

# Chandra/HST Observations of X-ray Transients in M31

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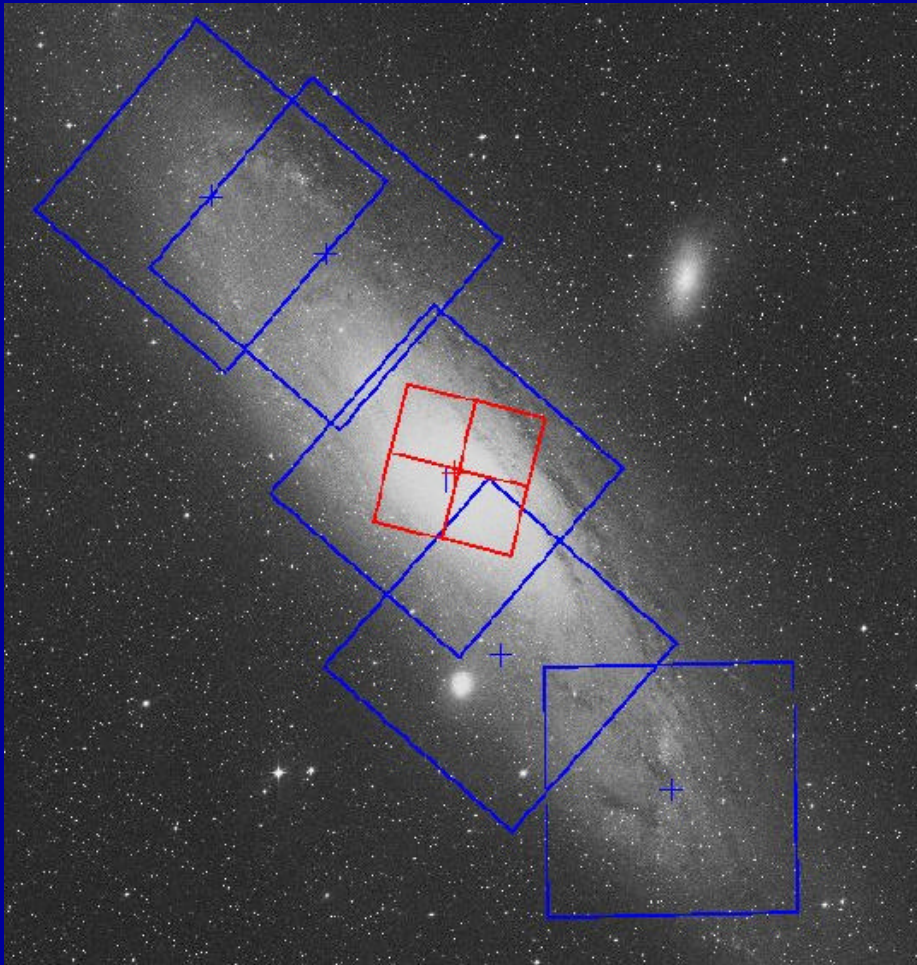
with

M.R. Garcia, F.A. Primini, J. McClintock,  
R. Di Stefano, S.S. Murray



Chandra HRC

# M31 monitoring program with Chandra



- 5 x 16 HRC snapshots ( $\sim 1$  ks)  
+ 18 ACIS ( $\sim 5$  ks) follow-up
- HRC:  $\sim 10^{37}$  erg/s
- From mid-2001, we use HST to search for optical counterpart
- Provide long-term light curves of X-ray sources in M31 => M31 ASM + optical follow-up

# Variable sources in M31 central 17'x17' region (from 11/1999 to 6/2001)

	Number	Fraction
Variables	100	50%
Spectral variables	12	6%
Transients	13	6%

Total number of X-ray sources: 204

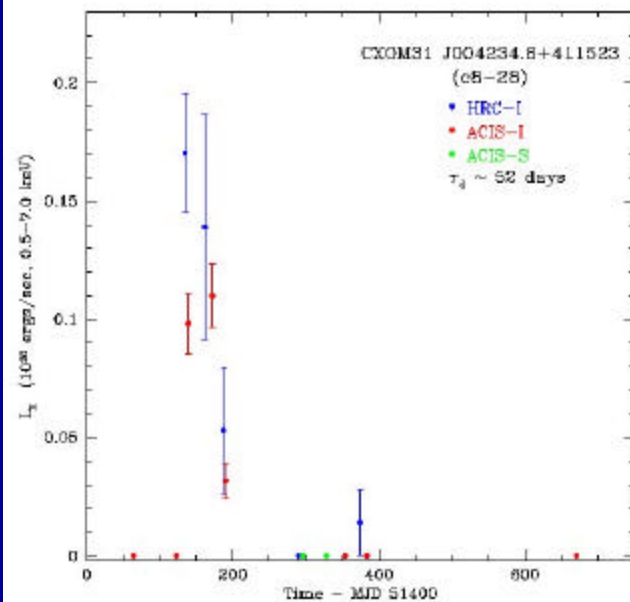
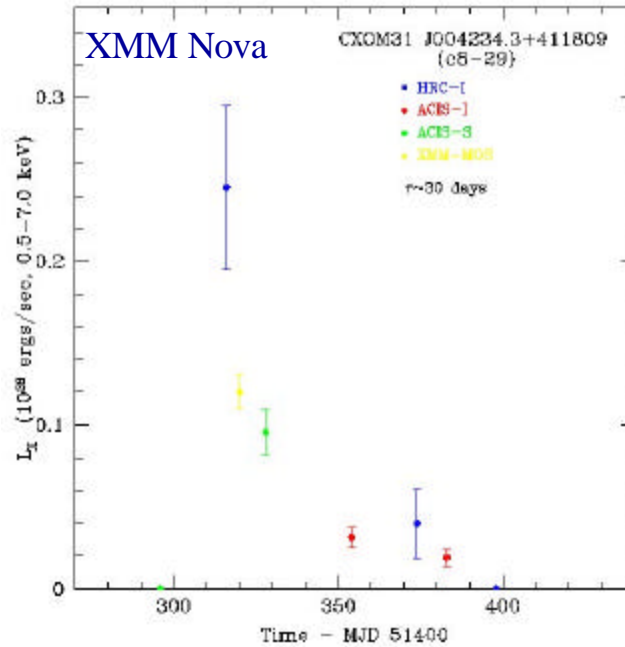
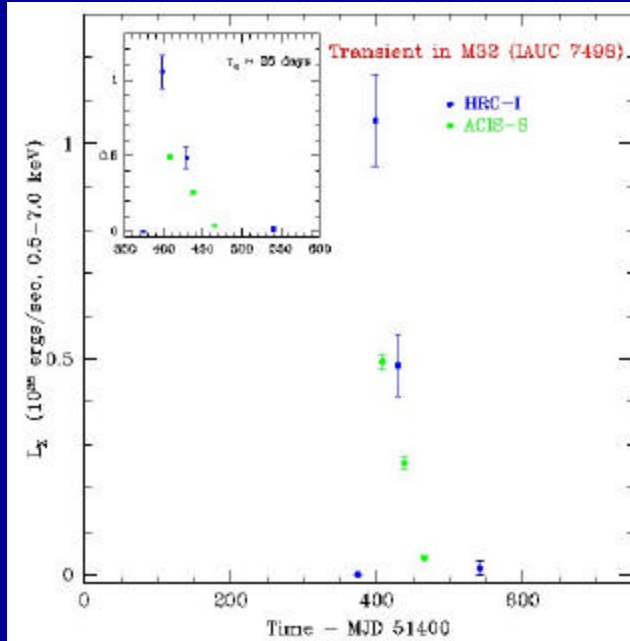
$$S(F_{max} - F_{min}) = \frac{|F_{max} - F_{min}|}{\sqrt{\sigma_{F_{min}}^2 + \sigma_{F_{max}}^2}} > 3$$

