UNIVERSITY of WASHINGTON

ADMX AXION DARK MATTER EXPERIMENT

Latest results and current progress of ADMX G2

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19th Patras Workshop on Axions WIMPs and WISPs

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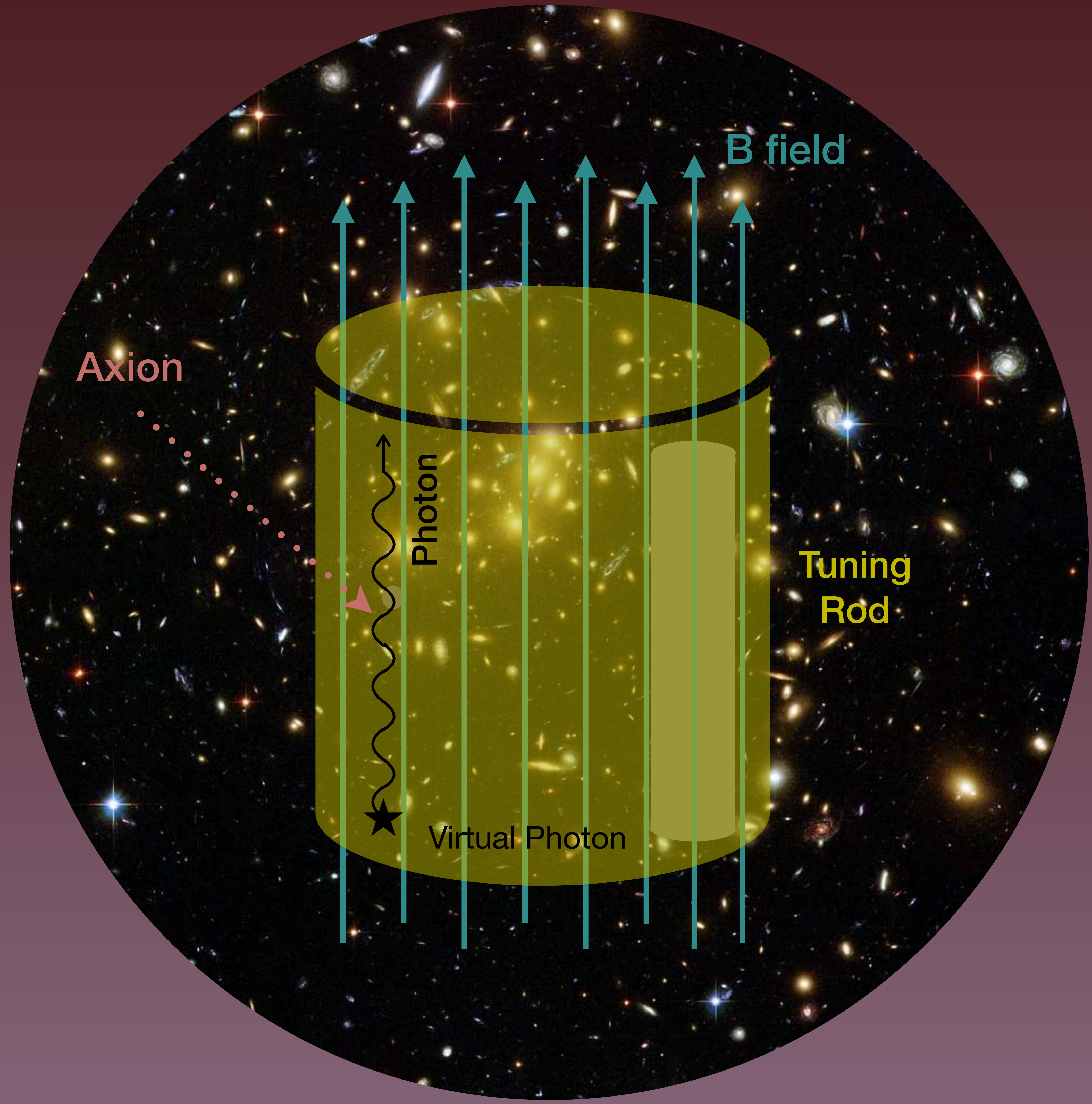
Axion Dark Matter eXperiment (ADMX)

- Axion direct detection experiment based at the University of Washington
- Utilizes a large magnetic field to convert "invisible" axions into observable microwave photons
- Tunable resonant cavity allows for power enhancement across a broad frequency range, but signal strength remains small
    - Use dilution refrigerator and ultra low-noise electronics to lower the noise floor



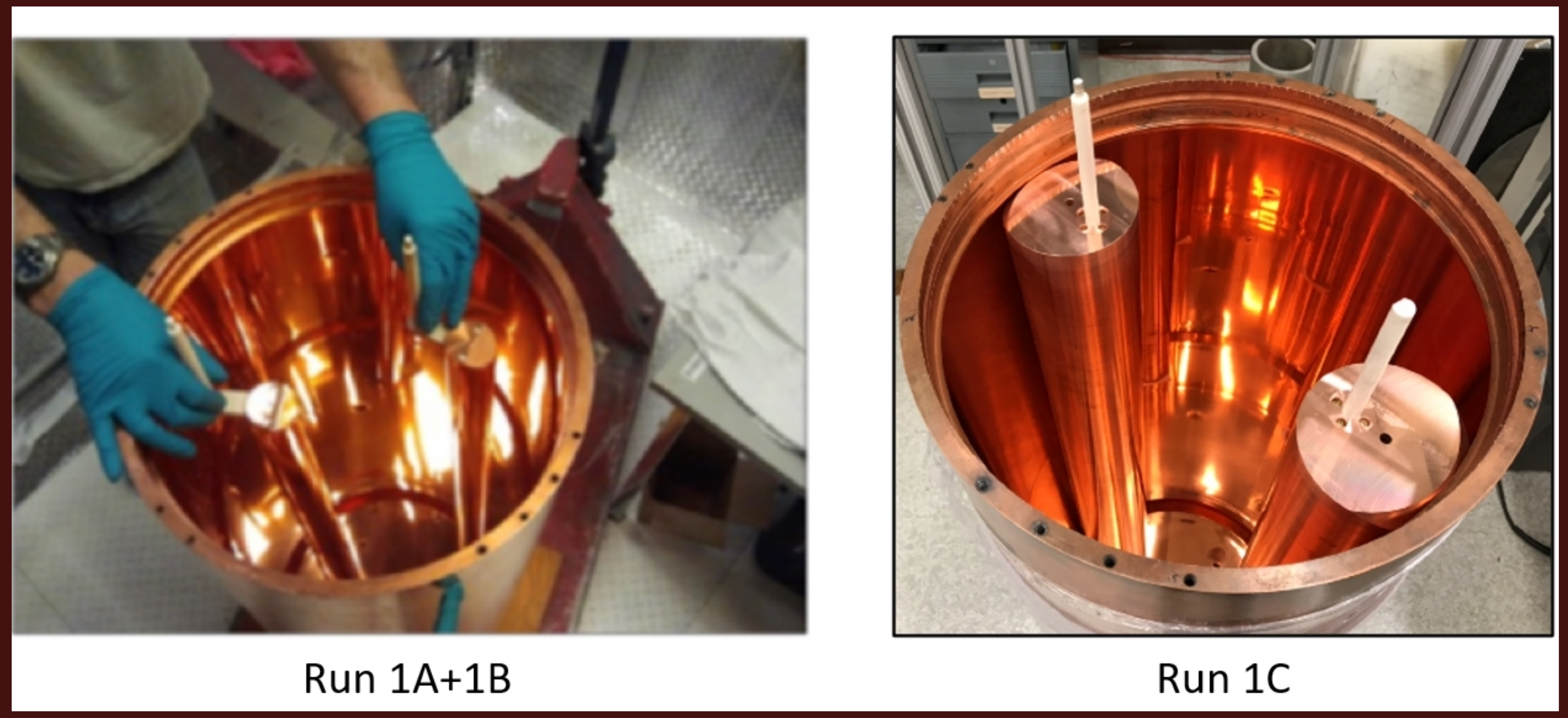
ADMX G2

- Began data taking operations in 2017
- Goal:
  - Search for axions at DFSZ sensitivity from 0.6 - 2 GHz
- Currently taking data for “Run 1D”
  - 1-1.4 GHz

ADMX collaboration (2022)

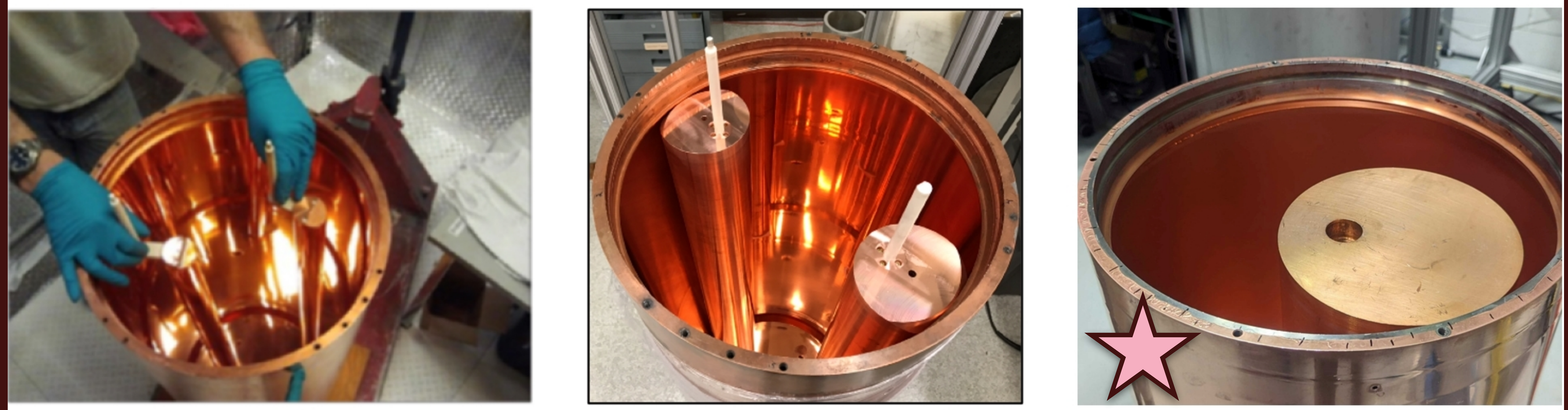
Run 1D Cavity

- 136 liter copper-plated stainless steel cavity ~1 m length, 0.4 m diameter



Run 1D Cavity

- 136 liter copper-plated stainless steel cavity ~1 m length, 0.4 m diameter
  - Single ~0.2 m diameter, 29 liter tuning rod



