Investigating the Chandra TGS Line Response Function (LRF)

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1. Scientific motivation
2. Chandra TGS LRFs - the RMFs
3. Testing the RMF
   - Difficulties and understanding source intrinsic profile
   - Testing through FWHM
   - Testing in the Fourier domain
4. Application to the plasma morphology on AB Doradus

Microphysics of Coronal Heating

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

- Ab initio models of coronal loops heated by convection-driven magnetic reconnection (Nordlund et al)
- Flows induced by miroflares leave velocity fingerprint
- Flows on active stars could be significantly larger than in solar corona (~20 km/s)

Coronal Morphology

AB Dor: ~25 Myr ZAMS K0 V; P_{rot}=0.5d; vsin i=95km/s

Models
By
K.Wood et al
(2002)

QuickTime™ and a
GIF decompressor
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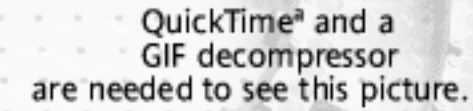


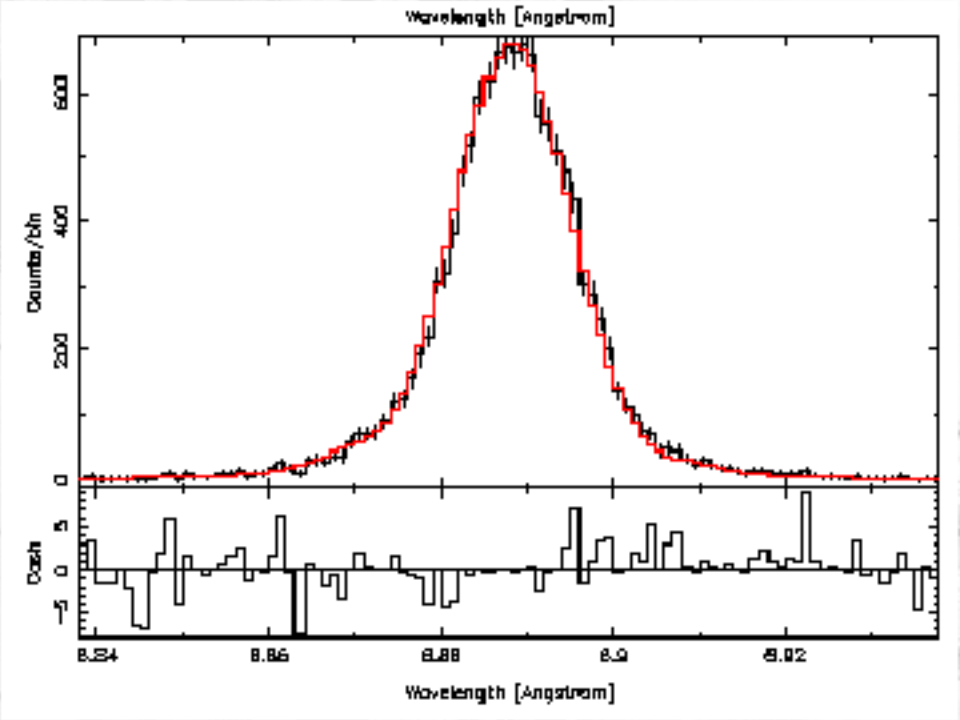
45 km/s

Optical Doppler imaging
And Coriolis force ==> B
Field emerges at poles

200 km/s

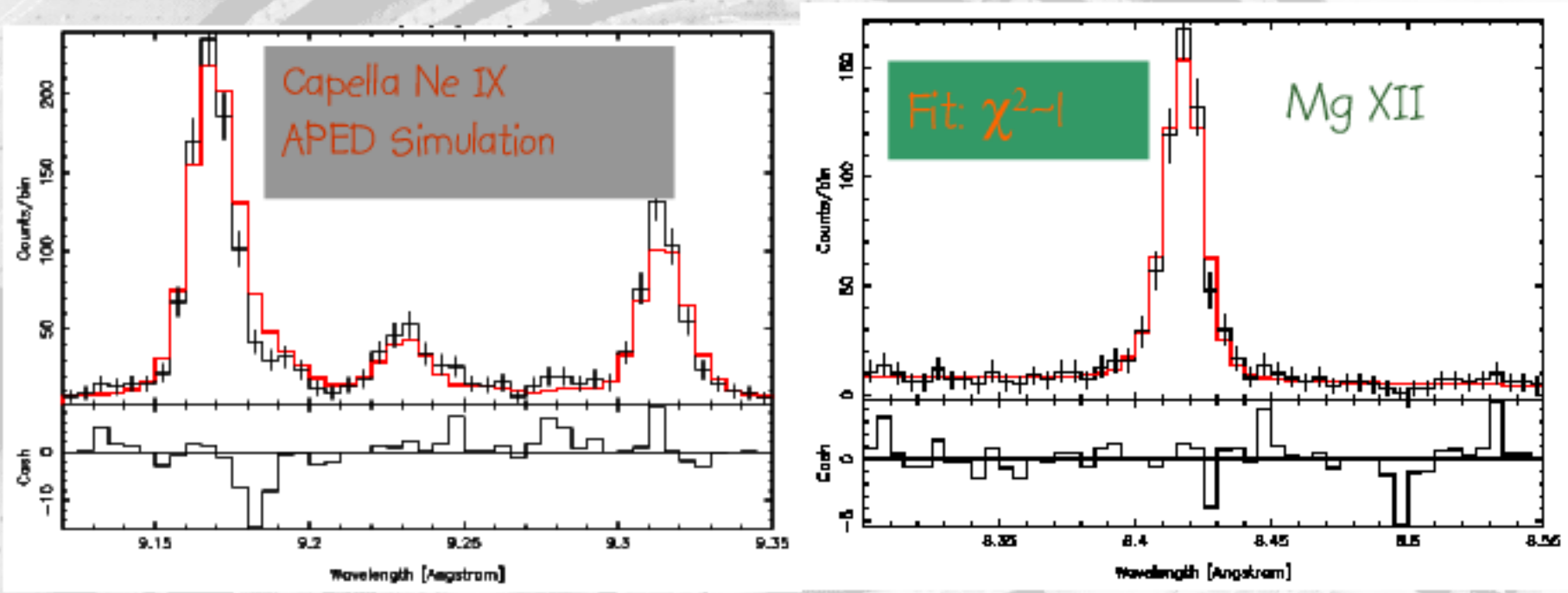
Model with significant
dipolar field

HETG & LETG RMFs



- Fits to MARCS ray-trace simulations using 2 gaussian, 2 lorentzian profiles (see memos by B.Ishibashi)
- Analysis here based on Cycle 6 release

Line-by-line Testing



- Cycle 6 RMF provides an accurate representation of the HEG/MEG LRF for S/N of most lines when treated in isolation
- BUT: more quantitative measure desireable

LRF Calibration Difficulties: Understanding Intrinsic Source Profile

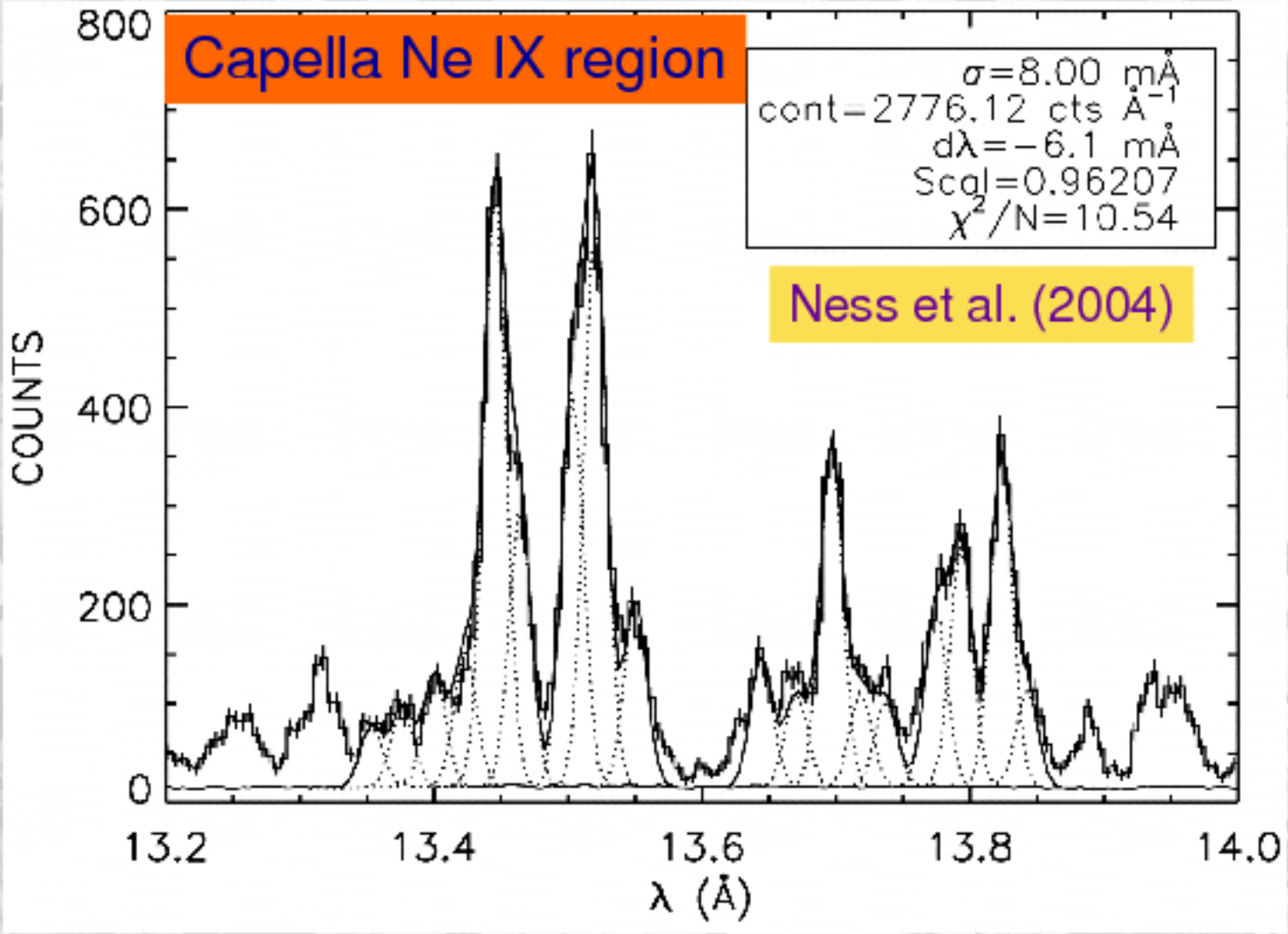
Typical HEG,MEG LRF FWHM: 0.012@12A,0.02@20A==> 300 km/s

