
# LIGO COMMISSIONING

OVERVIEW AND PROGRESS

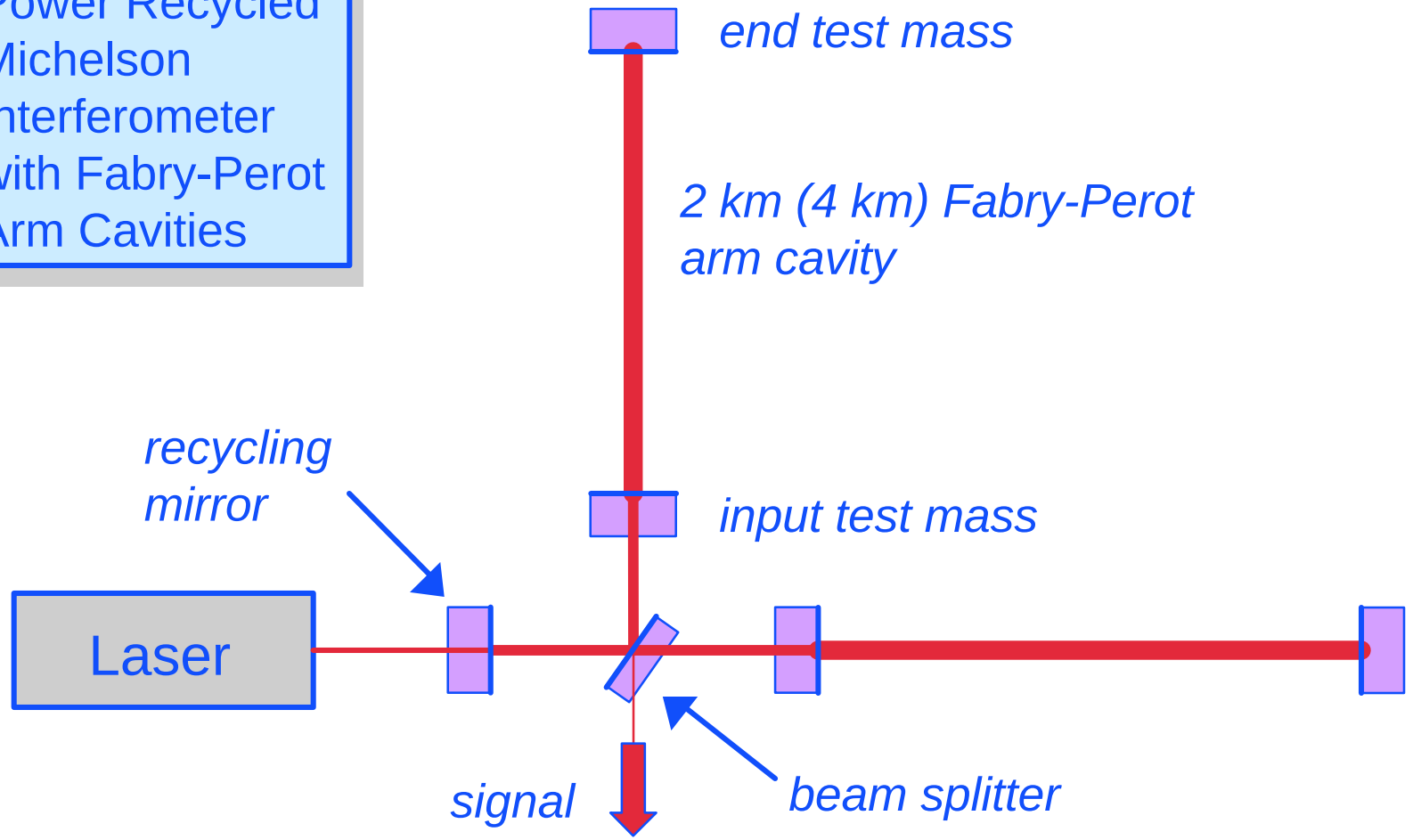
Rainer Weiss

DETAILS AND THE FUTURE

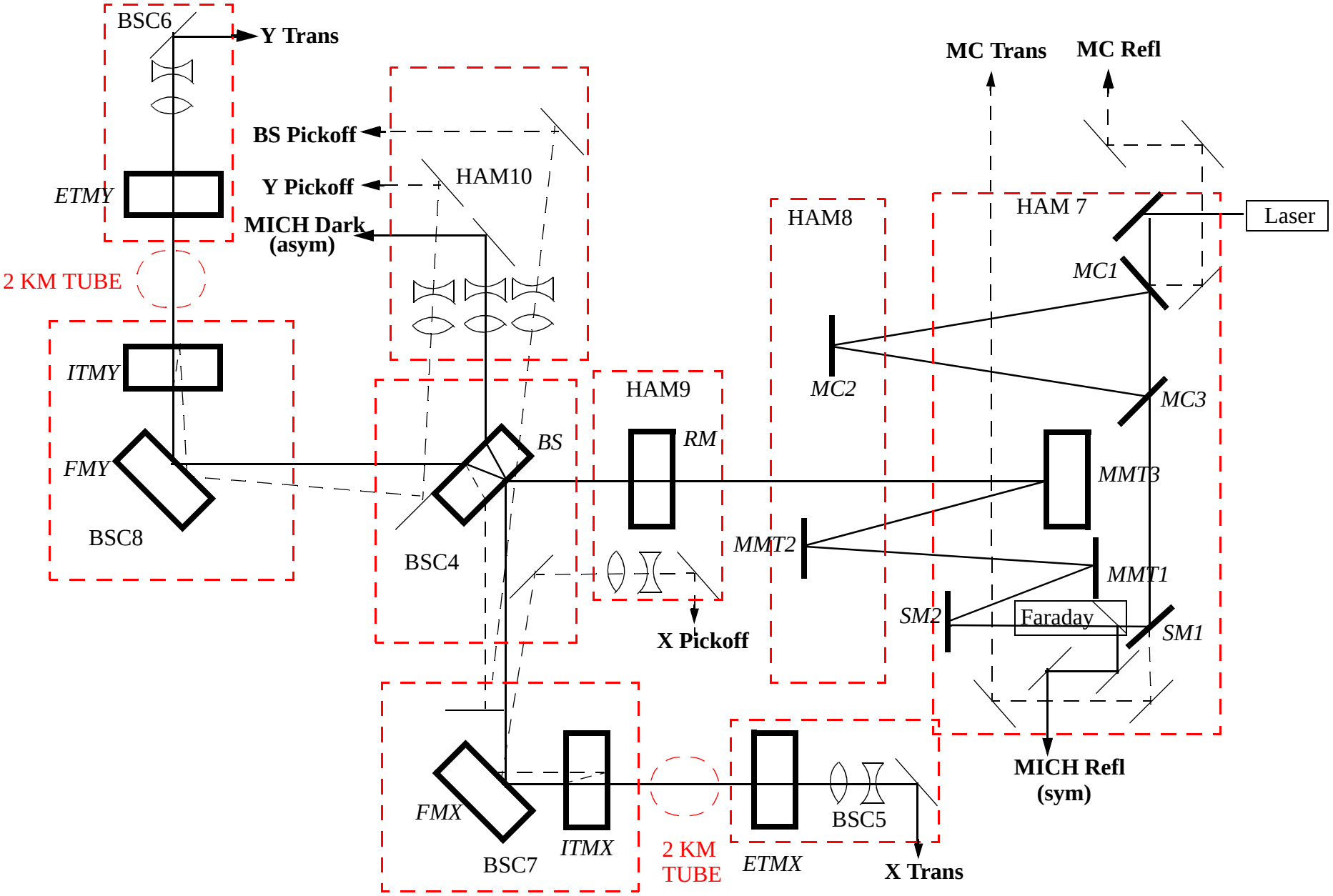
Peter Fritschel

# LIGO Interferometer (Detector)

Power Recycled Michelson Interferometer with Fabry-Perot Arm Cavities



# SCHEMATIC OF 2 KM INTERFEROMETER




# LIGO COMMISSIONING

- Primary functions of the commissioning
  - » After installation bring the interferometer, data acquisition and environmental monitoring system into operation
  - » Improve the ability to hold lock and make it more robust
  - » Reduce the noise in the interferometer
  - » Determine correlations between interferometer and environment
  - » Test the data acquisition system, diagnostic software and archiving
  - » Train operators to acquire, run and diagnose the interferometer
  - » Maintain technical communication between the Laboratory sites
  - » Couple modeling with the diagnostic measurements


