

Large Angle Optical Access in a sub-Kelvin Cryostat

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Purpose & Requirements

The cryostat is designed for beam pattern measurements of Antenna+Lens systems integrated with Kinetic Inductance Detectors (KIDs). This requires:

- Large opening angle
- $T \ll 1K$ for KID operation
- Fast turnaround time

→ **Custom designed optical access**

Cryogenic System

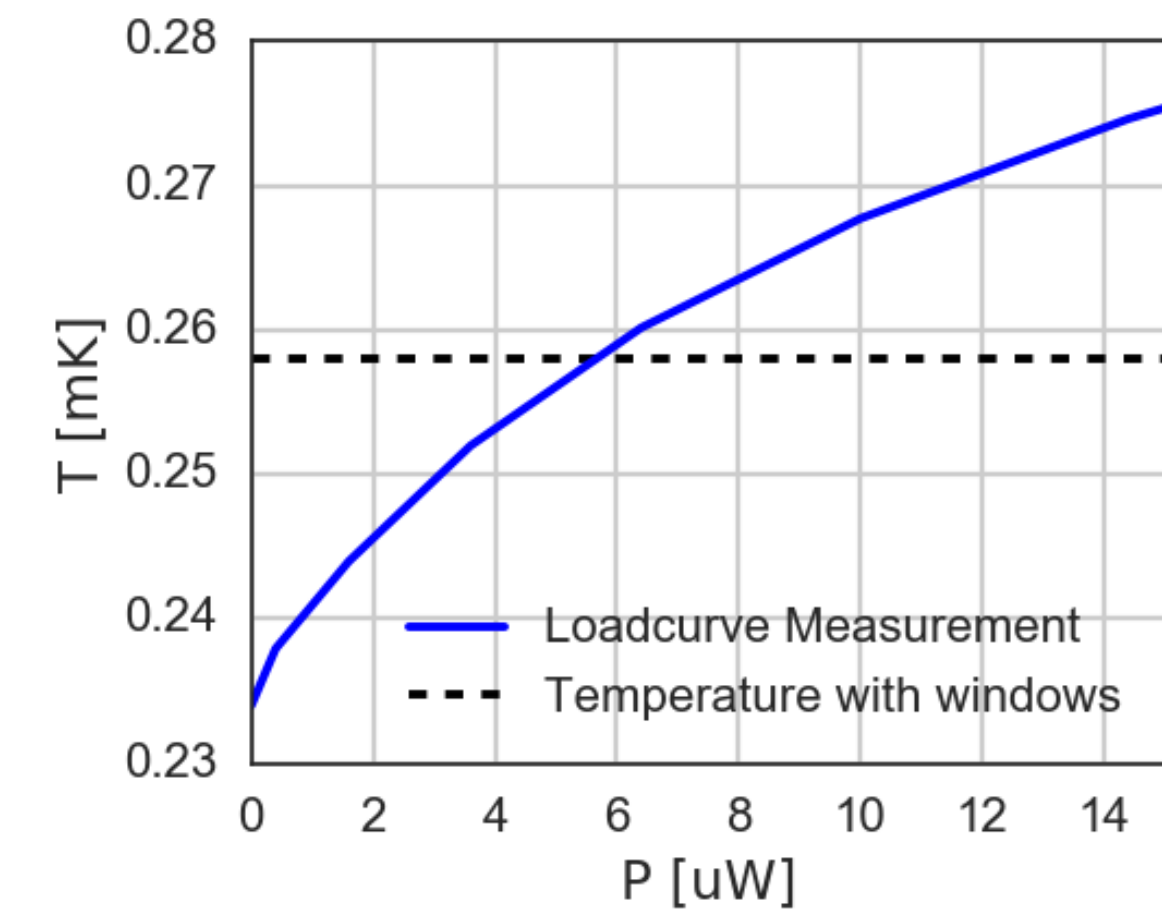
Bluefors cryostat with Cryomech Pulsetube:

- 40 W @ 50 K
- 1.2 W @ 4.2 K

2-stage sorption cooler (Chase Research Cryogenics)

