



Extreme and Fundamental TDAMM Science with DEUS-X

X-ray Timing SAG Co-chairs:

Tom Maccarone

Texas Tech University

Krista Lynne Smith

Texas A&M

Zaven Arzoumanian

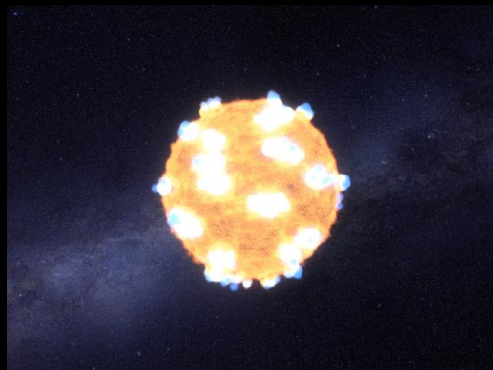
NASA GSFC

Riccardo Arcodia

Harvard



Broadband Variability: often the only direct observations from extreme astrophysical environments.



NASA Ames, STScI/G. Bacon

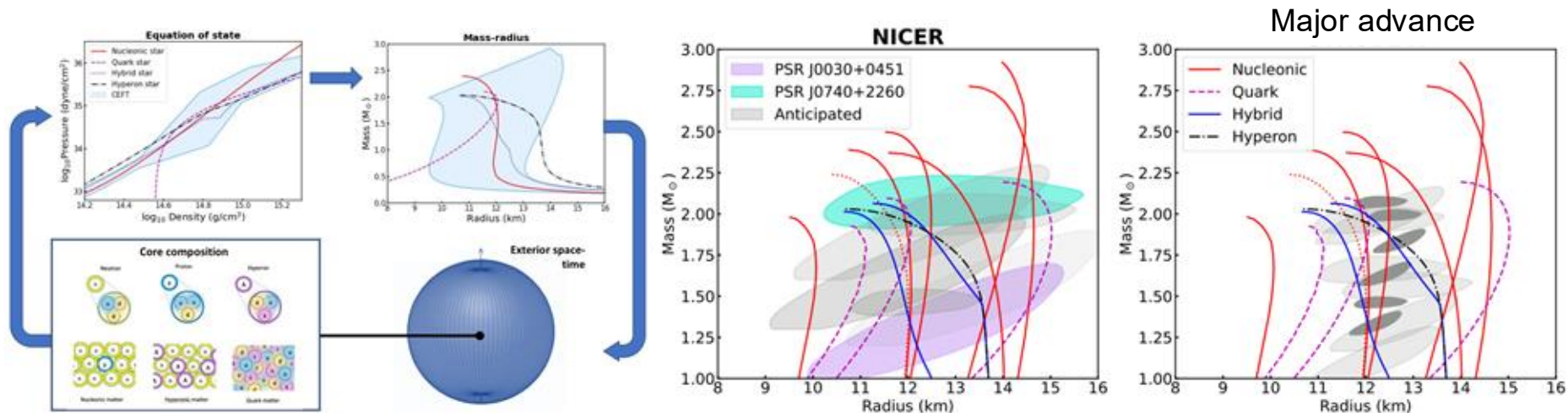


Niel Brandt

X-ray TDAMM: Unique Observables!

- Fundamental nuclear physics
 - Neutron star equation of state
 - Production of rare isotopes
 - Black hole spin across the mass scale
 - Precise stellar evolution models
 - Formation and growth of supermassive black holes
 - Gravitational wave counterparts from nHz to kHz!
 - Supermassive black hole mergers and extreme mass ratio inspirals
 - Short GRBs
 - Explosive and extreme astrophysics
 - Ultralong GRBs
 - Accretion of tidally disrupted stars
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Fundamental nuclear physics: nuclear matter



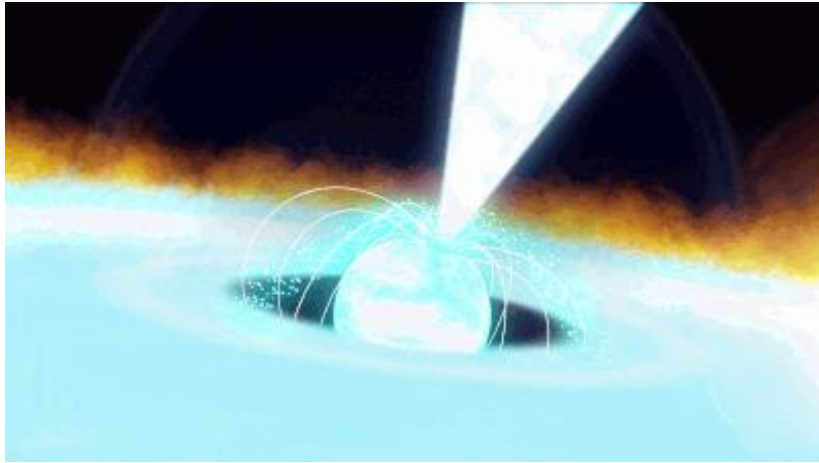
Equation of state of neutron stars: fundamental physics not accessible in a laboratory

NICER made outstanding progress, but higher precision and many more targets will unlock major advances.

CENAM has endorsed this mission concept!

Letter of support
from CeNAM!

Fundamental nuclear physics: bursts



NASA's Goddard Space Flight Center/Chris Smith (USRA)

The **r-p process** in bursts: a key item in the Nuclear Physics Long Range Plan!

