Chandra News

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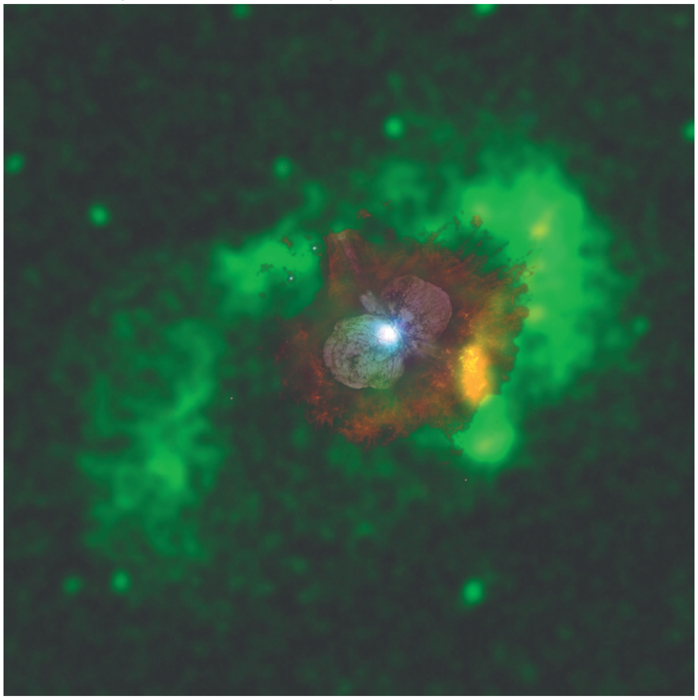

FIGURE 1: *Chandra* image of η Carinae superimposed on an HST/WFPC2 image from Nathan Smith & Jon Morse (private communciation). The X-ray image was made by merging the zeroth-order images from 5-100 ksec HETG observations. The X-ray image is color coded by photon energy (green-blue, soft-hard).

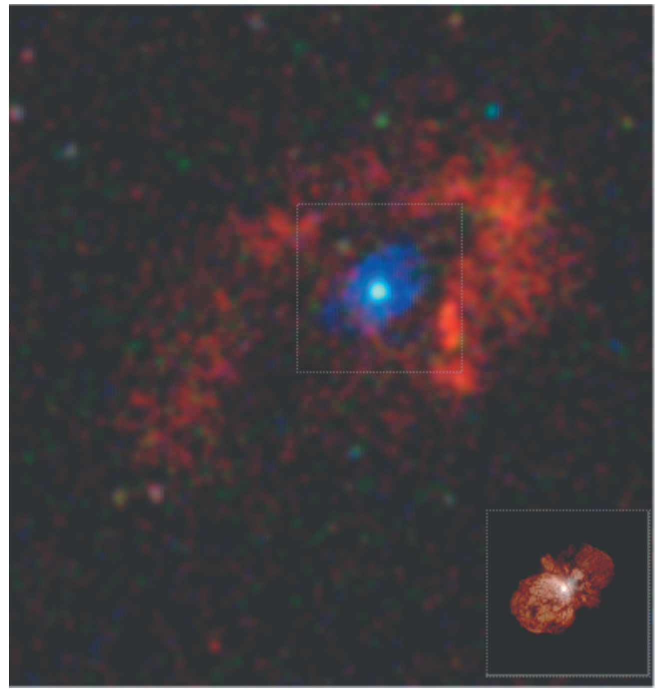

FIGURE 2: "True-color" *Chandra* image of η Carinae during the X-ray minimum. η Carinae is the blue-white source at the center of the image. The blue (hard) emission around η Carinae is X-ray emission backscattered by the Homunculus. The inset at the lower right shows a WFPC2 image of η Carinae on the same scale as the X-ray image. (The full size pictures in the online Newsletter look even better!).

Unveiling η Carinae with Chandra

The supermassive star η Carinae (Davidson & Humphreys 1997) is notorious for its extraordinarily large luminosity (L > 4 x 10^6 solar luminosities), its implicitly large mass (M > 100 solar masses), its wild instability (most notably the "Great Eruption" of 1843 when the star expelled more than 2 solar masses, and formed the striking, bipolar "Homunculus" nebula which now shrouds the star from direct view; see Figures 1 and 2) and its continued broad-band variations (Sterken et al. 1996, Davidson et al. 1999). Understanding η Carinae can help address a wide variety of astrophysical topics, namely: the formation and evolution of extremely massive stars; the dynamical and chemical interactions of these stars with their environment; the role of binarity in stellar instabilities and the formation of symmetrical nebulosity; and the relation of extremely massive stars to peculiar supernovae and hypernovae.

One Star or Two?

Evidence gathered since the 1990's suggests that η Carinae is actually a binary system with a less massive, hotter companion, which orbits η Carinae in an extremely eccentric (e ~ 0.9), 5.53-year orbit. The impact of the companion on understanding the formation of η Carinae, its subsequent evolution and the possible role the companion may play in moderating or driving instabilities in η Carinae is important and needs to be understood. Unfortunately, the study of the companion star is difficult since the entire system is buried within the Homunculus. Because hard X-rays penetrate the Homunculus, X-rays are an extremely useful probe of the system.

CONTENTS

η Carinae is a nice example of progress made in the field of X-ray astronomy. The first claim of X-ray detection was in 1972. A weak source at the limit of detectability appeared in a scan of the Galactic plane with a rocket-borne detector. In 1979, the first Einstein observation of this region showed that this source was the Carina Nebula, over 1 degree in extent - a bright (by present standards) diffuse source sprinkled with dozens of point-like O stars. Although η Carinae itself is the brightest of these, it accounts for only 6% of the emission from this area.

The observers claiming the first detection were blissfully ignorant of the true structure. We can now resolve η Carinae into a small horseshoe-shaped nebula around a central object and do high-resolution spectroscopy on each element.

As first shown by the *Einstein* Observatory, η Carinae is a hard X-ray source, and as shown by *ROSAT* and *RXTE,* these X-rays vary in sync with the rest of the emission, undergoing a 3-month long minimum every 5.53 years. The X-rays are believed to be produced by the collision of the slow, dense wind of η Carinae with the faster, low-density wind of the companion. Because the X-ray emission depends on the wind parameters of the two stars, and because the wind parameters are tightly coupled to the stellar parameters, X-ray observations can be used to constrain the stellar parameters. Unlike emission in any other waveband, the hard X-ray emission is not appreciably affected by absorption by or emission from the Homunculus.

Arguably, the hard X-ray emission provides our clearest view of the η Carinae system, and *Chandra* provides our clearest view of the hard X-rays, due to *Chandra*'s exquisite spatial and fine spectral resolution at energies up to 10 keV (which includes the bulk of η Carinae's emission). Spatial resolution is key to resolving emission from the star from that of other nearby sources. Spectral resolution is needed in order to determine accurate properties of the pre-shocked wind, and to probe densities and flow dynamics. In this article we discuss some recent *Chandra* HETG observations of η Carinae, mostly obtained during the star's last X-ray minimum in mid-2003.

<u>Chandra Observations of η Carinae</u>

Figure 1 compares a WFPC2 image of η Carinae with a *Chandra* image. This *Chandra* image is the equivalent of a 500 ksec zeroth-order grating image and is the deepest, most detailed X-ray image of η Carinae yet obtained. The X-ray image is color-coded by photon energy (green-blue, soft-hard) and shows an incomplete ring of X-ray emission (in green and yellow) which corresponds to material ejected from the star during the "Great Eruption'' (and perhaps older outer material as well), produced as the ejecta plows into the pre-existing interstellar environment. The star itself is the hard source (blue/white) at the center of the image. This hard source results from the X-ray emission in the colliding wind shocks, which is not spatially resolved by *Chandra.*

We obtained five 100 ksec HETG observations at important times before, during and after the X-ray minimum which occurred in mid-2003. Figure 3 shows the times of these observations on the X-ray lightcurve of η Carinae measured by *RXTE*. These HETG observations, along with an earlier one obtained in November 2000 near apastron, allow us to measure changes in the X-ray spectral energy distribution, and, for the first time, to use the X-ray line profiles to constrain the dynamics of the hot plasma during the large variations around the 2003 X-ray minimum. Because the X-ray emitting plasma flows along a conical surface where the winds collide, the X-ray emission line velocities should

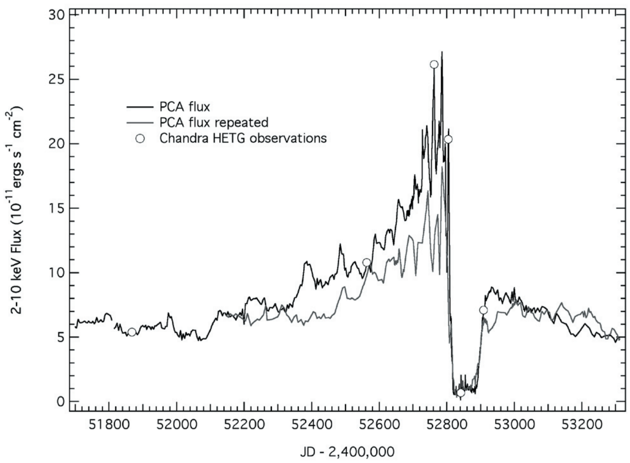

FIGURE 3: RXTE 2-10 keV X-ray lightcurve with times of the *Chandra* HETG observations noted. The lighter gray line shows the variation during the previous X-ray minimum which began in late 1997.

reflect the orbital motion of this cone and the plasma flow along the cone modulated by the phase-dependent orientation of the cone to the line of sight (Henley, Stevens & Pittard 2003). Figure 4 shows some of the variation seen. We highlight a few of the important results from these observations below.

X-ray Emission Line Variability

The HETG spectra showed clear changes in the emission lines. The forbidden-to-intercombination line ratios of the S and Si He-like ions seem to decrease on approach to the X-ray minimum, indicating that the X-ray emitting plasma is either increasing in density or being exposed to higher UV flux. Either explanation is qualitatively consistent with current colliding wind models of the system in which the X-ray minimum occurs near periastron.

A particularly surprising result is that the lower-temperature lines from H-like and He-like Si and S become increasingly blueshifted on approach to the X-ray minimum, while the higher-temperature He-like Fe lines (which are unresolved in the HEG spectra) do not. The line shifts in all cases are much larger than the expected orbital velocities near periastron, and so do not appear to represent the bulk motion of the shock cone. The discrepancy in redshift between the Si and S lines and the Fe lines is not fully understood yet, but may represent a spatial segregation between the hotter and cooler plasma. The *Chandra* grating spectra also show blended line emission between the Fe XXV lines and the Fe fluorescent line. This emission is probably produced by plasma that has not yet reached ionization equilibrium, and if so suggests a density of $\sim \rho = 10^{-18}$ g cm^{-3}, about that expected from the companion's shocked stellar wind using the model of Pittard & Corcoran (2002). Note that during these long HETG observations near the X-ray minimum, *RXTE* monitoring showed significant variations in the X-ray plasma, especially for those observations just before the X-ray minimum, so perhaps it's not surprising that at least some of the plasma had not reached ionization equilibrium.

Imaging η Carinae During the Minimum

The HETG observation of η Carinae during the X-ray minimum provided a surprising discovery (Corcoran et al. 2004). The zeroth-order image clearly showed X-ray emission from the star (proving for the first time that the X-ray "eclipse" is not total), but also showed faint, spatially-resolved X-ray emission from the Homunculus. This was the first detection of the Homunculus in X-rays, and it would not have been possible without *Chandra*'s excellent spatial resolution. This emission is produced by reflection of time-delayed X-rays from the wind-wind collision near the star by gas in the back wall of the Homunculus. Figure 2 shows a "true-color" image of η Carinae during the minimum which shows the soft (0.2-1.5 keV) outer emission in red, the faint stellar emission in white, and hard (3-8 keV) reflected emission from the Homunculus in blue. This adds the Homunculus to the small class of ``X-ray reflection nebula" and it is the only one in which the reflected source is observable apart from the reflecting source.

Recovery

We also obtained a grating spectrum after the X-ray minimum. The resulting spectrum showed a surprisingly large amount of absorption, so that the S and Si lines were difficult to measure accurately. This "enhanced absorption" may be direct evidence of some sort of interaction between the companion and η Carinae near periastron in which passage of the companion near η Carinae apparently increases the wind density of η Carinae for a period of time, a sort of "mini-Great Eruption". Though the S and Si lines were too absorbed to measure, the redshift of the Fe XXV blend decreased to nearly the value it had prior to the start of the X-ray minimum.

η Carinae in Context

The X-ray data must be understood in the context of observations with other X-ray and non-X-ray observatories, and vice-versa. Observations with the Advanced Camera for Surveys (ACS), obtained by Smith et al. (2004) during the 2003 X-ray minimum as part of the HST Treasury Project on η Car (Kris Davidson PI), show shadowing of the companion's UV flux by η Carinae, which helps define the orientation of the orbit, and which helps to clarify the interpretation of the X-ray variations. Another key observation during the 2003 event was made by Augusto Damineli and Joao Steiner, who discovered He II 4686 emission which reaches maximum strength just after the start of the X-ray minimum (Steiner & Damineli 2004). This is important since He II 4686 cannot be formed in the relatively cool wind of η Carinae. But it's not clear whether the He II 4686 emission is excited directly by flux from the companion, or if some or all of the emission is produced in the wind-wind shock. Other important observations in the IR (Whitelock, Feast, Marang, & Breedt 2004) and optical (Fernandez Lajus et al. 2003, van Genderen, Sterken,

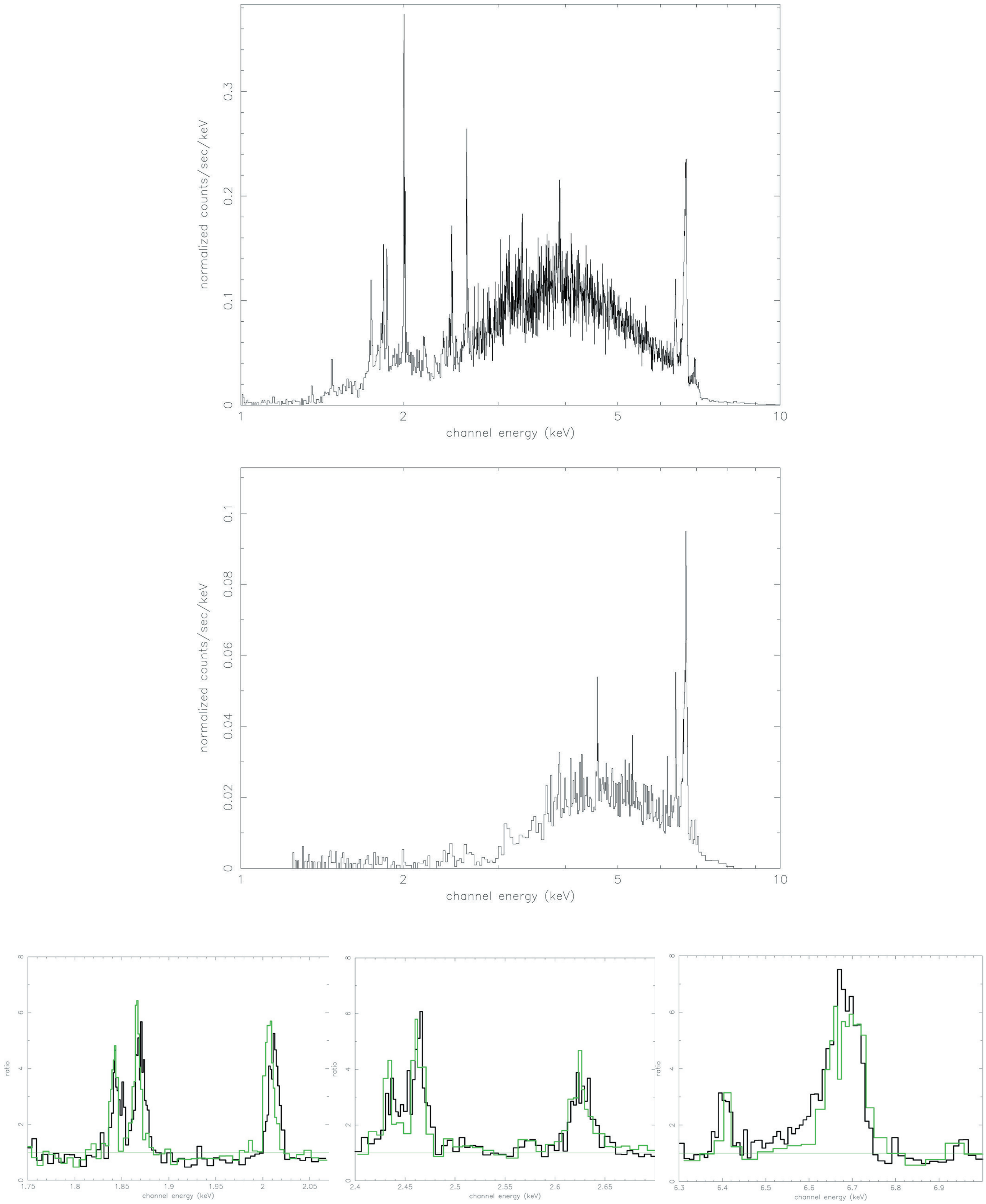

FIGURE 4: Top: HEG spectra of η Car from May 3 2003, before the X-ray minimum. Middle: HEG spectrum from September 26, just after the X-ray minimum. Bottom, left to right: Comparison of continuum-normalized Si XIII & XIV lines, S XV & XVI lines, and Fe XXV lines from November 2000 (believed to be near apastron, in green) and from June 16, 2003 (near periastron, in black).

Allen & Liller 2003, Martin & Koppelman 2004, van Genderen & Sterken 2004) showed minima which are correlated with the X-ray drop. Radio observations by Bob Duncan and Stephen White confirmed the presence of a minimum in radio brightness but also showed secular decreases in the radio emission. This is in contrast to the *RXTE* observations which showed secular increases in the 2-10 keV flux for most of the interval prior to the mid-2003 minimum. In addition to the ACS imaging, the HST η Carinae Treasury Project obtained a trove of spatially-resolved spectra using the Space Telescope Imaging Spectrograph (STIS), which show in unprecedented detail changes in the stellar flux and in the surrounding nebula at the sub-arcsecond level. The information density of these STIS observations is very large and the understanding of these data is ongoing.

