Our Chandra M31 Campaign
Some Surprises and M31*

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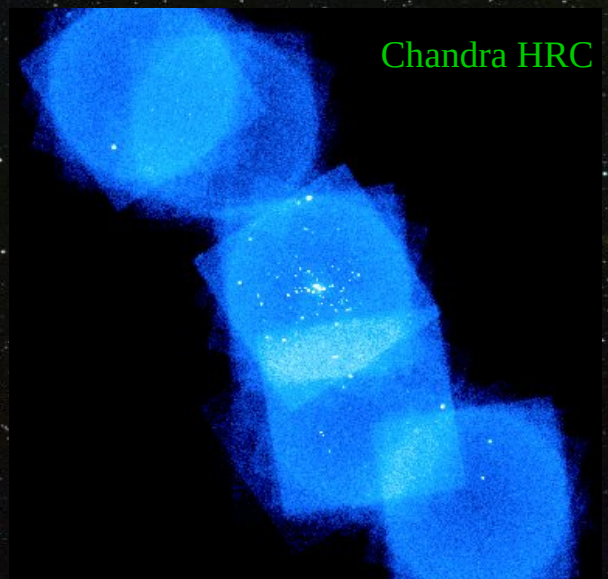
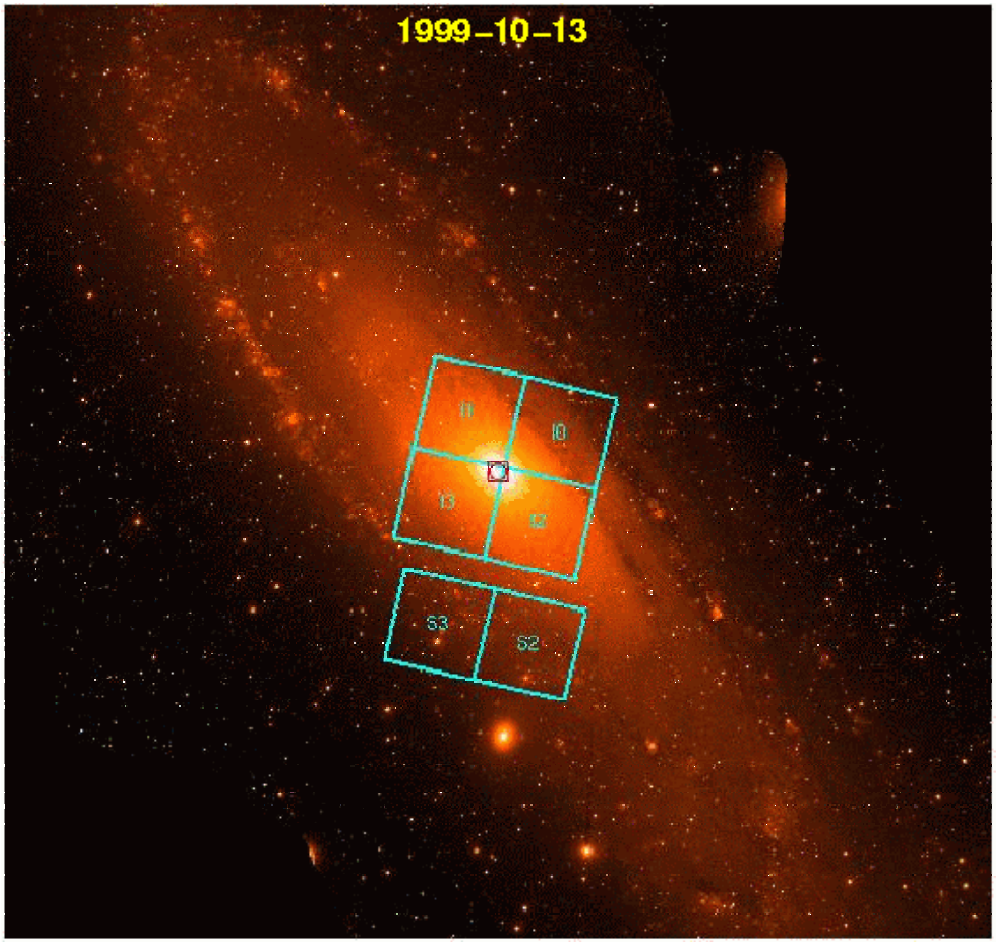
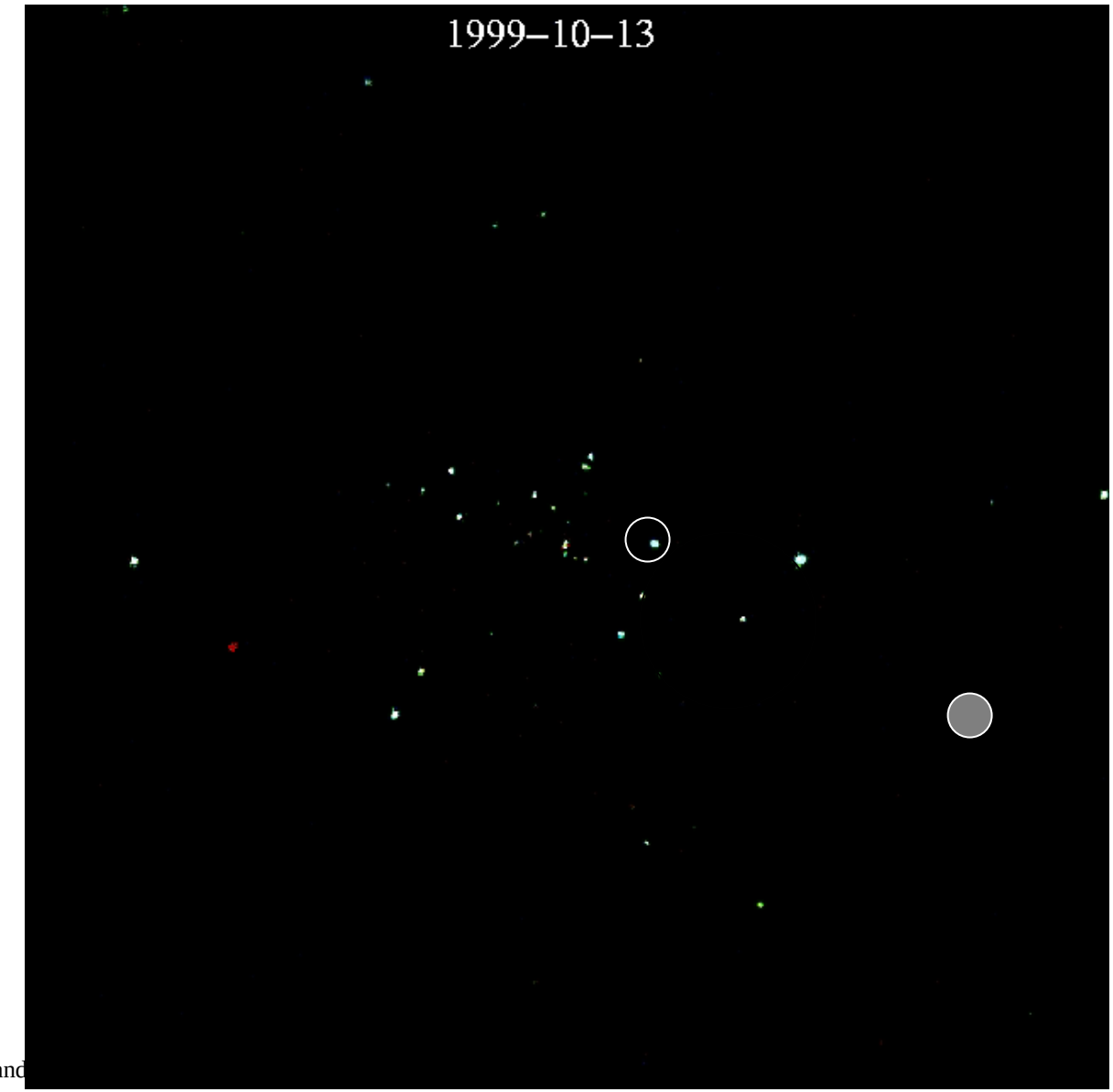


