ISGRI ENERGY CALIBRATION

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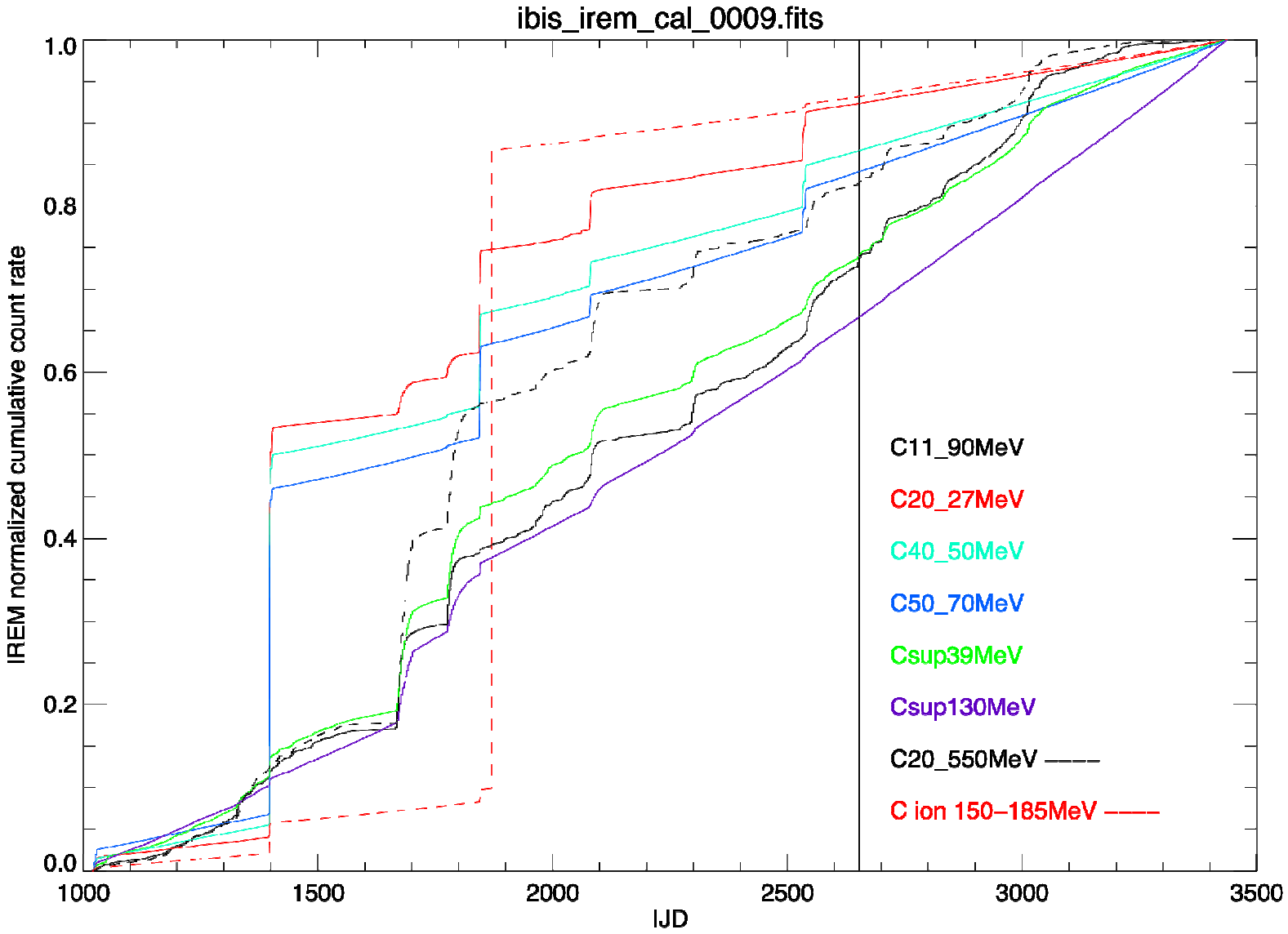
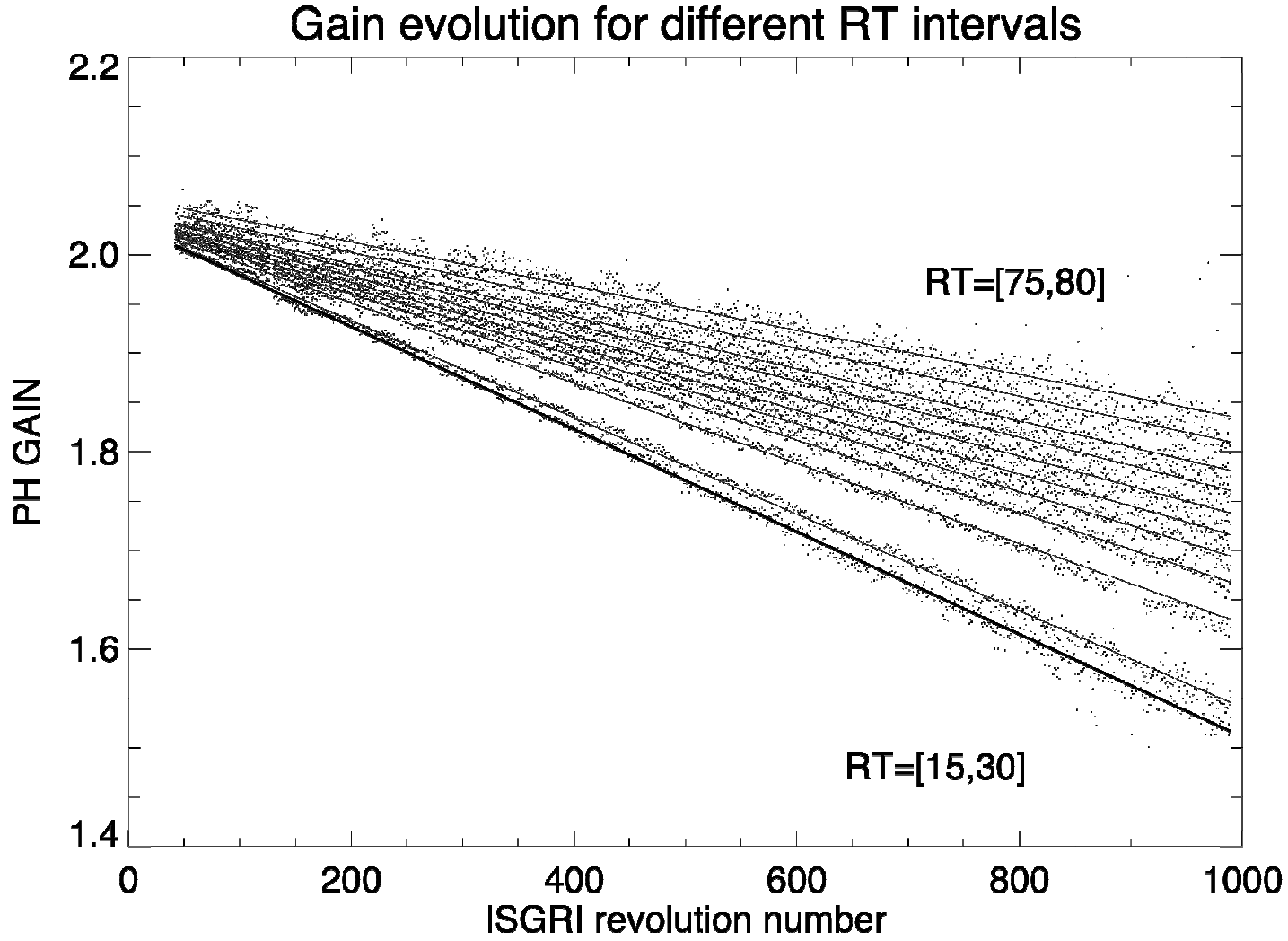
AIM CEA Saclay / APC+FACe Paris 7

1) Energy correction

OSA 9 correction based in IREM counters

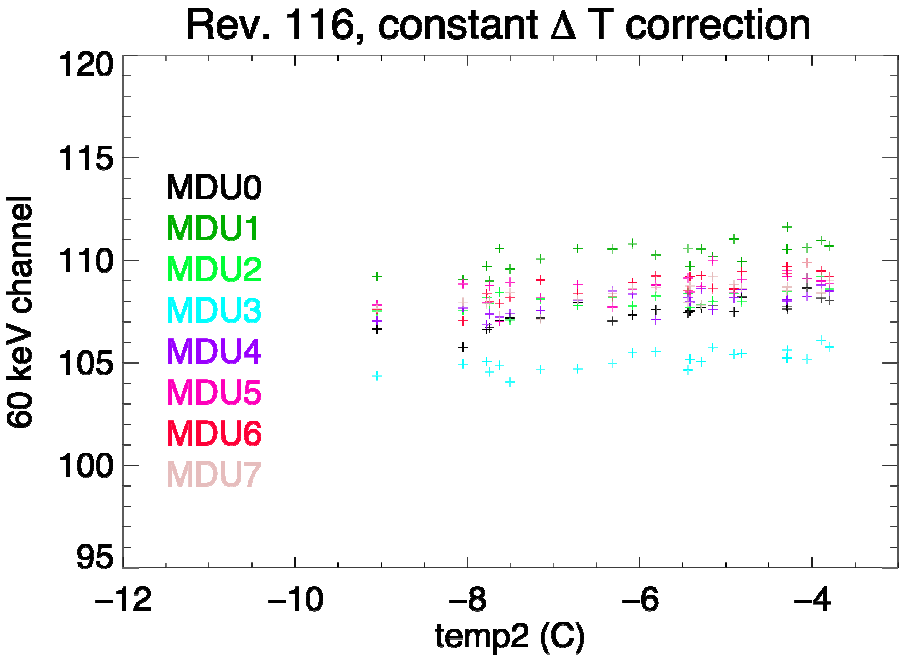


OSA 10: PH gain-offset described as a function of time (and RT), not using IREM counters

