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Detection of Nine High-Energy X-ray Flares from the Galactic Center Supermassive Black Hole Sgr A*

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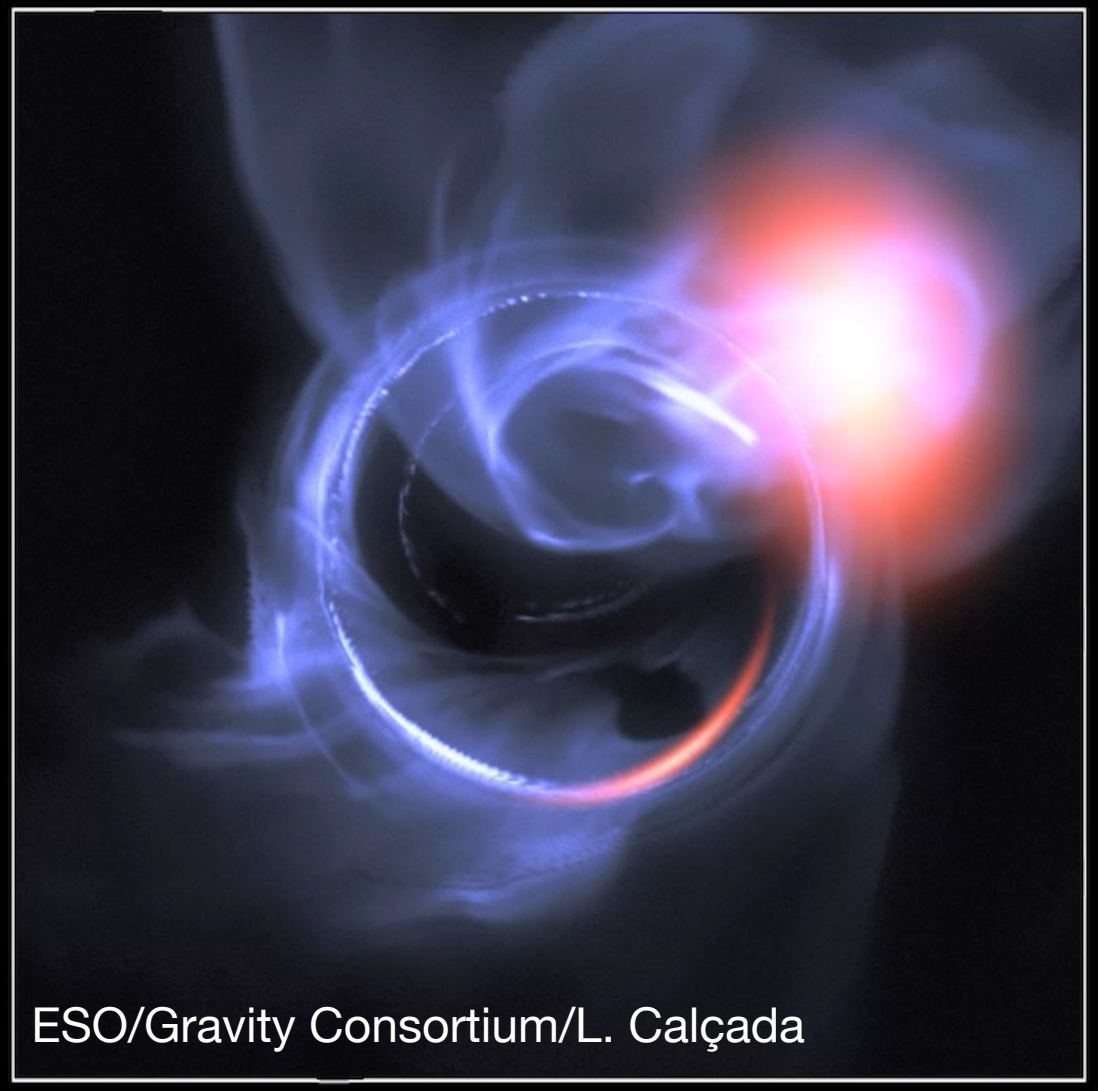
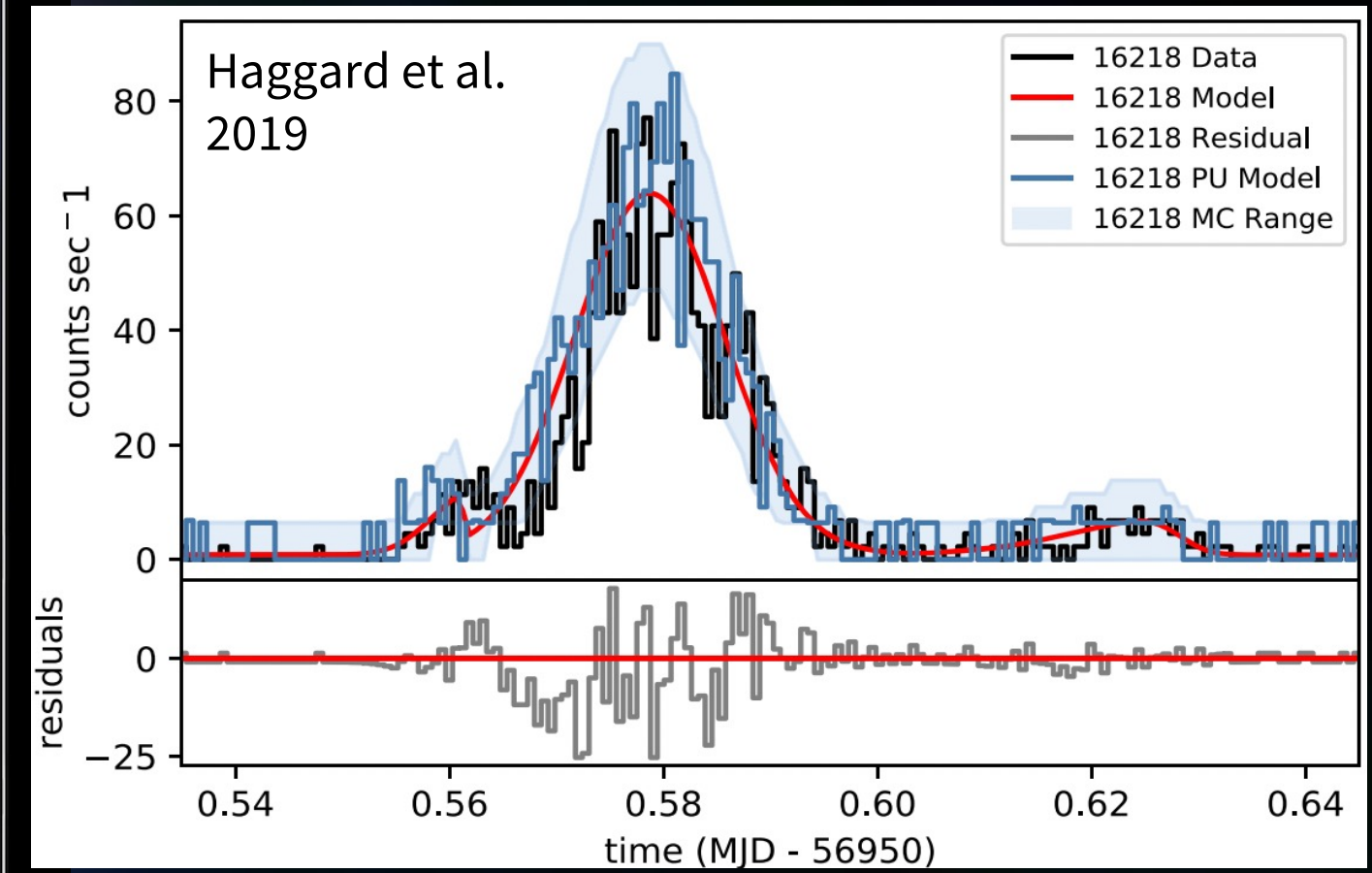
Supermassive Black Hole Sagittarius A* (Sgr A*)