Our Campaign: ACIS Followup of Transients

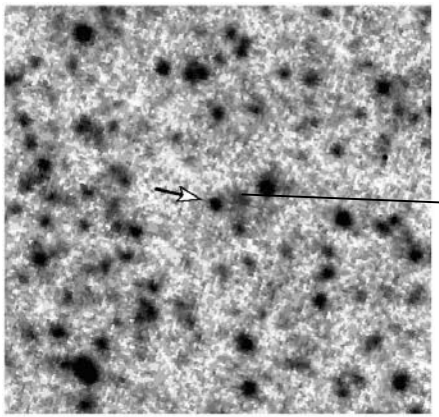


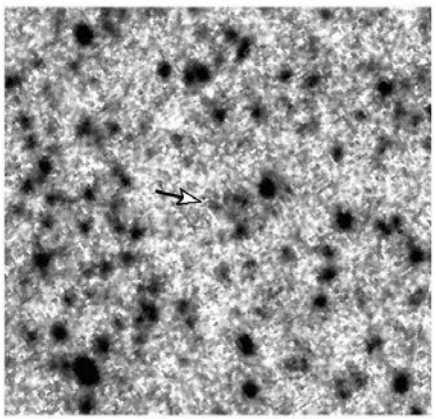
- Most transients in bulge, ACIS+HRC obs concentrated
- AO1,2,3,5,7… 107 separate obs, Σ=574ks! [141/814ks!!]
- Time 50/50 GO/GTO – multi-year program not possible w/o GTO time!
- 7 year span – yeilds numbers of SXT vs persistent, duty cycles.
- 574 ks – sensitive measure of M31*, LF, SNR, etc.