See Primini, Forman, & Jones (1993) & Kong et al. (2002)

# X-ray Transients in M31 and M32

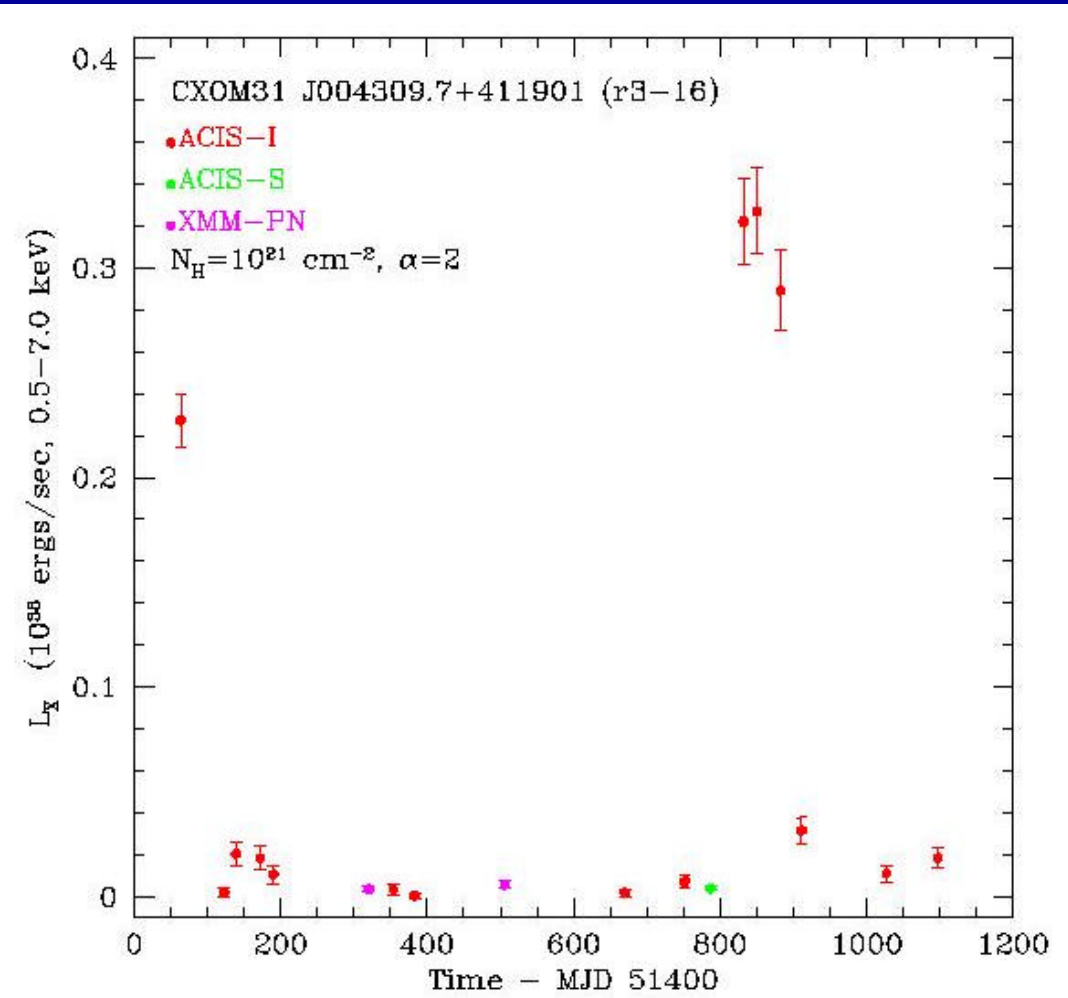
- 13 transients were discovered with 8 ACIS-I pointings in the central  $17' (4 \text{ kpc}) \times 17'$  region.
- $L_{\min} < 1e36 \text{ erg/s}$ ,  $L_{\max} = 1e37 - 3e38 \text{ erg/s}$
- $7.8/\text{year} = 3 \times 2.6/\text{year}$  in MW (Chen et al. 1997)
- $\sim 30$  transients were discovered by Chandra and XMM between 1999 and 2002.
- 4 supersoft ( $kT < 100\text{eV}$ ) X-ray transients
- 3-5 recurrent transients

