LIGO

Overview, and

AdvLIGO charging susceptibilities

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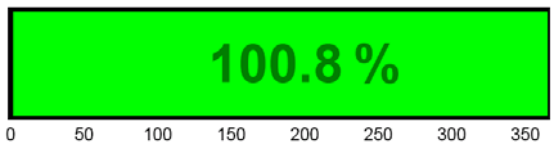
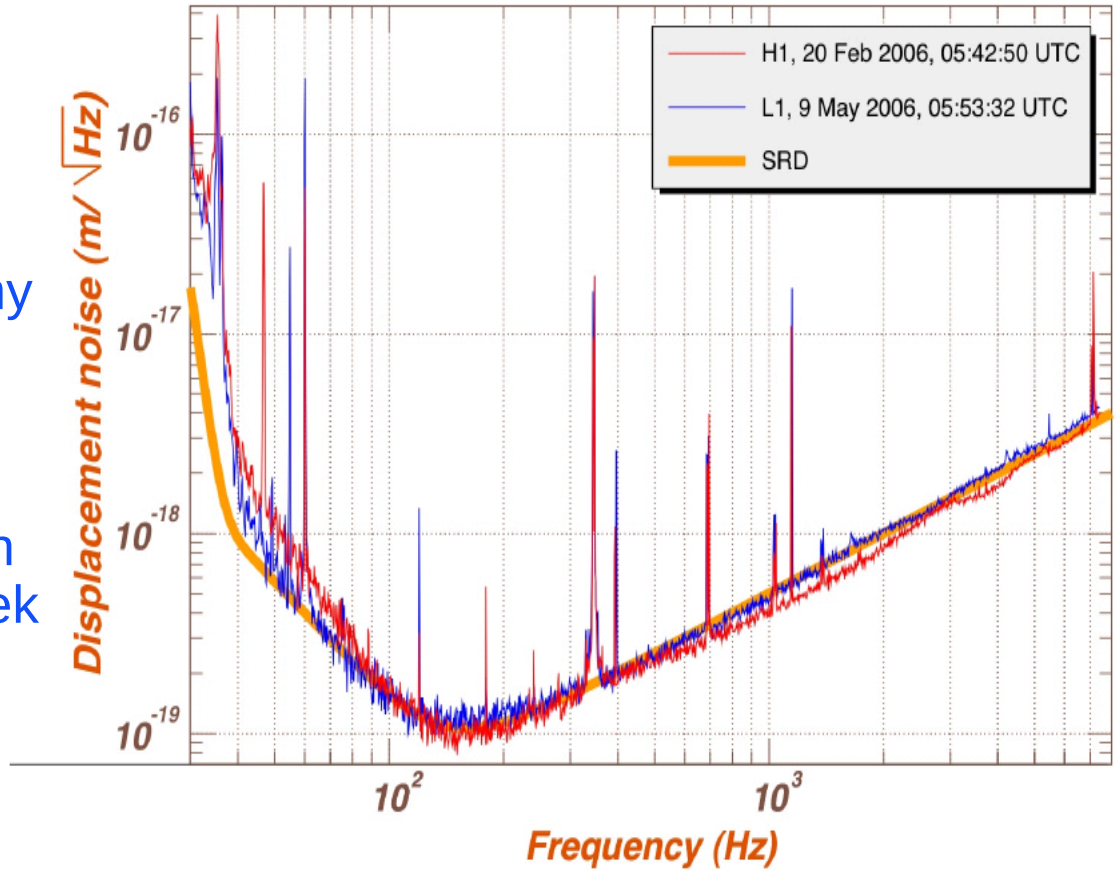
Charging Workshop MIT July 2007

