fwo

Einstein Telescope

The Einstein Telescope

Will ET land in Belgium?

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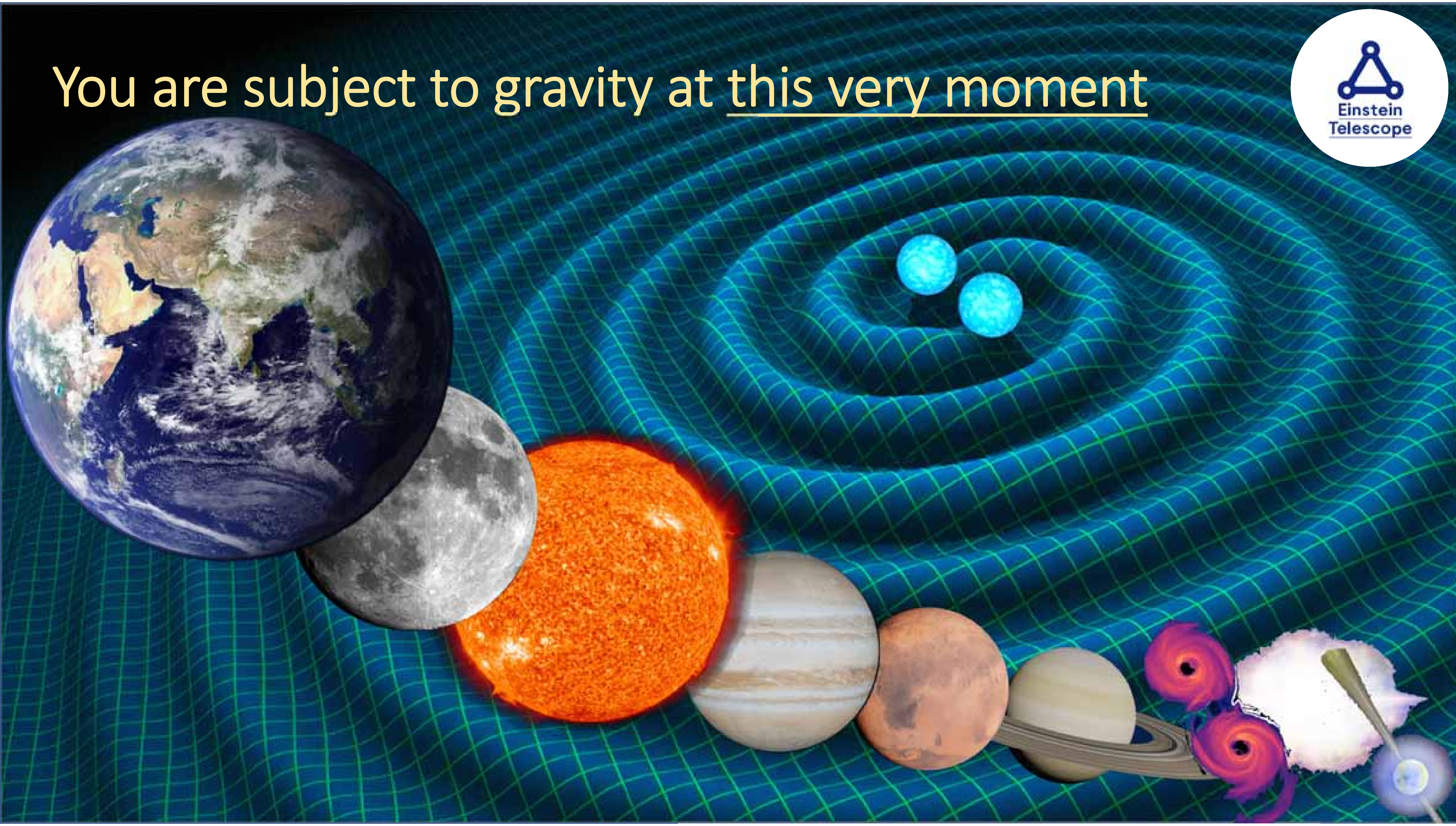
DEEL 1

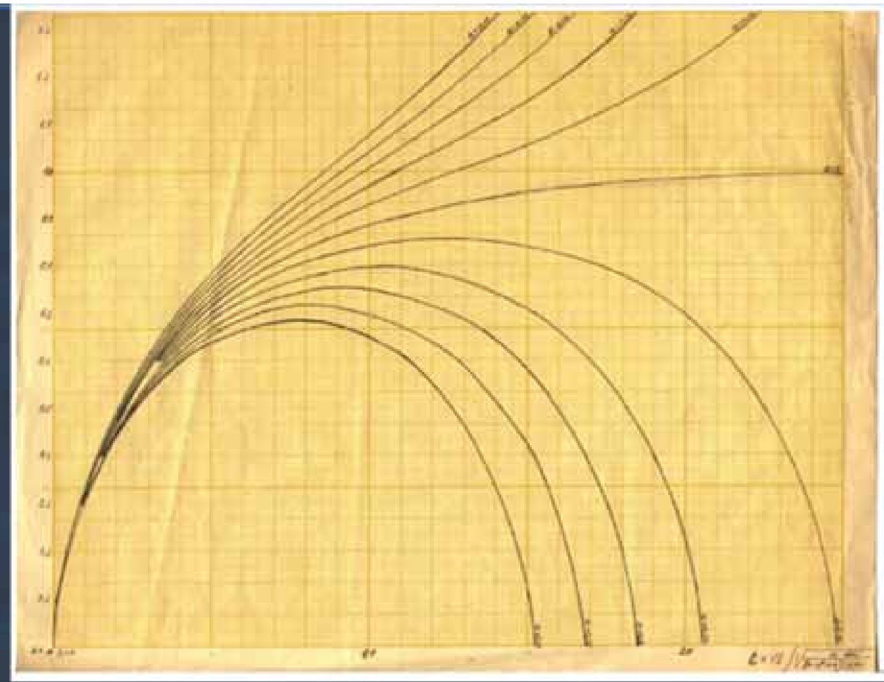
De Einstein Telescope Introductie

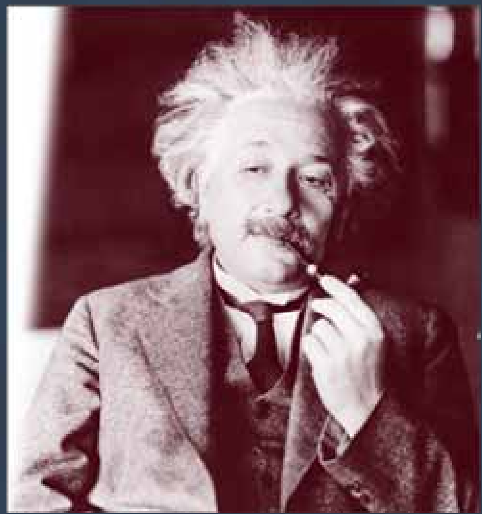

De wetenschap
Einstein
Telescope


You are subject to gravity at this very moment
Einstein
Telescope

Einstein's Relativity Theory

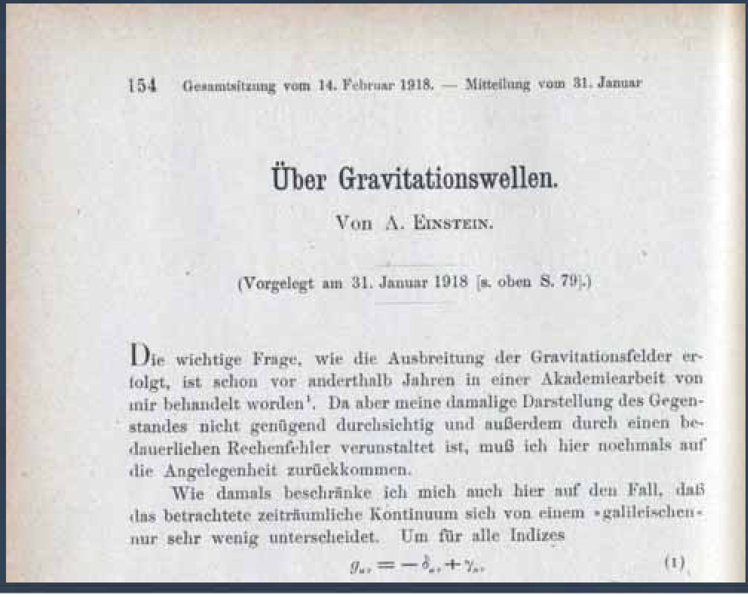
- Celestial Bodies bend light
  → Einstein 1907
  → Eddington expedition in 1919
- The Universe expands
  → Lemaître, Friedmann, Hubble
- Existence of Black Holes
  → Oppenheimer-Snyder
- Gravitational Waves
  → Einstein 1918





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

Curvature Spacetime = 10^{-43} Mass/energy



154 Gesamtsitzung vom 14. Februar 1918. — Mitteilung vom 31. Januar

Über Gravitationswellen.

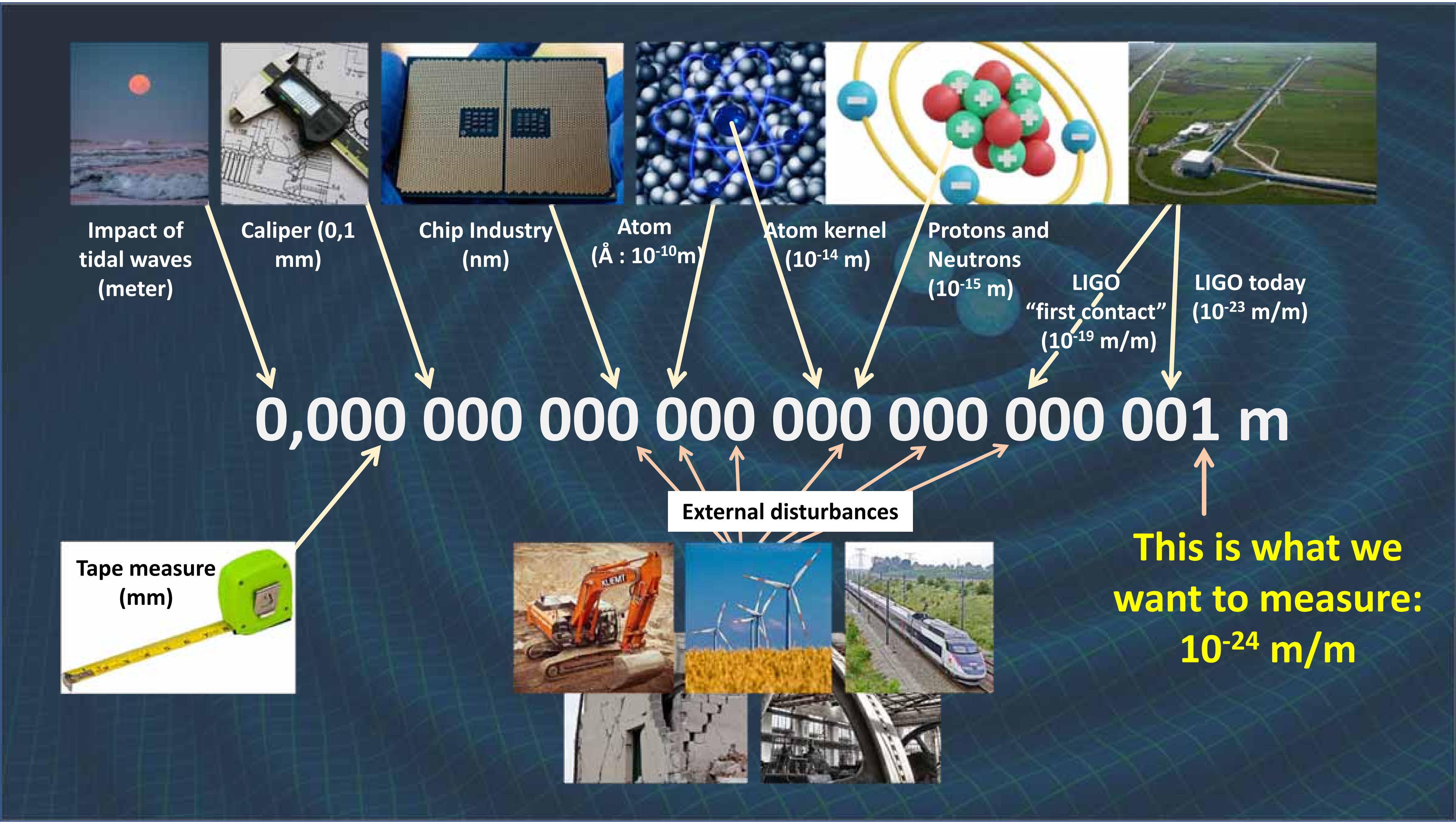
Von A. Einstein.

(Vorgelegt am 31. Januar 1918 [s. oben S. 79].)

Die wichtige Frage, wie die Ausbreitung der Gravitationsfelder erfolgt, ist schon vor anderthalb Jahren in einer Akademiearbeit von mir behandelt worden[1]. Da aber meine damalige Darstellung des Gegenstandes nicht genügend durchsichtig und außerdem durch einen bedauerlichen Rechenfehler verunstaltet ist, muß ich hier nochmals auf die Angelegenheit zurückkommen.

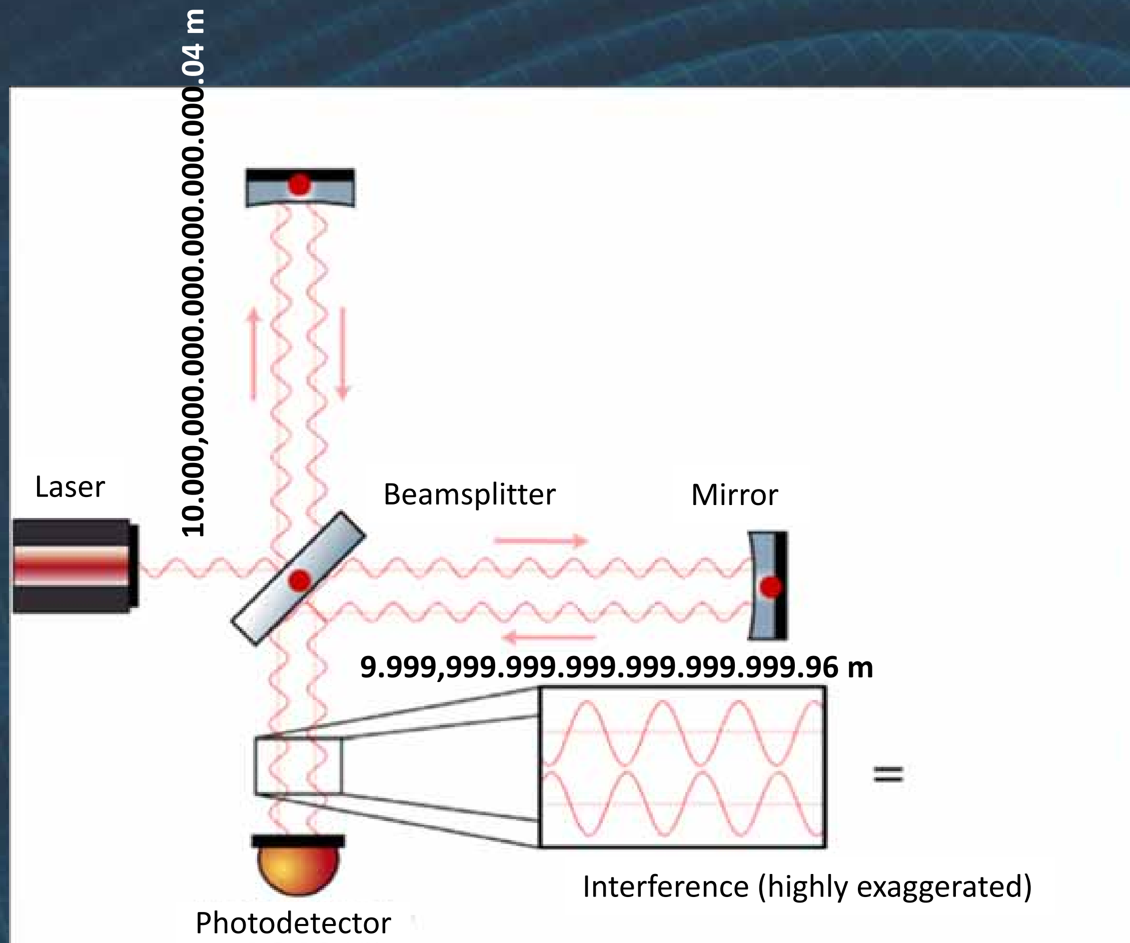
Wie damals beschränke ich mich auch hier auf den Fall, daß das betrachtete zeiträumliche Kontinuum sich von einem »galileischen« nur sehr wenig unterscheidet. Um für alle Indizes

$$g_{\mu\nu} = -\delta_{\mu\nu} + \gamma_{\mu\nu} \quad (1)$$

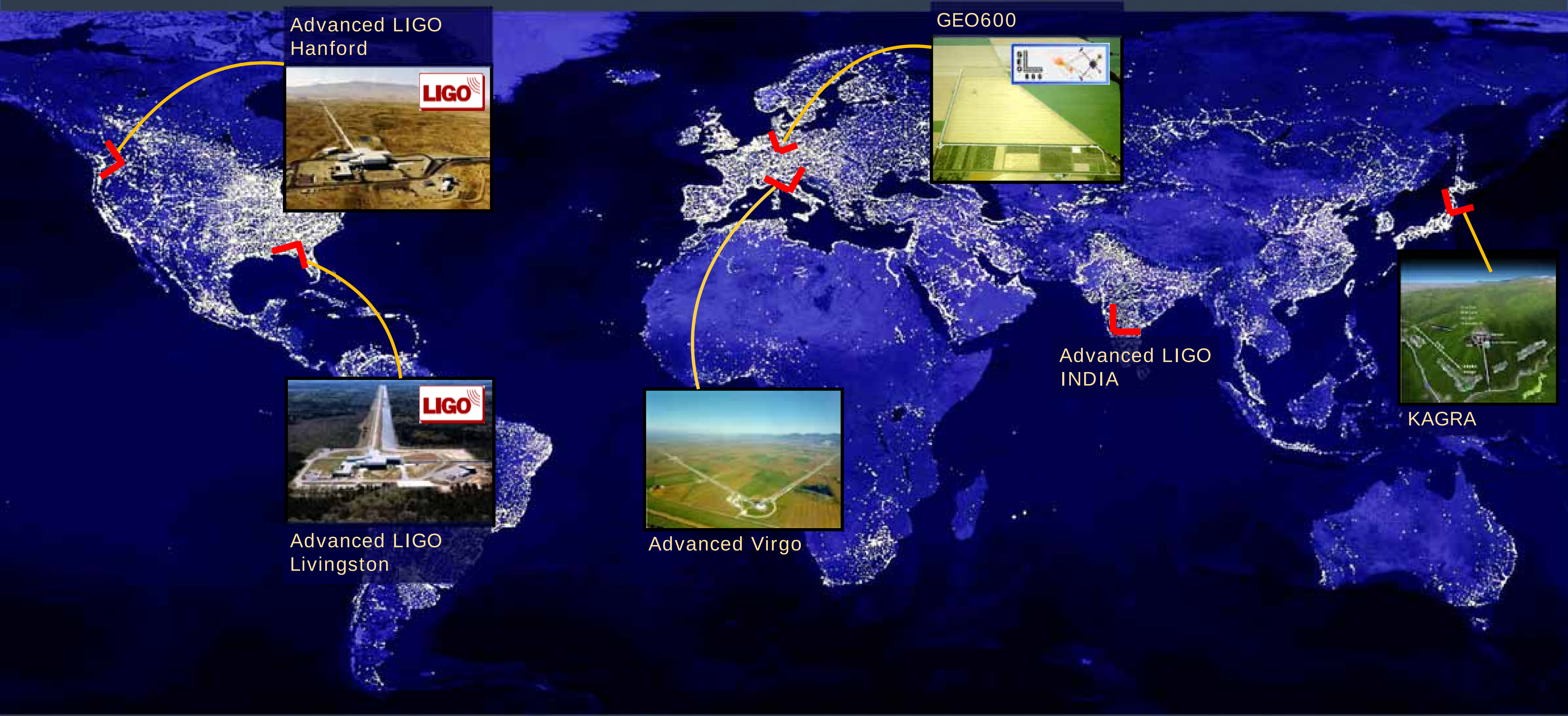


Impact of tidal waves (meter)
Caliper (0,1 mm)
Chip Industry (nm)
Atom (Å : 10-10m)
Atom kernel (10-14 m)
Protons and Neutrons (10-15 m)
LIGO "first contact" (10-19 m/m)
LIGO today (10-23 m/m)
0,000 000 000 000 000 000 000 001 m
Tape measure (mm)
External disturbances
This is what we want to measure: 10-24 m/m

Measurement principle of an interferometer



Existing and planned detectors



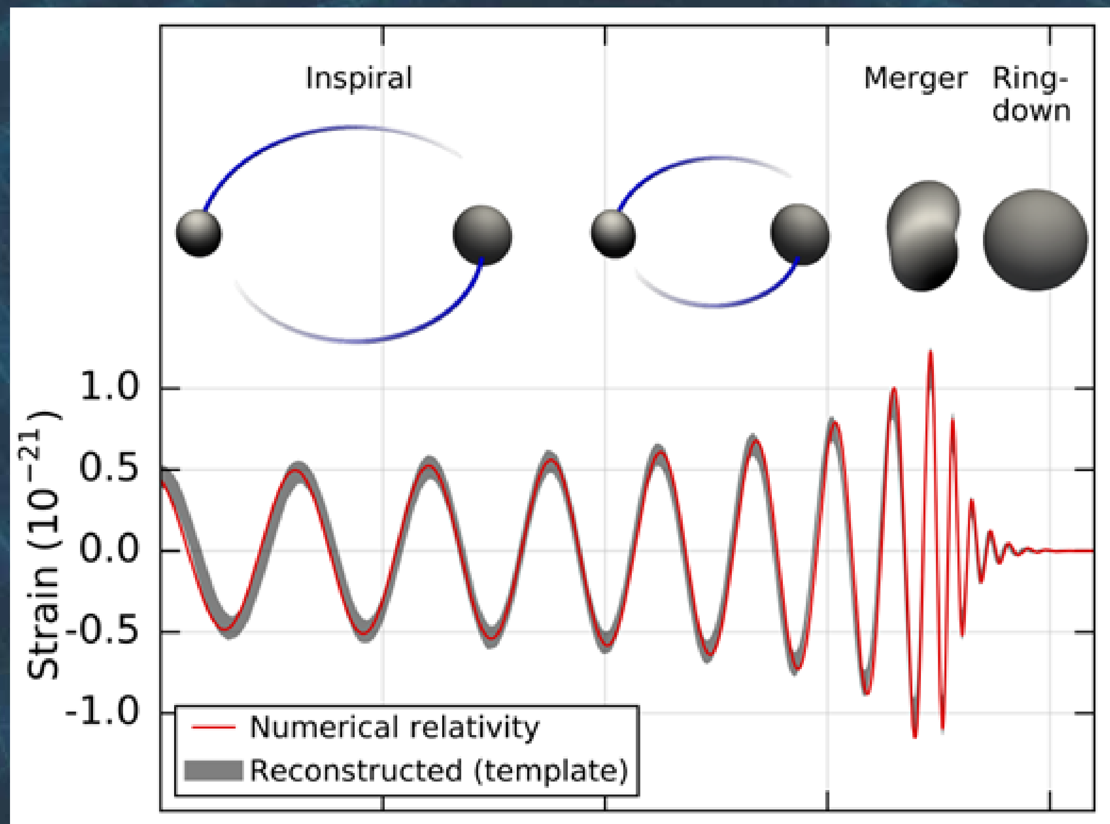
Theory versus Reality

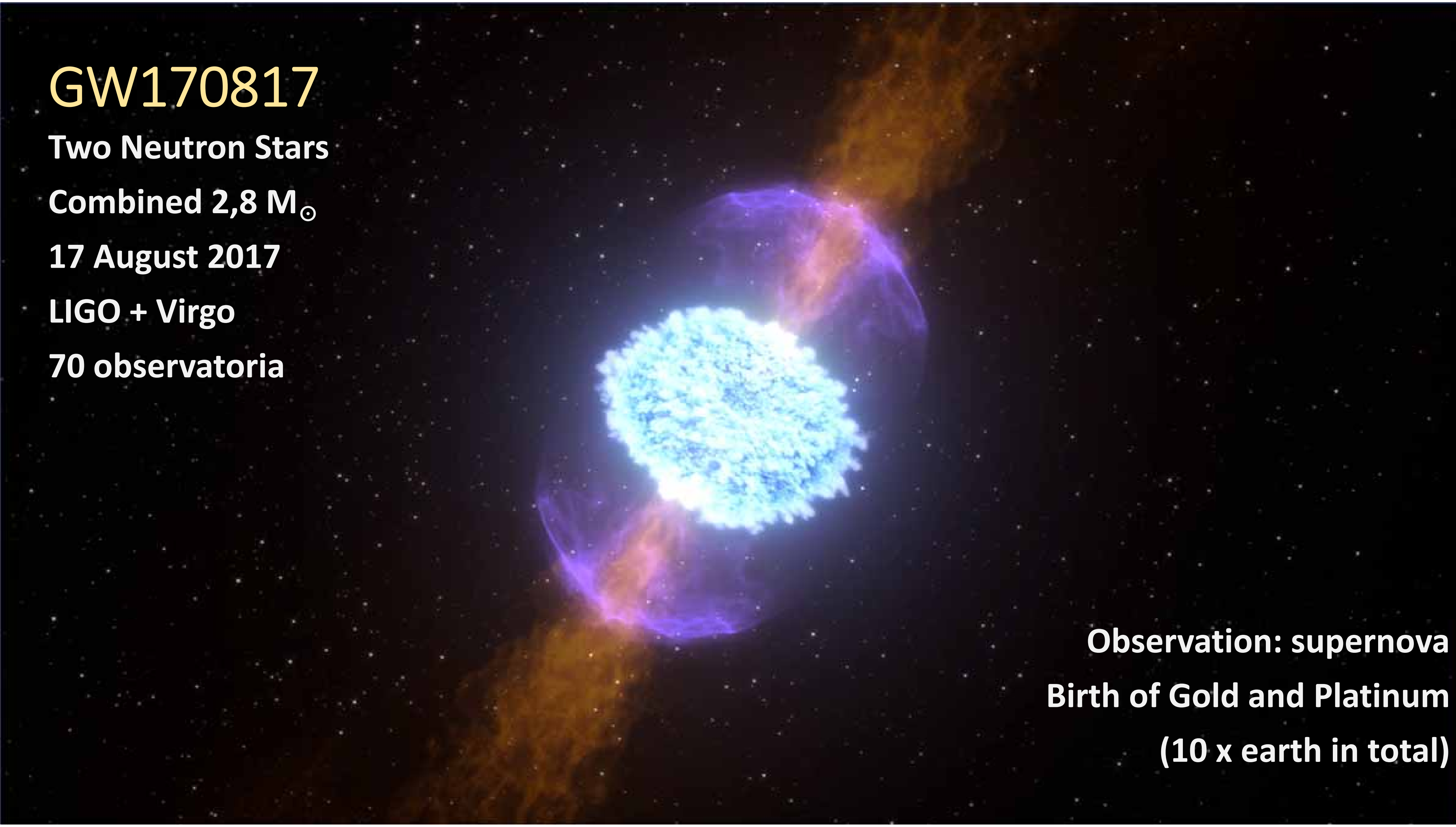
Simulation

Neutron Star merging with a Black Hole

GW150914

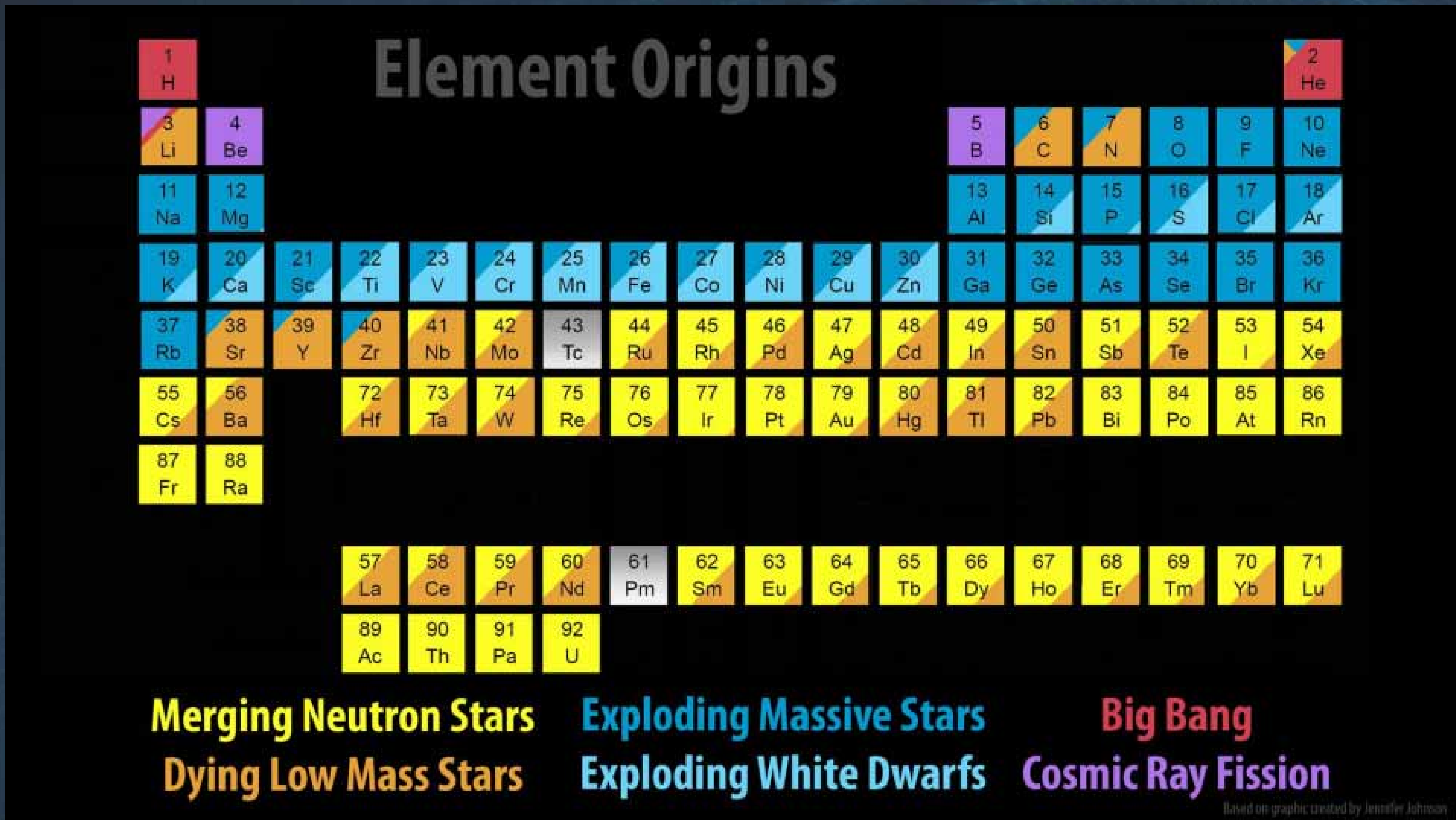
First Gravitational Wave detected by LIGO (VS) on September, 14, 2015




GW170817
Two Neutron Stars
Combined 2,8 $M_{\odot}$
17 August 2017
LIGO + Virgo
70 observatoria
Observation: supernova
Birth of Gold and Platinum
(10 x earth in total)

Where do our atoms come from?

Einstein Telescope



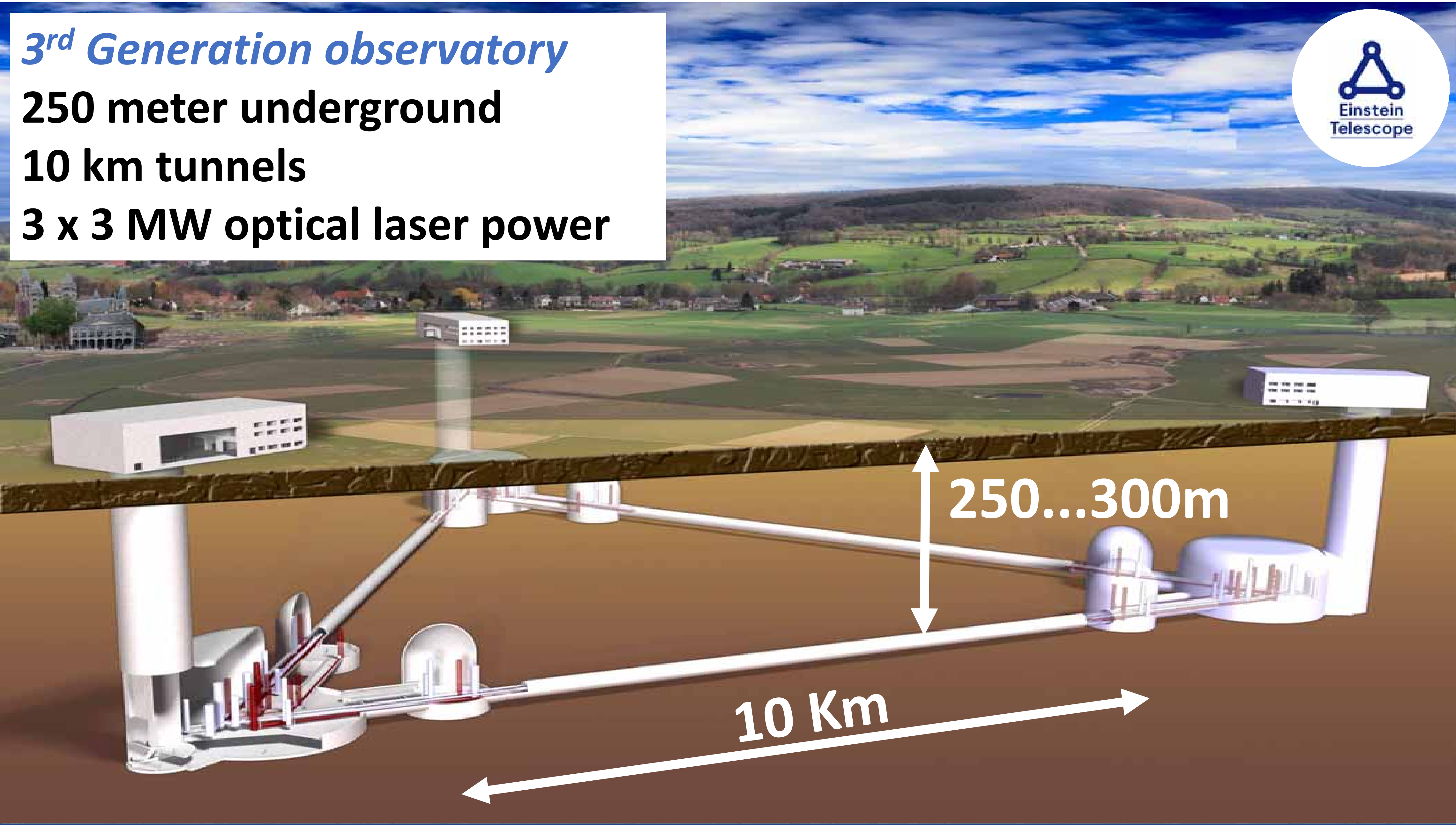
De ambitie

3rd Generation observatory

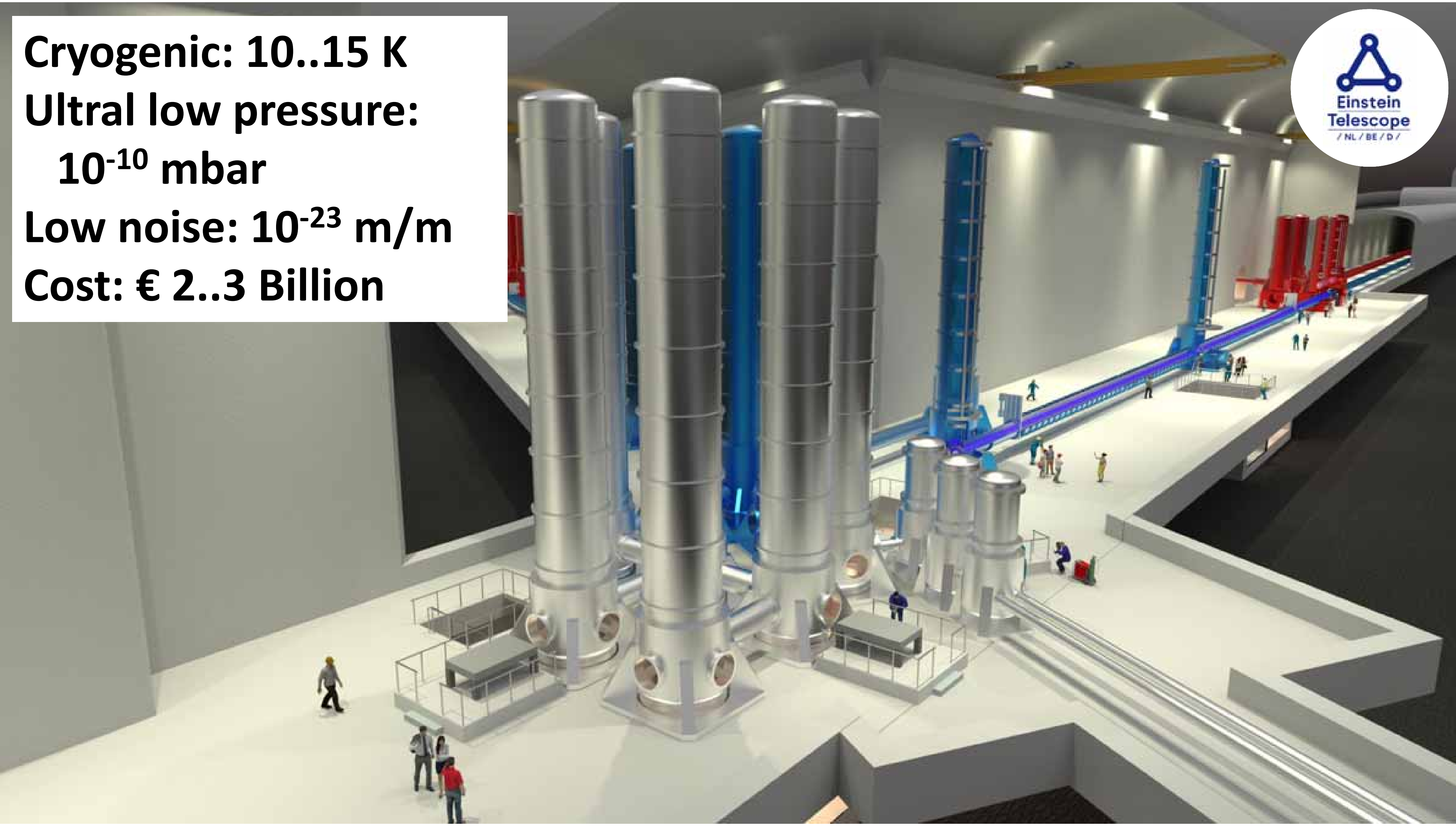
250 meter underground

10 km tunnels

3 x 3 MW optical laser power



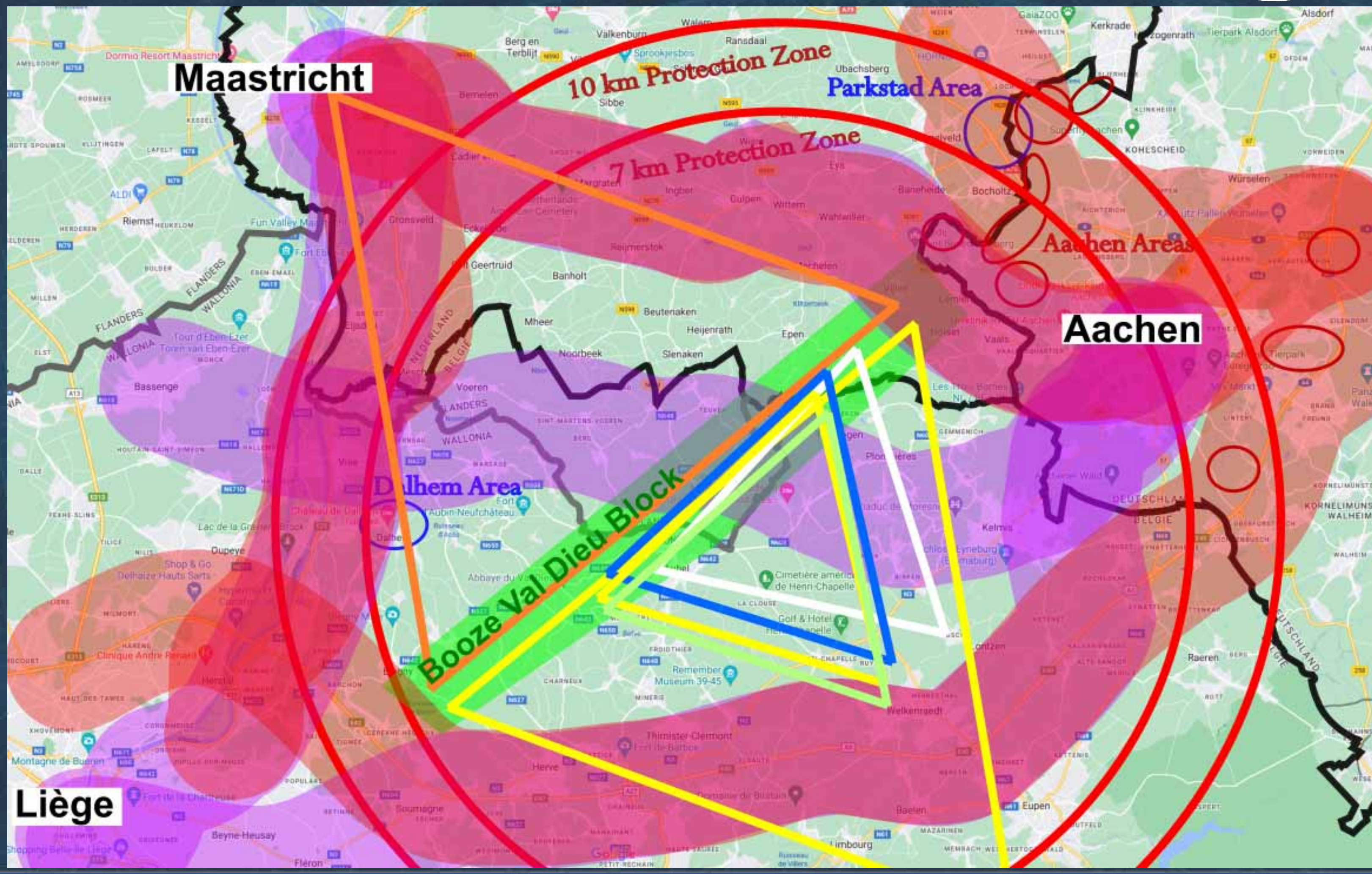
Cryogenic: 10..15 K
Ultral low pressure:
10^{-10} mbar
Low noise: 10^{-23} m/m
Cost: € 2..3 Billion

