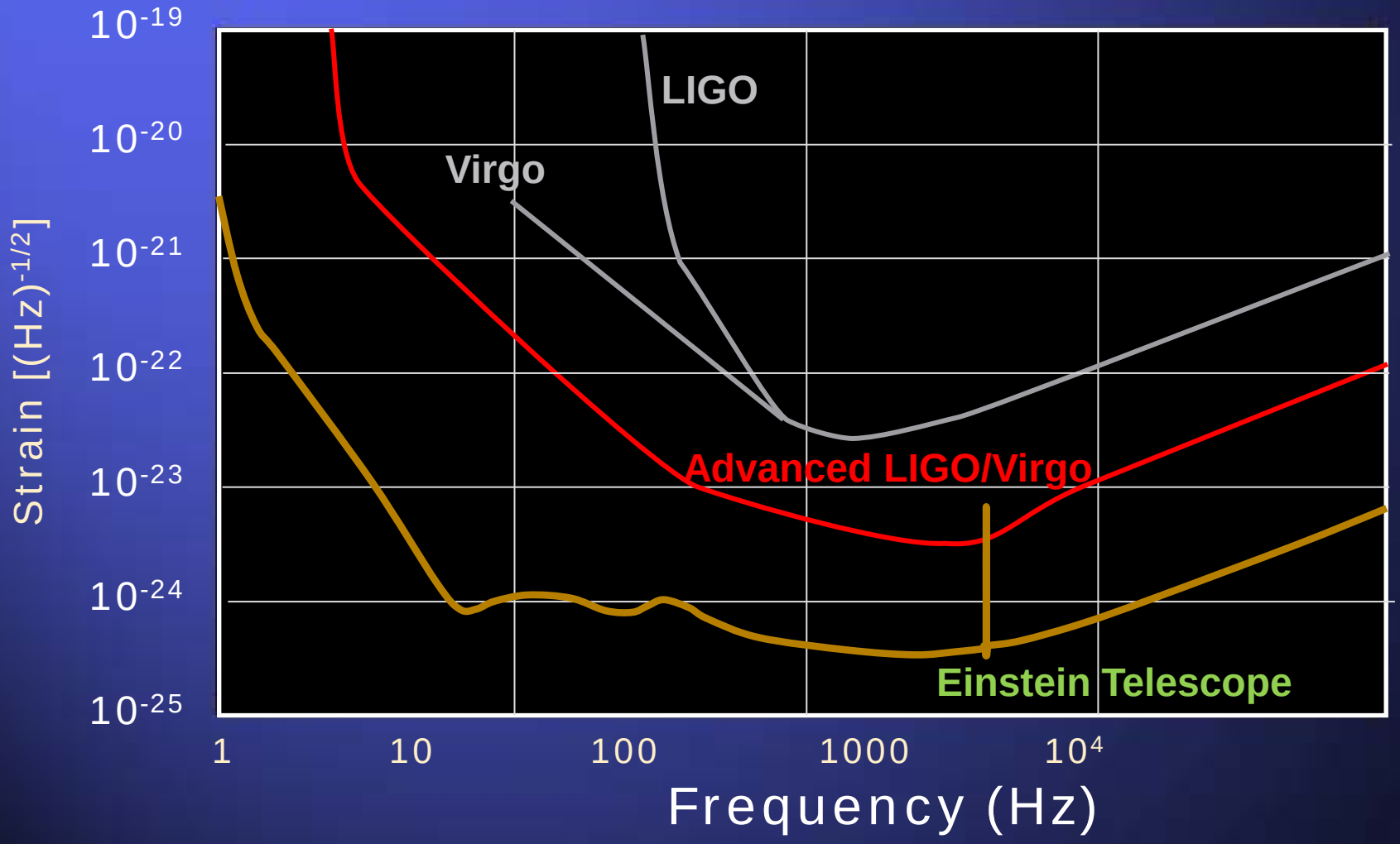
STATUS OF THE ET-PROJECT

Harald Lück

THE 3RD GENERATION ≡ ET
= GRAVITATIONAL WAVE ASTRONOMY



ET EINSTEIN TELESCOPE

Start of the project

- Preparations towards a European Design study already started years ago within the ILIAS project where we had a networking group on future gravitational wave detectors.
- Name finding was a difficult procedure ☺
- Submitted proposal on April 30th 2007. Start was foreseen for Jan. 2008
- Start of DS remained unclear for a long time and was postponed to May 2008.
- In Sept. 2008 funding finally became available (start backdated to May)

1st annual ET Meeting, Cascina, Nov 2008

2nd annual ET Meeting
Erice, Oct. 2009

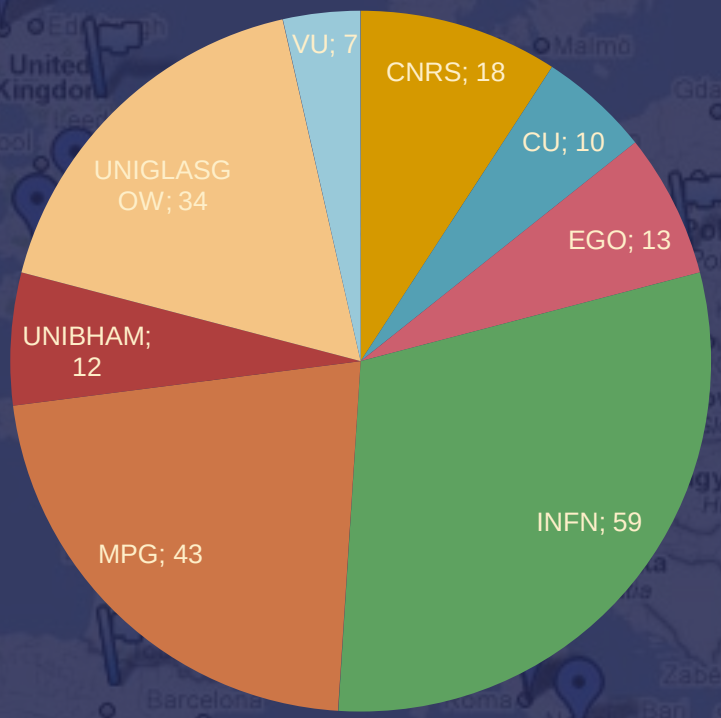
3rd annual ET Meeting
Budapest, Nov. 2010

Let‘s again take a picture of the whole team
In the coffee break @ 16:00
? here in this auditorium?

