GWANW 2023 Group Update WWU

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Western Washington University (WWU)

The Salish Sea

- Public university in Bellingham, WA, primarily undergraduate institution, ~16,000 students
- northernmost university in the Lower 48

LIGO @ Western Washington University

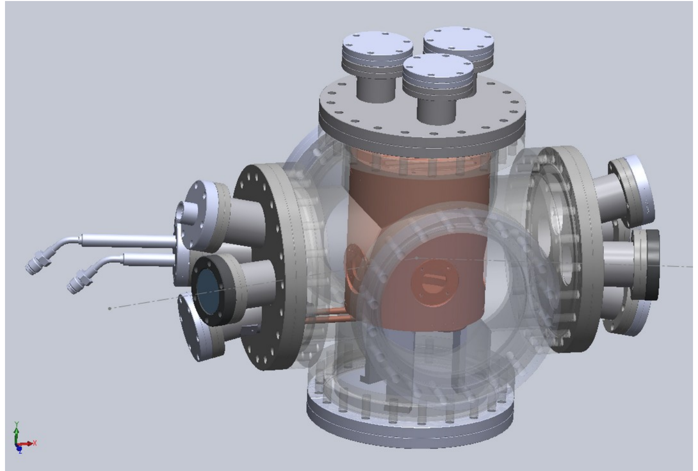
WESTERN WASHINGTON UNIVERSITY
MAKE WAVES.

- WWU has a LIGO group since 2021: SF and currently 4 undergraduate students
- also some torsion balance work with UW's Eotwash group

not pictured:
- Leah Vizmeg
- Veronica Russ

Icy mirrors in cryogenic GW detectors

- Currently building an optical cryostat to study ice films on cold optical surfaces (and possible mitigation strategies)



- Significant progress in lab setup (SF started at WWU in fall 2020)

Background: Cryogenic GW detectors

Operating future gravitational wave detectors at cryogenic temperatures has some very attractive benefits:

- improved material properties (given the right materials)
- e.g.: high thermal conductivity of mirror substrate allows for much greater circulating laser power
- decreased thermal noise

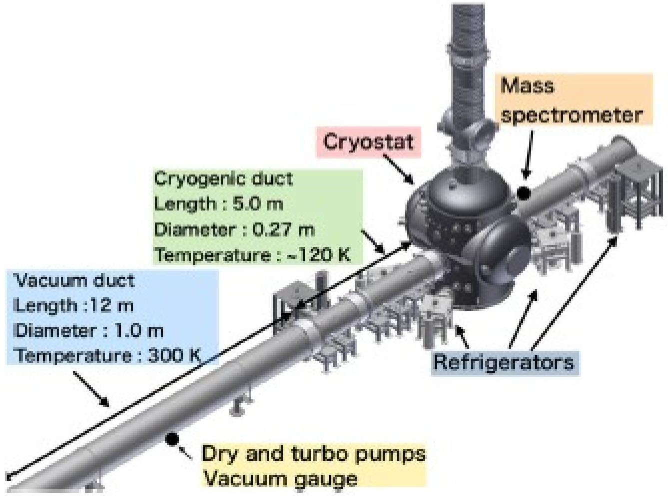
On the other hand: many new challenges!

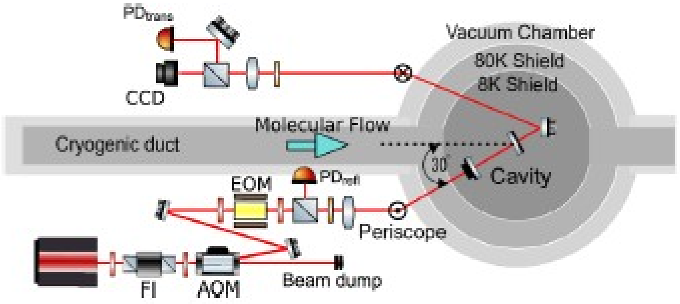
Current cryogenic GW detector concepts:

KAGRA, Einstein Telescope (ET), LIGO Voyager

Background: Ice layers on cold optics

- Even in ultra-high vacuum, residual gas will freeze out on the cold surfaces – initially observed at KAGRA: 27 +/- 1.9 nm/day
- Mostly amorphous water ice
- Very limited experimental data available on amorphous water ice