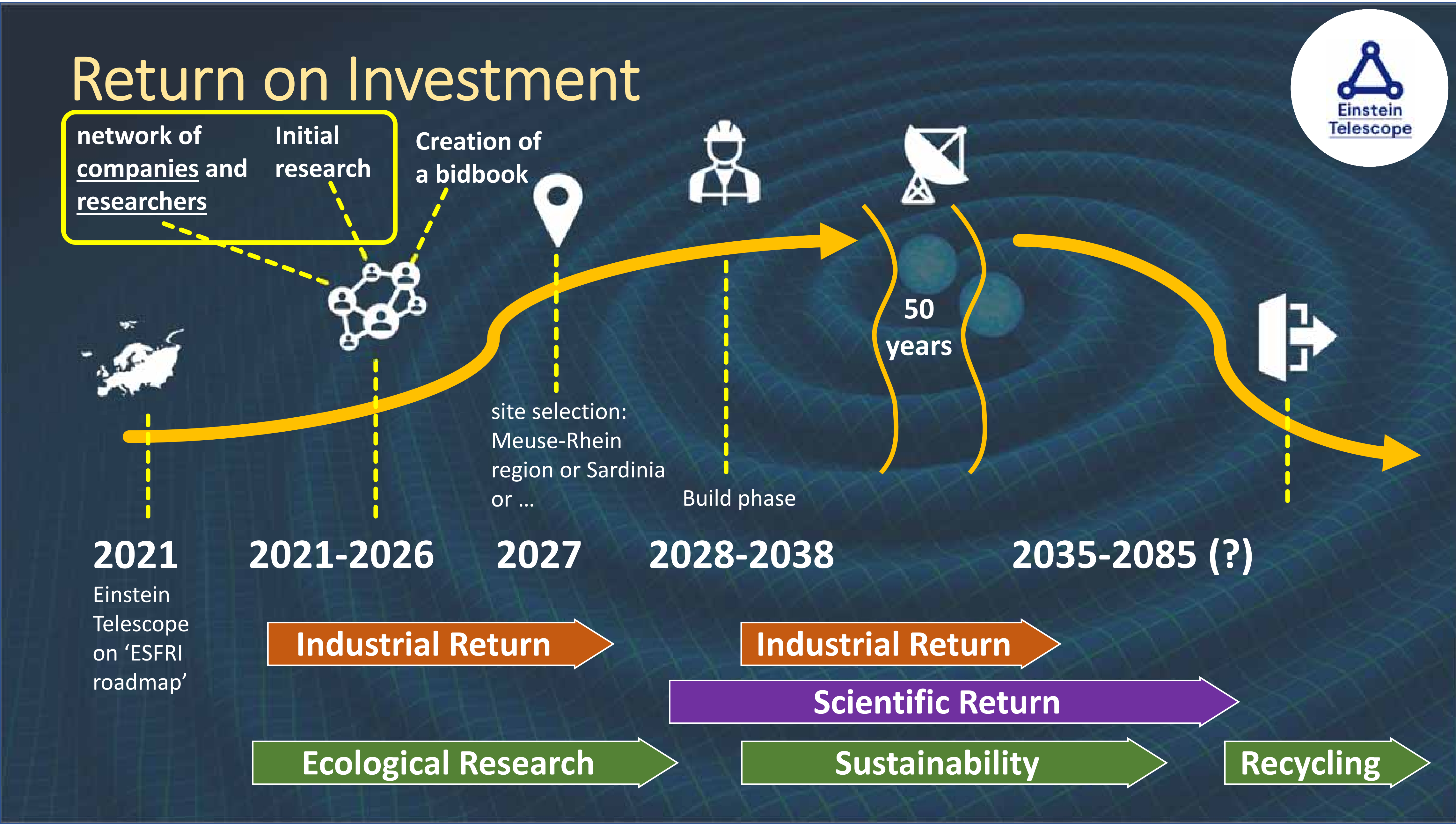


Three possible locations

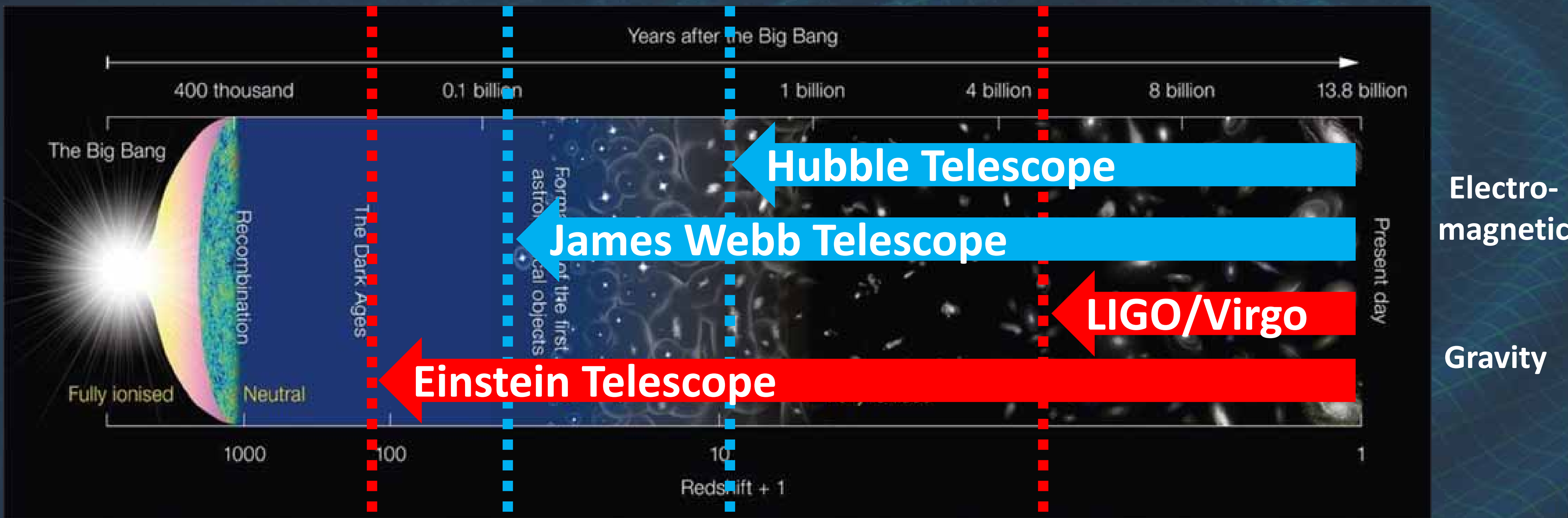
- **Three-corner point BE-NL-DE**
- **Sardinia** (IT)

- ***Saksen*** *(DE)?*




Return on Investment
Einstein Telescope
network of companies and researchers
Initial research
Creation of a bidbook
site selection: Meuse-Rhein region or Sardinia or …
Build phase
50 years
2021
Einstein Telescope on 'ESFRI roadmap'
2021-2026
2027
2028-2038
2035-2085 (?)
Industrial Return
Industrial Return
Scientific Return
Ecological Research
Sustainability
Recycling

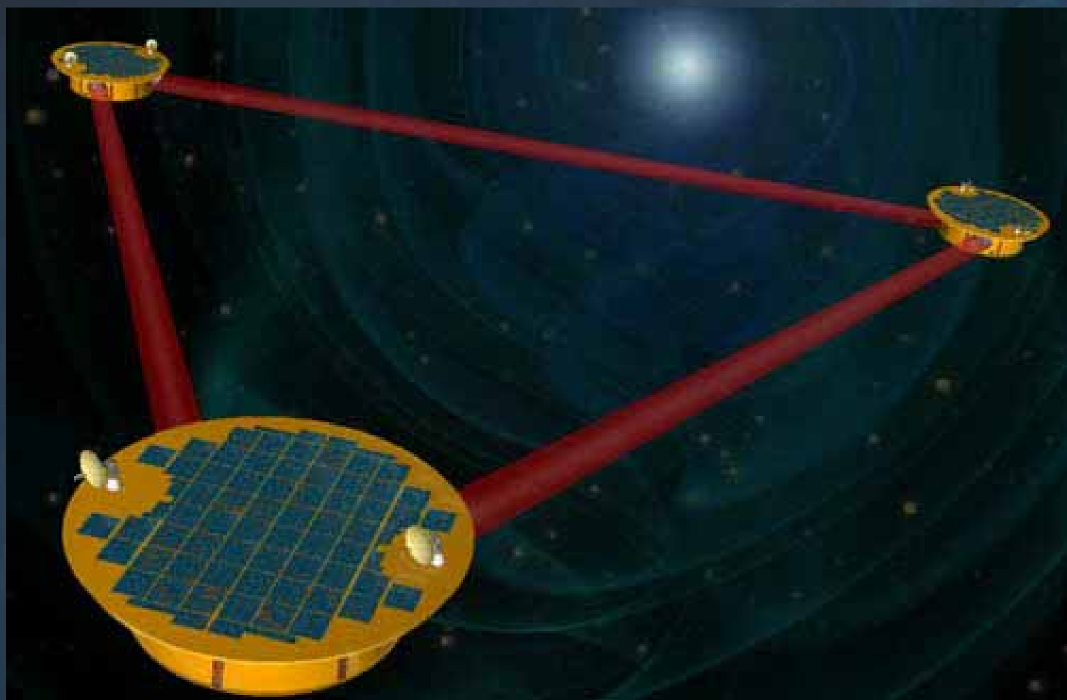
Ambition: look further into the past than when the first stars were born

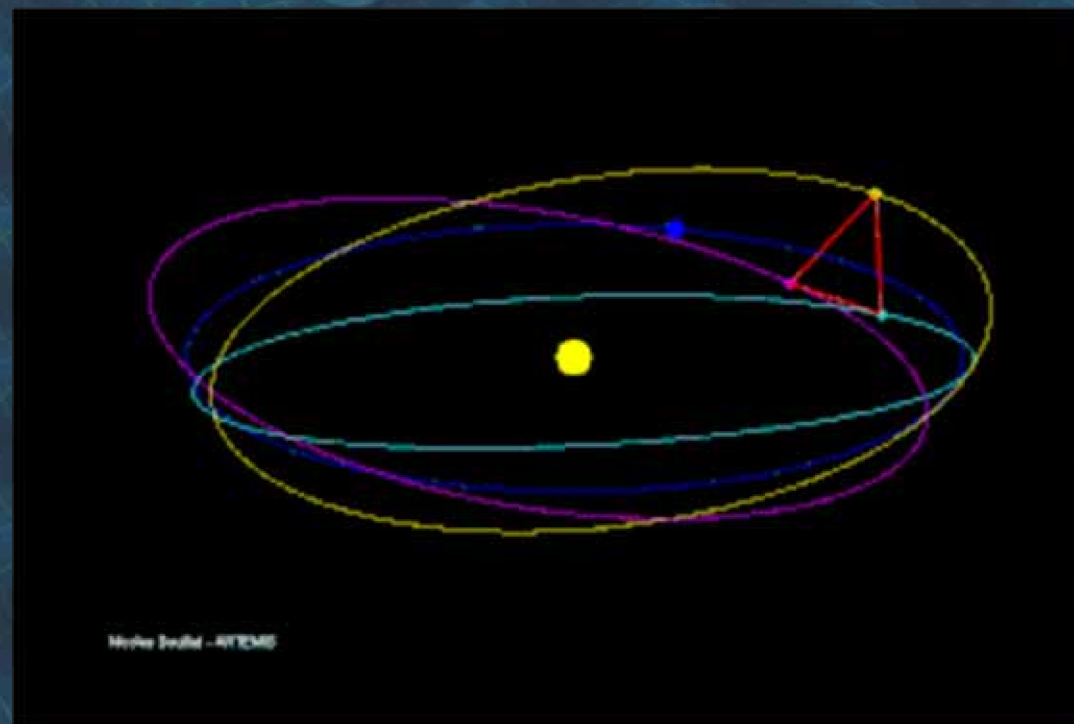


But also: discover dark energy and dark matter, test Einstein's General Relativity, find primordial black holes, particle physics, new detections ...

The Cosmic Explorer sister in the US (ETA mid 2030)

The LISA sister in space (ETA ~2035)





2 Watt @ 1064nm
Distance between mirrors : 2,5 million km
Frequency range: 10 to 10mHz
20 degrees behind the Earth

DEEL 2

De ET in wat meer detail

Menu

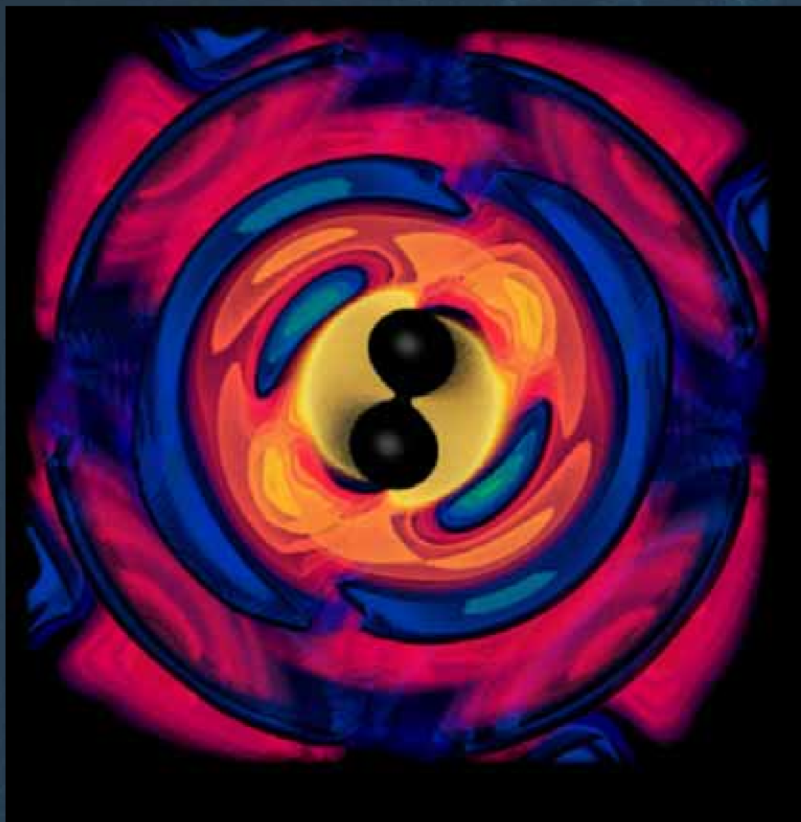
- RELISEER TEXT -

- Science Case
  - Wat willen we vinden?
- Het geologisch onderzoek in het drielandenpunt
- De ondergrondse constructies
- Het optische pad
  - Waarom hebben we zoveel torens nodig?
- Vibration Damping - de controle van de ET
- Spiegelcoatings
- Het vacuümsysteem van de ET
- Waar halen we de energie vandaan?
- Welk onderzoek wordt er zoal gedaan?
  - Business opportunities
  - Onderzoeksdomeinen
- ETpathfinder
- Het Europese onderzoekslandschap
  - De organisaties

Einstein Telescope

THE SCIENCE CASE
What do we want to find?

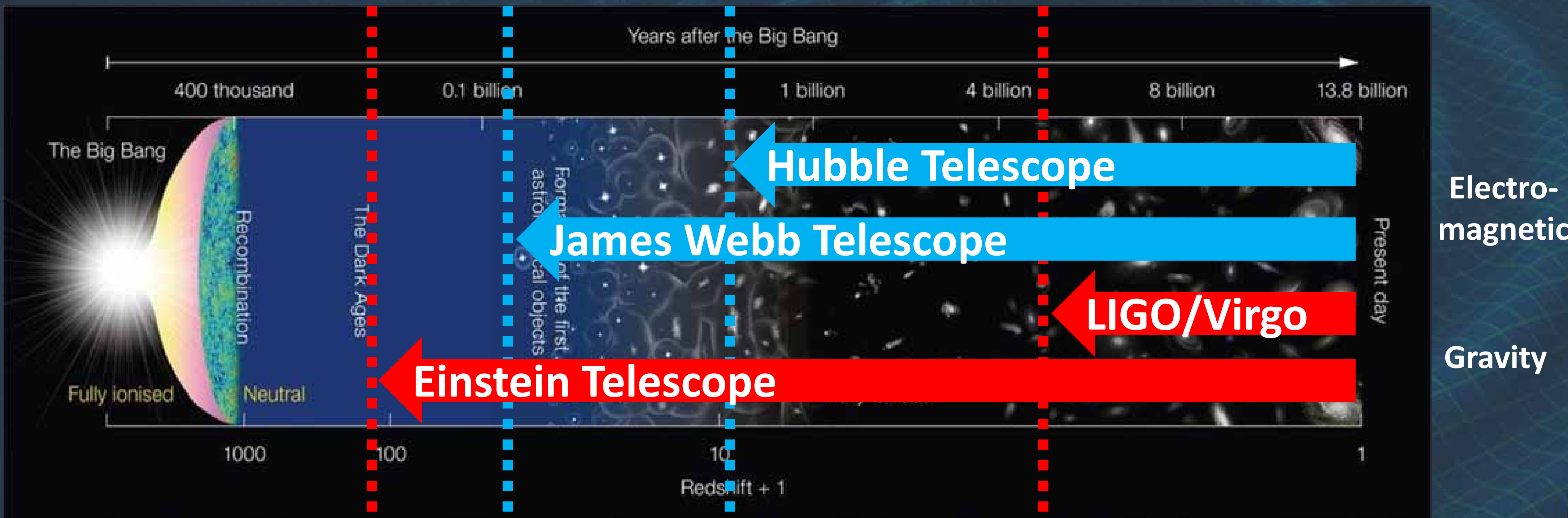
Coalescing Compact Binary Systems (CBC)



Credit: Cactus Framework: Black Holes to Gamma Ray Bursts - arXiv:0707.1607v1 [cs.DC] 11 Jul 2007

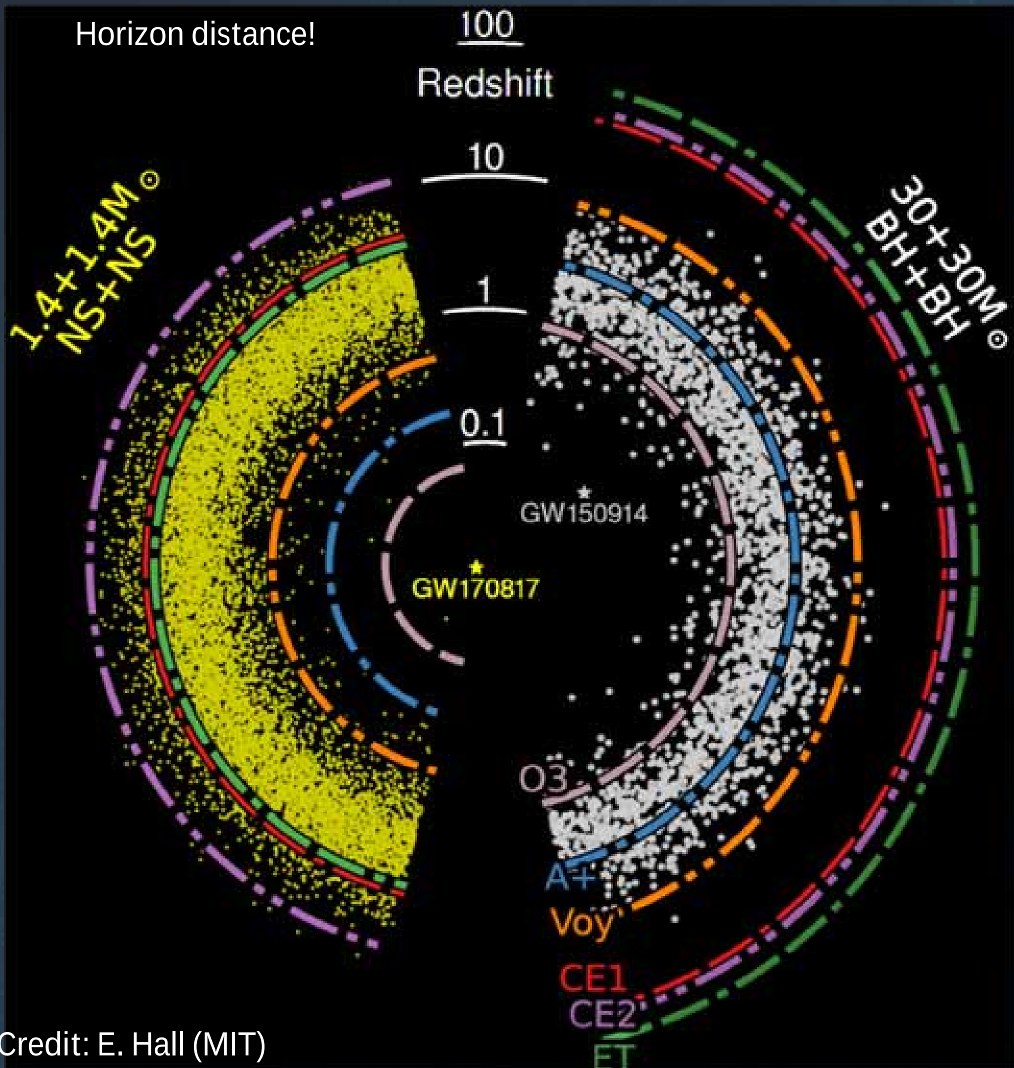
- Neutron Star-NS, Black Hole-NS, BH-BH
- Strong emitters, well-modeled
- (effectively) transient
- Black hole properties: origin (stellar / primordial), evolution, demography
- Near-horizon physics, probing the nature of compact objects

Ambition: look further into the past than when the first stars were born



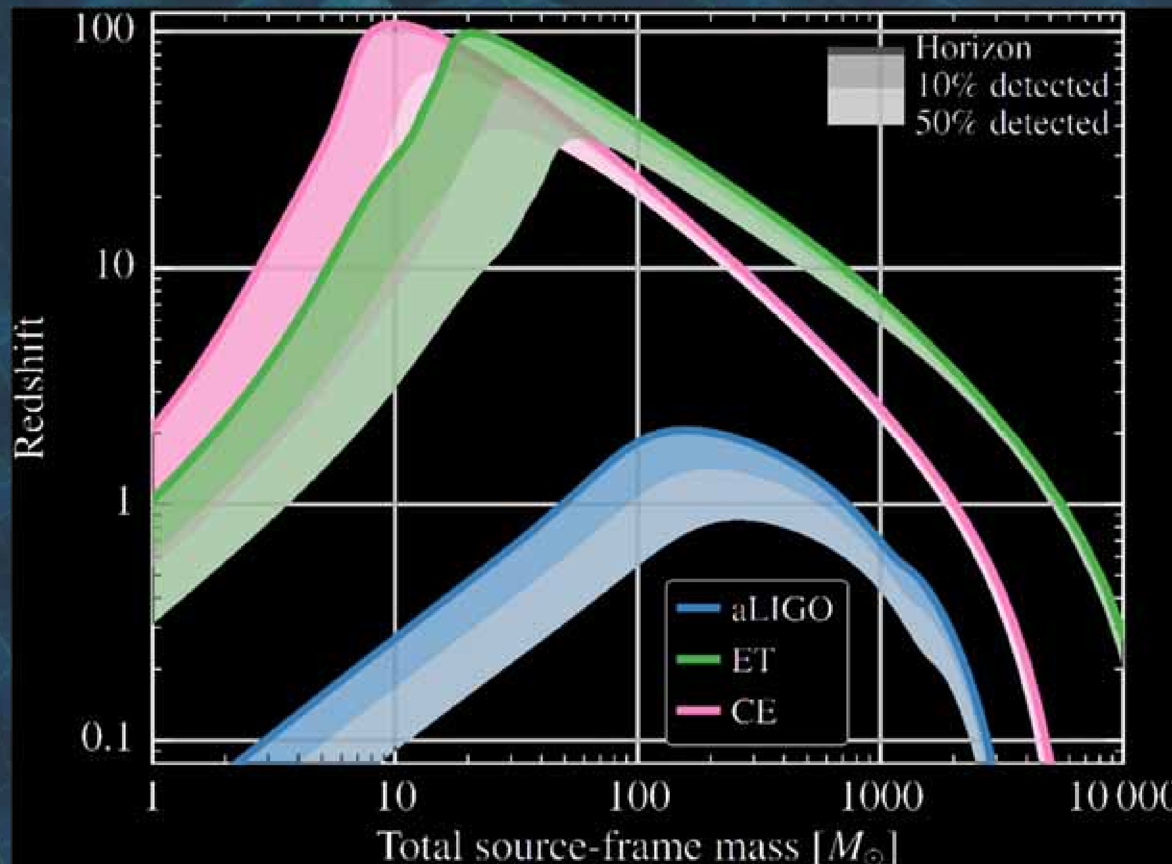
But also: discover dark energy and dark matter, test Einstein's General Relativity, find primordial black holes, particle physics, new detections ...

Binary mergers (Coalescent Binary)



Credit: E. Hall (MIT)

CBC Sources throughout the universe



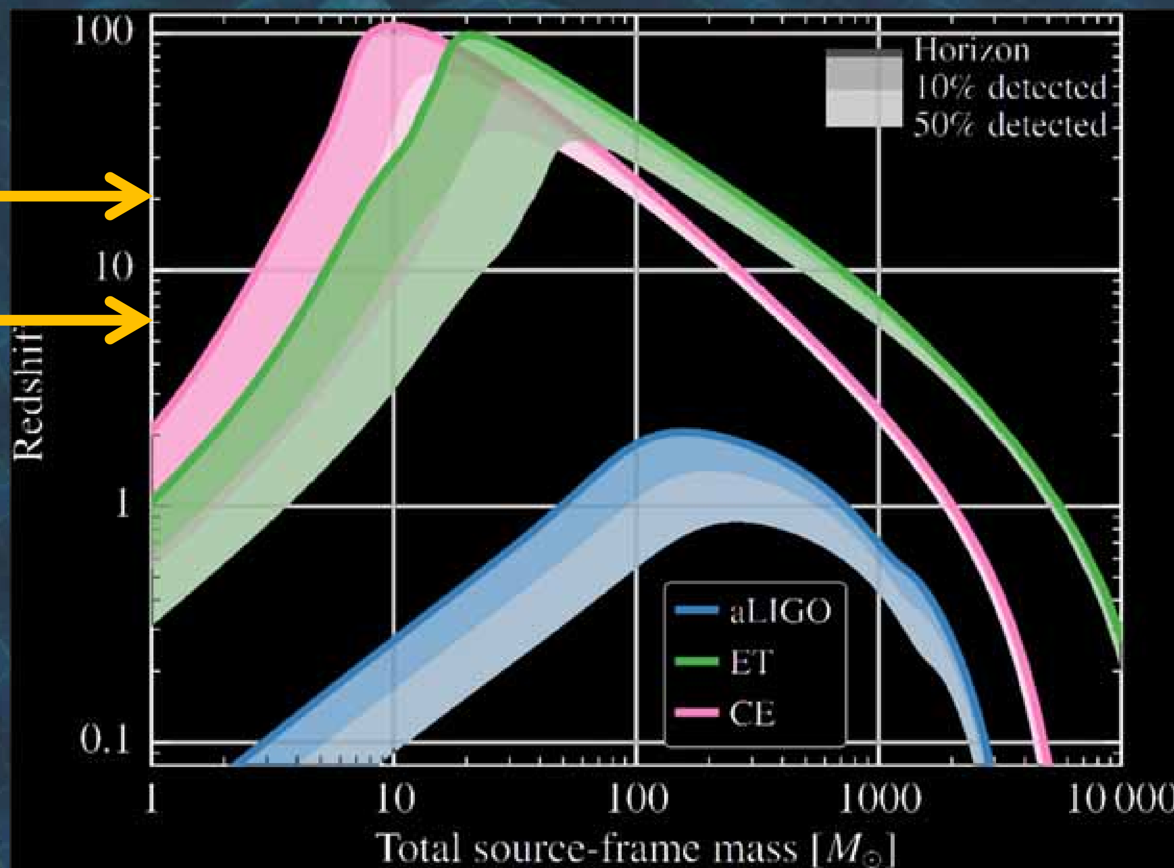
Binary mergers (Coalescent Binary)

Black hole mergers at z~20 and higher would necessarily have a primordial origin (Black holes already created in the primordial soup)

BH-BH mergers beyond reionization epoch (z>=6) will provide details of first metal-poor stars.

