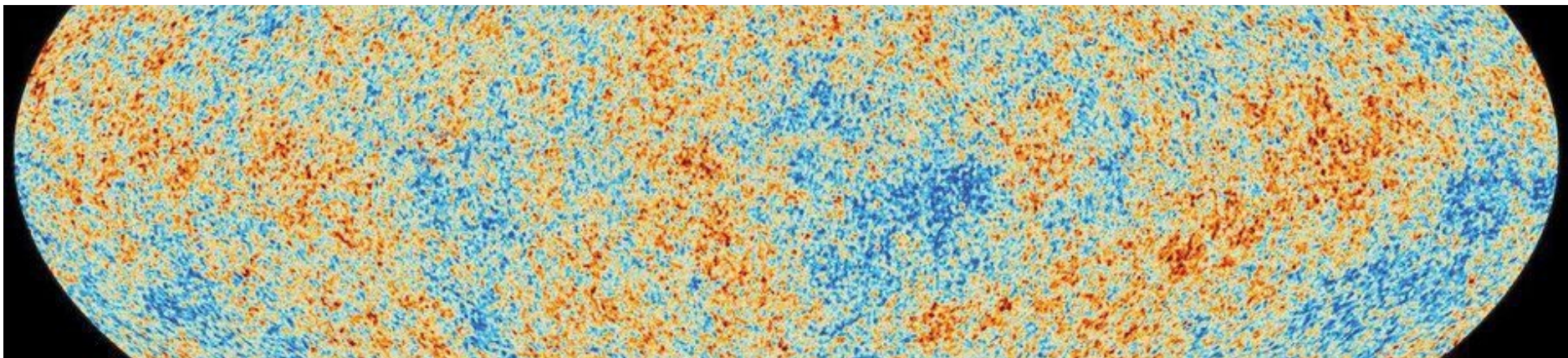
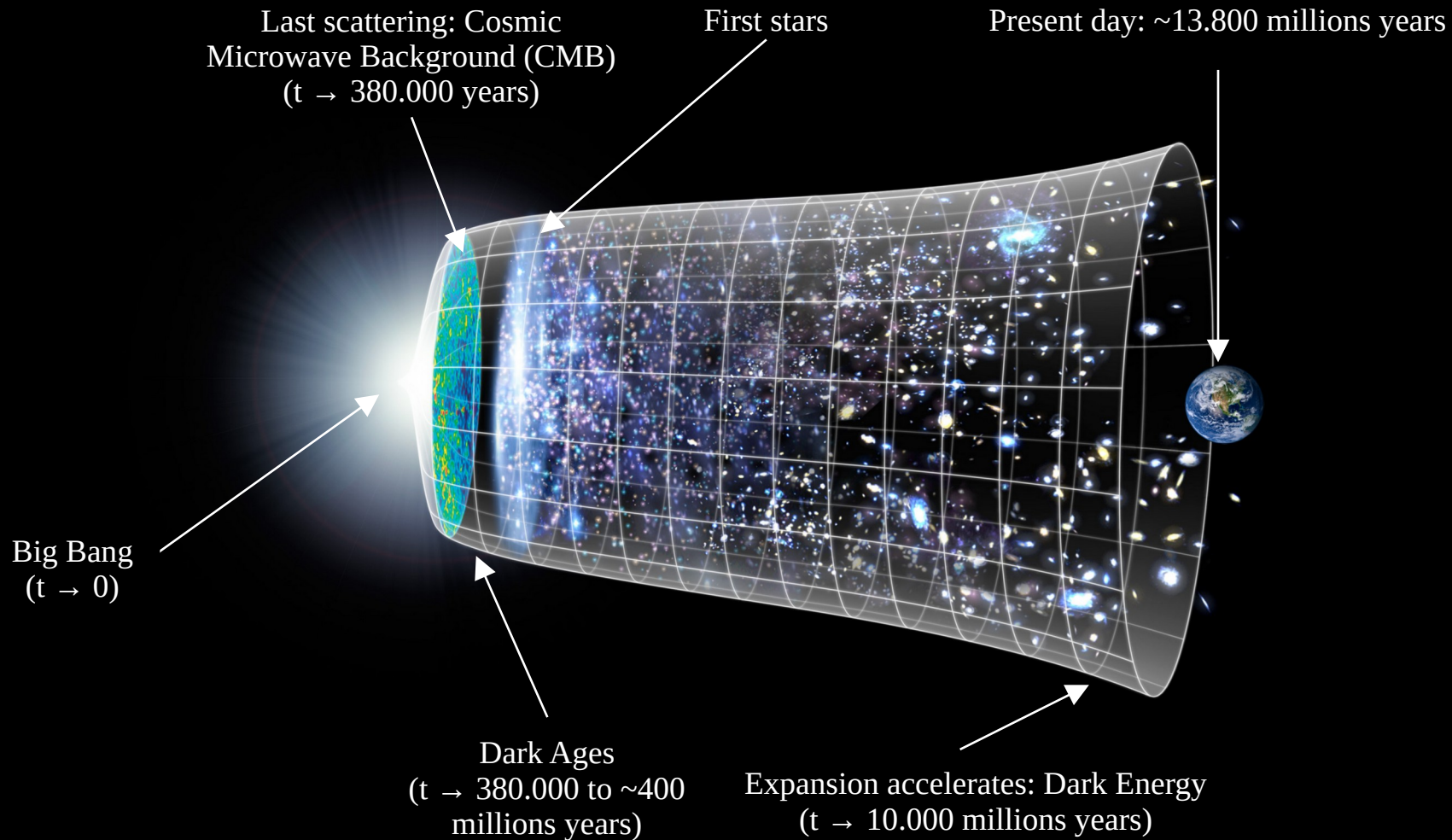


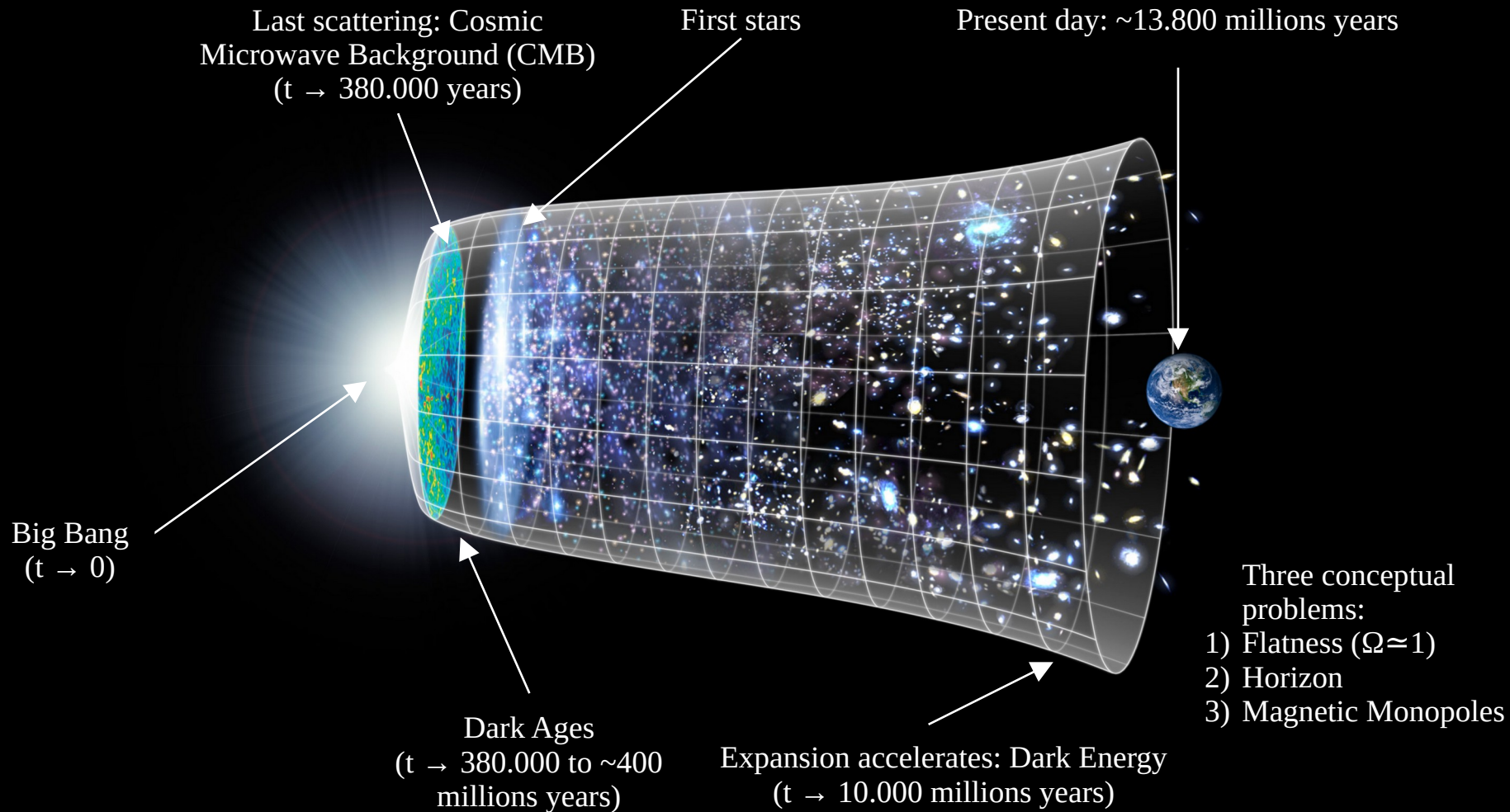
QUBIC: an instrument for unraveling the Universe's origin

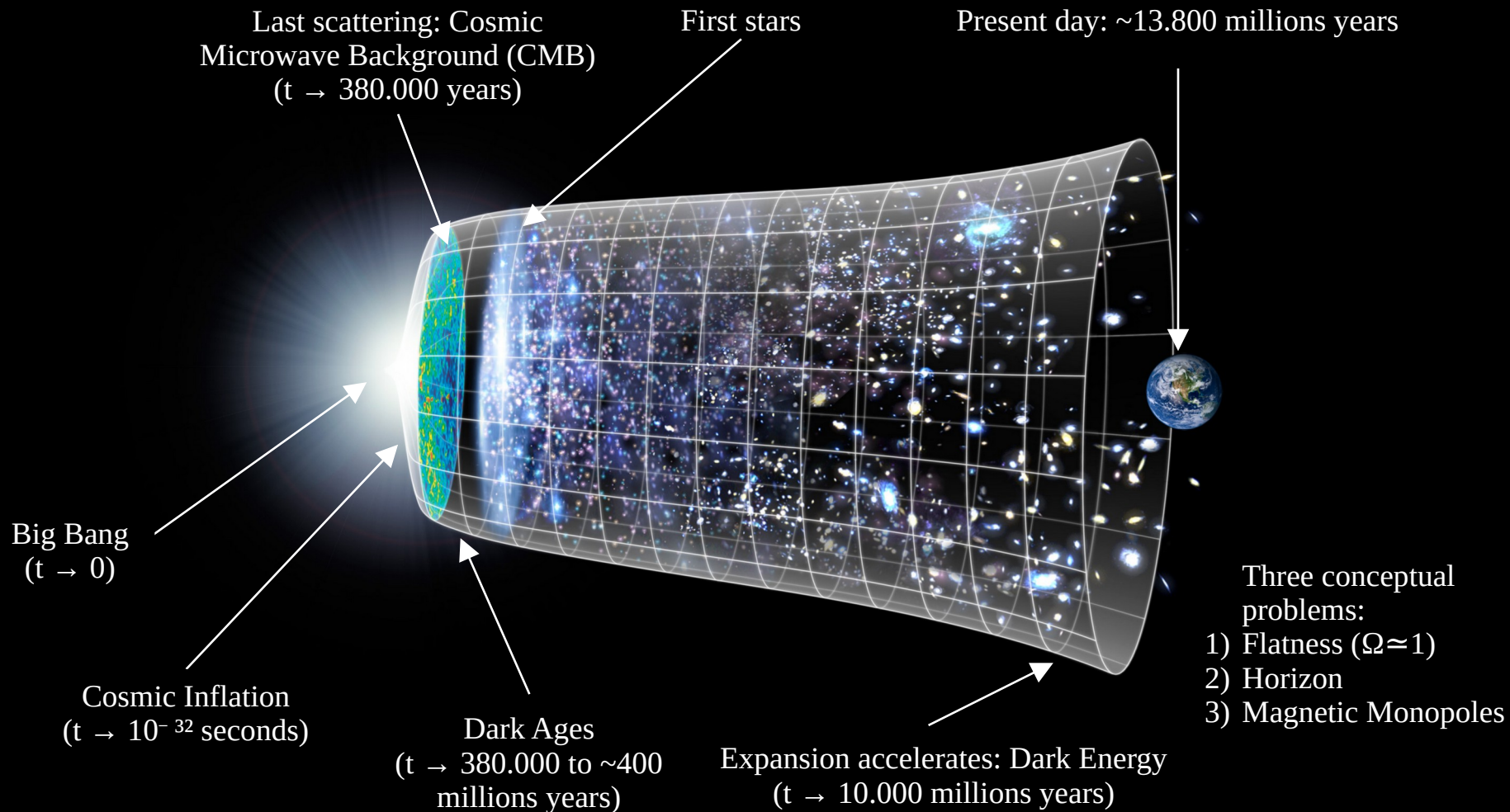
Annual Meeting of DDAp/DDEIT and HIRSAP 2025

