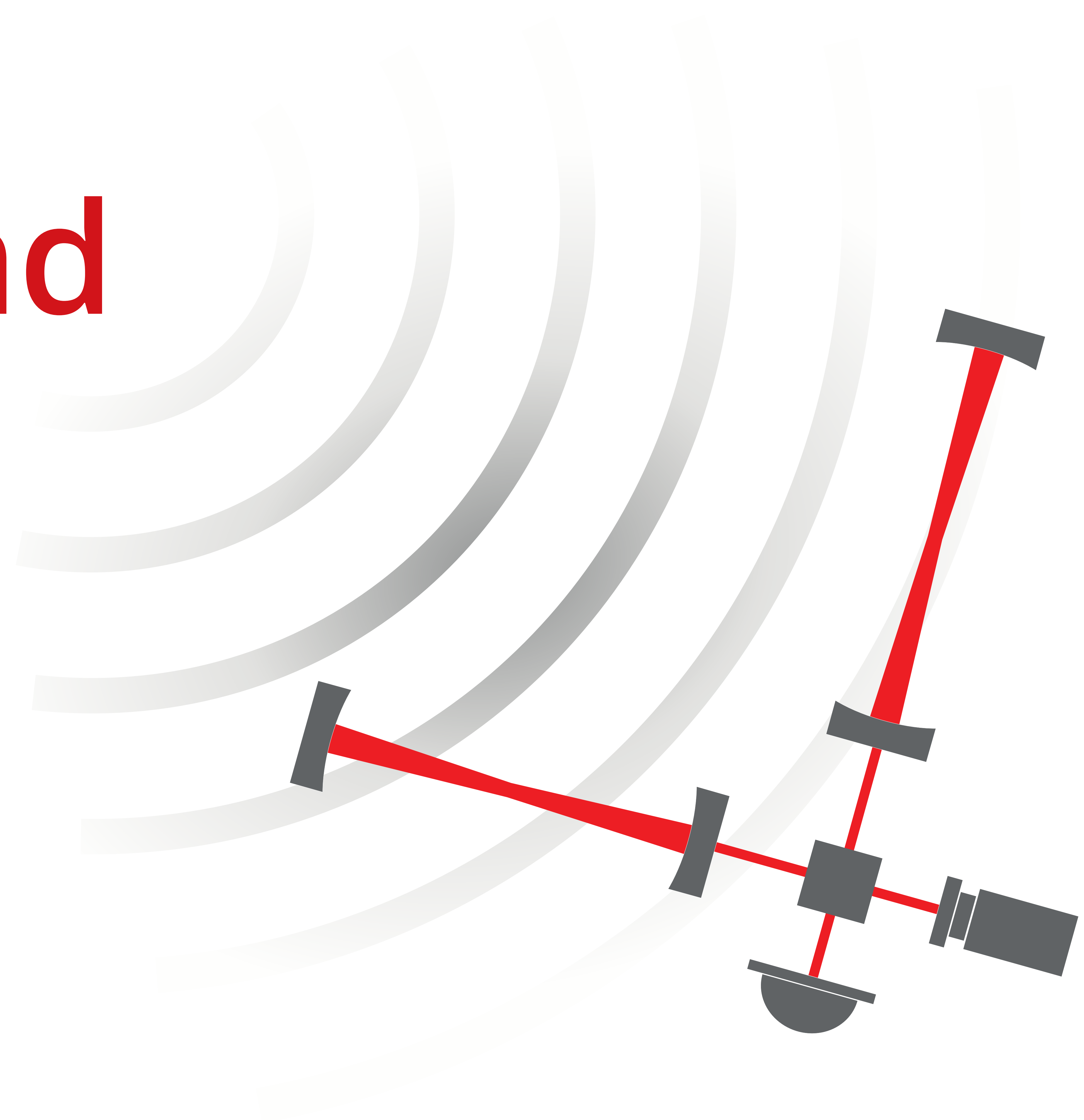
# Gravitational Waves, Einstein Telescope and Future Accelerators

