Galactic Bulge Survey

Peter Jonker (SRON & CfA)
Cees Bassa (SRON & RU Nijmegen)
Gijs Nelemans (RU Nijmegen)

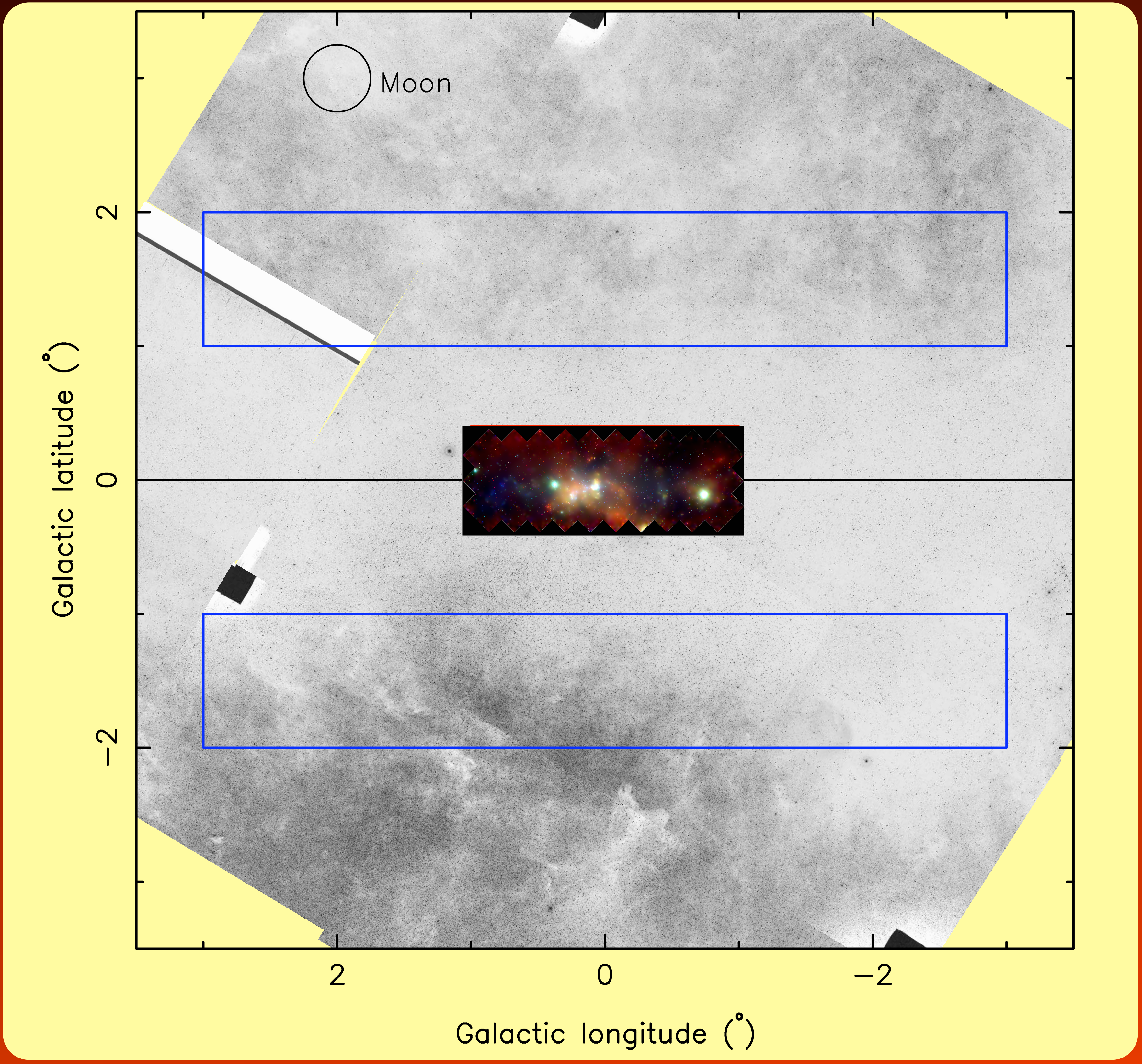
for the GBS team (15 active people)
see http://www.sron.nl/~peterj/gbs

Netherlands Institute for Space Research

Netherlands Organisation for Scientific Research

What is the Galactic Bulge Survey?

Chandra+Blanco r',i', Hα imaging of 12-sq.deg



Science goals

- Find eclipsing low-mass X-ray binaries

  Model independent mass measurements
  black hole formation & neutron star EoS

- Constrain common envelope evolution via number count

  Cataclysmic variables and ultra-compact
  low-mass X-ray binaries

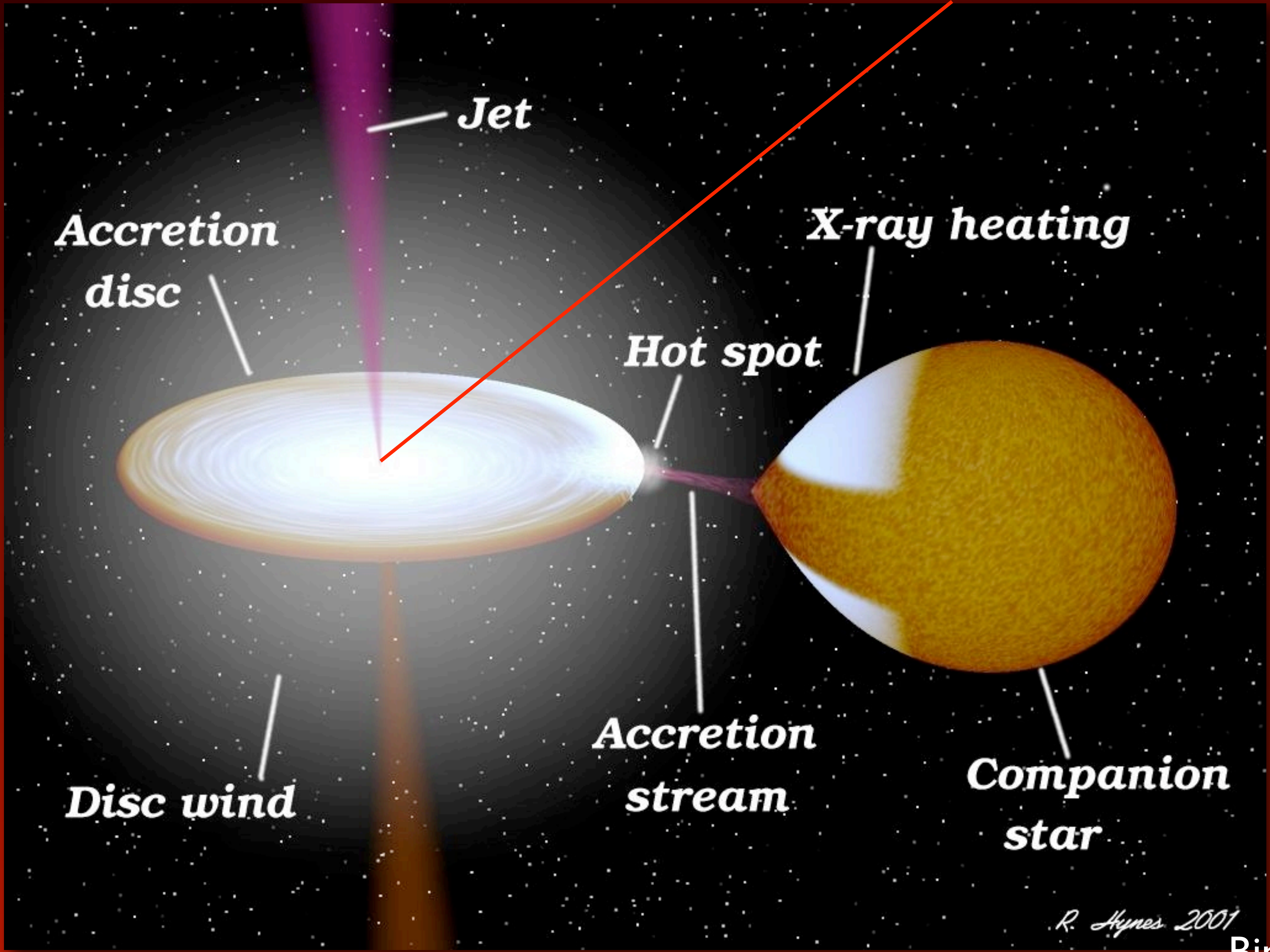
- Use quiescent LMXBs to map the Galactic structure

