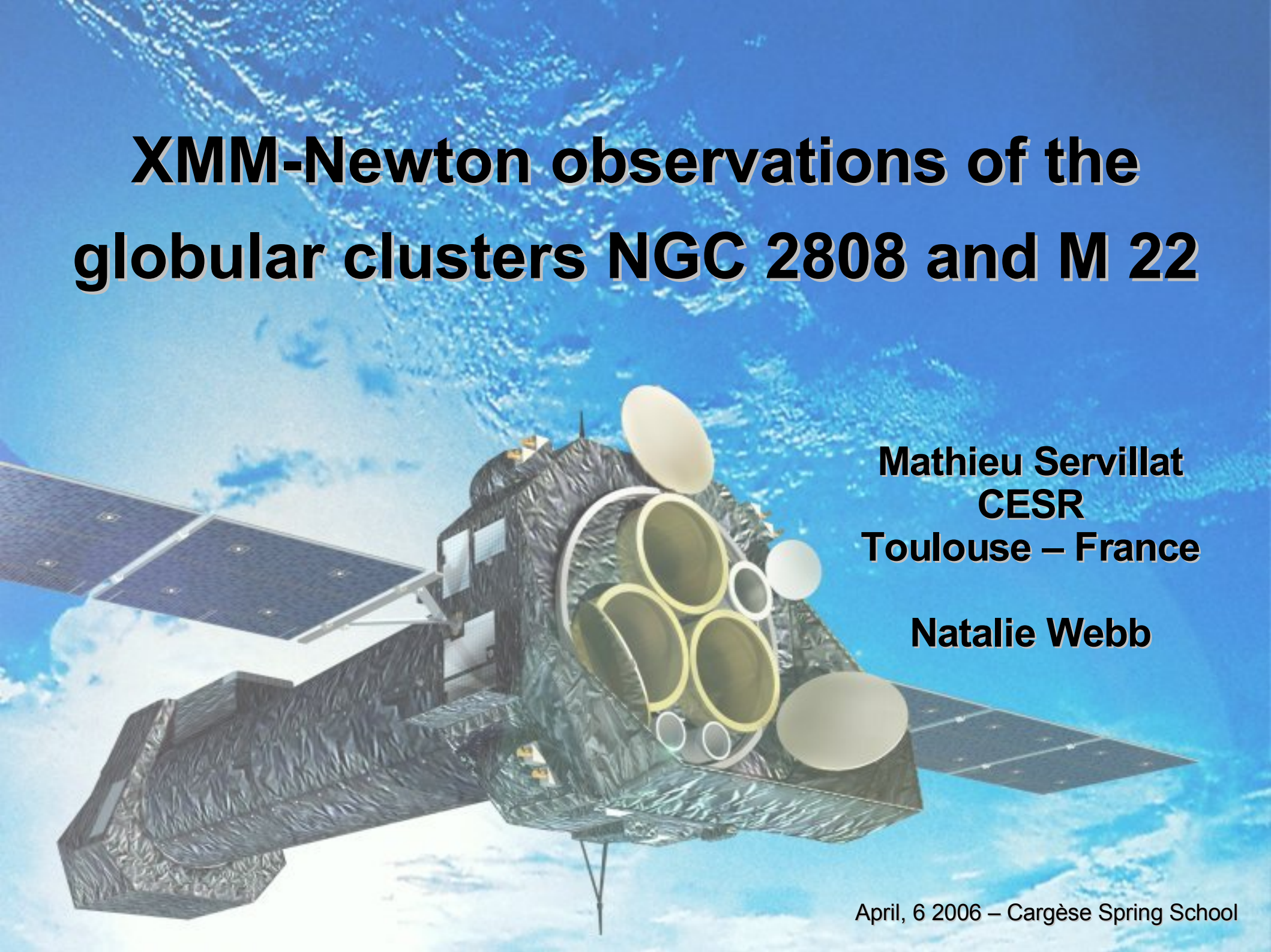
XMM-Newton observations of the globular clusters NGC 2808 and M 22



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April, 6 2006 – Cargèse Spring School

I.1. Globular Clusters (GCs)

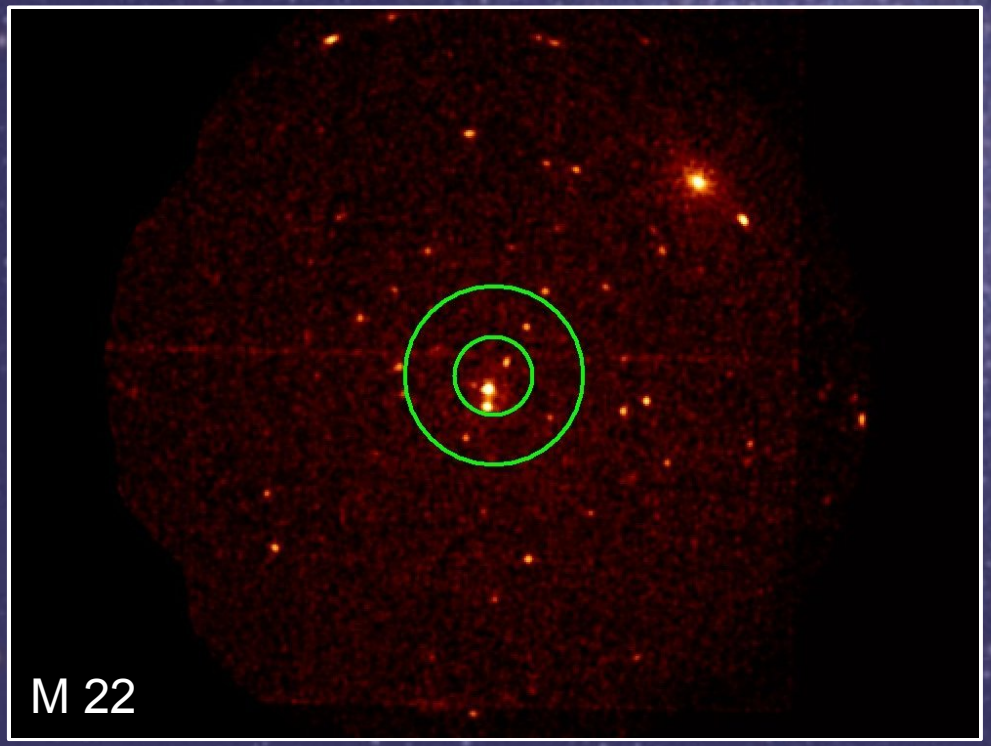
- **Dense** groups of **very old** stars (10-14×10^9 yrs)
- High **collision rate of stars** in the core
- Stable on dynamical timescales (t_{cross} ~ 10^6 yrs)
- **Unstable** on thermal timescales
  - t_{relax} = 1.66×10^9 yrs (NGC 2808) and 1.35×10^9 yrs (M 22)
  - All GCs should have collapsed in a few t_{relax}
- The **core collapse** must have been **delayed**
  - Binding energy of **close binaries**