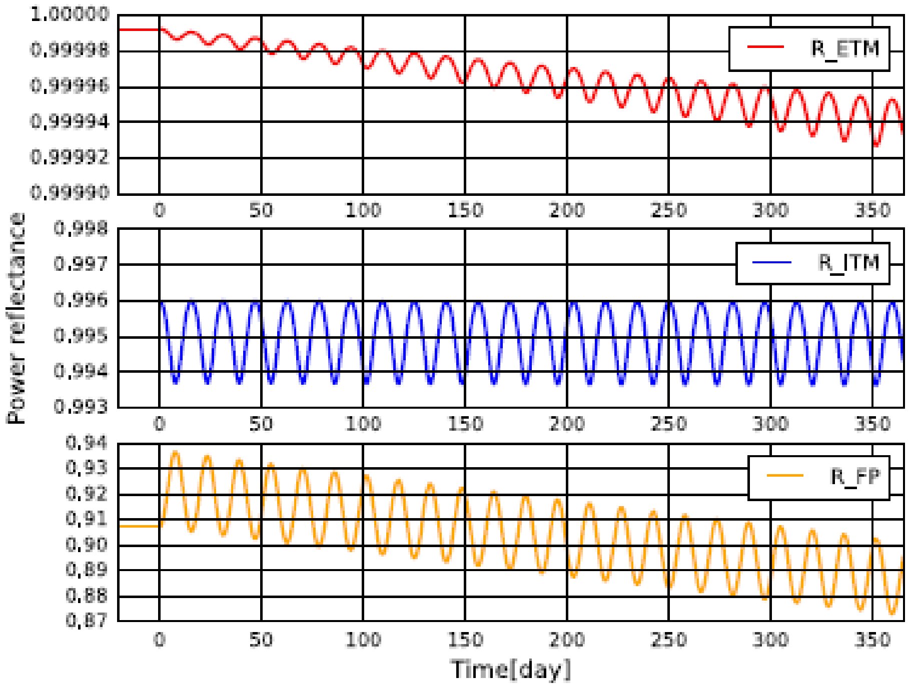




from Hasegawa et al., *Phys. Rev. D* **99**, 022003 (2019)

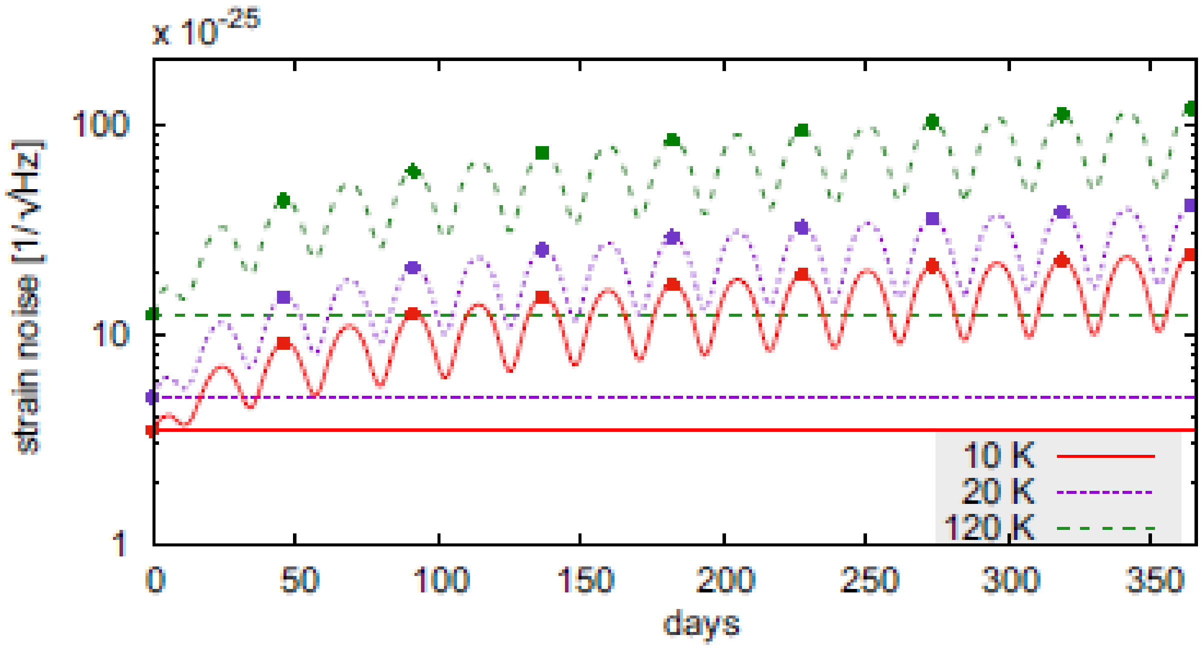
Effects of Ice Layers I

- changing reflectance



from Hasegawa *et al.*, *Phys. Rev. D* **99**, 022003 (2019)

