Advanced
LIGO UK

OSEM Development Update
"Show-and-Tell"

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Monolithic Suspension Workshop

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Latest OSEM Model Located on ALUK Birmingham webpage at:

http://www.sr.bham.ac.uk/research/gravity/rh,d,2.html

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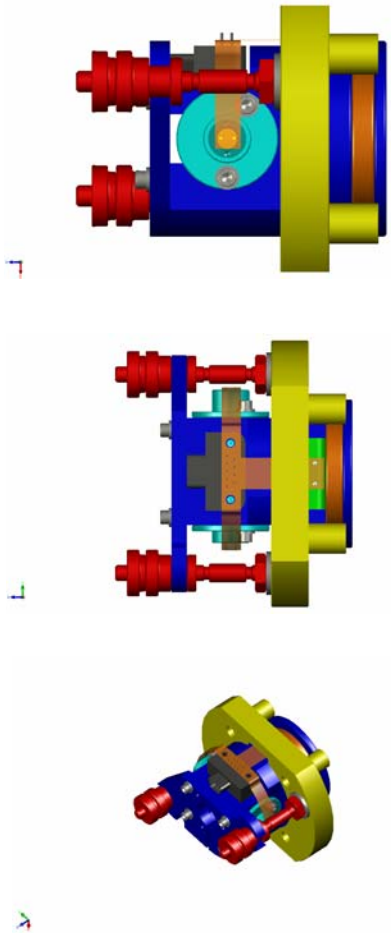
Overview

- OSEM Performance Summary
  - Required Performance
  - Latest Sensor Performance
- Current OSEM Design
  - Sensor Development
  - Inter-Connect Development
  - OSEM Mechanical Adjustment
  - PAM Retro-Fit Implementation
- Current OSEM Status
  - Part-Procurement
  - Vacuum Compatibility Testing
- OSEM Next Steps



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OSEM Performance Summary

- Required Range Performance:
  - 0.35*mm* (peak-peak) working range [1], incorporating:
    - 0.20*mm* OSEM positioning inaccuracy (adjustment resolution)
    - 0.15*mm* to cope with drifts in the suspension (thermal etc.)
  - Hybrid OSEM range has been demonstrated to be 0.7*mm*

  ➢ **We aim for no worse than 0.7*mm* working range**

- Required Sensitivity Performance:
  - $3\times10^{-10} m/\sqrt{Hz}$ at 1*Hz* has been demonstrated by the Hybrid OSEM (confirmed by N. Lockerbie [2], P. Fritschel and R. Adhikari [3])

  ➢ **We aim for no worse than $3\times10^{-10} m/\sqrt{Hz}$ at 1*Hz***

DCC References: [1] LIGO-T040110-01-K, [2] LIGO-T040106-01-K, [3] LIGO-T990089-00

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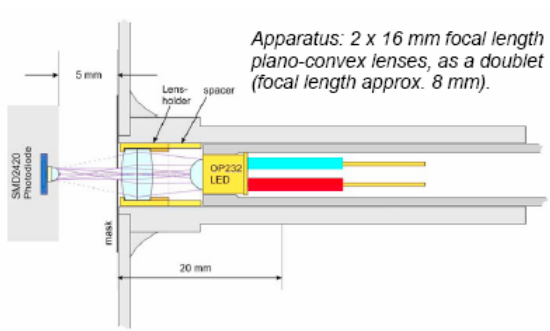
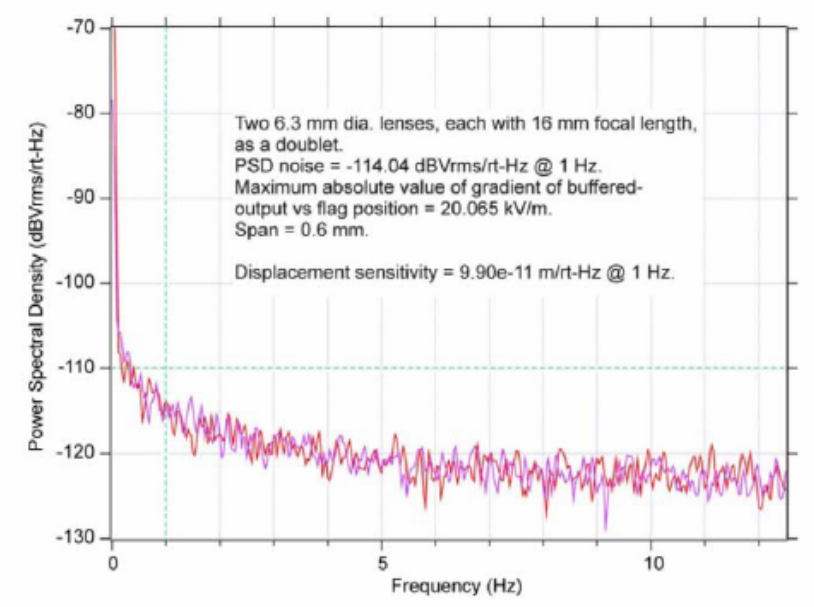
OSEM Performance Summary

