National Science Foundation (NSF)
Division of Materials Research (DMR)

National Science Foundation
MRSEC
Materials Research Science and Engineering Centers

Daniele Finotello
Program Director
Materials Research Science and Engineering Centers
National Science Foundation

Where Materials Begin & Society Benefits!

DMR Division of Materials Research
Directorate for Mathematical and Physical Sciences

National Science Foundation MRSEC Materials Research Science and Engineering Centers

EPSCoR Day
Mobile, AL
April 2, 2019

Q&A: Information Sheet (1)

What is the NSF MRSEC program? (see mrsec.org)

- A multimillion 6-year grant awarded by the Division of Materials Research (DMR) funding convergent transdisciplinary materials research at twenty academic institutions
- Each MRSEC has 2 or 3 different research thrusts known as Interdisciplinary Research Groups (IRGs)
- Education, outreach, and diversity initiatives are additional vital core components of MRSEC activities (umbrella)
- MRSECs include substantive academic, industrial, national laboratories and international collaborations
- Call for proposal is every 3 years. The Next Proposal Cycle Begins: June 24, 2019

Q&A: Information Sheet (2)

What is unique about the MRSEC?

- Built-in Seed programs provide opportunities for high risk ideas, innovation, and possible collaborations. Quite distinct IRGs
- State-of-the-art Facilities are made accessible to other researchers (see the Materials Research Facilities Network website mrfn.org)
- The six-years Awards do not automatically sunset; MRSECs reinvent themselves and re-compete
- MRSEC education/facilities directors networks.

Q&A: Information Sheet (3)

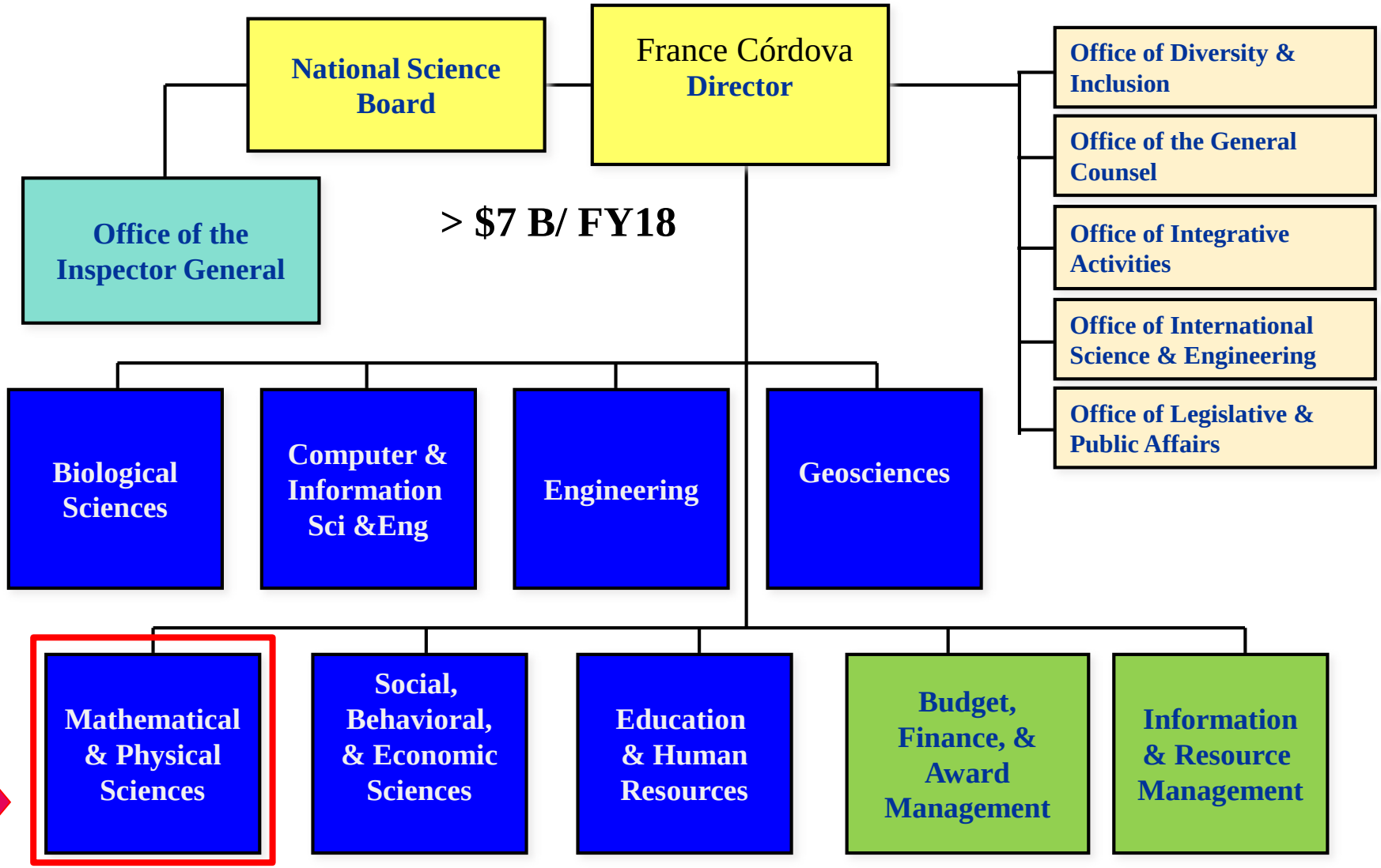
What are the benefits of the MRSEC?

