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The ROSAT Galactic Plane Survey: Analysis of a low latitude sample area in Cygnus*

The observations

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Abstract. The analysis of the part of the ROSAT all-sky survey covering the galactic plane is the scope of a dedicated project called the ROSAT Galactic Plane Survey. In order to statistically understand the nature of the $\approx 14\,000$ sources discovered by ROSAT at $|b| \leq 20°$, a number of sample areas have been chosen for follow-up optical identification. In this paper we present the X-ray and optical material gathered in a region located in the Cygnus constellation, centered at $l = 90°$, $b = 0°$ and covering an area of $64.5\,\mathrm{deg}^2$. A total of 95 and 128 sources are detected with a maximum likelihood larger than 10 and 8 respectively. With a typical survey exposure time of the order of 700 to 900 s the flux completeness level is ≈ 0.02 cts s^{-1} corresponding to $\approx 2\ 10^{-13}$ erg cm^{-2} s^{-1}. The position of the sample area allows to investigate the soft X-ray content of a rather typical region of the galactic plane. In this paper we describe the details of the observational procedures and data reduction. For each ROSAT source we list the main X-ray characteristics together with those of the proposed optical identification. When appropriate, we also show optical spectra and finding charts. The full analysis and discussion of these data are presented in a companion paper (Motch et al. 1997).[1]

Key words: X-ray general, X-ray stars, stars: activity, stars: neutron, stars: statistics

1. Introduction

The ROSAT all-sky survey (RASS; Voges 1992) was carried out during the first part of the ROSAT mission from 1990 July till 1991 February. Two instrumentations, the X-ray Telescope (XRT; $0.07-2.4$ keV) and the Wide Field Camera were used at this occasion (Trümper 1983). The ROSAT XRT survey is the first X-ray survey ever made with an imaging instrument and thus offers an improved median sensitivity ($2-4\ 10^{-13}$ erg cm^{-2} s^{-1}) compared to previous non imaging devices (e.g., HEAO; Nugent et al. 1983; Wood et al. 1984, EXOSAT; Warwick et al. 1985). The analysis of the part of the all-sky survey restricted to absolute galactic latitude below 20° is the scope of a dedicated project, the ROSAT Galactic Plane Survey (RGPS: Motch et al. 1991). More than 14 000 sources, most of them new, are detected in the RGPS area by the Standard Analysis Software System (SASS; Voges et al. 1992). About 20% to 30% of the RGPS sources may be identified with high confidence on the basis of positional coincidence with objects, mostly stars, catalogued in the SIMBAD database. Owing to the large number of sources left, two paths of investigations were chosen; i) selection of sources over the whole galactic sky using criteria on their X-ray characteristics and optical content of the error box and ii) selection of sample areas at judicious positions for as complete as possible optical identification.

We present in this paper the X-ray and optical observational material concerning 158 X-ray detections in a $64.5\,\mathrm{deg}^2$ sample area centered at $l = 90°$ and $b = 0°$. We also describe the various optical instrumentations used for this project. Located in the Cygnus constellation, the region is void of nearby open clusters and is representative of the typical mid longitude galactic plane. For each source we list in Tables 2 and 3, X-ray position, count rate, hardness ratio and in Tables 4 and 5 the class of the proposed optical counterpart, name, spectral type, magnitudes,

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* Partly based on observations obtained at the Observatoire de Haute-Provence, CNRS, France.

[1] Tables 2 to 6 are also available in electronic form at the CDS via anonymous ftp cdsarc.u-strasbg.fr. Figures are only published electronically and are made available at http://www.edphys.fr/Abstract.html

optical position and distance to X-ray position. When applicable, finding charts and optical spectra of candidate objects are also printed. The analysis and discussion of these data are presented in a companion paper (Motch et al. 1997).

2. X-ray survey observations

The detector used for the XRT survey was the Position Sensitive Proportional Counter (PSPC) which offers a spatial resolution of $\approx 20''$ and medium energy resolution (40% at 1 keV) in the range of 0.07 to 2.4 keV (Pfeffermann et al. 1986). During survey observations, the sky was scanned in great circles bound to be perpendicular to the direction to the Sun thus covering the whole celestial sphere in six months. A given part of the sky was seen several times at 96 min intervals corresponding to the ROSAT orbit and scan period. For a given position on the sky, the number of available scans and total exposure time depends on the ecliptic latitude, the poles being the most deeply observed, and on possible detector switch off episodes (caused by radiation belts) close to the earth magnetic poles and South Atlantic Anomaly. With the field of view of 2° of the PSPC, each source was seen during a maximum of 32 s each orbit. Because of the blur at large off axis angles, the average survey point spread function (FWHM $\approx 3'$) is significantly larger than the one on-axis but still allows source positioning with a 1 σ accuracy better than $20''$ (Voges 1992).

The area chosen for our investigations was a rectangle extending from $l = 86°$ to $94°$ and from $b = -5°$ to $+5°$. However, part of the selected X-ray region is contaminated by hard diffuse emission from the Cygnus super bubble (Cash et al. 1980) and after rejection of the high background areas the final size of the region was 64.5 deg^2. Actual area boundaries are described in detail in Motch et al. (1997). By chance, the selected region is located in a range of galactic longitude which is closest to the north ecliptic pole. A strong gradient in exposure time is present in the selected field from about 500 s at $b = -5°$ to 1000 s at $b = 5°$. However, 84% of the sources in our field have exposure times ranging from 700 to 900 s.

The final list of sources was extracted from the merged survey data using the dedicated Extended Scientific Analysis System (EXSAS) developed at MPE (Zimmermann et al. 1992). Source detection was run separately in three energy bands (soft, $0.1 - 0.4$ keV; hard, $0.5 - 2.0$ keV and broad, $0.1 - 2.0$ keV) using the maximum likelihood (ML) algorithm and accepting sources above $ML = 7$. The three source lists were then merged into a single one in which we defined the "merged" source count rate and "merged" maximum likelihood as being the maximum of the count rates and maximum likelihood respectively in all three bands. The retained X-ray coordinates were those of the broad band detection or those of the hard or soft bands when the source was not detected in the broad band. A total of 95 and 128 sources were detected above $ML = 10$ and 8 respectively and 30 additional sources had ML in the range of 7 to 8. Each of the sources with $ML \geq 8$ has an associated index running from 1 to 128, increasing with decreasing count rates. Because of the expected high fraction of spurious sources with $7 \leq ML < 8$ we do not discuss these marginal detections in detail. We list separately these doubtful detections which were given index numbers in the range of 129 to 158.

The 90% confidence error radius was estimated assuming that the uncertainty on the source localization could be expressed as the quadratic sum of the statistical error determined by the maximum likelihood detection algorithm and of a systematic bore sight error of $8''$. For a subset of sources, standard ROSAT hardness ratios were computed. We defined hardness ratios 1 and 2 with energy boundaries as used in the latest SASS versions:

$$\mathrm{HR1} = \frac{(0.5-2.0)-(0.1-0.4)}{(0.1-0.4)+(0.5-2.0)}$$

$$\mathrm{HR2} = \frac{(1.0-2.0)-(0.5-1.0)}{(1.0-2.0)}$$

where $(A - B)$ is the raw background corrected source count rate in the $A - B$ energy range expressed in keV. Tables 2 and 3 summarize the main X-ray properties of each detected ROSAT source. From the bending of the $\log N(>S) - \log S$ curve we estimate that at $ML = 10$ our completeness level is 0.02 cts s^{-1} which roughly corresponds to a flux limit of 2 10^{-13} erg cm^{-2} s^{-1}. At this flux level the source density is ≈ 1.0 source deg^{-2}. Using $ML = 8$ may allow to improve on the sensitivity (see Motch et al. 1997) and at an estimated completeness level of 0.012 cts s^{-1} the source density is ≈ 1.8 deg^{-2}. However, the enhanced number of spurious sources complicates the definition of a completeness level at $ML = 8$.

3. Optical observations

All the optical material was collected at the Observatoire de Haute-Provence, CNRS, France. Observations took place during several runs spanning from 1991 May till 1993 September. This observing programme was part of a general project aiming at the optical identification and follow-up observations of area and X-ray selected sources extracted from the RGPS. All spectral and photometric data reductions were performed using standard MIDAS procedures (Banse et al. 1983).

