EPIC-pn re-distribution matrix an update

Frank Haberl

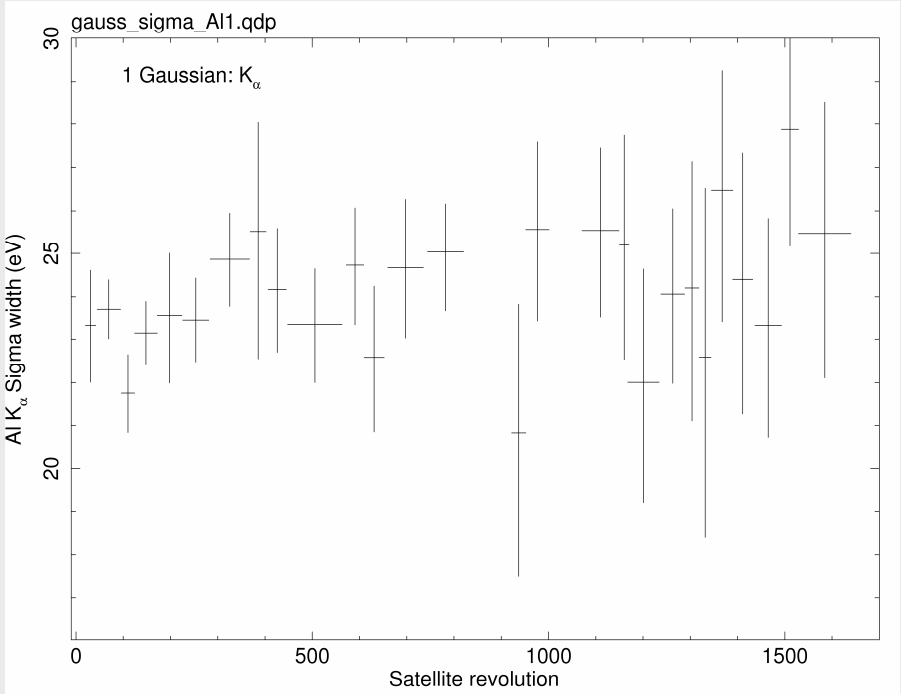
1. Energy resolution at Fe-K energies
2. Re-distribution at low energies
3. Future work

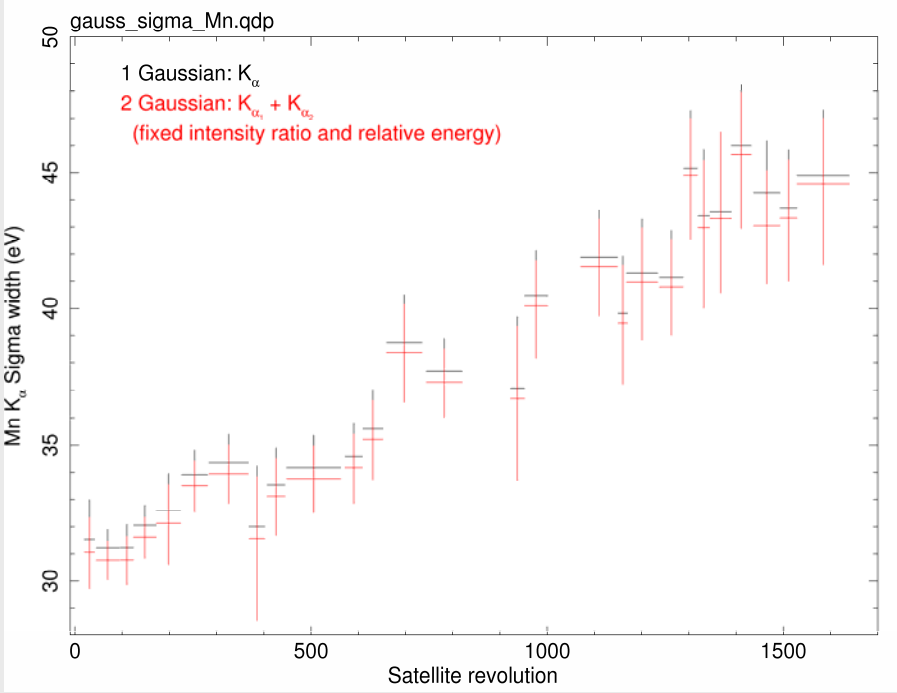
EPIC calibration meeting, ESAC, 2010 March 23-24

1. Energy resolution: On-board calibration source

Single-pixel events
CCD 4, RAWY > 180

592 spectra, revolutions 45-1640
Combined into 27 blocks
Line parameters linked within 1 block
Model powerlaw+gauss+gauss (Mn)
Model powerlaw+gauss (Al)



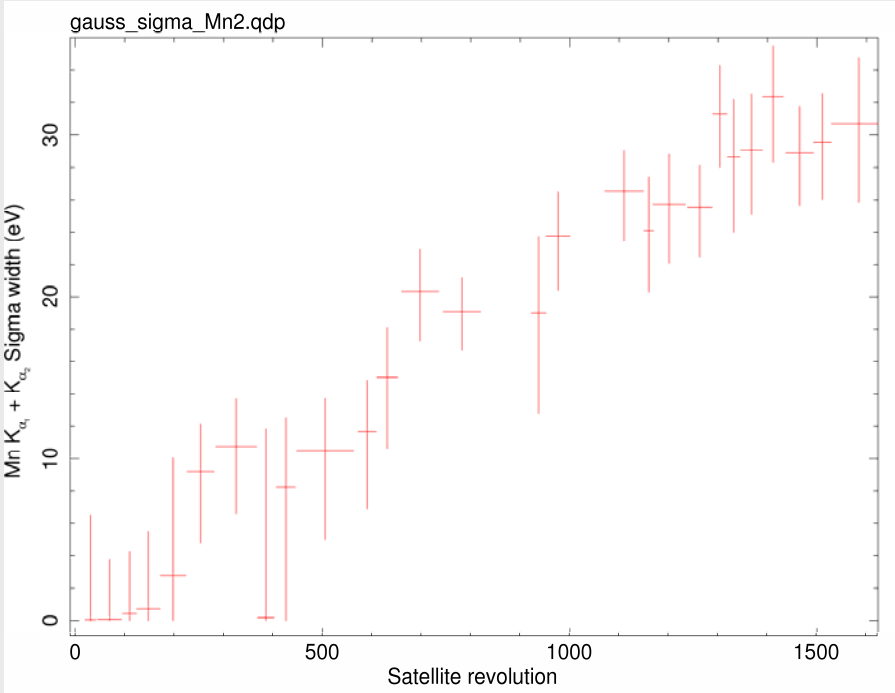


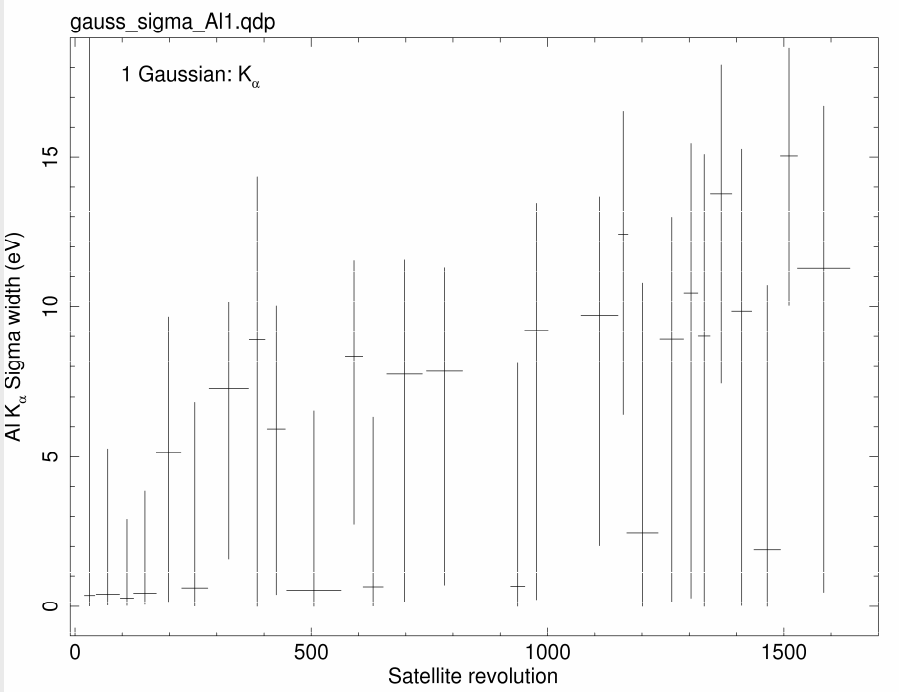
Current response

On-board calibration source

Single-pixel events
CCD 4, RAWY > 180

592 spectra, revolutions 45-1640
Combined into 27 blocks
Line parameters linked within 1 block
Model powerlaw+gauss+gauss (Mn)
Model powerlaw+gauss (Al)



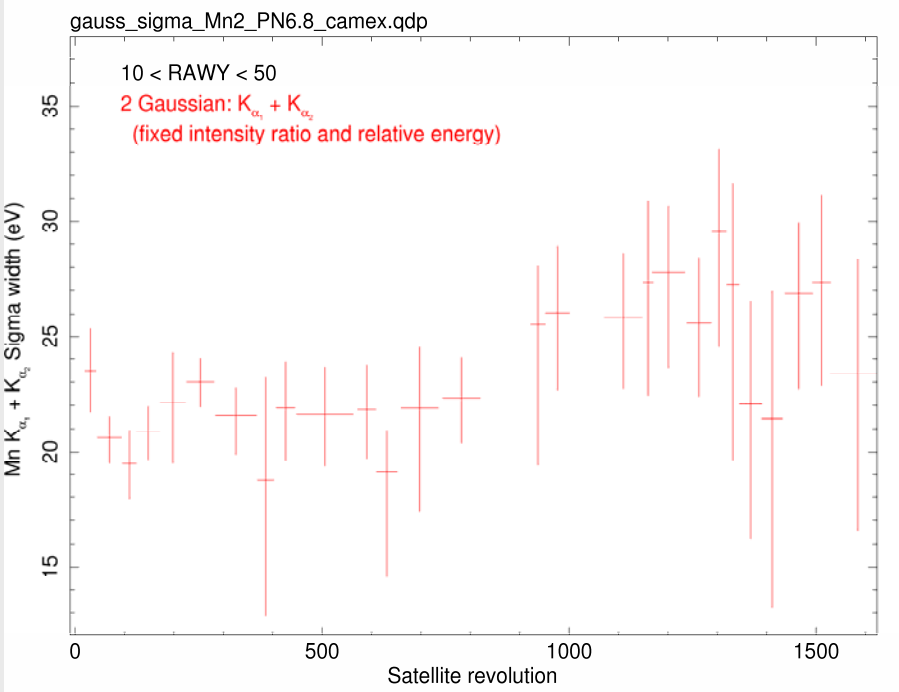


New response with increased FWHM

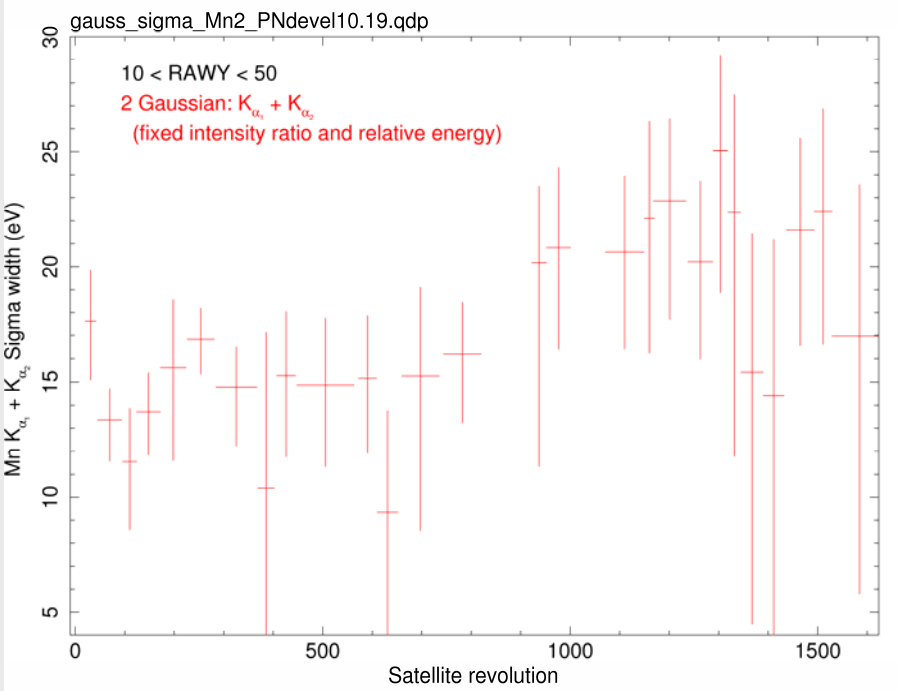
On-board calibration source

Single-pixel events
CCD 4, 10 < RAWY < 50

592 spectra, revolutions 45-1640
Combined into 27 blocks
Line parameters linked within 1 block
Model powerlaw+gauss+gauss (Mn)
Model powerlaw+gauss (Al)



