Novel ideas for axion dark matter detection
1) qubit-based photon counter
2) broadband axion antenna

Astro. Instrumentation

whitepaper

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Fermilab

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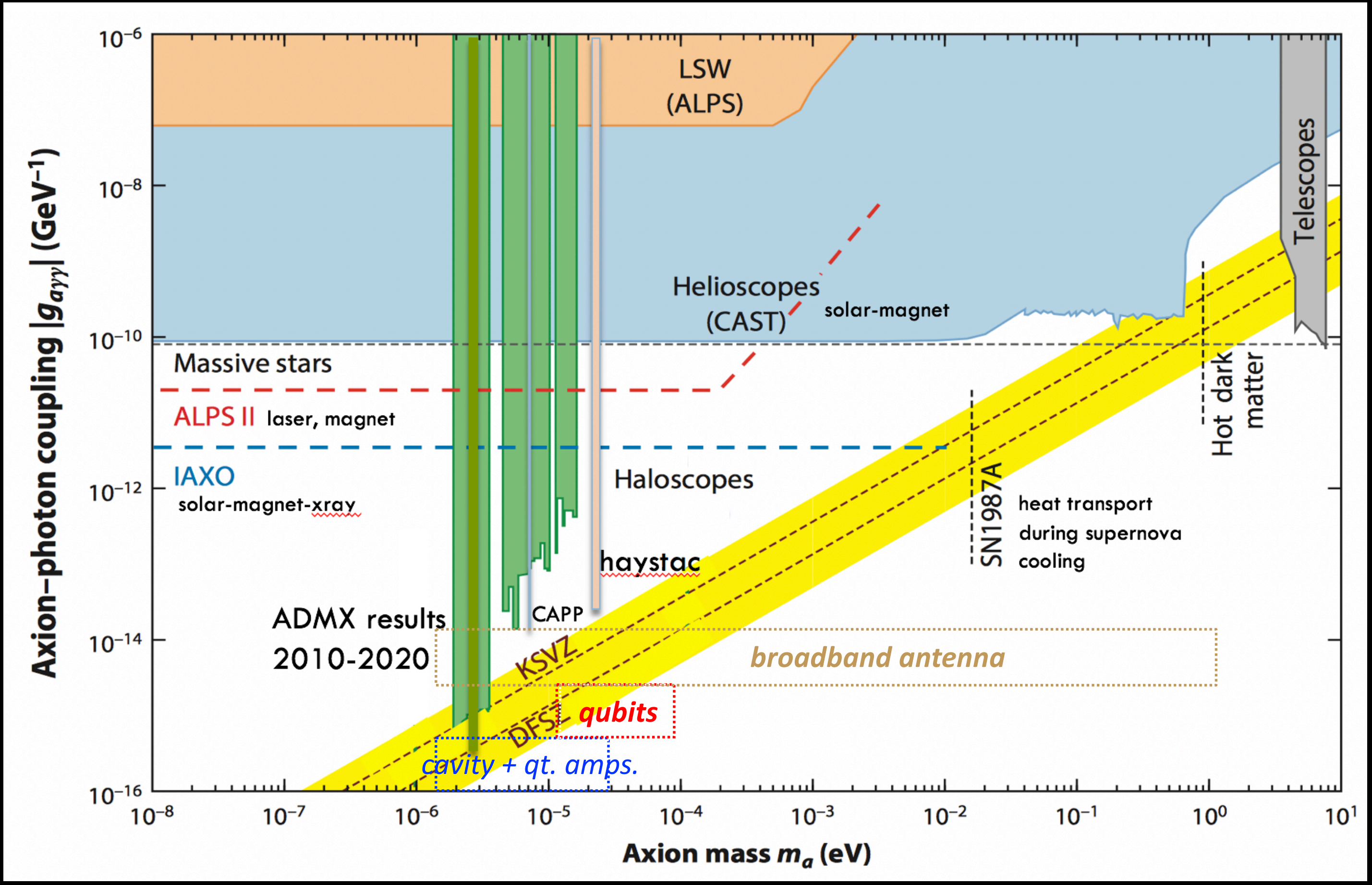
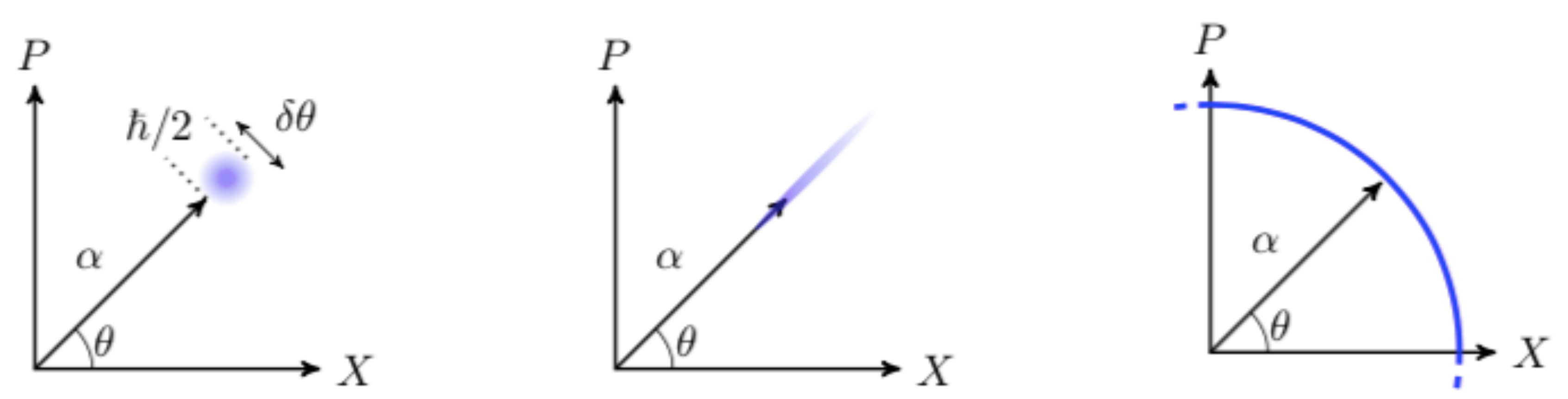
Axion dark matter searches



