



ORGAN: State of Play & Future Plans

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Overview

- ORGAN introduction
- Design considerations
- Photon counting
- Status and run plan

ORGAN: Axion Detection

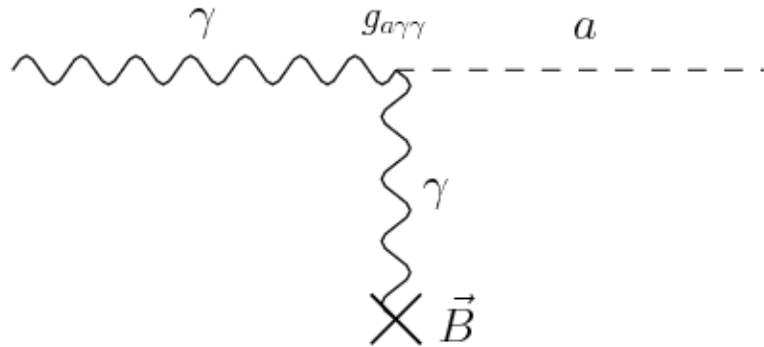
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- High mass axion haloscope
- Axion-photon conversion in resonant cavity

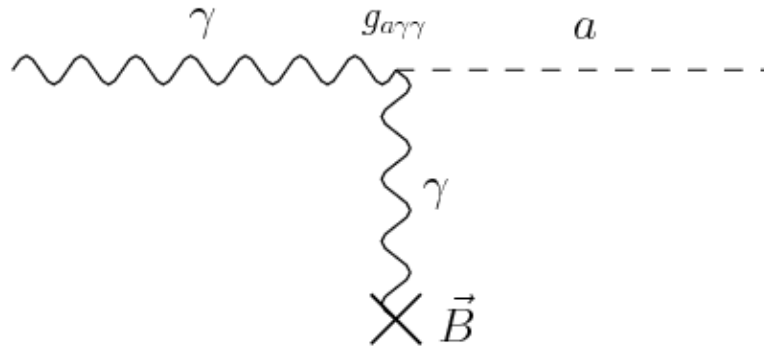
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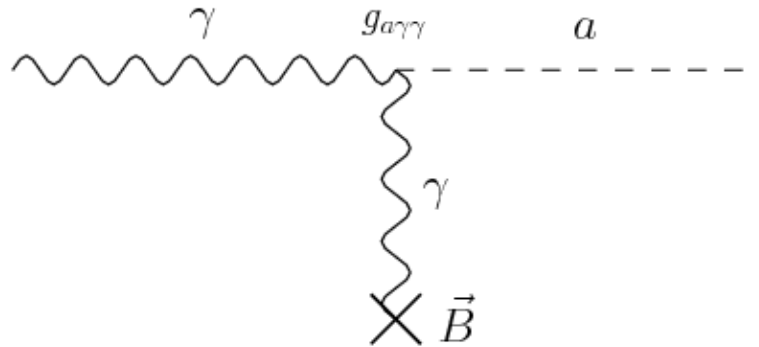
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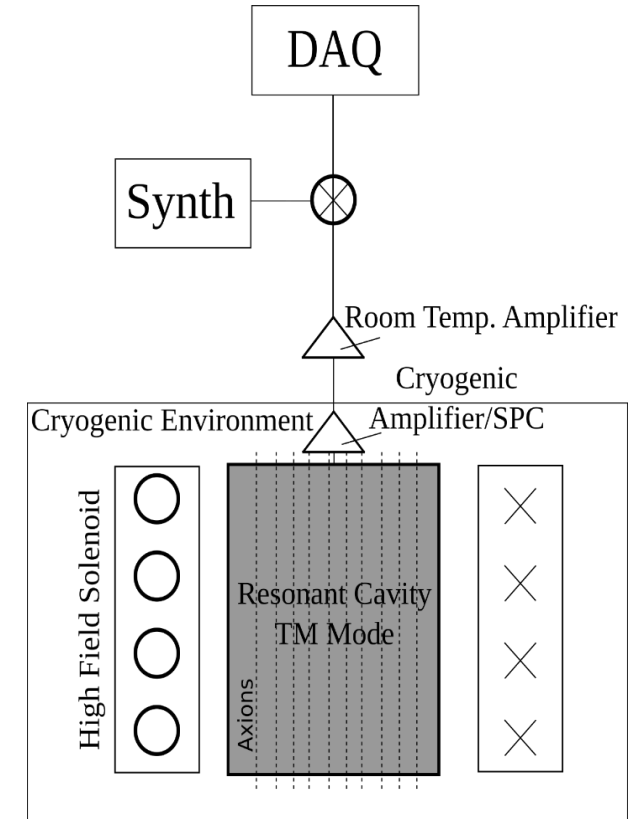
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- Oscillating Resonant Group AxioN Experiment

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- Mass range of interest – 60-200 micro-eV

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- Oscillating Resonant Group AxioN Experiment
- Mass range of interest – 60-200 micro-eV
- Motivations:
 - SMASH model
 - Josephson Junction results
 - High mass range relatively unexplored

ORGAN: Axion Detection

- Critical research areas:
 - Tunable resonators

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 - Data acquisition and analysis

ORGAN Sensitivity Considerations

- Haloscope scan rate:

$$\frac{df}{dt} \propto \frac{1}{SNR_{goal}^2} \frac{g_{a\gamma\gamma}^4 B^4 C^2 V^2 \rho_a^2 Q_L Q_a}{m_a^2 (k_B T_n)^2}$$

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ORGAN Dilution Refrigerator

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- Equipped with 12.5 T magnet