  X-ray binaries trace stellar mass distribution
  (modulo kick)

  Gilfanov 2004, Jonker & Nelemans 2004, cf. Weidenspointner et al. 2008

Cartoon image of a low-mass X-ray binary

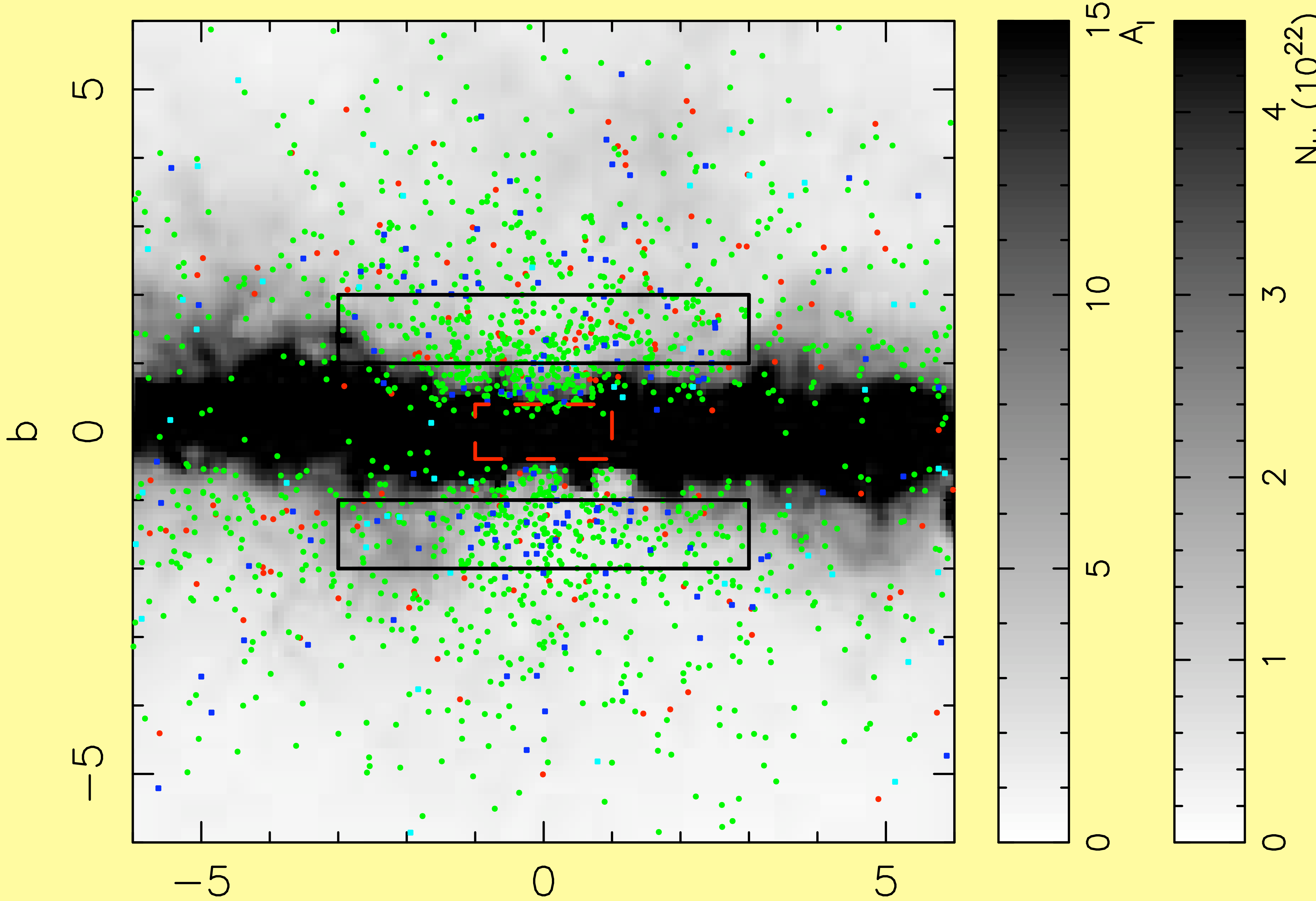
Compact object:
neutron star or black hole



BinSim R. Hynes

Population synthesis of LMXBs

pUCXBs
qUCXBs
qLMXBs
pLMXBs



Details of Galactic model: Nelemans et al. 2004

~400 qLMXBs predicted ≥10 eclipsing

Mapping Galactic structure?

