Composite Test Mass

Adv. LIGO Systems Meeting 17 May 2002 D. Coyne

Sapphire ITM

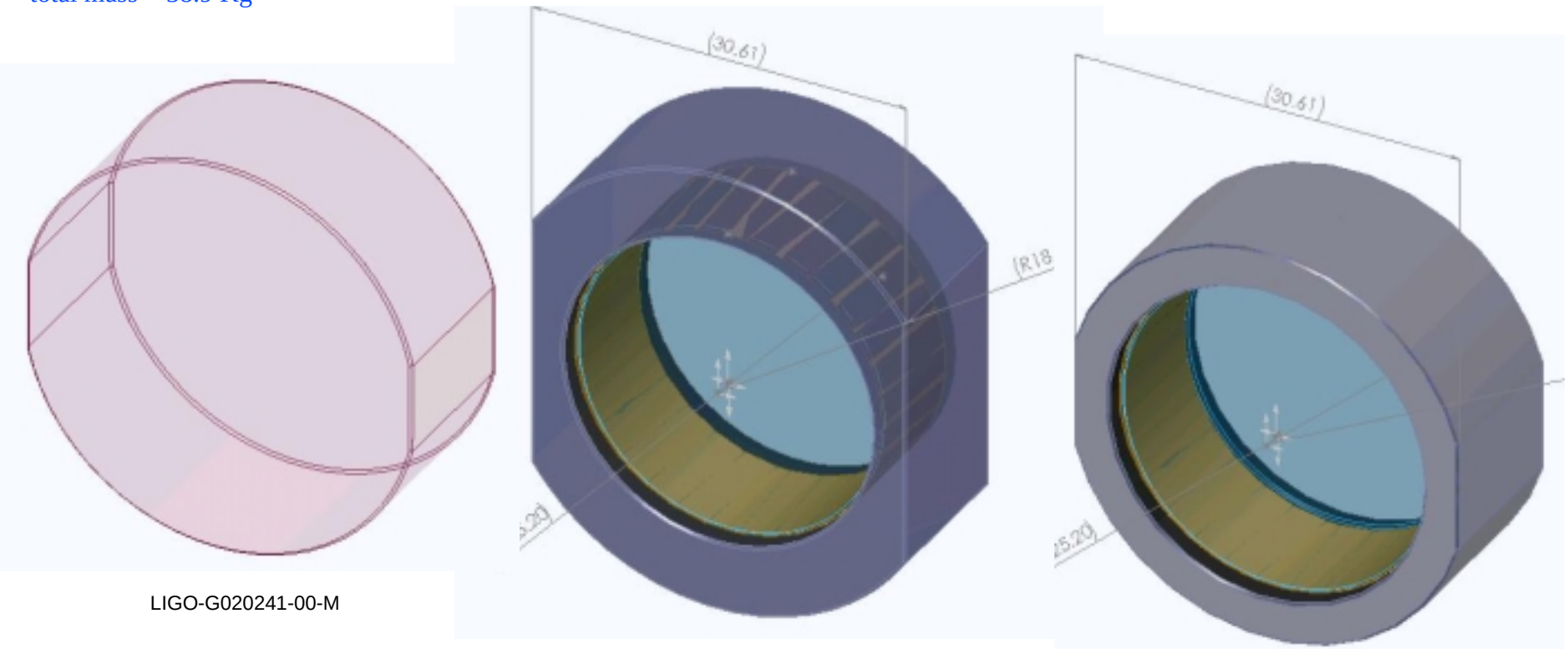
diameter = 31.4 cm
thickness (maximum) =13.0 cm
flat-to-flat = 30.61 cm
wedge = 1.10 deg total (vertical, thick end down, symmetrically wedged)
chamfer: 2 mm x 45 deg.
total mass = 38.9 Kg

SF4 Cradle + Fused Silica ITM_{4k}

diameter = 36.7 cm
thickness =13.0 cm
flat-to-flat = 30.61 cm
wedge = 0
chamfer: 2 mm x 45 deg.
total mass = 40.1 Kg

304SS Cradle + Fused Silica ITM_{4k}

diameter = 31.8 cm
thickness =13.0 cm
flat-to-flat = 30.61 cm
wedge = 0
chamfer: 2 mm x 45 deg.
total mass = 40.2 Kg