- Located at the dynamical center of the Milky Way Galaxy
- Closest supermassive black hole with 4 million times the mass of Sun
- One of the most inactive supermassive black holes known

Credit: Wide-field X-ray: NASA/CXC/SAO,
Close-up X-ray: NASA/UMass/D.Wang et al.,
IR: NASA/STScI

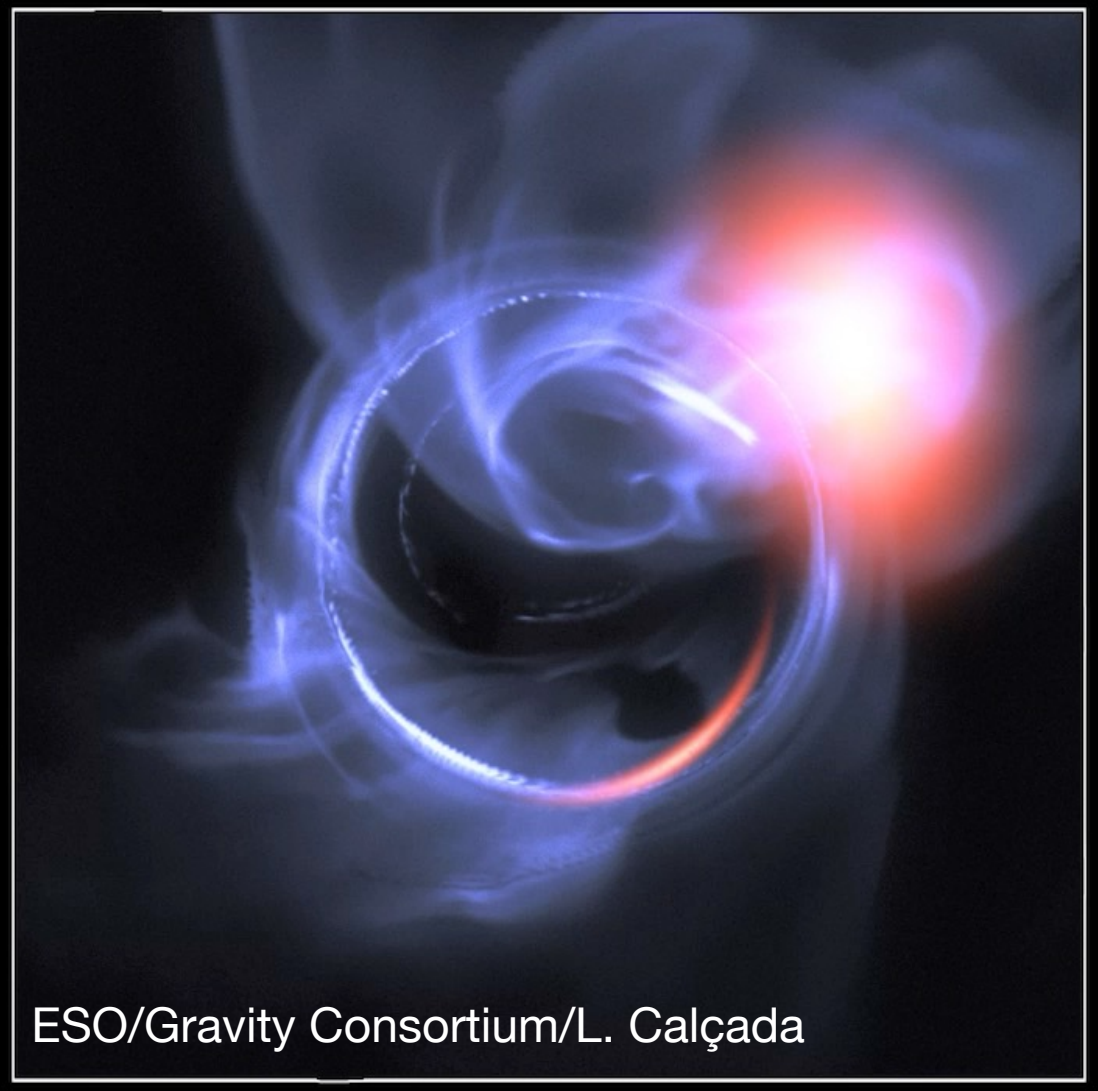
Mysterious Sgr A* X-ray Flares





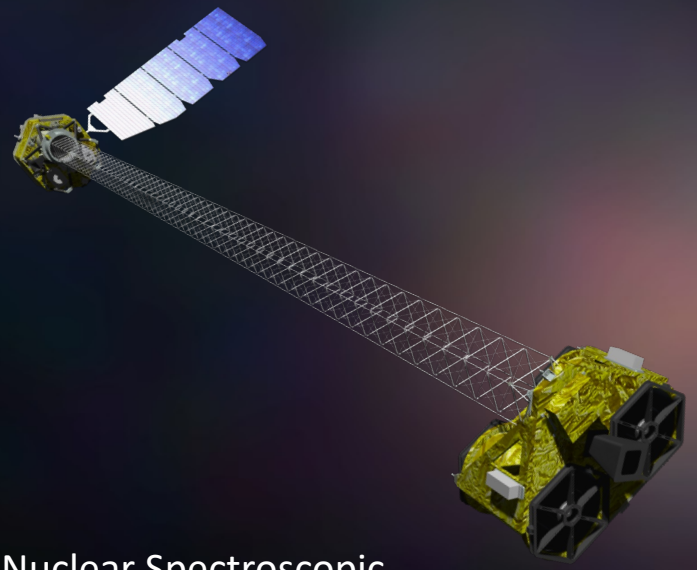
Chandra Sgr A* **light curve** on Oct 20, 2014.

Mysterious Sgr A* X-ray Flares