The ET Community

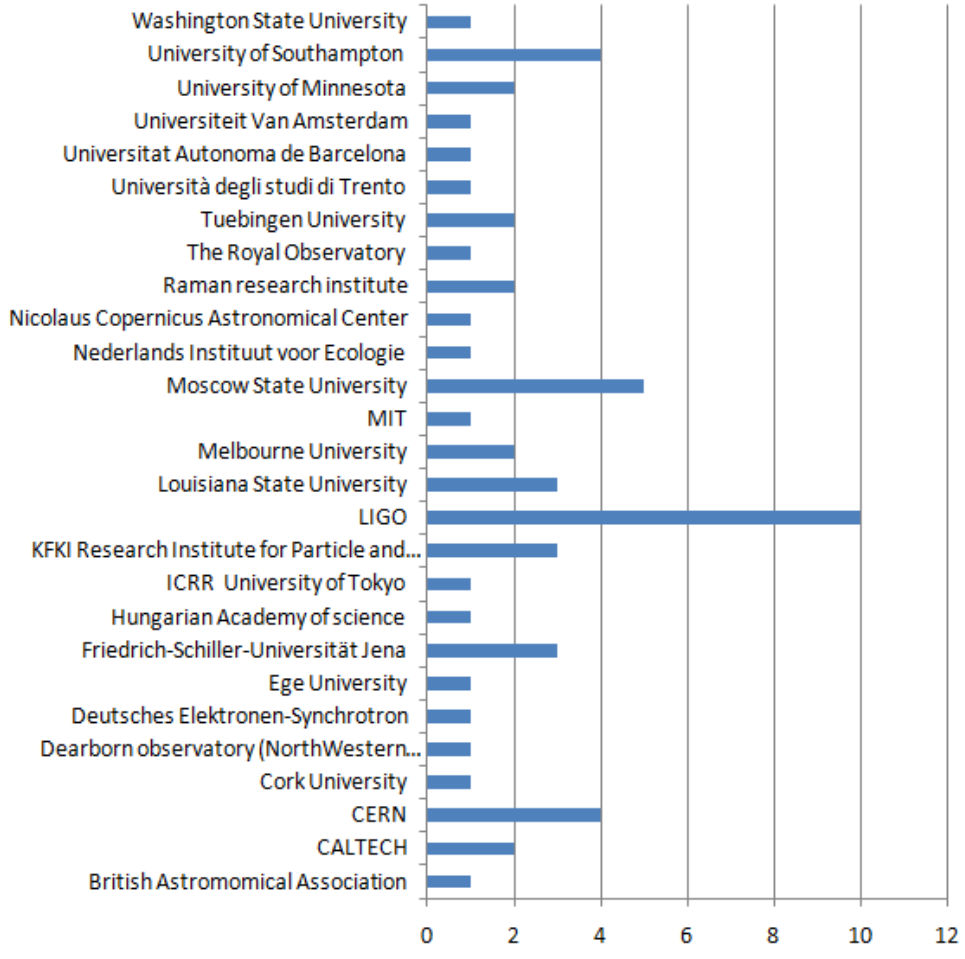
ET EINSTEIN TELESCOPE

Participants per Beneficiary



Science team total: 249

Participants per NON-Beneficiary



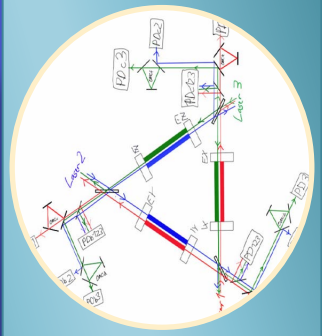
ET: Working groups

Site and infrastructure

J. v.d. Brand

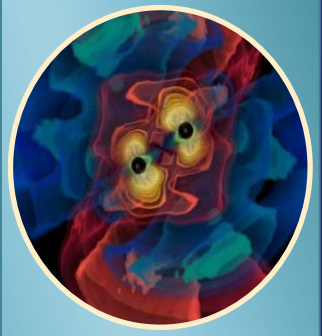
Thermal noise of mirrors and suspensions / cryogenics

F. Ricci



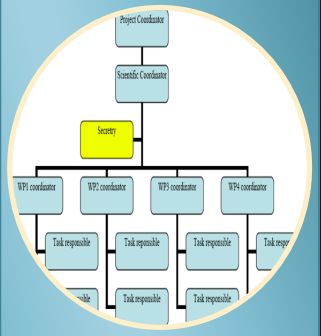
Optical configuration

A. Freise



Astrophysics issues

B. S. Sathyaprakash



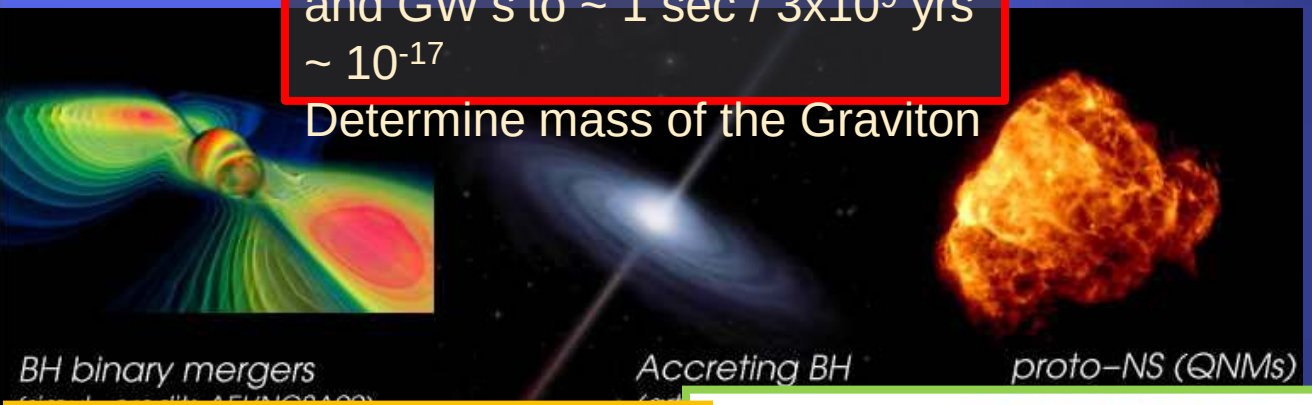
Management

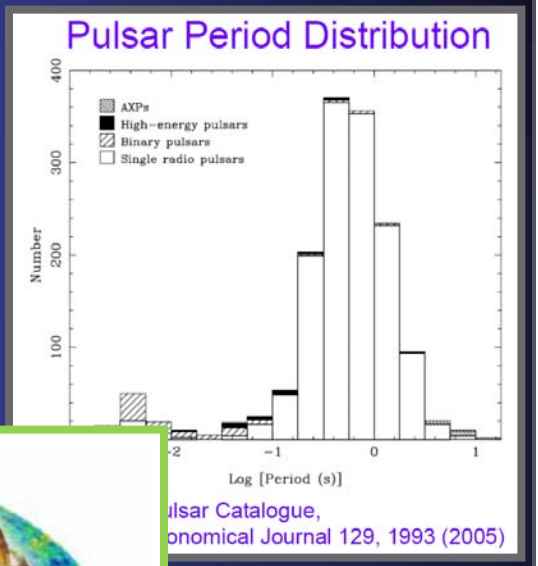
J. Colas
M. Punturo
H. Lück

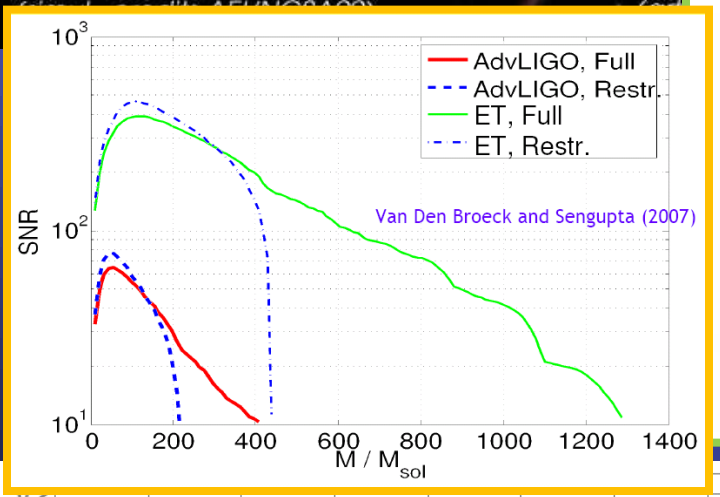
WG4: Astrophysics Issues

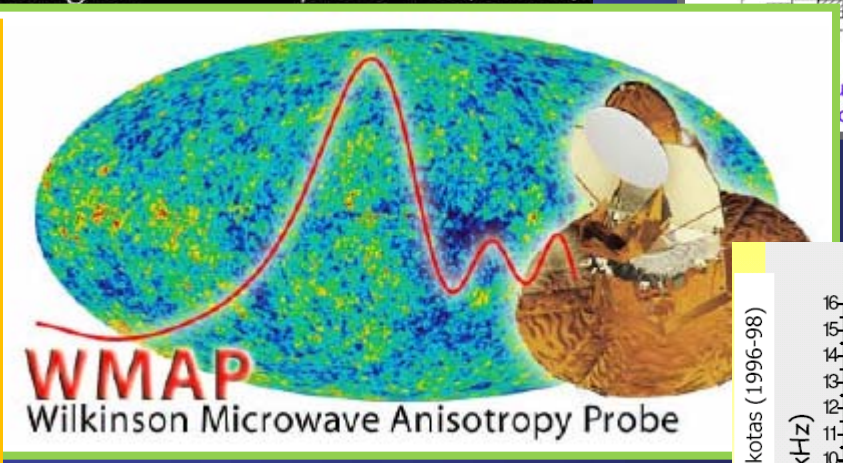
Deduce relative speed of light and GW's to ~ 1 sec / 3×10^9 yrs ~ 10^{-17}