G070546-00-R

LIGO

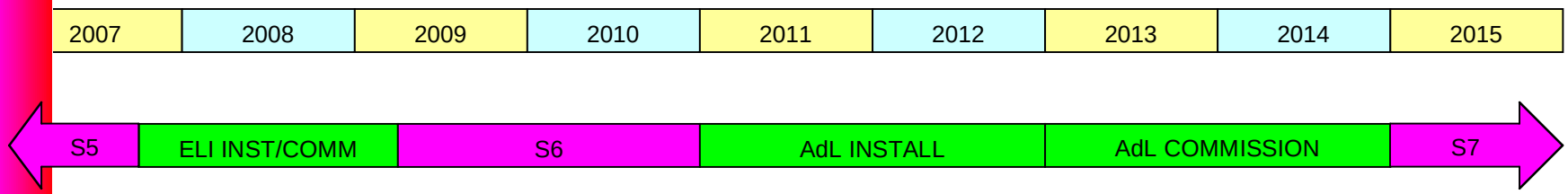
- Infrastructure to support gravitational wave astronomy
- Initial Detector installed, observing; one year integrated data set at design sensitivity achieved last week



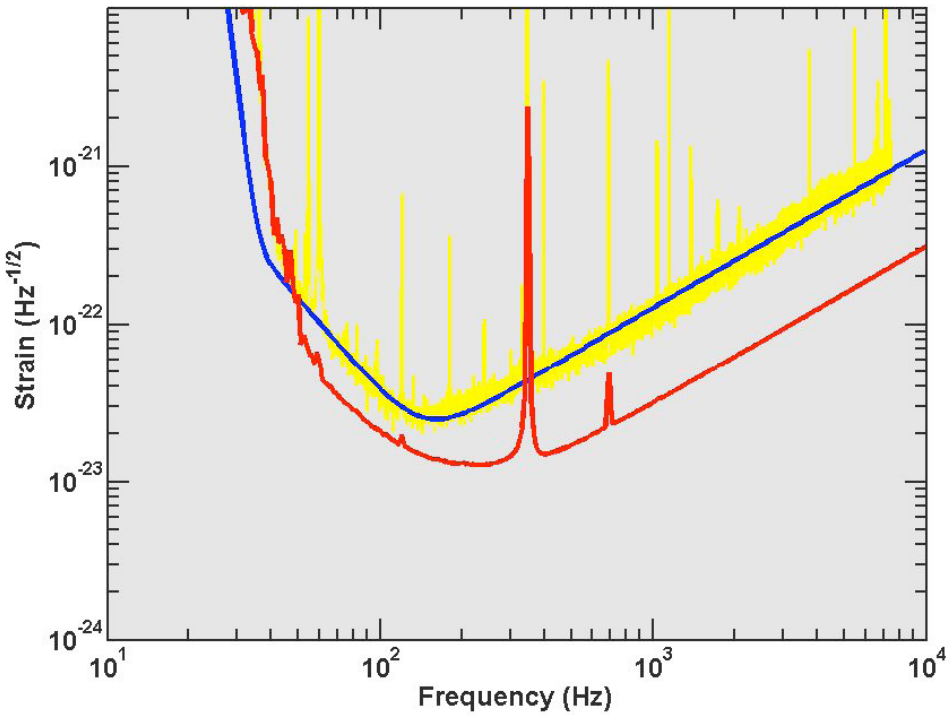


- Data analyzed for signals; none found to date, but best data not yet analyzed
  - » Interesting upper limits placed on stochastic background, Crab pulsar, signals in coincidence with GRBs, etc.
- Will observe until one year of triple coincidence, roughly Oct 2007
  - » Observing with GEO600, Virgo

