NSF's Strategic Planning Considerations and the Gravitational Wave Detector Community

Mark Coles

Senior Advisor for Facilities Development and Management

Division of Physics

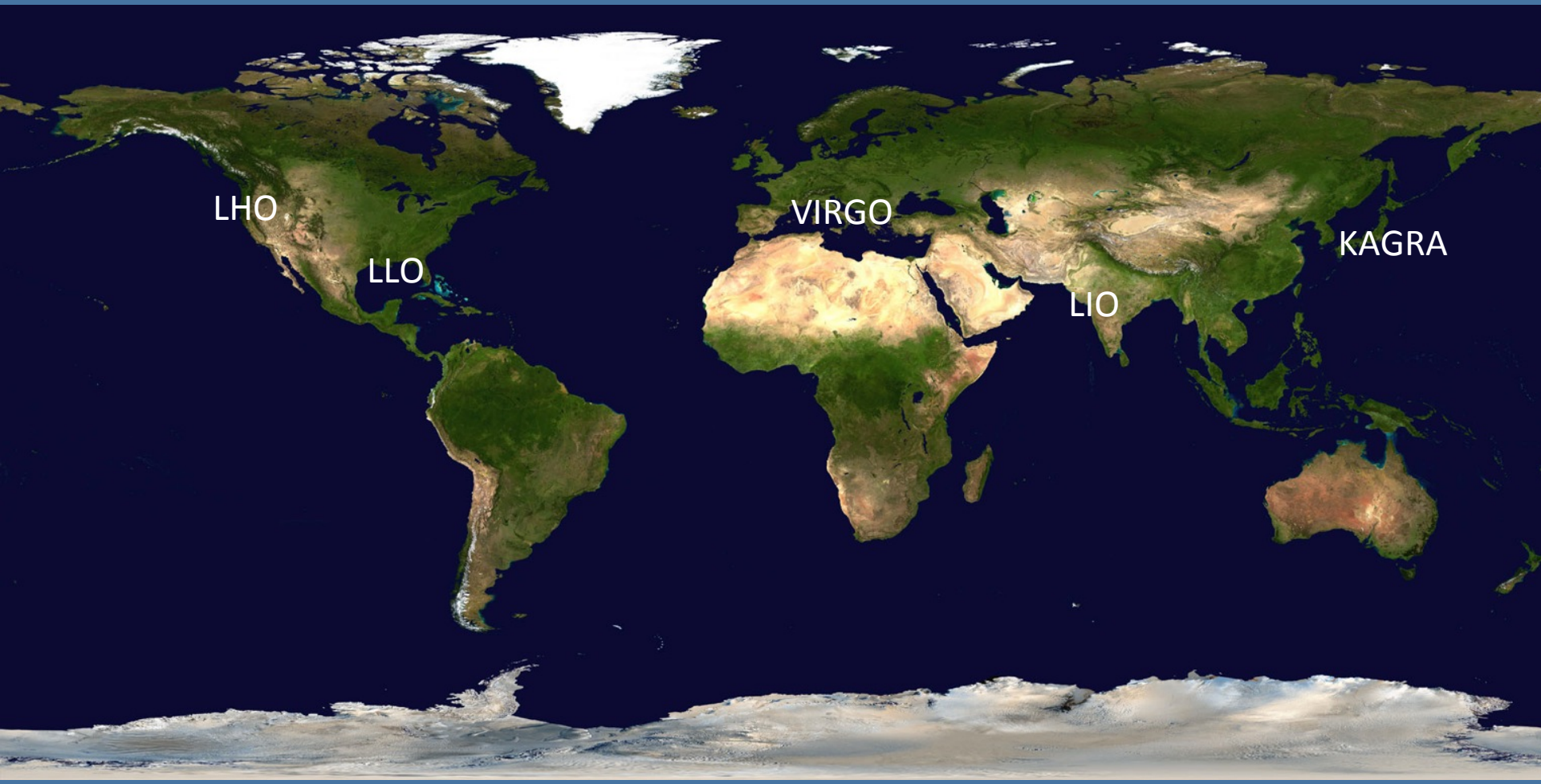
Mathematical and Physical Sciences Directorate

