Advancements in the Einstein Telescope project

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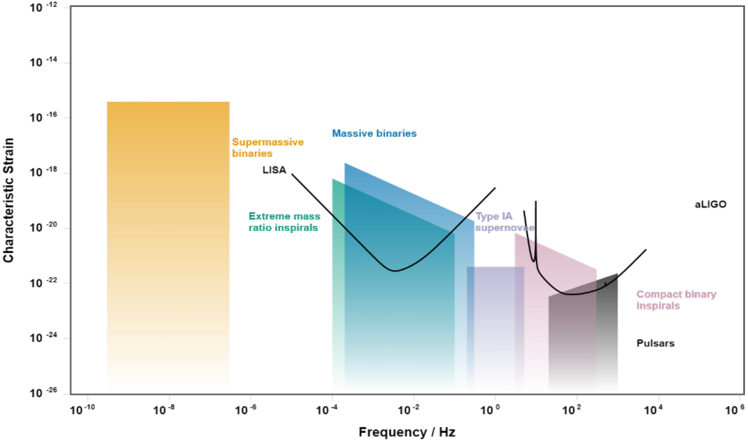
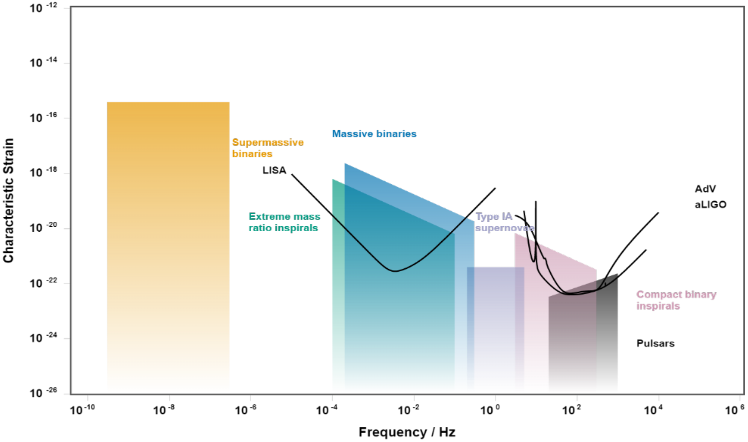
LIGO

Hanford and Livingston, USA, 4 km long arms.



VIRGO

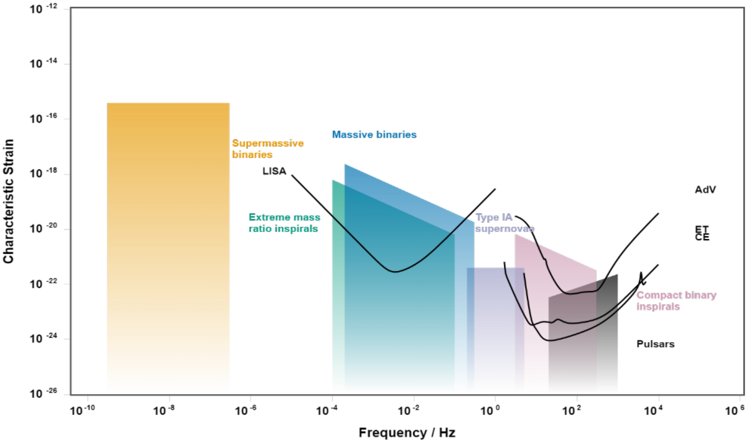
Santo Stefano (near Pisa), Italy, 3 km long arms.



... and many others exist or planned (space or ground-based).

Aims: wider frequency range + higher sensitivity.

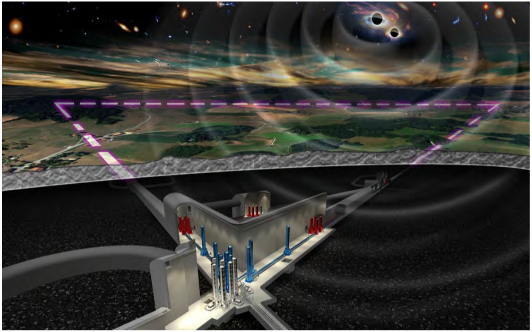
Detectors are designed for specific frequency intervals.
Einstein Telescope (ET): $\sim 1 - 10^4$ Hz. Critical part: $\sim 1 - 10$ Hz.