Run 1A+1B   Run 1C   Run 1D

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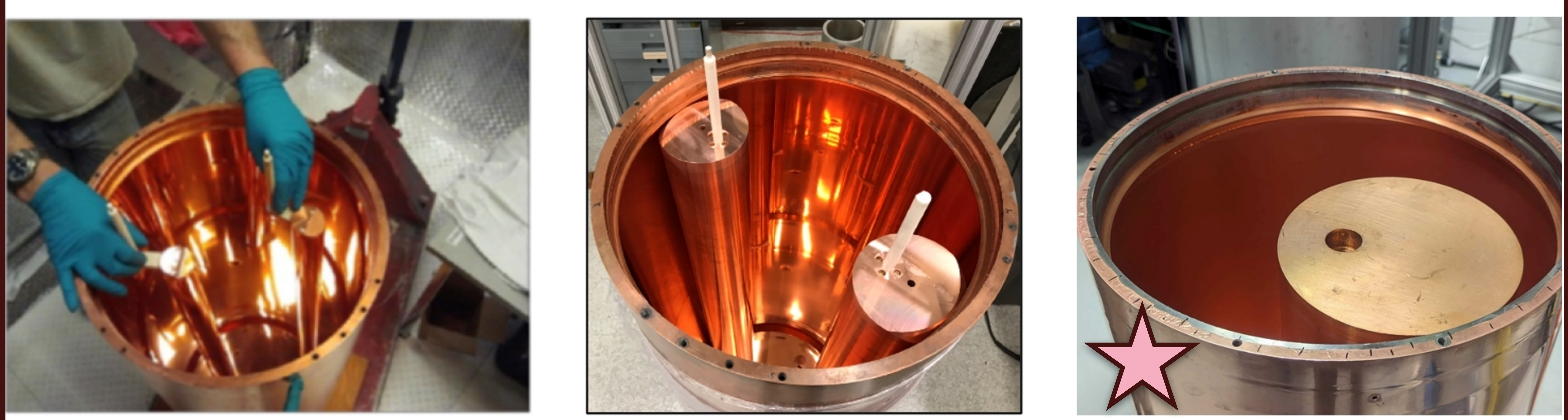
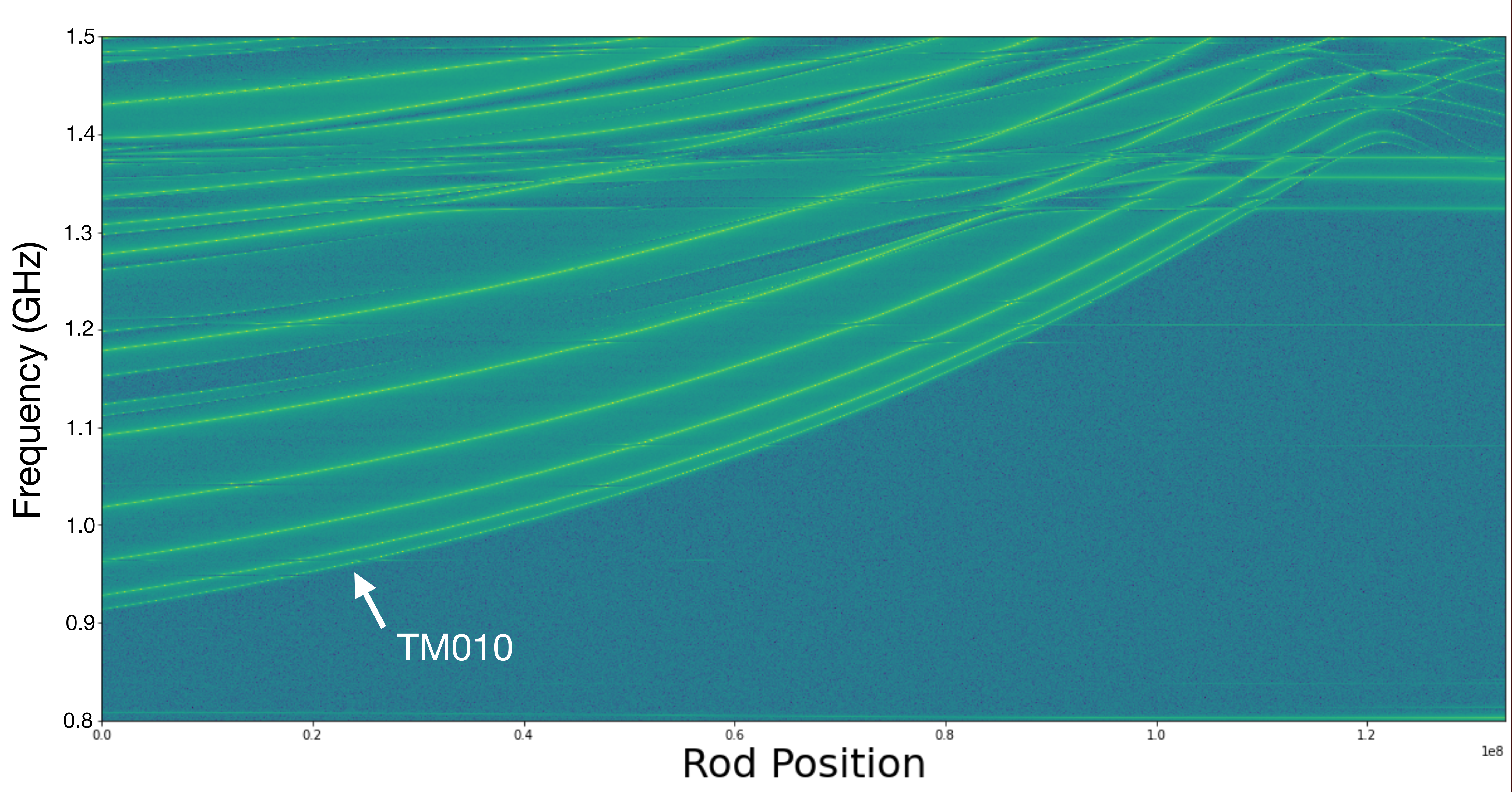
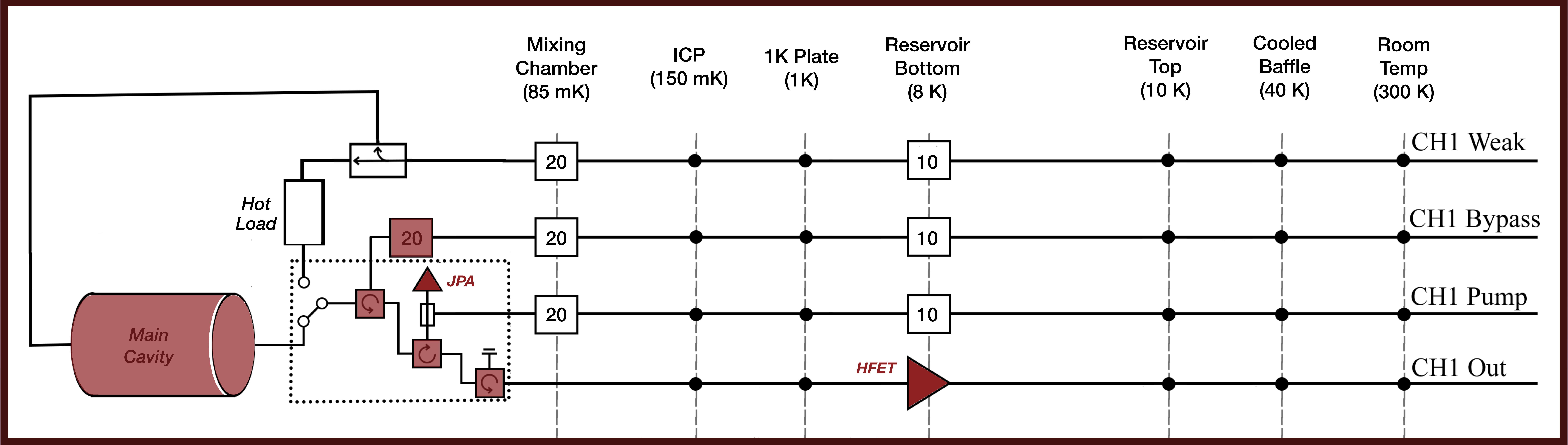


Run 1A+1B Run 1C Run 1D



Noise Calibration

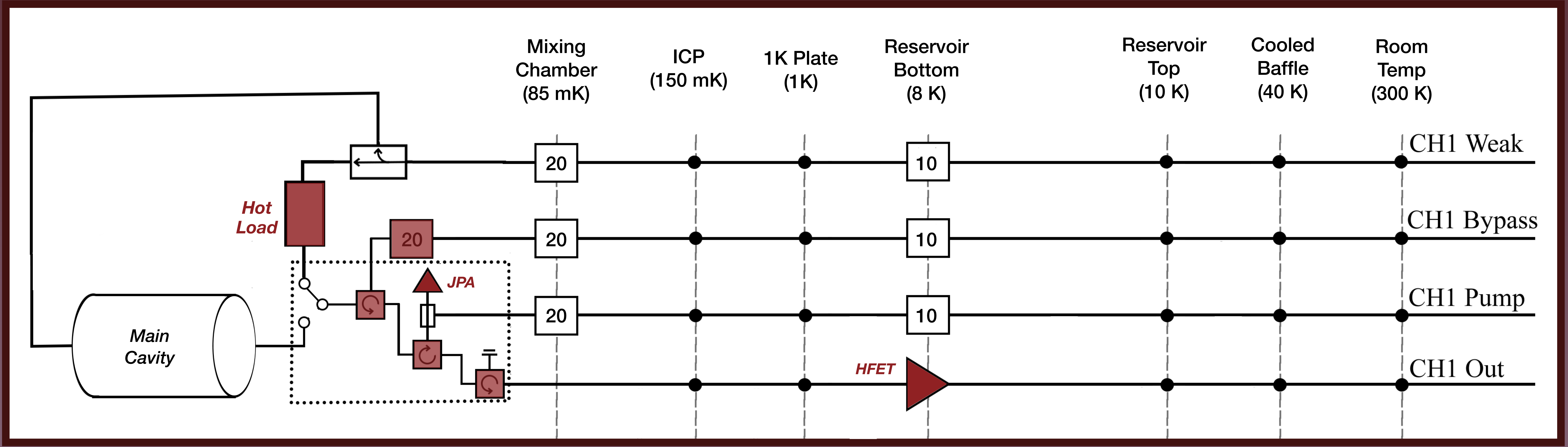
- Understanding the system noise is crucial to determining our sensitivity
  - 2 primary sources of thermal noise (cavity + bypass attenuator)
  - 2 amplifiers (1 JPA, 1 HFET)



★Noise paper to be released soon with more details

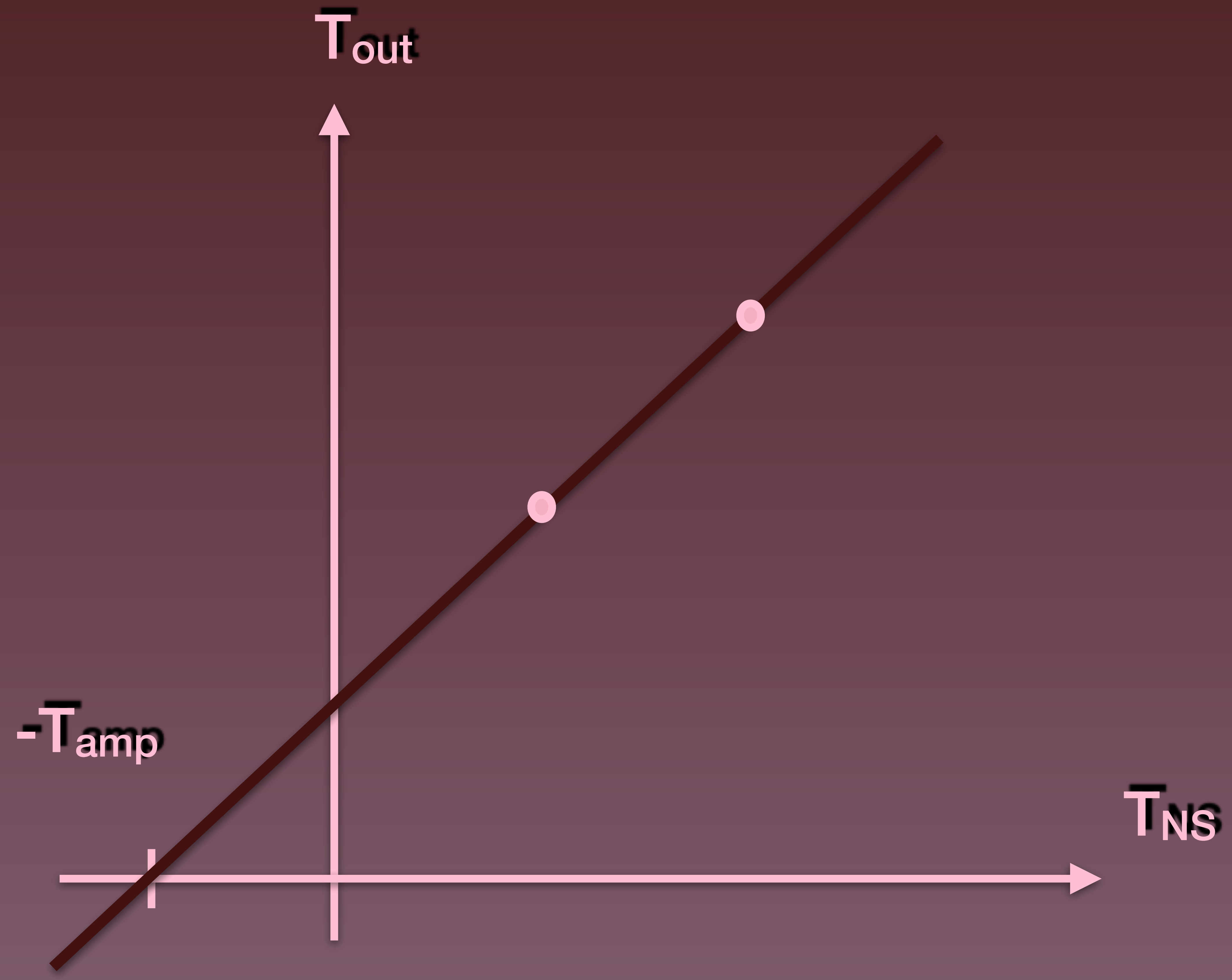
Noise Calibration

- To more easily perform noise calibrations we connect the receiver to a separate noise source in place of the cavity
- Can also use the cavity as the noise source, but it is more complicated★



Noise Calibration

- Two methods
  - Y-factor measurement with JPA off + Signal-to-Noise-Ratio-Improvement (SNRI)



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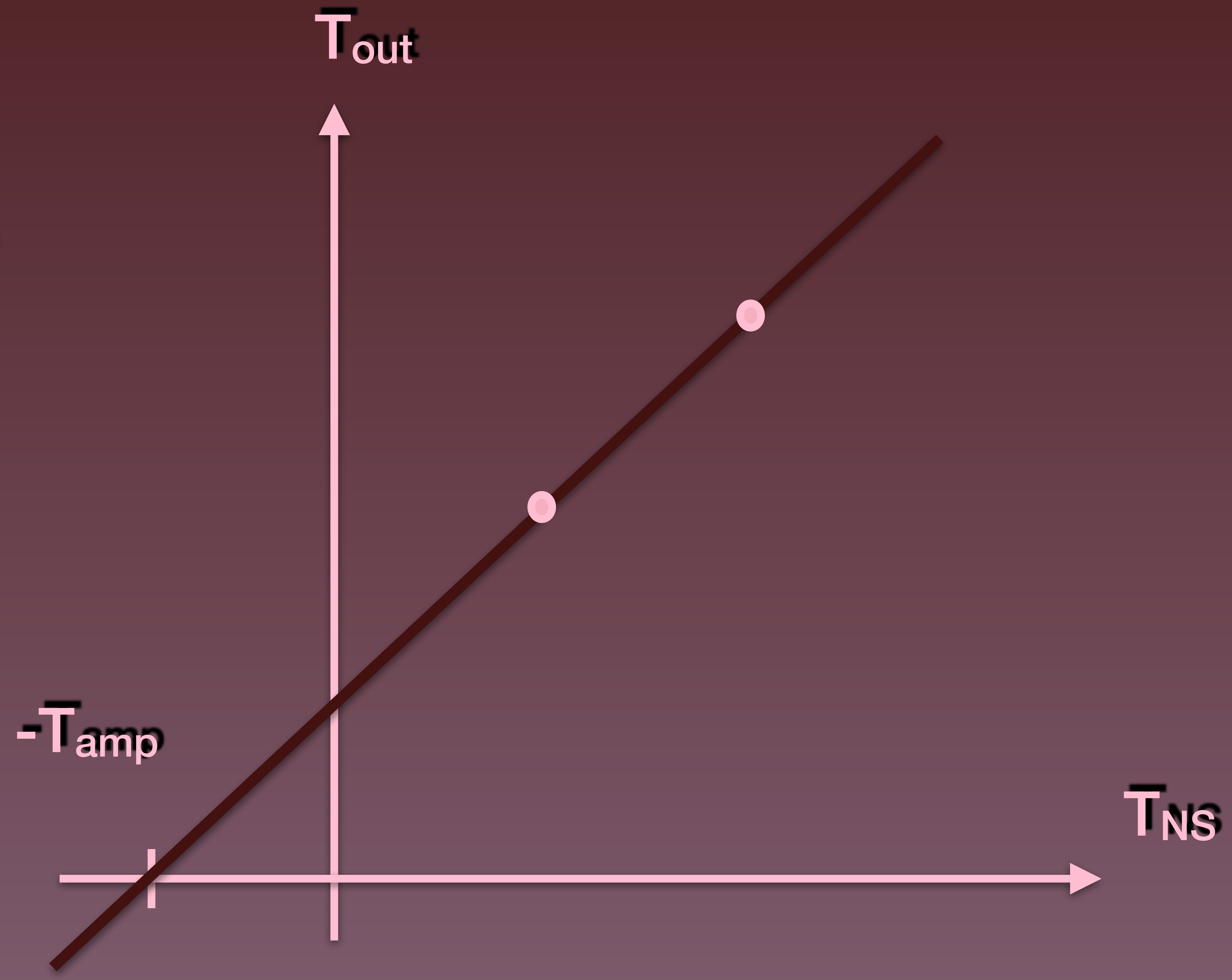