# LIGO COMMISSIONING

- Commissioning strategy
  - » Progression: Hanford 2km->Livingston 4km -> Hanford 4km
  - » Operate and test all in vacuum sub-systems as soon as possible after pumpdown – reduce water load on beamtubes and risk of contamination
  - » Operate interferometers even if sub-systems are incomplete -shakedown
  - » Assess the limiting noise terms and Iterate

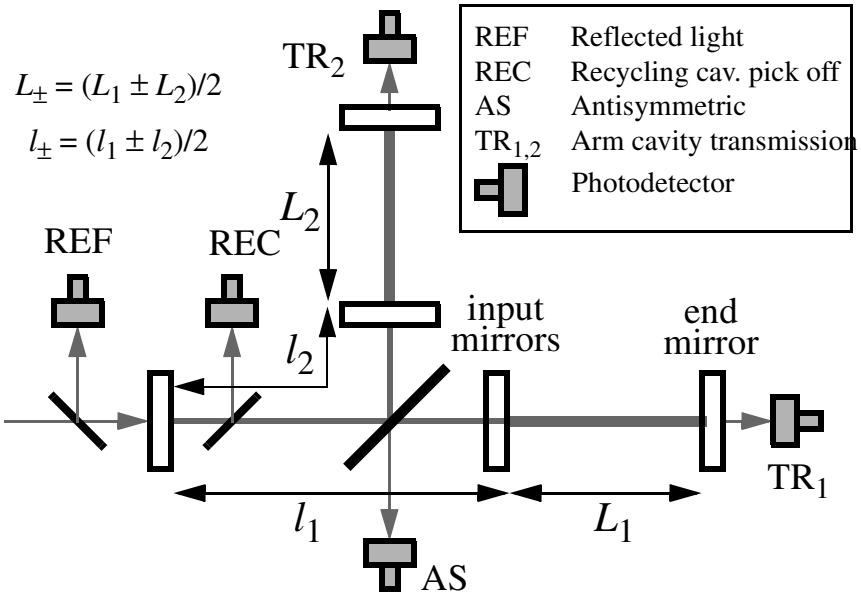
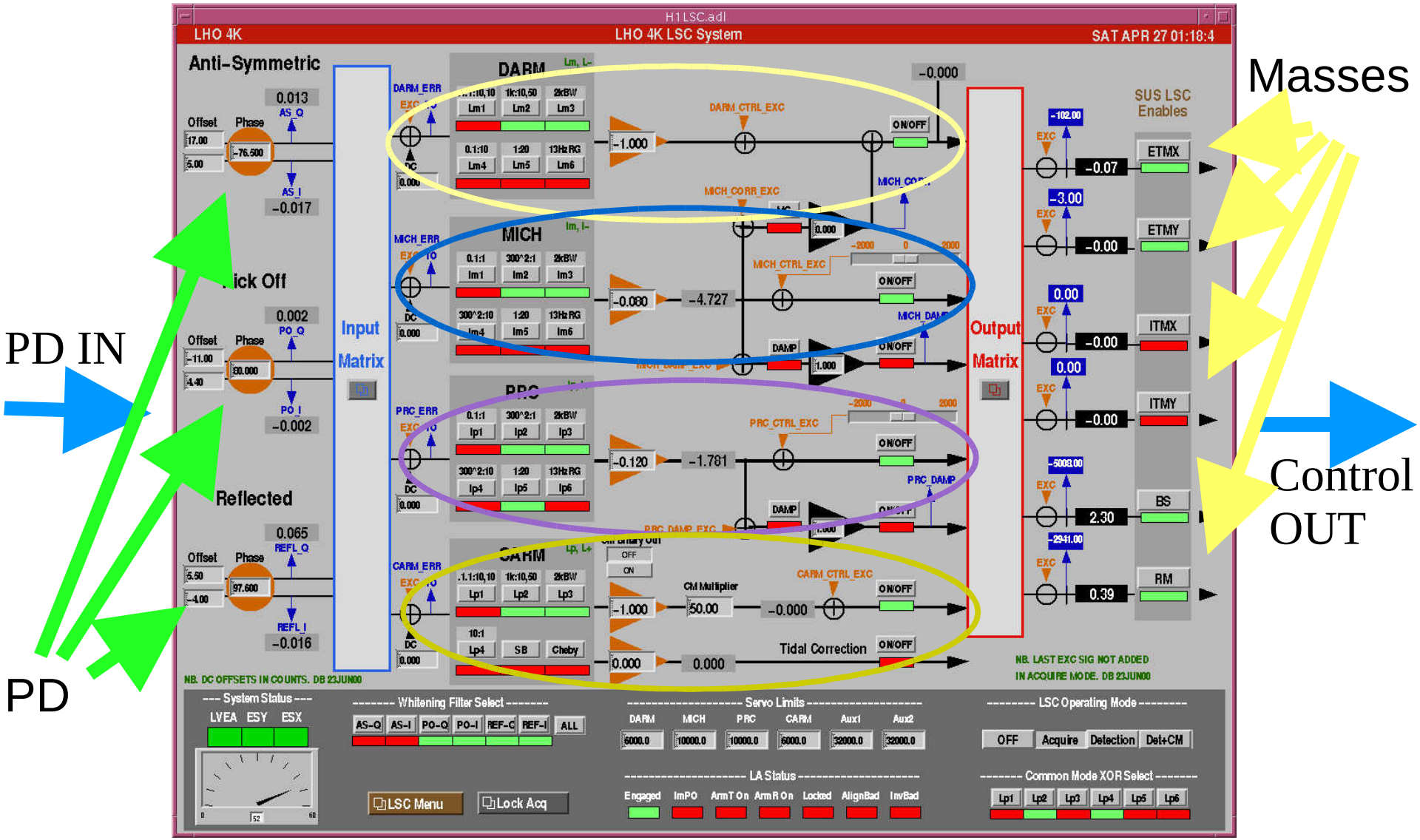

