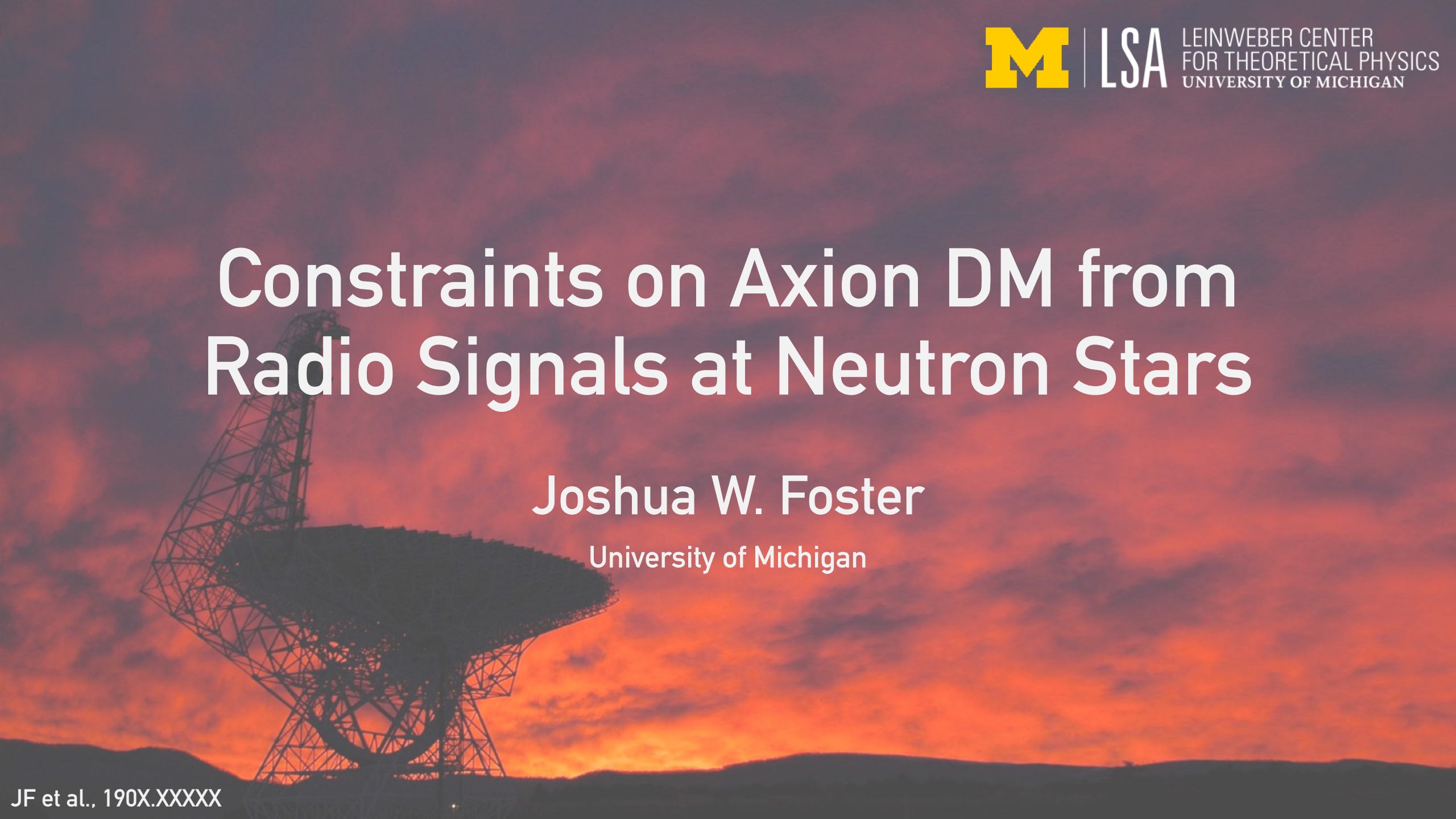

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Constraints on Axion DM from Radio Signals at Neutron Stars

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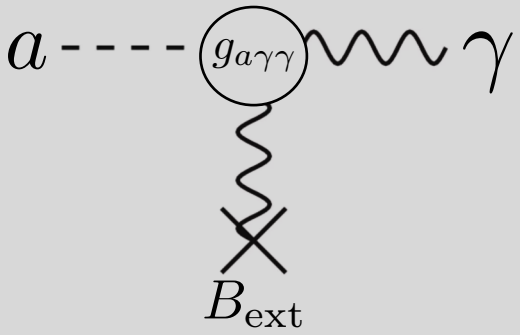
JF et al., 190X.XXXXX

Axion-to-Photon Conversion

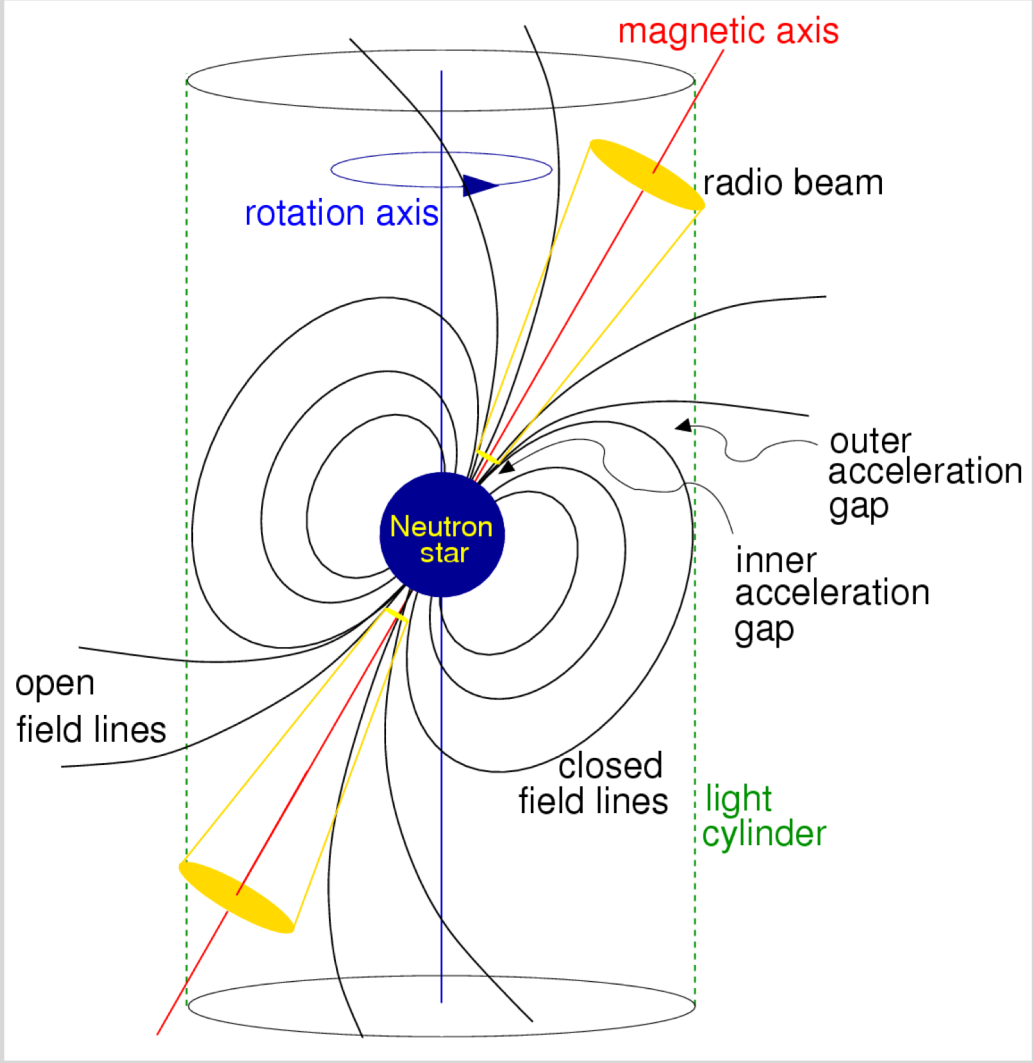
- Axions can convert in the presence of magnetic fields