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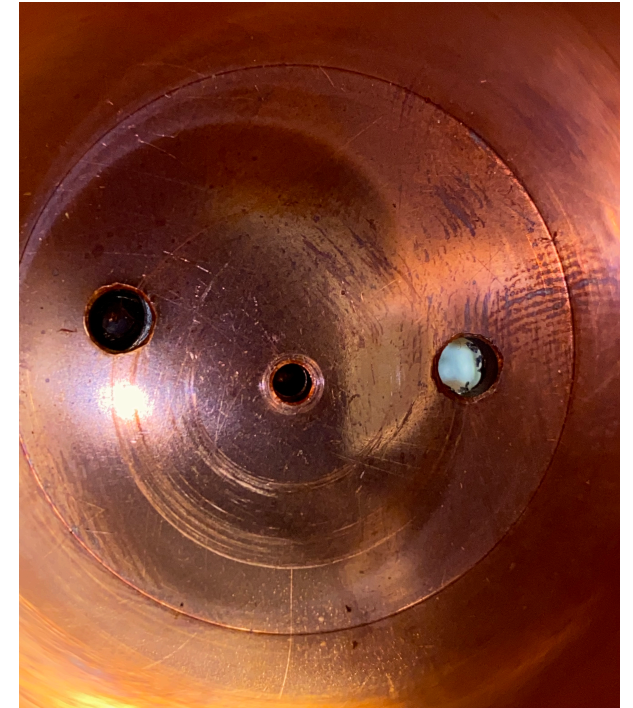
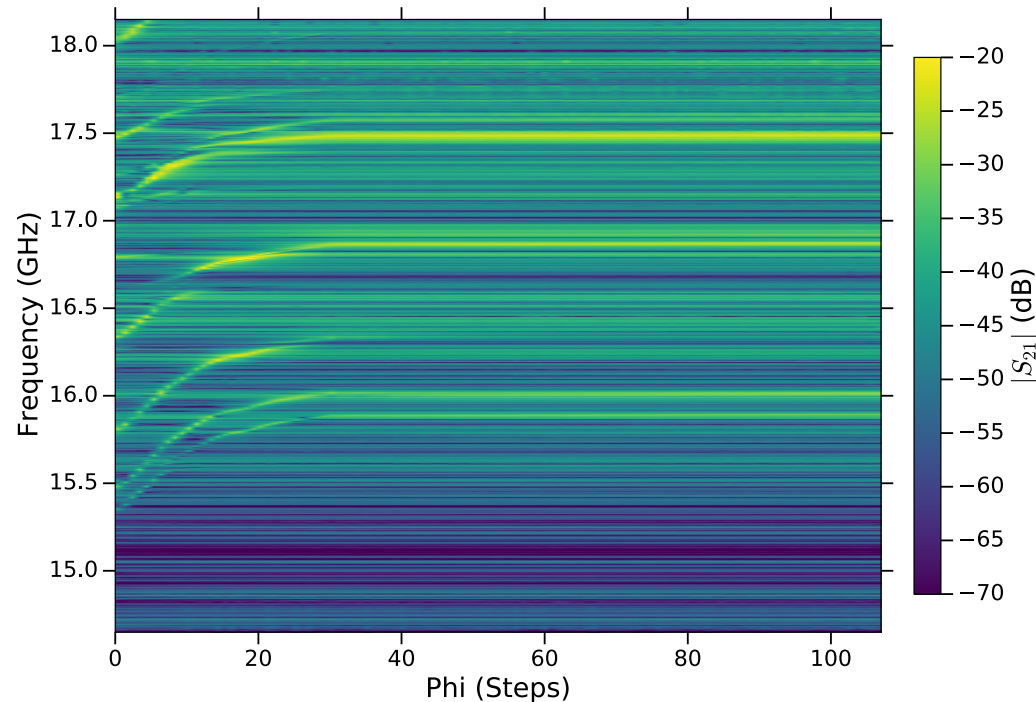
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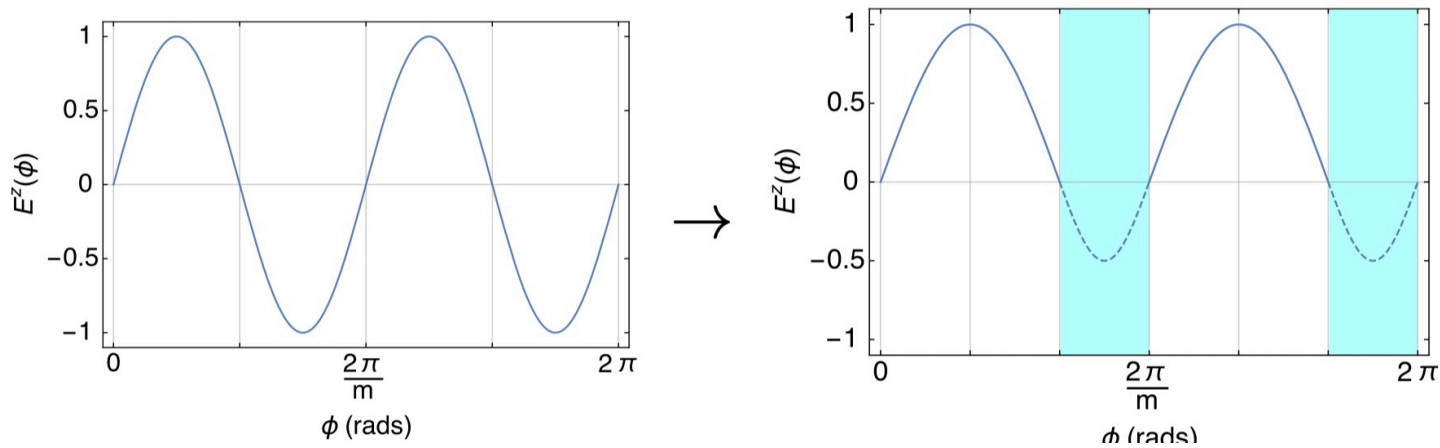
High Frequency is Difficult

- Reduced sensitivity isn't the only challenge at high frequency...
- There are also significant practical challenges
 - Absolute machining tolerances are what matter
 - We started with 0.1mm rod end gaps
 - Probe placement is difficult
 - Whole assembly needs to fit in 57mm diameter magnet bore

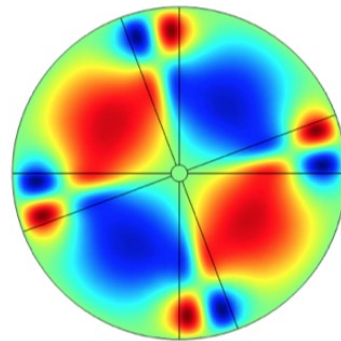
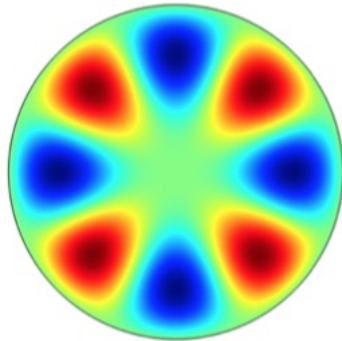


A Potential Solution?

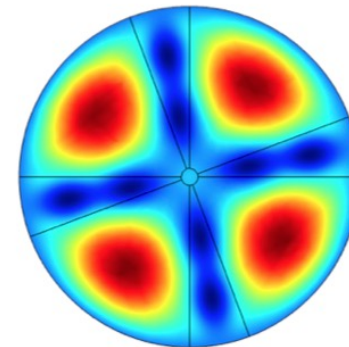
- Dielectric Boosted Axion Sensitivity (DBAS)
- Take a higher order TM mode and make it axion sensitive by placing dielectric in out of phase regions.
- Result \rightarrow decreased E^z field in those regions \rightarrow increase in C



TM_{410}

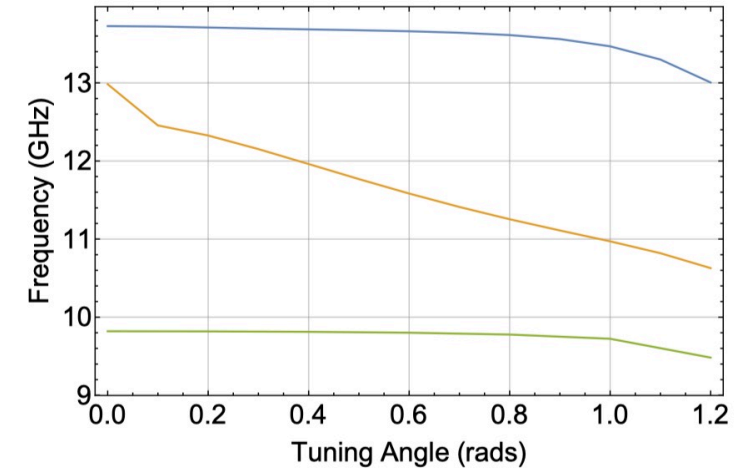
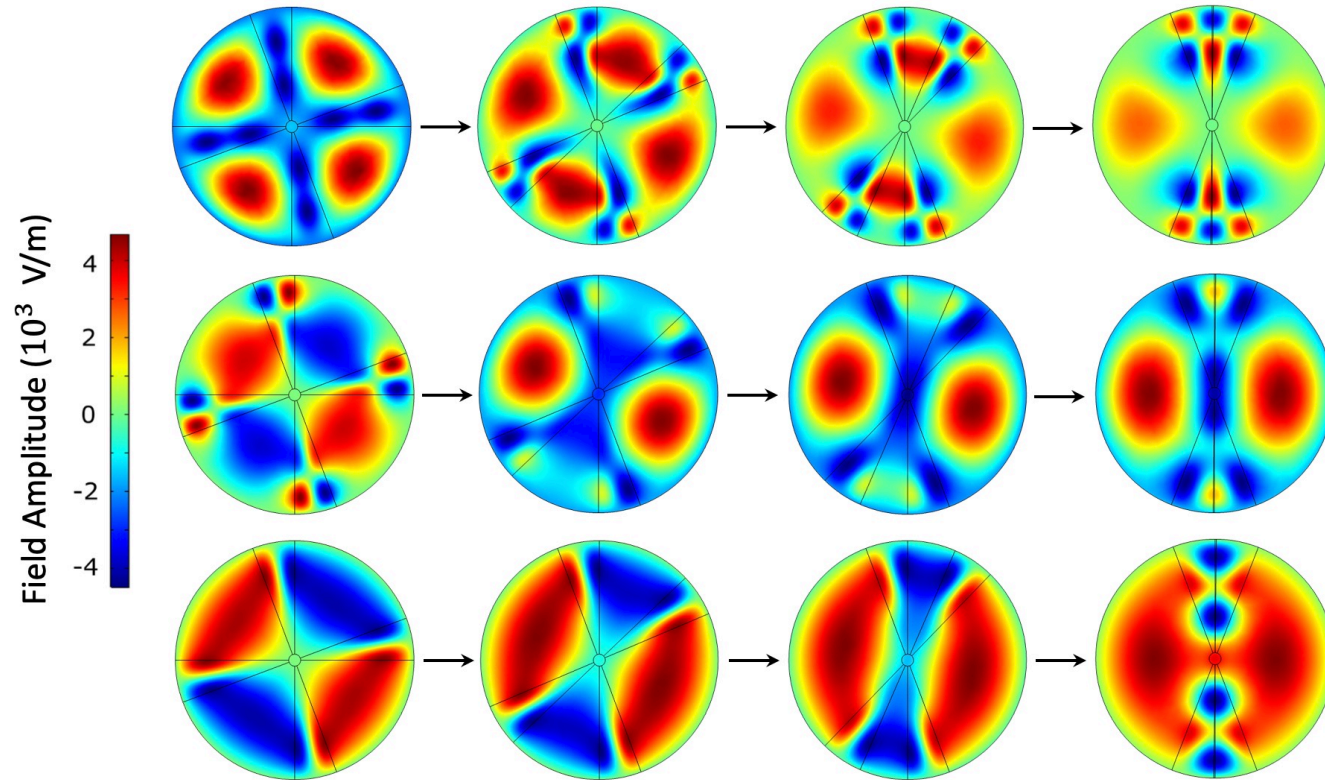