M31 ‘ACIS/ASM’ Movie



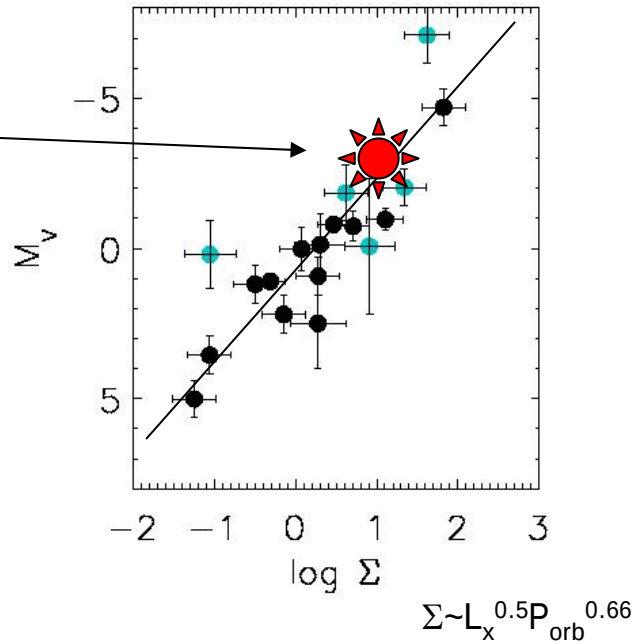
CXO+HST = RXTE/ASM + NOAO





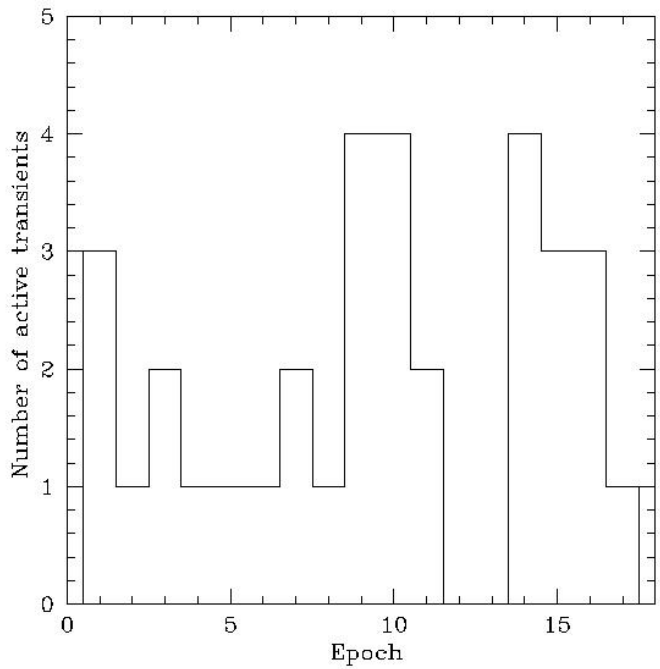
- AO3,5,(7)
- CXO SXT discovery, HST Optical ID
- Lx,Mv-> Porb (fundamental after population #s, -> a,evol,Mdot,XRT,etc.)
- 1, <1.6, <2.2, <2.3, 8, 23d
- MW, 0.15d<Porb<33d
- AO7, 2x deeper with HST

Van Paradijs & McClintock 94 +



Transients: Williams etal 2003 (surprise 1)

- Nov 99 – June 02, 2.5 years, HRC-I only - covering FULL disk
- 17 Transients in 17 Snapshots – concentrated in bulge
- 1 new source per obs, 100 persistent (NS) in bulge
- Transients concentrate in Bulge region – likely LM -> BH XRN?
- SURPRISE: IF Duty Cycle of BH ~1% (MW) -> similar # BH and NS
- Evolutionary calcs often predict #NS>>#BH ! (re-discovery of MW numbers)

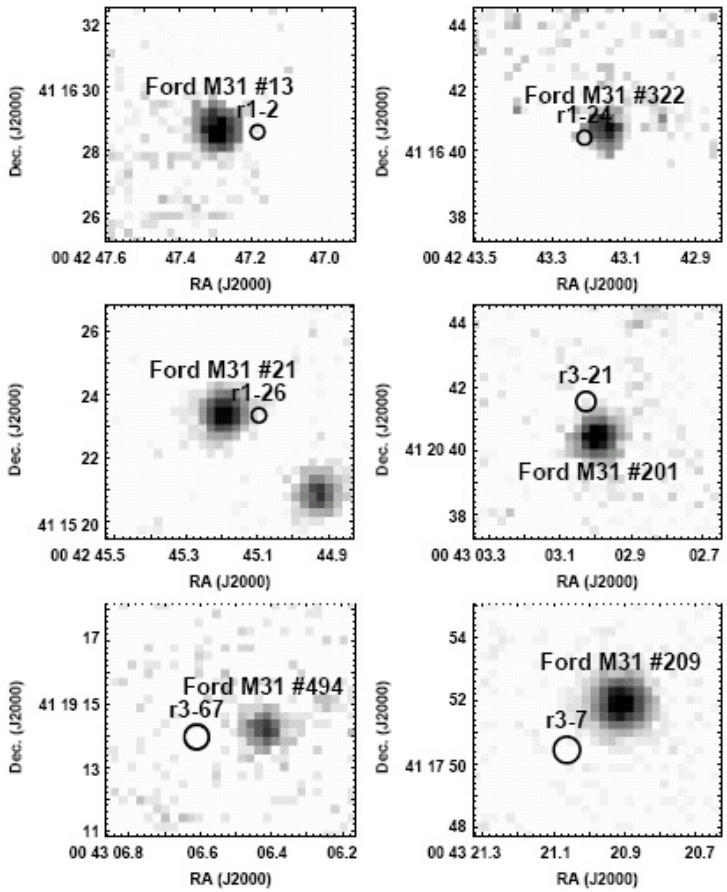


Williams 2005 ApJ submitted, 45(!) transients, ACIS, XMM, poster HERE

PN/SNR +XRB Associations (surprise 2)