- Institutional impact/visibility
  - umbrella structure crosses traditional disciplinary divides
  - size provides (internal) strong voice. Leveraging
  - independence creates a collaborative/cooperative team environment
- Faculty and industry research collaborations opportunities (seed programs, facilities, PREM, etc.)
- Undergraduate, Graduate and postdoctoral education / training
  - involvement in broad interdisciplinary ideas, expertise and networks
  - professional development and skill building opportunities
- Summer research experiences for undergraduates and teachers (REU/RET programs) and PREM awards

MRSEC Program Goals / Summary Achievements

- Stimulate and support outstanding **interdisciplinary** research and education in **materials** of a scope and complexity needing a center.
- All students, in or out of MRSEC benefit from it; network. Curriculum development. No departmental (jargon) barriers.
- Critical mass of investigators of **complementary/diverse** expertise addressing fundamental, complex **materials** problems that are intellectually challenging and important to society.
- Foster **partnerships** between academia, industry, National labs, and **international: Convergence / Transdisciplinarity**
- Re-competition model and **Seed** program provide a mechanism for reinvention and adaptation to address emerging areas (flexibility)
- **Leveraging** of funds (NSF ~$56M; $44M other sources; **Start-ups (10/year)**; **Patents (50/year).** Jobs creation
- Materials Research Facilities Network (~ 10 years), **www.mrfn.org**

U. S. National Science Foundation (NSF)



Where Materials Begin & Society Benefits

Mathematical and Physical Sciences (MPS)

MPS
Assistant Director
Anne Kinney

$1.36B
(FY 17 budget)

Office of Multidisciplinary Activities

$35 M

Astronomical Sciences
Director
Richard Green

$246 M

Chemistry
Acting Director
Carol Bessel

$246 M

Materials Research
Director
Linda Sapochak

$314 M

Mathematical Sciences
Director
Juan Meza

$234 M

Physics
Director
C. Denise Caldwell

$281 M

ONE OF THE LARGEST & MOST DIVERSE DIVISIONS in all of NSF

DIVISION OF MATERIALS RESEARCH (DMR)

Topical Materials Research Programs TMRP

"unsolicited"

- Biomaterials
- Ceramics
- Electronic & Photonic Materials
- Metals and Metallic Nanostructures
- Polymers
- Condensed Matter & Materials Theory
- Condensed Matter Physics
- Solid State and Materials Chemistry

Other types of Proposals: EAGER, RUI, GOALI (and CAREER*)

Cross-Cutting Activities

- Diversity
- International
- Education

STC

Centers & Teams

Materials Research Science & Engineering Centers **(MRSEC)**

Jun 24, 2019

Spring 2021

artnerships in Research & Education in Materials **(PREM)**

Feb 4, 2019

Designing Materials to Revolutionize & Engineer our Future **(DMREF)**

Solicitations

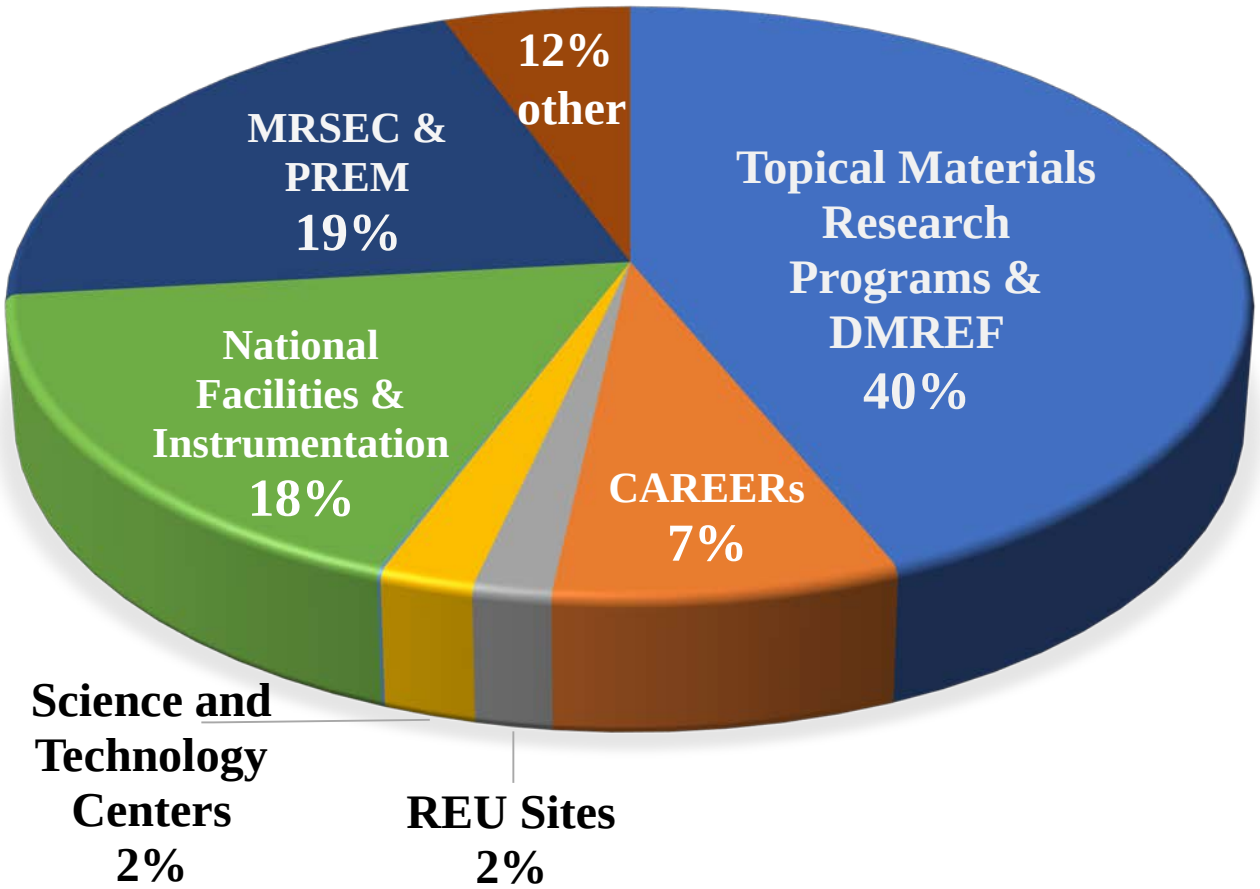
National Facilities & Instrumentation Program

