NATIONAL HIGH MAGNETIC FIELD LABORATORY

User Program Overview

Eric Palm
Deputy Laboratory Director

National High Magnetic Field Laboratory

1.4 GW Generator

Florida State University

45T Hybrid
DC Magnet

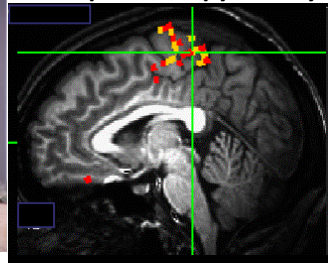
Los Alamos National Laboratory

101T Pulse Magnet
10mm bore

University of Florida

Advanced Magnetic
Resonance Imaging
and Spectroscopy Facility

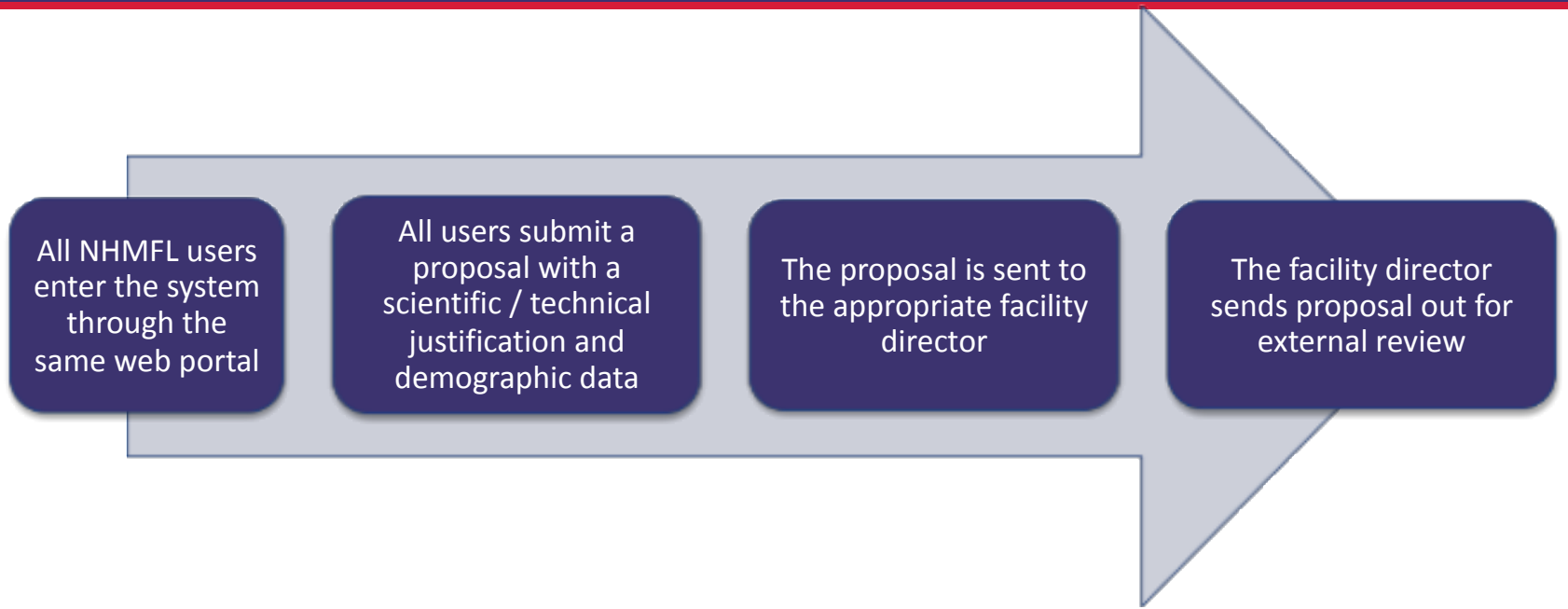
11.4T MRI Magnet
400mm warm bore