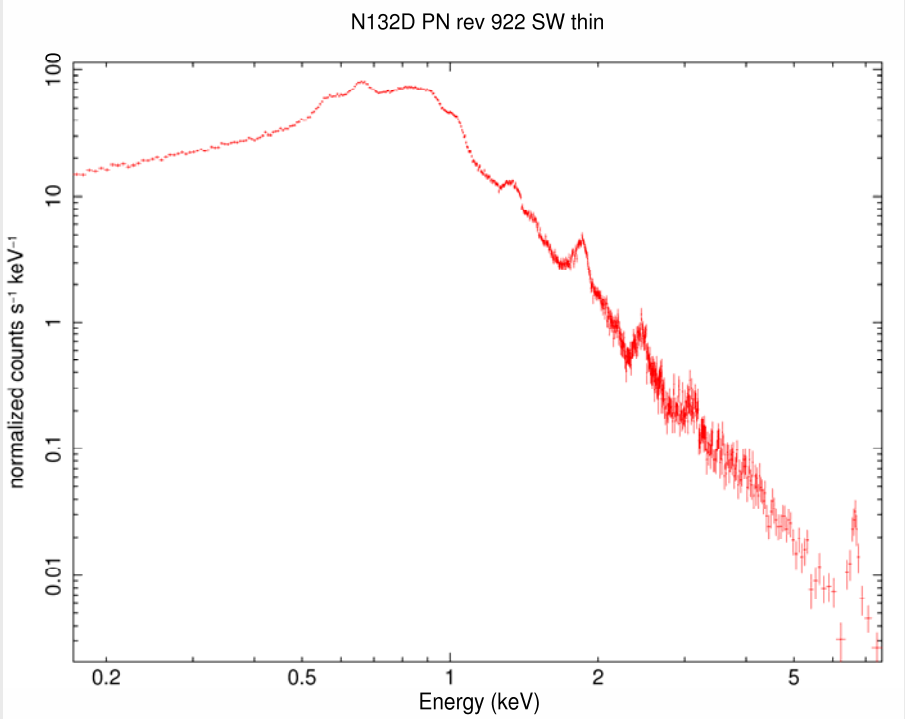
Current response

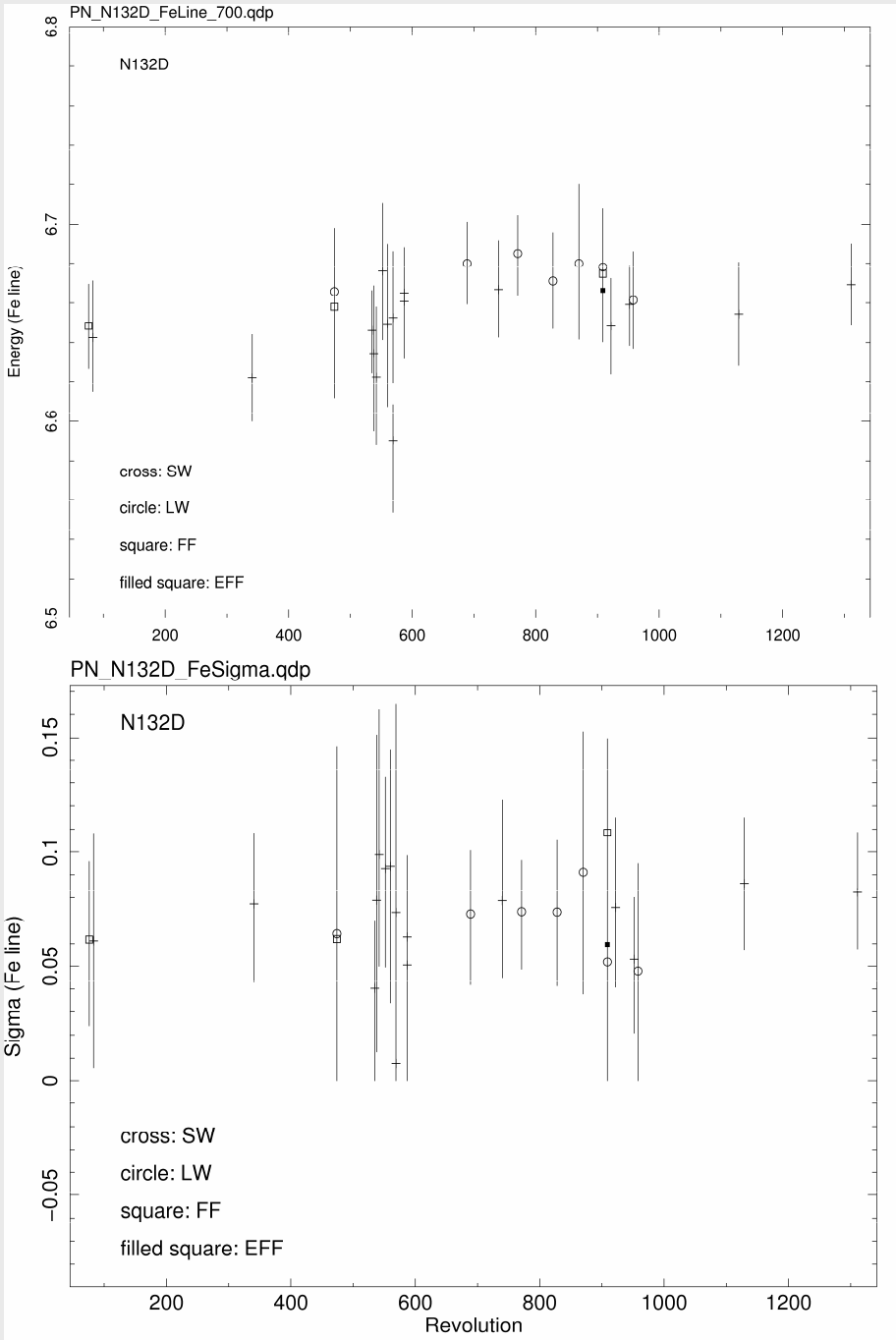


New response

The SNR N132D

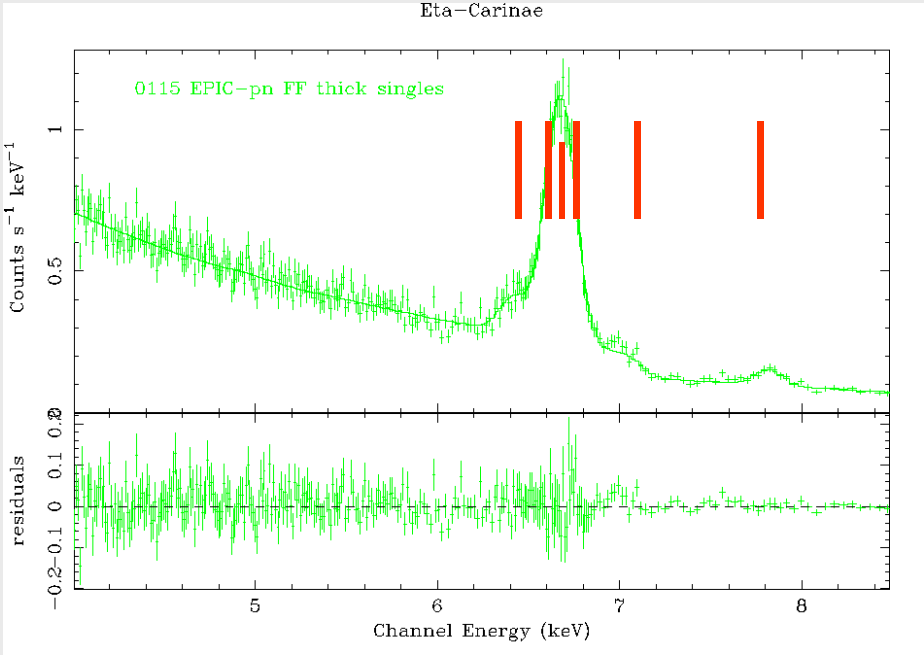
Single-pixel events
Model powerlaw+gauss
Current response



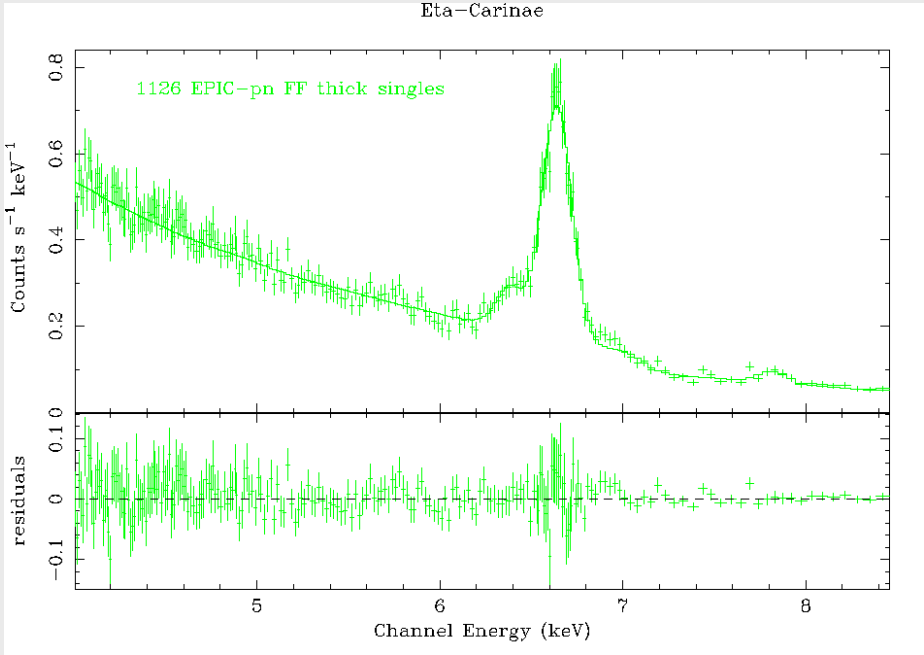


Eta Carinae

2000-07-26



2006-01-31



Model: egde*pow + gaus + gaus + gaus + gaus $\sigma_1 = \sigma_2 = \sigma_3 = \sigma_4$

Fe I	6.424 keV	$E_1 = E_3 - 0.275$	N_1
Fe XXV (f)	6.634 keV	$E_2 = E_3 - 0.065$	$N_2 = N_3 \cdot 0.441$
Fe XXV (i)			
Fe XXV (r)	6.699 keV	E_3	N_3
Fe K-edge		E_E	
Fe XXV Heβ 7.881 keV (blend with Ni XXVII f/i/r)		E_4	N_4

Eta Carinae

Model: egde*pow + gaus + gaus + gaus + gaus		$\sigma_1 = \sigma_2 = \sigma_3 = \sigma_4$	
Fe I	**6.424 keV**	$E_1 = E_3 - 0.275$	N_1
Fe XXV (f)	**6.634 keV**	$E_2 = E_3 - 0.065$	$N_2 = N_3 \cdot 0.441$
Fe XXV (i)			
Fe XXV (r)	**6.699 keV**	E_3	N_3
Fe K-edge		E_E	
Fe XXV Heβ	**7.881 keV (blend with Ni XXVII f/i/r)**	E_4	N_4

Results	**FF mode:**		**SW mode:**	
	2000-07-26	**2006-01-31**	**2003-06-08**	**2006-02-01**
	Rev 0115	**Rev 1126**	**Rev 0640**	**Rev 1126**
E_3 **(eV):**	**6694 ± 3**	**6658 ± 4**	**6685 ± 3**	**6670 ± 4**
σ (eV):	**46 ± 5**	**40 ± 8**	**45 ± 3**	**45 ± 7**
	1000 revolutions		**500 revolutions**	

2. Re-distribution: Sources and spectral models

Models derived from RGS spectra:

SNR 1E0102	**continuum + emission lines**
Star Zeta Puppis	**continuum + emission lines**
Comet C/2000 WM1	**emission lines (unknown spectrum below 300 eV)**

Other sources for consistency checks:

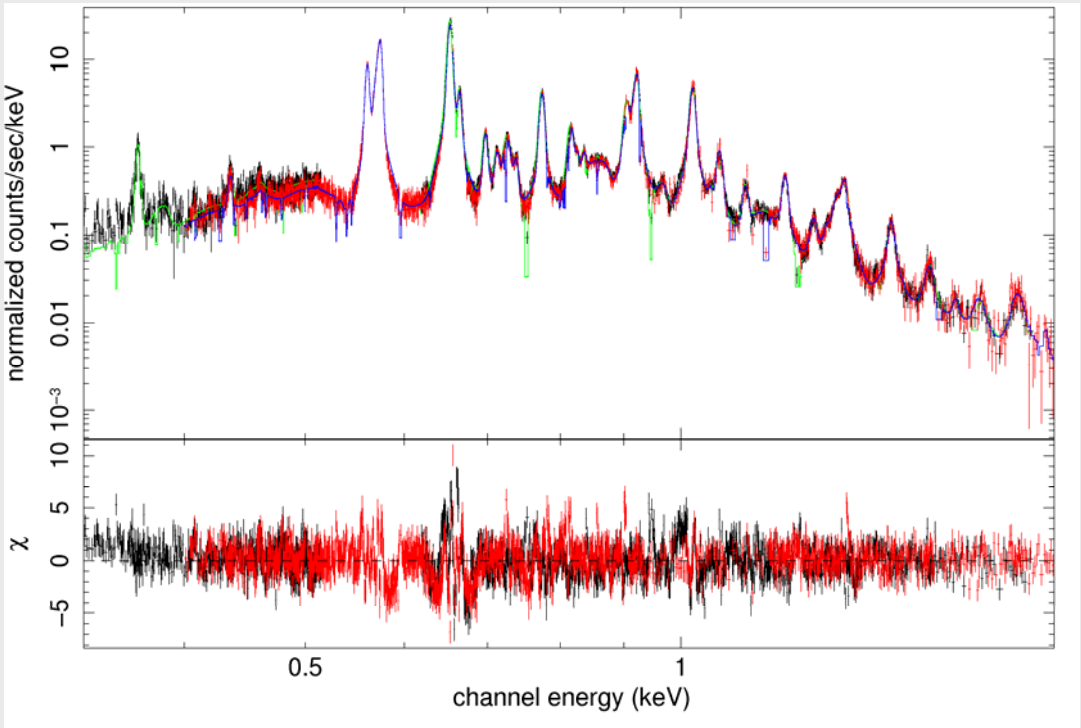
INS RXJ0720	**bbody + broad absorption line**
INS RXJ1856	**bbody (+bbody?)**
AGN MS1229.2+6430	**powerlaw**
AGN H1426+428	**broken powerlaw**
AGN PKS2155	**broken powerlaw**
SNR G21.5-09	**powerlaw**

1E0102

Model from the cross-calibration work (Plucinsky et. al 2008, SPIE 7011E, 68)
Derived from combined RGS spectra of 23 observations (+EPIC-pn for higher energies)
rgspn_mod_tbabs_tbvarabs_2apec_line_ratios_jd_v1.9.xcm

Fit to pn spectra:

- **only constant factor allowed to vary**
- **gain fit with slope==1.0 and shift as fit parameter**

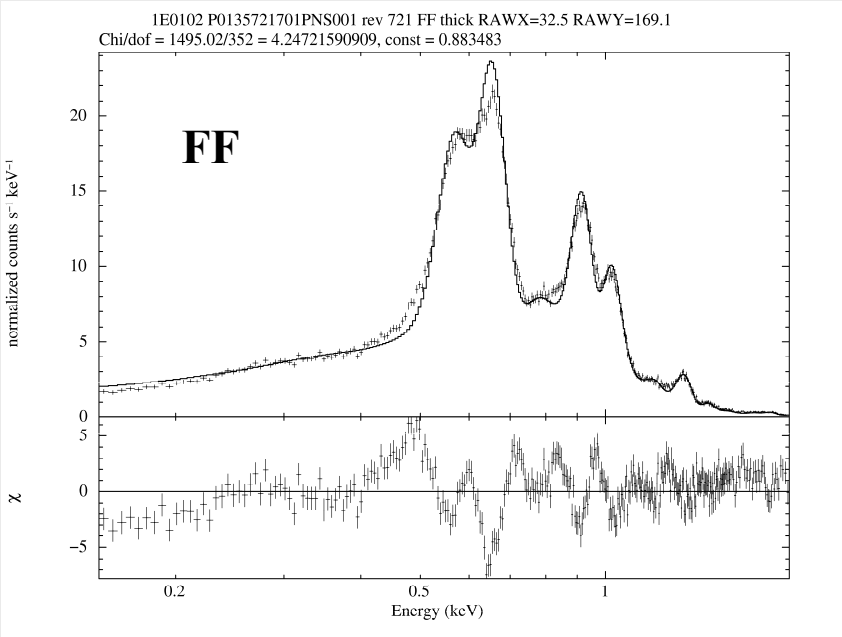


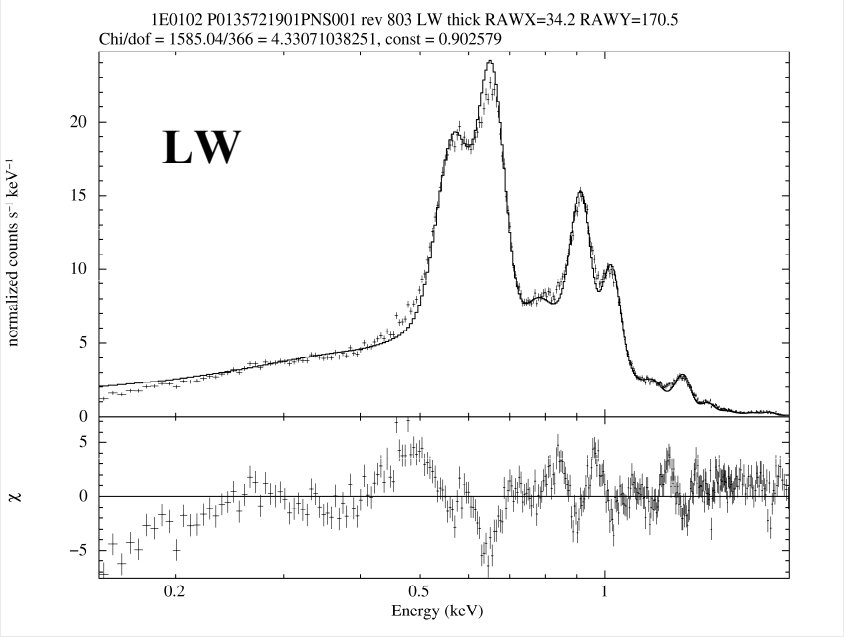
O VII f	561 eV
O VII i	567 eV
O VII r	574 eV
O VIII Lyα	654 eV
O VII Heß	666 eV

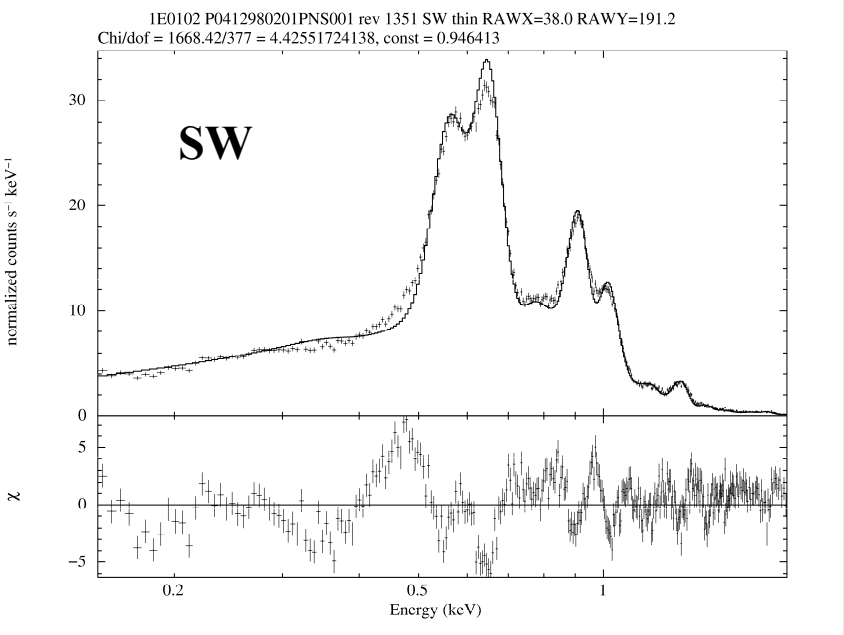
RGS1 708 ks
RGS2 680 ks

1E0102

The current response:
Problems with energy resolution
and
re-distribution of O-lines



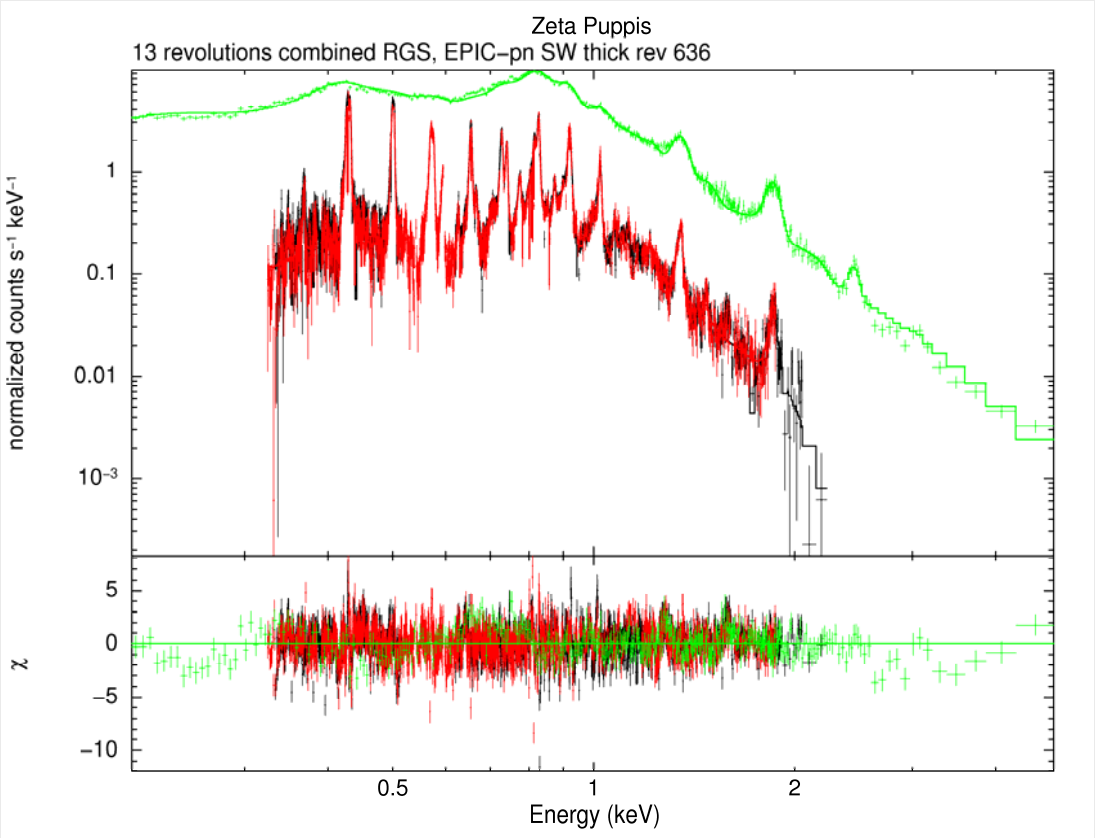




Zeta Puppis

Model similar to that of 1E0102
Derived from combined RGS spectra (+EPIC-pn for higher energies)

Fit to pn spectra:
- **only constant factor allowed to vary**
- **gain fit with slope==1.0 and shift as fit parameter**



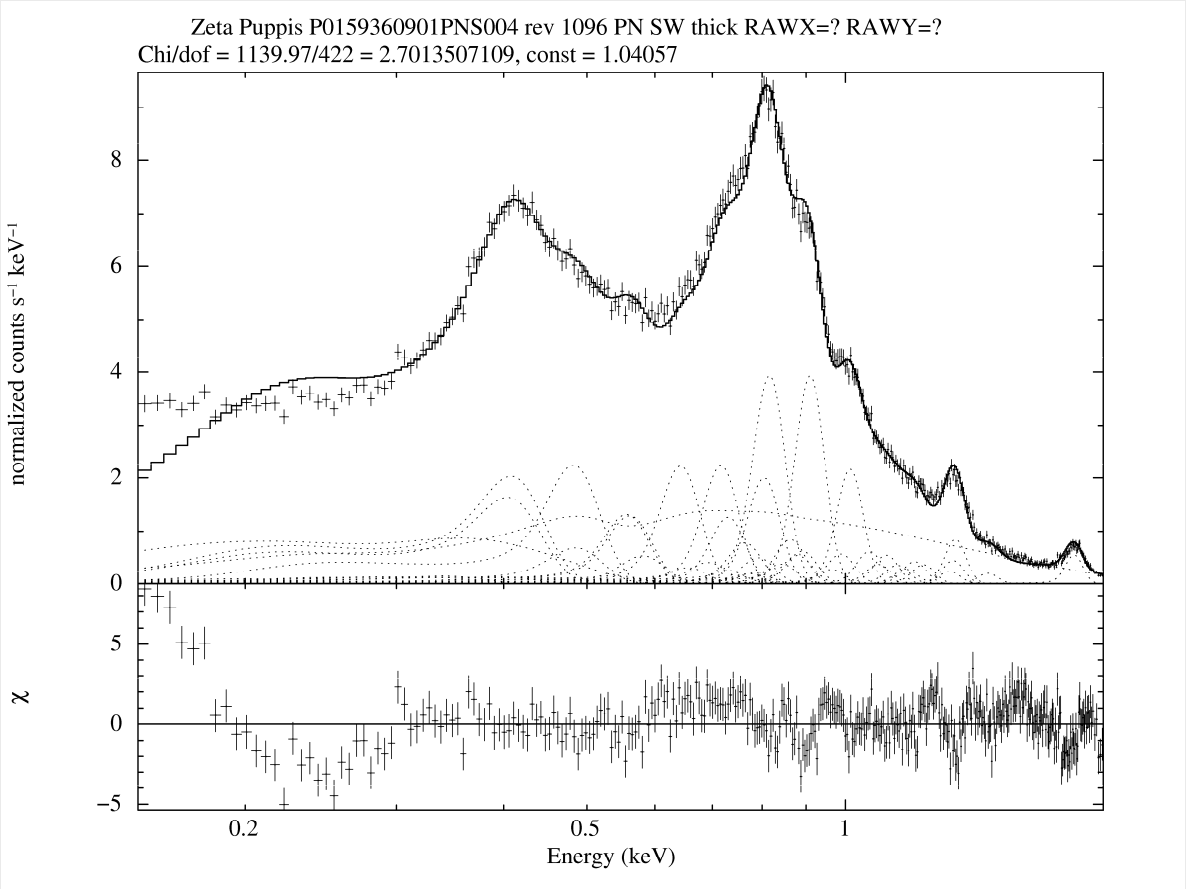
N VI f	420 eV
N VI i	426 eV
N VI r	431 eV
N VII Lyα	500 eV