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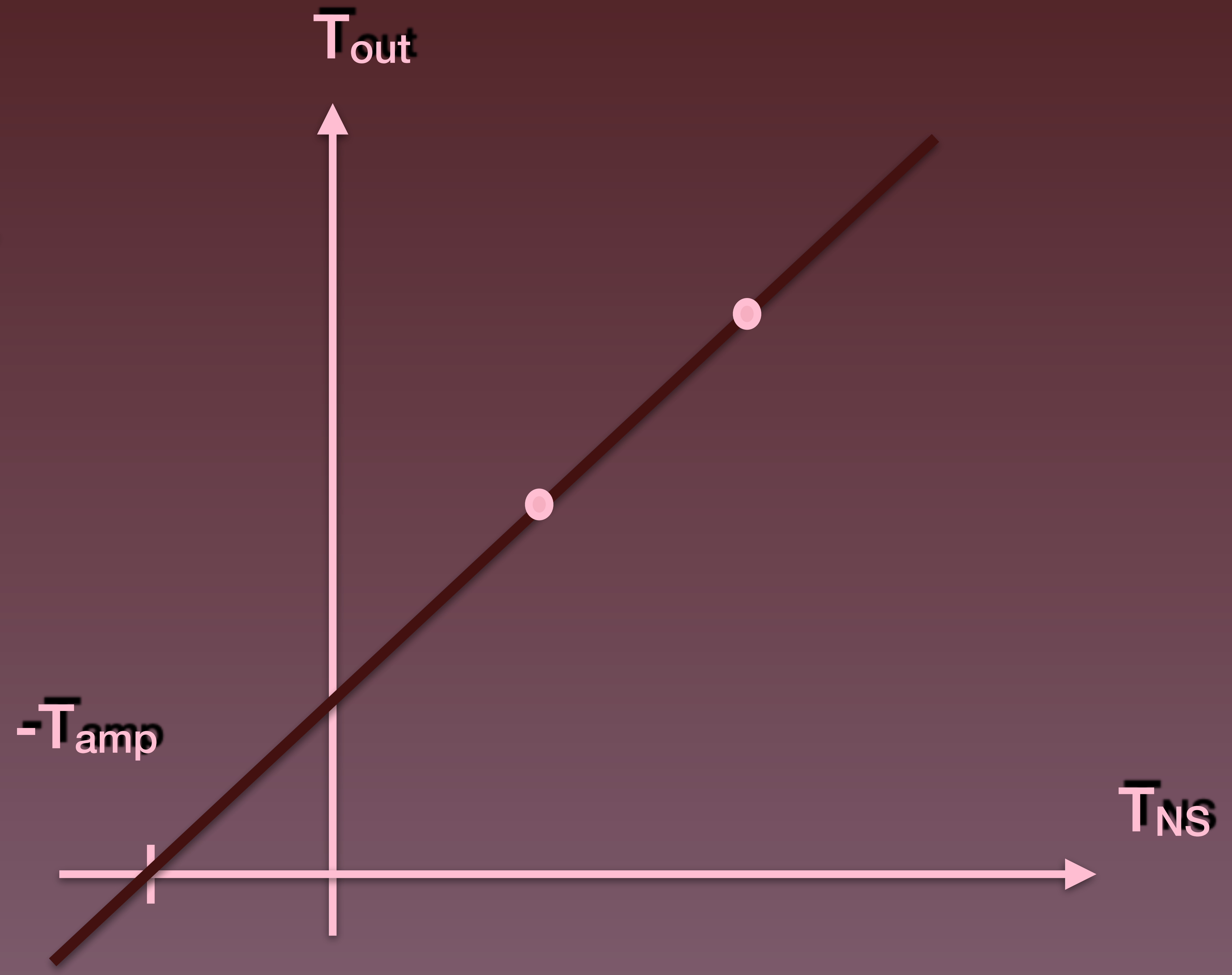
- Original method is less direct than the new method, but easier to update in real-time



Noise Calibration

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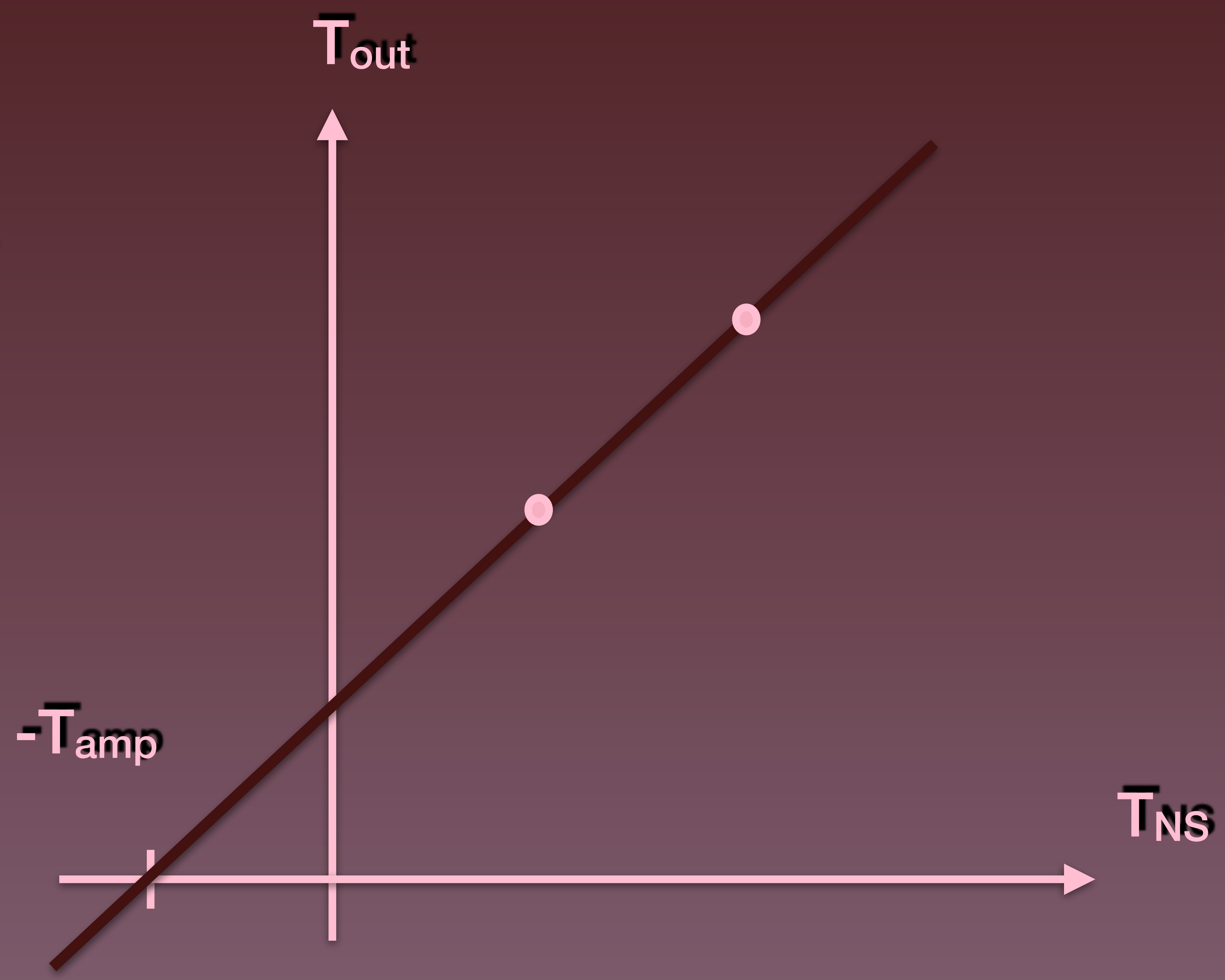
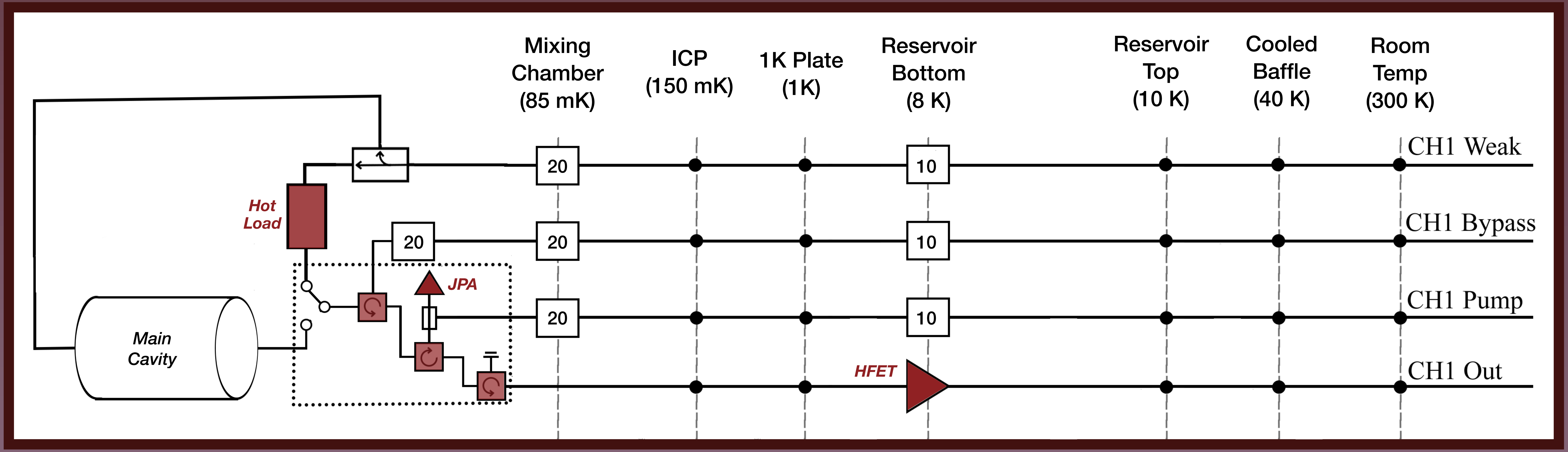
- Original method is less direct than the new method, but easier to update in real-time
- *Question:*
  - *Does the original SNRI method provide consistent results for T_{sys} compared with the new, more direct, method?*



Noise Calibration Results★

- Two calibrations with the dedicated noise source (hot load)



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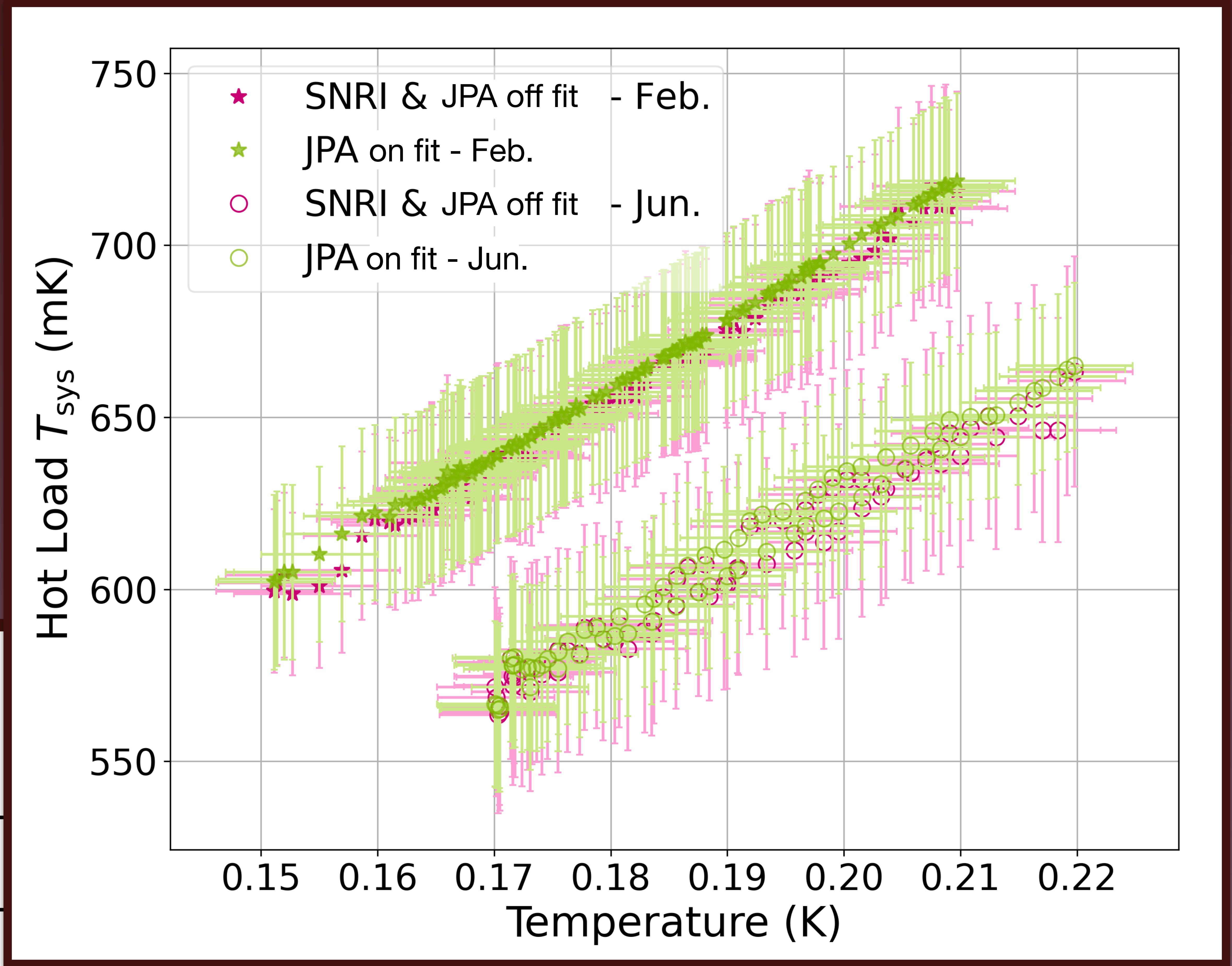