Universe age

CBC Sources throughout the universe

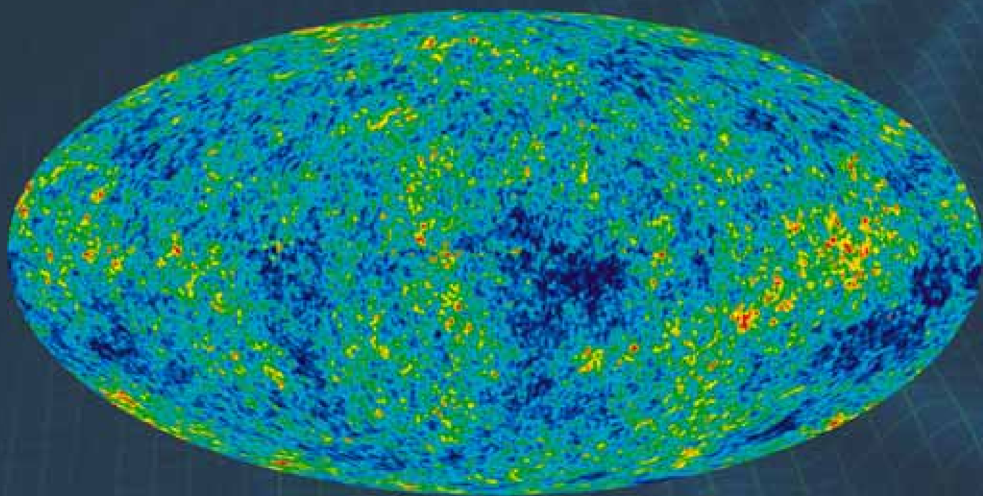


‘Bursts’, e.g. Asymmetric Core Collapse Supernovae

NASA / Chandra X-Ray Observatory: https://chandra.harvard.edu/photo/2024/sonify9/

- Weak emitters
- Not well-modeled (‘bursts’), transient
- New sources: supernovae, isolated neutron stars

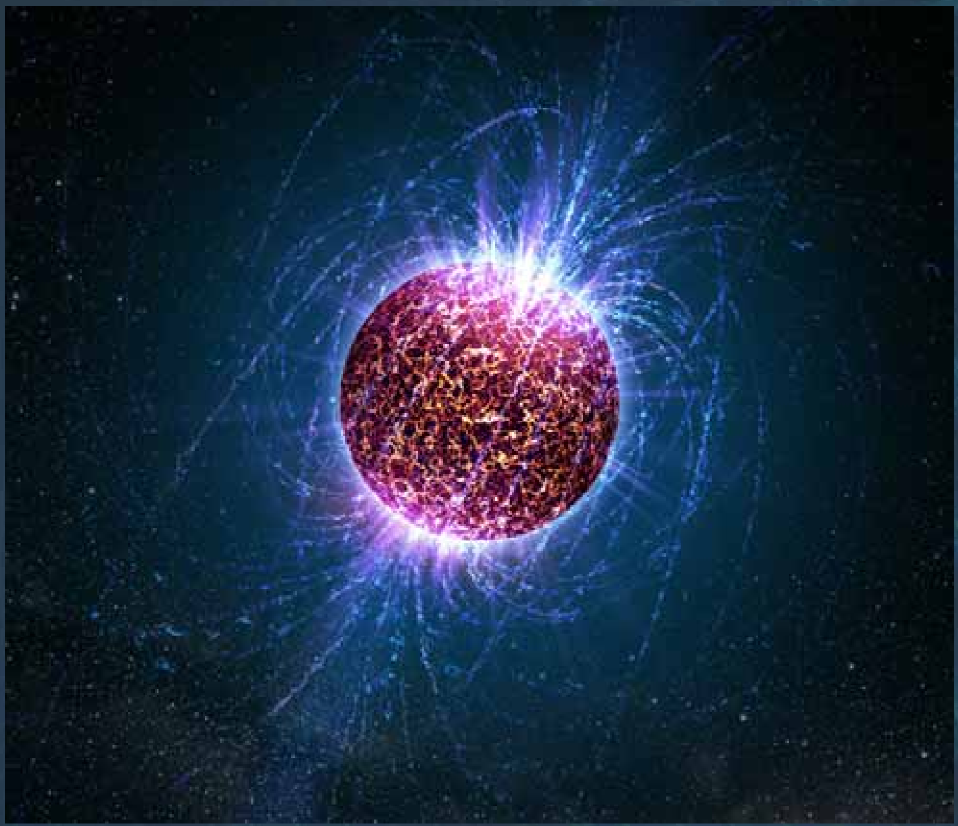
Stochastic Gravitational Wave Background



- Cosmological and astrophysical origin
- Long duration stochastic background
- Dark matter: primordial black holes, axion clouds, …
- Dark energy and modifications of gravity at cosmological scales

NASA / WMAP Science Team - http://map.gsfc.nasa.gov/media/121238/ilc_9yr_moll4096.png

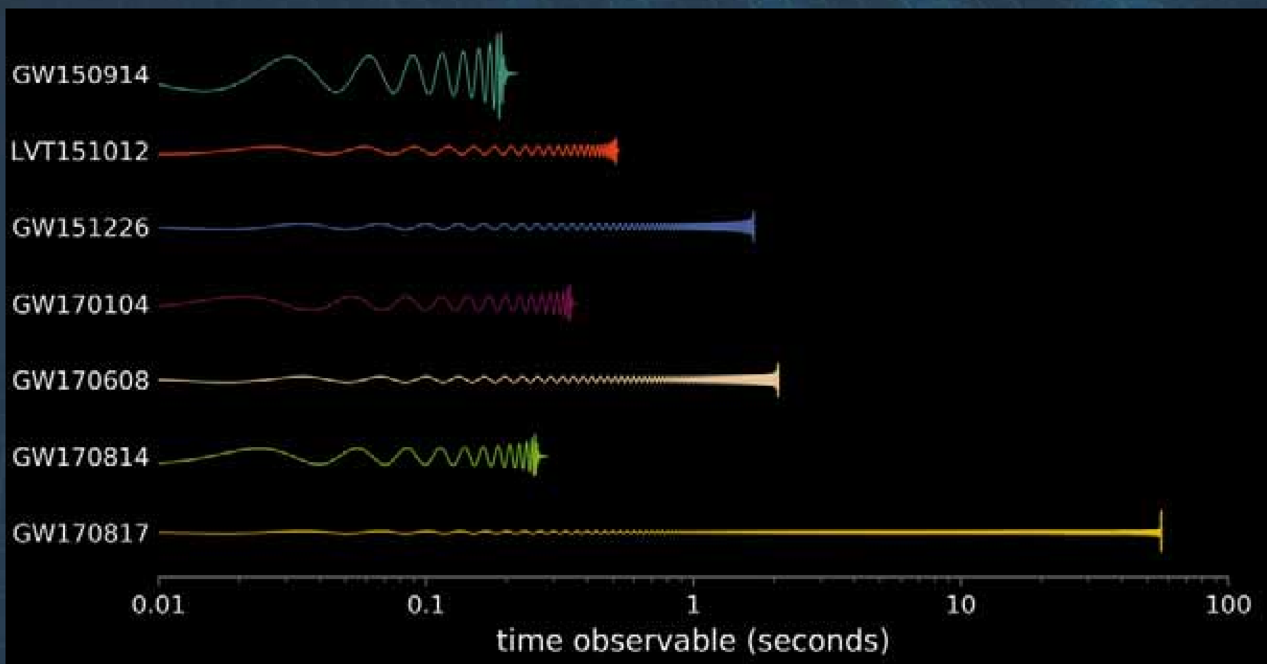
‘Continuous waves’ (CW)



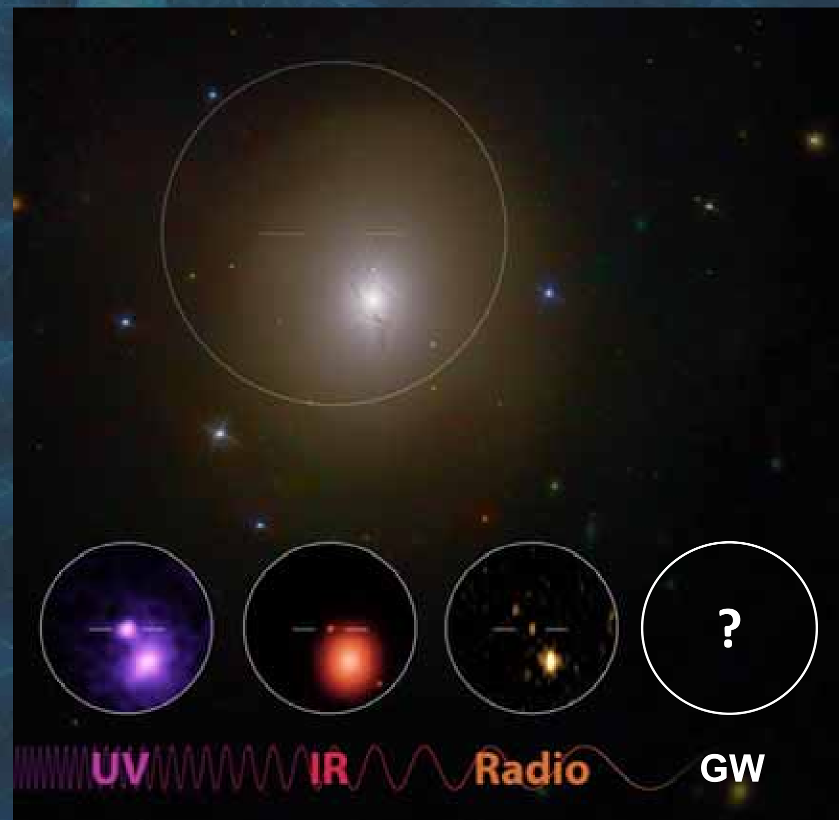
- E.g. Spinning neutron stars
- (Nearly) monotonic waveform
- Long duration
- Neutron star properties: strongly coupled matter, QCD, exotic matter

Multi-messenger astronomy

- Predict an event before it happens
- Extend the time to warn other observatories



NGC 4993; redshift: ~ 0.01



Images courtesy: Alan J Weinstein, “Fundamental physics with Gravitational Waves”

In search of the mass gap

Mergers into
heavier systems

- Black holes merge and form larger black holes
- Neutron Stars merge too

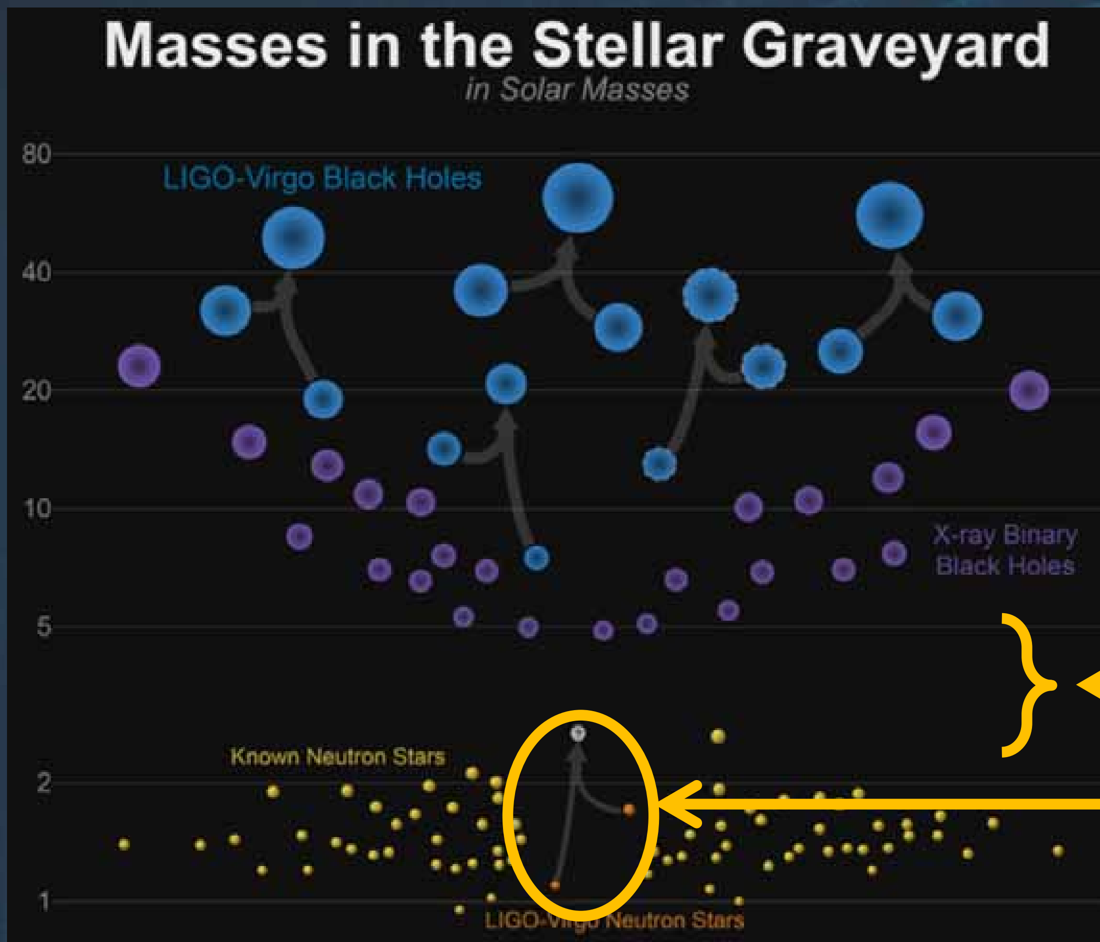


Image courtesy https://www.ligo.caltech.edu/image/ligo20171016a - BH and NS Mass Chart

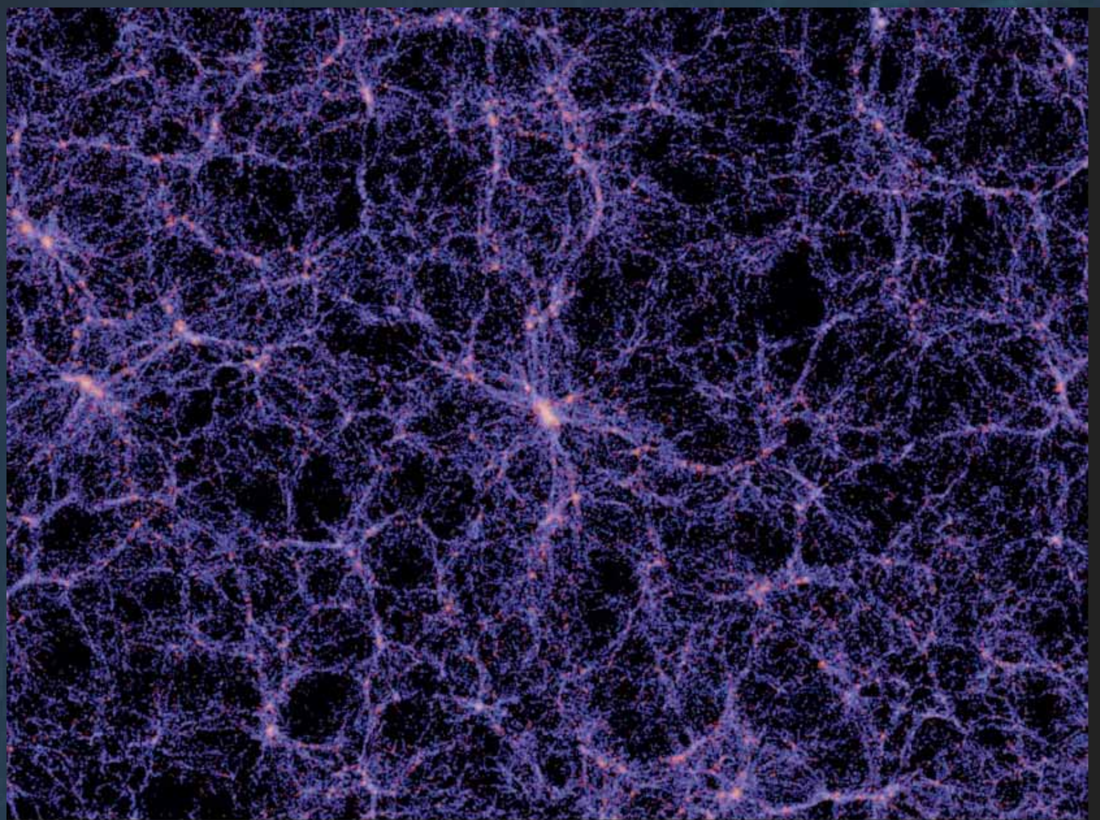
Why is this region empty?

What happens when Neutron stars merge (what remains)??

Dark Matter and Dark Energy

- Presence of dark matter in a Neutron Star
  - imprint on GW signal during inspiral and merger
  - Low frequency detector needed
- Accumulation of dark matter inside a neutron star
  - can result in a Black hole that accretes the Neutron Star remainder
  - Result: 1 to 2 $M_{\odot}$ Black Holes
- Investigate if Dark Matter comes from 0.1 $M_{\odot}$ to 100 $M_{\odot}$ primordial Black Holes
- Investigate if superradiant ultralight Bosons spinning around BH are sources of Dark Matter
  - detectable through Compton wavelength
- Measuring Hubble constant H_0 (expansion of the universe by Dark Energy)
  - "Standard Candle" type Ia supernovae assisted by binary GW signals : "Standard Sirens"
  - Coalescent binaries provide Luminance, redshift measured with electromagnetic signal
  - Change in H_0 over time can provide information on Dark Energy
- Difference in gravity over very long distances

Cosmic Strings (speculative)



Courtesy: Rich Murray - static.flickr.com/13/18135102_07a58fd89d_o.jpg

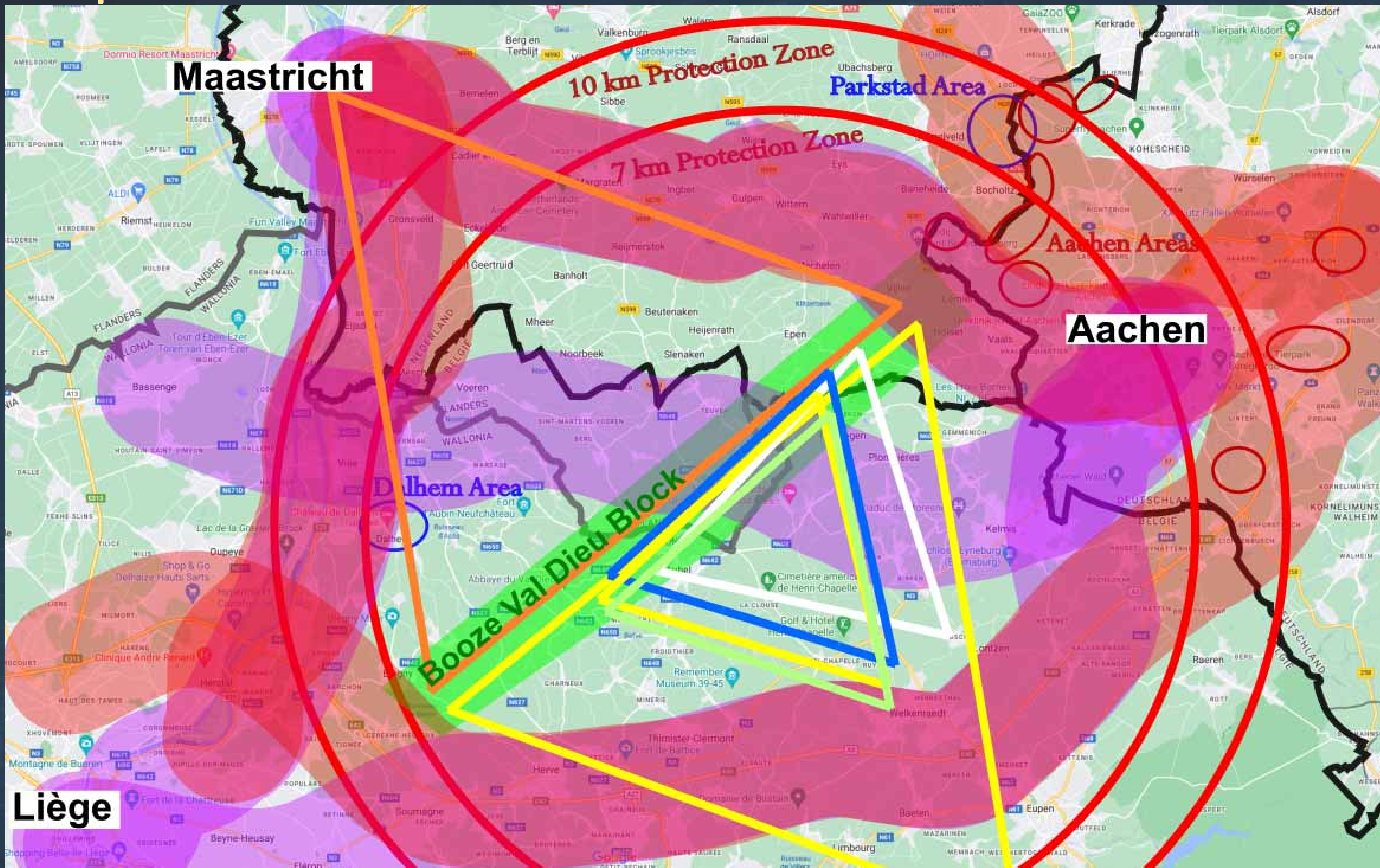
- Strings thinner than a proton but that pack immense mass and density
- Likely disappeared over time, but the effects may be seen in the early universe

… and much more

- “black hole mimickers“
  - boson stars
  - gravastars
  - stars composed of dark matter particles

GEOLOGICAL RESEARCH
(Hydro)geological mapping

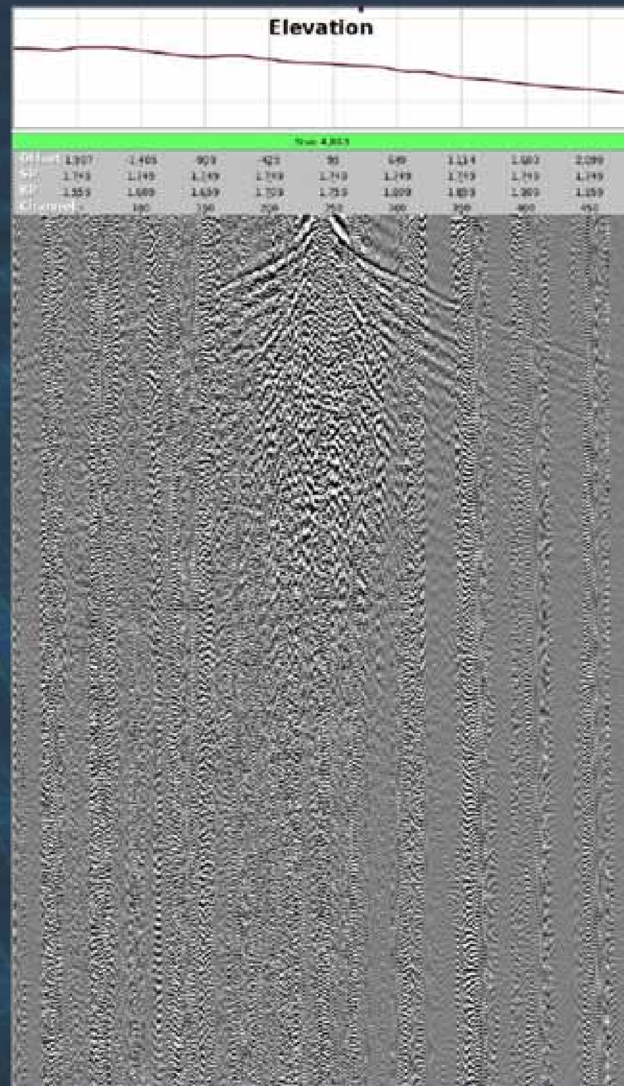
Noise protection zones



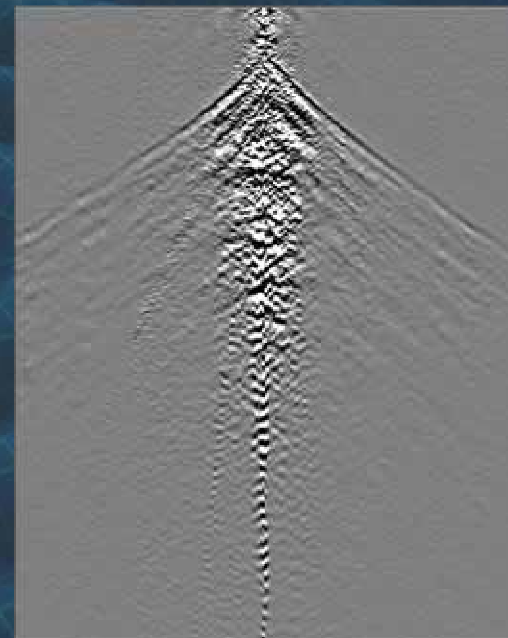
First try: Vibro-Seis

Frequency ranges

- Electro-vibe: 2-100 Hz
- Vibro-Seis 6 – 90 Hz or 10 – 90 Hz

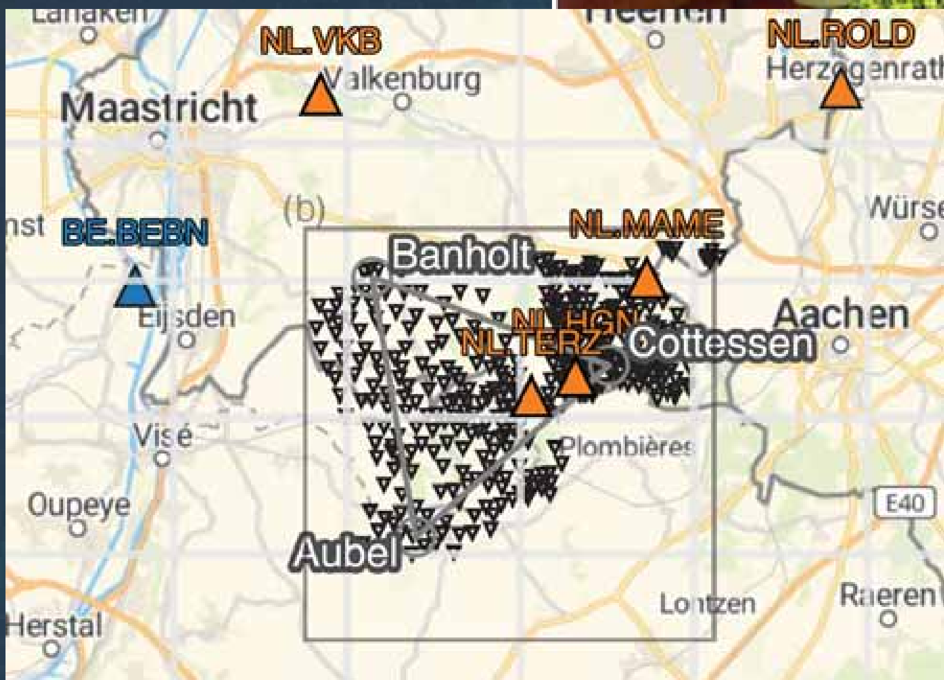


After noise suppression

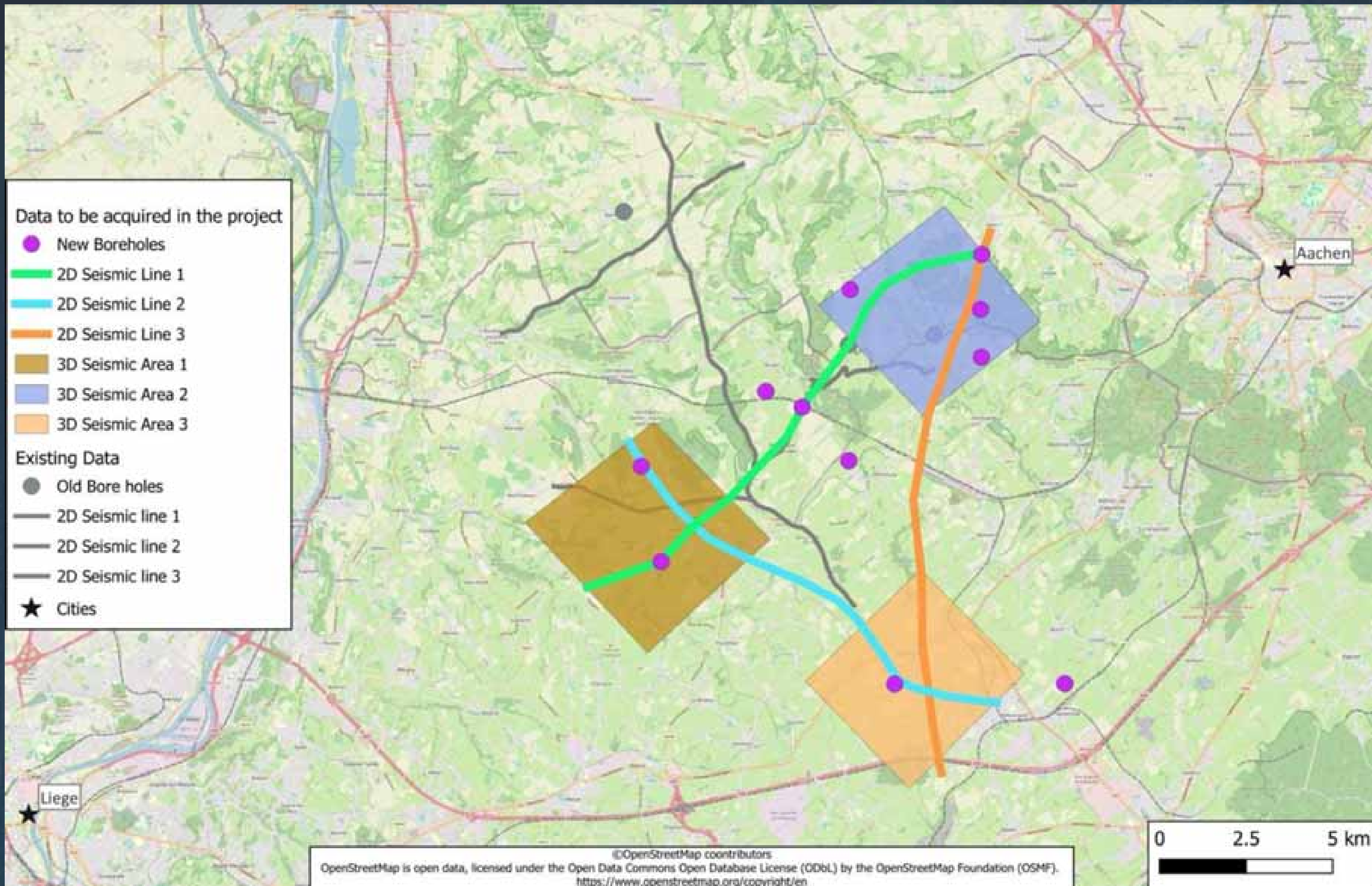


Seismological Research

- 400 type 3C (5Hz) geophones @ €1K /st
- 200 type 1C (vertical) geophones @ €300 /st
- The largest geological lab in the world!



Seismological Research



Borehole campaign

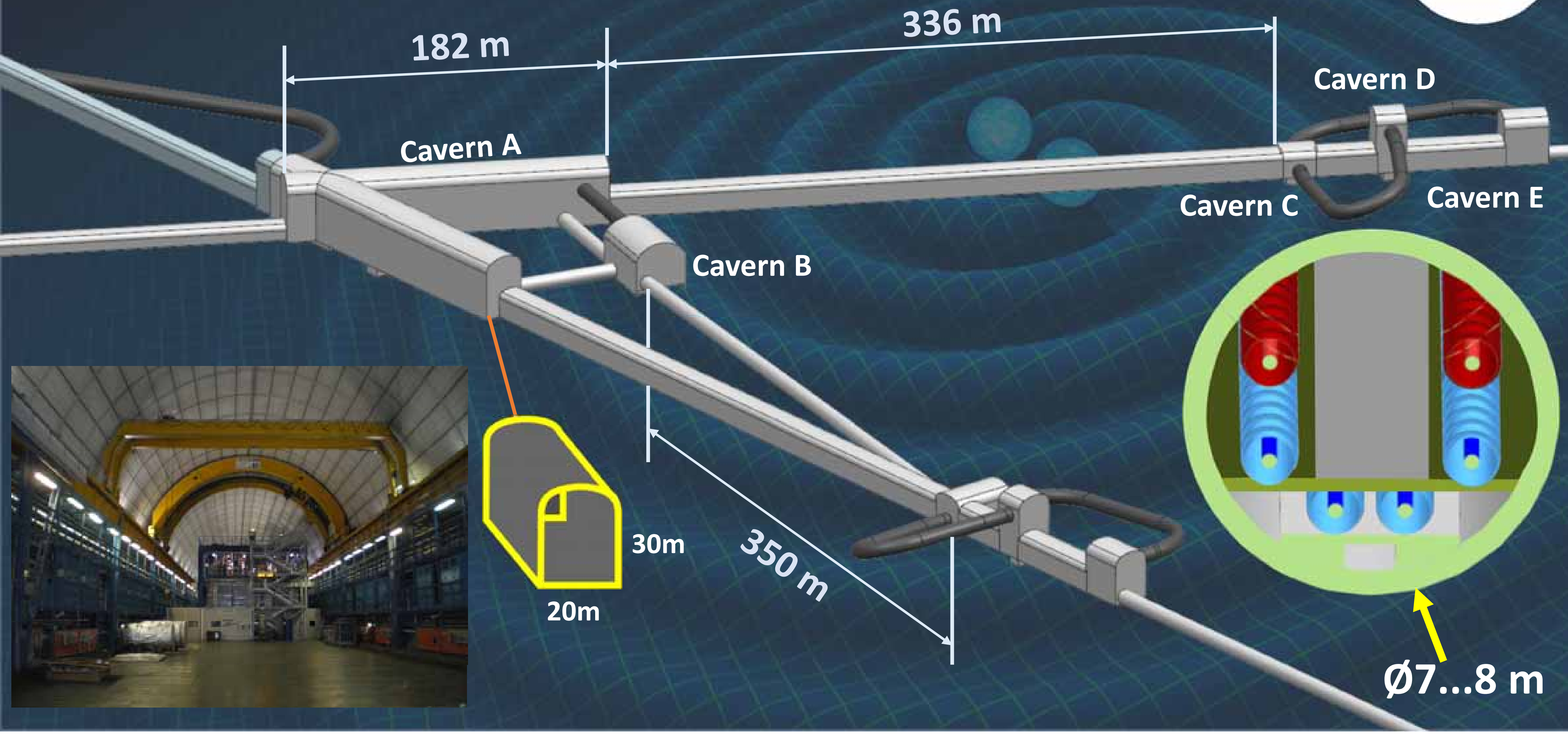
Borehole campaign

Carboniferous rock at ET depth (161m)

Transition from chalk to shales/mudstones at 29m

UNDERGROUND CONSTRUCTIONS

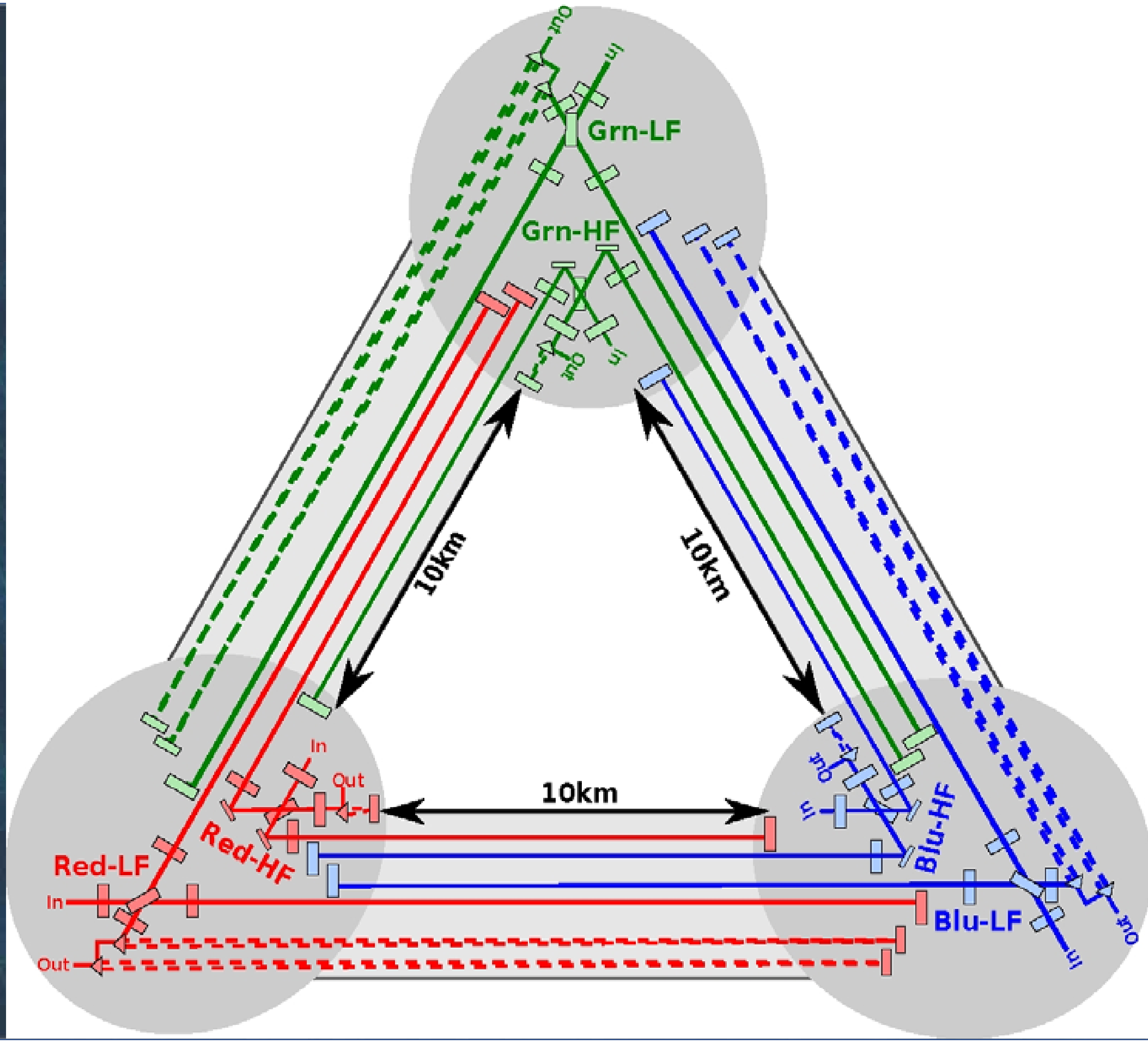
Corner Points



6 Interferometers

2 per Corner Point

- “Cold” interferometer
  - Temperature: 10K ... 20K
  - Low frequency: 2 Hz ... 20 Hz
  - Optical Power: 18KW
- “Hot” interferometer
  - Room temperature
  - High frequency: 20Hz ... 20KHz
  - Optical Power : +1MW



Concrete options for the tunnels

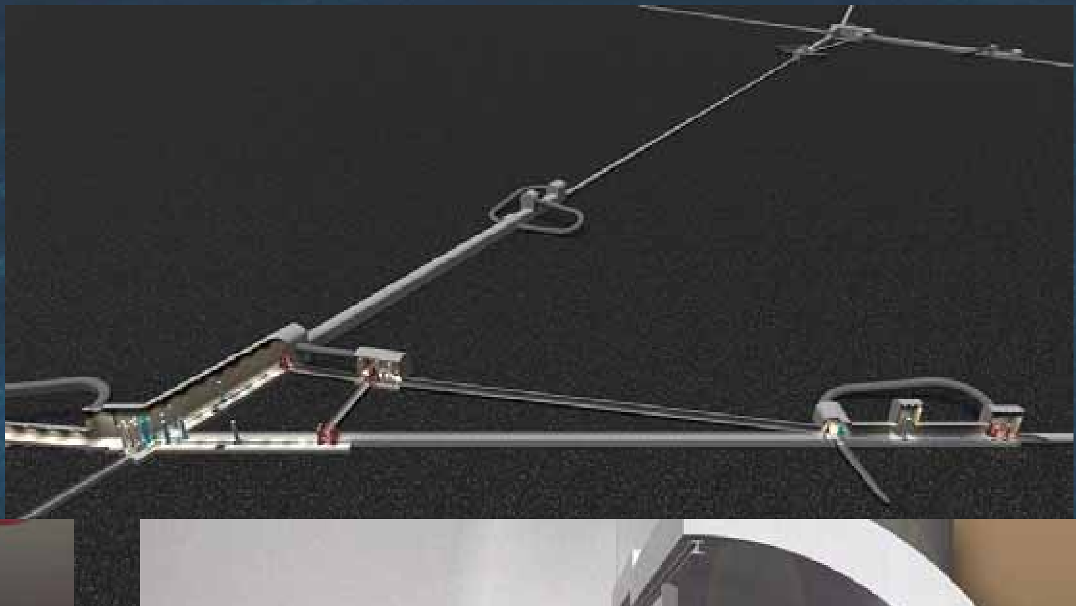
Option 1: shielded TBM excavation

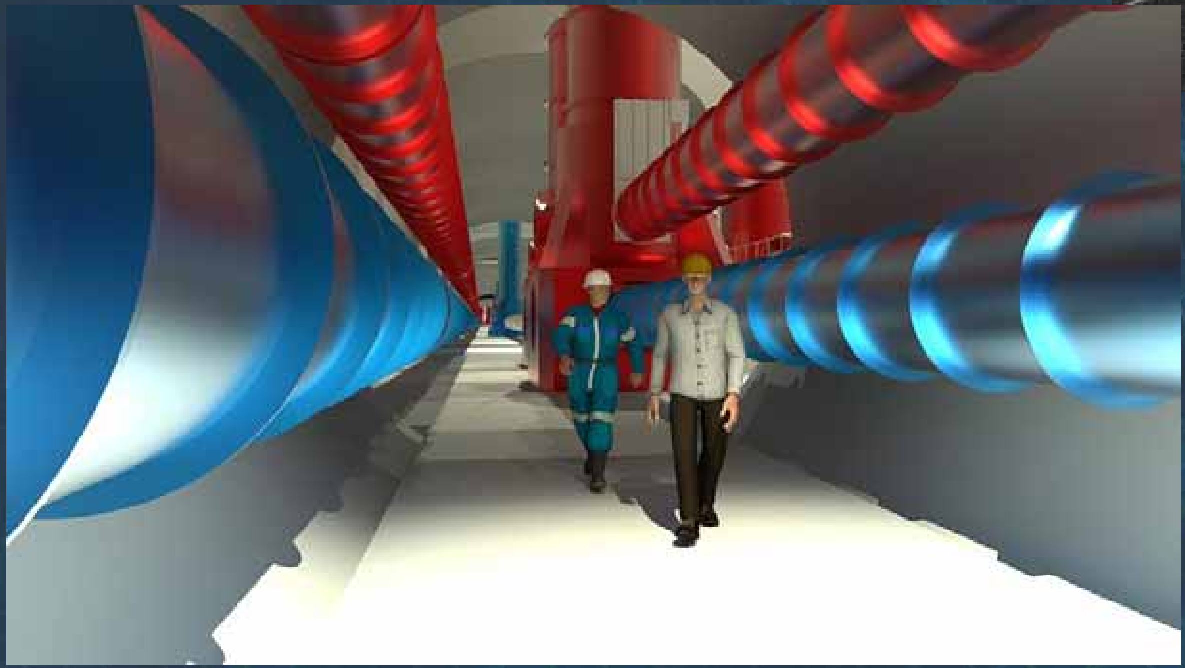
- Ø8.4 m for Ø6.5 inner diameter
- prefabricated segmental lining