Luciano Ferreyro | 14. November 2025

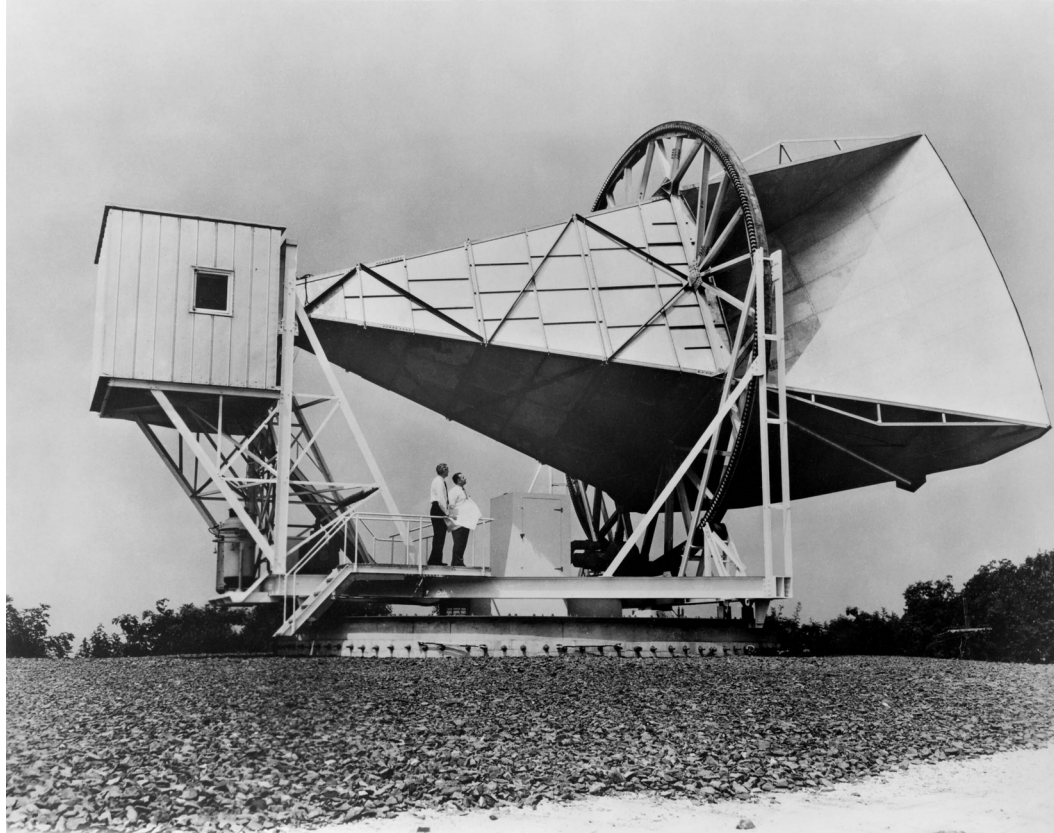








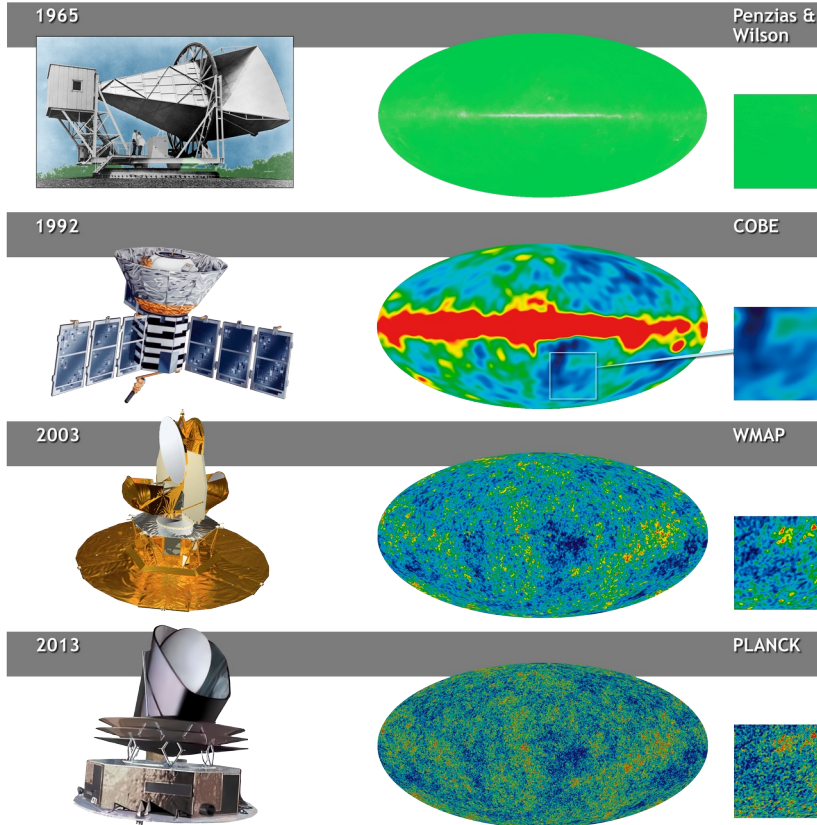
Introduction



Introduction



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Introduction



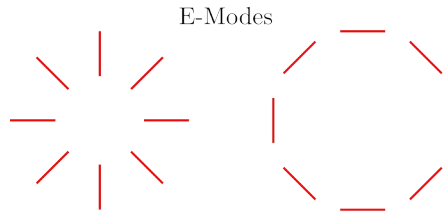
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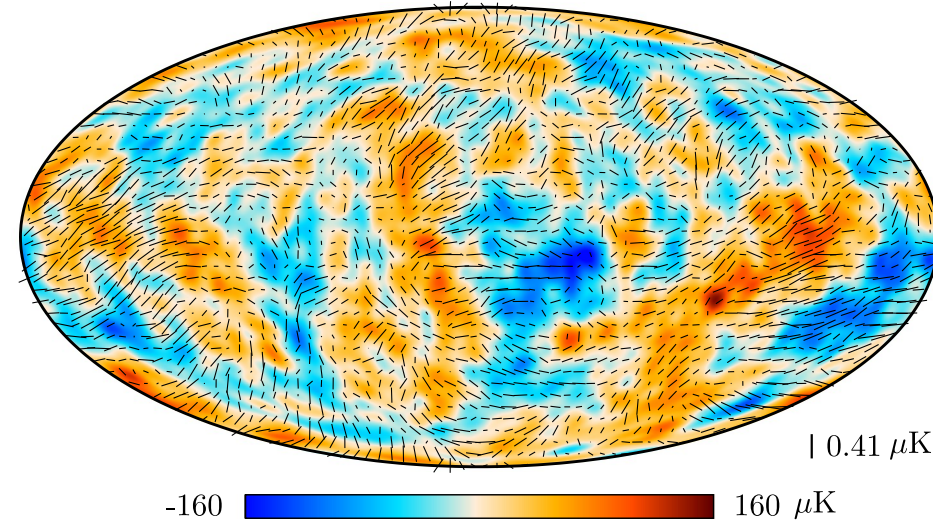
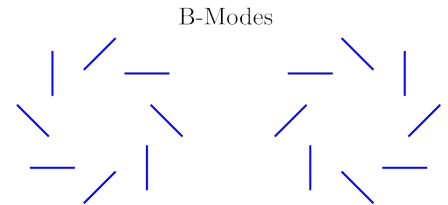
Scalar perturbations (density) → Produces temp. anisotropies and E-modes polarization

Tensorial perturbations (gravitational waves) → Produces both E-modes and B-modes polarization

Gradient-like pattern
(like an Electric field)



Curl-like pattern (like
an Magnetic field)



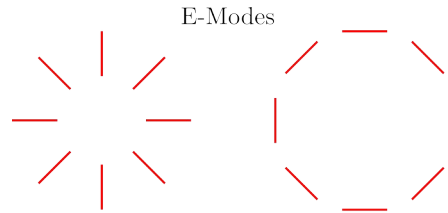
Introduction



Scalar perturbations (density) → Produces temp. anisotropies and E-modes polarization

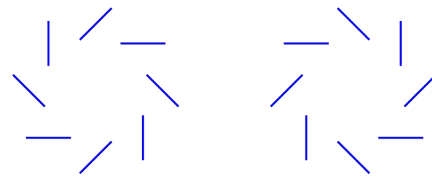
Tensorial perturbations (gravitational waves) → Produces both E-modes and B-modes polarization

Gradient-like pattern
(like an Electric field)

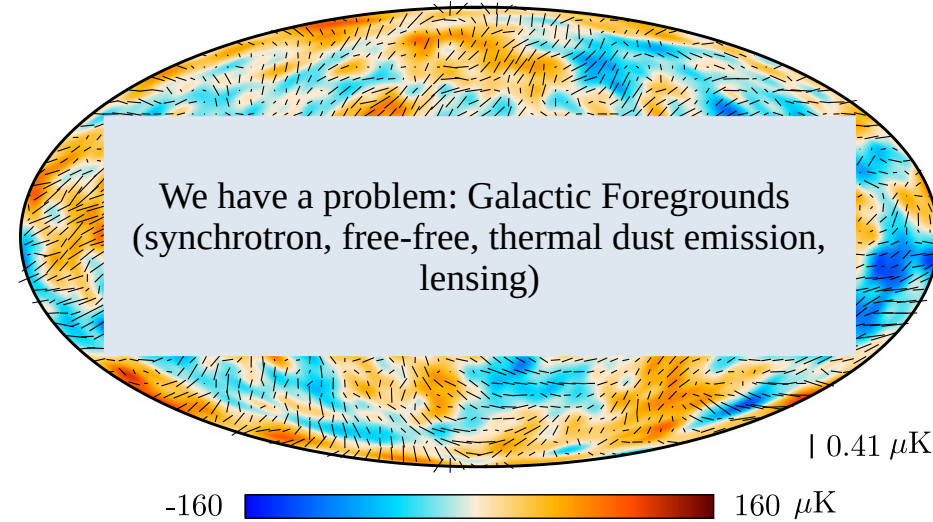


E-Modes

Curl-like pattern (like
an Magnetic field)



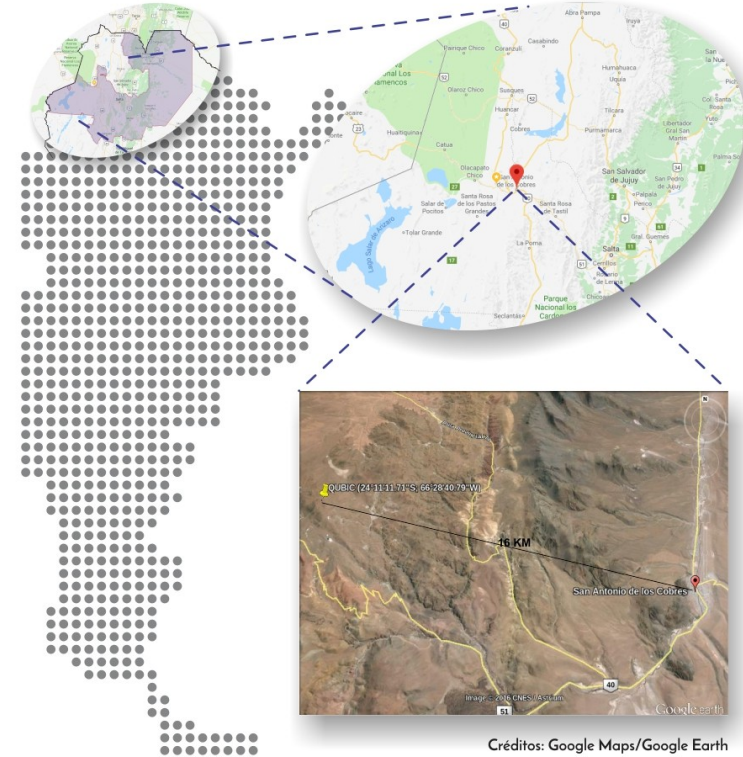
B-Modes



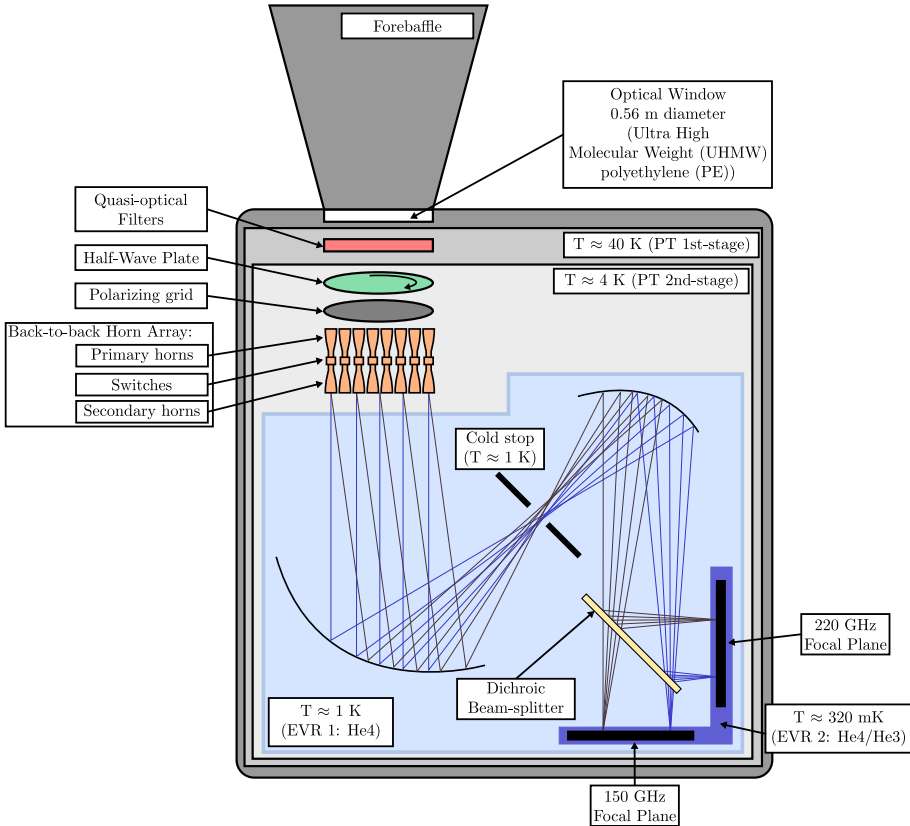
Q&U Bolometric Interferometer for Cosmology



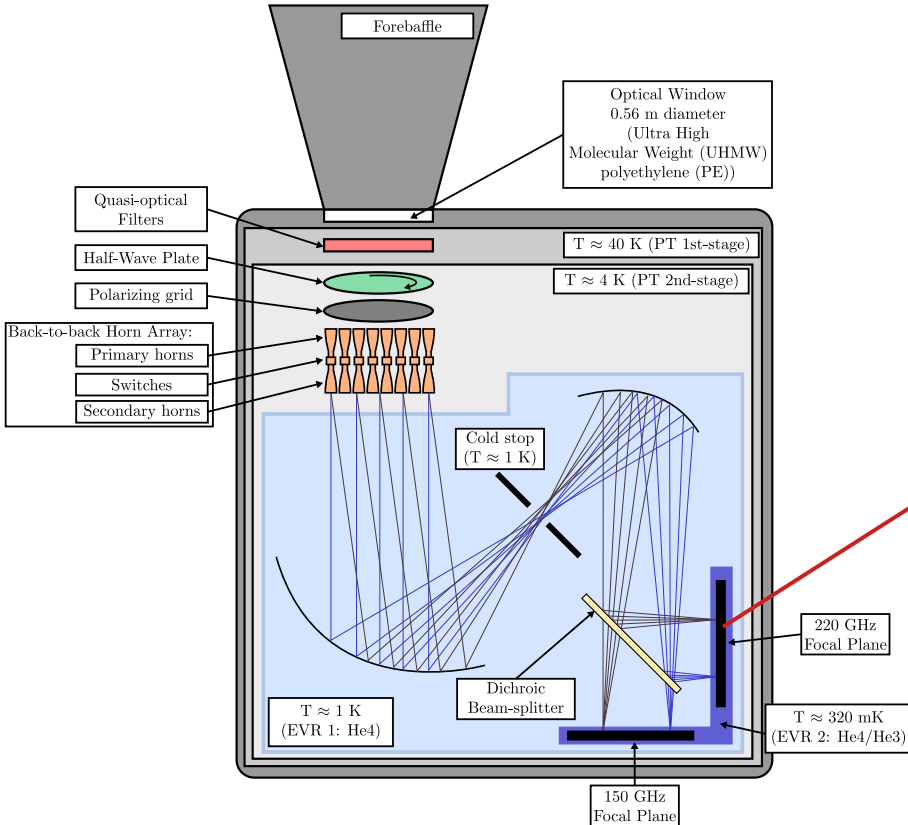
Location: Altos Chorrillos, Argentina (~ 4.820 m.a.s.l.)