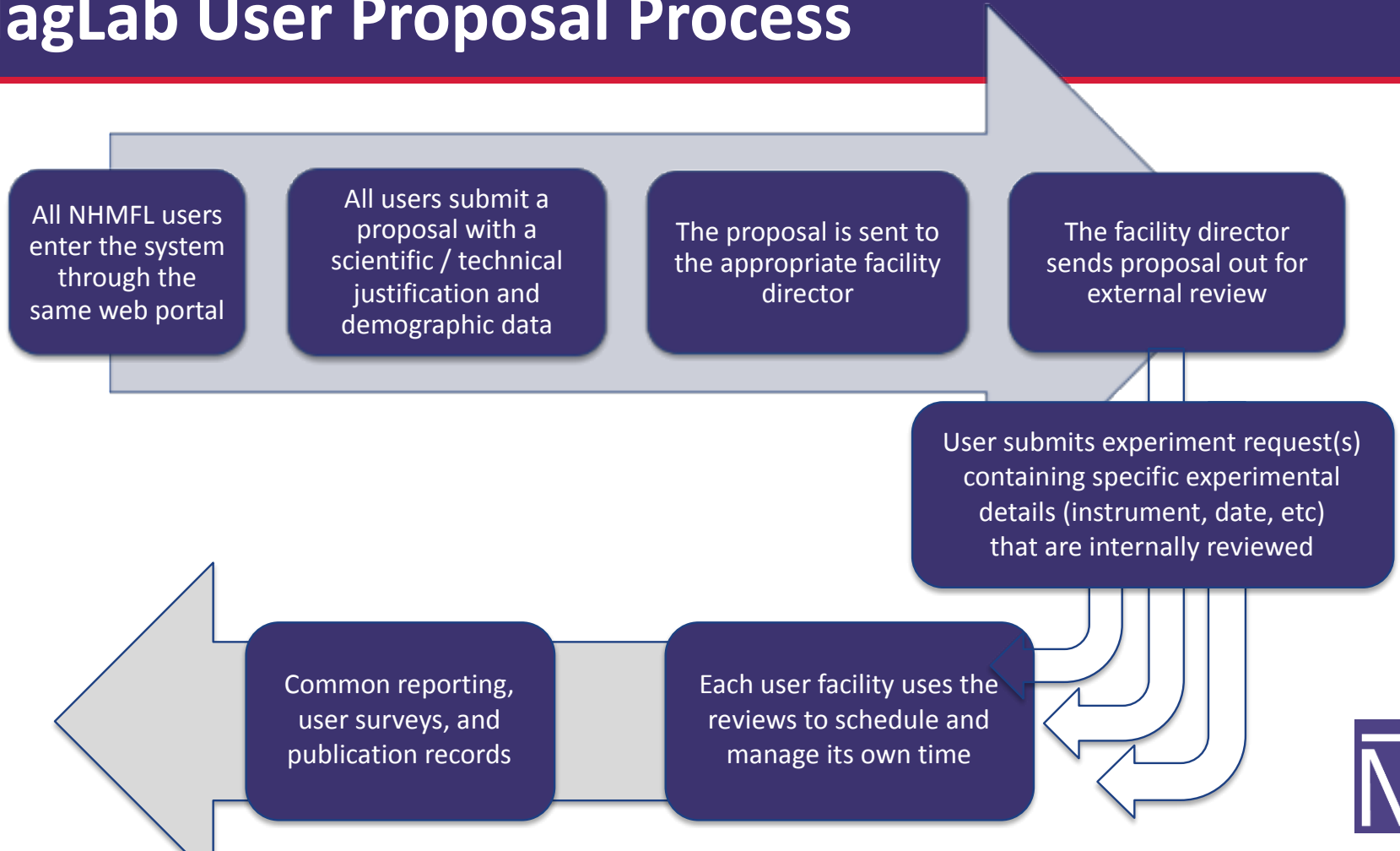
High B/T Facility
17T, 6weeks at 1mK

900MHz, 105mm bore
21T NMR/MRI Magnet

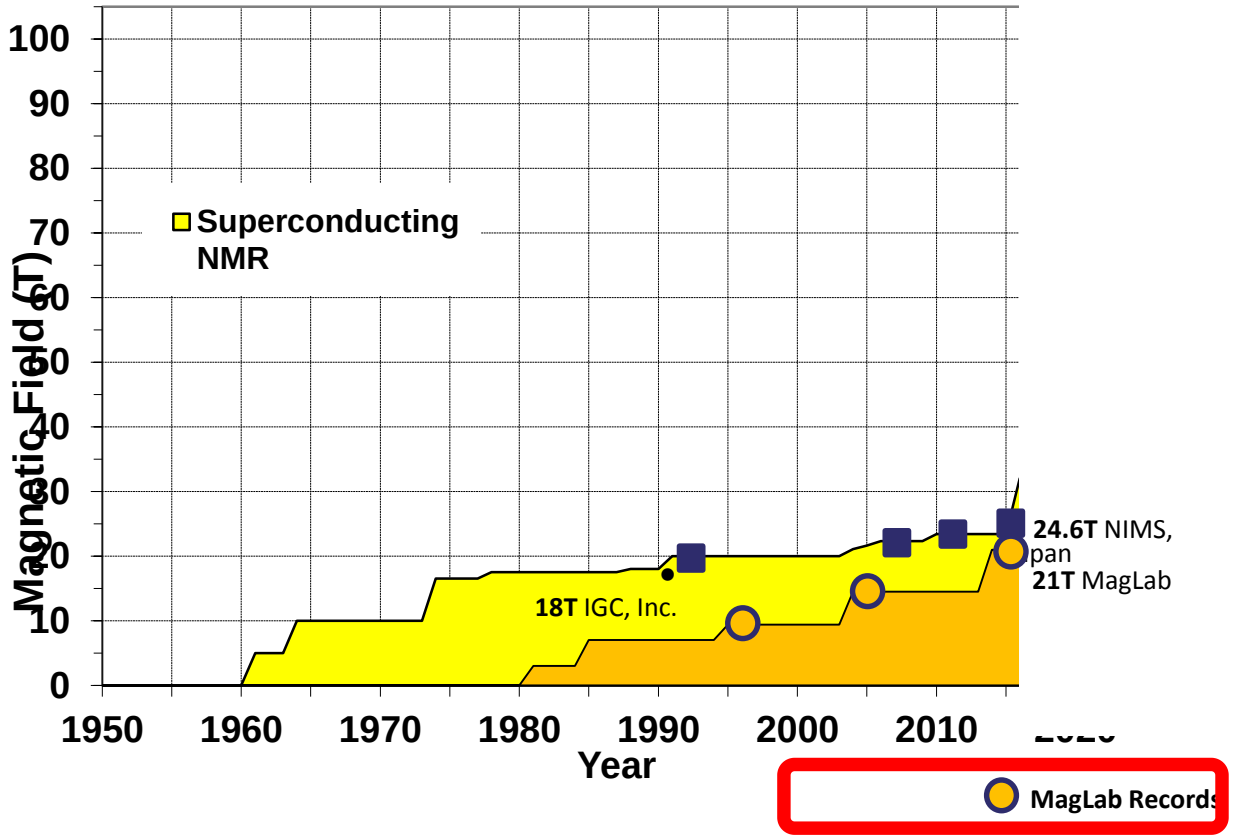
MagLab User Proposal Process



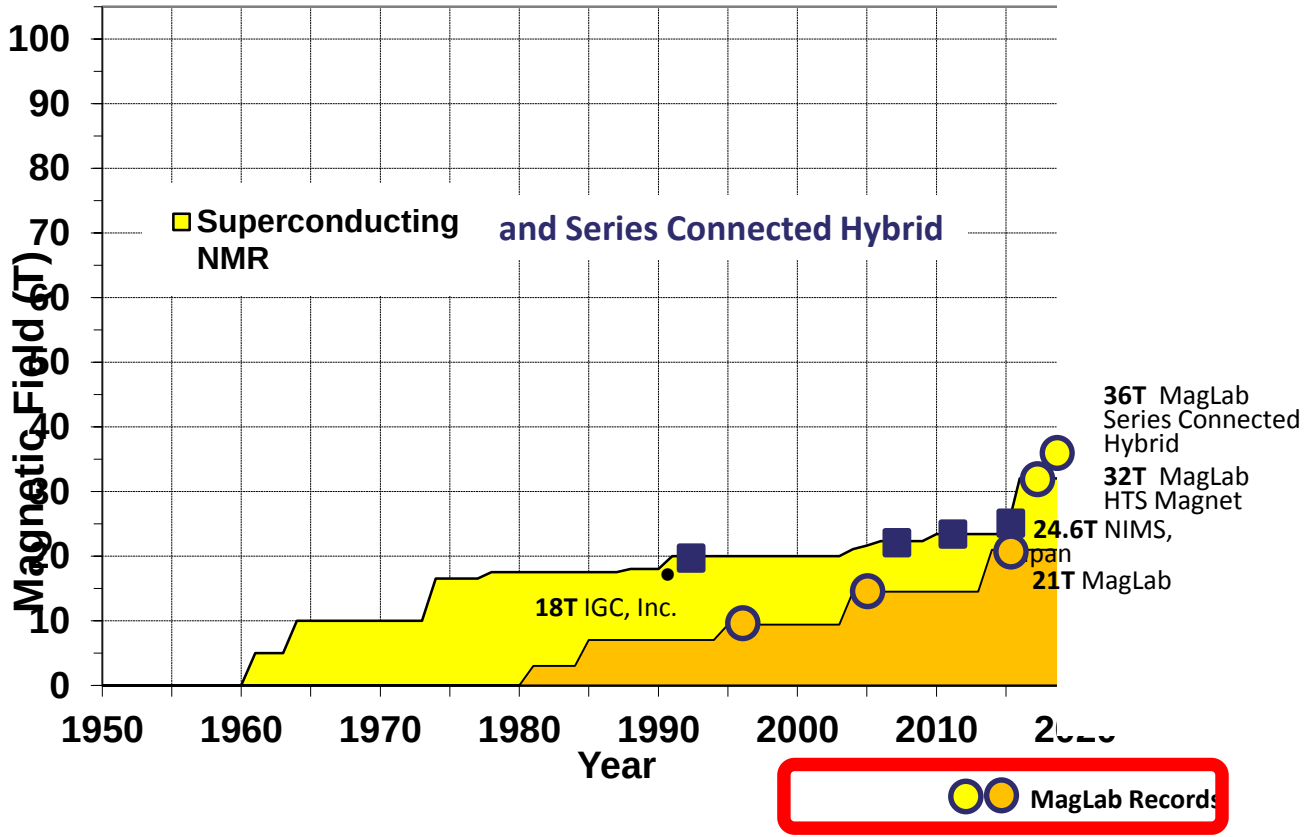
MagLab User Proposal Process



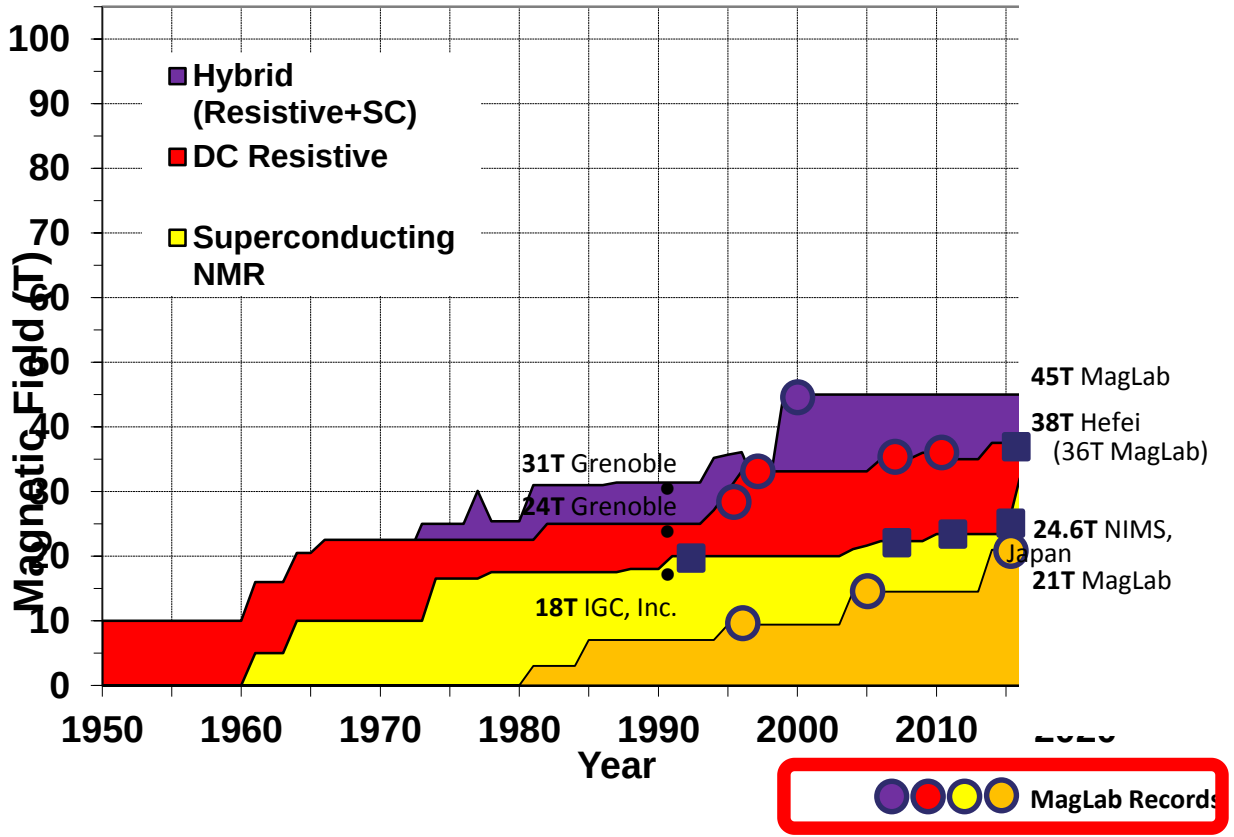
Superconducting, Resistive, Hybrid, and Pulsed Magnets



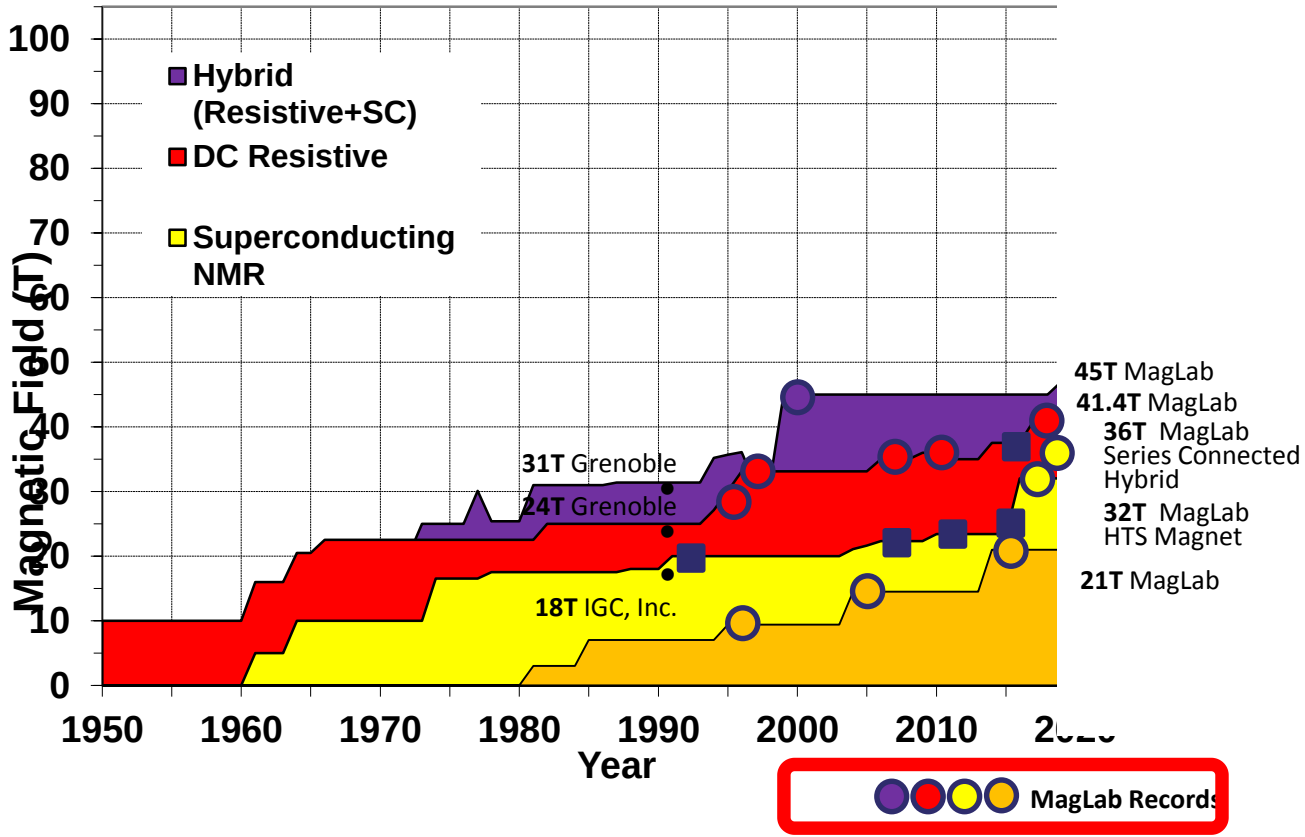
Superconducting, Resistive, Hybrid, and Pulsed Magnets