photon counting advantage



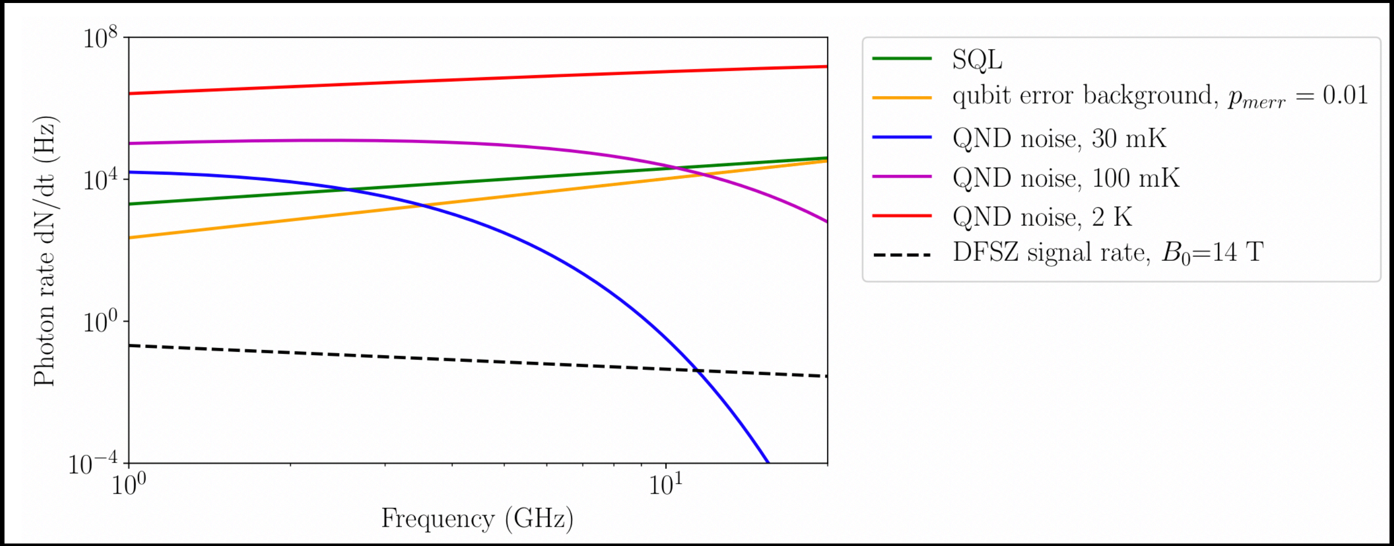
*uncertainty in phase and amplitude both