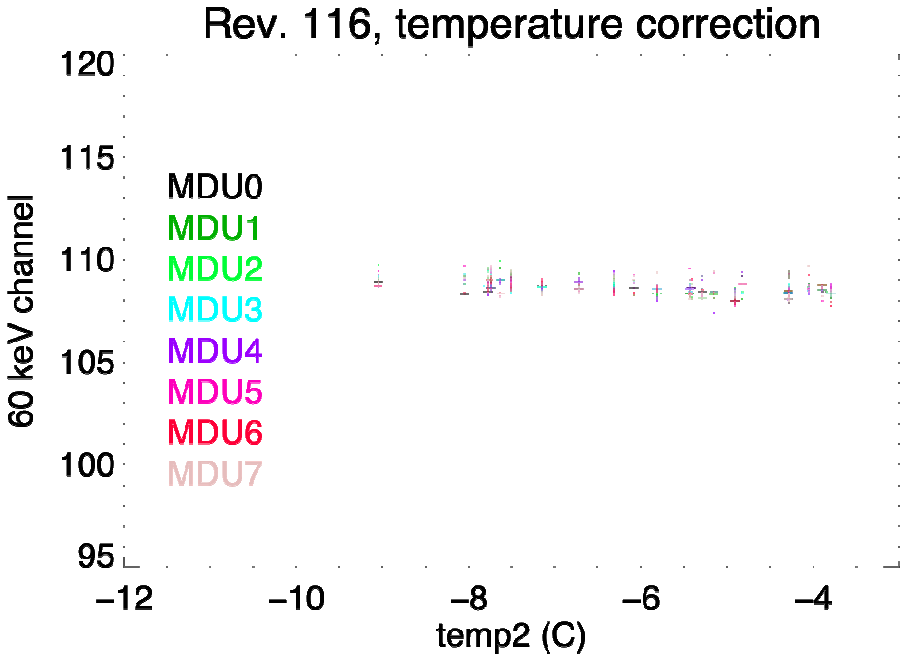


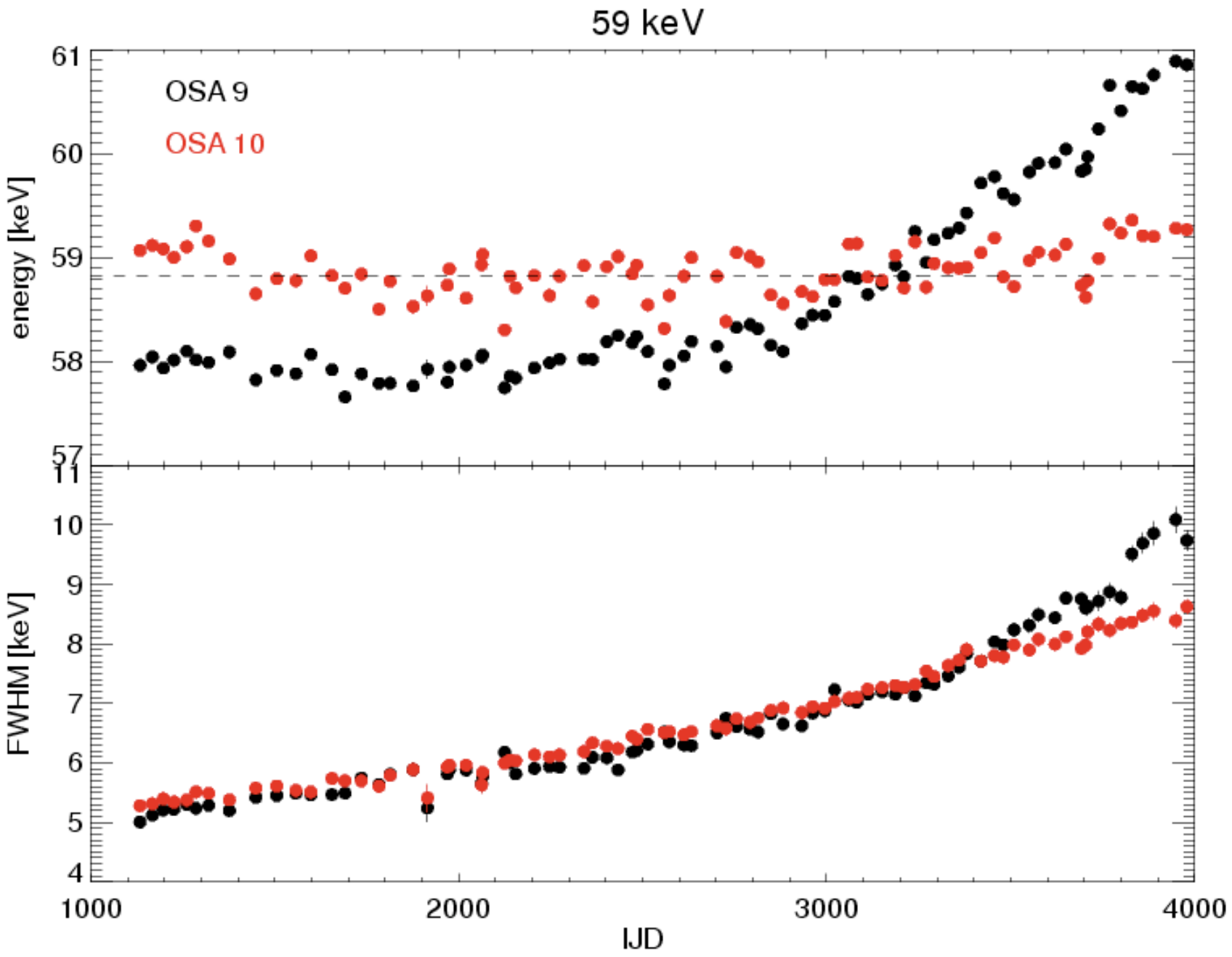
Temperature correction/ MDU

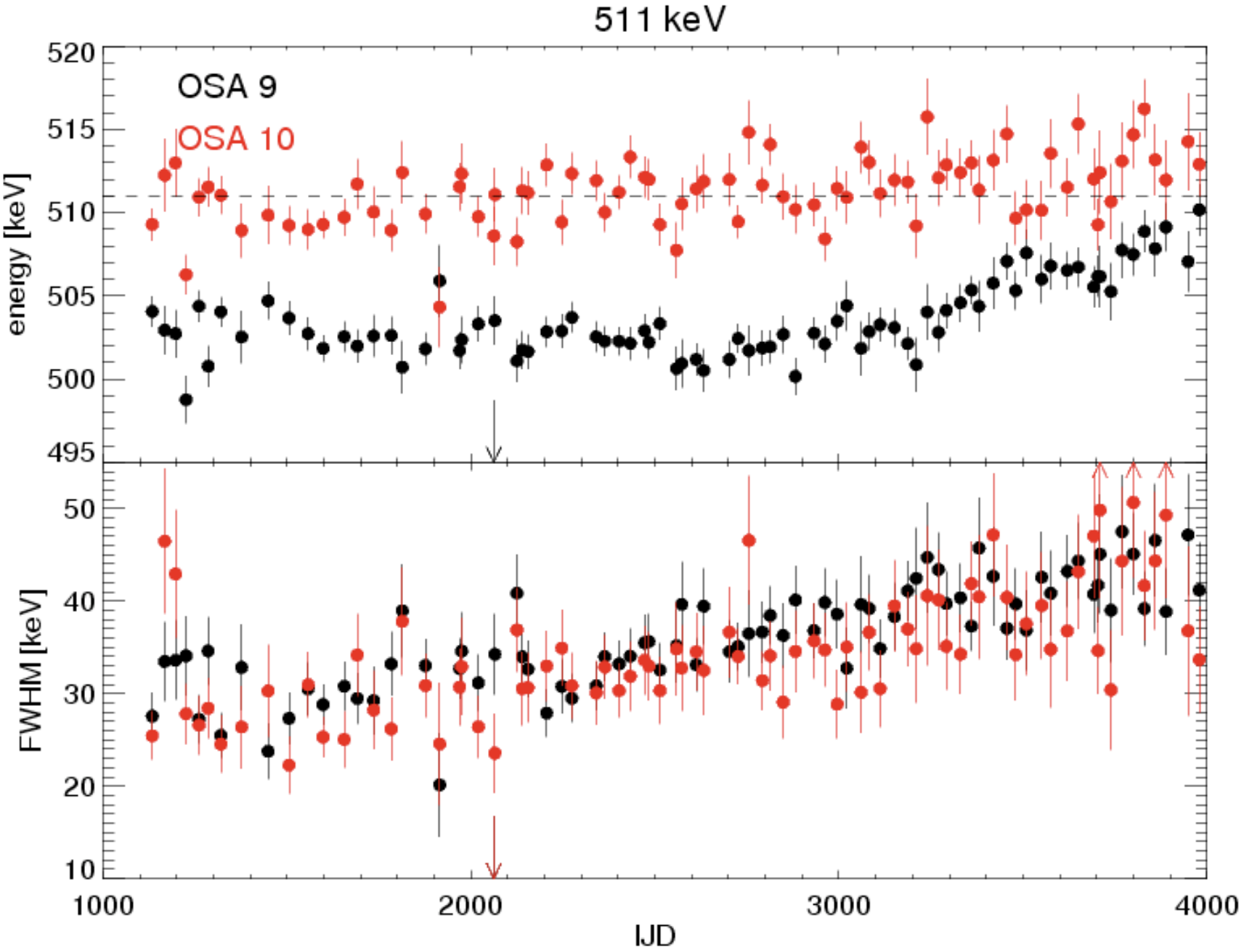
OSA 9: constant ΔT between modules assumed



OSA 10: real MDU temperature




59 keV
OSA 9
OSA 10
energy [keV]
FWHM [keV]
IJD
61
60
59
58
57
11
10
9
8
7
6
5
4
1000
2000
3000
4000


511 keV
OSA 9
OSA 10
energy [keV]
520
515
510
505
500
495
FWHM [keV]
50
40
30
20
10
1000
2000
3000
4000
IJD

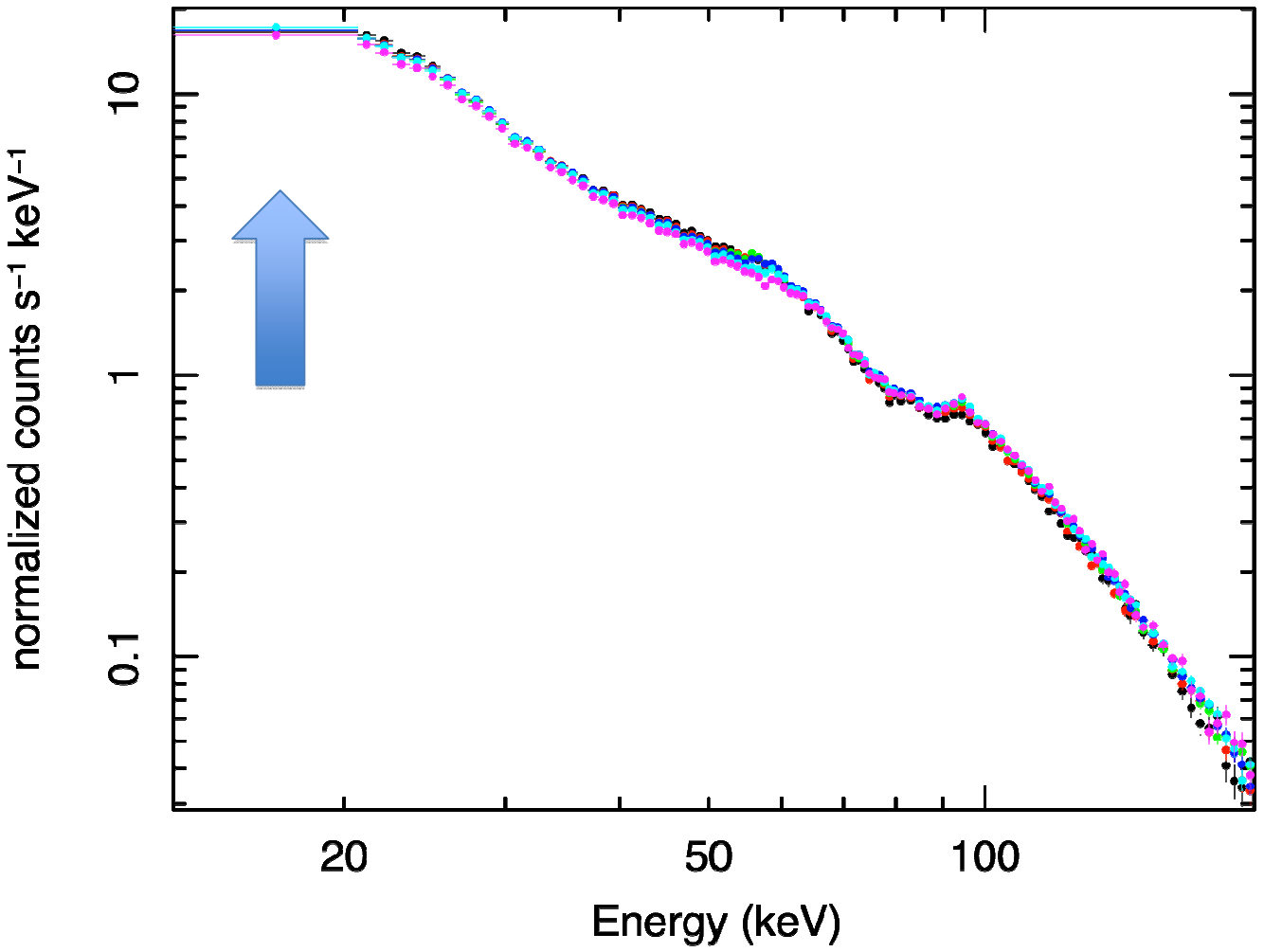
Status

- ✓New correction developed in IDL
- ✓Implemented in OSA
- ✓Validation between IDL/OSA codes done
- •TO DO:
  - olow threshold correction (see next section)
  - oARFs, to be produced by Lorenzo with our input (Crab spectra for all the mission)

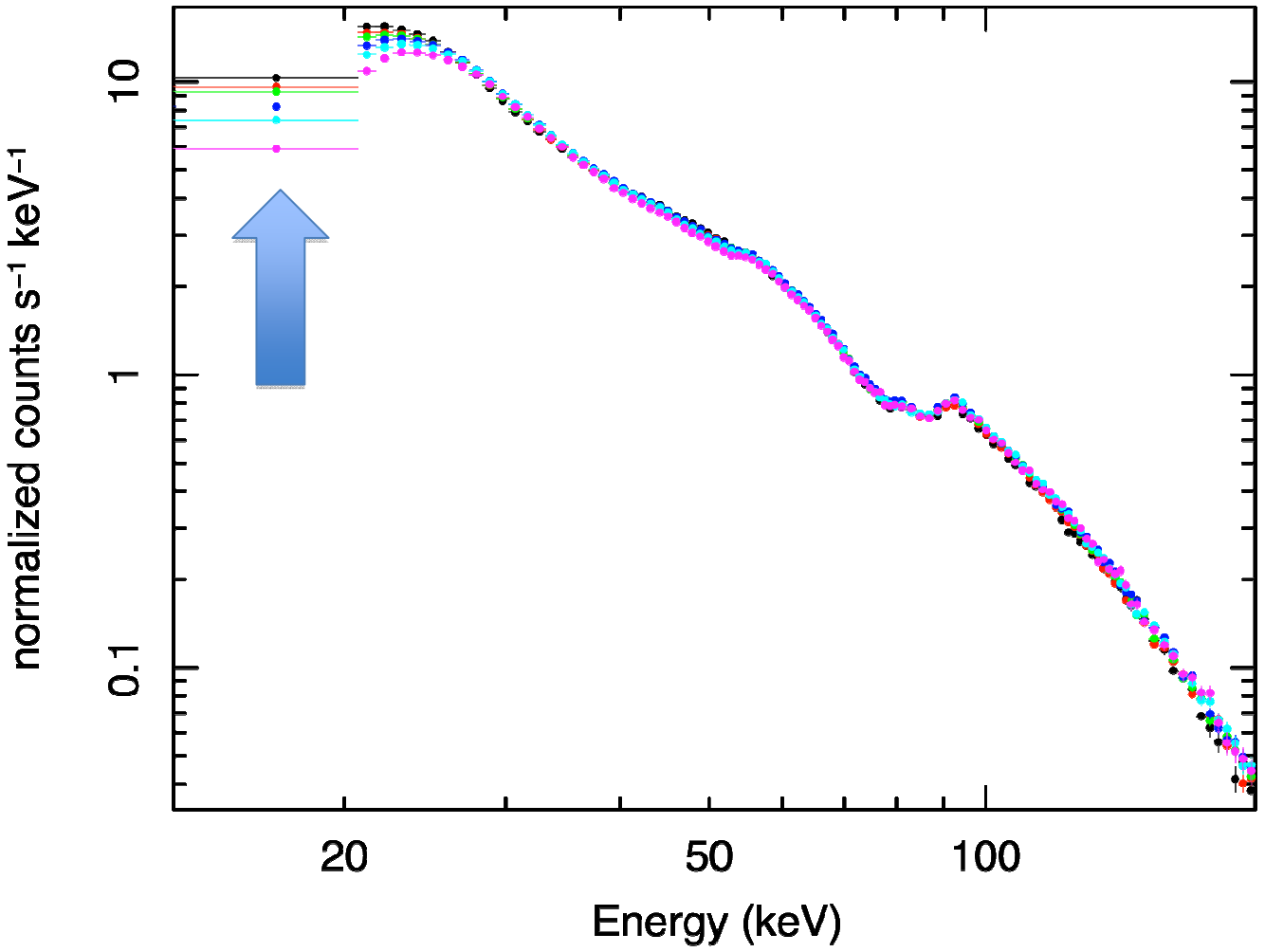
2) Low Threshold

LT correction:
IDL => make_LT_b3D.pro
OSA => ii_shadow_build

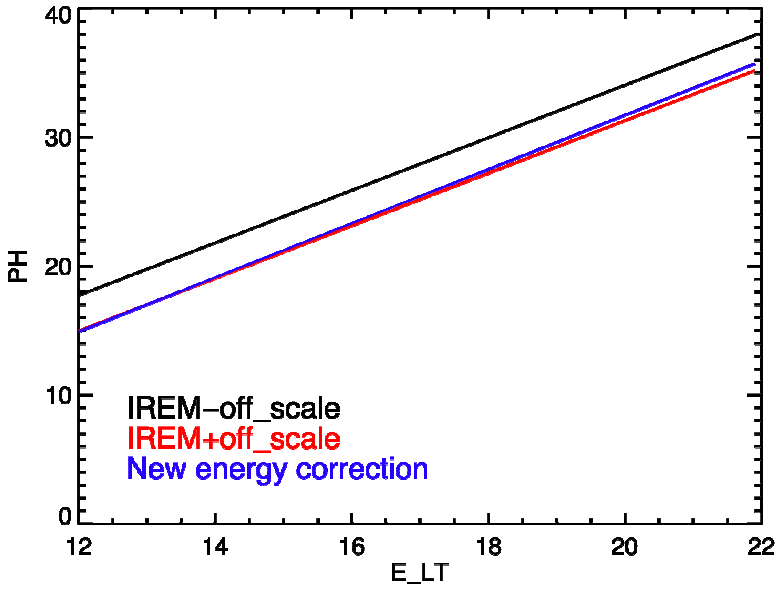
Crab with OSA9



Crab with OSA10



Transformation of Energy Low Threshold (E_LT) into Pulse Height (PH) in make_LT_b3D



- Black: OSA9-IDL equation

  PH=gain0*(gs*(E_LT-olut2)-os/2.)+offset0

  But isgri_energy and make_LT_b3D are not coherent.