# Light curves of X-ray Transients



Fast-rise-exponential-decay  
light curves

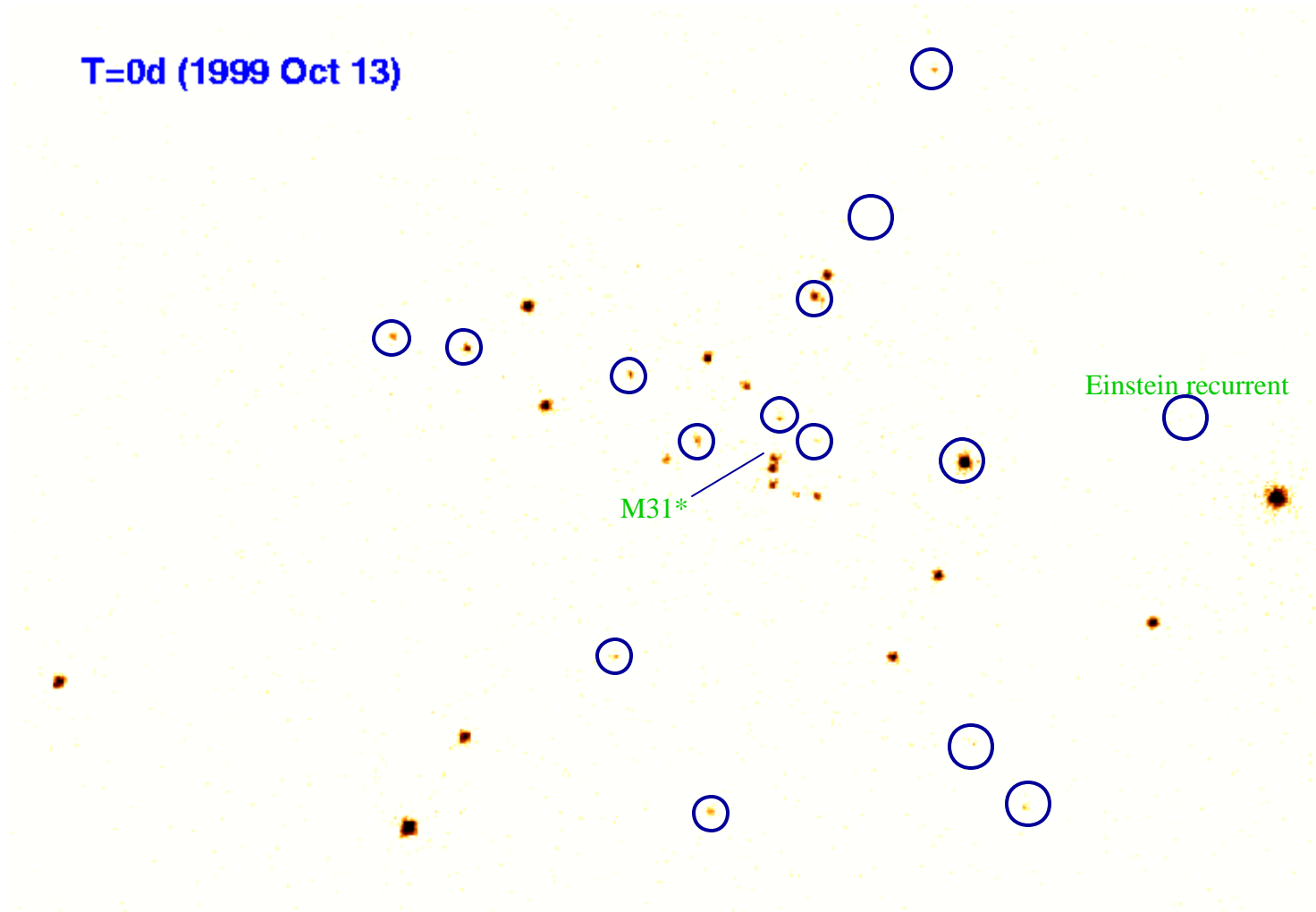
# Recurrent Transient r3-16



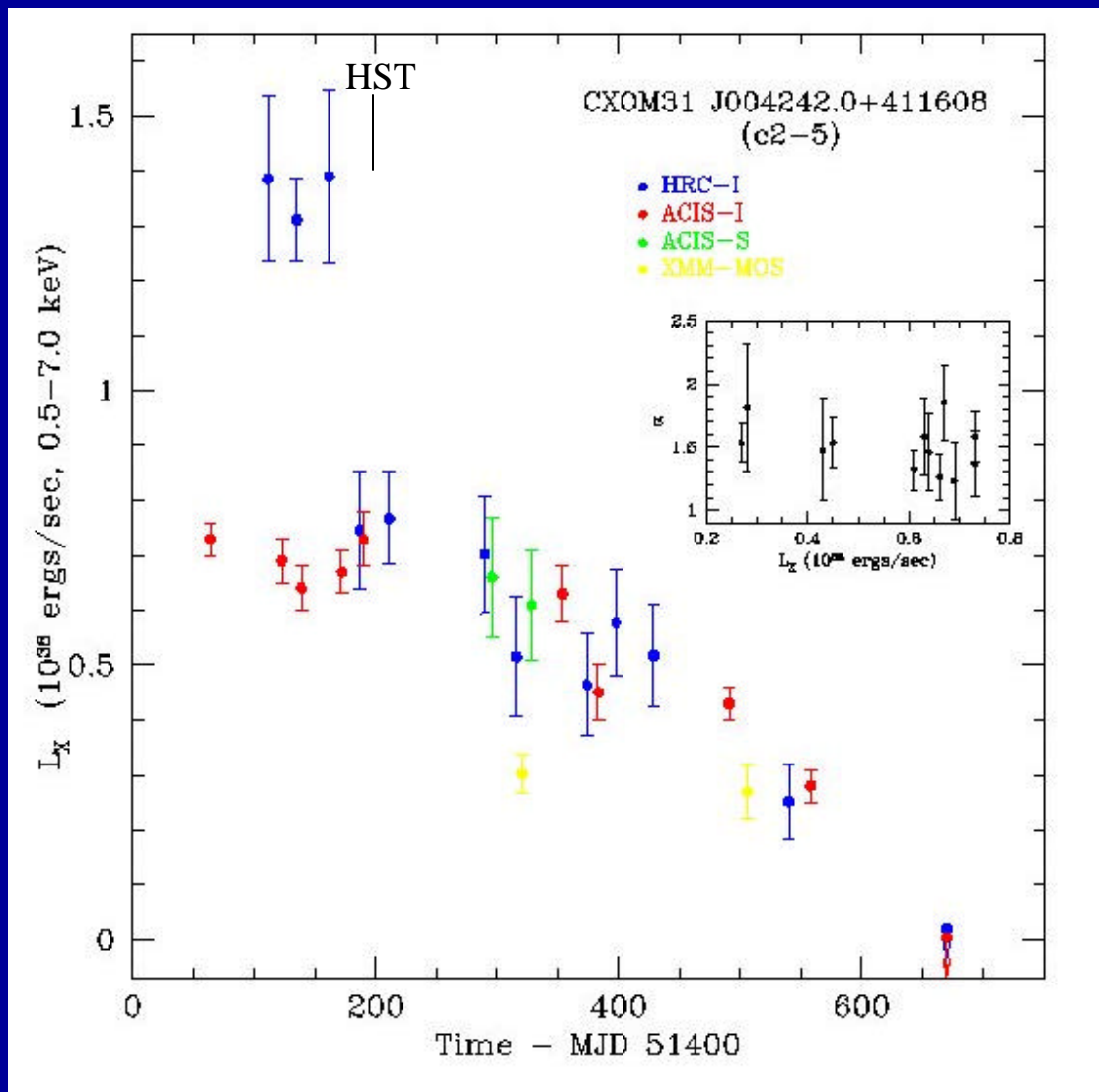
- Detected by Einstein, ROSAT HRI+PSPC ( $1-8e37$  erg/s)
- $< 8e35 - 3e37$  erg/s in 1999-2002