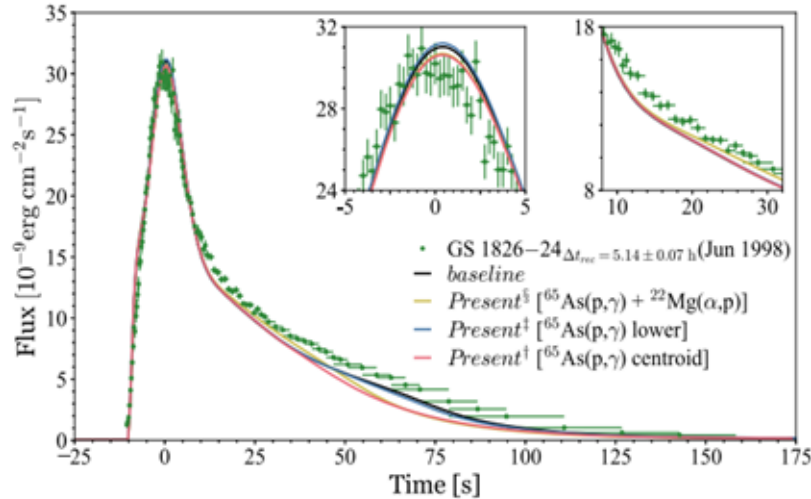
Recurrence times of bursts: accretion onto compact objects

Burst spectroscopy: extreme surface gravity measurements!

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Fundamental nuclear physics: bursts



RXTE Light curve of burst; Lam et al. 2022

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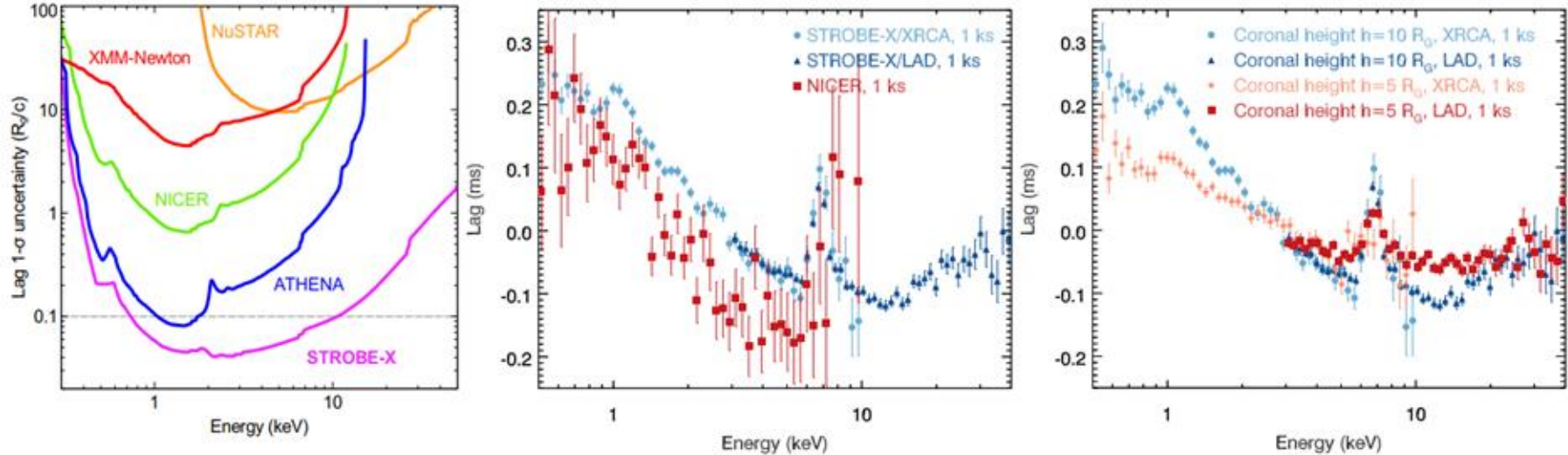
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Black hole spin: untangling the message

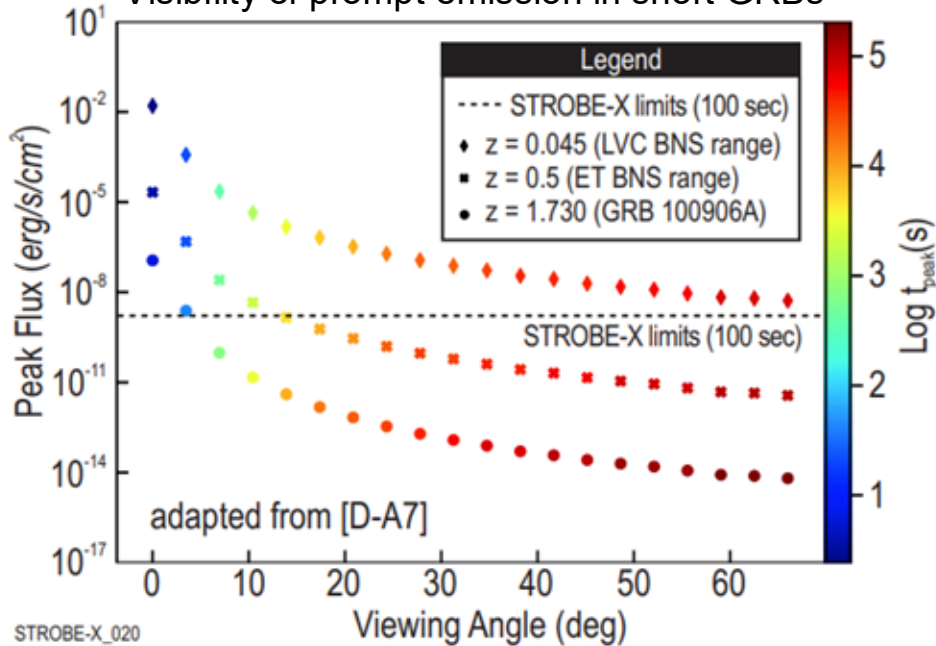


Time lags *resolved across the FeK profile* break key degeneracies in time-averaged reflection spectroscopy.

