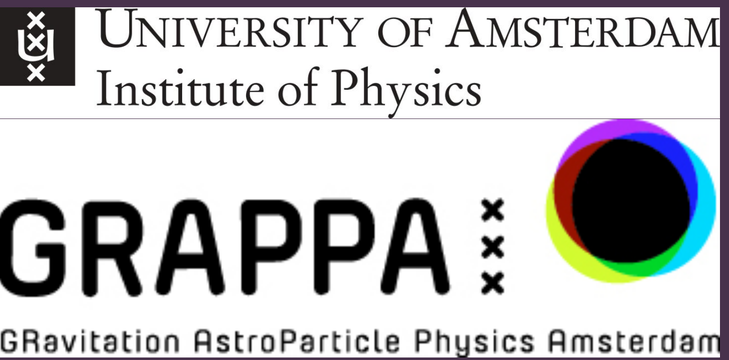
Probing sterile neutrinos and axion-like particles from the Galactic halo with eROSITA

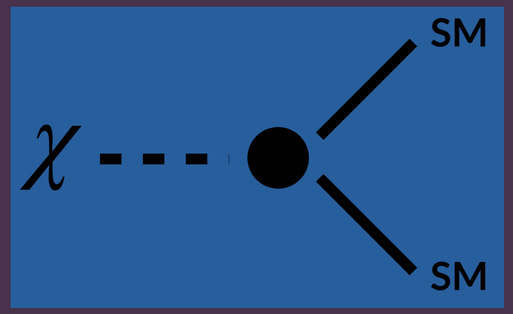
Ariane Dekker — PhD candidate at GRAPPA/University of Amsterdam
ICRC 2021



A Dekker, E Peerbooms, F Zimmer, K Ng, S Ando
arXiv: 2103.13241
Accepted by PRD

X-ray searches for dark matter

Indirect dark matter searches



Warm dark matter

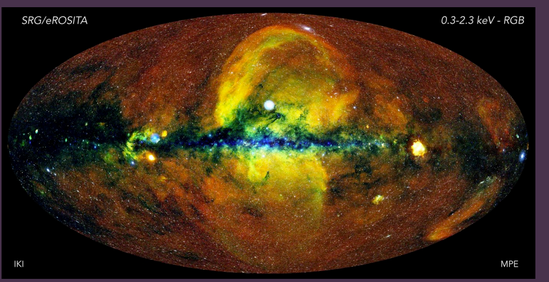
Sterile neutrinos & axion-like particles

Where to look?

Highest flux from Galactic Halo

X-rays

eROSITA 4yr survey



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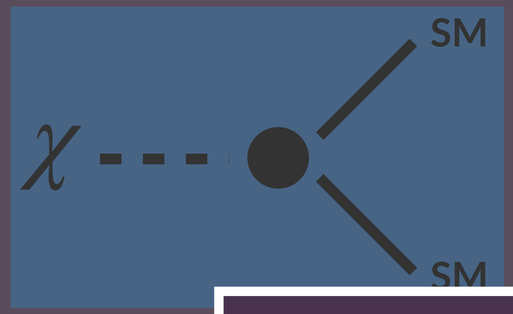

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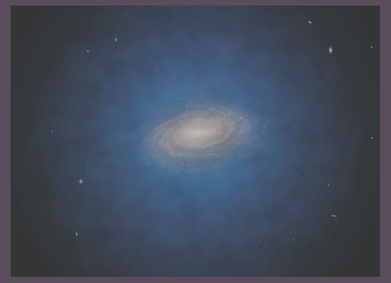

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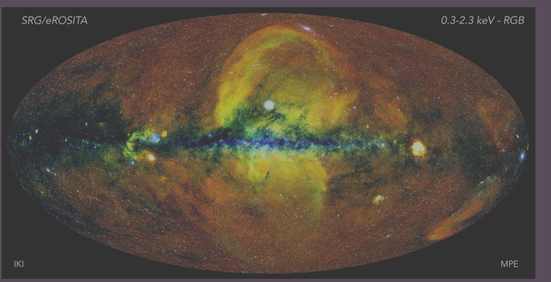
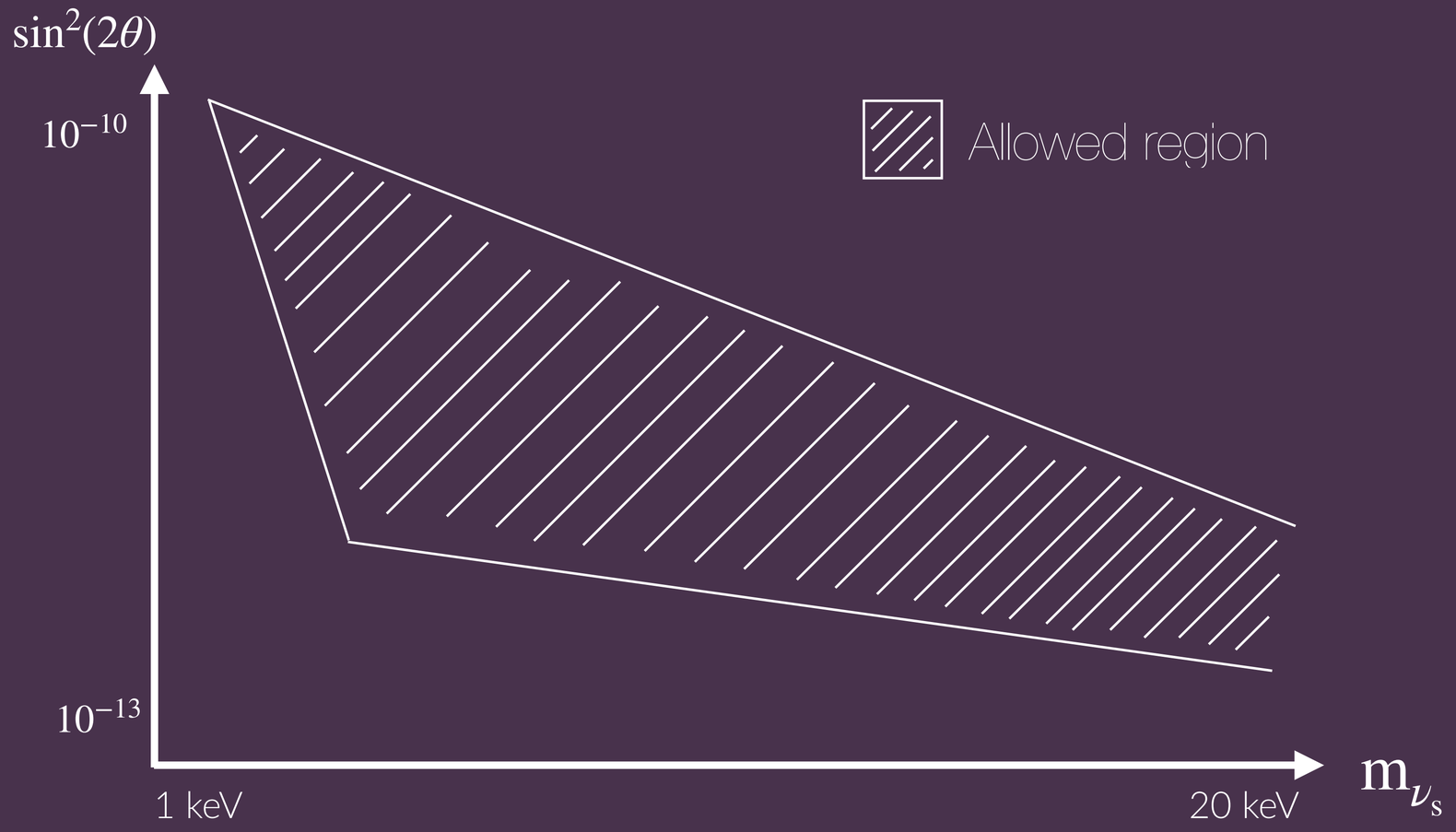


