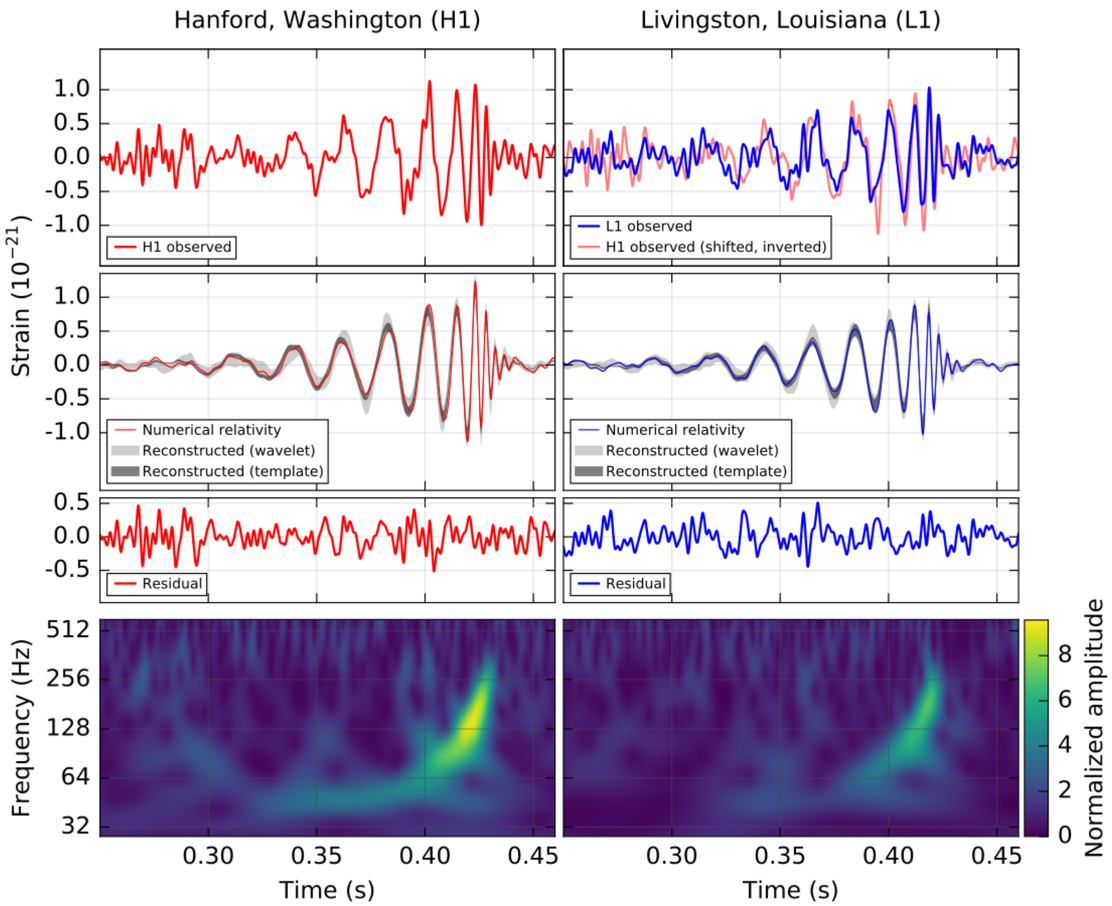
CHIPP and gravitational waves:
The Einstein Telescope