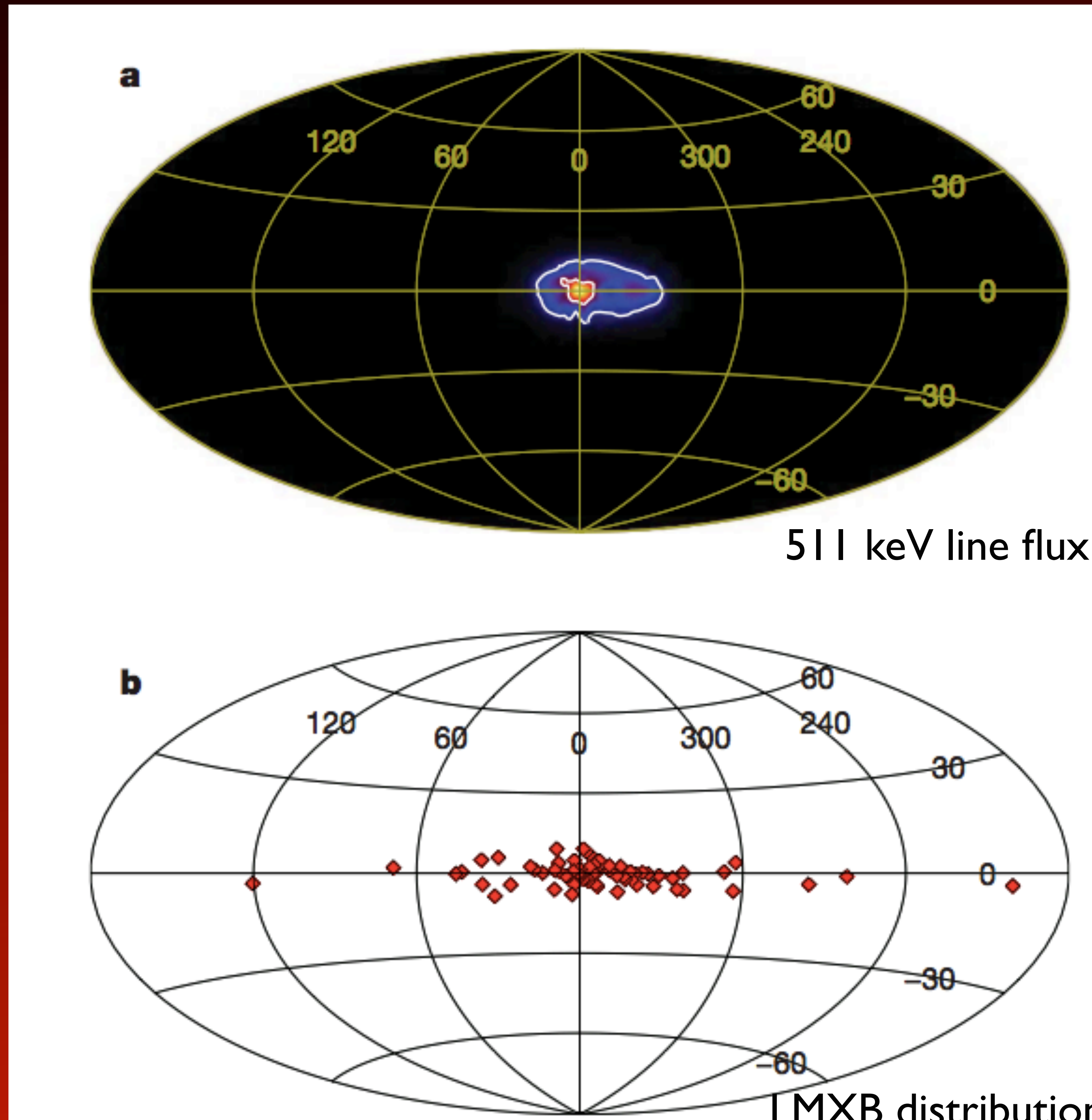
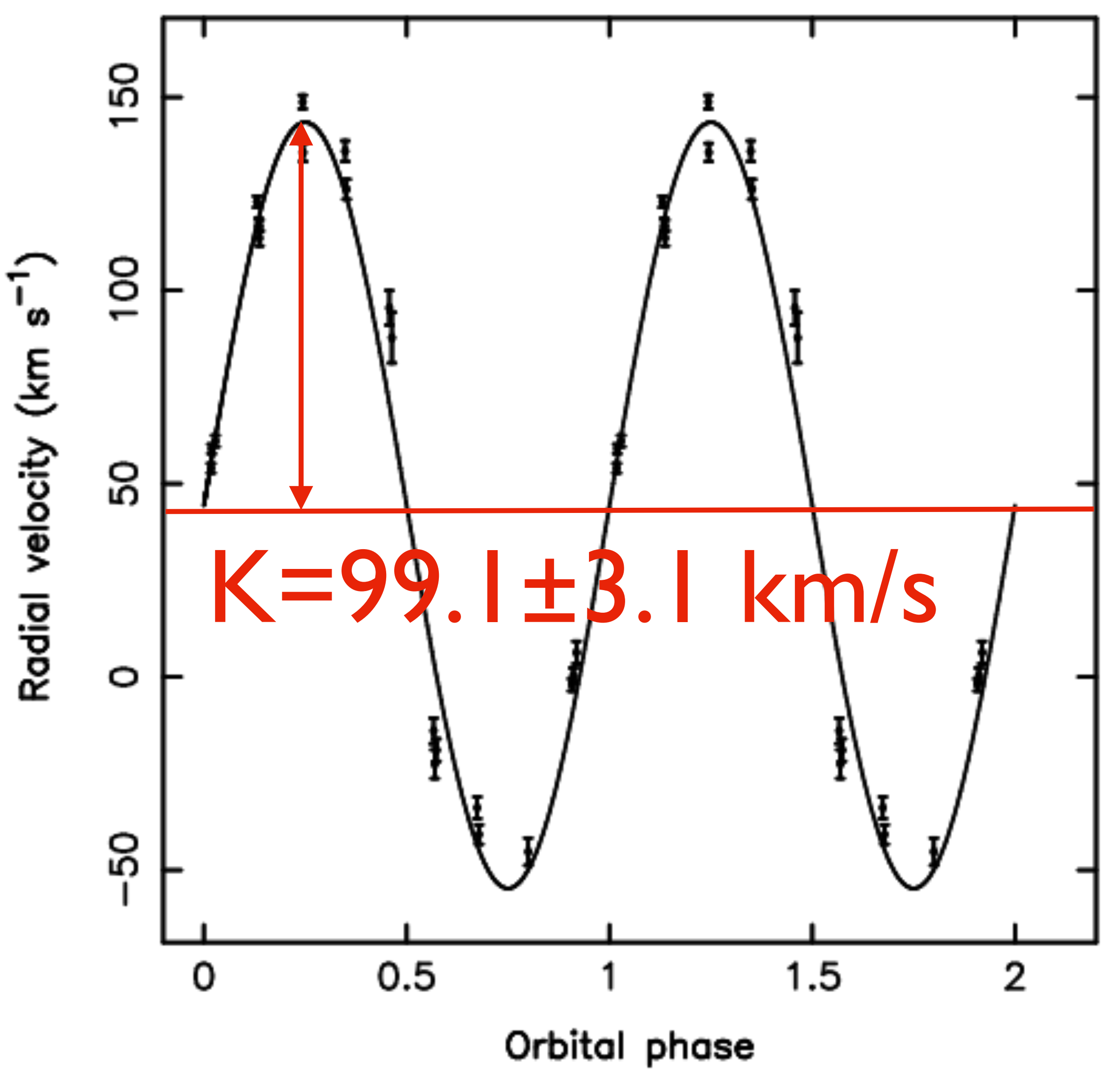
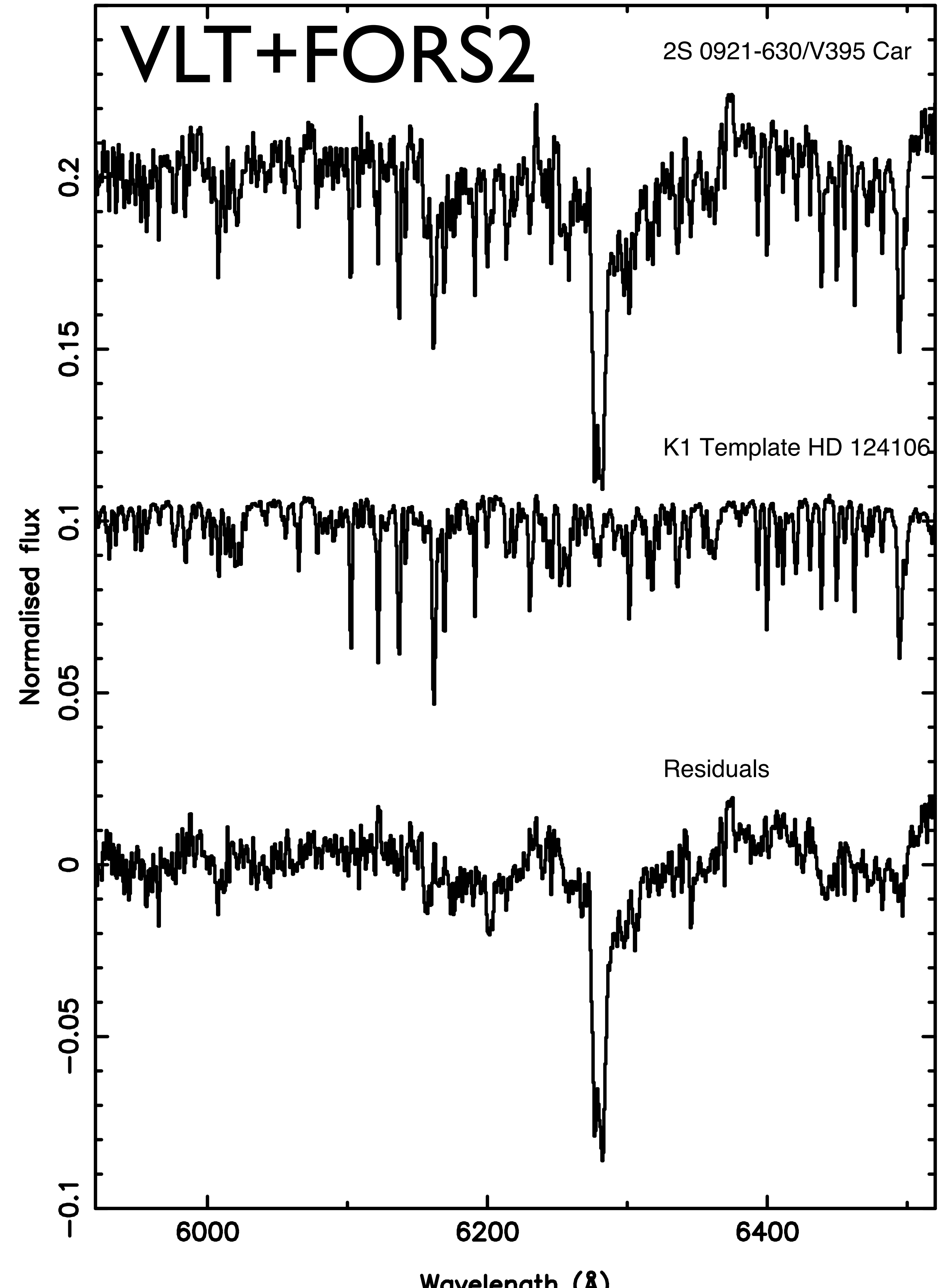


