GWADW: Gravitational Wave Detectors for 2015, 2020, and 2025

Setting the Stage

Dave Reitze
LIGO Laboratory

http://surfing-place.blogspot.com/2011/06/hawaii.html

Ground-based Detectors-- Past, Present, & Future

- 2010 -- First Generation Interferometers:

'We built km scale interferometers. ***They work.***'

- 2015 -- Second Generation Interferometers:

'We're building more sensitive interferometers. We have 'knobs' to play with – signal recycling, input power. We can tune to go after specific astrophysical targets, We'll soon make detections of binary mergers. And if we get lucky, maybe something else.'

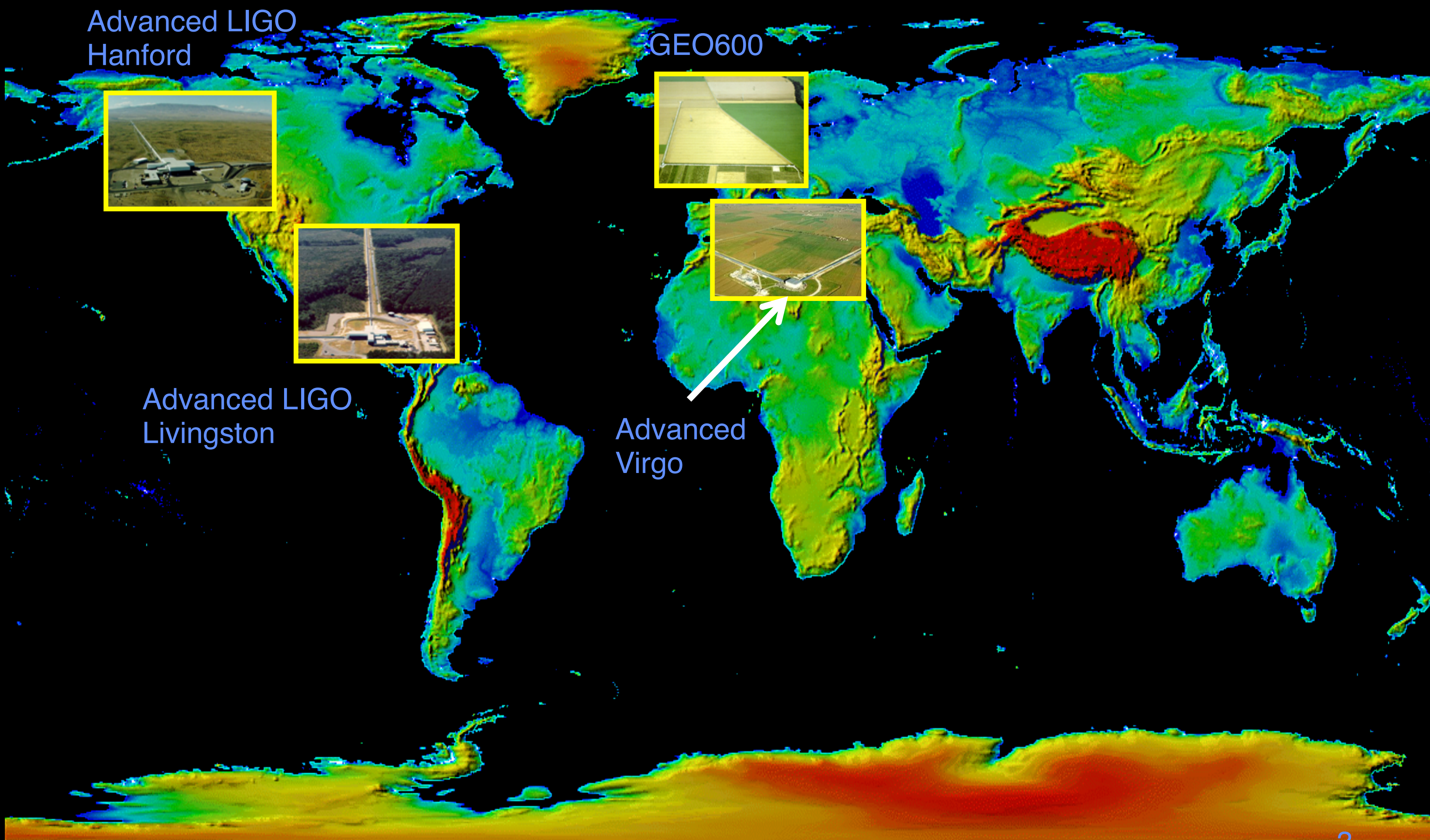
- 2020 -- Global Gravitational-wave Network

'We're doing multi-messenger astronomy with the network.'

