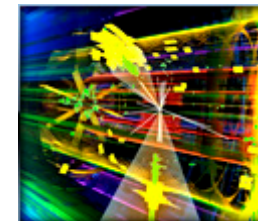
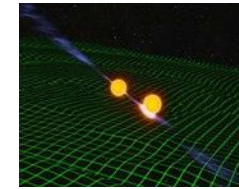
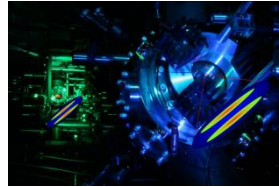




News from NSF Physics

Denise Caldwell

Division Director
Division of Physics



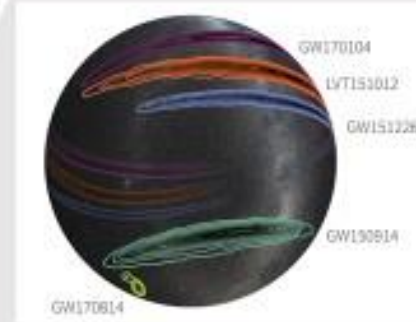


LIGO

An amazing year!

The 2nd Observational Run (O2) ended in August 2017 with an impressive collection of achievements

- Jan. 4: LIGO detects the 3rd binary black hole merger (BBH)
- June 8: LIGO detects the 4th BBH merger
- Aug. 14: First triple detection of a BBH merger (LIGO + Virgo)
- Aug. 17: First detection of a binary neutron star (BNS) merger
- Oct. 3: Weiss, Thorne and Barish win the 2017 Nobel Prize in Physics



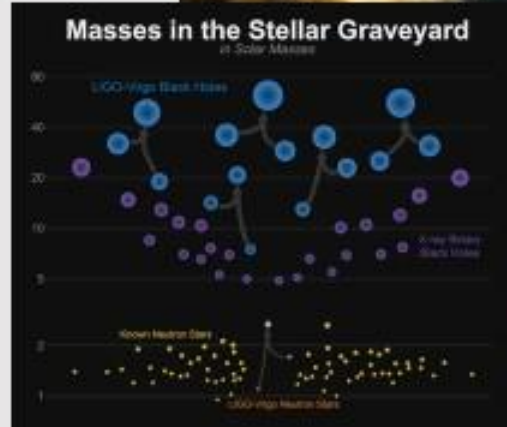
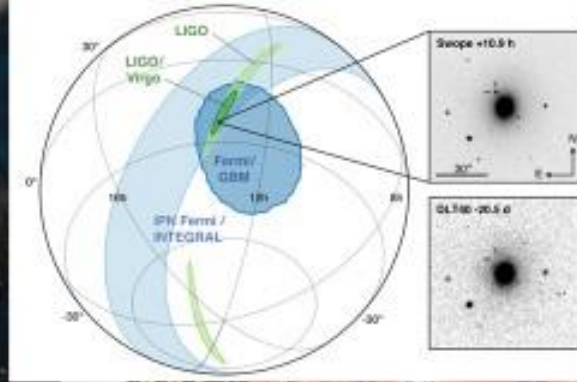
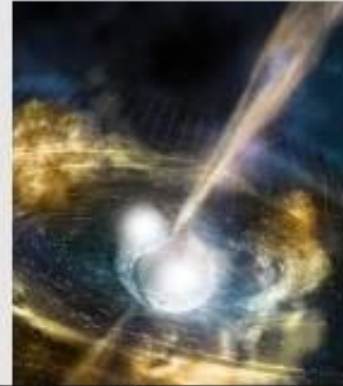


LIGO

The first binary neutron star merger detection

The joint observation of the first BNS merger by GW and EM observatories was a milestone in astronomical history, heralding the new era of Multimessenger astronomy

- Only 1.7 seconds after the GW detection, a gamma-ray burst (GRB) was detected by NASA Fermi satellite
- A massive EM follow up campaign determined that the event was located in the galaxy NGC 4993 (40 Mpc, 130 Mly)
- First direct evidence of the BNS merger as progenitors of short duration GRBs
- First clear observation of a kilonova (emissions of the radioactive decay of the BNS merger ejecta)
- New determination of the Hubble constant, independent of any form of the cosmic "distance ladder"