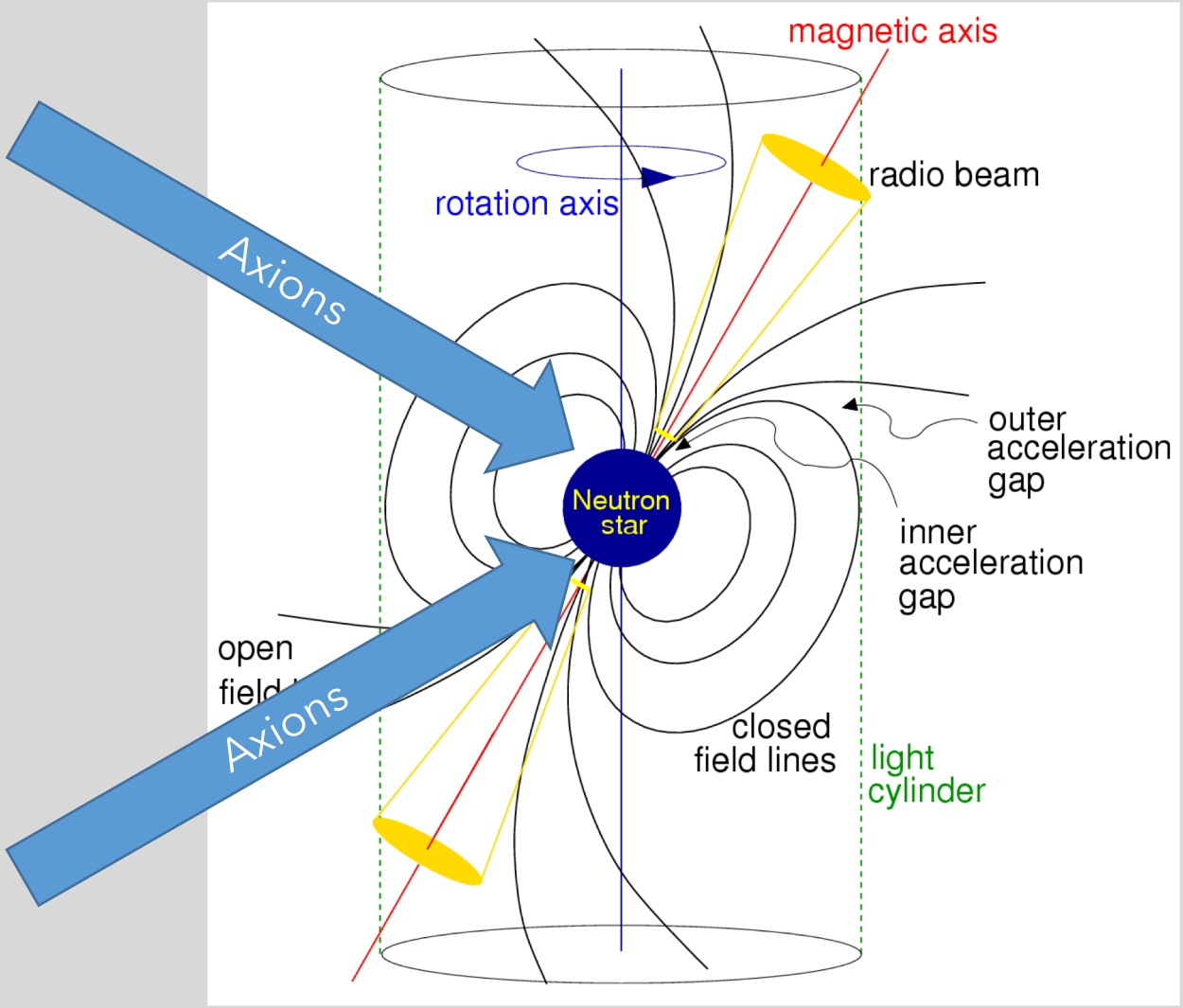
- Conversion probability suppressed by mismatched masses
- Efficient resonant conversion by tuning effective photon mass
- This can be done in the lab: CAST Experiment

