

The Einstein Telescope

Will ET land in Belgium?

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L'Echo 04.05.2021

Le télescope Einstein, un "mini-Cern" très prisé



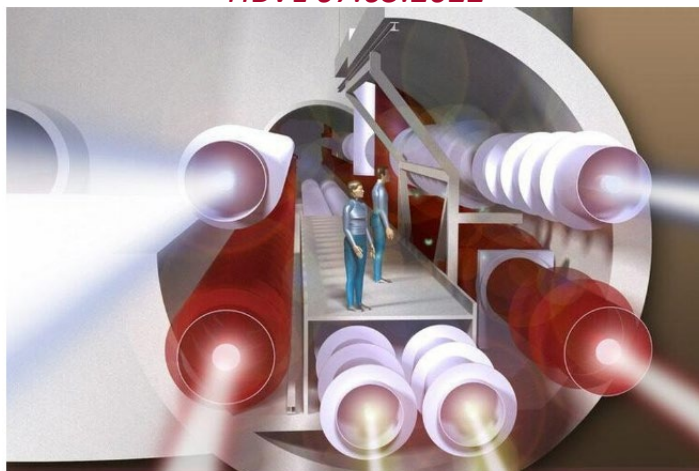
Le Centre spatial de Liège (CSL) est impliqué dans les travaux préparatoires du projet de télescope souterrain Einstein. ©Valentin Bianchi / Hans Lucas

OLIVIER GOSSET | 04 mai 2021 01:15

L'Euregio Meuse-Rhin veut pousser ses entreprises à participer au projet de télescope souterrain Einstein, une aventure technologique à près de deux milliards d'euros.

C'est une belle initiative scientifique de près de 2 milliards d'euros qui pourrait atterrir près de la région liégeoise. L'Euregio Meuse-Rhin, à cheval sur la Belgique, les Pays-Bas et

HBVL 07.05.2022



© Einstein Telescope.nl

Geloof in Einstein Telescoop in Limburg groeit: "Dit onderzoek zal ons wereldbeeld veranderen"

Hasselt - Ontdekken we diep onder onze voeten straks de geheimen van het heelal? Nu Nederland bijna een miljard euro heeft gereserveerd voor de Einstein Telescoop, groeit het geloof dat de Euregio het brandpunt kan worden van baanbrekend wetenschappelijk

Het Nieuwsblad 21.10.2020

Euregio bereidt zich voor op komst Einstein Telescoop

Hasselt/Luik

Europa heeft het startschot gegeven voor een grondig bodemonderzoek in de Euregio naar aanleiding van de komst van de Einstein Telescoop. Twee locaties zijn nog in de running: het drielandenpunt en Sardinië.

In 2025 start misschien het grootste project ooit in de Euregio Maas-Rijn. Het drielandenpunt tussen Luik, Aken en Maastricht is dus naast Sardinië een stevige kandidaat om straks de Einstein Telescoop te bouwen. Dit ondergrondse observatorium zal zwaartekrachtgolven meten. Dat gebeurt 200 tot 300

NEWS | 03 May 2023

Nature 03.05.2023

'Einstein' telescope high on Europe's astronomy wish list

A massive gravitational-wave detector and the new solar telescope are among the priorities on funders' latest roadmap.

[Katharine Sanderson](#)

HLN 16.05.2022

Haalt Limburg de 'Einsteintelecoop' binnen? Unizo ijvert: "Zou minstens 1.500 Limburgse jobs opleveren"

LIMBURG Als de politiek mee wil, en de concurrentiestrijd met regio Sardinië in ons voordeel valt, staat er op termijn een 'Einsteintelecoop' in Limburg. Dat is een telescoop die zwaartekrachtgolven detecteert, bestudeert waar baanbrekende technologie uit kan voortvloeien. De Limburgse ondernemerswereld pookt nu de politiek nog eens aan om het monsterproject van 2 miljard euro naar onze provincie te halen.

Marco Mariotti 16-05-22, 17:57 Laatste update: 16-05-22, 18:06

Sudinfo 22.11.2023

Projet du télescope Einstein près d'Aubel : les premiers tests sont plus qu'encourageants!

Le projet de télescope Einstein est le projet le plus ambitieux d'observatoire d'ondes gravitationnelles sur terre. Et il pourrait bien s'implanter en partie dans notre région. Si le site retenu ne sera

20.11.2023

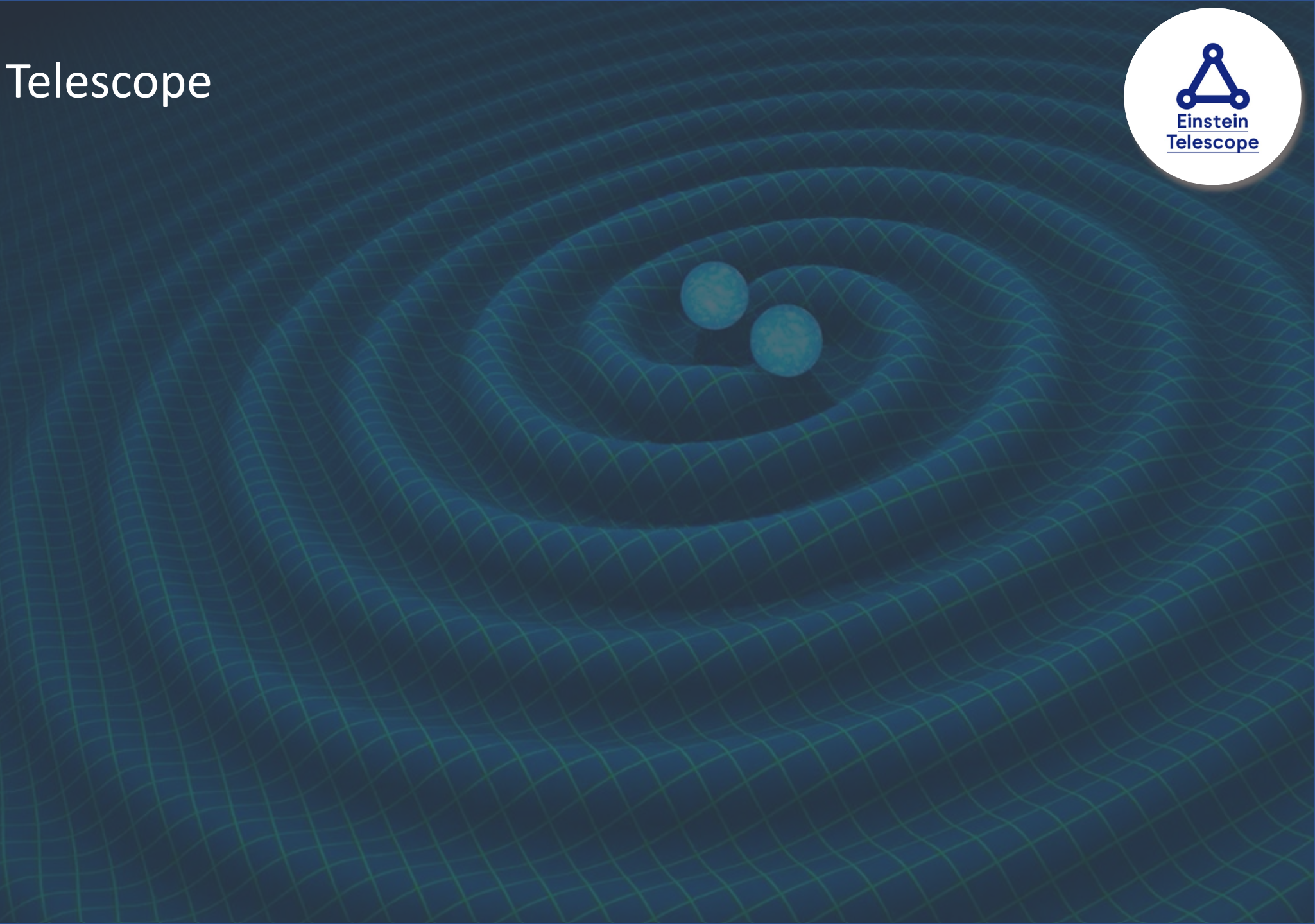
„E.T. nach Hause telefonieren“ – Wichtiger Schritt für NRW: Deutscher Bundestag fördert Einstein-Teleskop

In der vergangenen Woche wurde im Haushaltsausschuss des Deutschen Bundestages eine Millionenhilfe in Höhe von 9 Millionen Euro für das Einstein-Teleskop, von Wissenschaftlern auch liebevoll „E.T.“ genannt, im Dreiländereck Deutschland-Belgien-Niederlande beschlossen.

The Einstein Telescope



- What?
- How?
- Why?
- Where?
- When?



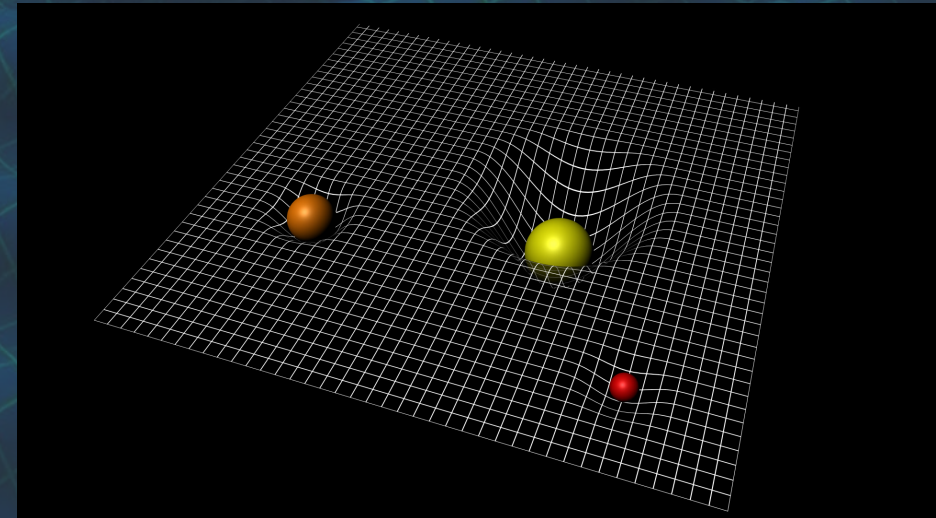


What?