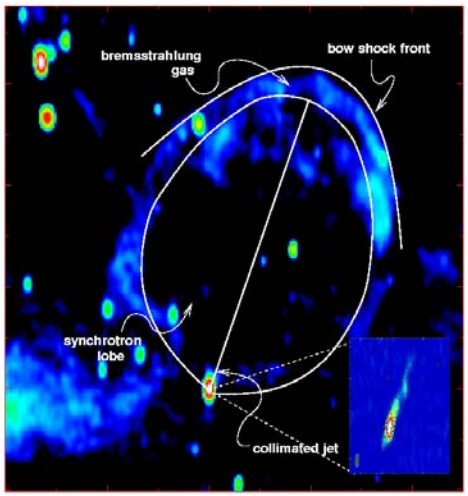
- Kong etal 2002 – 8 PNs w/ Lx~10^{37} (!)
- Williams etal 2004
- Register with LGS to 0.25’’, O[III],S[II], Hα.
- NOT matches! Near misses – Prob 1%
- X-ray spectra/timing ~ XRBs
- What are they?
  - Probably NOT SNR – Lx < 10^{35}
  - Probably not Ejected XRB – V too high
- Don’t Know! (survey eased in M31) optical spectra will help

O[III]

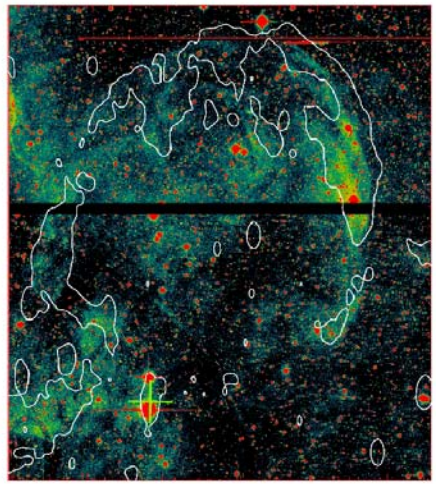


PN/SNR +XRB Associations (surprise 2)

Radio



Optical w/ contours

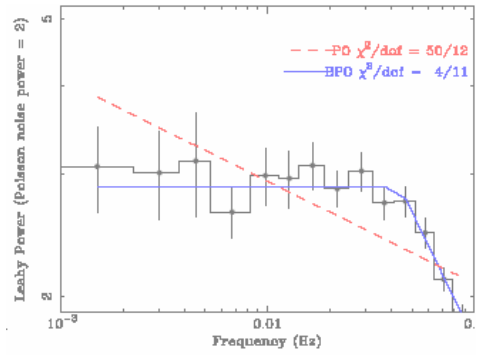


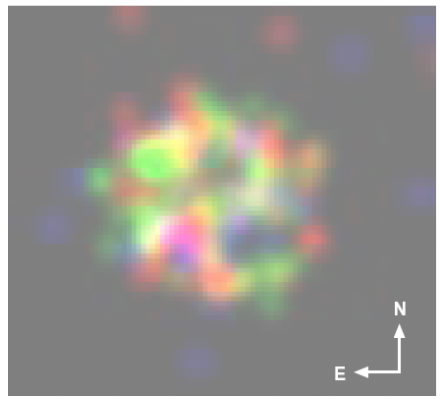
- Gallo, Fender etal 2005 Nature
- Cyg X-1 radio/optical ‘bubble’ blown by jet
- Separation @M31 = 1 arcsec… as seen in PN/SNR + XRBs
- Optical spectra could tell!

