

ET-LF Optics: Heat Load Contributions

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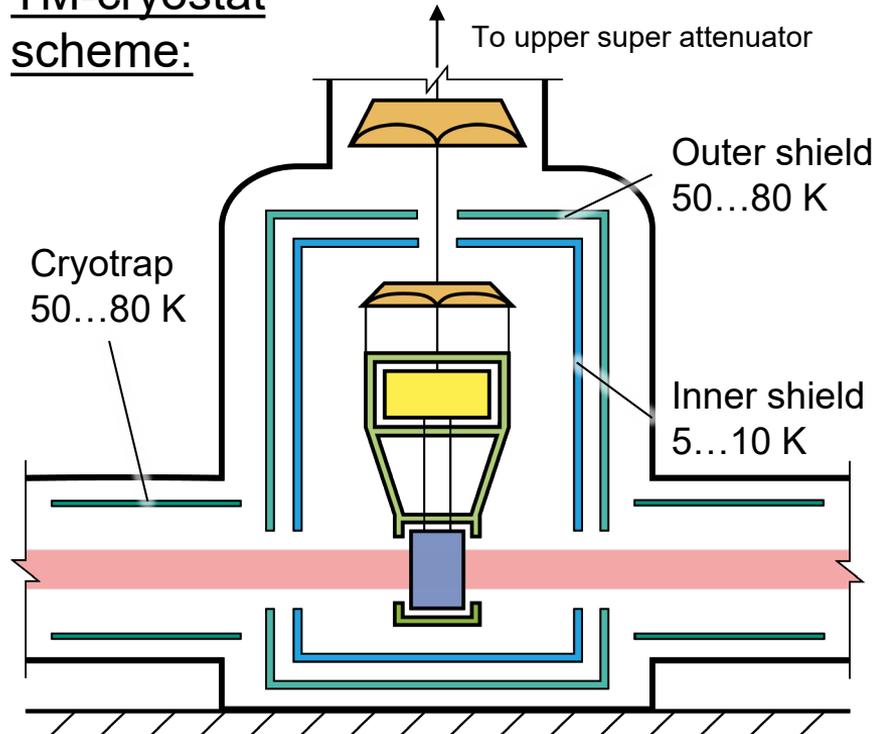
ET-LF
Wavelength Workshop
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Laser Power Absorption

ET-LF optics: laser power absorption

TM-cryostat scheme:



Laser power absorption estimate:

■ $\dot{Q} \approx 40 \text{ mW}$

Estimated heat load by laser power absorption depends on:

- Laser wavelength,
- TM bulk material absorption,
- TM coating material absorption,
- Frost layer buildup (**x times 10^2 mW !**),
- Mirror temperature (?)
- ...

Frost on Mirror Adsorption properties

Optical loss study of molecular layer for a cryogenic gravitational-wave detector

Satoshi Tanioka, Kunihiko Hasegawa, and Yoichi Aso
Phys. Rev. D **102**, 022009 – Published 27 July 2020

R. A. Matthew *et al.*, Einstein gravitational wave Telescope (ET) conceptual design study, ET-0106C-10, <https://tds.ego-gw.it/ql/?c=7954> (2010).

ET Available thermal budget ~ 100 mW

1 nm H₂O $\rightarrow \sim 3$ L $\rightarrow \ln P_{\text{H}_2\text{O}} \sim 1 \times 10^{-10}$ mbar it takes 10.000x z s (**~ 9 h**) to start observing detrimental effects!!! \rightarrow A drift of mirror T due to augmented heat adsorption! And???

If $P_{\text{H}_2\text{O}} \sim 1 \times 10^{-12}$ mbar $\rightarrow \sim 1$ month

