# Hydraulic External Pre-Isolation Progress on the Seismic Retrofit

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# News Headlines

Two similar systems with different actuator types tested at LASTI, both work!

Actuators for LLO will be Hydraulic (announced June ’03)

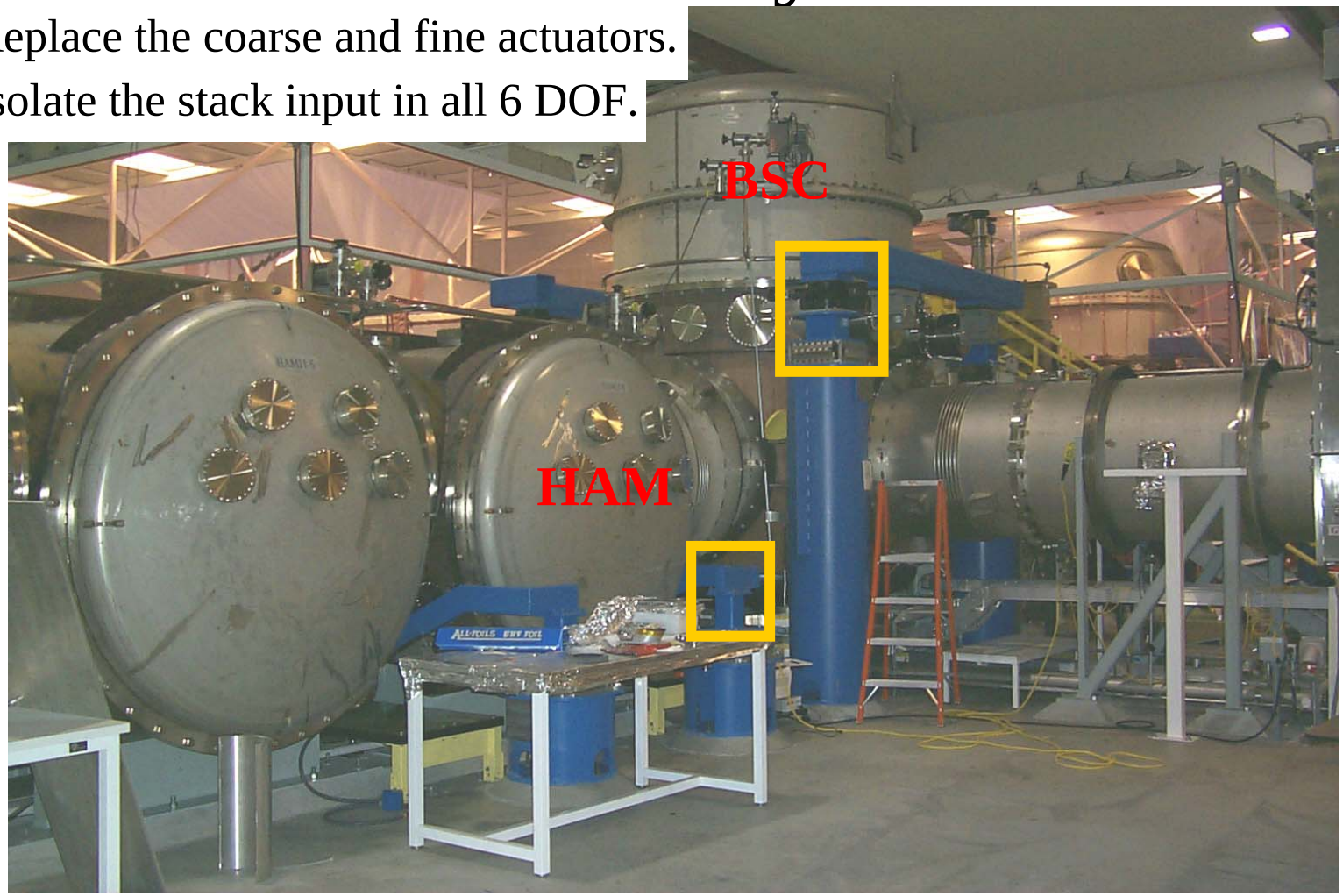
Installation to begin after S3

# Key ideas of the External Pre-Isolators (EPI)

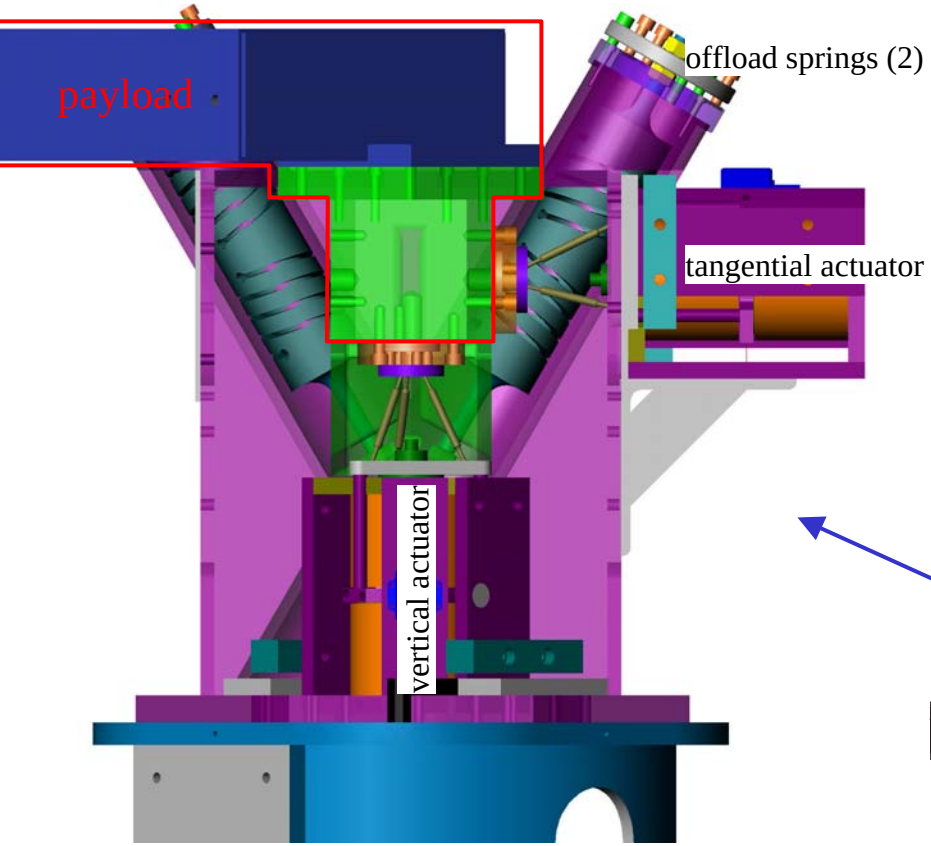
- Anthropogenic ground motion at LLO problematic, requires a fix.
- Control the support table (base of the passive stack) in all 6 DOF.
- Use active feedback to control the support table
  - Displacement sensors at low frequencies
  - Inertial sensors at high frequencies (sometimes)
  - Blend between high and low is ~0.5 Hz to 1.0 Hz
- Correct the displacement sensors with ground motion sensors
- Isolate all three translational DOFs from microseism to ~ 10 Hz
- Cause minimal disruption to the interferometer
- Achieve necessary performance from .15 Hz to 3 Hz

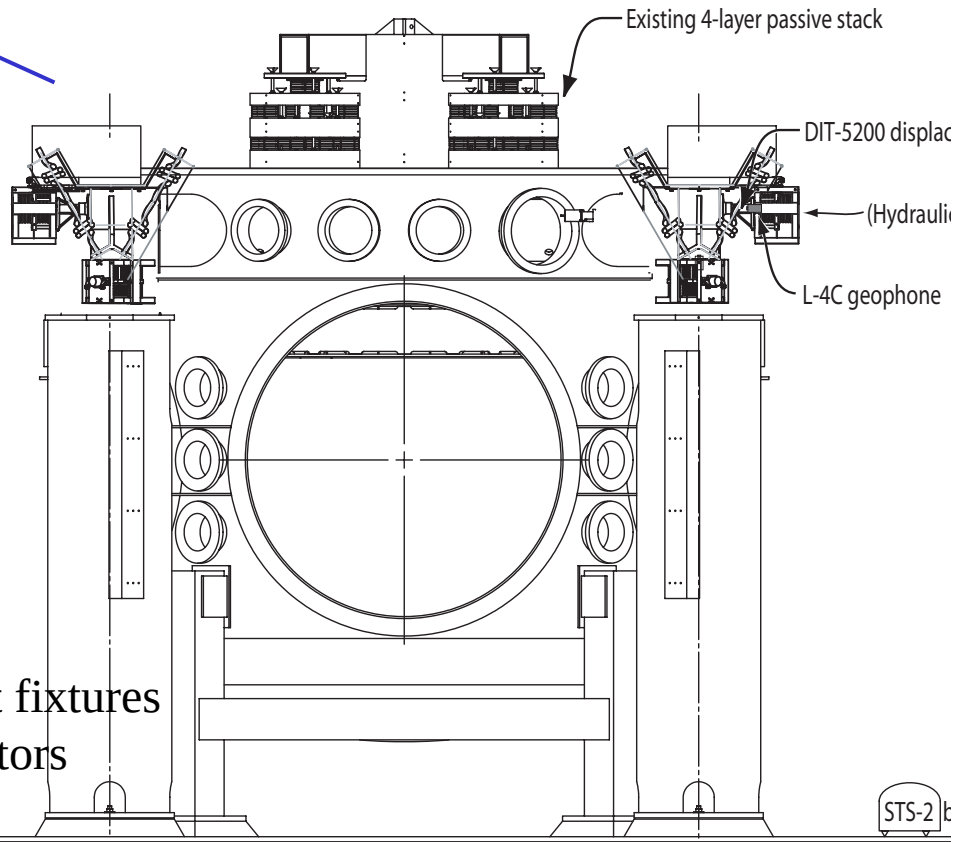
# Placement of an External Isolation System

- Replace the coarse and fine actuators.
- Isolate the stack input in all 6 DOF.



# Placement of the Actuators and Offload Springs



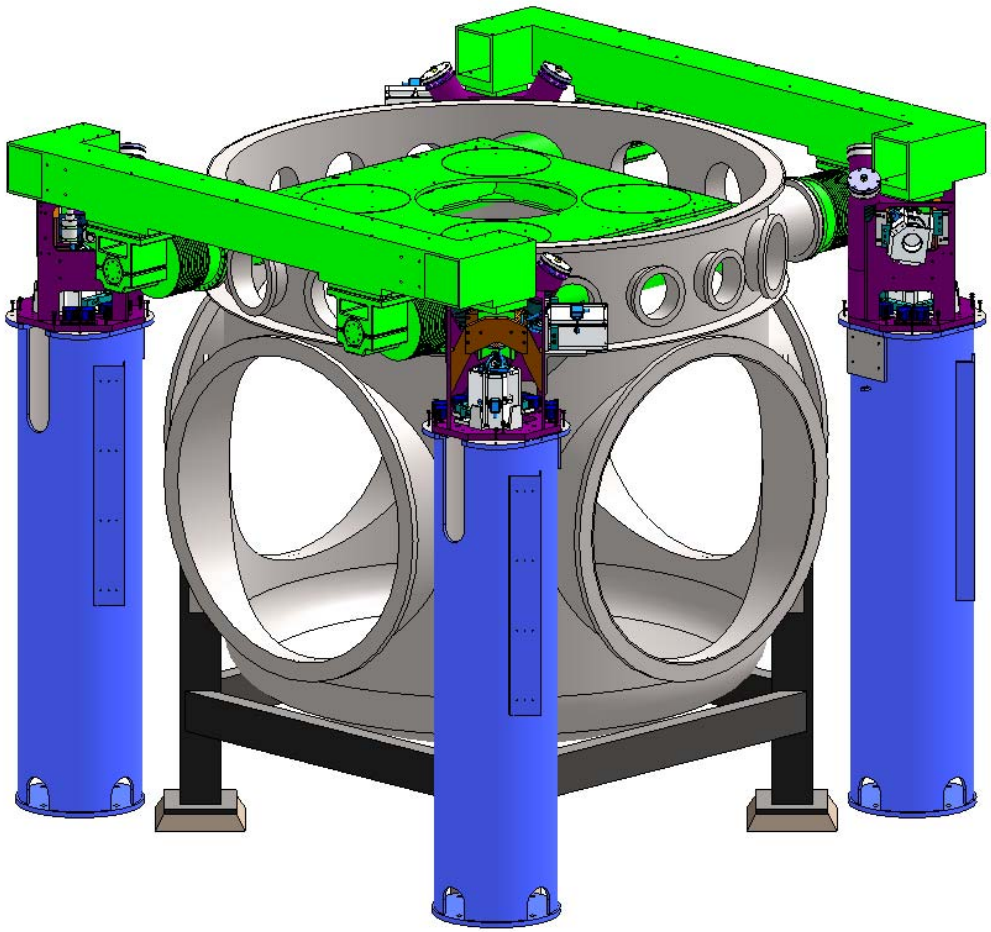

All the pier-top components are mounted into a frame

Frame holds:

- 1 vertical and 1 tangential actuator,
  (isolation and alignment in 6 DOF)
- Pair of offload springs and initial alignment fixtures
- Sensors which are not included in the actuators

# Implementation in 6 DOF

- Piers support the payload (blue)
- EPI system frame (purple) atop the pier
- EPI controls the support table (green)
- Stack (not shown) sits on the support table



# Implementation in 6 DOF

Piers support the payload (blue)

EPI system frame (purple) atop the pier

EPI controls the support table (green)