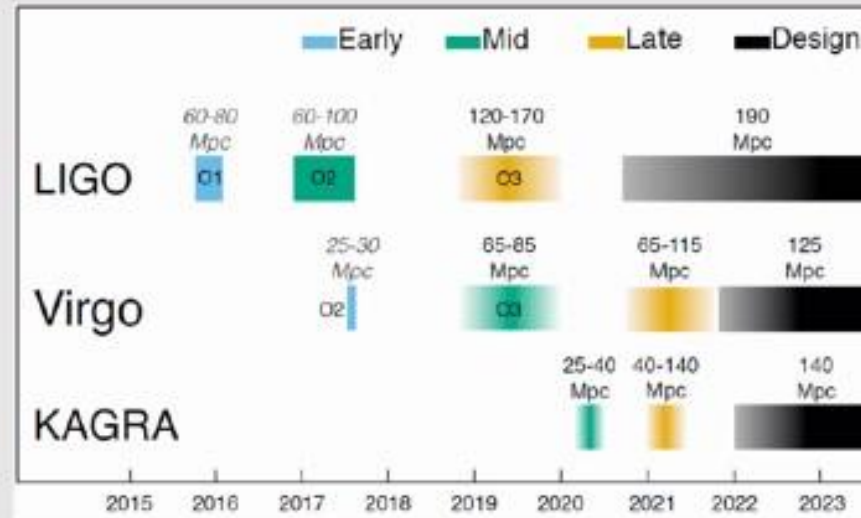




LIGO Schedule for 2018

LIGO and Virgo are currently undergoing commissioning tasks to prepare for O3

- O3 Start in late Fall 2018
- Planned duration: 9 months
- Sensitivity at 2/3 of design level
- Virgo expected join in from the start
- LIGO India currently in land acquisition process. Ground breaking planned for mid 2018





Major Sub-Areas of Physics (Experiment and Theory)

Research Support through Individual Investigator Awards > 50% of Budget

Gravitational Physics (Includes Support of LIGO Scientific Collaboration (LSC))

Atomic, Molecular, and Optical Physics

Quantum Information Science and Revolutionary Computing

Nuclear Physics

Particle Physics (Elementary Particle Physics and Particle Astrophysics)

Physics of Living Systems

Plasma Physics

Plus Cross-Cutting Activities through Integrative Activities in Physics

(REU, Special Center Awards, Outreach, Broadening Participation)

(Note that Condensed Matter Physics is **NOT** included – Housed in DMR)

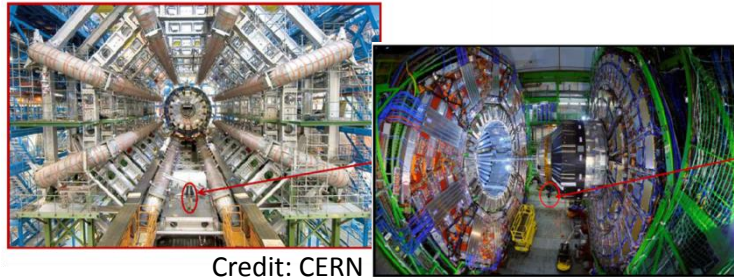


Facilities in Physics Division

Laser Interferometer Gravitational
Wave Observatory (LIGO)



Credit: LIGO Laboratory



Credit: CERN

ATLAS

CMS

ATLAS and CMS Detectors at
Large Hadron Collider (LHC)

National Superconducting
Cyclotron Laboratory (NSCL)



Credit: NSCL



Credit: IceCube

IceCube

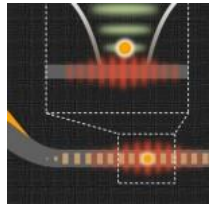


Physics Frontiers Centers

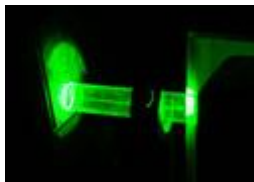
FY 2017 Competition Concluded



NanoGrav



CUA



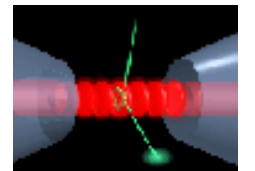
PFC@JQI



JILA



CTBP



IQIM

PFC@JILA, University of Colorado

Institute for Quantum Information and Matter, CalTech (With CISE/CCF)