- Red: OSA9-IDL with sign «+» for off_scale in make_LT_b3D

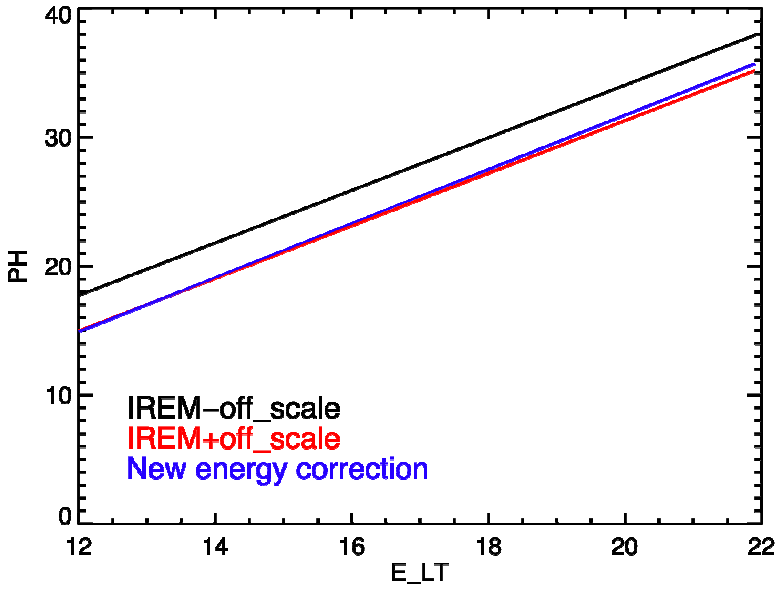
  PH = gain0*(gs*(E_LT-olut2)+os/2.)+offset0

- Blue: OSA10 LT with new energy correction

  PH = gain0*(E_LT*gs+os)+offset0

- Parameters definition:
  gain0,offset0: energy drift correction law < 50 keV
  gs,os: final gain,offset scale
  olut2: offset after LUT2 application (only OSA9)
  values changed between OSA9 and 10

Transformation of Energy Low Threshold (E_LT) into Pulse Height (PH) in make_LT_b3D



- Black: OSA9-IDL equation

  PH=gain0*(gs*(E_LT-olut2)-os/2.)+offset0

  But isgri_energy and make_LT_b3D are not coherent.

- Red: OSA9-IDL with sign «+» for off_scale in make_LT_b3D

  PH = gain0*(gs*(E_LT-olut2)+os/2.)+offset0

- Blue: OSA10 LT with new energy correction

  PH = gain0*(E_LT*gs+os)+offset0

- Parameters definition:
  gain0,offset0: energy drift correction law < 50 keV
  gs,os: final gain,offset scale
  olut2: offset after LUT2 application (only OSA9)
  values changed between OSA9 and 10

✓No problem with new energy correction in OSA10
✓Also present in OSA9 but hidden by the wrong sign in front of « os »
✓But the low threshold applied is… too low

Goal: determine true LT function

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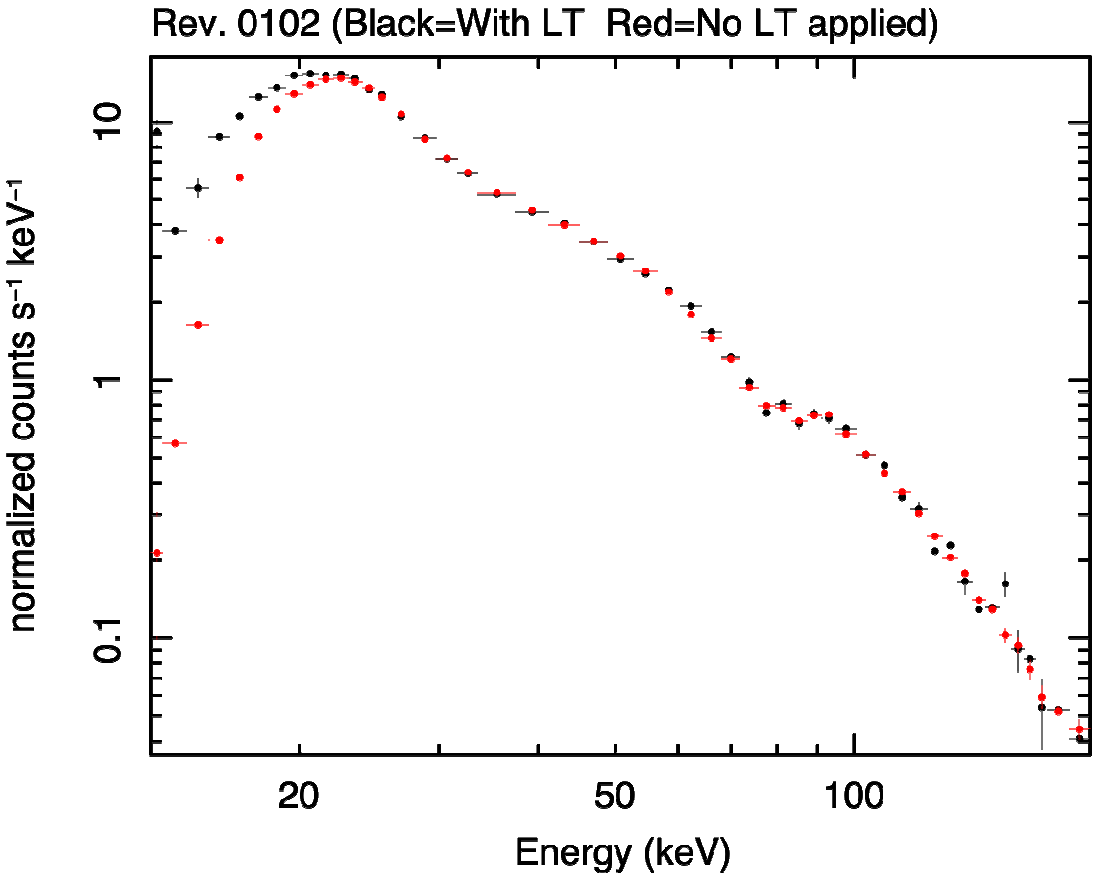
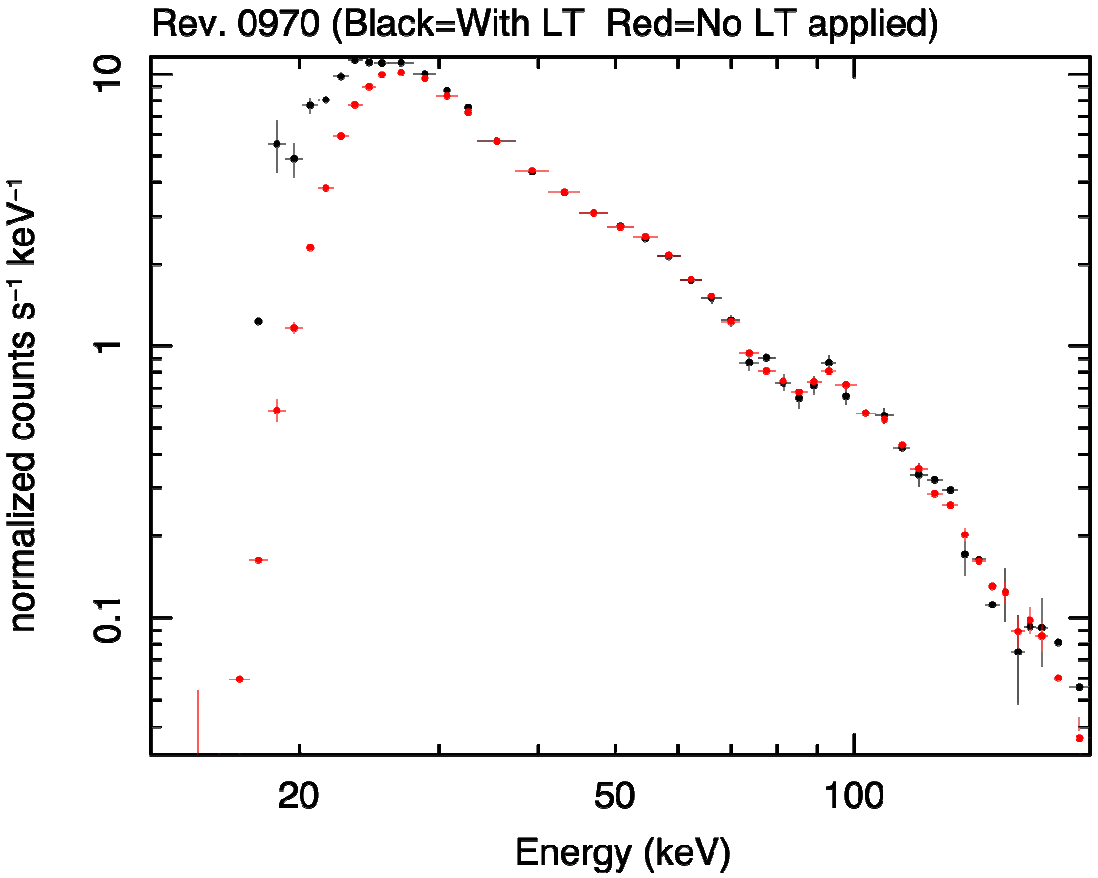
1. Obtain Crab spectrum using OSA without the LT correction



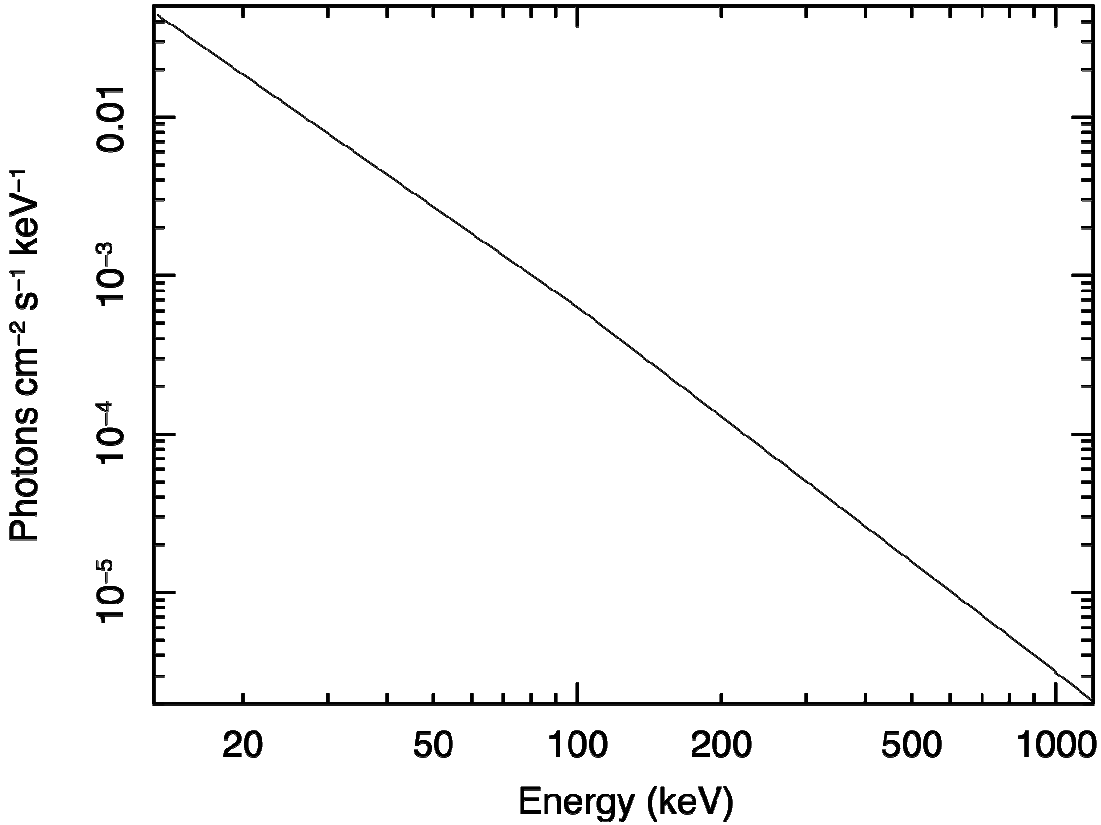
Goal: determine true LT function

1. Obtain Crab spectrum using OSA without the LT correction



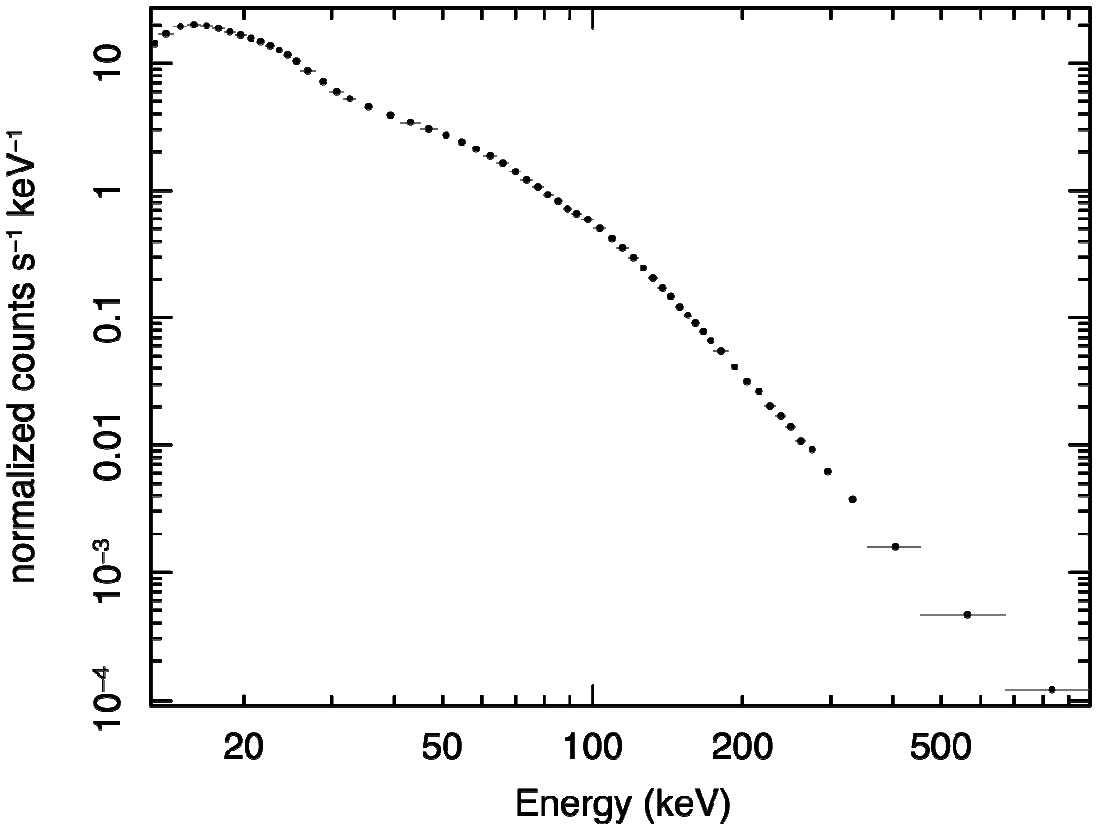
Goal: determine true LT function

2. simulated Crab spectrum: model broken PL
Γ_1=2.1, E_{break}=100 keV, Γ_2=2.3, Norm(1 keV)=10 ph $cm^{-2}s^{-1}keV^{-1}$