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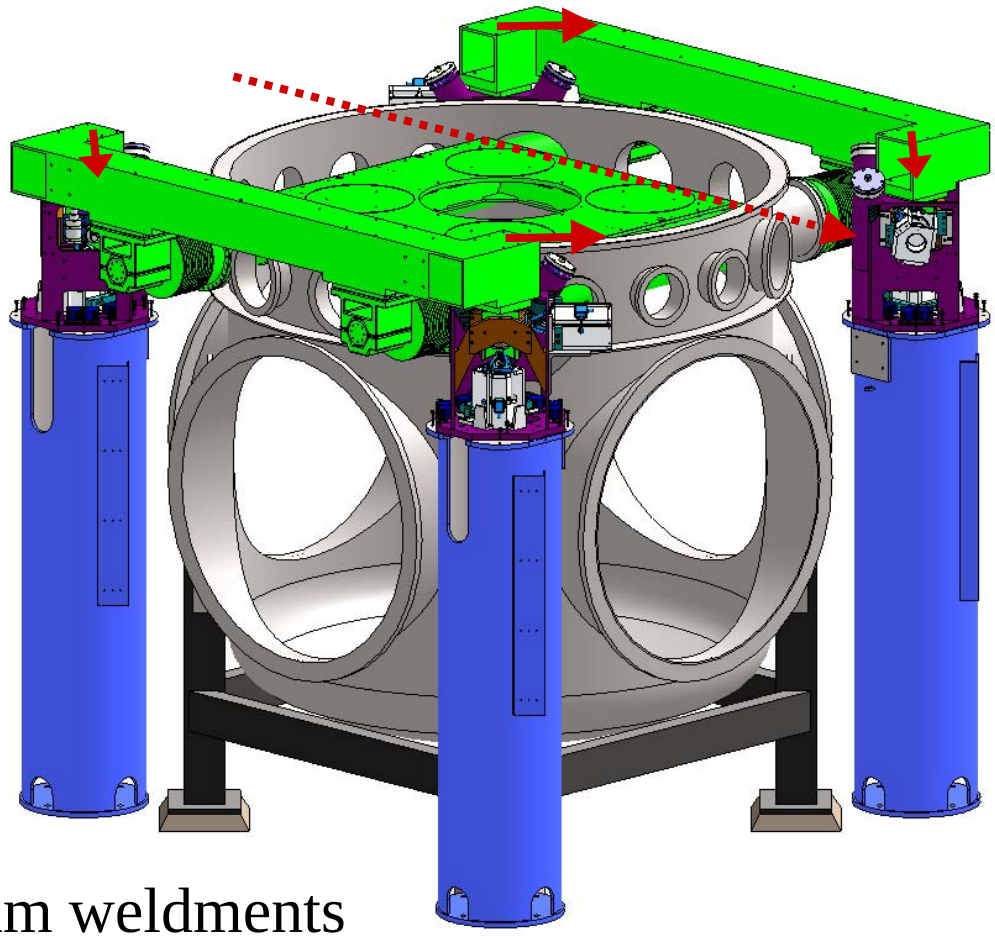
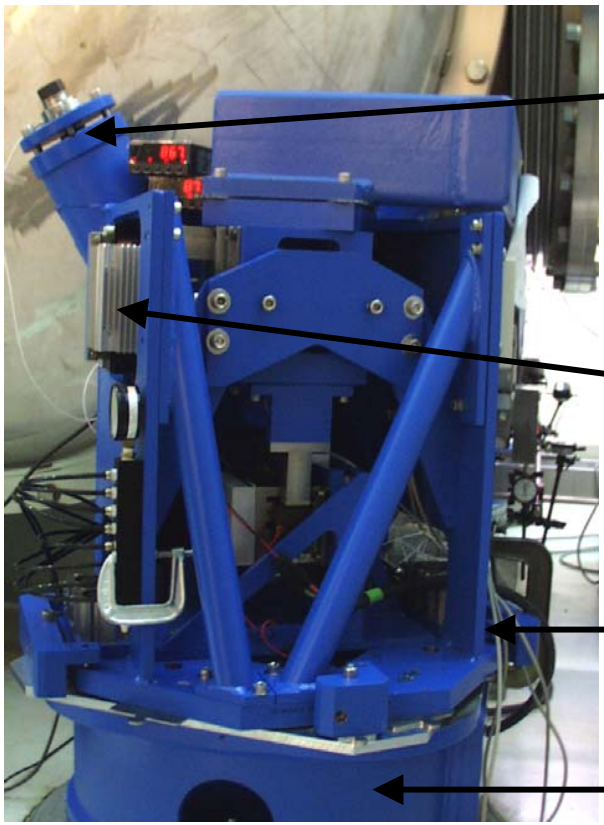


translate parallel to cross beam weldments

# Two types of actuators under test at LASTI

MEPI on HAM



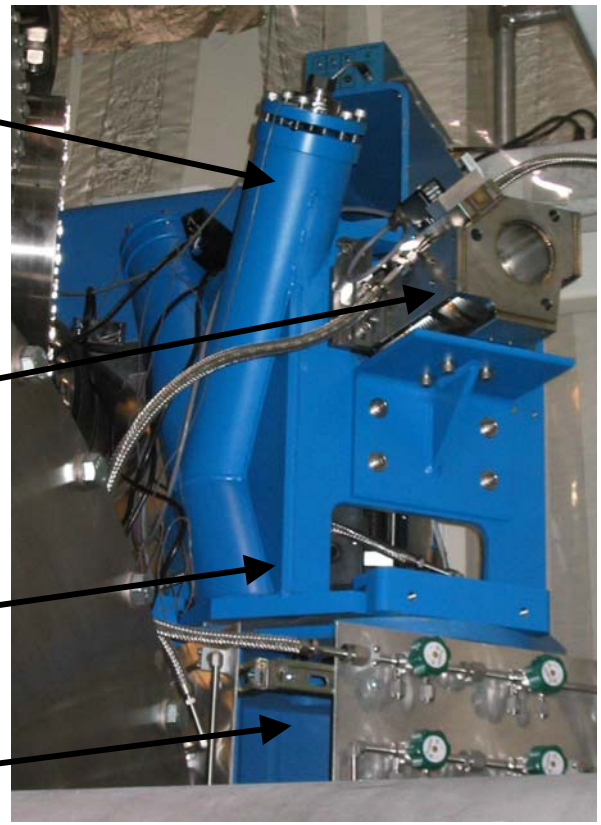
springs

horizontal actuators

frames

piers

HEPI on BSC

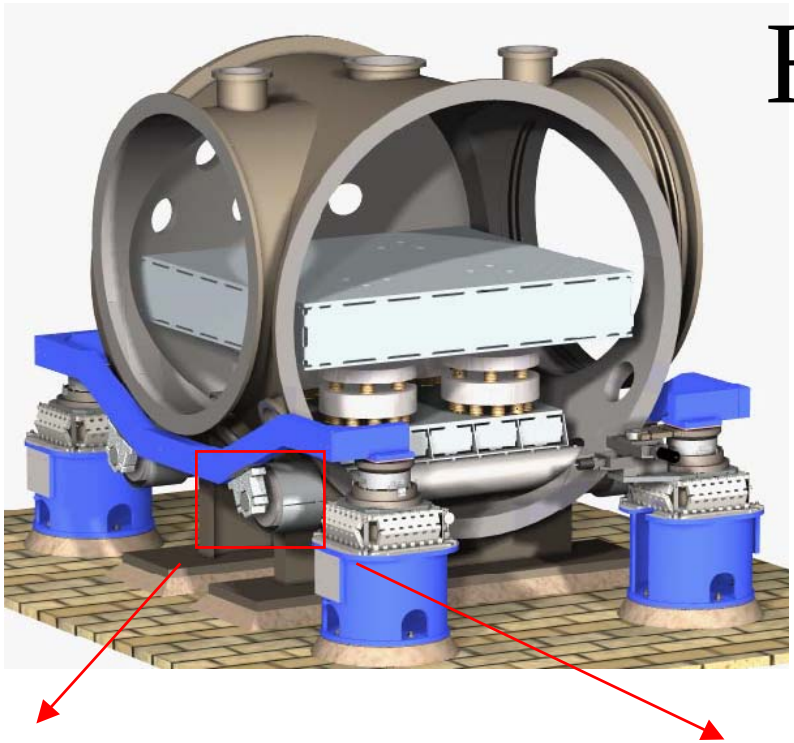


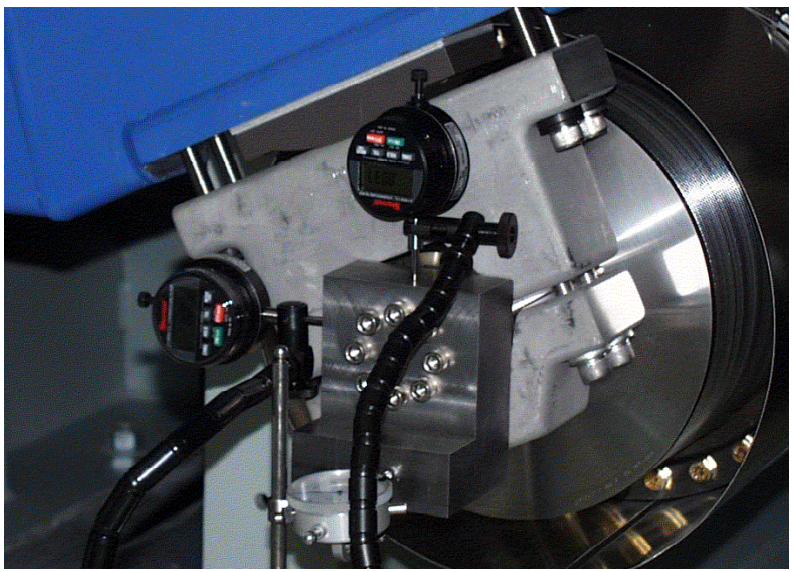
# Installation

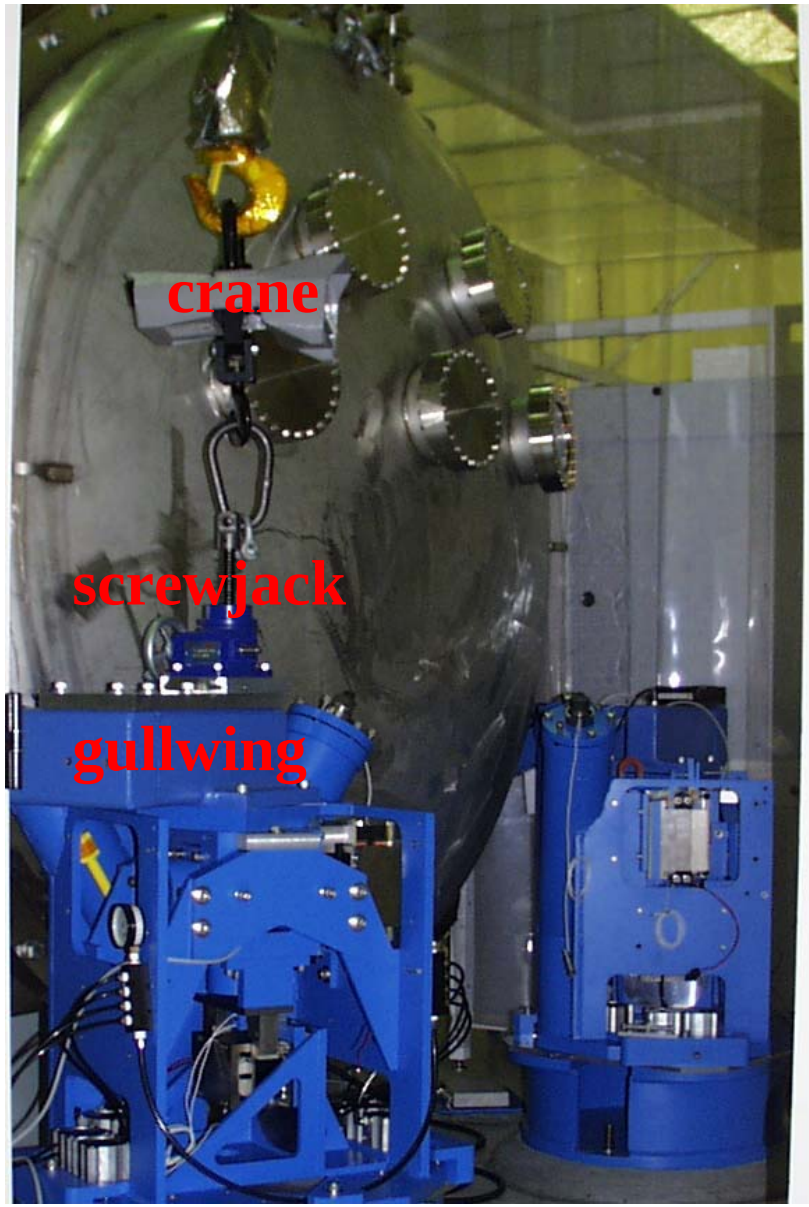
Do not open the vacuum chambers.
Do not disturb the alignment of the installed optics.
Do not drop the baby.

