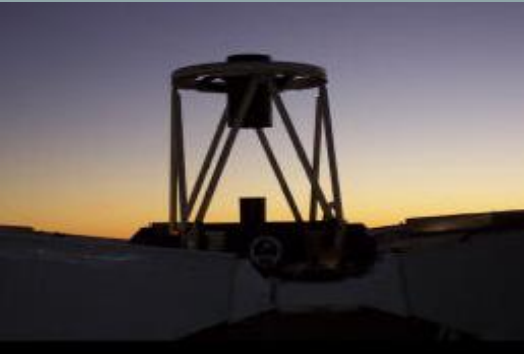


Monitoring LMXBs with the Faulkes Telescopes

Fraser Lewis
(University of Glamorgan,
Open University,
Cardiff University)

Thesis Title:
Temporal Fluctuations in Accretion Around
X-ray Binaries



We will always be able to keep you in the dark



Also to blame (a bit)

David Russell (University of Amsterdam)

Paul Roche (FT/University of Glamorgan)

Rob Fender (University of Southampton)

The Faulkes Telescope Project

£10 million donation from
the Dill Faulkes Educational
Trust

£1 million PPARC

£600K DfES

Why?

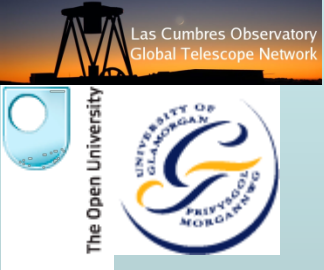
Inspirational projects in
maths, science and ICT

Address failing interest in
these areas



The Telescope Sites





Filters / Cameras

BVRI (Bessel)

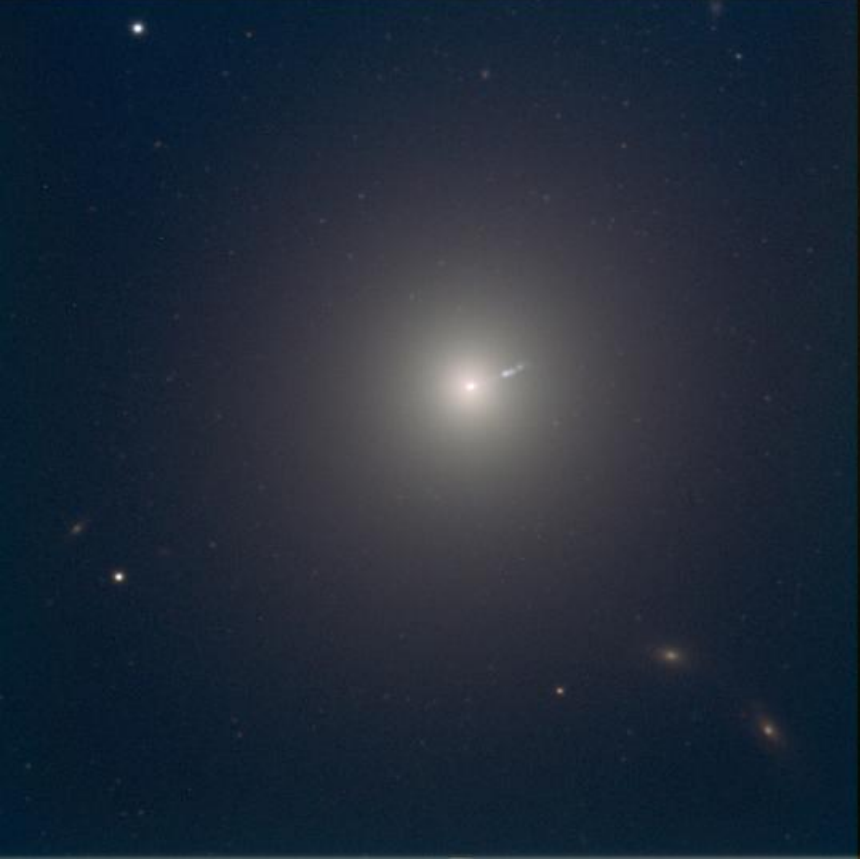
u'g'r'i' (Sloan) Z Y (Pan-Starrs)

H α , H β , O III narrow-band

Seeing $\sim 0.75'' - 2''$

Initially 4.6' x 4.6' FOV, currently 10' x 10'

2048 x 2048 pixels in 2 x 2 binning



M87

M1



Low-Mass X-ray Binaries (LMXBs)

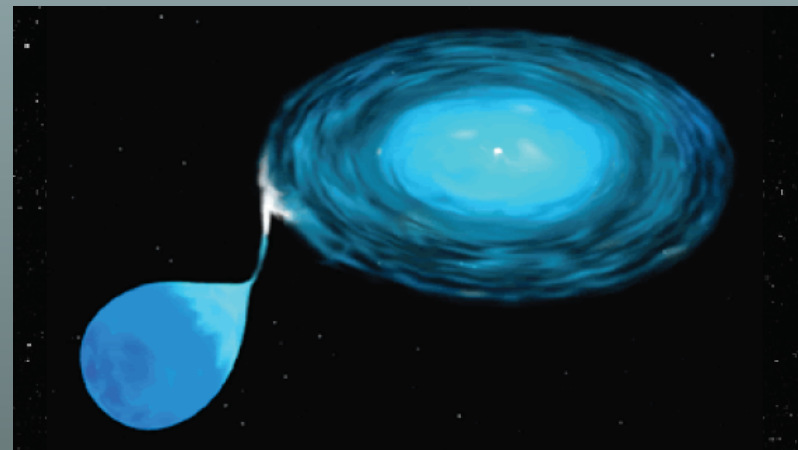
NS/BH + 'normal star'

System's luminosity dominated by disc, rather than donor

Usually found in globular clusters and Galactic bulge

Donor usually K or M star (small, red, faint, long-lived, low-mass)

Does what a quasar does (assuming you don't have the time or funding to wait for a quasar !)



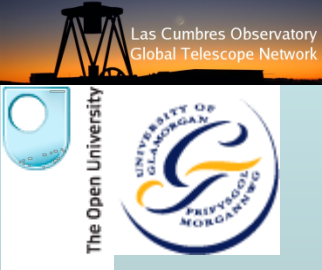
Our LMXB Monitoring

35 sources split between FTN & FTS (NS & BH)

Monitored once per week since 2006

Cadence increased after ATel or if 'interesting' activity is observed

Future plans for LCOGT include infra-red, more telescopes, spectroscopy, faster camera read-out