- He4 buffer head, 100 μ W @ 800 mK
- He3 cold head, 1 μ W @ 240 mK

Thermal Loading Curve



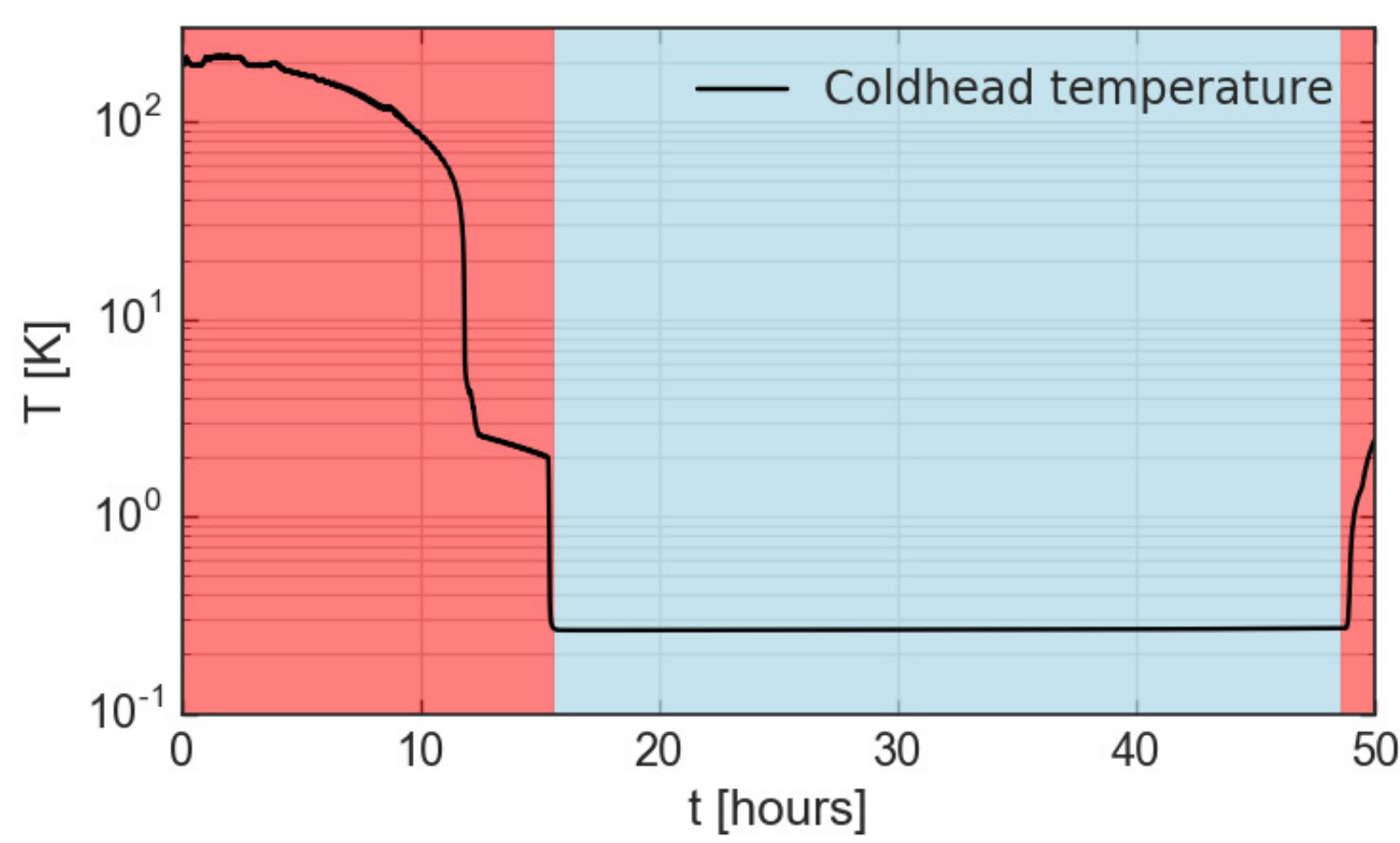
Thermal simulations were verified using load measurements with the He3 cold head functioning as bolometer