The Strange World of Einstein's Theory of Relativity...

1. **Spacetime** – space and time are not independent from each other
2. **The fabric of spacetime** – not just a mathematical construct or metaphysical concept, but real physical object
 - Spacetime can stretch, curve, vibrate, ...
 - There's no such thing as 'the' time
3. **'Gravity' is the curvature of spacetime**—

“Spacetime tells mass how to move,
matter tells space-time how to curve”

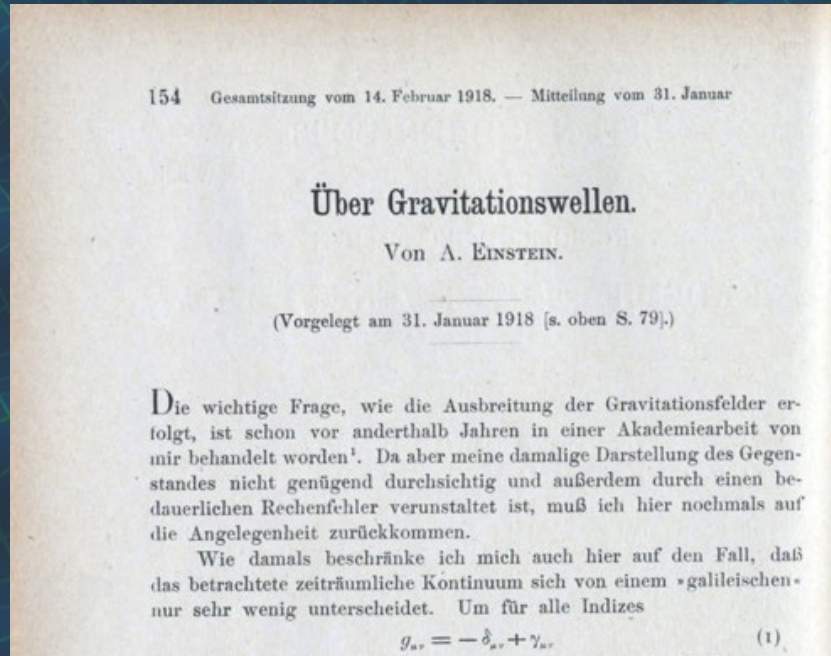


The Strange World of Einstein's Theory of Relativity...

1. **Celestial Bodies bend light** → Eddington expedition in 1919
2. **The Universe expands** → Friedmann, Lemaître and Hubble
3. **Black Holes exist** → Oppenheimer-Snyder
4. **Gravitational Waves exist** → Einstein

$$G_{\mu\nu} + \Lambda g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

Kromming
ruimtetijd = 10^{-43} Massa/energie



LIGHTS ALL ASKEW IN THE HEAVENS

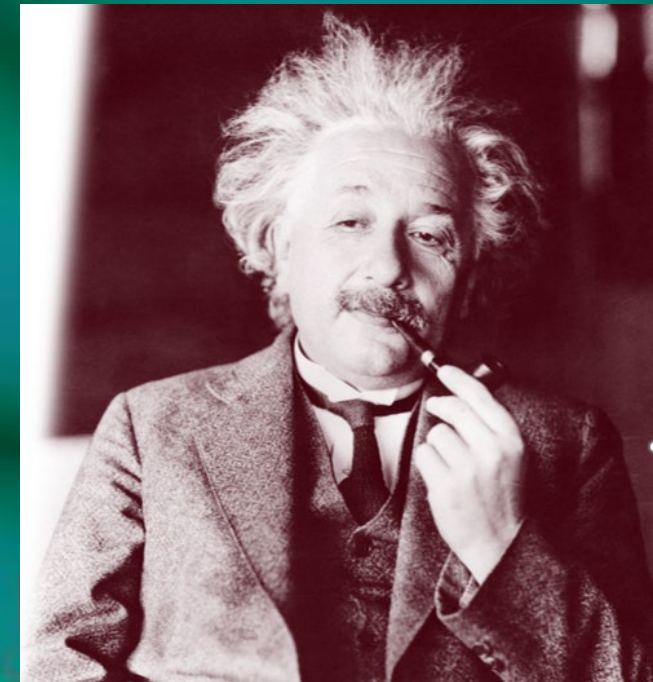
Men of Science More or Less
Agog Over Results of Eclipse
Observations.

EINSTEIN THEORY TRIUMPHS

Stars Not Where They Seemed
or Were Calculated to be,
but Nobody Need Worry.

A BOOK FOR 12 WISE MEN

No More in All the World Could
Comprehend It, Said Einstein When
His Daring Publishers Accepted It.





How?

Can we measure Gravitational Waves?



- Einstein himself had doubts

688 Sitzung der physikalisch-mathematischen Klasse vom 22. Juni 1916

Näherungsweise Integration der Feldgleichungen der Gravitation.

VON A. EINSTEIN.

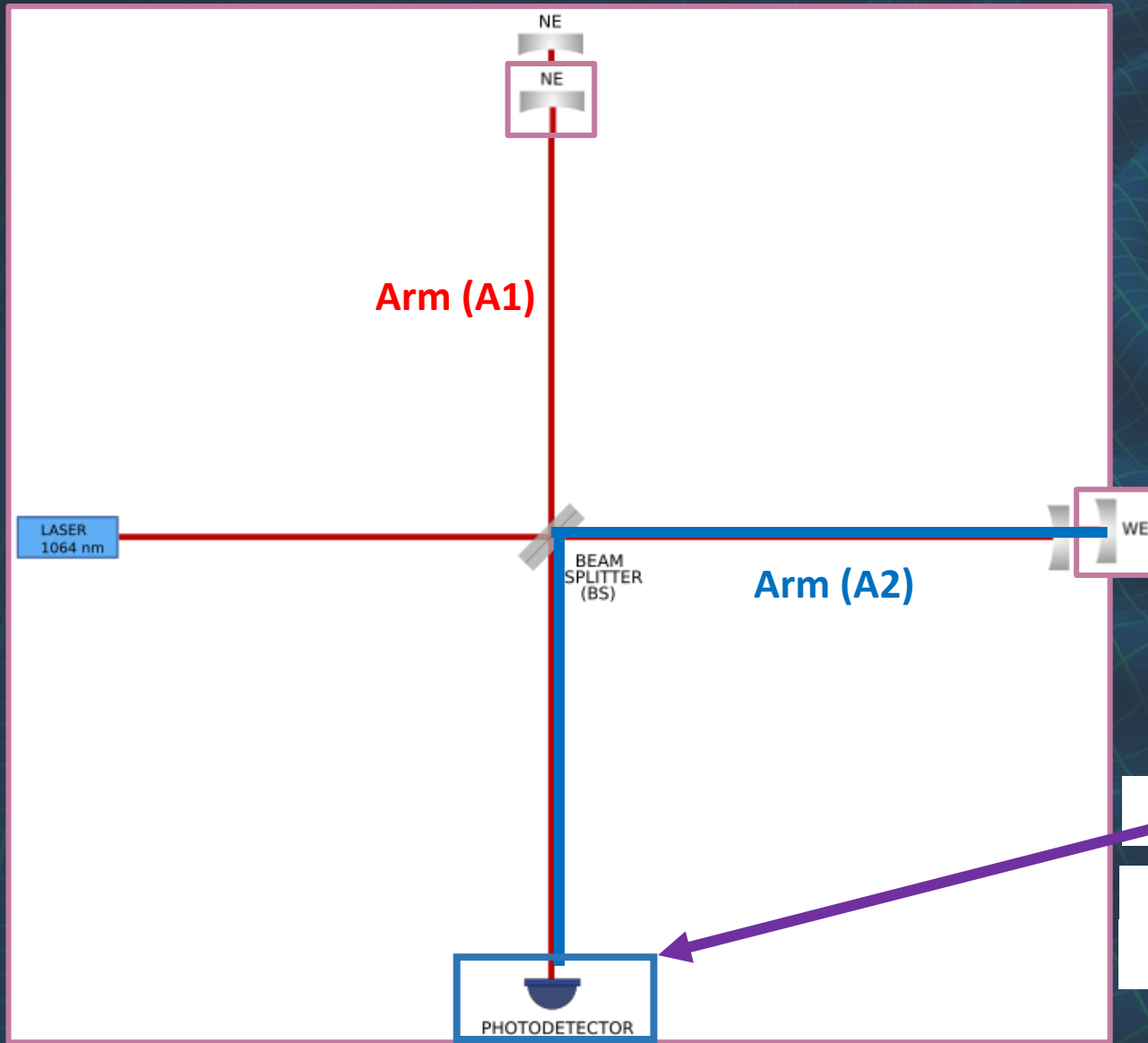
ein. Man erhält aus ihm also die Ausstrahlung A des Systems pro Zeiteinheit durch Multiplikation mit $4\pi R^2$:

$$A = \frac{\kappa}{24\pi} \sum_{\alpha\beta} \left(\frac{\partial^3 J_{\alpha\beta}}{\partial t^3} \right)^2. \quad (21)$$

Würde man die Zeit in Sekunden, die Energie in Erg messen, so würde zu diesem Ausdruck der Zahlenfaktor $\frac{1}{c^4}$ hinzutreten. Berücksichtigt man außerdem, daß $\kappa = 1.87 \cdot 10^{-27}$, so sieht man, daß A in allen nur denkbaren Fällen einen praktisch verschwindenden Wert haben muß.