Black hole spins in stellar and supermassive holes are clear predictions of evolutionary theories.

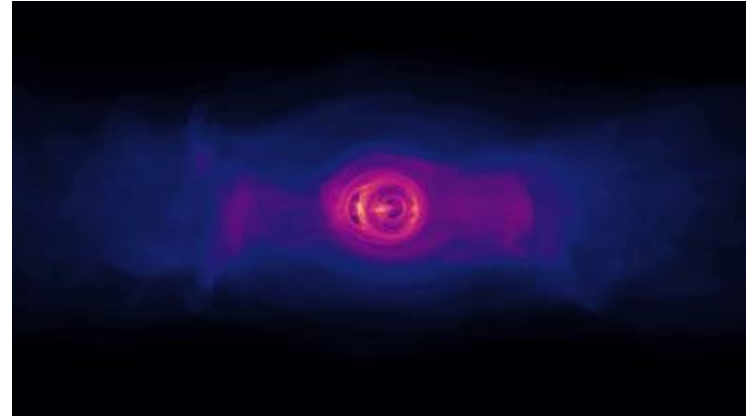
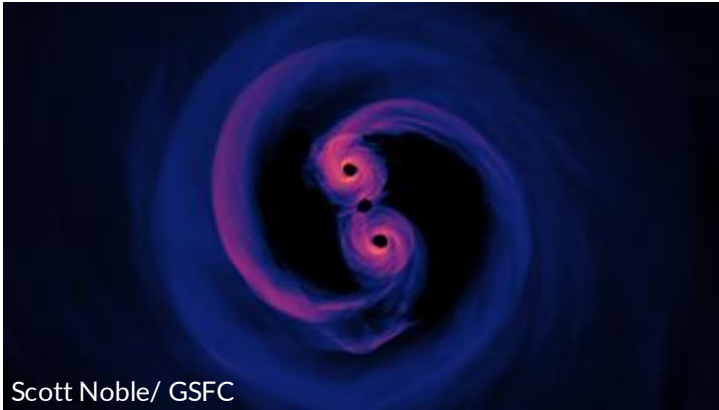
Gamma-ray bursts with DEUS-X

Visibility of prompt emission in short GRBs



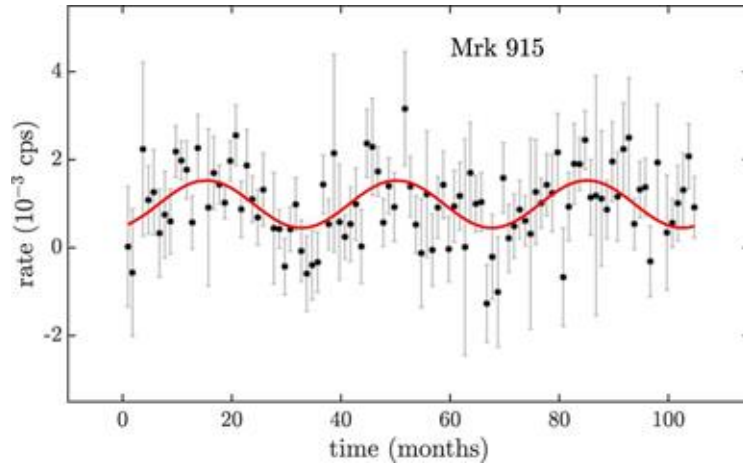
- Capture long-term behavior of all neutron star mergers out to 325 Mpc, and many at $z > 1$.
- Standard siren cosmology!
- X-ray redshifts for many long GRBs.

Binary Supermassive Black Holes

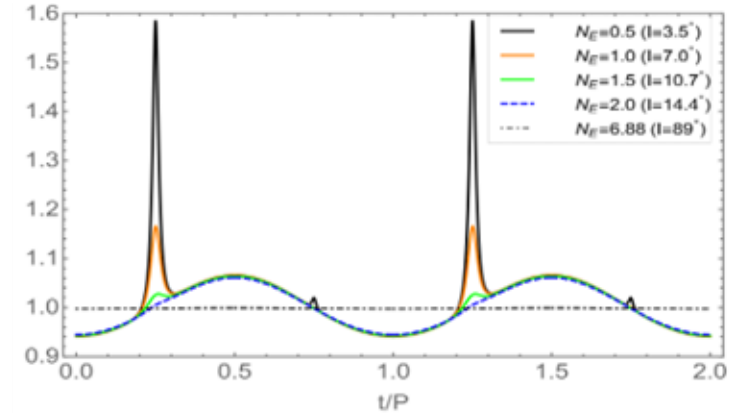


- Months-years periodicity from Doppler boosted orbital signal
 - Self-lensing flares repeating at orbital phase as transients.
-