Spectroscopic observations were obtained with the CARELEC spectrograph (Lemaitre et al. 1990) attached at the 1.9 m telescope. Several CCDs have been used during the course of the observations (see Table 1). Low resolution spectroscopy ($\lambda\lambda 3500 - 7500$ Å; FWHM resolution ≈ 14 Å) and medium resolution blue spectroscopy ($\lambda\lambda 3800 - 4300$ Å; FWHM resolution ≈ 1.8 Å) were acquired using a 260 Å/mm grating and 33 Å/mm grating, respectively. Two-dimensional spectra were corrected for bias and flat-field. Extracted spectra were calibrated in wavelength using arcs of iron and helium lamps. Observations of standard stars allowed to formally calibrate in flux all spectra. However, bad meteorological conditions and the narrow slit entrance width used for some bright stars may considerably bias the mean flux level on occasions and therefore, the flux information should be considered with some caution.

CCD images were collected using the standard camera at the 1.2 m telescope. Most of the time the Johnson B, V, and I filters were used. Depending on the CCD mounted, the field of view was either $7.1' \times 4.4'$ (RCA) or $6.5' \times 6.5'$ (TK512). All CCD frames were corrected for bias and flat-field. These CCD images were mainly used as a guide for selecting potentially interesting candidates for spectroscopic observations and to provide differential astrometry and photometry with respect to Guide Star Catalogue entries (GSC; Lasker et al. 1990).

4. Optical data analysis

4.1. Spectral classification

We acquired medium resolution spectra for stars with spectral types earlier than ≈ M0 and low resolution spectra for late M type stars. Only a few bright stars having well documented spectral classification available in the literature were not observed.

Because of the relatively short wavelength range in the medium resolution mode (≈ 500 Å) computerized algorithms involving theoretical reference spectra are not suitable (Cayrel et al. 1991). Instead we extensively used the classification methods presented in Jaschek & Jaschek (1987) and Turnsheck et al. (1985). Our spectral type determinations result from a visual comparison of our spectra with those of MK standards. For this purpose we used the library of Jaschek (1992); Turnsheck et al. (1985) and Jacoby et al. (1984). In addition we also observed few MK standard stars in the range G0 − M3 with the same instrumentation, wavelength range, and resolution as for our candidate stars.

Various classification criteria were considered depending on whether a blue medium resolution or a low resolution spectrum was available and depending on whether the star had an early or a late spectral type. For stars of spectral type earlier than F, the classification depends on the strength of the Ca II H&K lines, which become much stronger than the hydrogen lines of the Balmer series. For spectral types later than G5 the Ca I line (λ 4227 Å) becomes highly sensitive to temperature. Metallic lines increase both in number and in intensity and are the main criteria of classification toward later spectral types. One of the major difficulties concerning the classification of our candidates is that for these active stars, a fraction of the energy is re-emitted in the Balmer lines. Therefore, all spectral determinations involving Hδ (a major indicator in our wavelength range) may undergo a shift of several tenths of spectral subtype. Whenever possible, the Hδ line has not been taken into account in the spectral type determination. We have also checked for luminosity effects using Sr II lines (λ 4077 Å and λ 4215 Å) but no significant enhancement has been detected implying that most of our stars are main sequence stars. Although this is consistent with results from former *Einstein* stellar surveys (see e.g. Rosner et al. 1985), we cannot exclude that a small fraction of our candidates have erroneous luminosity classes. For most M stars only low resolution spectra were available and the main criteria of classification were the strength of the CaOH and TiO molecular bands.

Comparing our own spectral type determinations with those quoted in the literature for stars observed in various RGPS test areas or X-ray selected samples, we estimate that the uncertainty on the spectral classification should not exceed two spectral subtypes.

4.2. Visual magnitudes

Visual magnitudes were either extracted from the SIMBAD database or from the Guide Star Catalogue (Lasker et al. 1990). We also list the $B-V$ colour index in Tables 4 and 5 when available from the literature. For all stars having a spectral type determination we corrected the V magnitudes taken from the GSC for colour effects according to relation (1) of Russell et al. (1990), assuming a $B-V$ colour index corresponding to the spectral type and neglecting interstellar reddening. The magnitudes of GSC stars without spectral types were left unchanged. In order to estimate the photometric quality of the corrected GSC magnitudes we compared these GSC based determinations with V magnitudes extracted from SIMBAD header and associated literature. SIMBAD values generally arise from photometric measurements and have therefore much smaller associated errors than the photographic determinations used in the GSC. Based on 33 stars found in the course of RGPS optical identifications in various test fields and having both GSC and photometric SIMBAD measurements we conclude that ignoring a few pathological cases for which the difference in magnitudes is larger than 0.6 mag, the difference $\Delta m = m_{\rm GSC} - m_{\rm SIMBAD}$ had a mean value of 0.047 and a rms of 0.18 down to $m = 13.5$. We thus adopted a 1σ error of 0.2 mag as statistically representative of the uncertainties affecting the colour corrected GSC V magnitudes. For stars without spectral types we assumed a photometric error of ≈ 0.3 mag (Russel et al. 1990). For the few stars with no SIMBAD nor GSC identification (generally Me stars fainter than $V \approx 14$) we derived visual magnitudes by differential photometry with nearby GSC stars using V CCD images. The corresponding

Table 1. Characteristics of the CCD used for spectroscopy and imagery

CCD name	Format	Pixel size in μm	Read out noise (e^-)	Instrument	Scale (″/ pixel)
RCA1 SID 501	323×512	30	110	CARELEC	1.22
RCA3 SID 501EX	323×512	30	55	Imagery	0.85
THX1 TH 7882	384×576	23	11	CARELEC	0.94
TK512 # 1 TK512CB	512×512	27	10	CARELEC	1.10
TK512 # 2 TK512CB	512×512	27	9	Imagery	0.77

photometric errors are dominated by those of the comparison GSC stars and are therefore of the order of 0.3 mag.

4.3. Astrometry

As for photometric data, the coordinates of the proposed optical counterparts were preferentially extracted from the SIMBAD database which most of the time lists high quality determinations (e.g. PPM). For the candidates without accurate SIMBAD positions we used the GSC coordinates. The coordinates of the remaining counterparts fainter than the GSC threshold were measured on CCD images with respect to nearby GSC stars. The maximum positional error for the overall identified set is therefore comparable to that internal to the GSC which is typically less than 2″ (Russel et al. 1990; Egret et al. 1992). However, some high velocity objects may have a somewhat larger positional error since neither SIMBAD nor GSC coordinates are corrected for proper motion. In most cases, the error on the optical position is expected to be an order of magnitude smaller than the X-ray 90% confidence radius which is in the range of 17″ to 58″ (see Tables 2 and 3).

4.4. Photometric correction of Ca II H&K *fluxes*

The Ca II H&K chromospheric emission lines are a very sensitive indicator of stellar activity. Studies based on *Einstein* X-ray data revealed that the luminosity of these lines correlate well with X-ray luminosity (e.g. Maggio et al. 1987). We extensively used this correlation in order to quantify the likelihood of our stellar X-ray identification (Guillout 1996; Motch et al. 1997). Ca II H&K reemission fluxes were measured on the blue flux calibrated medium resolution spectra using MIDAS routines. The photospheric level was estimated by fitting Gaussian profiles to the broad wings of the absorption profiles. This allows a reasonably accurate measurement of the residual re-emission fluxes even in the cases of low chromospheric to photospheric contrast.

Although the blue medium resolution spectra are in principle flux calibrated, the Ca II H&K fluxes extracted from these spectra have to be corrected for the unavoidable spectrophotometric errors resulting from unnoticed clouds, changing diffuse absorption in the UV or from erratic light losses in the spectrograph slit due to variable seeing conditions. For each candidate star we computed the λ4000 Å to λ5500 Å (V band) mean flux ratio corresponding to its spectral type. This flux ratio was estimated using digitized spectra extracted from the spectrophotometric library of Jacoby et al. (1984). The true mean flux at λ4000 Å was then computed using as reference flux level the V magnitude. Finally, the Ca II H&K emission lines fluxes were multiplied by the ratio of the expected λ4000 Å flux to that measured from our "flux calibrated" medium resolution spectra. In all cases we assumed negligible interstellar absorption for these nearby sources (see next subsection).