Figure from Weidenspointner et al. 2008

Neutron star or black hole mass measurement:

$$\frac{P_{orb}K^3}{2\pi G} = \frac{M_{NS}\, sin^3 i}{(1+q)^2}$$





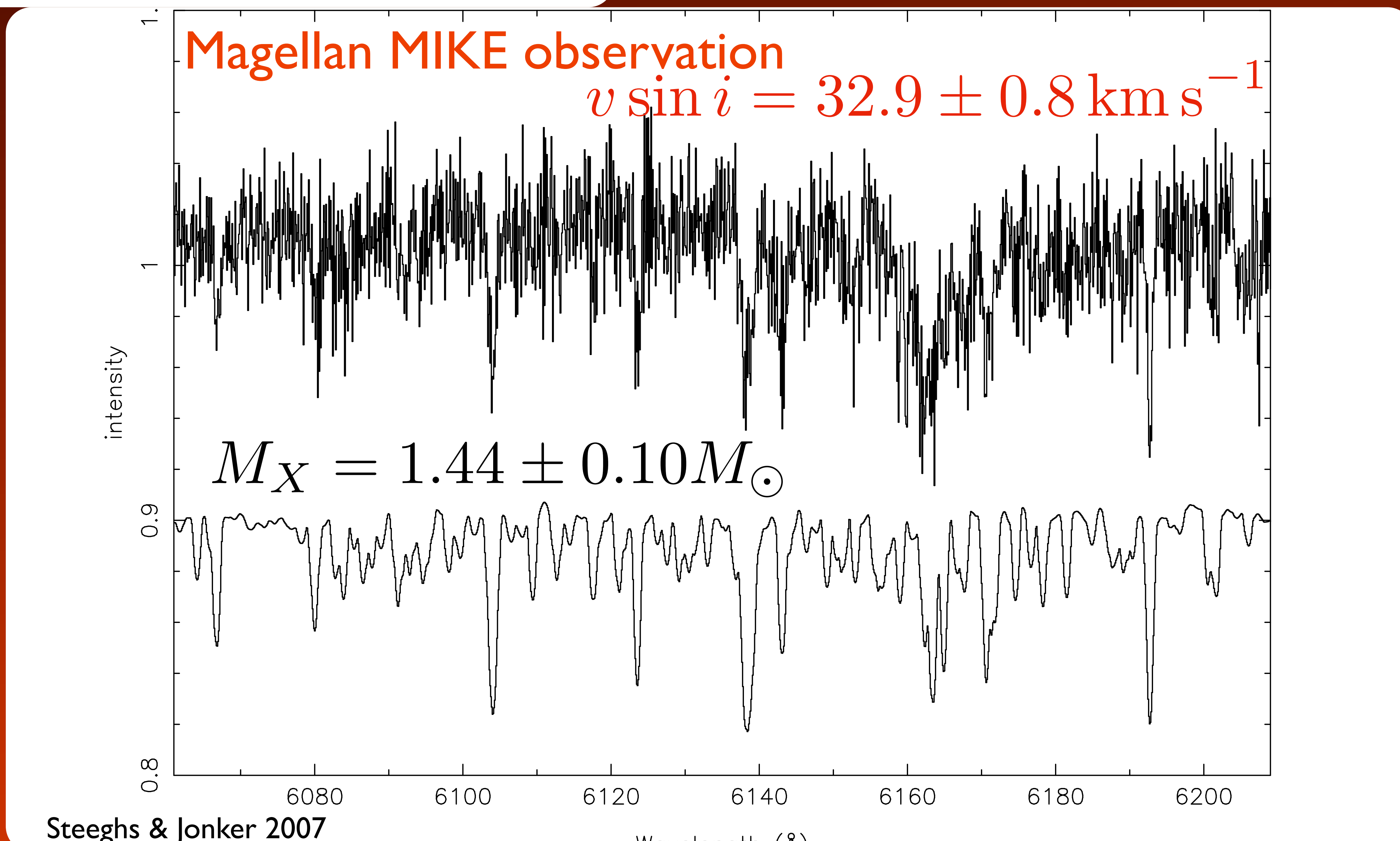
Outburst system, partial eclipse

Jonker et al. 2005

Measure rotational line broadening

$$\frac{P_{orb}K^3}{2\pi G} = \frac{M_{NS}\,sin^3 i}{(1+q)^2}$$

$$\frac{v\ sin\ i}{K} = 0.46[(1+q)^2 q]^{1/3}$$



Steeghs & Jonker 2007

Neutron star or black hole mass measurement:

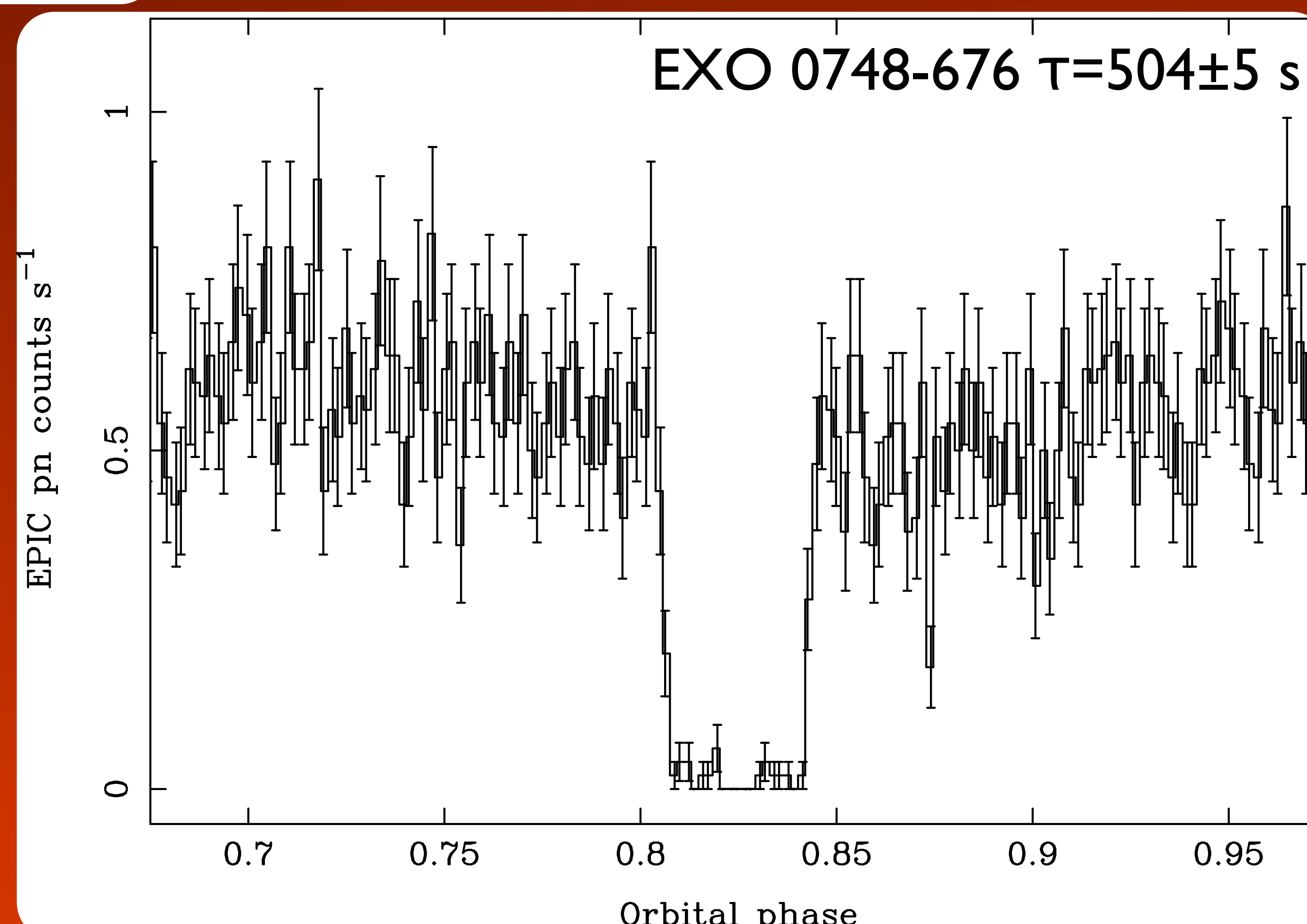
$$\frac{P_{orb} K^3}{2\pi G} = \frac{M_{NS}\, sin^3 i}{(1+q)^2}$$