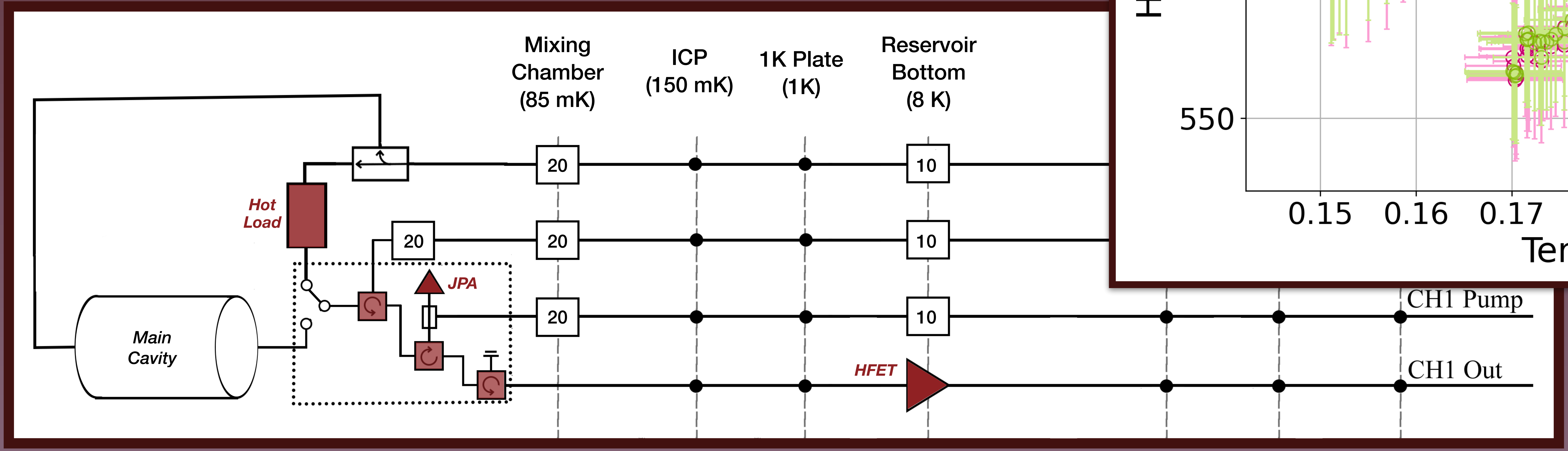

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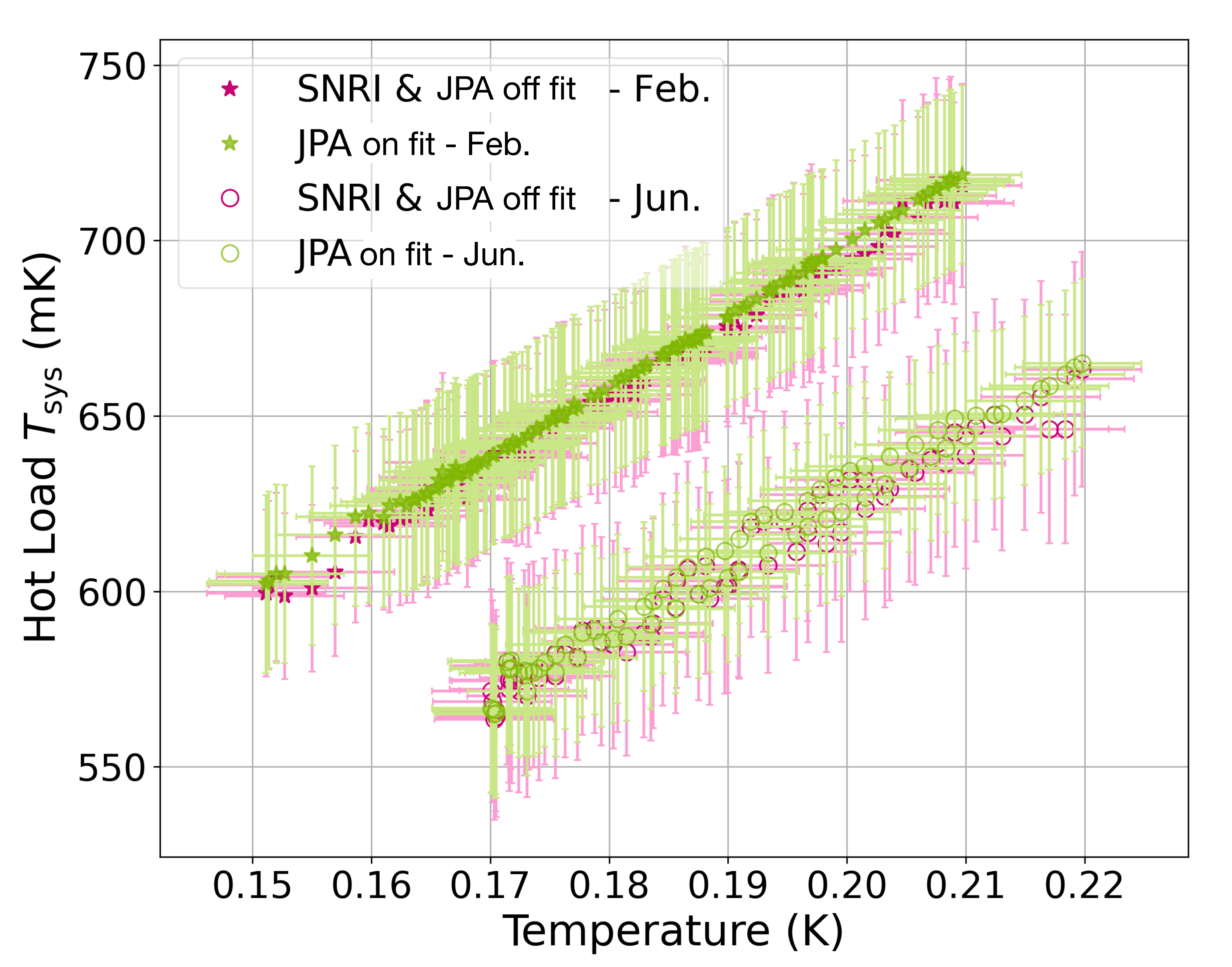

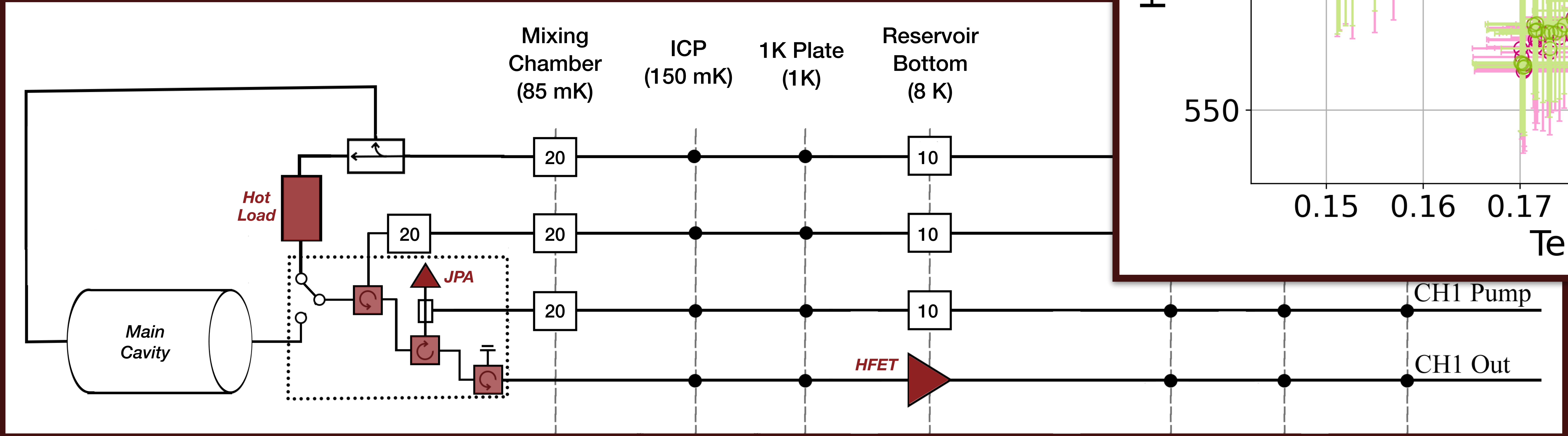

Noise Calibration Results★

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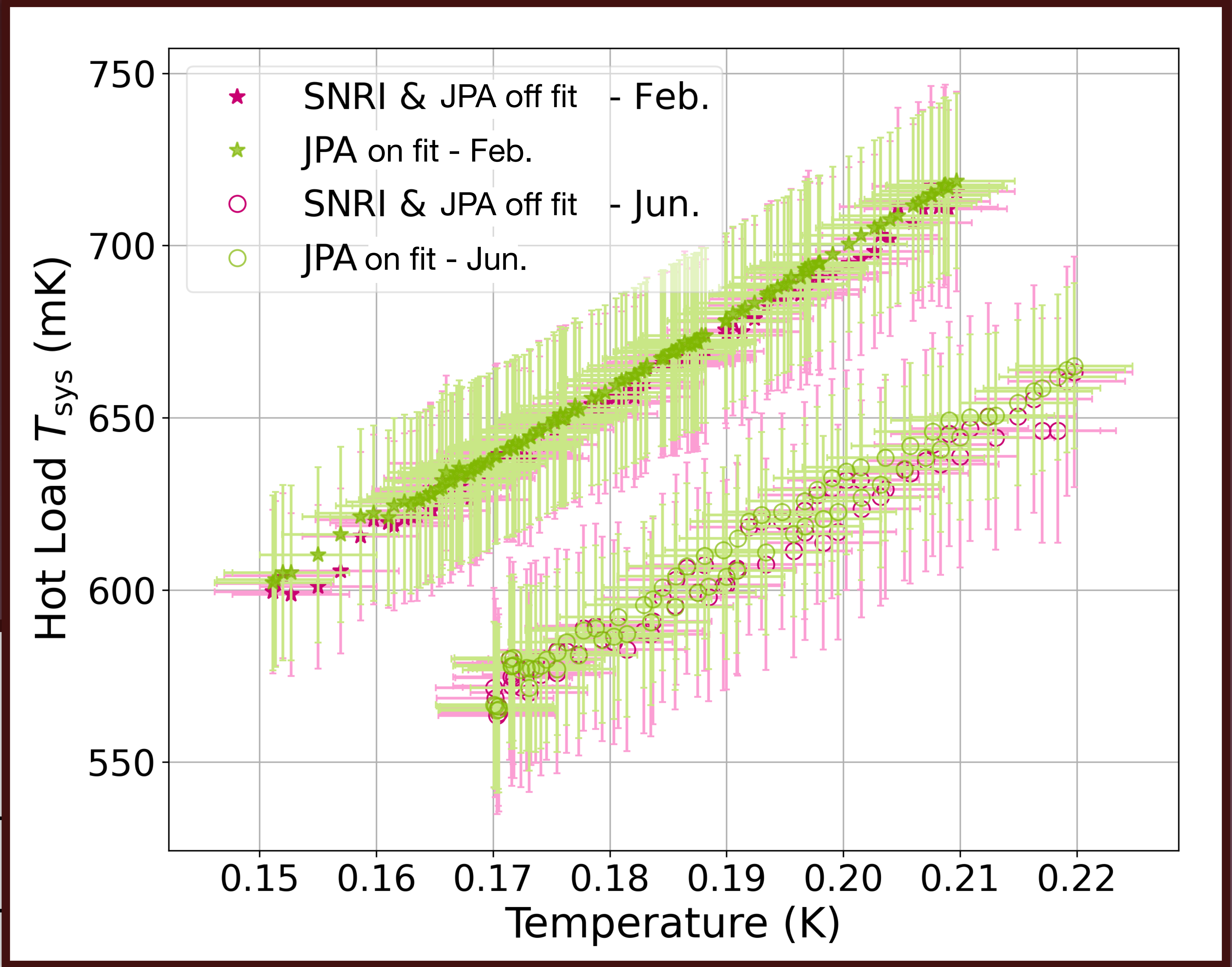
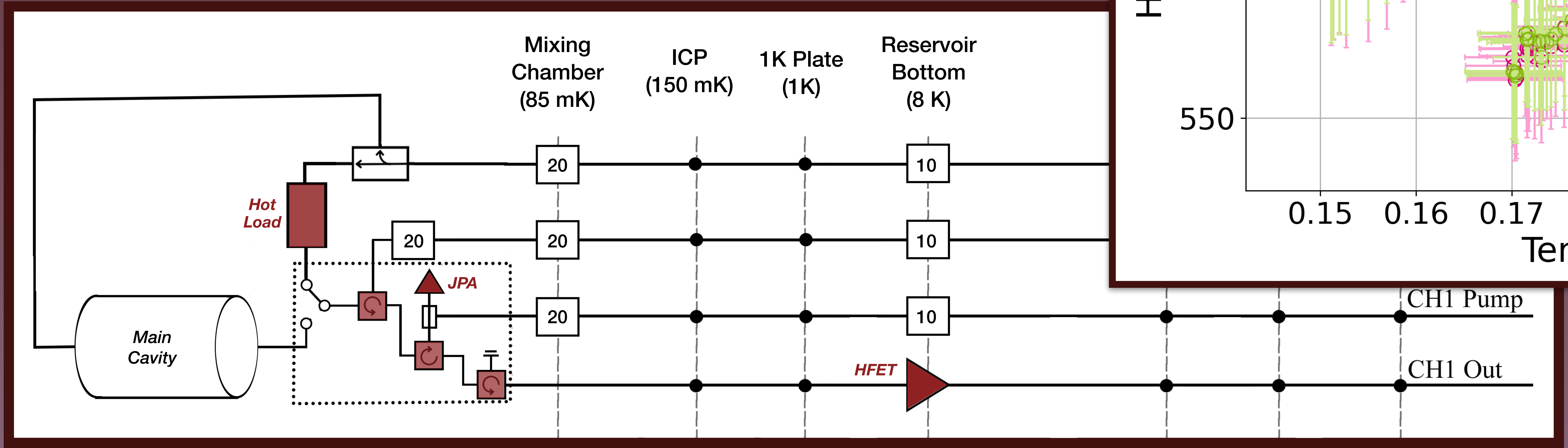
  - Measurement in June had higher JPA gain so contribution to T_{sys} from the HFET was smaller
- Indirect (SNRI + JPA off) and direct methods (JPA on) match up very well





