

# Brief of the May 2006 LIGO

## Charging Event

LSC-Virgo Charging Workshop

M.I.T.

7/27/2007

G070572-00-R

Rupal S. Amin

Louisiana State University

LIGO Livingston Observatory

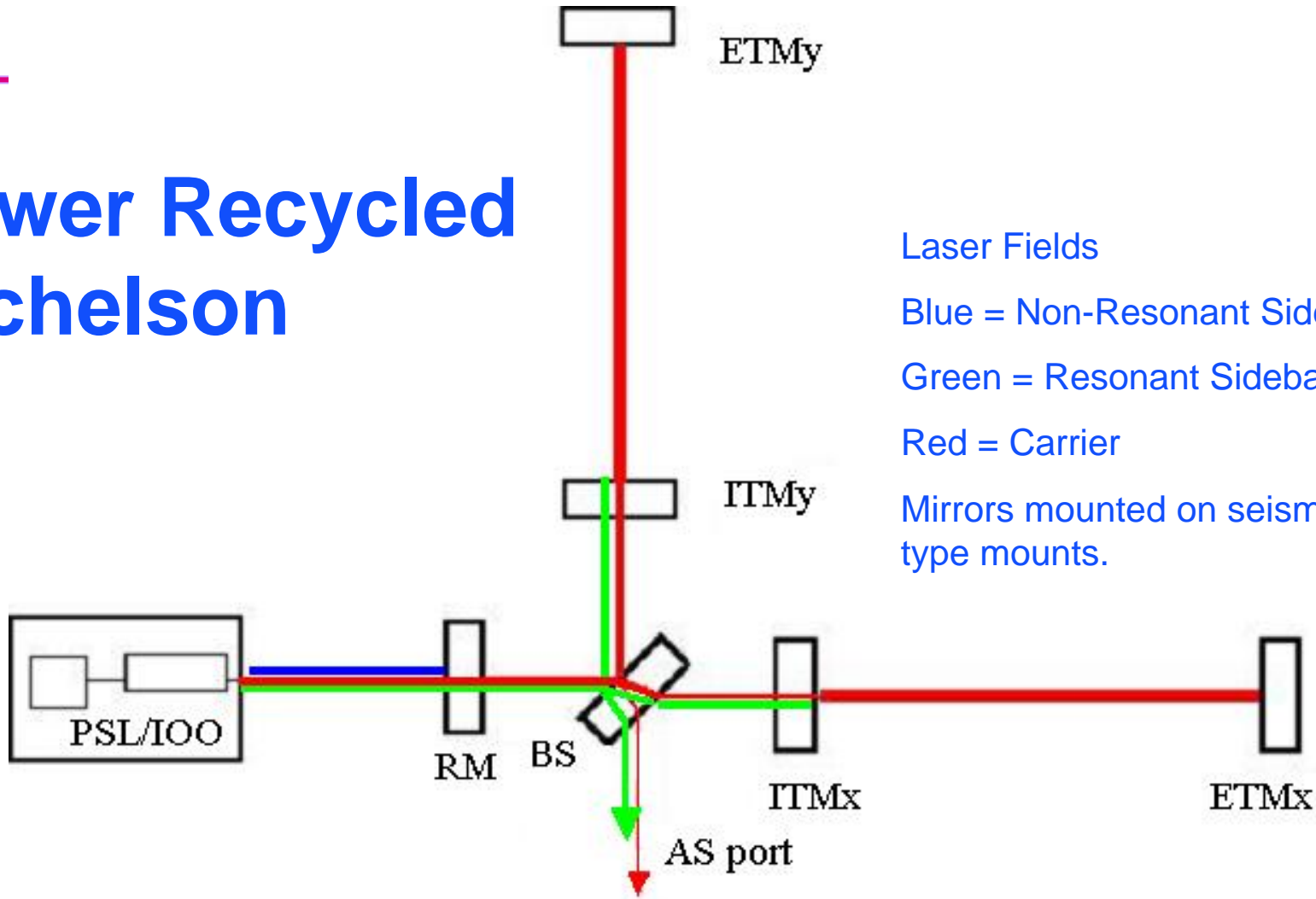
# Outline

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- LIGO Overview
- Suspensions
- Charging Noise Prediction/Observed
- Reason for Charging
- Possible Means of Monitoring/Discharging
- Summary