4.5. Stellar distances

In the survey Cygnus region, most of the detected X-ray stars are closer than 300 pc (Motch et al. 1997). At this distance, A_V is always smaller than 0.5 over the whole investigated field (Neckel & Klare 1980) and we decided not to apply additional photometric correction for interstellar absorption. Absolute magnitudes were derived from spectral type using the calibration of Schmidt-Kaler (1982). Taking into account the uncertainties on the V magnitudes and absolute calibrations we estimate that the photometric distances have an error of the order of 20% yielding an additional $\approx$ 40% error on the X-ray and Ca II H&K luminosities.

5. Optical identifications

The details of the procedure leading to positive optical identification are presented at large in Motch et al. (1997). Tables 4 and 5 summarize the status of the identification of each ROSAT source. Class acronyms are AC (active corona), AGN, CV (cataclysmic or possible precataclysmic systems), OB (normal OB star coronal emission), WD (isolated white dwarf) and ?? for unidentified source. For stars, the probability of the optical identification was estimated from the Ca II H&K or Hα emission to X-ray luminosity ratio, and/or from the probability of positional coincidence with a GSC star (Motch et al. 1997). We decided to accept as "secure" optical counterparts all proposed identifications having a probability larger than 98%, implying a formal number of misidentified sources of the order of $\approx 1-2$ for the whole sample. For the sake of completeness, we also list in Table 4 and 5 the proposed counterparts having a probability of identification in the range $95\%-98\%$. These more uncertain cases are marked by a "?" as first letter of the identification name and the class acronym is followed by a "?".

We print in Fig. 1 and following for each source a summary of all available optical information. When we consider it necessary for follow-up optical observations, we display a finding chart based on one of our CCD images, with sometimes inserted a smaller field obtained in a different filter for comparison. In most cases, however, we print finding charts drawn from the Guide Star Catalogue (Lasker et al. 1990) extracted with the help of the STARCAT facility at ESO (Pirenne et al. 1993) and later from the SIMBAD catalogue GSC browser (Preite-Martinez & Ochsenbein 1993).

When available, we also show medium and/or low resolution optical spectra of the proposed optical counterpart with inserted enlargement of the Ca II H&K lines when appropriate. When we fail to identify the source, we show the spectra obtained for all objects marked on the finding chart. Specific comments on individual sources are printed in Table 6.

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Table 2. X-ray characteristics of ROSAT survey sources detected with $ML \geq 8$ in the Cygnus test region. Entries are sorted by decreasing count rates

Source index	ROSAT name	Right ascension	Declination	r_{90} ($''$)	Cnt rate (cts/s)	Error (cts/s)	Max lik.	HR 1	Error	HR 2	Error
1	RX J2112.7+5006	21H12M44.20S	50D06M16.9S	17.5	1.310	0.041	3643.6	-0.98	0.01	0.10	0.93
2	RX J2133.9+4535	21H33M58.78S	45D35M33.5S	17.6	0.779	0.035	1297.3	0.05	0.05	-0.17	0.07
3	RX J2052.7+4639	20H52M43.71S	46D39M41.2S	18.2	0.351	0.021	863.4	-0.81	0.06	-0.41	0.38
4	RX J2125.2+4942	21H25M12.37S	49D42M21.6S	18.2	0.250	0.019	422.2	0.08	0.09	0.32	0.11
5	RX J2100.8+4530	21H00M48.01S	45D30M09.1S	18.5	0.244	0.017	425.1	–	–	–	–
6	RX J2106.0+5421	21H06M01.45S	54D21M56.5S	22.5	0.140	0.017	106.2	-0.05	0.14	-0.23	0.17
7	RX J2104.1+4912	21H04M10.04S	49D12M58.2S	17.9	0.139	0.014	267.3	0.14	0.11	-0.14	0.14
8	RX J2130.8+4827	21H30M48.78S	48D27M39.0S	19.3	0.136	0.015	168.7	0.04	0.12	0.17	0.16
9	RX J2120.9+4636	21H20M55.17S	46D36M18.0S	19.0	0.114	0.013	150.5	0.31	0.12	0.07	0.14
10	RX J2124.7+4639	21H24M43.66S	46D39M52.1S	19.2	0.113	0.013	159.4	0.14	0.14	-0.13	0.18
11	RX J2117.3+5044	21H17M19.42S	50D44M07.5S	23.9	0.109	0.013	105.3	-1.00	0.09	–	–
12	RX J2135.9+4728	21H35M54.38S	47D28M28.3S	18.8	0.101	0.012	160.4	0.87	0.12	0.76	0.11
13	RX J2102.6+4552	21H02M40.84S	45D52M57.4S	19.7	0.095	0.011	168.8	–	–	–	–
14	RX J2123.1+4831	21H23M08.11S	48D31M05.8S	21.1	0.077	0.011	81.2	-0.43	0.18	-0.40	0.40
15	RX J2055.3+5025	20H55M21.83S	50D25M33.3S	21.8	0.070	0.012	58.8	–	–	–	–
16	RX J2109.2+4810	21H09M17.12S	48D10M11.3S	21.9	0.070	0.011	68.3	-0.09	0.21	0.22	0.35
17	RX J2100.9+5103	21H00M59.30S	51D03M18.5S	21.0	0.062	0.011	51.8	-0.28	0.16	0.07	0.27
18	RX J2049.6+5119	20H49M37.35S	51D19M10.0S	22.3	0.061	0.011	46.4	–	–	–	–
19	RX J2059.3+5303	20H59M20.66S	53D03M11.7S	22.5	0.061	0.012	38.8	-0.29	0.22	-0.28	0.35
20	RX J2056.7+4940	20H56M42.63S	49D40M09.6S	26.2	0.060	0.010	61.7	–	–	–	–
21	RX J2123.1+5021	21H23M11.94S	50D21M48.8S	22.7	0.059	0.010	52.2	0.13	0.18	-0.52	0.21
22	RX J2107.8+4932	21H07M52.28S	49D32M39.3S	23.4	0.049	0.009	44.6	0.21	0.21	-0.09	0.24
23	RX J2100.1+4841	21H00M07.71S	48D41M28.6S	25.7	0.048	0.009	37.4	–	–	–	–
24	RX J2104.7+5223	21H04M43.36S	52D23M31.7S	25.2	0.048	0.011	33.0	0.47	0.42	-0.11	0.27
25	RX J2044.6+4758	20H44M39.77S	47D58M01.9S	21.0	0.048	0.009	49.6	0.09	0.40	0.93	0.84
26	RX J2107.3+5202	21H07M21.38S	52D02M57.1S	22.4	0.047	0.010	40.1	–	–	–	–
27	RX J2052.3+4820	20H52M23.88S	48D20M03.5S	21.4	0.045	0.009	43.8	–	–	–	–
28	RX J2118.4+4356	21H18M25.99S	43D56M44.9S	19.8	0.045	0.009	48.6	1.00	0.30	-0.43	0.21
29	RX J2109.3+5138	21H09M23.36S	51D38M05.5S	27.7	0.041	0.009	29.7	–	–	–	–
30	RX J2120.4+4733	21H20M25.75S	47D33M42.8S	24.5	0.040	0.008	34.9	-0.52	0.21	-0.57	0.62
31	RX J2104.2+5015	21H04M15.36S	50D15M08.3S	57.5	0.038	0.008	16.0	–	–	–	–
32	RX J2057.3+4813	20H57M23.37S	48D13M29.2S	23.1	0.037	0.008	33.6	–	–	–	–
33	RX J2119.0+5207	21H19M00.28S	52D07M08.4S	22.5	0.036	0.009	32.3	0.13	0.45	-0.26	0.50
34	RX J2117.8+5112	21H17M52.30S	51D12M08.4S	29.1	0.035	0.008	20.7	0.16	0.62	0.34	0.61
35	RX J2133.3+4726	21H33M22.11S	47D26M34.1S	22.3	0.035	0.008	41.8	0.96	0.27	0.62	0.16
36	RX J2134.0+4525	21H34M04.12S	45D25M25.3S	32.1	0.034	0.010	16.0	0.13	0.23	-0.08	0.32
37	RX J2103.4+5021	21H03M25.45S	50D21M10.1S	20.5	0.034	0.008	35.0	-0.01	0.28	-0.40	0.36
38	RX J2040.6+4859	20H40M38.46S	48D59M56.6S	20.9	0.033	0.008	38.4	0.40	0.94	-0.55	0.91
39	RX J2102.9+4854	21H02M59.58S	48D54M42.4S	24.1	0.033	0.008	24.1	0.05	0.23	-0.09	0.34
40	RX J2113.3+5140	21H13M23.70S	51D40M06.5S	20.2	0.032	0.008	42.9	–	–	–	–
41	RX J2123.5+4621	21H23M34.16S	46D21M35.1S	23.3	0.032	0.008	28.1	0.45	0.22	0.08	0.25
42	RX J2100.9+4857	21H00M55.58S	48D57M08.0S	26.3	0.032	0.008	23.5	–	–	–	–
43	RX J2130.1+4901	21H30M11.83S	49D01M33.0S	22.2	0.032	0.008	26.6	-0.09	0.23	-0.62	0.38
44	RX J2054.1+4942	20H54M09.47S	49D42M47.0S	31.5	0.032	0.009	14.8	–	–	–	–
45	RX J2116.6+4645	21H16M36.64S	46D45M27.8S	21.3	0.032	0.008	29.7	0.03	0.37	-0.84	0.76
46	RX J2110.2+5333	21H10M16.55S	53D33M58.7S	24.2	0.031	0.010	18.4	-0.29	0.30	-0.03	0.47
47	RX J2125.3+4642	21H25M20.50S	46D42M55.6S	25.9	0.031	0.008	26.0	-0.35	0.38	0.32	0.83
48	RX J2118.5+5247	21H18M30.96S	52D47M45.4S	27.6	0.030	0.008	23.0	-0.20	0.22	-0.06	0.34
49	RX J2128.7+4409	21H28M46.26S	44D09M16.0S	41.1	0.029	0.009	10.4	0.77	0.18	-0.10	0.20
50	RX J2121.7+5049	21H21M46.06S	50D49M28.5S	26.5	0.029	0.008	28.0	0.10	0.23	0.07	0.27
51	RX J2132.5+4849	21H32M33.83S	48D49M41.3S	24.9	0.028	0.008	19.7	-0.23	0.48	0.82	0.90
52	RX J2122.4+5023	21H22M29.15S	50D23M47.1S	25.8	0.028	0.008	22.2	0.06	0.23	0.09	0.29
53	RX J2035.9+4900	20H35M57.61S	49D00M40.1S	22.4	0.027	0.007	22.5	0.35	0.26	-0.06	0.25
54	RX J2108.2+5313	21H08M17.65S	53D13M33.9S	27.5	0.027	0.009	15.2	–	–	–	–
55	RX J2128.6+4653	21H28M40.44S	46D53M55.3S	22.9	0.026	0.007	21.7	0.14	0.39	0.02	0.54
56	RX J2048.0+4903	20H48M03.92S	49D03M08.1S	20.8	0.026	0.007	27.5	–	–	–	–
57	RX J2115.4+4437	21H15M25.18S	44D37M24.6S	35.2	0.025	0.007	20.7	0.33	0.22	0.03	0.25
58	RX J2109.9+4809	21H09M55.86S	48D09M20.1S	25.8	0.025	0.007	16.1	–	–	–	–
59	RX J2108.6+4927	21H08M37.97S	49D27M34.3S	22.3	0.024	0.007	22.9	0.12	0.40	0.37	0.48
60	RX J2050.8+4743	20H50M48.56S	47D43M54.7S	26.4	0.024	0.007	21.0	0.93	0.27	0.20	0.25
61	RX J2135.6+4523	21H35M41.85S	45D23M11.5S	24.9	0.023	0.008	10.6	0.37	0.25	0.53	0.29
62	RX J2119.9+5227	21H19M54.30S	52D27M36.4S	24.5	0.023	0.007	23.4	0.09	0.40	0.39	0.38
63	RX J2100.3+5219	21H00M19.66S	52D19M04.9S	25.2	0.022	0.008	19.0	0.16	0.28	-0.05	0.28

