

Chandra X-Ray Observation of the Young Cluster NGC 6530

S. Sciortino, F. Damiani, E. Flaccomio, G. Micela,

(INAF- Oss. Astronomico di Palermo G.S. Vaiana),

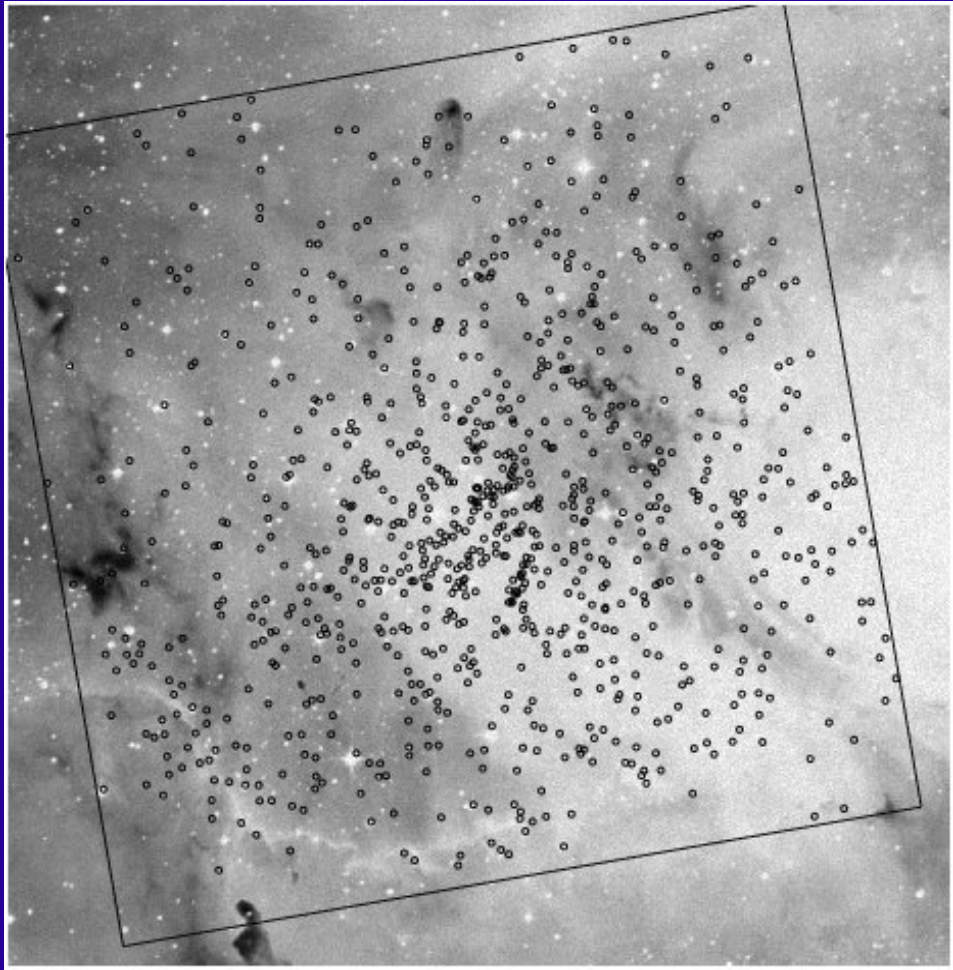
F.R. Harnden, Jr., S.S. Murray

(Smithsonian Astrophysical Observatory)

† Based on HRC Team GT

NGC6530: A young cluster associated with a well known star formation region: the Lagoon Nebula (M8)

Chandra ACIS-I
field of view
(~16x16 arcmin)



Hourglass
Nebula &
O star
Herschel
36



Distance = 1.8 kpc, within the
1.3-2.0 kpc range

It contains several O + ~ 60 B
stars, 3-4 times richer in
massive stars than Orion
Nebula Cluster (ONC)

Age: 1.0-2.0 Myr, like ONC

Sequential Star formation: NGC6530 first and then Herschel 36 or .. ?

