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Stray Light Measurements With an Instrumented Baffle in the Advanced Virgo Input Mode Cleaner Cavity.

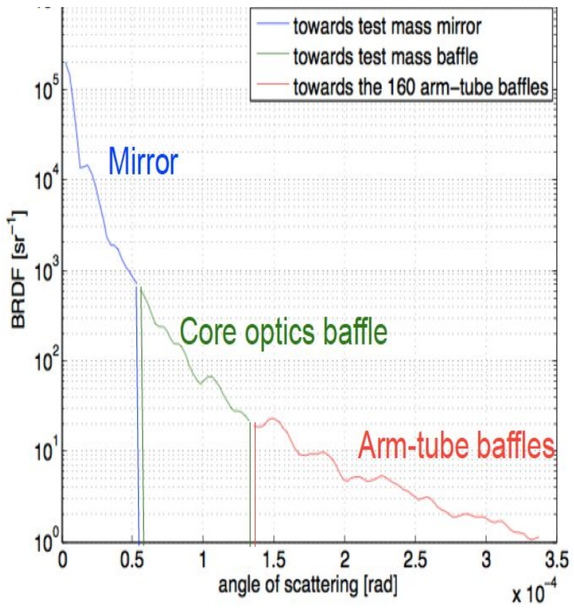
M. Andres-Cascasona, O. Ballester, O. Blanch, G. Caneva, L. Cardiel, M. Cavalli-Sforza, A. Chiummo[2], C. García, J.M. Illa, C. Karathanasis, M. Kolstein, A. Macquet, M. Martínez, A. Menéndez-Vázquez, Ll. M. Mir, J. Mundet, O. Piccinni, A. Romero-Rodríguez, D. Serrano, H. Yamamoto[3]

(1) Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology, Campus UAB, E-08193 Bellaterra (Barcelona), Spain
(2) European Gravitational Observatory (EGO), Cascina, Pisa, Italy
(3) LIGO laboratory, California Institute of Technology (Caltech), Pasadena, CA, US

Email: mkolstein@ifae.es

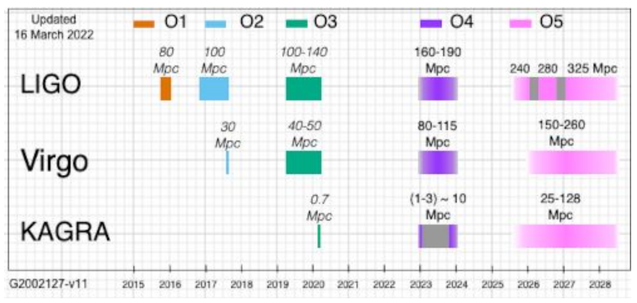
Stray Light at Virgo

- >70% of light in interferometer = stray light
- 99.5% of stray light eliminated by passive baffles
  - No control on where light goes
- **Can have harmful effect on GW signal!**
- Instrumented baffles in the main arms around the test masses would
  - monitor scattered light at low angles
  - help laser alignment
  - help look for correlations with interferometer glitches



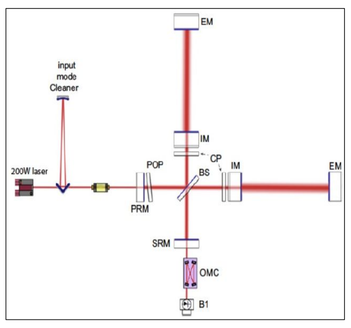
AvV+ Phase I (O4):

- 100 W laser input power
- 40 W power into interferometer
- Frequency depending squeezing
- Newtonian noise cancellation
- Signal recycling cavity
- **Instrumented baffle in IMC**



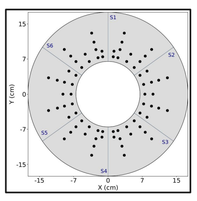
AdV+ Phase II (05):

