IACHEC campaign on 3C273

Update on Cross-calibration of INTEGRAL with NuSTAR and XMM

Lorenzo Natalucci ([1])
Manuela Molina ([2]), Angela Malizia ([2])

(1) INAF/Institute for Space Astrophysics and Planetology, Rome
(2) INAF/Institute for Space Astrophysics, Bologna, Italy

Campaigns on 3C273

- Results with IACHEC campaigns in 2012, 2015, 2016,2017
- Instruments on Chandra, NuSTAR, Suzaku, XMM and INTEGRAL

Published results

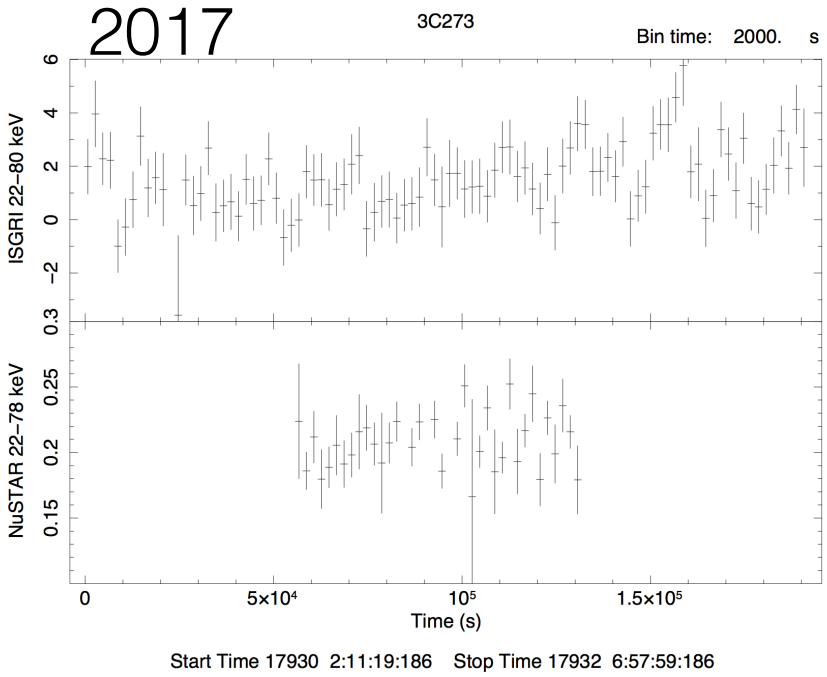
- Previous results of 3C273 with INTEGRAL and NusTAR joint fits published by Madsen et al 2016 (ApJ 812,14)
- Previous results in the soft band (<10 keV) published in Madsen+16 (arXiv: 1609.0903)
- Madsen et al., NuSTAR calibration paper

NuSTAR-INTEGRAL results

- From analysis of single spectra

Exposure times 2017:
INTEGRAL ~2 days
NuSTAR: 35ks

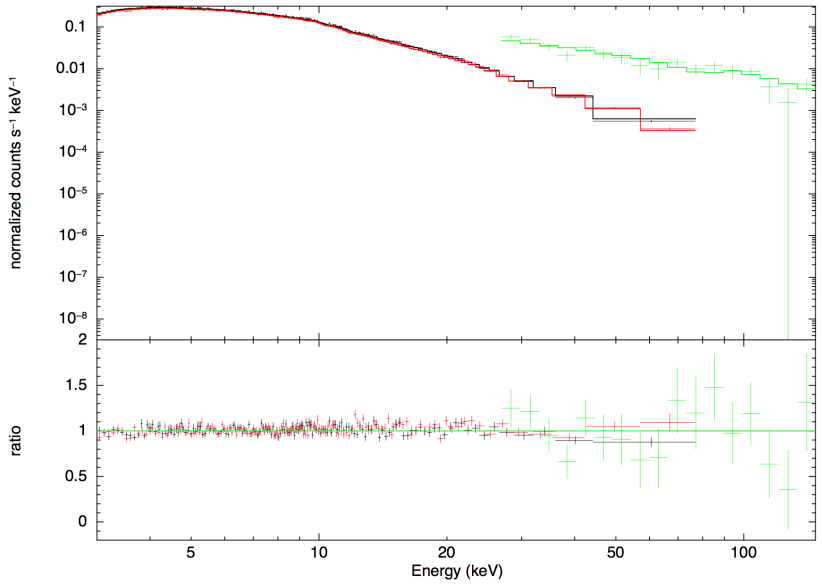
SW & cal versions:
nustardas_06Jul17_v1.8.0 &
CALDB version : 20180126
IBIS OSA10.2