Enhanced LIGO = ELI

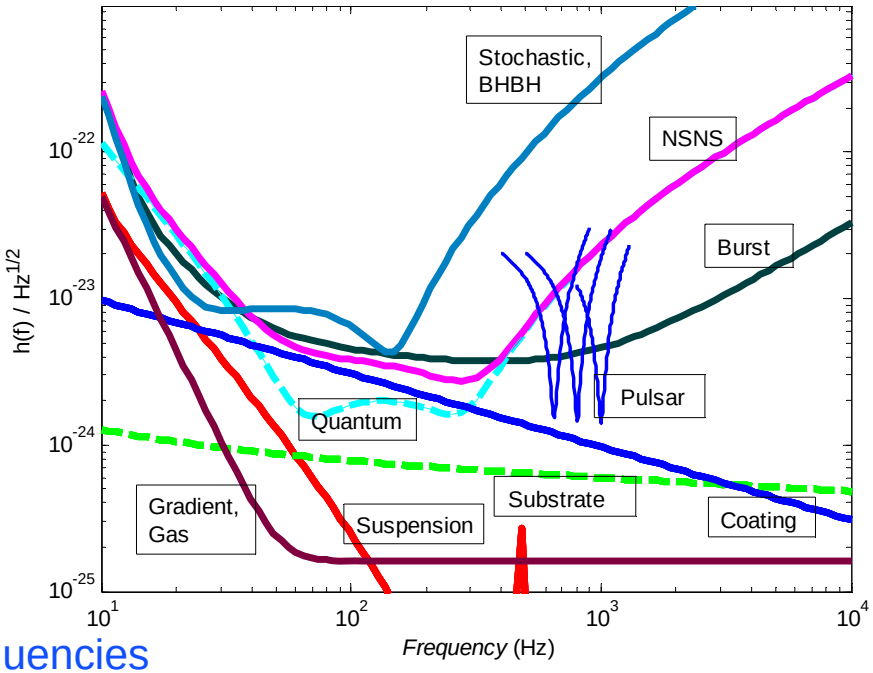


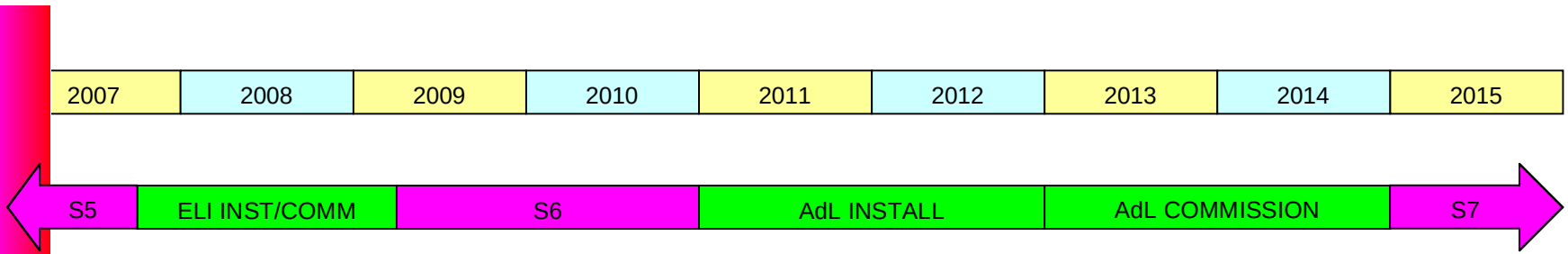
- Objective: use the time between end of initial LIGO and start of Advanced LIGO installation to
  - » Do more astrophysics
  - » Exercise Advanced LIGO subsystems
- Increased laser power, more robust thermal compensation, DC strain readout, use of AdvLIGO seismic isolation
- Changes to ‘earthquake stops’ to reduce charge transfer
- No other baseline plans for suspension changes...but if we were to change something….
  - » Magnet changes to reduce upconversion
  - » Changes in wire standoffs to decrease suspension thermal noise



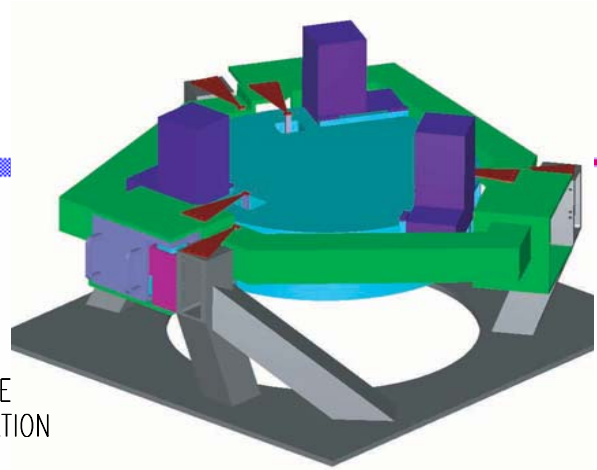
Advanced LIGO

- Objective: start GW astronomy
  - » Status: in NSF and OMB, and now appropriation committee plans
- Factor 10 broad-band sensitivity improvement
- Wholesale change of detector, electronics, cabling; reuse of vacuum tubes, buildings
- Low-frequency wall from 40 to 10 Hz
  - » This is *very* demanding due to increases in stochastic forces at lower frequencies
- Much improved seismic noise → consider it negligible
- Thermal noise, quantum noise, gravitational gradient noise sure to limit performance
- ….and perhaps also forces due to migrating charges

