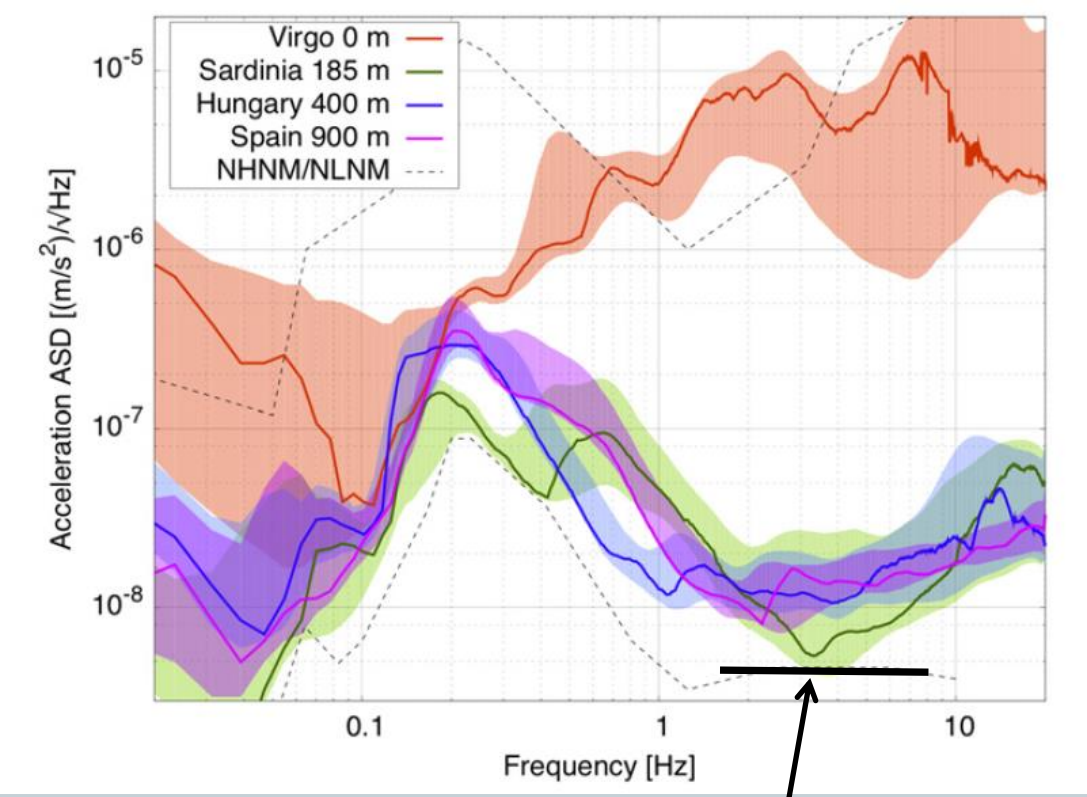
Low-Frequency Impact

JAN HARMS & JENNE DRIGGERS

GWADW 2016

Underground Seismic Spectra

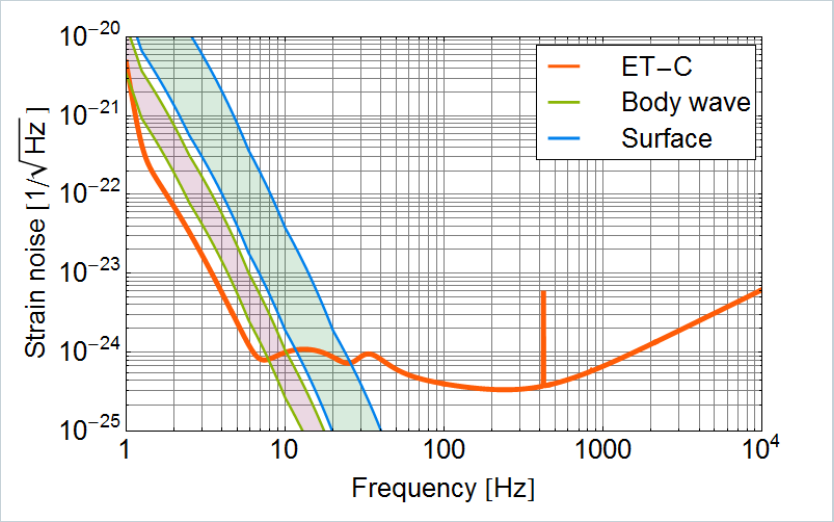
Beker et al, 2012



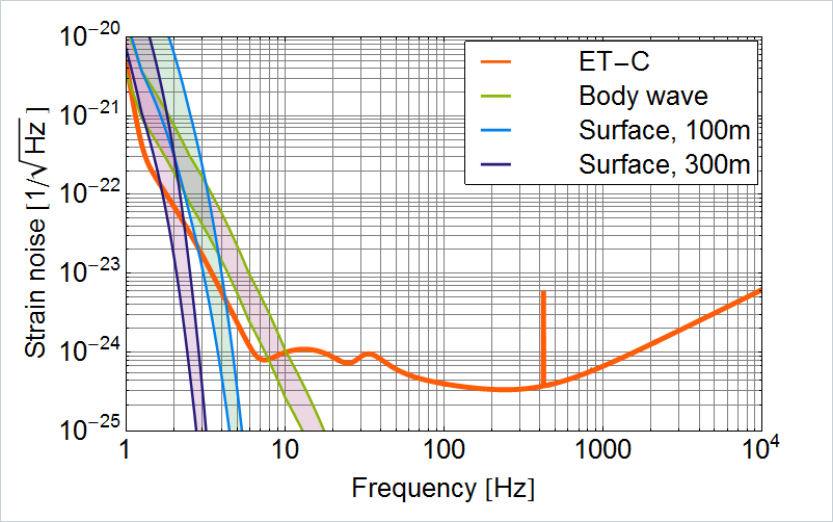
Requirement ET
(conservative: underground displacement dominated by compressional waves)

Seismic NN

Seismic NN in a surface detector