# Layout

## Power Recycled Michelson



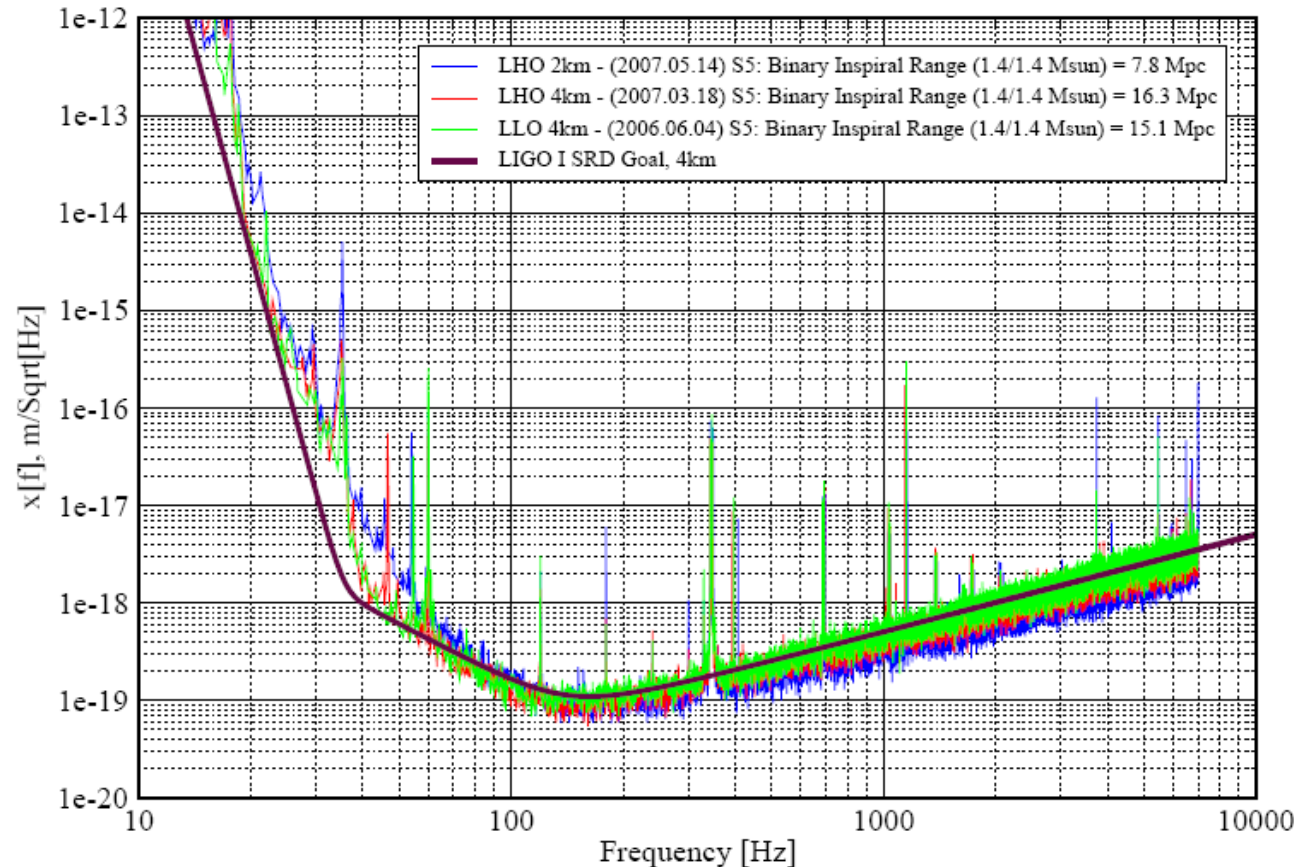
# LIGO

## Displacement Sensitivity

### Displacement Sensitivity of the LIGO Interferometers

Performance for S5 - May 2007

LIGO-G070367-00-E



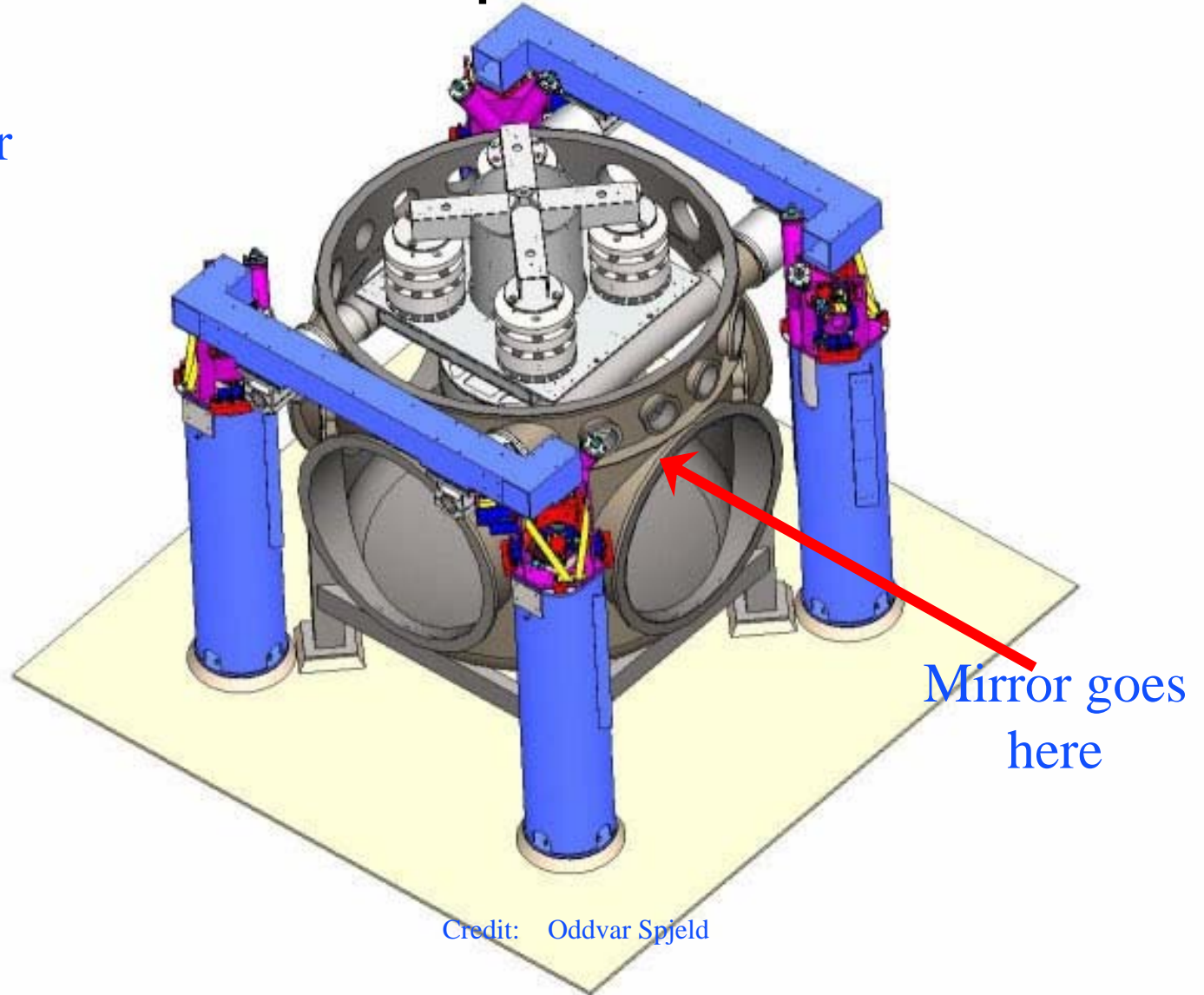
Displacement  
Sensitivity of LIGO  
Livingston and  
Hanford  
Observatories.