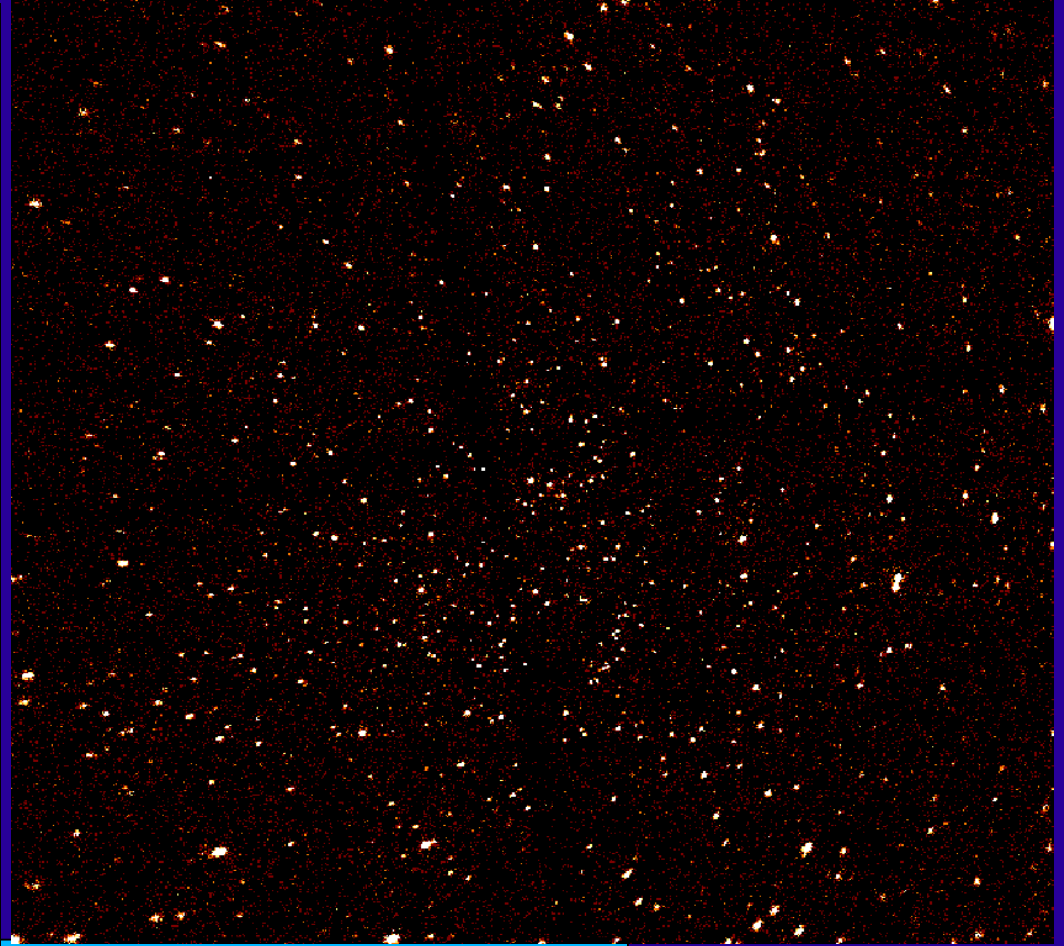
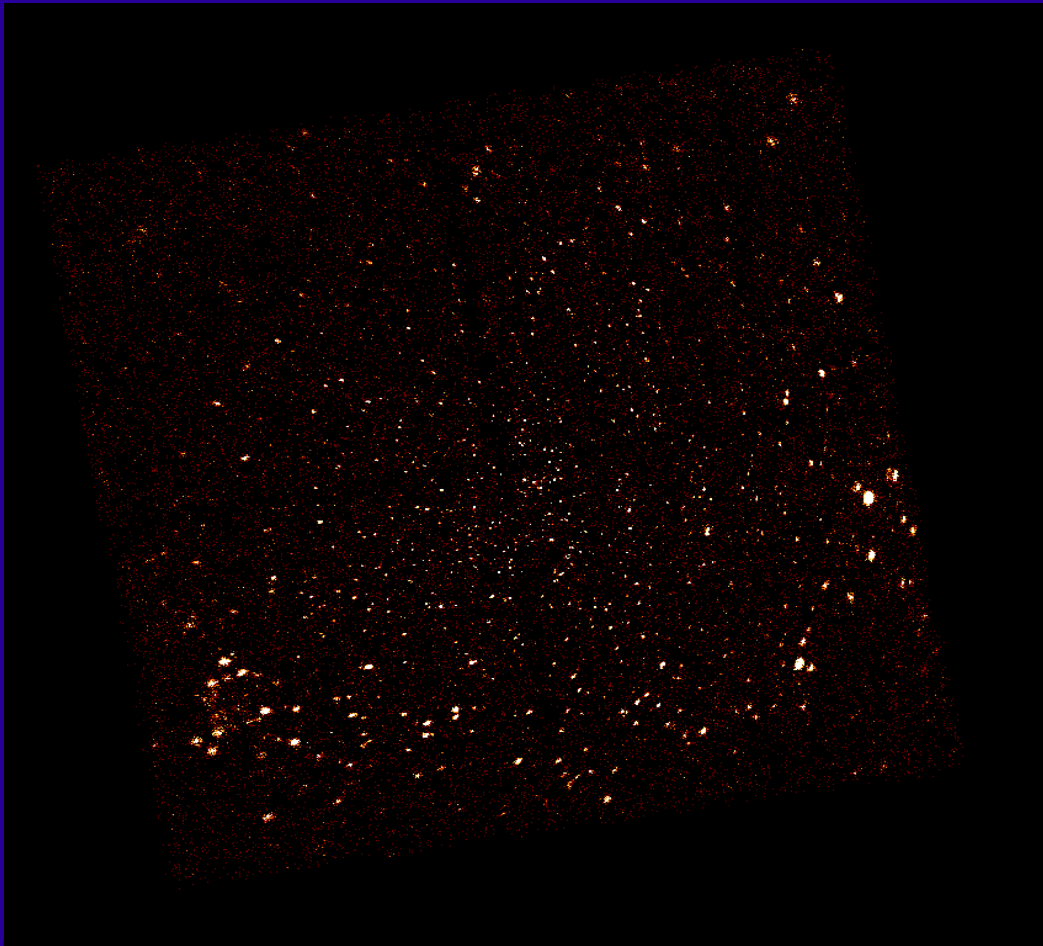
DSS red image

The Chandra Observation
Exposure time: 60 ksec

Full ACIS fov

Bandpass 0.3-7.0 keV

Central ~ 10' x 10'



X-ray Source Population

Number of X-ray sources detected⁽¹⁾ in ACIS-I fov: 884 (1 spurious).