1. Instrument the position of the support table
2. For each corner, lift the crossbeam weldment (.010”) with the crane and manual screwjack
   a) Lower the scissor jack
   b) Remove the old coarse and fine actuators
   c) Install the new frame and actuators
   d) Align the frame, align the payload, align the sensors & actuators
3. With all 4 new corners installed, iterate the alignment with the offload springs and coarse actuation system. (.001”)

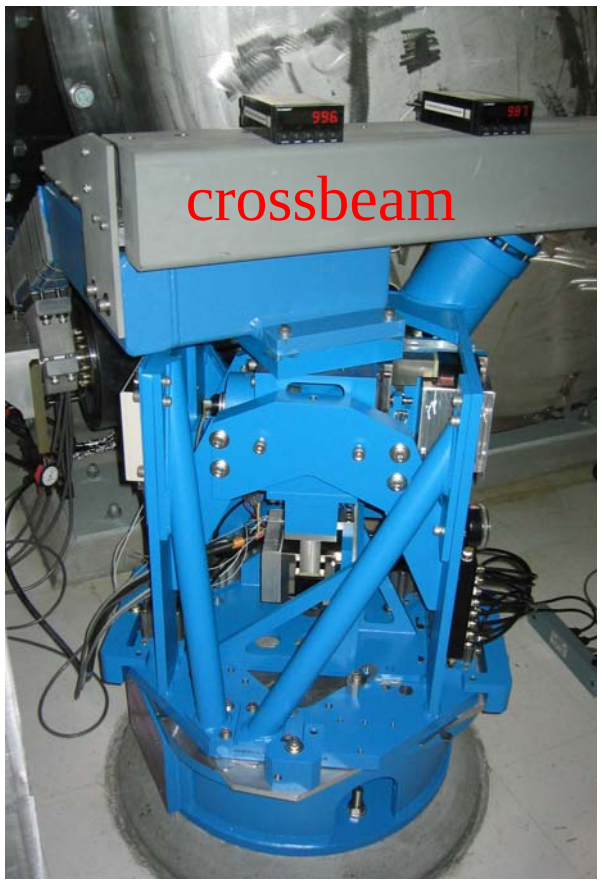
# HAM Installation

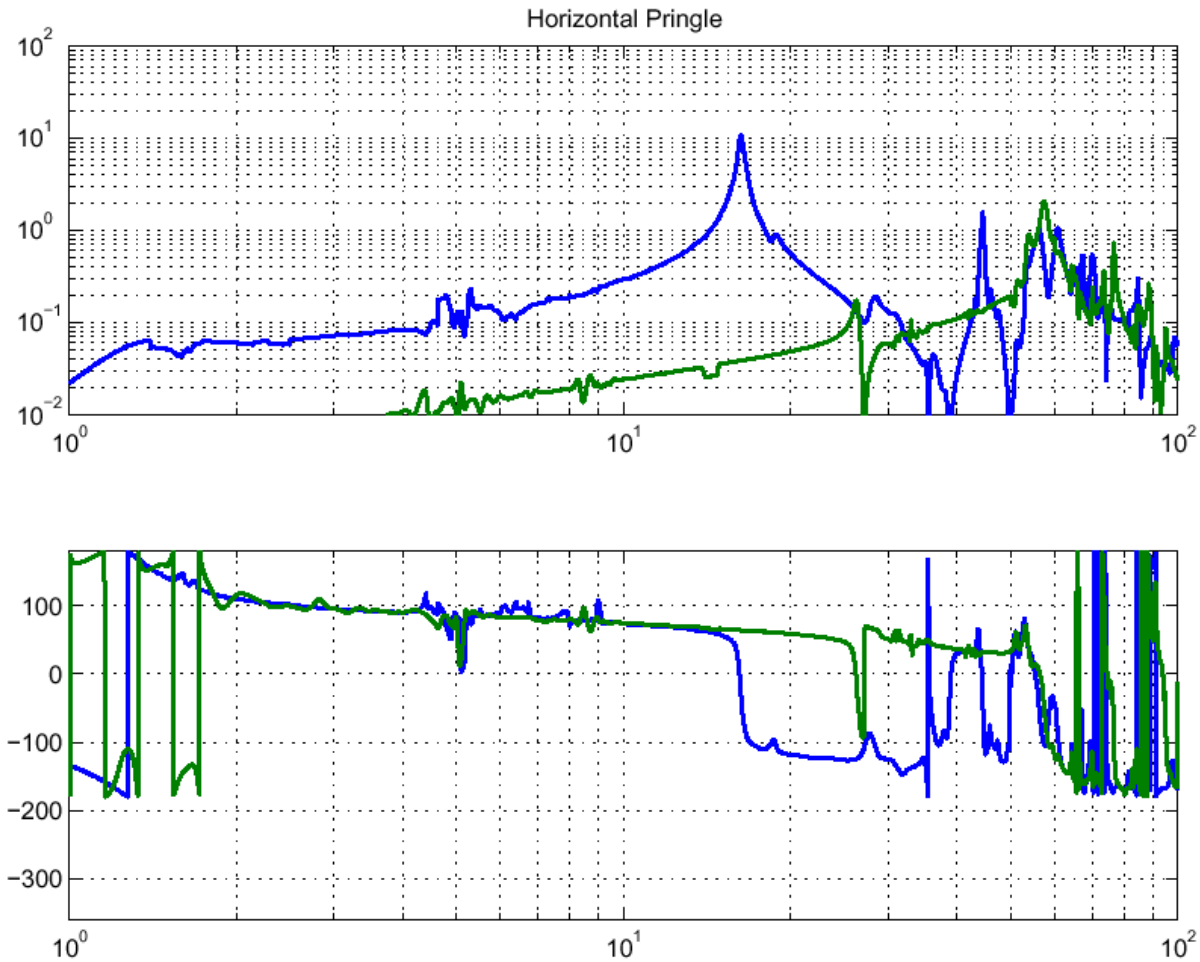




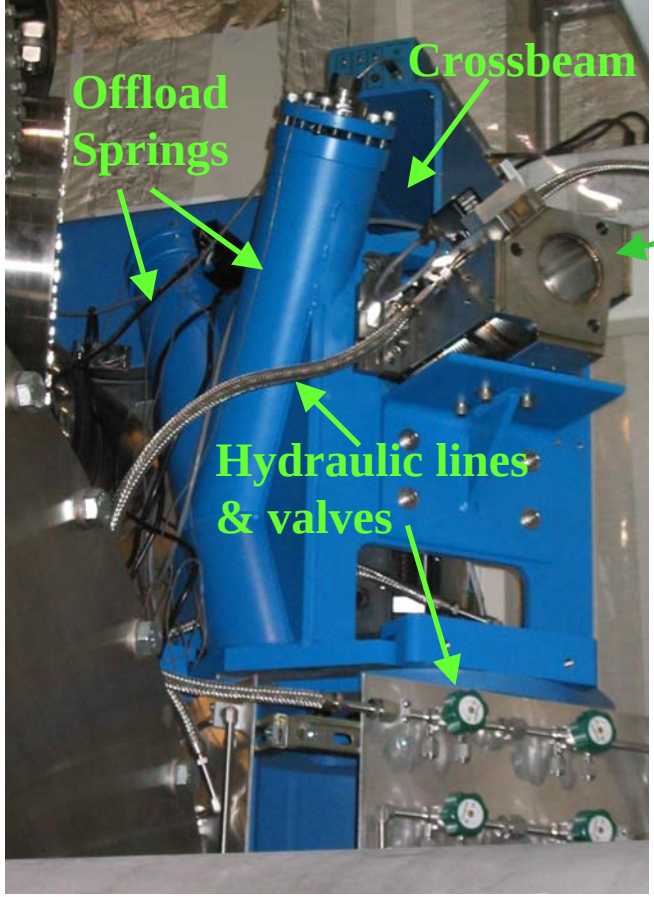


# Adding External Crossbeams to HAM Chamber

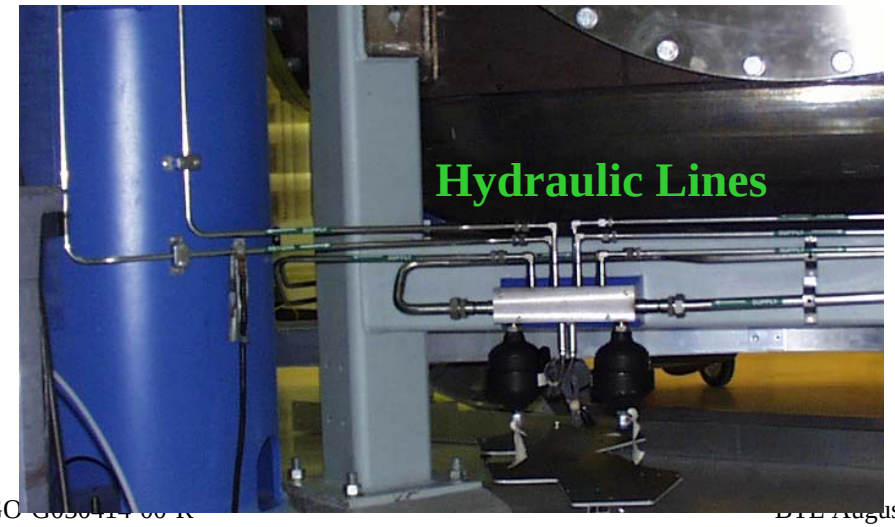


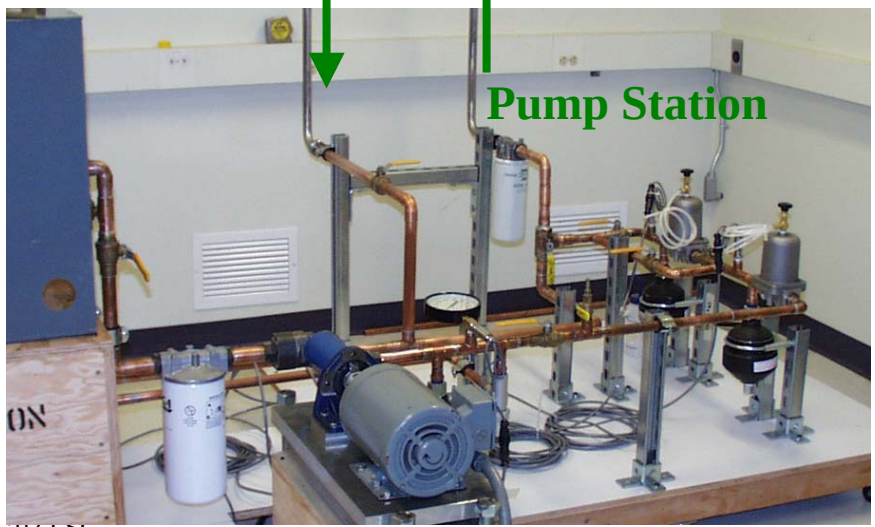



# Hydraulic Installation







# Commissioning of the Hydraulic system

Preliminary results

Bandwidth of 10 Hz

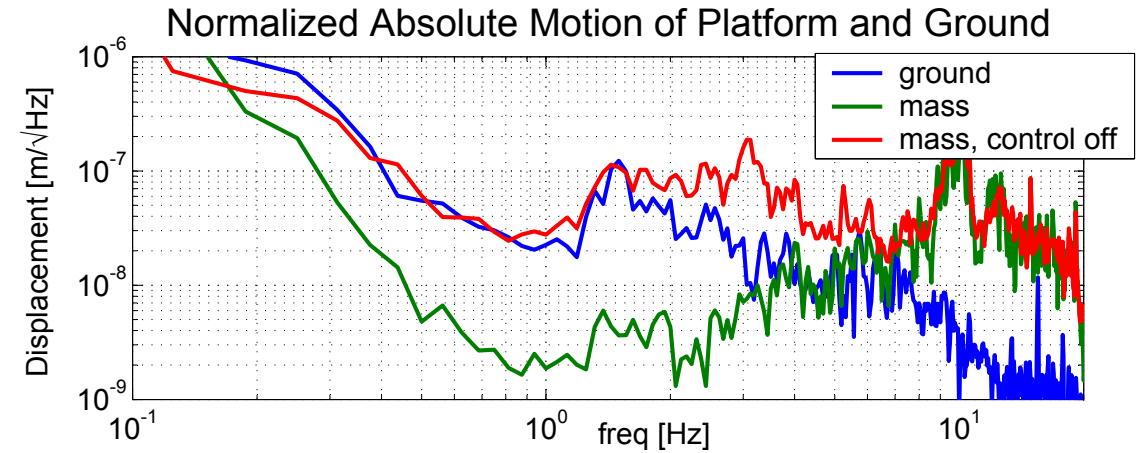
Blended sensors in the vertical direction, using –
corrected displacement sensors, and
inertial feedback geophones,
blended at 0.8 Hz

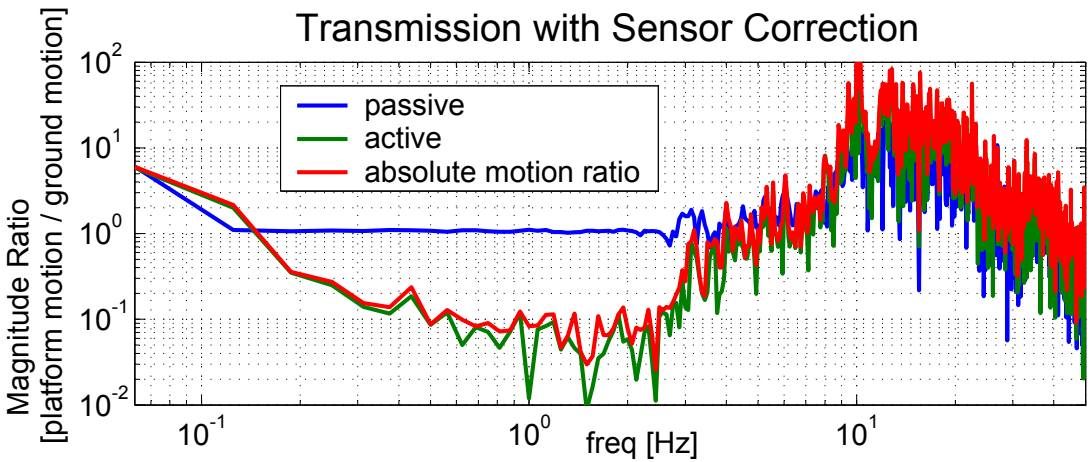
Loops in the coordinate basis (x, y, z, pitch, roll, yaw, O.C.)

