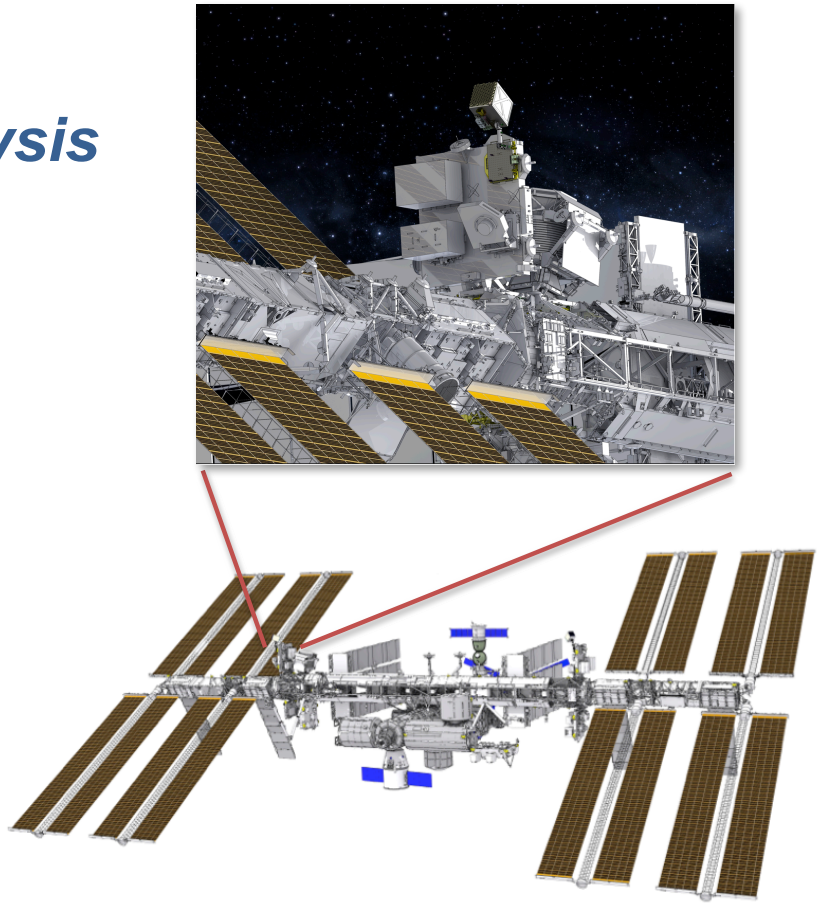
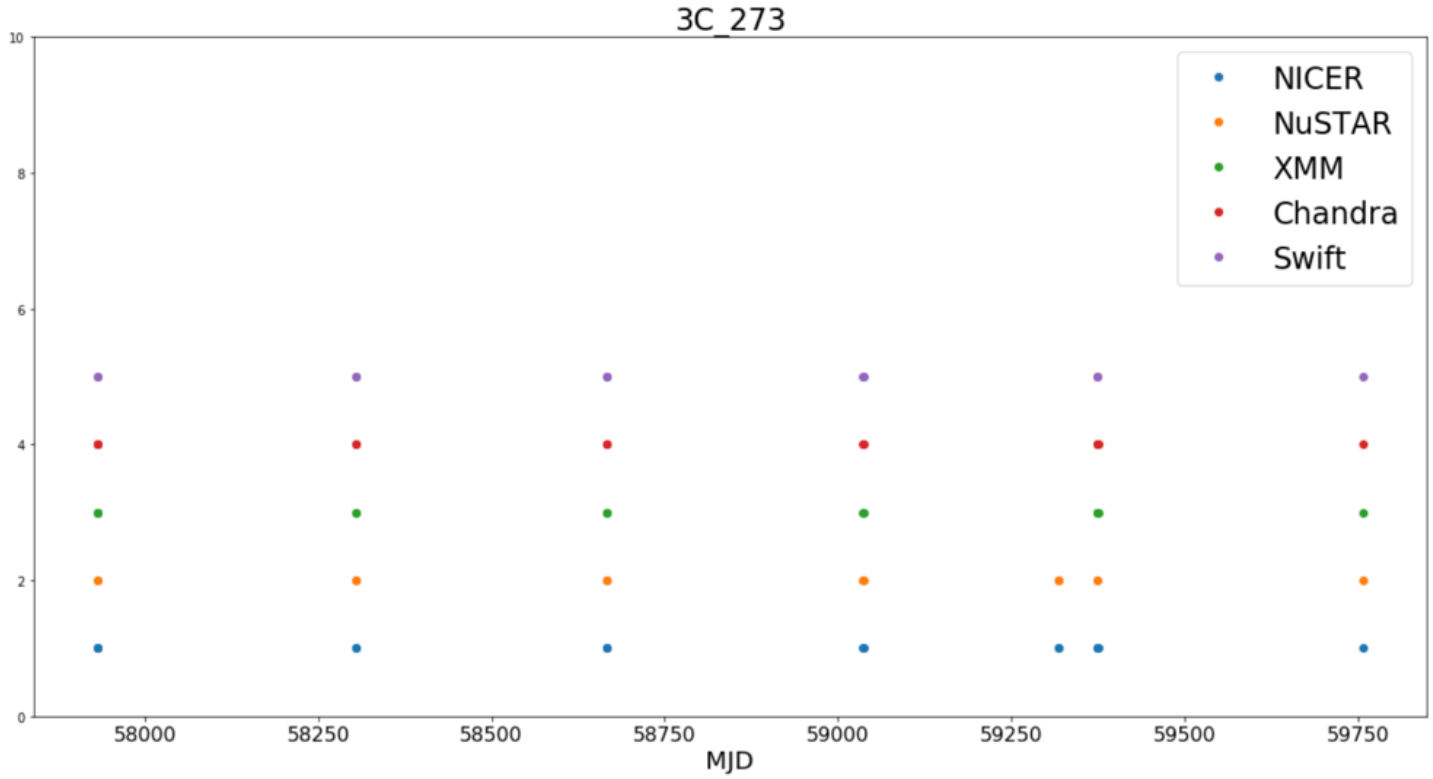

NICER
Neutron star Interior Composition ExploreR
A NICER Look at Cross-calibration using 3C 273
Jeremy Hare (NASA/GSFC/CRESST/CUA)
on behalf of the NICER team
NASA
GSFC
MIT KAVLI INSTITUTE
DTU
BROAD REACH
MOOG

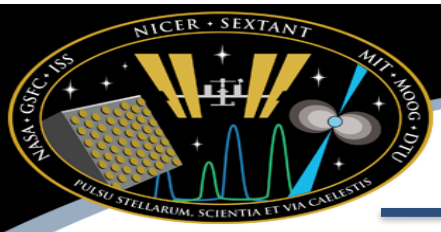
Overview

1) Update on 3C 273 analysis
2) IACHEC Online
3) Looking Forward
4) Summary



IACHEC Observing Campaign 3C 273

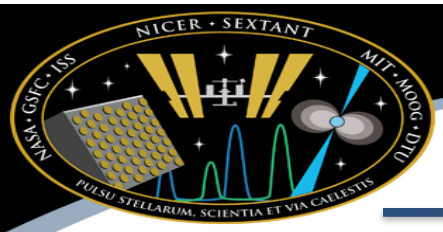




IACHEC Observing Campaign 3C 273

6 total epochs included

TIME	NIC_ID	NU_ID	NU_S	CH_ID	CH_S	XMM_ID	XMM_S	SW_ID_1	SW_S_1
57931	10100101	10302020002	S	19867	S	414191301	S	50900023	S
57931	10100102	10302020002	S	19867	S	414191301	S	50900024	S
58304	1010100104	10402020006	S	20709	S	414191401	S	50900025	S
58304	1010100105	10402020006	S	20709	S	414191401	S	50900025	S
58667	2010100101	10502620002	S	21815	NS	810820101	S	50900026	S
58667	2010100102	10502620002	S	21815	S	810820101	S	50900027	S
59036	3010100101	10602606002	S	22828	S	810821501	S	89029001	S
59037	3010100102	10602606002	S	22828	NS	810821501	S	89029002	S
59375	4010100101	10702608002	S	24585	NS	810821601	S	50900028	S
59375	4010100102	10702608002	S	24585	S	810821601	S	50900029	S
59758	5010100105	10802608002	S	25691	S	810821901	S	89372001	S