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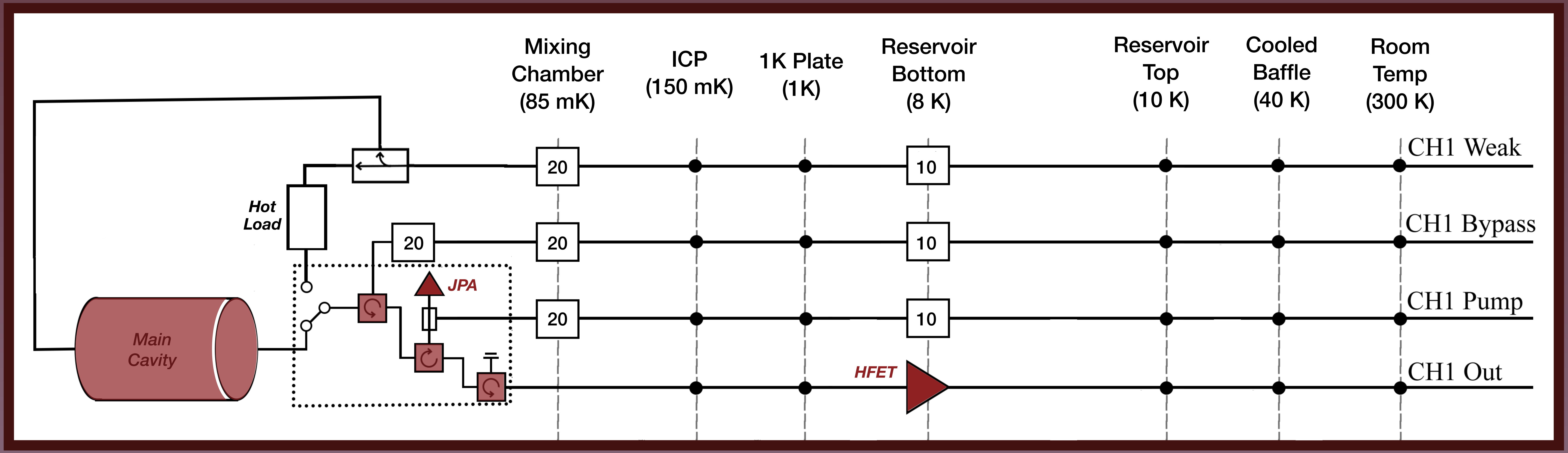

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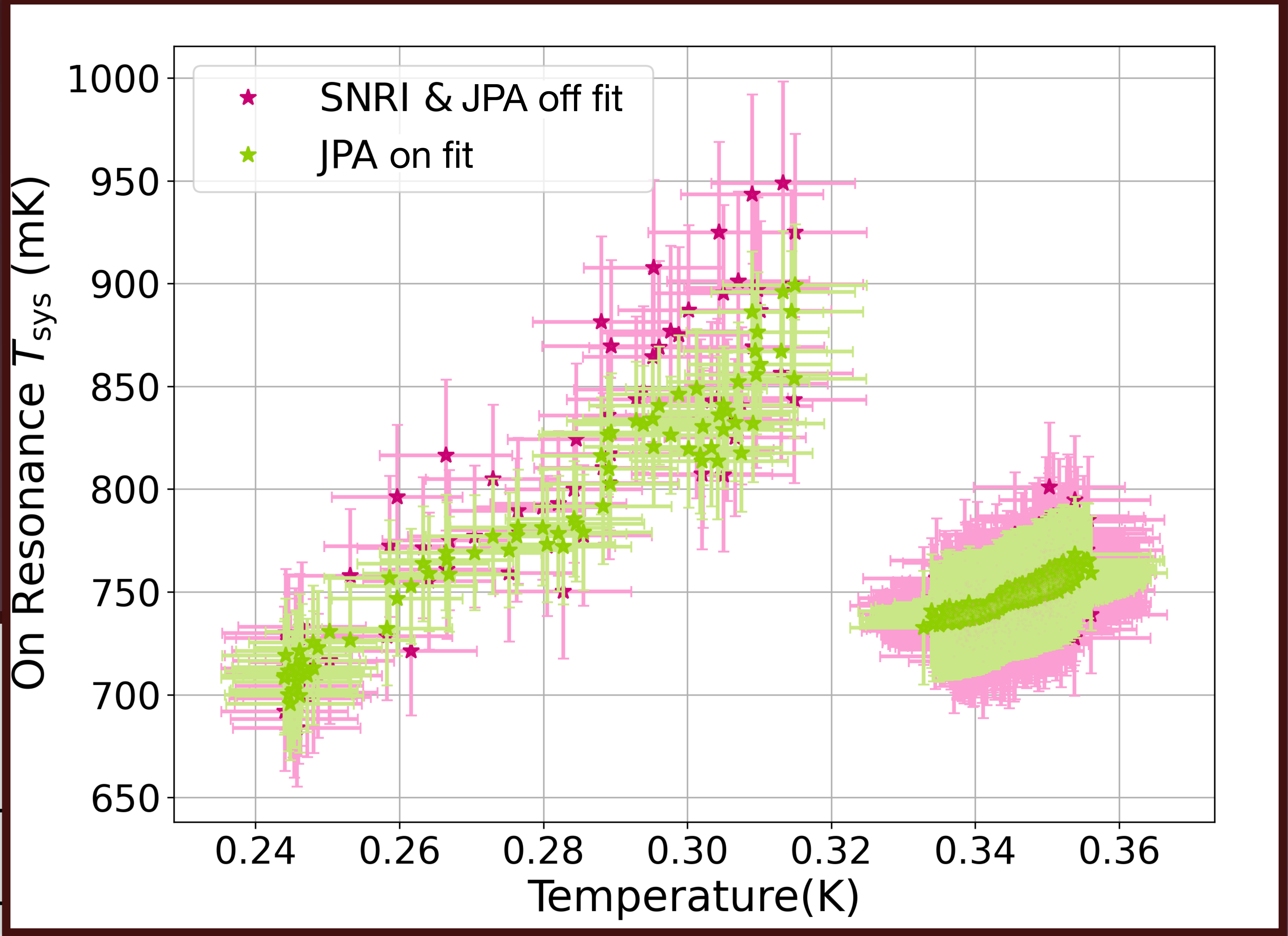
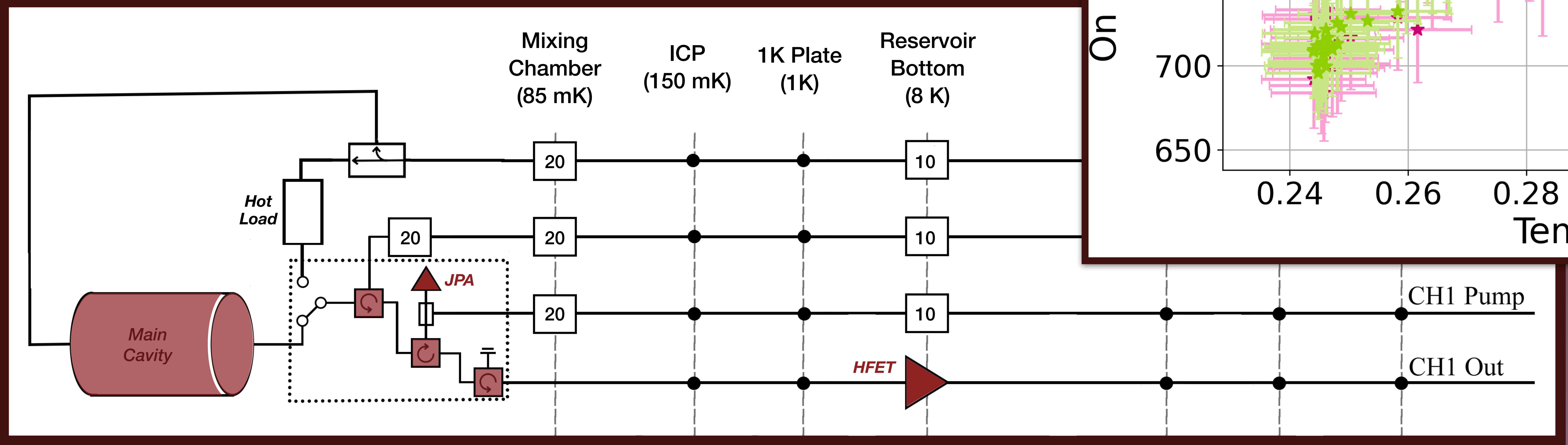
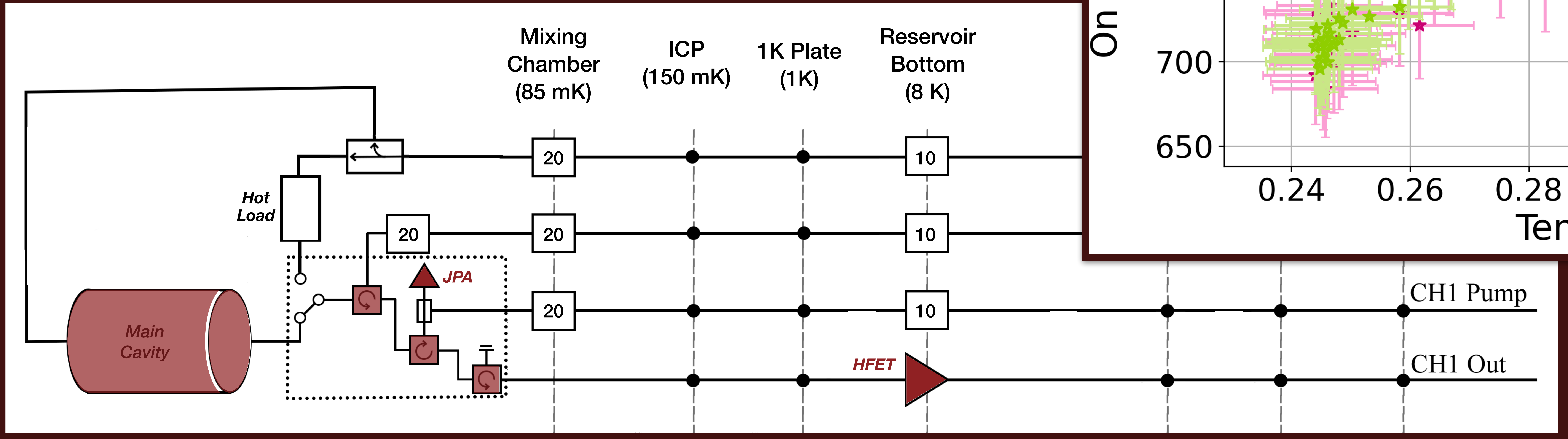
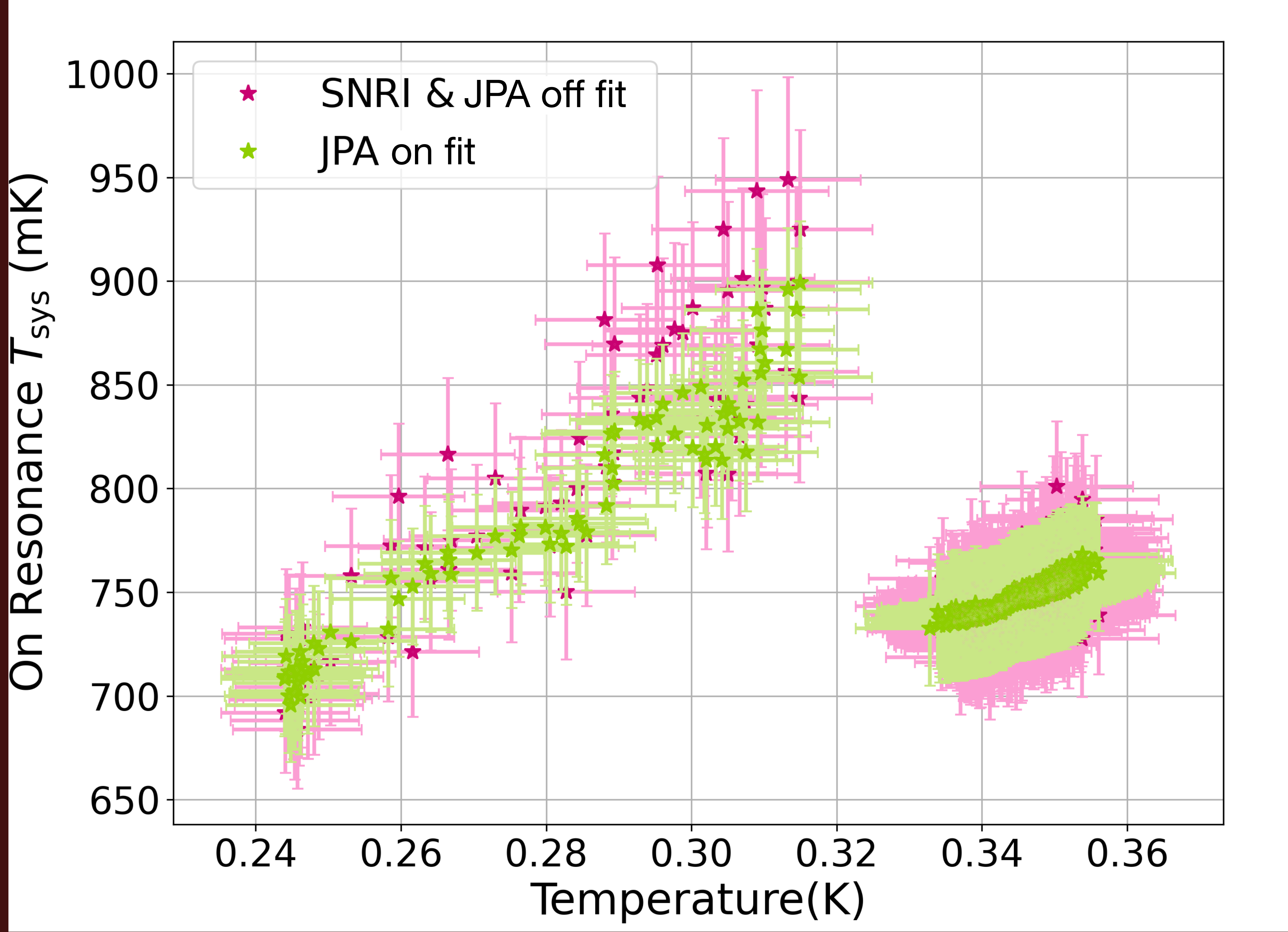