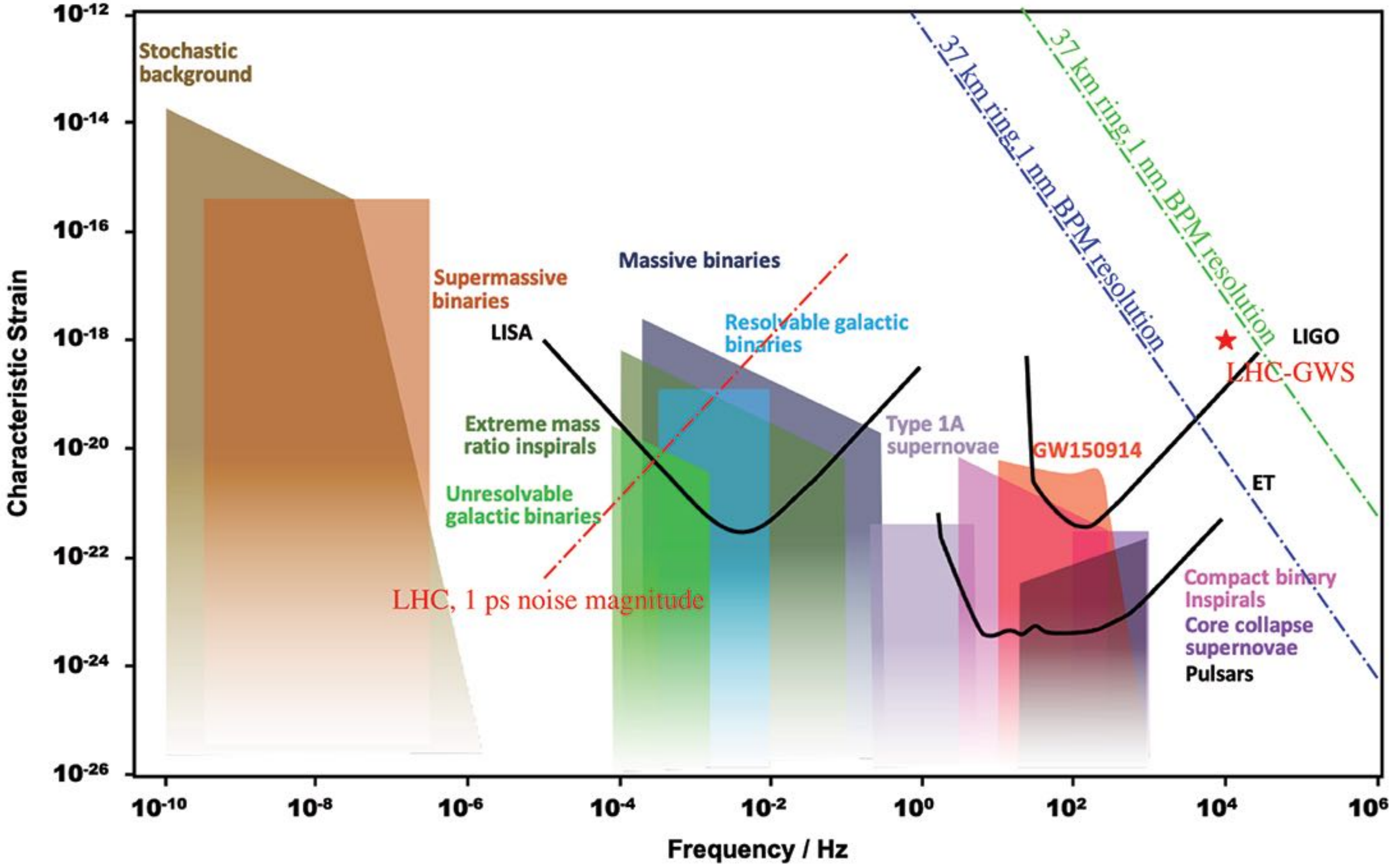


Andreas Freise
Nikhef strategy day, 15.10.2024

# Accelerators meet gravitational waves

science

The workshop with this very promising title was held at CERN in 2021, seems largely explore the options to detect GWs with accelerator physics.




