Status of LIGO

June 22, 2015

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(on behalf of the LIGO Scientific Collaboration)

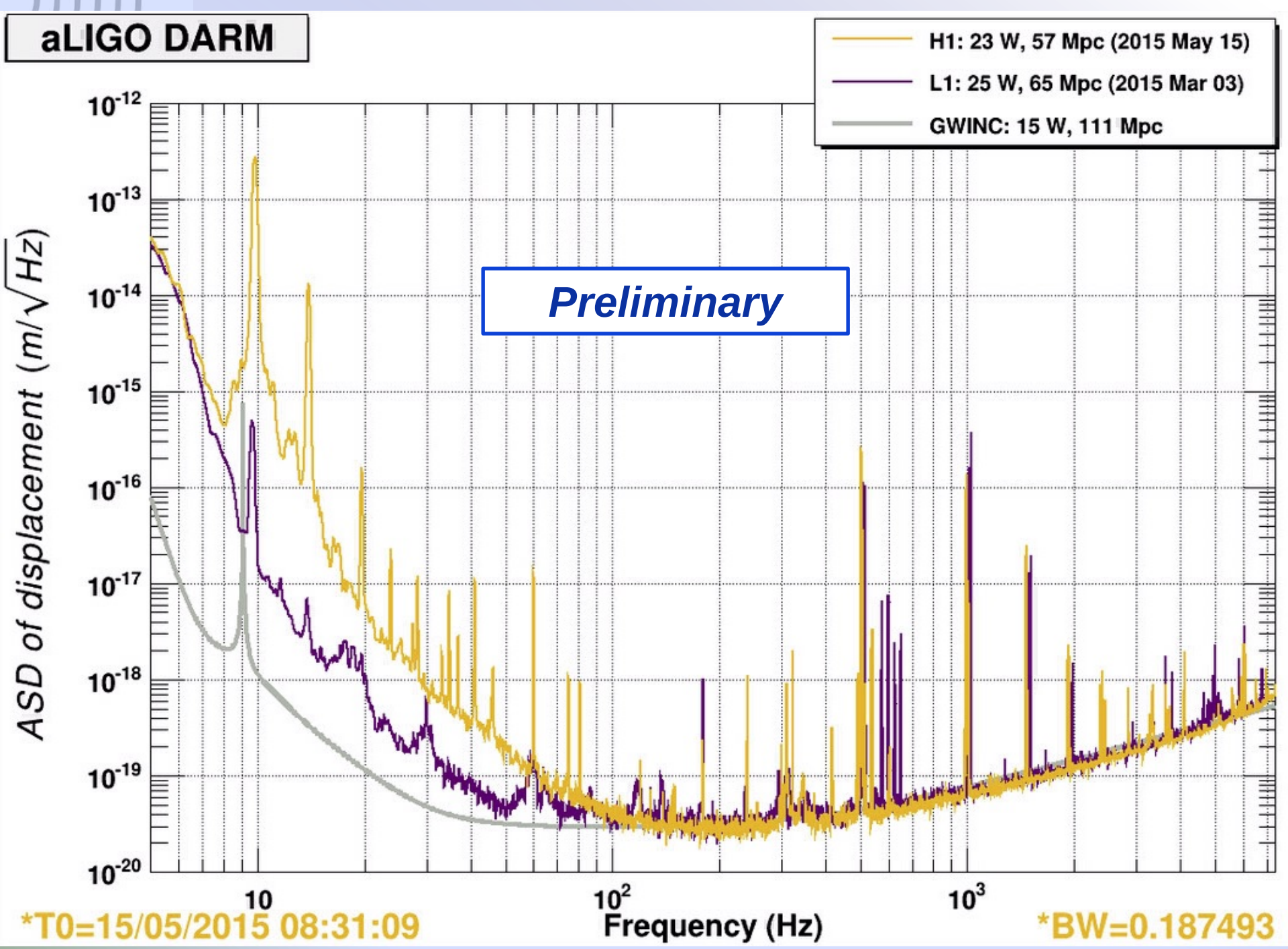
LIGO

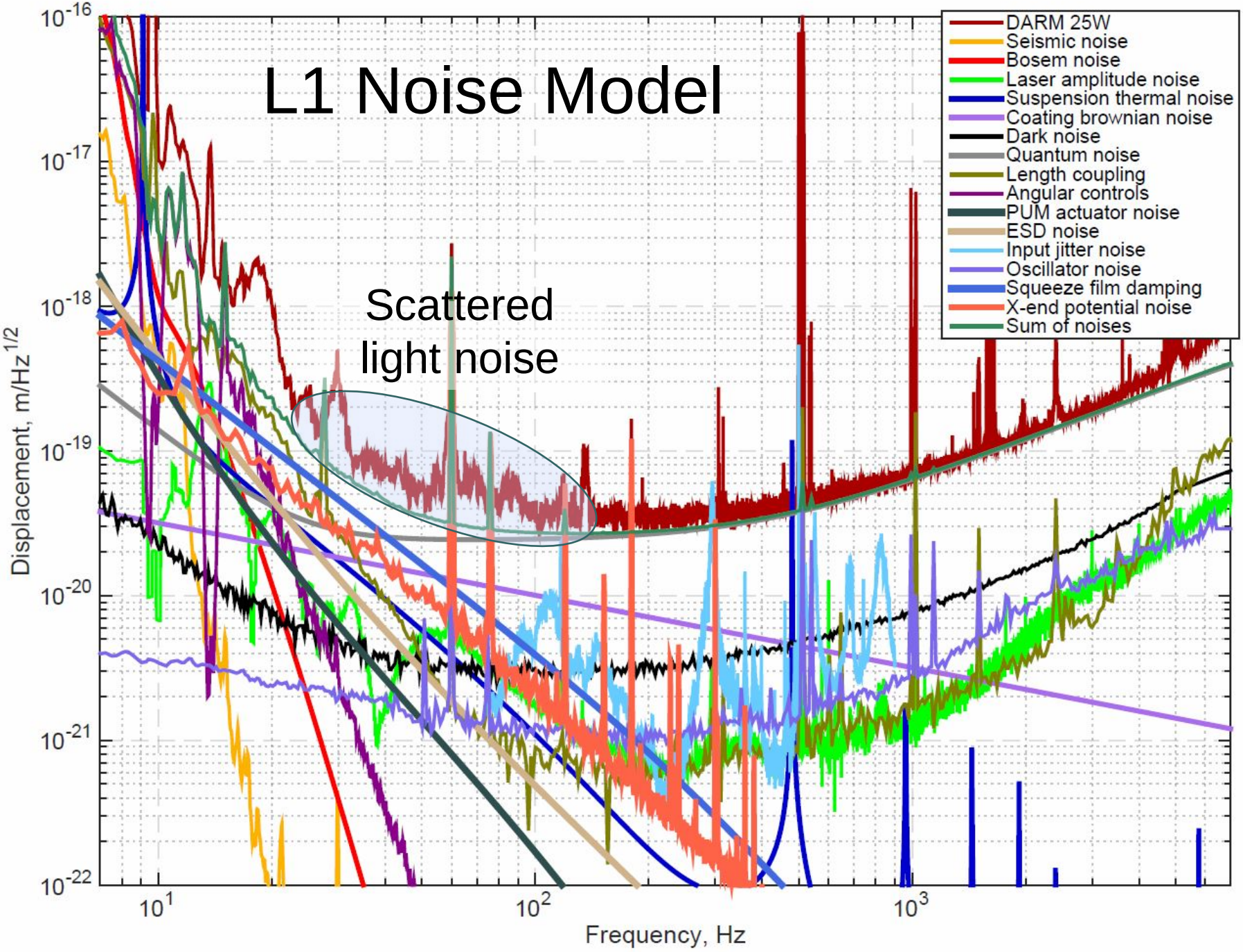
Highlights

- Robust Locking Achieved
  - Livingston Observatory: First lock on May 27, 2014
  - Hanford Observatory: First lock on February 7, 2015
- Sensitivity of initial detectors surpassed quickly
