A very deep X-Ray-Look into the young stellar cluster IC348

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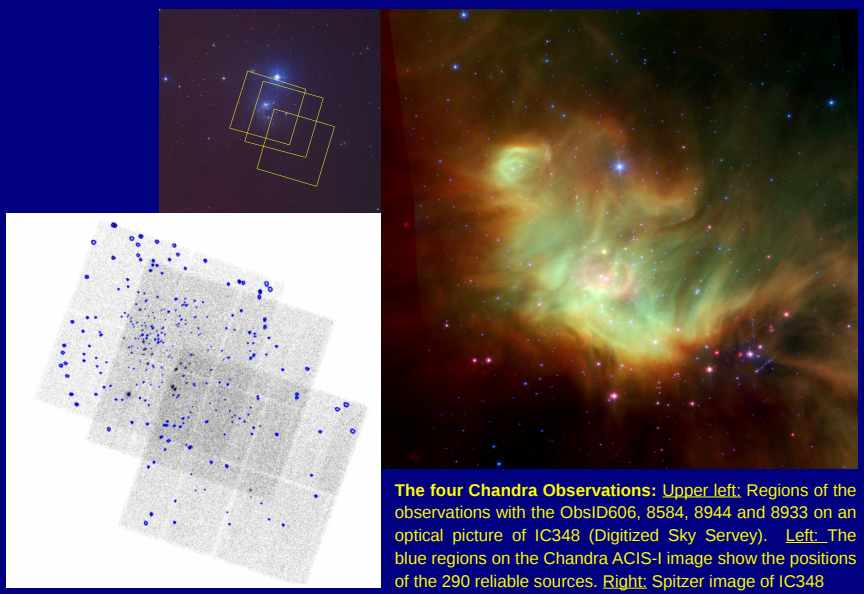
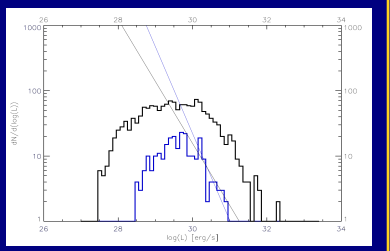
Introduction: **IC348 is arguably the best investigated rich (> 100 members) and very young (2-3 Myr old) stellar cluster lying at the eastern edge of the Perseus dark cloud complex. As nearest rich cluster of young stars to earth (300 pc) with more than 300 individual cluster members having masses down to 0.03 M_{sun} - including 23 young brown dwarfs - it's well characterized by means of optical and infrared spectroscopy and photometry.**

In addition to the observation with Chandra in 2000 (ObsID 606), which led to the detection of 215 X-Ray-sources by Preibisch&Zinnecker (2001), there have been three further observations in 2008 (ObsIDs 8584, 8944 and 8933), which lead to an total observation-time of 247.4 ks. After merging the data with the *Chandra* data analysis package *CIAO 4.2*, a preliminary source list with 372 sources was produced with the *WAVEDETECT* program of *CIAO*. 20 additional candidate sources were found through investigating XMM and Infrared data. 290 have been confirmed as reliable sources with a probability of 99.0% and 99.9% for 287 sources. 58% of the sources have a counterpart in the red picture of the DSS and 72% have an Infrared counterpart according to Lada et al. (2006) and Currie&Kenyon (2009). Furthermore 46% of the newly detected sources lie in the field of the oldest observation.



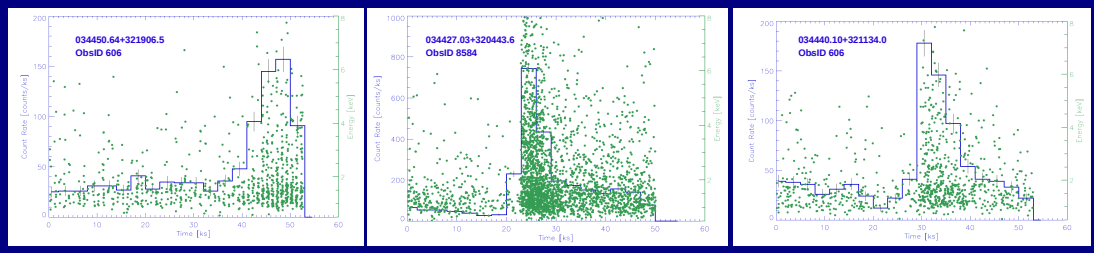
The four Chandra Observations: Upper left: Regions of the observations with the ObsID606, 8584, 8944 and 8933 on an optical picture of IC348 (Digitized Sky Servey). Left: The blue regions on the Chandra ACIS-I image show the positions of the 290 reliable sources. Right: Spitzer image of IC348