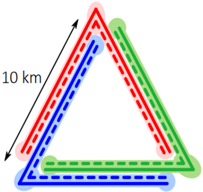


Competitor from USA: Cosmic Explorer (CE), 40 km arm length.

ET design

Underground facility. LF and HF instrumentation for each arm. Overall: 6 detectors. Cryogenic.





OR: two 15 km length L-shaped arms: better sensitivity props.

KAGRA (Japanese): underground water difficulties.

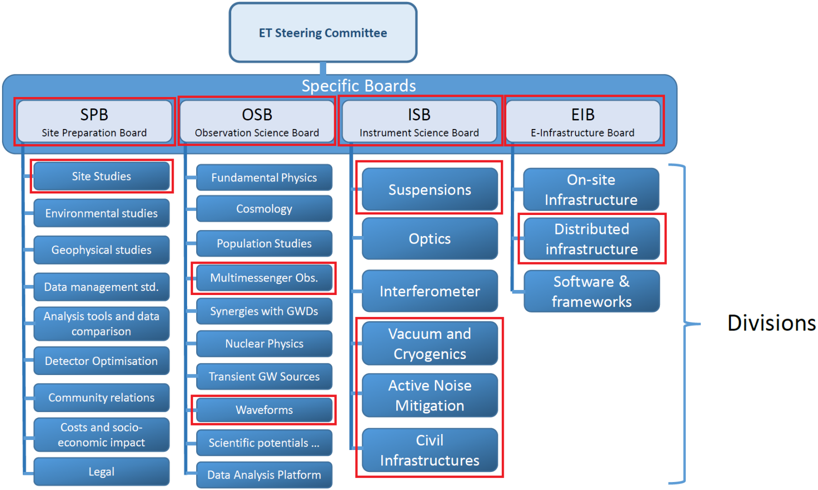
Organization

ET collaboration is formed in June, 2022, Budapest: $\sim 1000+$ collaborators.

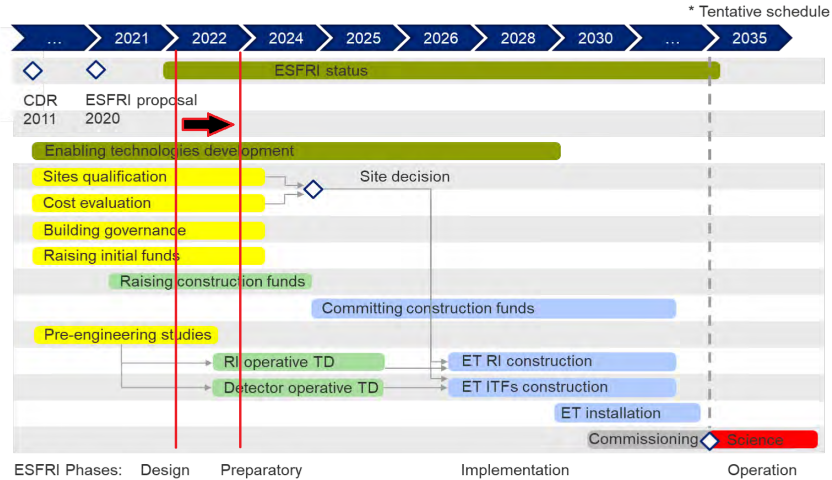
CERN recognized experiment? $\Rightarrow$ YES.
Collaboration in vacuum pipe system design.

Kick-off events for specific boards are finished in Q1 2022.

Joining to the boards is still continous.
Groups from Hungary: Wigner RCP, BME, ATOMKI, Konkoly Observatory.



+ advisory and ethics committees.