Best sensitivity at  
~150 Hz of ~ $10^{-19}$   
m/sqrt(Hz)

# Suspensions

BSC Chamber

Isometric drawing of external suspension



# Suspensions

Pendulum suspension

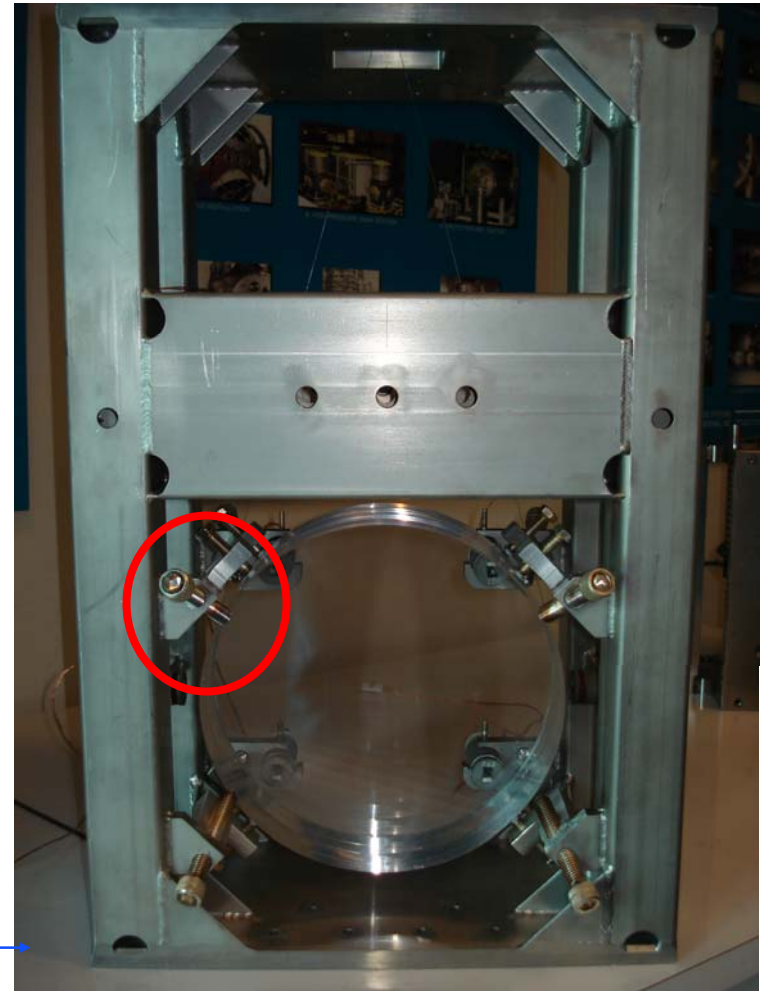
Steel Piano Wires

Steel Cage

Earthquake Stops

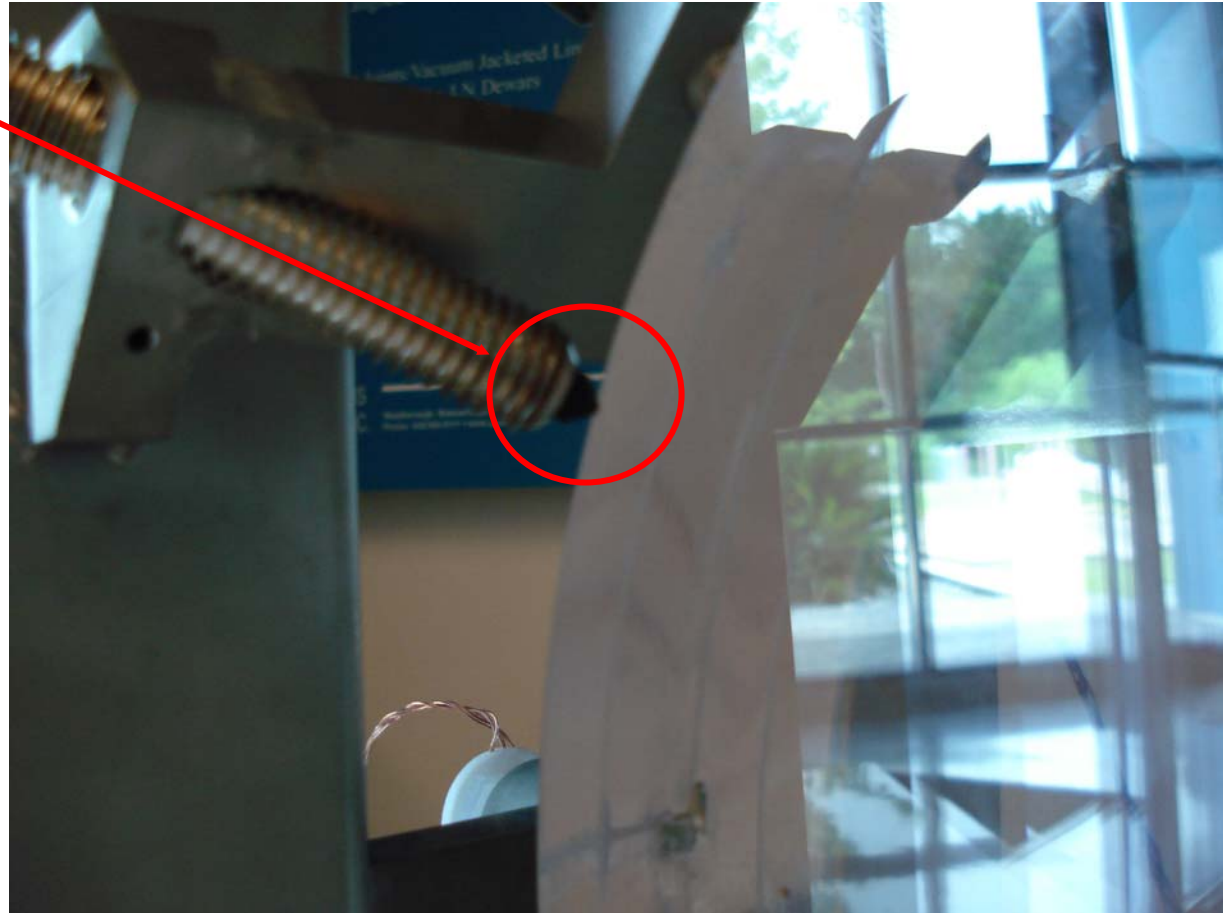
1/2x13 stainless steel  
silverplated SHCS screws  
with viton ends

Demonstration piece in LLO  
multipurpose room



# Suspensions Earthquake Stops

- Current Earthquake stops have viton tips