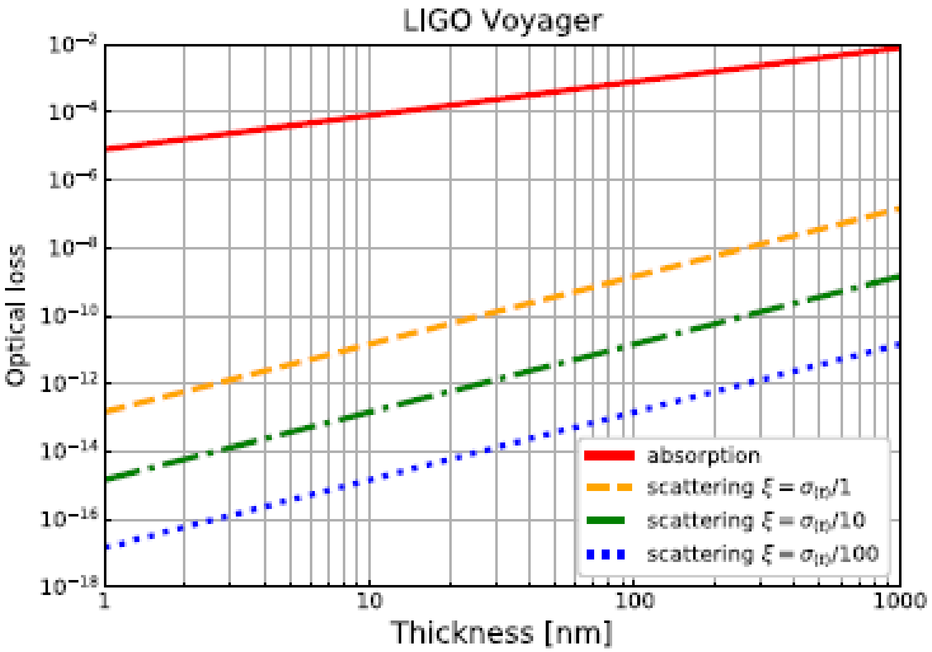
- increased coating thermal noise

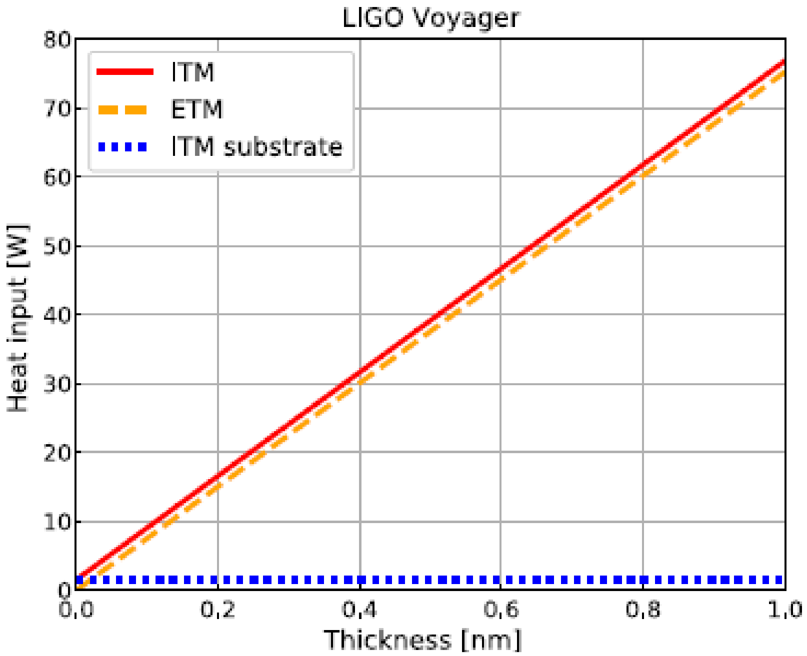


from J. Steinlechner, I. Martin, *Phys. Rev. Res.* **1**, 013008 (2019)