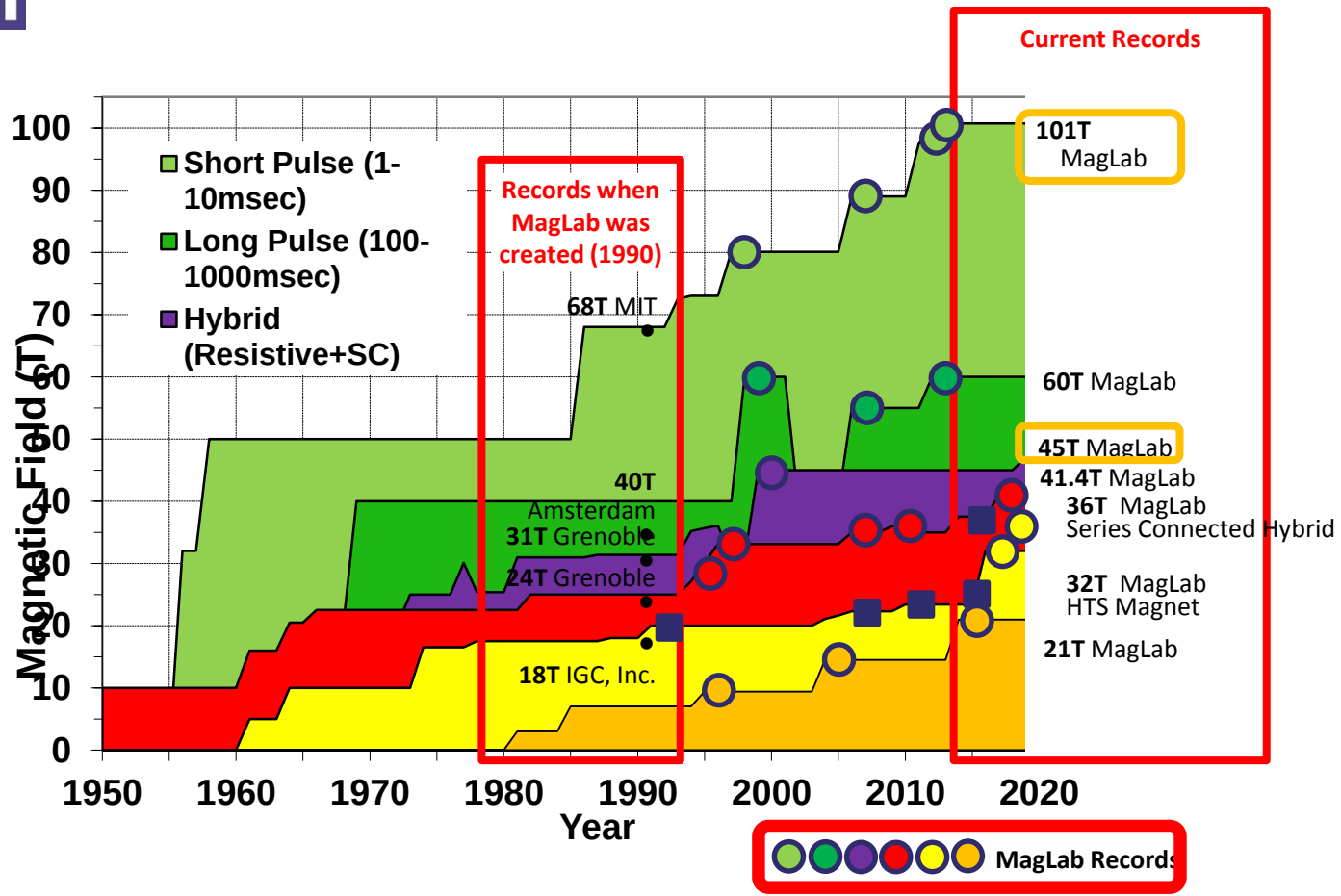
Superconducting, Resistive, and Hybrid, Pulsed Magnets



Superconducting, Resistive, and Hybrid, Pulsed Magnets



Superconducting, Resistive, Hybrid, and Pulsed Magnets

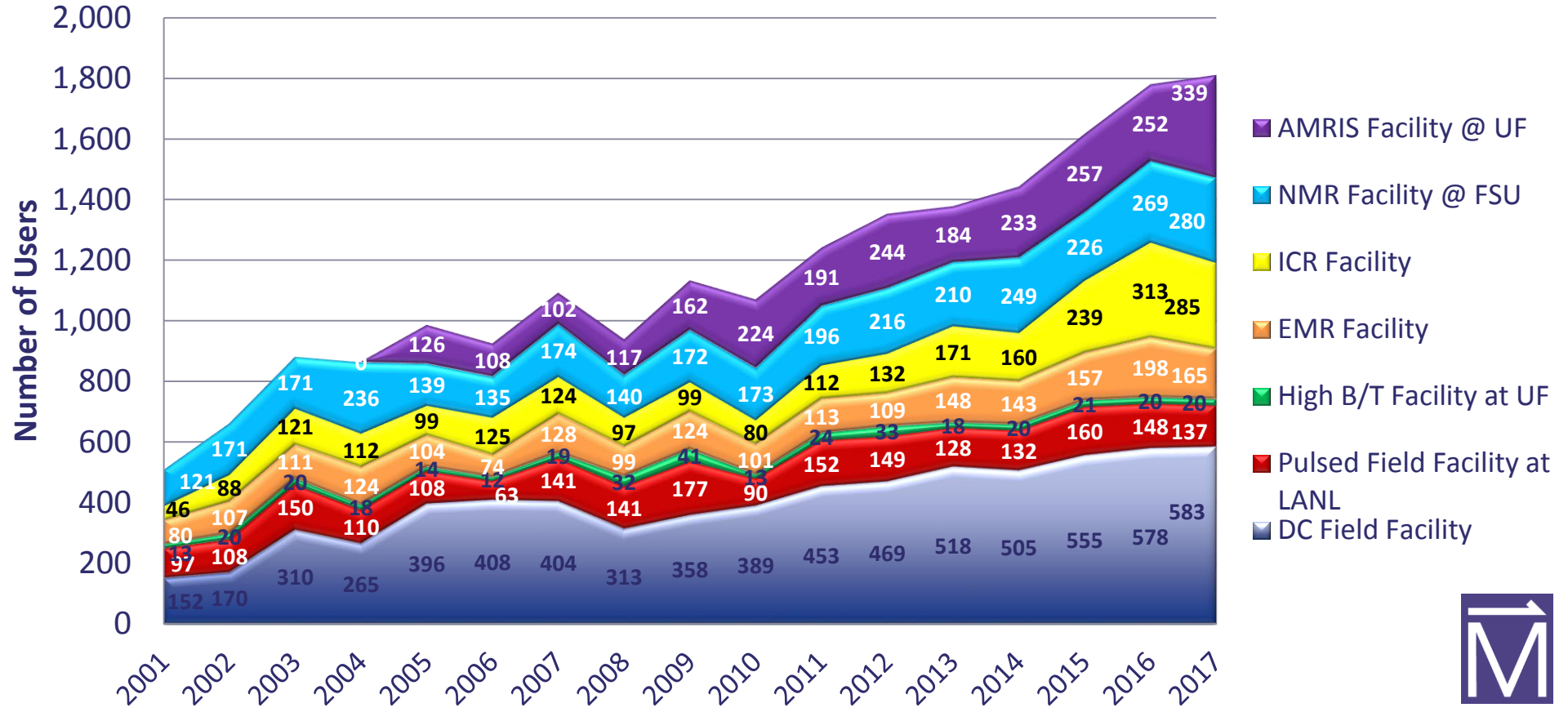


Magnet Usage

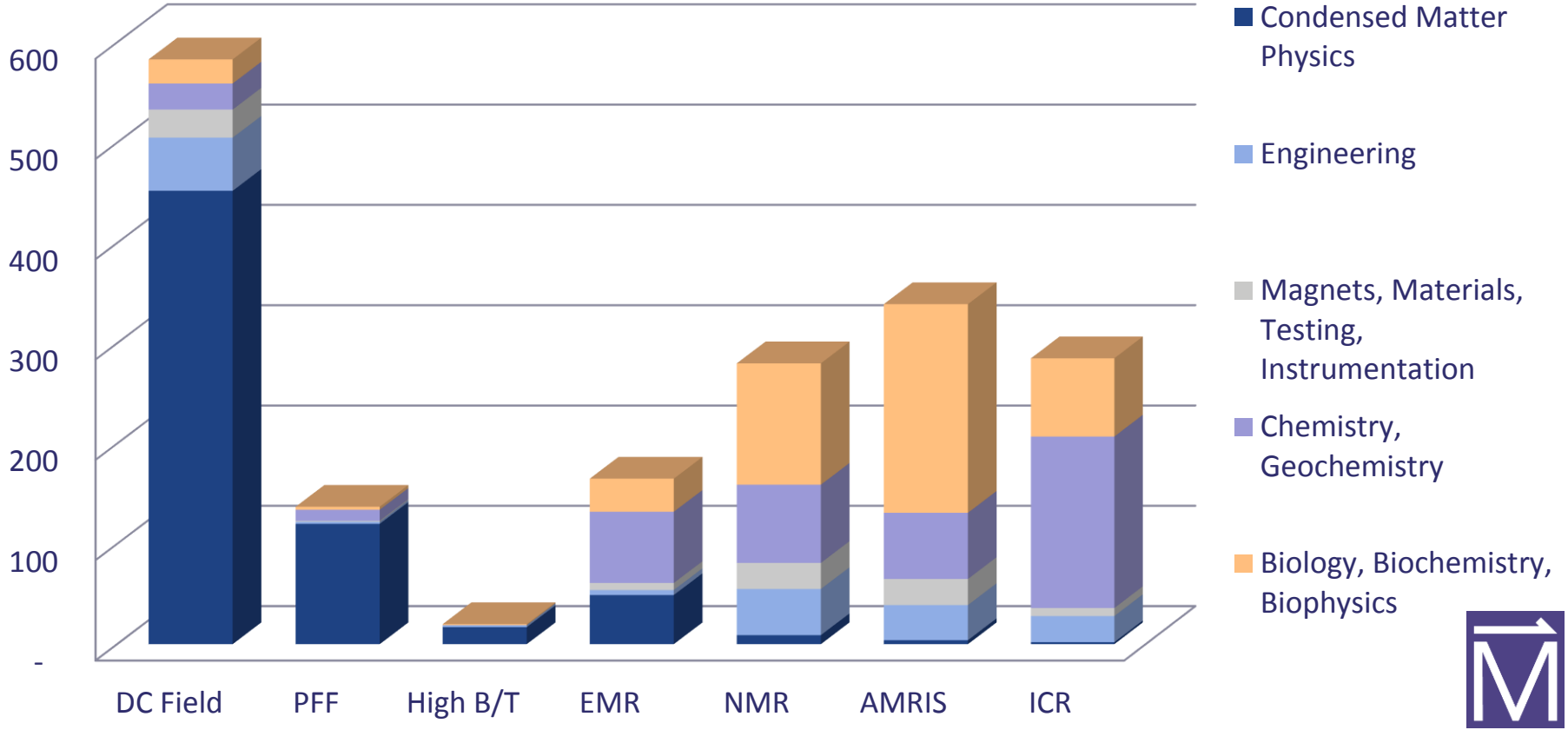
***Table 4:** User Facility Operations*

DC Field Facility	Resistive Magnets & Hybrid	Superconducting Magnets	Total Days Used	Percentage of Total Days Used
	Number of Magnet Days[1]			
NHMFL-Affiliated	160.15	211	**371.15**	20.84%
Local	0	35	**35**	1.97%
U.S. University	360.44	521	**881.44**	49.50%
U.S. Govt. Lab.	36.06	57	**93.06**	5.23%
U.S. Industry	0	7	**7**	0.39%
Non-U.S.	183.08	134	**317.08**	17.81%
Test, Calibration, Set-up, Maintenance, Inst. Dev.	48.85	27	**75.85**	4.26%
Total:	**788.58**	**992**	**1,780.58**	**100%**