Capella: G1III + G8III

QuickTime™ and a
YUV420 codec decompressor
are needed to see this picture.

- Thermal broadening (~$m^{-1/2}$ - different for different elements; ~50 km/s)
- 108 day orbital period
- Projected orbital speed ~25 km/s
- Gl 8 day spin period
  - Equatorial velocity ~36 km/s

LRF Calibration Difficulties: Line Blends



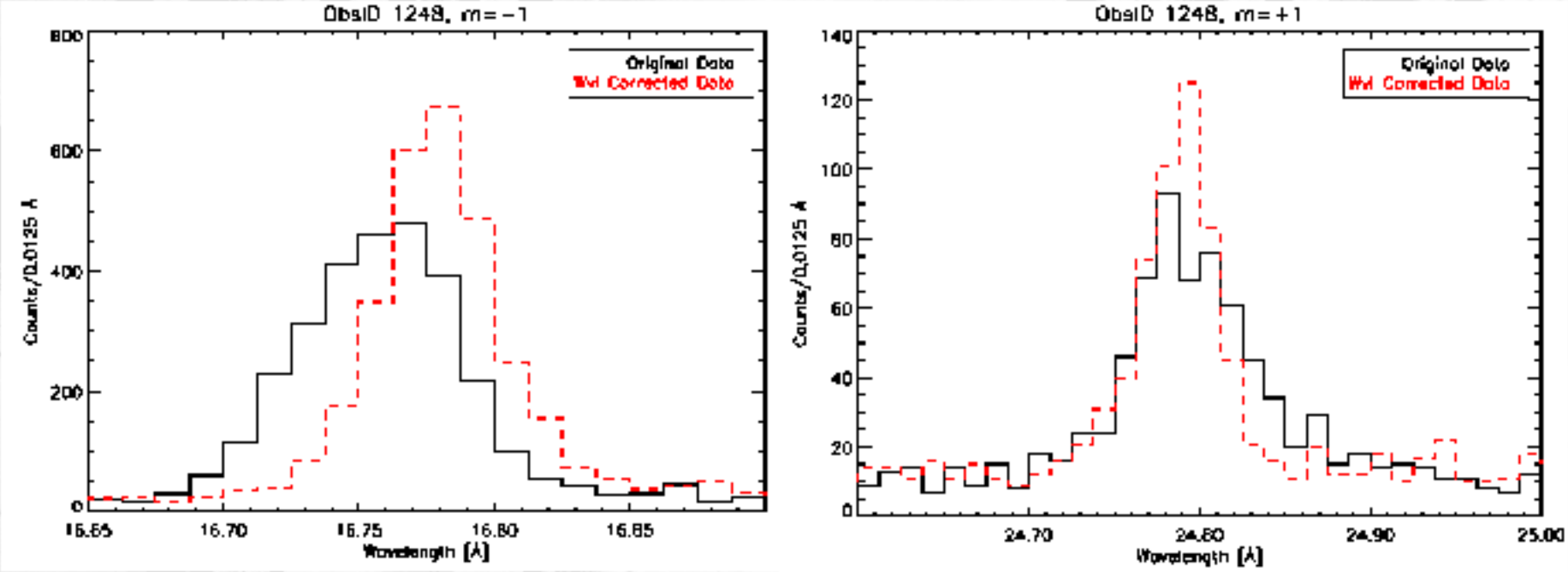
Calibration of LRF more difficult than PSF(!)

Probing the FWHM: Method

- Choose Capella observations at phases ~0,0.5 to avoid orbital splitting
- Accurate model of intrinsic source profile
  - Full DEM modelling to obtain T structure for thermal broadening of each element
  - Rotational broadening of Gl III component
- Use only "unblended" lines
- Line fitting in PINTofALE using "β-profile" with β=2.5
- LETG+HRC-S: include photon event pos… Chung et al. poster)

