



Performance test of KAGRA cryogenic duct shield

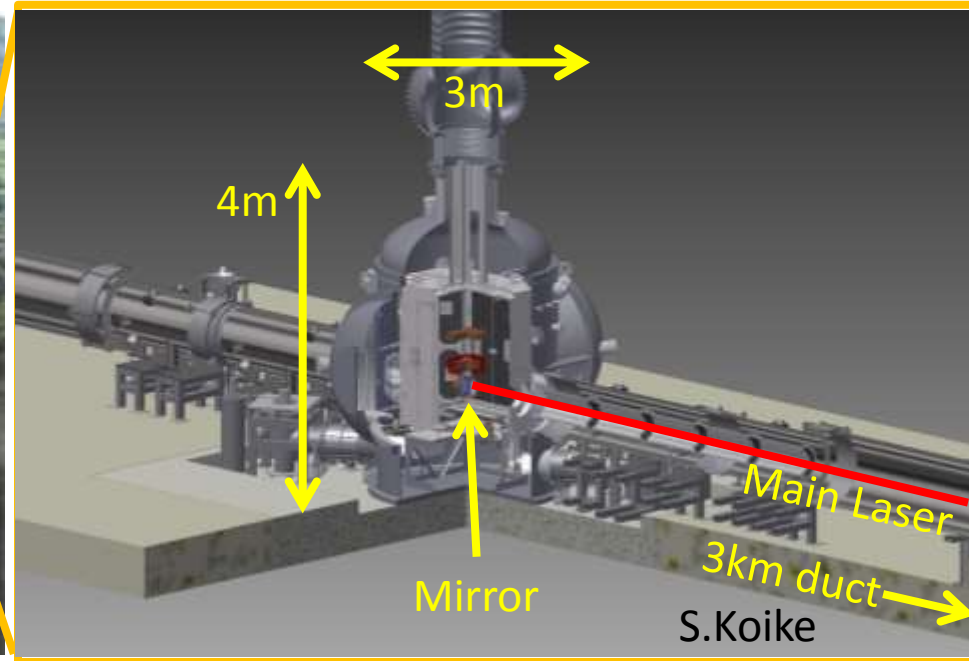
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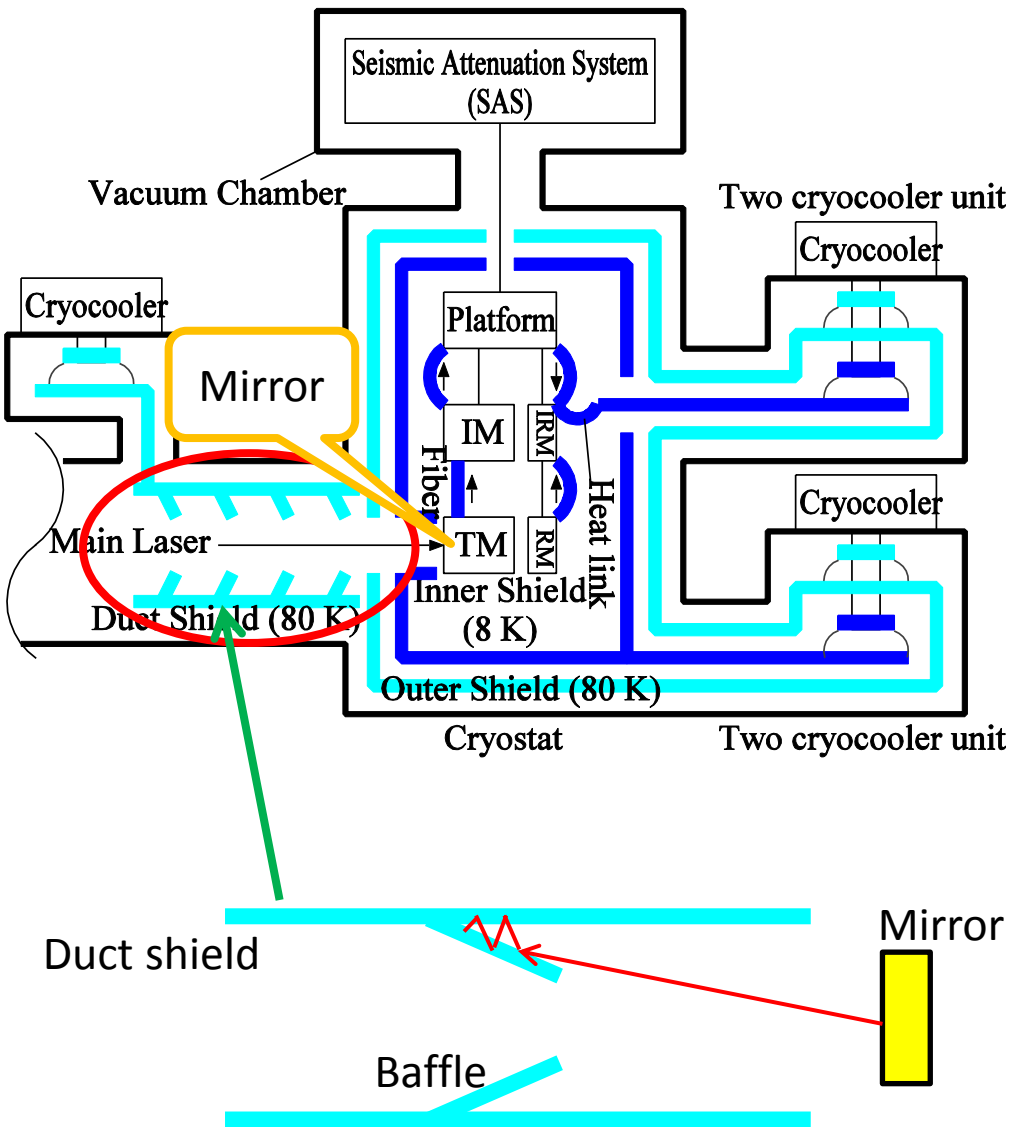
- KAGRA cryogenic system
- Pipe-shaped radiation shield (duct shield)
 - Thermal radiation
 - Calculation
 - Measurement (supported by Jecc Torisha)
 - Scattered light noise
- Future work