- Cornell High Energy Synchrotron Source (CHESS)
- National High Magnetic Field Laboratory (NHMFL)
- Center for High Resolution Neutron Scattering (CHRNS)
- National Nanotechnology Coordination Network (NNCI)
- Materials Innovation Platforms **(MIPs)**

Apr 2019

User Facilities

DMR Typical Annual Budget Distribution



National Science Foundation
MRSEC
Materials Research Science and Engineering Centers

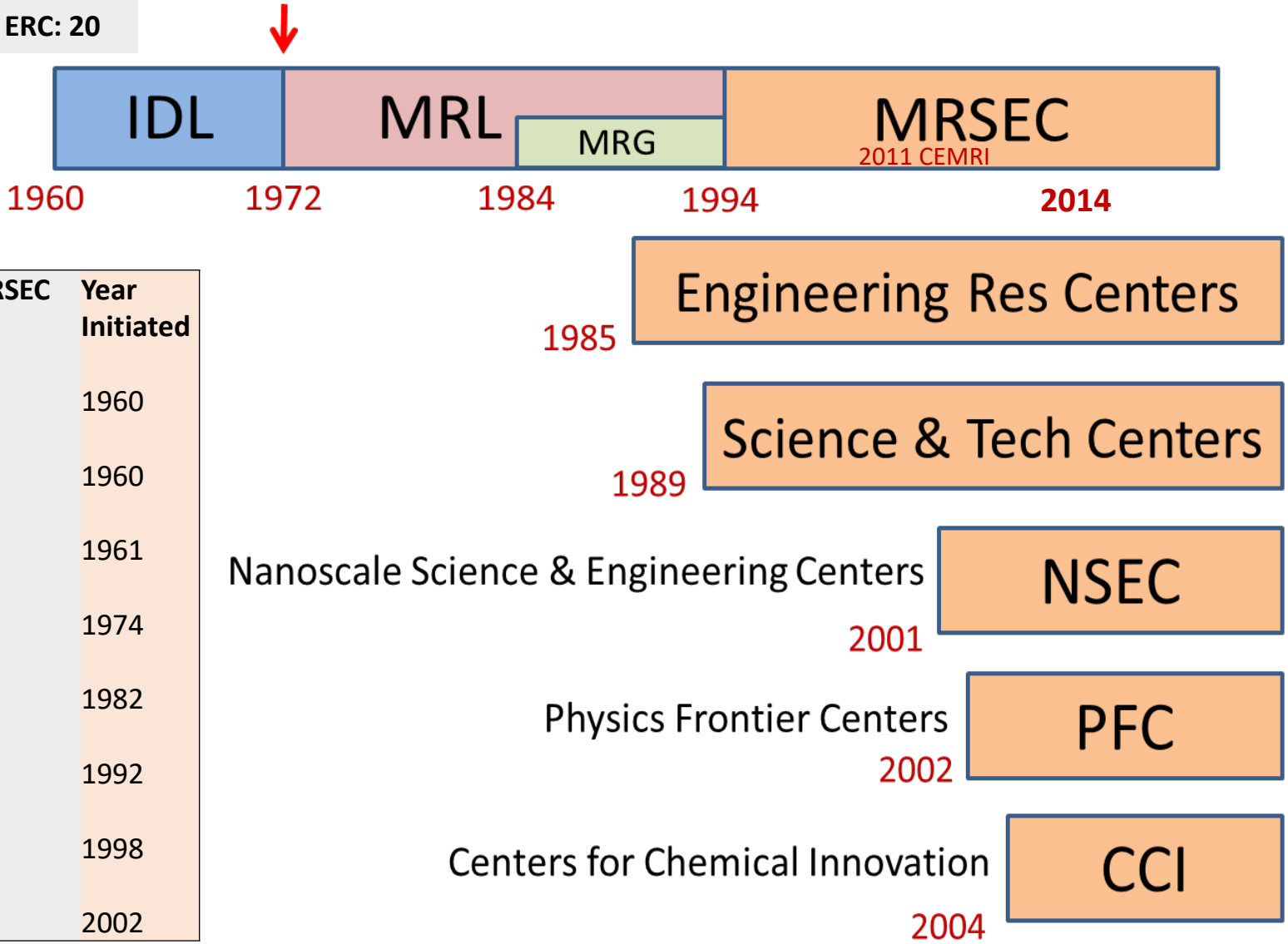
MRSEC History

- 1960-61 - Interdisciplinary Research Labs (IDLs) -ARPA
- 1971 - Proposal to transfer IDLs to NSF as a result of the (Senator) Mansfield Amendment (no defense related research)
- 1972 - NSF establishes DMR, MRL program (later MRGs)
- 1994 - DMR creates MRSEC program (4 Years Awards: 6 Years awards in 2002); 1-5 IRGs
- 2004 – First PREMs awarded
- 2010/11 - DMR establishes CEMRI (Centers) and MIRT (small team) programs
- 2013/14 - DMR drops CEMRI/MIRT nomenclature: MRSEC returns with no MIRT; 2-5 IRGs
- 2016/17 – 2019/20: MRSEC: 2-3 IRGs
- 2018 – PREMs with Nat Fac and STC, and Tribal

MRSEC & Other NSF Centers

MRSEC: 20
STC: 12 **PFC: 11**
CCI: 15 **ERC: 20**

NSF established DMR



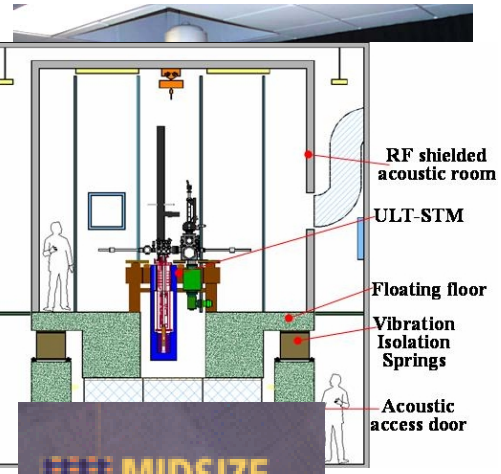
IDL/MRL/MRSEC University	Year Initiated
Cornell	1960
U Penn	1960
Harvard	1961
Penn State	1974
Ohio State	1982
UCSB	1992
Minnesota	1998
Nebraska	2002