*squeezed phase

*squeezed amplitude
*randomized phase

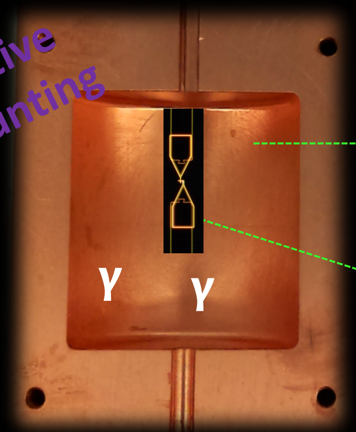
No Quantum noise of amps.

--count the photons



Qubit based photon counter

Non absorptive photon counting



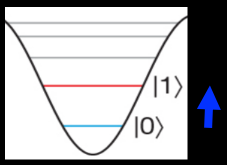
readout cavity

qubit nonlinear oscillator

$$H = \omega_c a^\dagger a + \omega_q \sigma_z + 2\frac{g^2}{\Delta} a^\dagger a \sigma_z$$

Cavity
Harmonic Oscillator

qubit
two level system

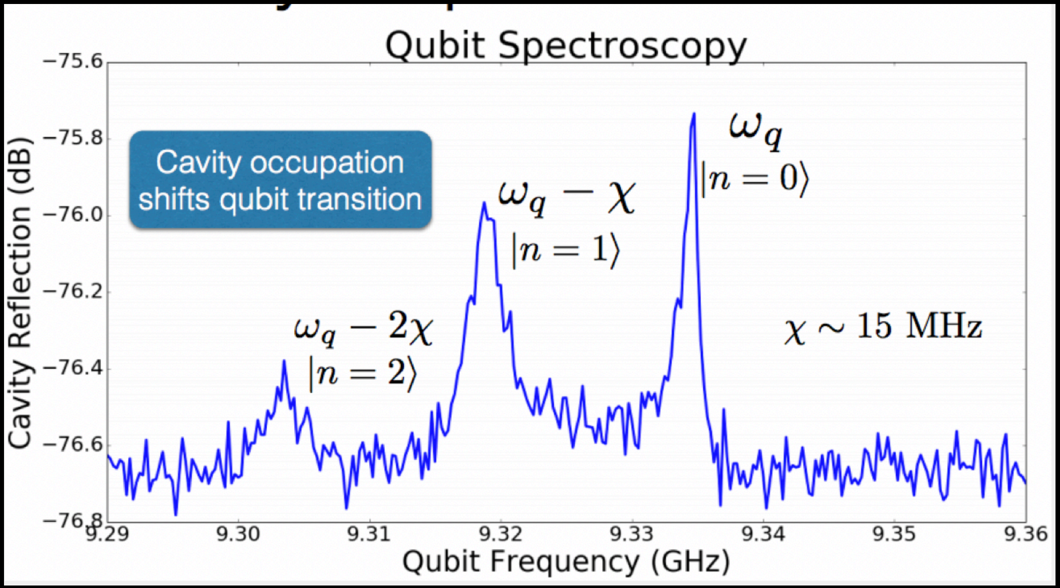


mixed state
g ~ **d.E**:
Δ: ω_q-ω_c
g^2/Δ: Stark shift

Photon shifts qubit frequency

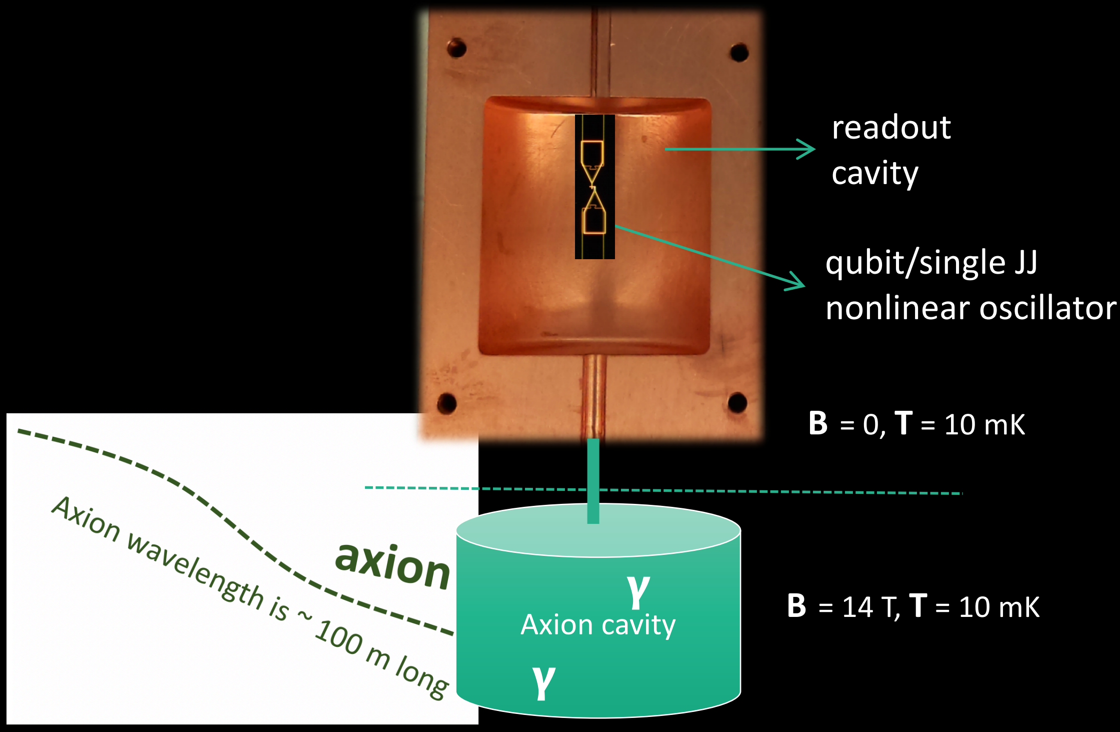
Shift quantized in units of photon # in the cavity

Entangle qubit with cavity state (spectroscopy) measurement



counts photons!

Qubit based axion detector



Ways of enhancing the signal:

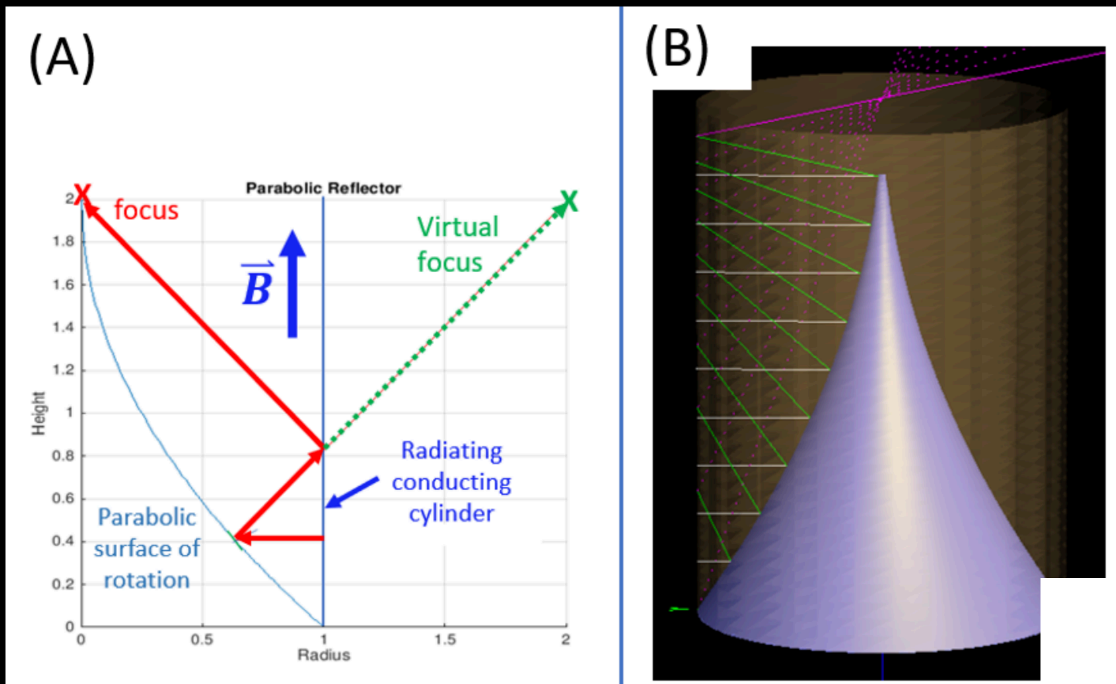
→Multiple measurements:
Mulitple qubits:

$$p_{err} \rightarrow (0.01)^N$$

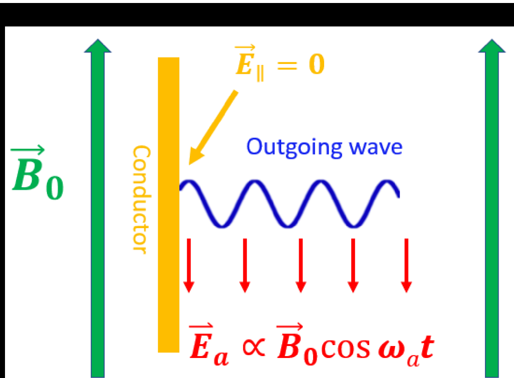
→Stimulated emission

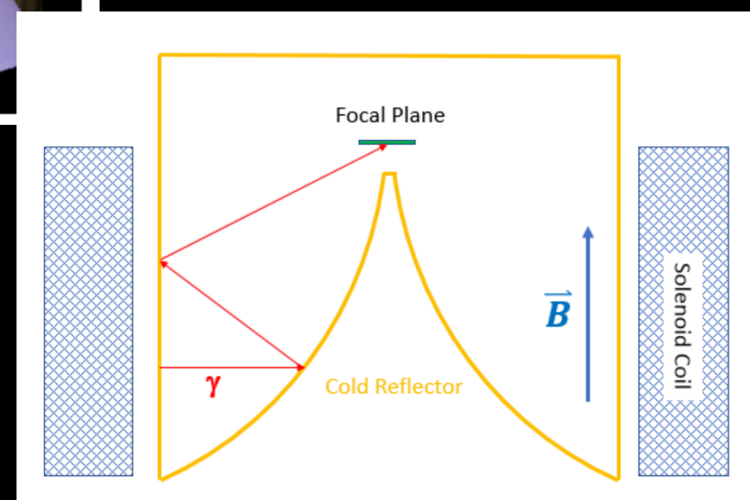
Photon # counting evades the quantum noise limit

