N132D model

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General features

- The model(s) are based on a concurrent analysis of the EPIC-pn and RGS spectra
  - EPIC-pn: merging of 4 observation in Large Window, source photons extracted from the ACIS region
  - RGS: spectrum extracted by AP using regions optimized to account for the N132 surface brightness
- As we want to use the model at energies >2 keV, we can't simply use the RGS spectrum to calculate the reference model

Generation process

- Fit the EPIC-pn spectrum in the 2-10 keV band
  - Continuum+Σunresolved Gaussian lines+power-law (high-energy background)
- Freeze all the parameters in #1, and fit the RGS spectrum
  - Another continuum+photoelectric absorption+Σunresolved Gaussian lines
  - We try to add full “atomic series” of lines (e.g.: OVIII, NeIX, FeXX …) rather then being simply driven by the statistics.
  - Lines are identified and their energy frozen to the value in ATOMDB (via the XSPEC `identify` command)
  - Once the lines are identified, a fit cycle is run on the whole model to determine the best-fit line width for each series. The width of each line in each series is calculated rescaling linearly with energy the width of its first line
  - This is: `N132D_E0212_v2.3_20120324_RGS.mdl`
  - <u>This model does not necessarily work well above 2 keV</u>
- Freeze the energy and the width of the Gaussian components in the RGS energy bandpass in #2. and fit the EPIC-pn spectrum again
  - This is: `N132D_E0212_v2.3_20120324_PN.mdl`
- Free the energy, the widths *and the normalizations* of the Gaussian components in the RGS energy bandpass in #2, and fit the EPIC-pn spectrum again
  - This is: `N132D_E0212_v2.3_20120324_PN_RGSLinesFrozen.mdl`