Close all 6 DOF

Reasonable isolation at target frequency

# Performance in X




Performance measures:

Top plot shows ASDs of motion:

Ground (blue)

Support table with control off (red)

Support table with control on (green)

Lower plot shows ratios:

Transmission with control off (blue)

Transmission with control on (green)

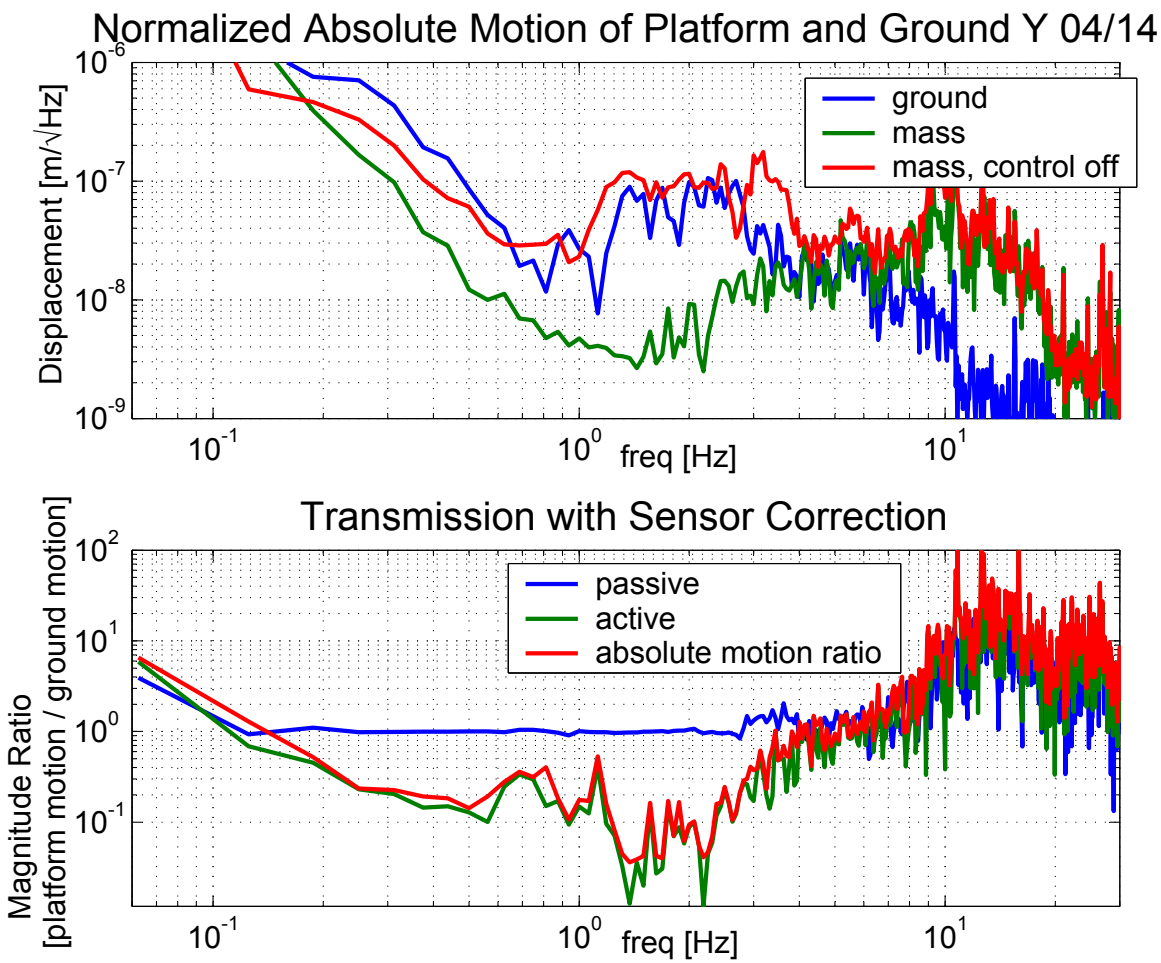
Relative motion with control on (red)

Good performance.

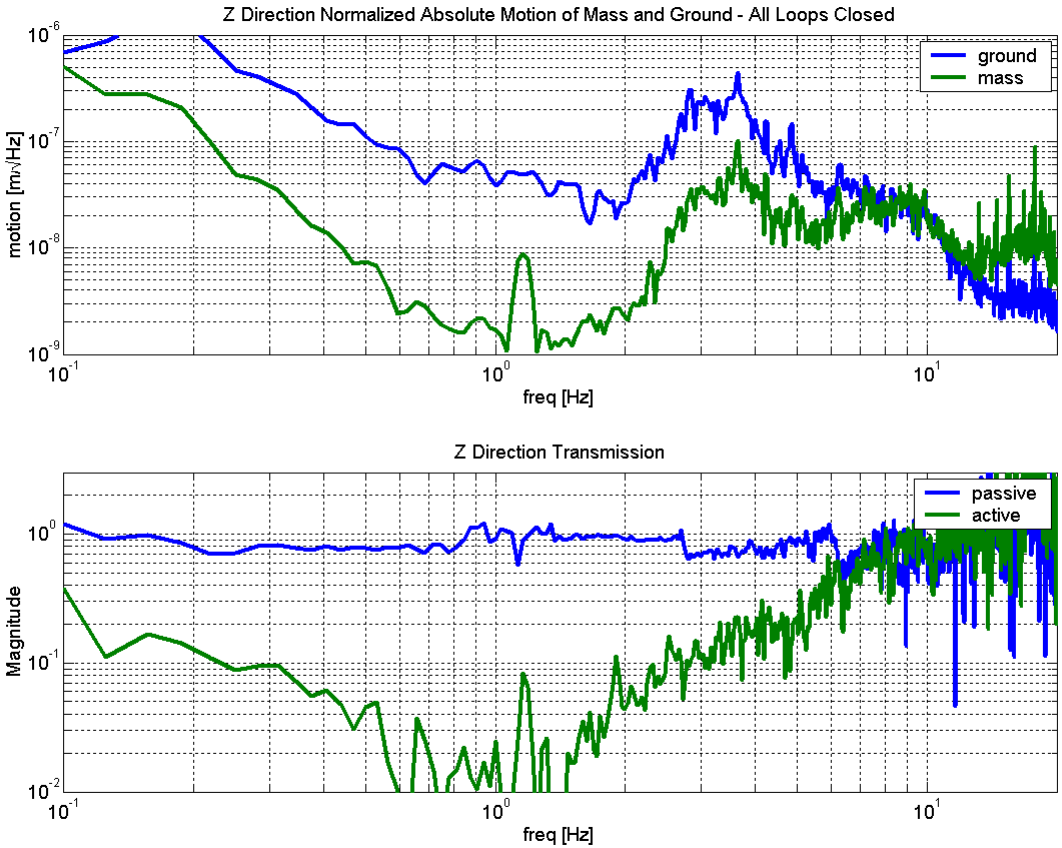
See motion of 2e-9 m/rtHz

Match of trans&ratio indicates limits are loop gain and correction match.

# Performance in Y



# Performance in Z




January data for z direction,
a good set of data.
Top plot shows ASDs of motion:
Ground (blue)
Support table with control on (green)

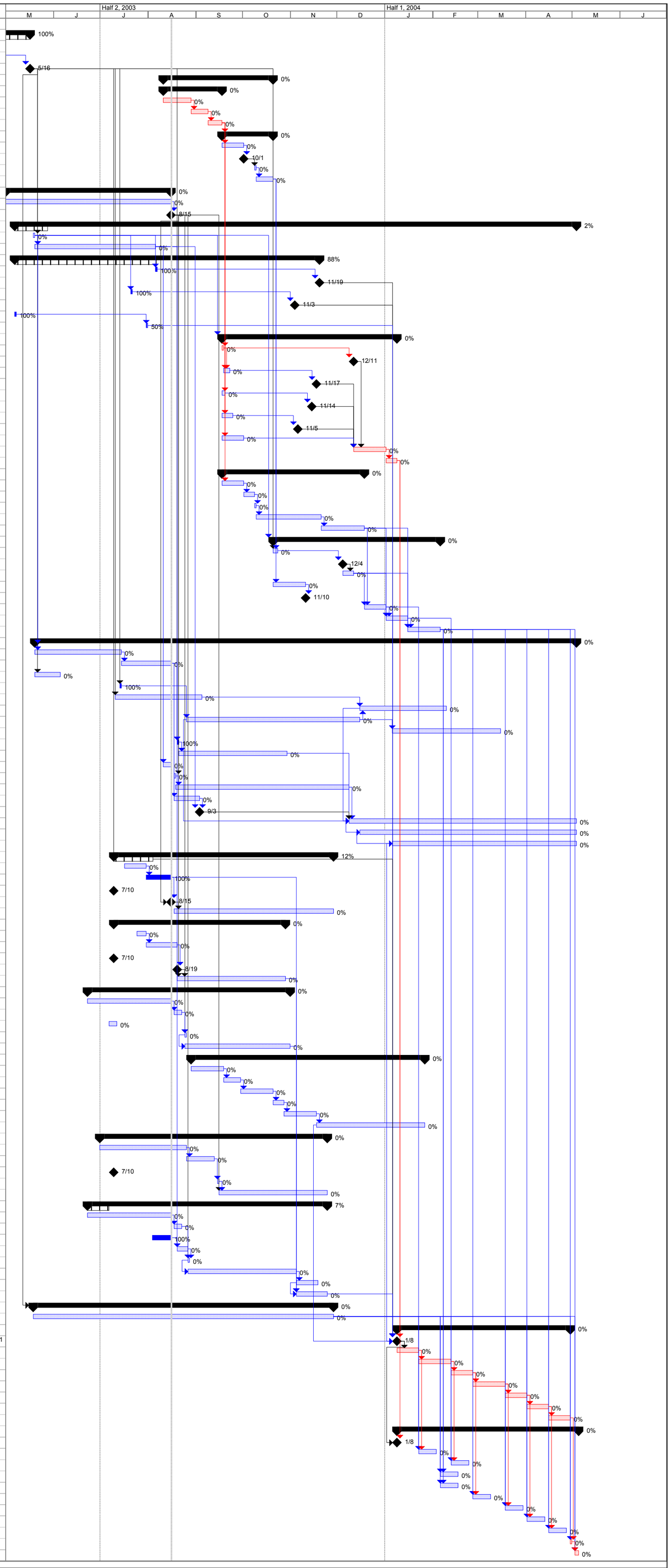
Lower plot shows ratios:
Transmission with control off (blue)
Transmission with control on (green)

Peak above 1 Hz is ADC noise
Performance not always this good –
Coupling between payload motion
and the ground motion STS-2?

# Status of Tasks

Ground motion sensors – in place
geophones & displacement sensors – ordered
valves – in production (last one arrives 12/03)
calibration ready Sept., finished by March
springs – production began yesterday
actuator machining – internal reviews done, ready to make
actuator delivery – Dec 9 – Feb 9
housings – submitted to NSF, delivery end of Nov.
pump station – updating design, review ~Sept 8
plumbing – being laid out, review ~Oct 1
control electronics – LASTI system installed, in testing
Installation (slip free) – Jan – April 03