OR

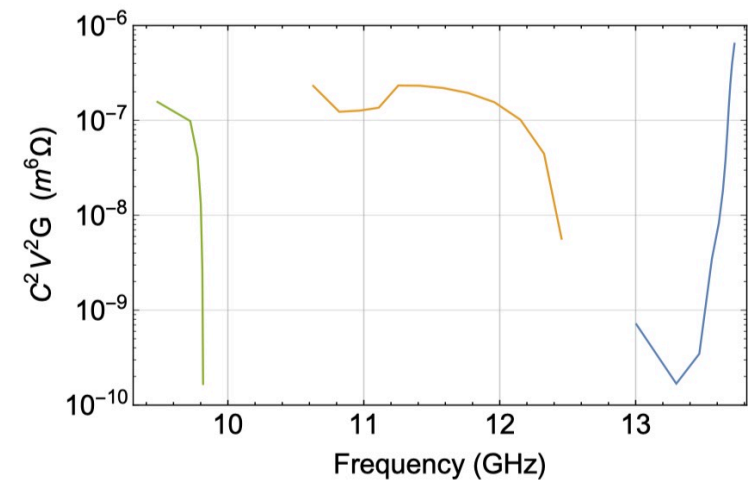


FEM Modelling with 4 Sapphire Wedges

Built-in tuning \rightarrow 2-wedges remain stationary, while the other 2 are allowed to move relative to the stationary ones.



- TM410
- TM410-like
- TM210



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- If we lower the temperature this ratio can become order of thousands

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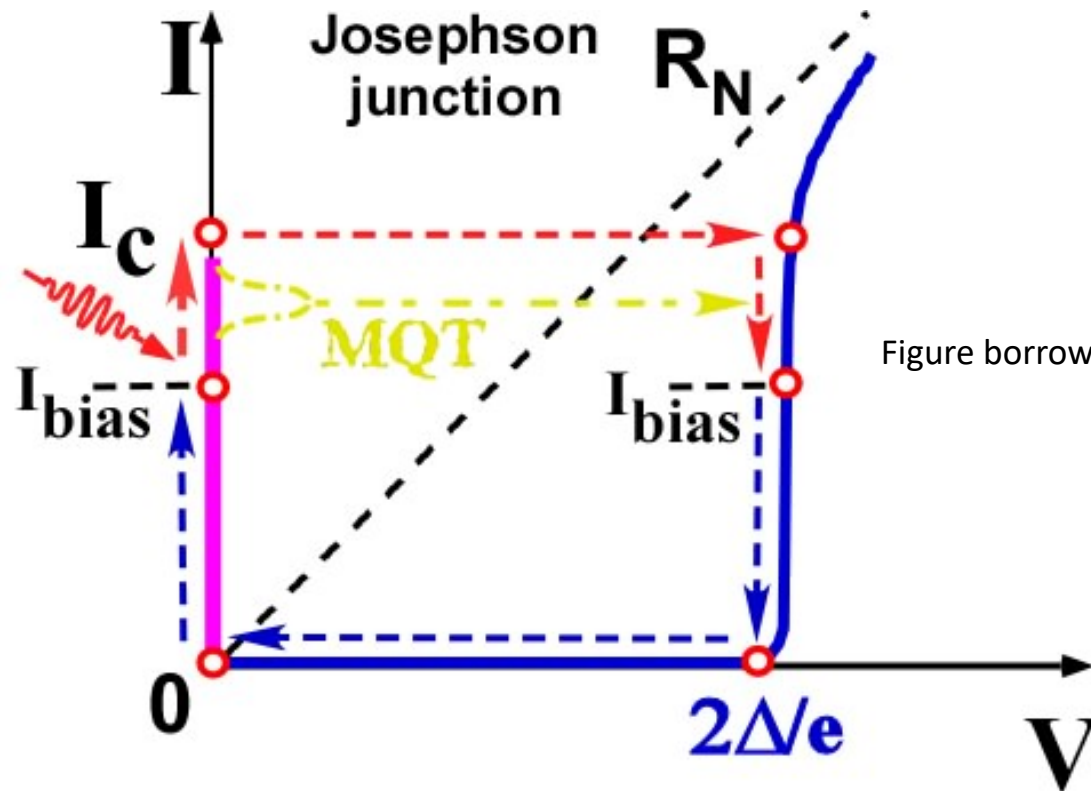


