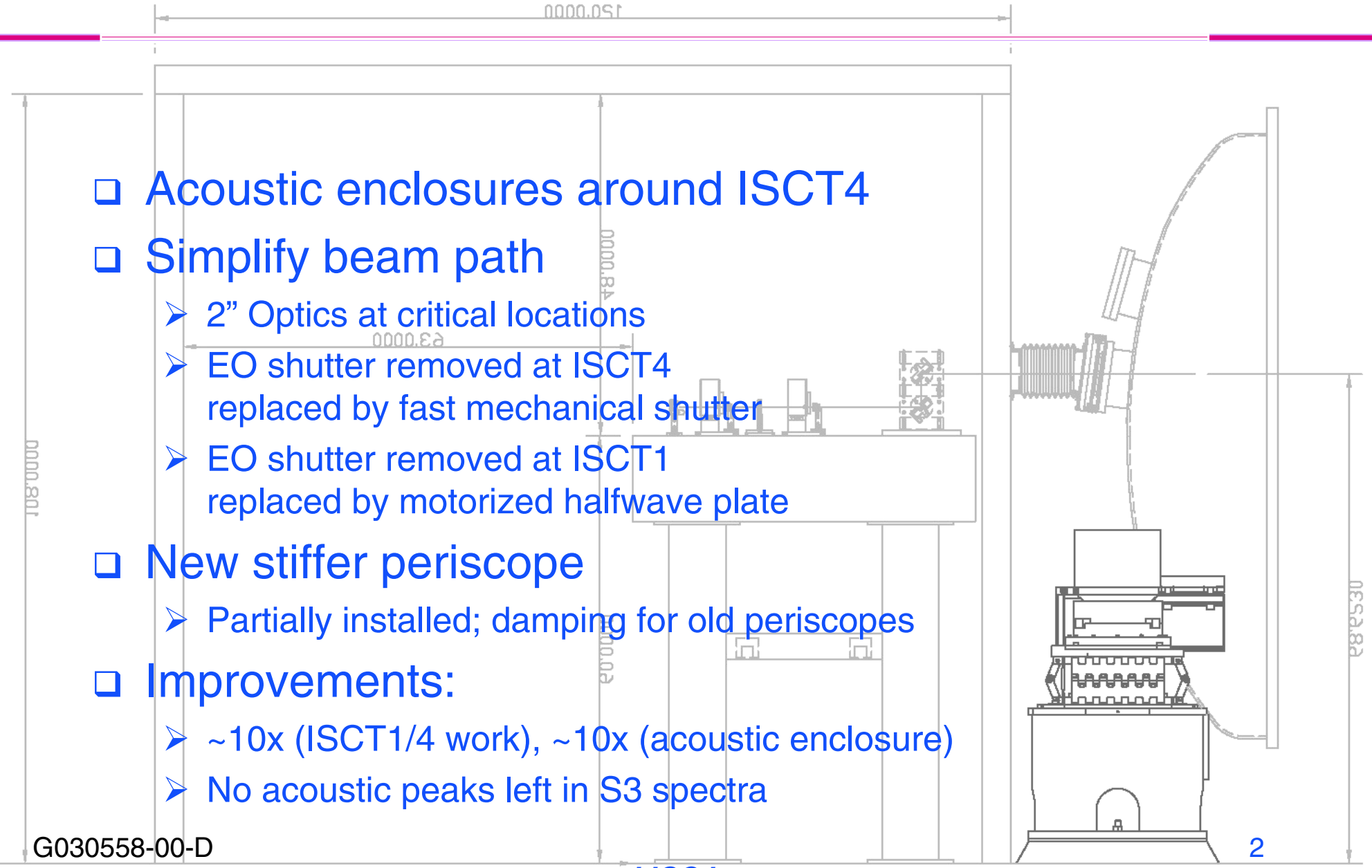
LIGO Commissioning Update

LSC Meeting, Nov. 11, 2003

Daniel Sigg

G030558-00-D

Acoustic Mitigation



- Acoustic enclosures around ISCT4
- Simplify beam path
  - 2” Optics at critical locations
  - EO shutter removed at ISCT4
    replaced by fast mechanical shutter
  - EO shutter removed at ISCT1
    replaced by motorized halfwave plate
- New stiffer periscope
  - Partially installed; damping for old periscopes
- Improvements:
  - ~10x (ISCT1/4 work), ~10x (acoustic enclosure)
  - No acoustic peaks left in S3 spectra

