

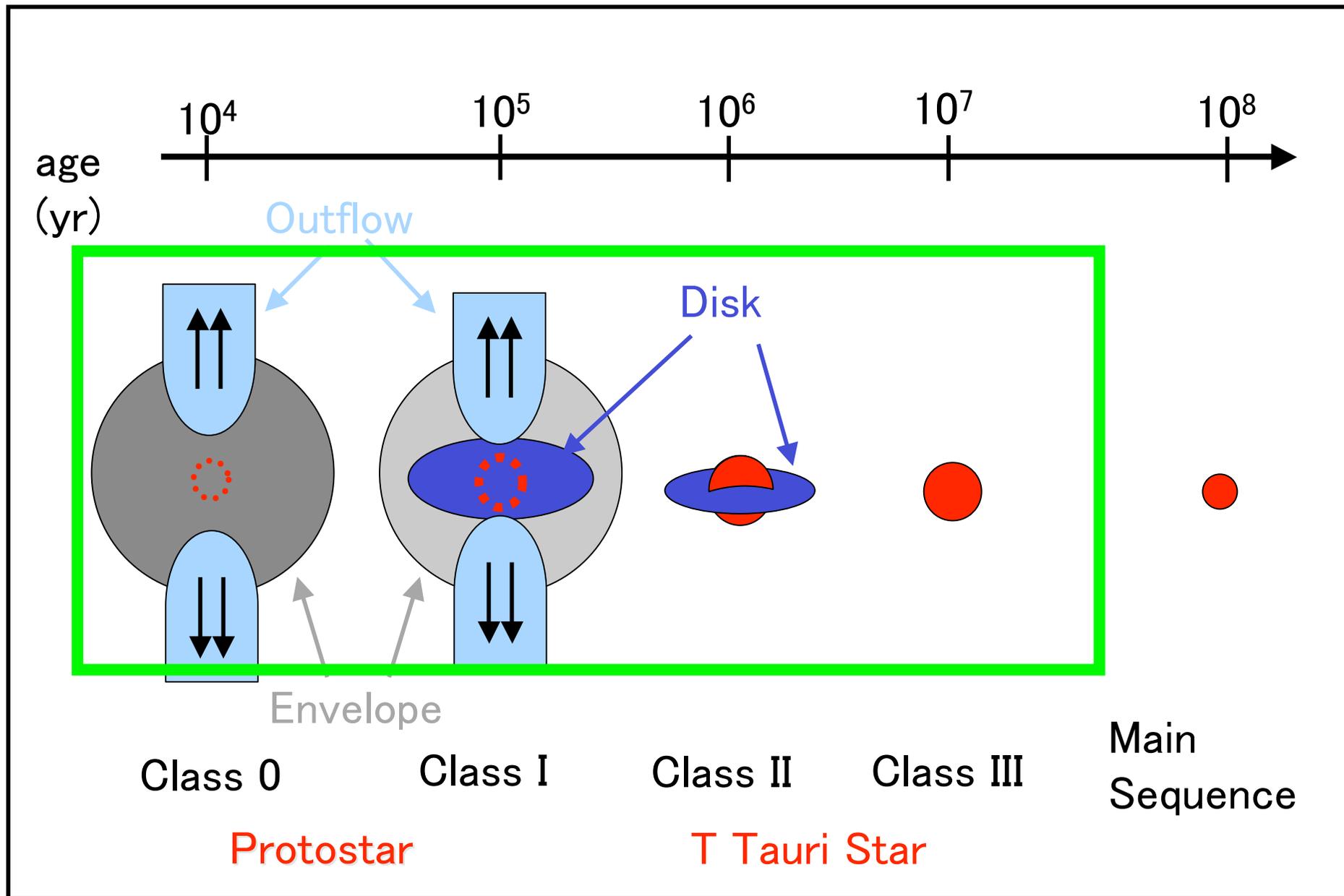


若い星状天体における ジェットとフレア

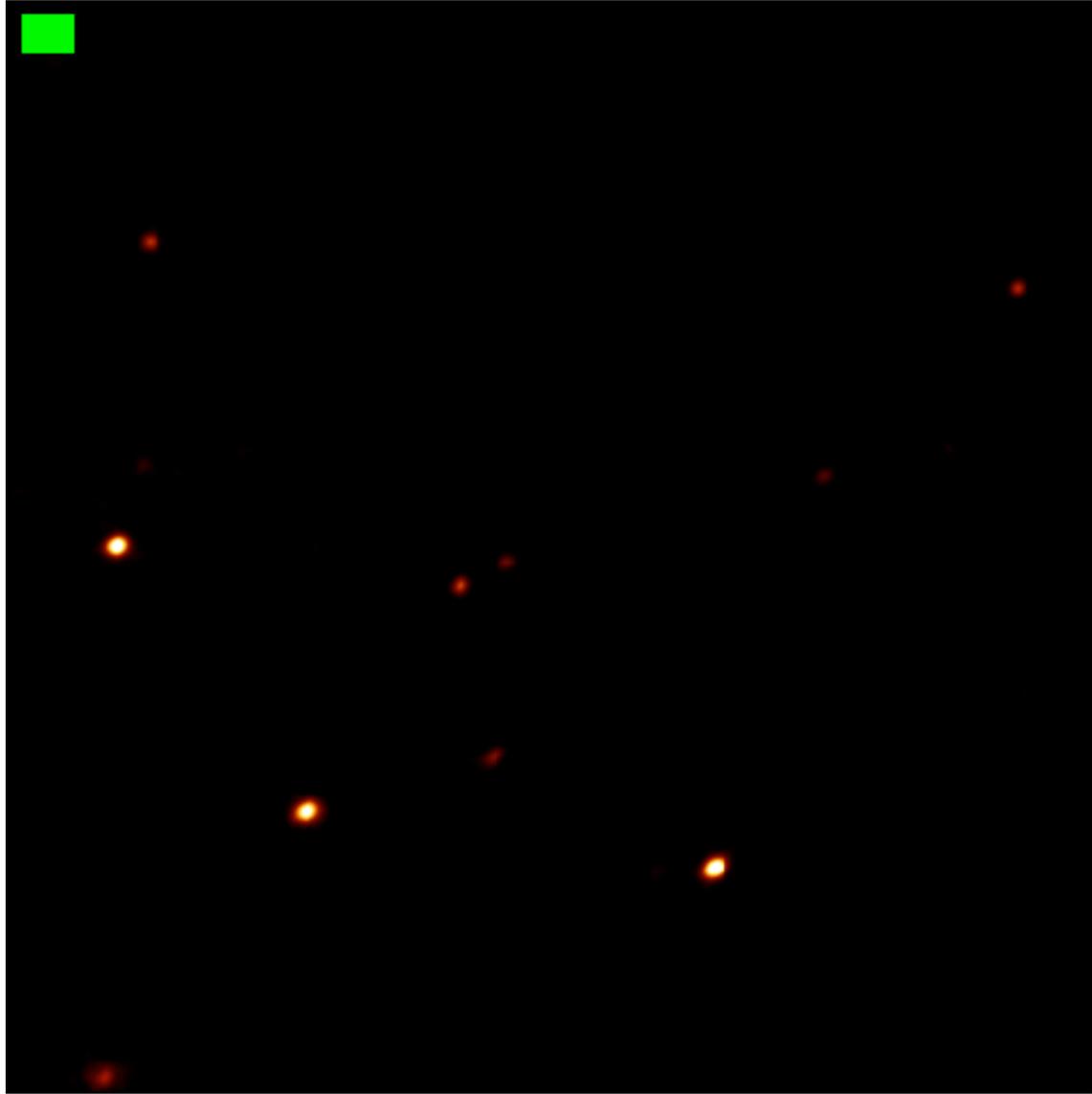
坪井陽子

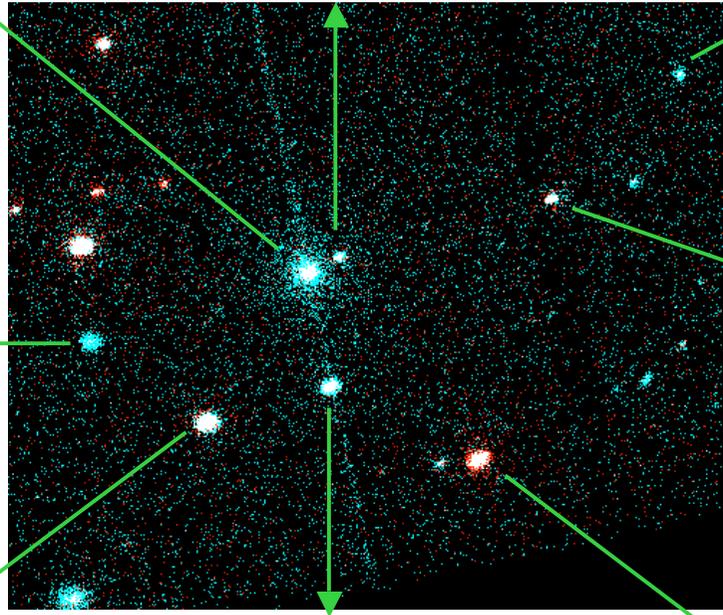
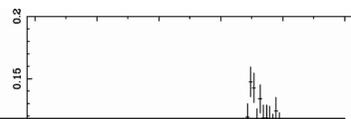
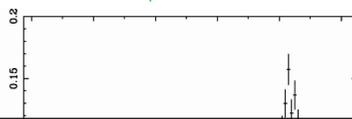
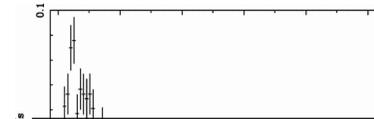
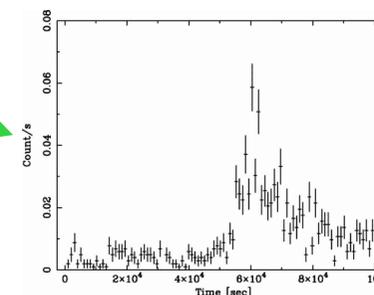
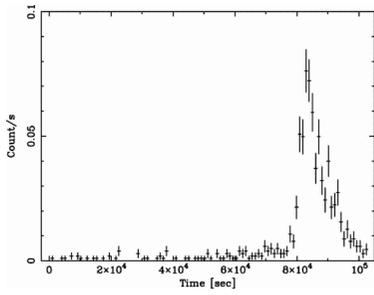
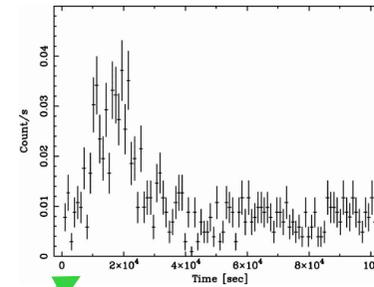
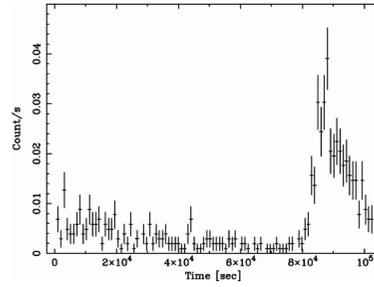
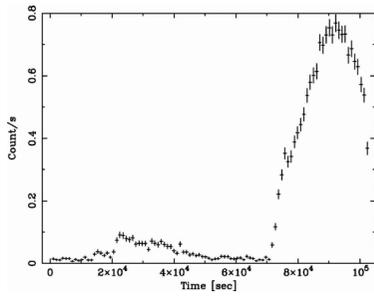
中央大学理工学部

Early Evolution of a Star



Movie





>60% of the Class I showed flares with 10,000-100,000 times larger luminosities than solar flares.