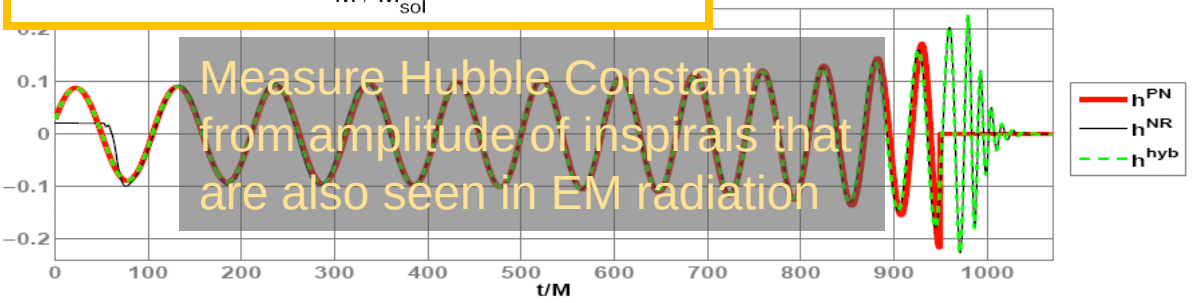
Determine mass of the Graviton



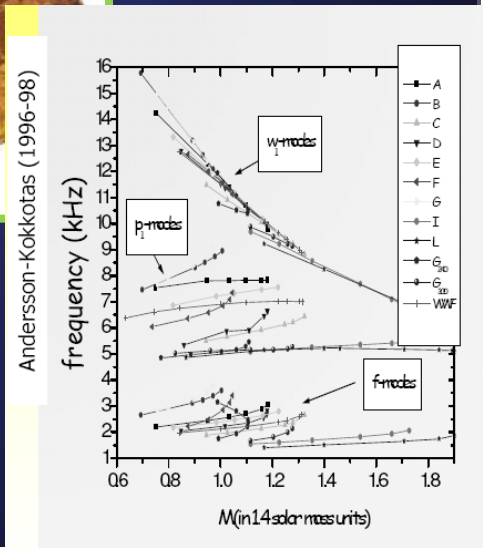




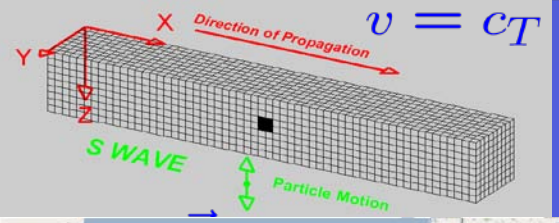


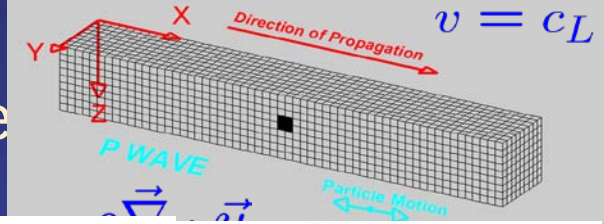


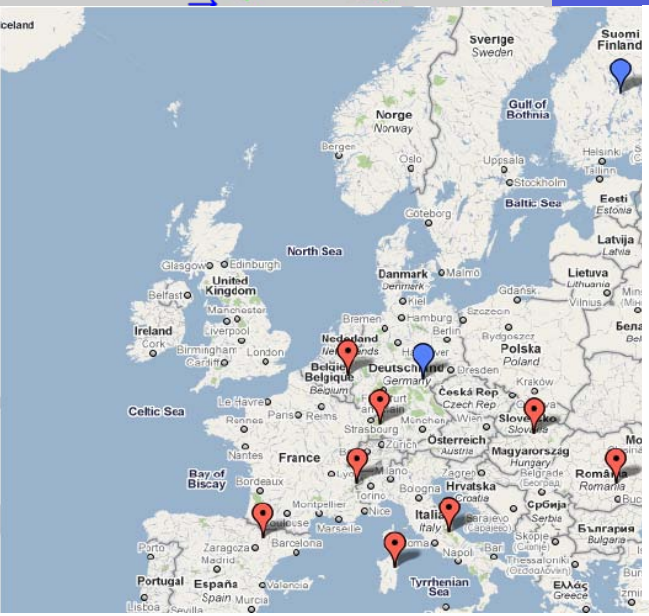
Measure Hubble Constant from amplitude of inspirals that are also seen in EM radiation