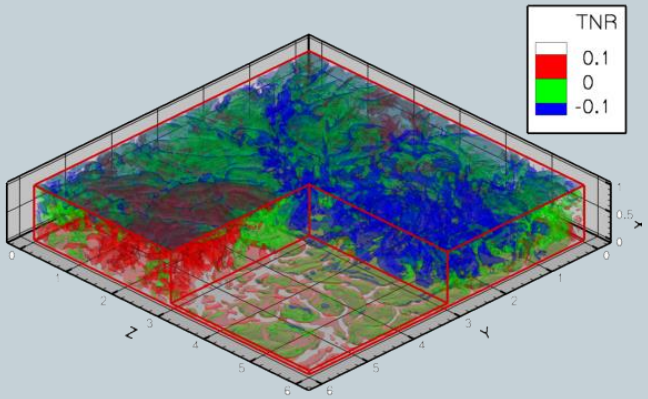


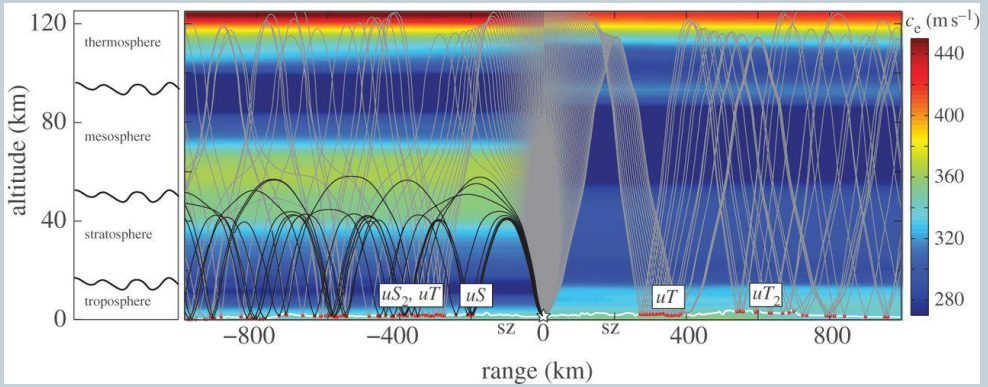
Seismic NN in an underground detector



- Seismic models: Body wave: 3x – 12x LNM, Surface: 50x – 1000x LNM
- Rayleigh dispersion model: 1.5km/s @ 1Hz → 300m/s @ 10Hz
- Includes contributions from cavity-wall displacement
- Homogeneous half space (except for Rayleigh dispersion)