Binary Supermassive Black Holes



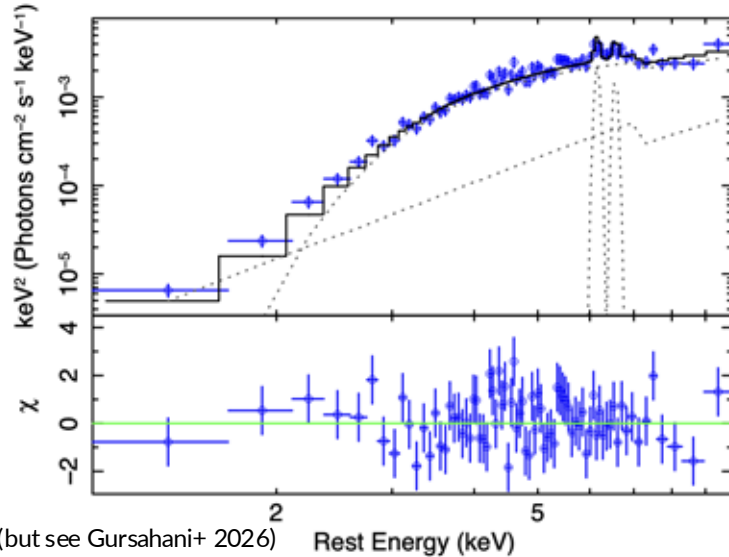
Serafinelli+ (2020)



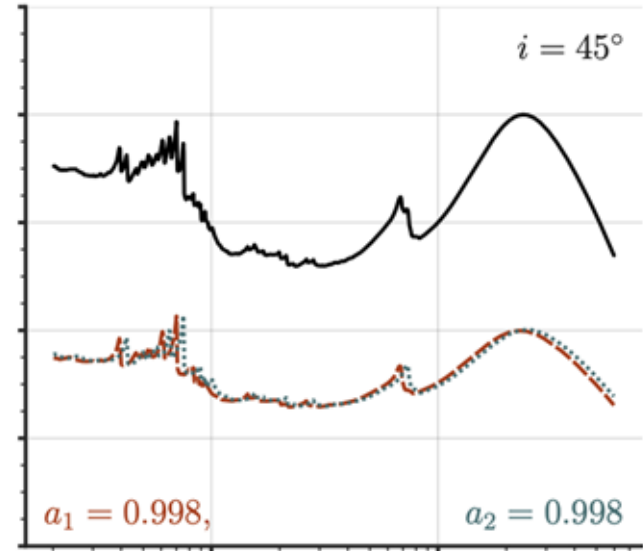
D'orazio et al. (2018)

- Months-years periodicity from orbital Doppler boost or stream collisions.
 - Self-lensing flares repeating at orbital phase as transients.
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Binary Supermassive Black Holes



Severgnini+ (2018) (but see Gursahani+ 2026)

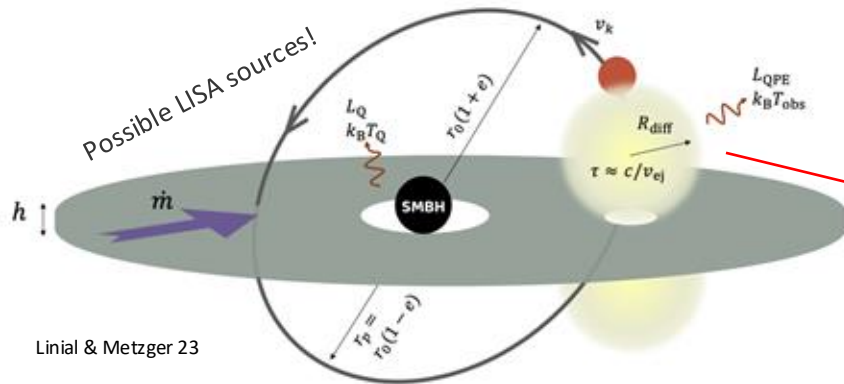


Malewicz+ 2026 (2608.04961)

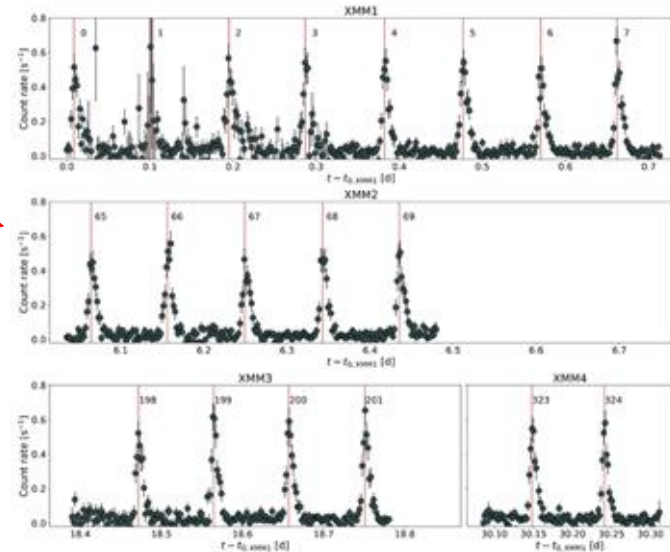
Spectroscopic binary signatures: complex FeK α profiles, weird reflection spectrum residuals.