Center for Theoretical Biological Physics, Rice U (Joint with MPS/DMR, BIO/MCB)

PFC@JQI, U Maryland

NANOGrav, U Wisconsin Milwaukee (With MPS/AST)

Center for the Physics of Living Cells, UIUC (Joint with MPS/CHE, BIO/MCB)

Center for Ultracold Atoms, MIT/Harvard (With CISE/CCF)

JINA: Joint Institute for Nuclear Astrophysics, Michigan State

Center for the Physics of Biological Function, Princeton (Joint with BIO/MCB;IOS) (new in 2017)

Kavli Institute for Theoretical Physics, UCSB (With MPS/DMR, MPS/AST)

Programs now funded through Integrative Activities in Physics (IAP) program

Kavli Institute for Cosmological Physics, U Chicago (With GEO/PLR)

PFC support phased out over two years



Major Thrust – Fostering Connections

Focus on Science Question, not Discipline or Subarea

Partner with Others whenever Possible to Promote Science

Partnering within Division – AMO-Nuclear, AMO-Particle, AMO-Gravity, Nuclear-Particle

Partnering with other NSF divisions on specific topics – MPS/AST,CHE,DMR,DMS;
BIO/MCB,IOS,DBI; GEO/PLR,AGS; ENG/ECCS,CBET; CISE/CCF,OAC

Participation in NSF priority areas jointly with other Directorates/Divisions - Big Ideas

Partnering with DOE in Particle Physics, Nuclear Physics, Plasma Physics

Partnering with NASA in Gravitational Physics and Plasma Physics

Public-Private Partnerships – Gordon & Betty Moore Foundation, SU2C



MPS Funding
(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change over FY 2017 Actual	
				Amount	Percent
Astronomical Sciences (AST)	\$252.05	-	\$230.69	-\$21.36	-8.5%
Chemistry (CHE)	246.24	-	230.58	-15.66	-6.4%
Materials Research (DMR)	314.31	-	295.05	-19.26	-6.1%
Mathematical Sciences (DMS)	233.54	-	218.82	-14.72	-6.3%
Physics (PHY)	281.43	-	266.73	-14.70	-5.2%
Office of Multidisciplinary Activities (OMA)	34.86	-	103.45	68.59	196.8%
Total	\$1,362.43	-	\$1,345.32	-\$17.11	-1.3%



PHY Funding

(Dollars in Millions)

	FY 2017 Actual	FY 2018 (TBD)	FY 2019 Request	Change Over FY 2017 Actual	
				Amount	Percent
Total	\$281.43	-	\$266.73	-\$14.70	-5.2%
Research	178.57	-	159.01	-19.56	-11.0%
CAREER	10.04	-	7.30	-2.74	-27.3%
Centers Funding (total)	4.60	-	5.00	0.40	8.7%
STC: Center for Bright Beams	4.60	-	5.00	0.40	8.7%
Education	5.87	-	4.92	-0.95	-16.2%
Infrastructure	96.99	-	102.80	5.81	6.0%
IceCube Neutrino Observatory (IceCube)	3.50	-	3.50	-	0.0%
Large Hadron Collider (LHC)	16.00	-	16.00	-	0.0%
Laser Interferometer Gravitational Wave Observatory (LIGO) ¹	41.93	-	45.00	3.07	7.3%
National Superconducting Cyclotron Laboratory (NSCL)	24.00	-	24.00	-	0.0%
Midscale Research Infrastructure	5.85	-	8.00	2.15	36.8%
Pre-construction Planning:					
High-Luminosity LHC Upgrade Planning	5.71	-	6.30	0.59	10.3%

¹FY 2017 includes one-time supplemental funding of \$2.50 million for a critical vacuum repair.