Performance

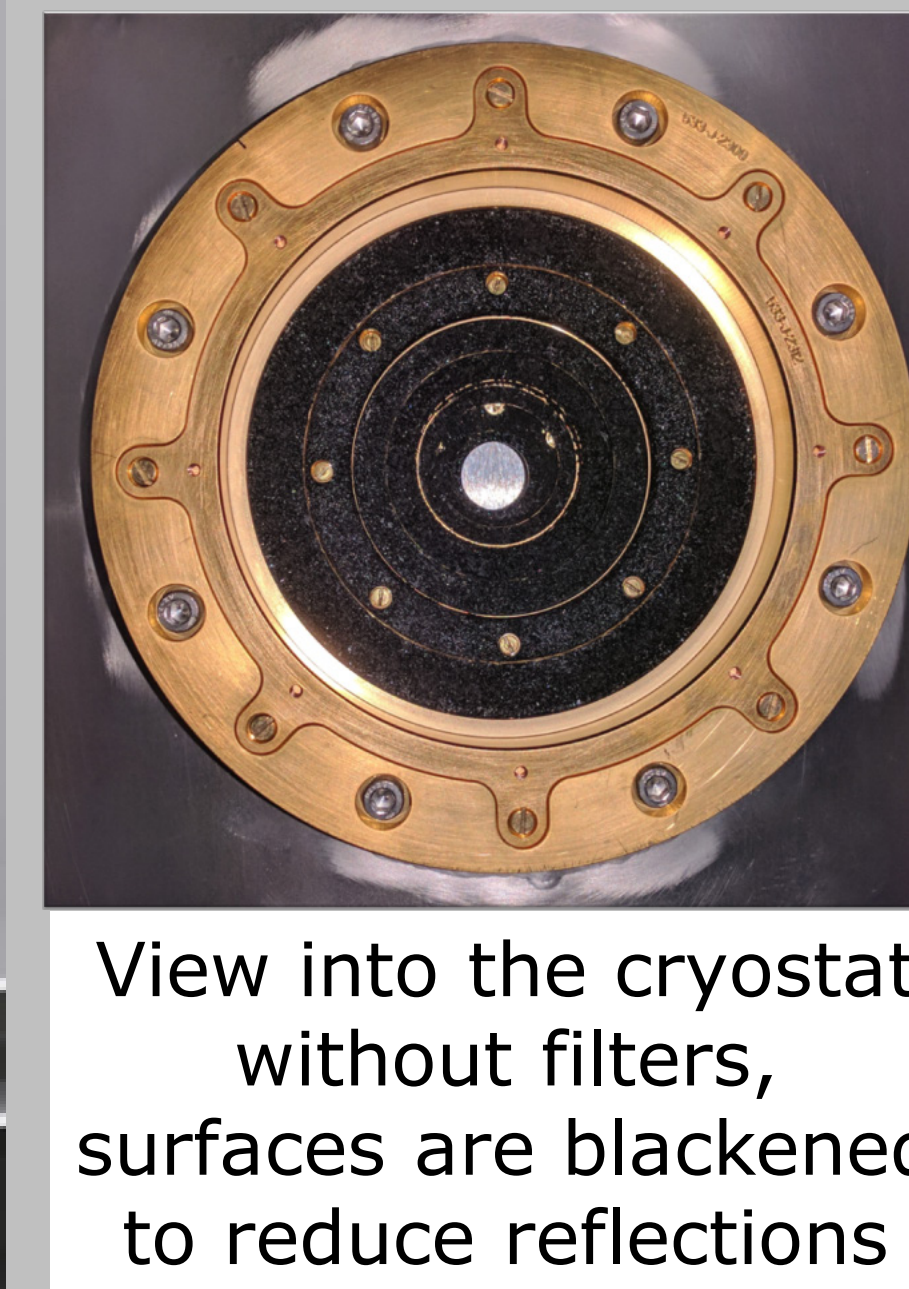
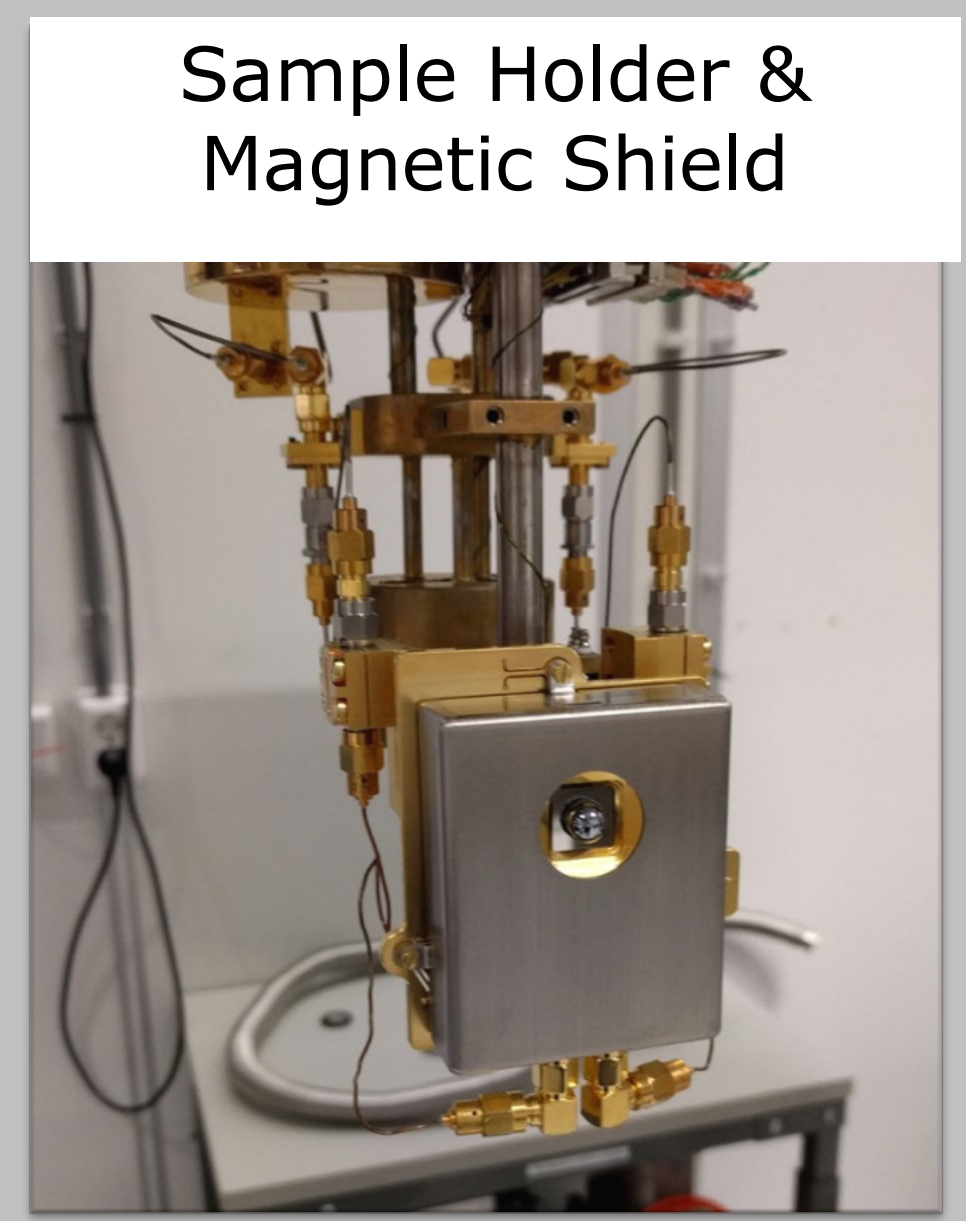