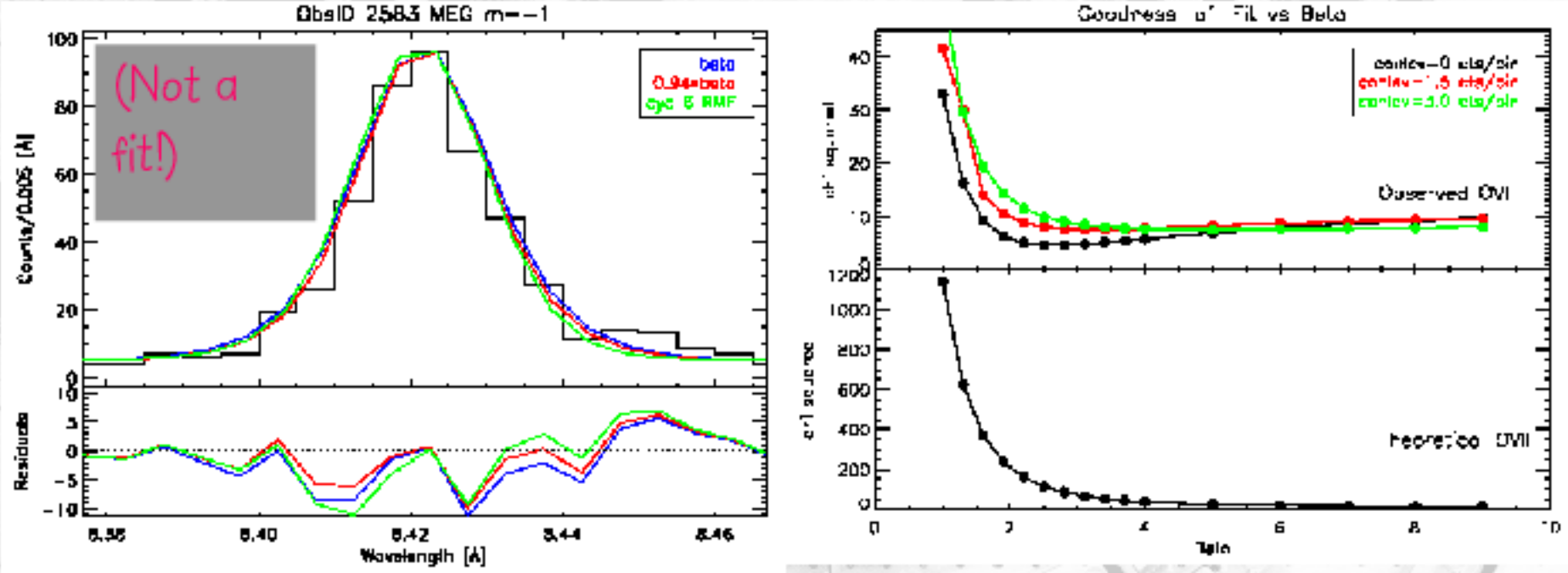
$$I(\lambda) = \frac{a}{\left(1 + \left(\frac{\lambda - \lambda_0}{\Gamma}\right)^2\right)^{\beta}}$$

Effect of Event Position Correction on LETG+HRC-S Line Profiles



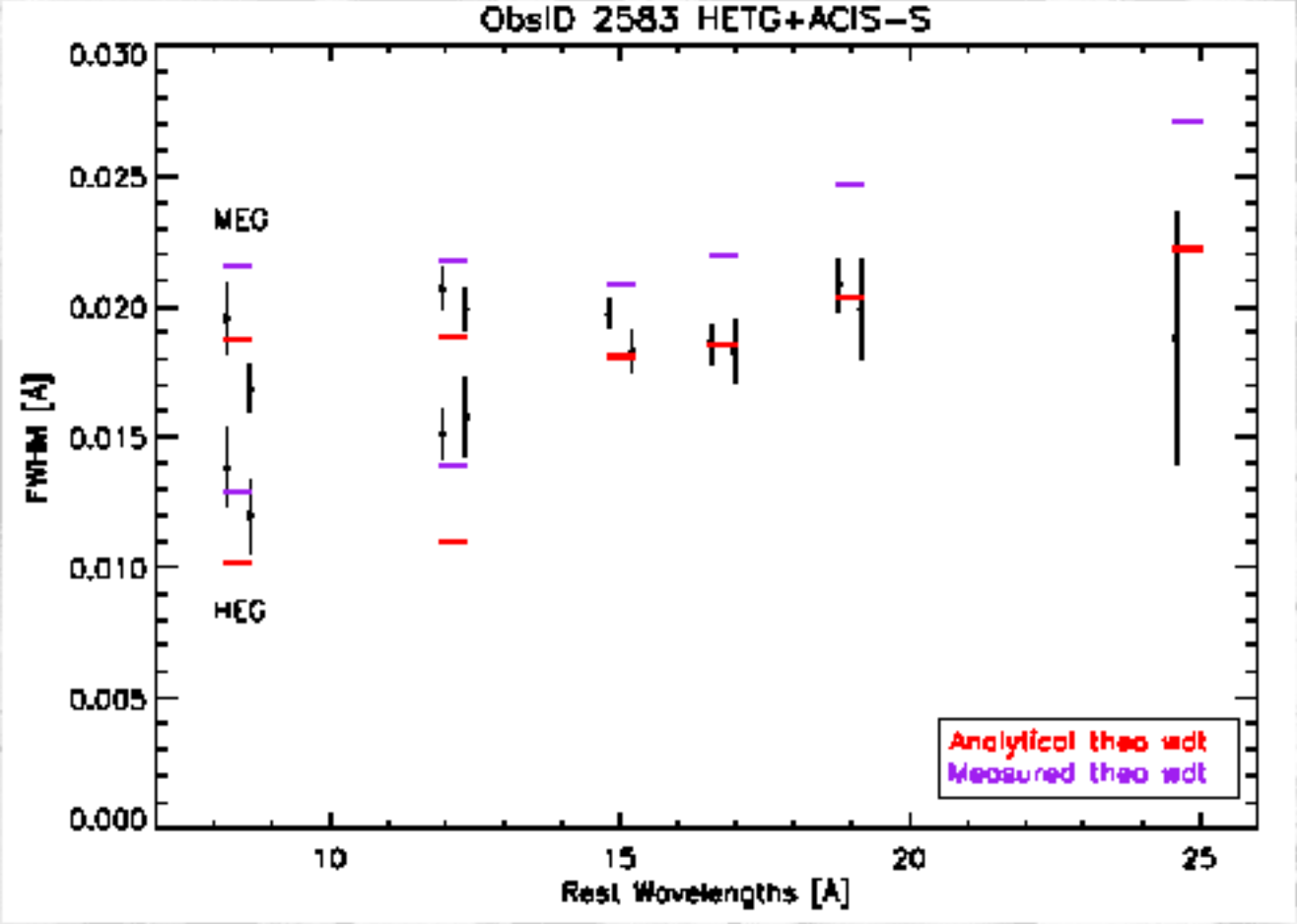
- HRC-S event position errors cause significant line-broadening and profile disortion