RGS1 663.6 ks
RGS2 668.8 ks

Zeta Puppis

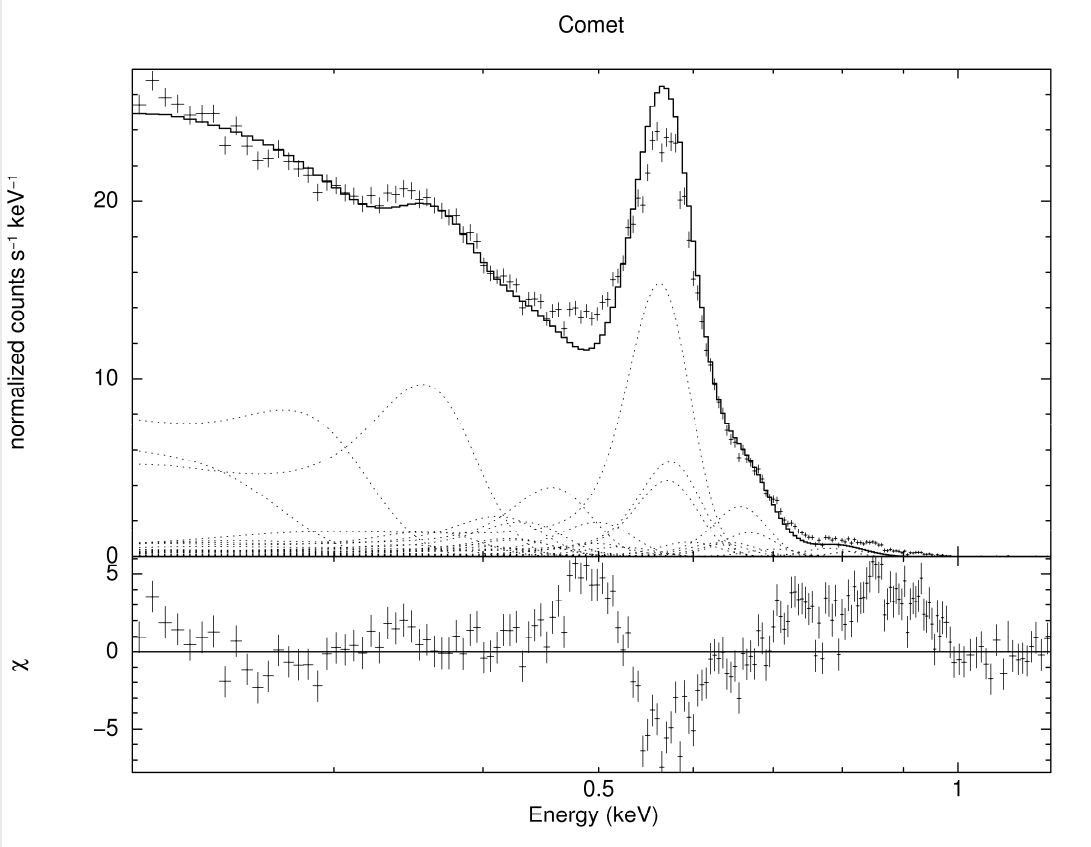
To avoid pile-up and optical loading:
Use SW mode with thick filter!

The current response:
Problems with energy resolution
and
re-distribution of N-lines
(the shoulder is too narrow)



Comet C/2000 WM1

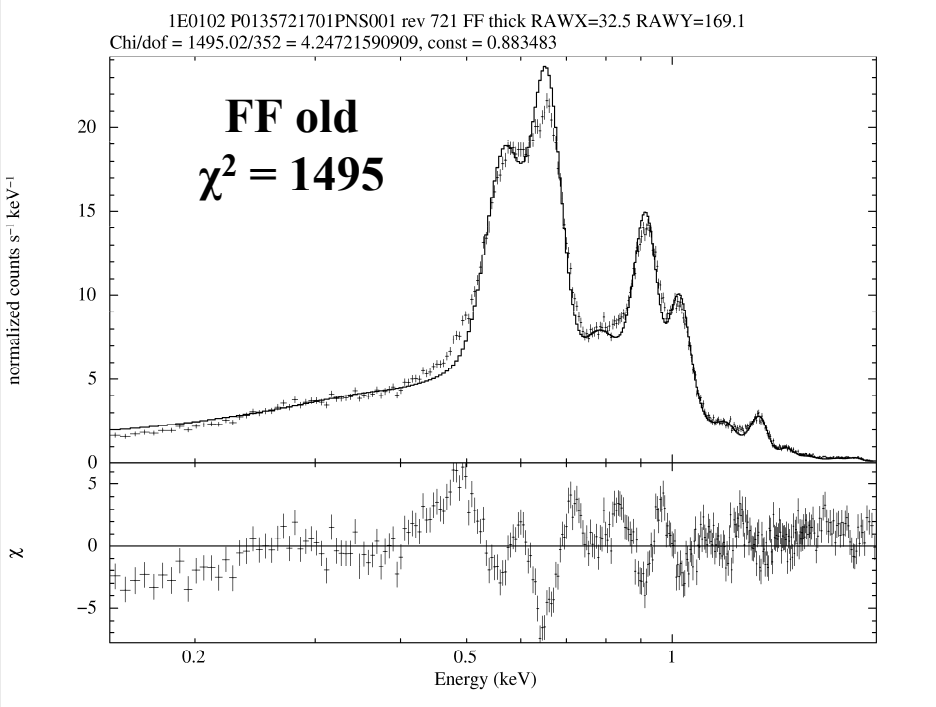
A pure line spectrum with no continuum
The current response:
Unknown spectrum below 300 eV

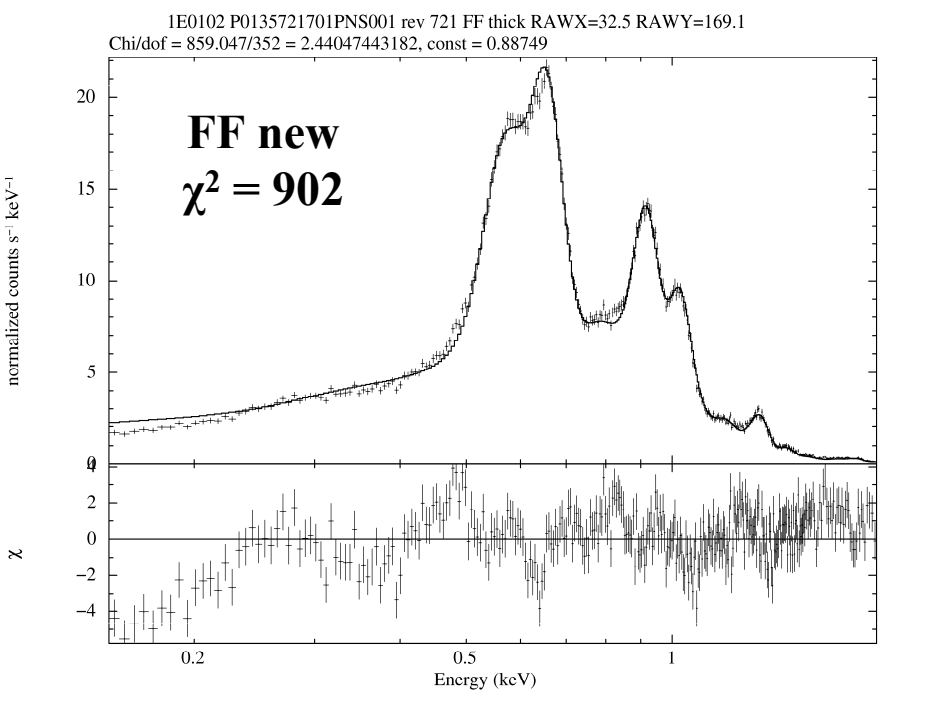


C VI Lyα 368 eV
O VII f 561 eV

1E0102

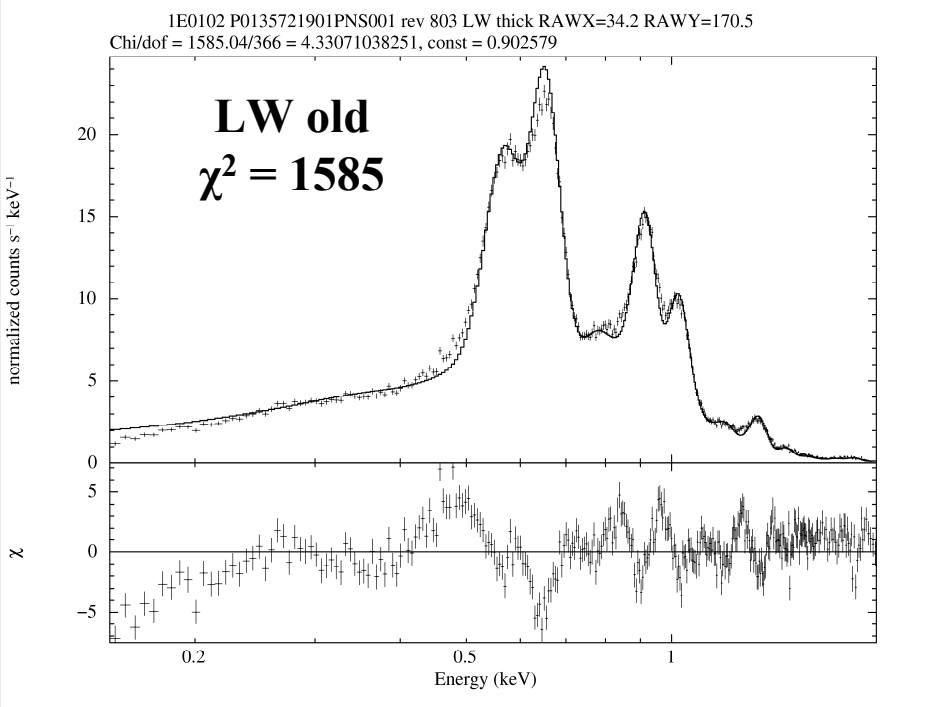
New response matrix:
Adjustment of energy resolution
and
re-distribution below ~700 eV