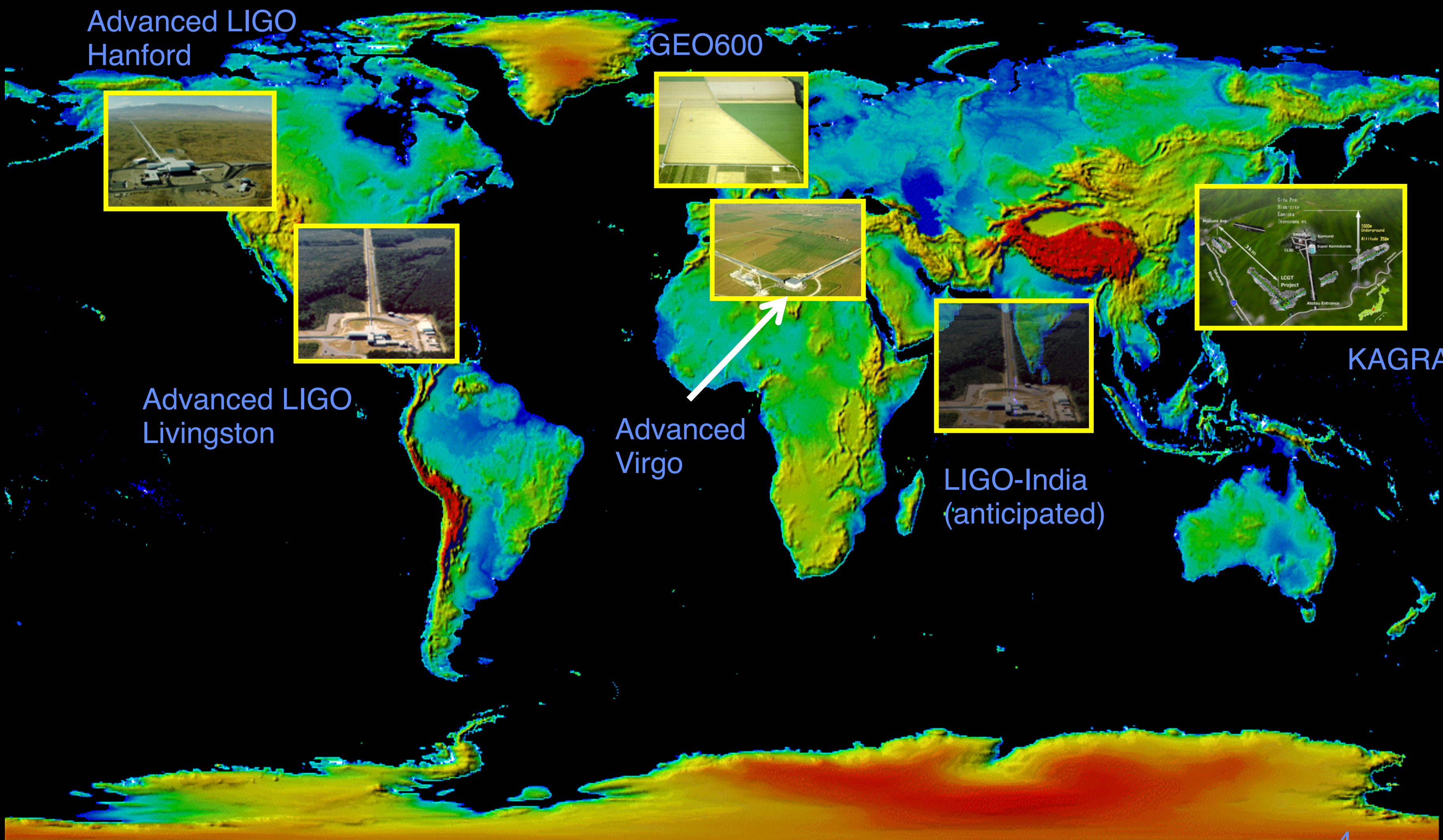
- 2025+… -- Third Generation Interferometers:

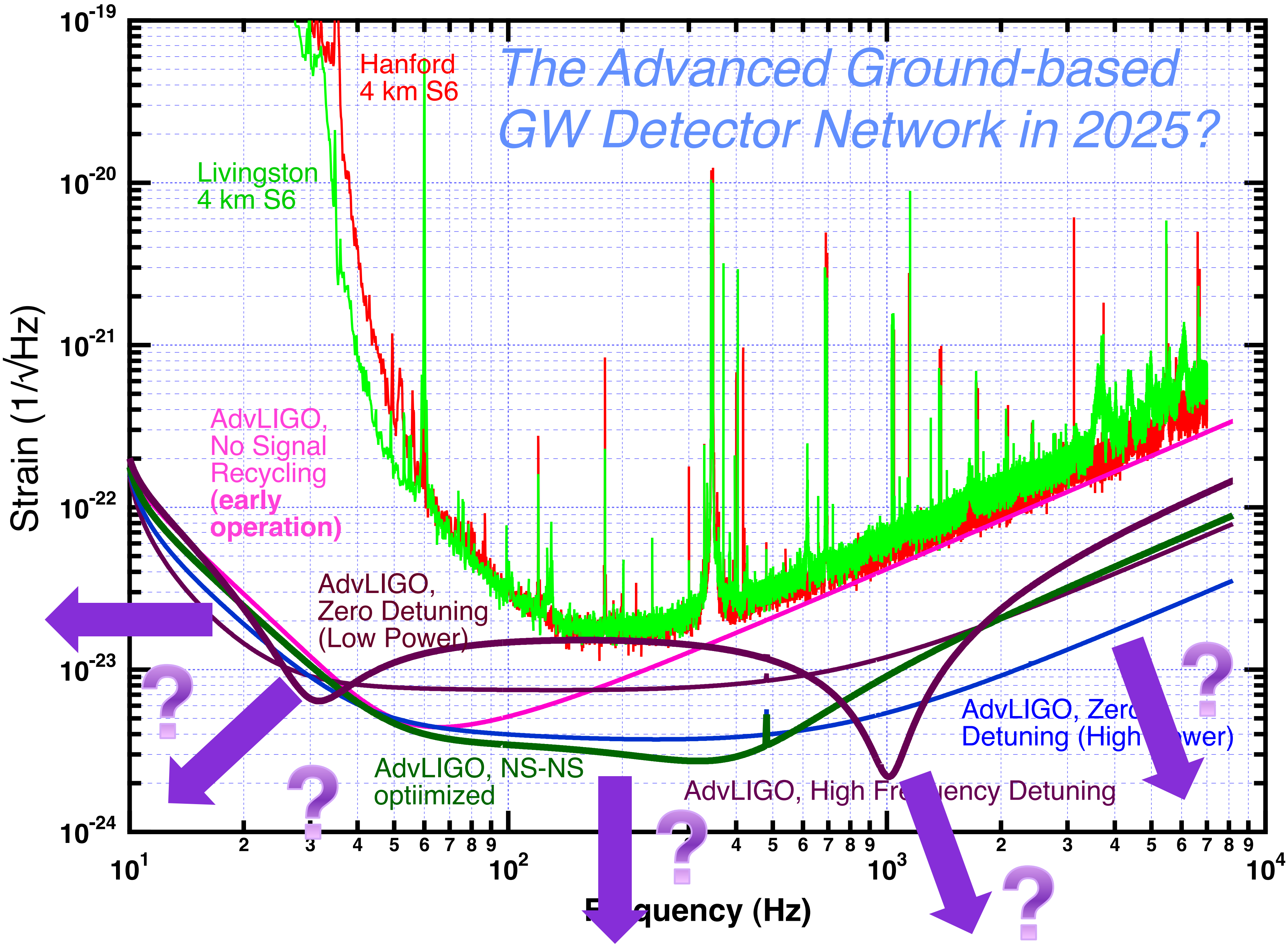
'We'll building interferometers that will be even more sensitive and probe astrophysics at cosmological distances. They'll provide stringent tests of GR. ***Their designs will be influenced as much by astrophysics as by the limits of technology***.'

The Advanced Ground-based GW Detector Network in 2015



The Advanced Ground-based GW Detector Network in 2020





LIGO-G1200558-v1

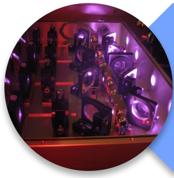
Timescales for a US third generation detector

- Assumptions:
  - aLIGO completed in 2015
  - 2 - 3 years needed to reach design sensitivity
  - First detections come between 2015-2018
  - Depending on NS-NS, NS-BH, BH-BH rates or surprises, 2 or more years of science running after detection
- Constraints and Prerequisites:
  - Advanced LIGO: our first priority must be to get aLIGO operational and sensitive
  - Science: any major upgrade proposal (~$100M scale) will have to wait until we have detections
- Near Term Possibilities (2016-2020):
  - Incremental, lower cost upgrades which improve sensitivity by small factors and/or in different frequency bands, eg.
    - Squeezing
    - Mirrors possessing optical coatings with significantly lower thermal noise
    - ???