  - Current inspiral range: 50 to 70 Mpc
- ER7 completed
  - 40 hours of coincident data
- Preparing for O1: September to December
- Issues:
  - High Q Resonances and Uncontrolled DOFs
  - ESD Charging Issues
  - Parametric Instabilities

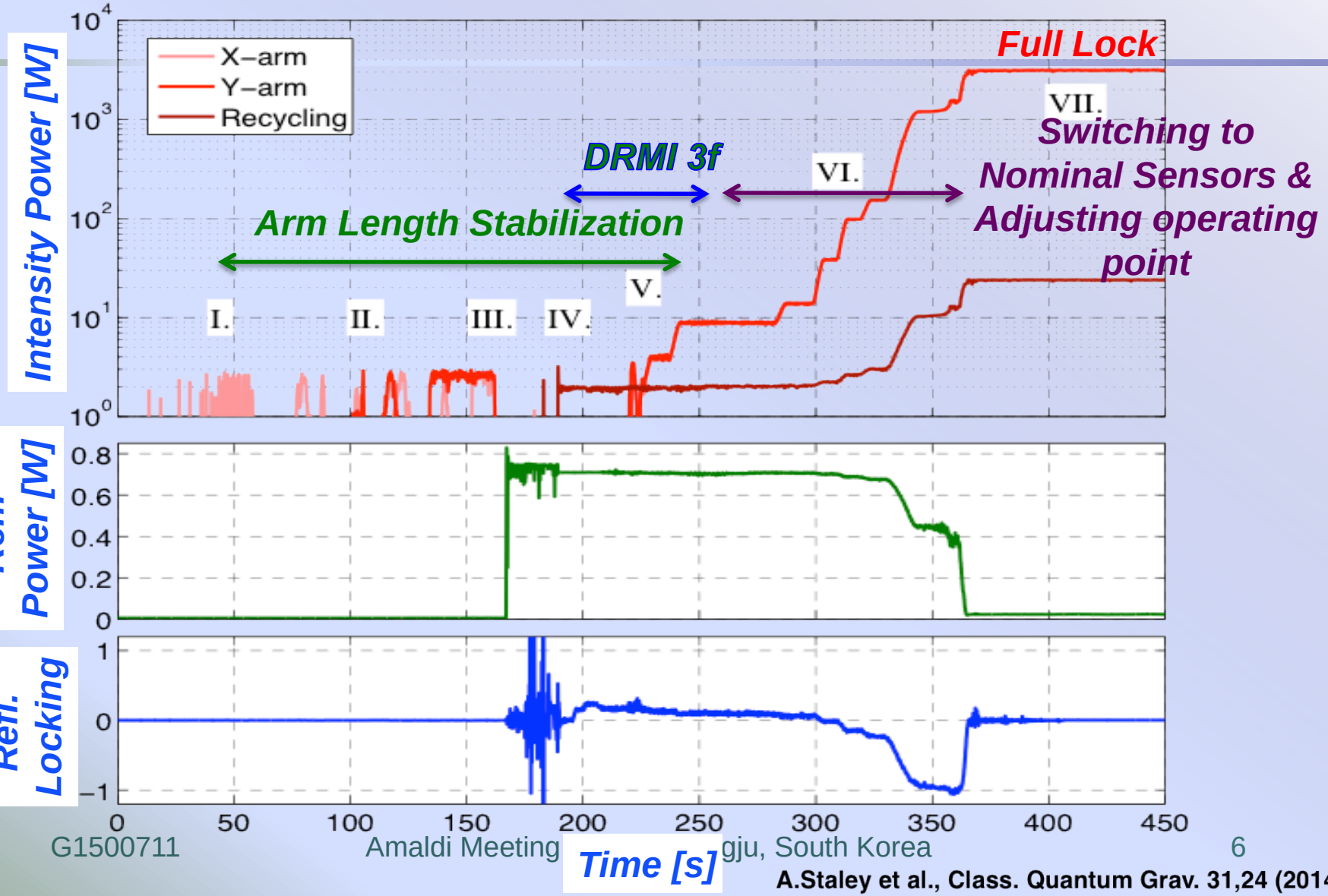
Progress


aLIGO Commissioning Progress
Inspiral Range, Mpc
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
Days since start of commissioning
LLO
LHO
O1-lower
O1-upper


