Putting it all together: from white dwarfs to Crab using high spectral resolution: how accurate can we get?

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Where were we with RGS?

- Effective area corrected using blazar spectra known to have power law spectra in 10-25 Å
- ➔ area now known modulo a power law
- Question: how to get slope and norm of this PL correction factor?

Step 1: determining slope

- Slope determined using Crab spectra:
- PL index Crab for E>2 keV well known (eg Kuiper et al 2001)
- RGS observations Crab then determine ISM transmission, needed for all E<2 keV

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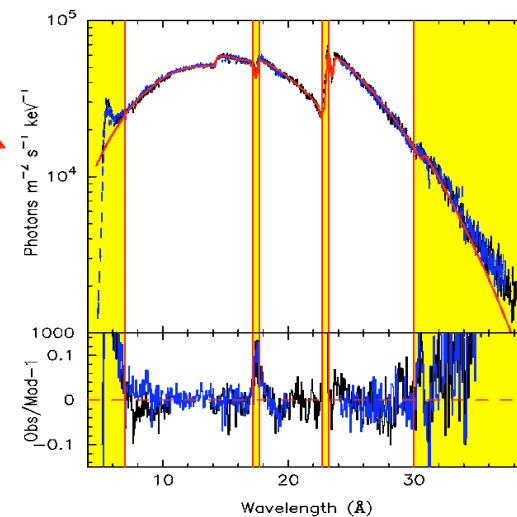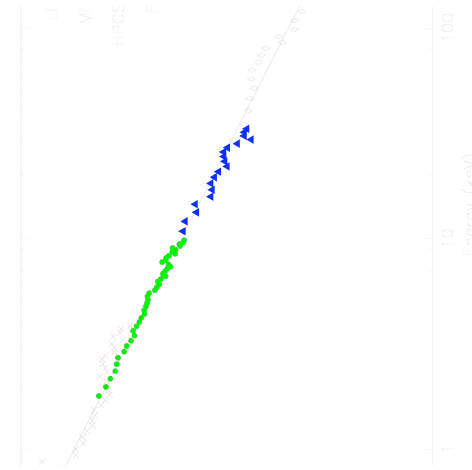
Crab Curvature Correction

- Photon index Crab varies over nebula

- ➔ intrinsically curved spectrum

- ➔ need curvature correction

- CCC derived from Chandra data; agrees within 2 % with crude EPIC analysis

Chandra, Mori et al.

$$f_c(E) = 1 + 0.411e^{-E/0.46}$$
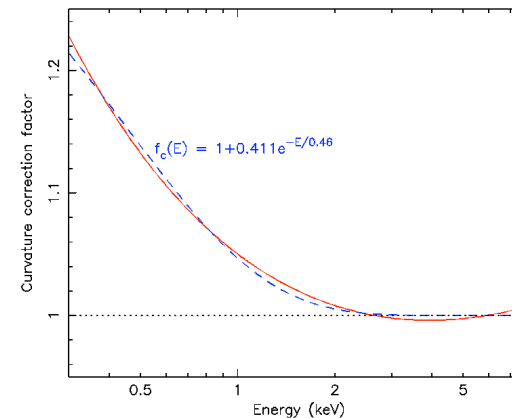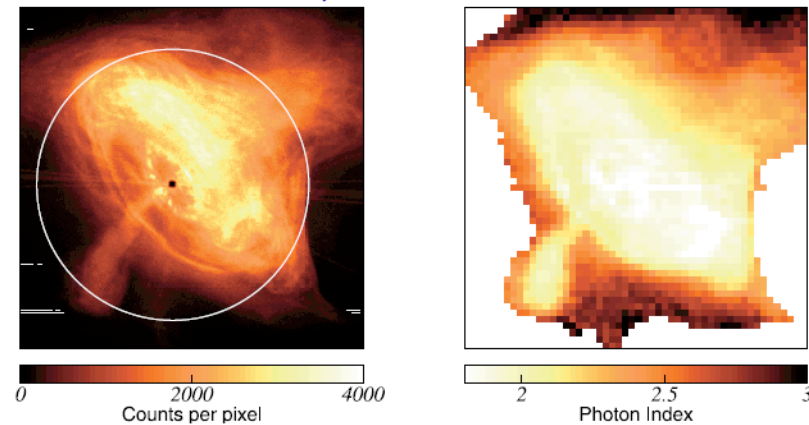
ISM transmission Crab

