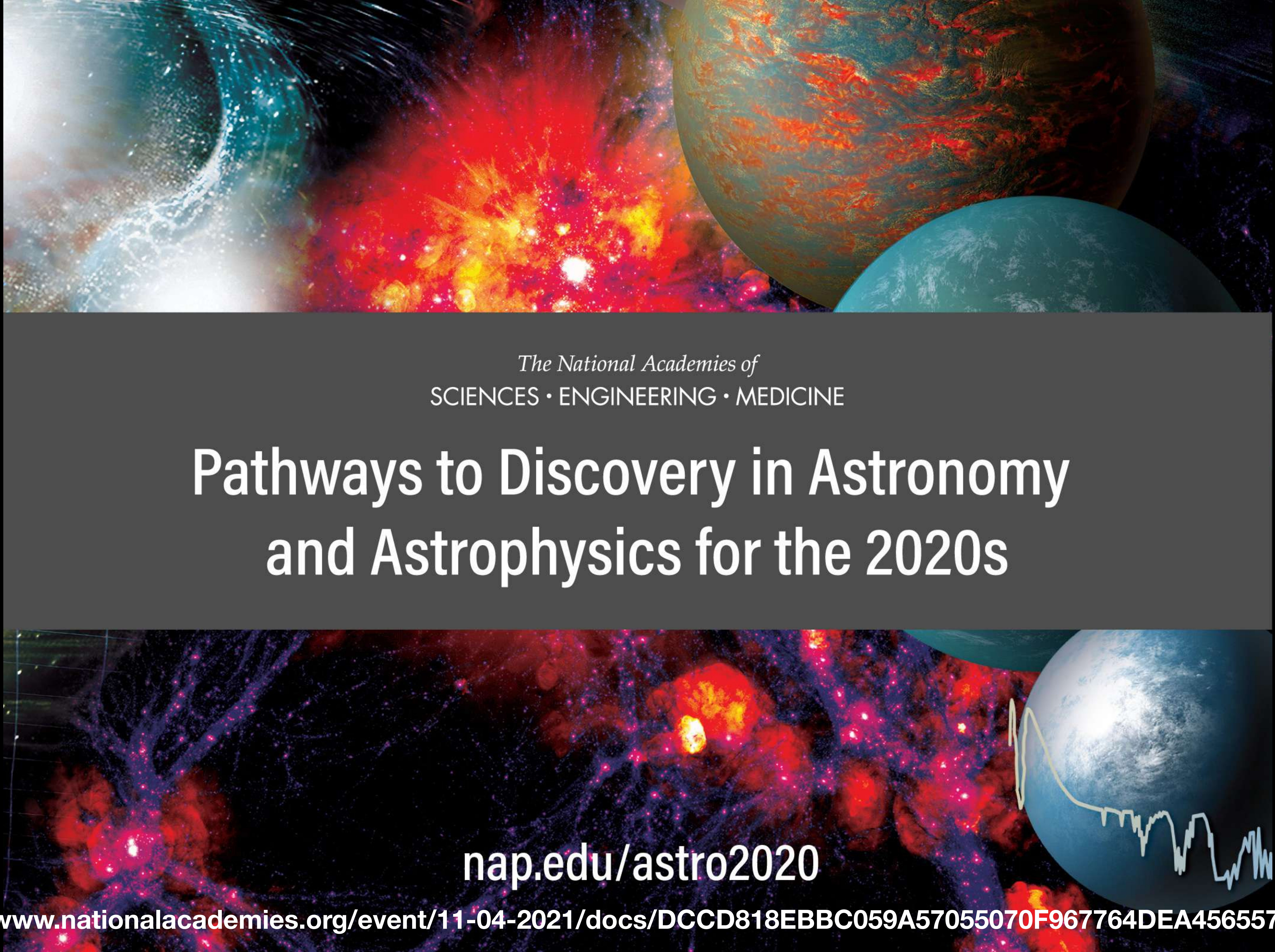
米国での将来計画の議論のやり方について

村山斉 (Berkeley, Kavli IPMU)

2022/09/21 光赤天連シンポジウム



https://www.nationalacademies.org/event/11-04-2021/docs/DCCD818EBBC059A57055070F967764DEA456557CCBDC

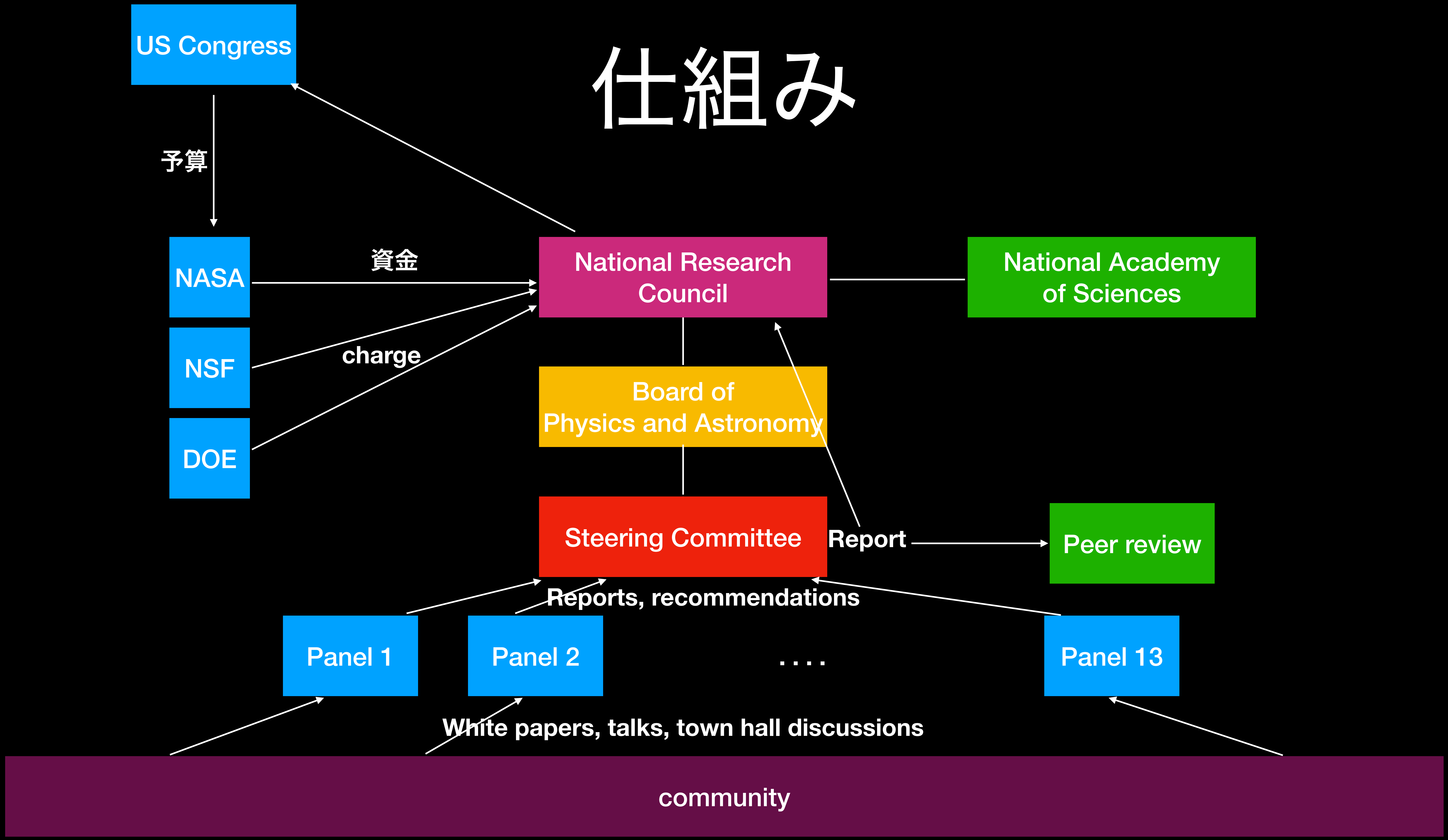
基本的な考え方

- Funding agency (NASA, NSF, DOE)が数億円のお金を出して、次の10年の計画を練ることを National Academies of Sciences に注文
  - その際、今後の予算のシナリオをいくつか提示
  - 何についてアドバイスが必要か、詳細な Statement of Task
  - Chair を選ぶ
- NAS と chair で steering committee, 各パネルを構成、約150人が参加
  - サイエンスが軸のパネル、手法が軸のパネル両方ある
- White paper を募集
  - Town hall で講演、議論
- 各パネルが recommendation をまとめる
- Steering committee が一つの recommendation にまとめる

National Academy of Sciences

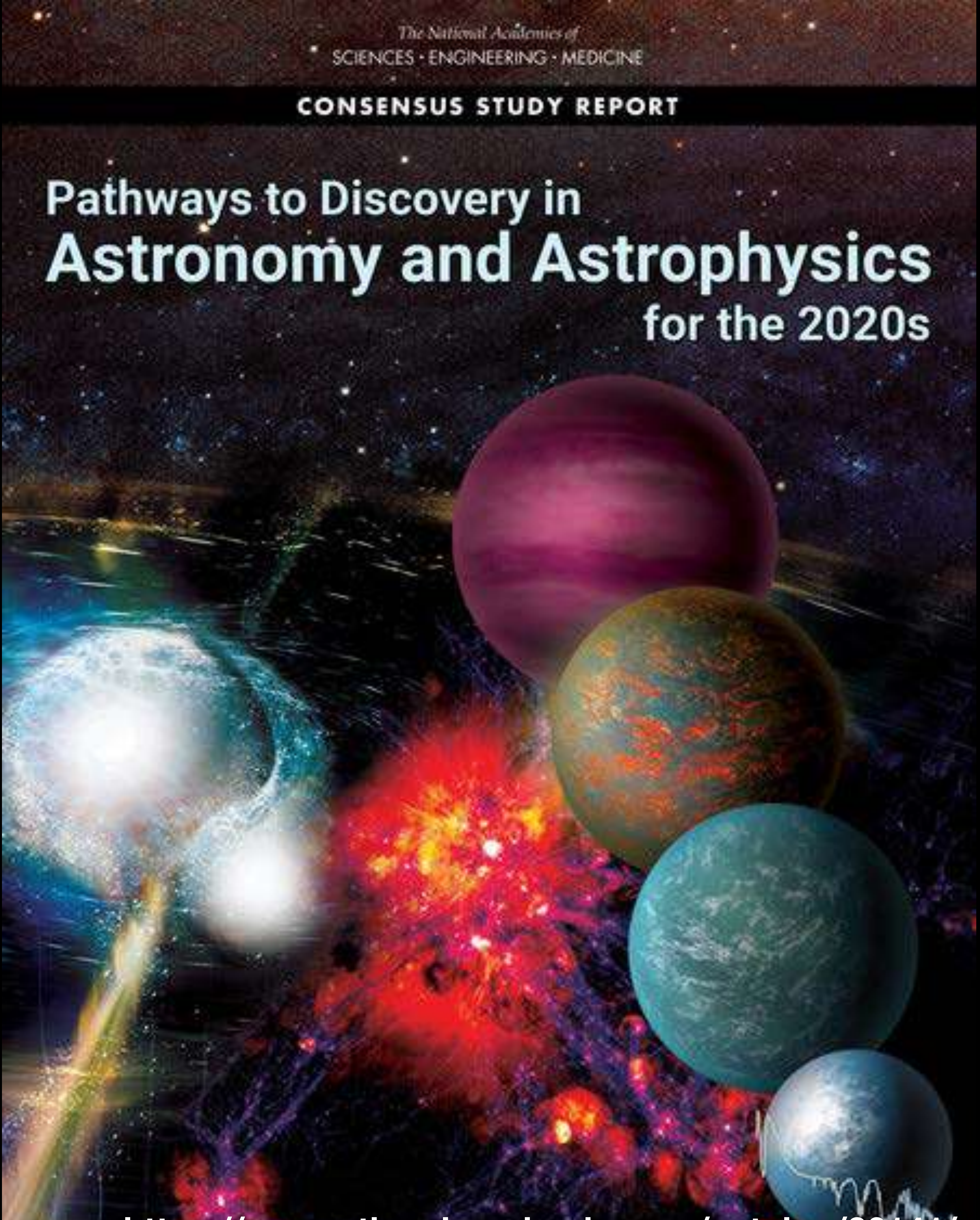
- 私的非営利団体
  - Physical and Mathematical Sciences
  - Biological Sciences
  - Engineering and Applied Sciences
  - Biomedical Sciences
  - Behavioral and Social Sciences
  - Applied Biological, Agricultural, and Environmental Sciences
- 2400人のアメリカ人研究者、500人の国際メンバー、内ノーベル賞190人
- メンバーが新メンバーを推薦、選出、終身
- 会費有り、しかし収入は endowment と NRC reports
- *The three Academies work together as the National Academies of Sciences, Engineering, and Medicine to provide independent, objective analysis and advice to the nation and conduct other activities to solve complex problems and inform public policy decisions. The National Academies also encourage education and research, recognize outstanding contributions to knowledge, and increase public understanding in matters of science, engineering, and medicine. The National Academies' service to government has become so essential that Congress and the White House have issued legislation and executive orders over the years that reaffirm its unique role.*