The QUBIC Instrument

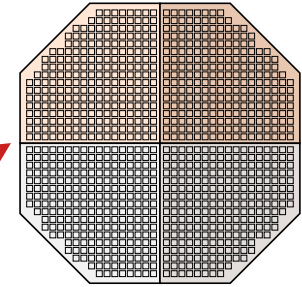


The QUBIC Instrument

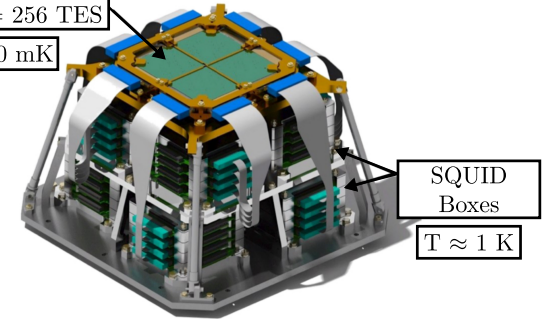


QUBIC Focal Plane

- 1024 pixels
- 992 exposed
- 32 used for systematics

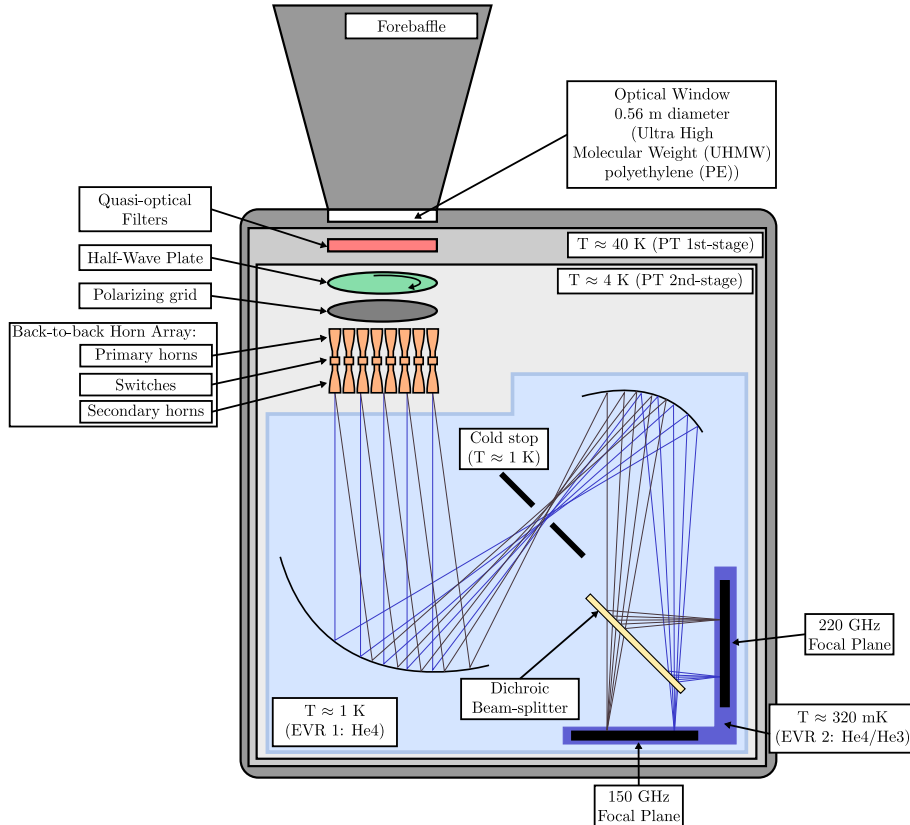


One quarter of focal plane.
 One wafer = 256 TES
 $T \approx 320$ mK



The QUBIC Instrument

Dichroic beam-splitter → Major technological challenge (*cannot be built*)



The QUBIC Instrument

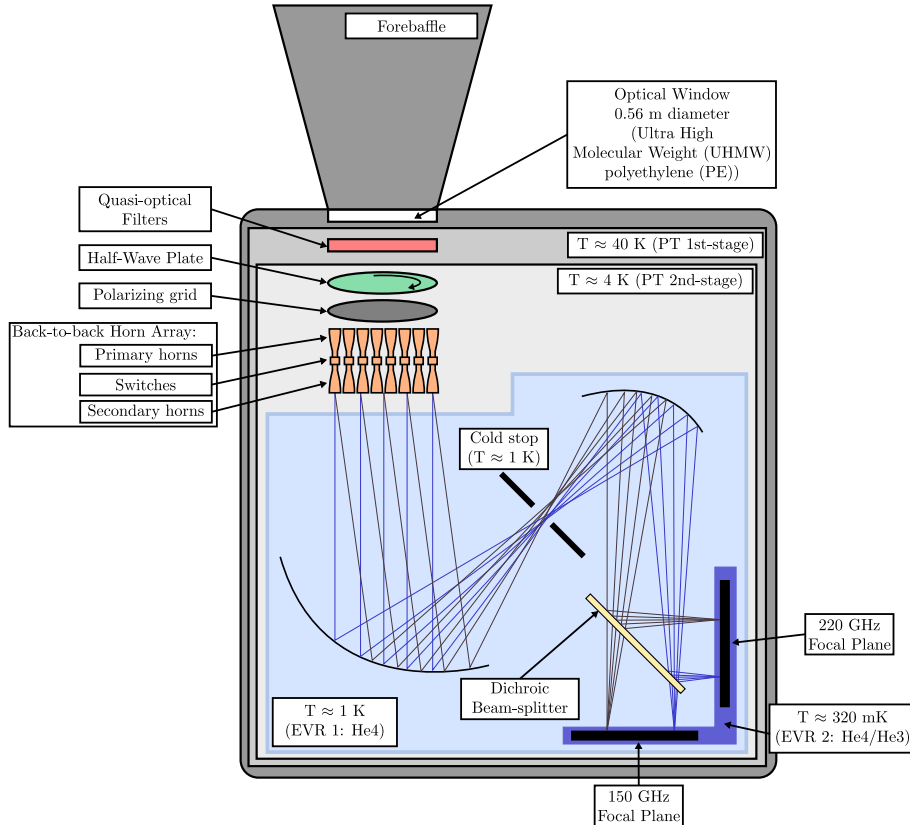


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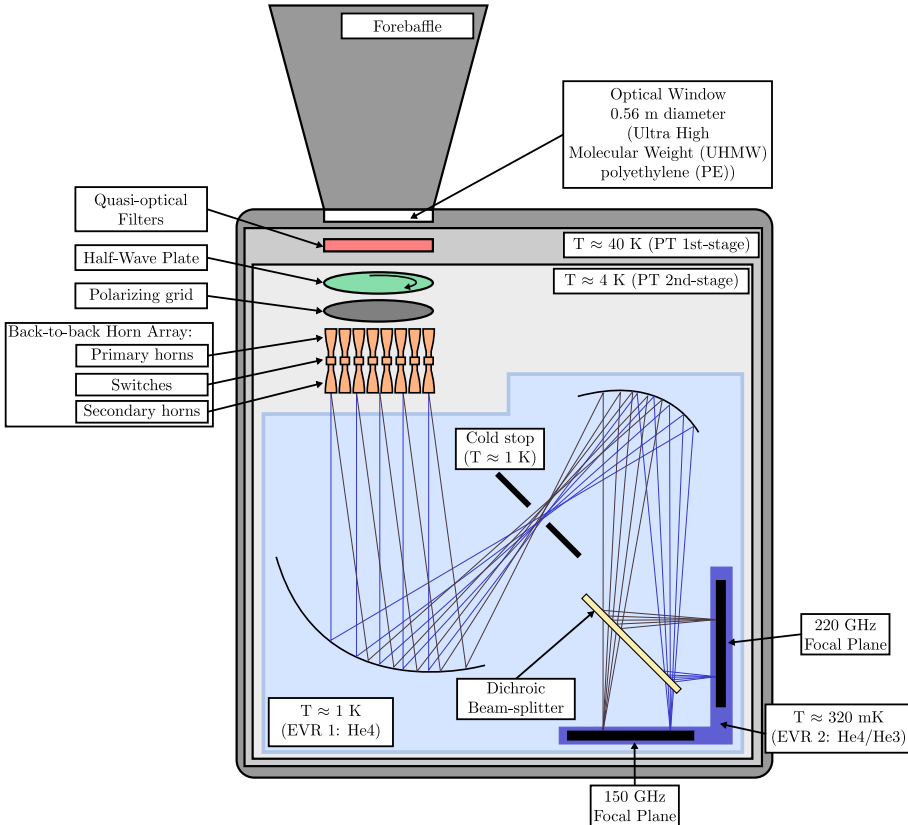


Dichroic beam-splitter → Major technological challenge (*cannot be built*)

Multiband not possible



The QUBIC Instrument

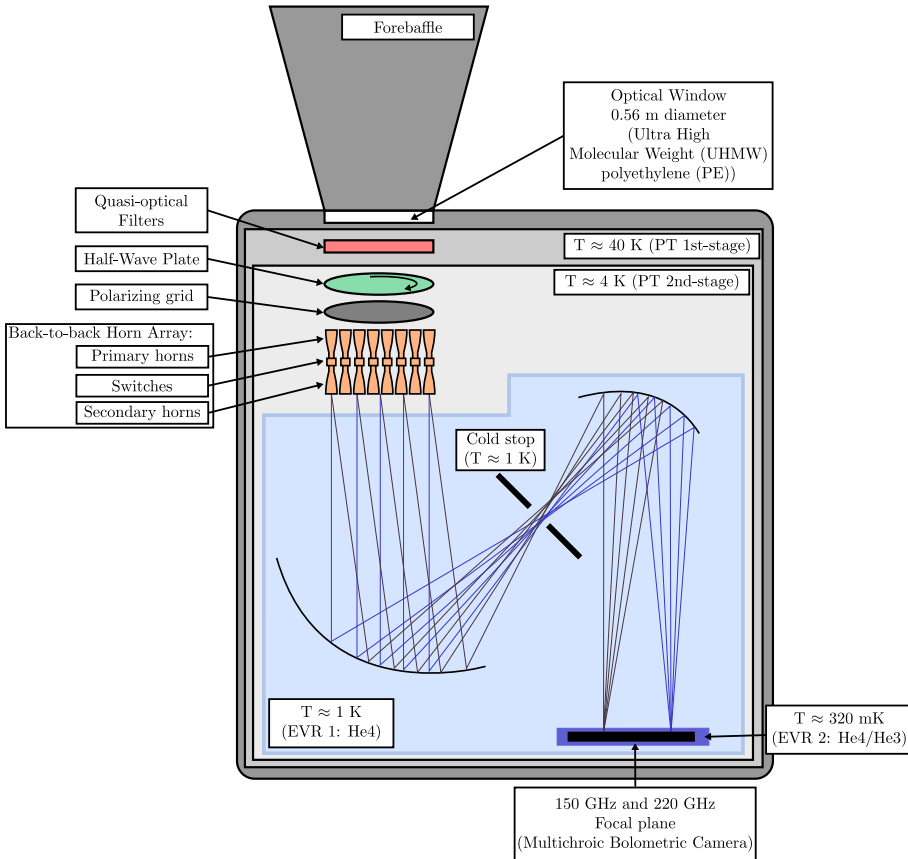


Dichroic beam-splitter → Major technological challenge (*cannot be built*)