Sterile neutrinos



- Mix with standard neutrinos through mixing angle θ

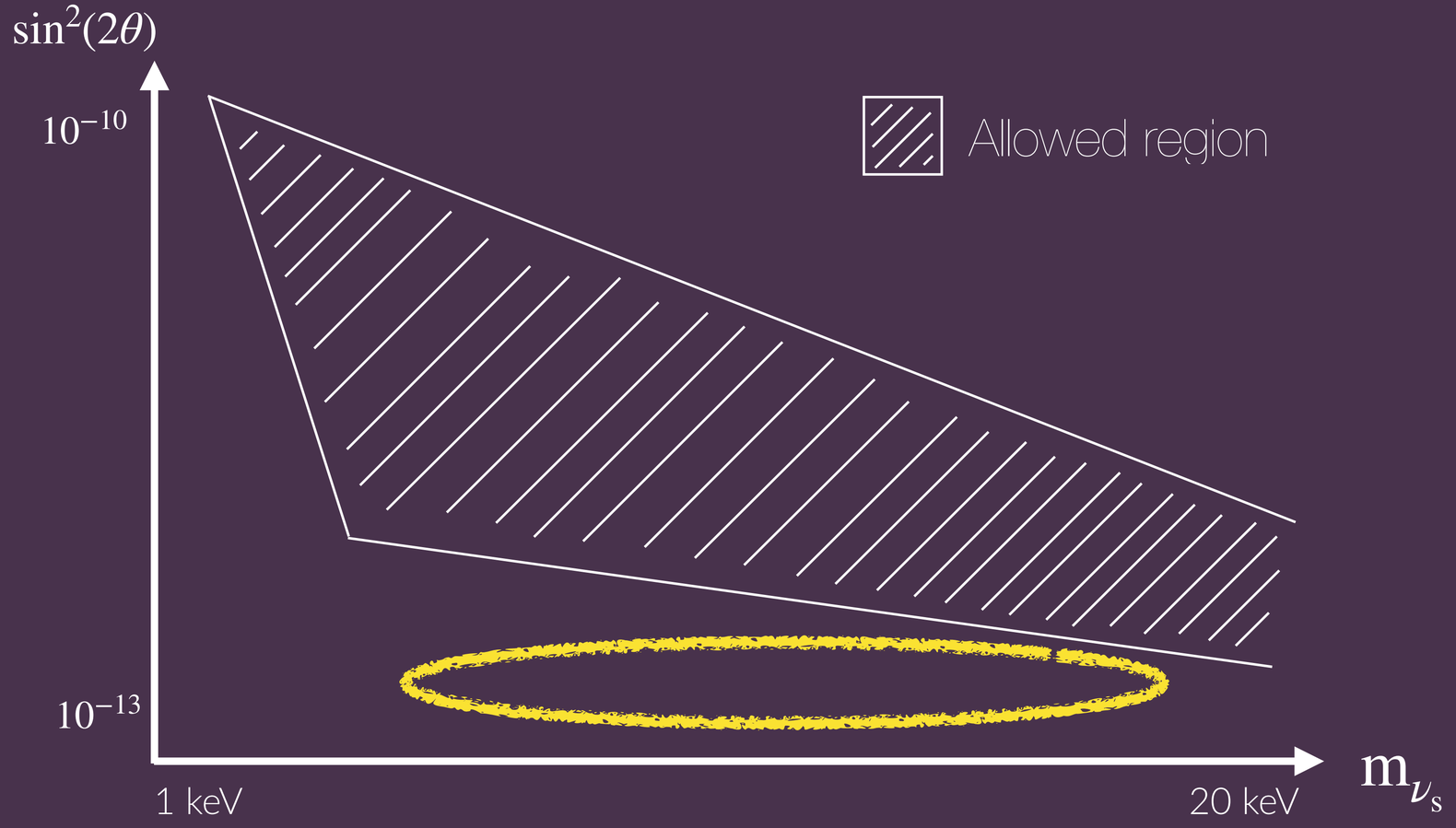
  $\nu_s \rightarrow \nu_a + \gamma$

- Monochromatic X-ray line with

  $E_\gamma = m_{\nu_s}/2$

- 3.5 keV line?
- Rate of decay $\Gamma_{\nu_s} \propto m_{\nu_s}^5 \sin^2(2\theta)$