| ID | Task Name | Duration | Start | Finish | Predecessors |
|---|---|---|---|---|---|
| 1 | **HEPI** | **127 days?** | **Mon 10/7/02** | **Thu 4/3/03** | |
| 67 | **PDR** | **96 days** | **Thu 1/2/03** | **Fri 5/16/03** | |
| 68 | release documents | 0 days | Thu 1/2/03 | Thu 1/2/03 | 58 |
| 69 | review | 1 day | Fri 4/18/03 | Fri 4/18/03 | 68FS+2 wks |
| 70 | final decision | 0 days | Fri 5/16/03 | Fri 5/16/03 | 69FS+4 wks |
| 71 | **Incremental FDRs** | **51 days** | **Mon 8/11/03** | **Mon 10/20/03** | |
| 72 | **Pump Station FDR** | **28 days** | **Mon 8/11/03** | **Wed 9/17/03** | |
| 73 | release documents | 14 days | Mon 8/11/03 | Thu 8/28/03 | |
| 74 | review | 7 days | Fri 8/29/03 | Mon 9/8/03 | 73 |
| 75 | final decision | 7 days | Tue 9/9/03 | Wed 9/17/03 | 74 |
| 76 | **Distribution System FDR** | **23 days** | **Thu 9/18/03** | **Mon 10/20/03** | **75** |
| 77 | finalize design pkg/dws | 2 wks | Thu 9/18/03 | Wed 10/1/03 | 75 |
| 78 | docs released | 0 days | Wed 10/1/03 | Wed 10/1/03 | 77 |
| 79 | review | 1 day | Thu 10/9/03 | Thu 10/9/03 | 78FS+1 wk |
| 80 | incorporate recommendations of review | 7 days | Fri 10/10/03 | Mon 10/20/03 | 79 |
| 81 | **Integrated SolidWorks model of EPI** | **77 days** | **Thu 5/1/03** | **Fri 8/15/03** | |
| 82 | finalize design pkg/dws | 15.4 wks | Thu 5/1/03 | Fri 8/15/03 | |
| 83 | docs released | 0 days | Fri 8/15/03 | Fri 8/15/03 | 82 |
| 84 | **Production** | **259 days?** | **Wed 5/7/03** | **Mon 5/3/04** | |
| 85 | CCB decision on production | 1 day | Mon 5/19/03 | Mon 5/19/03 | 70 |
| 86 | NSF decision on large contracts | 56 days | Tue 5/20/03 | Tue 8/5/03 | 85 |
| 87 | **EPI: order long lead items** | **141 days?** | **Wed 5/7/03** | **Wed 11/19/03** | **58** |
| 88 | L4C geophones | 1 day | Wed 8/6/03 | Wed 8/6/03 | 85 |
| 89 | receive L4C | 0 days | Wed 11/19/03 | Wed 11/19/03 | 88FS+15 wks |
| 90 | displacement sensors | 1 day | Mon 7/21/03 | Mon 7/21/03 | 85 |
| 91 | receive displacement sensors | 0 days | Mon 11/3/03 | Mon 11/3/03 | 90FS+15 wks |
| 92 | Maraging Steel order | 1 day? | Wed 5/7/03 | Wed 5/7/03 | |
| 93 | receive maraging steel | 1 day? | Thu 7/31/03 | Thu 7/31/03 | 92FS+12 wks |
| 94 | **HEPI: Pump Station production** | **81 days** | **Thu 9/18/03** | **Thu 1/8/04** | **85** |
| 95 | order pumps (7) | 1 day | Thu 9/18/03 | Thu 9/18/03 | 75 |
| 96 | receive pumps | 0 days | Thu 12/11/03 | Thu 12/11/03 | 95FS+12 wks |
| 97 | order reservoirs (7) | 2 days | Fri 9/19/03 | Mon 9/22/03 | 95,75 |
| 98 | receive reservoirs | 0 days | Mon 11/17/03 | Mon 11/17/03 | 97FS+8 wks |
| 99 | order machined parts | 2 days | Thu 9/18/03 | Fri 9/19/03 | 75 |
| 100 | receive machined parts | 0 days | Fri 11/14/03 | Fri 11/14/03 | 99FS+8 wks |
| 101 | order misc COTS parts | 1 wk | Thu 9/18/03 | Wed 9/24/03 | 75 |
| 102 | receive COTS parts | 0 days | Wed 11/5/03 | Wed 11/5/03 | 101FS+6 wks |
| 103 | obtain assembly quotes | 2 wks | Thu 9/18/03 | Wed 10/1/03 | 75 |
| 104 | assembly & air leak testing | 3 wks | Fri 12/12/03 | Thu 1/1/04 | 103,96,98,100,102 |
| 105 | ship to LLO | 1 wk | Fri 1/2/04 | Thu 1/8/04 | 104 |
| 106 | **HEPI: Actuator Isolation Valve Tree** | **66 days** | **Thu 9/18/03** | **Thu 12/18/03** | |
| 107 | finalize design pkg/dws | 2 wks | Thu 9/18/03 | Wed 10/1/03 | 75 |
| 108 | final design review | 1 wk | Thu 10/2/03 | Wed 10/8/03 | 107 |
| 109 | order valves and fittings (48) | 1 day | Thu 10/9/03 | Thu 10/9/03 | 108 |
| 110 | receive valves and fittings | 6 wks | Fri 10/10/03 | Thu 11/20/03 | 109 |
| 111 | assembly & He leak testing | 4 wks | Fri 11/21/03 | Thu 12/18/03 | 110 |
| 112 | **HEPI: Fluid distribution system production** | **78 days** | **Tue 10/21/03** | **Thu 2/5/04** | **85** |
| 113 | order distribution manifolds | 3 days | Tue 10/21/03 | Thu 10/23/03 | 70,80 |
| 114 | receive distribution manifolds | 0 days | Thu 12/4/03 | Thu 12/4/03 | 113FS+6 wks |
| 115 | leak test manifolds | 1 wk | Fri 12/5/03 | Thu 12/11/03 | 114 |
| 116 | obtain plumbing quotes | 3 wks | Tue 10/21/03 | Mon 11/10/03 | 80 |
| 117 | award plumbing contract | 0 days | Mon 11/10/03 | Mon 11/10/03 | 116 |
| 118 | install X end station | 2 wks | Fri 12/19/03 | Thu 1/1/04 | 111,115 |
| 119 | install Y end station | 2 wks | Fri 1/2/04 | Thu 1/15/04 | 118,111,115 |
| 120 | install corner station | 3 wks | Fri 1/16/04 | Thu 2/5/04 | 119,111,115 |
| 121 | **HEPI: hydraulic actuator production** | **250 days** | **Tue 5/20/03** | **Mon 5/3/04** | **85** |
| 122 | finalize dwg pkg | 8 wks | Tue 5/20/03 | Mon 7/14/03 | 85 |
| 123 | review & DCN | 24 days | Tue 7/15/03 | Fri 8/15/03 | 122 |
| 124 | get quotes | 2.5 wks | Tue 5/20/03 | Thu 6/5/03 | 70 |
| 125 | order ~100 servo-valves | 1 day | Mon 7/14/03 | Mon 7/14/03 | 70 |
| 126 | order ~500 nozzles | 8 wks | Fri 7/11/03 | Thu 9/4/03 | 70 |
| 127 | insert nozzles & test (Parker) | 8 wks | Tue 12/16/03 | Mon 2/9/04 | 126,128 |
| 128 | receive servo-valves | 4 mons | Tue 8/26/03 | Mon 12/15/03 | 125FS+30 days |
| 129 | Calibrate servo valves | 50 days | Tue 1/6/04 | Mon 3/15/04 | 128FS+15 days |
| 130 | order bellows | 1 day | Wed 8/20/03 | Wed 8/20/03 | 70,123 |
| 131 | receive bellows | 10 wks | Thu 8/21/03 | Wed 10/29/03 | 130 |
| 132 | Contract let by Caltech | 5 days | Mon 8/11/03 | Fri 8/15/03 | 86 |
| 133 | order machined parts | 1 day | Mon 8/18/03 | Mon 8/18/03 | 83 |
| 134 | receive machined parts | 16 wks | Tue 8/19/03 | Mon 12/8/03 | 133 |
| 135 | get quotes for welded assy | 2.5 wks | Mon 8/18/03 | Wed 9/3/03 | 123 |
| 136 | award assy contract | 0 days | Wed 9/3/03 | Wed 9/3/03 | 135,86FS+10 days |
| 137 | welded assembly | 21 wks | Tue 12/9/03 | Mon 5/3/04 | 136,128SS+2 wks,131,134,127SS-6 wks |
| 138 | leak testing | 20 wks | Tue 12/16/03 | Mon 5/3/04 | 137SS+5 days |
| 139 | units become available | 17 wks | Tue 1/6/04 | Mon 5/3/04 | 138SS+3 wks |
| 140 | **EPI Spring Production** | **102 days** | **Thu 7/10/03** | **Fri 11/28/03** | **70** |
| 141 | finalize dwg pkg | 2 wks | Thu 7/17/03 | Wed 7/30/03 | |
| 142 | DCN | 12 days | Thu 7/31/03 | Fri 8/15/03 | 141 |
| 143 | get quotes | 0 wks | Thu 7/10/03 | Thu 7/10/03 | |
| 144 | Order production | 0 wks | Fri 8/15/03 | Fri 8/15/03 | 142,83 |
| 145 | machine parts | 15 wks | Mon 8/18/03 | Fri 11/28/03 | 144 |
| 146 | **EPI Actuator,Sensor & Spring bracket production** | **79 days** | **Thu 7/10/03** | **Tue 10/28/03** | |
| 147 | finalize dwg pkg | 0.8 wks | Fri 7/25/03 | Wed 7/30/03 | |
| 148 | DCN | 14 days | Thu 7/31/03 | Tue 8/19/03 | 147 |
| 149 | get quotes | 0 wks | Thu 7/10/03 | Thu 7/10/03 | |
| 150 | Order Production | 0 wks | Tue 8/19/03 | Tue 8/19/03 | 148 |
| 151 | machine parts | 10 wks | Wed 8/20/03 | Tue 10/28/03 | 83,150 |
| 152 | **EPI Boot (machined Foot) Production** | **95 days** | **Mon 6/23/03** | **Fri 10/31/03** | |
| 153 | finalize dwg pkg | 8 wks | Mon 6/23/03 | Fri 8/15/03 | |
| 154 | review & DCN | 1 wk | Mon 8/18/03 | Fri 8/22/03 | 153 |
| 155 | get quotes for machining | 1 wk | Mon 7/7/03 | Fri 7/11/03 | |
| 156 | order boot | 1 day | Mon 8/25/03 | Mon 8/25/03 | 154,83 |
| 157 | receive machined parts | 10 wks | Mon 8/25/03 | Fri 10/31/03 | 156SS |
| 158 | **HEPI: Flow bench for calibrating Parket valves** | **107 days?** | **Fri 8/29/03** | **Mon 1/26/04** | |
| 159 | finalize design of complete test fixture | 3 wks | Fri 8/29/03 | Thu 9/18/03 | |
| 160 | order parts | 7 days | Fri 9/19/03 | Mon 9/29/03 | 159 |
| 161 | Assemble | 3 wks | Tue 9/30/03 | Mon 10/20/03 | 160 |
| 162 | ship to LLO | 1 wk | Tue 10/21/03 | Mon 10/27/03 | 161 |
| 163 | Assemble sensors, pump and test fixture | 15 days | Tue 10/28/03 | Mon 11/17/03 | 162 |
| 164 | Calibrate ~100 valves | 50 days? | Tue 11/18/03 | Mon 1/26/04 | 163 |
| 165 | **EPI Ham Pier production** | **105 days?** | **Tue 7/1/03** | **Mon 11/24/03** | |
| 166 | finalize dwg pkg | 8 wks | Tue 7/1/03 | Mon 8/25/03 | |
| 167 | DCN | 14 days | Tue 8/26/03 | Fri 9/12/03 | 166 |
| 168 | get quotes | 0 wks | Thu 7/10/03 | Thu 7/10/03 | |
| 169 | Release drawing for production | 1 day? | Mon 9/15/03 | Mon 9/15/03 | 167 |
| 170 | machine parts | 10 wks | Tue 9/16/03 | Mon 11/24/03 | 83,169 |
| 171 | **EPI Actuator Housing Production** | **111 days** | **Mon 6/23/03** | **Mon 11/24/03** | |
| 172 | finalize dwg pkg | 8 wks | Mon 6/23/03 | Fri 8/15/03 | |
| 173 | review & DCN | 1 wk | Mon 8/18/03 | Fri 8/22/03 | 172 |
| 174 | get quotes for welded assy | 2 wks | Mon 8/4/03 | Fri 8/15/03 | |
| 175 | award assy contract | 5 days | Wed 8/20/03 | Tue 8/26/03 | 174,86FS+10 days |
| 176 | Release drawing for production | 1 day | Wed 8/27/03 | Wed 8/27/03 | 83,173,175 |
| 177 | receive machined parts | 10 wks | Wed 8/27/03 | Tue 11/4/03 | 176SS |
| 178 | welding and painting and assembly | 2 wks | Wed 11/5/03 | Tue 11/18/03 | 177 |
| 179 | 1st set available | 14 days | Wed 11/5/03 | Mon 11/24/03 | 178SS,151,157,142 |
| 180 | **VME System** | **140 days** | **Mon 5/19/03** | **Fri 11/28/03** | **70** |
| 181 | to be detailed | 7 mons | Mon 5/19/03 | Fri 11/28/03 | |
| 182 | **Installation** | **80 days** | **Thu 1/8/04** | **Thu 4/29/04** | |
| 183 | ready to start | 0 days | Thu 1/8/04 | Thu 1/8/04 | 118,105,89,91,140,93,179,139SS,164SS+2 wks,181 |
| 184 | install X-end mechanicals | 2 wks | Fri 1/9/04 | Thu 1/22/04 | 183 |
| 185 | Install Y-end mechanicals | 3 wks | Fri 1/23/04 | Thu 2/12/04 | 184 |
| 186 | Install BSC | 2 wks | Fri 2/13/04 | Thu 2/26/04 | 185 |
| 187 | Install H1 | 3 wks | Fri 2/27/04 | Thu 3/18/04 | 186 |
| 188 | Install H2 | 2 wks | Fri 3/19/04 | Thu 4/1/04 | 187 |
| 189 | Install H3 | 2 wks | Fri 4/2/04 | Thu 4/15/04 | 188 |
| 190 | Install H4 | 2 wks | Fri 4/16/04 | Thu 4/29/04 | 189 |
| 191 | **Commissioning** | **83.25 days?** | **Thu 1/8/04** | **Wed 5/5/04** | |
| 192 | ready to start | 0 days | Thu 1/8/04 | Thu 1/8/04 | 183,105 |
| 193 | X-end | 1.5 wks | Fri 1/23/04 | Tue 2/3/04 | 184,181,118 |
| 194 | Y-end | 1.5 wks | Fri 2/13/04 | Tue 2/24/04 | 185,181,119 |
| 195 | ITMx | 1.5 wks | Fri 2/6/04 | Tue 2/17/04 | 181,120 |
| 196 | ITMy | 1.5 wks | Fri 2/6/04 | Tue 2/17/04 | 181,120 |
| 197 | BSC | 1.5 wks | Fri 2/27/04 | Tue 3/9/04 | 181,186,120 |
| 198 | H1 | 1.5 wks | Fri 3/19/04 | Tue 3/30/04 | 187,181,120 |
| 199 | H2 | 1.5 wks | Fri 4/2/04 | Tue 4/13/04 | 181,188,120 |
| 200 | H3 | 1.5 wks | Fri 4/16/04 | Tue 4/27/04 | 181,189,120 |
| 201 | H4 | 1 day? | Fri 4/30/04 | Fri 4/30/04 | 181,190,120 |
| 202 | ISC-EPI testing | 2.25 days | Mon 5/3/04 | Wed 5/5/04 | 181,120,201 |




Project: M020142-06_snipit
Date: Sat 8/16/03

Critical
Critical Split
Critical Progress
Task
Split
Task Progress
Baseline
Baseline Split
Baseline Milestone
Milestone
Summary Progress
Summary
Project Summary
External Tasks
External Milestone
Deadline

# To Conclude

We can install an external isolation system with minimal disruption to the LIGO optics.

We have achieved ~10x isolation performance from the microseism to ~2 Hz, partly covering the problematic frequency band.

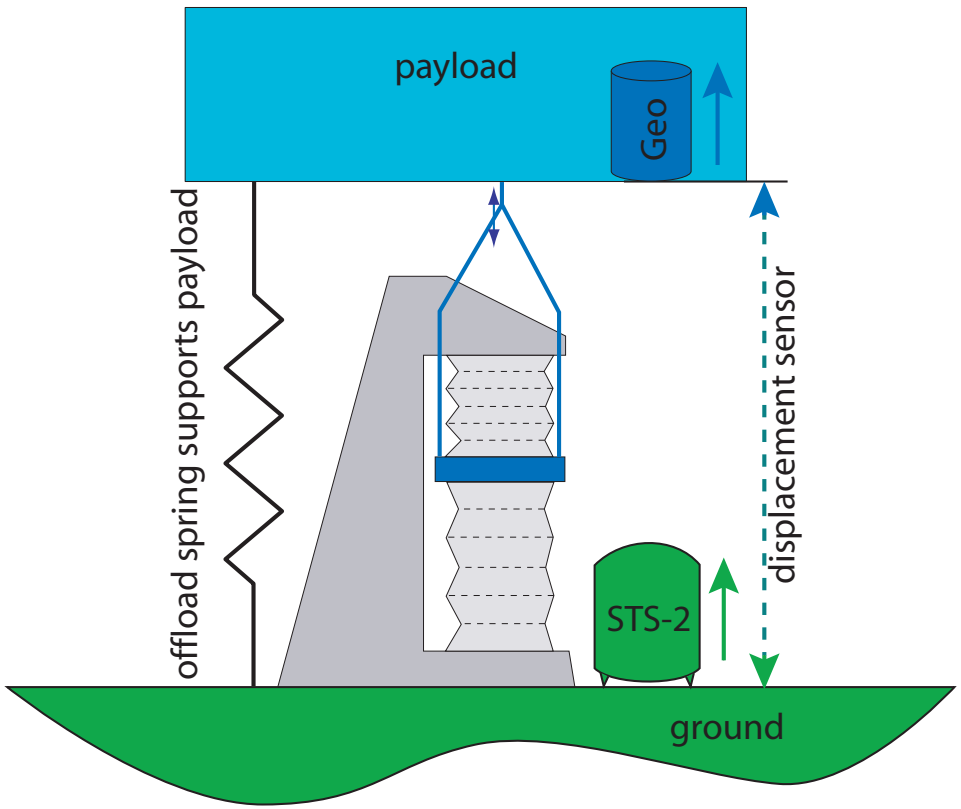
We can easily track the tidal motion.