Aims of the Project

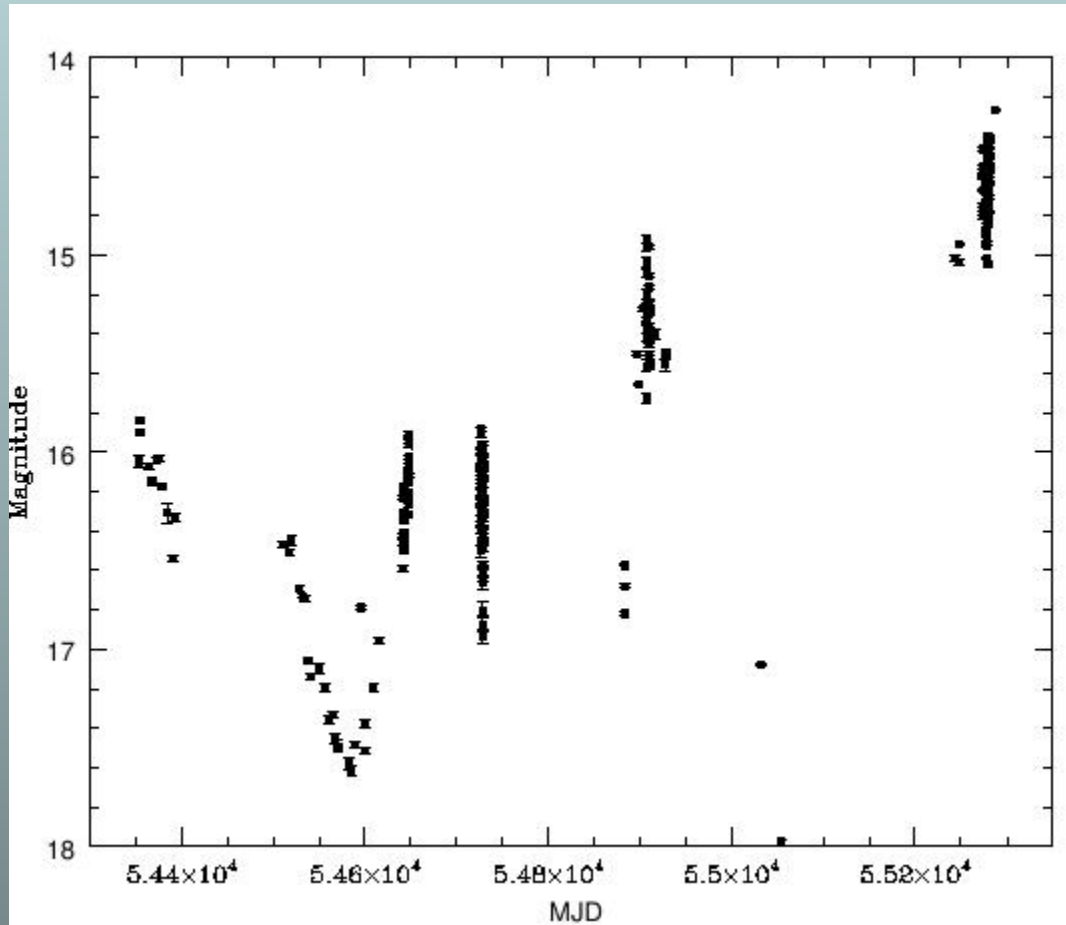
To identify and monitor transient outbursts in LMXBs (LMXBs can brighten in the optical / near infrared a few weeks before X-ray detection)

To study their variability in quiescence

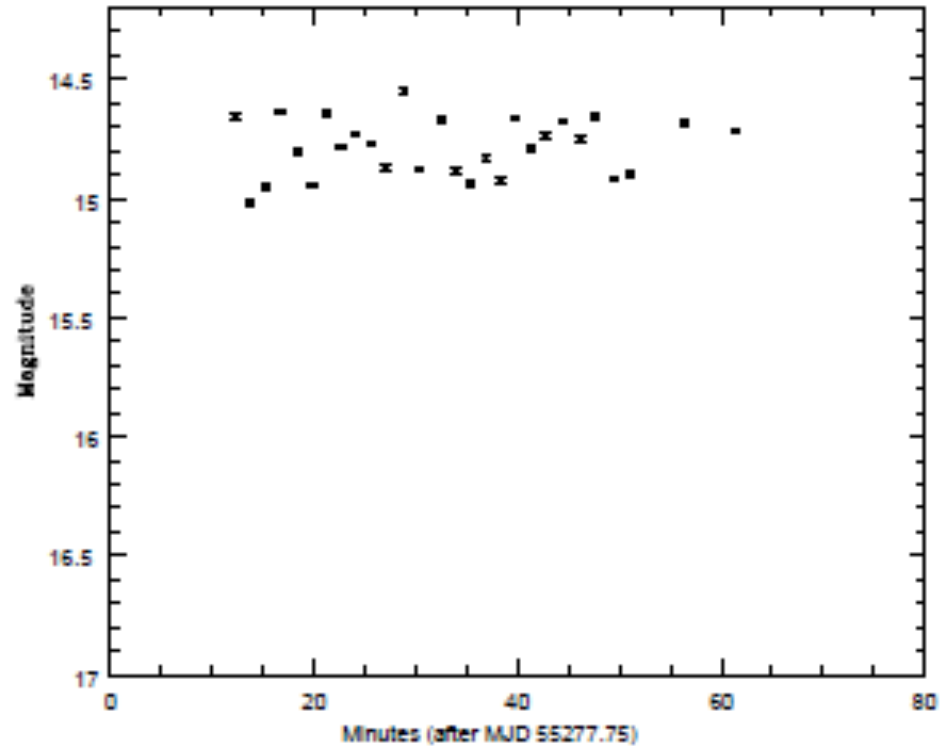
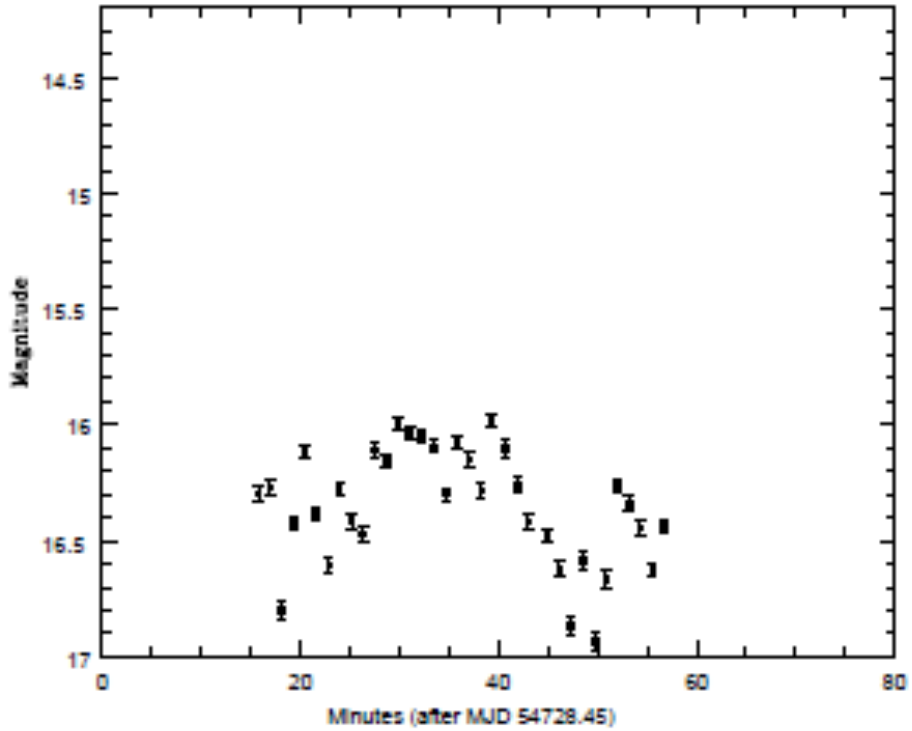
Monitoring during outbursts

Simultaneous observations with other facilities/wavebands

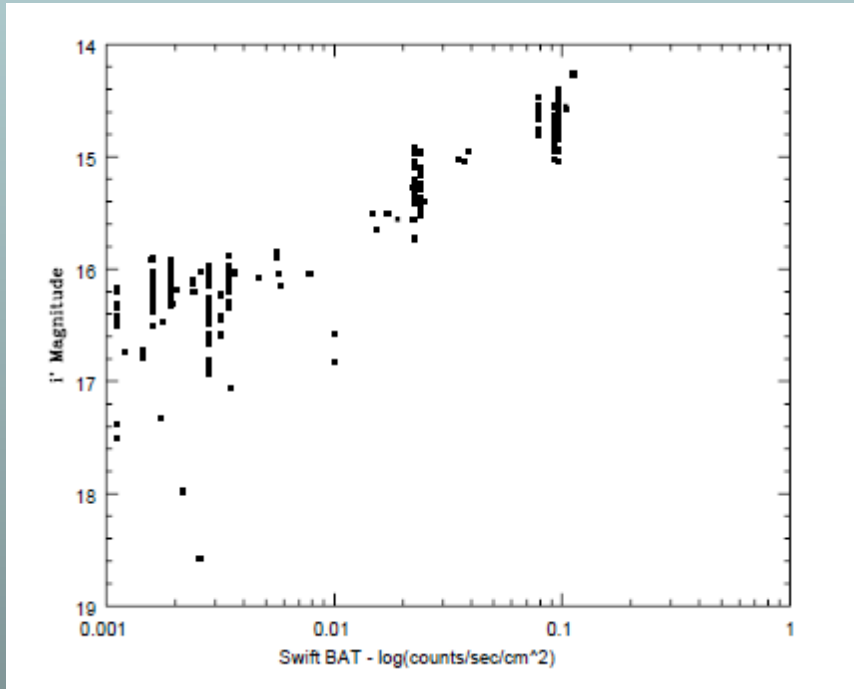
GX 339-4 (i' band data)