While η Carinae is a unique object, it does have some stellar cousins. Its X-ray variability is similar in many ways to the "canonical" colliding wind binary WR 140, which is also a hard, variable source of X-rays and which is a long period (P = 7.9 years), highly eccentric (e = 0.88) massive binary. Another related object is the "Pistol Star" near the center of the Galaxy, which vies with η Carinae for the title of most massive known star. *Chandra* imaging (Law & Yusef-Zadeh 2004) has shown that other extremely massive stars found in the clusters near the Galactic center, like the bright stars in the Quintuplet Cluster, are X-ray bright and probably colliding wind binaries. Perhaps the most intriguing η Carinae analog is HD 5980, a short-period WR+WR binary in the Small Magellanic Cloud. The primary star (star A) has a mass of about 50 solar masses, while the secondary (star B) is a Wolf-Rayet star (subtype WNE) of mass ~ 28 solar masses. Star A is believed to have undergone a large-scale eruption in 1994 similar to the 1843 Great Eruption of η Carinae. *Chandra* and *XMM* observations show that HD 5980 is also a variable X-ray source, but is more difficult to study than η Carinae due to its much larger distance. It's interesting to note that all these systems (except possibly the Pistol star), and other important ones as well, appear to be binaries. The effects of companions on the evolution of these stars is an issue that needs to be addressed, and an important way to address it is to probe the wind-collision zone using X-rays. The availability of *Chandra* to make detailed observations of X-ray spectra offers us a unique tool to understand these important systems.

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Important Dates

Cycle 6 Observations Begin	November, 2004
Cycle 7 Call for Proposals	December 15, 2004
Cycle 7 Proposals Due	March 15, 2005
Cycle 7 Peer Review	June 21-23, 2005
Cycle 7 Budgets Due	August 18, 2005
Next Users' Committee Meeting	October, 2005
Cycle 7 Observations Begin	December, 2005
6 Years of Chandra Symposium	November 2-4, 2005
Cycle 8 Call for Proposals	December, 2005

Project Scientist's Report

My personal highlight during this reporting period was receiving, with Harvey Tananbaum (CXC Director), the Rossi Prize of the High-Energy Astrophysics Division of the American Astronomical Society (AAS) for contributions towards creating and operating this Great Observatory. We realize and acknowledge that the award reflects not only our contributions, but also the technical and scientific contributions of hundreds of individuals over the decades it took to conceive, design, build, test, launch, and operate *Chandra*. Along with the prize comes the honor of addressing the attendees at the AAS's winter meeting. We did this at the San Diego meeting in January of this year - a daunting experience, in that nearly 2000 people listened to our review of the contributions that *Chandra* has made in its first five-plus years of operation.

We were especially pleased to acknowledge the tremendous contribution of Riccardo Giacconi. We noted that the true origin of this Observatory traces directly to Riccardo's 1963 proposal, "An Experimental Program of Extra-Solar X-Ray Astronomy", written barely 15 months after the historic rocket flight that discovered Sco X-1 and what was to become known as the diffuse X-ray background. Amongst other things, that historic proposal called for a scanning survey satellite mission (ultimately Uhuru) to be launched in 1966 and a mission featuring a 1.2-meter diameter, 10-meter focal length, grazing-incidence X-ray telescope mission to be launched in 1968.5. The additional 30 years that it took to accomplish this are an unfortunate testament to the challenges one faces in accomplishing major astrophysics missions. The overwhelming technical and scientific success of this mission, designed for three years of operation with a goal of five and currently well into its sixth year is, however, extremely gratifying.

We also specifically acknowledged the contributions of our dear departed colleague and *Chandra* Telescope Project Scientist Leon Van Speybroeck. We discussed the true first light on August 12, 1999, when the last door to space was opened. Fifteen sources were detected, the brightest of which we nicknamed "Leon X-1" and have recently identified with a bright Seyfert galaxy at redshift 0.32.

Our presentation covered a wide variety of *Chandra* observations: Jupiter and its moons; the earth's moon; 30 Doradus; the Crab and Vela pulsar nebulae; the isolated neutron star RX J1856.5-3754; the binary systems Circinus X-1 and Vela X-1; SS433; the globular cluster 47 Tucanae; the center of the Milky Way, including Sag A*; the center of the Andromeda galaxy including M31*; the galaxies NGC 4631, 4697, and the Antennae; the double quasar NGC 6240; jets in M87 and GB 1508+5714; the *Chandra* surveys, including the deep fields and CHAMP and the evolving view of AGN that we have gleaned from these surveys; recent searches for missing baryons in the WHIM; the remarkable energetics of the cluster MS 0735.6+7421; and the use of *Chandra* observations of X-ray clusters to study dark matter and dark energy.

A PPT file of our presentation is available at http://chandra.harvard.edu/resources/pptshows.

Finally, Project Science is continuing to support efforts related to potential bake-out of the ACIS filters, in order to remove a molecular contaminant that has accumulated on this cold surface (see also ACIS section). Deciding whether to bake out and, if so, how to minimize risk to the ACIS instrument has turned out to be a complex problem, which explains why a decision has been so long in the making.

Martin Weisskopf

Chandra Fellows for 2005

This year we had a record number of applications for Chandra Postdoctoral Fellowships. The list of the Fellows for 2005 has just been finalized and is provided below.

Keep an eye on our web pages for information about the Chandra Fellows Symposium (October 2005) and the annual Fellowship competition (November 2005).

Table 1 - List of accepted Chandra Fellows for 2005.

Name	PhD Institution	Host Institution
Elena Gallo	Amsterdam	UC Santa Barbara
Jon Miller	MIT	CfA
Jan-Uwe Ness	Hamburg	Arizona State
Elena Rossi	Cambridge	Colorado
David Sand	CalTech	U. Arizona

Nancy Remage Evans

Instruments: ACIS

Status of an ACIS Bakeout

The *Chandra* project decided in July 2004 to postpone indefinitely the bakeout of the ACIS instrument which had been tentatively scheduled for September 2004. There are two reasons for the postponement. The proposed bakeout intended to use additional heaters on the Science Instrument Module (SIM) to heat the ACIS aperture in the SIM and the top of the ACIS collimator to improve the effectiveness of the bakeout. A safety review of the use of these heaters revealed a concern that the heaters may not work as expected and may pose a threat to the other heaters on that circuit. The heaters in question were designed to be used on the first day of the mission in case the shuttle needed to return to earth with *Chandra* in the payload bay. They have not been used since the first day of the mission, but some of the other heaters on the circuit are used during normal operations. Second, further analysis of the rate at which the contaminant(s) have built up in the centers and edges of the Optical Blocking Filters (OBFs) indicates that the contaminant(s) might be less volatile than what was assumed in the simulations of the bakeout.

The *Chandra* project, led by the Project Science team at MSFC, has been simulating the effects of the bakeout without the additional heaters on the SIM and with different assumed volatilities for the contaminant(s). The project is evaluating the results of these simulations in order to decide if the outcome of the bakeout is likely to be positive. In addition, the ACIS team is planning additional irradiation tests on the ground to understand better the implications of a bakeout for the CCDs' performance.

The *Chandra* project will continue to investigate the feasibility of a bakeout of the ACIS instrument. At this time it is impossible to predict if this effort will result in a decision to bakeout the instrument.

Paul Plucinsky

Science Highlights: Chandra Ms Observation of Cassiopeia A

The most recent of the known supernova explosions in our Galaxy occurred more than 330 years ago in the constellation Cassiopeia. It was apparently so dim that it went unnoticed at the time, but since then, its remnant Cassiopeia A has become one of the best-observed astronomical objects at all wavelengths. Last spring, the *Chandra* Observatory took a 1 million-second look at Cas A with ACIS--the deepest X-ray view ever taken of this or any other supernova remnant.

This mammoth observation was executed in 9 OBSIDs between 14 April and 5 May 2004, except for a "short" 50 ks segment completed earlier in the year on 8 February. The observation produced approximately 300 million X-ray photons, most of which are shown in Figure 5. Three energy-selected images are color-coded and overlaid in Figure 6 to illustrate the remnant's distinct morphologies at different energies (Si He α in red, Fe Kα in blue, and 4-6 keV in green).

The deep Cas A observation makes the spectra of Cas A's fine knots, filaments, and diffuse emission accessible at or near *Chandra*'s angular resolution throughout the remnant. The knots and filaments are important keys to understanding the explosion that produced Cas A because most of them are glowing in X-ray emission from shock-heated ejecta. Moreover, their spectra are dominated by the very elements, Si and Fe, that are formed nearest the core of the star during the supernova explosion. Though theorists have been coming closer and closer to generating core-collapse explosions on their computers, successful simulated explosions have generally been elusive so far, and the actual mechanism or mechanisms of core-collapse remains incompletely understood. Though it is not likely that Cas A was a "typical" core-collapse explosion (if one even exists), it is a key target for studying core-collapse explosions because its central debris are much more accessible to us than in any other remnant.

<u>Cas A and Chandra</u>

From its beginnings, *Chandra* has been associated with Cas A, which was its first light target. That 5 ks snapshot immediately gave us a revolutionary new view of Cas A. First, it revealed the presence of a faint, bare, compact remnant near Cas A's center (Tananbaum et al. 1999). It was expected to exist because Cas A shows fast O-rich ejecta filaments that point to a core-collapse origin, but had not been previously detected. It had remained elusive until *Chandra* because it is faint and compact, rather than being a classical Crab-like pulsar surrounded by a bright synchrotron wind nebula. *Chandra* has since uncovered a number of other examples of faint, quiet neutron stars in supernova remnants (e.g., Kaspi et al. 2004). *Chandra* first light also showed that Fe ejecta in Cas A are located out beyond the Si ejecta at large radii in the southeast (Hughes et al. 2000; also see Figure 6), implying that the explosion was a turbulent one. The Fe was

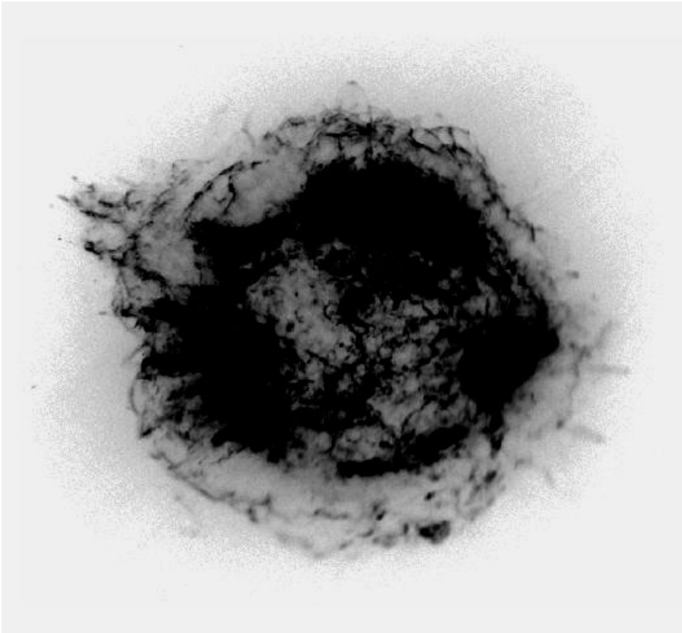

FIGURE 5: The mega-sec image of Cas A. In all the Cas A images the orientation is standard, N up, E on the left.

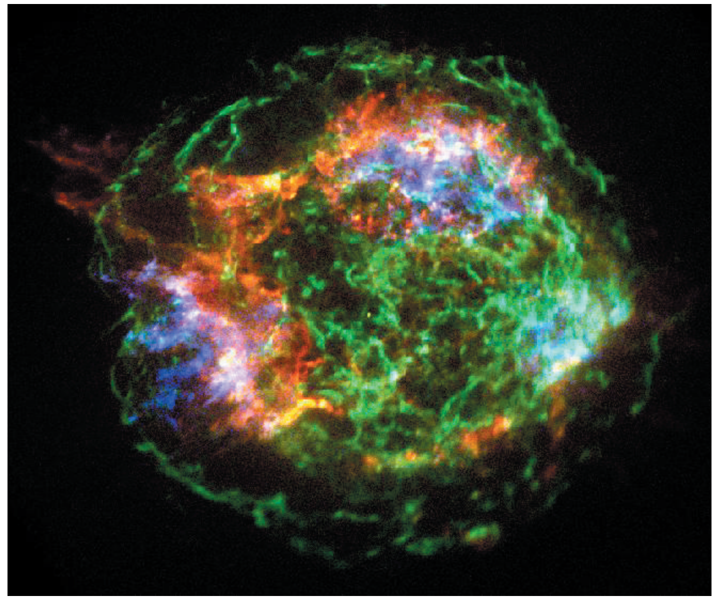

FIGURE 6: The Cas A image showing three energy bands in different colors (Si He α in red, Fe Kα in blue, and 4-6 keV in green).

formed in the hottest regions of the ejecta during the explosion, (i.e., just outside the neutron star) but now, at least some of the Fe is found out beyond elements ranging from O to Si to Ca, that were presumably formed in layers above the Fe. Further studies with XMM-Newton have confirmed that the Fe Doppler velocities in Cas A generally exceed those of Si even where the Fe and Si are projected to the same apparent radius (Willingale et al. 2002). This indicates that the Si-Fe turbulent overturn is widespread in Cas A.

Knots with a highly enhanced Fe composition are readily identified in the southeastern region of Cas A. These must have been produced by complete Si-burning, possibly with α- rich freezeout (when expansion at low densities quenches the nucleosynthesis in the presence of excess α particles). The primary product is ^{56}Ni decaying to ^{56}Fe, along with trace amounts of radioactive ^{44}Ti. In hard X-rays and γ-rays, the ^{44}Ti by-product of this process is also observed through the nuclear de-excitation lines of its decay products (Iyudin et al. 1994, Vink et al. 2001), but cannot be localized within the remnant. By modelling the hydrodynamics and plasma physics in conjuction with the *Chandra* spectra (Laming & Hwang 2003), it is inferred that the Fe is mixed outwards roughly to the position of ejecta at the Si-O boundary layer in the pre-supernova star. Hwang & Laming (2003) also identify a particular knot that appears to be almost pure Fe, and is thus inferred to have originated very close to the mass cut (the division between mass ejected in the explosion and mass falling back onto the neutron star).

The Long Ms View of Cas A

It will be many months and years before the information in the Ms observation of Cas A is fully mined, but our initial look has already raised some interesting issues. A remarkable (if faint) jet of high-velocity S ejecta is seen in the northeast region of the remnant in the optical emission, and *Chandra* revealed its X-ray Si ejecta counterpart early on (Hwang et al. 2000). The recent deep *Chandra* observation of Cas A confirms that the jet filaments in the northeast have even fainter counterparts in the southwest. These “counterjet” filaments are extremely faint, and do not extend as far as the northeast filaments, either out from the remnant or in to the center of the remnant. They can be seen in the over-exposed image in Figure 5 , as well as in the ratio image shown in Figure 7 (credit: Jacco Vink). This ratio image of photons selected by energy cuts at the Si He α blend relative to the Mg-Fe L region highlights the jet knots on both sides of the remnant. The images also show the relative position of the compact source and the jet axis: the compact source is distinctly to the south, in the direction of its motion (inferred by its position relative to the explosion center defined by the presumably undecelerated optically-emitting ejecta). This morphology is not restricted to X-rays, but was first seen in the optical ejecta (Fesen 2001) and is also evident in infrared dust emission (Hines et al. 2004). (The compact source is just visible as a bright dot in the center of Figure 6.)

Laming & Hwang (2003) showed that the spectra of knots in the vicinity of the jet (compared to knots elsewhere) were consistent with models where more explosion energy was deposited in the direction of the jet, suggesting a global asphericity in the deposition of explosion energy. The amount of asphericity was relatively modest however, at about a factor of two, so it remains to be determined what roles, if any, were played by the jets during the explosion, or if they were instead a by-product of the explosion (e.g., Burrows et al. 2004).

That the jet knots are actually ejecta seems evident, based on their thermal characteristics. If the jet-like morphology were instead caused by low density regions in the remnant’s circumstellar environment, the X-ray emission should correspond to significantly lower ionization ages (electron density times shock time) than those determined for these knots by spectral fitting (Hwang et al. 2004). The composition of the jet knots in the east compared to those in the west are remarkably similar: they are both dominated by strong, highly ionized Si, S, Ar, and Ca, plus some Fe. The Fe enrichment varies somewhat throughout the northeast jet, where composition differences may be readily probed. There is significant Fe line emission in some of the jet knots, but never the kind of Fe dominance that is seen in the Fe-rich southeast region. The enhanced explosion energies along the jet should have led to significant Fe nucleosynthesis, but most of the Fe is observed elsewhere in the remnant. Interestingly, the X-ray line spectra of the jets are remarkably similar to those reported in some gamma-ray burst afterglows (Reeves et al. 2002, Watson et al. 2003), though Cas A appears to have had a fairly normal total explosion energy of 2-4 x 10^{51} ergs.

Future Prospects

Our first look at the Ms data for *Chandra* has been fun, but there is an incredible wealth of data to explore---enough to keep many people busy for some years to come (volunteers are welcome!). The 5' remnant can be probed at virtually *Chandra* angular resolution, which translates to a vast number of spectra to characterize to build a comprehensive ejecta profile for the remnant. The jet knots and the Fe ejecta will be particularly important for obtaining clues to the nature of the explosion, including the kick imparted to the neutron star. Accomplishing these goals will require not only a large amount of data analysis, but also the development of models to interpret the X-ray spectra. These in turn will depend on improvements in both the X-ray spectral emission models and the development of realistic hydrodynamical models in cooperation with theorists. Although we have focused on the ejecta in this brief article, the deep *Chandra* data also promise to shed light on the apparently nonthermal filaments that outline the remnant. For the point source, it yielded a high signal-to-noise spectrum, which is well-characterized by a black-body (Slane et al. in prep, 2005). In a few years' time, we expect these data will have helped us to gain valuable insights into how core collapse explosions proceed.