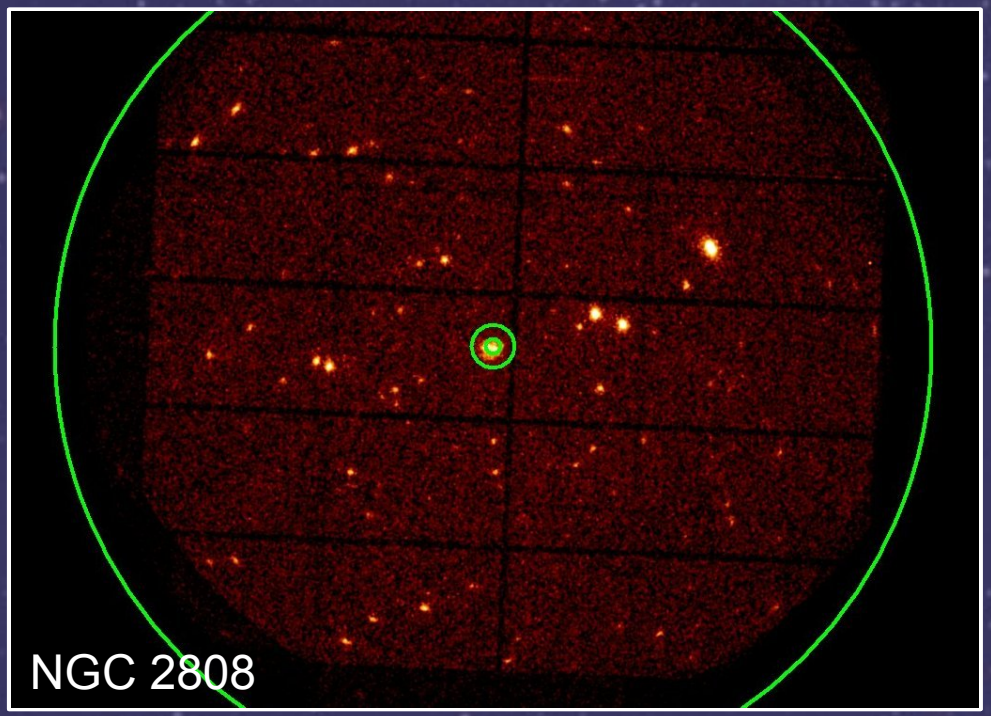
Hut et al. 1992
for a review

- How can we find these close binaries ?

I.2. X-ray sources in GCs

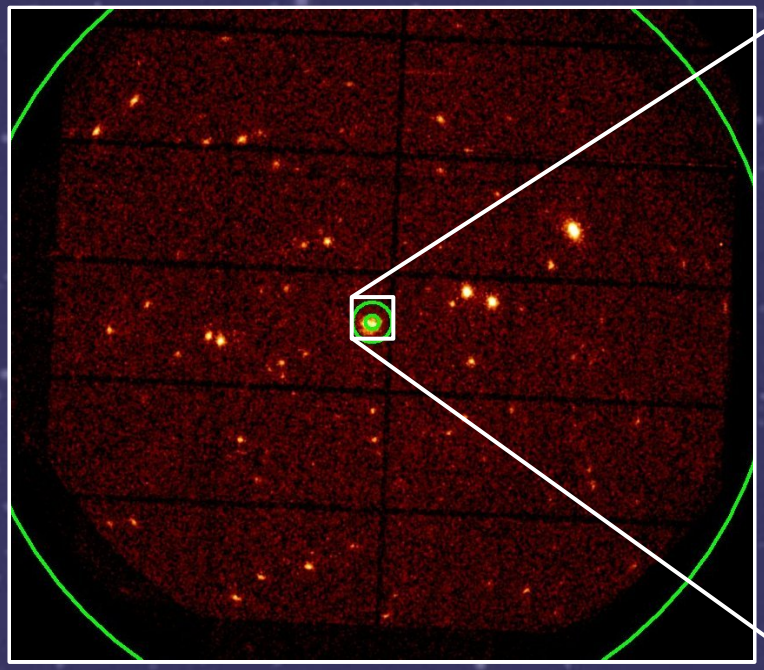
- Tracers of **close binaries** !
  - Cataclysmic Variables (CVs)
  - Low Mass X-ray Binaries (LMXBs) often in quiescence (qLMXBs)
  - Millisecond Pulsars
  - Active Binaries
- Excess in GCs vs. field (Clark 1975, Katz 1975)
- **Faint** X-ray sources (Hertz & Grindlay 1983)
  - $L_X < 10^{34.5}$ erg.s^{-1}
  - 13 bright sources in 150 GGCs $L_X > 10^{36}$ erg.s^{-1}

