Advanced LIGO Prestabilized Laser Requirements

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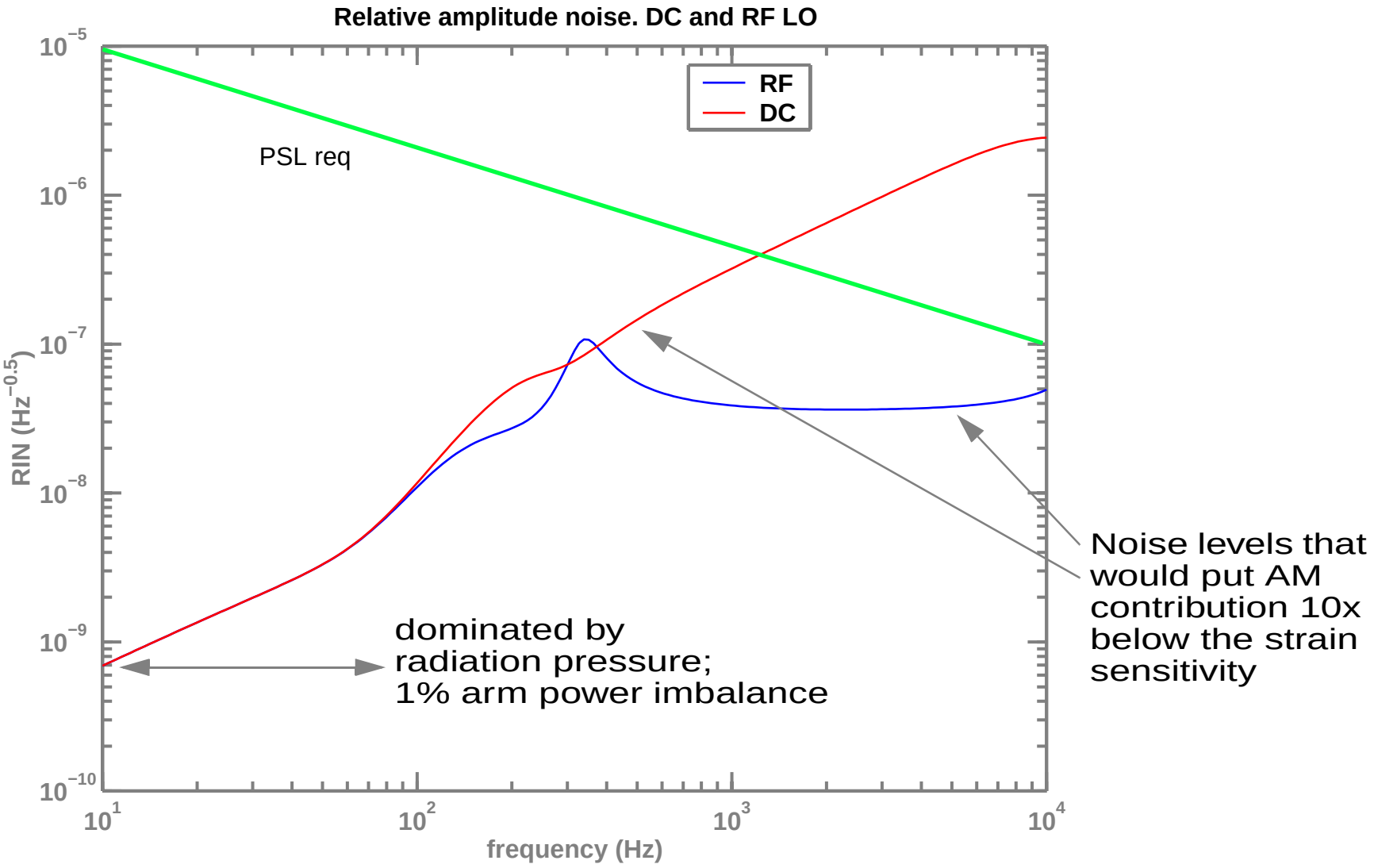
Output Power

- 120 W required at interferometer input (PRM)
  - 180 W from PSL (66% efficiency through input optics)
    - ➢ too pessimistic on efficiency?
  - Non-TEM00 content (static): mode cleaner sensing
    - ➢ not critical; MC needs at most 1W effective input power for shot noise sensitivity
    - ➢ higher order mode power: < 10 W
- Power control
  - Static: better to do control in input optics, just before mode cleaner
  - Dynamic: power control input for stabilization and modulation
    - ➢ DC – 100 kHz (3 dB point; excepting any laser physics dynamics)
    - ➢ Range: sufficient to correct power fluctuations in 1Hz-100 kHz band, but no less than ~ +/– 1% of output power

POWER STABILITY

- Long term
  - better than 1% over any 24 hr period
- Control band, f < 10 Hz
  - better than 1% rms
- GW band, f > 10 Hz
  - ultimate noise requirement determined by –
    - unbalanced radiation pressure at low frequency
    - readout scheme (DC vs RF) and defects/deviations at high frequencies
  - final stabilization done by detecting a sample of the mode cleaner transmission (in-vacuum photodetector), and feeding back to the PSL power control input
  - modest level of power stability required of PSL to ease gain required in final loop

