

IACHEC

International Astronomical Consortium for High Energy Calibration



**Coordinated  
Observations  
Working Group**

Report for IACHEC Fall WG meeting

Karl Forster (Caltech)

Nov 10<sup>th</sup>, 2021



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**The Big Finish**

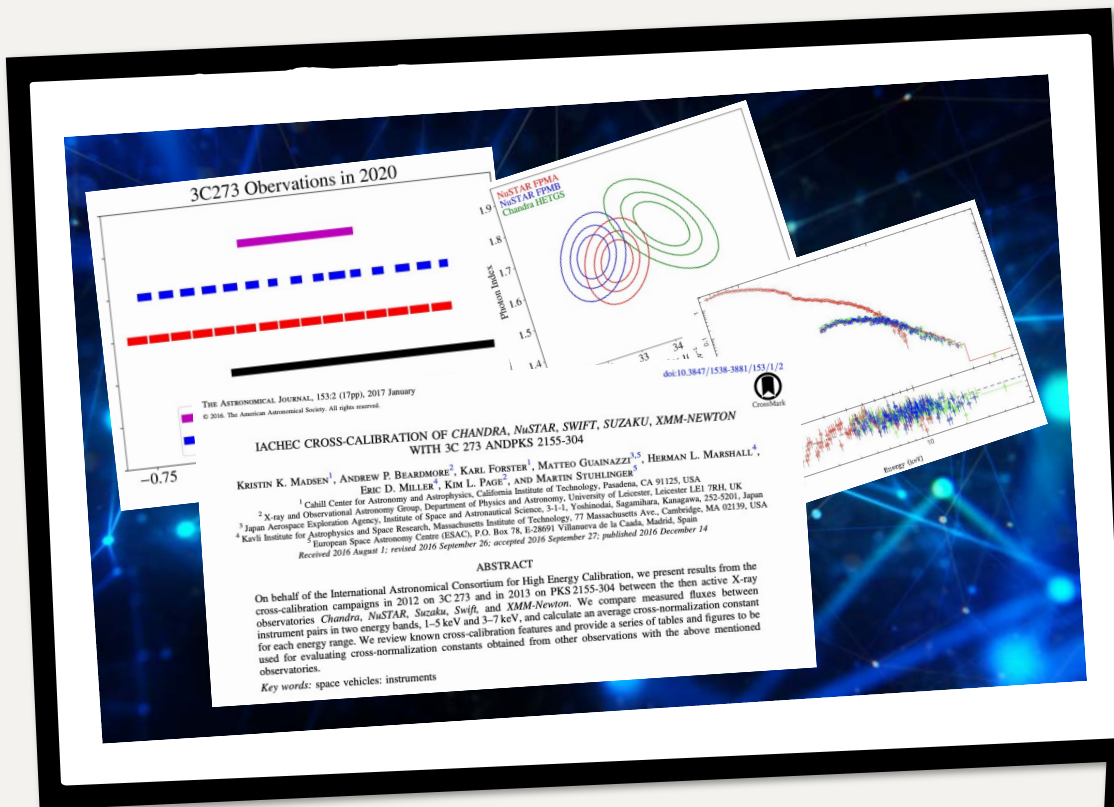
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coordinate new observations jointly among different telescopes

analyze those observations

and publish the results.

# Scope of the Co-Obs Working Group



# Activity in 2021

## Spring meeting

- May 13<sup>th</sup> on zoom
- Organize annual cross calibration observations of 3C 273
- Introduce new communications channels
  - + Slack, Email distribution list, Google sheets
- Introduction of IVOA visibility and observation scheduling standards
- Potential of 1ES 0229+200 for calibration

[iachec-co-obs@lists.srl.caltech.edu](mailto:iachec-co-obs@lists.srl.caltech.edu)  
<https://tinyurl.com/4z94r895>

Link to Clusters WG  
google sheet

## Coordination of observations of 3C 273, 1ES 0229+200 and Crab

- 2021 June 9-11<sup>th</sup> with Chandra, INTEGRAL, NICER, NuSTAR, Swift, & XMM-Newton
  - + Using new communication channels

## Fall meeting

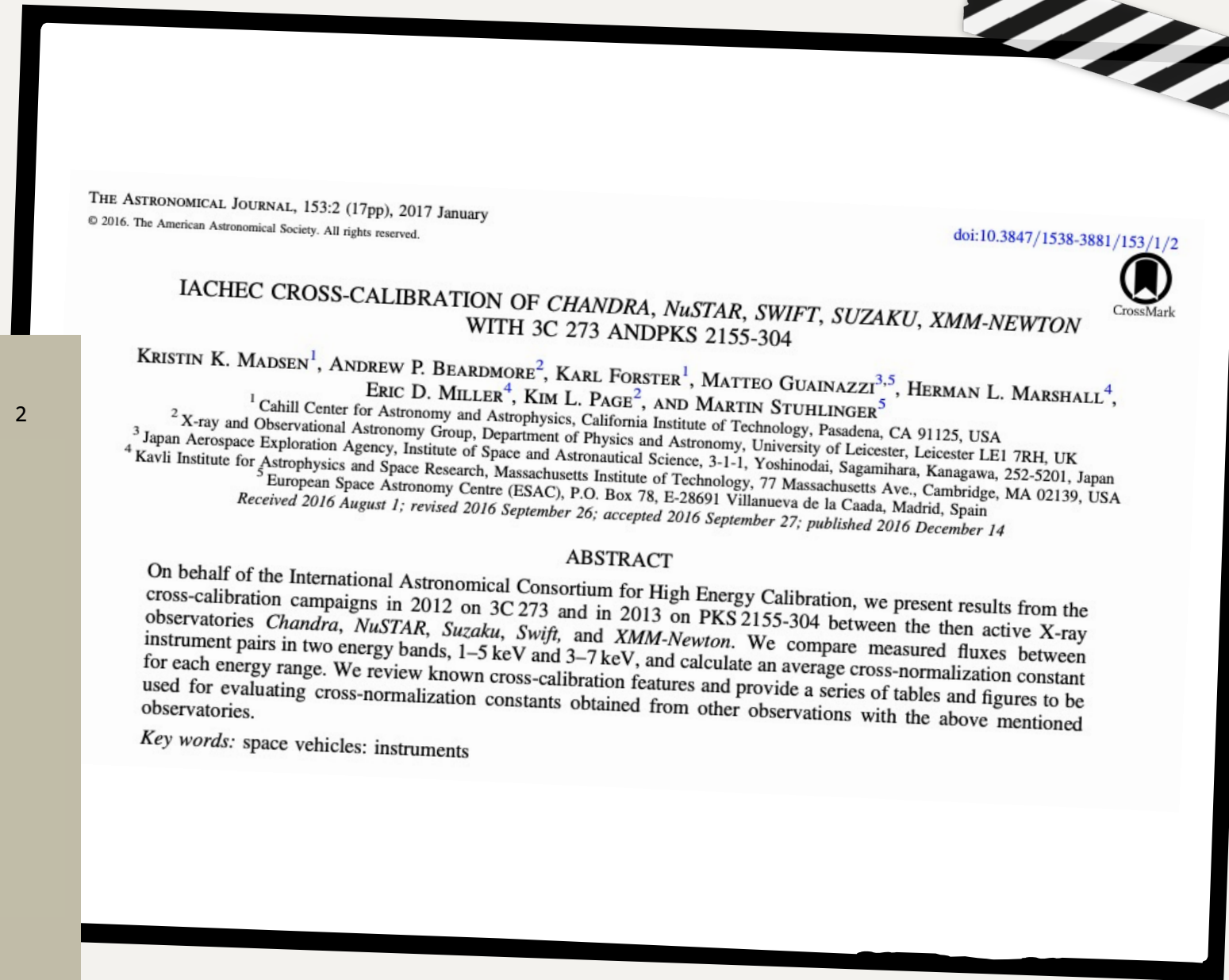
- October 22<sup>nd</sup> on zoom
- Report on 2021 3C 273 observing campaign
  - + Presentation by Kristin Madsen on an update to multi-mission cross calibration
- Report on 1ES 0229+200 campaign
  - + Presentation on analysis of NuSTAR observations of 1ES 0229+200 – Hannah Earnshaw
  - + Presentation on analysis of XMM-Newton (and NuSTAR) observations of 1ES 0229+200 by Felix Fuerst
  - + Presentation of Astrosat observations of 1ES 0229+200 by Sunil Chandra
- Report on XMM-Newton/NuSTAR Crab campaign
  - + Felix Fuerst presented preliminary work towards possible XMM-pn calibration update
- Discussion of supporting in-flight calibration of IXPE (and XRISM)