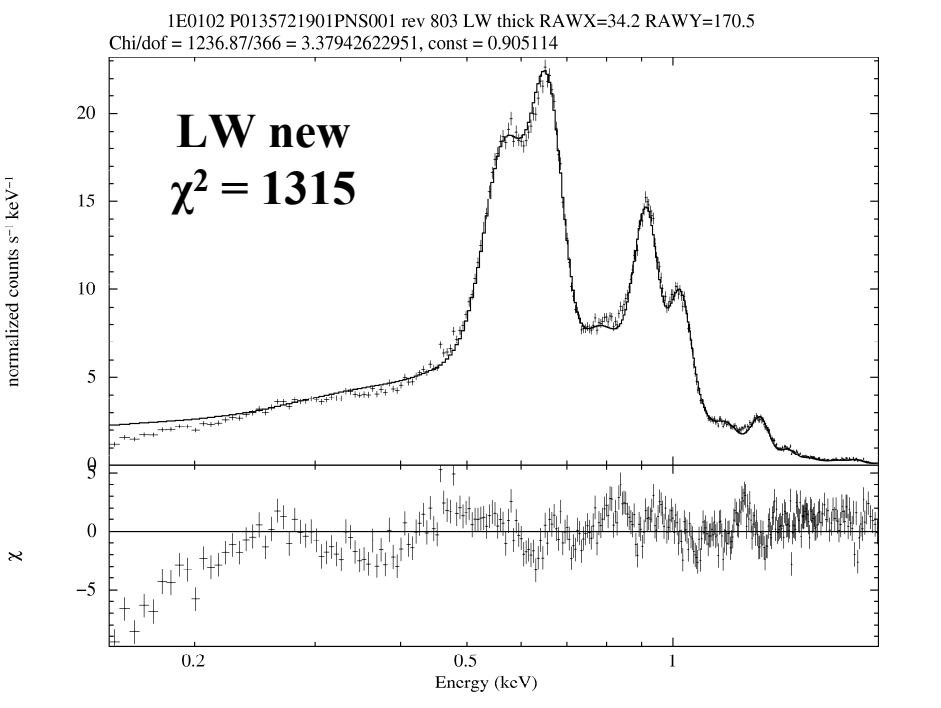




1E0102

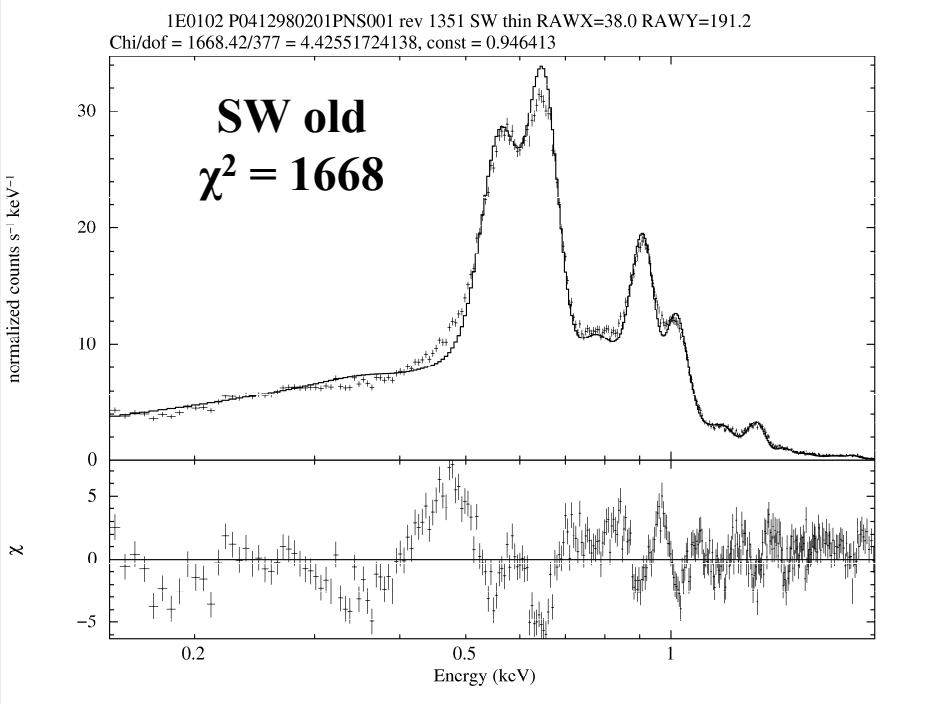
New response matrix:
Adjustment of energy resolution
and
re-distribution below ~700 eV

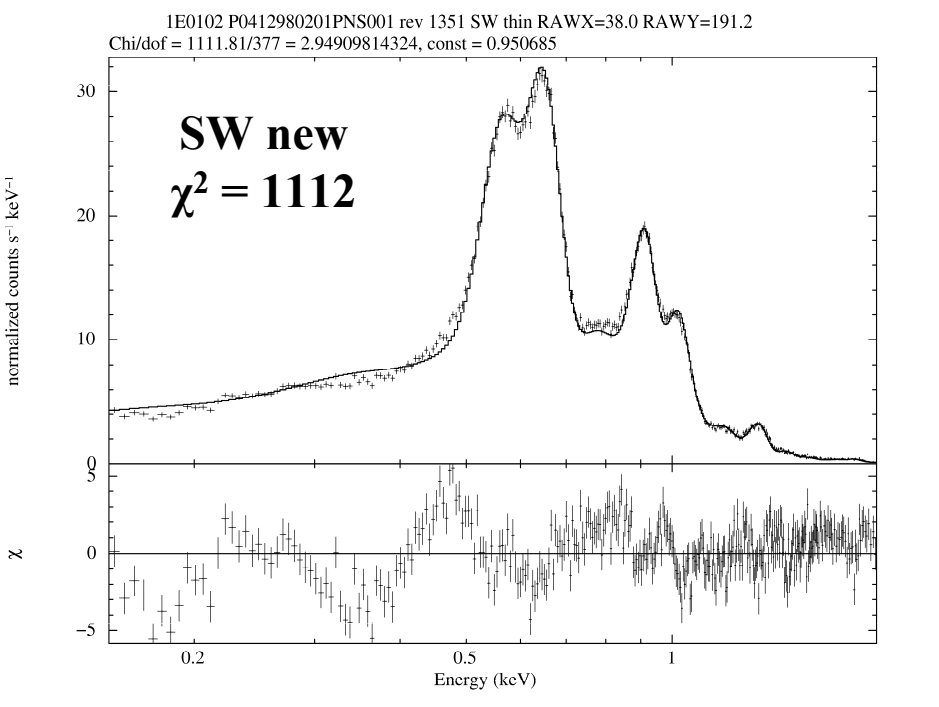




1E0102

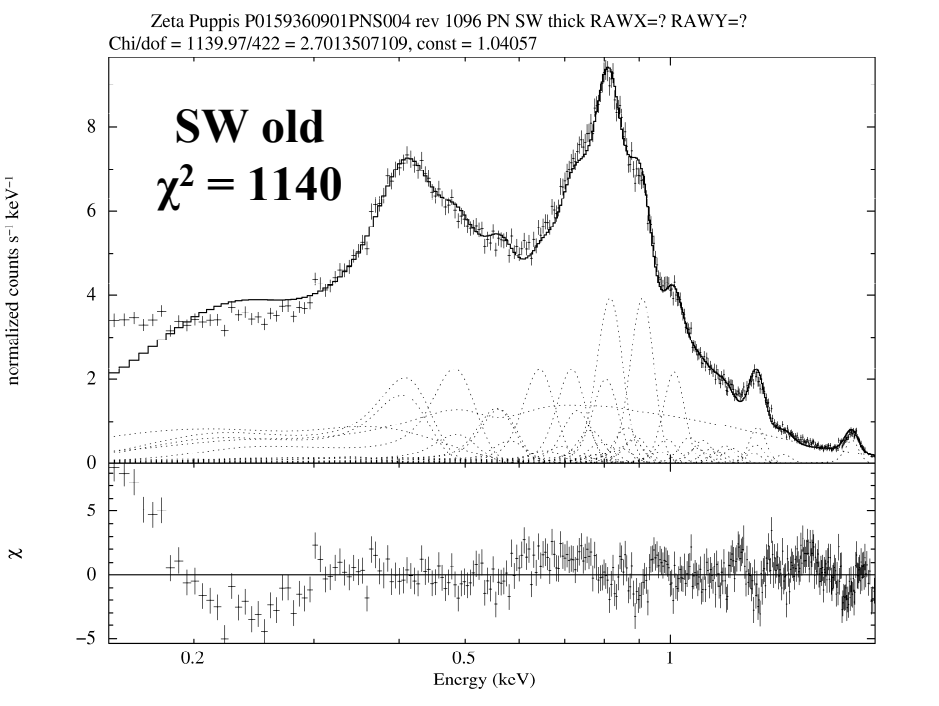
New response matrix:
Adjustment of energy resolution
and
re-distribution below ~700 eV