Modelling Atmospheric NN

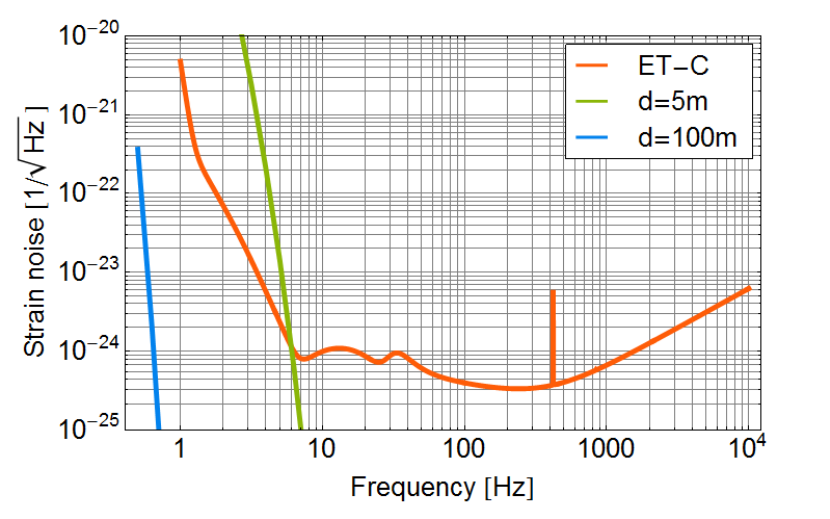




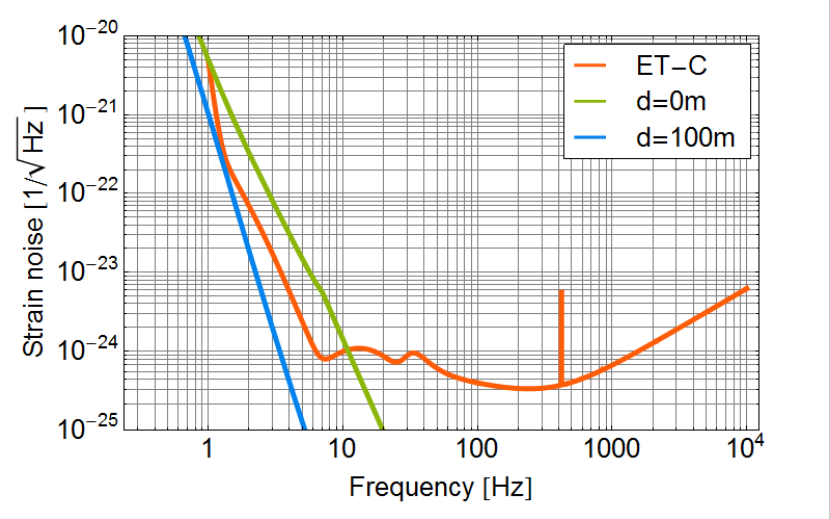
- Atmospheric NN
  - (So far poorly modelled) quasi-static temperature perturbations advected along (so far poorly modeled) streamlines
  - Sound propagation inside atmosphere and laboratory buildings (scattering not yet simulated)