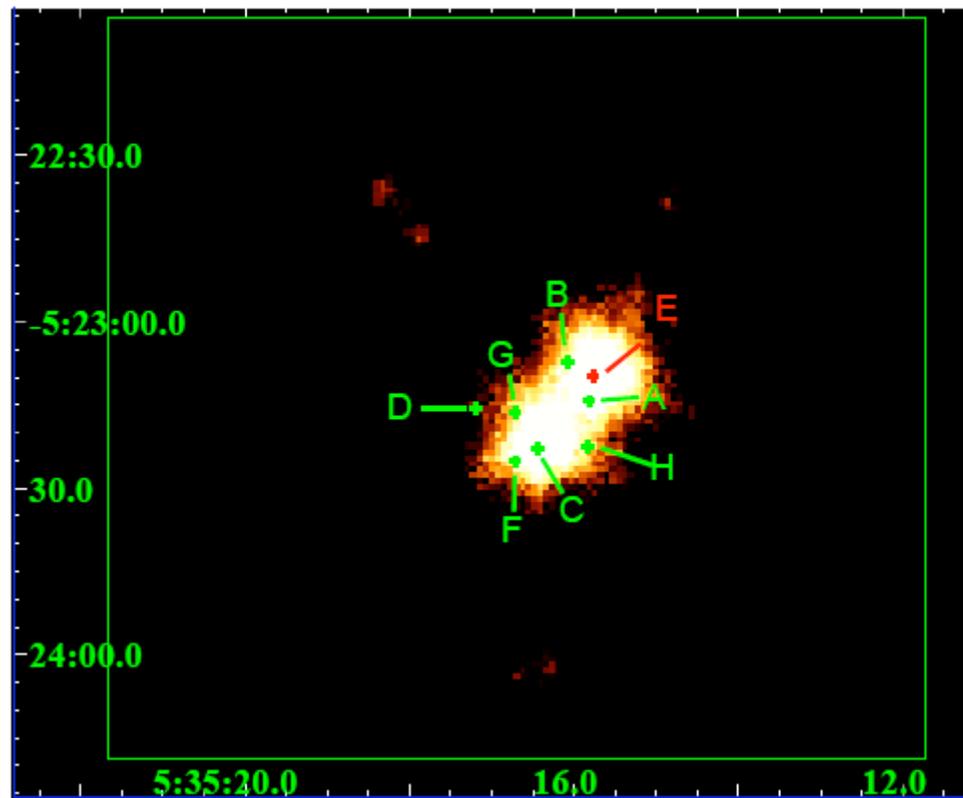
B型星 θ Ori E におけるフレア

Orion Trapezium

Chandra

XMM-Newton

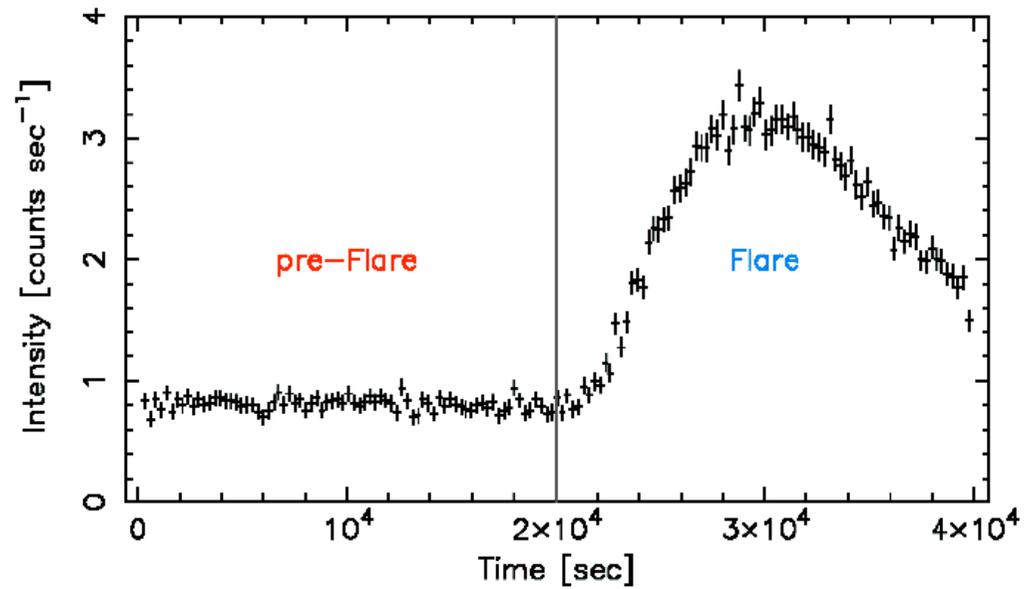
図 3.7: Orion Trapezium core-image (XMM)



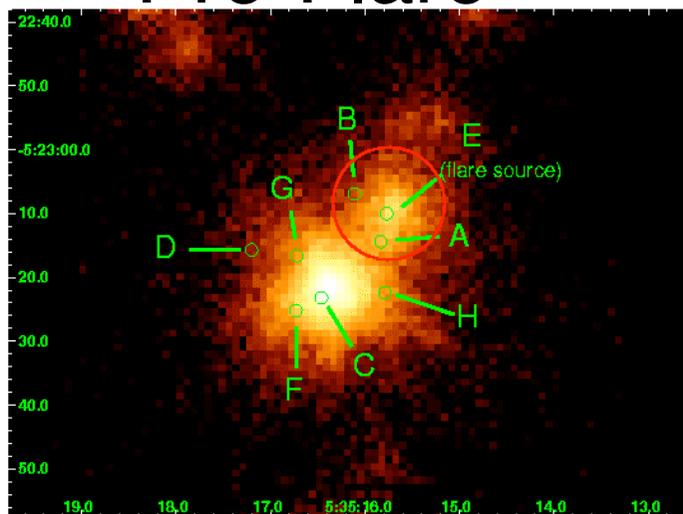
B0.5型星からのフレア

Theta Ori E

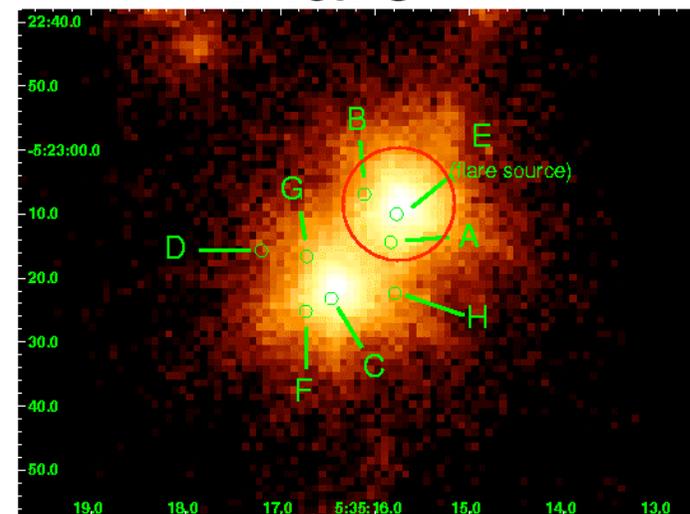
(Tsuboi et al. 2009 in prep. 鬼形 修論)



