Particle Physics at the NSF

DPF 2017

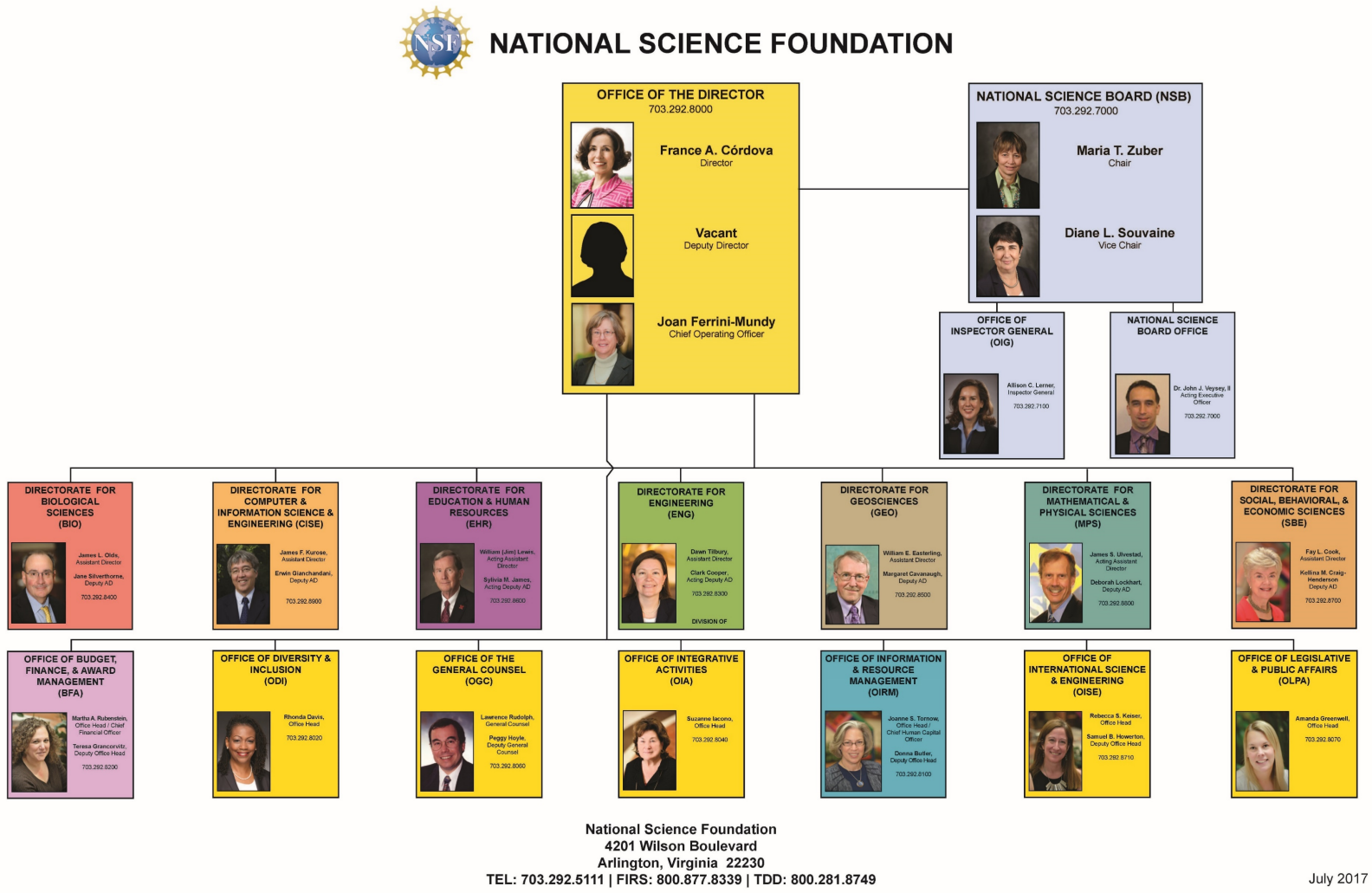
Fermilab

August 1, 2017

Saúl González

Transitions

- Major NSF leadership transition in Jan/Feb
- New Chief Operating Officer
- GEO AD started on June 1; ENG AD started on June 19.
- Fleming Crim returned to Wisconsin in January 2017; Jim Ulvestad is MPS Acting Assistant Director.
- Future Assistant Director has not yet been identified.
- AST Acting Division Director (Ralph Gaume)