Atmospheric NN

Temperature NN
Uniform air flow, v=20m/s

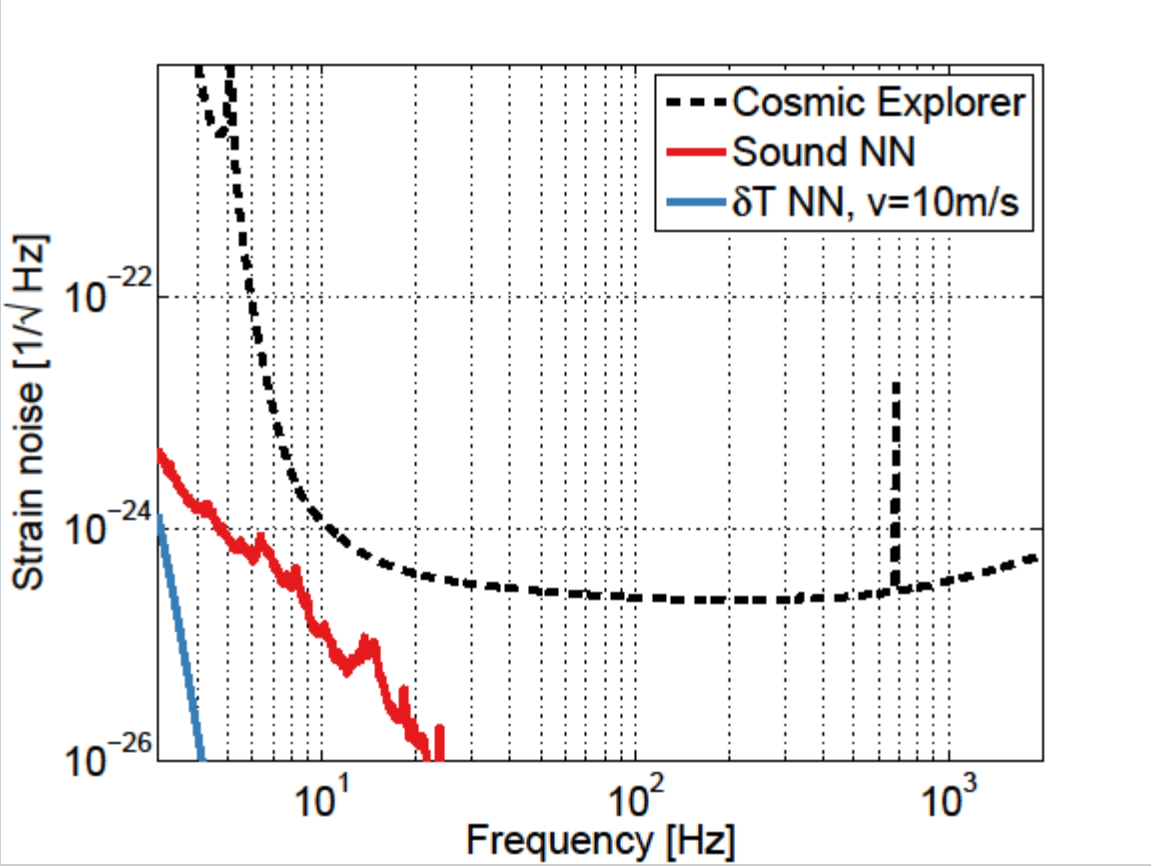


Infrasound NN



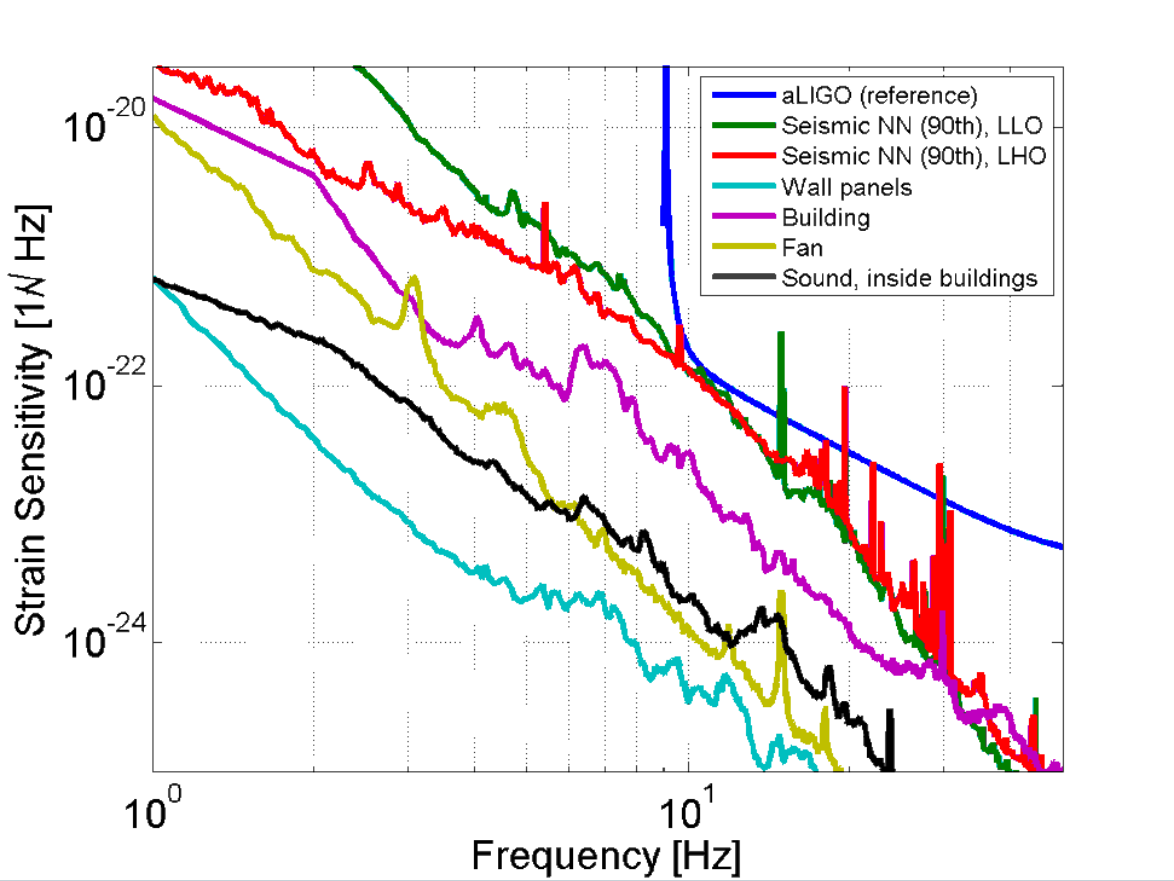
- Atmospheric NN limits sensitivity of ET-type detectors if built at the surface
- Going underground very efficiently suppresses atmospheric NN
- Atmospheric NN will be extremely challenging to cancel