Multiband not possible

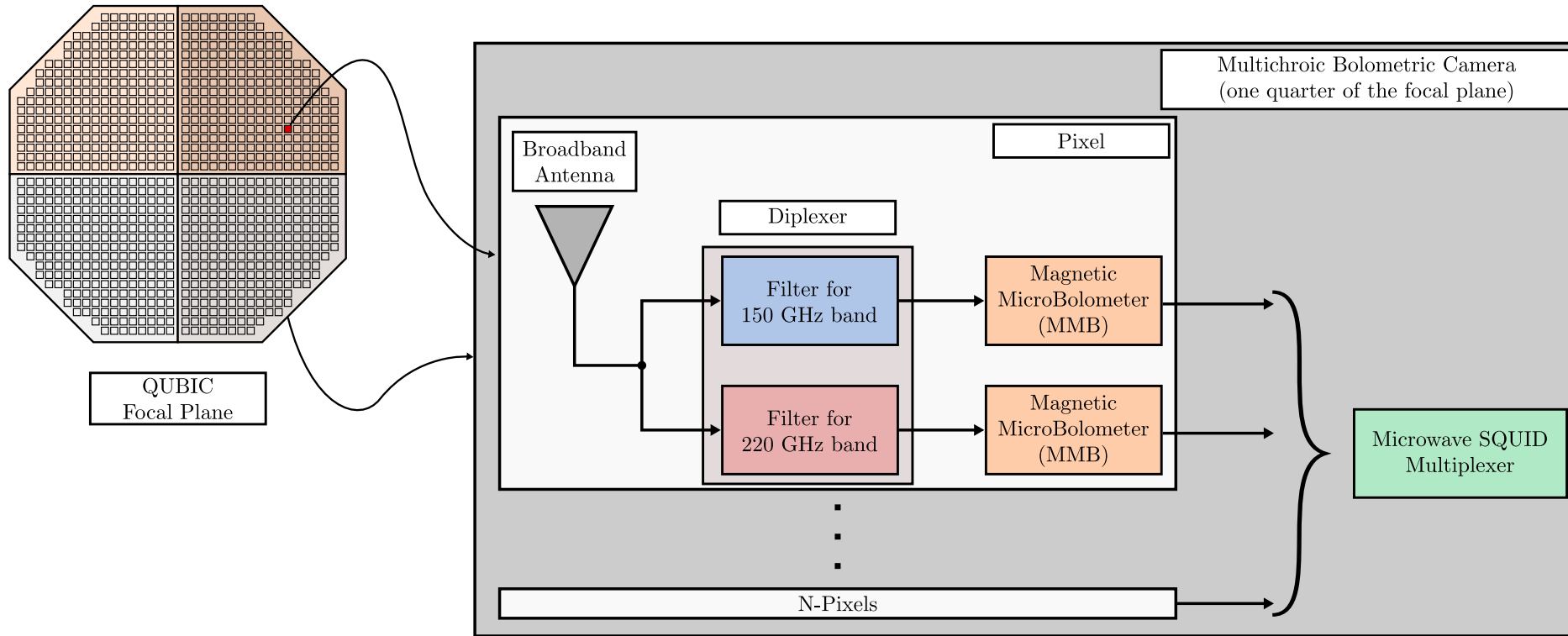


The QUBIC Instrument - Proposal

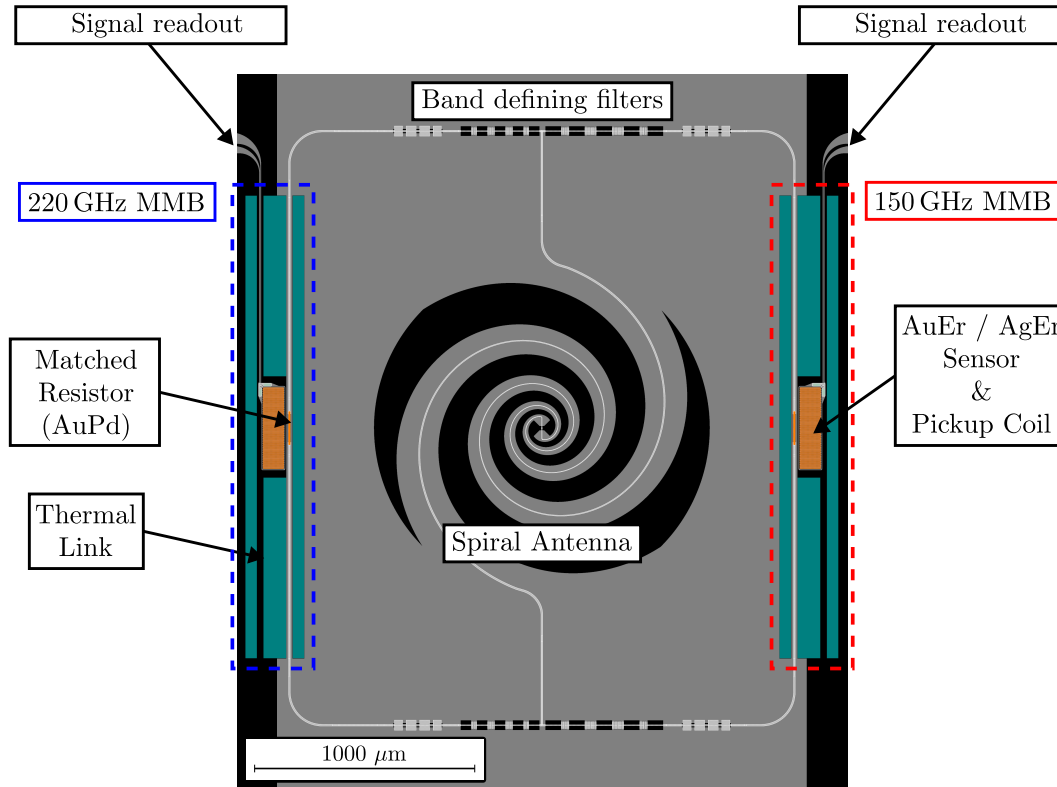


Multichroic bolometric camera

Multichroic Bolometric Camera



Multichroic Pixel



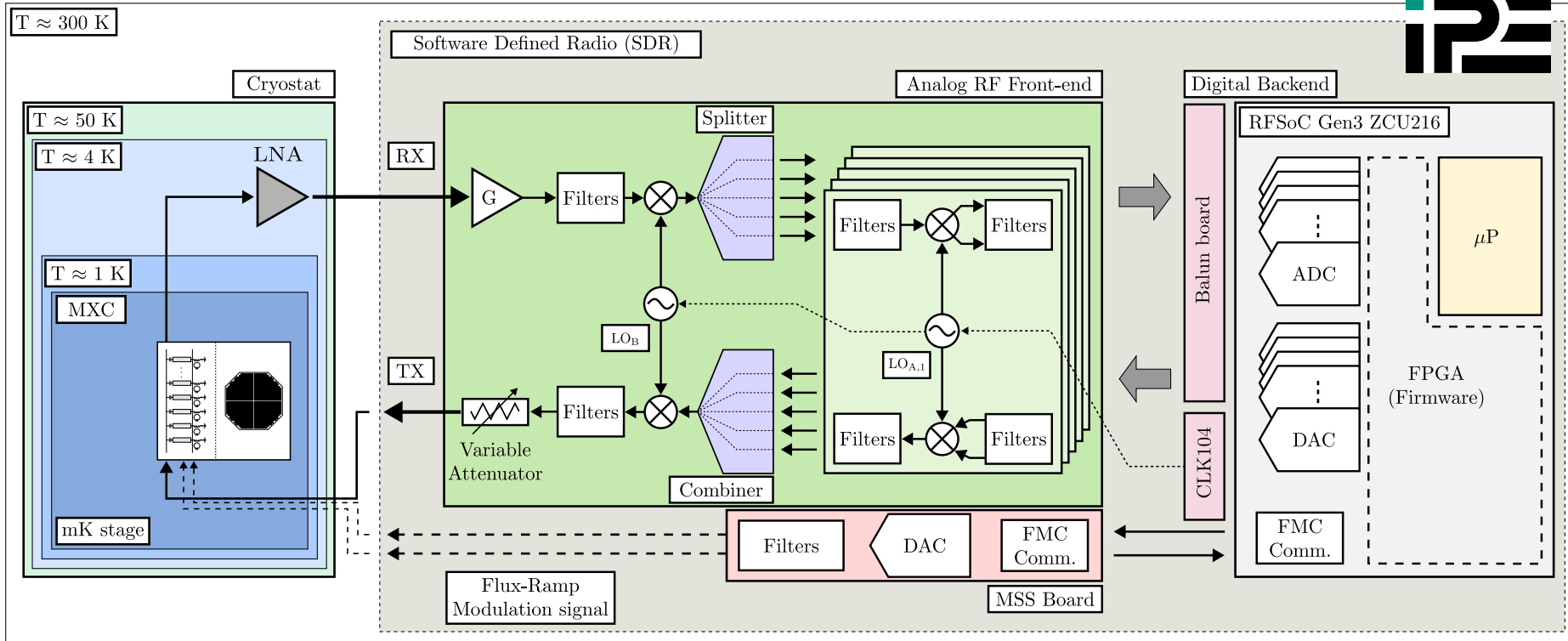
New detector:
Magnetic Microbolometer (MMB)



The Software Defined Radio



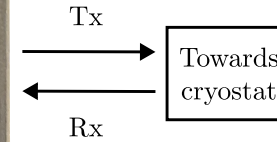
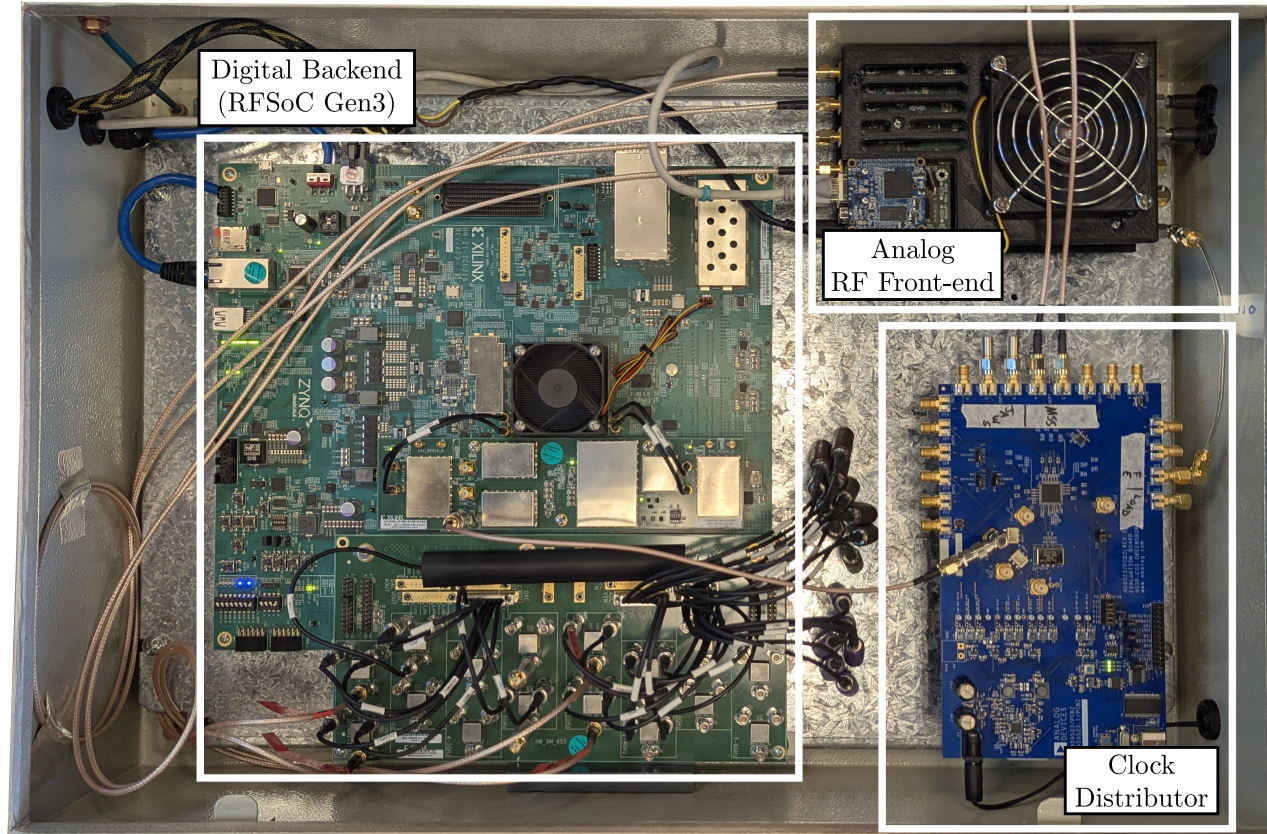
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The Software Defined Radio



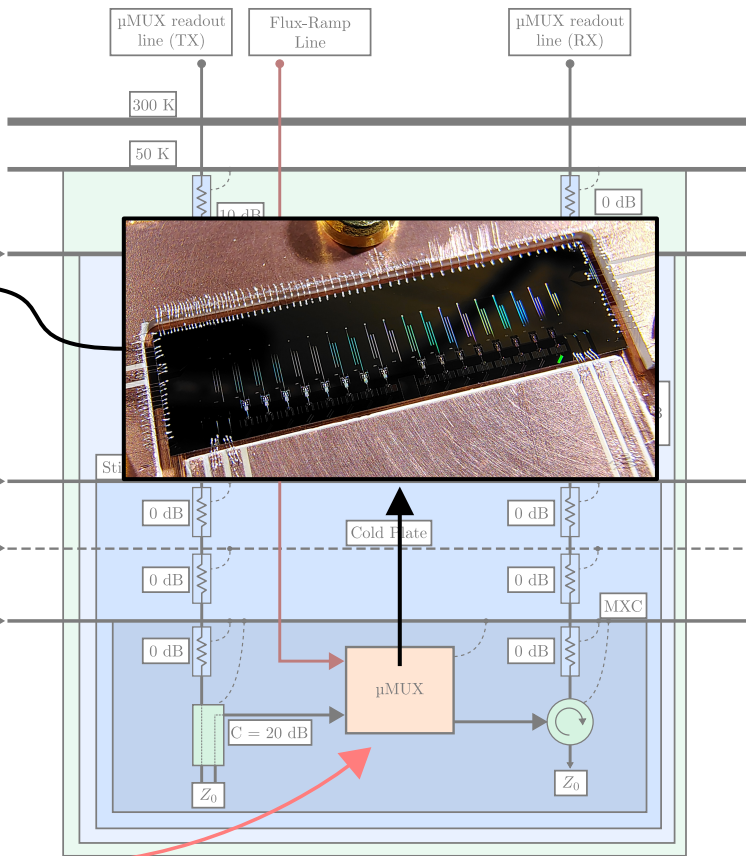
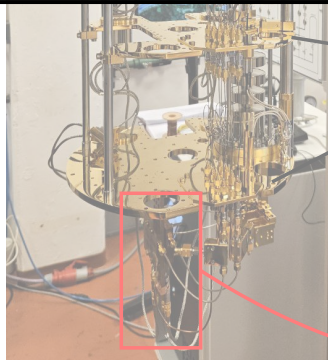
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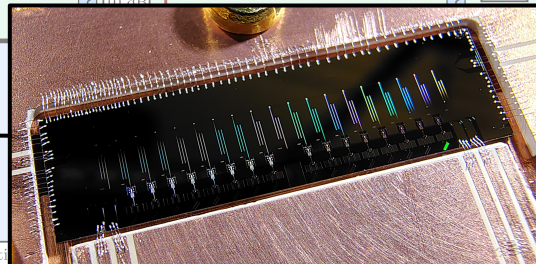
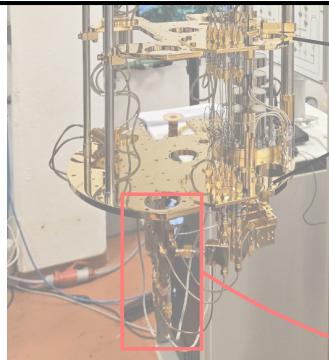


Clock distributor:

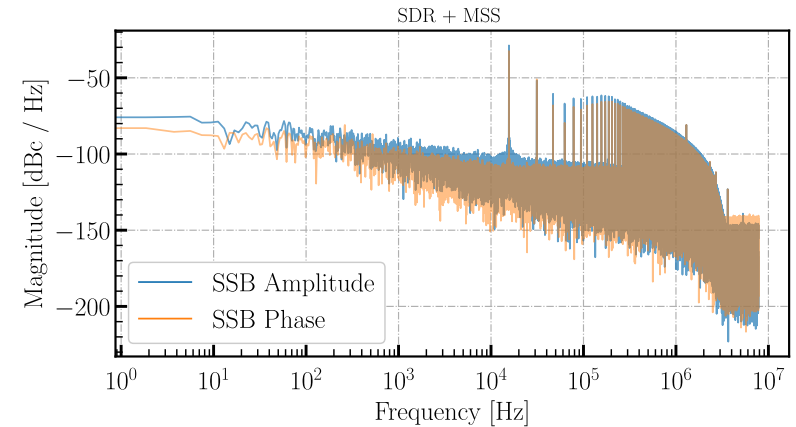
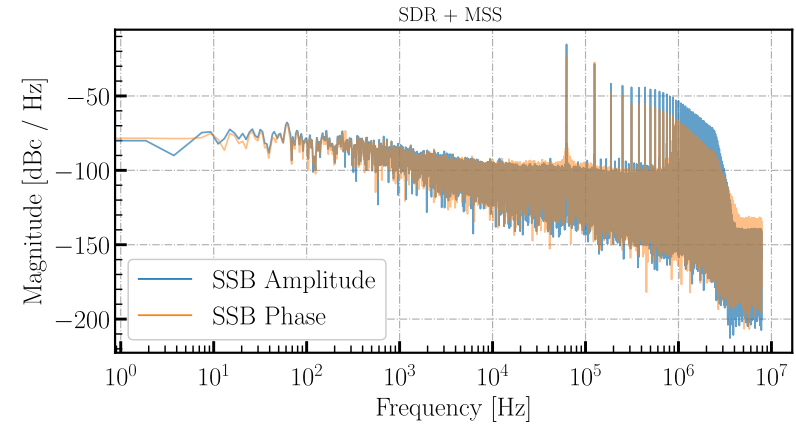
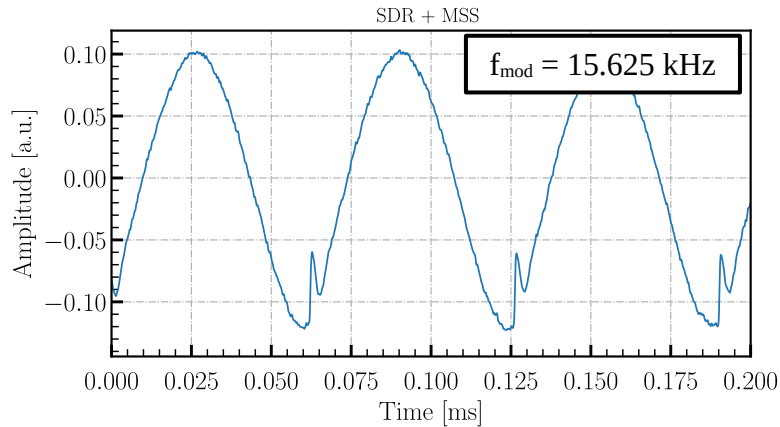
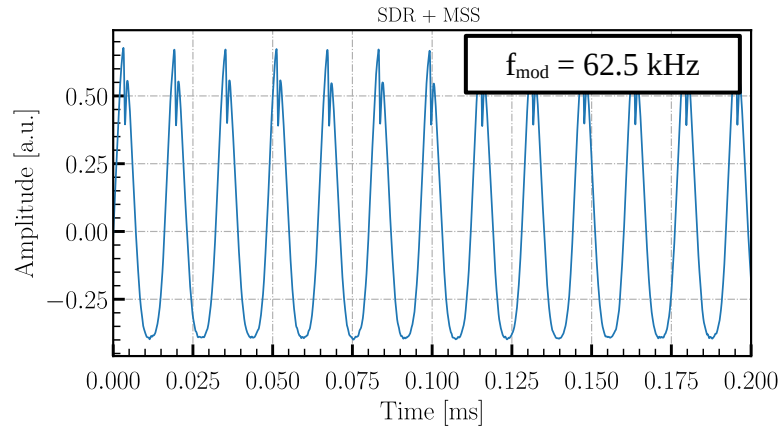
- Used for synchronize external devices with the SDR