- The brightest optical star, 9 Sgr (O4 V), is also the brightest X-ray source

211 counterparts (2" positional match) out of 611 stars down to $V \sim 17$ (Sung et al. 2000 catalogue). Up to 28 ids can be spurious.

- Number of previous ($H\alpha$ -selected) PMS candidates in NGC6530: 37
- Number of known variable stars: 41

Cross-matches with 2MASS in progress: at least ~ 260 counterparts found

→ Are these X-ray sources largely NGC6530 (low-mass) members ?

The analysis of new deep (down to $V \sim 20-21$) BVI data taken with the ESO 2.2m/WFI is in progress (Prisinzano et al. 2003)

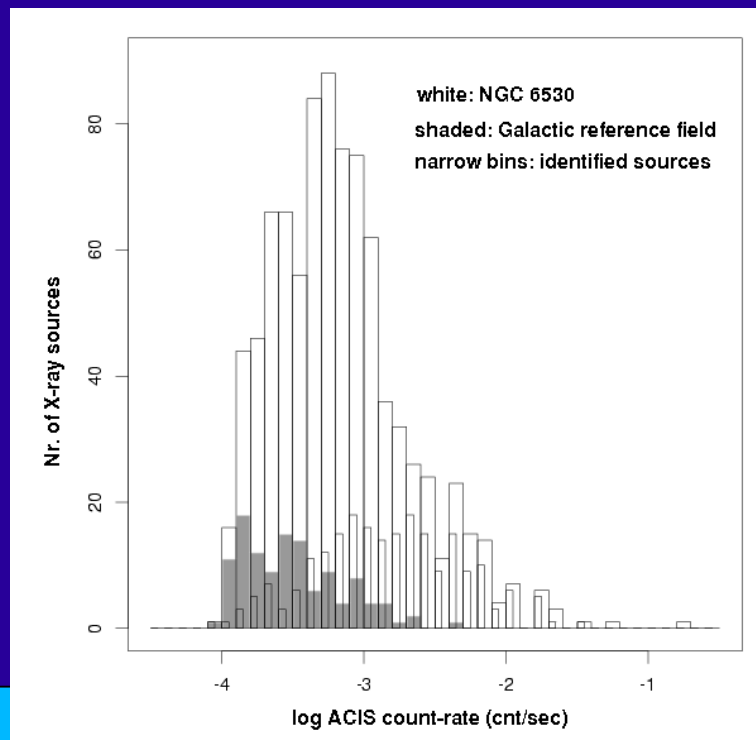
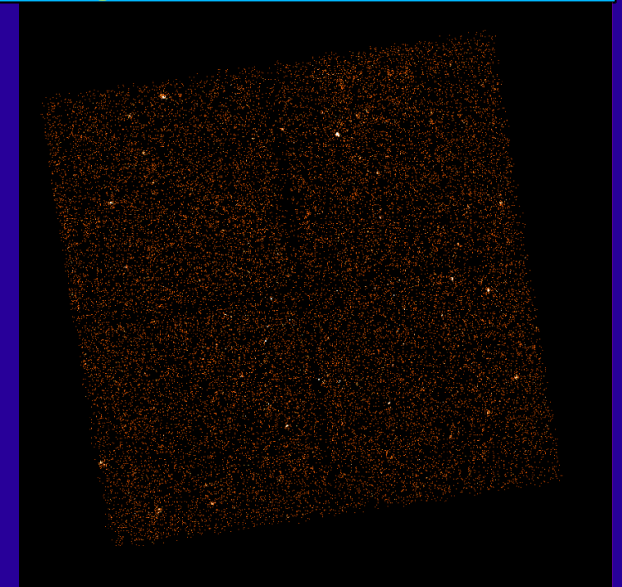
(1) With Pwdetect V1.0 developed by F. Damiani et al. available at www.astropa.unipa.it

Are these X-ray sources NGC6530 members or field stars ?

→ Look for a field reference image

Best ACIS reference found in archive : Galactic Ridge
(Exposure time: 57 ksec, almost same b)

Pwdetect detects 119 X-ray sources above the same
threshold as in NGC6530 (some may be farther out..)