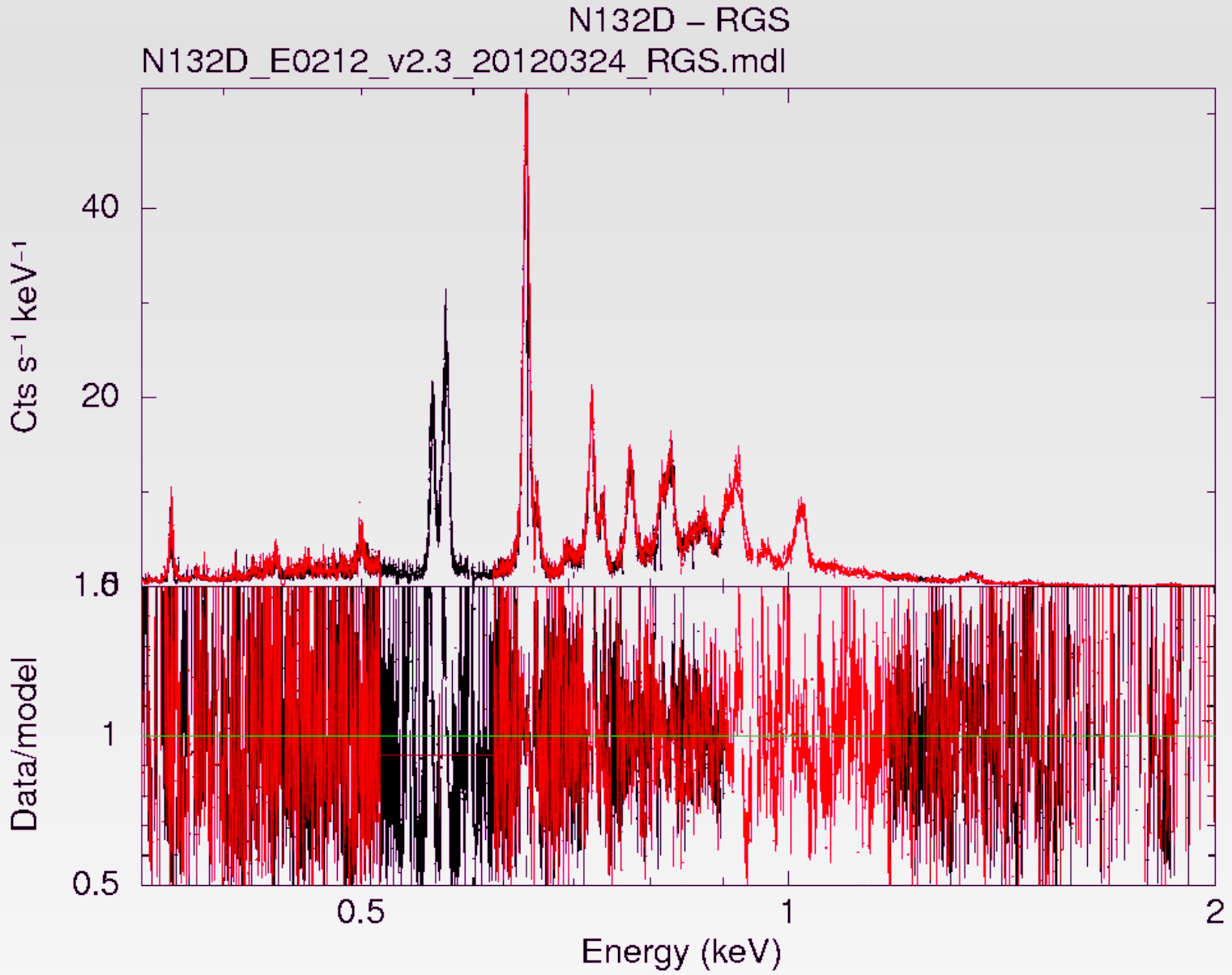
Model history

- V2.0: initial version
  - Two versions: `E210` (E>2 keV), `E0210` (full EPIC-pn energy band)
  - Thermal continuum: `brems`
  - RGS spectra extraction not optimized
  - E210 model still calculated with $\chi 2$
  - RGS residuals in the 10-12Å
- V2.1
  - Thermal continuum: `APECNoLine`
  - More RGS lines, EPIC-pn background via `CLOSED` filter esposures
  - Wrong normalization of a SiXIII line yielded huge residuals at 2.1 keV
- V2.2 (never public)
  - Optimized RGS spectrum
  - EPIC-pn also subsumed into the Cash regime
- V2.3
  - Full identification of lines (in accompanying text file), several small bugs fixed etc. etc
  - Three different flavours: `RGS`, `PN`, `PN_RGSLinesFrozen`