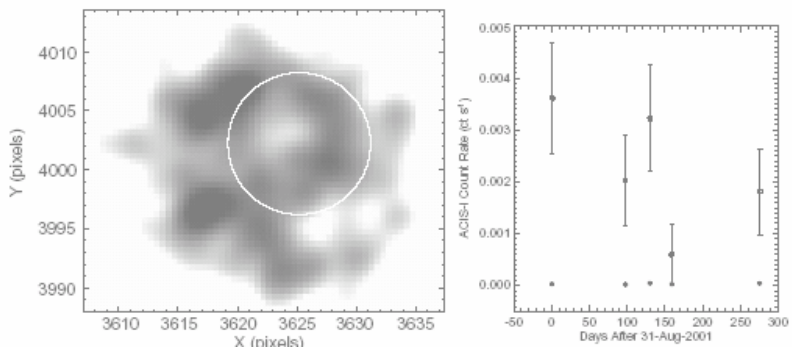
R3-63: A resolved SNR w/ XRB (surprise 3)

- Williams, Barnard etal 2005
- In MW, only SS433 (Cir X-1?)
- Highly Significant Variability detected in XMM PL+break = disk accretion
- SNR resolved with Chandra
- Low significance variability w/ Chandra in NW quadrant

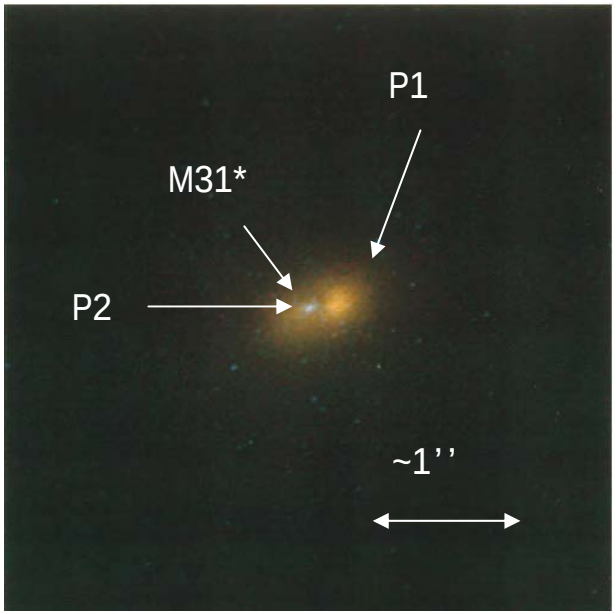
- Maybe there are ejected XRBs?
- Optical spectra could ID SNRs

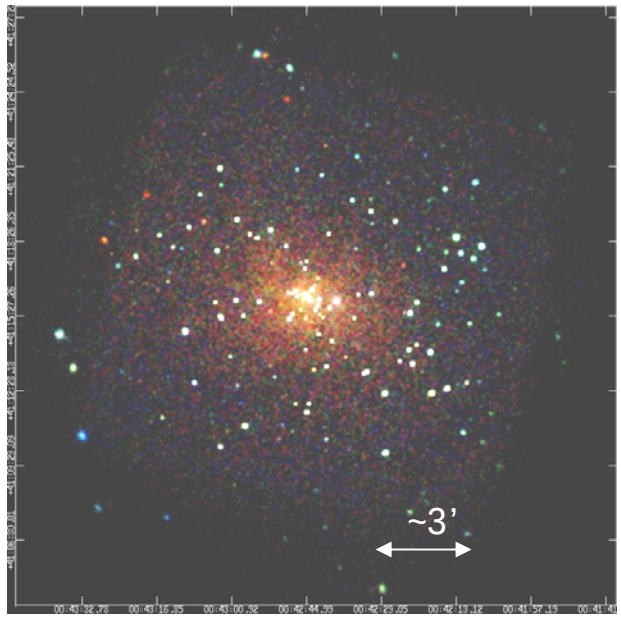






M31* SMBH





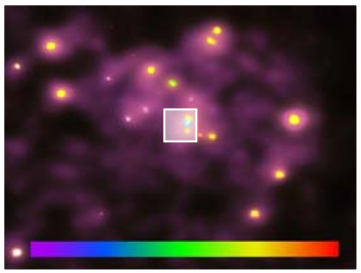
Kormendy and Bender 1999
Rare Double Nucleus, plus
3 x 10^7 Msun SMBH @P2