$$P_{conv} \sim g_{a\gamma\gamma}^2 B^2 L^2$$

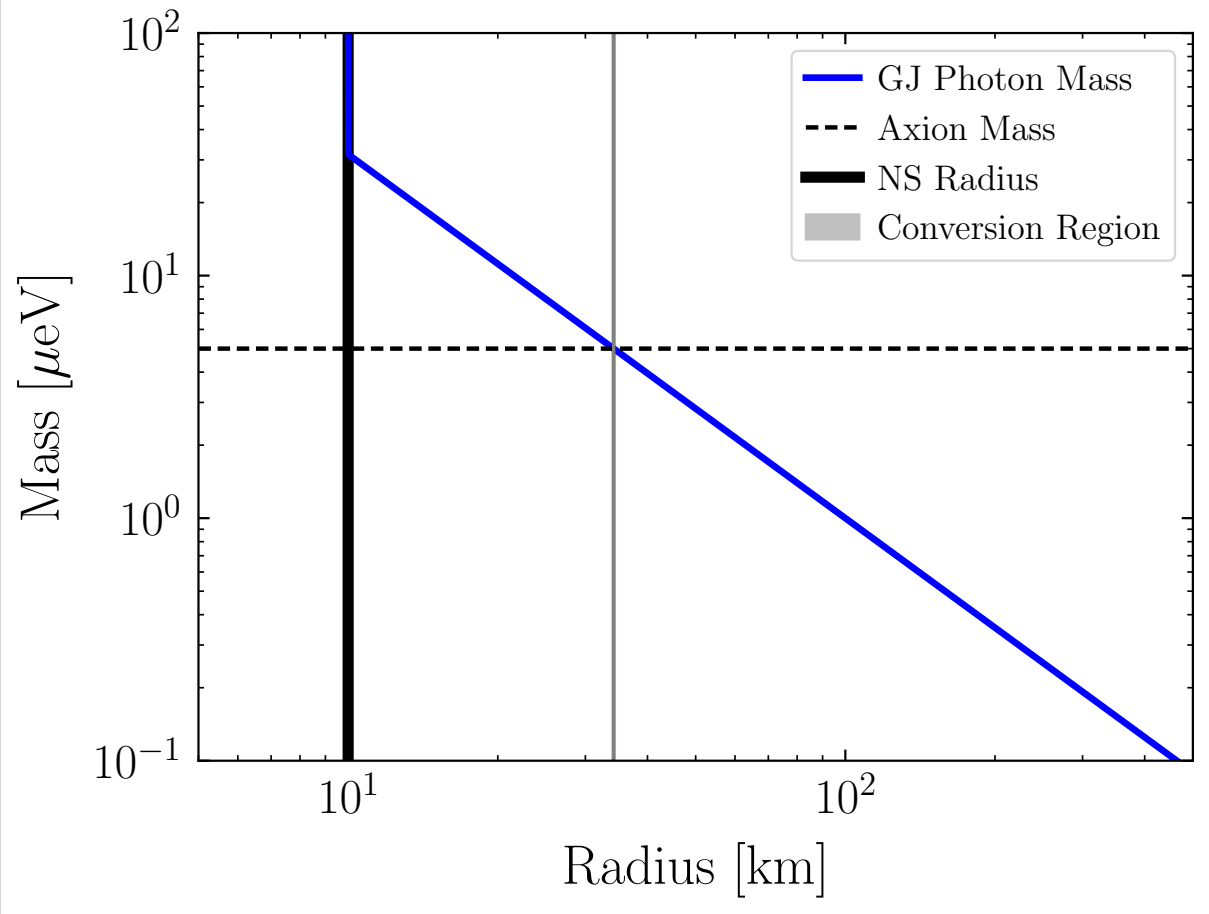
Conversion at Neutron Stars



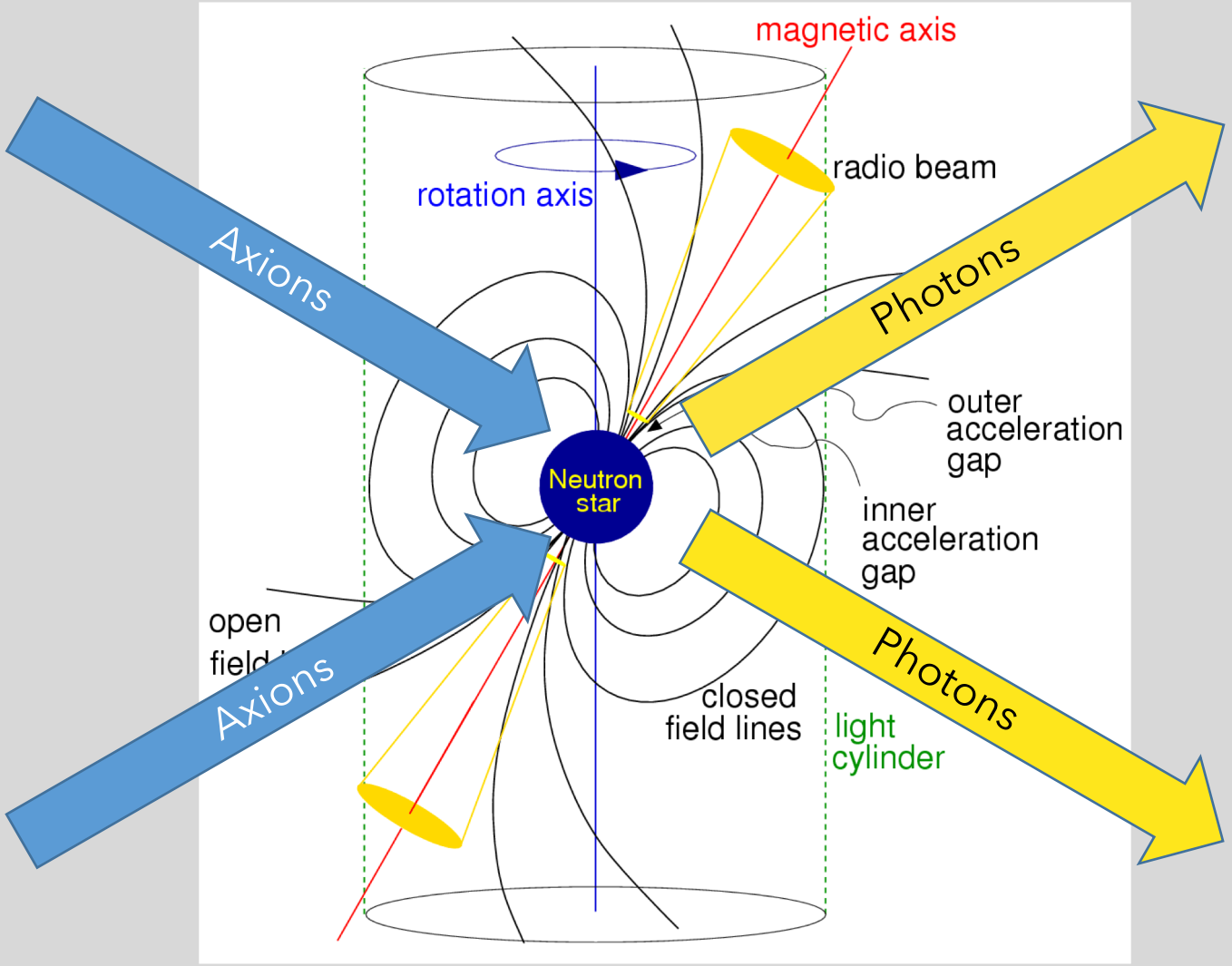
Conversion at Neutron Stars



Conversion at Neutron Stars



Conversion at Neutron Stars



NS Population Models and Signal Strengths

- Assuming Goldreich-Julian model, calculate the conversion radius

$$r_c = 224\,\mathrm{km} \times |3\cos\theta \hat{\mathbf{m}}\cdot\hat{\mathbf{r}} - \cos\theta_m|^{1/3} \times \left(\frac{r_0}{10\,\mathrm{km}}\right)\left[\frac{B_0}{10^{14}\,\mathrm{G}}\frac{1\,\mathrm{sec}}{P}\left(\frac{1\,\mathrm{GHz}}{m_a}\right)^2\right]^{1/3}$$

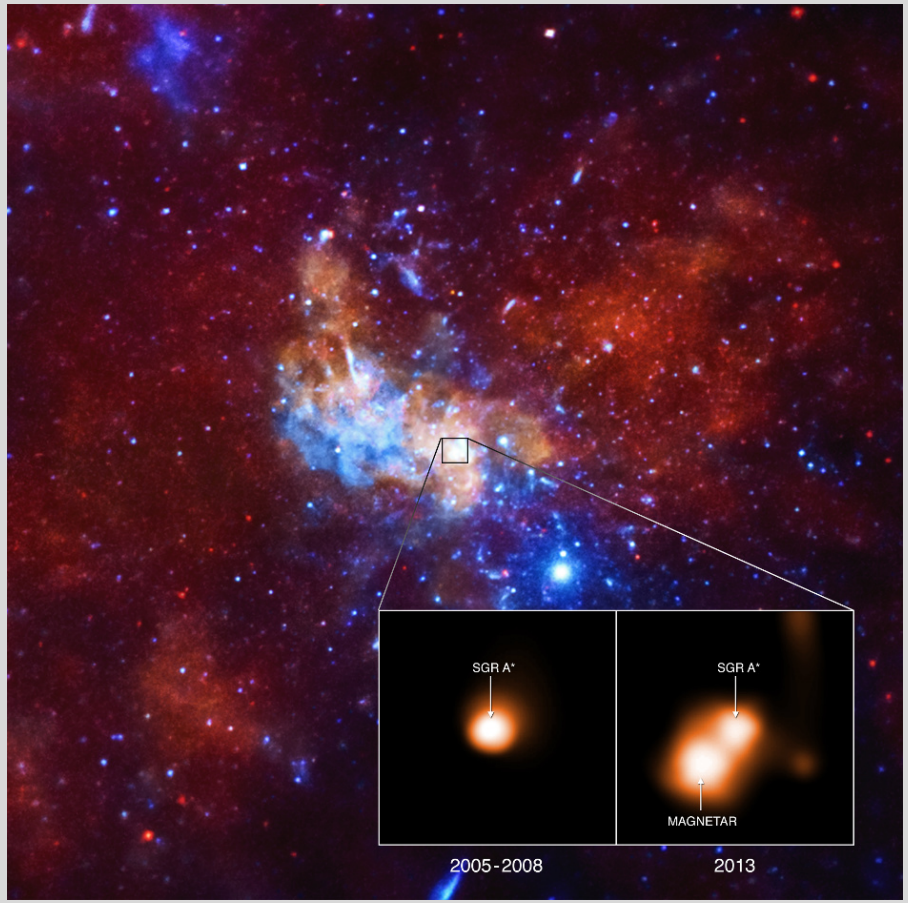
- Resonant conversion if $r_c < r_0$, otherwise NS is inactive
- Predict power output from neutron star:

$$\frac{dP}{d\Omega} = 4.5\times10^8\,\mathrm{W}\left(\frac{g_{a\gamma\gamma}}{10^{-12}\,\mathrm{GeV}^{-1}}\right)^2\left(\frac{224\,\mathrm{km}}{r_c(\Omega)}\right)^4\left(\frac{B(\Omega)}{5\times10^{13}\mathrm{G}}\right)^2\left(\frac{1\,\mathrm{GHz}}{m_a}\right)\left(\frac{\rho_\chi}{0.3\,\mathrm{GeV/cm}^3}\right)\left(\frac{200\,\mathrm{km/s}}{v_0}\right)$$

