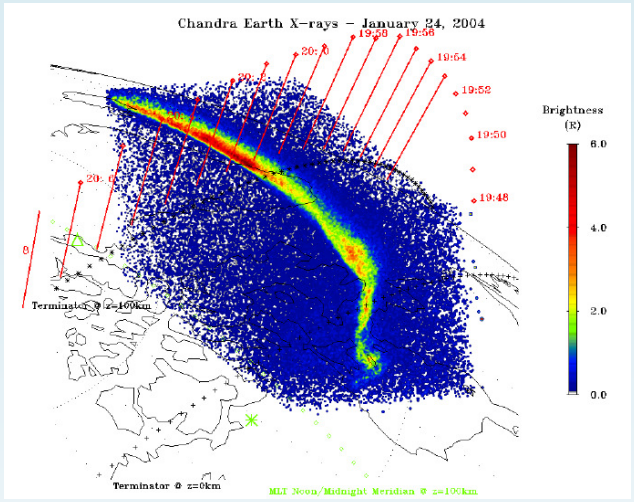
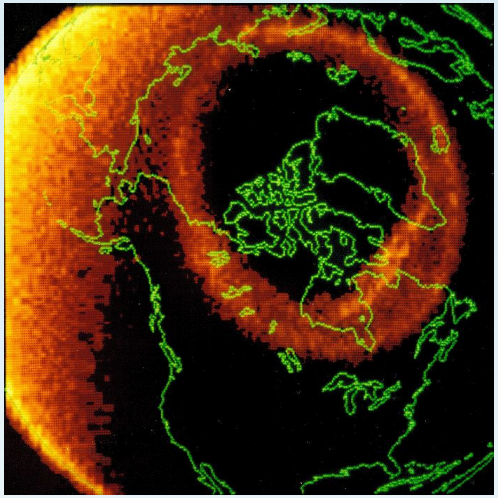