# X-ray Sky of M31 (from 1999 Oct to 2002 Aug)

## Central 2' x 2' region

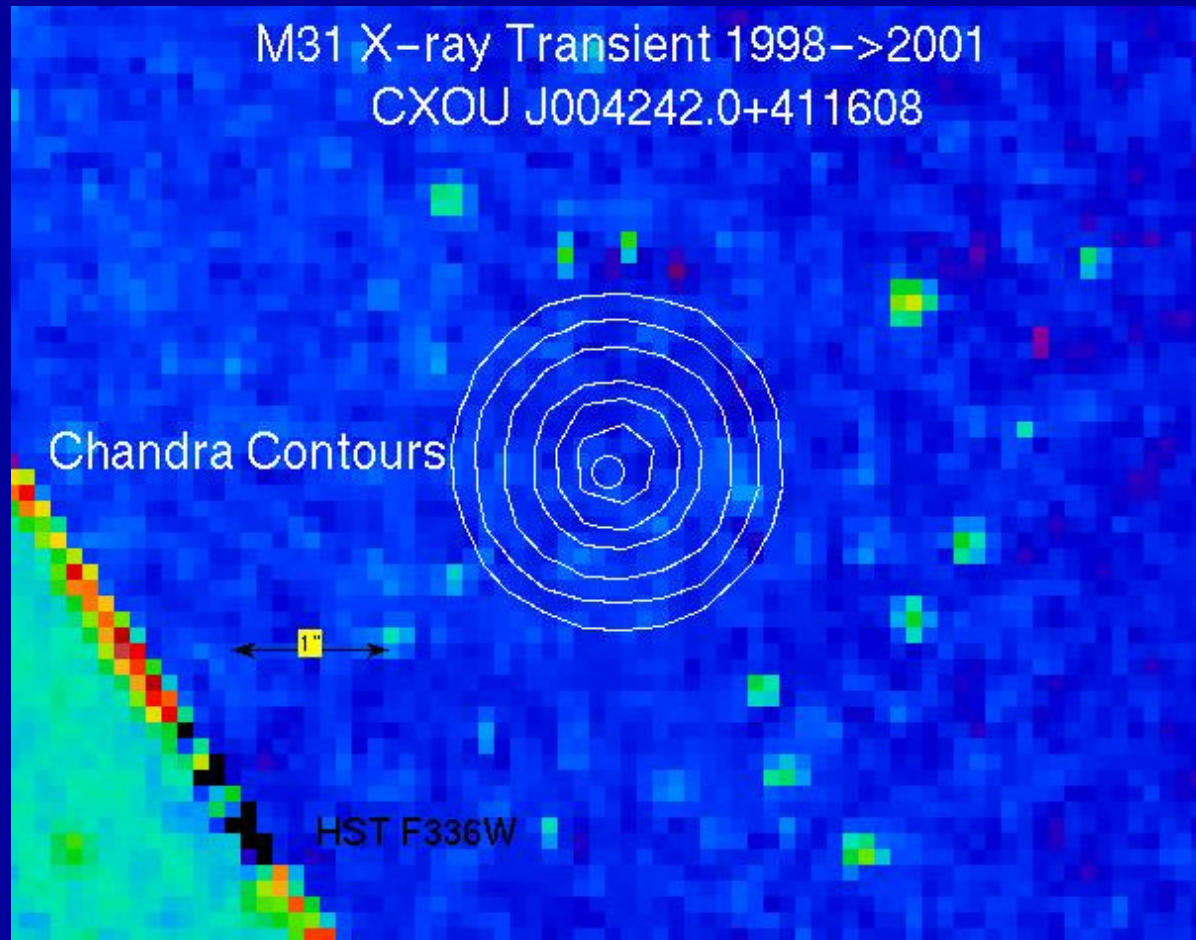


# The first X-ray transient discovered by Chandra





# The first X-ray transient discovered by Chandra



Our first try: 2000 Feb 25

Brightest star U~22

Faintest star U~24

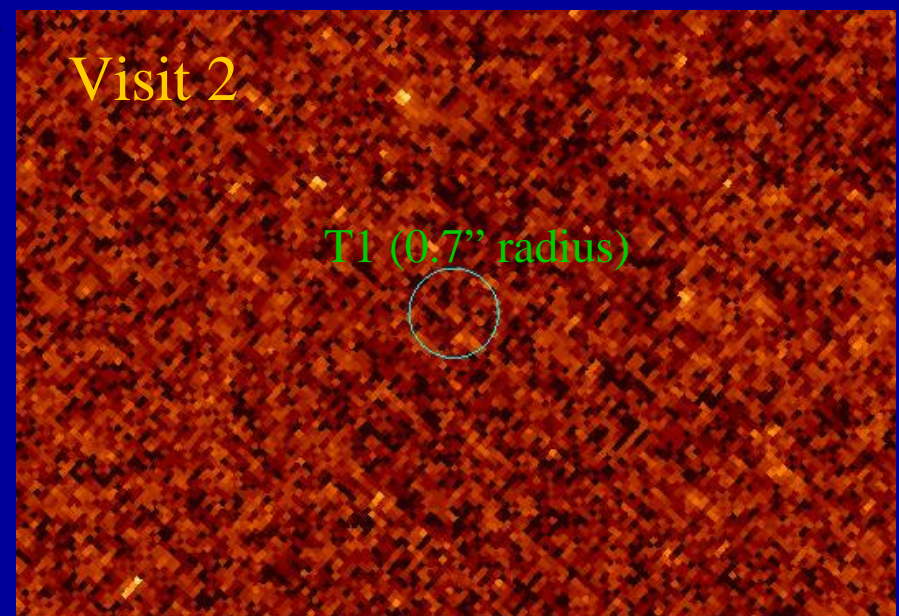
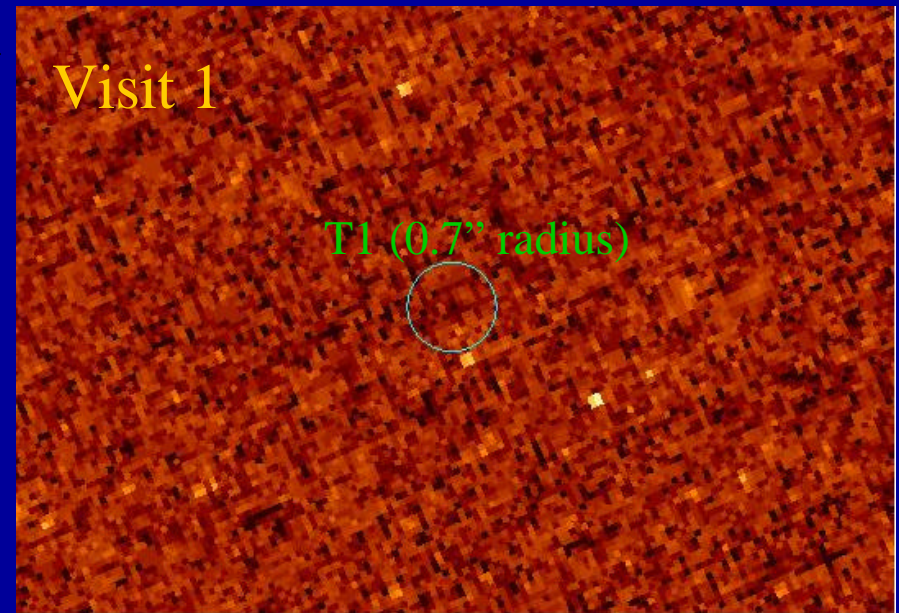
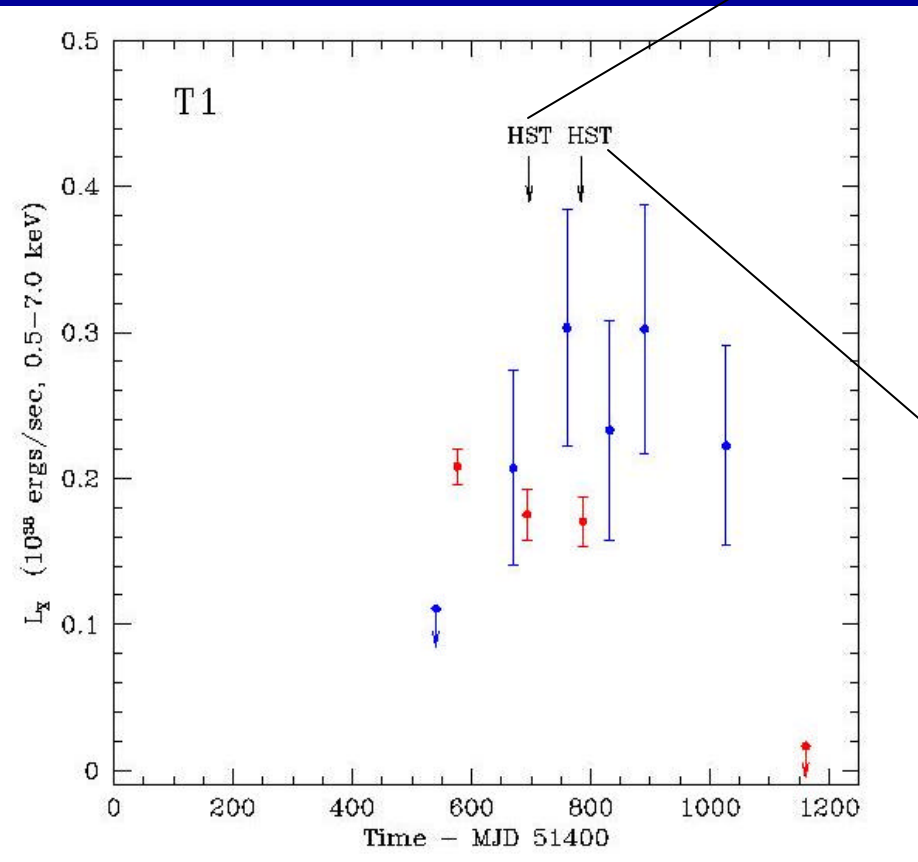
**NO** candidates to U~24!