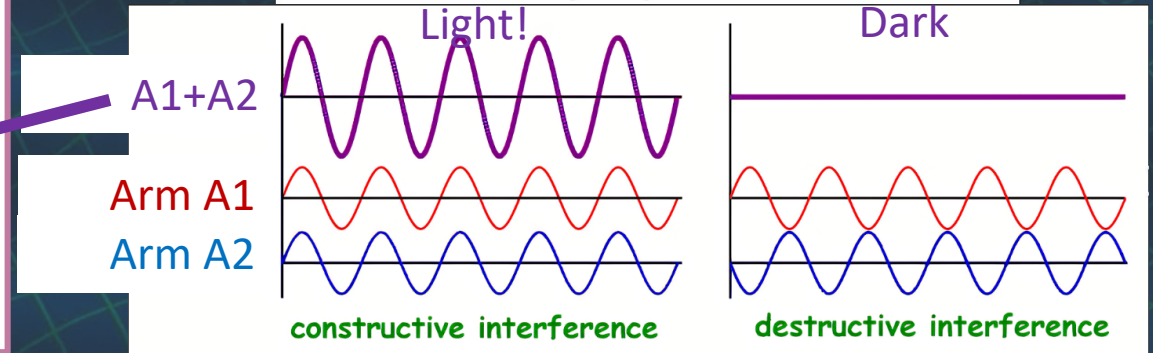
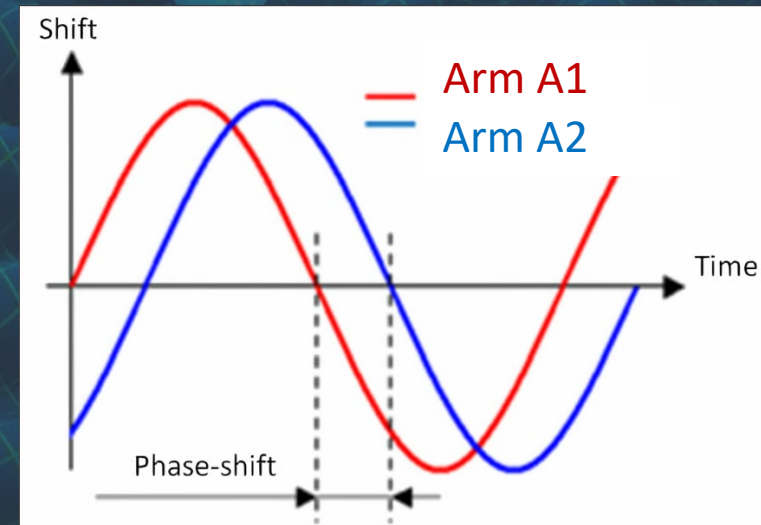
Measurement principle

- Based on 'old' instrument: **Michelson's interferometer** (1887)

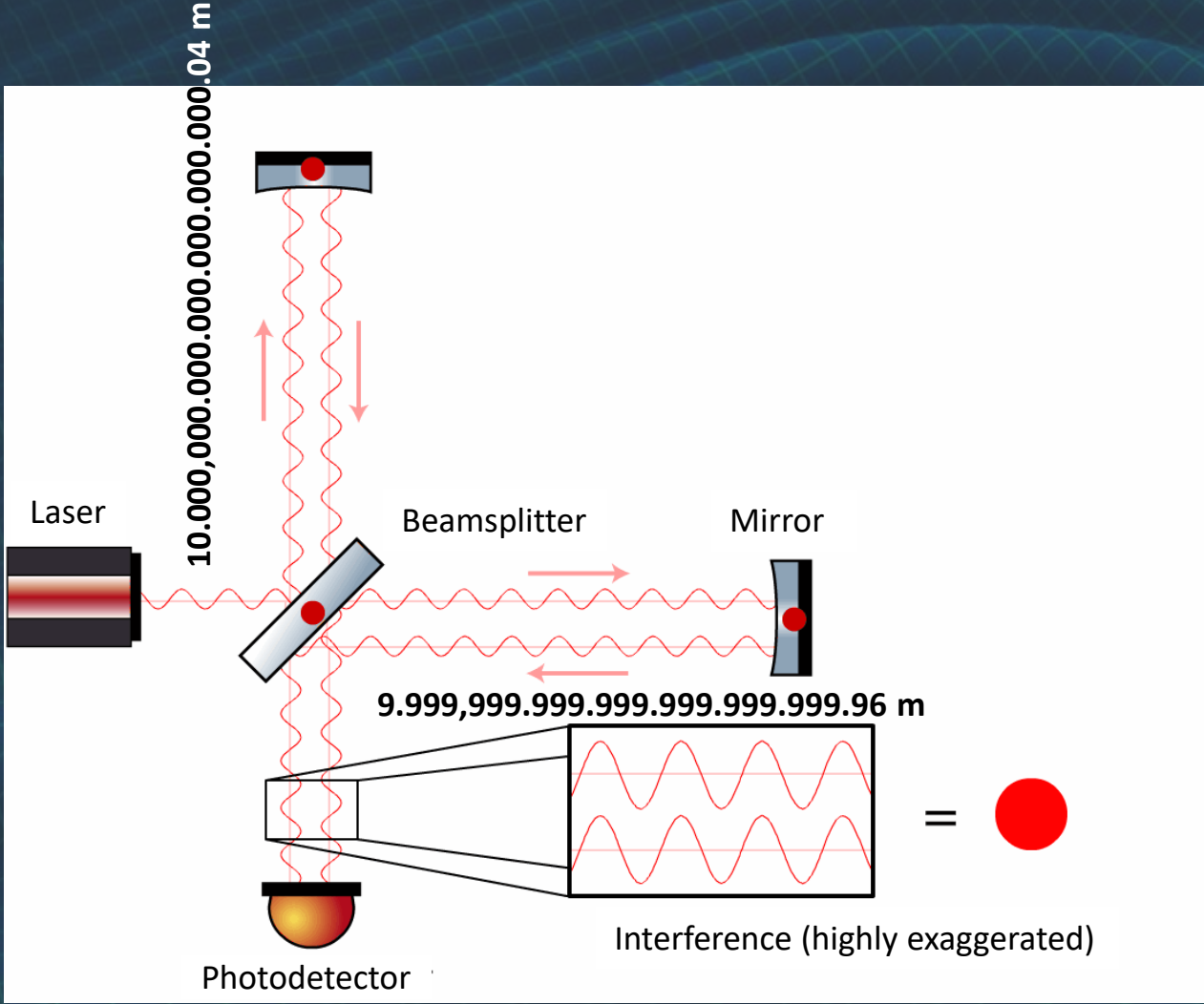
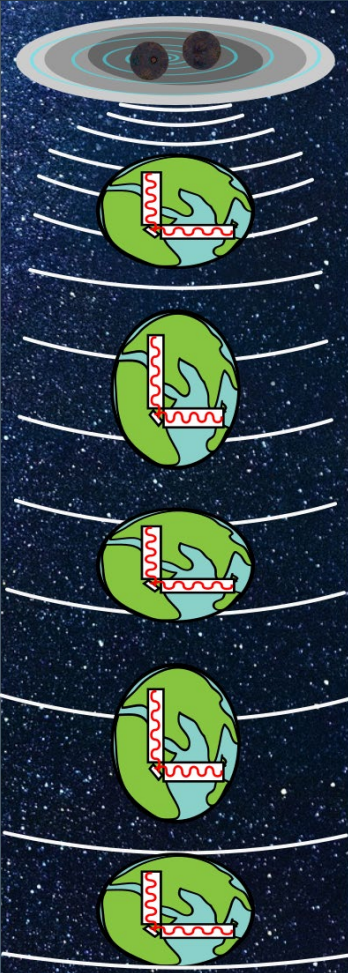


GW \rightarrow length A1 & A2 change

\rightarrow Phase-shift of the light waves

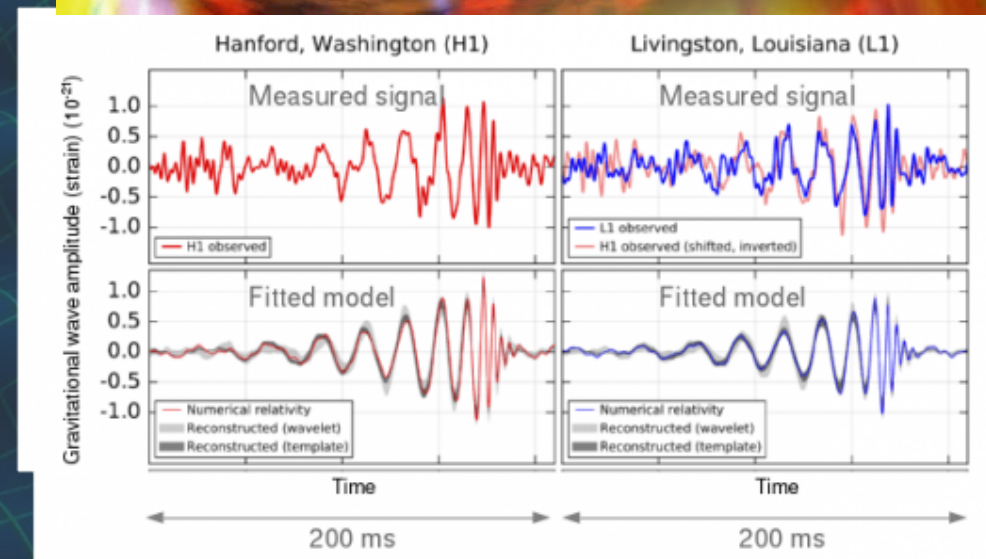
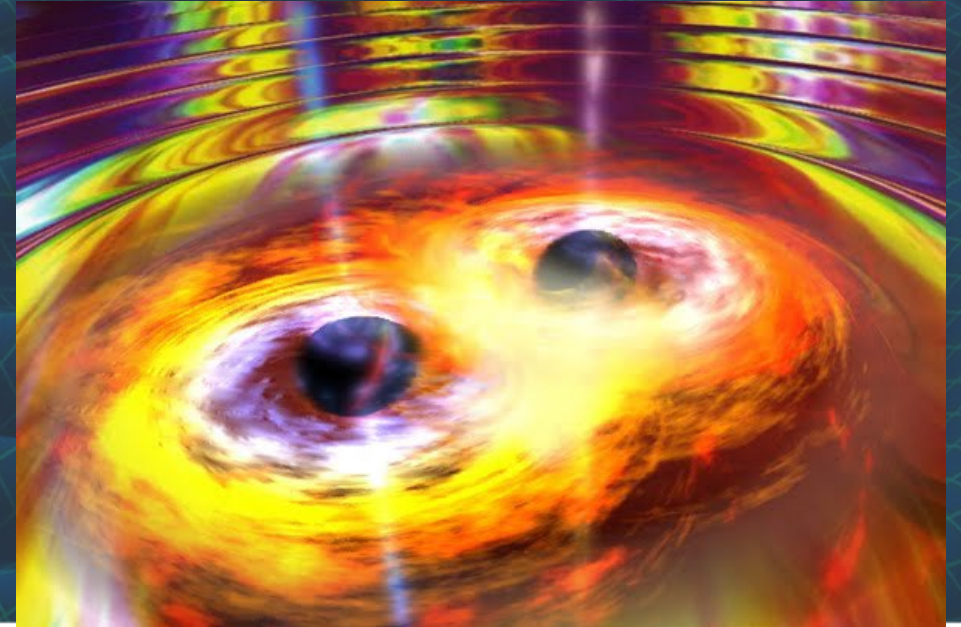