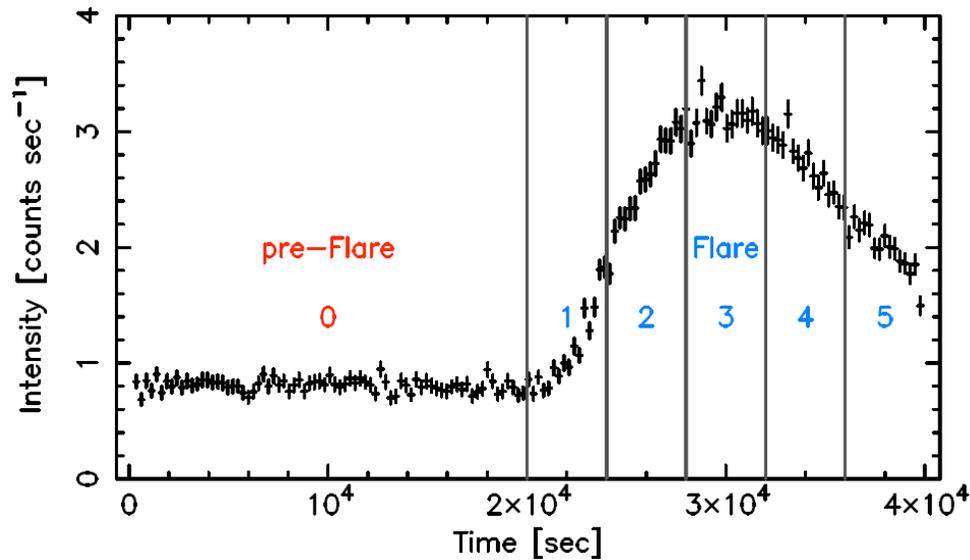
Pre-Flare



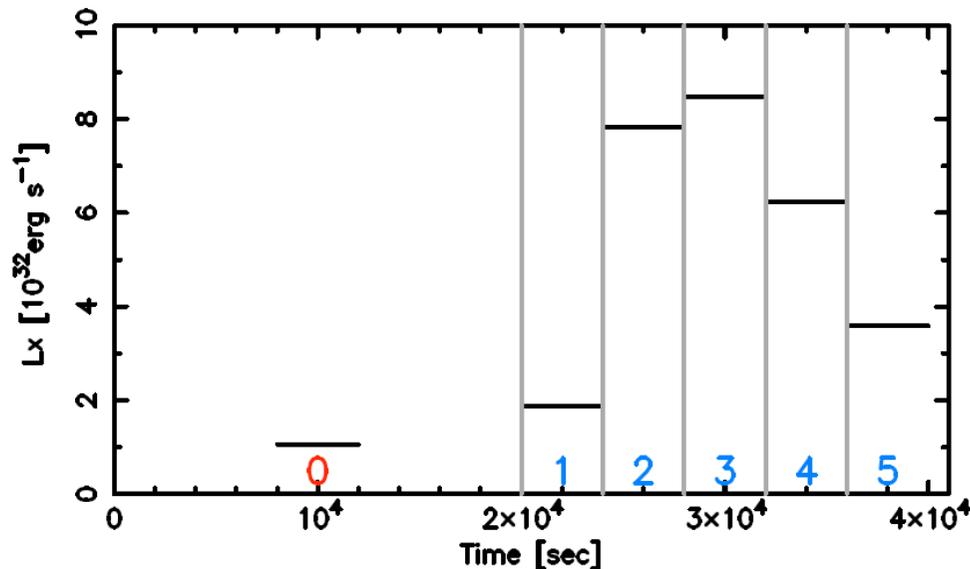
Flare



L_x の変動



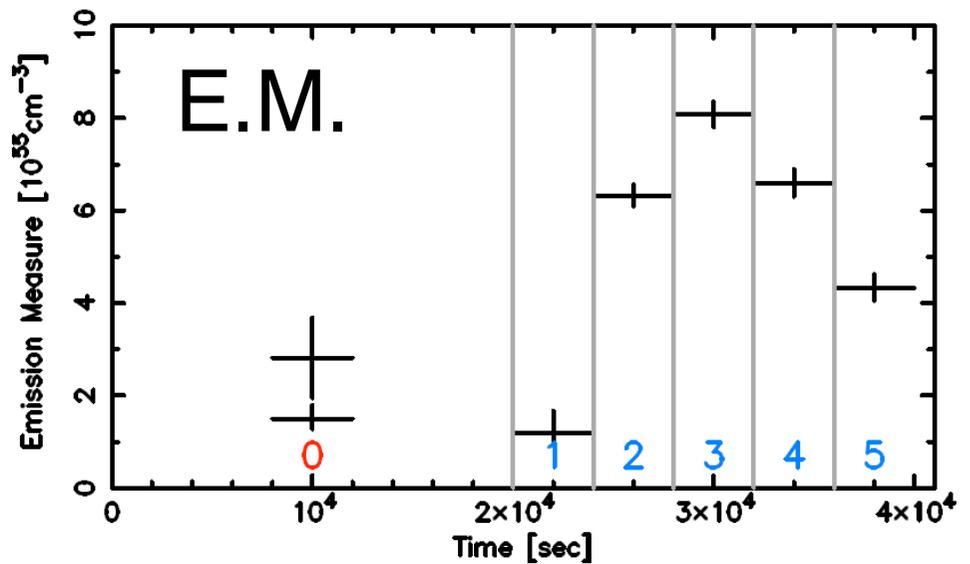
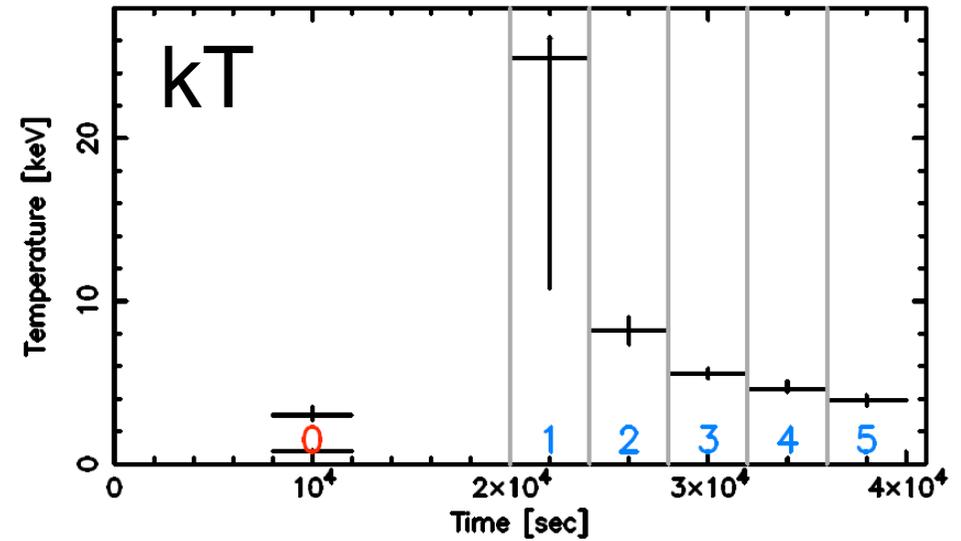
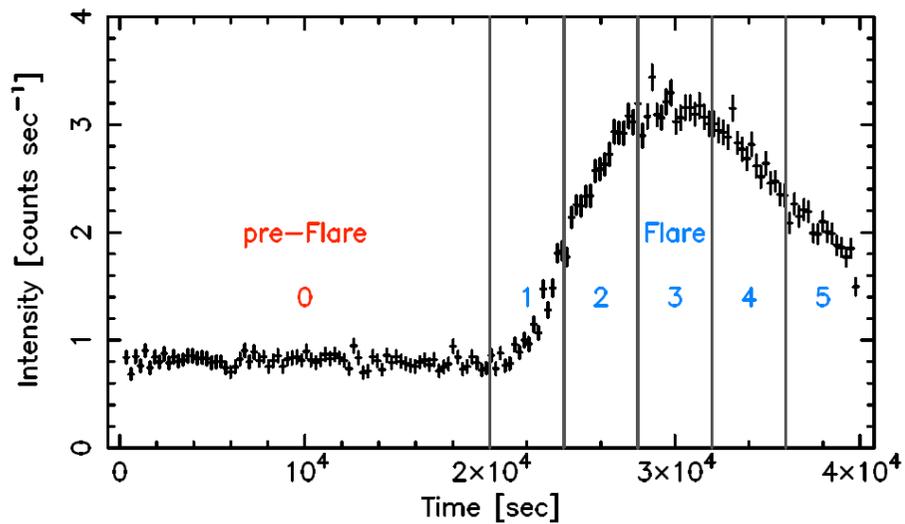
最大級の太陽フレア
より6桁大きい光度



星のフレアとして
最大級

(e.g. V773 Tau;
Tsuboi et al. 1998)

kT および E.M. (n_e^2V) の変動



太陽フレアと類似

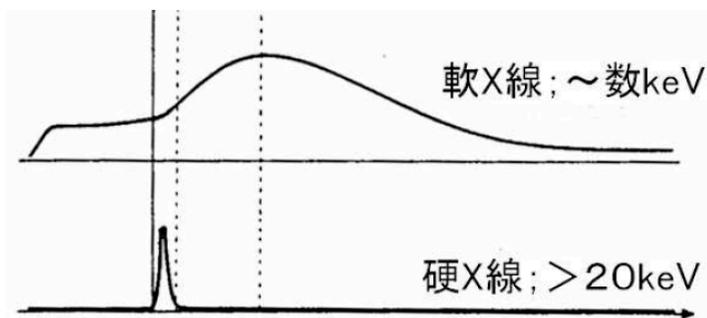
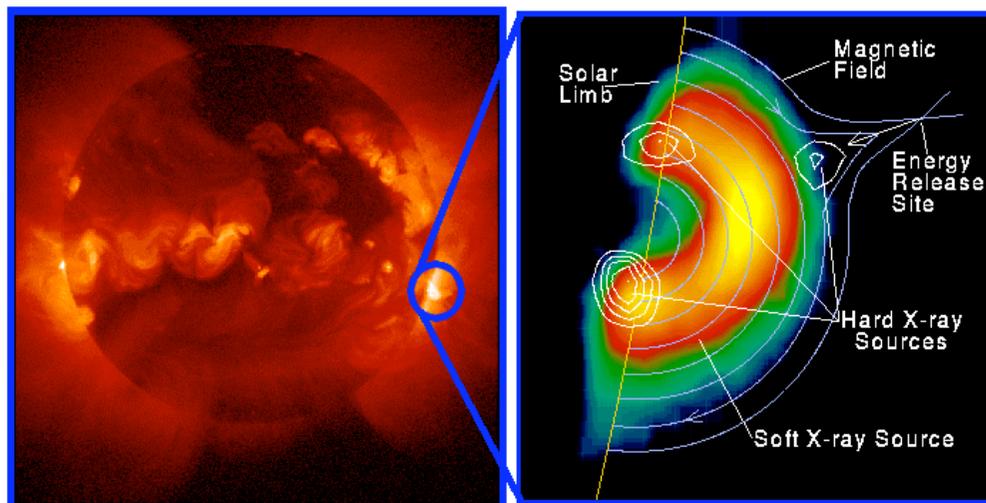


図 4.10: 太陽 X 線ライトカーブ



Yohkoh X-ray Image of a Solar Flare, Combined Image in Soft X-rays (left) and Soft X-rays with Hard X-ray Contours (right). Jan 13, 1992.

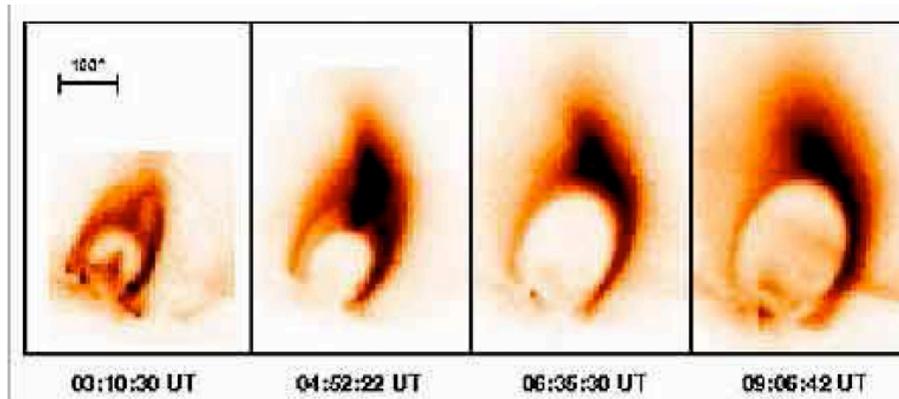
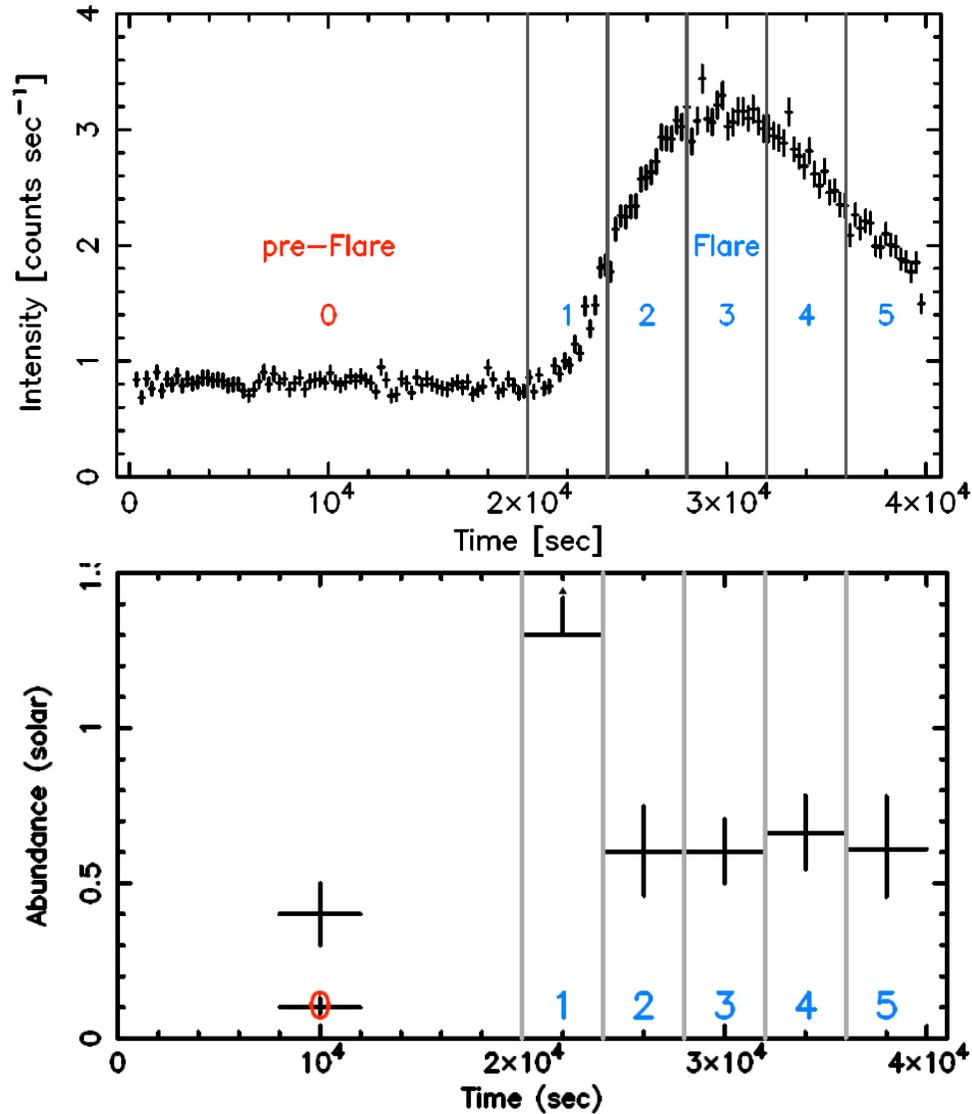