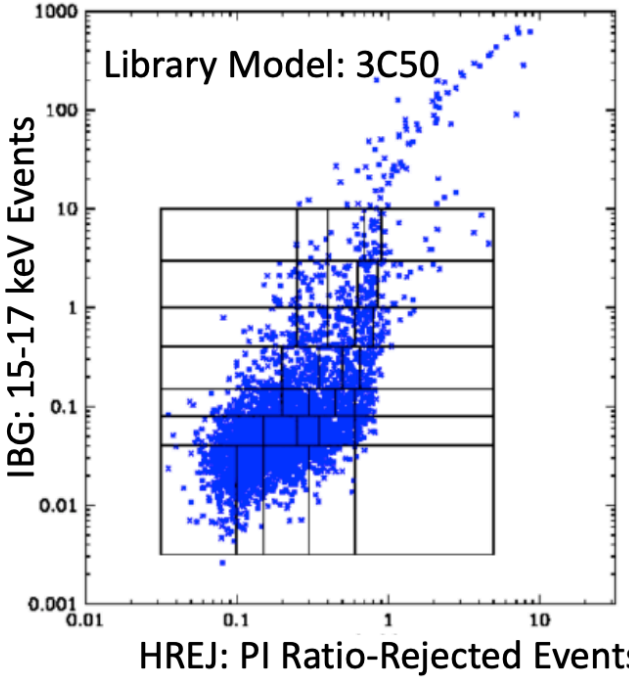


Automated Analysis Pipelines

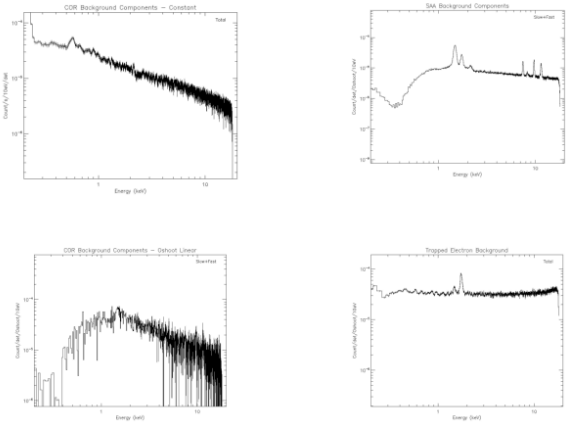
- Jupyter notebooks which run the end to end spectra and light curve extractions, fit the spectra and plot confidence contours and light curves
- NICER and NuSTAR analysis using heasoft and standard analysis tools (I.e., nicerl2, nicerl3-spect, nupipeline)
- Swift using online XRT reduction pipeline called by python API
- Chandra using CIAO and standard reduction procedures from analysis threads
- XMM using SAS and standard reduction procedures from analysis threads implemented by personal scripts

Analysis choices

Remillard et al. 2022



Template Model: SCORPEON



NICER is non-imaging must rely on blank sky or background models for background subtraction

- Break parameter space into cells, measure background in each shell (library of spectra)
- Application: calculate exposure in each shell, make weighted sum of library spectra

- Measure "basis vector" of each unique component
  - Make smoothed version of template as XSPEC model
- Normalized based on known telemetry (overshoots, etc)
- Application: predict norms from telemetry & load into XSPEC

Analysis choices

- As mentioned yesterday XMM now implementing corrections based on NuSTAR
- Previously performed both correction and non-correction fits
- Now moving to correction only fits using fluxcorr and caladjustment
- Merging both NICER observations and both Swift observations when there is more than 1 obsID
- Not using simultaneous windows

- My philosophy has been to analyze data as a typical user would as I think these results are most useful to community