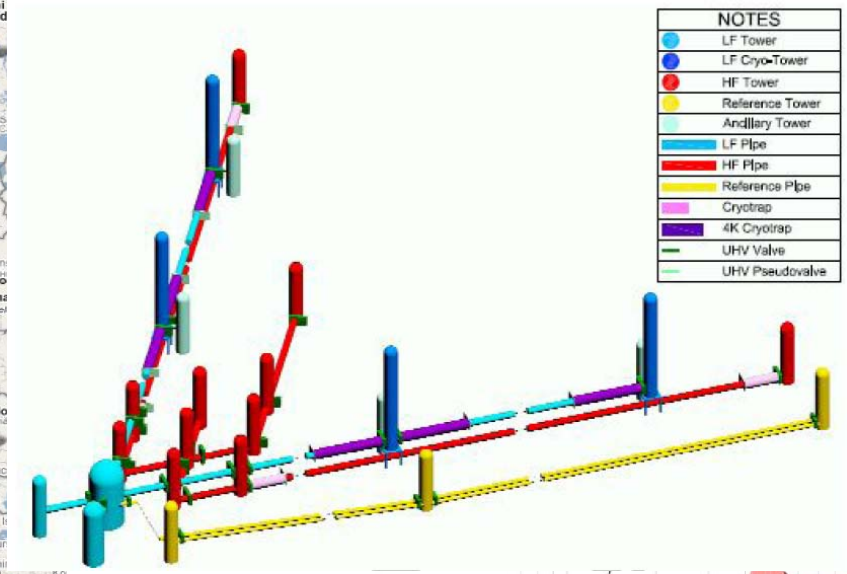


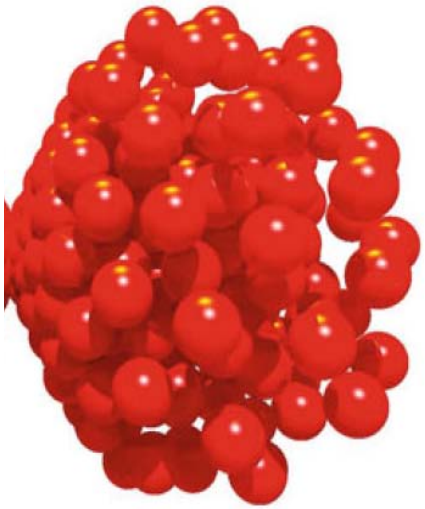
WG1: Site & Infrastructure

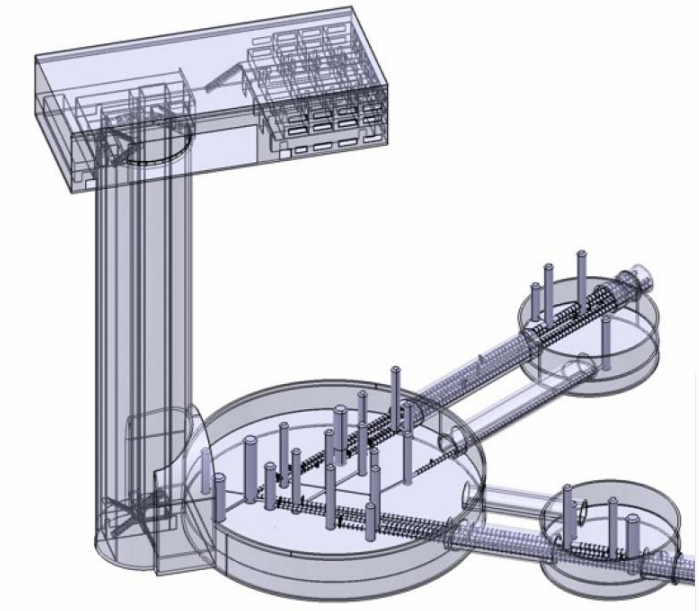


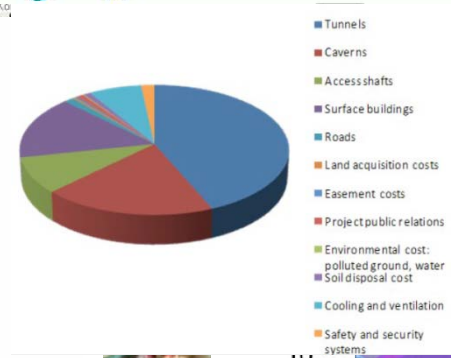


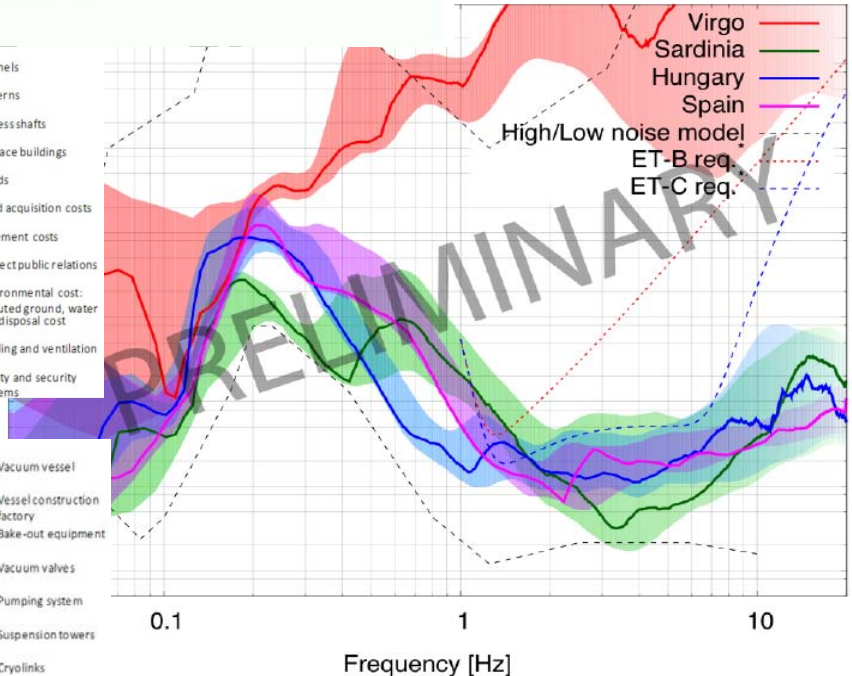




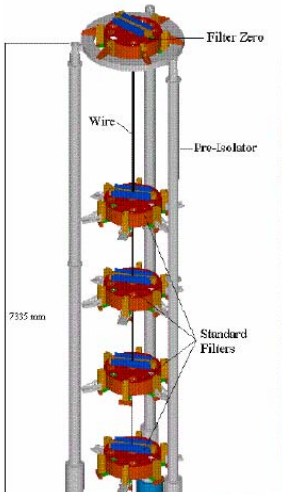


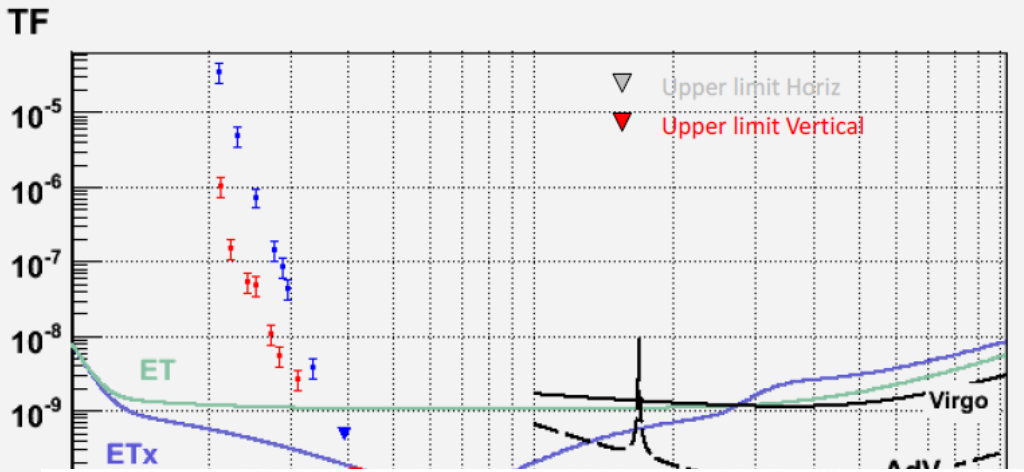


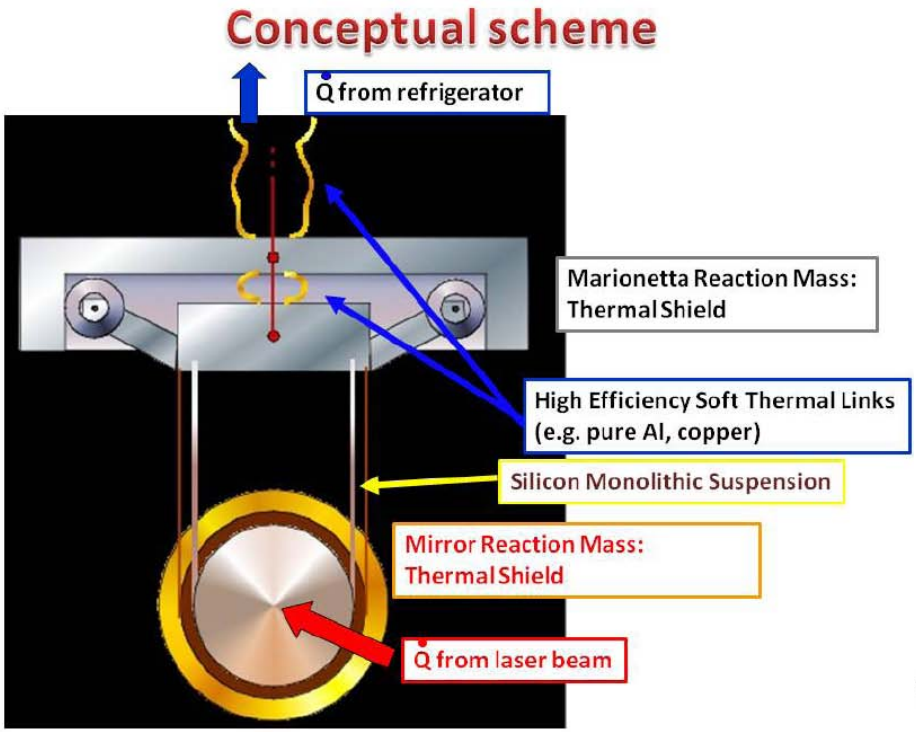


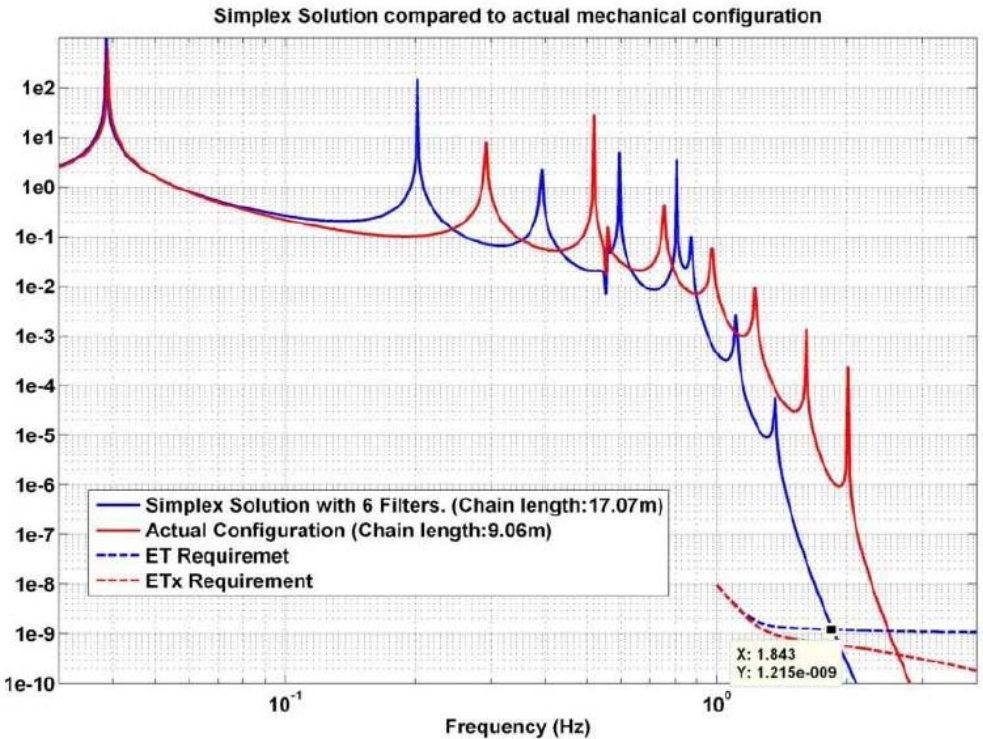


WG2: Thermal Noise, Suspension, Cryogenics

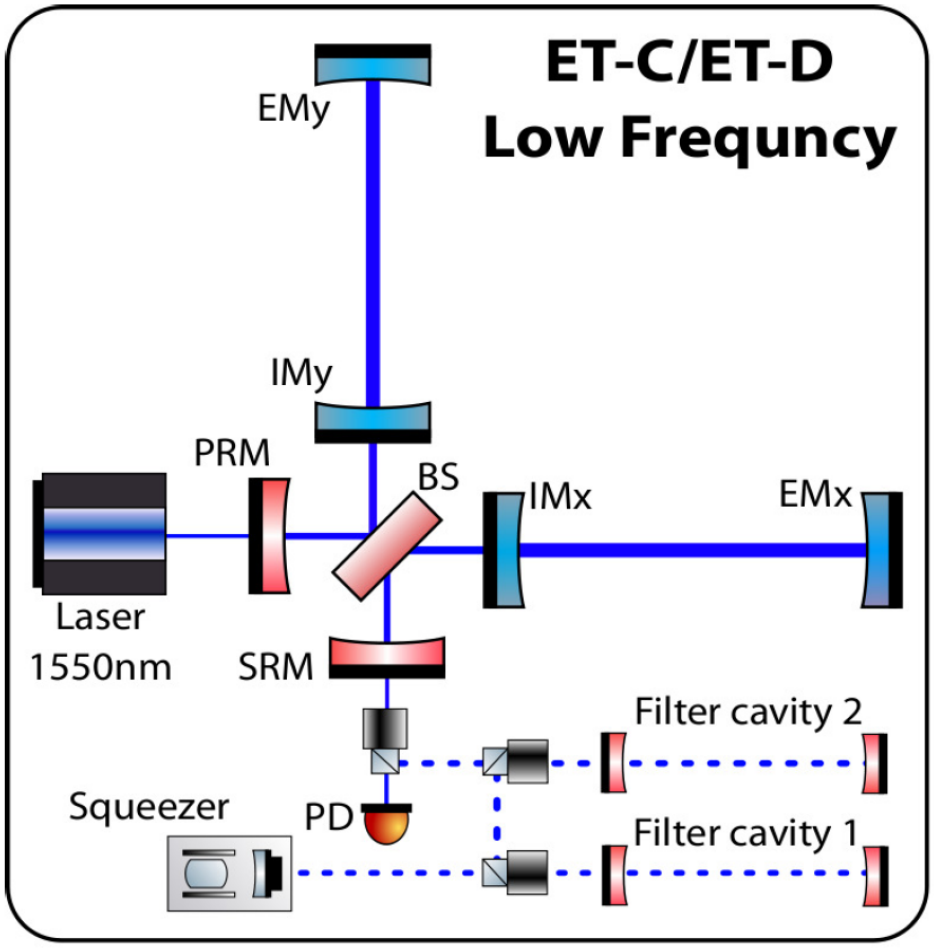


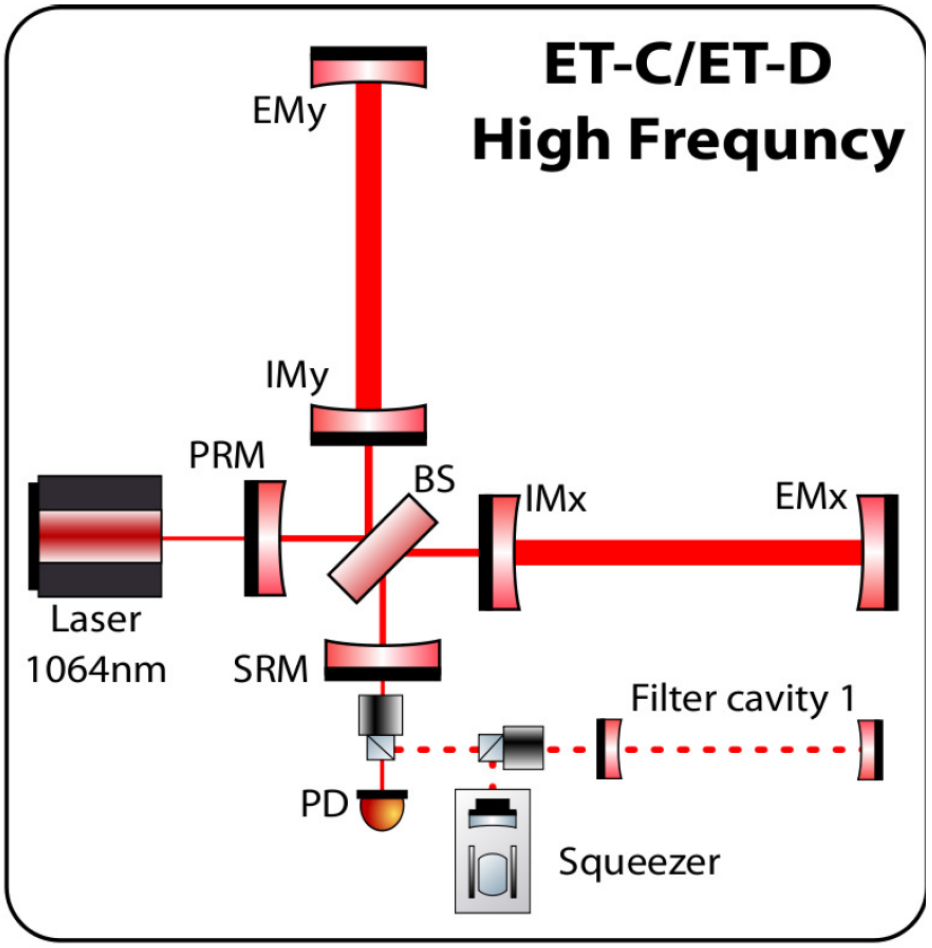


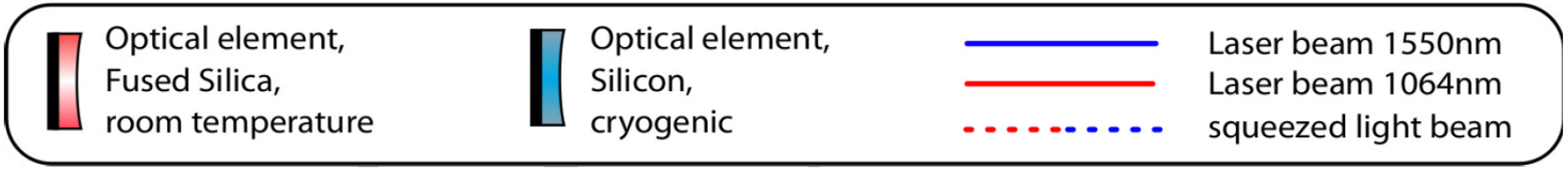




WG3: Optical Configuration







Material selection

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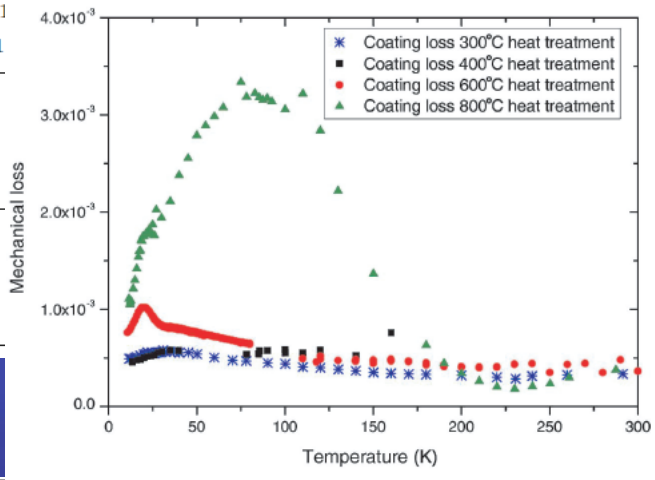
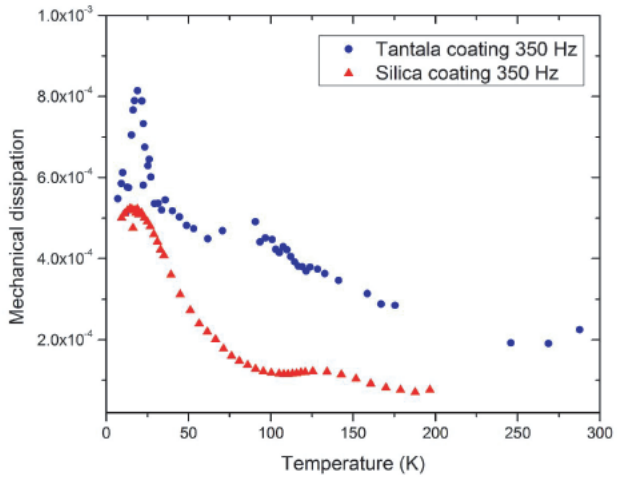
Parameter	T (K)	Fused Silica Value	Ref.	Sapphire Value	Ref.	Silicon Value	Ref.