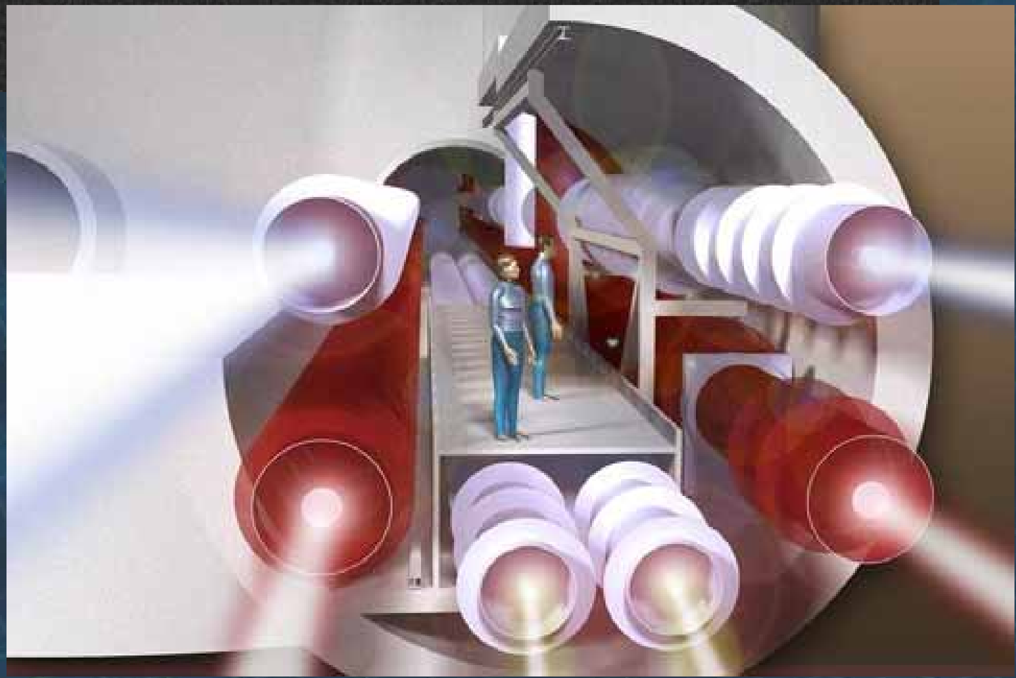
Option 2: open TBM excavation

- Ø7.3 m for Ø6.5 inner diameter
- shotcrete lining

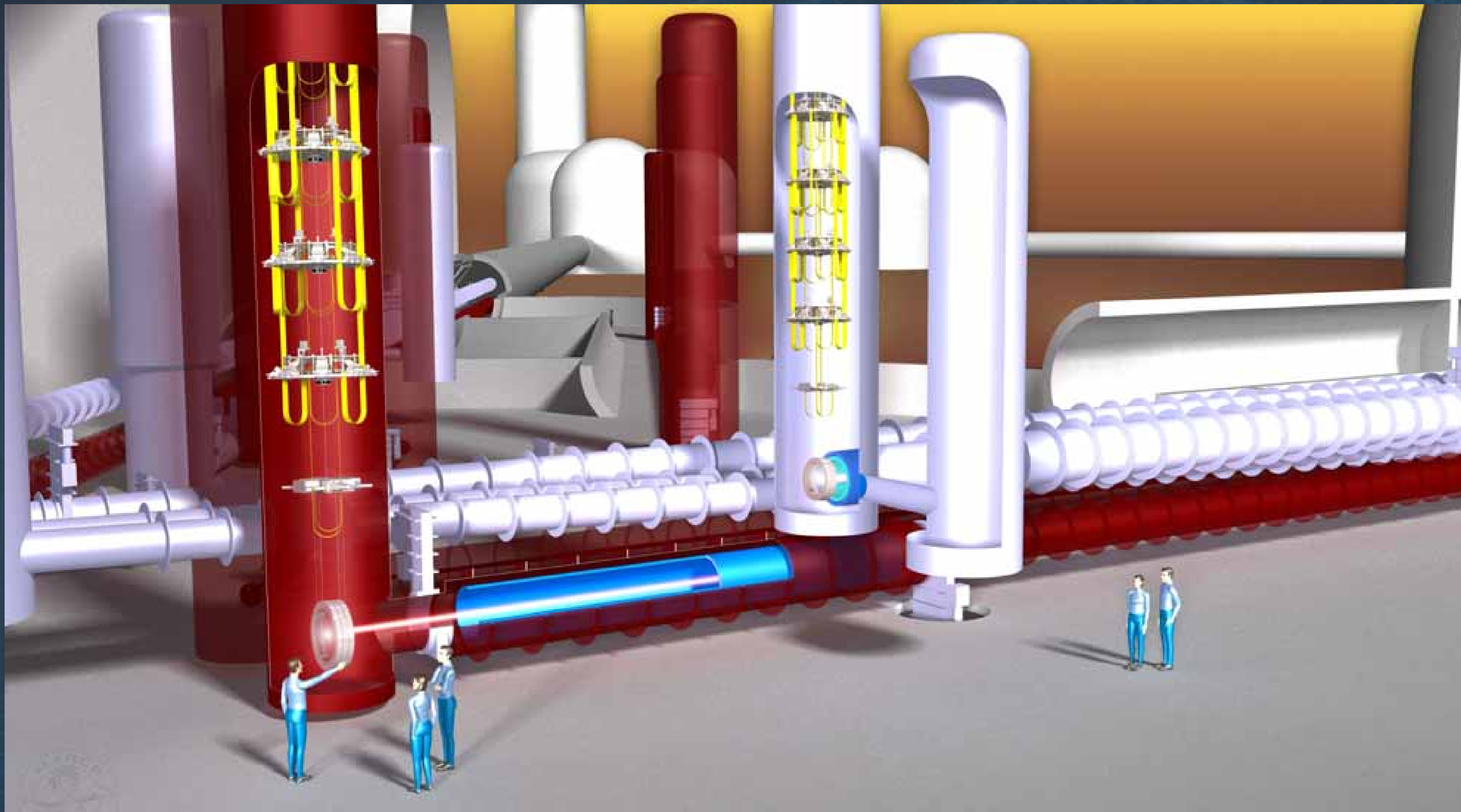
The Tunnels



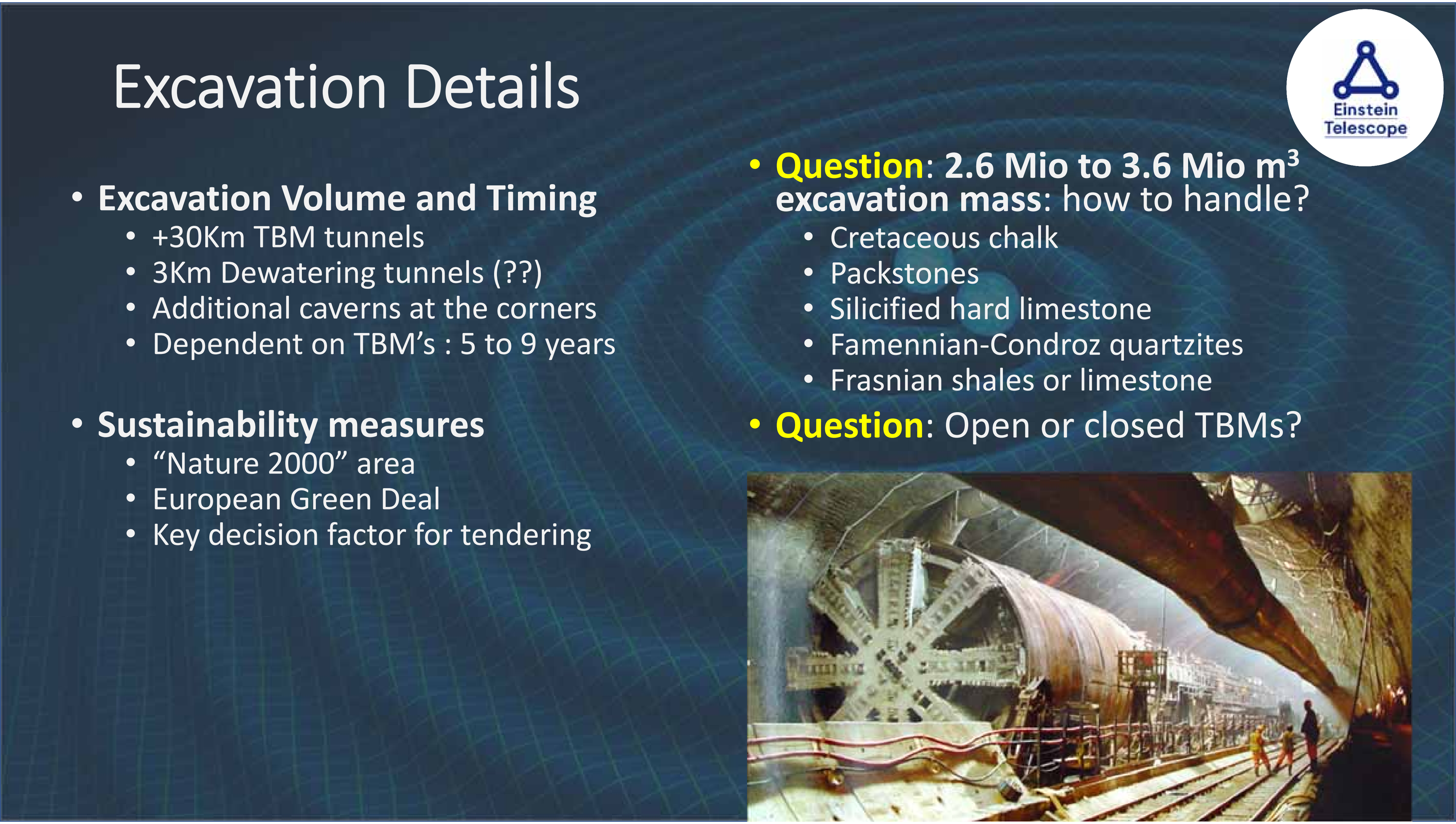


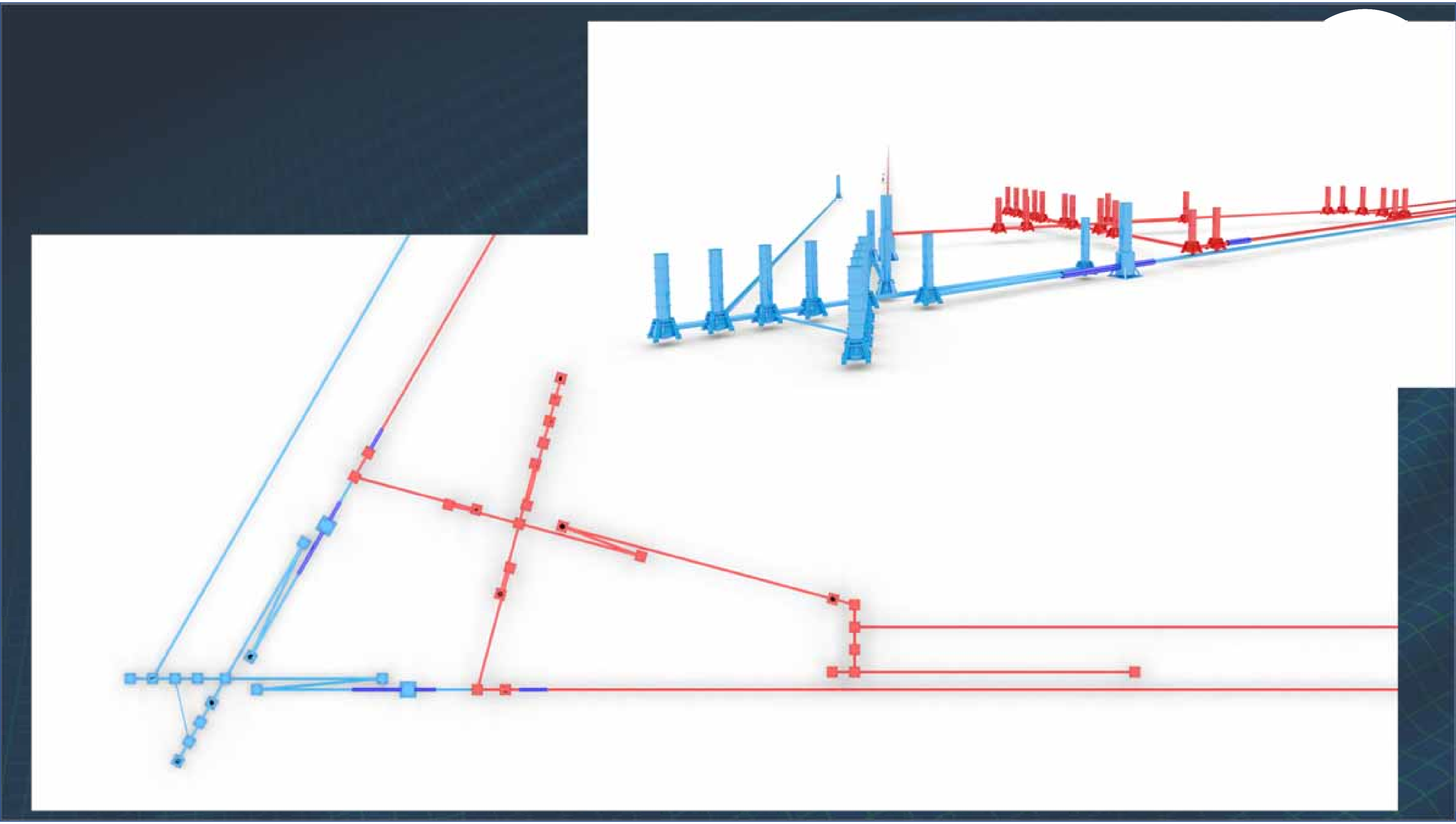


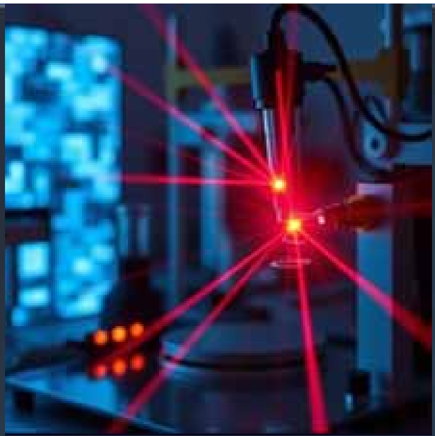
The vacuum towers




All images: © Marco Kraan (Nikhef)

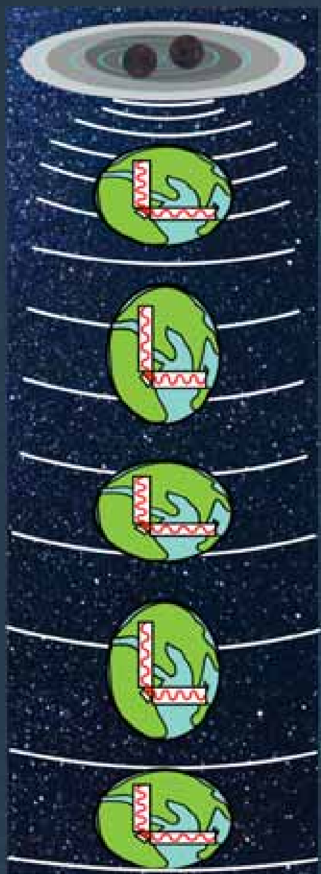

Excavation Details
Einstein Telescope
• Excavation Volume and Timing
• +30Km TBM tunnels
• 3Km Dewatering tunnels (??)
• Additional caverns at the corners
• Dependent on TBM's : 5 to 9 years
• Sustainability measures
• "Nature 2000" area
• European Green Deal
• Key decision factor for tendering
• Question: 2.6 Mio to 3.6 Mio m3 excavation mass: how to handle?
• Cretaceous chalk
• Packstones
• Silicified hard limestone
• Famennian-Condroz quartzites
• Frasnian shales or limestone
• Question: Open or closed TBMs?

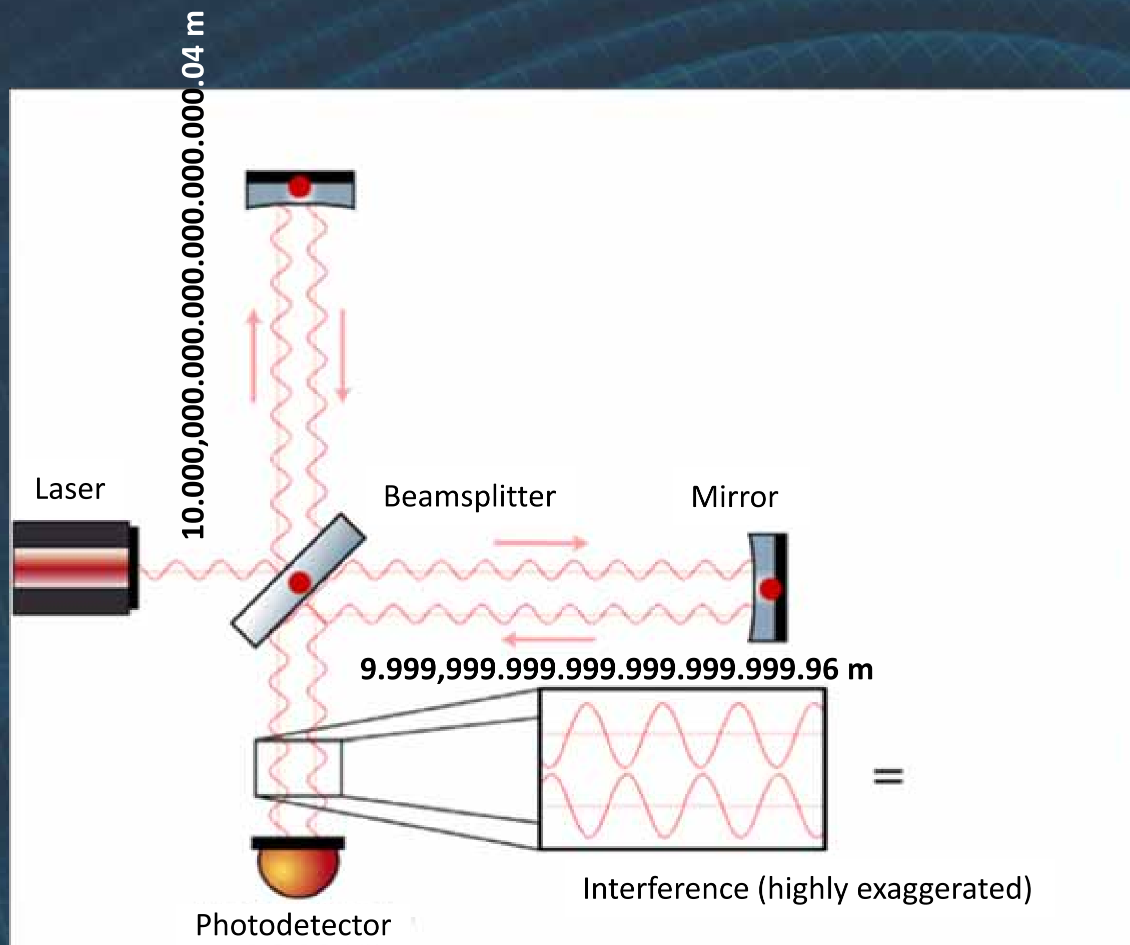




THE OPTICAL PATH
Why are so many towers needed?

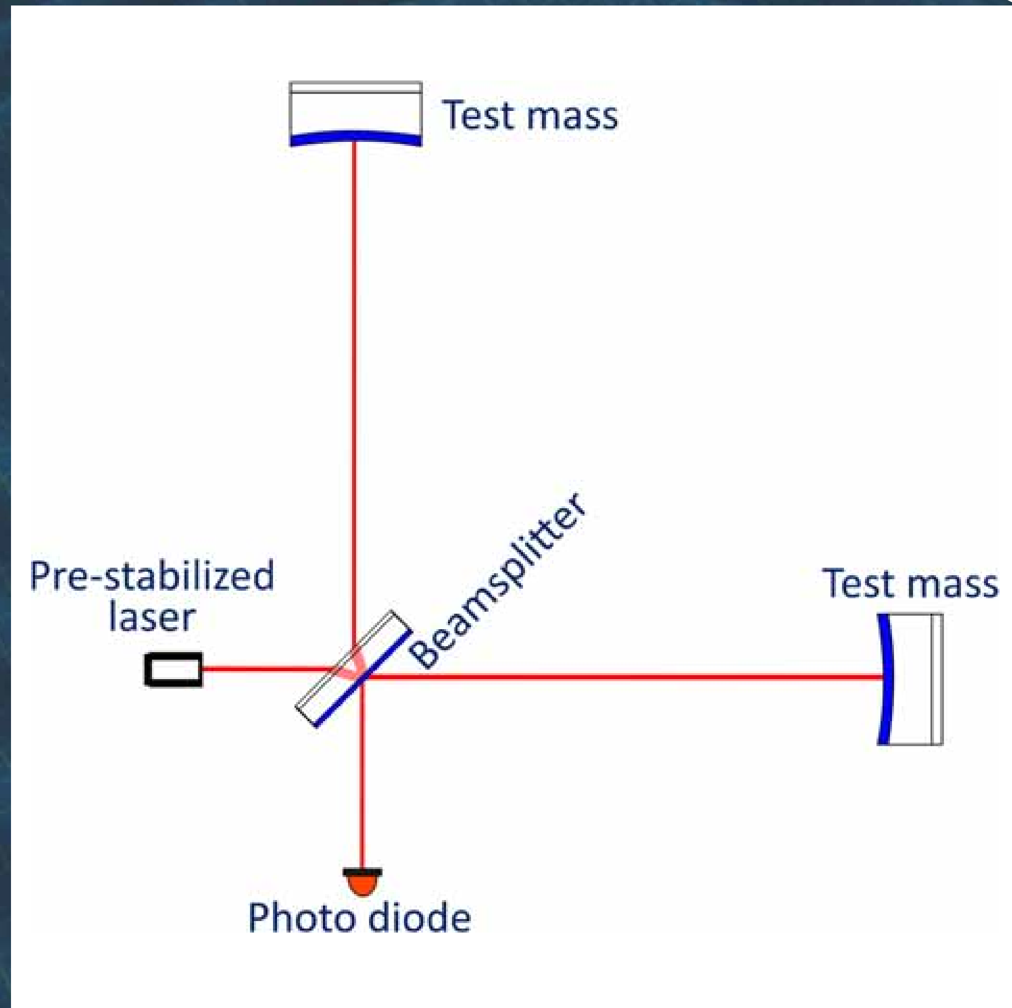
Recap: principle of an interferometer





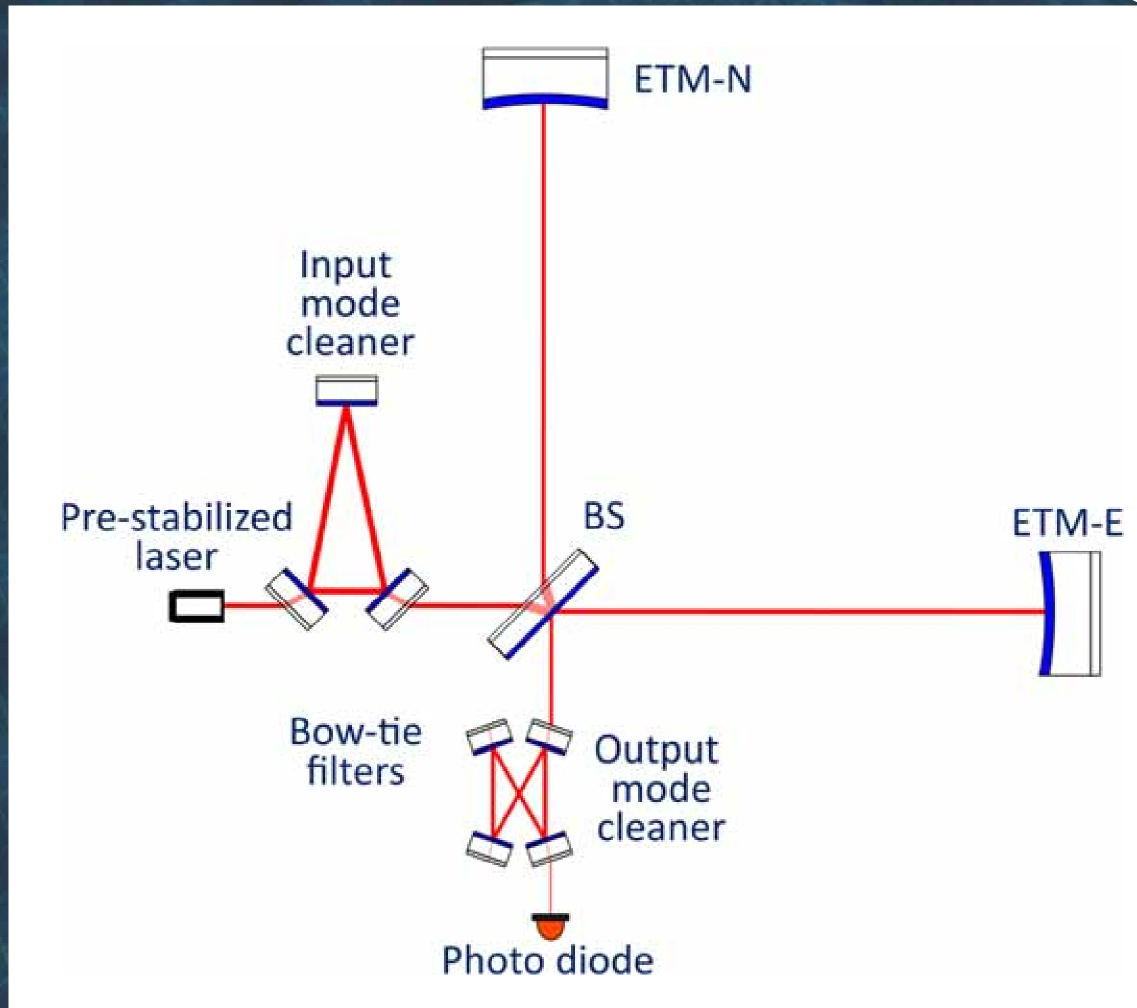
Let’s start: really simplified principle

- Arms of 10km
- Test masses at the end of the arm
- Beamsplitter to split and collect laser beams
- Stabilized laser



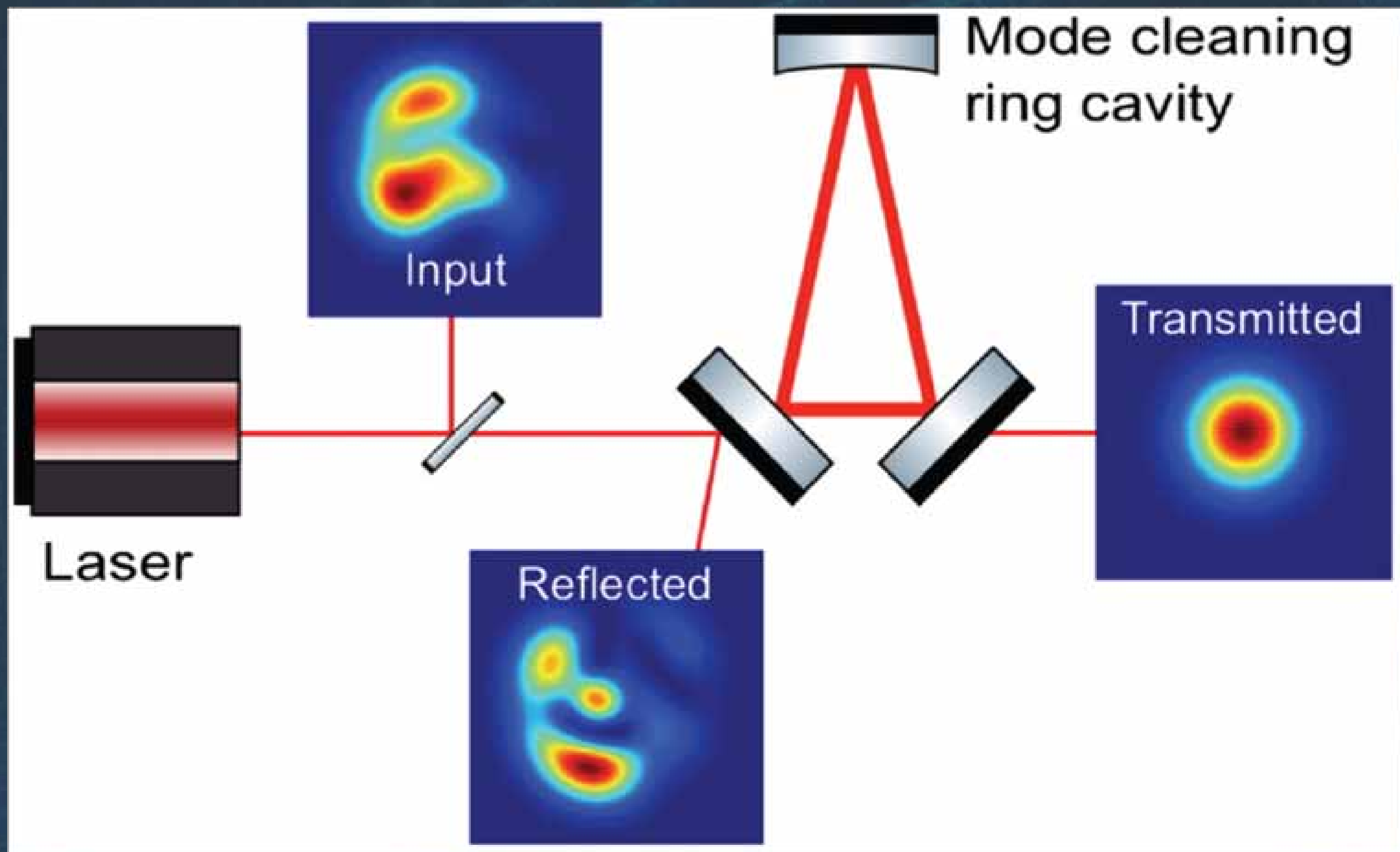
Optimization 1: adding Mode Cleaners

- ETM-N/E = End Test Mass North/East
- BS = Beamsplitter
- Input Mode Cleaner for cleaning input laser
- Output Mode Cleaner for recovering signal and remove higher mode frequencies

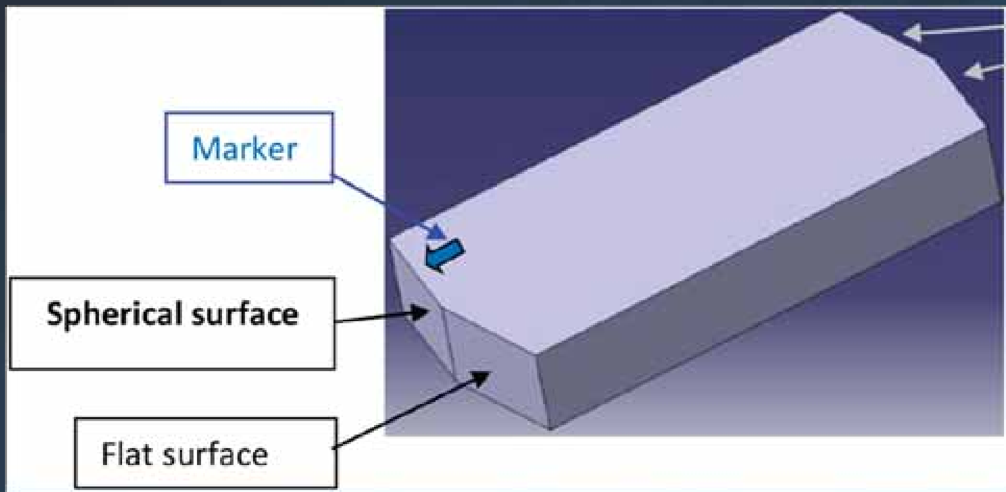


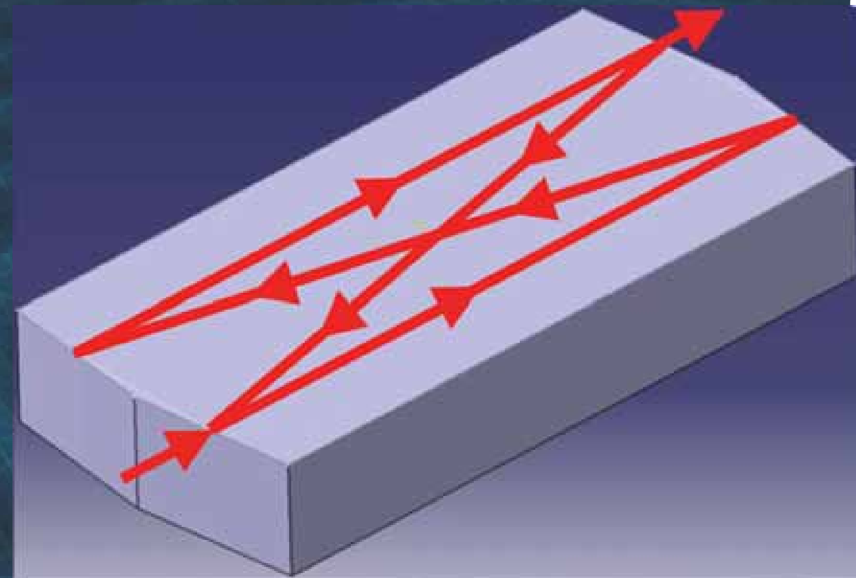
Mode Cleaner?