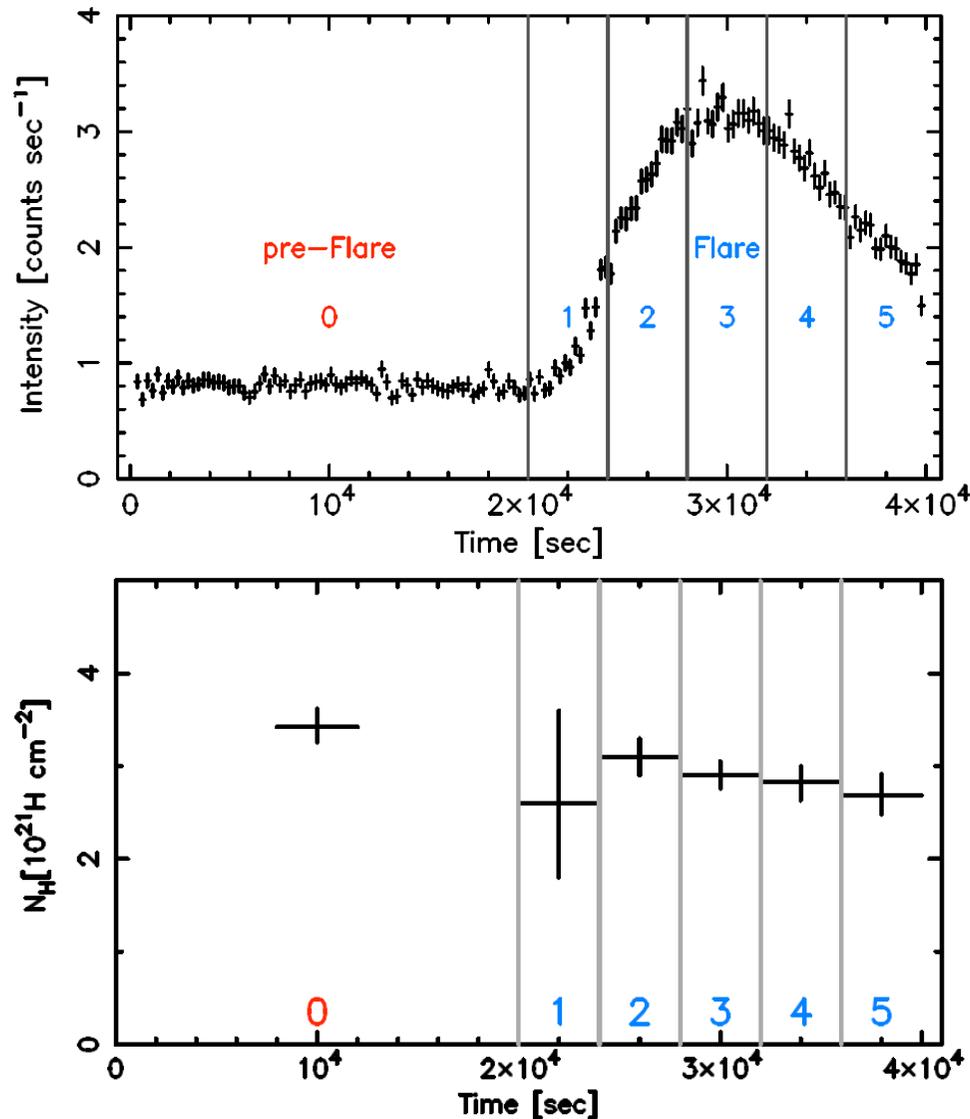
図 4.12: 1992/2/21 フレア ; ようこ
う軟 X 線バンド

Abundance の変動



太陽フレア、
星のフレア
(RS CVn, YSOs)
でいくつか報告あり

N_H の変動



変動？

他には唯一

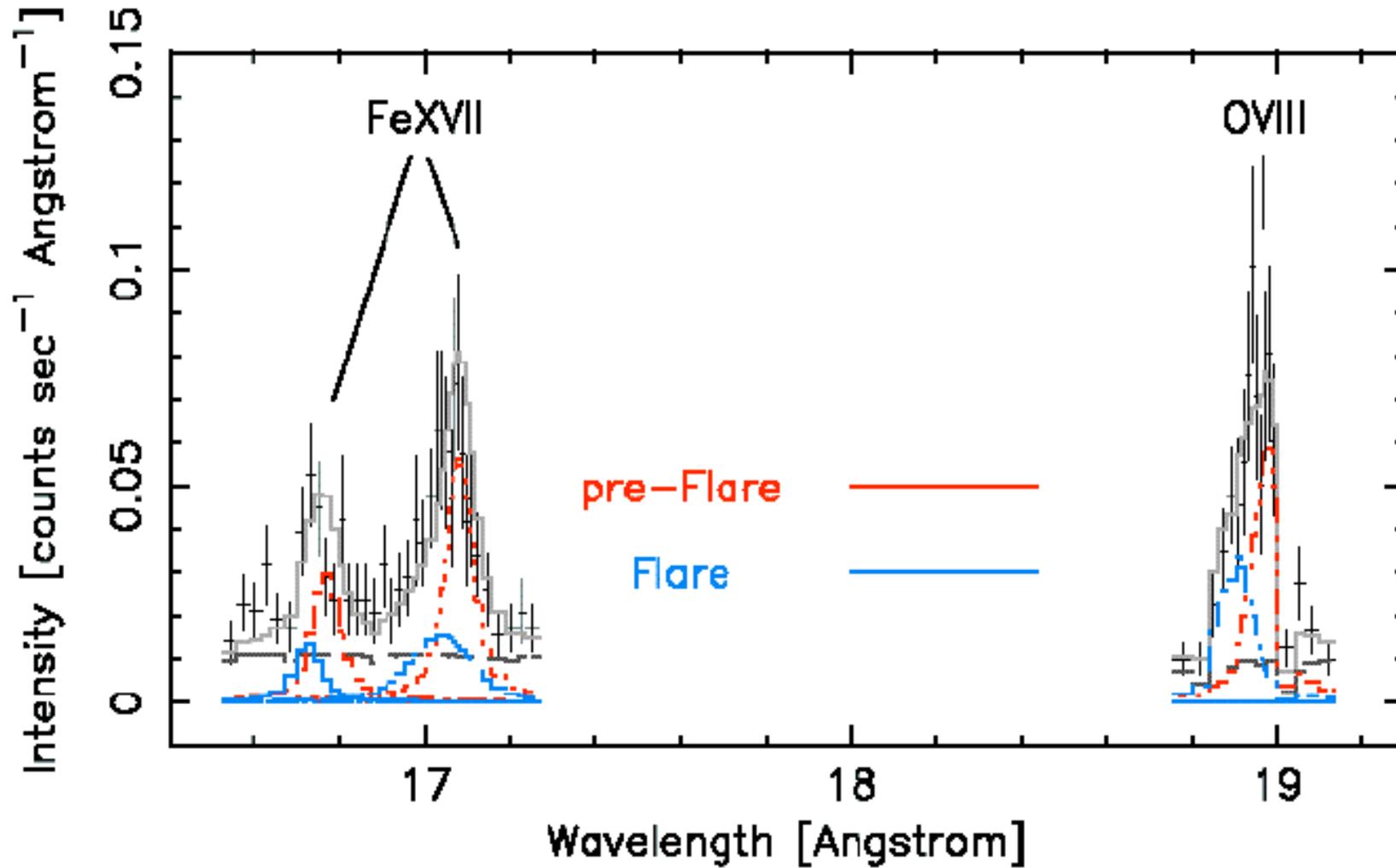
YSO、V773 Tau

で変動の報告あり

(Tsuboi et al. 1998)

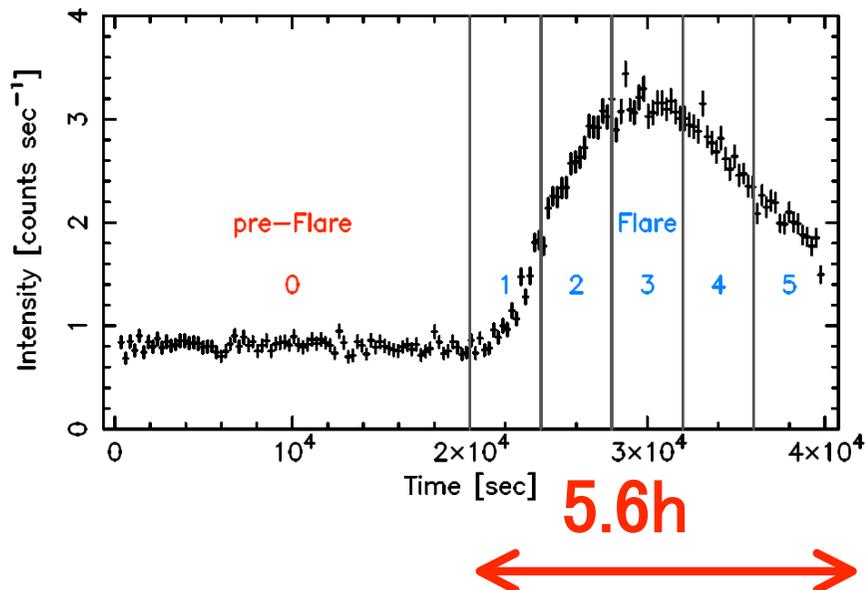
フレア中のラインの青方偏移

$$\Delta v \sim -1700 \text{ (} -2100 \sim -1200 \text{) km s}^{-1}$$



phase 別 青方偏移

phase	Δv [km s ⁻¹]
1~5	-1700 (-2100 ~ -1200)
1~2	-1800 (-2800 ~ -1000)
4~5	-1500 (-2100 ~ -900)



5.6h にわたって
同じシフト

プラズマの密度 および 体積

- ・ $3n_e kT = \Lambda \tau_{\text{cool}}$ 放射冷却を仮定

- ・ $n_e^2 V$

$$n_e = 2 \times 10^{11} \text{ cm}^{-3}$$

$$V = 2V_{\text{solar}}$$

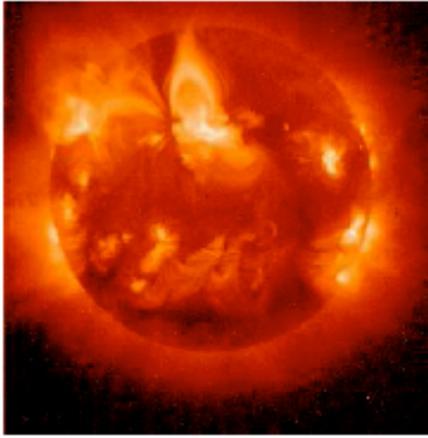


図 4.5: 太陽フレア; ようこう

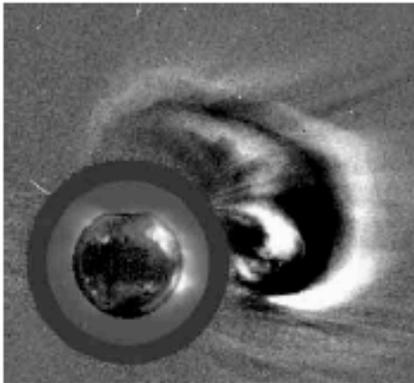


図 4.8: CME
外側; SOHO、
内側; ようこう

An Example of Solar X-Ray Jets

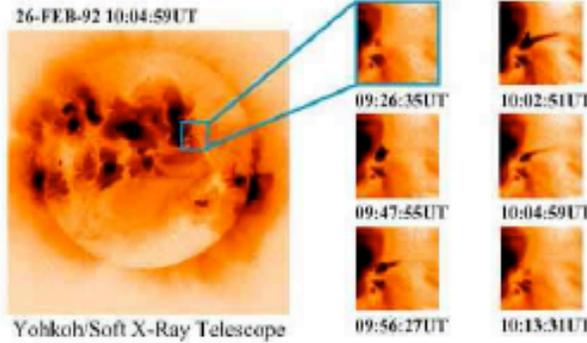


図 4.6: 太陽ジ
ェット; ようこ
う

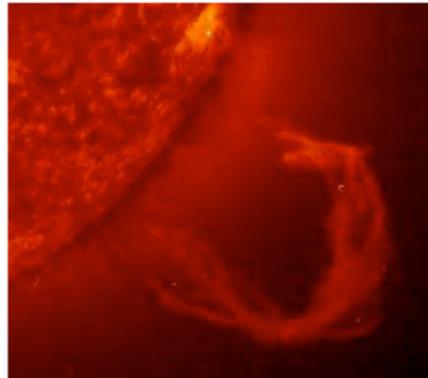


図 4.9: 太陽
プロミネンス;
SOHO(紫外線)