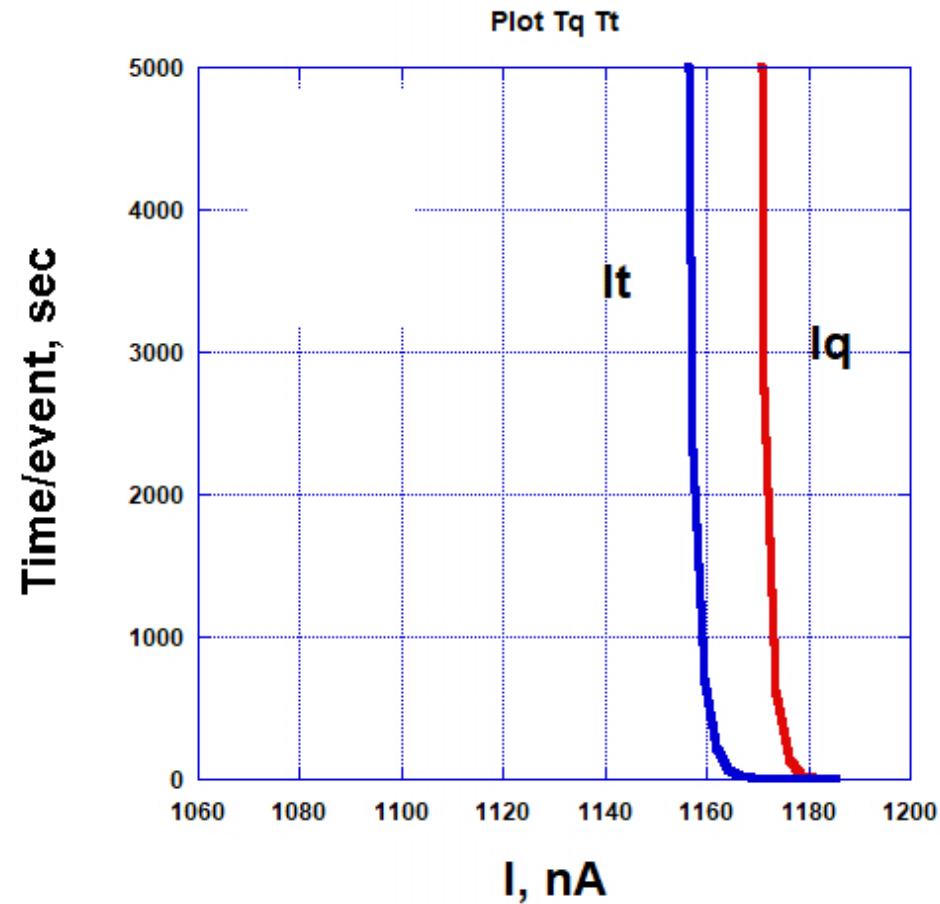
Figure borrowed from Leonid Kuzmin

Single Photon Counters

- Design is non-trivial

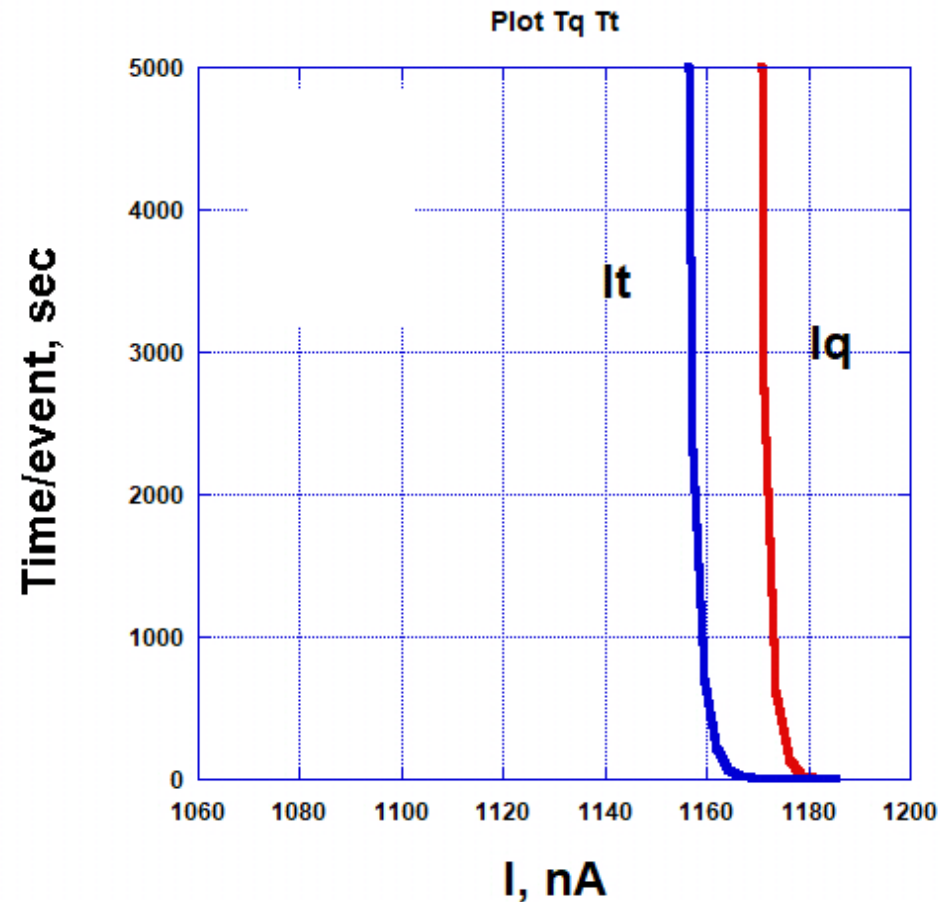
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- Initial design of 25 GHz+ detector

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- In the dilution fridge right now
- Watch this space

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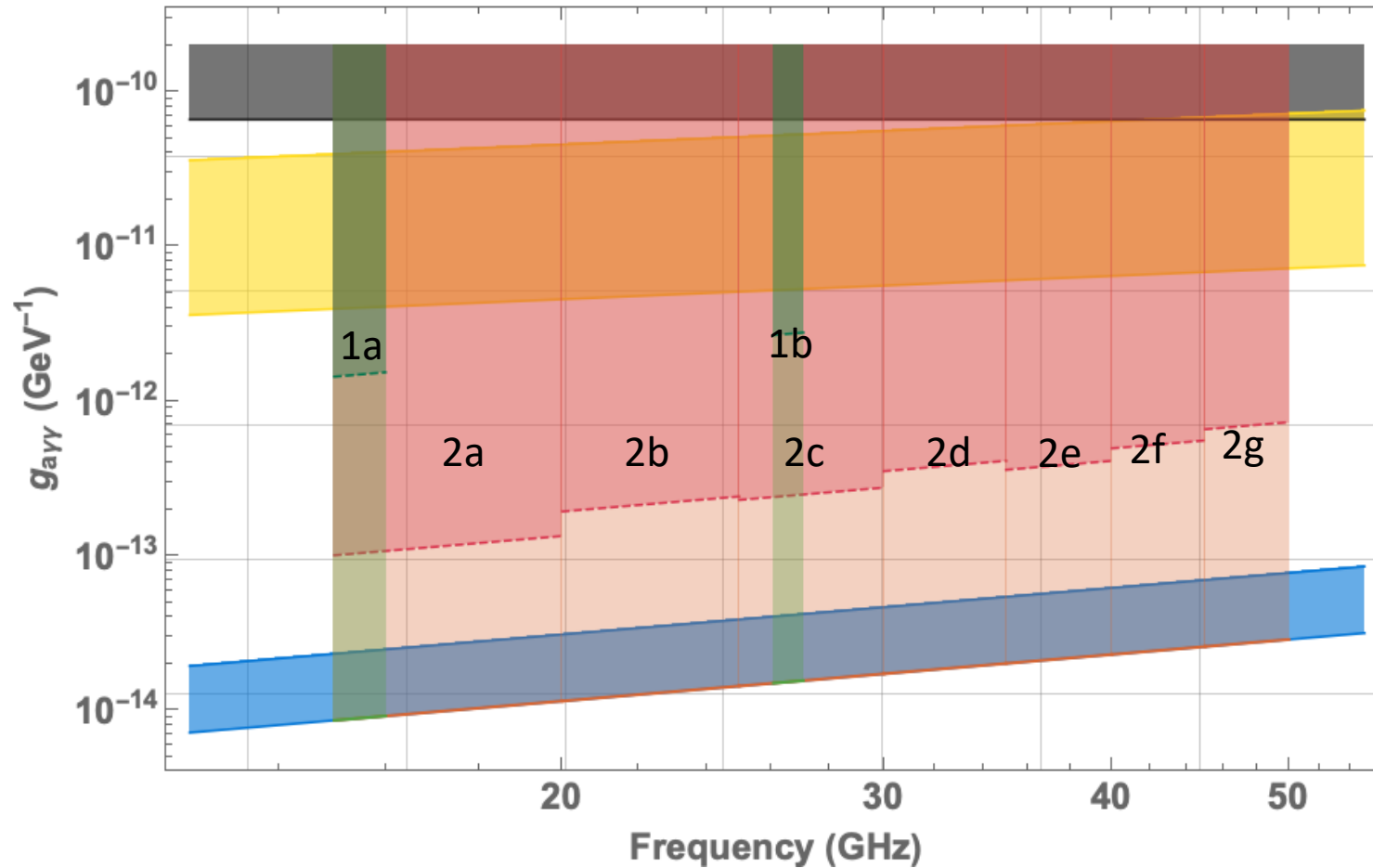
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ORGAN: Run Plans