Broadband axion antenna

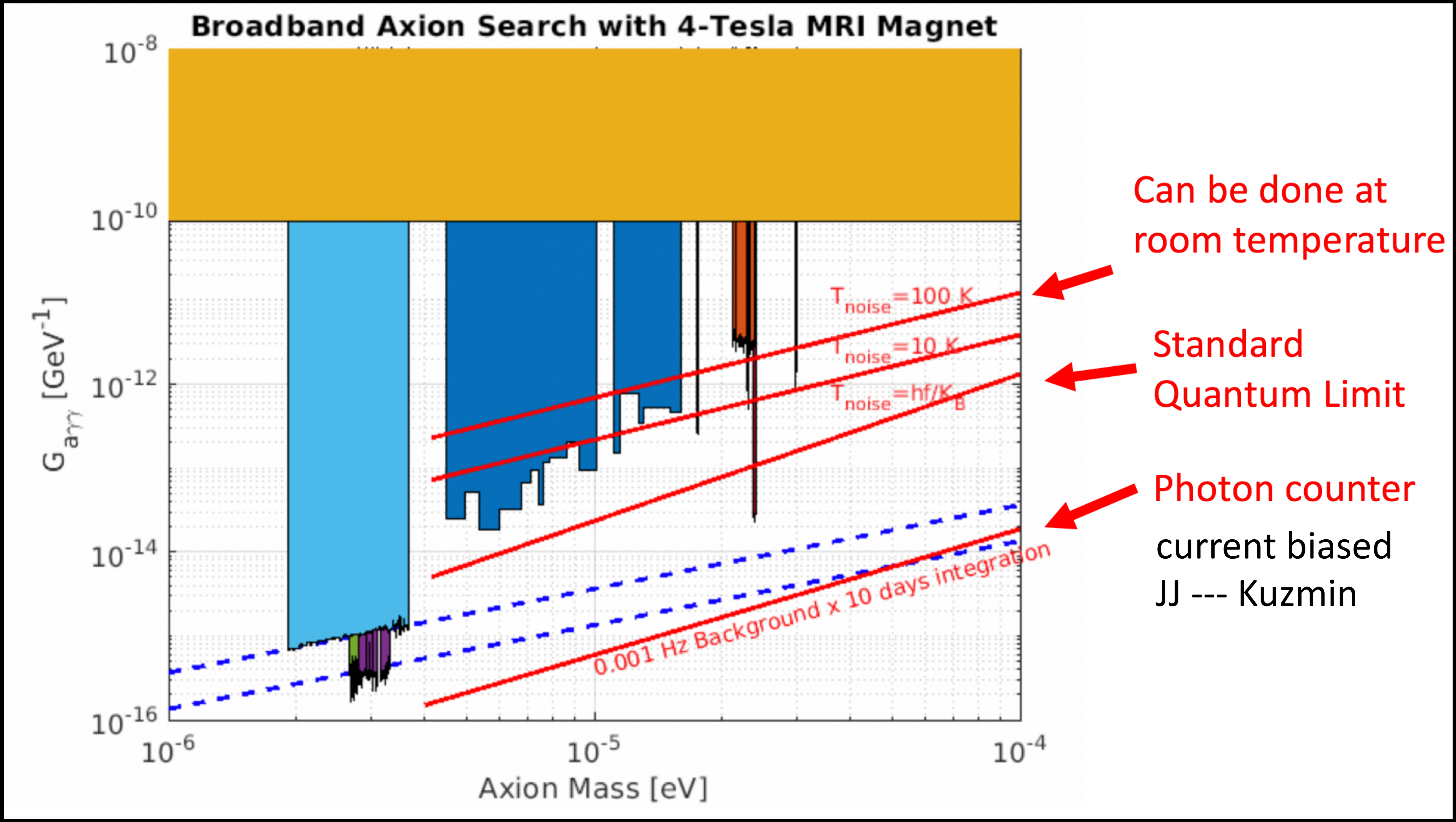


*photon sensor at focal plane
sensitivity needed: 10^{-26} W
*candidates:
--SNSPDs etc. (> 0.17 eV)
--MKIDs (< 0.04 eV)
--superconducting qubits
(10-100 μeV)





Projected sensitivity



Can be done at room temperature

Standard Quantum Limit

Photon counter

current biased JJ --- Kuzmin