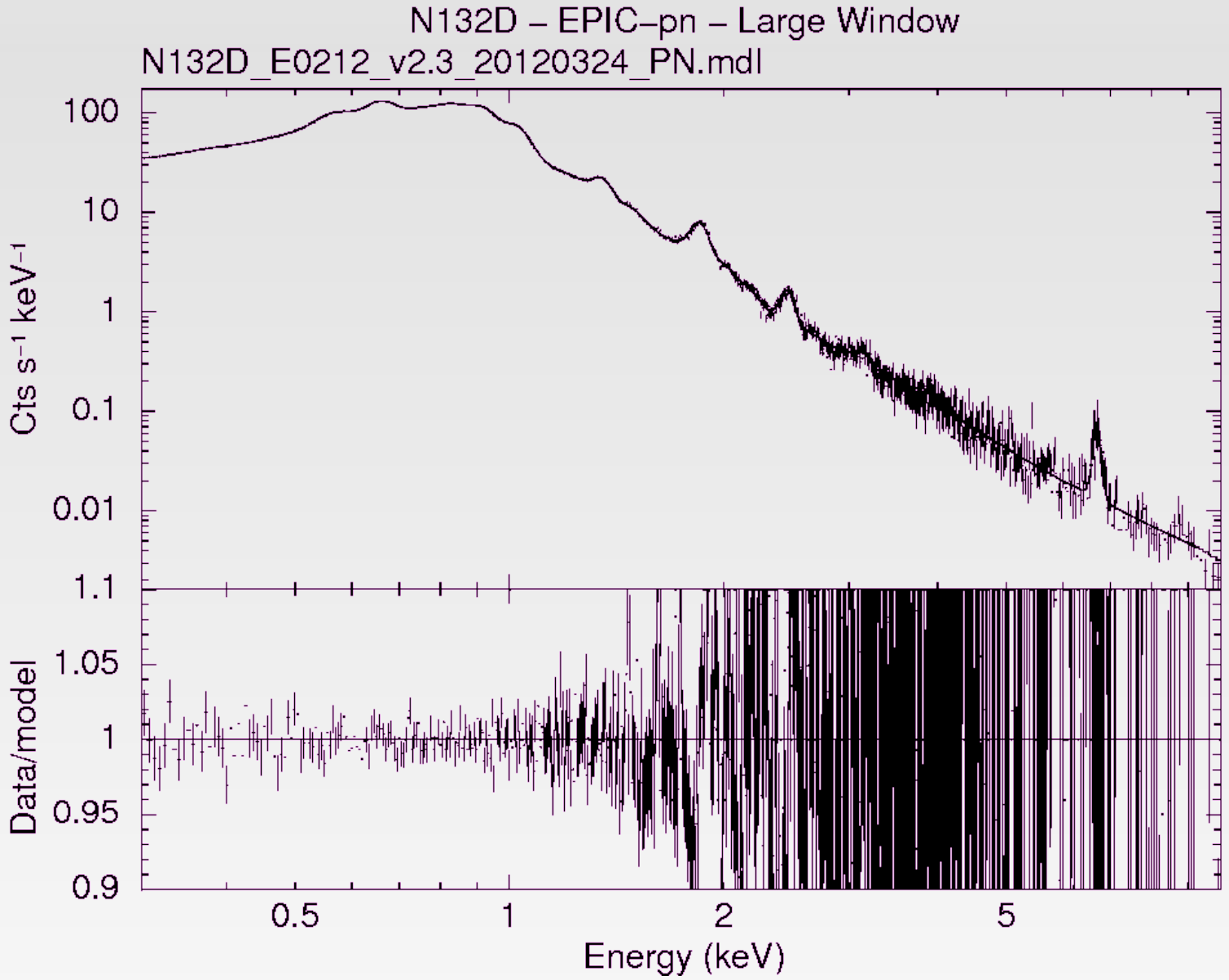
The accompanying text file

```
# What: 0.3-12 keV model of N132 XMM RGS and EPIC-pn spectrum
#
# When: Version 1.0 - 2011 April 30
#       Version 2.0 - 2012 January 18
#       Version 2.1 - 2012 February 17
#       Version 2.3 - 2012 March 25
#
# Who: Matteo Guainazzi, Martin Stuhlinger, Andy Pollock (ESAC-ESA)
#
# How: 1. Fit of the merged EPIC-pn spectrum of the following Obs.# 0129340801, Obs.#0210681401, Obs.#0210682801
#         (Large Window, MEDIUM Filter)
#            Source region: Chandra-ACIS
#            Background subtraction: CLOSED background spectrum (from the same region as the source) + phenomenological
#             power-law for the sky background
#            Spectral handling: no rebinning
#            Statistics: Cash
#
#      2. Fit of 1st RGS observation with ObsID 0125100201 before analysis of sample of 32
#            Selection regions in cross-dispersion arcminute units centred on J2000 RA,DEC = 81.263750,-69.640944
#            Source [-1.50,+1.50]
#            Background [-2.58,-2.00,+2.00,+2.58]
#            Spectral handling: No rebinning
#            Statistics: Cash
#
   1    1   TBabs      nH         10^22    7.34041E-02  +/-  4.49276E-03
   2    2   apec       kT         keV      0.311499     +/-  1.20825E-02
   3    2   apec       Abundanc            1.00000      frozen
   4    2   apec       Redshift            0.0          frozen
   5    2   apec       norm                8.43663E-02  +/-  4.47737E-03
#
# CV 7 1
#
   6    3   gaussian   LineE      keV      0.307902     frozen
   7    3   gaussian   Sigma      keV      8.50548E-04  frozen
   8    3   gaussian   norm                1.58632E-22  +/-  -1.00000
```