LIGO

with acoustic injections at ISCT4

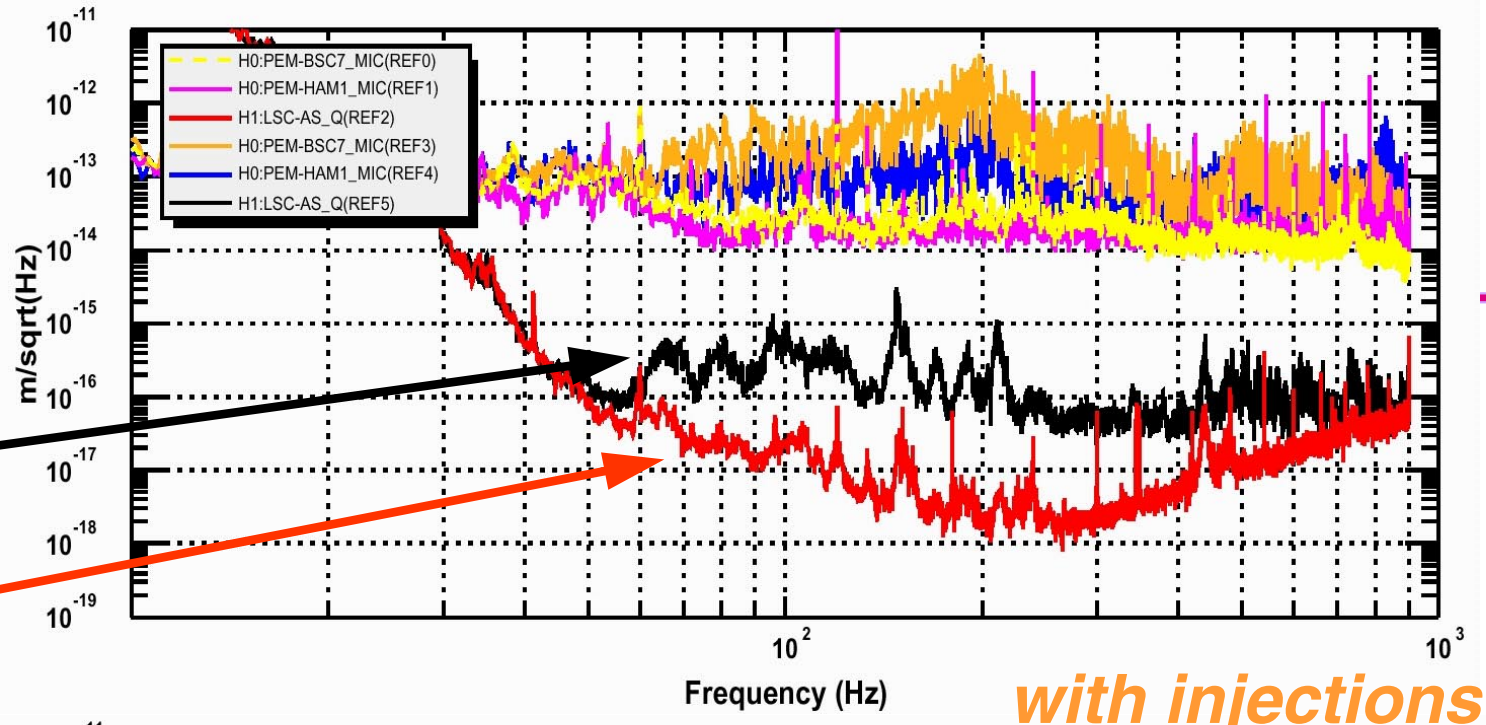
S2

Displacement Spectra

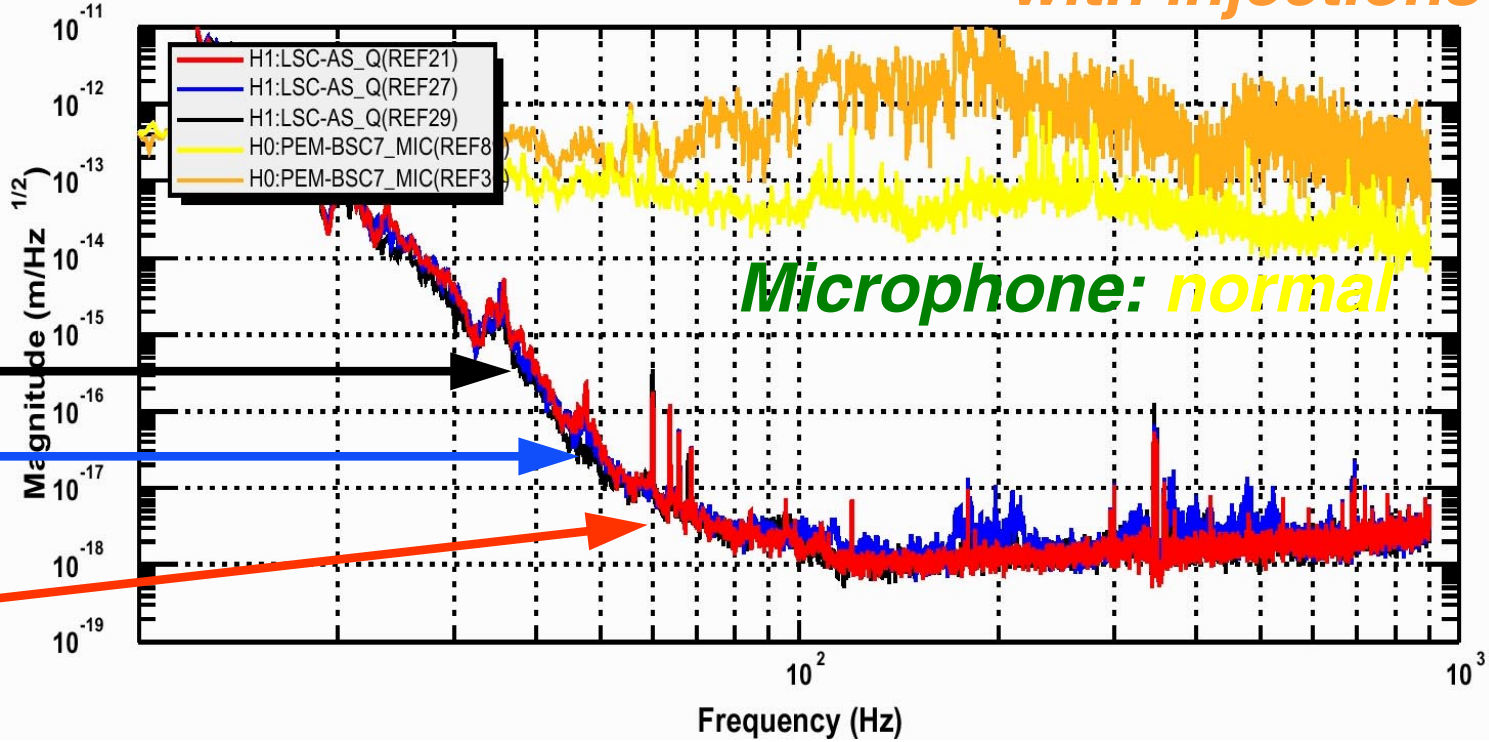
with acoustic injections at ISCT4 and

ISCT1

S3



with injections

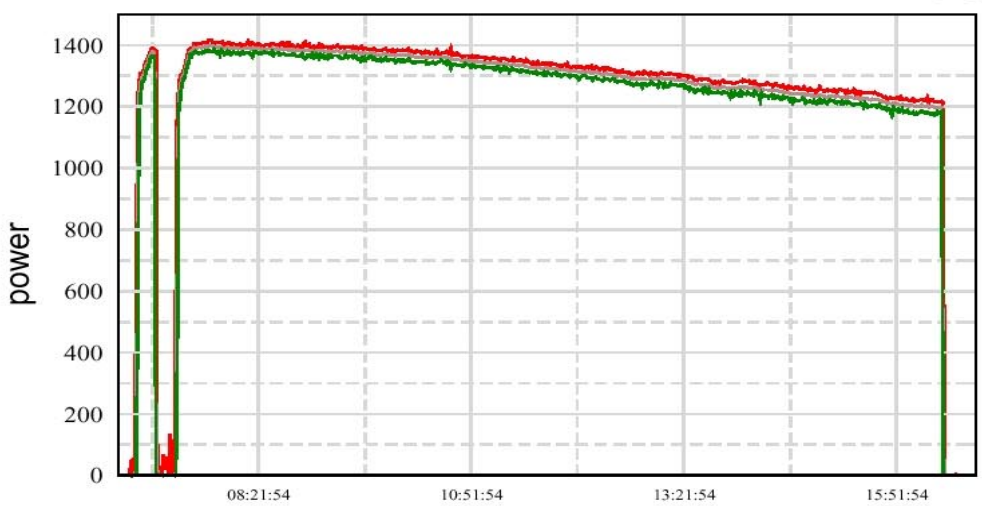


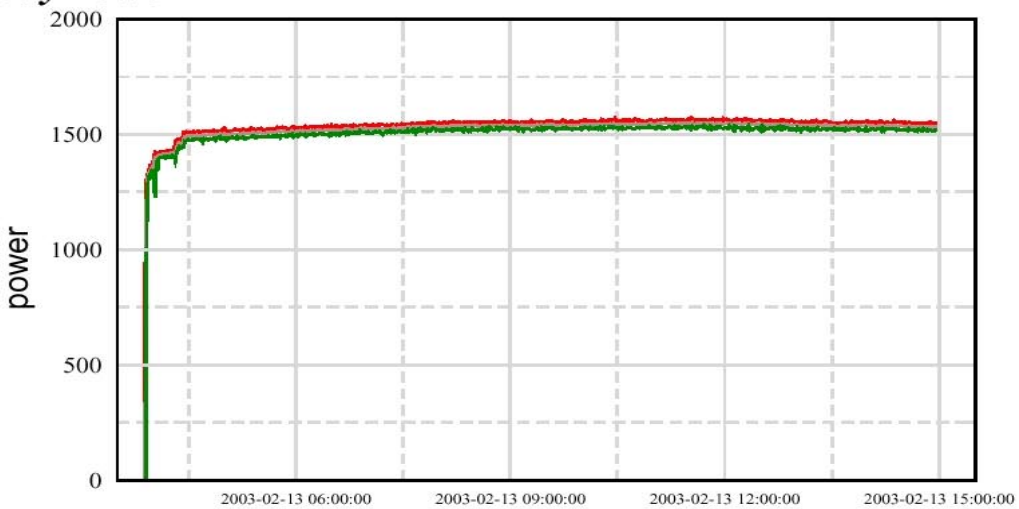
Microphone: normal

Auto-Alignment System

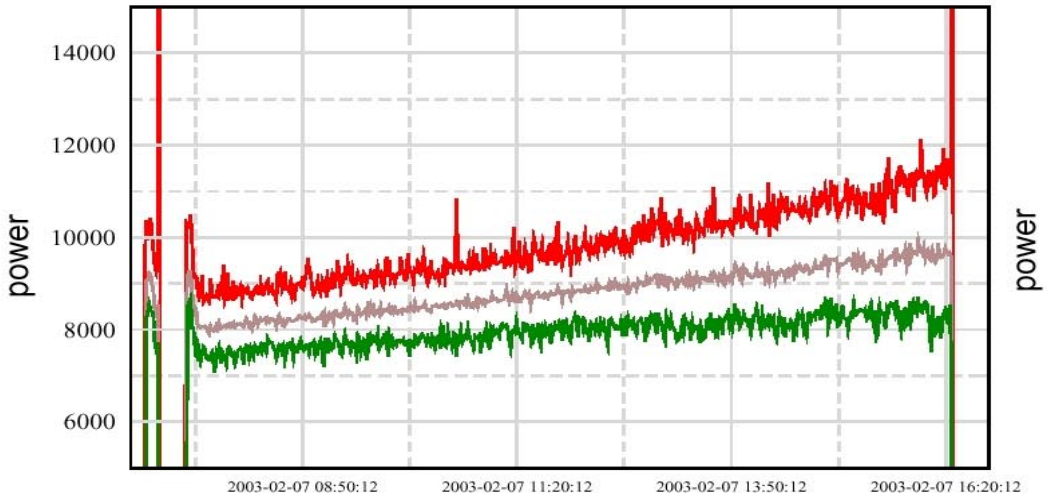
WFS OFF **WFS ON**

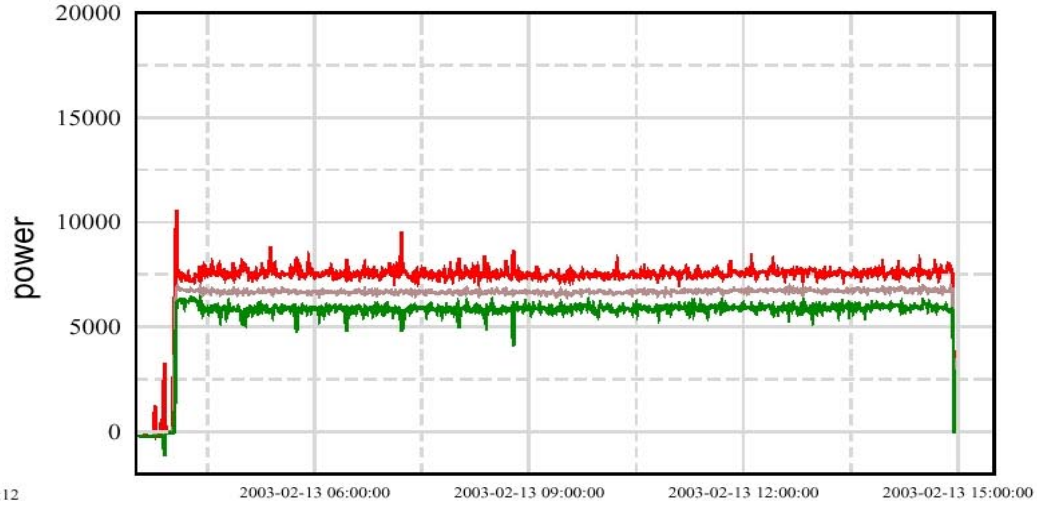
Arm Cavity Power



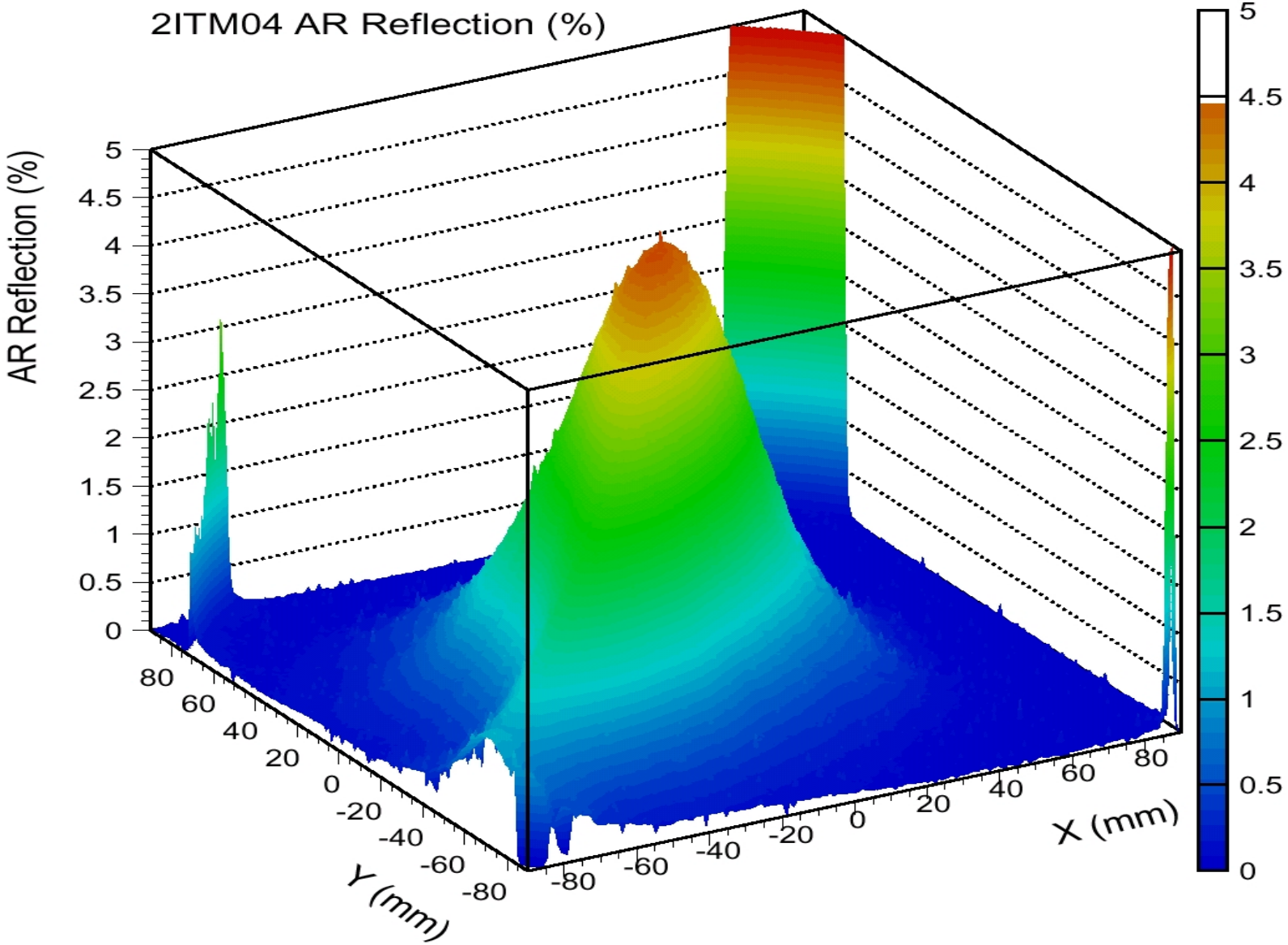


Anti-symmetric Port Power



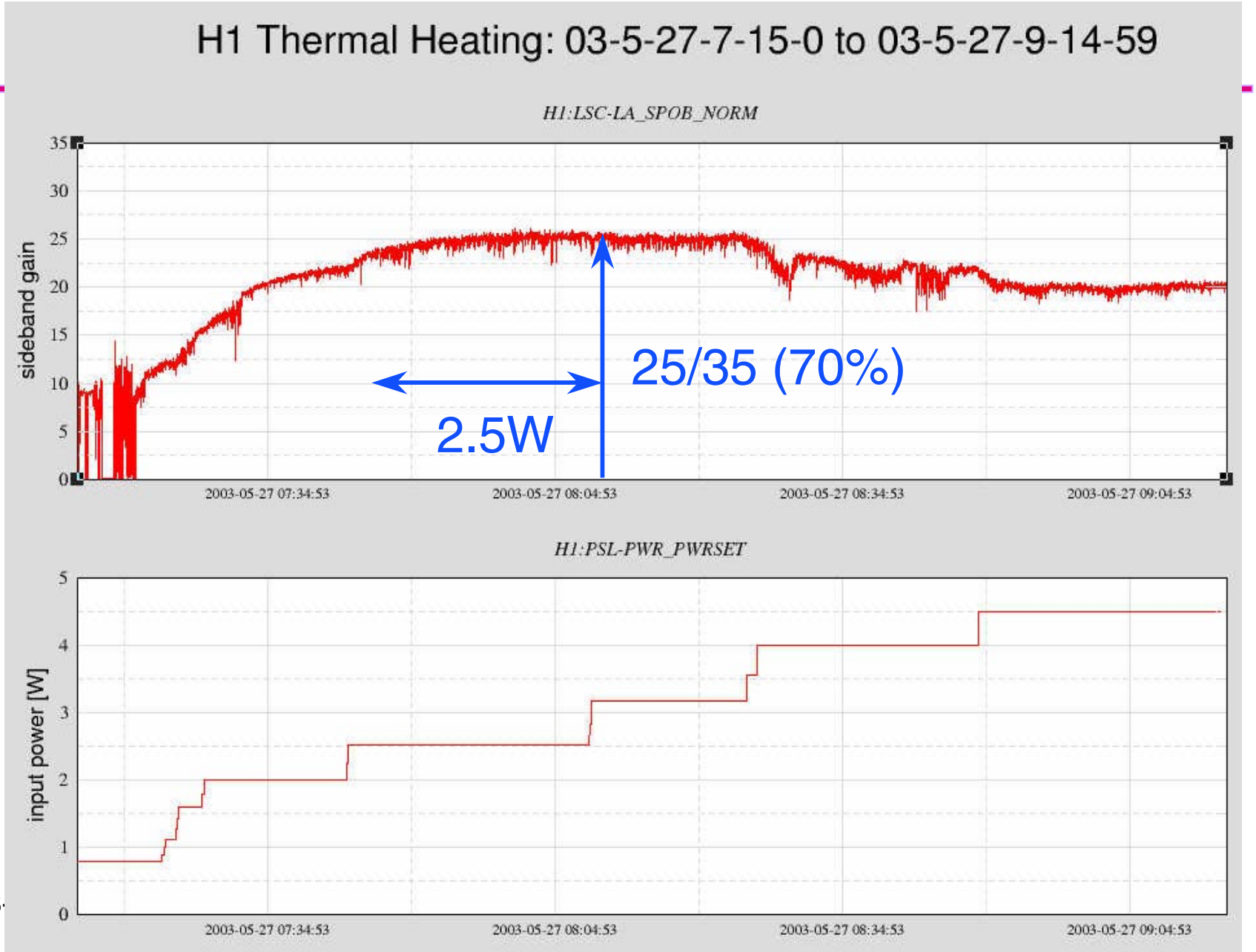


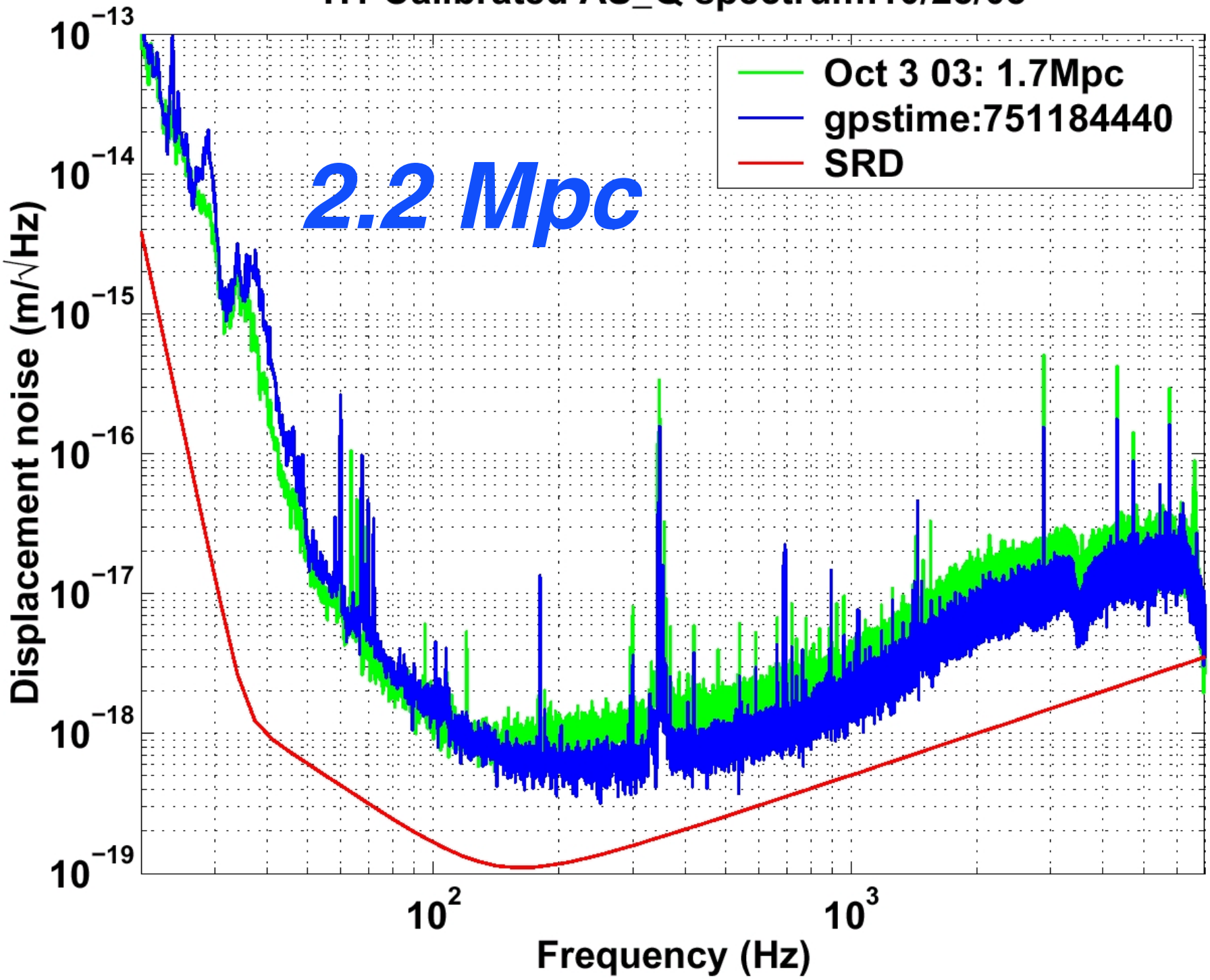
H2 ITMX Replacement



High Power Operations

Thermal Lensing




H1 Calibrated AS_Q spectrum:10/25/03
Oct 3 03: 1.7Mpc
gpstime:751184440
SRD
2.2 Mpc
Displacement noise (m/√Hz)
Frequency (Hz)
10^-13
10^-14
10^-15
10^-16
10^-17
10^-18
10^-19
10^2
10^3

Major Goals and Tasks After S3

- Sensitivity
  - Operate at high power
    - Laser
    - Thermal compensation system (TCS)