model: wa_g*cflux*po				
Year	Instrument	Γ	$F_{20-40keV}$ (10^{-11}erg cm^{-2}s^{-1})	$\Delta\chi^2$
2012	FPMA	1.674 ± 0.005 (1.669÷1.679)	$6.42^{+0.05}_{-0.04}$ (6.38÷6.47)	0.994
	FPMB	1.664 ± 0.005 (1.659÷1.669)	6.697 ± 0.05 (6.648÷6.748)	
	ISGRI	$1.646^{+0.20}_{-0.19}$ (1.456÷1.846)	$6.418^{+0.77}_{-0.73}$ (5.688÷7.186)	
2015	FPMA	1.727 ± 0.01 (1.717÷1.738)	4.478 ± 0.07 (4.412÷4.545)	1.009
	FPMB	1.706 ± 0.01 (1.695÷1.716)	4.663 ± 0.07 (4.592÷4.735)	
	ISGRI	$2.861^{+1.79}_{-1.05}$ (1.811÷4.646)	$5.85^{+3.28}_{-2.24}$ (3.612÷9.135)	
2016	FPMA	1.606 ± 0.007 (1.599÷1.613)	12.578 ± 0.127 (12.451÷12.705)	1.096
	FPMB	1.609 ± 0.003 (1.602÷1.617)	$12.735^{+0.127}_{-0.14}$ (12.595÷12.862)	
	ISGRI	$1.743^{+0.18}_{-0.17}$ (1.570÷1.928)	$11.927^{+1.258}_{-1.203}$ (10.724÷13.185)	
2017	FPMA	1.700 ± 0.01 (1.690÷1.710)	5.531 ± 0.08 (5.45÷5.612)	1.046
	FPMB	1.651 ± 0.01 (1.641÷1.661)	6.046 ± 0.09 (5.957÷6.139)	
	ISGRI	$1.724^{+0.31}_{-0.28}$ (1.444÷2.033)	$6.367^{+1.18}_{-1.37}$ (5.267÷7.545)	

NuSTAR-INTEGRAL joint fitting (3-110 keV)

model: const*wa$_g$*po							
Year	Γ	$C_{FPMA/ISGRI}$	$C_{FPMB/ISGRI}$	$F^{ISGRI}_{20-40keV}$ (10^{-11}erg cm^{-2}s^{-1})	$F^{FPMA}_{20-40keV}$ (10^{-11}erg cm^{-2}s^{-1})	$F^{FPMB}_{20-40keV}$ (10^{-11}erg cm^{-2}s^{-1})	$\Delta\chi^2$
2012	1.669±0.003	$0.995^{+0.07}_{-0.06}$	$1.024^{+0.07}_{-0.06}$	6.49	6.46	6.65	0.994
2015	1.739±0.012	$1.196^{+0.411}_{-0.244}$	$1.211^{+0.416}_{-0.247}$	3.74	4.47	4.53	1.012
2016	1.608±0.005	1.069±0.06	1.087±0.06	11.73	12.54	12.75	1.094
2017	1.677±0.007	$0.861^{+0.09}_{-0.07}$	$0.88^{+0.09}_{-0.08}$	6.62	5.70	5.84	1.055



IBIS-NuSTAR 2017

NuSTAR-XMM/pn results

- From analysis of single spectra

Exposure times:
NuSTAR: 35ks
XMM: 65 ks

model: wa_g*cflux*po				
Year	Instrument	Γ	$F_{2-10keV}$ (10^{-11}erg cm^{-2}s^{-1})	$\Delta\chi^2$
2012	pn	1.672±0.03	6.937±0.07	0.992
		(1.641÷1.703)	(6.87÷7.00)	
	FPMA	1.651±0.03	7.577±0.10	
		(1.615÷1.687)	(7.473÷7.678)	
	FPMB	1.675±0.04	7.75±0.11	
		(1.637÷1.712)	(7.64÷7.86)	
2015	pn	1.680±0.02	$6.16^{+0.04}_{-0.03}$	1.023
		(1.660÷1.700)	(6.13÷6.20)	
	FPMA	1.706±0.02	6.30±0.05	
		(1.684÷1.728)	(6.25÷6.35)	
	FPMB	1.694±0.02	6.31±0.05	
		(1.672÷1.717)	(6.26÷6.36)	
2016	pn	1.549±0.01	$12.98^{+0.05}_{-0.06}$	1.129
		(1.535÷1.563)	(12.92÷13.03)	
	FPMA	1.585±0.01	$14.24^{+0.08}_{-0.09}$	
		(1.569÷1.601)	(14.15÷14.32)	
	FPMB	1.575±0.02	14.46±0.09	
		(1.558÷1.591)	(14.37÷14.55)	
2017	pn	1.491±0.01	$6.55^{+0.02}_{-0.03}$	1.051
		(1.478÷1.503)	(6.52÷6.57)	
	FPMA	1.625±0.02	$7.32^{+0.06}_{-0.07}$	
		(1.603÷1.648)	(7.25÷7.38)	
	FPMB	1.623±0.02	$7.41^{+0.06}_{-0.07}$	
		(1.600÷1.645)	(7.34÷7.47)	

NuSTAR-XMM joint fitting

model: const*wa$_g$*po							
Year	Γ	$C_{FPMA/XMM}$	$C_{FPMB/XMM}$	$F^{XMM}_{2-10keV}$ (10^{-11}erg cm^{-2}s^{-1})	$F^{FPMA}_{2-10keV}$ (10^{-11}erg cm^{-2}s^{-1})	$F^{FPMB}_{2-10keV}$ (10^{-11}erg cm^{-2}s^{-1})	$\Delta\chi^2$
2012	1.667±0.02	1.095±0.02	1.115±0.02	6.926	7.588	7.724	0.987
2015	1.693±0.01	1.019±0.01	1.023±0.01	6.15	6.27	6.30	1.021
2016	1.567±0.01	1.093±0.01	1.113±0.01	12.95	14.17	14.42	1.131
2017	1.541±0.01	1.10±0.01	1.114±0.01	6.53	7.18	7.27	1.116

Conclusions

- NuSTAR vs INTEGRAL good agreement confirmed within ~10% (mostly limited by the low statistics)
- epic-PN spectra significantly harder than NuSTAR in the 2017 observation
- epic-PN flux normalisation lower than NuSTAR (~10%).