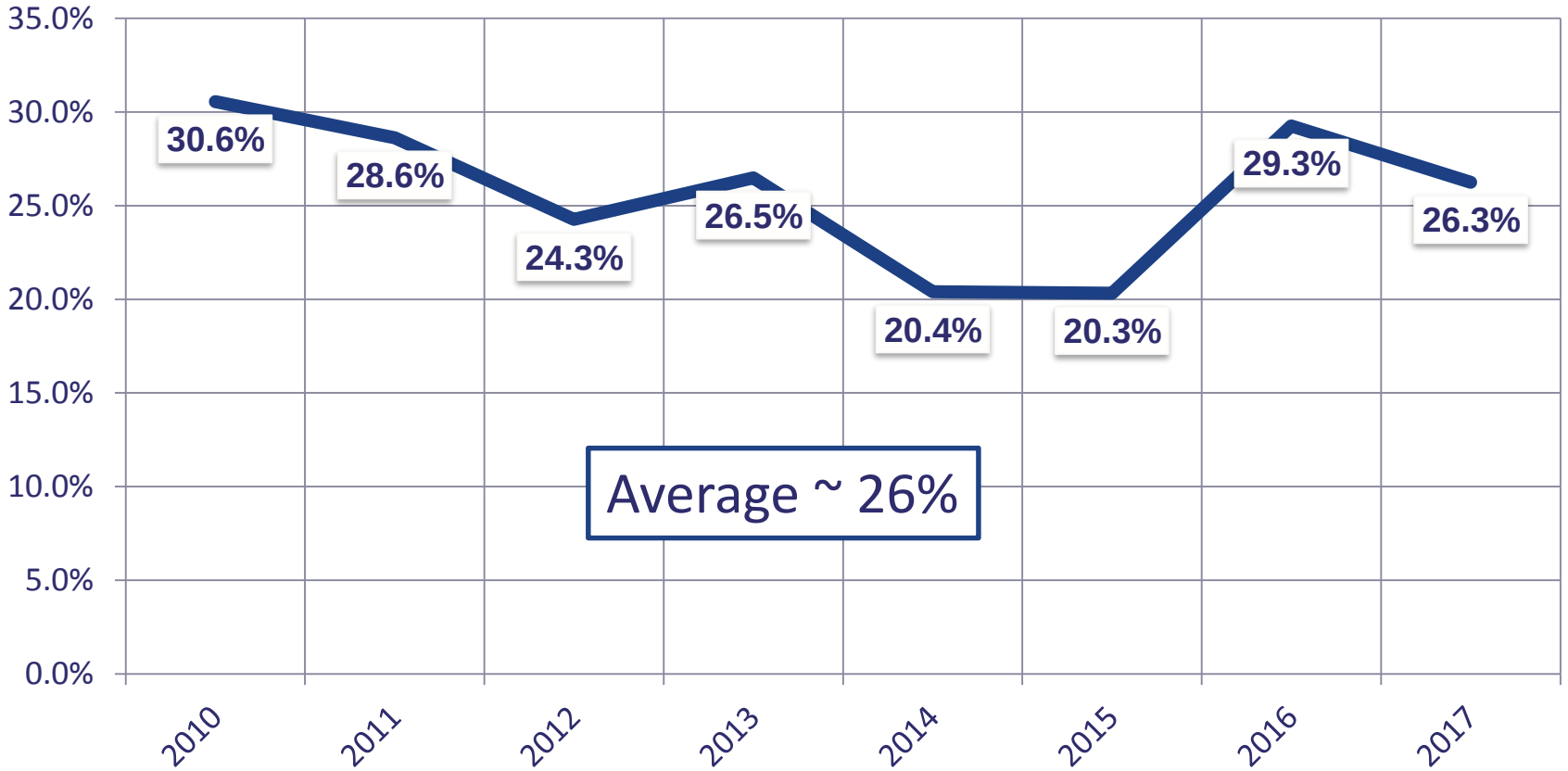
MagLab User by Facility



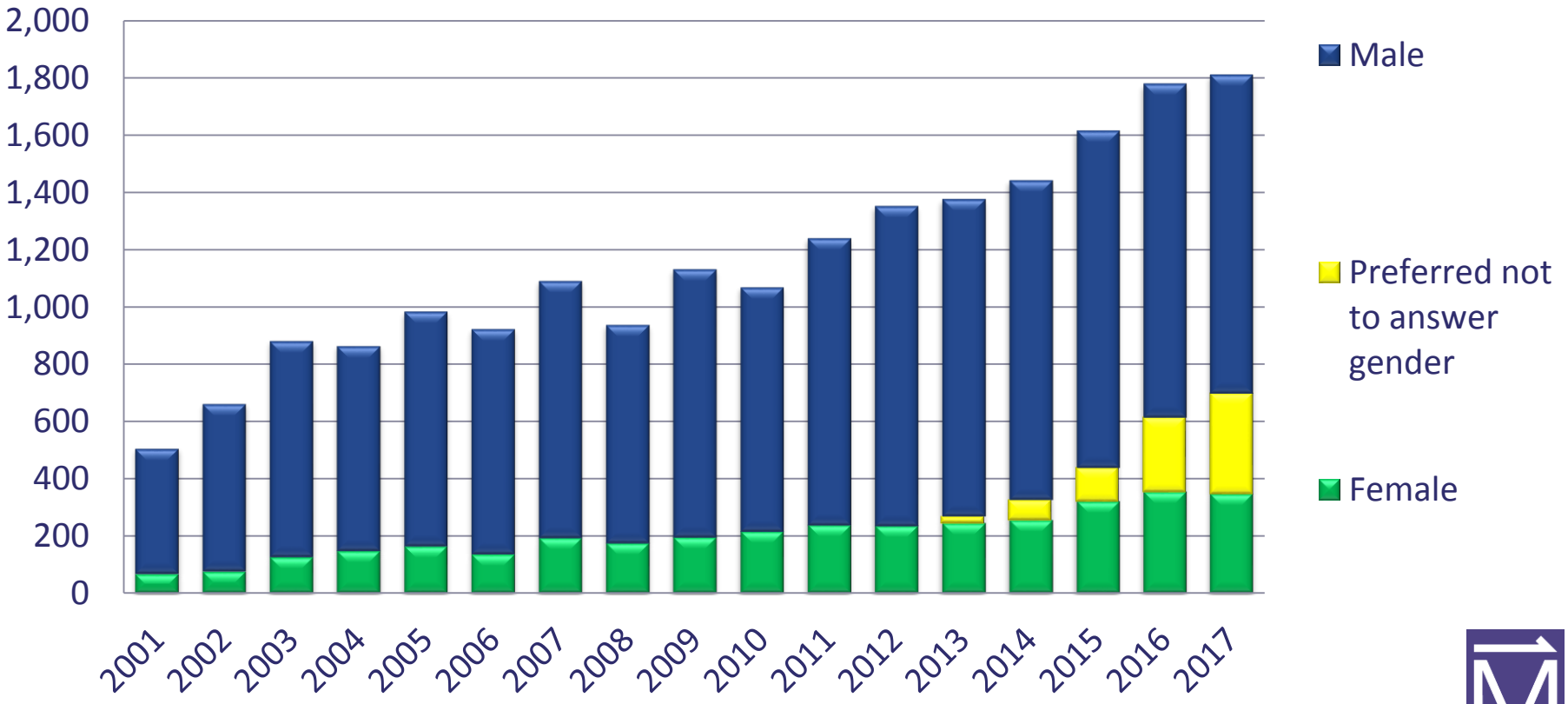
MagLab User by Discipline for each Facility