E.g. Input Mode Cleaner principle



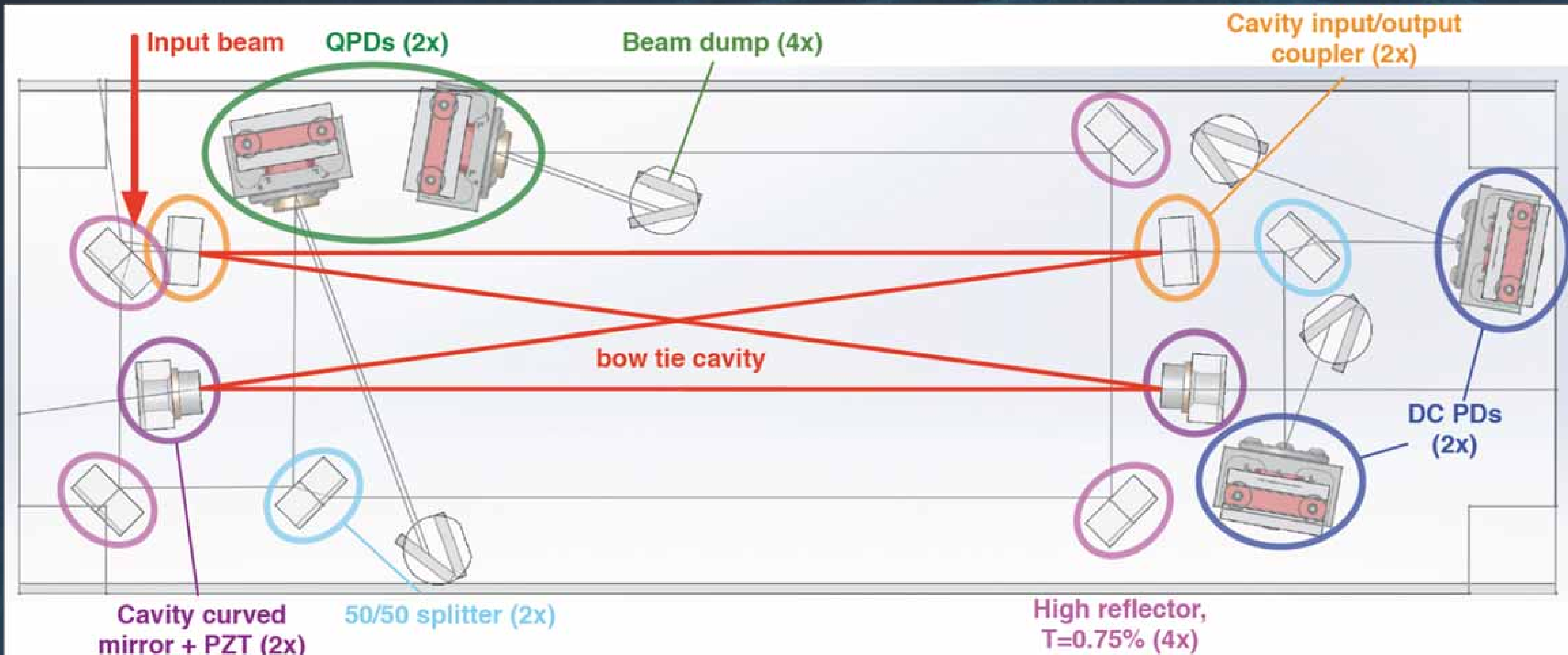
Example: Virgo Output mode cleaner





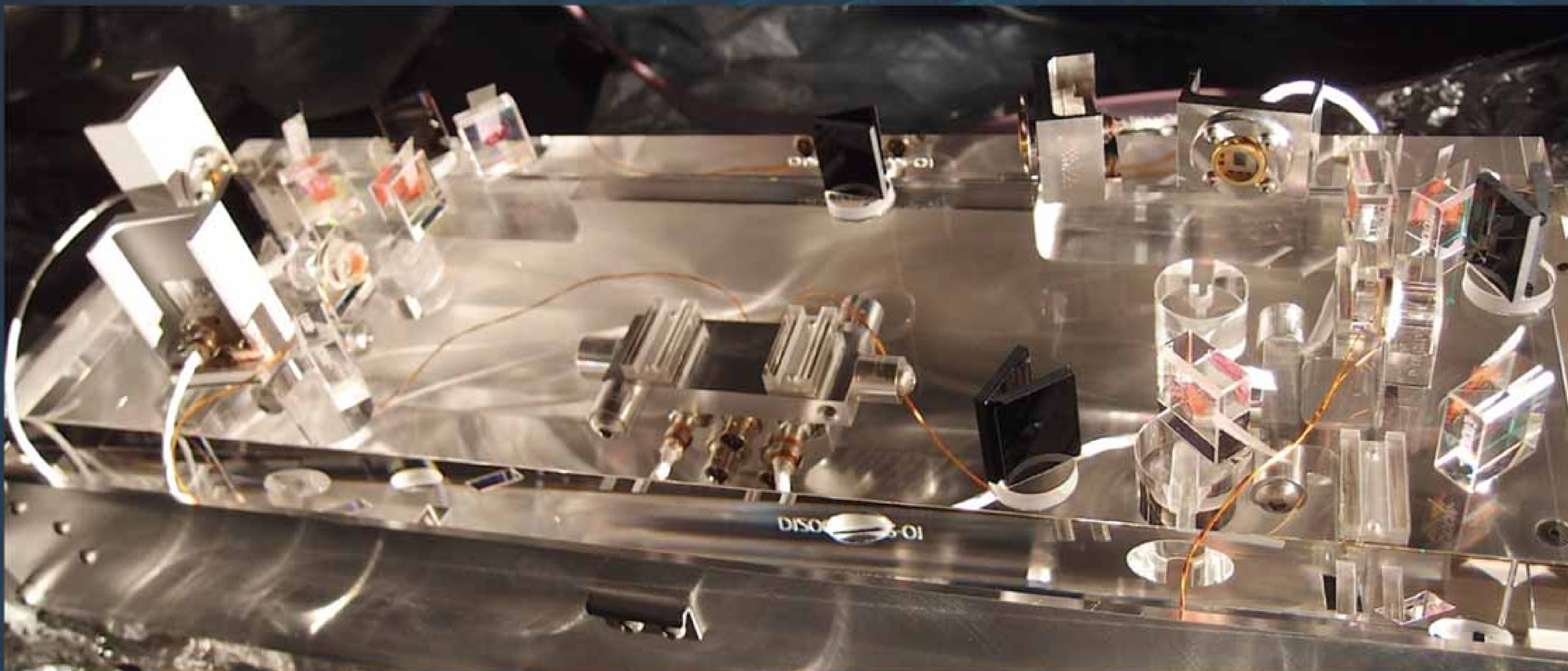
Images credit: VIR-0093A-14, VIR-0635A-22

Example: LIGO Output mode cleaner



Images credit: https://dcc.ligo.org/public/0108/G1301001/001/KArai_OMC_LVC_2013_9.pdf

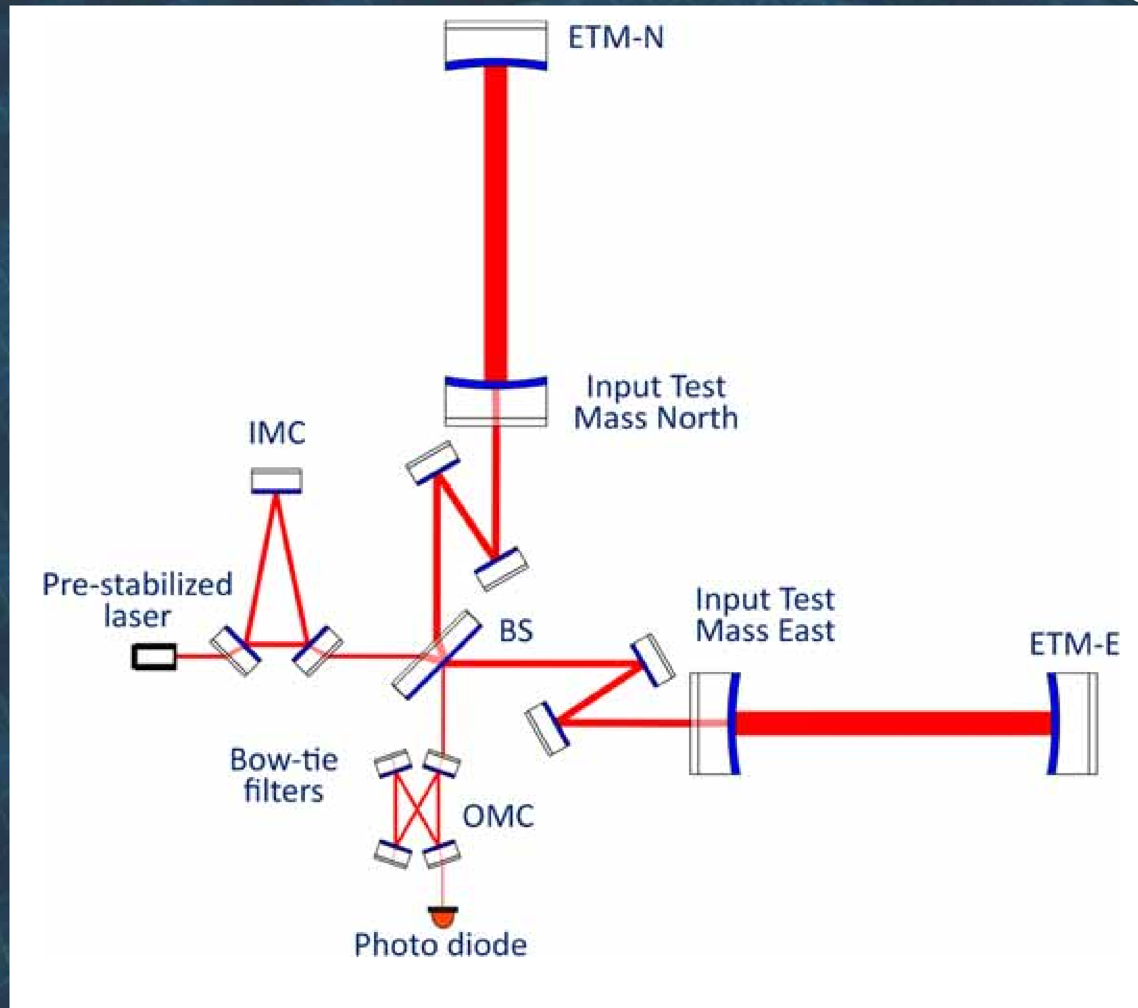
LIGO Output mode cleaner



Images credit: https://dcc.ligo.org/public/0108/G1301001/001/KArai_OMC_LVC_2013_9.pdf

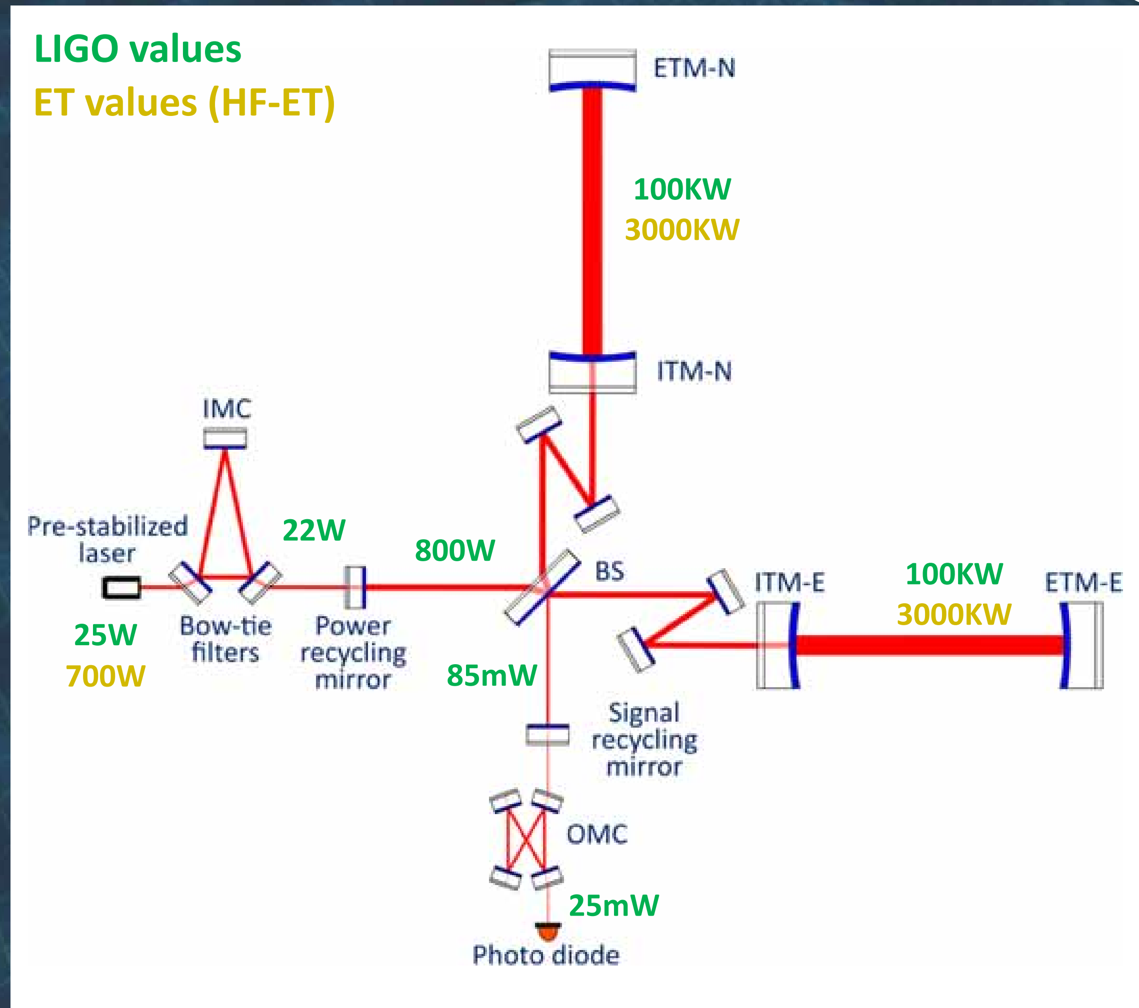
Optimization 2: extend arm length with cavities

- I/OMC = Input/ Output Mode Cleaner
- Input Test Masses are added to create cavities in the arms
- Optical Power in the arm goes from 700W to 3MW
- The arm is virtually extended thousands of times
- Adding mirrors to align the beam in the tunnels



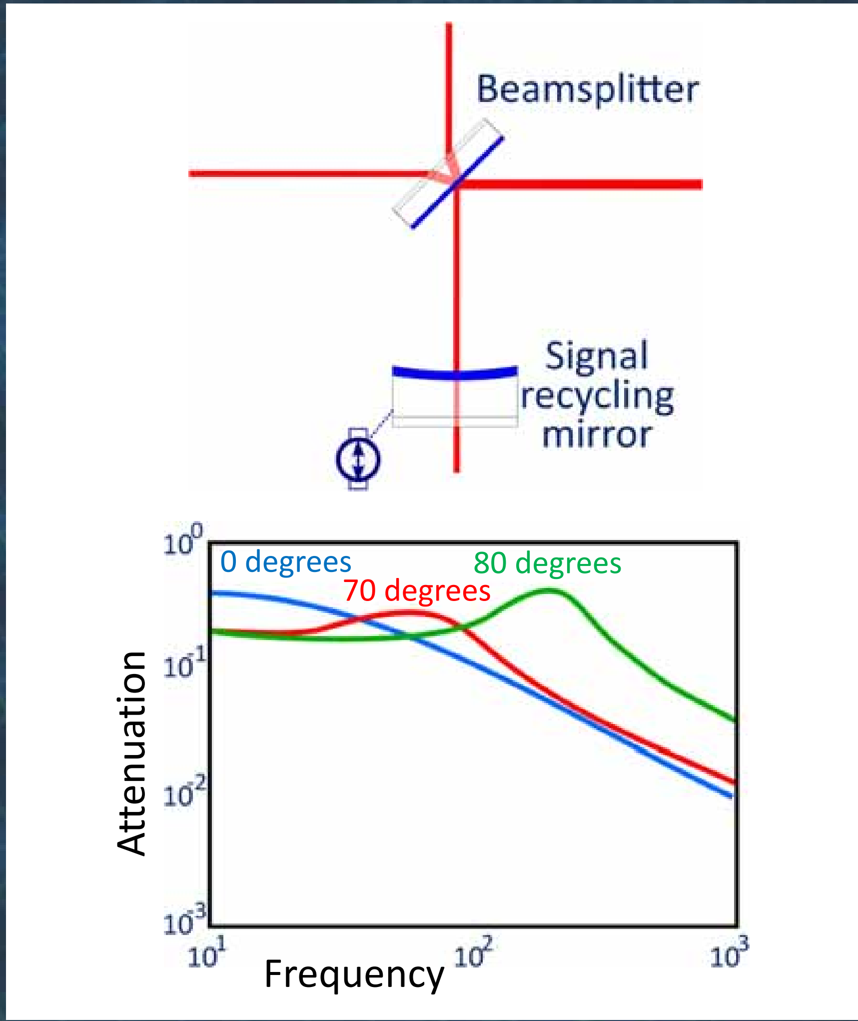
Optimization 3: add Recycling Mirrors

- ITM-N/E = Input Test Mass North/East
- Power Recyling Mirror for increasing power in the arms
- Signal Recycling Mirror to increase signal optical power



The effect of Signal Recycling

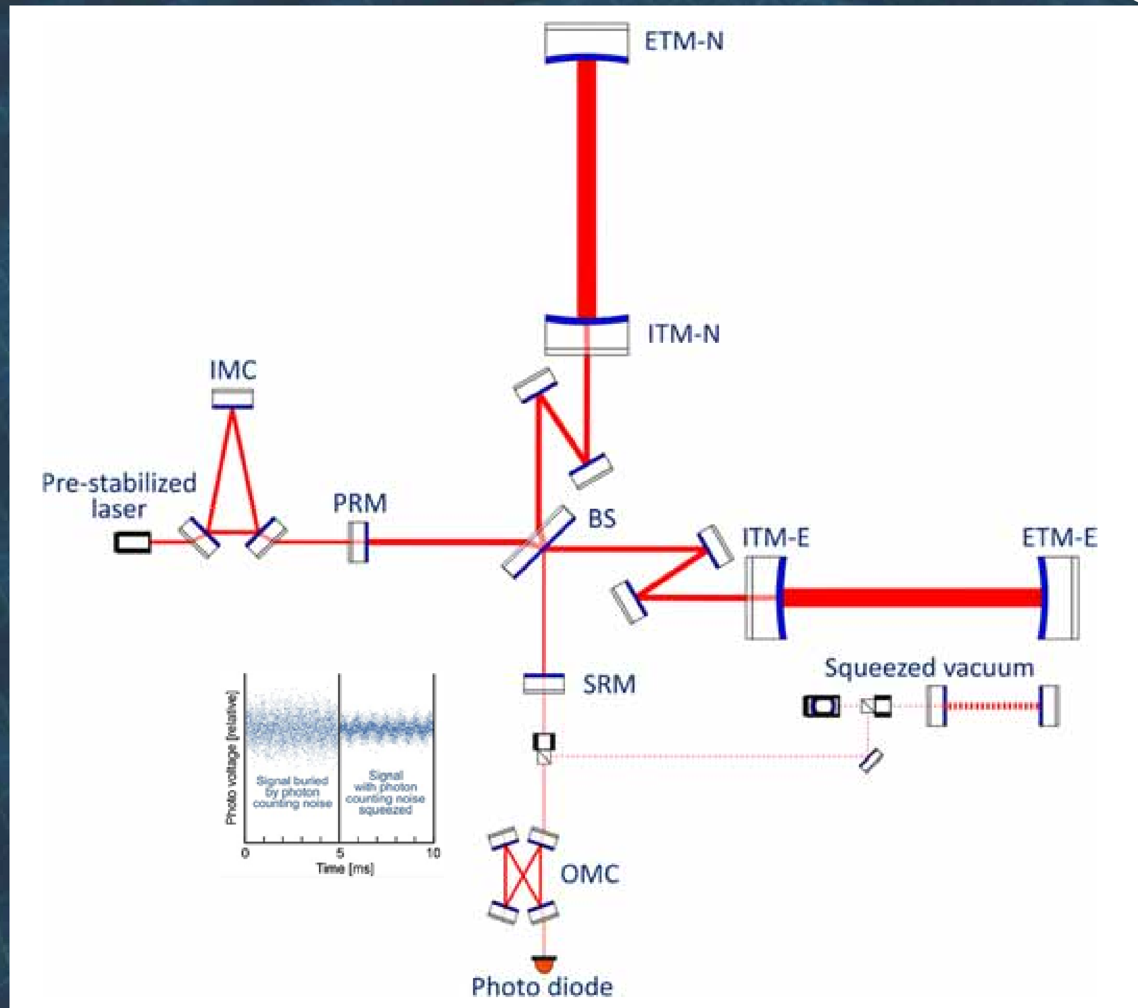
- Reflecting the signals back into the interferometer allows the response of the system to be 'tuned'.
- Moving the signal recycling mirror by a fraction of a wavelength (shown here as phase: 90 degrees = λ/4) changes the frequency of the peak response of the interferometer
- The bandwidth is controlled by the reflectivity of the signal recycling mirror



Courtesy: David Robertson – University of Glasgow

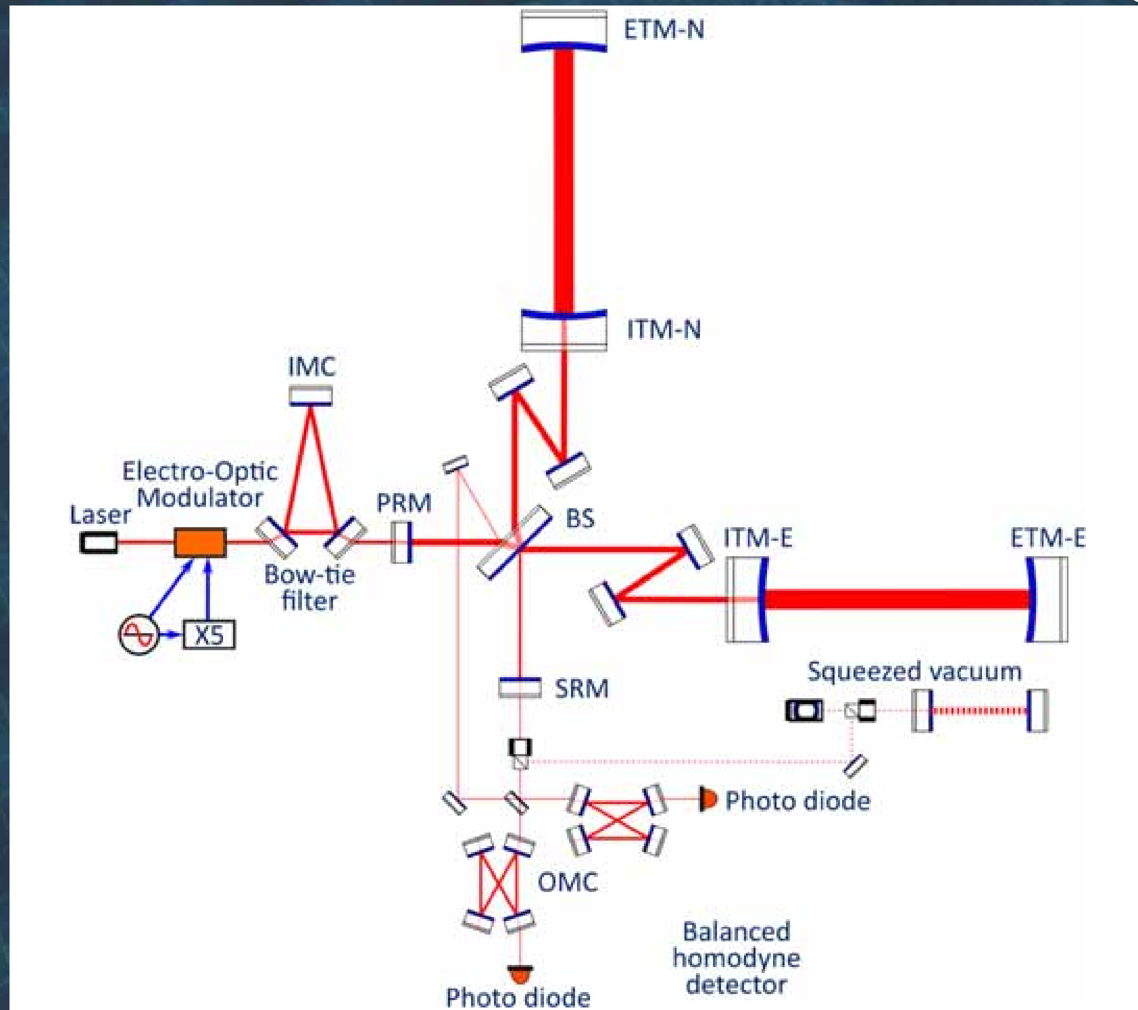
Optimization 4: implement Squeezed Vacuum

- P/SRM = Power/ Signal Recycling Mirror
- Output Signal is squeezed
- A second laser is used to create extra squeezed vacuum
- The second laser is mixed with the signal with quantum entanglement



Optimization 5: measure the signal with a Homodyne detector

- The laser signal is modulated
  - E.g. 9MHz and 45MHz (LIGO)
- High frequency modulation to control the towers
- Low frequency modulation to recover the signal
- Recovery with a balanced homodyne detection



Homodyne detection

Interferometric readout

1 the collimator

2, 6, 7 Polarising Beam Splitter Cubes (PBS)

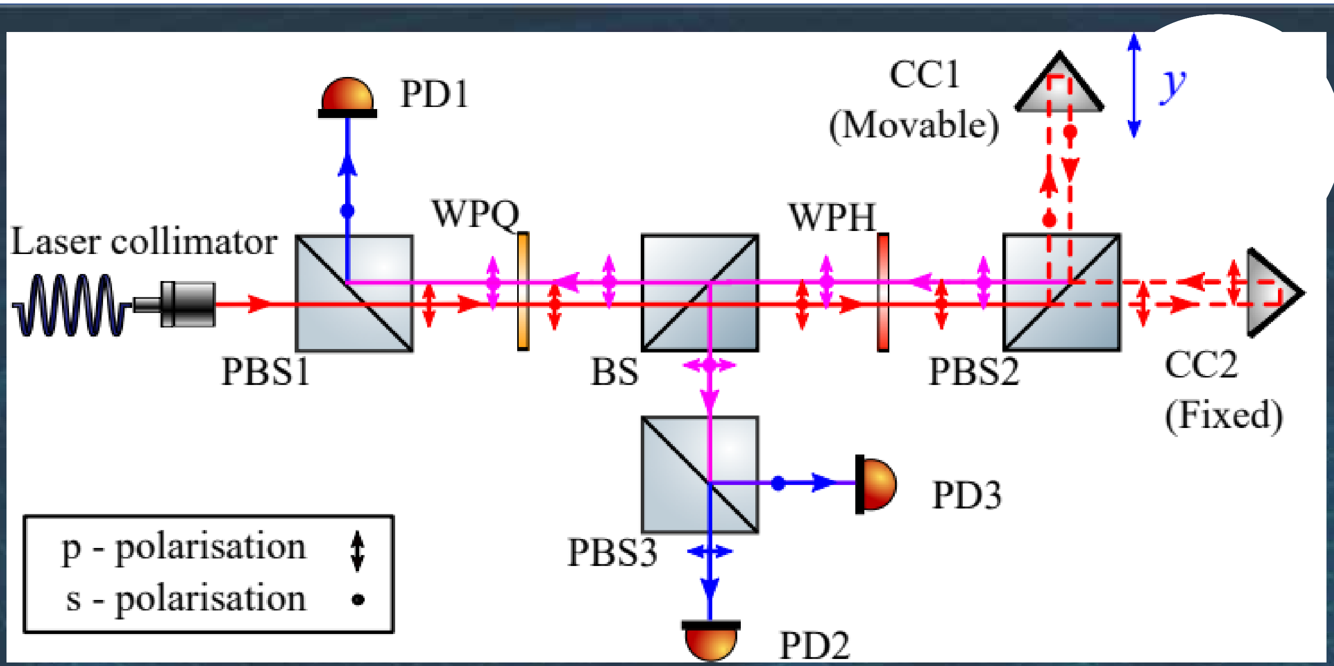
3 Quarter-Wave Plate (WPQ)

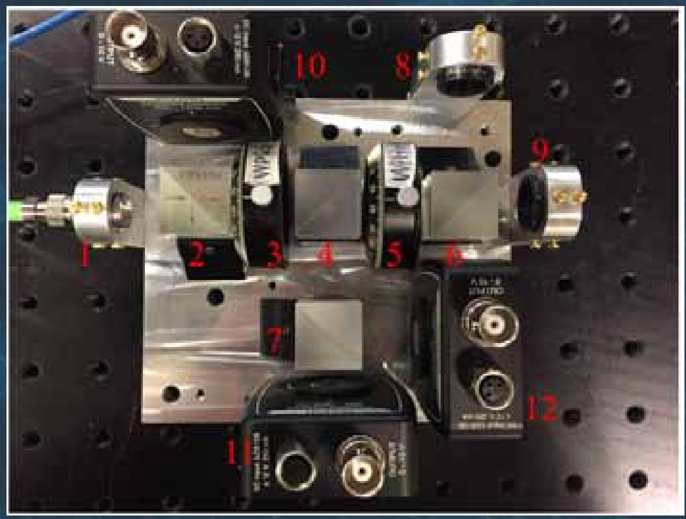
4 Non-Polarising Beam Splitter Cube

5 Half-Wave Plate (WPH)

8, 9 Corner Cubes

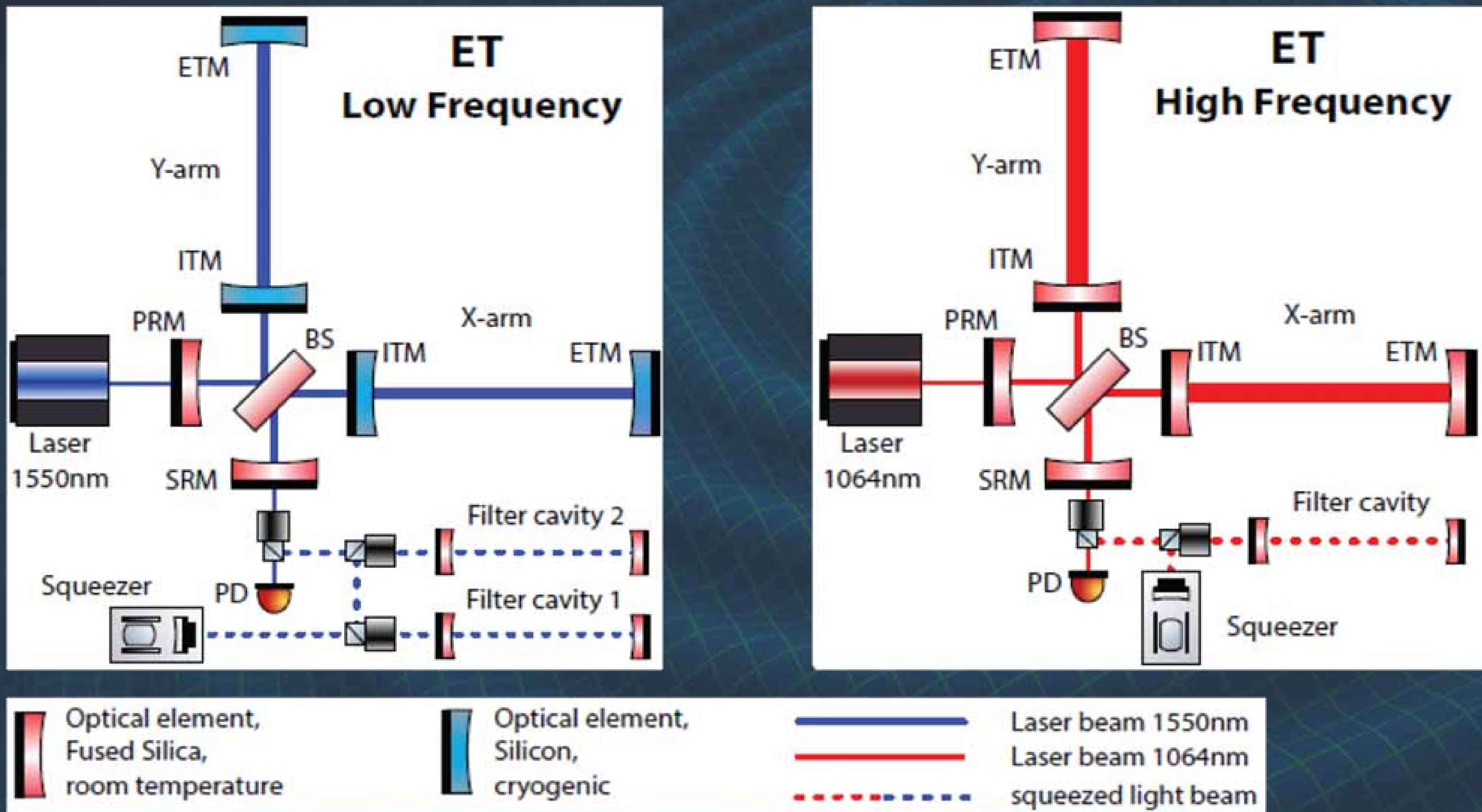
10, 11, 12 Switchable Gain Amplified Photodiodes (PD)





B. Ding, Development of High Resolution Interferometric Inertial Sensors, Ph.D. thesis, University of Bruxelles, 2021

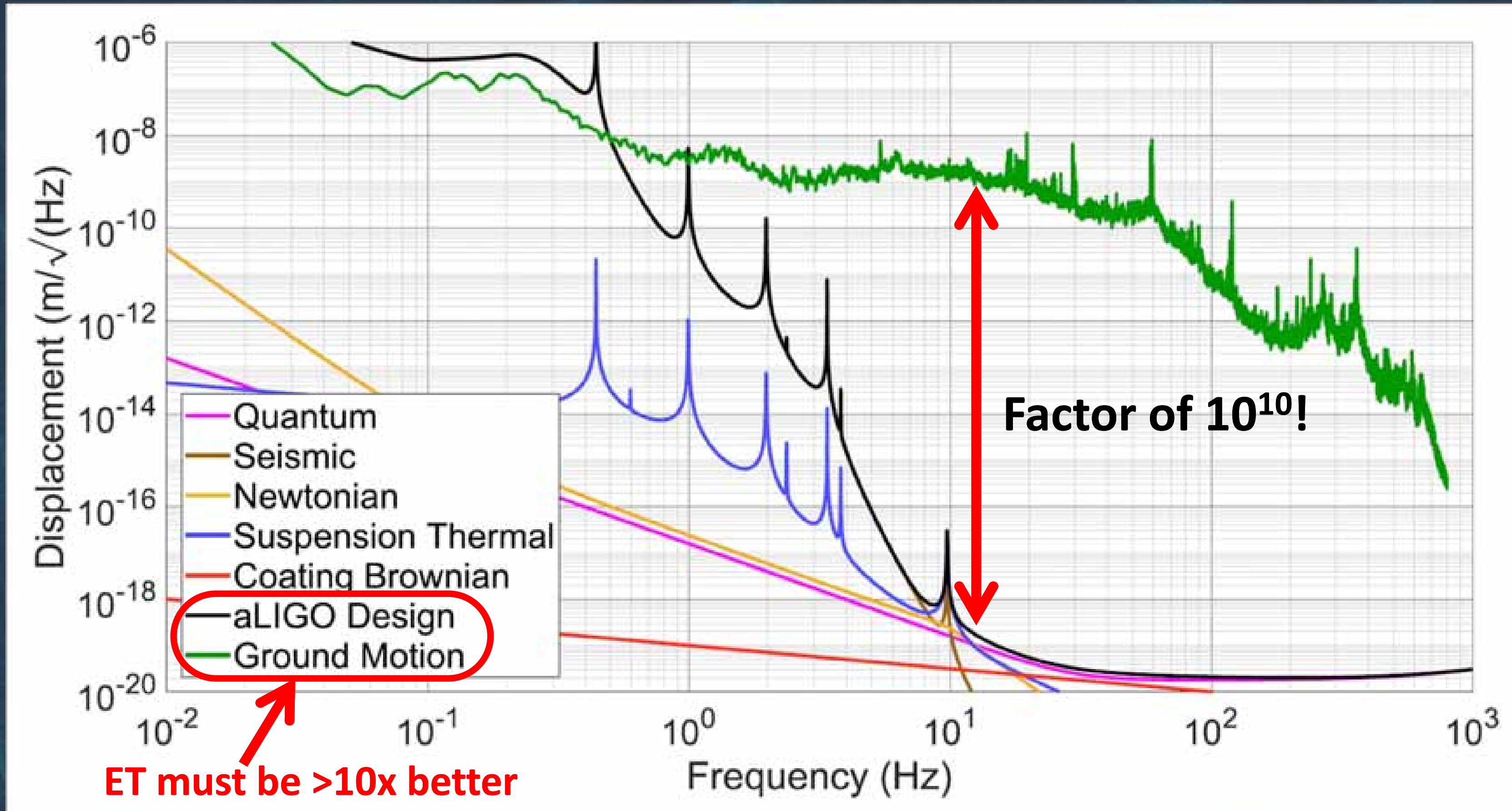
High and Low Frequency configurations



VIBRATION DAMPING

Geological isolation

- Isolators
- Active damping systems
- Seismometers
- Inertial sensors



Types of Seismic noise

Are damped exponentially with depth

Seismic noise
+ Newtonian

Seismic noise

Are dominant at >200m depth

Seismic noise + Newtonian
Density changes
Cavity wall displacement

Seismic noise + Newtonian
Cavity wall displacement

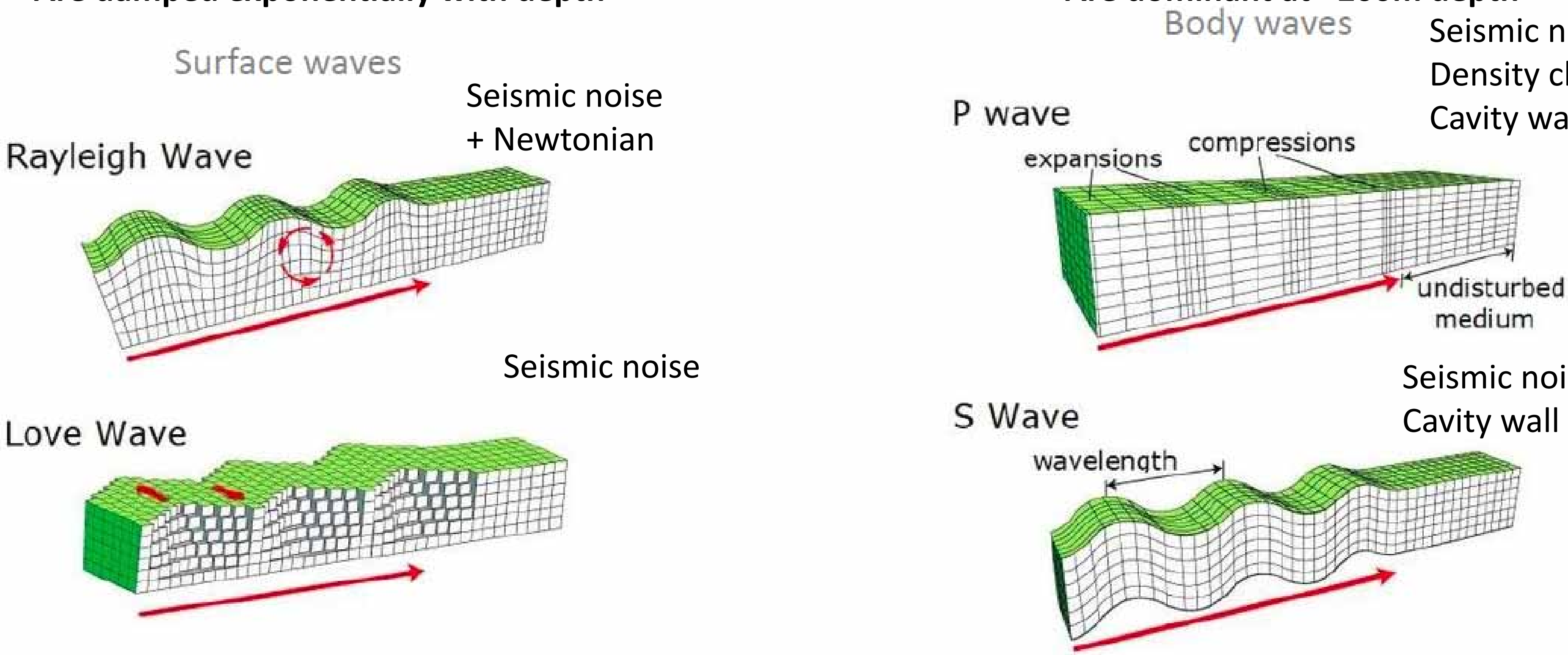


Fig. 10: Illustration of the different types of seismic waves.