aLIGO DARM
H1: 23 W, 57 Mpc (2015 May 15)
L1: 25 W, 65 Mpc (2015 Mar 03)
GWINC: 15 W, 111 Mpc
Preliminary
ASD of displacement (m/√Hz)
10^-12
10^-13
10^-14
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10
10^2
10^3
Frequency (Hz)
*T0=15/05/2015 08:31:09
*BW=0.187493


L1 Noise Model
Scattered light noise
DARM 25W
Seismic noise
Bosem noise
Laser amplitude noise
Suspension thermal noise
Coating brownian noise
Dark noise
Quantum noise
Length coupling
Angular controls
PUM actuator noise
ESD noise
Input jitter noise
Oscillator noise
Squeeze film damping
X-end potential noise
Sum of noises
Displacement, m/Hz^1/2
Frequency, Hz
10^-16
10^-17
10^-18
10^-19
10^-20
10^-21
10^-22
10^1
10^2
10^3

Locking



A.Staley et al., Class. Quantum Grav. 31,24 (2014)

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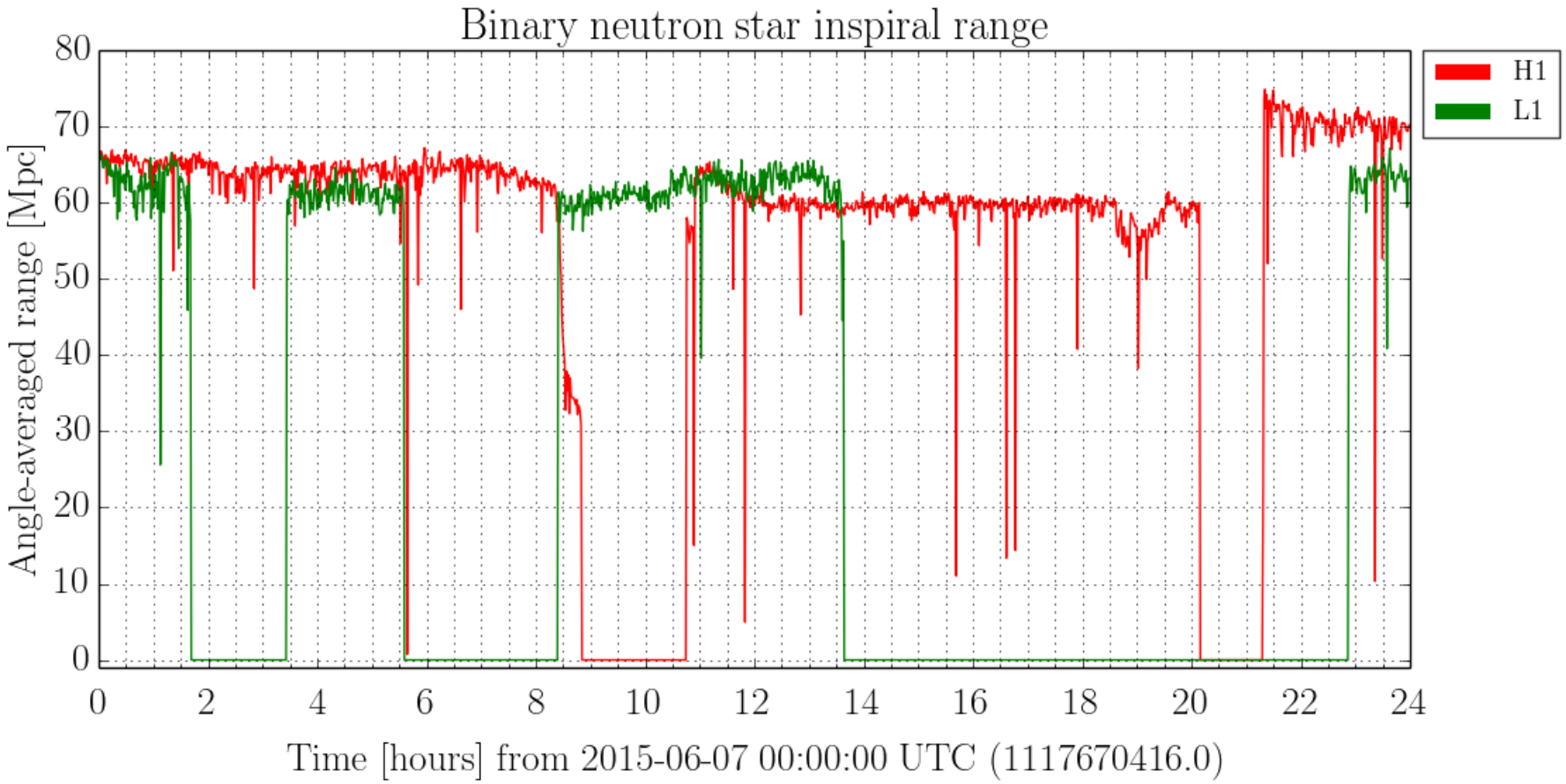
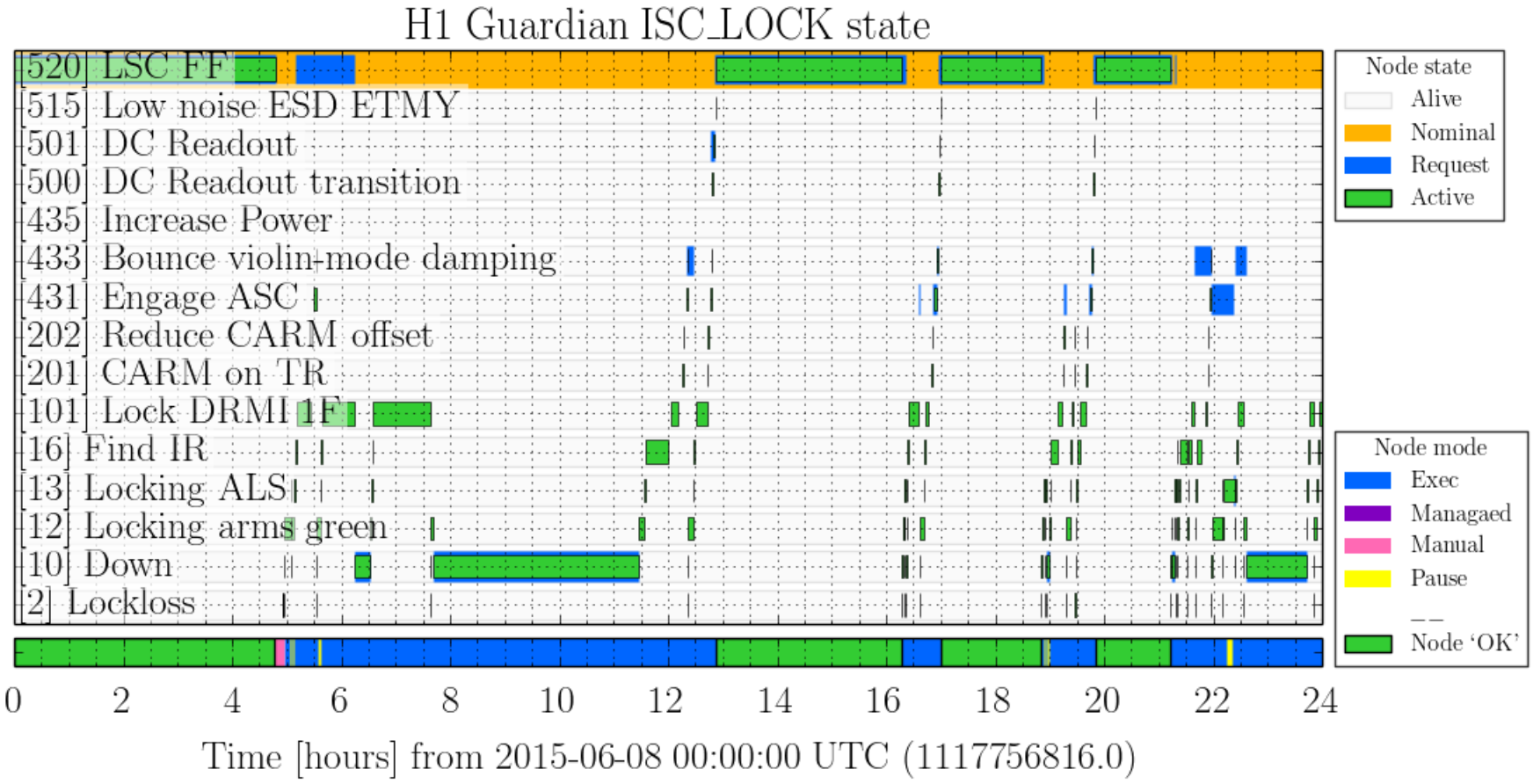
7th Engineering Run

