

# Superconducting Qubit Advantage for Dark Matter (SQuAD)

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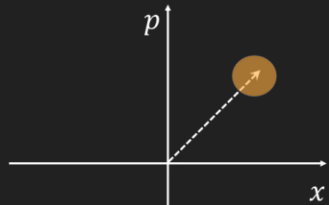
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# Motivation

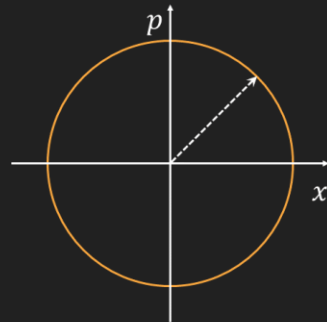
Dark matter searches in the GHz region encounter two main challenges

Quantum noise associated with state of the art linear amplifiers

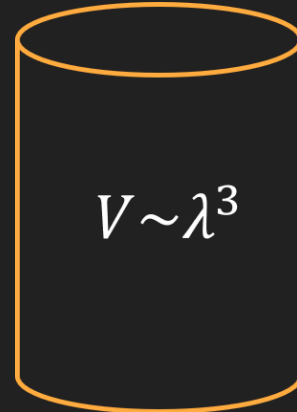
Signal scales with volume of cavity, volume shrinks with increase in frequency