heat capacity	10 K	6.3 J/kgK	[134]	0.085 J/kgK	[134]	0.276 J/kgK	[134]
	20 K	25.2 J/kgK	[134]	0.72 J/kgK	[134]	3.41 J/kgK	[134]
	30 K	54.6 J/kgK	[134]	2.6 J/kgK	[134]	18.55 J/kgK	[134]
	300 K	738 J/kgK	[134]	781 J/kgK	[134]	713 J/kgK	[134]
thermal conductivity	10 K	0.098 W/mK	[134]	68 W/mK	[134]	2110 W/mK	[134]
	20 K	0.13 W/mK	[134]	575 W/mK	[134]	4940 W/mK	[134]
	30 K	0.18 W/mK	[134]	1478 W/mK	[134]	4810 W/mK	[134]
	300 K	1.5 W/mK	[134]	284 W/mK	[134]	148 W/mK	[134]
thermal expansion coefficient	10 K	-2.2×10^{-7} K^{-1}	[134]	1.0×10^{-9} K^{-1}	[134]	8.8×10^{-10} K^{-1}	[134]
	20 K	-5.8×10^{-7} K^{-1}	[134]	4.0×10^{-9} K^{-1}	[134]	-2.5×10^{-9} K^{-1}	[134]
	30 K	-8.0×10^{-7} K^{-1}					
	300 K	5.0×10^{-10} K^{-1}					
mechanical loss	10 K						
	20 K						
	30 K						
	300 K						
dn/dT	10 K						
	20 K						
	30 K						
	300 K						



