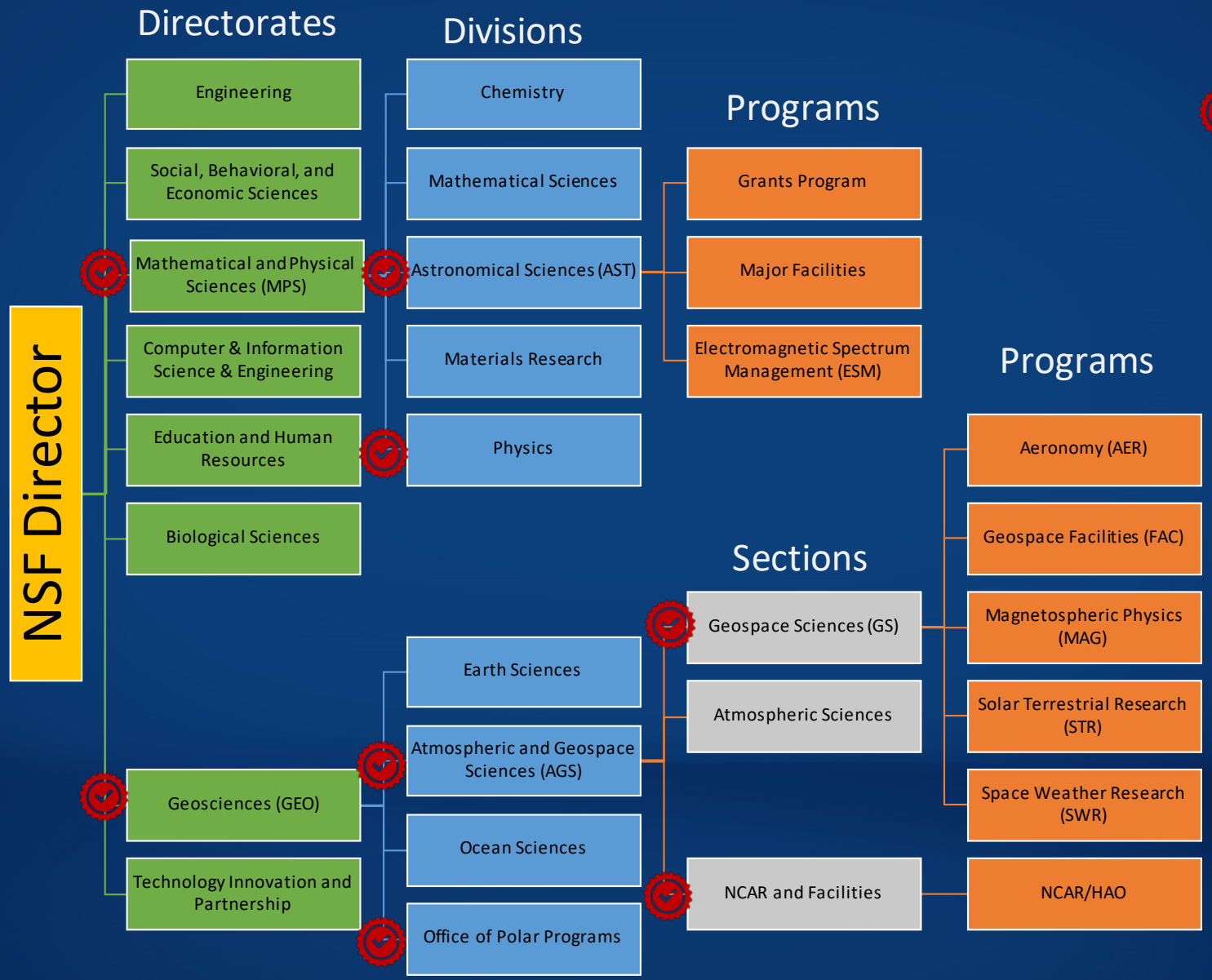
NSF and the Solar and Space Physics Decadal 2024-2033

Alan Liu, GS Section Head, GEO/AGS
Lisa Winter, PO GEO/AGS
Carrie Black, PO MPS/AST

Outline

- Overview of Programs that support solar and space physics
  - Overview of GEO Programs
  - Overview of MPS programs
- Overview of NSF and Priorities
- How NSF Uses Decadals
- Summary of NSF Needs

Solar and Space Physics Support at NSF



Supporting solar and space physics research and the 2024 decadal survey

Aeronomy
PO: Tai-Yin Huang



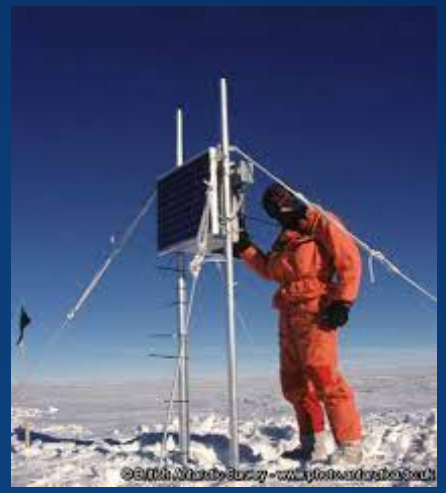

Program Summary:

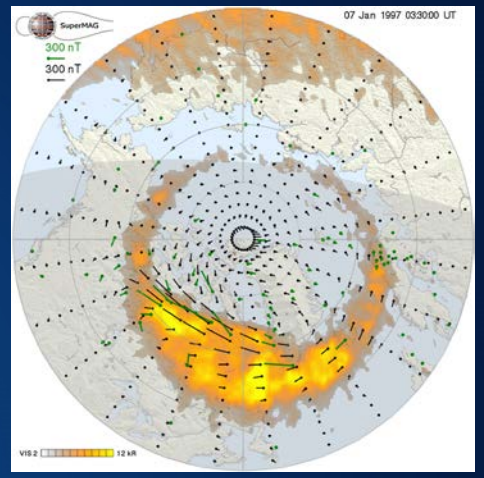
Supports research on the mesosphere, thermosphere and ionosphere of the Earth, with a focus on momentum within and between these regions, ionization, recombination, chemical reaction, photoemission, and the transport of energy.

