



**A Brief Advertisement
Before Your Regularly
Scheduled Program**

PKS 1441+25

Optical, X-, Gamma-ray flare of the FSRQ PKS 1441+25

ATel #7402; *Luigi Pacciani (INAF-IAPS)*

on 16 Apr 2015; 12:08 UT

Credential Certification: *Luigi Pacciani (luigi.pacciani@iaps.inaf.it)*

Subjects: Optical, Ultra-Violet, X-ray, Gamma Ray, >GeV, Blazar

Referred to by ATel #: [7416](#), [7417](#), [7429](#), [7433](#)

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 Recommend 2

We detected a gamma-ray flare from the FSRQ PKS 1441+25 ($z=0.939$), triggering on FERMI-LAT data at $E > 10$ GeV with $TS \sim 44$, from 2015-03-21 to 2015-04-15, following the prescription of Pacciani et al. 2014, ApJ, 790, 45. The gamma-ray flux was $(38 \pm 3)E^{-8}$ ph cm $^{-2}$ s $^{-1}$, photon index 1.93 ± 0.07 , $TS \sim 760$ ($E > 0.1$ GeV), to be compared with the catalog flux of $1.3E^{-8}$ ph cm $^{-2}$ s $^{-1}$ reported in the 3rd Fermi-LAT point-source catalog. The FERMI-LAT revealed gamma-ray emission up to 33 GeV. The source has been detected in high gamma-ray state also on January 2015 (ATEL#6878). The Swift Follow-up revealed the source in high state in optical and X-ray. The preliminary Swift-UVOT photometry on 2015-04-15 is:

V = 16.79 +/- 0.06

B = 17.01 +/- 0.03

U = 16.21 +/- 0.02

UVW1 = 16.36 +/- 0.03

UVM2 > 18.4

UVW2 = 16.59 +/- 0.03 which is ~ 4 times brighter than the optical flux on 2015 January 5th and 28th (swift obsid 00040618005, 00040618003, see also ATEL#6895, ATEL#6923). Magnitudes are in the UVOT photometric system (Poole et al. 2008, MNRAS, 383, 627) and have not been corrected for Galactic extinction. We verified the optical photometry using SDSS J144357.93+250051.0 as a reference. The simultaneous Swift-XRT observation gives a counting rate of 0.109 ± 0.006 cps (to be compared with 0.045 ± 0.004 cps of the brightest state on 28th January 2015, Swift obsid 00040618005) and an unabsorbed flux of $(5.3 \pm 0.5)E^{-12}$ erg cm $^{-2}$ s $^{-1}$ (0.3-10 keV). We encourage further multi-wavelength observations. We thank the Swift team and Swift Observatory Duty Scientist for rapidly scheduling our observations.

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on 16 Apr 2015; 12:08 UT

Credential Certification: *Luigi Pacciani (luigi.pacciani@iaps.inaf.it)*

Discovery of Very High Energy Gamma-Ray Emission from the distant FSRQ PKS 1441+25 with the MAGIC telescopes

ATel #7416; *R. Mirzoyan (Max-Planck-Institute for Physics)*

on 20 Apr 2015; 02:09 UT

Credential Certification: *Masahiro Teshima (mteshima@mppmu.mpg.de)*

Subjects: Gamma Ray, TeV, VHE, AGN, Blazar

Referred to by ATel #: 7417, 7433

 Tweet 9

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z=0.939!

VHE detection over more than a single day!

The MAGIC collaboration reports the discovery of very high energy (VHE; $E > 100$ GeV) gamma-ray emission from the FSRQ PKS 1441+25 (RA=14h43m56.9s DEC=+25d01m44s), located at redshift $z=0.939$ (Shaw et al. 2012, ApJ, 748, 49). The object was observed with the MAGIC telescopes for ~ 2 hours during the night 2015 April 17/18, and for ~ 4 hours during 18/19. A preliminary analysis of the data yields a detection with a statistical significance of more than 6 standard deviations for the night of April 17/18, and more than 11 standard deviations for 18/19. This is the first time a significant signal at VHE gamma rays has been seen from PKS 1441+25. The flux above 80 GeV is estimated to be about $8e-11$ cm⁻² s⁻¹ (16% of Crab Nebula flux). PKS 1441+25 has entered an exceptionally high state at optical, X-, and Gamma-ray frequencies (ATel #7402), which triggered the MAGIC observations. The Swift Follow-up observation from April 18/19 revealed that the high state in X-rays is continuing: <http://www.swift.psu.edu/monitoring/source.php?source=PKS1441+25> MAGIC observations on PKS1441+25 will continue during the following nights, and multiwavelength observations are encouraged. The MAGIC contact persons for these observations are R. Mirzoyan (Razmik.Mirzoyan@mpp.mpg.de) and E. Lindfors (elilin@utu.fi). MAGIC is a system of two 17m-diameter Imaging Atmospheric Cherenkov Telescopes located at the Canary island of La Palma, Spain, and designed to perform gamma-ray astronomy in the energy range from 50 GeV to greater than 50 TeV.

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ATel #7416; *R. Mirzoyan (Max-Planck-Institute for Physics)*

on 20 Apr 2015; 02:09 UT

Credential Certification: Masahiro Teshima (mteshima@mppmu.mpg.de)

High Optical Polarization Detected in PKS 1441+25


ATel #7417; *Paul S. Smith (Steward Observatory, University of Arizona), Demet Tutar Ozdarcan (Steward Observatory & Ege University)*

on 20 Apr 2015; 16:01 UT

Credential Certification: Paul S. Smith (psmith@as.arizona.edu)

Subjects: Optical, AGN, Blazar

Referred to by ATel #: [7433](#)

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 Recommend 16

An optical observation of the $z=0.939$ quasar PKS 1441+25 (RA=14h43m56.89s DEC=+25d01m44.5s) was obtained on UTC 2015 April 20 using the SPOL spectropolarimeter at the 1.54m Kuiper Telescope on Mt. Bigelow, Arizona. This observation was prompted by ATEL #7416, which reported the detection by MAGIC of very high energy (VHE) emission from this object within the past few days. The object was found to be highly polarized, with $P = 37.7\%$ (0.1%) at a position angle of 107.6 deg (0.1 deg) during a 16-minute observation centered at 11:00:59 UT. The linear polarization reported is derived from the median Stokes values found in a 5000-7000 Angstrom bandpass of the spectrum. Measurement uncertainties are given in parentheses and are based on photon statistics. The polarization is constant with wavelength from 4000-8000 Angstroms and the flux spectrum appears to be featureless. Rapid-cadence flux and polarization monitoring of PKS 1441+25 are encouraged while it remains in an active state (see also e.g., ATEL #6923 and #7402).

37.7% polarization!

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on 20 Apr 2015; 16:01 UT

Credential Certification: Paul S. Smith (psmith@as.arizona.edu)

ASAS-SN Detection of an Optical Brightening in FSRQ PKS 1441+25


ATel #7429; *B. J. Shappee (Hubble Fellow, Carnegie Observatories), K. Z. Stanek, T. W.-S. Holoiien, C. S. Kochanek, A. B. Danilet, G. Simonian, U. Basu, N. Goss, J. F. Beacom, T. A. Thompson (Ohio State), J. L. Prieto (Diego Portales; MAS), D. Bersier (LJMU), Subo Dong (KIAA-PKU), P. R. Wozniak (LANL), E. Falco (CfA), J. Brimacombe (Coral Towers Observatory), D. Szczygiel, G. Pojmanski (Warsaw University Observatory)*

on 22 Apr 2015; 01:29 UT

Credential Certification: Benjamin Shappee (bshappee@obs.carnegiescience.edu)

Subjects: Optical, AGN, Blazar

Referred to by ATel #: [7433](#)

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Continues optical activity!

During the ongoing All Sky Automated Survey for SuperNovae (ASAS-SN or "Assassin"), using data from the quadruple 14-cm "Brutus" telescope in Haleakala, Hawaii, we detect optical brightening from the flat spectrum radio quasar PKS 1441+25 coincident with the Optical, X-, Gamma-ray flare detected by Fermi from 2015-03-21 through 2015-04-15 (ATel #7402).

ASAS-SN first detected the brightening in images obtained on UT 2015-03-20.40 at V~17.0 mag. We also detected PKS 1441+25 in images obtained on 2015-03-21.50, 2015-03-24.43, 2015-04-09.50, 2015-04-10.43, 2015-04-13.55, 2015-04-15.52, and 2015-04-18.43 but we do not detect any emission at this location 2015-03-18.55 (V>17.5) and before (from 2012-01-25.63; upper limits range from V~16.2-18.2).

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on 16 Apr 2015; 12:08 UT

Credential Certification: *Luigi Pacciani (luigi.pacciani@iaps.inaf.it)*

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on 20 Apr 2015; 02:09 UT

Credential Certification: *Masahiro Teshima (mteshima@mppmu.mpg.de)*

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ATel #7417; *Paul S. Smith (Steward Observatory, University of Arizona), Demet Tutar Ozdarcan*
(Steward Observatory & Ege University)
on 20 Apr 2015; 16:01 UT

Credential Certification: *Paul S. Smith (psmith@as.arizona.edu)*

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ATel #7429; *B. J. Shappee (Hubble Fellow, Carnegie Observatories), K. Z. Stanek, T. W.-S. Holoien, C. S. Kochanek, A. B. Danilet, G. Simonian, U. Basu, N. Goss, J. F. Beacom, T. A. Thompson (Ohio State), J. L. Prieto (Diego Portales; MAS), D. Bersier (LJMU), Subo Dong (KIAA-PKU), P. R. Wozniak (LANL), E. Falco (CfA), J. Brimacombe (Coral Towers Observatory), D. Szczygiel, G. Pojmanski (Warsaw University Observatory)*
on 22 Apr 2015; 01:29 UT

Credential Certification: *Benjamin Shappee (bshappee@obs.carnegiescience.edu)*

Very-high-energy gamma-ray emission from PKS 1441+25 detected with VERITAS

ATel #7433; *Reshmi Mukherjee (Barnard College, Columbia University)*
on 23 Apr 2015; 03:37 UT

Credential Certification: *Jamie Holder (jholder@physics.udel.edu)*

Subjects: Gamma Ray, TeV, VHE, AGN, Blazar

 Tweet 3

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**Detection at VHE 4 days
after VHE discovery by
MAGIC!**

The VERITAS collaboration reports the detection of very-high-energy (VHE) gamma-ray emission from the flat spectrum radio quasar PKS 1441+25 ($z=0.939$) during the night of April 21, 2015 (UT). Observations were triggered by the discovery of VHE emission from PKS 1441+25 with the MAGIC telescope (see ATel #7416). Flaring activity in optical, X-rays and gamma rays has also been recently detected (see ATel #7402, #7417, #7429). VERITAS observed the quasar for about 4 hours, detecting it at a significant level above 5 standard deviations. Preliminary analysis indicates that the source flux was 8.0 ± 1.5 (stat) $e^{-11} \text{ cm}^{-2} \text{ s}^{-1}$ above 80 GeV. VERITAS will continue to monitor the source for the next few days (weather permitting). Multi-wavelength observations

**MWL Observations
of PKS 1441+25 are
Encouraged!**



MIWL

**TELEVISION
NETWORK**

NuSTAR Observations of Blazars

Amy Furniss

Stanford University

(gamma-ray)

for the NuSTAR Team, VERITAS Collaboration, MAGIC Collaboration, Fermi Collaboration, ++Optical and radio partners