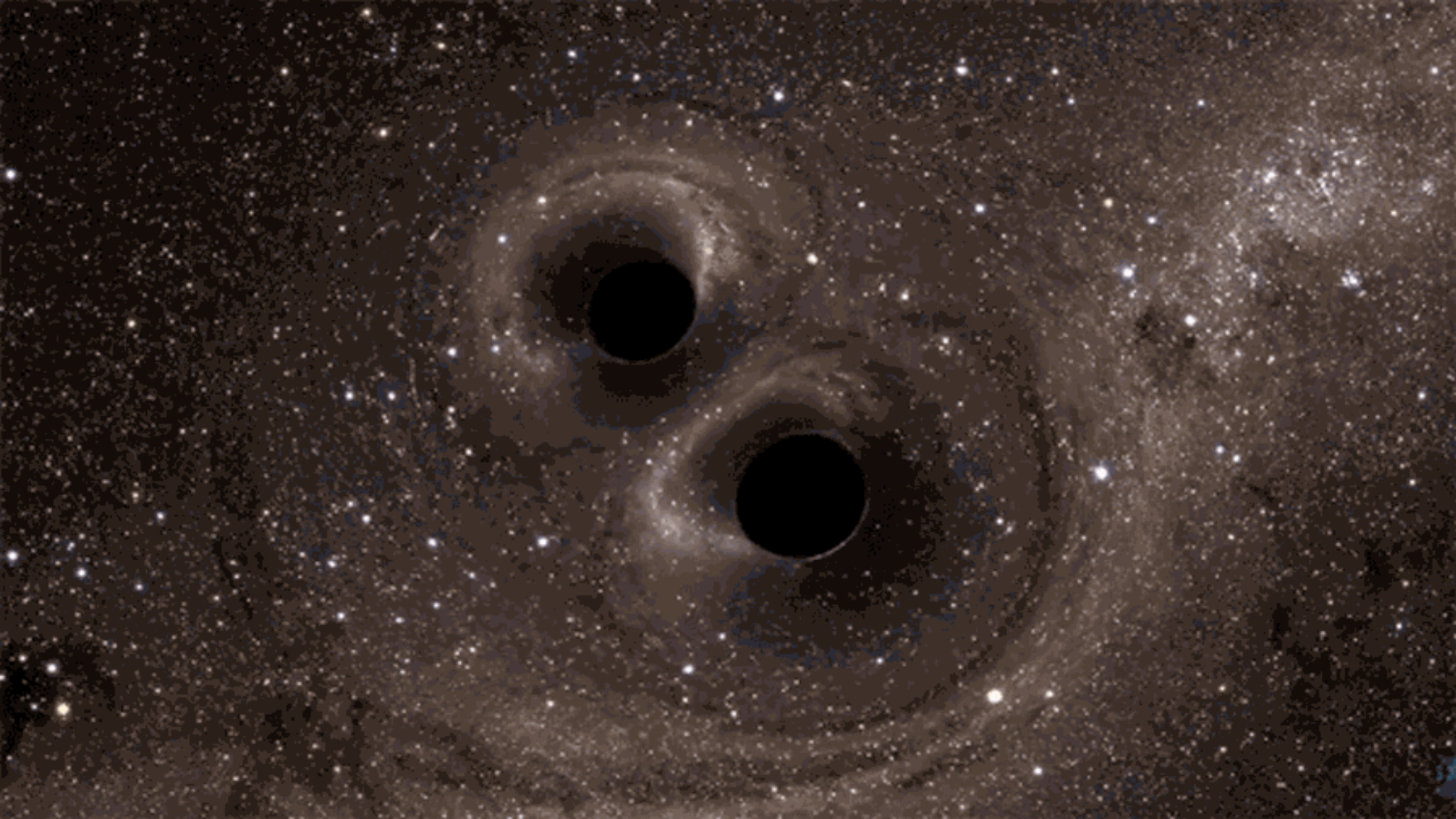
Measurement principle of an interferometer



Up to the first detection

- **First GW detector:** LIGO (VS – Hanford & Livingston)
 - 2002-2010: nothing...
 - Upgrade to GW detector of **2nd generation:** ‘Advanced LIGO’
- **14.09.2015, ‘GW150914’:** first GW detection!
 - Merger of 2 black holes at 1.3 billion light years from us
 - Last 0.2 second of the merger
 - Before: 36 and 29 M_{Sun} , After: 62 M_{Sun}
 - 3 M_{Sun} c^2 radiated away as GW, peak power = 3.6×10^{49} W
- Now: Ca. 1 detection per week







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English

[English \(pdf\)](#)

Swedish

[Swedish \(pdf\)](#)

Press Release: The Nobel Prize in Physics 2017

3 October 2017

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Physics 2017 with one half to

Rainer Weiss
LIGO/VIRGO Collaboration

and the other half jointly to

Barry C. Barish
LIGO/VIRGO Collaboration

and

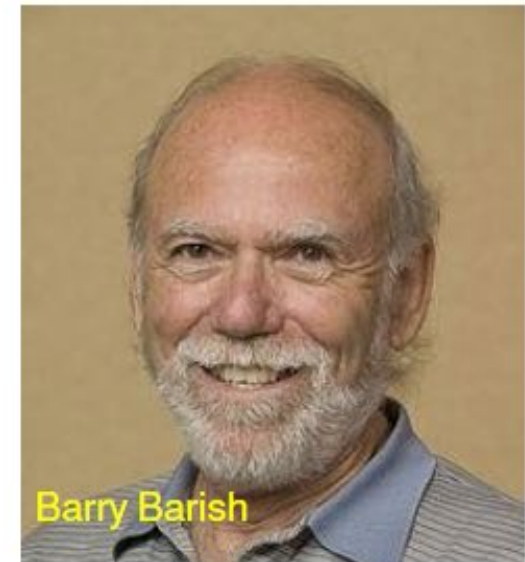
Kip S. Thorne
LIGO/VIRGO Collaboration



Rai Weiss



Kip Thorne



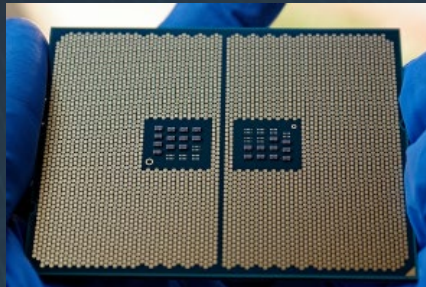
Barry Barish



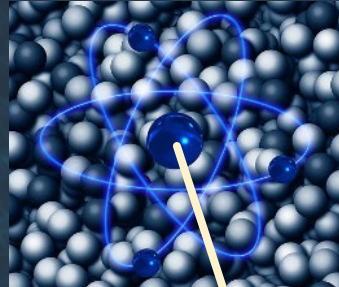
Impact of tidal waves (meter)



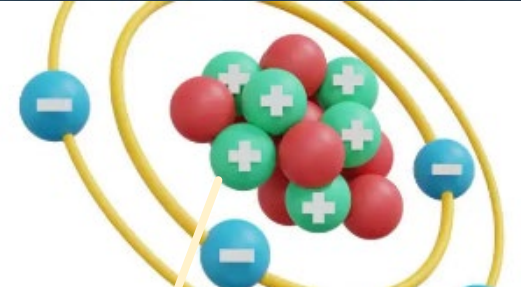
Caliper (0,1 mm)



Chip Industry (nm)



Atom (Å : 10^{-10} m)



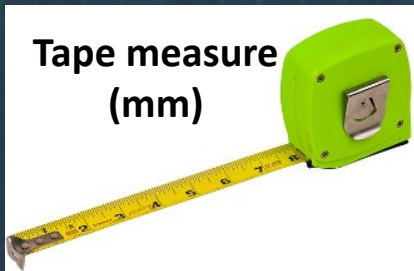
Protons and Neutrons (10^{-15} m)



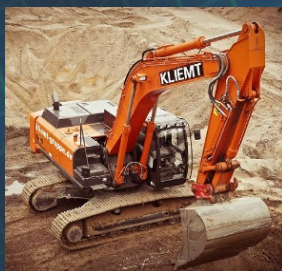
Ligo "first contact" (10^{-19} m/m)

0.000 000 000 000 000 000 000 1

External disturbances



Tape measure (mm)