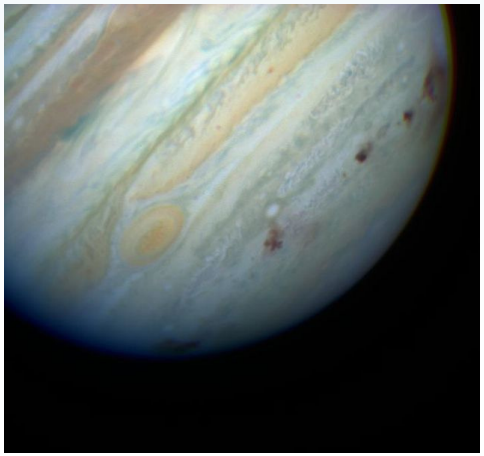



# *IXO studies of the solar system*


## G. Branduardi-Raymont

**Mullard Space Science Laboratory**
**University College London**





***IXO Science meeting***
***Paris, 27 – 29 April 2010***

# X-rays from Jupiter

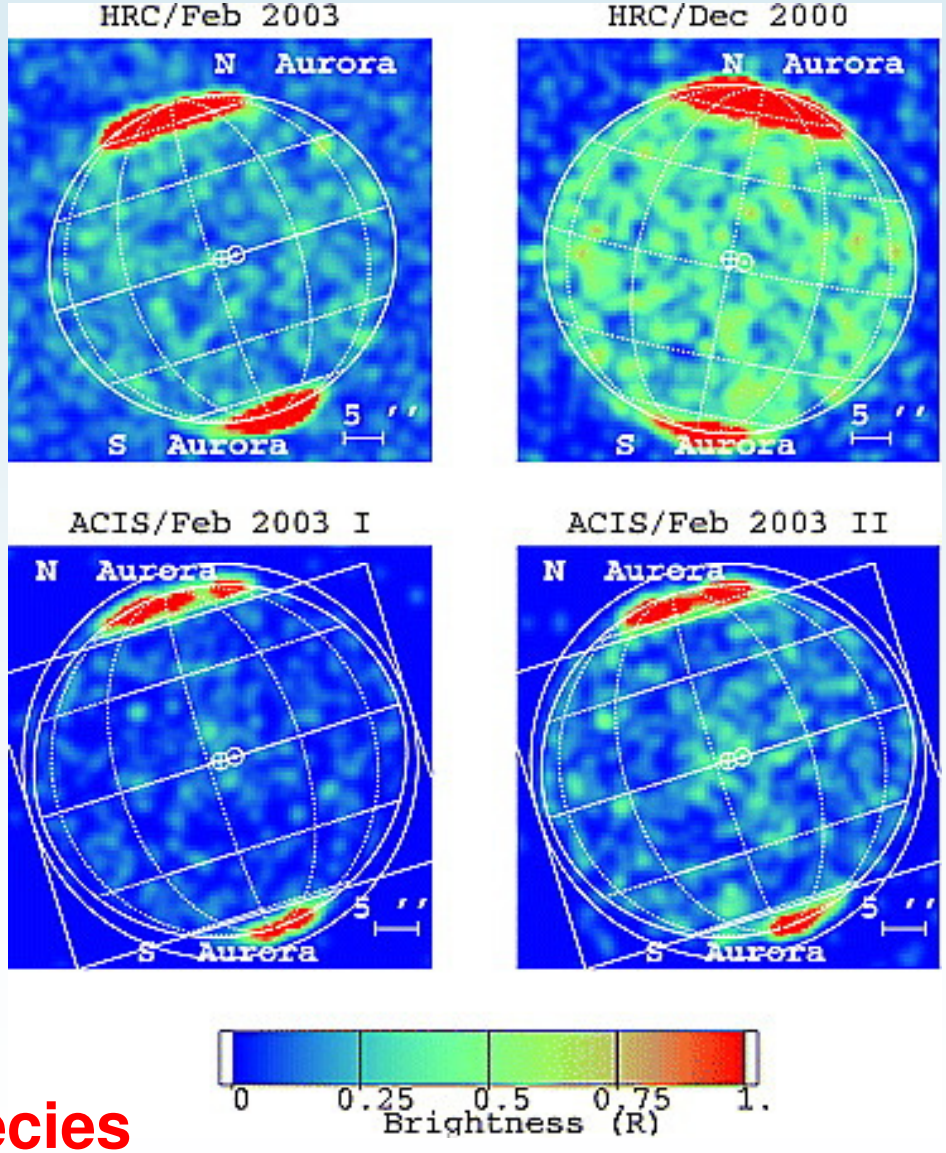
The *Chandra* view

***Bhardwaj et al. 2006*** →

**Aurorae** + **disk** (coronal) X-ray emission

Auroral soft