Sterile neutrinos



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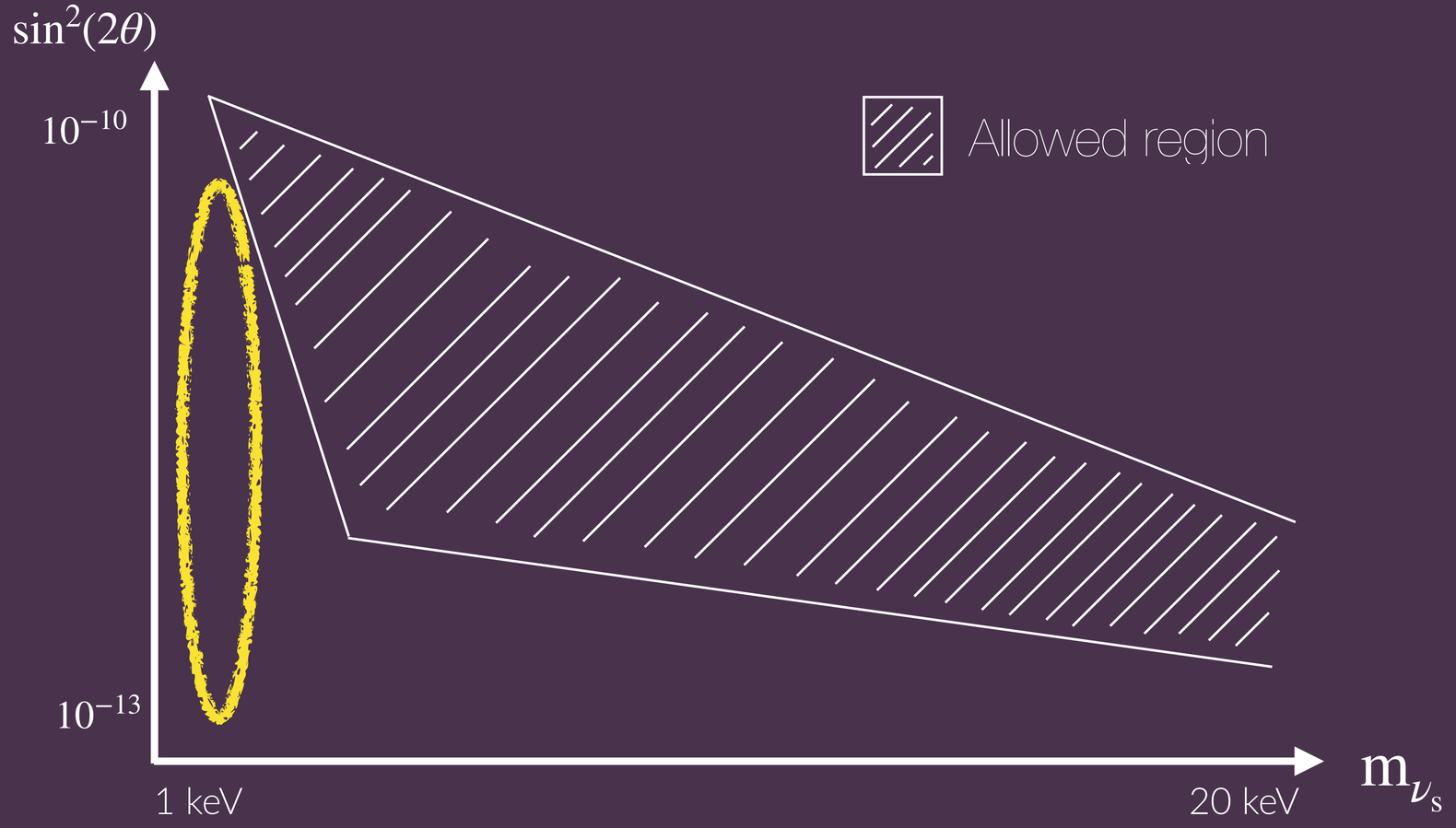