Core Program:
https://beta.nsf.gov/funding/opportunities/aeronomy

Solicitation
Coupling, Energetics, and Dynamics of Atmospheric Regions (CEDAR):
https://www.nsf.gov/pubs/2022/nsf22570/nsf22570.htm

Magnetospheric Physics
PO: Chia-Lin Huang





Program Summary:

Supports research on Earth's magnetosphere and the coupling of the magnetosphere to the atmosphere and the solar wind

including energization by the solar wind; the origin of geomagnetic storms and substorms; the population by solar and ionospheric sources; the origin of electric fields; the coupling among the magnetosphere, ionosphere, and atmosphere; and waves and instabilities in the natural plasma.

GEM

Core Program:

https://beta.nsf.gov/funding/opportunities/magnetospheric-physics

Solicitation:

Geospace Environment Modeling (GEM):
https://beta.nsf.gov/funding/opportunities/geospace-environment-modeling-gem

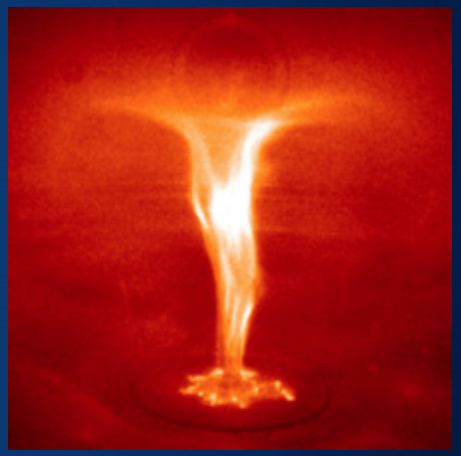
NSF

Solar Terrestrial Research
PO: Lisa Winter

Program Summary:

Supports research on the processes by which energy in diverse forms is generated by the Sun, transported to the Earth, and ultimately deposited in the terrestrial environment.

Includes: space weather impacts, helioseismology, the solar dynamo, the solar activity cycle, magnetic flux emergence, solar flares and eruptive activity, coronal mass ejections, solar wind heating, solar energetic particles, interactions with cosmic rays, and solar wind/magnetosphere boundary problems.



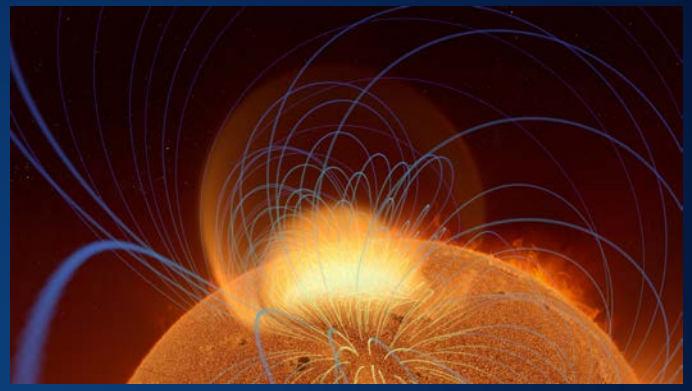
Core Program:
https://beta.nsf.gov/funding/opportunities/solar-terrestrial

Solicitation
Solar, Heliospheric, and INterplanetary Environment (SHINE):
https://www.nsf.gov/pubs/2022/nsf22570/nsf22570.htm

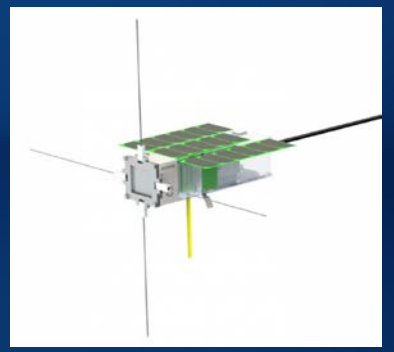
Space Weather Research
PO: Mangala Sharma

Program Summary:

- Funds innovations in *coupled Sun-Earth system* observing capabilities, CubeSat-based science missions, and extended network of observing capabilities
- Stimulates research in the development of integrative geospace system models and breakthrough advances to understand space weather
- Supports R2O2R and building resilience – e.g., NOAA, NASA, NSF, DoD partnership
- Funds targeted education and outreach activities – e.g., annual Space Weather Workshop, community conferences, summer schools




SuperDARN at Wallops



Geospace Facilities Program
PO: Roman Makarevich

Class 1: complex facility at a single site with a lifetime of 20+ years

- AMISR: Resolute Bay ISR–North (RISR-N), Poker Flat ISR (PFISR)
- Arecibo Observatory
- Jicamarca Radio Observatory
- Millstone Hill Observatory

Class 2: more modest and diverse investment (value-added products, model support, distributed networks)

- Active Magnetosphere and Planetary Electrodynamics Response Experiment (AMPERE)
- Community Coordinated Modeling Center (CCMC)
- Subauroral Geophysical Observatory
- Expanded Owens Valley Solar Array
- Distributed Arrays of Small Instruments (DASI)

GS Data Systems – In Development
PO: Tai-Yin Huang

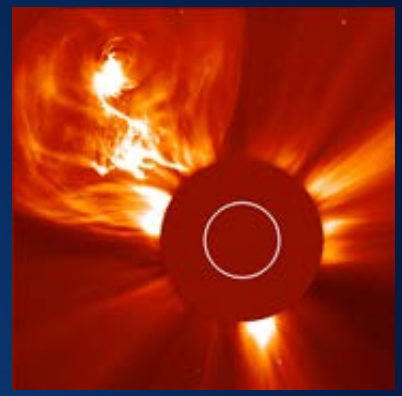
In response to the recommendation in the GS portfolio review: “Investments in Critical Capabilities for Geospace Science, 2016 to 2025”, the GS created a position to assess and help support the community’s Data Systems needs.
The overarching goal is to develop a funding mechanism to support the GS research community for their research products to be compliant with open science and the FAIR principles.