KAGRA (Large-scale Cryogenic Gravitational wave Telescope)



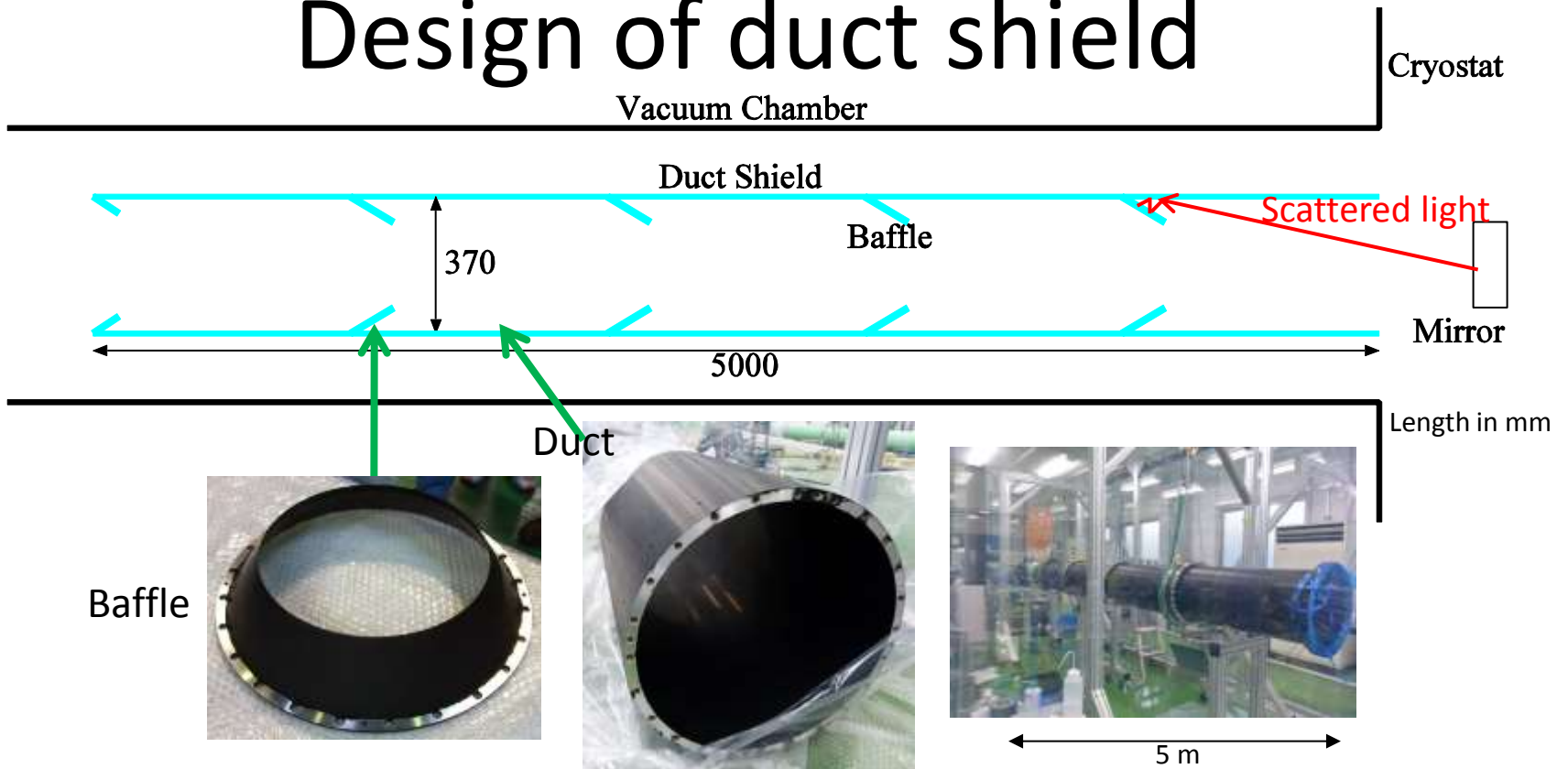
- Interferometer with 3 km arms
- Features
 - Kamioka underground with small seismic motion
 - **Mirrors (~20 kg) are cooled down to 20 K**
 - Reduce thermal noise