- May 16 to June 14, 2015
- First coincidence data between L1 and H1
- Test of the analysis pipeline
- H1 110 hours, L1 74 hours, 42 hours of coincidence (as of June 11)
- Successfully completed
  - Calibrated strain readout
  - Sufficient automation to be controllable by operators
  - Hardware injections
    Blind Injections Implementation and Testing
  - Approximately 7 days of data taking

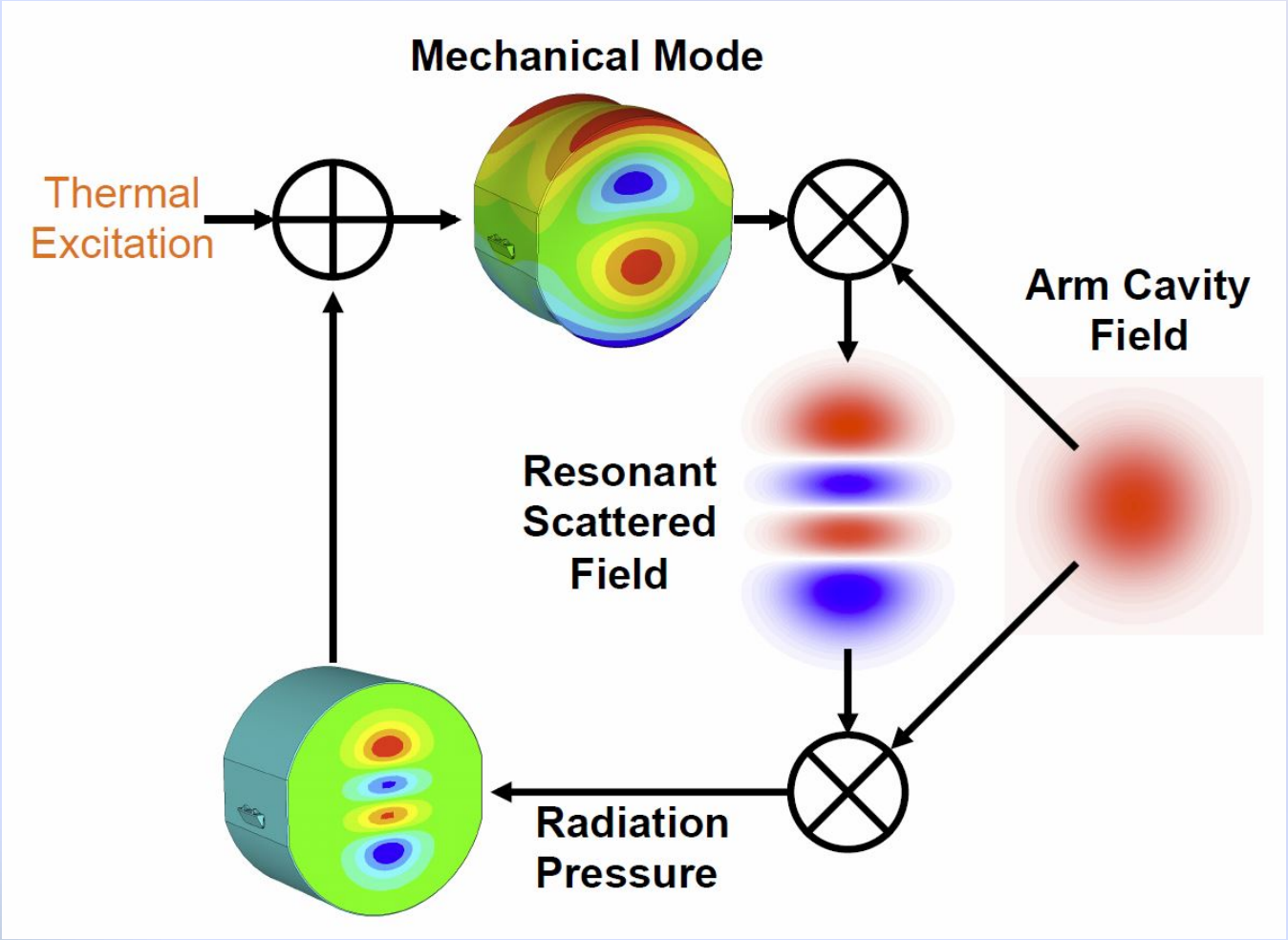
Binary Neutron Star Range (SNR 8, 1.4$M_\odot$, sky average)



ER7 Segments (24 hours)

