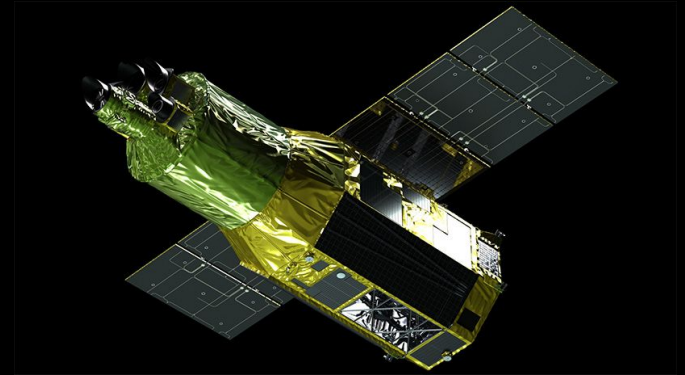


Limits from the Grave: Resurrecting Hitomi for Decaying Dark Matter and Forecasting Leading Sensitivity for XRISM



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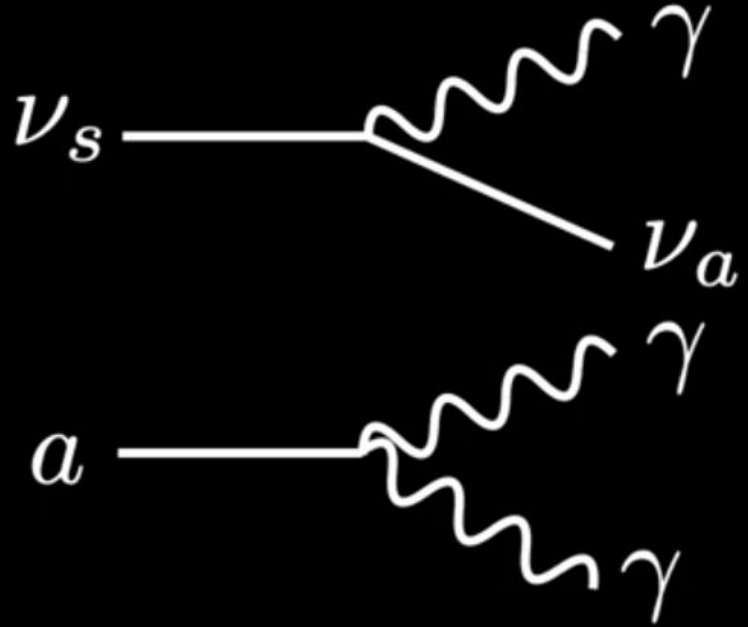
In collaboration with Chris Dessert, Ben Safdi, Nick Rodd
arXiv:2305.17160

Key Highlights:

1. Power of Blank-Sky Observations (BSO) as a probe of DM decay using Hitomi as proof-of-concept
2. Forecasting leading sensitivity to DM decay for XRISM using BSO

DM Decay and Photon Lines

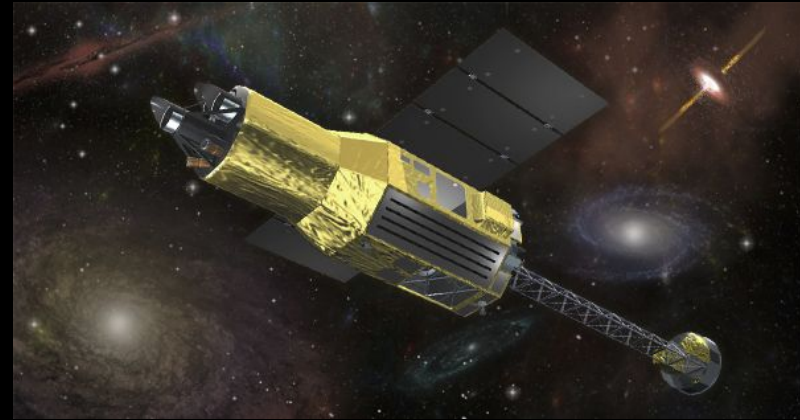
- Generic Prediction of various particle DM models
- Possible to have two-body final states including photons and/or neutrinos
- Concrete models overlapping X-ray energy band (e.g. Hitomi, XRISM) includes sterile neutrino and axion-like particle (ALP) DM
- For DM mass range of $\sim 1\text{-}30$ keV, current bounds on lifetime set a lower limit of $\sim 10^{28}\text{-}10^{29}$ seconds



Line-like monochromatic photon signatures \rightarrow powerful probe of DM

Hitomi (ASTRO-H) (2016)

- Launched in 2016, but destroyed in orbit after 1 month
(doi.org/10.1117/12.2232509)
- Energy Resolution of $O(0.1\%)$ → critical for precise line-like DM signals
- Cf. , e.g., XMM-Newton and Chandra (energy resolution of $O(5\%)$)
- Managed to obtain some data pointed toward Perseus (1607.07420)



