MPSAC Subcommittee for the Review of the Physics Frontiers Centers Program

MPSAC Meeting

August 23, 2019

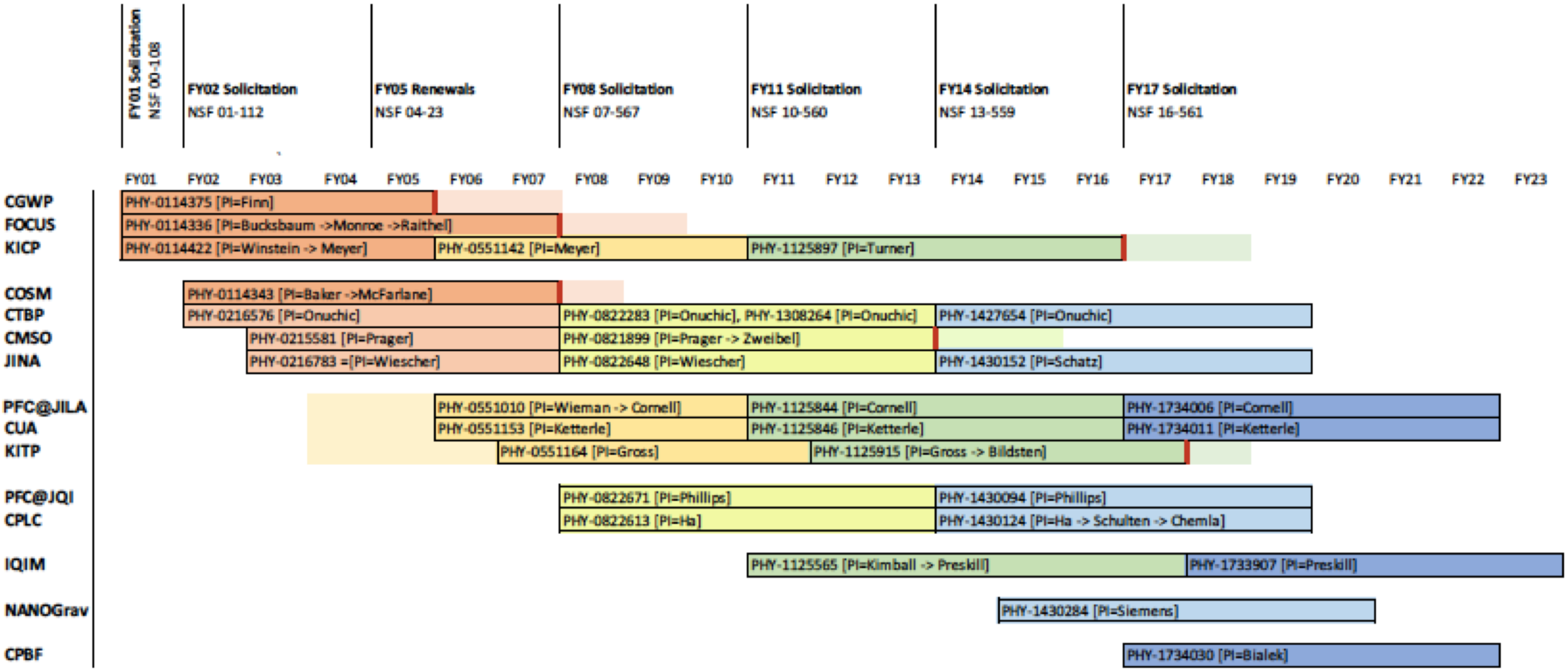
What is the Physics Frontiers Centers Program?

“The NSF Physics Division’s Physics Frontiers Centers (PFC) program is designed to foster major breakthroughs at the intellectual frontiers of physics by providing needed resources such as combinations of talents, skills, disciplines, and/or specialized infrastructure, not usually available to individual investigators or small groups, in an environment in which the collective efforts of the larger group can be shown to be seminal to promoting significant progress in the science and the education of students. PFCs are expected to demonstrate potential for profound advances in physics; creative and substantive activities aimed at enhancing education, diversity, and public outreach; potential for broader impacts, e.g., impacts on other fields and benefits to society; and a synergy or value-added that justifies a center- or institute-like approach.