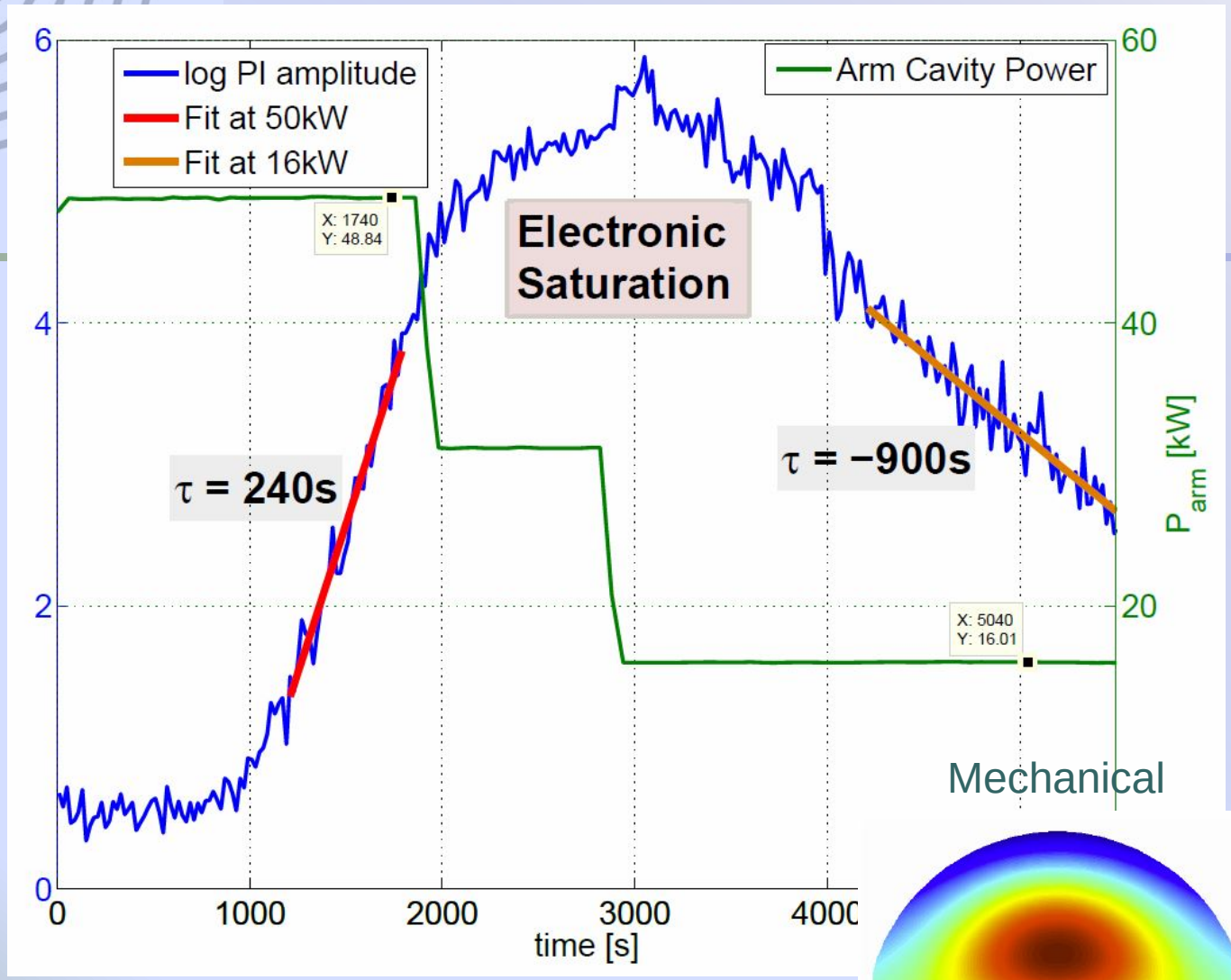


Parametric Instabilities



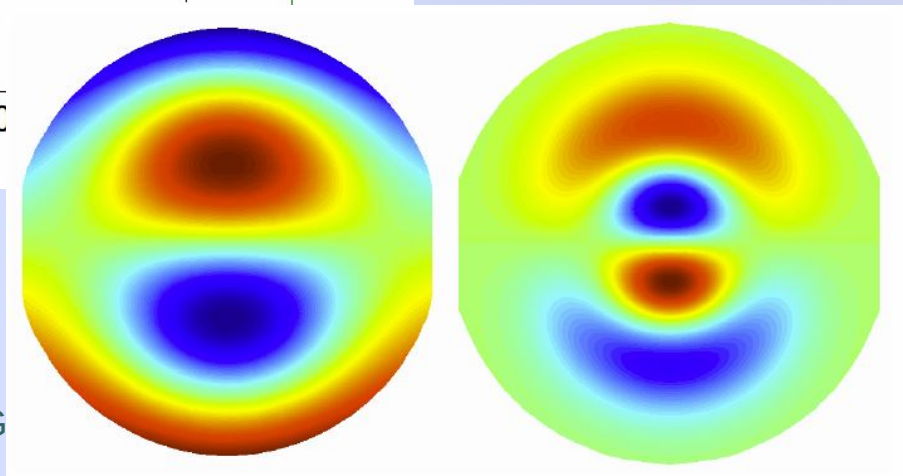
Evans et al., Phys. Rev. Lett. 114, 161102 (2015)

Parametric Instabilities (3)