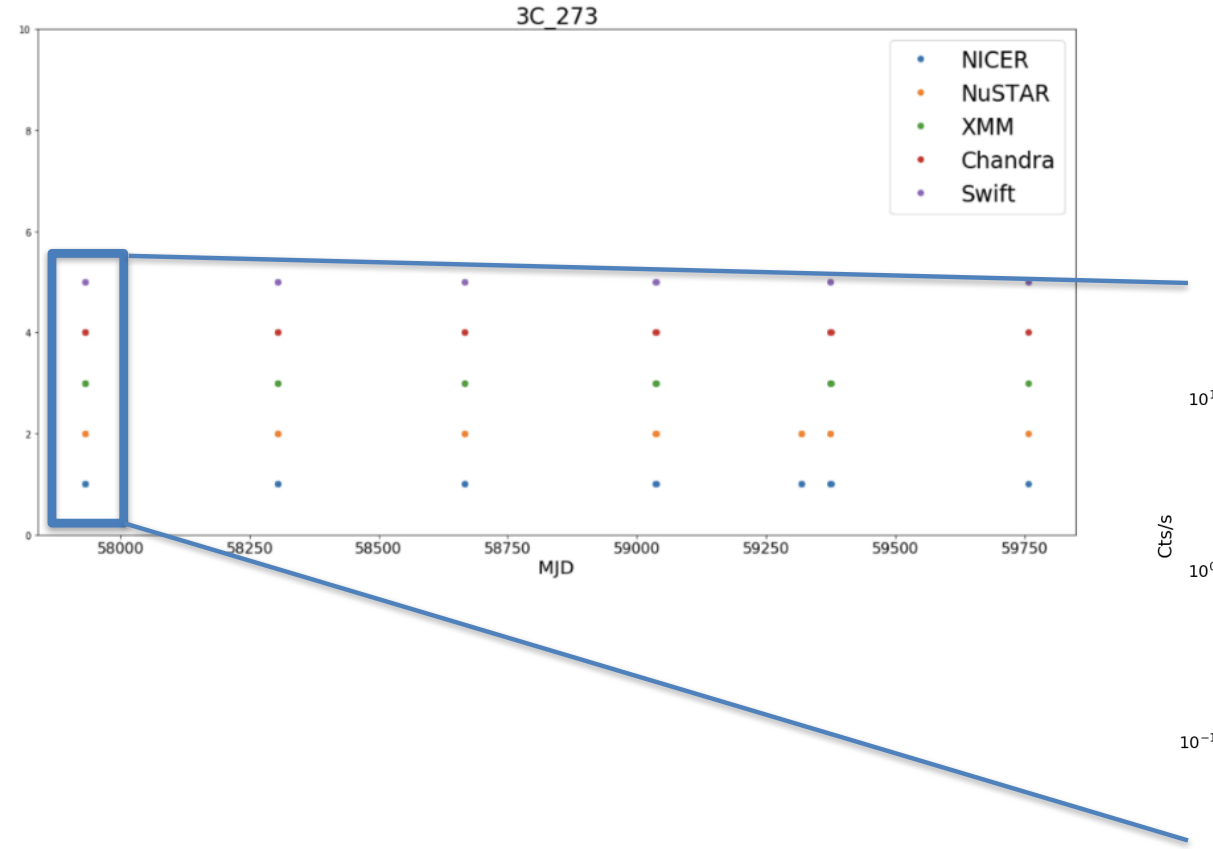
IACHEC Observing Campaign 3C 273

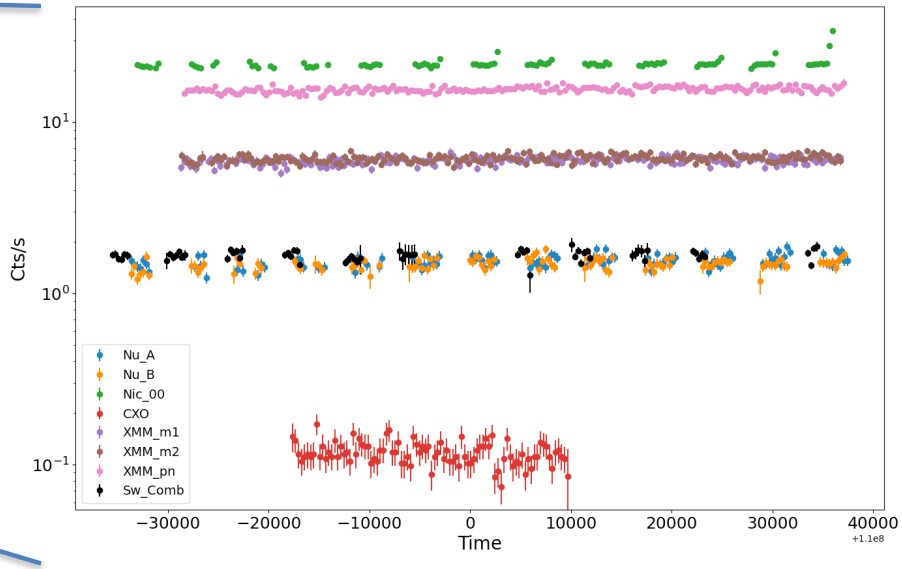
- Would be great for each observatory to assign a lead to look over these analysis scripts/decisions to ensure they follow best practices. I am happy to share these analysis scripts for review.

Procedure

- Followed Madsen et al. (2017)
- Spectra extracted from each observatory following standard procedures (e.g., reprocessing, cleaning)
- Spectra binned to 1 count per bin for use with C-stat
- Spectra fit in 1-5 and 3-7 keV energy ranges
- Updated HI4PI N_H maps give 1.69×10^{20} cm^{-2} (HI4PI collab. et al. 2016)
- N_H fixed to 1.79×10^{20} cm^{-2} using Wilms abundances (Wilms et al. 2000) and Verner cross-sections (Verner et al. 1996)
- C-stat used for fitting spectra
- Chi-square/d.o.f. reported by loading in best-fit cstat model and using 50 cts/bin data

First NICER observation of 3C 273





First observation light curves

NICER

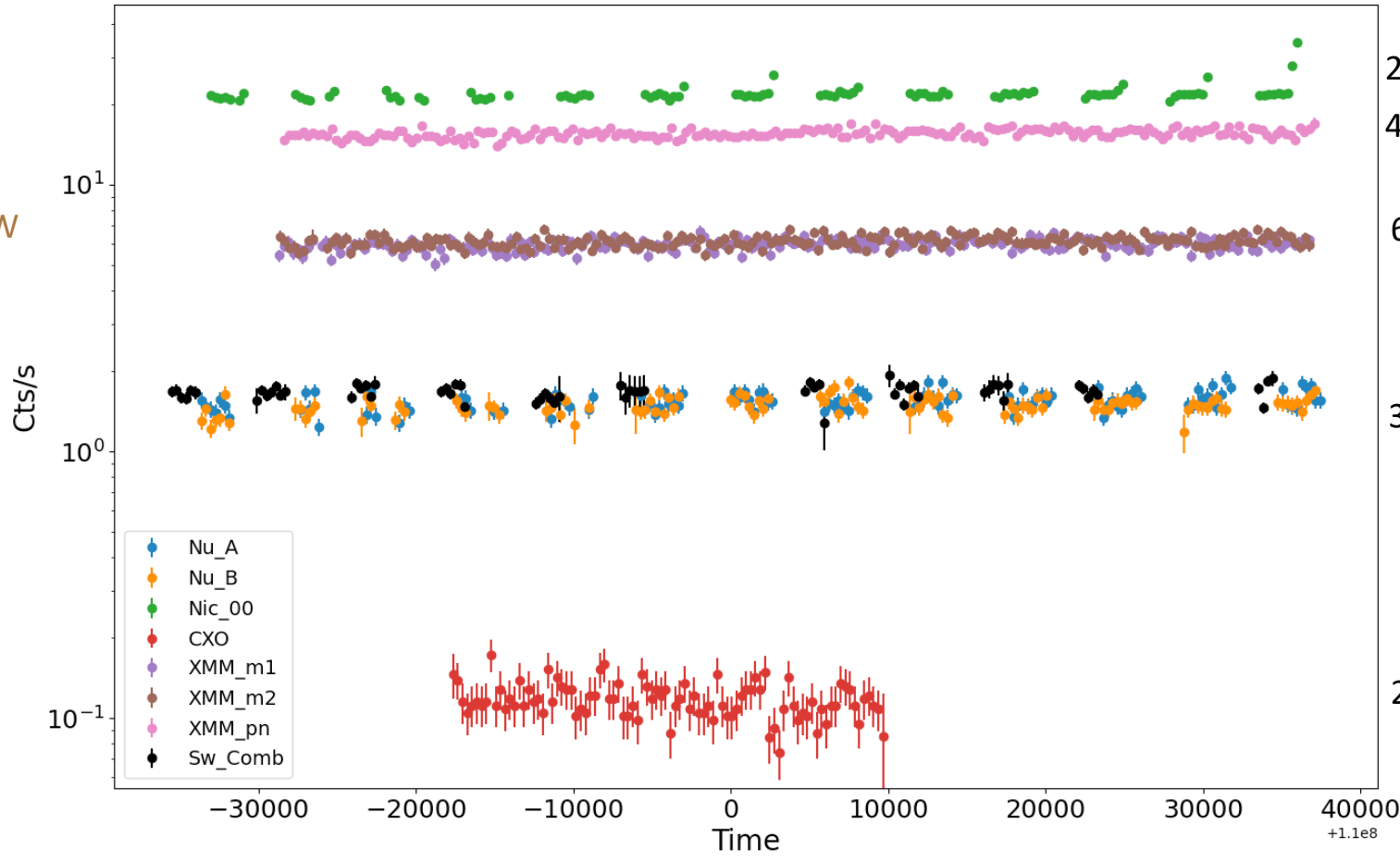
XMM pn (SW)