Currently ~$20M per year from Physics ($311M FY18 Physics budget) and several $M from other partners at NSF.

Center	Location	1st Award	2nd Award	3rd Award	Ramp Down
Center for Gravitational Wave Physics (CGWP)	Penn. State	2001-2005			2005-2006
Frontiers in Optical Coherence and Ultrafast Science (FOCUS)	Michigan	2001-2007			2008-2009
Kavli Institute for Cosmological Physics	Chicago	2001-2005	2006-2010	2011-2016	2017-2018
Center for the Study of the Origin and Structure of Matter (COSM)	Hampton	2002-2007			2008-2009
Center for Theoretical Biological Physics (CTBP)	UCSD/Rice	2002-2007	2008-2013	2014-2019	
Center for Magnetic Self Organization (CMSO)	Wisconsin-Madison	2003-2007	2008-2013		2014-2015
Joint Institute for Nuclear Astrophysics (JINA)	Notre Dame/MSU	2003-2007	2008-2013	2014-2019	
JILA	Colorado	2006-2010	2011-2016	2017-2022	
Center for Ultracold Atoms	Harvard/ M.I.T.	2006-2010	2011-2016	2017-2022	
Kavli Institute for Theoretical Physics	UCSB	2007-2011	2012-2017		2018
PFC at the Joint Quantum Institute (PFC@JQI)	Maryland	2008-2013	2014-2019		
Center for the Physics of Living Cells (CPLC)	UIUC	2008-2013	2014-2019		
Institute for Quantum Information and Matter (IQIM)	CalTech	2011-2017	2018-2023		
North Amercan NanoHertz Observatory for Gravitational Waves (NANOGrav)	Wisonsin-Milwaukee	2015-2020			
Center for the Physics of Biological Functions (CPBF)	Princeton	2017-2022			

Award History



Quotes from the 2015 Physics Division Committee of Visitors Report Concerning the PFC program

Our charge was to evaluate process and in that regard the program comes through in flying colors.

One would like independent confirmation that the PFC's add value in a way that individual investigator grants do not. Are the claims of synergy justified? And if they are, should the fraction of the Physics Division budget be increased? These are questions we were not equipped to address, but clearly need answering.

Whether the portfolio of PFC's requires more shaping is another issue for the external review to decide.

Perhaps be helpful if Center communication and outreach coordinators… were to form a network

Consider pro-actively jump-starting a PFC aimed squarely at diversifying the nation's talent pool.

2015 COV Recommendations %

- We recommend that the Physics Division charge an appropriate high-level body to conducts a retrospective review of the PFCs, outside of the context of a funding competition for renewal and new starts

- We further suggest that the Physics Division use the PFCs as laboratories to explore the most effective ways to broaden participation and communicate effectively. The Division should continue to seek ways for the PFC directors to learn from each other, and at the same time, transmit that learning to the broader community.

Charge -1

National Science Foundation Directorate for Mathematical and Physical Sciences
Charge to: MPSAC Subcommittee for the Review of the Physics Frontiers Centers Program

The NSF Physics Division's Physics Frontiers Centers (PFC) program is designed to foster major breakthroughs at the intellectual frontiers of physics by providing needed resources such as combinations of talents, skills, disciplines, and/or specialized infrastructure, not usually available to individual investigators or small groups, in an environment in which the collective efforts of the larger group can be shown to be seminal to promoting significant progress in the science and the education of students. PFCs are expected to demonstrate potential for profound advances in physics; creative and substantive activities aimed at enhancing education, diversity, and public outreach; potential for broader impacts, e.g., impacts on other fields and benefits to society; and a synergy or value--added that justifies a center-- or institute--like approach.