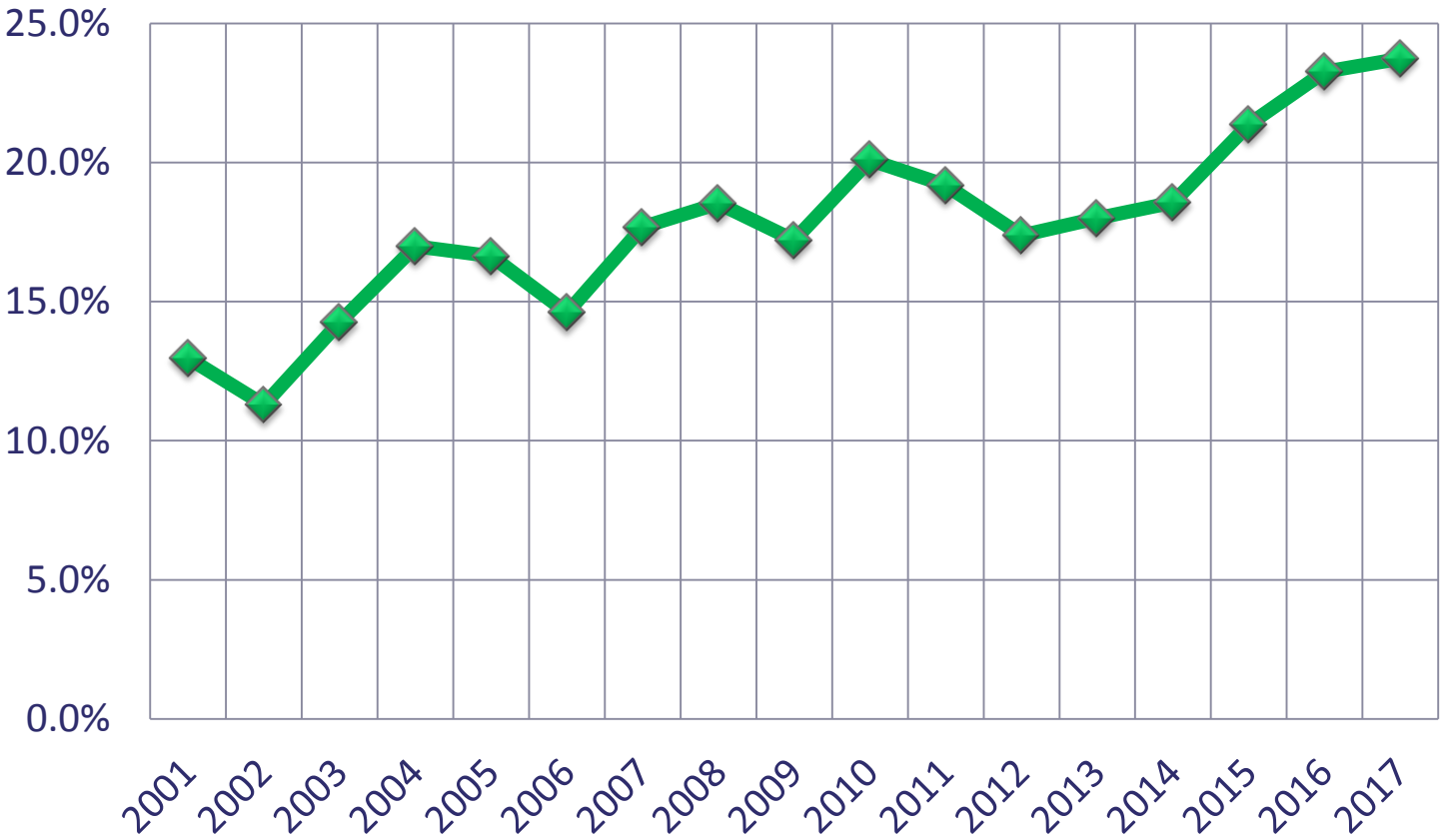
Percentage of NEW MagLab PI's



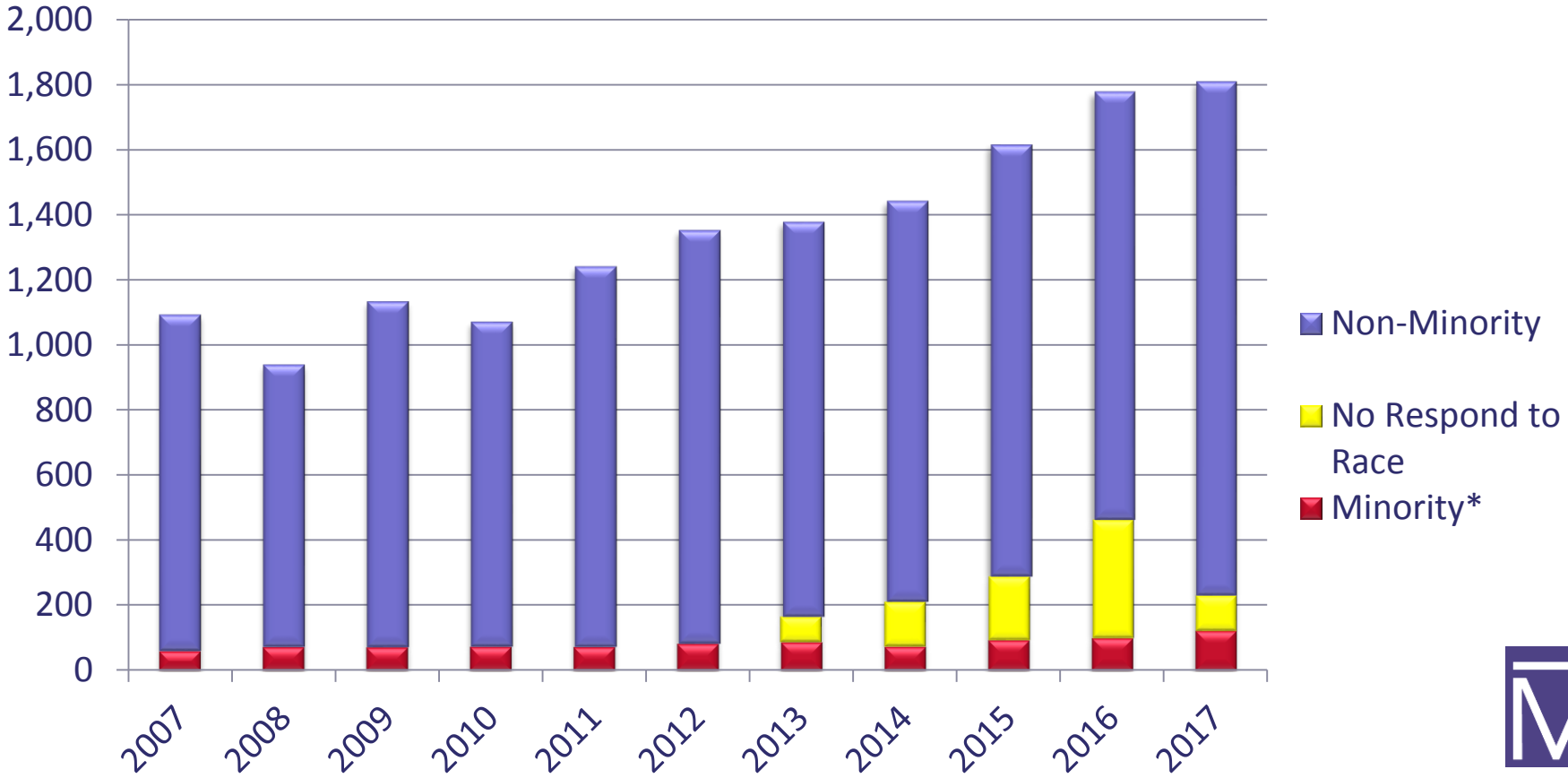
MagLab Users: Gender Diversity



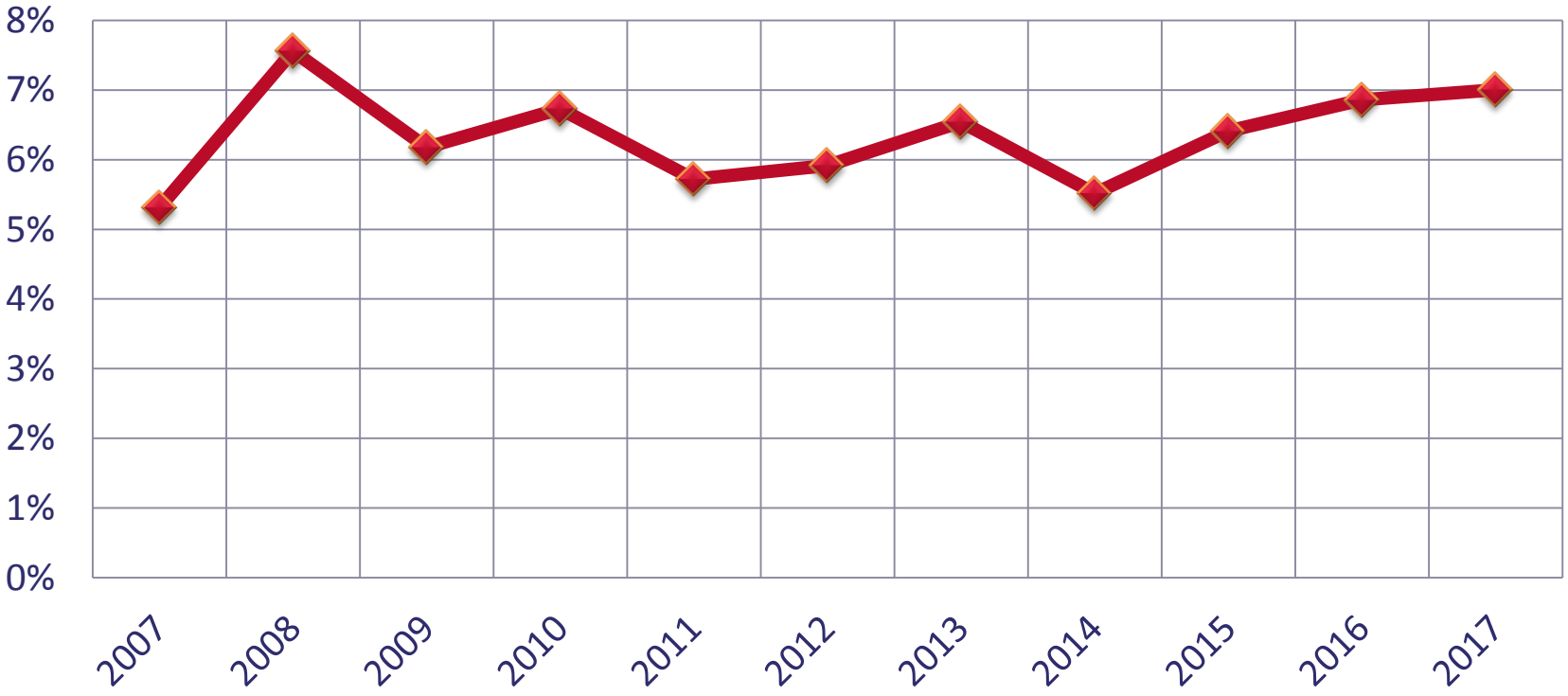
MagLab User: %Female (of those who self identify)



MagLab Users: Race Diversity



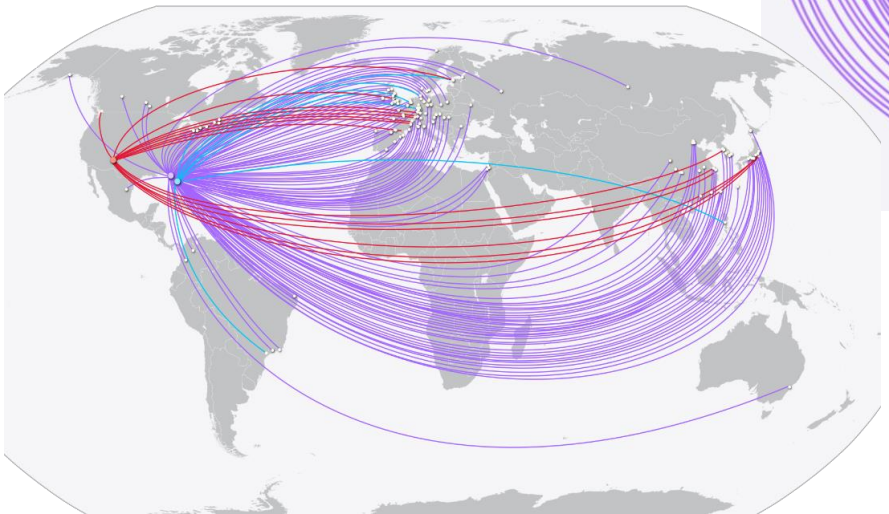
MagLab User: % Minority (of those who self identify)