- Heterogeneous materials → charge transfer
- Stops set ~1 mm away from optic





# Suspensions Earthquake Stops

Contacted ITMy  
earthquake stop

Upper left stops

Credit: G. Traylor May 5, 2006





# Charge Induced Noise

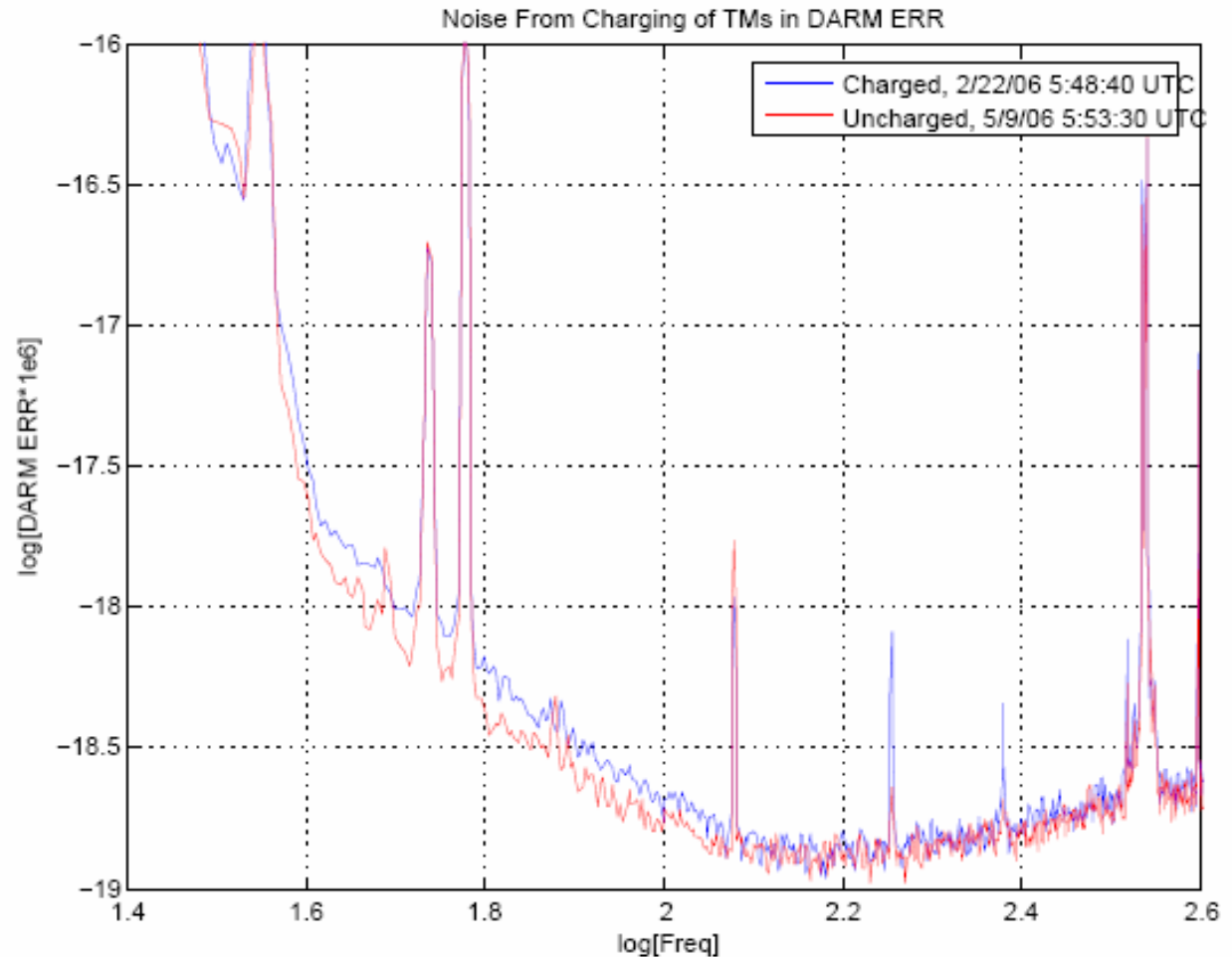
- From a note from R. Weiss May 10, 2006 i-log
- Charging noise trend follows  $f^{-3}$
- Possible to transfer charge to a test mass by contacting earthquake stops, friction, cosmic rays, dust/residual gas
  