EPP News

FY18 Base Program

- CAREER Solicitation
 - 11 proposals (~typical)
 - 1 award. Karagiorgi (Columbia)
- Physics Division Solicitation
 - 51 proposals (~40% increase)
- MRI
 - 2 proposals relevant to EPP-relevant
 - (~typical)
- AGEP-GRS Supplements
 - 3 proposals

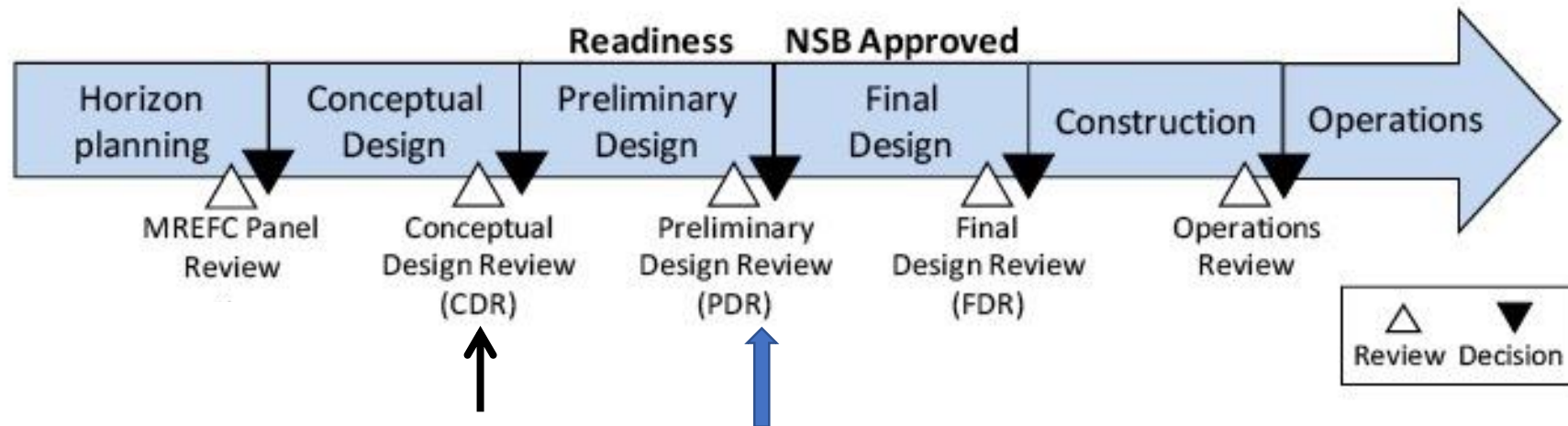
FY18 Projects and Operations

- ATLAS and CMS Operations
- ATLAS, CMS Phase I Upgrades
- LHCb Upgrade
- MREFC Process for ATLAS and CMS Phase II Upgrades
 - PDRs
 - Internal reviews prior to NSB Review



High-Luminosity LHC Upgrade

Planning for a possible MREFC in support of the high-luminosity upgrades of the ATLAS and CMS detectors at CERN; Preliminary Design under review



Coordinating with the DOE in support of the US-CMS and US-ATLAS Teams

NSF has identified well-defined scope independent of DOE scope



Particle Astrophysics

- **Cosmic Phenomena**

Research that uses astrophysical sources and particle physics techniques to study fundamental physics. This includes gamma-rays, cosmic-rays, and neutrinos.

- **Underground Physics**

Research that locates experiments in low background environments. This includes studies of solar, underground, and reactor neutrinos; neutrino mass measurements; searches for the direct detection of Dark Matter.

- **IceCube Research Support**

Research that utilizes the facilities of IceCube at the South Pole. Currently supported activities include: searches for ultra-high energy neutrinos and studies of the properties of neutrinos.

FY18 PA Program

- **CAREER Solicitation**

- 9 proposals
- 1 award: S. Wissel (CalPoly)

- **Physics Division Solicitation**

- 65 proposals
- Awards Pending

- **MRI Solicitation**

- 7 proposals
- Under review



PA Program Scope – Supported Projects

- Direct Dark Matter Detection – WIMP and non-WIMP experiments

SuperCDMS at SNOLAB, XENON100/1T/nT, DArkSide-50/20k, PICO, COSINE-100, SABRE, DAMIC, HAYSTAC (ADMX-HF), ALPS2 and Light mass DM experiments