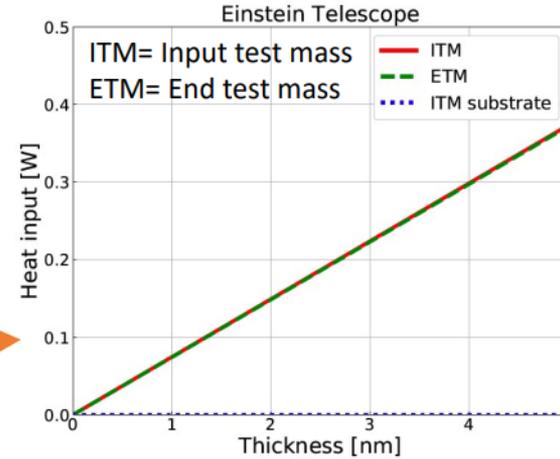
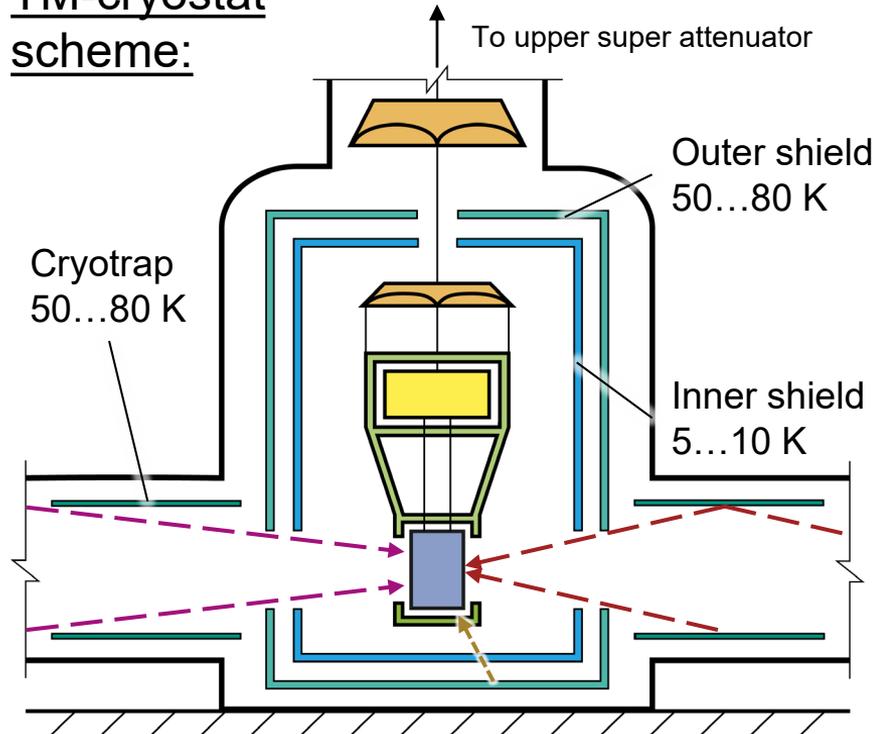


FIG. 6. Heat input to each test mass mirror in ET induced by the optical absorption of CML. As a result of strong absorption of amorphous ice, the heat load to test mass exceeds 100 mW even when the CML thickness is only a few nm. It should be noted that the radiation from the beam ducts is not taken into account for the case of ET.

Thermal Radiation

ET-LF optics: thermal radiation

TM-cryostat scheme:



Thermal radiation sources:

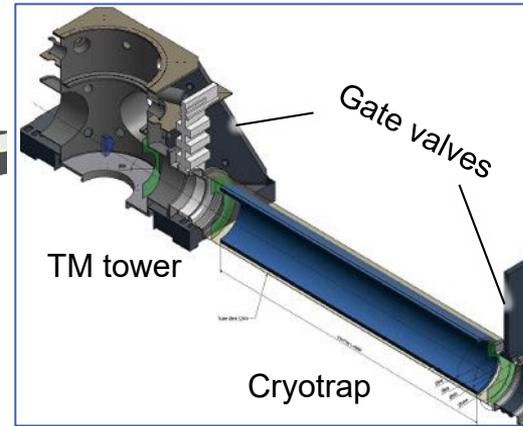
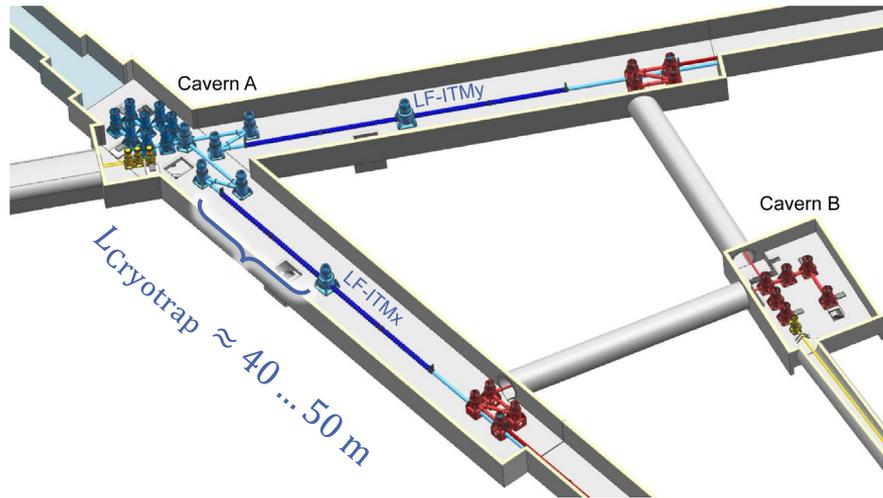
- Arm pipe solid angle (300 K)
- Funneling & cryotrap solid angle
- Thermal shield imperfections