X-rays (< 2 keV): K-shell line emission from charge exchange (CX) by energetic ions from > 30 $R_J$, precipitating along magnetic field lines, e.g.

**$H_2 + O^{7+} \rightarrow H_2^+ + O^{6+} + h\nu$ (0.57 keV)**




→ What are the **other ion species** (C or S) and thus their origin (solar wind / magnetosphere)?

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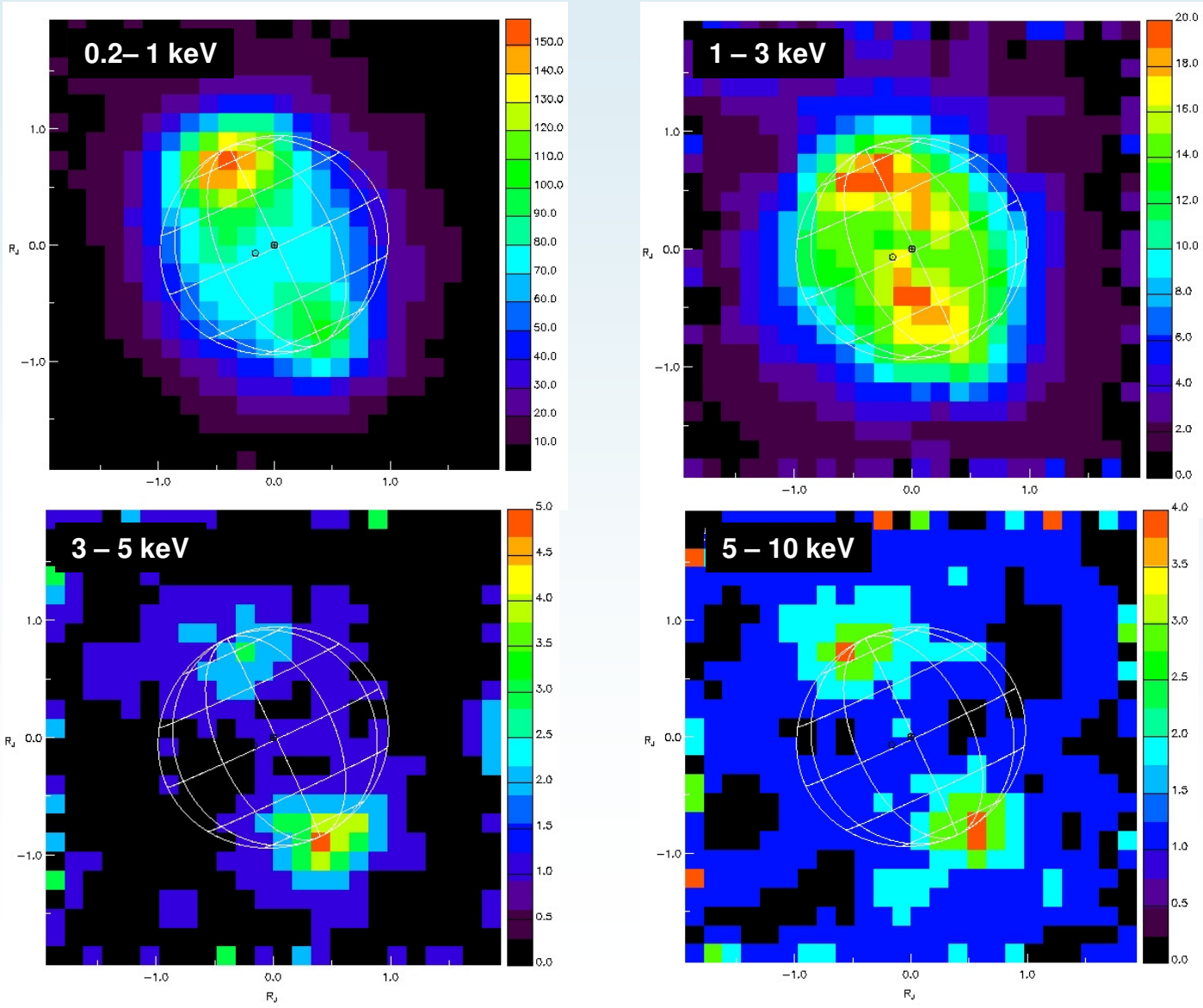
# Jupiter