The PFC program was initiated in 2001. Over its 17--year history, 15 centers or institutes have been awarded PFC funding and, of these, 6 have been phased out. Since 2008 open competitions for new and renewing centers have been held every three years. The PFC program is open to any subfield of physics within the purview of the NSF Physics Division and PFCs have been awarded in almost all subfields: atomic, molecular, optical, plasma, elementary particle, nuclear, astro-, gravitational, and biological physics. As the PFCs address frontier science, their scope often extends beyond the programmatic boundaries of the Division and significant partnerships with other divisions have been established to support these centers.

Charge -2

The Physics Division's Committees of Visitors have recommended a review of the program: "We believe that the Center program would benefit from a dedicated comprehensive review by a high--level body with the time, access and expertise to evaluate the PFC program. One would like independent confirmation that the PFCs add value in a way that individual investigator grants do not." After nearly 2 decades of PFCs, the Physics Division agrees that this is an excellent time to evaluate the impacts and effectiveness of the program.

This MPS subcommittee is asked to assess how well the PFC program is addressing its goals of fostering profound advances in physics, enhancing education, diversity, and public outreach, and addressing broader impacts through center or institute awards. In particular, the subcommittee should assess how well the PFC program is enabling advances in the following areas in ways that are distinct or best accomplished in a center structure:

Advancing the frontiers of Physics

a. %How well is the PFC program contributing to major scientific breakthroughs?

b. %Has the PFC program had significant impacts on Physics or related fields?

Enhancing education, diversity, public outreach, and broader impacts

a. %In what ways is the program enabling unique or enhanced educational experiences for students and postdoctoral fellows?

b. %In what ways is the program contributing significantly to broadening participation of traditionally underrepresented groups?

c. %In what ways is the program enabling substantive outreach to the general public?

d. %Are there other broader impacts of the PFC program?

Charge -3

The subcommittee should conduct an independent assessment of the PFC program as a whole and not perform in--depth evaluations of each center. Rather than providing specific recommendations, the subcommittee should identify strengths and weaknesses of the PFC program and issues that the Division can address in developing and evolving the program. The subcommittee will not review the PFC proposal review and selection process or the program funding levels, which are regularly reviewed by the Division's Committee of Visitors.

Timeline: Charge Delivered to MPSAC: May 2018
Interim Report Due to MPSAC: April 2019
Final Report Due to MPSAC: June 2019

We would appreciate an interim report from the Subcommittee to the MPSAC in April of 2019, and a final report delivered to the MPSAC in June of 2019. The interim report will detail progress and interim (draft) findings. The final written report will be due no later than June 30, 2019. The Chair of the subcommittee should coordinate delivery of materials with the MPSAC Chair in advance of scheduled MPSAC meetings. Presentations to the MPSAC may be delivered remotely or in person and will be coordinated by the MPSAC.

The Subcommittee will terminate once MPSAC as accepted the final report and determined that no further edits or substantive changes need to be made by the subcommittee.

Resources
NSF will arrange for and host in--person or virtual meetings of the subcommittee as required by the Chair.

Specifically Excluded in our Charge

- Not perform evaluation of specific centers
- Not review proposal review and selection process
- Not review program funding levels
- Not provide specific recommendations

Charge states the middle two are reviewed by COV. $

The proposal review and selection process is explicitly reviewed there. $

The program funding levels are not. $

The Subcommittee $

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✱ MPSAC member ✕. Withdrew

Process

- June-July 2018: Subcommittee members selected
- Sept 2018: Orientation Video meeting (thanks to hurricane)
- We contacted all the Divisions of APS to request they make their members aware of the Subcommittee and its work. A web site for community input was set up at Auburn University.
- Information gathering visits scheduled for all the PFCs by 1-3 Subcommittee members. Due to government shutdown, 3 did not occur until the spring.
- Nov. 2018: Presentation at Midwest Physics Chairs Meeting
- Nov. 2018: Chair attended meeting of PFC Directors
- Jan. 2018: Video meeting to share results of PFC visits
- Feb. 2018: In person meeting at NSF to discuss issues and conclusions
- Apr. 2018: Interim report
- June 2018: Final report submitted