Parametric amplifiers

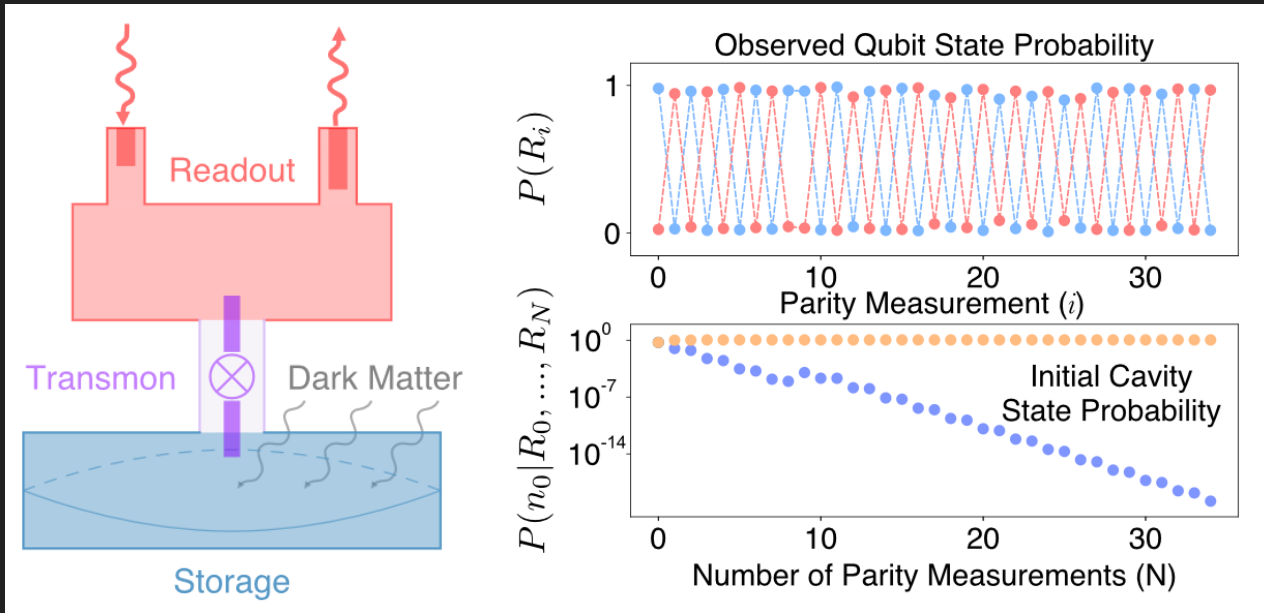


Photon counting



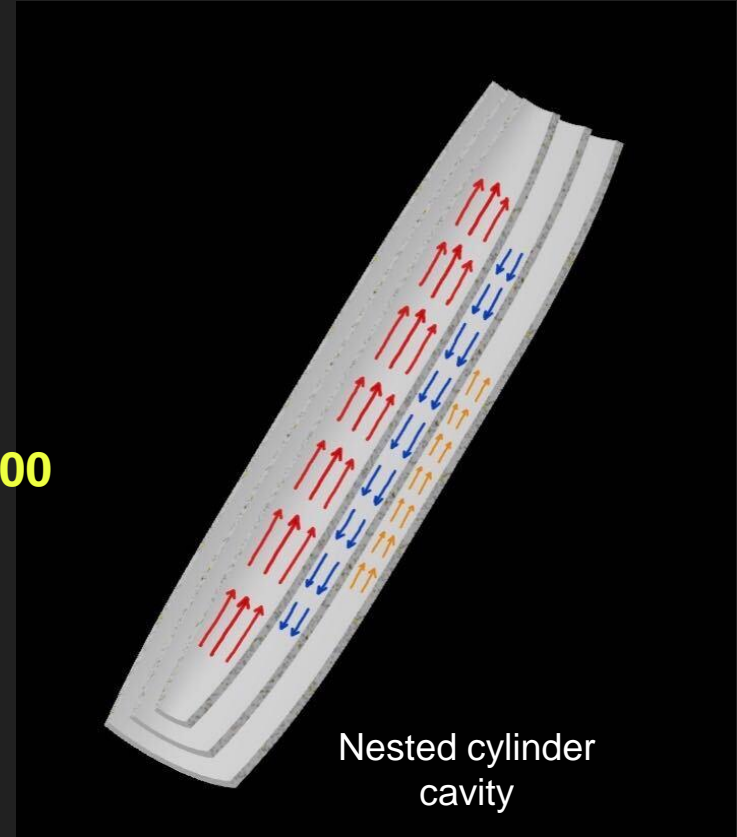
# Photon Counting

- Used superconducting qubit to count photons
- Repeated quantum non-demolition measurements suppress detector errors
- Demonstrated noise 15.7 dB below quantum limit
- Path to background free search



# High-Q Photonic Bandgap Cavities

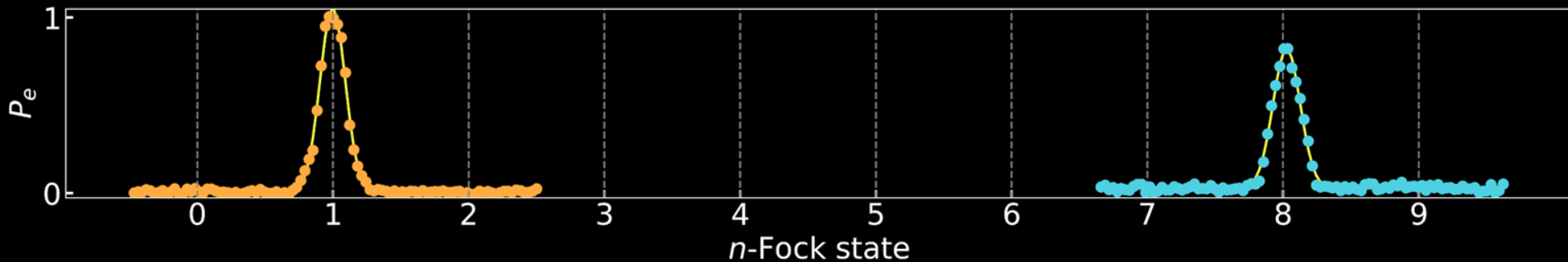
- Currently limited by copper cavity Q  $\sim 10^4$
- Compatible with high magnetic fields, dielectric cavities can achieve Q's of  **$10^8$**
- Signal rate increases by a factor of **at least 100**



# Stimulated Emission

$$|\langle n + 1 | \hat{D}(\alpha) | n \rangle|^2 \propto (n + 1)$$

- Initializing the cavity in a Fock state enhances the signal by **(n+1)** factor
- Quantum optimal control pulses used to generate Fock states in the cavity



# Conclusion

- Noise suppressed by 15.7 dB with qubit based photon counting
- Signal improvement with high-Q PBG cavity
- Further signal enhancement with stimulated emission