# 3C 273 cross calibration

Corin Marasco & Kristin Madsen

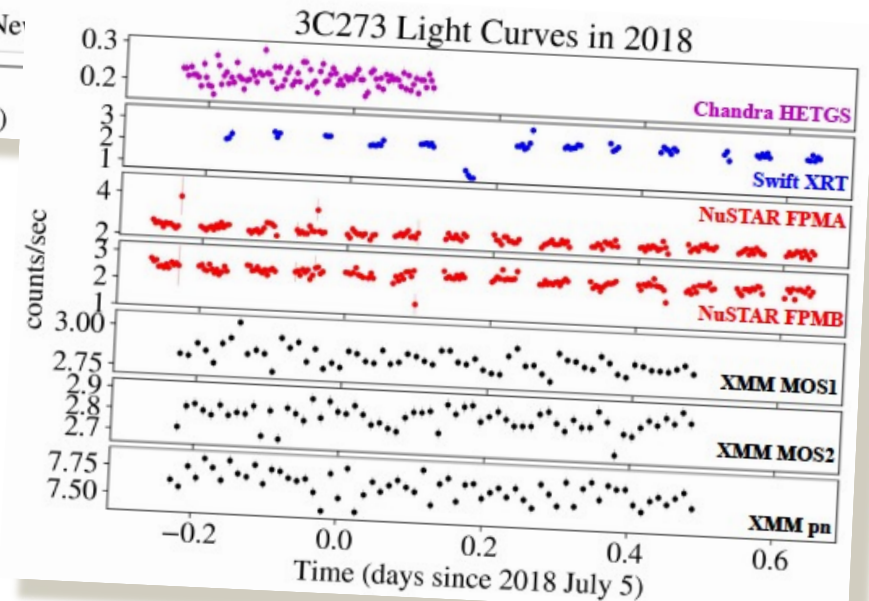
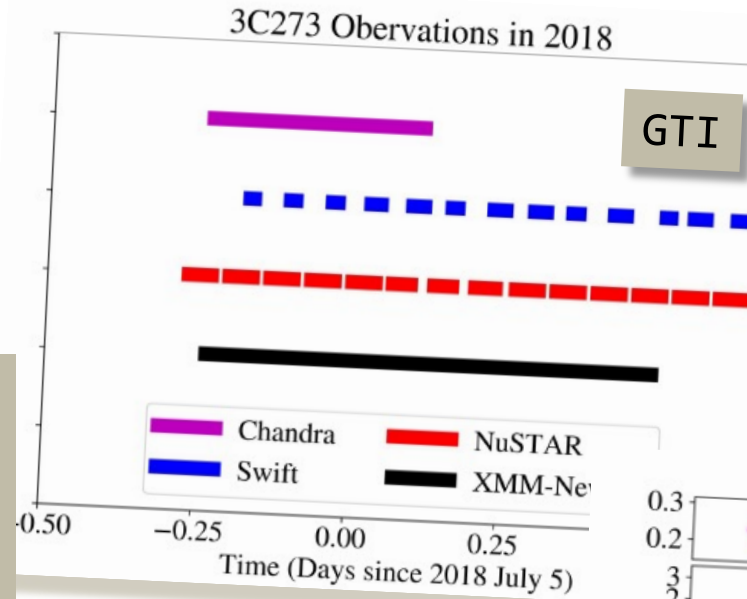
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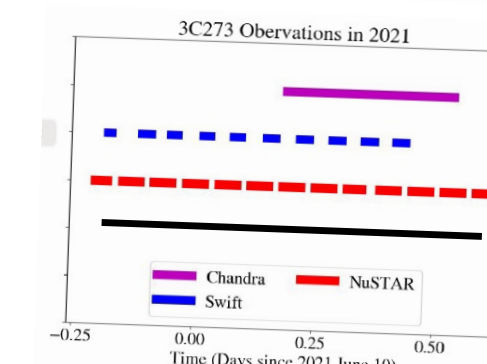
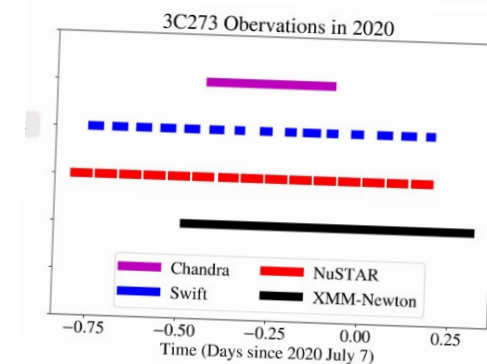
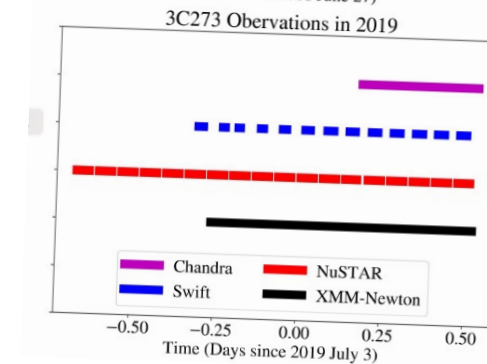
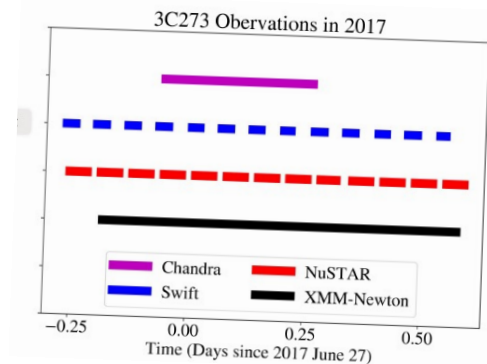
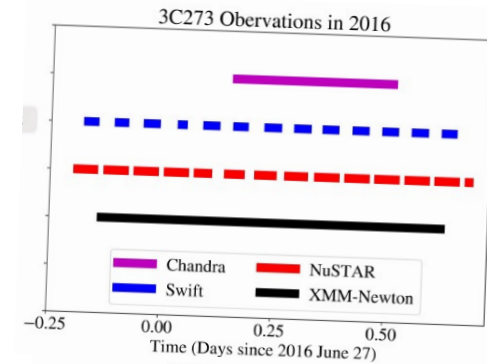
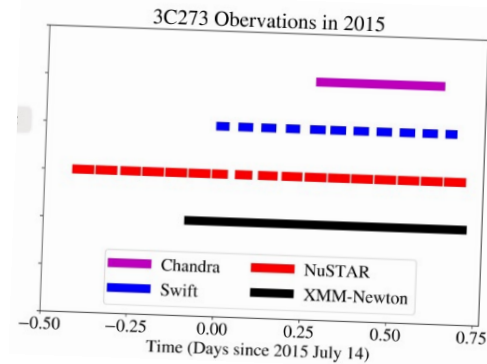
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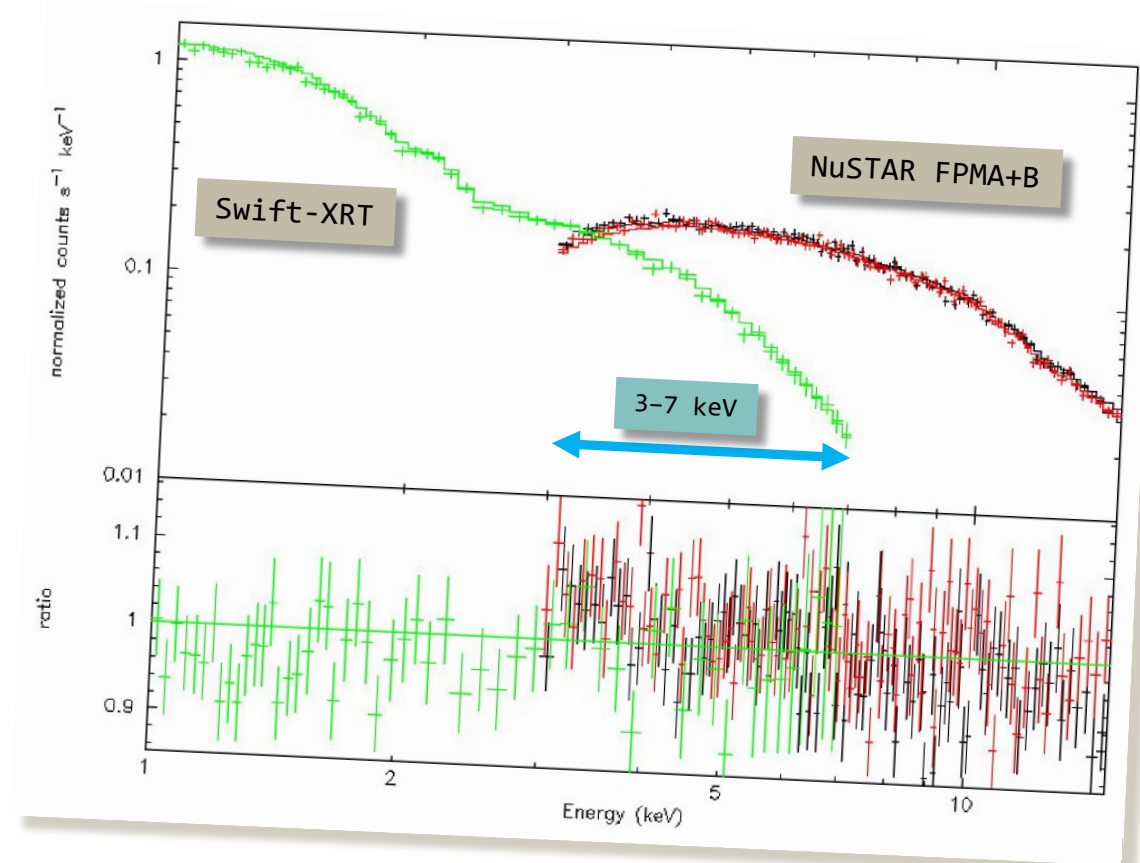
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- analysis of the XMM-Newton, Chandra, NuSTAR, and Swift observations of 3C 273 that have been performed annually since 2015.
- Joint fitting of the spectra from pairs of observations
- matching GTI were examined in bands:
  - 3-7 keV for NuSTAR + Chandra/Swift/XMM-Newton pairs
  - 1-5 keV for Chandra/Swift/XMM-Newton pairs
- Absorbed power-law model ( $z_{\text{pow}} * c_{\text{flux}} * t_{\text{babs}}$ )
- examine the measured flux relative to the model flux