仕組み


US Congress
予算
NASA
NSF
DOE
資金
charge
National Research Council
National Academy of Sciences
Board of Physics and Astronomy
Steering Committee
Report
Peer review
Reports, recommendations
Panel 1
Panel 2
. . . .
Panel 13
White papers, talks, town hall discussions
community

COMMITTEE FOR A DECADAL SURVEY ON ASTRONOMY AND ASTROPHYSICS 2020 (ASTRO2020): STEERING COMMITTEE

FIONA A. HARRISON, NAS,[1] California Institute of Technology, *Co-Chair*
ROBERT C. KENNICUTT JR., NAS, University of Arizona and Texas A&M University, *Co-Chair*
JULIANNE DALCANTON, University of Washington
TIM DE ZEEUW, Leiden University
ANDREW S. DRIESMAN, Johns Hopkins University Applied Physics Laboratory
JONATHAN J. FORTNEY, University of California, Santa Cruz
GABRIELA GONZÁLEZ, NAS, Louisiana State University
JORDAN A. GOODMAN, University of Maryland
MARC P. KAMIONKOWSKI, NAS, Johns Hopkins University
BRUCE MACINTOSH, Stanford University
JACOBUS M. OSCHMANN, Independent Consultant
RACHEL A. OSTEN, Space Telescope Science Institute, *Executive Officer*
LYMAN A. PAGE, JR., NAS, Princeton University
ELIOT QUATAERT, NAS, Princeton University
WANDA A. SIGUR, NAE,[2] Independent Consultant
RACHEL SOMERVILLE, Flatiron Institute
KEIVAN G. STASSUN, Vanderbilt University
JEAN L. TURNER, University of California, Los Angeles
PIETER VAN DOKKUM, Yale University
ELLEN G. ZWEIBEL, NAS, University of Wisconsin, Madison



結果

- 616 ページ
- *We live in a time of extraordinary discovery and progress in astronomy and astrophysics. The next decade will transform our understanding of the universe and humanity's place in it. Every decade the U.S. agencies that provide primary federal funding for astronomy and astrophysics request a survey to assess the status of, and opportunities for the Nation's efforts to forward our understanding of the cosmos. Pathways to Discovery in Astronomy and Astrophysics for the 2020s identifies the most compelling science goals and presents an ambitious program of ground- and space-based activities for future investment in the next decade and beyond. The decadal survey identifies three important science themes for the next decade aimed at investigating Earth-like extrasolar planets, the most energetic processes in the universe, and the evolution of galaxies. The Astro2020 report also recommends critical near-term actions to support the foundations of the profession as well as the technologies and tools needed to carry out the science.*
- 大抵 space で３つ、ground based で３つの最優先プロジェクト
- 実際にはそのうち１〜２しか実現しないことが多い

https://nap.nationalacademies.org/catalog/26141/pathways-to-discovery-in-astronomy-and-astrophysics-for-the-2020s

Statement of Task and Panel Descriptions

STATEMENT OF TASK

The National Academies of Sciences, Engineering, and Medicine shall convene an ad hoc survey committee and supporting study panels to carry out a decadal survey in astronomy and astrophysics. The study will generate consensus recommendations to implement a comprehensive strategy and vision for a decade of transformative science at the frontiers of astronomy and astrophysics. The committee, with inputs from study panels covering the breadth of astronomy and astrophysics, will carry out the following tasks:

1. Provide an overview of the current state of astronomy and astrophysics science, and technology research in support of that science, with connections to other scientific areas where appropriate;
2. Identify the most compelling science challenges and frontiers in astronomy and astrophysics, which shall motivate the committee's strategy for the future;
3. Develop a comprehensive research strategy to advance the frontiers of astronomy and astrophysics for the period 2022-2032 that will include identifying, recommending, and ranking the highest priority research activities—taking into account for each activity the scientific case, international and private landscape, timing, cost category and cost risk, as well as technical readiness, technical risk, and opportunities for partnerships. The strategy should be balanced, by considering large, medium, and small activities for both ground and space. (Activities include any project, telescope, facility, experiment, mission, or research program of sufficient scope to be identified separately in the final report.) For each recommended activity the committee will lay out the principal science objectives and activity capabilities, including assumed or recommended activity lifetime, where possible;
4. Utilize and recommend decision rules, where appropriate, for the comprehensive research strategy that can accommodate significant but reasonable deviations in the projected budget or changes in urgency precipitated by new discoveries or unanticipated competitive activities;
5. Assess the state of the profession, using information available externally and, if necessary, data gathered by the study itself, including workforce and demographic issues in the field. Identify areas of concern and importance to the community raised by this assessment in service of the future vitality and capability of the astronomy and astrophysics work force. Where possible, provide specific, actionable and practical recommendations to the agencies and community to address these areas. This report shall be made available following the completion of the study.

- 6 Science Panels
  - Compact Objects and Energetic Phenomena
  - Cosmology
  - Galaxies
  - Exoplanets, Astrobiology, and the Solar System
  - Interstellar Medium and Star and Planet Formation
  - Stars, the Sun, and Stellar Populations
- 6 Program Panels
  - Enabling Foundation for Research
  - Electromagnetic Observations from Space 1
  - Electromagnetic Observations from Space 2
  - Optical and Infrared Observations from the Ground
  - Particle Astrophysics and Gravitation
  - Radio, Millimeter, and Submillimeter Observations from the Ground
- Panel on the Profession and Societal Impacts

Approach

NASA, NSF, and DOE provided budget guidance, bounded by ambitious and conservative scenarios

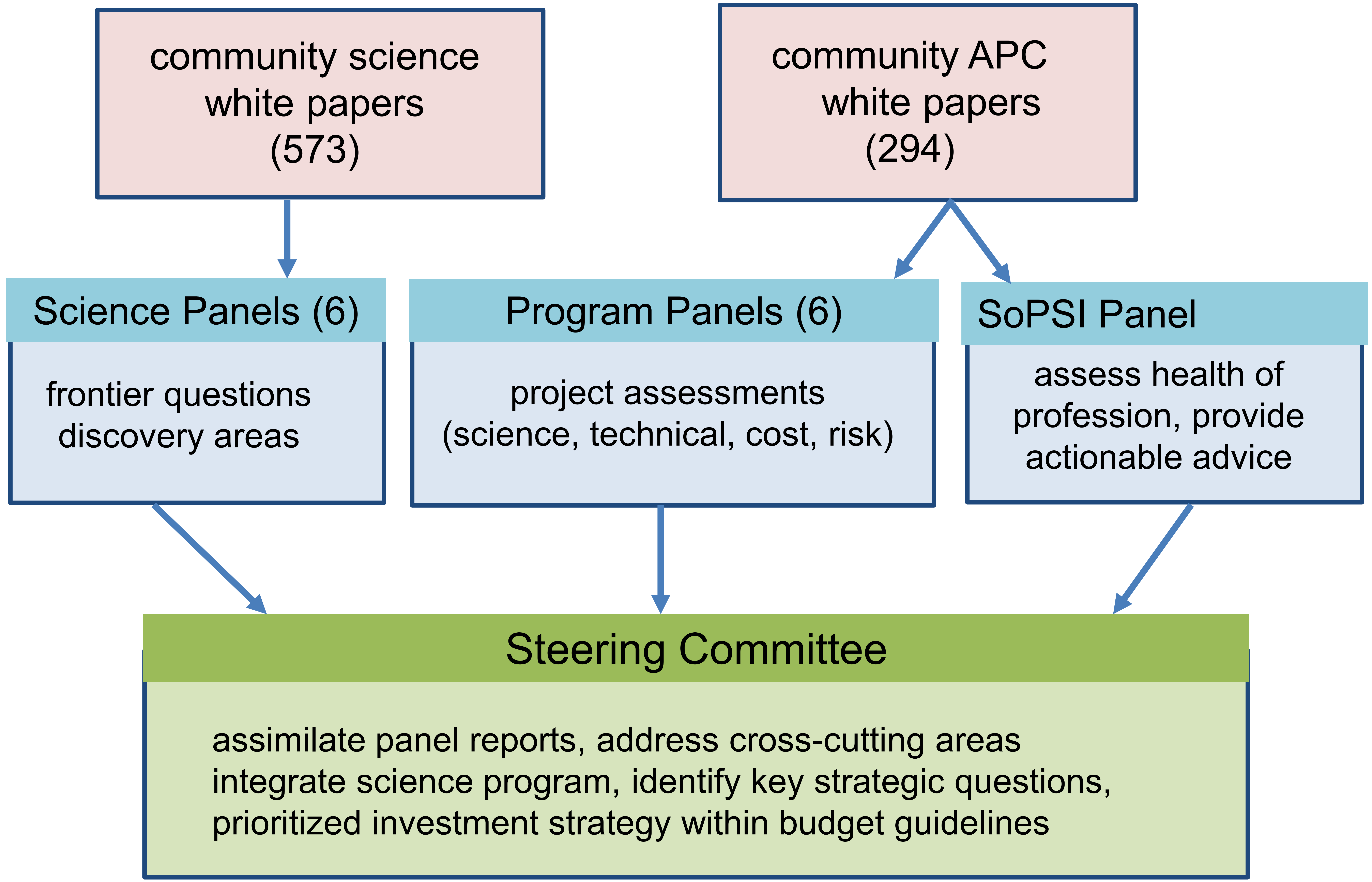
The agencies urged the survey to develop an “ambitious”, “aspirational”, and “inspirational” plan

But a plan also needs to be realistic, responsible, achievable, sustainable

The Survey’s Approach:

- Propose an ambitious program, but with decision rules, decision points, and contingencies
- Emphasize phased development of many projects to lower risks and provide flexibility to agencies
- Present a strategy, with details of implementation resting with agencies and their advisory committees

Astro2020 Process



3つの Science Themes

- Worlds and Suns in Context
  - *The quest to understand the interconnected systems of stars and the worlds orbiting them, from the nascent disks of dust and gas from which they form, through the formation and evolution of the vast array of extrasolar planetary systems so wildly different than the one in which Earth resides*
- New Messengers and New Physics
  - *New Messengers and New Physics captures the scientific questions associated with inquiries ranging from astronomical constraints on the nature of dark matter and dark energy, to the new astrophysics enabled by combined observations with particles, neutrinos, gravitational waves, and light*
- Cosmic Ecosystems
  - *The universe is characterized by an enormous range of physical scales and hierarchy in structure, from stars and planetary systems to galaxies and a cosmological web of complex filaments connecting them*

前回

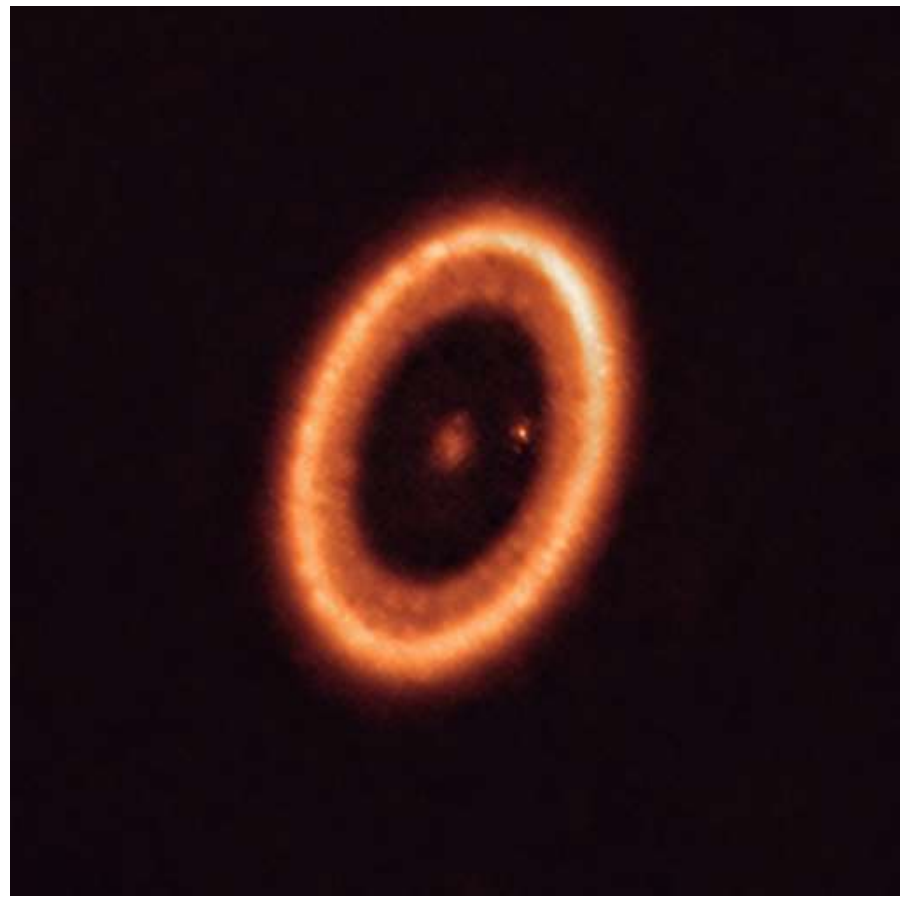
- Cosmic Dawn:
  - Searching for the First Stars, Galaxies, and Black Holes
- New Worlds:
  - Seeking Nearby, Habitable Planets
- Physics of the Universe:
  - Understanding Scientific Principles