Blank Sky Observations (BSOs) and Hitomi DM Search Setup

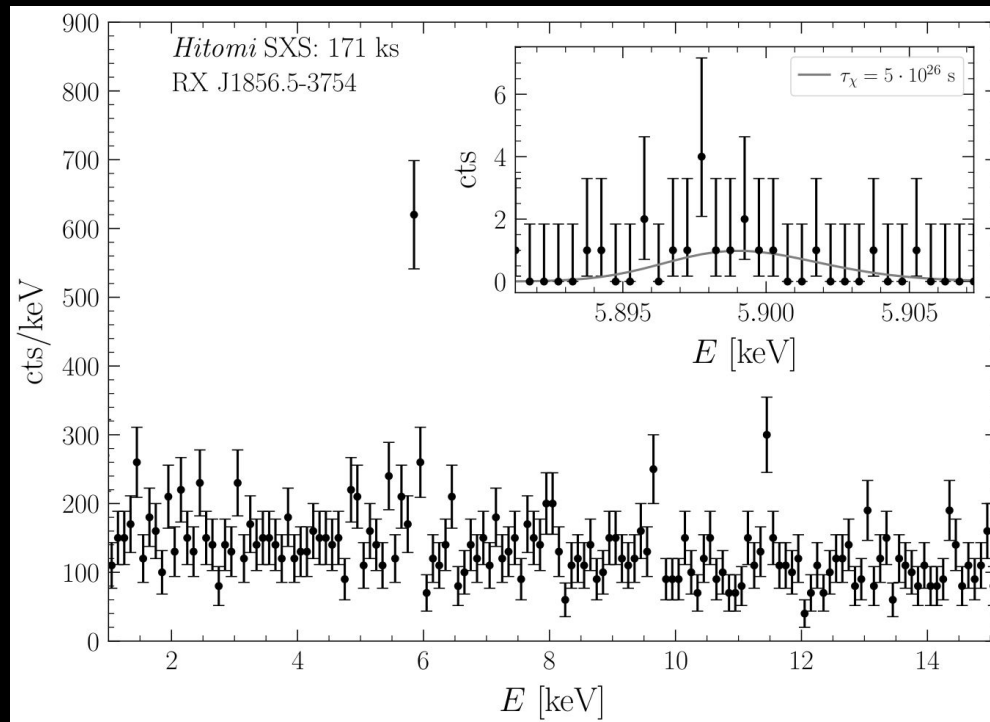
Pointings Toward:

- NS RX J1856.6-3765 (171 ks, 17° from GC)
- HMXRB IGR J16318-4848 (250 ks, 25° from GC)