- Current Sensor Performance: *(N. Lockerbie)*
  - 0.6*mm* (peak-peak) working range
  - $1 \times 10^{-10} m/\sqrt{Hz}$ at 1*Hz*





  - September 2004: Includes additional emitter lens + mask configuration
  - Present: Includes additional emitter <u>& receiver</u> lens + mask configuration

(to aid commonality of sensor parts and assembly)

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Current OSEM Design

- Sensor Development:
  - Honeywell Surface-Mount Emitter (SME2470) Replaced with Optek leaded device (OP232)

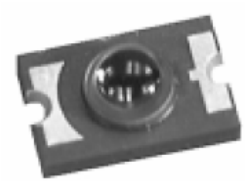
TO-46 Package

Hermetically Sealed

Kovar

(n.b. anode-to-case)

  - Honeywell Surface-Mount Receiver (SMD2420) Replaced with Centronics leaded device (BPX65)



TO-18 Package

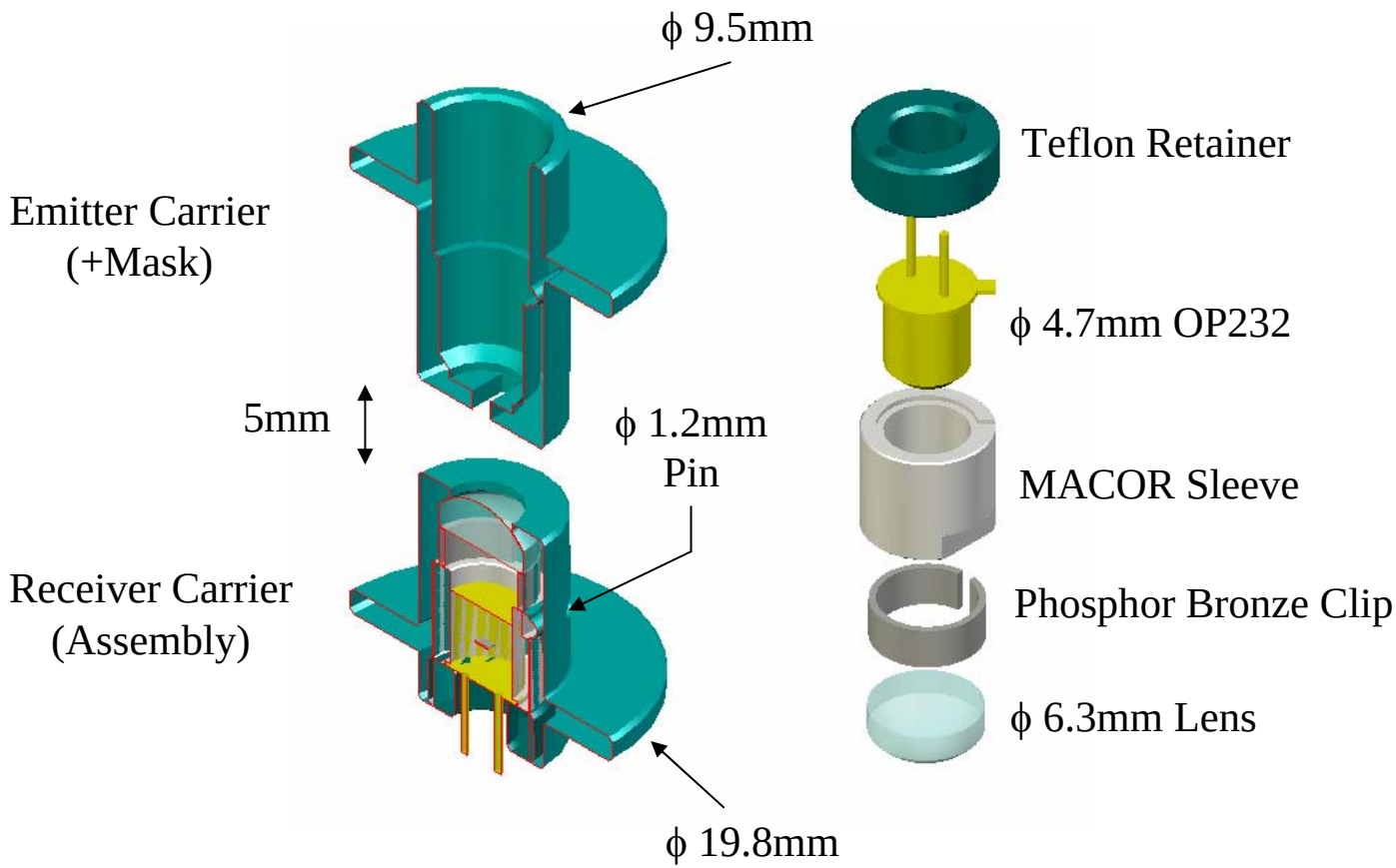
Hermetically Sealed

Steel

(n.b. cathode-to-case)