Modifications the HAM simplify the installation and control.

LIGO engineers have been cranking out designs and drawings.

We are eager to begin installation after S3.

# How to maintain Alignment, and have Isolation from the Ground



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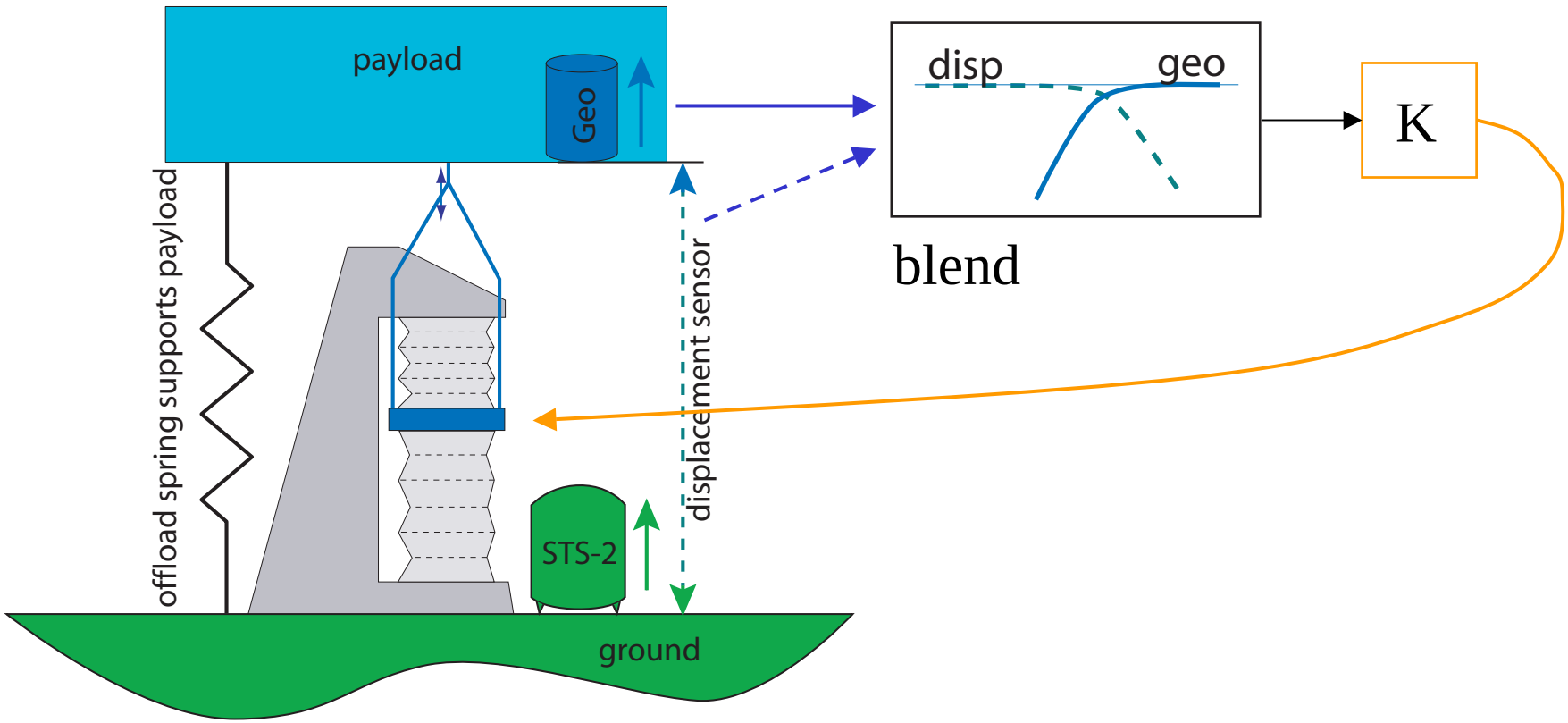

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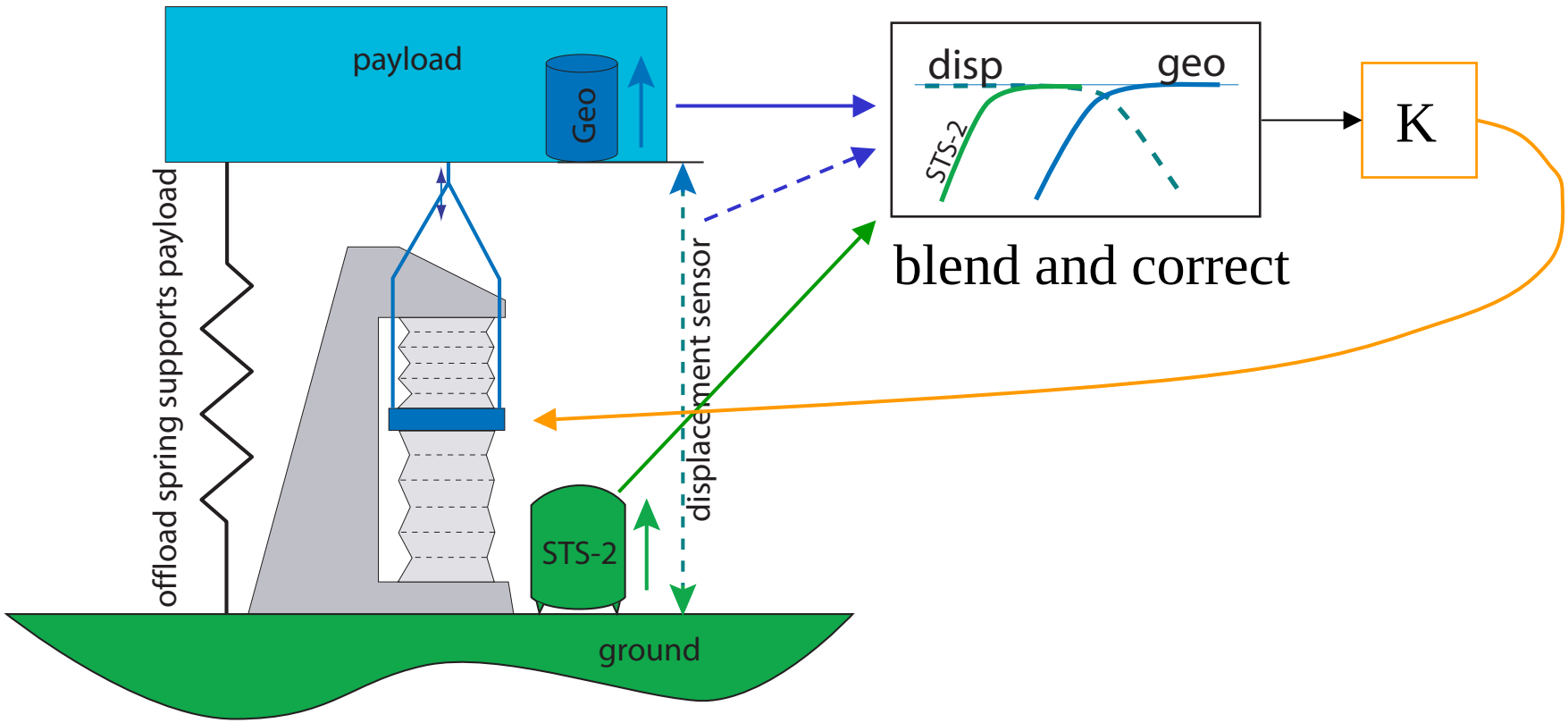


# Commissioning of the Electromagnetic System

Preliminary results

Bandwidth of 10 Hz

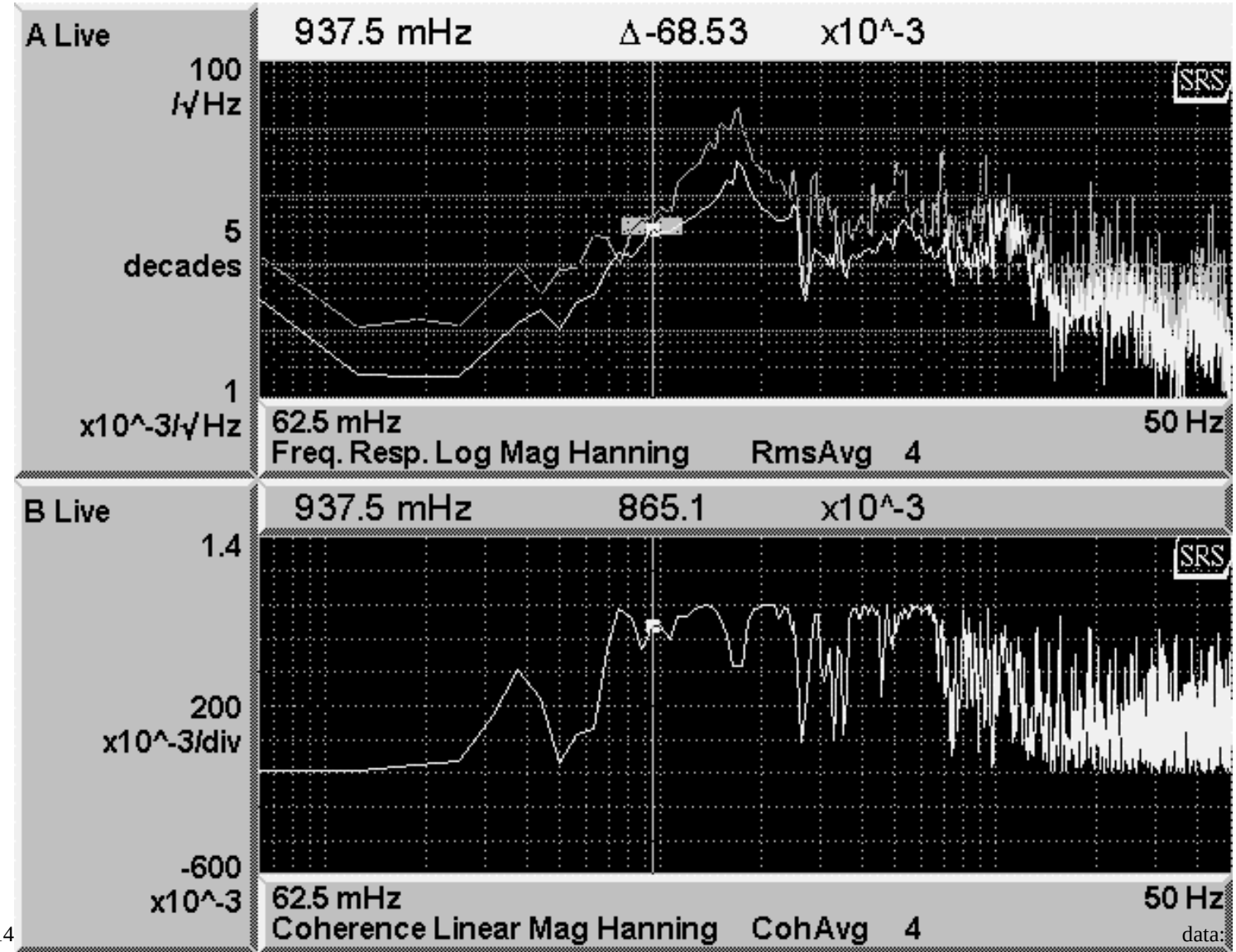
Blended sensors, using –
corrected displacement sensors, and
inertial feedback geophones,
blended at 0.5 – 0.7 Hz

Loops in the coordinate basis (x, y, z, pitch, roll, yaw, O.C.)