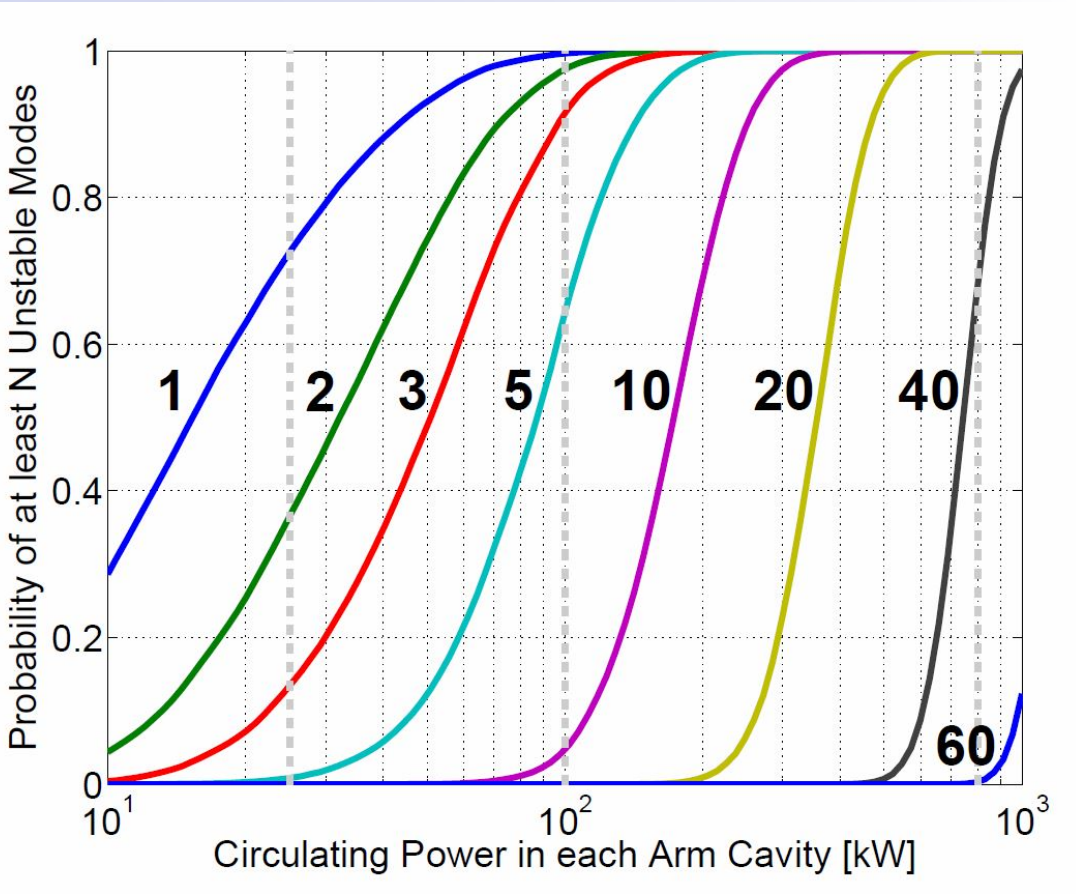


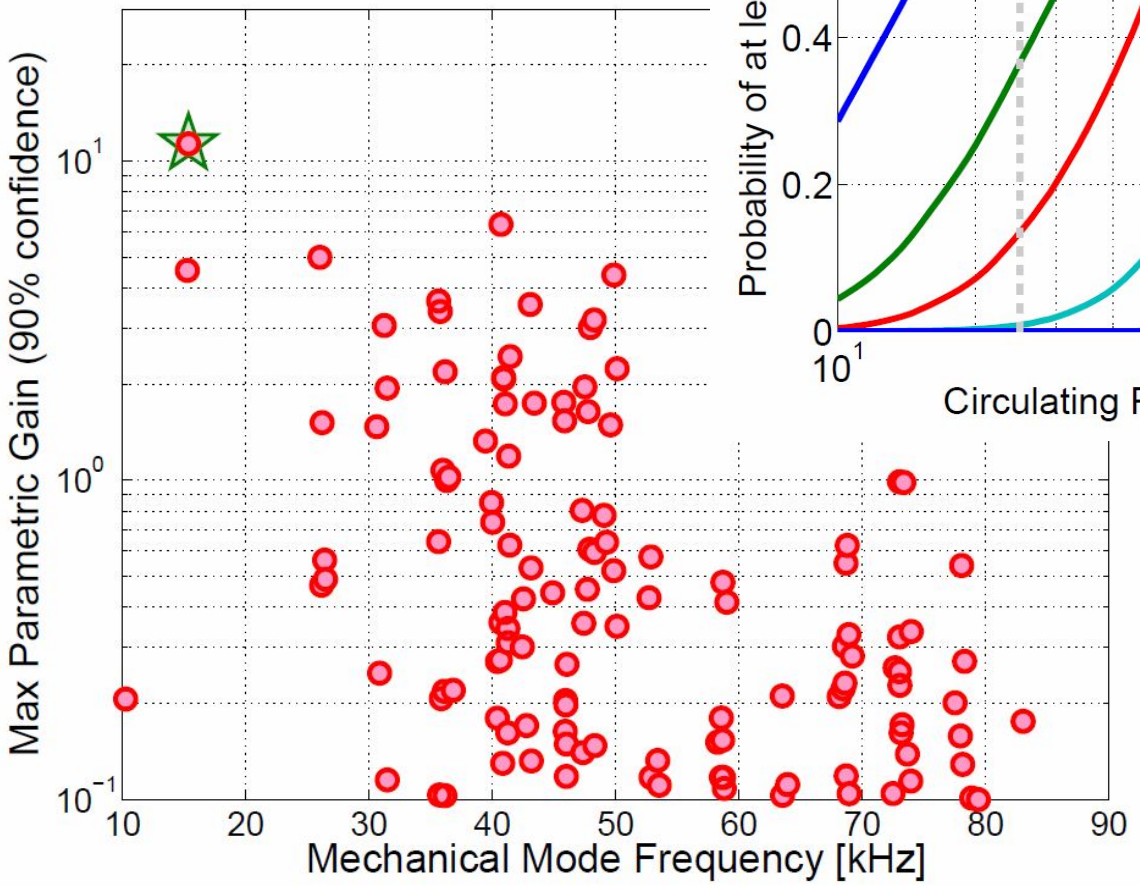
Mechanical

Optical



Parametric Instabilities (2)