Credit: Science Learning Hub – Pokapū Akoranga Pūtaiao, University of Waikato - https://www.sciencelearn.org.nz

Problem 1:
In-Tower damping control

- Damping of the mirrors is required
- Multi-staging damping systems with Super-attenuators

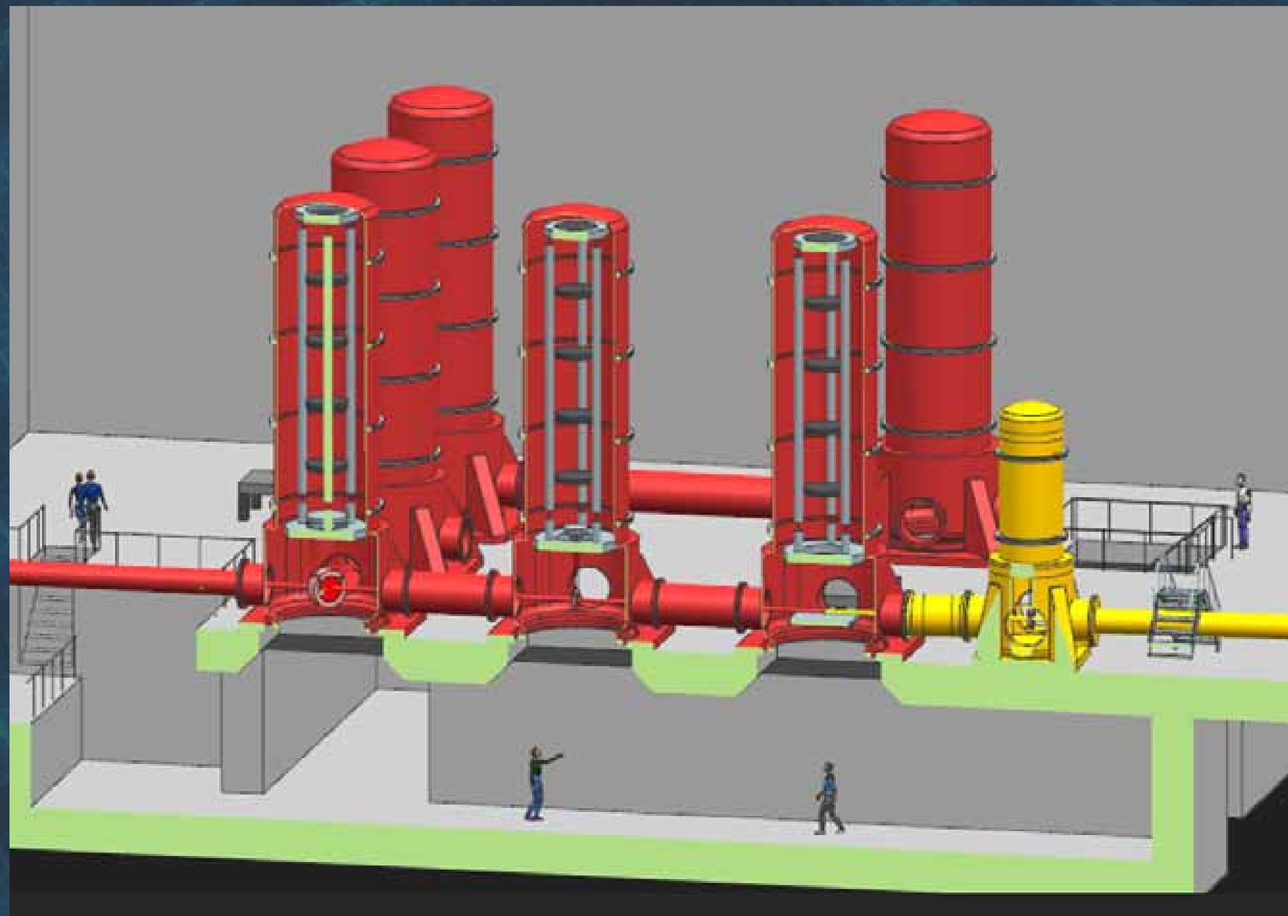


Figure: Marco Kraan - Nikhef

Inverted Pendulum isolation

- Mirror vibration damping in the Vacuum Towers
  - Sensor and control up to 10^{-18} m at low frequencies (0.1 Hz)

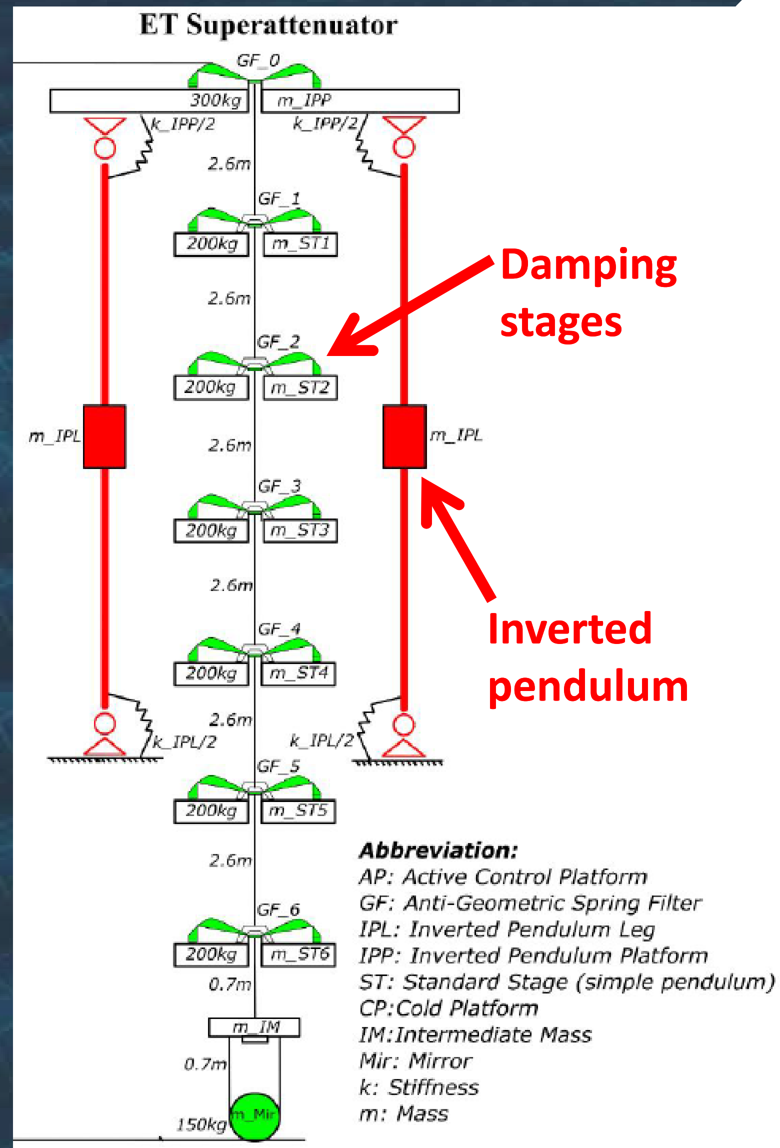
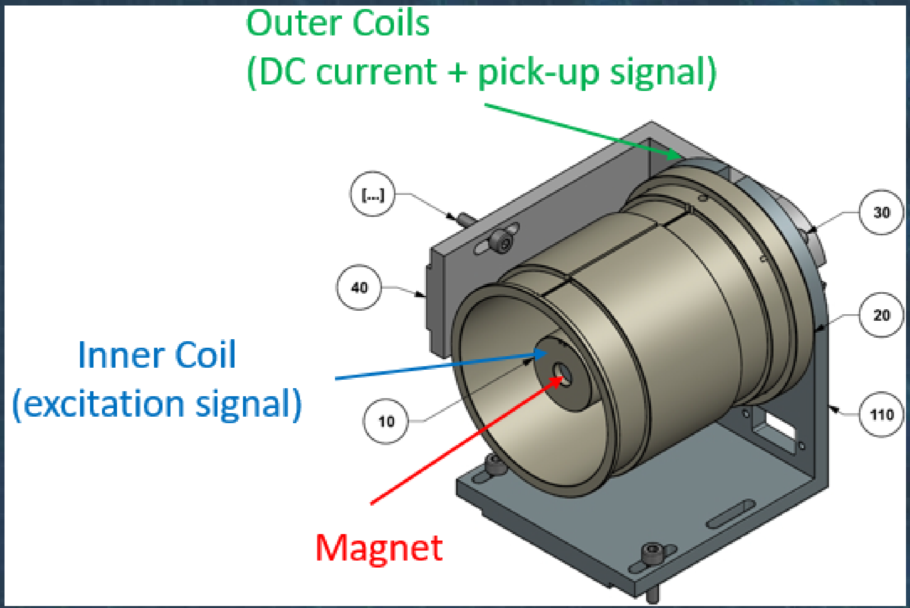


Figure: Christophe Collette - ULiège

Sensors are also actuators

- Linear Variable Differential Transformer (LVDT)
- Wires are used for both sensing and control
  - Minimize transfer of vibrations
- Implementation in ETpathfinder



Images: Pengbo Li and Hans Van Haevermaet – University of Antwerp

Problem 2:
Equipment Damping

- Separate “Inverted Pendulum” for stabilizing measurement equipment
  - HRTS (HAM Relay Triple Suspensions)
- 6 Degrees of Freedom (DoF) control
- Must operate in vacuum or even cryogenic environments

$$\begin{bmatrix} H\_x \\ H\_y \\ V\_z \\ Roll \\ Pitch \\ Yaw \end{bmatrix} = \begin{bmatrix} a & b & c & 0 & 0 & 0 \\ 0 & 0 & 0 & d & 0 & 0 \\ 0 & 0 & 0 & 0 & e & f \\ 0 & 0 & 0 & 0 & g & h \\ i & 0 & l & 0 & 0 & 0 \\ 0 & m & 0 & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} H1\_cal \\ H2\_cal \\ H3\_cal \\ H4\_cal \\ V1\_cal \\ V2\_cal \end{bmatrix}$$

Sensing matrix

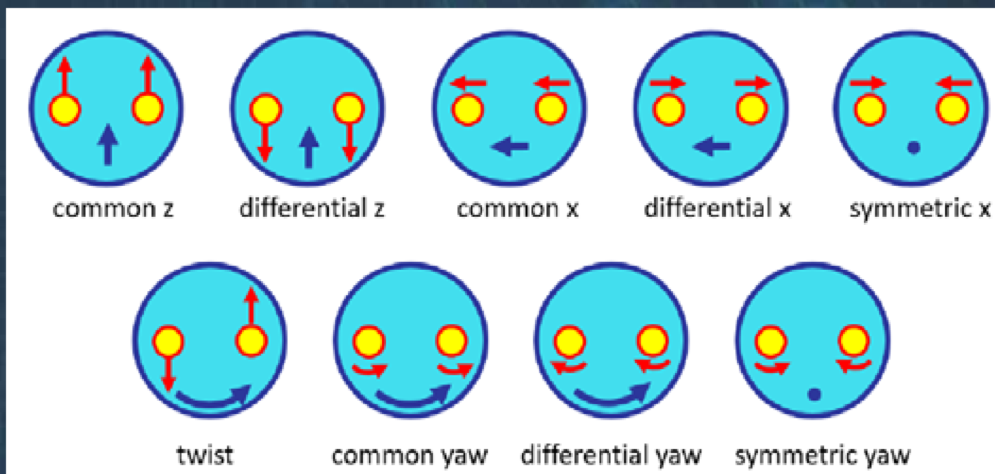
$$\begin{bmatrix} act\_H1 \\ act\_H2 \\ act\_H3 \\ act\_H4 \\ act\_V1 \\ act\_V2 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & -1 \\ 1 & 0 & 0 & 0 & -1 & 0 \\ 0 & -1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & -1 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} Act\_x \\ Act\_y \\ Act\_z \\ Act\_Roll \\ Act\_Pitch \\ Act\_Yaw \end{bmatrix}$$

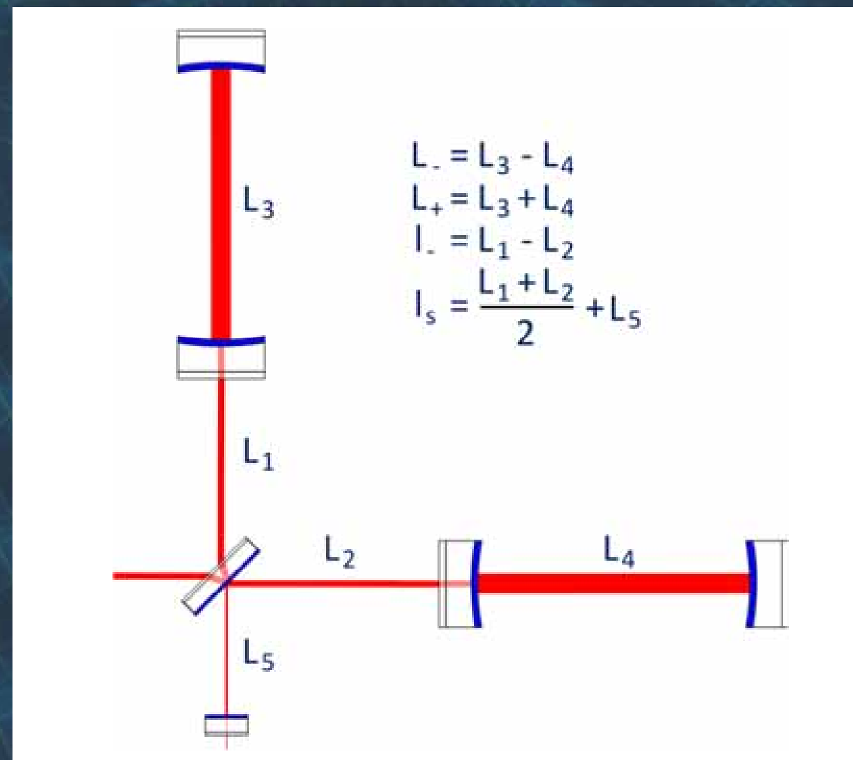
Driving matrix

Images: Pengbo Li and Hans Van Haevermaet – University of Antwerp

Problem 3:
Tower-to-Tower control

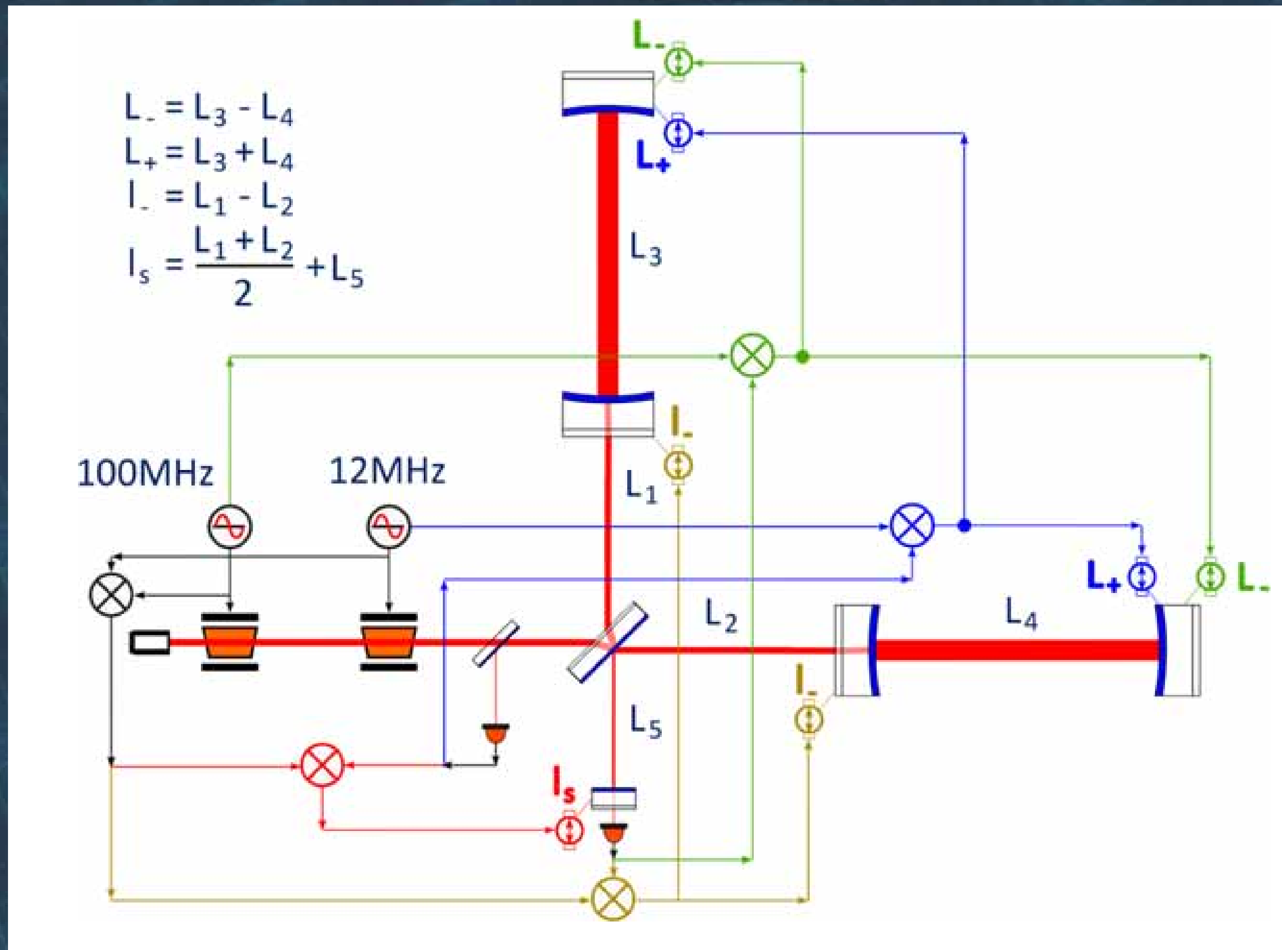
- Target: keep the towers “in lock”
  - Distances between towers must be controlled
- what must be controlled?
  - Complex vibrations between towers (6DoF)
  - Optical paths





Control Scheme (LIGO simplified)

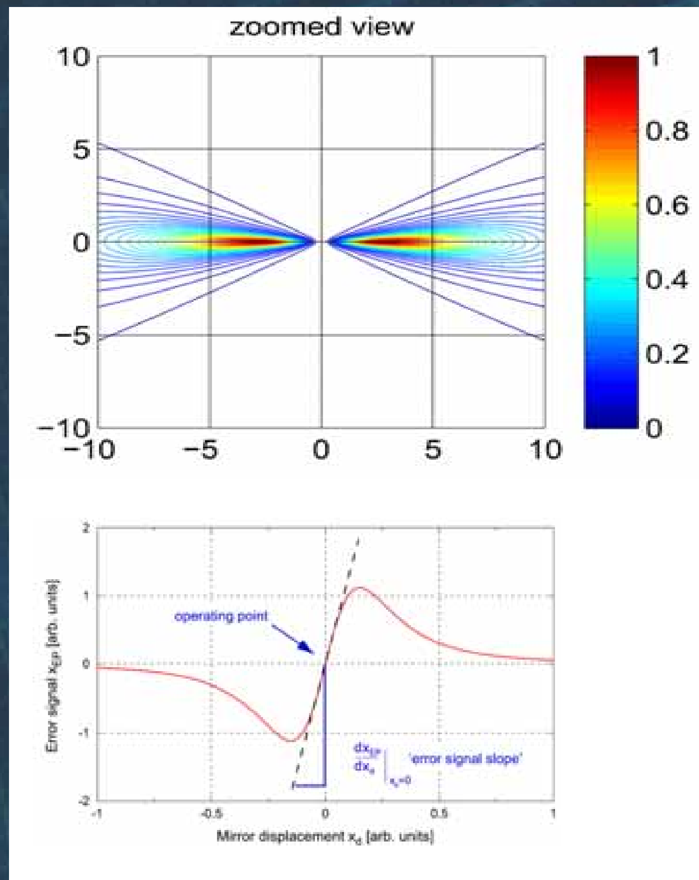
- The laser light is modulated
  - Photo diodes capture the laser light in the system
- l_s controls the Signal Recycling Mirror
- l_- controls the dark port setpoint
- L_+ controls the arm lengths
- L_- controls the arms differential length (setpoint to zero)

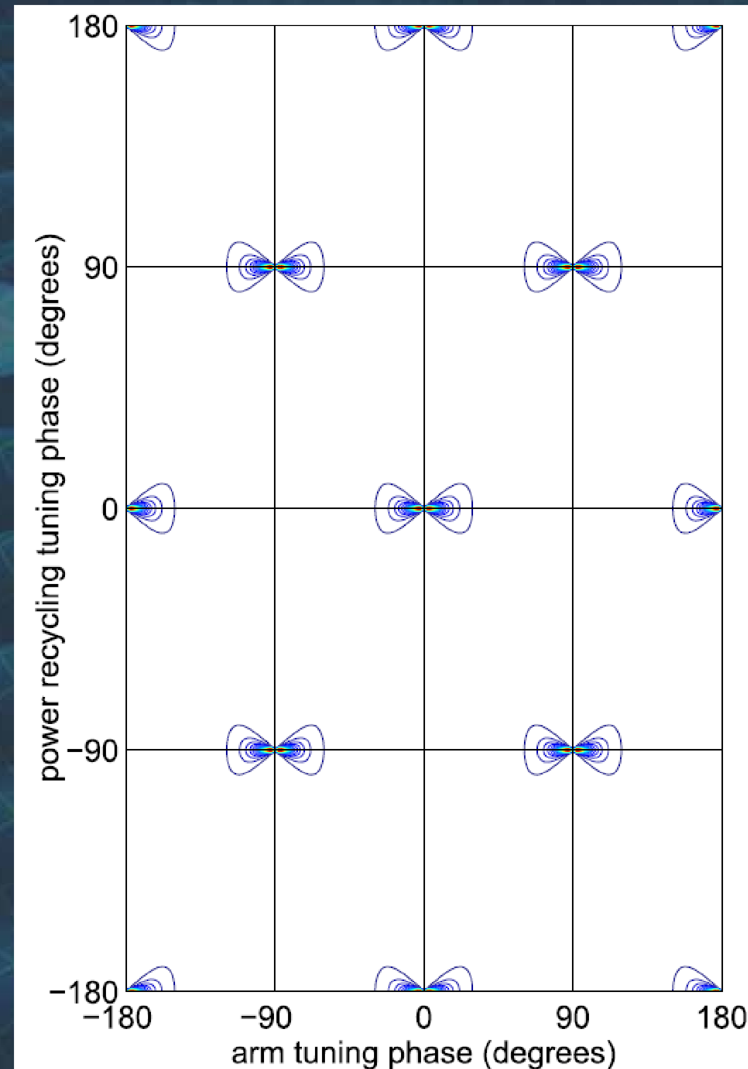


Courtesy: David Robertson – University of Glasgow

Other complexities

- Additional control schemes necessary for Squeezed vacuum
- Multiple setpoints possible over the 10 km arm
  - The “next control point” is only micrometers away



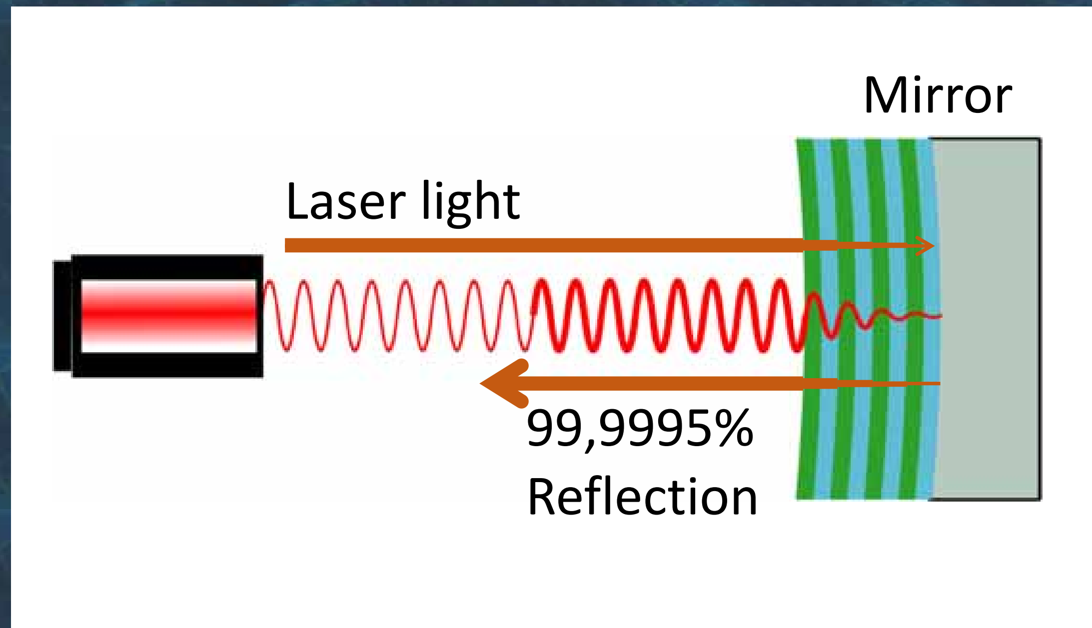


Courtesy: “Interferometer techniques for gravitational-wave detection”, Springer

COATING DESIGNS

Why are special coatings needed? The mirror reason

- The laser wavelenghts are precisely tuned to 1550 nm or 2090 nm
- The mirror coating must bounce back as much as possible → 99,9995%



Remark: the mirrors seem transparent

- Mirror coating only needs to reflect 1550 nm or 2090 nm
- Other light may go through the coating
  - ... or is coloured because of the protective film over the mirror (photo Kagra observatory)

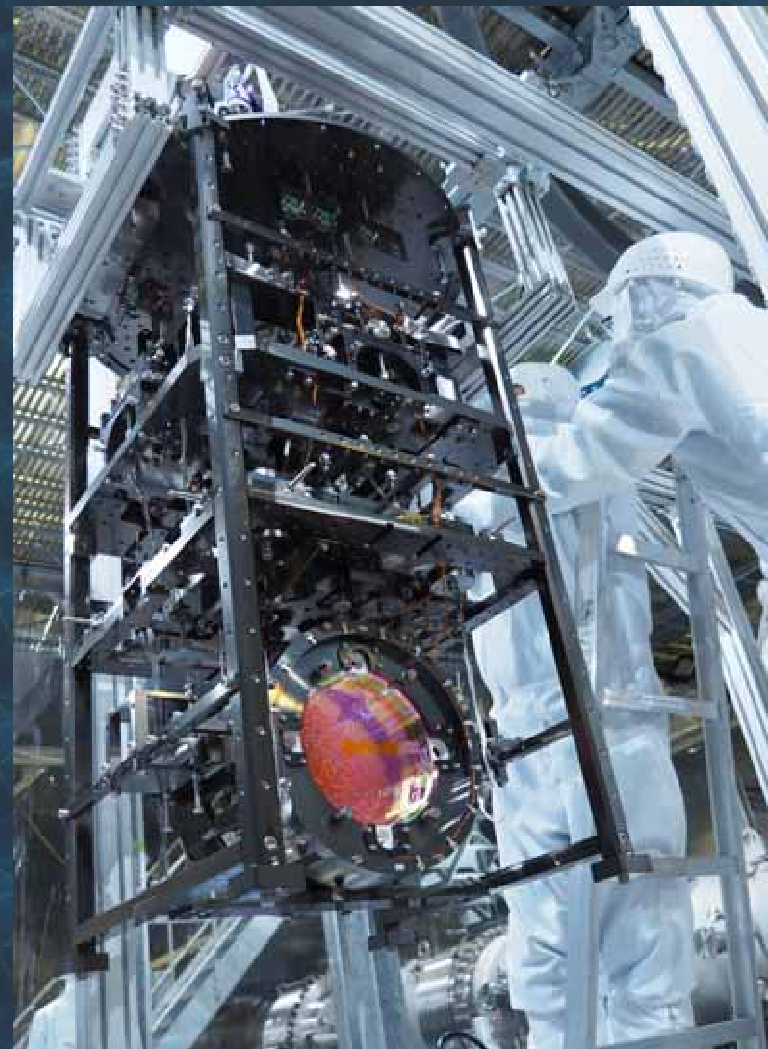
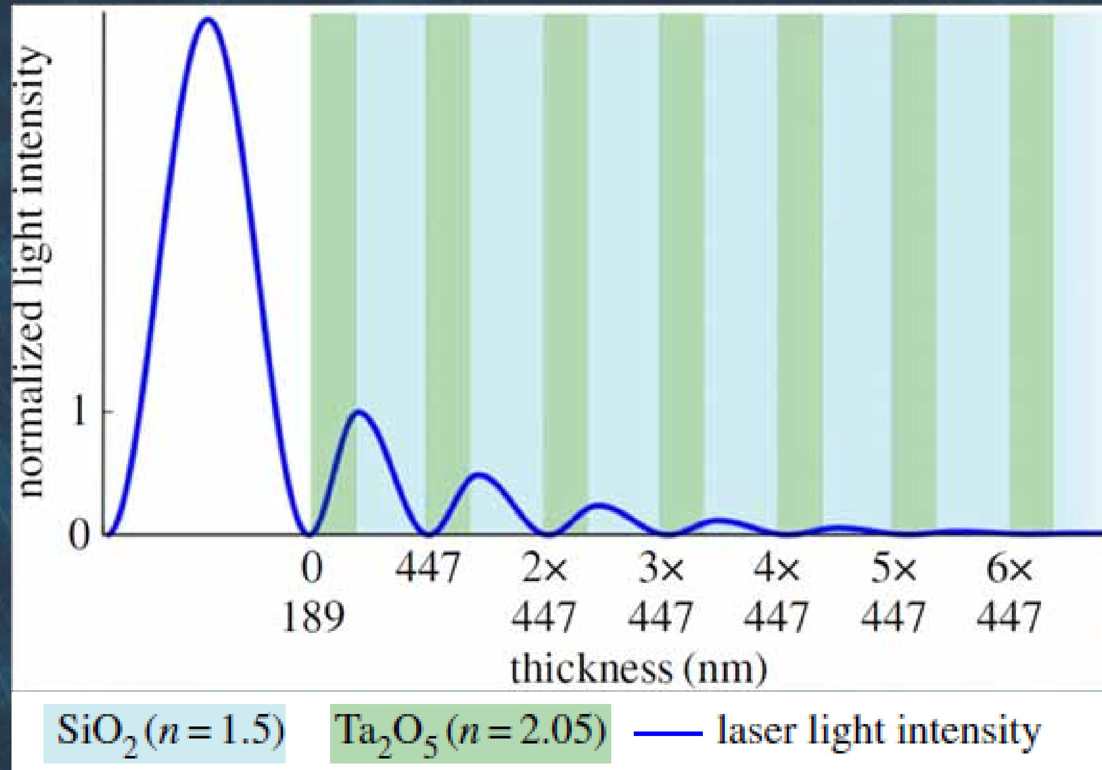


Photo courtesy: KAGRA Observatory, ICRR, The University of Tokyo

Why are special coatings needed? The mirror reason

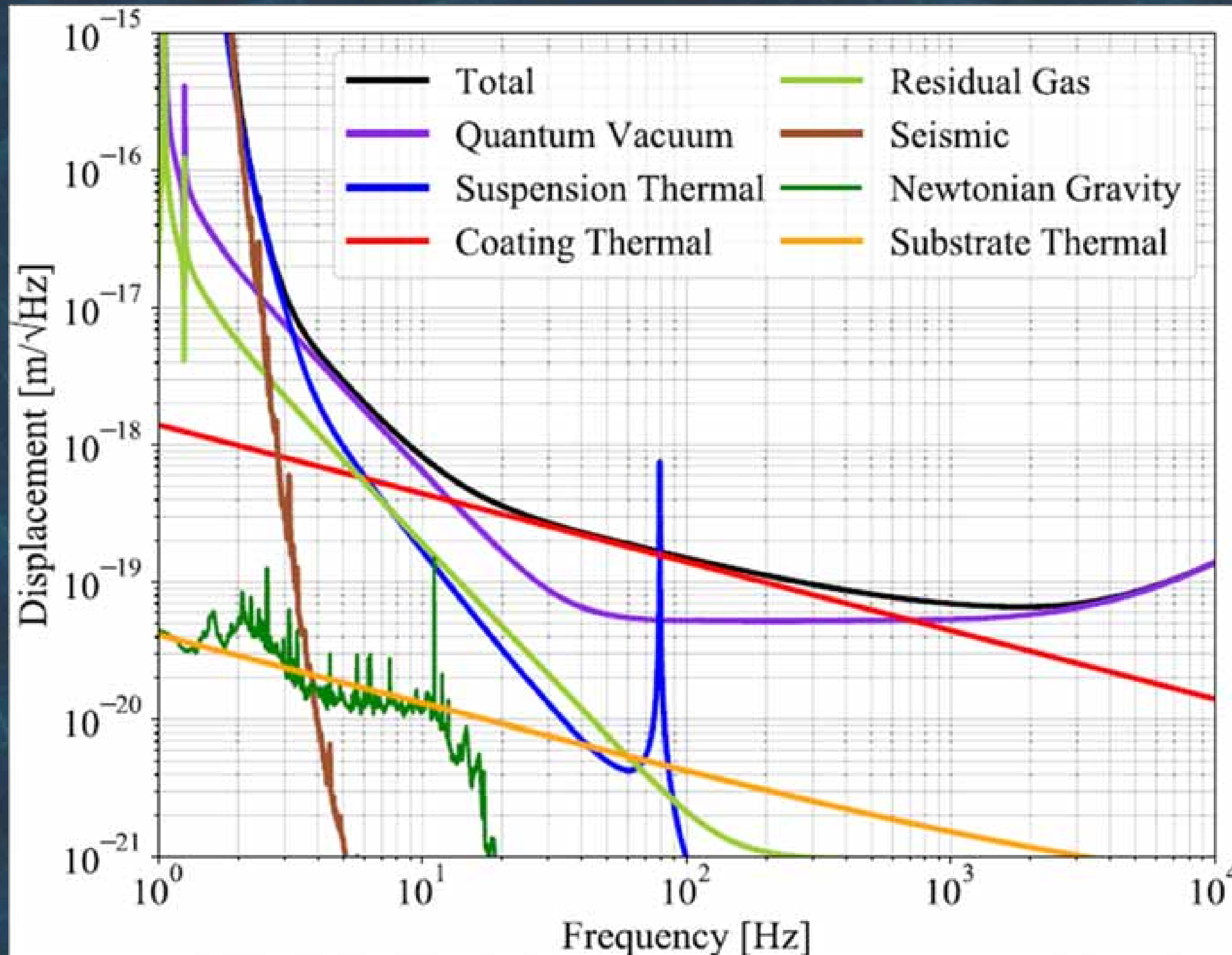
- Solution: dedicated coatings of exactly λ/2 acting as mirror
  - sub-nanometer precision
- 30 layers of coating required



	in air	in Ta_2O_5	in SiO_2
Refraction Index	~1	2.05	1.5
Light speed (m/s)	299·792·458	146·240·223	199·861·639
Wavelength λ (nm)	1550	756	1033
Coating thickness (nm)		189	258
Relative λ in coating		λ/4	λ/4

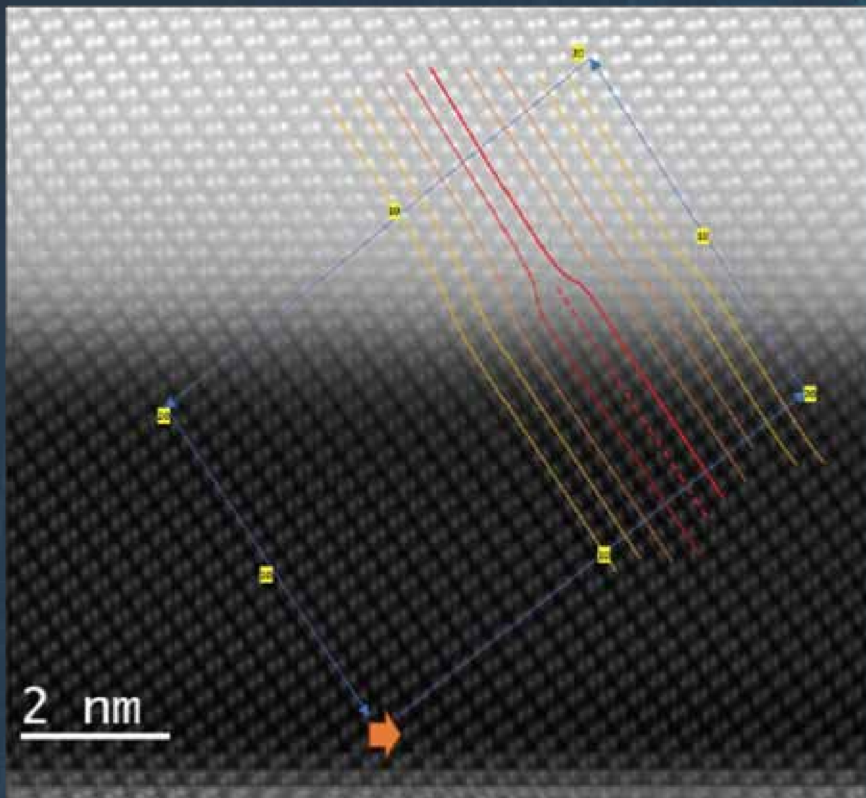
Why are special coatings needed? The noise reason

- Coatings as source of noise
  - Thermal noise
  - Brownian noise
- Example: 1550 nm laser light at 18 K