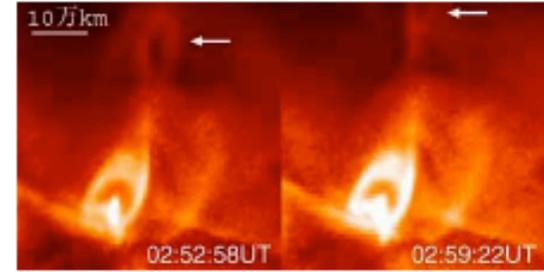


図 4.7: プラズ
モイド; ようこ
う

CME 典型的質量

$10^{14} \sim 10^{16} \text{g}$

ちなみに

大質量星の星風

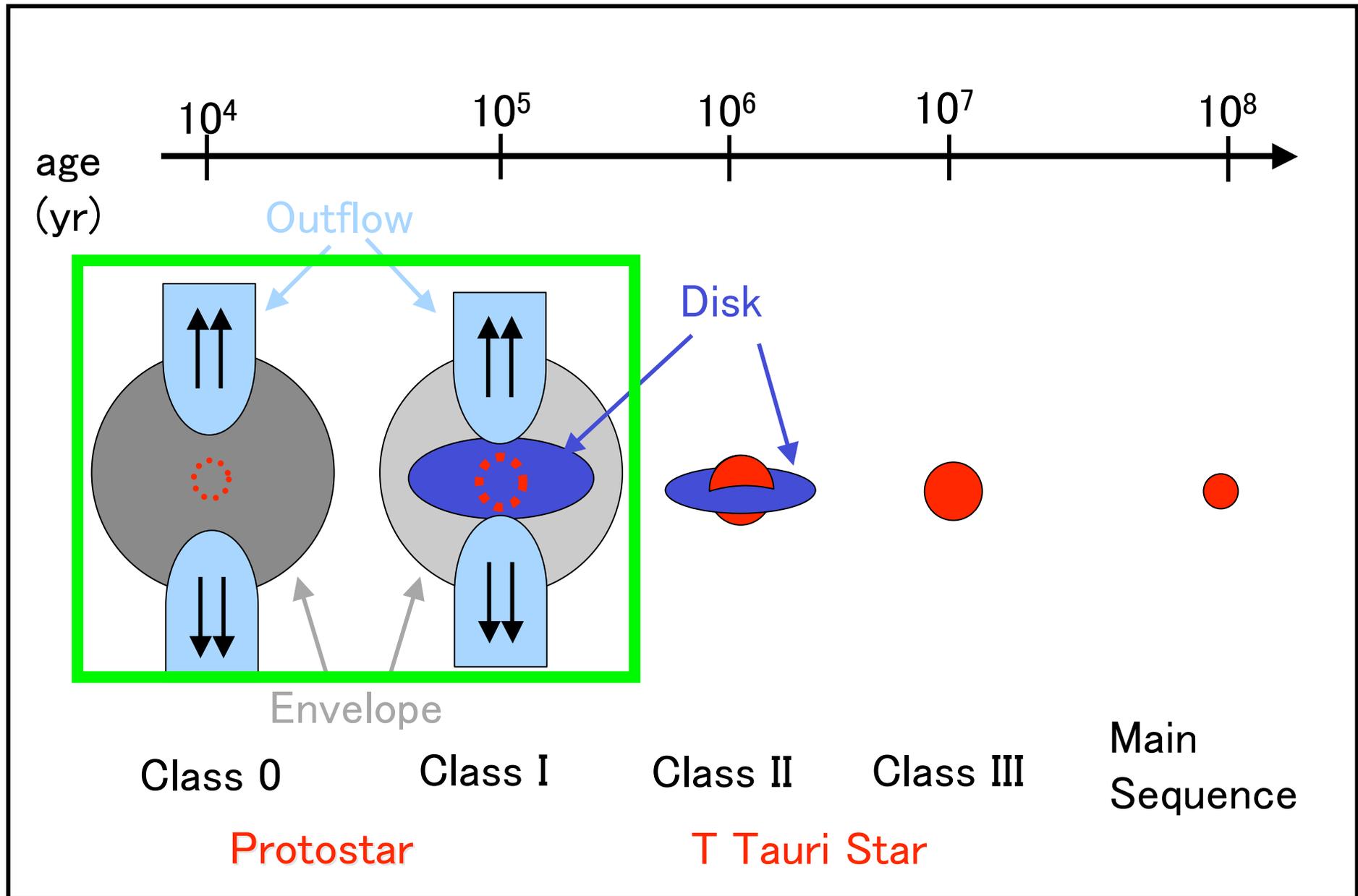
$10^{20} \sim 10^{22} \text{g}/5.6 \text{hr}$