β -Profile vs RMF



- β-profile wings are slightly broader than those of RMF

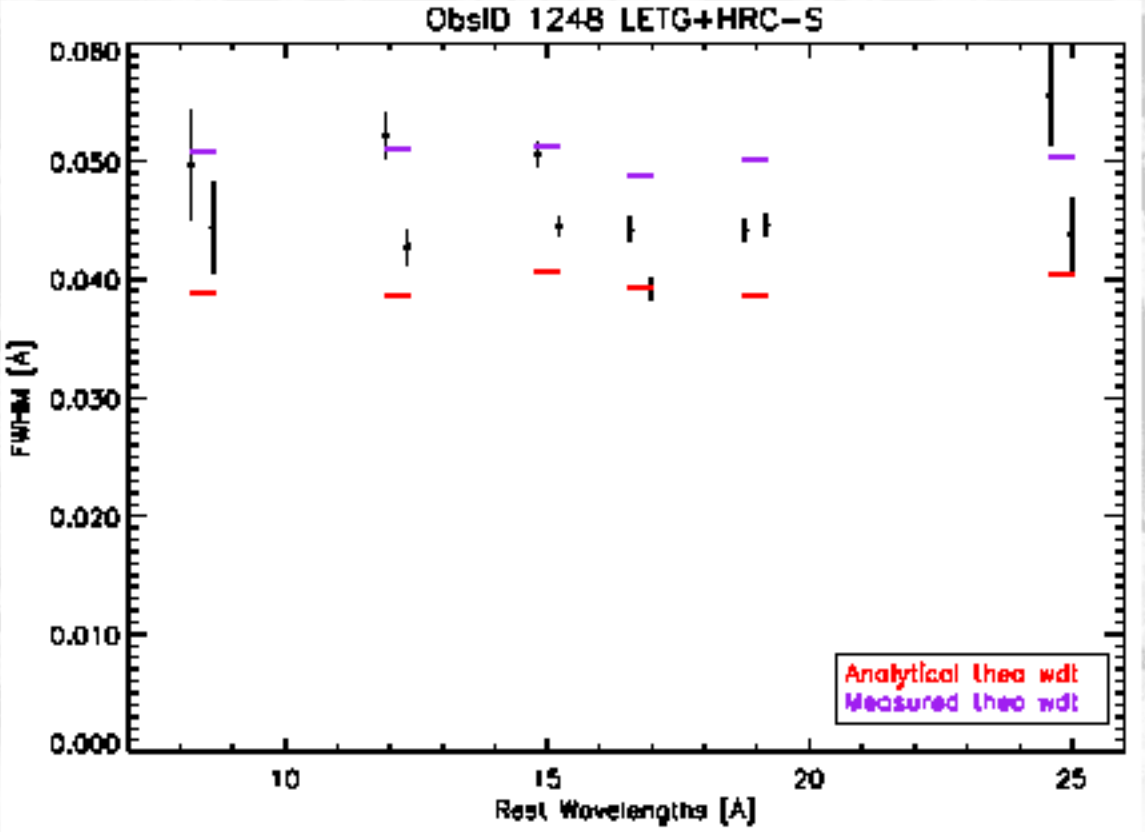
Line-by-line Testing: HETG FWHM



β -profile fits to theoretical profiles yield larger FWHM than true profile FWHM

- MEG observed and theoretical FWHM in good agreement to better than 5% - RMF line core very close match to reality
- HEG observed FWHM appears slightly larger than theory

