Solar Wind Charge Exchange as seen by XMM-Newton

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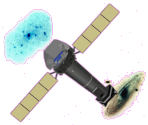
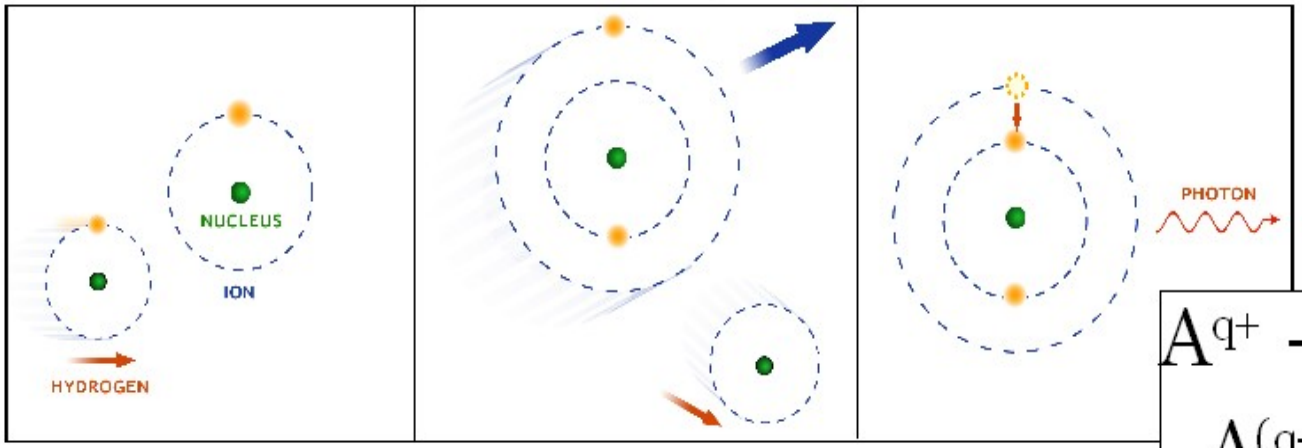