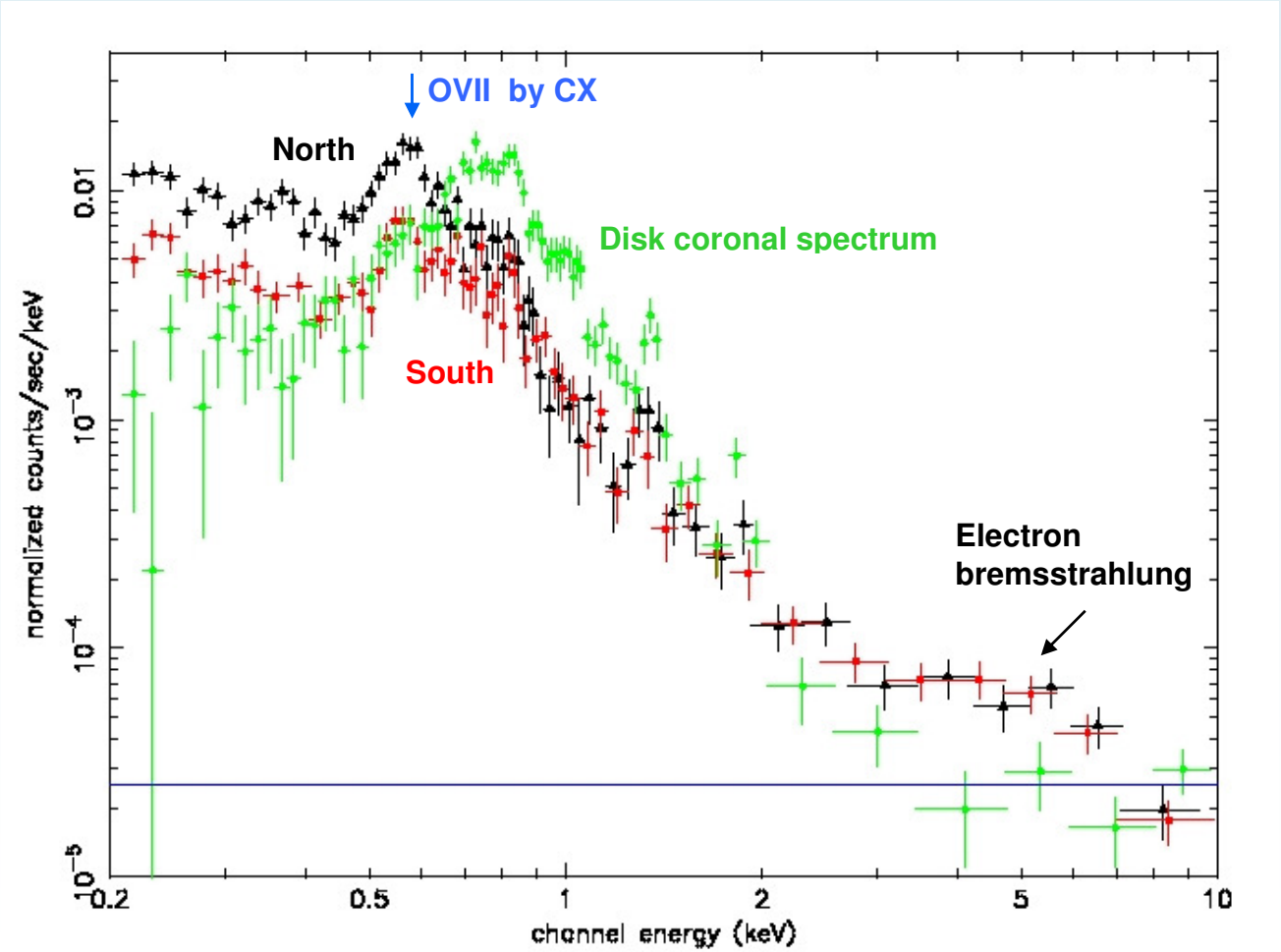
# *XMM-Newton* – Nov. 2003: EPIC



**Jupiter**

# *XMM-Newton* – Nov. 2003: EPIC

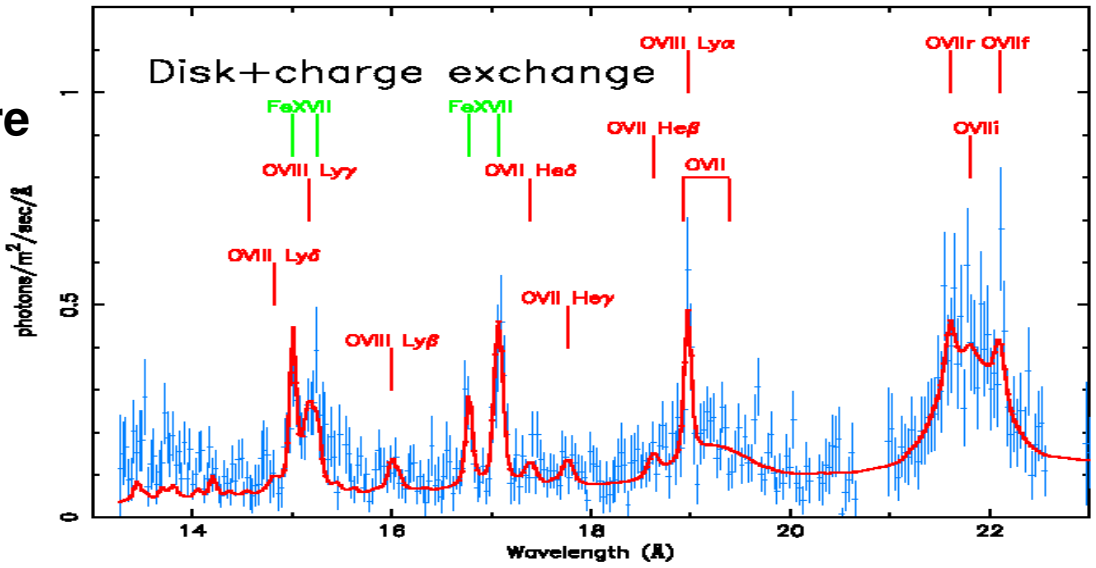
## Auroral and disk spectra



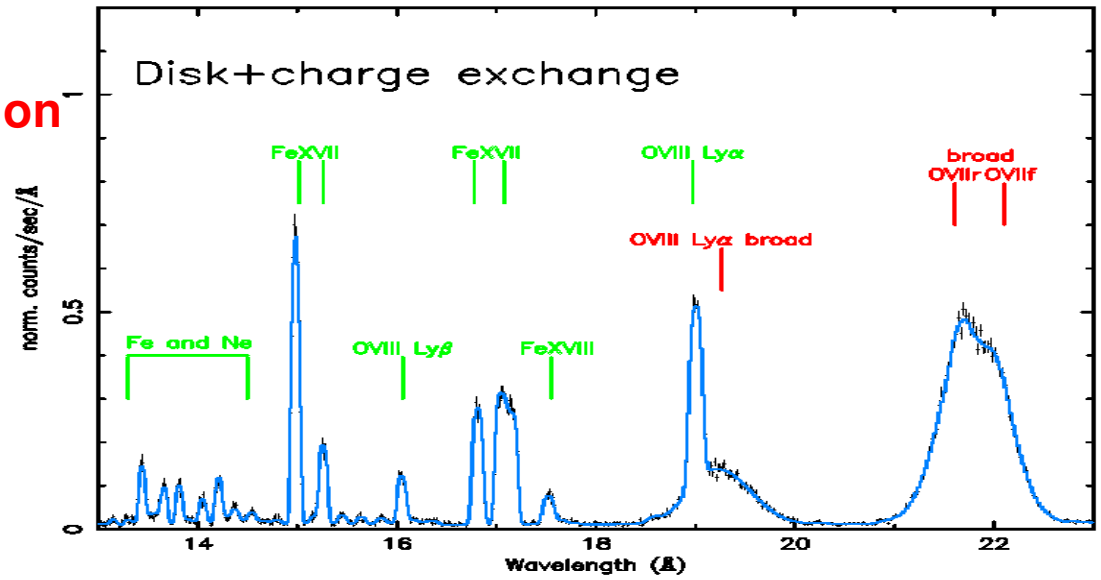

*B-R et al. 2007*

# Jupiter

**XMM RGS**
**200 ks exposure**
*B-R et al. 2007*




**IXO XMS**
**100 ks simulation**




**XMM RGS resolves disk from auroral CX emission lines**

**Ion velocities → ion energies**

**Wider IXO XMS energy range, resolves C – S dichotomy → ions origin**

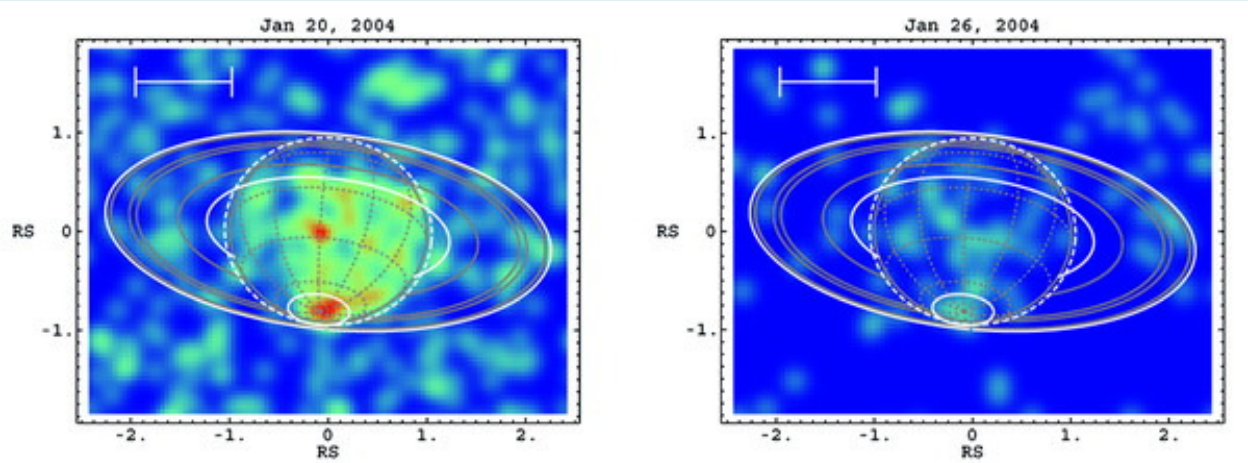