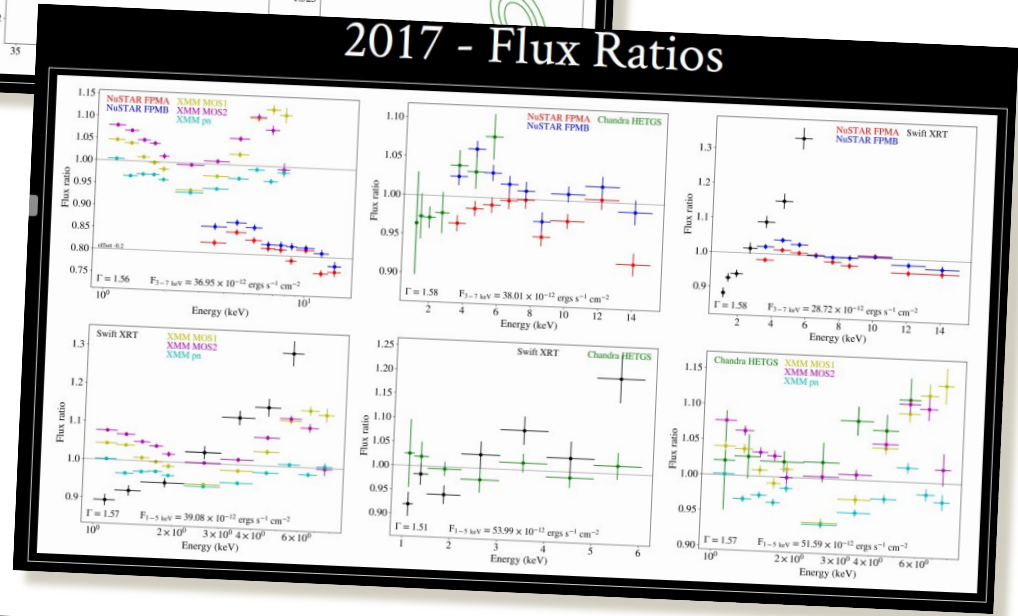
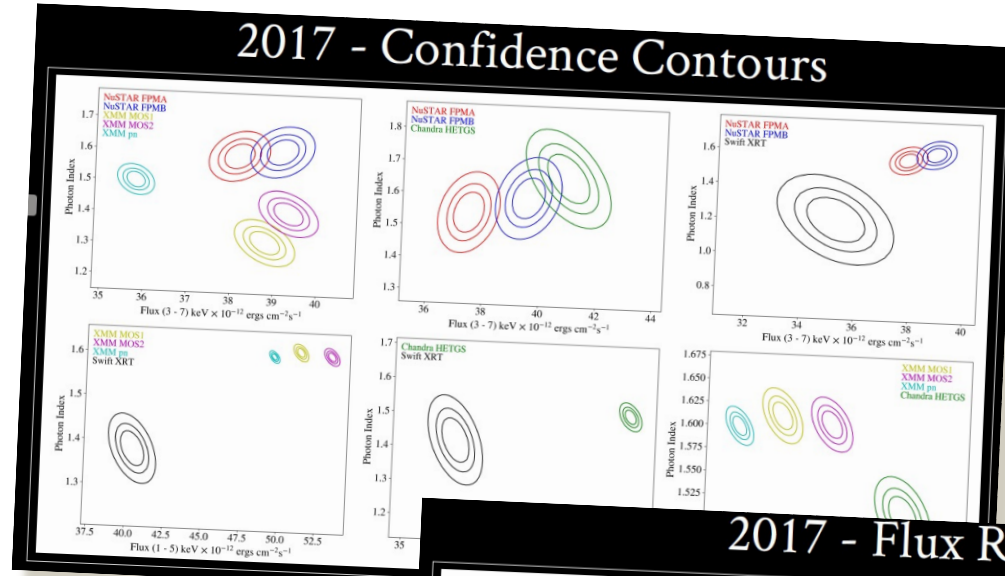