$$\frac{v\ sin\ i}{K} = 0.46[(1+q)^2 q]^{1/3}$$

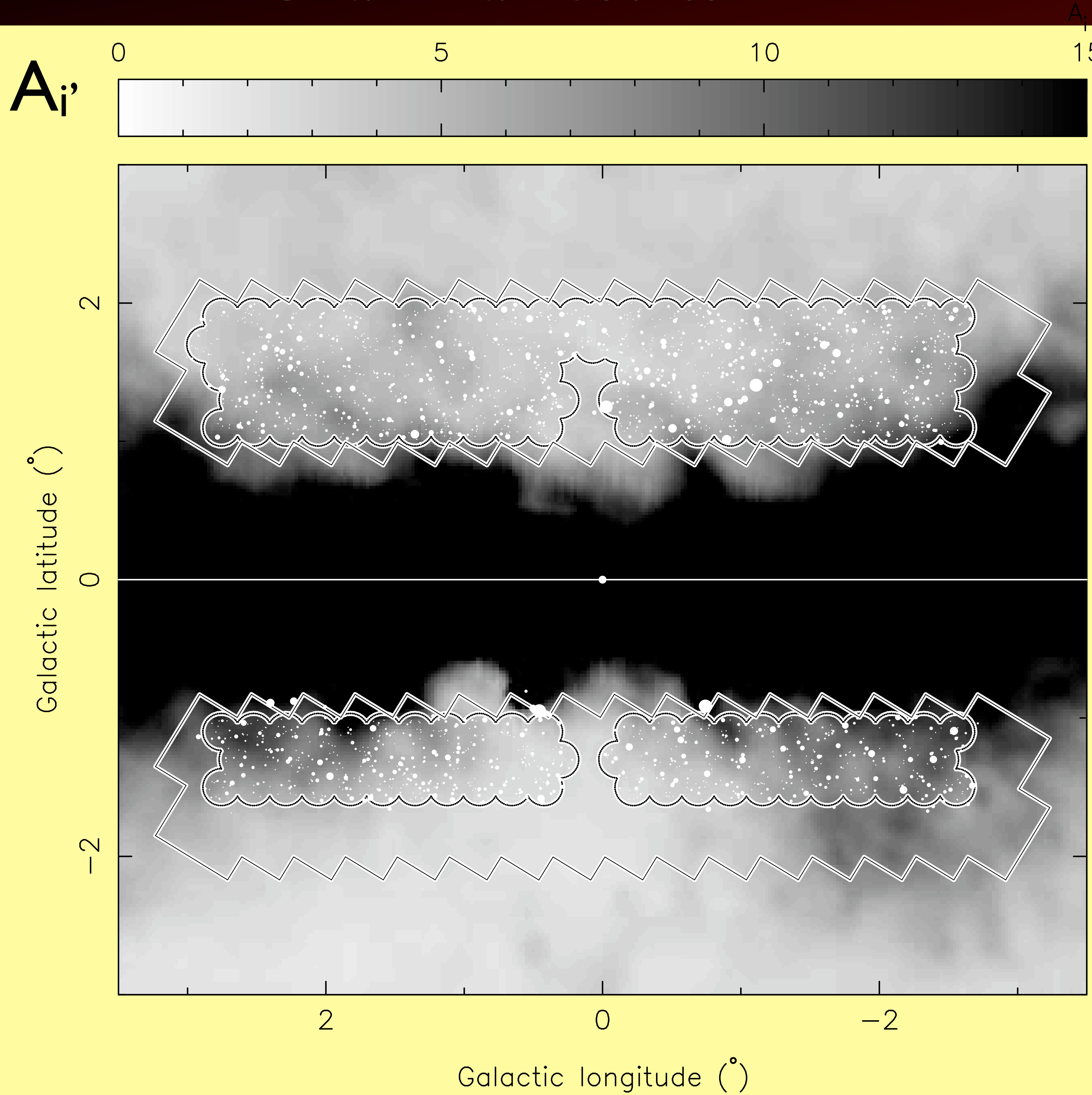
$$\Delta\phi^2 = \left(\frac{0.49\, q^{2/3}}{0.6\, q^{2/3} + \ln(1+q^{1/3})}\right)^2 - \left(\frac{\cos i}{1+q}\right)^2$$

Horne 1985

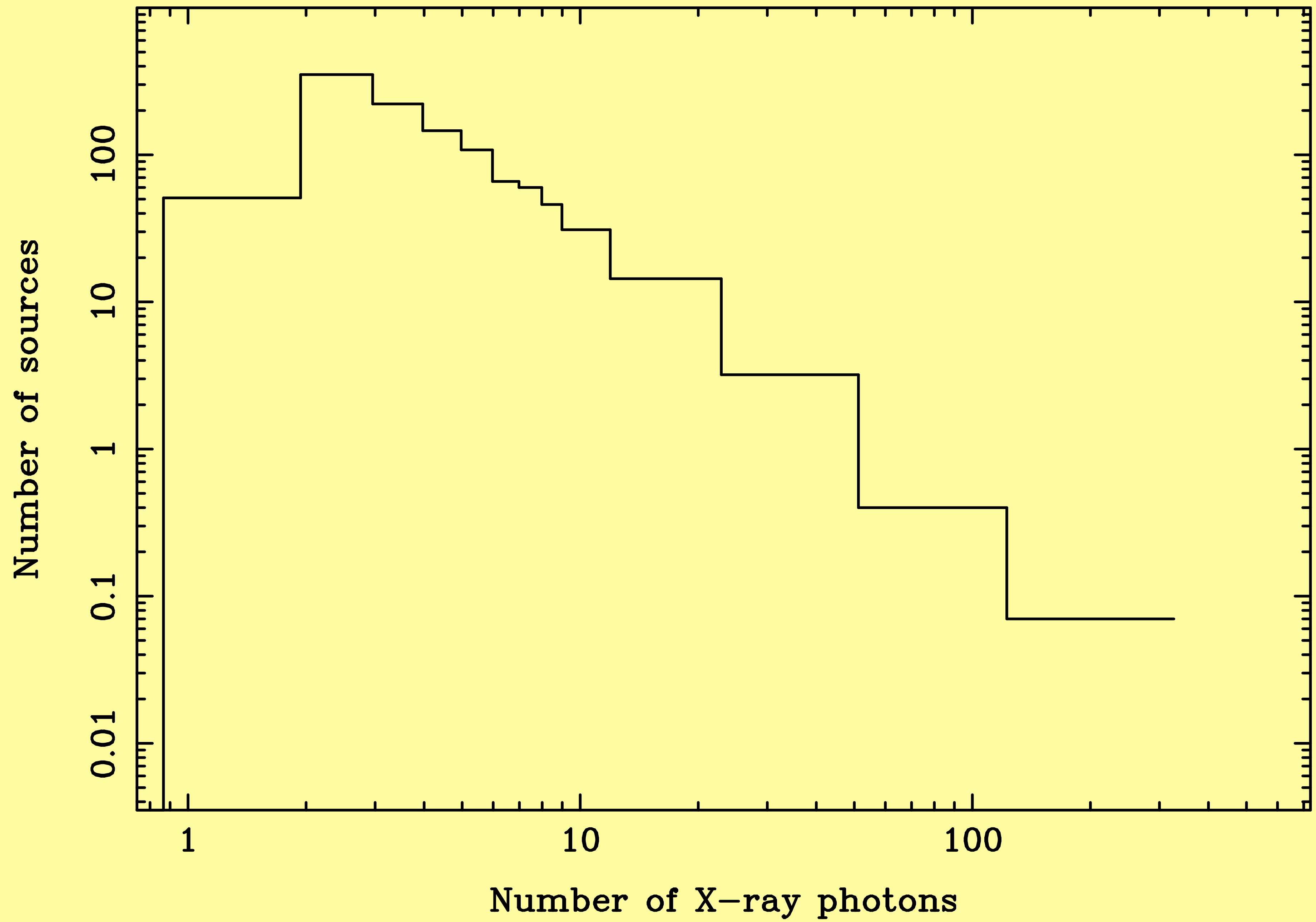
Best results: quiescent eclipsing systems