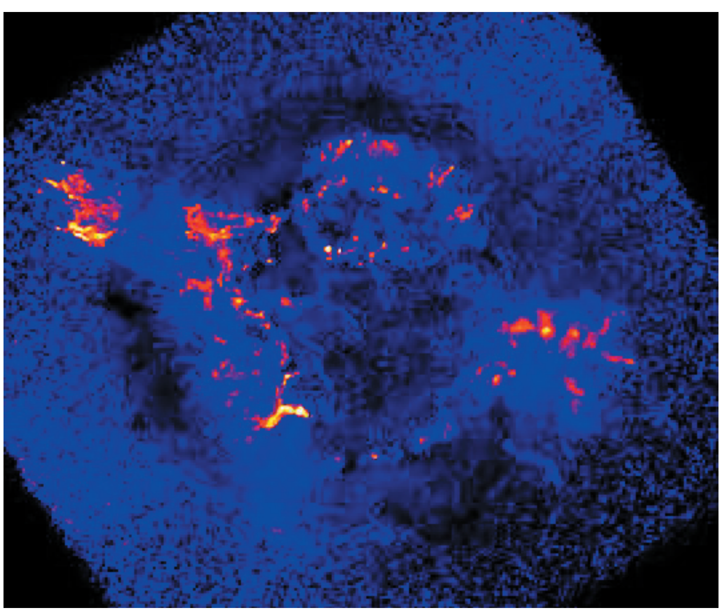

FIGURE 7: The ratio image of photons at the Si He α blend and the Mg-Fe L region. (credit: Jacco Vink)

Una Hwang and Martin Laming

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Instruments: HRC

Status of Flight Instrument

The HRC continues to function smoothly with no major problems or anomalies. Analysis of in-flight and laboratory calibration data is on-going. Regular observations of AR Lac indicate a noticeable decrease in the gain of the MCPs (microchannel plates) in both detectors at the position of best focus. The magnitude of the droop is not sufficient to make any significant difference in the performance or operation of the flight instrument. There are no plans to raise the MCP voltage to increase the gain for at least several more years. The shutter failure described in the previous Newsletter has been traced to a failure in a relay. Because of concern that the shutter could get stuck in the 'IN' position, all future use of the HRC shutters has been discontinued.

Regular use of the HRC door has been discontinued as well because it is controlled by the same type of relay. Because the HRC sits at the telescope focus during radiation belt passages, this has increased the radiation dose received by the HRC. The HRC is an intrinsically radiation hard detector, and there has been no indication that this increased dose has had any effect on the flight instrument. The primary concern about this enhanced radiation dose is longterm degradation of the polyimide in the UVIS. Such a degradation would show up as an increased UV sensitivity long before it was noticeable in the X-ray band. Regular calibration/monitoring observations of Vega have found no change in the UV sensitivity of either the HRC-I or HRC-S. A study of the feasibility of using the HRC anti-coincidence shield as a replacement for the EPHIN to monitor the particle environment has been completed. It has been determined that the anti-co rates can be used to safe the instruments prior to entry into the radiation belt. Plans are currently being drawn up to implement this when the EPHIN can no longer monitor the particle background.

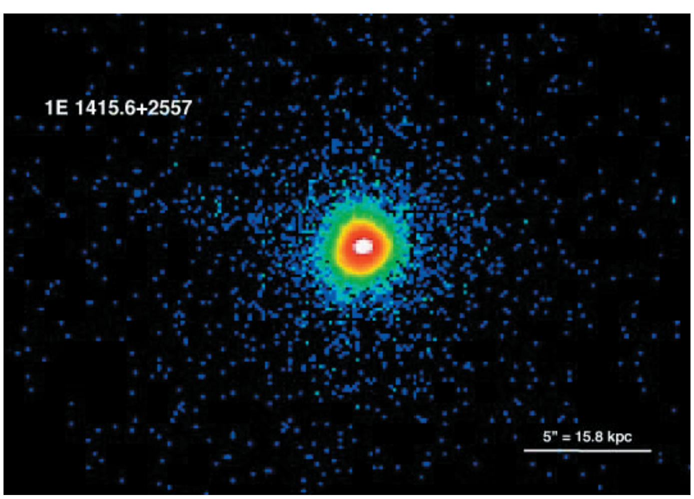

FIGURE 8: The HRC-I image of the BL Lac 1E 1415.6+2557

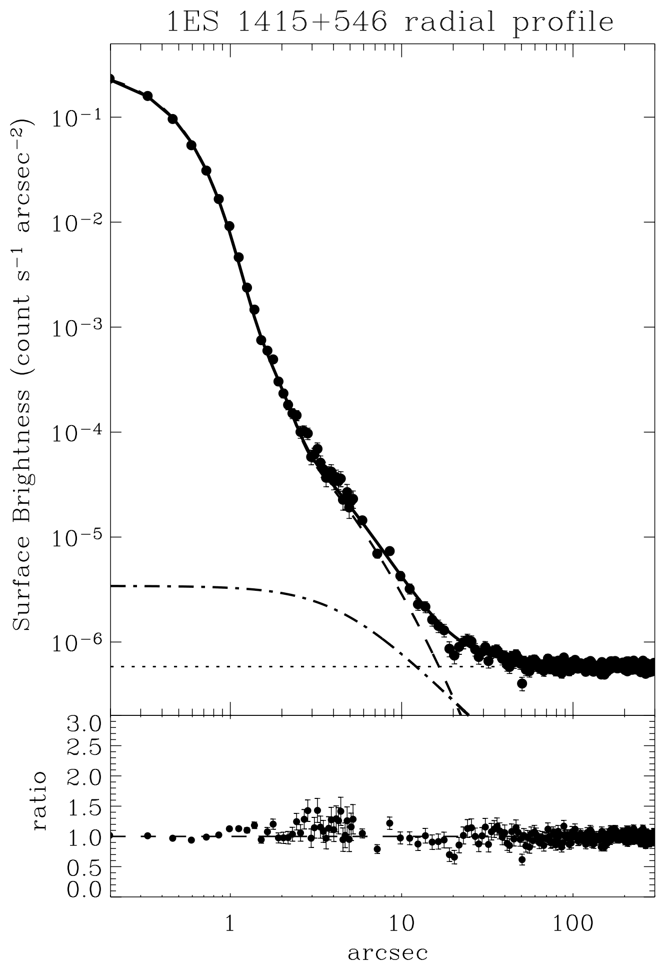

FIGURE 9: The radial profile of 1E 1415.6+2557 (Fig. 1). The dashed line is the instrument PSF, and the dot-dashed line the beta model. The continuous thick line is the total model, while the thin dotted line is the background. The residual of the best-fit model are shown in the bottom panel.

Science Highlights

The HRC has been used to make a wide range of scientific investigations over the past year. Here we present preliminary results from two of them: an HRC survey of BL Lacs to search for extended emission due to coronal gas, and HRC monitoring of the X-ray binary population of M31 and detection of an X-ray counterpart to M31*.

Gaseous Environments of BL Lacs

Rita Sambruna and Davide Donato of George Mason University performed X-ray imaging observations of 6 higher-redshift BL Lacs with the HRC to study the gaseous environment

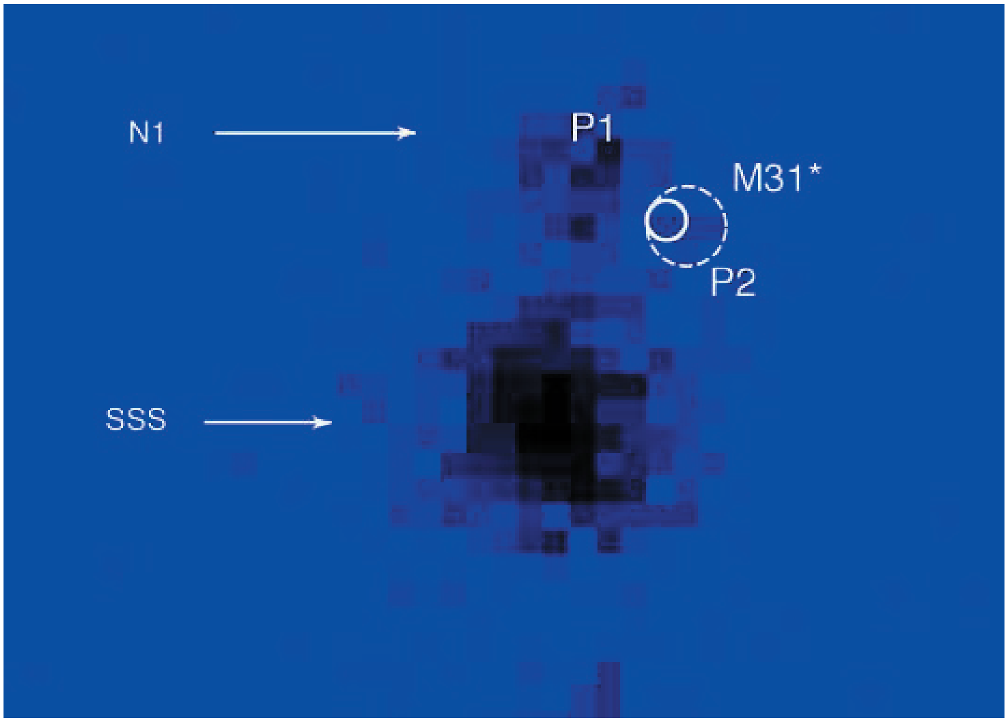

FIGURE 10: The HRC-I image of the center of M31. See text for discussion.

around the nucleus. The sample extends an AO1 sample to higher luminosities in order to probe the circumnuclear environs as a function of core power and distance. The science goal of this investigation is to confirm the presence of diffuse hot halos around the cores of BL Lacs, testing unification models which unify these sources with FRI galaxies.

The presence of this halo can be assessed fitting the surface brightness profile of each source using an analytical model of the instrument Point Spread Function (PSF) with or without an additional beta model, necessary to describe the diffuse soft X-ray emission. The significance of this additional model can be determined using an F-test.

The shape of the instrument PSF is obtained fitting the surface brightness profile of different point-like sources with a 9-parameters analytical formula. To model the PSF of a point source, we considered three candidates: an observed star (AR Lac), a simulated BL Lacertae object (using Chart and MARX), and an observed distant BL Lacertae object. The results obtained using the third candidate are the best to fit their observations.

Figures 8 and 9 show the HRC-I raw image and the radial profile, respectively, of one of the most promising targets, 1E 1415.6+2557. The dashed line is the instrument PSF, and the dot-dashed line the beta model. The continuous thick line is the total model, while the thin dotted line is the background. The residual of the best-fit model are shown in the bottom panel. The beta model is detected with high (> 99.9 %) significance. The core radius for this source is ~4" (corresponding to 12.6 kpc) and the beta parameter is 0.45.

Monitoring M31 - X-ray Detection of M31*

Michael Garcia and co-workers continue to monitor the X-ray point source population of the nearby galaxy M31. The HRC has been used to resolve what is believed to be the X-ray counterpart of M31* from the diffuse emission and point sources near the center of the galaxy. A 47 ks HRC-I image of the M31 nucleus, with 1/8" pixels, is shown in Figure 10. The source at the top is N1, the brighter source in the center is the super-soft source SSS. The position of M31* is marked with a small heavy circle (0.1" radius = 1σ position error) in the center. The source outlined with the dashed circle is clearly consistent with the position of M31*. There are 13 counts within this dashed circle. The approximate locations of the diffuse double nucleus P1/P2 are indicated. ACIS observations are consistent with the apparent flux from M31*, but do not appear to resolve it from the nearby bright sources and diffuse surrounding emission.

Ralph Kraft & Almus Kenter

Instruments: LETG

Nearly Calibrated

At a *Chandra* workshop over a year ago, I was recounting progress in LETG calibration to a colleague and caught myself saying that the instrument was "nearly calibrated". This immediately brought to mind sayings of my grandmother's, one of which was "in my day you could go to town with threepence ha'penny, buy an X-ray mirror and detector system and launch it all and still have change for a fish n chip supper". (That times have changed was dramatically brought home on July 23, 1999 with the launch of *Chandra* - no change at all from threepence ha'penny and none of us got a fish n chip supper.) The saying that I remembered though was "nearly's not half way!". As in "yes, grandma, we've devised a cross-correlation technique to map out imaging non-linearities in the detector and the analysis is nearly finished". "Well my boy, nearly's not half way! Now shut up and finish your tripe and cabbage".

By "nearly calibrated", I had meant that the remaining significant problems with understanding the performance - effective area, dispersion relation and line response function - seemed tractable and that we were well on the way to having new calibration products available. It has of course taken until now to get the final calibration products released.

Revised Diffraction Efficiencies

First came new LETG diffraction efficiencies for higher orders, which were released in August 2004. It had become apparent that the effective area in the vicinity of edges of instrumental origin seen in the higher orders in continuum sources was not correct. In principle, one could tease out corrections to the diffraction efficiencies using LETG+ACIS-S in-flight observations. Such an analysis was made more entertaining by given wavelengths in different orders appearing on different chips, both front- and back-illuminated, and by significant pile-up in the brightest spectral regions. Residual absolute ACIS QE uncertainties rendered the exercise one for abstract artistic wonder as much as for improving calibration. Long-awaited ACIS QE revisions, however, and further pile-up correction refinements enabled Brad Wargelin to derive corrections to efficiencies for orders 2-7. Corrections to even orders were largest - not surprising since these efficiencies should be precisely zero for a perfectly manufactured grating, and the small but finite efficiencies are painfully sensitive to small departures from perfection. The correction factor for 2nd order is the largest and is illustrated as a function of wavelength in Figure 11 (see also Wargelin et al. 2004).

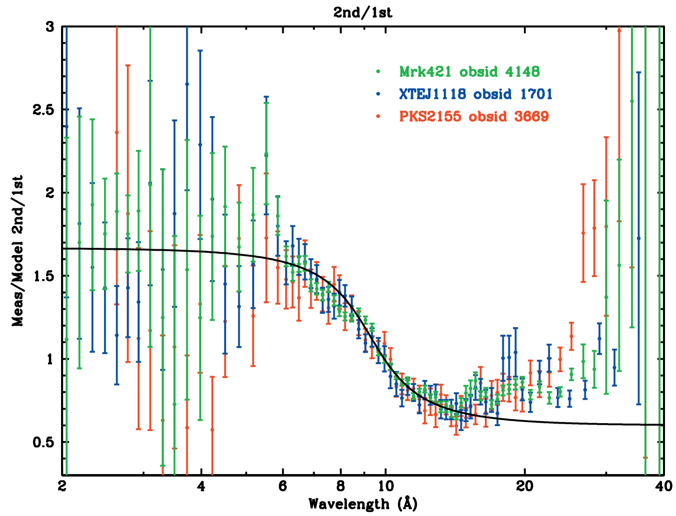

FIGURE 11: Comparison between measured and model ratios of 2nd/1st order LETG diffraction efficiencies (figure courtesy of Brad Wargelin).

Quantum Efficiency and its Uniformity

Uncertainties in the HRC-S QE at launch meant that the effective area of this instrument has largely been re-calibrated in-flight. This process involved use of the LETG to obtain dispersed spectra of hot white dwarfs for use as standard candles at longer wavelengths, and bright, power law continua toward shorter wavelengths. Revision of the diffraction efficiencies meant that the calibration of the HRC-S QE was no longer perfectly consistent with observations and thus also needed revision. At the same time, work was already underway to use flight data to improve the laboratory-based QE uniformity map of the detector. Both the revised QE uniformity map and QE itself were released in CALDB v3.0.1.

Correcting HRC-S Imaging Non-Linearities

In earlier Newsletters, I have described some artifacts of the HRC-S imaging characteristics that lead to distortion and non-linearity of the dispersion relation and distortion of line profiles. We have been working on a way to correct for these effects for some time. These distortions probably arise because of subtle differences in the different amplification stages applied to different detector *taps* (essentially the different wires in the cross-grid used to detect the charge cloud generated by a photon event and subsequent electron cascade in the microchannel plate). *Ab initio* correction for this effect might have been possible if we could perform further laboratory experiments on the detector, but flight data are almost certainly insufficient for this. We are therefore left with the problem of deriving empirical corrections from what flight data we have and can realistically obtain.

Given about a megasecond of calibration time, it would be possible to observe a bright line source, such as Capella, at different off-axis angles and use the detector positions of spectral lines with known wavelengths to map out fairly completely the event position distortions. As it is, existing GO and calibration observations have allowed us to do this to a limited extent: we have been able to derive event position corrections over most of the central plate and some small regions of the outer plates. A *Perl* script written by Pete ``Wonderscript'' Ratzlaff to apply these corrections to standard level 1.5 or 2.0 files was released on the CXC user-contributed software site in December 2004 (http://cxc.harvard.edu/cont-soft/software/corrlam.1.0.html).

The effects of applying this script are quite visible for some lines, as illustrated for the H-like O Lyα doublet seen in Capella in Figure 12.

We continue to work to refine the event position corrections, and the software group is currently attempting to ingest the algorithm and associated correction data into CIAO for more seamless application.

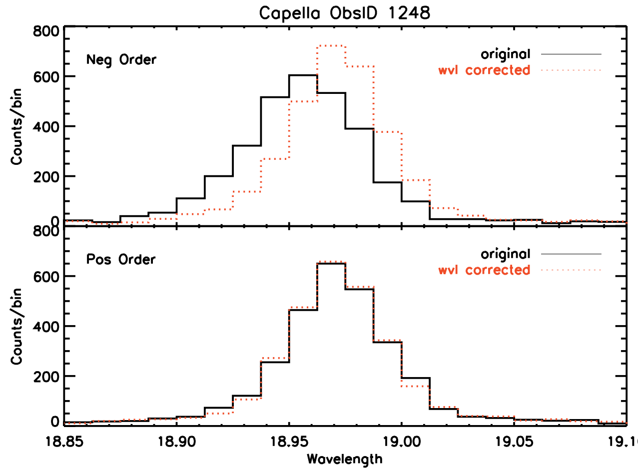

FIGURE 12: Capella line profiles for H-like O Lyα in negative and positive orders. Plotted in solid black are the standard-processed data, and in dotted red are the wavelength-corrected data. The improvement in the corrected data is more drastic for some lines than in others. In general, the wavelength-corrected data have smaller line widths, sharper peaks, and more accurate wavelength positions.

The X-ray Forest as a Renewable Resource

It's getting more and more difficult for us stellar physicists to make fun of cosmology these days. The X-ray analogue of the Lyman-α forest is a bit more tricky to observe than its UV-optical counterpart. The resolving power of the LETGS is 300-500 in the region of the O, N and C lines of interest, and the intrinsic absorption line profiles are far from being resolved. Contrast between lines and continuum is therefore much reduced and photons entering the modest effective area to populate the continuum with signal are somewhat sparse - you can't see the forest for the trees.

Nevertheless, Nicastro et al. (2005) have recently succeeded in detecting X-ray absorption features in the warm-hot phase of the intergalactic medium (WHIM) in the line-of-sight toward the blazar Mkn 421 (Figure 13). The observations were obtained on 26-27 October 2002 and 1-2 July 2003 as a target of opportunity when the blazar was especially bright in X-rays, and provide insight into that thorny problem of the ``missing baryons''. While the number of baryons detected at early times (redshifts $z > 2$) is in accord with recent cosmological measurements, and with predictions from studies of the production of the lightest elements, closer to our own epoch ($z < 2$) the number of baryons detected add up to just over half (~55%) that expected - about ~45% appear to be missing. The amount of hot, ionized matter seen in absorption in the LETGS spectra indicates that this phase, which is essentially invisible at other wavelengths, has a mass density consistent, within the uncertainties, with the mass density of the missing baryons. The missing baryons might then have been found. Or nearly, at least.

