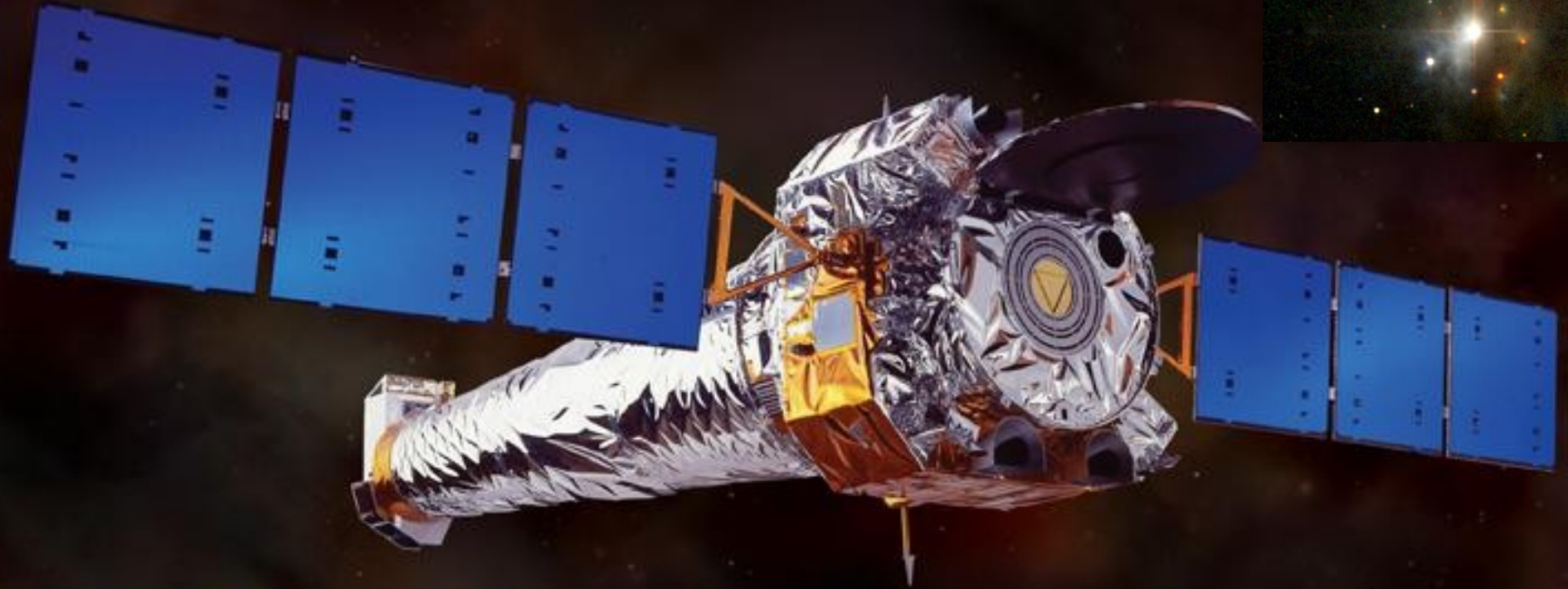


# Coronae in the *Coronet*

Simultaneous X-ray, radio, near-infrared, and optical monitoring of Young Stellar Objects in the *Coronet* cluster




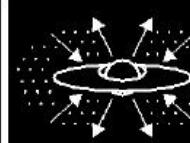

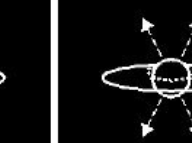

Jan Forbrich

Max-Planck-Institut für Radioastronomie Bonn



with Th. Preibisch, K. Menten (MPIfR),  
R. Neuhäuser (Jena), F. Walter (SUNY), M. Tamura  
(NAOJ), N. Matsunaga (Tokyo), N. Kusakabe (Tokyo),  
Y. Nakajima (NAOJ), A. Brandeker (Toronto), S.  
Fornasier (Paris), B. Posselt (MPE/AIU), K. Tachihara  
(Kobe), C. Broeg (Jena)

# Radio, X-ray, and infrared emission of protostars

PROPERTIES	<i>Infalling Protostar</i>	<i>Evolved Protostar</i>	<i>Classical T Tauri Star</i>	<i>Weak-lined T Tauri Star</i>	<i>Main Sequence Star</i>
SKETCH					
AGE (YEARS)	$10^4$	$10^5$	$10^6 - 10^7$	$10^6 - 10^7$	$> 10^7$
mm/INFRARED CLASS	Class 0	Class I	Class II	Class III	(Class III)
X-RAY	?	Yes	Strong	Strong	Weak
THERMAL RADIO	Yes	Yes	Yes	No	No
NON-THERMAL RADIO	No	Yes	No ?	Yes	Yes