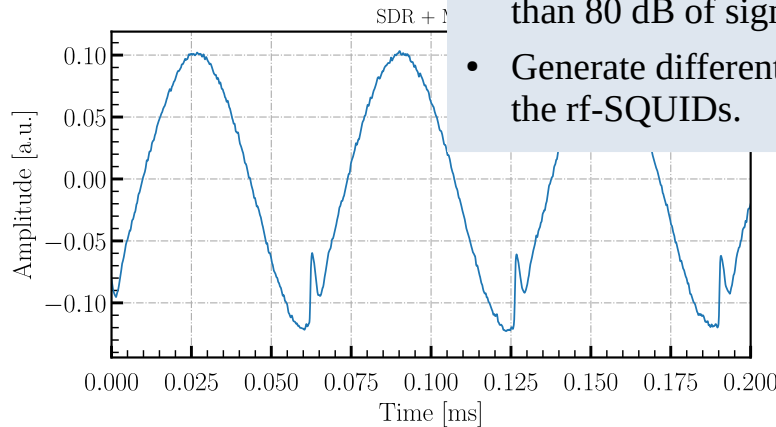
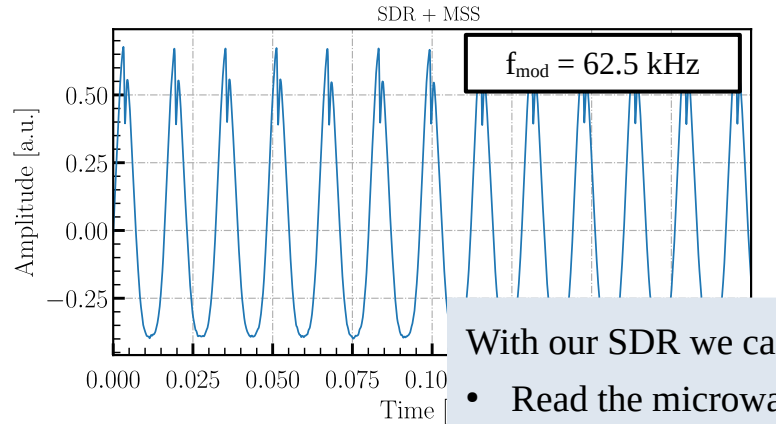




Last results with our complete setup

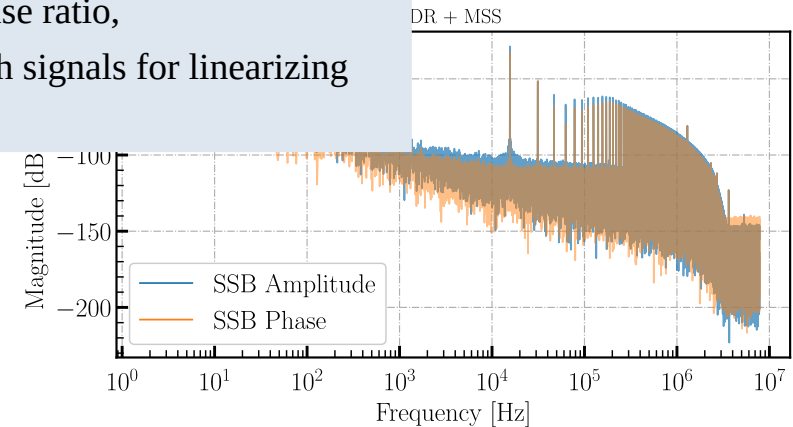
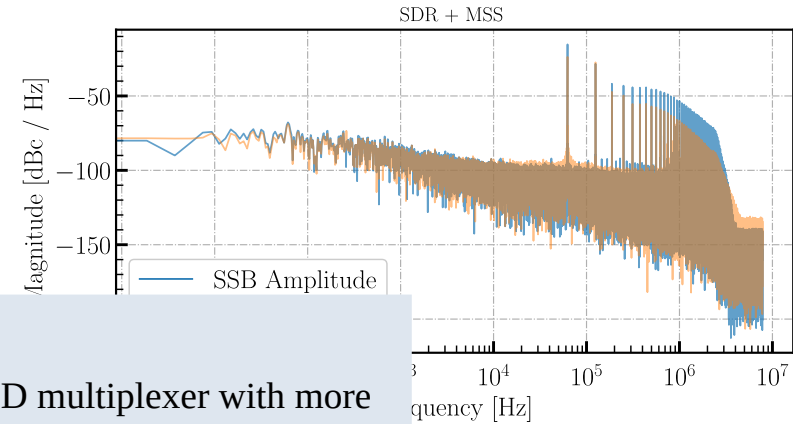


Last results with our complete setup



With our SDR we can:

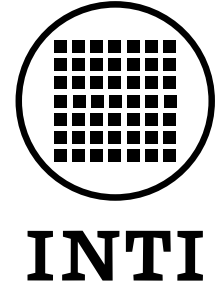
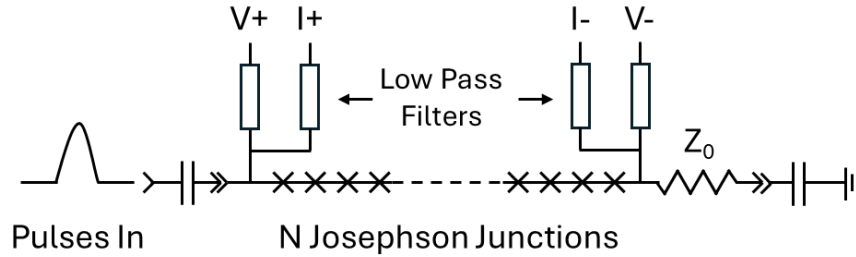
- Read the microwave SQUID multiplexer with more than 80 dB of signal-to-noise ratio,
- Generate different sawtooth signals for linearizing the rf-SQUIDs.



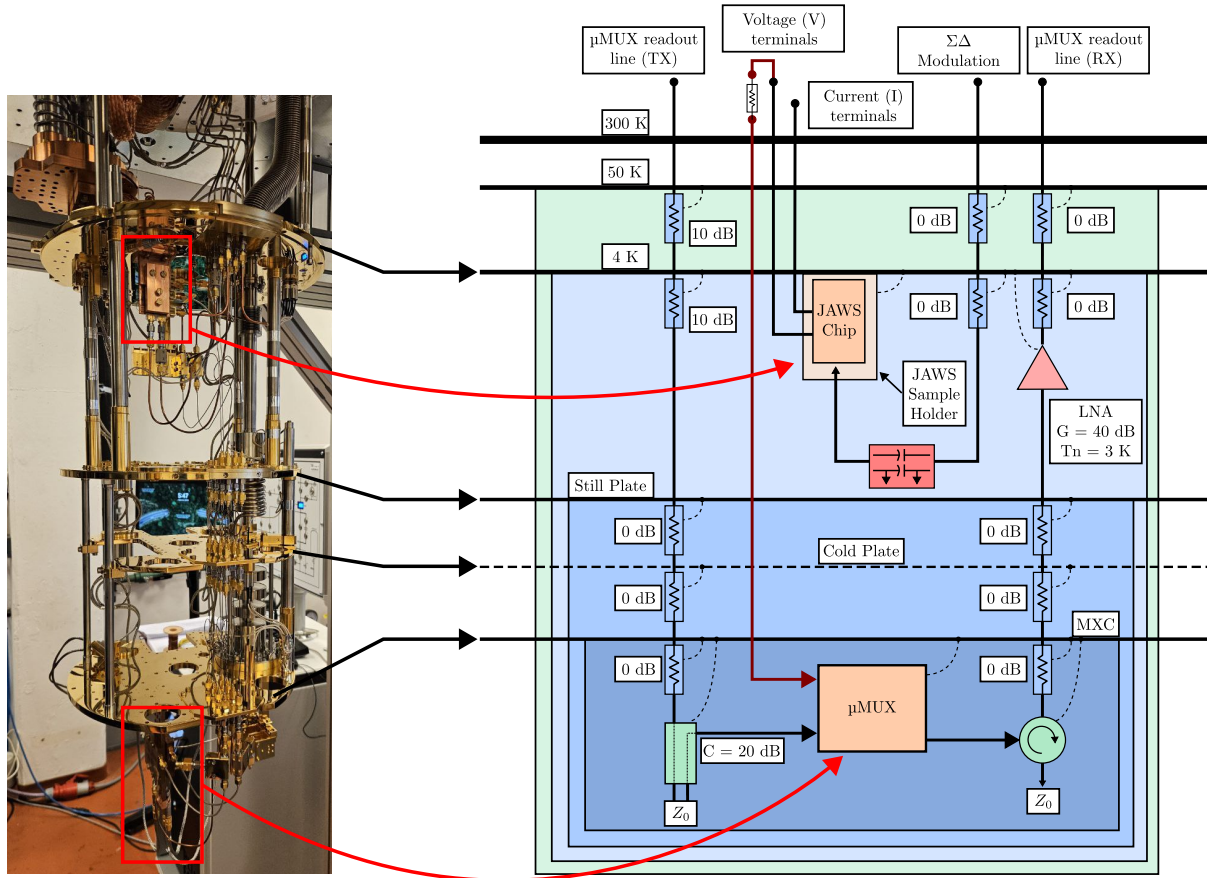
Josephson Arbitrary Waveform Synthesizer



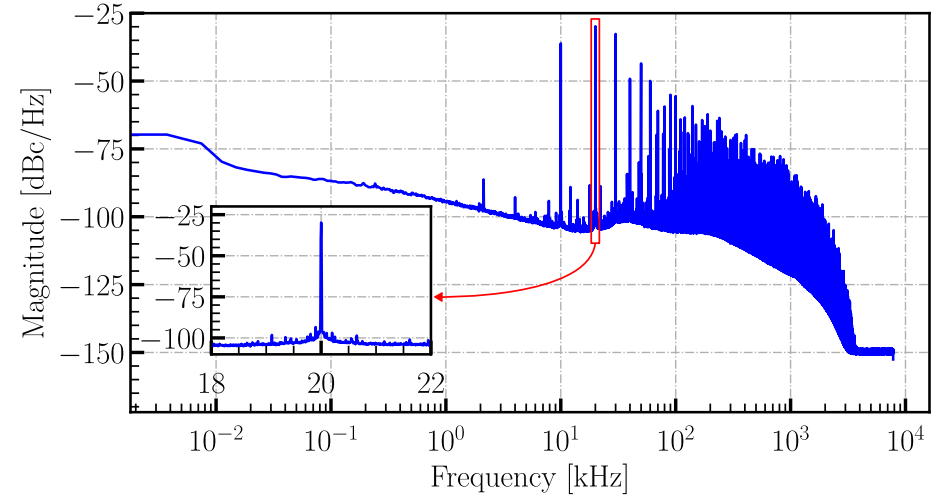
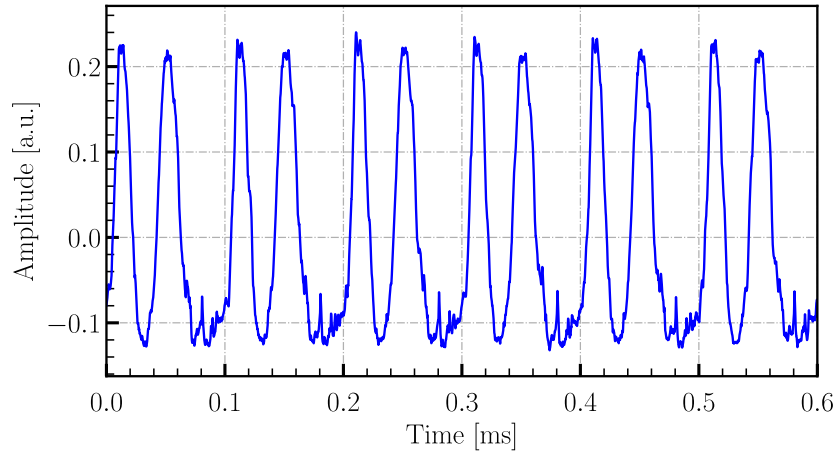
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Josephson Arbitrary Waveform Synthesizer

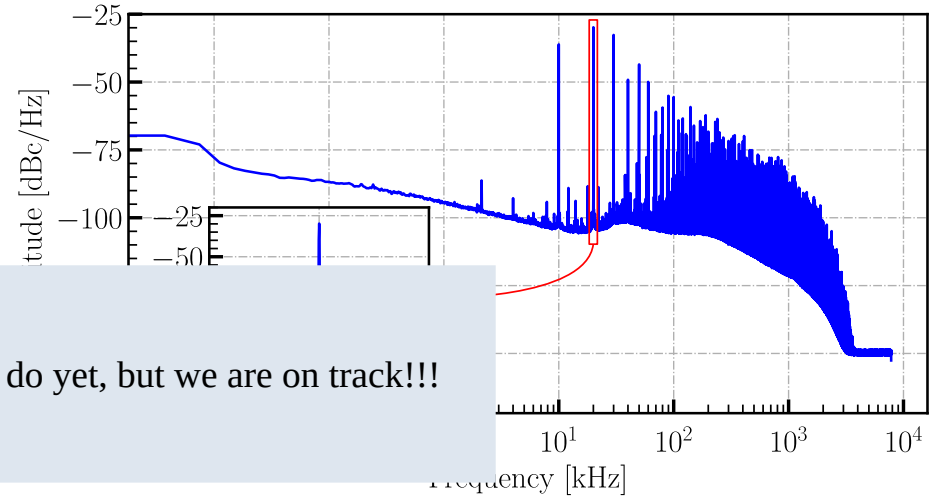
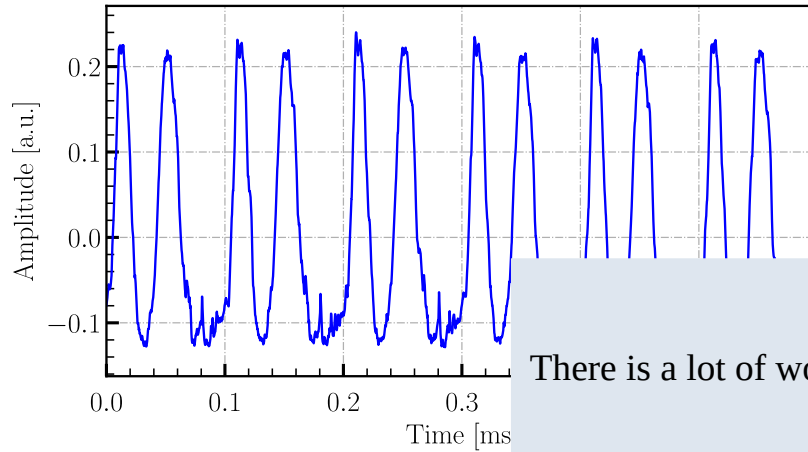


Josephson Arbitrary Waveform Synthesizer



- We were able to generate a sawtooth signal of 20 kHz (highlighted in red),
- A signal-to-noise ratio of more than 70 dB was achieved.

Josephson Arbitrary Waveform Synthesizer



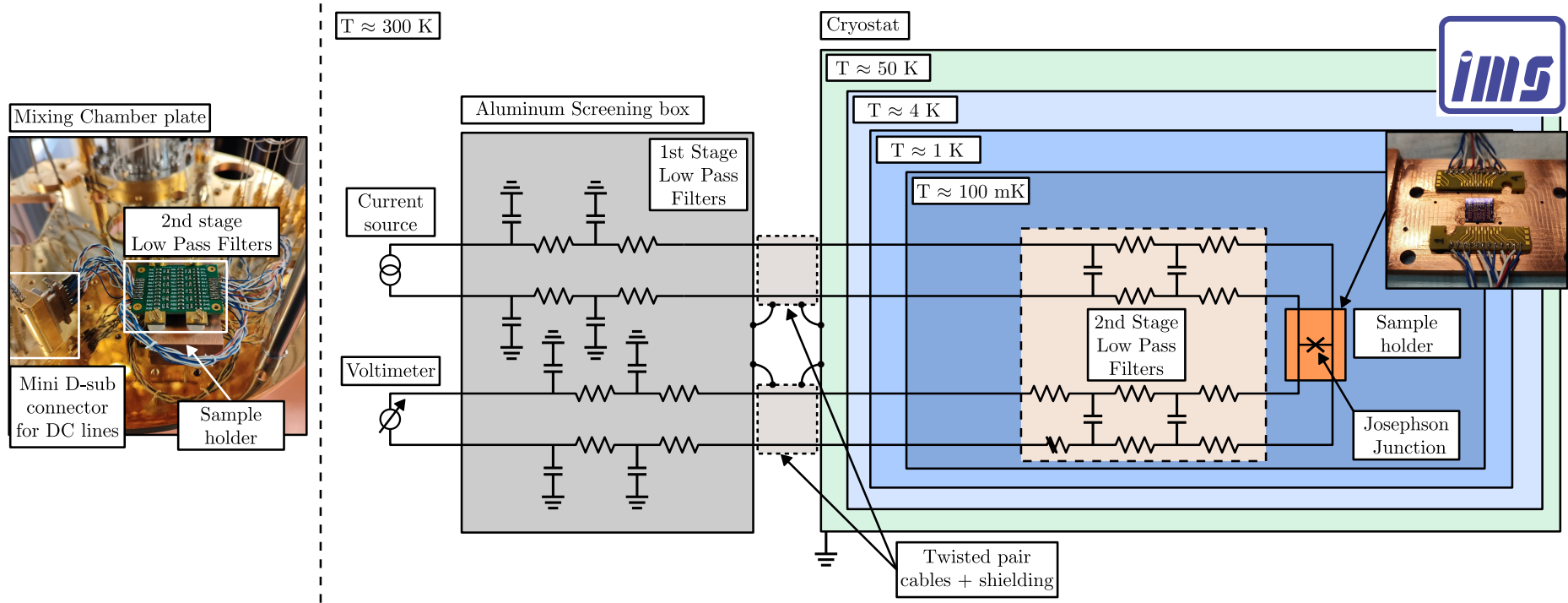
There is a lot of work to do yet, but we are on track!!!