Multidisciplinary User Facilities for Research

Materials Research Facilities Network (MRFN): mrfn.org

MRFN Statistics
20 centers
1159 instruments
263 experts

Mrfn.org

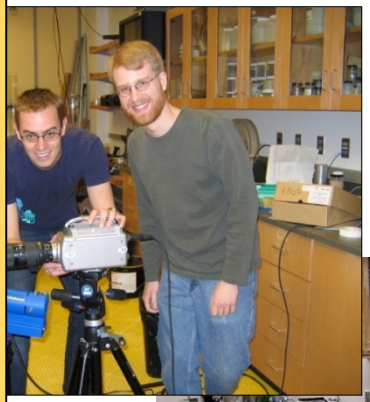


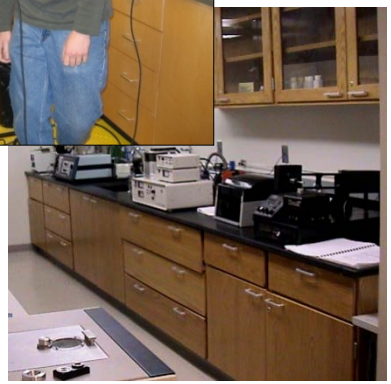
Yearly Users of MRSEC Facilities

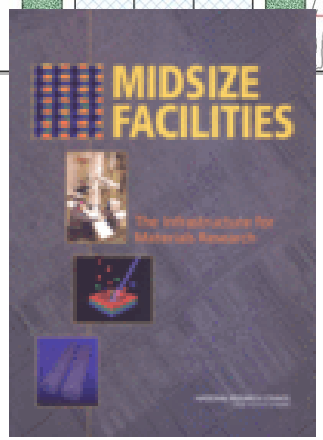
> 1380 Academic
> 530 Industry
>50 National Labs

>700 Publications acknowledge MRSEC SF

- 75 MRSEC Technical Staff in SEFs
- 31 Other Technicians
- 51 Administrative Staff
- 37 Education Staff