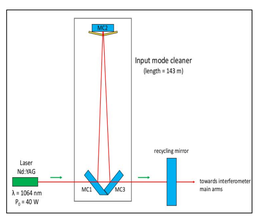
- 130 W laser input power
- 60 - 80 W power into interferometer
- Larger end mirrors
- Better coating
- **Instrumented baffles at main test masses**

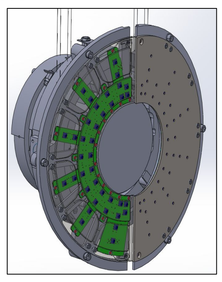


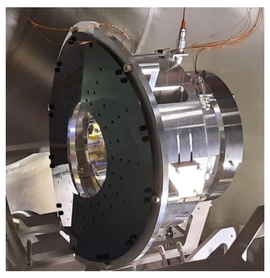
Baffle design and installation

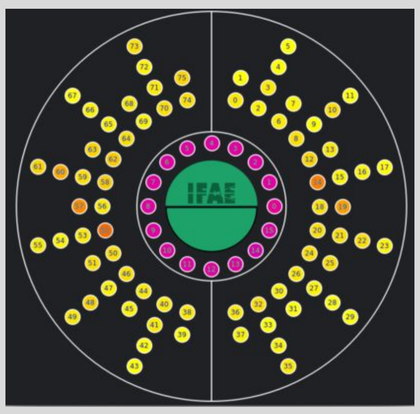
- Baffle Φ_{inner} = 140 mm, Φ_{outer} = 350 mm
  baffle half tilts: 9 degrees
- **76 photosensors** on gold-plated PCBs (efficient heat dissipation)
- 1st ring R = 88 mm, 2nd ring R = 98 mm
- **16 ADCs** + temperature sensors
- Operating voltage = 3 V
- Conical holes (12º), Φ = 4 mm at polished baffle front
- All elements UHV certified
- AR coating @ 1064 nm