DEUS-X = QPEs follow-up

QPEs leading model: orbital phenomena (e.g., a stellar-mass orbiter colliding with the accretion disk of the primary SMBH)



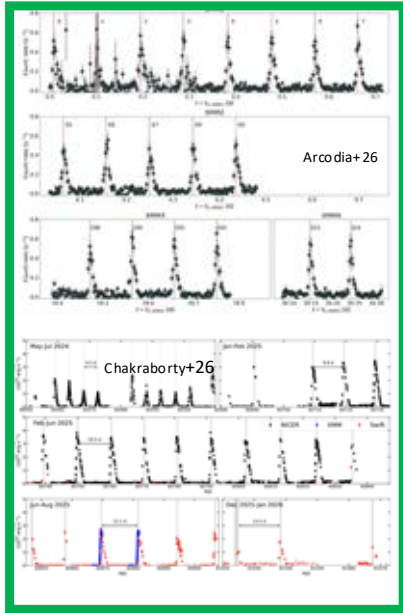
Testing this model requires consistent X-ray follow-up on days to months timescales!



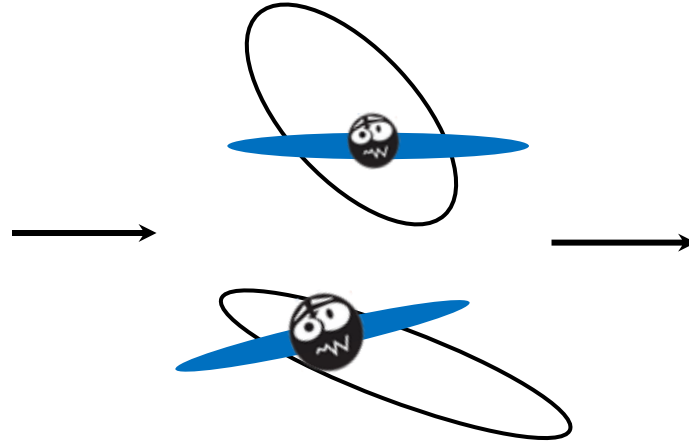
Arcodia+26

DEUS-X = QPEs x LISA

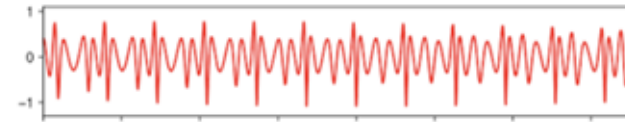
High cadence follow-up of QPE sources may inform LISA EMRI waveforms and formation channels!



High-cadence X-ray
follow-up campaigns



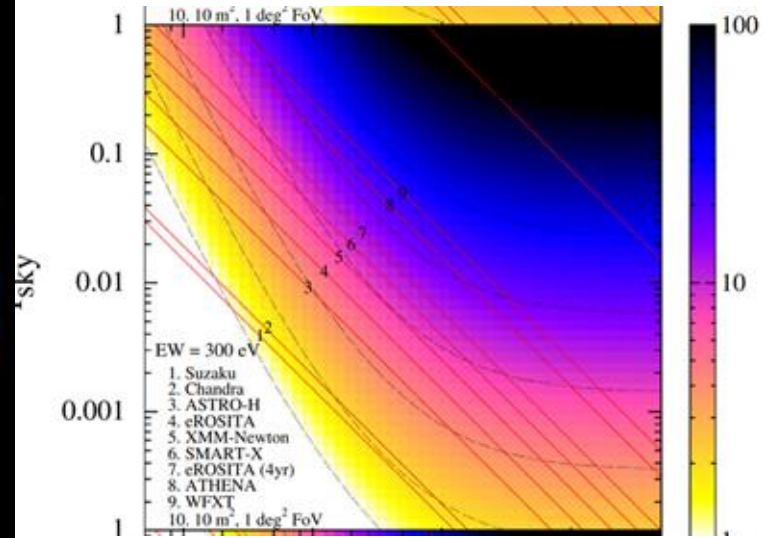
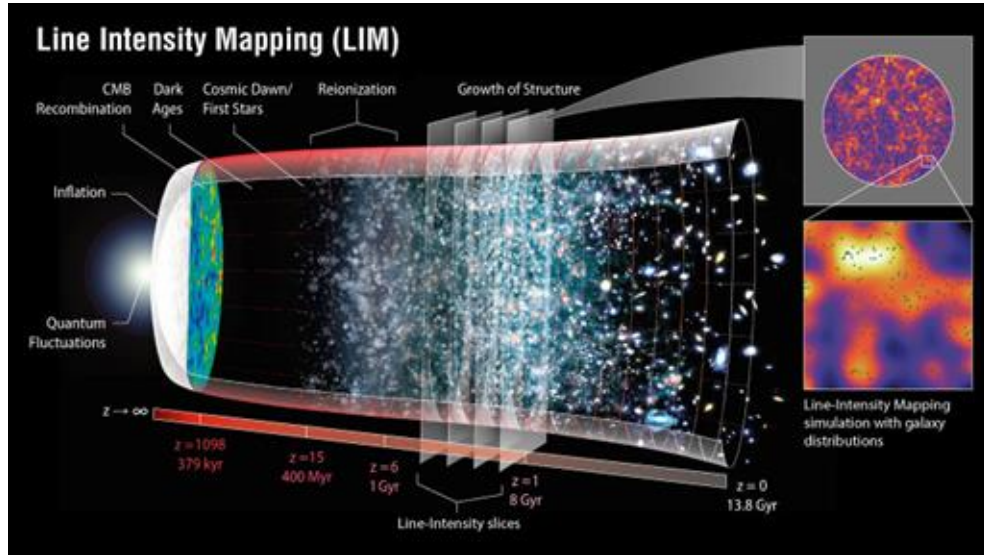
Orbital parameters inference



Realistic EMRI waveforms?

