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KAGRA BRT/GPT

Preliminary results

Junko Katayama, Matteo Barsuglia

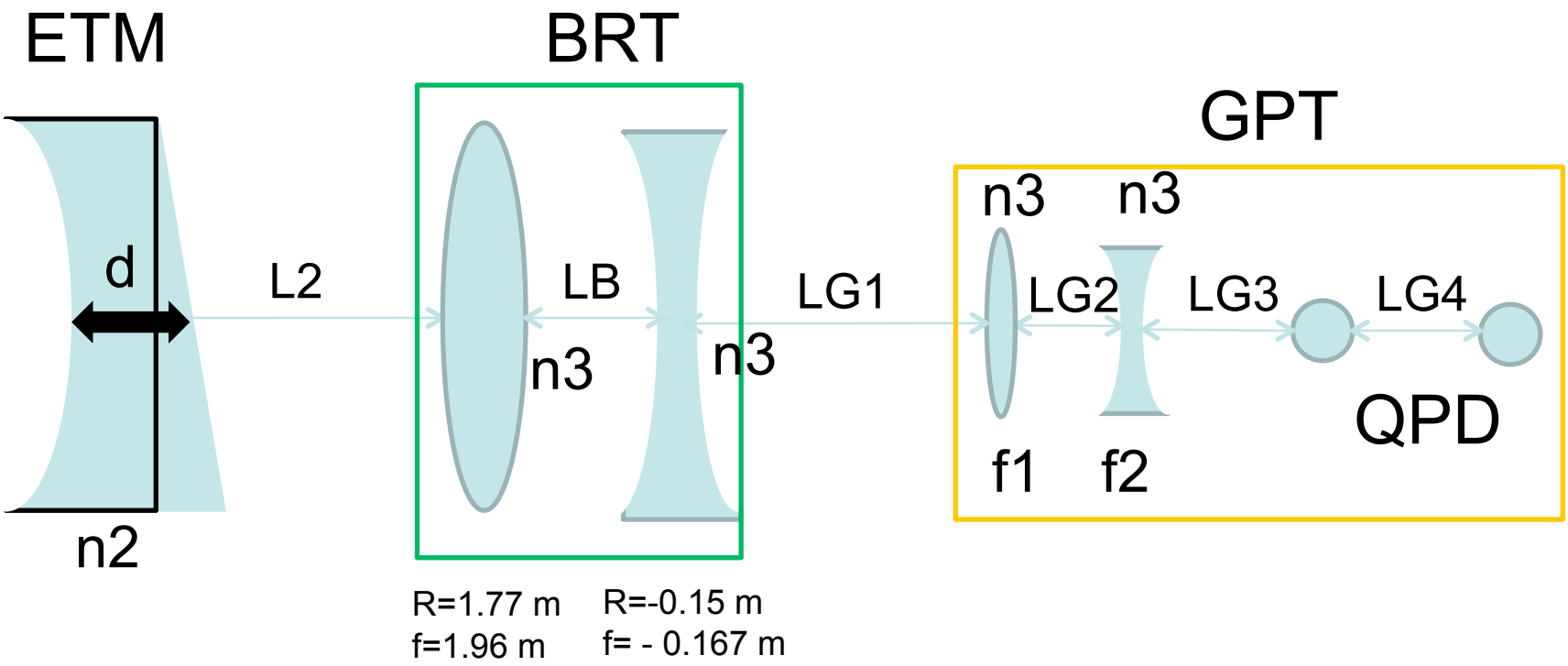
Outline

- Backscattering / reflection
- Tolerancing / aberrations (→ Zemax, see presentation by C.Buy)
- Constraints on the alignment system

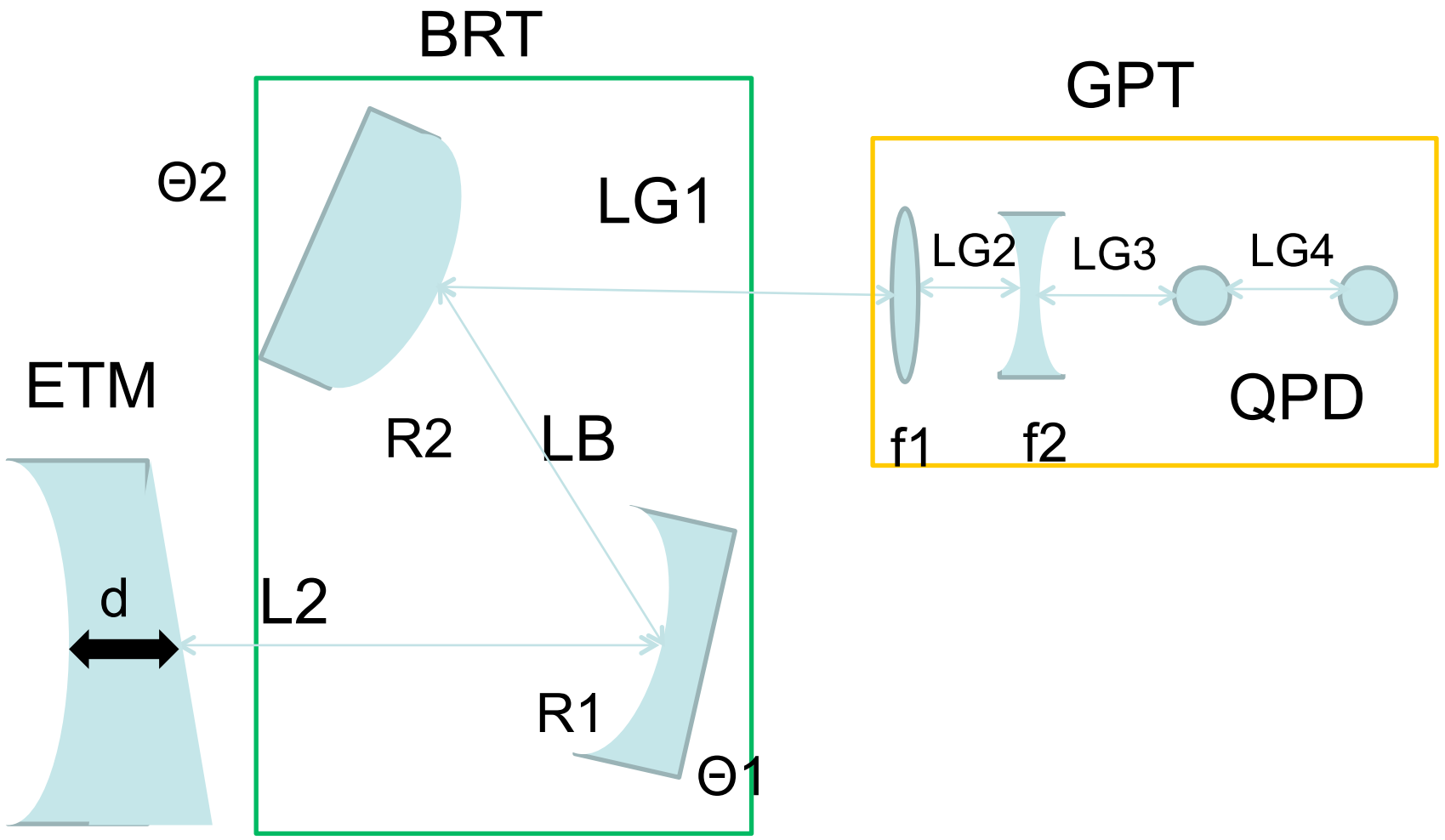
- Open questions ?