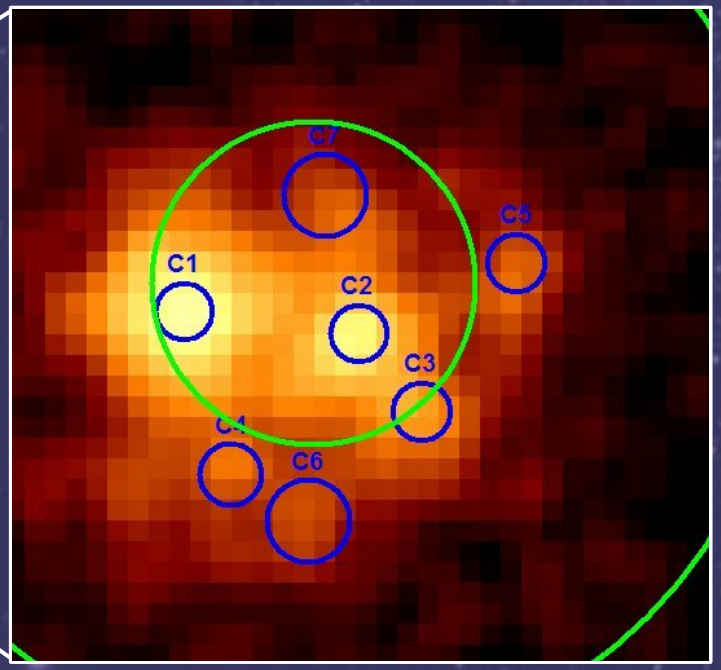


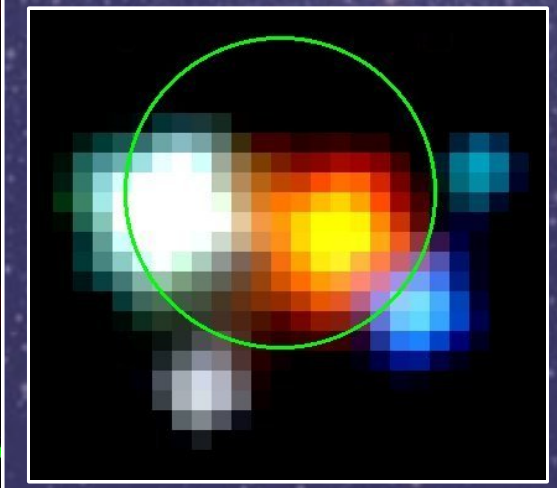


II.1. NGC 2808 with XMM-Newton

- 42 ks of observation
- PN, MOS1 and MOS2 detectors in imaging mode





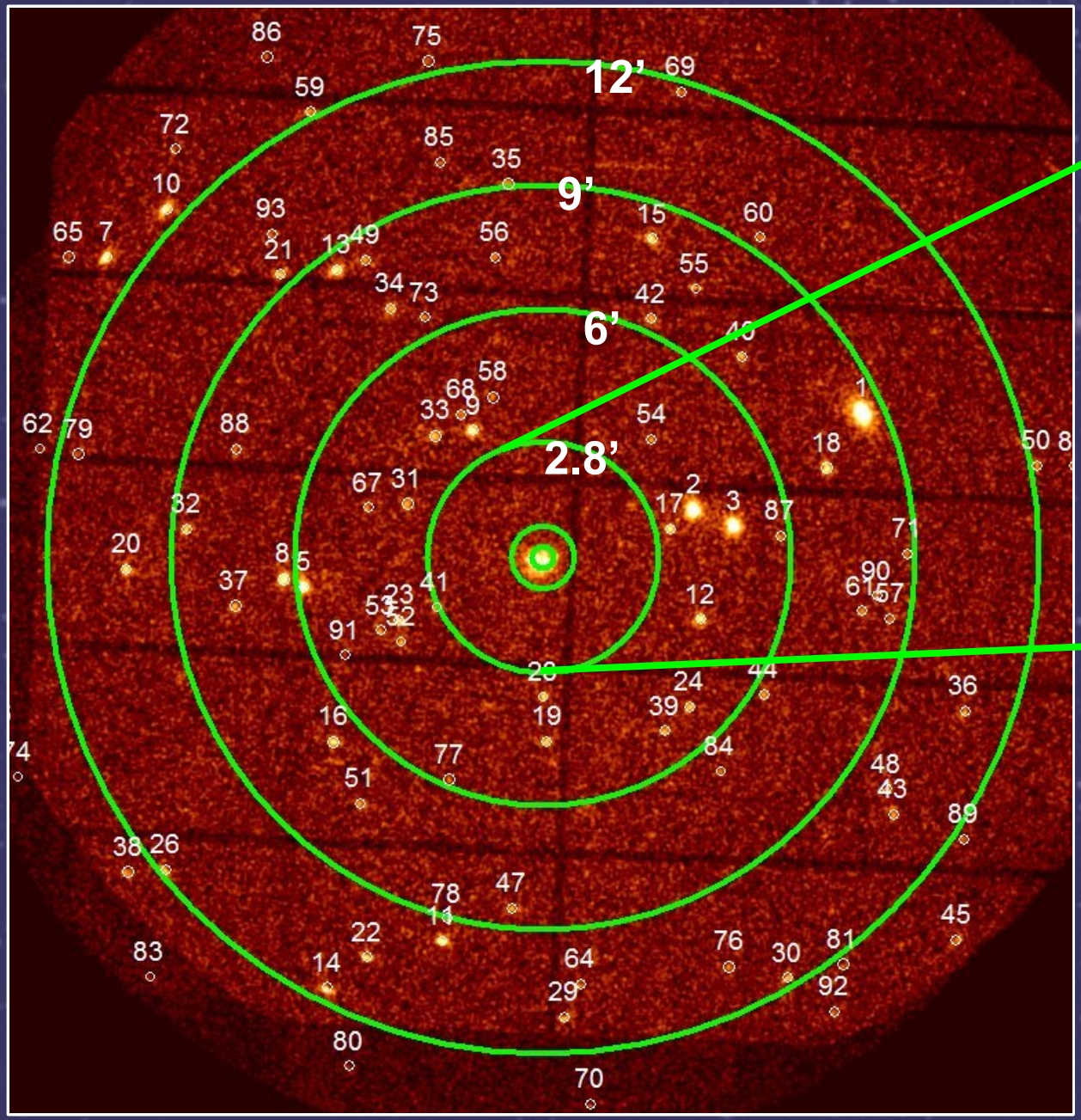


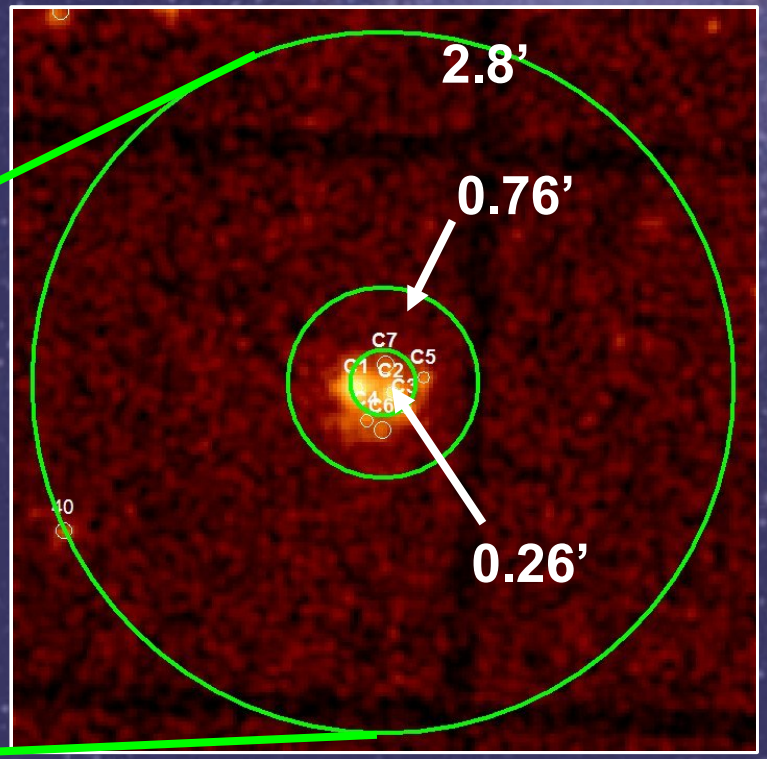
- 71 sources (SAS)
- 2 + 1 in the core radius
  3 + 1 in the half-mass radius
- $6\times10^{33} > L_{0.2\text{-}10\ keV} > 1.5\times10^{31}$ erg.s^{-1}

- From other studies :
  - 2 qLMXBs (Gendre et al. 2003)
  - ~60 CV candidates
    ~40 WD candidates
    (Dieball et al. 2005)