Cosmic Explorer



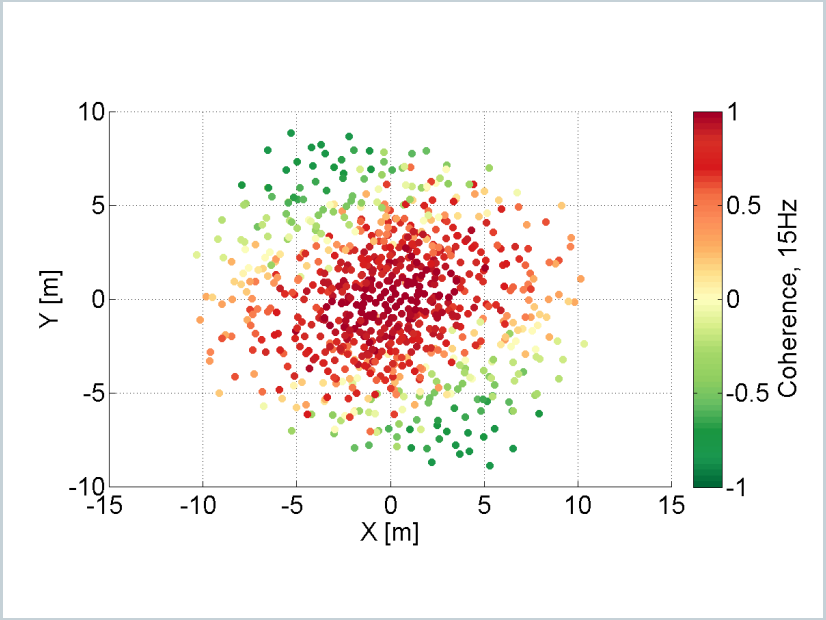
NN in Advanced LIGO

Driggers et al, 2012

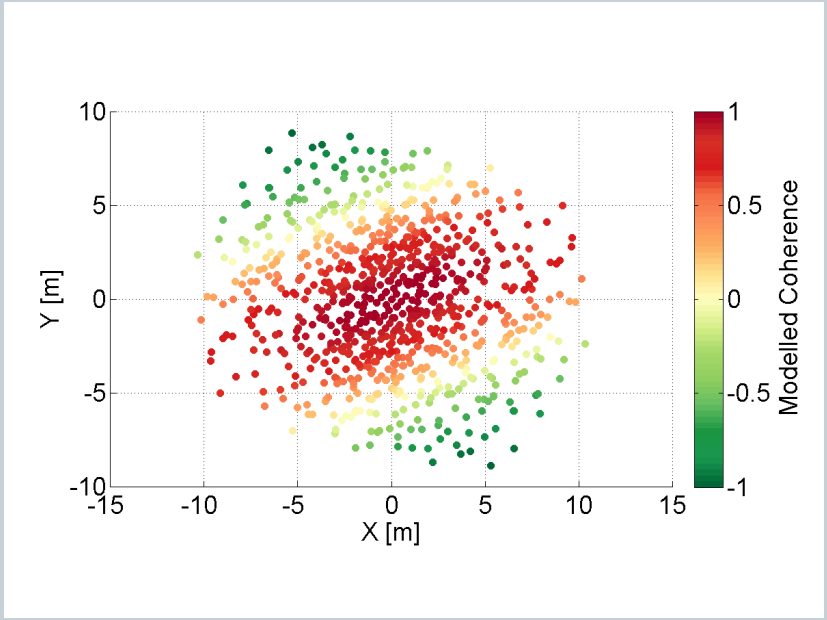


LIGO Hanford Measurements (2012)