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Source index	ROSAT name	Right ascension	Declination	r_{90} ($''$)	Cnt rate (cts/s)	Error (cts/s)	Max lik.	HR 1	Error	HR 2	Error
64	RX J2056.3+4817	20H56M23.14S	48D17M22.5S	28.5	0.022	0.007	13.5	0.54	0.27	-0.08	0.24
65	RX J2127.3+5121	21H27M19.87S	51D21M56.2S	22.3	0.020	0.007	21.1	-0.11	0.37	-0.13	0.49
66	RX J2041.9+4746	20H41M57.45S	47D46M08.8S	43.5	0.020	0.007	8.4	–	–	–	–
67	RX J2126.3+4654	21H26M23.47S	46D54M31.0S	32.8	0.020	0.007	10.2	–	–	–	–
68	RX J2055.8+5044	20H55M51.81S	50D44M32.3S	28.0	0.019	0.007	15.1	–	–	–	–
69	RX J2117.5+5127	21H17M33.20S	51D27M10.2S	23.8	0.019	0.007	12.8	-0.52	0.28	-0.71	0.79
70	RX J2057.7+4752	20H57M42.33S	47D52M12.6S	28.6	0.018	0.006	11.3	–	–	–	–
71	RX J2131.2+4533	21H31M17.47S	45D33M14.4S	25.4	0.018	0.007	9.3	–	–	–	–
72	RX J2054.6+5120	20H54M41.48S	51D20M38.7S	45.2	0.018	0.006	12.0	–	–	–	–
73	RX J2121.5+4317	21H21M35.61S	43D17M29.4S	57.6	0.018	0.006	8.2	–	–	–	–
74	RX J2128.4+4900	21H28M24.79S	49D00M39.3S	29.4	0.017	0.006	10.5	–	–	–	–
75	RX J2058.5+4836	20H58M31.16S	48D36M01.5S	30.1	0.017	0.006	10.7	–	–	–	–
76	RX J2130.0+4740	21H30M05.91S	47D40M30.8S	24.9	0.017	0.006	12.6	–	–	–	–
77	RX J2106.2+4437	21H06M17.37S	44D37M00.9S	21.2	0.017	0.006	16.7	0.01	0.44	0.21	0.66
78	RX J2128.5+4626	21H28M30.05S	46D26M55.3S	32.4	0.017	0.007	11.1	–	–	–	–
79	RX J2117.7+5139	21H17M46.61S	51D39M05.4S	24.3	0.017	0.006	23.3	0.30	0.34	0.75	0.26
80	RX J2101.6+4730	21H01M40.31S	47D30M21.3S	26.5	0.017	0.006	10.1	–	–	–	–
81	RX J2046.7+4728	20H46M45.18S	47D28M34.7S	34.1	0.017	0.006	9.2	–	–	–	–
82	RX J2136.6+4911	21H36M39.63S	49D11M00.9S	23.5	0.017	0.006	19.0	–	–	–	–
83	RX J2118.6+5010	21H18M41.25S	50D10M53.8S	24.9	0.017	0.005	19.1	0.74	0.74	0.12	0.43
84	RX J2130.3+4709	21H30M20.75S	47D09M52.9S	26.1	0.016	0.006	10.6	-0.14	0.26	-0.26	0.43
85	RX J2116.0+4827	21H16M03.35S	48D27M00.3S	33.4	0.016	0.006	8.9	-0.60	0.60	-0.74	2.32
86	RX J2124.7+4714	21H24M42.93S	47D14M36.5S	24.6	0.016	0.006	12.2	–	–	–	–
87	RX J2117.5+4330	21H17M32.58S	43D30M59.6S	33.3	0.016	0.006	8.7	–	–	–	–
88	RX J2137.6+4916	21H37M38.54S	49D16M09.7S	26.3	0.016	0.005	15.3	–	–	–	–
89	RX J2100.6+5039	21H00M38.19S	50D39M27.0S	29.4	0.016	0.006	9.1	–	–	–	–
90	RX J2110.5+4913	21H10M32.18S	49D13M32.9S	29.5	0.016	0.006	8.6	–	–	–	–
91	RX J2121.5+4732	21H21M30.99S	47D32M52.1S	31.2	0.016	0.006	8.4	0.08	0.24	0.55	0.27
92	RX J2052.8+4723	20H52M53.05S	47D23M34.6S	32.4	0.015	0.006	8.0	–	–	–	–
93	RX J2118.6+5039	21H18M40.10S	50D39M06.4S	35.3	0.015	0.006	8.3	–	–	–	–
94	RX J2122.3+4730	21H22M20.15S	47D30M45.4S	26.1	0.015	0.006	10.4	-0.22	0.28	-0.35	0.48
95	RX J2050.4+4913	20H50M27.45S	49D13M16.2S	25.6	0.015	0.006	9.3	–	–	–	–
96	RX J2113.0+4834	21H13M05.12S	48D34M30.5S	29.0	0.015	0.006	9.9	0.28	0.42	-0.07	0.46
97	RX J2134.2+4911	21H34M15.78S	49D11M23.0S	21.7	0.015	0.005	21.7	–	–	–	–
98	RX J2119.5+4351	21H19M31.82S	43D51M51.5S	36.7	0.014	0.006	8.9	–	–	–	–
99	RX J2117.4+5152	21H17M25.10S	51D52M20.1S	30.8	0.014	0.005	13.1	-0.10	0.28	0.72	0.32
100	RX J2123.2+5057	21H23M14.80S	50D57M09.5S	40.6	0.014	0.005	10.3	–	–	–	–
101	RX J2053.4+4759	20H53M28.87S	47D59M14.3S	26.2	0.014	0.006	9.0	–	–	–	–
102	RX J2124.3+5059	21H24M18.31S	50D59M52.4S	24.4	0.013	0.005	17.3	0.33	0.29	0.60	0.23
103	RX J2114.1+4840	21H14M09.88S	48D40M27.9S	28.6	0.013	0.005	14.4	–	–	–	–
104	RX J2043.7+4727	20H43M44.64S	47D27M11.9S	28.0	0.013	0.006	8.8	–	–	–	–
105	RX J2122.6+4956	21H22M40.00S	49D56M04.0S	29.8	0.013	0.005	11.7	0.29	0.46	0.41	0.43
106	RX J2103.6+4845	21H03M39.94S	48D45M41.1S	26.9	0.013	0.005	9.7	–	–	–	–
107	RX J2059.8+4937	20H59M48.59S	49D37M34.6S	36.2	0.013	0.005	8.8	–	–	–	–
108	RX J2126.9+4636	21H26M58.87S	46D36M43.9S	33.7	0.013	0.005	8.1	–	–	–	–
109	RX J2120.2+5127	21H20M17.48S	51D27M46.7S	25.2	0.013	0.006	12.1	–	–	–	–
110	RX J2130.7+4919	21H30M44.80S	49D19M19.2S	26.2	0.012	0.005	11.7	-0.18	0.35	-1.00	0.70
111	RX J2123.7+4636	21H23M44.89S	46D36M59.4S	30.9	0.012	0.005	8.7	–	–	–	–
112	RX J2043.4+5002	20H43M27.86S	50D02M33.9S	28.4	0.012	0.005	8.2	–	–	–	–
113	RX J2107.6+5048	21H07M38.56S	50D48M51.5S	23.8	0.012	0.005	12.9	–	–	–	–
114	RX J2117.5+5243	21H17M31.42S	52D43M09.5S	22.9	0.012	0.004	18.3	–	–	–	–
115	RX J2120.8+5209	21H20M49.63S	52D09M27.7S	25.8	0.011	0.005	12.3	–	–	–	–
116	RX J2121.8+5135	21H21M51.46S	51D35M16.5S	27.9	0.010	0.005	9.2	–	–	–	–
117	RX J2121.0+5049	21H21M02.19S	50D49M57.6S	28.9	0.010	0.004	10.4	–	–	–	–
118	RX J2058.1+4552	20H58M11.60S	45D52M57.6S	24.4	0.010	0.005	9.4	–	–	–	–
119	RX J2112.9+5314	21H12M55.73S	53D14M24.0S	34.5	0.010	0.005	8.8	–	–	–	–
120	RX J2122.6+4856	21H22M37.14S	48D56M13.8S	30.1	0.009	0.004	8.1	–	–	–	–
121	RX J2122.0+5059	21H22M02.40S	50D59M18.7S	29.9	0.009	0.004	9.0	–	–	–	–
122	RX J2105.7+4933	21H05M45.89S	49D33M36.5S	32.6	0.009	0.004	8.0	–	–	–	–
123	RX J2116.0+5254	21H16M03.91S	52D54M56.1S	27.7	0.009	0.004	8.3	–	–	–	–
124	RX J2059.6+4731	20H59M40.20S	47D31M11.8S	23.4	0.008	0.004	8.4	–	–	–	–
125	RX J2100.8+5213	21H00M52.03S	52D13M58.1S	31.1	0.008	0.004	8.9	–	–	–	–
126	RX J2111.8+4942	21H11M53.70S	49D42M33.3S	25.9	0.008	0.004	9.2	–	–	–	–
127	RX J2108.9+4958	21H08M56.32S	49D58M07.8S	30.8	0.008	0.004	8.1	–	–	–	–
128	RX J2122.9+4941	21H22M58.94S	49D41M00.9S	23.7	0.006	0.003	9.8	–	–	–	–