X-Ray-Luminosity-Function



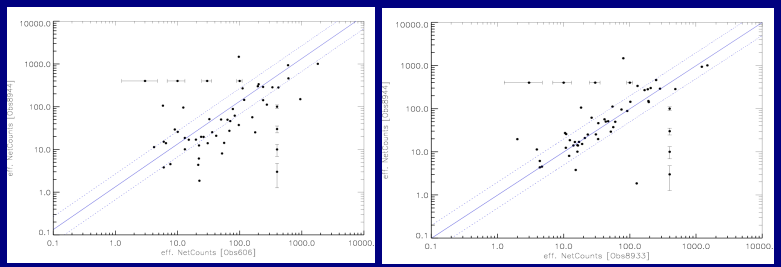
Comparison of the XLF: The blue line shows the XLF of IC348, while the black line is the XLF of the Orion Nebula Cluster from the COUP data (Getman et al. 2005b). The dotted lines show the power-law fits to the distributions in the luminosity range $L_x=10^{30.5}$–10^{32} erg/s. Intrinsic full band [0.5 – 8.0] keV luminosities were calculated by XPHOT. The resulting power law components for the distribution of X-Ray-luminosities are α=-0.95 for the Orion COUP data and α=-1.33 for the IC348 data. As the shapes of the slopes are nearly consistent, we could estimate the size of the total young stellar population of IC348. From the vertical offset of the two distributions, we conclude that IC348 must have 8 times less stars than the ONC and hence about 350 stars. This result is in accordance with the detection of 290 X-Ray-Sources in this study.

Lightcurves:



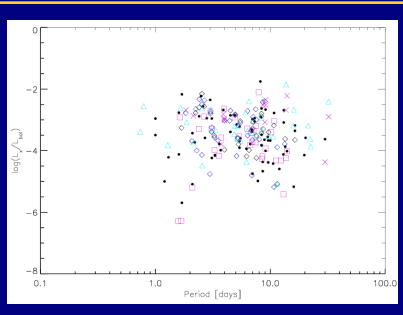
Lightcurves for three significantly variable sources. The solid dots show the arrival time and the energy of each of the detected source photons. The histograms show the corresponding binned lightcurves. 43 of the sources in the four observations show flare-like behaviour, hence fast increase of the count rate and exponential decay followed by the emission of photons with comparatively high energy. Source 034450.64+321906.5 seems to show pulsed emission of the photons. But as the source is located at the edge of the observation-field, the "pulsed emission" is due to the dither motion of the telescope.

Variability: As Chandra is now working since 1999 the opportunity was given to observe the cluster with a time interval of about 7.5 years (Observations 606 and 8944). The plots show the effective net counts in the first pointing compared to the effective net counts in the second pointing. Only sources, which have been observed in all 4 observations, are included. The solid line shows the expected relation for sources with count rates in the two pointings, while the dotted lines are offset by factors of 2. The error bars show Poisson statistical uncertanties for different numbers of effective net counts.

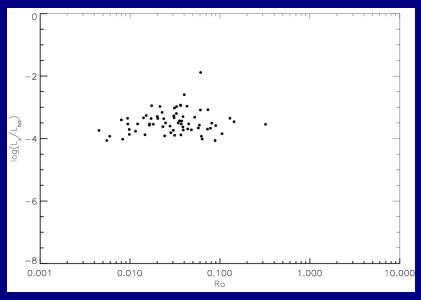


Left plot: The comparison of the counts in observation 606 and 8944 shows, that the sources have a higher number of counts in the older observation. 19 sources show a two times higher number of effective net counts in observation 606 than expected. 4 sources have a more than 2 times higher number of counts in observation 8944.
Right plot: Comparison of the effective net counts in observations 8944 and 8933. The time interval is only five days. As expected, there is no big deviation of the net count number from the expected relation. Only 10 sources lie outside the two dotted lines.

Rotation: Plot of $\log(L_x/L_{bol})$ against the rotation periods from Cieza (black dots), Nordhagen (blue diamonds), Kiziloglu (turquoise triangles), Littlefair (red squares) and Cohan (black diamonds). The pink crosses mark sources with X-Ray-flares. The plot shows, that there is no correlation between X-Ray-emission and the rotation-period of the star. The median of L_x/L_{bol} lies at $10^{3.6}$, which is consistent with the median of $10^{3.7}$ from Preibisch&Zinnecker in 2002.



Rossby number: Plot of $\log(L_x/L_{bol})$ against the Rossby number. As expected from Preibisch et al. 2004, we found a slightly lower median $\log(L_x/L_{bol})$ value of -3.61 for the stars in the supersaturated regime compared to -3.58 for those in the saturated regime.



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