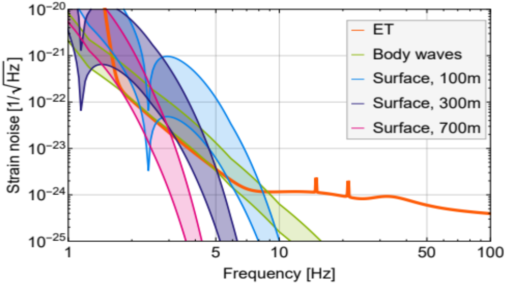


Horizon proposals: INFRA-DEV has received funding.
Technical Design Report is under preparation.

Newtonian noise?

Crucial for high sensitivity.

Pressure variation in the atmoshphere and rocks.
NN contribution of shear and body waves in rocks:
T. Andrić, J. Harms



Filtering?

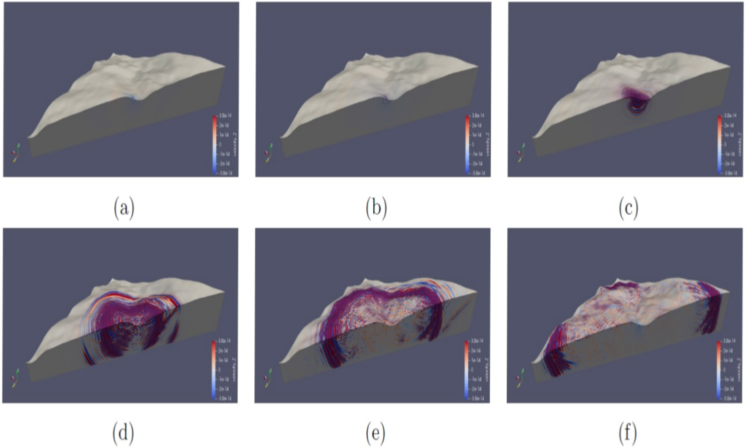
First attempts of VIRGO

T. Andrić, J. Harms:
Providing priors to Bayesian array optimization,
ET – Site studies and characterization, 08.-11. 11. 2021.

Geology+topography → numerical simulations → seismic correlations in 3D.

Seismometer measurements → filters.

T. Andrić, J. Harms:
Using SPECFEM3D: only Hookean (elastic) model.



Does not really work as intended...what is missing?

Rheology

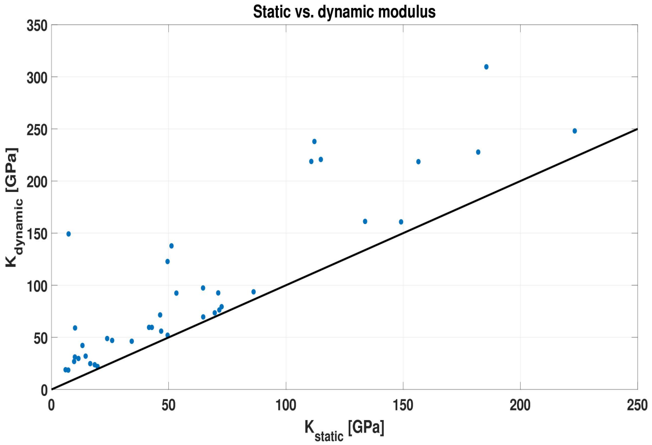
Collaboration with M. Szücs, T. Fülöp, P. Ván and ROCKSTUDY Ltd. (HU)

Hookean case: $\sigma = E\varepsilon$. Elastic model, no dissipation.

Poynting-Thomson-Zener case: $\tau\dot{\sigma} + \sigma = E\varepsilon + \hat{E}\dot{\varepsilon}$.

Complex dissipative behaviour, damping, thermal effects.
$\rightarrow$ Thermal expansion.