18 January 2024 @ Balsthal

The first detection of GW

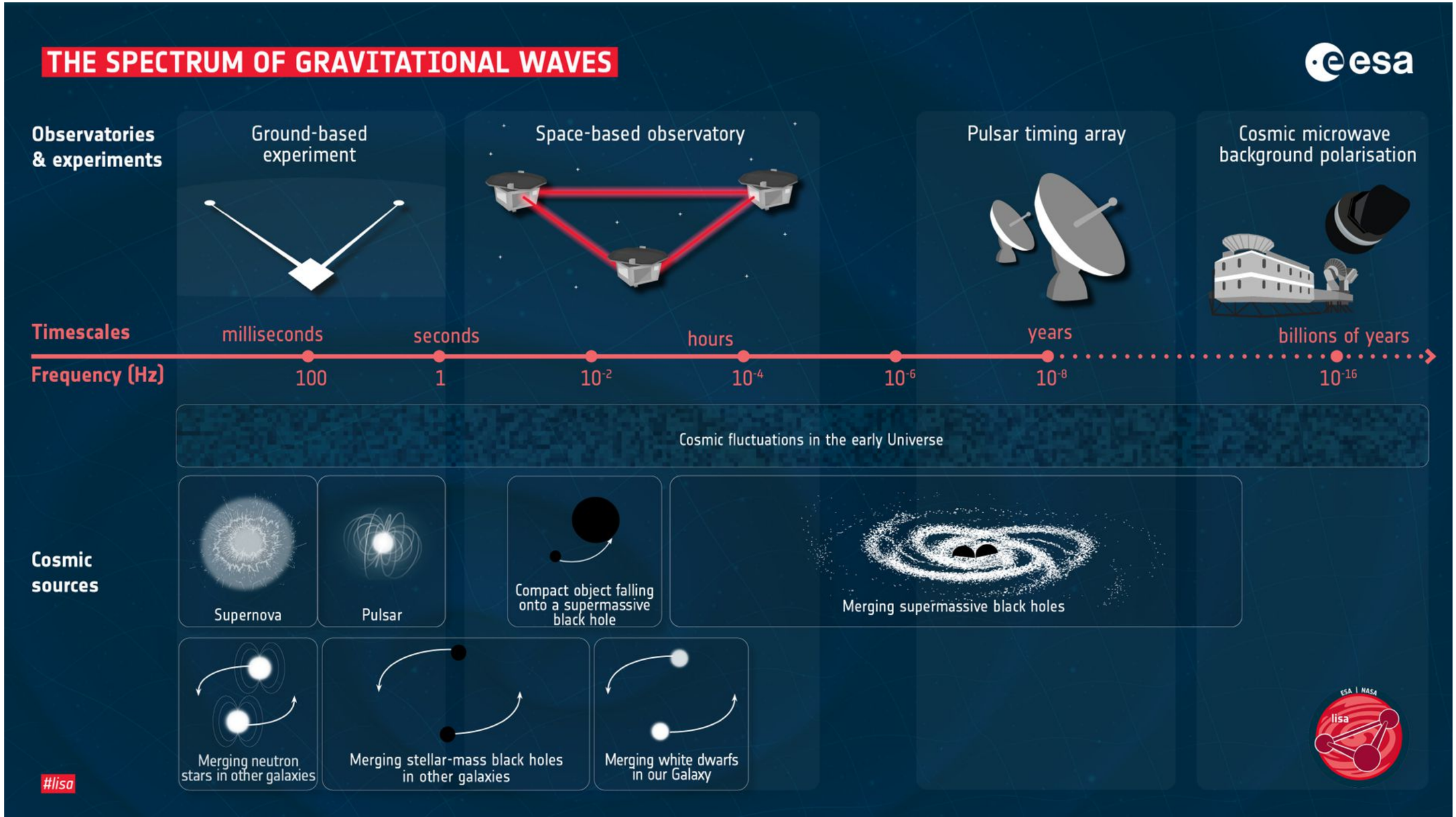


GW signals are a recent discovery
- Predicted by Einstein in 1916
- First detection was in 2015
- Announced in 2016, Nobel Prize 2017

Truly a spectacular first event
- BH1: 36 solar masses
- BH2: 29 solar masses
- Result: 62 solar masses
- **3 solar masses of GW in a few ms!**

GW are a new window on the Universe
- Advanced LIGO/Virgo lead the way

Different observation strategies



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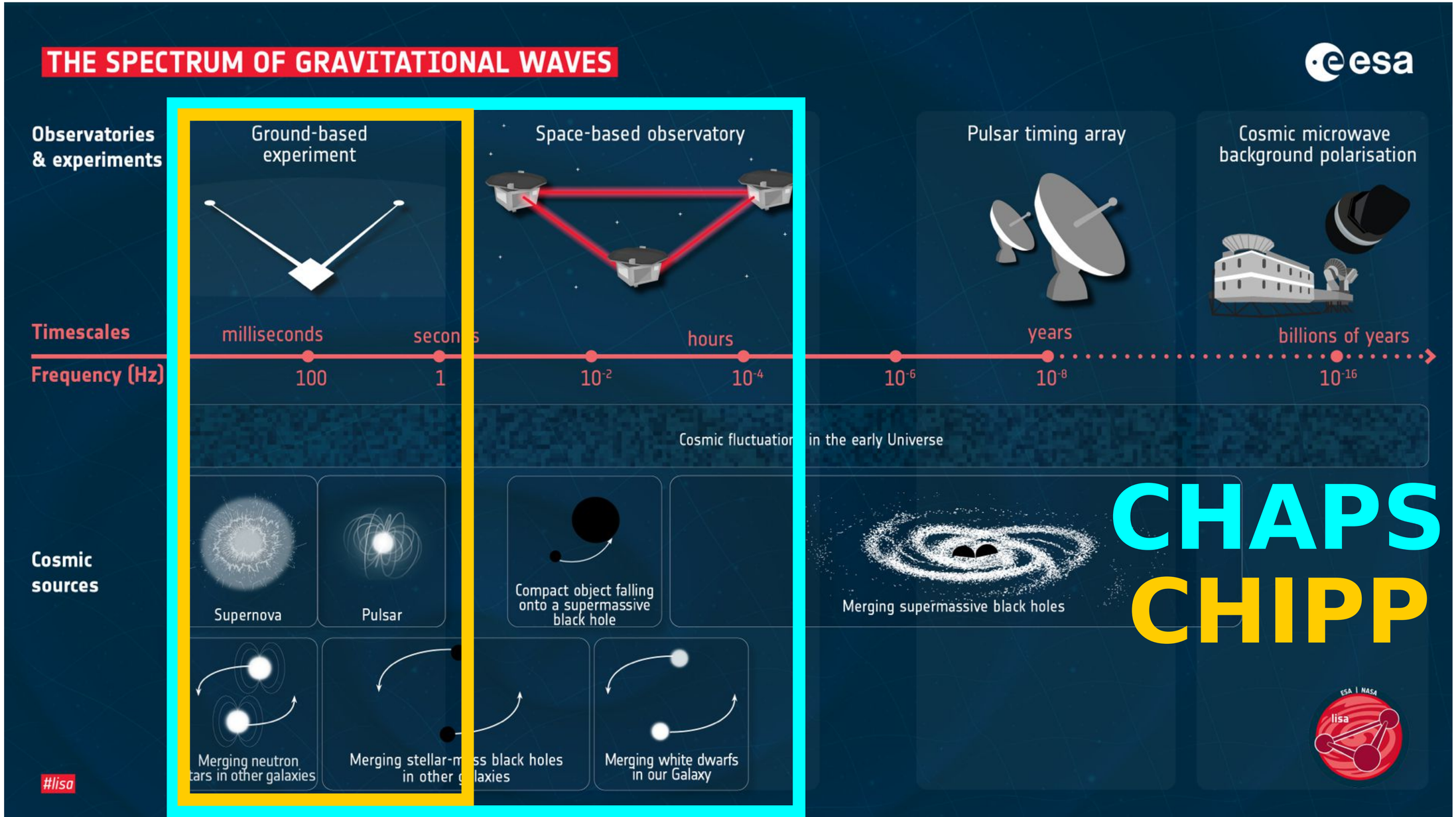
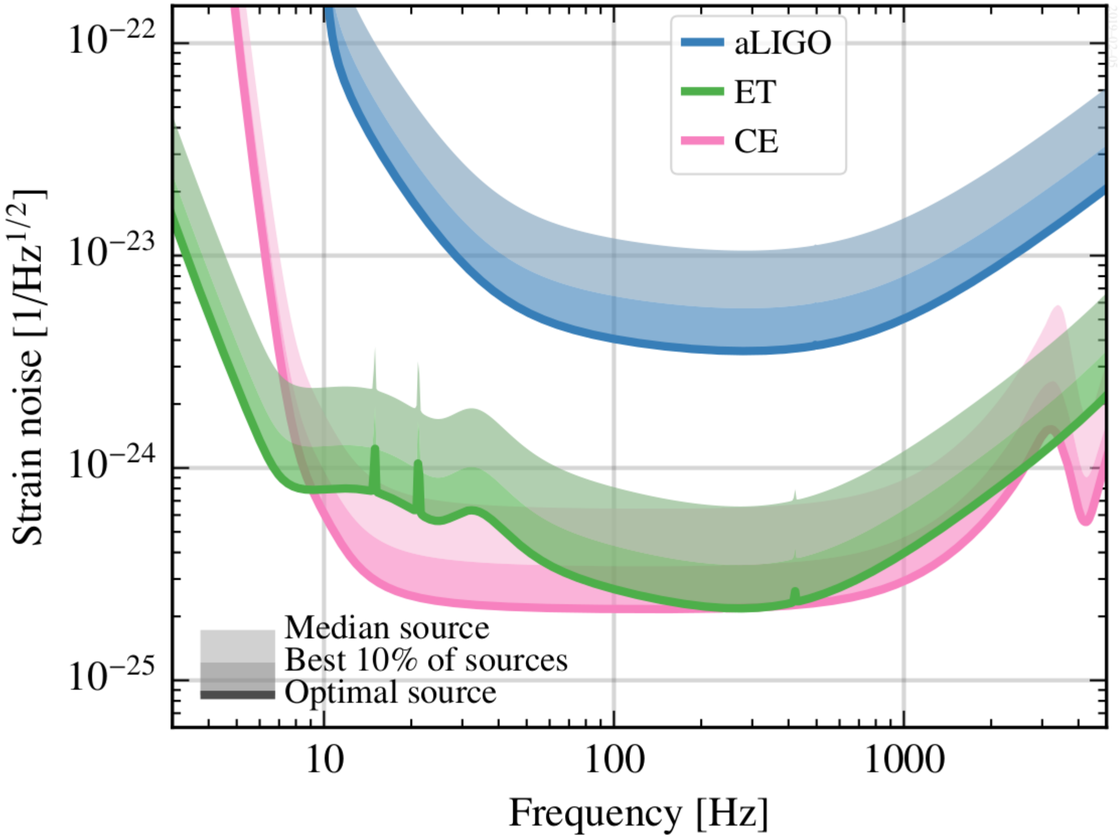


