RGS Calibration Status

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on behalf of the SRON and ESAC RGS Teams

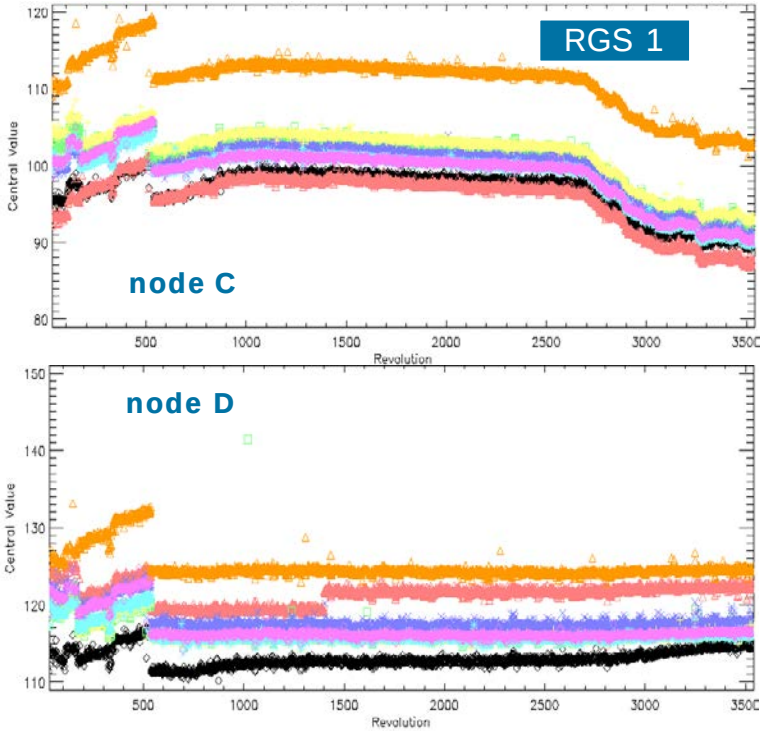
Outline

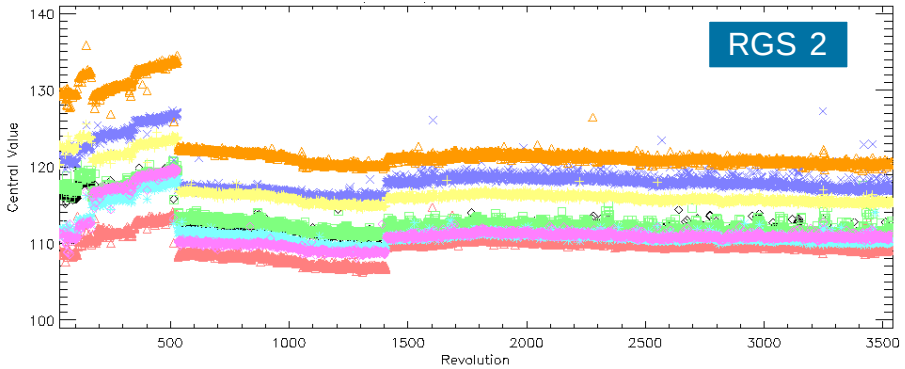
- **Instrument Status**
  - Operations
  - System Peak
  - CTE
  - Bad Surface
- **Calibration**
  - Wavelength Scale
  - Contamination
  - Effective Area
    - RGS1 vs RGS2
    - RGS vs EPIC-pn

Instrument Status -> Operations

- ✓ RGS operations are running smoothly
- ✓ No changes in operational configuration
- ✓ No anomalies

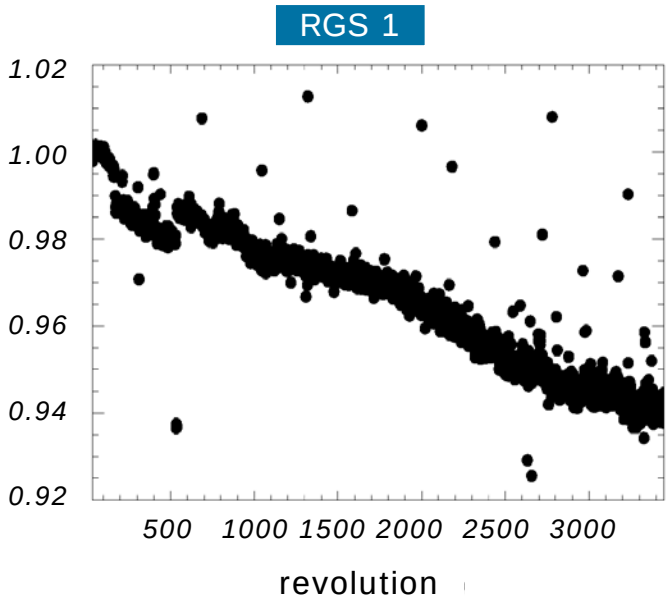
Instrument Status -> System Peak (data free from X-ray events)

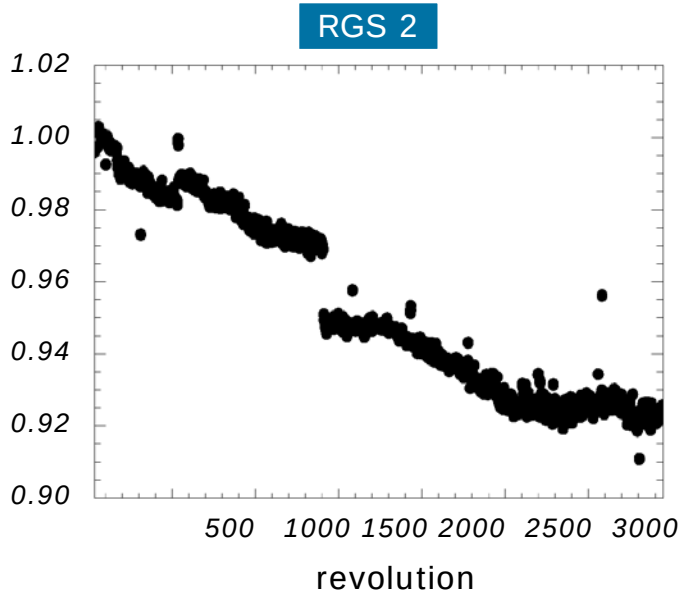




CCF	RGS1_ADUCONV_0029 (C. Gabriel & A. Ibarra)
Release Note	365
Purpose	Updated RGS1 offset
Date	March 2019