    - Output mode cleaner (OMC)
    - Design of sensing chain
  - Manage auxiliary degrees-of-freedom (e.g., POB light level)
  - Finish acoustic mitigation
  - Clean up electronics: RFI mitigation
- Reliability & Stability
  - Seismic retrofit at LLO
  - Auto-alignment system at full bandwidth

“10 W” Laser

- Current maximum power levels going into MC
  - L1: 4.3 Watts
  - H1: 3.0 Watts
  - H2: 3.65 Watts
  - Factor of 2-2.5 short
- IO transmission efficiency not great either; max power estimated at RM
  - H1: 1.8 W (60%)
  - H2: 2.6 W (72%)
  - L1: 2.6 W (60% -- ??)
  - Supposed to be 6 W
- Is a reliable 10 Watts feasible with present system?

Thermal Compensation System

- Add missing heat with a CO_2 laser
  - See G030167-01
- Build a prototype to fully equip a single ifo
- Testing on H1 is highest priority task at LHO
- Install phase cameras
- RF sideband measurement setup(?)
- Requires a quick vent to install ZnSe windows
- Aim to have hardware ready at end of S3
- Modeling of asymmetric heating

Output Mode Cleaner

- Study feasibility of OMC
  - Fixed spacer triangular Fabry-Perot cavity
  - In vacuum design?
  - Seismic isolation required?
  - Length sensing & control system: RF + thermal? PZT + dither?
- Model of sideband asymmetry
- OMC prototype & in-air test at LHO
  - Effect on contrast defect
  - Effect on ASI
  - Effect on 2Ω problem
  - Effect on fringe offset
  - Effect on noise

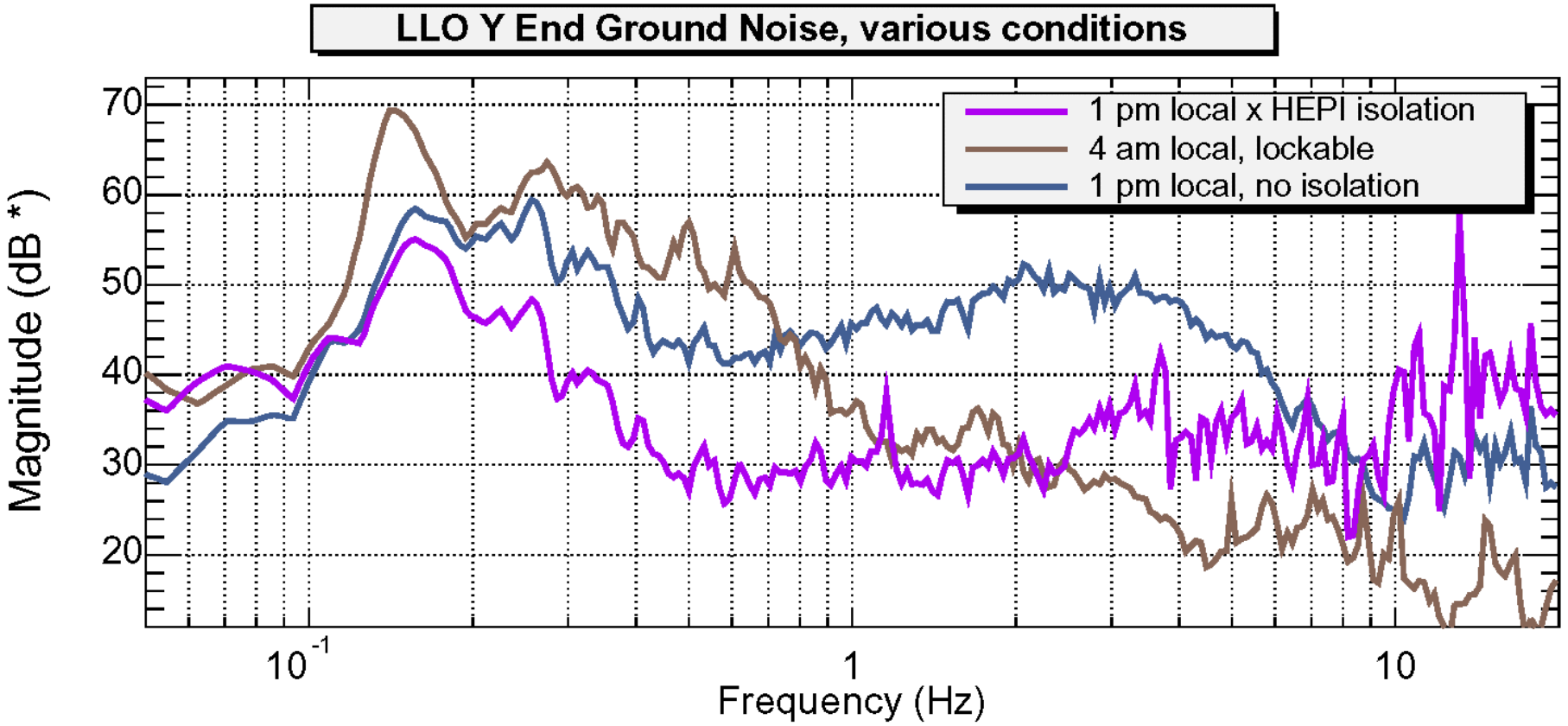
H1 at 2.3 W into MC

All WFS engaged

Port	*DC photocurrent per PD*	*Orthogonal phase signal*	*Notes*
AS	25 ma ± 2 ma	AS2I_CORR = 10,000 ± 4000 cnt (7ma ± 3 ma)	❑ Designed for 100ma per PD ❑ WFS introduces offset into AS_I?
POB	4 ma ± 0.15 ma		Designed for ~50ma
REFL	0.5 ma ± 0.1 ma	REFL_Q = ± 2500 cnts → ± 140 mV RF	Designed for ~50ma; will need REFL_Q servo

Seismic Retrofit at LLO

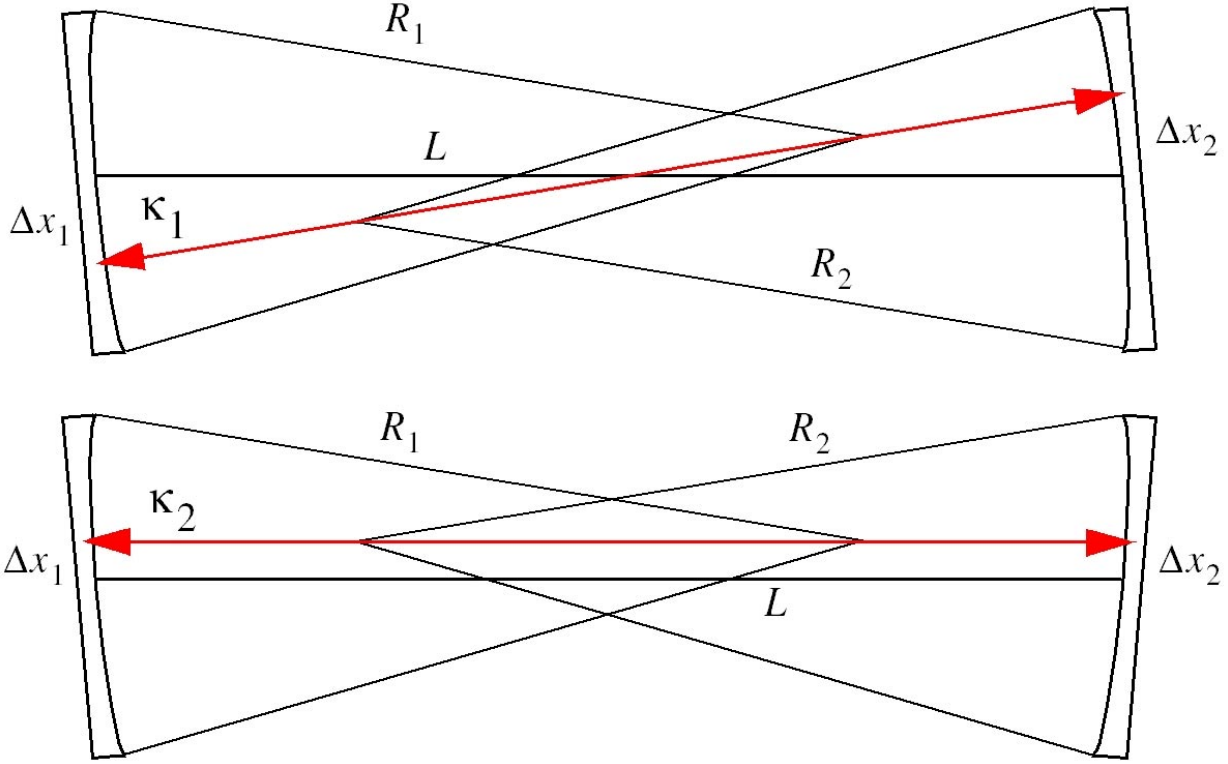
Example effect of HEPI isolation on daytime ground noise:

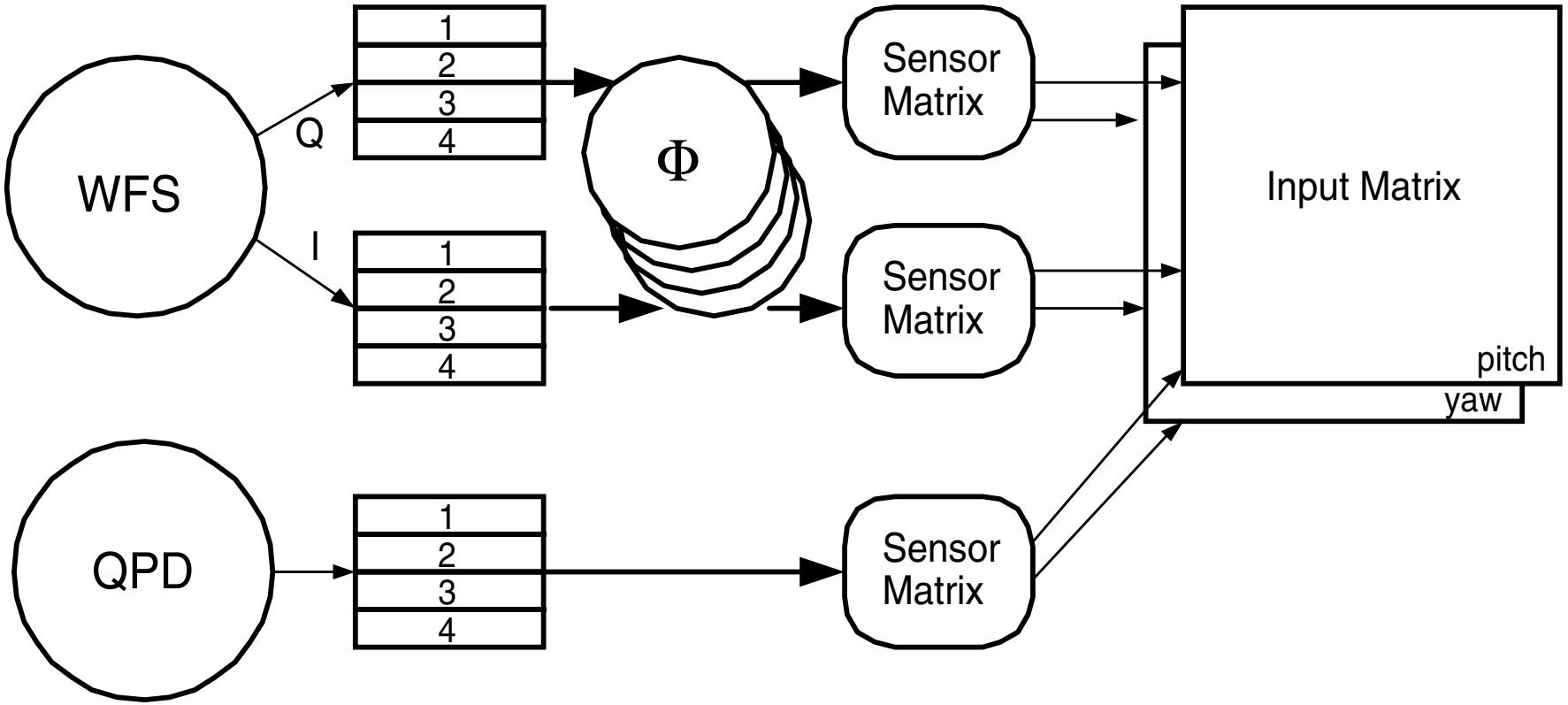


*T0=03/10/2003 18:20:50 Avg=10/Bin=7L BW=0.0117187

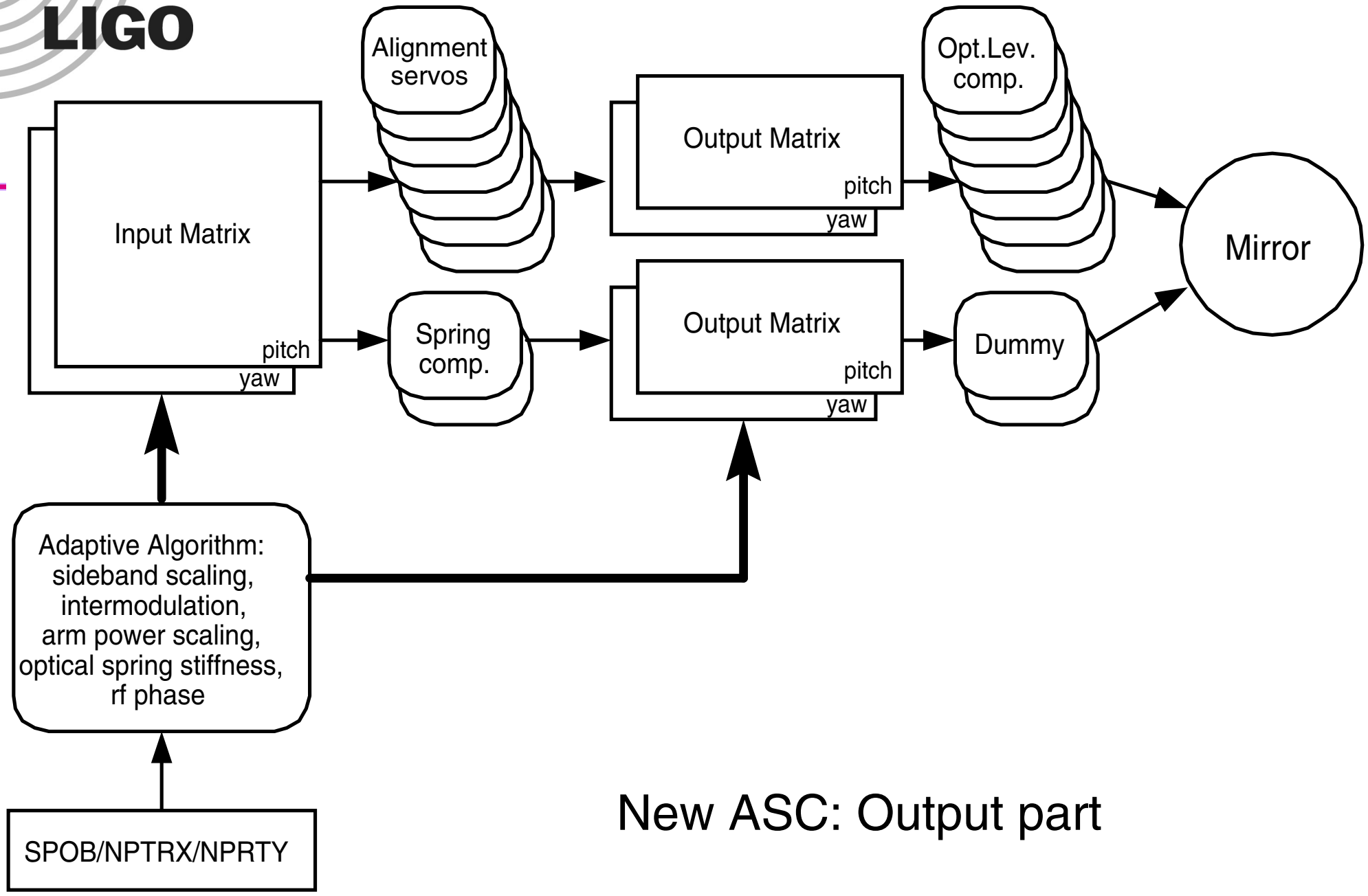
Wavefront Sensing

- High bandwidth
- Noise investigations
- Study and minimize cross-couplings
- New software
  - Radiation pressure compensation
  - Input matrix
  - Adaptive control: power levels, SPOB & intermodulation
- Initial Alignment
  - WFS5 / Dither