    - Which configuration (lenses, mirrors, others?)
    - Should we suspend the telescope?
    - Is there a configuration which minimizes the coupling with the bench displacements?

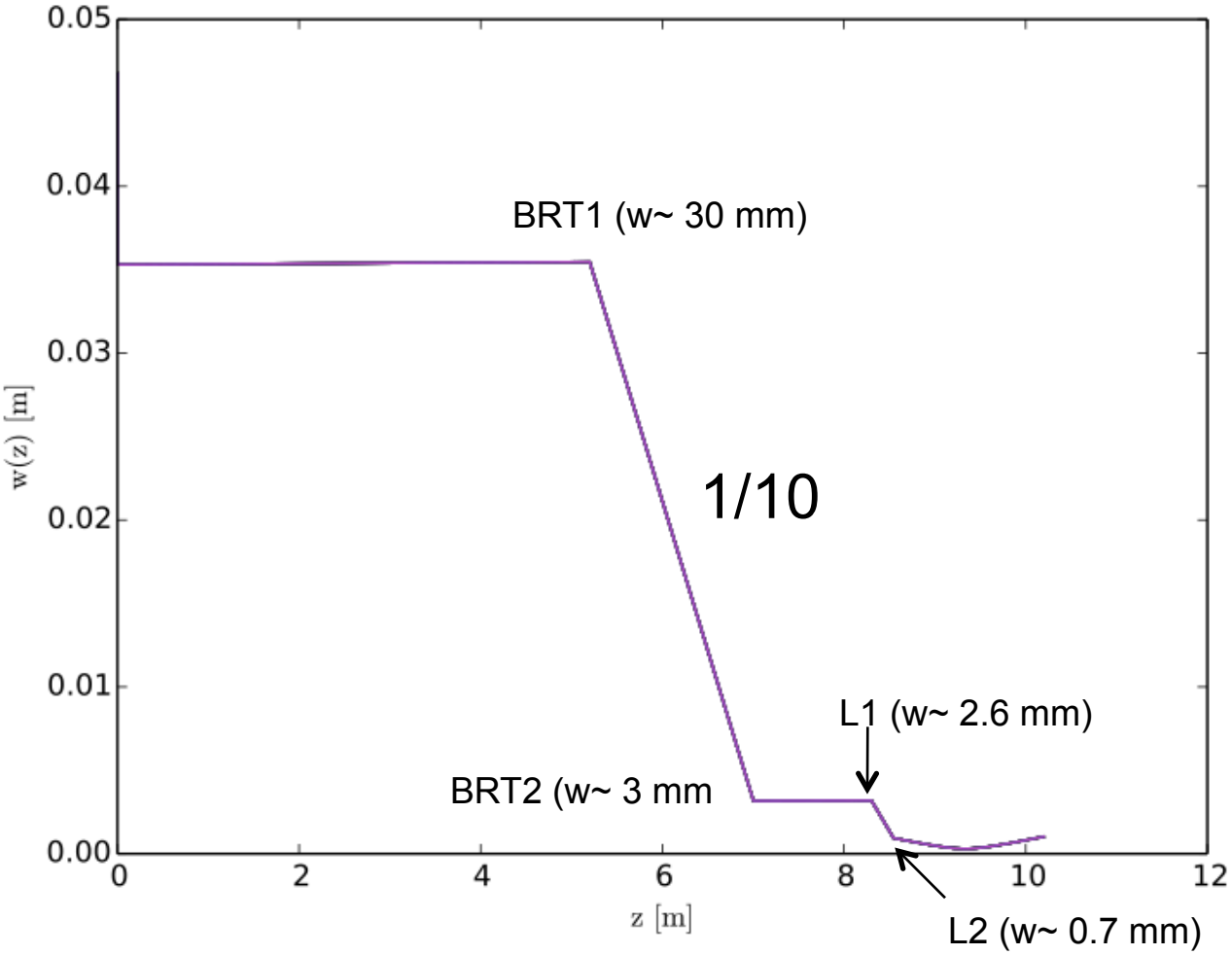
Configuration/1: lenses



Configuration/1: mirrors



Beam radius evolution

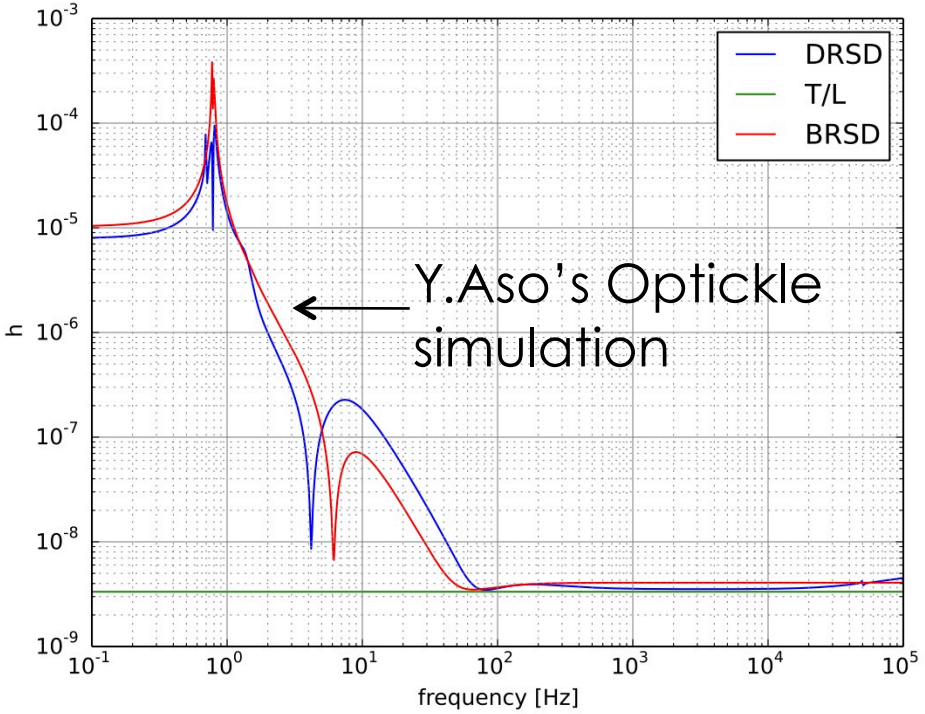


Computation of h_{eq}/1: simple model

$$h = \sqrt{f_{sc}}\,T\,\frac{\lambda}{4\pi}\,\frac{1}{L}\sin(\varphi) = \sqrt{f_{sc}}\,K_{end}\sin(\varphi) \sim \sqrt{f_{sc}}\,\frac{T}{L}\,x$$

- Only term in phase with GW is considered in this formula