Observer and proposer information and news on the performance of the Chandra LETGS can be found on the instruments and calibration page: http://cxc.harvard.edu/cal/Links/Letg/User/

Jeremy Drake

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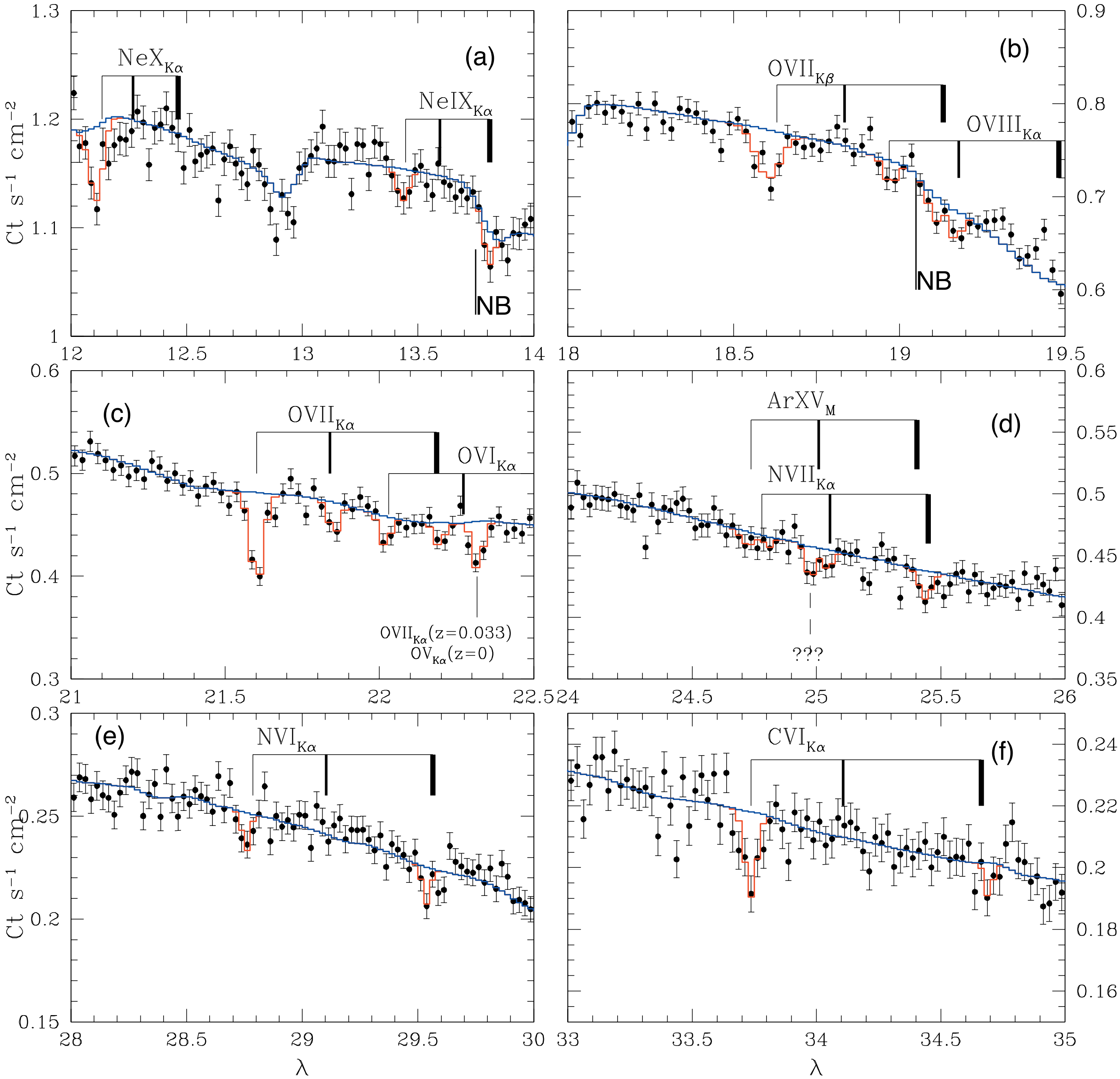

FIGURE 13: The WHIM absorption in the Chandra LETG spectrum of Mkn 421. Six portions of the LETG spectrum of Mkn 421 along with its best-fitting continuum plus narrow absorption model (solid line), centered around the rest wavelengths of the Ne IX Ne X Ka (a), O VIII Ka (b), O VII Ka (c), N VII Ka (d), N VI Ka (e) and C VI Ka (f) transitions are shown. This spectrum contains a total of 5,000 counts per resolution element in the continuum at 21Å (Nicastro et al., 2005).

Instruments: HETG

HETG Calibration

There has been good calibration progress for the HETG spectrometer (HETGS = HRMA+HETG+ACIS-S) as described in the Chandra Calibration Workshop 2004, presentations to the Chandra Users Committee, and on the CXC Calibration web pages. Specifically, the ACIS contamination thickness is now characterized in the CALDB, varying with both time in the mission and with location on the ACIS arrays; the ACIS "FI/BI" QE issue has been reduced from a 15% effect to < 5%; and the HRMA "Ir-M edge" 10% area jump at 2.075 keV can be reasonably modeled by a constant 17Å layer of hydrocarbon on the HRMA. With these issues solved we are at the point of cross-calibrating HEG and MEG effective areas by adjusting their diffraction efficiencies with energy; note, however, that this is at most a 7% effect.

In terms of geometry, and hence resolving power and wavelength scale, we have measured and updated the ACIS-S

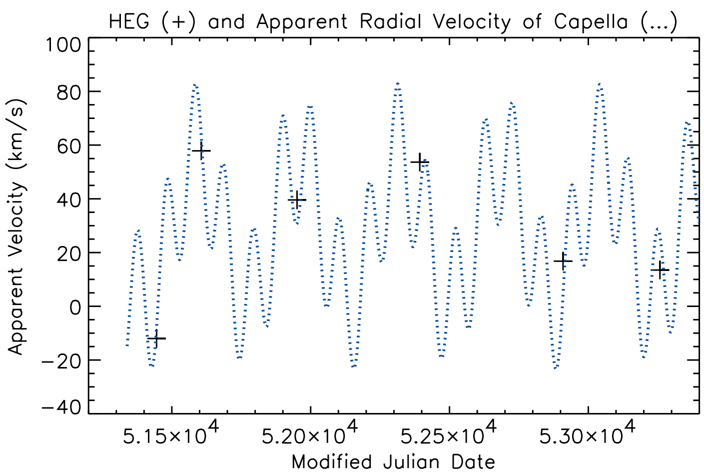

FIGURE 14: Predicted variations in our Capella line of sight velocity over five years of Chandra observations. The HEG measured values are shown by the "+"s.

chip locations to the 0.2 pixel level (Ishibashi and Dewey 2004) and in the process demonstrated the stability of the HETGS wavelength scale to better than a part in ten thousand from observation to observation over the mission; see the Capella velocity example below. This improved geometry allowed us to have confidence in calibrating the HEG and MEG wavelength scales and we have adjusted the MEG period to 4001.95Å; a small change equivalent to a 40 km/s velocity shift.

HETG Science: X-rays from Moving Bodies

In one of his 1905 papers, Einstein wrote: "... assume the quantity c to be a universal constant - the velocity of light in

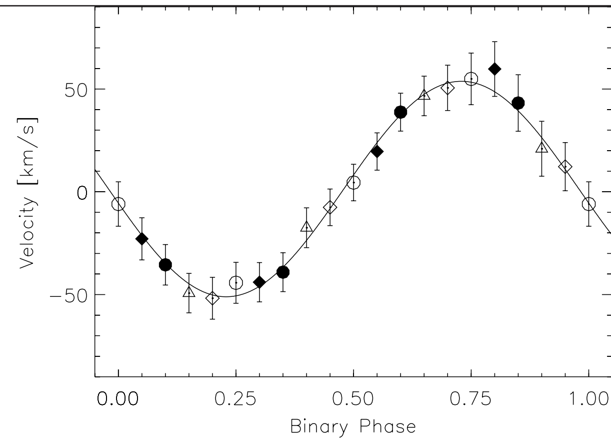

FIGURE 15: The ≈60 km/s velocity amplitude of the CV EX Hya is measured with the HETGS. (From Hoogerwerf et al 2004)

empty space." And further he notes that "... the velocity of light in our theory plays the part, physically, of an infinitely great velocity." In astrophysically useful units this "infinite" velocity is a mere 6-digit figure: 299,792 km/s. How does this compare with velocities of everyday life? We walk at a speed of about 0.001 km/s; fast cars and fast baseballs go at around 0.04 km/s; commercial aircraft, sound, and the rotation of the surface of the earth are all in the range of 0.20 to 0.45 km/s. Perhaps the fastest terrestrial speed is obtained by Superman, exceeding 1 km/s.

Beyond the Earth, greater velocities are common becoming a significant fraction of c resulting in Doppler shifts of spectral lines that can be measured with the HETGS. The examples below cover the range β=v/c from 10^{-4} to 0.27.

In calibration observations of the binary star system Capella made yearly with the HETGS, the combined effect of the Earth's orbital motion and the Capella 104 day period, each of ≈ 30 km/s amplitude, produces a small but measurable shift in the wavelength of its spectral lines, Figure 14. Other binary systems have been measured with the HETGS. For example, the white dwarf system EX Hydrae (Hoogerwerf et al. 2004), with a 1.63 hour period, is shown in Figure 15; the velocity measurement allowed a very accurate determination of the white dwarf's mass. Although in these two examples the orbits show sinusoidal shapes,

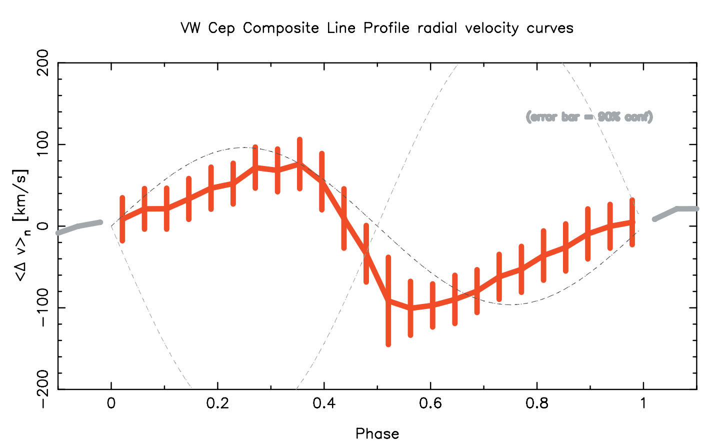

FIGURE 16: Velocity vs orbital phase for the contact binary VW Cep. Note that the velocity centroid does not exactly mimic the expected orbital velocity curve. (Courtesy D. Huenemoerder)

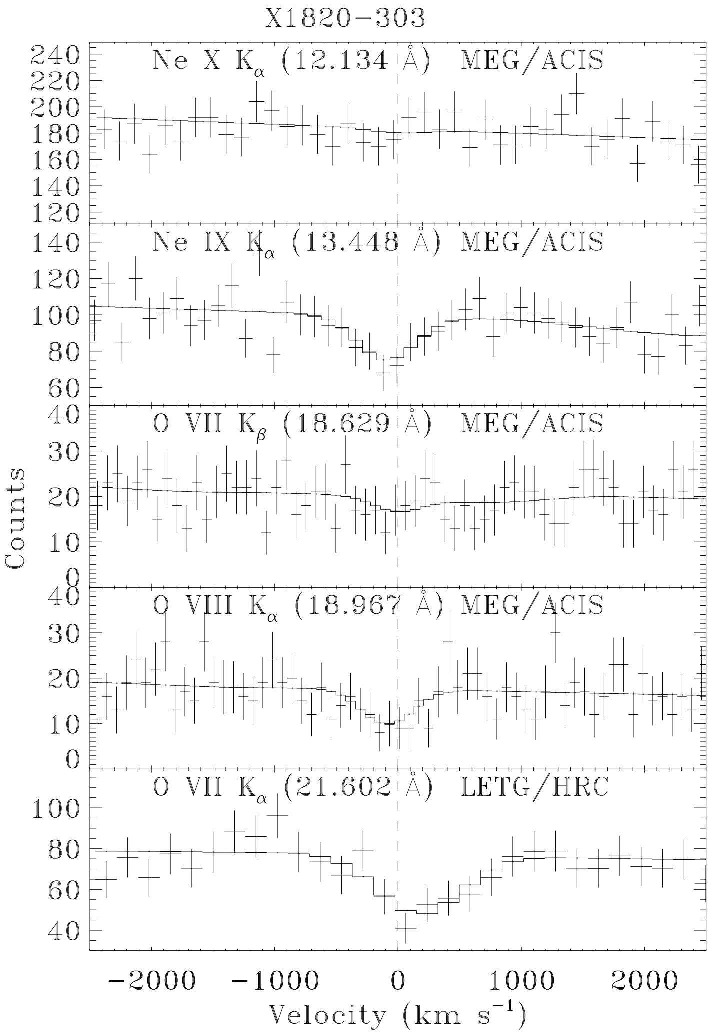

FIGURE 17: Absorption at v = 0 is seen along the line-of-sight to X1820-303, probing the hot interstellar medium, HISM, around our Galaxy. The data are consistent with an HISM temperature of log T ≈ 6.4 K. (From Yao et al 2005)

the velocity signature need not be so simple as the case of the contact binary VW Cep with a period of 6.72 hours shows, Figure 16. This shape is likely due to the geometric complexity of the synchronized, distorted, and partially eclipsing components of the system. The binary Algol (Chung et al. 2004) shows an amplitude of ≈ 180 km/s for the X-ray emitting material and suggests that the emission is "not perfectly centered on Algol B, but is shifted slightly inward toward the primary star".

Velocities in the few thousand km/s range are seen in young supernova remnants, for example E0102 (Flanagan et al. 2004) shows 2000 km/s velocity effects in its Ne X emission observed with the HETGS. The brightening SNR 1987A is expanding with a speed of 4167 km/s (Park et el. 2004) - will Doppler effects be seen from this source in *Chandra* gratings data? Stay tuned. Perhaps the highest discrete, rest-frame velocity material seen with the HETGS are the oppositely directed jets of the binary system SS 433 which travel at ≈ 80,000 km/s or 0.27*c* (Marshall et al. 2002; Newsletter Issue 8). Additional observations of this source, e.g. during partial jet eclipse, are helping to study the jet structure (*Chandra* Press Release, 5 January 2004; http://chandra.harvard.edu/press/04_releases/press_010504.html).

Ionized Absorption

The previous examples involved the observation of emission lines from hot plasmas. The existance and motion of hot plasma can also be detected in absorption with the plasma along the line-of-sight to an X-ray emitter. One such plasma is the hot interstellar medium, HISM, which surrounds our Galaxy. Because this gas is essentially at rest, it can be detected as absorption lines at zero-velocity in the spectra of bright Galactic and extra-Galactic sources (Yao et al. 2005). Figure 17 shows data from the binary X1820-303 and a simultaneous model fit to five X-ray absorption features. Adopting the ISM abundances of Wilms et al. (2000) the main free parameters are the total column density and the plasma temperature, assuming collisional equilibrium. By measuring the column density to a variety of sources at various distances and directions the extent and geometry of the HISM is coming into focus.

Ionized absorption lines are also seen in binary systems, e.g., the P Cygni profile seen in Cir X-1 (Newsletter Issue 8.) More recently, a 400 km/s outflowing disk wind is indicated in the HETG spectrum of the low-mass X-ray binary GX 13+1 where K absorption lines are seen from hydrogen-like Fe, Mn, Cr, Ca, Ar, S, Si, and Mg ions (Ueda et al. 2004). A somewhat higher velocity is inferred for the Seyfert 1 galaxy NGC 3516 (Turner et al. 2005.) Figure 18 shows allowed regions for several absorption lines plotted in the two parameter space of line centroid (Observed Redshift) and width (Velocity Dispersion); outflow velocities ≈1000 km/s are indicated. Finally, in the HETG spectrum of the Seyfert 2, IRAS 18325-5926, we believe we are seeing Fe absorption in a highly ionized outflow with velocity of order 25,000 km/s, or ≈ 0.1*c*, Figure 19. Now, that's a wind.