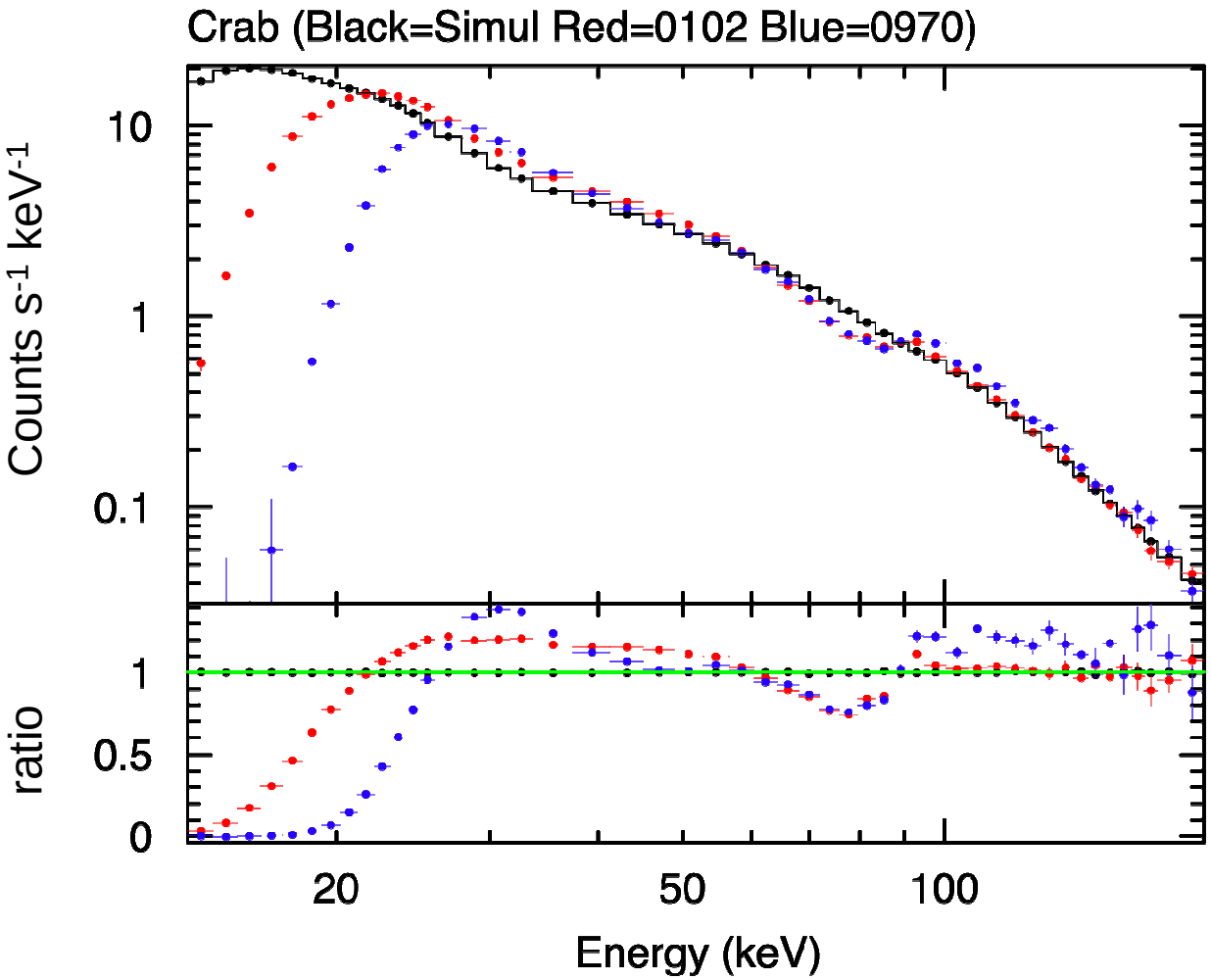
Goal: determine true LT function

2. simulated Crab spectrum:
   model + ARF (MC simulation, P. Laurent) in Xspec



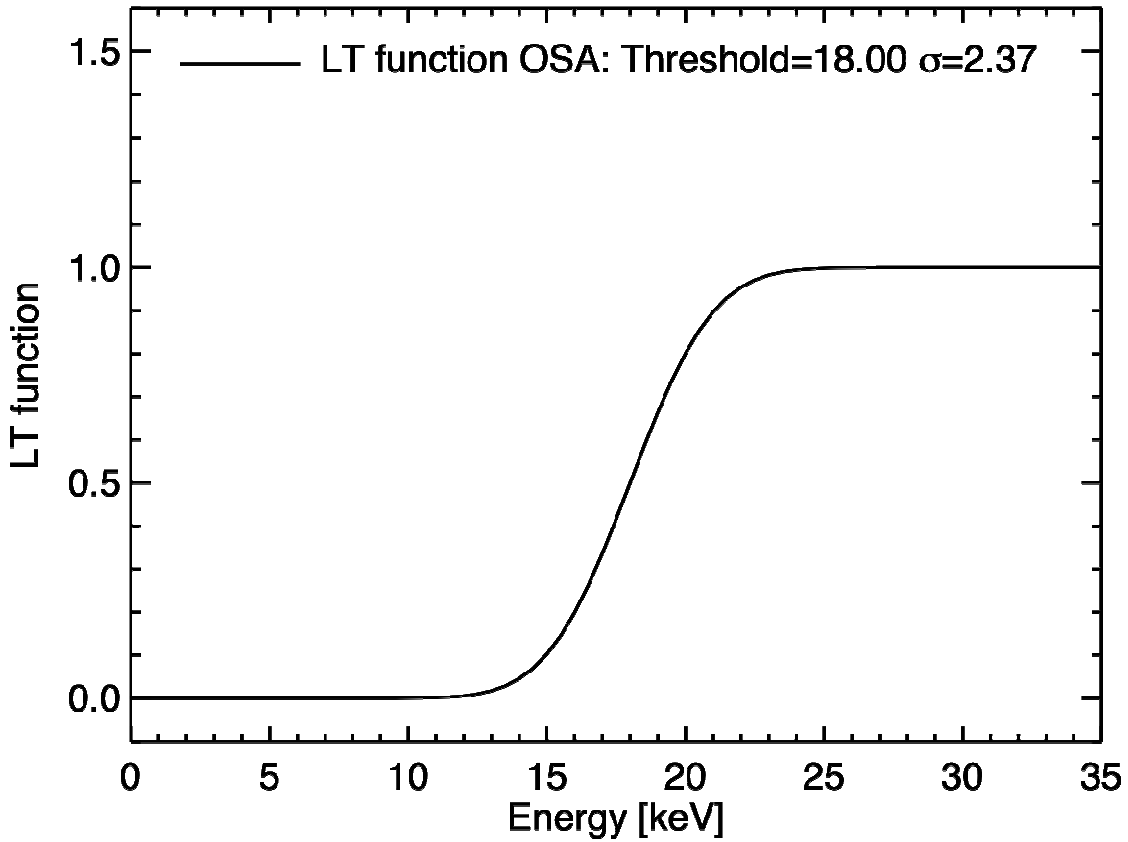
Goal: determine true LT function

3. LT function = OSA Spec. / Simulated Spec.

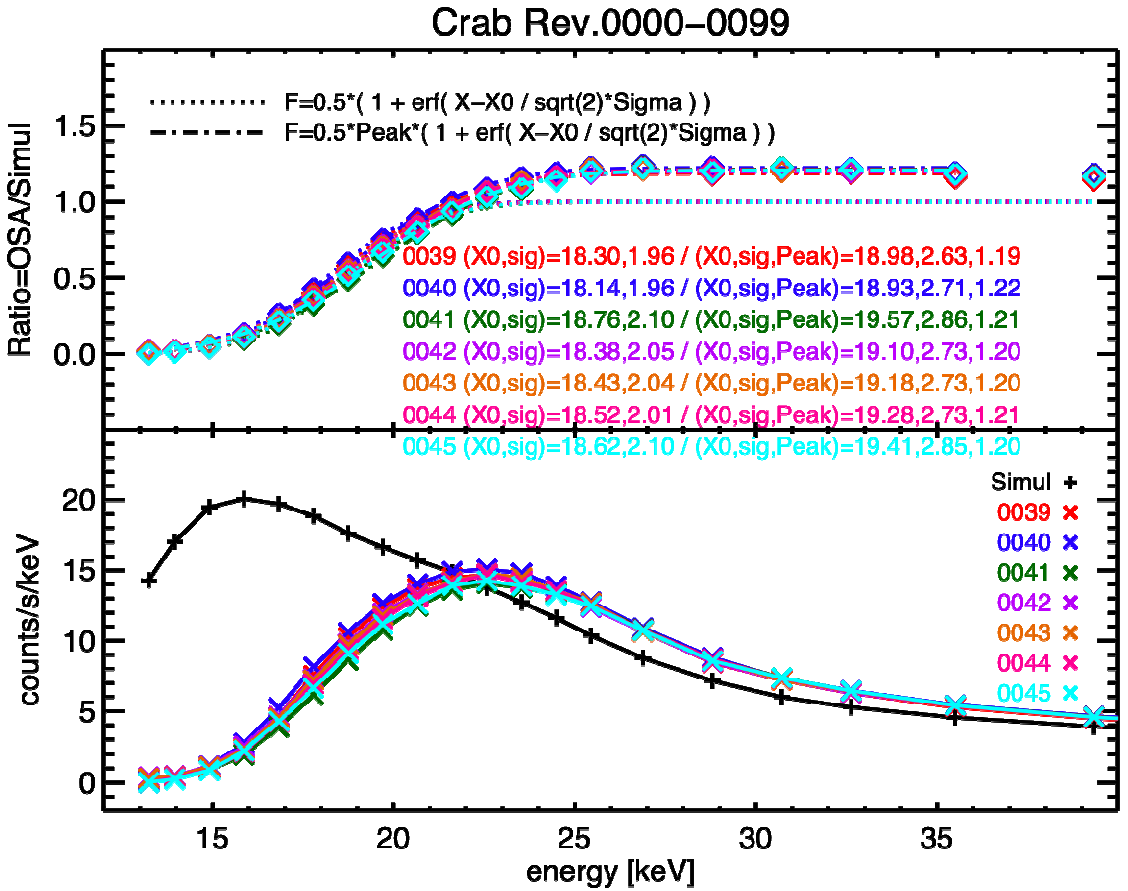


Goal: determine true LT function

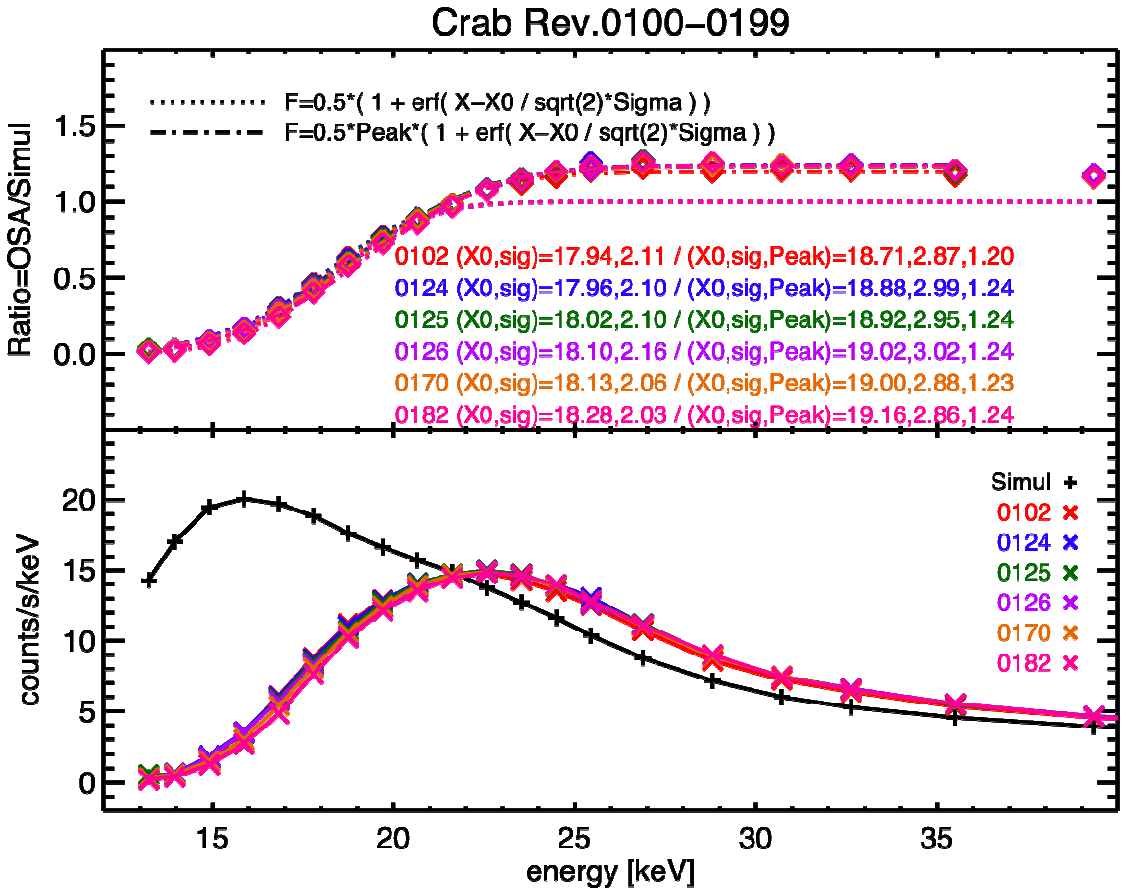
3. $F(E, LT, \sigma) = 0.5\,(1 + erf(\frac{E - LT}{\sqrt{2}\,\sigma})) = 1 - 0.5\,erfc(\frac{E - LT}{\sqrt{2}\,\sigma})$