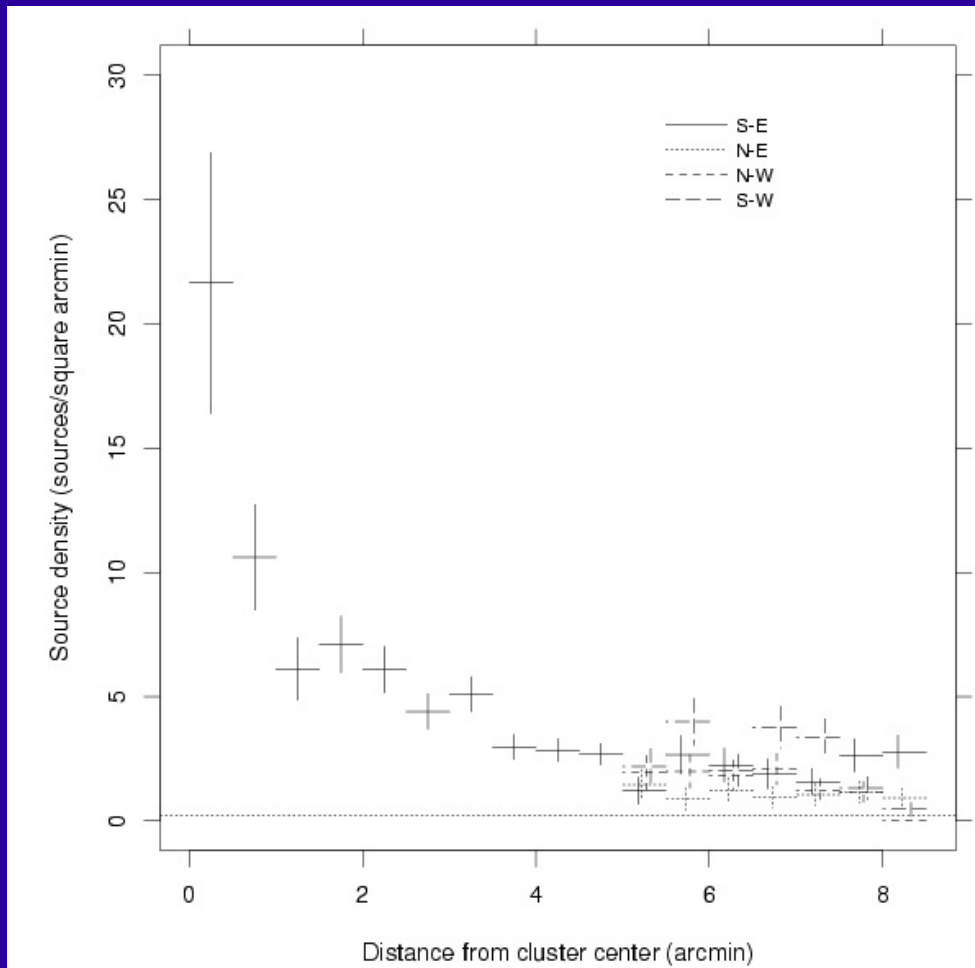


Most of the sources in the Galactic reference field
are harder than those in NGC 6530.
Likely background (extra-galactic) objects.
We expect a maximum (foreground)
contamination of 10%, none above 10^{-3} cnt/sec.

Are these X-ray sources NGC6530 members or field stars ?



Look for their spatial distribution



Unbiased radial profiles of sources detectable across the whole ACIS fov ($> 3 \cdot 10^{-4}$ cnt/sec) .

Dotted line is the average density in the reference Galactic Plane field.

An entirely new cluster population uncovered by optical observations has emerged thanks to Chandra --> IMF determination