Table 3. X-ray characteristics of ROSAT survey sources detected with $7 \leq ML < 8$ in the Cygnus test region. Entries are sorted by decreasing count rates

Source index	ROSAT name	Right Ascension	Declination	r_{90} ($''$)	Cnt rate (cts/s)	Error (cts/s)	Max lik.	HR 1	Error	HR 2	Error
129	RX J2053.2+4951	20H53M17.01S	49D51M25.9S	41.6	0.020	0.008	7.9	–	–	–	–
130	RX J2054.0+4858	20H54M00.97S	48D58M49.6S	53.9	0.019	0.007	7.7	–	–	–	–
131	RX J2049.6+5128	20H49M39.60S	51D28M26.6S	28.8	0.017	0.008	7.3	–	–	–	–
132	RX J2052.3+4843	20H52M21.56S	48D43M24.4S	38.3	0.016	0.006	7.1	–	–	–	–
133	RX J2129.2+4604	21H29M15.28S	46D04M45.2S	36.5	0.016	0.006	7.9	–	–	–	–
134	RX J2124.5+5133	21H24M32.10S	51D33M57.5S	33.6	0.015	0.006	7.0	–	–	–	–
135	RX J2117.2+5241	21H17M13.60S	52D41M09.1S	32.4	0.014	0.006	7.9	–	–	–	–
136	RX J2057.6+4750	20H57M36.51S	47D50M42.0S	25.3	0.013	0.006	7.8	–	–	–	–
137	RX J2111.6+4809	21H11M37.34S	48D09M17.5S	33.5	0.013	0.005	7.6	–	–	–	–
138	RX J2051.8+4741	20H51M48.74S	47D41M23.5S	34.4	0.013	0.005	7.7	–	–	–	–
139	RX J2057.1+4929	20H57M06.24S	49D29M33.5S	38.7	0.013	0.005	7.9	–	–	–	–
140	RX J2043.1+4752	20H43M07.49S	47D52M04.0S	27.6	0.013	0.005	7.4	–	–	–	–
141	RX J2127.1+4801	21H27M08.86S	48D01M20.9S	27.9	0.012	0.005	7.5	–	–	–	–
142	RX J2048.8+4631	20H48M48.64S	46D31M09.8S	29.5	0.012	0.005	7.8	–	–	–	–
143	RX J2110.5+5244	21H10M30.63S	52D44M23.8S	45.5	0.011	0.005	7.8	–	–	–	–
144	RX J2052.3+4656	20H52M19.45S	46D56M39.3S	42.9	0.011	0.005	7.5	–	–	–	–
145	RX J2101.2+4609	21H01M12.09S	46D09M01.4S	38.4	0.011	0.005	7.7	–	–	–	–
146	RX J2055.7+4815	20H55M42.91S	48D15M49.7S	46.3	0.011	0.005	7.3	–	–	–	–
147	RX J2045.1+4805	20H45M10.04S	48D05M07.7S	23.4	0.011	0.005	8.0	–	–	–	–
148	RX J2110.3+4832	21H10M19.49S	48D32M31.1S	46.2	0.011	0.004	7.5	–	–	–	–
149	RX J2131.2+4812	21H31M12.24S	48D12M14.0S	24.6	0.010	0.005	7.5	–	–	–	–
150	RX J2058.7+4845	20H58M45.38S	48D45M48.5S	30.7	0.010	0.004	8.0	–	–	–	–
151	RX J2100.3+4810	21H00M22.02S	48D10M24.9S	34.2	0.010	0.004	7.9	–	–	–	–
152	RX J2130.8+4842	21H30M50.85S	48D42M40.9S	28.6	0.009	0.004	7.1	–	–	–	–
153	RX J2052.6+4703	20H52M38.94S	47D03M46.4S	26.6	0.009	0.004	7.5	–	–	–	–
154	RX J2055.0+5039	20H55M01.34S	50D39M32.4S	27.7	0.009	0.004	7.4	–	–	–	–
155	RX J2121.1+4907	21H21M07.66S	49D07M37.5S	27.5	0.008	0.004	7.2	–	–	–	–
156	RX J2122.4+4709	21H22M24.16S	47D09M17.9S	30.3	0.008	0.004	7.3	–	–	–	–
157	RX J2054.6+4903	20H54M40.01S	49D03M34.3S	26.3	0.008	0.004	7.8	–	–	–	–
158	RX J2121.5+4951	21H21M34.26S	49D51M33.6S	26.7	0.006	0.003	7.5	–	–	–	–