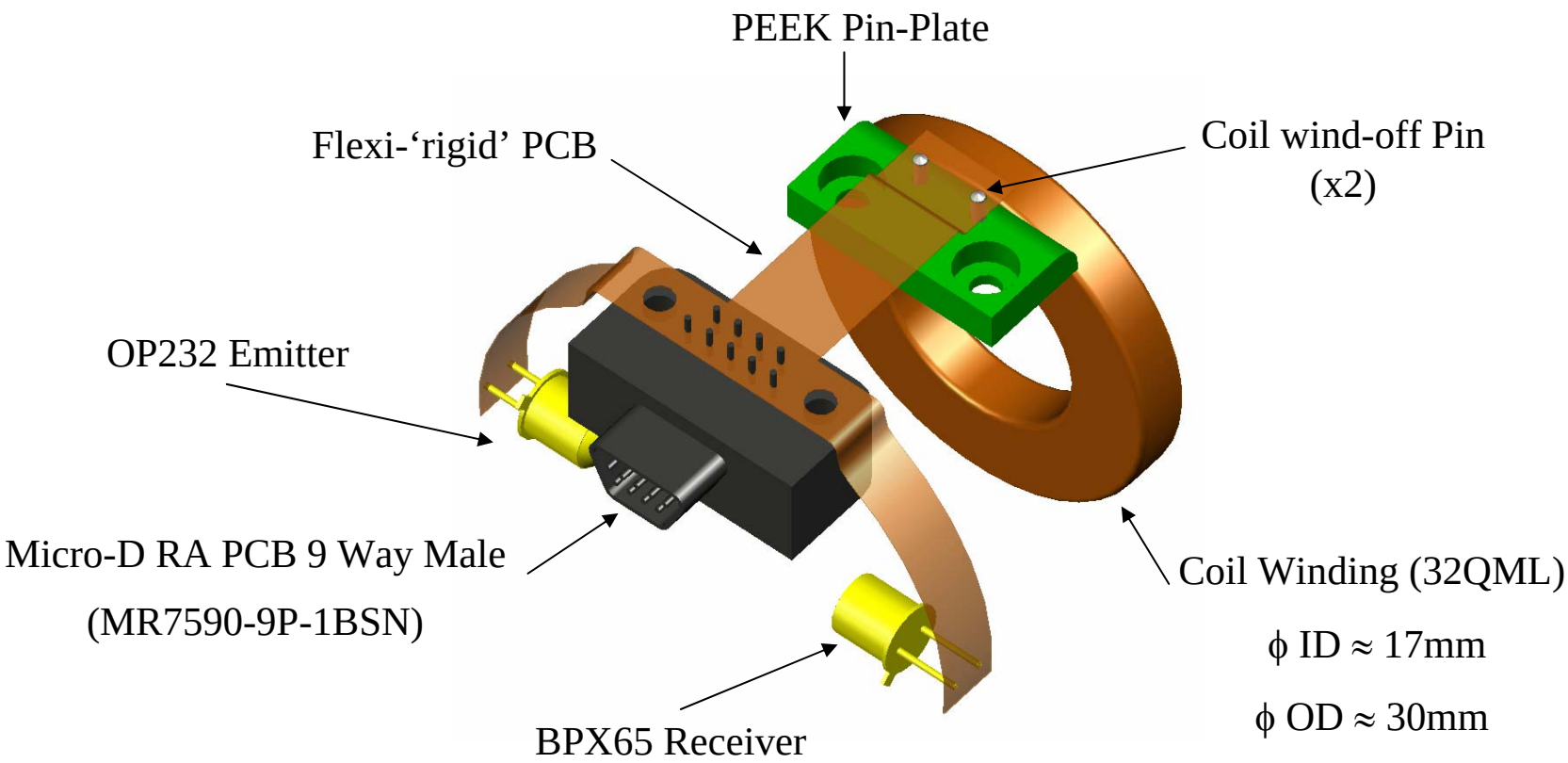
Current OSEM Design

- Sensor Development:



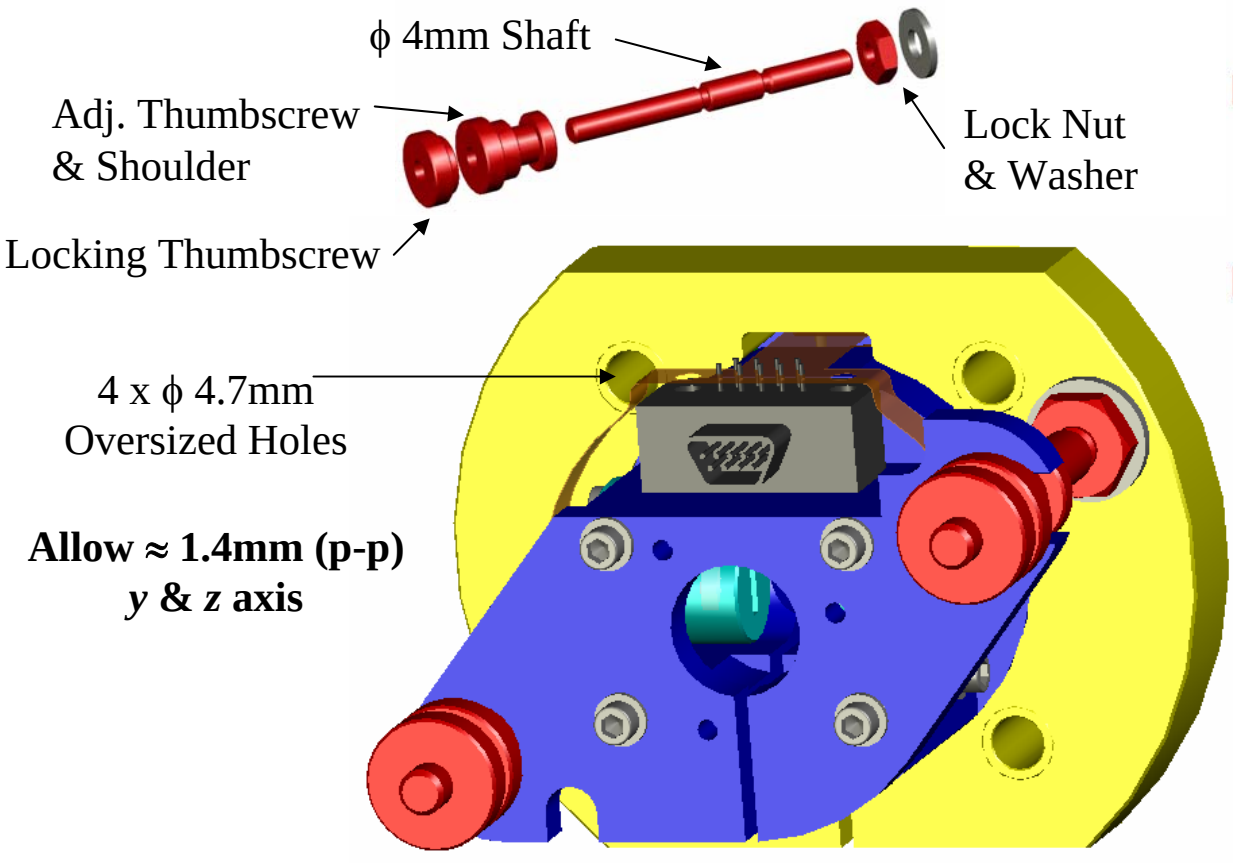
Current OSEM Design

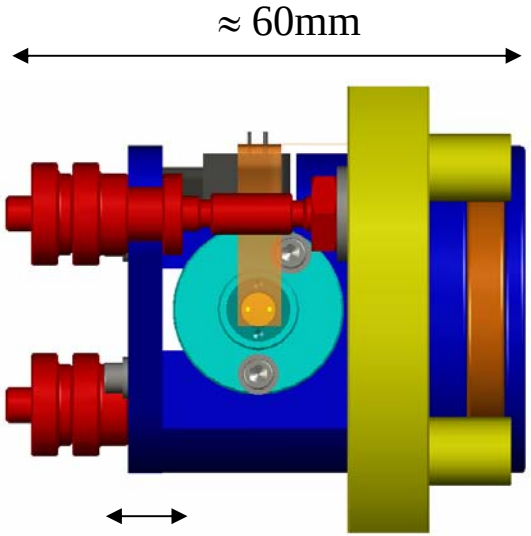
- Inter-Connect Development:



Current OSEM Design

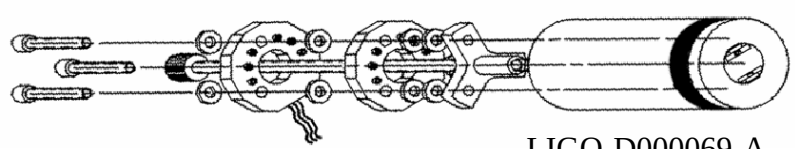
- OSEM Mechanical Adjustment:





Current OSEM Design

- Pitch Actuation Magnet (PAM) Retro-Fit Implementation:



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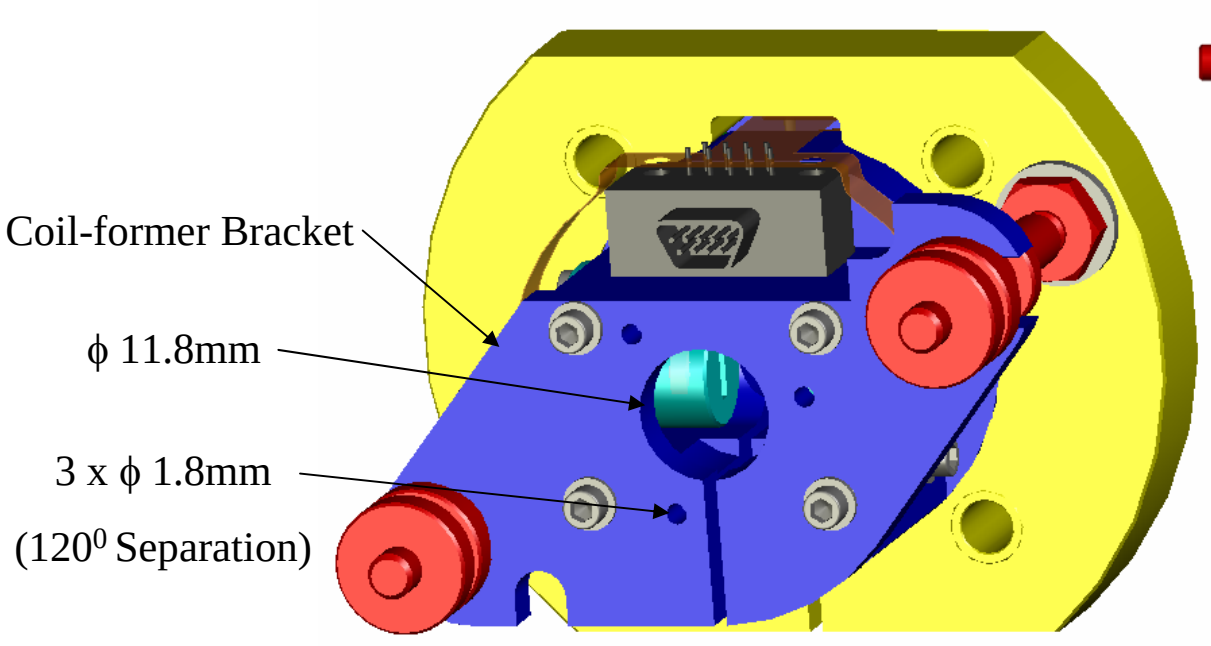
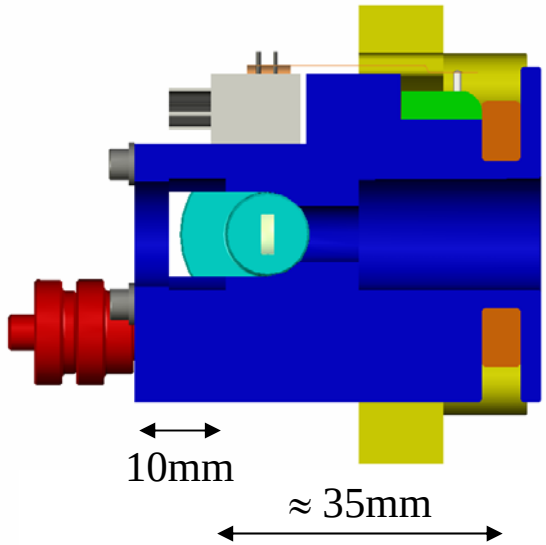