II.2. Expected and observed sources

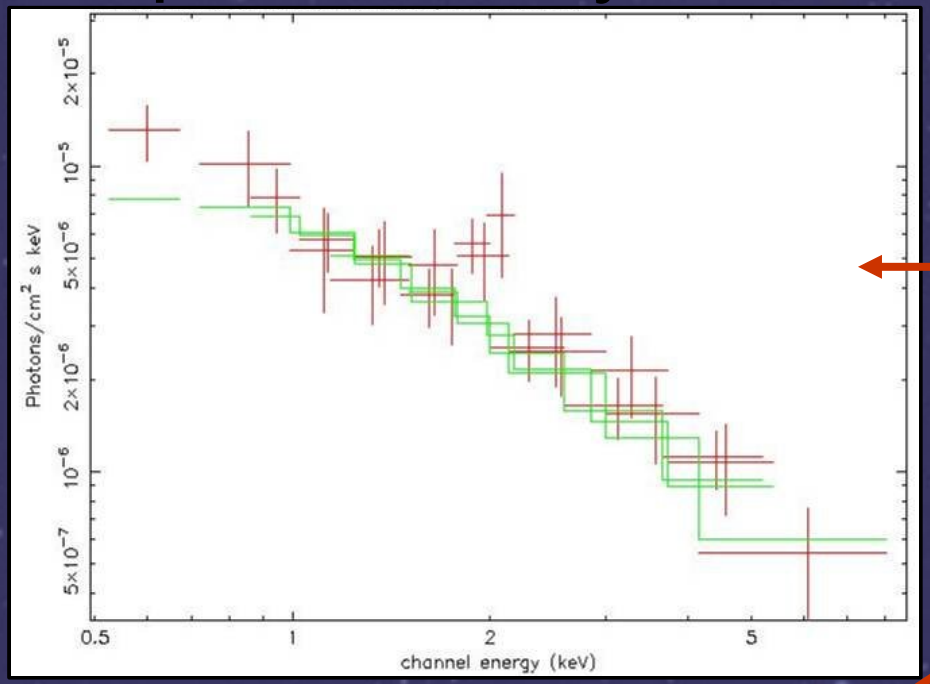
Hasinger et al. 2001

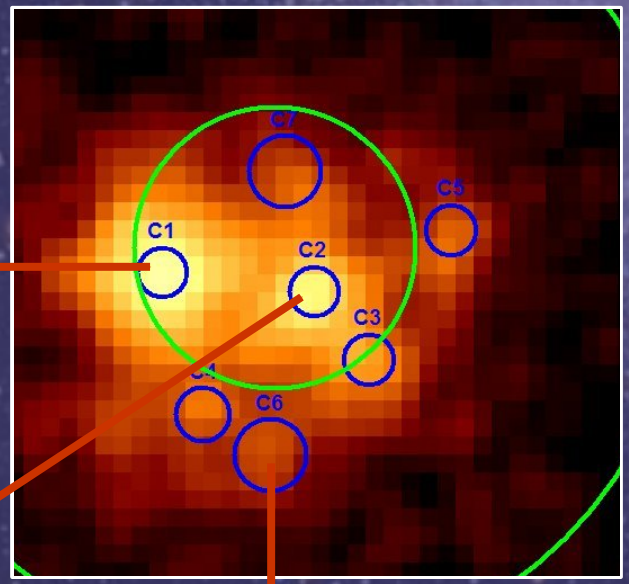


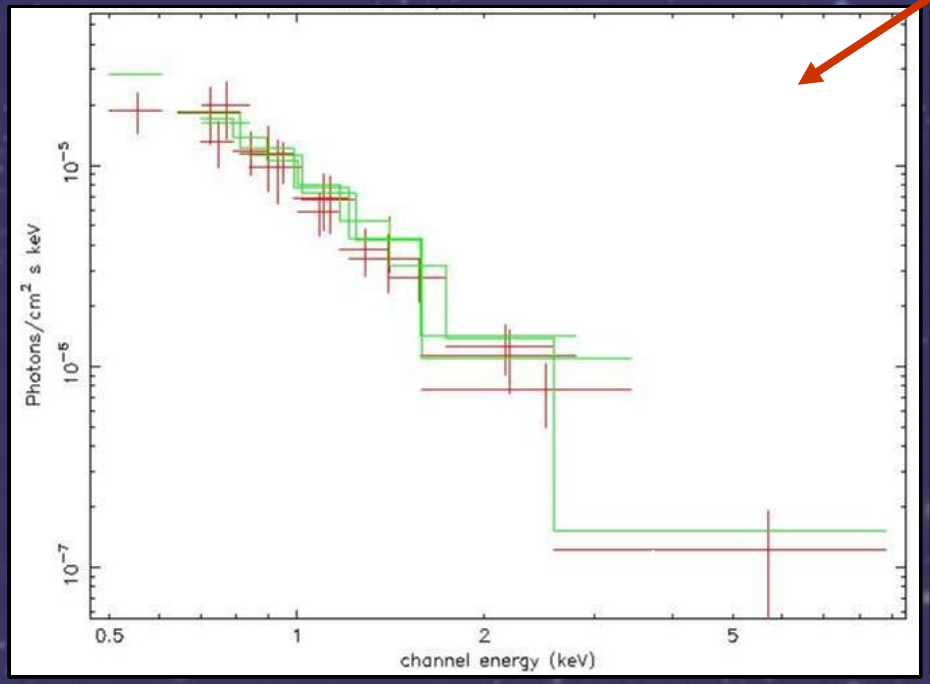


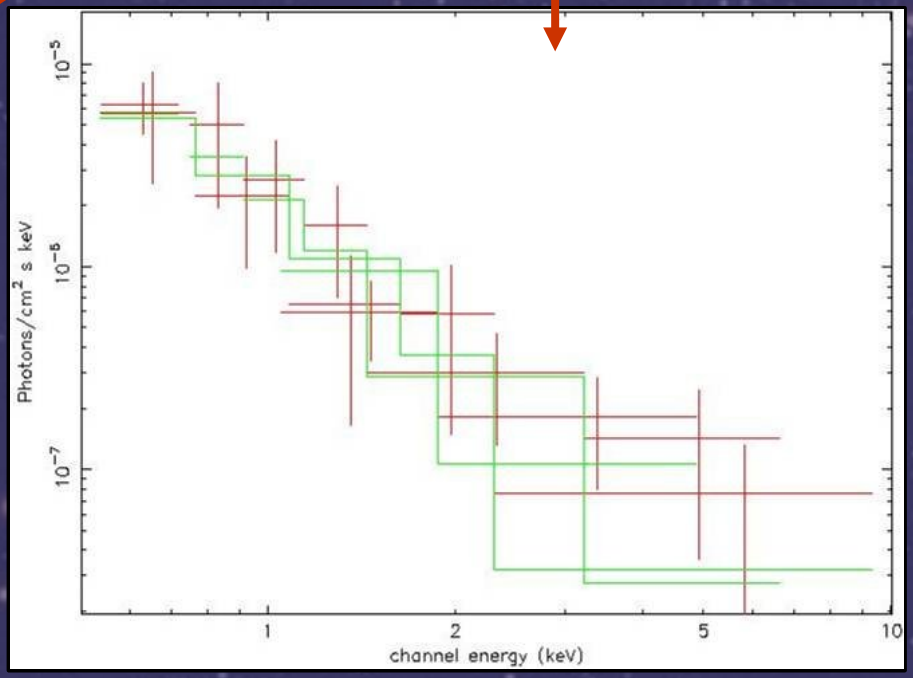
Annulus	Expected	Observed
0.26’	0.04 ± 0.001	3
0.76’	0.31 ± 0.009	4
2.8’	4.12 ± 0.13	0
6’	14.8 ± 0.8	23
9’	22 ± 2	23
12’	21 ± 3	19