Overview 2G GW detectors

Advanced LIGO
Hanford



GEO600



Advanced LIGO
Livingston



Advanced Virgo

Advanced LIGO
INDIA



KAGRA

Visual impression



Multimessenger astronomy

- 'GW170817'
 - Advanced **LIGO** and Advanced **Virgo** on 17 August 2017
 - Fermi **Gamma-ray** Burst Monitor: GRB 170817A, 1.7 sec later
 - Bright **optical** transient (AT 2017gfo) in NGC 4993, ~11 hours later
 - Also in UV, IR, X-ray, radio
- Interpretation: **Merger 2 neutron stars**, followed by a **gamma-ray burst** and a **kilonova**



GW170817

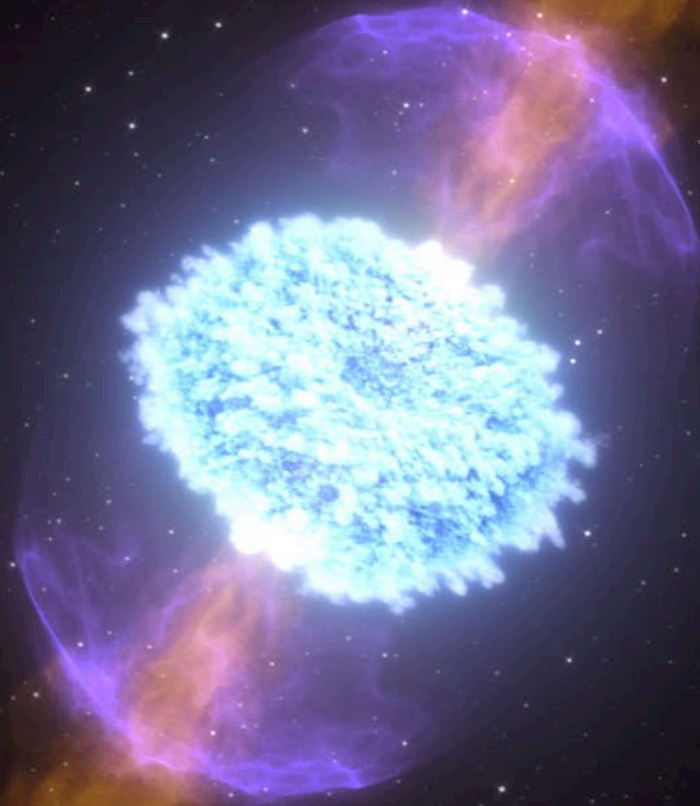
Two Neutron Stars

Combined 2,8 M_⊙

17 August 2017

LIGO + Virgo

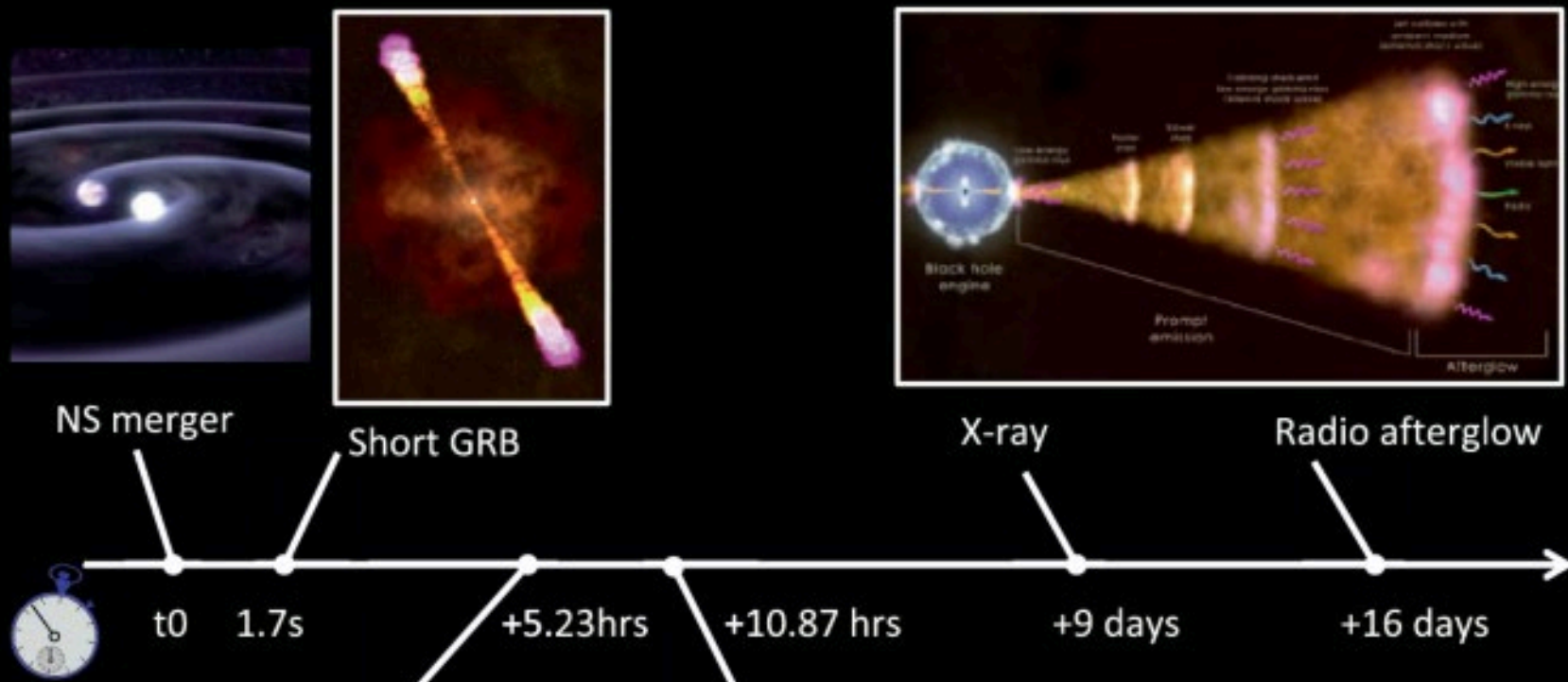
70 observatoria



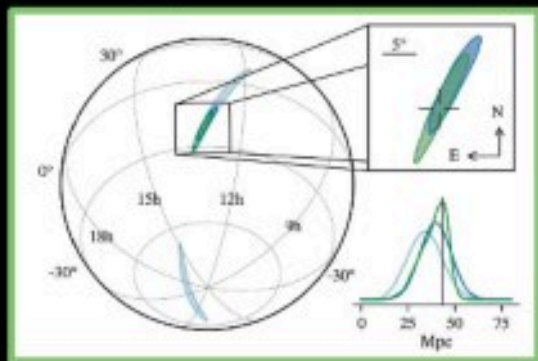
Observation: supernova

Creation of Gold and Platinum

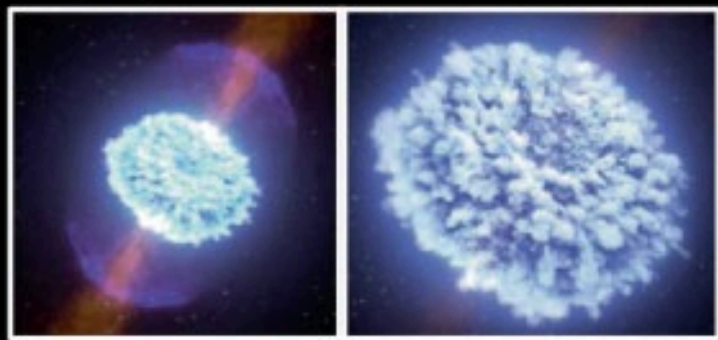
GW170817



LHV sky localization



UV/Optical/NIR Kilonova