XMM
EPIC
MOS

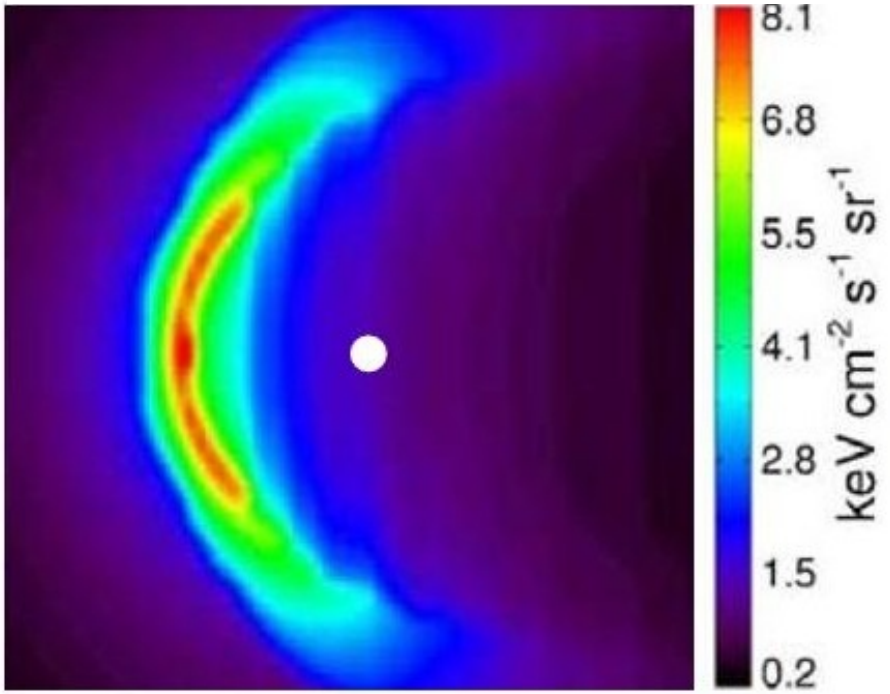
University *of* Leicester

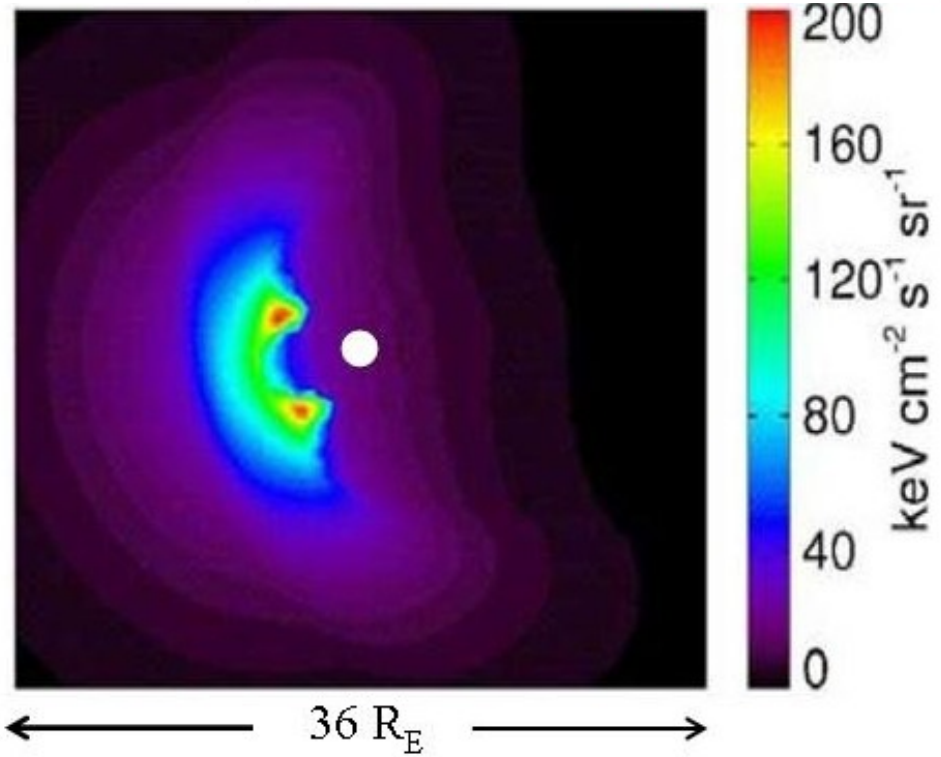
SWCX process, Robertson & Cravens modelling