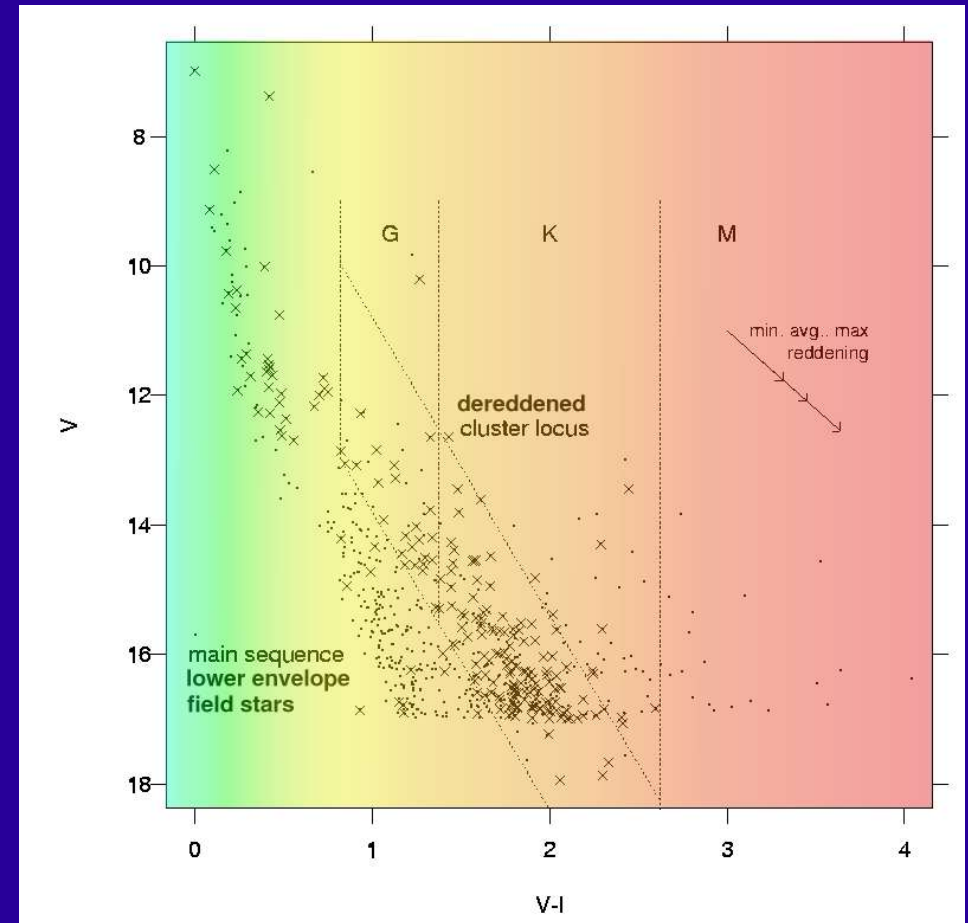
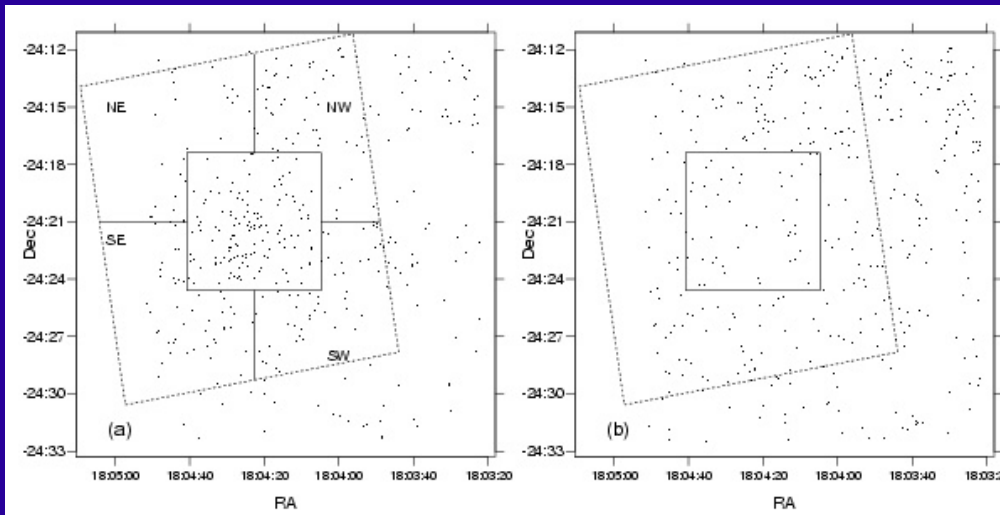
NGC6530 (V,V-I) color-magnitude diagram

Note the lack of stars more distant than NGC 6530, due to obscuration from the dark cloud behind NGC 6530

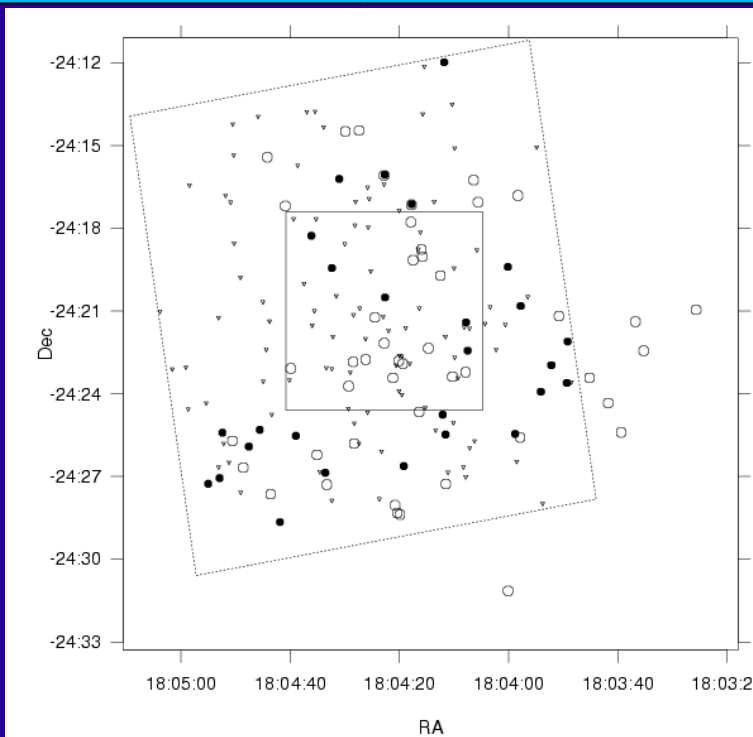
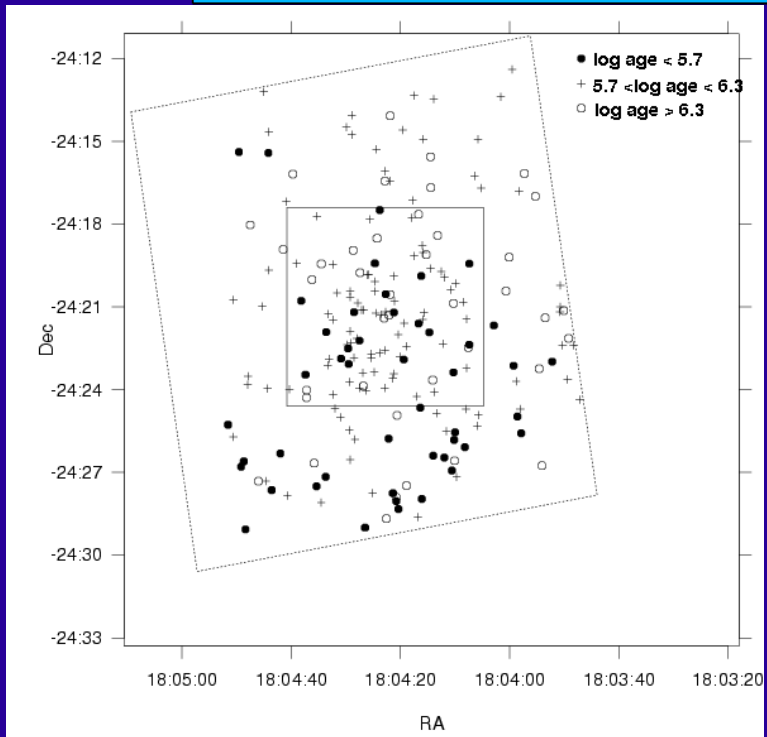
X = X-ray detected, dots = non-detected