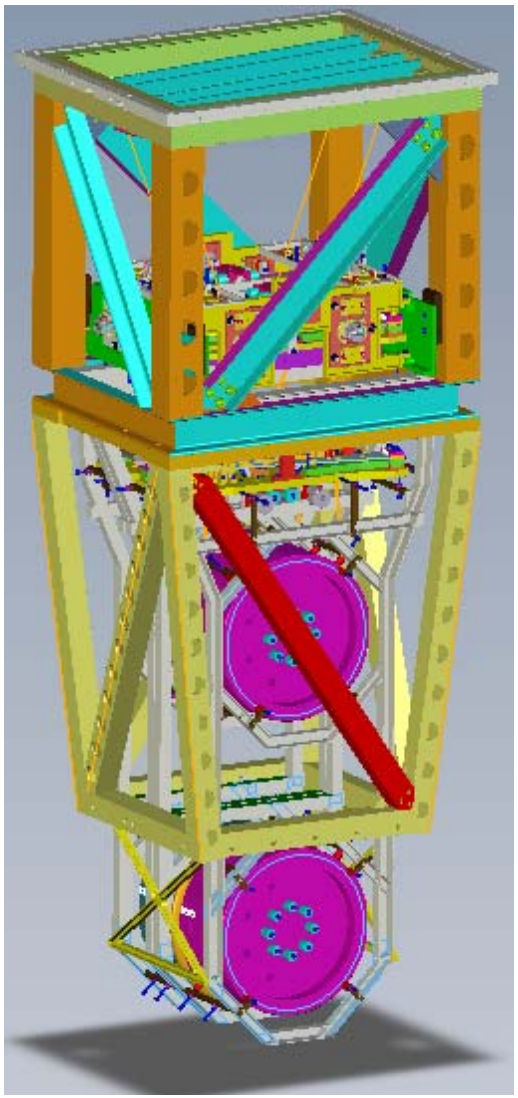




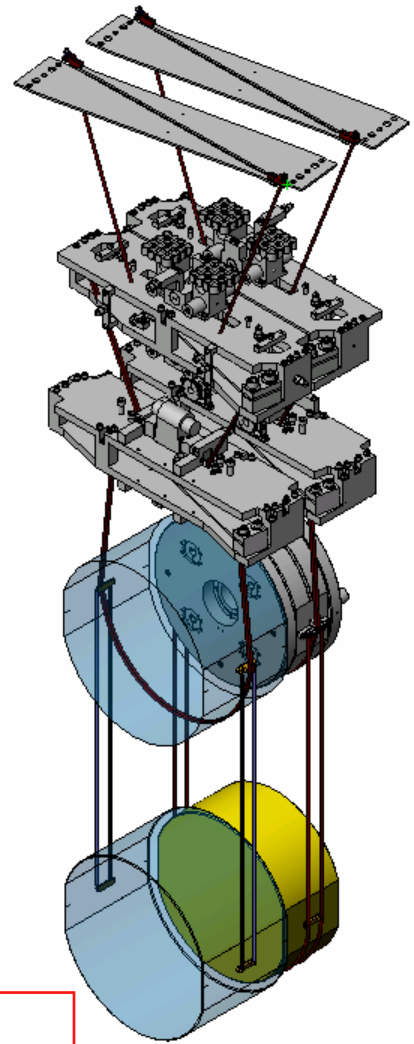
Design features



From Norna: Test Mass Quadruple Pendulum Suspension



- **Key Design features**
  - » **Monolithic final stage: 40 kg fused silica mirror (34 cm diam x 20cm) on 4 fused silica ribbons (600mm x 1.1mm x 0.11 mm) for good thermal noise performance**
  - » **4 stages for longitudinal seismic isolation plus 3 stages of blades for vertical isolation**
  - » **6 degree of freedom damping (local control) at top mass for all low frequency modes (requires good mode coupling)**
  - » **Parallel reaction chain for quiet global control actuation: electrostatic (ESD) at test mass, electromagnetic at upper stages (hierarchical)**