Instrument Status -> Charge Transfer Efficiency

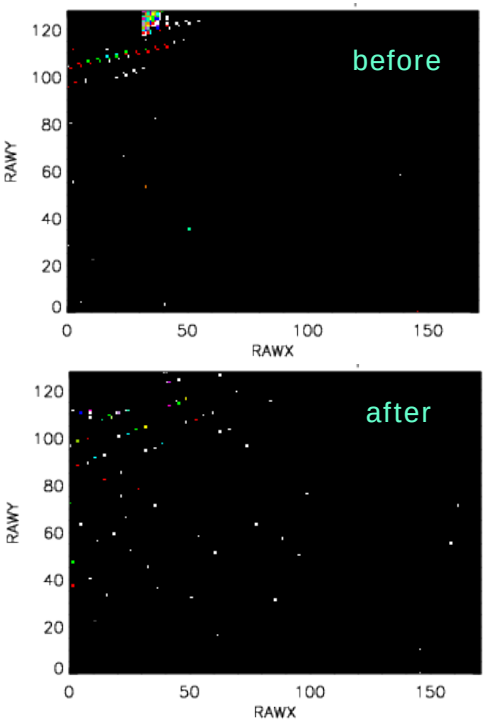




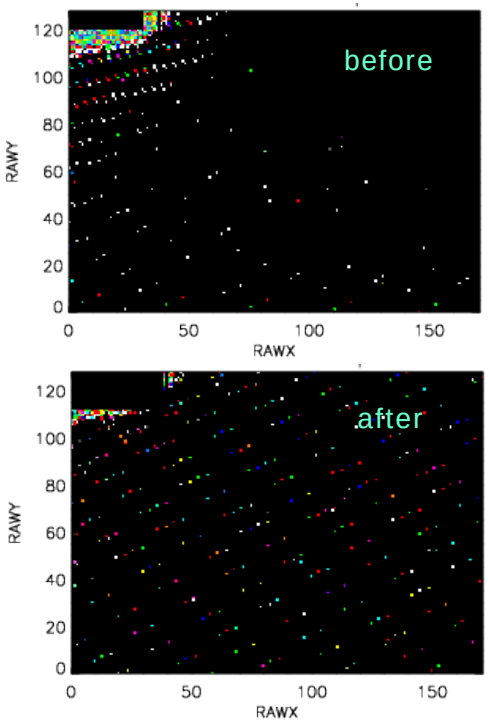
C. de Vries

Instrument Status -> Bad Surface

node C



node D



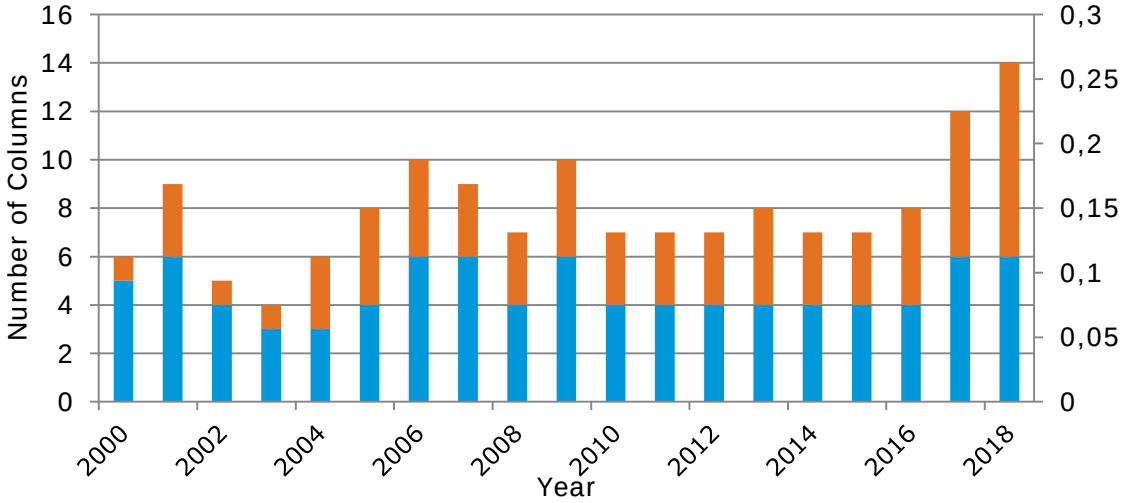
RGS1 CCD1:
Enlarged regions masked on-board
(as of 15/03/2019)

16 pix x 39 cols

CCF	**RGS1_BADPIX_0038 (C. Gabriel & R. Pérez)**
Release Note	**370**
Purpose	**Uploaded Hot Stuff**
Date	**March 2019**