$$A^{q+} + B \rightarrow A^{(q-1)+*} + B^{+}$$

$$A^{(q-1)+*} \rightarrow A^{(q-1)} + h\nu$$



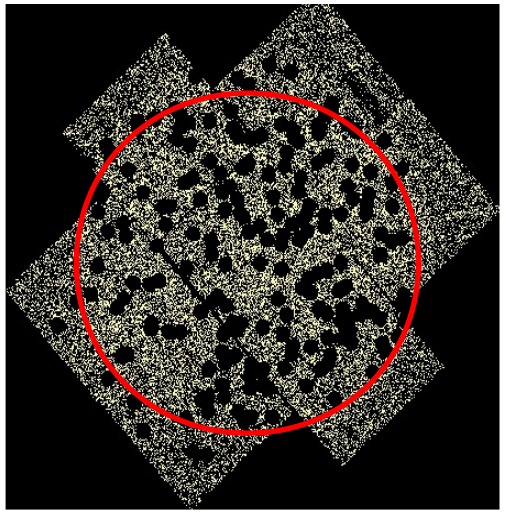


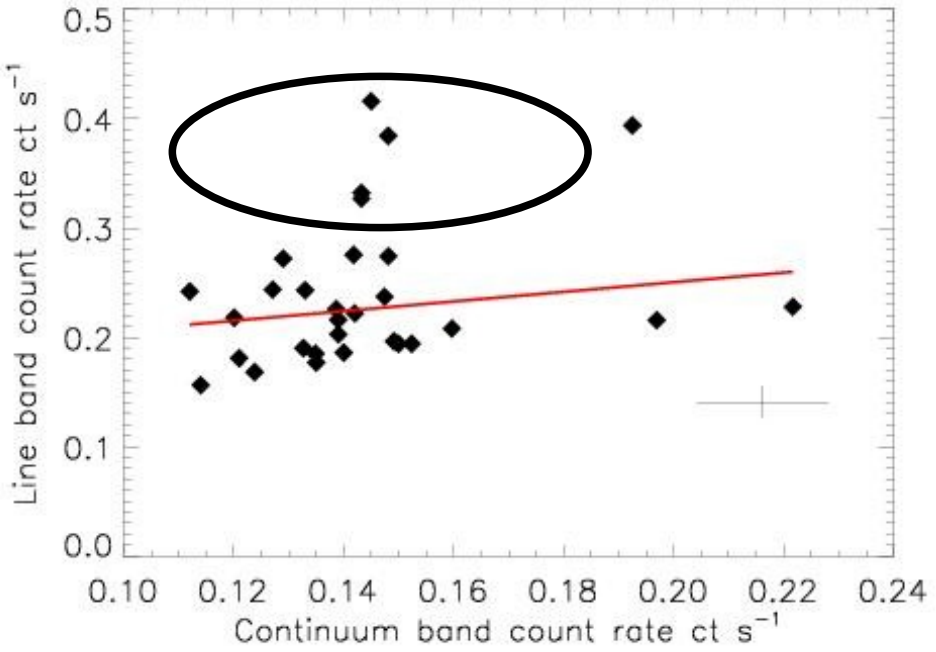
SWCX & the BGWG

- BGWG 1 – Steve Snowden presented HDFN 2004 case, proposed observation looking through nose of magnetosheath
- Kuntz & Snowden 2008 – particle bkg + SWCX
- Sun quiet at time – Snowden et al. 2009
- Leicester looked through sample of archive for SWCX affected observations - Carter & Sembay, 2008
  - Lightcurve analysis of a line (SWCX) band and a continuum band
- Coronal Mass Ejection (CME) observed by XMM – Carter, Sembay & Read, MNRAS, 2010

Method

- Event lists flare-filtered using ESAS task mos-filter
- Resolved point sources removed
- Compare SWCX line band (0.5 – 0.7 keV) to continuum band (2.5 – 5.0 keV) lightcurve
- Deviation from a straight line fit: χ_{μ}
- Variation within each band, compute ratio: $R\chi$