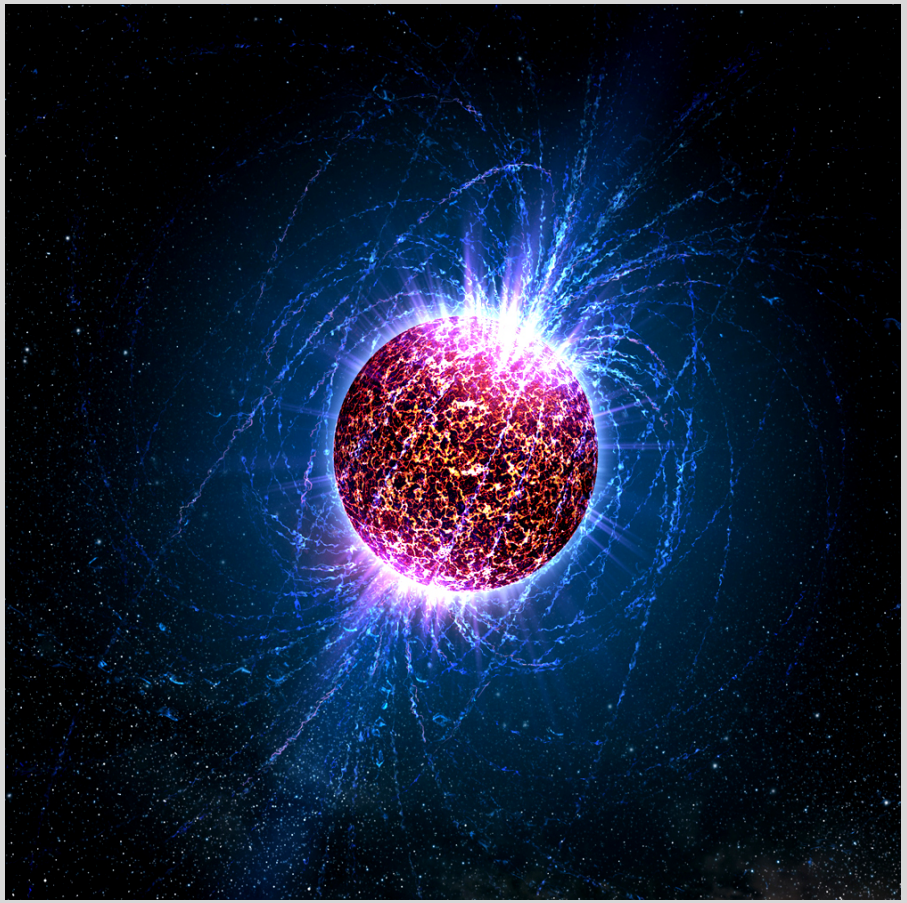
- Requires accurate modelling of NS properties, NS locations, and the DM phase space