- Planned runs in coming years

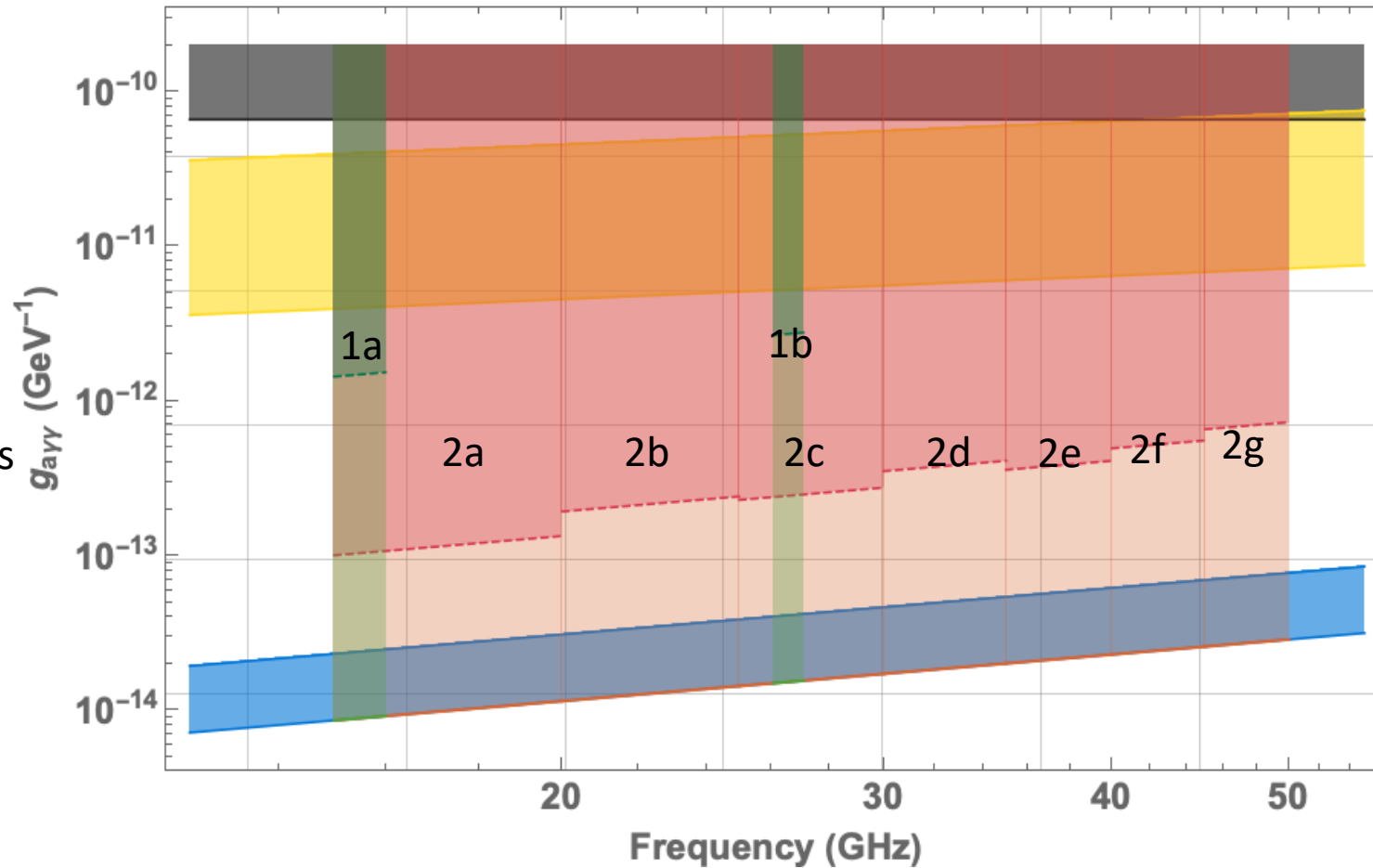


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Phase 1:
Standard TM010 Tuning
Rod Resonators