Immediate Goals:

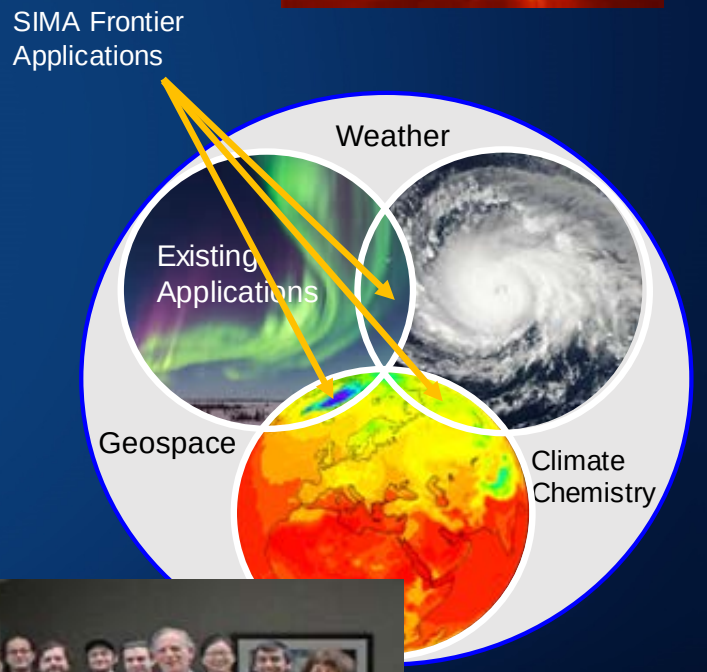
- To identify and create opportunities to address our community’s data systems needs
- To identify and address challenges faced by the community in implementing open science practices
- To explore opportunities to support open science and data systems infrastructure
- To leverage resources to maximize science returns

NCAR High Altitude Observatory

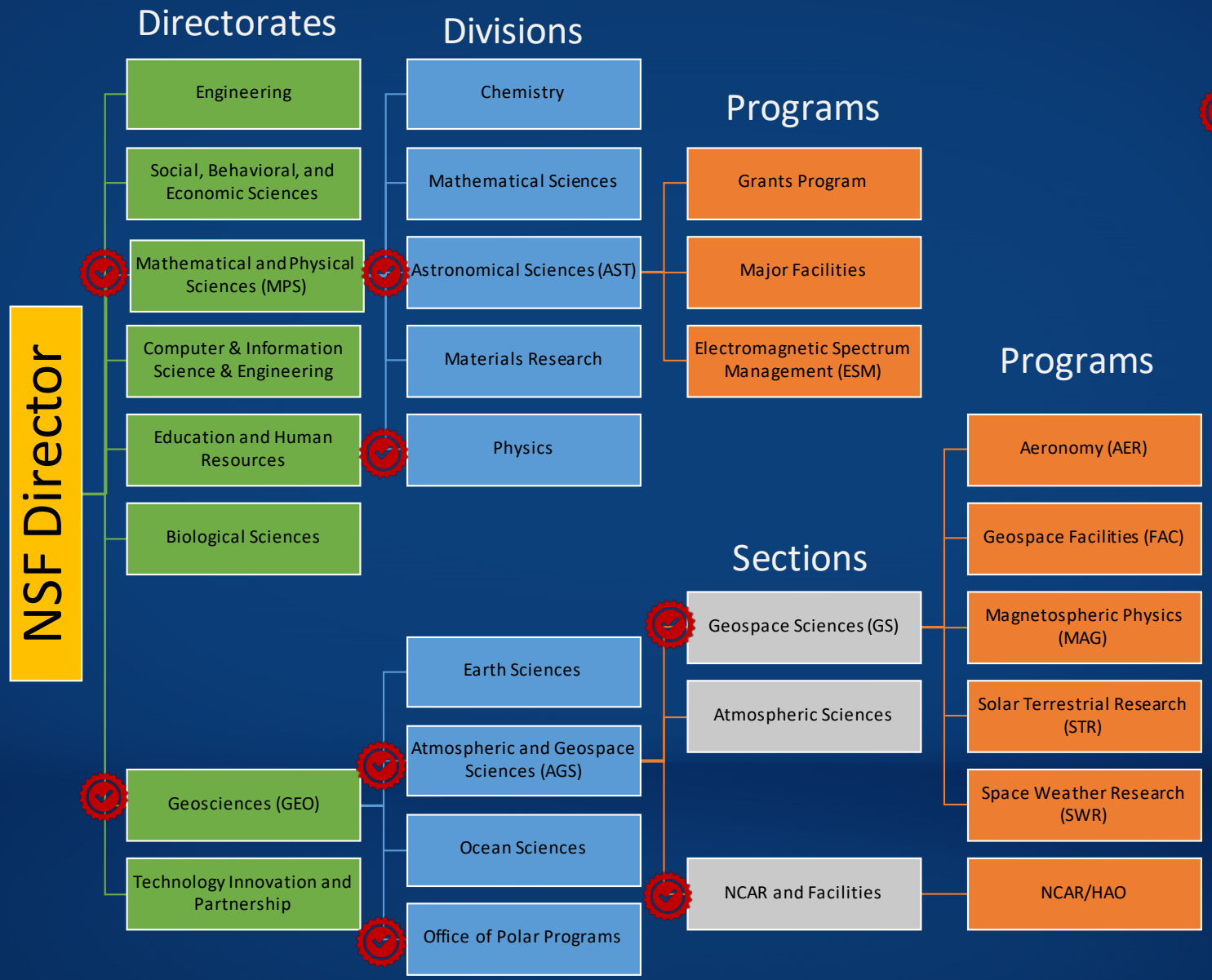
NCAR's bridge to the Earth-Sun coupled system