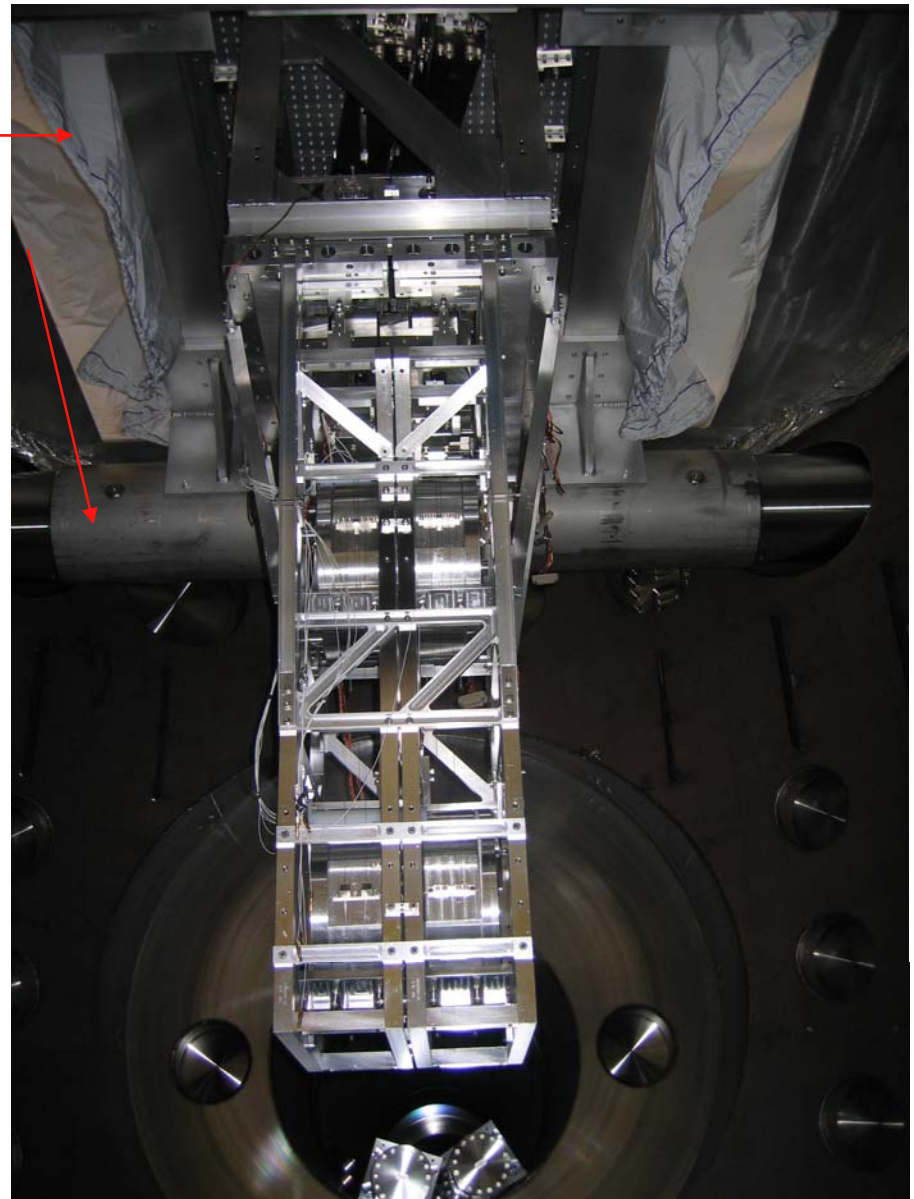


Major noise requirements

Suspension thermal noise 10^-19 m /√ Hz @ 10 Hz

Residual seismic noise 10^-19 m /√ Hz @ 10 Hz

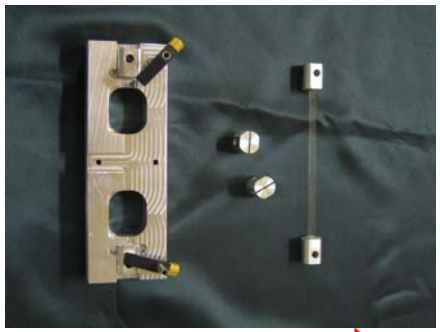
Test Mass
Quadruple Pendulum Suspension continued