XMM MOS1/2 SW

Swift-XRT WT

NuSTAR FMPA/B

Chandra HETGS



26.75 ks

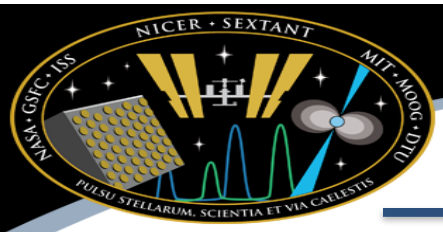
45.9 ks

64.5/62.7 ks

6.7/11.7 ks

34.7 ks

26.9 ks

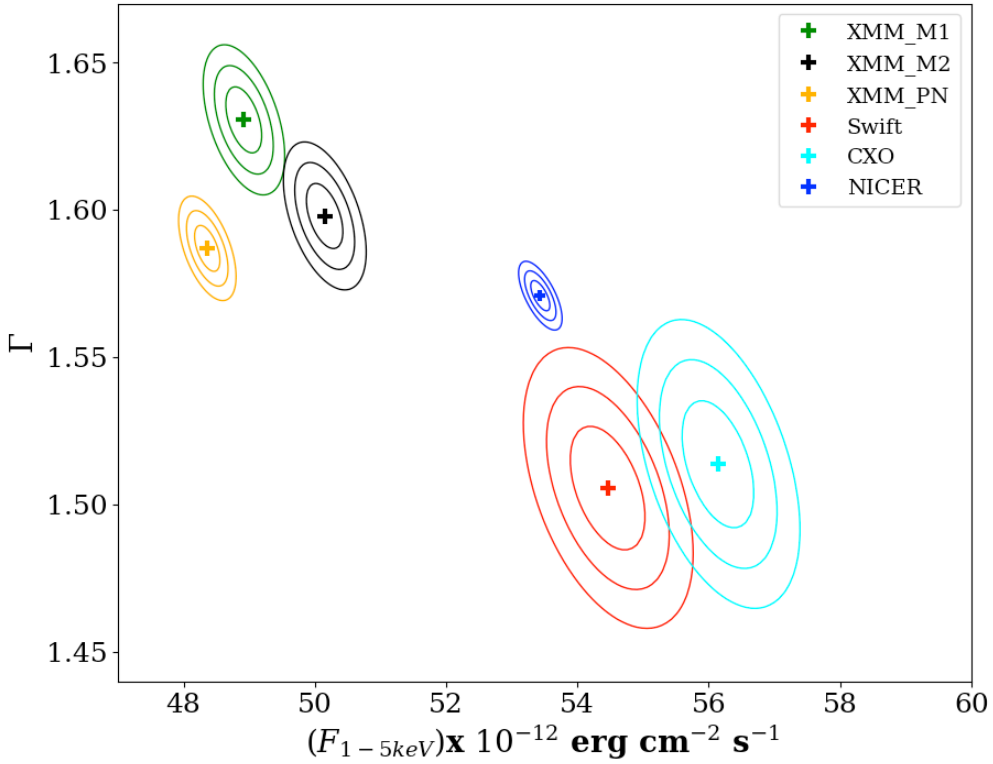


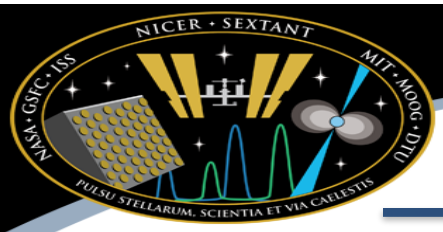
Preliminary Results 1-5 keV

Table 1. NEW Fits performed in the 1-5 keV energy range.

Obs.	Bkg	ObsID	$N_{\rm H}$	Γ	$F_{1-5\ \rm keV}$	χ^2/dof
			10^{20} cm^{-2}		10^{-11} cgs	
NIC	3C50	10100100	1.79	1.571(3)	5.34(1)	361.10/397
CXO	Sub	19867	1.79	1.51(1)	5.61(4)	228.14/583
Sw	Sub	23+24	1.79	1.51(1)	5.45(4)	339.05/361
$XMM_{PN,abs}$	Sub	0414191301	1.79	1.590(5)	4.83(1)	887.03/800
$XMM_{MOS1,abs}$	Sub	0414191301	1.79	1.632(7)	4.89(2)	721.77/664
$XMM_{MOS2,abs}$	Sub	0414191301	1.79	1.596(7)	5.02(2)	686.90/675

Preliminary Results 1-5 keV



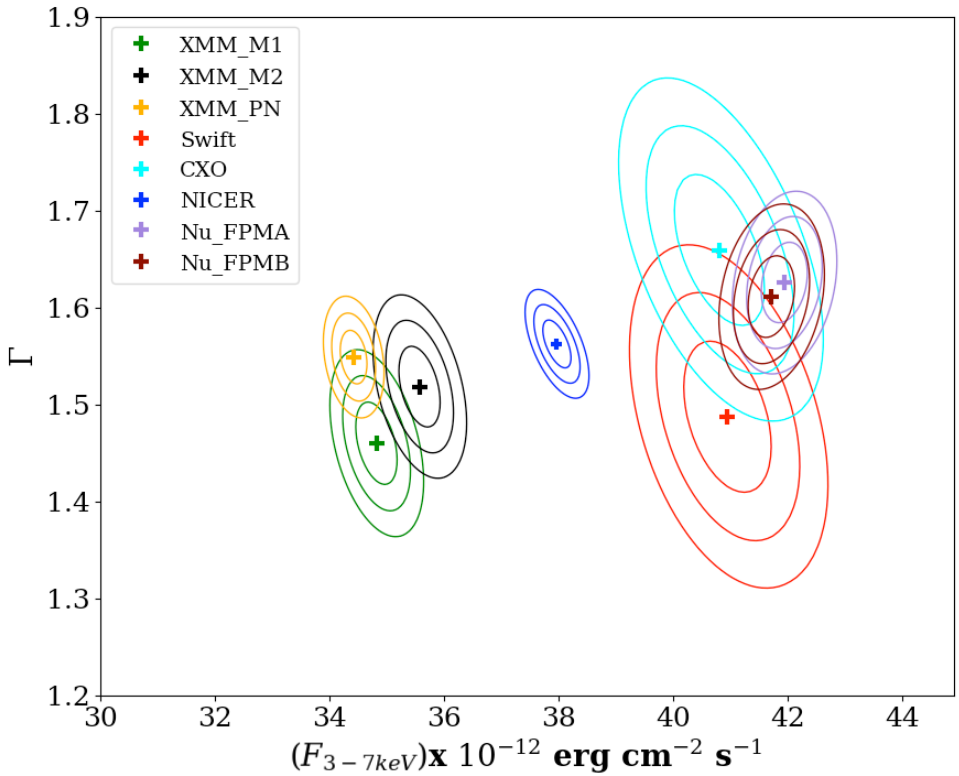


Preliminary Results 3-7 keV

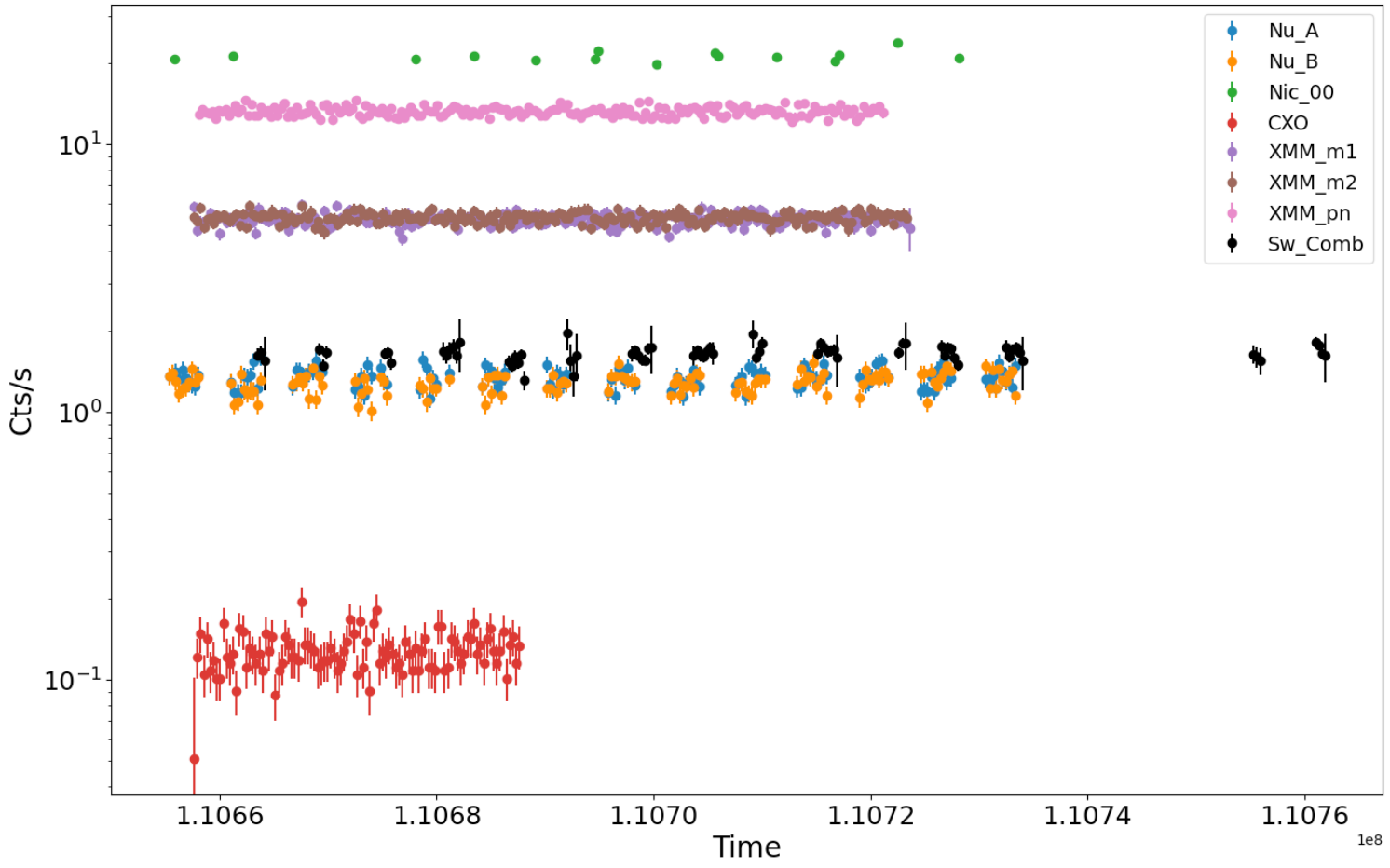
Table 3. NEW Fits performed in the 3-7 keV energy range using cstat.