Instrument Status -> Bad Surface

Columns found hot in more than 95% of the observations

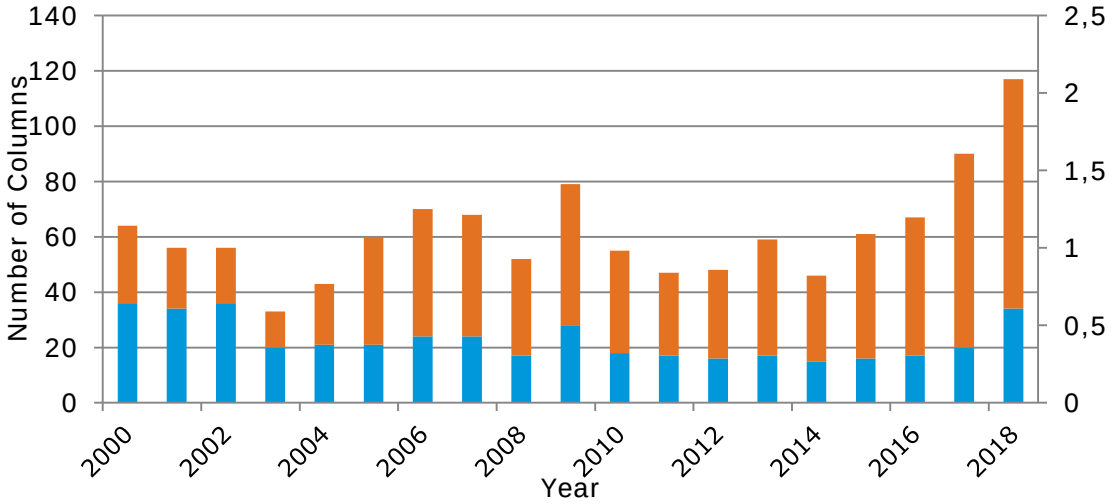


< 0.3 % of detector surface

XMM-SOC-CAL-TN-0221
C.Gabriel & R. Pérez

Instrument Status -> Bad Surface

Columns found hot in more than 25% of the observations



< 2.5% of detector surface

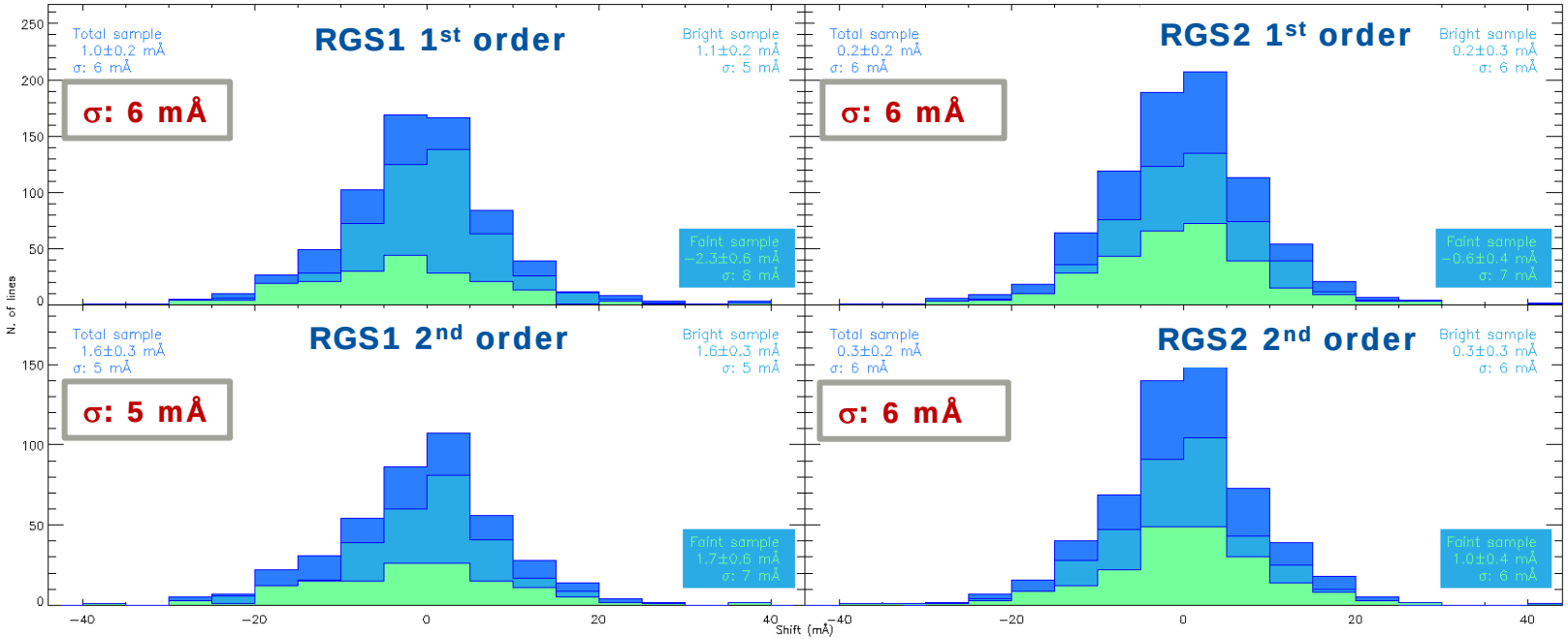
XMM-SOC-CAL-TN-0221
C.Gabriel & R. Pérez

Calibration -> Wavelength Scale

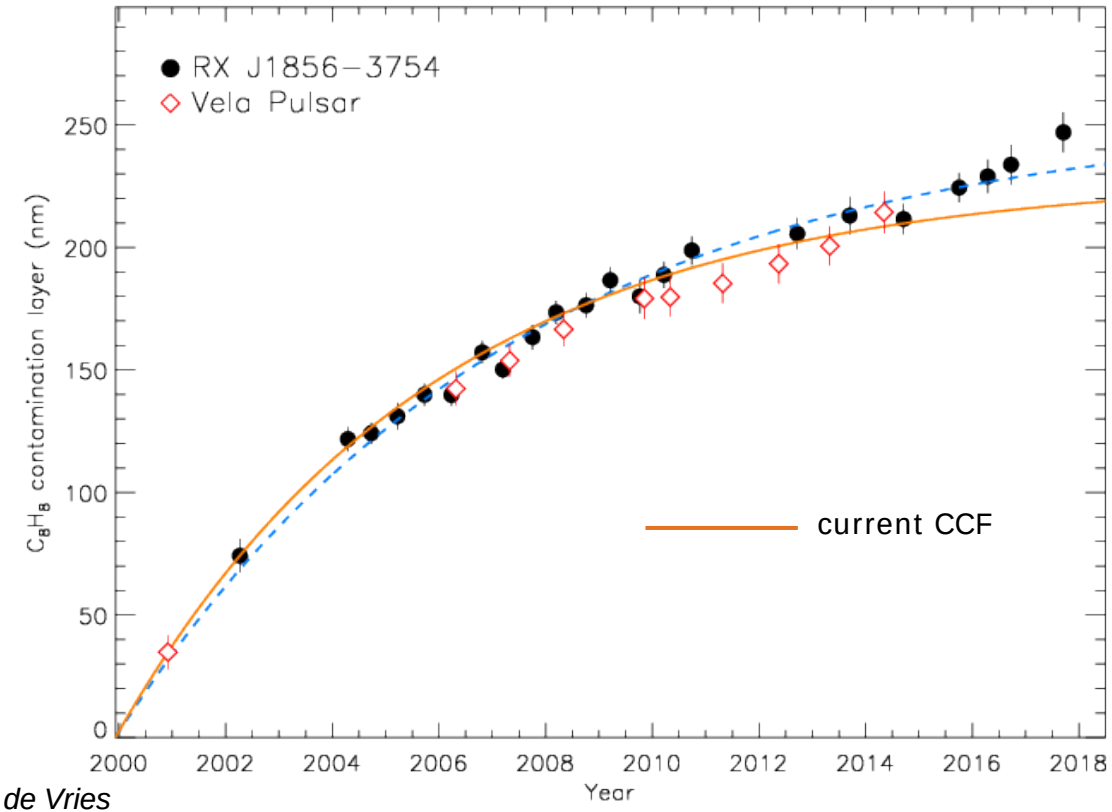
Bright sample: AB Dor, Capella, HR 1099 and Procyon

Faint sample: fainter emission line stars

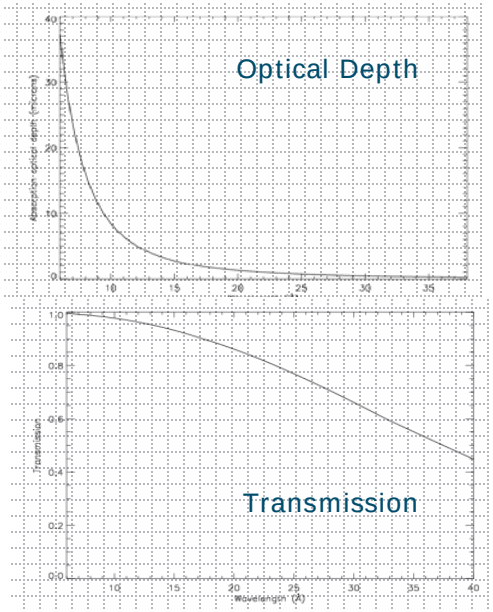
Sun Aspect Angle and Heliocentric corrections applied
Most recent XMM BORESIGHT (#29)



Calibration -> Contamination



Thickness of layer ∝ flux @35Å



Indications of increasing contamination?