- Indirect Dark Matter Detection

VERITAS, HAWC, IceCube

- Cosmic Ray, Gamma Ray, and UHE Neutrino Observatories

IceCube, VERITAS, HAWC, Auger, Telescope Array, ARA, ARIANNA

- Cosmic Microwave Background

SPT and BICEP

- Neutrino Properties

Double Chooz, Project 8, IceCube, IsoDAR, CHANDLER

- Solar, SuperNova and Geo-Neutrinos

Borexino, SNEWS

- Detector R&D

NaI/CsI, LiSc/QuDots

AST

Polar Programs



Theory

A vibrant, intellectually diverse Theory program is vital to the success of the entire Particle Physics mission. We capitalize on the talents and creativity of the Theory community by supporting the best, most cutting-edge investigator-driven research in two programs:

- Theoretical High-Energy Physics
- Theoretical Particle Astrophysics and Cosmology

These two theory programs interface regularly with many other programs at NSF (EPP, PA, Gravity Theory, Nuclear Theory, Astronomy, Materials Research, Mathematical Sciences, etc.) We also coordinate, as needed, with DOE.

Approximately 110 separate active grants supporting ~180 PIs; ~30 large university groups.

Supporting individuals, RUI's, and special facilities or initiatives (Aspen Center for Physics, TASI summer school, LHC Theory Initiative, etc.)



Preparing for FY 2019

FY19 Base Program

- CAREER Solicitation
 - **Deadline July 20, 2018**
- Physics Division Solicitation
 - **New Deadlines ***Tentative**
 - **November 28, 2018 for IAP**
 - **December 5, 2018 for EPP, PA, NP**
 - **December 12, 2018 for THY**
- MRI
 - **Submission Window**
 - **January 1 – 22, 2019**

FY19 Planning: Stay Tuned...

- DCL on Instrumentation R&D
- Internal discussions...Midscale considerations and opportunities
- Stay alert to NSF-wide calls



10 Big Ideas for Future NSF Investments

- Bold questions that will drive NSF's long-term research agenda
- Catalyze investment in fundamental research
- Collaborations with industry, private foundations, other agencies, universities
- Solve pressing problems and lead to new discoveries



Looking Ahead: Ten Big Ideas



Navigating the New Arctic




Harnessing Data for 21st Century Science and Engineering



Work at the Human-Technology Frontier: Shaping the Future


RESEARCH IDEAS



Understanding the Rules of Life: Predicting Phenotype



The Quantum Leap: Leading the Next Quantum Revolution



Windows on the Universe: The Era of Multi-messenger Astrophysics

PROCESS IDEAS



Growing Convergent Research at NSF



NSF-Includes: Enhancing Science and Engineering through Diversity



Mid-scale Research Infrastructure



NSF 2050: Seeding Innovation



NSF's 10 BIG IDEAS FY 2019 REQUEST FUNDING

(Dollars in Millions)

Big Ideas	FY 2019 Request
Research Ideas	\$180.00
Harnessing the Data Revolution for 21st- Century Science and Engineering - HDR (CISE/ITR) ¹	30.00
Navigating the New Arctic - NNA (GEO/ICER)	30.00
The Future of Work at the Human-Technology Frontier - FW-HTF (ENG/EFMA) ¹	30.00
The Quantum Leap - QL (MPS/OMA)	30.00
Understanding the Rules of Life - URoL (BIO/EF)	30.00
Windows on the Universe - WoU (MPS/OMA)	30.00
Process Ideas	\$102.50
Growing Convergence Research - GCR (IA)	16.00
Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science - NSF INCLUDES (EHR)	20.00
Mid-Scale Research Infrastructure (IA)	60.00
NSF 2026 Fund (IA)	6.50
Total, NSF Big Ideas	\$282.50



Windows on the Universe

The goal of “Windows on the Universe” is to bring electromagnetic waves, high-energy particles, and gravitational waves together to study the universe and probe events in real time in a way that was previously impossible.



