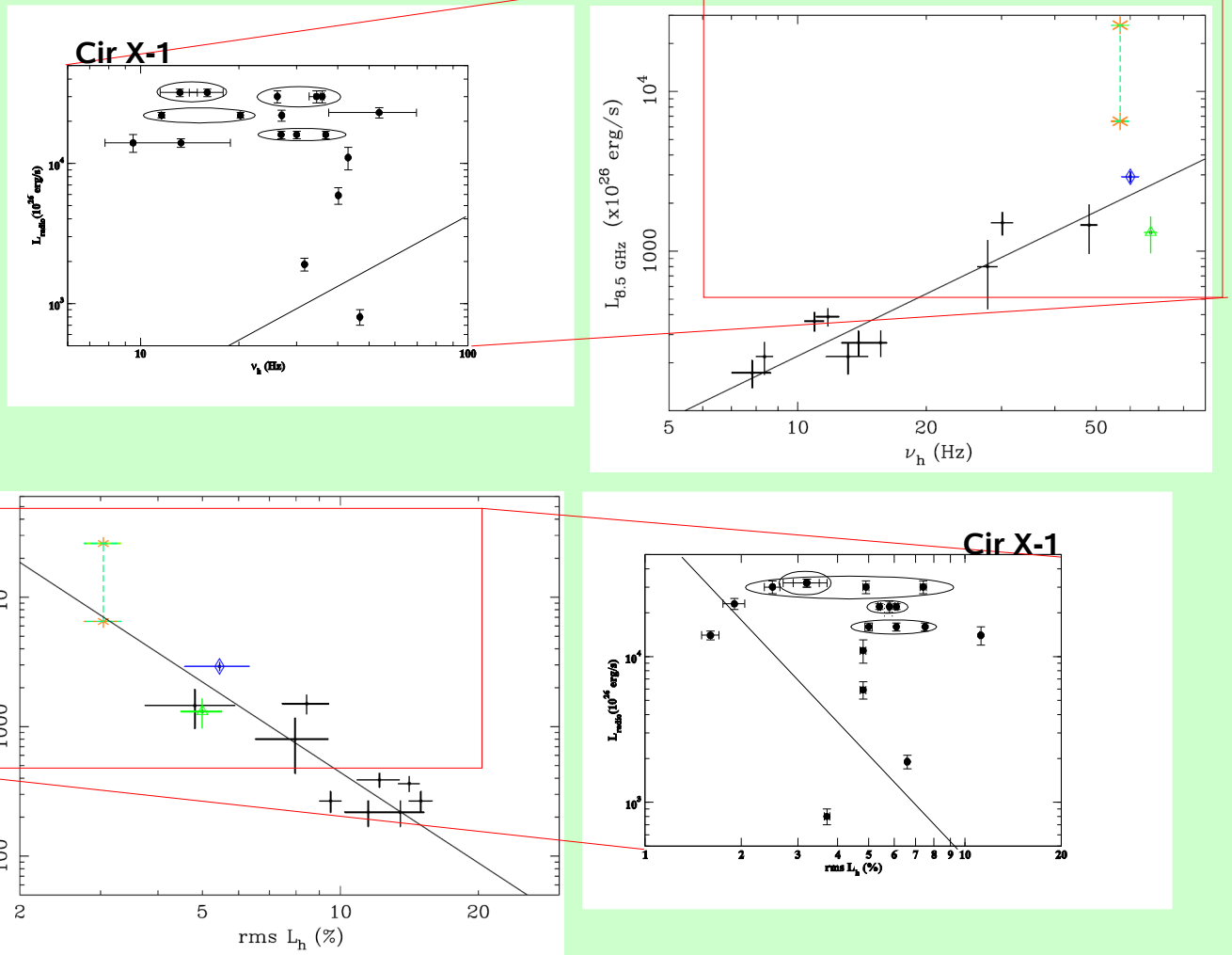


Light curve → **Fourier Transform** → **Power Density Spectra**



Soleri et al., in preparation

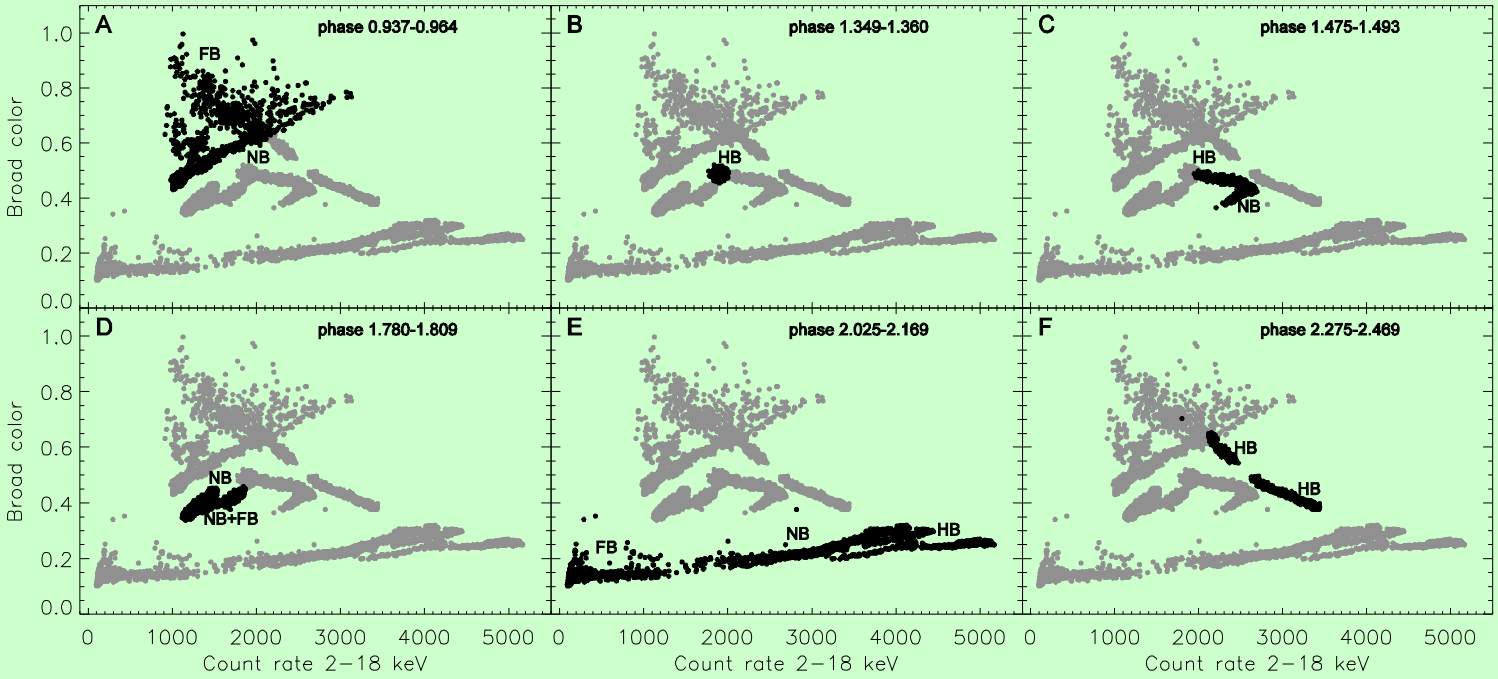
Radio luminosity and X-ray timing



Correlations for the radio luminosity and ν_h and rms L_h from Migliari et al., 2005, MNRAS 363, 112 for the neutron star X-ray binaries 4U 1728-30 (dots), Ser X-1 (open triangle), MXB 1730-335 (open diamond), the peculiar Atoll GX 13+1 (asterisks show the range of values in outburst), and our data on Cir X-1.