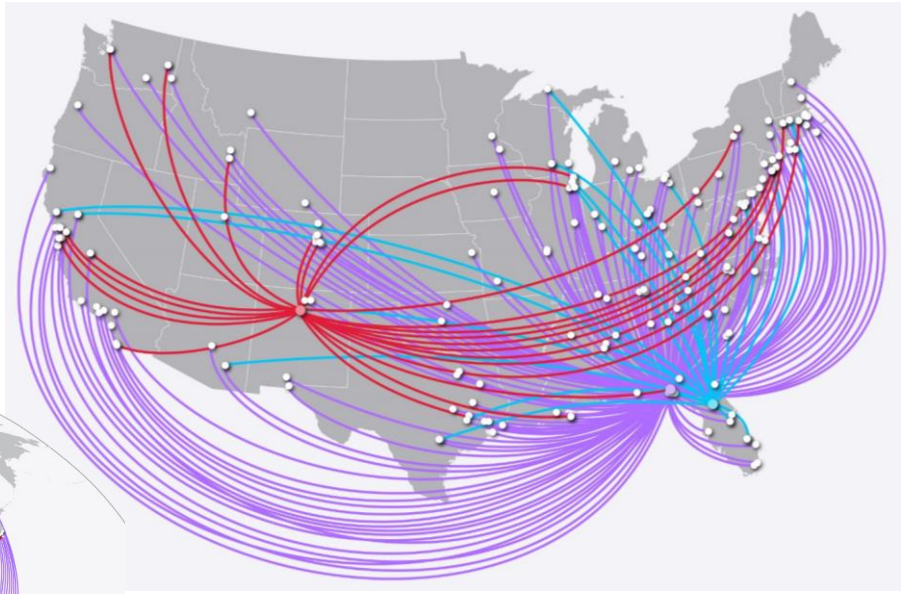


The MagLab attracts Researchers from Around The World

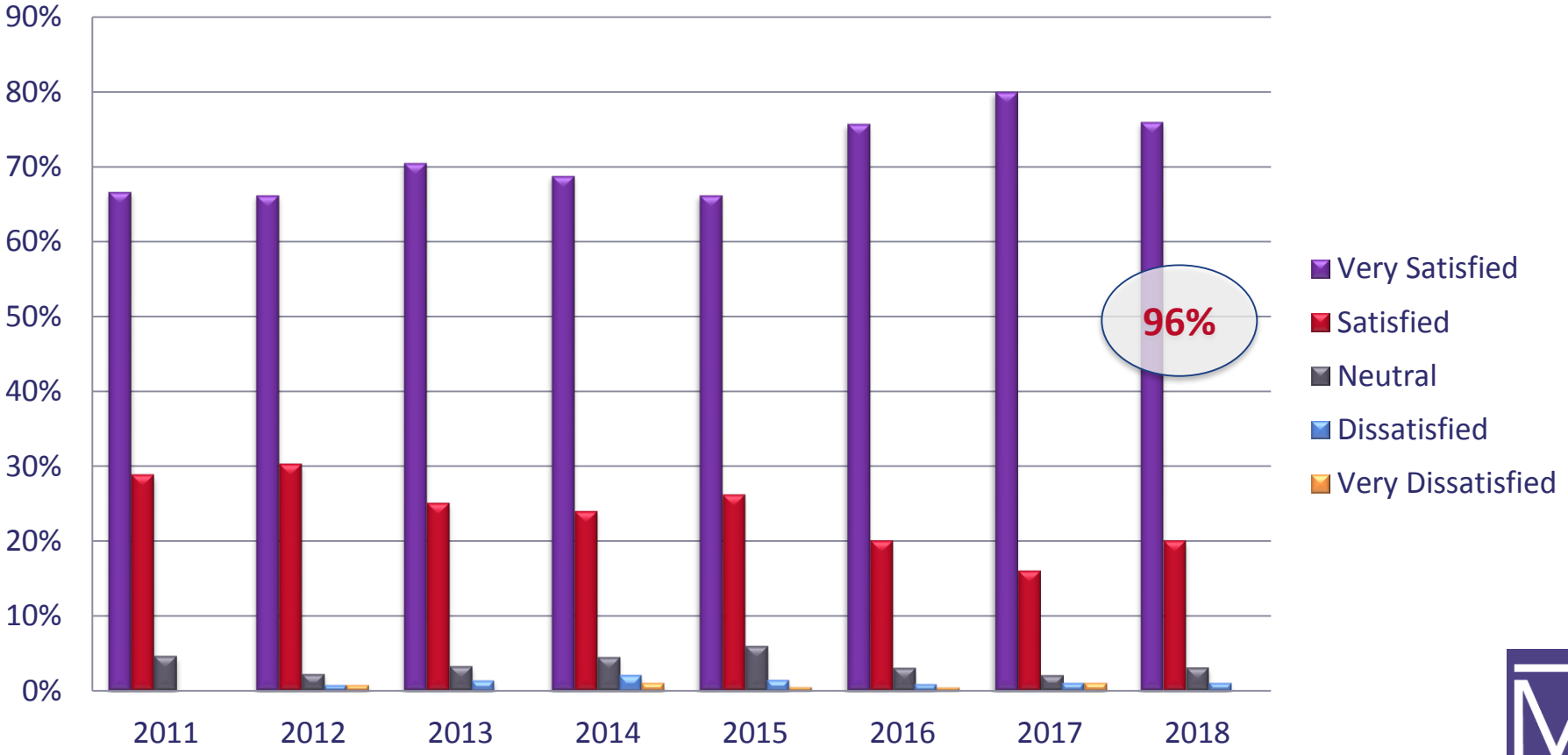
In 2017, the MagLab hosted experiments by more than 1800 users from 173 institutions across the United States…

…and a total of 324 institutions from throughout the world.

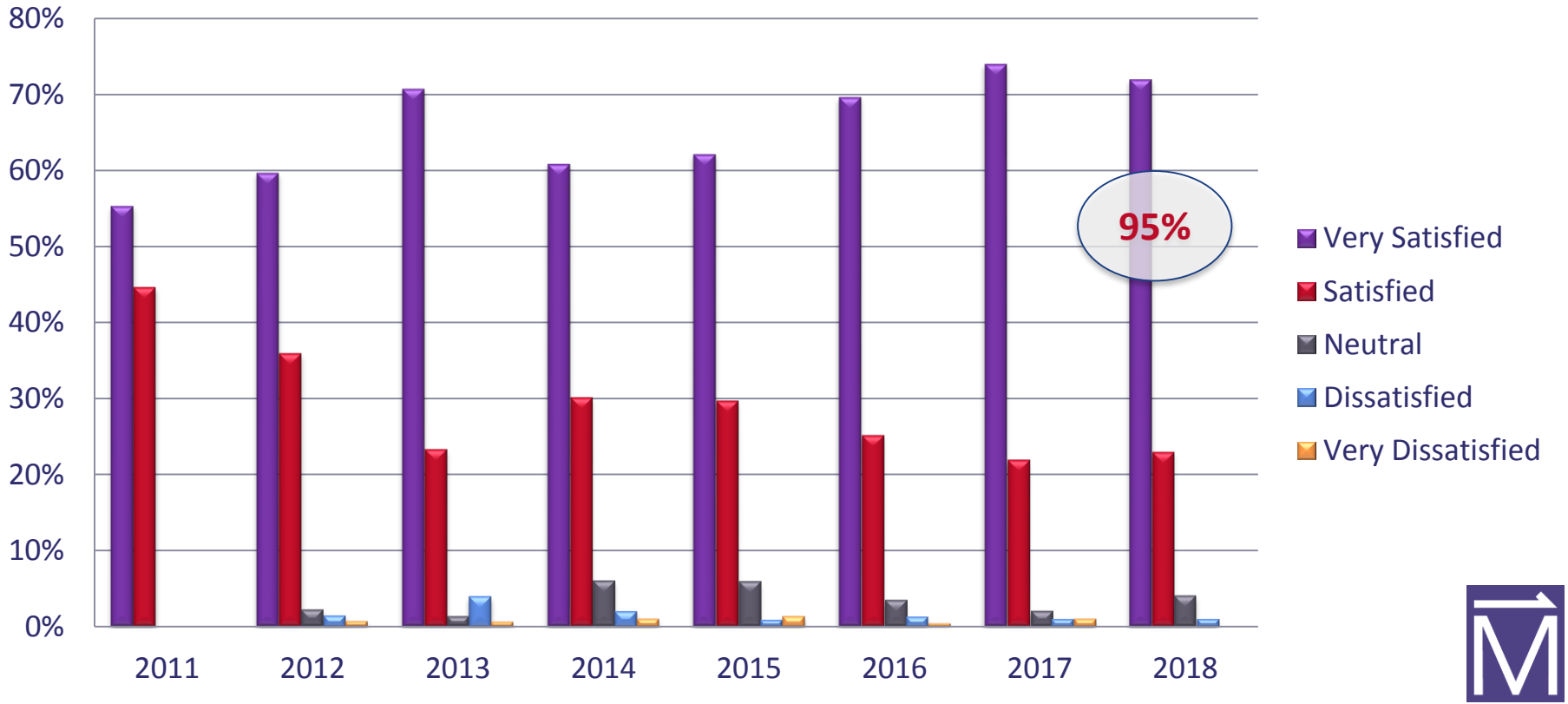




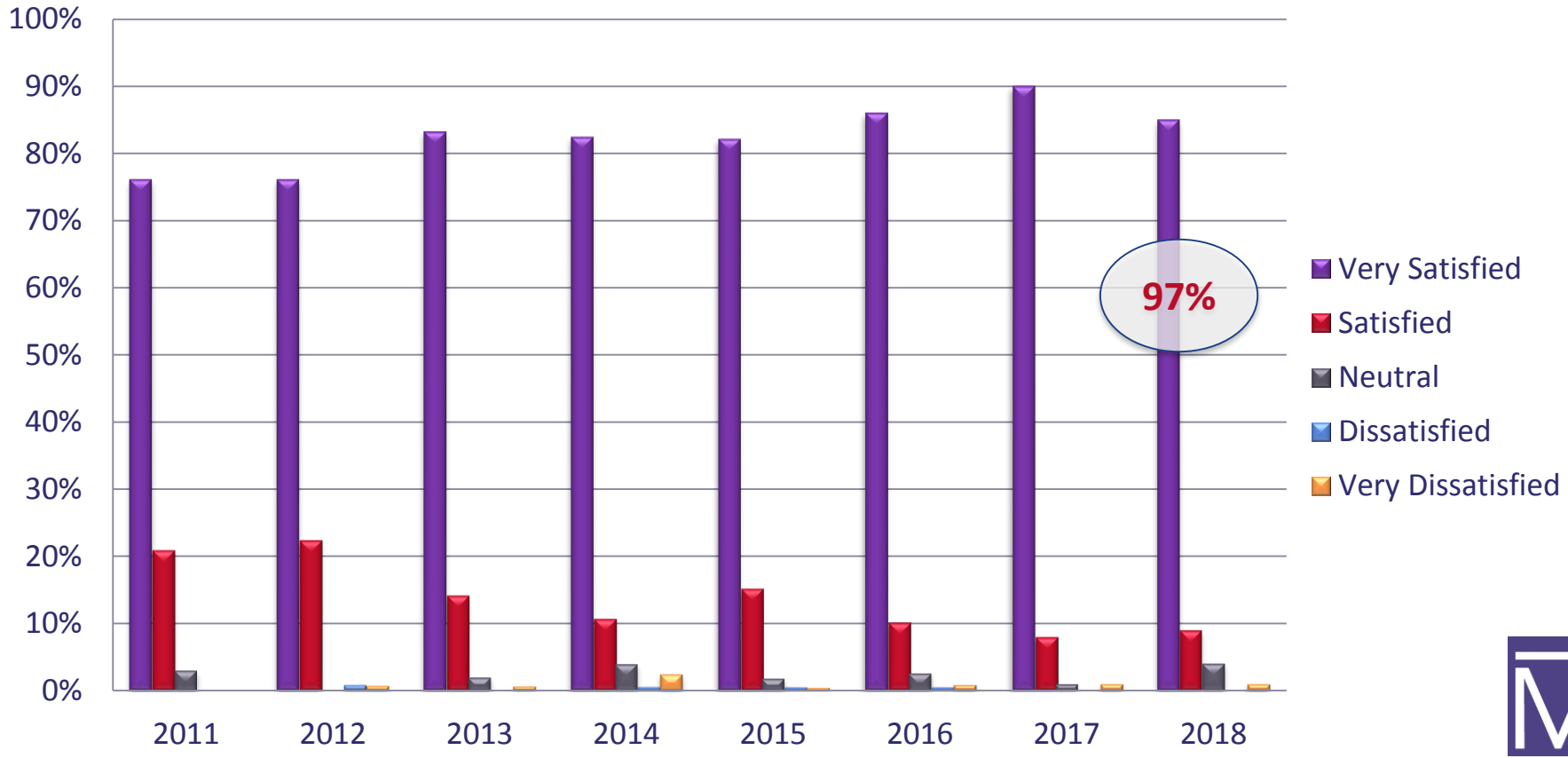
How satisfied were you with the availability of the facilities and equipment?



How satisfied were you with the performance of facilities and equipment



How satisfied were you with the assistance provided by Magnet Lab facilities technical staff?