Credit: LIGO Laboratory



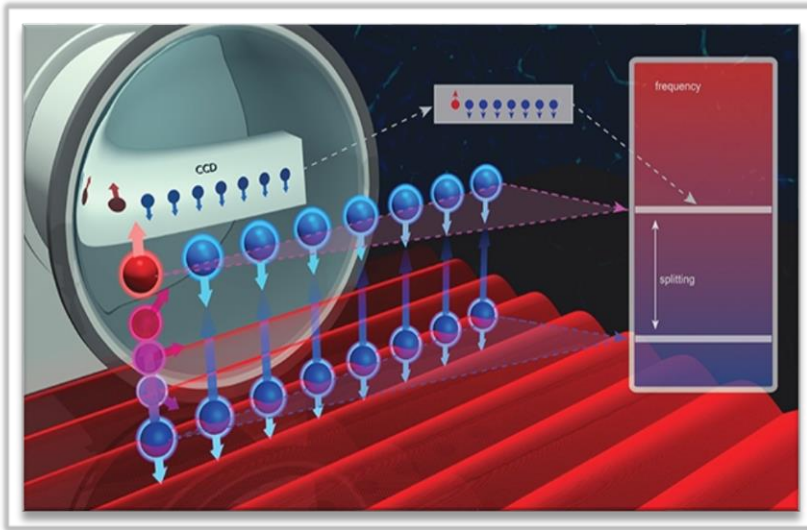
Credit: IceCube



Credit: AURA



Quantum Leap: Leading the next Quantum Revolution



Trapped ion computation
(JQI – University of Maryland)

Today:

- lasers, atomic clocks, GPS, semiconductors, storage media

Tomorrow:

- Ultra-secure communication
- Ultra-precise sensing, measurement
- Quantum simulators
- Computing beyond the scale of supercomputing



Builds on 20-Year NSF Investment in **Quantum Information Science**

“Advancing Quantum Information Science: National Challenges
and Opportunities”, NSTC, July 2016

Quantum Leap is an NSF-Wide Activity Involving Multiple Directorates
that extends QIS into new regimes of materials science and engineering

Division of Physics participation is built on foundation of disciplinary programs and centers

Atomic, Molecular and Optical Physics
Quantum Information and Revolutionary Computing

PFC@JQI – Physics Frontier Center at Joint Quantum Institute, U Maryland

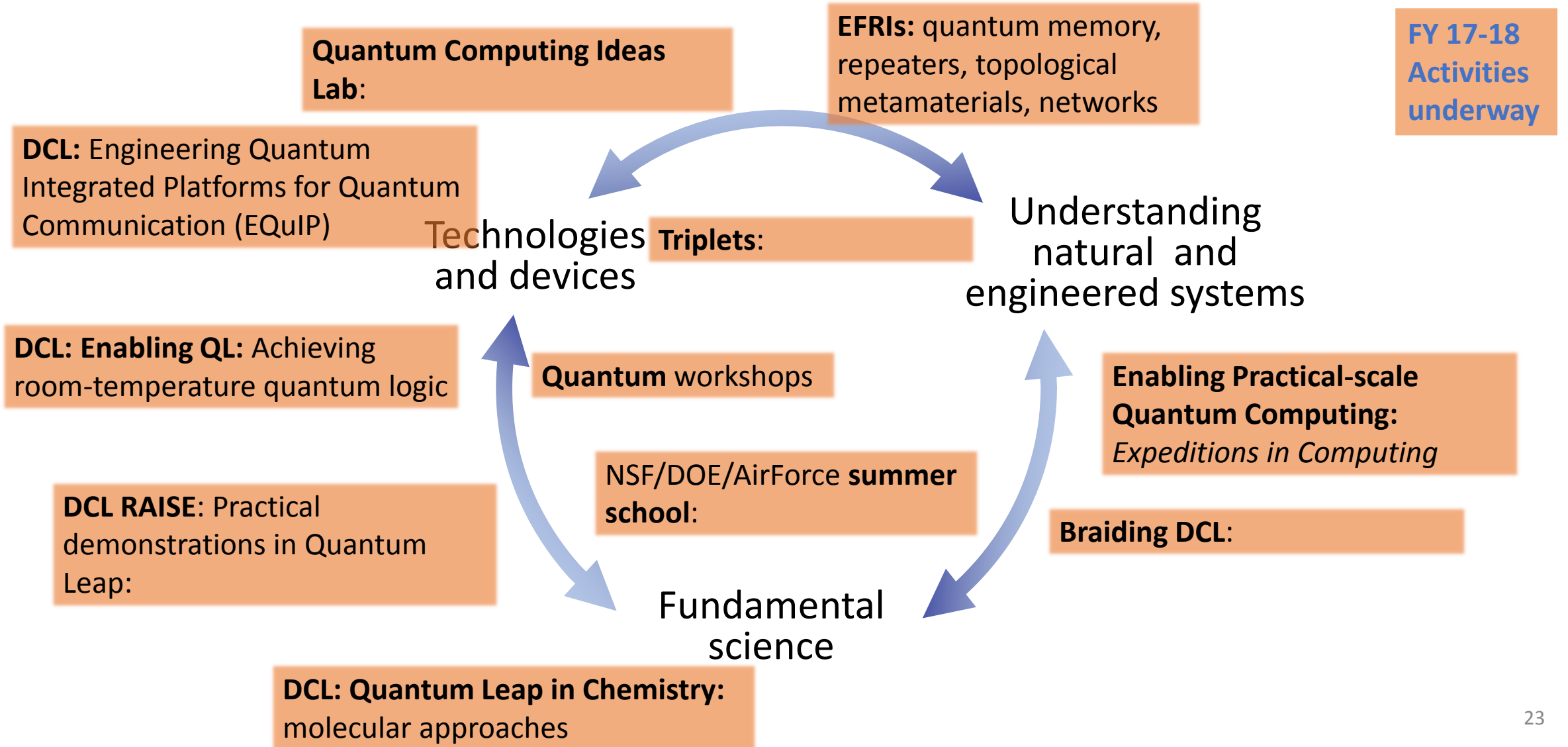
PFC@JILA – Physics Frontier Center at JILA