II.3. Spectral analysis



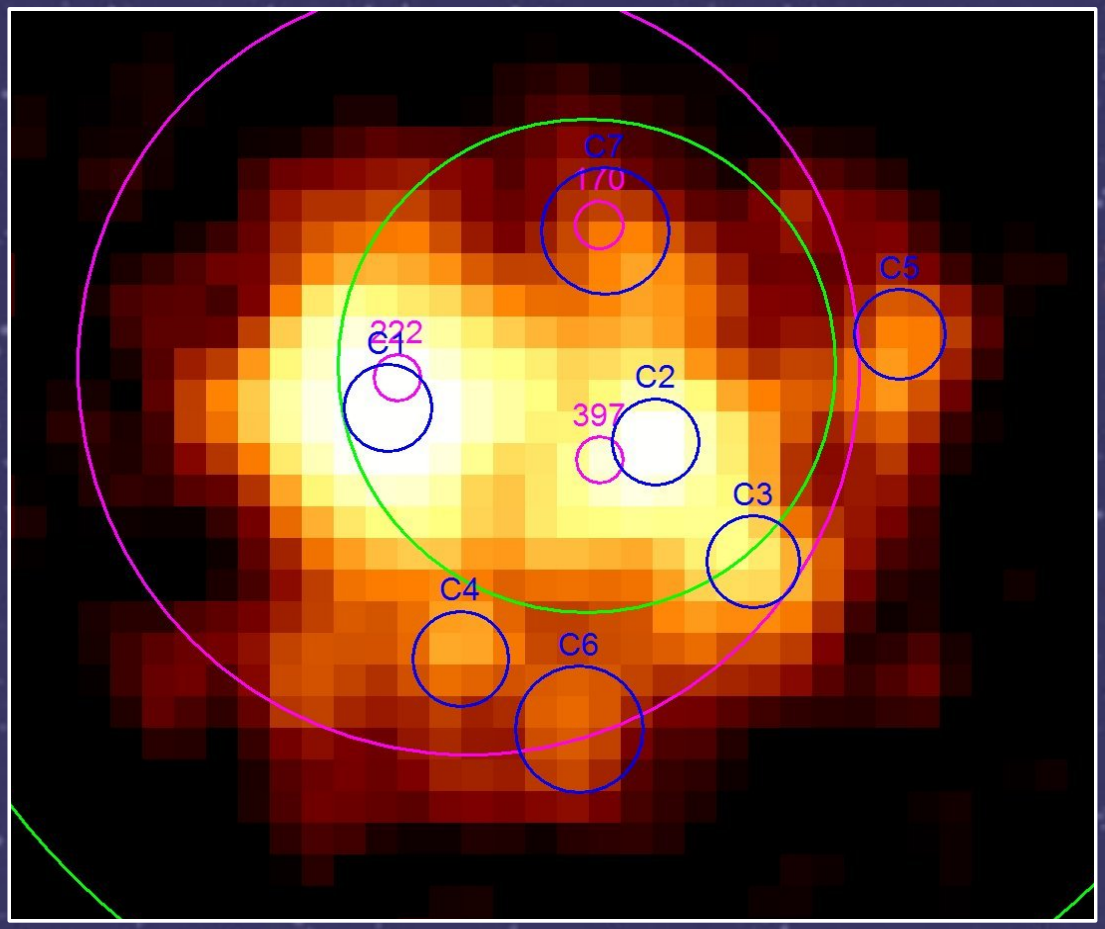






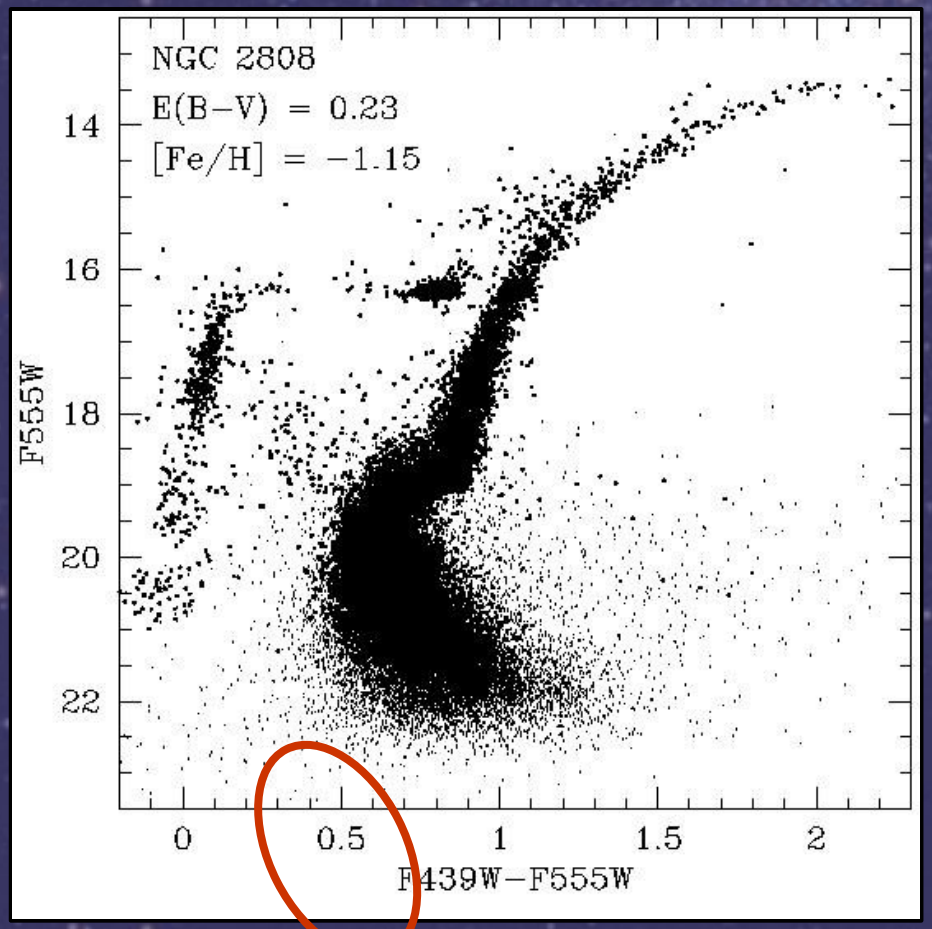
II.4. Multi-wavelength study
Looking for counterparts

Far UV CV candidates (HST)



Dieball et al. 2005

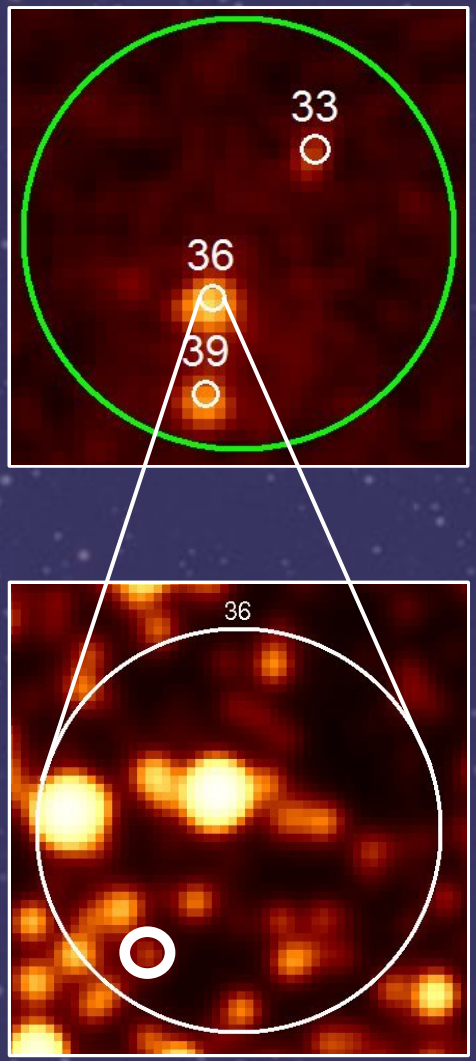
Optical data (HST)