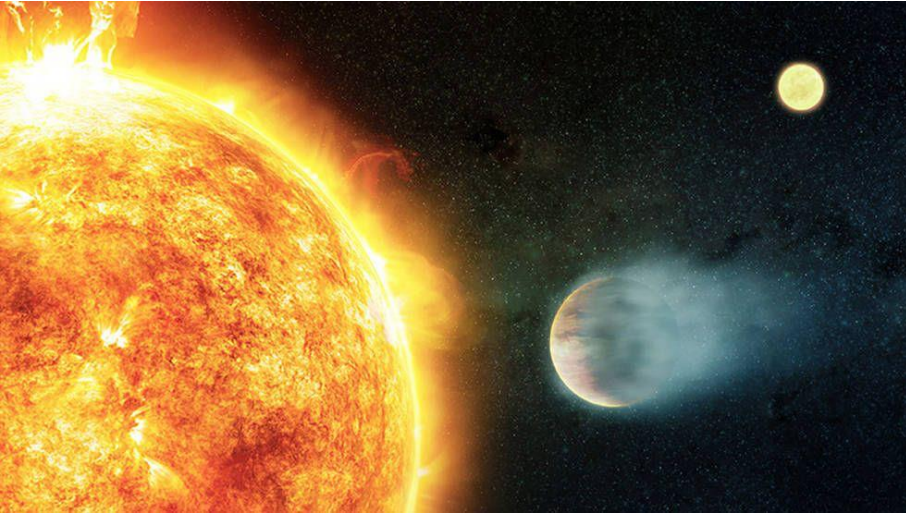
EMRI formation channels?

Additional science: X-ray line intensity mapping

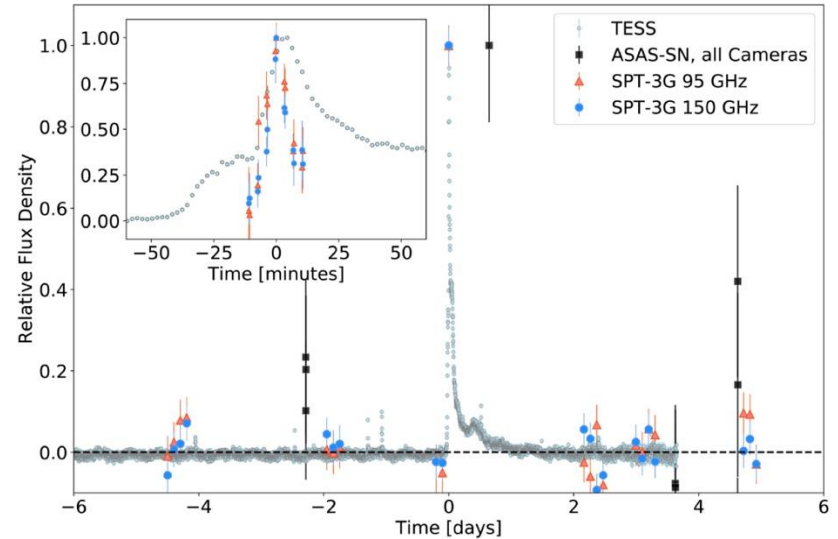


Hutsi et al. (2012)

Additional science: Exoplanet Habitability



NASA/CXC/M.Weiss

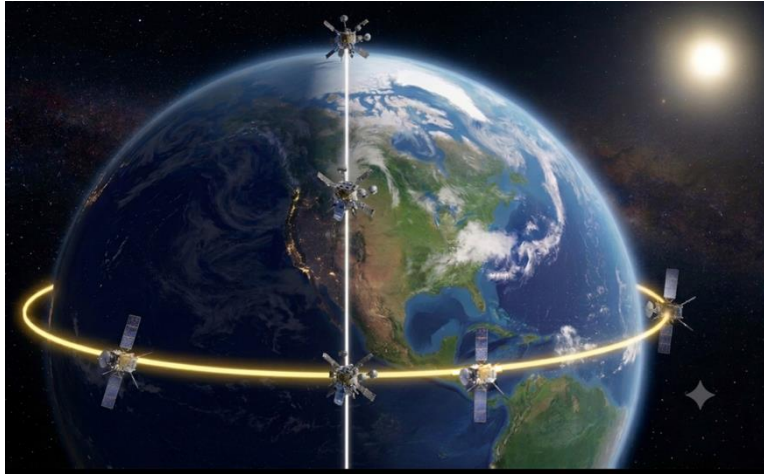


M-dwarf flare in optical and mm-wave; Guns et al. (2021)

Detailed optical flares of planet hosts will become routine in coming decades. We need X-rays!

Extreme flares are most likely to affect planetary habitability!