Relativistic Jets: Creation, Dynamics, and Internal Dynamics

Krakow, Poland

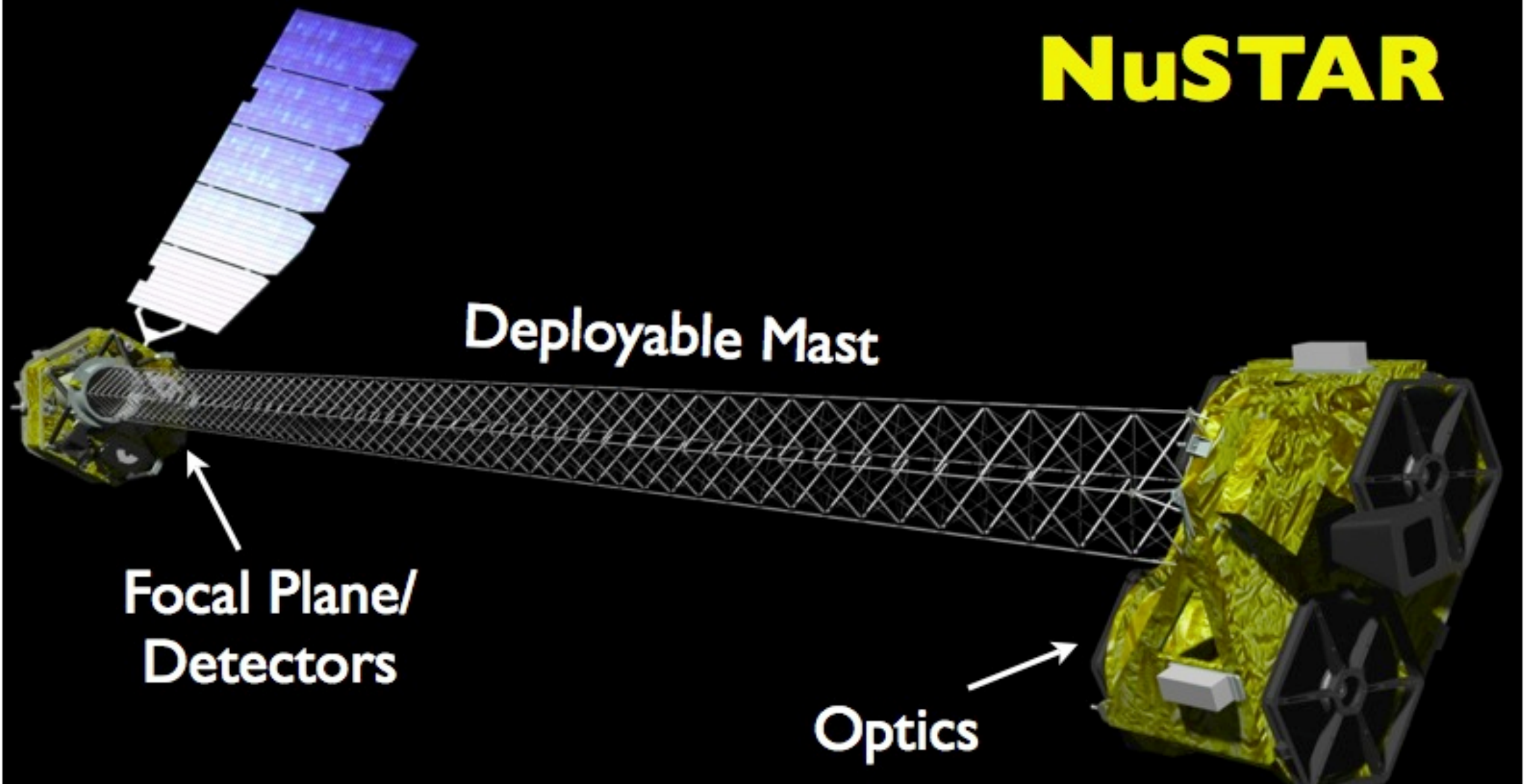
April 20- 24



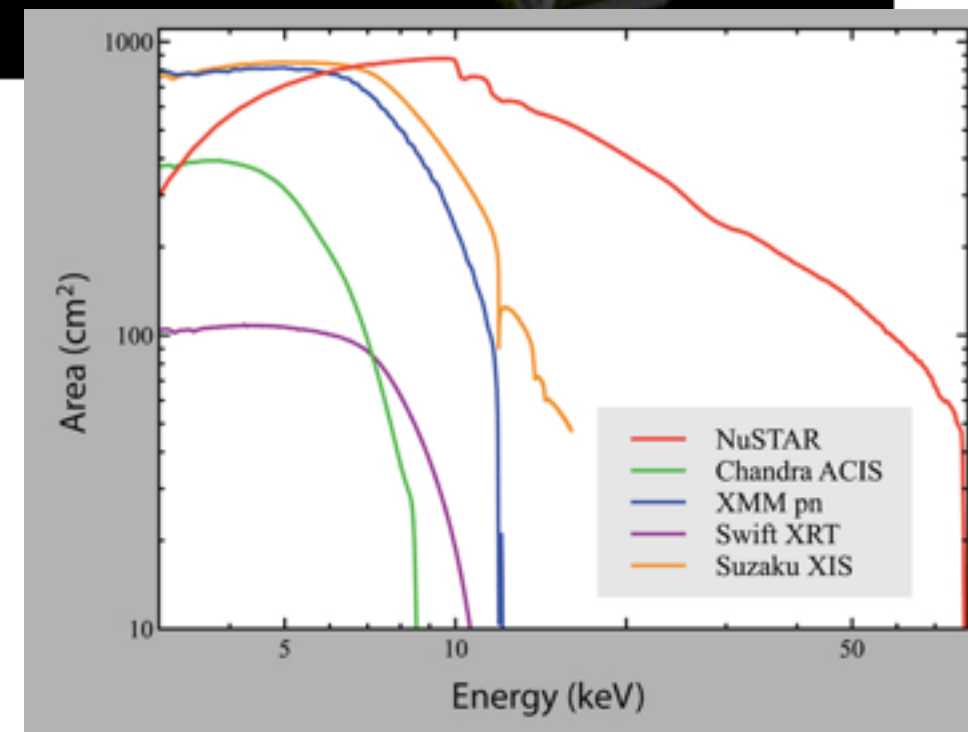
STANFORD
UNIVERSITY



NuSTAR

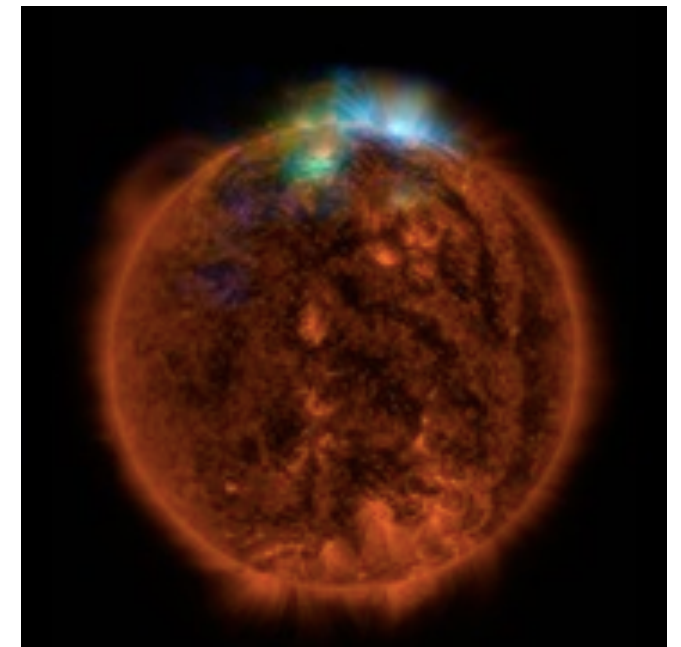
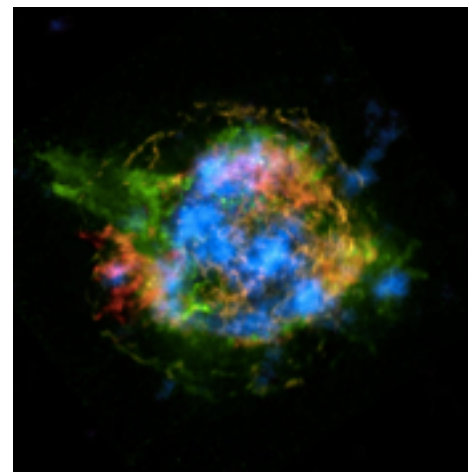


- Nuclear Spectroscopic Telescope Array
- Launched 13 June 2012
- Focusing high energy X-ray telescope (3-79 keV)
- Low background and good angular resolution (18" FWHM)
- ~100X sensitivity improvement over other instruments in this bandpass
- < 24 hour ToO response
- Harrison et al. 2013, ApJ, 770, 103

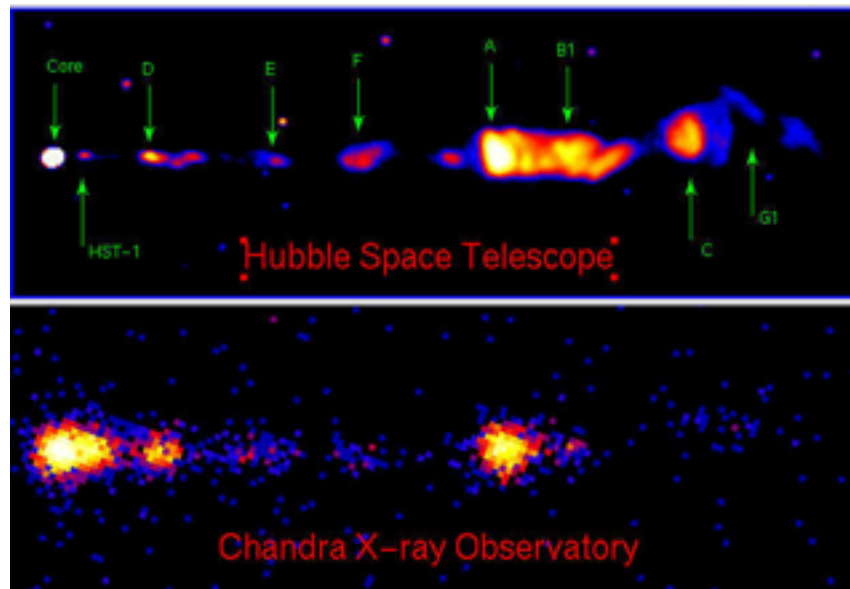
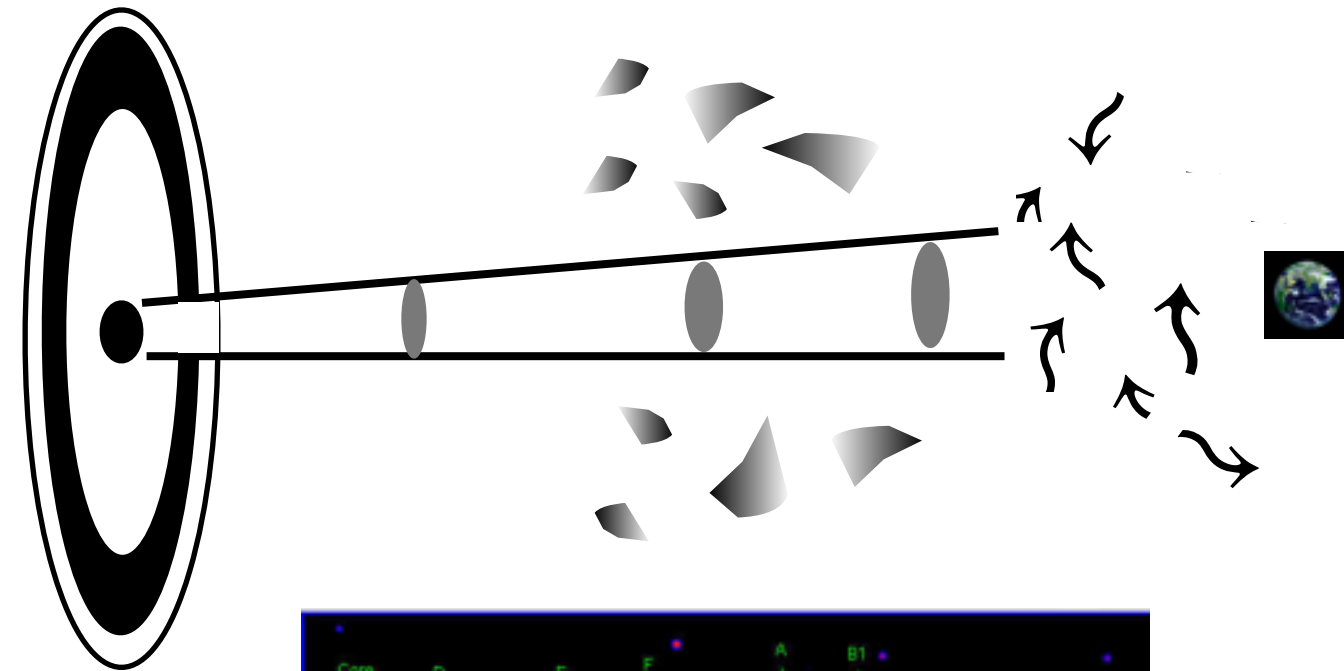
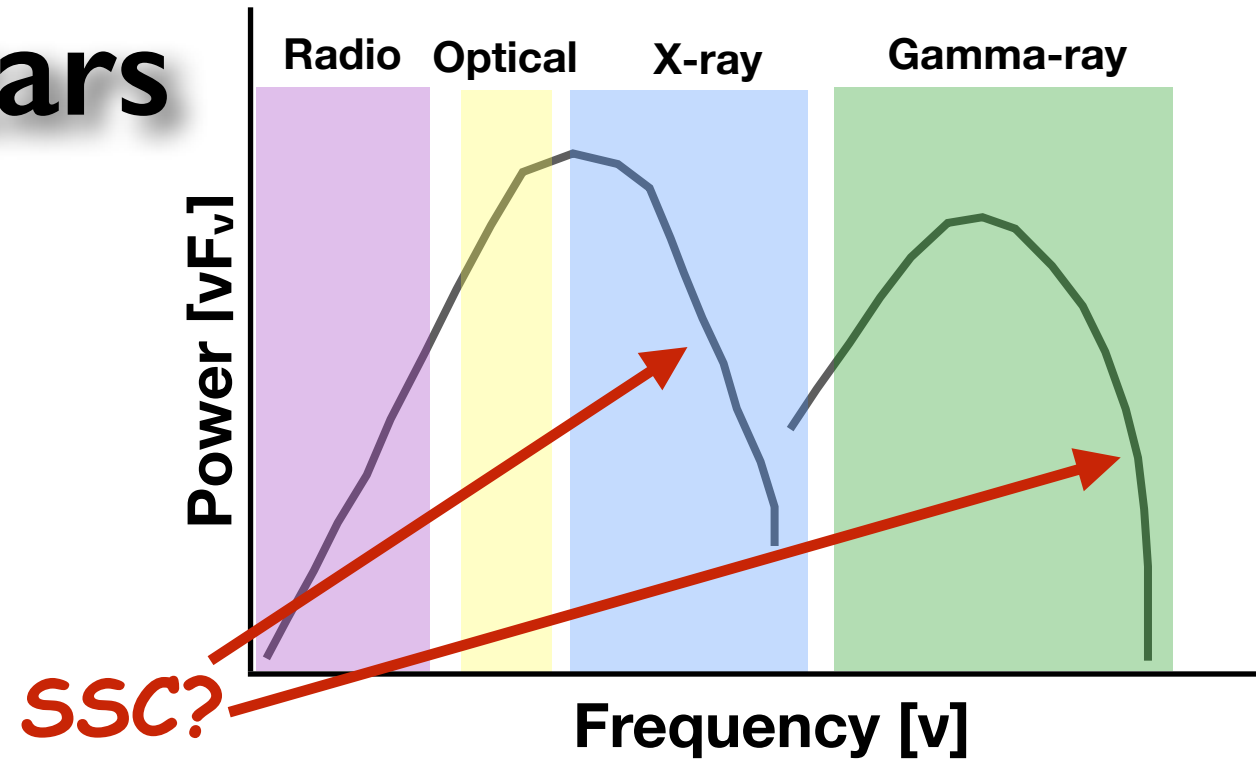
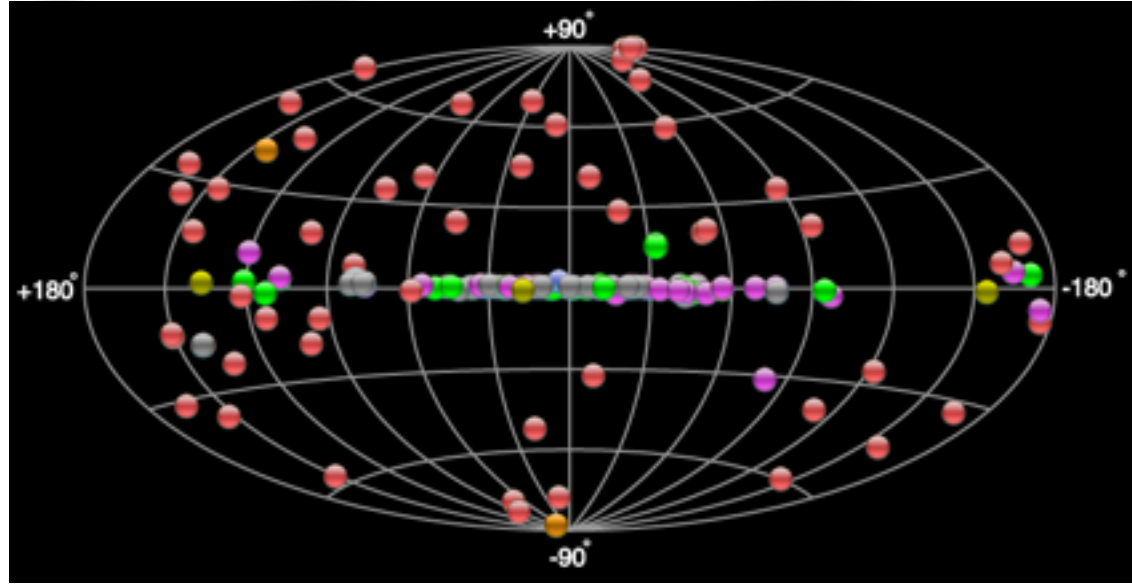


A Busy Observing Schedule

- Probe obscured **AGN**
- Study the population of Galactic hard X-ray-emitting **compact objects**
- Study the non-thermal radiation in young **supernova remnants**
- Observe **core-collapse supernovae** in the Local Group
- Observation of solar activity
- Observe **blazars** contemporaneously with ground-based radio, optical, and TeV telescopes, as well as with *Fermi* and *Swift*, to understand the structure of AGN jets
- +++!