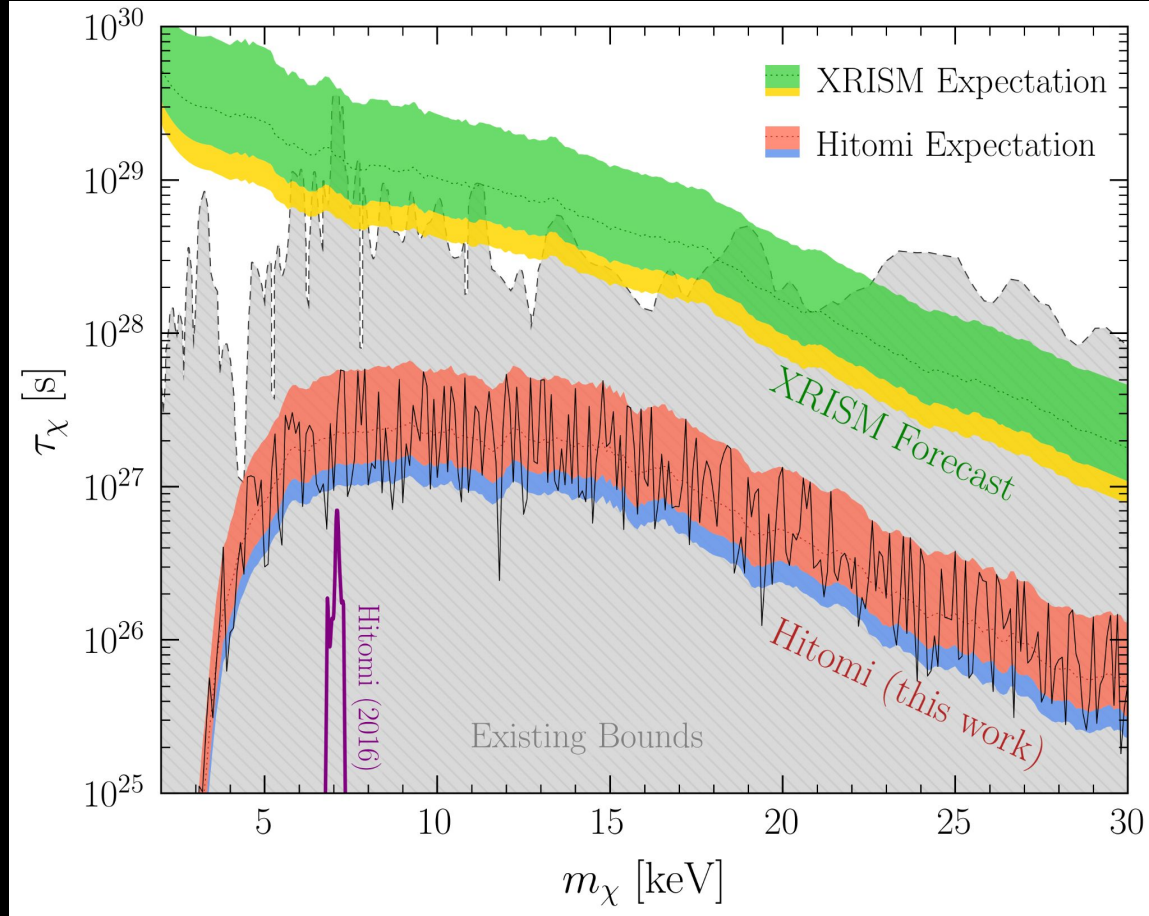
NFW Profile for MW

- $\rho_{\text{DM}} \sim 0.29 \text{ GeV/cm}^3$

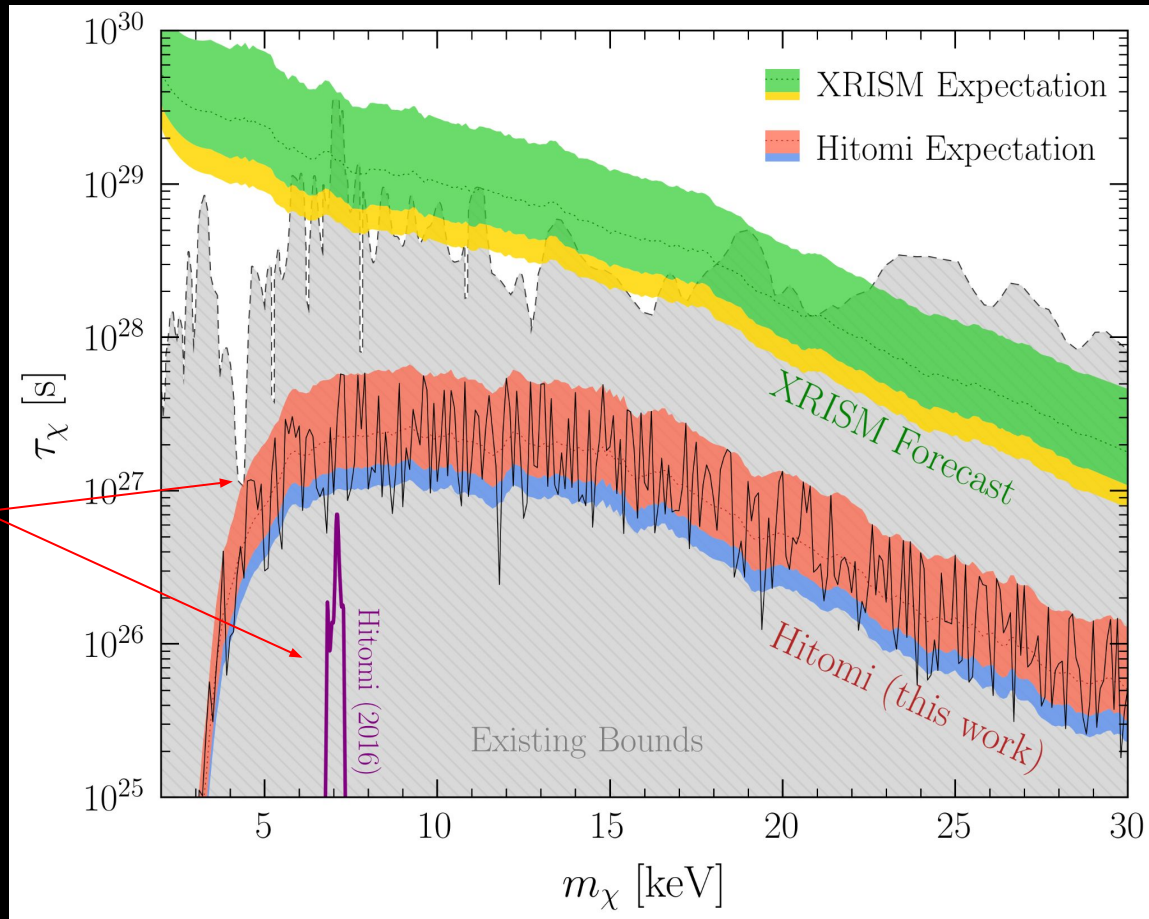
We also account for Doppler broadening and shifting – crucial, since the energy resolution is so fine



No Evidence for DM Decay and Our Limits using Blank Sky Searches



No Evidence for DM Decay and Our Limits using Blank Sky Searches



BSO searches notably improve upon those done on Perseus

XRISM X-Ray Telescope

- Successor to Hitomi with identical detector instruments (2003.04962)
- Set to launch 2023

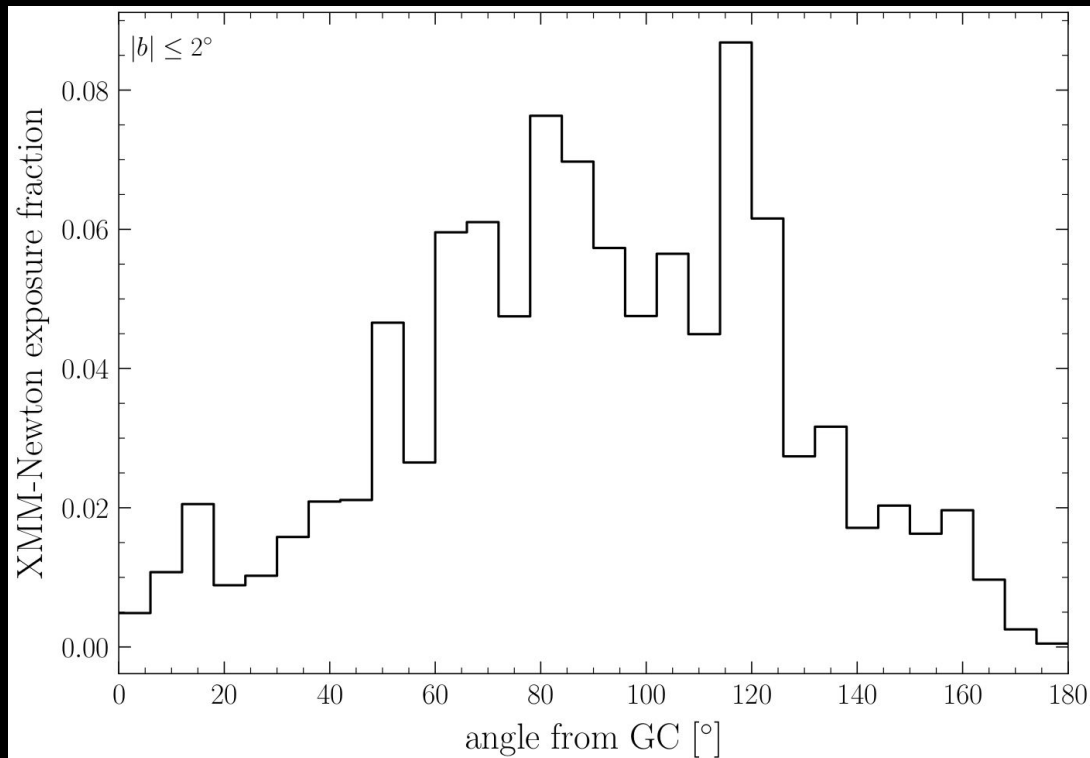
Parameter	Requirement	Goal
Energy Resolution	7 eV (FWHM)	5.0 eV
Energy Scale Accuracy	± 2 eV	± 0.5 eV
Residual Background	2×10^{-3} counts/s/keV	$< 1 \times 10^{-3}$ counts/s/keV
Field of View	2.9 x 2.9 arcmin	same, by design
Angular Resolution	1.7 arcmin (HPD)	1.2 arcmin
Effective Area (1 keV)	> 160 cm ²	250 cm ²
Effective Area (6 keV)	> 210 cm ²	312 cm ²
Cryogen-mode Lifetime	3 years	4+ years
Operational Efficiency	$> 90\%$	$> 98\%$