National Science Foundation

NSF's LIGO current commitments and announced intentions

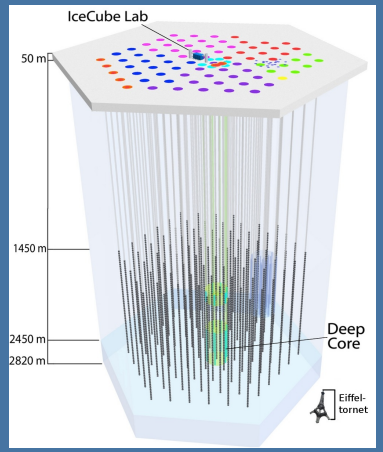
- Complete Advanced LIGO construction
- Commission Advanced LIGO to achieve design sensitivity
- Operate Advanced LIGO to observe gravitational waves
- Partner with the Government of India to establish an identical Advanced LIGO interferometer in India, commencing operation no later than 2022

Creation of a global network through international collaboration:



Many complementary activities are underway with NSF support

- GW detection is one component of a larger campaign to promote multi-messenger astronomy
- Large Synoptic Survey Telescope
- IceCube



Further NSF commitments

- NSF Astronomy Division is supporting construction of the Large Synoptic Survey Telescope (LSST) in partnership with DOE and multiple private donors
- The LSST will be a large, wide-field ground-based telescope designed to provide time-lapse digital imaging of faint astronomical objects across the entire visible sky every few nights – systematic monitoring of transient phenomena in the optical sky
- LSST will enable a wide variety of complementary scientific investigations of dynamic sky, utilizing a common database

NSF View of LIGO Timeline

- Progressive sensitivity improvements
- Periodic data collection at meaningful sensitivities
- Approx 1 year of data collection at design sensitivity prior to 9/30/18
- Initial GW detection hopeful

- Extended scientific operation
- Modest sensitivity upgrades
- LIGO-US + VIRGO network for source location
- KAGRA too?
- Detection rates and source localization for EM?

2018

2022

NSF View of LIGO Timeline

Adv LIGO Commissioning

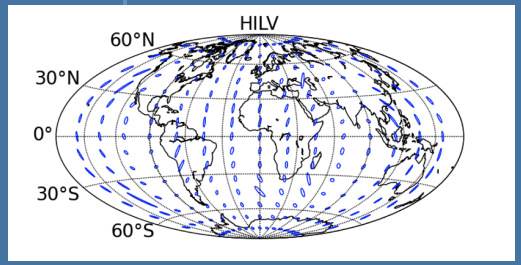
Adv LIGO Operation

Joint US + **India** operation

LIGO India Planning and Construction

- Site selection and preparation
- Facility and vacuum system design
- Facility construction start
- Vacuum construction start