Science Theme: Worlds and Suns in Context

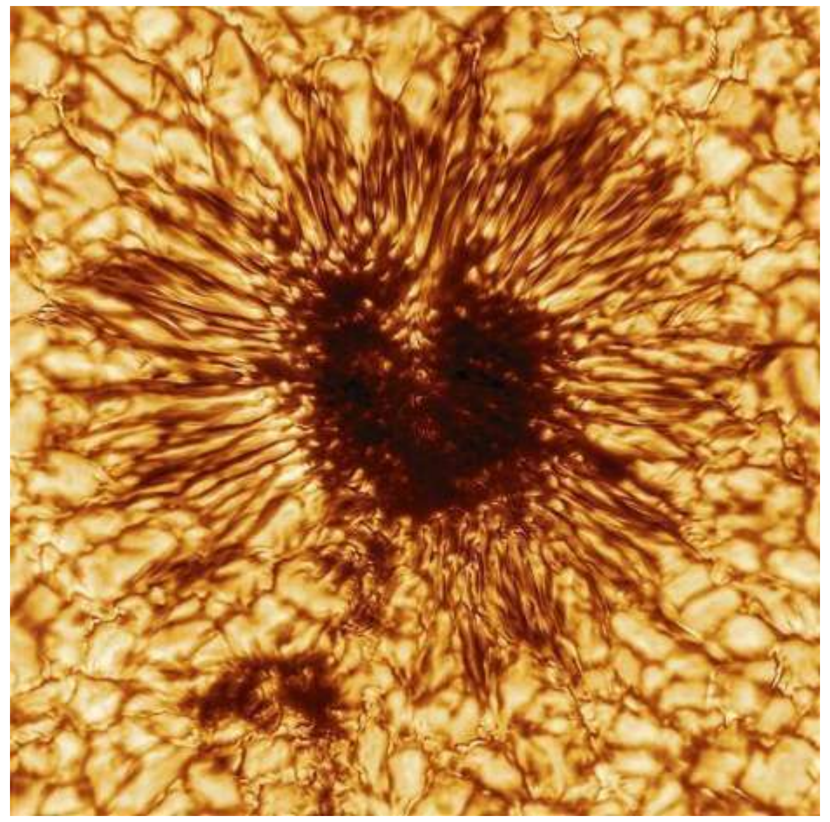
The quest to understand the interconnected systems of stars and the worlds orbiting them, from the nascent disks of dust and gas from which they form, through the formation and evolution of the vast array of extrasolar planetary systems so wildly different than the one in which Earth resides

This theme is forefront this decade because of:

- The extraordinary rate of discovery of new exoplanets– understanding the demographics and finding the nearest planets for detailed study
- The promise of JWST to make pioneering observations of exoplanet atmospheres
- The revolution DKIST will bring to understanding the Sun's atmosphere
- The revolution in studying planet formation by imaging protoplanets and their accretion disks using large ground-based telescopes (OIR and ALMA)



ALMA image of a young planet-forming star



DKIST image of a sunspot

Priority Area: Pathways to Habitable Worlds

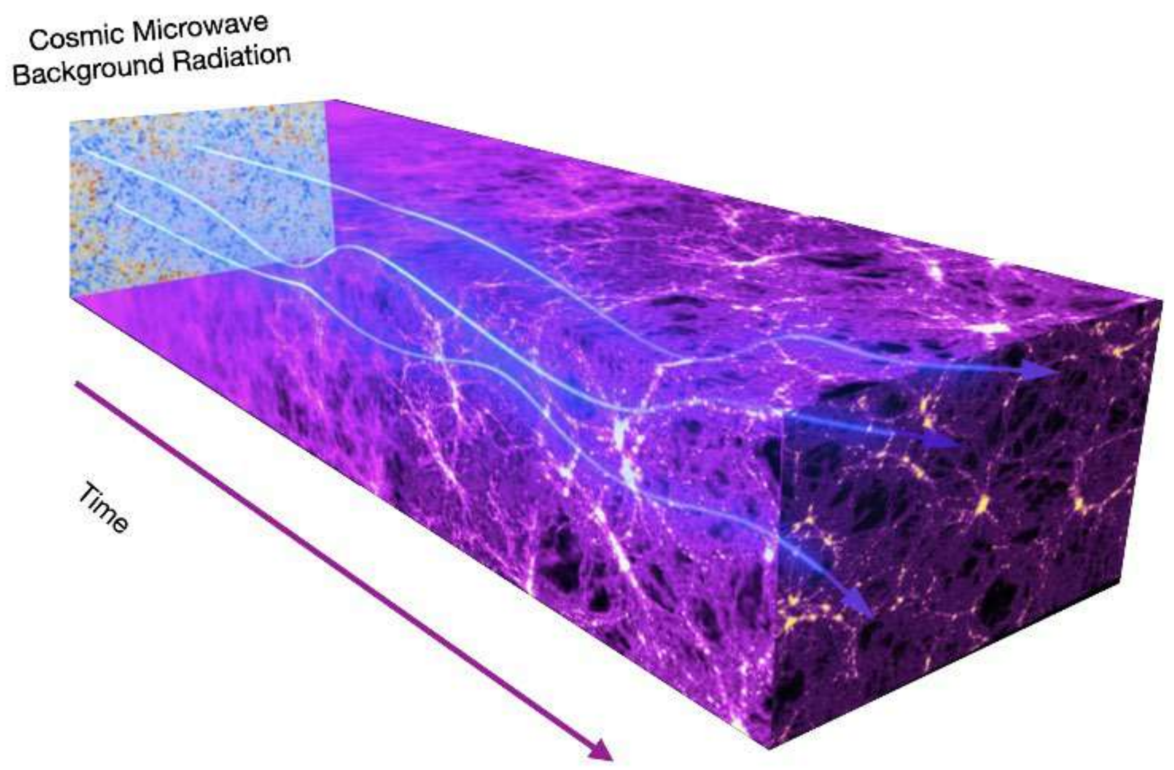
We are on a path to exploring worlds resembling Earth and answering the question: "Are we alone?" The task for the next decades will be finding the easiest of such planets to characterize, and then studying them in detail, searching for signatures of life.

The needed capabilities include:

- Ground-based ELTs equipped with high-resolution spectroscopy, high-performance AO, and high-contrast imaging
- A large space-based IR/O/UV telescope with high contrast imaging and spectroscopy capable of observing planets 10 billion times fainter than their host star
- High spatial and spectral resolution X-ray observations to probe stellar activity across the entire range of stellar types
- Laboratory and theoretical studies

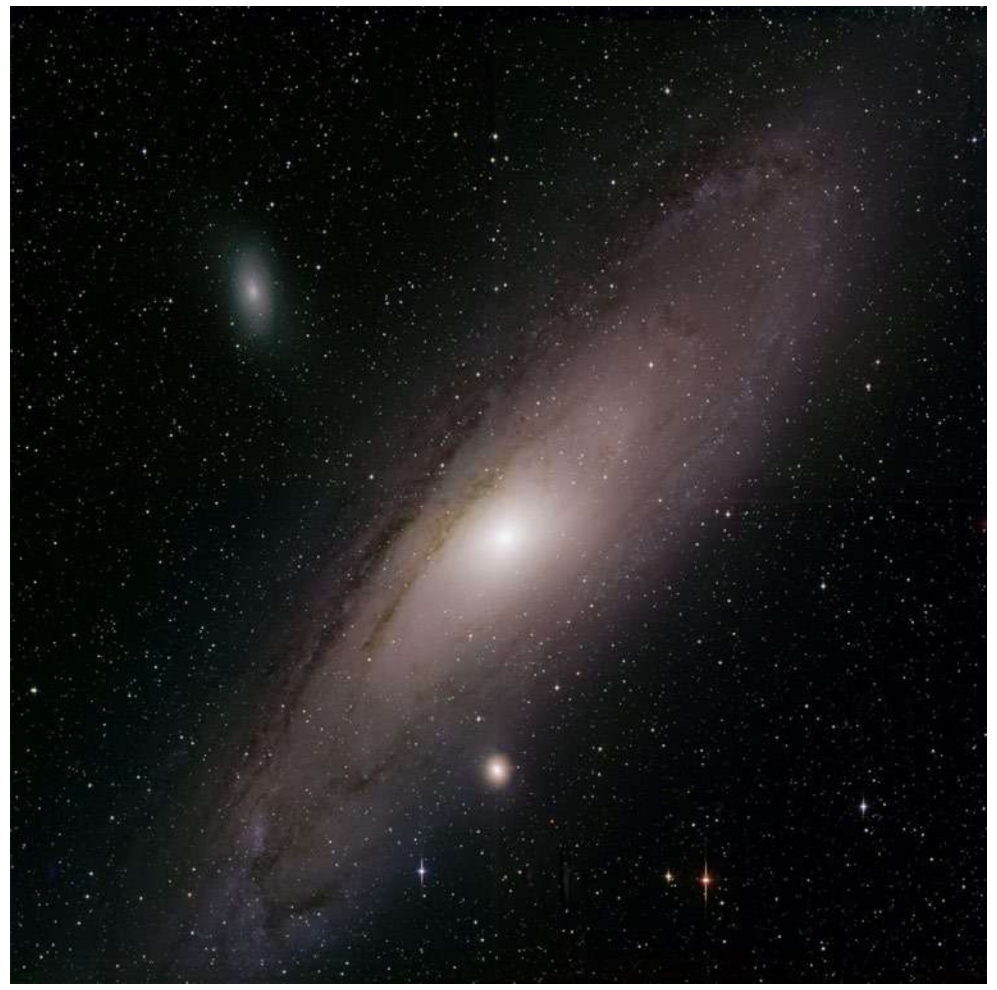
Science Theme: New Messengers and New Physics

New Messengers and New Physics captures the scientific questions associated with inquiries ranging from astronomical constraints on the nature of dark matter and dark energy, to the new astrophysics enabled by combined observations with particles, neutrinos, gravitational waves, and light



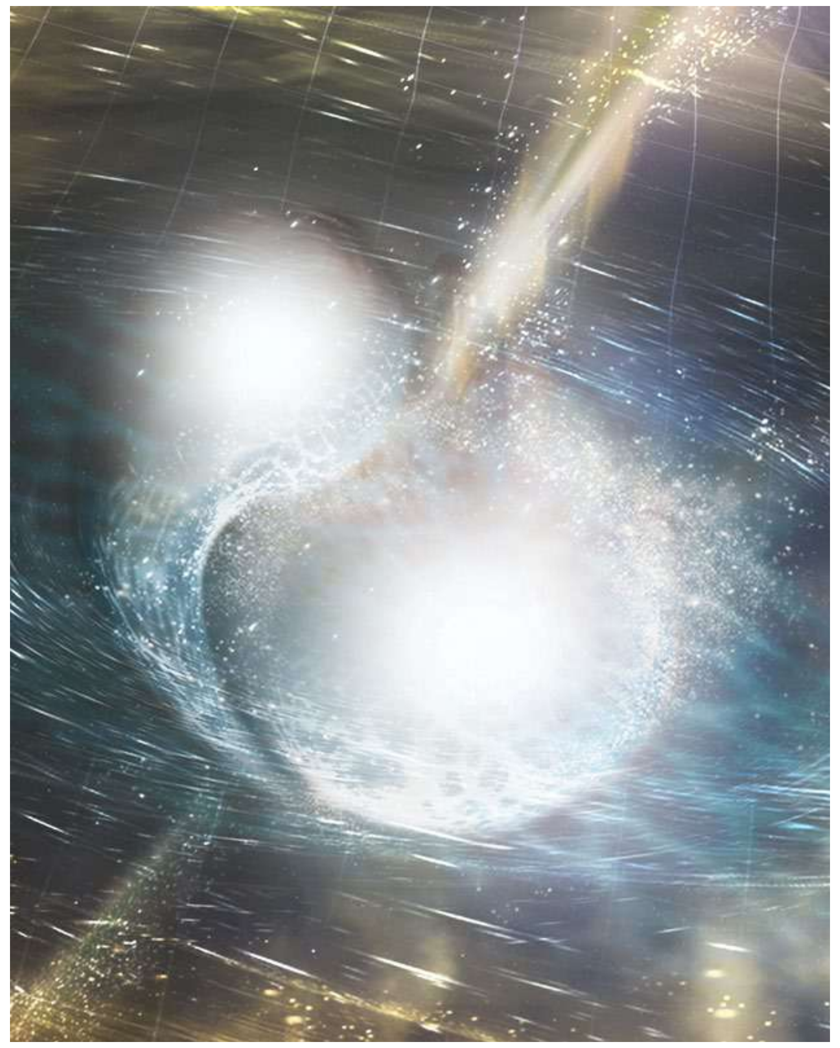
This theme is forefront this decade because of:

- Tremendous progress in observations of the Cosmic Microwave Background
- Time domain surveys that have uncovered an astounding array of transient phenomena
- The discovery of compact object mergers with LIGO, and the detection of electromagnetic counterparts
- Ice Cube's detection of high energy neutrinos of astrophysical origin



Priority Area: New Windows on the Dynamic Universe

The New Windows on the Dynamic Universe priority area involves using light in all its forms, gravitational waves, and neutrinos to study cosmic explosions on all scales and the mergers of compact objects

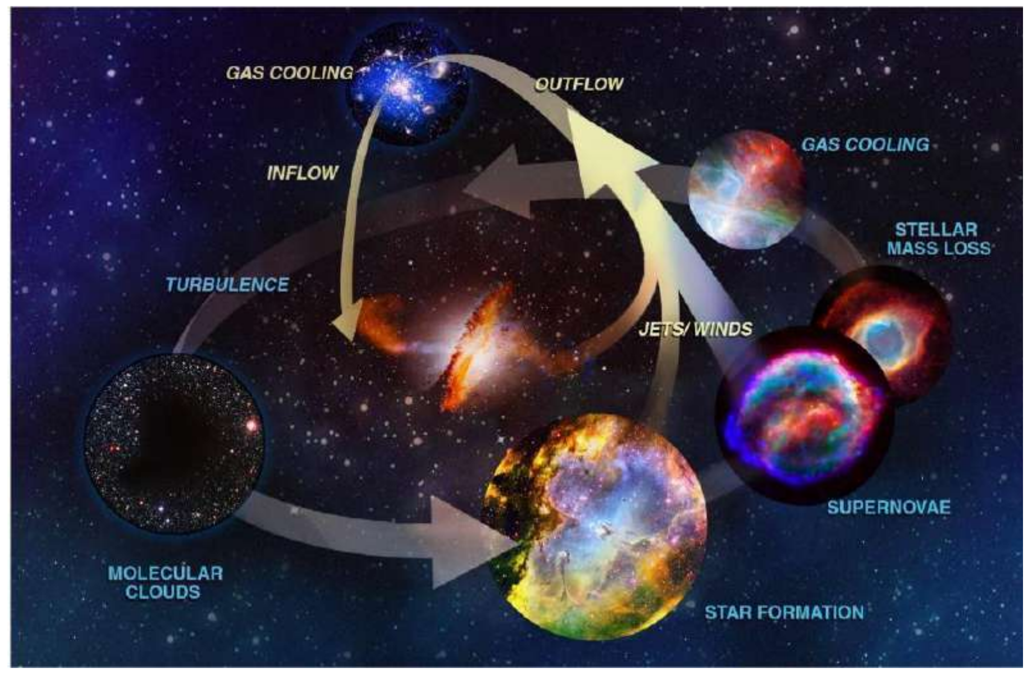


The needed capabilities include:

- Facilities to discover and characterize the brightness and spectra of transient sources as they appear and fade away
- Ground-based ELTs to see light coincident with mergers
- A next-generation radio observatory to detect the relativistic jets produced by neutron stars and black holes
- Next generation CMB telescopes to search for the polarization produced by gravitational waves in the infant universe
- Upgrades to current ground-based gravitational wave detectors, and development of next generation technologies
- Improvements in the sensitivity and angular resolution of high energy neutrino observatories

Science Theme: Cosmic Ecosystems

The universe is characterized by an enormous range of physical scales and hierarchy in structure, from stars and planetary systems to galaxies and a cosmological web of complex filaments connecting them



This theme is forefront because:

- JWST will provide definitive observations of the earliest stages of galaxy formation and evolution
- The Rubin Observatory, Roman, and Euclid will provide imaging and spectral energy information for millions of galaxies, complementing the in-depth observations from JWST
- Progress in numerical simulations is evolving rapidly and is driving our understanding of the observations

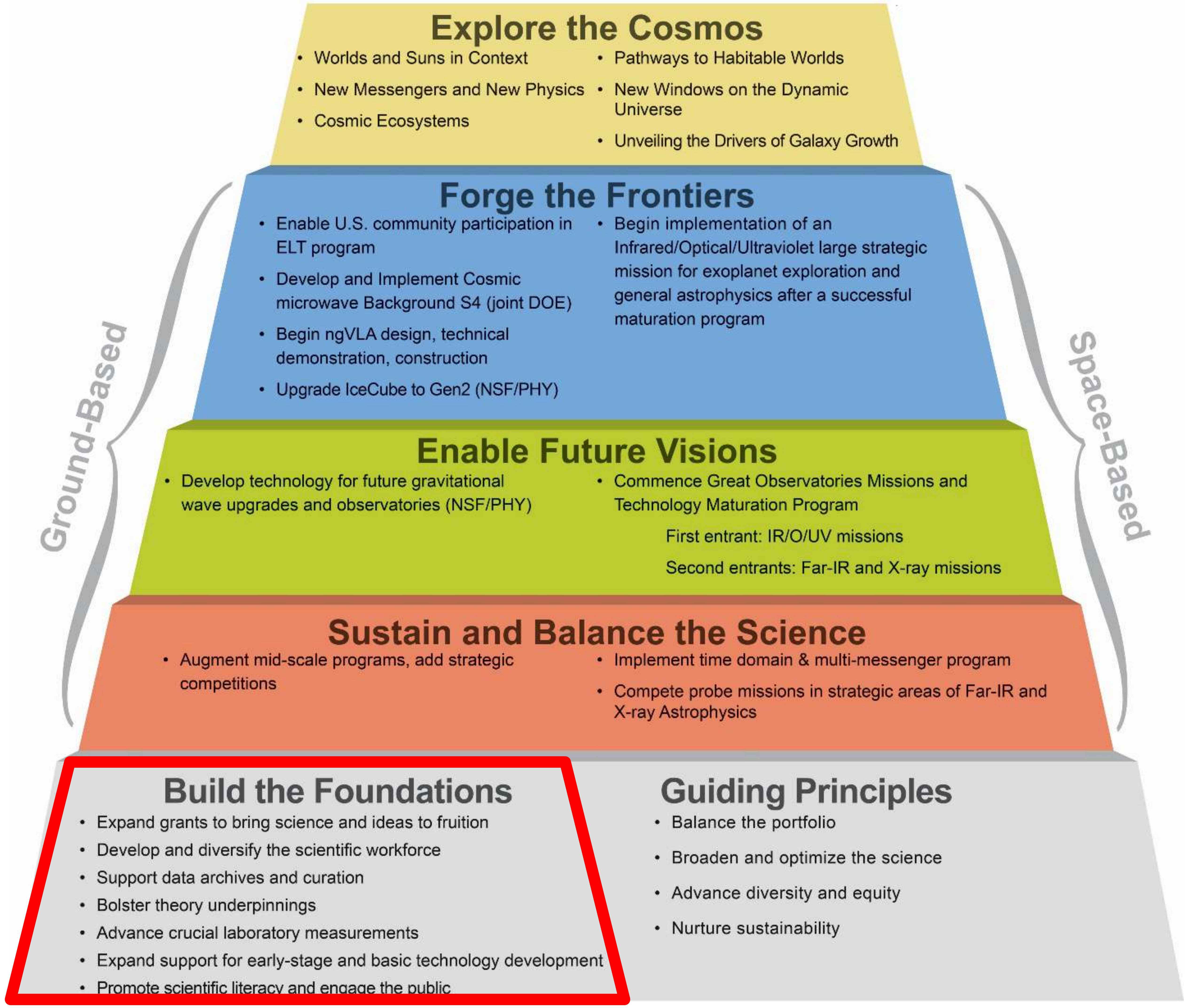
Priority Area: Unveiling the Drivers of Galaxy Growth

The priority area involves unveiling the drivers of galaxy growth, focusing on processes affecting galactic scales

The needed capabilities include:

- ELTs to observe galaxies in the young universe
- A next generation radio telescope to map emission lines of molecular gas, tracing cold gas
- A next generation IR/O/UV space telescope to trace the details of the nearby, evolved universe
- FIR and X-ray missions to peer into the dusty hearts of galaxies to reveal enshrouded black holes, and trace the hottest gas phases
- Investments in theory to realize a new scientific foundation for understanding galaxy evolution

Realizing the Astro2020 Program: Pathways From Foundations to Frontiers



The National Academies of
SCIENCES · ENGINEERING · MEDICINE

The Profession and its Societal Impacts

"The pursuit of science, and scientific excellence, is inseparable from the humans who animate it."
-- Panel on the State of the Profession and Societal Impacts

Guiding principles: diversity, equitable access, benefits to the nation and the world, sustainability and accountability

Astro2020 report includes 10 recommendations in this area

Here we provide a brief synopsis: see the full report for additional discussions of education, career paths and pipelines, public outreach and engagement, climate change, and benefits to the nation

The Profession and its Societal Impacts

Areas of key recommendations for the state of the profession

- Collecting demographic data to understand equity in funding
- Diversity of the profession
  - Improving diversity of project and mission teams
  - Investing in and sustaining workforce diversity ”bridge” programs
  - Undergraduate and graduate traineeship programs
- Professional policies related to harassment and discrimination
- Community relations
- Dark skies and protecting the radio frequency spectrum

アメリカの教員への応募では必須

Statement on Advancing Diversity, Equity, and Inclusion

[redacted]

Introduction

I firmly believe that *diversity* plays a key role in advancing science. The variety of world views and ways of thinking, arising from our personal experiences and the culture we grew up in, is a tremendous resource of new ideas, viewpoints, critical questioning of existing paradigms, and stimulating discussions. In comparison with the world at large, the average conference room in high energy particle physics is sadly quite uniform, both in the audience and the selection of speakers. I am dedicated to changing this as best I can. This is, of course, a challenging task with no simple magical solutions. We need to proactively ensure *equity*, the fair treatment and access to support for those who have had structural issues and barriers placed in their career paths. The current worldwide COVID-19 crisis is tremendously increasing those barriers for some, with many children cut off from the education and programs provided by their schools. It will be an additional challenge in the upcoming years to reach out to and support these young people. Finally, I strive to achieve a high level of *inclusion* in scientific environments by providing a welcoming and respectful atmosphere. Research thrives on asking critical questions and recognizing mistakes, so I believe it is crucial to value all contributions to a discussion, encourage questions, and openly admit errors. I also believe it is important (and often neglected) to provide feedback, both critical and positive, to students and colleagues.

Advancing diversity, equity and inclusion is a complex and multi-dimensional task. In this statement I will focus mainly on aspects of geographic, socioeconomic and gender diversity, but other aspects such as race, ethnicity, religion, language, abilities/disabilities, sexual orientation are by no means less important. Some aspects which I discuss here can be extended into these other directions, but the complexity necessitates a multitude of carefully tailored steps to address them all.

Track record

As an undergraduate, I spent a semester in Singapore and travelling the neighbouring countries of Southeast Asia, curious to explore the world beyond the boundaries of Europe. I learned some science there, too, but mostly I was impressed by cultural differences, some of them rather entertaining but others leading me to seriously question my views of the world. I was deeply impressed by the hospitality and the open-mindedness of people who in my 'western' eyes were bitterly poor and had very little education. After finding myself stranded in the countryside of Laos during a motorcycle tour, a schoolteacher in a remote village brought me into his home. The next day when I met his students, I was struck by their tremendous enthusiasm for science; at the same time it was sadly clear that these kids had little chance of any higher education. I felt there was little I could do, beyond setting up their only computer, answering some questions, and helping them to practice English. Later on in my career, I have tried to create opportunities for students and young researchers from countries which are not traditionally strong in natural sciences. I have given talks and visited research institutes in Vietnam and India, and recently, during the COVID-19 crisis, I gave a public lecture to undergraduate students in Bangladesh. Last year, I was a co-organizer of a workshop on gravitational waves at ICTP, Trieste, with a special budget and strategy to attract participants from developing countries.