Noise Calibration Results★

- One calibration with the cavity as the noise source
  - At ~0.32 K the JPA gain increased dramatically and became much more stable causing the discontinuity





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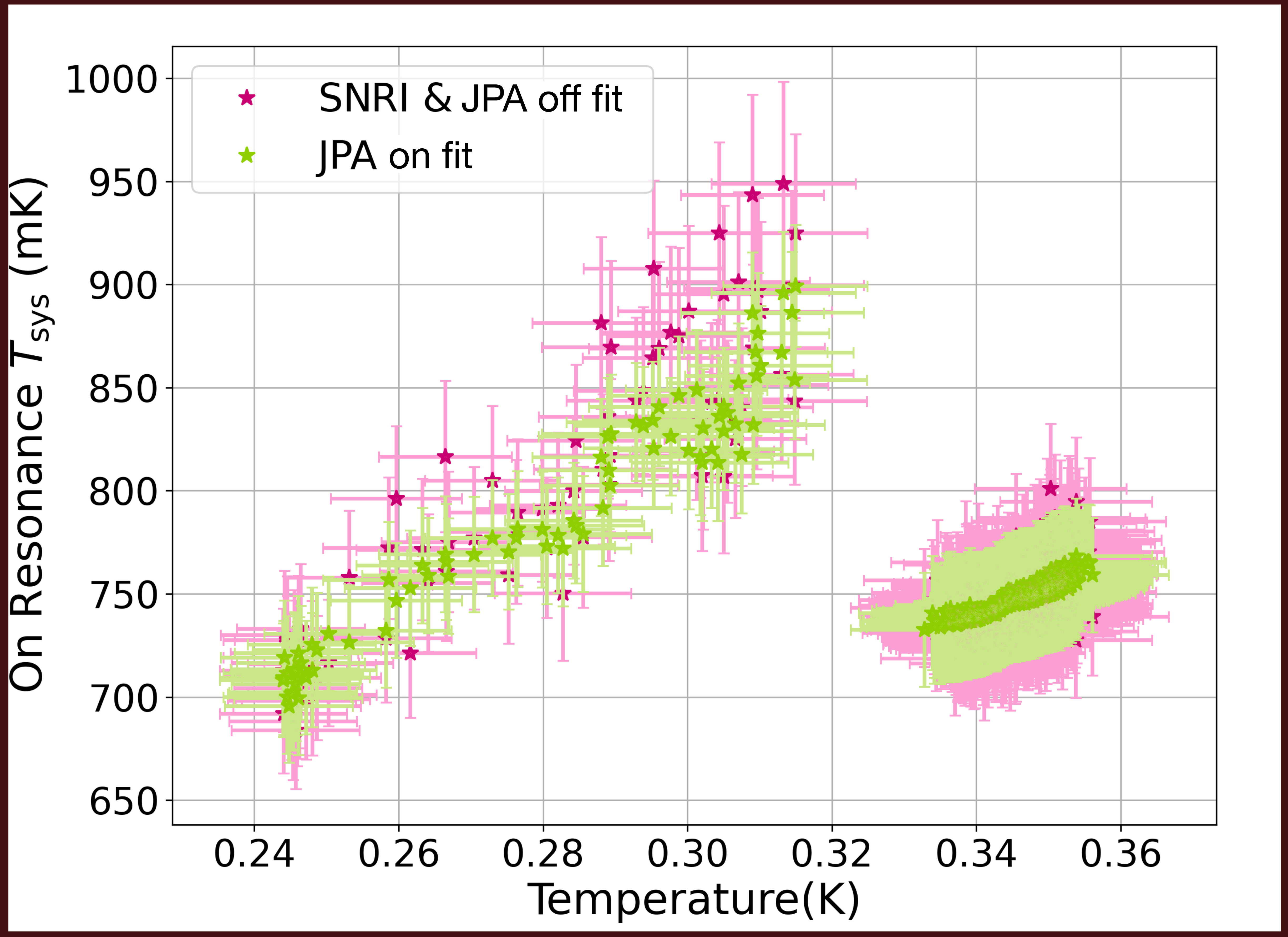
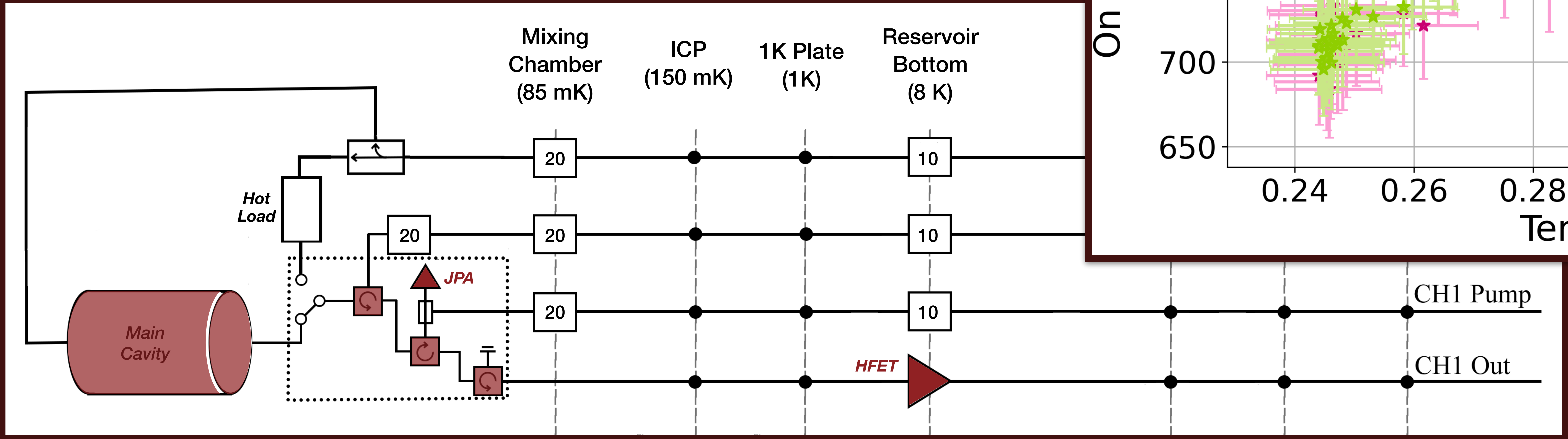
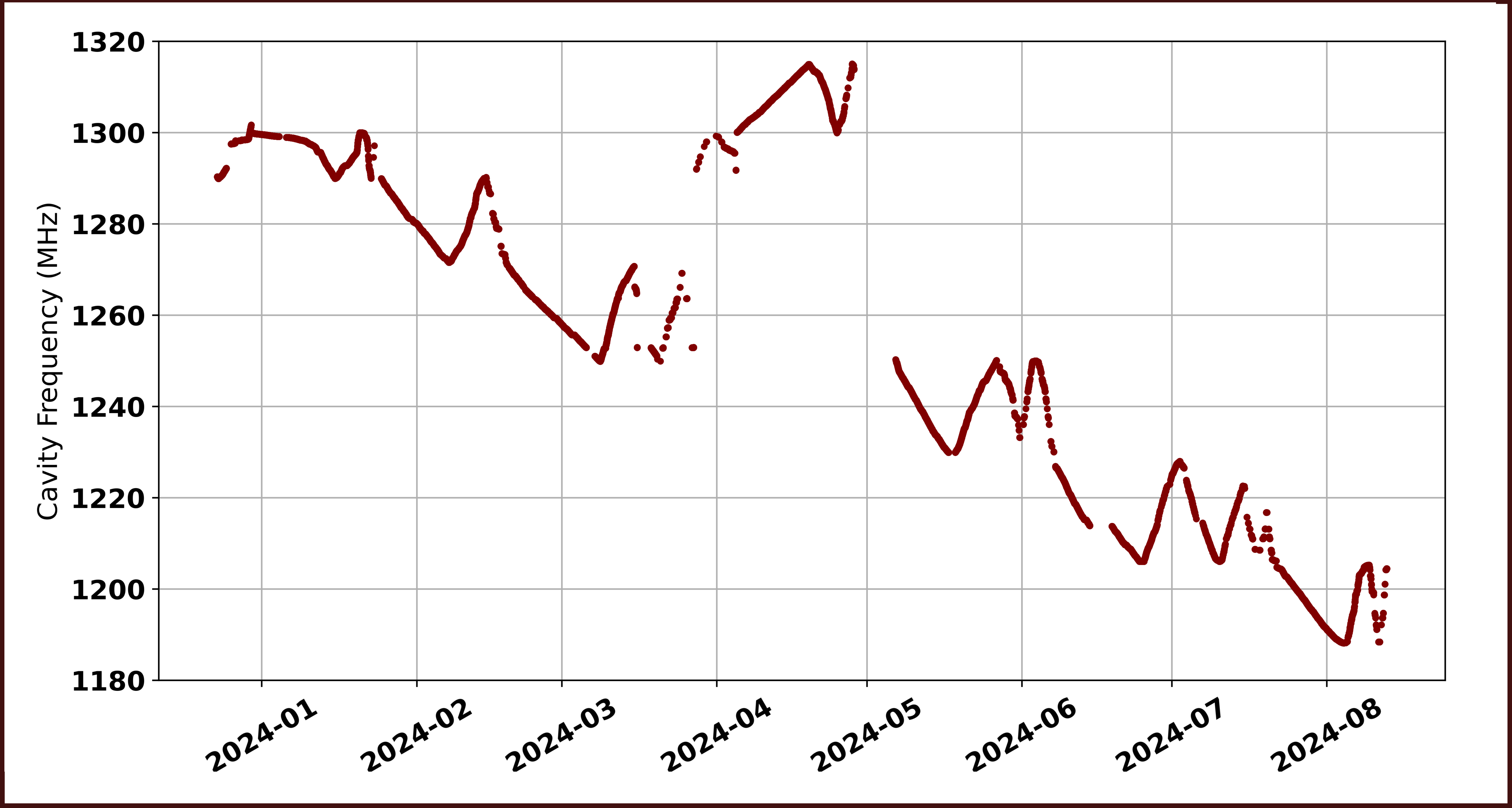