- Mauna Loa Solar Observatory (physical and data site)
- Observational Science (COSMO/COSADA)
- Model Development & Support (WACCM-X, SIMA)
- Education/Outreach/DEI

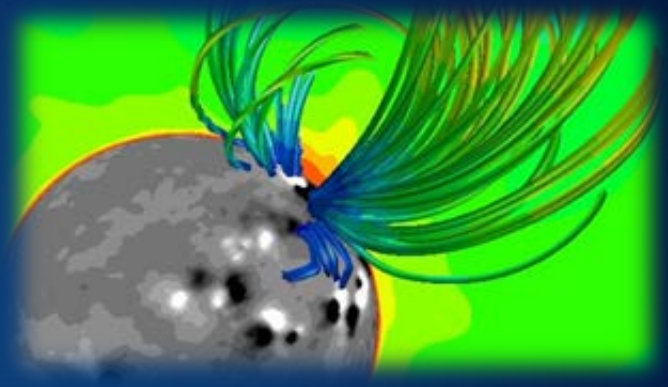


Solar and Space Physics Support at NSF



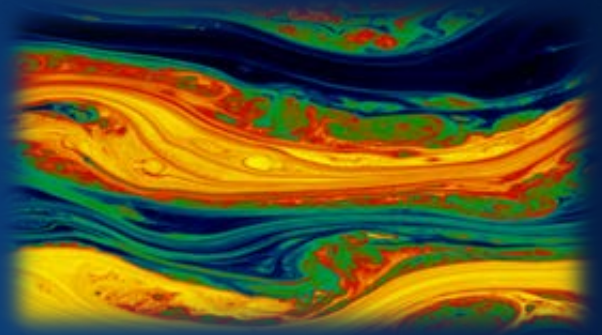
Supporting solar and space physics research and the 2024 decadal survey

Div. of Physics (PHY): Plasma Physics
PO: Vyacheslav Lukin



- Provides consistent support for the solar and space physics community in cooperation with NSF Geospace and others.
- Supports the laboratory and computational plasma physics communities that directly contribute to enabling discovery in solar & space science, as well as translational research focused on improving space weather prediction capabilities.
- Supports and manages many projects led by Principal Investigators from the solar and space physics community, such as *Cynthia Cattel (U. Minnesota), James Drake (U. Maryland), Gabor Toth (U. Michigan), Yi-Hsin Liu (Dartmouth C.), Anna Tenerani (UT Austin), Nikolai Pogorelov (UAH), Meers Oppenheim (Boston U.), Paul Cassak (WVU), and William Matthaeus (U. Delaware) among others*.
- PHY was proud to lead the joint **NSF-NASA *Next Generation Software for Data-driven Models of Space Weather with Quantified Uncertainties* (SWQU)** competition currently supporting six multi-disciplinary teams addressing the topic.
    - PHY in partnership with GEO and ENG has established a new cross-NSF program – **ECosystem for Leading Innovation in Plasma Science and Engineering (ECLIPSE)** – with the primary goal to "*identify and capitalize on opportunities for bringing fundamental plasma science investigations to bear on problems of societal and technological need*". Research efforts within the scope of the program may span the range from development of new computational methods and tools for space weather prediction to novel sensor development for cubesat-based geospace measurements.

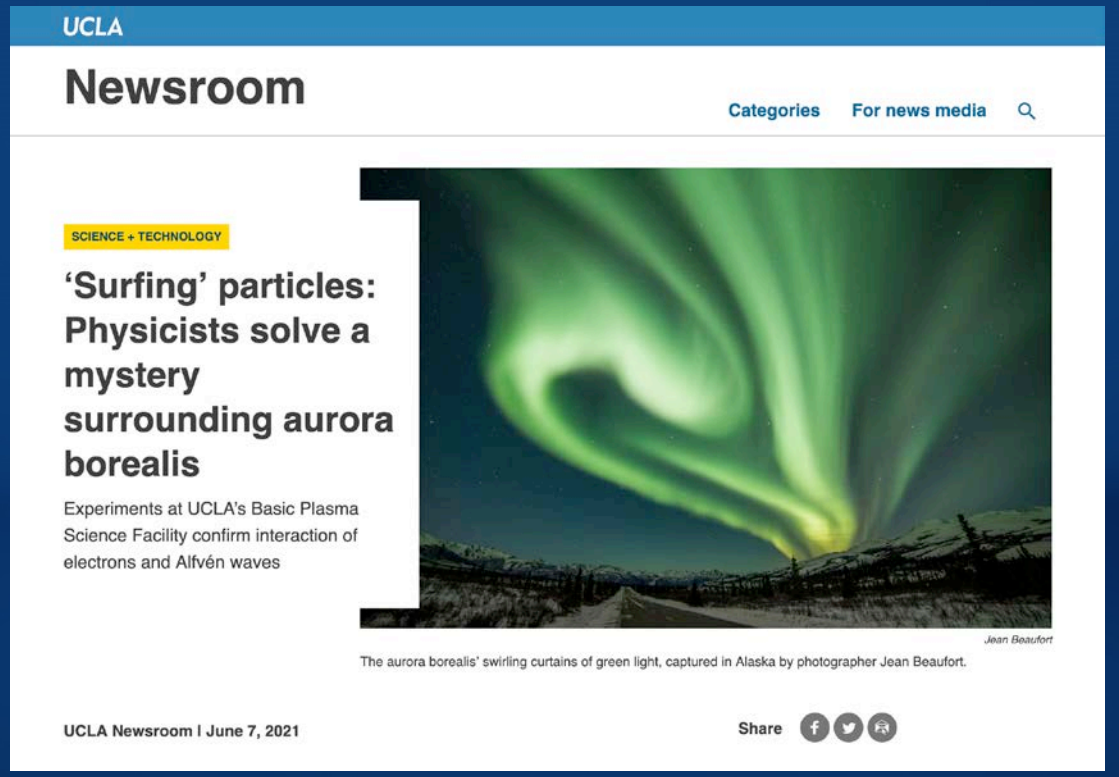
Div. of Physics (PHY): Plasma Physics
PO: Vyacheslav Lukin