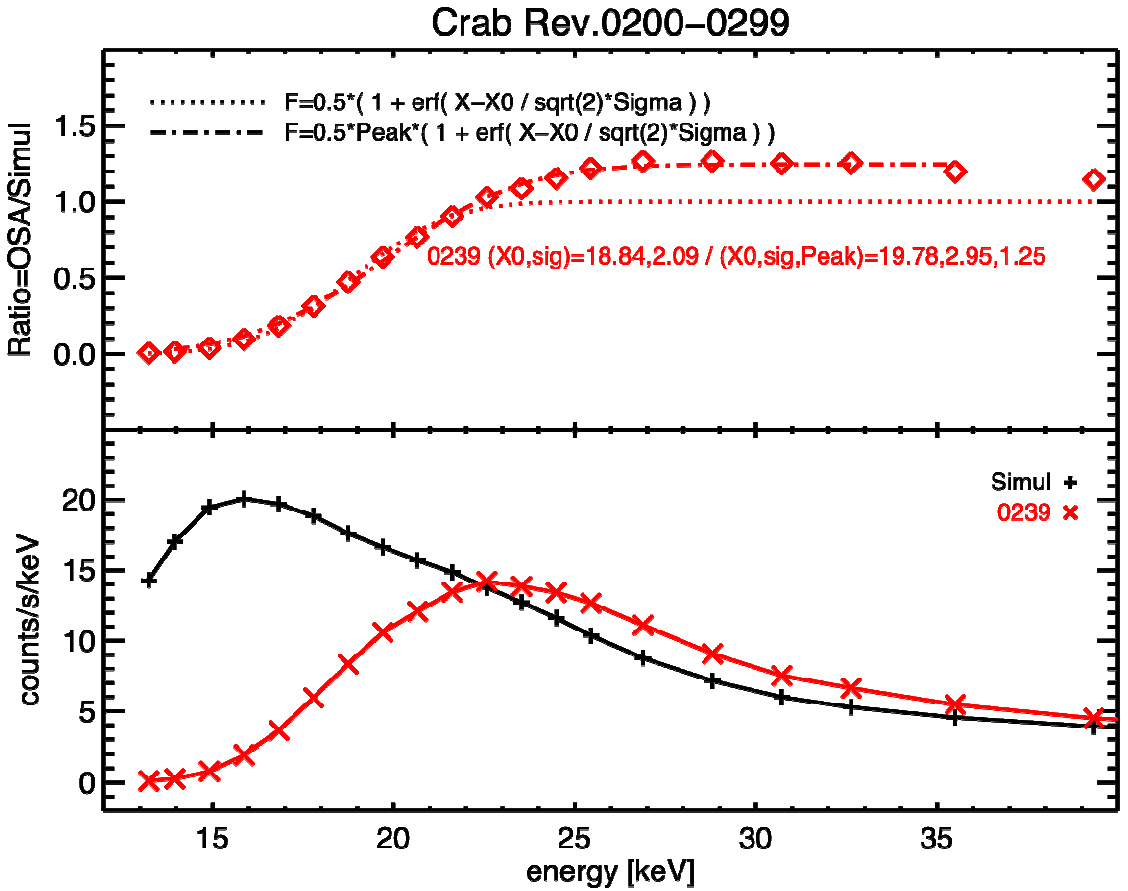
Fit results


Crab Rev.0000–0099
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
0039 (X0,sig)=18.30,1.96 / (X0,sig,Peak)=18.98,2.63,1.19
0040 (X0,sig)=18.14,1.96 / (X0,sig,Peak)=18.93,2.71,1.22
0041 (X0,sig)=18.76,2.10 / (X0,sig,Peak)=19.57,2.86,1.21
0042 (X0,sig)=18.38,2.05 / (X0,sig,Peak)=19.10,2.73,1.20
0043 (X0,sig)=18.43,2.04 / (X0,sig,Peak)=19.18,2.73,1.20
0044 (X0,sig)=18.52,2.01 / (X0,sig,Peak)=19.28,2.73,1.21
0045 (X0,sig)=18.62,2.10 / (X0,sig,Peak)=19.41,2.85,1.20
Ratio=OSA/Simul
counts/s/keV
energy [keV]
Simul
0039
0040
0041
0042
0043
0044
0045

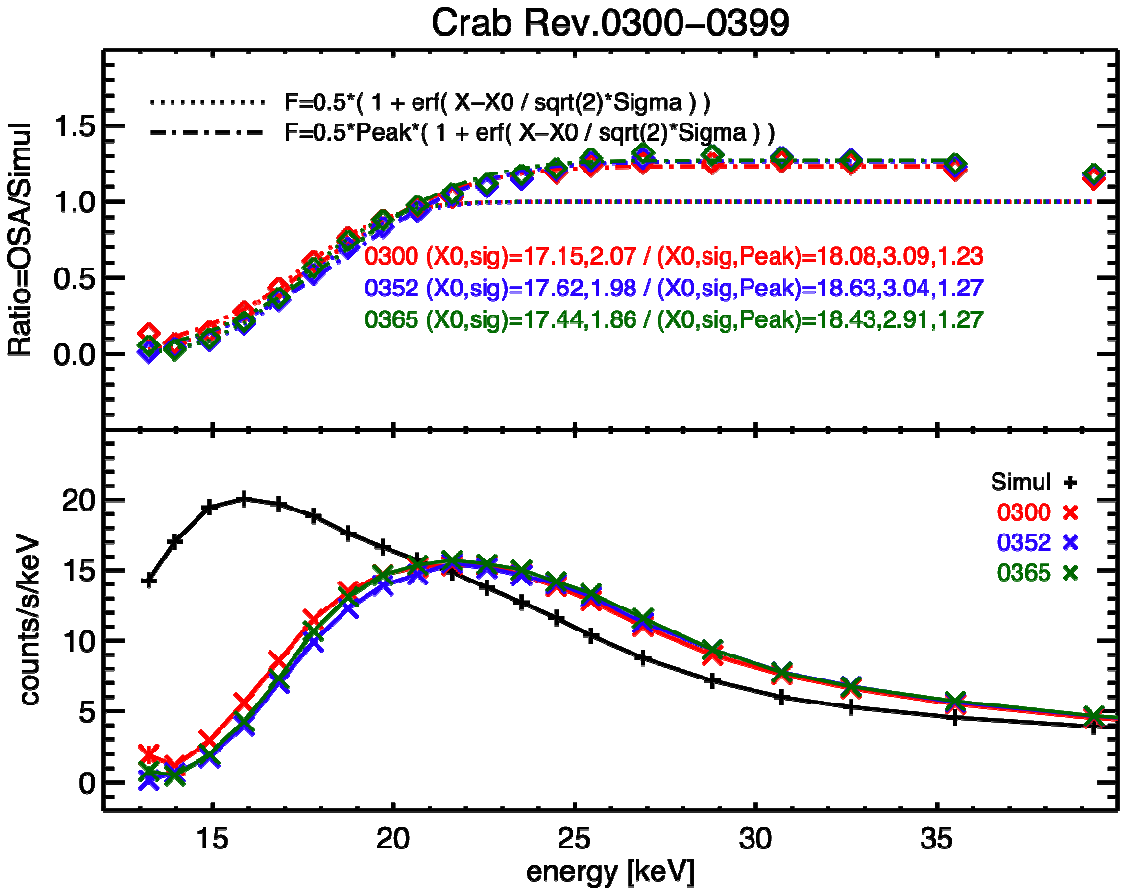
Fit results


Crab Rev.0100–0199
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
0102 (X0,sig)=17.94,2.11 / (X0,sig,Peak)=18.71,2.87,1.20
0124 (X0,sig)=17.96,2.10 / (X0,sig,Peak)=18.88,2.99,1.24
0125 (X0,sig)=18.02,2.10 / (X0,sig,Peak)=18.92,2.95,1.24
0126 (X0,sig)=18.10,2.16 / (X0,sig,Peak)=19.02,3.02,1.24
0170 (X0,sig)=18.13,2.06 / (X0,sig,Peak)=19.00,2.88,1.23
0182 (X0,sig)=18.28,2.03 / (X0,sig,Peak)=19.16,2.86,1.24
Ratio=OSA/Simul
1.5
1.0
0.5
0.0
Simul
0102
0124
0125
0126
0170
0182
counts/s/keV
20
15
10
5
0
15
20
25
30
35
energy [keV]

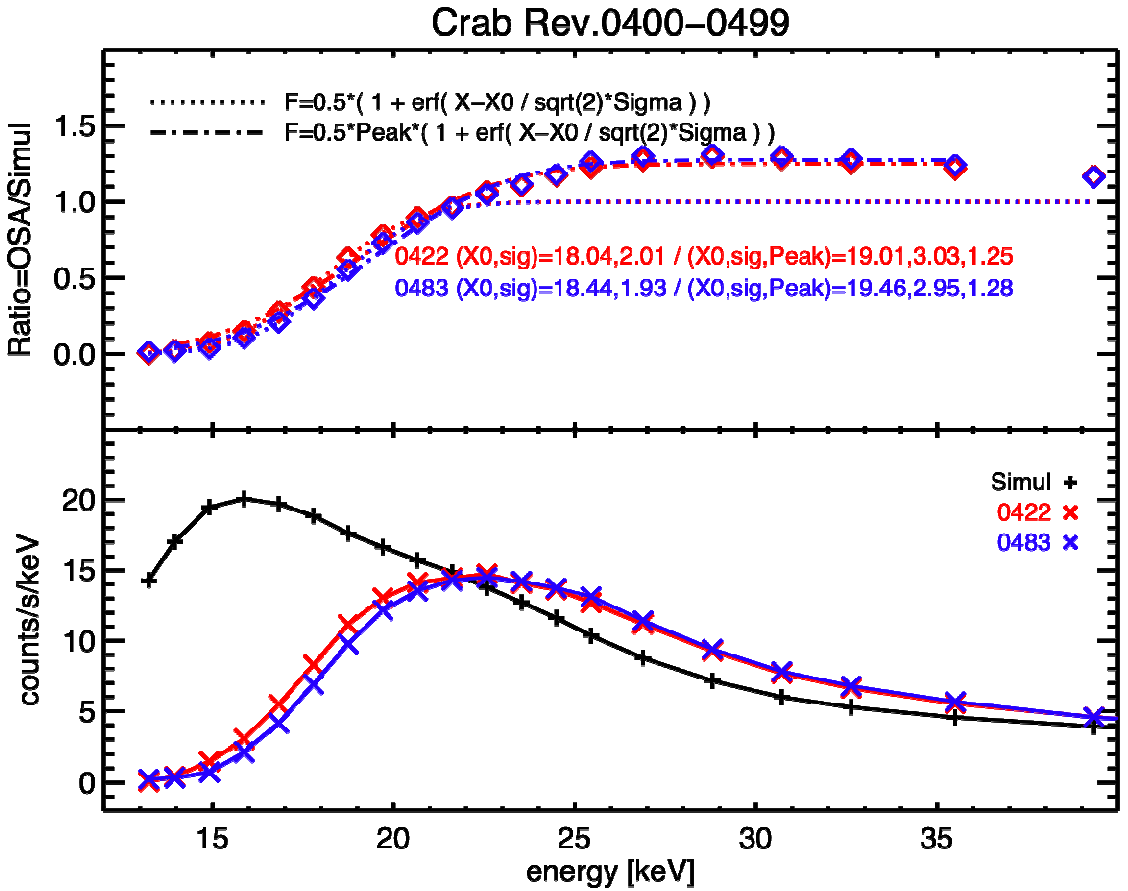
Fit results


Crab Rev.0200–0299
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
0239 (X0,sig)=18.84,2.09 / (X0,sig,Peak)=19.78,2.95,1.25
Ratio=OSA/Simul
1.5
1.0
0.5
0.0
Simul
0239
counts/s/keV
20
15
10
5
0
15
20
25
30
35
energy [keV]

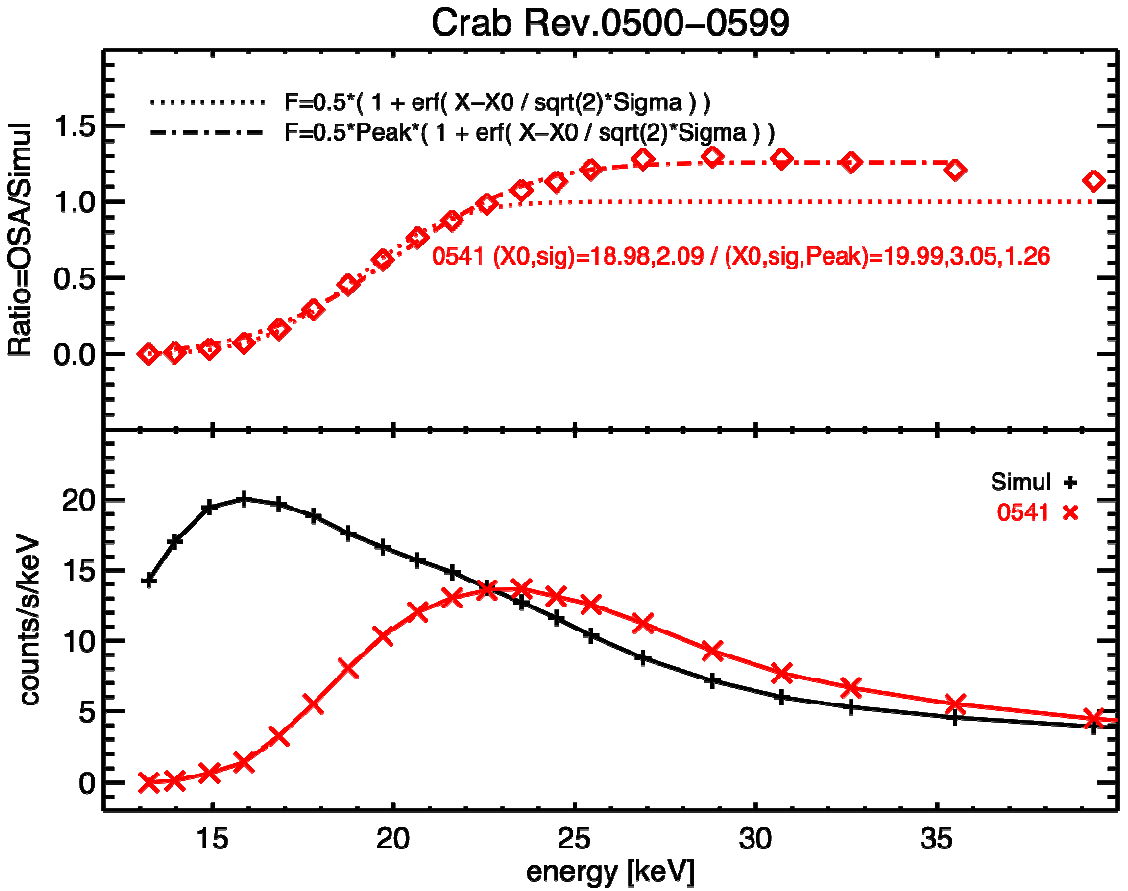
Fit results


Crab Rev.0300–0399
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
0300 (X0,sig)=17.15,2.07 / (X0,sig,Peak)=18.08,3.09,1.23
0352 (X0,sig)=17.62,1.98 / (X0,sig,Peak)=18.63,3.04,1.27
0365 (X0,sig)=17.44,1.86 / (X0,sig,Peak)=18.43,2.91,1.27
Ratio=OSA/Simul
1.5
1.0
0.5
0.0
Simul
0300
0352
0365
counts/s/keV
20
15
10
5
0
15
20
25
30
35
energy [keV]