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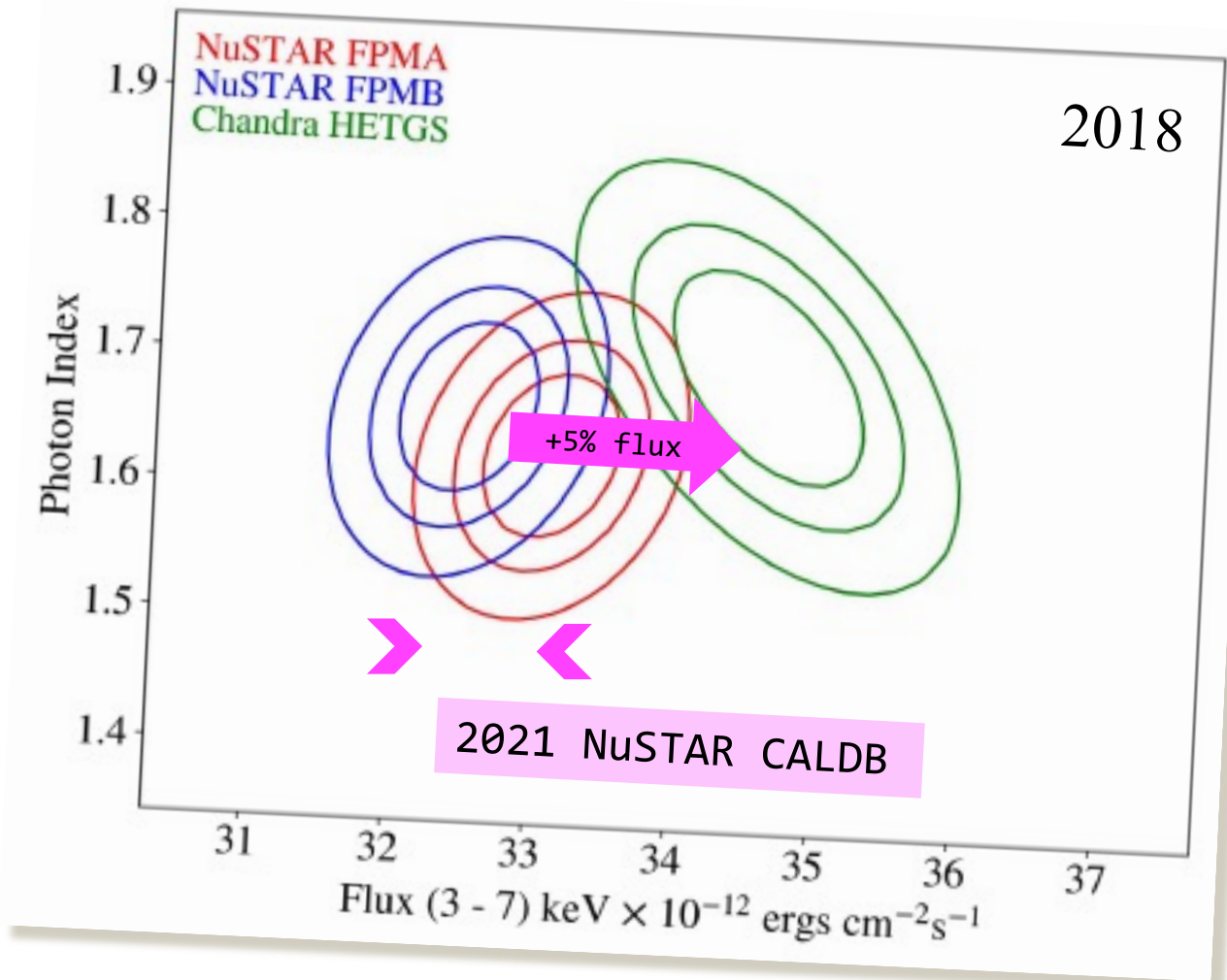
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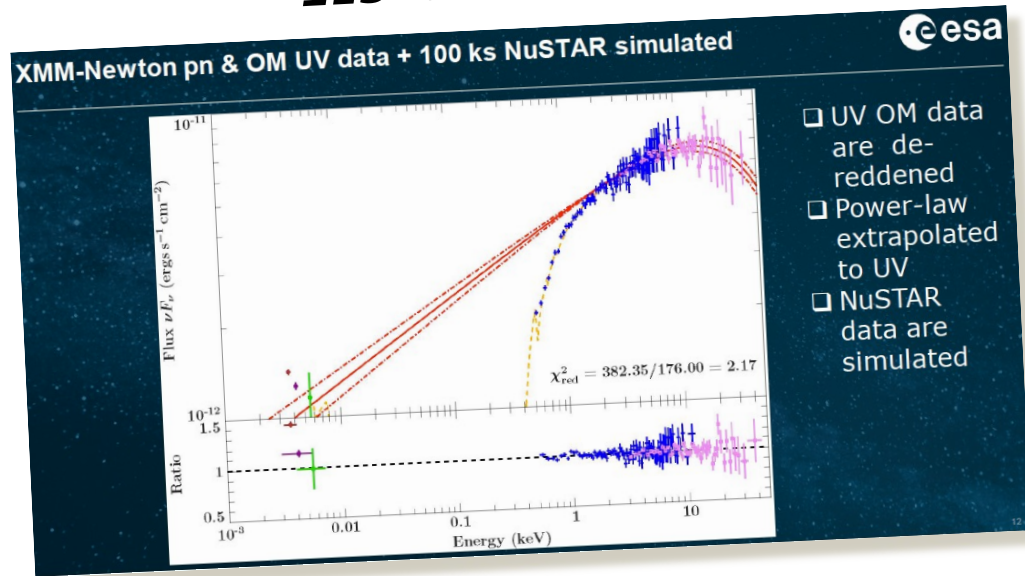
# 3C 273 cross calibration