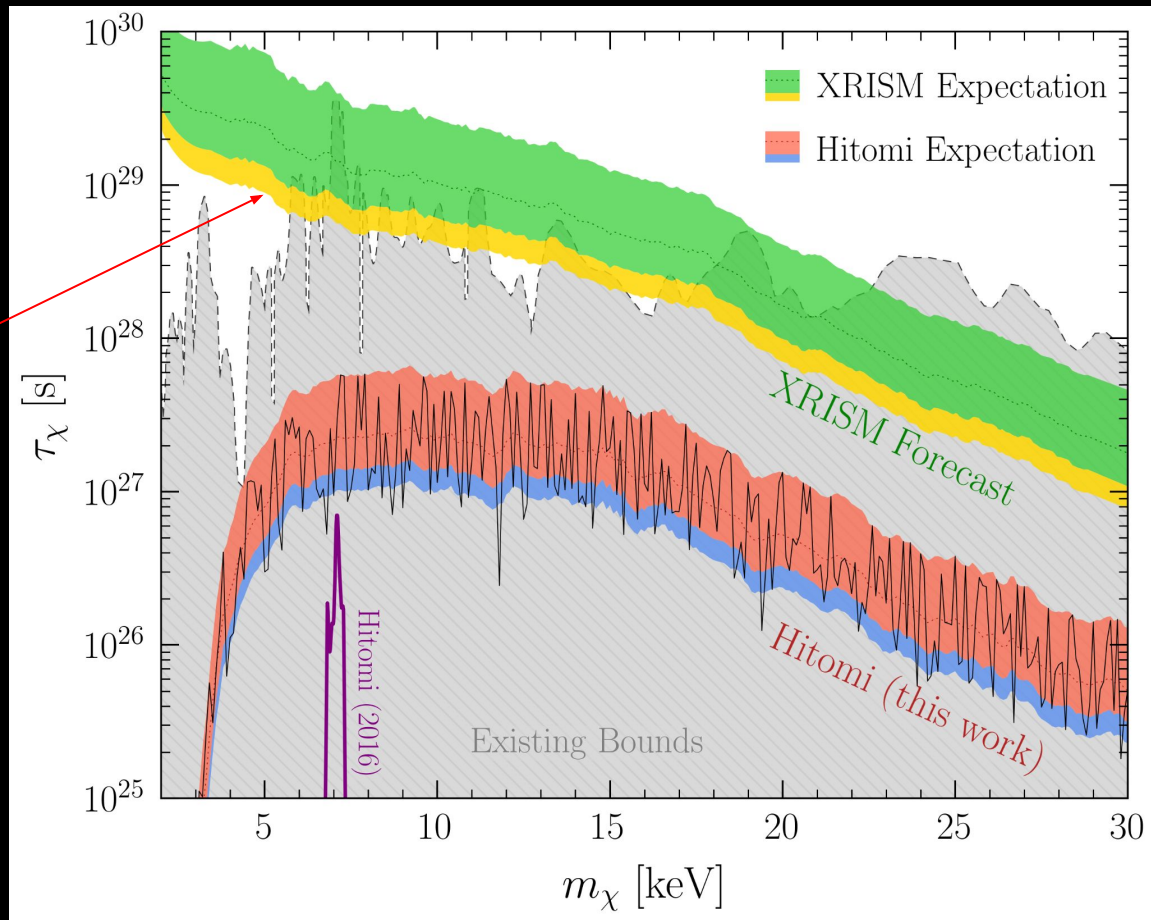
← We assume 10 years operation including cryogen-free period

XRISM DM Decay Projections

- Blank Sky Exposure Time ends up around 6.7 years
- Scanning strategy similar to XMM Newton: 30 annular bins around GC
- Background Rates derived from Hitomi's Blank-Sky data