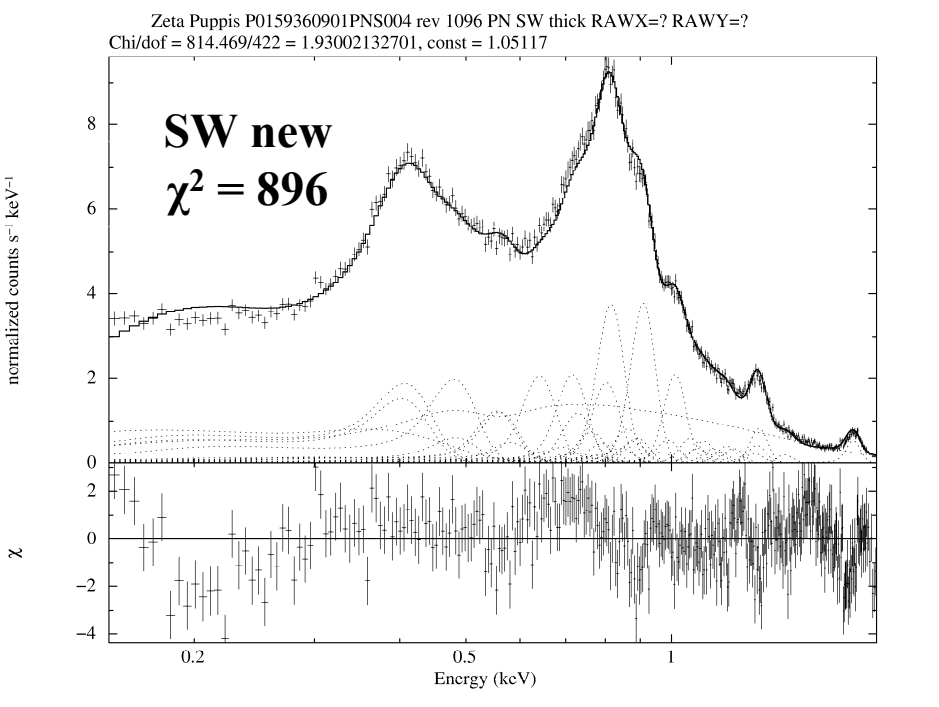




Zeta Puppis

New response matrix:
Adjustment of re-distribution between 400 eV and 700 eV



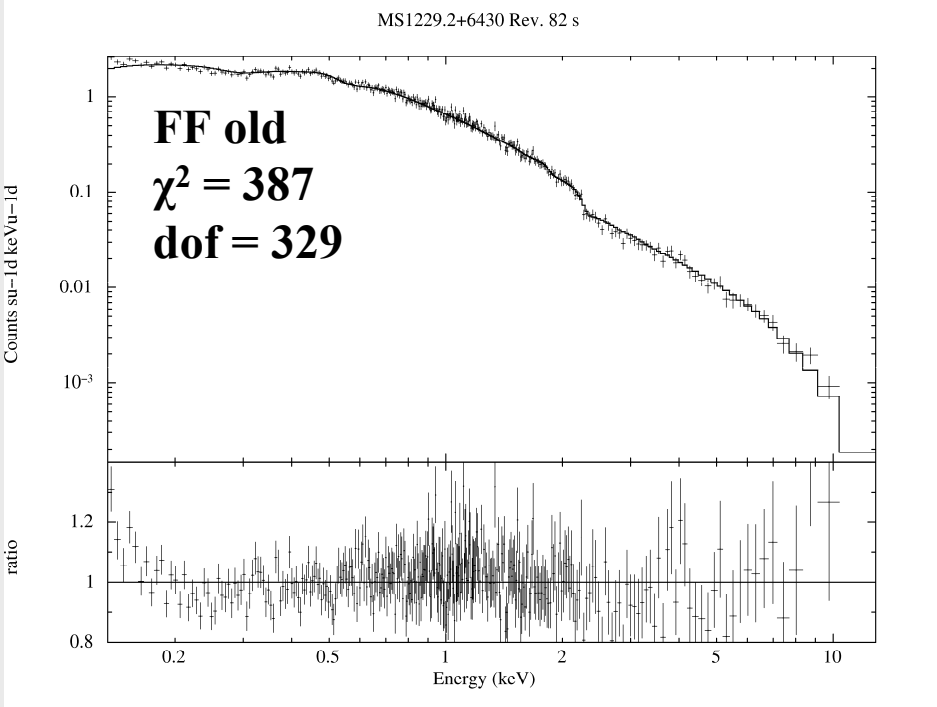


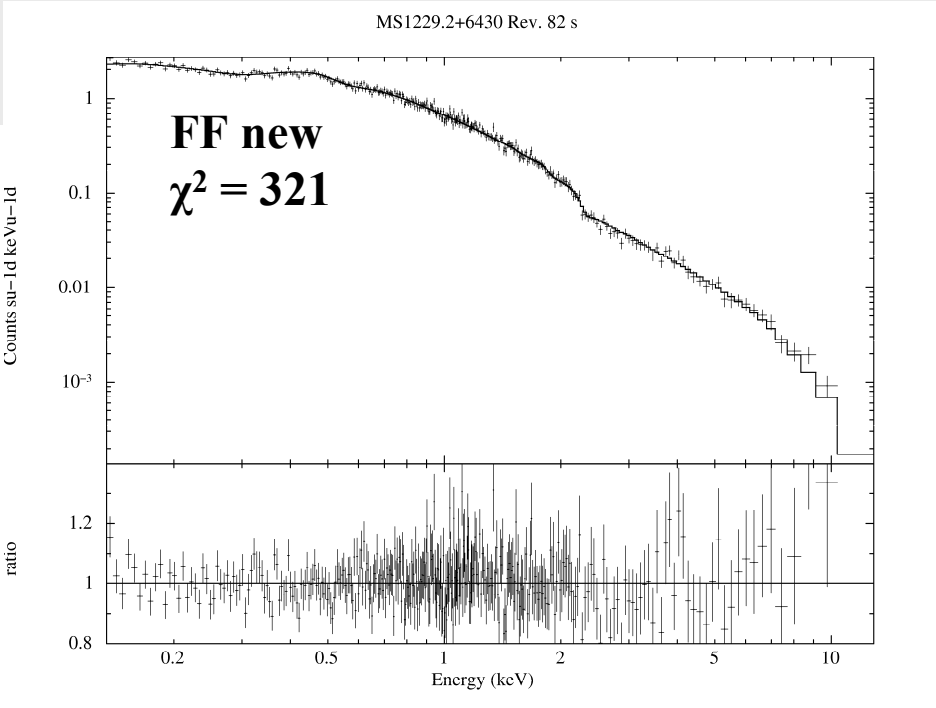
Chi-squared comparison

		old (epn6.8)	new 11.19
1E0102			
P0123110201PNS001	FF	849.583	532.
P0123110301PNS002	FF	728.090	474.
P0135720601PNS001	FF	806.368	489.
P0135720801PNS001	SW	1323.634	1186.
P0135720901PNS001	FF	1136.760	525.
P0135721001PNS001	FF	1111.822	584.
P0135721001PNS017	LW	821.673	623.
P0135721101PNS001	SW	521.431	518.
P0135721101PNS017	LW	792.709	723.
P0135721301PNS001	SW	586.281	549.
P0135721301PNS017	LW	1064.937	980.
P0135721401PNS017	LW	1144.645	935.
P0135721401PNU002	SW	541.300	517.
P0135721501PNS001	FF	1764.823	915.
P0135721701PNS001	FF	1495.017	902.
P0135721901PNS001	LW	1585.040	1315.
P0135722001PNS001	LW	1337.826	935.
P0135722101PNS001	FF	2277.290	1052.
P0135722201PNS001	FF	980.917	512.
P0135722201PNU014	FF	717.297	386.
P0135722201PNU027	FF	863.390	482.
P0135722301PNS001	FF	2238.106	937.
P0135722401PNS001	SW	980.980	915.
P0135722501PNS001	LW	2047.707	1421.
P0135722601PNS001	SW	1114.171	1049.
P0135722701PNS001	SW	1771.811	1038.
P0412980101PNS001	SW	1225.191	1111.
P0412980201PNS001	SW	1668.415	1111.
P0412980301PNS001	SW	1074.206	1023.
Zeta Puppis thick			
P0414400101PNS003	SW	1034.00	688.4
P0159360901PNS004	SW	889.45	649.2
P0159360701PNU002	SW	682.43	602.9
P0159360501PNS004	SW	1197.04	859.3
P0159360401PNS003	SW	524.18	538.2
P0159360301PNS003	SW	1139.97	895.4
P0159360101PNU014	SW	1279.45	933.2
Comet			
rgs+pn_sY9(sys)	FF	678	667
		41979	**29570**

MS1229.2+6430

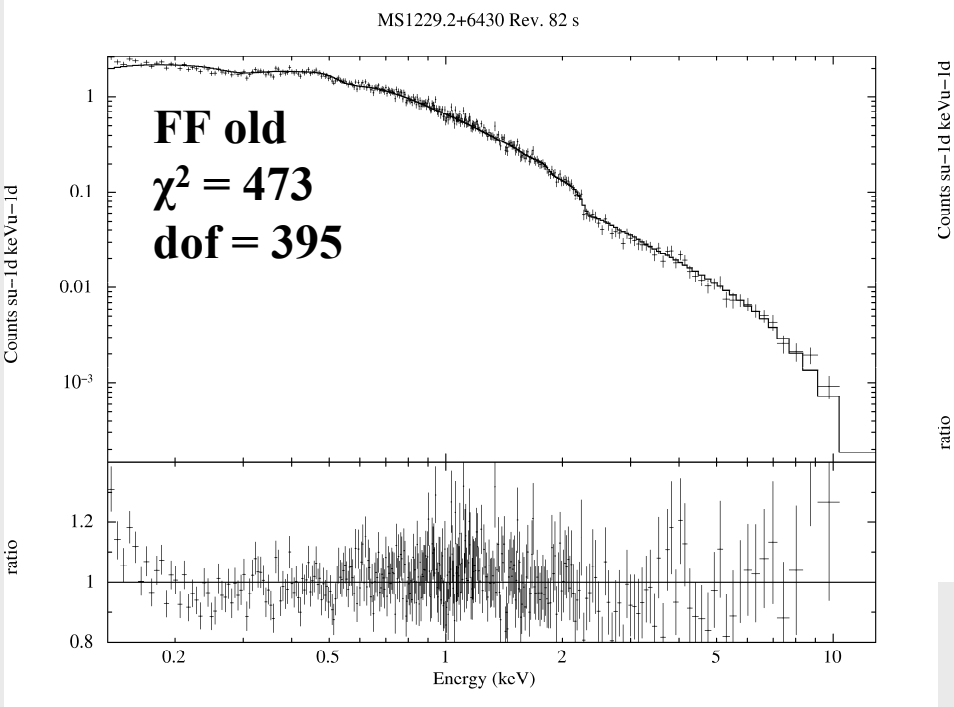
Powerlaw fits
singles

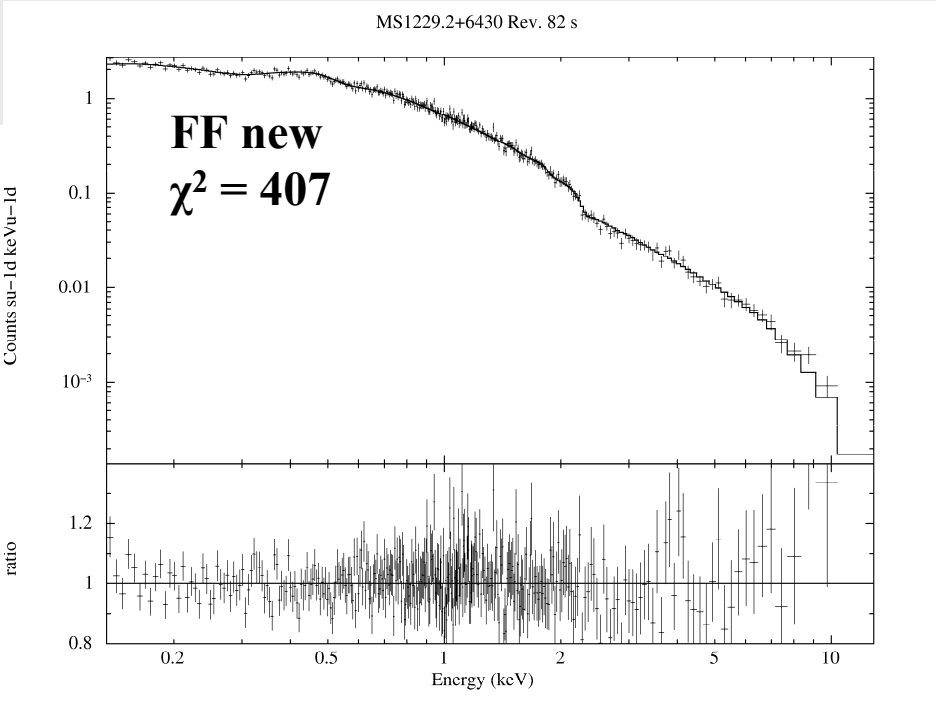




MS1229.2+6430

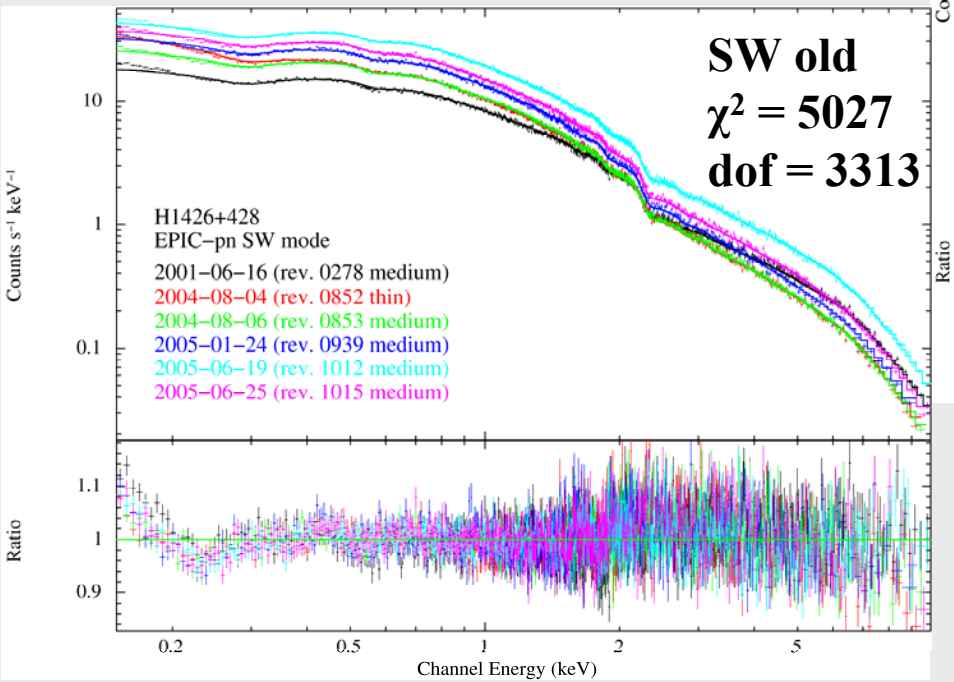
Powerlaw fits
singles+doubles

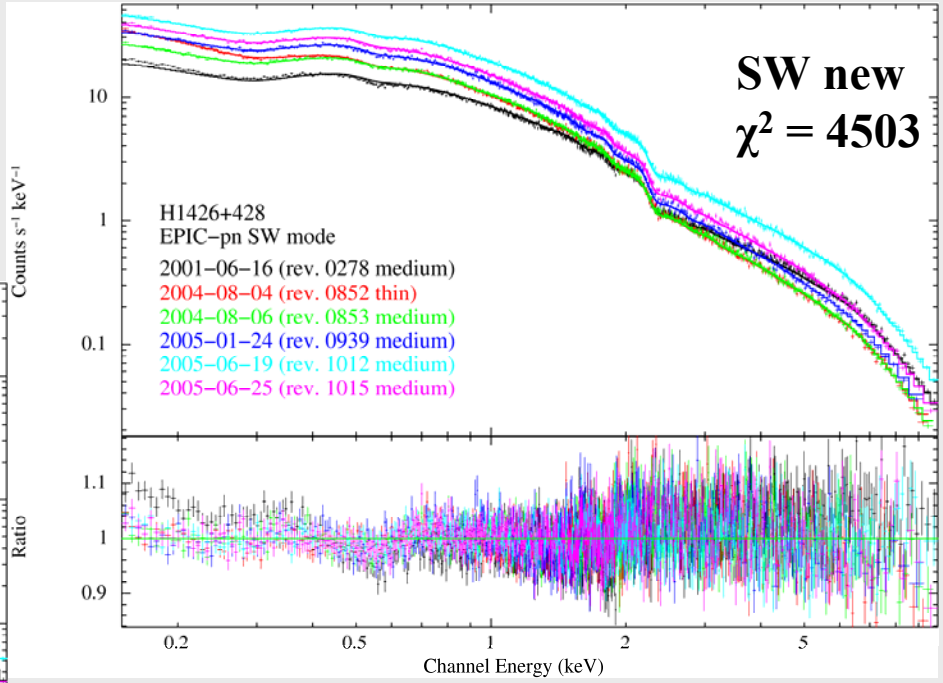




H1426+428

Broken-powerlaw fits
NH fixed at 1.36 1020 (phabs-wilms)
singles+doubles
Rev. 278: no break