Corin Marasco & Kristin Madsen  
Analysis Continues

- check Chandra and Swift analysis
- include NICER observations
- update with 2021 NuSTAR CALDB
- extend analysis to evaluate within concordance framework
  - flux ratios examined in narrow bands (model independent)
- investigate complexity seen in XMM-Newton spectrum
- publish next year



## 1ES 0229+200



Presented at May WG meeting

## The Potential of 1ES 0229+200

Norbert Schartel & Felix Fuerst

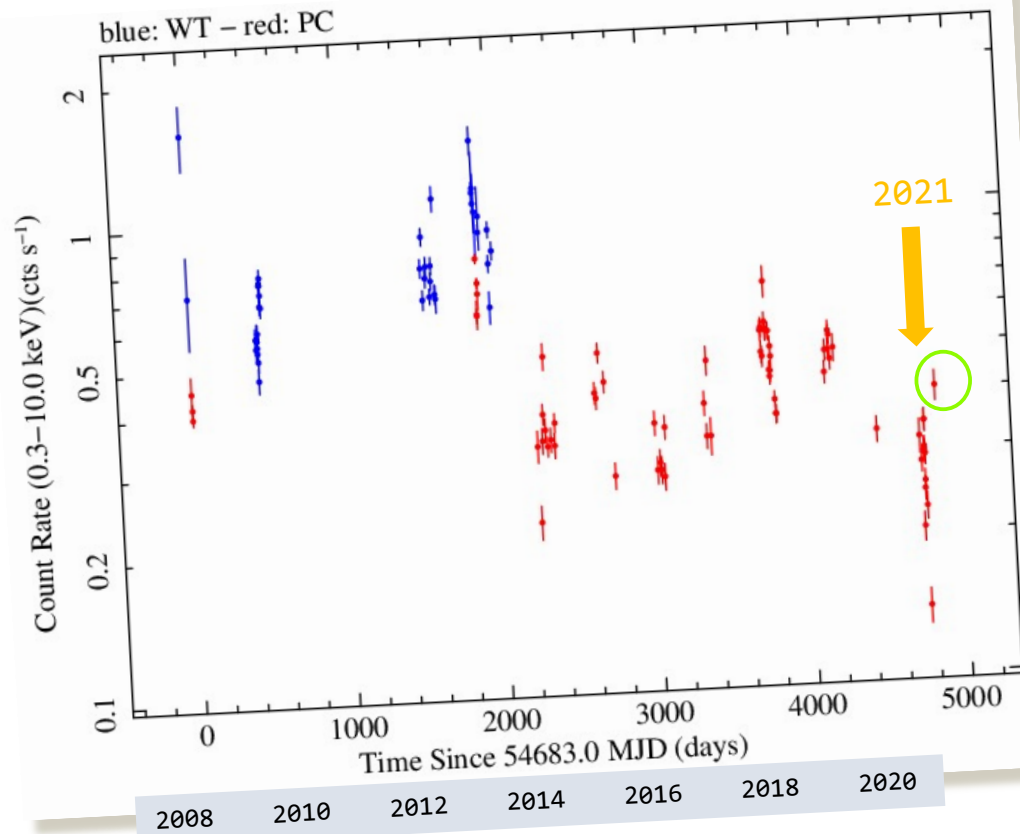
- blazars have flat spectra between 200 eV and 15 keV
  - calibrate from UV to hard X-rays
- 1ES 0229+200 is fainter than 3C 273
  - avoid pile-up
- Astrosat can observe

### But

- variable -> simultaneous observations
- longer exposure times required
- too faint for INTEGRAL

# 1ES 0229+200

## 1ES 0229+200



Swift-XRT Monitoring of *Fermi*-LAT Sources of Interest

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# 1ES 0229+200

IACHEC COWG data

File Edit View Insert Format Data Tools Add-ons Help

100% Comment only

2021/22

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	2021/22	Calibration observations				IACHEC									
2	facility_name	instrument_name			obs_id	t_min	t_max			t_exptime	execution_status		IVOA ObsLocTAP		
3	Observatory	Instrument	Settings	Target	Observation ID	Start MJD	End MJD	Start UTC	End UTC	Exposure time [ks]	Status	Coordinated	TOBY		
31	NuSTAR	FPMA+B	standard		10702609006	59439.20833333	59440.61458333	2021:225:05:00:00	2021:226:14:45:00	63	S	NI-Nu-S	ATOM BVRI measurements		
32	NuSTAR	FPMA+B	standard		10702609004	59437.19444444	59438.67013889	2021:223:04:40:00	2021:224:16:05:00	65	S	A-NI-Nu-S	also 1.4 GHz (VLA? to be confirmed)		
33	Swift	XRT, UVOT	PC, NUV		31249	59434	59443	2021:220:00:00:00	2021:229:00:00:00	20	P	A-NI-Nu-S-X	UVOT mode 0x308f (NUV)		
34	XMM	pn		1ES 0229+200	0810821801	59434.70736111	59436.17379630	2021:220:16:58:36	2021:222:04:10:16	122.6	S	A-NI-Nu-S-X	MAGIC (30 GeV - 100 TeV)		
35	NICER				4010180100	59434.28127315	59440.67803241	2021:220:06:45:02	2021:226:16:16:22	45.9	S	A-NI-Nu-S-X	Effelsberg 100m at 14 and 24 GHz (possibly lower frequencies)		
36	ASTROSAT	UVIT, SXT, LAXPC				59434.23958333	59438.59722222	2021:220:05:45:00	2021:224:14:20:00	70	S	A-NI-Nu-S-X	40 ks UVIT, 160 ks LAXPC		
37	ASTROSAT	FPMA+B	standard		10702609002	59434.23888889	59436.65625000	2021:220:05:44:00	2021:222:15:45:00	107	S	A-NI-Nu-S-X	H.E.S.S. (GeV to TeV) 10 ksec/day Aug 8-12th		

Observatory	Exposure Time (ks)
Astrosat	160 LAXPC (40 ks UVIT)
NICER	45.9
NuSTAR	107 + 65 + 63
Swift	20 (UVOT-NUV)
XMM-newton	122.6

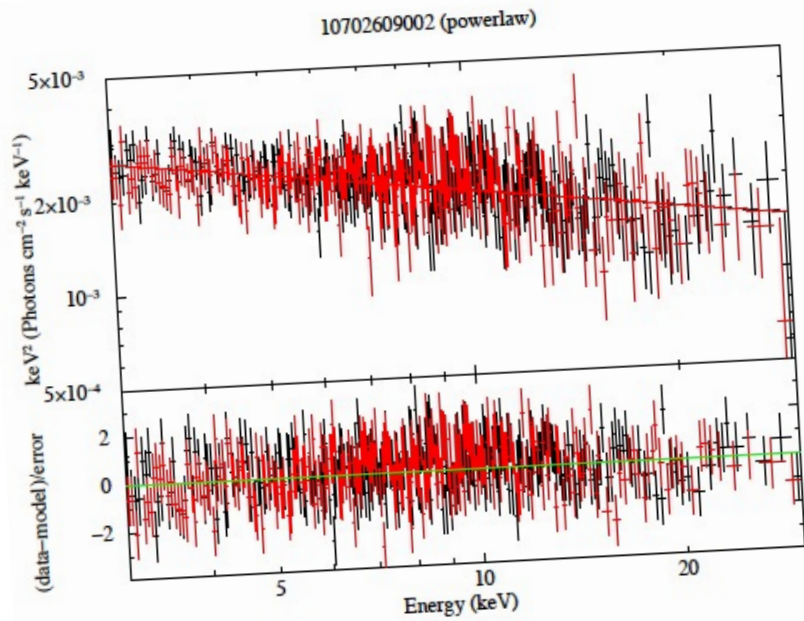
...and at other wavelengths	
ATOM	BVRI
Effelsberg 100m	2cm and 15mm bands
H.E.S.S	TeV 10 ks/day
MAGIC	30 GeV - 100 TeV