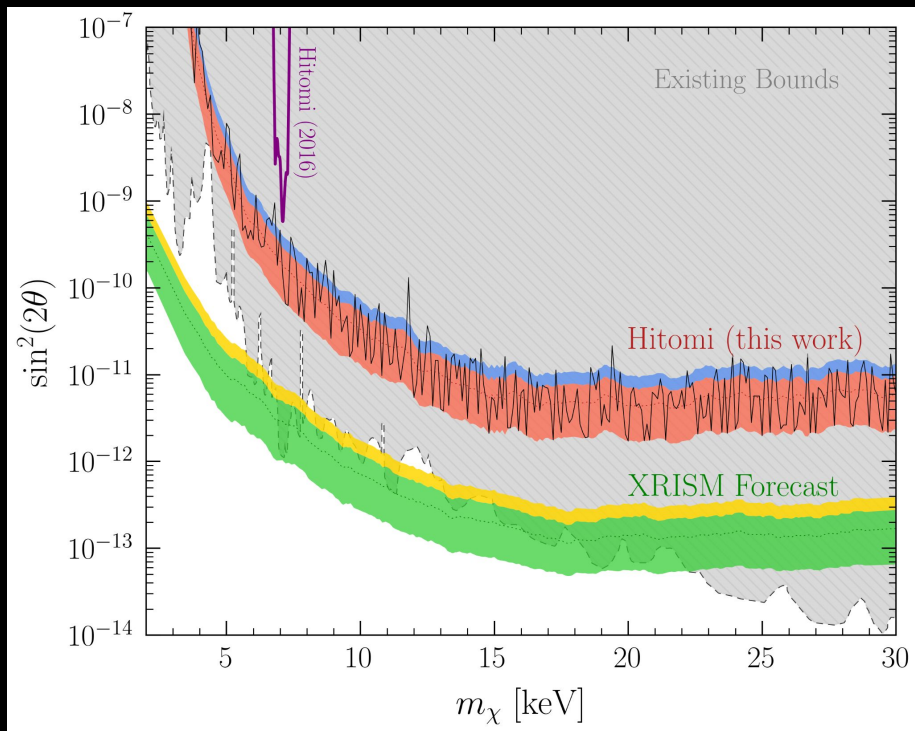


XRISM Projected End-of-Mission BSO Limit

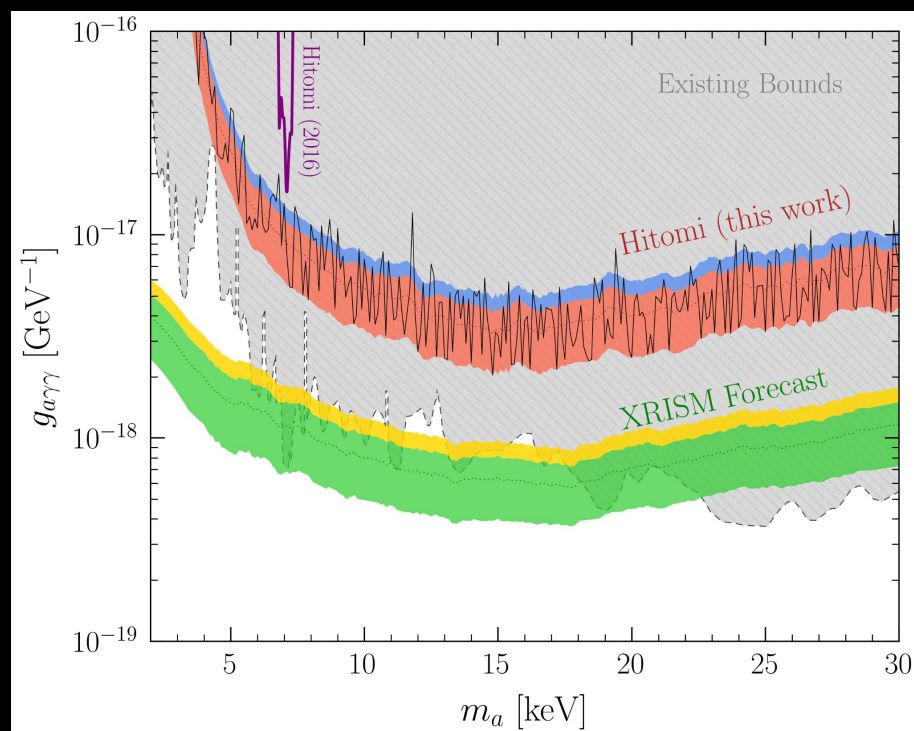


XRISM expected to have leading sensitivity under ~20 keV

Sterile Neutrinos

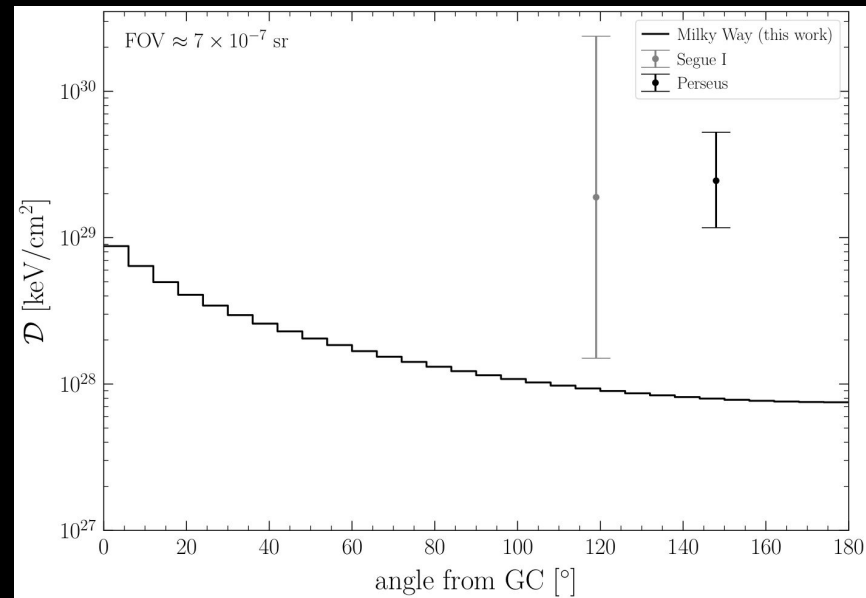


Axion-like Particles



Blank Sky Limits Discussion

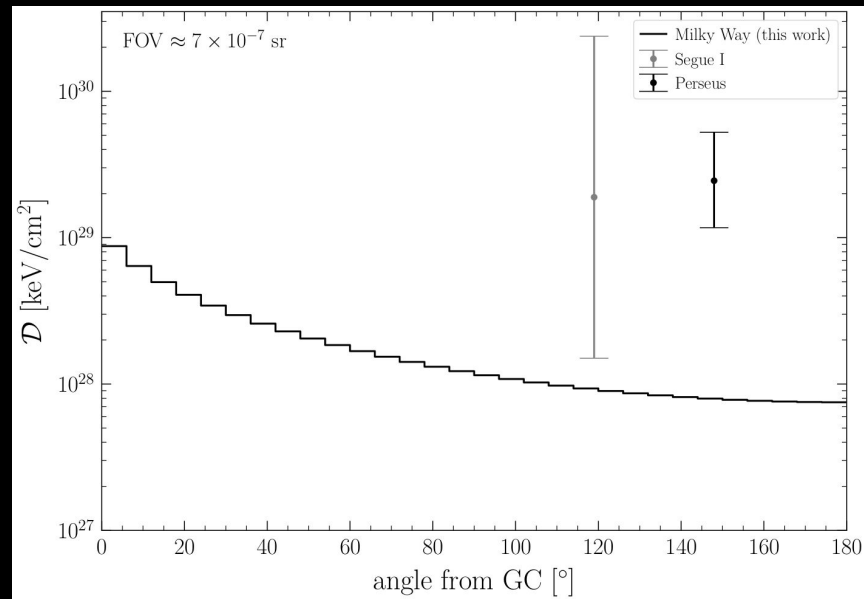
- As shown with Hitomi, Blank Sky Limits can be powerful
- Reuse observations that are already used for other purposes
- Could point at, e.g. Perseus or Segue I, but comparable D-factors anyways