We note the following in the guidelines for this Survey Committee:

The survey report should also ***consider experimental and theoretical plasma physics investigations*** *that would enhance progress on the prioritized science goals.*

- There are many examples of high impact space physics results enabled by laboratory-based plasma physics studies
- **We urge the Survey Committee to devote appropriate attention to this topic**


UCLA

Newsroom

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SCIENCE + TECHNOLOGY

‘Surfing’ particles: Physicists solve a mystery surrounding aurora borealis

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Jean Beaufort

The aurora borealis’ swirling curtains of green light, captured in Alaska by photographer Jean Beaufort.

UCLA Newsroom | June 7, 2021

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Astronomy Grants Programs

- Astronomy and Astrophysics Grants (AAG) Program
  - Main grants program in AST – all astronomy disciplines
  - Proposal pressure driven – provides flexible funding for emerging fields
  - Program Summary: Planetary, Astrophysics, and Solar Physics
    - Solar Physics includes: DKIST science, Outer heliosphere, planetary magnetospheres, astrospheres, space weather throughout the solar system and in astrospheres / for exoplanets
    - Solar physics proposals must make the case for the Sun as a star / astronomical object (as opposed to the sun as the dominant influence on Earth)
    - Fund coordinated work with space missions
- Advanced Technologies and Instrumentation (ATI)
  - Focused on technology development
- MidScale Innovation Program (MSIP)
  - Access to private facilities, new science programs, instrumentation, etc
  - $4M-$30M
  - Anticipate next solicitation for awards in FY24
- Plus agency wide program participation and fellowship support

National Solar Observatory

SOLIS

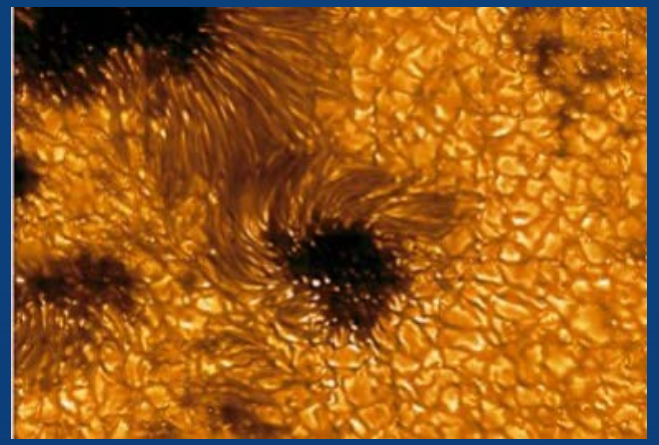
DKIST

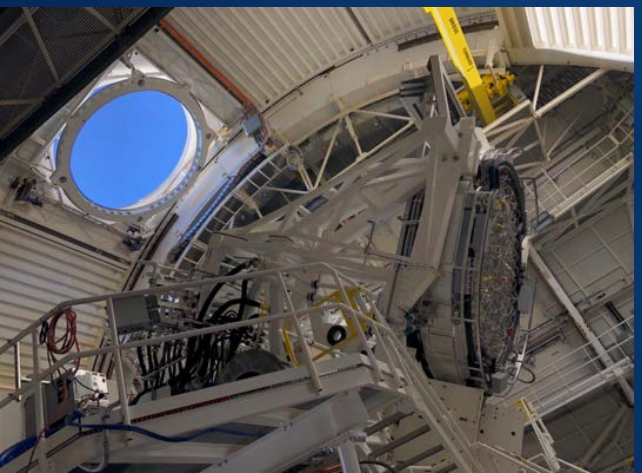
GONG – Cerro Tololo

Dunn Solar Telescope

Mission: The mission of the NSO is to advance knowledge of the Sun, both as an astronomical object and as the dominant external influence on Earth.