I also strive to improve the gender balance in natural sciences. As a postdoc in Paris, I was

Statement on Contributions to Advancing Diversity, Equity, and Inclusion

[redacted]

The lack of diversity in physics as a whole and in theoretical particle physics in particular is a serious problem. I believe that there is a lot that I can do as a professor to try to increase the number of women and members of underrepresented minorities in the field. Below I outline some of the strategies that I have implemented towards this end since starting at the University of Michigan and transitioning to LBNL. I have been actively approaching this problem from two different perspectives. First, I work to encourage women and members of underrepresented minorities to consider careers in theoretical physics. Second, I work to promote researchers from underrepresented groups already in the field.

In my first semester at Michigan it became clear to me that while there are many white women and members of underrepresented minorities in the department, these undergraduate and graduate students were not approaching me about research opportunities. After talking with colleagues, I started to suspect that many of these students were simply more intimidated about approaching the faculty, especially in the particle theory group. To counter this issue I decided to approach Zhiquan Sun, an extremely strong undergraduate student in my advanced physics class, to see if she would be interested in working in my research group. She was enthusiastic and told me that she was hoping to work with someone in the theory group on a research project but felt too intimidated to approach anyone directly. My work with Zhiquan has been extremely successful, and we have authored three papers together. I encouraged her to present some of her work at the APS conference in Denver in 2019, where she made valuable connections with successful female faculty members in the field (who I asked in advance to chat with Zhiquan). I also encouraged her to apply for the FUTURE of Physics workshop at Caltech for aspiring young women in physics in the fall of 2019. I nominated her for the program and her application was successful. She said that the program made her excited about graduate school and helped her ease her sense of impostor syndrome. I helped Zhiquan prepare her graduate school applications, and she was accepted to an impressive number of top programs in theoretical physics, including MIT, Princeton, Stanford, and Caltech; she is now pursuing a PhD in theoretical physics at MIT.

Last year I tried applying the same hiring approach to graduate students. I was frustrated that our incoming class of graduate students interested in high-energy phenomenology was almost exclusively male, so I searched through the applications of the incoming class and found that one of the graduate students (Yujin Park) who was accepted for cosmology theory indicated on her application that one of her main interests is dark matter. I contacted her over the summer of 2019 to see if she would be interested in discussing research prospects with me, and I started having conversations with her. I quickly discovered that she was is fact most interested in working on exactly the type of physics done in my group but that she felt intimidated by the high-energy theory group and so was planning to approach faculty members in cosmology instead. Yujin and I have been working together now for around a year, and I have found her to be a very strong physicist. We are currently finishing our first paper together. One point that I have taken away from these experiences is that there may be barriers that make it less likely for students from underrepresented groups to contact faculty directly about research opportunities. One way to help work around this is to contact promising students from these groups directly, which is an approach that I plan to continue in the future.

In 2019/2020 I served on the Michigan graduate admissions committee, and I was specifically in charge of phenomenology and cosmology theory applications. I am proud to have helped recruit one of the most diverse groups of incoming students, starting in fall 2020, in these subfields in recent years at Michigan. I believe that part of this success was due to an aggressive recruiting strategy that I adopted, where I spent extra time encouraging women and members of underrepresented minorities to attend Michigan. In the future I would like to continue exploring ways to increase the diversity of incoming graduate students in high-energy theory, phenomenology, and cosmology.

In addition to encouraging white women and members of underrepresented minorities to consider careers in theoretical physics, I believe that serious effort needs to be done to make sure that these aspiring researchers stay in the field. In my own group I try to foster an inclusive atmosphere, where everyone feels comfortable and respects professional boundaries. At the same time I try to make sure that my group feels like a community, for example we all have lunch together almost every day (since going virtual due to COVID-19 we all have a daily virtual coffee time), as I believe that having a sense of belonging is especially helpful for members of underrepresented groups in maintaining confidence with their career choices.

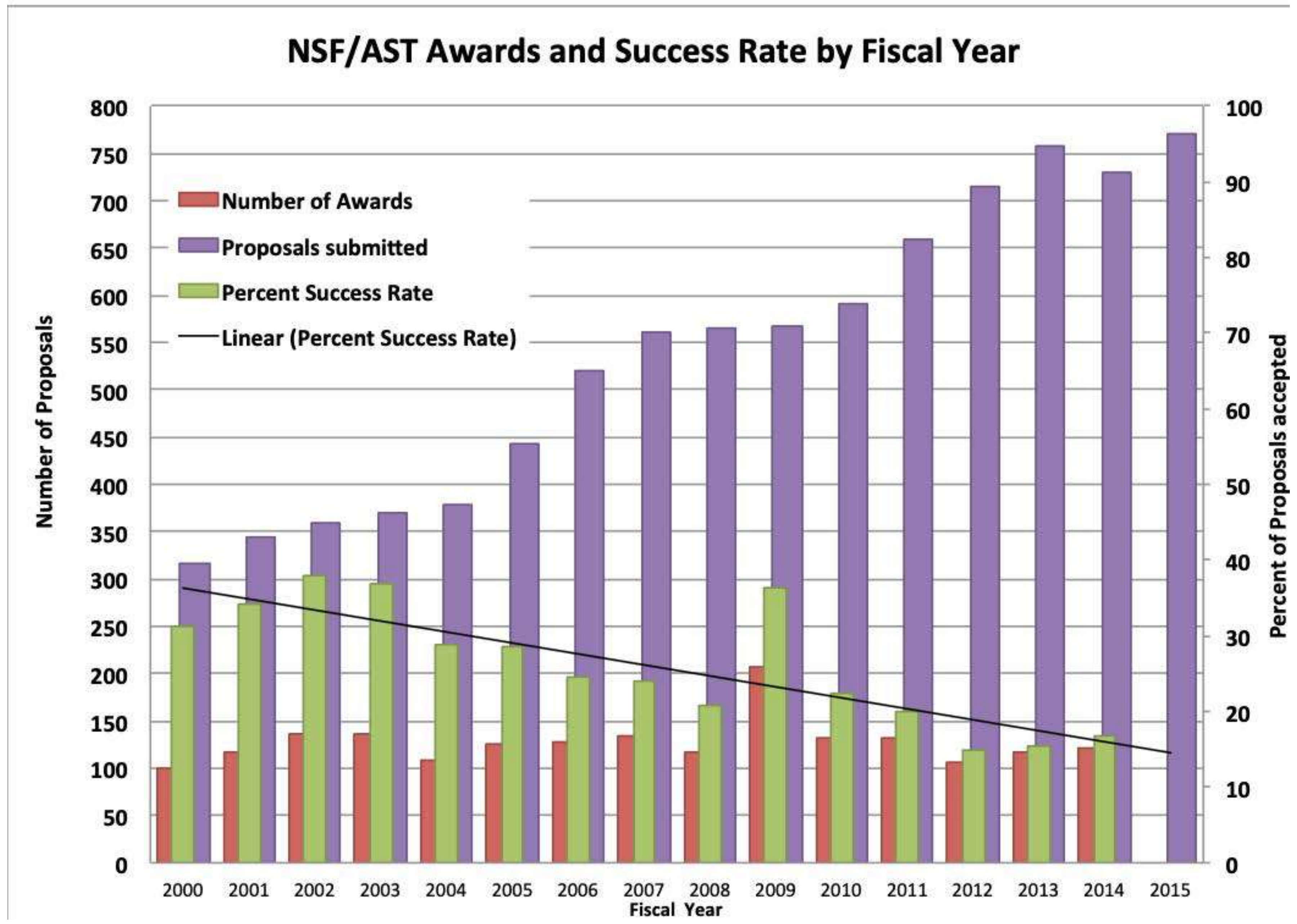
At the professional level I make an effort when organizing seminars, conferences, and workshops to include a diverse array of participants and speakers. I have organized multiple conferences and workshops, and this is always one of my

NSF Investigator Grants Programs

The NSF AAG program is a cornerstone of the enabling research foundation

Over the past 20 years success rates have steadily declined from 45% to 25% or lower; much lower for first-time proposers

These grants are crucial for achieving the scientific goals of the decadal survey



Recommendation: NSF should increase funding for the individual investigator Astronomy and Astrophysics Research Grants by 30 percent in real dollars (i.e. above the rate of inflation) over five years from 2023-2028 starting with the FY 2019 budget inflated appropriately. This will have the effect of restoring success rates to a healthy competitive level

The Frontiers: Major New Projects and Sustaining Programs

The compelling programs recommended by past surveys are vital to the scientific vibrancy of the coming decade

Ground

- Midscale Innovations Program
- Daniel K. Inouye Solar Telescope
- Vera Rubin Observatory

Space

- Explorer Program Augmentation
- James Webb Space Telescope
- Roman Space Telescope
- US Contribution to Euclid
- US Contribution to Athena
- US Contribution to LISA

Conclusion: The Survey's recommendations for advancing the new programs or augmentations are predicated on the assumption that the major astrophysics facilities and missions in NASA, NSF, and DOE's current plans are completed and fully supported for baseline operations and science

Space Program Medium/Large Programs Overview

Enabling and Realizing Large Strategic Missions

Great Observatories Mission and Technology Maturation Program

Infrared/optical/UV mission

High resolution X-ray imaging mission

Far-IR imaging and spectroscopy mission

2022

Review

2032

Implement Infrared/optical/UV mission

Sustaining Programs

Time Domain Astrophysics Program

A Competed Line of Probe Missions with areas identified by Decadal Surveys

Recommended Missions for Maturation

Highest Priority:

- *An IR/O/UV Large Telescope Optimized for Observing Habitable Exoplanets and General Astrophysics*

  To the program as soon as possible. Target cost for mission: 11B$ (FY20). Analysis estimates maturation program of ~six years, $800M required before review and transition to mission adoption

Of Co-equal Priority:

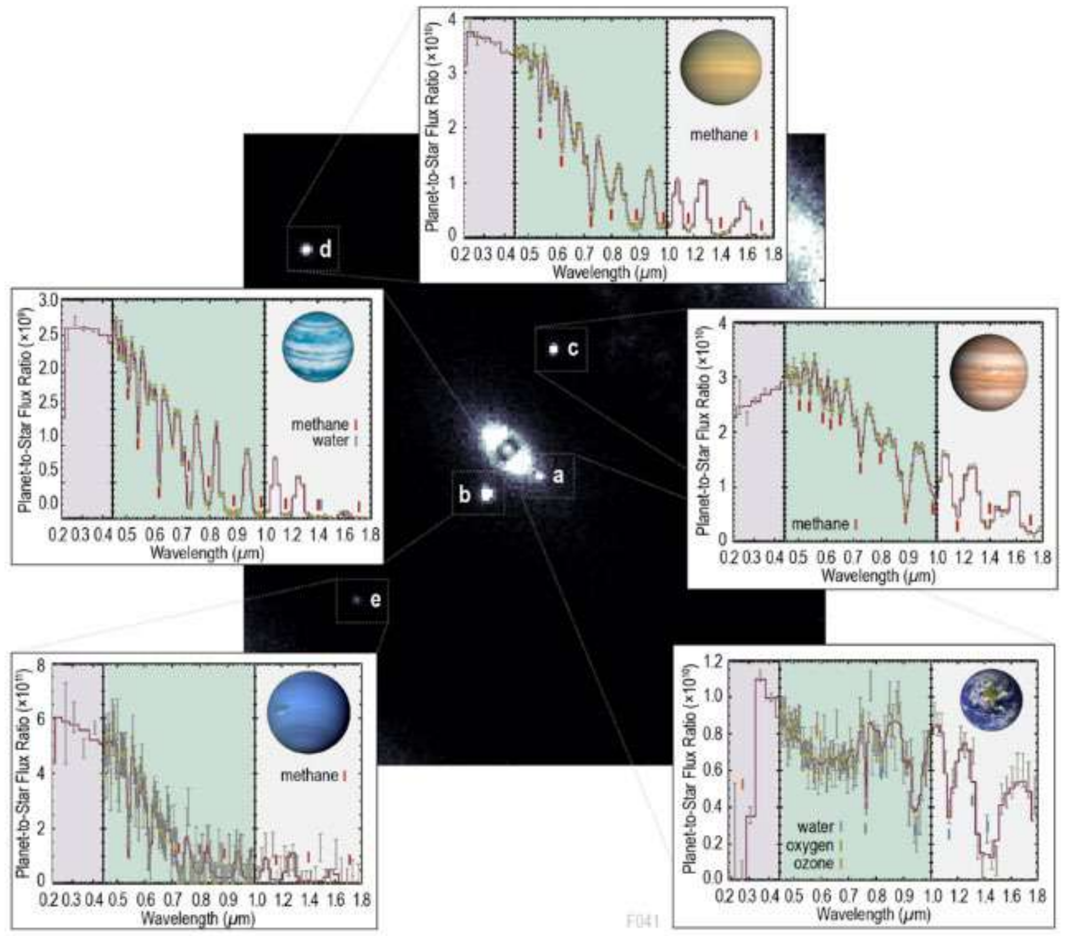
- *A far-IR spectroscopy and/or imaging strategic mission*