Estimated heat load by thermal radiation depends on:

- Cryotrap length,
- Cryotrap/shield temperatures,
- Material (surface) properties,
- Shield design

ET Design Report Update 2020

Corner cavern scheme:



Cryotrap design
(LIGO, Virgo)

Current dimensioning concept &
experience from KAGRA:

$$\sum \dot{Q}_{\text{rad},i} = x \dots 100 \text{ mW}$$

Conclusions

R&D Focus: LF-mirror surface adsorption

Dependent on vacuum quality

- A few nm of water layer build-up per day

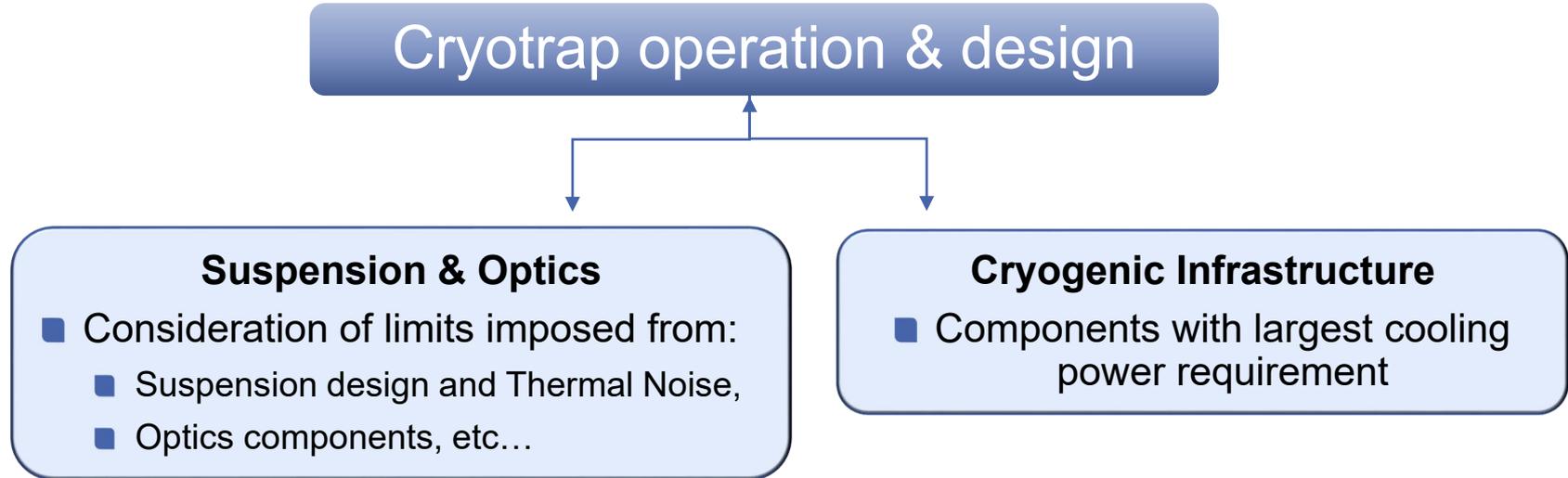
Potentially large laser power absorption in the water frost layer

- Approximately 200 mW per day
- **Dependent on wavelength?**

Changing absorption yields mirror temperature drift

Surface regeneration method to be developed

R&D Focus: Cryotrap design



Thank you for your attention!

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