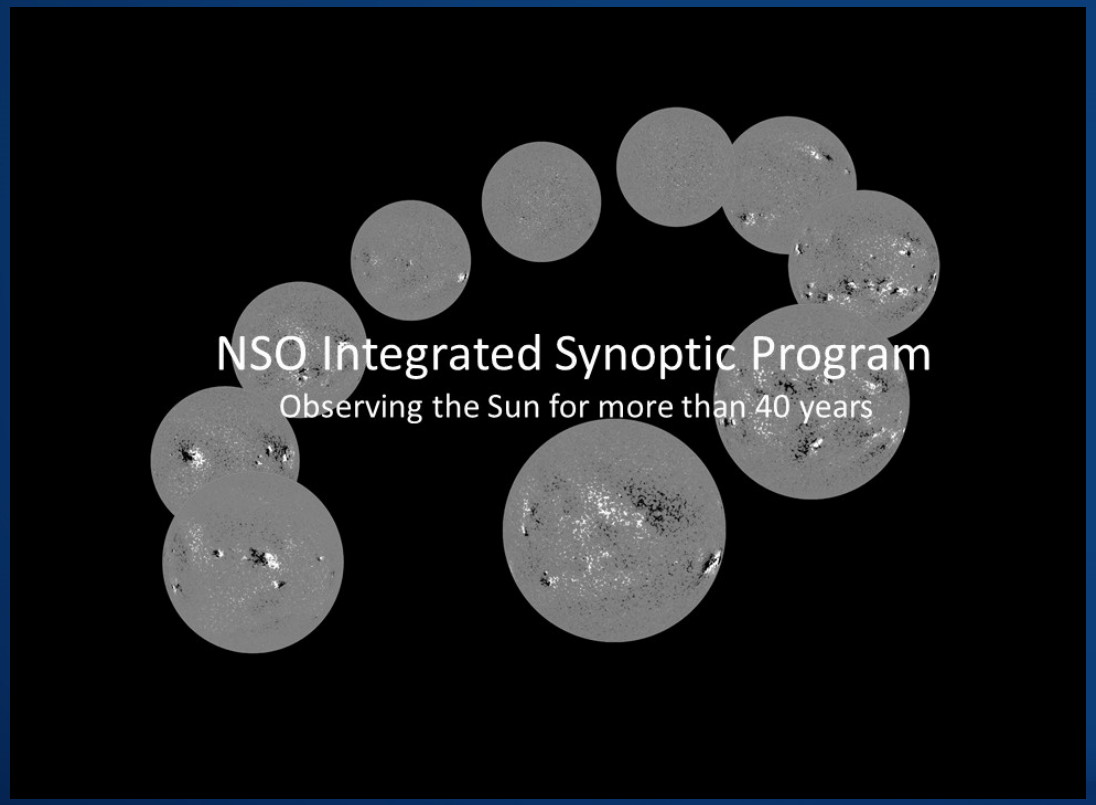
Forefront Capabilities: NSO operates the world's most extensive collection of ground-based optical and infrared solar telescopes and instrumentation.





Daniel K. Inouye Solar Telescope

- The largest, most powerful solar observatory on planet Earth
- Now in operations commissioning phase!
- Observations from first proposal cycle are ongoing.
- Second Call for proposals closed August 8, 2022
- What can NSF do to help the community optimize the science return from DKIST over the coming decade?



- SOLIS relocation to BBSO is almost complete
- GONG in its final stages of life.
  - Continued degradation expected over the next decade
  - End of life expected in early – mid 2030s.
- Next Generation GONG (ngGONG)
  - Programs in this range are competed in agency – wide MSRI and MREFC.
  - Strong science case decided by community consensus is essential for research infrastructure competitions
  - Community recommendation on scientific priority and implementation is needed

NSF Participation in Carrying Out NSWSAP

- 2012 Recommendation to recharter the National Space Weather Program
- Participants: AGS and AST
- NSF's role in SWORM is to support and identify fundamental science needs on the research side of the R2O2R chain.
- NSF supports several facilities whose fundamental science activities are extended to or overlap with operational activities
- Our ability to support SWORM must come through our grants process and documented community priorities.
- This decadal is an important documentation of community priority.

ASTRO2020 Outcomes of Note

- "…an appropriate role for astronomy and astrophysics decadal surveys is to comment on the value of ground-based solar physics projects for astronomy and astrophysics priorities, **with the solar and space physics decadal survey being the more appropriate body to prioritize and rank ground-based solar physics projects within the context of the full range of multi-agency activities in solar physics.**"
- State of the profession had many recommendations that would move the scientific communities toward inclusiveness and have prompted discussion within AST and AAAC including demographics data release

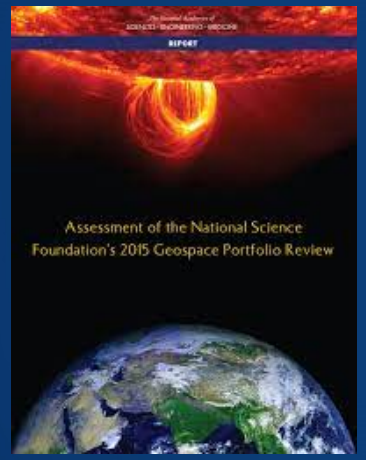
MPS Needs from the Decadal

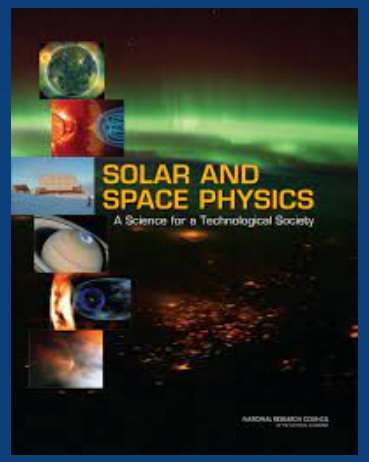
- State of the community – number and diversity of the research community- research scientists, academic faculty, and early career scientists
- PHY is engaged in the Decadal with focus on theoretical, computational and laboratory-based plasma physics studies that enable progress in solar and space science.
  - This falls under the study approach document.
  - "*The survey report should also consider experimental and theoretical plasma physics investigation that would enhance progress on the prioritized science goals*."
- AST is looking for guidance on solar physics:
  - Science priorities for solar astrophysics - including laboratory based studies
  - Mid-Scale Research Infrastructure
    - up to $100M for design and construction
  - Major Facilities
    - $100M+ for construction
- Welcome comments on cyberinfrastructure for solar and space physics.