Run 1D Scan Progress



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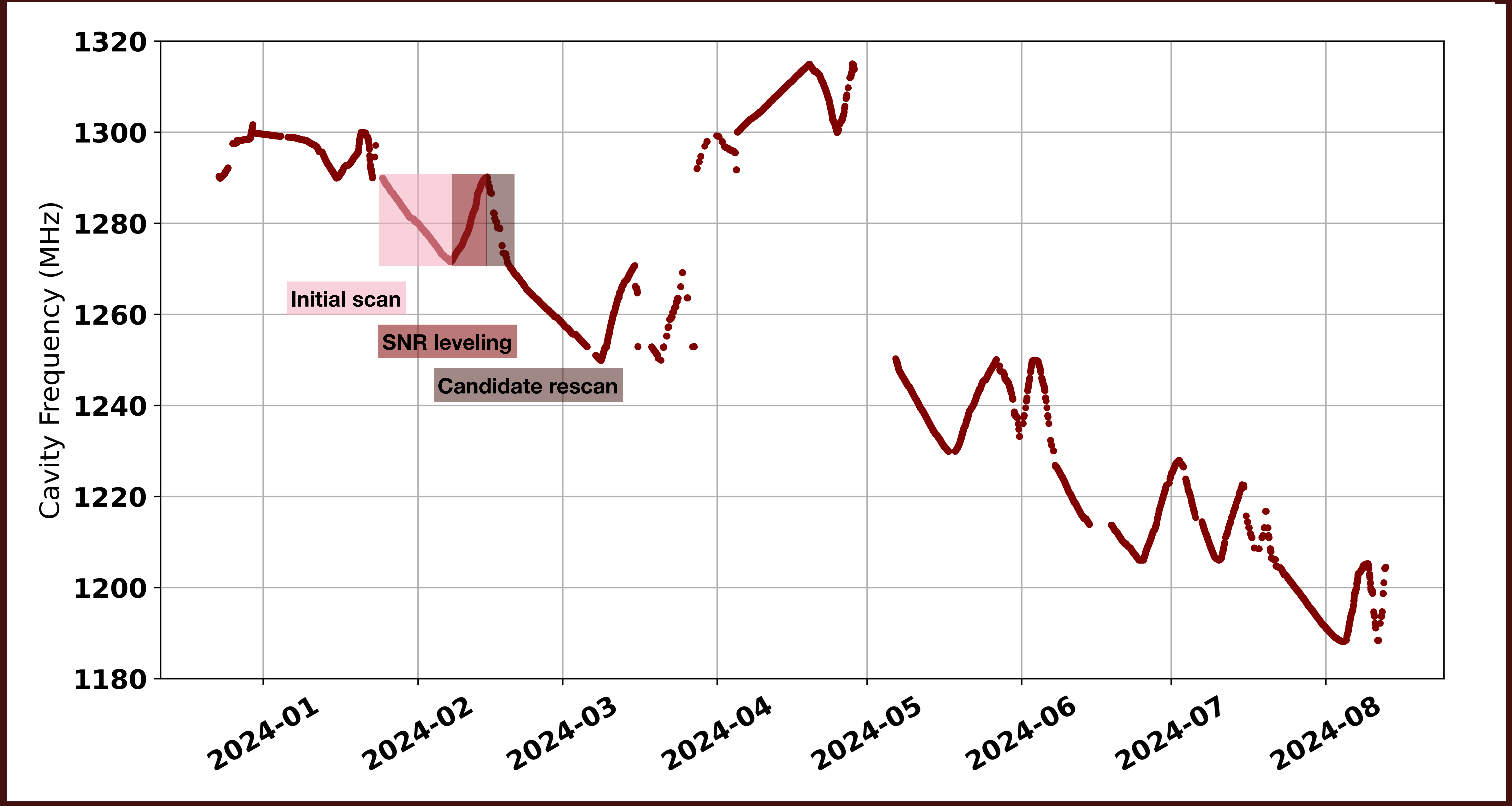

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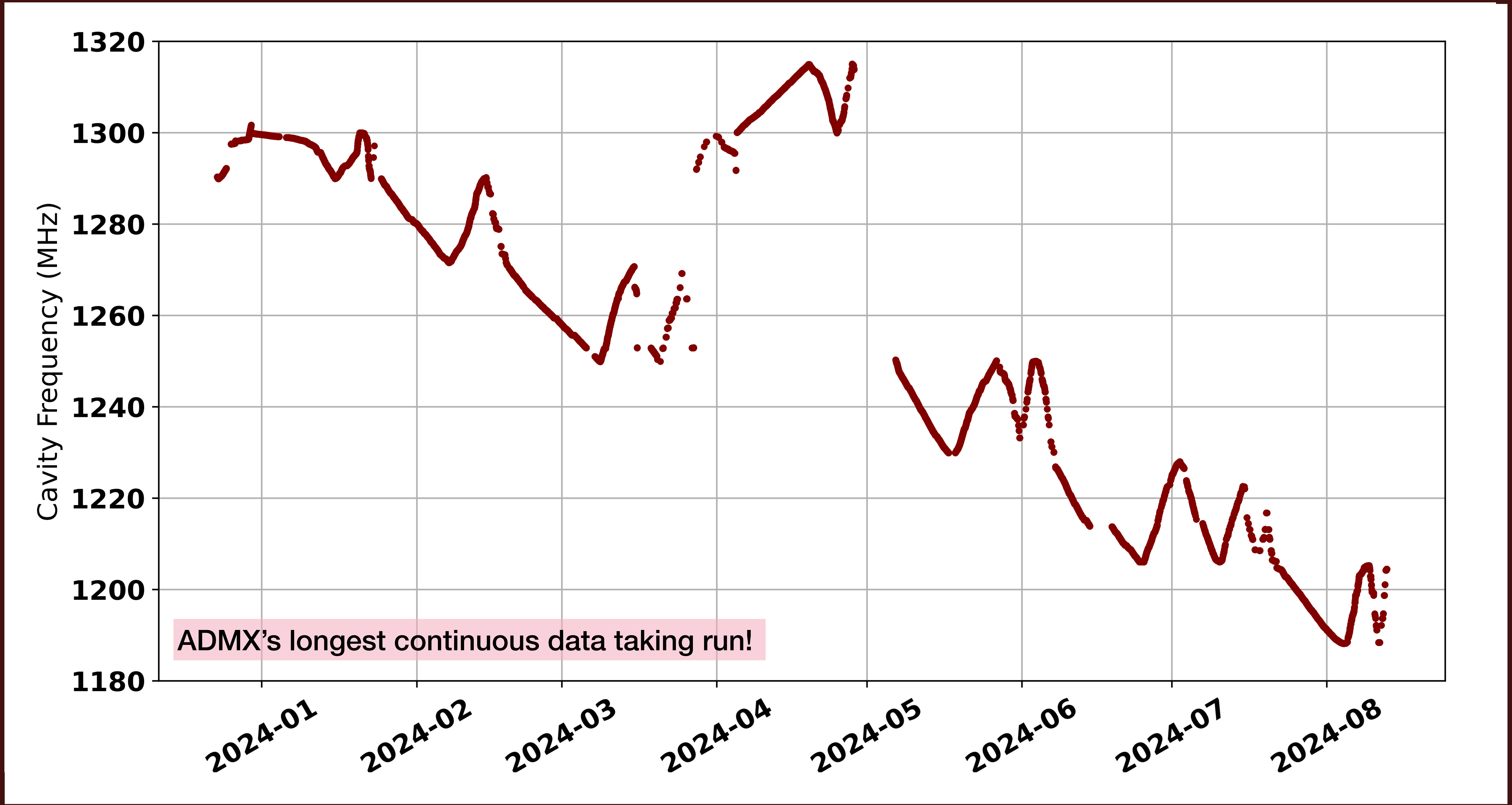
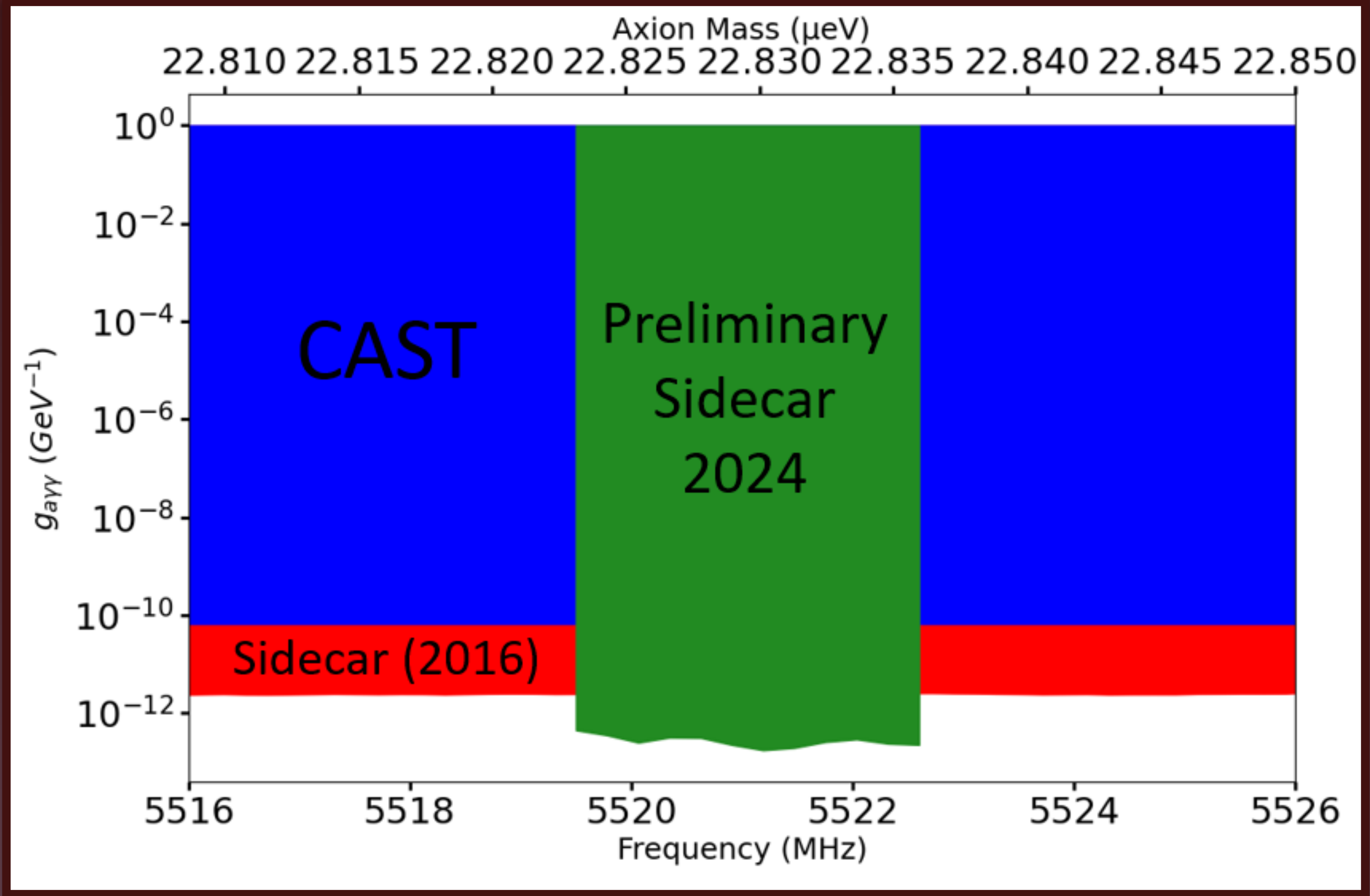
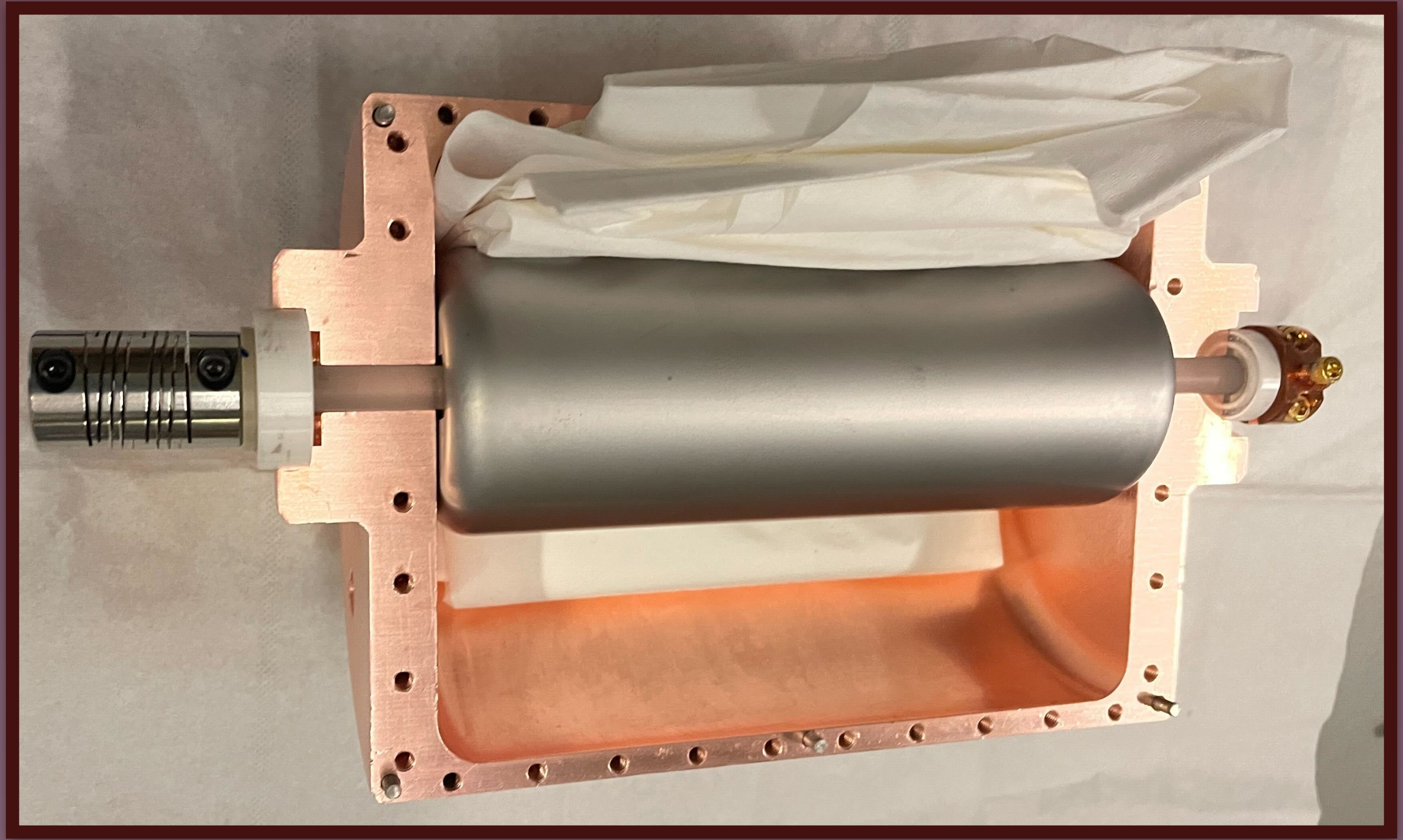


