GA #211743

Michele Punturo on behalf of the ET team

ET: Einstein Telescope Design Study

A short introduction to the project

What is the ET Project

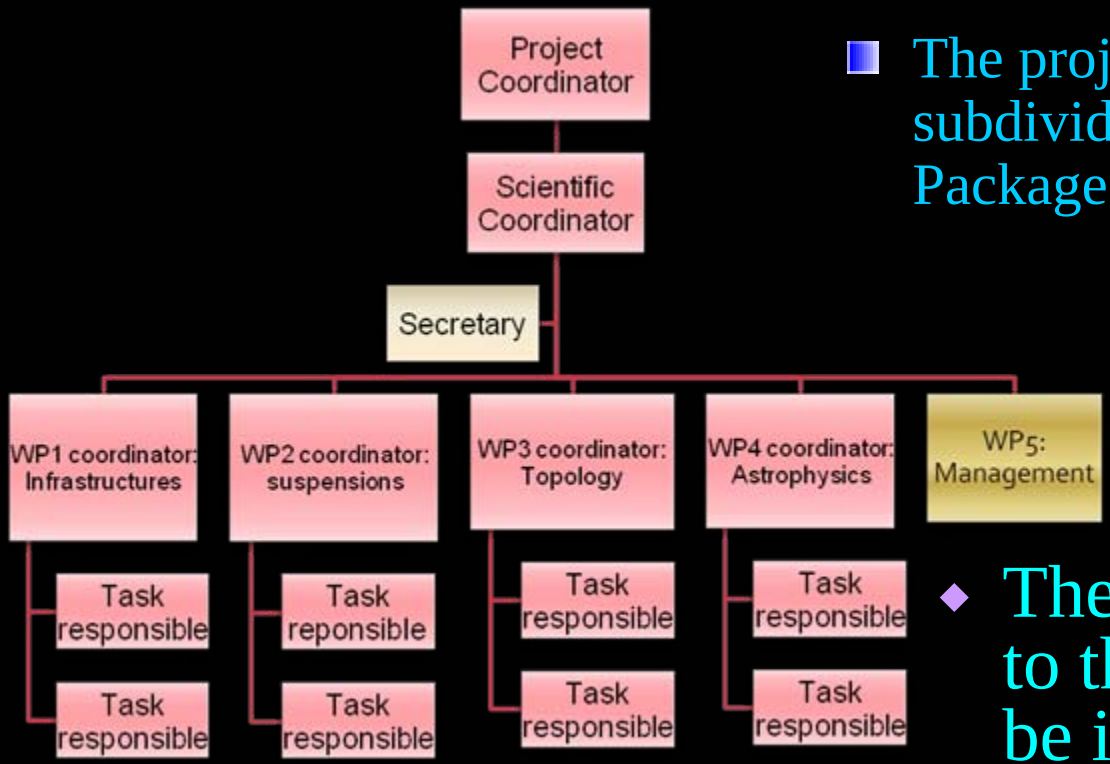
- ET is a conceptual design study supported, for about 3 years (2008-2011), by the European Commission under the Framework Programme 7 (PF7)
  - EU financial support ~ 3M€
  - Aim of the project is the delivery of a conceptual design of a 3rd generation GW observatory
    - Sensitivity of the apparatus~10 better than advanced detectors

Participants

- The proposal has been presented by the major groups working in GEO600 and Virgo
- Project coordinator:
  - EGO

EGO	
INFN	
MPG	
CNRS	
Birmingham Univ.	
Glasgow Univ.	
NIKHEF	
Cardiff University	

Project Organization



- The project is substantially subdivided in 4 technical Working Packages

- These WPs are related to the main aspects to be investigated drafting a 3rd generation GW detector

ET Working Packages

- WP1: Infrastructures - Coordinator: Jo van den Brand
  - Definition of the site requirements. Keywords:
    - Low seismic activity, reduction of the Newtonian noise
    - Multi-km (~10km) arms possibilities. Costs
- WP2: Suspensions and test masses – (Piero Rapagnani)
  - Keywords:
    - 1 Hz seismic filtering, reduction of the thermal noise through cryogenics and new materials; mechanical and optical properties of new materials for the test masses
- WP3: Topology – (Andreas Freise)
  - Design of the geometry and configuration of the core ITF. Keywords:
    - HP lasers, alternative ITF geometries, quantum noise reduction
- WP4: Astrophysics issues – (B.S. Sathyaprakash)
  - The goal of WP4 is to address ET science and data analysis. Keywords:
    - ET potentialities, Science Case, computational costs