- Same transfer function for GW and scattered light
- Coupling not frequency dependent

Computation of h_{eq}: Effect of the radiation pressure



Impact of upconverted scattered light on advanced interferometric gravitational wave detectors, Ottaway et al., Optics express 2012

P_{cav}=500 kW
P_{in}= 78 W
T=10 ppm
M=20 kg

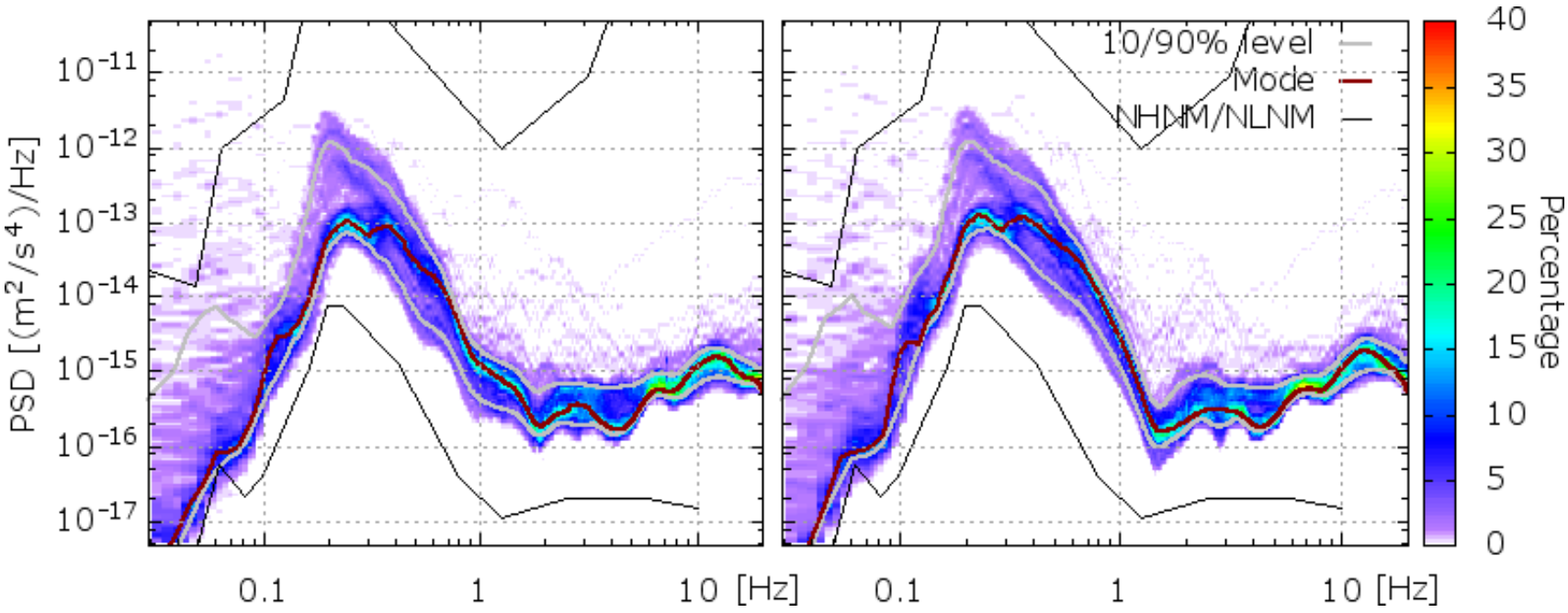
- Frequency dependend coupling factor
- Increase of coupling in the 10-100 Hz region
- If time avaiblable: check with other simulations (Finesse, MIST), check what happens decreasing the power