C. de Vries

Calibration -> Effective Area -> RGS1 vs RGS2

Correction implemented since SASv16

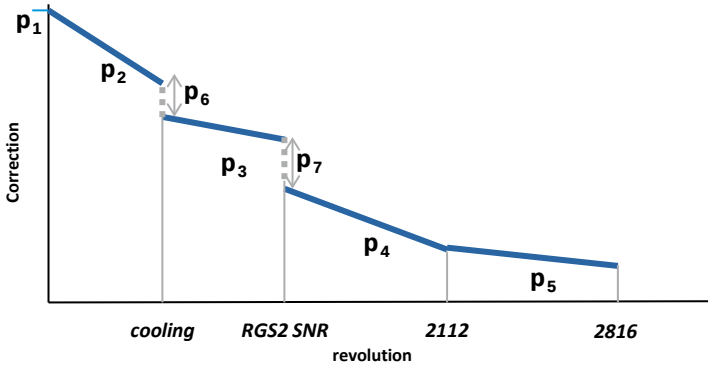
$t = \frac{rev}{1000}$

P_1 correction at t=0

$P_2 - P_5$ slopes

P_6 discontinuity at cooling

P_7 discontinuinity at change to RGS2 SNR Mode



J. Kaastra, C. de Vries & J.W. den Herder, 2017

For each 0.05 Å bin:

$t < 0.538$ $\quad P_1 + \left(\frac{t}{0.538}\right) P_2$

$0.538 \leq t < 1.408$ $\quad P_1 + P_2 + P_6 + \left(\frac{t - 0.538}{0.870}\right) P_3$

$1.408 \leq t < 2.112$ $\quad P_1 + P_2 + P_3 + P_6 + P_7 + \left(\frac{t - 1.408}{0.704}\right) P_4$

$2.112 \leq t < 2.816$ $\quad P_1 + P_2 + P_3 + P_4 + P_6 + P_7 + \left(\frac{t - 2.112}{0.704}\right) P_5$

$t > 2.816$ $\quad P_1 + P_2 + P_3 + P_4 + P_5 + P_6 + P_7$

+narrow gaussians at specific wavelengths

Calibration -> Effective Area -> RGS1 vs RGS2

Updated with improved algorithm and extended time range

CCF to be released soon

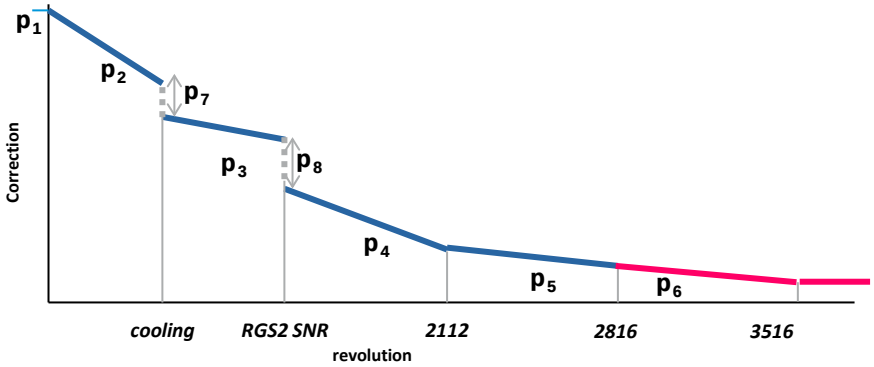
$$t = \frac{rev}{1000}$$

P_1 correction at t=0

$P_2 - P6$ slopes

P_7 discontinuity at cooling

P_8 discontinuinity at change to RGS2 SNR Mode



For each 0.05 Å bin:

t<0.538 $P_1 + \left(\frac{t}{0.538}\right) P_2$

0.538 ≤t<1.408 $P_1 + P_2 + P_6 + \left(\frac{t - 0.538}{0.870}\right) P_3$

1.408 ≤ t< 2.112 $P_1 + P_2 + P_3 + P_7 + P_8 + \left(\frac{t - 1.408}{0.704}\right) P_4$

2.112≤t<2.816 $P_1 + P_2 + P_3 + P_4 + P_7 + P_8 + \left(\frac{t - 2.112}{0.704}\right) P_5$

2.816≤t<3.516 $P_1 + P_2 + P_3 + P_4 + P_5 + P_7 + P_8 + \left(\frac{t - 2.816}{0.700}\right) P_6$