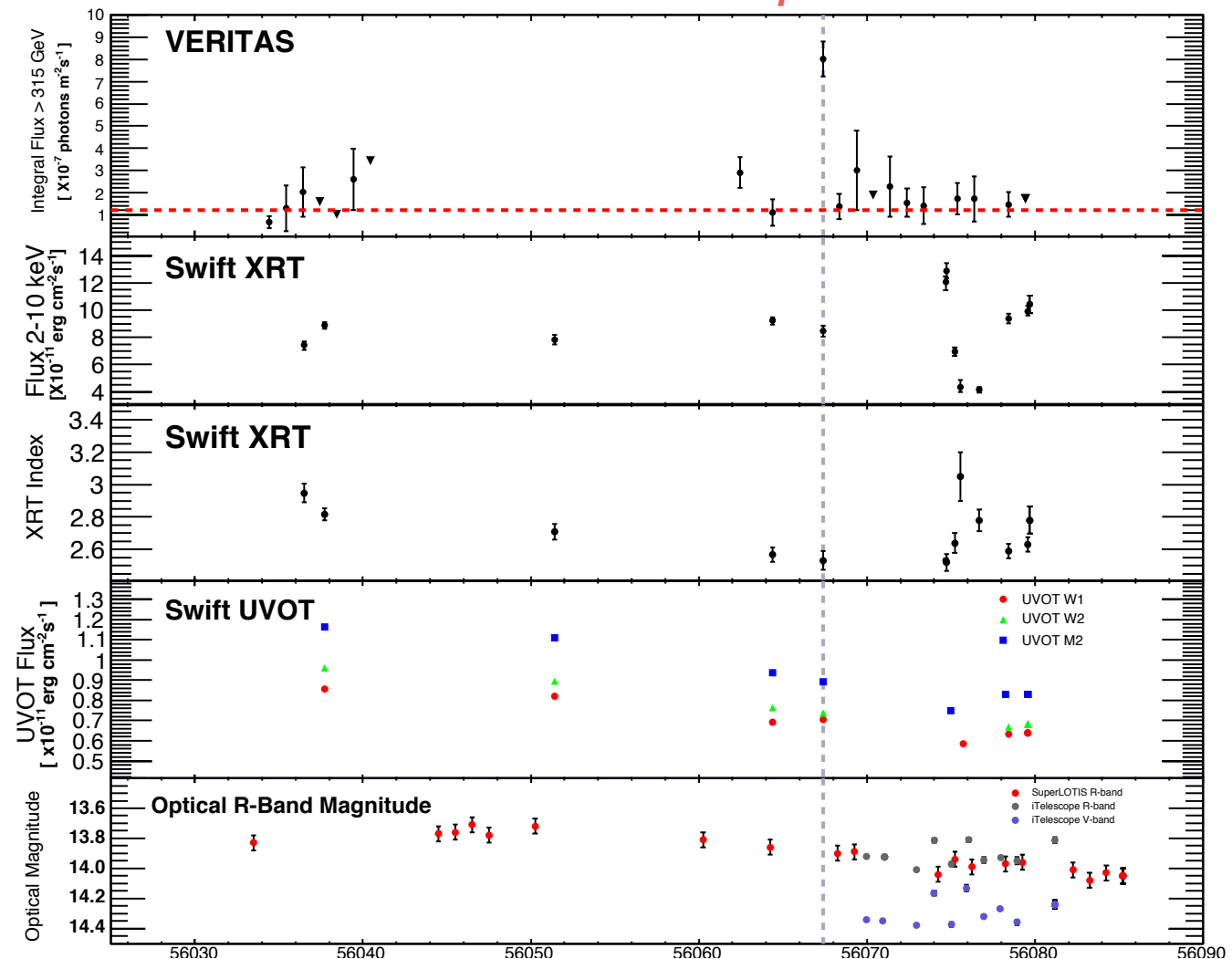


Very-High-Energy Blazars



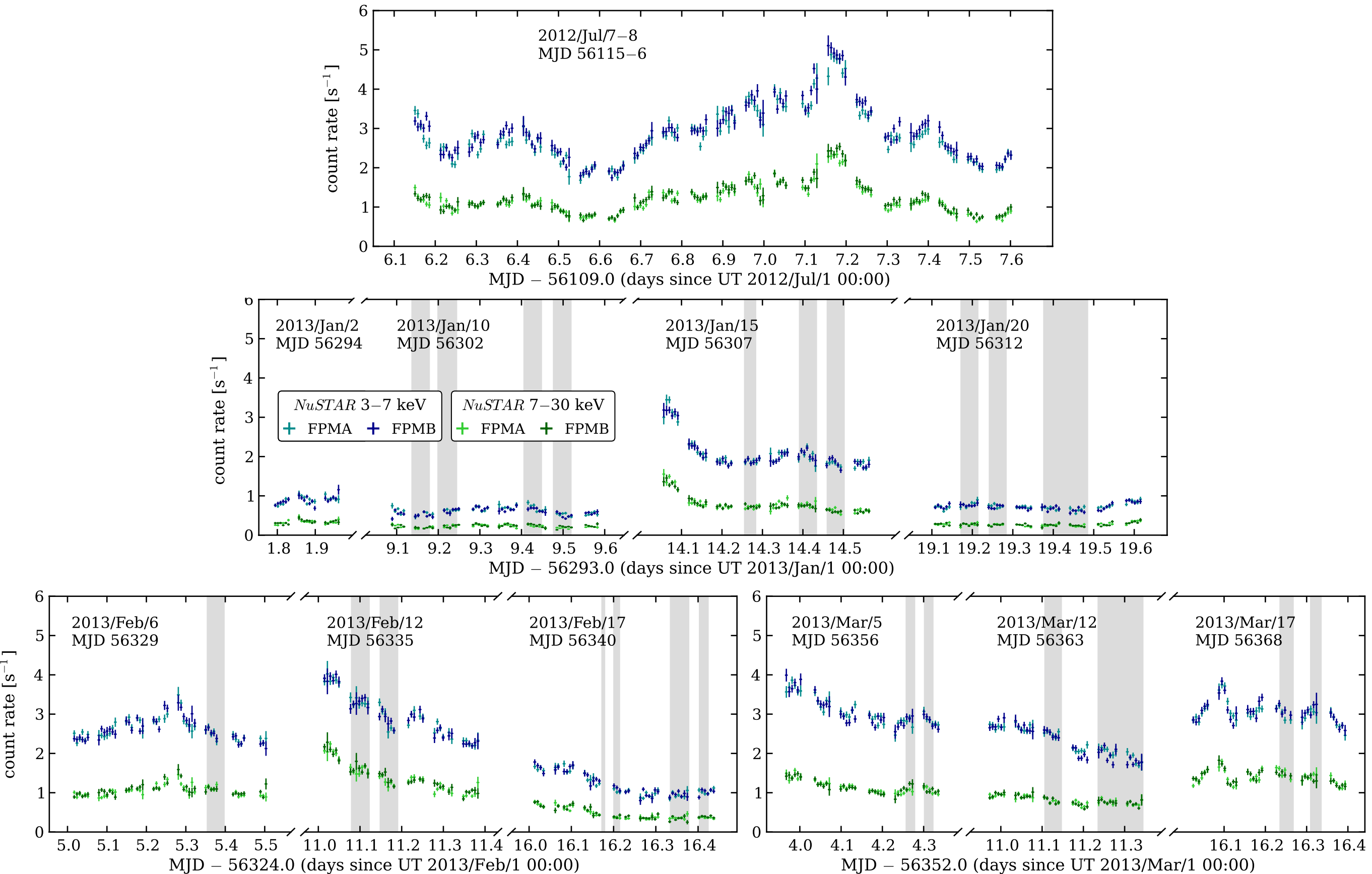
(ApJ, 2014, 797, 89)

1ES 1959+650
Orphan VHE flare in 2012?



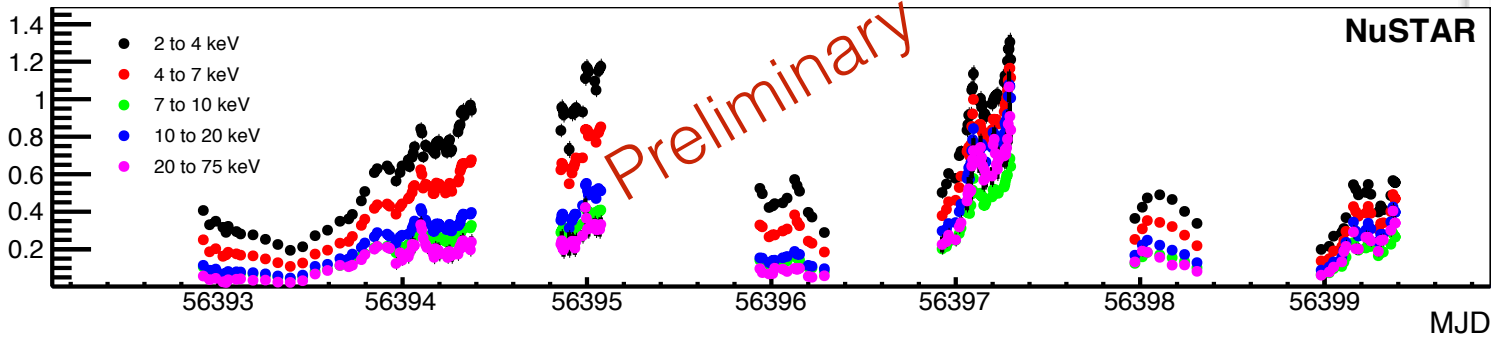
MWL Study of Quiescent States of Mkn 421 with Unprecedented Hard X-ray Coverage Provided by NuSTAR in 2013

Baloković et al., in preparation, Baloković et al. arXiv:1309.4494



April of 2013

Borracci et al., in preparation



MAXI observation of a bright X-ray flare with multiple peaks from Mrk 421

ATel #4978; *H. Negoro, K. Suzuki (Nihon U.), N. Kawai (Tokyo Tech), M. Serino (RIKEN), S. Ueno, H. Tomida, S. Nakahira, M. Kimura, M. Ishikawa (JAXA), T. Mihara, M. Sugizaki, M. Morii, T. Yamamoto, J. Sugimoto, T. Takagi, M. Matsuoka (RIKEN), R. Usui, K. Ishikawa, T. Yoshii (Tokyo Tech), A. Yoshida, T. Sakamoto, Y. Nakano (AGU), H. Tsunemi, M. Sasaki (Osaka U.), M. Nakajima, K. Fukushima, T. Onodera, (Nihon U.), Y. Ueda, M. Shidatsu, T. Kawamuro (Kyoto U.), Y. Tsuboi, M. Higa (Chuo U.), M. Yamauchi, K. Yoshidome, Y. Ogawa, H. Yamada (Miyazaki U.), K. Yamaoka (Nagoya U.)* report on behalf of the MAXI team
on 15 Apr 2013; 02:32 UT

Credential Certification: *Hitoshi Negoro (negoro@phys.cst.nihon-u.ac.jp)*

Subjects: X-ray, AGN, Blazar

Referred to by ATel #: [4982](#), [4983](#), [5021](#)

Recent optical activity of Mrk 421

ATel #4982; *E. Semkov, R. Bachev, A. Strigachev, S. Ibryamov, S. Peneva (Institute of Astronomy and NAO, Sofia, Bulgaria), A. C. Gupta (ARIES, Nainital, India)*
on 16 Apr 2013; 12:08 UT

Credential Certification: *E. Semkov (esemkov@astro.bas.bg)*

Subjects: Optical, Blazar

Referred to by ATel #: [5021](#)

NuSTAR detects extreme X-ray flaring of Mrk 421

ATel #4974; *Mislav Balokovic (Caltech), Amy Furniss (UCSC), Grzegorz Madejski (KIPAC/Stanford), Fiona Harrison (Caltech)*

on 13 Apr 2013; 00:00 UT

Credential Certification: *Amy Furniss (afurniss@ucsc.edu)*

Subjects: X-ray, Request for Observations, AGN, Blazar

MAGIC and VERITAS detect an unprecedented flaring activity from Mrk 421 in very high energy gamma-rays

ATel #4976; *Juan Cortina (IFAE Barcelona) and Jamie Holder (University of Delaware) for the MAGIC and VERITAS collaborations*

on 13 Apr 2013; 20:22 UT

Credential Certification: *Juan Cortina (cortina@ifae.es)*

Subjects: Optical, X-ray, Gamma Ray, TeV, VHE, Request for Observations, AGN, Blazar, Transient

Referred to by ATel #: [4977](#), [4978](#), [4982](#), [4983](#), [5021](#), [5107](#)

Fermi-LAT and Swift-XRT observe exceptionally high activity from the nearby TeV blazar Mrk421

ATel #4977; *D. Paneque (MPI for Physics, Munich), F. D'Ammando (INAF-IRA Bologna), M. Orienti (INAF-IRA Bologna) on behalf of the Fermi LAT Collaboration, and A. Falcone (PSU) on behalf of the Swift team*

on 13 Apr 2013; 20:30 UT

Credential Certification: *David Paneque (dpaneque@slac.stanford.edu)*

Subjects: X-ray, Gamma Ray, >GeV, TeV, VHE, Blazar, Transient

Referred to by ATel #: [4978](#), [4982](#), [4983](#), [5021](#), [5107](#)