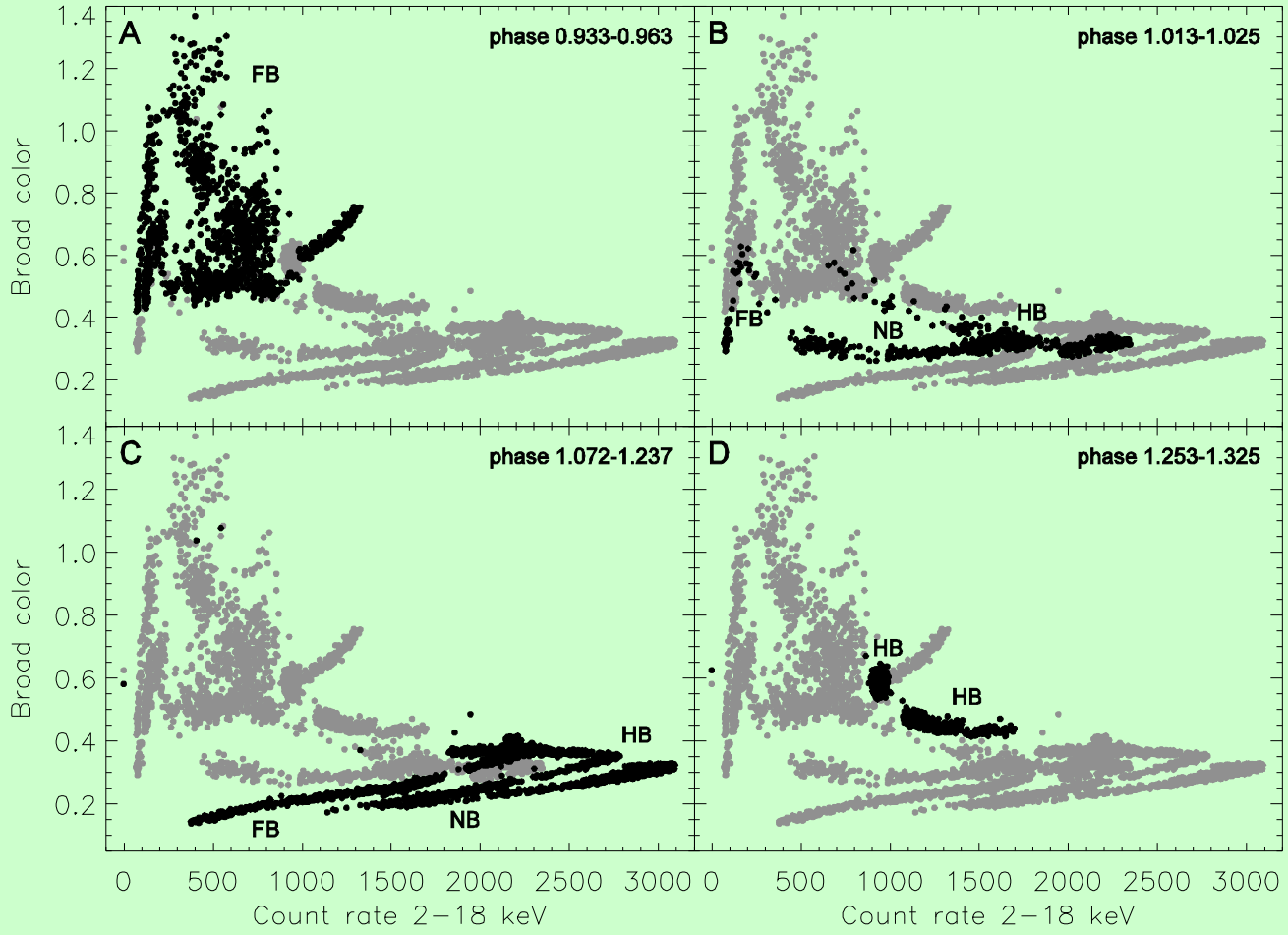
Tudose et al., 2006, PoS (MQW6) 098

Hardness-intensity diagram
2000 October



Soleri et al., in preparation

Hardness-intensity diagram
2002 December



Soleri et al., in preparation

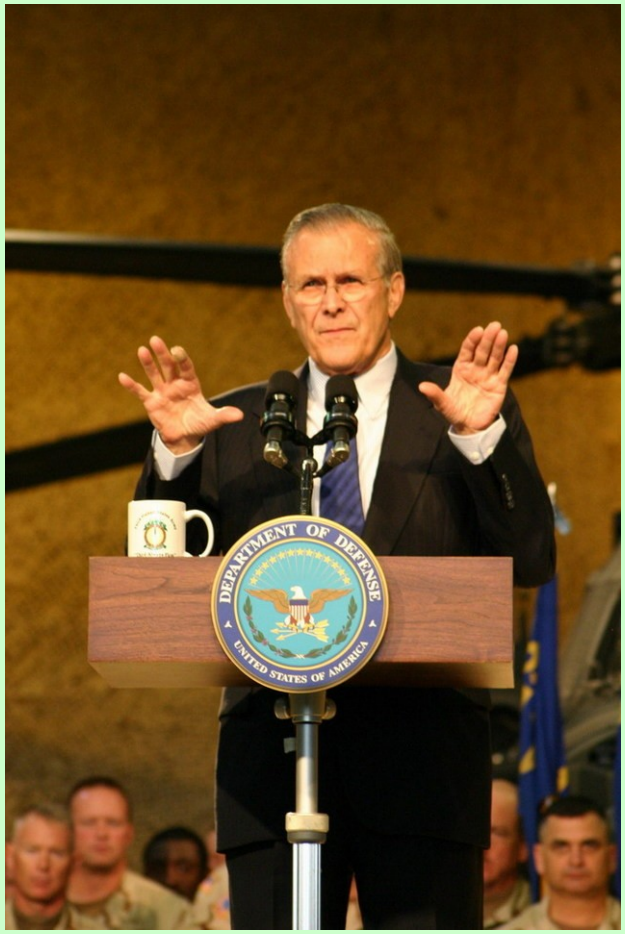
Conclusions

- structural and brightness variations at timescales of days
- evidence for flares at orbital phase 0.5
- typical spectral index between -0.5 and -1.0
- possible identification of a link between the radio and X-ray behaviour during flares

You know…

"As we know, there are known knowns. There are things we know we know. We also know there are known unknowns. That is to say, we know there are some things we do not know. But there are also unknown unknowns, the ones we don't know we don't know."

Donald Rumsfeld, February 12, 2002, Department of Defense news briefing



How Far Will They Go?

How Far Will They Go?