Computation of $h_{eq}/2$: Optickle simulation

$$h = \sqrt{f_{sc}}\,\frac{4\pi}{\lambda}\sqrt{\frac{P_{in}}{P}} = \sqrt{f_{sc}}\,K_{end}\sin(\varphi) \sim \sqrt{f_{sc}}\,\frac{T}{L}\,x$$

- Only term in phase with GW is considered in this formula
- Same transfer function for GW and scattered light
- Coupling not frequency dependent

Seismic noise



From M.Beker

Scattering: Lenses at normal incidence

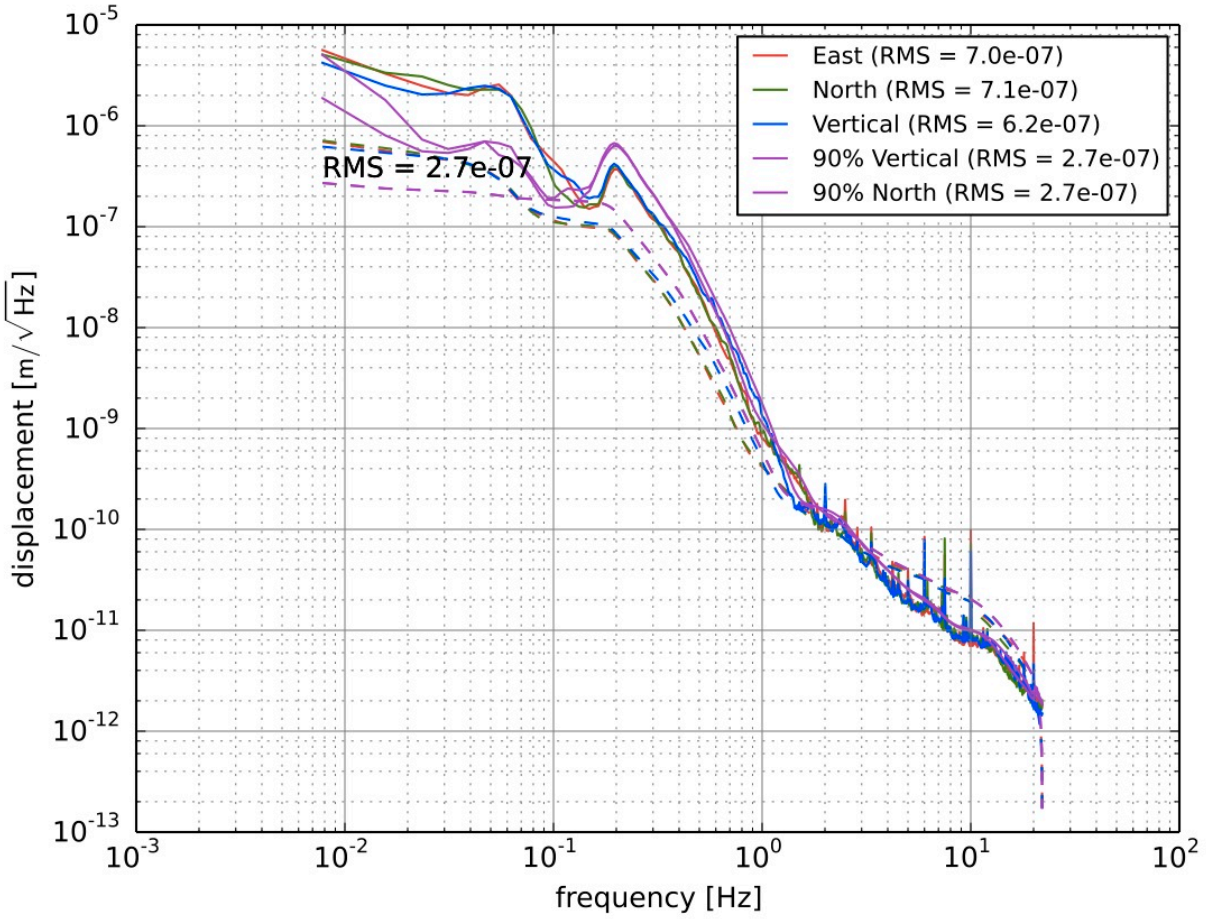
• No measurement (at our knowledge) of BRDF at small anglesf on AR components

• Measurements at < 1 deg very difficult, but BRDF measured at ~ 5 deg could already give some indications.