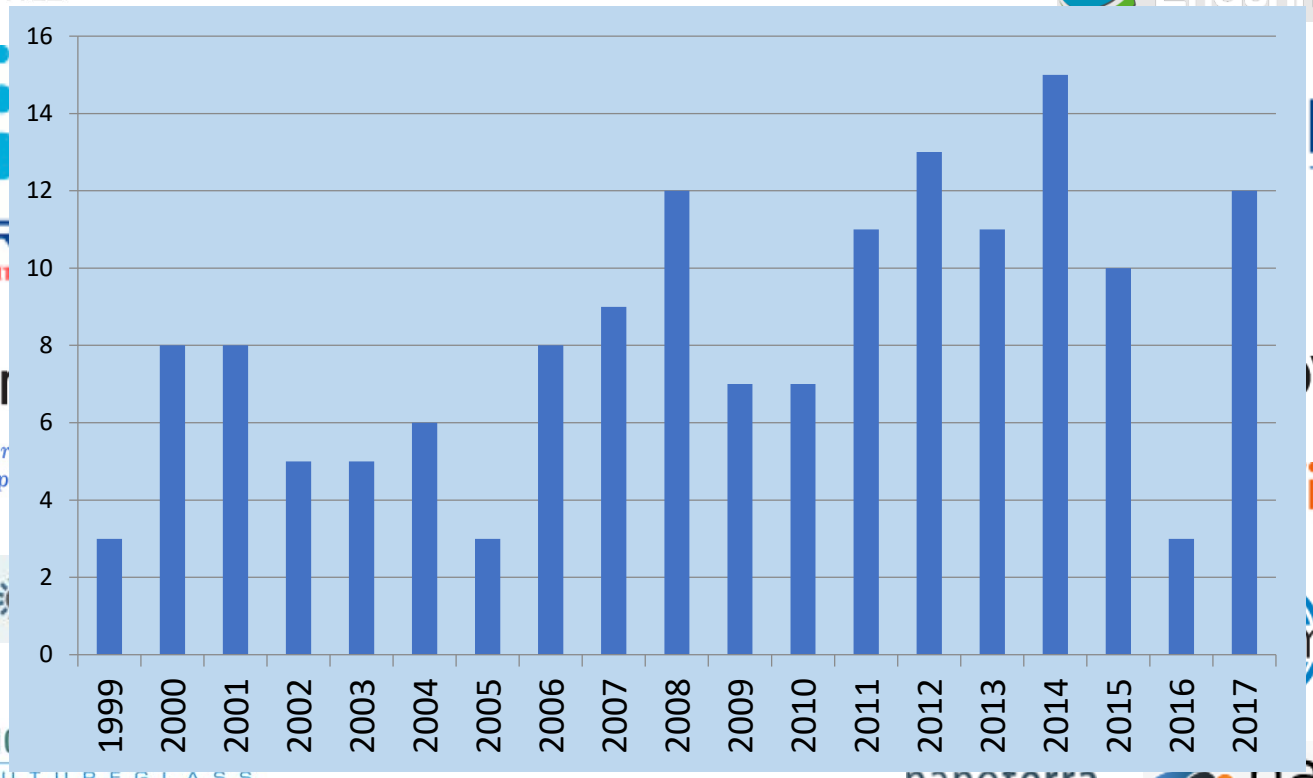


Materials Research Facilities Network

< All user proposal driven >

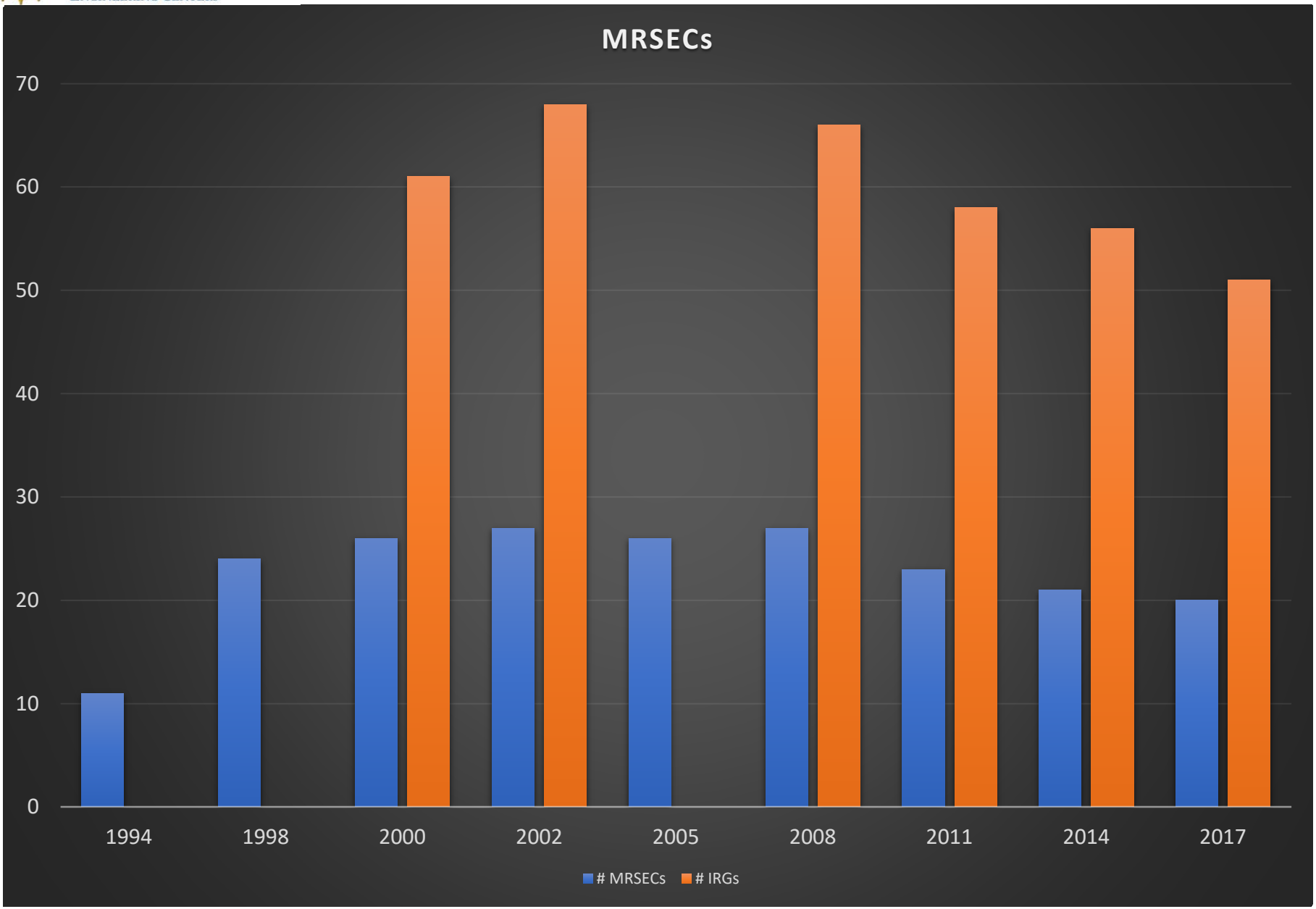
Innovation

MRSEC Startup Companies

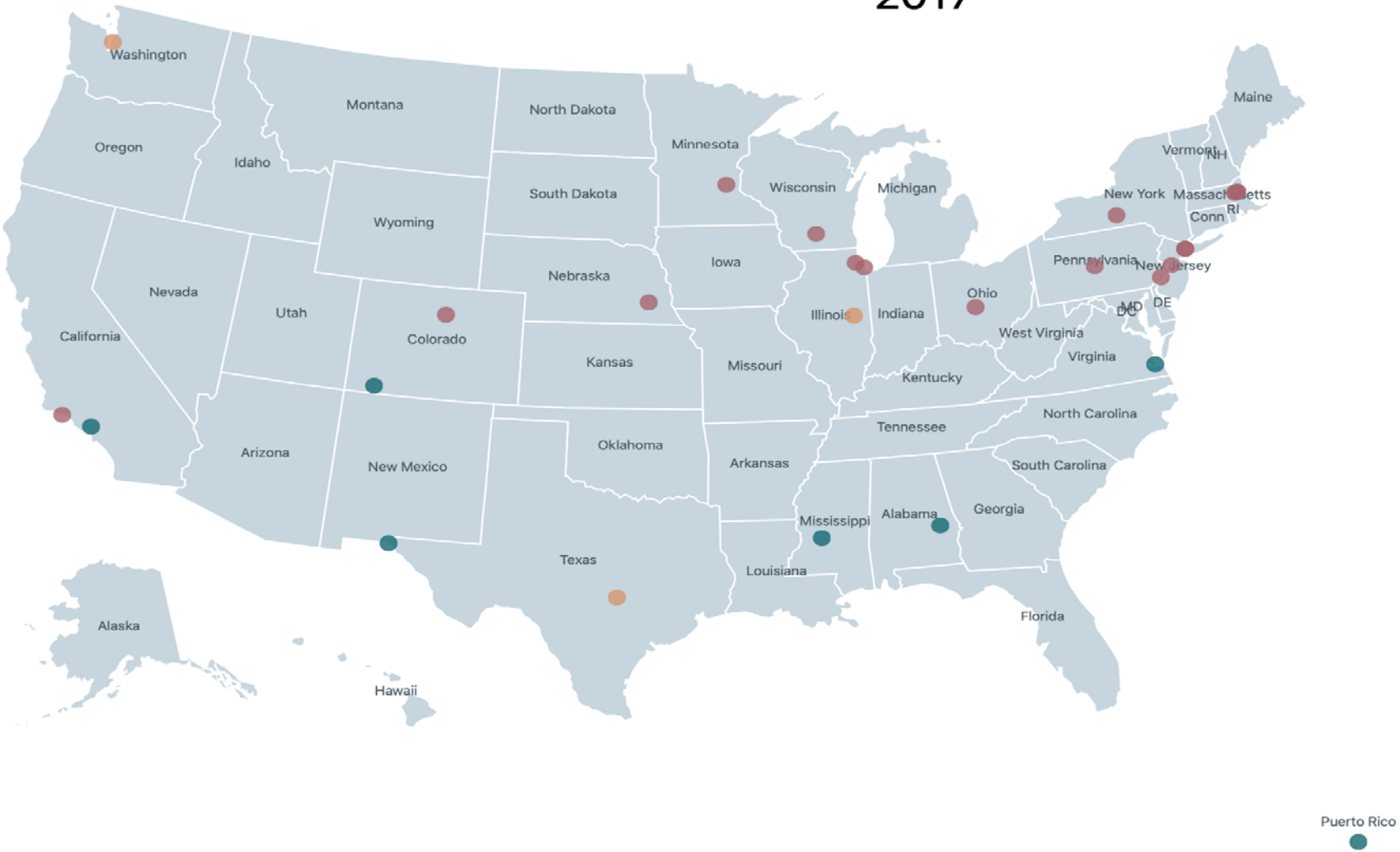


Since 1985: 161 (85 since 2010) companies in 22 states plus 5 abroad, employing ~ 2877 individuals;
More than 1500 patents awarded

MRSEC through the years

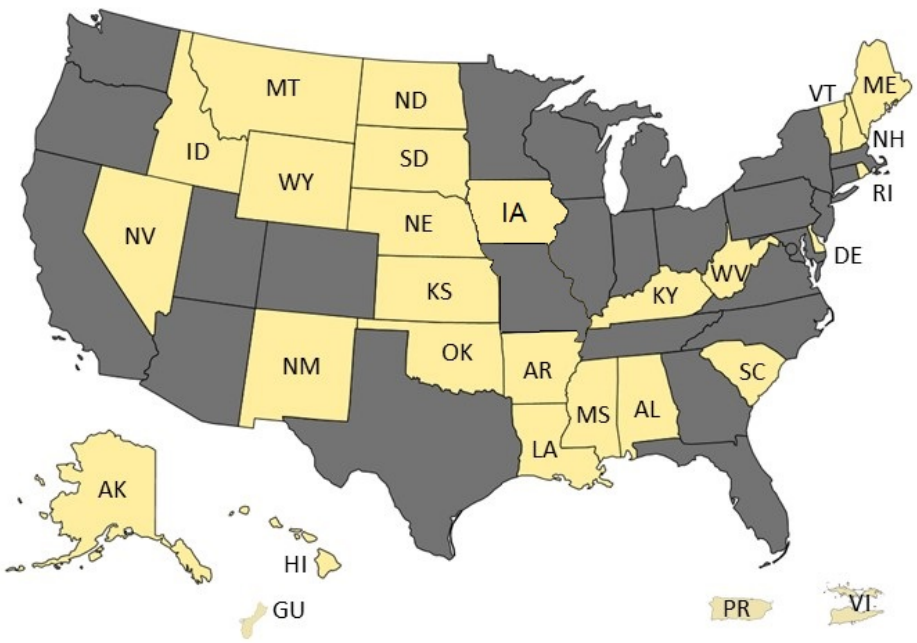


2017



- Existing MRSECs
- Class of 2017
- PREM Awards 2018

MRSECs in EPSCoR Jurisdictions: Nebraska (2002); Oklahoma/Arkansas (2000); Alabama (1992); Southern Mississippi (2002); Utah (2011)



States

AL Alabama
AK Alaska
AR Arkansas
DE Delaware
HI Hawaii
IA Iowa
ID Idaho
KS Kansas
KY Kentucky
LA Louisiana
ME Maine
MS Mississippi
MT Montana
NE Nebraska
NH New Hampshire
NM New Mexico