Input

- ✓List and timelines of centers
- ✓Copies of Solicitations
- ✓Annual reports of centers
- ✓Reports of formal site visits
- ✓Discussions with directors of each of the current and past centers
- ✓Information gathering visits to all current and recently closed centers
- ✓Input from the broader community
- ✓Diversity Plans for each center -NSF
- ✓Statistics on # of proposals and submitted vs accepted –NSF

We were not given access to the original proposals so we could not evaluate if the centers had succeeded in doing what they proposed to do. We were expected to make our evaluation based only on what they had accomplished.

Bottom Line %

Advancing the frontiers of Physics

a. How well is the PFC program contributing to major scientific breakthroughs? Great job!

b. Has the PFC program had significant impacts on Physics or related fields? Great Job!

Enhancing education, diversity, public outreach, and broader impacts

a. In what ways is the program enabling unique or enhanced educational experiences for students and postdoctoral fellows?

Great environment for students and post-docs! What works?)

b. In what ways is the program contributing significantly to broadening participation of traditionally underrepresented groups?

Mixed record! Some notable work. What works?)

c. In what ways is the program enabling substantive outreach to the general public?)

Some very creative approaches. What works?)

d. Are there other broader impacts of the PFC program?)

Yes.

The primary question is can we answer “What have we learned in this second area?” There is a need for a more scholarly approach and more consistent reporting of the results in the literature.)

From the Solicitation

It is expected that the PFC supported unit will have some or all of the following characteristics of successful units of similar size and complexity in physics and other fields. In no particular order, these are:

(1) combining talent, skills, or facilities required for a major advance in physics;

(2) combining groups, departments, institutions, etc. required to make a major advance in physics;

(3) providing critical mass or specialized infrastructure needed for an advance by the unit, and often the broader field;

(4) providing the context and/or organization to bring together leaders and students to initiate work in a promising new area, a new interdisciplinary field, an important application, or a new facility of strategic importance to physics;

(5) fostering field-wide exploration of frontier research within the community at large;

(6) making available specialized infrastructure to others; and

(7) creating innovative projects to promote education, the participation of traditionally underrepresented groups in science, and public outreach using the center as a focal point.

We can point to many scientific advances

A difficulty is being able to conclude that these would not have happened without the center structure. We tried to identify these elements among the successes.

- Novel direction
- Theory – Experiment collaboration
- Multiple shared experimental expertise is required
- Sustained long term progress is required
- Results stemming from community building activities to bring scientists together to focus on a problem

Examples that struck me

CPBF: Record the neural activity in populations with about 100 neurons in the worm C. elegans and track its motion. Using the neuron information they can model the activity and remarkably reproduce the motion based on these models.

PFC@JQI and CUA: Greater than

50 qubit quantum simulators.