**More CX ions → better modelling**

**Faster and more precise ion energy samples**

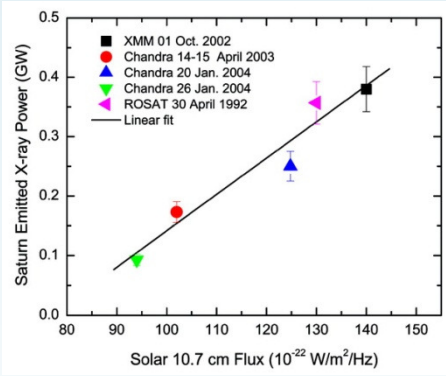
# Where are Saturn's X-ray aurorae?

- Disk and polar cap X-rays have coronal-type spectra

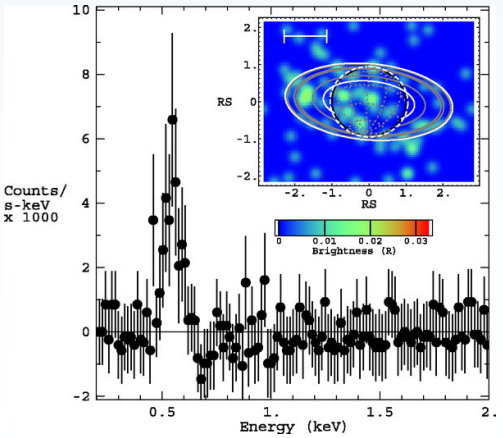
***Bhardwaj et al. 2005a***




***Chandra* ACIS**



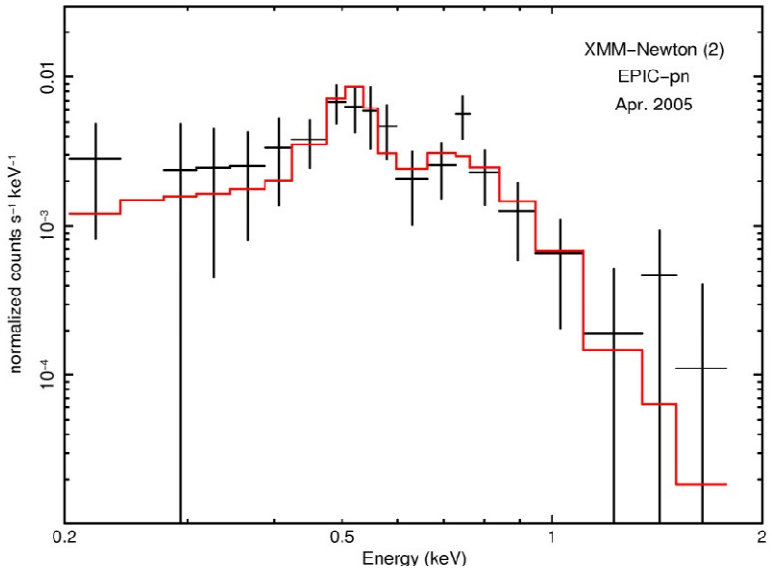

- 0.53 keV O-Kα fluorescent line from scattering of solar X-rays on atomic oxygen in $H_2O$ icy ring material