Close all 6 DOF

Reasonable isolation at target frequency

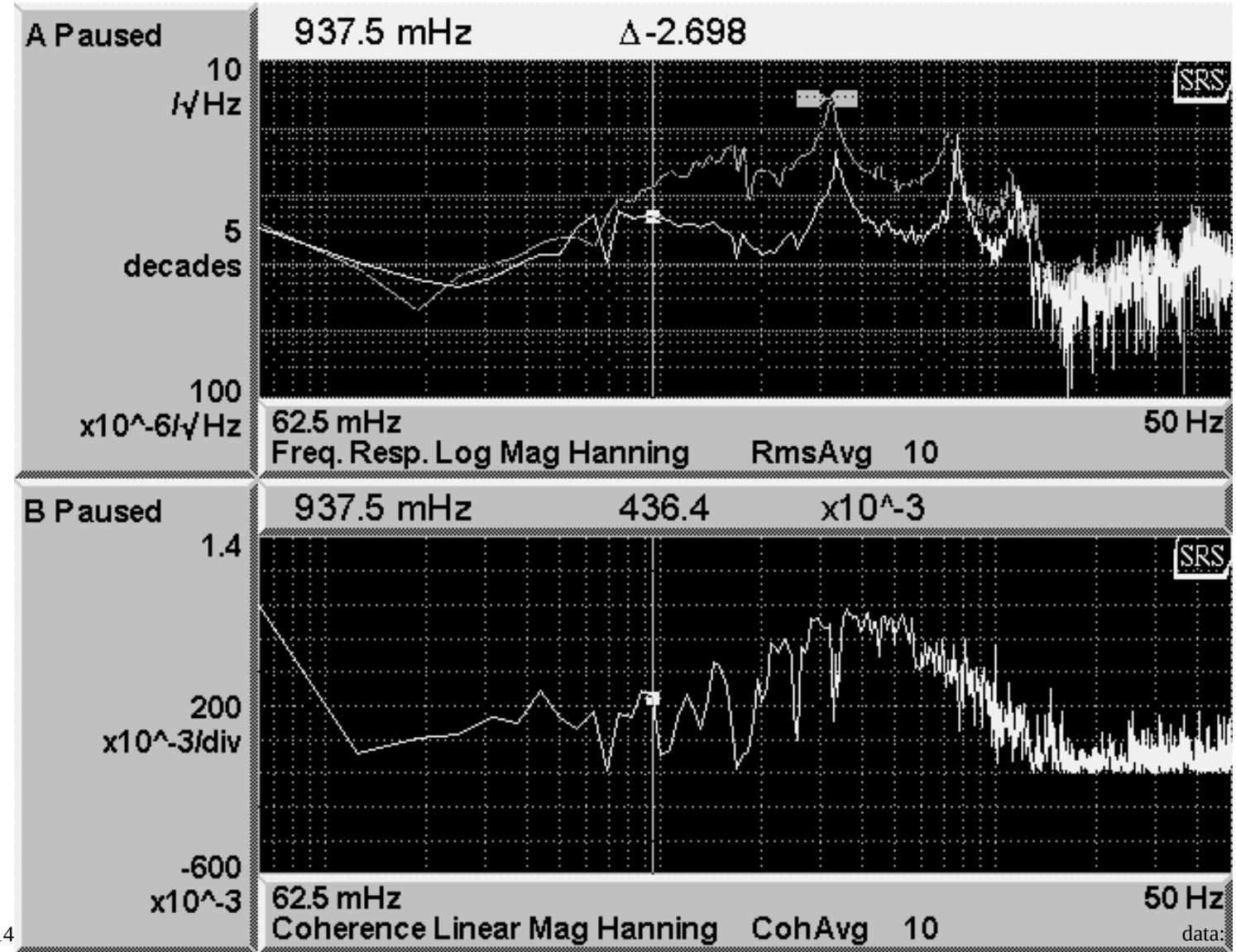
# Preliminary Performance in X Electromagnetic system on HAM






data: Dave Ottoway

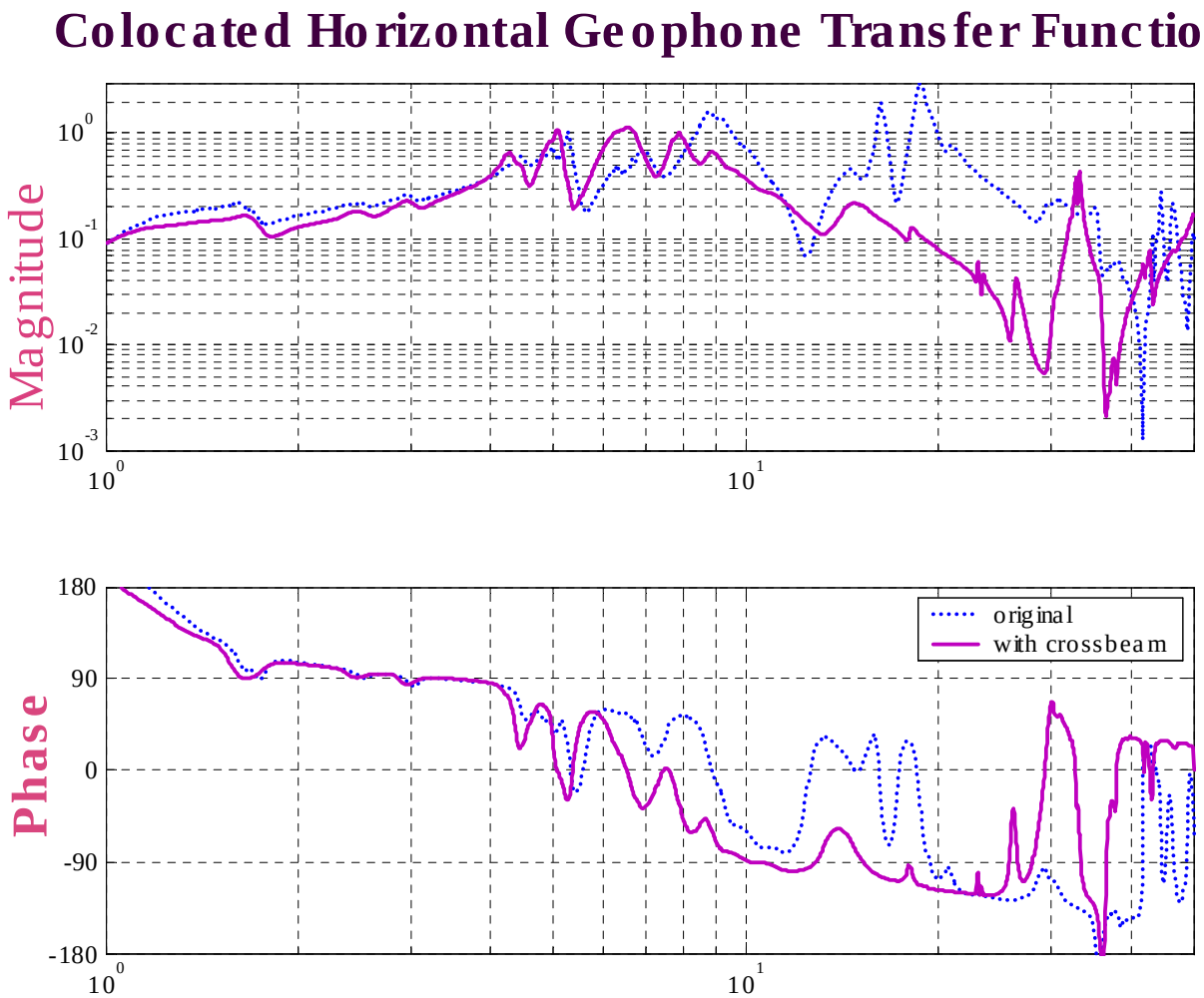
# Preliminary Performance in Z Electromagnetic system on HAM



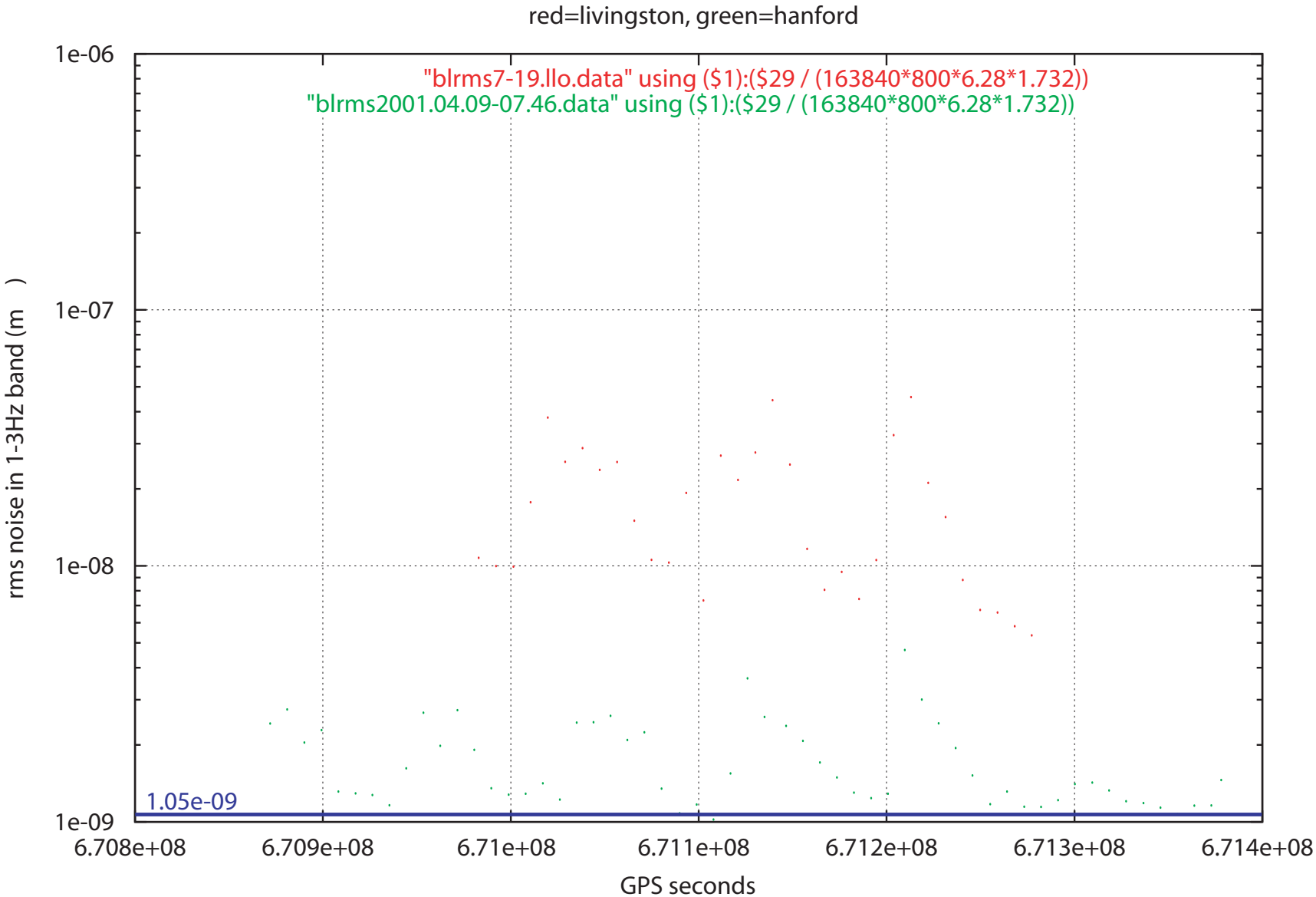



data: Dave Ottoway

# Improvement in the bending mode



# Comparison of the sites

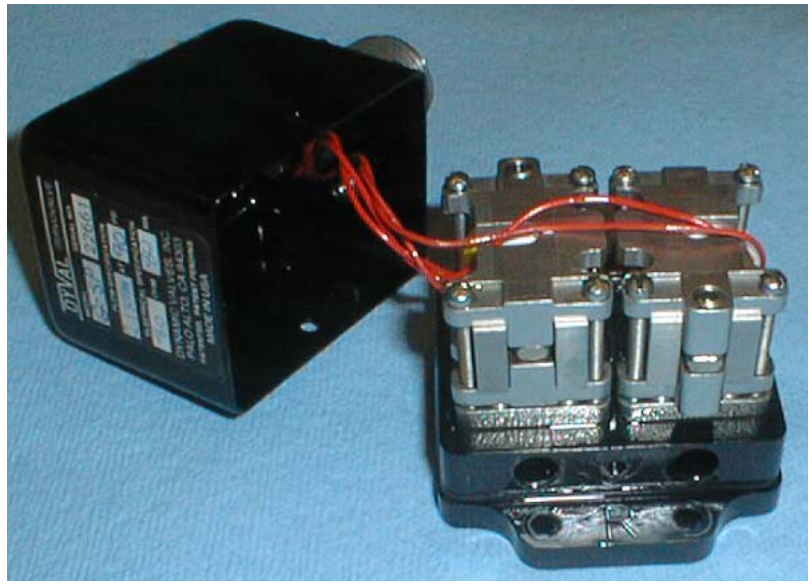


# Design Trades

| Parameter / Performance | Specification | | Design | | | | | Related Parameter | |
|---|---|---|---|---|---|---|---|---|---|
| | δ=1mm | Δt=10 sec | Ps=5 bar | β=2e3 bar | R = 5e10 Pa-sec/m$^3$ | A=.01 m$^2$ | V=3e-4 m$^3$ | m=1e3 kg | k=4e6 N/m |
| 1) Hydraulic Resonance $\omega_n^2 = \frac{2A^2\beta}{mV}$ ↑ | | | ↑ | ↑ | | ↑ | ↓ | ↓ | |
| 2) Damping $\zeta = \frac{1}{RA}\sqrt{\frac{m\beta}{2V}}$ ↑ | | | ↑ | ↑ | ↓ | ↓ | ↓ | ↑ | |
| 3) Bridge Power Dissipation $P_b = \frac{P_s^2}{R}$ ↓ | | | ↓ | | ↑ | | | | |
| 4) Acquisition Power $P_{acq} = \frac{k\delta^2}{\Delta t}$ ↓ | ↓ | ↑ | | | | | | | ↓ |
| 5) Microseism Power $P_\mu = k\delta\delta_s w_s$ ↓ | ↓ | | | | | | | | ↓ |
| 6) Microseism vs. Bridge $\frac{P_{acq}}{P_b} = \frac{k\delta\delta_s\omega_s R}{P_s^2}$ ↓ | ↓ | | ↑ | | ↓ | | | | ↓ |
| 7) Microseism vs. Acquisition $\frac{P_\mu}{P_{acq}} = \frac{\delta_s\omega_s\Delta t}{\delta}$ ↓ | ↑ | ↓ | | | | | | | |

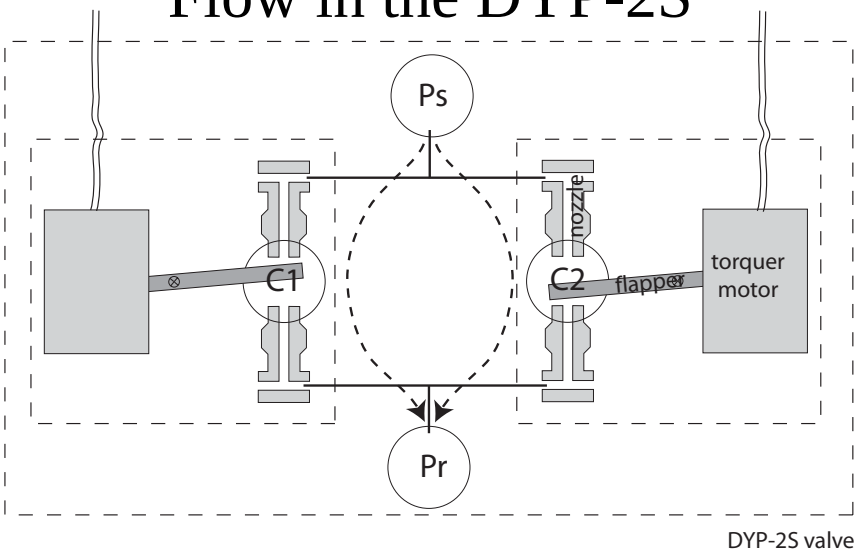
# Hydraulic Valve forms the bridge

- Differential bridge in a single valve body
- 4 nozzles – one for each resistor in the bridge
- Original nozzles replaced with custom units shown below right.