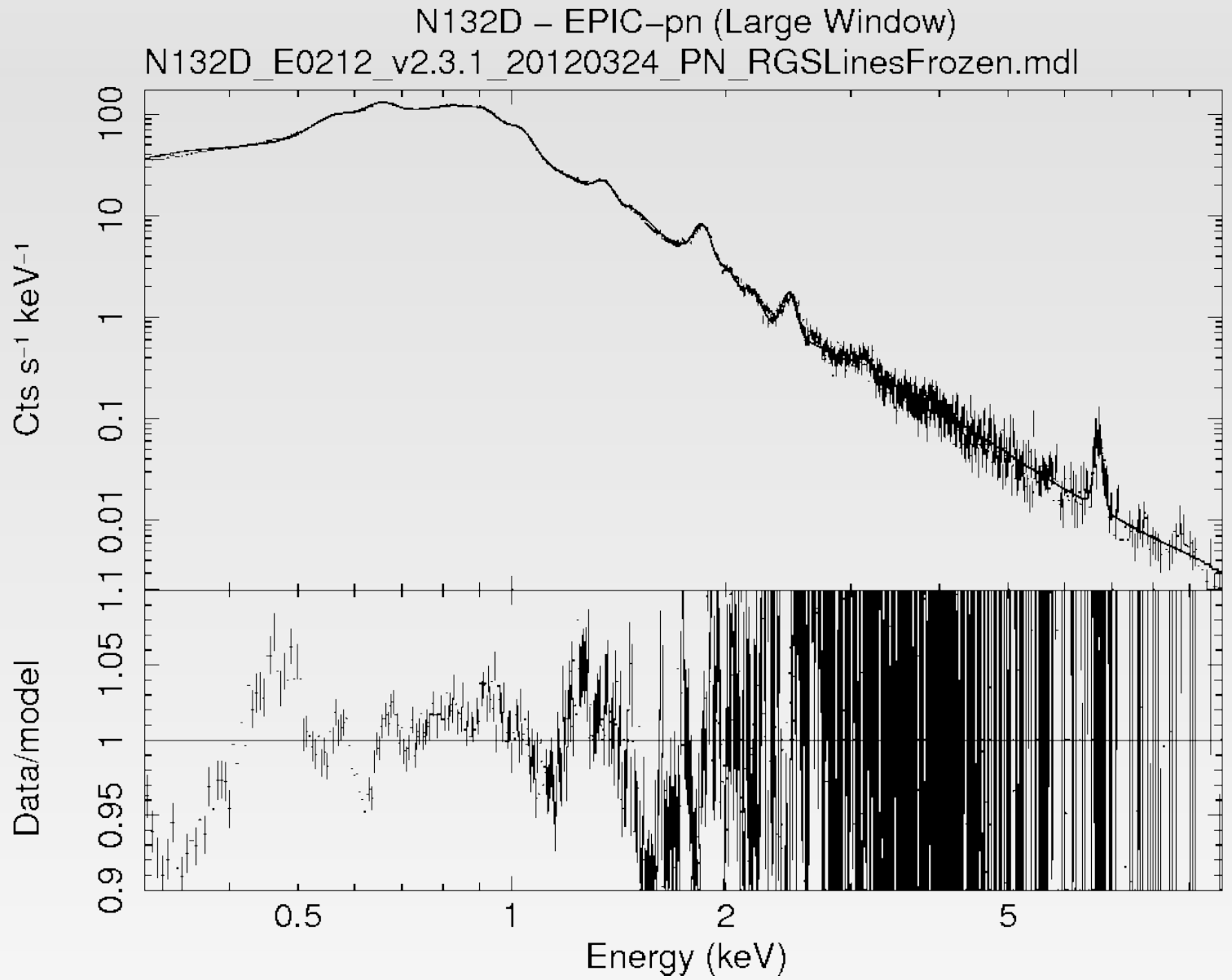
Application of the RGS flavour to the RGS



Application of the PN flavour to the EPIC-pn



Application of the `PN_RGSLinesFrozen` flavour to the EPIC-pn



How to use it?

- Currently:
  - Energies are frozen to the laboratory values
  - Widths are fixed to the
    - RGS best-fit value (between 0.2-2 keV)
    - 0 (above 2 keV)
  - All the line normalizations are free (clearly an overkill), except in the `PN_RGSLinesFrozen` flavour
  - Column density (`Tbabs`) is free
  - Temperatures and normalizations of the thermal components (`APECNoLine`) are free
  - The spectral index of a phenomenological power-law to fit the hard X-ray background is fixed to 0 – normalization free

Challenges and opportunities

- The soft X-ray spectrum in N132D does not exhibit the system of isolated prominent lines which makes the analysis of 1E0201-72 so fruitful
  - It is questionable whether we can follow the same data analysis approach
- The hard X-ray spectrum of N132D is the only benchmark we have currently in the IACHEC on emission line normalizations above 2 keV