Next Activities

- The WPs are under construction just now:
  - The coordinators are contacting potential collaborators:
    - Please, facilitate their job!
- A collaboration email distribution has been created:
  - science-team-et@ego-gw.it
  - Please, register here:
    - https://mail.virgo.infn.it/mailman/listinfo/science-team-et
  - The Science Team will include also scientists not belonging to the 8 "beneficiaries"
- A WP4 meeting is scheduled for tomorrow
- WPs (virtual) meetings are scheduled from now to November
- 24-26 November: first ET general meeting at EGO/Virgo (in collaboration with ILIAS-GWA)
- More info: http://www.et-gw.eu/

ET Design Study: WP4 - Science Potential and Data Analysis

B.S. Sathyaprakash

CARDIFF UNIVERSITY

Objectives of WP4

- ET Requirements
  - Detection capabilities requirements
  - Data analysis requirements
  - Computational power requirements
- Evaluation of design driven potentialities of ET
  - Astrophysics
  - Cosmology
  - Fundamental Physics

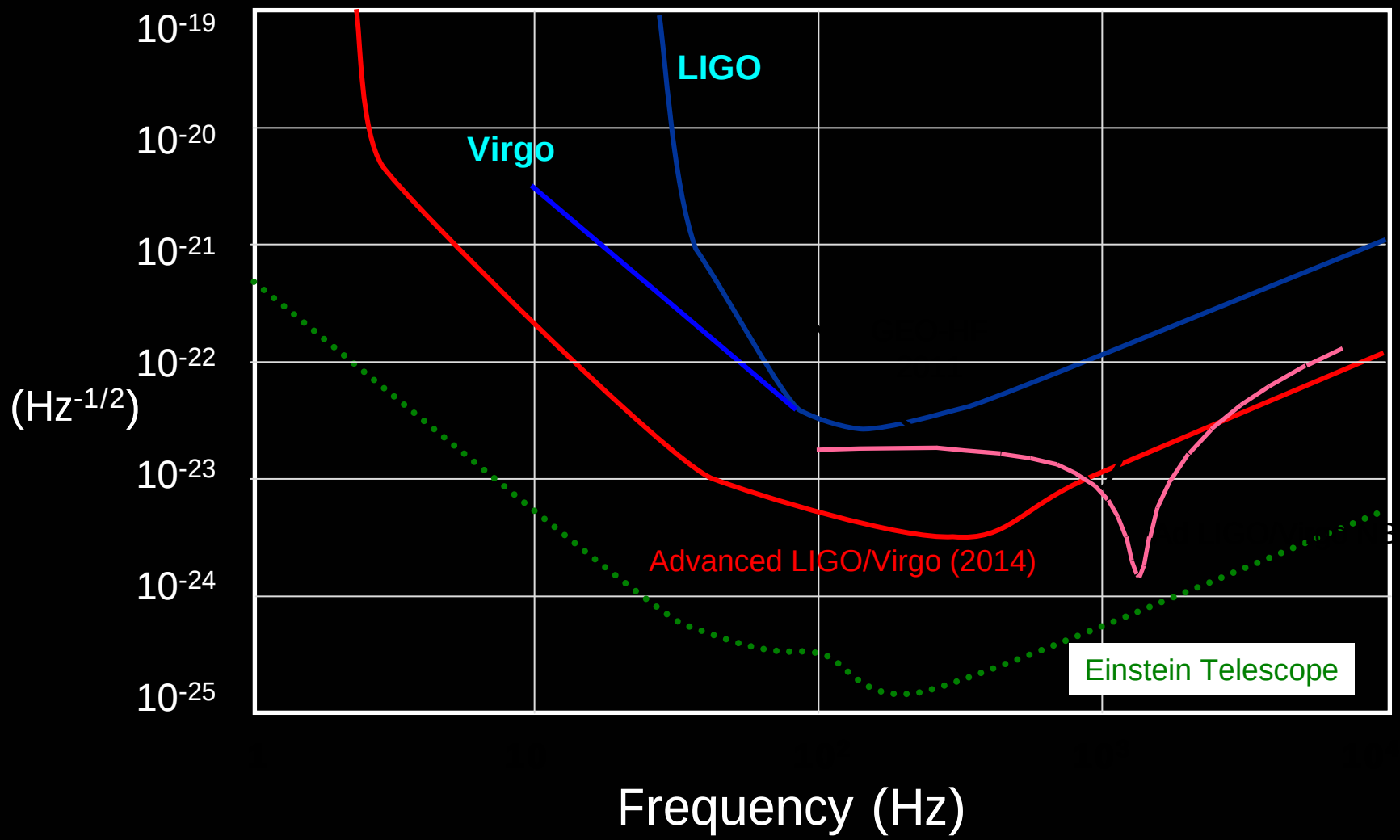
Deliverables

- Vision document
  - Assume a frequency range of operation of 1 Hz – 10 kHz
  - produce a straw man document discussing a minimum and an optimum (ambitious?) science requirement
- Study of the benefit of tuning to different frequencies
  - low frequency (1-10 Hz)
  - medium frequency (10-100 Hz)
  - high frequency (0.1-1 kHz)
  - very high frequency (1-10 kHz)
- Reports
  - Annual report (after 12 months)
  - Annual report (after 24 months)
  - Final Report (after 36 months)
  - Also half-yearly reports to ET Executive Committee and Governing Council