  To start mid-decade. Target cost for mission: 3 – 5 B$ (FY20). ~40M$ per year required for maturation program this decade

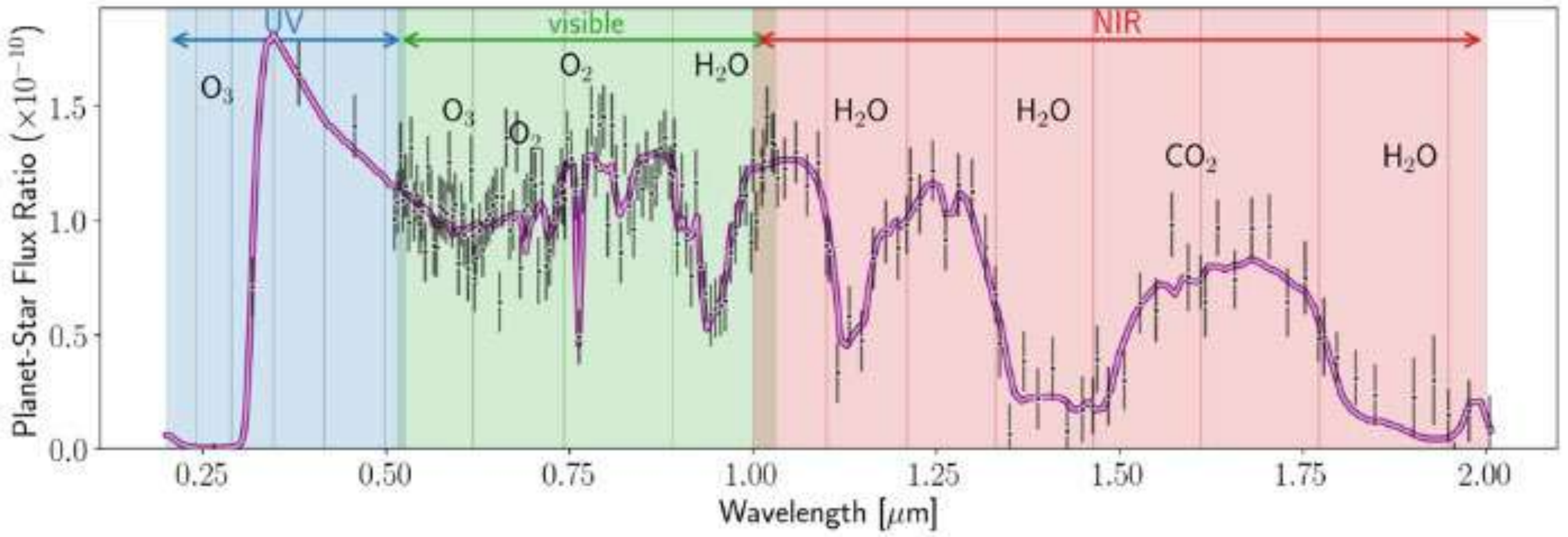
- *A high spatial and spectral resolution X-ray strategic mission*

  To start mid-decade. Target cost for mission: 3 – 5 B$ (FY20). ~40M$ per year required for maturation program this decade

A Future IR/Optical/UV Telescope Optimized for Observing Habitable Exoplanets and General Astrophysics



Simulated space-telescope image of a complete planetary system including a life-bearing Earth-like planet



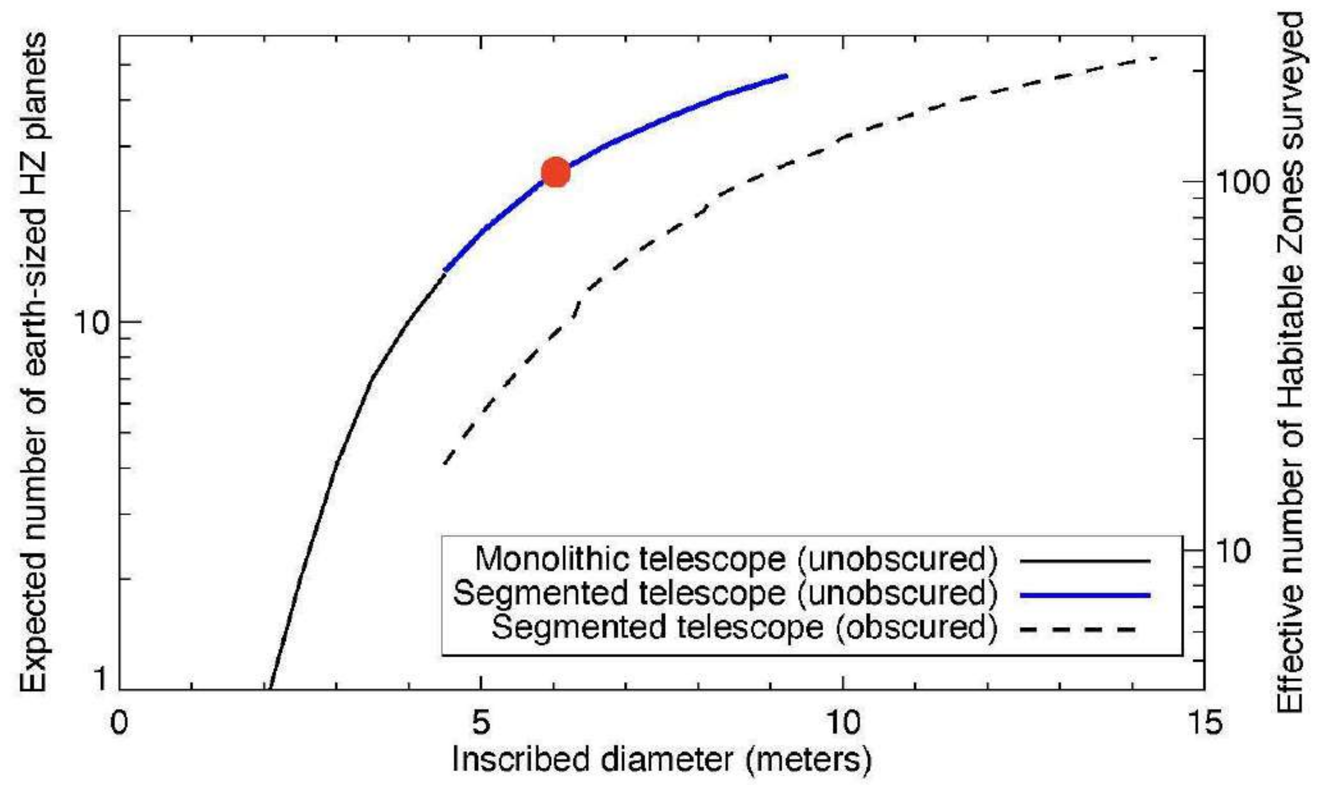
Simulated spectrum of an Earth-twin planet observed from the UV to near-IR by a space coronagraph

Recommendation: After a successful mission and technology maturation program, NASA should embark on a program to realize a mission to search for biosignatures from a robust number of about ~25 habitable zone planets and to be a transformative facility for general astrophysics. If mission and technology maturation are successful, as determined by an independent review, implementation should start in the latter part of the decade, with a target launch in the first half of the 2040's

A Future IR/Optical/UV Telescope Optimized for Observing Habitable Exoplanets and General Astrophysics

IR/O/UV Telescope Characteristics

- ~6 m off-axis inscribed diameter provides robust sample of ~25 spectra of potentially habitable planets, and would be transformative for general astrophysics
- Estimated cost: 11B$
- Target launch: first half of 2040's



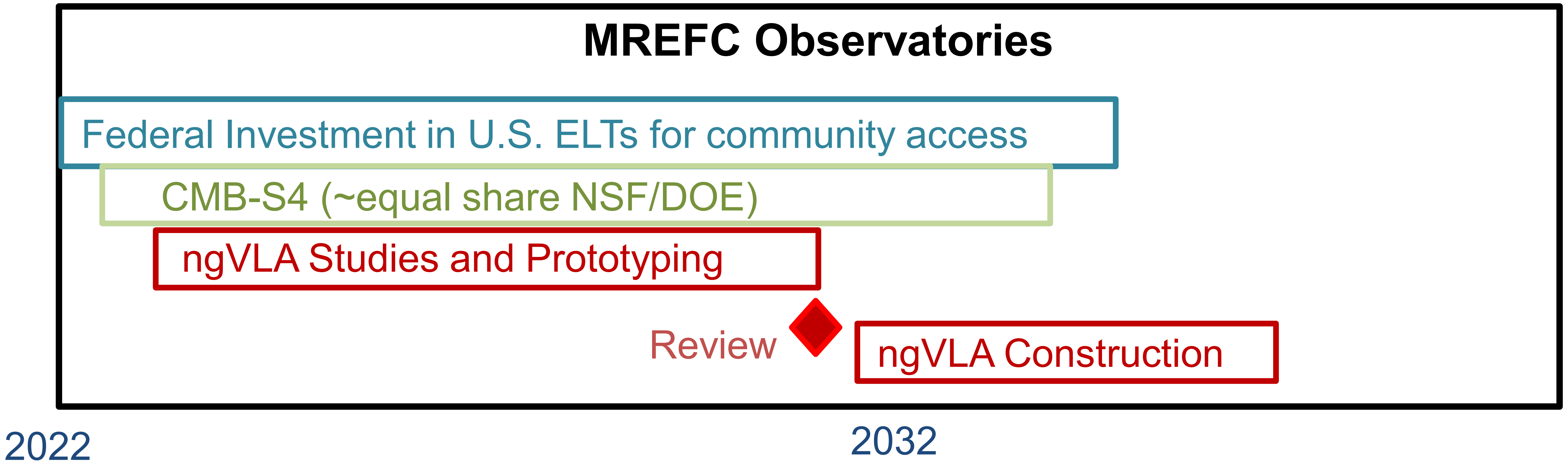
The scientific goals of this mission, when achieved, have the potential to change the way that we as humans view our place in the Universe

With sufficient ambition, we are poised to make this transformational step

This is a quest at the technical forefront, and of an ambitious scale that only NASA can undertake, and where the U.S. is uniquely situated to lead