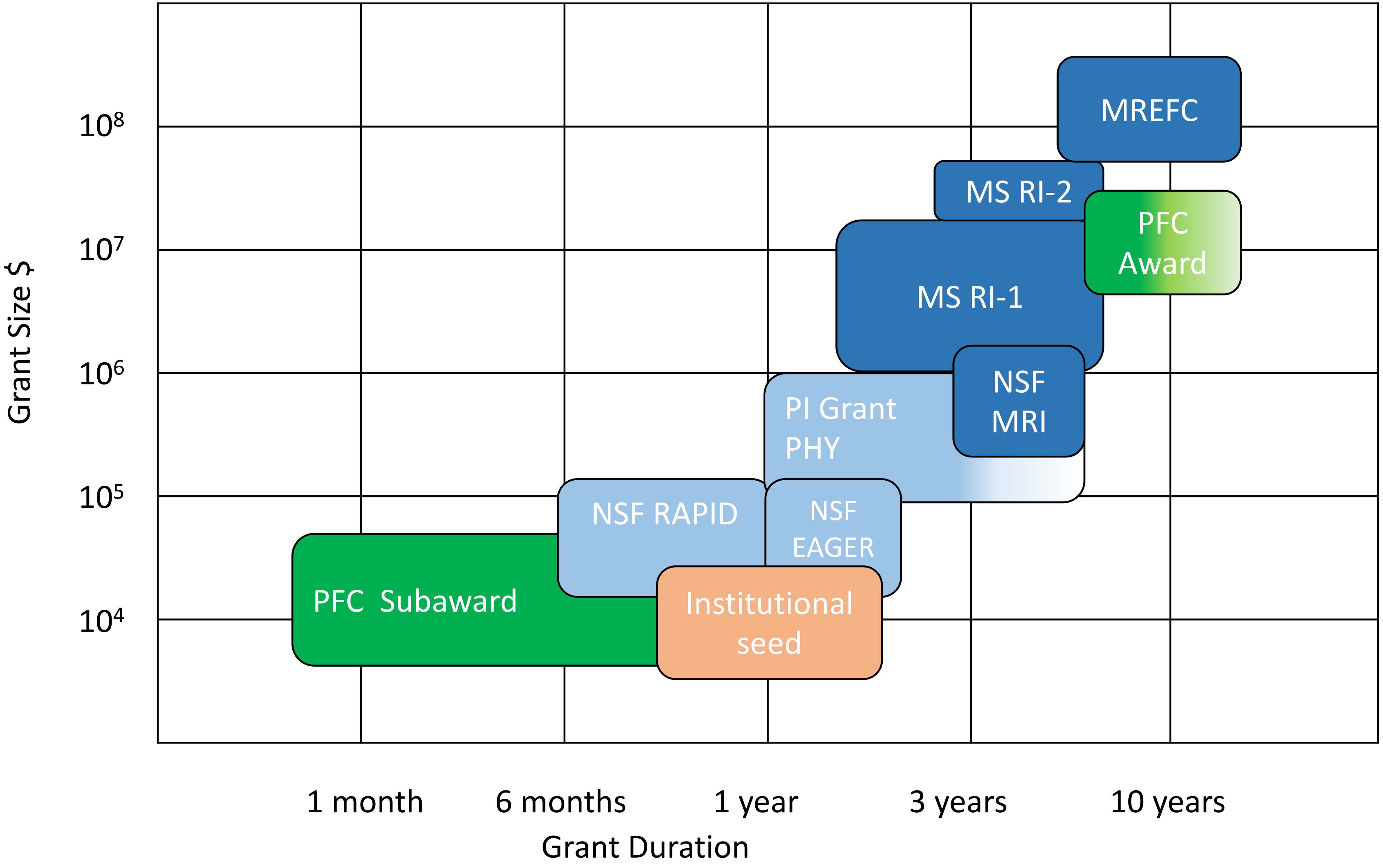
Zhang et al. Nature **551**, 601 (2017)

Quantum simulations are used to study the dynamics of quantum magnetism.

Advantages of PFCs in advancing the frontiers of science

- PFCs foster collaboration
- PFCs enable rapid responses to research developments
- PFCs provide local oversight over research progress
- Postdoctoral researchers mature more rapidly within PFCs
- PFCs offer additional unique opportunities to pursue research
- PFCs enable the U.S.A. to better compete globally