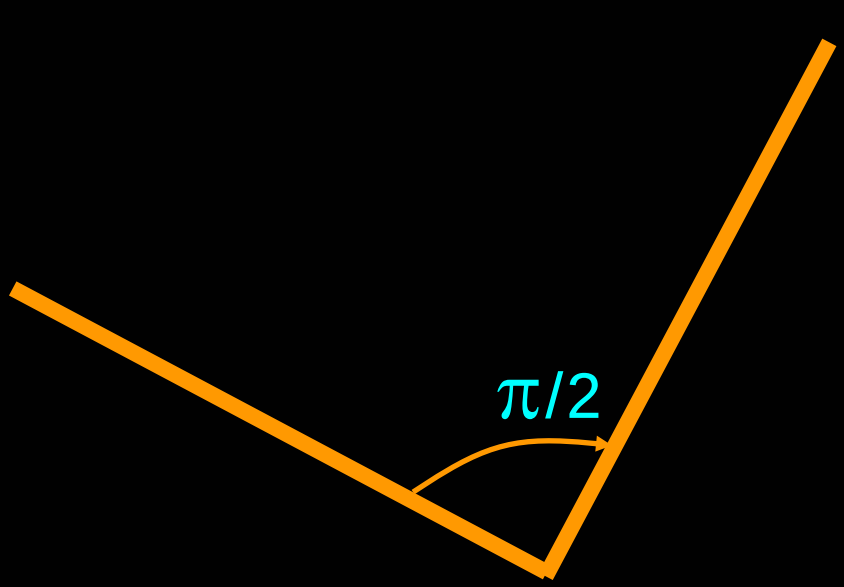
Initial Thoughts on ET Specs

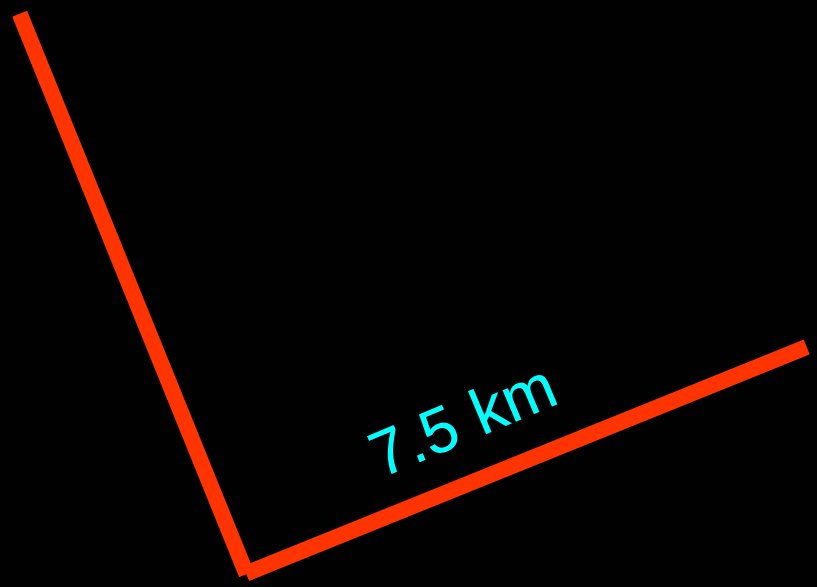
- A total of 30 km beam tube
  - Different topologies to be explored
- Underground
- Cryogenic
- Non-diffractive optics
- Broadband sensitivity in the range 1 Hz to 10 kHz