+narrow gaussians at specific wavelengths

J. Kaastra, C. de Vries & J.W. den Herder, 2019

Calibration -> Effective Area -> Changes

Evidences for decrease in effective area

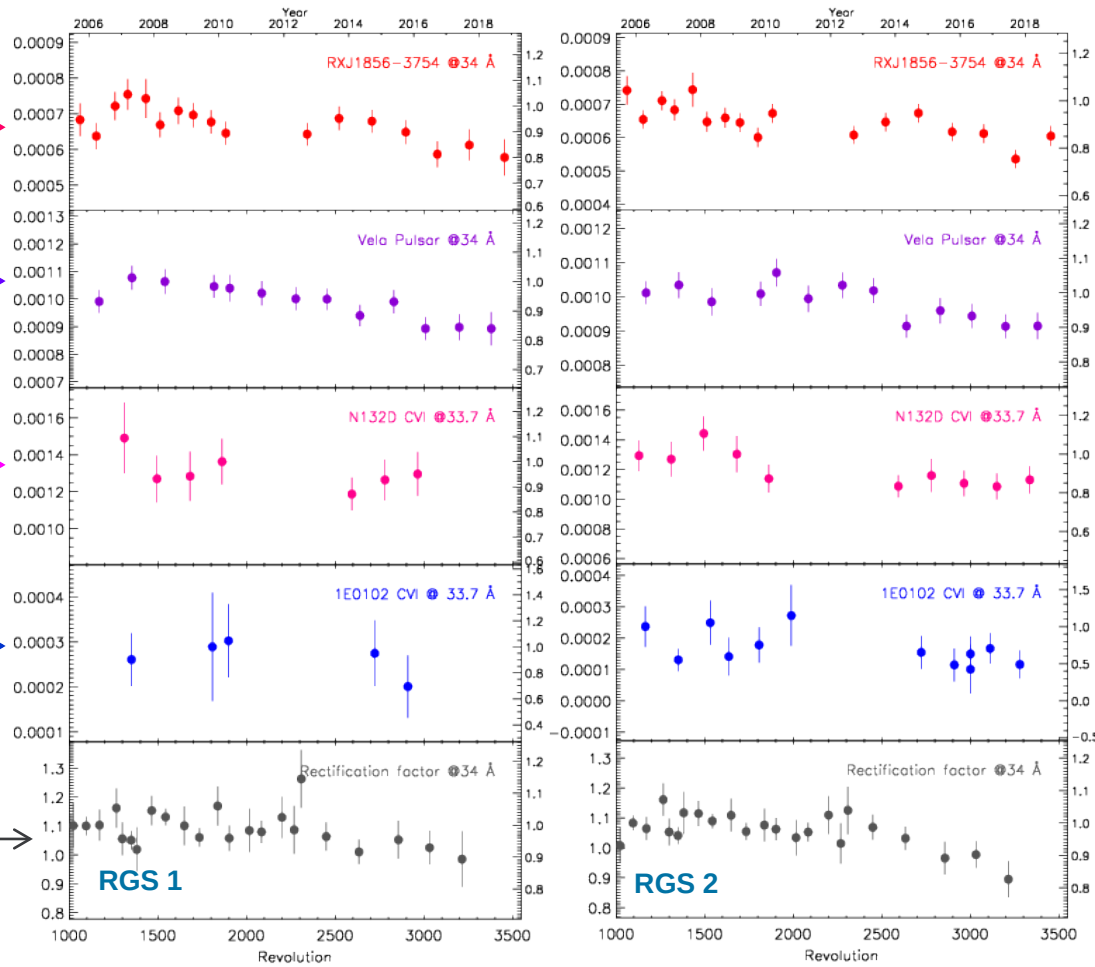
- Flux decrease observed in

  ISN RXJ1856-3754

  Vela Pulsar

  Emission lines in compact SNRs
  N132D
  1E0102

- Decrease of the ratio of fluxes RGS/EPIC-pn (aka “Rectification Factors”)



Calibration -> Effective Area -> Changes

Possible instrumental causes

- Increase in the thickness of the C_8H_8 contamination layer

X very different wavelength dependence

- Increase in the thickness of the O layer

X would require an increase of 300 nm

- Mismatch in the PI selection regions

X would imply an unrealistic error in gain

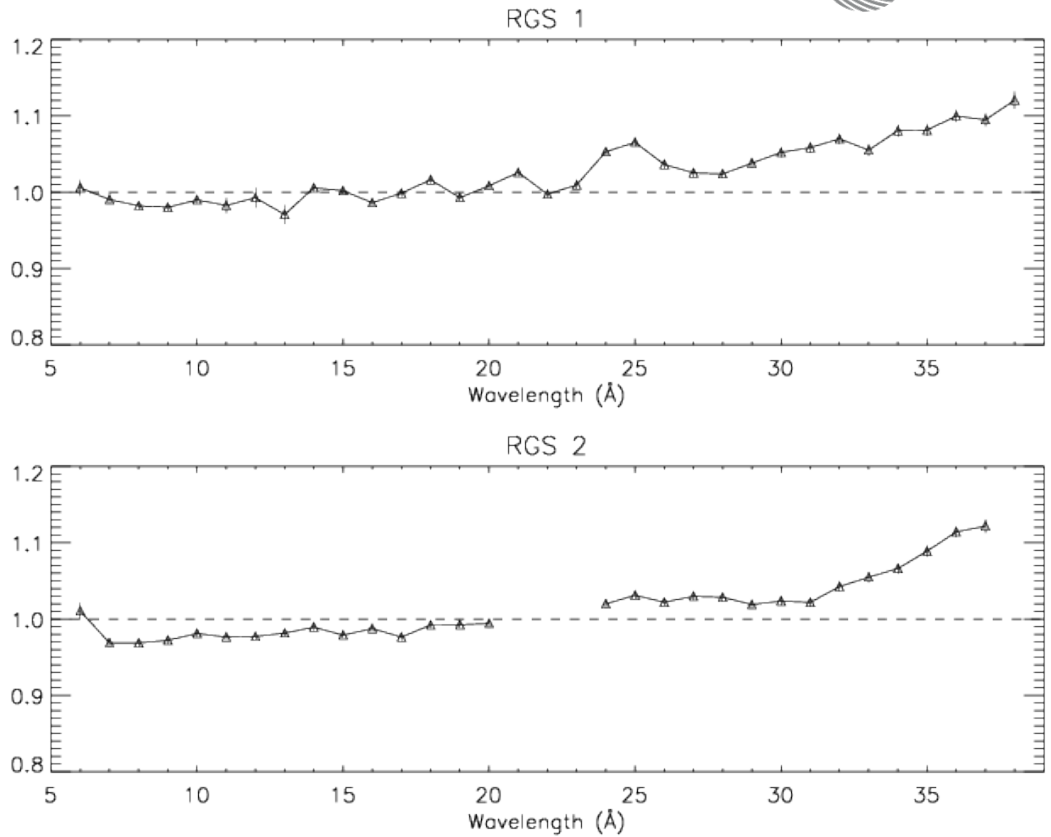
?

-> Empirical Correction

Calibration-> Effective Area -> Rectification Factors

Rectification Factors [RF]

- Ratio of fluxes RGS[12] / EPIC-pn in steps of 1Å
- First implemented December 2010; single epoch
- Updated in 2015 to take into account new improvements in EPIC-pn and RGS calibrations, and with optimised EPIC-pn extraction regions.
- Data used: Observations of PKS2155 and 3C 273, EPIC-pn in Small Window Mode + Thin or Medium filters

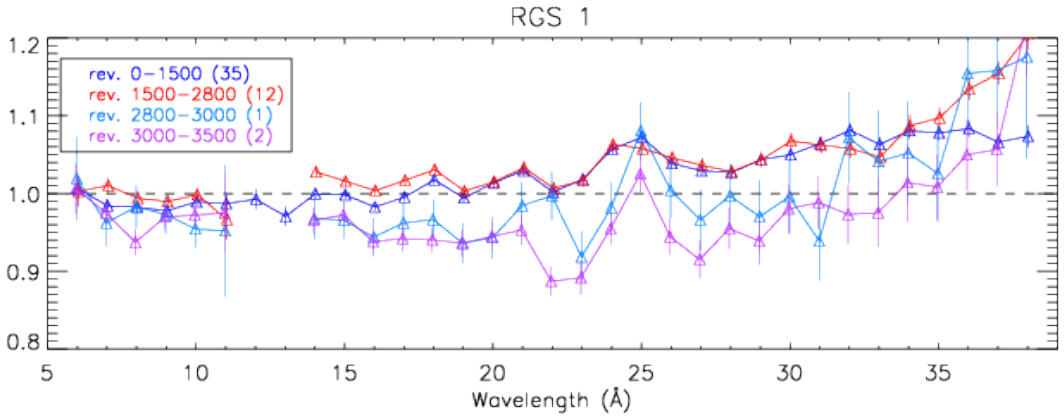


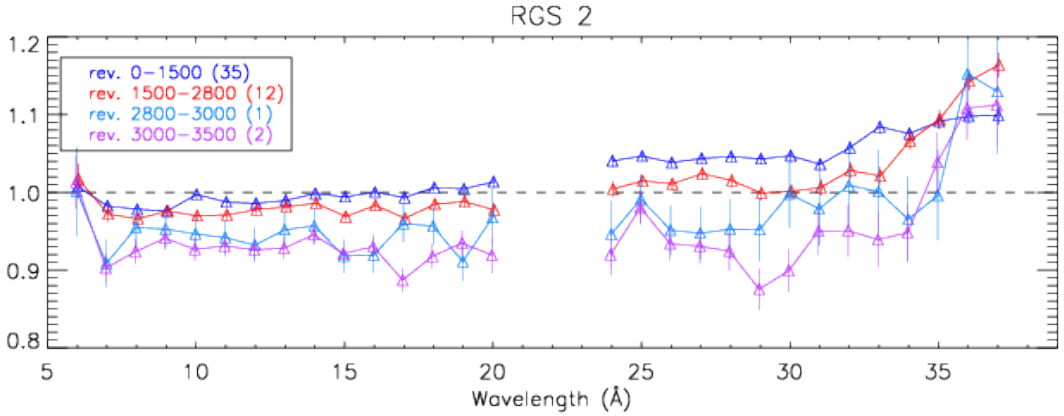
Calibration -> Effective Area

-> Time dependent Rectification Factors

Time Dependent Rectification Factors [TdRF]