Purpose of duct shields



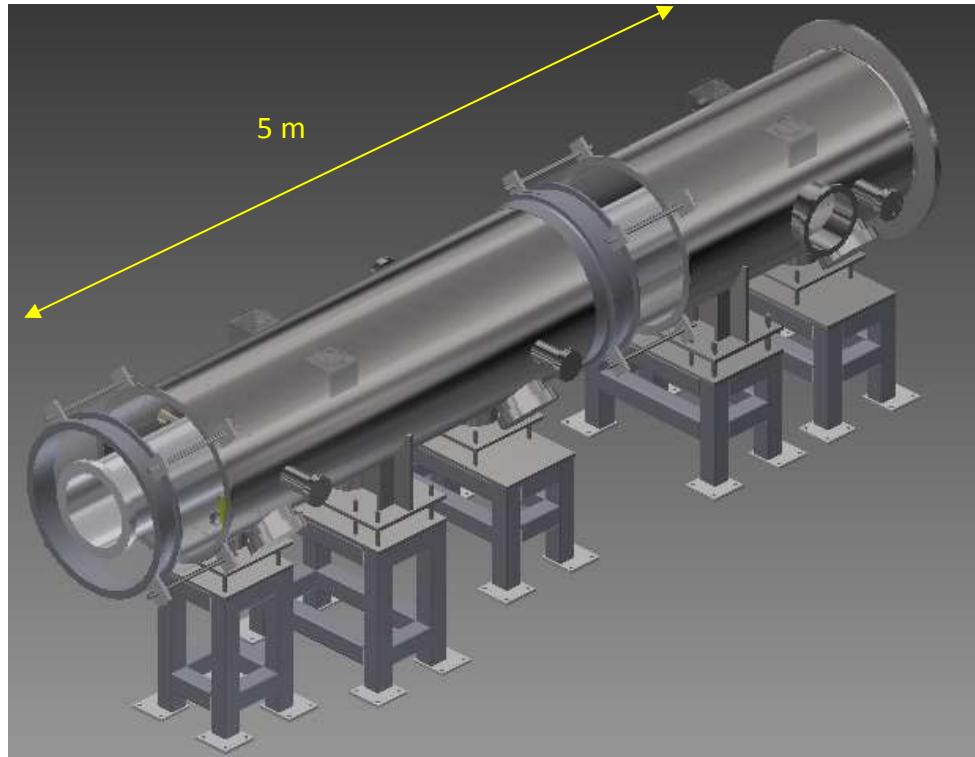
- Only suspension system is cooled down (3 km duct and SAS: 300 K)
- Mirror must be surrounded by radiation shields
- Holes for main laser are necessary
- Duct shields
 - To reduce thermal radiation
 - Duct to decrease solid angle to 300 K region
 - Duct reflects radiation
 - Baffles can reduce thermal radiation through duct shield
 - To cause no scattered light noise
 - Small vibration with rigid supports