LETG+HRC-S FWHM

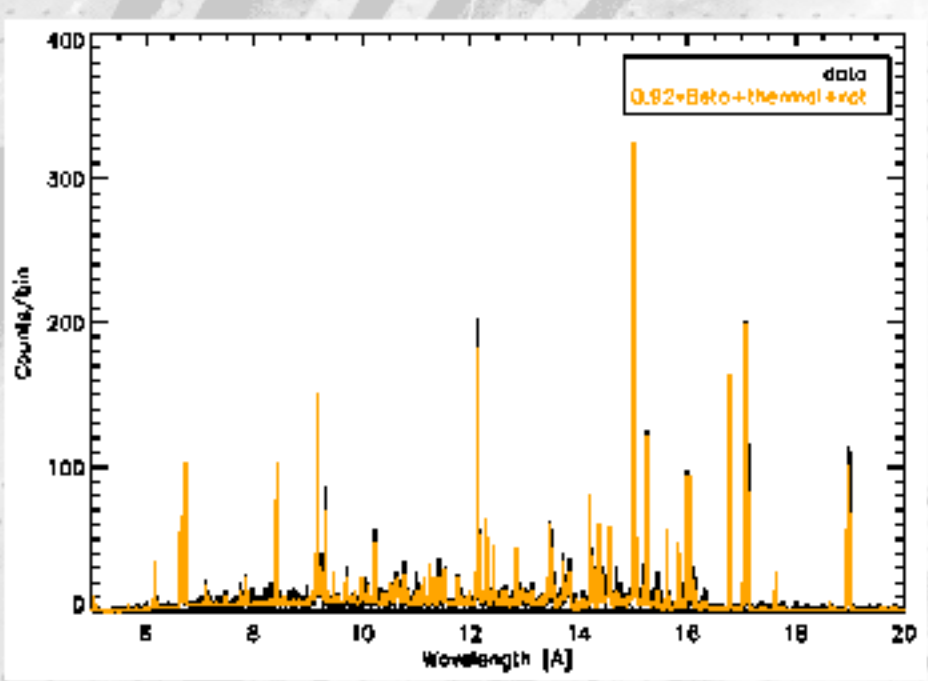


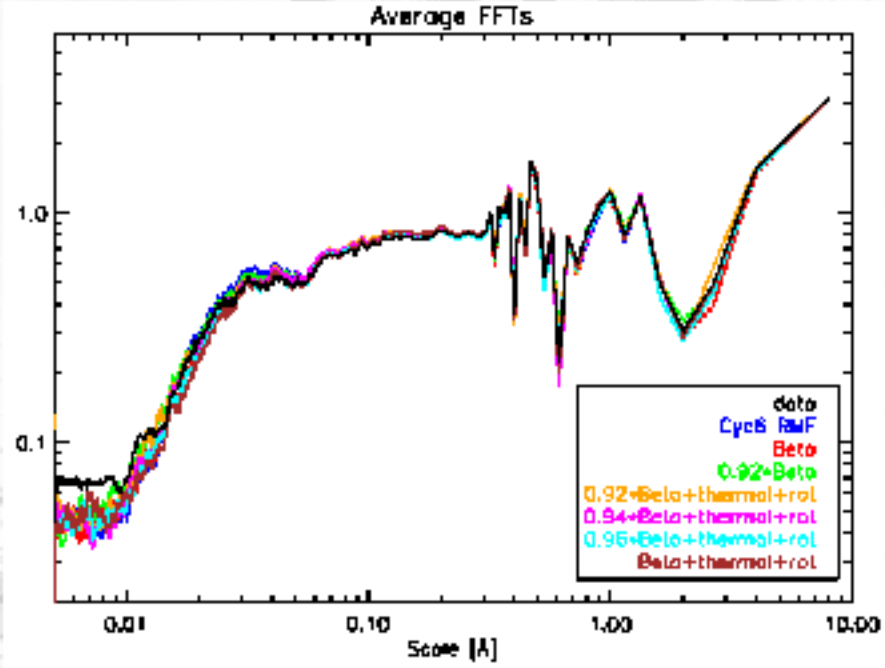
- Measured widths for most lines significantly larger than theoretical ones by ~10-20%
- Worst agreement for -ve order where detector event position errors are worse; position errors preclude quantitative RMF evaluation