Dan Dewey

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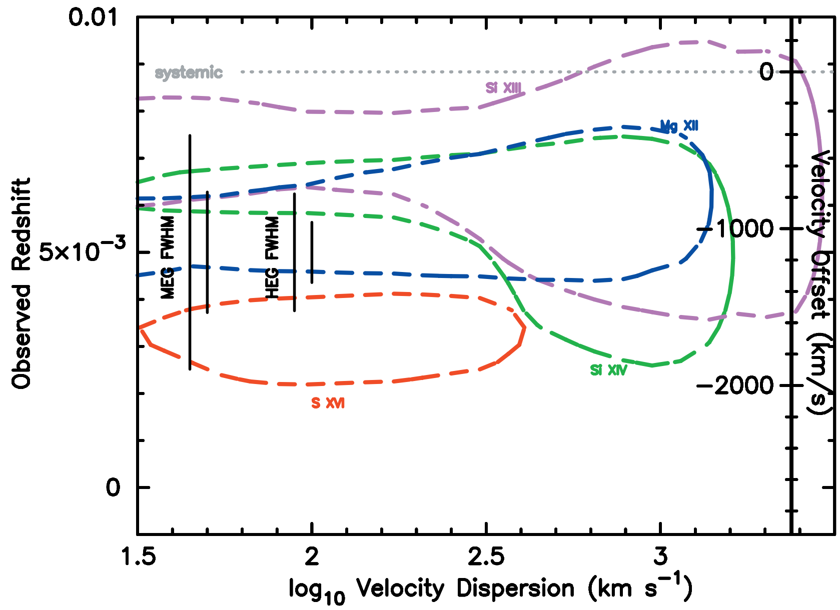


FIGURE 18: Confidence contours (90%) are shown for absorption lines detected with the HETGS in NGC 3516. Bars indicating the FWHM of the HEG and MEG are shown at left for the S XVI and Mg XII lines. (From Turner et al 2005)

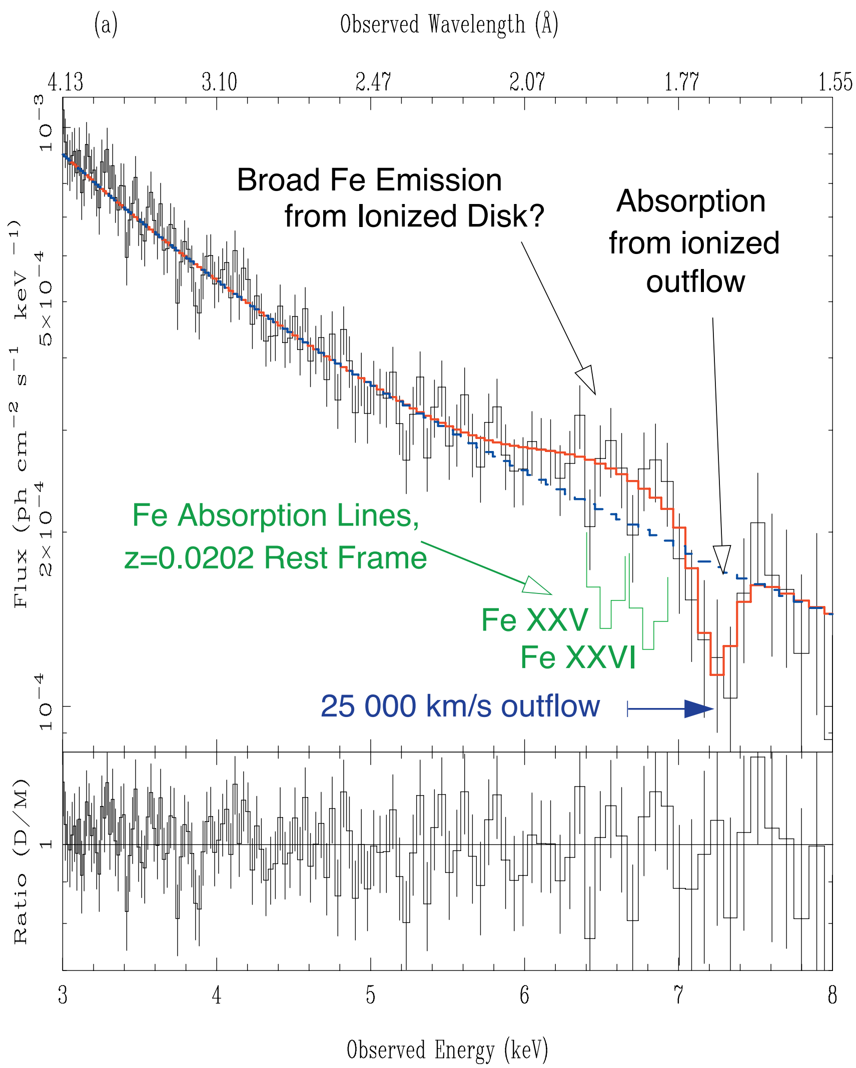


FIGURE 19: A tantalizing absorption feature in the spectrum of Seyfert 2, IRAS 18325-5926, could have its origin in a highly ionized outflow with a velocity of order 0.1*c*. (Courtesy J.C. Lee)

Chandra Operations: Warming Makes Propellant Lines Colder!

Since last December, *Chandra* mission planning guidelines prohibit observations which point greater than 170 degrees from the sun. This does not exclude the possibility of pointing at any celestial position, but does potentially restrict constrained observations. For example, a point on the ecliptic plane will be inaccessible for 24 days while it is situated opposite the sun, and simultaneous observations with optical observatories will not be possible for targets near zenith at local midnight.

This exclusion has been implemented to prevent any possibility of freezing two hydrazine propellant lines, monitored by thermistors PLINE03 and PLINE04. Ironically, the possibility has arisen because of a warming trend in a third propellant line, with thermistor PLINE02. The explanation is that the heater circuit which warms all three lines is controlled by a single thermostat near PLINE02. By design, it was expected that PLINE02 would be the coolest of the three, and this was indeed the case for the first several years of the mission. This is no longer the case, as *Chandra* is generally becoming warmer through the years due to the degradation of its multi-layer insulation.

Hydrazine freezes at 35 deg F, and the thermal control was set so that the lines would never fall below 40 deg F. This is a hardware setting which cannot be altered. About a year ago, NGST Flight Operations Team engineers noticed PLINE03 and PLINE04 dipping below 45 deg F for the first time. By last November, 18 such cases had been observed, with temperatures reaching as low as 42 deg F. It was established that these cool excursions were correlated with *Chandra*'s pitch angle, occurring as low as 158 deg pitch from the sun. At that time we therefore established an immediate, temporary restriction against pitch angles greater than 150 deg from the sun.

Hydrazine contracts as it freezes. This allows more liquid to flow into the resulting void and also freeze. When the lines subsequently warm up, they are not expected to thaw uniformly, so that the liquid expands against the remaining frozen "plug" and stresses the walls of the pipe. In ground testing, repeated such cycles have been observed to eventually split the line. It is impossible to analyze the exact consequences, but obviously release of such a contaminant into the *Chandra* HRMA or equipment volumes could have disastrous consequences, and must absolutely be avoided.

Further analysis involving the original design engineers has established that the thermistors do read the coldest portion of the lines. With all tolerances on local gradients, thermistor errors and quantization, and a temperature difference in the event that the primary heater circuit failed over to the redundant heater/thermostat, the hydrazine will not freeze as long as the temperature reading remains above 42.5 deg F. Analysis of current thermal performance shows that this can be achieved allowing pitch angles as large as 170 deg F, hence our current operational limit.

Although this restriction excludes only a very small percentage of the sky, about 1.1%, it has the additional effect of constricting the regions where we can point to cool our radiation monitor, EPHIN, prior to dwelling at attitudes where EPHIN is subject to overheating. We will monitor performance as the mission proceeds. Continued change in thermal performance could lead to greater restriction on the maximum pitch angle. However, the team is also investigating special operational scenarios which could allow some targets at attitudes beyond 170 deg.
(Chandra Electronic Bulletins, such as Bulletin #35, will continue to update users on restrictions. -Editor)

Dan Schwartz, Sabina Bucher, Dan Shropshire

Data Analysis: Do I Need To Reprocess My Data?

This is the question that most users of the "*Chandra* Interactive Analysis of Observations" (CIAO) software are confronted with every time a new release of CIAO or the *Chandra* Calibration Database (CALDB) appears on the horizon. It is an even more pressing issue if a paper is about to be submitted with data analysed with an "old" version of the software or "old" calibration files.

Relax! The answer is often: "No, you do not need to reprocess!" Depending on the nature of the release, however, the response could be: "If you reprocess, you will gain X amount of accuracy." In rare cases we may also say: "All users should reprocess to take advantage of this improvement."

In order to determine whether or not to reprocess your particular dataset, there are two pieces of information needed:

1. The version of the software used to process the data in the first place, and the version of the CALDB used to create the data.

The software and CALDB version information are stored in the file header in the ASCDSVER and CALDBVER keywords, respectively. The software version listed will either be the standard data processing (SDP, aka "the pipeline") version number (e.g. "6.6.0") or the version of CIAO used to create the data product (e.g. "CIAO 3.2 Thursday, December 2, 2004").

The "Note on Processing Versions" [http://cxc.harvard.edu/ciao/threads/reprocessed/] has more information.

2. A list of the changes in the new CIAO and CALDB releases.

The CIAO and CALDB release notes contain a complete listing of all changes in each update. As of CIAO 3.2, the CIAO release notes also contain a special section called "How CIAO 3.2 and CALDB 3.0.0 Affect Your Analysis". This section of the release notes describes the tool and calibration changes that affect analyses in progress, i.e. any processing steps which should be run again for greater accuracy.

In the future, this information will be also organized by science category and instrument, such as "point source, ACIS-S, no grating". The page will be updated with relevant information at every CIAO and CALDB release, so users have a one-stop location to determine if an analysis task needs to be redone.

CIAO release notes: http://cxc.harvard.edu/ciao/releasenotes/
CALDB release notes: http://cxc.harvard.edu/caldb/downloads/releasenotes.html

When reprocessing is the best or worst decision

There are two extremes when discussing reprocessing: brand new and very old data. In this case, "new" and "old" are relative to the current version of SDP.

Data that a user has just received from the *Chandra* X-Ray Center - e.g. General Observing (GO) projects - has been processed with the most recent version of SDP. These data have been created with the newest tools and calibration. In some cases, it is better than what can be achieved in CIAO, as updates often get added to SDP sooner than to a CIAO release.

The only reason a user would reprocess this data is to change any of the default parameter settings used in SDP. For instance, an ACIS dataset could be reprocessed to look at the difference between CTI-corrected (the pipeline default) and CTI-uncorrected data.

At the other extreme is very old data. If a user is working with a dataset that was last processed a few years ago, it may be a better use of time to simply reprocess the data rather than work out what calibration files or tools have been changed since then.

References on how to reprocess data in CIAO:
Analysis Guides
http://cxc.harvard.edu/ciao/guides/
Data Preparation threads
http://cxc.harvard.edu/ciao/threads/data.html
For the most general case, refer to the
Create a New Level=2 Event File
http://cxc.harvard.edu/ciao/threads/createL2/

Recent CIAO and CALDB Releases

- CIAO 3.2 and CALDB 3.0.0: 15 December 2004

The CIAO 3.2 software release contains a new tool for creating ACIS response matrices (mkacisrmf), four new ACIS hot pixel tools, and an enhanced ARDLIB to handle ACIS spatial contamination. It also includes the latest proposal planning tools for Chandra Cycle 7. CALDB 3.0.0 contains essential elements for CIAO 3.2 to work properly: new ACIS response, gain, and spatially-dependent CONTAM files for making RMFs, ARFs, GARFs, and exposure maps.

- CIAO 3.2.1 and CALDB 3.0.1: 10 February 2005

The CIAO 3.2.1 patch contains updated versions of the acis_build_badpix and acis_run_hotpix tools. CALDB 3.0.1 includes new HRC-S QE and QE Uniformity files, as well as improved ACIS-S chip corner positions.

Please note that although they were released at the same time, the CIAO 3.2.1 patch does NOT require the CALDB 3.0.1 upgrade. The two releases function independently.

See the release notes for complete details.
CIAO: http://cxc.harvard.edu/ciao/releasenotes/
CALDB: http://cxc.harvard.edu/caldb/downloads/releasenotes.html

CIAO and CALDB are available for download from:
http://cxc.harvard.edu/ciao/download/

They are also available from the European mirror site:
http://ledas-cxc.star.le.ac.uk/ciao/download/

Elizabeth Galle and Antonella Fruscione, on behalf of the CIAO Development team

HELPDESK

Questions can be sent to the CXC by using the HelpDesk facility. The HelpDesk is reached from a link on the header of the CXC web pages (i.e., at http://cxc.harvard.edu). The information entered into the form is passed into our HelpDesk Archive; we can easily track pending items with this tool. An introduction to the HelpDesk system is available from this same link.

Questions can also be sent to the HelpDesk staff using email (cxchelp@cfa.harvard.edu), but we prefer submissions through the web.

Chandra Data Archive: New Procedures and New Services

Over the past months several new features have been introduced for the *Chandra* Data Archive. Some of these were already announced in *Chandra* Bulletin 33, but it seemed helpful to repeat the information and put it all together for the *Chandra* Newsletter. The new webpages mentioned below are also linked from the CDA homepage at

http://cxc.harvard.edu/cda/

V&V Reports and Data Distribution

In December 2004, a new format was introduced for the Verification and Validation (V&V) reports. They are now formatted as PDF files and included in the primary data products package. In addition, the secondary package contains a V&V reference document (also PDF) that is considerably longer and contains much more detail about the data.

The on-line data distribution no longer works through pre-packaged tar files that are put in an ftp staging area. Users (PIs and Observers) are still being notified that new data have become available, but they are directed to retrieve the data through WebChaSeR using its login feature (either the proposal or PI account) as long as the data are proprietary; the e-mail message contains a reminder of relevant information required for downloading the data. Please note that anybody can retrieve the non-proprietary data products for a proprietary observation. But one needs to be logged in to the authorized PI or proposal account in order to have the proprietary products included in the retrieval package (in particular, the event files and the images). WebChaSeR, on its login dialog box, provides an option to send users a reminder of their passwords. Account names are proposal numbers, for proposal accounts. or (usually) first initial plus full last name (all lower case), for PI accounts.

Dataset Identifiers

The journals managed by the AAS now provide authors with a mechanism that allows them to establish links between their articles and the observational data that are presented in them. We would like to urge our users to take full advantage of this opportunity to incorporate a meaningful linkage in their future papers. The links will automatically be entered into the *Chandra* Bibliographic Database. An explanation of the system and the syntax of the identifiers is provided at:

http://cxc.harvard.edu/cda/datasetid.html

Special Data Services Requests

The CXC-DS Operational groups provide various services through web interfaces, such as browsing the archive and the bibliographic database and retrieving data products. However, there are also a number of services that are not covered by web interfaces and require incidental e-mail messages instead. We have consolidated the requests for those services though a single webpage interface:

http://cxc.harvard.edu/cgi-gen/cda/specreq/

It covers requests for old data versions, for special processing, for data on physical medium, for custom database queries, as well as anything not covered by these categories (or anywhere else). Custom database queries so far have included specialized searches of the observation catalog and the bibliography database that are not available through the standard interfaces. The system also allows us to track these requests in order to ensure that they do not get lost.

Chandra Fast Image

A new *Chandra* Data Archive Interface to public data:

http://cda.harvard.edu/pop/

Chandra Fast Image is a simplified interface that offers the general public, as well as professional astronomers, quick access to images and event files. It can operate in two modes: Quick Image (default) and Advanced.

In Quick Image mode it will search the archive for JPEG images based on a celestial position or an object name; if there is more than one image it will return the one that it thinks may be the most interesting for the user.

In Advanced mode there are a few more search options, the user may indicate whether (s)he wants all or just the best candidates returned, and the user will be given the choice of JPEG or FITS images or event files. It also provides access to directories containing the Primary and Secondary data products and to published articles for selected ObsIds.

This interface has been incorporated into DS9.

SPIE Papers on Chandra

We are in the process of expanding our collection of online *Chandra*-related SPIE papers and expect to have a significantly increased list by the time you read this.

http://cxc.harvard.edu/cda/bib.html

SIAP Service

For the Virtual Observatory (VO) afficionados, the CDA now offers a Simple Image Access Protocol (NVO's SIAP) service. Proper access information is available from the NVO Registries.

Arnold Rots & Sherry Winkelman for the Archive Operations team

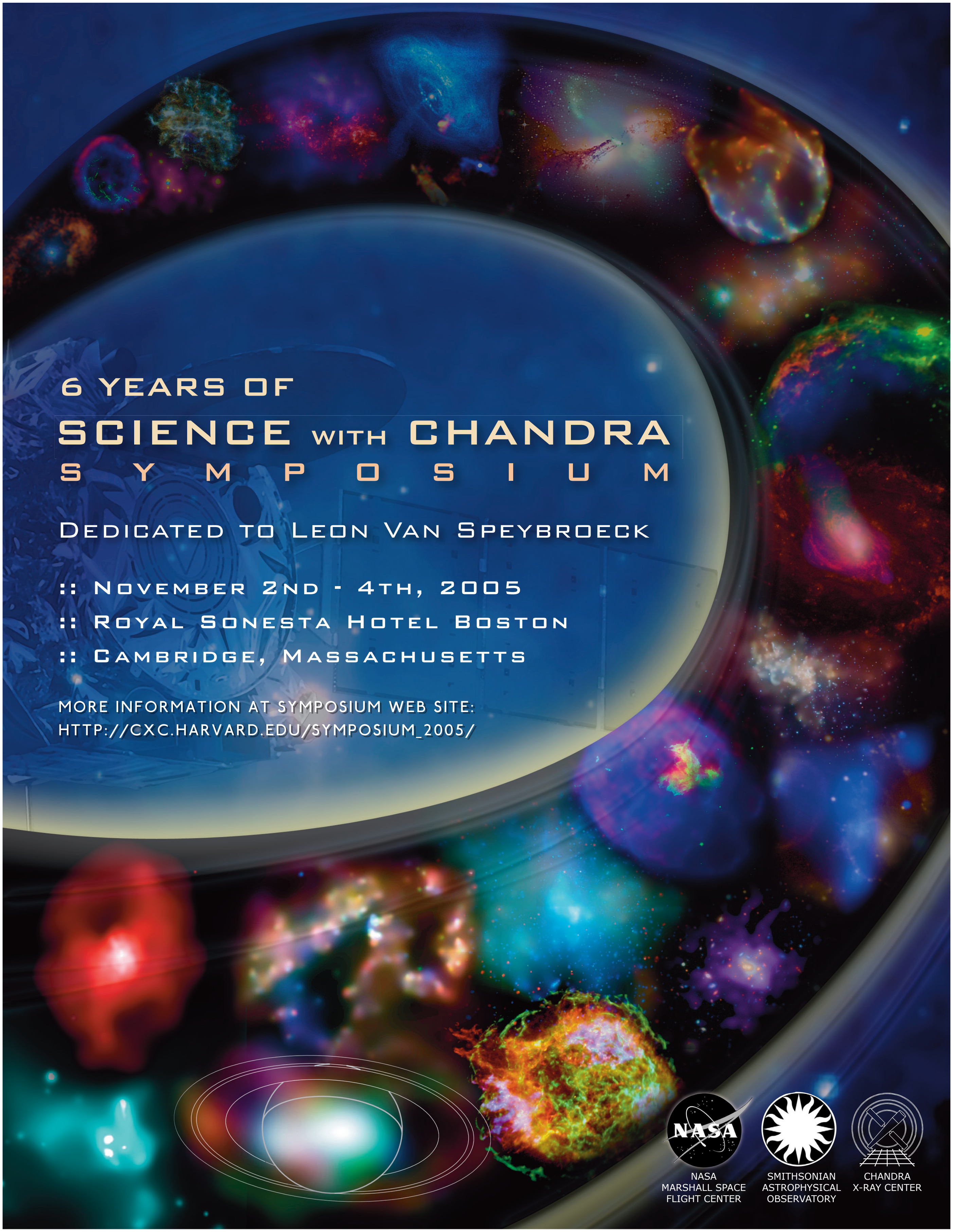
CXC 2004 Science Press Releases

See http://chandra.harvard.edu/press/press_release.html for more details.