The Einstein Telescope

ET: the next-generation GW observatory
- Move from surface to underground
- Switch to cryogenic technology
- Significantly extend arm length
- Separate LF and HF interferometers



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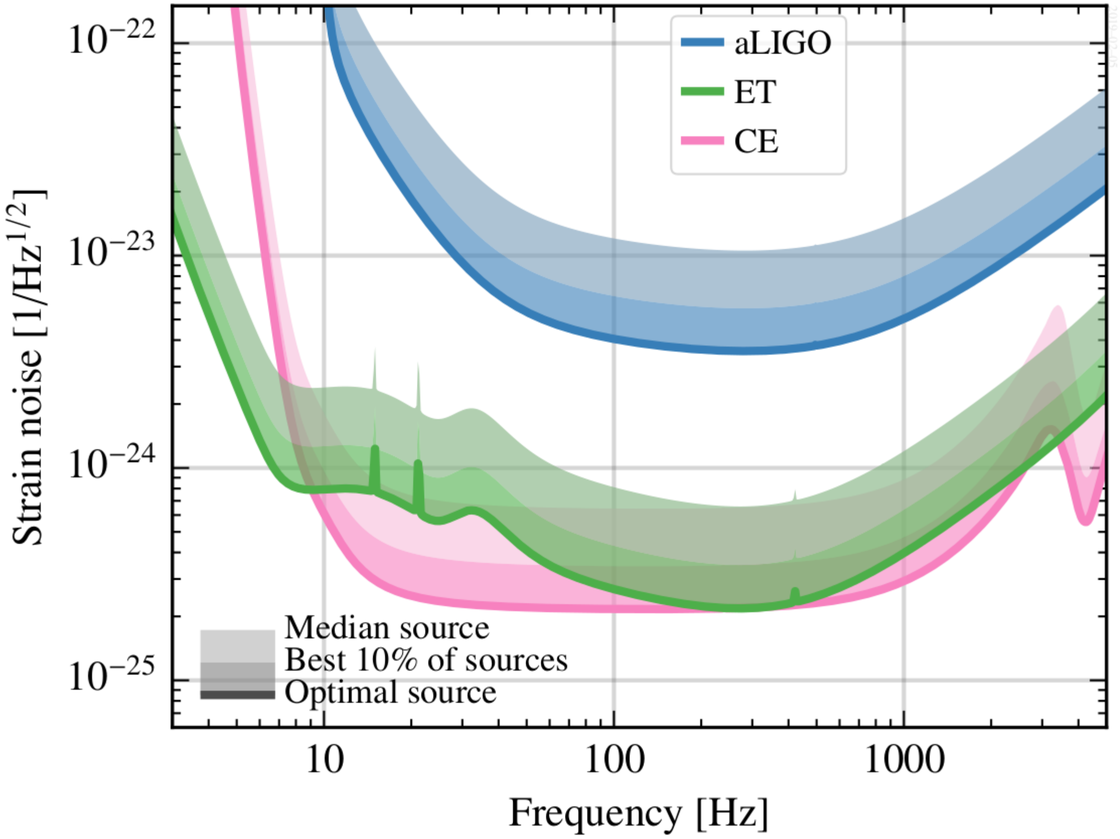
- 1 event/week -> 1 event/minute
- Extreme precision, SNR can be >>>100
- Both precision + discovery; LEP+LHC

