Neutralising the electrostatic charges of the VIRGO test masses

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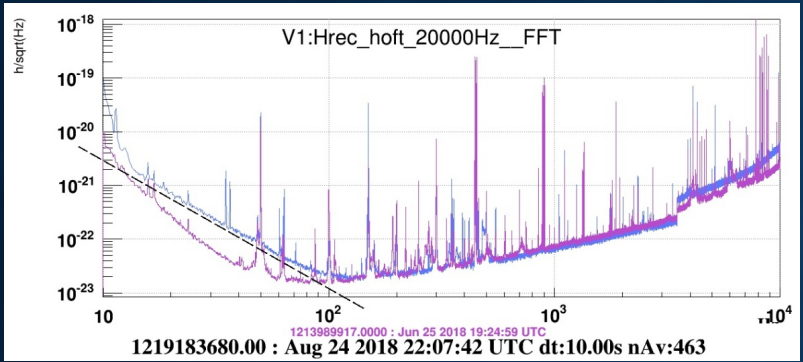
History of the electrostatic charges

A "low frequency" noise appeared in 2018 which has been removed since



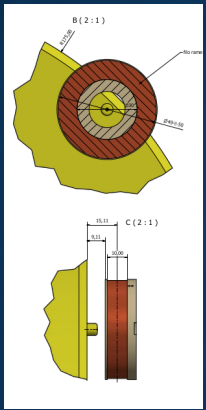
- Coupling with a faulty electronic card with the mirror electrostatic charges

“Recent” history of the electrostatic charge

Measures made by the ENV_NOISE group at EGO (I. Fiori, F. Paoletti, M. Tringali)

- Injecting a signal through the electromagnetic control coils (very invasive)
- Charge of ∼100 pC but localization, polarity and distribution are unknown

Coil	Q_{mir} (pC)	V_{mir} (V)
WI_{DL}	77.3±22.4	80.1±22.9
WI_{DR}	146.2±42.3	151.4±43.2
WI_{UL}	71.3±20.6	73.8±21.1
WI_{UR}	89.5±5.9	92.7±26.5



- Monitoring and neutralisation will be mandatory for future upgrades

Electrostatic noises

Reducing the mirror charges without direct intervention (simulations and developments)

- Design of 2 neutralisation systems:
  - N_2 plasma generation by RF fields
  - Corona discharge (streamer) by HV needles

Monitoring of the charges (simulations)

- Monitoring pads under the mirrors

Origin and "cleaning" of the charges (simulations)

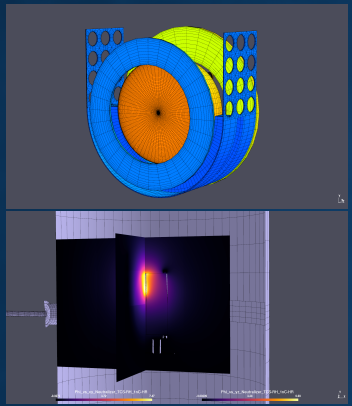
- Collecting spheres connected to electrometers

Neutralisation: simulations

Electric field simulations and charge transport on GPU:

- Charge distribution on the dielectric material
- Electric field calculation depending on the neutralisation system
- Charge transport for system optimisation
- Adjusting the pressure, electrostatic lensing for charge focusing, streamer ignition conditions...

▶ Invasive system requiring to break the chamber vacuum to reach the desired pressure (few mbar of N_2)

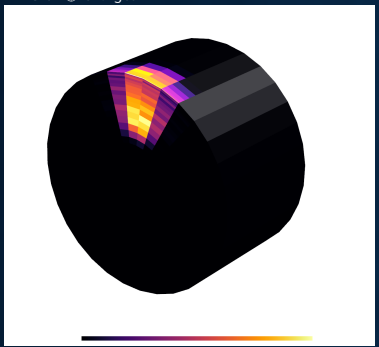


Neutralisation: simulations

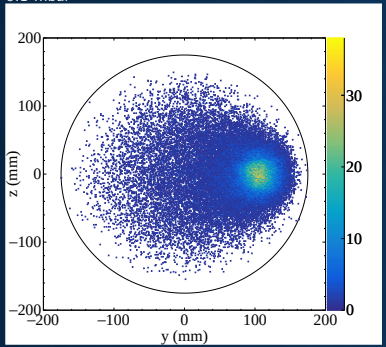
Effect of the tower pressure:

- UHV less invasive: no need to break the vacuum
- Low pressure (0.1 mbar): shutdown of the ITF