Table 4. Optical properties of all proposed optical counterparts in the Cygnus test region for sources with $ML \geq 8$. The last column lists the distance between X-ray an optical position in units of the 90% confidence radius. For the sake of completeness, we also list the proposed counterparts having a probability of identification in the range 95% − 98%. These more uncertain cases are marked by a "?" as first letter of the identification name and the class acronym is followed by a "?"

Source index	ROSAT name	Class	Identification	Spectral type	V	$B-V$	RA (optical)	DEC (optical)	$D_{\rm X-Opt}$ (r_{90})
1	RX J2112.7+5006	WD	GD 394	DAw	13.09	-0.24	21H12M43.50S	50D06M17.0S	.38
2	RX J2133.9+4535	AC	HR 8252	G8III	4.00	0.88	21H33M58.87S	45D35M35.3S	.12
3	RX J2052.7+4639	WD	C	DO	17.50	–	20H52M43.87S	46D39M35.2S	.35
4	RX J2125.2+4942	AC	A =GSC-0359801594	K4V	10.95	–	21H25M12.11S	49D42M20.3S	.15
5	RX J2100.8+4530	AC	SAO 50350	G3V	8.82	0.72	21H00M46.72S	45D30M09.6S	.73
6	RX J2106.0+5421	AC	HD 235440	F8V	9.20	0.70	21H06M00.57S	54D21M51.0S	.42
7	RX J2104.1+4912	AC	B	M4e	16.00	–	21H04M10.64S	49D12M47.5S	.69
8	RX J2130.8+4827	AC	SAO 50961	G3V	8.54	0.74	21H30M47.88S	48D27M33.0S	.56
9	RX J2120.9+4636	AC	A =GSC-0358903858	F9V	9.73	–	21H20M55.39S	46D36M13.0S	.29
10	RX J2124.7+4639	AC	A+B	K3+K7V	10.59	–	21H24M43.75S	46D39M42.2S	.52
11	RX J2117.3+5044	WD	B =LAN 121	DA	13.39	–	21H17M17.72S	50D44M06.0S	.67
12	RX J2135.9+4728	AGN	B	Seyf 1	16.30	–	21H35M53.97S	47D28M20.9S	.45
13	RX J2102.6+4552	AC	HD 200560	K3V	7.68	0.97	21H02M38.67S	45D52M58.4S	1.14
14	RX J2123.1+4831	AC	HD 203839	F0V	7.80	0.40	21H23M07.70S	48D31M09.3S	.25
15	RX J2055.3+5025	AC	A =GSC-0358301038	G0V	9.58	–	20H55M23.35S	50D25M36.4S	.69
16	RX J2109.2+4810	AC	A =GSC-0359205781	K7V	11.40	–	21H09M17.84S	48D10M12.8S	.34
17	RX J2100.9+5103	AC	A =G 231 -24	M2Ve	14.80	–	21H00M59.62S	51D03M15.0S	.23
18	RX J2049.6+5119	AC	HD 198638	F2V	6.70	0.50	20H49M36.46S	51D18M54.2S	.80
19	RX J2059.3+5303	AC	A =GSC-0395201062	M3.5Ve	14.10	–	20H59M20.09S	53D03M04.9S	.37
20	RX J2056.7+4940	AC	SAO 50269	A7V	9.90	0.10	20H56M41.86S	49D40M17.8S	.42
21	RX J2123.1+5021	AC	A =BD+49 3512	G0V	9.56	–	21H23M12.30S	50D21M47.2S	.17
22	RX J2107.8+4932	AC	A =GSC-0359600261	G8V	10.66	–	21H07M52.88S	49D32M29.2S	.50
23	RX J2100.1+4841	AC	BD+48 3260 E	G9V	12.03	–	21H00M07.88S	48D41M29.6S	.08
24	RX J2104.7+5223	AC	A =GSC-0360000513	G2V	11.44	–	21H04M44.32S	52D23M25.8S	.42
25	RX J2044.6+4758	AC	A =GSC-0357800872		11.43	–	20H44M37.95S	47D58M08.3S	.91
26	RX J2107.3+5202	AC	V1061 Cyg =HD 235444	F8V	9.24	0.55	21H07M20.33S	52D02M56.3S	.42
27	RX J2052.3+4820	AC	A =GSC-0357901469	G9V	11.64	–	20H52M23.08S	48D19M57.3S	.47
28	RX J2118.4+4356	OB	HR 8154	O8Ve	5.01	-0.03	21H18M27.05S	43D56M45.8S	.59
29	RX J2109.3+5138	AC	A =GSC-0360000175	G3V	9.66	–	21H09M22.23S	51D37M50.2S	.67
30	RX J2120.4+4733	AC	HD 203418	K4V	8.30	1.60	21H20M25.27S	47D33M35.0S	.37
31	RX J2104.2+5015	AC	A	K7e	15.00	–	N/A	N/A	–
32	RX J2057.3+4813	AC	A =GSC-0357900338	A2m	10.93	–	20H57M22.55S	48D13M31.5S	.36
33	RX J2119.0+5207	AC	A =GSC-0360101235	G1V	11.72	–	21H18M59.28S	52D07M03.3S	.46
34	RX J2117.8+5112	AC	HD 203028	A2V	8.36	0.23	21H17M52.51S	51D12M25.7S	.60
35	RX J2133.3+4726	??			–	–			–
36	RX J2134.0+4525	AC	A =GSC-0359101945	G3V	11.07	–	21H34M05.47S	45D25M33.6S	.52
37	RX J2103.4+5021	AC	HR 8072	K0III	6.37	0.98	21H03M25.63S	50D21M04.7S	.28
38	RX J2040.6+4859	AC	SAO 49928	F9V	9.70	0.60	20H40M38.29S	48D59M59.6S	.16
39	RX J2102.9+4854	AC	A =GSC-0359600374	G3V	10.69	–	21H03M00.75S	48D54M28.1S	.77
40	RX J2113.3+5140	AC	A	M4Ve	16.50	–	21H13M23.09S	51D40M02.4S	.34
41	RX J2123.5+4621	AC	A =GSC-0359002325	K4V	11.55	–	21H23M34.77S	46D21M40.3S	.35
42	RX J2100.9+4857	AC	A =GSC-0359601318	K2V	10.51	–	21H00M57.32S	48D56M46.7S	1.04
43	RX J2130.1+4901	AC	B	M5Ve	14.11	1.59	21H30M12.64S	49D01M25.7S	.49
44	RX J2054.1+4942	AC	A =GSC-0358300309	F8V	10.98	–	20H54M09.16S	49D42M41.4S	.20
45	RX J2116.6+4645	AC	A	M5Ve	15.50	–	21H16M37.23S	46D45M16.2S	.62
46	RX J2110.2+5333	OB	HR 8106	Ap	5.61	-0.12	21H10M15.38S	53D33M47.5S	.63
47	RX J2125.3+4642	AC	HR 8208	F0V	5.60	0.35	21H25M18.57S	46D42M49.2S	.80
48	RX J2118.5+5247	AC	A =GSC-0395301190		11.17	–	21H18M31.01S	52D47M40.8S	.17
49	RX J2128.7+4409	??			–	–			–
50	RX J2121.7+5049	AC	HD 235498	A0V	10.30	0.20	21H21M47.33S	50D49M31.6S	.47
51	RX J2132.5+4849	??			–	–			–
52	RX J2122.4+5023	AC	A =GSC-0359700228	G9V	11.55	–	21H22M26.82S	50D23M56.2S	.92
53	RX J2035.9+4900	AC	A =GSC-0358101856	G5-8V	10.97	–	20H35M57.27S	49D00M43.7S	.21
54	RX J2108.2+5313	AC	HD 201543	A0V	7.30	0.10	21H08M17.85S	53D13M31.1S	.12
55	RX J2128.6+4653	AC	A =GSC-0359400075	K5V	12.22	–	21H28M40.68S	46D53M56.7S	.13
56	RX J2048.0+4903	AC	A =GSC-0358200586		11.51	–	20H48M04.31S	49D03M12.5S	.28
57	RX J2115.4+4437	AC	A =GSC-0318101403	K0V	10.43	–	21H15M24.00S	44D37M42.4S	.62
58	RX J2109.9+4809	AC	SAO 50523	A5V	9.10	0.35	21H09M54.72S	48D09M17.2S	.45
59	RX J2108.6+4927	AC	A	M2Ve	14.10	–	21H08M38.91S	49D27M32.4S	.43
60	RX J2050.8+4743	??			–	–			–
61	RX J2135.6+4523	AC	A =GSC-0359102803	F9V	11.65	–	21H35M38.51S	45D23M10.6S	1.41