$L_{\pm} = (L_1 \pm L_2)/2$
$l_{\pm} = (l_1 \pm l_2)/2$
TR2
REF Reflected light
REC Recycling cav. pick off
AS Antisymmetric
TR1,2 Arm cavity transmission
Photodetector
L2
REF
REC
input mirrors
end mirror
l2
TR1
l1
L1
AS

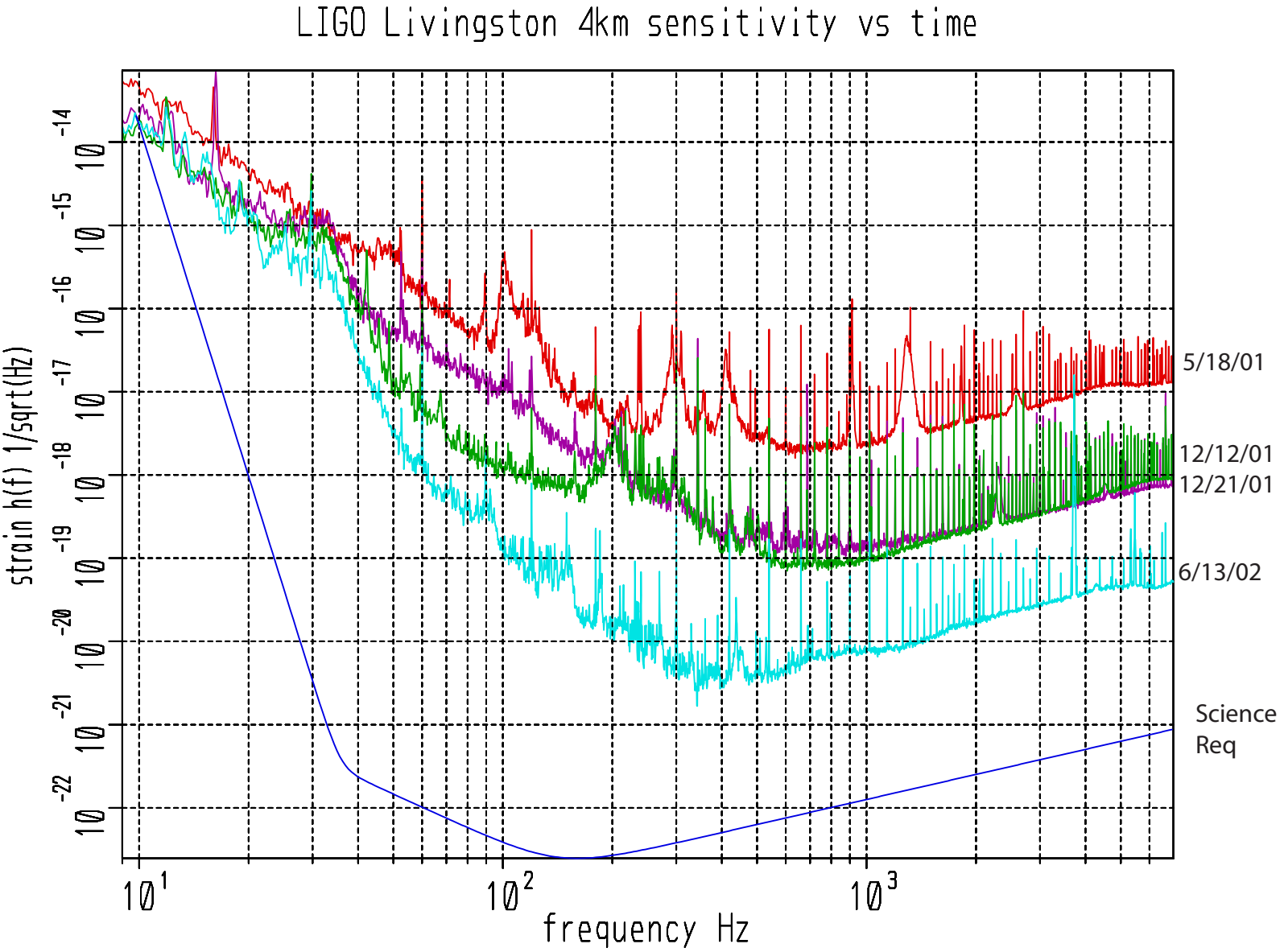
Figure 1

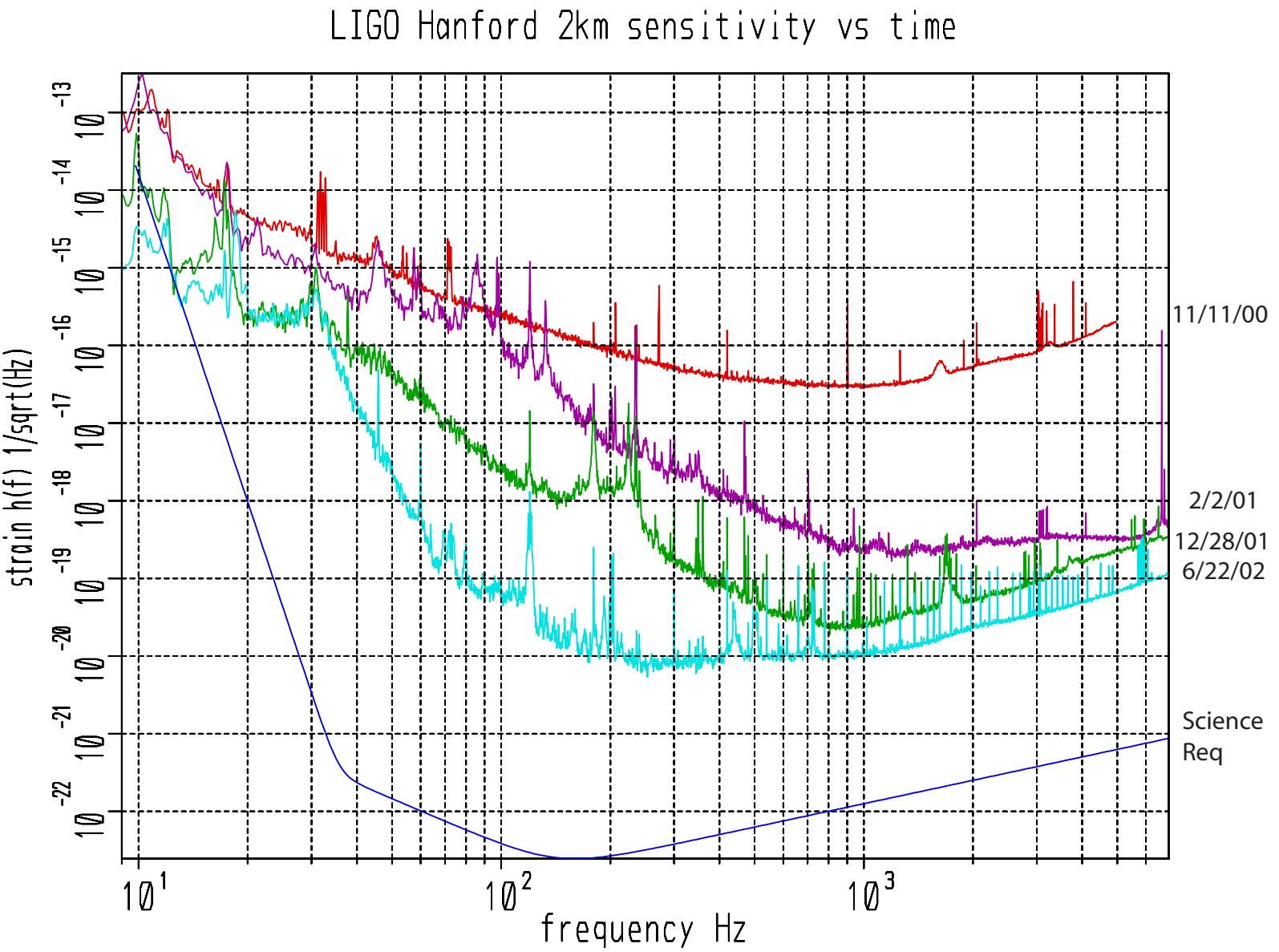
# The LSC Control Screen

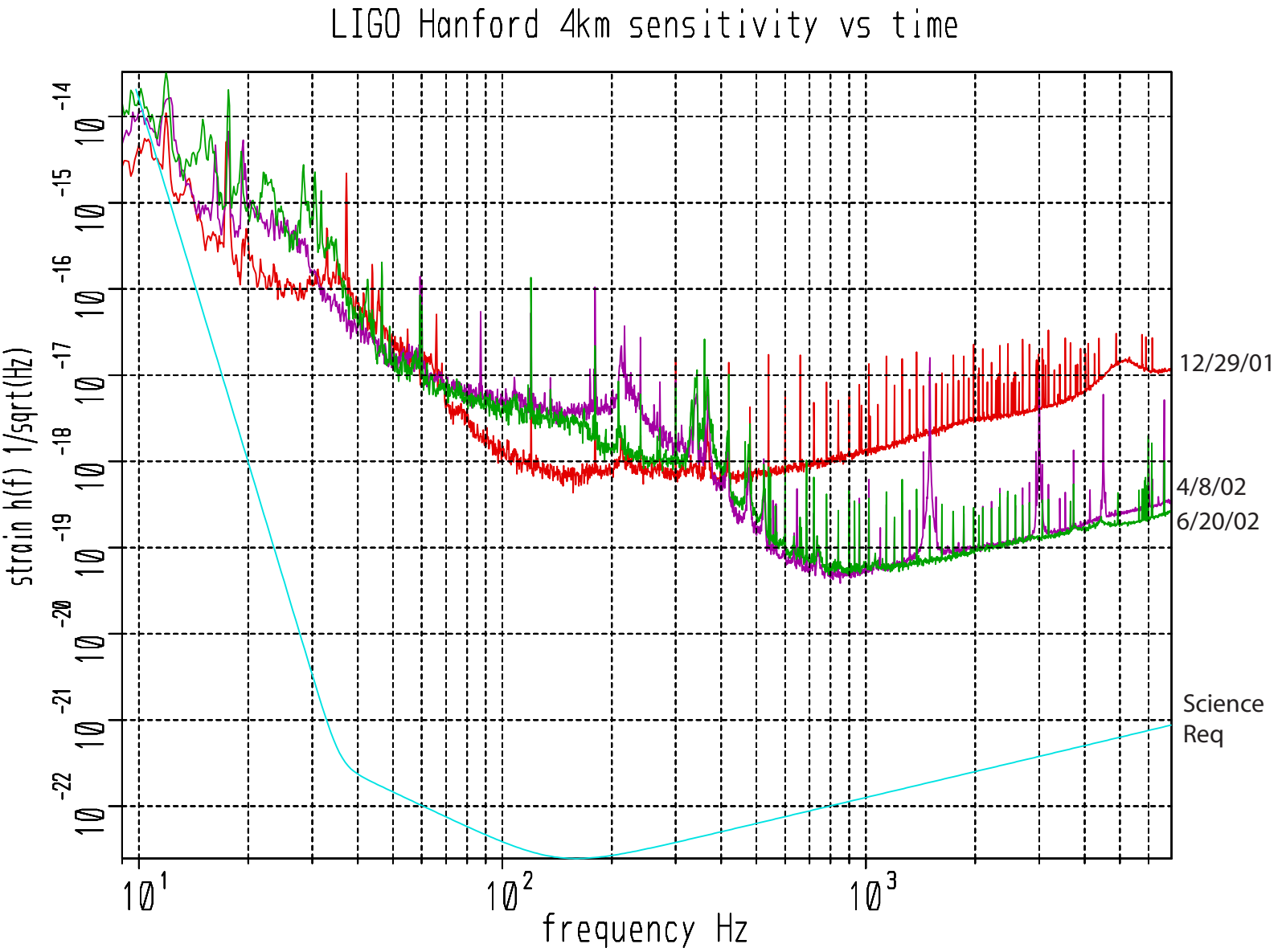



# LIGO COMMISSIONING

- Sub-systems
  - » Length and angle sensing and control
    - – Control longitudinal degrees of freedom
    - – Longitudinal and angular damping – OSEMS
    - – Optical lever monitor and active angular damping
    - – Wavefront sensors for final alignment
  - » Light frequency and amplitude control