More chances.....

6 pairs of HST C10 +

Chandra AO2-3

# Searching X-ray transients in M31

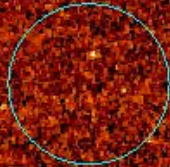


# Searching X-ray transients in M31

- 30 eV SSS discovered by XMM (IAUC 7659) in 2001 June
- Possibly detected in UV by Optical Monitor
- Turn off when Chandra observed in 2001 Aug

Visit 1 (2001 Aug 27)

T2 (3" radius)



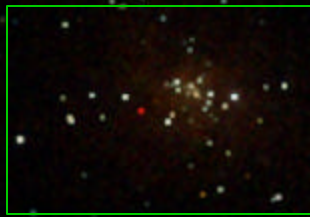
Visit 2 (2001 Dec 2)

T2 (3" radius)

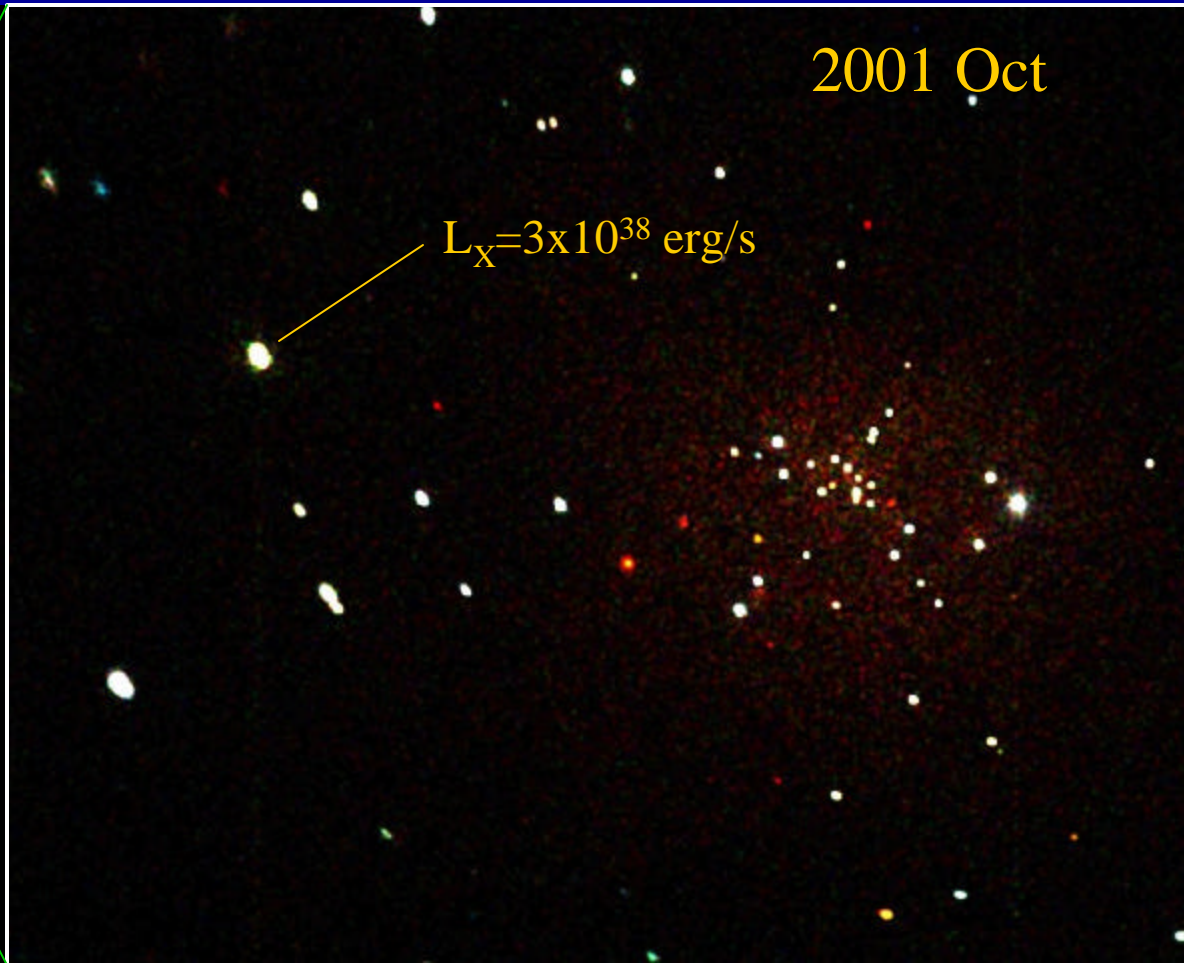


# The brightest X-ray transient

1999 Oct -2001 Jun

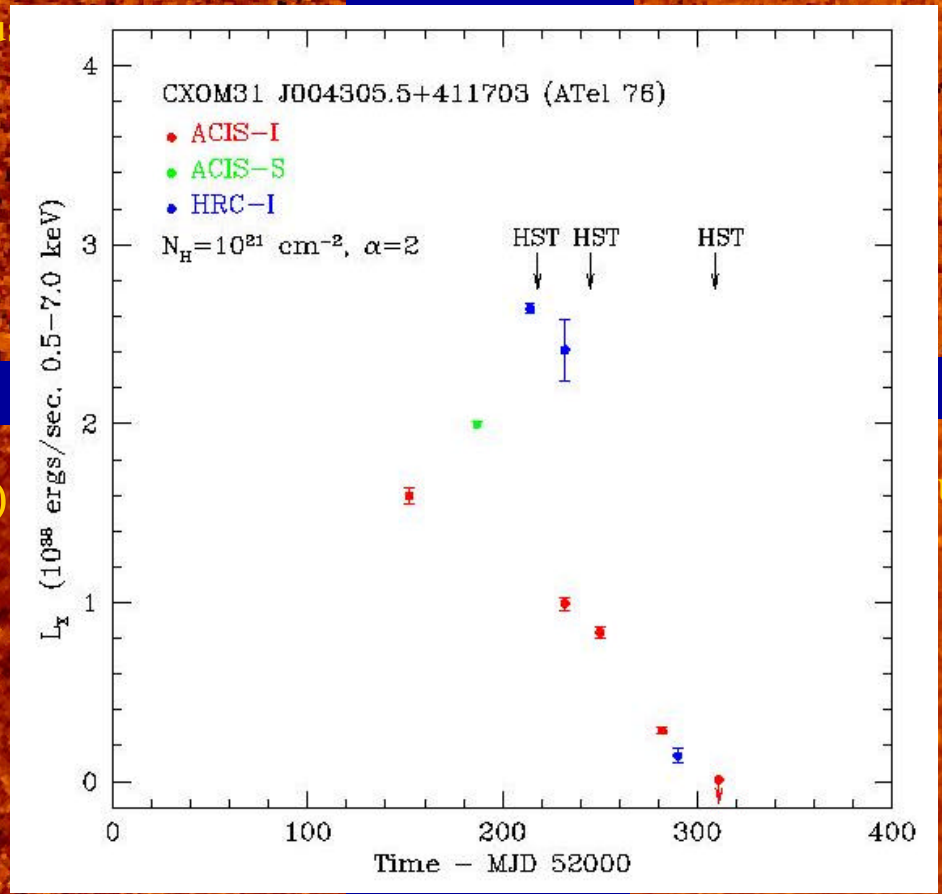
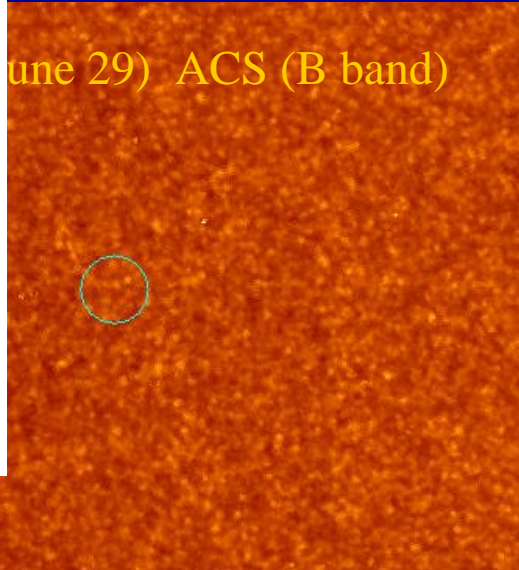
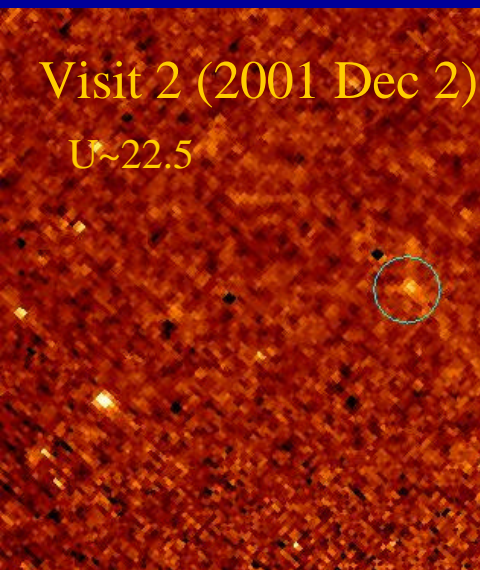
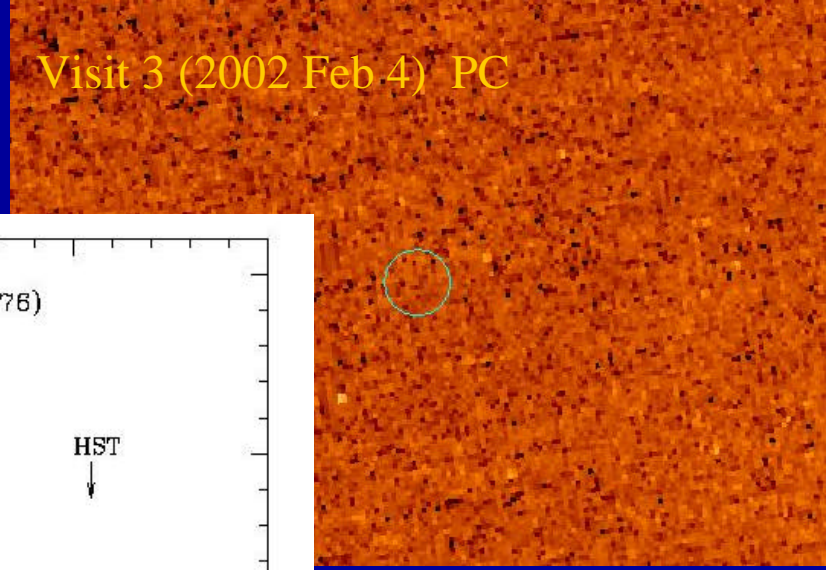
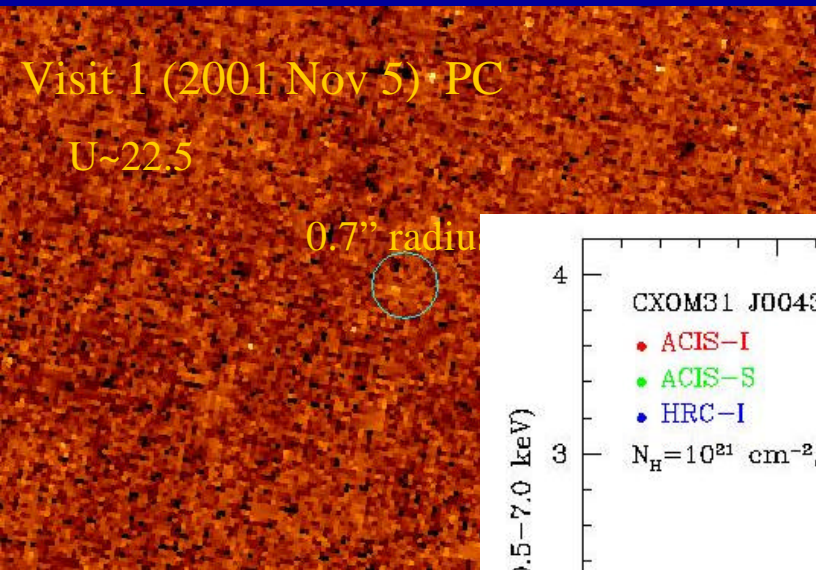