Observational Targets and Data Collection

Galactic Center

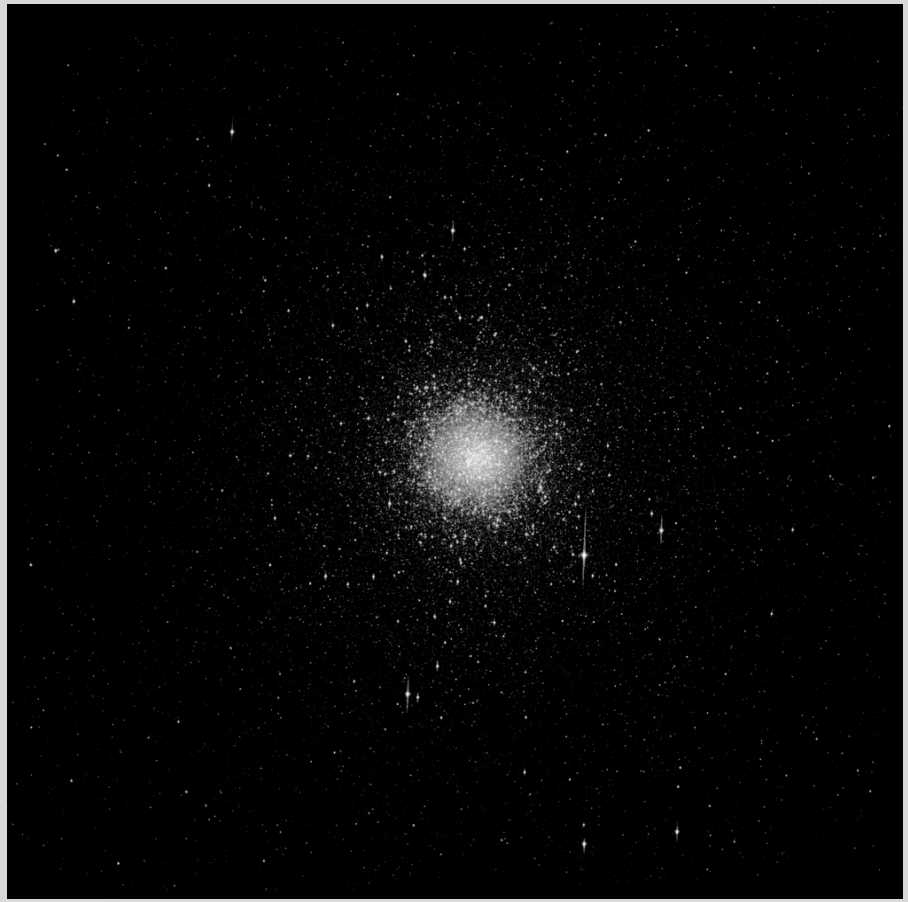


Isolated Neutron Stars



Observational Targets and Data Collection

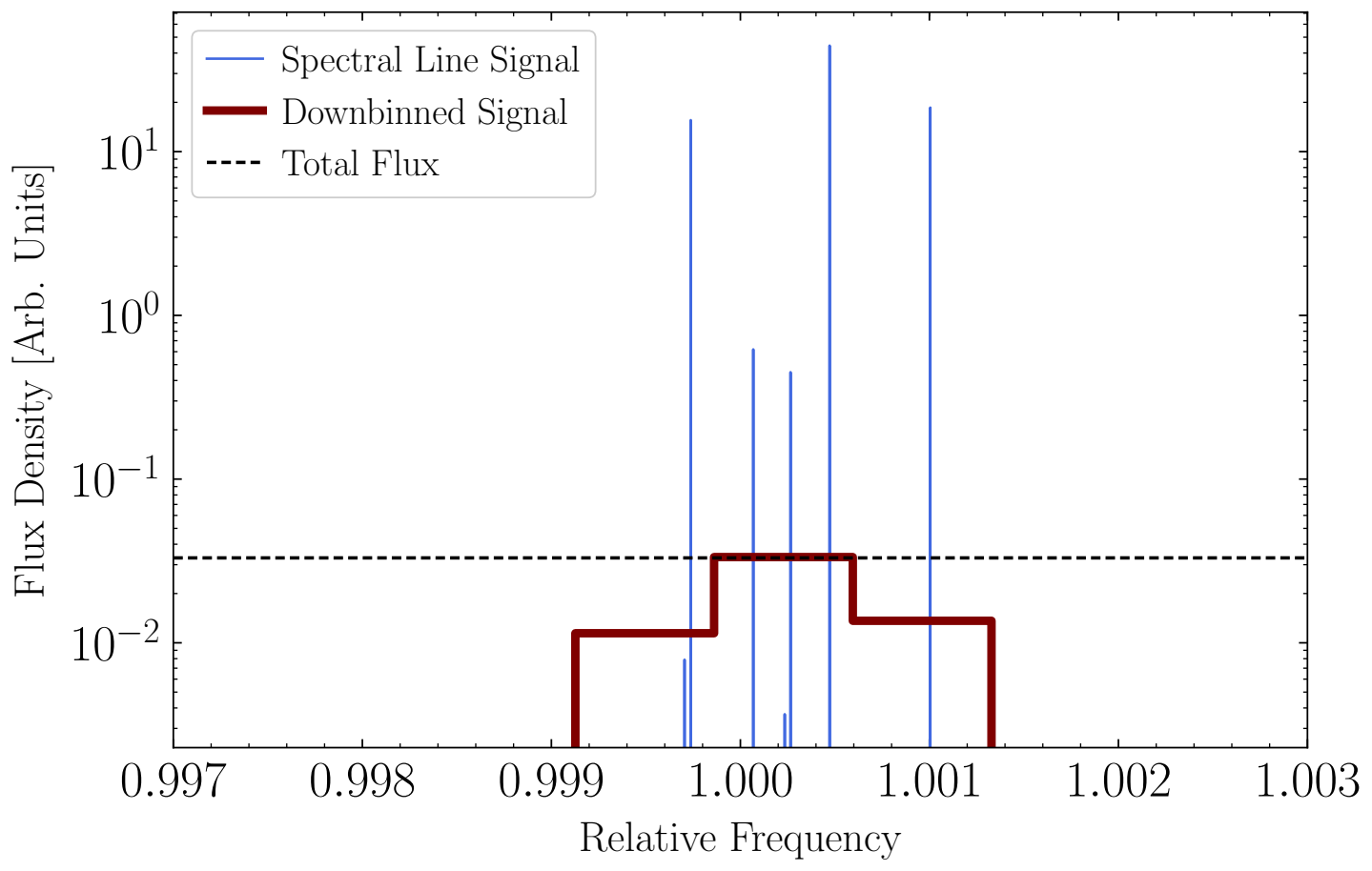
M54 Globular Cluster



M31

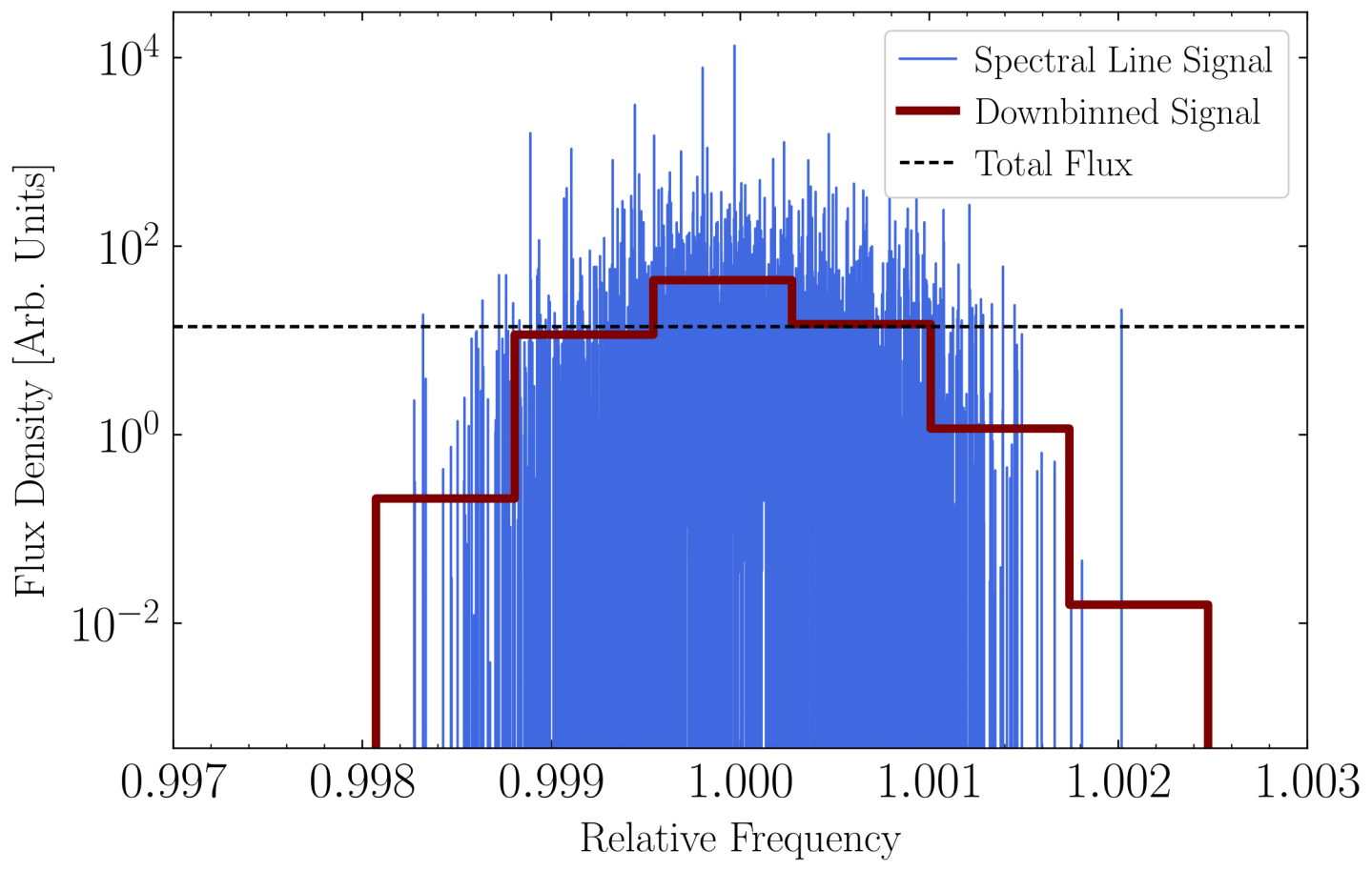
Expected Signal: Single Line Excess

- At high axion masses, relatively few neutron stars participate in conversion
- Spectral line searches most promising
- Broader population signal challenging to characterize statistically



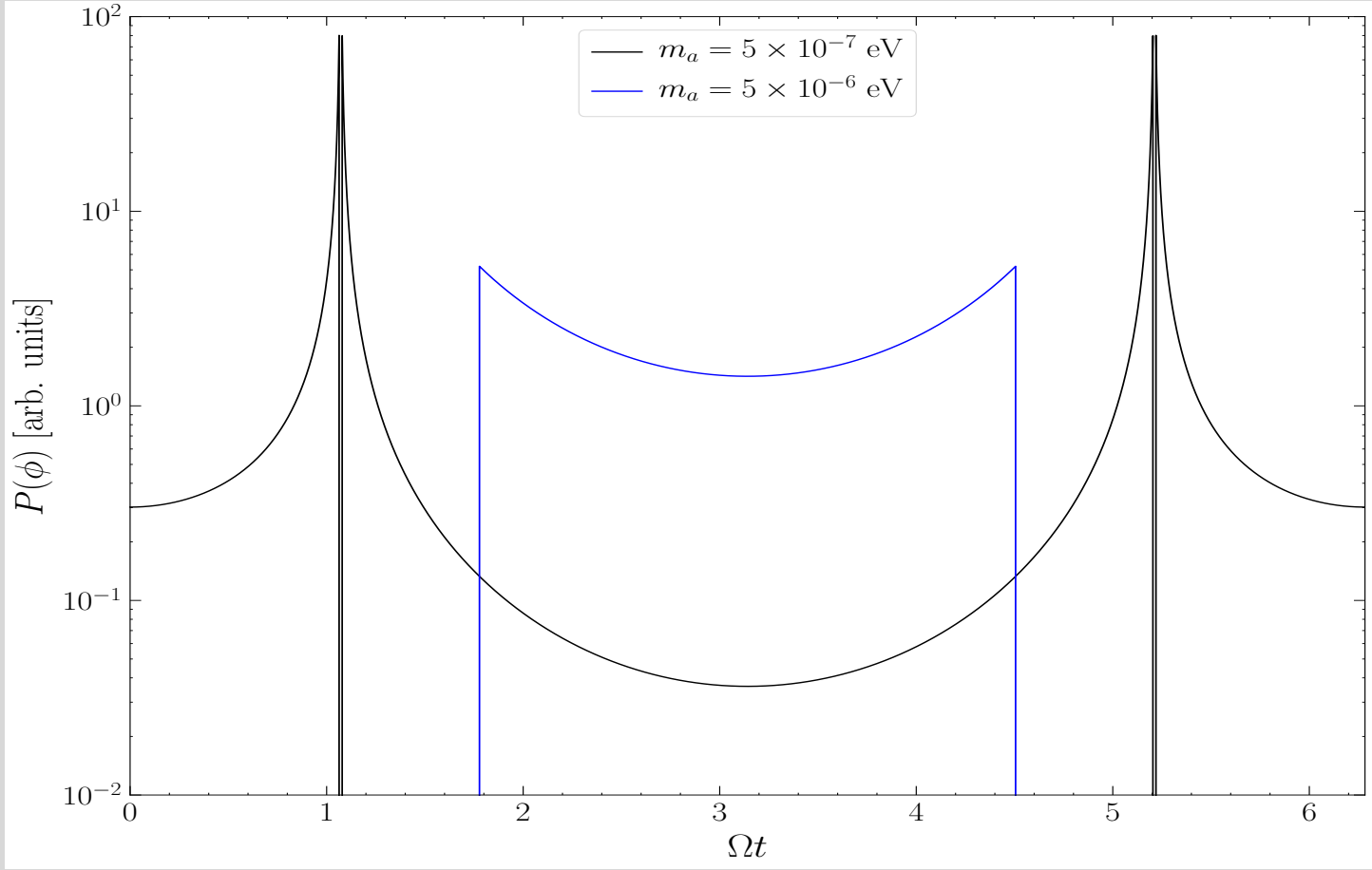
Expected Signal: Population Envelope

- At low axion masses, many neutron stars participating
- Can look for spectral lines, but possible large local variance
- Well-characterized population signal
- Complementary search strategy