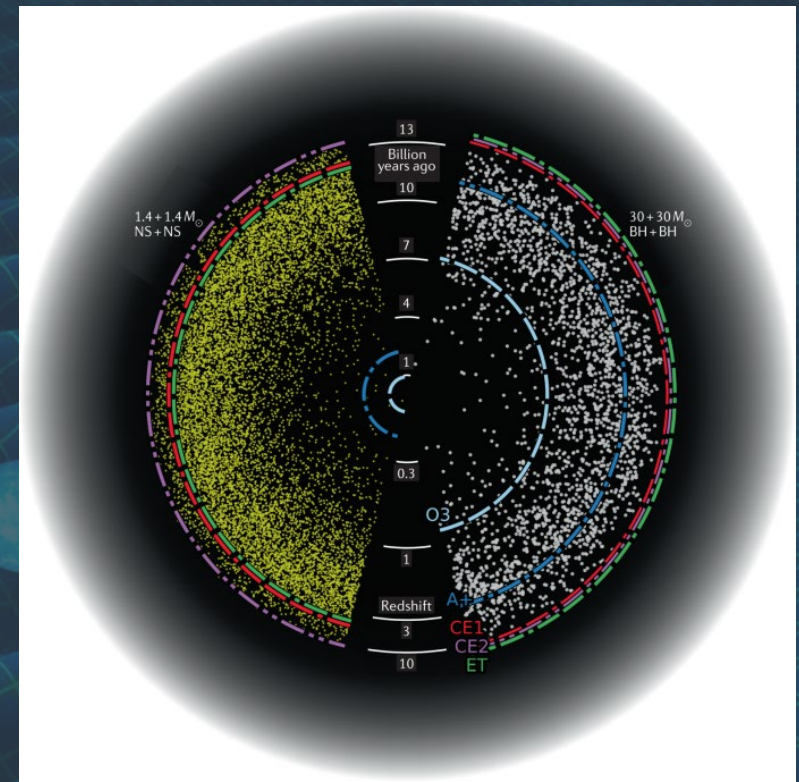


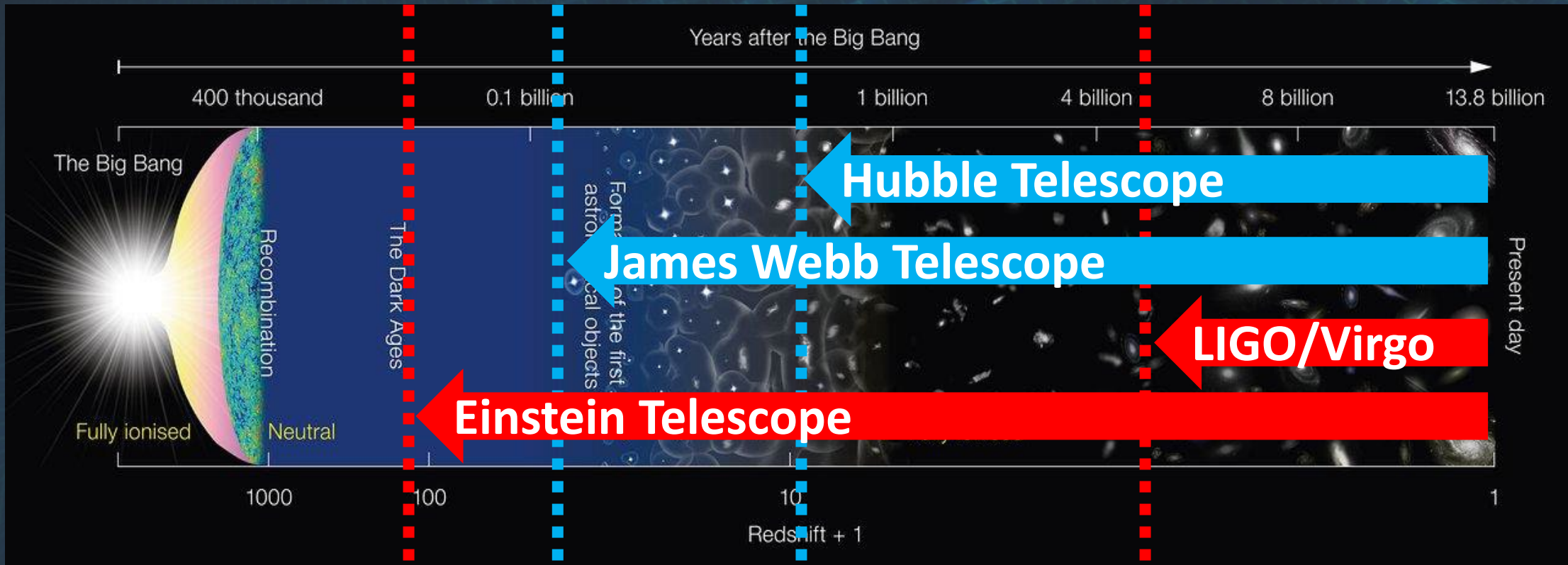


Why ET?

2G GW detectors: not bad, but we can do better...

- What should improve?
 1. From cosmic backyard to Big Bang
 2. Broader scientific scope
- Upgrade LIGO, Virgo & KAGRA?
 - Physical constraint: above-ground infrastructure with 3-4 km arm length
- Enter **Einstein Telescope** – 1st 3G GW detector
 1. 10 x more sensitive → 1000 x bigger volume + closer to Big Bang
 2. Extension to low frequencies (1-10 Hz) → access to the dark & young Universe





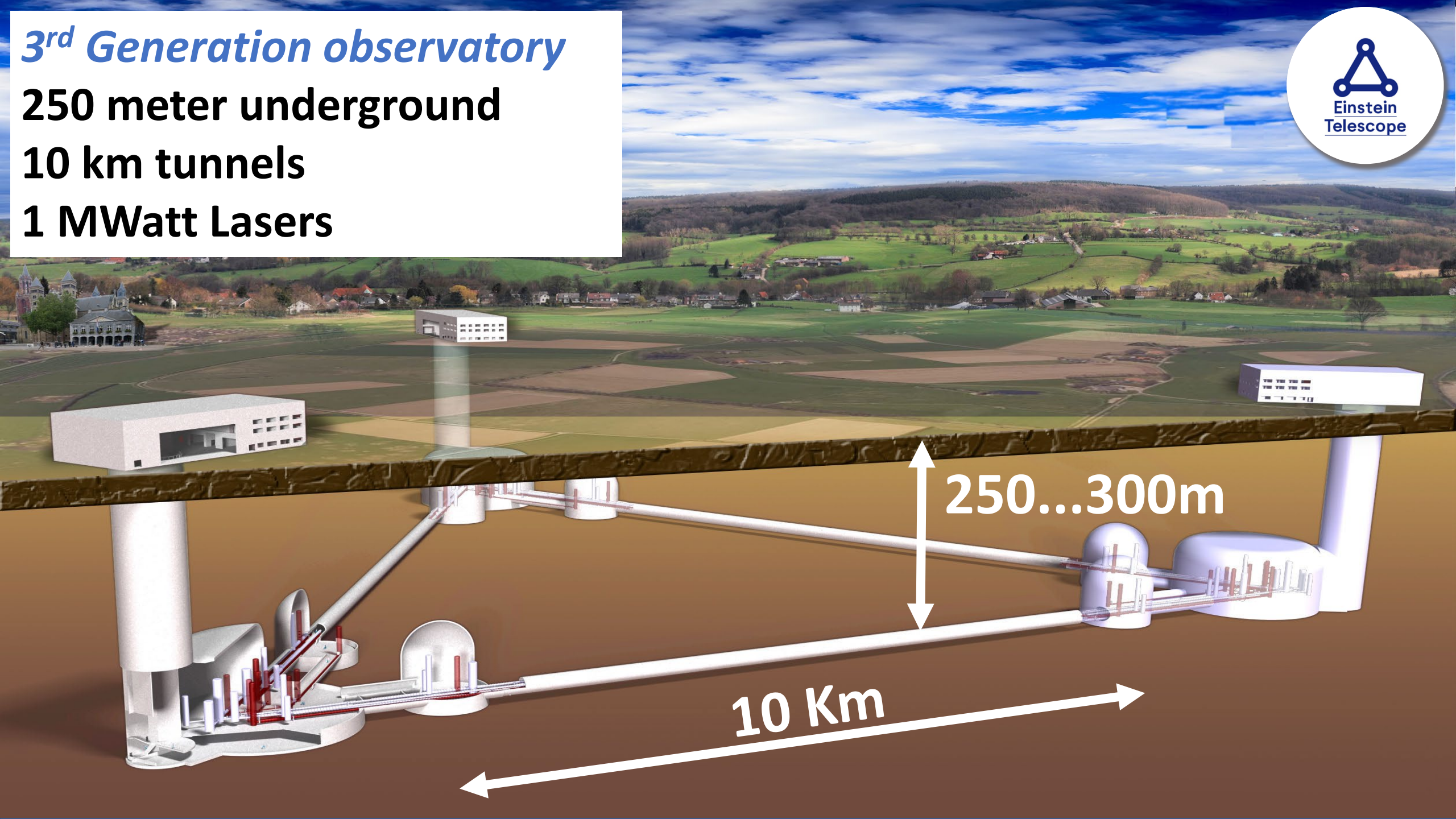
But also: discover dark energy and dark matter, test Einstein's General Relativity, find primordial black holes, particle physics, new detections ...

3rd Generation observatory

250 meter underground

10 km tunnels

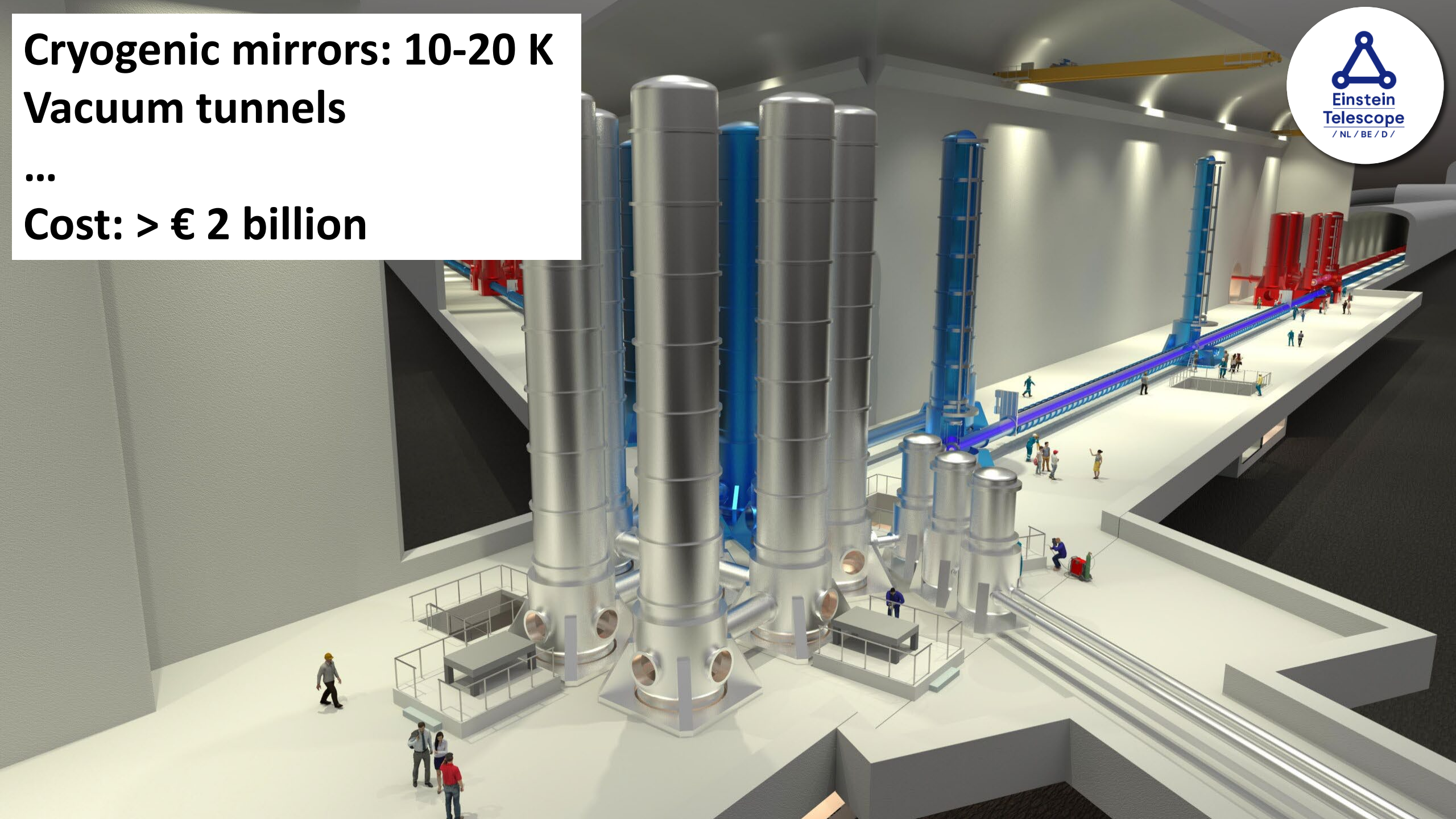
1 MWatt Lasers



Cryogenic mirrors: 10-20 K
Vacuum tunnels

...