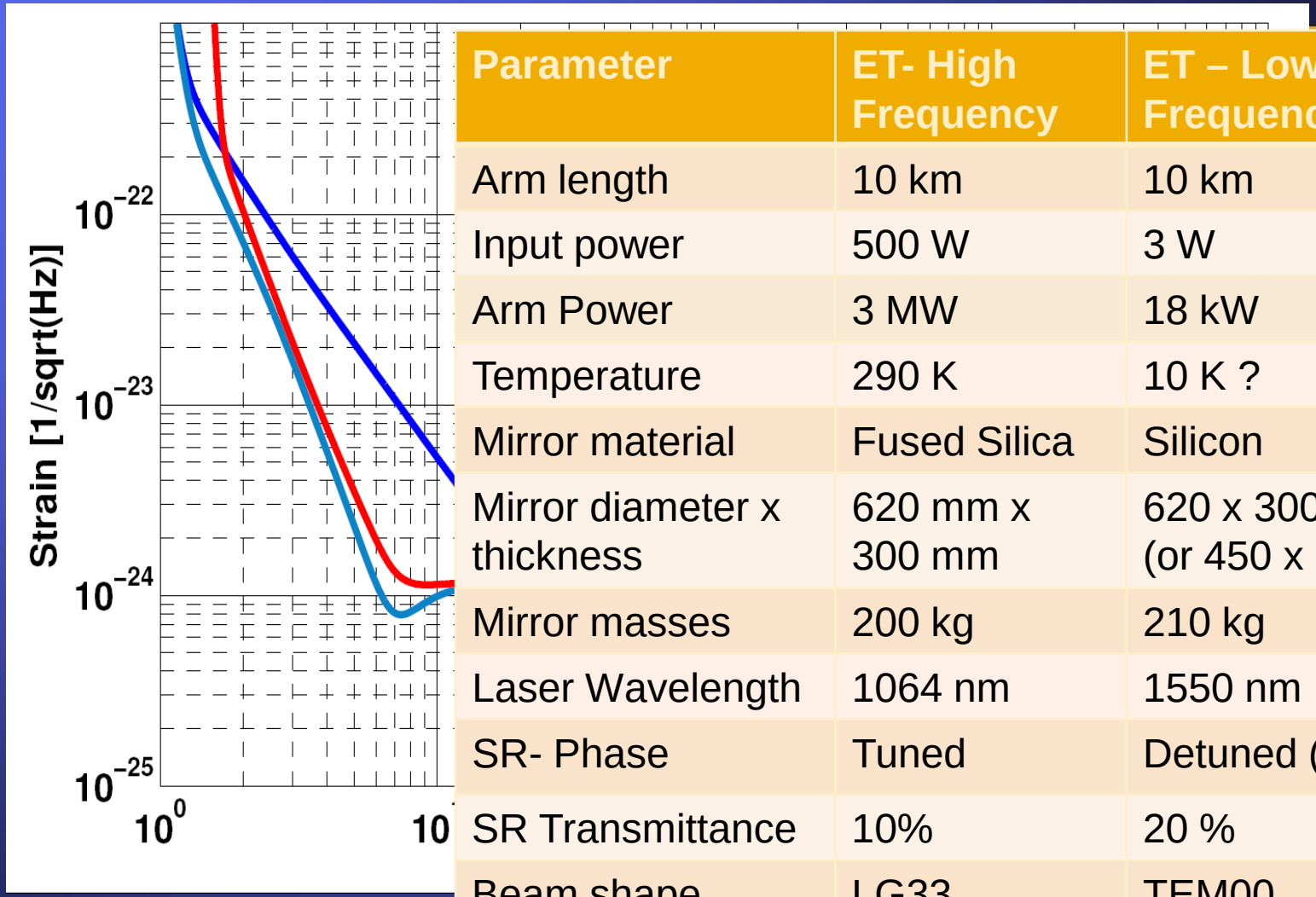


@ 300K	SiO_2	Al_2O_3	$Ti:Ta_2O_5$	Ta_2O_5	TiO_2	Nb_2O_5
Loss angle	0.5×10^{-4}	2.4×10^{-4}	2×10^{-4}	3.8×10^{-4}	6.3×10^{-3}	6.7×10^{-4}
Density (kgm^{-3})	2200	3700	6425	6850	4230	4590
Thermal conductivity ($Wm^{-1}K^{-1}$)	0.5	3.3	0.6	0.6	0.45	1
Specific heat ($JK^{-1}kg^{-1}$)	746	310	269	306	130	590
Thermal expansion coefficient (K^{-1})	0.51×10^{-6}	8.4×10^{-6}	3.6×10^{-6}	3.6×10^{-6}	5×10^{-5}	5.8×10^{-6}
Thermo-optic coefficient (K^{-1})	8×10^{-6}	1.3×10^{-5}	14×10^{-6}	2.3×10^{-6}	-1.8×10^{-4}	1.43×10^{-5}
Young modulus (GPa)	60	210	140	140	290	60
Poisson's ratio	0.17	0.22	0.23	0.23	0.28	0.2
Refractive index	1.45	1.63	2.06	2.03	2.3	2.21