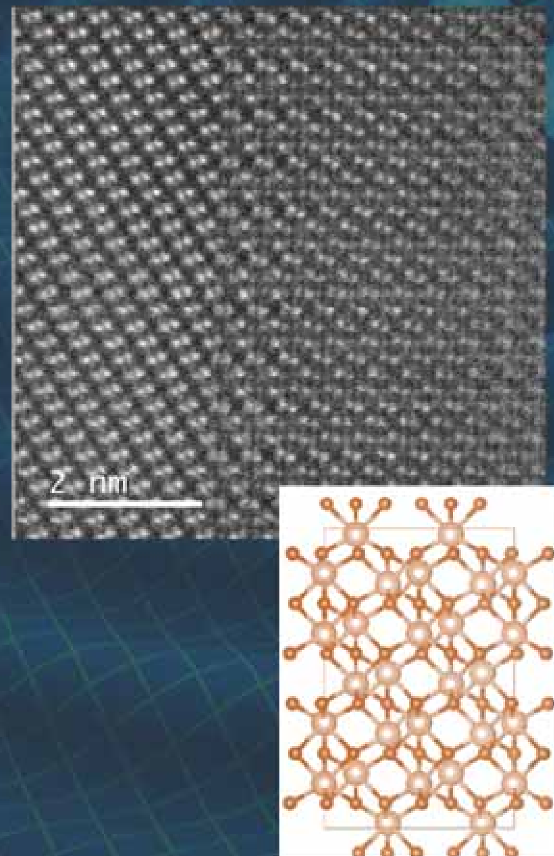


Sources of errors in mirrors

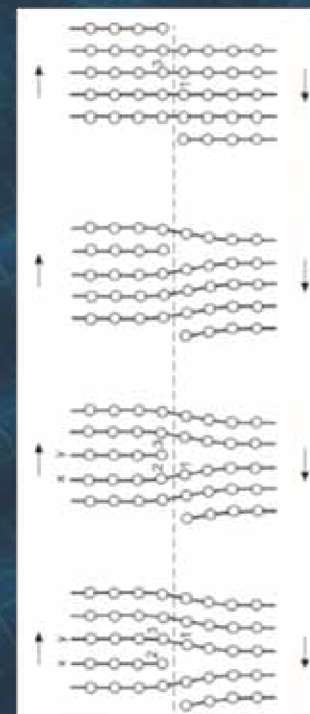
Dislocations



Twin Boundaries

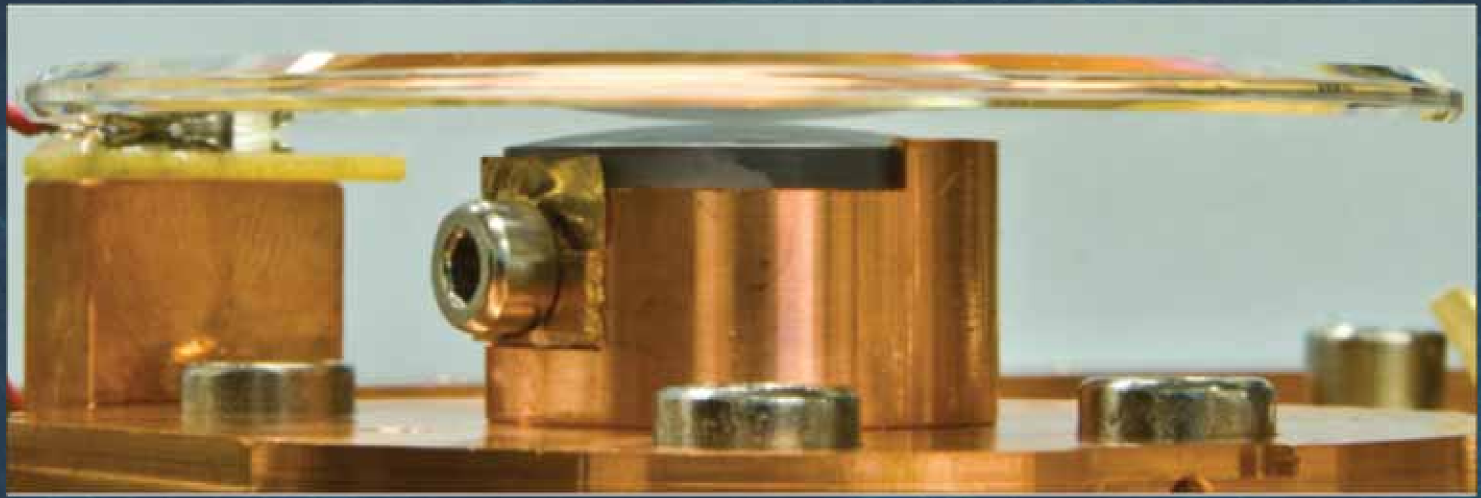


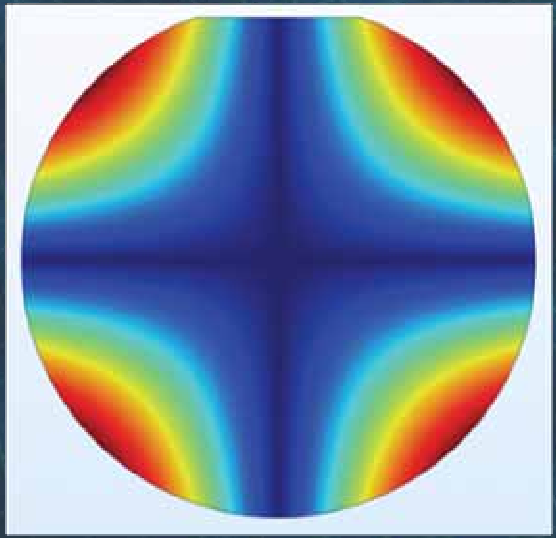
Dislocations

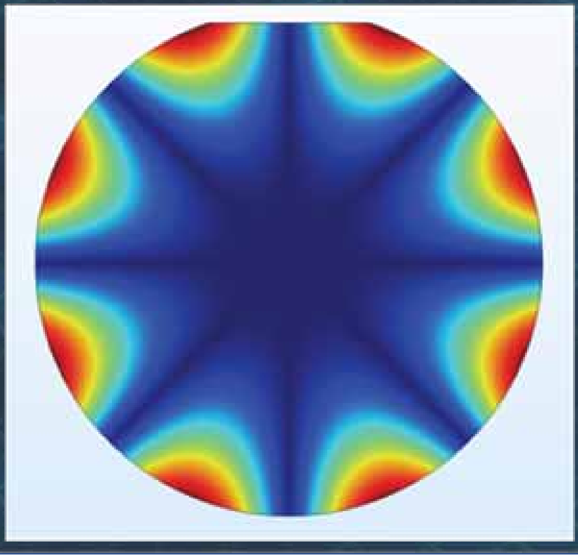


Measuring mechanical loss

- Mechanical loss is related to noise



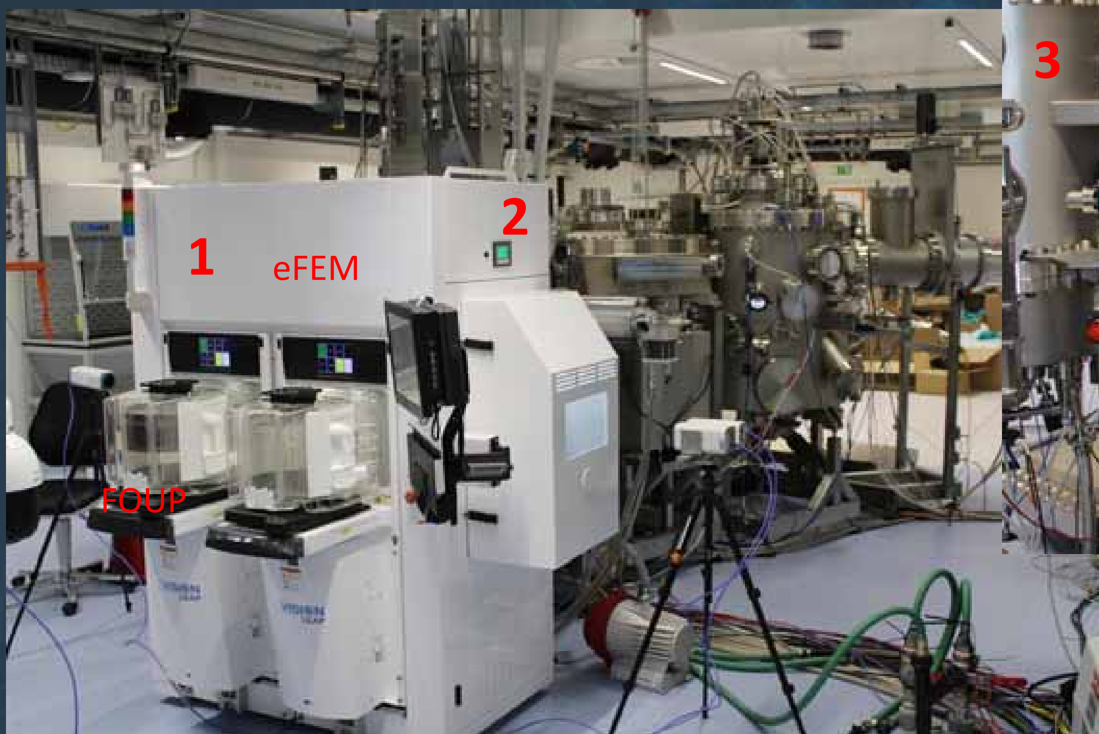


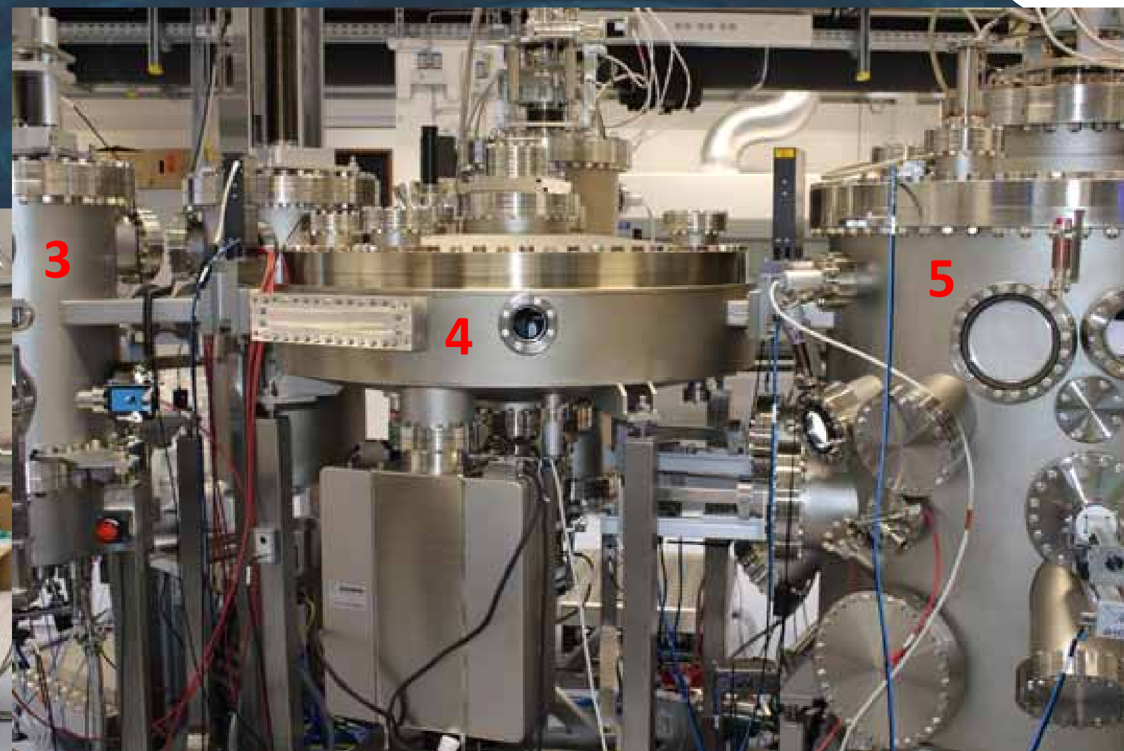


Coating setup for monocrystalline coatings

1. efem-foup
2. load lock
3. Storage
4. annealing chamber : pre anneal
5. growing chamber

Optional Second post anneal

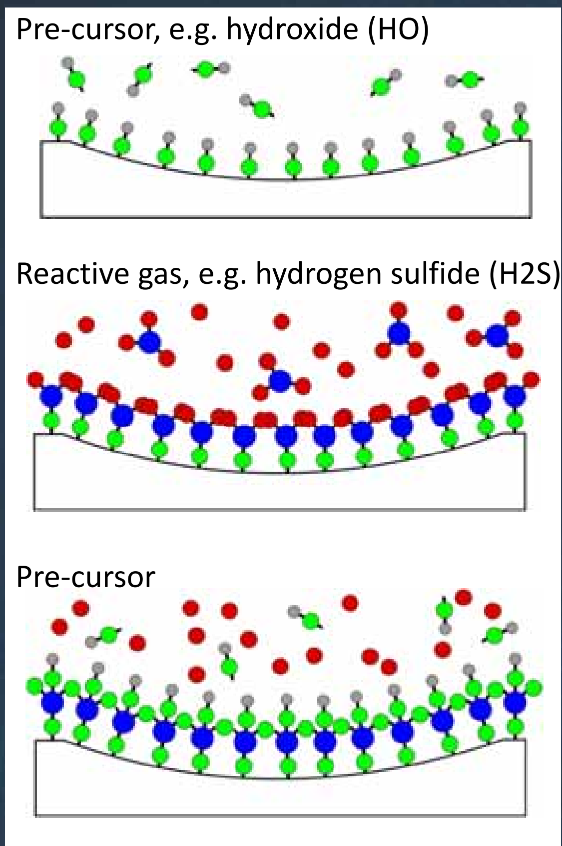


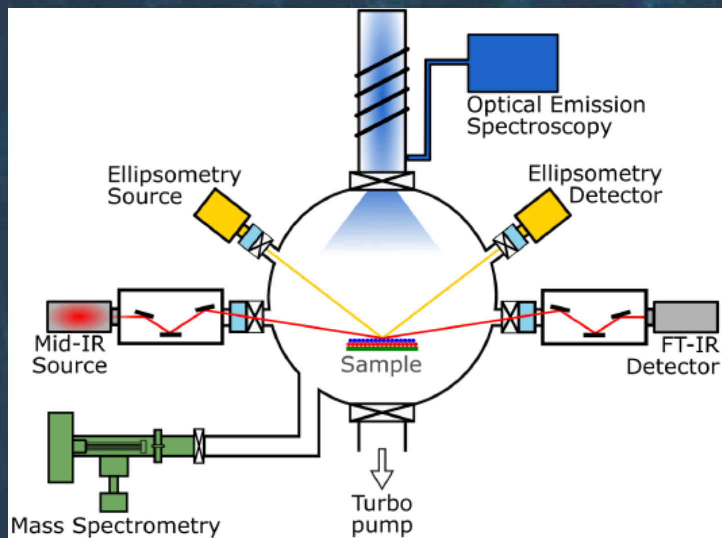


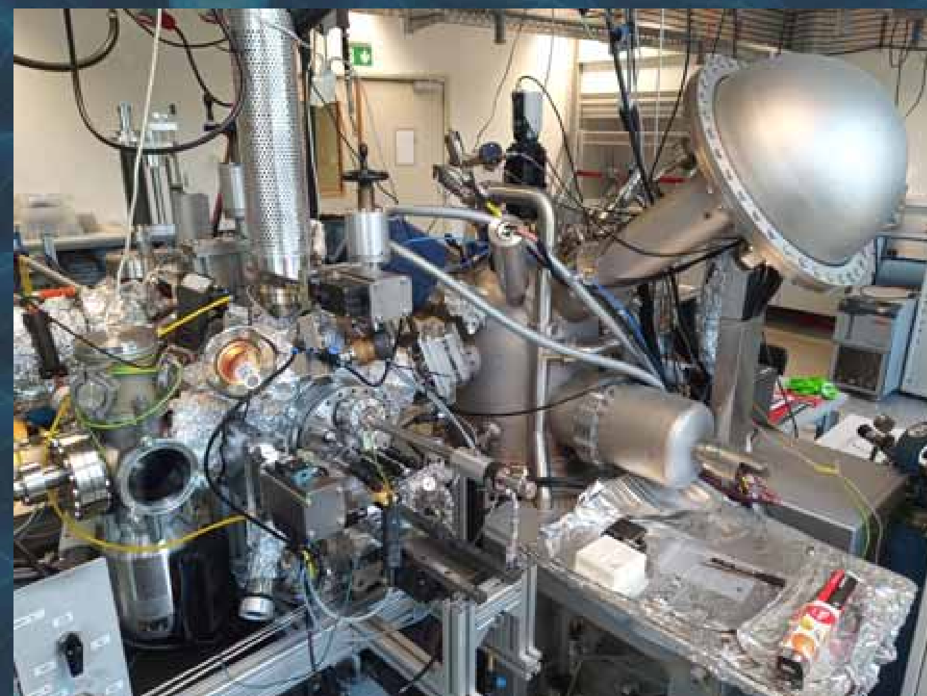
Coating setup example for polymorphic coatings

Atomic Layer Deposition (ALD)

Growing layer by layer with sequence of pre-cursor, reactive gas, pre-cursor, reactive gas, pre-cursor, reactive gas ...







EINSTEIN TELESCOPE ENERGY REQUIREMENTS

What are the ET power needs?

⚠ All values are rough estimates

One-Time: 14MW (2 TBMs)

- Tunnel Boring Machines: ~5MW /piece

- Vacuum System Bake-Out: 1.1MW

- Mining equipment: 2MW

Operational : 8MW (with contingency)

- Vacuum pumps: 1.25MW

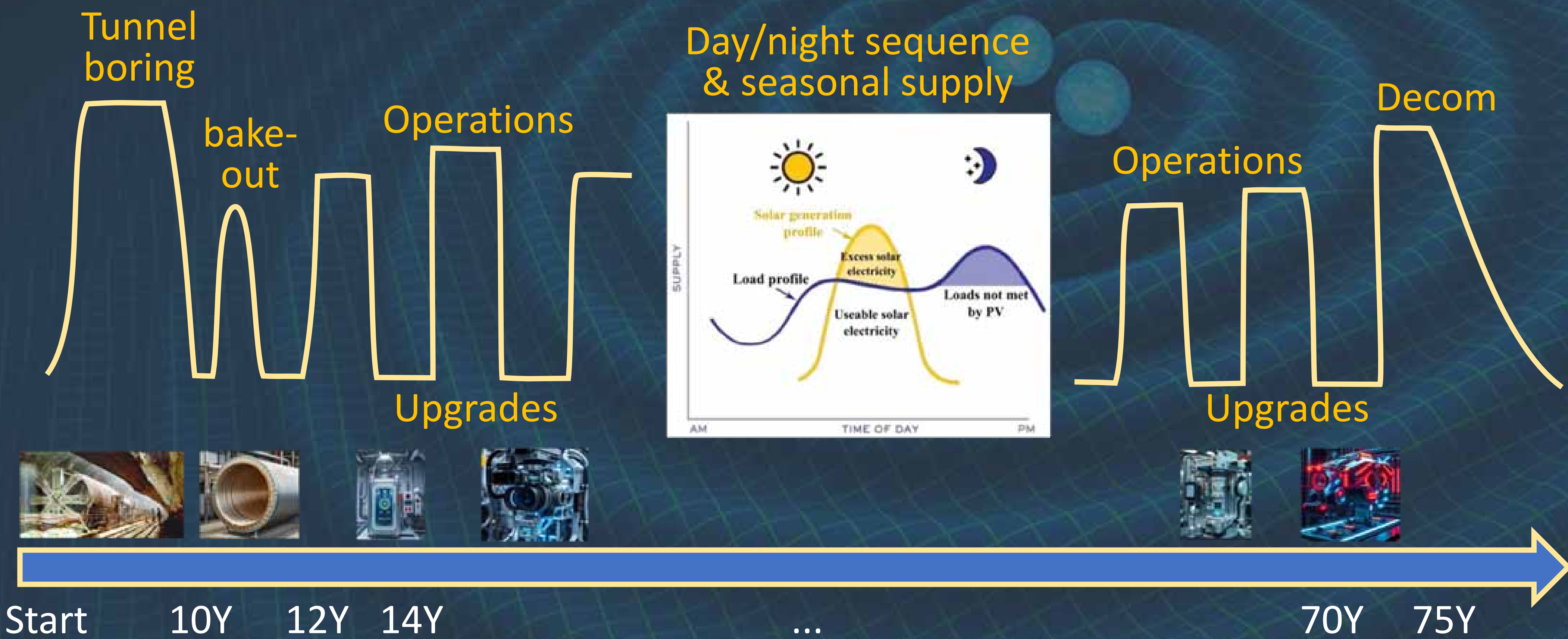
- Cryogenics: 4.5MW

- Lasers: 120KW

- Surface Buildings: 1MW

What are the ET power needs?

- Highly fluctuating power needs ... and supply



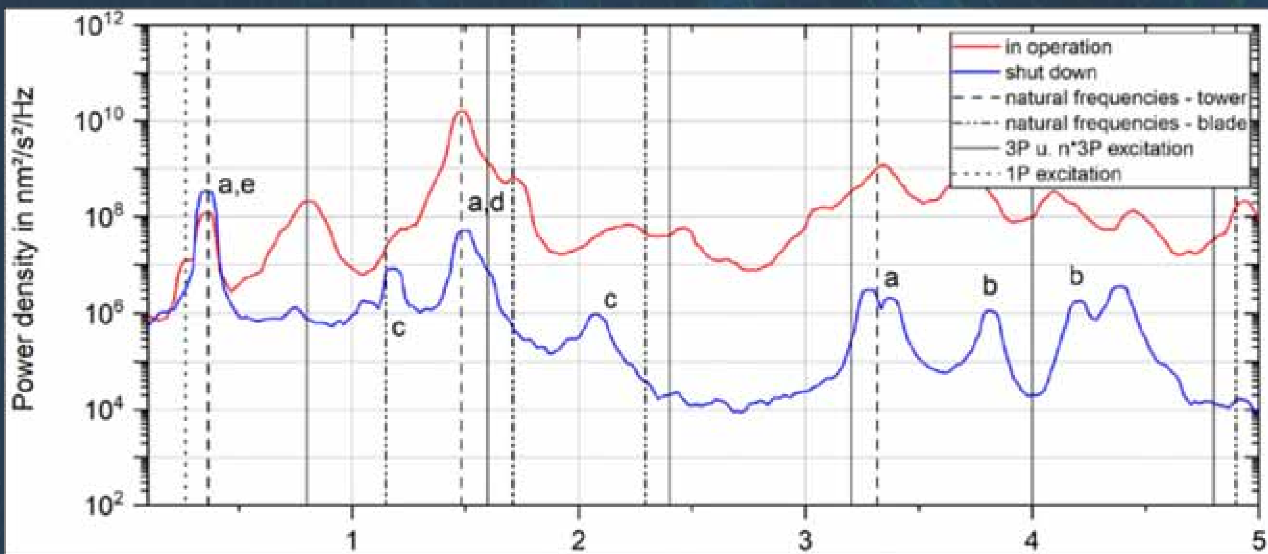
Power sources

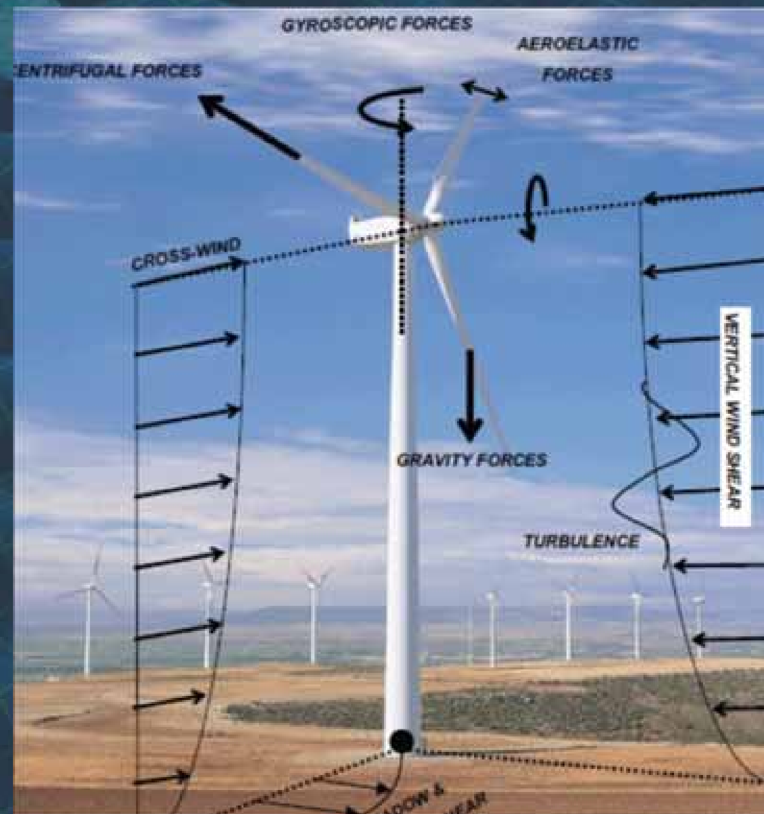
- Hydrogen
  - Power needs too low for H_2 extraction point (single digit MW)
  - Looking for other H_2 users
  - Optional: containers on railroad

- PV Installations
  - 70 ... 80 hectares of solar panels
  - Expected to be not acceptable in Voeren landscape
  - Optional: participatory solar panels
  - Elsewhere if converted to high voltage

Power sources

- Wind Turbines
  - Blade vibrations are most important
  - Vibration of pole also when turbine not in use

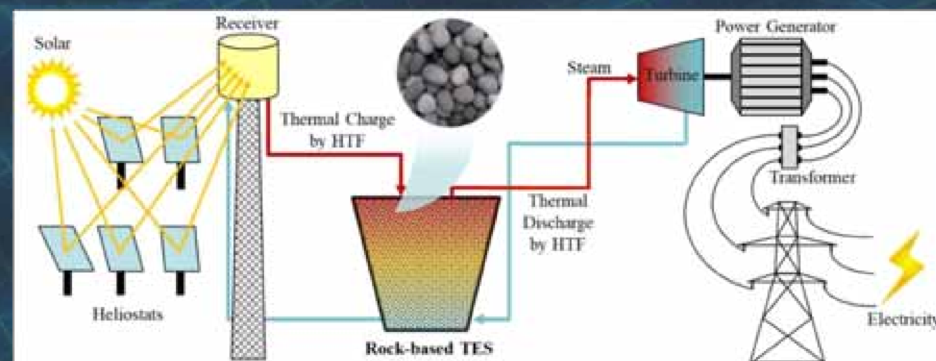




Power sources

- Off-shore Wind Turbines
  - Need to be within 10km for DC grid → high voltage net

- Heliostat?
  - Solar heliostat
  - Thermal storage possible to cover for day/night
  - Low supply in Belgium / in winter period



Energy storage

Einstein Telescope

- H_2 filling / charging stations
  - Electrolyser and hydrogen storage
  - Expected to be unprofitable
  - Connection to H_2 grid required

- Local use by inhabitants
  - Low cost power supply
  - Part of participatory design

Energy storage

- Inject in high power electricity grid
  - Complex power demand

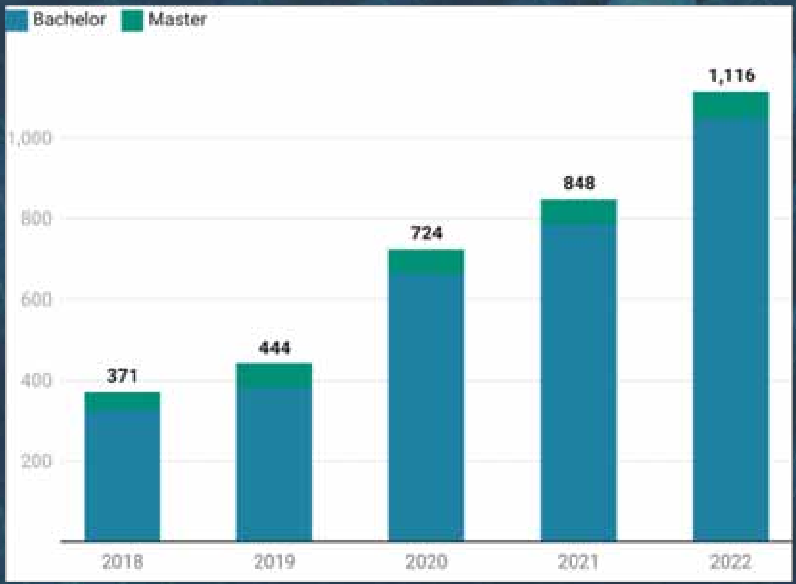
- Battery storage
  - Advantage of grid stability and peak shaving
  - High cost and size
  - New developments in batteries needed

Energy storage

- Flywheel energy storage
  - Limited capacity
  - Small energy fluctuations only
- Other
  - Hydro-electric storage (hydropower)
    - Decommissioned in NRW
  - Geothermal: risk of vibrations caused by pumps
  - Kite wind turbines: only offshore
  - Compressed air: large systems

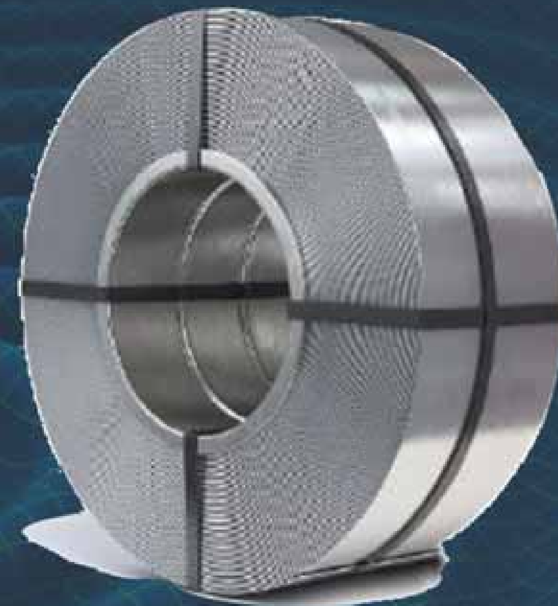
Where are we now?
Business oportunities

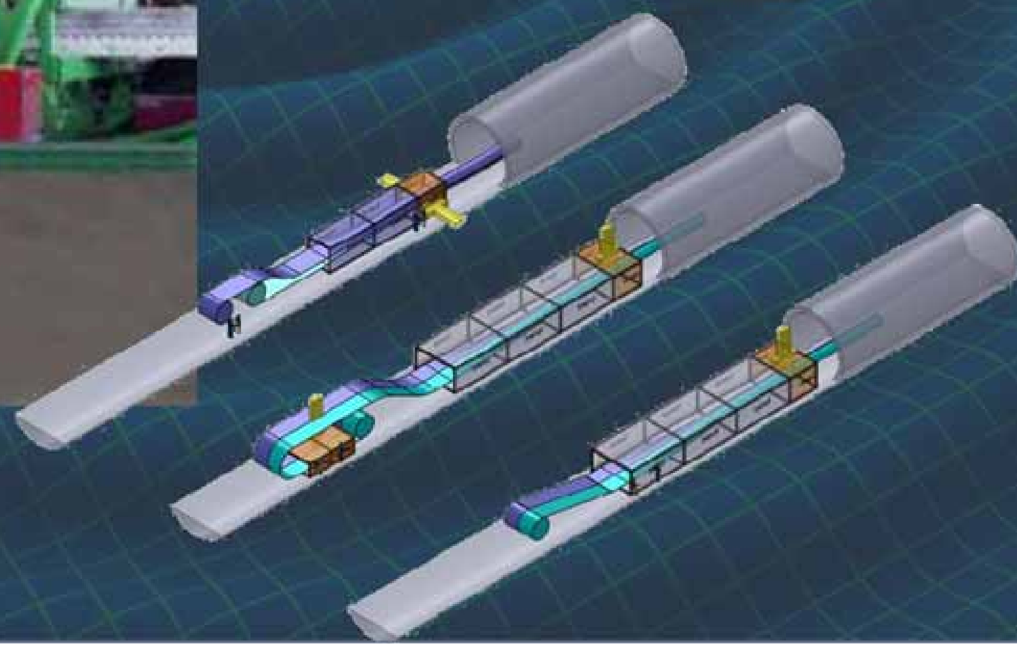
Interest in STEAM



STEM Maastricht

New inventions happening today beampipes at Werkhuizen Hengelhoef

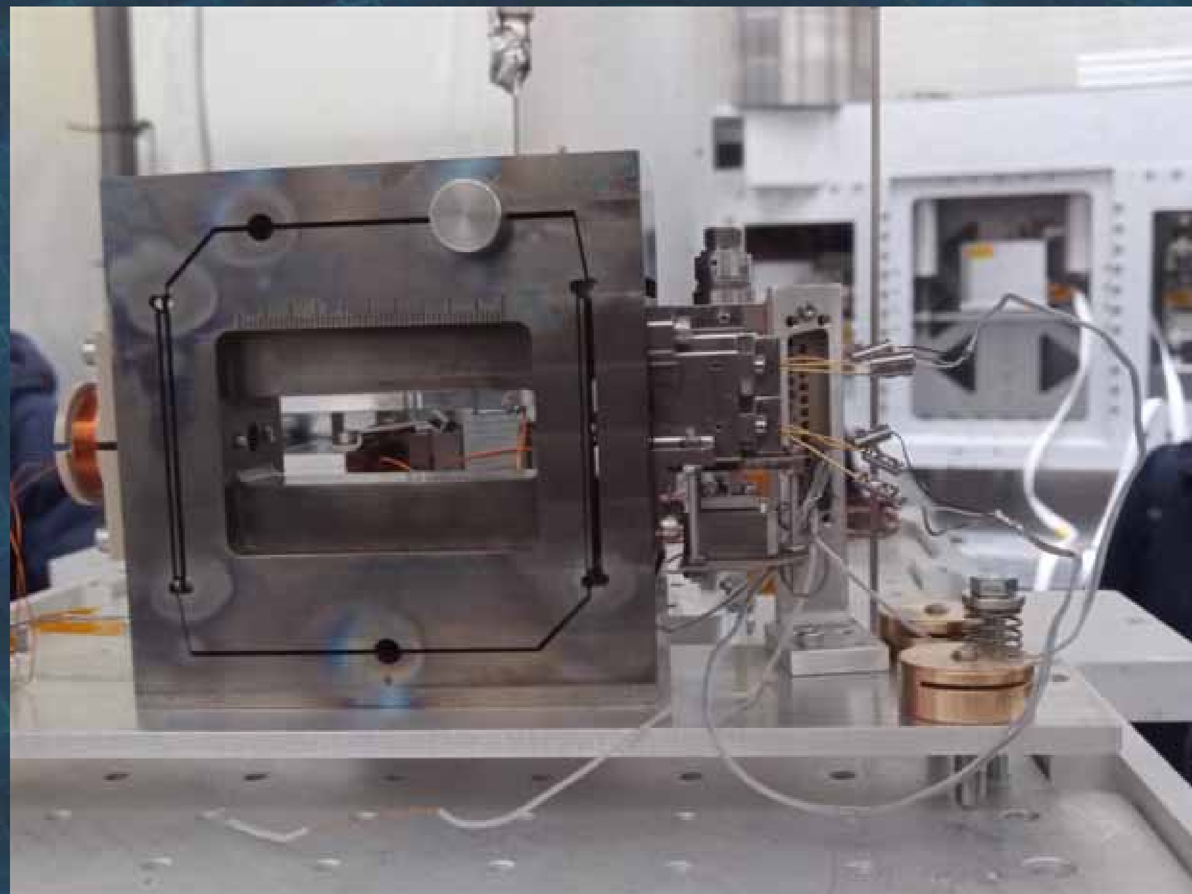




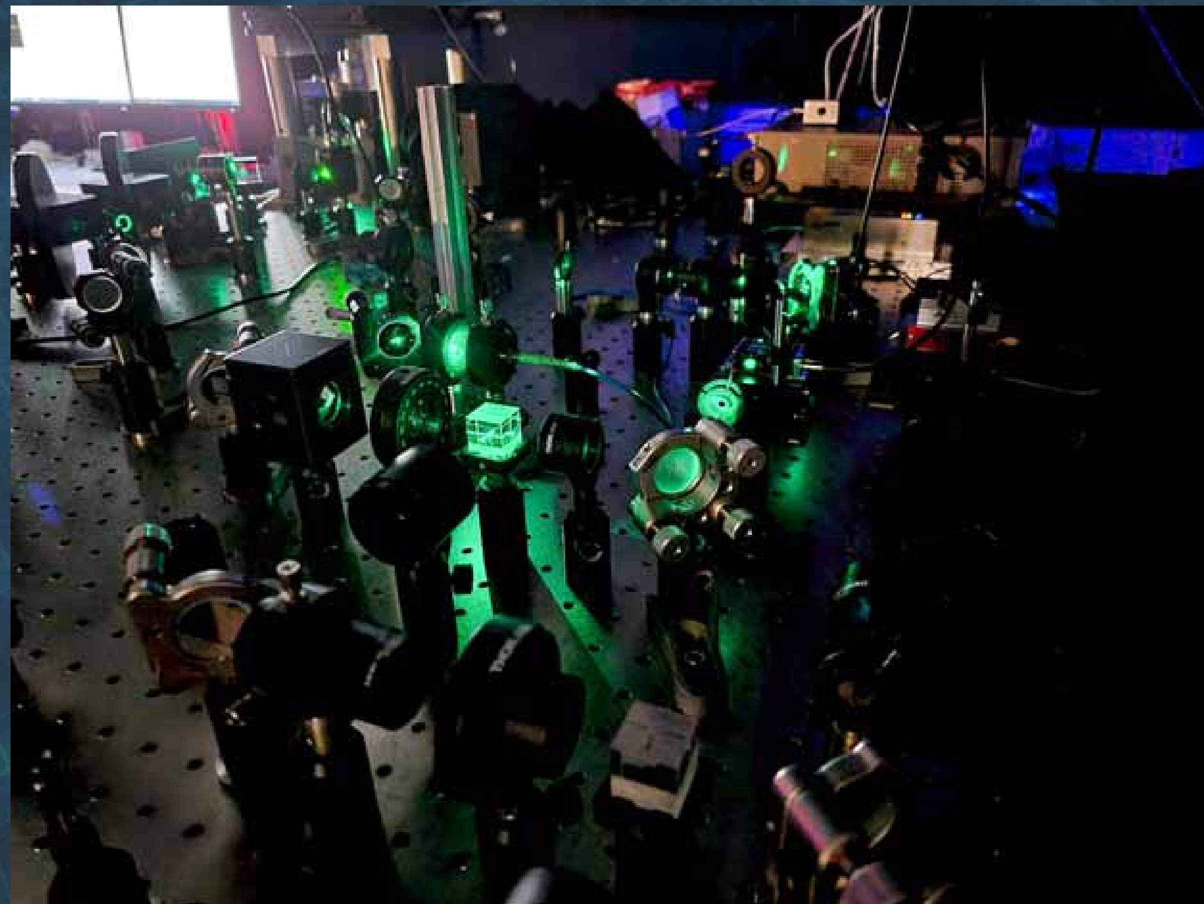
Vacuum tubes

- Tests done at CERN

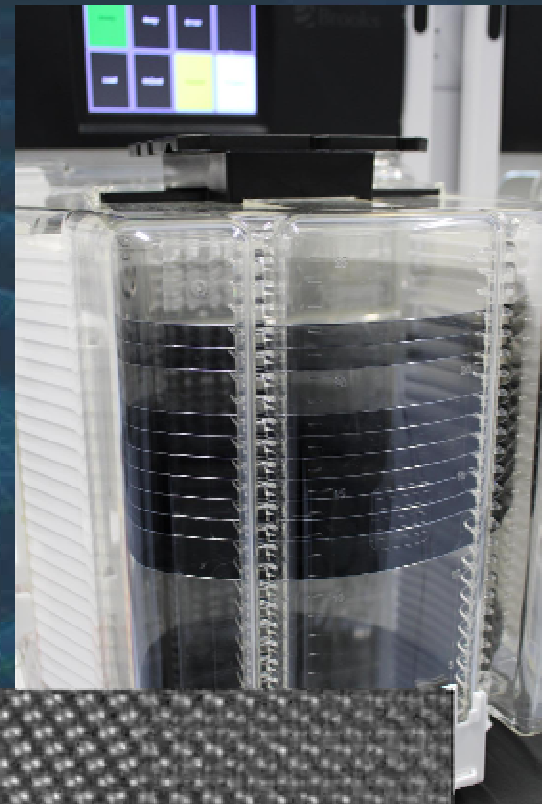
New inventions happening today
Ultrasensitive accelerometers