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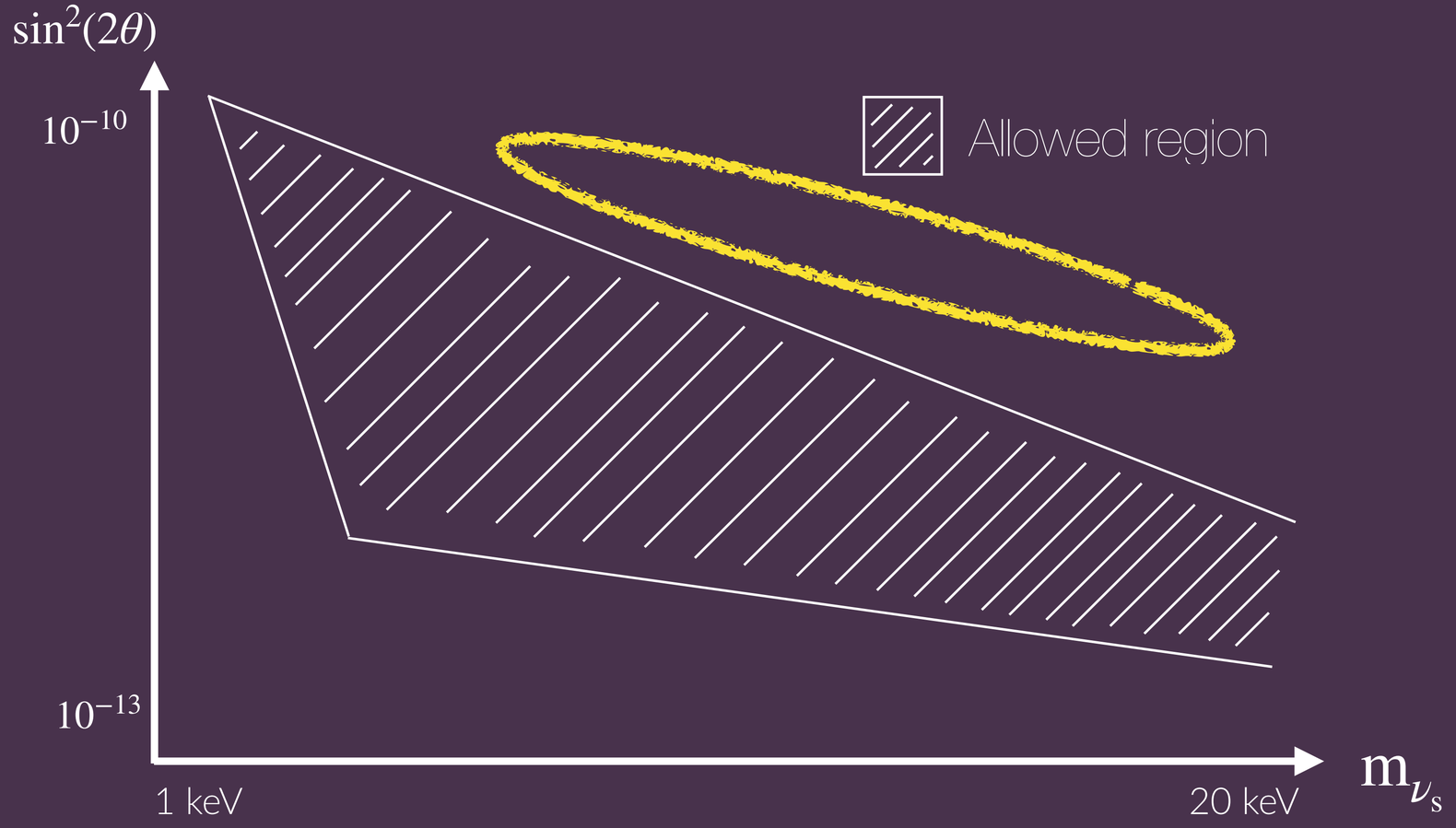

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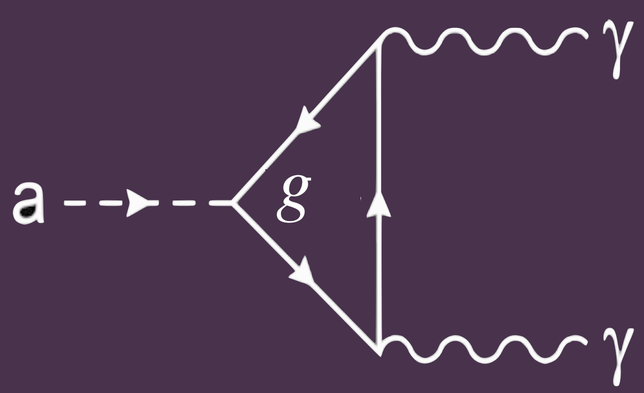
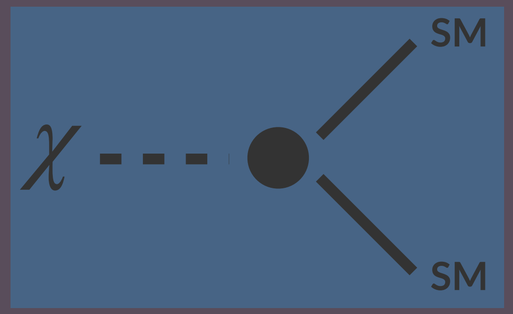
Axion-like particles



- Monochromatic X-ray line with $E_\gamma = m_a/2$
- Rate of decay $\Gamma \propto g^2$
- XENON1T detector observed excess in recoil events. ALP explanation at 3σ with best-fit mass 2.3 keV
- Consider $g_{a\gamma\gamma}$, g_{ae}

X-ray searches for dark matter

Indirect dark matter searches



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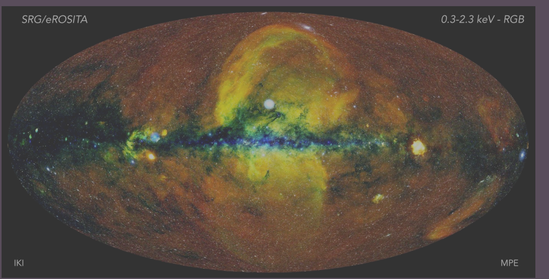
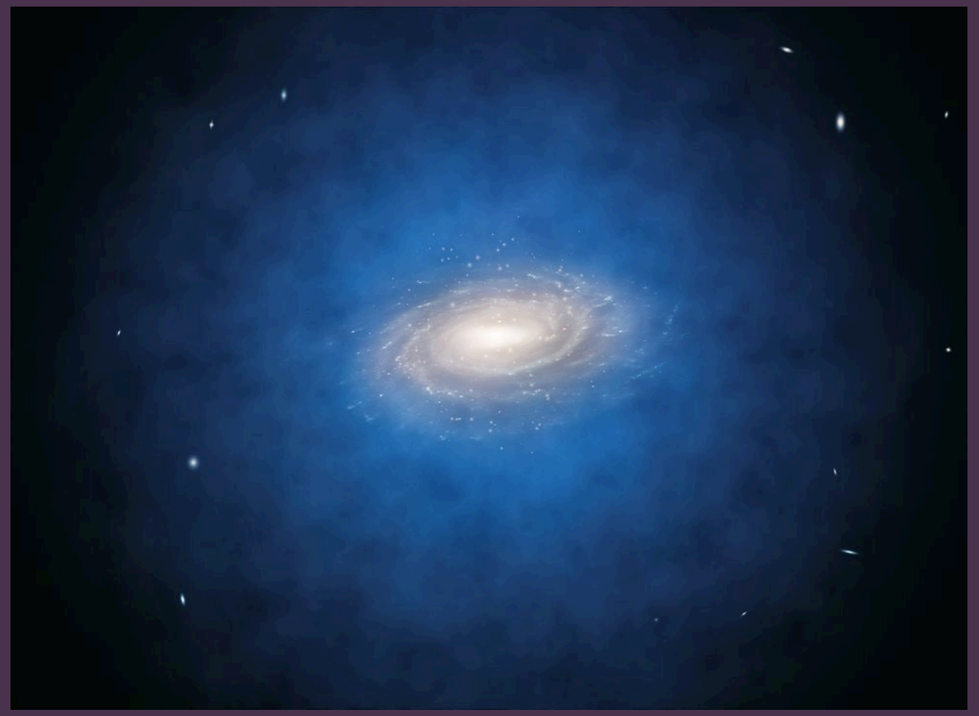