Design of duct shield



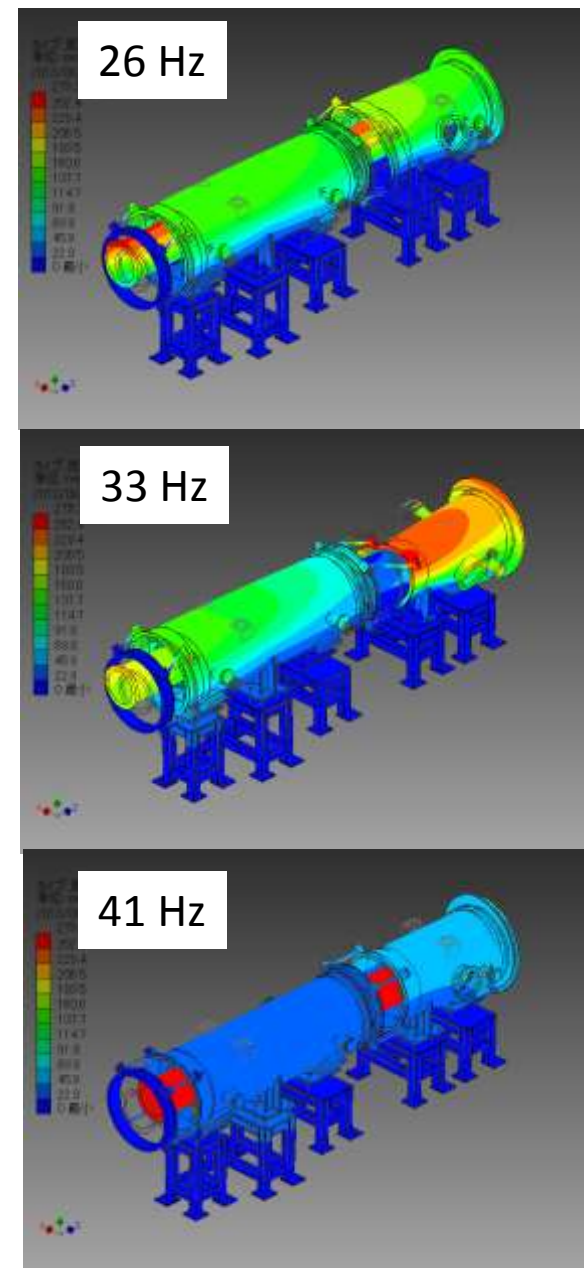
- Baffles are designed to satisfy KAGRA requirement of thermal radiation and scattered light
- Duct and baffles are coated with black coating Solblack to absorb thermal radiation and scattered light
- Baffles are tilted to catch scattered light
- Cooled down by one cryocooler

Design of duct shield



S. Koike

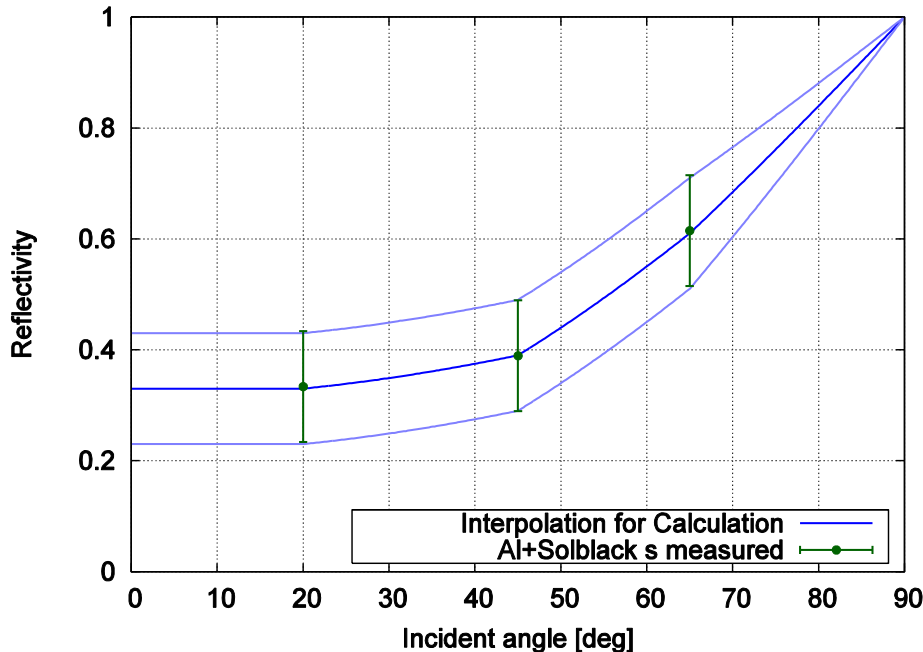
- Vacuum duct and duct shield is fixed rigidly to the ground to reduce vibration, and, to reduce scattered light noise