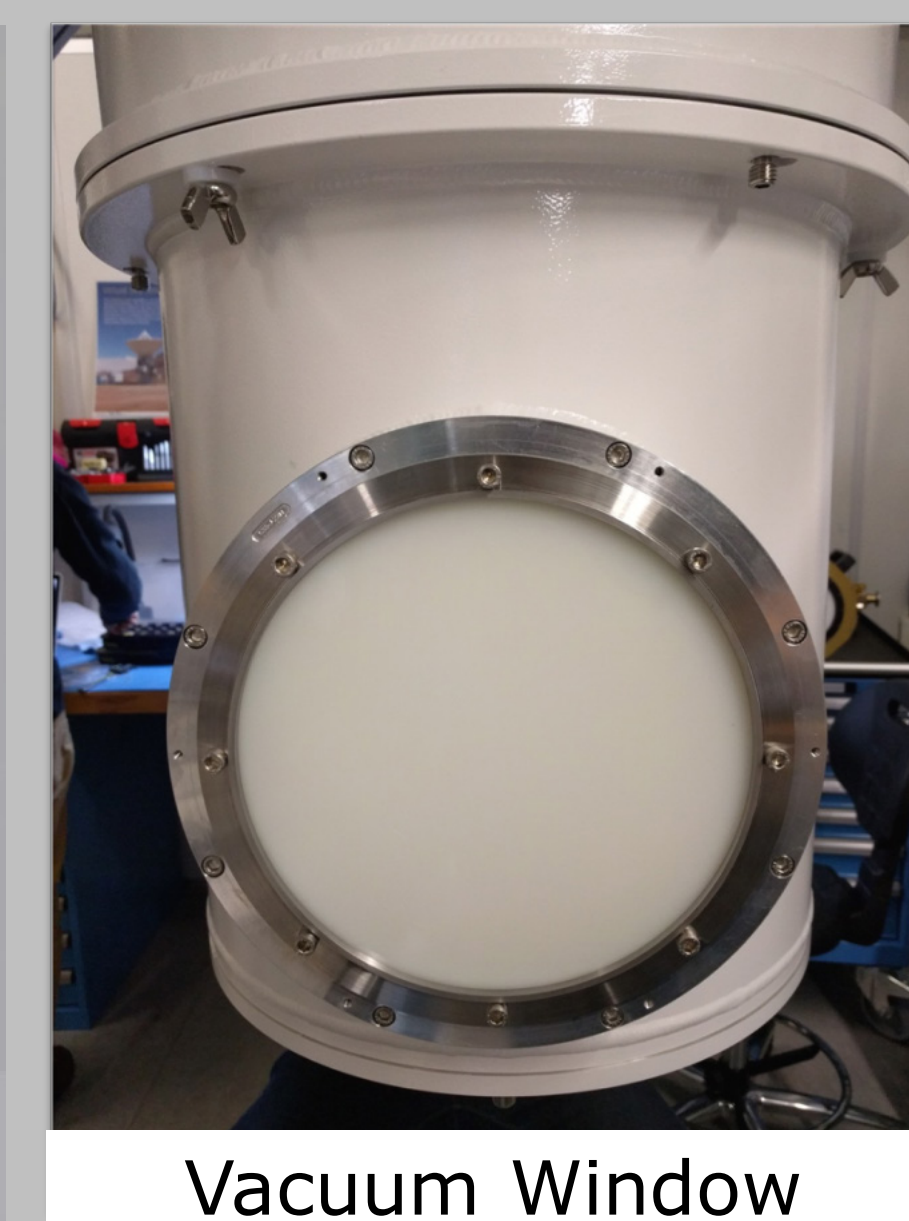
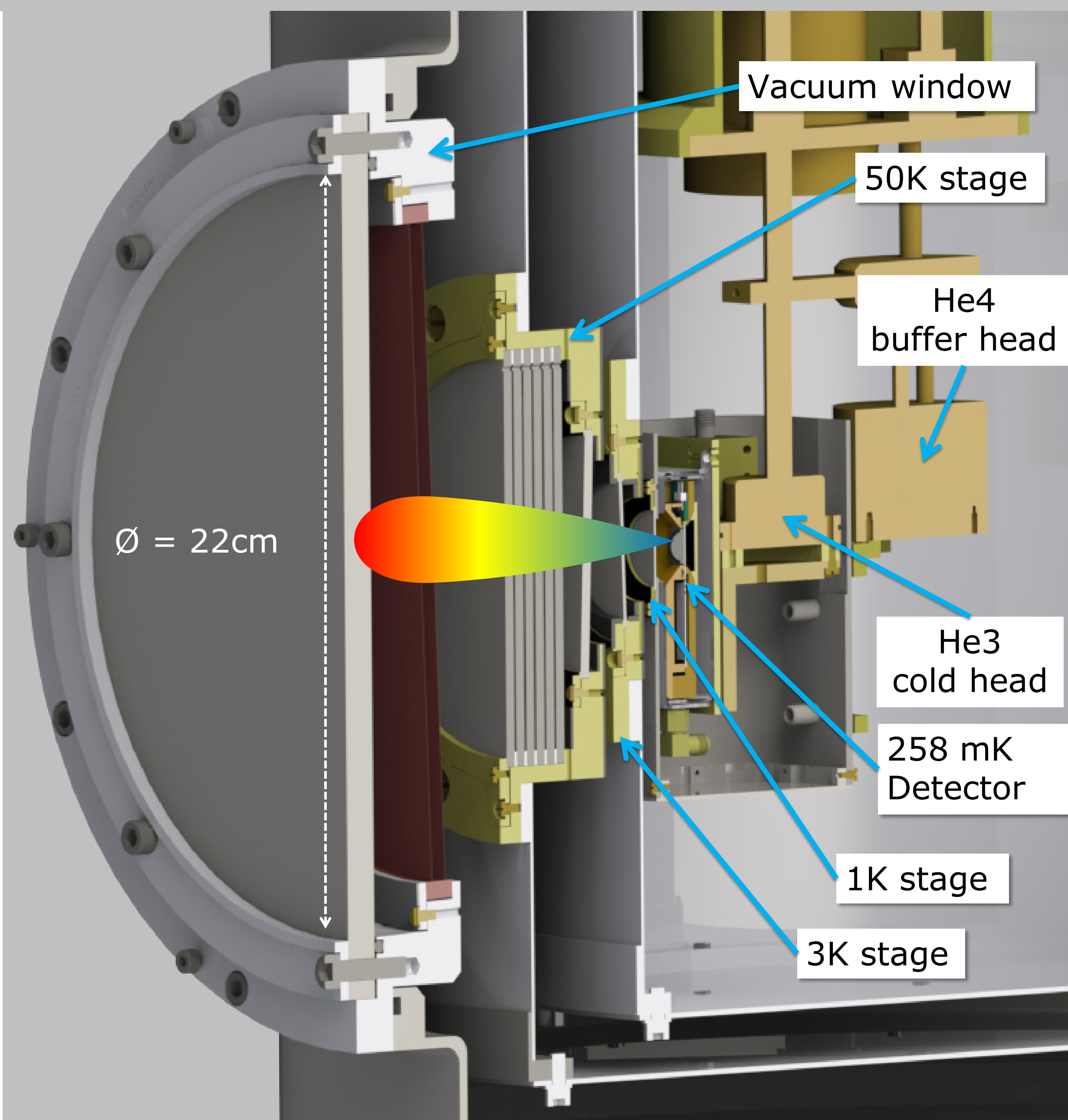
Total opening angle: **75.6°**
 Frequency band: **50 - 950 GHz**