***Bhardwaj et al. 2005b***

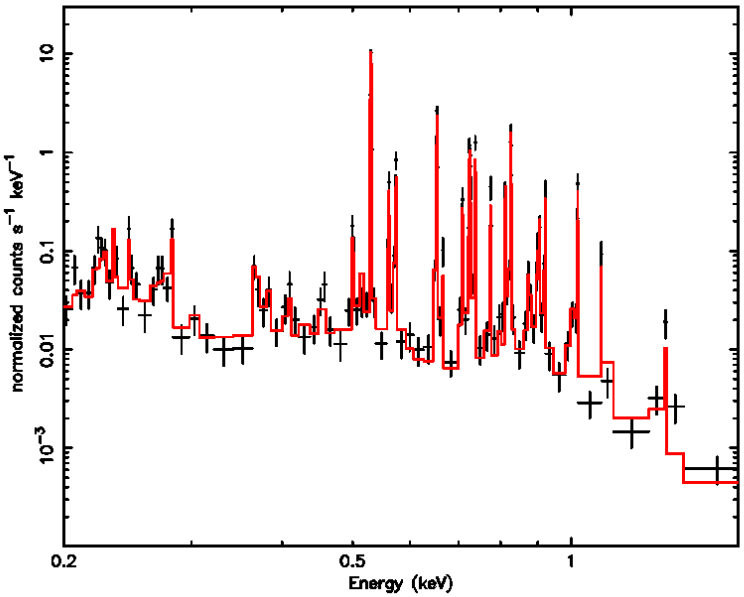
# Saturn

**XMM EPIC**
**84 ks exposure**
***B-R et al. 2010***




**XMM EPIC separates disk and ring spectrally**

**IXO XMS**
**50 ks simulation**

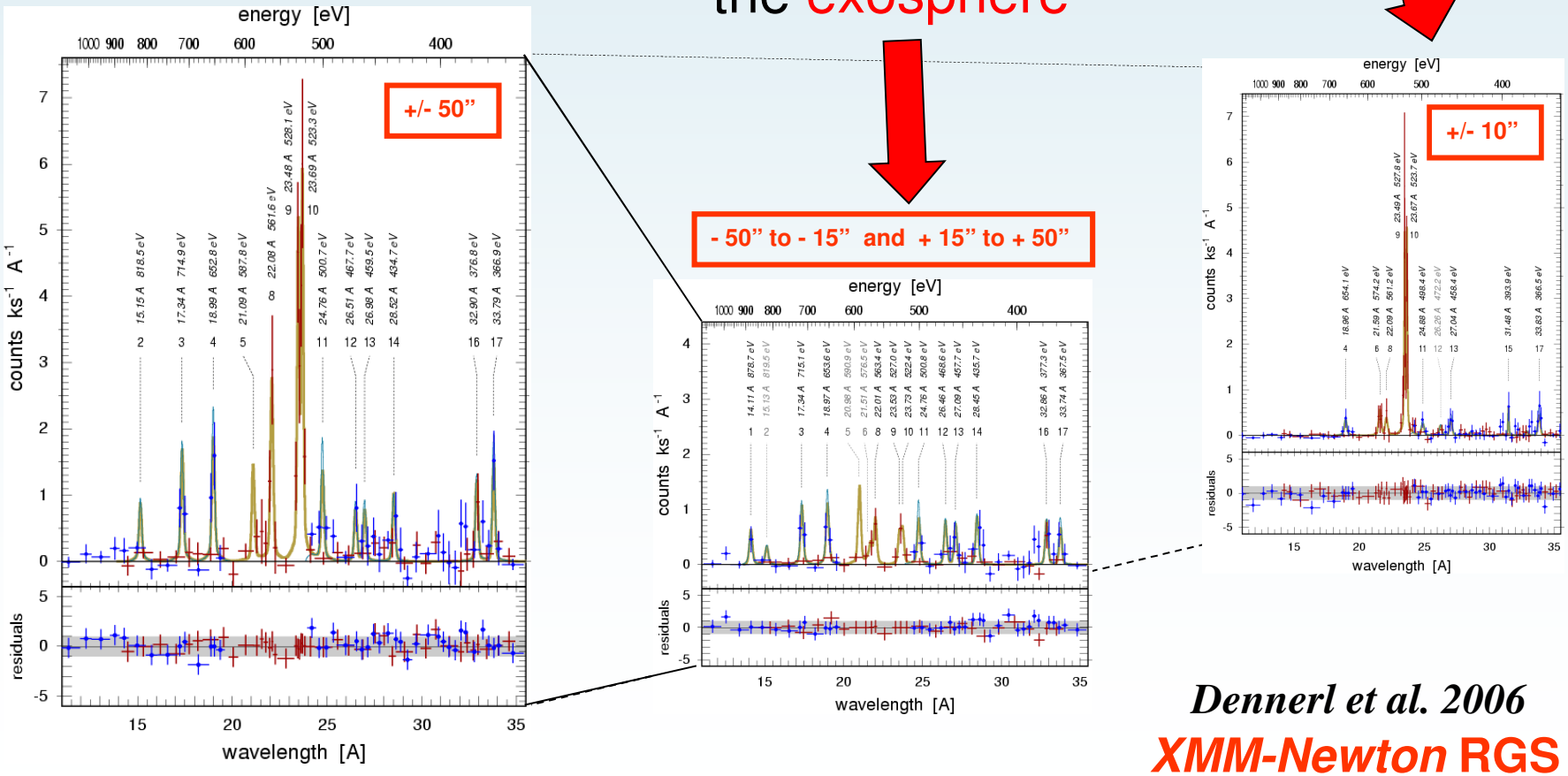



**IXO XMS resolves disk coronal lines from ring X-ray line**

**→ Ring line origin, solar irradiation modelling**

# Mars disk and exosphere (halo)

- Fluorescent scattering of solar X-rays in $CO_2$ atmosphere
- Solar wind charge exchange (SWCX) in the exosphere