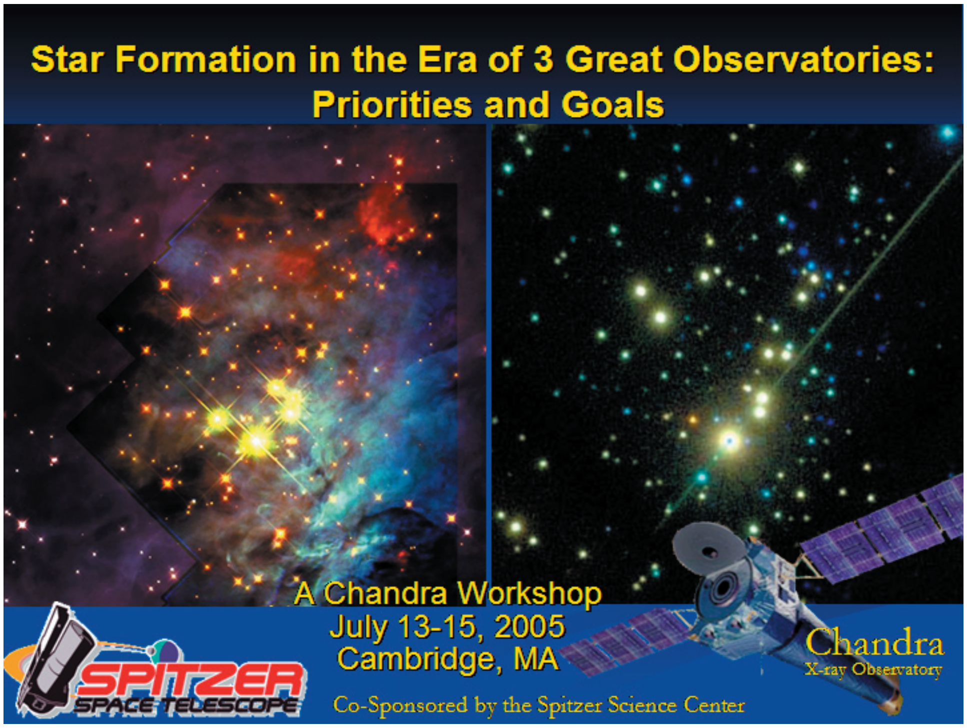
Table 2 - *Chandra* 2004 press releases.

Date	PI	Objects	Title
14 Dec 04	Slane	3C 58	Going to Extremes: Pulsar Gives Insight on Ultra-Dense Matter and Magnetic Fields
22 Nov 04	Schwartz	SDSSp J1306	Precocious Supermassive Black Holes Challenge Theories
26 Oct 04	O'Sullivan	NGC 4555	Chandra's Find of Lonely Halo Raises Questions About Dark Matter
6 Oct 04	Sankrit	Kepler SNR	NASA's Great Observatories May Unravel 400-Year-Old Supernova Mystery
23 Sept 04	Gaensler	G359.23-0.82	The Mouse That Soared
8 Sept 04	Scharf	Fornax Cluster	Motions in Nearby Galaxy Cluster Reveal Presence of Hidden Superstructure
23 Aug 04	Hwang	Cas A	Deepest Image of Exploded Star Uncovers Bipolar Jets
13 Aug 04	Wang	Abell 2125	Chandra Catches Early Phase of Cosmic Assembly
4 Aug 04	Soderberg	GRB 031203	Chandra Contributes to ESA's Integral Detection of Closest Gamma-Ray Burst
22 Jul 04	Kastner	McNeil's Nebula	X-ray Outburst from Young Star in McNeil's Nebula
6 Jul 04	Chartas	H1413+117	Chandra Looks Over a Cosmic Four-Leaf Clover
22 Jun 04	Muno	Galactic Center	Chandra Turns Up the Heat in the Milky Way's Center
2 Jun 04	Keohane	W49B	Smoking Gun Found for Gamma-Ray Burst in Milky Way
1 Jun 04	Dickinson	GOODS fields	Spitzer Leads NASA's Great Observatories to Uncover Black Holes and Other Hidden Objects in the Distant Universe
18 May 04	Allen	26 clusters	Chandra Opens New Line of Investigation on Dark Energy
10 May 04	Forman	M87	Giant Galaxy's Violent Past Comes Into Focus
5 Apr 04	Mori	Titan/Crab	Titan Casts Revealing Shadow
8 Mar 04	Ness	Saturn	X-rays From Saturn Pose Puzzles
1 Mar 04	Di Stefano	M101, M83, M51, NGC 4697	Enigmatic X-ray Sources Point to Possible New Black Hole Population
18 Feb 04	Komossa	RX J1242-11	Giant Black Hole Rips Apart Star
30 Jan 04	Drake	V471 Tauri	Star Shows It Has The Right Stuff
7 Jan 04	Fabbiano	The Antennae	Chandra Locates Mother Lode of Planetary Ore In Colliding Galaxies
6 Jan 04	Keel	C153	Too Fast, Too Furious: A Galaxy's Fatal Plunge
2 Jan 04	Rosati	RDCS 1252.9-2927	A Tale of Two Record-Breaking Galaxy Clusters

Megan Watzke



More details on the Symposium can be found on page 24.



We are pleased to announce "Star Formation in the Era of Three Great Observatories", a workshop sponsored by the Chandra X-ray Center, Co-Sponsored by The Spitzer Science Center and organized primarily by the CXC Director's Office.

The Workshop will be held July 13-15, 2005 in Cambridge Massachusetts at the Sheraton Commander Hotel.

The goal of the workshop is to review topics in star-formation which are inherently multiwavelength, and to both define the current state of knowledge and the points of current controversy where new observations are most needed. We plan to focus on topics where the Great Observatories have the most to contribute during this unique period of simultaneous operation but observations from other facilities and theoretical models are also expected to contribute. We hope to come away with a useful set of goals and priorities for near term observations with the three telescopes.

Confirmed and Probable Speakers (as of March 1):

Lori Allen
Bernard Brandl
Eric Feigelson
Marc Gagne
Lee Hartmann
William Herbst
Paul Ho
Thierry Montmerle
Deborah Padgett
Steven Strom
Fred Walter
Harold Yorke

There is time and space for contributed talks and posters but space is limited to about 100 participants. The registration deadline is May 6.

Science Topics

The ISM
Protostars
Disk Evolution
Rotation/saturation/dynamos
Clustering/populations
Multi telescope studies in the Orion Star Forming complex and other star Forming regions

There will be splinter sessions on Disk Evolution, Rotation, Populations and other selected topics.

The Scientific Organizing Committee

Scott Wolk (CfA) Chair
Jeremy Drake (CfA)
Nancy Evans (CfA)
Dave Huenemoerder (MIT)
Ray Jayawardhana (University of Toronto)
Claus Leitherer (STScI)
Tom Megeath (CfA)
Norbert Schulz (MIT)
John Stauffer (Spitzer Science Center)
Leisa Townsley (PSU)
George Rieke (University of Arizona)

The latest information can be found at our web page:
http://cxc.harvard.edu/stars05/

Scott Wolk

Six Years of Science With Chandra

The symposium "Six Years of Science with *Chandra*: Dedicated to Leon van Speybroeck", will be held at the Royal Sonesta Hotel in Cambridge, Massachusetts, USA from Wednesday, 2 November to Friday, 4 November 2005. The meeting will highlight key science results from the first six years of operation of the *Chandra* X-Ray Observatory with emphasis on recent results. Contributions covering recent results from the XMM-Newton Observatory will also be presented.

More details are available at
http://cxc.harvard.edu/symposium_2005/

Antonella Fruscione

The 4th X-ray Astronomy School

The 4th X-ray Astronomy School will be held in Cambridge, MA on August 14-19, 2005. See web page for more information: xrayschool.gsfc.nasa.gov

With the launch of *Chandra* and XMM-Newton, X-ray astronomy is becoming increasingly important for research into many topics in astrophysics. The X-ray astronomy school is intended for graduate students and recent post-docs who want to understand the intricacies of X-ray astronomy. The lectures will cover the characteristics of X-ray detectors with particular emphasis on implications for correct interpretation of the data. They will also cover the basic physics related to the X-ray emission processes and a review of science addressed in X-ray astronomy (i.e., clusters of galaxies, AGN, CVs, pulsars, x-ray binaries, supernova remnants, stars).

Aneta Siemiginowska

Chandra Calibration Workshop 2005

The 2005 *Chandra* Calibration Workshop will be held on Oct 31 and Nov 1, immediately preceding the 6 Years of *Chandra* Symposium. Presentations are solicited on various aspects of *Chandra* calibration and its applications to data analysis. Please contact ccw@head.cfa.harvard.edu. More details are available at http://cxc.harvard.edu/ccw/index05.html.

Vinay Kashyap

Chandra-Related Meetings Planned for the Next Year

Keep an eye on the CXC Webpage:
http://cxc.harvard.edu for further information

Star Formation in the Era of Three Great Observatories
July 13-15, 2005 — Cambridge, MA
http://cxc.harvard.edu/stars05/

X-ray Astronomy School
August 14-21, 2005 — Cambridge, MA

Chandra Users' Committee Meeting
October, 2005
http://cxc.harvard.edu/cdo/cuc/index.html

Chandra Fellows Symposium
October, 2005 — Cambridge, MA

Calibration Workshop
October 31 and November 1, 2005 — Cambridge, MA
http://cxc.harvard.edu/ccw/index05.html

Six Years of *Chandra* Science Symposium
November 2-4, 2005 — Cambridge, MA
http://cxc.harvard.edu/symposium_2005/

Previous Chandra-related meetings:

X-ray Astrophysical Plasma Diagnostics
November 15-17, 2005 — Cambridge, MA
http://itamp.harvard.edu/xdap.html

Third *Chandra* Calibration Workshop 2004
October 27-28, 2003 — Cambridge, MA
http://cxc.harvard.edu/ccw/proceedings/04_proc/

Chandra Fellows Symposium
October 13, 2004 — Cambridge, MA
http://cxc.harvard.edu/fellows/program_2004.html

Galaxies Viewed With *Chandra*
July 7-9, 2004 — Cambridge, MA
http://cxc.harvard.edu/gals04/

Surveying the Galaxy With ChaMPlane

The *Chandra* Multiwavelength Plane (ChaMPlane) Survey is an ongoing extensive survey of the galactic plane ($b < 12^o$) to probe the nature and distribution of the point source population in the Galaxy. Initiated by our CfA team (J. Grindlay, J. Hong, X. Koenig, S. Laycock, E. Schlegel, M. van den Berg and P. Zhao), its primary goal is to constrain the accretion-powered source distribution for low luminosity ($Lx \leq 10^{33}$ erg/s) compact objects – accreting white dwarfs (CVs), neutron stars and black holes. Although the luminous persistent low mass X-ray binaries (LMXBs) and high mass X-ray binaries (HMXBs) have been catalogued since the UHURU and HEAO-1 surveys (apart from new transients), the vast underlying population of the most abundant compact accretion sources, the CVs, remains poorly known with local space density of $\sim 10^{-5}$ pc^{-3} but still uncertain by nearly an order of magnitude and with a galactic spatial distribution even less well constrained. Similarly, the underlying population of quiescent LMXBs (from which "soft" X-ray transients arise) and HMXBs (likely to be primarily accreting Be systems with excretion disk outbursts which feed their compact companions) are even more uncertain. Yet these objects are signposts for stellar and binary evolution and provide tracers for old (bulge) and young (massive star) populations in the Galaxy and thus the more luminous accretion-powered X-ray sources detectable in even local group galaxies and beyond.

ChaMPlane was proposed to utilize the superb *Chandra* spatial resolution and sub-arcsec source positions to enable source identifications. A "typical" CV with $Lx \sim 10^{31}$ erg/s and $Mv \sim 7$ would finally be detectable at "typical" galactic distances: at 6kpc, a 50ksec exposure would yield 10 cts and V ~23 counterpart for a low extinction field with Av ~2. Even with this exquisite sensitivity, ChaMPlane harvests mostly stars ($>10^4$ times more common than CVs), detected mostly by their coronal emission (for, typically, G or later). Early type stars and emission from colliding winds are less likely to appear in the survey fields since these are chosen to be a) relatively free of bright diffuse emission (which would limit sensitivity) and bright stars (e.g. young clusters), which would contaminate our deep followup optical ChaMPlane survey and b) local minima (if possible) in their absorbing column, NH, to optimize optical identifications and spectra. ChaMPlane fields are chosen from archived (or scheduled) observations and are c) ideally deep (>30-50ksec) exposures to enhance sensitivity. From this mining of the serendipitous *Chandra* galactic plane database, 141 fields from cycles 1-6 have been selected (see Figure 20) of which ~120 have been now been processed in a customized pipeline processing system to yield some 10^4 sources. Accretion sources are identified initially as Hα emission objects in our parallel NOAO ChaMPlane survey with the Mosaic CCD on the CTIO and KPNO 4m telescopes: 59 fields (36arcmin) covering the 141 *Chandra* ACIS fields.

Initial Papers: Galactic Anti-Center Source Distributions and First Bulge IDs

A suite of ChaMPlane papers have been submitted by the following lead authors: an overview of the Survey and science goals, data products and example results (Grindlay); X-ray pipeline processing methods and spatial-spectral distributions of Anti-Center sources (Hong); a full description of the optical followup photometry (Zhao); and deep IR photometry of the

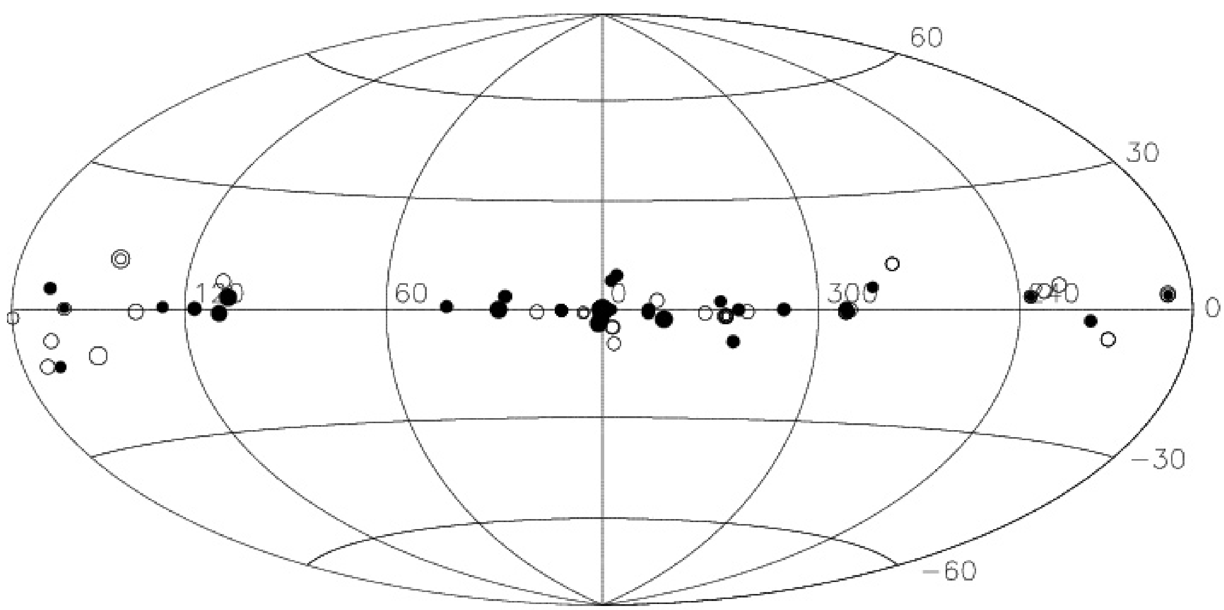


FIGURE 20: Galactic distribution of ChaMPlane fields. Filled symbols are ACIS-I, open symbols are ACIS-S, and symbol size is proportional to exposure time. Some 45 fields are contained within the symbol at the galactic center (Grindlay et al 2005).

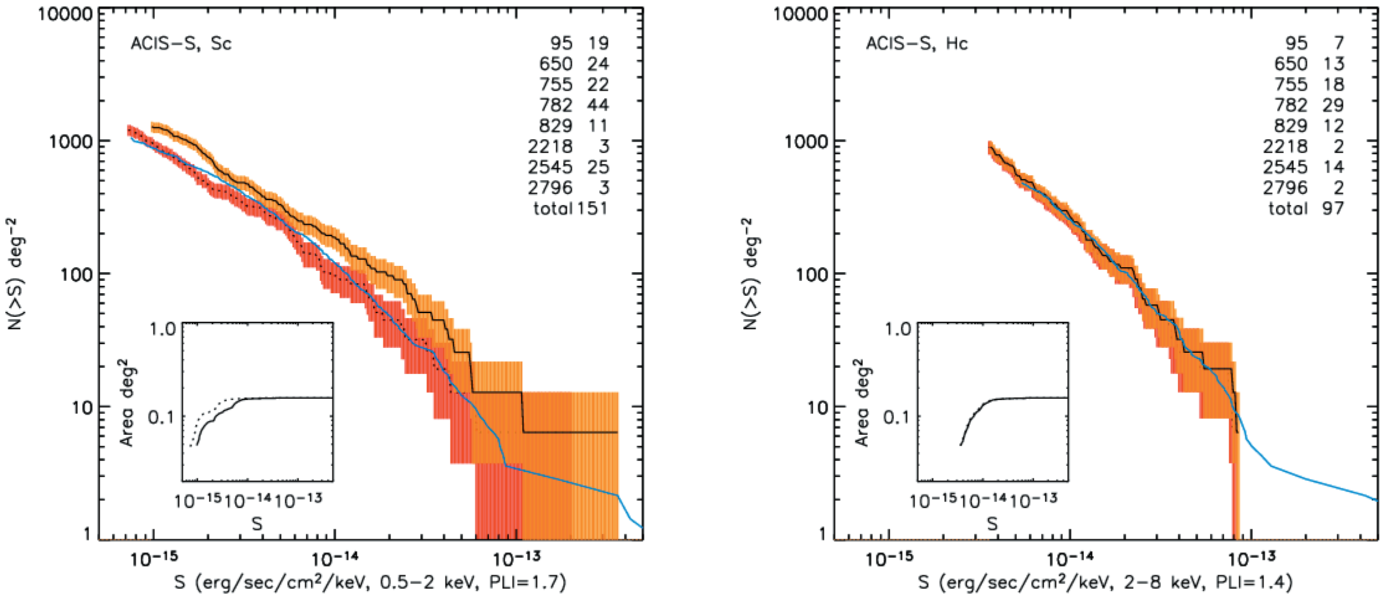


FIGURE 21: logN-logS source counts (from Hong et al (2005) for 8 ACIS-S anti-center fields for two de-reddening models: Schlegel et al (1998) (yellow; full plane NH) vs. Drimmel et al (2001) (red; distance dependent NH) vs. AGN background counts (blue) from the ChaMP survey (Kim et al 2004). Results from ACIS-I observations of 7 additional fields also show that AGN dominate the hard source distribution for fluxes $S \leq 10^{-13.5}$ cgs. Chandra obsIDs and source numbers in each band are given in the key.