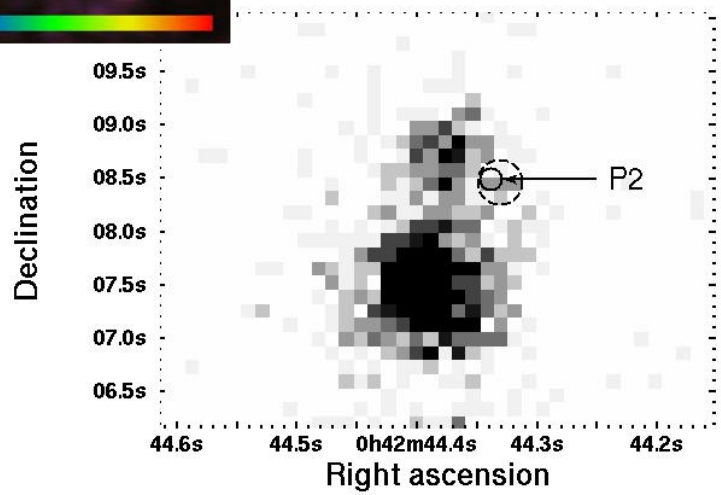
Kong etal 2002
ACIS Mosaic – Clear Diffuse emission
In central region

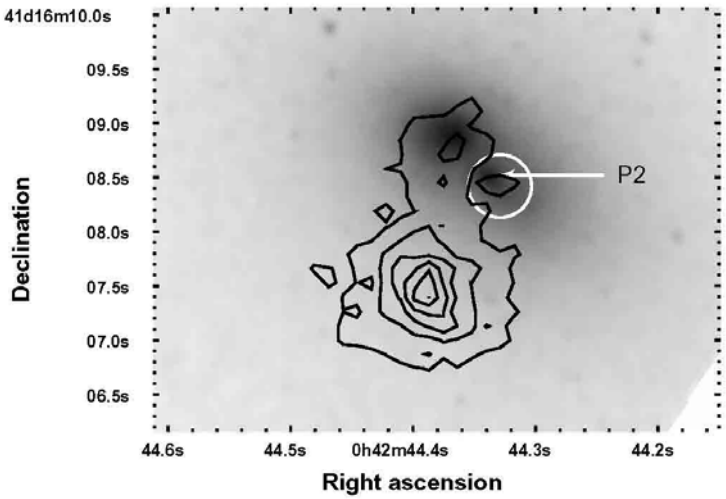
Bondi accretion rate? Bondi Radius? Accretion (radiation) efficiency? jets?
Position of Crane 1992 pt radio source? (within 0.5'', accurate to 0.15''...)

M31* - HRC and ACS to 0.1’’