LF enhances MM alert capabilities
- Binary NS in-band up to 24 hours



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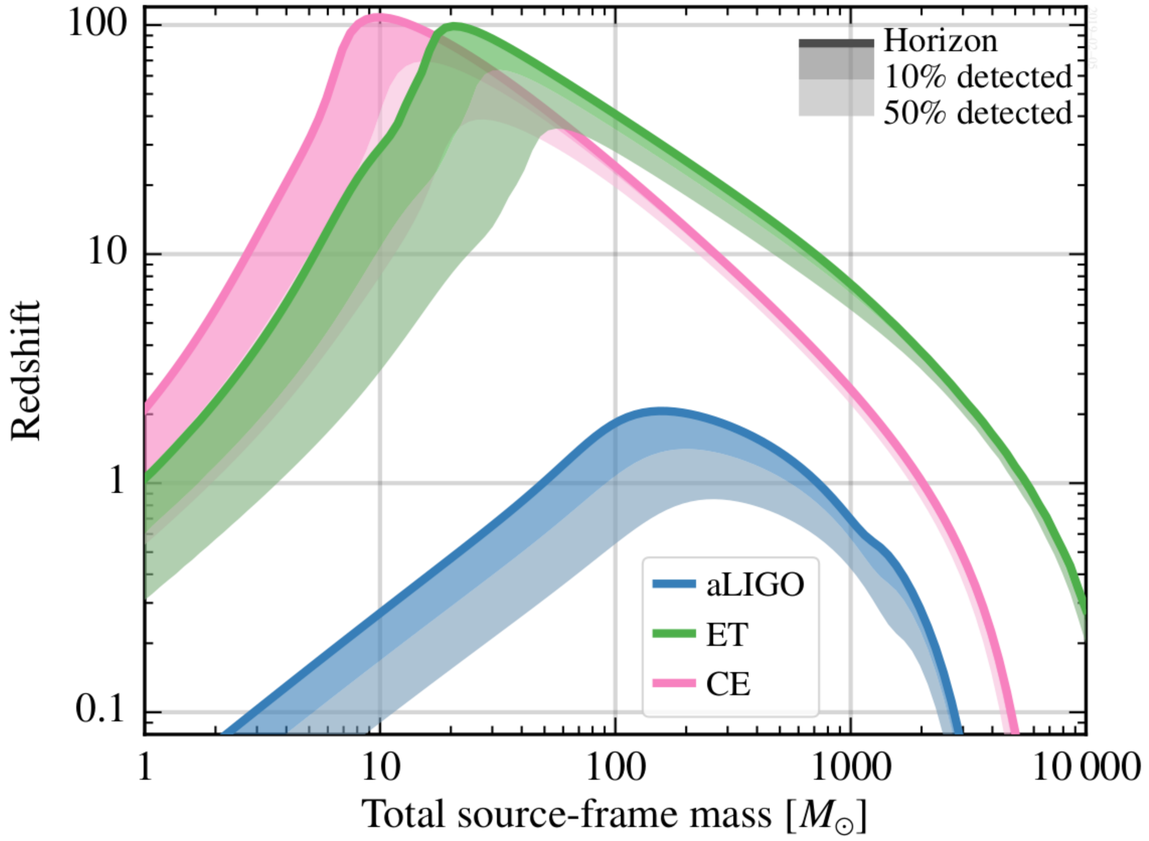
- PBH, cosmological grav. modifications