**1ES 0229+200**

- Observations performed between 2021-08-08 to 14



# 1ES 0229+200



powerlaw:

-  $\Gamma = 2.25 \pm 0.03$ , norm =  $3.6 \pm 0.2 \text{ e-}3$

logpar:

-  $\alpha = 2.12 \pm 0.08$ ,  $\beta = 0.23 \pm 0.11$ ,

norm =  $2.04 \pm 0.06 \text{ e-}4$

Flux =  $7.2 \times 10^{-12} \text{ erg/cm}^2/\text{s}$

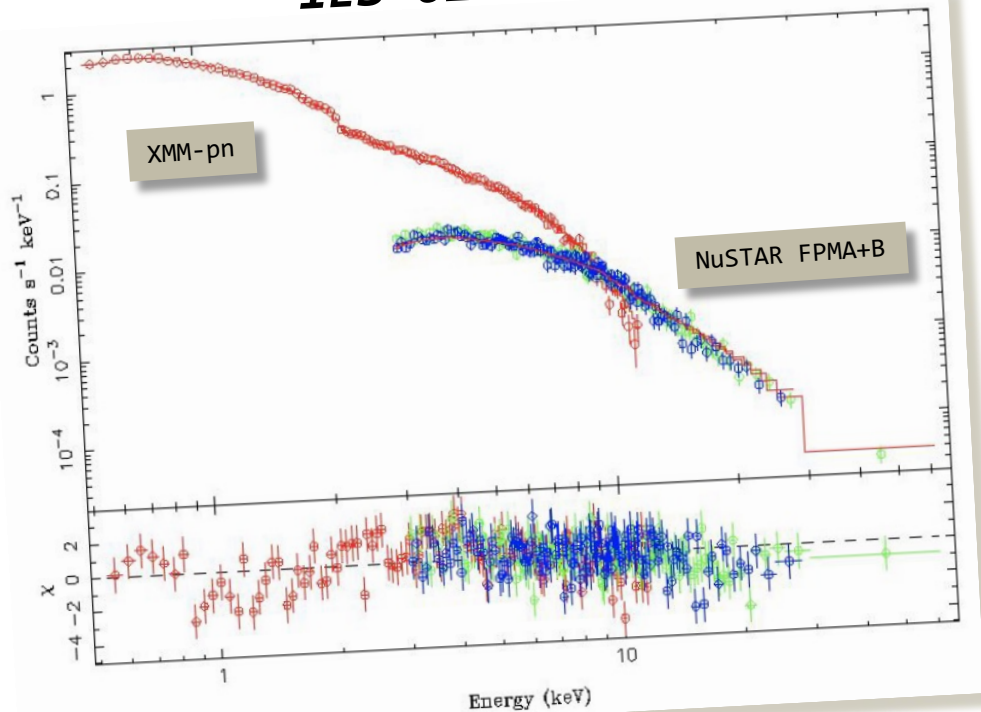
## NuSTAR observations

Hannah Earnshaw (Caltech)

- Three 2021 exposures (200 ks total)
  - Compared to three short (~20 ks each) exposures obtained in 2013
  - Spectrum can be modeled as an absorbed power law or a log-parabola continuum
- The source appears softer ( $\Gamma$  2.03  $\rightarrow$  2.25) and fainter (about 25%) in the 2021 observations compared to 2013
- Even at historically low flux state the source is still sufficient for cross-calibration purposes

# 1ES 0229+200

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tbnew\*powerlaw 2021 CALDB (NEW)

$N_H = 0.148 \pm 0.005 \text{ e22}$   
 $\Gamma = 2.125 \pm 0.011$   
 $C_{\text{FPMA}} = 1.131 \pm 0.026$   
 $C_{\text{FPMB}} = 1.131 \pm 0.026$   
 $\chi^2_{\text{red}} = 1.28 (487/379)$

## 1ES 0229+200 with XMM-Newton

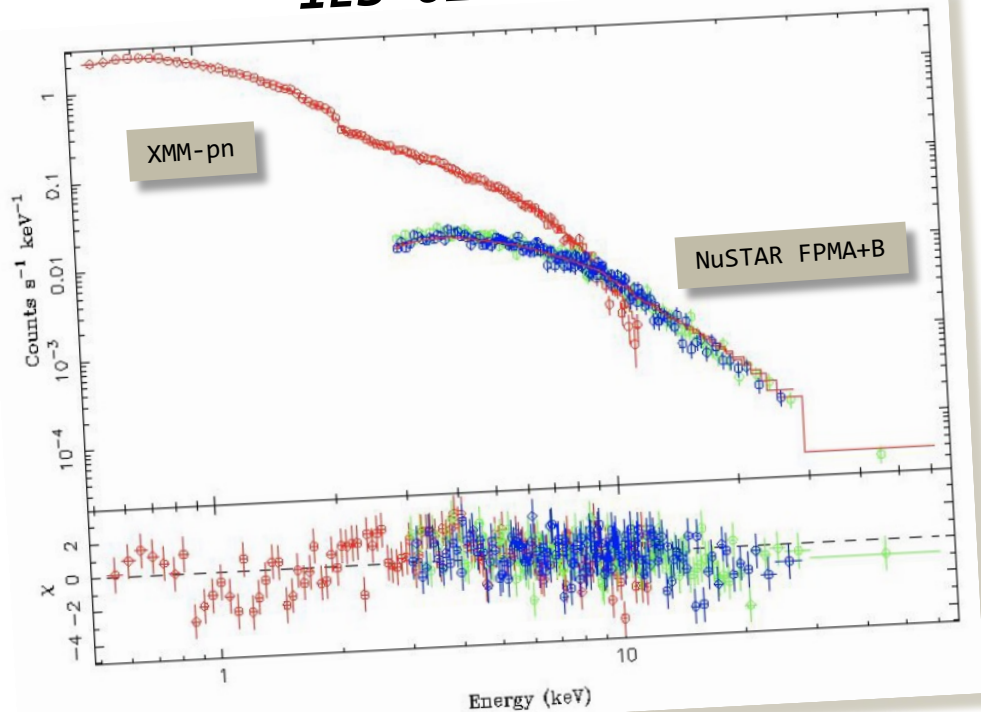
and its impact on calibration

Felix Fuerst (ESAC)

- 1ES 0229+200 observed on Oct 8-10, 2021
  - 18.8 ks full frame exposure lost due to very bad background flaring
- Analysis of 60 ks small window EPIC-pn exposure presented
  - can be modeled as an absorbed power law or cutoff power law
- Combined analysis with simultaneous 95 ks NuSTAR observation
  - Fit improved with cutoff power law above 20 keV
  - 2021 NuSTAR calibration improves agreement between NuSTAR FPM modules