Until now, *protostars* have not been studied for correlations in radio – X-ray variability.

subsequently less embedded


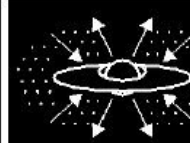

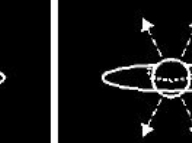

magnetospheric Bremsstrahlung and/or accretion

e.g. from shock-induced ionisation

e.g. gyrosynchrotron radiation

**protostars**

# Radio, X-ray, and infrared emission of protostars

PROPERTIES	Infalling Protostar	Evolved Protostar	Classical T Tauri Star	Weak-lined T Tauri Star	Main Sequence Star
SKETCH					
AGE (YEARS)	$10^4$	$10^5$	$10^6 - 10^7$	$10^6 - 10^7$	$> 10^7$
mm/INFRARED CLASS	Class 0	Class I	Class II	Class III	(Class III)
X-RAY	IRS 7E*	Yes	Strong	Strong	Weak
THERMAL RADIO	Yes	Yes	Yes	No	No
NON-THERMAL RADIO	No	IRS 5*	No ?	Yes	Yes

Until now, *protostars* have not been studied for correlations in radio – X-ray variability.

subsequently less embedded

magnetospheric Bremsstrahlung and/or accretion

e.g. from shock-induced ionisation

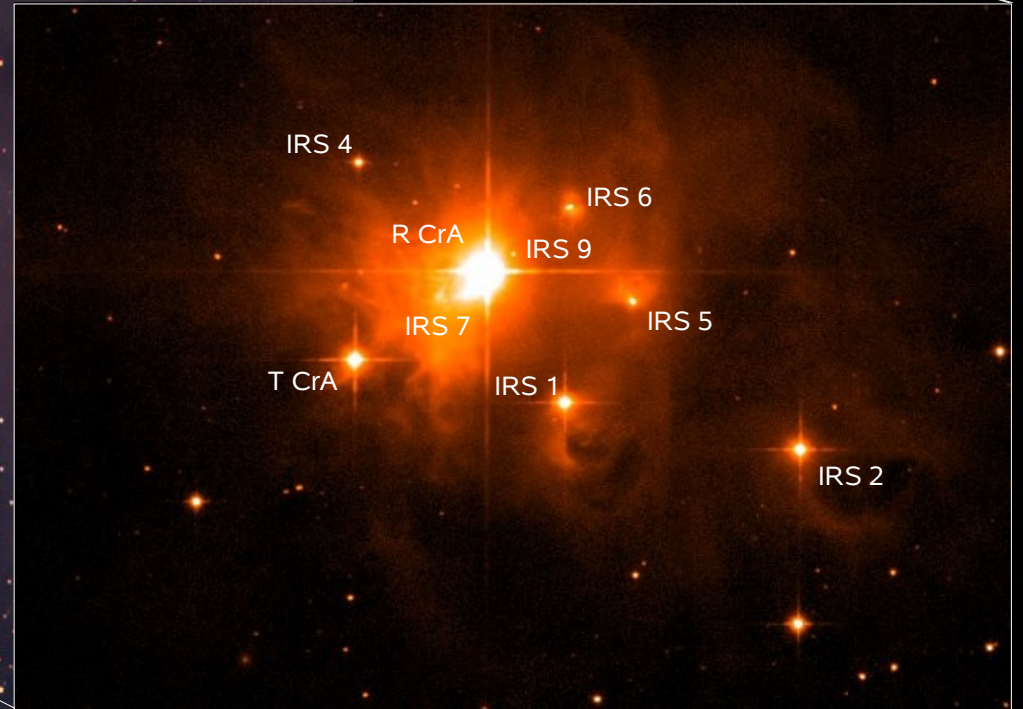
e.g. gyrosynchrotron radiation

protostars

\*in the *Coronet* cluster !