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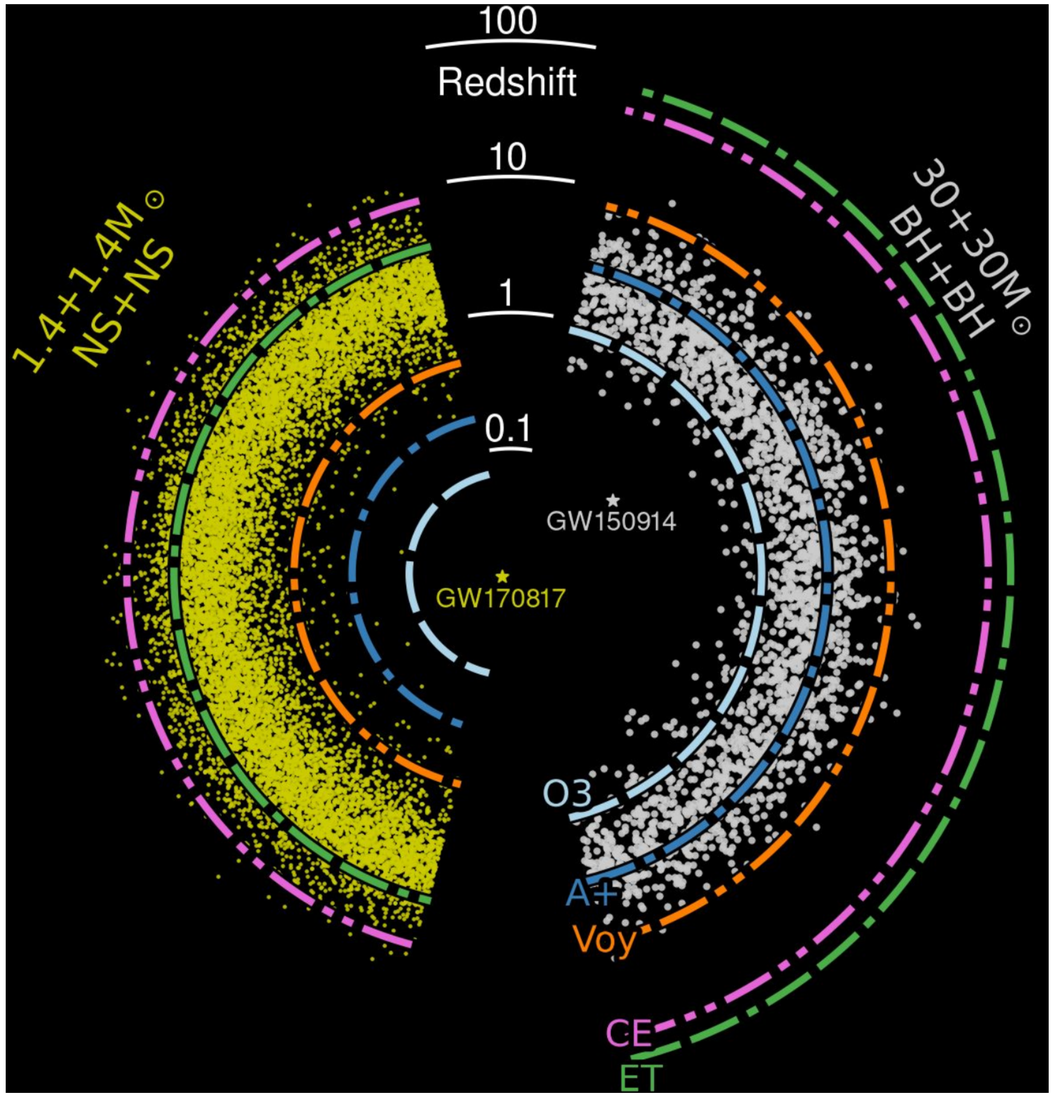
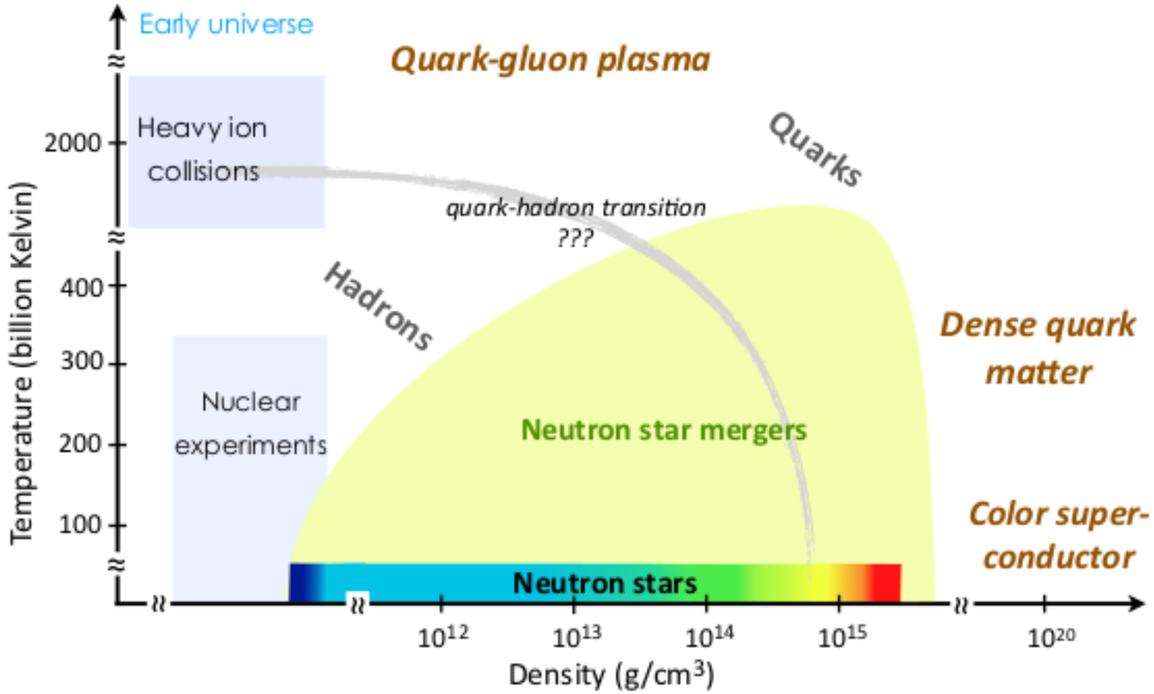