Observation

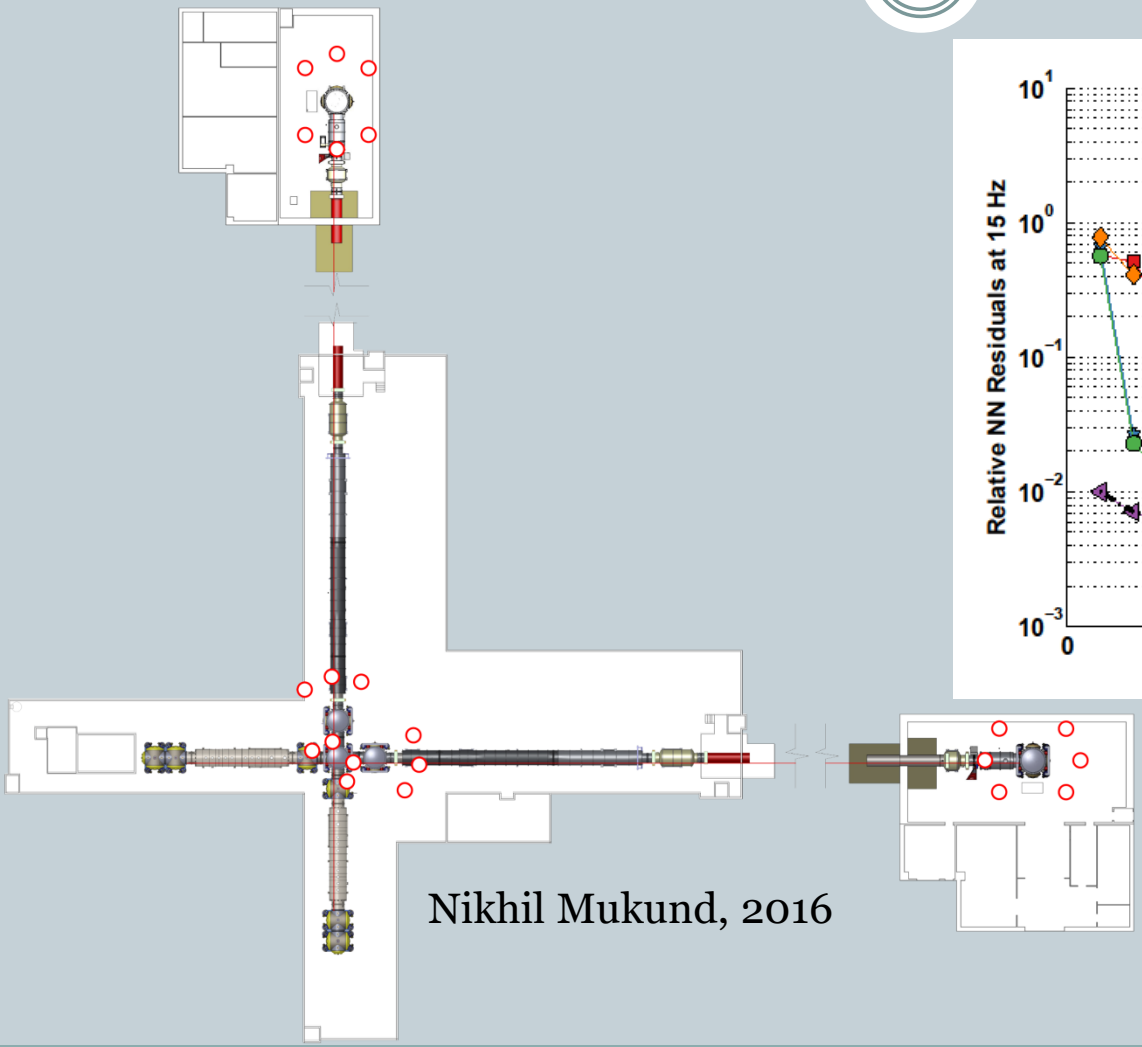


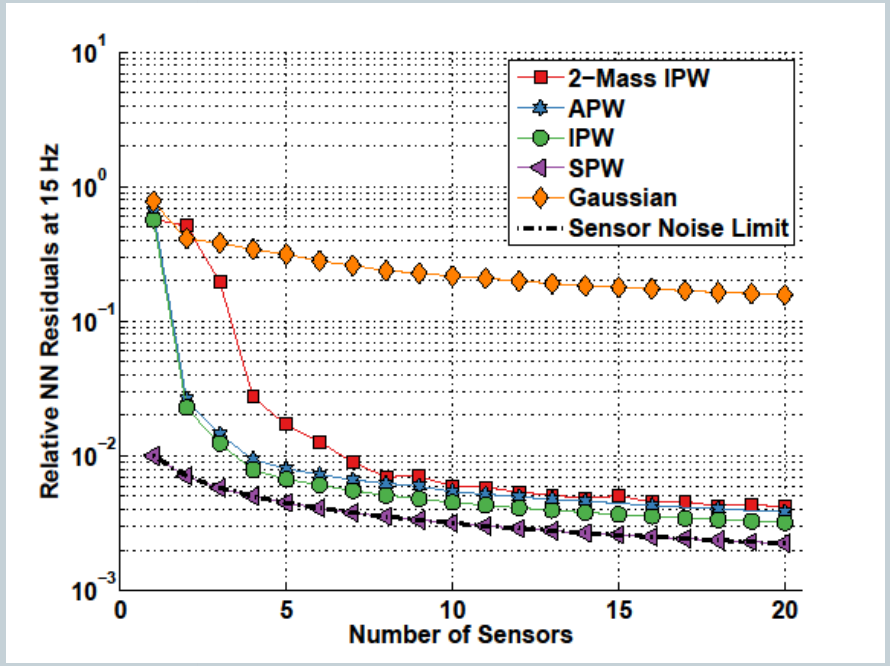
Plane-wave model



- Anisotropic, plane-wave model gives qualitatively good match with observation
- Mismatch is not minor. It demonstrates inhomogeneity of the seismic field, due to local seismic sources