# Target: *Coronet Cluster* ... a compact cluster of protostars !



Wilking et al. (1997),  $K'$

R Coronae Australis Complex (Detail) (MPI/ESO 2.2-m + WFI)

ESO PR Photo 25b/00 (6 October 2000)

© European Southern Observatory



$d = 130 \text{ pc}$

Review: Neuhäuser & Forbrich (2007)

# August 2005: Simultaneous multi-wavelength observations



Chandra  
(5x)

VLA  
(4x)



CTIO / SMARTS  
(6x) *UBVRI*

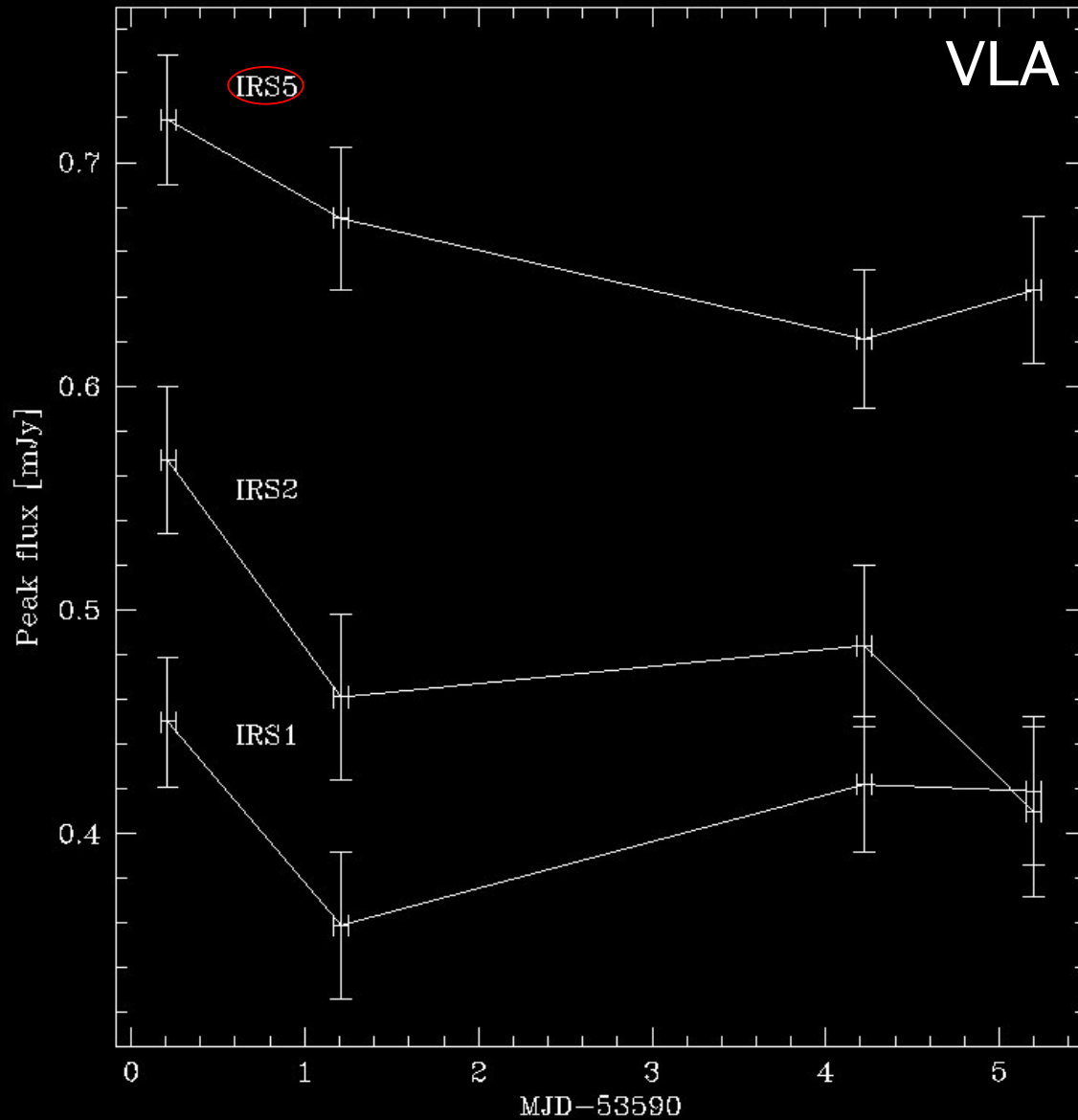


ESO  
(3x) *JHK*

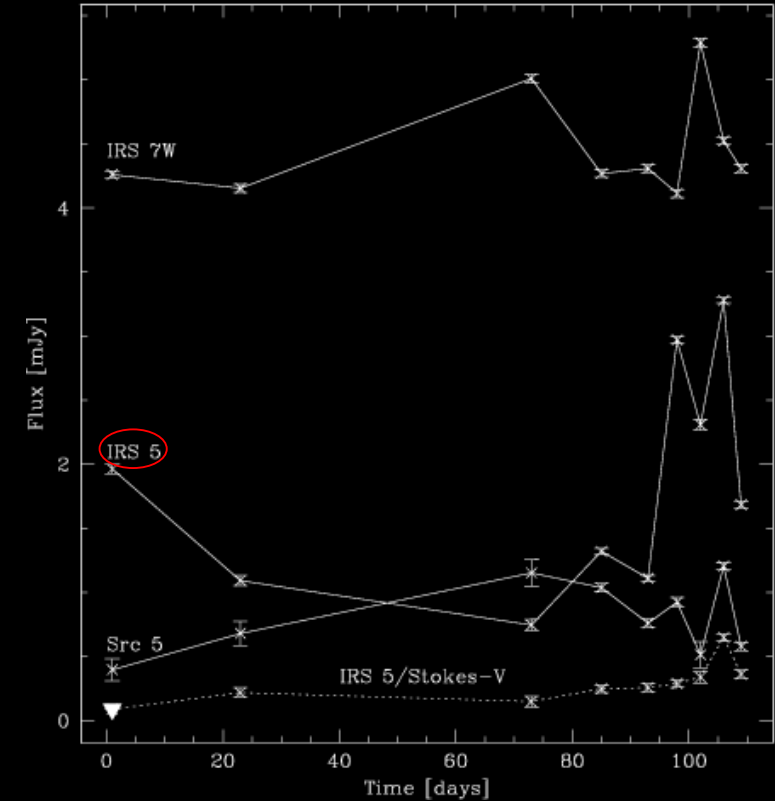


IRSF  
(5x) *JHK*

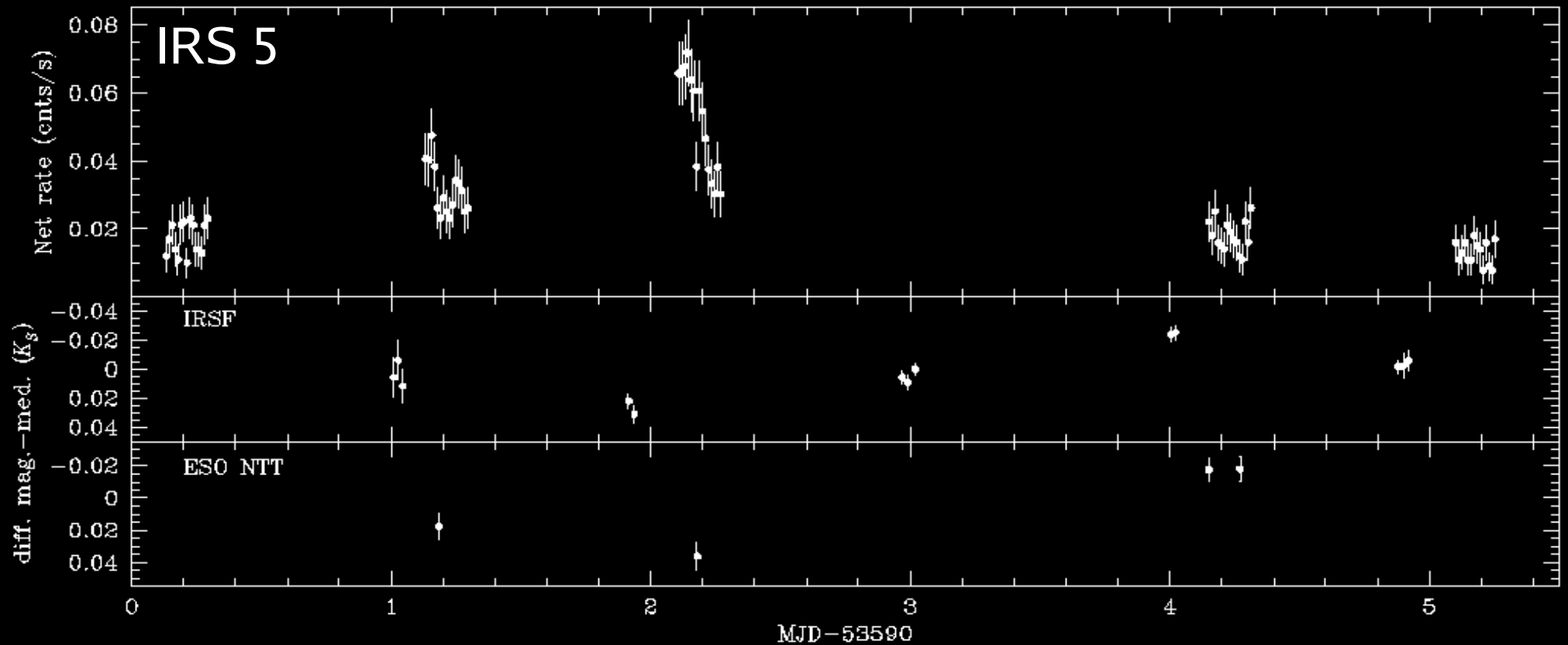
# August 2005: Simultaneous multi-wavelength observations