- Personal communique from G.Traylor
- ITMy most likely was contacting viton stops following HEPI spring adjustment. (friction/work function charging?)
  
- [http://ilog.ligo-la.caltech.edu/ilog/pub/ilog.cgi?group=detector&date\\_to\\_view=05/10/2006&anchor\\_to\\_scroll\\_to=2006:05:10:09:41:18-RaiW](http://ilog.ligo-la.caltech.edu/ilog/pub/ilog.cgi?group=detector&date_to_view=05/10/2006&anchor_to_scroll_to=2006:05:10:09:41:18-RaiW)

# DARM spectrum Before/After May 2006 Vent

DARM Error spectrum plotted prior to ITMy sticking and following the vent to free ITMy

Difference visible between ~40 and 100 Hz

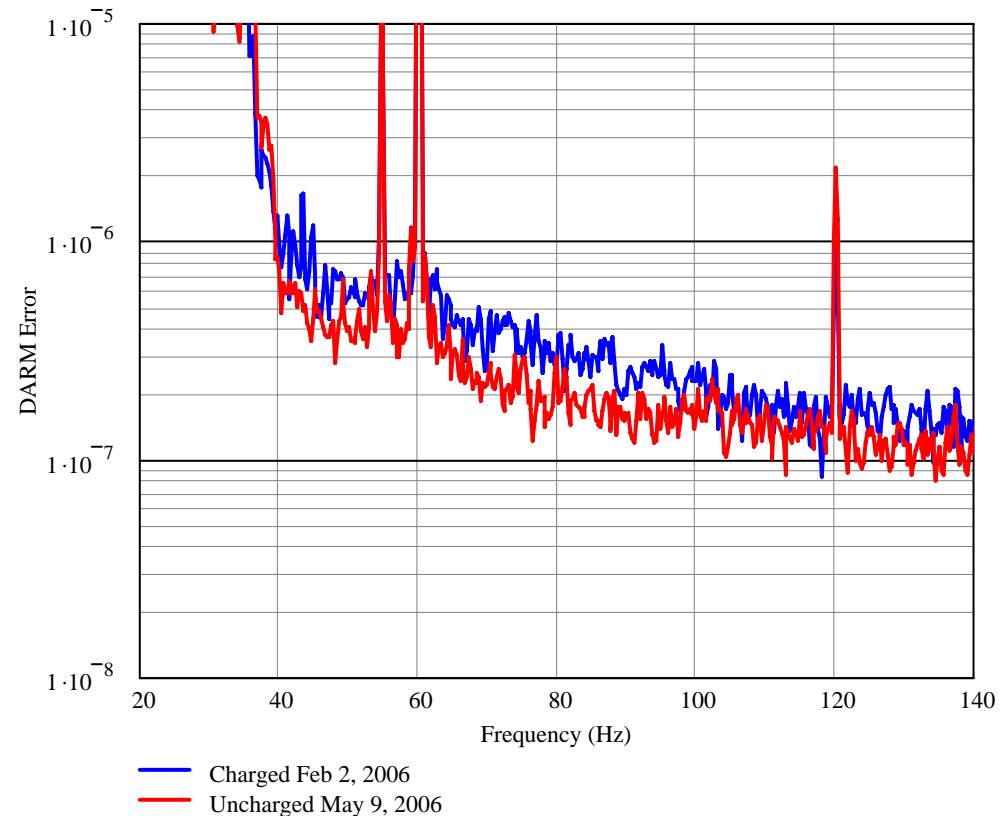
April 2, 2007 LLO i-log entry



# DARM spectrum Before/After May 2006 Vent

DARM Error  
spectrum plotted  
prior to ITMy  
sticking and  
following the vent to  
free ITMy