Blank Sky Limits Discussion

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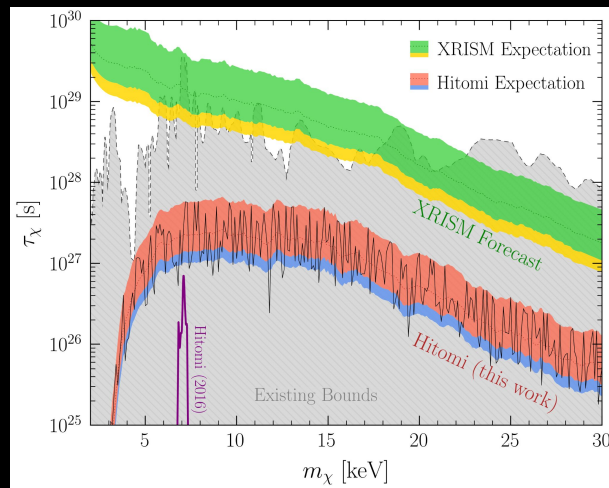
Ultimately BSO's are a powerful and convenient technique in probing for DM decay



Outlook

- Instruments like XRISM crucial for DM Decay Searches
- Ideal detector for this type of search would have comparable energy resolution and effective area to XRISM, but much larger FOV

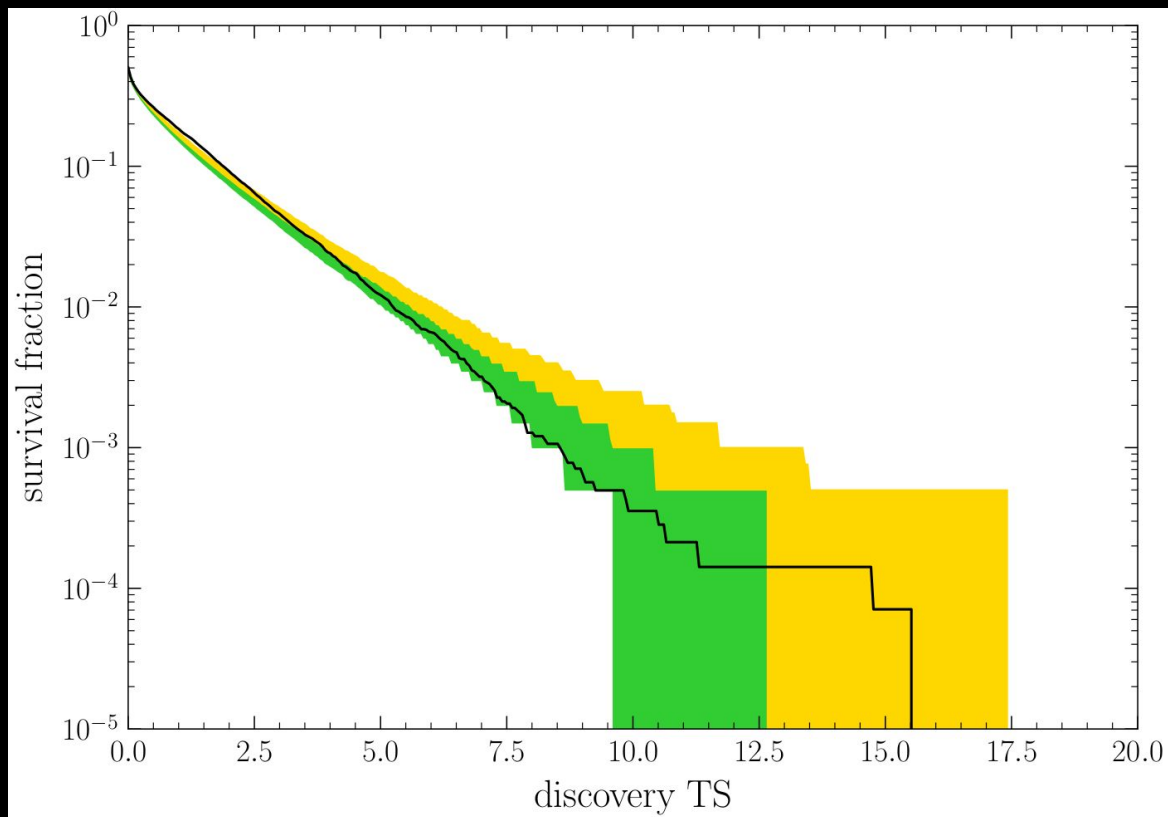
XRISM launches this year
– Exciting time ahead!