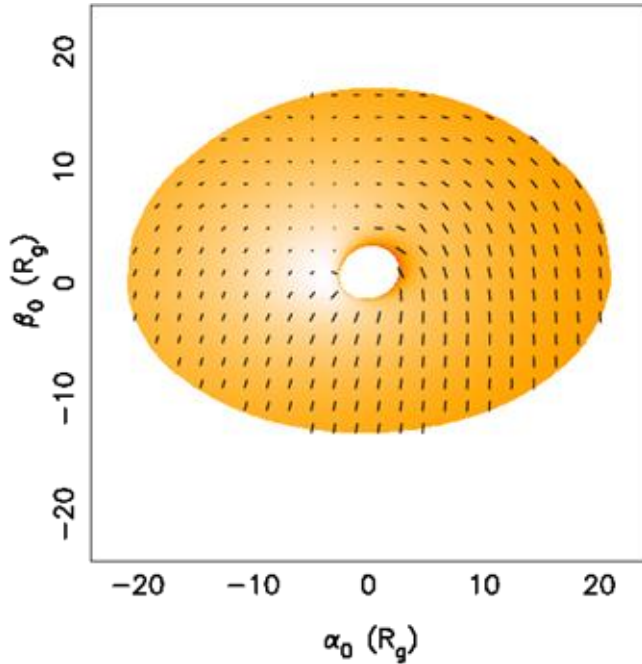
DEUS-X Mission concept: key capabilities



- Gap-free coverage and rapid trigger response for transient detection and high collecting area monitoring
 - Ability to observe bright sources
 - CCD-level spectral resolution
 - Absolute timing precision
 - Broadband/multiwavelength coverage
 - Proven or rapidly advancing technologies for low-cost, early implementation — builds on STROBE-X Probe concept and *Swift*'s multi- λ model.
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Bonus Slides

Accretion disk physics

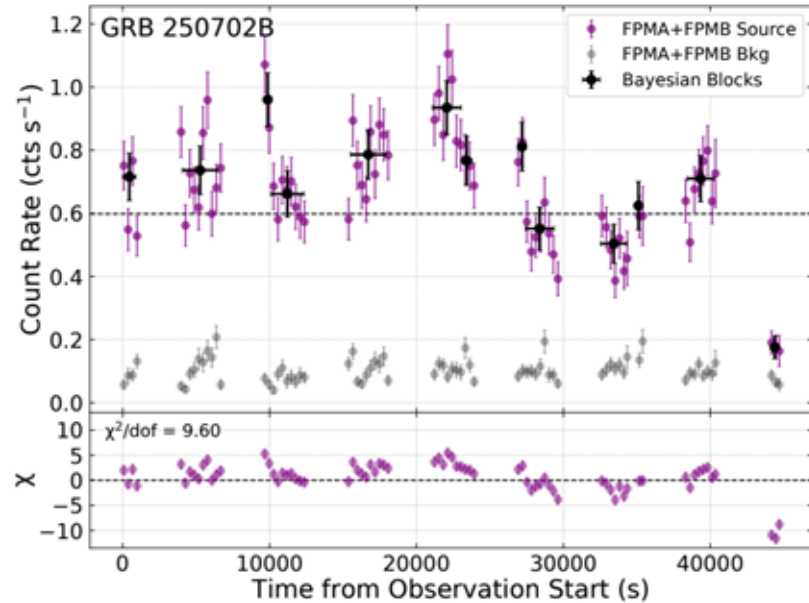
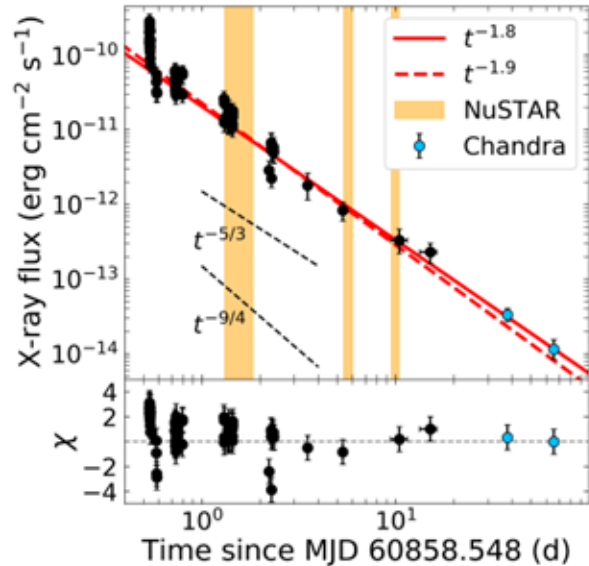


Real-time movies of iron line energies in X-ray binaries with quasi-periodic oscillations!

Fundamental tests of dynamic disk geometry and precession.