New ASC: Input part



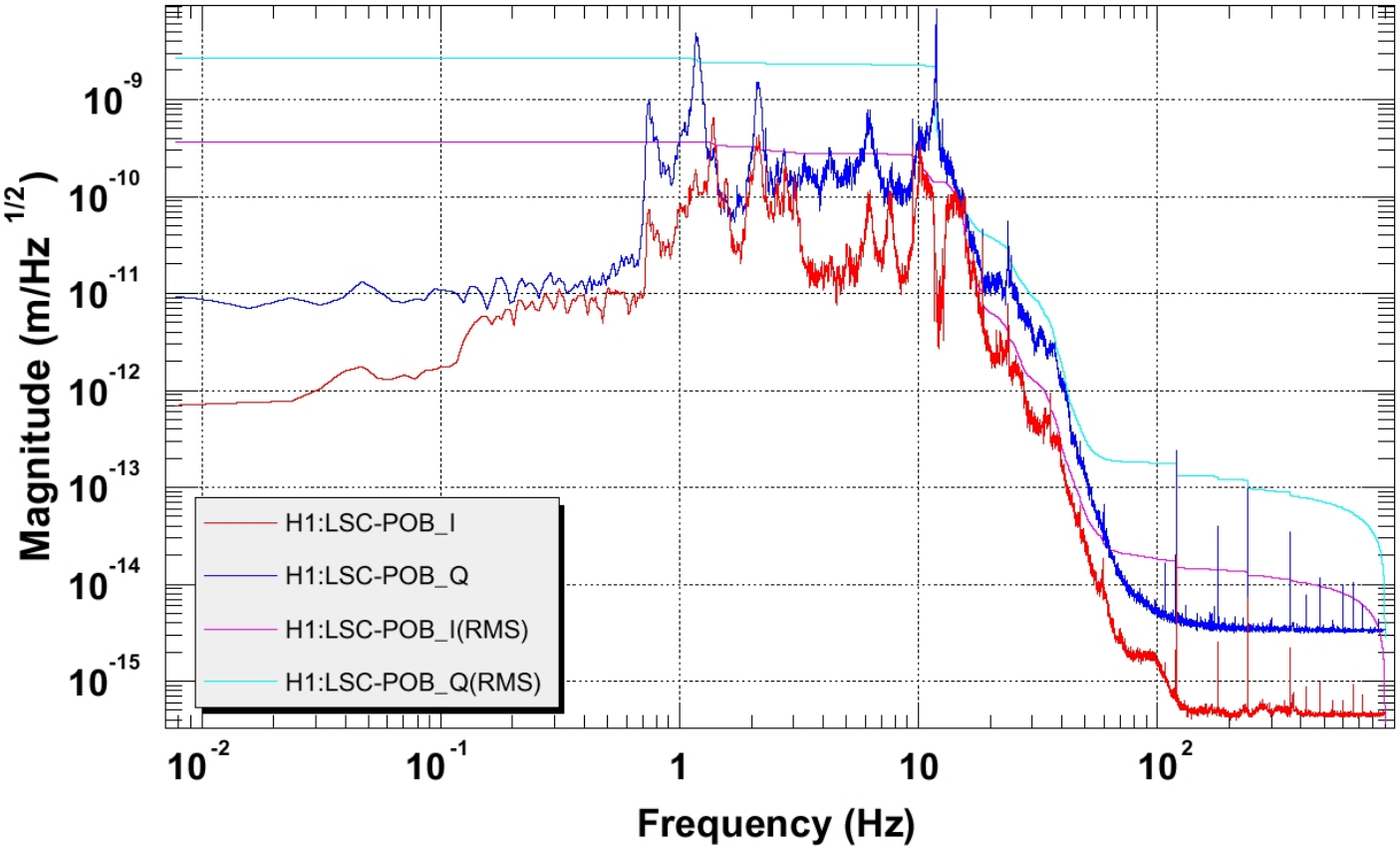
New ASC: Output part

Finish Acoustic Mitigation

- ISCT1/ISCT7 acoustic mitigation
  - acoustic enclosure? Not necessary.
  - REFL PD2, fast shutter & analog switching for CM
- IOT1/IOT7(?)
- Implement new periscope design
- Source isolation
- Move racks

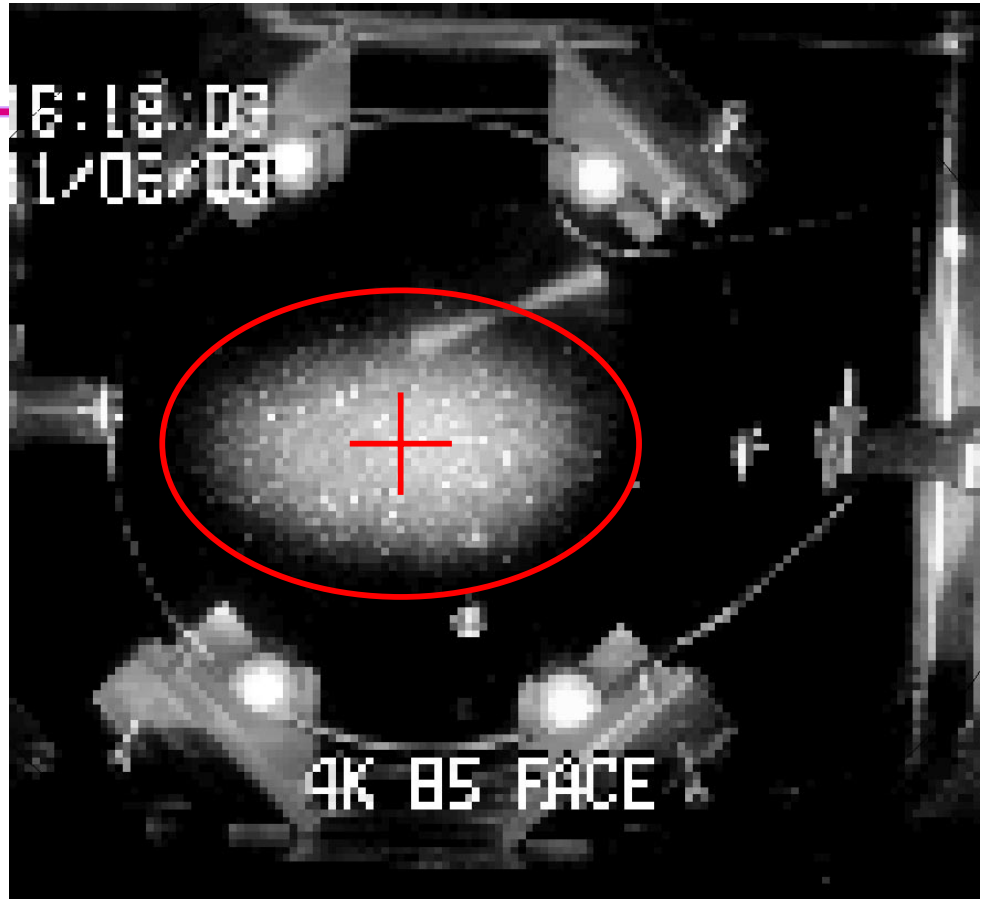
Auxiliary Degrees-of-Freedom

- More light power for POB
  - Install POB2 on POX or POY
  - ~~New ITM with reduced AR coating efficiency??~~
- Bounce mode damping(?)



Beam Centering

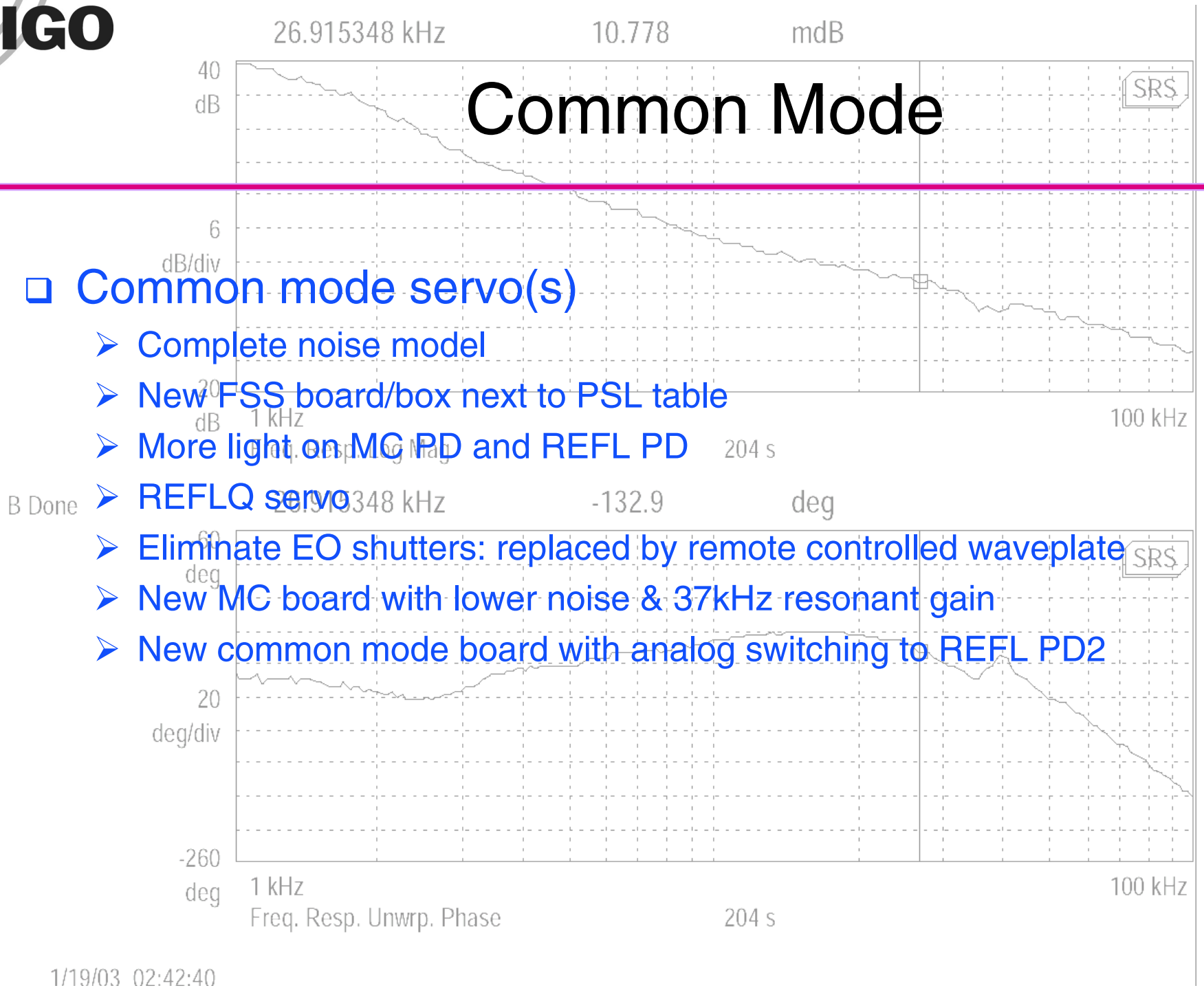
- Center beams on mirrors to within 1mm
  - 300mm zoom lenses for ITMs w/ remote controlled iris
  - Determine center of rotation with radiation pressure shifts?
  - Fast image processing for MMT1 servo?