Result: Baseline Conceptual Design

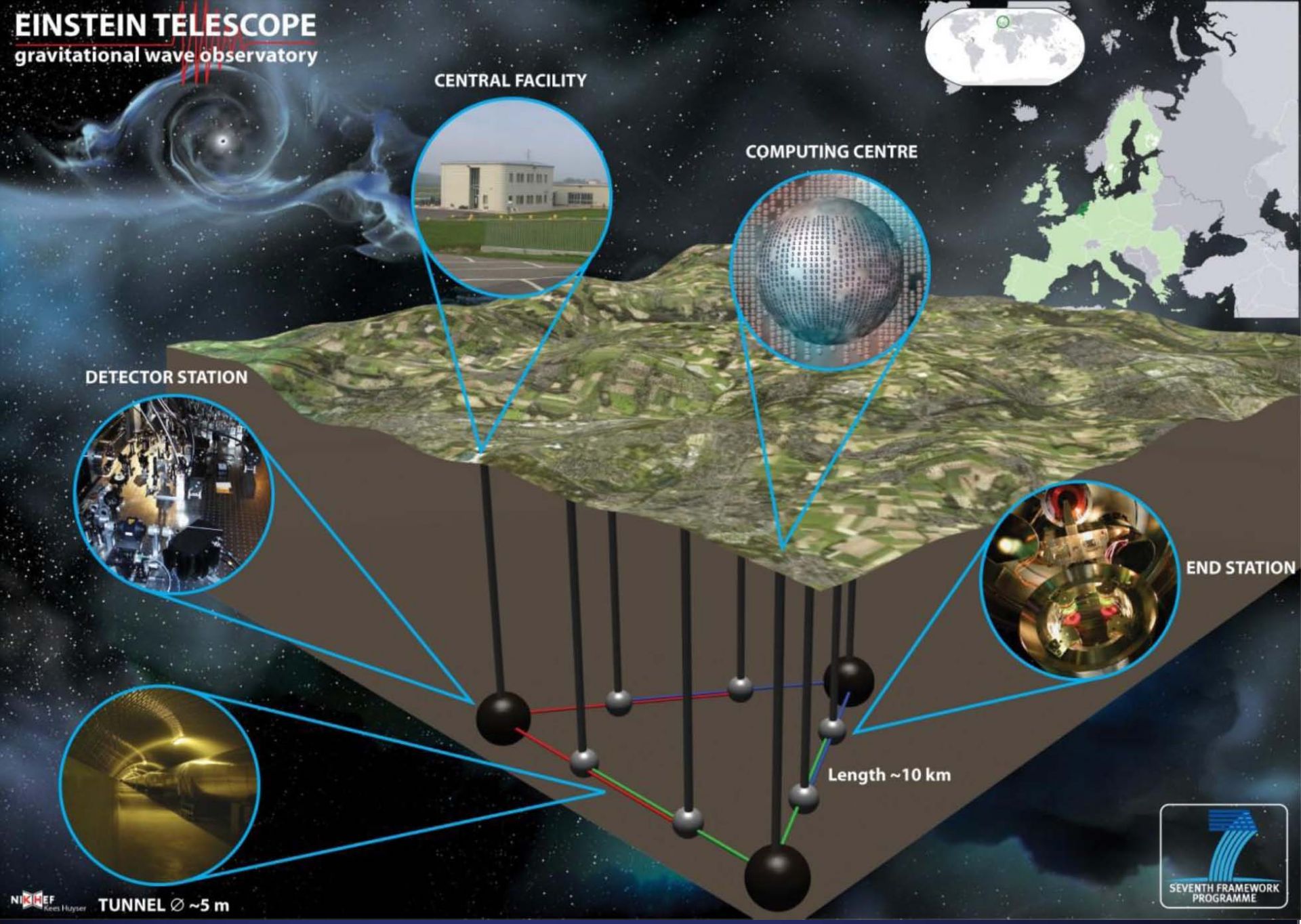
- Single Site Geometry (mostly political reasons)
- Underground 100 – 200 m
- 30km overall tunnel length
- Triangular Topology, tunnels doubly used
- Dual Recycled FP Michelson
- 10 dB Squeezing + Filter Cavities
- Xylophone configuration: cryo low power, room temp. high power

Xylophone: hot & cool



Parameter	ET- High Frequency	ET – Low Frequency
Arm length	10 km	10 km
Input power	500 W	3 W
Arm Power	3 MW	18 kW
Temperature	290 K	10 K ?
Mirror material	Fused Silica	Silicon
Mirror diameter x thickness	620 mm x 300 mm	620 x 300mm (or 450 x 600mm)
Mirror masses	200 kg	210 kg
Laser Wavelength	1064 nm	1550 nm
SR- Phase	Tuned	Detuned (0.6 rad)
SR Transmittance	10%	20 %
Beam shape	LG33	TEM00
Beam Radius	72 mm	90 mm
Suspension	SA 8m?	SA 17 m