Obs.	Bkg	ObsID	$N_{\rm H}$	Γ	$F_{1-5\ \rm keV}$	χ^2/dof
			10^{20} cm^{-2}		10^{-11} cgs	
NIC	3C50	10100100	1.79	1.56(2)	3.79(2)	409.35/397
$\rm XMM_{PN,abscorr}$	Sub	0414191301	1.79	1.55(2)	3.43(2)	852.11/797
$\rm XMM_{M1,abscorr}$	Sub	0414191301	1.79	1.46(3)	3.48(2)	416.55/380
$\rm XMM_{M2,abscorr}$	Sub	0414191301	1.79	1.51(3)	3.56(2)	424.64/395
CXO	Sub	19867	1.79	1.65(5)	4.08(5)	68.35/158
Swift	Sub	23+24	1.79	1.49(5)	4.10	127.5/139
$\rm NuSTAR_{FPMA}$	Sub	10302020002	1.79	1.62(3)	4.19(3)	98.27/97
$\rm NuSTAR_{FPMB}$	Sub	10302020002	1.79	1.61(3)	4.16(3)	107.18/97

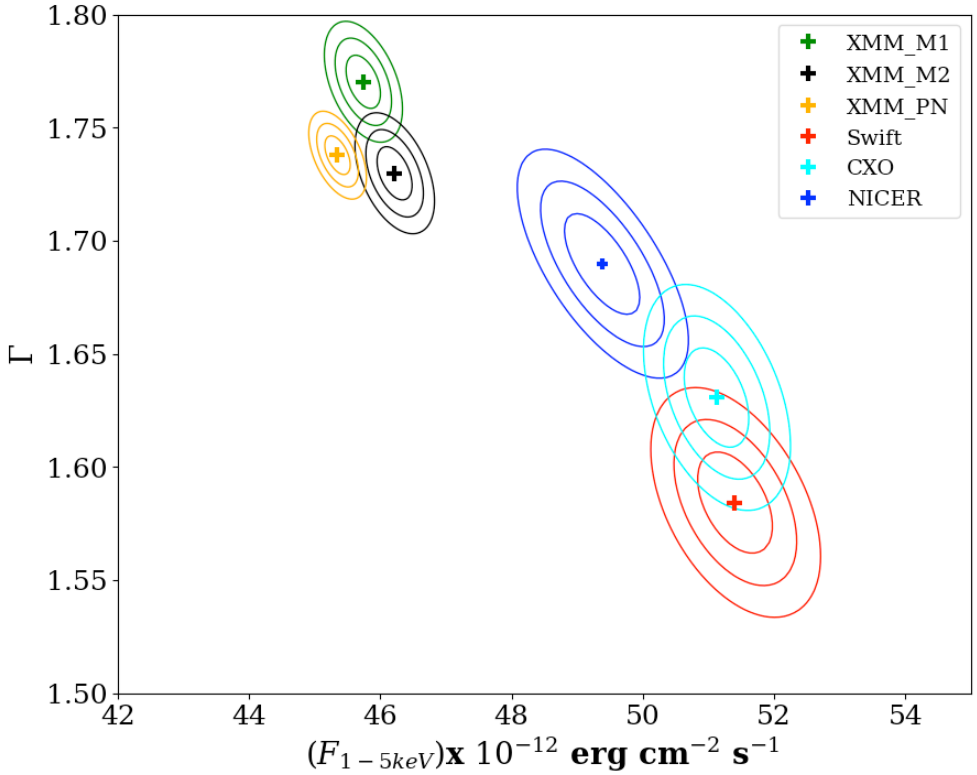
Preliminary Results 3-7 keV

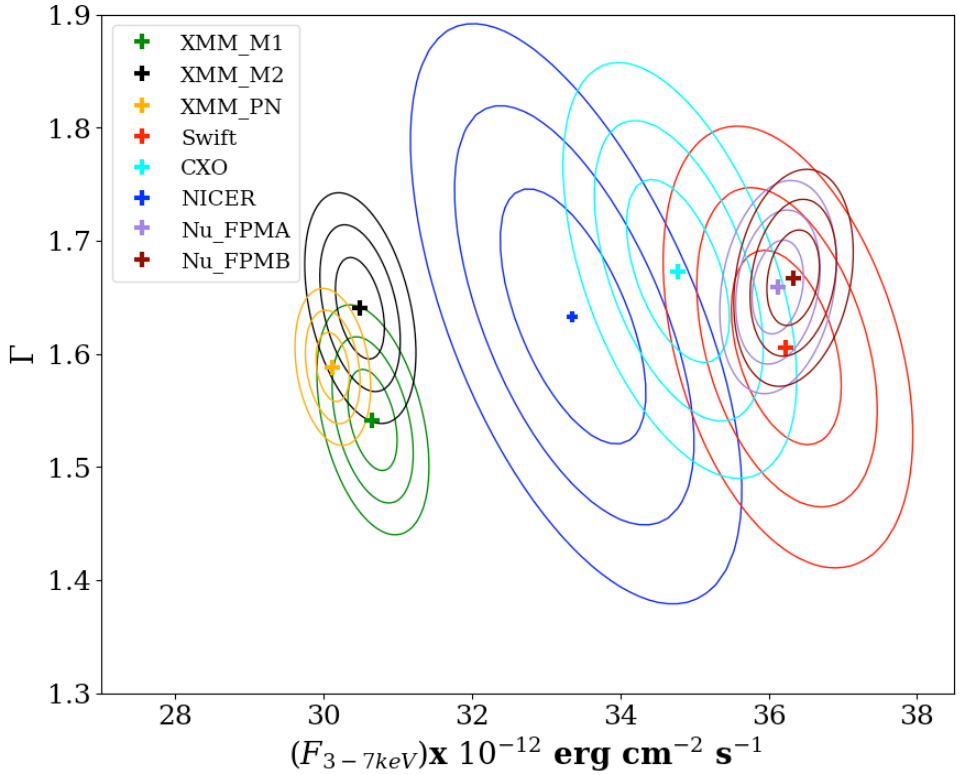


Second Observation

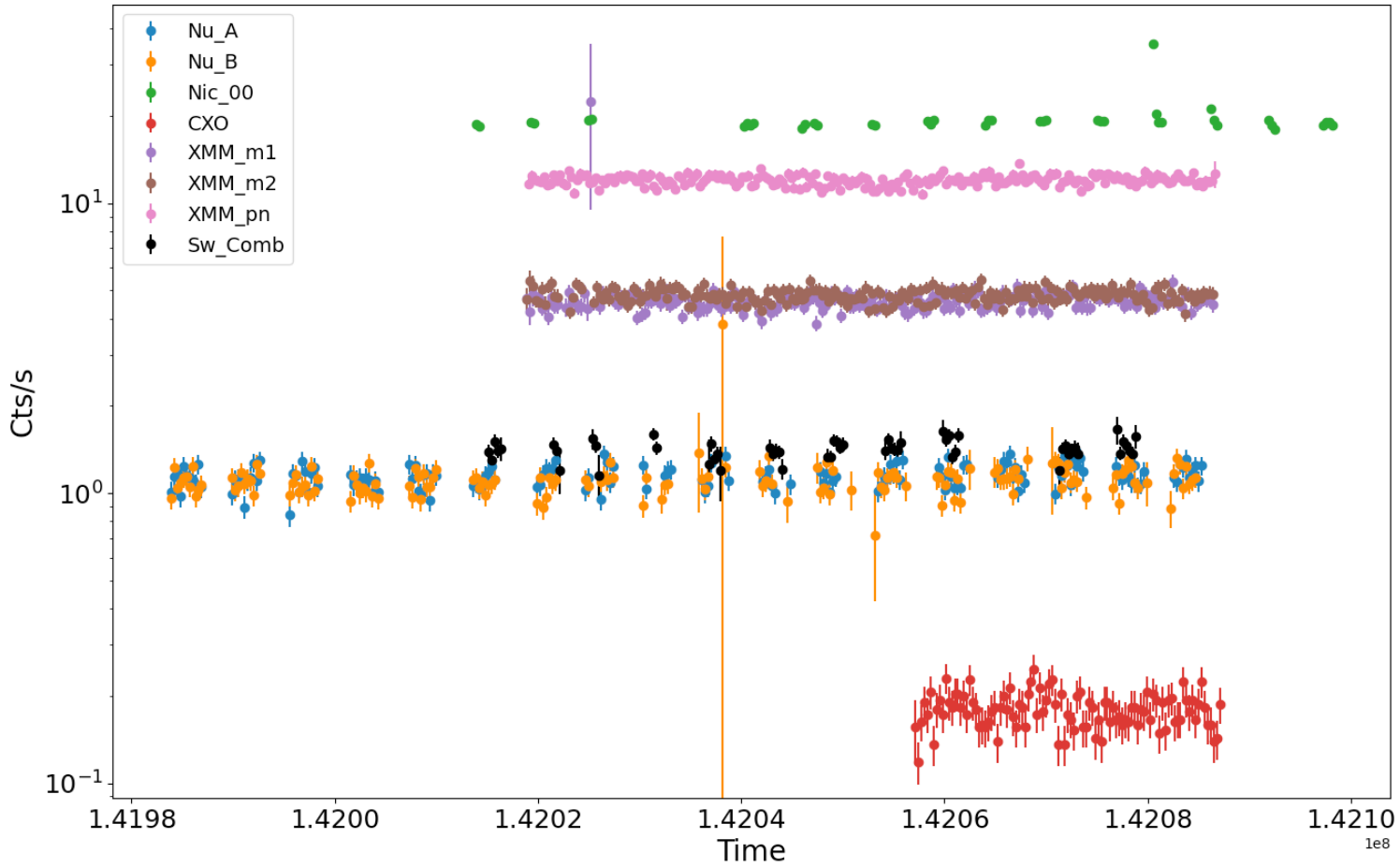


Second Observation

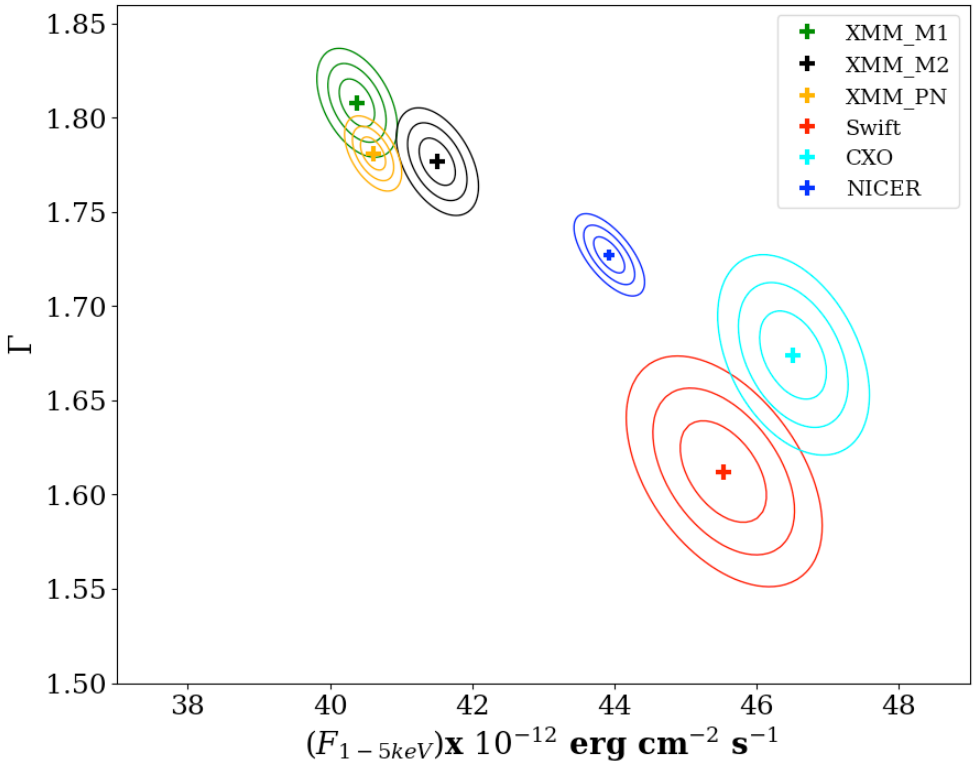


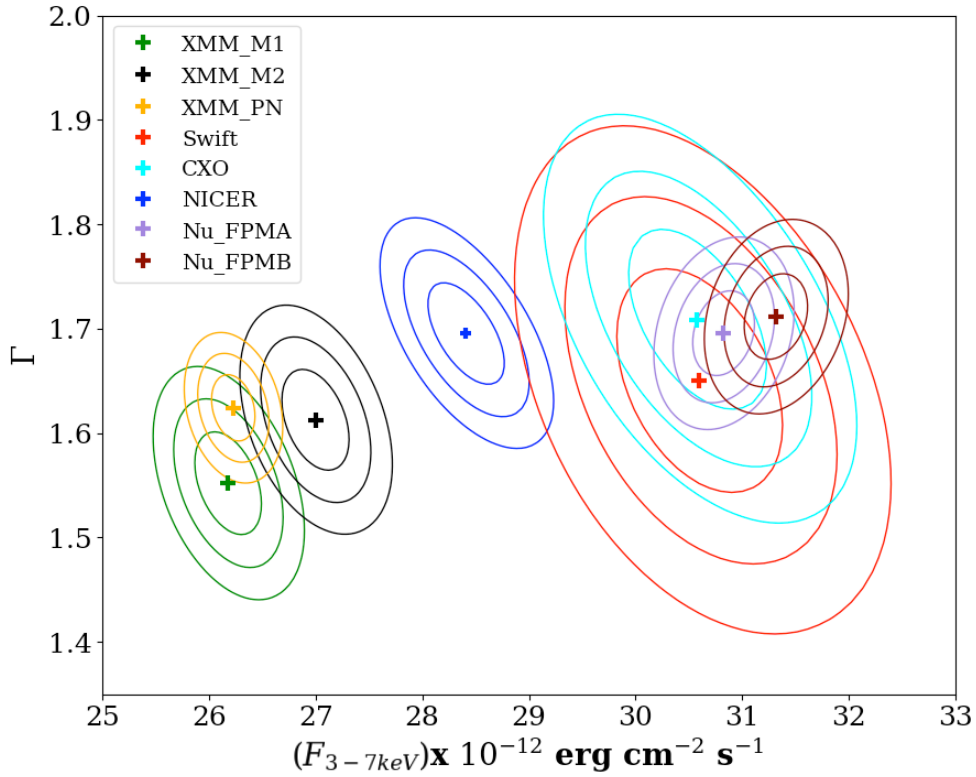


Third observation

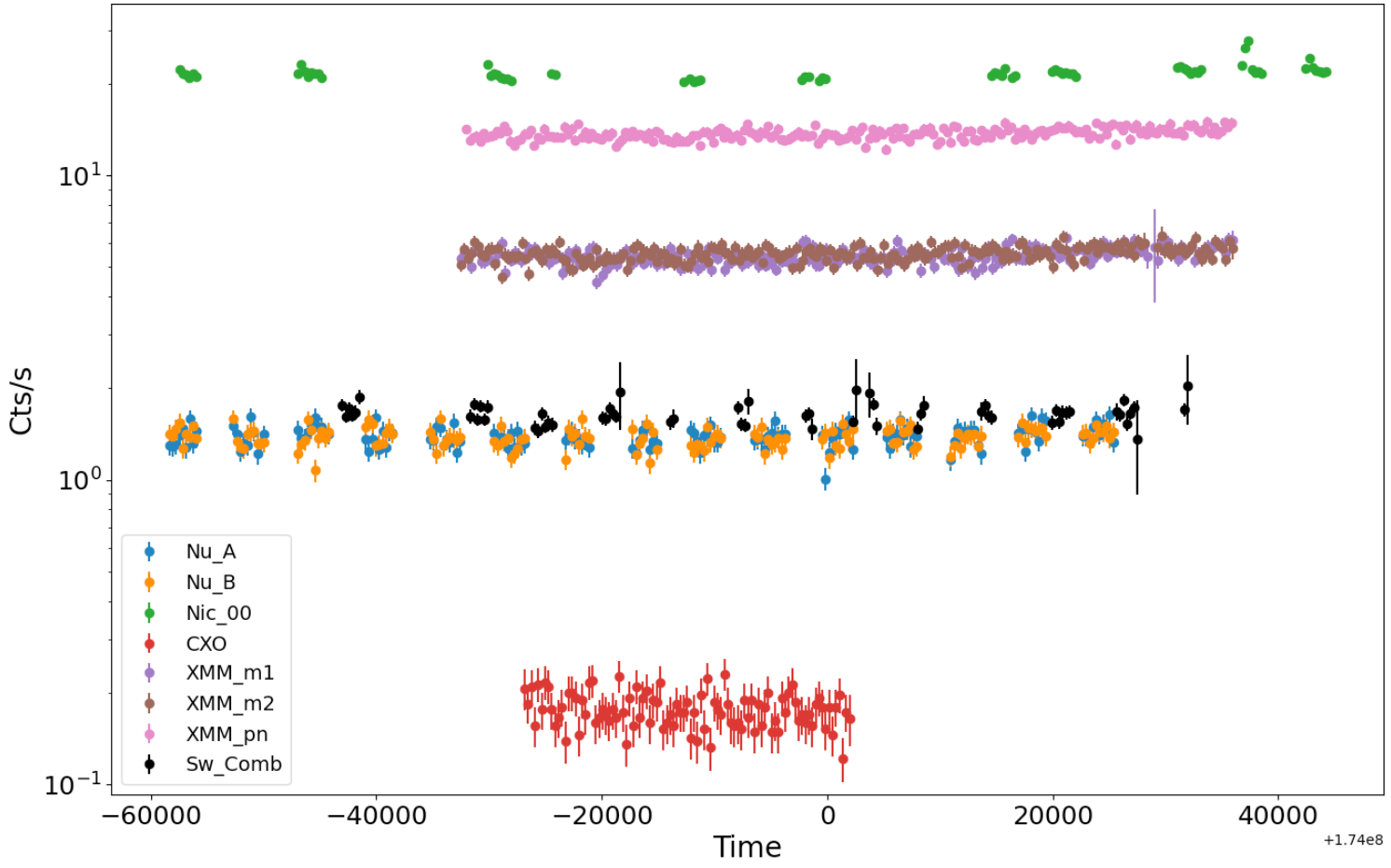


Third observation

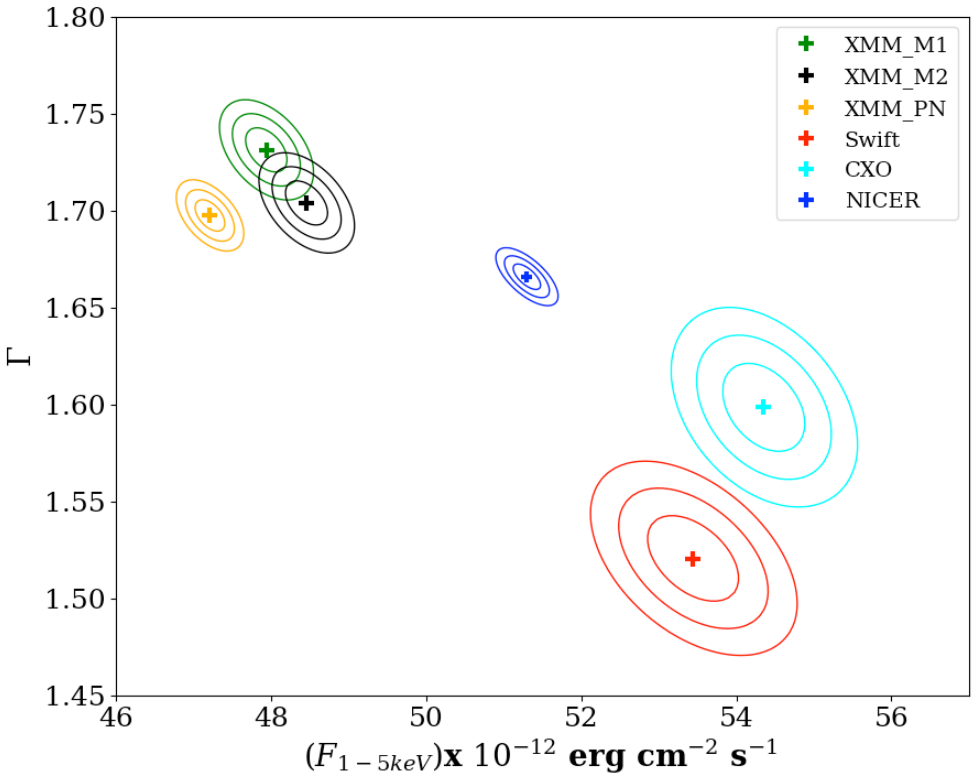


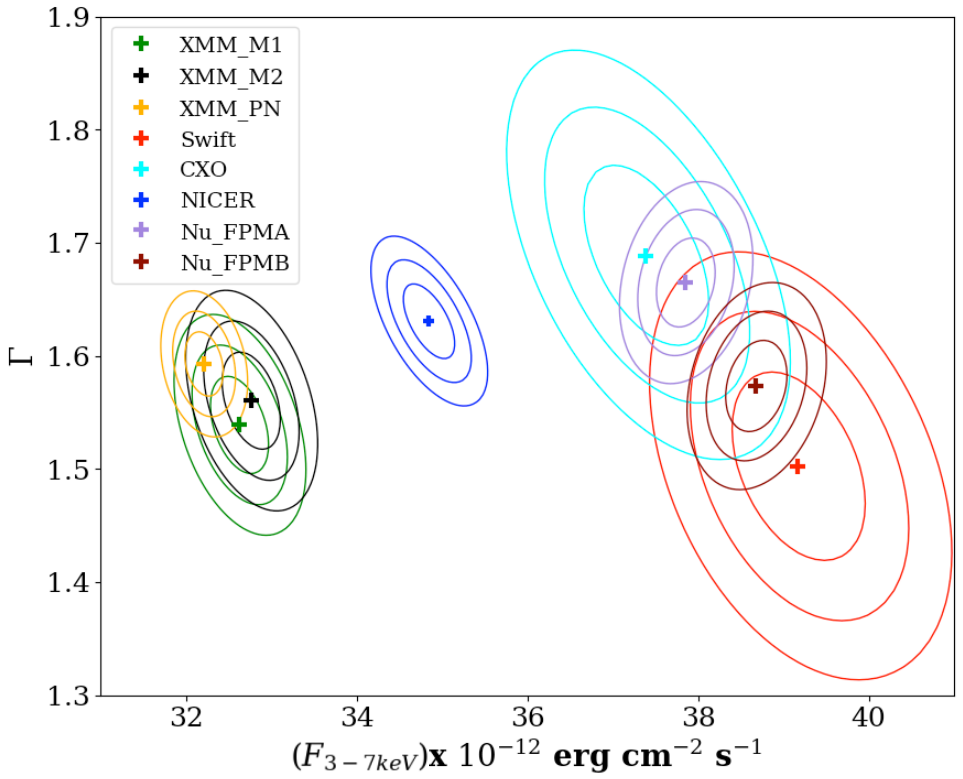


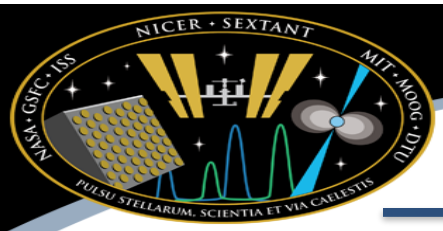
Fourth observation