今回のプラズマ放出

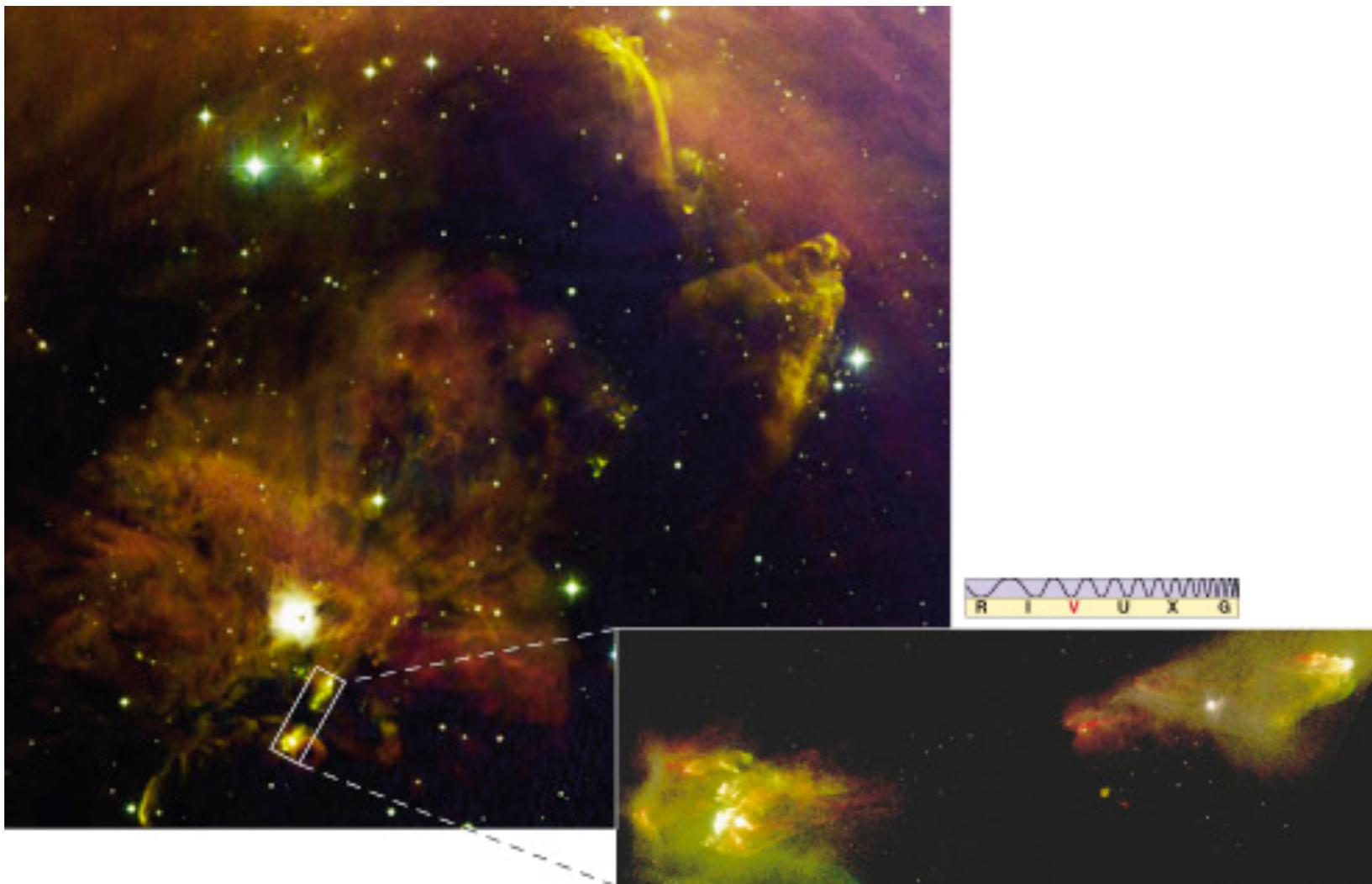
$2 \times 10^{20} \text{g}$

原始星ジェットからのX線

Early Evolution of a Star

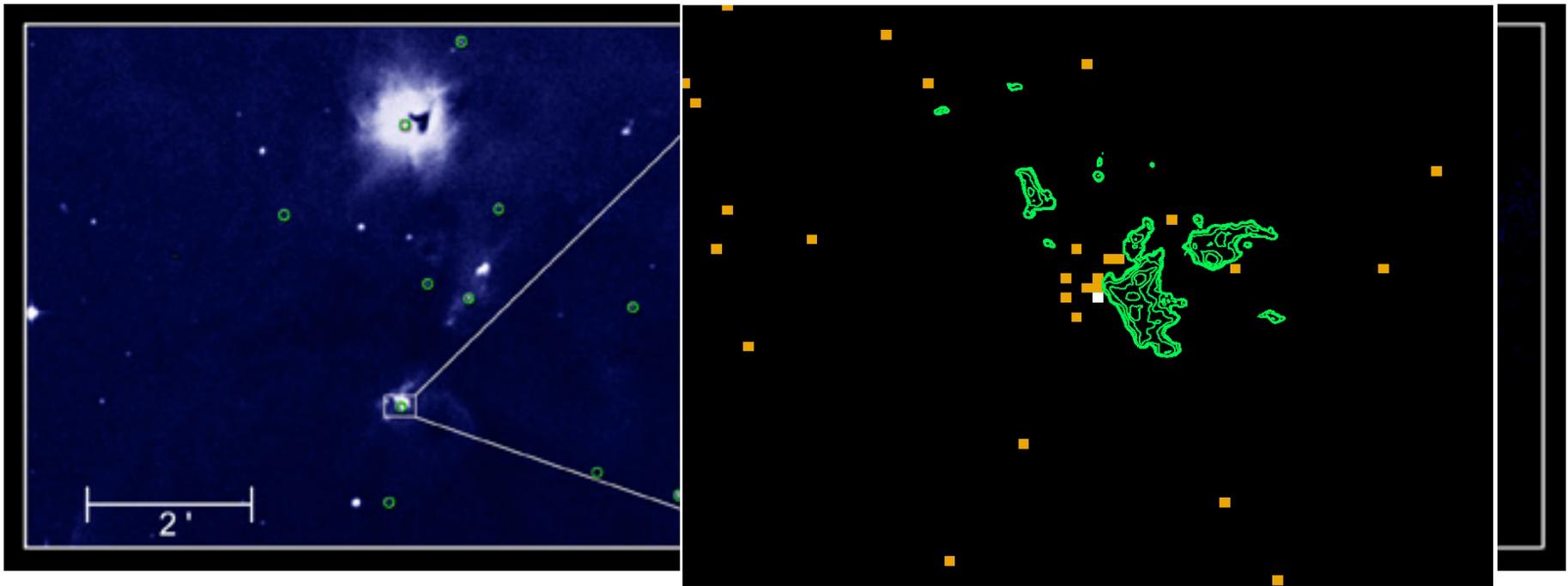


原始星 HH1/2 からのジェット



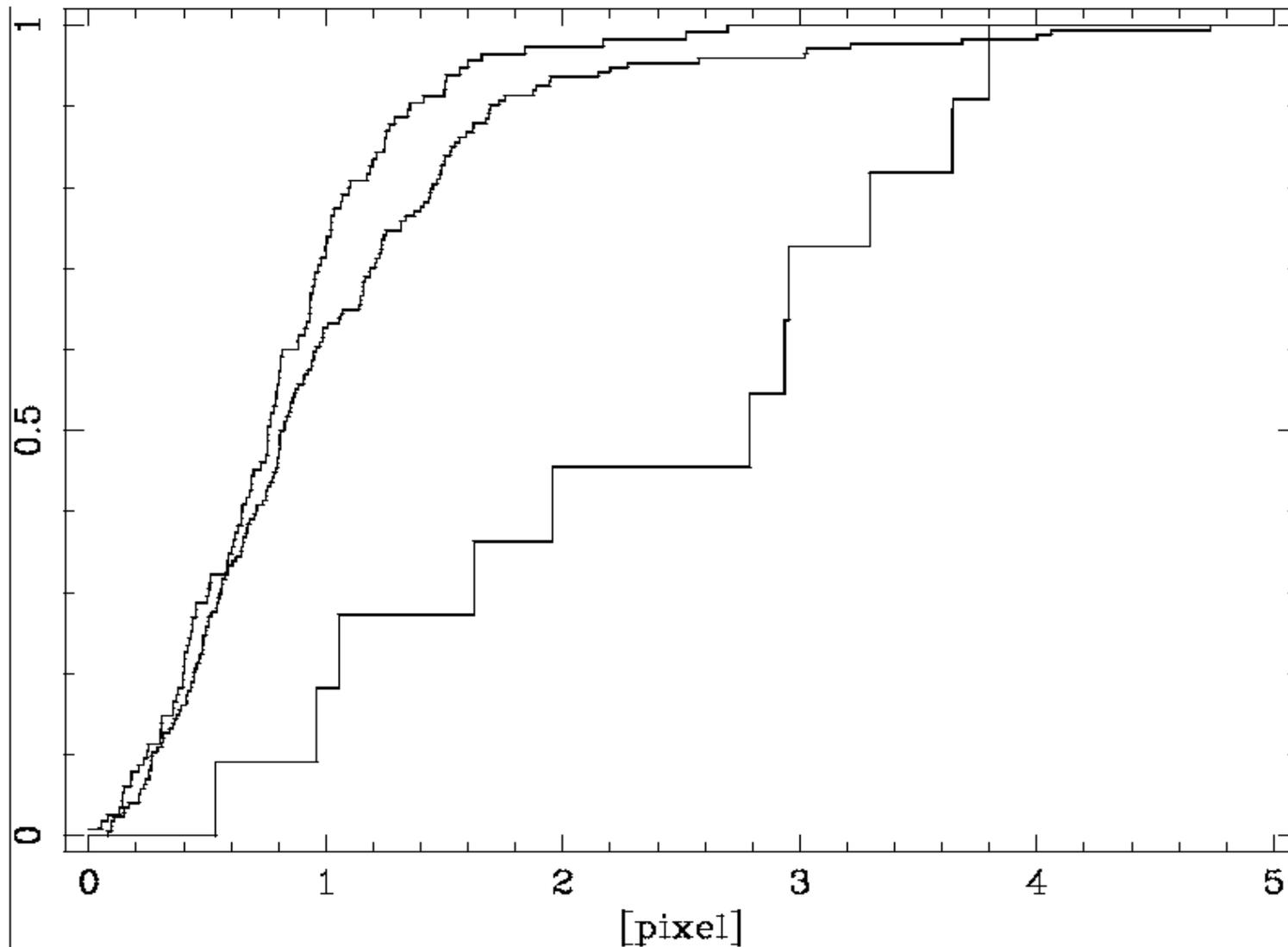
X-rays from HH 2

(Pravdo et al. 2001 Nature)

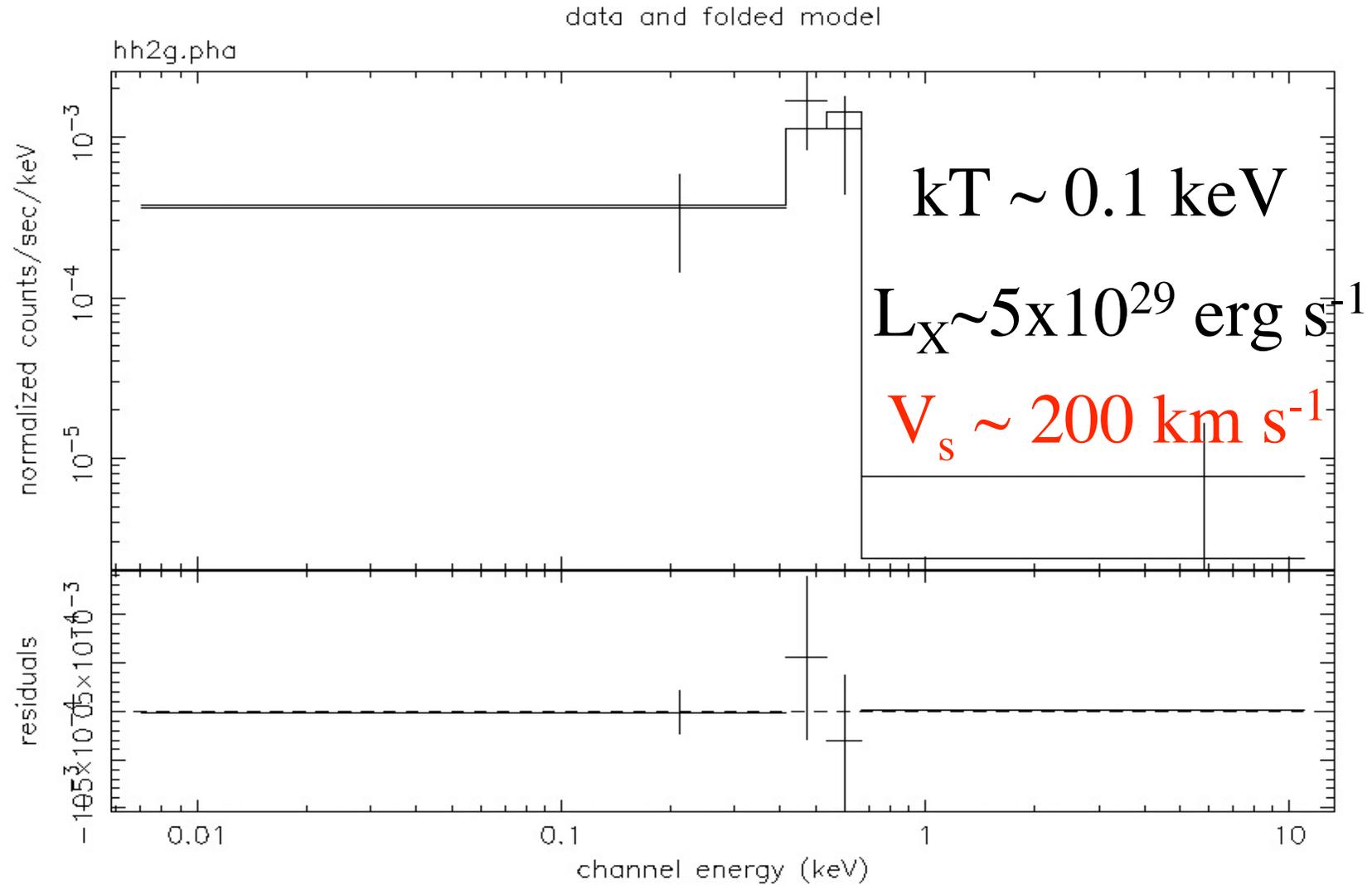


等高線: H α (HST)

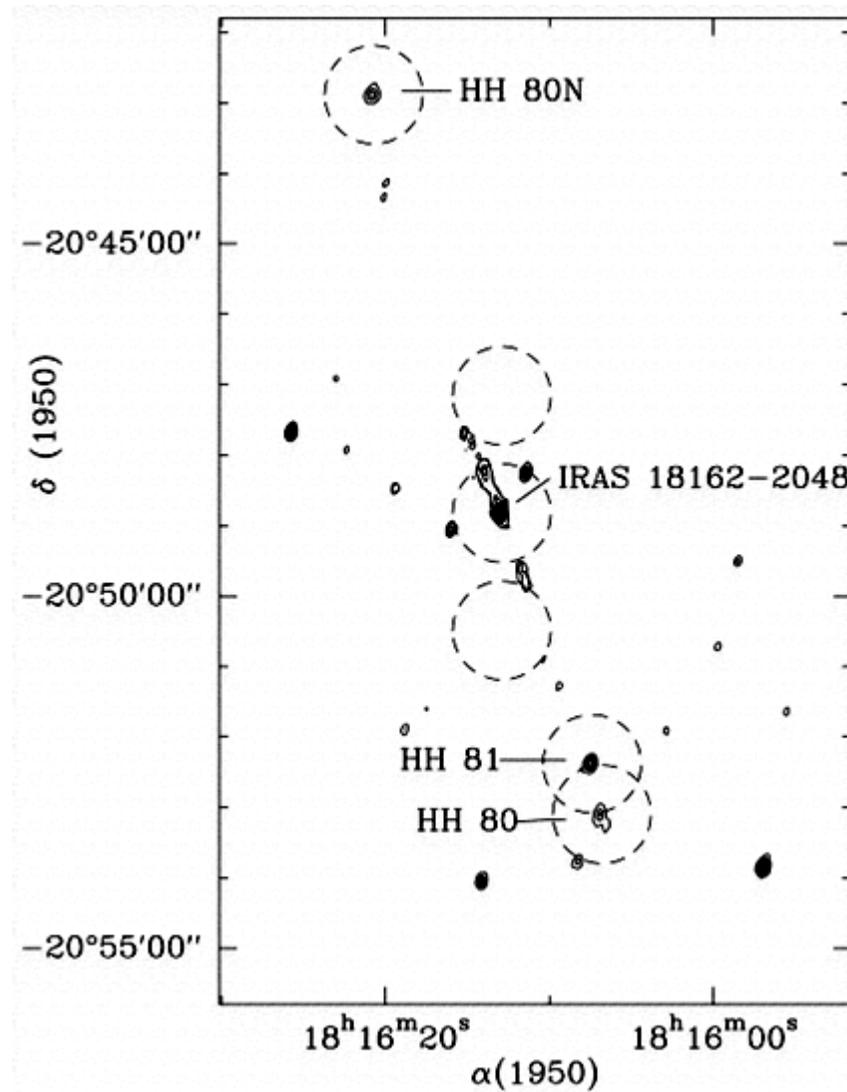
X線の広がり



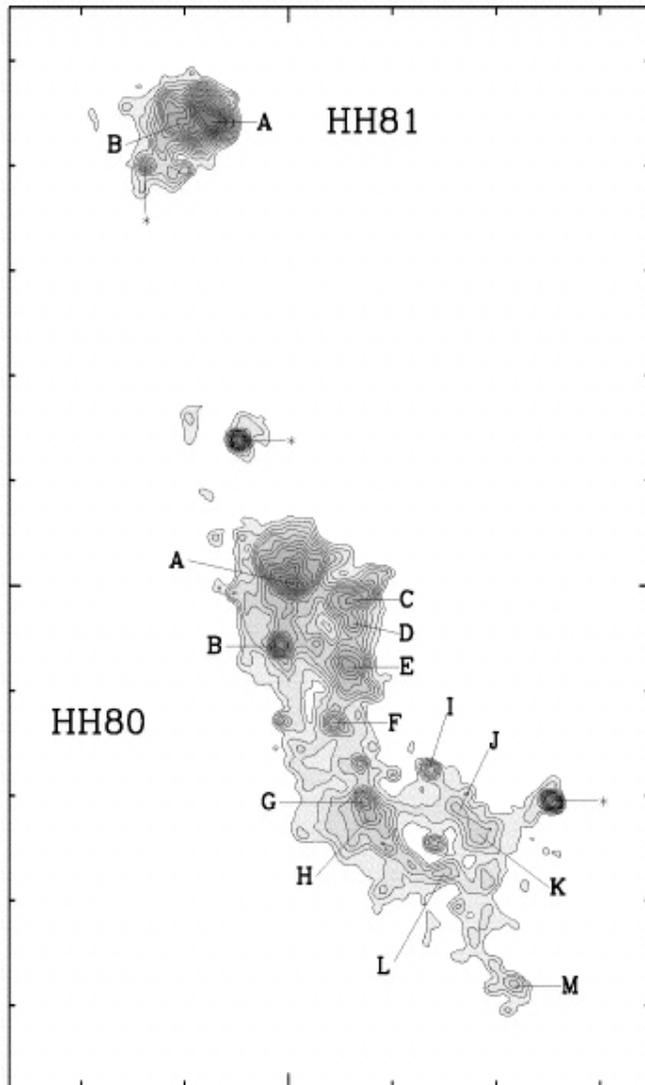
Spectrum of HH2



原始星 HH80/81 からのジェット (radio cm波)