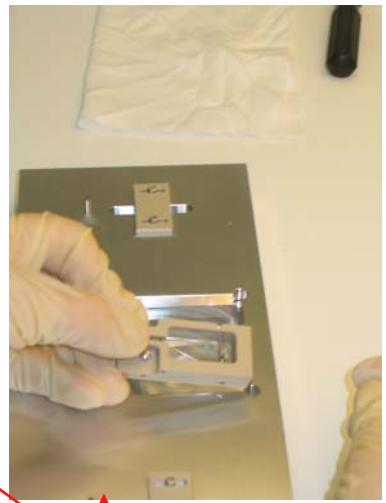


Test Mass
Quadruple Pendulum Suspension continued

Development work on monolithic assembly techniques at Glasgow

CO_2 ribbon puller/welder





Preparing ribbon for pulling

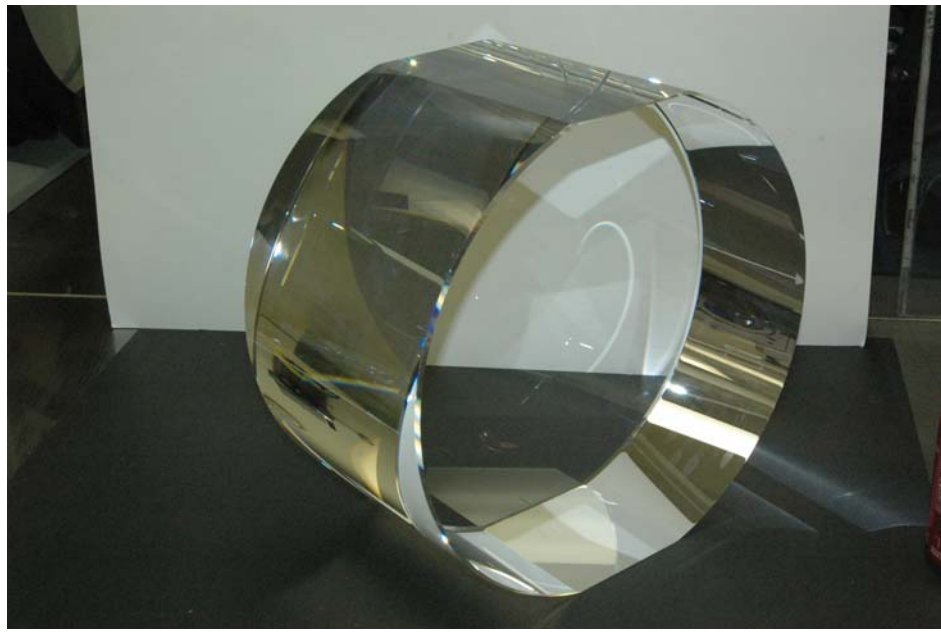
Prism strength testing

Ear bonding fixtures

Prototype quad at Rutherford Appleton Lab

Core Optics/Coatings

- Full sized Optic for integration testing
  - » Coated by LMA; now being characterized
  - » Looks like a good, low-loss coating
- To be joined to the UK soon to the quad suspension, installed at LASTI on the BSC Seismic Isolation
- Front face HR coating
- Back face AR coating
- Reaction mass same size, fused silica
  - » Front face gold pattern



Physical Quantity	
Diameter of substrate,φs (cm)	31.4
Substrate Thickness, ds (cm)	13
1 ppm intensity contour diameter (cm)	31.5
Lowest internal mode frequency (kHz)	9.35
Weight of Suspended Component (kg)	40[9]

Charge-related Worries

- Interaction between test mass and reaction mass
  - » Coated silica faces
  - » Gold electrostatic actuator surface
    - – DC vs RF excitation
- Interaction between test mass and frame
- Gold coating on barrel (thin)
  - » To reduce emissivity on sides for thermal compensation
  - » Damps some test mass modes: less risk of parametric instabilities, slight increase in thermal noise
  - » A conductive coating….
- Cosmic rays
- Anything strange with either laser-beam heating or thermal compensation heating