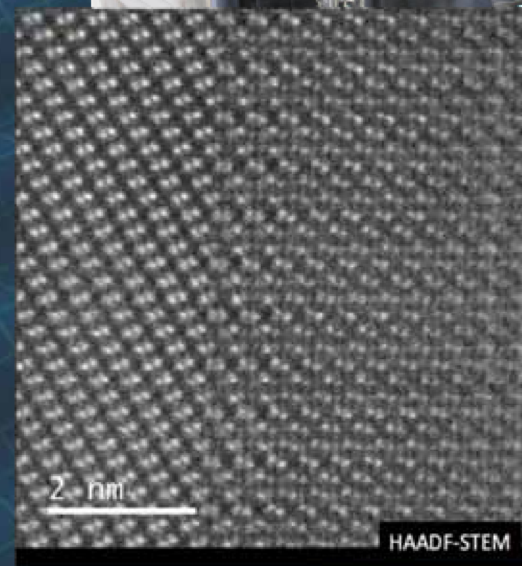


New inventions happening today
Ultrasensitive magnetometers



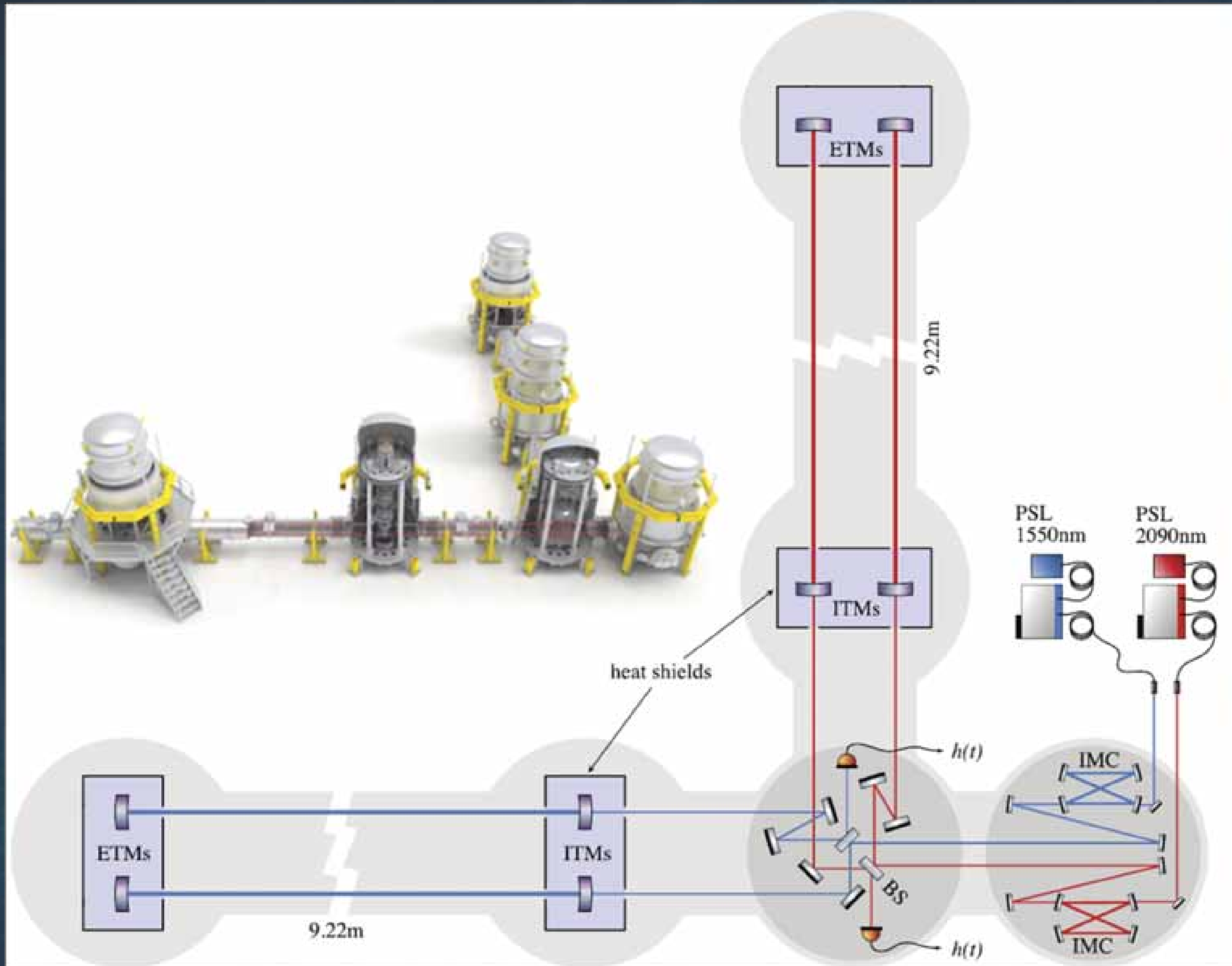
New inventions happening today
New coating machines





ETpathfinder in Maastricht

Vacuum Tower Lasers



E-TEST in Liège (CSL)

Challenges for the climate

Use of **Energy**

Reuse of **excavations**

Prepare for **decommissioning** upfront

Carbon-free transport

Waste water treatment

Protected **Bocage landscape**

OTHER RESEARCH AREAS

Technologies

Einstein Telescope

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

ETPathfinder


Ca. 1980s


January 2020


April 2020


Summer 2020


MANITOU
Autumn 2020

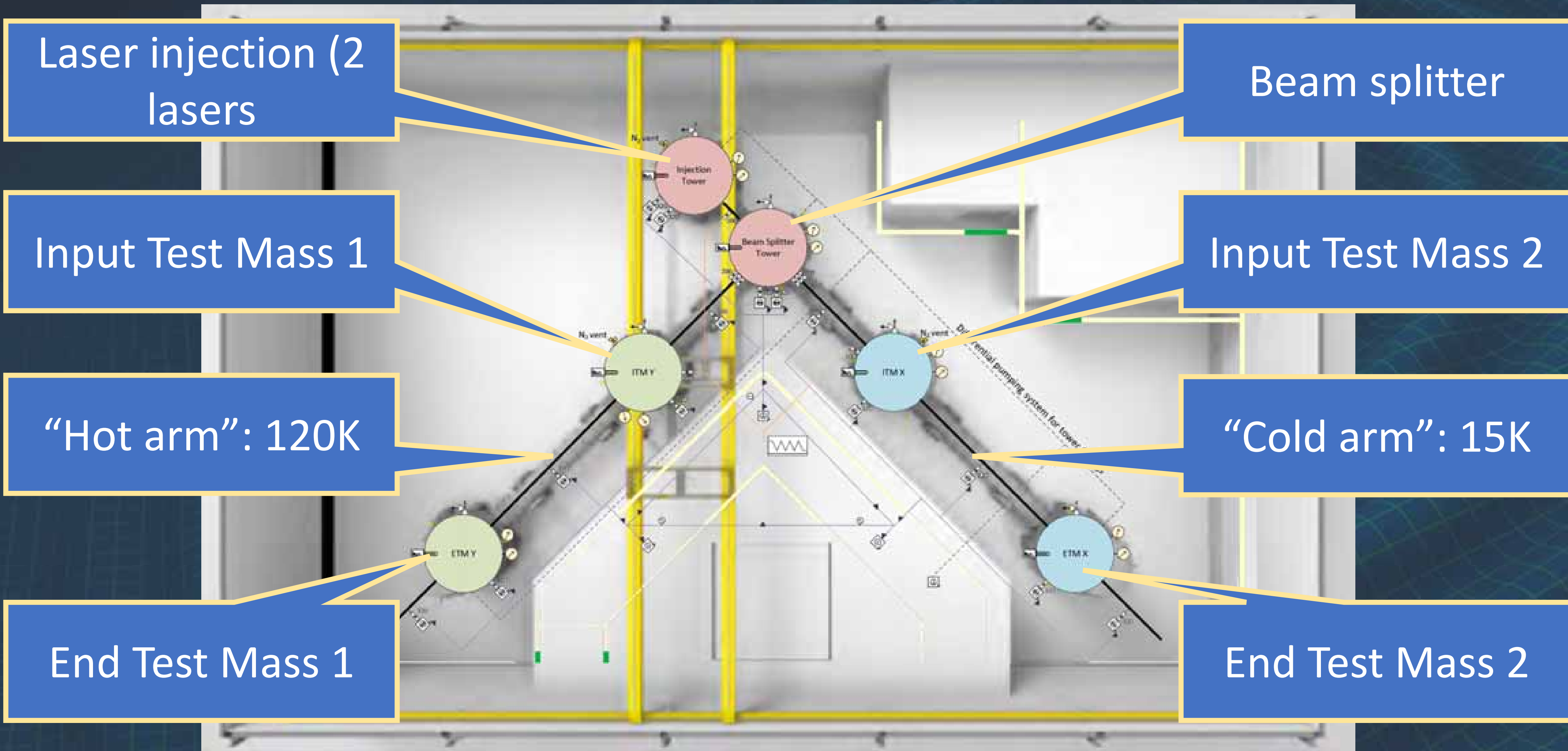

ALTMANN - 2 x 2 to
Summer 2021


Spring 2022

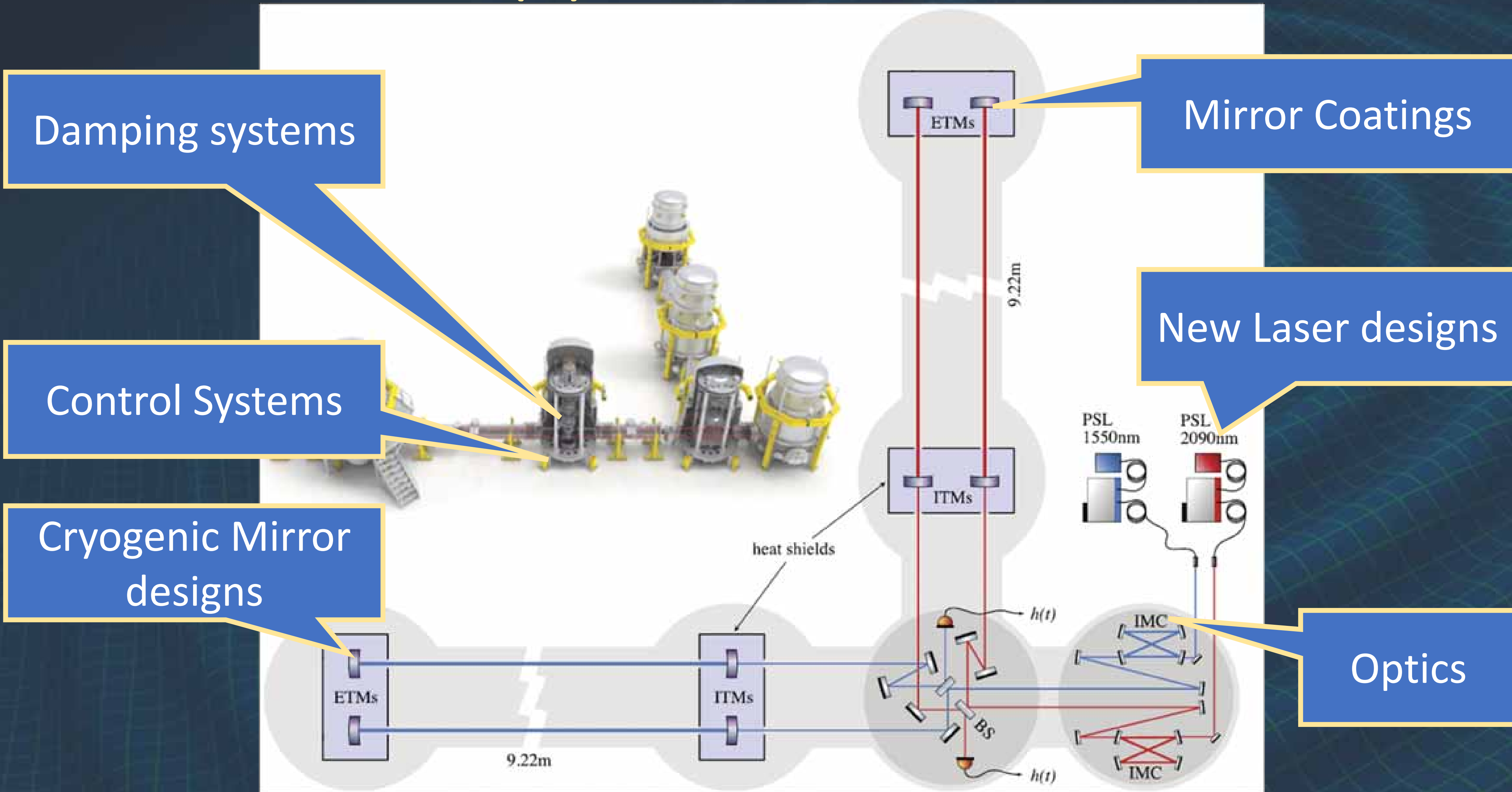
ETpathfinder in Maastricht



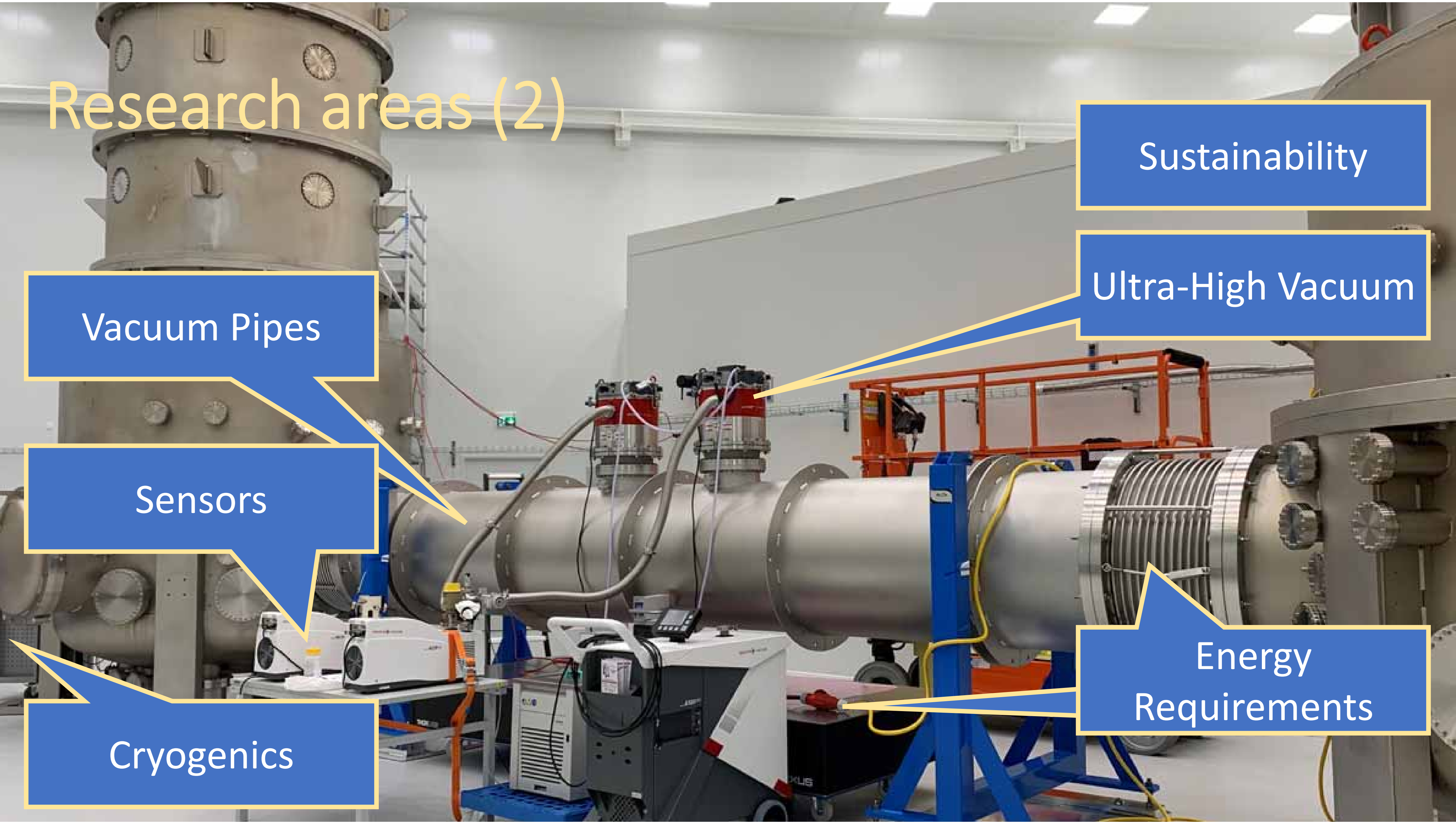

ETpathfinder layout



Research areas (1)



Research areas (2)



Silicon as a mirror material

A COMPLEX ORGANIZATION

Einstein Telescope

Einstein Telescope Preparatory Phase (ET-PP)

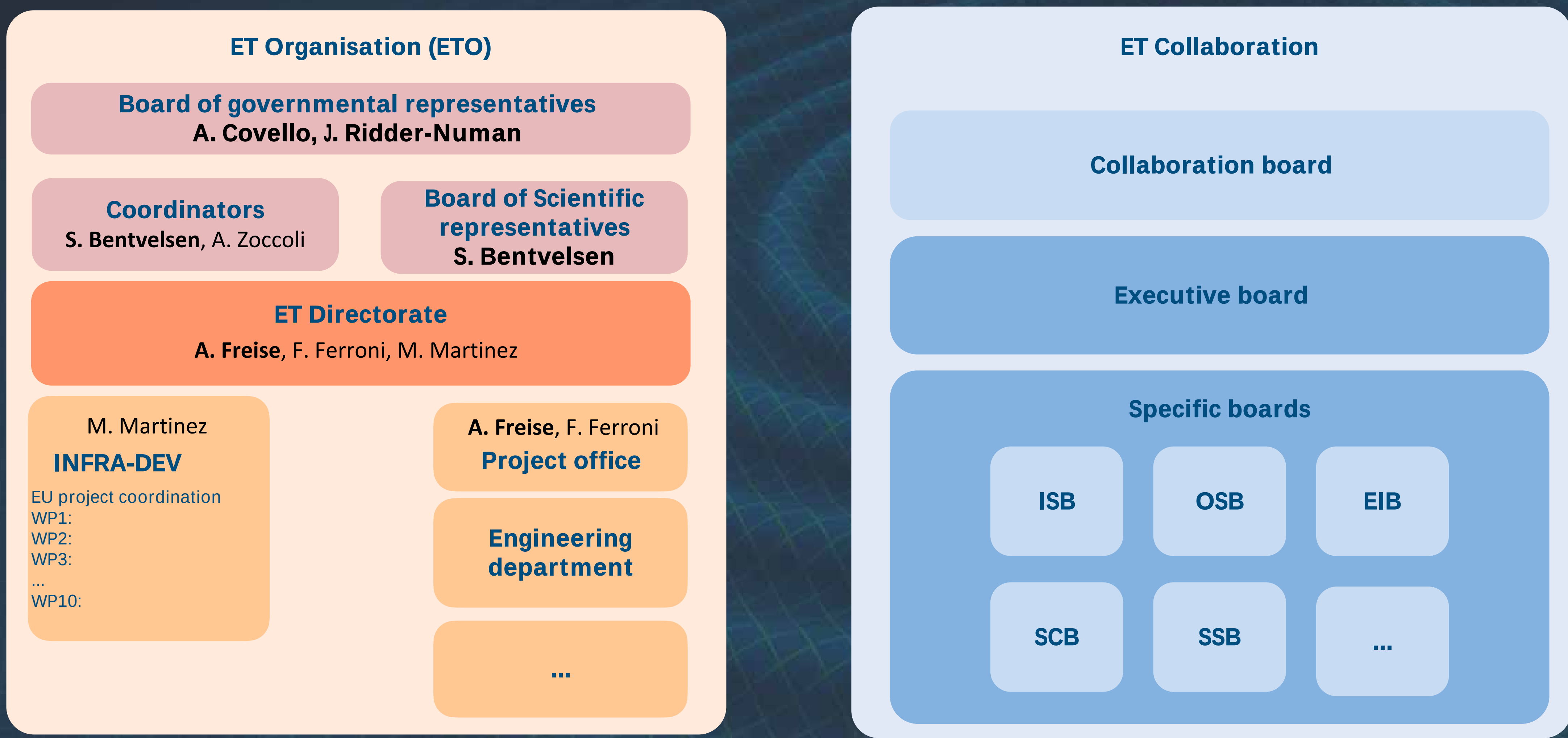
ET Preparatory Phase Project About Partners Work Packages Publications News & Events Open Positions Contact Internal

ET-PP

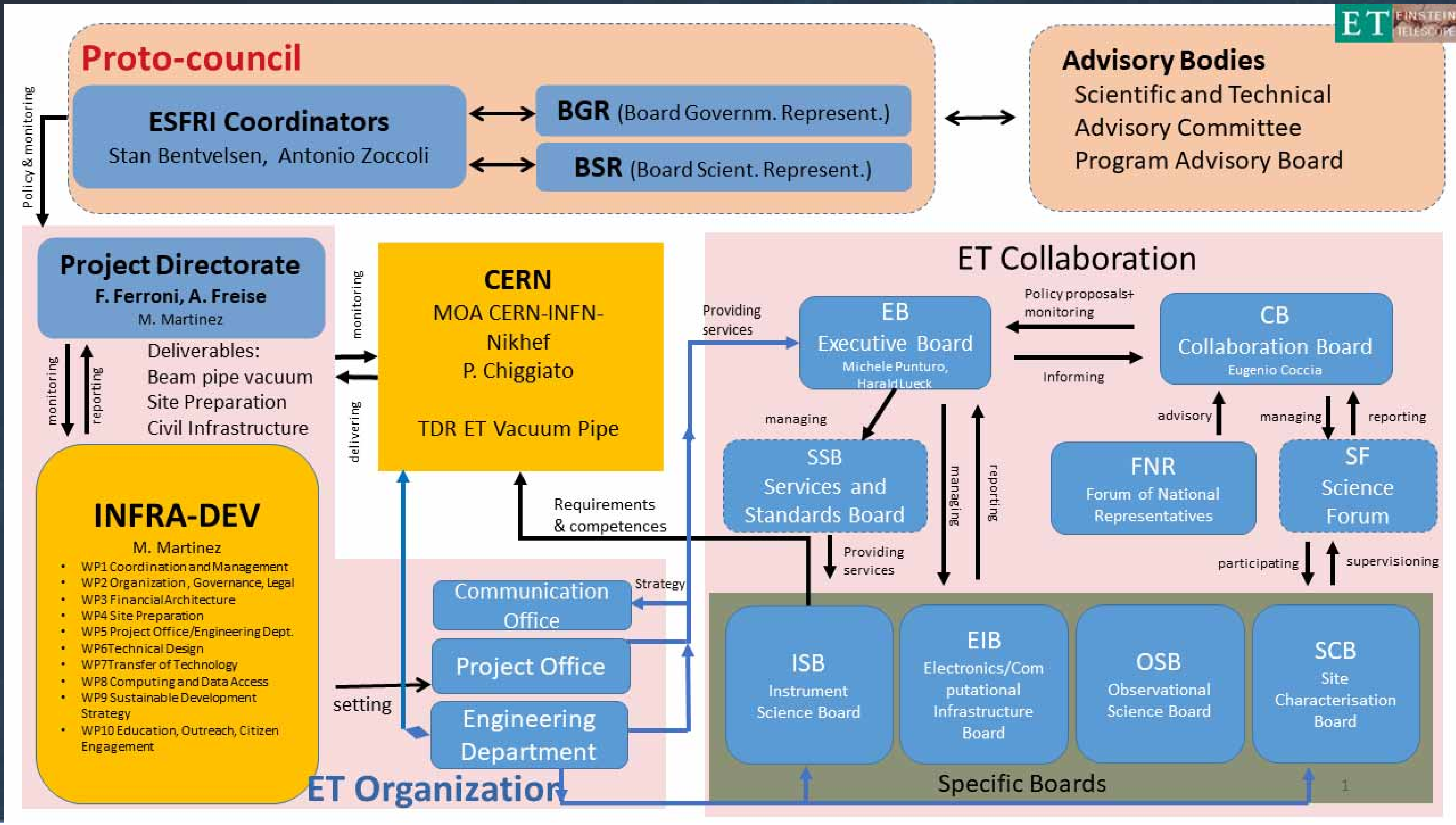
Preparatory Phase for the Einstein Telescope Gravitational Wave Observatory

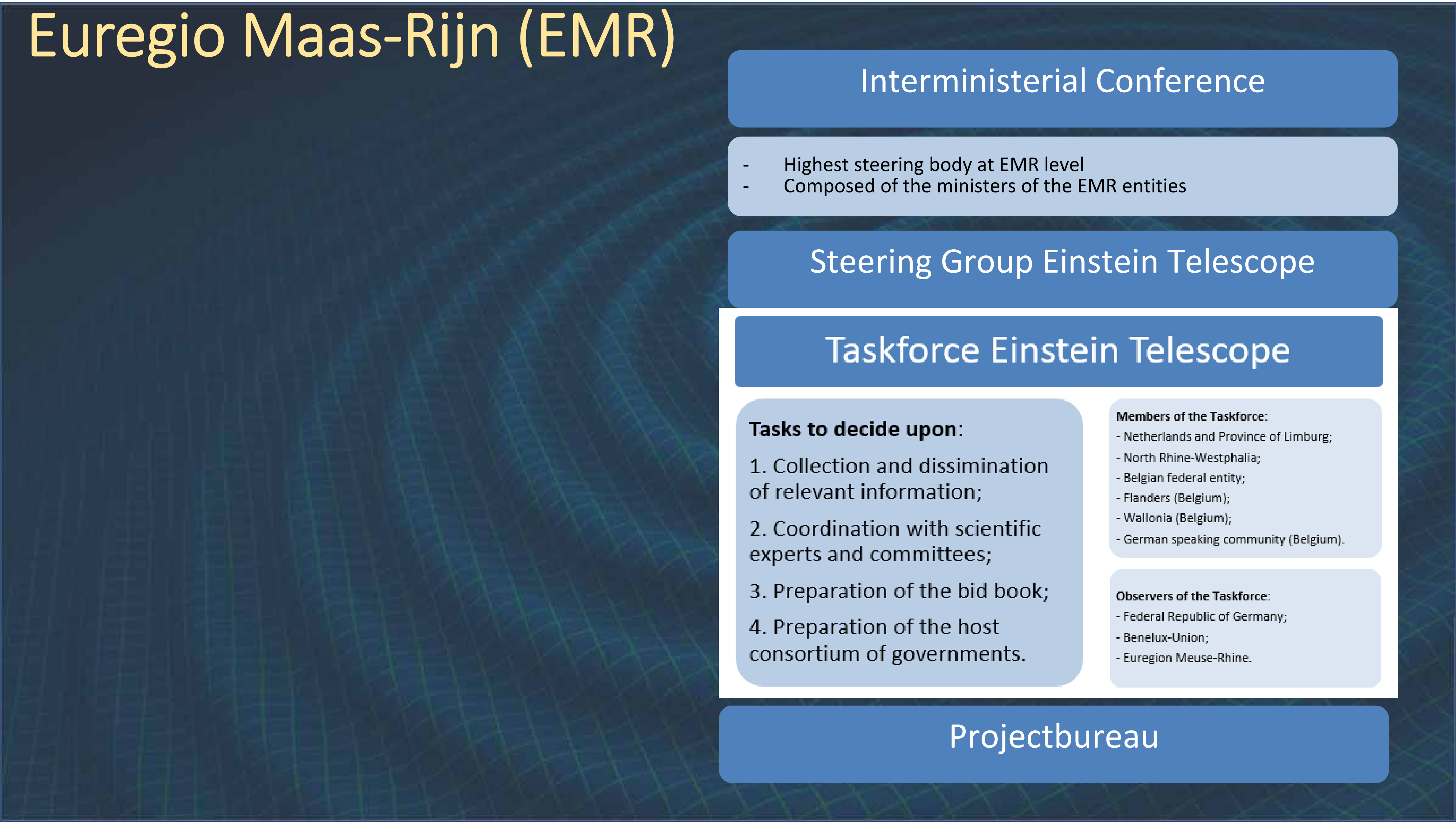
ET EINSTEIN TELESCOPE

European Level

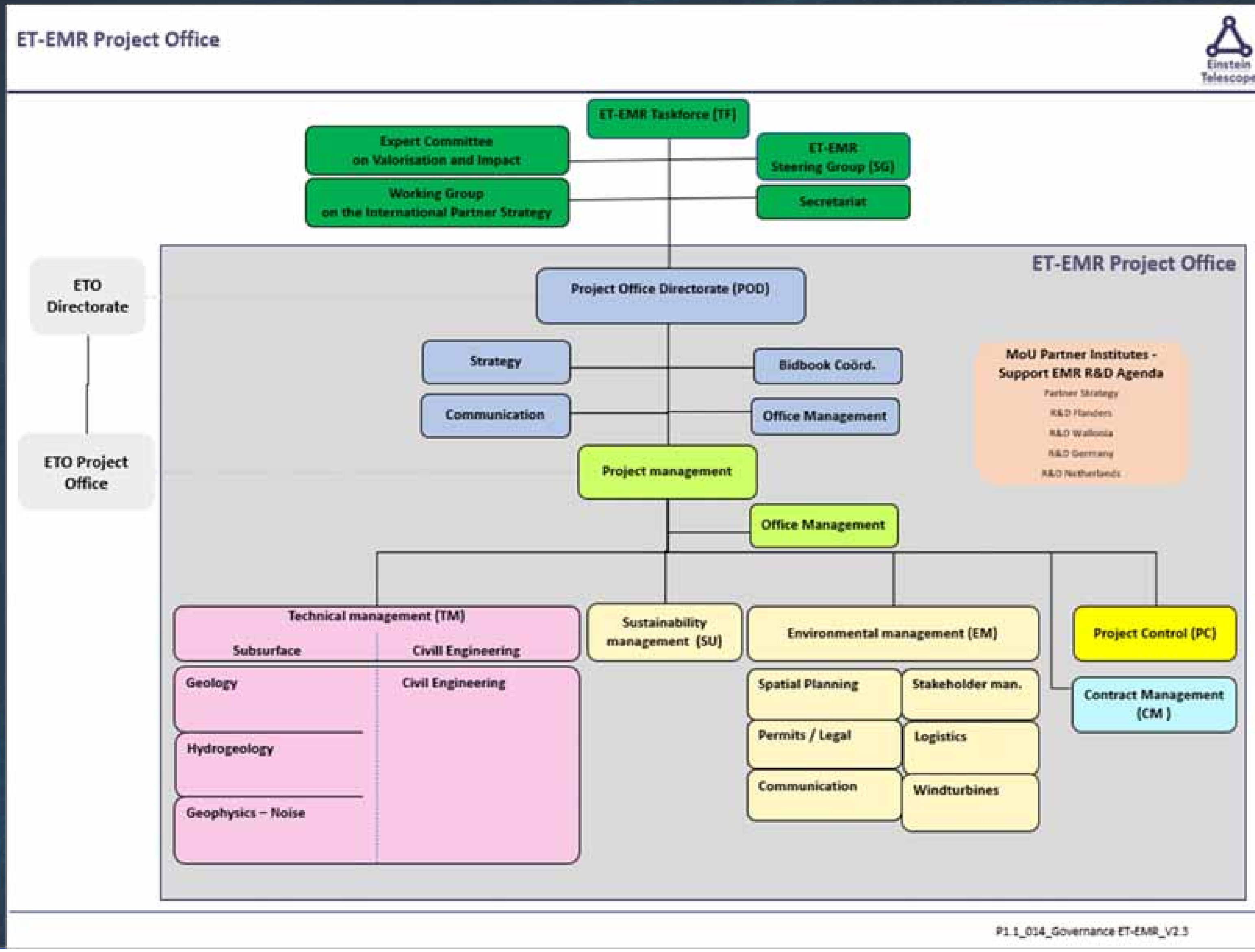


Einstein Telescope Collaboration



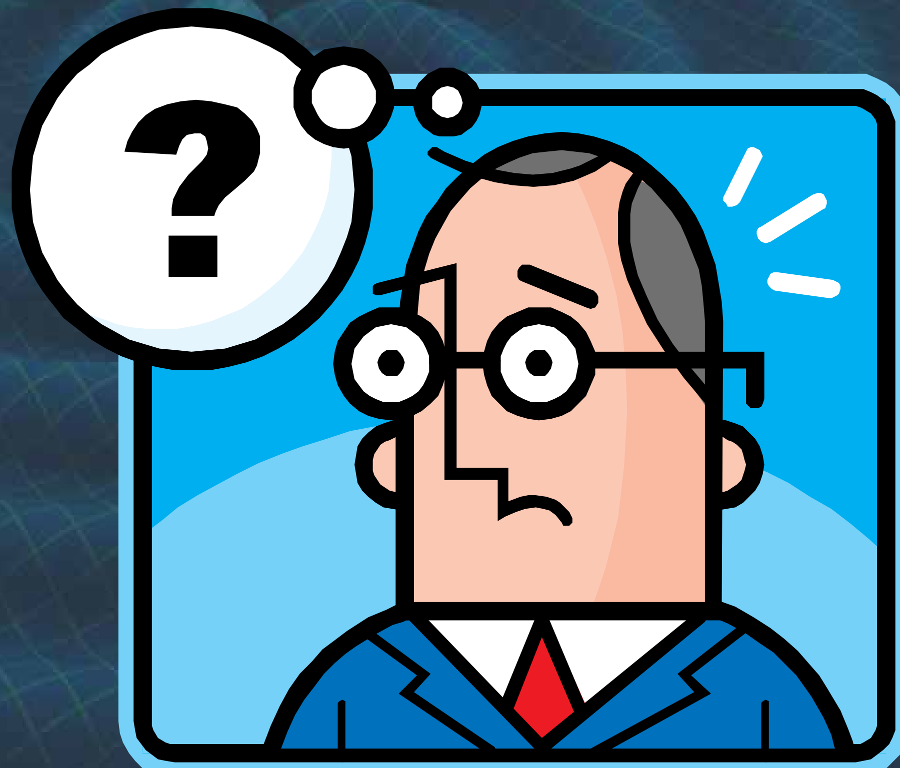

Euregio Maas-Rijn (EMR)
Interministerial Conference
- Highest steering body at EMR level
- Composed of the ministers of the EMR entities
Steering Group Einstein Telescope
Taskforce Einstein Telescope
Tasks to decide upon:
1. Collection and dissimination of relevant information;
2. Coordination with scientific experts and committees;
3. Preparation of the bid book;
4. Preparation of the host consortium of governments.
Members of the Taskforce:
- Netherlands and Province of Limburg;
- North Rhine-Westphalia;
- Belgian federal entity;
- Flanders (Belgium);
- Wallonia (Belgium);
- German speaking community (Belgium).
Observers of the Taskforce:
- Federal Republic of Germany;
- Benelux-Union;
- Euregion Meuse-Rhine.
Projectbureau

Euregio Maas-Rijn (EMR)



What is the request?

- "Spread the word"
- More parties interested? Let us know!
  - Schools?
  - Companies?



Thank you!

Questions please?