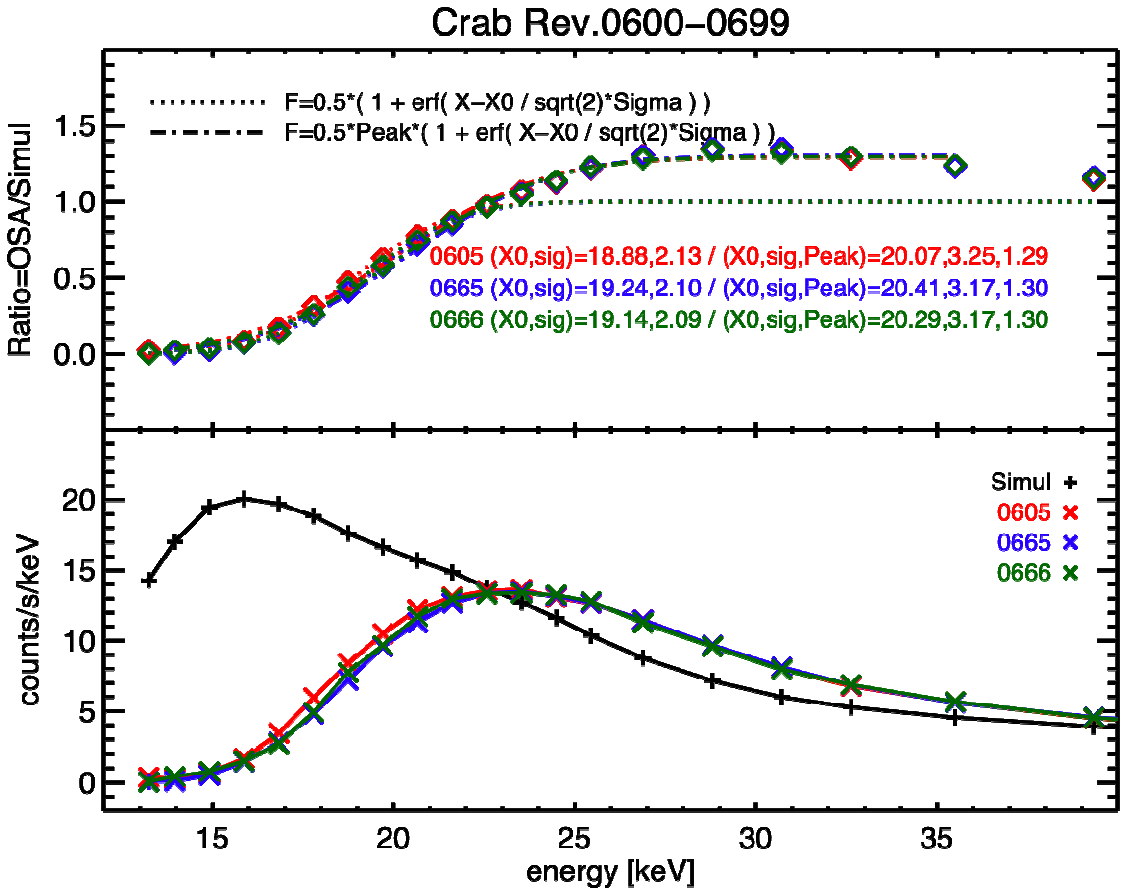
Fit results


Crab Rev.0400–0499
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
0422 (X0,sig)=18.04,2.01 / (X0,sig,Peak)=19.01,3.03,1.25
0483 (X0,sig)=18.44,1.93 / (X0,sig,Peak)=19.46,2.95,1.28
Ratio=OSA/Simul
1.5
1.0
0.5
0.0
Simul
0422
0483
counts/s/keV
20
15
10
5
0
15
20
25
30
35
energy [keV]

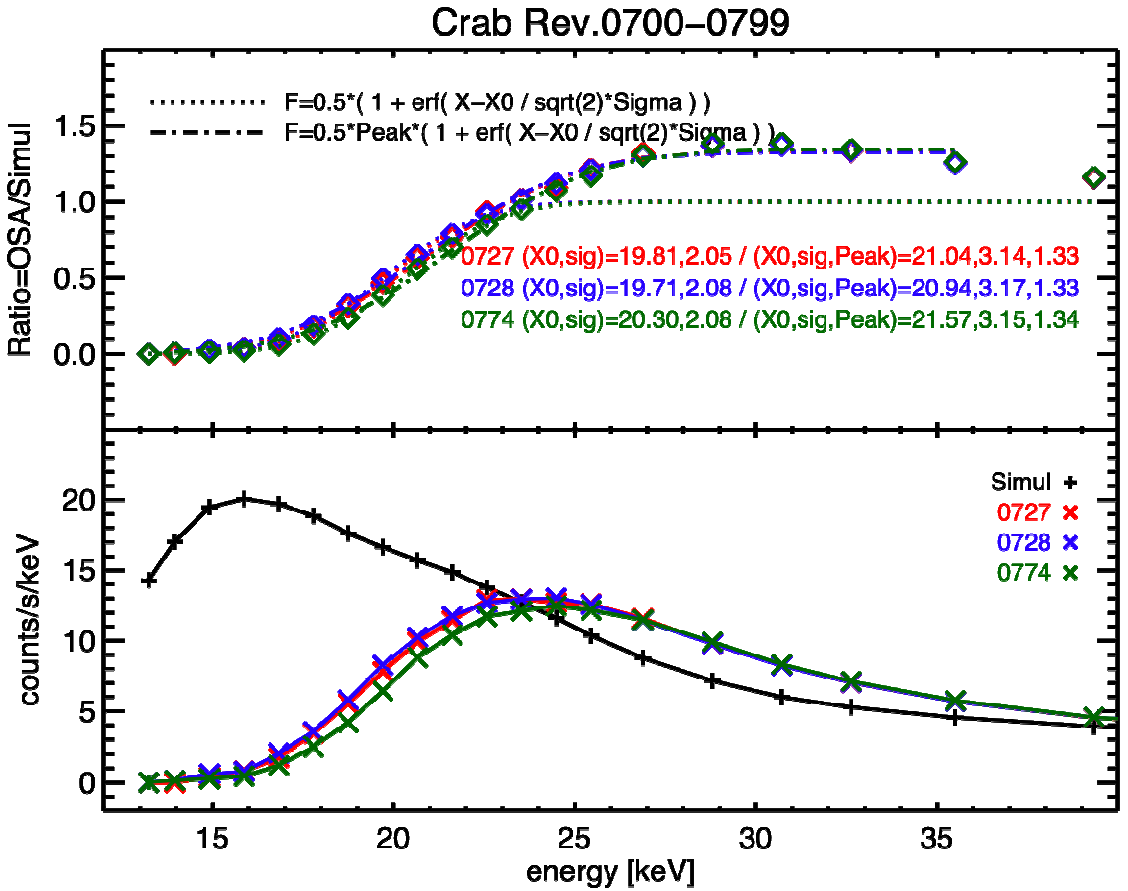
Fit results


Crab Rev.0500–0599
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
0541 (X0,sig)=18.98,2.09 / (X0,sig,Peak)=19.99,3.05,1.26
Ratio=OSA/Simul
1.5
1.0
0.5
0.0
Simul
0541
counts/s/keV
20
15
10
5
0
15
20
25
30
35
energy [keV]

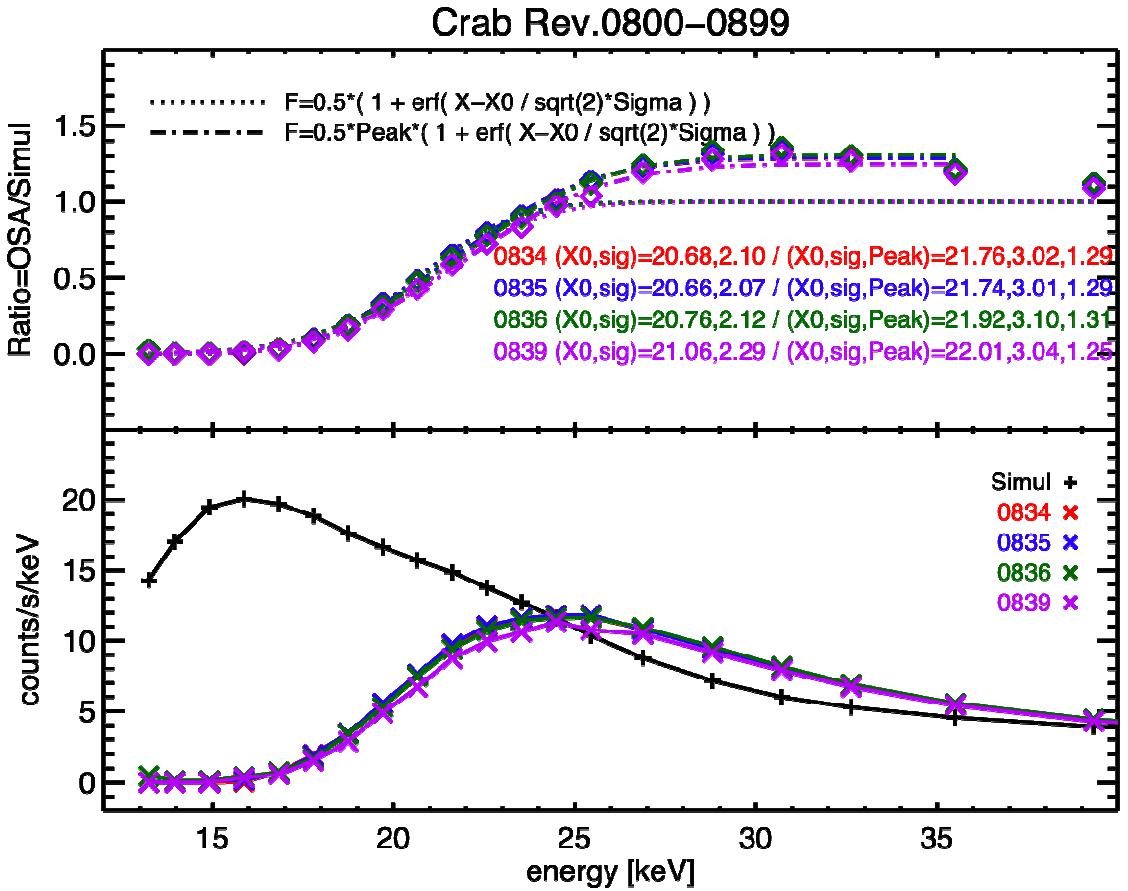
Fit results


Crab Rev.0600–0699
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
0605 (X0,sig)=18.88,2.13 / (X0,sig,Peak)=20.07,3.25,1.29
0665 (X0,sig)=19.24,2.10 / (X0,sig,Peak)=20.41,3.17,1.30
0666 (X0,sig)=19.14,2.09 / (X0,sig,Peak)=20.29,3.17,1.30
Ratio=OSA/Simul
1.5
1.0
0.5
0.0
Simul
0605
0665
0666
counts/s/keV
20
15
10
5
0
15
20
25
30
35
energy [keV]

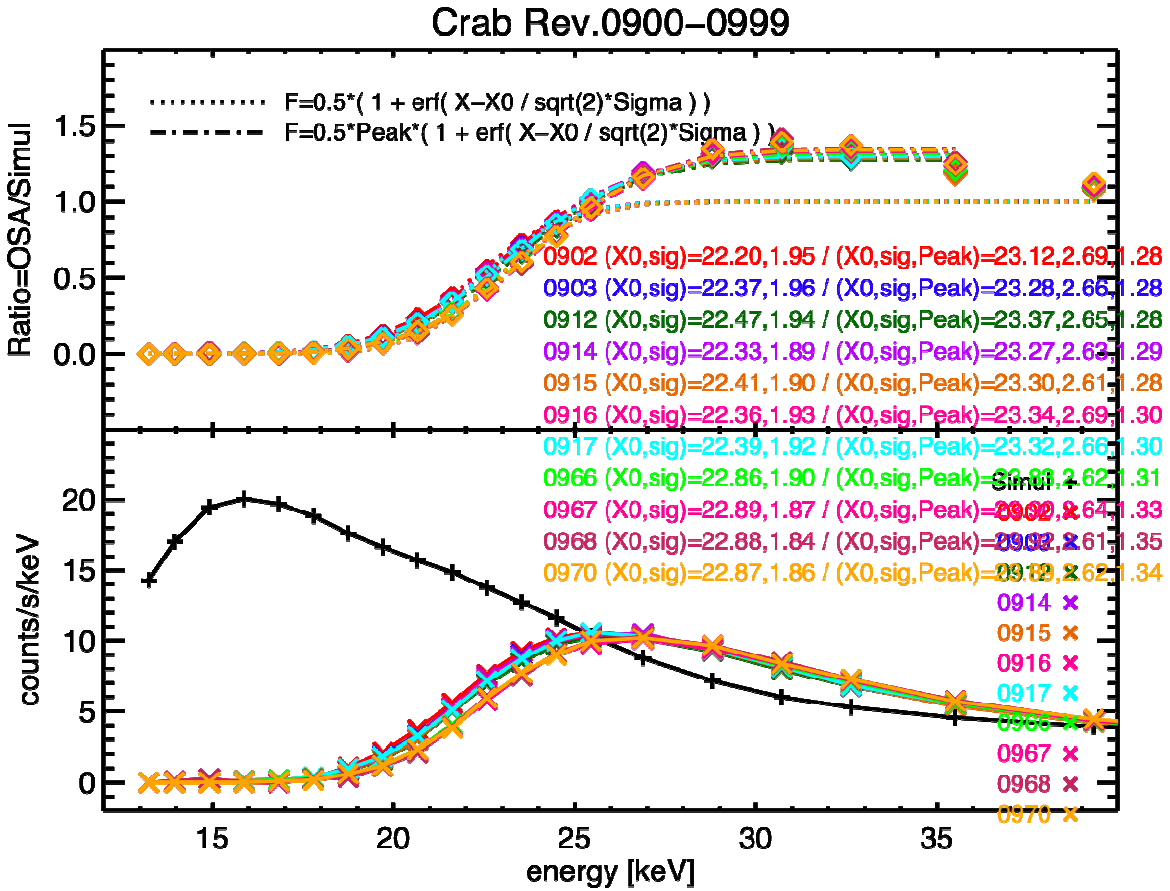
Fit results


Crab Rev.0700–0799
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
0727 (X0,sig)=19.81,2.05 / (X0,sig,Peak)=21.04,3.14,1.33
0728 (X0,sig)=19.71,2.08 / (X0,sig,Peak)=20.94,3.17,1.33
0774 (X0,sig)=20.30,2.08 / (X0,sig,Peak)=21.57,3.15,1.34
Ratio=OSA/Simul
1.5
1.0
0.5
0.0
Simul
0727
0728
0774
counts/s/keV
20
15
10
5
0
15
20
25
30
35
energy [keV]