• We need a measurement on a sample with 2 AR faces and same surface quality needed (to avoid the contamination by the diffusion of the 2nd face)

• Measurements are on going at LMA on the compensation plates AR/AR superpolished

Seismic noise



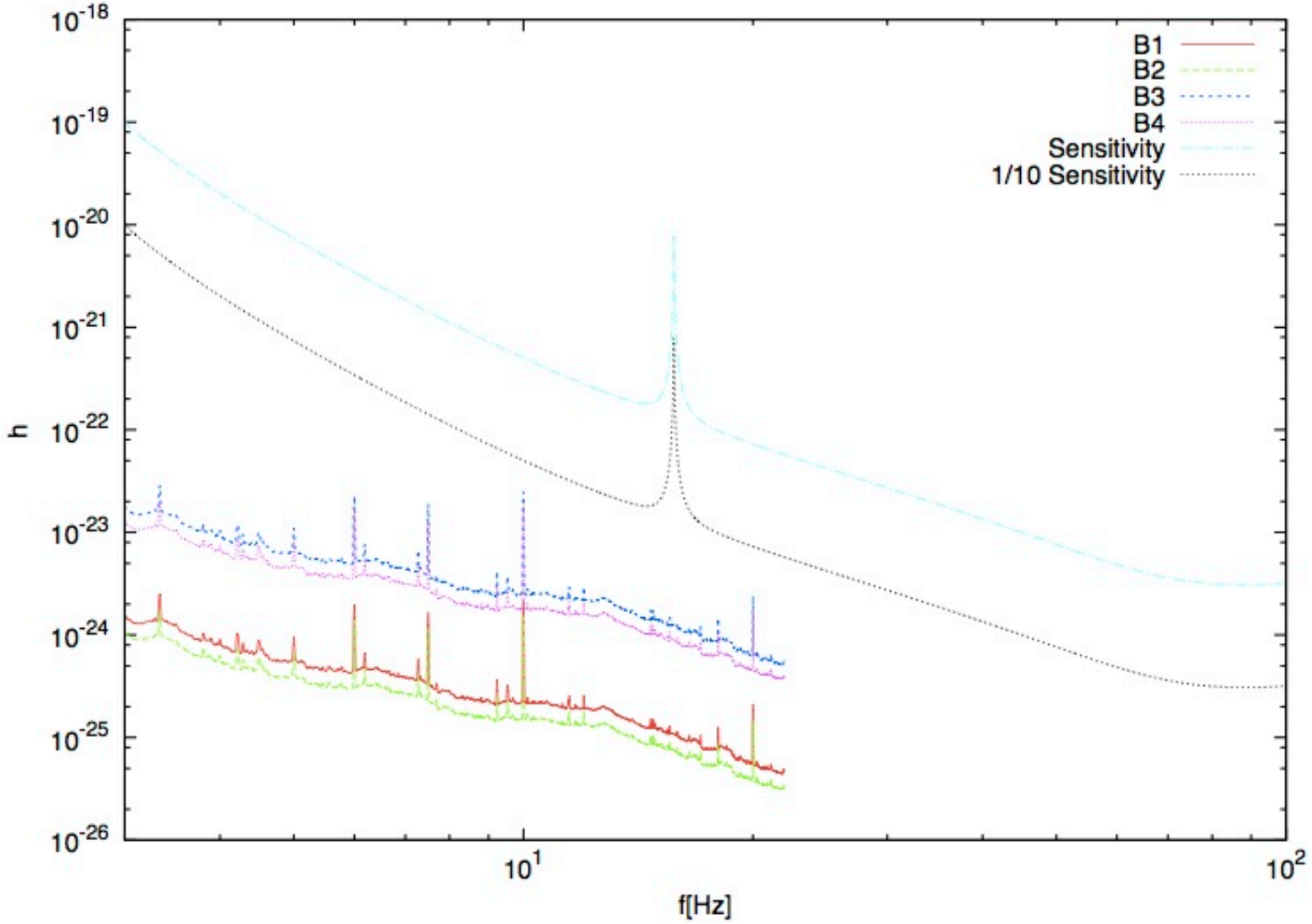
- How to compute upconversion?