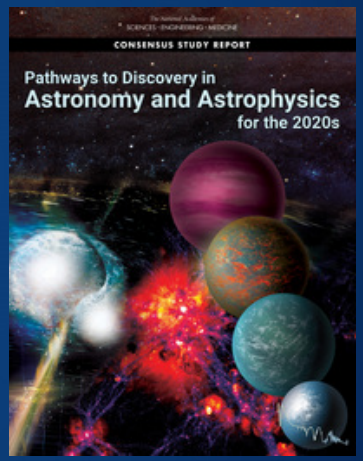
Philosophy of NSF

- NSF has a goal of supporting fundamental science from the community – this is where discoveries begin! This philosophy complements our sister agencies.
- Feeds into the Merit Review Criteria
  - Intellectual Merit – How good is the science and the plan?
  - Broader Impacts – How does the project further the societal goals?
    - Includes but are not limited to:
      - STEM Education and Workforce
      - Broadening Participation
      - Enhanced Infrastructure and Partnerships
      - Knowledge Dissemination and Scientific Literacy
      - Societal Impact and Economic Competitiveness
- NSF relies on the community to determine what the priorities are

How NSF Divisions Receive Community Guidance on Science: Decadal Surveys, Portfolio Reviews, Committee of Visitors







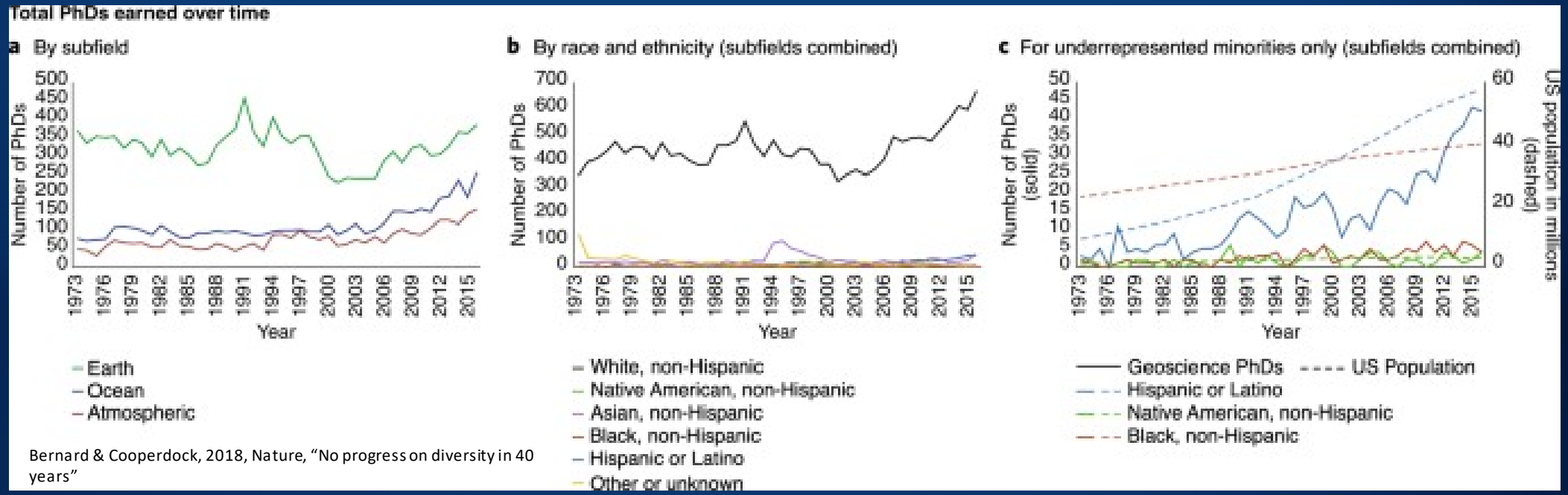
- NSF is not mandated by law to carry out the decadal surveys
- HOWEVER, the decadals are **extremely** important to NSF, because these priorities are from the whole community.
- The agency as a whole is more easily able to respond when multiple decadals recommend similar things.

Science of the Next Decade

- What are the fundamental science questions that should be addressed in the next decade for
  - Aeronomy, Magnetospheric Physics, Solar Physics, Space Weather,
  - Plasma Physics in the treatment of the heliosphere and geospace as a natural plasma science laboratory?
- How can an interdisciplinary or integrated approach be used to address large, system-wide problems?
- What are the new and emerging frontiers in solar and space physics?

Needed: Support for the Community of Researchers

- Early-career scientists, Academic Faculty appointments
- Diversity, Equity, and Inclusion
- Broader Impacts
- Where are we and how can we be better?



Bernard & Cooperdock, 2018, Nature, "No progress on diversity in 40 years"

Programs Supporting the Solar and Space Physics Community

NSF's Diversity and Inclusion Mission Statement:

To recruit, retain, and develop a diverse, high-performing workforce that draws from all segments of society and values fairness, diversity and inclusion to promote the progress of science.

- Agency wide:
  - Research Experience for Undergraduates (REU), Graduate student Research Fellowship Program (GRFP), CAREER
- Postdocs:
  - AGS Postdoctoral Research Fellowship (AGS-PRF), Astronomy and Astrophysics Postdoctoral Fellowship (AAPF)
- Special Solicitations:
  - Faculty Development in the Space Sciences (FDSS), AGS Mid-Career DCL, Launching Early-Career Academic Pathways (MPS-LEAPS), Partnerships in Astronomy & Astrophysics Research and Education (PAARE)
- Workshops and Summer Schools
  - GEM, SHINE, CEDAR student support
  - Boulder Space Weather Summer School
  - ISR Summer School
- Additional Programs for Broadening Participation:
  - Alliances for Graduate Education and the Professoriate (AGEP)
  - AGU Bridge Program