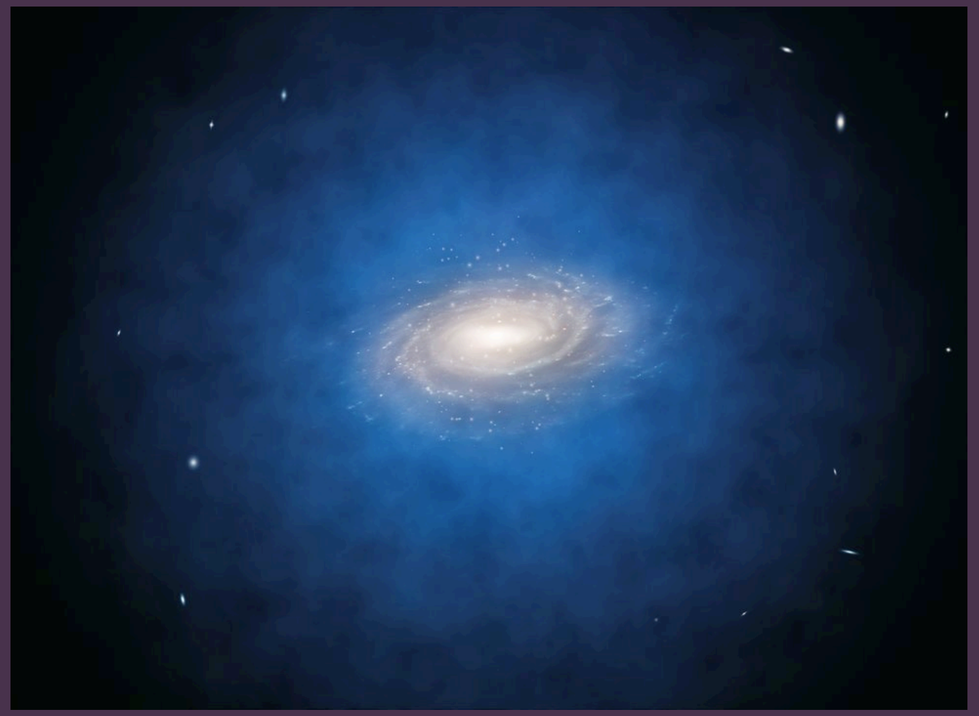
Dark matter flux



Largest observable flux from the Galactic halo

$$\frac{dF}{dE} = \frac{\Gamma}{4\pi m_\chi}\frac{dN}{dE}\int d\Omega \int d\ell\, \rho_\chi[r(\ell)]]$$

Dark matter flux



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X-ray counts

$$N(l,b) = T\int dE A_{eff}(E)\int dE' P(E,E')\frac{dF}{dE'}$$

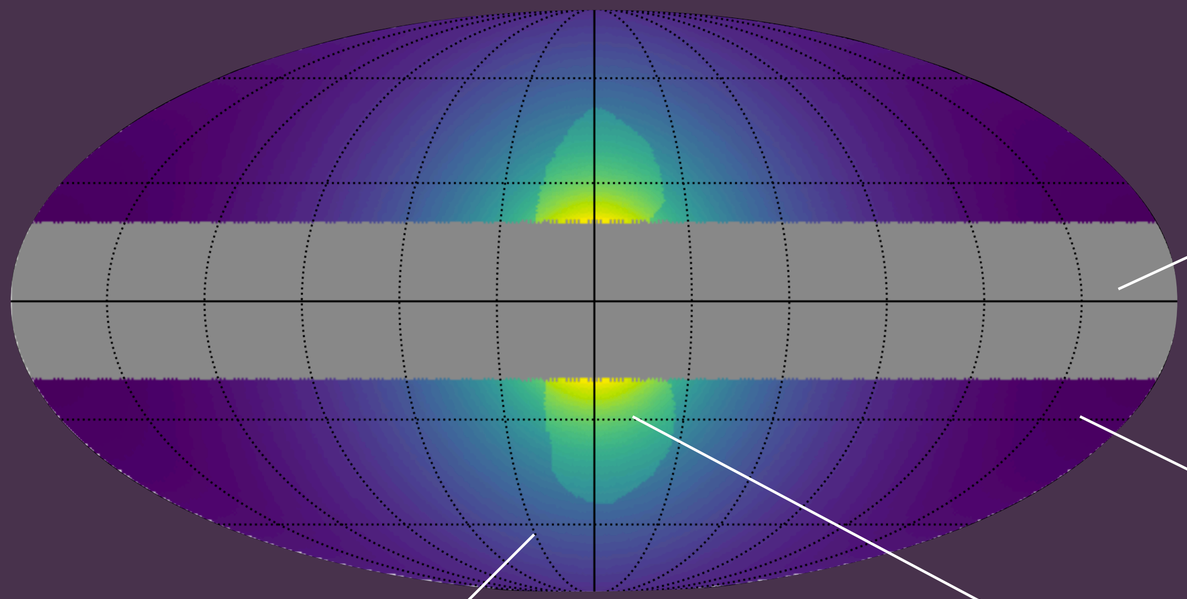
13 Energy bins around m/2

ΔE fixed to angular resolution ~0.35 keV

Normal distribution for the energy resolution

X-ray count sky maps

2.5 ks eROSITA exposure



Remove Galactic plane with |b|<20

Decay signal from the Galactic halo

$m_{\nu_s} = 9\mathrm{keV}, \Gamma_{\nu_s} = 10^{-28}\mathrm{s}^{-1}$

X-ray bubbles

(Predehl et al. 2020)