User Feedback

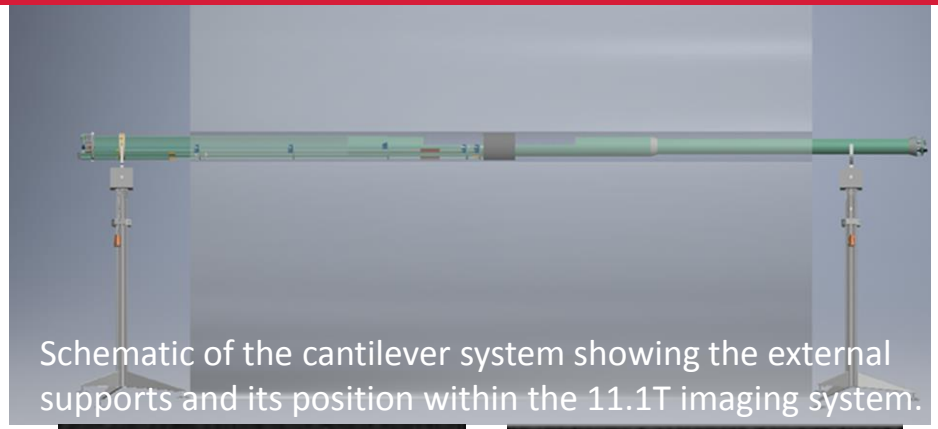
After their magnet time each user gets an email requesting feedback. This email in part reads:

Comments of any nature are welcome, but specifics help us greatly. For example:

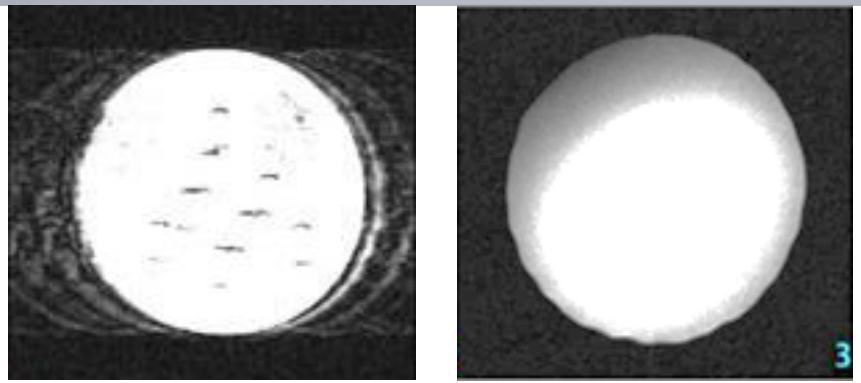
- Was some piece of equipment in need of repair or calibration?
- Was someone particularly helpful (or not)?
- Have you used an electronic instrument that does a job better than the one you used here?
- Do you have any safety concerns or questions that should be addressed?
- Did a staff member talk to you about safety both at the start and the end of your experiment?
- To report safety concerns or other safety related issues visit http://safemag.magnet.fsu.edu/. You may submit anonymously.

We use this feedback as we consider raises, job assignments, equipment purchases, safety concerns,…

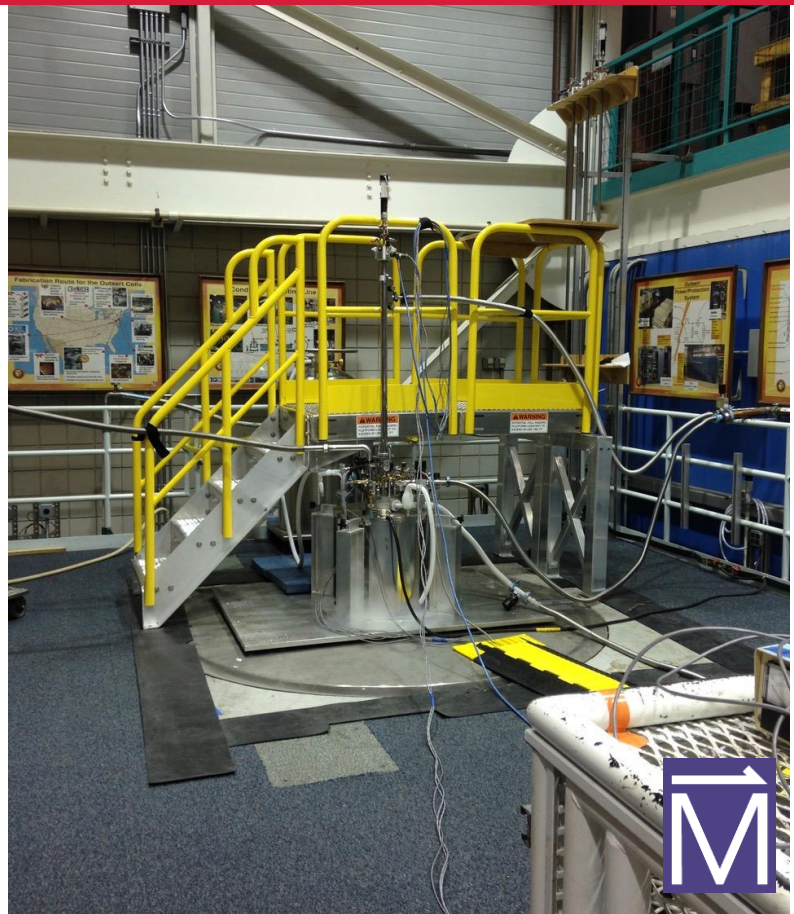
User Feedback



Schematic of the cantilever system showing the external supports and its position within the 11.1T imaging system.



Images highlighting the motion artefact without the cantilever (left), and it's removal with the cantilever (right)



Oversubscription Pressure

Table 4: *User Program Proposal Pressure by User Facility for 2017*

User Facility	Experiments submitted (current year)	Experiments submitted (deferred from prev. year)	Experiments reviewed	Days submitted	Days outside users used	Days awardee institution personnel (local) used	Total days used	Subscription % (days submitted/ days used)
AMRIS-NSF Funded	31	23	54	1,124	450.3	0	**1,124**	**100%**
AMRIS Non-NHMFL Funded	82	112	194	1,396	875.8	79	**1,396**	**100%**
DC Field	411	118	529	3,121	1,298.6	35	**1,780.6**	**175.3%**
EMR	151	23	174	1,707	721	22	**1,120**	**152.4%**
High B/T	10	5	15	840	403	0	**590**	**142.4%**
ICR	105	50	155	2,371	362.8	42.4	**1,120**	**211.7%**
NMR	503	45	548	3,597	1,870.5	185.5	**3,417**	**105.3%**
Pulsed Field	75	27	102	625	440	30	**612**	**102.1%**
Total	**1,368**	**403**	**1,771**	**14,781**	**6,422**	**394**	**11,159.6**	**132.5%**

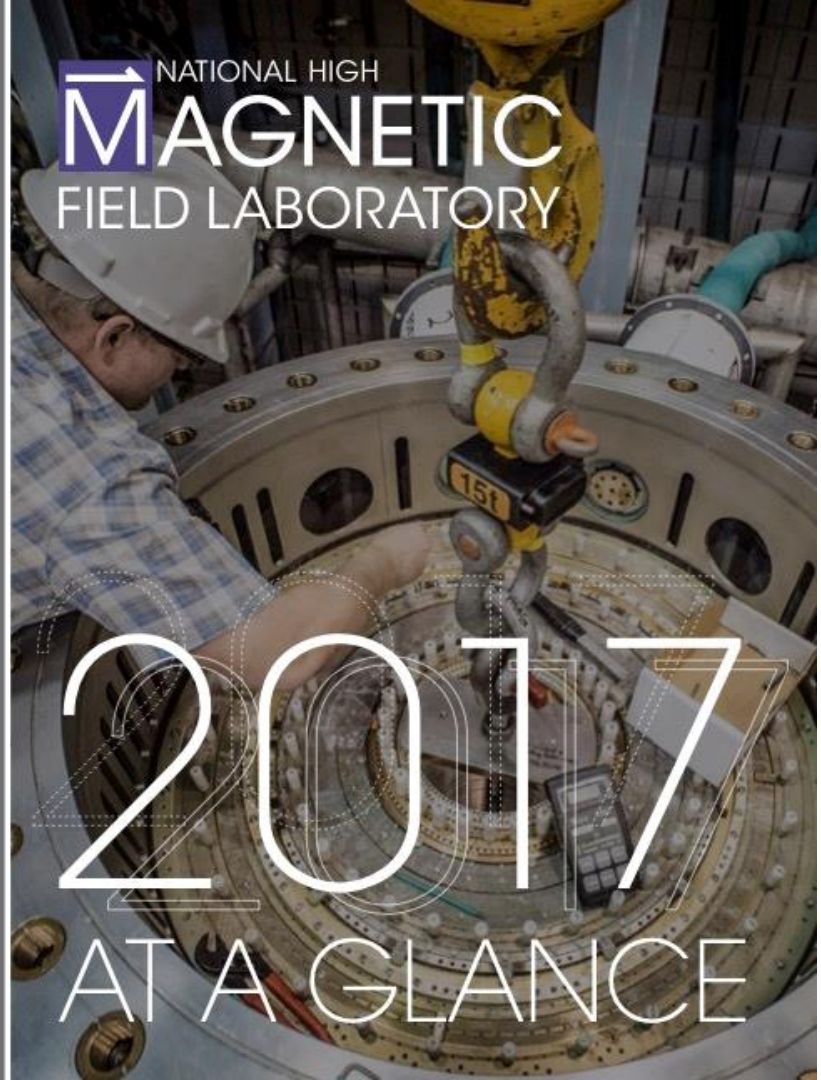
Publications

Table 5.2: Overview of publications generated by external users and in-house research activities.

Facility	All Internal Authors		Internal Corresponding Author(s) with External Co-Authors		External Corresponding Author(s) with Internal Co-Authors		All External Authors		Totals		Total
	NSF Core Grant Cited	NSF Core Grant Not Cited	NSF Core Grant Cited	NSF Core Grant Not Cited	NSF Core Grant Cited	NSF Core Grant Not Cited	NSF Core Grant Cited	NSF Core Grant Not Cited	NSF Core Grant Cited	NSF Core Grant Not Cited	Pubs for 2018
AMRIS at UF	-	-	8	4	8	9	-	1	16	14	**30**
DC Field at FSU	3	-	5	2	56	4	10	-	74	6	**80**
EMR at FSU	-	-	8	-	27	-	5	1	40	1	**41**
High B/T at UF	-	-	4	-	2	-	-	-	6	-	**6**
ICR at FSU	6	-	8	-	16	2	10	-	40	2	**42**
NMR at FSU	2	-	12	2	24	2	1	2	39	6	**45**
PF at LANL	1	-	8	2	23	3	-	-	32	5	**37**
ASC	1	-	3	-	12	3	-	-	16	3	**19**
MS&T	9	-	5	2	8	2	-	-	22	4	**26**
Education at FSU	-	-	1	-	-	-	-	-	1	-	**1**
CMT/E	5	1	12	4	24	6	-	1	41	12	**53**
Geochemistry	2	-	2	1	2	13	-	-	6	14	**20**
MBI at UF	-	-	2	3	-	11	2	13	4	27	**31**
UF Physics	-	-	4	-	3	-	-	-	7	-	**7**
Total of Publications	**23**	**1**	**69**	**18**	**171**	**52**	**28**	**18**	**291**	**89**	**380**
% of Publications	**6%**	**0%**	**18%**	**5%**	**45%**	**14%**	**7%**	**5%**	**77%**	**23%**	**100%**

"In-house" Publications
88%

"User Driven" Publications
94%


NATIONAL HIGH
MAGNETIC
FIELD LABORATORY
15t
2017
AT A GLANCE

A Range of Research Possibilities

1 LAB, 3 SITES, 7 USER FACILITIES,

3 IN-HOUSE RESEARCH GROUPS & MAGNET DEVELOPMENT

The only facility of its kind in the United States, the National High Magnetic Field Laboratory (National MagLab) is the largest and highest-powered magnet laboratory in the world.