Calculation of thermal radiation

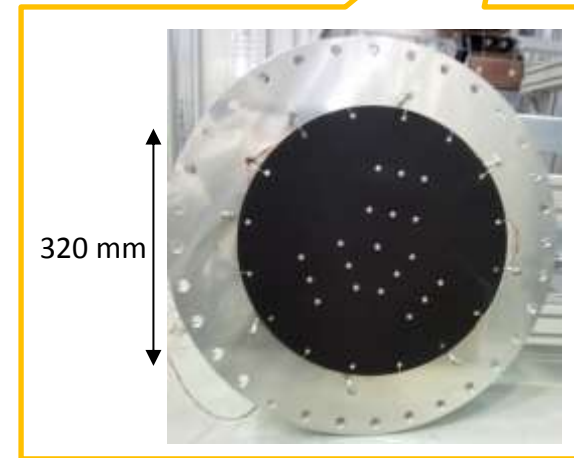
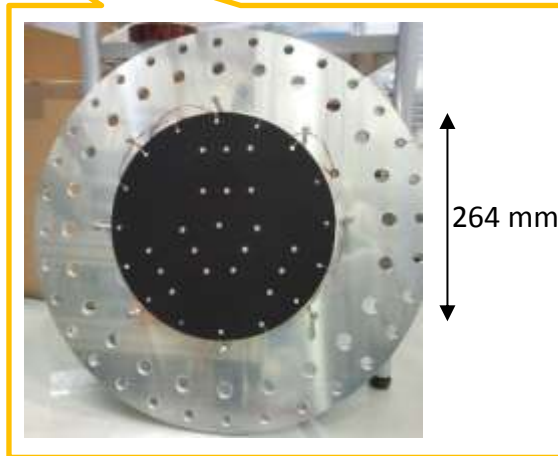
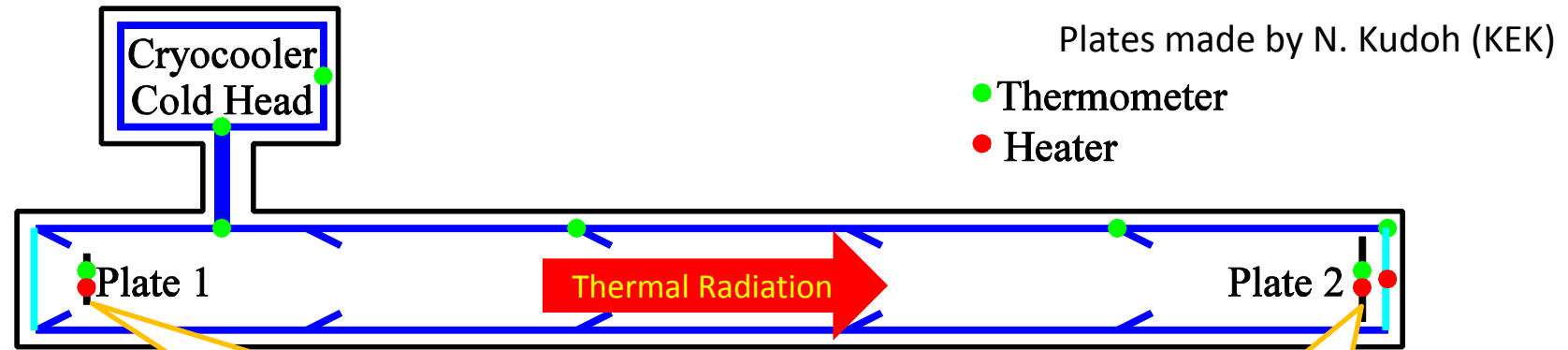