Sensitivity

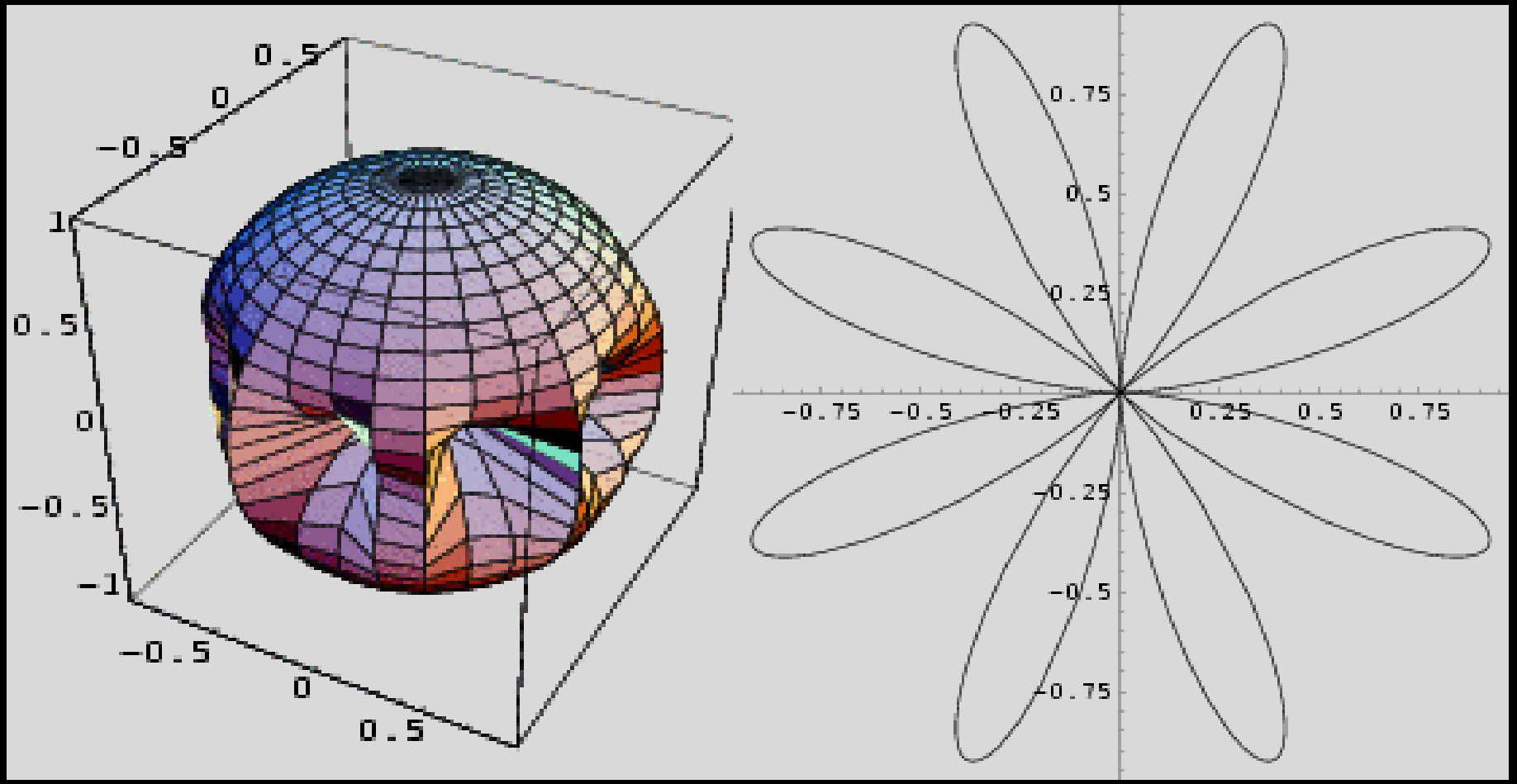


What Topology and What Network? Distributed Detectors

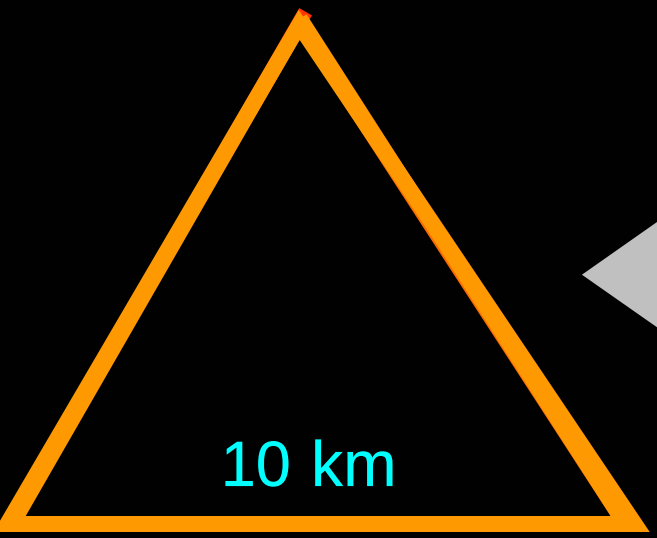