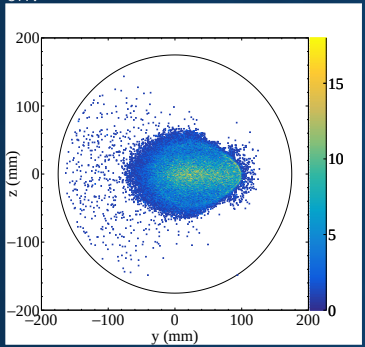
1 nC of $\oplus$ charges



0.1 mbar



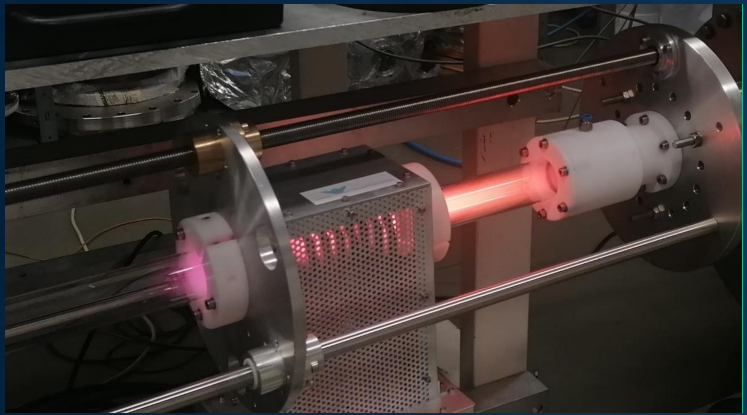
UHV



Neutralisation: developments at EGO

R&D on the neutralisation systems by the VAC team

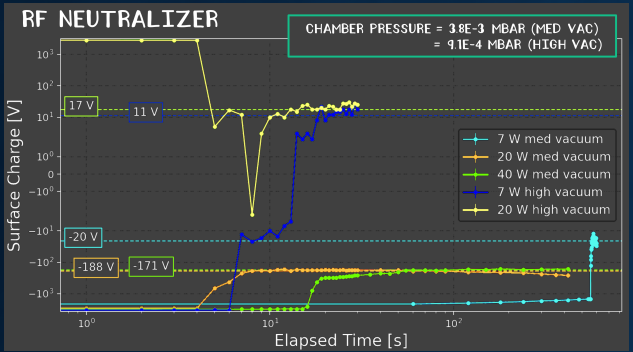
- RF plasma system using N_2:



Courtesy B. D'Angelo

Neutralisation: developments at EGO

RF system: results

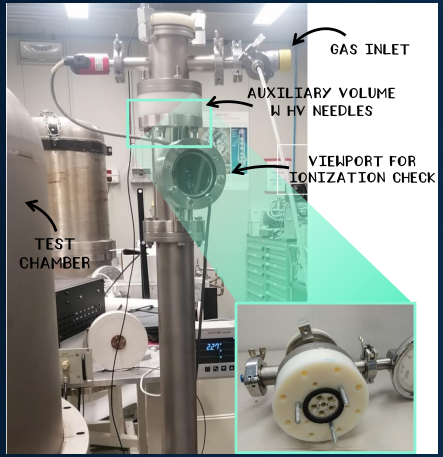


Courtesy B. D'Angelo

- Charging a dielectric by friction inside the vacuum chamber
- Electric potential measurement using a close electrometer probe
- Neutralisation seems correct but not complete...
- ▶ Difficult to control the neutralisation process (plasma ignition, automatize valve opening)

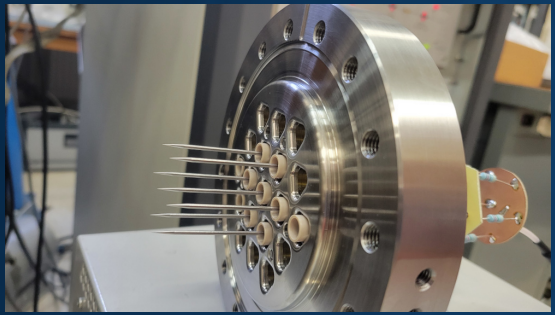
Neutralisation: developments at LPC

R&D on a pulsed HV system using the Corona effect (streamer)



Courtesy B. D'Angelo

- Design and production of a prototype
- Plasma is generated by pulsed HV tungsten needles in N_2 or Ar
- Tests to extract the optimised parameters for the streamer development (pressure, HV, polarity, frequency)

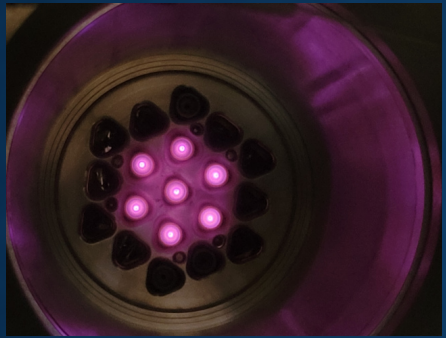


Neutralisation: developments at LPC

First results using:

- N_2

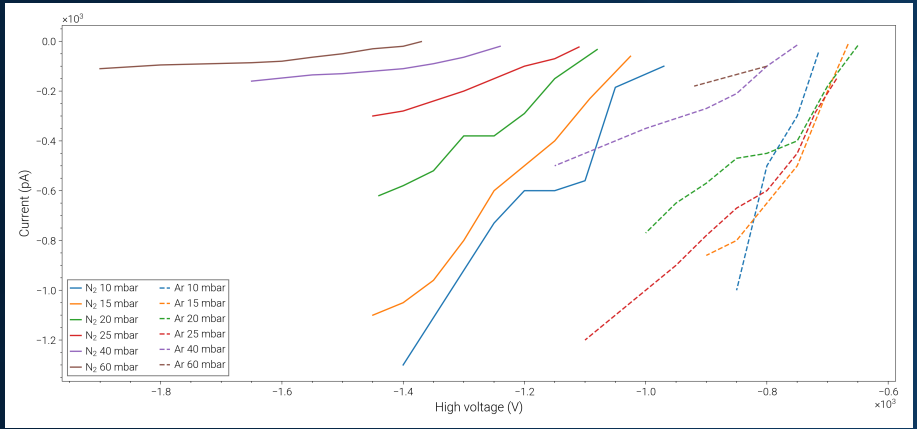
- Ar



Neutralisation: developments at LPC

Measured current with 7 needles

- Bare wire connected to a pico-ammeter 30 cm in front of the device



Summary

The mirrors are known to be electrostatically charged, but:

- Unknown coupling in Hrec
- Unknown origins of the charges
- Monitoring the neutralisation process and “cleaning” of residual charges

Integration in VIRGO

- the 2 different systems are being developed simultaneously but awaiting approval of the Product Readiness Review for remaining founding
- Tests foreseen for the end of O4 for both systems
- Integration for AdV+ phase II (O5) using multiple or a moving system