

# Noise Requirement for QPDs on TMS

Yuta Michimura

Department of Physics, University of Tokyo

# 2016 Update

- Requirement below 1 Hz was wrong
  - I was using wrong seismic noise data
  - replaced with Type A seismic noise in normal seismic
- Requirement on RMS motion was added

# Scope

- Derive noise requirements for QPDs on TMS from ASC point of view
- References:
  - [JGW-T1301878](#) (B=0 idea)
  - [JGW-G1301664](#) (WFS shot noise requirement calculation described in detail in Japanese)
  - [JGW-G1301779](#), [Phys. Rev. D 88, 043007 \(2013\)](#) (WFS shot noise requirement calculation; final version)
  - [JGW-G1402171](#) (calculation method for noise coupling from TMS motion; note that conclusions are somewhat wrong; making B=0 does help)
  - [JGW-G1402223](#) (TMS QPD noise calculation based on actual TMS design)

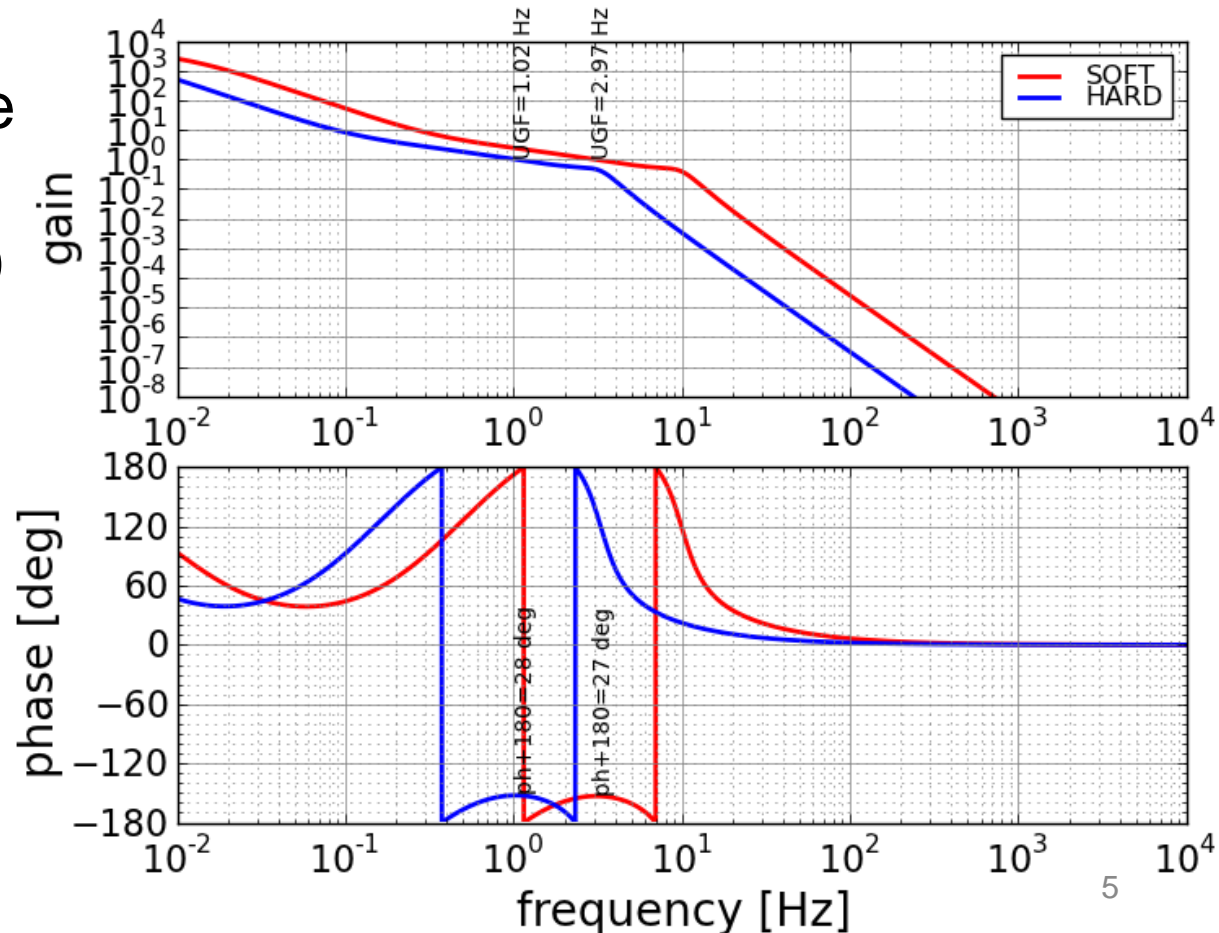
# Requirement Derivation

- Derivation method is the same as the one done when deriving WFS shot noise requirement described in documents [JGW-G1301664](#), [JGW-G1301779](#), and [Phys. Rev. D 88, 043007 \(2013\)](#).
- WFS noise requirement calculation was already done by simulating ASC sensing matrix, assuming servo filters, and assuming beam mis-centering.
- WFS shot noise requirement is set to satisfy above requirement above 10 Hz.
- I redid the same calculation but in SOFT/HARD basis