- Sgr A* flares occur on daily basis
- Each flare lasts up to a few hours
- During a flare, X-ray luminosity of Sgr A* increases by a factor of up to ~600
- Ideal probe of physical condition at merely a few gravitational radii from the black hole
- Physical origin: magnetic phenomena involving a plasma blob orbiting the black hole

NuSTAR Sgr A* Observation Campaign from 2012-2024



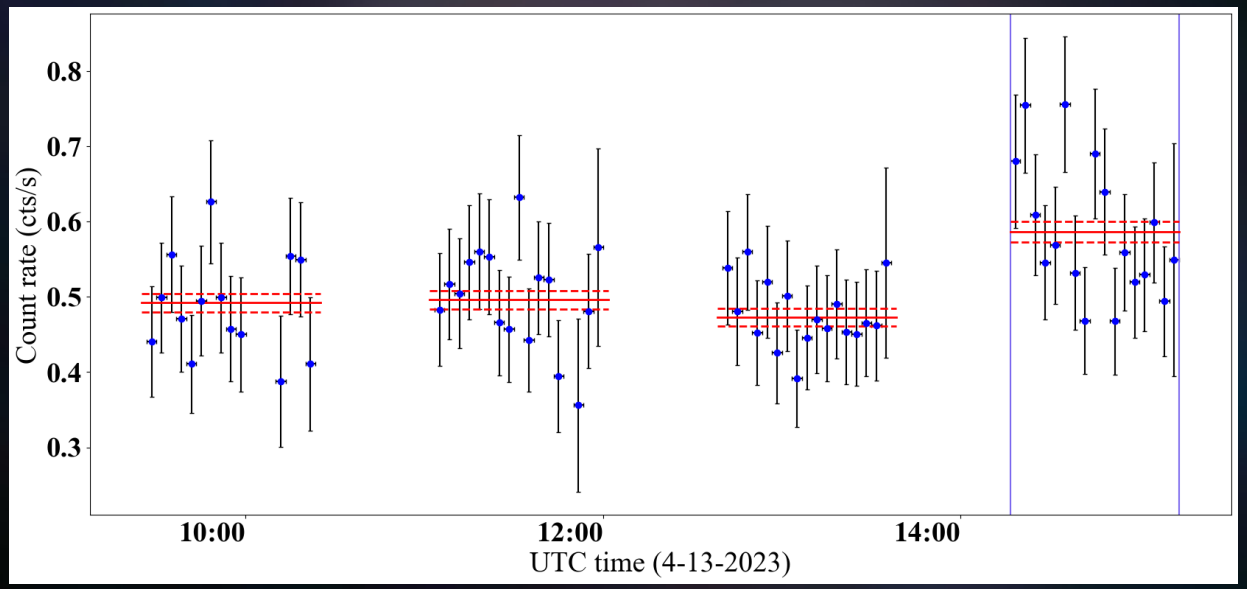
Nuclear Spectroscopic Telescope Array **(NuSTAR)**