Earlier data (Forbrich, Preibisch, & Menten 2006)

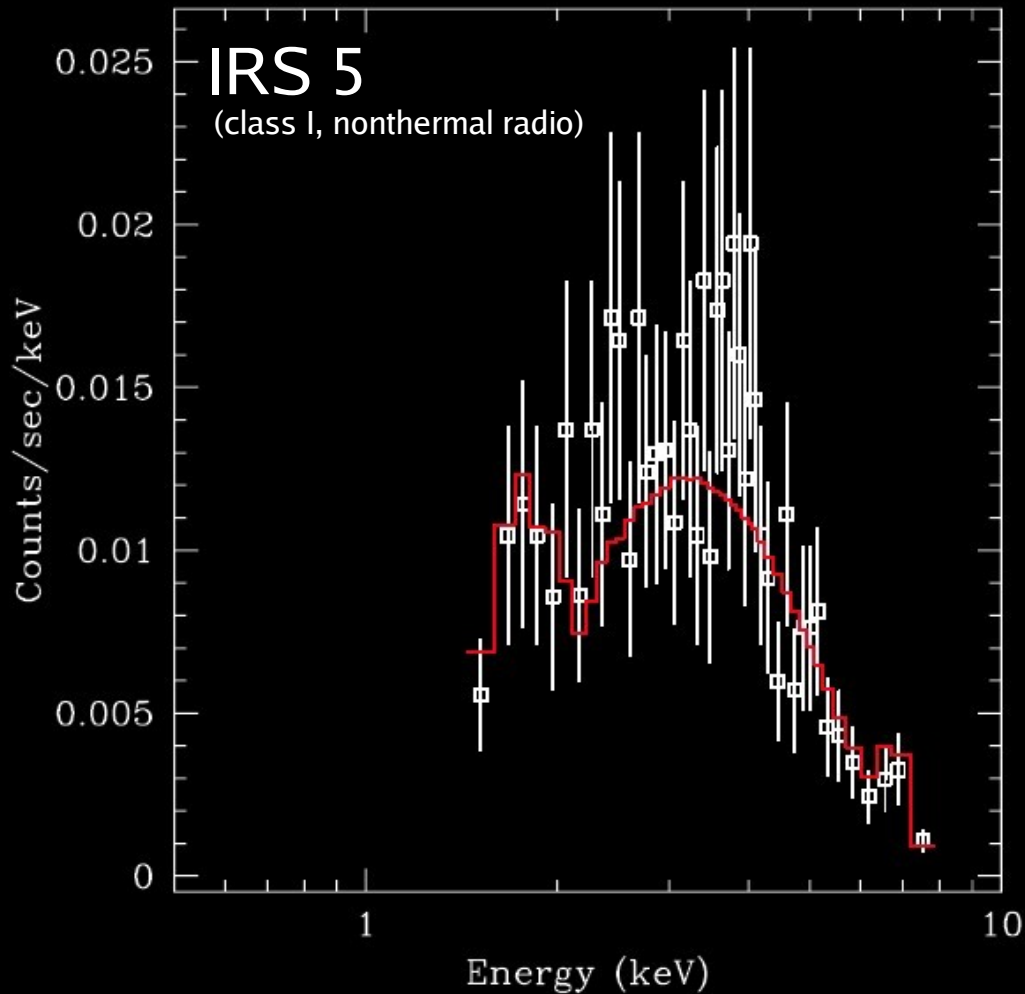


# August 2005: Simultaneous multi-wavelength observations

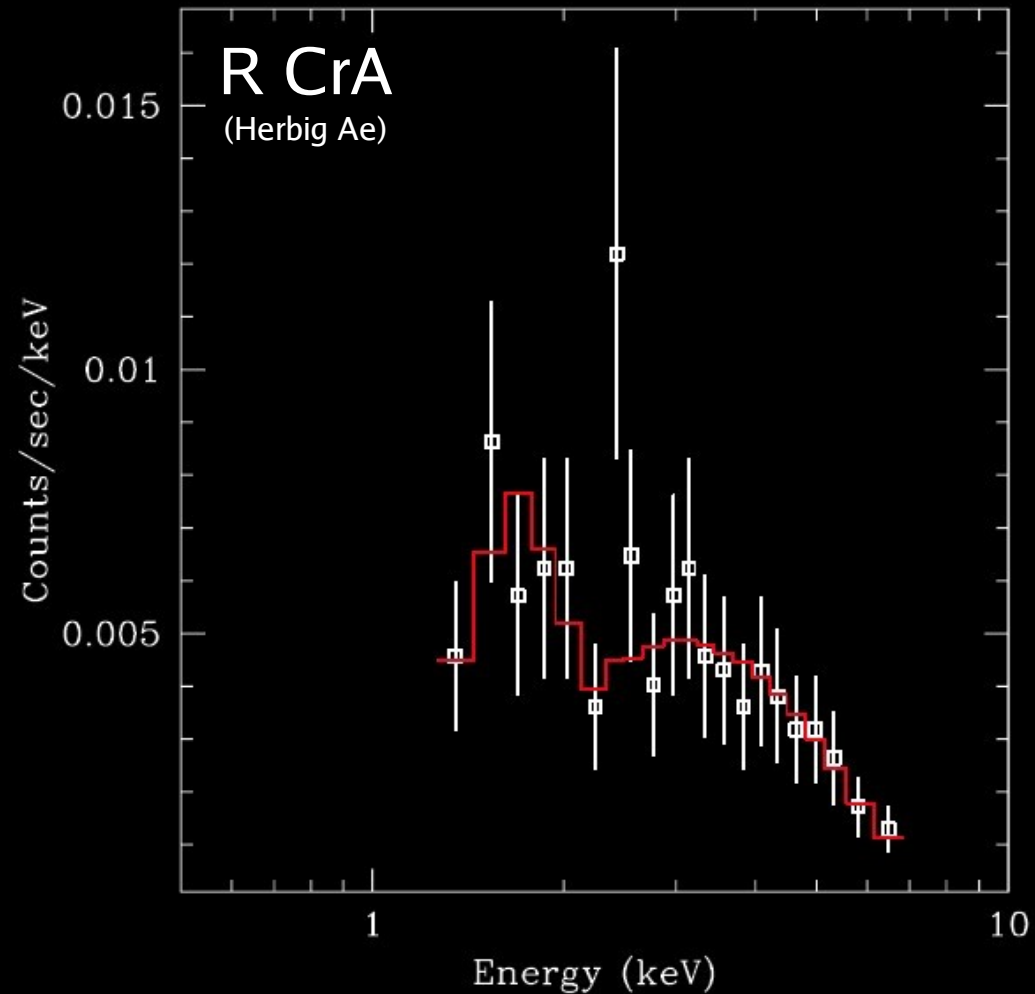


...lots of light curves...!

# X-ray spectra



$$\text{NH} = 3.9 \cdot 10^{22} \text{ cm}^{-2}$$
$$T = 107 \text{ MK}$$



$$\text{NH} = 1.6 \cdot 10^{22} \text{ cm}^{-2}$$
$$T > 100 \text{ MK}$$

(due to a companion ?)



# (some) Conclusions

In simultaneous multi-wavelength observations, the **variability** of several CrA YSOs appears to be **mostly uncorrelated** at different wavelengths (however: “no flares”).

The *Coronet* protostars appear to be compatible with the **Güdel-Benz** relation of  $L_X$  vs.  $L_R$  (measured for the first time).

The Herbig Ae star **R CrA** shows X-ray emission of  $> 100$  MK plasma (and radio emission), possibly due to a close companion.

There are now 160 ksec of *Chandra* data of CrA, constituting a **deep census** of a star-forming region, four times as sensitive as the COUP (**5e26 erg/s** at 130pc for light absorption !)  
Coronal emission is the dominant mechanism, not accretion.

Forbrich, Preibisch, & Menten, A&A 2006

Forbrich, Preibisch, Menten, Neuhäuser, Walter, Tamura, et al., A&A 2007 *in press*

Forbrich & Preibisch, A&A 2007 *submitted*