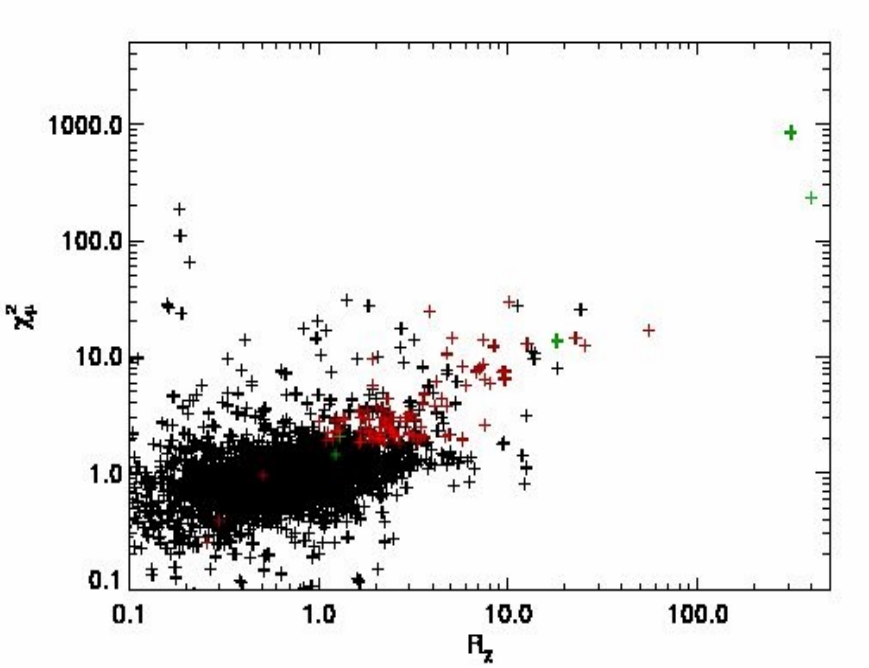


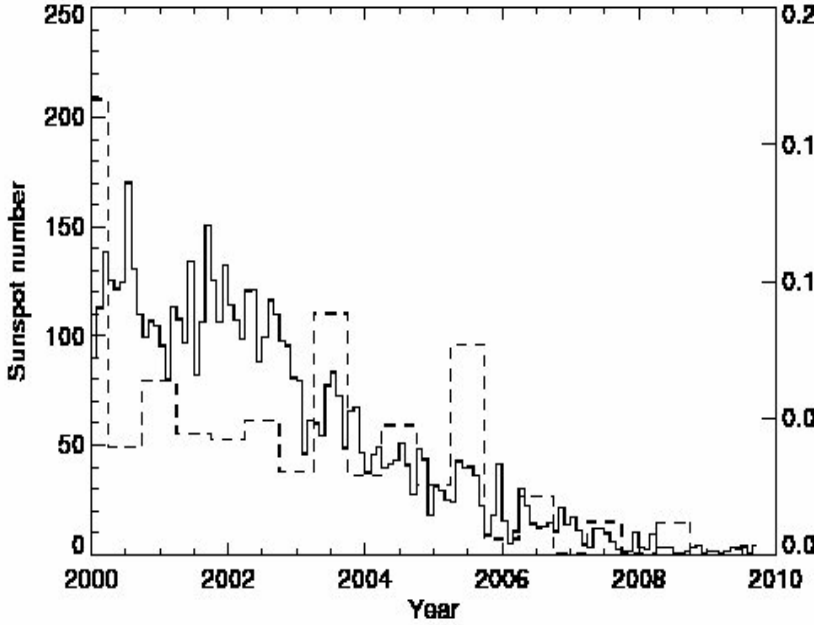
Current work – paper II in prep.

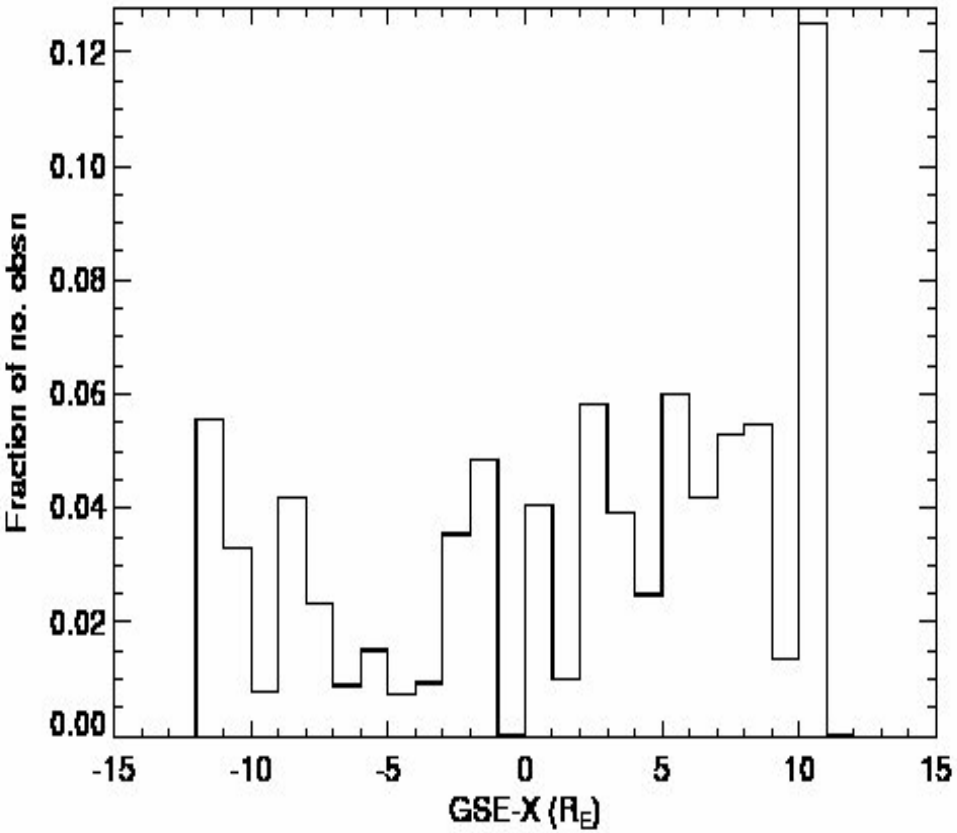
- Have extended to all Leicester archive, MOS full-frame
- Apply method as previously, identify SWCX cases
- Split identified observations into SWCX and SWCX-free periods
- Spectral model; model based on laboratory cross-sections concentrating on prominent SWCX lines. Applied to difference spectra of SWCX cases
- Line of sight analysis: modelling XMM-Newton orbit, magnetosheath under solar wind conditions