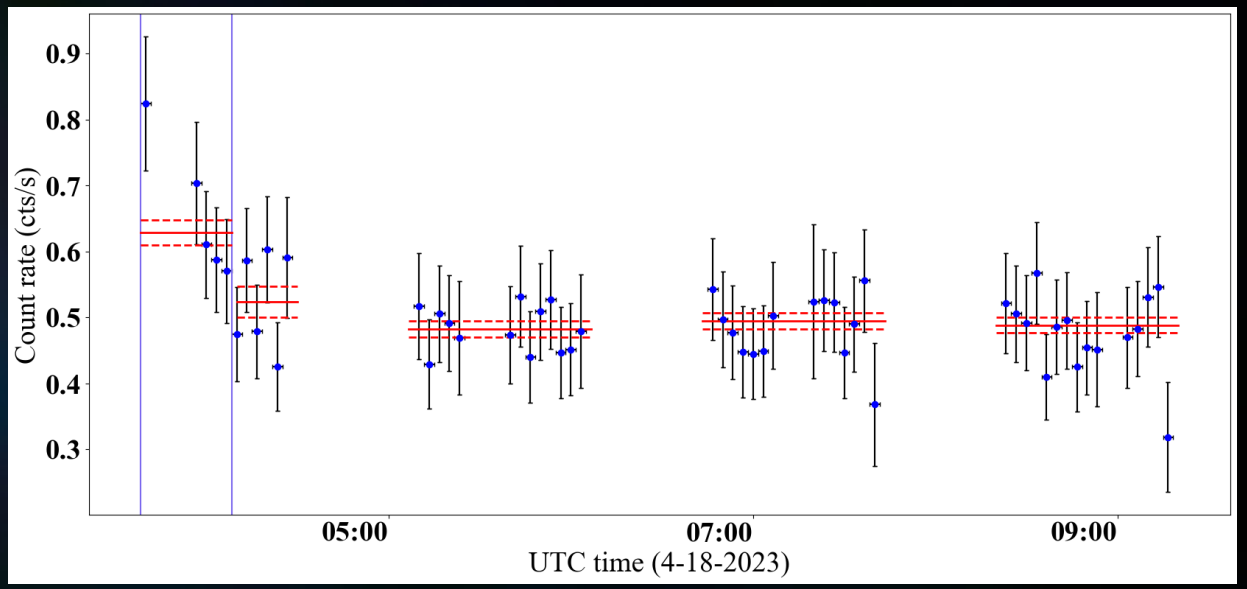
Year	Instruments	NuSTAR Exposure
2012	NuSTAR + Chandra/Keck	335 ks
2013	NuSTAR	367 ks
2014	NuSTAR + Chandra/Spitzer/XMM	227 ks
2015	NuSTAR + XMM	92 ks
2016	**NuSTAR**	**151 ks**
2017	**NuSTAR + EHT/Chandra**	**196 ks**
2018	**NuSTAR + EHT/Chandra**	**81 ks**
2019	**NuSTAR + Gravity/Chandra/XMM**	**466 ks**
2020	**NuSTAR + Gravity/EHT**	**72 ks**
2021	**NuSTAR**	**276 ks**
2022	**NuSTAR + EHT**	**157 ks**
2023	**NuSTAR + EHT/Chandra**	**82 ks**
2024	**NuSTAR + EHT/Chandra**	**84 ks**
Total	**2.5 Ms**	