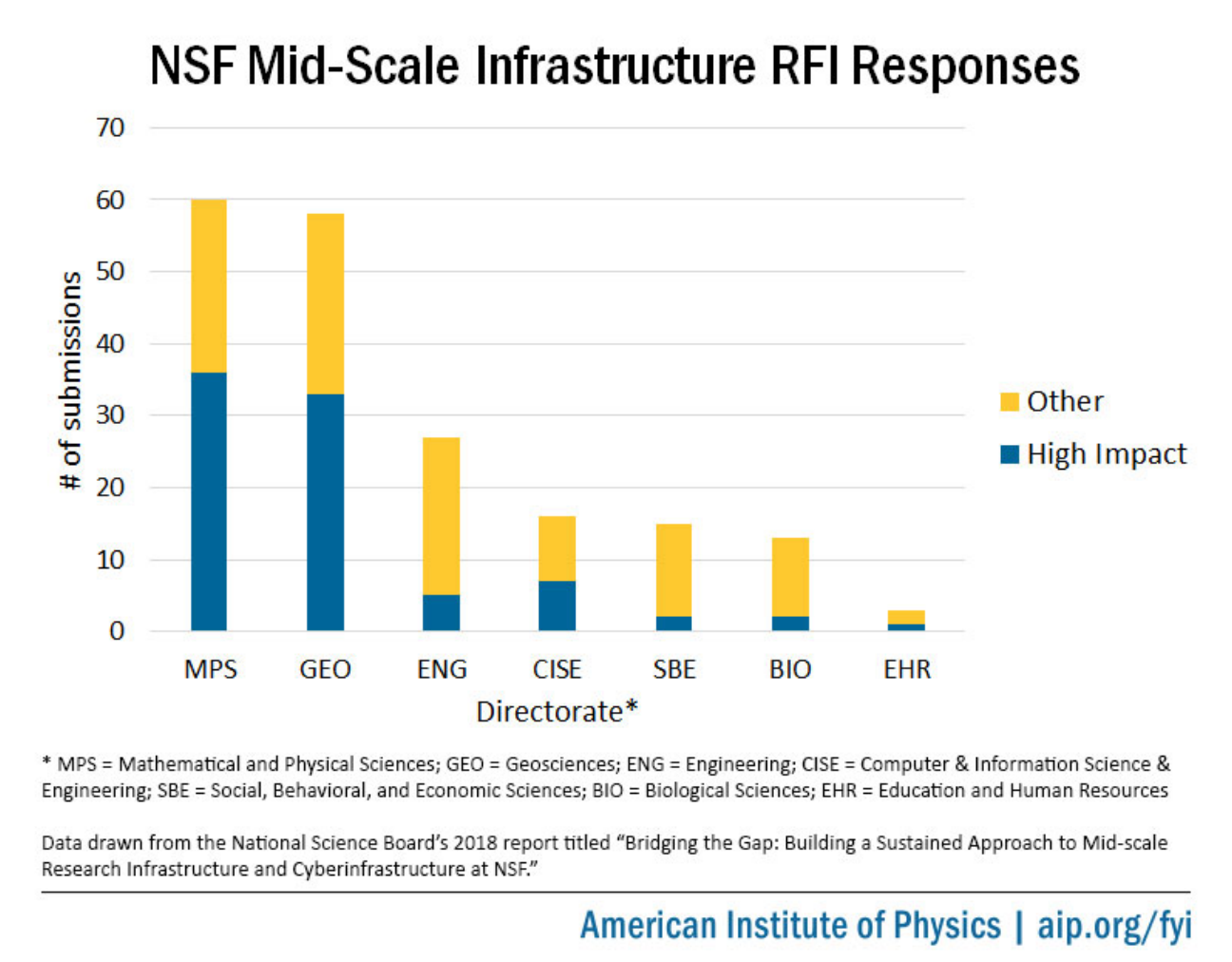
Solar and Space Physics Research Infrastructure

- NSF Federally Funded Research and Development Centers (FFRDCs)
  - National Solar Observatory (AST)
    - DKIST, GONG + SOLIS
  - High Altitude Observatory (AGS/NCAR)
    - KCor, uCOMP
- Geospace Facilities
  - AMISR, Arecibo (AST lead), Millstone Hill Observatory, Jicamarca Radio Observatory
  - AMPERE, Expanded Owens Valley Solar Array, HAARP
- Supported within science programs:
  - SWR: CubeSats, SuperDARN, SuperMag
  - STR: Big Bear Solar Observatory, Neutron Monitoring Network
  - MAG: Magnetometers, Plasma Physics Experiments (collab with PHY)
- Instrumentation Projects and Support
  - Meteor radars, lidars, ionosondes, FPI, imagers, etc
  - Distributed Array of Small Instruments

Cyberinfrastructure

- Supercomputing
  - ACCESS – XSEDE replacement
  - NCAR Computing resources
- Data Repositories
  - Madrigal
  - NSO Data Center
  - SuperMAG

Research Infrastructure Needs



- Cyberinfrastructure for the next decade
- Defining the Next Generation Ground-based Facilities
- NSF Mid-Scale Research Infrastructure (2013 Decadal Recommendation)
  - Mid-Scale RI 1: $6-20M
  - Mid-Scale RI 2: $20-100M
  - MREFC: > $100M

Thank you for your service to the community!

- NSF is looking to the 2024 decadal to define:
  1) The **SCIENCE** priorities
  2) Support for the diverse community of the **PEOPLE** we want to be engaged in science
  3) The **INFRASTRUCTURE** needed for the people to achieve the science goals

- Please direct questions to both:
  - Lisa Winter (lwinter@nsf.gov) and Carrie Black (cblack@nsf.gov)

- Back up slides

NSF Priorities

- NSF's Mission

  "To promote the progress of science; to advance the national health, prosperity, and welfare; and to secure the national defense; and for other purposes."

- At the highest level, set by the Administration and Legislation (organic, authorization, and appropriations)
- National Science Board provides ongoing guidance (e.g. Vision 2030, NSF Strategic Plan)
- NSF Director establishes agency high-level priorities