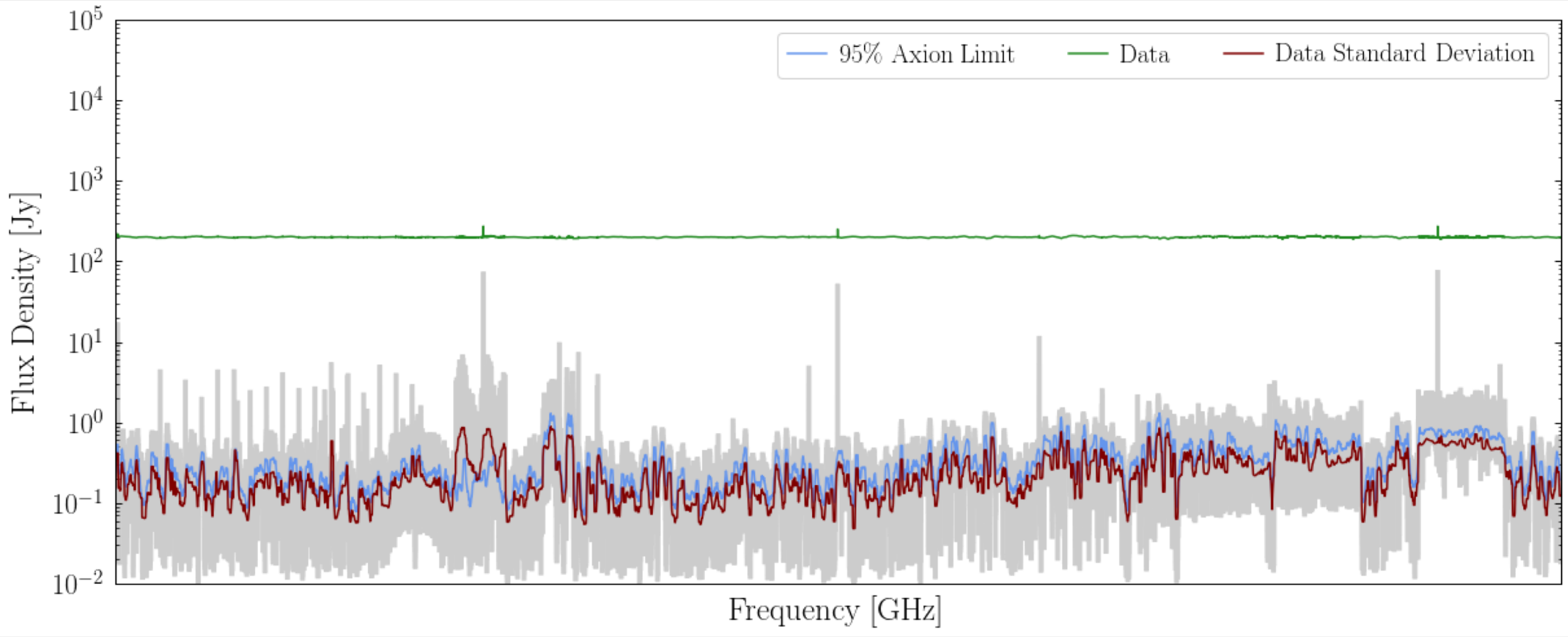


Expected Signal: Time Variation

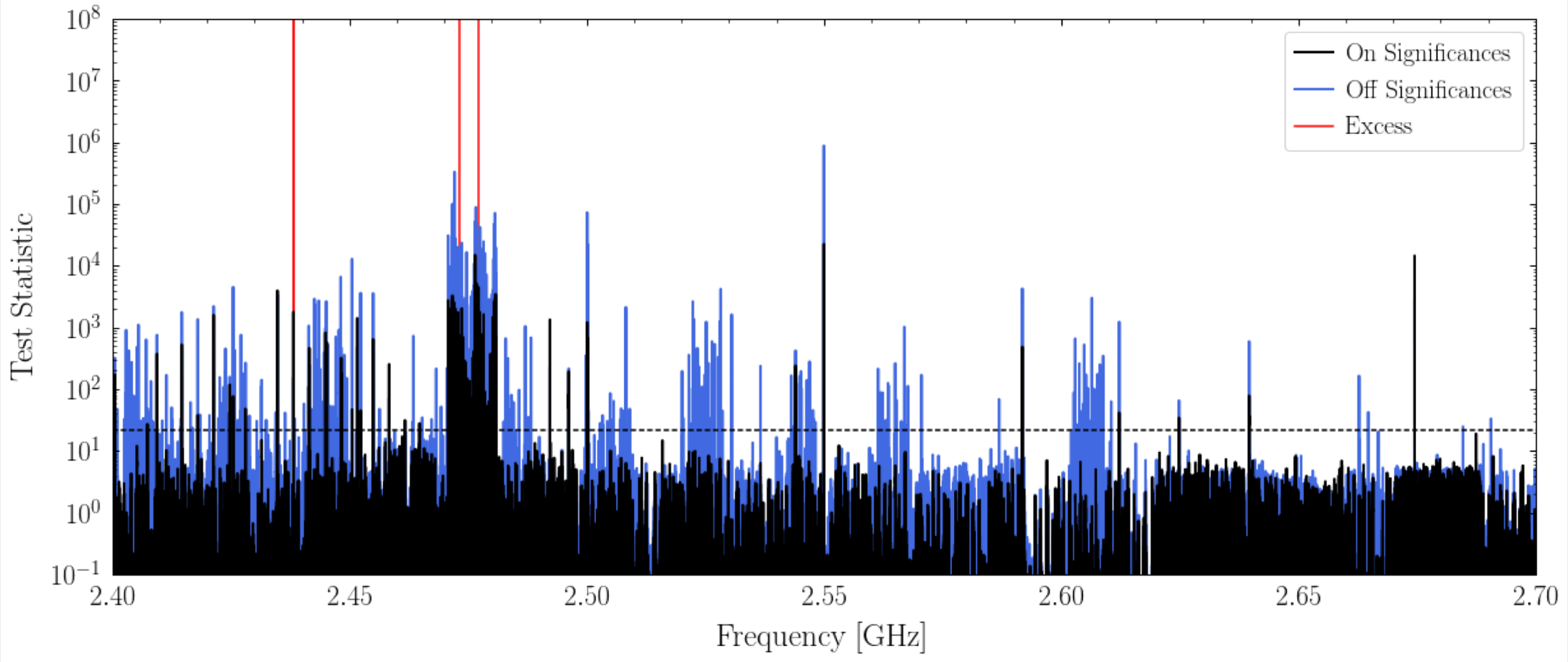
- Distinct time-variation due to misalignment of magnetic dipole and rotation axis
- Signal morphology strongly dependent on NS properties
- Allows for detailed follow-ups at well-characterized known NS