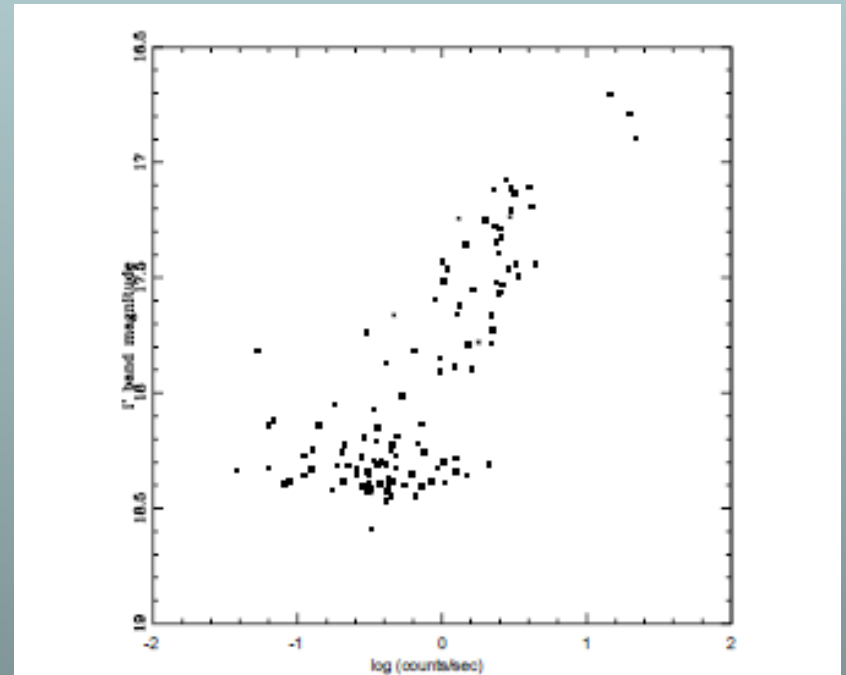
Short-term Variability



X-ray vs Optical Correlation

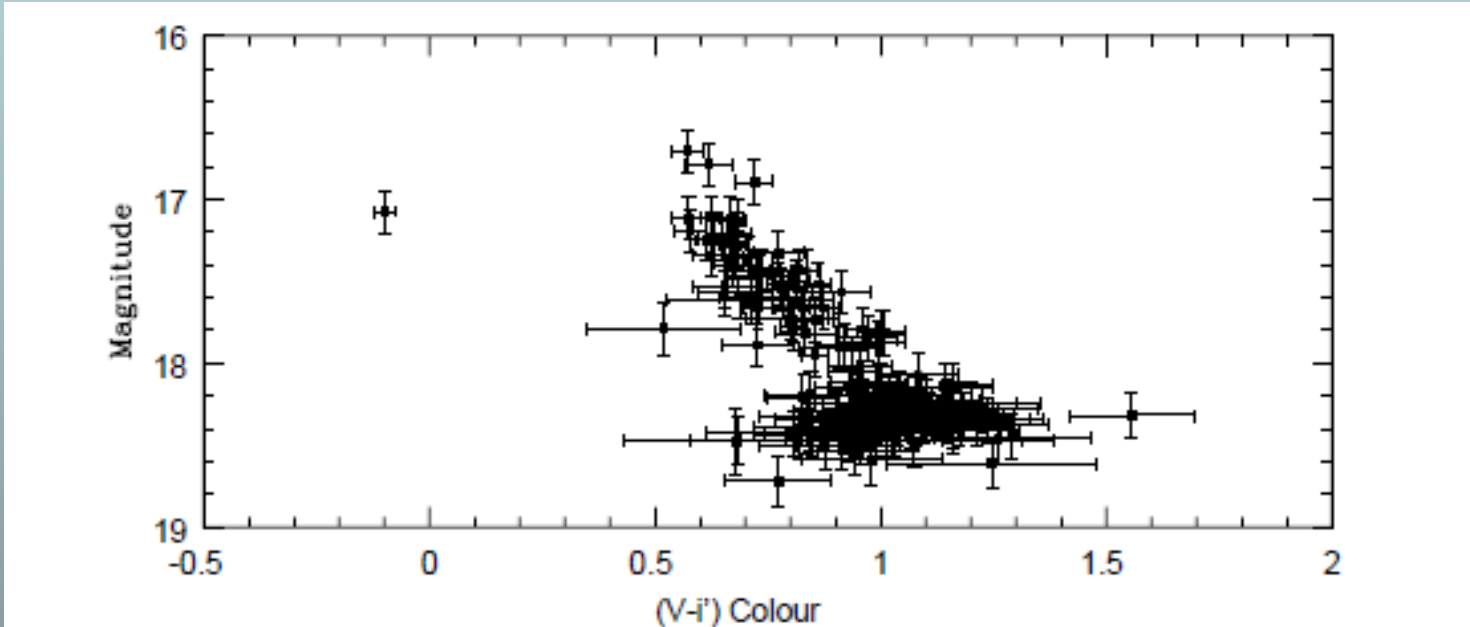


GX 339-4

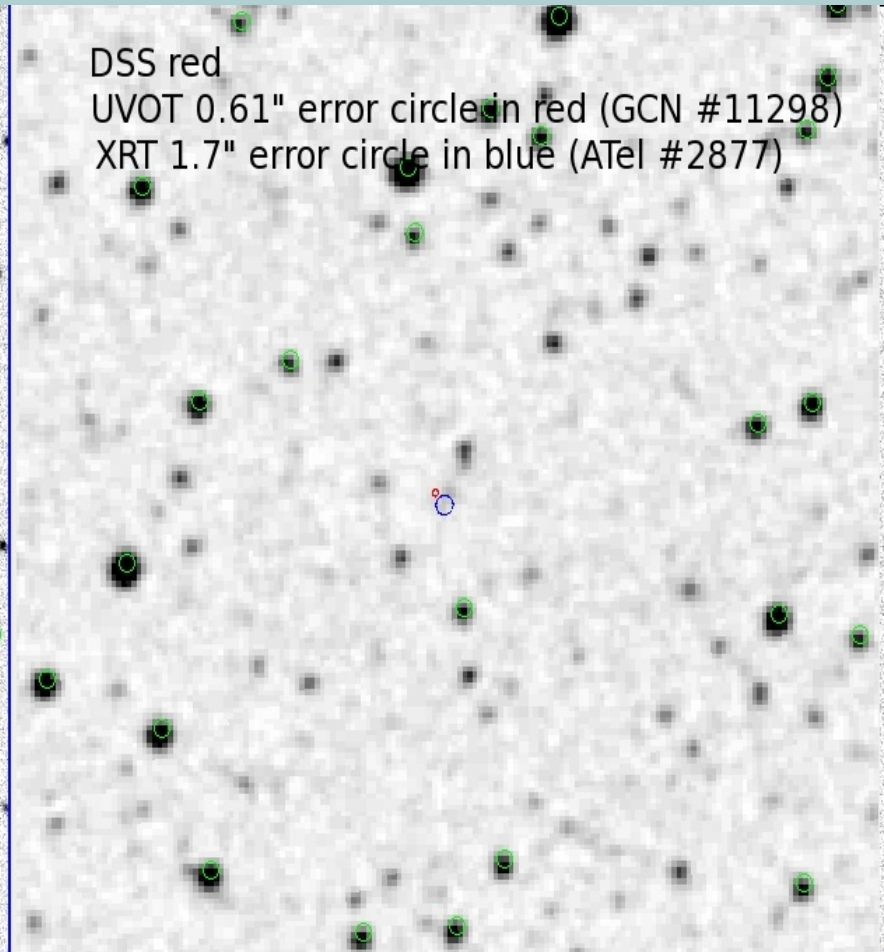
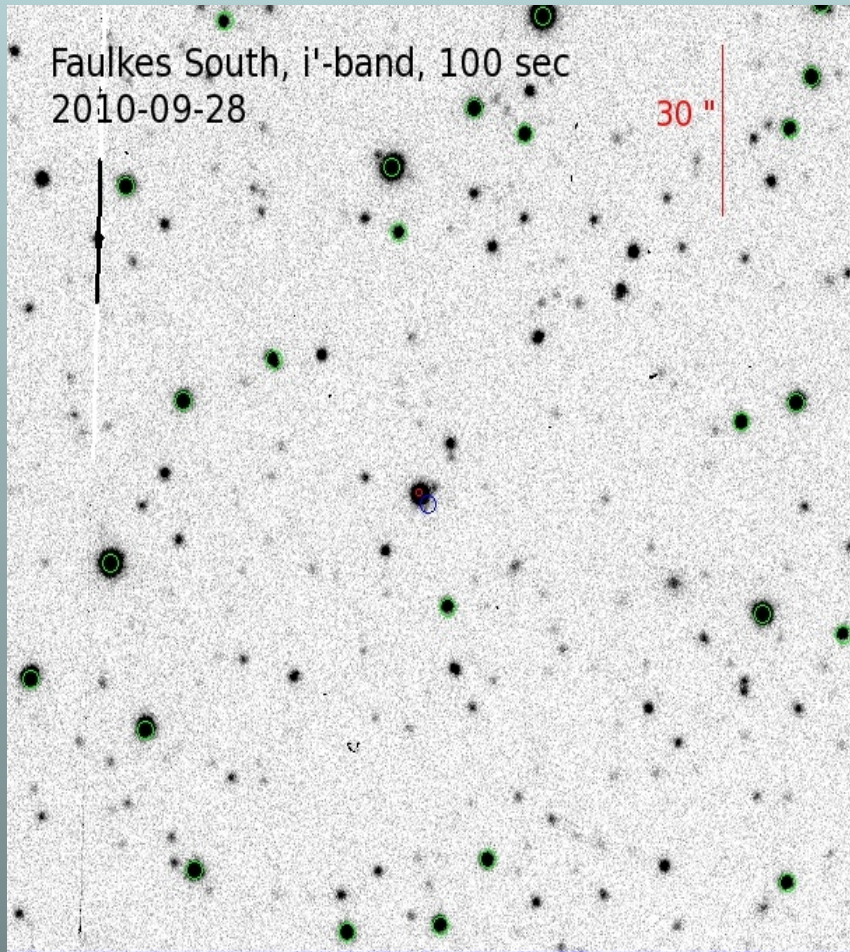


Aquila X-1

Colour-magnitude Correlation (Aquila X-1)