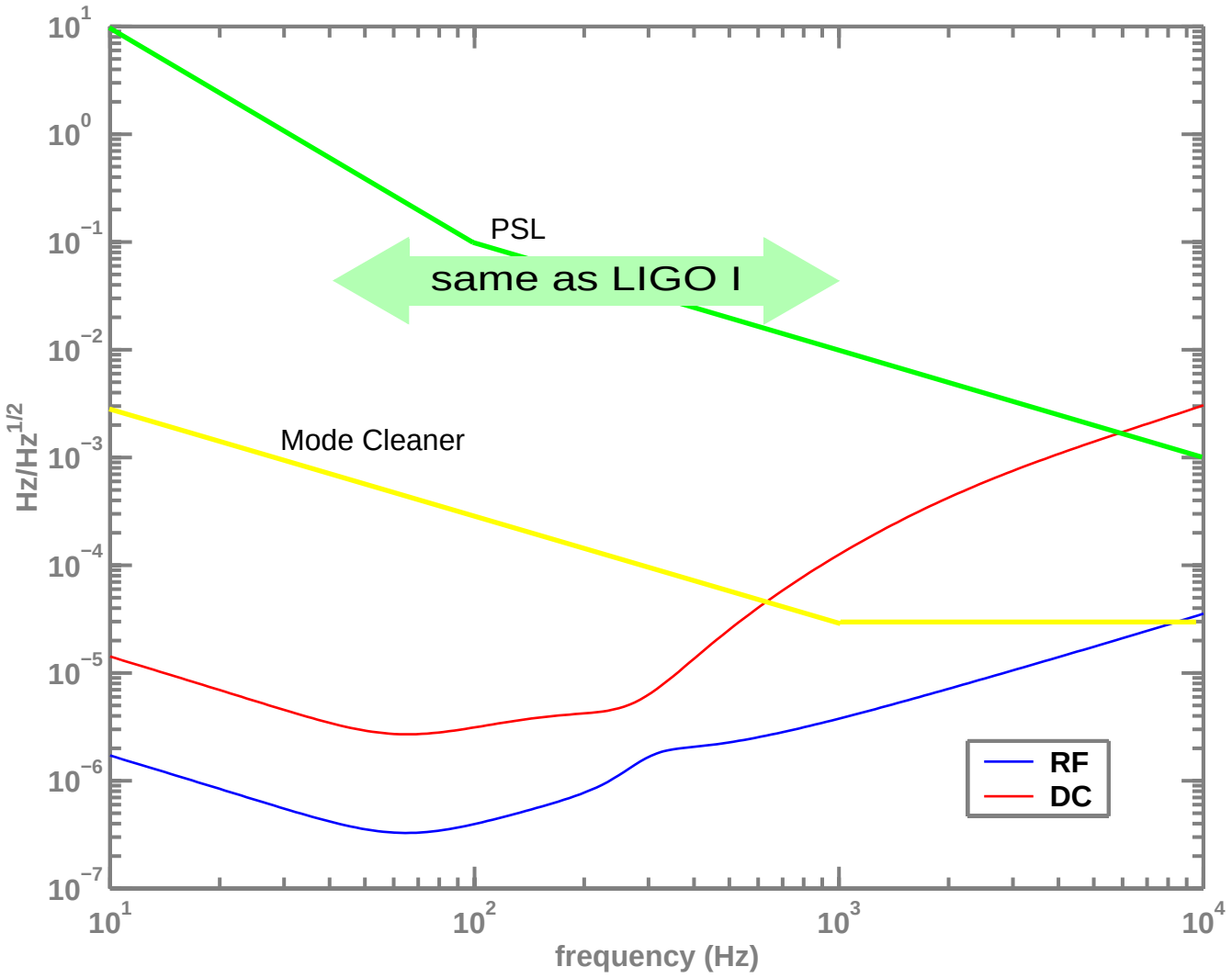
POWER STABILITY



TECHNICAL POWER NOISE AT THE MODULATION FREQUENCY

- Critical if RF heterodyne readout is used
  - f_{mod} = 10–30 MHz
  - technical AM should be 1/10 of shot noise in the total power of the detected beam → much easier than LIGO I, due to addition of output mode cleaner (>1000x rejection of higher order mode light)
    - expect < few mW of TEM00 + residual higher-order carrier light
    - total detected power: < few 10s of mW
    - technical AM: less than 1/10 of shot noise in 30 mW
- Detection of auxiliary beams
  - pick-off beam power: ~100 mW
  - technical noise should be less than 1/2 of shot noise in a 100mW beam (slightly less stringent than above)

Frequency Noise



stabilization hierarchy designed for RF readout

PSL Frequency control inputs

- Wideband input
  - Frequency response: speed to allow 100kHz BW loop
    - amplitude response flat to within 2 dB up to 100 kHz
    - phase lag less than 20 deg at 100 kHz
  - Control range:
    - DC – 1 Hz: 1 MHz pk-pk (to account for ground motion below 1 Hz)
    - 1 – 10 Hz: may roll off (for noise filtering); need only ~1 kHz range
- Tidal correction input
  - 50 MHz pk-pk
    - corresponds to 670 microns common mode arm length change
  - Speed: step response time constant less than ~30 min

Miscellaneous PSL Reqs

- Beam jitter TBD (listen to Guido's talk)
  - any active stabilization handled by input optics
- Availability
  - operate continuously for at least ~1 week
- Scattered light
  - dump beams down to 1 mW (?); control diffuse scattered light
- Diagnostics