Direct reflection by the lenses

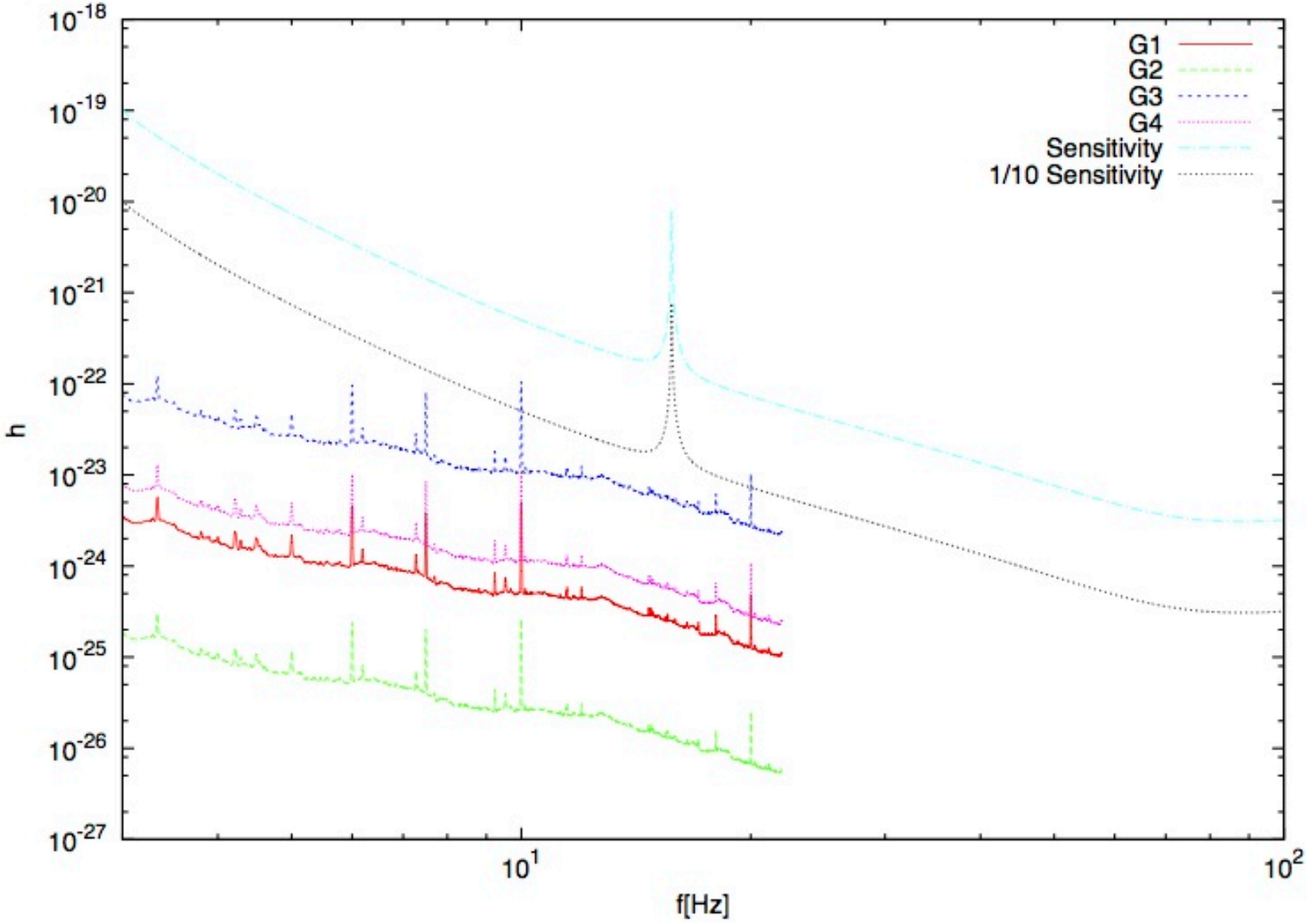
Light recombined = R_{AR} * [overlap integral]^2

- Overlap between incoming beam and reflected beam
- R_{AR}=100 ppm
- 8 surfaces (4 BRT, 4 GPT)
- No tilt – normal incidence
    - Tilt drastically reduces the coupling
    - Check if we can tilt the lenses (with Zemax)

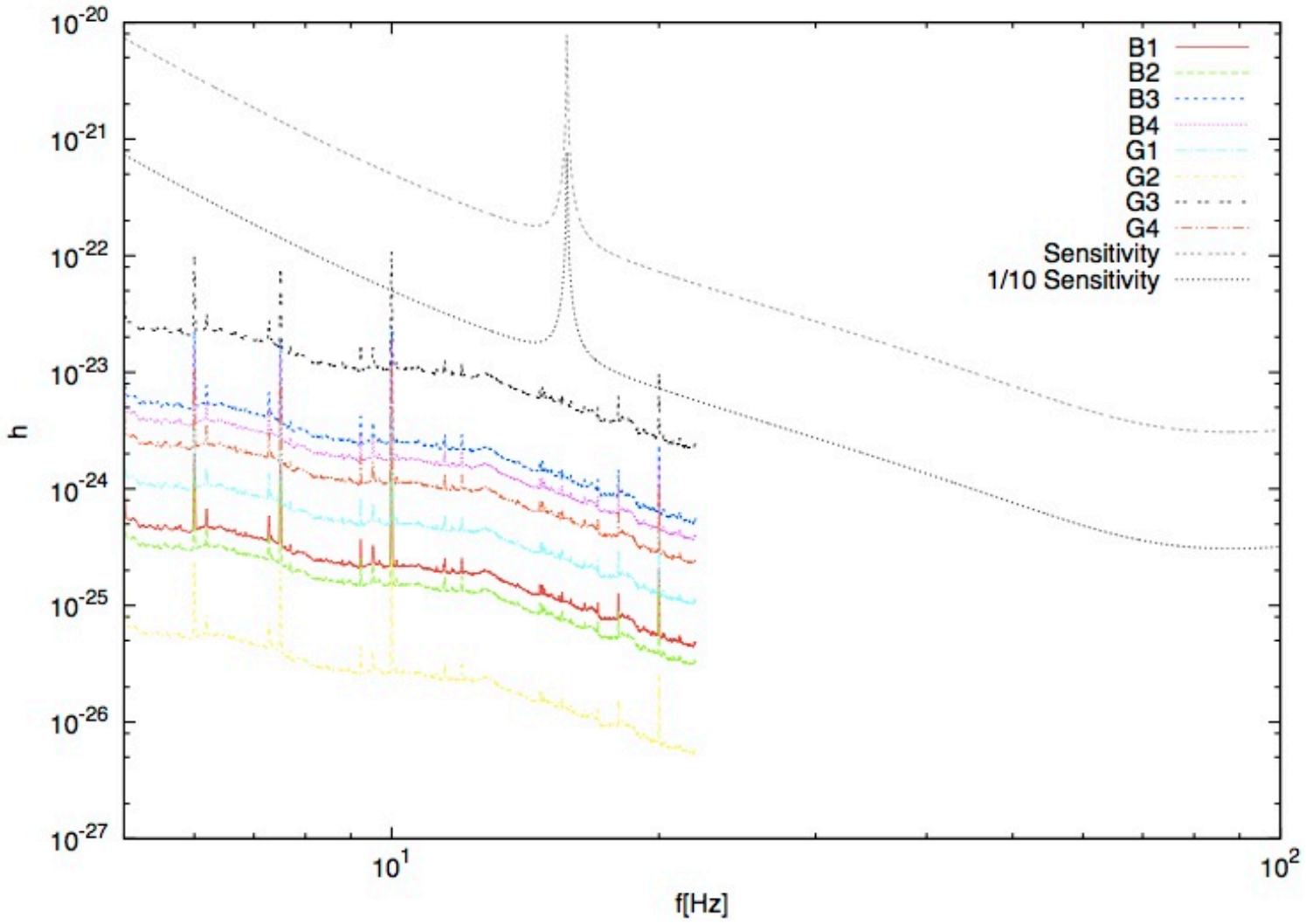
Reflection – BRT (simple model)