Cluster locus

Putative field stars



Ages, Flares & Hard Sources



Filled dots = X-ray flares

Empty circles = H α excess stars

Others = 101 Hard ($\frac{3}{4}$ counts above 1.5 keV) X-ray sources

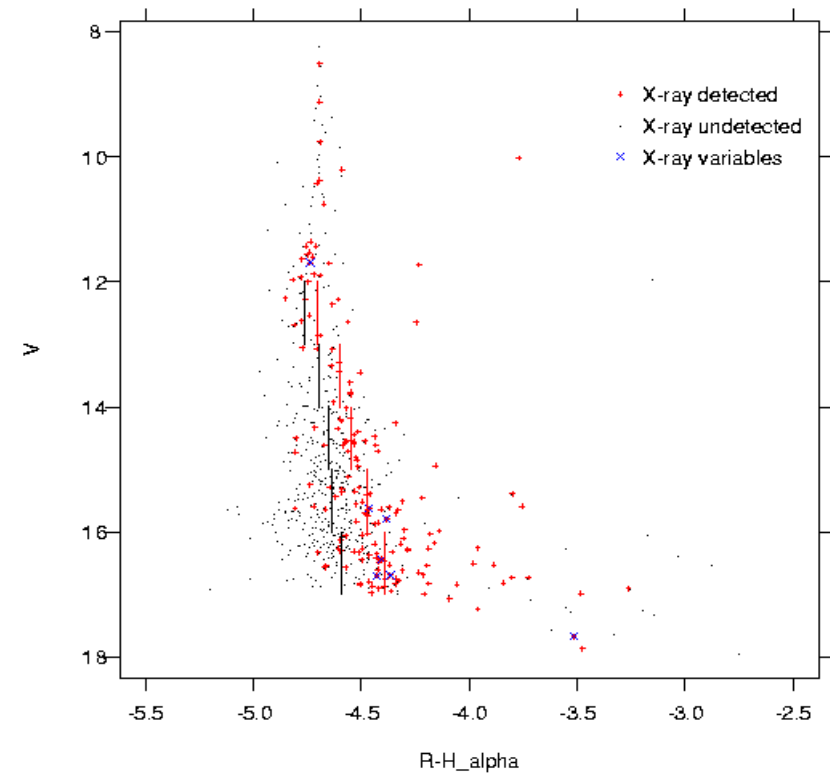
- Flares are associated with the youngest of the PMS stars.
- Only 7/101 hard sources identified. They can be either embedded members or background objects. Optical/IR data needed.