2001 Oct

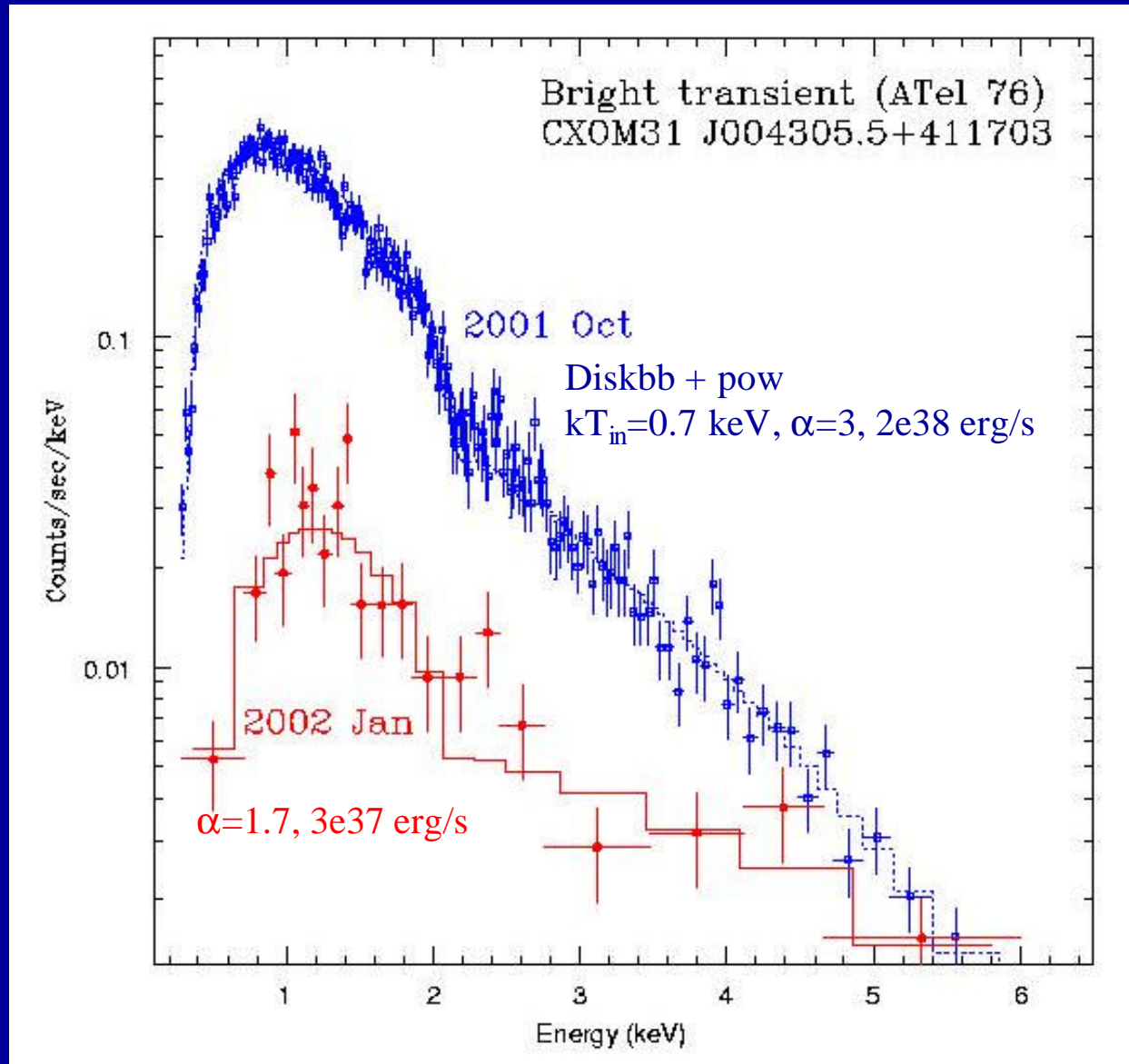


Discovered on 2001 Aug 31 at  $2 \times 10^{38}$  erg/s (ATel 76)