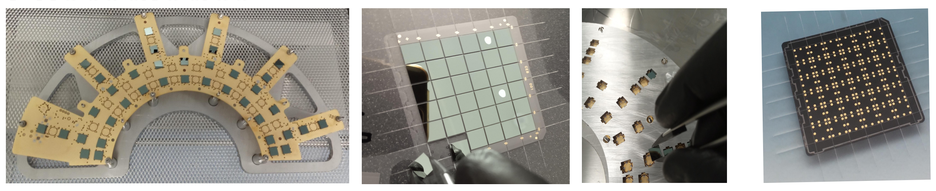






Photodiodes

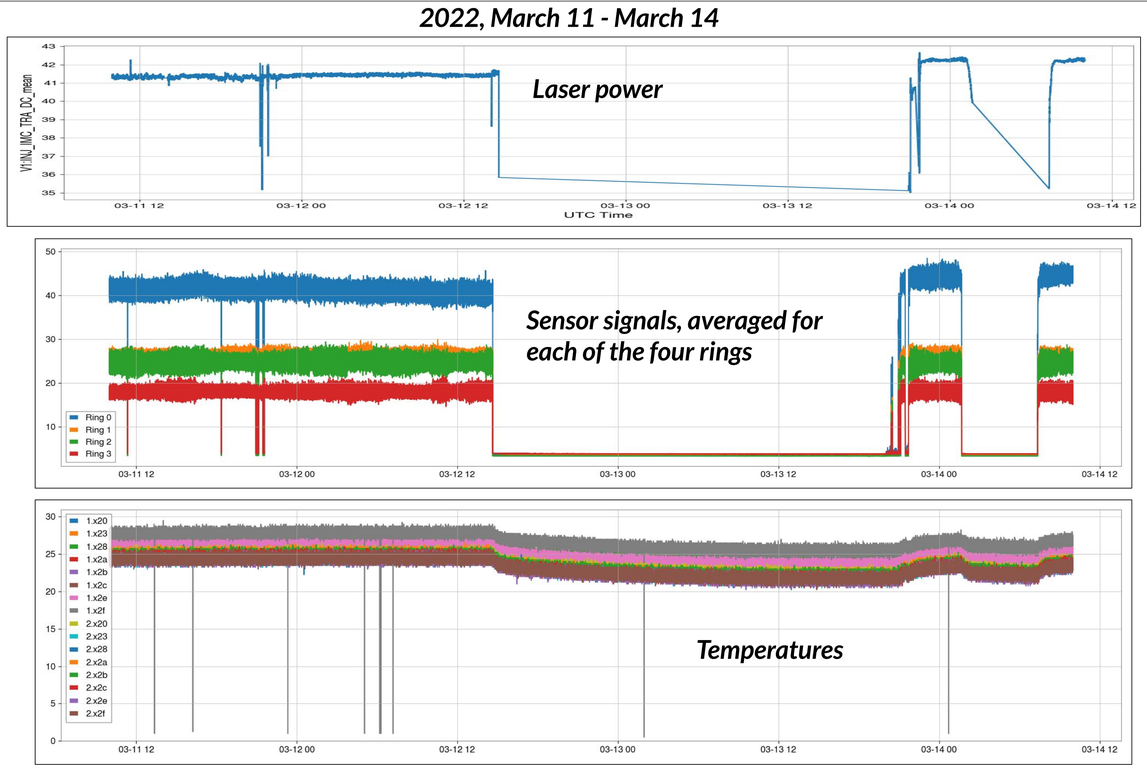
HAMAMATSU



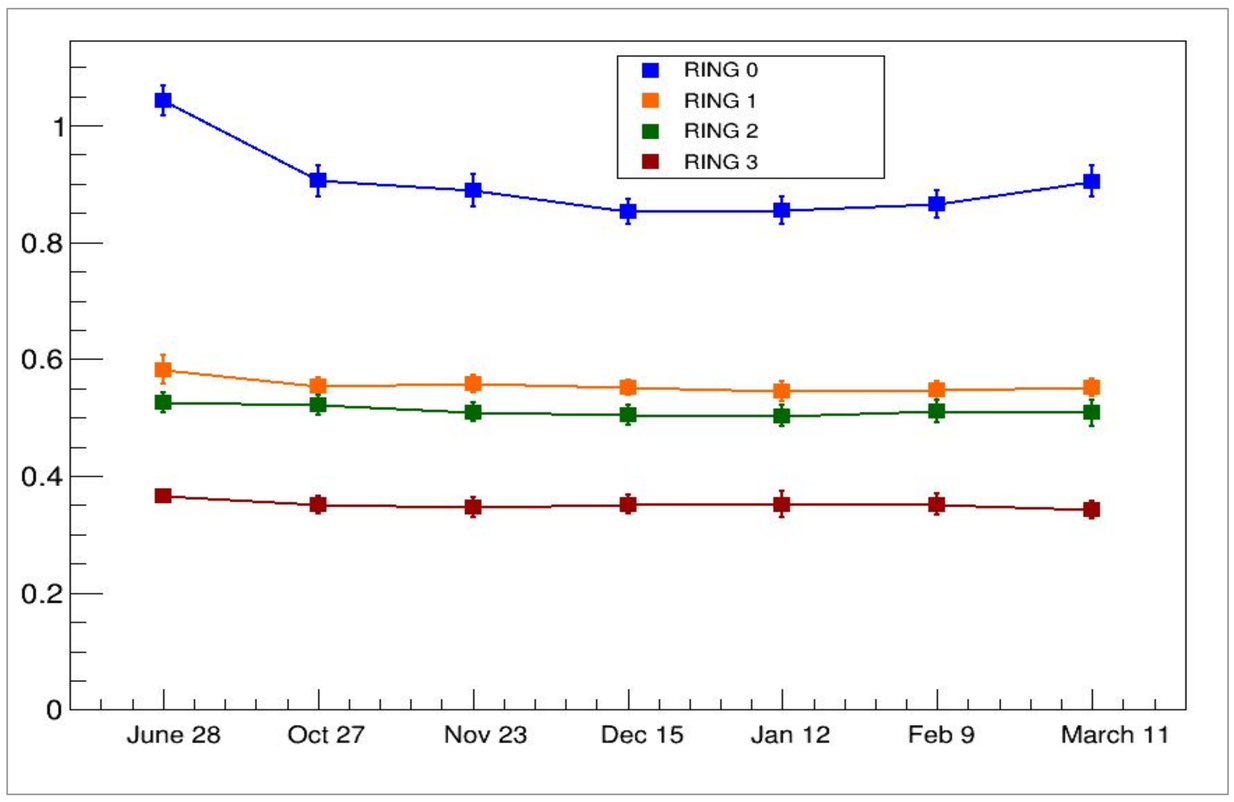
Diode dimensions	7.37 x 7.37 mm^2
Diode sensitive area	6.97 x 6.97 = 49 mm^2
Diode area covered with light	12.6 mm^2
Operation temperature	-40 to 100 ºC
Power dissipation	50 mW
Reflectivity	1.8%