    - – nested frequency control loops:pre mode cleaner, reference cavity,
    - – common mode of the interferometer – laser to follow common mode
    - – Intensity stabilization:around the laser, around mode cleaner
  - » Light geometric control
    - – Mode cleaner alignment and damping
    - – Mode matching telescope stability and damping
    - – Control of parasitic interferometers and scattered paths
  - » Environment control : reduction in control dynamic range
    - – Tidal servo common and differential mode
    - – Microseismic feed forward system
    - – Seismic noise reduction using external PZT controllers (Livingston)


LIGO Livingston 4km sensitivity vs time
strain h(f) 1/sqrt(Hz)
10^-14
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10^-21
10^-22
10^1
10^2
10^3
frequency Hz
5/18/01
12/12/01
12/21/01
6/13/02
Science Req


LIGO Hanford 2km sensitivity vs time
strain h(f) 1/sqrt(Hz)
10^-13
10^-14
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10^-21
10^-22
10^1
10^2
10^3
frequency Hz
11/11/00
2/2/01
12/28/01
6/22/02
Science
Req


LIGO Hanford 4km sensitivity vs time
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10^-14
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10^-21
10^-22
10^1
10^2
10^3
frequency Hz
12/29/01
4/8/02
6/20/02
Science
Req


# LIGO COMMISSIONING

- Improvement in sensitivity and robustness
  - » Key issue : maintain operating points against the large low frequency noise in the environment, electronics and the laser
  - » Maintain linearity to avoid mixing the low frequency noise into the gravitational wave band
  - » Necessary conditions to approach the fundamental noise terms: thermal noise, intrinsic phase noise of the light represented in the Science requirement
  - » Periodic assessment of the limiting noise terms : gain redistribution and filtering to bring the system into a comfortable dynamic range of the measurement system
  - » Special problems at Livingston with excess anthropogenic seismic noise – full interferometer operation restricted to nights – seismic retrofit using active external control – interim PZT control