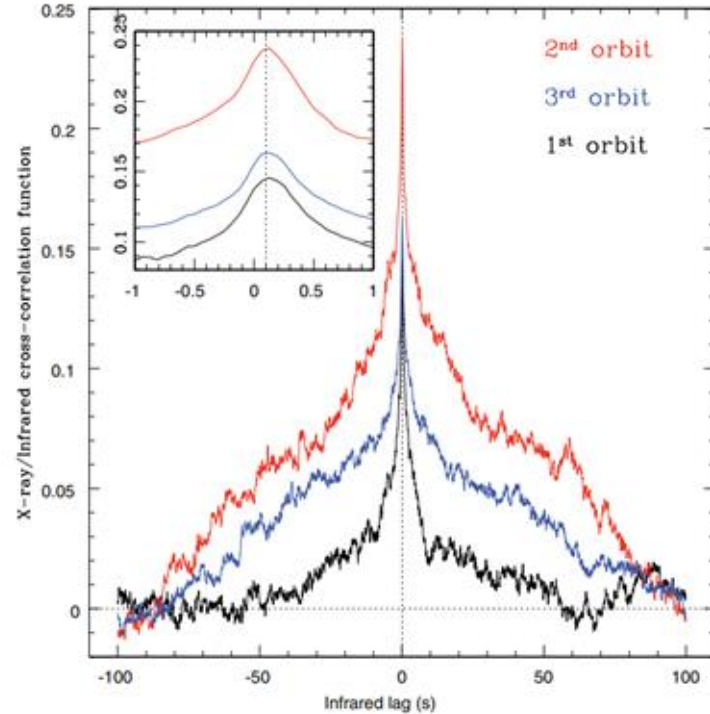
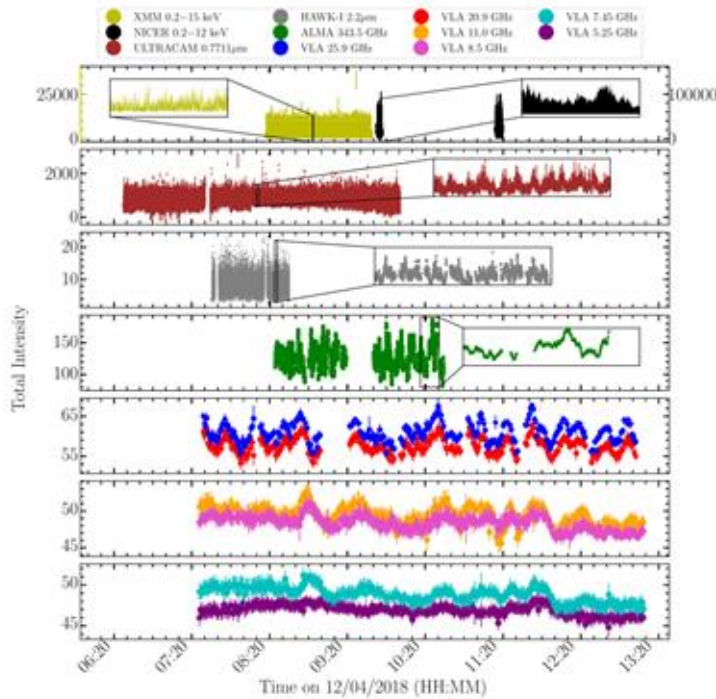
Ingram, Maccarone, Poutanen & Krawczynski (2015)

Explosive transients - ultralong GRB example



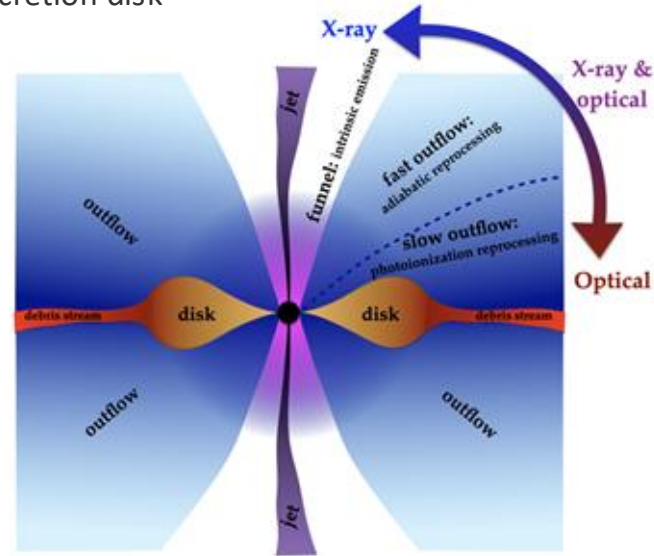
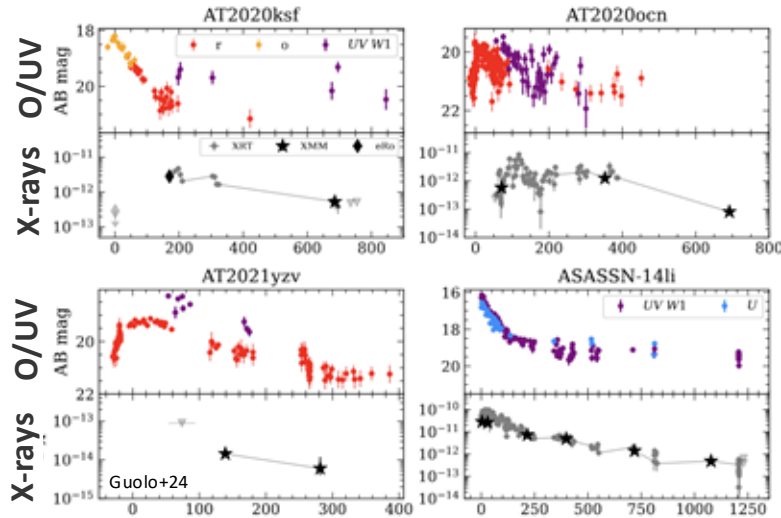
O'Connor et al. 2025

Origin of relativistic jets: XRBs



Tidal disruption events

X-rays from TDEs trace the formation and evolution of the accretion disk



X-rays often seen at later times, but largely due to incomplete and inhomogeneous early X-ray follow-up