Phase 2:
Novel Dielectric Resonators
Better Amplifiers

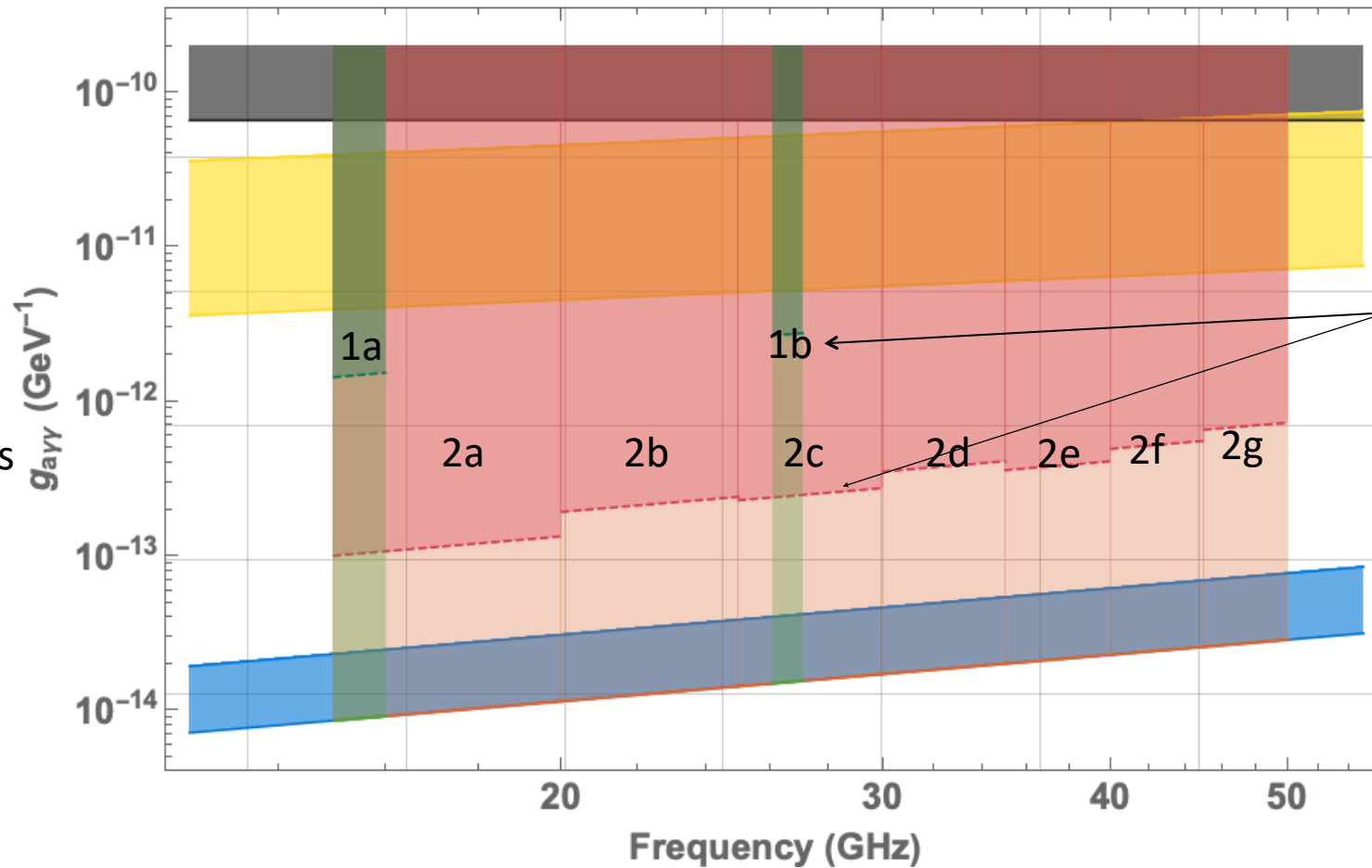


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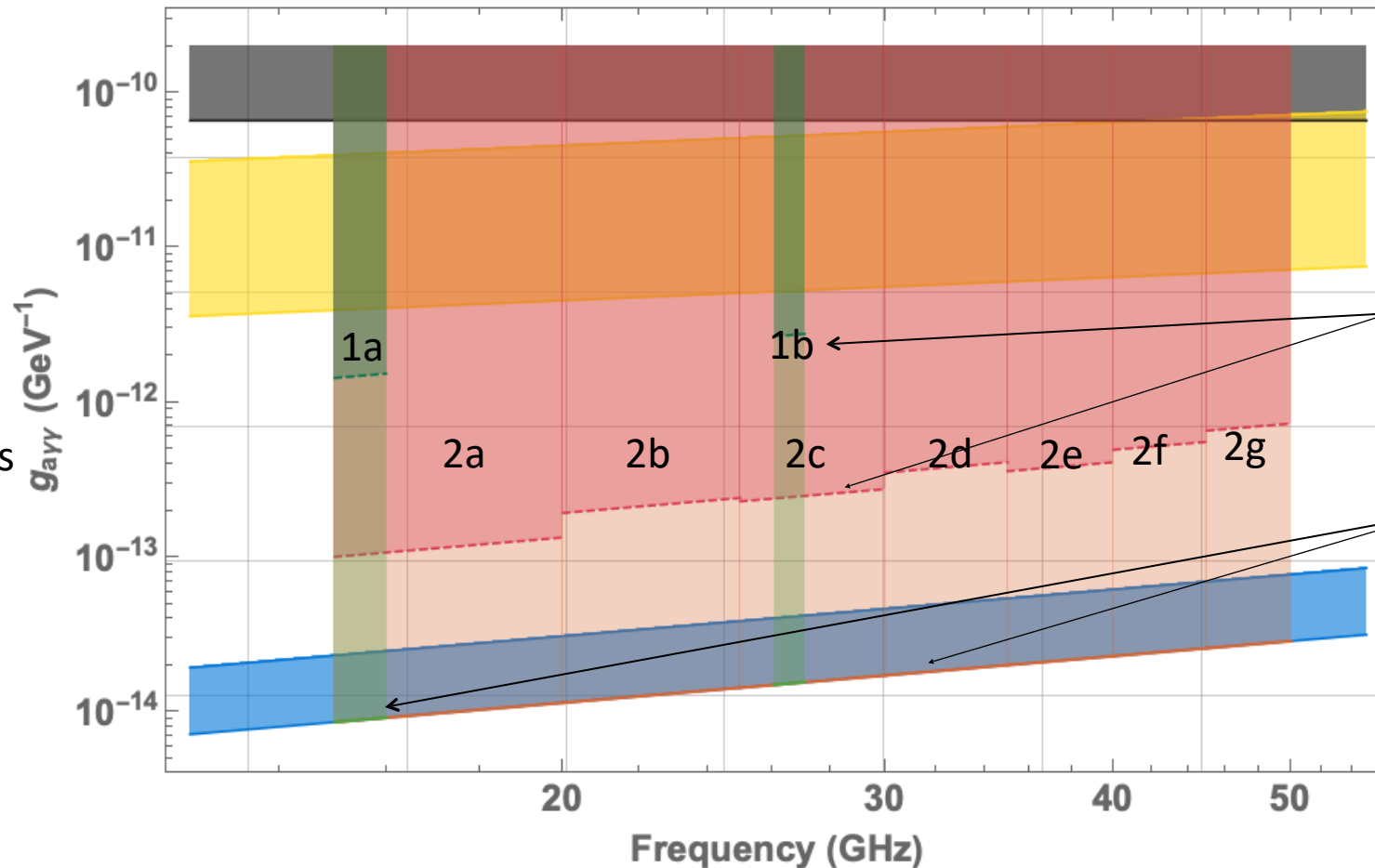


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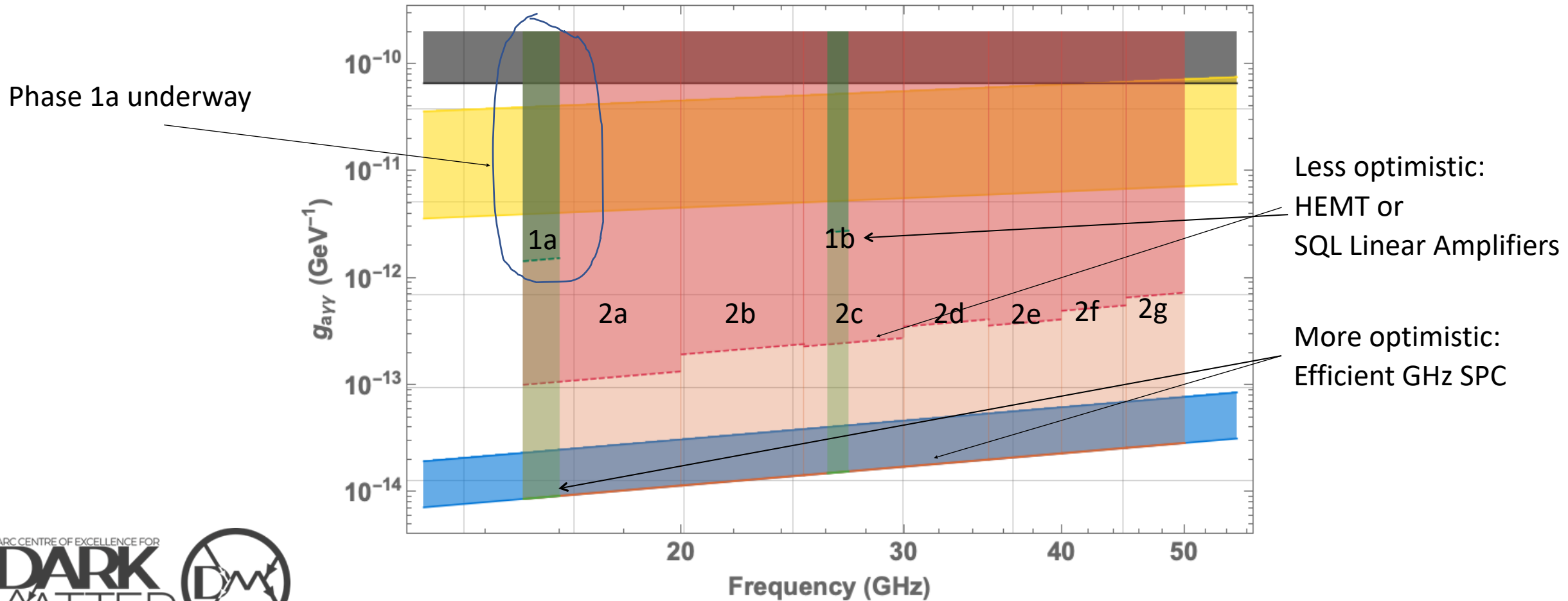