Continued on next page

Source index	ROSAT name	Class	Identification	Spectral type	V	$B-V$	RA (optical)	DEC (optical)	D_{X-Opt} (r_{90})
62	RX J2119.9+5227	AC?	? A =GSC-0360101367		12.20	–	21H19M54.50S	52D27M46.7S	.43
63	RX J2100.3+5219	AC	A =GSC-0360000514	M1Ve	13.39	–	21H00M20.71S	52D19M10.6S	.45
64	RX J2056.3+4817	??			–	–			–
65	RX J2127.3+5121	AC	A+B		11.46	–	21H27M20.74S	51D22M03.1S	.48
66	RX J2041.9+4746	??			–	–			–
67	RX J2126.3+4654	AC	A =GSC-0359401755		10.62	–	21H26M23.54S	46D54M31.5S	.03
68	RX J2055.8+5044	AC	A =GSC-0358700365	G8V	12.99	–	20H55M53.12S	50D44M23.1S	.56
69	RX J2117.5+5127	AC	A =GSC-0360100450	M0Ve	12.90	–	21H17M32.20S	51D27M14.1S	.42
70	RX J2057.7+4752	??			–	–			–
71	RX J2131.2+4533	??			–	–			–
72	RX J2054.6+5120	??			–	–			–
73	RX J2121.5+4317	??			–	–			–
74	RX J2128.4+4900	??			–	–			–
75	RX J2058.5+4836	??			–	–			–
76	RX J2130.0+4740	AC?	? A =Plat 2137	K4V	11.98	1.09	21H30M03.89S	47D40M25.4S	.84
77	RX J2106.2+4437	AC	A	M5Ve	15.40	–	21H06M16.63S	44D37M03.8S	.39
78	RX J2128.5+4626	??			–	–			–
79	RX J2117.7+5139	??			–	–			–
80	RX J2101.6+4730	AC	HD 200406	G0V	7.93	0.54	21H01M38.16S	47D30M04.6S	1.03
81	RX J2046.7+4728	AC?	? A =GSC-0357800892		11.20	–	20H46M43.30S	47D28M33.3S	.56
82	RX J2136.6+4911	??			–	–			–
83	RX J2118.6+5010	AC	HD 203136	K0V	7.76	0.88	21H18M40.34S	50D10M57.0S	.37
84	RX J2130.3+4709	CV	B	Me+DA	–	–	21H30M18.49S	47D10M07.6S	1.04
85	RX J2116.0+4827	??			–	–			–
86	RX J2124.7+4714	AC	A =GSC-0359402027		10.63	–	21H24M42.66S	47D14M42.5S	.26
87	RX J2117.5+4330	AC	A =GSC-0318100914	F8V	10.29	–	21H17M35.40S	43D30M52.1S	.95
88	RX J2137.6+4916	??			–	–			–
89	RX J2100.6+5039	AC	A =GSC-0360000197		10.69	–	21H00M37.82S	50D39M29.4S	.14
90	RX J2110.5+4913	AC	A =GSC-0359601415		10.49	–	21H10M32.49S	49D13M25.9S	.26
91	RX J2121.5+4732	AC	A =GSC-0359303030	M0Ve	12.84	–	21H21M32.55S	47D32M49.8S	.52
92	RX J2052.8+4723	??			–	–			–
93	RX J2118.6+5039	??			–	–			–
94	RX J2122.3+4730	AC	A =GSC-0359305051	M4.5Ve	13.50	–	21H22M20.75S	47D30M44.6S	.24
95	RX J2050.4+4913	AC	A =GSC-0358300408		10.76	–	20H50M26.17S	49D13M25.4S	.60
96	RX J2113.0+4834	AC	A =GSC-0359303505	G1V	11.09	–	21H13M04.46S	48D34M23.4S	.33
97	RX J2134.2+4911	AC?	? A =Plat 5991	M2-M6	12.62	1.49	21H34M16.99S	49D11M21.4S	.56
98	RX J2119.5+4351	??			–	–			–
99	RX J2117.4+5152	??			–	–			–
100	RX J2123.2+5057	??			–	–			–
101	RX J2053.4+4759	??			–	–			–
102	RX J2124.3+5059	AC	A	K7Ve	13.30	–	21H24M17.95S	50D59M46.4S	.28
103	RX J2114.1+4840	AC?	? A+B		11.36	–	21H14M09.20S	48D40M53.0S	.90
104	RX J2043.7+4727	AC?	? A =GSC-0357801789		11.70	–	20H43M47.00S	47D27M19.4S	.90
105	RX J2122.6+4956	??			–	–			–
106	RX J2103.6+4845	AC	A =GSC-0359600092		10.65	–	21H03M37.95S	48D45M40.6S	.73
107	RX J2059.8+4937	AC?	? A =GSC-0358300546		12.58	–	20H59M50.22S	49D37M30.9S	.45
108	RX J2126.9+4636	??			–	–			–
109	RX J2120.2+5127	AC	A =GSC-0360100440		11.08	–	21H20M17.38S	51D27M44.2S	.11
110	RX J2130.7+4919	AC	A =Plat 2930	F9	12.44	0.56	21H30M43.51S	49D18M59.7S	.88
111	RX J2123.7+4636	??			–	–			–
112	RX J2043.4+5002	AC?	? A =GSC-0358200283		12.90	–	20H43M29.31S	50D02M13.3S	.88
113	RX J2107.6+5048	AC	A =GSC-0360000137	G1V	11.31	–	21H07M37.64S	50D48M60.0S	.51
114	RX J2117.5+5243	AC?	? A =GSC-0395301075		12.62	–	21H17M31.78S	52D43M07.5S	.17
115	RX J2120.8+5209	??			–	–			–
116	RX J2121.8+5135	AC	A =GSC-0360100693		11.47	–	21H21M52.28S	51D35M18.0S	.29
117	RX J2121.0+5049	??			–	–			–
118	RX J2058.1+4552	AC?	? A =GSC-0357501843		10.67	–	20H58M11.67S	45D52M49.1S	.35
119	RX J2112.9+5314	AC	A =GSC-0395300355		9.95	–	21H12M56.17S	53D14M31.1S	.24
120	RX J2122.6+4856	AC?	? A =GSC-0359800927		11.37	–	21H22M37.38S	48D56M19.0S	.19
121	RX J2122.0+5059	??			–	–			–
122	RX J2105.7+4933	??			–	–			–
123	RX J2116.0+5254	??			–	–			–
124	RX J2059.6+4731	AC?	? A =GSC-0357901518		12.47	–	20H59M40.43S	47D31M09.6S	.14
125	RX J2100.8+5213	AC?	? A =GSC-0360000242		13.27	–	21H00M52.05S	52D13M58.8S	.03
126	RX J2111.8+4942	??			–	–			–
127	RX J2108.9+4958	??			–	–			–
128	RX J2122.9+4941	??			–	–			–

Table 5. Optical properties of all proposed optical counterparts in the Cygnus test region for sources with $7 \leq ML < 8$. The last column lists the distance between X-ray an optical positions in units of the 90% confidence radius. For the sake of completeness, we also list the proposed counterparts having a probability of identification in the range 95% − 98%. These more uncertain cases are marked by a "?" as first letter of the identification name and the class acronym is followed by a "?"