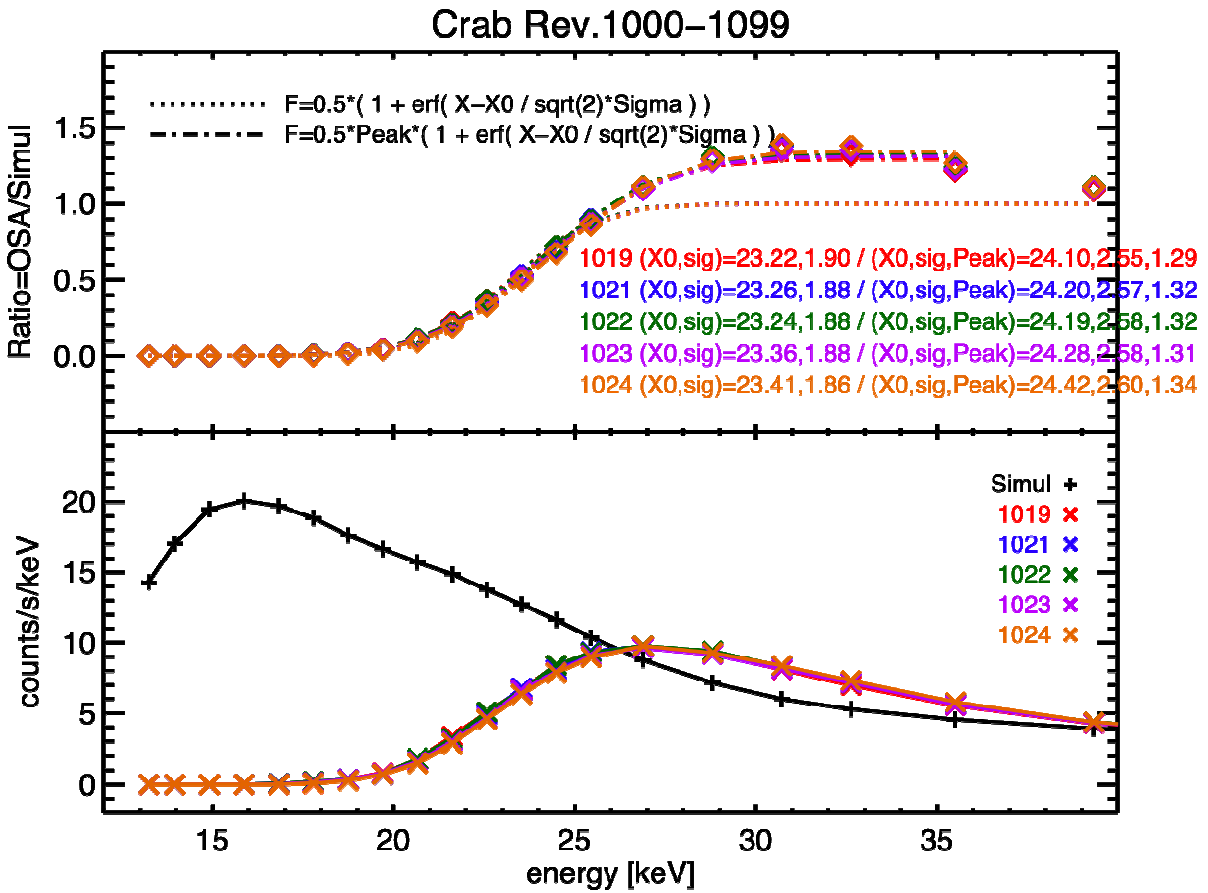
Fit results


Crab Rev.0800–0899
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
0834 (X0,sig)=20.68,2.10 / (X0,sig,Peak)=21.76,3.02,1.29
0835 (X0,sig)=20.66,2.07 / (X0,sig,Peak)=21.74,3.01,1.29
0836 (X0,sig)=20.76,2.12 / (X0,sig,Peak)=21.92,3.10,1.31
0839 (X0,sig)=21.06,2.29 / (X0,sig,Peak)=22.01,3.04,1.25
Ratio=OSA/Simul
1.5
1.0
0.5
0.0
Simul
0834
0835
0836
0839
counts/s/keV
20
15
10
5
0
15
20
25
30
35
energy [keV]

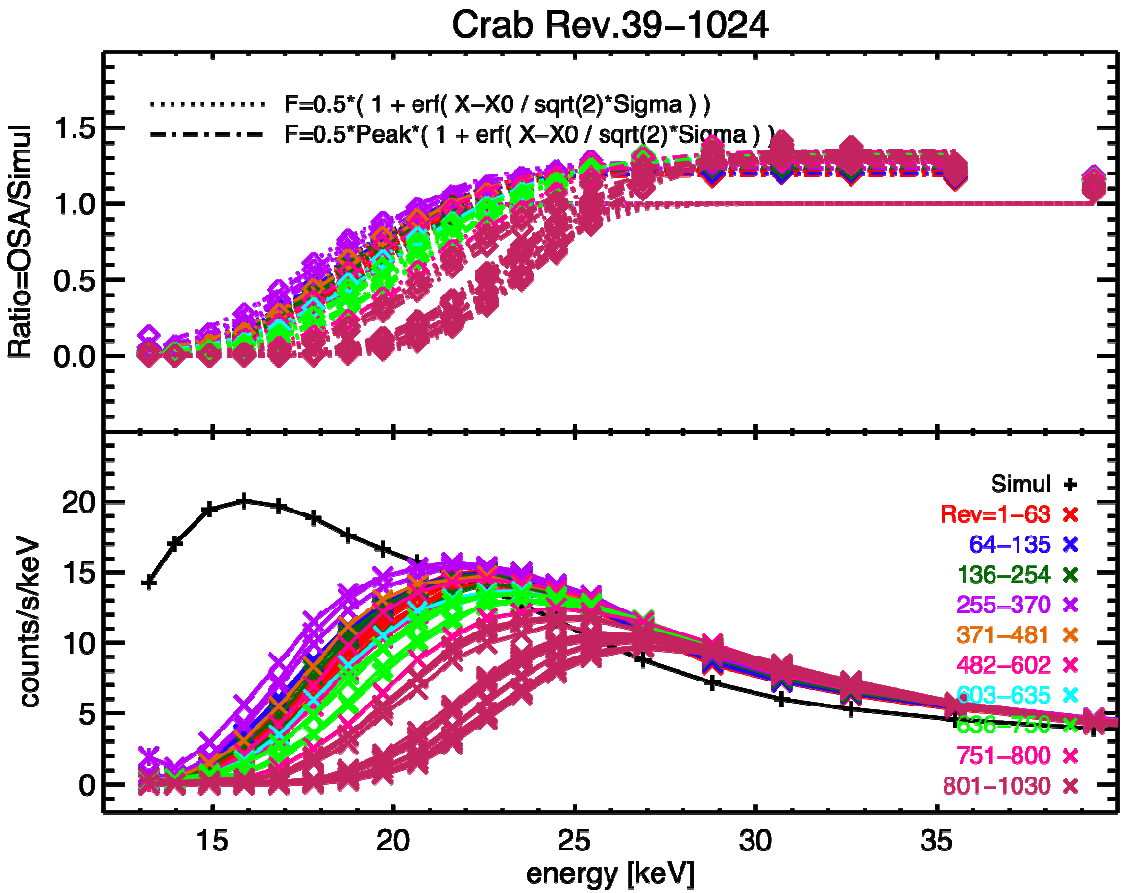
Fit results


Crab Rev.0900–0999
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
Ratio=OSA/Simul
counts/s/keV
energy [keV]
0902 (X0,sig)=22.20,1.95 / (X0,sig,Peak)=23.12,2.69,1.28
0903 (X0,sig)=22.37,1.96 / (X0,sig,Peak)=23.28,2.66,1.28
0912 (X0,sig)=22.47,1.94 / (X0,sig,Peak)=23.37,2.65,1.28
0914 (X0,sig)=22.33,1.89 / (X0,sig,Peak)=23.27,2.63,1.29
0915 (X0,sig)=22.41,1.90 / (X0,sig,Peak)=23.30,2.61,1.28
0916 (X0,sig)=22.36,1.93 / (X0,sig,Peak)=23.34,2.69,1.30
0917 (X0,sig)=22.39,1.92 / (X0,sig,Peak)=23.32,2.66,1.30
0966 (X0,sig)=22.86,1.90 / (X0,sig,Peak)=23.83,2.62,1.31
0967 (X0,sig)=22.89,1.87 / (X0,sig,Peak)=23.82,2.64,1.33
0968 (X0,sig)=22.88,1.84 / (X0,sig,Peak)=23.82,2.61,1.35
0970 (X0,sig)=22.87,1.86 / (X0,sig,Peak)=23.82,2.62,1.34
Simul.
0902
0914
0915
0916
0917
0967
0968
0970

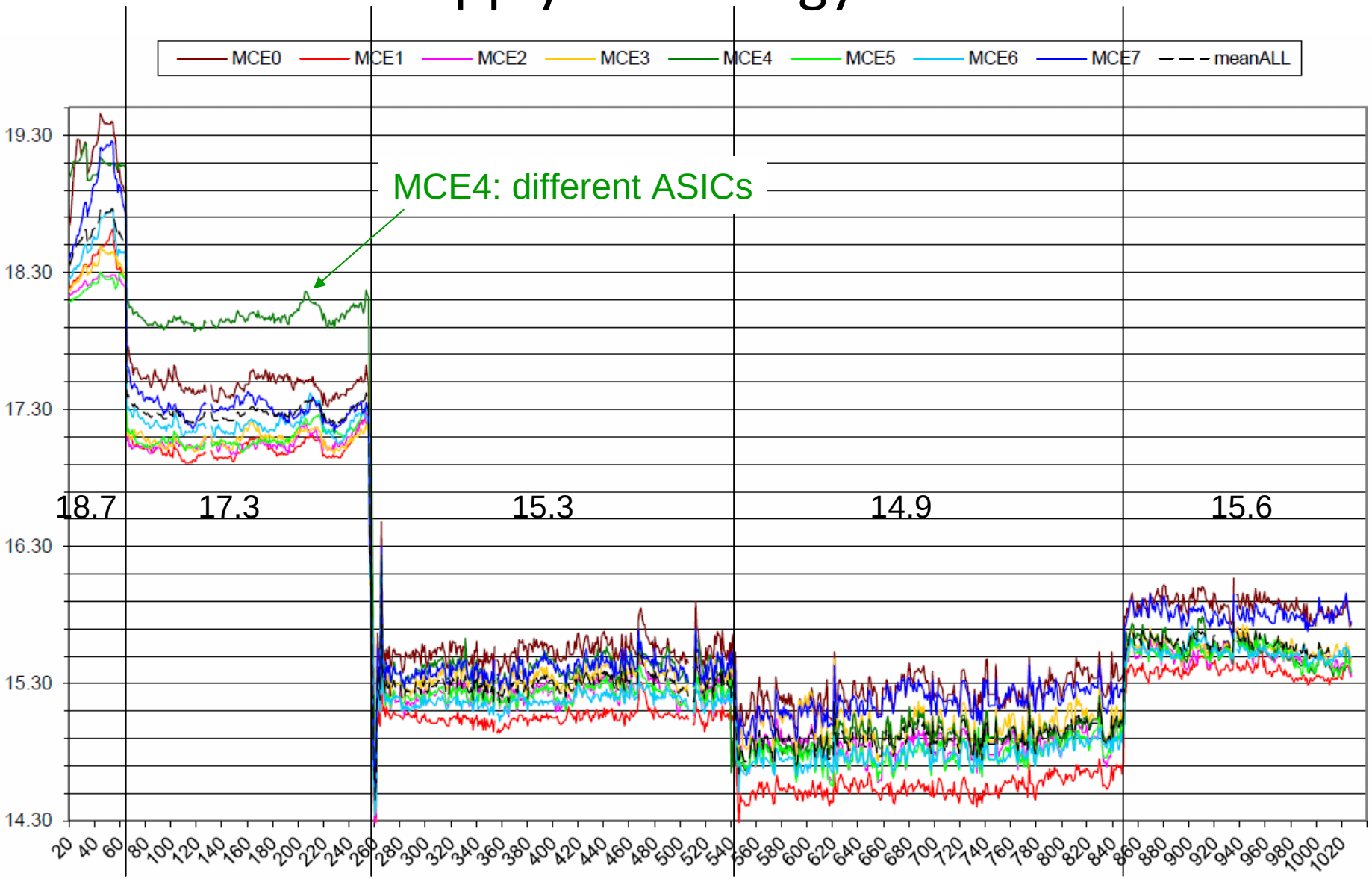
Fit results


Crab Rev.1000–1099
F=0.5*(1 + erf(X–X0 / sqrt(2)*Sigma))
F=0.5*Peak*(1 + erf(X–X0 / sqrt(2)*Sigma))
1019 (X0,sig)=23.22,1.90 / (X0,sig,Peak)=24.10,2.55,1.29
1021 (X0,sig)=23.26,1.88 / (X0,sig,Peak)=24.20,2.57,1.32
1022 (X0,sig)=23.24,1.88 / (X0,sig,Peak)=24.19,2.58,1.32
1023 (X0,sig)=23.36,1.88 / (X0,sig,Peak)=24.28,2.58,1.31
1024 (X0,sig)=23.41,1.86 / (X0,sig,Peak)=24.42,2.60,1.34
Ratio=OSA/Simul
1.5
1.0
0.5
0.0
Simul
1019
1021
1022
1023
1024
counts/s/keV
20
15
10
5
0
15
20
25
30
35
energy [keV]