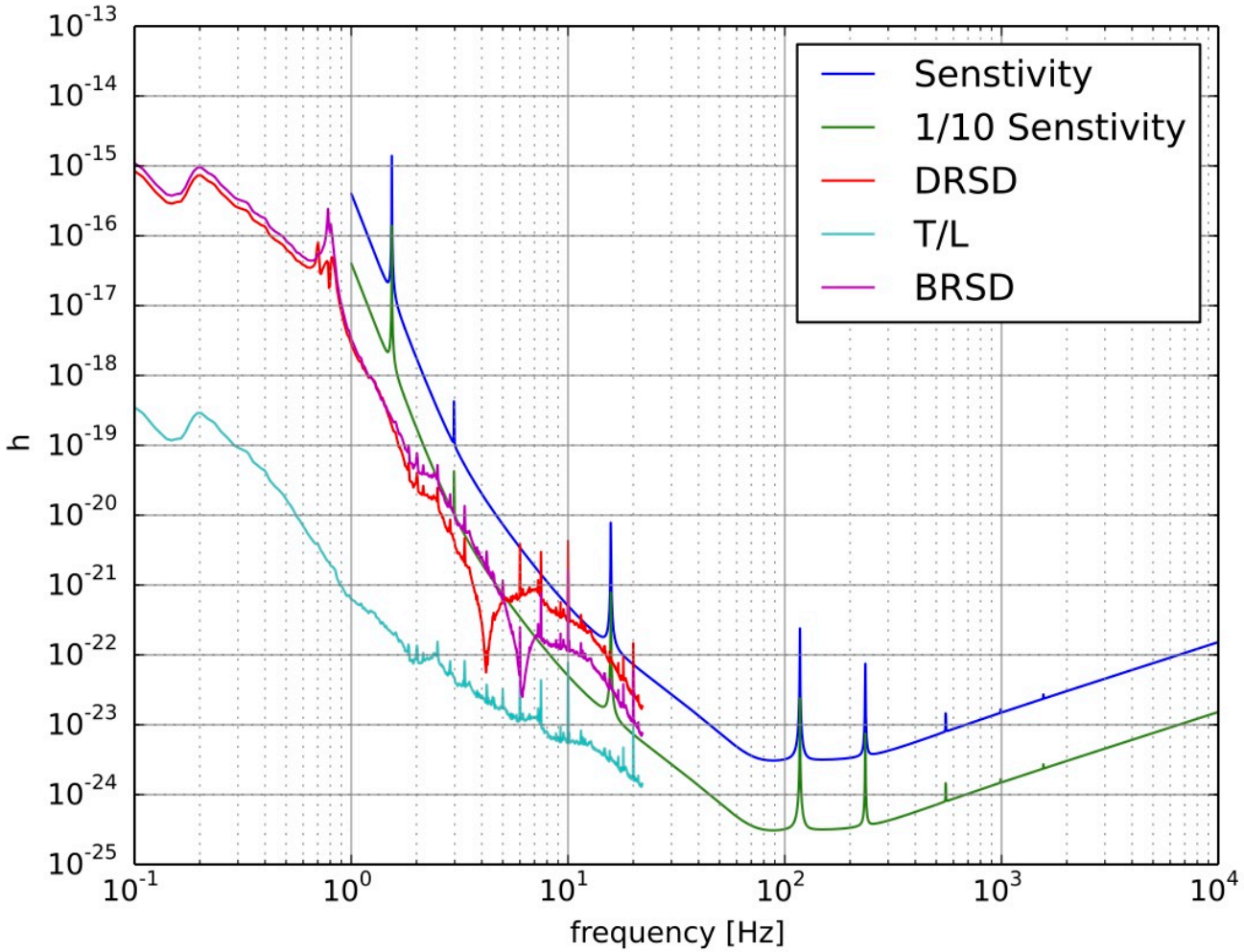
Reflection – GPT (simple model)