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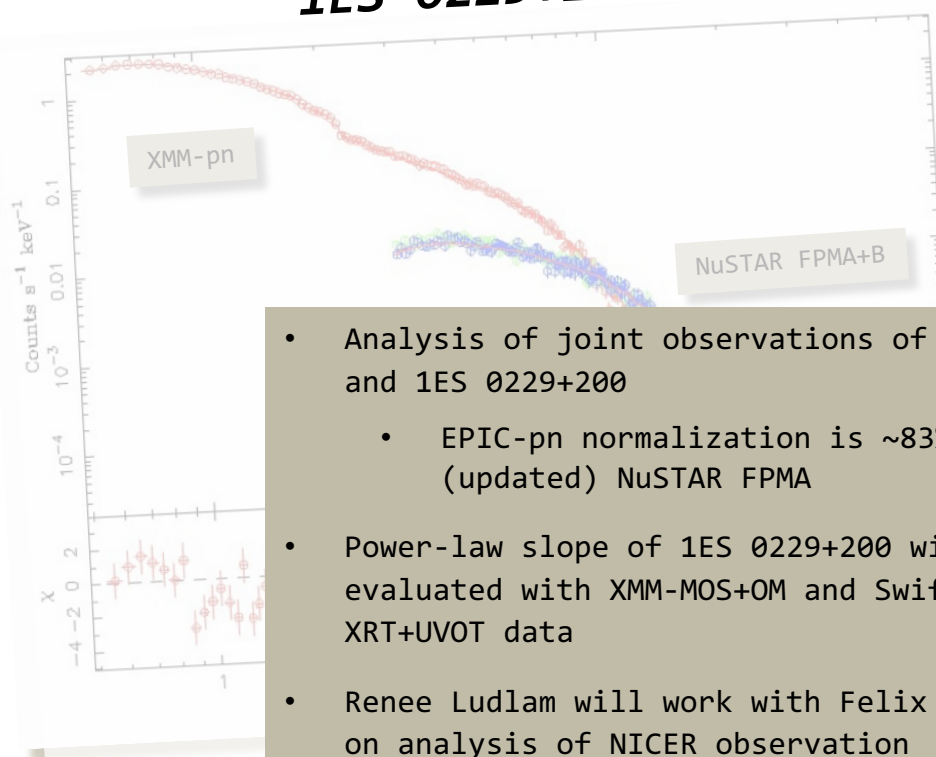
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# 1ES 0229+200



## 1ES 0229+200



- Analysis of joint observations of 3C 273 and 1ES 0229+200
  - EPIC-pn normalization is ~83% of (updated) NuSTAR FPMA
- Power-law slope of 1ES 0229+200 will be evaluated with XMM-MOS+OM and Swift-XRT+UVOT data
- Renee Ludlam will work with Felix Fuerst on analysis of NICER observation

$$\begin{aligned} N_H &= 0.148 \pm 0.005 \text{ e22} \\ \Gamma &= 2.125 \pm 0.011 \\ C_{\text{FPMA}} &= 1.131 \pm 0.026 \\ C_{\text{FPMB}} &= 1.131 \pm 0.026 \\ \chi^2_{\text{red}} &= 1.28 \text{ (487/379)} \end{aligned}$$

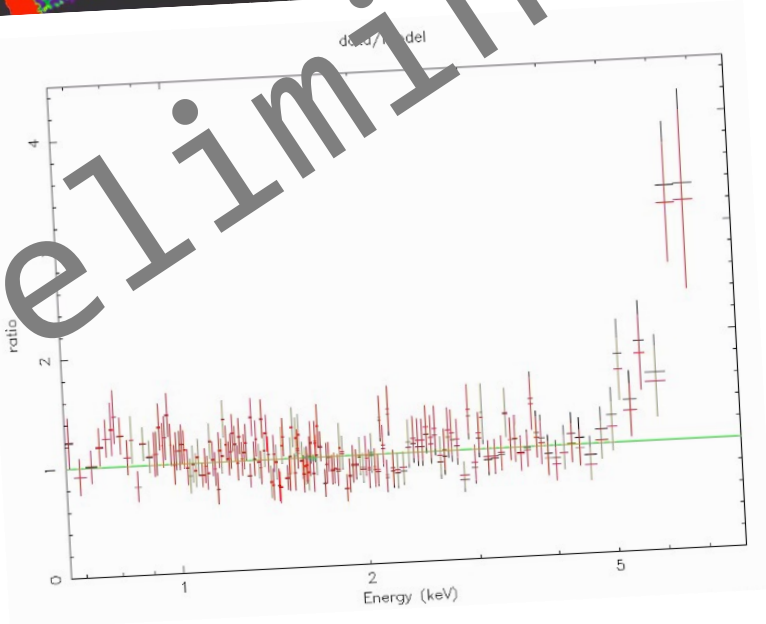
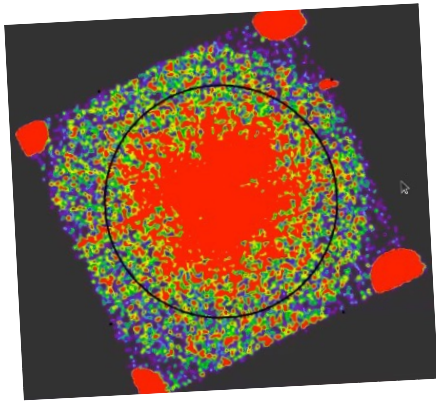
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# 1ES 0229+200



## 1ES 0229+200 with Astrosat

Sunil Chandra (NWU-Potchefstroom SA)

- 1ES 0229+200 is a faint source for Astrosat-SXT
- 74 ks exposure obtained in 2021 August
- modeled as an absorbed power law
  - excess above 5 keV may be due to background
  - features below 0.5 keV may be residual calibration artifacts
- Astrosat-UVIT data is yet to be released
- There is also a previous observation by Astrosat (that may not be available yet)