- Our analysis (Kaastra et al. 2007, A&A, to be submitted next week) uses 3 models:
- A: gas only, curvature correction
- B: gas+dust, curvature correction (preferred model)
- C: gas, no curvature correction
- Models A & B do not differ much, at long λ model C differs by ~10 %

Step 2: determining absolute flux

- With RGS Crab analysis (model B) eff area RGS now has correct slope

- Absolute area still uncertain by ~10 %, due to uncertainty Crab flux at higher energies

- Solution: use White Dwarf models at low energies

White Dwarf models

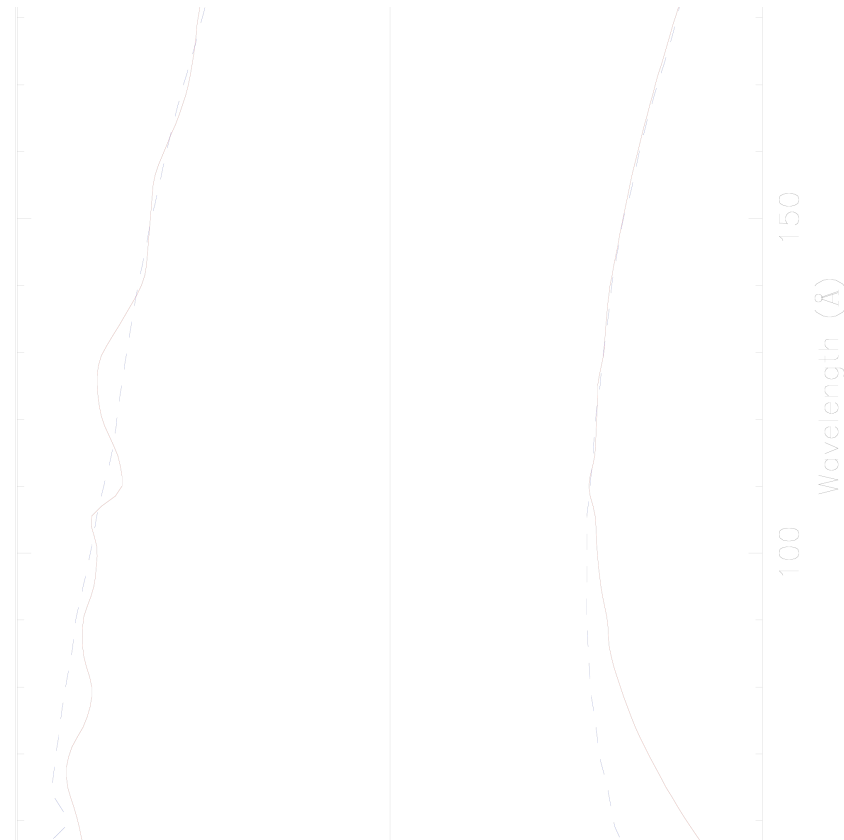## (Kaastra, Lanz, Hubeny & Paerels, in preparation)