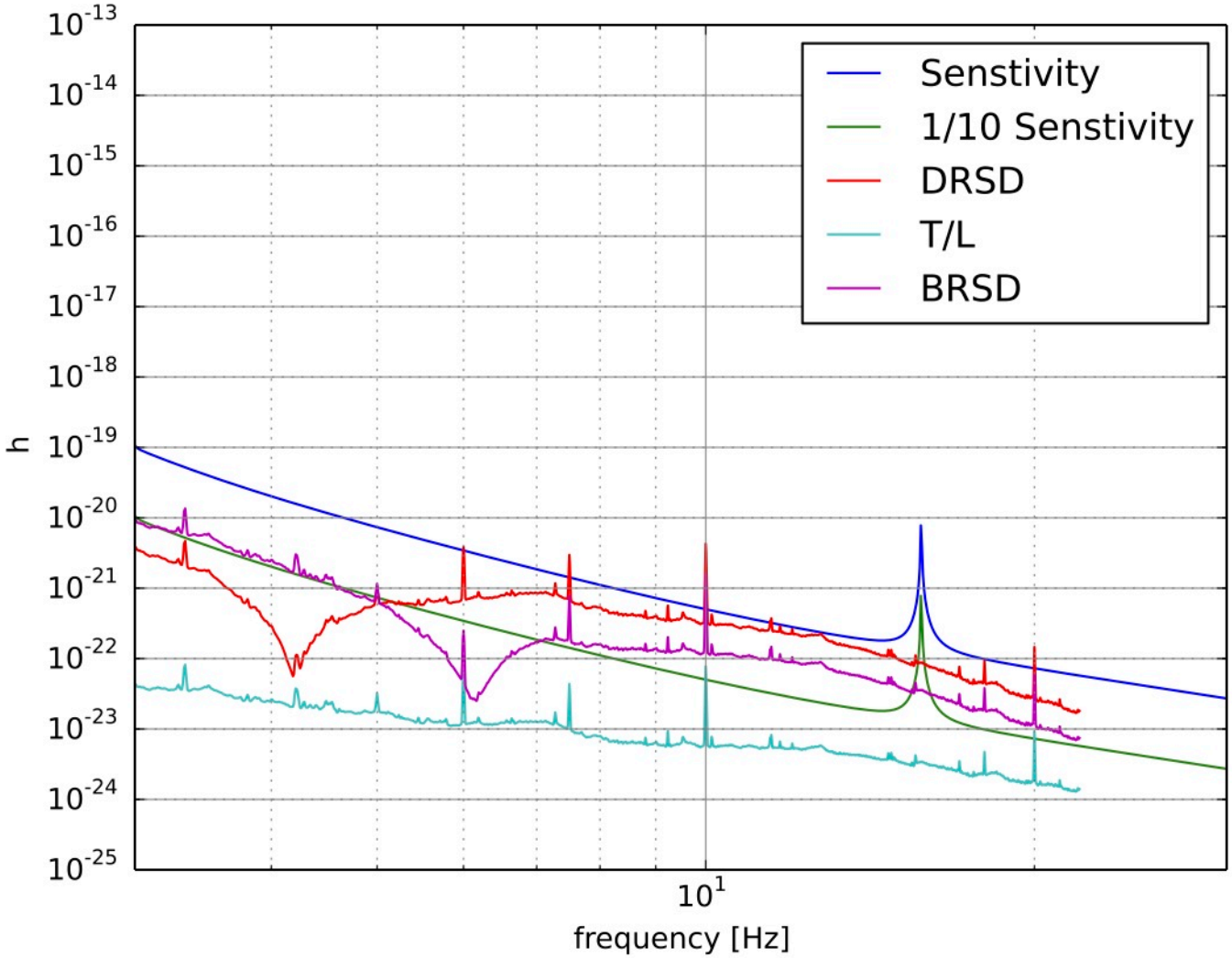
Reflection – BRT+GPT (simple model)



Reflection – leading term

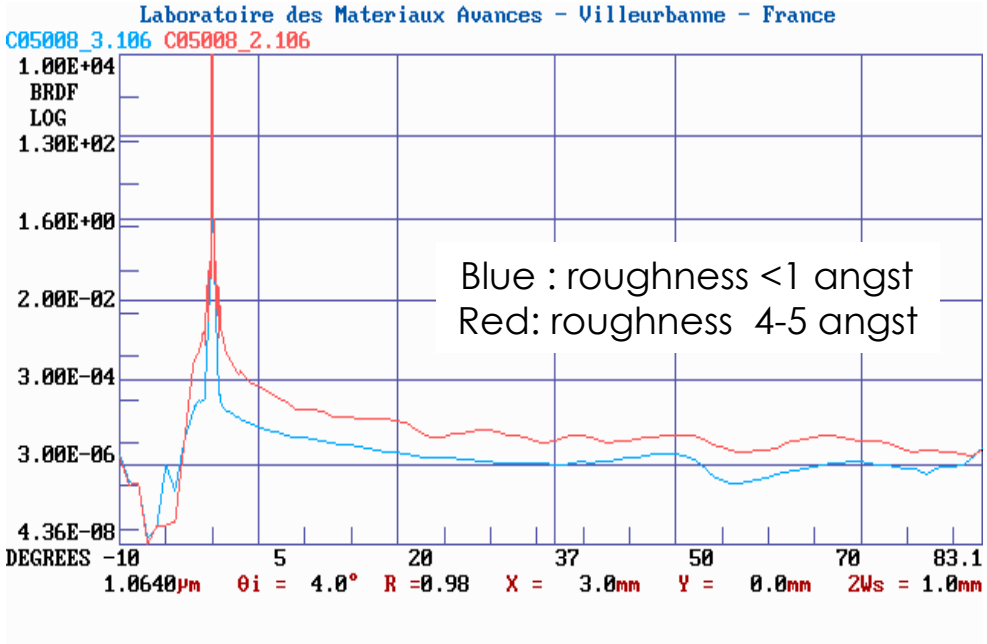


Reflection – leading term – zoom



Scattering of superpolished components

We assume a Lambertian distribution (BRDF = constant → TIS/π)



Hypothesis (some numbers)

- Superpolished (~ 3 angst)
  - TIS=10 ppm, BRDF=3x10^{-6} strd^{-1}
- Parabolic (roughness ~ 1 nm)
  - TIS=150 ppm, BRDF= 50x50^{-6} strd^{-1}

Credit: L.Pinard