- Automatic beam centering on ISCTs
  - Fast steering mirrors & quad detectors on every ISC/IOO table
  - Feedback using digital or analog controllers(?)
  - Automatic turn on and turn off

Common Mode

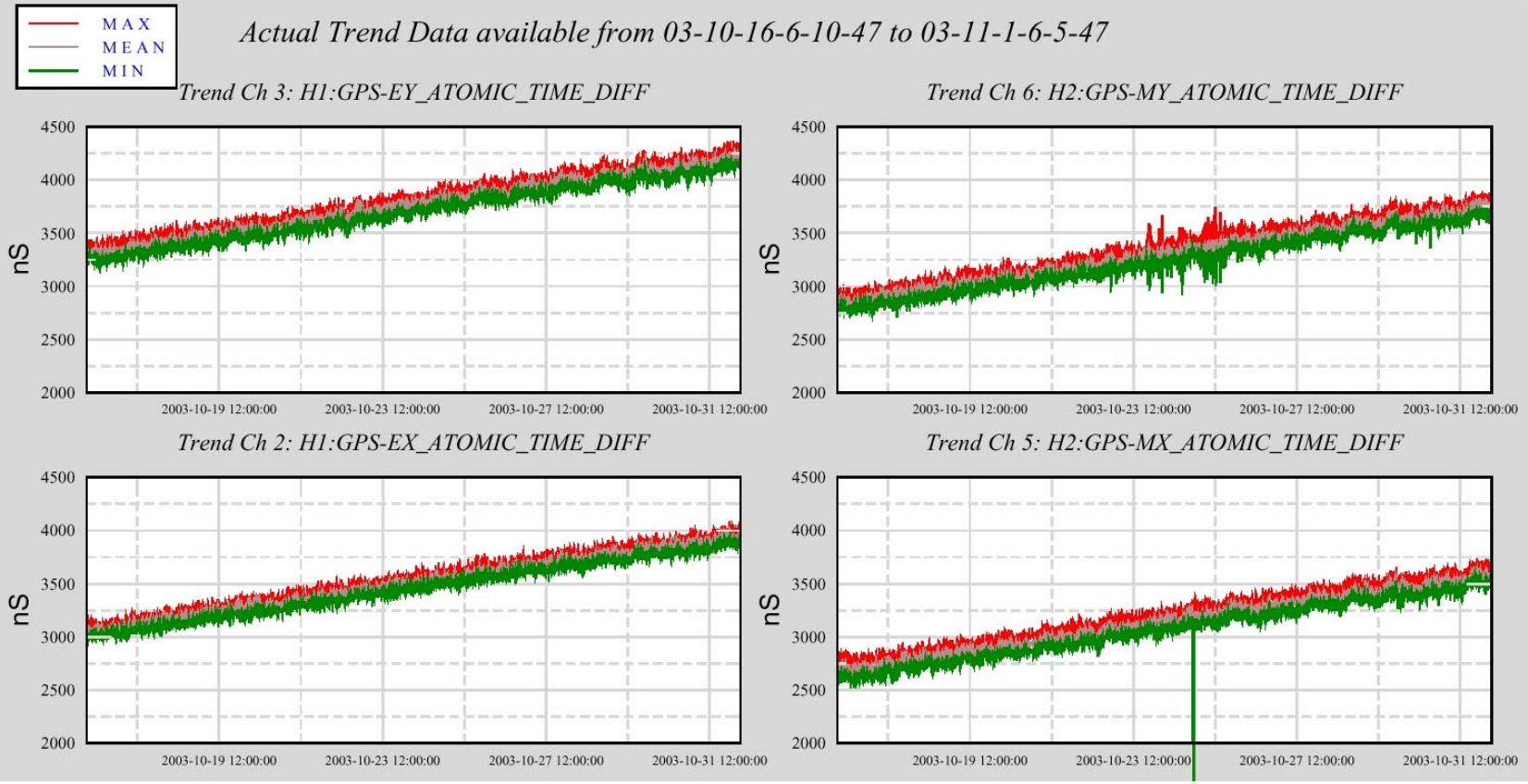
- Common mode servo(s)
  - Complete noise model
  - New FSS board/box next to PSL table
  - More light on MC PD and REFL PD
  - REFLQ servo
  - Eliminate EO shutters: replaced by remote controlled waveplate
  - New MC board with lower noise & 37kHz resonant gain
  - New common mode board with analog switching to REFL PD2



Atomic Clock

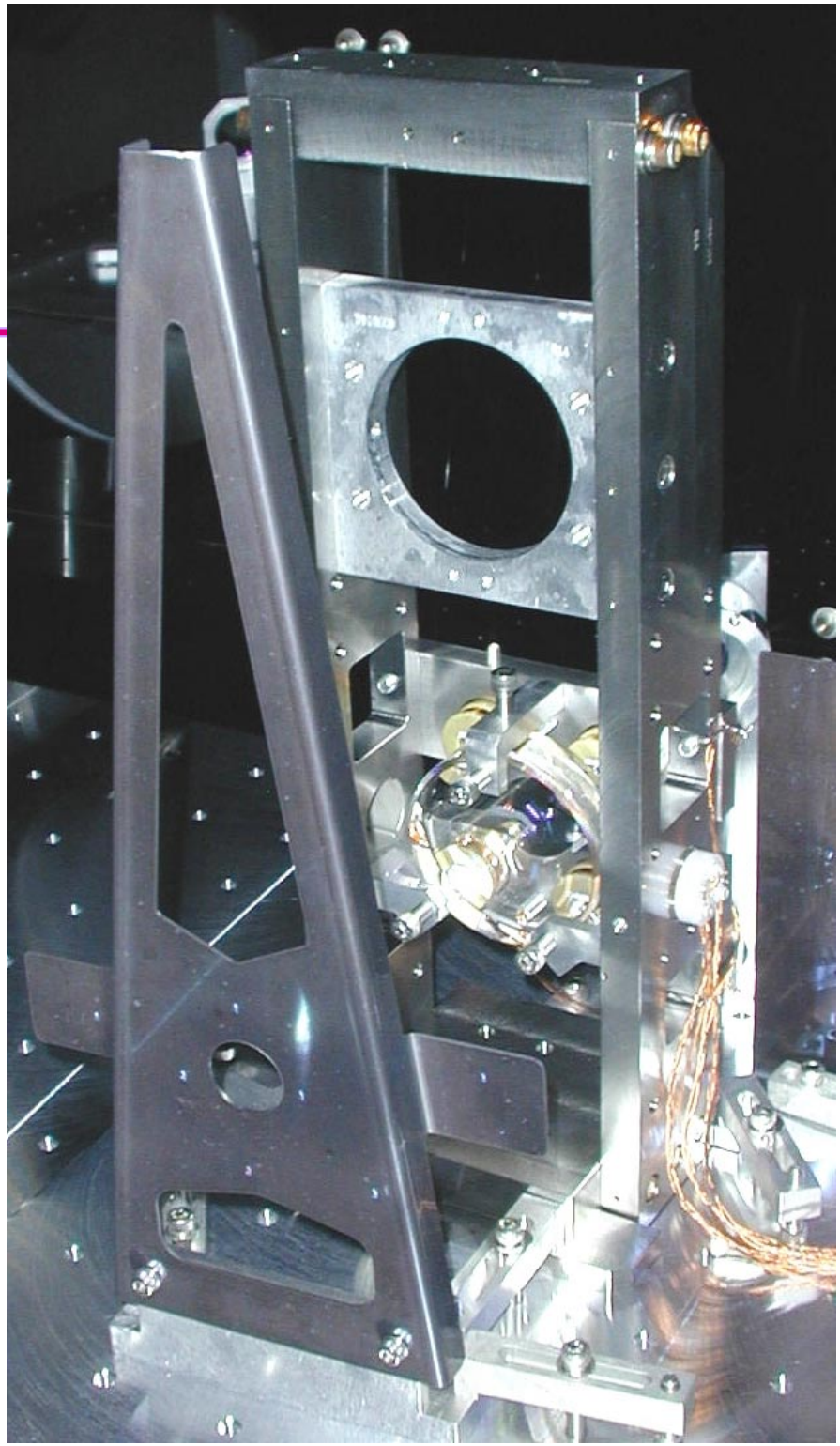
- New timing diagnostics
  - Implement and test new timing distribution system
  - Implement and calibrate new atomic clocks
  - Implement photon calibrators