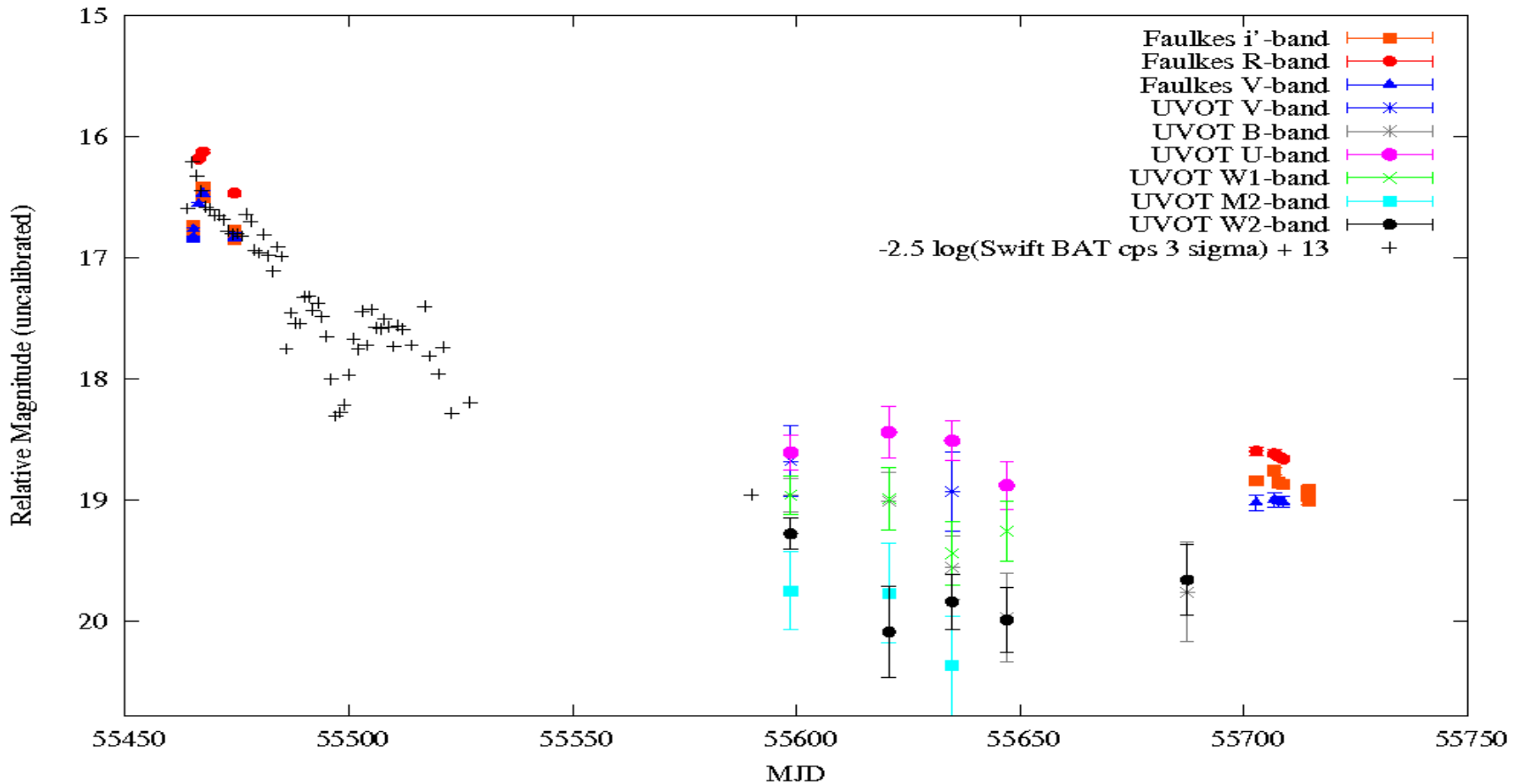


MAXI J1659-152



MAXI J1659-152

Light curve of MAXI J1659-152



The AMXP, IGR J00291+5934 System Parameters

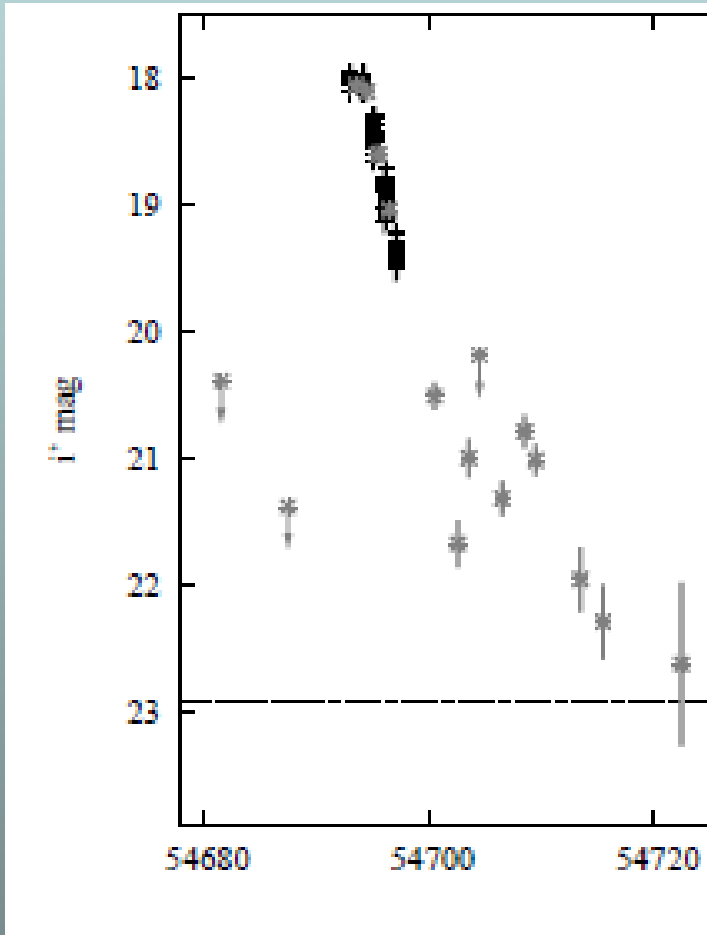
$$d \sim 2 - 10.7 \text{ kpc}$$

$$P_{\text{spin}} - 699 \text{ Hz}$$