Effects of Ice Layers II

- probably most concerning: optical absorption @ 2µm





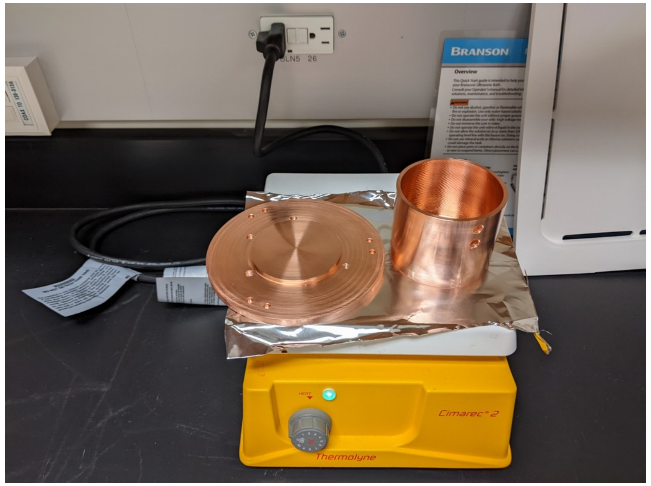
from Tanioka *et al.*, *Phys. Rev. D.* **102**, 022009 (2020)

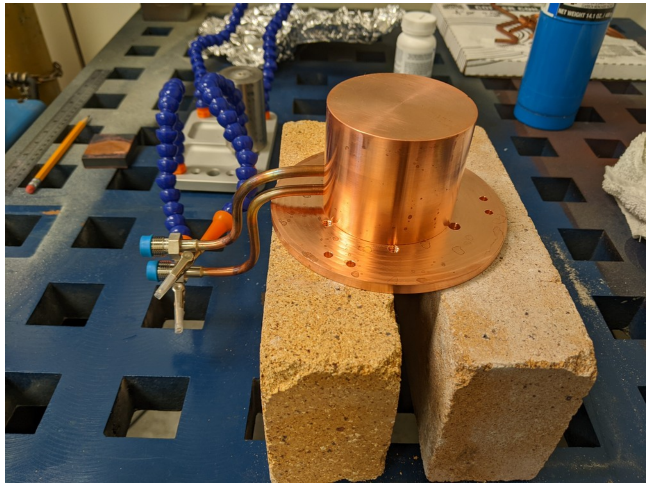
For LIGO Vo ... **yer of ice could increase th** ... K.

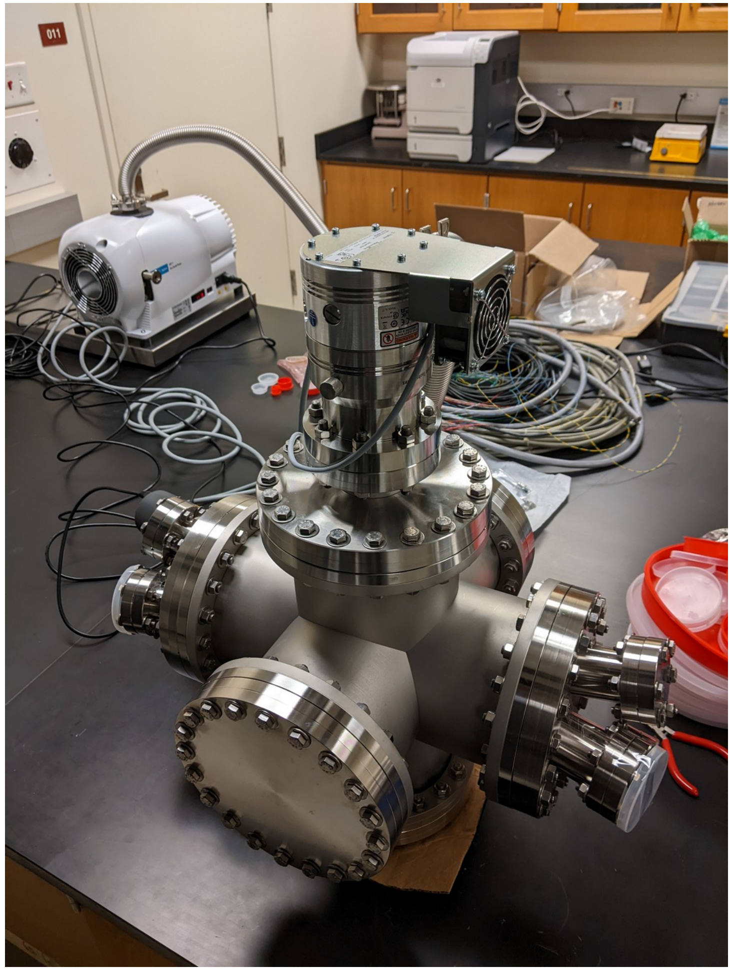
This appears to overestimate the absorption in thin layers – but still: maximum tolerable ice layer estimated to be around 20-30nm!