Preliminary results

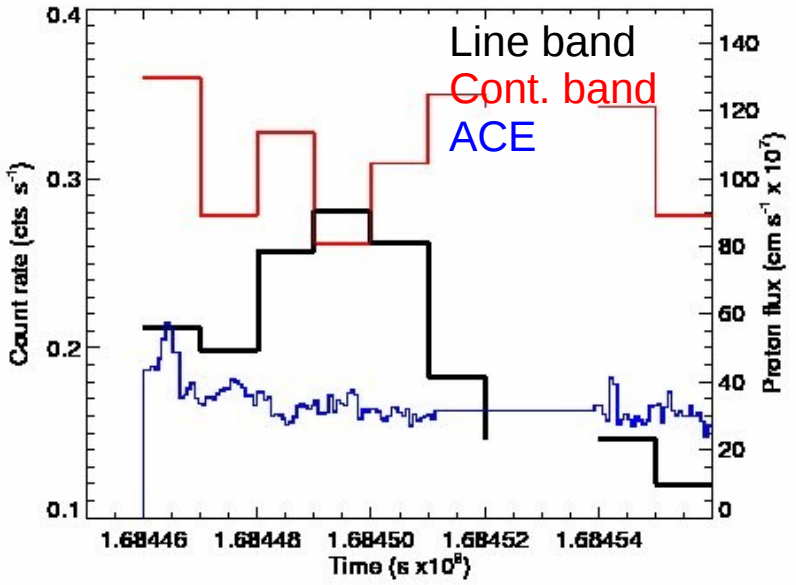
- Top cases (most variability) are comets (green)
- Exospheric SWCX cases (red)
- Preferentially at beginning of mission
- Preferentially XMM-Newton found sunward of Earth