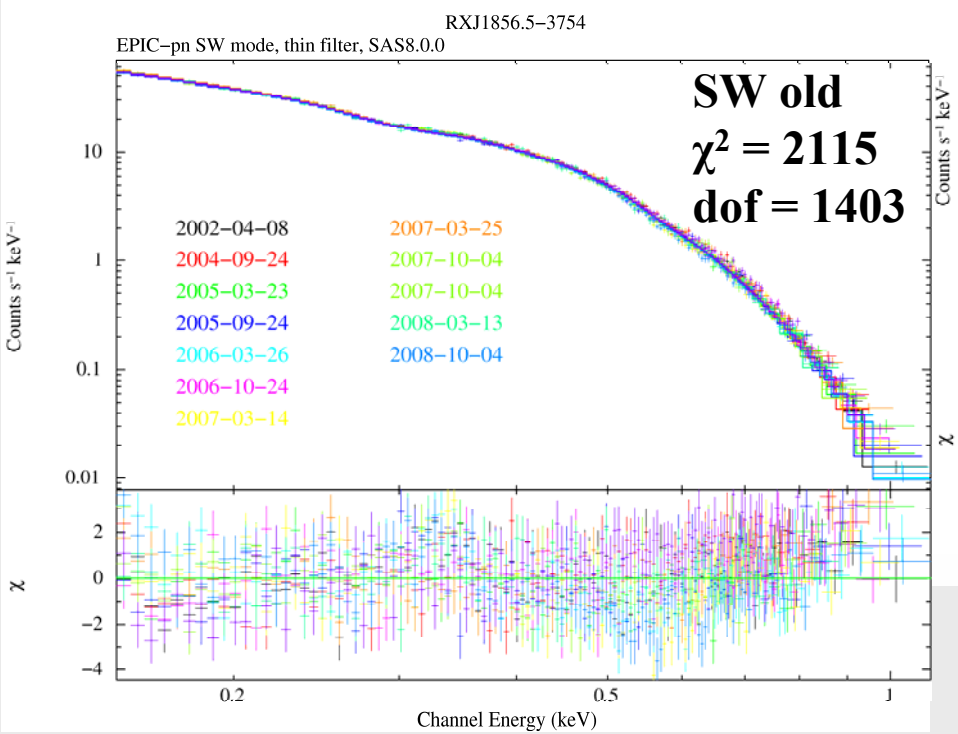




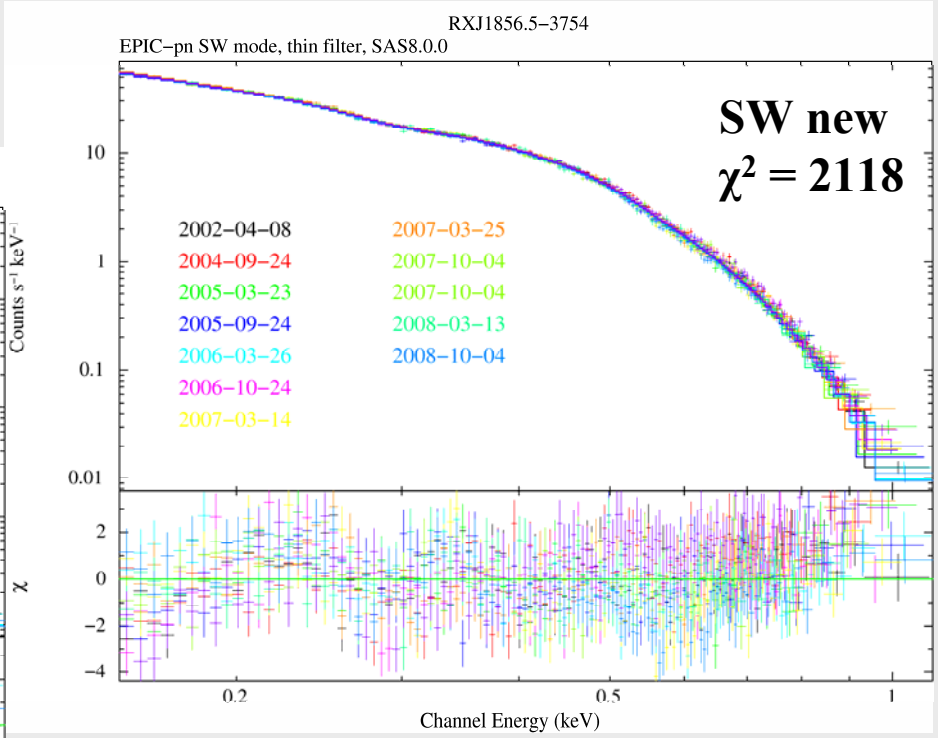
Allow break for Rev. 278:
χ^2 = 4145
Index 1.89/1.78

RX J1856.5-3754

Blackbody fits
singles
NH, kT, norm linked
free constant

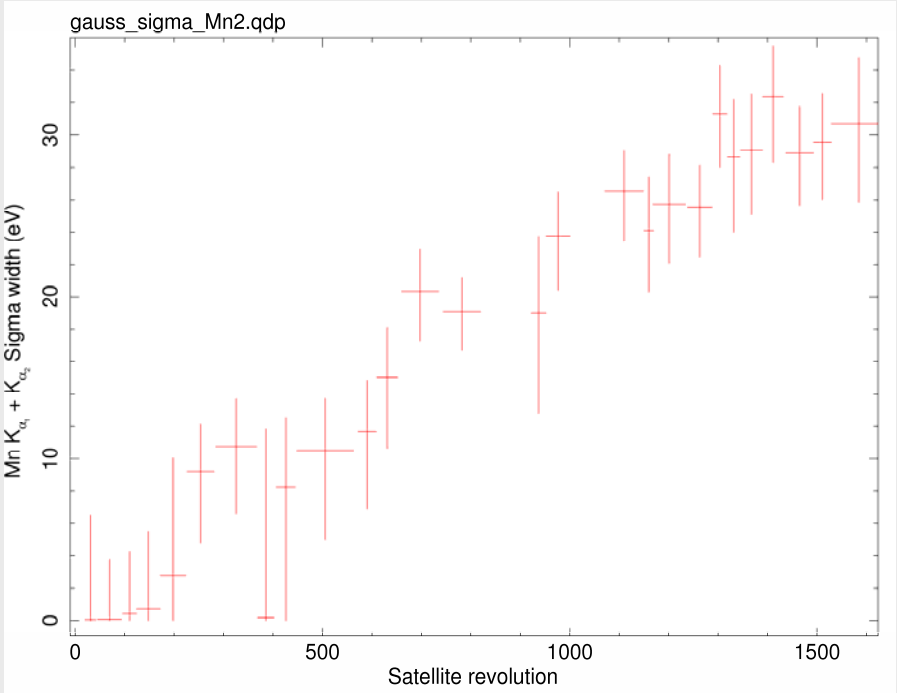


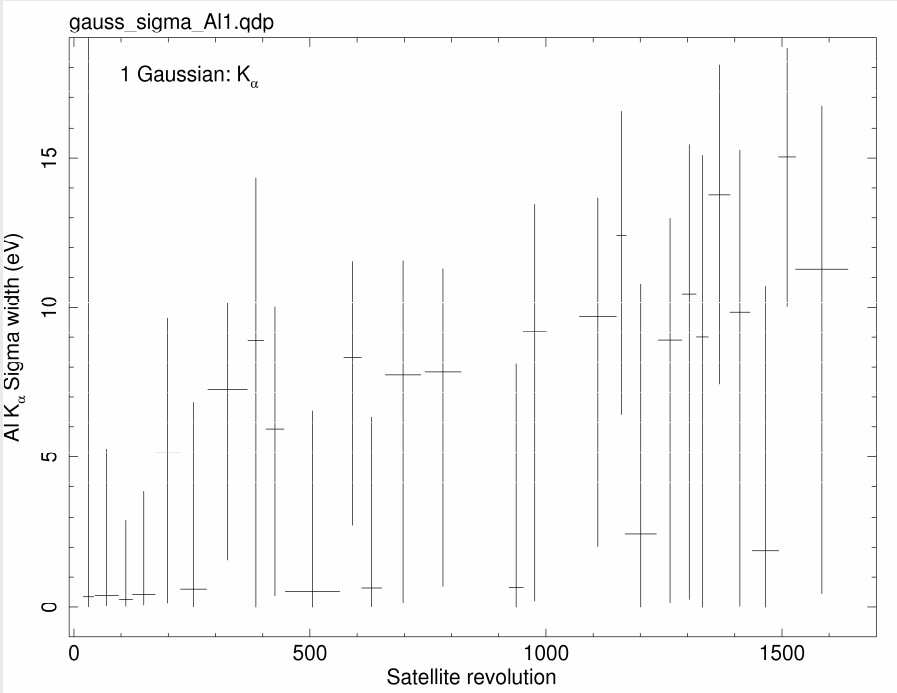
$N_H = 6.8 \times 10^{19}$
kT = 62.3 eV



$N_H = 5.2 \times 10^{19}$
kT = 61.5 eV

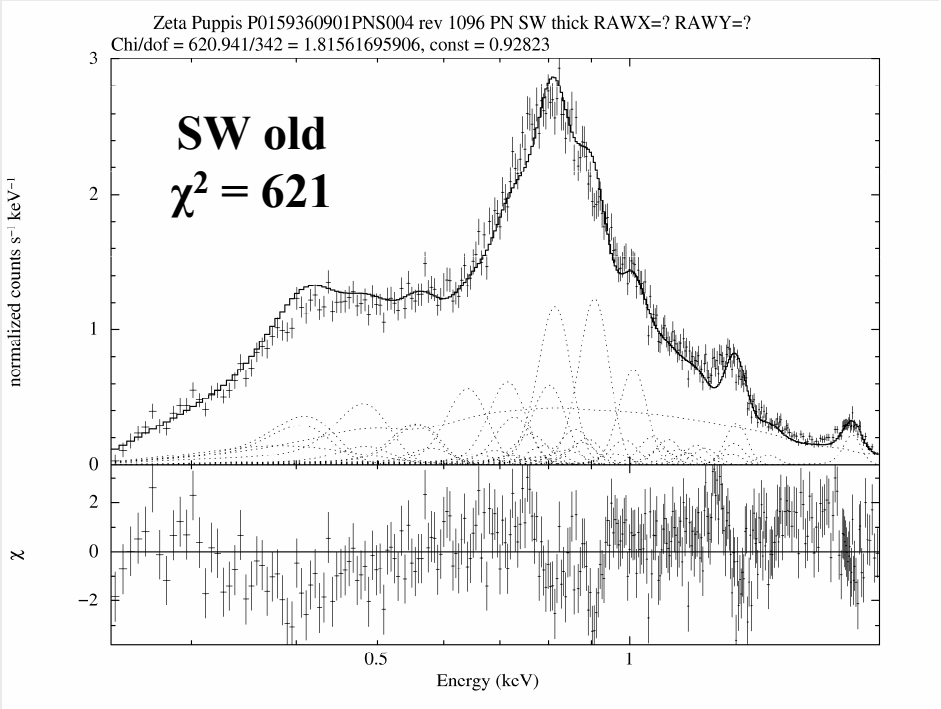
3. Problems for future work

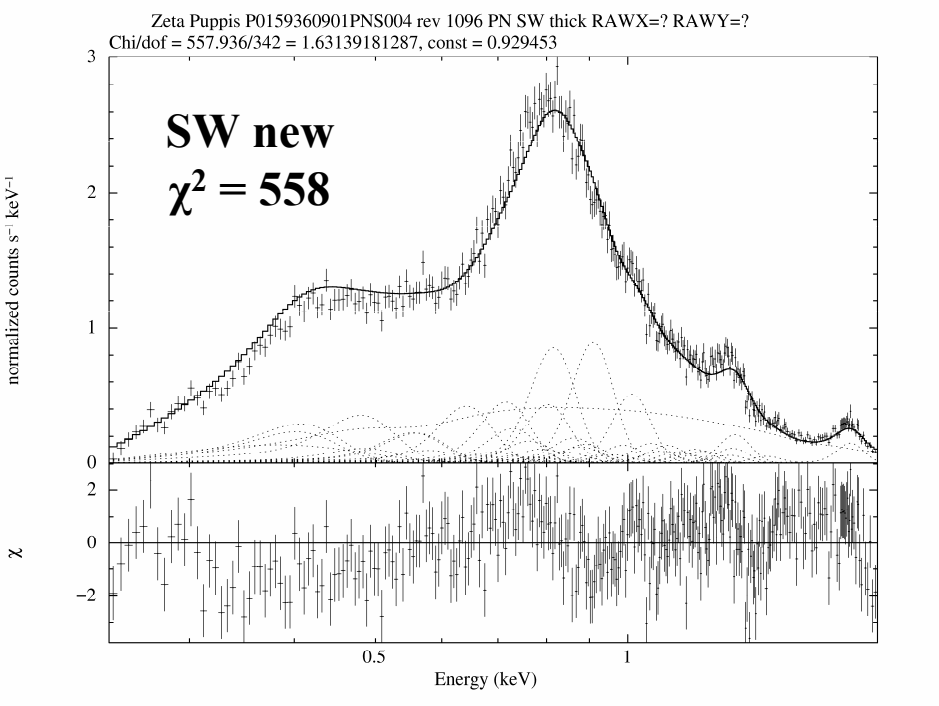




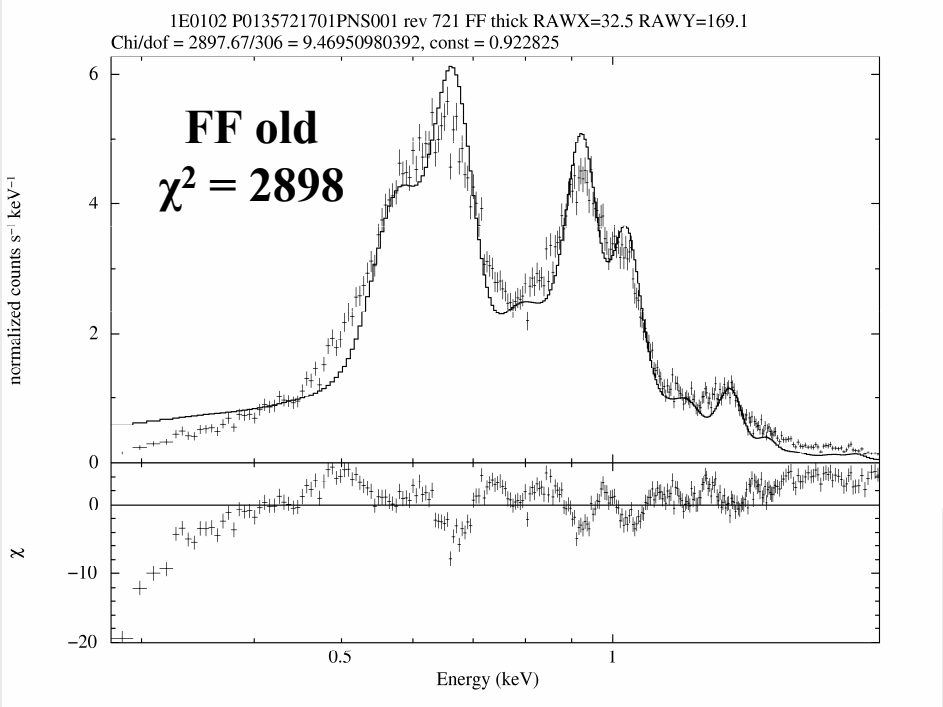
Time dependence of energy resolution
Not seen in point source spectra?
Requires time dependent CCFs or software+CCF update