Cost: > € 2 billion



Technologies



Instrumental Technologies

Cryogenics

Vacuum

Precision instruments

High grade mirrors

Mirror coatings

Sensors

Lasers

Advanced algorithms

Construction Technologies

3D models & Simulations

Geografic imaging

Tunneling techniques

Ground water techniques

Sustainability

Sustainable constructions

Sustainable waste ground removal

Climate neutral and sustainable energy

Sustainable logistics

Sustainable maintenance

Sustainable decommissioning

Challenges for the climate



Reuse of excavations



Carbon-free transport



Waste water treatment

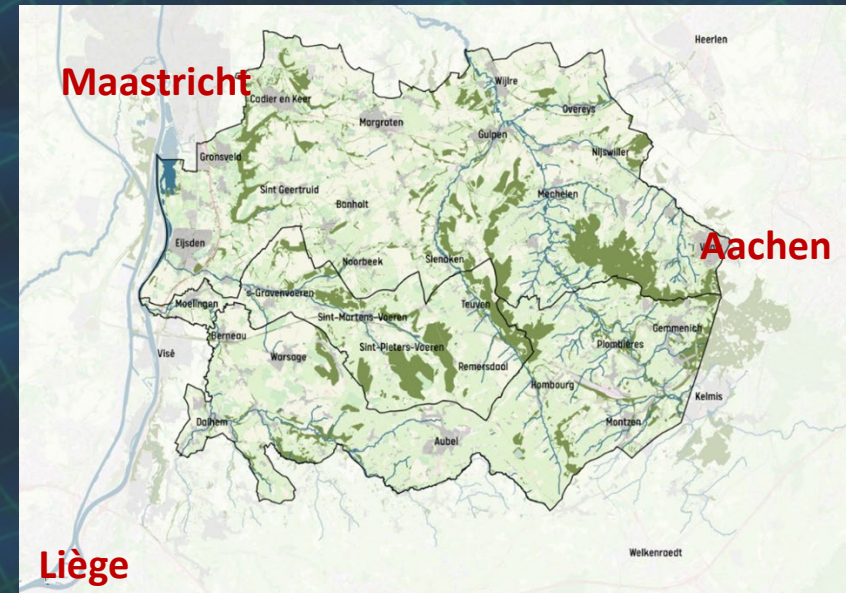
Use of Energy



Prepare for decommissioning upfront



Protected Bocage landscape



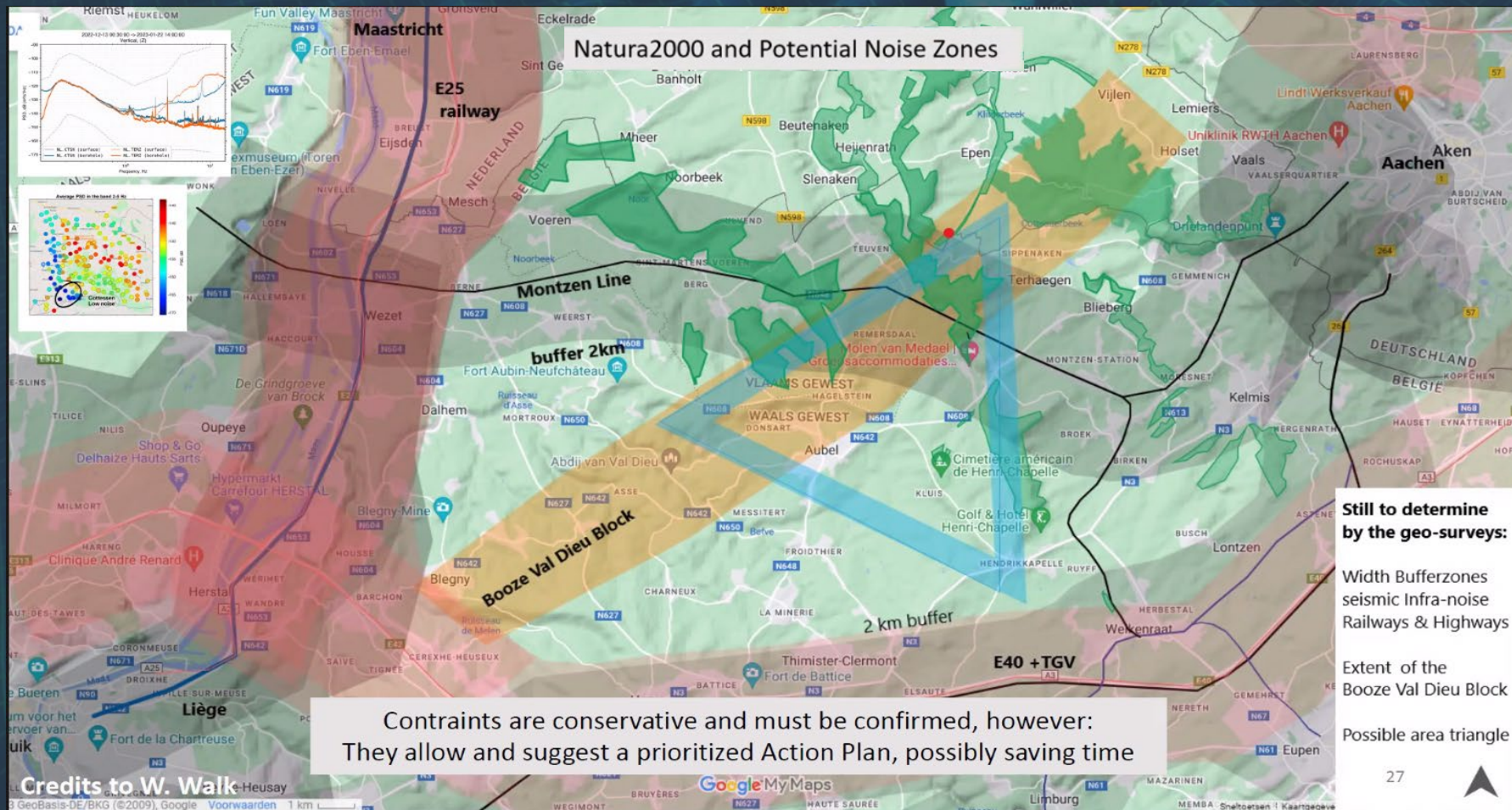


Where?

Option 1



- Three-border region Belgium-The Netherlands-Germany
Euregio Meuse-Rhine, EMR



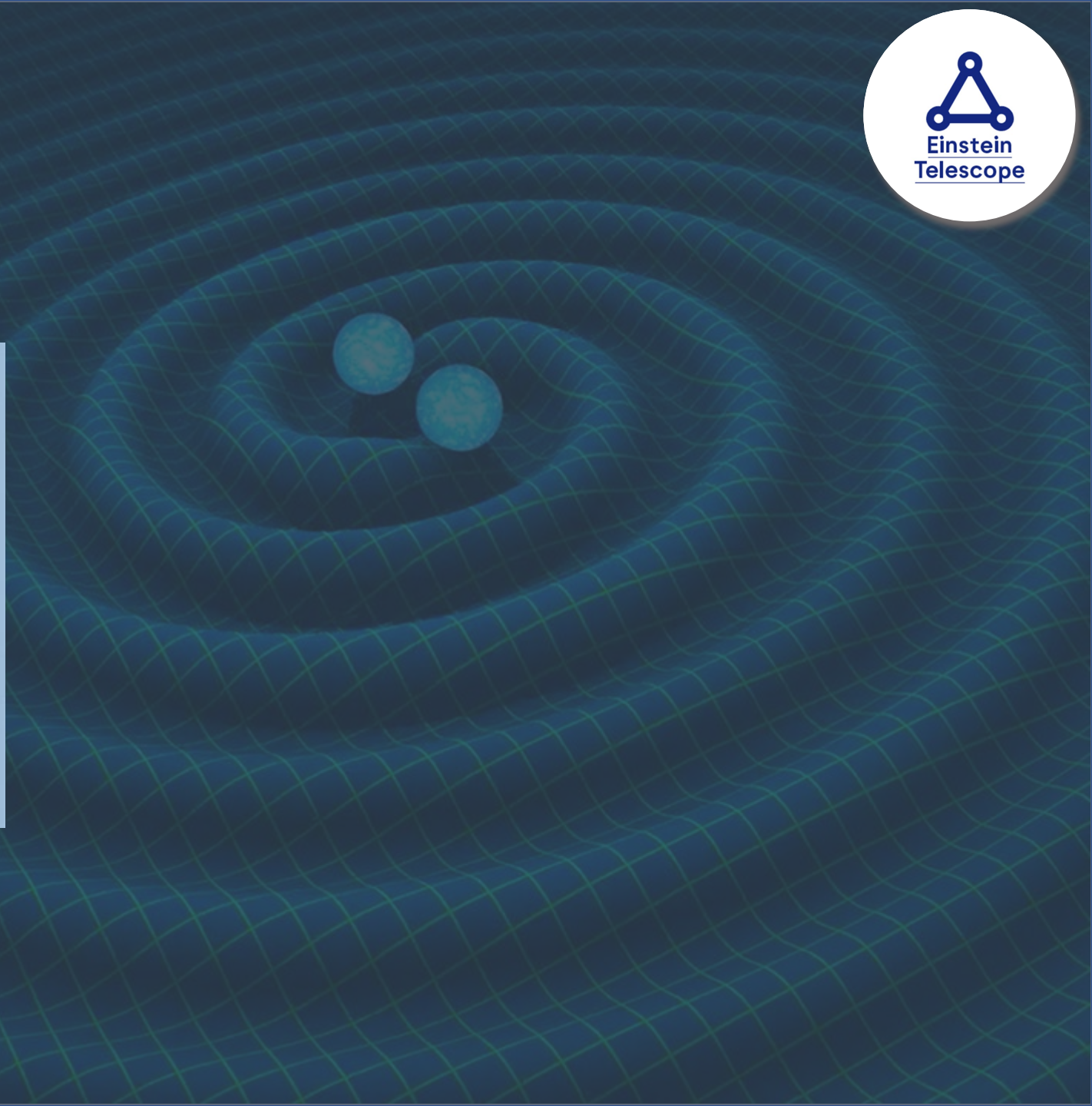
Option 2



- Sardinia (Italy)