(V,R-H α) color-magnitude diagram

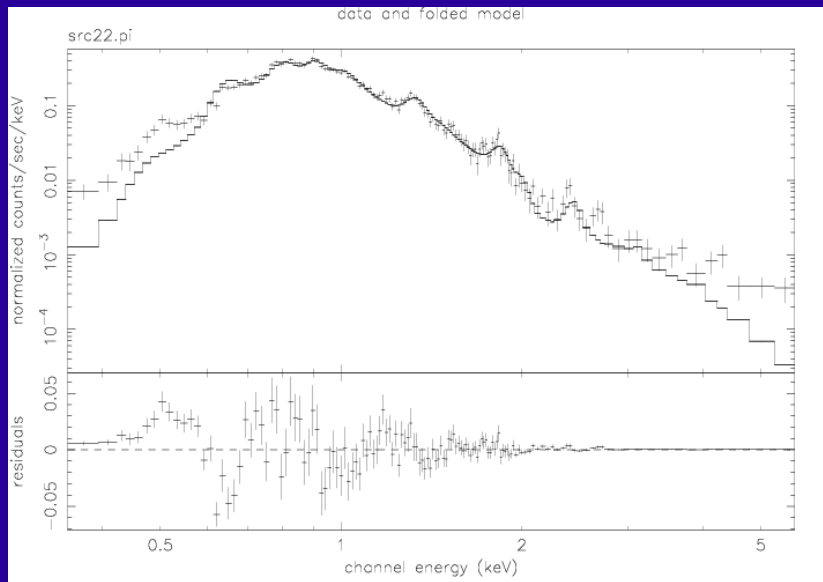
10 stars with strong H α are not detected in X-rays. They are confirmed NGC6530 members. However most X-ray detected PMS stars have H α similar to X-ray undetected.

X-ray and H α are two complementary ways of selecting NGC6530 member. X-rays is more efficient in the range of masses explored in NGC6530.

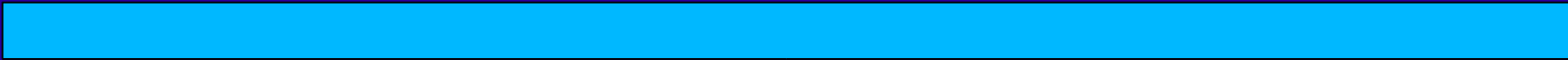
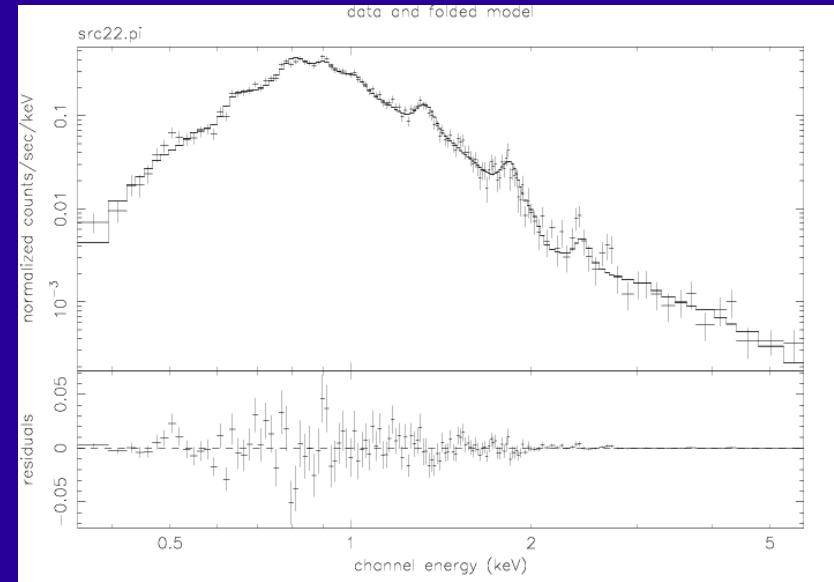


X-ray spectra and lightcurves (just a few examples..)