Garcia etal 2005 ApJ







50ks HRC image

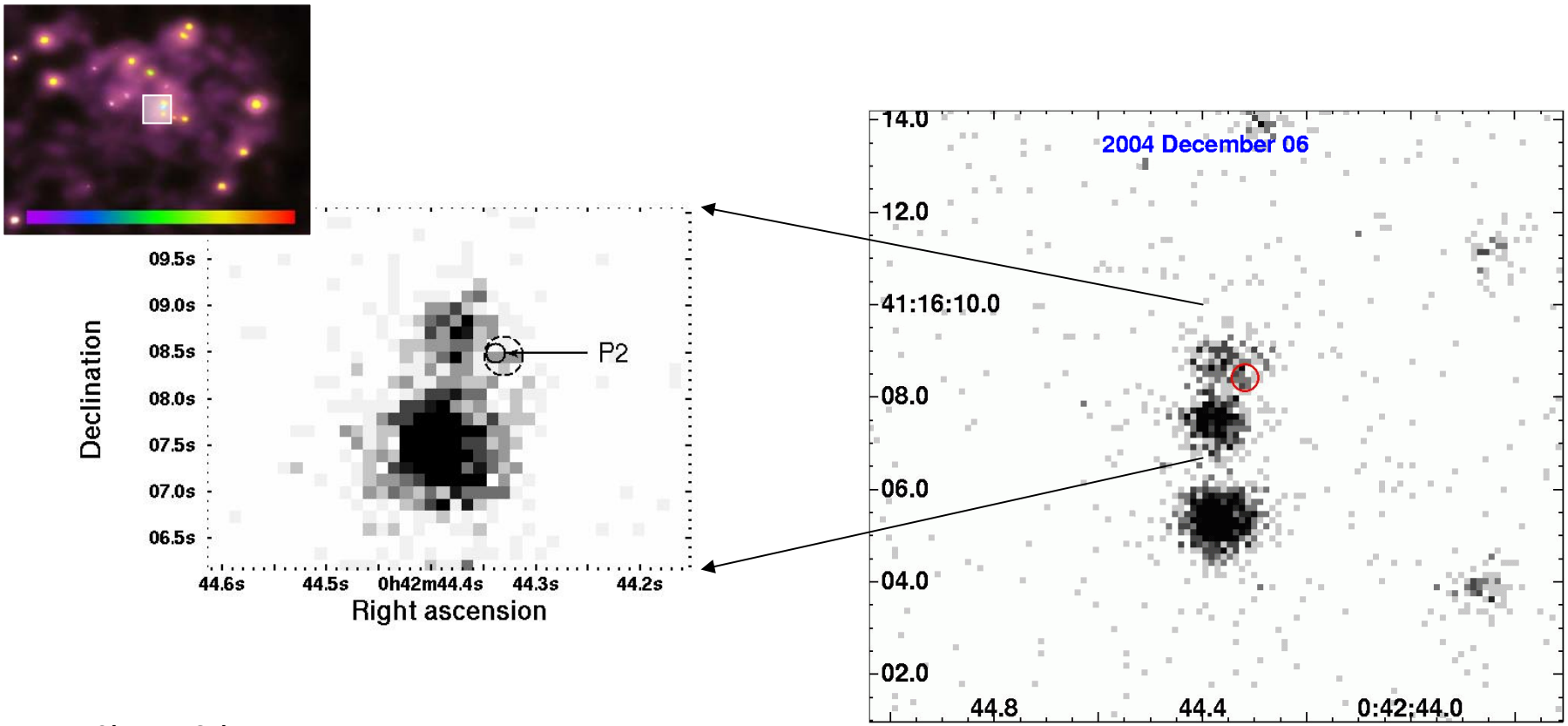
P1/P2 indicated schematically
M31* error circle = 0.1’’ radius
Dashed line = resolved source, 13 counts, 2.5σ
Above N1+SSS+diffuse
13 counts ~ 10^36 ergs/sec

ACS image, HRC contours

Separate (=resolved) contour at M31*

Radio pt source in white – predates
Discovery of double nucleus!

M31* - A06 HRC/VLA Movie



50ks HRC image

P1/P2 indicated schematically
M31* error circle = 0.1'' radius
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Above N1+SSS+diffuse
13 counts ~ 10^36 ergs/sec

4 x 50 ks HRC images, simultaneous VLA

MUCH varaibility!

Radio/X-ray may distinguish Jets/ADAF

Summary: Chandra M31 Campaign, Some Surprises and M31*

- 7 Year Synoptic program – Modest exposures, but sum 574ks, could obtain ~1 Msec if continued
- Many Transients found – 45 total, Williams 2005
- SXT Counterparts - 6 ORBITAL PERIODS, 5 more in AO7
- Surprises
  - N(NS) ~ N(BH) – expect N(NS) > N(BH)
  - X-rays near PNebula/SNR? Ejected XRBs? Jets?
  - Resolved SNR w/ embedded XRB
- M31* RBH resolved, 'Severe and Secure' constraints
- M31* X-ray/Radio Variablity – Jets or ADAF?