SgrA* cusp source distribution (Laycock).

The galactic anti-center ($90^{o} < l < 270^{o}$) is a natural place to start, with generally lower NH and stellar crowding. Preliminary logN-logS distributions for sources detected in 8 ACIS-S fields in soft (0.5-2 keV) vs. hard (2-8 keV) bands is shown in Figure 21. Soft sources appear to have a flatter distribution (as expected for disk sources) than the background AGN distribution for the Schlegel reddening model, whereas hard sources are consistent with the high latitude background at $S \geq 10^{-13}$ cgs. The bulk of the soft sources are coronal stars in the disk, and the hard sources are likely accretion-powered, with AGN clearly dominant at faint fluxes. Indeed, the optical followup photometry (Zhao et al 2005) as well as WIYN-Hydra spectroscopy (Rogel et al 2005) yields no Hα emission objects in the (typical) ≤1" *Chandra* error circles (99% confidence) apart from a number of dMe counterparts. Several CVs have been found, however, in the 36'x36' full Mosaic optical fields for these anti-center sources, which are 5 to 20 times larger than the embedded ACIS-I and S fields, respectively.

The situation changes dramatically towards the galactic Bulge. Here ChaMPlane is extending uniform re-processing to selected ACIS fields within Bulge, including the wide-field survey of Wang et al (2002) and deep SgrA* survey of Muno et al (2003), along with our own targeted program of deep (100ksec) exposures on three low-extinction windows (e.g. Baades Window) within 4^{o} of the galactic center. Analysis is still underway, but *Chandra* CVs are being found as well as giants (spectroscopically identified) that are hard *Chandra* sources and probably harbor CV or quiescent LMXB companions (either neutron stars or black holes). Perhaps most dramatic are the deep IR photometry results on the SgrA* cusp source distribution, as reported by Laycock et al (2005), which appears to rule out a HMXB origin for this galactocentric population of low luminosity hard *Chandra* sources.

Full access to the ChaMPlane catalogs and processing archives, both *Chandra* and optical, is being released as publications are submitted, and will be posted soon after March 15 for the anti-center fields. Information and tools are available from the ChaMPlane website, http://hea-www.harvard.edu/ChaMPlane/.

Josh Grindlay

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Zhao, P. et al. 2005, ApJ,submitted

Education And Public Outreach

Cycle 6 Education and Outreach Peer Review

The Cycle 6 Chandra EPO Peer Review, conducted by the CXC, was held in Cambridge MA on Oct. 20-22, 2004. A five member panel representing science, education, museum, Forum, and NASA mission and management perspectives reviewed 10 proposals. The submitted proposals significantly oversubscribed the available funding. One individual proposal and 5 institutional proposals were selected for funding. An overview of the selected proposals follows.

Individual PI proposals

Building Interest in Science Among Middle School-Age Girls Using Big Explosions and Strong Gravity (BESG)

Science PI: Dr. Ann Hornschemeier (annh@pha.jhu.edu)

A program to bring current space science content and hands-on activities to middle-school age girls leveraging an existing NASA collaboration with the Girl Scouts.

Institutional Proposals

The Chandra Astrophysics Institute

Science PI: Dr. Frederick Baganoff (fkb@space.mit.edu)

The Astrophysics Institute will develop a year long research program in X-ray astrophysics to address the needs of students from underserved groups in the Lynn, MA, Public School District who show strong interest and motiviation to pursue an education, and eventually a career, in math, science and/or technology.

Chandra After-School Astronomy Project

Science PI: Prof. Deepto Chakrabarty (deeptop@space.mit.edu)

The After-School Astronomy Project (ASAP) will provide out-of-school time programs to underserved youth to reinforce learning in physics, space science, and technology, leveraging the community outreach structure of the Timothy Smith Network in Boston, MA.

Does Dark Matter Really Exist?

Science PI: Dr. Megan Donahue (donahue@pa.msu.edu)

This proposal will develop and produce a series of pedagogical animations that will assist museum personnel, educators, and media product developers in explaining the evidence for dark matter.

Penn State In-Service Workshops

Science PI: Prof. Eric Feigelson (edf.astro.psu.edu)

This proposal provides funding to support the attendance of teachers and the provision of curricular resources at the tenth annual Penn State In-Service Workshops in Astronomy (PSIWA).

Stellar Evolution Planetarium Show at the Science Museum of Virginia

Science PI: Gregory Sivakoff (grs8g@virginia.edu)

This program will introduce planetarium visitors to stellar evolution and stellar populations through the development and production of a planetarium show at the Science Museum of Virginia. The show will introduce the science content through the reminiscences of Stella, a Black Hole who used to be a Big Star.

For more information, including contact information for the EPO Co-I's and education partners on these proposals, go to: http://chandra.harvard.edu/edu/proposals_c6.html

Cycle 7 Education and Public Outreach Proposals

The deadline for submitting an electronic copy of the Cycle 7 Chandra EPO proposal will be 5 p.m. EDT on 21 October 2005 (and hardcopy deadline 4 p.m. EDT on 25 October 2005). The deadline has been moved later than previous years to avoid conflict with preparation of Chandra science proposal budgets.

What's New in Chandra EPO

A new link from http://cxc.harvard.edu/, "New in Education/ Outreach" takes scientists to a page specifically designed to highlight the newest education and outreach products from Chandra, and to provide a quick link to resources on the Chandra public site for talks and classroom use. Announcements of new products and web features will be posted here, as well as other information of relevance to education and public outreach efforts. The page contains direct links to on-line order forms for outreach materials. The posting of new material on this page will also be announced in the periodic Chandra electronic bulletins.

Kathy Lestition

Education and Public Outreach

User Support Leader Steps Down

Fred Seward formed the User Support group in 1993, long before there were any users, and long before there was a *Chandra* X-ray Observatory. The observatory, which was called AXAF while it was being built, would not be finished and launched until 1999. In 2000, the User Support group was restructured, and the *Chandra* Director's Office (CDO) was formed. Fred and Belinda Wilkes became Assistant Directors for the CXC. By the time he resigned in January 2004 (retired February, 2005) he had supervised the review of some 4,000 proposals for *Chandra* time, which recommended about 1,000 observing proposals for acceptance.

Seward was the natural and highly popular choice for the position when the AXAF Science Center (which was later renamed the *Chandra* X-ray Center) was established at the Smithsonian Astrophysical Observatory. He was highly regarded for his pioneering contributions to X-ray astronomy, and widely recognized as uniquely qualified in the practical, sometimes esoteric art of helping the scientific community use an X-ray observatory. From 1977 through 1981 he had organized and led the *Einstein* Observatory Guest Observer program.

The *Einstein* program helped bring about a sociological change in X-ray astronomy. A substantial amount of observing time was reserved for guest observers, thus making X-ray data available to a broad segment of the astronomical community for the first time. This helped propagate the notion that astronomy is best done by looking at the Universe over a wide range of wavelengths, and helped pave the way for the acceptance of the AXAF mission by NASA and the scientific community.

"The tremendous success of the *Einstein* Guest Observer program is testimony to Fred's leadership and commitment," said Harvey Tananbaum, Director of the *Chandra* X-ray Center. "Even more indicative of his effectiveness in this role over the years is the emphasis now placed on 'support to the community' at the *Chandra* X-ray Center. Fred's leadership has trained us all and has made it automatic for CXC staff to 'think of the observers' and how to assist them in their use of *Chandra* to maximize the science return from the mission."

That hasn't always been easy, largely because of the tremendous demand to use *Chandra*.

"With *Einstein*, we had half a dozen reviews," Seward recalled. "With 50-70 proposals in each review, and one committee, I would read them all, and could remember them all. With Chandra there are typically 800 proposals in each review, and one person cannot read or review all of them. The number of proposals was a surprise, as was the difficulty in dealing with so many proposals."

Because of this heavy case load, help from the astronomical community has been important and Seward praised the willingness of astronomers to volunteer their time. "It takes so much of their time and effort, but they are essential, particularly the panel chairs, who are the backbone of the review. Every year, unexpected problems arise such as a reviewer having to drop out at the last minute, and the panelists cope to produce a conscientious and competent review."

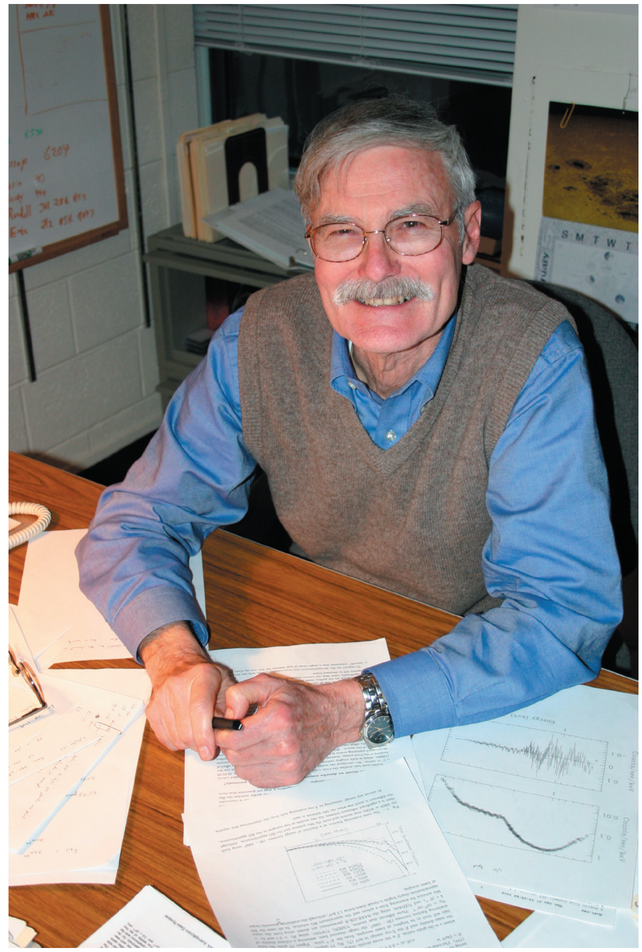

FIGURE 22: Fred Seward.

The key to the success of the program, and the highlight of his tenure, Seward said, "Has been the high quality of the CDO staff. Belinda Wilkes (now group leader as the Assistant Director of the CXC), Andrea Prestwich, Nancy Evans, Paul Green, Diane Hall (of the Data Systems group), and the CDO Computer Specialists are all very competent and great to work with. We couldn't have done it without them."

What's next for Seward?

"I want to finish the analysis of the data on the Crab Nebula's X-ray halo, and three supernova remnants in the Large Magellanic Cloud. I also hope to update the book (his book with Phil Charles, *Exploring the X-ray Universe*, published by Cambridge U. Press in 1995)."

And yes, he does intend to submit *Chandra* observing proposals to the CXC.

Wallace Tucker

How To Write An X-ray Proposal

This article was adapted from a presentation at the conference "X-ray and Radio Connections"
http://www.aoc.nrao.edu/events/xraydio/
Note that there was a companion piece on radio astronomy proposals by Ed Fomalont.
- Editor.

Chance of Success

Each year there are 700-800 proposals for *Chandra* observations, archival work, and theory projects. Because of observing time and funding limits, only about 200 are accepted, one in four. The numbers for Cycle 5 were:

Type	Submitted	Accepted	Observing Time
Normal	606	173	70 ks (ave)
Large Project	68	10	300-1000 ks
Archive	71	17	
Theory	40	8	
Total	785	208	19,400 ks

TABLE 3: *Chandra* Cycle 5 Proposals.

Chandra proposals are solicited once a year. The *Call for Proposals* contains schedule and rules. The *Proposer's Observatory Guide* contains instrument descriptions. Software for feasibility calculations, information, and help are available at http://cxc.harvard.edu/.

Content

If a proposal is truly excellent, and the review panel recognizes this, it will quickly be approved. However, 85% of proposals submitted are considered "good" and reviewers spend most of their time ranking the "good" proposals. Your challenge is to write the proposal so the excellence of the project is clear to the panel; or, at least, produce a clear, pleasing document that will stand out in the pack of "good" proposals.

A proposal has three vital parts: Science goals, feasibility, and suitability of *Chandra* for the project. The panel must be convinced that the science derived from an observation will be interesting. The proposal must show that the observing time requested will produce enough signal (counts for X-rays) to do the job. It must also demonstrate that *Chandra* capabilities (e.g. arcsecond resolution) are needed.

You can write a single proposal (for example) for *Chandra* Time and VLA/VLB, NOAO, HST, XMM, RXTE, or Spitzer time. The *Chandra* review can award up to a few percent of the observing time on another instrument to such joint proposals (subject to approval of the appropriate Director). The proposal must show that both *Chandra* and the other instrument are essential to meet scientific objectives, and must demonstrate feasibility for each.

Format

Two sections comprise a *Chandra* proposal:

The Target Form contains investigator information, target details, and instrument settings. The Science Justification is a little science paper; length limited to 4 pages (6 for Joint Proposals or Large Projects), explaining the scientific basis of the project and showing feasibility calculations.

Take care to avoid mistakes. Misspelling investigator or institution names negate the use of the computer to find conflicts of interest. Every year at least one proposer puts first names in the last name boxes.

Errors in target coordinates can prevent the review organizers from finding target conflicts. Every year there are ~25 gross errors in target coordinates submitted; for example,

Target: MS0735+7421 @ RA = 07 41 50.3, Dec = -74 14 50.6, and
Target: Tololo 0109-383 @ RA = 13 35 22.1, Dec = -42 32 20.0.

A latex/pdf template is supplied which will produce an easy-to-read Science Justification. Keep in mind that reviewers have to read 60-70 proposals. Documents with tiny font, small margins, or small figures with minuscule captions will not be enthusiastically received.

The organizers enforce page limits by removing any excess pages.

Submission

All proposals must be submitted electronically using the RPS software. Before the deadline, errors can be corrected and proposals resubmitted. No post-deadline submissions are accepted. Each year we get 1000 submissions for 800 proposals. There are 600 submissions in the last day and 100 in the last hour. People wait until the last hour, submit the proposal, then read it, then hurriedly resubmit or call to explain the special circumstances leading them to request a late submission. "I accidentally sent an early version of our proposal." is not uncommon. Late corrections to the Science Justification are not accepted.

The Peer Review

Proposals are divided among 12 or 13 panels according to science topic. Each science topic is covered by 2 or 3 panels so proposals can be placed to avoid conflicts. There are ~65 proposals/panel and 8 reviewers/panel.

Before the review, each panelist reads all proposals and assigns a preliminary grade. These grades are used for Triage. The first task for each panel is to view the list of the lowest-ranked proposals. The bottom 25% (~15 for each panel) are then eliminated from further consideration. However, if a panelist thinks any proposal in this group should be considered further, it can be resurrected and discussed with the rest. The panel then discusses and grades the remaining 50 proposals - about 10 minutes for each! Each has been assigned a primary and a secondary reviewer who are responsible for a detailed reading of the proposal, presentation to the panel, and writing of a report communicating the grade and panel comments for the proposer.

On the third day of the review, the Large Projects, already graded by the topical panels are discussed and ranked by a Big-project panel which awards 20-30% of the observing time.

Advice

We go to a great deal of trouble to find competent reviewers and to avoid conflict of interest in the review process. All proposers are treated equally. Reviewers are conscientious and fair but this is an intense process. There is a lot to accomplish in a limited time. Proposers should retain the perspective of Ecc 9:11 where, "the race is not to the swift, nor the battle to the strong, nor bread to the wise , nor riches to the intelligent, nor observing time to the writers of good proposals, but time and chance happen to them all."

- Start early. Don't wait until the last minute.
- Write some of the description for someone who is not an expert in the field. Remember some of the panelists do not work in your specific area and the proposal has to survive triage.
- Print the proposal and read it before submitting.
- Avoid unnecessary Coinvestigators. Reviewers cannot participate in reviews of proposals for which they are CoIs and sometimes for those which have CoIs from their institutions.
- Volunteer to be a peer reviewer. Having seen the process you will be able to write better proposals.

Fred Seward

Erratum

Due to an error on the part of the author (Harvey Tananbaum) in his article "Nobel Days and Nights in Stockholm: From Black Holes to White Ties" published in Chandra News Issue 10 (March 2003), the data on Her X-1, Cyg X-3, and Cyg X-1 shown in Figure 21 and referred to in the associated text are incorrectly attributed to UHURU observations. As noted by Elihu Boldt, these data were obtained by Richard Rothschild et al. in a 1973 rocket-borne experiment carried out by the Goddard Space Flight Center X-ray astronomy group. The discoveries of rapid X-ray variability in Cen X-3, Her X-1, and Cyg X-1 described in the article are correctly credited to observations made with UHURU.

Chandra Users' Committee Membership List

The Users' Committee represents the larger astronomical community. If you have concerns about *Chandra*, contact one of the members listed below.

Name	Organization	Email
Vassiliki Kalogera	Northwestern	vicky@northwestern.edu
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Knox Long (Chair)	STScI	long@stsci.edu
Smita Mathur	OSU	smita@astronomy.ohio-state.edu
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Ex Officio, Non-Voting

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CXC Coordinator

Belinda Wilkes	CXC Director's Office	belinda@head.cfa.harvard.edu

CXC Contact Personnel

Director:	Harvey Tananbaum	Calibration:	Christine Jones
Associate Director:	Claude Canizares	Development and Operations:	Dan Schwartz
Assistant Director:	Belinda Wilkes	Mission Planning:	Bill Forman
Manager:	Roger Brissenden	Science Data Systems:	Jonathan McDowell
		Deputy:	Mike Wise
Systems Engineering:	Jeff Holmes	Data Systems:	Pepi Fabbiano
Education & Outreach:	Kathy Lestition	Media Relations:	Megan Watzke

Note: E-mail address is usually of the form: <first-initial-lastname>@cxc.harvard.edu
(addresses you may already know for nodes head.cfa.harvard.edu or cfa.harvard.edu should work also)

Useful Chandra Web Addresses

To Change Your Mailing Address:	http://cxc.harvard.edu/cdo/udb/userdat.html
CXC:	http://chandra.harvard.edu/
CXC Science Support:	http://cxc.harvard.edu/
CXC Education and Outreach:	http://chandra.harvard.edu/pub.html
ACIS: Penn State:	http://www.astro.psu.edu/xray/axaf/
High Resolution Camera:	http://hea-www.harvard.edu/HRC/HomePage.html
HETG: MIT:	http://space.mit.edu/HETG/
LETG: MPE:	http://wave.xray.mpe.mpg.de/axaf/
LETG: SRON:	http://www.sron.nl/divisions/hea/chandra/
CIAO:	http://cxc.harvard.edu/ciao/
MARX simulator:	http://space.mit.edu/ASC/MARX/
MSFC: Project Science:	http://wwwastro.msfc.nasa.gov/xray/axafps.html

Constellation-X Mission Update

The 2004 calendar year has been an eventful one for the Constellation-X team, highlighted by the formal assignment of management responsibility to GSFC for NASA's Beyond Einstein program with the signing of the FAD (Formulation Authorization Document). The flagship missions within Beyond Einstein are LISA and Constellation-X, with LISA first in the queue having recently entered into Phase A and Constellation-X (Con-X) scheduled to move into Phase A in FY 07. The schedule for the Beyond Einstein missions and for Con-X in particular is still being re-worked in response to budget changes necessitated in part by the introduction of the Exploration Initiative in NASA's FY 05 budget. A planned RFP (request for proposal) to industry to study the design and assembly methods of the large Con-X Spectroscopy X-ray Telescope (SXT) was therefore put on hold. The team has taken advantage of this slip to push harder on the mirror and detector technologies needed to meet the most stringent Con-X mission design goals.