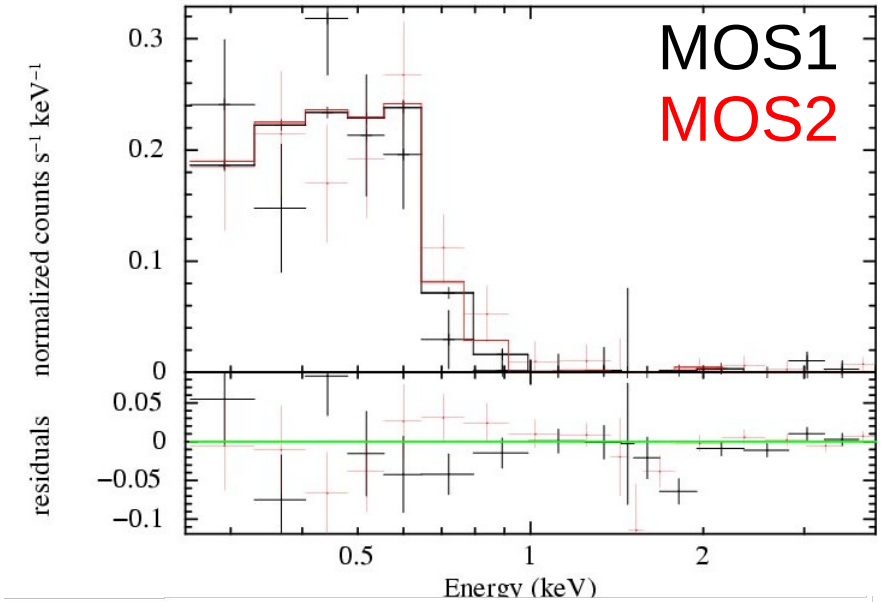


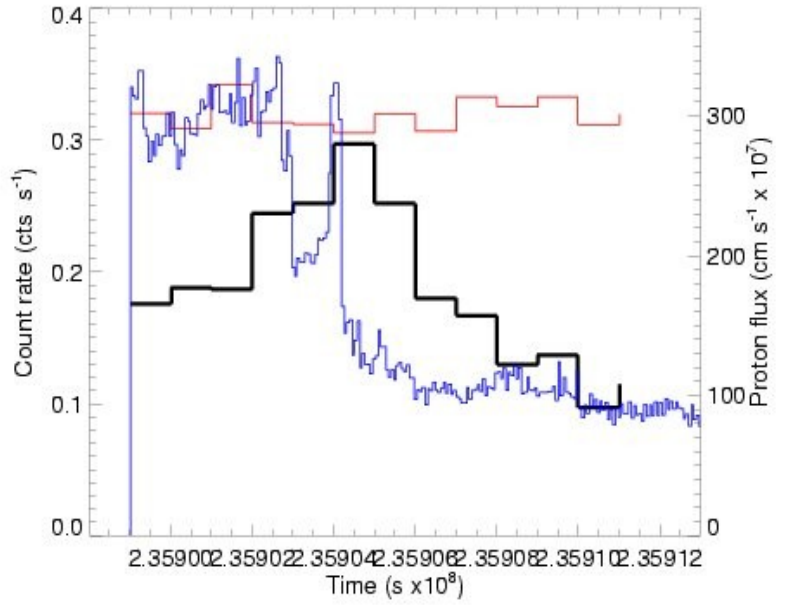


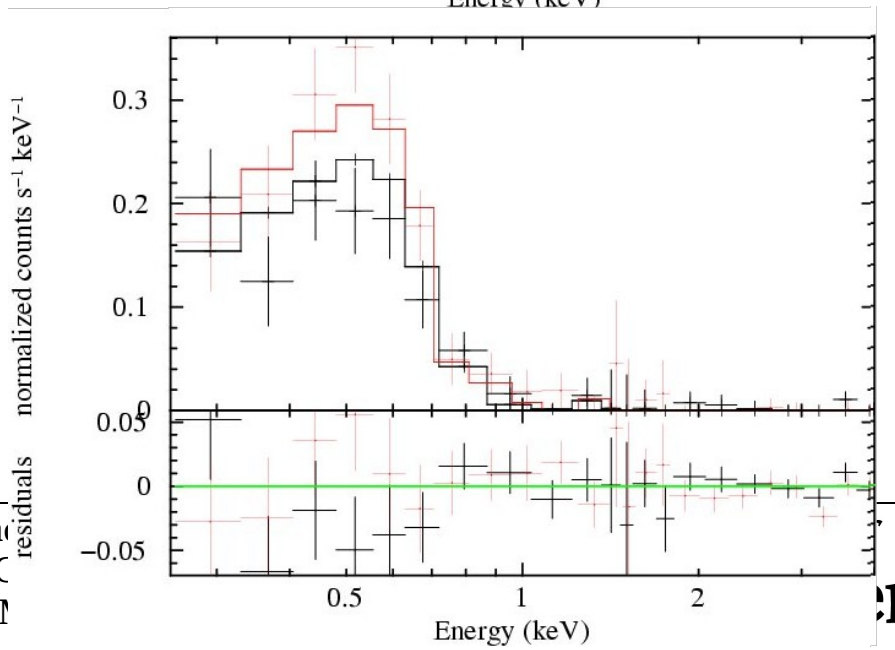

Fraction of no. obsn
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-15
-10
-5
0
5
10
15
GSE-X (R_E)