Reflectivity (Al + Solblack) used for calculation



- Rays are reflected by duct shield many times -> power of rays is reduced
- Radiation was calculated by commercial ray-tracing software ZEMAX
 - Rays of thermal radiation were emitted with random direction
 - When ray hits duct shield, power of ray is multiplied by reflectivity

Measurement of thermal radiation

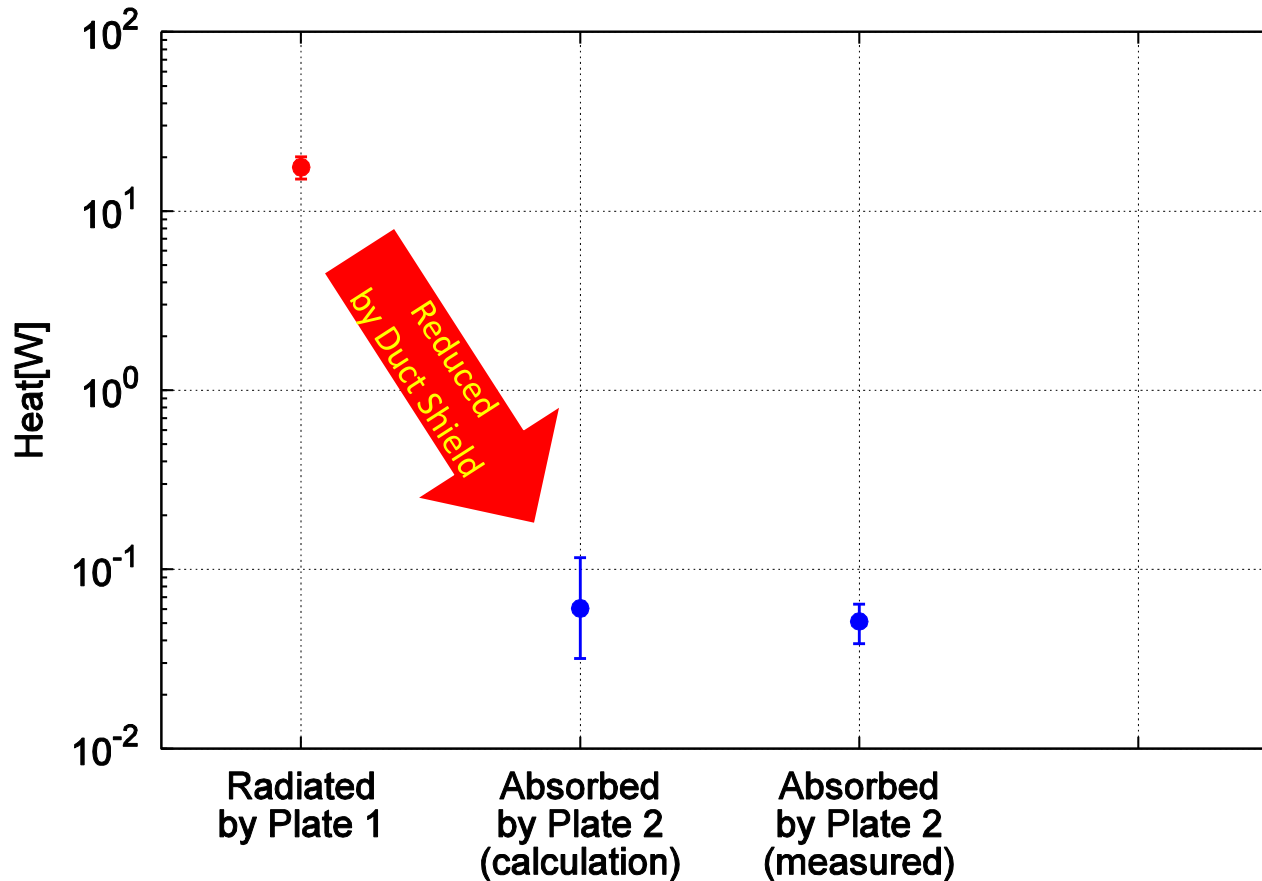


- Two aluminum plates suspended
 - Coated with Solblack to enhance emissivity or absorptivity
 - Plate 1 is heated up to 300 K and emits thermal radiation
 - Plate 2 absorbs radiation and is heated up
 - Calibration is conducted using heater on plate 2