NN Cancellation



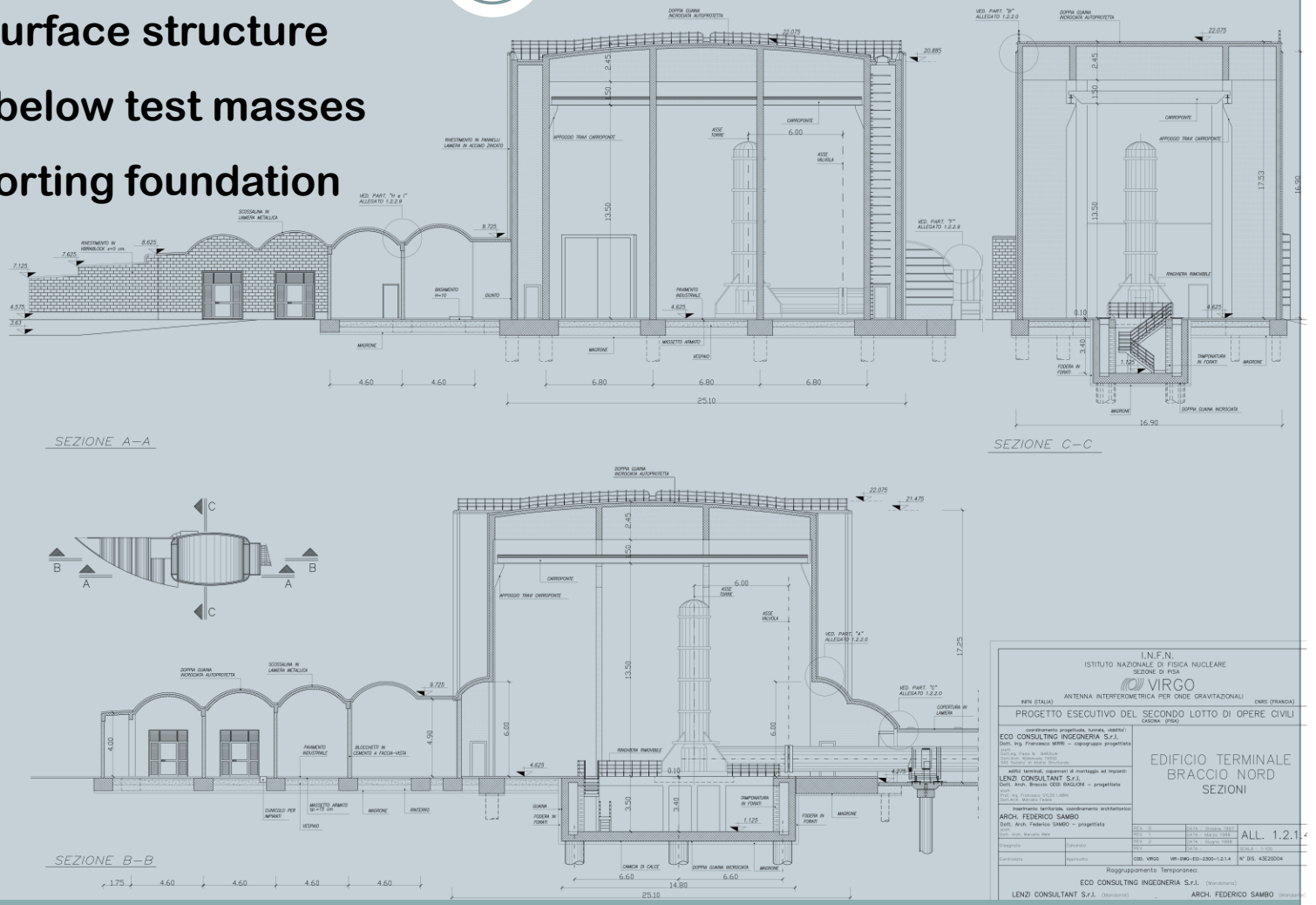


Nikhil Mukund, 2016

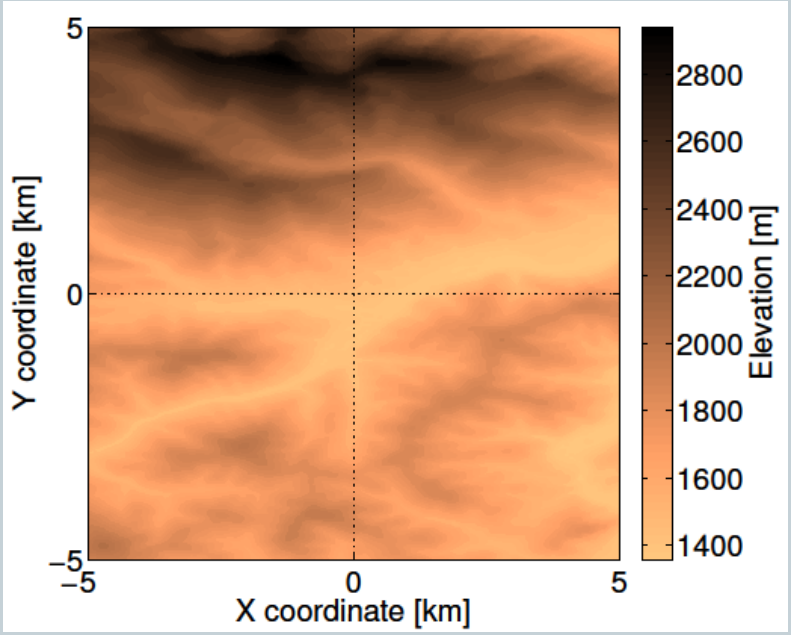
Advanced Virgo

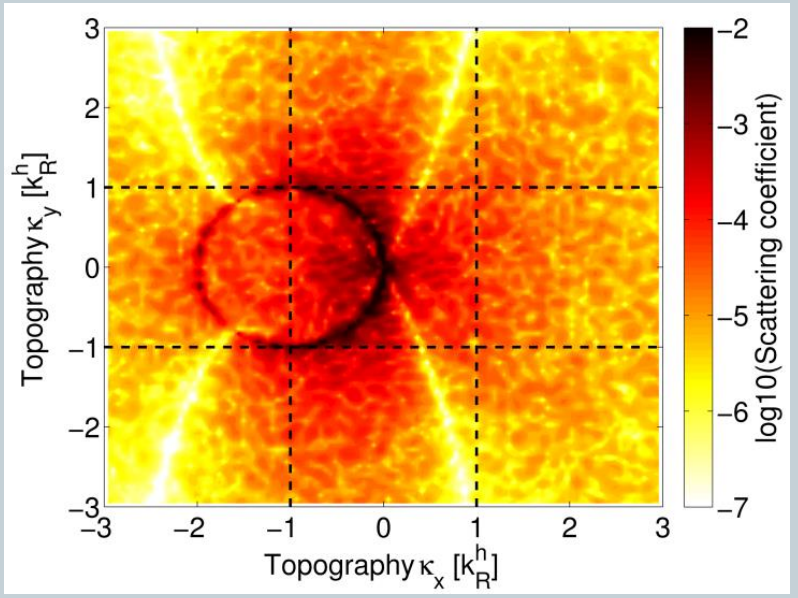
Complicated surface structure

- **Lab space below test masses**
- **Poles supporting foundation**



Topographic Scattering





Class. Quantum Grav. **29** (2012) 075004

- So far, calculations of topographic scattering only carried out in Born approximation
- Measurements with Sweetwater array confirm that seismic correlations are complicated in regions with rough topography

Constrains on Observatory Designs

- Surface
  - Wind noise – Few meters underground or aerodynamically shaped buildings?
  - Strong seismic noise from local sources – Improve design of laboratory infrastructure?
  - How much digging required for 40km arms?
- Stick ends into mountains
  - Strong mitigation of atmospheric NN
  - Detrimental effects on seismic NN cancellation (necessarily complex topography)
- Underground
  - Detector infrastructure – How to avoid elevated underground seismic noise?