Less optimistic:
HEMT or
SQL Linear Amplifiers

More optimistic:
Efficient GHz SPC

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ORGAN: Phase 1a

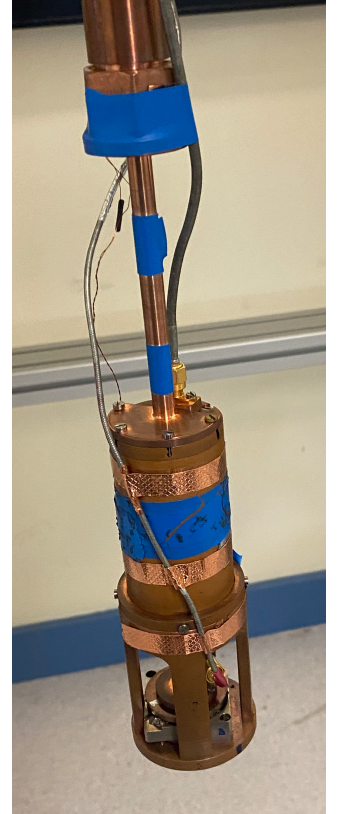
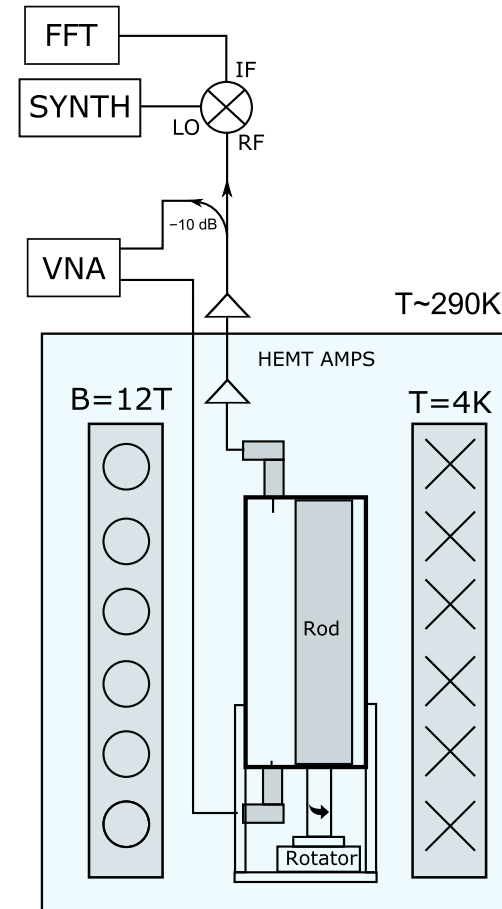
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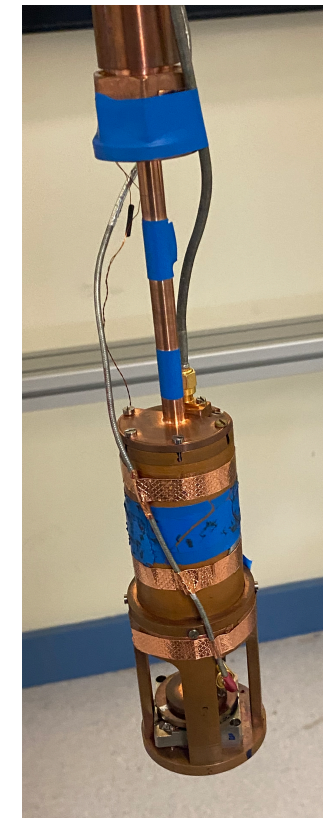
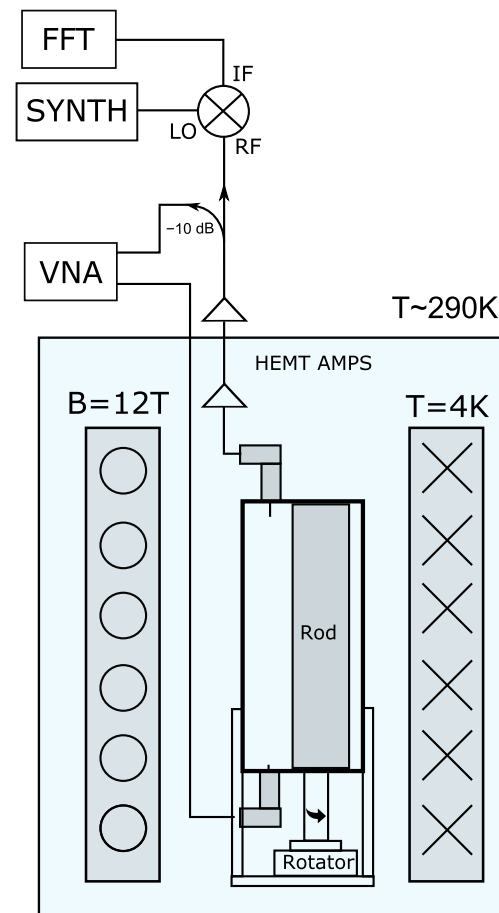
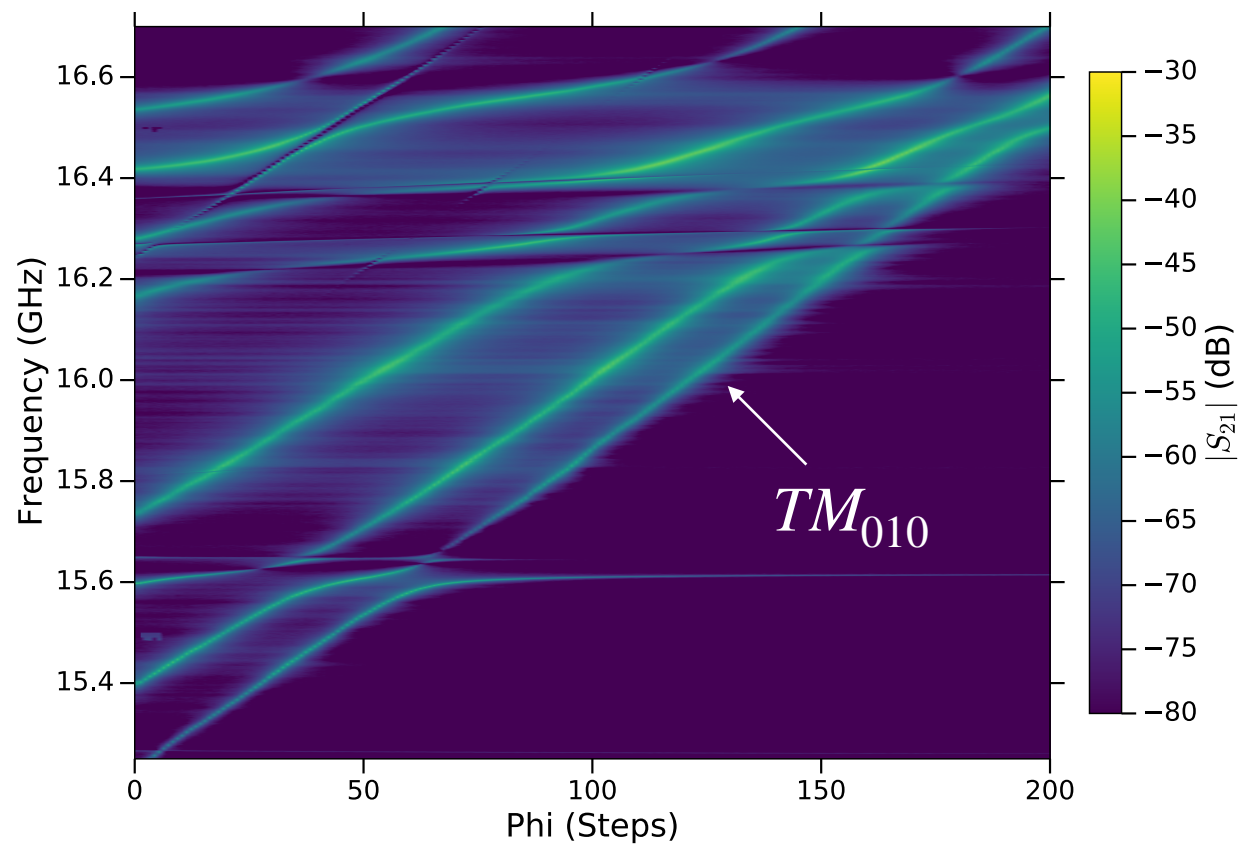
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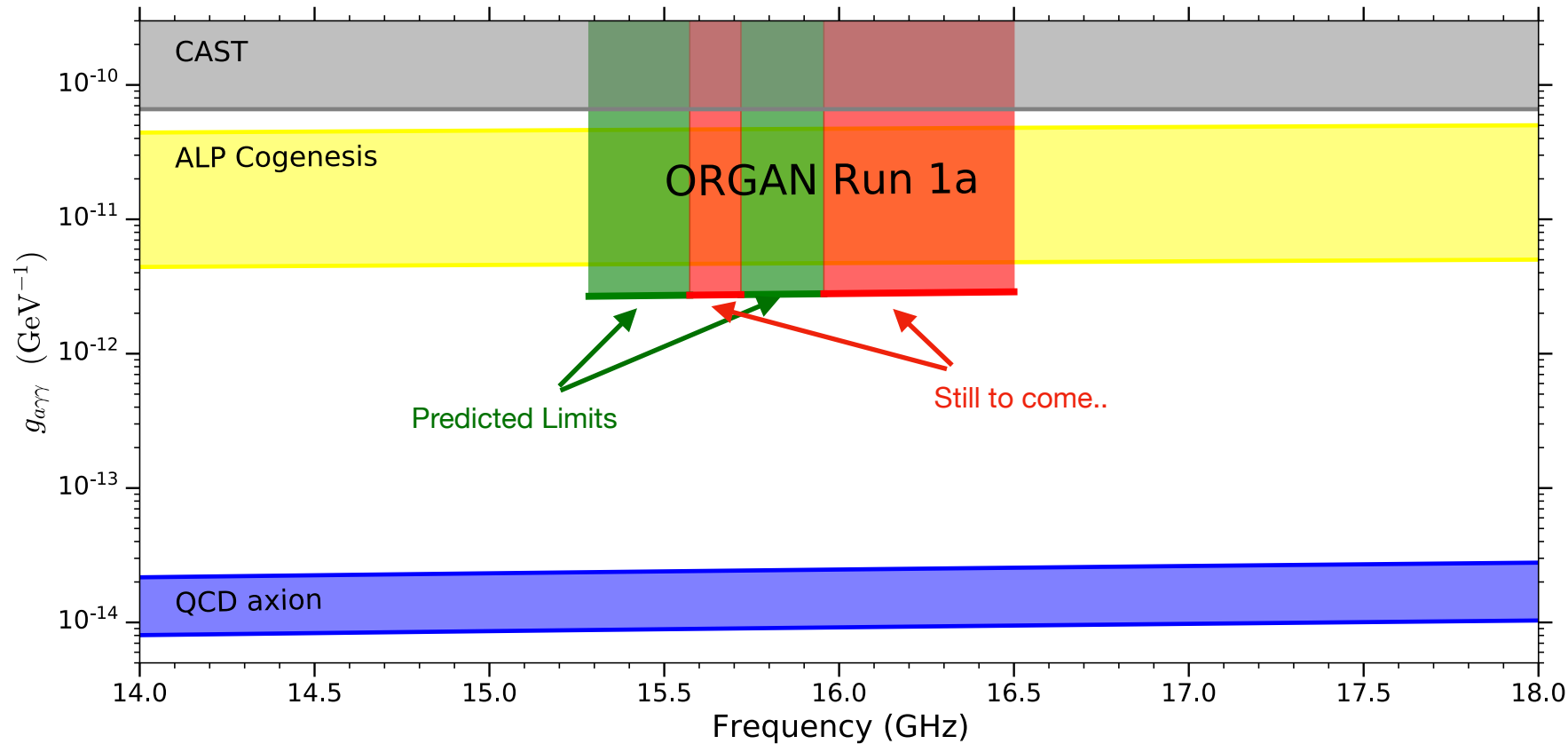