Antenna pattern of 2 L-shaped Detectors



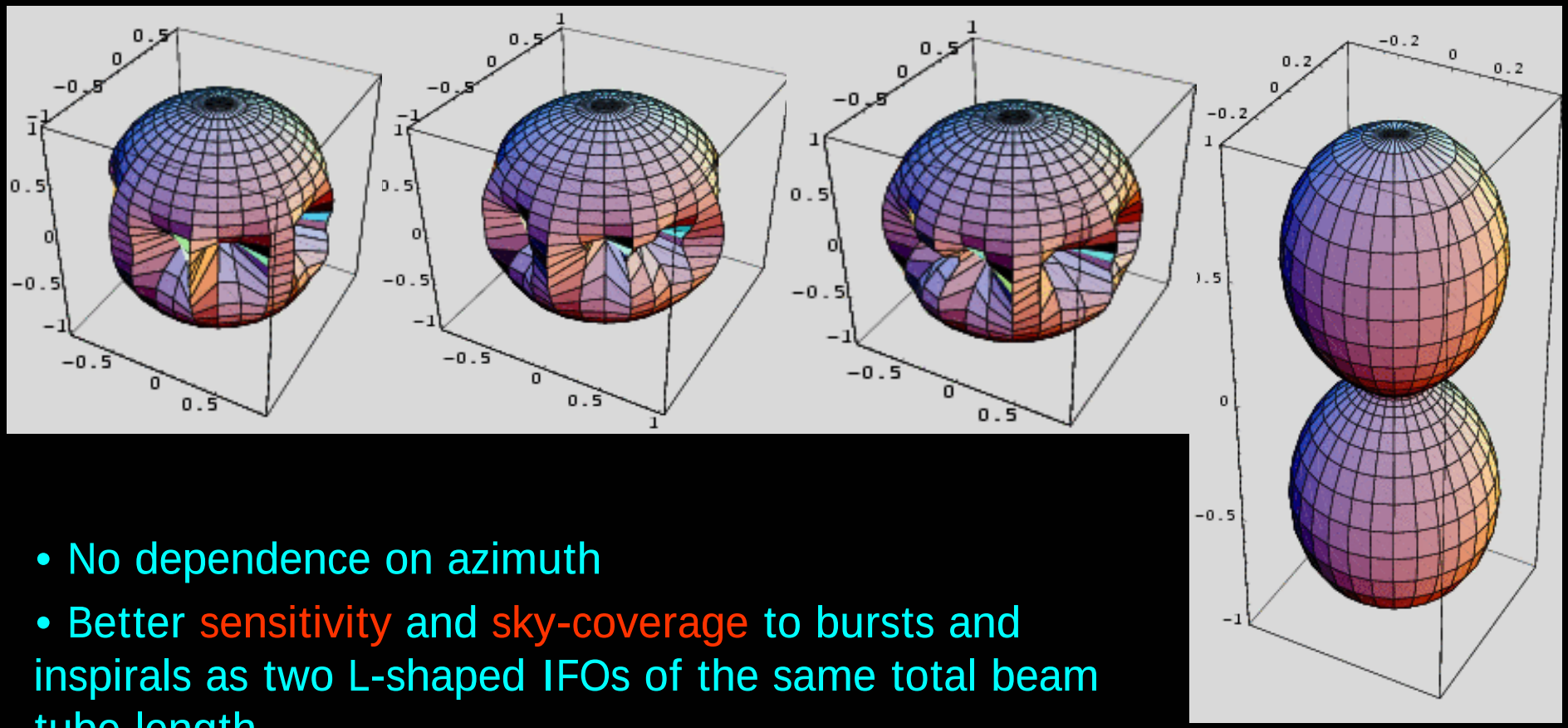
What Topology and What Network? A Triangle