Ground Medium/Large Program Overview

Enabling and Realizing Major Observatories



Sustaining Programs

Enhancements to Astronomy Mid-scale Programs

Endorsements for Programs in NSF/PHYS

Technology Development for Future Gravitational Wave Observatories

The IceCube-Generation 2 High Energy Neutrino Observatory

NSF Funding for Major Research Facilities

Astronomy frontiers have been driven by new observatories

Construction costs have been borne by MREFC

Operations costs then transfer to AST

This is not sustainable

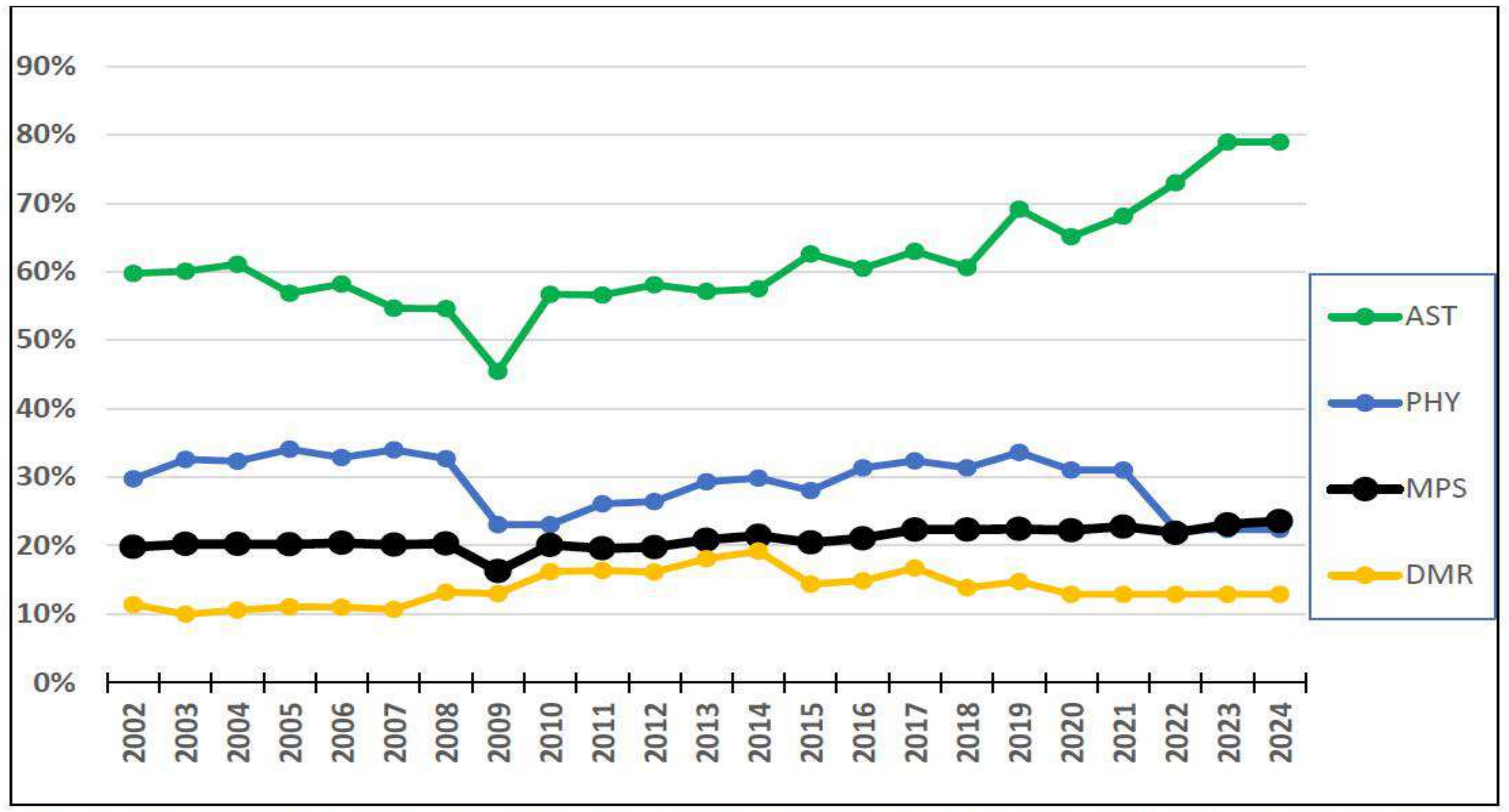
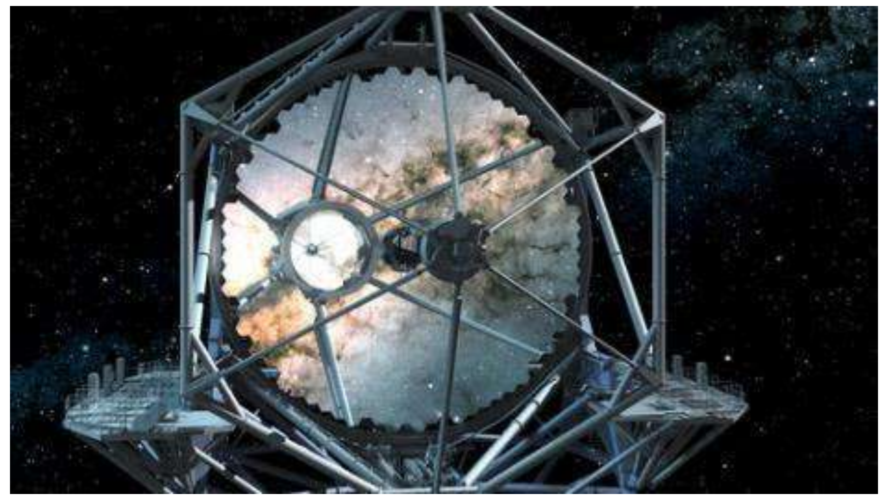


Figure 2, Percentage of Selected MPS Division Budgets to Facilities (O&M) and Overall MPS Share. AST: Division of Astronomical Sciences, PHY: Division of Physics, MPS: Directorate of Mathematical and Physical Sciences, DMR: Division of Materials Research

Recommendation: The NSF should develop a sustainable plan for supporting the operations and maintenance costs of its astronomical facilities, while preserving an appropriate balance with funding essential scientific foundations and the remainder of the NSF AST portfolio. *The addition of new MREFC facilities should be contingent on implementation of this plan*

U.S. Extremely Large Telescope Program



Thirty Meter Telescope

Giant Magellan Telescope

The scientific potential of 20-40m optical-infrared telescopes is vast

- resolution of 0.01-0.02 arcsec with adaptive optics

  1-2 au @ 100 pc, 0.8-1.6 pc @ Virgo cluster, 60-120 pc @ z=2.5 (!)
- 36-81x gain for point sources over 10-m telescopes (scales as D^4)
- immense range of scientific goals

  detection, imaging, spectroscopy of rocky planets, exoplanet atmospheres, protoplanetary disks; high-z supernovae and GRBs, cosmological yardsticks; spectroscopy of faint JWST sources; spectra of CGM/IGM, stellar fossil records of Galaxy, …

The combination of TMT, GMT, and NOIRLab (for community and science support) would provide the U.S. community with essential access to these transformative capabilities

US-ELT Program

Recommendation: The NSF should achieve a federal investment equal to at least 50 percent time for the U.S. community in at least one and ideally both of the two extremely large telescope projects – the Giant Magellan Telescope and the Thirty Meter Telescope, with a target level of at least 25% of the time on each telescope. If both projects are viable, then that time should be distributed across the two proposed telescopes. If only one project proves to be viable, the NSF should aim to achieve a larger fraction of the time, in proportion to its share of the costs and up to a maximum of 50 percent

Participation in both projects is the optimal outcome

- full-sky access
- maximizes public nights available (~180/yr total)
- exploit complementary instrumentation

If circumstances preclude participation of one observatory (financial, site availability) goal should be to obtain as large a share on the other as available

This is the survey's top priority MREFC recommendation due to the timeliness and transformative potential

US-ELT Program: Decision Rules

Prior to major investment by the NSF, a review must determine that:

- The projects have demonstrated financial viability with agreed-upon commitments from partners for all necessary capital and operations funds, pending only NSF investment
- A final site selection has been made in the case of the TMT
- A public share of telescope time (run through the NSF's NOIRLab) roughly equivalent to the NSF's share of total federal investment of construction and operations expenses
- Development of a management plan and governance structure for the joint project, including the relevant observatory corporations and the NSF

Success of both projects at the levels presented to the survey represents an NSF investment of 1.8 B$*, leveraging private and international investments of 3.6 B$, bringing these transformative observatories on-line early in the 2030's

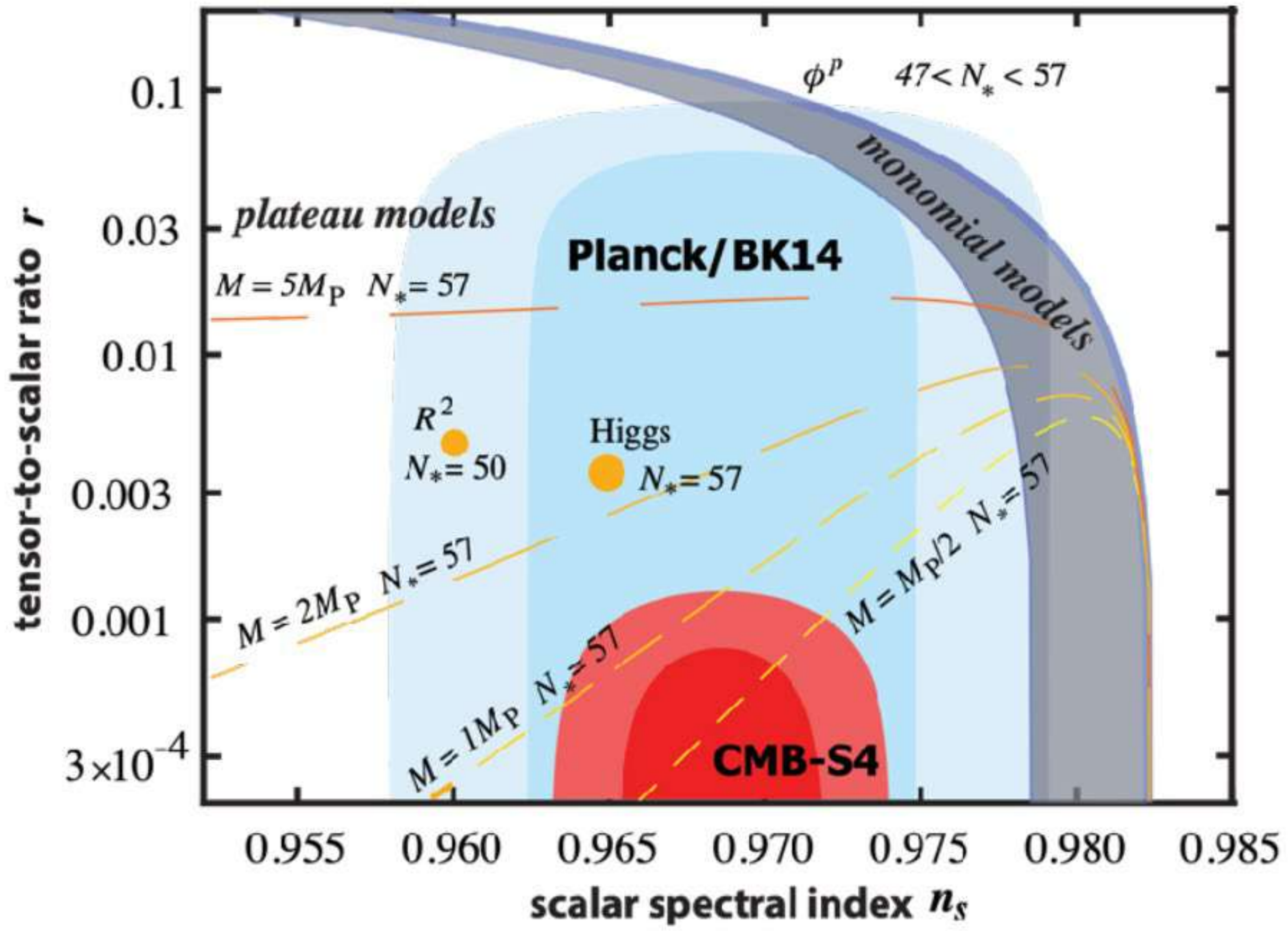
*Based on TRACE evaluation

The Cosmic Microwave Background Stage 4 Observatory

CMB-S4 builds on the foundation of decades of CMB measurements to take a major leap, pushing CMB science to the next level

Scientific goals

- B-mode CMB polarization signatures of primordial gravitational waves and inflation
- Maps 50% sky, every other day from 0.1- 1 cm with unprecedented sensitivity
- Broad science including systematic time domain science



CMB-S4 consists of a systematically planned suite of facilities in Antarctica and Chile designed to sample a wide range of independent frequencies, and probe a combination of large and small angular scales

The Next Generation Very Large Array (ngVLA)

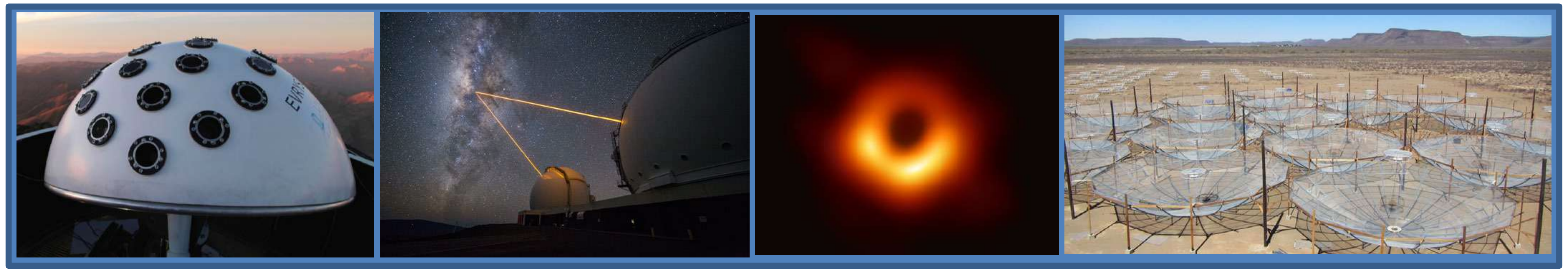
The ngVLA presented to the survey is a very ambitious project

- Estimated cost $3.2B (75% NSF, 25% foreign contribution TBD); operations >$100M/yr
- Up to 224 antennas arrayed across North America; operates from 1.2 - 116 GHz

Astro2020 concluded that the project scope and design need further development before a review determines the scope is appropriate, and before proceeding to construction

Recommendation: The NSF should proceed with a program to support science design, development, cost studies, and antenna prototyping for the Next Generation Very Large Array. After completion of the studies, NSF should convene a review to assess the project's readiness and available budget and proceed with construction if possible.