https://cerncourier.com/a/accelerators-meet-gravitational-waves/

# Heavy ion collisions and GWs

Science

**Article**

## Constraining neutron-star matter with microscopic and macroscopic collisions

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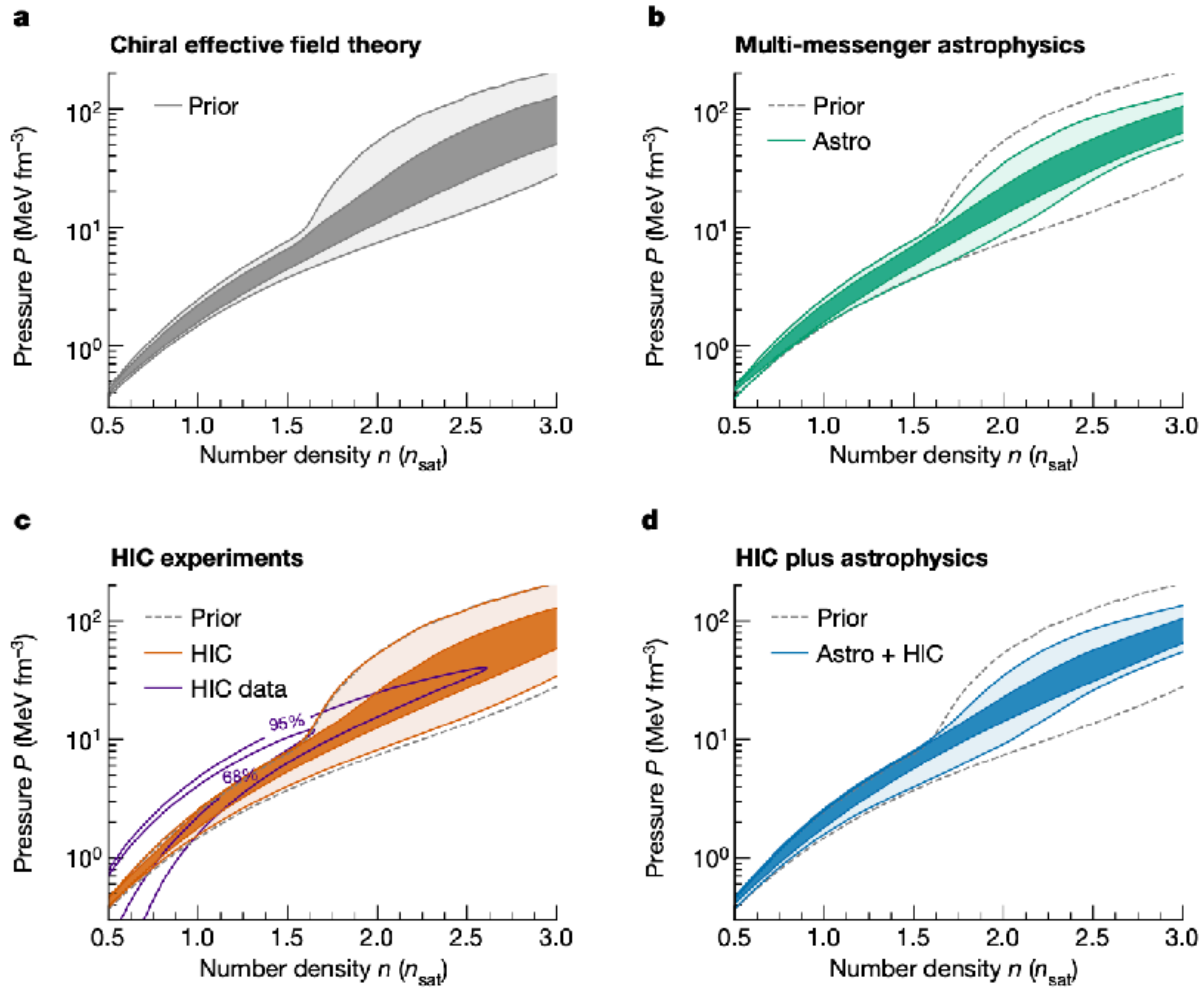
Interpreting high-energy, astrophysical phenomena, such as supernova explosions or neutron-star collisions, requires a robust understanding of matter at supranuclear densities. However, our knowledge about dense matter explored in the cores of neutron stars remains limited. Fortunately, dense matter is not probed only in astrophysical observations, but also in terrestrial heavy-ion collision experiments. Here we use Bayesian inference to combine data from astrophysical multi-messenger observations of neutron stars[1–9] and from heavy-ion collisions of gold nuclei at relativistic energies[10,11] with microscopic nuclear theory calculations[12–17] to improve our understanding of dense matter. We find that the inclusion of heavy-ion collision data indicates an increase in the pressure in dense matter relative to previous analyses, shifting neutron-star radii towards larger values, consistent with recent observations by the Neutron Star Interior Composition Explorer mission[5–8,18]. Our findings show that constraints from heavy-ion collision experiments show a remarkable consistency with multi-messenger observations and provide complementary information on nuclear matter at intermediate densities. This work combines nuclear theory, nuclear experiment and astrophysical observations, and shows how joint analyses can shed light on the properties of neutron-rich supranuclear matter over the density range probed in neutron stars.