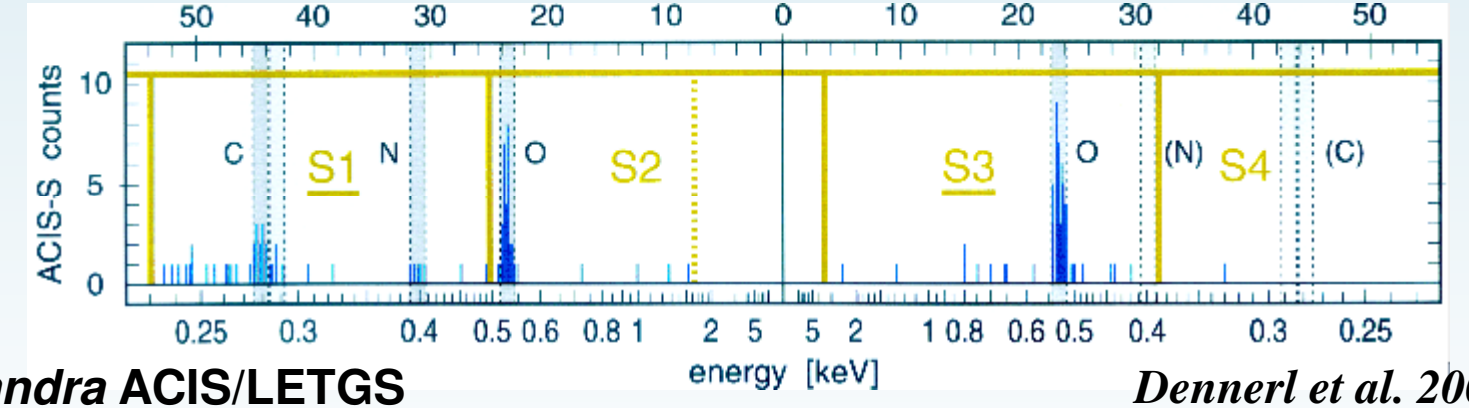



*Dennerl et al. 2006*

***XMM-Newton* RGS**

# X-rays from Venus at solar maximum (2001)

- Fluorescent scattering of solar X-rays in upper atmosphere
- O-Kα, C-Kα (and N-Kα ?) detected; also $CO/CO_2$ signature




***Chandra* ACIS/LETGS** ***Dennerl et al. 2002***

- Venus exosphere more condensed than Mars
  → SWCX radiation closer to limb
  → should be easier to detect at solar minimum
  (and indeed it was! ***Dennerl et al. 2007***)

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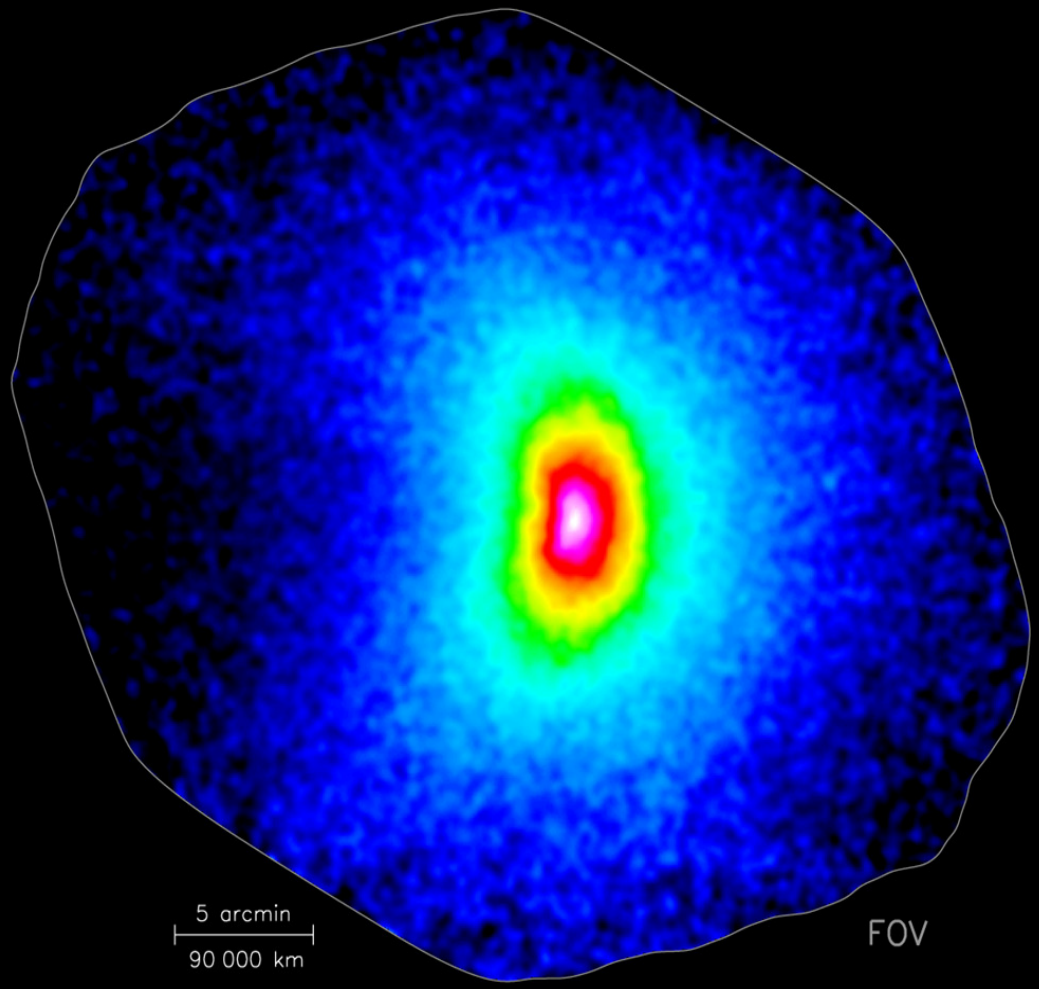
# Comet C/2000 WM1, 2001 Dec. 13 – 14