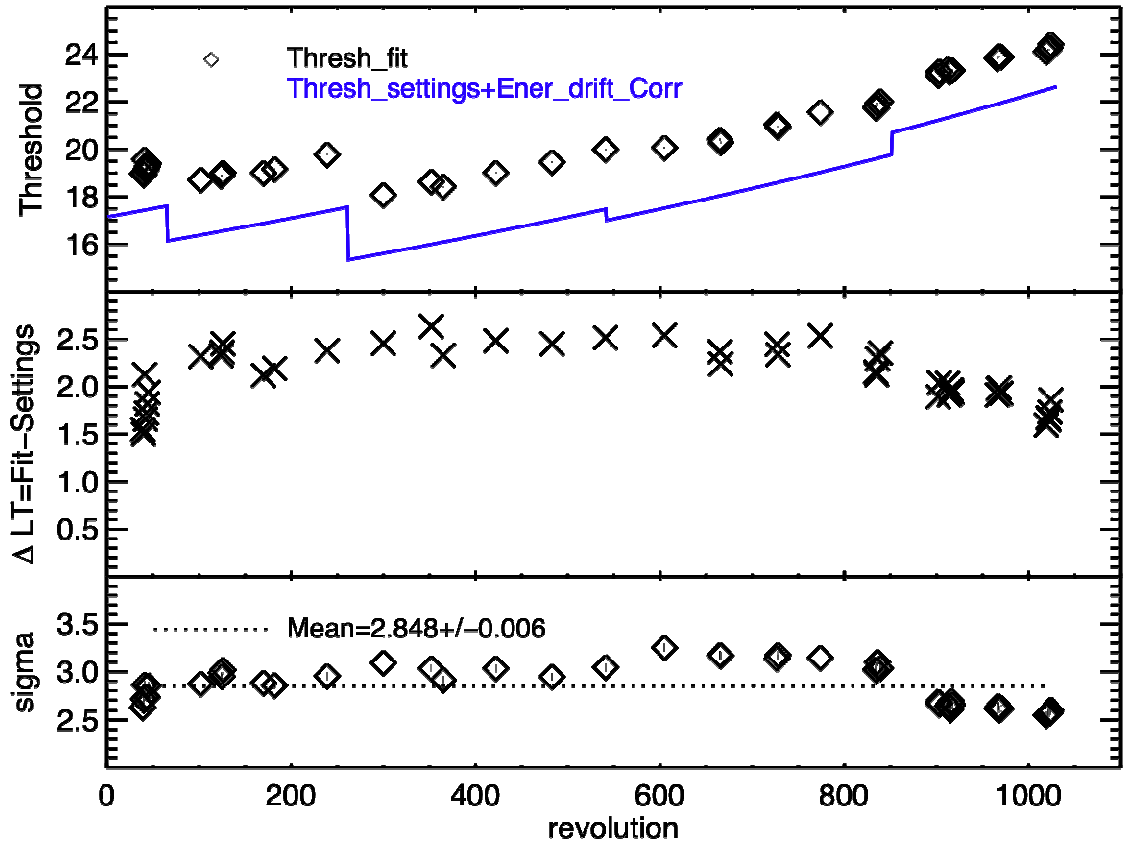
Fit results total



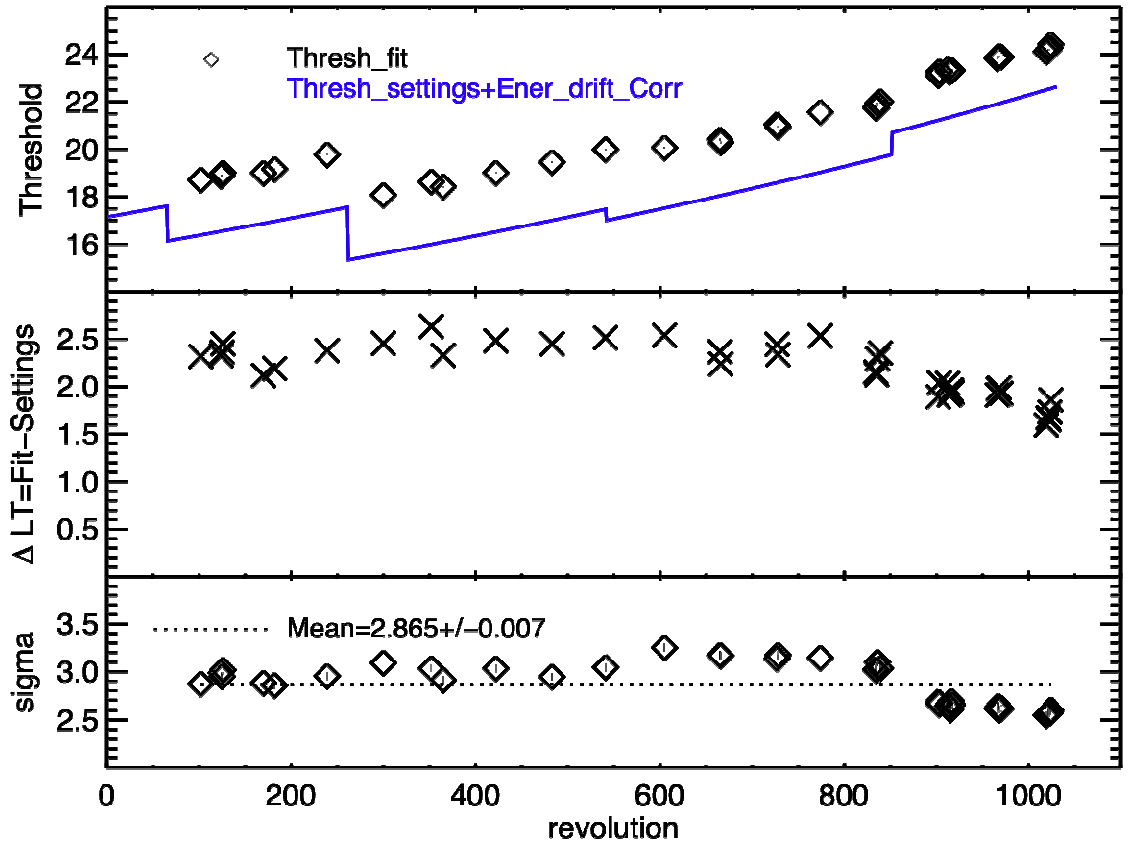
ISGRI low threshold settings
=> we must apply the energy drift correction

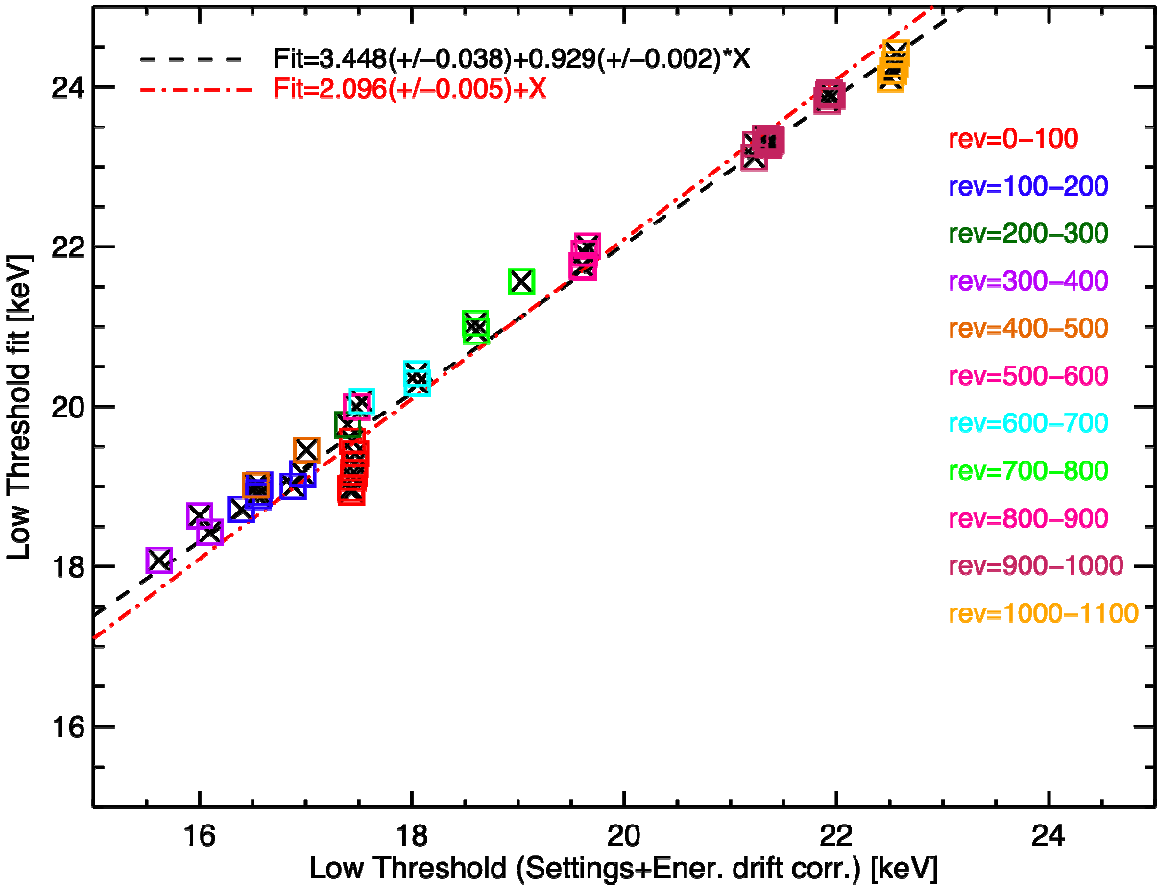


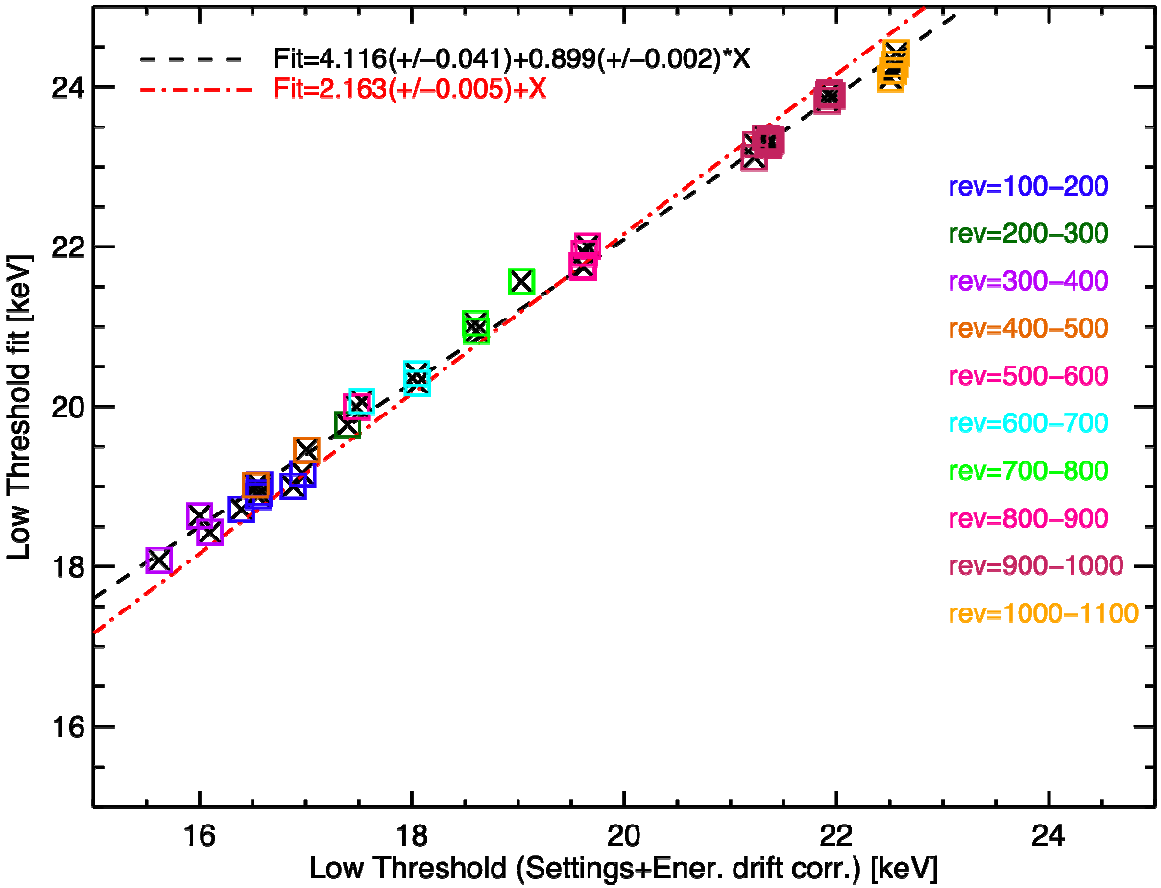
Mean LT settings with energy drift correction (blue)
Comparison with the fitted LT



Mean LT settings with energy drift correction (blue)
Comparison with the fitted LT




Fit=3.448(+/−0.038)+0.929(+/−0.002)*X
Fit=2.096(+/−0.005)+X
rev=0−100
rev=100−200
rev=200−300
rev=300−400
rev=400−500
rev=500−600
rev=600−700
rev=700−800
rev=800−900
rev=900−1000
rev=1000−1100
Low Threshold fit [keV]
Low Threshold (Settings+Ener. drift corr.) [keV]
16
18
20
22
24


Fit=4.116(+/–0.041)+0.899(+/–0.002)*X
Fit=2.163(+/–0.005)+X
rev=100–200
rev=200–300
rev=300–400
rev=400–500
rev=500–600
rev=600–700
rev=700–800
rev=800–900
rev=900–1000
rev=1000–1100
Low Threshold fit [keV]
Low Threshold (Settings+Ener. drift corr.) [keV]
16
18
20
22
24

Status

✓New correction developed in IDL

✓Implemented in OSA

✓Validation between IDL/OSA codes done

•TO DO:

- low threshold correction is underestimated:
  - ✓Suggested correction:

$$New\ LT = 4.12 + 0.9 \times LT_{\mathrm{DriftCorrected}} \qquad \sigma = 2.83$$

- ARFs: to be produced by Lorenzo with our input (Crab spectra for all the mission)