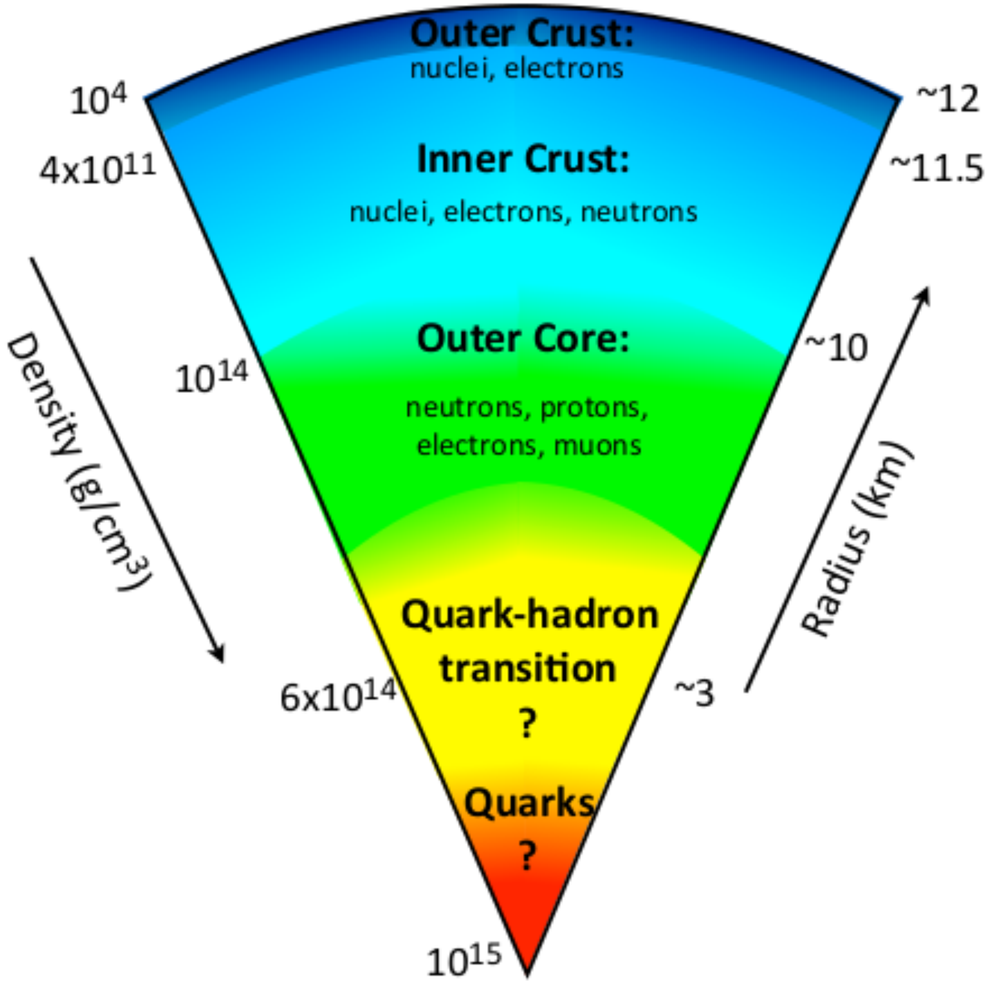
ET will see ~all binary coalescence signals

CHIPP-related synergies

QCD-related physics

- Neutron stars are a great QCD probe
- Equation of state gives access to different temperatures/densities
- NS+NS mergers push this further
- Complementary to other approaches





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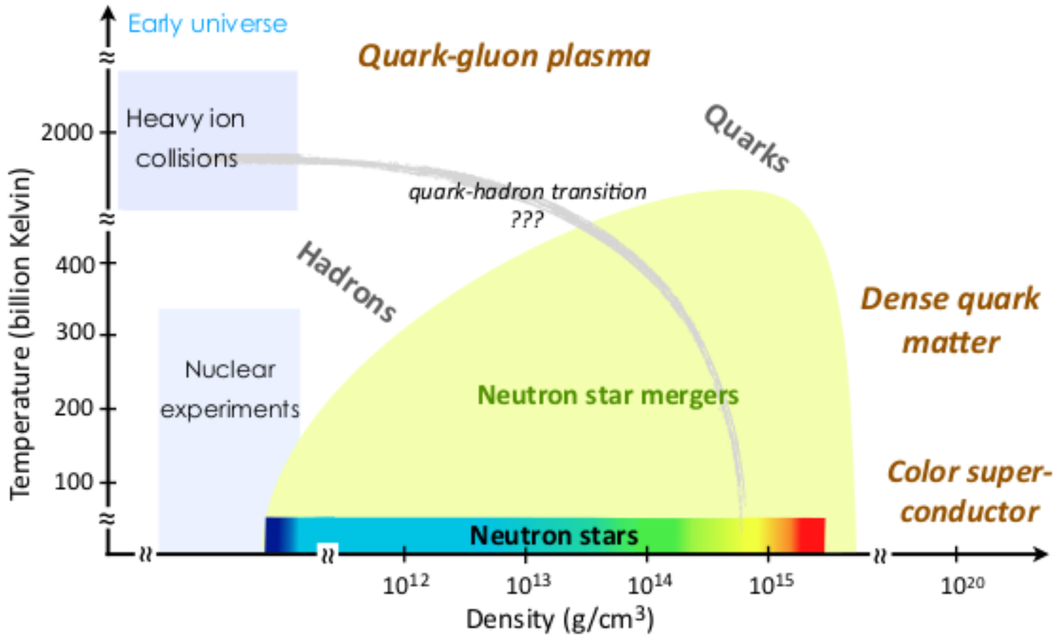
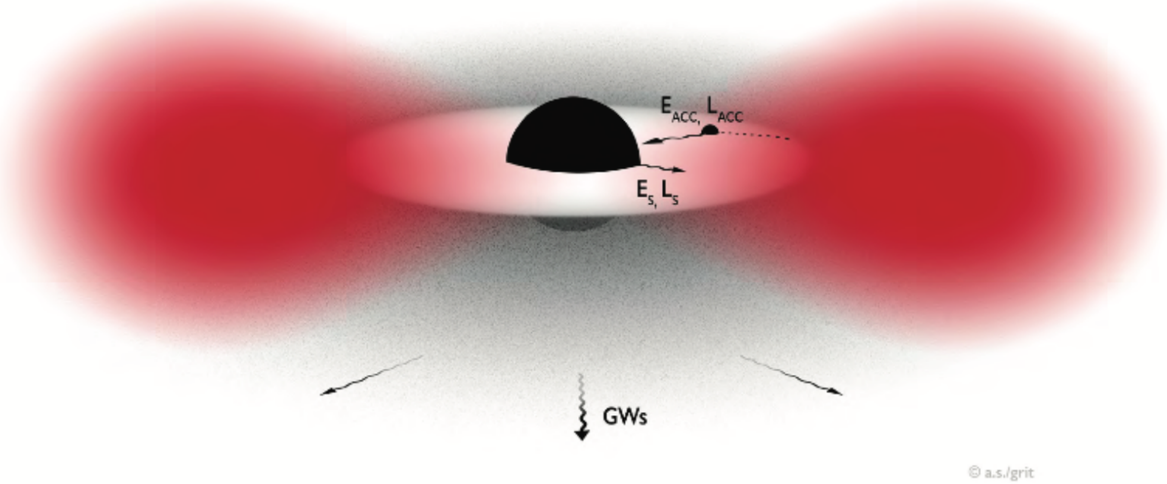