Swift/BAT observations of the X-ray flare from Mrk 421

ATel #4983; *H. A. Krimm (CRESST/GSFC/USRA), S. D. Barthelmy (GSFC), W. Baumgartner (CRESST/GSFC/UMBC), J. Cummings (CRESST/GSFC/UMBC), N. Gehrels (GSFC), A. Y. Lien (NASA/GSFC/ORAU), C. B. Markwardt (GSFC), D. Palmer (LANL), T. Sakamoto (AGU), M. Stamatikos (OSU/GSFC), T. Ukwatta (MSU)*

on 16 Apr 2013; 18:20 UT

Credential Certification: *Hans A. Krimm (Hans.Krimm@nasa.gov)*

Subjects: X-ray, Blazar, Transient

A weak intra-day variability detected in blazar Mrk 421

ATel #5021; *X. Liu (XAO), M.-Q. Lin (XAO/UCAS), J. Liu (XAO/UCAS), T. P. Krichbaum (MPIfR), L. Fuhrmann (MPIfR), N. Marchili (University of Padova)*

on 27 Apr 2013; 12:26 UT

Credential Certification: *Xiang Liu (liux@xao.ac.cn)*

An increase in the millimeter and centimeter band flux density of Mrk421

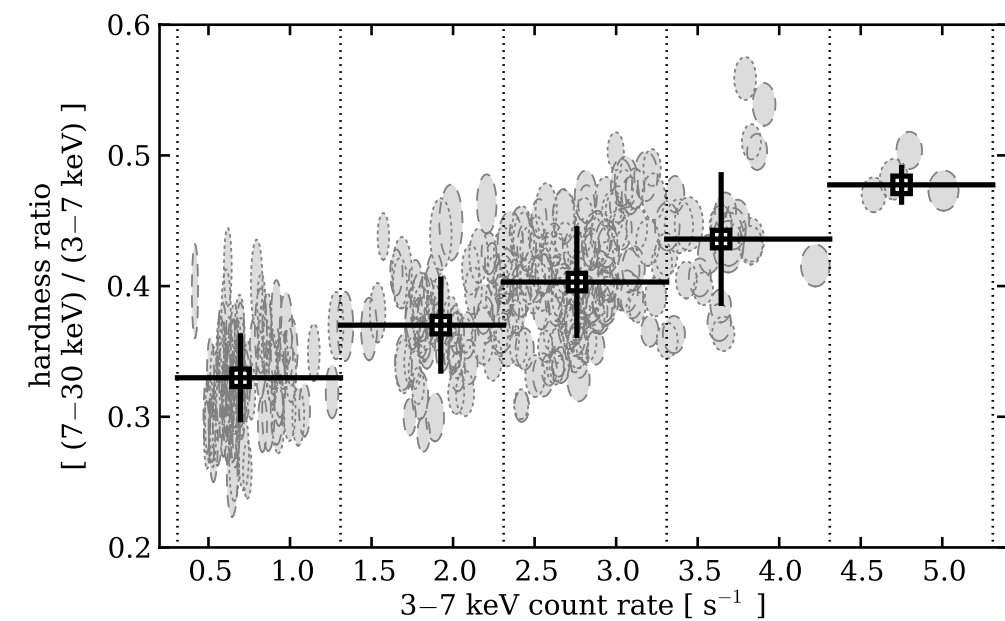
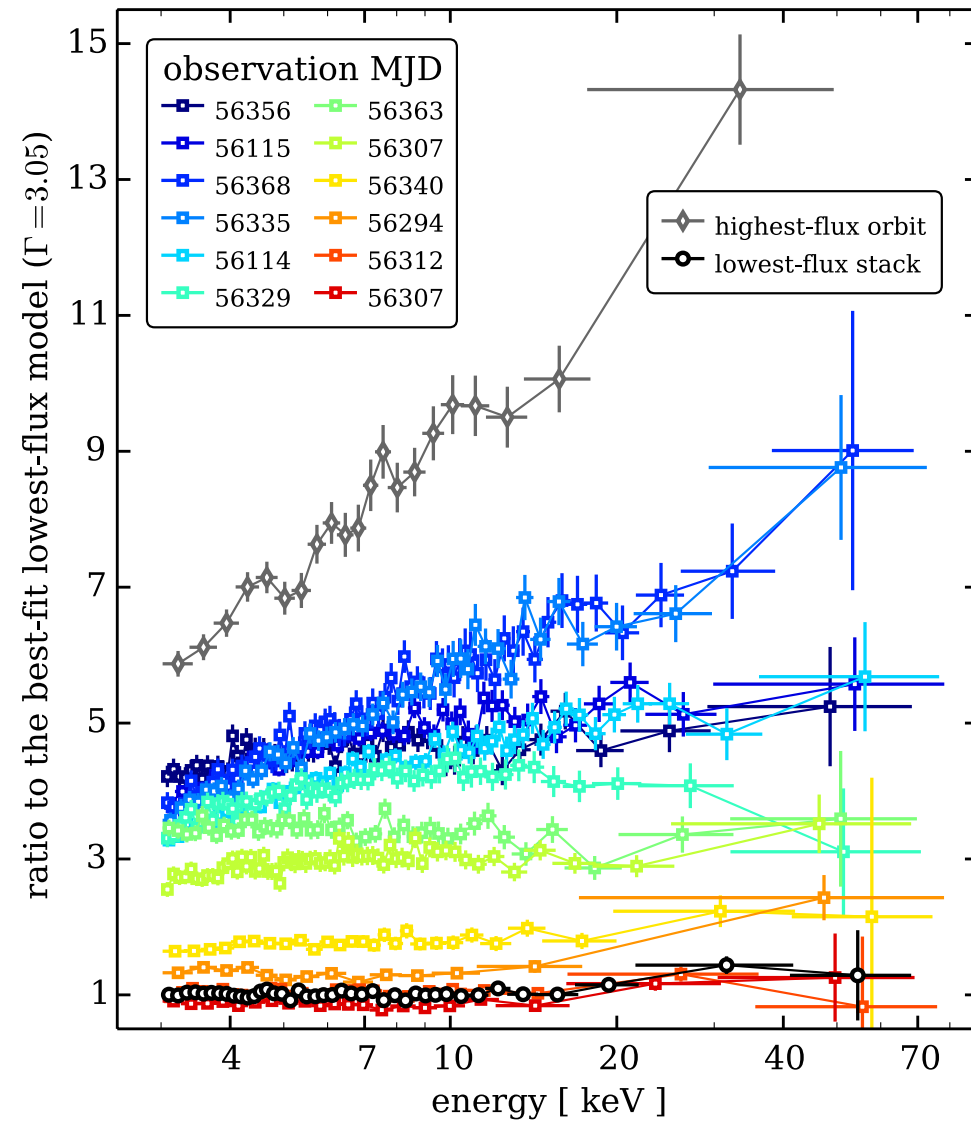
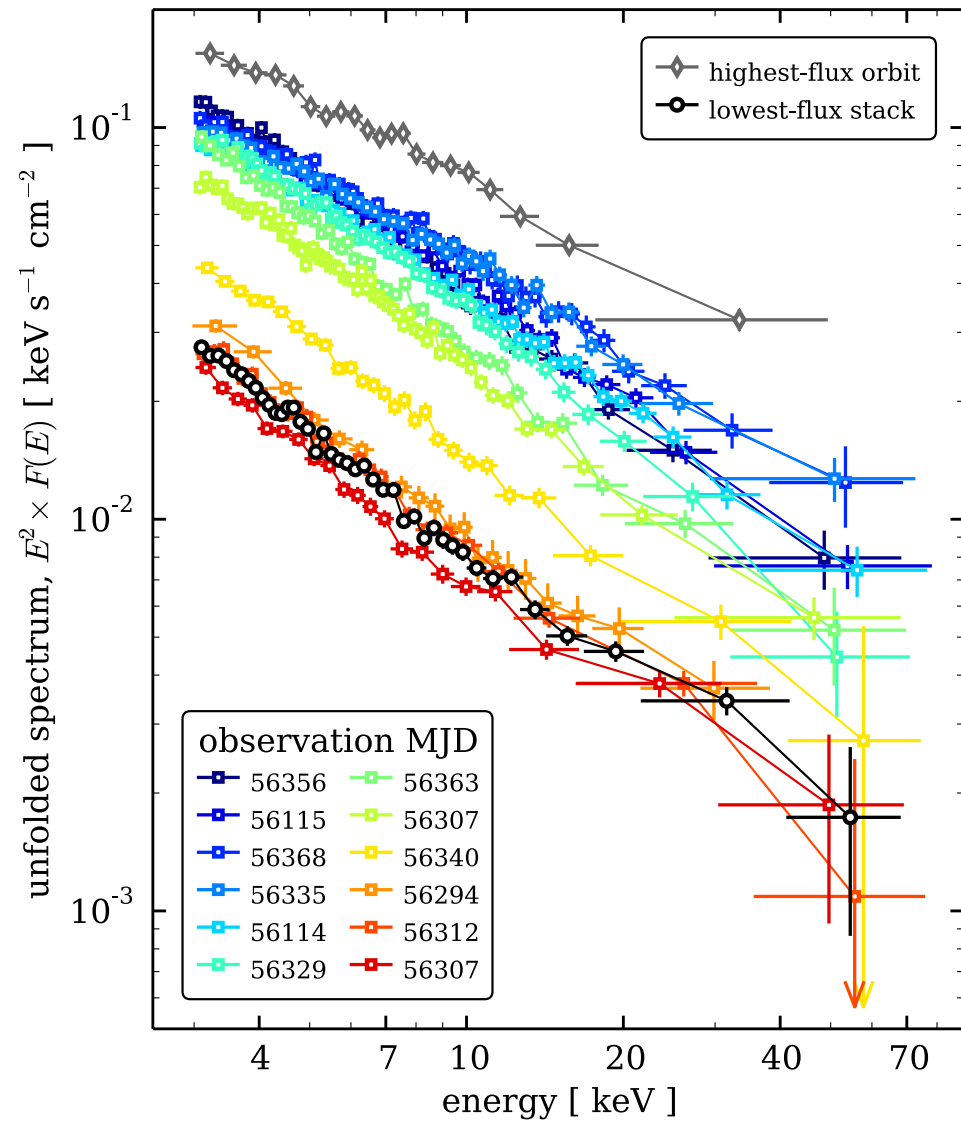
ATel #5107; *Talvikki Hovatta (Caltech), Mislav Balokovic (Caltech), Joseph L. Richards (Purdue), Walter Max-Moerbeck (NRAO), Anthony C. S. Readhead (Caltech)*

on 5 Jun 2013; 18:45 UT

Credential Certification: *Talvikki Hovatta (thovatta@caltech.edu)*

Subjects: Radio, Millimeter, Blazar

Mrk 421 Hard X-ray Spectral Variability



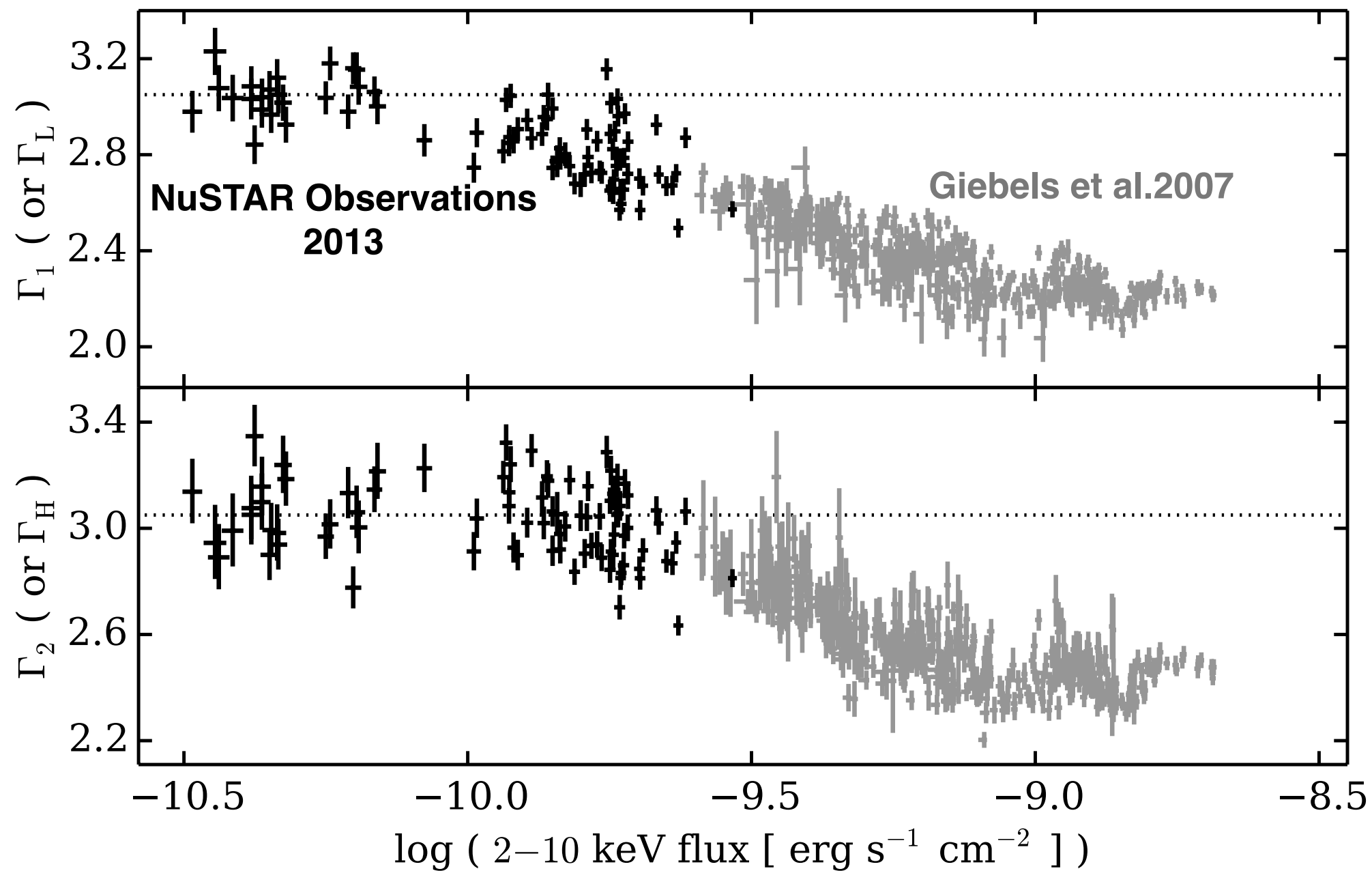
| Sequence ID | Start Date [UTC] | Start Time [MJD] | Number of Orbits | Duration [ks] | Exposure ^a [ks] | Count Rate ^b [s ⁻¹] | |
|-------------|--------------------|--------------------|------------------|-----------------|------------------------------|---|---------------|
| | | | | | | FPMA | FPMB |
| 10002015001 | 2012-Jul-07 | 56115.1353 | 14 | 81.0 | 42.0 | 3.71 ± 0.01 | 3.84 ± 0.01 |
| 10002016001 | 2012-Jul-08 | 56116.0732 | 8 | 46.2 | 25.4 | 4.18 ± 0.01 | 4.45 ± 0.01 |
| 60002023002 | 2013-Jan-02 | 56294.7778 | 3 | 15.6 | 9.2 | 1.162 ± 0.009 | 1.155 ± 0.008 |
| 60002023004 | 2013-Jan-10 | 56302.0533 | 8 | 44.6 | 22.6 | 0.785 ± 0.007 | 0.751 ± 0.006 |
| 60002023006 | 2013-Jan-15 | 56307.0386 | 8 | 45.9 | 22.4 | 2.79 ± 0.01 | 2.74 ± 0.01 |
| 60002023008 | 2013-Jan-20 | 56312.0980 | 8 | 45.2 | 24.9 | 0.923 ± 0.006 | 0.899 ± 0.006 |
| 60002023010 | 2013-Feb-06 | 56329.0116 | 8 | 42.2 | 19.3 | 3.52 ± 0.01 | 3.55 ± 0.01 |
| 60002023012 | 2013-Feb-12 | 56335.0106 | 6 | 35.4 | 14.8 | 4.39 ± 0.02 | 4.43 ± 0.02 |
| 60002023014 | 2013-Feb-17 | 56339.9828 | 7 | 41.7 | 17.4 | 1.50 ± 0.01 | 1.54 ± 0.01 |
| 60002023016 | 2013-Mar-04 | 56355.9631 | 6 | 35.0 | 17.3 | 4.11 ± 0.02 | 4.13 ± 0.02 |
| 60002023018 | 2013-Mar-11 | 56362.9690 | 6 | 31.9 | 17.5 | 3.04 ± 0.01 | 3.02 ± 0.01 |
| 60002023020 | 2013-Mar-17 | 56368.0210 | 6 | 35.1 | 16.6 | 4.33 ± 0.02 | 4.38 ± 0.02 |

^a Livetime-corrected sum of all good time intervals comprising the observation.