- Use Tlusty code to produce synthetic spectra Sirius B & Hz43A

- Refine parameters of both stars until observed LETGS ratio is matched (ratio does not depend on eff. area uncertainties)
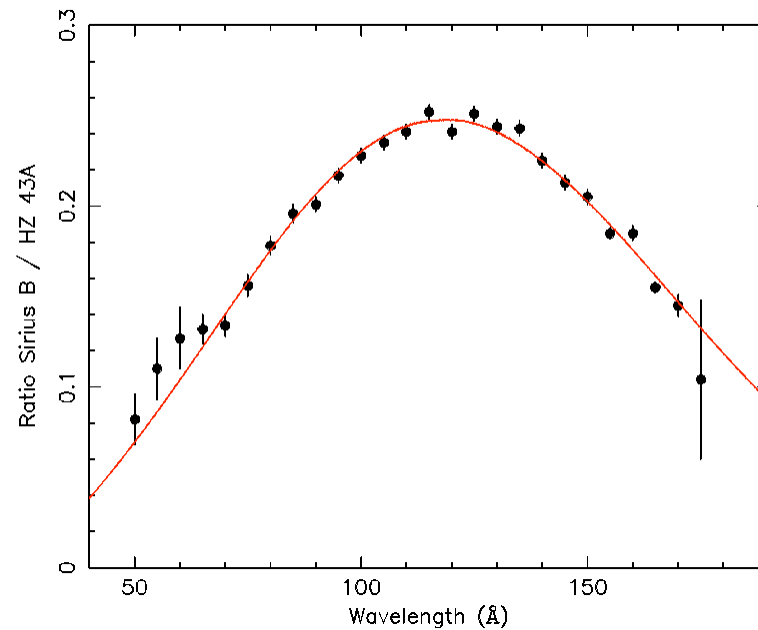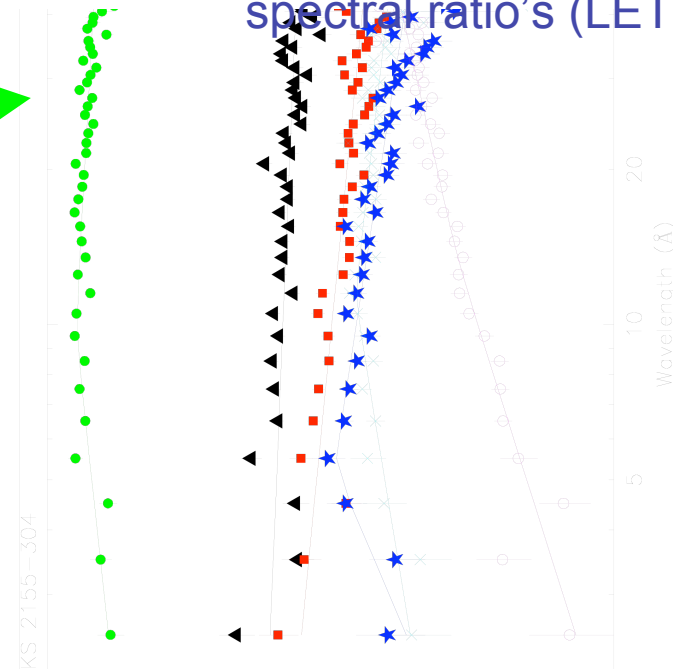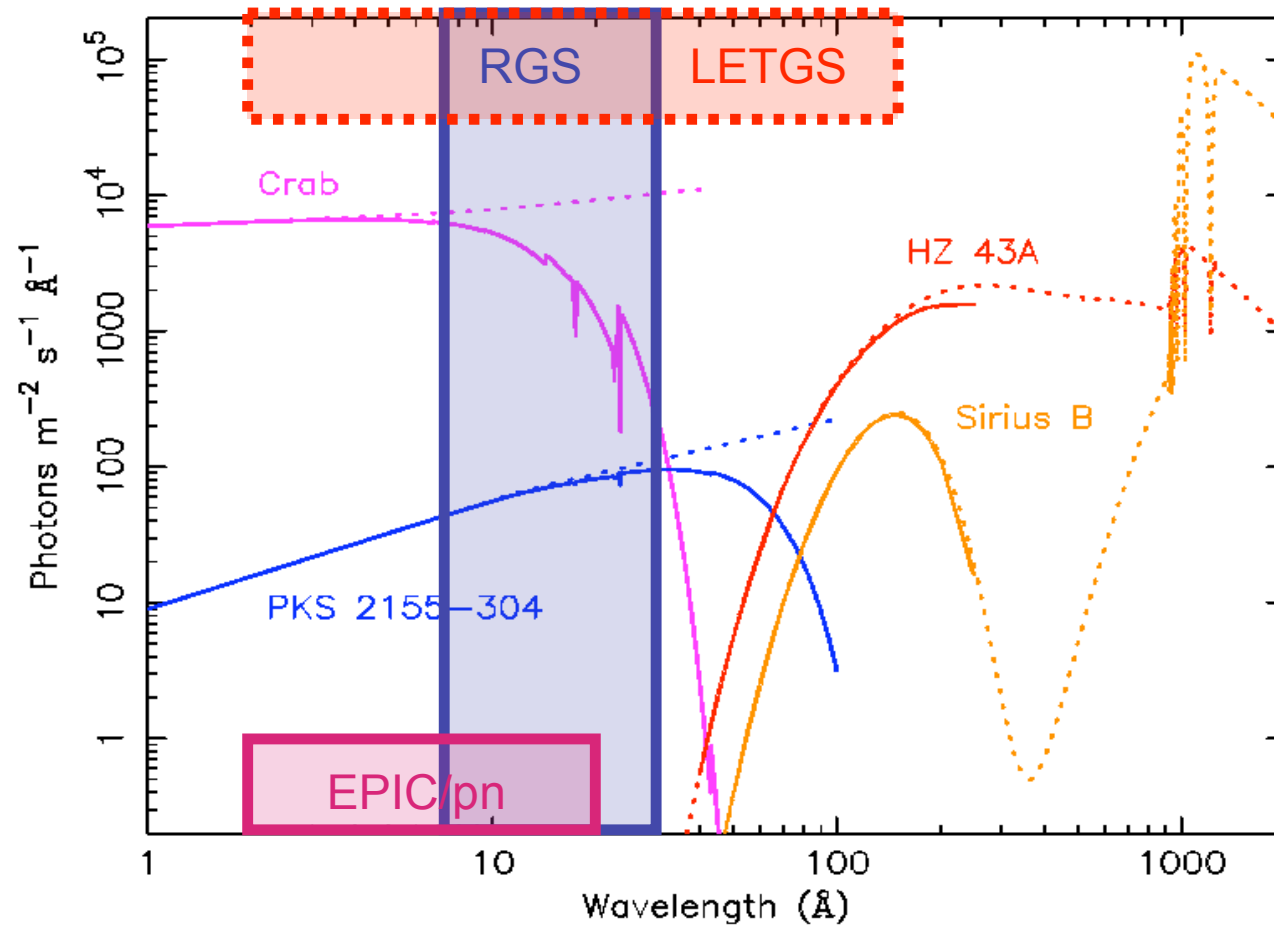
Accuracy reached:

Sirius B
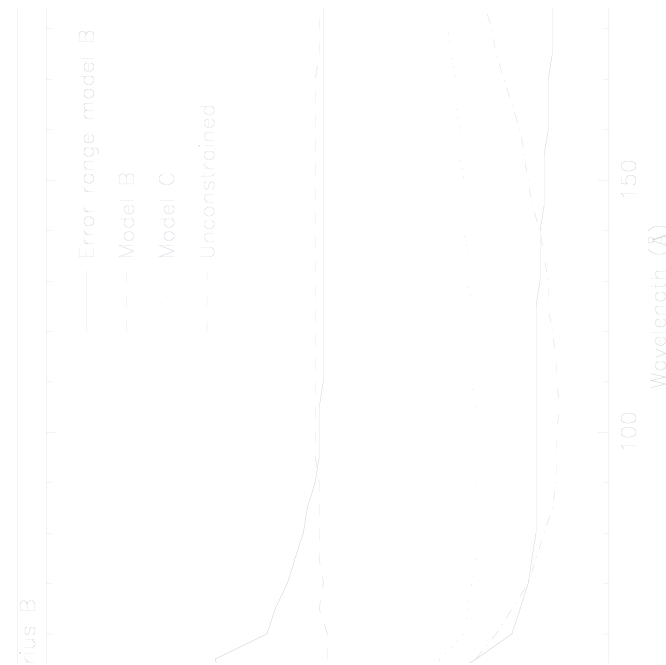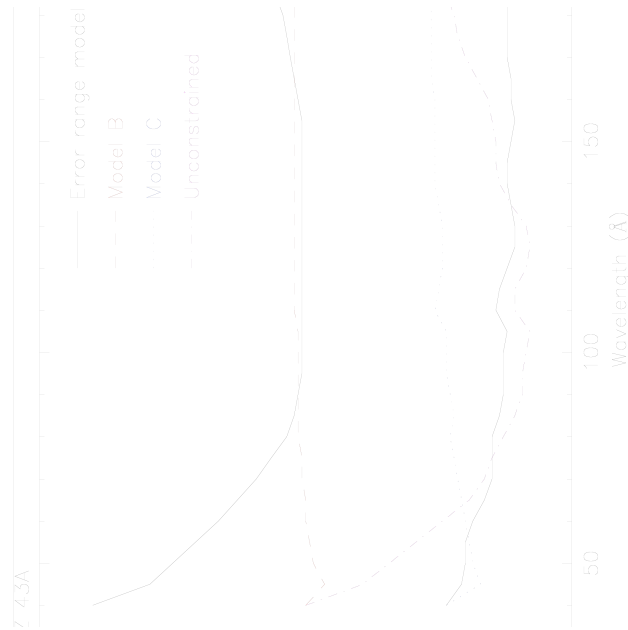
HZ 43A

Last step: bridging the gap

- Use PKS 2155-304 spectra taken simultaneously with RGS (slope now known from Crab!)

