

# Noise Requirement for QPDs on TMS

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# 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)

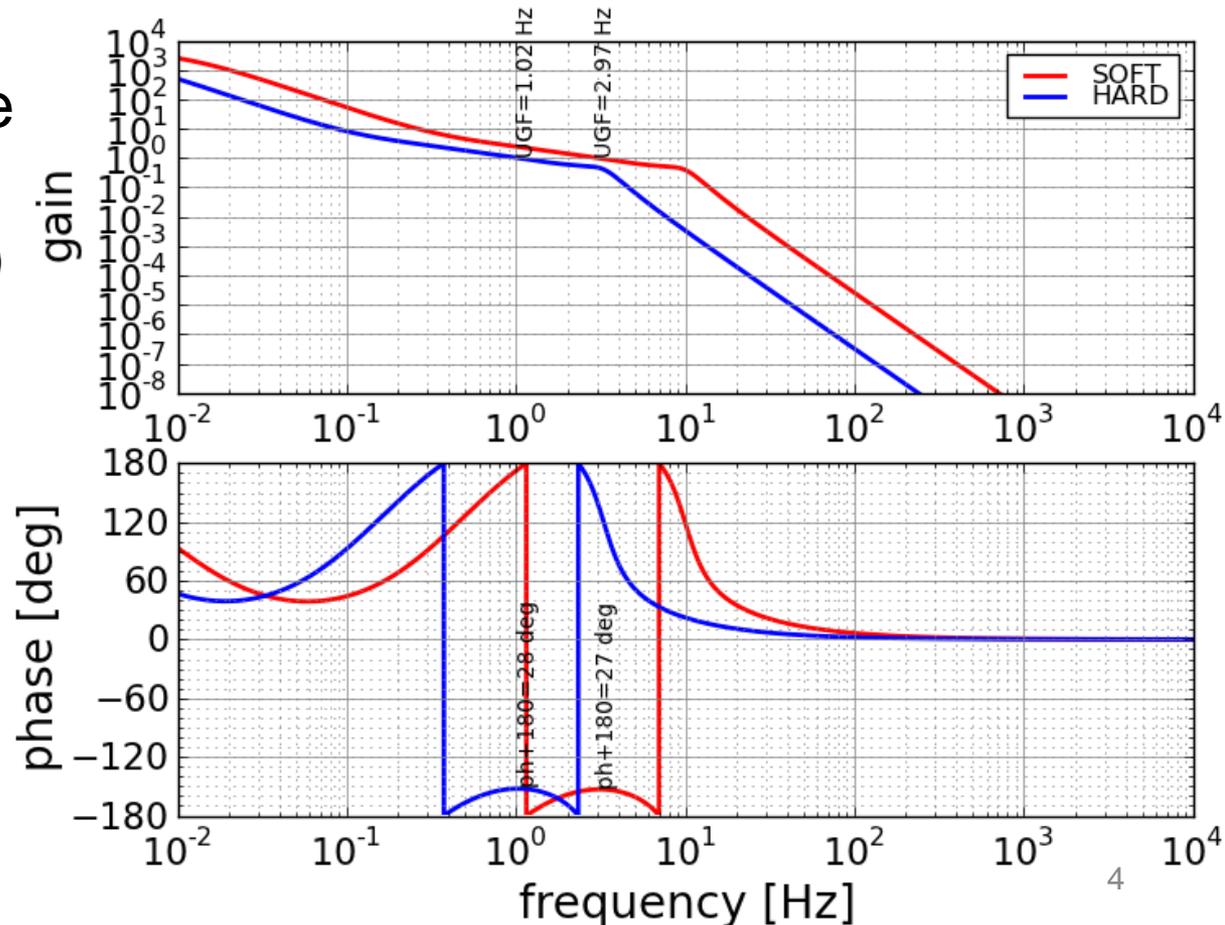
# Requirement Derivation

- 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

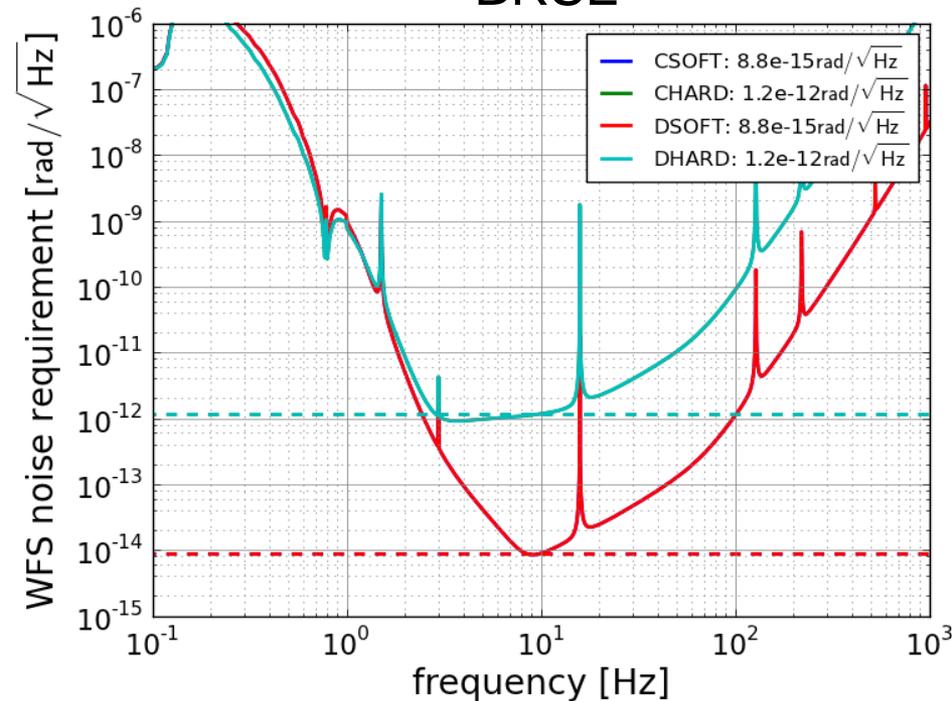
(higher UGF for SOFT mode since it's unstable pole is at around 1 Hz)