NSF Mid-Scale Program Background



Mid-scale (4 – 100 M$) competed programs harness the creativity of the community and fuel innovation

A broad, balanced scientific program demands expansion of opportunities at the mid-scale to fulfill strategic needs and harness innovations

Recommendation: The NSF Division of Astronomical Sciences (AST) should create three tracks within the AST Mid-Scale Innovations Program and within (its share of) the NSF-wide Mid-Scale Research Infrastructure Program. The first track should be for *regularly competed, open calls*, the second track should solicit proposals in strategically identified priority areas, and the third should invite ideas for upgrading and developing new instrumentation on existing facilities. All tracks should solicit proposals broadly enough to ensure healthy competition.

Technology Development for Future Ground-based Gravitational Wave Observatories

Gravitational wave detection is one of the most exciting and expanding scientific frontiers impacting central questions in astronomy

- Directly relevant to two Astro2020 priority areas: New Windows on the Dynamic Universe, Hidden Drivers of Galaxy Formation

More advanced detectors in the current LIGO facility (beyond A+) and planning for future generation facilities such as Cosmic Explorer are essential

Conclusion: … Continuous technology development will be needed this decade for next generation detectors like Cosmic Explorer. These developments will also be of benefit to the astrophysical reach of current facilities.

IceCube-Generation 2 Neutrino Observatory

IceCube at South Pole detects 100 TeV – 10 PeV cosmic neutrinos

Upgrade to Generation-2 observatory will add detector elements and a radio array to increase sensitivity (5x), detection rate (10x), and energy range (to 1000 PeV)

- resolve diffuse (currently) cosmic neutrino background
- localize, identify individual astrophysical sources
- coordinated multi-messenger observations

Conclusion: The IceCube-Generation 2 neutrino observatory would provide significantly enhanced capabilities for detecting high-energy neutrinos, including the ability to resolve the bright, hard-spectrum TeV-PeV neutrino background into discrete sources. Its capabilities are important for achieving key scientific objectives of this survey

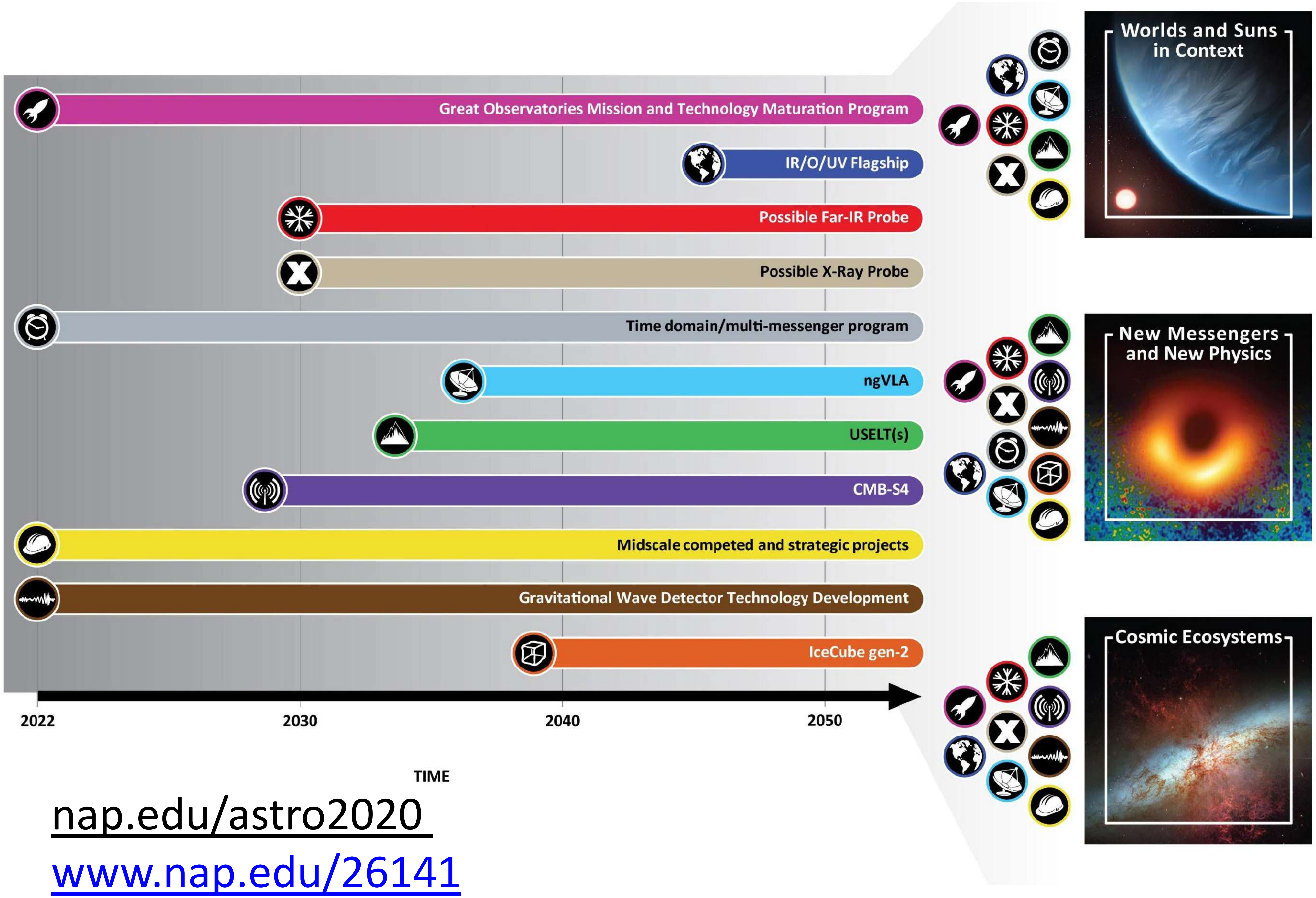
Consistency with Budget Guidance

Agency budgets projected forward are uncertain

We planned our program to be within the optimistic scenarios provided by the agencies (time averaged)

The program we set forth allows for future opportunities

We live in exciting times for astronomy and astrophysics. Amazing scientific opportunities lie in front of us that strongly motivate increased investment in the future



nap.edu/astro2020

www.nap.edu/26141

日本でこれができるか？

- 学術会議が持つ性格・役割はかなり違う
  - 「日本学術会議の役割は、主に以下の4つです。
    - 政府・社会に対して日本の科学者の意見を直接提言
    - 市民社会との対話を通じて科学への理解を深める
    - 地域社会の学術振興や学協会の機能強化に貢献
    - 日本を代表するアカデミーとして国際学術交流を推進」
- 省庁が関わる仕組みがない
  - 文科省は自前で委員会を作る
  - 予算に結びつくプロセスにならない
  - マスタープランはなくなってしまい、学術フロンティアに結びつかない
- 日本独自のモデルが必要

Blueprint for P5 process

Put Captions Here

JoAnne Hewett, HEPAP chair

Preliminary timeline

- Form panel by early Fall
  - Call for nominations for P5 members in early Aug 2022
  - Panel members wear a community hat
- Hold hybrid in-person/virtual townhalls in Fall 2022
  - Aim for further community input and further information on potential future projects
  - Opportunity for each panel member to start with equal footing covering all frontiers
- Deliberations Winter/Spring 2023
  - Will provide ample opportunity for further community input
- Aim for report late Spring/Early Summer 2023 for HEPAP to approve and submit to DOE/NSF

Process to select a chair

- Developed a set of criteria/attributes
  - Broad understanding of the field scientifically
  - Well respected
  - Understanding of the agencies and how they work
  - Experience with both universities and labs, and projects
  - Responsible
  - No bias or major project/institution in the race – wears a “big hat” for the good of the whole field
  - Helps people to work together
  - Will see the program through and able to follow up after the report.
- Agreement between DOE, NSF, HEPAP Chair

Hitoshi Murayama

Put Captions Here


symmetry
dimensions of particle physics
topics
follow +
A joint Fermilab/SLAC publication

Illustration by Sandbox Studio, Chicago with Corinne Mucha

Hitoshi Murayama brings people together

04/19/22 | By Kimberly Hickok

Building international research communities is a cornerstone of Murayama's physics career.

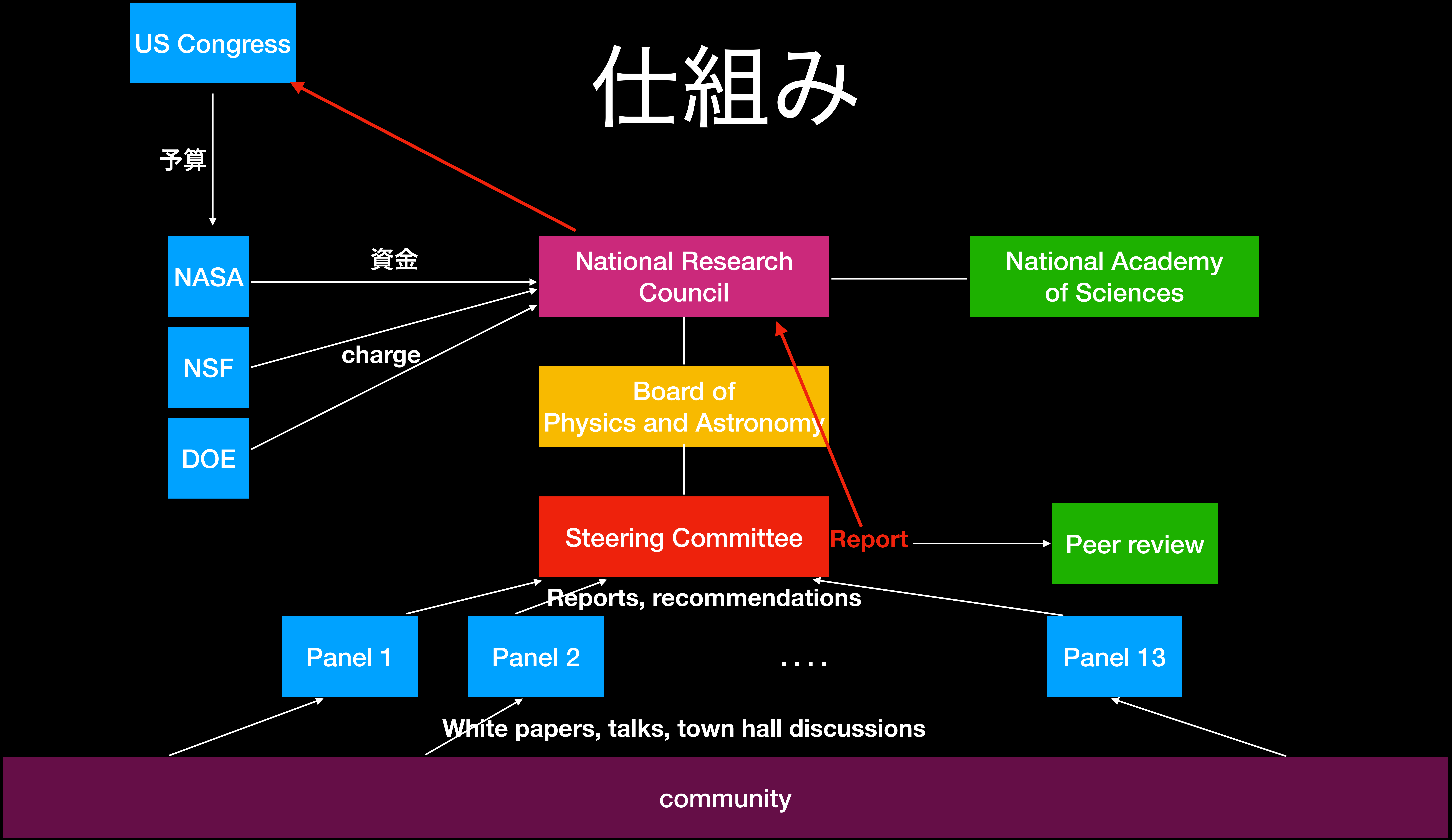
- MacAdams Professor of Physics at the University of California, Berkeley

JoAnne Hewett, HEPAP chair

- Faculty Senior Staff at Lawrence Berkeley National Lab
- University Professor, Kavli Institute for the Physics and Mathematics of the Universe, University of Tokyo
  - Member, American Academy of Arts and Sciences
  - Fellow, American Association for the Advancement of Science
  - Fellow, American Physical Society
  - Humboldt Research Prize
  - Breakthrough Prize (KamLAND)
  - Yukawa Commemoration Prize
  - Sloan Research Fellowship
  - Served on SLAC Policy Committee, HEPAP & subpanels, Fermilab Physics Advisory Committee, CERN Scientific Policy Committee, CEPC/SppC International Advisory Committee

JoAnne Hewett, HEPAP chair

仕組み


US Congress
予算
NASA
NSF
DOE
資金
charge
National Research Council
National Academy of Sciences
Board of Physics and Astronomy
Steering Committee
Report
Peer review
Reports, recommendations
Panel 1
Panel 2
. . . .
Panel 13
White papers, talks, town hall discussions
community