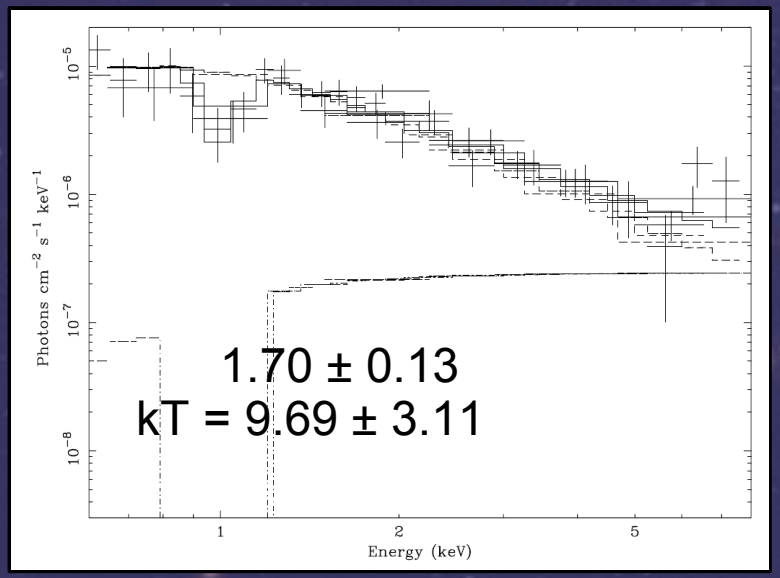


Piotto et al. 2002

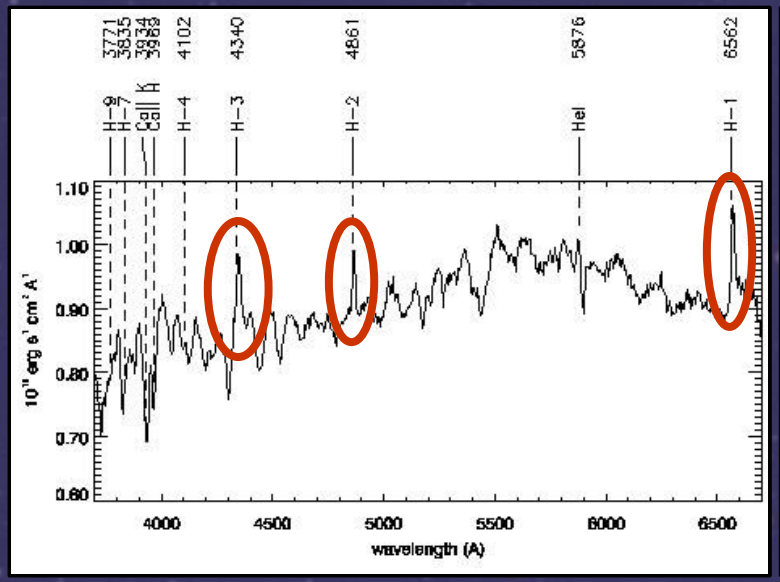
II.5. Cataclysmic Variable in M22

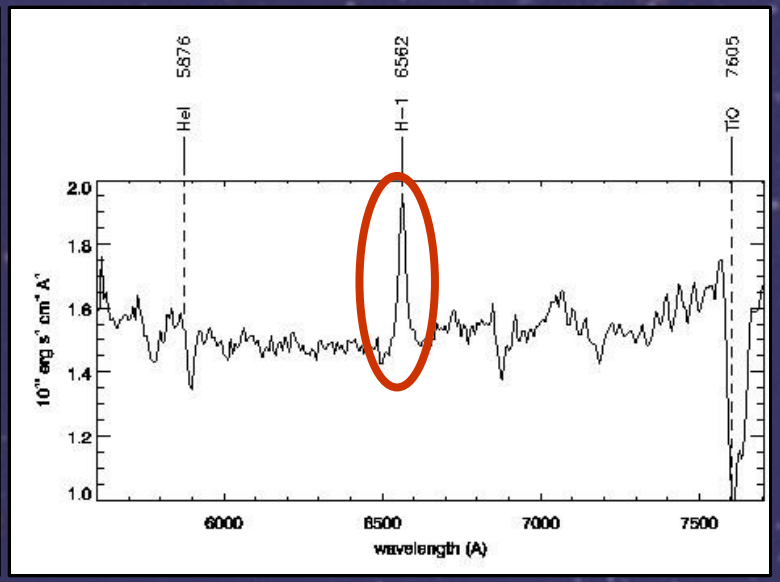
Webb et al. 2004





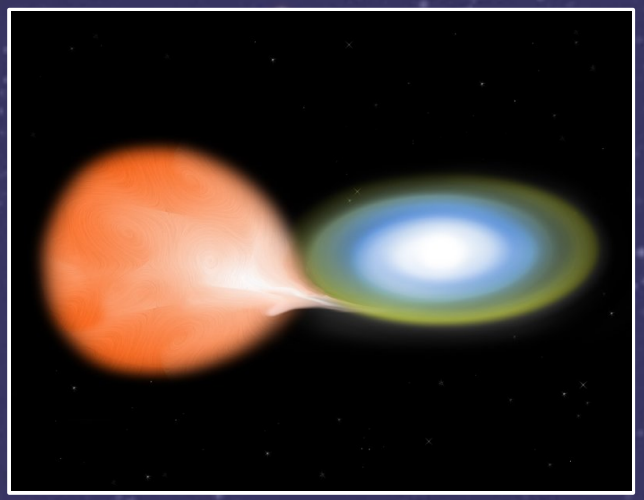
- Ambiguous X-ray spectrum
- Possible dwarf nova outburst (Anderson et al. 2003)
- VIMOS+VLT observation in 2004



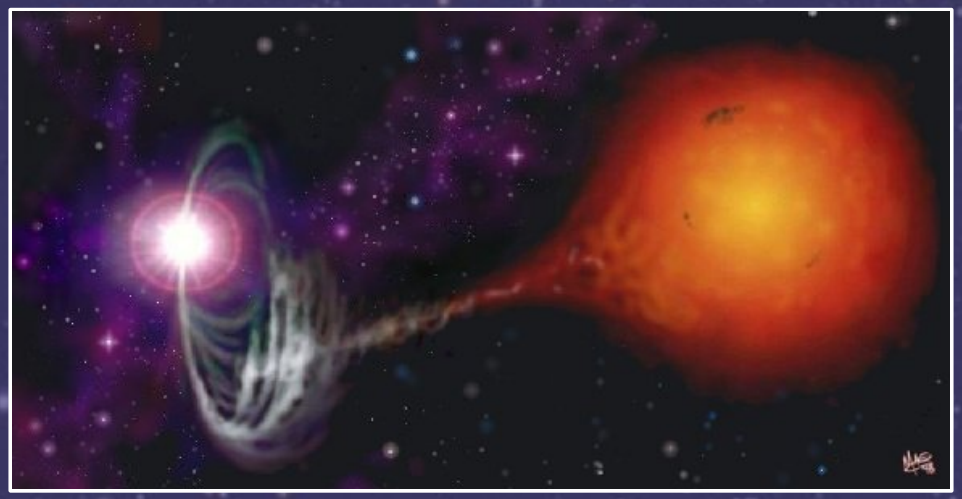


Closing remarks

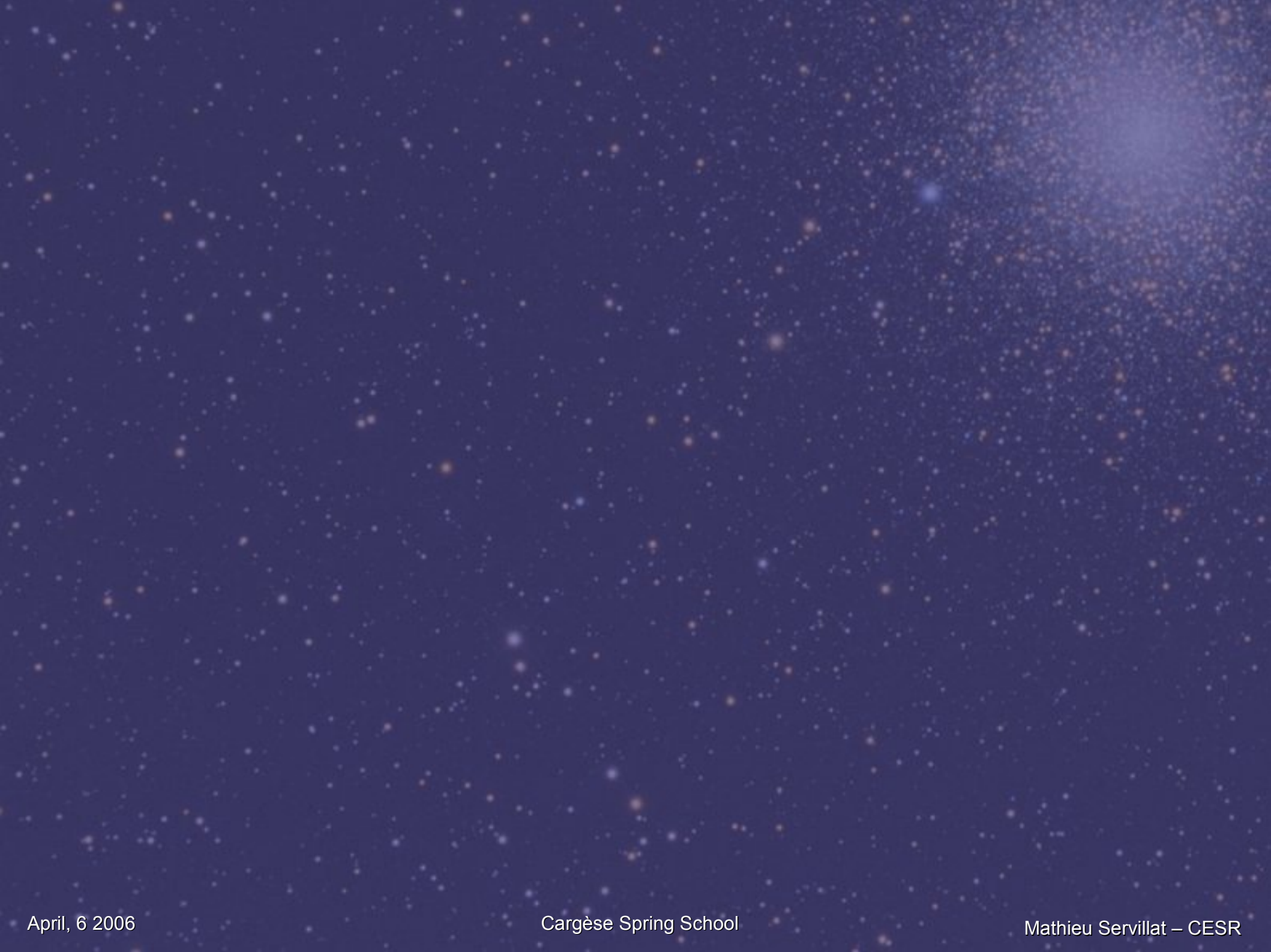
- CV confirmed in M 22
- Excess of X-ray sources in the core of NGC 2808
  - Detection of 1 CV and possibly several others
- Anomaly of source distribution
- Confusion in the center
  - Proposal for Chandra observation
  - Waiting for optical observations with ESO 2.2m and CFHT