^b PSF-corrected source count rate and its uncertainty in the 3–30 keV band averaged over the exposure time.

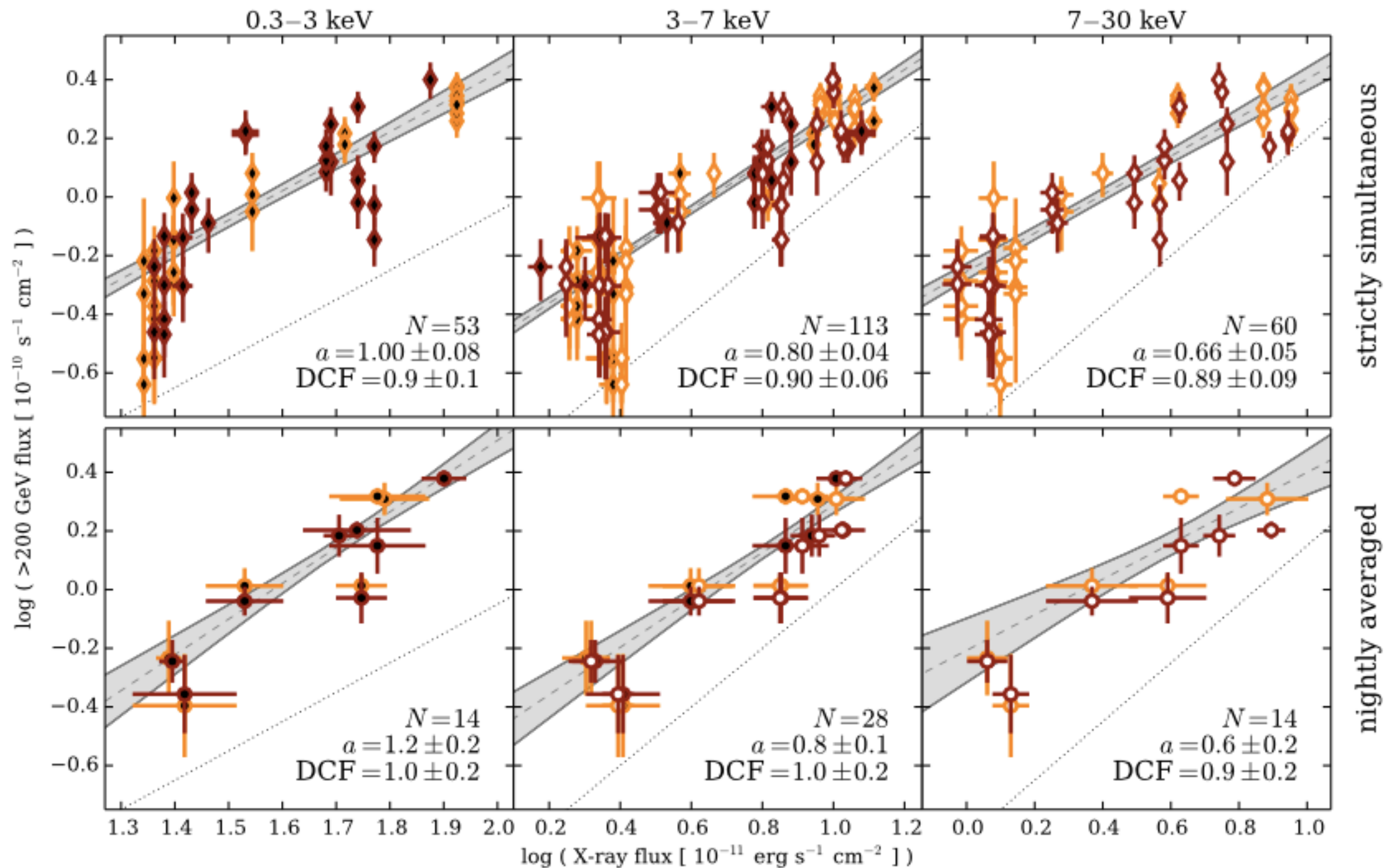
Mrk 421 Hard X-ray Spectral Variability

Extending the Insight on Spectral State at Low Flux Levels



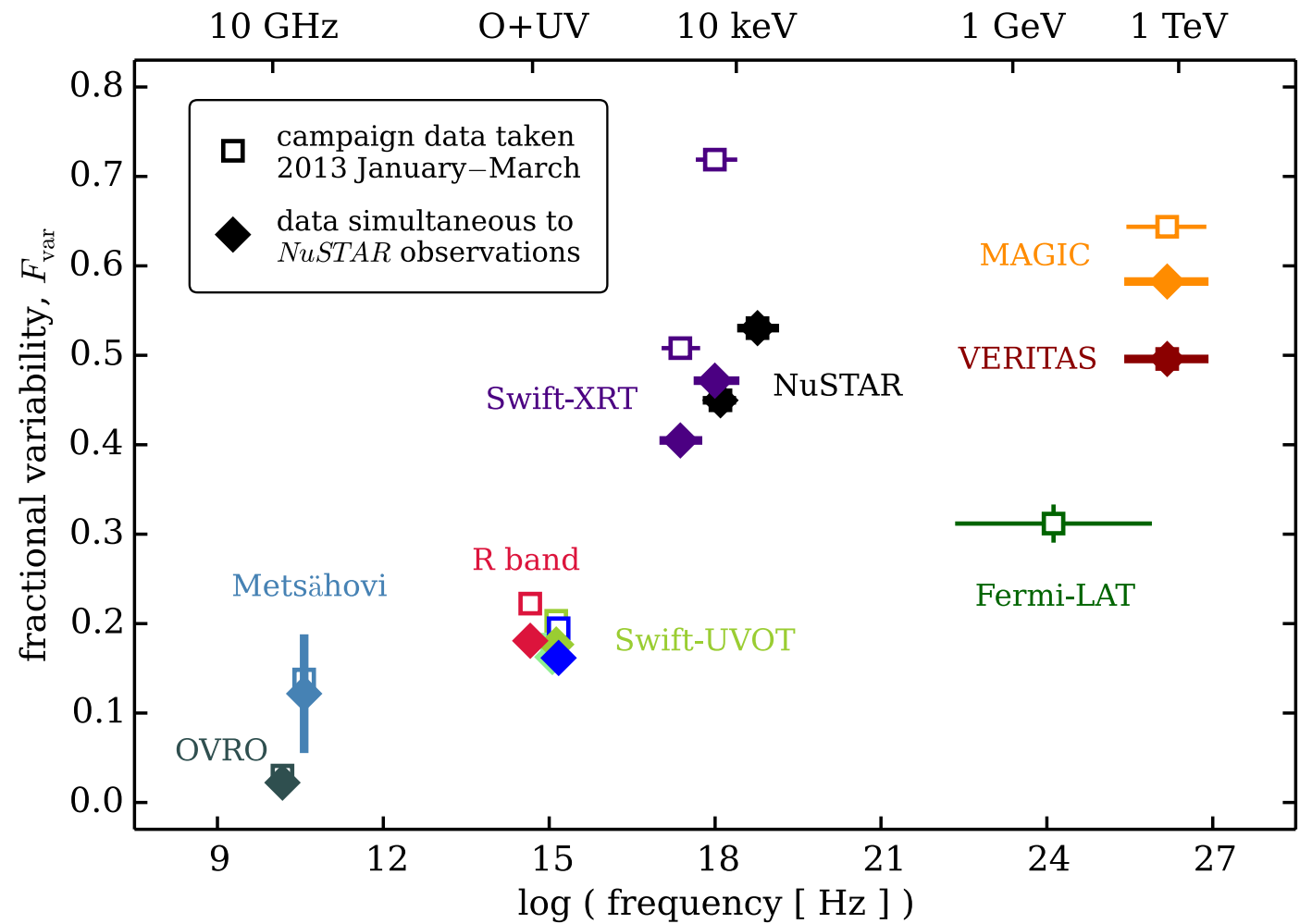
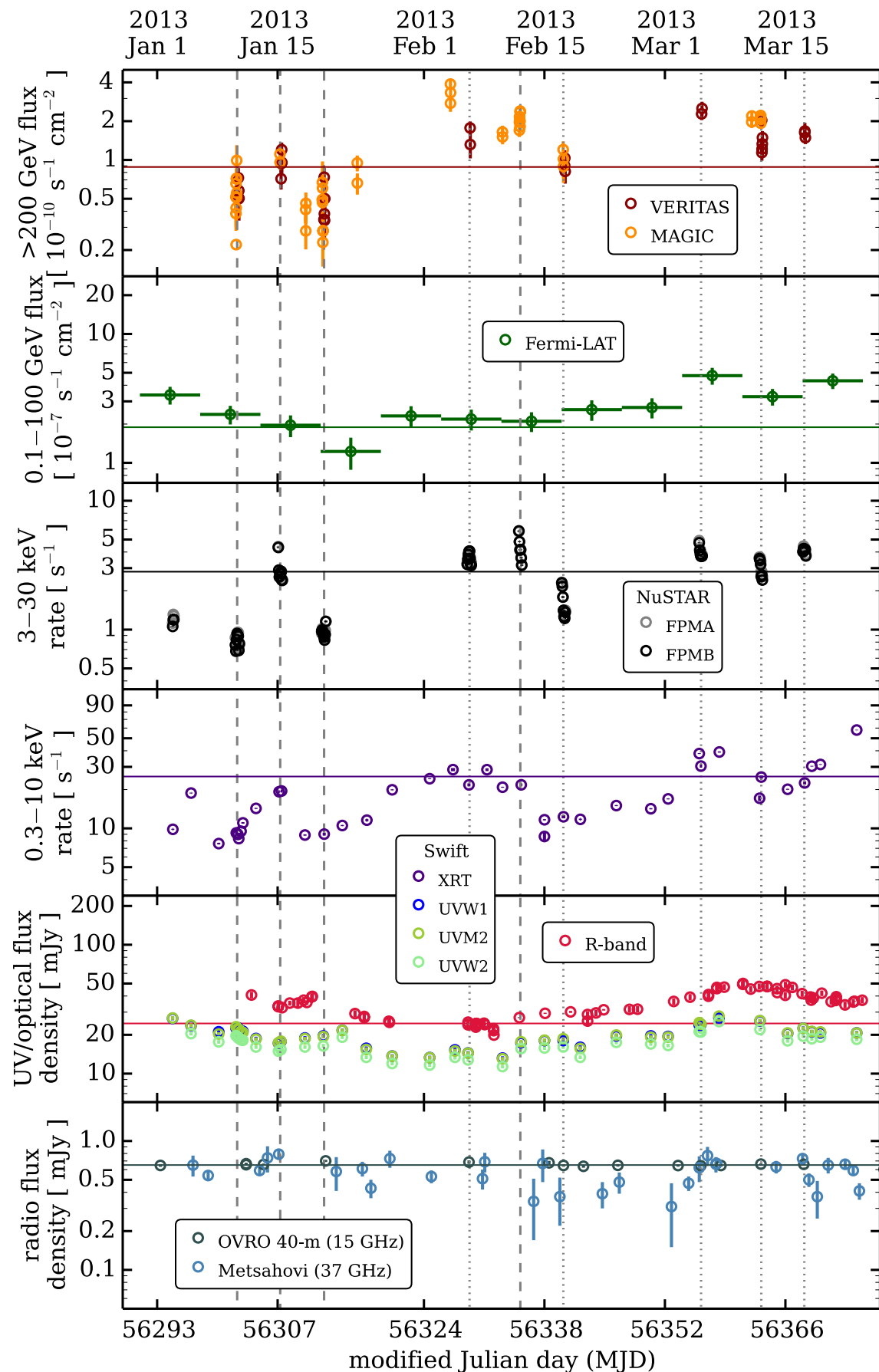
- ◆ Spectral trends found in NuSTAR observations
- ◆ Break energy kept fixed at 7 keV
- ◆ Smooth trend
- ◆ Apparent saturation at both ends
- ◆ No longer a break when $\text{Log}(\text{flux}) < \sim -10.0$ ($\Gamma_{\text{low}} \sim 3.0$)
- ◆ Archival from Giebels et al. 2007

Mrk 421 X-ray vs VHE Flux



- ◆ Fitted slopes of between 0.6-1.2 in all X-ray bands
- ◆ Trend remains for strictly simultaneous observations
- ◆ Consistent with IC up-scattering occurring in the Klein-Nishina regime