Filling gaps in the research infrastructure support



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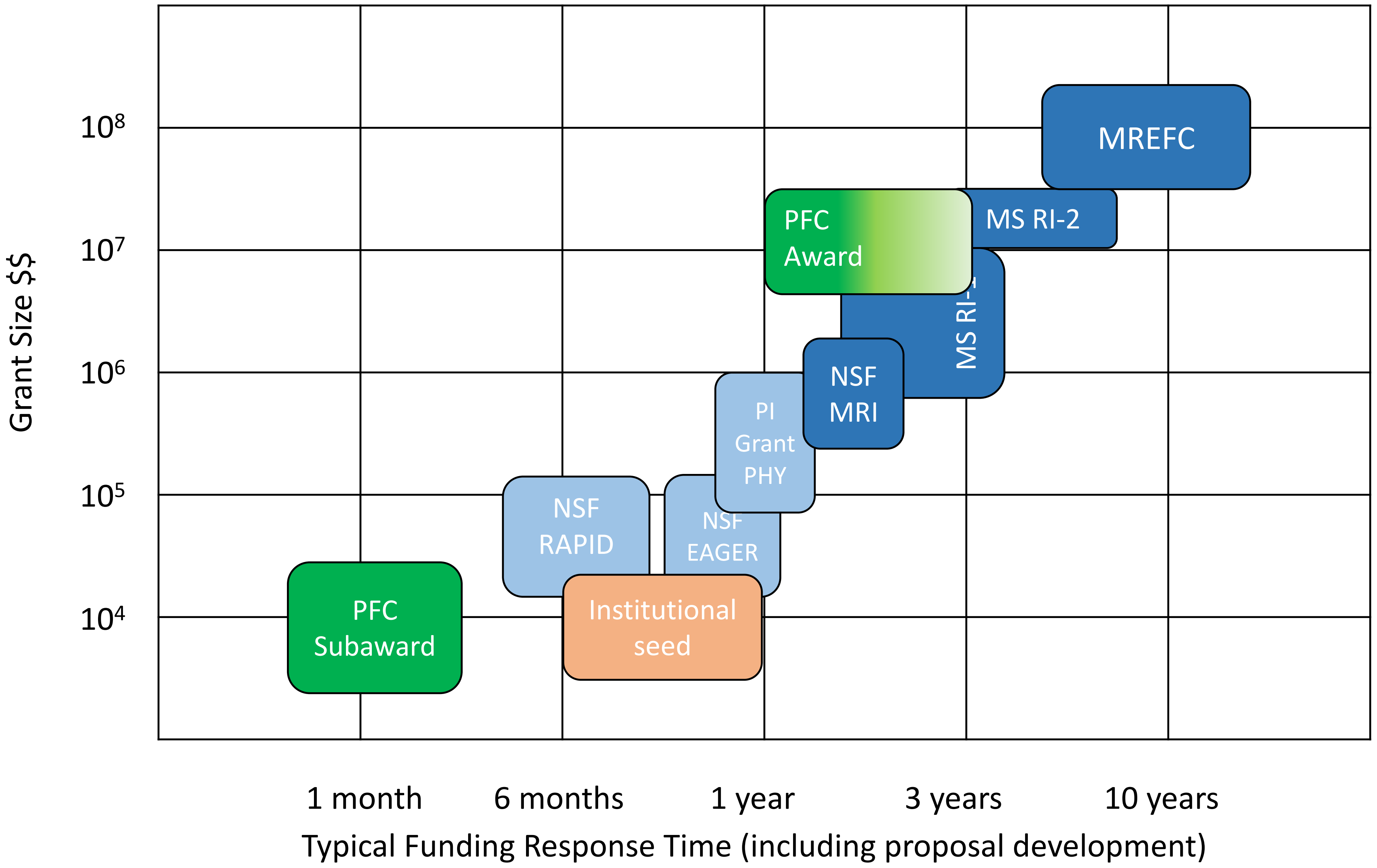

Issues that may inhibit innovation and collaboration in science

- Standard funding mechanisms tend to favor more conservative advances in science.
- Standard funding mechanisms tend to favor disciplinary over broadly interdisciplinary science.
- The nature of peer-review cycles slows the process of truly exploratory science.