- We were able to generate a sawtooth signal of 20 kHz (highlighted in red),
- A signal-to-noise ratio of more than 70 dB was achieved.

Josephson Junctions: characterization setup



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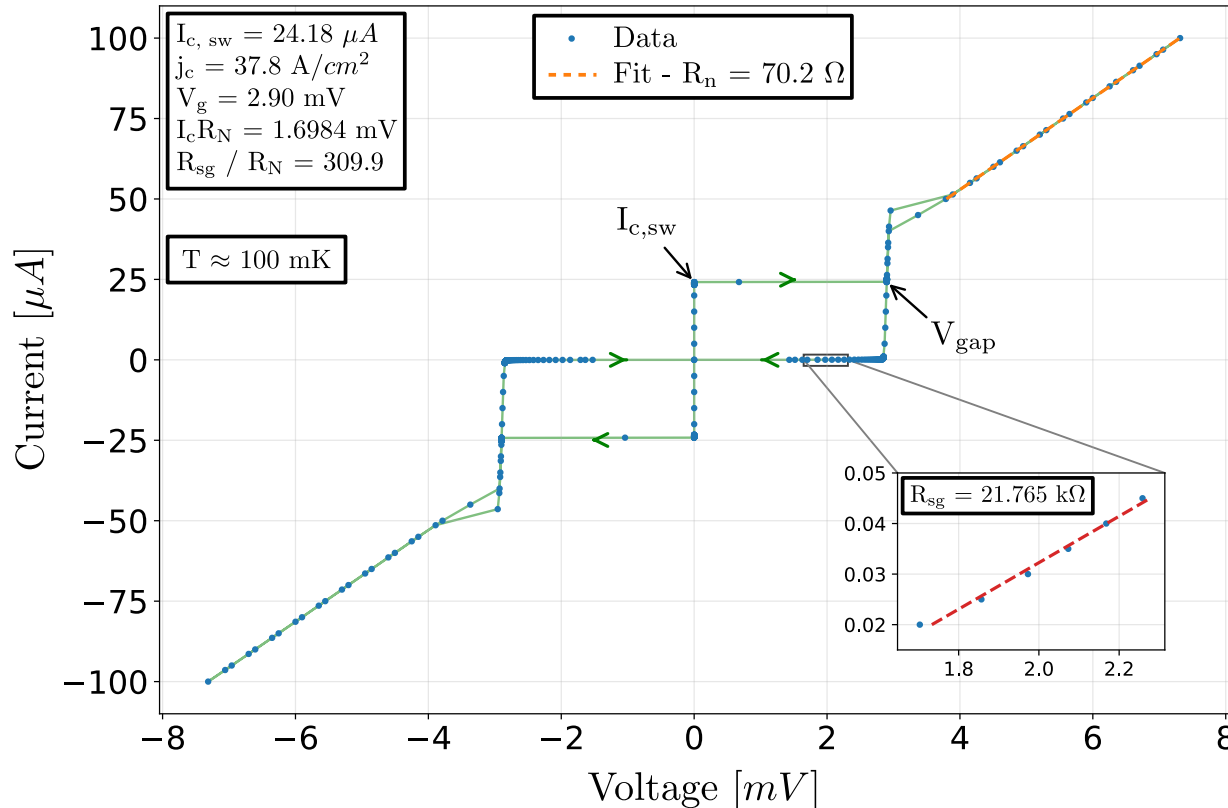
Josephson Junctions: first measurements



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Josephson Junction I-V Curve

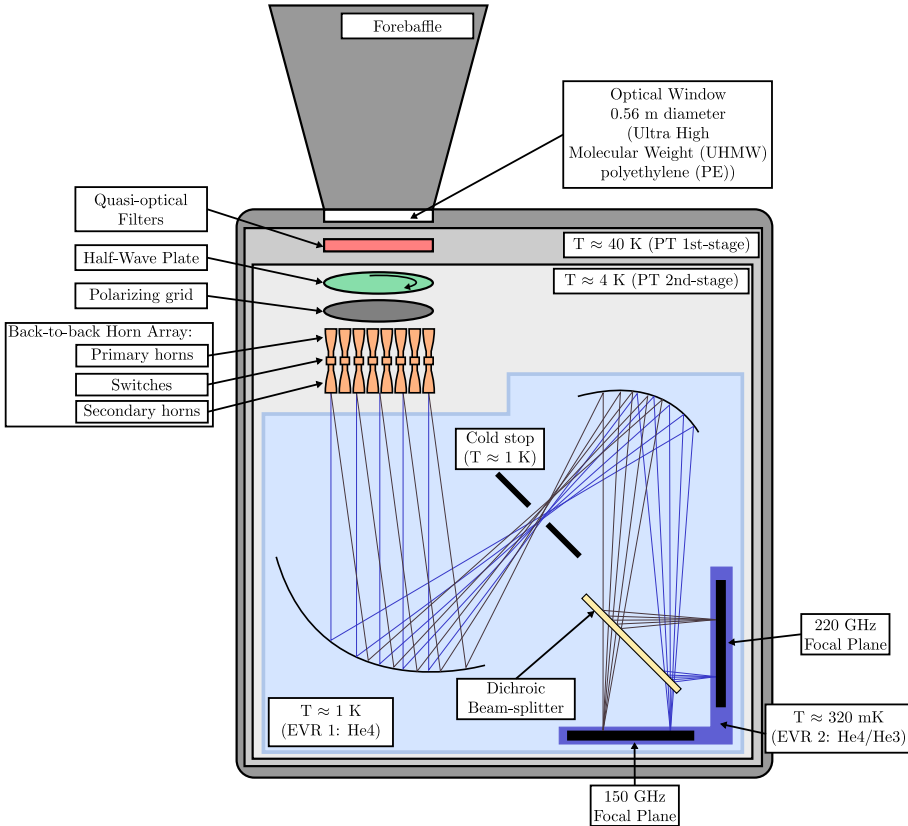


Thank you!
Vielen Danke!
¡Gracias!



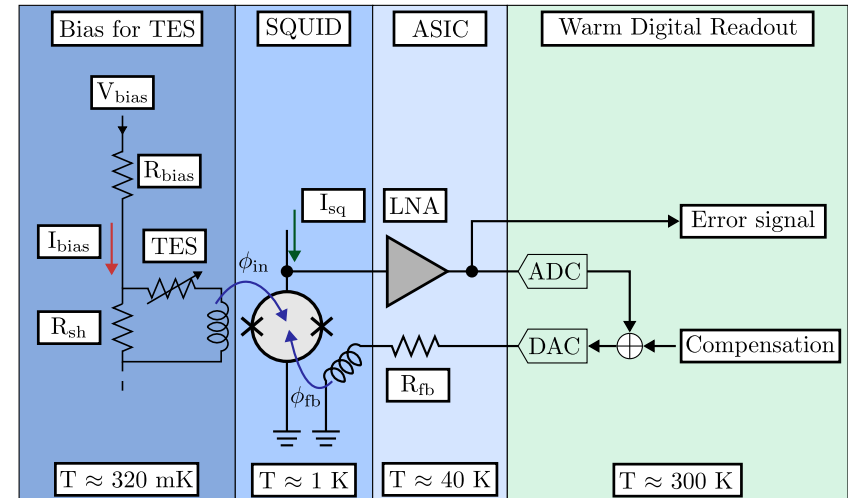
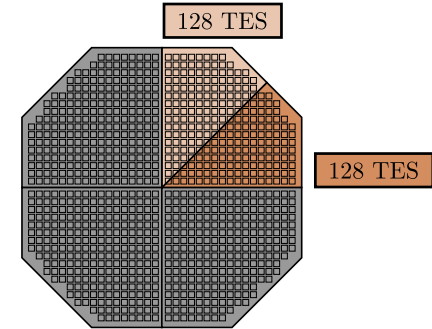
Back - Up

The QUBIC Instrument



QUBIC Focal Plane

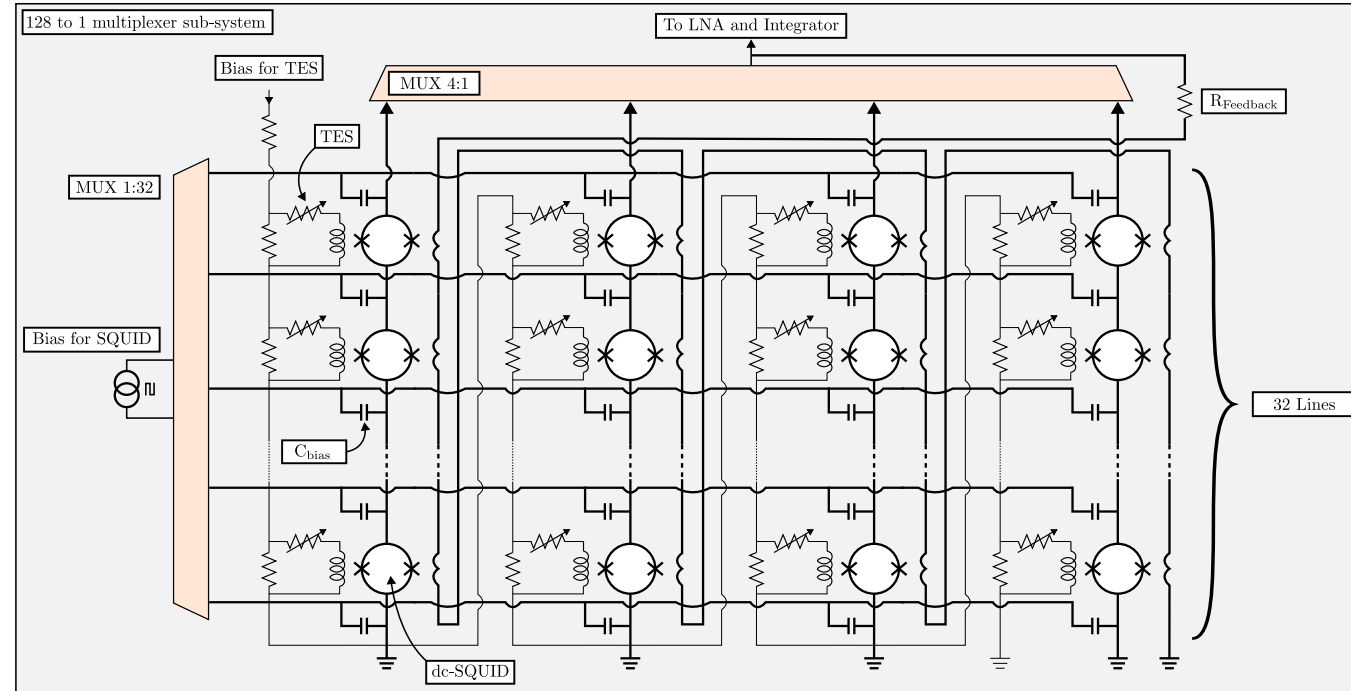
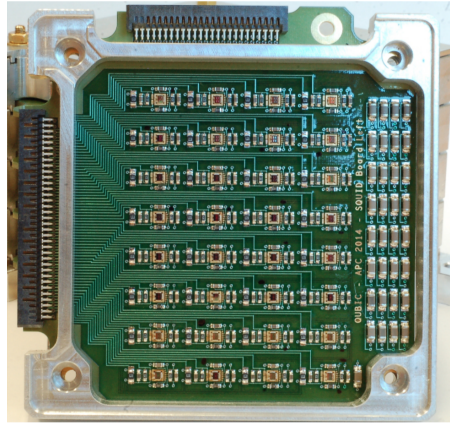
- 1 SQUID Mux. for 128 TES
- Each TES operates in flux-locked loop (FLL) mode



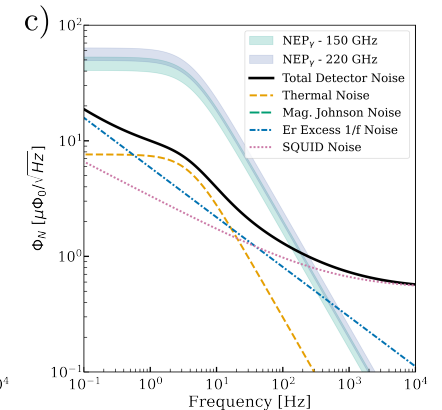
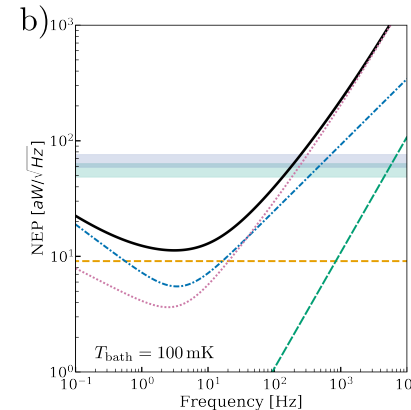
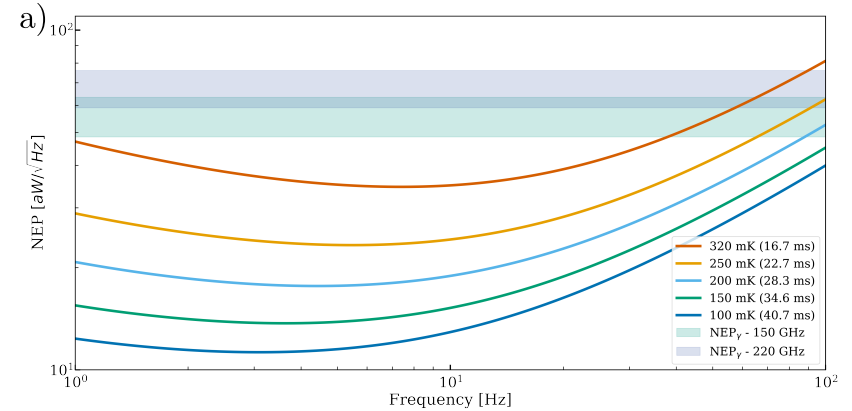
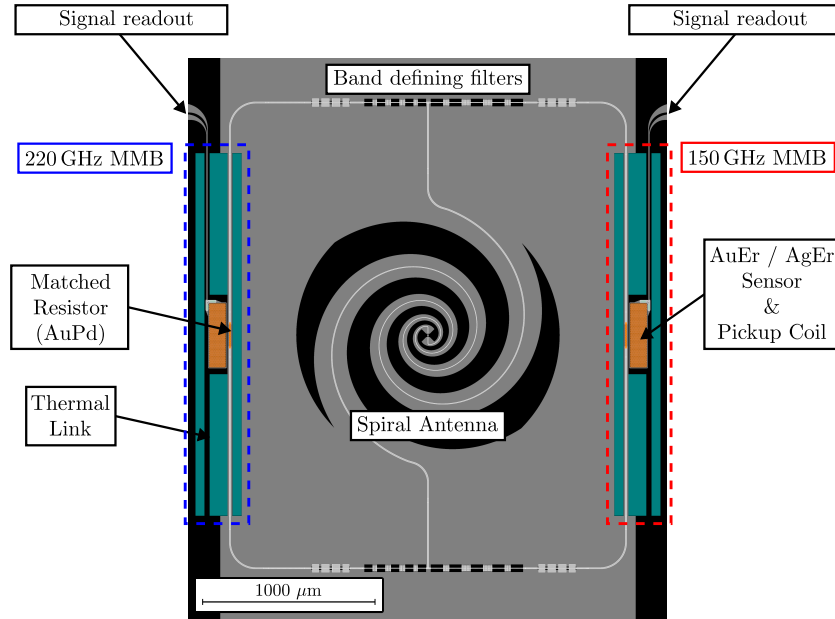
QUBIC TD dc-SQUID readout