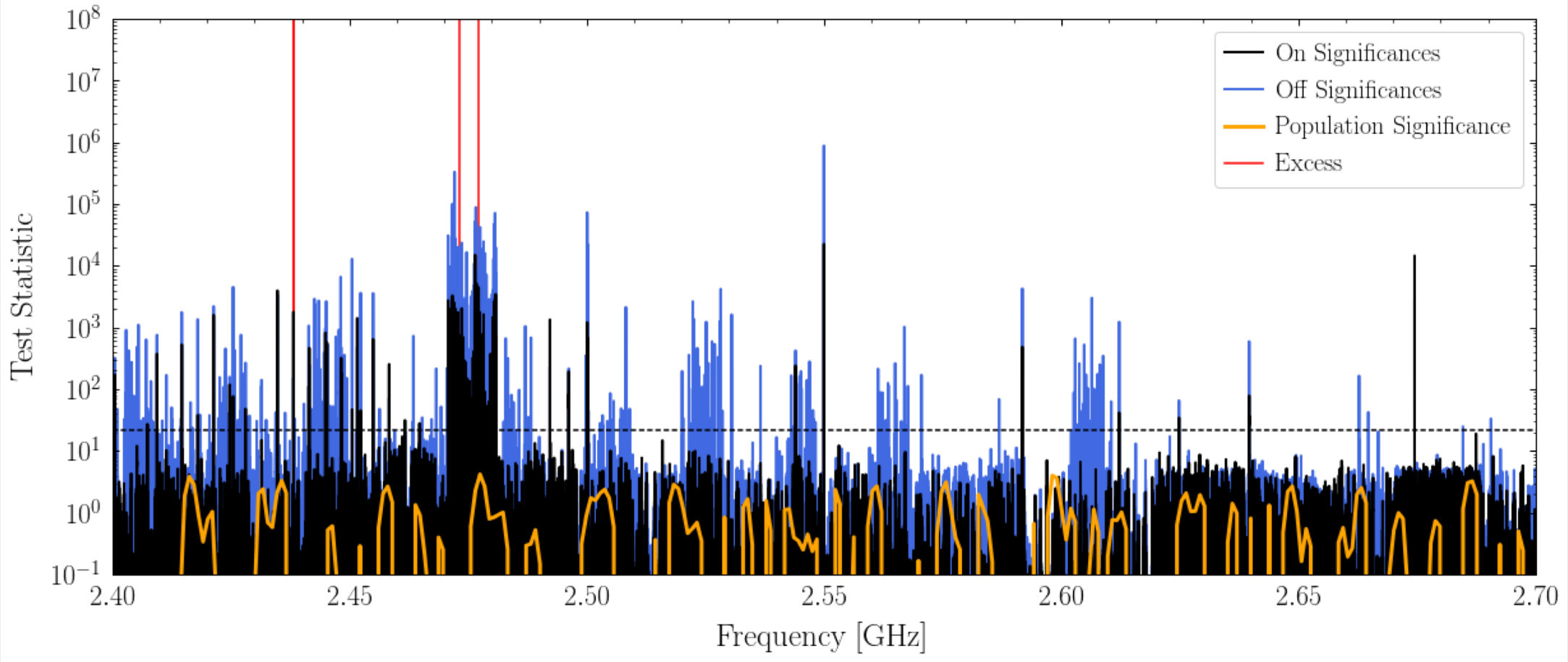
Data Example: Spectral Line Limits



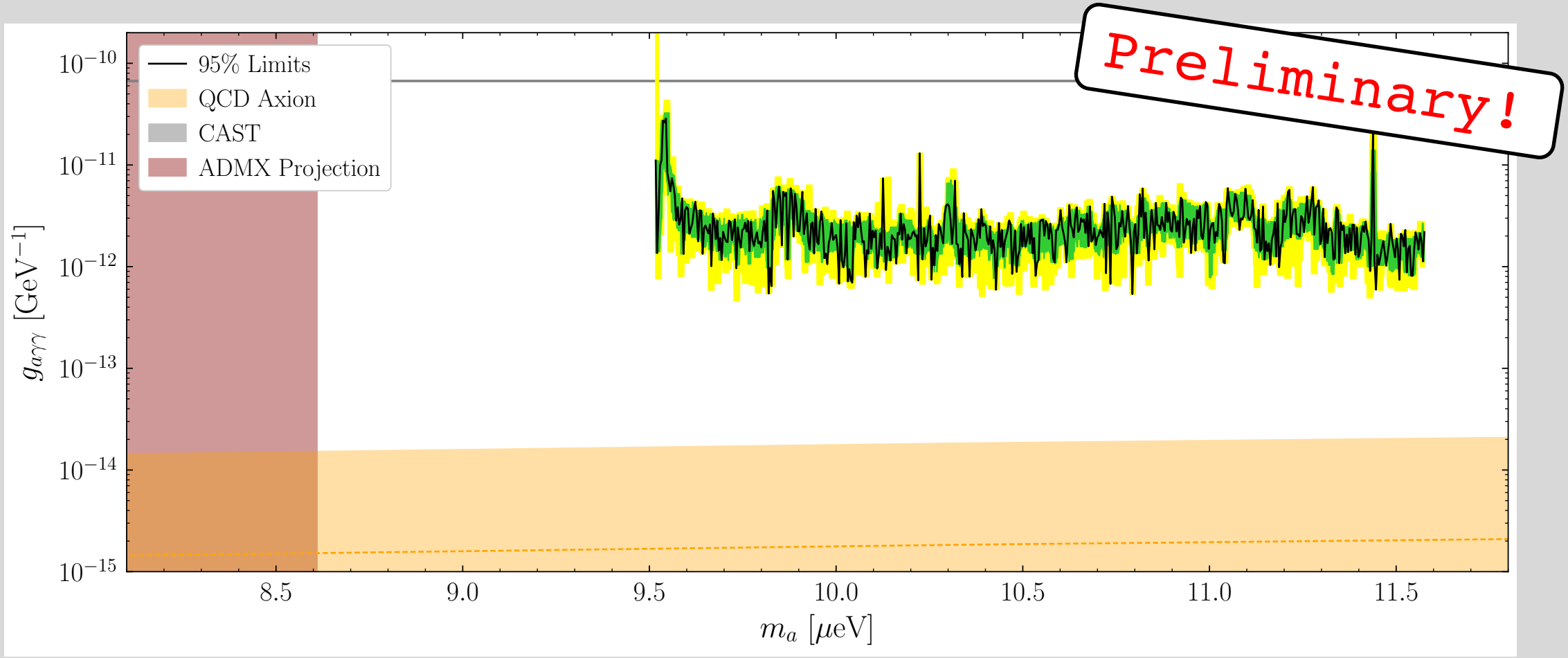
Data Example: Finding & Vetoing Excesses