Baffle operation

2022, March 11 - March 14



Long term behaviour: pedestal subtracted sensor output (normalized to injection laser power) averaged for each of the four rings

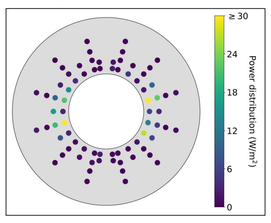


Comparison data with simulations

- Data and simulation show same φ dependence (peaks at φ ~ 15º and φ ~ 195º)
- **Mainly due to MC1 and MC3 surface maps**

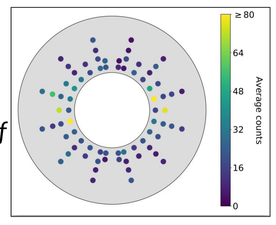
Simulation

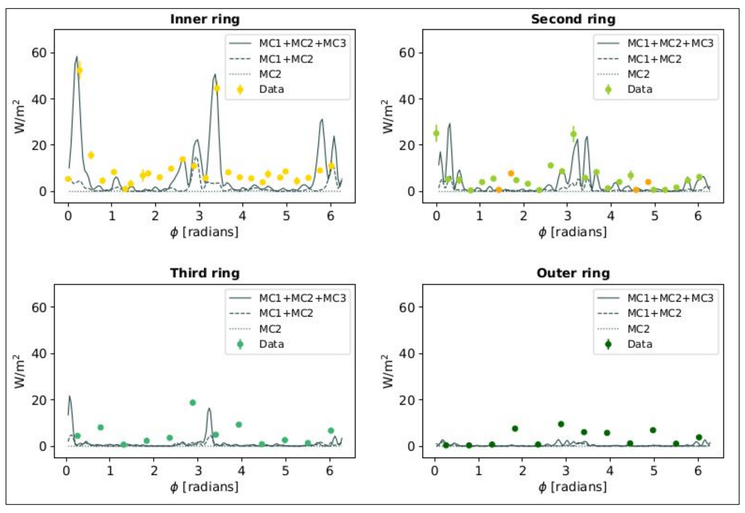
Simulation assumes nominal laser power of 28.5 ± 0.1 W



Data (2021-06-15)

Data averaged over a period of one hour. Readout rate = 2 Hz





Conclusions

- Stray light is a significant source of noise with a large effect on interferometer sensitivity.
- IFAE has designed an instrumented baffle which was successfully installed in April 2021 in the Virgo IMC cavity and is fully integrated in the Virgo data system.
- Baffle temperature sensors and photo sensors show stable output.
- Optical simulations show good agreement but better mirror maps are needed.
  - Light distribution in the baffle dominated by scattering from mirrors "MC1" and "MC3".
- Experience with IMC baffle will help to:
  - calibrate simulations
  - detect mirror defects
  - provide tool for alignment and cavity monitoring
  - design future instrumented baffles for test masses in time for O5

References:

[1]: A. Romero-Rodríguez *et al*, 2021, *Class. Quantum Grav.* **38** 045002

[2]: O. Ballester et al, 2022, *Class. Quantum Grav.* **39** 115011