ND North Dakota
NV Nevada
OK Oklahoma
RI Rhode Island
SC South Carolina
SD South Dakota
VT Vermont
WV West Virginia
WY Wyoming

Other

GU Guam
PR Puerto Rico
VI U.S. Virgin Islands

EPSCoR states and other U.S. jurisdictions eligible for EPSCoR co-funding during FY 2019
This includes twenty-five states, Guam, Puerto Rico, and the U.S. Virgin Islands.

New MRSEC

Materials Research Science & Engineering Centers

2 IRGs

3 IRGs

4 IRGs

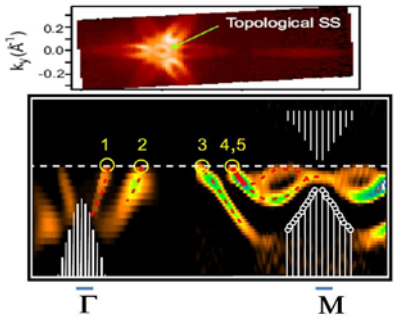
CLASS of 2014

12 Awards, 32 IRGs: Brandeis, Chicago, Colorado, Columbia, Harvard, Minnesota, MIT, Nebraska, NYU, Ohio State, Penn State, Princeton.

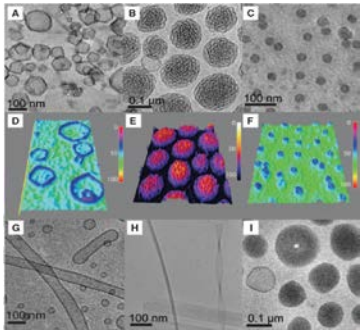
CLASS of 2017

8 Awards, 19 IRGs: Cornell, Northwestern, UC Santa Barbara, U Penn, U Wisconsin, U Texas-Austin, U of Washington, U of Illinois.