Example cases, temporally and spectrally







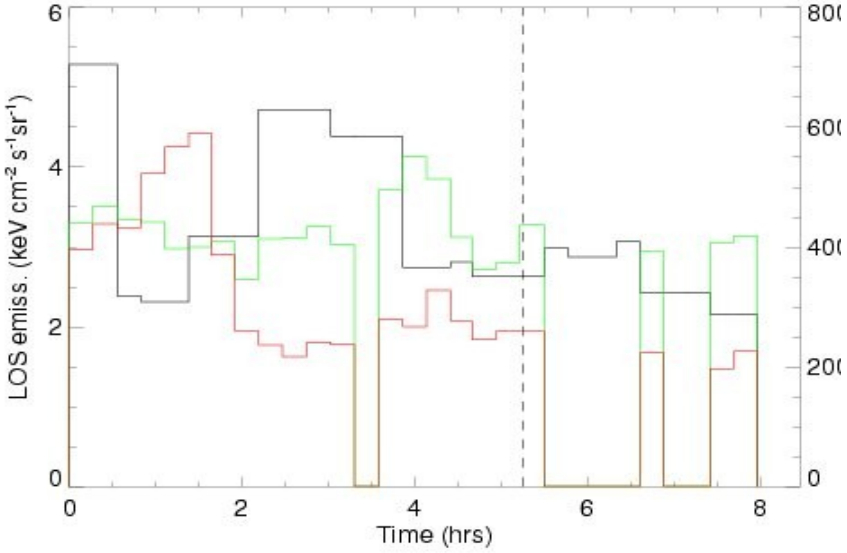


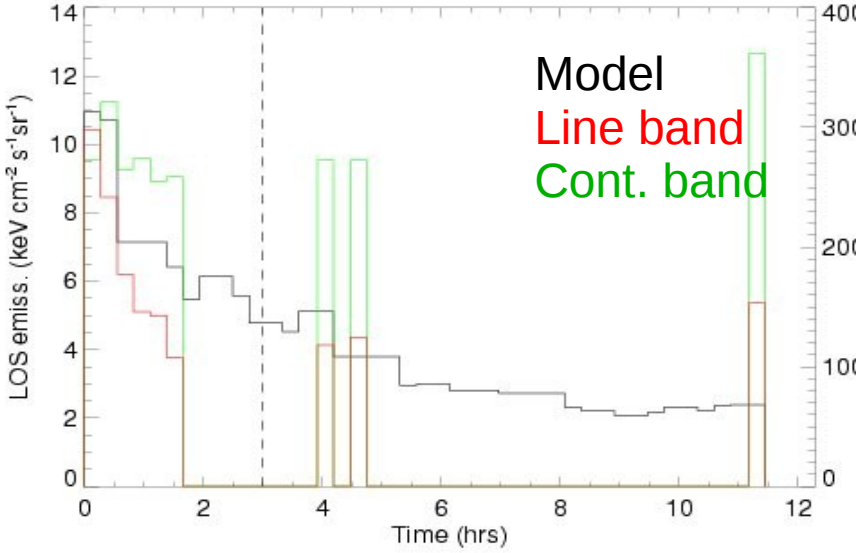
Line of sight modelling

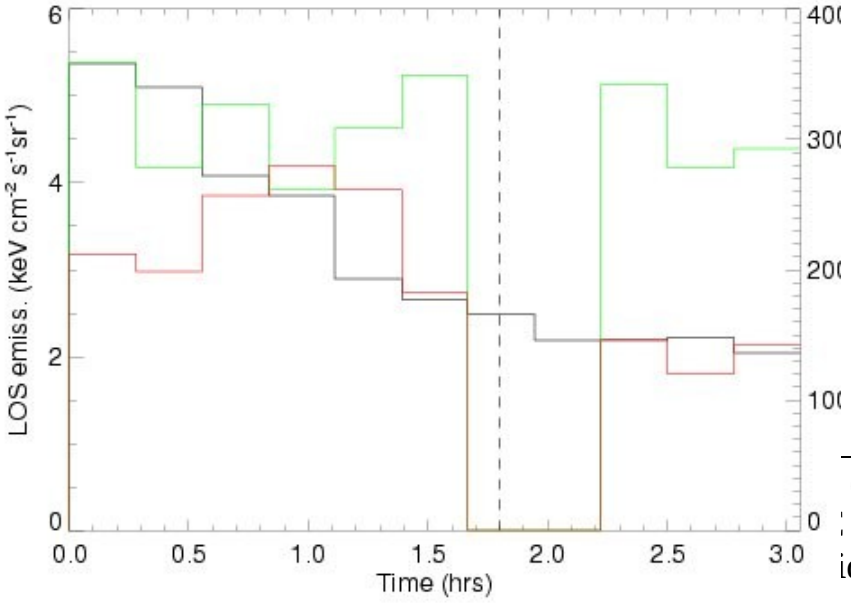
$$P_{X\text{-}ray} = \alpha n_H n_{SW} \langle g \rangle \ (eV\ cm^{-3}\ s^{-1})$$

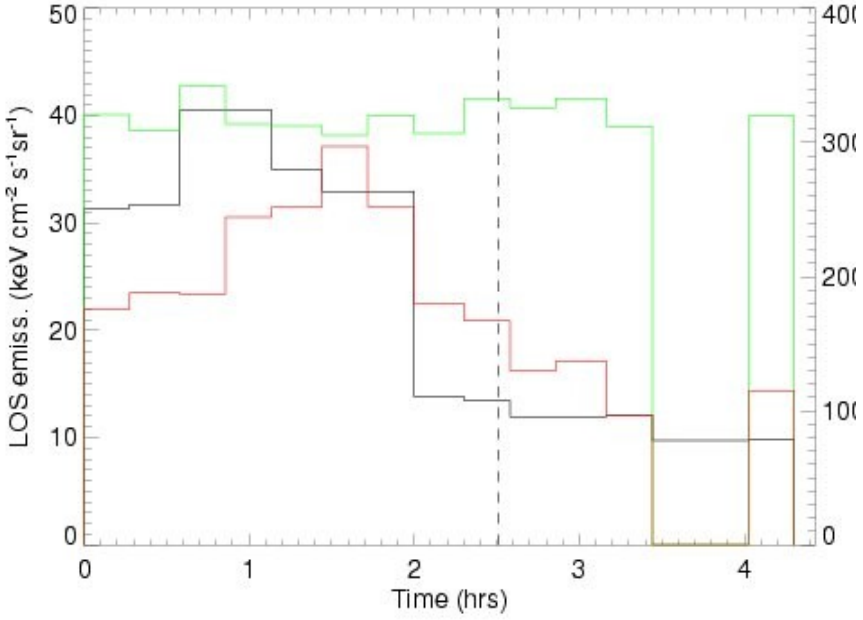
- Dependent on ion species, neutral density, solar wind flux
- Solar wind data from OMNI (combined data from SW monitors such as ACE and Wind)
- Magnetopause location via Shue model, bow shock via Khan and Cowley
- Neutrals fall off with R_E^{-3} (limitation)
- XMM-Newton position and viewing angle from orbit files
- Charge exchange cross-sections included in term α
- Model LOS in each time step and emissivity through the magnetosheath

LOS modelling examples









Conclusions & future aims

- About 5% of observations exhibit temporally variable SWCX
- Method does NOT identify cases where SWCX constant throughout the observations – need comparison of fields, e.g. Kuntz & Snowden 2008 etc.
- LOS modelling challenging – components of SWCX emission from inside and outside of bow shock (see Carter et al. 2010)
- Provide online 'SWCX likelihood' information for user, maybe in observation log browser
  - BGWG to decide where information useful