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Yusuke Sakakibara

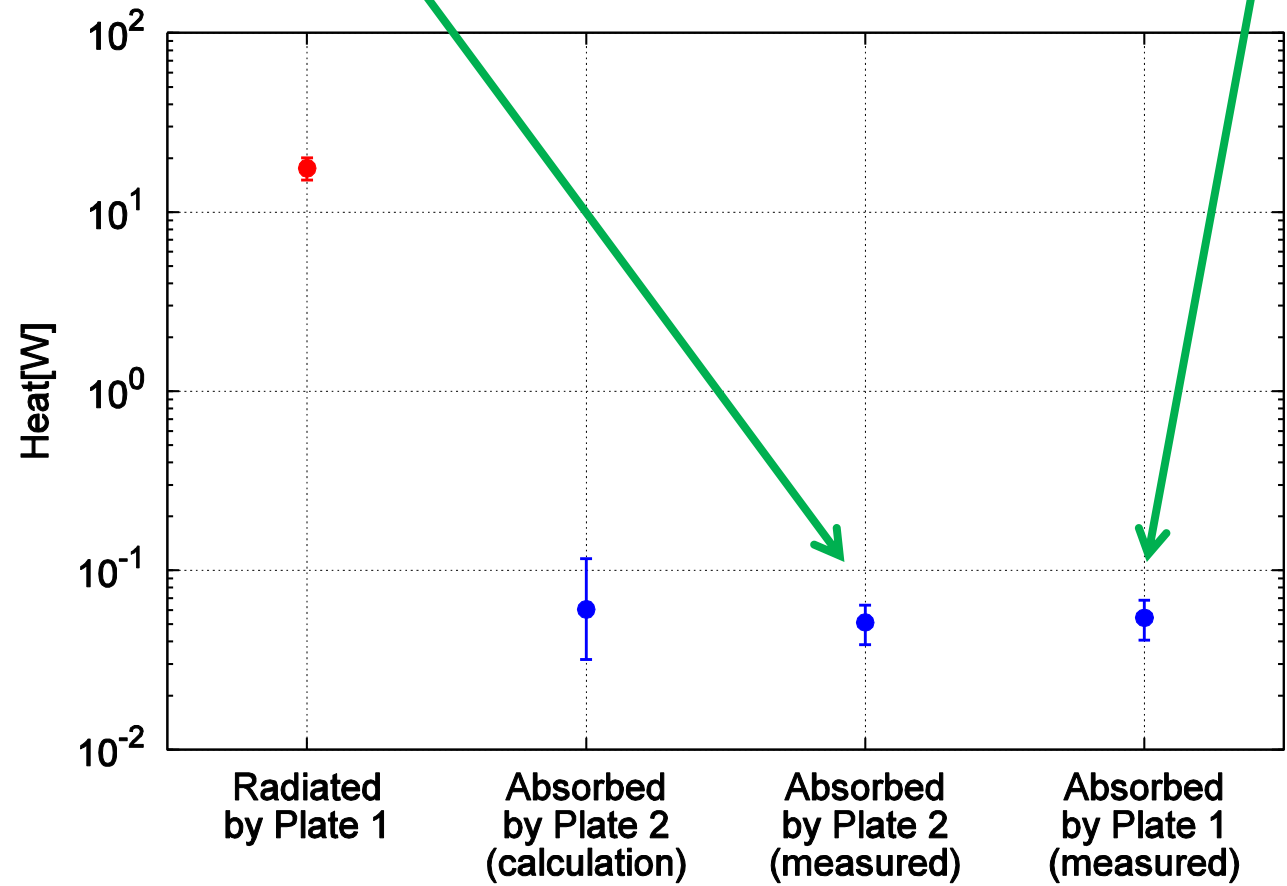
Results



- Calculation predicts only order of magnitude of heat input
 - Measured reflectivity at 10 μm of shield has error
 - Rays are reflected by shield many times
- Mirror will absorb 10 mW (It satisfies KAGRA requirement: 1 W including laser absorption)