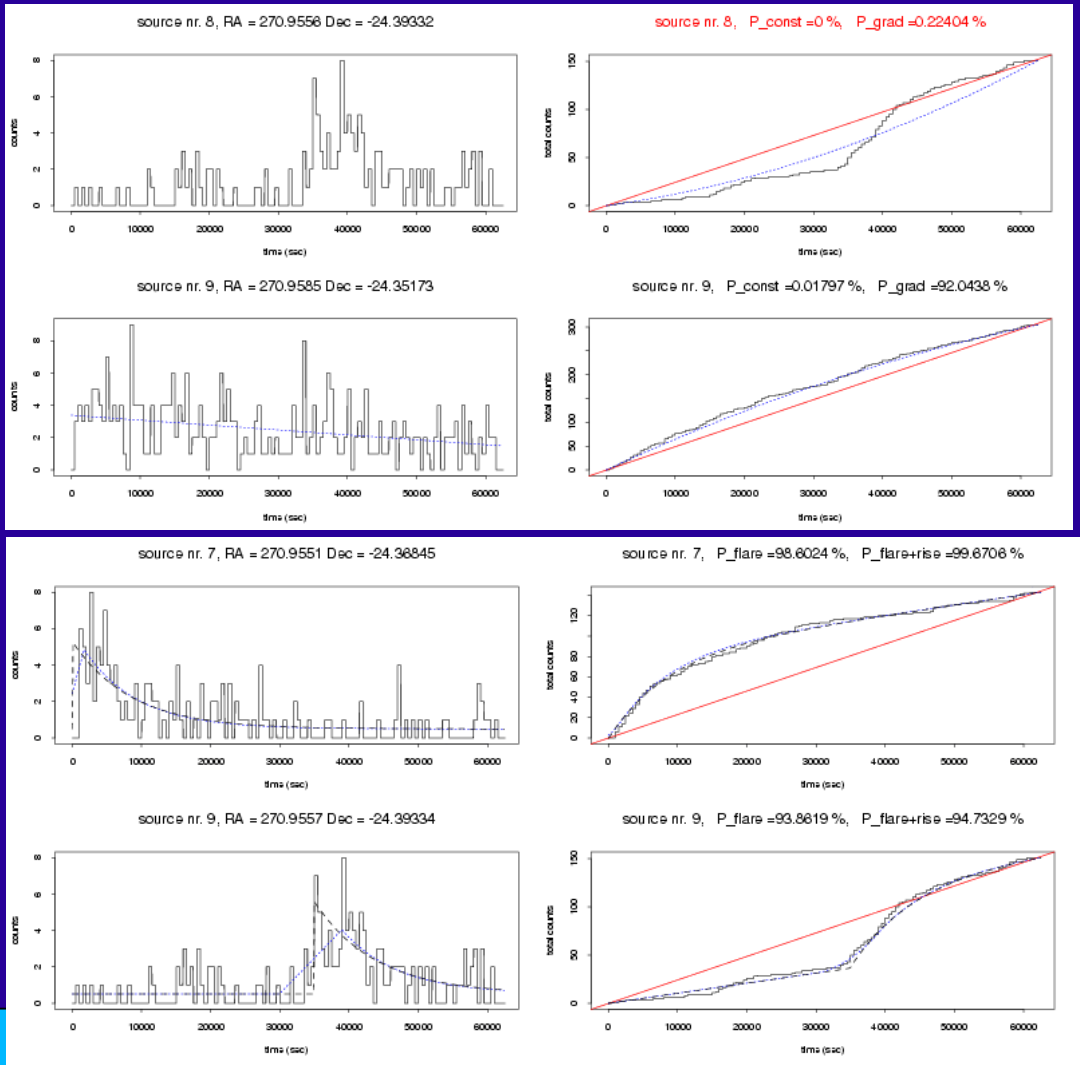
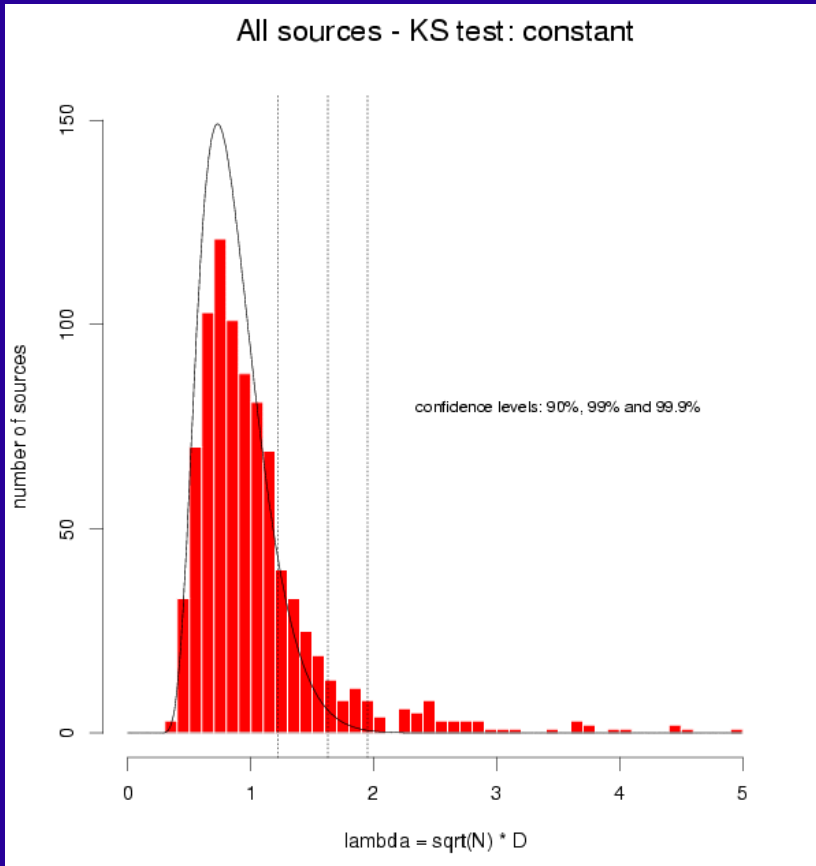
2T



4T



X-ray spectra and lightcurves (just a few examples..)



Conclusions

- NGC6530 has been observed using Chandra/ACIS-I, and 884 point X-ray sources have been detected. More than 800 of them are likely NGC 6530 members. Our new Chandra data enlarge the known PMS population of NGC6530 by a factor about 15-20 with respect to the past.
- Completeness estimates based on optical/H α studies need to be revised (and also IMF at low masses).
- Finding an age difference between cluster stars in the N-W and those in the S-E of the observed region, we propose that sequential formation has occurred in NGC 6530
- We find that the X-ray and H α selection criteria are complementary, but the completeness of X-ray selection is much larger than that of H α selection in NGC 6530.
- We find a population of hard X-ray sources, which may be either background objects and/or a more embedded PMS population.
- Thanks to Chandra superb resolution, SFRs/clusters near 2 kpc become now to be accessible for detailed X-ray studies.