- Refit WD spectra with allowed margin in N_H of Crab & PKS2155

- Additional 3 free parameters: N_H Crab & PKS, Norm Crab

Sample of PKS 2155-304 spectral ratio's (LETGS)

The absolute flux determination of the Crab

Solution accuracy: few %

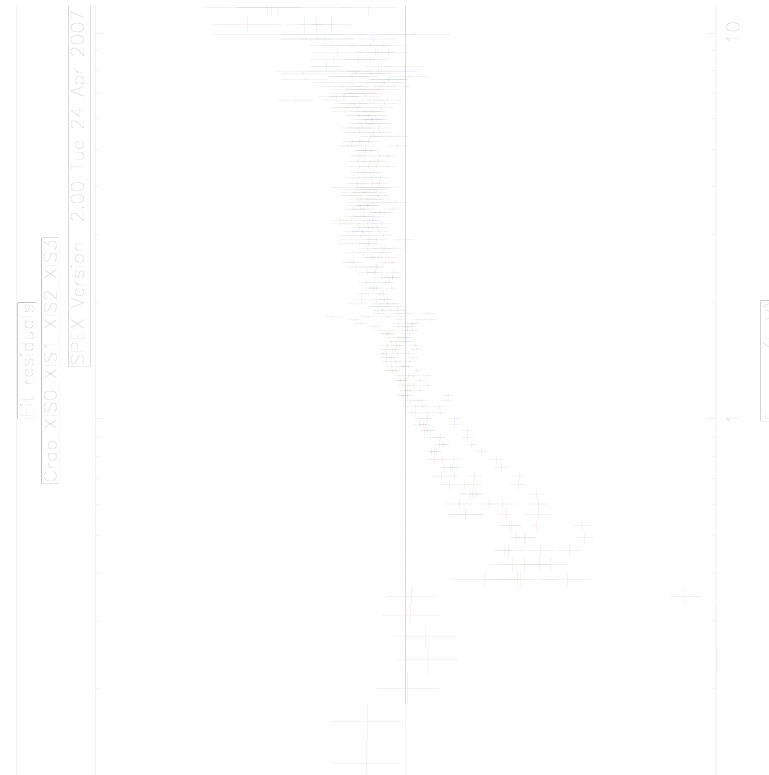Uncertainty on HZ 43 continuum =
uncertainty on LETGS effective area

Final normalisation Crab

- Norm Crab is 0.933±0.03 (on scale where BeppoSAX MECS = 1 and PDS 0.87)
- ➔ absolute calibration accuracy of ~3 % can be achieved
- SPEX & Xspec-compatible table models available for Crab model including absorption ftp://xmm.esac.esa.int/pub/XMM/mk/iachec/Crab_XMM_RGS/ (accessible through www.iachec.org link)

Comparison with pn
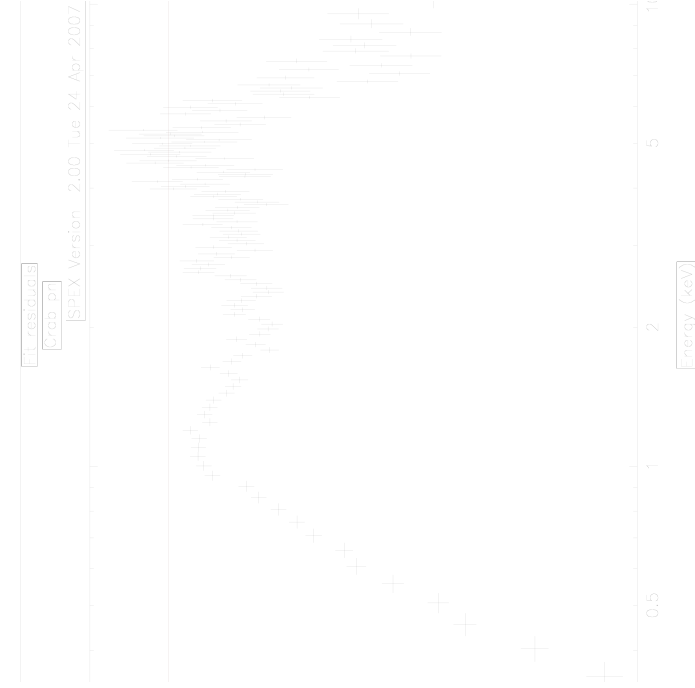
Comparison with Suzaku XIS

Higher Energies
(L. Kuiper)