Parker DYP-2S valve

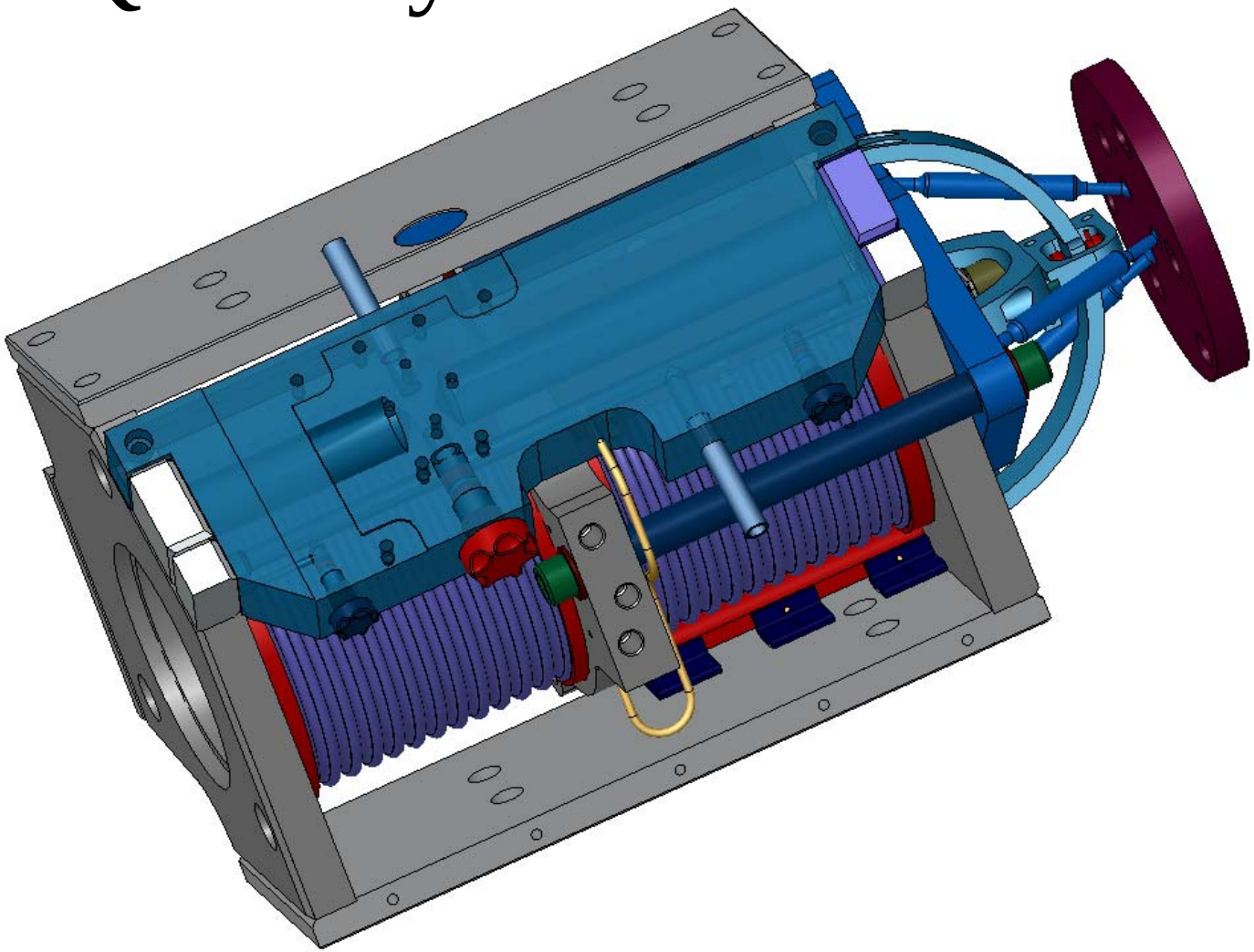
## Flow in the DYP-2S



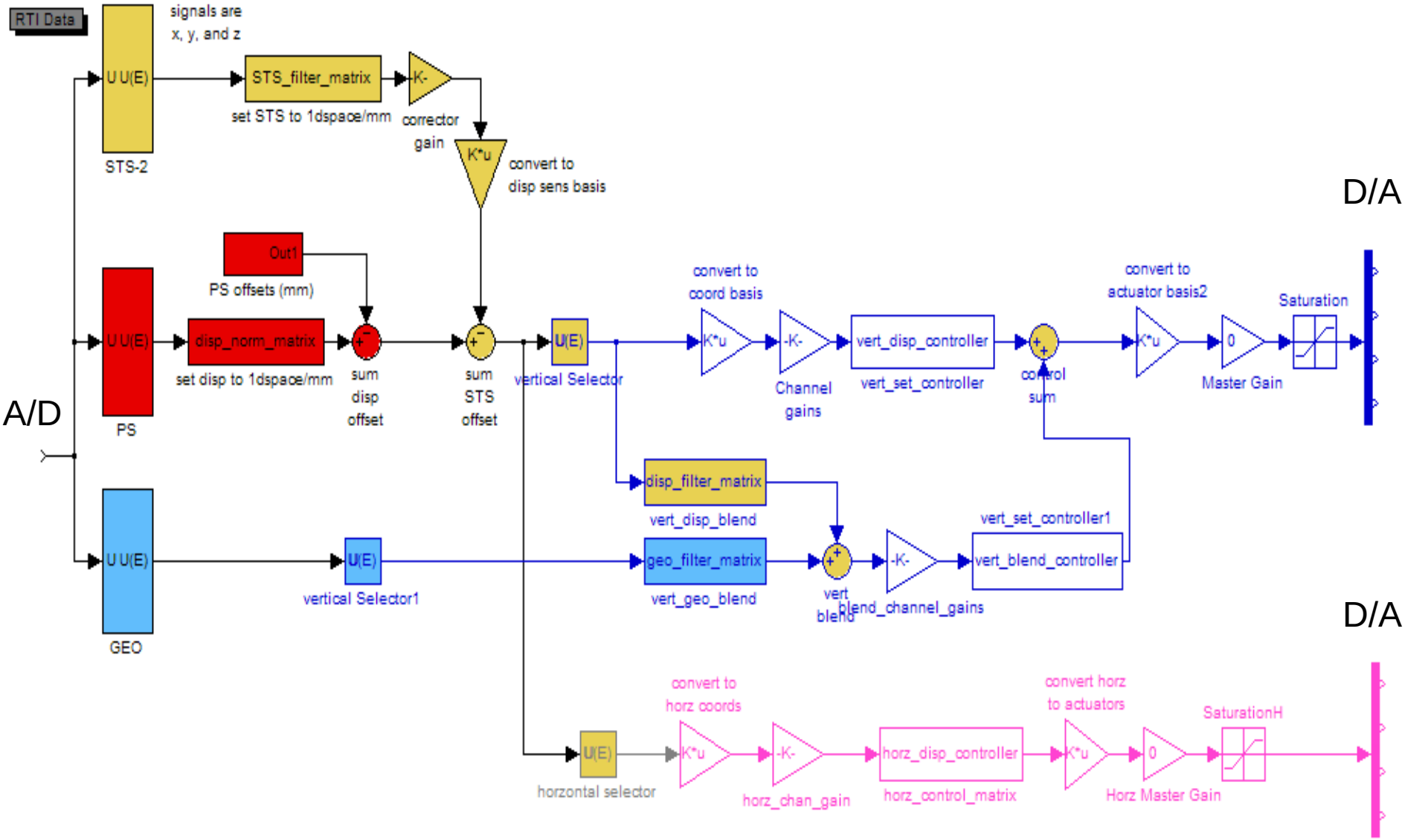

DYP-2S valve

## The new nozzle

# Quiet Hydraulic Actuator



# Controller

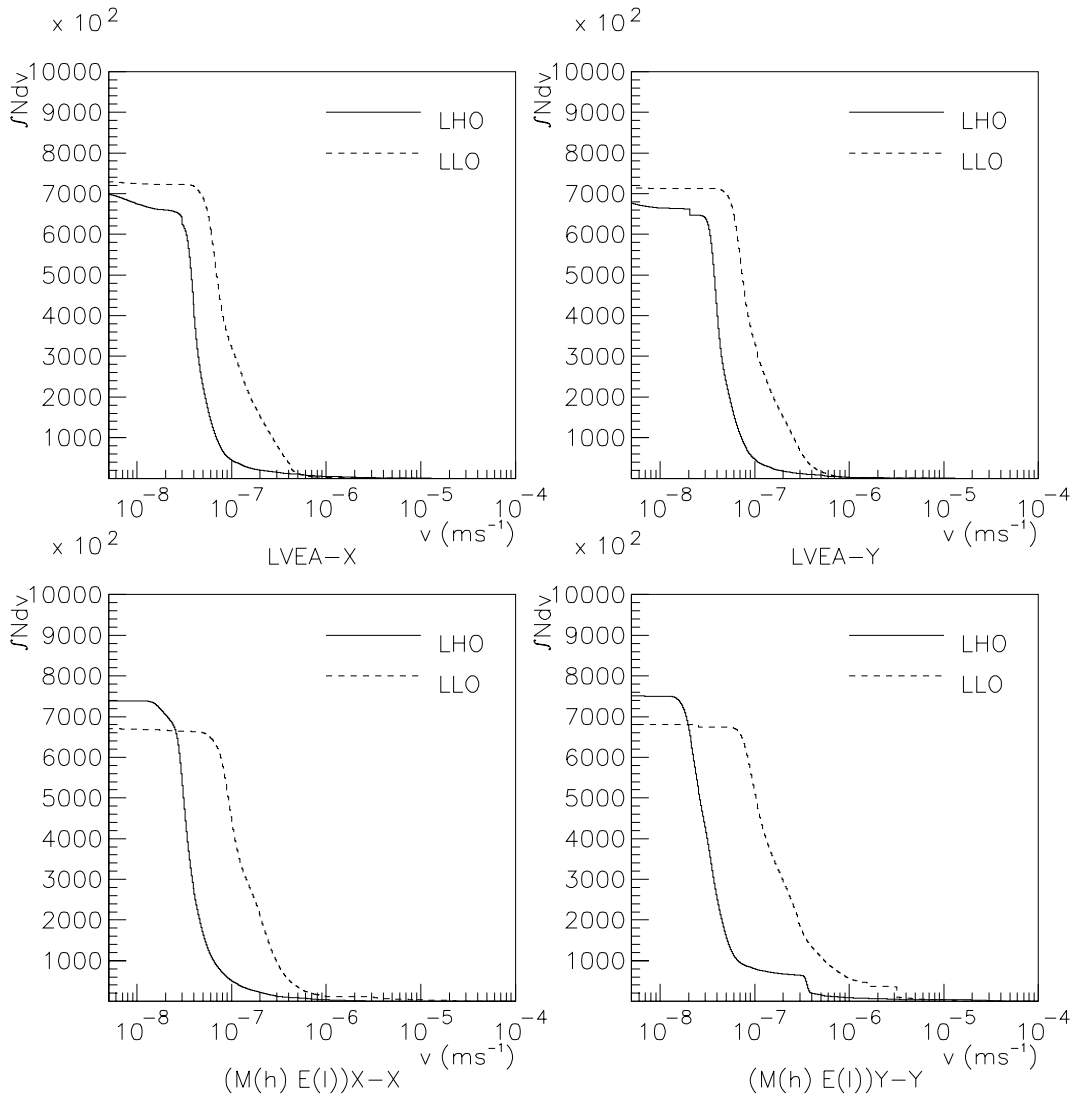

RTI Data
signals are
x, y, and z
U U(E)
STS-2
STS_filter_matrix
set STS to 1dspace/mm
K-
corrector
gain
K*u
convert to
disp sens basis
D/A
Out1
PS offsets (mm)
U U(E)
PS
disp_norm_matrix
set disp to 1dspace/mm
sum
disp
offset
sum
STS
offset
U(E)
vertical Selector
convert to
coord basis
K*u
-K-
Channel
gains
vert_disp_controller
vert_set_controller
control
sum
convert to
actuator basis2
K*u
0
Master Gain
Saturation
A/D
disp_filter_matrix
vert_disp_blend
vert_set_controller1
U U(E)
GEO
U(E)
vertical Selector1
geo_filter_matrix
vert_geo_blend
vert
blend
-K-
blend_channel_gains
vert_blend_controller
D/A
convert to
horz coords
U(E)
horzontal selector
K*u
-K-
horz_chan_gain
horz_disp_controller
horz_control_matrix
convert horz
to actuators
K*u
0
Horz Master Gain
SaturationH

# Histograms of the ground motion

2 years of data compiled by Ed Daw
1-3 Hz BLrms monitor

We appear to need a factor of 10 isolation in the 1-3 Hz band.

Many caveats to this, please see Ed's talk tomorrow at 10 in D.C.



# Program Overview

- Ground motion issues:
  - @ LLO
    - Steady-state ambient noise is higher due to anthropogenic sources; Transients, particularly from logging.
    - Impossible to hold the interferometers locked reliably during the day.
  - @ LHO
    - Wind induced seismic noise at LHO exceeds locking threshold at ~25 mph, or 10% of the time
    - Expect that up-conversion is a problem at significantly lower wind speeds & a large fraction of the time
- External Pre-Isolation (EPI) Upgrade is required to allow both reliable locking and to allow better noise performance while locked
  - Prototype testing at LASTI facility has demonstrated 10x reduction in 0.5 to ~2.5 Hz band (compared to 15x reduction requirement in the 1-3 Hz band); testing and optimization continues
  - Design review scheduled for ~4/18
  - Earliest installation start is Oct with completion ~Jan
  - To date have focused on LLO (more acute) problem; Plan to install PEPI systems at LHO for wind noise needs more evaluation.