Located at Florida State University, the University of Florida and Los Alamos National Laboratory, the National MagLab expands the boundaries of scientific knowledge and advances basic science, engineering and technology in the 21st century.

In 2017, 1,809 researchers from academia and the corporate world conducted cutting-edge research using our unique, world-record instruments. The MagLab exists for these users to explore promising new materials, research pressing global energy problems and expand our understanding of the biochemistry that underlies living things by performing experiments in our seven user facilities:

- **Advanced Magnetic Resonance Imaging and Spectroscopy (AMRIS)**
- **DC Field**
- **Electron Magnetic Resonance**
- **High B/T**
- **Ion Cyclotron Resonance**
- **Nuclear Magnetic Resonance & Magnetic Resonance Imaging/Spectroscopy**
- **Pulsed Field**

The lab also has a number of important in-house research groups that complement the user facilities through development of new techniques, theories and equipment, including **Materials & Condensed Matter Science**, **Geochemistry** and **Cryogenics**.

The MagLab's **Magnet Science & Technology (MS&T)** group and **Applied Superconductivity Center (ASC)** work to develop the most efficient and strongest resistive, pulsed, superconducting and hybrid magnets in the world.

The 32 T All-Superconducting magnet reached full field on December 8, 2017.

WE USE MAGNETS TO STUDY

MATERIALS

Scientists use our magnets to explore semiconductors, superconductors, crystals and atomically thin materials — research that reveals the secret workings of materials and empowers us to develop new technologies.

- Graphene
- Correlated Electrons
- Topological Matter
- Kondo/Heavy Fermion Systems
- Magnetism and Magnetic Materials
- Quantum Fluids and Solids
- Qubits & Quantum Entanglement
- Semiconductors
- Superconductivity
- Molecular Conductors

ENERGY

Scientists use magnets to study energy and the environment. They work to optimize petroleum refining, advance potential biofuels such as pine needles and algae and fundamentally change the way we store and deliver energy by developing better batteries.

- Petroleomics
- Catalysis
- Dissolved Organic Matter
- Lithium Battery Imaging
- Biofuels
- Superconductivity - Applied Research
- Fuel Cell Membranes
- Geochemistry
- Environmental Analysis

LIFE

Scientists study the foundational science of protein and disease molecules that underlies the cells and creates life itself. This work could improve future treatment of AIDS, cancer, Alzheimer's and other diseases.

- Natural Products
- Quadrupolar NMR
- Dynamic Nuclear Polarization
- Sodium MRI
- Membrane Proteins
- Metabolomics
- Biomarkers

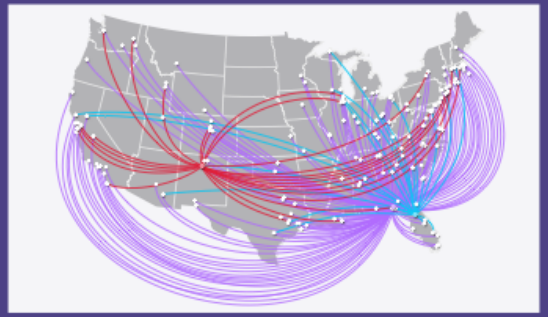
2017 LAB STATS

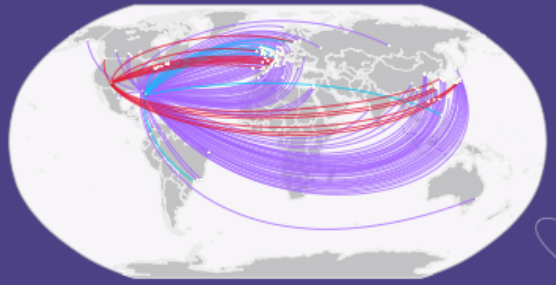
Users	Number of Principal Investigators	MagLab World Records
1,809	480	16

Percentage of Users Who Were New	Articles Published in Peer-reviewed Journals	Ph.D. Dissertations & Master's Theses
21%	408	46

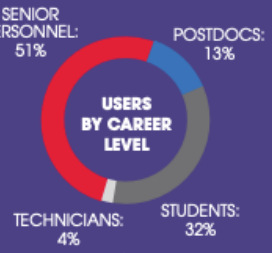
WORLDWIDE USER COMMUNITY

In 2017, the MagLab's **1,809** users represented **173** universities, government labs and private companies in the United States and a total of **324** worldwide.





USER DIVERSITY



DC FIELD - **583**
PULSED FIELD - **137**
HIGH B/T - **20**
EMR - **165**
NMR - **280**
AMRIS - **339**
ICR - **285**

23% OF STUDENT USERS ARE FEMALE.

AND

23% OF POSTDOC USERS ARE FEMALE.

DOMESTIC INSTITUTIONS	INTERNATIONAL INSTITUTIONS
133 UNIVERSITIES	113 UNIVERSITIES
20 GOVERNMENT LABS	25 GOVERNMENT LABS
20 INDUSTRY	13 INDUSTRY

WHAT OUR USERS SAY

94% of users were satisfied with performance of the facilities and equipment.

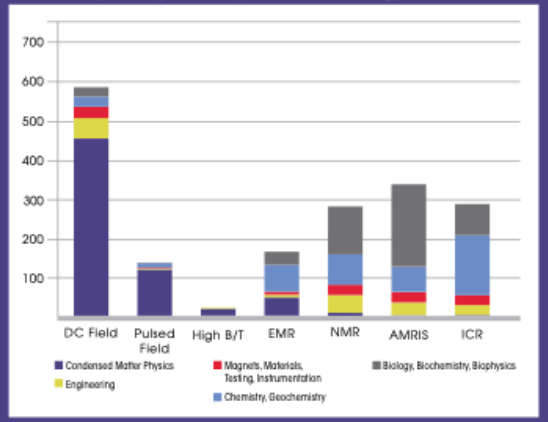
96% of users were satisfied with the assistance provided by MagLab technical staff.

94% of users were satisfied with the proposal process.

Data reflects external users only. All users were surveyed anonymously.

2017 USERS BY DISCIPLINE

The MagLab's interdisciplinary research environment brings scientists from a variety of disciplines to explore materials, energy and life.



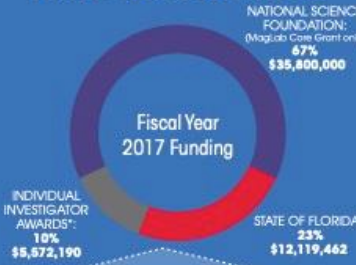
> Thank you for being the best user research facility that I've had the privilege of working at! All the equipment we used on this trip was in perfect condition. The choice of instruments at the MagLab is very extensive, and they cover almost the entire spectrum of measurements.
>
> **Hema C. P. Movva**
> The University of Texas at Austin

> As always thank you so much for your best-of-the-world facility and support.
>
> **Fang Tian**
> Pennsylvania State University

RESEARCH INVESTMENTS

FINANCIAL REPORT

TOTAL BUDGET: $53,491,652



Physics & Materials Research: **46%**
Magnets, Materials & Engineering: **27%**
Chemistry: **9%**
Biology & Biochemistry: **7%**
Management & Administration: **9%**
Education/Diversity: **2%**

*These are new 2017 awards from funding other than the NSF core grant and State of Florida that benefit the MagLab user program.

PARTNERSHIPS

Cross-Sector Partners

NEW WORLD-RECORD MAGNETS

New magnets are an important part of the lab's research ecosystem.
These two world-record magnets will explore the quantum world with greater depth than ever before.

41.4 T RESISTIVE MAGNET

41.4 tesla | copper-silver alloy & copper Bitter disks
32 mm bore | 32 MW power supply

32 T ALL SUPERCONDUCTING MAGNET

32 tesla | YBCO, niobium-tin and niobium-titanium
34 mm bore | 33% stronger than previous record holder

The first high-field magnet to feature high-temperature superconducting YBCO.

ECONOMIC IMPACT

THE MAGLAB **ANNUALLY GENERATES**

IN THE USA
$182 million in economic output
more than **1,560 jobs**

→

OVER THE NEXT 20 YEARS, **PROJECTED TO GENERATE**

IN THE USA
$3.6 billion in economic output
more than **31,000 jobs**

RETURN ON INVESTMENT

$1 INVESTED BY THE STATE = **$6.57** ECONOMIC ACTIVITY IN FLORIDA

BUILDING THE STEM WORKFORCE

ENGAGING THE COMMUNITY

8,000 visitors walked the red carpet at the 2017 movie-themed Open House, **46%** of whom visited the lab for the first time.

97 scientists engaged in outreach to **4,500** people.

11,000 printed copies of *fields* magazine distributed in 2017 and nearly **6,000** *fields* page views online.

2.1 MILLION minutes of MagLab videos watched on our YouTube channel.

ENGAGING STUDENTS & TEACHERS

More than **10,000** K-12 students participated in a tour or classroom outreach, **69** percent of whom came from Title I schools.

5 middle school summer camps reached **90** students, **86%** from underrepresented groups.

10 teachers participated in Research Experiences for Teachers, **80%** from Title I schools.

250+ teachers attended MagLab presentations at science education conferences.

35 high school and college students were interns at the MagLab.

ENGAGING EARLY CAREER SCIENTISTS

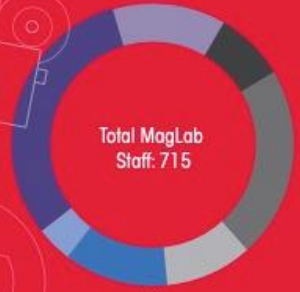
275 lectures, talks or presentations were given by MagLab staff across **14** countries and a dozen states.

80 early career participants in MagLab Theory Winter and User Summer schools.

800+ of the MagLab's 2017 users were postdocs or students.

MAGLAB STAFFING

Personnel at FSU, UF & LANL includes employees funded by the NSF Core Grant or State of Florida.



Senior Personnel: **220**
Other Professional: **93**
Postdoc: **56**
Graduate Student: **162**
Undergraduate Student: **63**
Support Staff - Technical/Managerial: **94**
Support Staff - Secretarial/Clerical: **27**

Postdocs, graduate students and undergraduate students make up **39%** of the staff.

43% OF UNDERGRADS
41% OF GRAD STUDENTS ARE FEMALE
29% OF POSTDOCS

Thank You!

Eric Palm

palm@magnet.fsu.edu

NATIONAL HIGH MAGNETIC FIELD LABORATORY