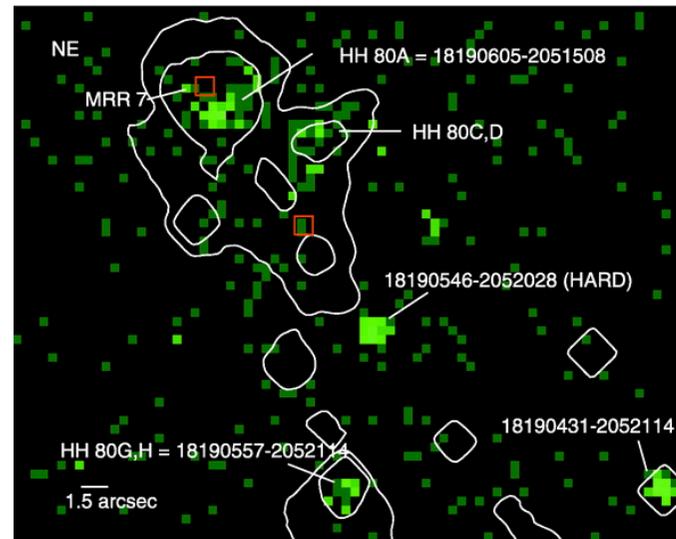
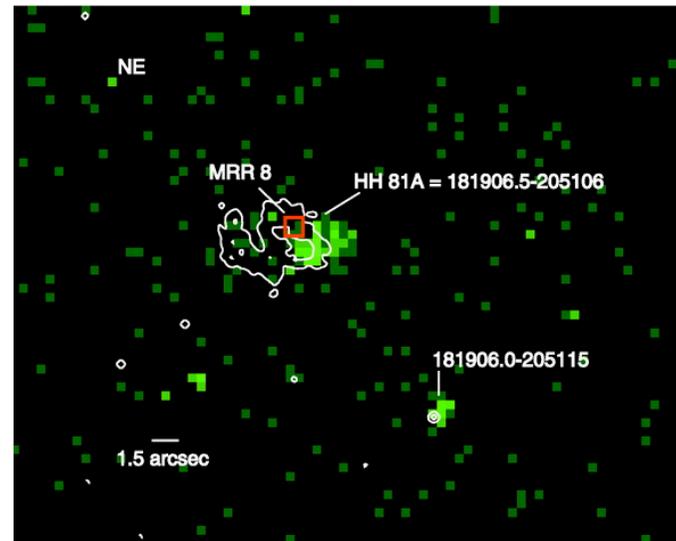


可視光



X線: Chandra

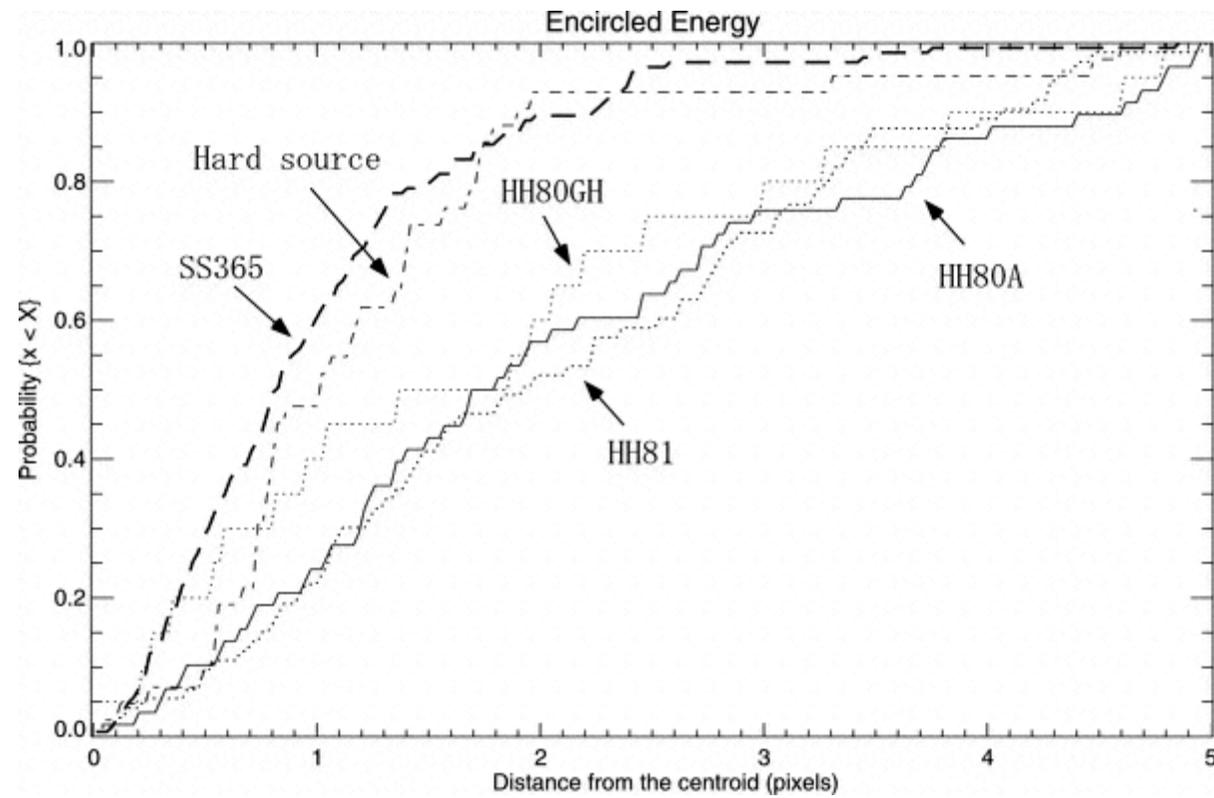
Pravdo, Tsuboi, Maeda 04 ApJ



等高線: 可視光

□ :
radio (cm波)