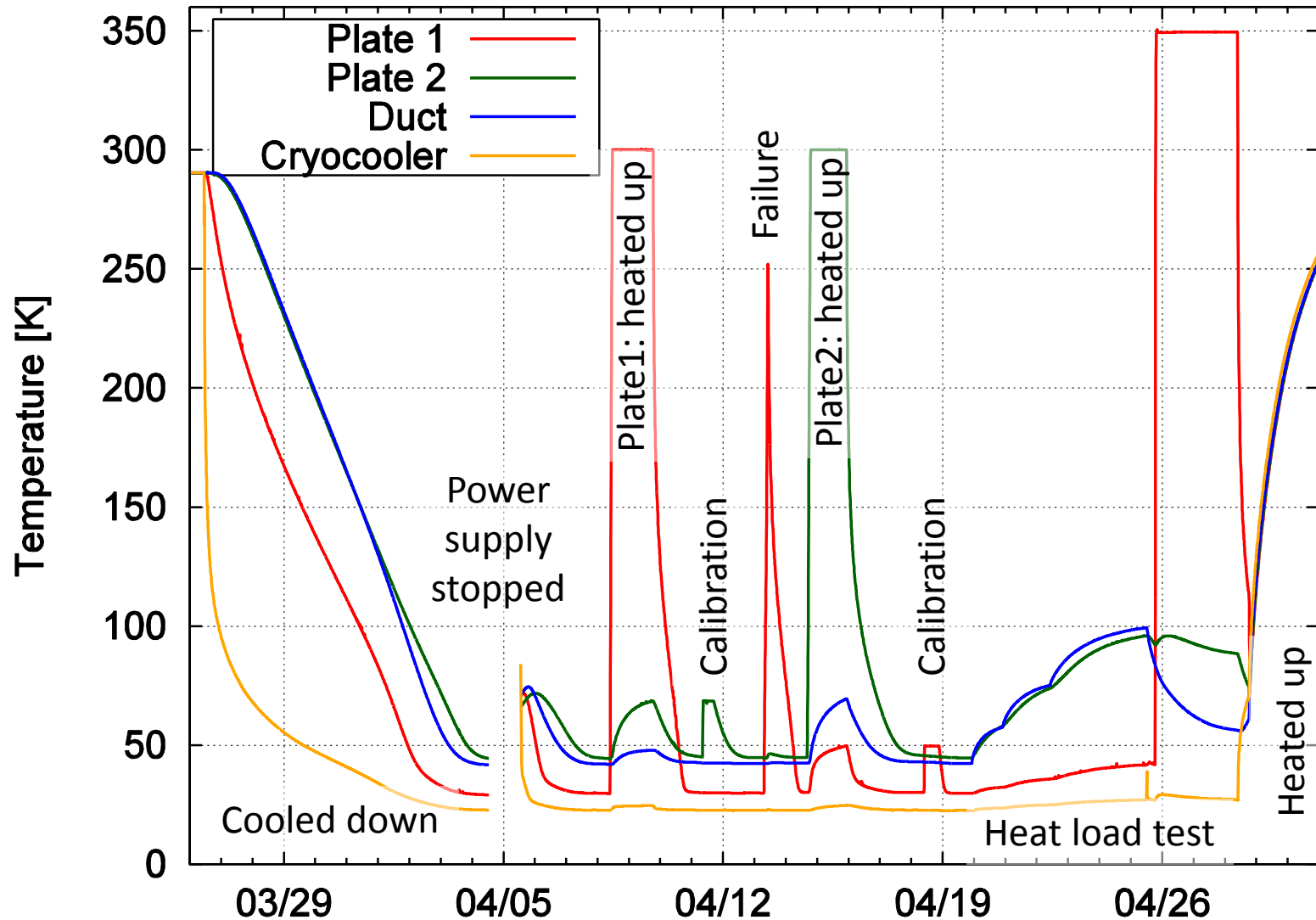


Results



- Experiment where PLATE 2 is heated up to 300 K and PLATE 1 absorbs radiation was conducted
- Heat transfer of left and right direction should be equal
 - Otherwise, even if two plates have same temperature, heat will be transferred

Temperature log



Summary

- Summary
 - Duct shields were designed to satisfy KAGRA requirement of thermal radiation and scattered light
 - Thermal radiation through duct shield was measured
 - Result is consistent with calculation and satisfies KAGRA requirement
- Future work
 - Similar measurements for three duct shields will be conducted to check if the result is reproduced
 - Vibration measurement of duct shield