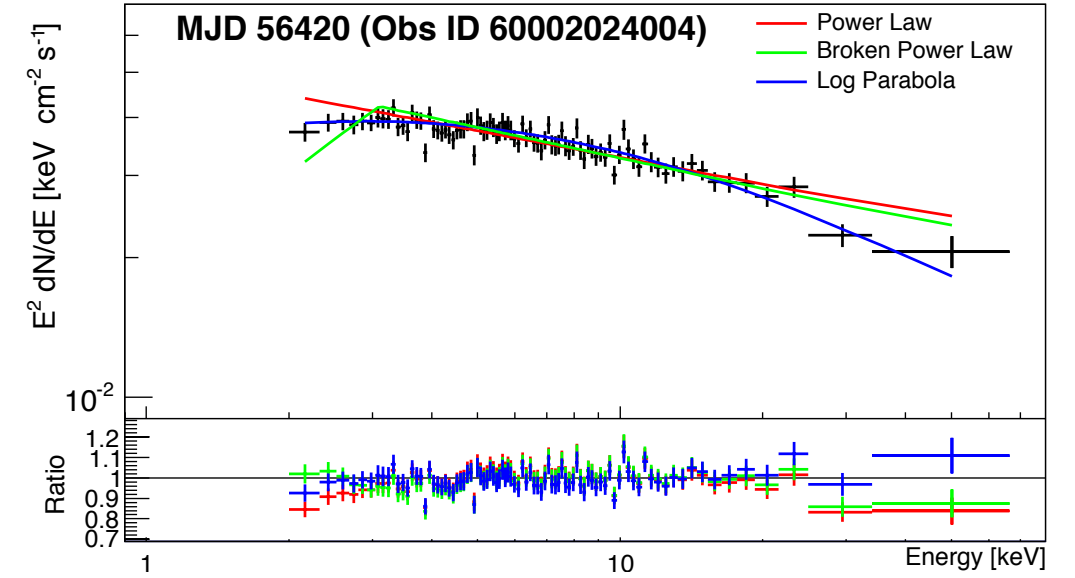
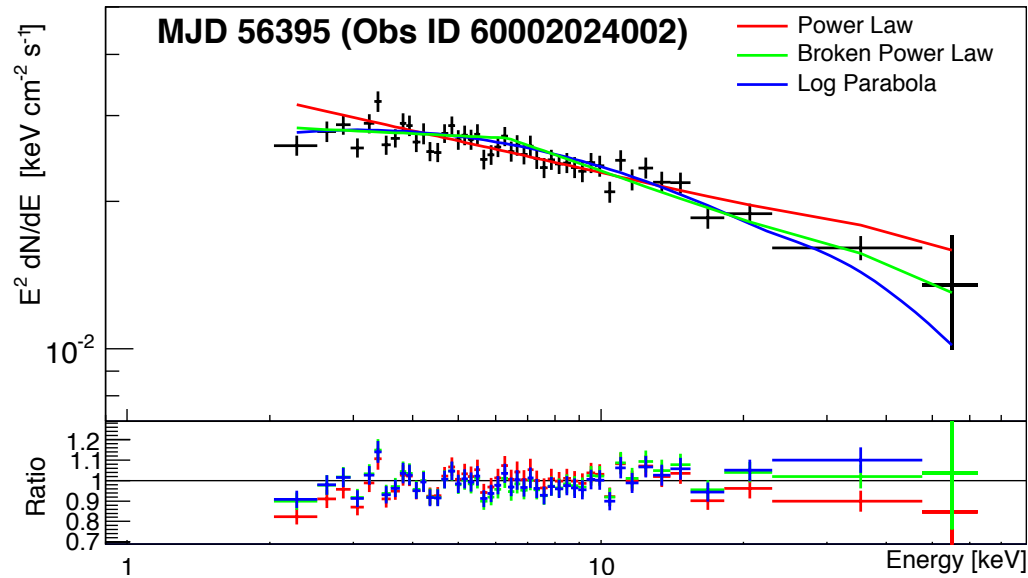
Mrk 421 Broadband Variability



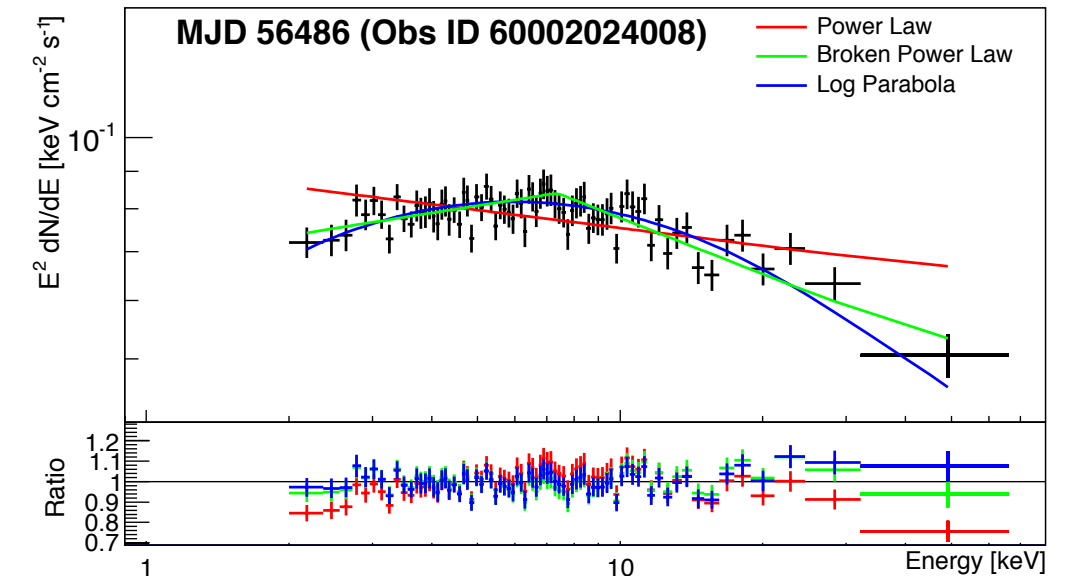
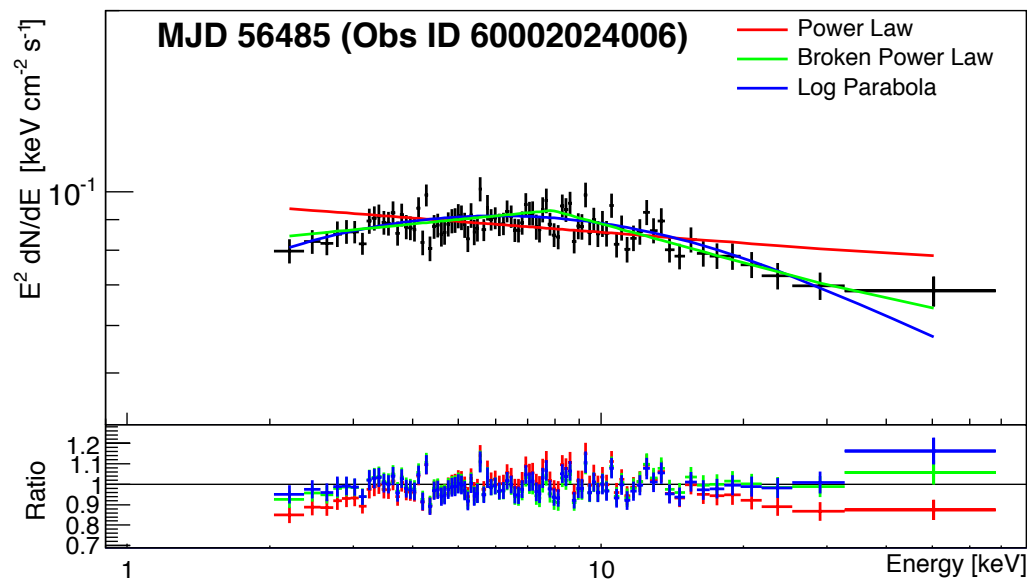
- ◆ Observations from radio to TeV
- ◆ Higher fractional variability in X-ray and VHE bands as compared to optical and radio
- ◆ *Fermi* LAT shows evidence of significant fractional variability

First *NuSTAR* Observations of Mrk 501 within a Radio to TeV Multi-Instrument Campaign

Furniss et al., ApJ submitted (as of yesterday!)

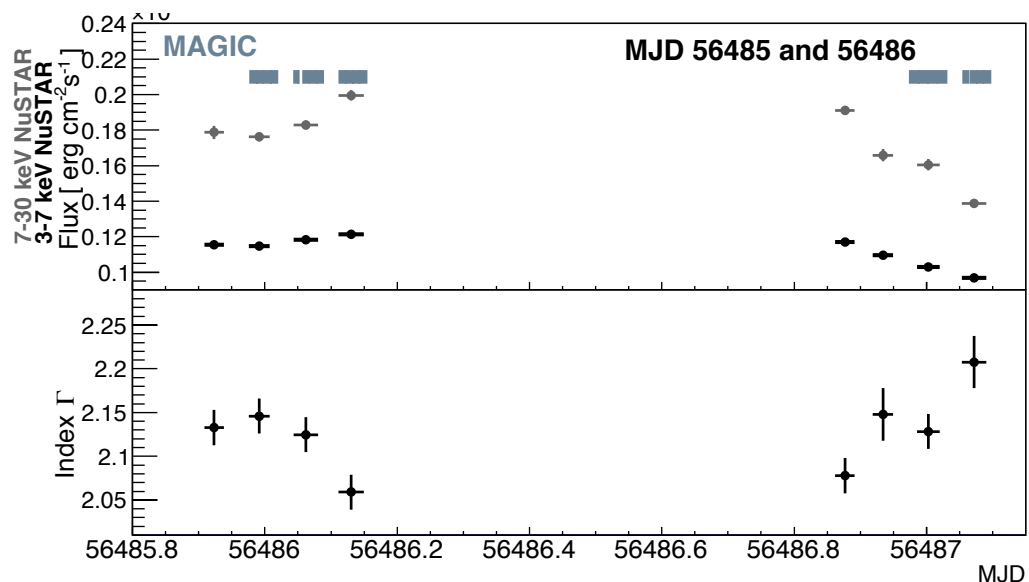
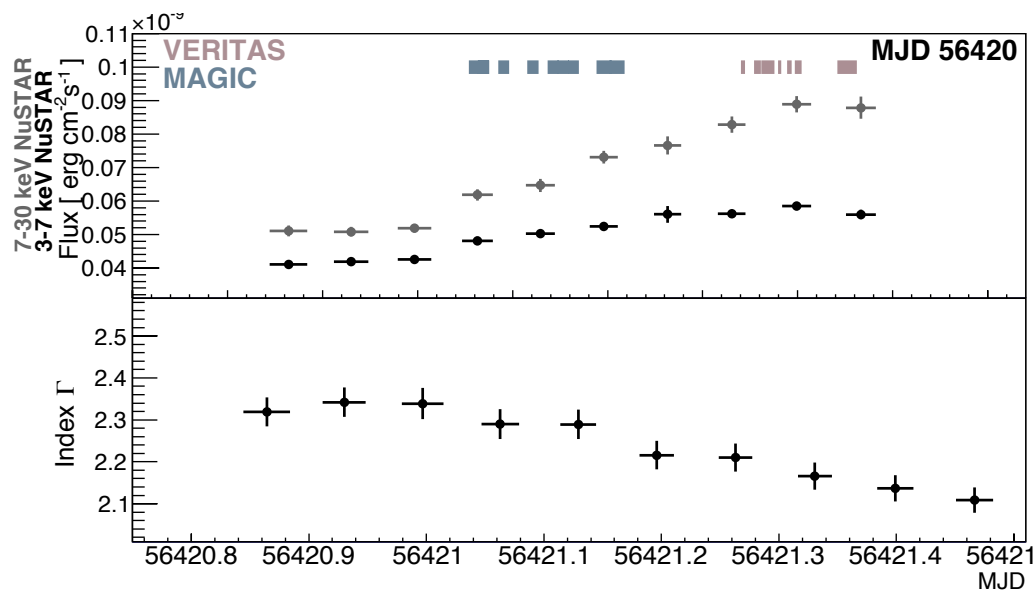
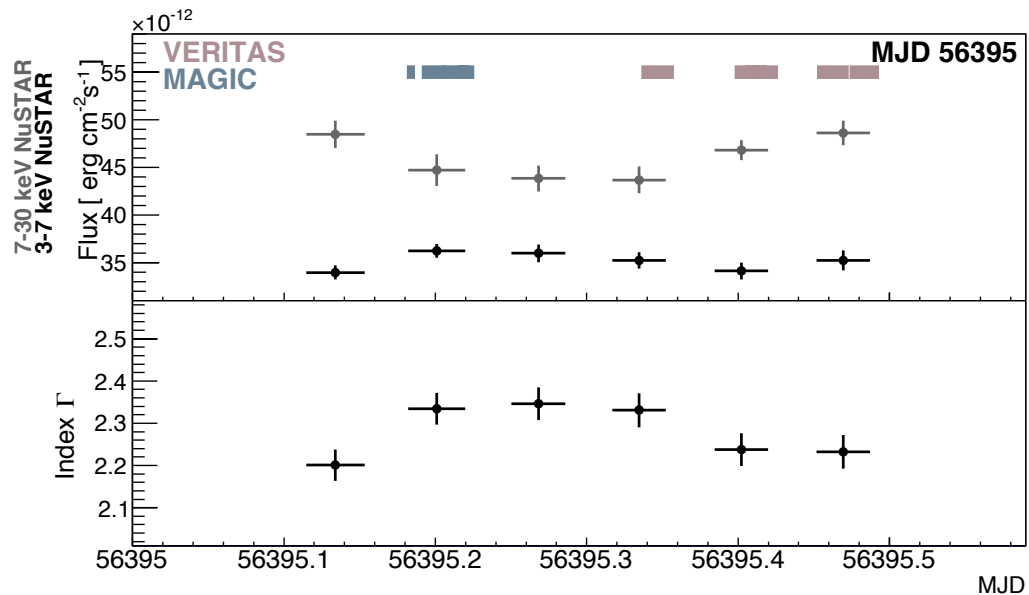


| Observation ID | MJD Exposure Range | Exposure [ks] | Number Orbits | Detection Range [keV] |
|----------------|--------------------|---------------|---------------|-----------------------|
| 60002024002 | 56395.1-56395.5 | 19.7 | 6 | 3-60 |
| 60002024004 | 56420.8-56421.5 | 28.3 | 10 | 3-65 |
| 60002024006 | 56485.9-56486.2 | 11.9 | 4 | 3-70 |
| 60002024008 | 56486.8-56487.1 | 11.4 | 4 | 3-70 |