$\pi/3$

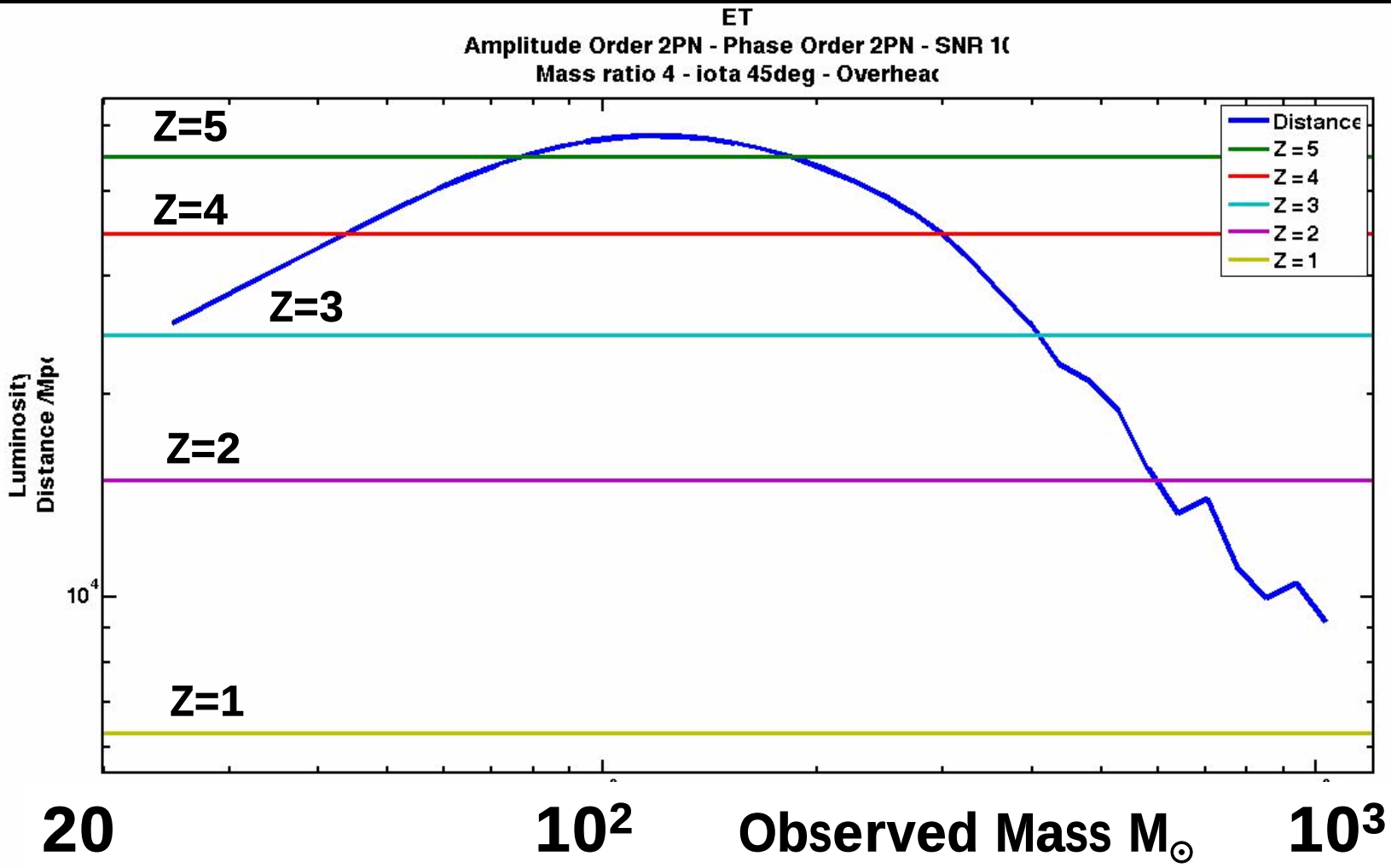
Three independent detectors

Antenna Pattern of a Triangle



- No dependence on azimuth
- Better sensitivity and sky-coverage to bursts and inspirals as two L-shaped IFOs of the same total beam tube length