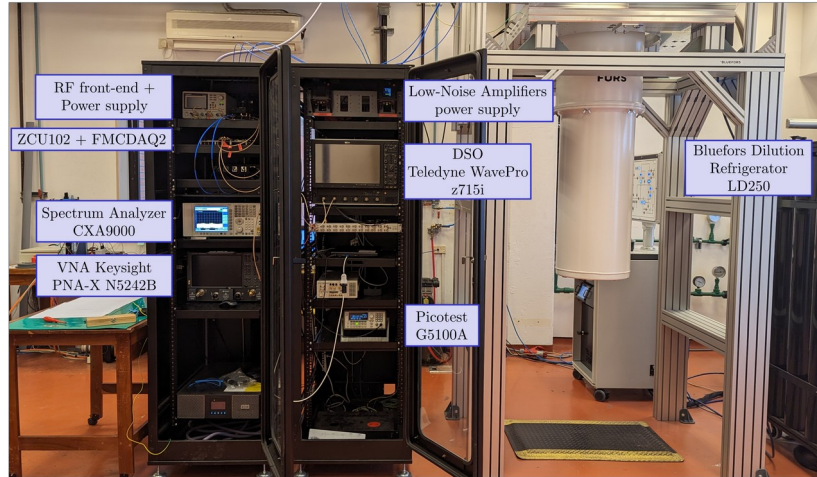
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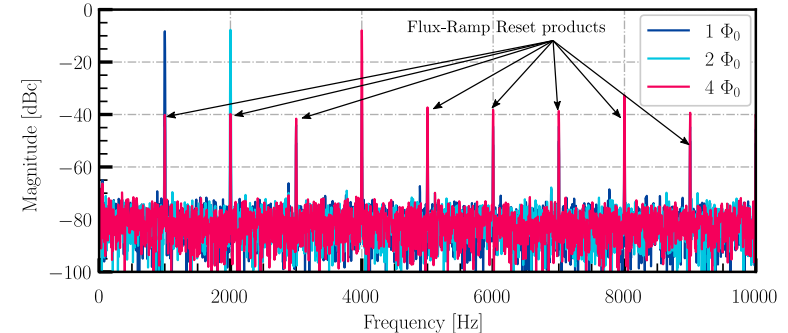
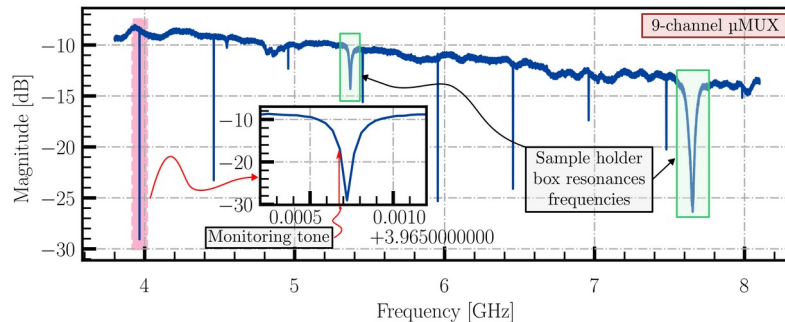
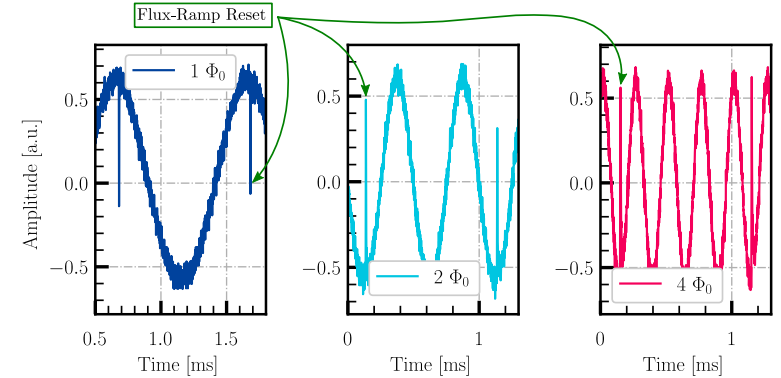
Multichroic Pixel – MMB NEP



Readout electronics characterization



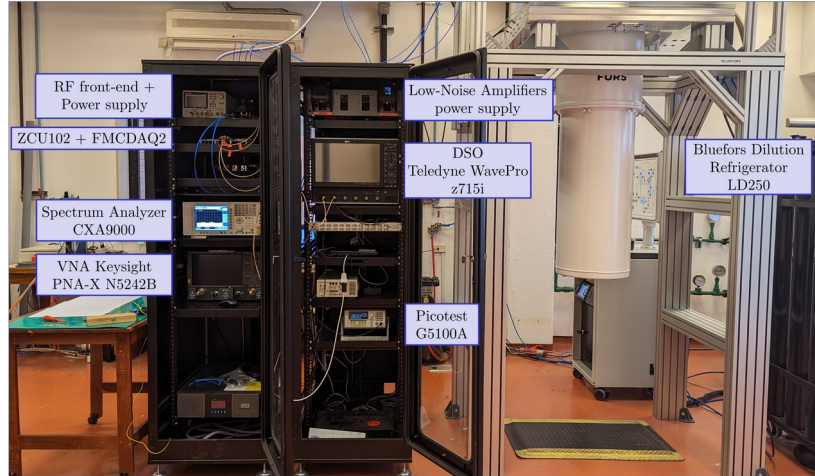
μ MUX readout (SDR): Flux-Ramp only



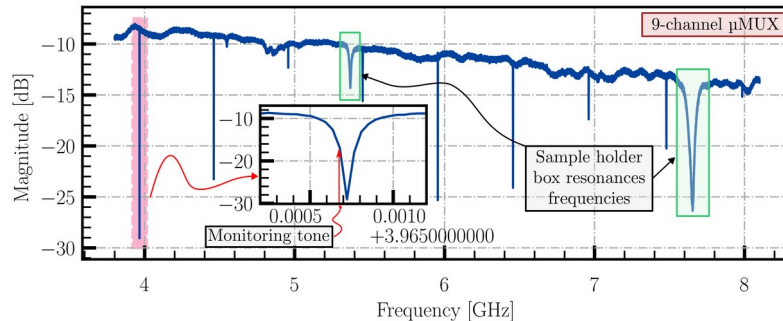
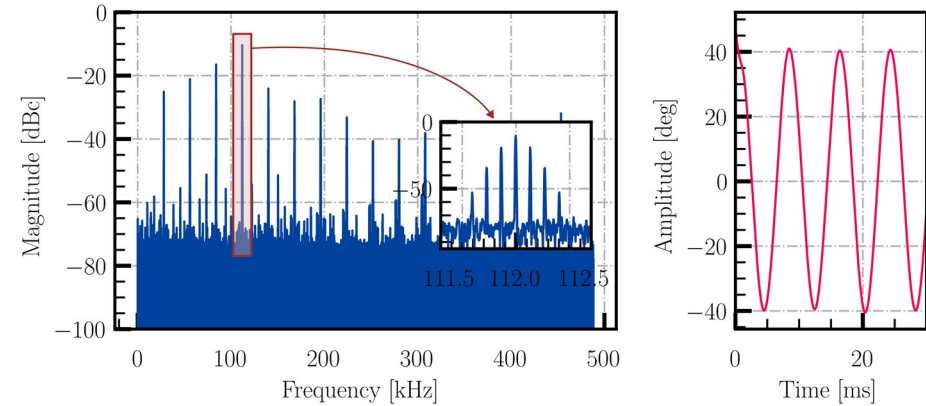
Readout electronics characterization



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μ MUX readout (SDR): Flux-Ramp with PM

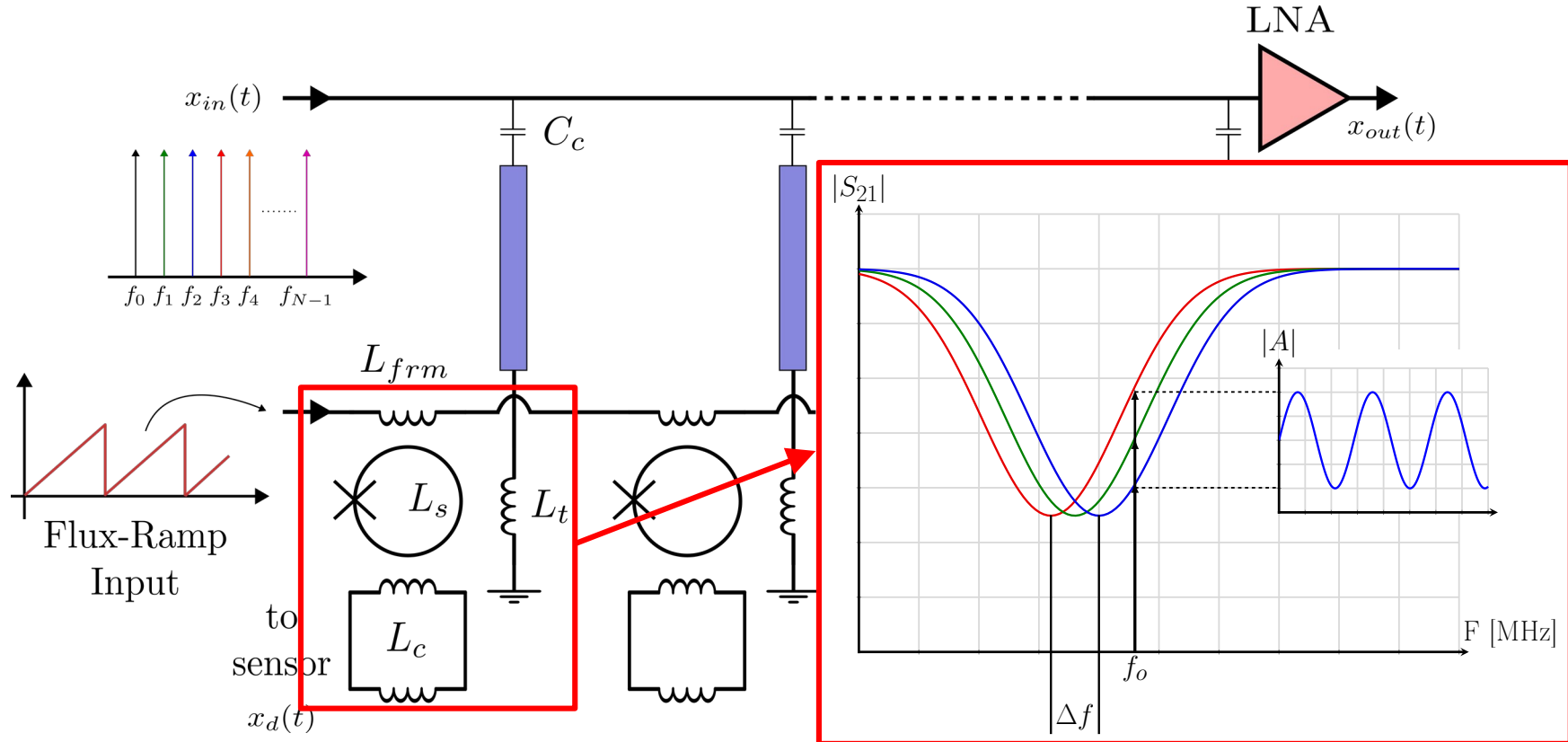


$$f_{\text{ramp}} = 28 \text{ kHz} \rightarrow k_{\text{rf-squid}} * A_{\text{ramp}} 4 = 4 \Phi_0$$

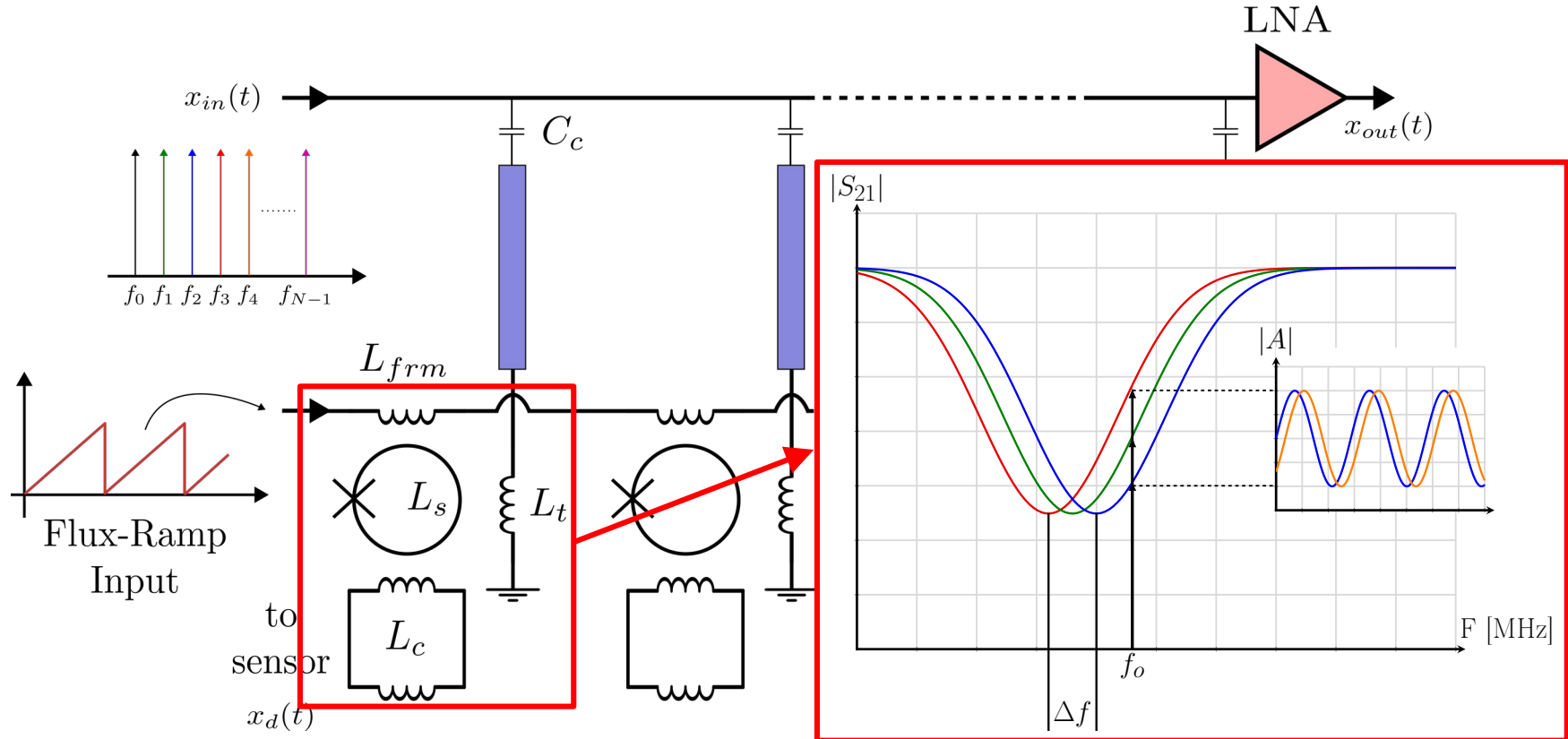
$$\rightarrow f_{\text{squid}} = 112 \text{ kHz}$$