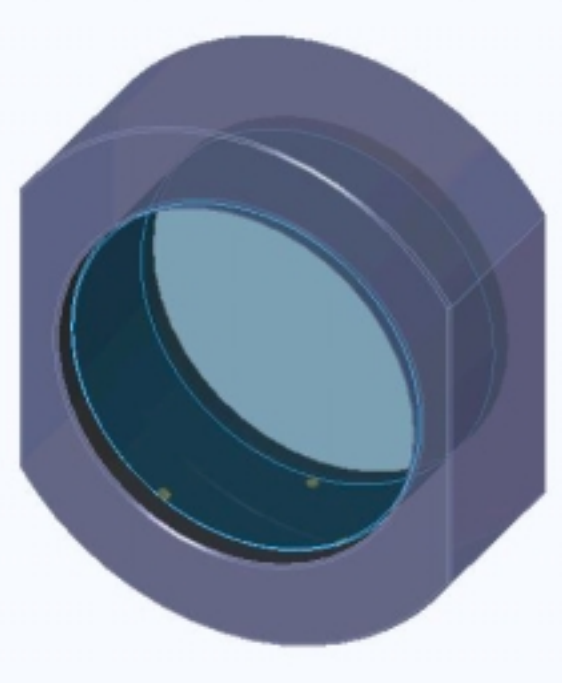


Attachments

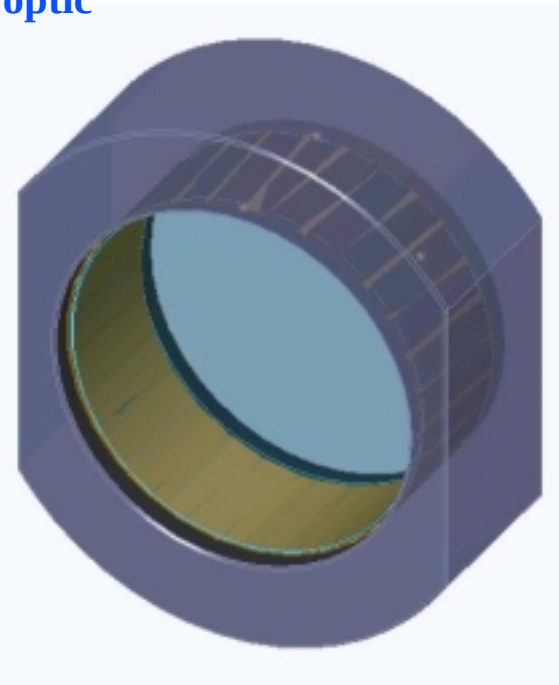
- Glass Cradle (e.g. SF4):
  - » Might preserve moderately high Q:
    - – See Sheila's notes
    - – … but do we/should we care about preserving Q – see David's notes
  - » Can polish flats to λ/10
  - » hydroxy catalysis bond "ears"
  - » Weld fibers or ribbons to the ears
- Metal Cradle (e.g. 304SS):
  - » VacSeal epoxy bond standoffs
  - » Suspend with "music" wire
  - » Accommodating wire requires a change to the penultimate mass
  - » Alternatively:
    - – metalize the mating surface of a fused silica ear
    - – braze using a lead-silver alloy
    - – Probably requires some complex interface geometry be machined into the cradle for relief of thermal gradients & thermoelastic stresses
    - – Compliance at the ear-cradle interface may compromise:
      - the (relatively) high first resonance
      - suspension thermal noise
      - vertical bounce frequency

Optic Boundary Conditions

3 point support with clearance around the barrel



Complete or circumferentially segmented indium layer between the Cradle and the fused silica optic



Material Properties

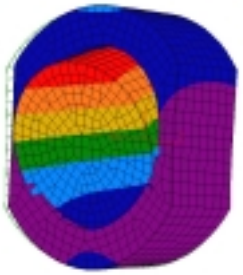
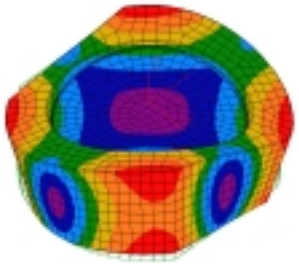
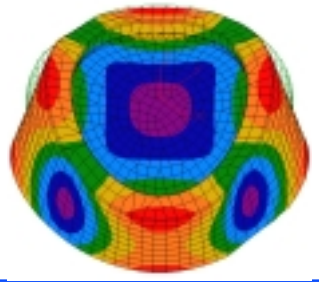
Material	density g/cc	Young's Modulus GPa	Poisson's Ratio -	
Sapphire	3.98	345	0.27	anisotropic
SF4	4.79	56	0.24	
304 Stainless Steel	7.90	200	0.29	
Indium	7.30	13	0.45	
Fused Silica	2.20	73	0.17	
IRG-2 (germanate)	5.00	96	0.3 (?)	small size only?

Moments of Inertia

- Norna Robertson looked at the suspension control with the SF4 cradle and FS test mass:
  - » replaced the sapphire test mass in the current Matlab quad pendulum model with the SF4 cradle plus FS test mass; no other changes
  - » Penultimate mass = 72 kg in this model
  - » After quick look, seems fine
  - » Pitch mode goes from 0.35 to 0.30 Hz and settling times go from 8.4 sec to 10.4 sec (which can be recovered with additional gain)
  - » Roll mode goes from 10.9 to 9.5 Hz
- Stainless Steel cradle and FS test mass assembly has a closer match to the sapphire test mass principal moments of inertia

	Principal Moments of Inertia (10^6 g cm^2)		
Material	**Px**	**Py**	**Pz**
Sapphire Optic	2.89	2.93	4.77
304 SS + Fused Silica Optic	3.86	4.03	6.90
SF4 Cradle + Fused Silica Optic	3.80	5.12	7.91

Frequency Analysis

Test Mass	3 point	Complete Indium 'seal' (1 mm thick)	Segmented Indium Seal
Sapphire		8600 Hz (?)	
SF4/FS	432 Hz, Optic rolling 	2172 Hz, "butterfly" 	NA
SS/FS	NA	2888 Hz, "butterfly" 	NA
IRG-2/FS	510 Hz, Optic pitching	NA	NA