Fourth Observation

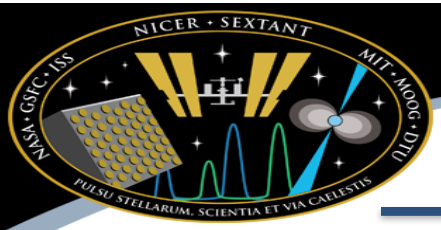






Fifth and Sixth observations

- Issue with XMM in the fifth observation, could use help diagnosing issue
- Also issue with Swift in 6th observation, will work with Swift team to resolve



3C 273 Observations and Data Overview

Made by Felix

Created by Felix Fuerst, last modified on Jul 28, 2023 05:37

Purpose

This page is intended to collect all relevant observations of 3C273 performed under the coordinated IACHEC calibration program. We want to collect observation information (e.g., dates, exposure times, modes, etc.) as well as the extracted data by the instrument teams. The data will be available for use by any calibration team within the IACHEC consortium to perform instrument calibration.

Common GTIs

While most observations have a significant overlap, the start and stop times between the different missions do not align. We aim to provide a set of common GTIs that should be used for all instruments to select on the most useful overlapping time range. Data should be provided for the whole observation for each instrument, as well as the one filtered for the common GTI.

Observation overview

2021

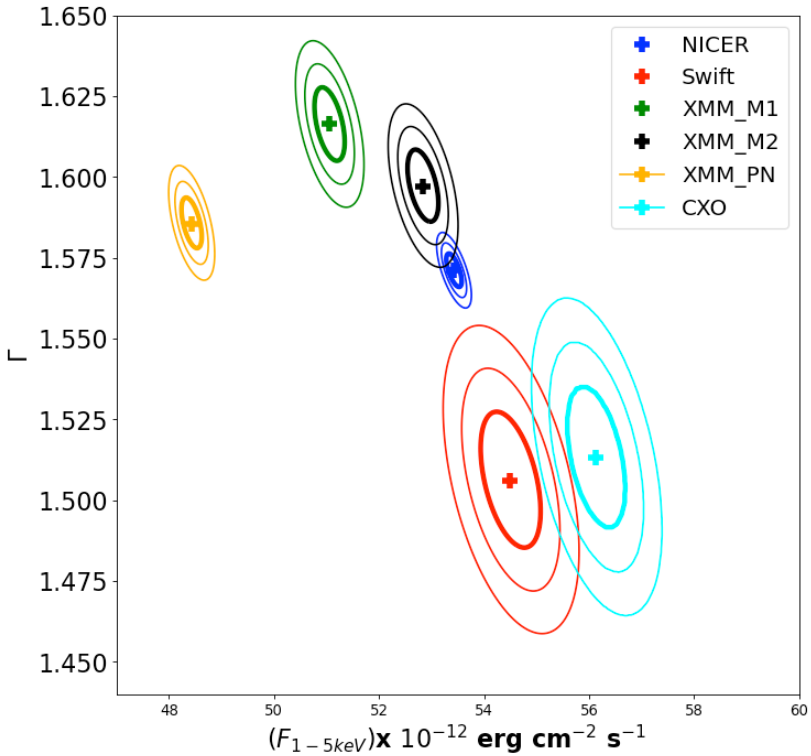
Instrument	ObsID	StartDate	EndDate	Good exposure	Link to Data
XMM-Newton EPIC/pn	0810821601	2021-06-09 19:26:58	2021-06-10 13:30:18		
NuSTAR FPM	10702608002	2021-06-09 18:36:09			
Chandra	24585				

2020

Instrument	ObsID	StartDate	EndDate	Good exposure (ks)	Link to Data
XMM-Newton EPIC/pn	0810821501	2020-07-06 11:59:20	2020-07-07 07:24:20	47.632	0810821501_ann135-720_spec.tar.gz
NuSTAR FPM	10602606002	2020-07-06 04:56:09	2020-07-08 08:22:01		
Chandra	22828				

IACHEC Online

- Website will include spectra and light curves reduced by each observatory team (currently my scripts)
- Python notebooks that fit the spectra
- Models used will also be included
- Notebooks can be used to choose energy ranges and produce contour plots
- Currently any energy ranges can be used so these notebooks can also easily be used for concordance studies with minor tweaking



IACHEC Online

- Plan to eventually include analysis scripts through Python notebooks, which will download the observations and reduce them, fit the spectra, and plot contours.
- HEASARC agreed to host the products. Have all relevant spectra and light curve files to host, will work towards this goal this summer.

Looking Forward

- Goal is to publish results of these 6 3C 273 observations and advertise the online calibration platform
- Analyze 2 additional observing campaigns in 2024 and 2025
- Add new observatories (e.g., IXPE, XRISM)
- Have been in contact with IXPE team have a lead for that analysis notebook
- Any other missions that have taken part in the observing campaigns and want to join please let me know!
- Expand to other calibration targets?

Summary

- NICER has taken part in 6 (7 with NuSTAR) calibration observing campaigns of 3C 273
- Automated the analysis of these is observations, results still consistent with Madsen et al. (2017)
- Have been working with HEASARC to create a webpage to host the IACHEC cross-calibration campaign results. Hoping to start adding data there this summer.

- I appreciate any feedback, questions, and/or suggestions!