Difference visible  
between ~40 and 100  
Hz

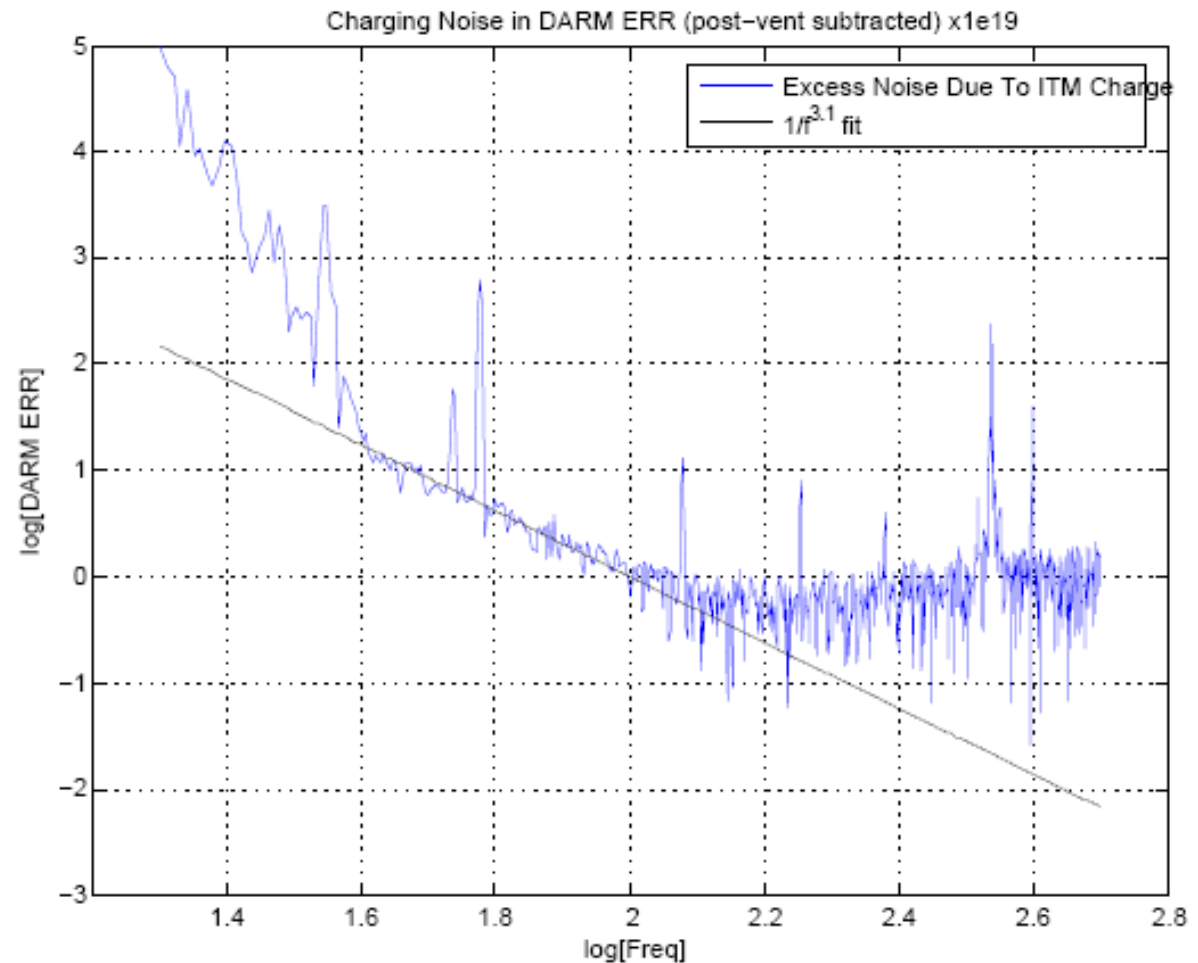


Zoom and plot