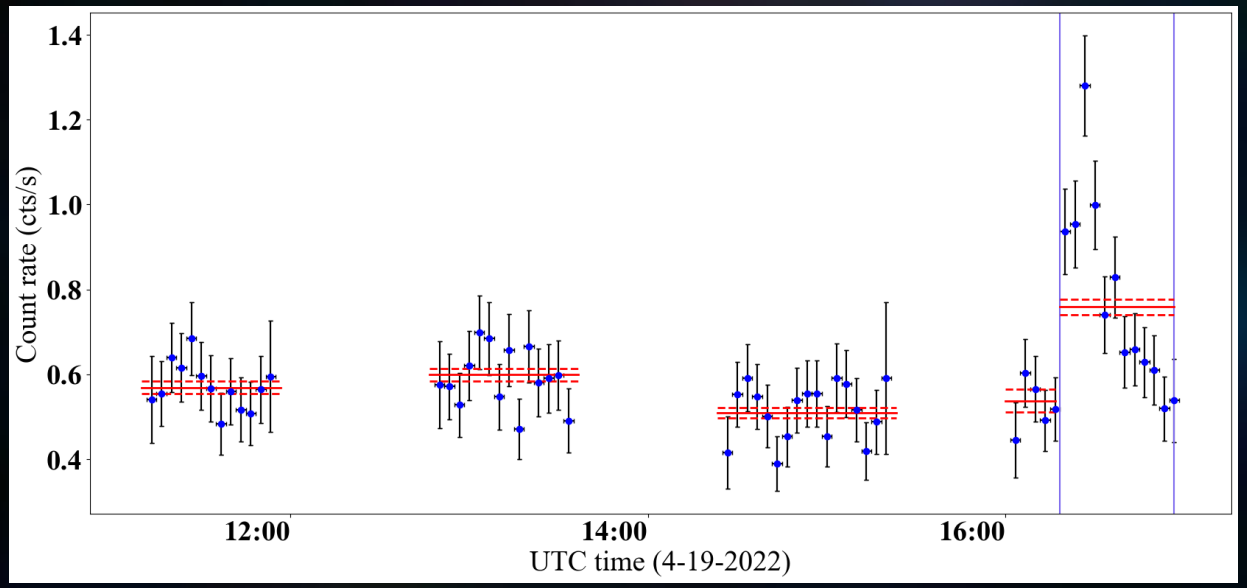
EHT image credit: ESO/M. Kornmesser

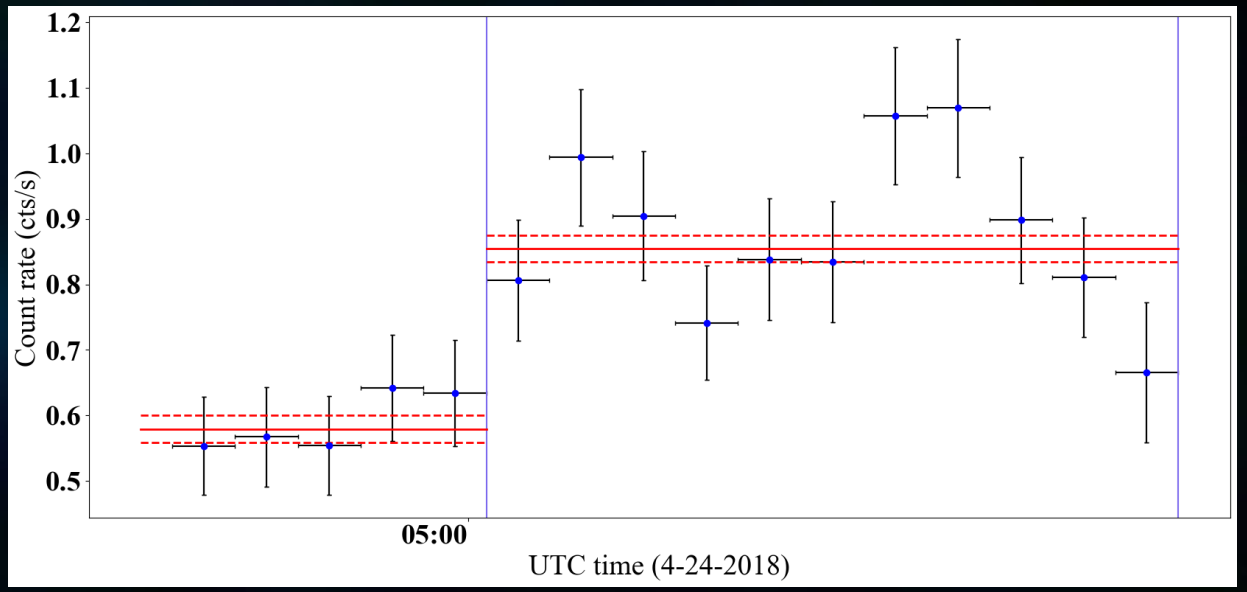
Chandra image credit: NASA

Selected Sgr A* Flares Detected during 2016-2024

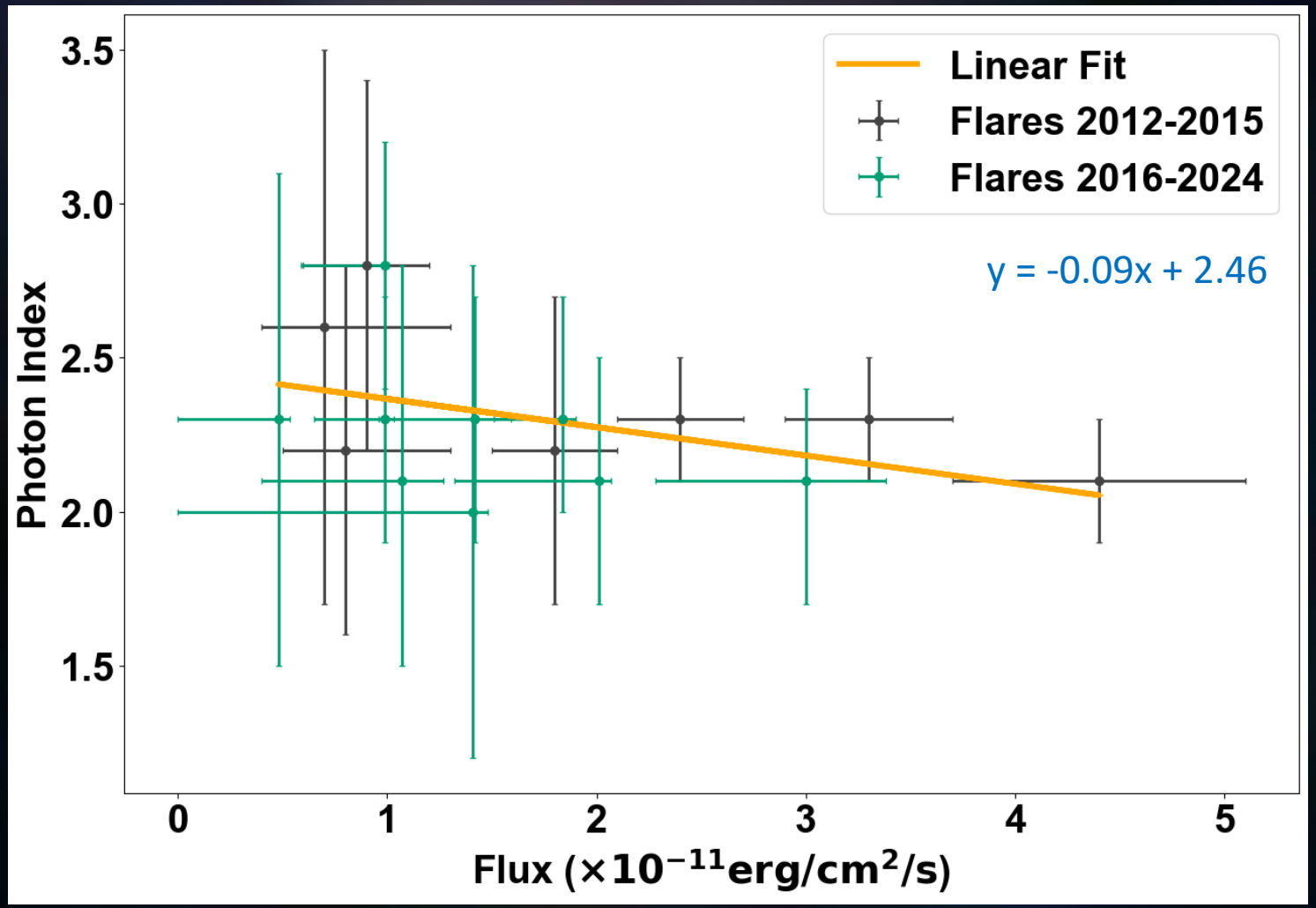








Do Bright Flares and Faint Flares Share the Same Origin?



- Investigated flare spectra dependence on their brightness
- Found a trend that brighter flares have hard spectrum at 2σ confidence level
- It suggests that bright and faint flares might have different origin, but it calls for more flare samples to confirm or reject this trend.

Black: 7 hard X-ray Sgr A* flares during 2012-2015 (Zhang et al. 2017)
Green: 9 newly detected hard X-ray Sgr A* flares during 2016-2024 (this work)

Summary

- Detected **9** bright high-energy X-ray Sgr A* flares using NuSTAR observations from 2016 to 2024, totaling 1.6 Ms exposure time.
- More than doubled previously known bright Sgr A* high-energy X-ray flares.
- Found a trend that bright flares have harder spectra compared to fainter flares, which needs more data to confirm.

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