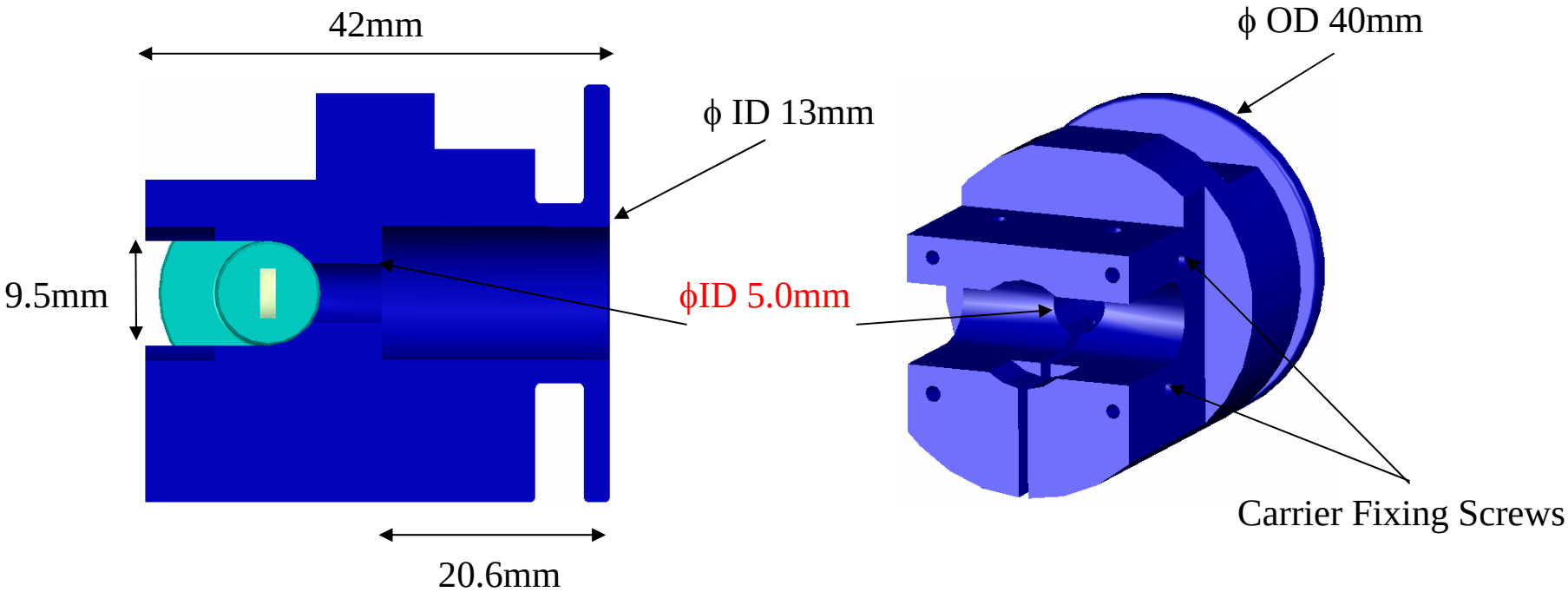


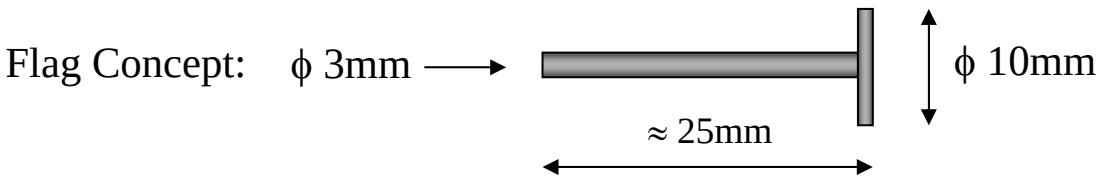
Initial LIGO Design: 10mm separation between magnets

Modified Hybrid OSEM Design: 35mm separation between magnets

