Quantity of interest is encoded in the state of system “b”:

\[ |\psi_b\rangle = \sum c_n |n\rangle_b \]

“n photons in mode b”

In general, we cannot make a measurement that reveals \( |\psi_b\rangle \) (i.e., all the \( c_n \))

Most measurements return a single number
(project \( |\psi_b\rangle \) onto the measurement basis, chose an eigenvalue from a random distribution specified by the \( c_n \)).

This process changes \( |\psi_b\rangle \) (measurement back-action)

Usually this process is accomplished via an auxiliary system “a” that scatters photons from a waveguide “c”

Given all of this, what is the SNR for determining the quantity of interest? What arrangements optimize this?
Detection of “c” photons w/ photodiode (quantity of interest: is there a phonon in the LHe?):

T = 140 mK

Key Instrumentation Requirements (100% selfish perspective):

- New physical insights regarding measurement and control processes (QND, quantum control, decoherence-free spaces, etc.)
- Advanced nanofab for electronic, mechanical, and optical components
- Optical photon number-resolving detectors (not PMTs!!!)
- Feedback & classical control
- Affordable and reliable cryogenics

Next steps:
Replace photodiode with PMT
Improved performance via levitated superfluid sample