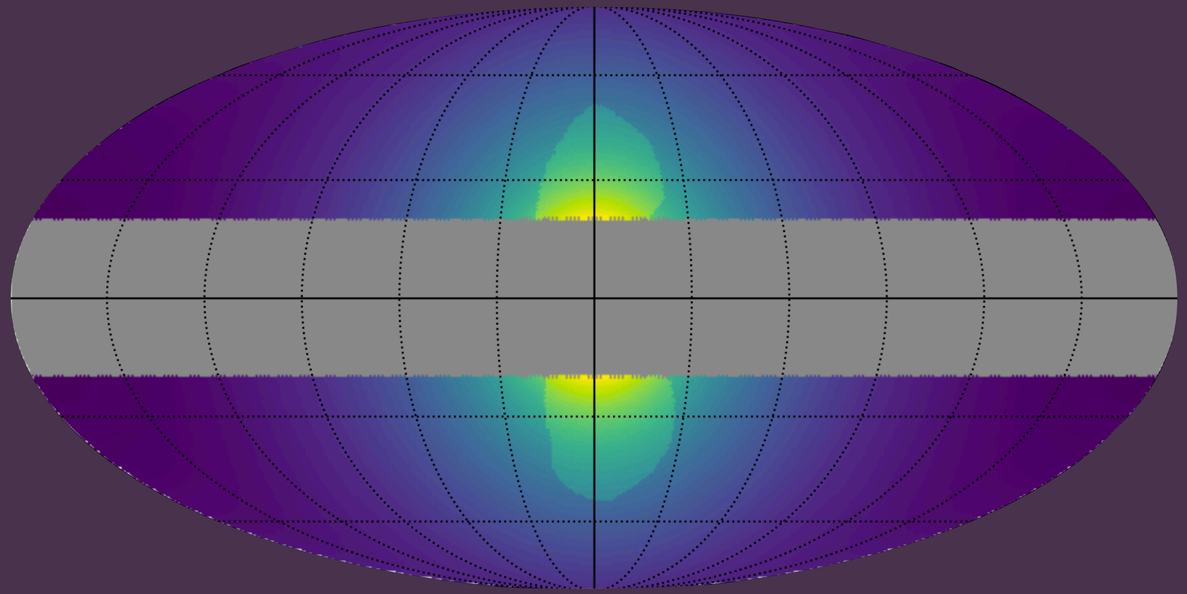
Isotropic components

- Cosmic X-ray background
- eROSITA's detector
- Extragalactic dark matter signal