Optical Cryostat: Current Status

- Ultra-high vacuum system to allow for ice film growth under controlled conditions:
  - vacuum chamber assembled
  - $7x10^{-9}$ mbar without baking
- Thermal shield / LN2 system in progress

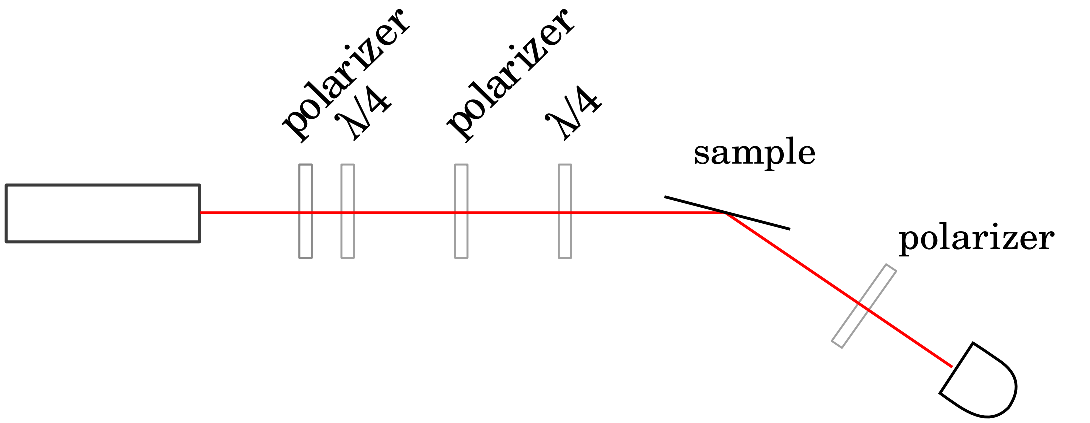


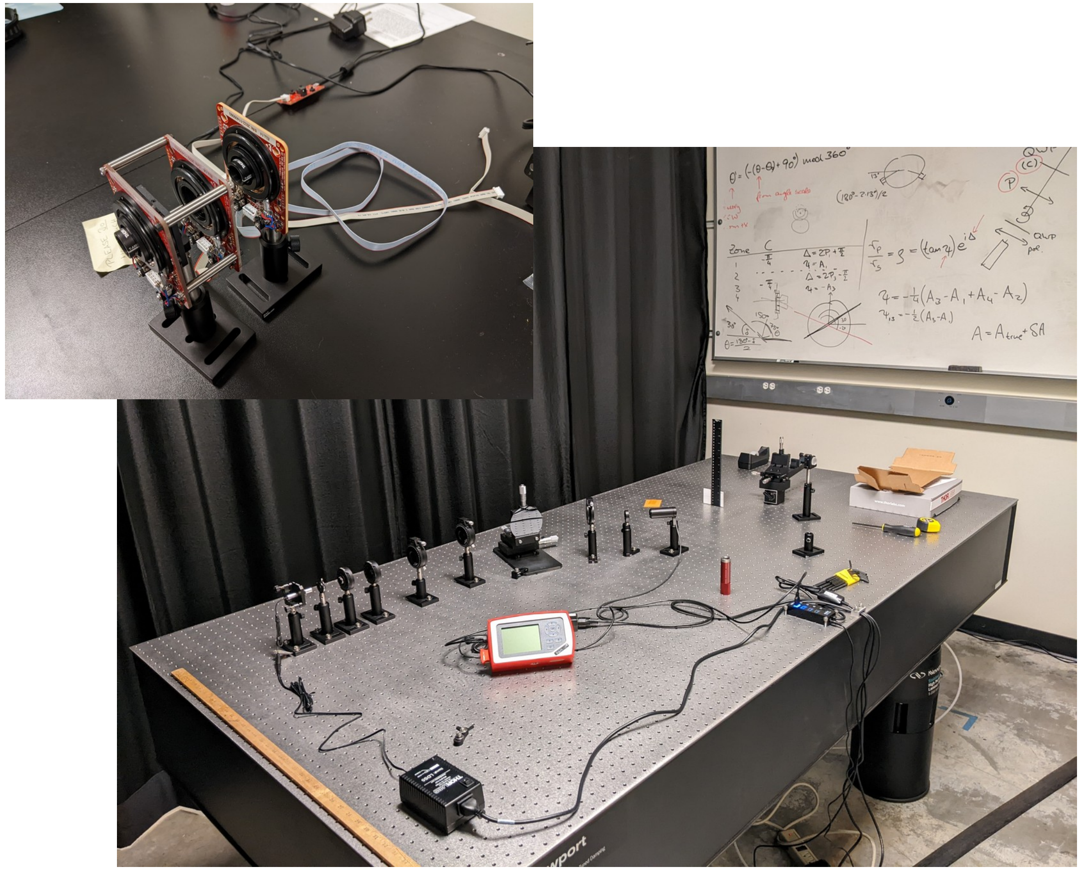




Diagnostics: Monitoring Ice Layer Thickness

- Built a simple single-wavelength ellipsometer
- Ellipsometry can optically measure (sub-)nanometer layers:
- Currently testing with calibration target (13.3nm SiO_2 on Si wafer)



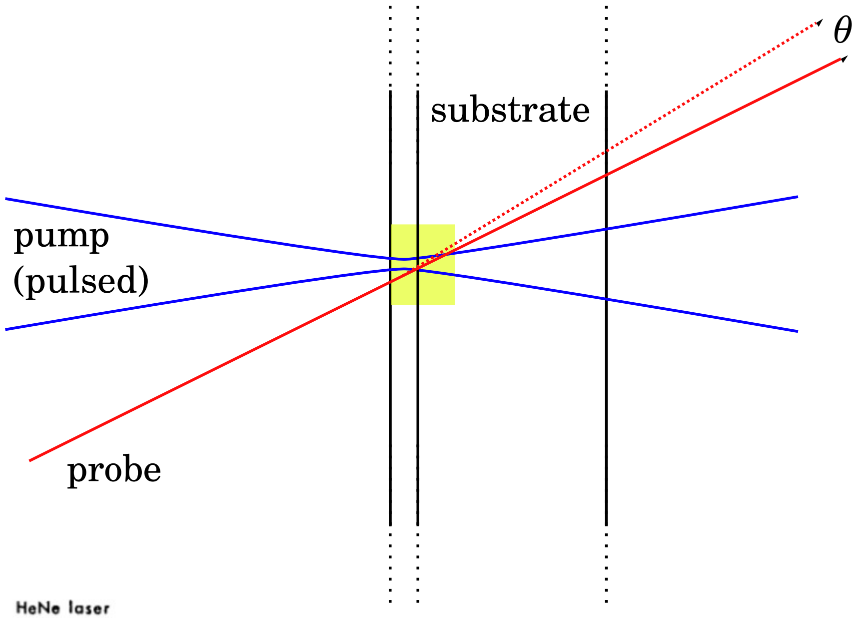


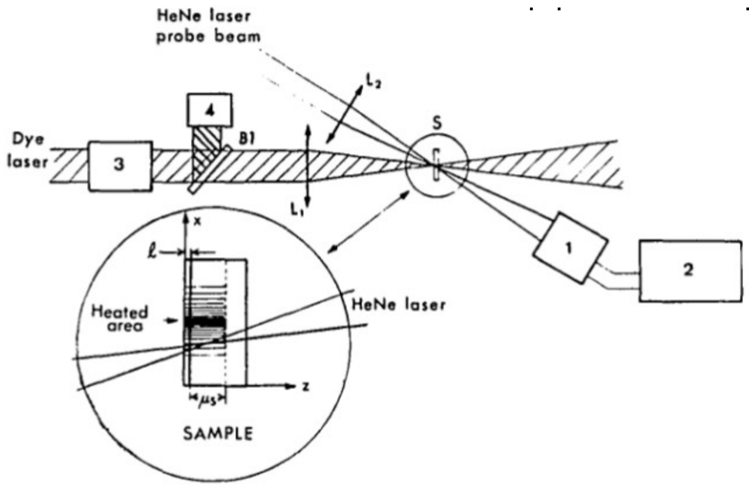
Optical Cryostat: Next Steps

- Add ion pump to vacuum system and bake out
- Assemble LN2 system and temperature sensing/control
- Continue ellipsometer tests, integrate with cryostat; check effects of window birefringence
- Look at ice buildup from residual gas, consider controlled dosing of clean water vapor

Next Steps: Studying Ice Films on Cold Surfaces

- Little experimental data, various parameters of interest
- What to try first...?
- Very interesting would be a direct absorption measurement using photothermal deflection spectroscopy (PDS)...





from A.C. Boccara *et al.*, Optics Letters **5**, 377 (1980).

Thank you for your attention!

Questions?

Students on this project:

- Jackson Larsen
- Douglas Slater
- Leah Vizmeg

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