Analysis in Fourier Domain

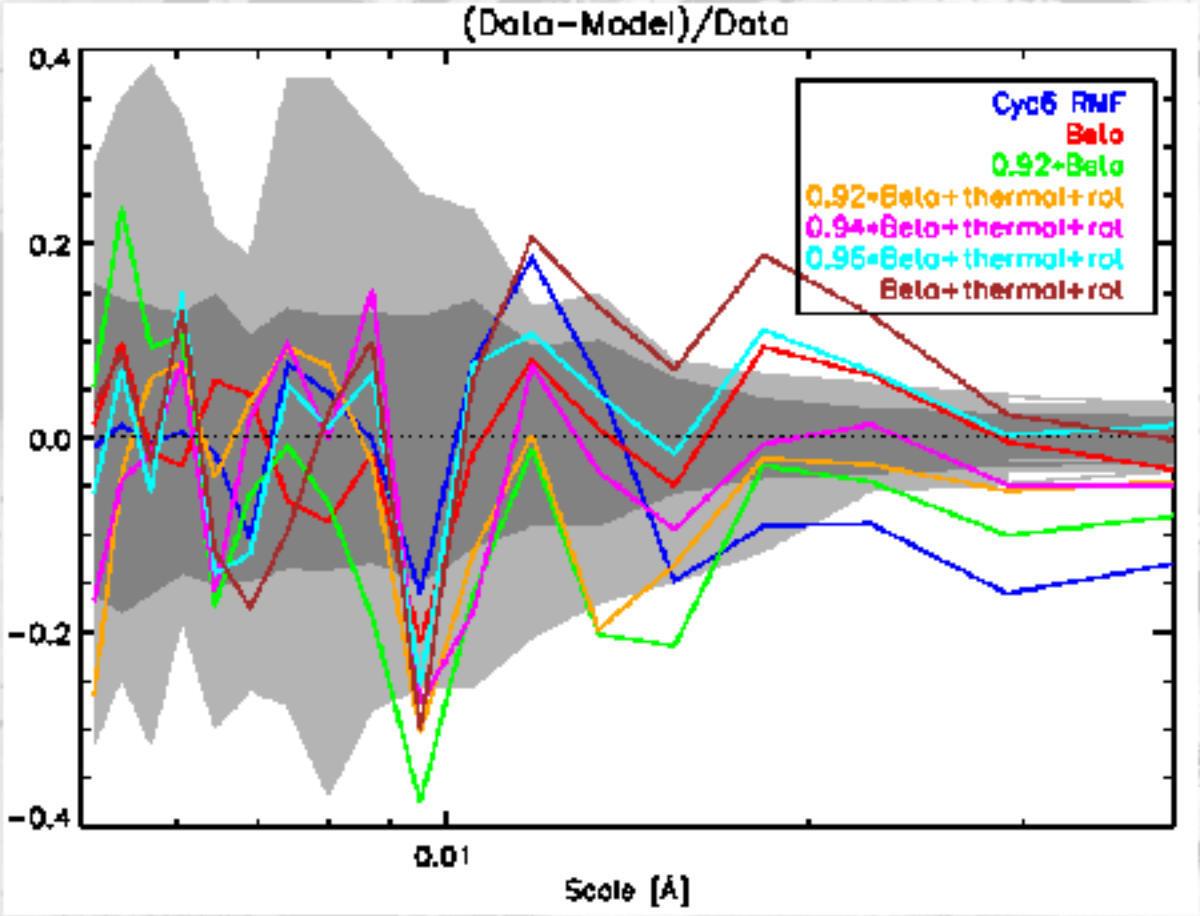
- Compare power spectra of observed and synthetic spectra
  - Full treatment of thermal and rotational broadening
- Uses all information in observed spectrum
- Line blends are not a problem if allowed for in synthetic spectrum