In each case the PFC concept can allow these inhibitions to be overcome

Community building activities

One of the biggest strengths of the PFCs is that they have the resources to do significant community building.

- North American Nanohertz Observatory for Gravitational Waves
- Joint Institute for Nuclear Astrophysics
- Center for Gravitational Wave Physics

In fields where PFC community building is a priority, there seems to be broad support for the PFCs.

Enhancing education, diversity, public outreach, and broader impacts - Strengths

- PFCs have the resources to hire dedicated EPO coordinators.
- PFCs provide an exceptional environment for graduate student and post-doctoral training.
  - Atmosphere of collaboration and mobility
  - Large pool of expertise and equipment
  - PFCs serve as an important tool for recruiting talented students and postdocs.
- Summer/Winter schools for the community.
- Record with underrepresented groups are mixed.
  - All have diversity plans
  - NANOGrav is a shining example.
  - JINA is another
  - COSM was hosted by three historically minority serving colleges and outreach to a broader network was part of their plain.
- Several innovative initiatives in outreach and training of science teachers
  - CUA: TOPS brought in students with an interest in science education for a several-week-long training camp. Also developed an on-line course to train AP physics teachers in minority high schools in the Boston area.
- Often they build on existing programs at their local institutions. For example the University of Wisconsin Wonders of Physics or the MSU Math, Science and Technology residential program for junior high students.

Education and Outreach Examples

- CUA: TOPS brought in students with an interest in science education for a several-week-long training camp. A number went on to become science teachers.
- JILA: Partnerships for Informal Science Education in the Community uses afterschool activities to connect JILA researchers with K-12 populations that are underrepresented in science. JILA personnel are trained in inquiry-based teach practices. One to the few PFCs to publish results in the science education literature.
- JINA: Art 2 Science Camp: two one-week sessions for kids age 8-12 with 300 participants. Junior counselors age 13-18 play an important role.
- KICP: Astronomy Conversations at the Adler (Planetarium)
- IQIM produced short films *Anyone can Quantum* and *Quantum is Calling* featuring Stephen Hawking and Hollywood A-listers Paul Rudd, Keanu Reeves, Zoe Saldana, Simon Pegg and John Cho. Over six million views on YouTube.
- NANOGrav: PFC graduate and undergraduate students presenters for the Space Public Outreach Team (SPOT) visited 66 schools reaching over 5000 students- more than 50% were female and about 30% were underrepresented minorities.

On the other hand

We heard complaints that, even when there was coordination with Schools of Education at their university, the expenses were often viewed as prohibitive, for example, $10K to prepare, administer and analyze a survey.

If this were a physics research expense, I doubt it would have limited anyone.

Weaknesses and Issues

- The orientation toward Broader impacts seems grounded in an enumeration approach.
- There are few statistics available to evaluate diversity of the people working for the different PFC initiatives.
- Education and Outreach efforts can be the first to be terminated when a center is not renewed. A more thoughtful ramp down of the educational and outreach programs deserves attention.
- There is a need to track networks of graduate students and postdoctoral researchers.
- There is a need to prepare PFC junior researchers for their future roles as sophisticated physics educators.
- There is a need to document what works and what does not in education and outreach in the literature.
- If the NSF is serious about the priority of the education and outreach missions of the PFCs this needs to be better communicated in the solicitation and to the selection and review panels.

- The current practice of a 5 year award, a proposal for a 1-year extension, and then a new full proposal seems wasteful of effort for the PFCs, the NSF and the reviewers.

Summary

The subcommittee concludes the PFCs are indeed contributing to major scientific breakthroughs at the frontiers of physics.

We echo the recommendation of the Committee of Visitors that the PFCs should be laboratories to explore the most effective ways to broaden participation and communicate effectively. They are doing some very good things, but we emphasize the importance of sharing the results.

We expect the Physics Frontiers Centers program is primed to produce new success stories in the future.