Current OSEM Design

- Coil-former Development:





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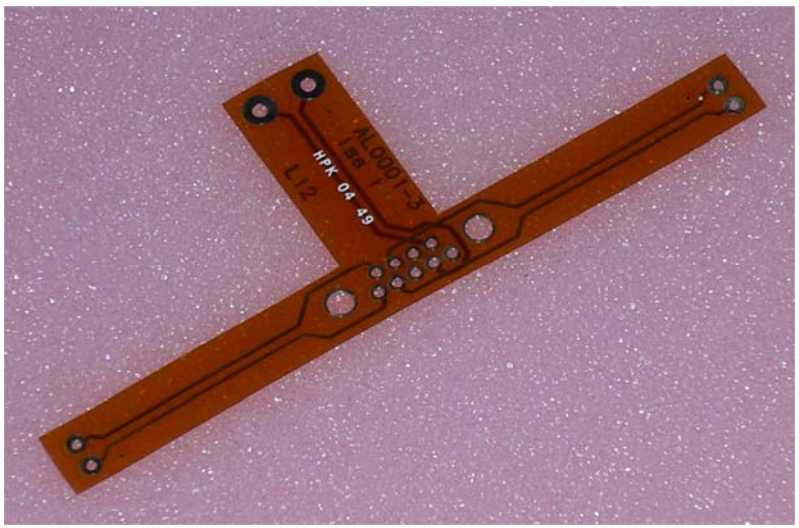
Current OSEM Status