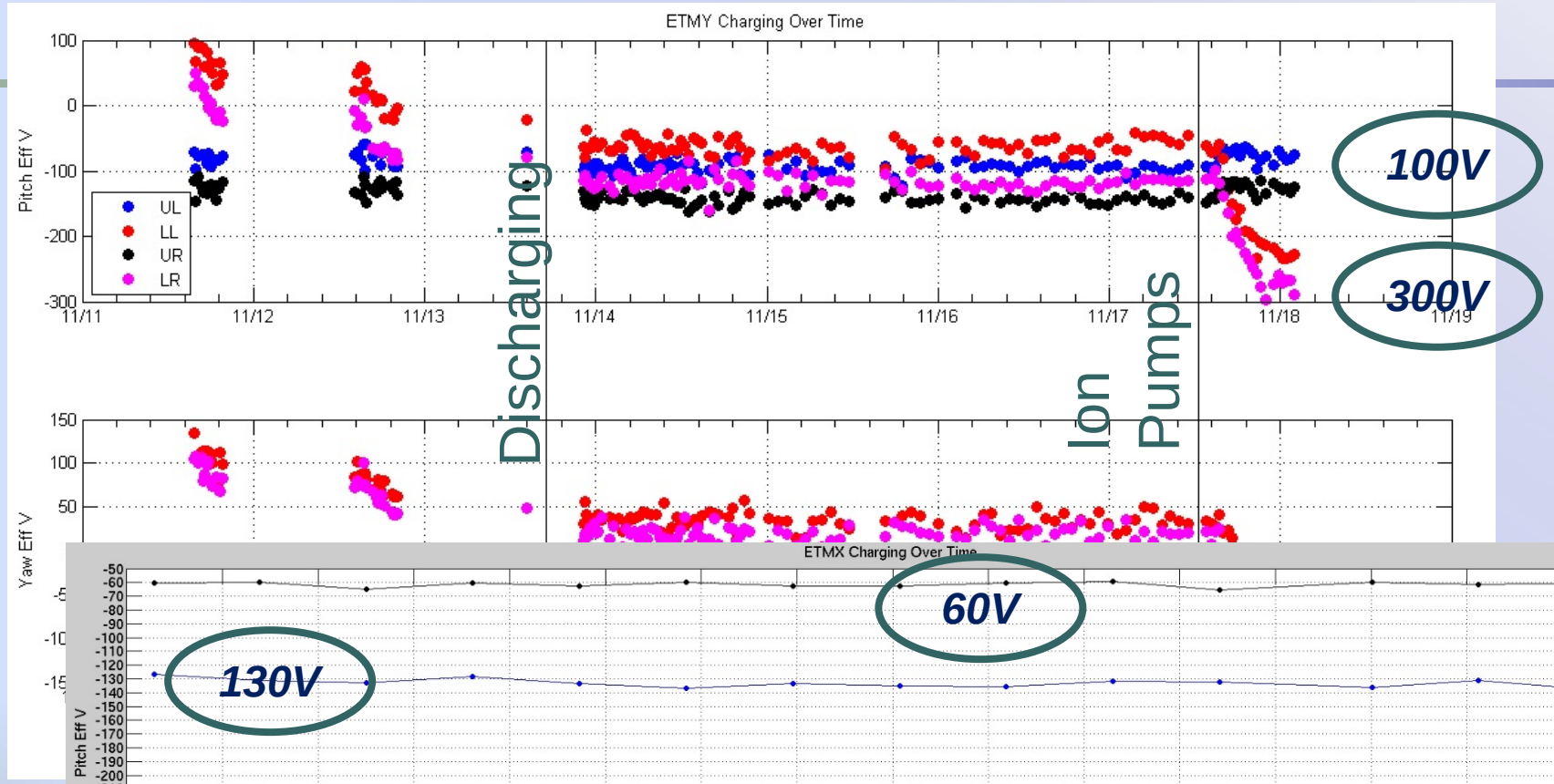
Number of Unstable Modes Depends on ROC

Thermal control of ROC can work for small N

High Power Operations

- With 25W input power
  - No significant thermal loading
  - Parametric instabilities mitigated with ETM ring heater
  - Angular instabilities under control
- At higher powers
  - Hartmann wavefront sensors to map ITMs
  - Ring heaters for ITMs and ETMs
  - CO_2 laser heating for ITM compensation plates
  - Active damping control for parametric instabilities
  - Testing a passive mode damper (shunted piezo-electric transducer)
  - Angular instabilities require more control bandwidth (induces noise)

Electro Static Drive

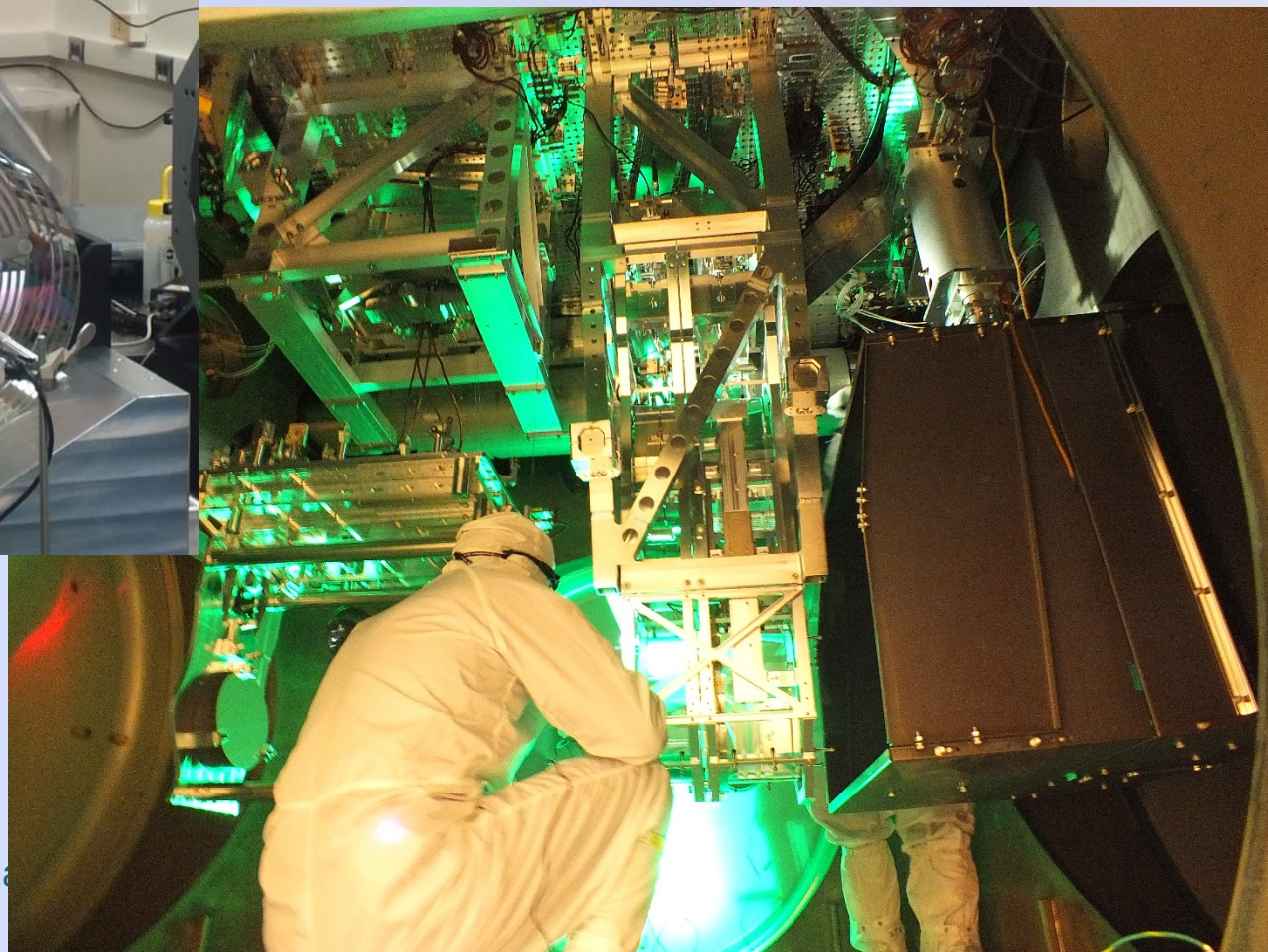


4 hours

Electro Static Drive (2)

- Why so much charge? Can be 100s of Volts
  - First contact leaves a charge behind
  - Charge variation appears to be caused by ultraviolet light emitted by ion pumps mounted at the test mass chambers (recharging)
- Additional Noise and Uncertainty
  - Field lines must terminate somewhere (e.g. ring heater)
  - Drive strength depends on charge, adds a linear term
  - Charge is not uniform and varying
- In-vacuum ion injecting did not fix the problem
  - Hard to reach the back surface
- In-air, in-situ neutralization procedure
  - Test mass stays discharged (without an ion pump)

Test Mass Discharging



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Summary

- Sensitivity of initial detectors surpassed quickly
- Robust locking achieved
- Parametric instabilities are real; need to be dealt with
- Test mass charge is a problem
  - Discharging effort underway
- Looking forward to the first observing run
- What's left?
  - High power operations: thermal control, PI, alignment instability
  - Low frequency noise hunting & controls optimization
  - Make the seismic system work during bad weather
  - Damping of high Q modes