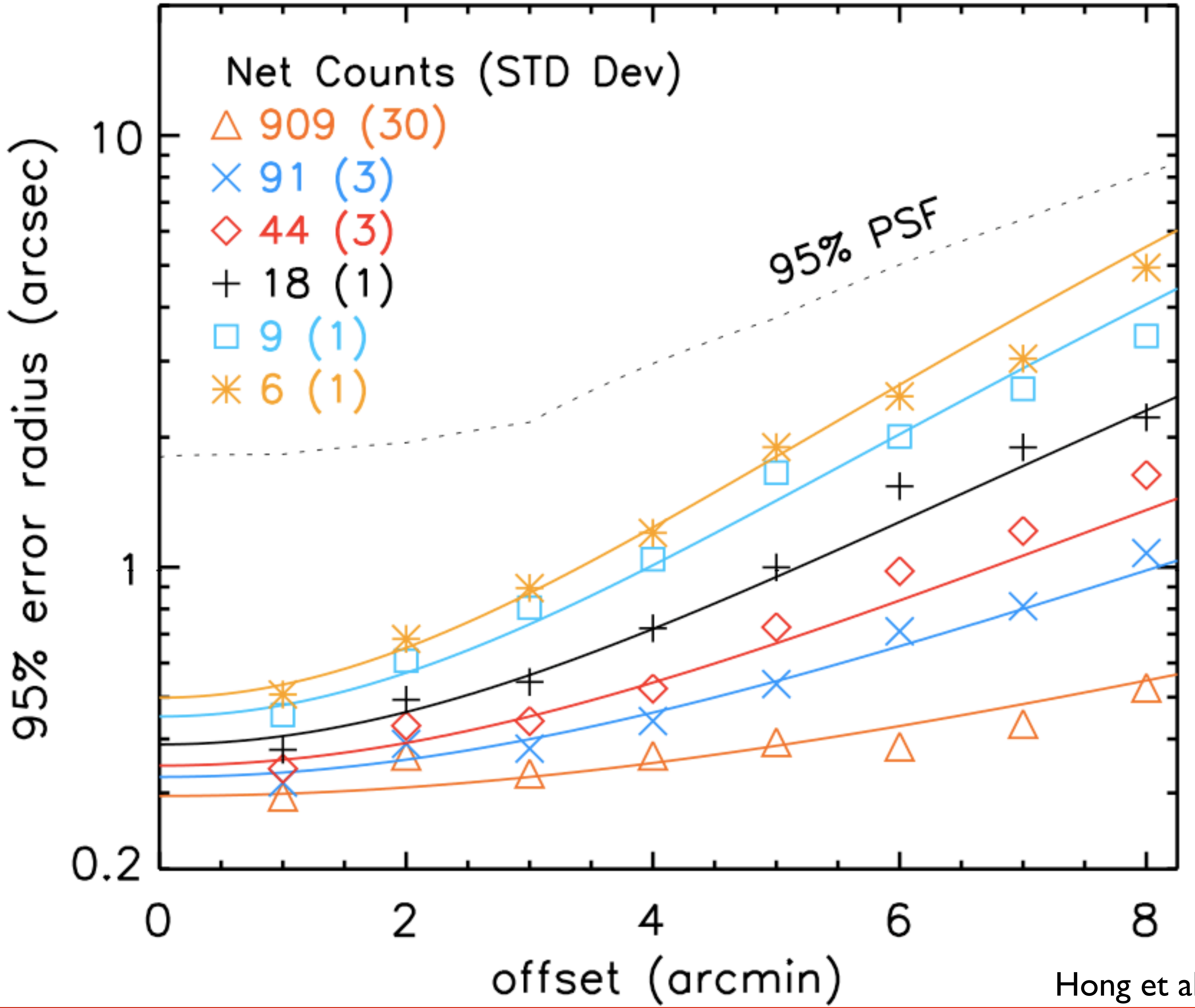
Chandra results



Number of Chandra sources as a function of detected counts (in 1 cnt bins)