Nova Aquilae (CV)
NASA/CXC/M. Weiss



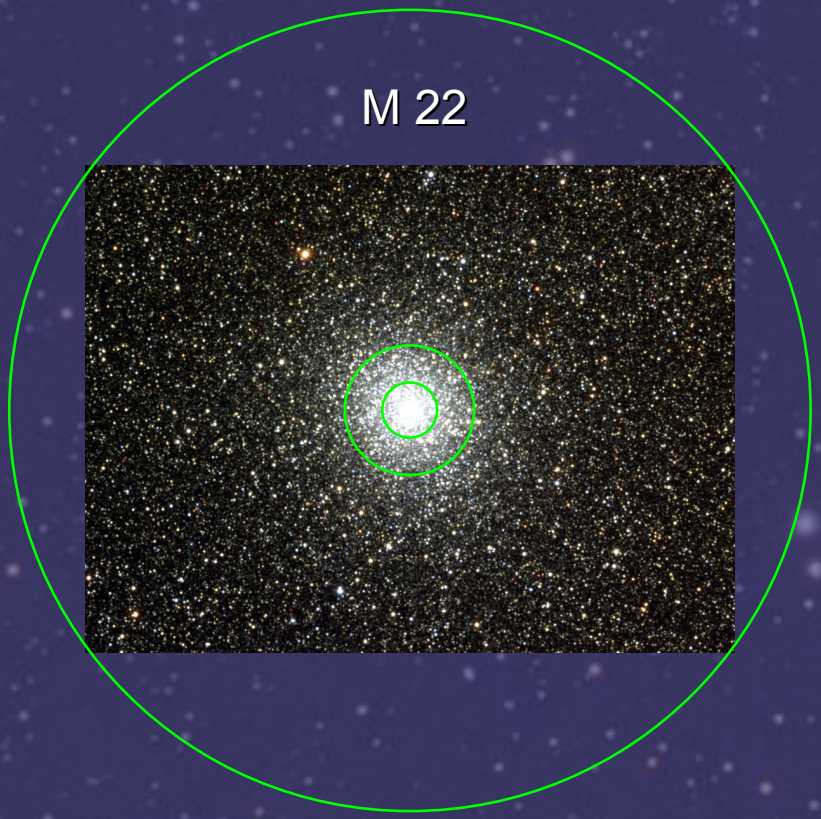
Polar (magnetic CV)
Mark Garlick 1998

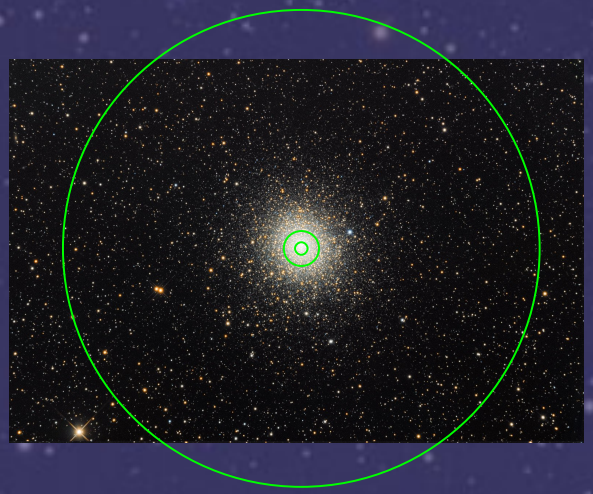


Globular Clusters (GC) parameters

	M22	NGC 2808	
core radius	1.42	0.26	arcmin
half mass radius	3.26	0.76	arcmin
tidal radius	28.97	15.55	arcmin
distance	3.2	9.6	kpc
concentration	4 365	38 904	$L_{\odot}.pc^{-3}$
age	~10-14		Gyr

(Harris, W.E. 1996, revised in feb. 2003)