# Comet C/2000 WM1, 2001 Dec. 13 – 14

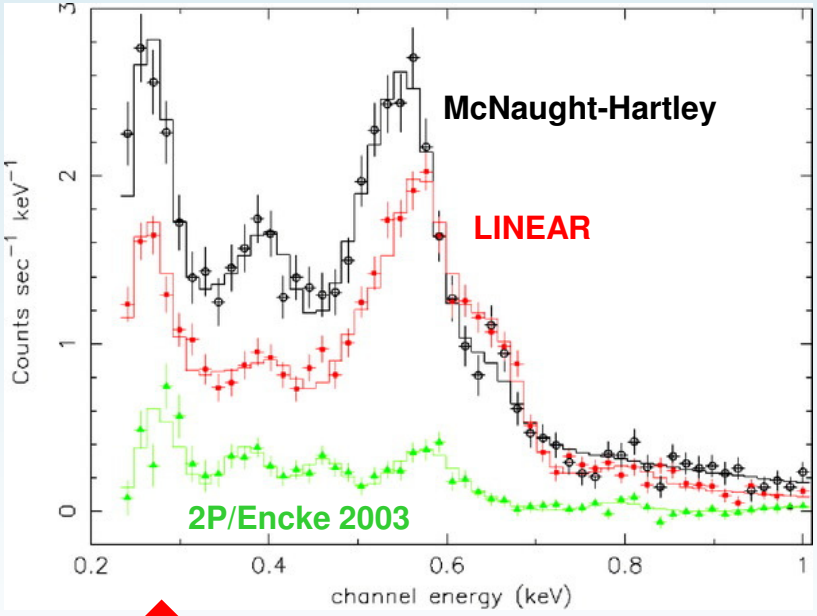



***XMM-Newton***

*Dennerl et al. 2003*

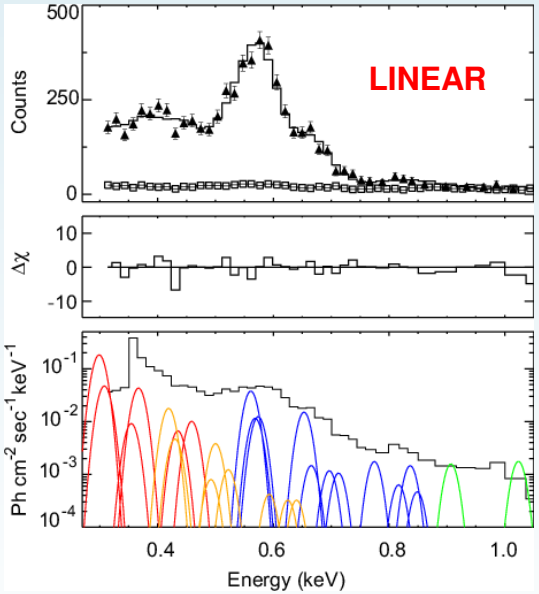
# Cometary X-rays

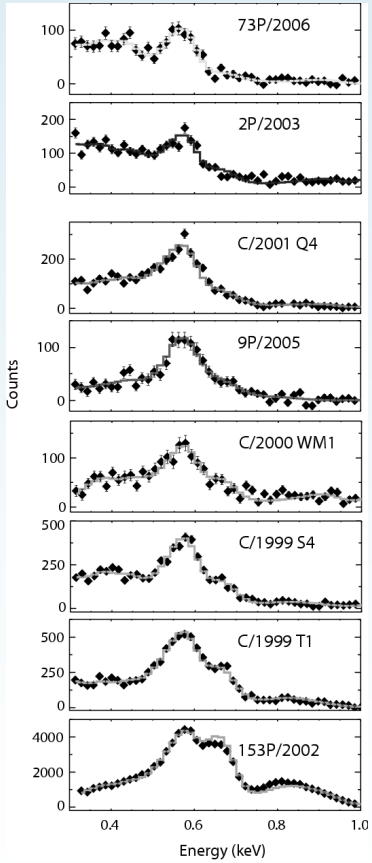
- SWCX with coma neutrals well established emission process




*Lisse et al. 2005*

***Chandra* ACIS**




***Bodewits et al. 2007***

- $C^{+5}$, $C^{+6}$, $N^{+6}$, $O^{+7}$, $O^{+8}$, $Ne^{+9}$ from SW
- Cometary spectra reflect state of SW

→ IXO will explore comet environs and probe SW conditions in unprecedented detail

# Our solar system is well worth (many) IXO looks!

- IXO will expand enormously the X-ray view of the solar system (appropriate FOV and spatial resolution, outstanding sensitivity and spectral resolution – filters needed to avoid optical contamination)
- Will give a global view of Jupiter, exploring both ion and electron populations, and planet's response to solar activity and X-ray illumination
- Search for Saturn's (and Uranus?) X-ray aurorae
- Mars and Venus exospheres: atmospheric evaporation under X-ray irradiation
- Comets as probes of the solar wind ....
- Soft X-ray background from heliospheric CX reactions
- (SWCX within the Earth's magnetosphere)