Center for Ultracold Atoms – Physics Frontier Center at MIT/Harvard

Institute for Quantum Information and Matter – Physics Frontier Center at CalTech



Taking the Leap: First Steps





NSF Funding Activities –Details of FY17 and FY18

Emerging Frontiers in Research and Innovation 2016 (EFRI-2016): “Advancing Communication Quantum Information Research in Engineering (ACQUIRE)”

NSF News Release 16-091: \$12M to support six interdisciplinary teams of 26 researchers

Dear Colleague Letter NSF 17-053– “A Quantum Leap Demonstration of Topological Quantum Computing”, EAGERs to demonstrate topological qubits (MPS/DMR)

“Convergence QL: NSF/DOE Quantum Science Summer School” DMR-1743059
(Funded by: NSF; DOE/BES, DOE/ASCR, + (recent) AFOSR)

First school held: Johns Hopkins University, 5-16 June 2017

Three scheduled (tentative): Cornell (2018), Penn State (2019), TBD (2020)

“Quantum Information Science and Engineering Network” of “triplets” of students, faculty, industry partners to work on Quantum Leap challenges (OIA, DMR, CHE, PHY, ECCS, CCF, OAC, SES, OMA)

UChicagoNews

Nationwide program launches to train new generation of quantum engineers

NSF-funded project pairs graduate students with industry, academia

<http://news.uchicago.edu/article/2018/05/08/nationwide-program-launches-train-new-generation-quantum-engineers>



Details of FY17 and FY18 (continued)

Solicitation NSF 17-548 “Ideas Lab: Practical Fully-Connected Quantum Computer Challenge (PFCQC)”

A co-design approach to integrating hardware, software and quantum algorithms”

Ideas Lab was held in fall, 2017; Proposals have been submitted

Review is complete and awards are being processed

NSF 18-046: Dear Colleague Letter: Enabling Quantum Leap: Achieving Room-Temperature Quantum Logic through Improved Low-Dimensional Materials (issued 15 February 2018)

CCF-1730449: “Collaborative Research: EPiQC: Enabling Practical-scale Quantum Computing”, a new award in *Expeditions in Computing* program in CISE; See NSF news release 18-011

NSF 18-035 “Dear Colleague Letter: RAISE on Enabling Quantum Leap: Transformational Advances in Quantum Systems” (issued 14 December 2017)

Letters of intent have been received and invitees selected