Dark matter

- Primoridal black holes
- Axion clouds around black holes
- More general search for DM via NS EOS environmental effects (accumulate DM in/on neutron star)



AI/ML: numerous uses in GW science

The Swiss GW community

Currently, Swiss ET is a UniGe-led effort, but we hope that changes soon!
- Marcelle Soares-Santos just started at UZH, look forward to meeting her
- EHTZ is hiring an experimental GW prof, looking forward to the outcome

UniGe astronomy department
- Anastasios Fragkos (CHAPS)
- Corrine Charbonnel (CHAPS)
- Paul Laycock [staff]

UniGe theoretical physics department
- Antonio Riotto (CHIPP)
- Camille Bonvin
- Michele Maggiore (CHIPP)
- Stefano Foffa [staff]

UniGe experimental physics department
- Steven Schramm (CHIPP)

UniGe investment in ET

Leadership roles in ET:

- Anastasios Fragkos: ETO task leader, CH rep. on Board of Scientific Reps.
- Antonio Riotto: ET science division leader
- Michele Maggiore: ET science board leader, ET exec board, ET ESFRI science lead, ET COBA science lead
- Steven Schramm: ET computing division leader

Institute investment:

- Created a cross-departmental centre on gravitational wave science
- DPT+DPNC+DASTRO+SecPhysique joint statement that solidfying GW leadership in ET is their single leading priority for next four years
  - Recognised and supported by the UNIGE rectorate
  - Creation of tenured professorships (one confirmed, second pending)