Huth, S., Pang, P.T.H., Tews, I. *et al.* Constraining neutron-star matter with microscopic and macroscopic collisions. *Nature* **606**, 276–280 (2022). https://doi.org/10.1038/s41586-022-04750-w

# Einstein Telescope at CERN

not science

- We already make good use of CERN's technical support (vacuum, civil engineering). We strongly believe this partnership is not only useful for ET but also CERN and Nikhef. (Instead of e.g. us partnering with ESO).
- We want CERN technical teams to continue to provide support for the ET project. But we would like CERN to be allowed to use some of it's own funds for their technical support (see next slide).
- ET must not become a competitor to any accelerator related project!
- We do not need CERN to build or run ET.

# Paying CERN extra money: Cash contributions to ETO (2024-2026)

not science

| | FA | *committed* | *intention* | *remarks* |
|---|---|---|---|---|
| NETHERLANDS | Nikhef | 556 | | Vacuum project at CERN |
| | Nikhef | 112 | | Civil engineering MoU INFN-Nikhef-IFAE |
| | Nikhef | 1000 | | CERN new contracts |
| | Nikhef | | 1000 | Additional contribution granted to ETO |
| ITALY | INFN | 556 | | Vacuum project at CERN |
| | INFN | 112 | | Civil engineering MoU INFN-Nikhef-IFAE |
| | INFN | 1000 | | CERN new contracts |
| | INFN | | 1000 | Additional contribution granted to ETO |
| SPAIN | IFAE | 112 | | Civil engineering MoU INFN-Nikhef-IFAE |
| | NATIONAL | | 1000 | Proposed Spanish Central Budget for 2025, pending for approval |
| BELGIUM | VLA | 278 | | Not earmarked |
| | BELSPO | 278 | | Not earmarked |
| | WAL | | 278 | Not earmarked |
| GERMANY | BMBF | | 940 | CERN new contracts |
| | **total** | **4004** | **4218** | *8222 cash contribution* |

# Conclusion

- As far as I know, the GW science cases do not lead to a strong preference for any suggested new accelerator.
- The GW community at large (Virgo, LISA, IGWN, etc.) does not require CERN involvement. But the Einstein Telescope is unique and will require our attention no matter what.
- The ET project strongly benefits from CERN. Nikhef and CERN can benefit from ET. The ET leadership has a strong CERN background.
- We plan for ET to be visible during the CERN strategy update, and aim at a small change in the status quo. Our exact strategy is still to be decided. Input is very welcome!

… end.