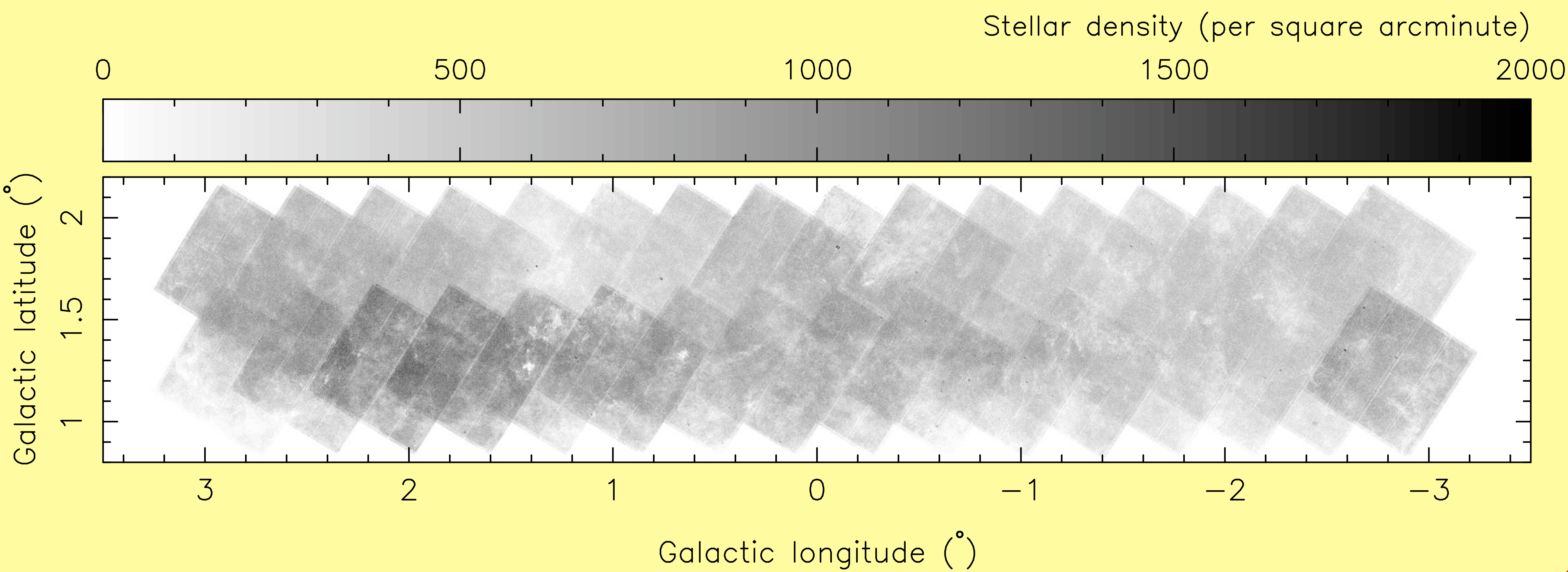


Chandra localisation accuracy vs offset and # of cnts



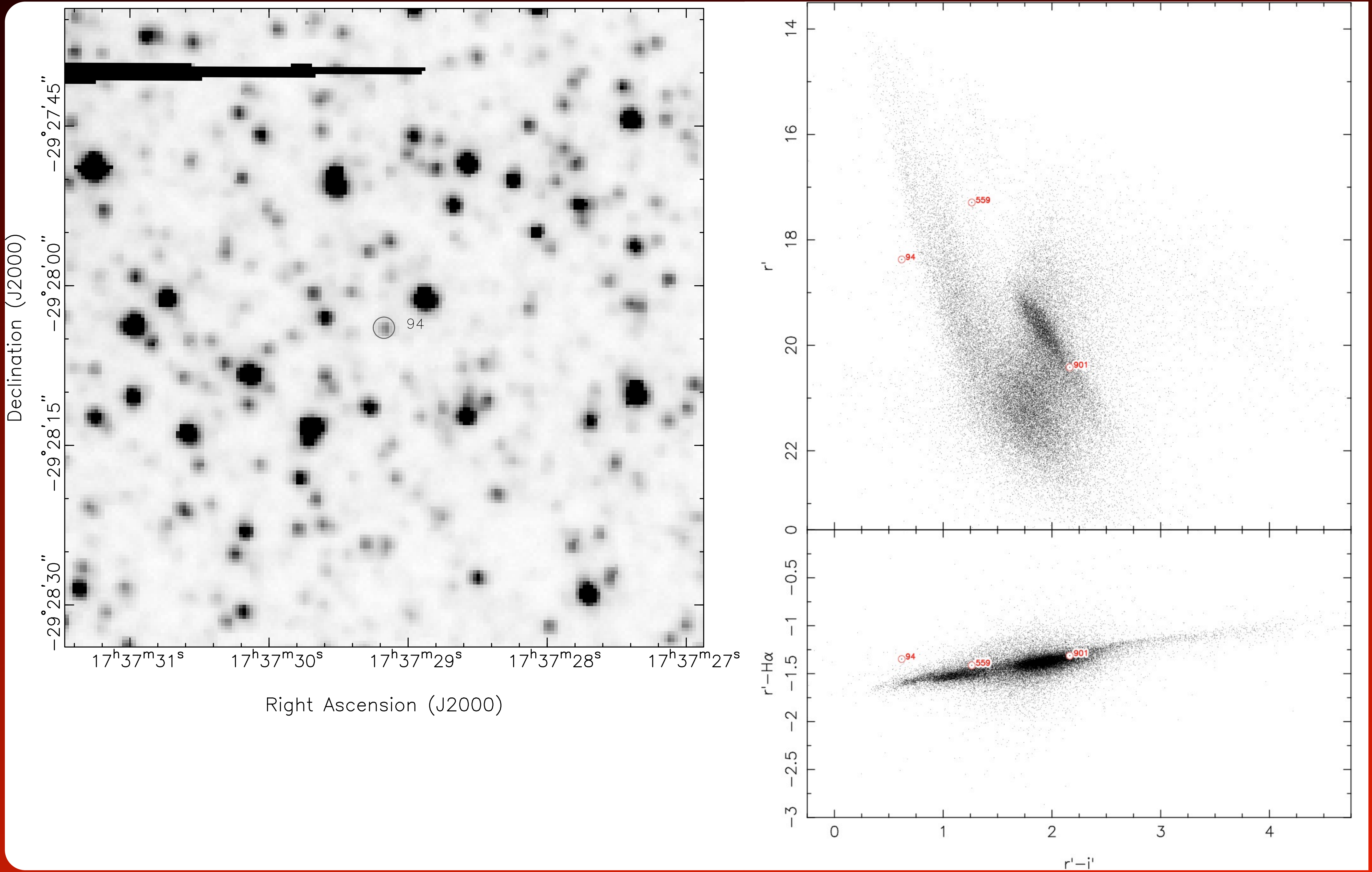
Hong et al. 2005

Stellar density image Northern GBS strip



Northern strip:
801 X-ray sources
556 sources with optical counterpart

Chandra localisations + CMD (instrumental)