Data Example: Joint Excess Rejection

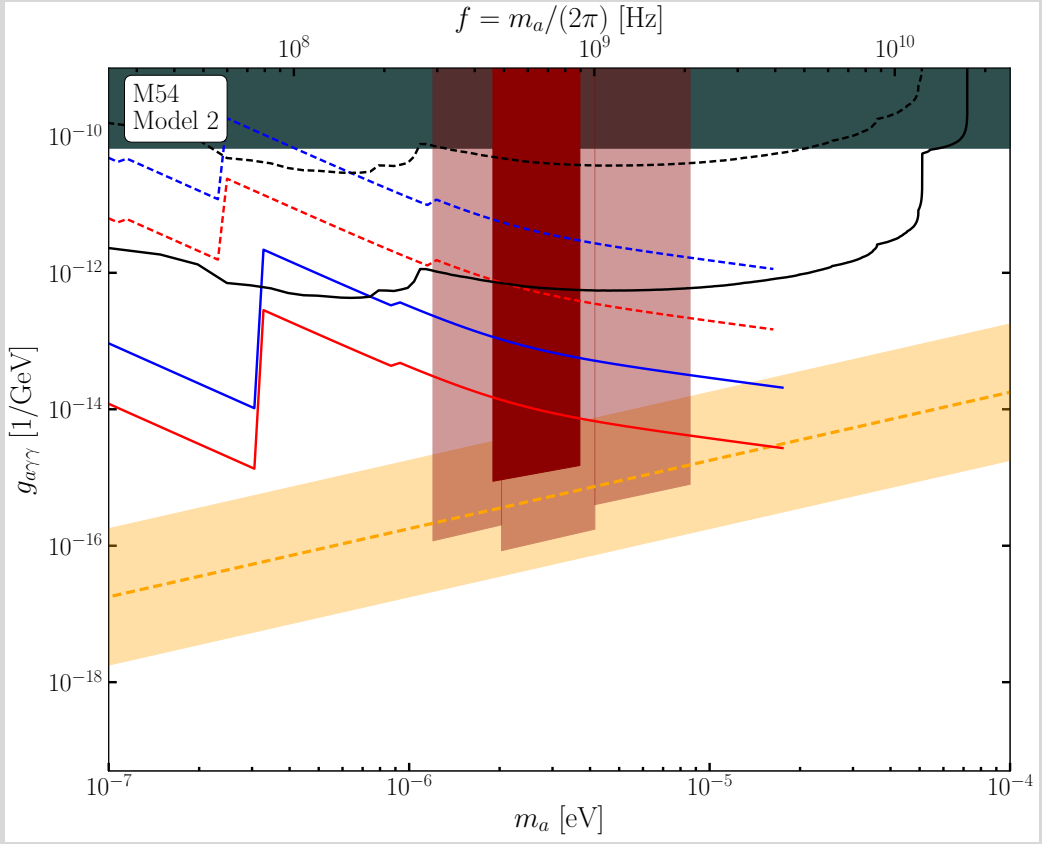


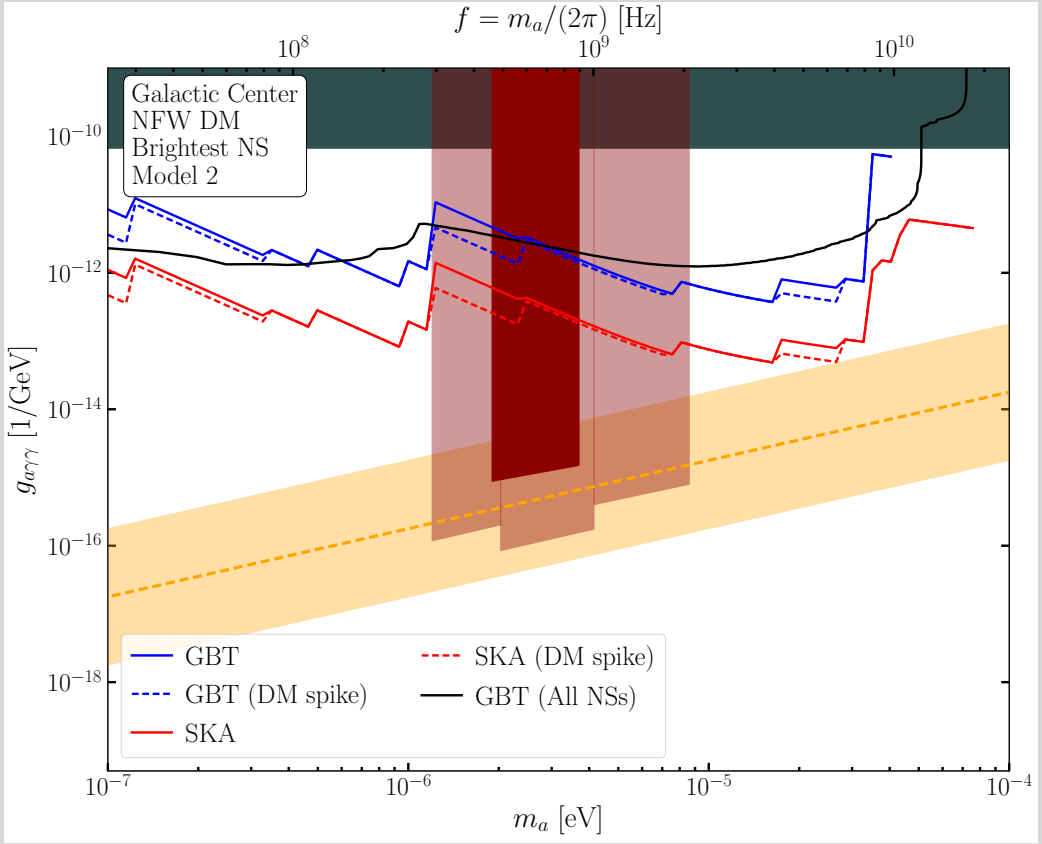
Current Status and Future Projections



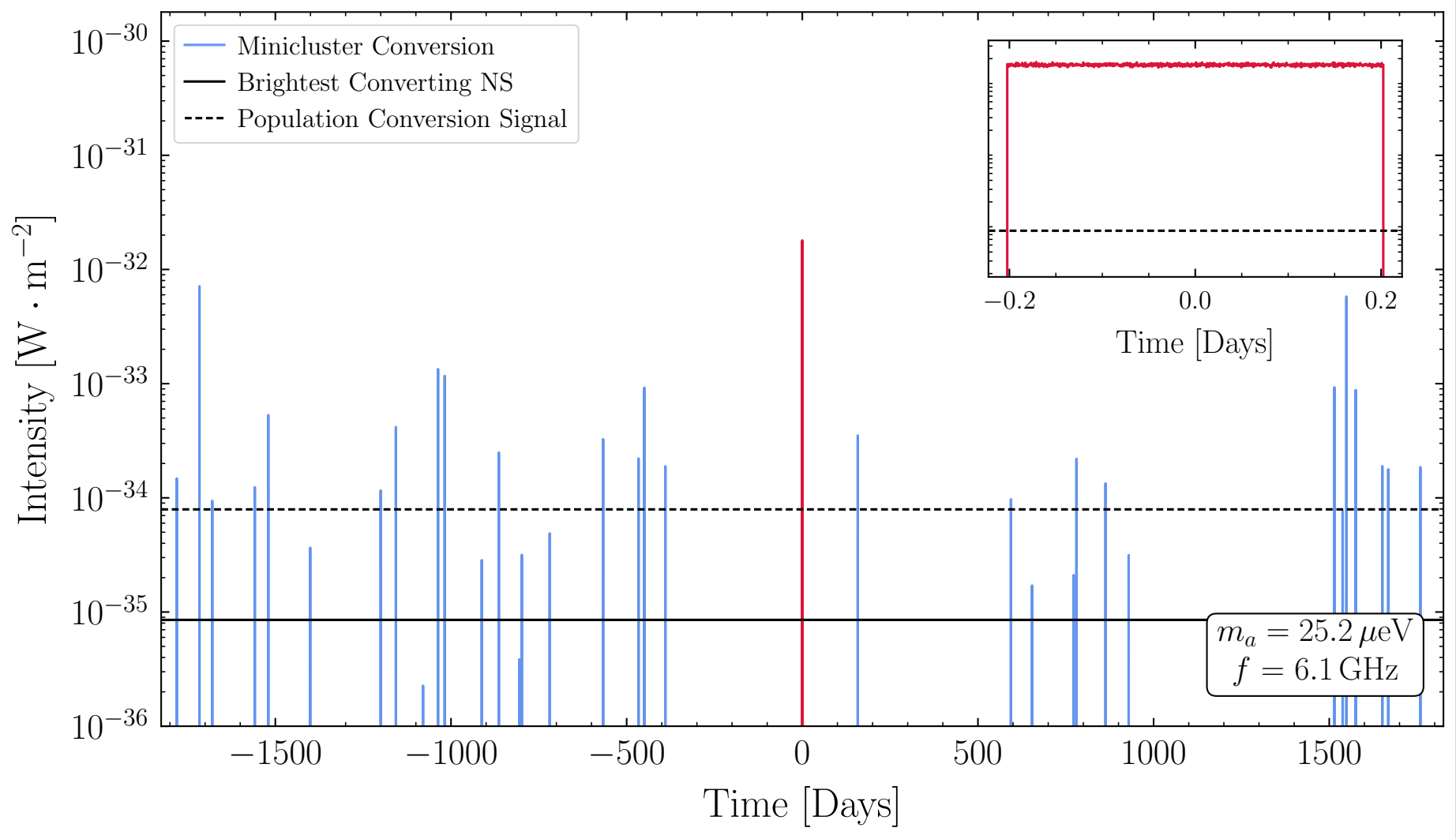
Constraints from 1 hour of observation at the Galactic Center

Current Status and Future Projections





Implications for Axion DM Substructure



Questions?