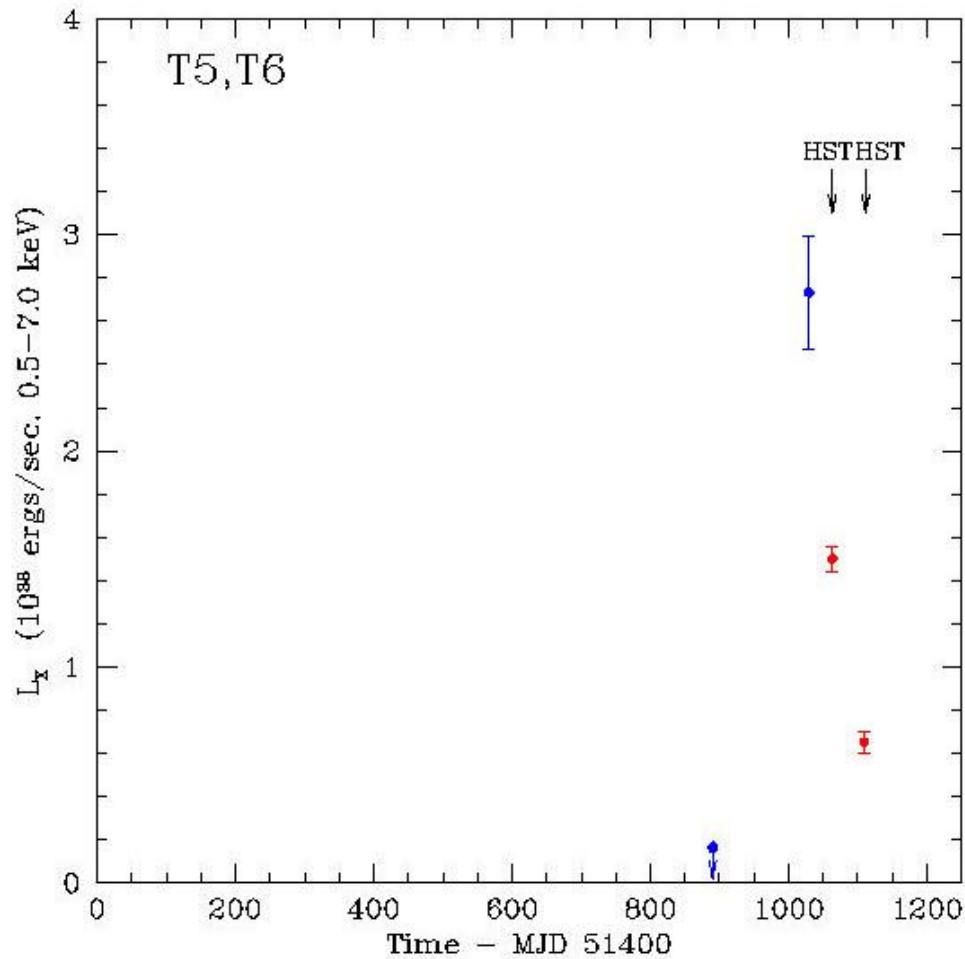
# Optical Counterpart of T3



# Spectral change of T3



# Possible Counterpart for T5,T6



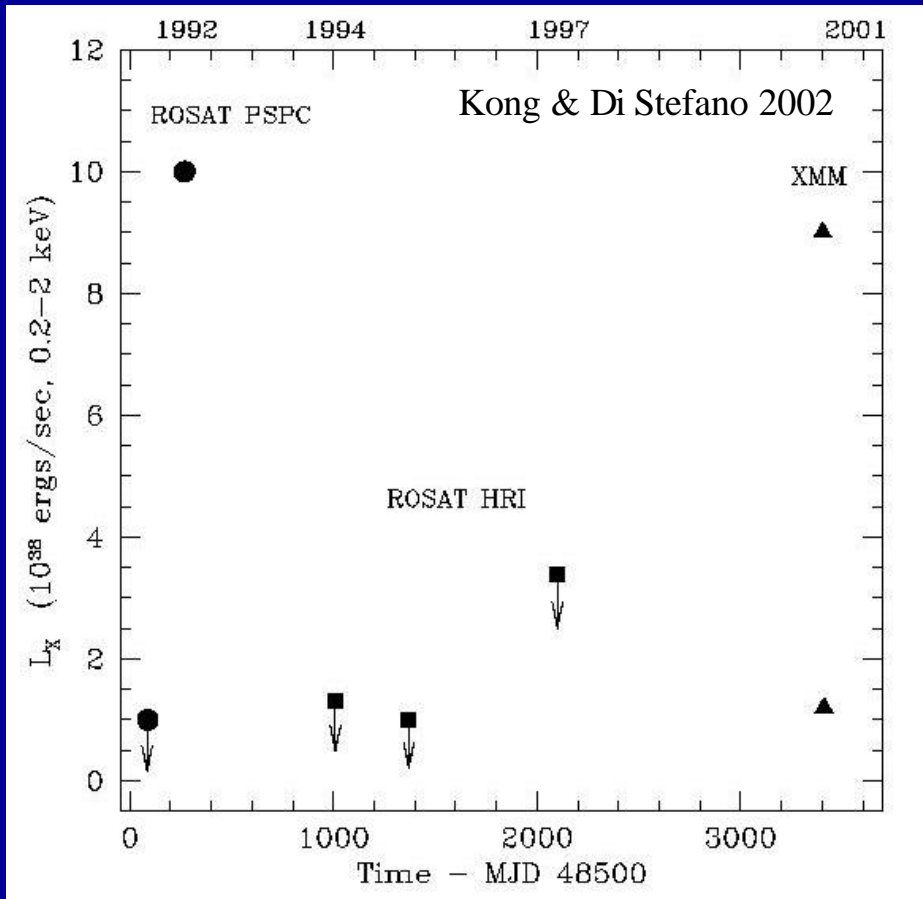
Visit 1 (2002 July 8) ACS

0.7" radius

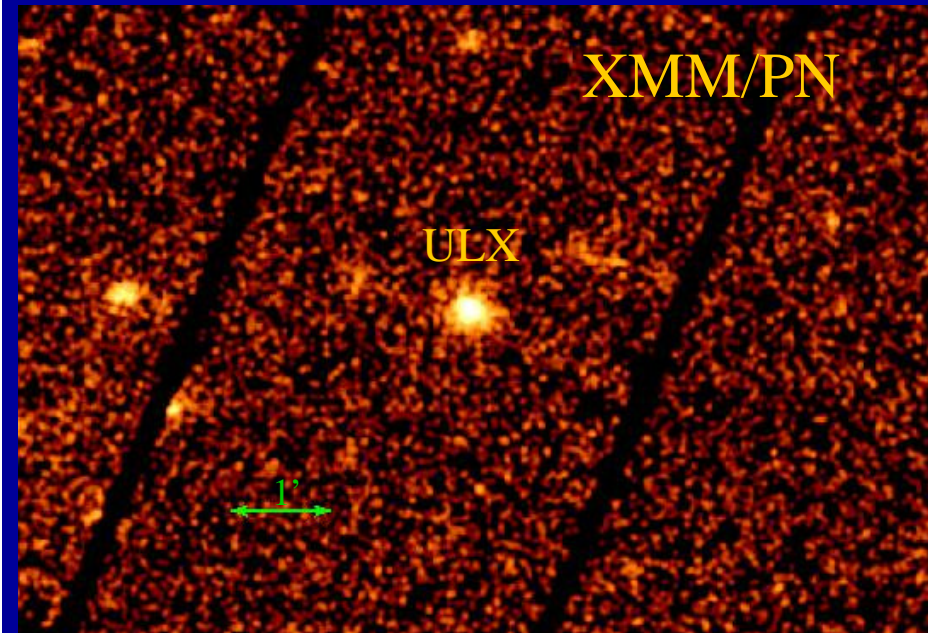
Visit 2 (2002 Aug 25) ACS

# Ultraluminous Transients

Ultraluminous supersoft (60 eV)  
recurrent transient in NGC300



Ultraluminous transient  
in M74 (Soria & Kong 2002)



- Not seen by Chandra ( $<1e37$  erg/s) in June and October 2001
- Detected by XMM in Feb 2002 at  $2e39$  erg/s





# CXOU J004305.5+411703

- $u=23$ ,  $N_H=10^{21}$ :  $M_V=-1.5, -2.9$

$$\Sigma = (L_X/L_{\text{Edd}})^{1/2} (P/\text{hr})^{2/3}$$

- $L_X=3 \times 10^{38} = 0.1 L_{\text{Edd}}$
- $P_{\text{orb}} = 27\text{d} - 210\text{d}$  (colors)
  - V404 Cyg = 6.5d,  
GRS1915+105=33.5d
  - U~V404 Cyg,  $L_X=0.1$  V404  
Cyg