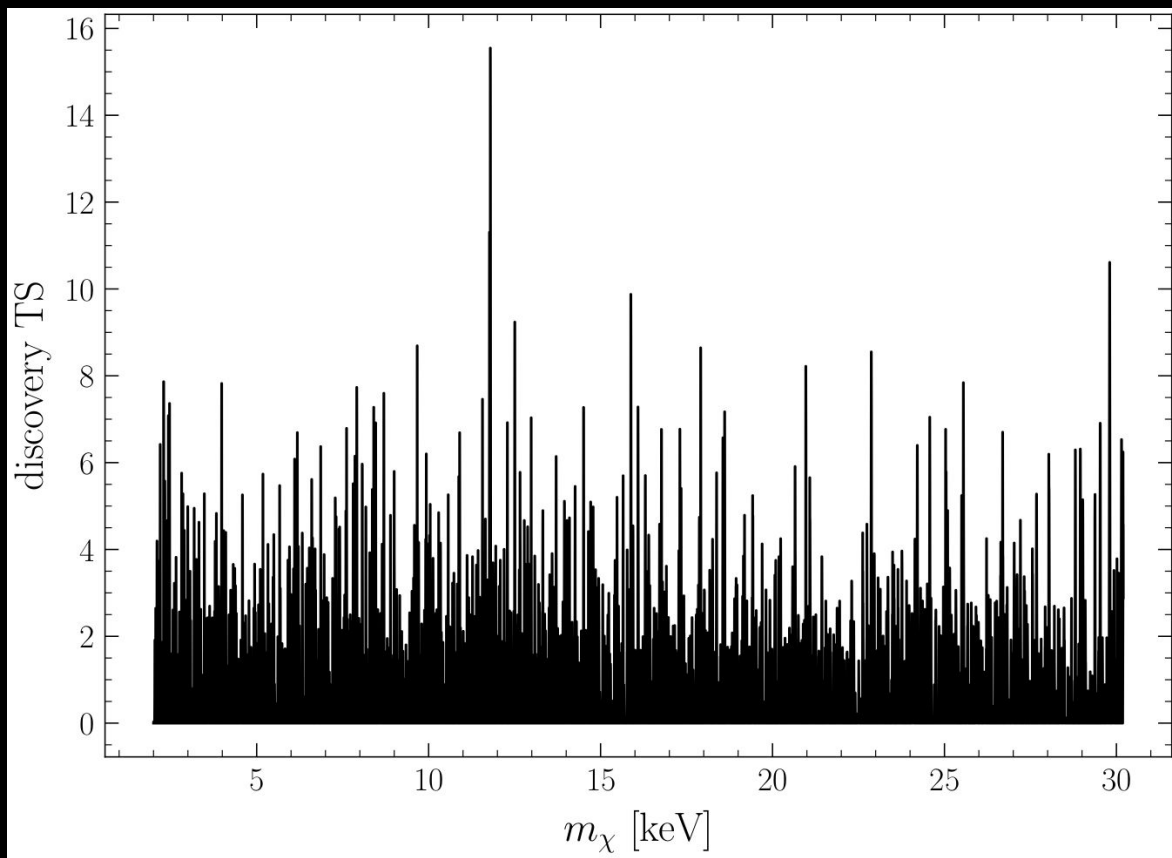
Thank you!