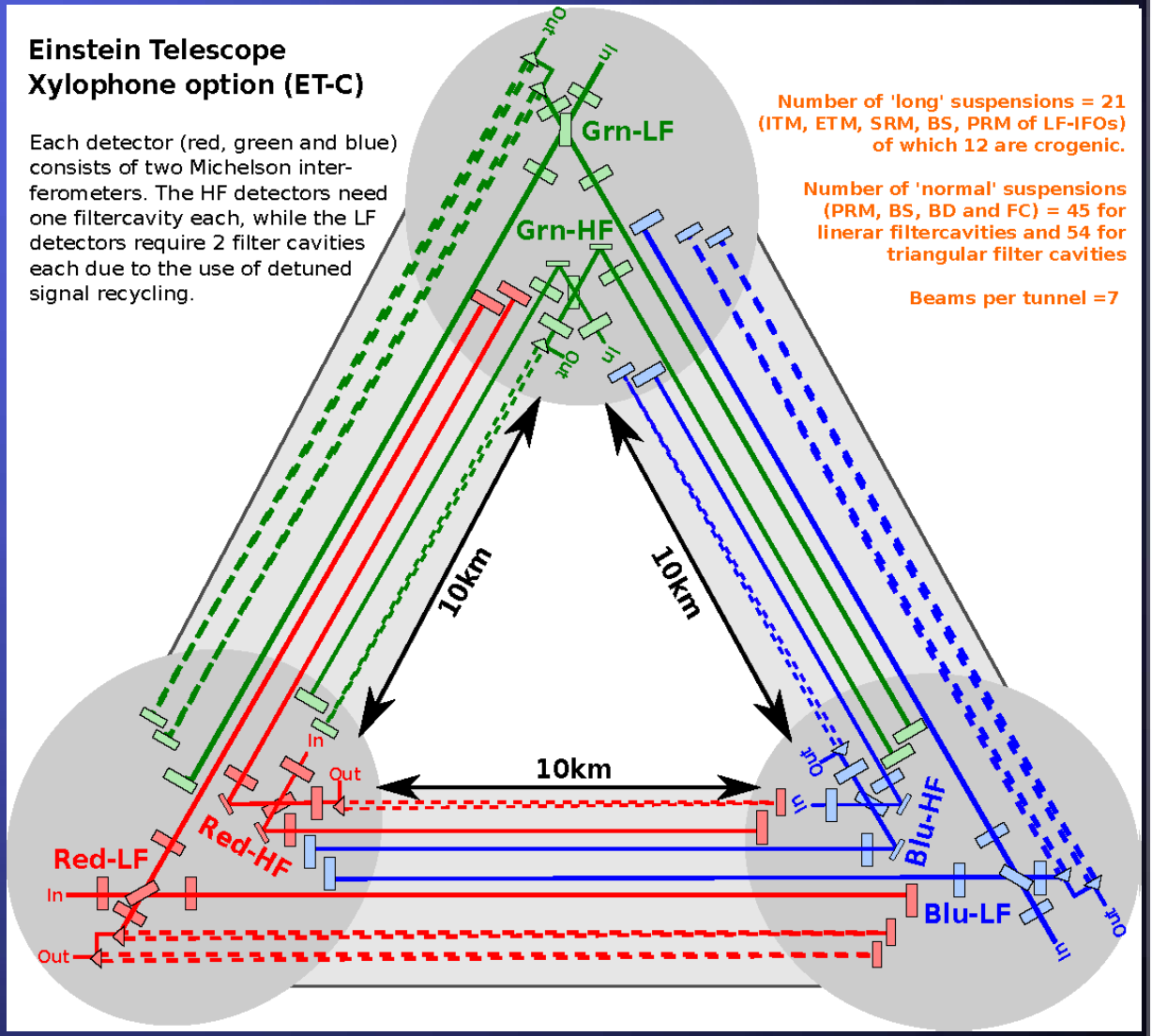
ET EINSTEIN TELESCOPE

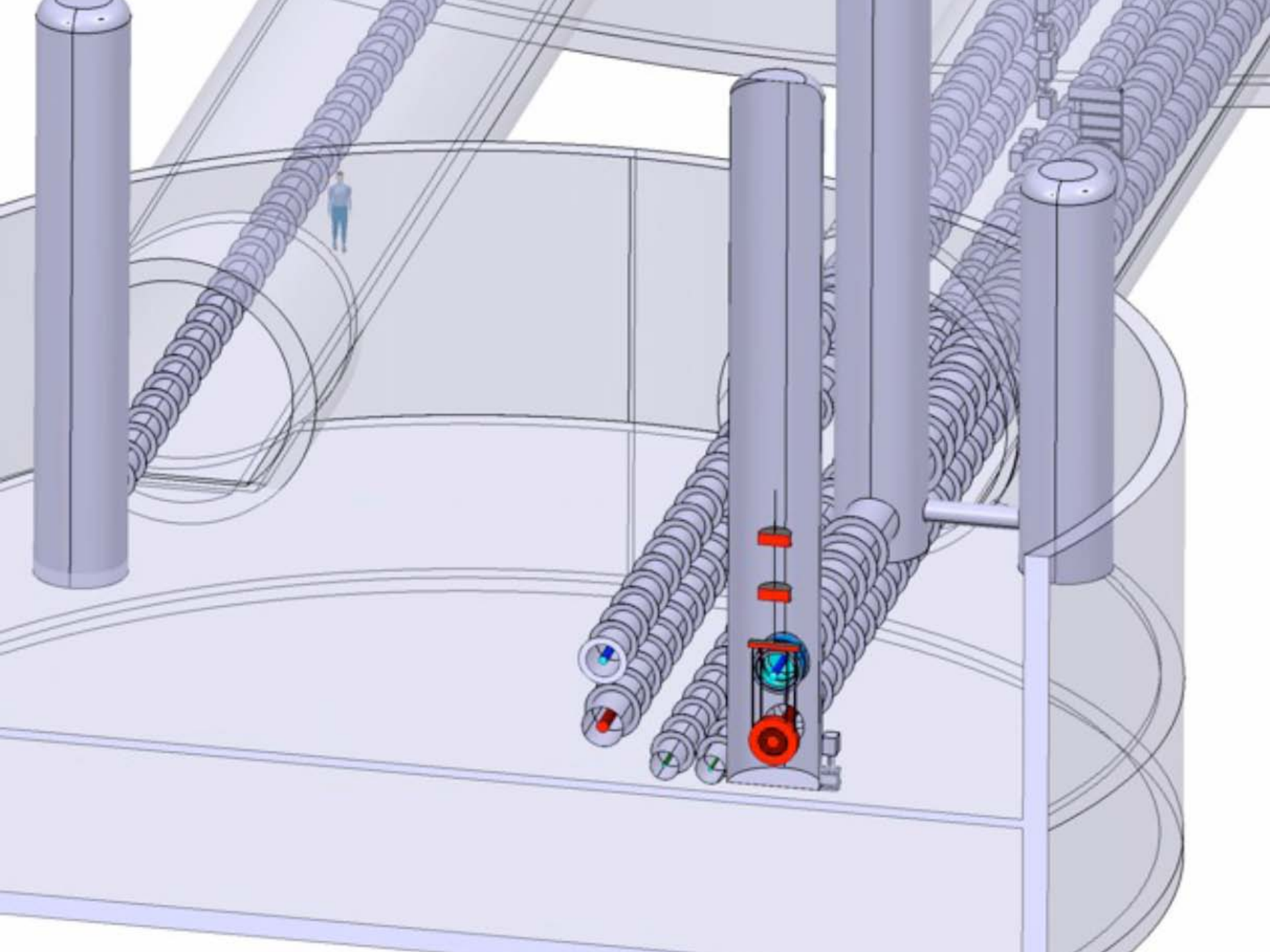

EINSTEIN TELESCOPE
gravitational wave observatory
CENTRAL FACILITY
COMPUTING CENTRE
DETECTOR STATION
END STATION
Length ~10 km
TUNNEL ∅ ~5 m
NIKHEF Kees Huyser
SEVENTH FRAMEWORK PROGRAMME

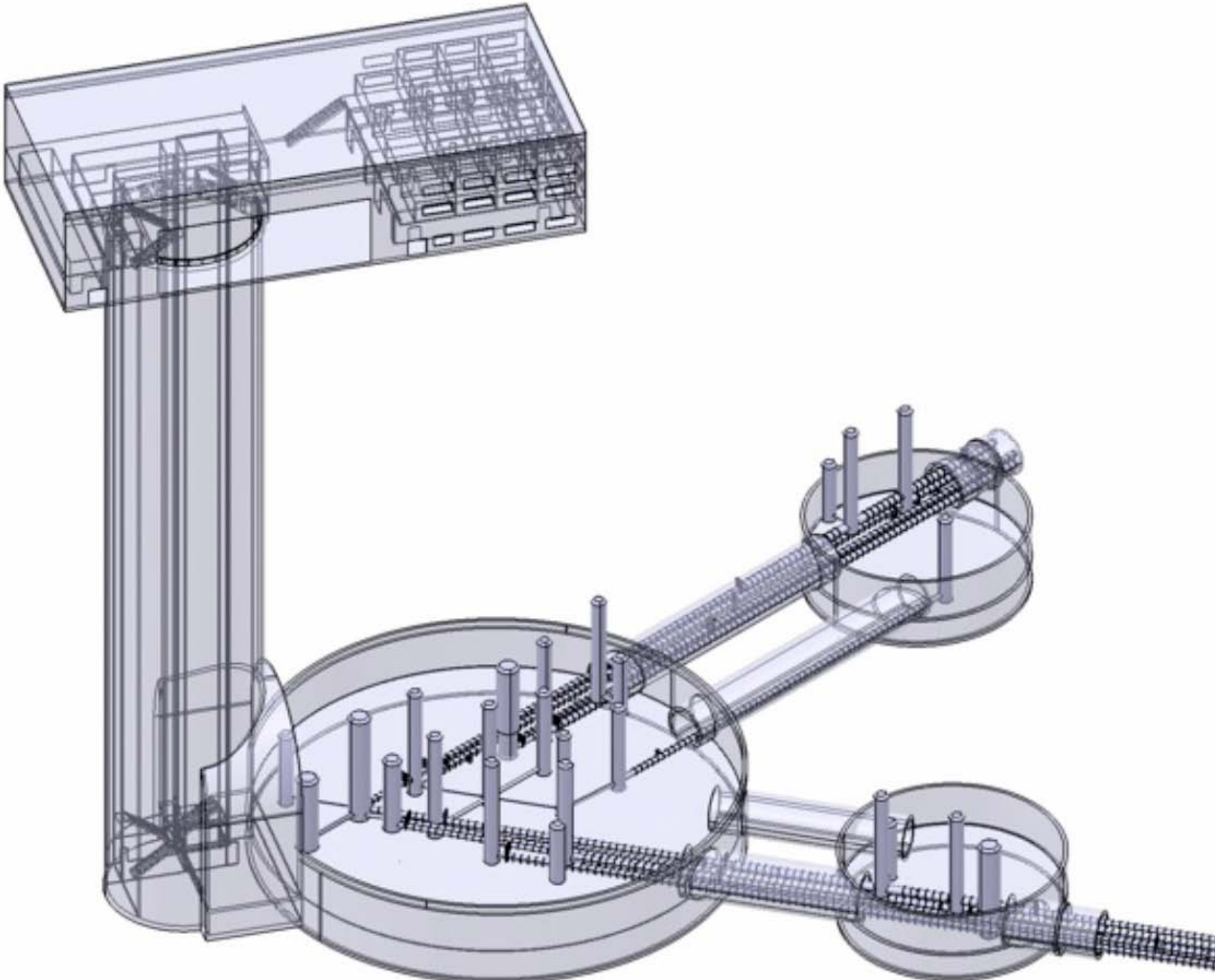
The infrastructure

Schematic view

- Full infrastructure realized
- Initial detector(s) implementation
  - 1 detector (2 ITF)
  - Physics already possible in coincidence with the improved advanced detectors
- Progressive implementation
  - 2 detector (4 ITF)
  - Redundancy and cross-correlation
- Full implementation
  - 3 detector (6 ITF)
  - Virtual interferometry
  - 2 polarizations reconstruction







The *Transversal Writing Team* -

- - consists of researchers of each working group and participant
- - is writing the Design Study document
- - has got weekly telecon meetings
- - has produced a very nice draft of the design study document; now containing 232 pages and still rapidly growing
- - is discussing ‚transversal' issues, e.g. compatibility of vacuum- and optical system.

The *Transversal Writing Team* -

Harald Lück, Michele Punturo, ET-EB, Stefano Braccini, Carlo Bradaschia, Chris Van Den Broeck, David Rabeling, Franco Frasconi, Paola Puppo, Roberto Passaquieti, Ronny Nawrodt, Sheila Rowan, Stefan Hild, Tania Regimbau, Thomas Dent, Andre Thüring, Badri Krishnan, Daniel Friedrich, Giancarlo Cella, Helge Müller Ebhardt, Janyce Franc, Keiko Kokeyama, Matteo Lorenzini, Peter Wessels, Sofiane Aoudia, Stuart Reid

The Design Study Document

European Commission
FP7, Grant Agreement 211743

Einstein gravitational wave Telescope conceptual design study

ET-0106A-10

S Aoudia[1], P Amaro-Seoane[10], S Braccini[2], C Bradaschia[2,5], J van den Brand[3], C Van Den Broeck[4], G Cella[2], J Colas[5], K Danzmann[1], T Dent[6], V Fafone[8], R Flaminio[7], J Franc[7], F Frasconi[2], A Freise[9], D Friedrich[1], E Genin[5], C Gräf[1], S Hild[13], K Kokeyama[9], B Krishnan[10], M Lorenzini[11], H Lück[1], B Mours[12], H Müller-Ebhardt[1], R Nawrodt[13], G Parguezt[5], A Pasqualetti[5], M Punturo[14,5], P Puppo[15a], D Rabeling[3], T Regimbau[16], S Reid[17],

F Ricci[15ab], S Rowan[17], L Santamaría[18] B Sathyaprakash[6], S Tarabrin[1], A Thüring[1], P Weßels[19]
on behalf of the ET science team

Issue: 1

Date: November 22, 2010