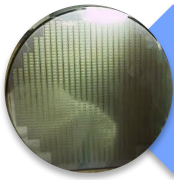
Next generation timescales

- Longer Term Possibilities (2020-2030):
  - » Upgrades which have a high price tag will require a dedicated proposal to NSF.
    - – It takes a years to get on to and work though the queue of Major Research Equipment and Facilities Construction projects.
  - » A 3G proposal will need to have a thorough conceptual design underpinning the proposal
    - – The design will be strongly motivated by astrophysics goals, exploring trades
    - – The 'Catch-22' problem
- Recall History
  - » Initial LIGO – 'Blue book' design in 198? → first science run (S1) in 2002, design sensitivity in 2005
  - » Advanced LIGO – Conceptual design in 1998 → first science slated for 2015
- It takes 15-20 years to go from design to working interferometers; this points to an operational 3G interferometer in the late 2020's
  - » Could possibly be accelerated by breakthrough science by 2G detectors, a more limited scale upgrade

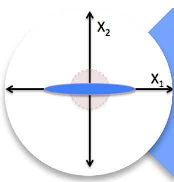
What's needed? An partially complete list…



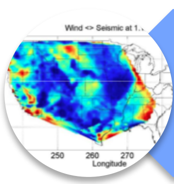
Source Development: high power, stabilized 1.5-1.6 μm lasers, modulators, isolators



Optical Materials Science: large silicon optics, metrology, optical coating development, materials science



Quantum-enhanced interferometry: quantum non-demolition, squeezing, displacement-free interferometry



Low Frequency Interferometry: gravity gradient sensing and feed forward, mirror suspension, cryogenic mirrors, underground location

Interferometer Network Development: multi-messenger astronomy, event position reconstruction

RGB: R&D for third generation detectors

- LIGO Scientific Collaboration ‘Strawman’ design approach – ‘how do we design an interferometer to the facility limits of the LIGO sites?’
  - Not underground, not (necessarily) a wholesale upgrade (a la Advanced LIGO)
- Strawman design will evolve in a conceptual design
- What research should we ***not*** be doing?
- Prioritization is important, but I think it’s too early to be picking winners and losers
  - Many of the cool ideas are simply too untested to know they’ll work.

Pulsar Timing

- Pulsar timing arrays are in the thick of the hunt to directly detect the first gravitational wave
  - Bruce Allen: "I think they have a really solid chance of beating the ground-based detectors. It's a real race." (*Nature* **463**, 147 (2010))
- Progress driven by discovery of new millisecond pulsars by Fermi and radio telescopes
- Consortium of collaborations (NANOGrav, EPTA, PPTA) hunting for nHz gravitational waves

- More in Thursday "Pulsar Timing" Session
  - Talks by Finn, Cordes, Lazio

Space – the Final Frontier

- April 2012 decision by ESA to select JUICE (Jupiter Icy Moon Explorer) over eLISA/NGO for first L-class mission
  - » Some good news in this - the ESA scientific review committee placed eLISA/NGO #1 in science value/impact
- LISA pathfinder – launch expected in 2014, will test key LISA technologies
- eLISA/NGO will compete for L2 slot
  - » Launch late in the next decade (2028?)
- More in Thursday's "Space Antennae" session
  - » Talks by McKenzie, Sato, Ward, Buchmann

Exotica: Cool Ideas for Gravitational-wave Detectors

- Most of us here work on mainstream gravitational-wave detectors
- Nonetheless, there are other ideas being pursued – atom interferometers, torsion bars, superfluidity
- These ideas may seem exotic, but then again so did km scale gravitational-wave interferometers when they were proposed!

- More in Thursday's 'Novel Technologies' session
  - » Talks by Ando, Shoda, Schwab, Muller

Summary

- 2015 → On track to bring second generation detectors Advanced LIGO & Advanced Virgo on line
- 2020 → Global ground-based gravitational wave network operational
- 2025 → Third generation detectors under construction & space-based interferometer nearing launch

http://wallpapers.free-review.net/42___Kalalau_Valley,_Kauai,_Hawaii_-_Pacific_Breezes.htm


Enjoy the meeting!
http://hawaiiw.net/wp-content/uploads/2011/11/hawaii-red.jpg