$$f_{\text{detector}} = 135 \text{ Hz with } 40^\circ \text{ (peak)}$$

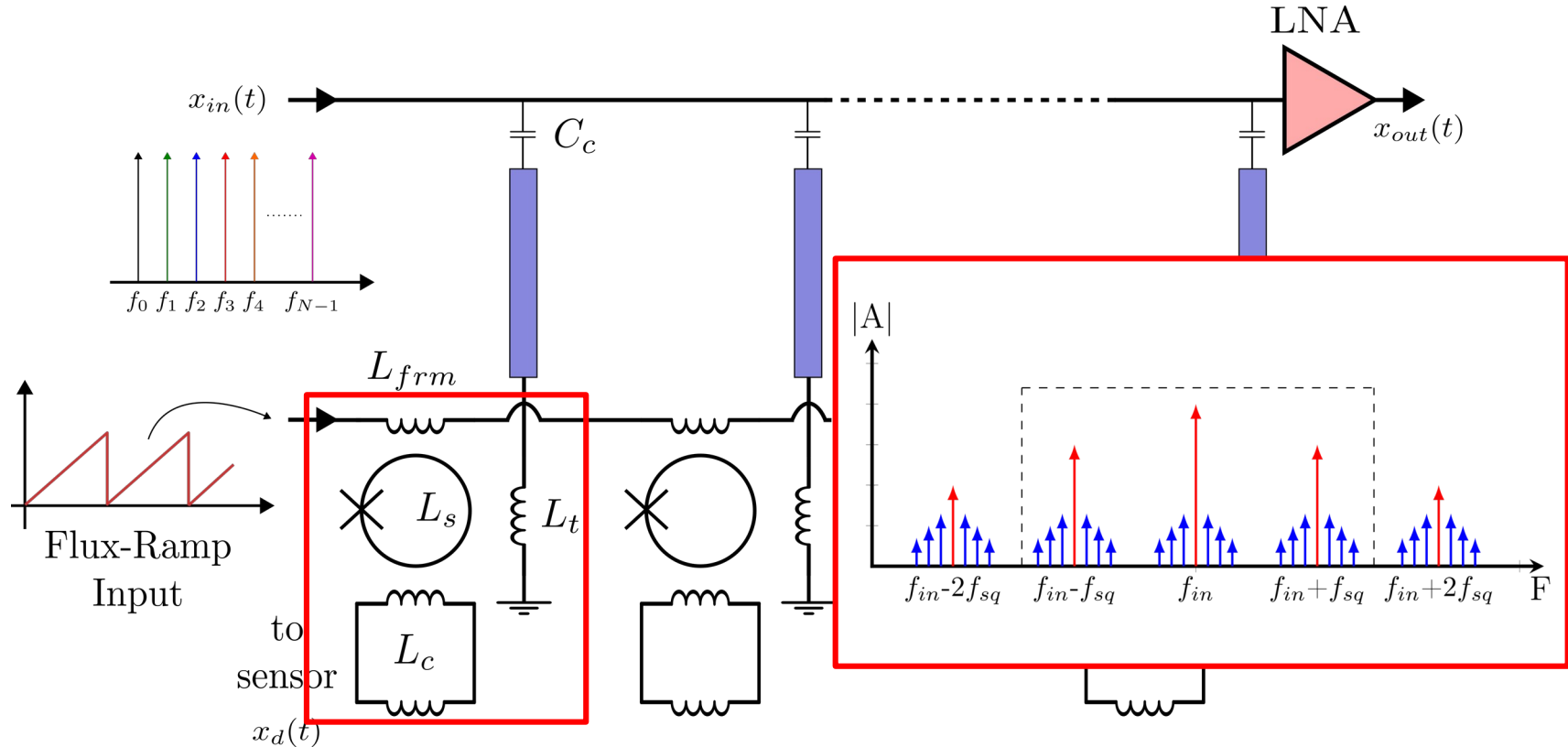
Microwave SQUID Multiplexing



Microwave SQUID Multiplexing



Microwave SQUID Multiplexing



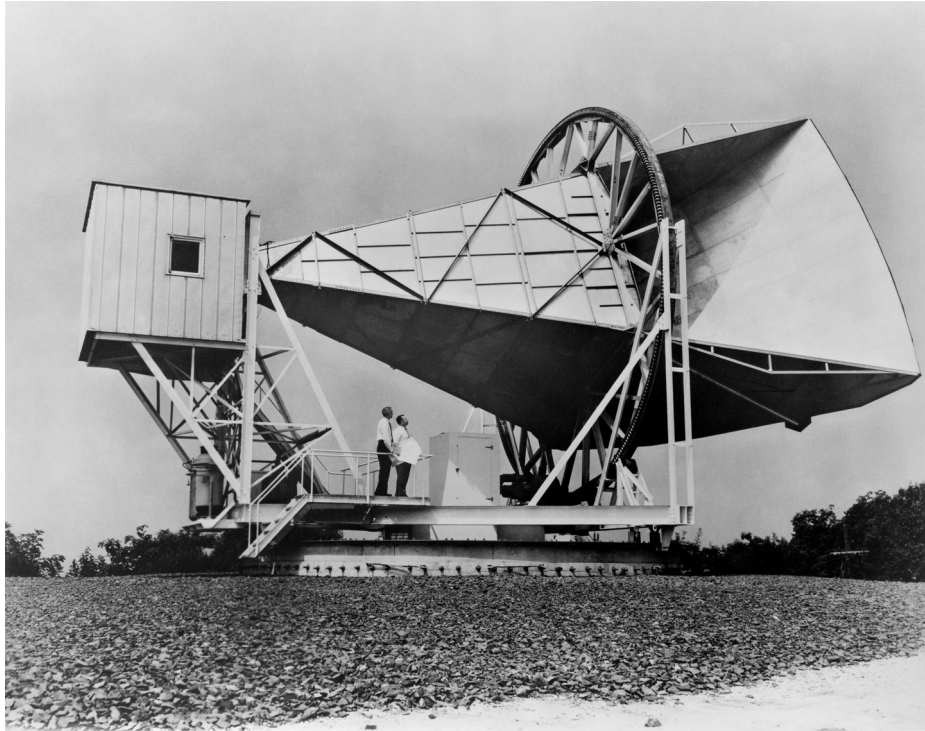
Introduction



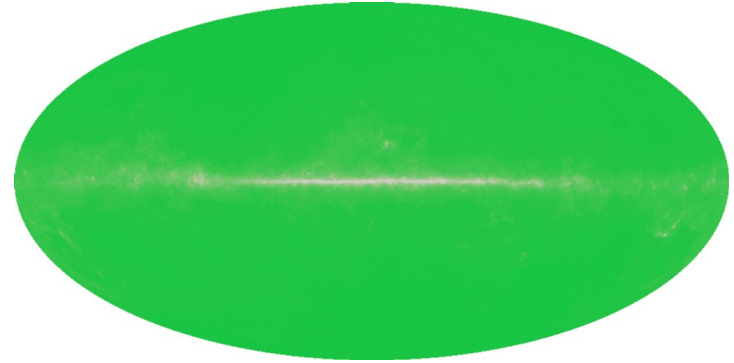
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Karlsruhe Institute of Technology



1964 – 1965: CMB measured for the first time by Penzias and Wilson at Bell Telephone Laboratories (Crawford Hill)

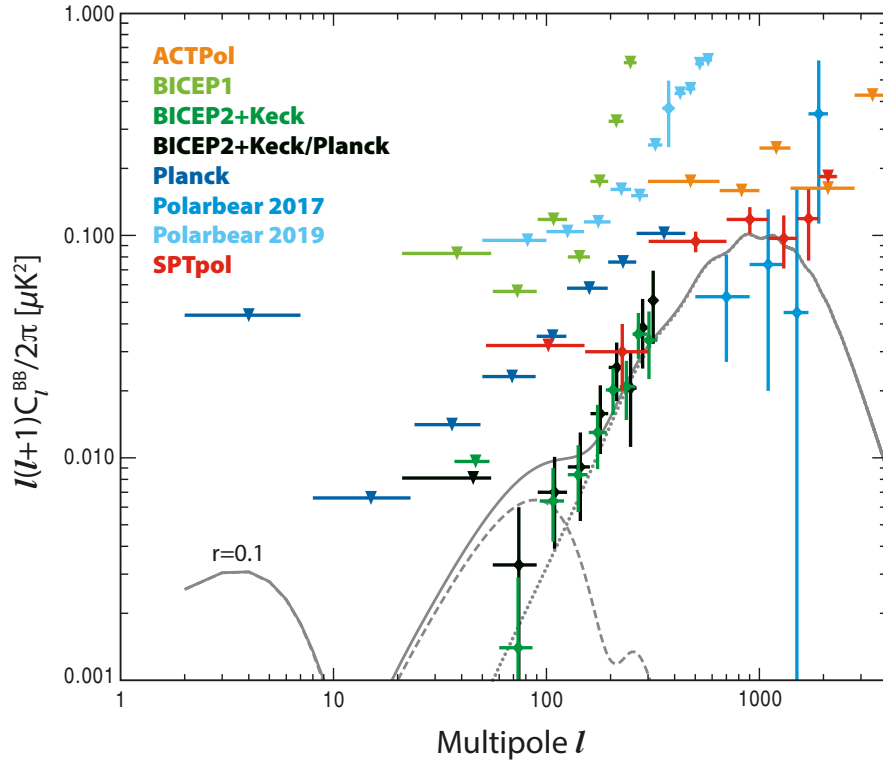


$$T = 3.5 \pm 1.0 \text{ K @ } 4.080 \text{ GHz.}$$

“Boys, we’ve been scooped” – Robert H. Dicke

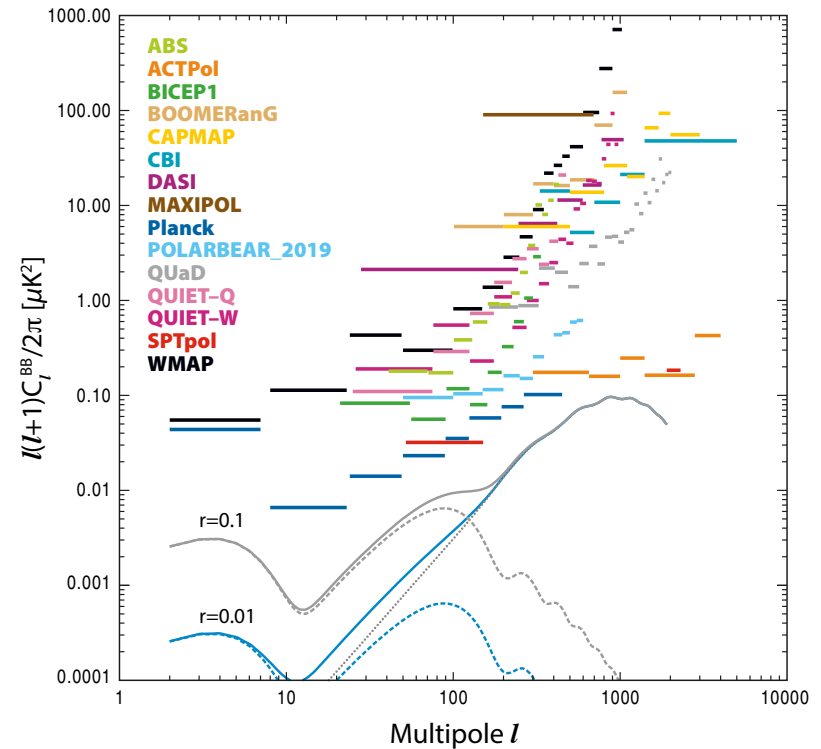
Introduction

Detections



LAMBDA - April 2021

Bounds



LAMBDA - April 2021

Cryogenic setup

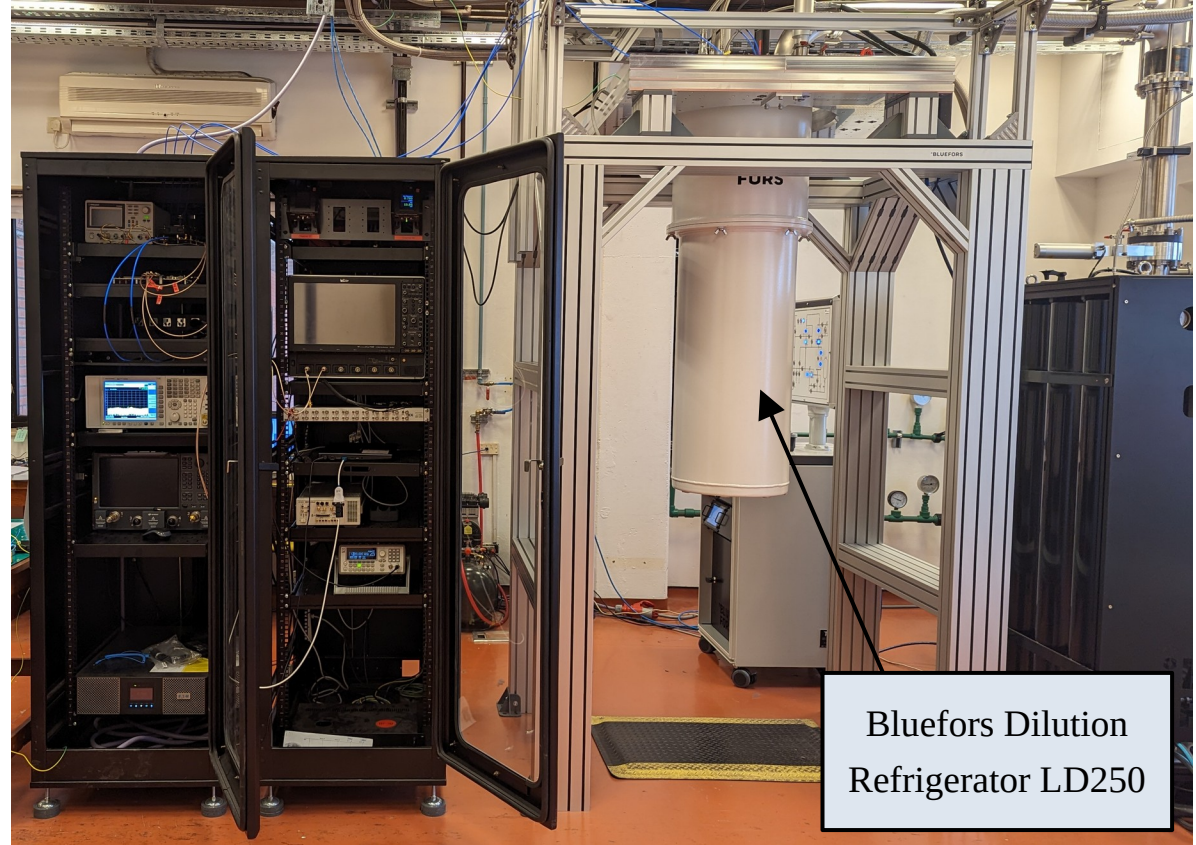


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Instrumental:

- Vector Network Analyzer
- Spectrum Analyzer
- Digital Oscilloscope
- Power Supplies
- Signal Generator



Bluefors Dilution
Refrigerator LD250

The Software Defined Radio



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