Recent ET milestones

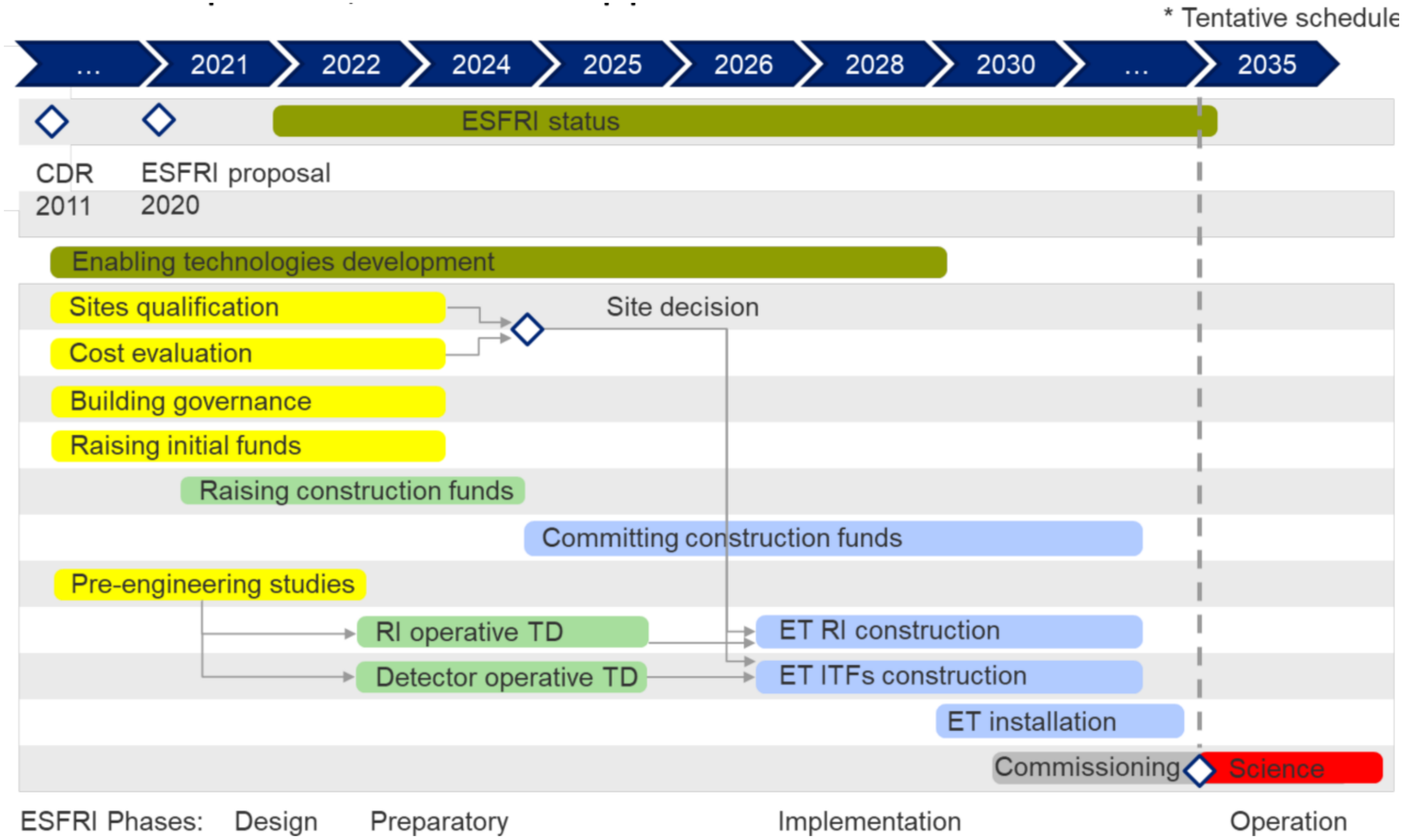
2020: ET proposed to the ESFRI roadmap

2021: ET ESFRI proposal officially accepted, largest ever ESFRI project

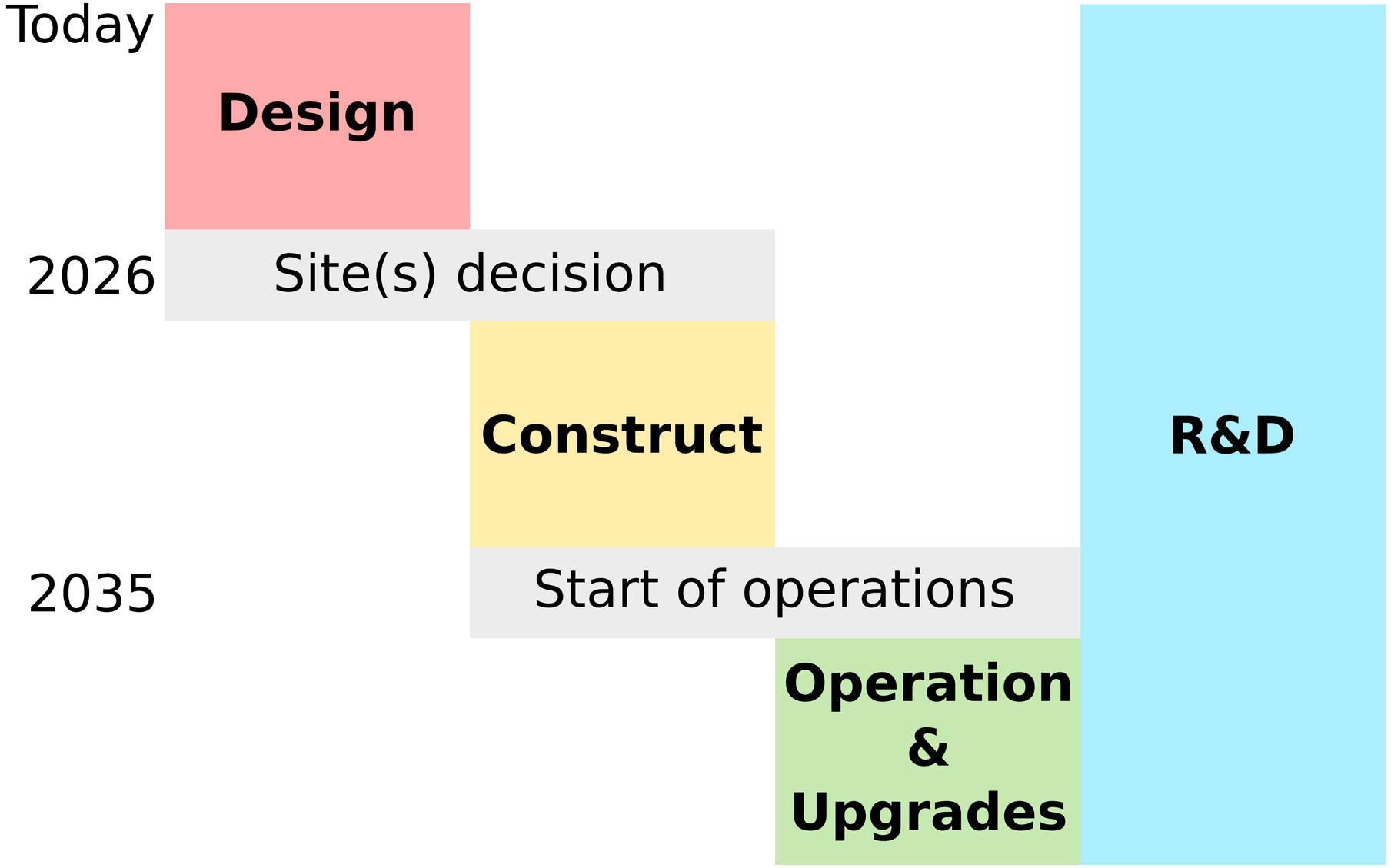
2022: ET collaboration officially formed, now >1500 members
2022: Start of ET-PP (INFRA-DEV) and ETO

2023: Growing political support from two leading candidate host sites
  - 0.9B Euro pledge from the Netherlands
  - 0.35B Euro pledge from Italy, plus "...political commitment..."
2023: ET configuration science study "COBA", triangle vs 2-L
2023: SNSF Sinergia project, GW-Learn, begins (ET+LISA)
2023: First SPS annual meeting with a GW session (CHIPP+CHAPS)
  - Very successful, intend to make this a permanent session

Path toward ET (ESFRI 06/2021)



Simplified path torward ET



Swiss plans

- **Continue to play a leading role in defining the science of ET**

- Take a leading role in the design and development of ET DAQ (CHIPP)
- Contribute to optical system of low-frequency interferometer (CHAPS)
- Establish Switzerland as a leader in the ET computing domain (joint)
  - Overall design of the ET computing model
  - Low-latency multimessenger alert system
- Prepare for data-taking with ET and participate in mock data challenges

- Investigate involvement in future upgrades of Virgo
  - Develop knowledge of how to handle real data, not only mock data
  - Prototype DAQ developments toward ET
  - Participate in the evolution/transition of the computing model to ET

Impact beyond science

Economical and technological impact

- ET requires new technologies, beyond the current leading edge
- Swiss involvement is currently planned in optics design, fast electronics, computing models, and low-latency computing infrastructure
- Each of these will put Switzerland in technological leadership roles
- Depending on selection processes, may have economic engagements

Societal impact and knowledge transfer

- Topic is fascinating to the general public, strong societal engagement
- Clear opportunities for knowledge transfer (electronics, computing, etc)
- Contribute to digital literacy and training of future generations, on an extended timescale (50 year infrastructure lifetime expectation)

Summary

The Einstein Telescope is a planned world-leading research infrastructure
- Plan to start operations in 2035, and take data for ~50 years
- Represents a paradigm change in our ability to observe GW signals

The Swiss community, through UniGe, has a significant role in ET
- Leadership of the full science case for ET
- Diverse leadership roles, up to top management (exec board)
- Plans to participate in optics, DAQ, and computing infrastructure
- Hope to extend to other Swiss institutes, please get in touch!

Our primary goal is to create a strong Swiss ET community, with both CHIPP and CHAPS community engagement, ready to benefit from the exciting GW science to come