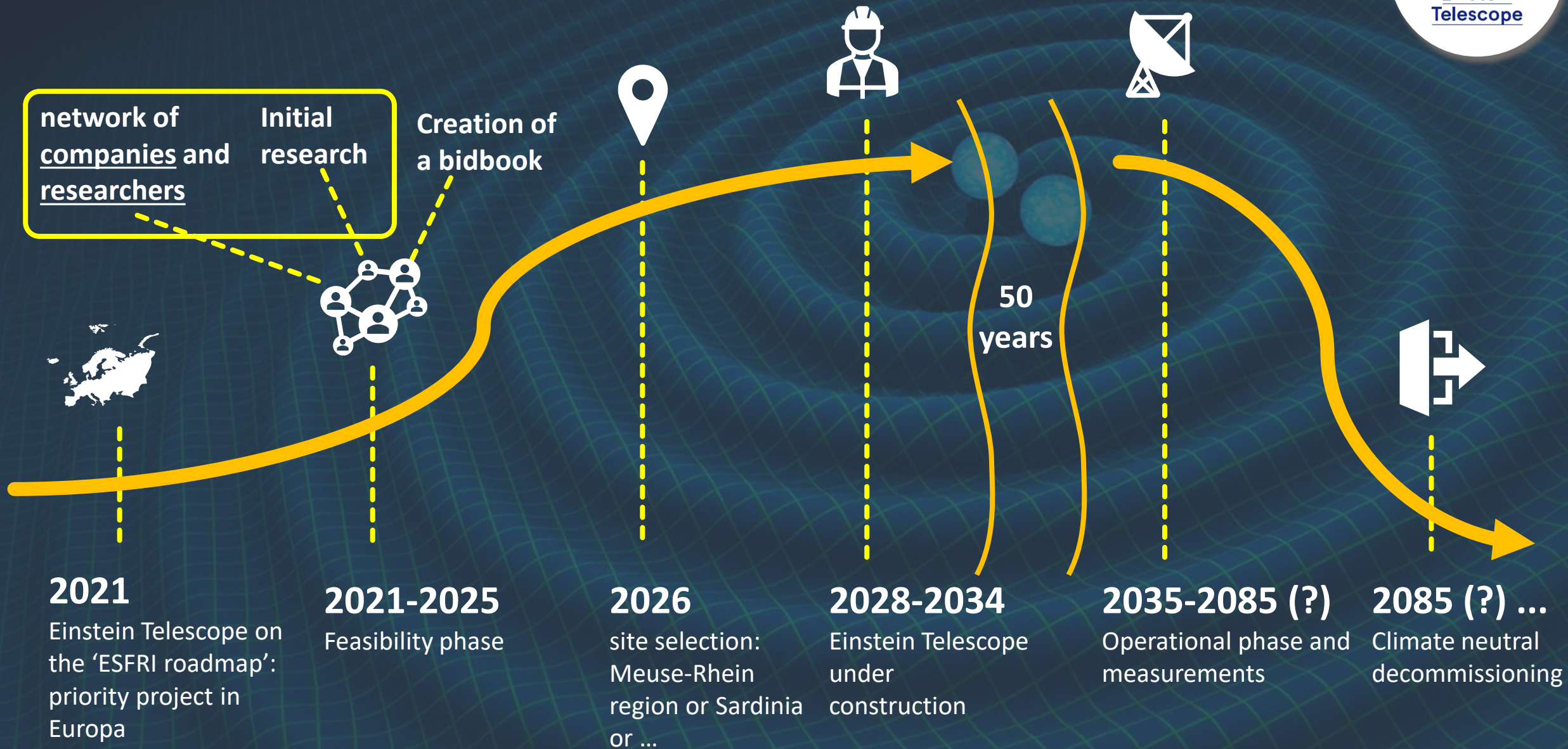
- Saxony (Germany)?





When?

Challenge: the planning





Status

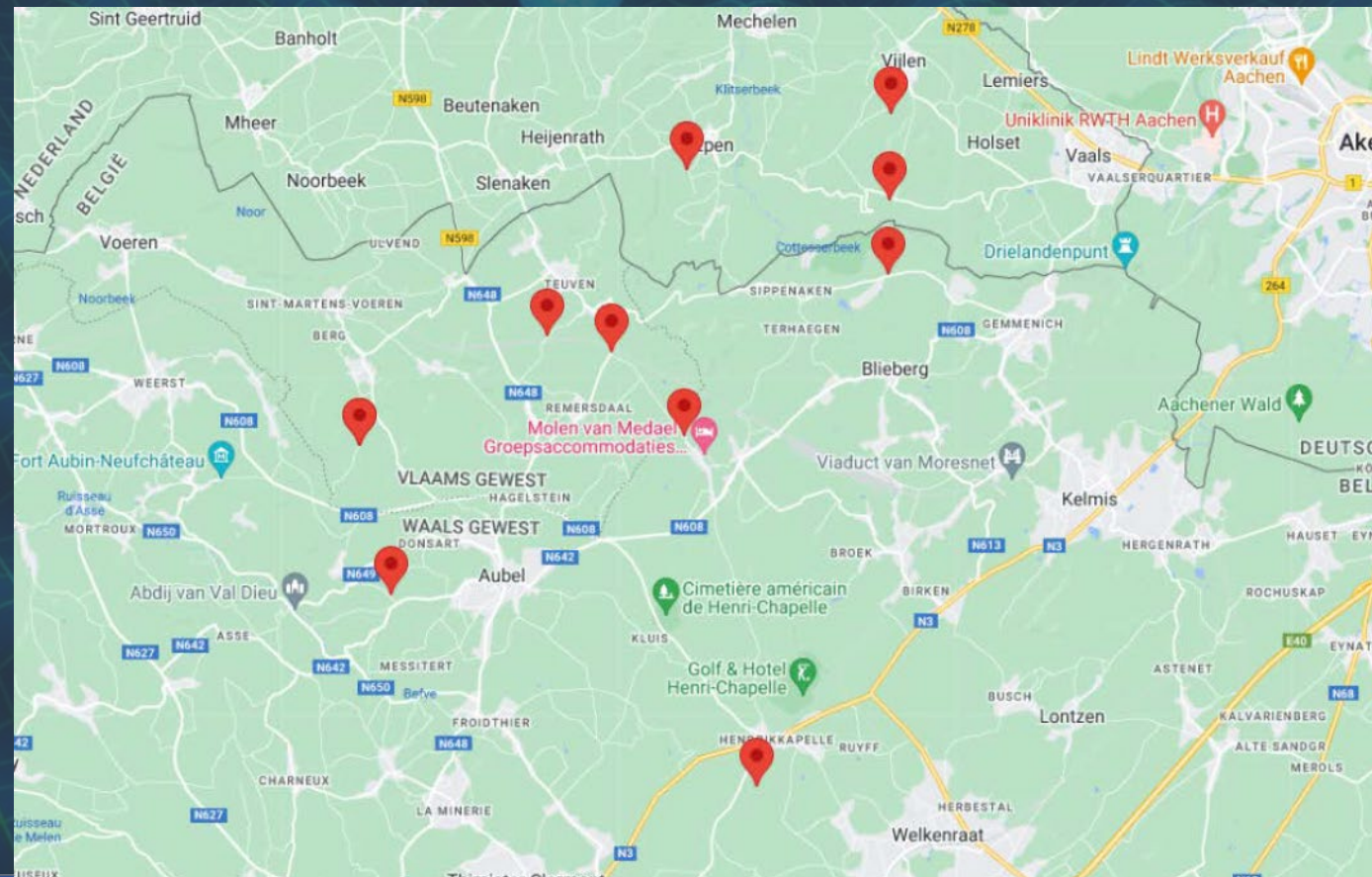
ET EMR Project Office



- Assess **feasibility** EMR candidacy in terms of
 - Technical requirements
 - **Geology**
 - Environment
 - Sustainability
 - Financing
 - Governance & organisation
- Determine the optimal **location** of the triangle
- Prepare an ambitious and high-quality **bidbook** by 2025
- Build a **consortium** to support the ET EMR candidacy
- Proactively **communicate** with stakeholders & public

Boreholes & engineering

- Geological campaign March-August 2024: 10 borehole drillings



- Engineering consortium including Tractebel



ETpathfinder: R&D-center in Maastricht



Cryogenic mirror: Centre Spatiale de Liège



Further information

<https://www.einsteintelescope.be>

hans.plets@fwo.be

- ET Newsletter: register via QR code