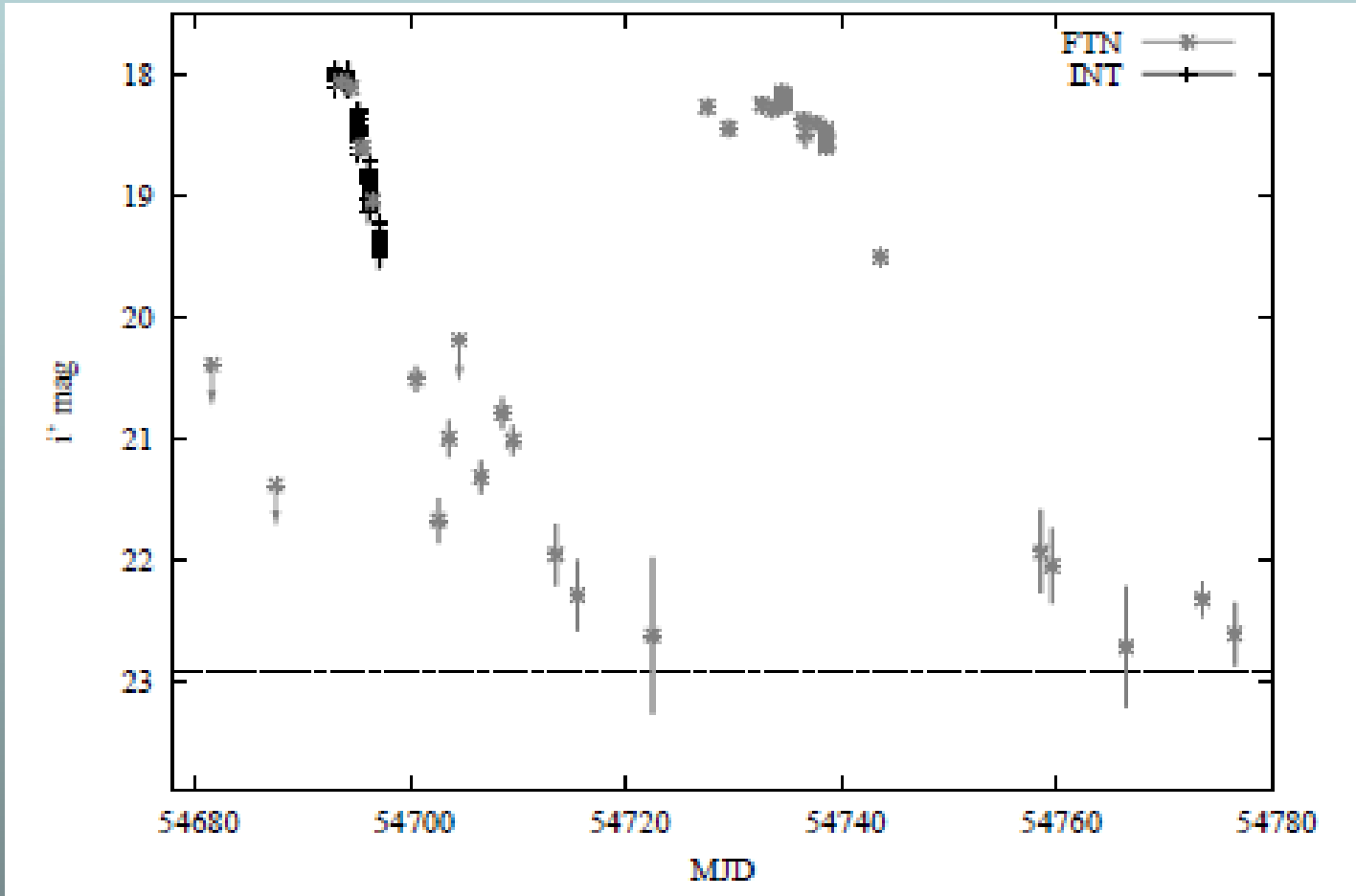
$$P_{\text{orb}} - 2.46 \text{ hours}$$

$$M_{\text{donor}} \sim 0.16 M_{\text{solar}}$$

IGR J00291+5934

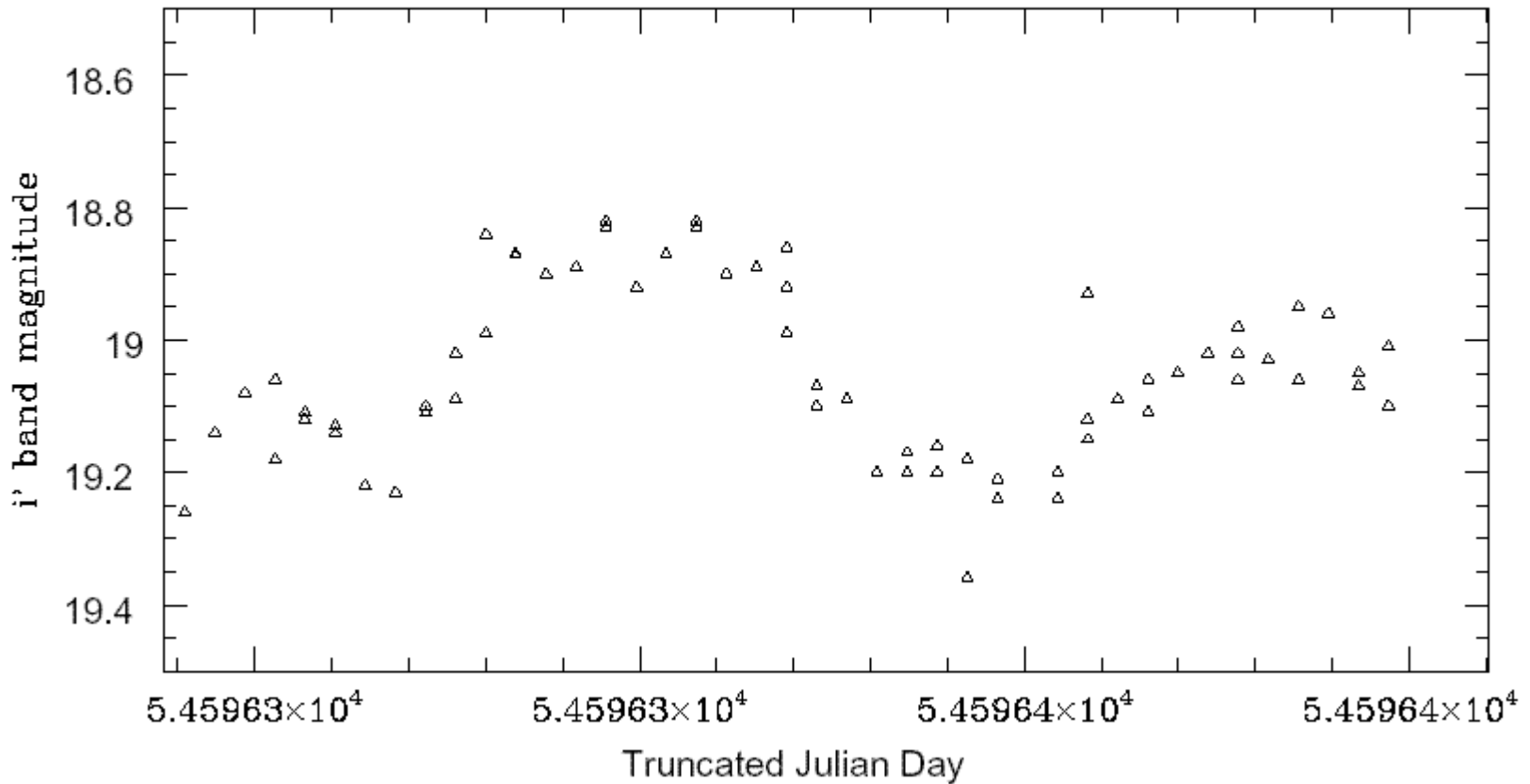


IGR J00291+5934

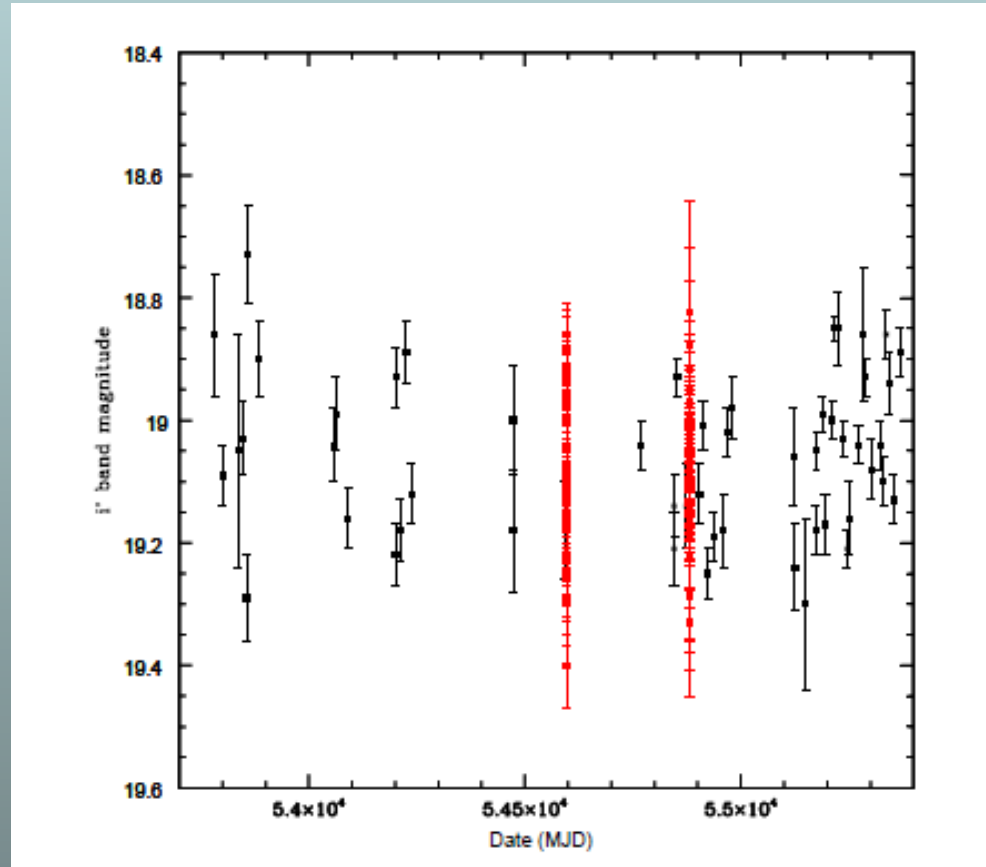