Base temperature: **258 mK**
 Loading He3 cold head: **6 μ W**

Holdtime: **32 hours**
 Cooldown from 300K: **14 hours**
 Recharge: **2 hours**



He3 cold head during cooldown

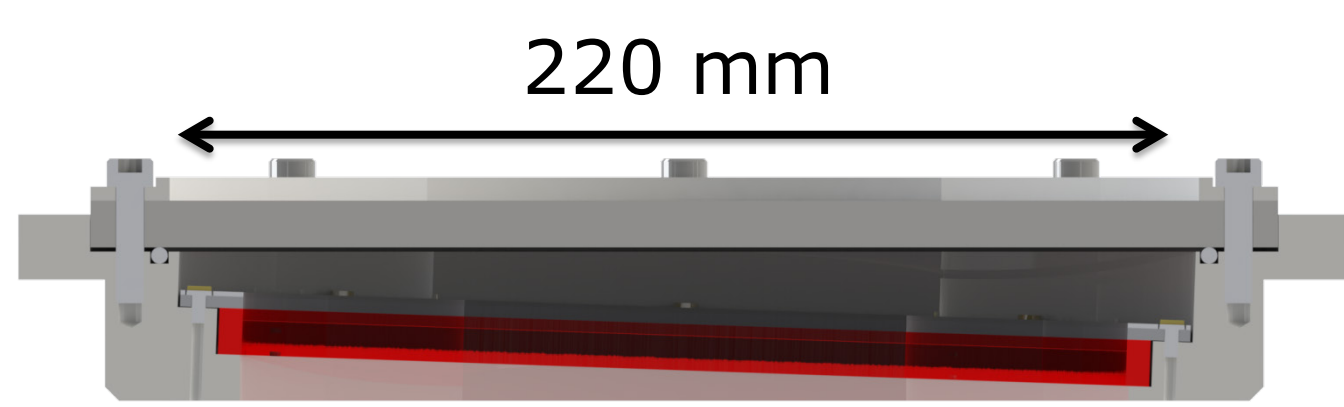


Geometric throughput suppression: **-40 dB**

Cryostat windows

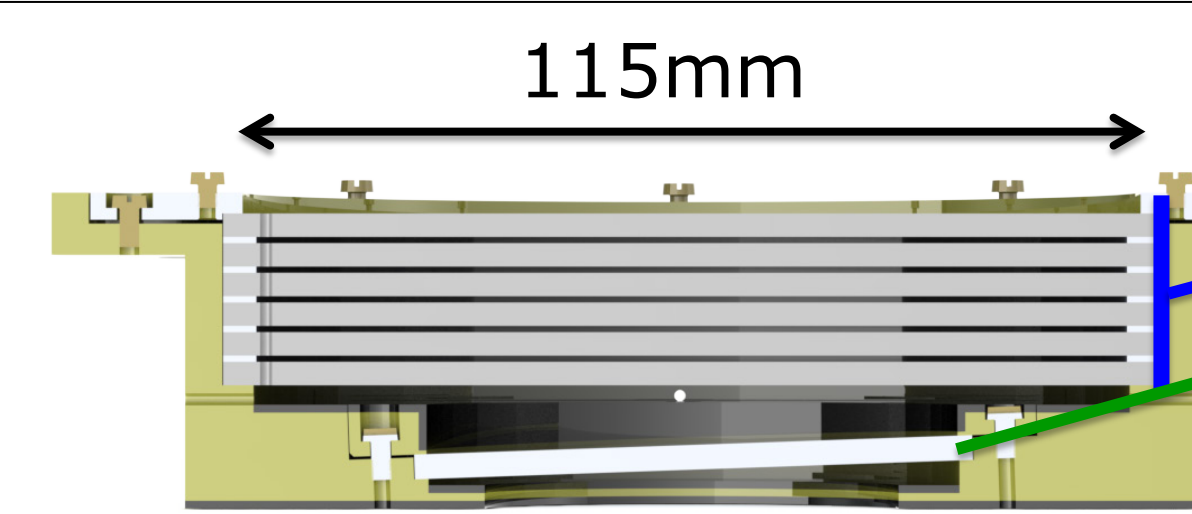
Vacuum window

- HDPE window
- Thermal shader
- $P_{in} = 18 W$



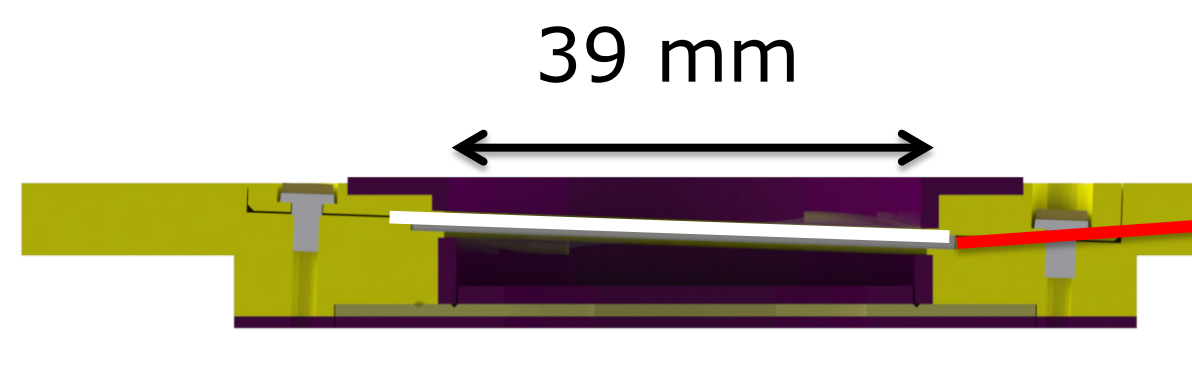
50K window

- 6 layers RT-MLI
- Low-pass mesh filter