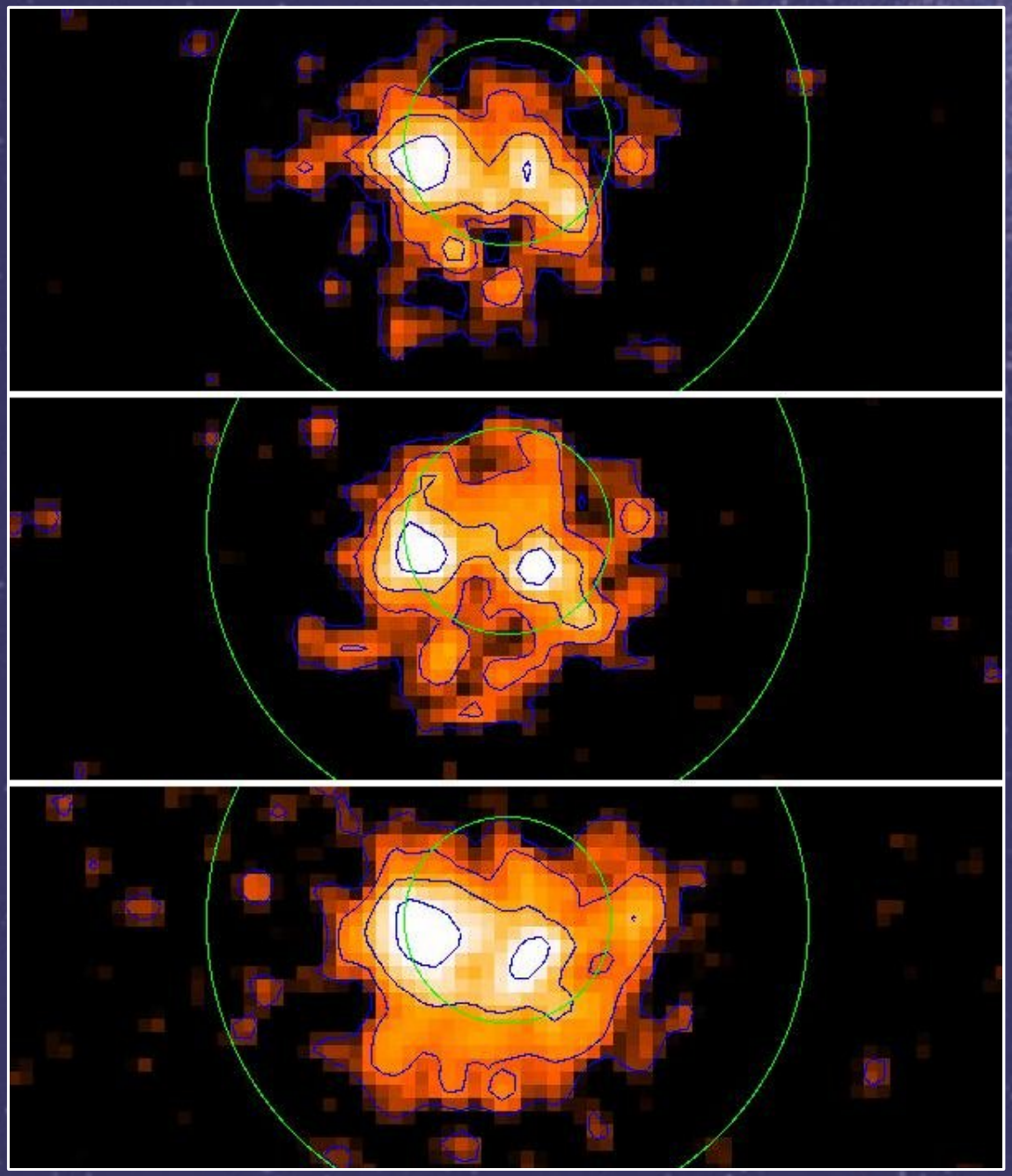


Detection by eye

MOS 1

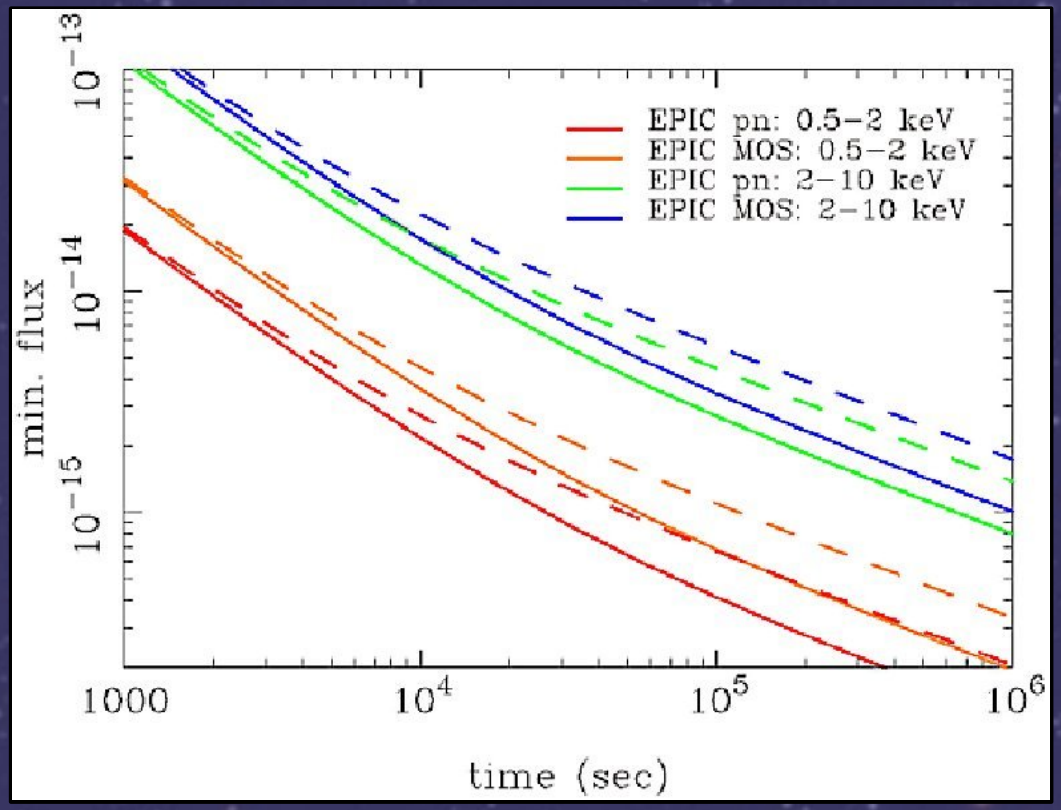
MOS 2

PN

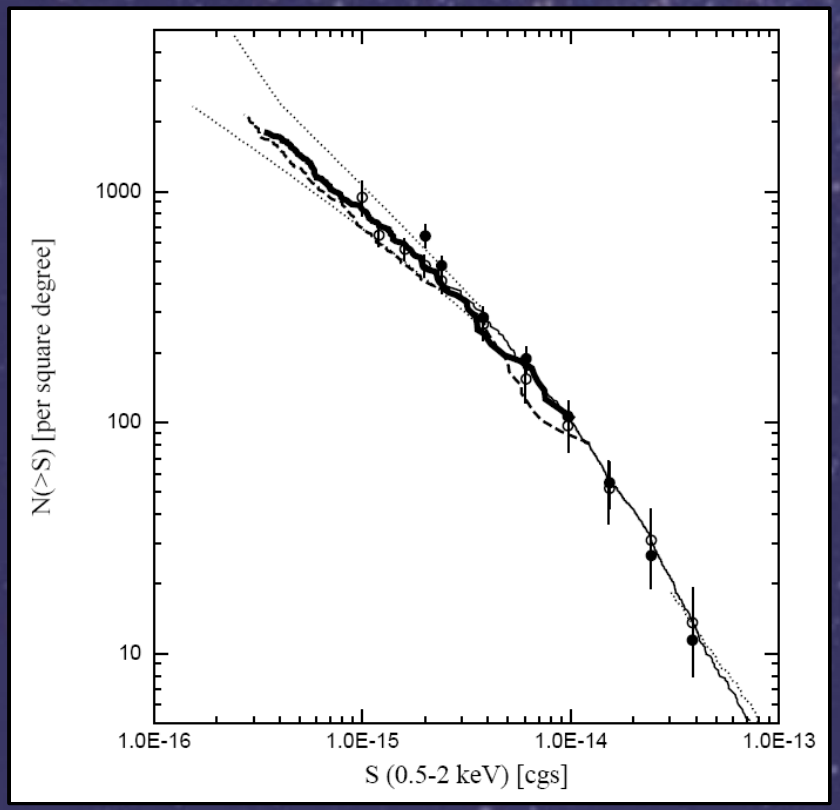


Expected sources

- Estimate the minimal flux with exposure time and sensitivity
- Estimate the number of X-ray sources

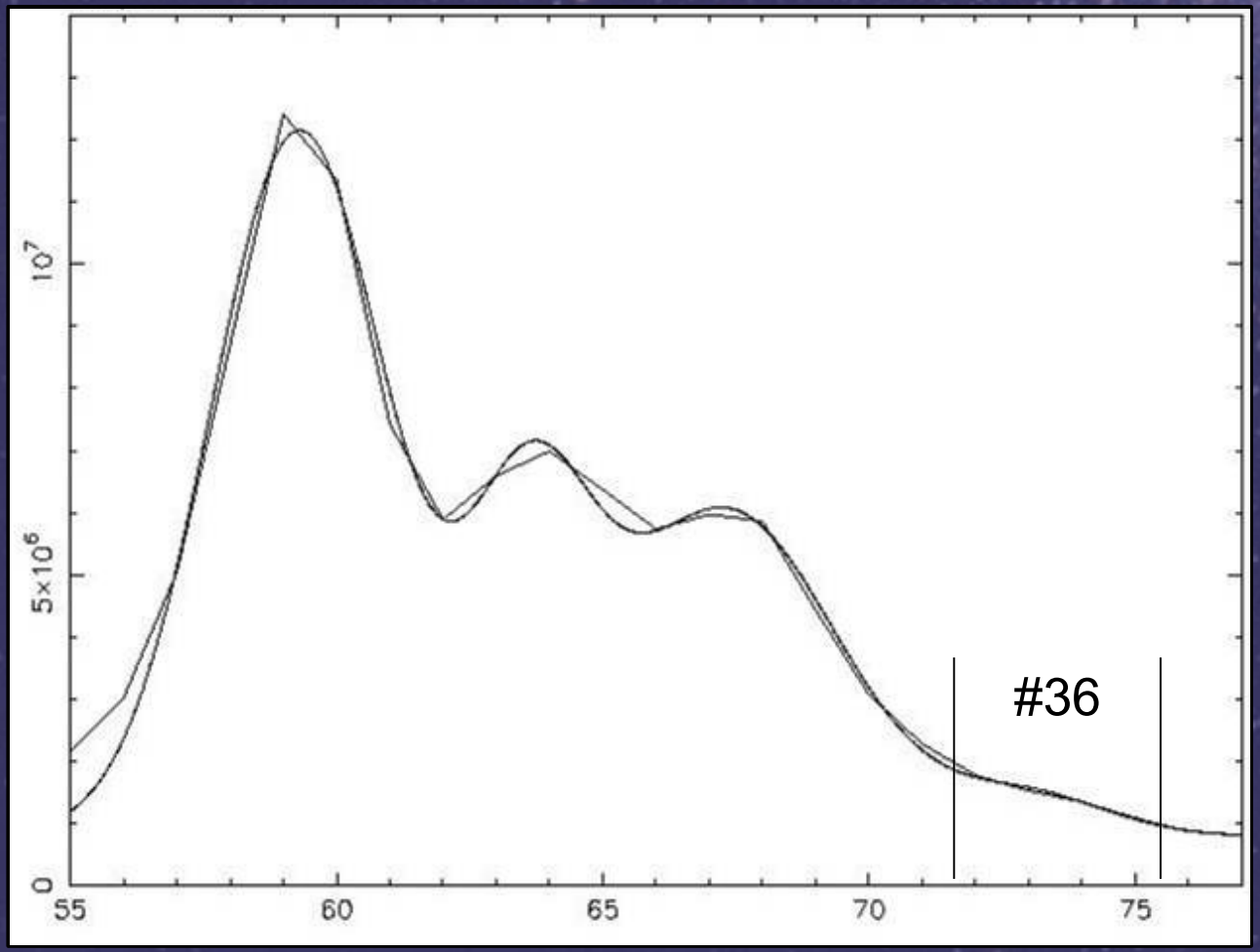


XMM-Newton User Handbook



Hasinger et al. 2001

CV in M22



Profile of sources around #36