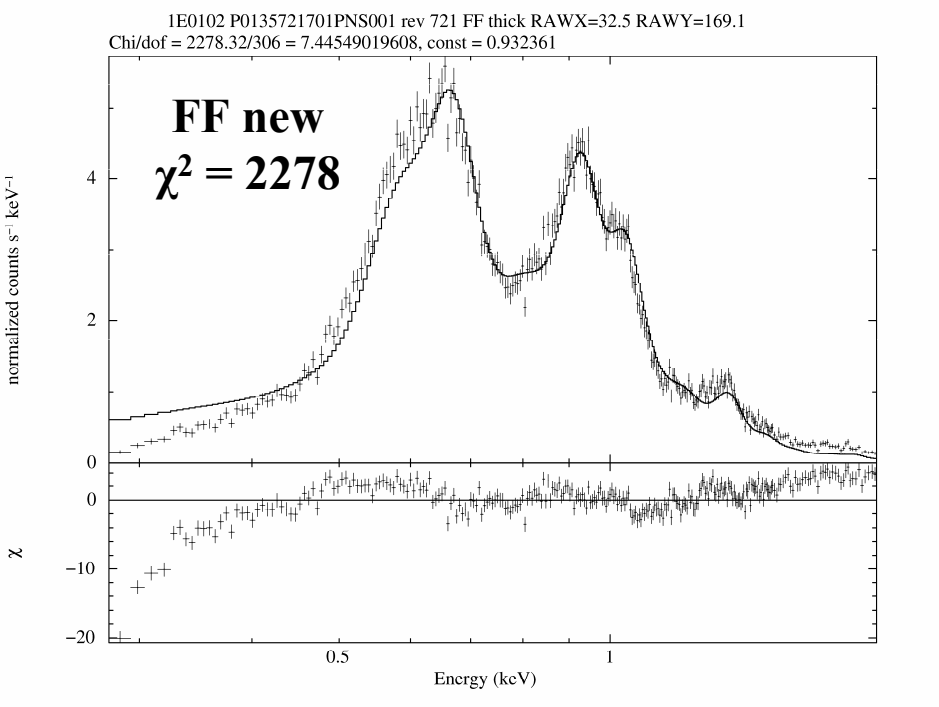
Zeta Puppis double pixel events



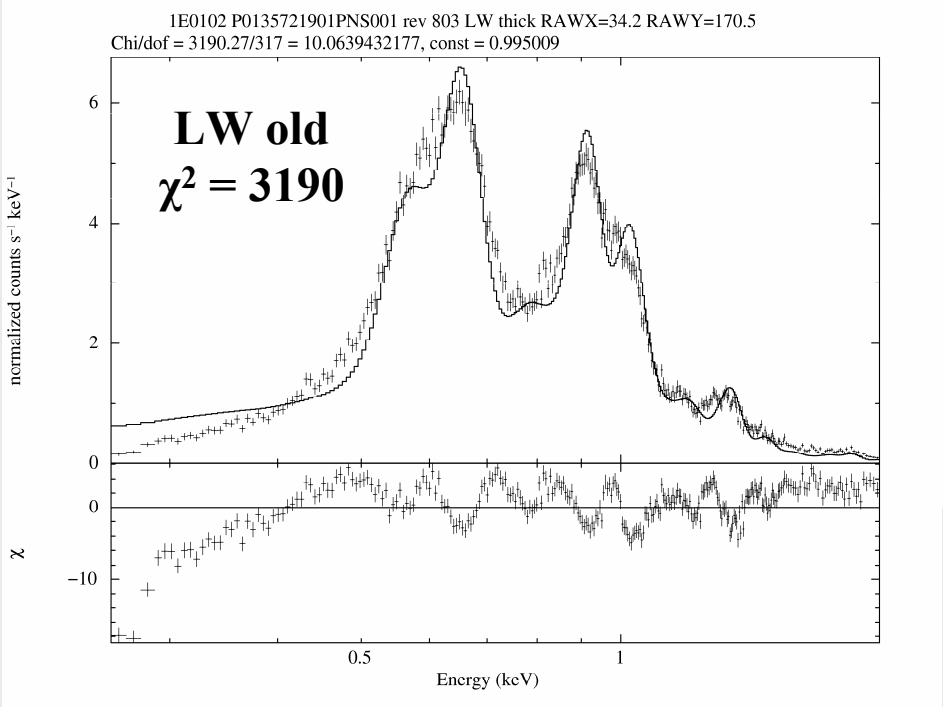


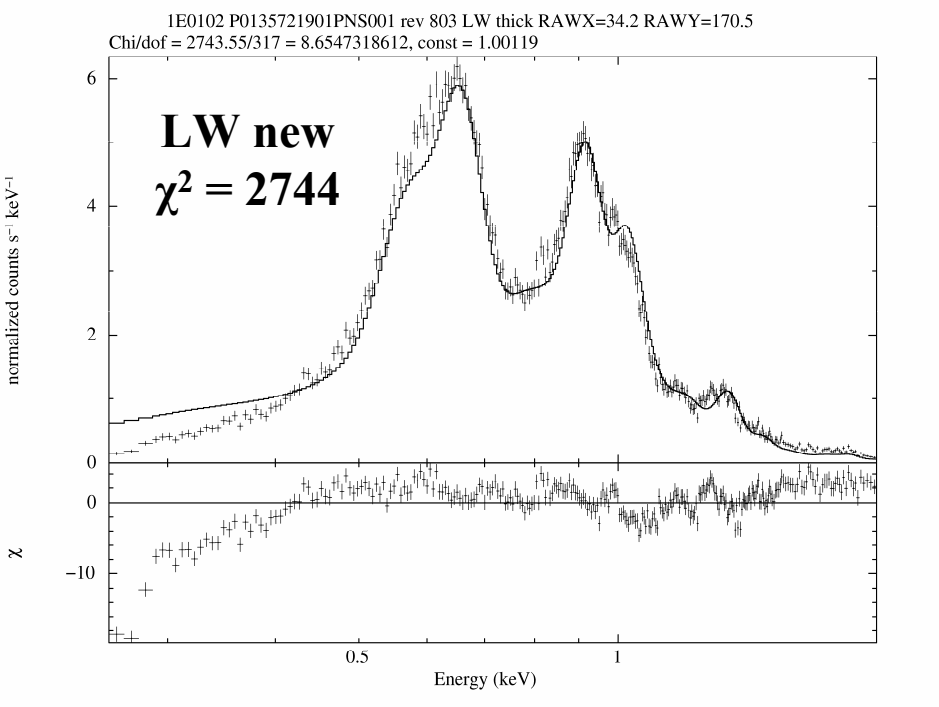
1E0102 double pixel events



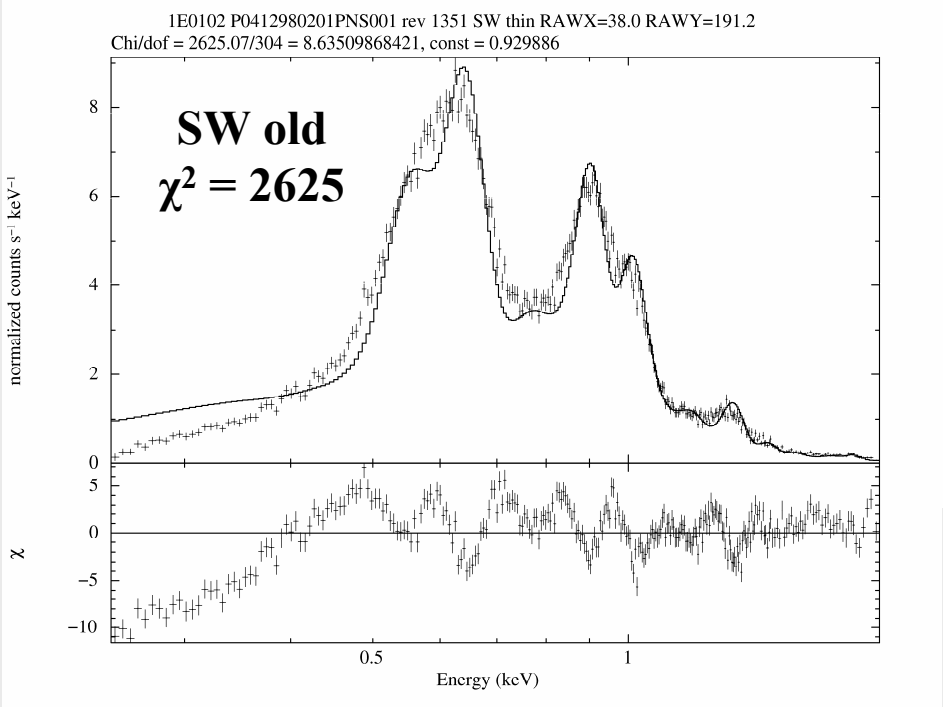


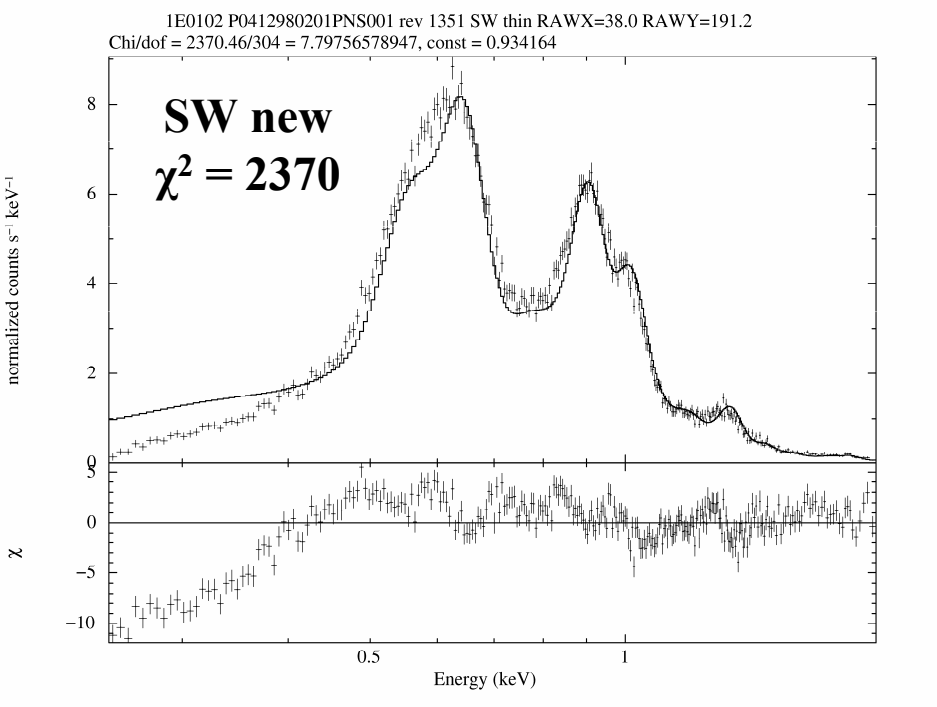
1E0102 double pixel events





1E0102 double pixel events





Different re-distribution for single/double pixel events?
Actually a threshold effect?
Needs software+CCF update