Source index	ROSAT name	Class	Identification	Spectral type	V	$B-V$	RA (optical)	DEC (optical)	$D_{\rm X-Opt}$ (r_{90})
129	RX J2053.2+4951	??			–	–			–
130	RX J2054.0+4858	??			–	–			–
131	RX J2049.6+5128	AC	A =GSC-0358700147		11.53	–	20H49M39.75S	51D28M34.1S	.26
132	RX J2052.3+4843	AC	A =GSC-0357901214		9.75	–	20H52M20.16S	48D43M26.5S	.36
133	RX J2129.2+4604	??			–	–			–
134	RX J2124.5+5133	??			–	–			–
135	RX J2117.2+5241	AC	A =GSC-0395301223		10.42	–	21H17M11.64S	52D40M41.8S	1.01
136	RX J2057.6+4750	??			–	–			–
137	RX J2111.6+4809	CV	V1500 Cyg		17.06	0.38	21H11M36.60S	48D09M02.0S	.51
138	RX J2051.8+4741	??			–	–			–
139	RX J2057.1+4929	??			–	–			–
140	RX J2043.1+4752	AC?	? A =GSC-0357802133		11.42	–	20H43M08.36S	47D52M13.8S	.48
141	RX J2127.1+4801	??			–	–			–
142	RX J2048.8+4631	??			–	–			–
143	RX J2110.5+5244	??			–	–			–
144	RX J2052.3+4656	??			–	–			–
145	RX J2101.2+4609	OB	HD 200310	B1Ve	5.40	-0.18	21H01M10.80S	46D09M20.8S	.61
146	RX J2055.7+4815	??			–	–			–
147	RX J2045.1+4805	AC	A =GSC-0357800263		11.37	–	20H45M10.39S	48D05M12.3S	.25
148	RX J2110.3+4832	??			–	–			–
149	RX J2131.2+4812	??			–	–			–
150	RX J2058.7+4845	??			–	–			–
151	RX J2100.3+4810	??			–	–			–
152	RX J2130.8+4842	??			–	–			–
153	RX J2052.6+4703	??			–	–			–
154	RX J2055.0+5039	??			–	–			–
155	RX J2121.1+4907	??			–	–			–
156	RX J2122.4+4709	??			–	–			–
157	RX J2054.6+4903	??			–	–			–
158	RX J2121.5+4951	??			–	–			–

Table 6. Notes on individual sources

Source index	ROSAT name	Note
1	RX J2112.7+5006	GD 394 = RE J211241+500619
2	RX J2133.9+4535	HD 205435 = HR 8252 = ρ Cyg
6	RX J2106.0+5421	In ADS catalogue
8	RX J2130.8+4827	Member of NGC 7092, in ADS catalogue
10	RX J2124.7+4639	GSC-0359001727 merges objects A and B
11	RX J2117.3+5044	Our candidate was independently discovered by Lanning, H.H. and Meakes, M. (1994; PASP, 106, 38) in a search for faint UV-bright stars in the galactic plane. A finding chart may be found in their work.
12	RX J2135.9+4728	$z = 0.025$
13	RX J2102.6+4552	Chromospheric activity in HD 200560 was reported by Soderblom (1985, AJ, 90, 2103).
15	RX J2055.3+5025	On the basis of its position outside the 90% confidence circle and weak Ca II H&K emission, star B is unlikely to contribute much to the X-ray source. The finding chart was extracted from the STSCI digitized sky survey.
23	RX J2100.1+4841	BD+48 3260 E = ADS 14531 E
26	RX J2107.3+5202	This star is an eclipsing binary of the Algol type with an orbital period of 2.3467 days.
30	RX J2120.4+4733	= ADS 14886 AB
37	RX J2103.4+5021	Ca H&K emission also visible in the high resolution spectrum of Strassmeier (1994, A&AS, 103, 413).
38	RX J2040.6+4859	= ADS 14161 A
43	RX J2130.1+4901	Candidate object 'B' coincides in position with star 2376 in the catalogue of stars in the region of the open cluster M39 compiled by Platais (1994). This M5Ve star lies far off the photometric sequence defined by Mohan and Sagar (1985, MNRAS, 213, 337) for this cluster and we conclude that object "B" is a foreground star not related to the open cluster. Object "A" would deserve follow-up observations.
51	RX J2132.5+4849	Candidates A and B are respectively stars 4522 and 4516 in the catalogue of stars in the region of the open cluster M39 compiled by Platais (1994). Our high and low resolution (not shown) spectra show that A is a G1 star and B is a K7 star. These spectral types are in agreement with the $B-V$ indices listed in Platais (1994). Assuming that the two stars are on the main sequence implies a distance modulus incompatible with a membership to M39. Recent additional optical observations (not shown) indicate that the two brightest objects east of "B" (D and E not marked) are M stars with weak Hα emission. The X-ray source could result from the combined coronal emission of several of the stars held in the error circle.
53	RX J2035.9+4900	The medium resolution spectrum of object "A", the proposed optical counterpart, exhibits clear line doubling revealing the presence of a close binary.
58	RX J2109.9+4809	The UBV photometry reported by Young et al. (1976, ApJ, 209, 882) suggests a spectral type slightly later than A5 for SAO 50523.
65	RX J2127.3+5121	Object A is GSC-0360200451 ($V = 11.92$) and B is GSC-0360200459 ($V = 11.46$). Optical coordinates and magnitudes recorded in Tables are those of B.

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Source index	ROSAT name	Note
68	RX J2055.8+5044	X-ray position compatible with IRAS 20544+5033
74	RX J2128.4+4900	Star A ($V = 13.75$; $B-V = 0.57$; $U-B = 0.45$) is number 889 in the catalog of objects in the direction of M39 by Platais (1994).
76	RX J2130.0+4740	Candidates A ($V = 11.98$; $B-V = 1.09$; $U-B = 0.68$) and B ($V = 11.00$; $B-V = 0.52$; $U-B = -0.10$, spectral type F6) are respectively stars 2137 and 2189 in the catalog of objects in the region of M39 (Platais 1994). The colour indices of object A suggest a K4 spectral type with a distance modulus smaller than M39 whereas candidate B is likely to belong to the open cluster.
92	RX J2052.8+4723	X-ray position compatible with IRAS 20512+4712.
97	RX J2134.2+4911	Candidate A is number 5991 in the catalog of objects in the region of M39 (Platais 1994). Its red colours are compatible with A being a nearby M2-M6 star. Two other stars in Platais's list (5981 and 5999) fall inside the 90% confidence radius. UBV photometry suggests that these two objects are G type stars located behind M39 and are therefore less likely optical counterparts of the X-ray source.
103	RX J2114.1+4840	Object A is GSC-0359304712 ($V = 11.36$) and Object B is GSC-0359304650 ($V = 13.61$). The optical positions and magnitudes recorded in Tables are those of A.
105	RX J2122.6+4956	X-ray position compatible with IRAS 21209+4943.
108	RX J2126.9+4636	X-ray position compatible with IRAS 21252+4624
141	RX J2127.1+4801	A possible identification based on positional coincidence is star 173 in the catalogue of objects in the region of M39 (Platais 1994).
149	RX J2131.2+4812	The GSC entry closest to the X-ray position is star 3359 in the catalogue of objects in the region of M39 (Platais 1994). Its colour suggests a G2-G5 type and a distance compatible with a membership to M39.
152	RX J2130.8+4842	Star number 3016 of the catalog of objects in the region of M39 (Platais 1994) falls into the 90% confidence error circle. The UBV photometry is consistent with a K2-K5 dwarf in M39.