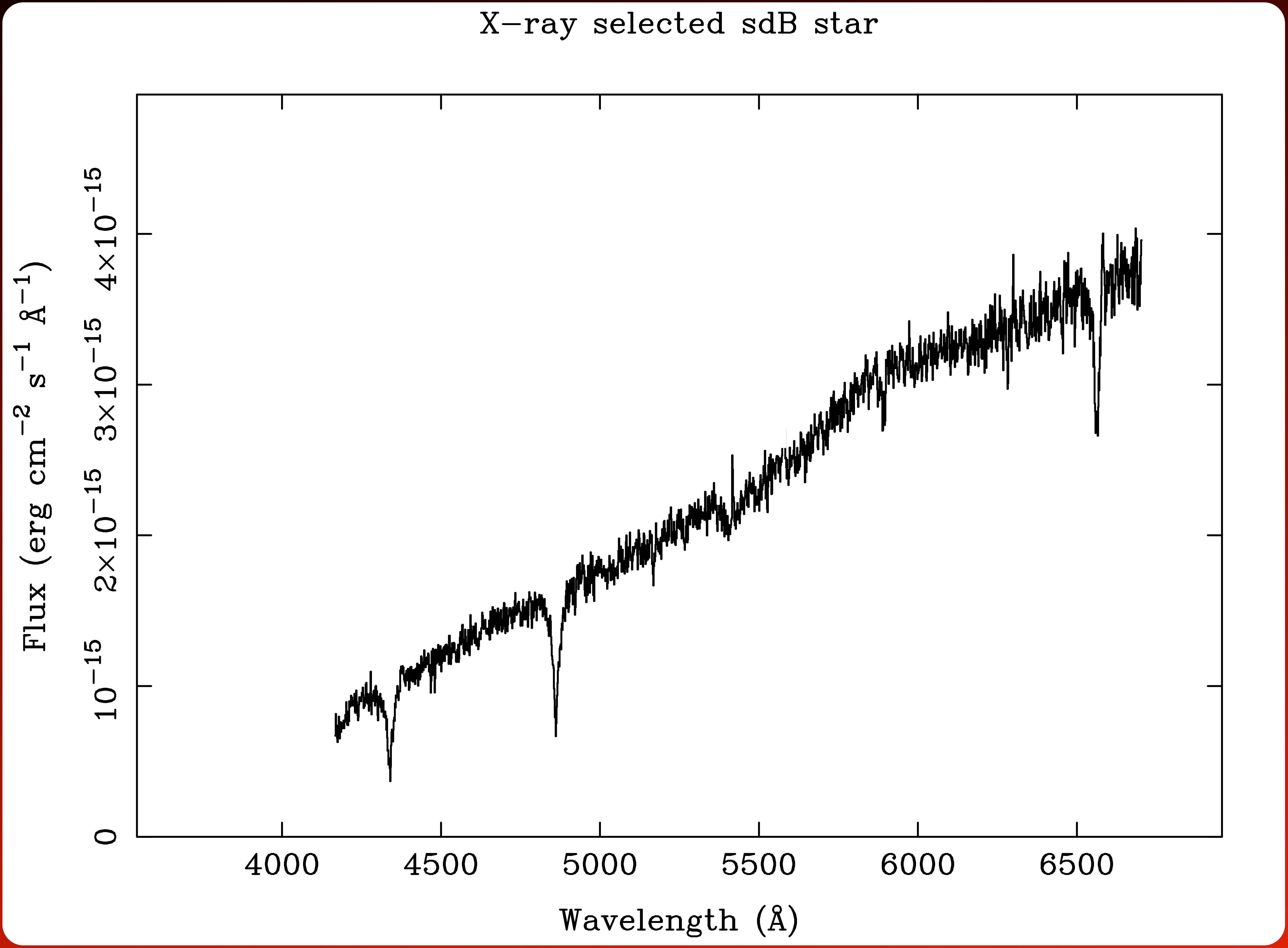
First spectroscopic observations: Hydra

- Three dark nights of CTIO 4m Blanco telescope time in June 2008

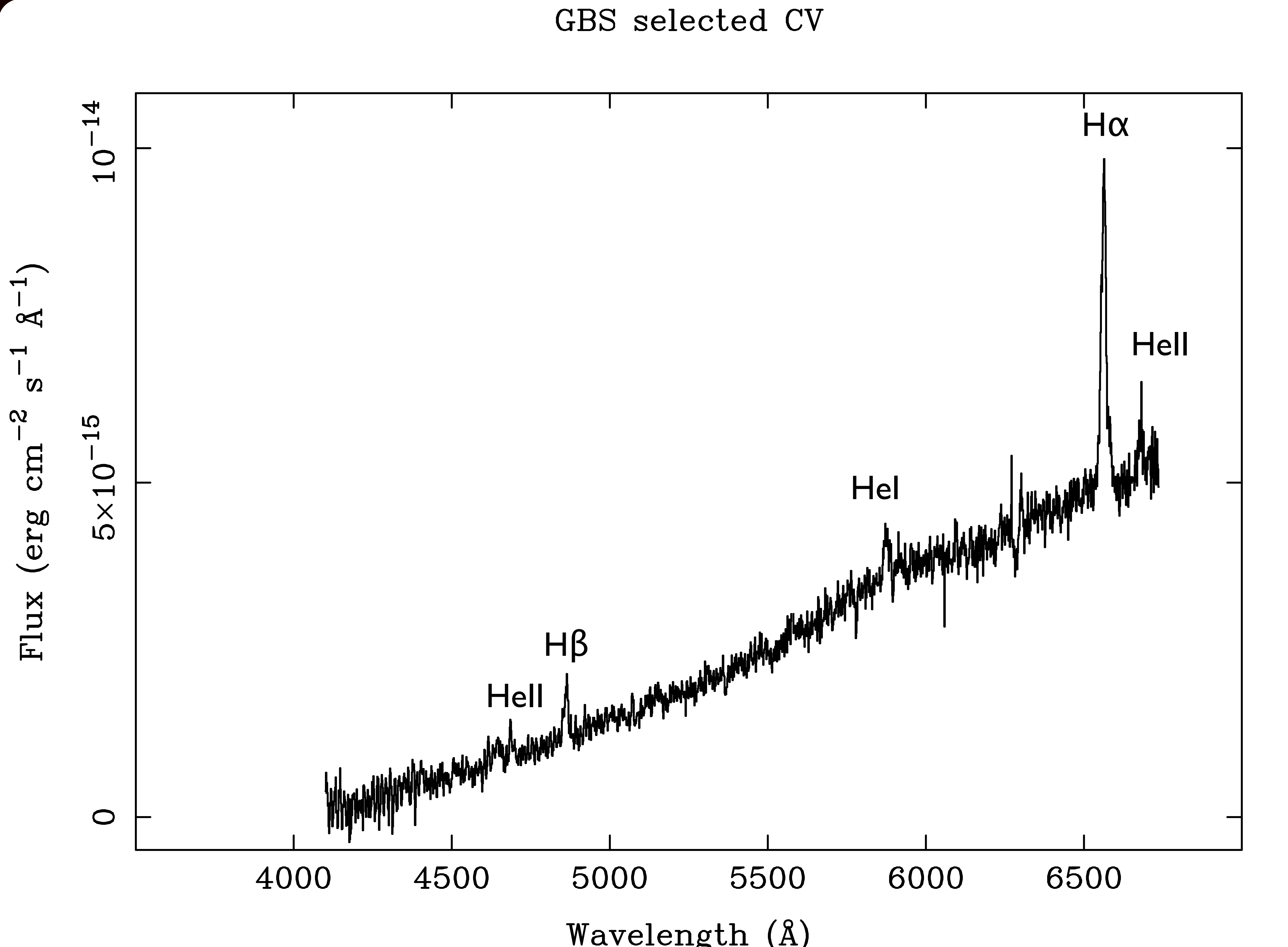
- Hydra: multi-object fiber-fed spectrograph.
    - 40 arcmin diameter FOV
    - 138 fibers (2 arcsec diameter)
    - Minimum fiber-to-fiber distance: 25”
    - Setup: slitless + KPGL3 grating
    - Useful ~4000-6900 A and 5 A FWHM

- We targetted bright (<18 mag) stars from UCAC and USNO B1.0 catalogs within < 5 arcsec from the position of an X-ray source

Initial Hydra results



Initial Hydra results (ii)



Lots and lots of optical follow-up needed

- Three more nights of Hydra in July 2009

- IMACS: Inamori Magellan Areal Camera and Spectrograph (proposal pending)
  - Multislit spectroscopy
  - 27.4 arcmin diameter FOV
  - Setup: 1 arcsec slit + 300 g/mm grating. Useful interval 3900-7000 with 7 A FWHM
  - s/n of 10 at Halpha in 30 min for r'=20

- VIMOS for identification the faint sources $20 < r' < 23$ to be proposed: in total needs ~170 pointings ➛300 hours

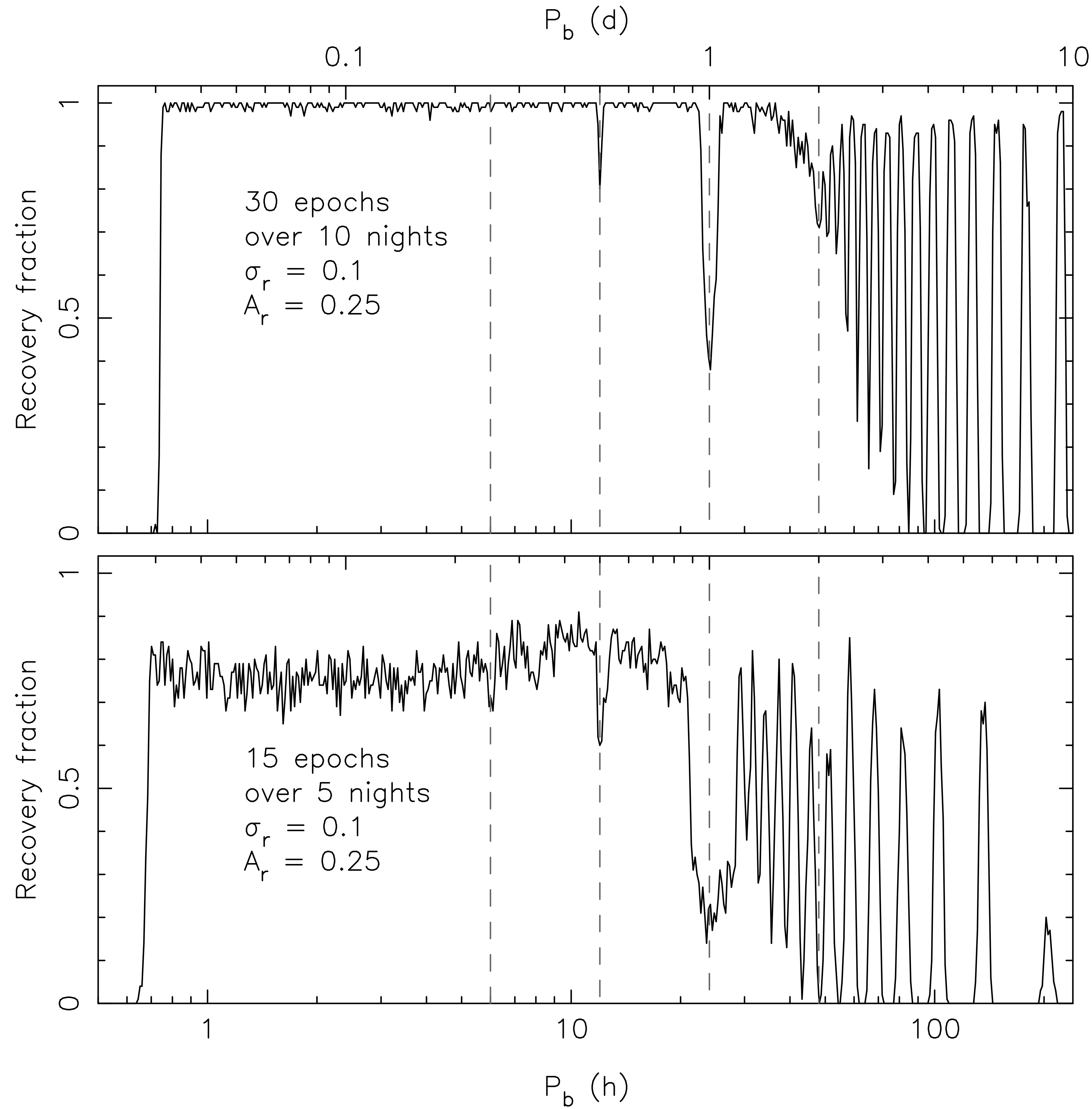
- FORS2 + X-shooter for phase resolved spectroscopic obs

  24 hours of X-shooter GTO time awarded

- Photometric follow-up to determine variability (orbital periods)

  Strategy: re-observe the whole GBS area 15-30 times in r'

Optical follow-up photometry



Finally:

Much more to be done with the data collaborations welcome (spare fibers, slitlets etc)

We will help raise the oversubscription rate for VIMOS