# Assumptions

- ASC sensing matrix is simulated by Optickle
- mis-centering at ITMs, ETMs: 0.1 mm
- servo filters shown below

(higher UGF for SOFT mode since it's unstable pole is at around 1 Hz)

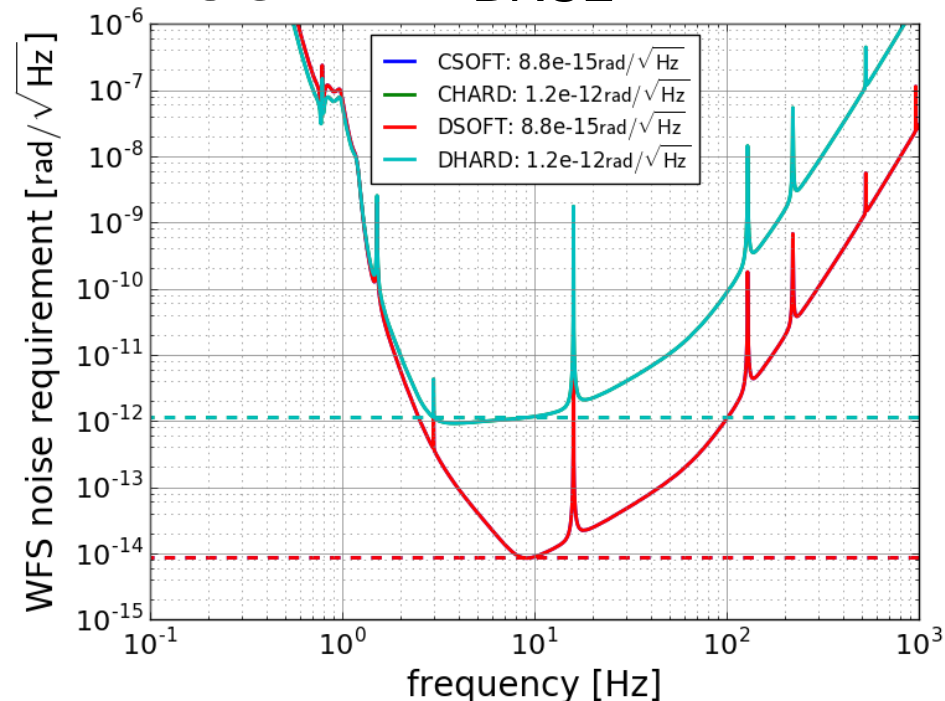


# Requirement

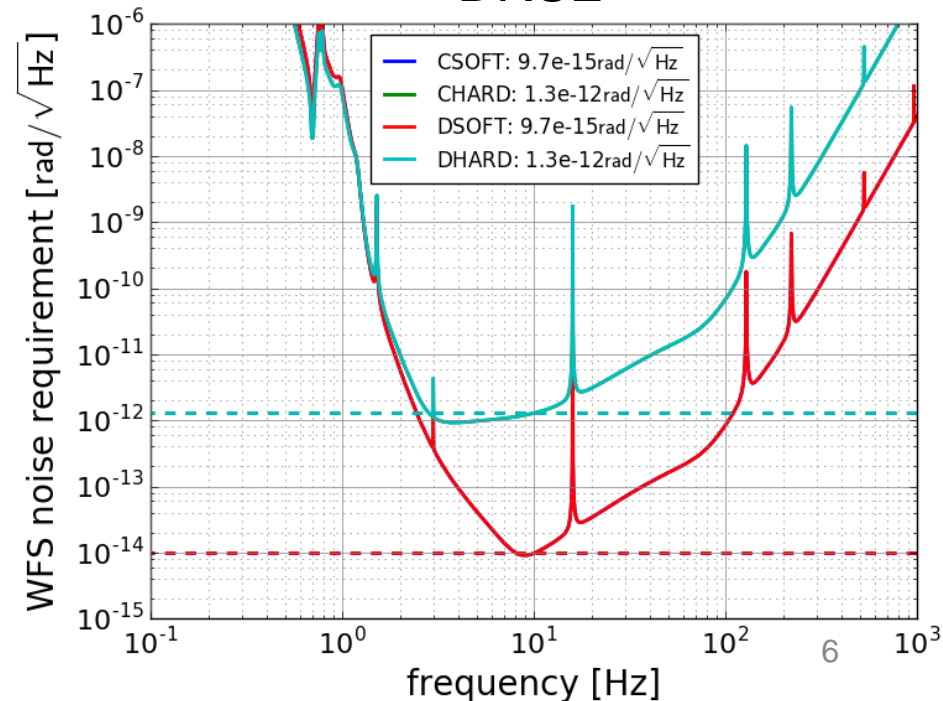
- in terms of SOFT/HARD motion equivalent noise in rad/rtHz
- safety factor = sqrt(22) for 11 mirrors, pitch/yaw
- 1e-7 rad/rtHz @ 1 Hz, 1e-14 rad/rtHz @ 10 Hz for SOFT
- 1e-7 rad/rtHz @ 1 Hz, 1e-12 rad/rtHz @ 10 Hz for HARD
- requirement for SOFT is more severe because of higher