9 MRSECs have PREMs (2 have 2)



Princeton MRSEC: 3D Topological Dirac Insulator with a Quantum Spin Hall Phase



U Penn MRSEC: Self-assembly of Janus-dendrimers into Uniform Dendrimersomes

https://mrsec.org/

Where Materials Begin & Society Benefits

2019-2020 MRSEC Competition

2019-2020 MRSEC Competition

- Preliminary Proposal (due by 5 p.m. submitter's local time):

  June 24, 2019

- Full Proposal Deadline (due by 5 p.m. submitter's local time):

  November 26, 2019

- Reverse Site Visits

  February/March 2020

2019-2020 MRSEC Competition

- **Anticipated Type of Award**:

  Yearly Cooperative Agreement

- **Estimated Number of Awards**:

  8 to 10 (12 are recompeting)

- **Anticipated Program Total Funding Amount**:

  $31,500,000 (maybe less !!!)

- **Anticipated Funding Amount per IRG**:

  $1,300,000 - $1,350,000

- **Award Duration**:

  6 Years

NSF Merit Review Criteria

- **Intellectual Merit**: The Intellectual Merit criterion encompasses the **potential to advance knowledge**; and
- **Broader Impacts**: The Broader Impacts criterion encompasses the **potential to benefit society** and contribute to the achievement of specific, desired societal outcomes.
- **Solicitation Specific Criteria**: collaborations, complexity, synergy, **partnerships, diversity**.

IRGs Suggested Research

Proposals are sought that address fundamental, timely and complex materials problems that are intellectually challenging, important to society, belonging to or broadening the current MRSEC portfolio, and possibly aligned with DMR's participation in the NSF Big Ideas:

https://www.nsf.gov/news/special_reports/big_ideas/.

Notably, DMR plays an important role in:

Harnessing the Data Revolution;

The Future of Work at the Human-Technology Frontier;

Understanding the Rules of Life;

The Quantum Leap.

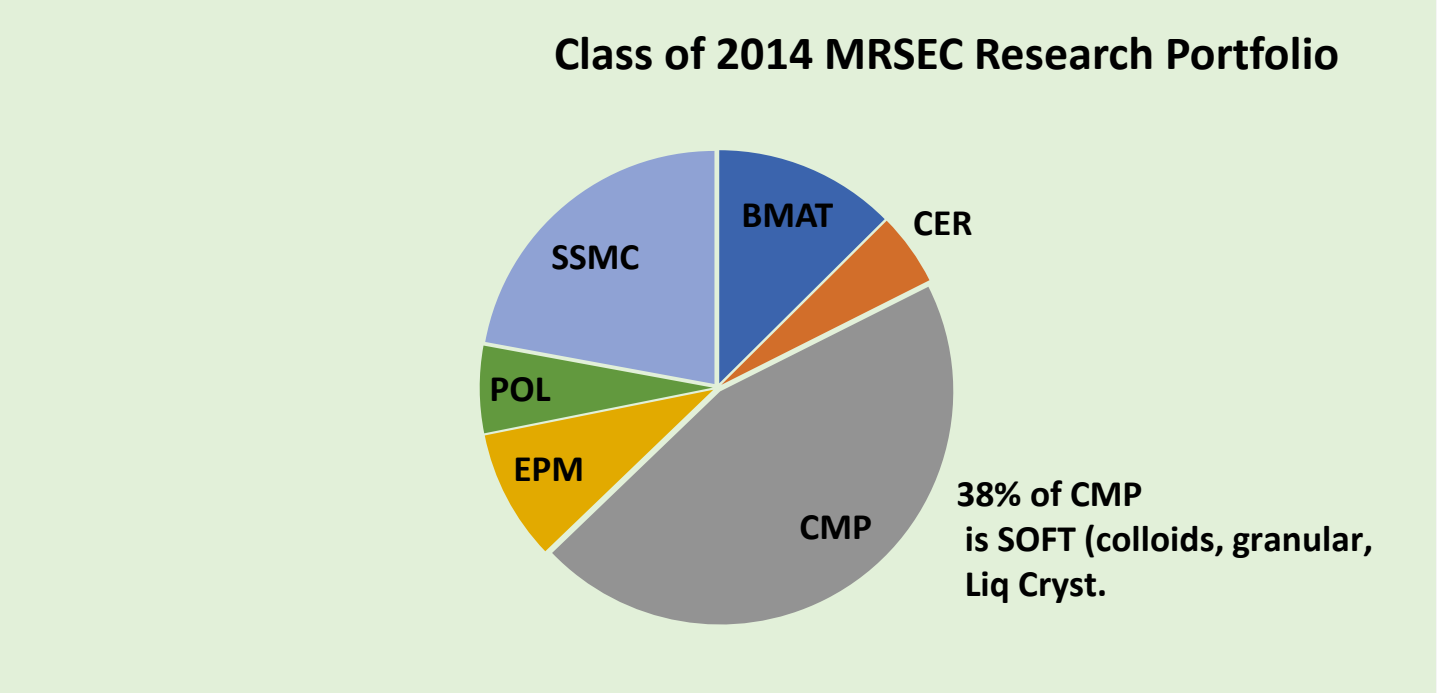
Research Topics Suggestions

Further, potential research topics broadening the current MRSEC portfolio include and of DMR interest:

- Supervised and Unsupervised Machine Learning addressing materials science complex problems, and in particular as applied to traditional materials science problems in: Ceramics, Metals, Metallic Alloys and others (polymers,….).
- Synthetic Materials Biology: in such an effort biologists and system engineers work with materials scientists to identify materials challenges hindering advancements of Synthetic Biology, as well as to generate new Synthetic Biology approaches to materials development i.e., "Materials Biology".
- Structural Materials under Extreme Conditions: this effort addresses fundamental challenges in ceramic, metallic, and polymeric materials and their composites for applications under extreme conditions.
- Recyclable Plastics and Alternative Materials for Sustainable Development: these efforts could include (i) development of intrinsically recyclable polymers, (ii) better understanding of mechanical properties of recycled plastic products, (iii) strategies to improve the properties of recycled plastics, (iv) materials alternatives for plastics.