X線の広がり



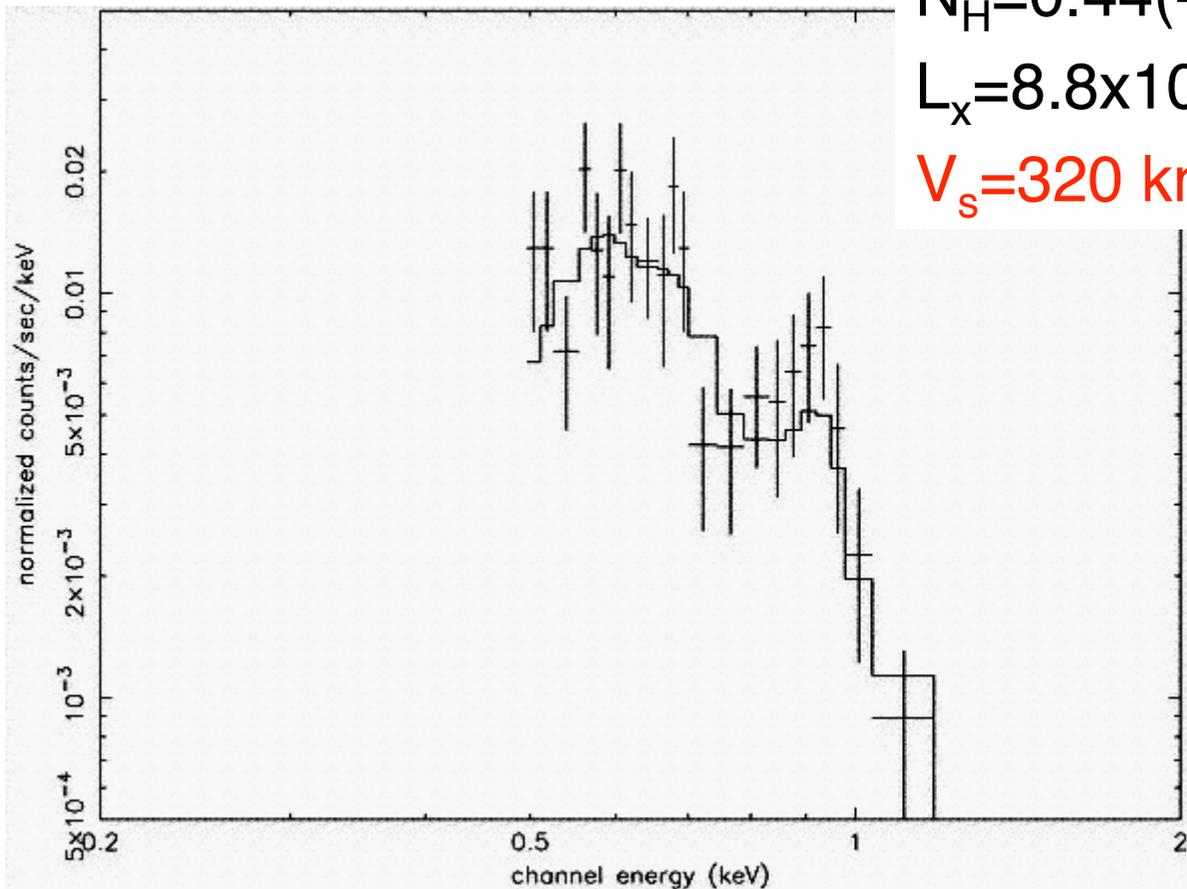
HH80/81のスペクトル

$$kT=0.13(\pm 0.05) \text{ keV}$$

$$N_H=0.44(+0.10-0.12)\times 10^{22} \text{ cm}^{-2}$$

$$L_x=8.8\times 10^{31} \text{ erg s}^{-1}$$

$$V_s=320 \text{ km s}^{-1}$$

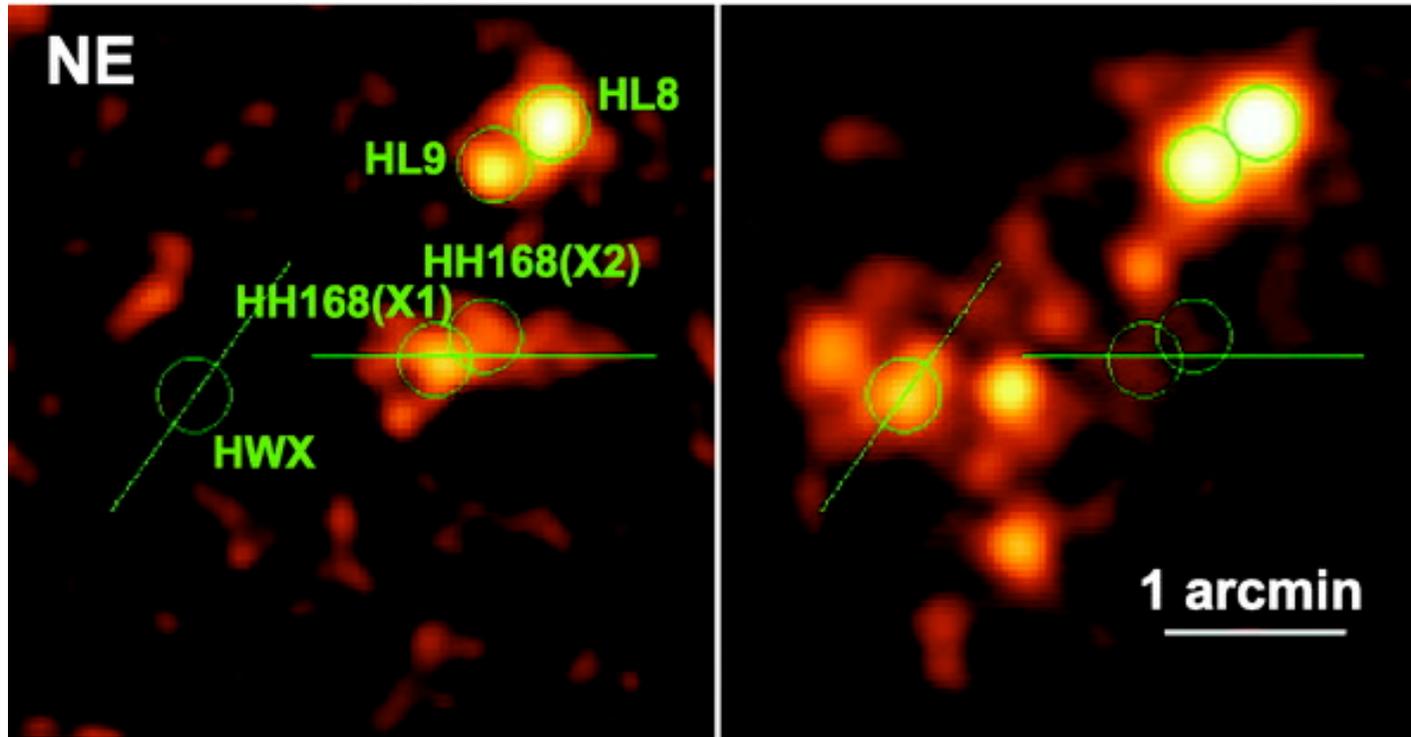


Cep A XMM-Newton image

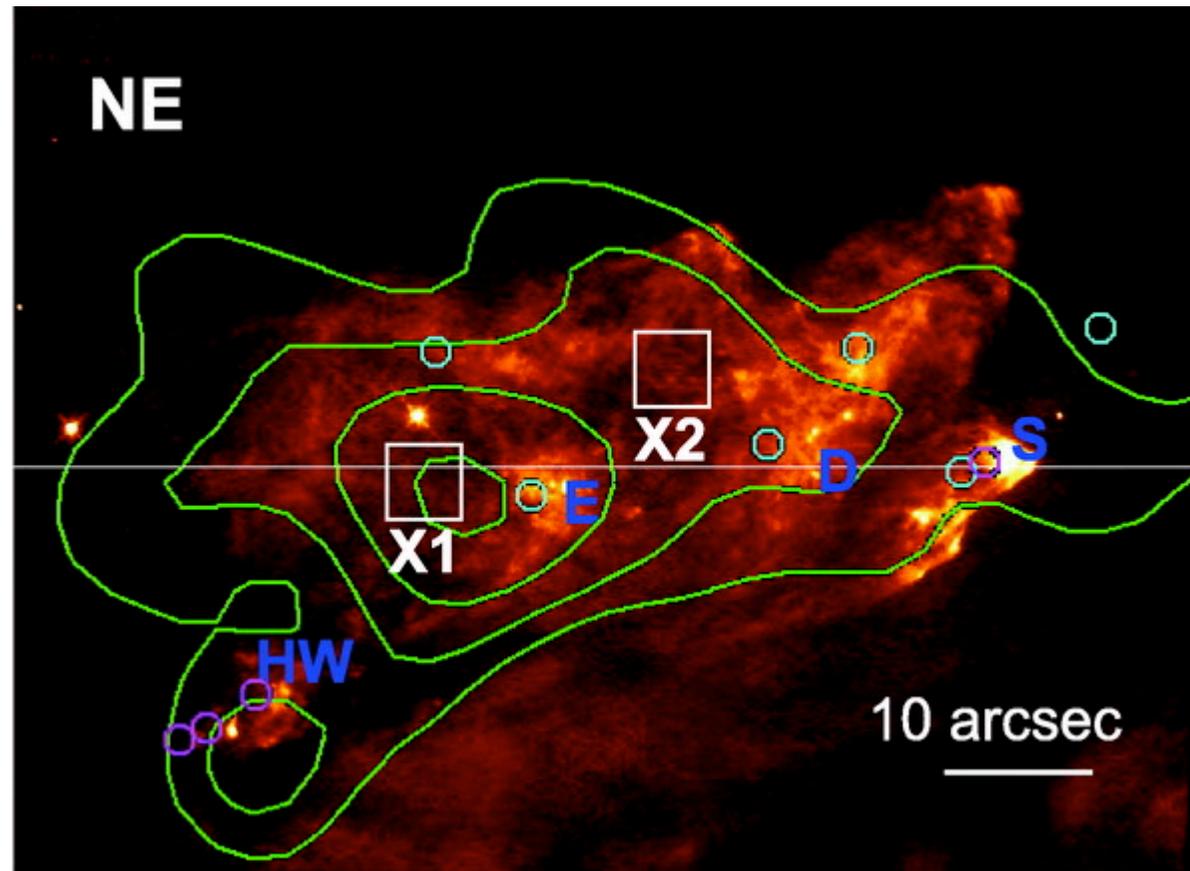
Pravdo & Tsuboi 05 ApJ

<2 keV

>2 keV

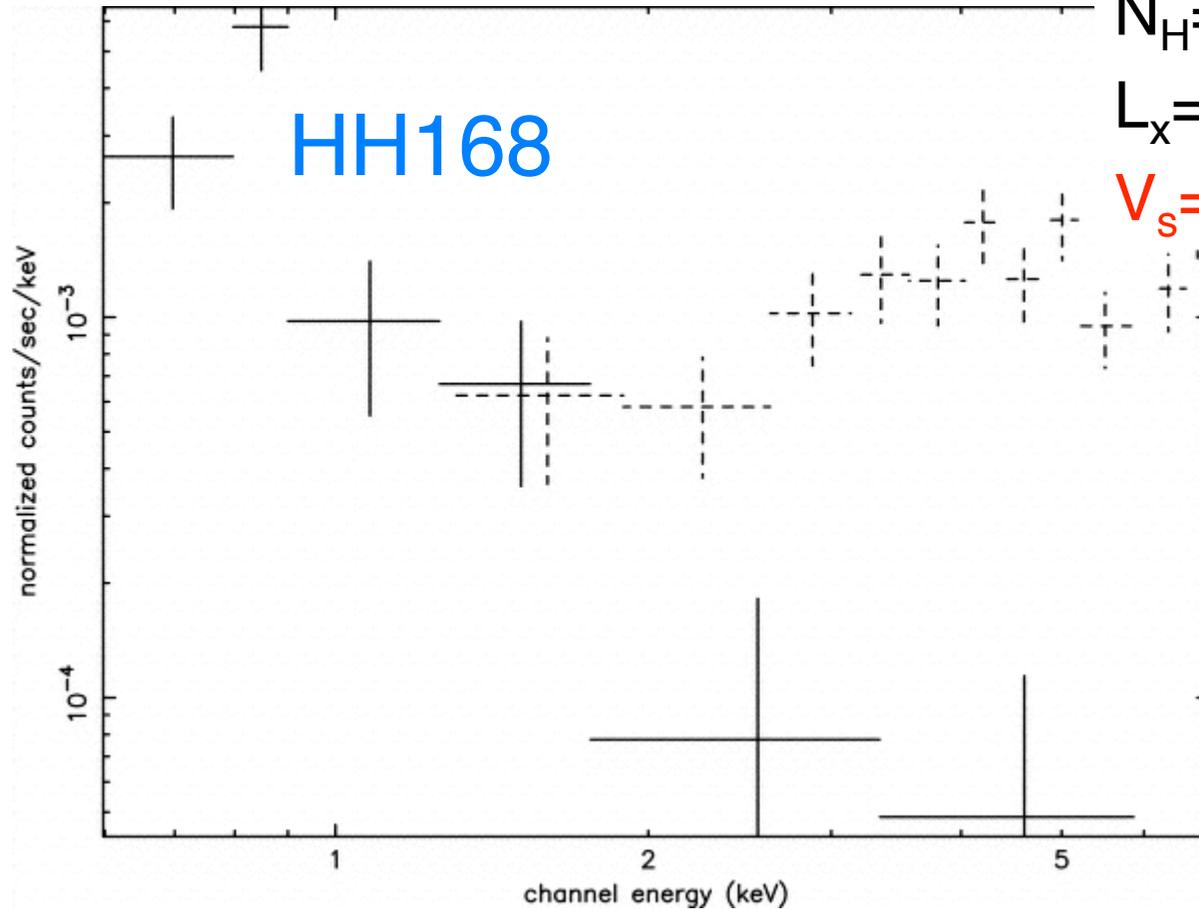


HH168 (XMM) vs. H α (HST)



等高線：XMM, 小円：radio cm波

HH168のスペクトル



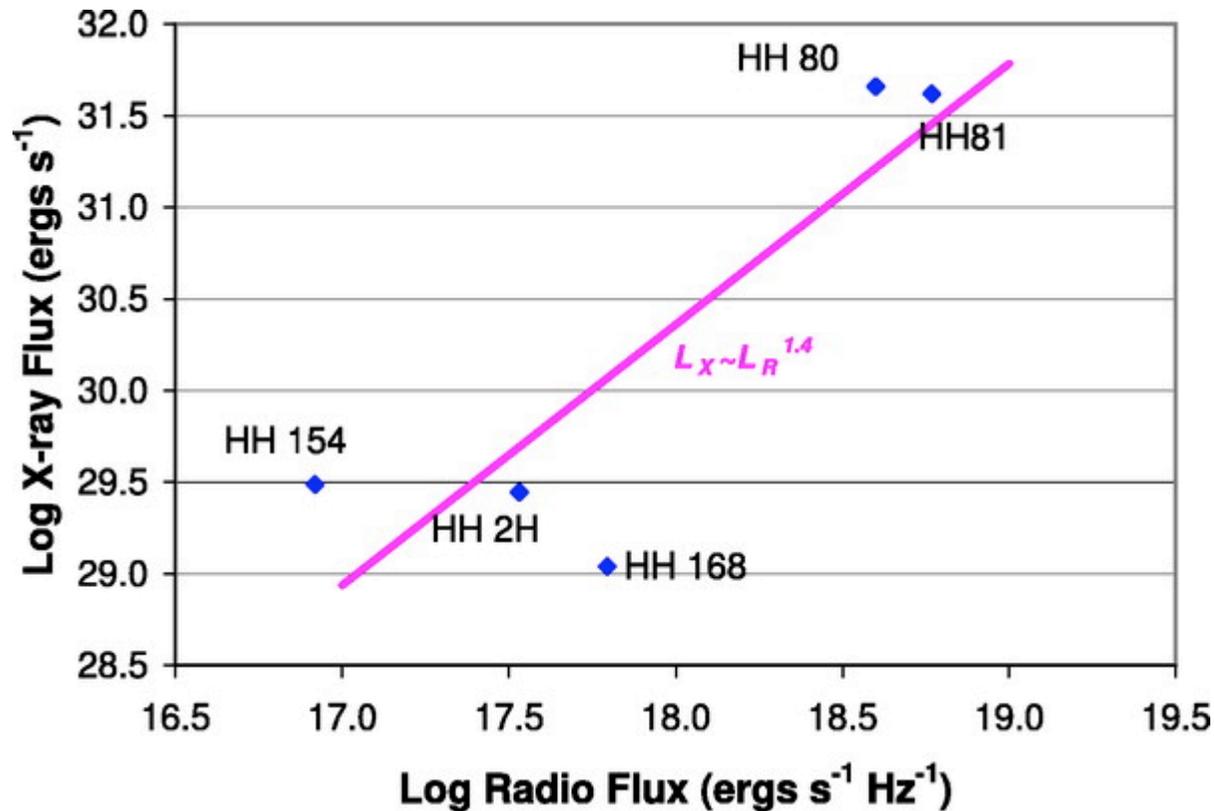
$$kT=0.5(+0.3-0.2) \text{ keV}$$

$$N_{\text{H}}=0.4(+/-0.4)\times 10^{22} \text{ cm}^{-2}$$

$$L_{\text{x}}=1.1\times 10^{29} \text{ erg s}^{-1}$$

$$V_{\text{s}}=620(+170-140) \text{ km s}^{-1}$$

X-ray vs. radio (cm波)



エラーの範囲で
小質量星における
関係 $L_X \sim L_R^{1.24}$
(Gudel 02 ARA&A)
と一致

野辺山電波ヘリオグラフ ようこう SXT、HXT

Asai et al. 2001