Capella MEG Observed vs Synthetic Spectra,FFT



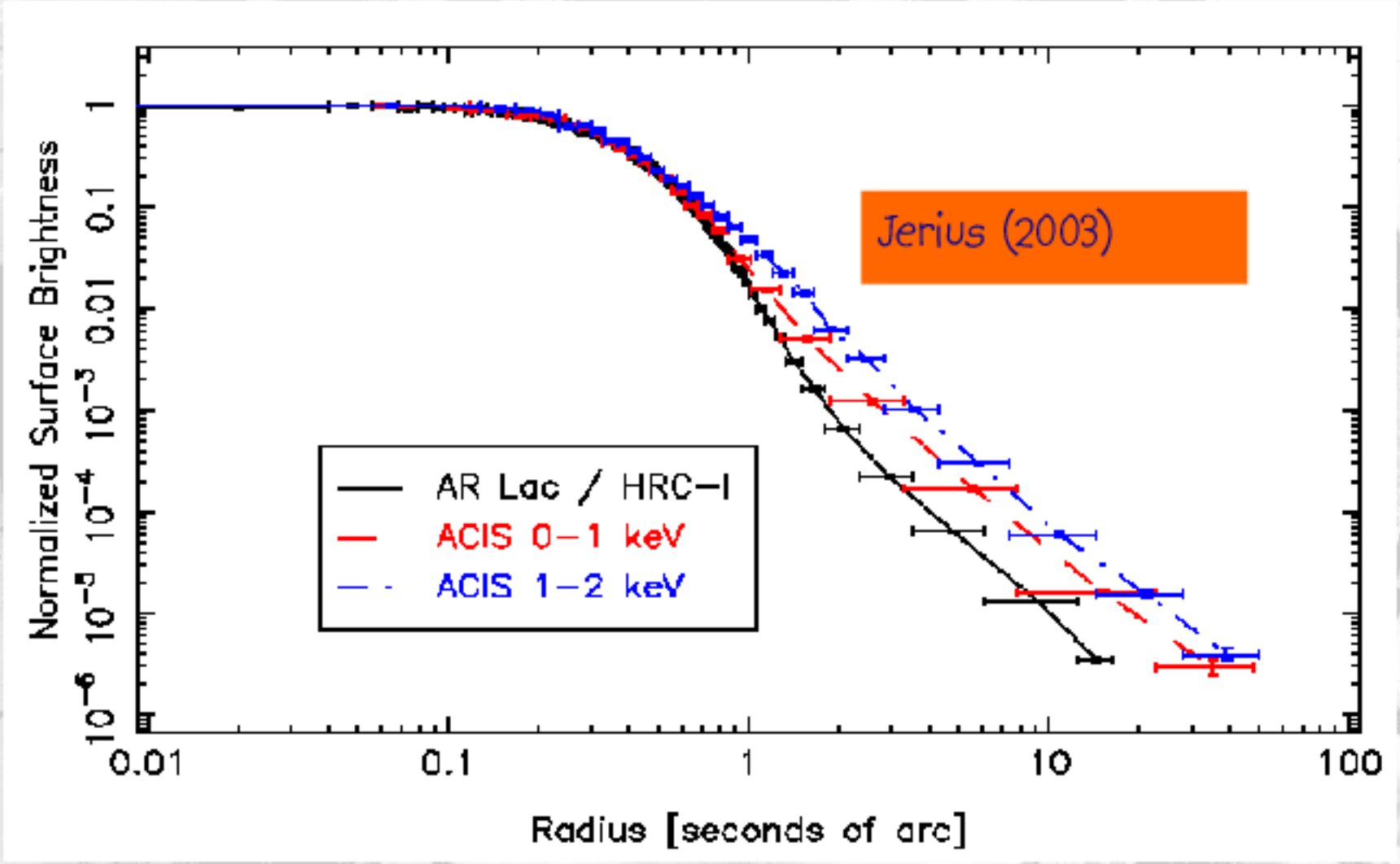


Capella MEG Observed vs Synthetic FFTs



- Power spectrum analysis tends to favour β-profile
- Scaling required - 0.94*rmf width - im agreement with FWHM analysis

Is this the ACIS vs HRC PSF problem?



[Or a grating scattering term?]

Coronal Morphology of AB Dor

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Or

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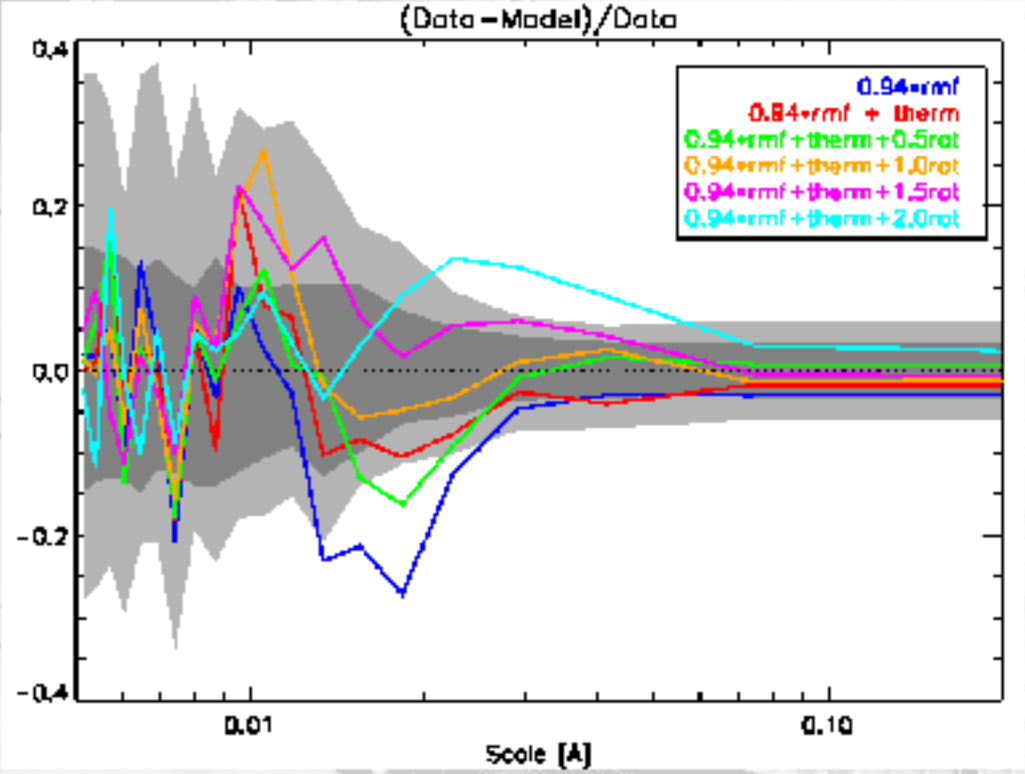
?



- Power spectrum analysis supports very compact or pole-dominated corona

Summary

- Cycle 6 RMFs provide excellent match to observed profiles for purposes of spectrum fitting/flux measurement
- Evidence from FFTs and line fitting suggest that β-profile wings might be slightly better match to observations
- Possible repeat of ACIS vs HRC PSF?
- Chandra spectra offer potential to investigate non-thermal velocity broadening down to ~50km/s levels