Class of 2014: 12 MRSEC 32 IRGs

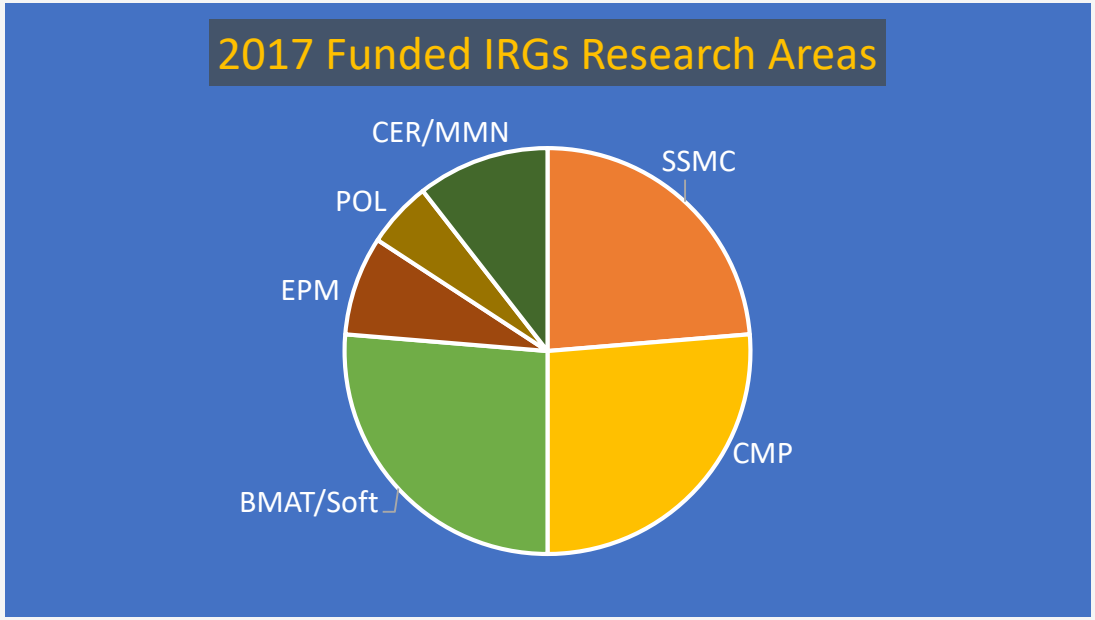
CLASS of 2014: **Brandeis, Chicago, Colorado, Columbia, Harvard, Minnesota, MIT, Nebraska, NYU, Ohio State, Penn State, Princeton.**



Class of 2017: 8 MRSEC 19 IRGs

CLASS of 2017

Cornell, Northwestern, UC Santa Barbara, U Penn, U Texas-Austin, U Washington, U of Illinois, U of Wisconsin.



Successful proposal

- Unique research: a niche. Complementary (not overlapping) expertise. Emerging area of DMR interest
- More than pairwise interactions: document synergy in writing. More than a collection of projects
- Diverse team in each IRG: ethnicity, gender, faulty rank, departmental affiliation, interdisciplinary
- Who is the competition? What can you (distinct) contribute?
- What is the complex materials science fundamental problem that is addressed?
- Are the solicitation specific criteria fully addressed? Will the answers be obvious to reviewers?
- Start with a small IRG Team. Add individuals as needed. Avoid excess individuals overlap in IRGs
- The center of intellectual effort at Lead Institution: a few outside collaborators is acceptable
- The IRG science must wow.

2019-2020 MRSEC Competition

The solicitation encourages the submission of proposals that align with materials aspects of NSF's Big Ideas; it also encourages proposals that may address any materials class, provided that they describe transformative fundamental materials science advances.

The proposed IRGs must focus on fundamental materials science research as it applies to the above mentioned topical areas.

The proposed IRG research topics would normally be aligned with DMR typically supported research; deviations from such research efforts may be considered upon prior consultation with the cognizant program officer(s) listed in the solicitation (email a half-pager).

2019-2020 MRSEC Competition

- A MRSEC may encompass two to three interdisciplinary research groups (IRGs). Each IRG involves several faculty members (typically from a minimum of 6 to a maximum of 10 to 12) addressing a major topic or area, in which sustained support for interactive effort by the several participants of complementary backgrounds, skills, and knowledge is critical to progress.
- The IRGs in a center may be thematically related, or they may address different aspects of materials research. The MRSEC as a whole is expected to be more than the sum of its IRGs, with the synergy arising from its common infrastructure, shared facilities, education and outreach activities, etc. Each IRG must show clear benefits of an interdisciplinary and collaborative approach to address a major materials topic or area and the linkages between researchers within the IRG.

2019-2020 MRSEC Competition Review

- Preliminary proposals will be reviewed by topical panels: IRGs will be reviewed in topical panels. A MRSEC proposal may be reviewed in 3 different panels. Panel advises which IRGs can be considered for a full submission. A full proposal will include a minimum of 2 viable IRGs.

- Full proposals will be reviewed by ad-hoc mail review. Full proposals with 2 viable IRGs may be recommended for the Reverse Site Visit Review.

- A panel of experts will be in attendance at the Reverse Site Visit; RSV Panels (2 proposals) will be held in February/March 2020 at NSF.

2019-2020 MRSEC Competition Review

- MRSEC proposals are evaluated in terms of the IRGs and of the Center as a whole, using the following additional criteria:

Interdisciplinary Research Groups: (Used in evaluating Preliminary and Full proposals)

- Does the IRG describe a well-integrated research program distinguished by intellectual excellence and driven by a clear vision leading to fundamental advances, new discoveries, and/or technological developments that could have national and international significance?
- Are the capabilities of the investigators, technical soundness of the proposed approach, and adequacy of the resources (available or proposed), including instrumentation and facilities appropriate for a center?
- Are the benefits of a multi-investigator, interdisciplinary approach to address a major topic or area normally supported by the Division of Materials Research for each IRG clearly laid out?; Does cooperation and interdependence of the investigators within the IRG come across?
- Is the work of a scope and complexity that requires Center support?
- Is the IRG addressing cutting edge science?