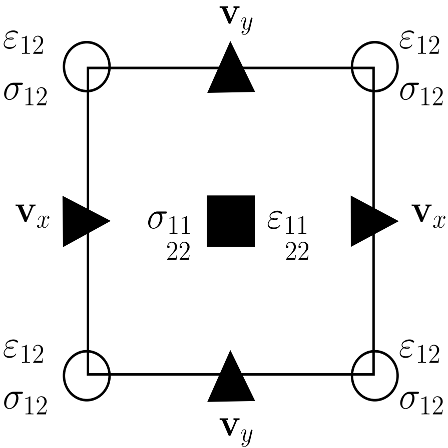
$+$ extra time scales (numerical methods $+$ measurements), dynamic vs. static


Static vs. dynamic modulus
$K_{dynamic}$ [GPa]
K_{static} [GPa]
0
50
100
150
200
250
300
350
0
50
100
150
200
250

Challenges for numerical solutions:

conserving energy: symplectic schemes

free from numerical dissipation and dispersion



1. Cylindrical object, elastic vs. rheological behaviour.
2. Temperature evolutions.

$\Rightarrow$ More realistic and accurate estimation for wave propagation.

$\Rightarrow$ More precise NN prediction.

Next step: absorbing boundary conditions, see the poster of M. Szücs.

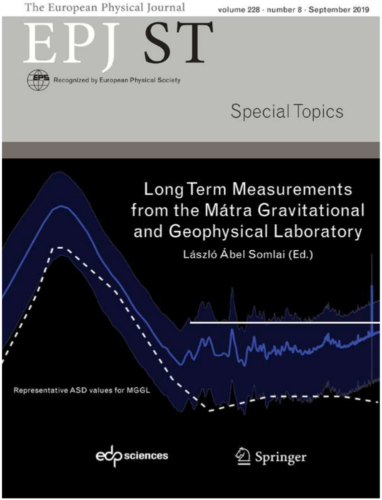
Gravitation in Hungary I.

P. Ván et al.: repeating the Eötvös experiment.

Jánossy Laboratory (Wigner)

Gravitation in Hungary II.

- MGGL underground lab.
- Mátra as former candidate for ET site.
- Seismometers.
- Infrasound detector.
- Magnetometer.
- Muon detector.
- Long-term seismic results.



Gravitation in Hungary III.

P. Ván and M. Pszota: modified theory of graviation.
(See their poster.)

Thermodynamic origins: internal variable - gravitational potential,

$u = e - \varphi - \frac{\nabla\varphi\cdot\nabla\varphi}{8\pi G\rho}$.

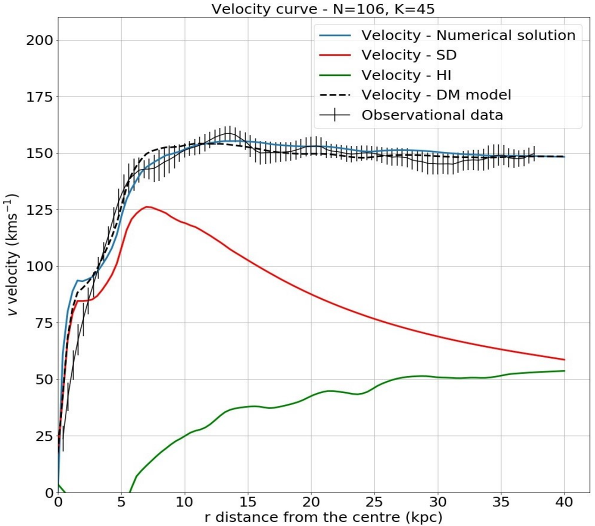
Constraints: balances.

$$\dot{\rho} + \rho\nabla\cdot\mathbf{v} = 0, \quad \rho\dot{\mathbf{v}} - \nabla\cdot\mathbf{P} = \mathbf{0}, \quad \rho\dot{e} + \nabla\cdot\mathbf{q} = -\mathbf{P} : \nabla\mathbf{v}.$$

Time evolution for φ: $\tau\partial_t\varphi = l^2\left(\Delta\varphi - K(\nabla\varphi)^2 - 4\pi G\rho\right)$.
$+$ Thermal and mechanical fields.

Gravitation in Hungary IV.

P. Ván and M. Pszota: testing on experimental data.



Thank you for your kind attention!