ET's Distance Reach



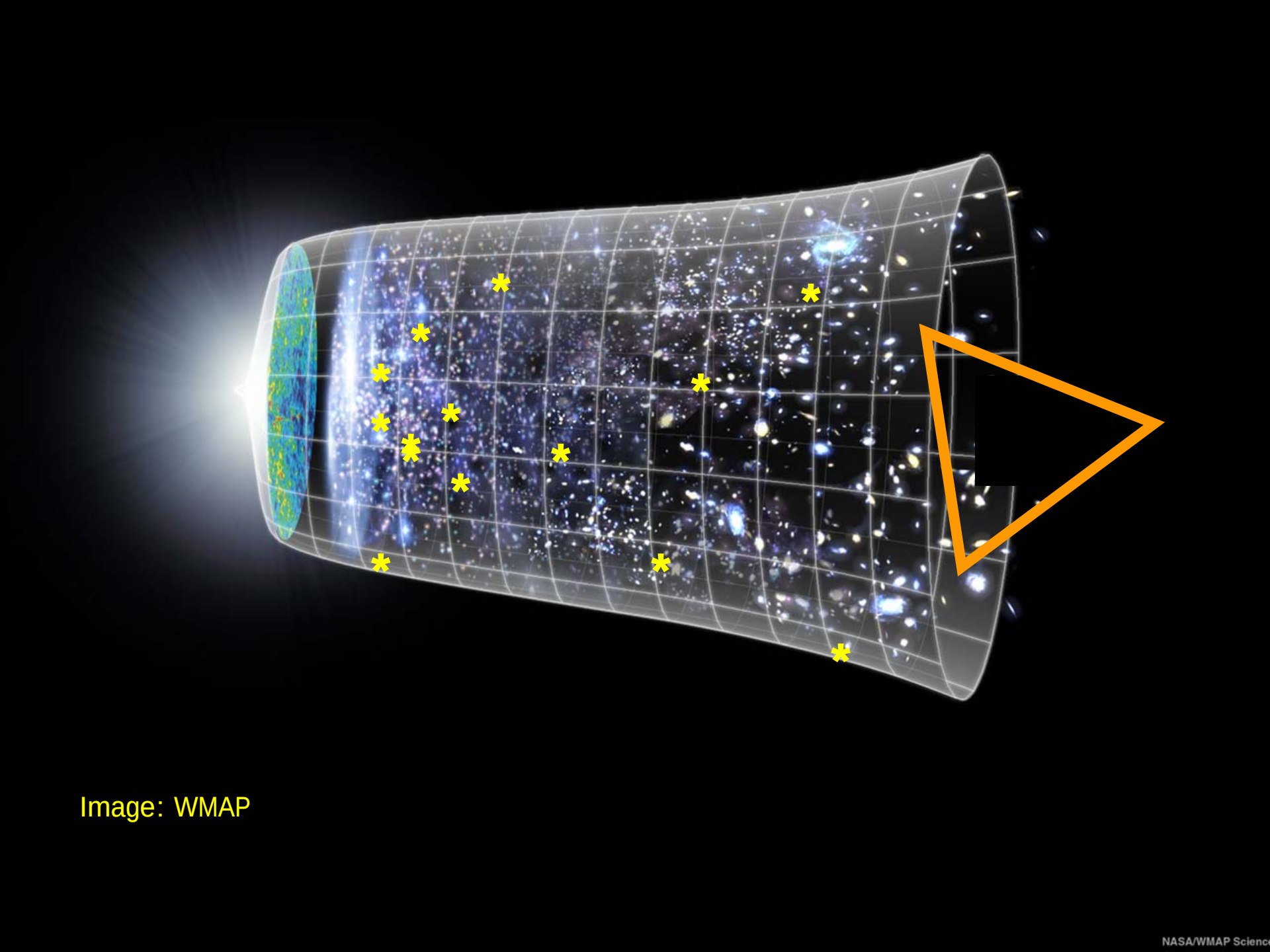
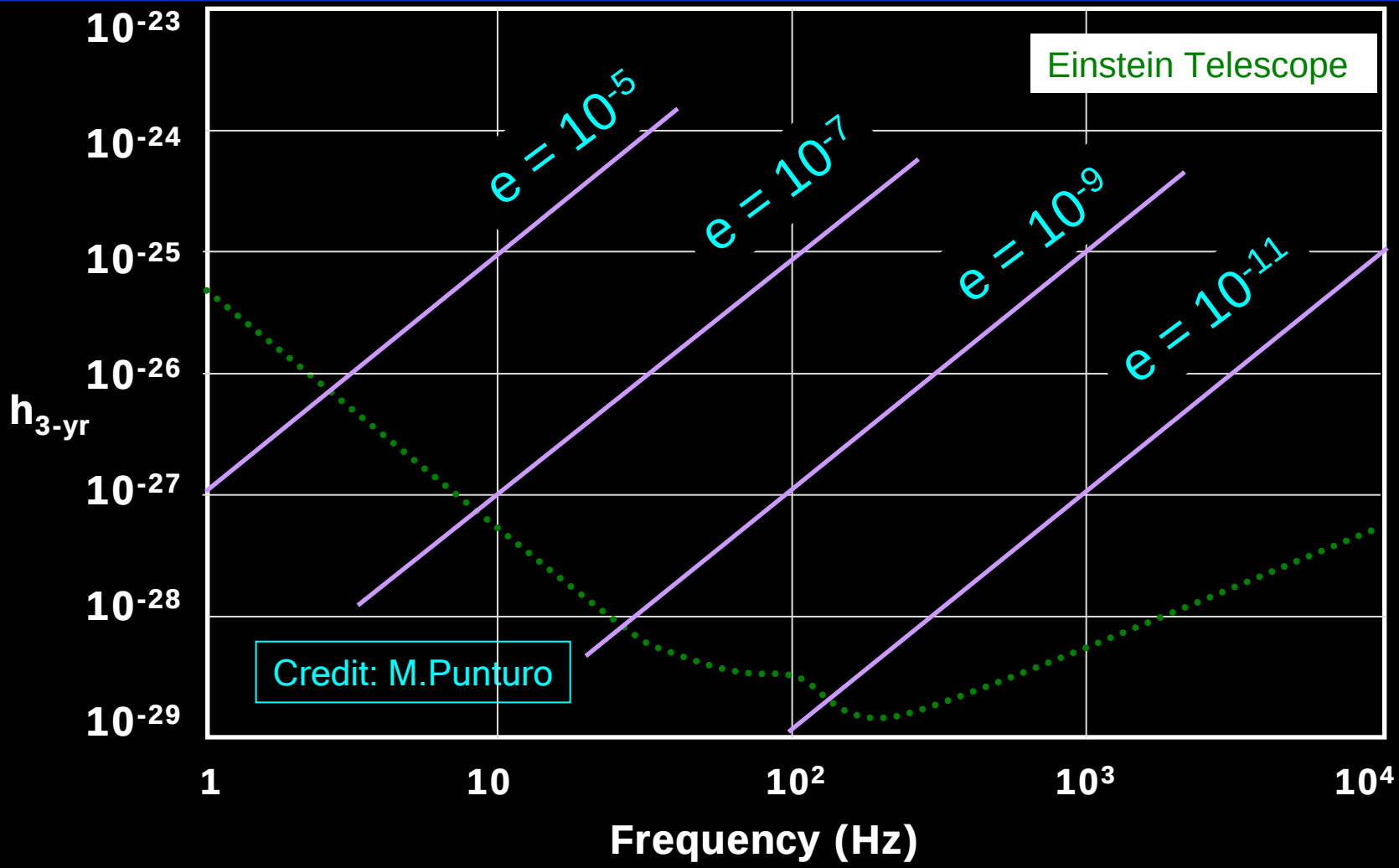