**1ES 0229+200**



# XMM-pn Crab calibration

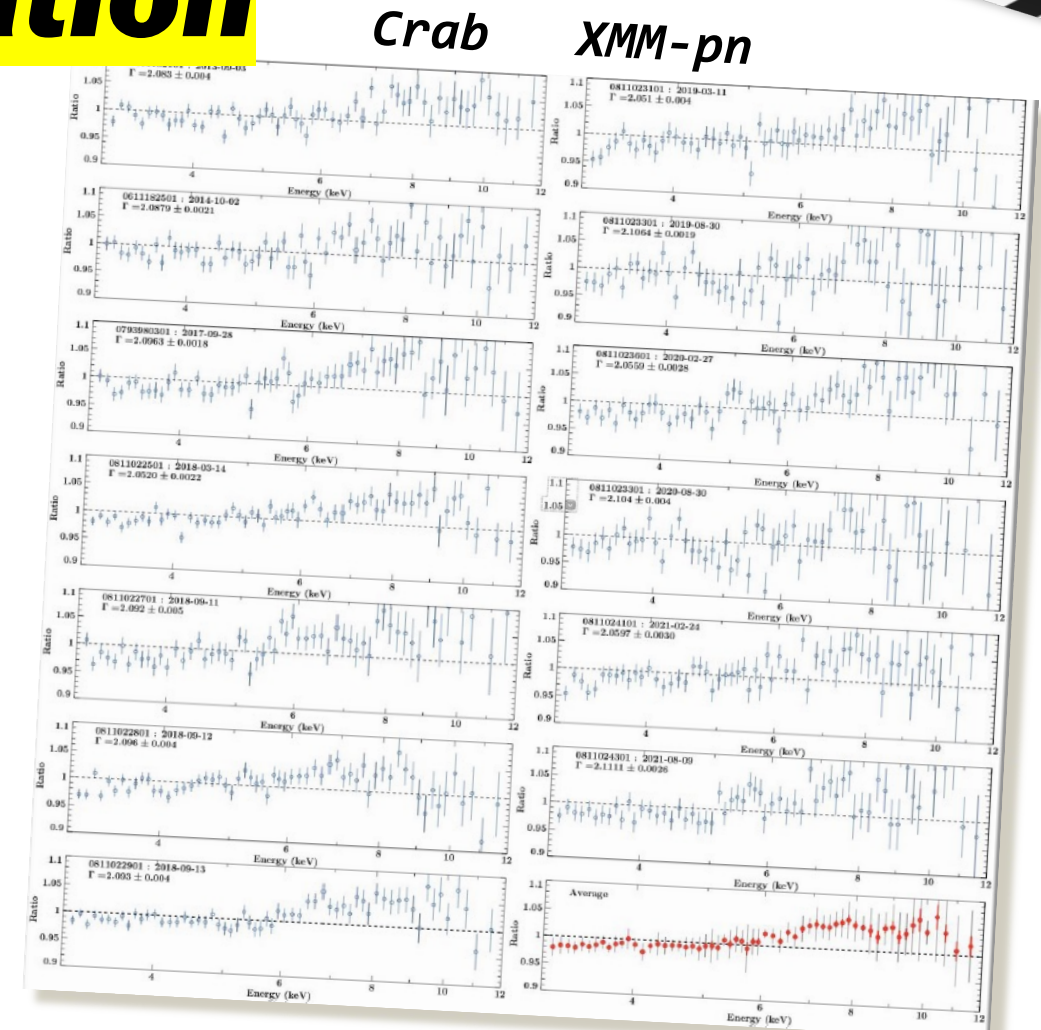
## Joint XMM / NuSTAR observing campaign

Felix Fuerst (ESAC)

- Analysis of joint XMM / NuSTAR observing campaign on the Crab
  - Observations performed every ~6 months
- used to create a *correction function* for EPIC-pn ARF
  - Correction function will be vetted with more observations
- calibration update for EPIC-pn is being developed

### Discussion

- the new NuSTAR calibration appears to push the relative normalizations of XMM-pn and NuSTAR-FPM further apart
- must use similar extraction regions in analysis of Crab observations for cross-calibration purposes
  - extended source so observations at different epochs = different roll can sample different areas of the remnant
- Chandra observations show spectral curvature
  - however, no improvement is seen when more complex models are used



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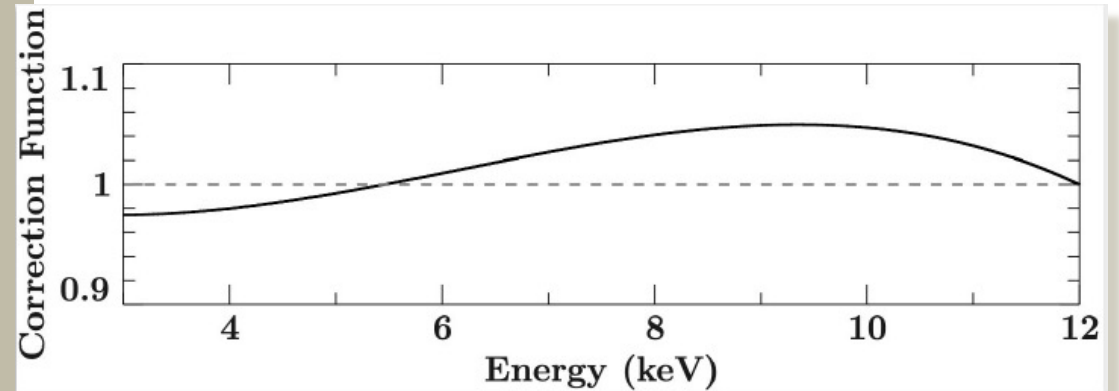
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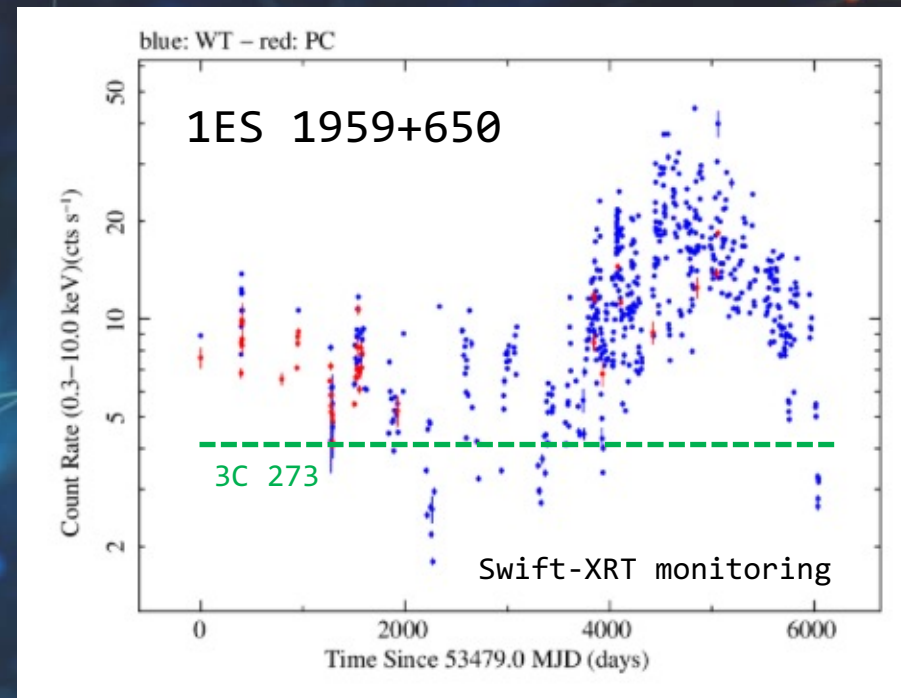
# Future activities

## IXPE in-flight calibration

- launch scheduled for Dec 9th, 2021
  - + A preliminary long term plan is available at [https://ixpe.msfc.nasa.gov/for\\_scientists/ltp.html](https://ixpe.msfc.nasa.gov/for_scientists/ltp.html)
- there are many coordinated observations approved for scientific programs with INTEGRAL, XMM-Newton, NuSTAR, etc.
  - + Some may be useful for cross-calibration
- Crab observation scheduled for 2022-02-21
- plan to observe 1ES 1959+650 during OV phase
  - + ...a blazar

## SRG-eROSITA and 3C 273 in 2022

- survey scan images 3C 273 in 2021-06-19
  - + 10 days after IACHEC campaign
- coordinate 2022 campaign?
- schedule usually driven by Chandra



## XRISM

- Meet to discuss details of coordinated calibration observations at least 3-months before the official launch date

**XPoSat** - launch in 2022

**SVOM-MXT** - launch in mid-2023

**SMILE-SXI** - launch in late-2024