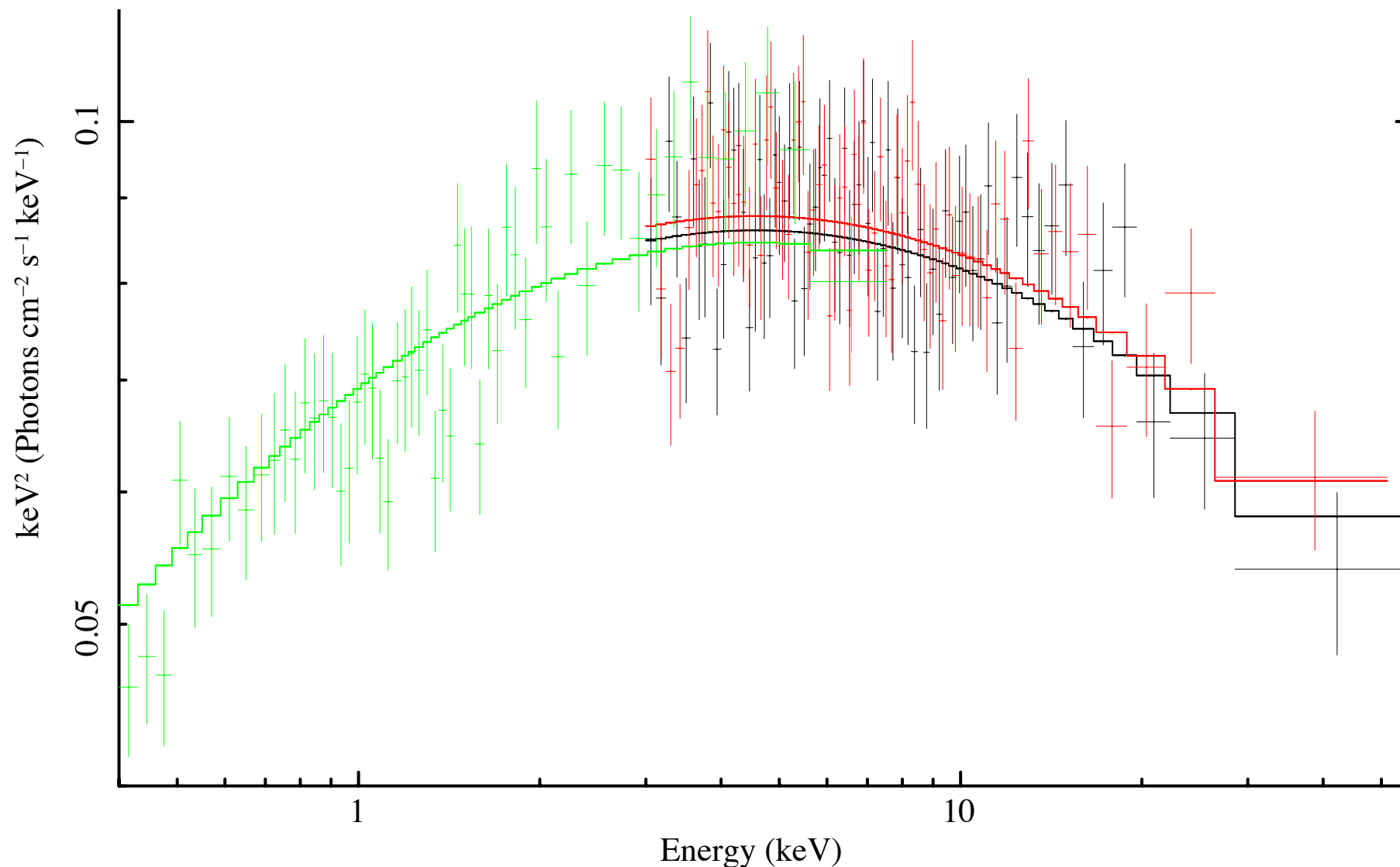
NuSTAR Mrk 501 Observation Orbit-by-orbit

- ◆ Flux variability in 3-7 keV and 7-30 keV bands on orbit timescale (~ 90 min)
- ◆ *NuSTAR* Detection to 30 keV in ~ 90 min
- ◆ Significant preference for log-parabolic fit versus power-law and broken power-law fits
- ◆ Simultaneous MAGIC and VERITAS observations for every *NuSTAR* exposure

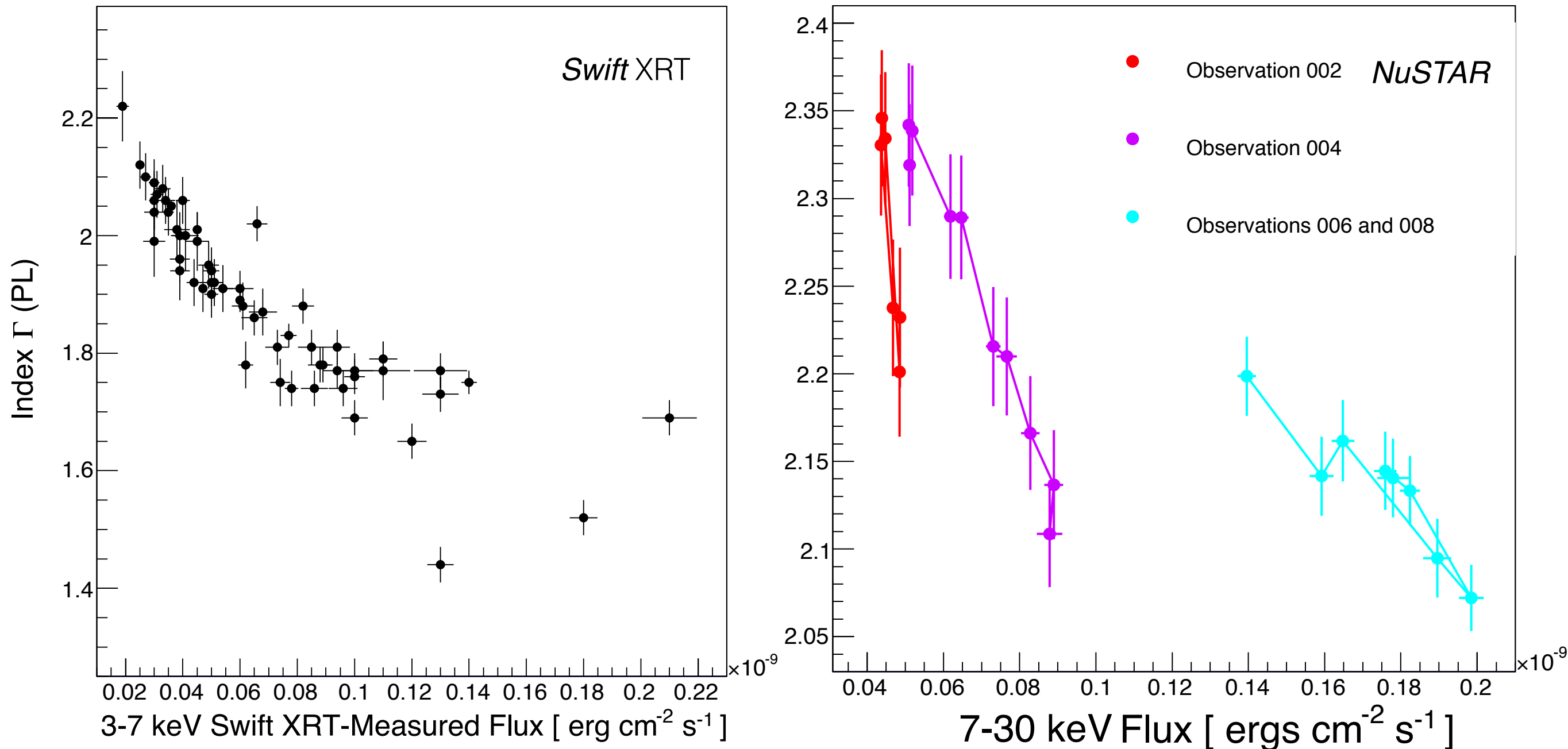


Full View of the Mrk 501 Synchrotron Peak

| Observation ID | Date [MJD] | Orbit Number | E_{syn} [keV] | $F(E_{\text{syn}})$ [$\times 10^{-11}$ ergs $\text{cm}^{-2} \text{s}^{-1}$] | Curvature β | χ^2/DOF |
|----------------|------------|--------------|------------------------|---|-------------------|---------------------|
| 60002024002 | 56395.1 | 1 | <0.85 | 4.1 | 0.061 | 669/673 |
| 60002024006 | 56485.9 | 1 | 4.9 ± 0.7 | 13.8 | 0.21 | 596/577 |
| 60002024006 | 56486.0 | 2 | 5.1 ± 0.9 | 13.7 | 0.22 | 697/715 |
| 60002024006 | 56486.2 | 4 | 7.0 ± 0.8 | 14.6 | 0.2 | 877/848 |
| 60002024008 | 56487.1 | 4 | 3.3 ± 0.9 | 11.2 | 0.17 | 832/851 |

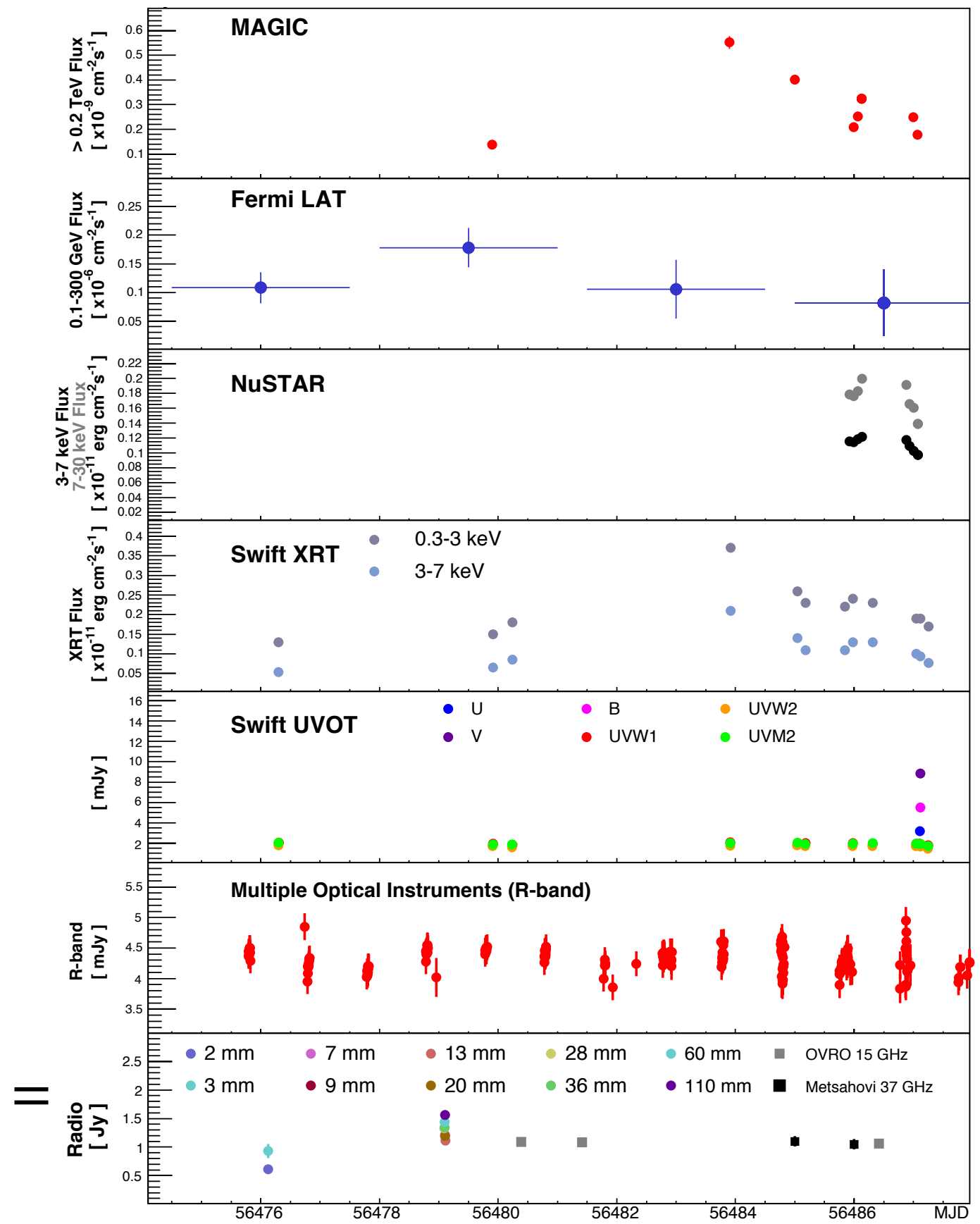
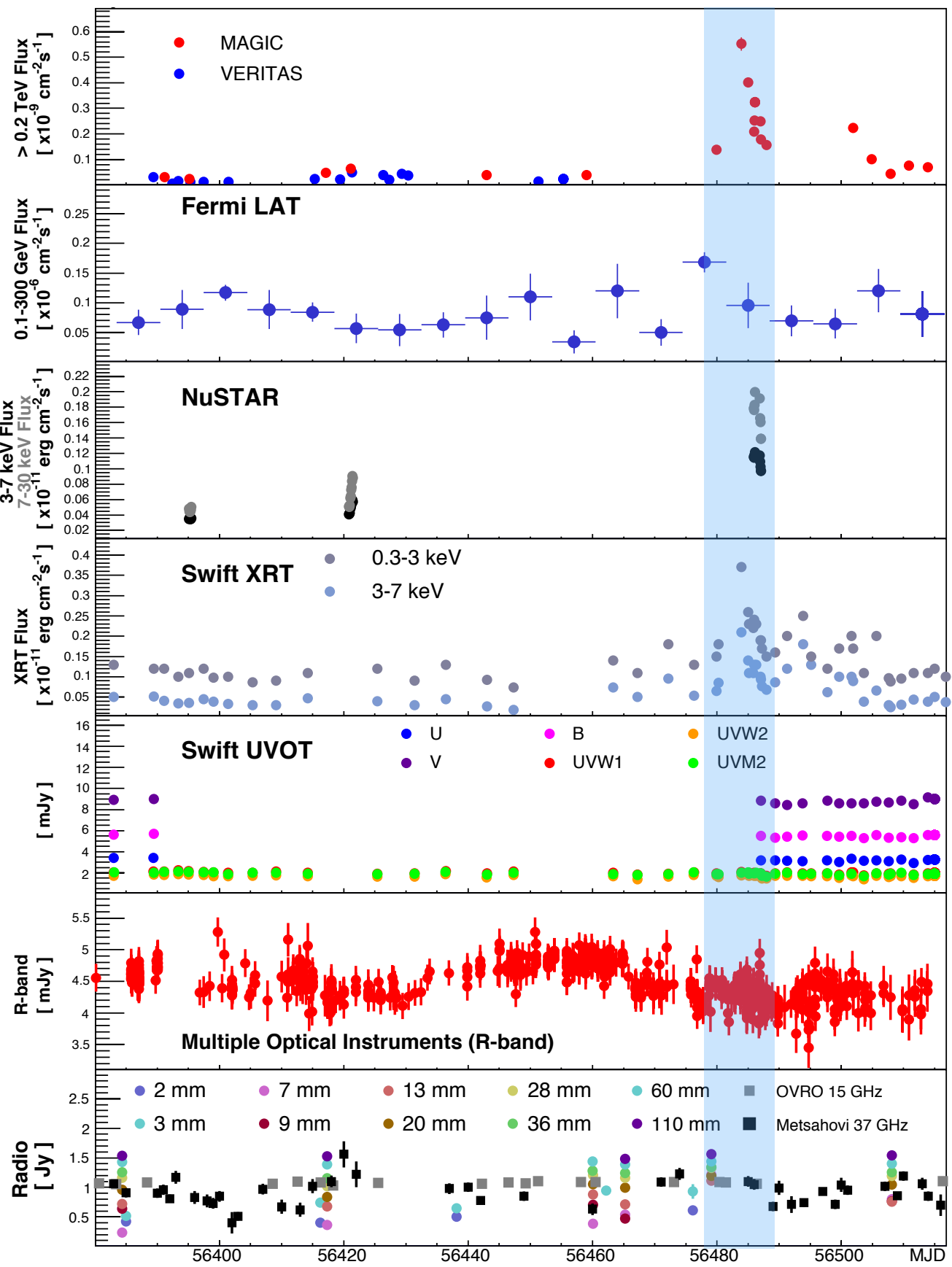