Due in part to the re-direction of NASA priorities in the last year, a series of National Academy-level reviews (ie, the Decadal Report mid-course review), and NASA Road-mapping efforts have been begun. To date these reviews have validated the conclusions of the most recent Decadal survey, which gave Con-X very high priority (second only to JWST among large space-based projects).

On the optics front, the SXT team has made significant progress toward making reflectors that meet the Con-X angular resolution requirement of 15'' final HEW (half energy width) for the full 4-telescope system. In order to meet this requirement, the contribution to the HEW from axial figure errors on each reflector pair must be less than 10''. The best reflectors produced in this past year have an axial figure that approach this 10'' HEW requirement. Metrology indicates that the X-ray scattering from the reflectors will fall within the allowed range, but X-ray reflectivity measurements have not yet been performed on the latest reflectors. Measurement of the X-ray reflectivity of individual reflectors, and possibly an imaging demonstration using an aligned pair of reflectors, will be performed by the end of this calendar year.

The baseline SXT reflector manufacturing plan is to replicate the final surface of each reflector using a thin layer of epoxy between the thermally formed glass substrate and a gold film deposited onto a precision replication mandrel. Significantly, this 10'' axial figure was achieved on the glass reflector substrate alone, suggesting that it may be possible to simplify the manufacturing process, or alternatively, that continued efforts to improve the figure and scattering may yield reflectors whose axial figures approach the 5'' HEW angular resolution goal.

FIGURE 23: A prototype Con-X mirror segment being removed from a replication mandrel.

The Hard X-ray Telescope team continues work on both the Nickel and Glass substrate designs for this telescope which will extend the energy range of Con-X to at least 40 keV. Both designs are expected to have <30'' HEW, which meets the design requirements by better than a factor of 2. Con-X technology development in this area has been significantly helped by the involvement of many Con-X team members in a robust NASA high energy balloon program, which includes InFocus, HEFT, and HERO. The HERO balloon program is based at MSFC, where several dozen nickel shells have been fabricated (for the HERO payload) with diameters ranging from 4 to 10 cm.; full illumination X-ray tests on individual shells over an energy range of 20 - 60 keV showed a range of 11'' - 13'' resolution HPD (half power diameter). Larger diameter thinner nickel shells which meet the mass requirements of Con-X have been fabricated at Brera Observatory. Measurements of the first shell (130 micron thick 30 cm diameter) at MPE Panter facility with full illumination X-ray tests at 1.5 keV showed a 25'' resolution HPD.

The Reflection Grating Spectrograph (RGS) team has made significant progress both in the lab and in the modeling of the RGS over this year. Two grating geometries have been extensively studied - the baseline 'in-plane' grating design, and a new 'off-plane' design. At the start of the year there were significant differences in the modeled performance of the candidate off-plane gratings. These have now been understood, and in some configurations the off-plane design may offer higher throughput and resolution. Several design studies of the full Con-X telescope system which were carried out this year used this newer off-plane grating configuration. An off-plane grating was tested at the Brookhaven synchrotron source, and absolute efficiencies and polarization sensitivities were measured. The grating efficiency was found to be dependent upon the polarization of the incoming beam, but the magnitude of this effect is highly dependent upon the detailed structure of the grating grooves.

On the detector front, the calorimeter team has also made significant progress. Both the Ge and Si based devices have seen improvements, with resolutions of less than 5 eV being reported.

Single Si based devices using Transition Edge Sensors (TES) have reached as low at 2.5 eV at 6 keV, but the Con-X devices must be large arrays. Design and testing work on the SQUID multiplexers needed to read out an array of these devices is progressing.

On the science side, one of the most significant efforts of the Facility Science Team (FST) and the FST Science Panels over the past year has been an in-depth update of the basic Con-X science case. The original science case (detailed in glossy booklets, web pages such as http://constellation.gsfc.nasa.gov/, etc.) was formulated prior to the launch of *Chandra* and XMM. In support of this update a series of mini workshops were held in the late fall and winter of 2004 to discuss recent scientific advances from *Chandra*, XMM and other facilities within the context of the technical capabilities of Con-X. Panels were also asked for inputs to a scientific trade study of the mission parameters, and to indicate which were the most important. These mini-workshops and some work by various science panels at their home institutions, covered topics ranging from cosmology to planets. A series of white papers resulting from these meetings are nearing completion and should soon appear on the main Constellation-X science web page: http://constellation.gsfc.nasa.gov/science/.

Another significant effort has been a series of engineering design studies lead by the Con-X Project Office. These have been motivated in part by the new availability of the Delta 4-Heavy launch vehicle, which has significantly more lifting power to L2 than the baseline Atlas 5. Several different configurations have been studied, including one using a single telescope consisting of a pair of formation flying spacecraft (one holding the detectors, the other the mirrors) separated by up to 50m.

NASA re-direction away from International Space Station (ISS) has impacted the European/Japanese XEUS X-ray mission, which no longer plans to utilize the ISS for assembly and then operate nearby in order to allow servicing. Instead, XEUS will operate at L2, as Con-X will. While the primary XEUS science is imaging of very faint objects, and that of Con-X is high resolution spectroscopy of brighter objects, both are large area, high throughput missions. This has opened up the possibility of a collaboration between ESA, JAXA and NASA. Discussions and joint engineering studies are underway to see what common ground there is in the science objectives and what degree of sharing of technologies might be beneficial to both agencies.

In closing we would like to welcome Ann Hornschemeier to the Con-X team. Ann is our new acting Deputy Project Scientist, filling in for Kim Weaver who is on a 1-year detail to NASA-HQ.

Michael Garcia and Jay Bookbinder, for the Constellation-X Team

Chandra Explores The "Downtown" Milky Way

This article is adapted from the Chandra Chronicles: http://chandra.harvard.edu/chronicle/0204/milkyway/index.html *A related CDROM "Destination: X-ray Milky Way" can be obtained from* http://chandra.harvard.edu/edu/cd/mw/ *- Editor.*

We live in the suburbs of the giant, spiral Milky Way galaxy. Earth is about 25,000 light years from the teeming, tumultuous Galactic Center where most of the action takes place. On the one hand, that's probably a good thing for fragile creatures such as ourselves. On the other hand, we are also incurably curious and would like to know what's happening there.

For modern-day optical telescopes that routinely look at objects billions of light years away, examining a region only 25,000 light years distant shouldn't present much of a problem. However, it's not that simple. Like many crowded cities on Earth, the smog in the Galactic Center is terrible. Dust and gas produced by millions of massive stars makes it impossible for the most powerful optical telescopes to see into this region.

Fortunately, other options are now available. Radio, infrared, X-ray and gamma-ray radiation can travel through the Galactic smog and be captured by telescopes sensitive to these forms of light. Using this information, astronomers have been gradually piecing together a picture of the center of the Milky Way. Chandra's unique ability to resolve X-ray sources as small as a tenth of a light year across in the Galactic Center has led to major advances in our understanding of the high-energy activity there. It has also posed some mysteries.

A panoramic X-ray view extending 400 light years by 900 light years shows that, even at this distance from the center of the Galaxy, conditions are getting crowded, and the energy level is increasing dramatically (Figure 24). Supernova remnants (SNR 0.9-0.1, probably the X-ray Thread, and Sagittarius A East), bright binary X-ray sources containing a black hole or a neutron star (the 1E sources), and hundreds of unnamed point-like sources due to neutron stars or white dwarfs light up the region. The massive stars in the Arches and other star clusters (the DB sources) will soon explode to produce more supernovas, neutron stars, and black holes.

Infrared and radio telescopes (Figure 26) have also revealed giant star-forming molecular clouds (Sagittarius A, B1, B2 and C, and the cold gas cloud near the Radio Arc), the edges of which are glowing with X-rays because of heating from nearby supernovae.

All this commotion takes place in a diffuse cloud of hot gas that shows up as extended X-ray emission. The gas appears to have two components - a 100-million degree Celsius part and a 10-million degree component. This diffuse X-ray glow gets

FIGURE 24: *Chandra* image of Galactic center. Credit NASA/UMass/D. Wang et al.

brighter toward the Galactic Center. The high temperature of the diffuse gas poses a problem - it should flow out of the Galactic Center in about 10,000 years, requiring continual replenishment and heating.

The massive stars in the Arches and other star clusters can supply the gas - the X-ray sources associated with these clusters show that they are blowing away a prodigious amount of matter - but they are unlikely to supply the heating mechanism. Another possibility is that magnetic fields are involved in heating the gas, or confining it to the center of the galaxy. The radio image, which is a tracer of magnetic fields in this region, shows that the magnetic fields are certainly there. However, their structure appears unlikely to be capable of confining the hot gas.

Within a dozen light years of the Galactic Center, the hurly burly increases (Figure 25). Sagittarius A, the bright blob in the center, is composed of three main parts - Sagittarius A East, Sagittarius A West, and Sagittarius A*. Sagittarius A East is the remnant of a supernova that stirred things up about 10,000 years ago (plus, of course, the 25,000 years that it takes the light to reach us from the Galactic Center).

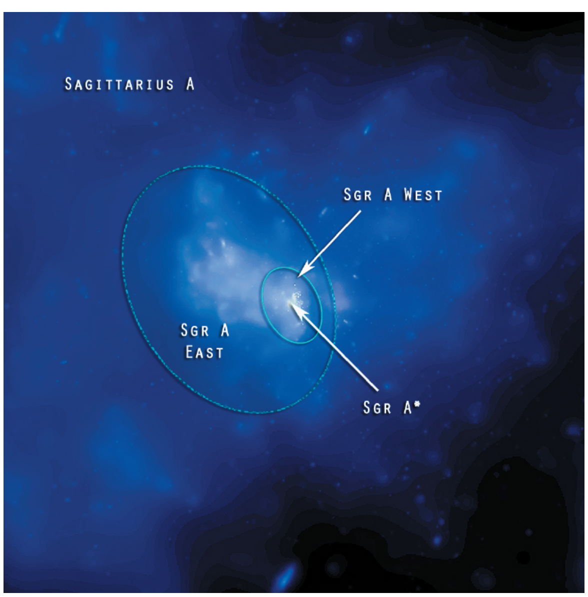


FIGURE 25: The Galactic center, close-up.

Sagittarius A West is a spiral-shaped structure of gas that may be headed toward Sagittarius A*, the supermassive black hole that marks the center of the Milky Way Galaxy. Sgr A* contains about 3 million times the mass of the Sun, and is gaining weight daily as it pulls in more material.

The mystery surrounding Sgr A* is why it is not growing faster. All the matter being spewed out by those massive stars should provide the central black hole with a good steady source of food, yet the X-ray power of Sgr A*, normally a good indicator of the rate of mass being swallowed by the black hole, is unusually low. *Chandra* has caught Sgr A* in the act of snacking - it produced a series of bright flares - but the amount consumed was small, about the weight of a comet.

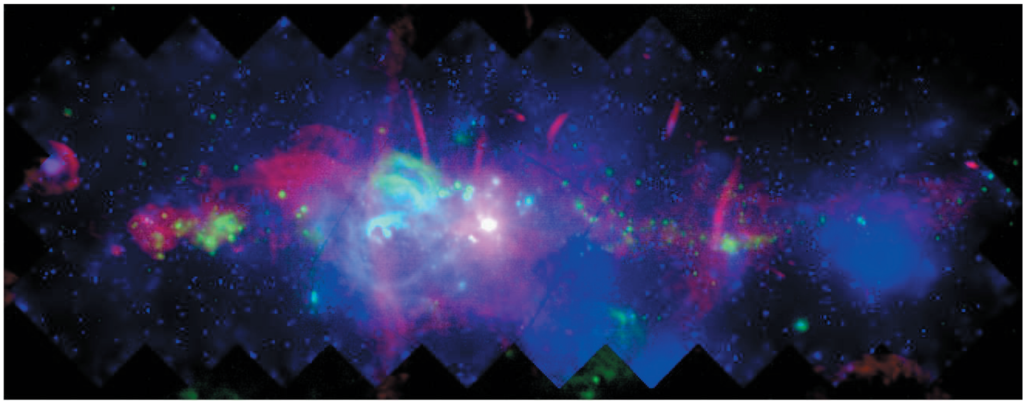
Explanations for the eating habits of Sgr A* abound. One is that the gas around it is simply too hot - blame the Sgr A East explosion for that.

According to this idea, we are seeing Sgr A* in a quiet period, and it may get back on a regular feeding schedule in the future. Another is that the winds from the massive stars are blowing too fast to be captured by the supermassive black hole. A black hole is in a way like a big, slow dog. If a rabbit stays far enough away, it can escape, but if it ventures too close, . . .

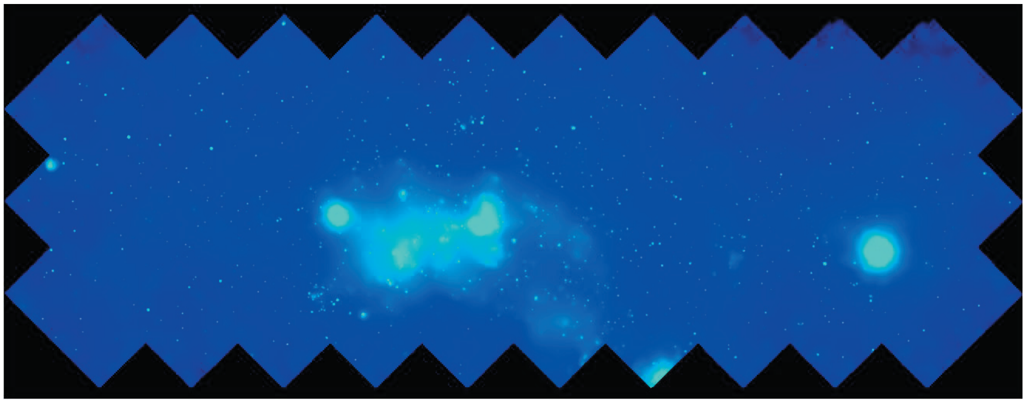
Finally, there is the possibility that it is eating normally and we don't know it. Either the gas is not spiraling into the black hole, falling in directly, so it radiates very few X-rays on the way in, or most of the X-rays are beamed away from us.

As with any exciting, vibrant downtown area of a big city, it obviously takes many visits to know what's going on.

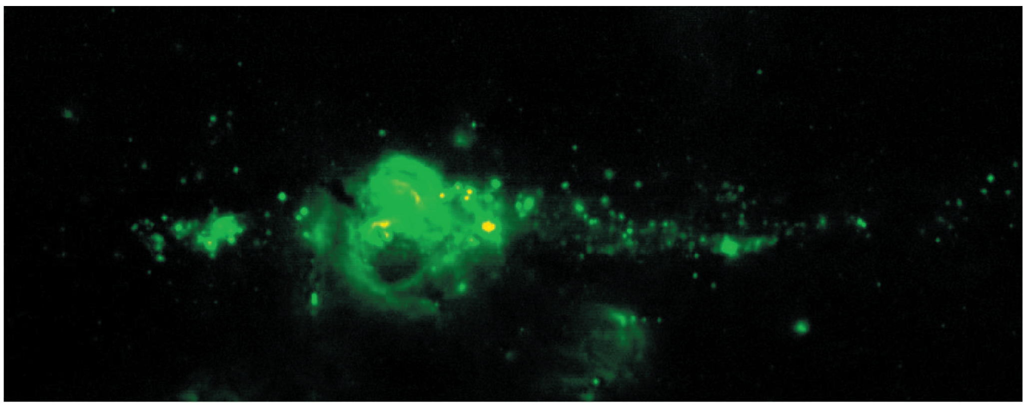
Wallace and Karen Tucker



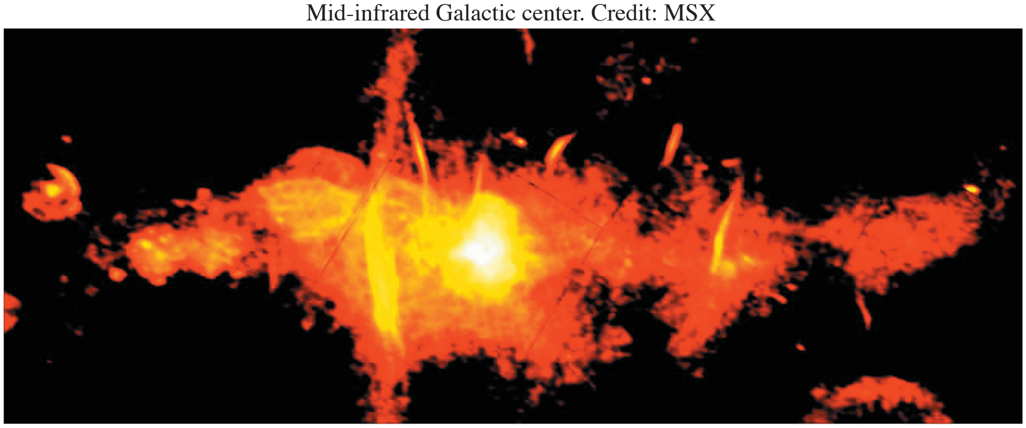
Composite image of Galactic center. X-ray: blue, mid-IR: green, radio: red.



X-ray Galactic center. Credit: NASA/UMass/D. Wang et al.



Mid-infrared Galactic center. Credit: MSX



90 cm Galactic center. Credit: VLA/NRL/N. Kassim

FIGURE 26: The Galactic center at many wavelengths.

The *Chandra* Newsletter currently appears approximately once a year. We welcome contributions from readers. Nancy Remage Evans edits "*Chandra* News", with assistance from Samantha Stevenson. Comments on the newsletter and corrections and additions to the hardcopy mailing list should be sent to: chandranews@cxc.harvard.edu.