The BH, XTE J1118+480

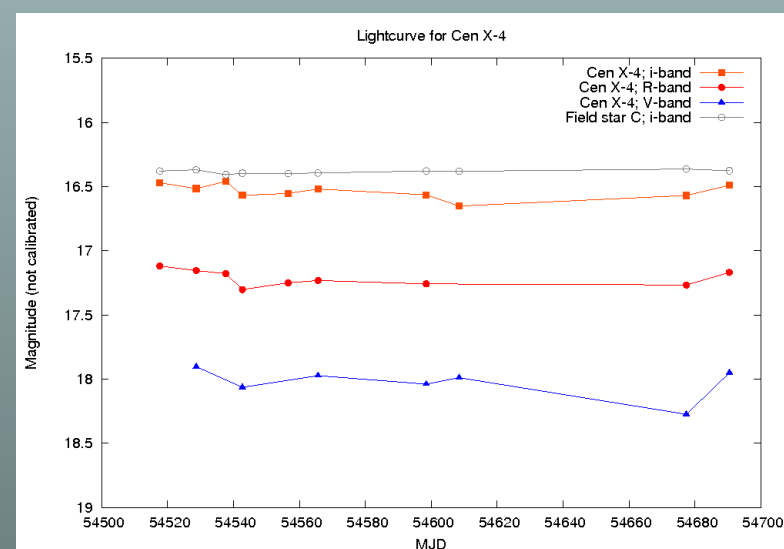
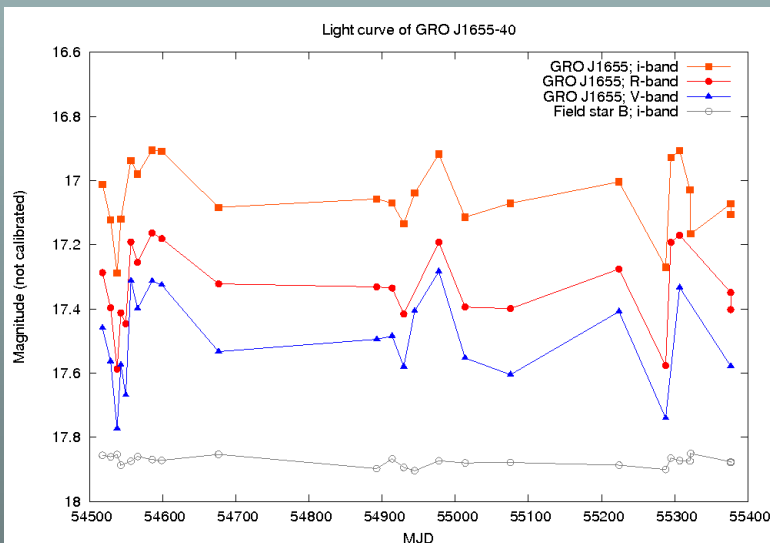
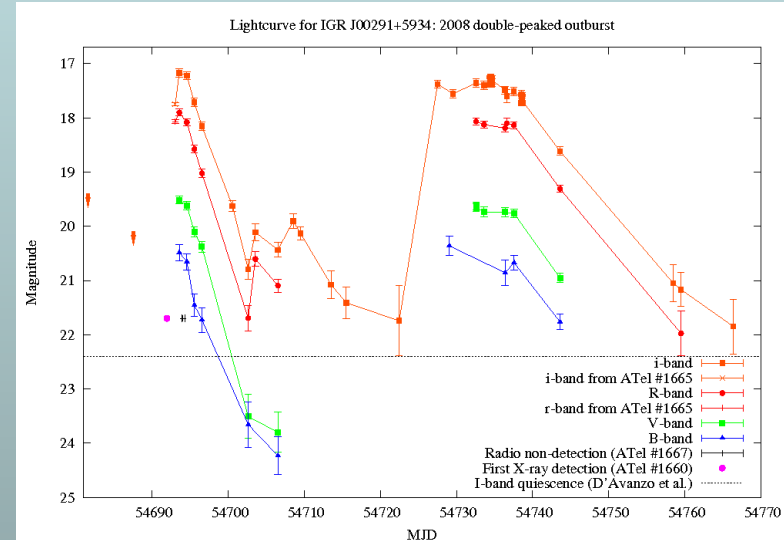
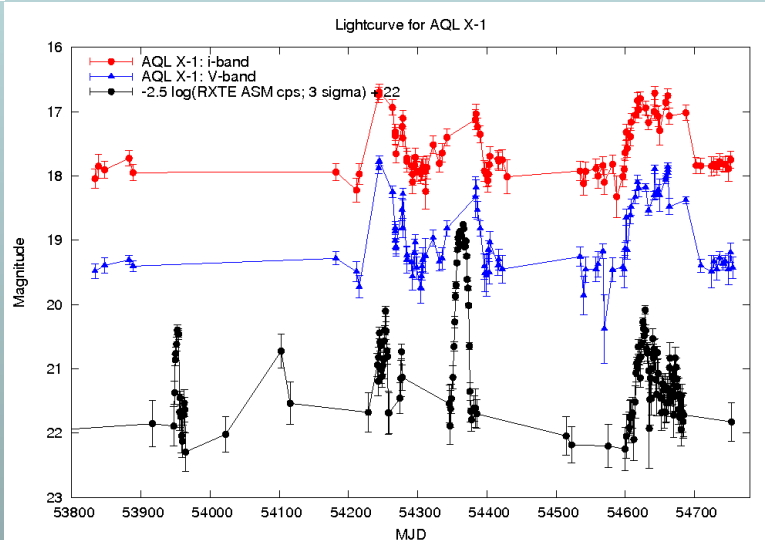
XTE J1118+480 - i' band data (de-reddened)