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- On track for most sensitive limits in the region

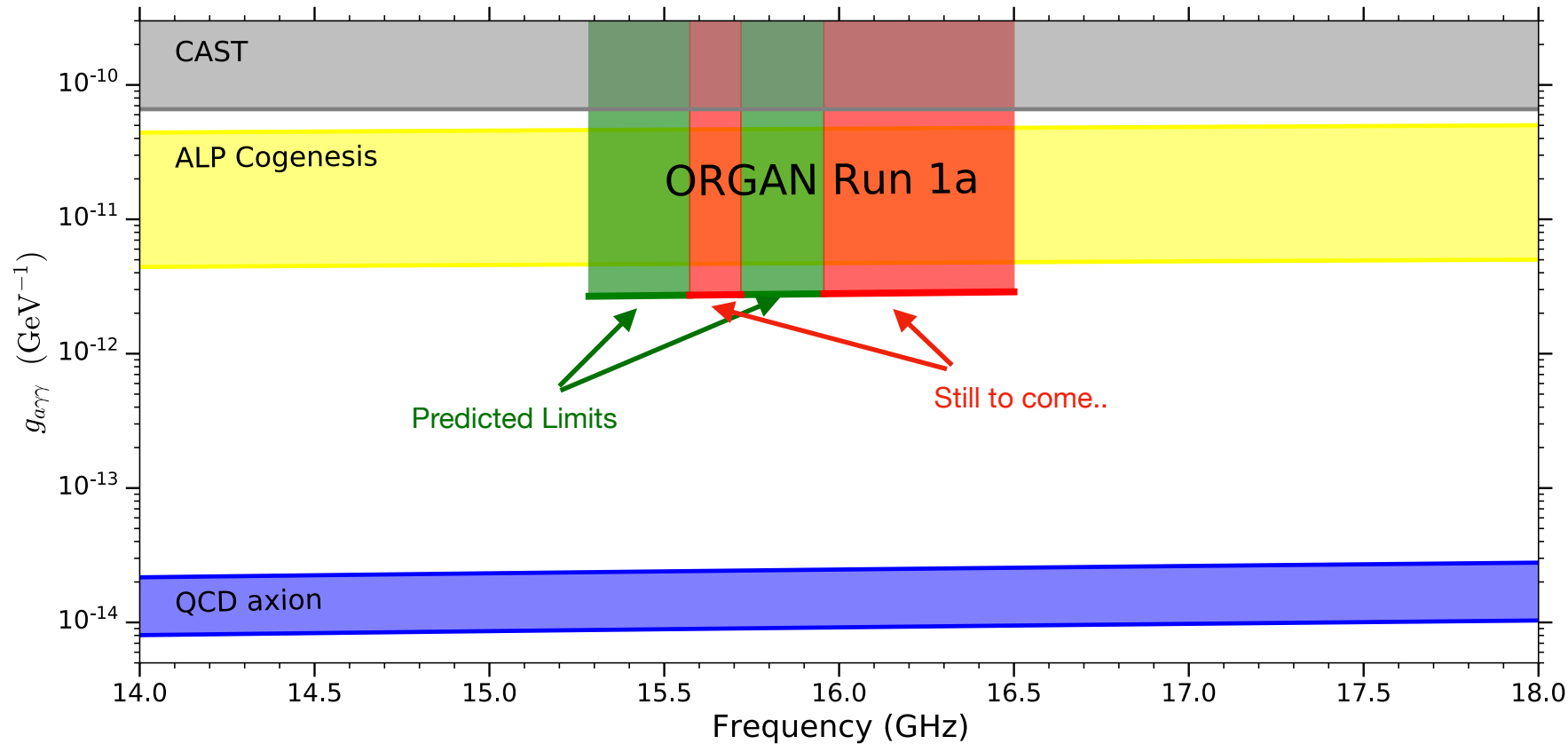
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ORGAN: Phase 1a

- On track for most sensitive limits in the region
- Green - data taken, limits based on preliminary analysis
- Red - cavity in fridge now



ORGAN: Phase 1b

- Expected to commence late 2021
- Currently prototyping dielectric wedge resonator

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ORGAN: Phase 2

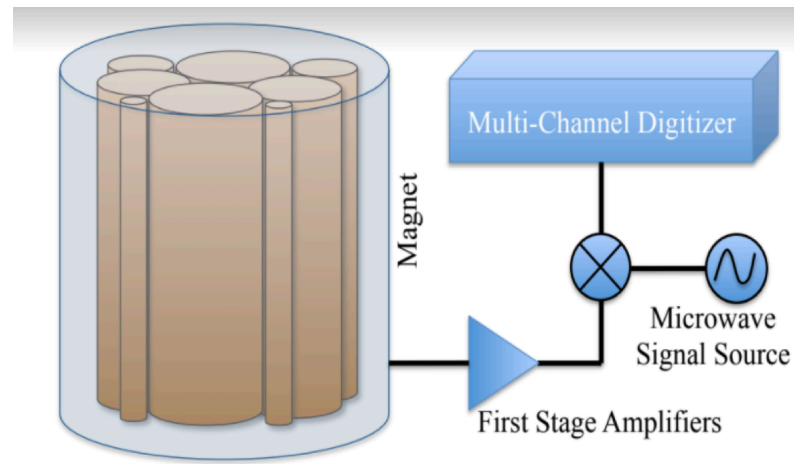
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Conclusion

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 - High mass axion haloscope (15+ GHz)
- Run Plans
 - Phase 1a commenced 2021
 - Limits coming soon
- Two phases
 - Short, targeted scans with existing equipment
 - Longer, broader scans with new technology
- Quantum Sensors
 - Testing a few SPC concepts for integration
 - Will be employed (if successful) during Phase 2
 - Possibility to quickly re-scan Phase 1a region