Mrk 501 X-ray Variability

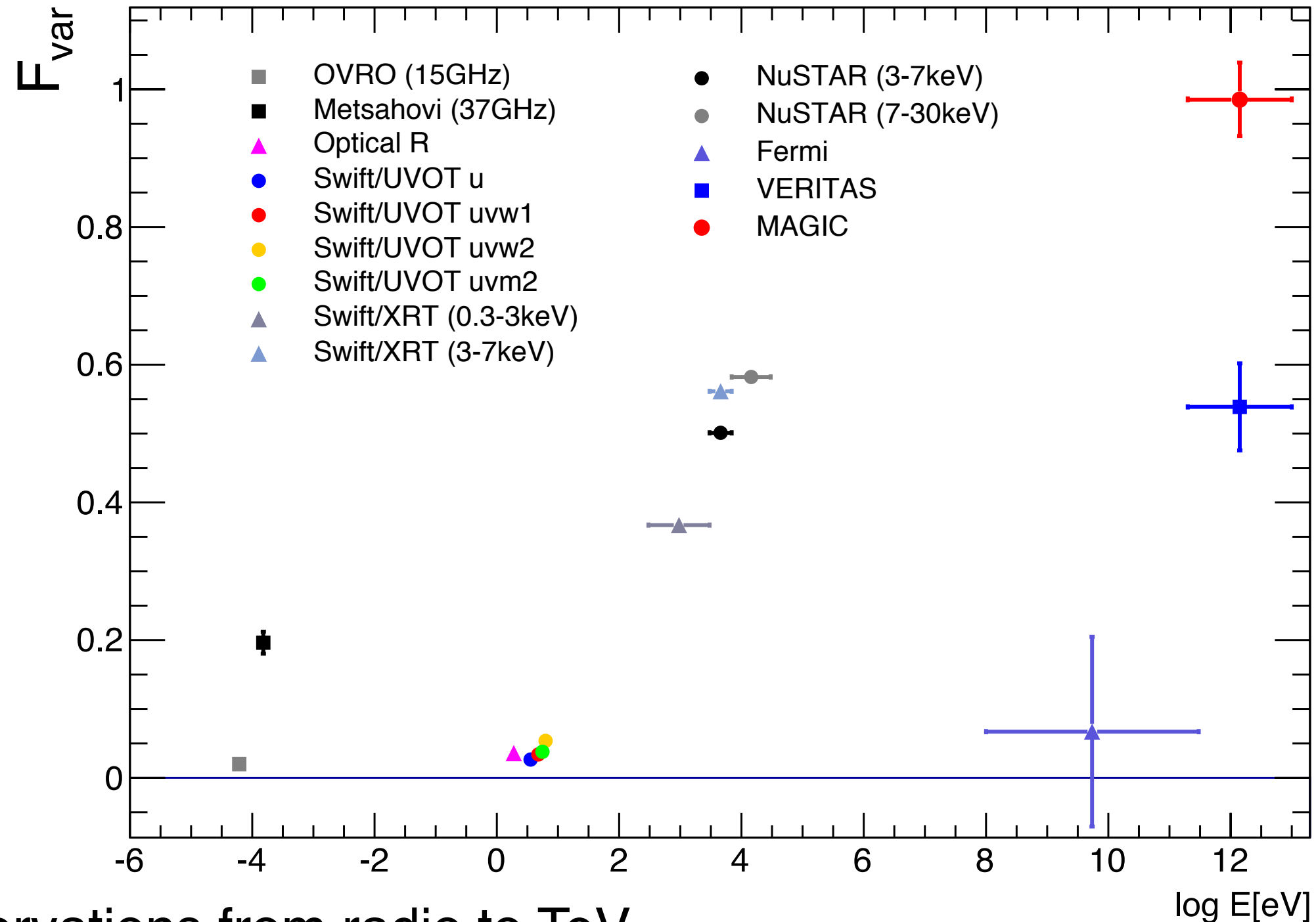


- ◆ Significant spectral variability observed within each *NuSTAR* exposure
- ◆ Harder when brighter pattern out to 30 keV
- ◆ *NuSTAR* 7-30 keV band consistently softer at 10 keV than at 1 keV

Mrk 501 Broadband Variability

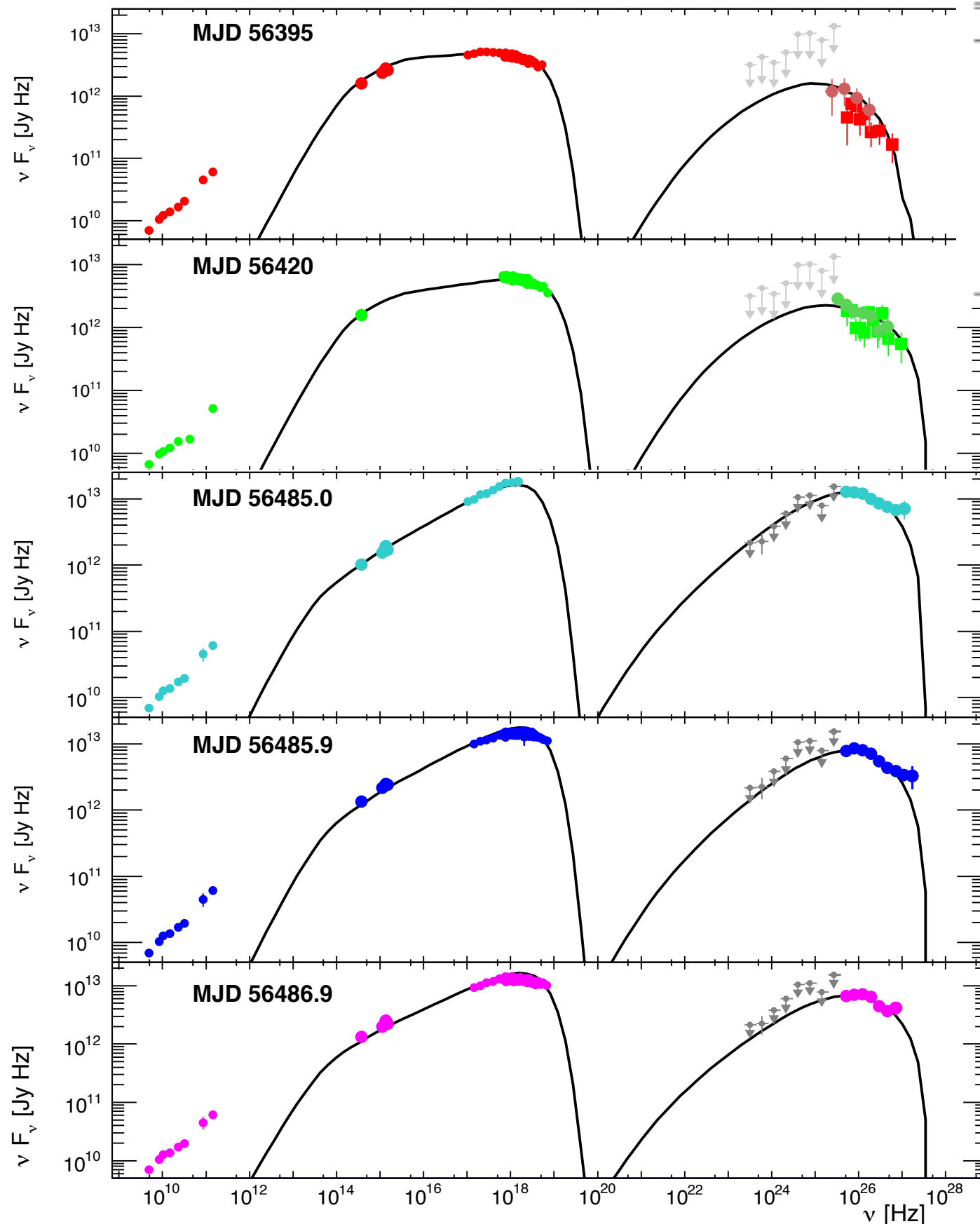


Mrk 501 Broadband Variability



- ◆ Observations from radio to TeV
- ◆ Higher fractional variability in X-ray and VHE bands as compared to radio, optical and Fermi LAT bands
- ◆ Fractional variability consistent with SSC emission scenario

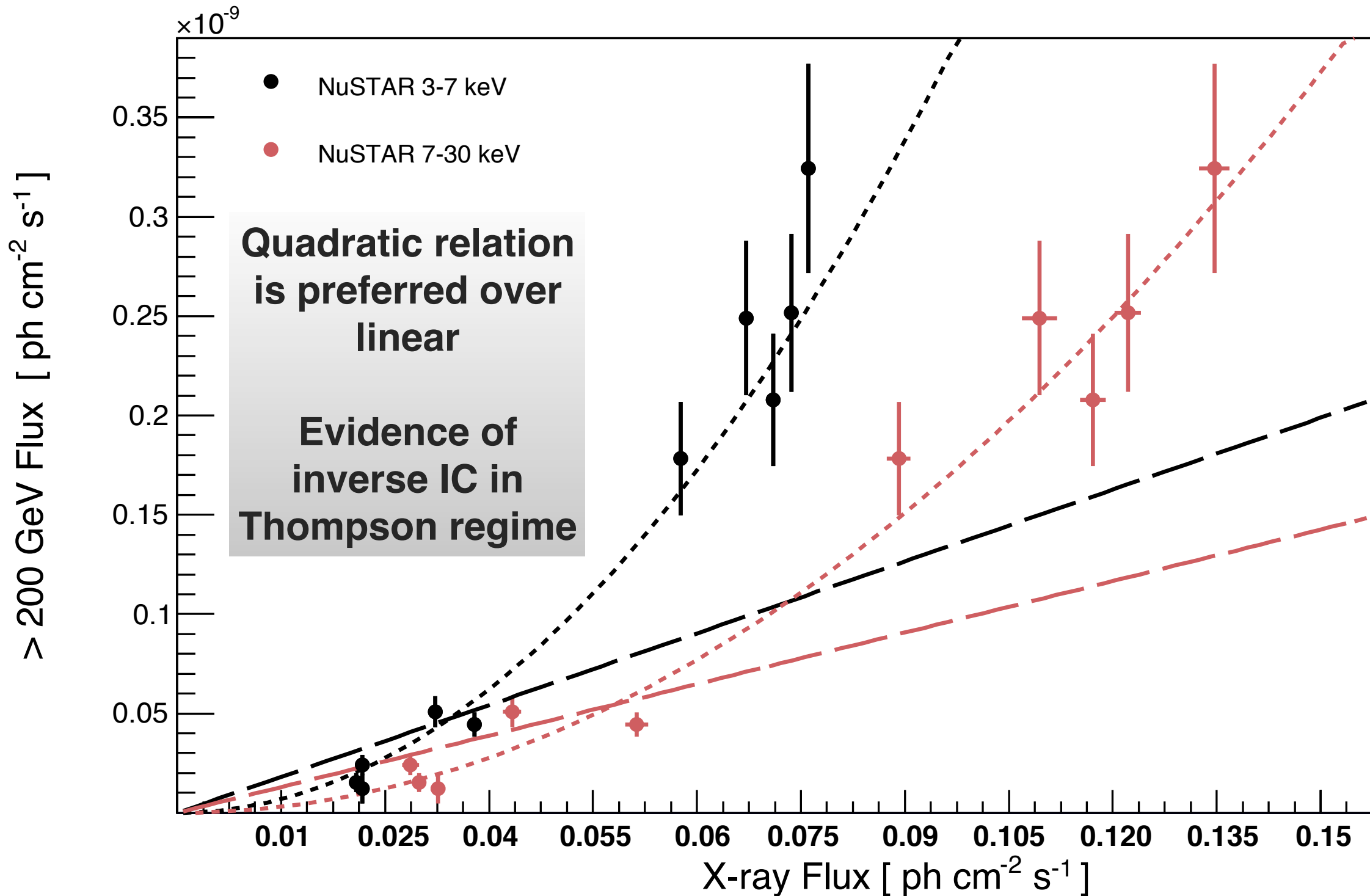
Modeling the Broadband SED



| Parameter | MJD 56395 | MJD 56420 | MJD 56485.0 | MJD 56485.9 | MJD 56486.9 |
|---|----------------------|----------------------|----------------------|----------------------|----------------------|
| $\gamma_{min} [\times 10^4]$ | 1.5 | 2.1 | 2.0 | 2.0 | 2.0 |
| $\gamma_{max} [\times 10^6]$ | 1.0 | 1.4 | 1.4 | 1.7 | 1.4 |
| q | 1.9 | 1.8 | 1.3 | 1.3 | 1.3 |
| η | 100 | 100 | 100 | 100 | 100 |
| B_0 [G] | 0.06 | 0.05 | 0.03 | 0.03 | 0.03 |
| Γ_j | 15 | 15 | 15 | 15 | 15 |
| $R [\times 10^{15} \text{ cm}]$ | 7.0 | 7.0 | 5.0 | 7.0 | 7.0 |
| θ [degrees] | 3.8 | 3.8 | 3.8 | 3.8 | 3.8 |
| t_{var} [hr] | 2.8 | 2.8 | 2.0 | 2.8 | 2.8 |
| $L_e [\times 10^{42} \text{ erg cm}^{-2} \text{ s}^{-1}]$ | 9 | 12 | 36 | 28 | 26 |
| $\epsilon = L_B/L_e$ | 1.8×10^{-2} | 6.1×10^{-2} | 5.3×10^{-4} | 1.3×10^{-3} | 1.4×10^{-3} |

- ◆ Use an equilibrium single-zone SSC model to describe the data on five different periods
- ◆ Provides a reasonable representation of the data
- ◆ Radio data is taken as upper limit, expected to have significant contribution from extended lobes
- ◆ Requires hard ($q=1.3$) injected particle spectrum
- ◆ Variability timescales are within agreement with those found within the paper (~ 10 hours)
- ◆ Result is \ll equipartition

Mrk 501 X-ray vs VHE Variability



Quadratic: $\chi^2=11.4$

Linear: $\chi^2=87.3$

9 Degrees of Freedom

Quadratic: $\chi^2=17.5$

Linear: $\chi^2=79.1$

9 Degrees of Freedom

Conclusions

- ◆ Hard X-ray observations of (gamma-ray) blazars by *NuSTAR* provide direct insight into the population of relativistic particles producing gamma-ray emission
- ◆ Extensive multi-instrument campaigns on Mrk421 and Mrk501 have happened every year since 2009 (see talk by David Paneque). The campaigns from 2013 could count, for the first time, with NuSTAR
- ◆ Special focus on *NuSTAR* observations simultaneous to MAGIC/VERITAS, as well as *Swift*/optical, which brought unprecedented insight into the broadband nature of both sources
- ◆ *NuSTAR* showed < day scale variability extends to hard X-ray energies within Mrk 421 and Mrk 501
- ◆ Mrk 421 and Mrk 501 are remarkably different animals
 - ◆ Mrk 421 VHE emission likely to occur in Klein-Nishina regime, while Mrk 501 VHE emission is within the Thompson regime
- ◆ Observations of additional gamma-ray emitting blazars will also provide interesting insight into the jet broadband emission - stay tuned!

PS Observe PKS 1441+25 if you've got a chance!