XTE J1118+480



4 Types of Behaviour



Summary

Significant outreach/education component to all our science

6 papers, 23 Astronomers Telegrams
Light curves from 35 LMXBs

Fastest asteroid rotator

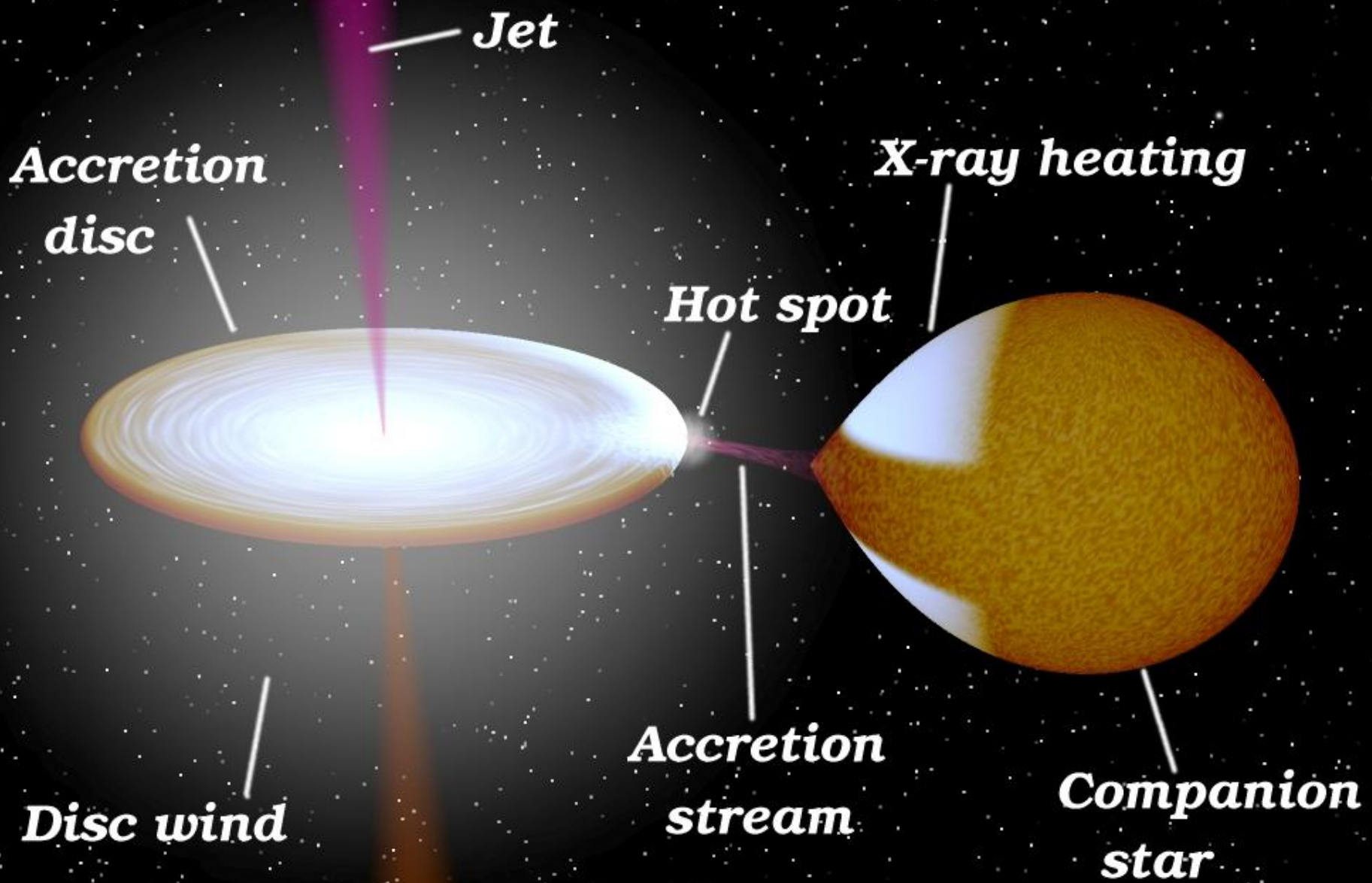
Exoplanet follow-ups

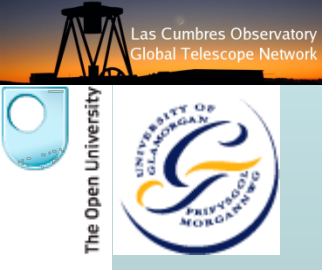
Uranian/Jovian moon light curves

Discovering variables in clusters

75 MPC/IAUC/CBET reports (comets / asteroids)

93 GCN circulars (GRBs)





LMXBs

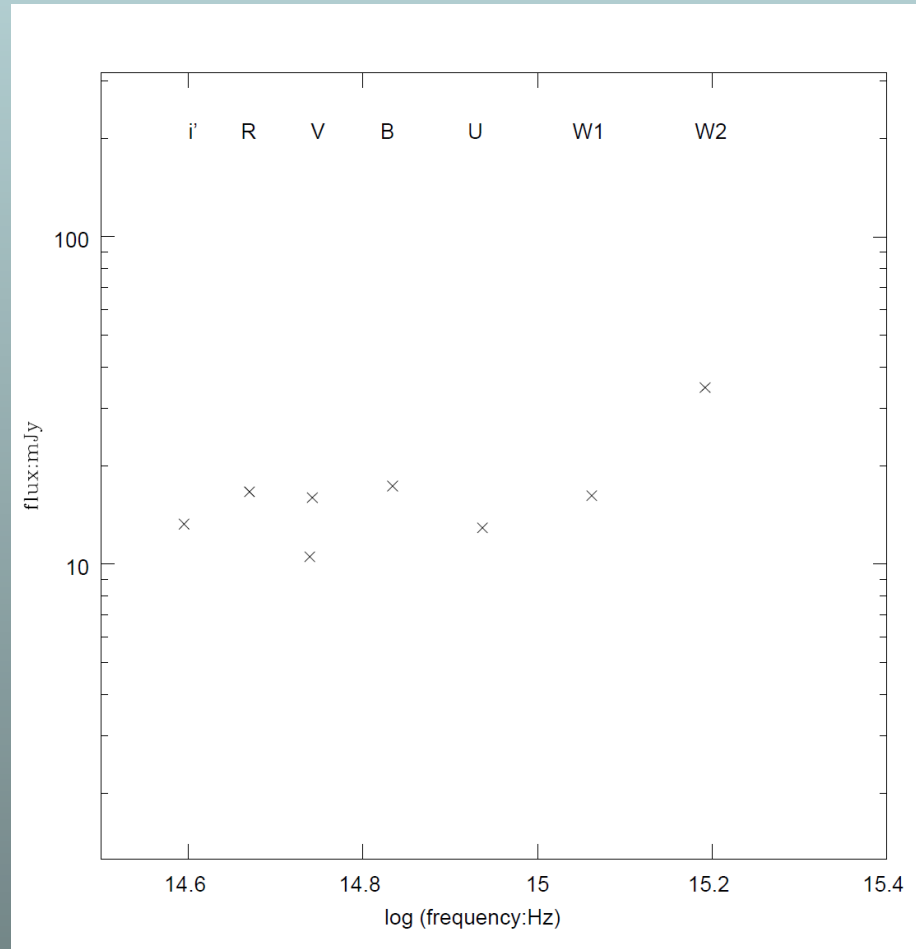
For once, big isn't better

Star doesn't dominate overall brightness

Great testbeds for gravitation/space-time theories

Does what a quasar does (assuming you don't have the time or funding to wait for a quasar !)

Spectral Energy Distributions (SEDs)



Averaged SED

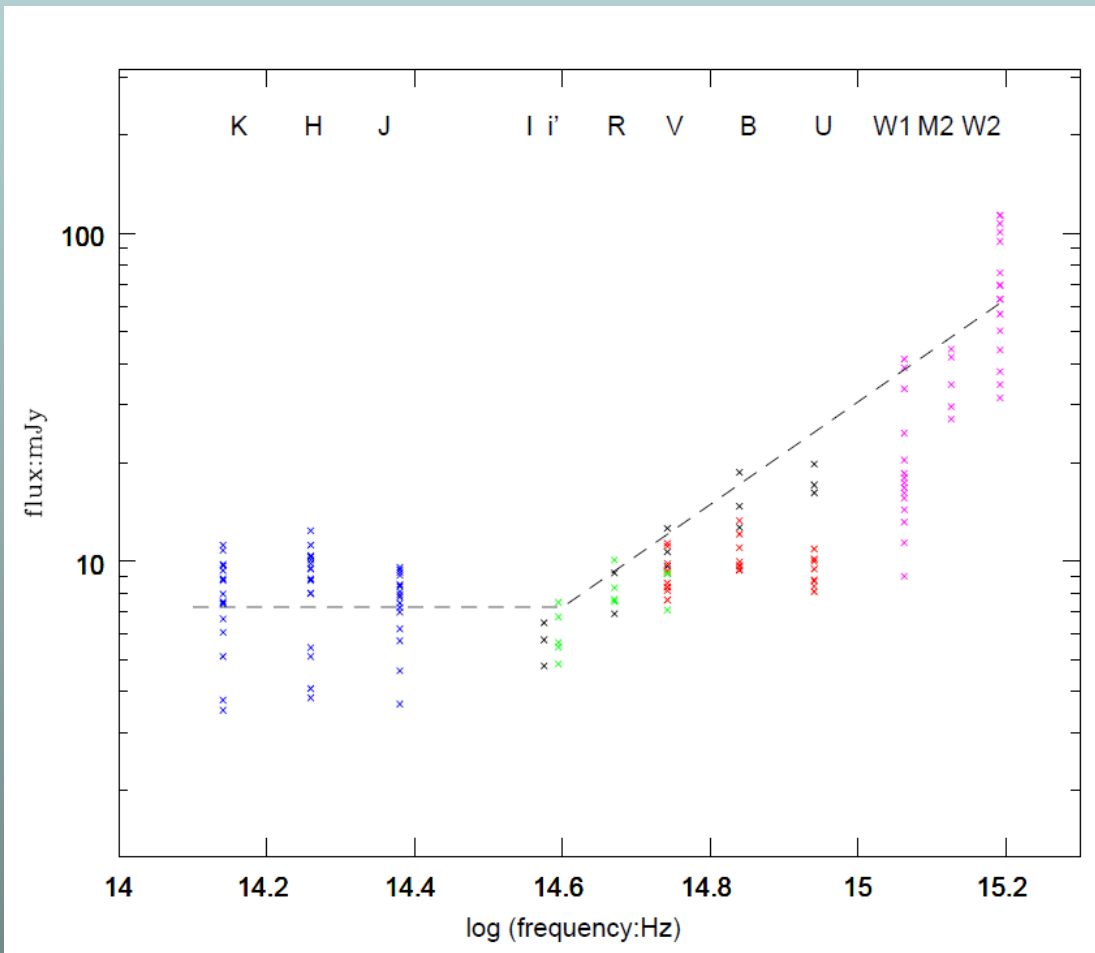


TABLE 3.3: Target List for Faulkes Telescope North Monitoring

Target	Type	First Observed	Exposures *	Publications †
IGR J00291+5934	AMXP	2007 Aug	463	Lewis et al., 2008a, 2010b, Russell et al., 2008b, 2011c
GRO J0422+32	BH	2006 Jan	238	
4U 0614+09	NS (MQ)	2006 Jan	339**	
A 0620-00	BH	2006 Jan	240	
XTE J1118+480	BH (MQ)	2006 Jan	1926	
H 1706-250	BH	2006 Feb	101	
GRO J1719-24	BHC	2006 Feb	98	
Swift J1752.1-2220	BHC	2010 Mar	262	
Swift J1753.5-0127	?	2010 Apr	268	
XTE J1859+226	BHC (MQ)	2006 Feb	130	