- Averages in periods of time
- There is a general decrease at all the wavelengths



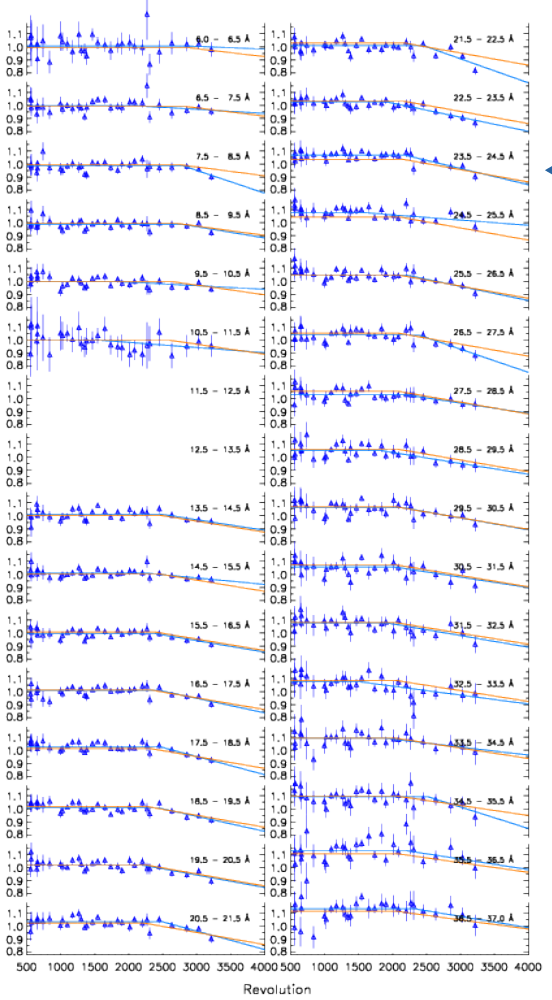


years
2000-2007
2008-2014
2015-2016
2017-2019

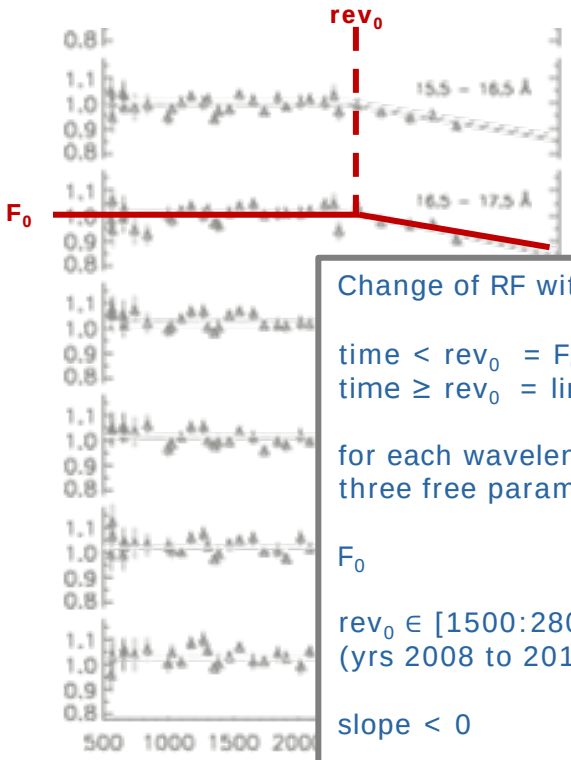
Calibration -> Effective Area ->TdRF

Rectification Factors

Individual points in bins of 1Å



Calibration -> Effective Area ->TdRF



Change of RF with time modelled as:

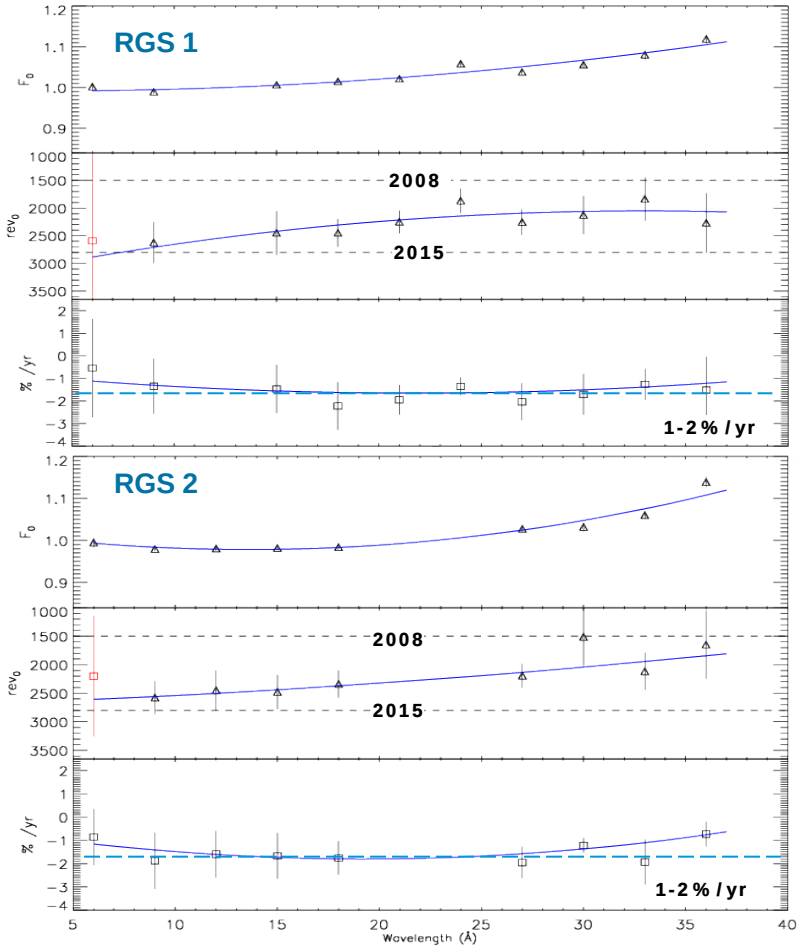
time < rev_0 = F_0
time ≥ rev_0 = linearly decreasing

for each wavelength bin, fit with three free parameters:

F_0

$rev_0 \in [1500:2800]$
(yrs 2008 to 2015)

slope < 0

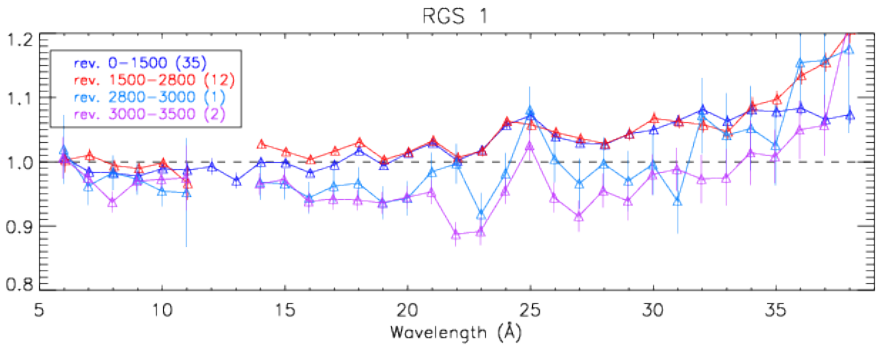


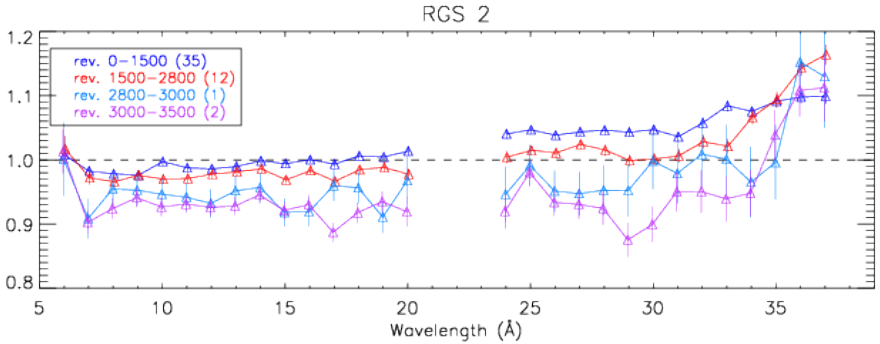
Calibration -> Effective Area -> TdRF

consistency check: BL Lac sample

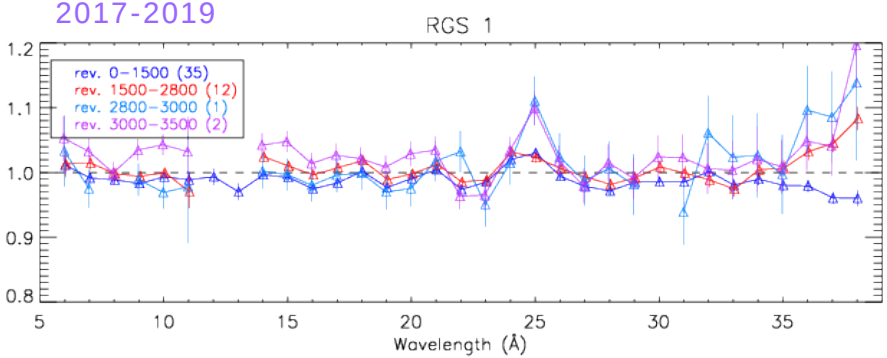
years
2000-2007
2008-2014
2015-2016
2017-2019

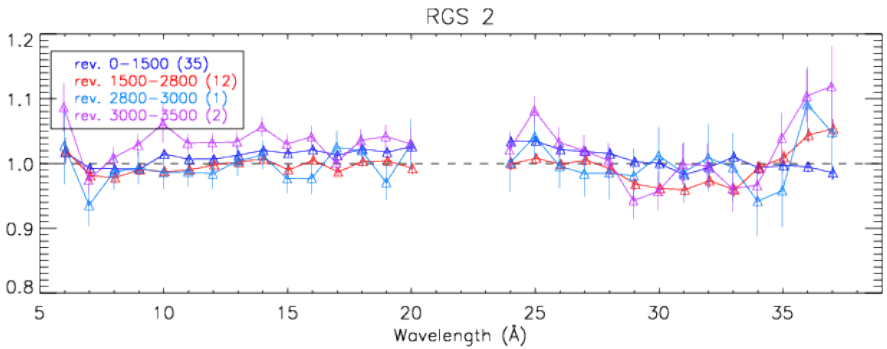
before correction





after correction



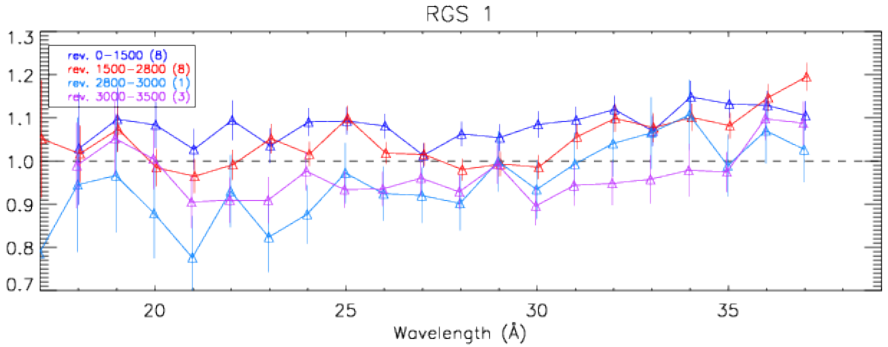


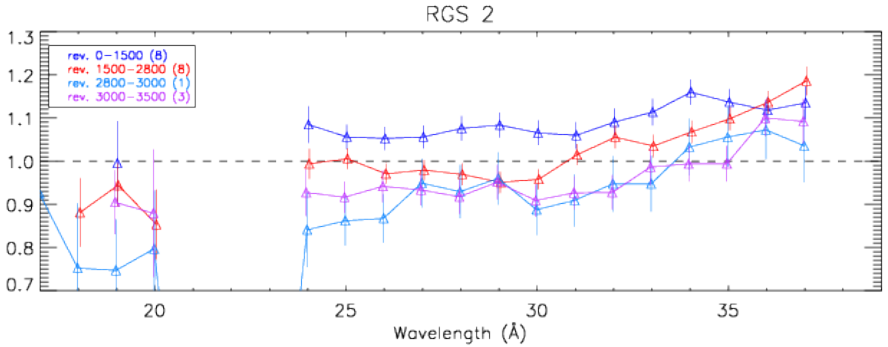
Calibration -> Effective Area -> TdRF

RX J1856-3754

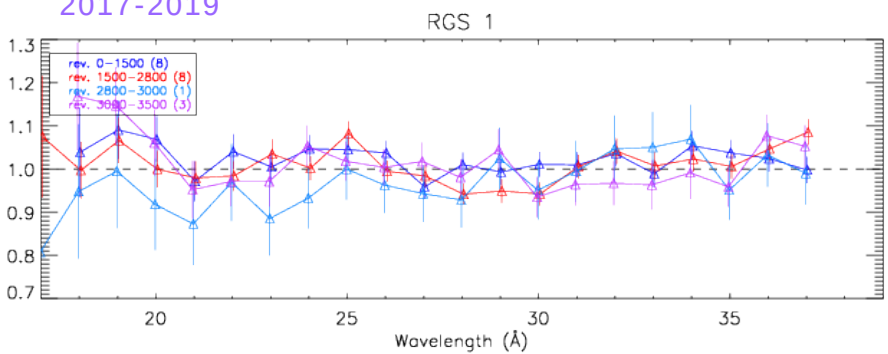
years
2000-2007
2008-2014
2015-2016
2017-2019