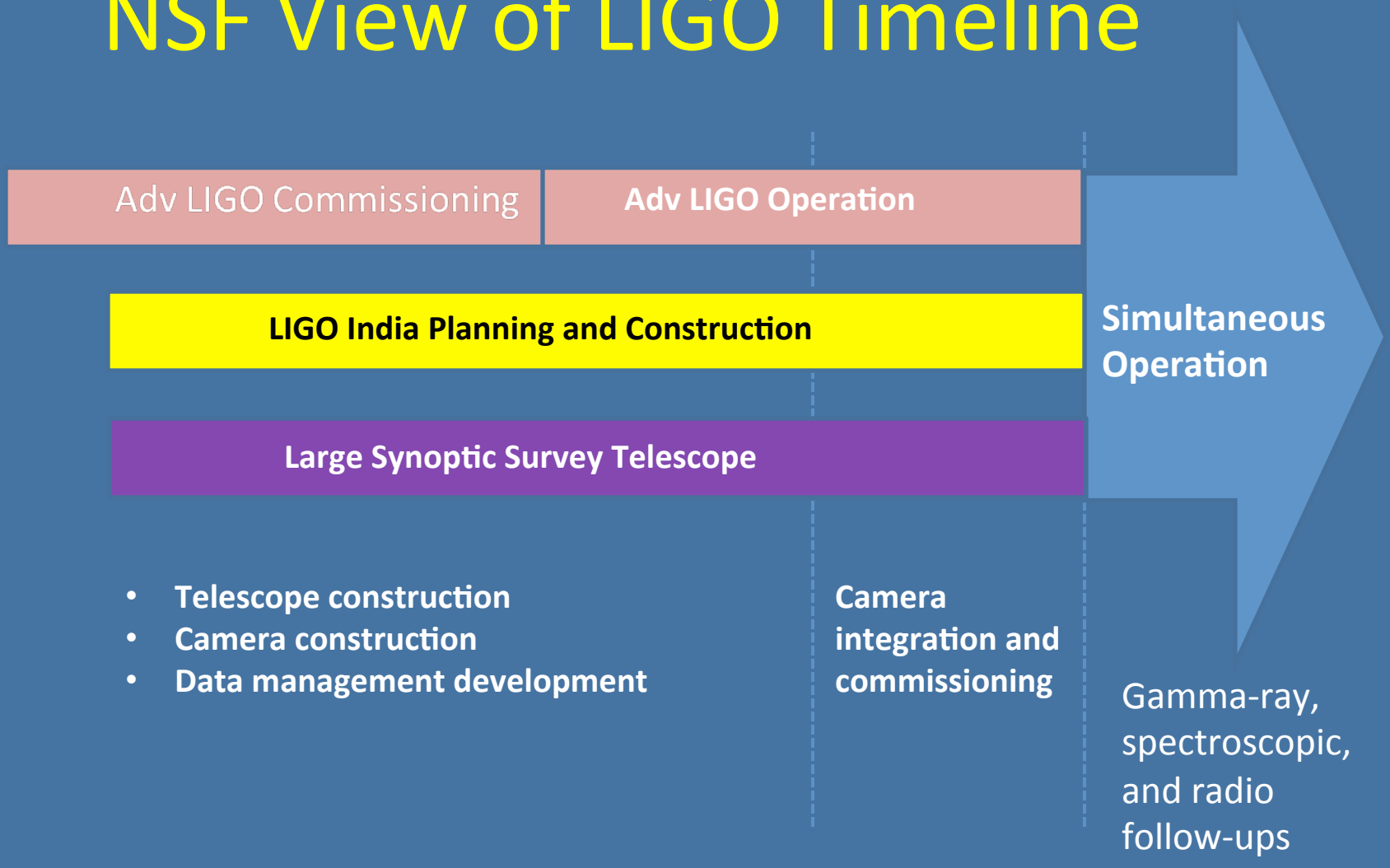
- Facility construction completion
- Vacuum system completion
- Detector installation
- Interferometer commissioning
- LIGO US assistance with detector installation and commissioning