Aql X-1	NS	2006 Apr	861**	Maitra et al., 2007, Linares et al., 2009 Russell and Lewis, 2009, Tudose et al., 2009b Russell et al., 2010e
4U 1957+11	BHC	2006 Apr	601**	Russell et al., 2010e, 2011e
GS 2000+25	BH	2006 Apr	115	
V404 Cyg	BH	2006 Apr	320	
XTE J2123-058	NS	2007 Jun	142**	

TABLE 3.4: Target List for Faulkes Telescope South Monitoring

Target	Type	First Observed	Exposures *	Publications †
MAXI J0656-332	NS	2011 Jan	44	Russell et al., 2011b
XTE J0929-314	AMXP	2007 Dec	188	
GRS 1009-45	BH	2007 Dec	88	
GRS 1124-68	BH	2007 Dec	182	
GS 1354-64	BH IMXB	2008 Jan	181	
Cen X-4	NS	2008 Feb	126	
MAXI J1639-152	BHC	2010 Sep	130**	Russell et al., 2010b
4U 1543-47	BHC IMXB	2008 Feb	146	
MAXI J1543-564	BHC	2011 May	11	Russell et al., 2011d
XTE J1550-564	BH (MQ)	2008 Feb	132	Calvelo et al., 2010, Russell et al., 2011c
4U 1608-52	NS	2007 Aug	255	Russell et al., 2009b, Del Monte et al., 2010a
4U 1630-472	BH	2008 Jan	121	
XTE J1650-500	BH (MQ)	2008 Feb	61	
GRO J1655-40	BH IMXB (MQ)	2008 Feb	184	
GX 339-4	BH (MQ)	2007 Sep	848	Russell et al., 2008a, 2009a, 2010a, 2011a Lewis and Russell, 2009, Cadolle Bel et al., 2010 Lewis et al., 2010a, Russell and Lewis, 2011
XTE J1728-295	?	2010 Sep	69**	Russell et al., 2010f,g
XTE J17464-3213	BHC	2008 Feb	237	
SAX J1808.4-3658	AMXP	2008 Feb	165	Elebert et al., 2009
XTE J1814-338	AMXP	2008 Feb	55	
V4641 Sgr	BH (MQ)	2007 Sep	137**	
HETE J1900.1-2455	AMXP	2008 Feb	253	