# DARM Spectrum

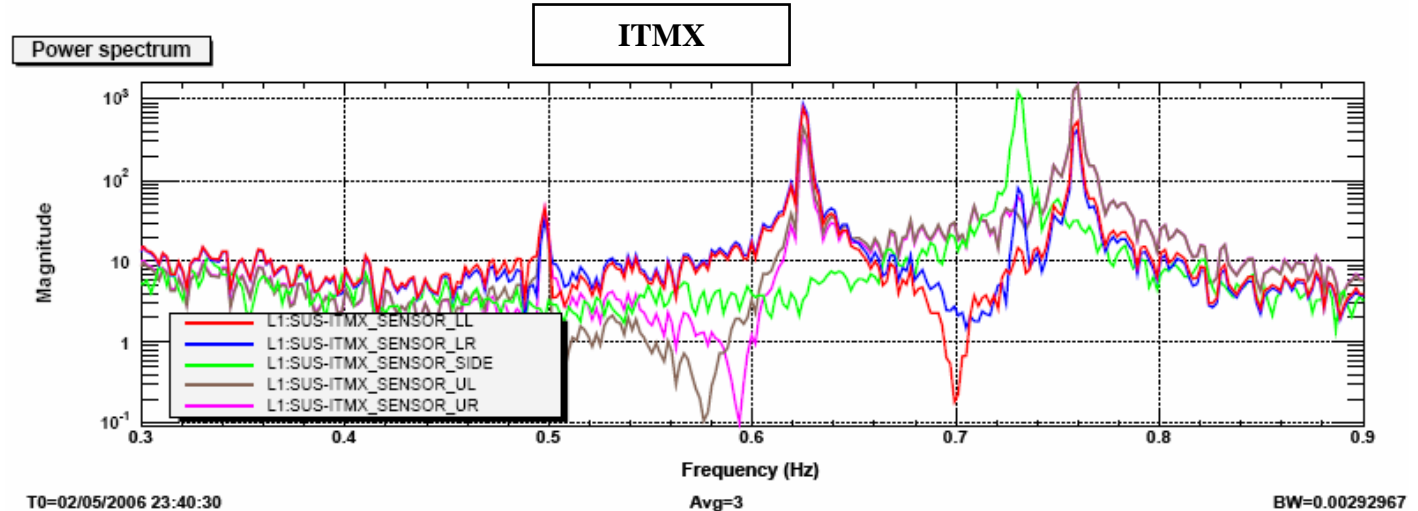
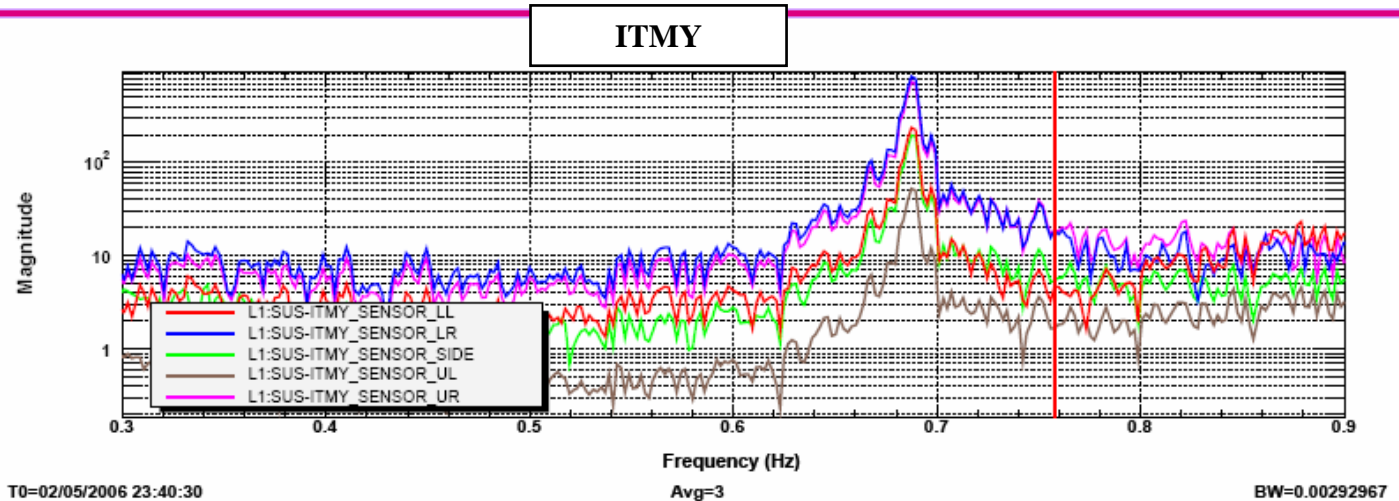
## Fit between 40 and 110 Hz