Image: WMAP

CW Signal in 3 Years Vs Noise



ET Science Goals

- Fundamental physics
  - What are the different polarization states of gravitational waves?
  - Black hole spectroscopy and the no-hair theorem
  - Is general relativity the correct description of strong gravity?
  - Are gravitons massive?
- Cosmology
  - Independent and accurate measurement of the Hubble constant
  - What is the nature of dark energy?
  - How is matter organized on very large scales?

ET Science Goals

- Astrophysics
  - What is the origin of gamma-ray bursts and what are the different populations?
  - Are ULX sources Intermediate Mass Black Holes? How and when did they form?
  - How asymmetric are neutron stars and what is their equation-of-state?
  - What is the mass function of compact objects and what does it tell us about the stellar mass function and history of star formation rate?
  - What is the end state of gravitational collapse?
  - What causes pulsar glitches and magnetar flares?

ET Data Analysis Goals

- ET is likely to observe long-lived sources and multiple sources at any given time
  - For example, a BNS signal starting at 1 Hz will last for 4 months and one starting at 5 Hz will last for half-a-day
  - We open the window to a host of slowly rotating neutron stars
- Are there source populations that could contaminate the sensitivity by confusion noise?
- A paradigm shift in the way we analyze the data might be needed
  - What can we learn from current data analysis efforts and what are relevant data analysis methods?
  - Similarities with LISA: How can MLDC benefit ET DA?
  - Opportunities for multi-messenger astronomy

ET Computational Infrastructure

- What is the computational burden ?
  - What is the computational cost for key science deliverables?
  - What is the cost to do secondary science deliverables?
  - What will be the data output rates and how do we manage data archival and access?
- What will be the status of computing environments on 2018 time scale?
- Do we benefit from having specialist hardware?

Participation in the Study

- As a member of an institution that led the FP7 proposal or via the ET Science Team.
- The ET web pages at: http://www.et-gw.eu/
- To register for WG4 mailing list go to
  - https://mail.virgo.infn.it/mailman/listinfo/wg4-et.
  - WG4 e-mail address is: WG4-et AT ego-gw.it
  - WG4 working area is at: https://workarea.et-gw.eu/et/WG4-Astrophysics
- To register for the ET Science Team go
  - https://mail.virgo.infn.it/mailman/listinfo/science-team-et
  - Science Team e-mail is: science-team-et AT ego-gw.it

Summary of WG4 Design Study

- Produce a vision document within the first six months that identifies the most important problems in fundamental physics, astrophysics and cosmology which ET could shed light on
  - What is the limitation of second generation detectors? And why do we need a new set of detectors and new infrastructure?
  - This may be our "CERN" – a facility for the next 30 or 50 years!
  - Focus away from "more of the same", what new can ET do?
  - Overlap with LISA: time for a binary of (10,1000) $M_\odot$ to evolve from 0.01 Hz to 10 Hz is ~6 yr. For (100,1000) $M_\odot$ it is 7 months!
- Develop tools that can assess the potential for different optical configurations, topologies, sites and networks
  - Don't focus on just parameter estimation, relate that to science (tests of general relativity, astrophysical and cosmological models, etc.)