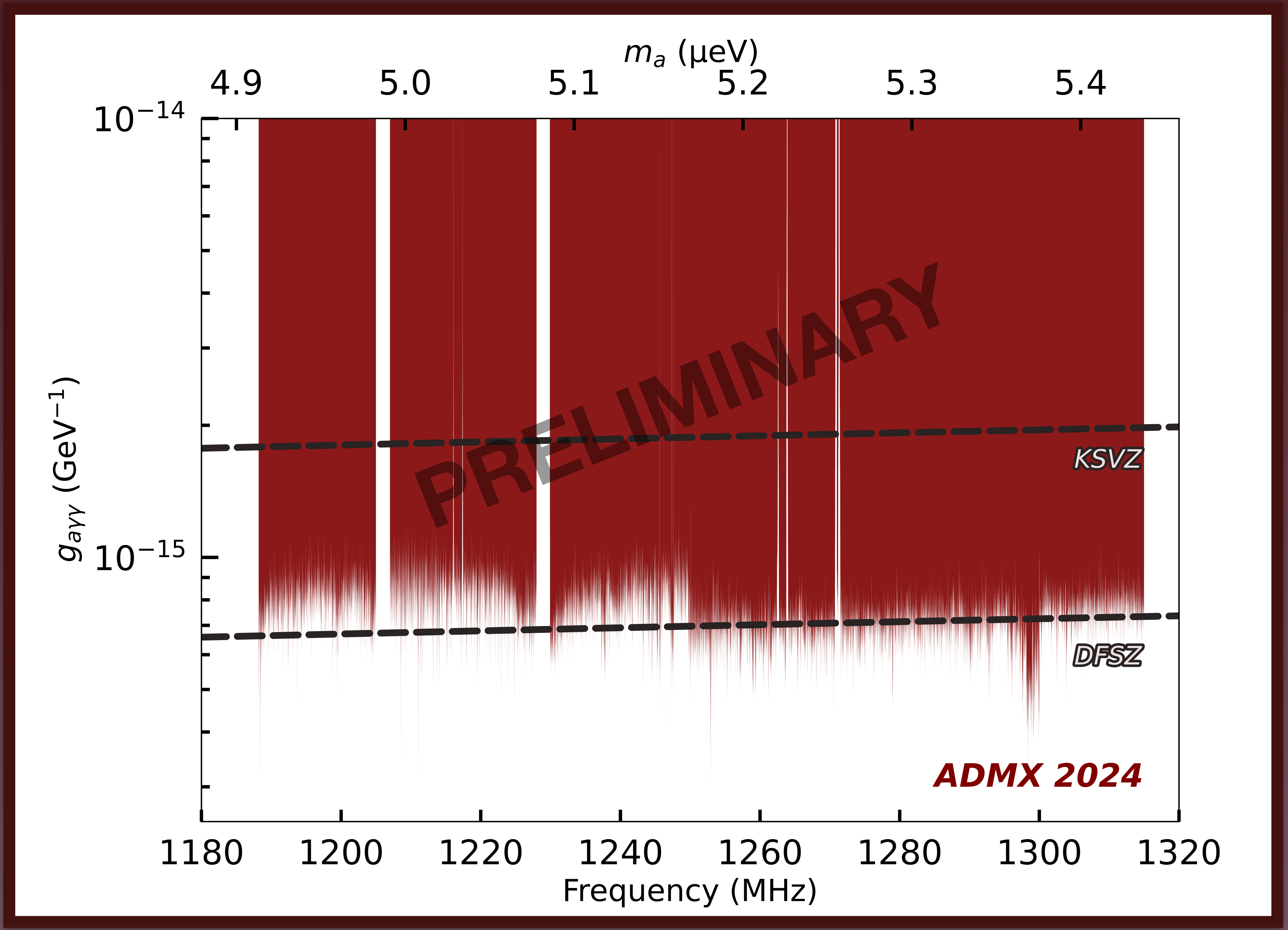
Run 1D Sidecar Updates

- Higher frequency (4-6 GHz) ‘sidecar’ cavity that rests on top of the main cavity which we can use for R&D testing
- For Run 1D, we switched the tuning rod out for a superconducting one
  - $\mathcal{O}(1\mu\mathrm{m})$ Nb3Sn film sputtered on pure Niobium substrate produced by SQMS at Fermilab
- Still evaluating the rod’s performance, which produced a Q lower than initially expected
- Able to take science data, only in a narrow frequency band due to piezomotor failure
- Paper with more details coming soon
  - Contact: thomas.braine@pnnl.gov

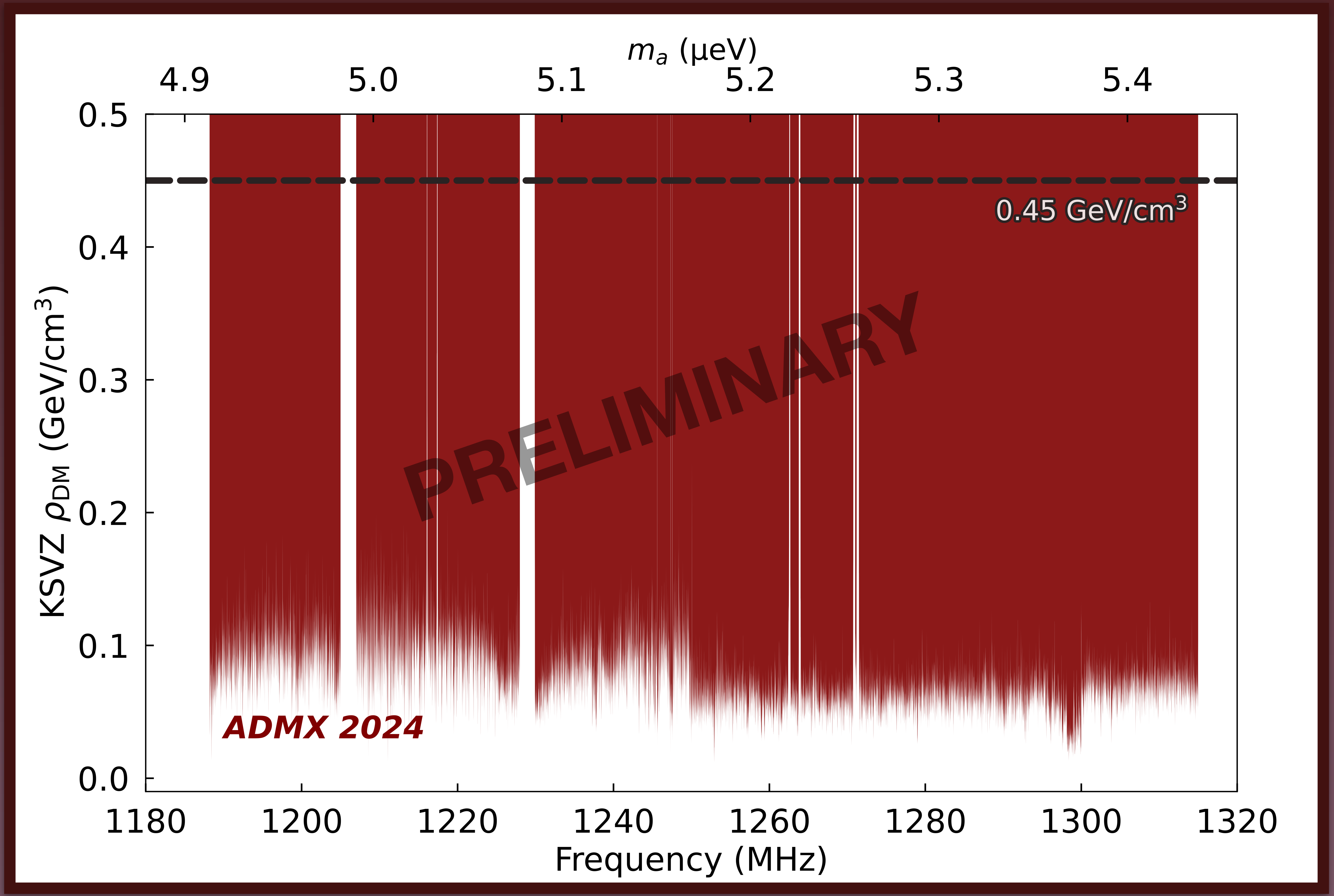




Run 1D Preliminary Sensitivity

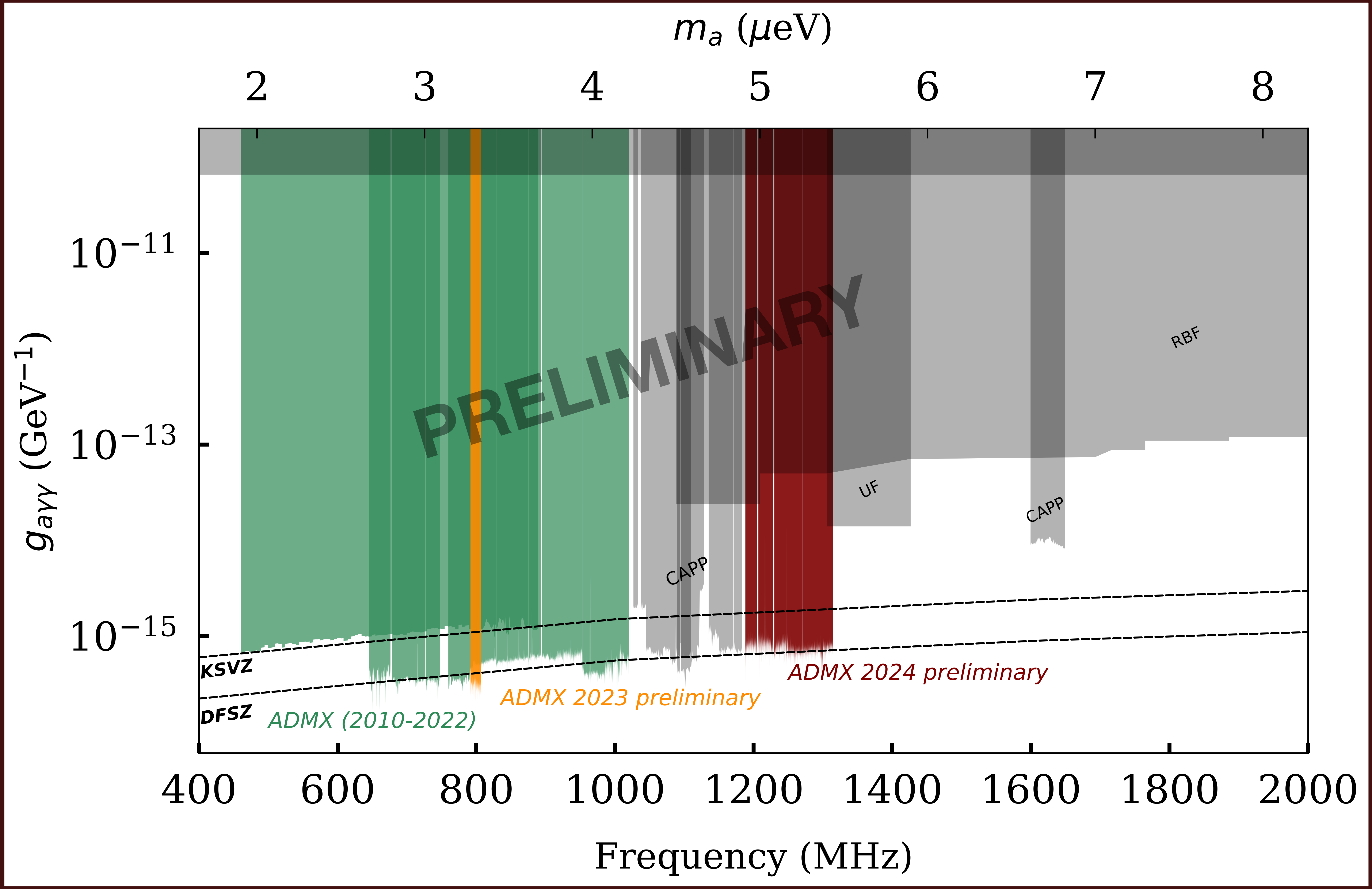


Assumed value of $\rho_{DM} = 0.45$ GeV/cm³



Assumed value of $g_\gamma = -0.97$

Run 1D Preliminary Sensitivity in Context



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Next Steps

- Right now:
  - Focusing on unexplored regions of parameter space in the accessible frequency range
    - Scanning large gaps from mode crossings/other issues in the recently published CAPP results
- Later this year:
  - Cryogenic and JPA/receiver upgrades to achieve a lower system noise temperature for a second, DFSZ-sensitive, pass of the Run 1D frequency range
- Beyond:
  - 4-cavity higher frequency (up to ~2 GHz) data taking run in the existing UW magnet

Acknowledgements

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