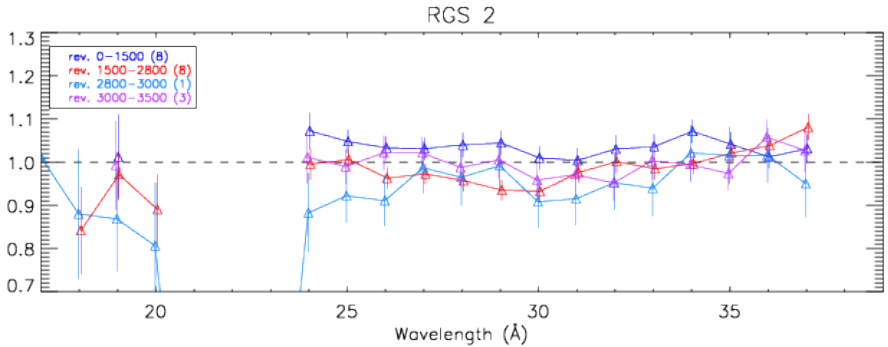
before correction





after correction



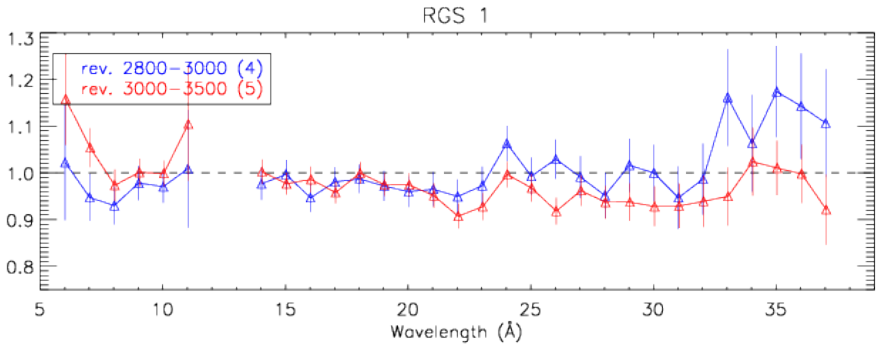


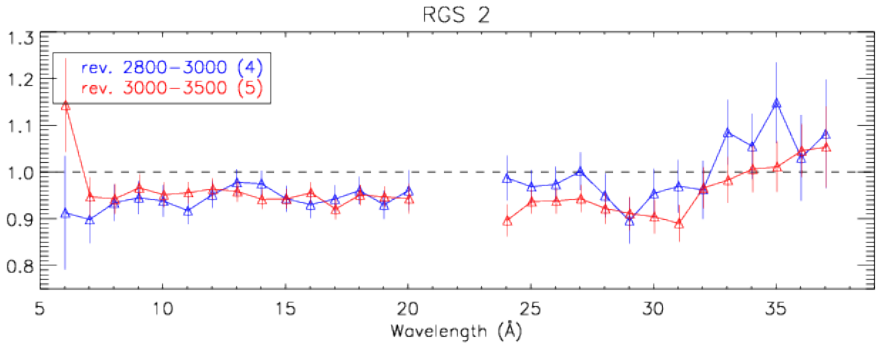
Calibration -> Effective Area -> TdRF

1ES1553+11.3

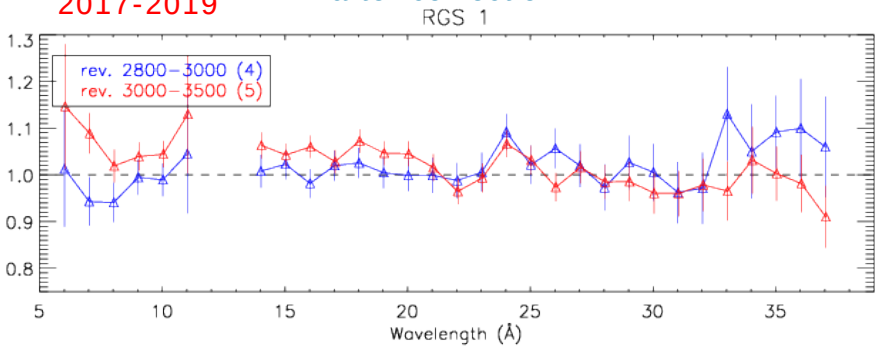
years
2015-2016
2017-2019

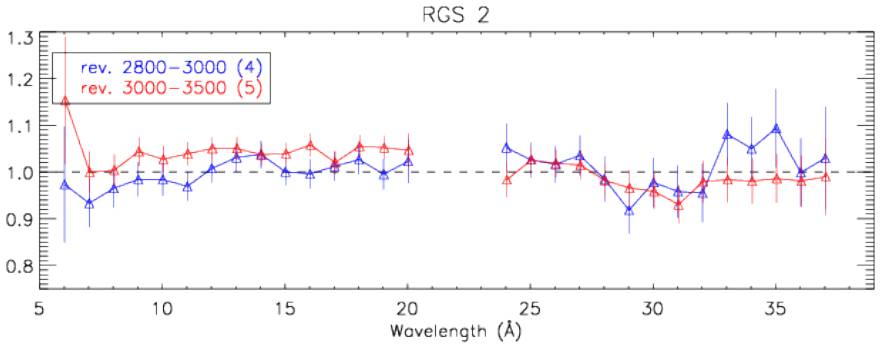
before correction





after correction





Calibration -> Effective Area -> Summary

- Updated RGS1 vs RGS2 Correction

- Time dependent Rectification Factors -> First version derived and tested

- Both corrections have been derived in parallel. A new version of the Time dependent Rectification Factors will be derived taking into account the updated RGS1 vs RGS2 correction
  - issue new effective area correction (RGS1 vs. RGS2) CCF **-> July 2019**
  - apply this correction to the BL Lac sample
  - re-derive the Time dependent Rectification Factors
  - apply both corrections to test datasets to evaluate its performance
  - issue CCF with TdRF **-> October 2019**

Summary and Conclusions

- ✓ RGS operations are running smoothly
- ✓ Wavelength scale is stable. Accuracy is ≈ 6 mÅ
- ✓ Reasons for the observed decrease in Effective Area are not understood yet
- ✓ Work in progress to derive and implement suitable corrections to take into account the change in Effective Area