### External Environmental Noise Influences on Virgo during O3


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### Introduction

Despite the seismic isolation system of test masses, the detector’s performance has been significantly degraded during adverse environmental conditions (e.g. bad weather, sea activity, earthquakes):

- Worse low frequency sensitivity;
- Difficulty to keep the “locked” condition.

Our goals of study team:

- Understand Virgo behavior in different seismic environmental conditions:
  - Topics: Wind, Sea, Earthquakes;
  - Figures of merit: BNS range, Duty cycle, Lock losses
- Propose strategies to improve detector robustness for the future O4 run (2022)

### Example: one day of particularly unfavorable weather conditions

#### Wind and Rain

- **60 km/h**

#### Seism R.M.S. in the SEA band, during O3 – 1 year

- **0.2 Hz**

#### Wind during O3

- Daily modulation, prevalent from NE direction, 10 km/h average

#### BNS range modulation

- Averaged over a week, variation w.r.t. local baseline;
- Day/night modulation similar to wind speed and anthropogenic.

#### Earthquakes during O3

- EQ seismic wave shake mirror suspensions (≈70 Hz) causing loss-of-lock and long recovery time.

### Scattered light during high microseism

Main cause of O3 sensitivity worsening during bad weather:

- Amplified by high relative velocity of the scattering source w.r.t. the interferometer beam;
- Mitigated in O3 for Virgo output and end benches, by acting on the suspension top stage to follow the test mass suspension (“tracking control”);
- SWEB (Suspended West End Bench) inertial damping was the main culprit. SNR BNS mirror velocity at least 10x smaller;
- Noise can be modeled and subtracted online using auxiliary witness channels → M. Was et al. doi:10.1103/2011.N0539

### How to improve EEWS?

- Current ranking: (magnitude, distance, time) ≥ (0.01 cut);
- Improved adding other parameters (depth, location, freq.);
- Seismic alert is based on US-based USGS network; not effective for Mediterranean areas; introduce early warning stream from Italy-centered network (ASPIS - Early-Ex, doi:10.5194/nhess-15-2018-2015);
- Implement a distributed network of seismometers ≥250 km from Virgo (AEGIS project);
- Identify sensible degrees of freedom of the interferometer.