- Flexi-Circuit Part-Procurement Underway:
  - Identification of Production issues
    - Inked, No radii on corners
  - Vacuum Compatibility Testing
    - Qty.≈ 20 complete units
    - Double Sided? (or Single?)



Kapton (25µm)	Coverlay
Adhesive (25µm)	(DuPont LF0110)
Copper (18µm)	
Adhesive (25µm)	Copper Clad Laminate
Kapton (25µm)	
Adhesive (25µm)	(DuPont LF8515)
Copper (18µm)	
Adhesive (25µm)	Coverlay
Kapton (25µm)	(DuPont LF0110)

Total Thickness ≈ 250 µm

(10 procured)

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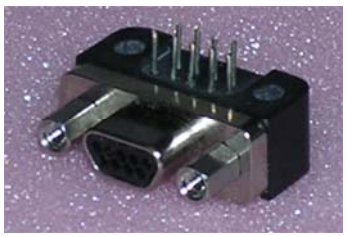
Current OSEM Status

- Connector Part-Procurement Underway:
  - Identification of Production issues
    - Inked
  - Vacuum Compatibility Testing
    - Qty.≈ 10-20 units (each connector type?)



RA OSEM Male

LCP Insulator Insert

STR Pigtail Female

Component	Material	Status
Potting Compound	Hysol C9-4215	*Helena (Procuring)*
Insulator	Liquid Crystal Polymer	*Stuart (10 procured)*
Interfacial Seal	Flourosilicone	*Not Fitted*

Concerns & Issues to Resolve

- Sensor ‘Alignment’ Issues
  - We presently have no mechanical adjustment for the alignment of the sensor optical components
  - However, we are confident that the emission pattern of the OP232 is consistent (device-to-device) within the batch of 25 units tested (N. Lockerbie, Oct 04). Further batch-to-batch testing is also available, if deemed to be necessary (n.b. fixed device orientation)
  - Possible device-to-device variability in radiated intensity
  - Manufacturer unable to supply graded devices (≈1000 off)
  - Potential solution via drive electronics

➢ **We would wish to test and characterise performance of the prototype OSEM’s (e.g. by obtaining the ‘spread’ of sensor transfer functions)**

Concerns & Issues to Resolve

- Thermal Issues:
  - Electrical isolation of the sensor packages leads to a reduction in the thermal link to the coil-former (via Macor sleeve)
  - Not clear if this has a significant impact upon the temperature stability of the device

➢ **We may wish to further investigate thermal effects by characterising the performance of the device in vacuum, and in a temperature controlled environment (e.g. Bham thermal vacuum chamber)**

Concerns & Issues to Resolve

- Further Questions / Issues:
  - Are thread inserts (brass / steel) required to hold ‘reliable’ threads in aluminium?
  - Are any coatings applied to any parts?
  - Current design omits any clearance holes in the coil-former clamp & bracket for access to earthquake stops etc. (We intend to use the MC controls prototype design as a template)

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OSEM Next Steps

- Prototype Production:
  - Possible in-house production of prototype devices
    - A few coil-formers, but additional sensor assemblies
  - Would expect to have these produced in time for the LSC
- Further Testing:
  - Carry out any performance characterisation as required (including any thermal analysis / testing)
- Part-Procurement:
  - Place orders for more substantial quantities of components (i.e. sufficient to fulfil vacuum compatibility testing requirements)
    - Flexi-circuit
    - Connectors (both OSEM and Pigtail mating connector)
    - Sensor Components (OP232 & BPX65)
  - Submit for Vacuum Compatibility Testing