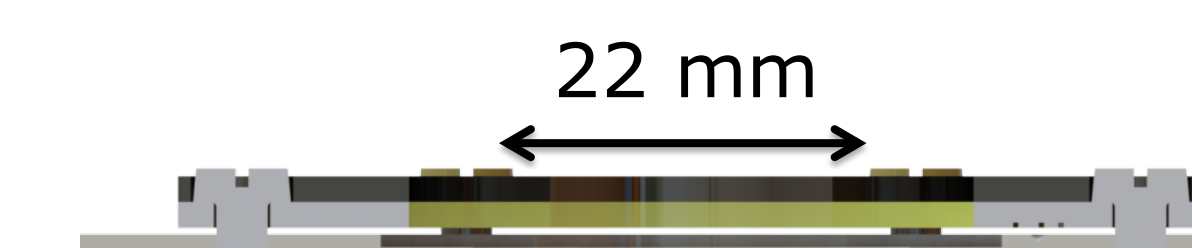
3K window

- Beam limiting aperture
- Low-pass mesh filter



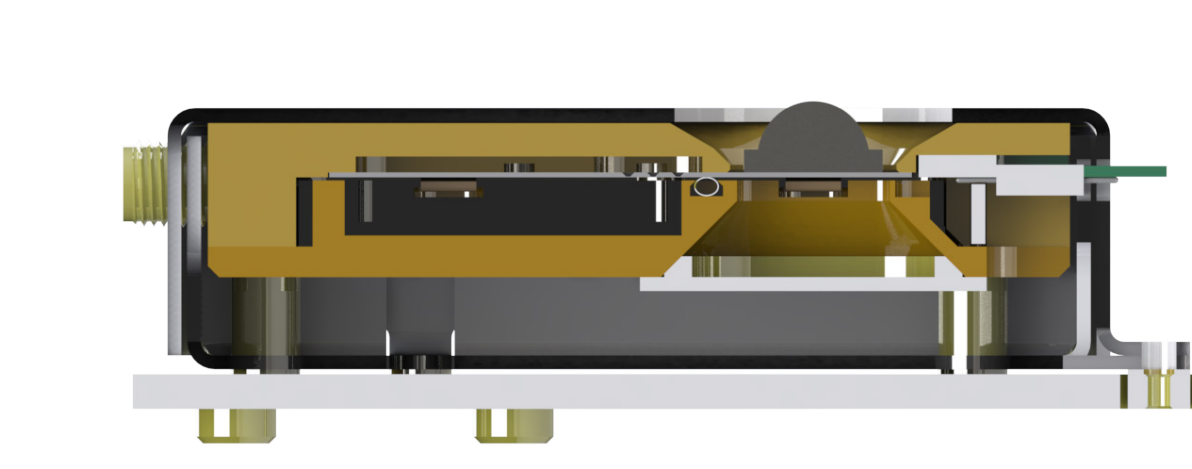
1K window

- Optional bandpass



Sample holder

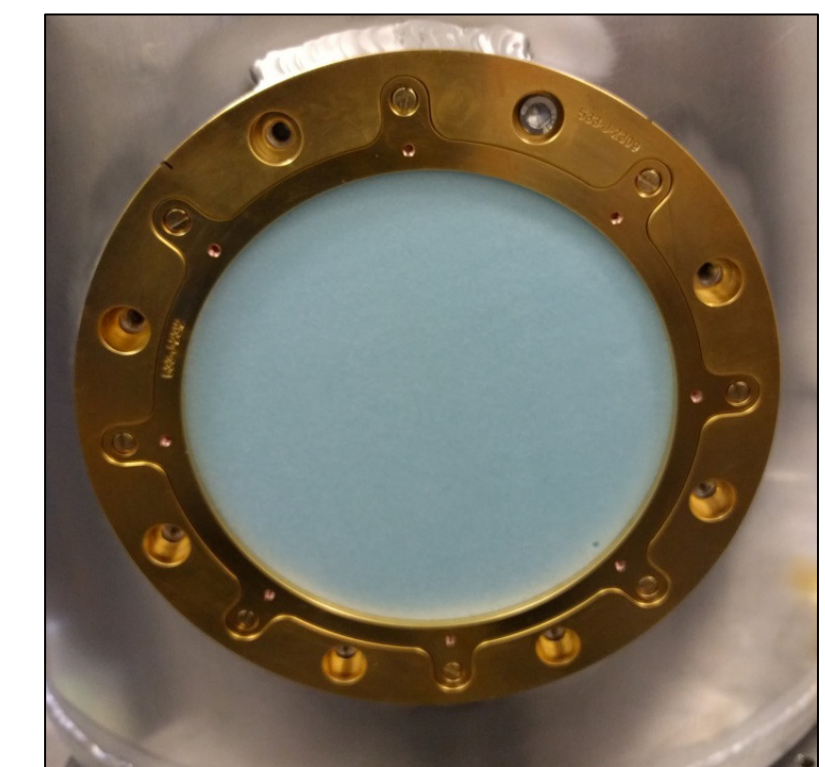
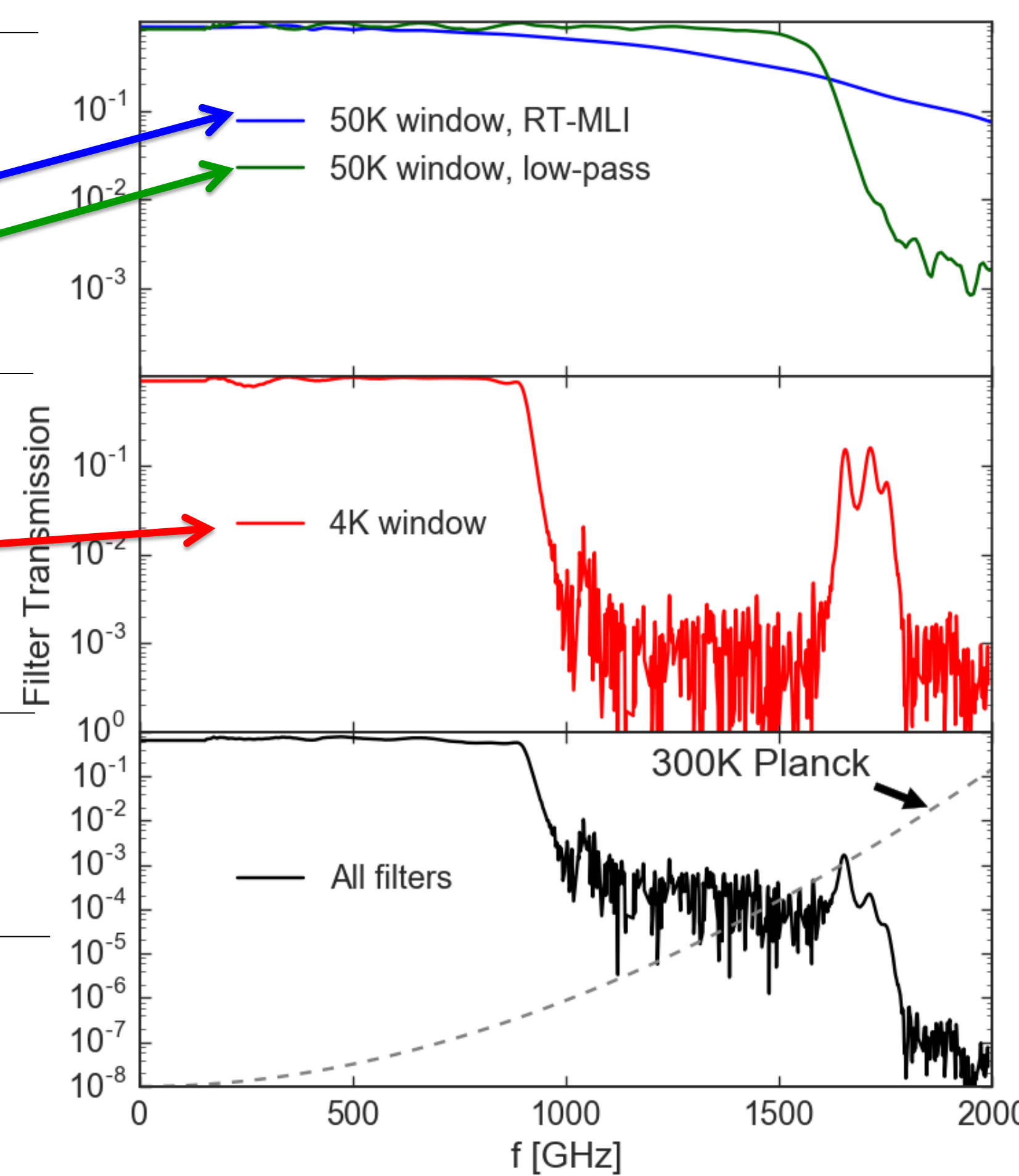
- mu-metal magnetic shield
- $P_{measured} = 6 \mu W$
- $P_{calc} = 3.6 \mu W$



Filter Transmission

Frequency band defined by optical filters: **50 - 950 GHz**

Radiation from 300 K environment is suppressed by **-30 dB**



Radio-Transparent Multilayer Insulation (RT-MLI)

- Scattering Filter
- Transparent @ $F < 1 THz$

Choi et al. 2013, Rev. Sci. Instrum.

Summary

The cryostat optics have been designed to allow beam pattern measurements with opening angles up to $\pm 37.8^\circ$ up to 1 THz.

Optimization of the thermal throughput and the quasi-optical filter system reduces incoming power from the 300K environment by **-60 dB** to **6 μ W**. This allows experiments at a base temperature of **258 mK** for **32 hours** before a recharge is required.