Basic fitting model yields powers -2.8 to -3.1



# Possible means of monitoring (big) charging?

OSEM spectra  
 Qualitative change in spectrum of a free swinging optic

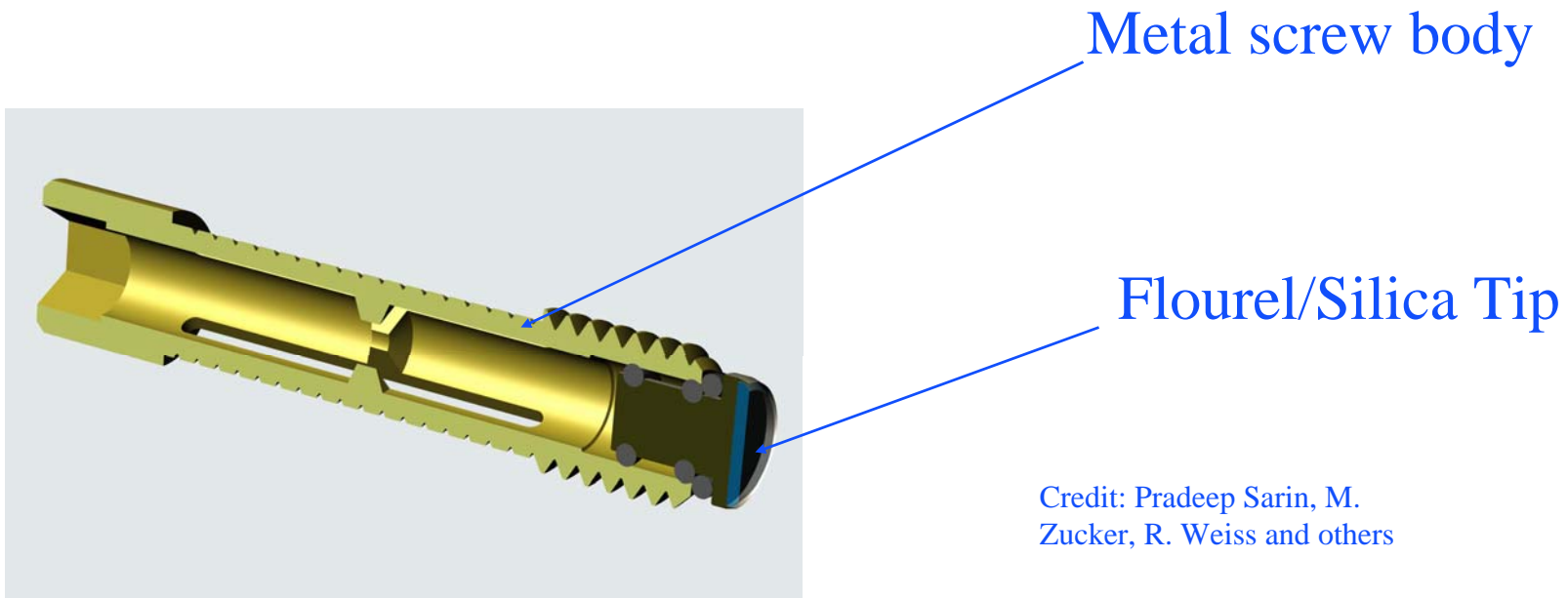


Data on right taken by B. O'Reilly May 2, 2006

# Future Efforts

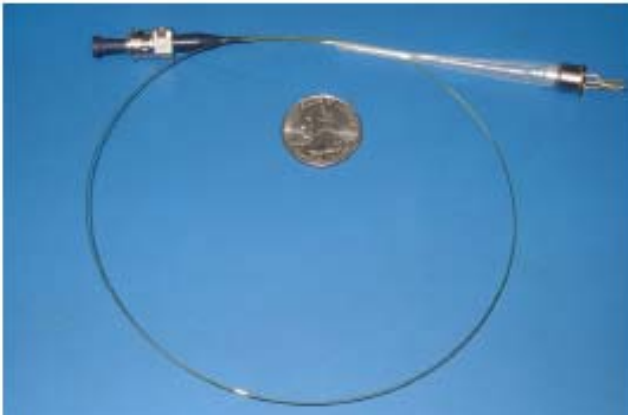
## Enhanced LIGO/Advanced LIGO

- Switch from viton tipped to glass tipped earthquake stops to mitigate contact charge transfer



# Future Efforts

## Enhanced LIGO/Advanced LIGO



LIGO\_LSC\_Sun\_UVLED\_060322.ppt, K. Sun

- Test UV irradiation and alternate means for charge removal
  - See Ke Xun's talk



# Summary

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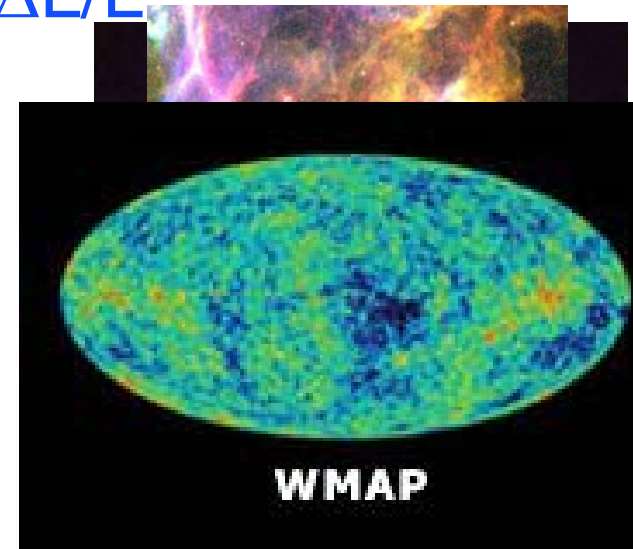
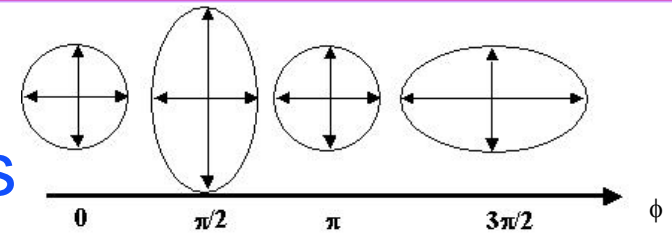
- Determined that 40-110 Hz region followed noise due to a charged optic
- Determined the most likely reason due to charging was due to ITMy contacting earthquake stops
- Use OSEM spectra of freely swinging pendula can qualitatively indicate whether an optic is charged
- Charging group continues to search for non-venting means to neutralize mirrors
- Future earthquake stops will be modified to reduce likelihood of contact charging

Done



# LIGO Overview

- Einstein 1916 paper
- Changing Mass Distributions
- No net motion, only strain  $h = \Delta L/L$
- Sources:
  - » Periodic (Pulsars)
  - » Chirp (Binary Neutron Star Inspiral)
  - » Burst (Asymmetric Supernova)
  - » Stochastic (Big bang)



Credit: NASA/WMAP Science Team  
 NASA

# Introduction

## LIGO

**3 detectors**

**2/4 km arms**

**3000 km separation**



Hanford, WA



Livingston, LA