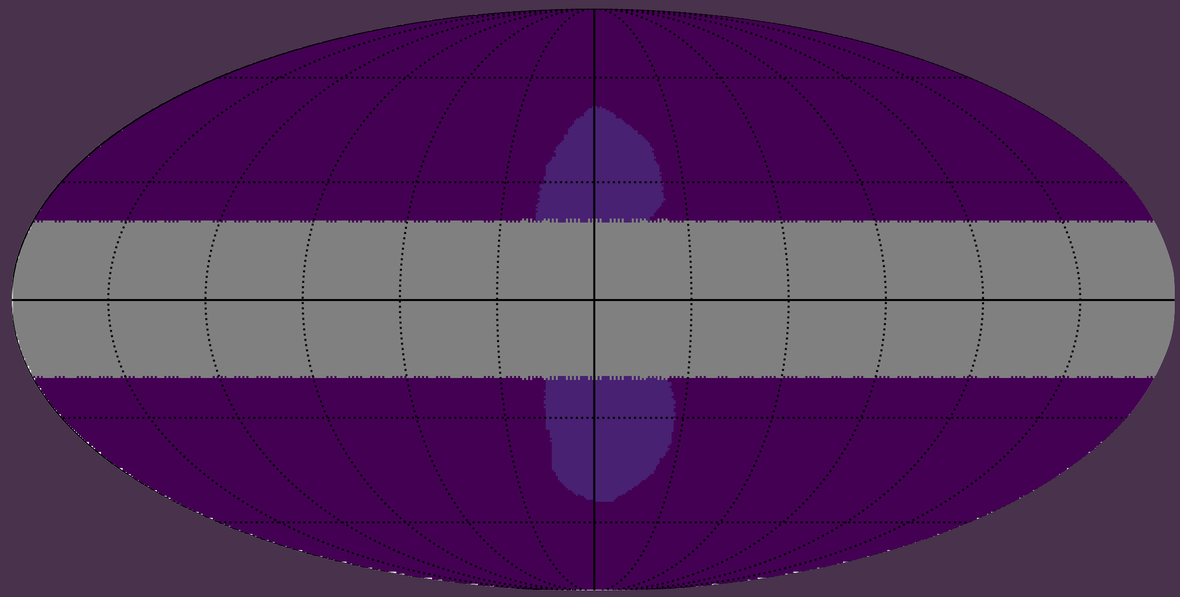
X-ray count sky maps

2.5 ks eROSITA exposure

Model



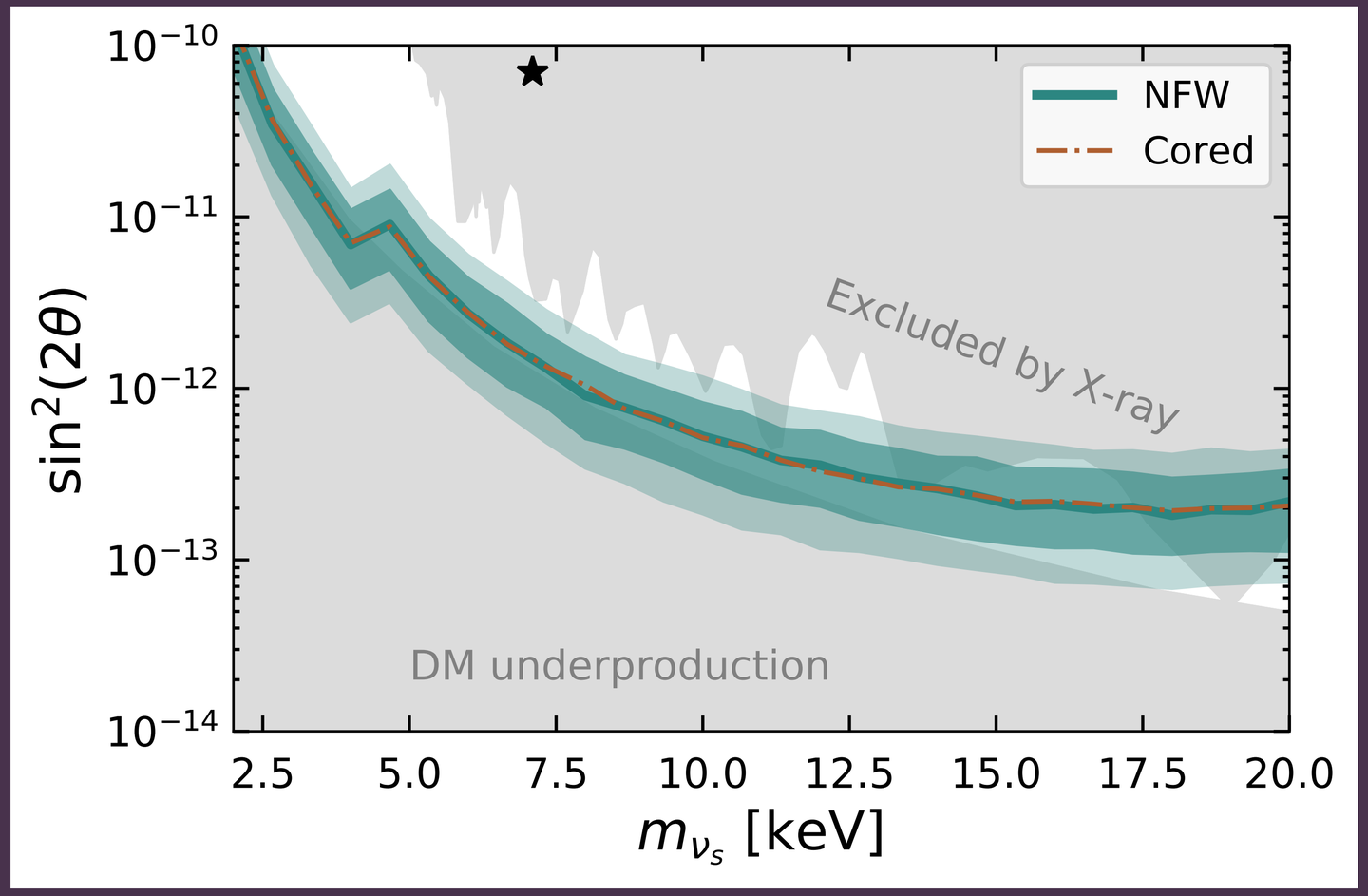
Mock data sets



Generate mock data sets

Joint likelihood analysis — Obtain upper limits at 95% CL

Sensitivity on mixing angle sterile neutrino



Median, 68% and 95% containment regions

Excluded regions *(Foster et al. 2021, Cherry et al. 2017, Ng et al. 2019)*

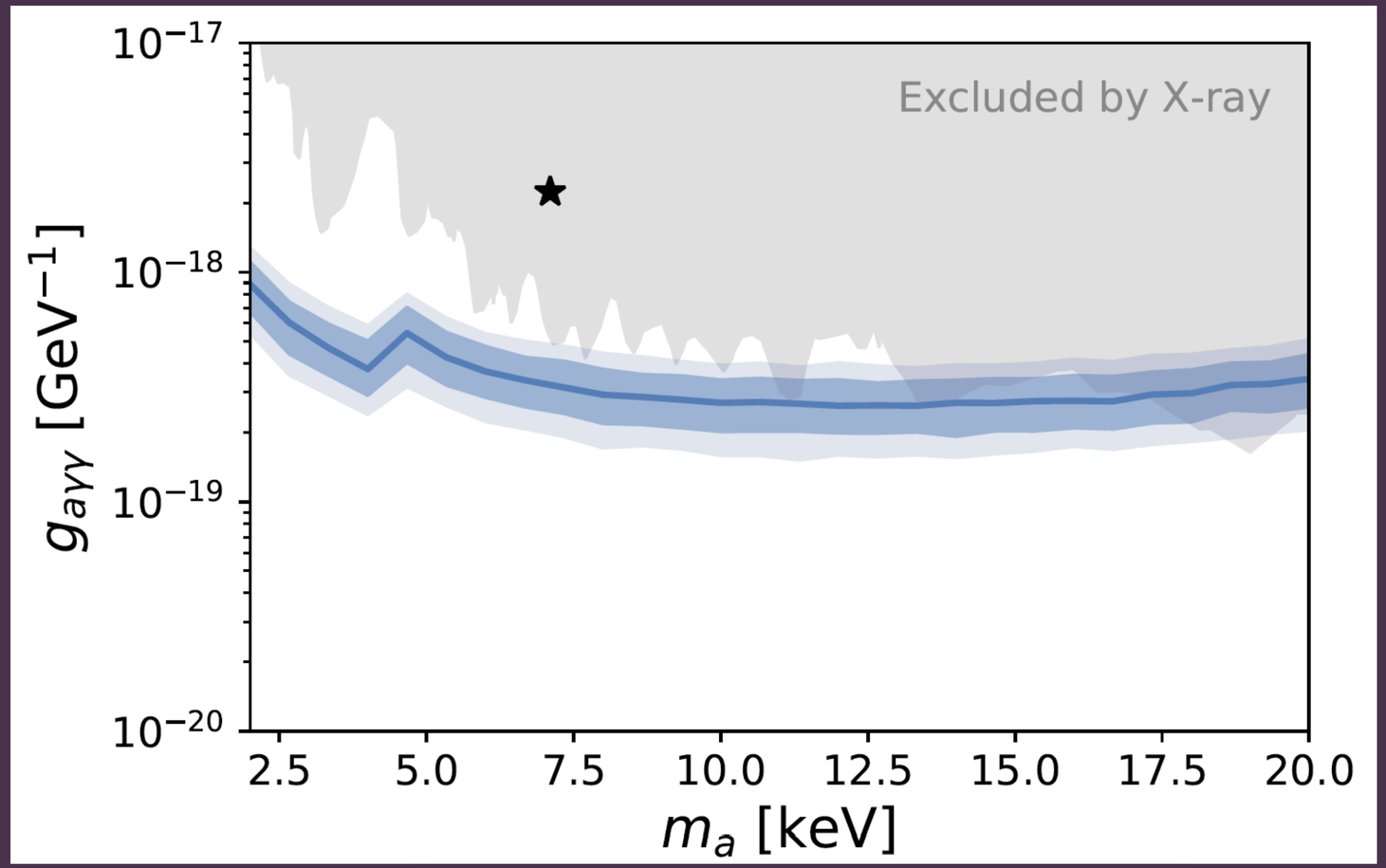
★ 3.5 keV line

Axion-like particle dark matter

Photon coupling

Median, 68% and 95%

Excluded regions



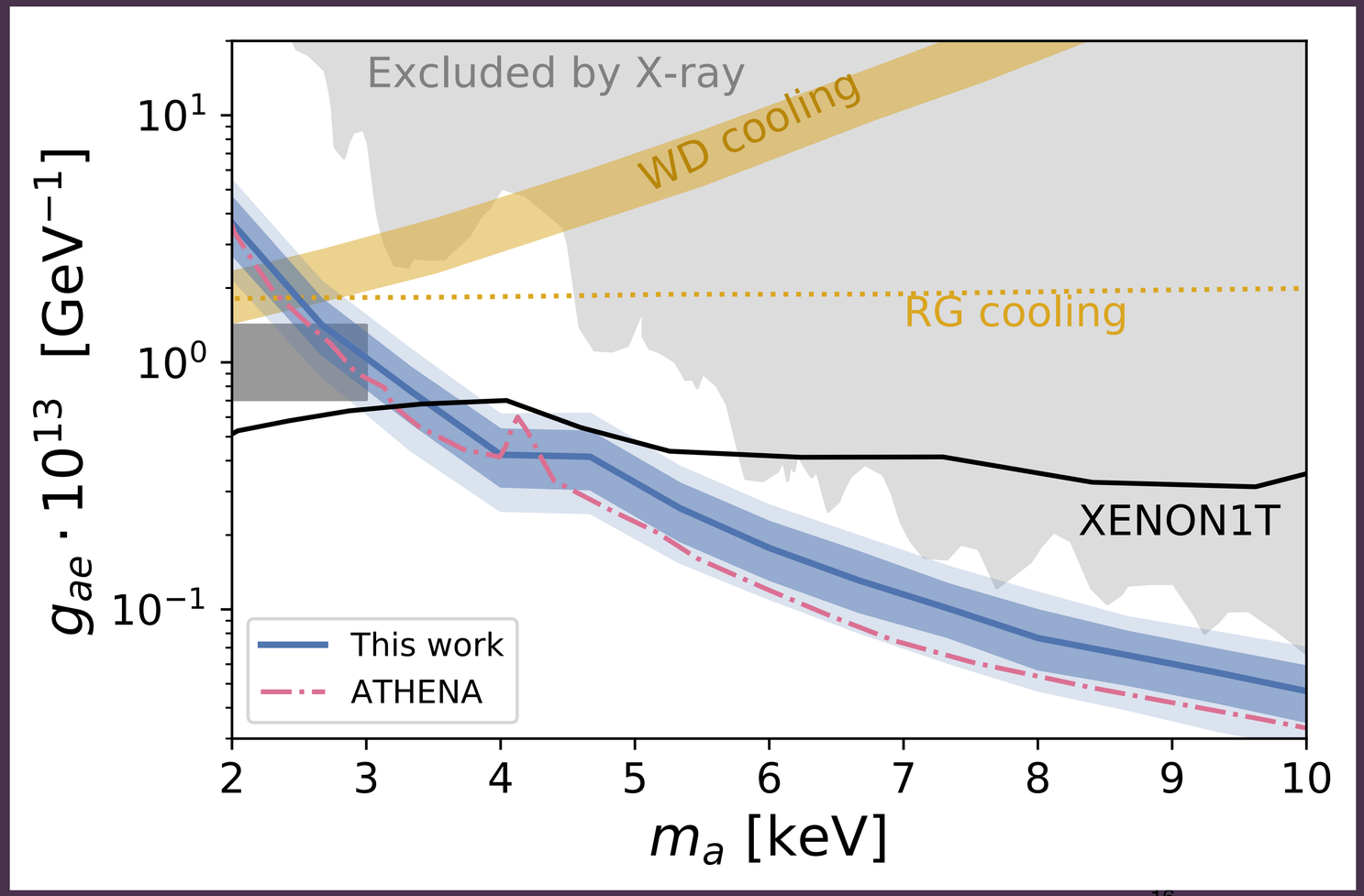
Axion-like particle dark matter

Electron coupling

Median, 68% and 95%

Best-fit region XENON1T

Stellar cooling anomalies



XENON1T excess explained by ALP at 3σ

↓

Photon production needs to be suppressed due to existing x-ray limits

↓

Anomaly free symmetry model

Take-home message

- Studied diffuse emission from Galactic halo from **decaying sterile neutrino & ALP**
- **Probe a large parameter space** of sterile neutrino with eROSITA
- Improve on current limits for ALP
- Possibly confirm parameter space of interest for the **XENON1T excess**
- **Poster by Fabian Zimmer** discussing similar analysis based on analysing Milky-Way satellite galaxies.

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Thank you for watching!