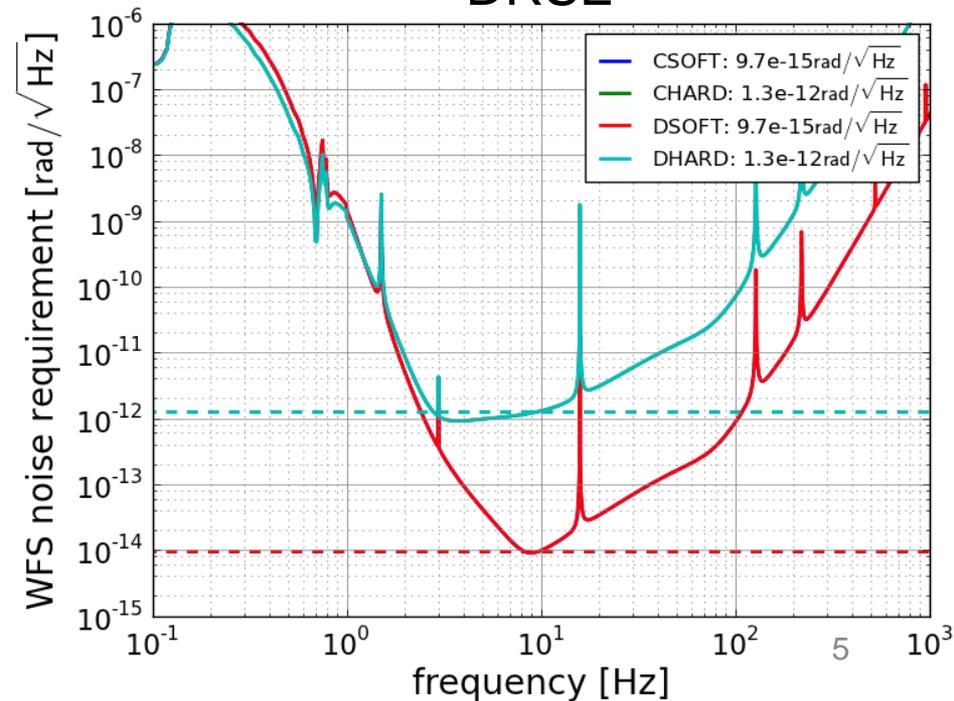
# Requirement

- in terms of SOFT/HARD motion equivalent noise in rad/rtHz
- safety factor = sqrt(22) for 11 mirrors, pitch/yaw
- 1e-9 rad/rtHz @ 1 Hz, 1e-14 rad/rtHz @ 10 Hz for SOFT
- 1e-9 rad/rtHz @ 1 Hz, 1e-12 rad/rtHz @ 10 Hz for HARD

## BRSE



## DRSE



# To Do

- 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, 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)