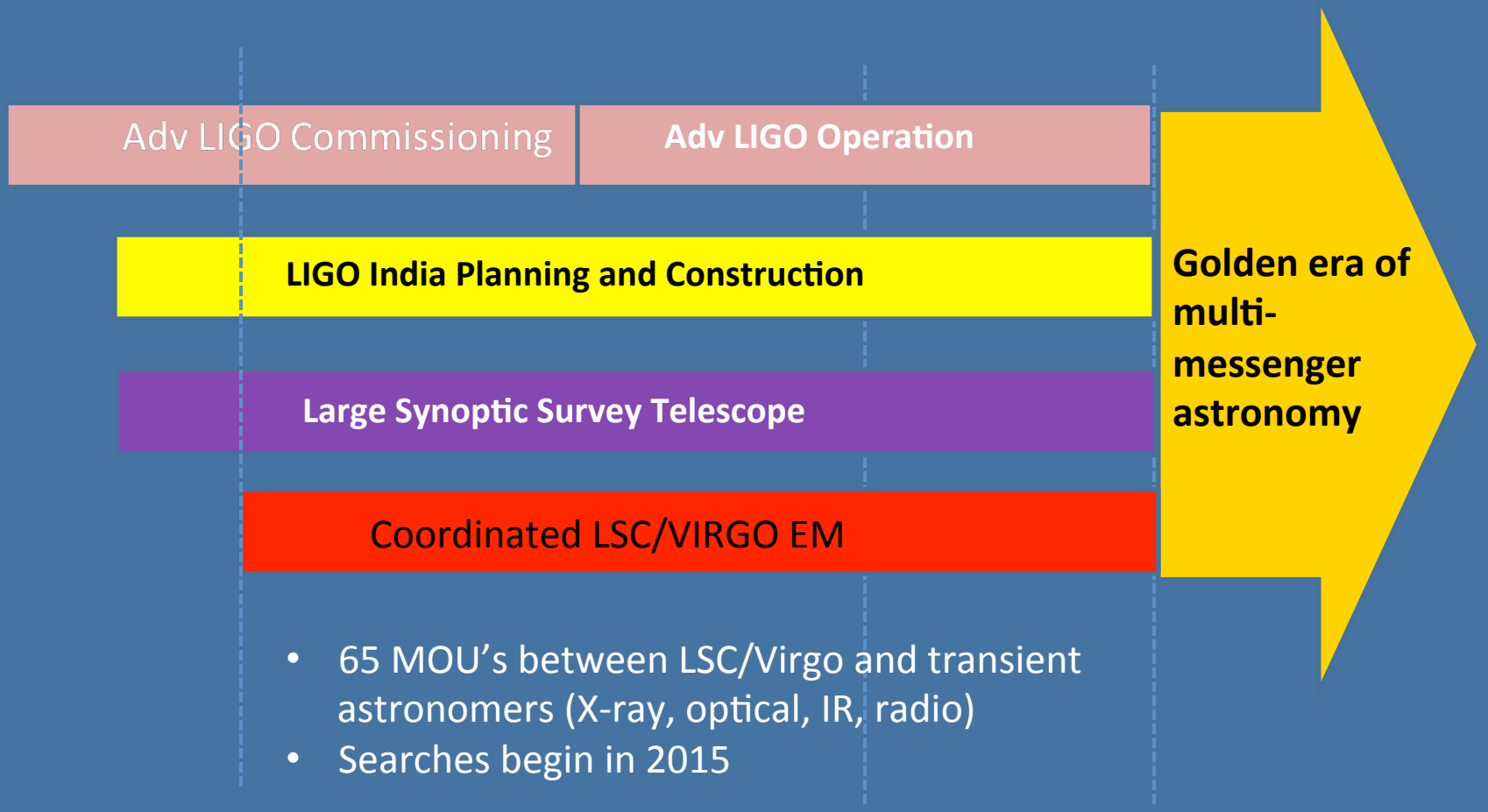
2018

2022

NSF View of LIGO Timeline

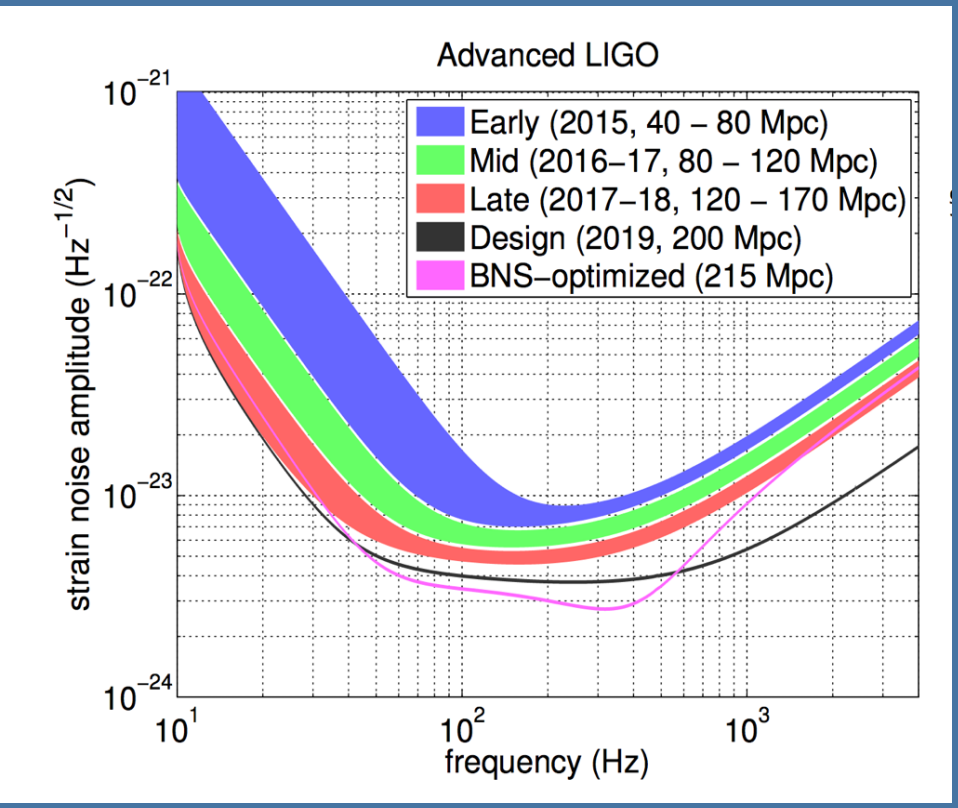


NSF View of LIGO Timeline



- 65 MOU's between LSC/Virgo and transient astronomers (X-ray, optical, IR, radio)
- Searches begin in 2015

LIGO Timeline uncertainties



How many GW detections will occur in 2015-18?

Few, or no detections by 2019 would motivate:

- Modest sensitivity upgrades
- Close coordination with LIGO India to control systematic effects
- Possible downward budget pressure

Multiple detections by 2022 ➔

- Greater emphasis on extended operation with LSST to get good angular resolution on sources, facilitate spectroscopic follow-up
- Tradeoff between improving SNR and live-time will depend on observed detection rate

See "Prospects for Localization of Gravitational Wave Transients by the Advanced LIGO and Advanced VIRGO Observatories" arXiv 1304.0670 – best estimates by LIGO and VIRGO

NSF budget outlook factors

- Recent NSF budgets are approximately flat
- US support for advanced detector development initiatives constrained by budget considerations and cautious future outlook
- Convincing GW detection, and detection rate, **may** change the budget landscape
- Historically, major construction initiatives at NSF have required more than 10 years from inception to **start** of construction

Timeline for possible advanced detector opportunity

- 2018 – 2022:
  - Low-cost, short down-time upgrades are feasible:
    - Squeezed light source (possibly before 2018), and/or mitigations of high power operation risk factors
    - Upgrades to electronics, software, support for noise coupling investigations
  - India's commitment or capacity to make parallel changes to baseline design is to be determined
  - Targeted enhancements may be possible as a reaction to knowledge of detected waveforms

Looking further into the future

- 2022-2026
  - Development of contingency strategies for risk mitigation, bounded by operational budget constraints and existing infrastructure, to enhance SNR and BW
  - Trigger improvements in data analysis?
  - Angular resolution aided by enhanced SNR
  - Active tuning of BW?
- Beyond 2026
  - Opportunities for major design initiatives, new technologies, etc.

What's immediately possible concerning advanced detectors

- Very small perturbations on PHY program - $250M
- Small perturbations on NSF gravity program - $13M/ year
- International collaborative activities leveraging NSF funds
- Modest cross-disciplinary initiatives
  - With EM and particle detectors
  - Advanced R&D in materials and AMO to explore connections with quantum systems, thermal noise suppression, feed-forward systems for compensating gravity gradient noise

Complementary funding areas are likely to increase funding for GW research over the longer term

- LSST
- Complementary physics areas
  - Pulsar timing arrays (PTA)
  - BICEP2 and other CMB B-mode results
- ***Convincing GW detections are an essential NSF prerequisite for significant new initiatives***