UGF

BRSE



DRSE

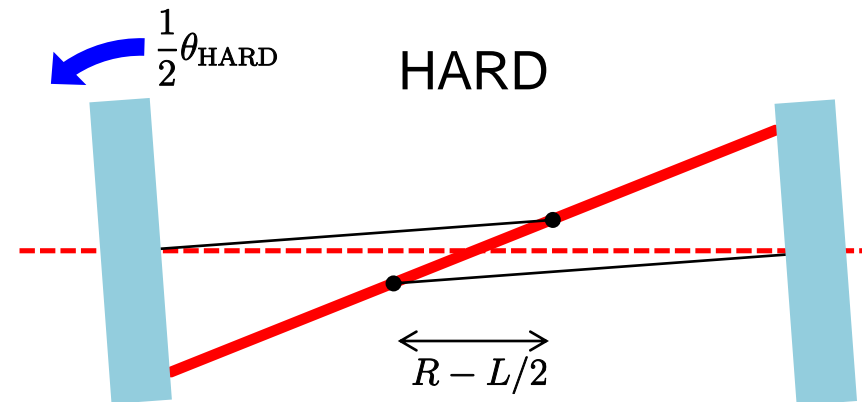
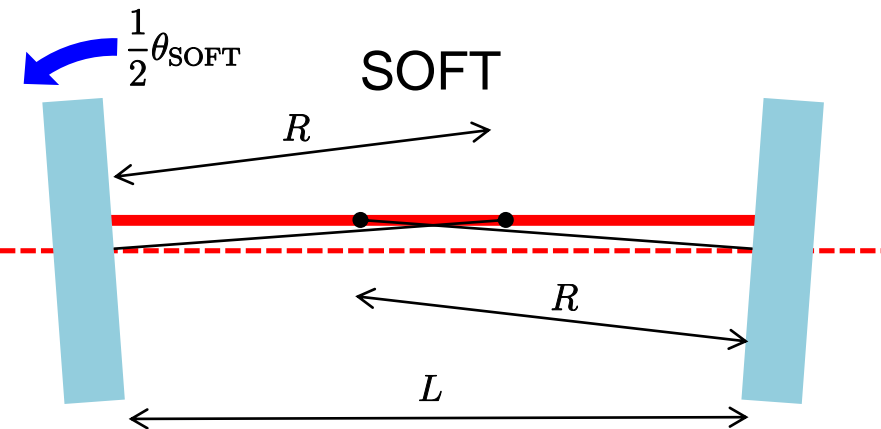


# Requirement on RMS

- the requirement spectra in p.6 was derived assuming beam spot motion on mirror to be less than 0.1 mm RMS
- but there is also requirement on mirror angular motion to achieve 0.1 mm RMS beam spot motion
- Requirement on RMS

$$\text{SOFT: } \theta_{\text{SOFT}} < \frac{2d}{R} = \frac{2 \times 0.1 \text{ mm}}{1.9 \text{ km}} = 0.1 \text{ urad}$$

$$\text{HARD: } \theta_{\text{HARD}} < \frac{2d}{RL/(2R - L)} = \frac{2 \times 0.1 \text{ mm}}{7.125 \text{ km}} = 0.03 \text{ urad}$$



# To Do (as of Apr 2014)

- design TMS (beam reducing telescope, Gouy phase telescope) that satisfy the requirement
- if sensitivity for SOFT meets the requirement, use TMS QPDs to sense SOFT
- if sensitivity for HARD meets the requirement, but not SOFT, use TMS QPDs to sense HARD
- if TMS QPDs don't satisfy the requirement above 1 Hz because of TMS motion, we need suspended TMS (according to Daniel's calculation [JGW-G1402223](#), it is likely that we have to suspend)
- if TMS QPDs don't satisfy the requirement below 1 Hz, we have to re-think ASC scheme (use B=0 method at TMS and use REFL/AS QPDs also to diagonalize SOFT/HARD)