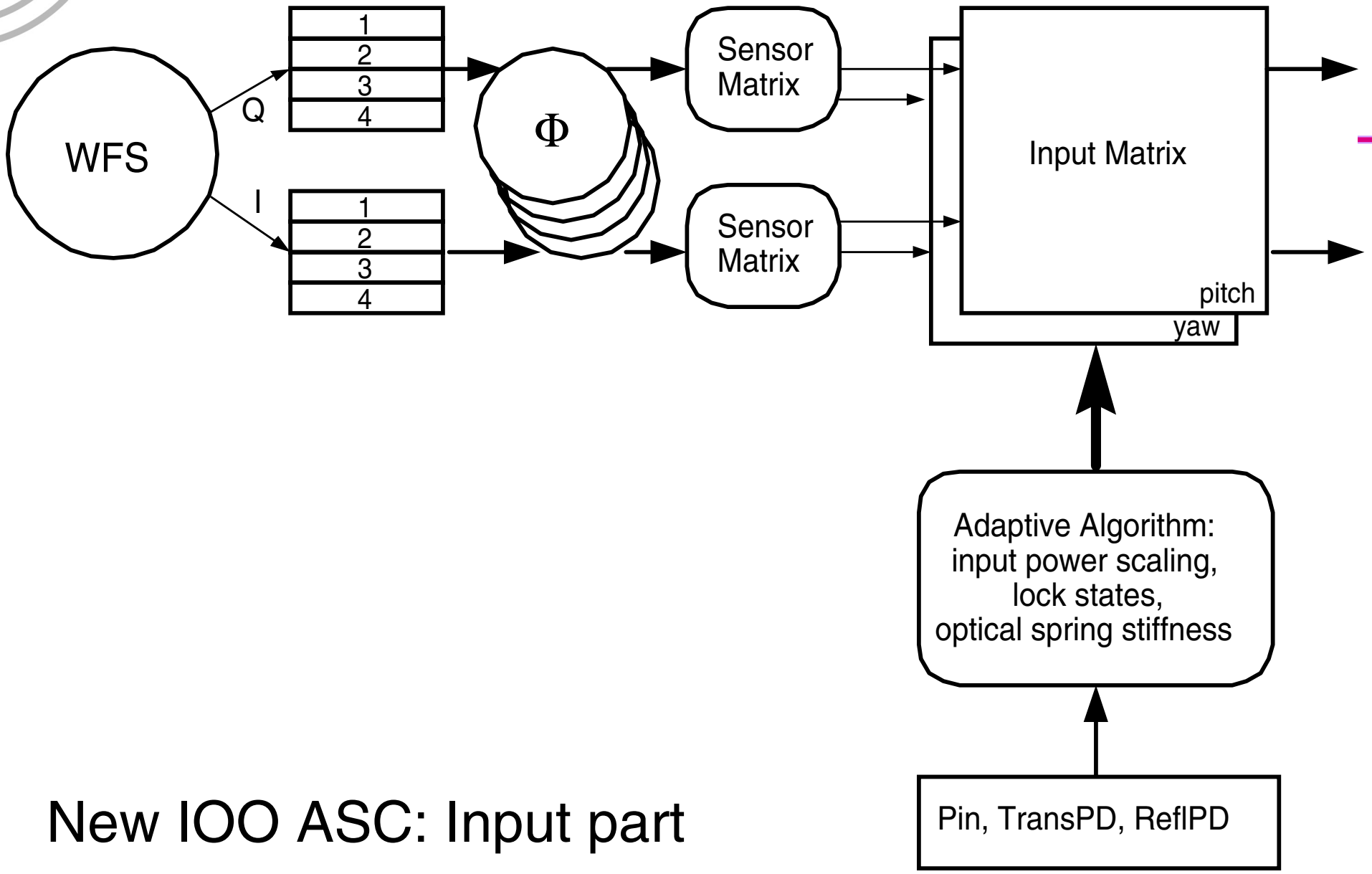
Drift: 50ns/day



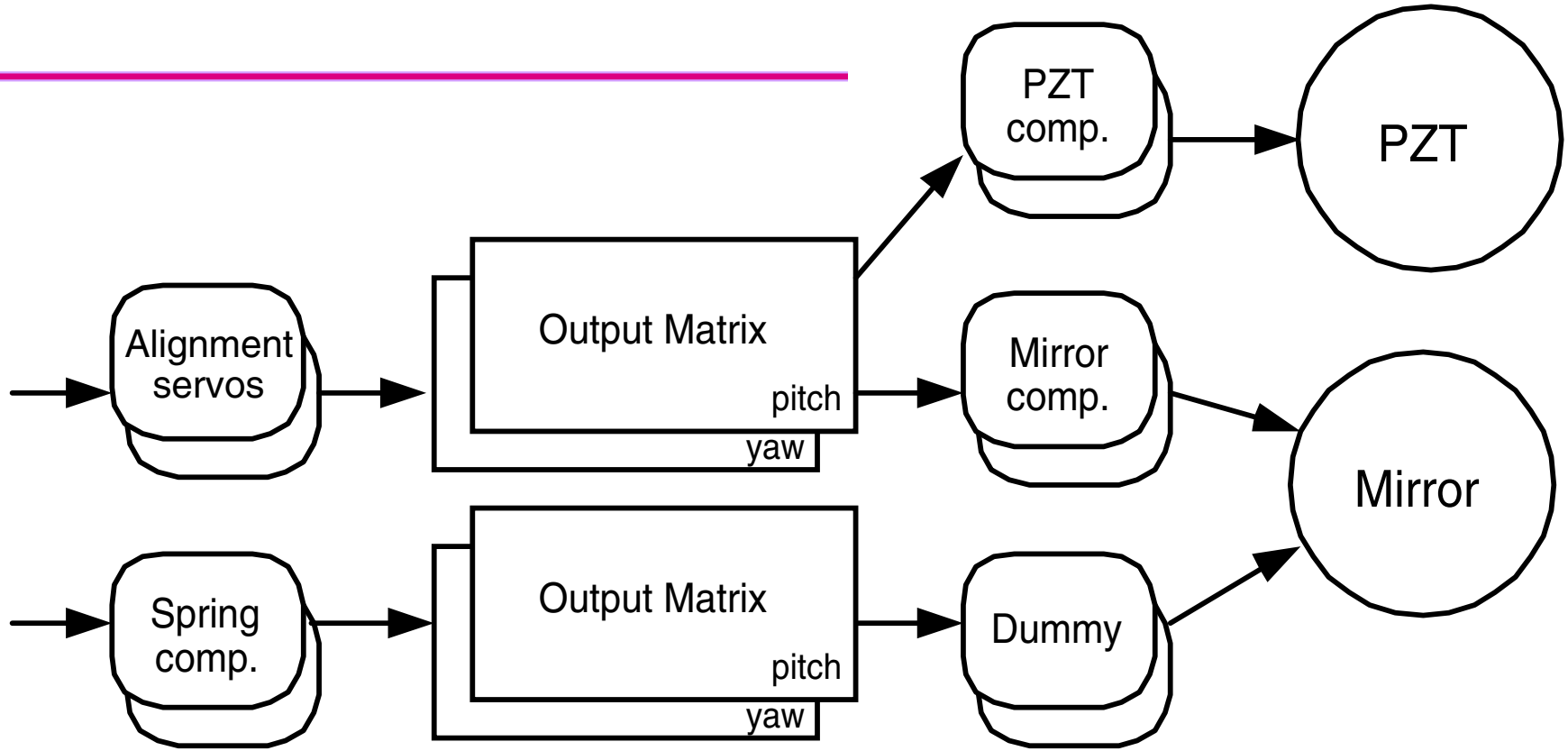
IOO Improvements

- IOO baffle retrofit at LHO
  - Target of opportunity or disaster?
- IOO Faraday
  - New larger aperture model(?)
  - Study thermal effects –
    UFI AdLIGO compensated design(?)
- Digital IOO WFS
  - Feedback to MC mirrors
  - Better filtering
  - Radiation pressure compensation





New IOO ASC: Input part



New IOO ASC: Output part

Miscellaneous (1)

- LSC photodetector redesign
  - ASI input
  - New 100Hz-10kHz output
- ISS
- Finish ASI servo design and fabrication
  - Anit-image & dewhitening
  - Modulator: >1/4W output power(?), phase adjust
- New low-noise DACs from FDI (40 dB lower noise)
- Dewhitening/whitening switching
  - New boards with stages or parallel paths
  - Need an intermediate stage to avoid switching in one big step

Miscellaneous (2)

- Dual ETM transmission photodetectors
  - Single element, high-gain PD for acquisition
  - Current QPD for detection
  - Lower offsets & less drift
- Servo to track modulation frequency to MC length(?)
- RFI cleanup
  - Rack re-allocation
  - New EMI shielded racks
  - Redo cabling and connectors.
  - Redesign of critical electronics for low noise

Summary: Post-S3 Steps

	First ~6 months after S3
L1	► Seismic upgrade: HEPI installation & commissioning ► Electronics rack relocation
H1	► New DACs (old DACs to HEPI) ►Thermal compensation trial ► New ASC code ► Wideband WFS control ► Laser power increase ► Output mode cleaner? ► Duty cycle
H2	► Power increase (thermal lens) testing