Appendix

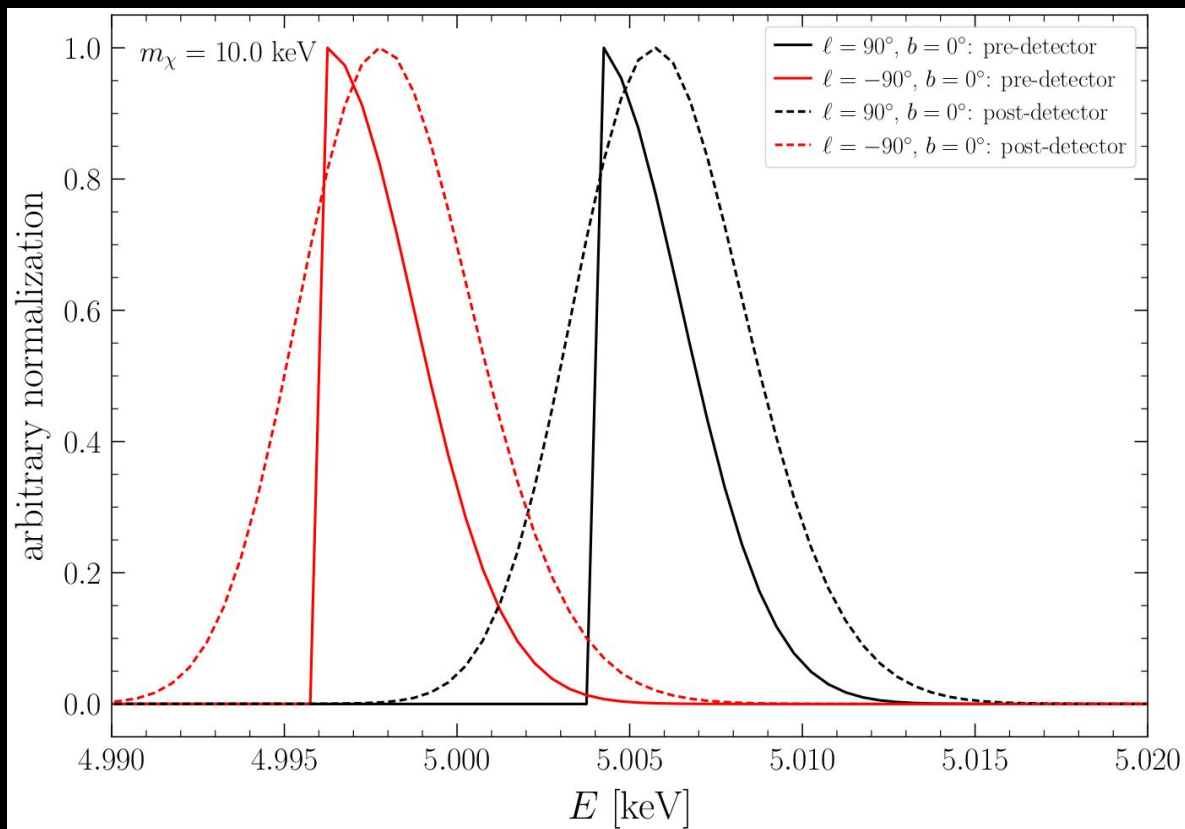
No Evidence for Decaying DM



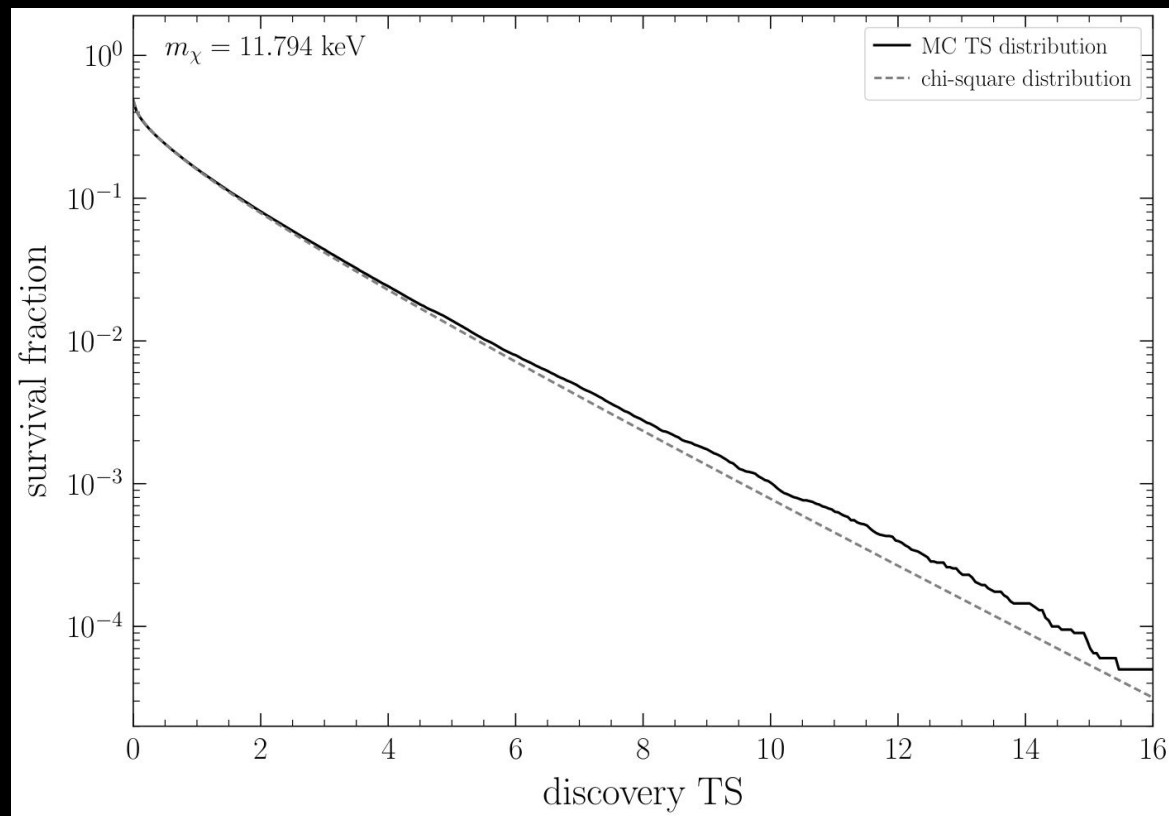
Discovery TS as a function of DM mass



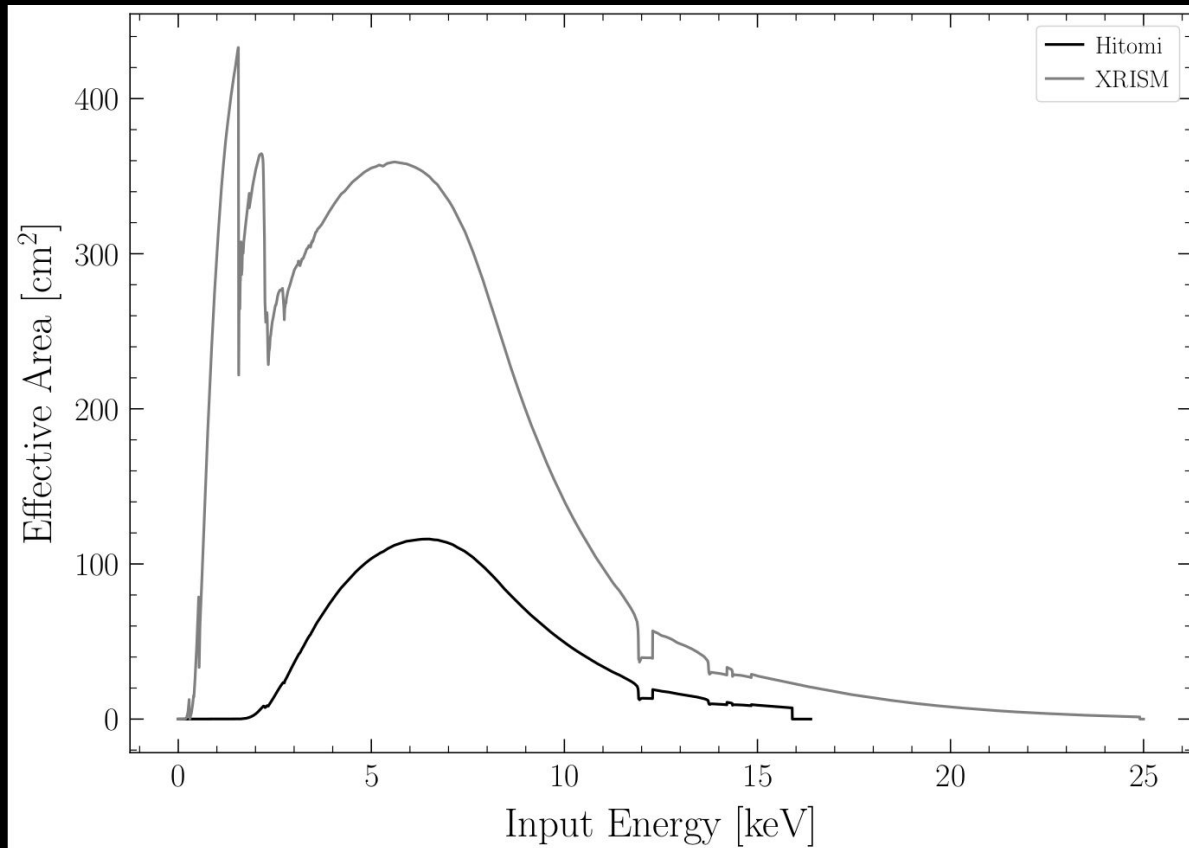
Doppler Shifting and Broadening



Distribution of TS Under the Null



Detector Effective Areas



FWHM of Hitomi