We are moving this summer

25 mins to/from DCA

4201 Wilson Boulevard
Arlington, VA 22230

MPS, including Physics, is scheduled to move in 4 weeks

10 mins to/from DCA

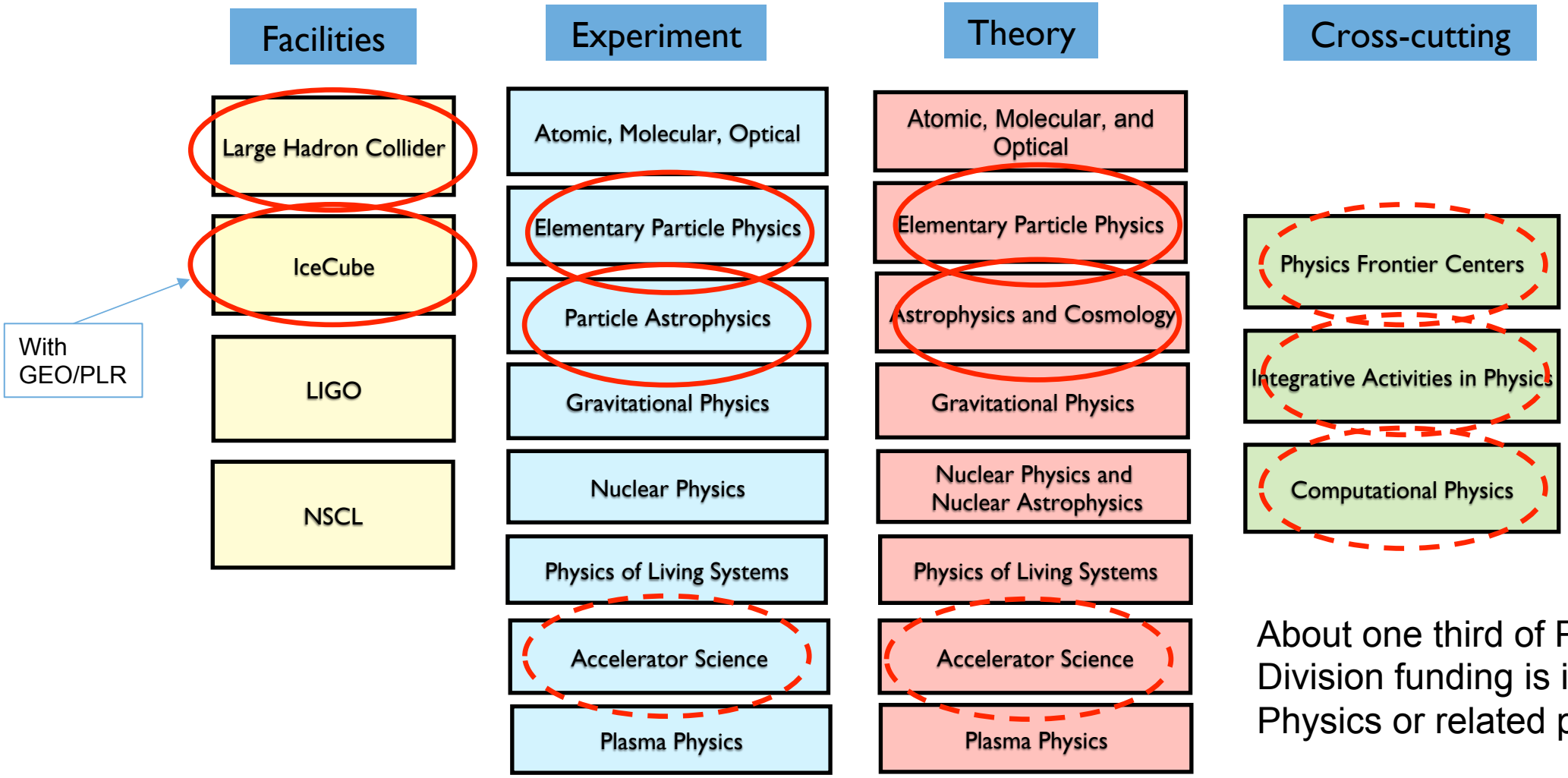
2415 Eisenhower Avenue
Alexandria, VA 22314

American Innovation and Competitiveness Act (AICA)

- New Authorization Act for NSF (and NIST), passed by Congress in early January.
- No specific funding targets incorporated.
- Supports NSF principles of merit review.
- Language relating to NSF awards being in the national interest.
- Language about facility oversight.
- Instructions to Physical Sciences Subcommittee of the National Science and Technology Council relating to HEP: *policies, procedures, and plans in the physical sciences, including high-energy physics*

NSF's 10 Big Ideas

Particle Physics in the NSF Physics Division



About one third of Physics Division funding is in Particle Physics or related programs

FY 2018 President's Budget Request

National Science Foundation
Summary Table

FY 2018 Budget Request to Congress

(Dollars in Millions)

NSF by Account	FY 2016 Actual	FY 2017 Annualized CR	FY 2018 Request	FY 2018 Request change over FY 2016 Actuals	
				Amount	Percent
BIO	$723.78	-	$672.11	-$51.67	-7.1%
CISE	935.20	-	838.92	-96.28	-10.3%
ENG	915.68	-	833.49	-82.19	-9.0%
Eng Programs	727.16	-	657.28	-69.88	-9.6%
SBIR/STTR	188.52	-	176.21	-12.31	-6.5%
GEO	876.51	-	783.31	-93.20	-10.6%
MPS	1,348.78	-	1,219.43	-129.35	-9.6%
SBE	272.20	-	244.02	-28.18	-10.4%
OISE	49.07	-	44.02	-5.05	-10.3%
OPP	448.87	-	409.18	-39.69	-8.8%
IA	426.57	-	315.74	-110.83	-26.0%
U.S. Arctic Research Commission	1.43	-	1.43	-	-
Research & Related Activities	$5,998.09	$6,022.18	$5,361.65	-$636.44	-10.6%
Education & Human Resources	$884.10	$878.33	$760.55	-$123.55	-14.0%
Major Research Equipment & Facilities Construction	$241.50	$199.93	$182.80	-$58.70	-24.3%
Agency Operations & Award Management	$351.11	$329.37	$328.51	-$22.60	-6.4%
National Science Board	$4.31	$4.36	$4.37	$0.06	1.5%
Office of Inspector General	$14.76	$15.13	$15.01	$0.25	1.7%
Total, NSF	$7,493.86	$7,449.30	$6,652.89	-$840.98	-11.2%

(*https://www.nsf.gov/about/budget/fy2018/tables.jsp*)

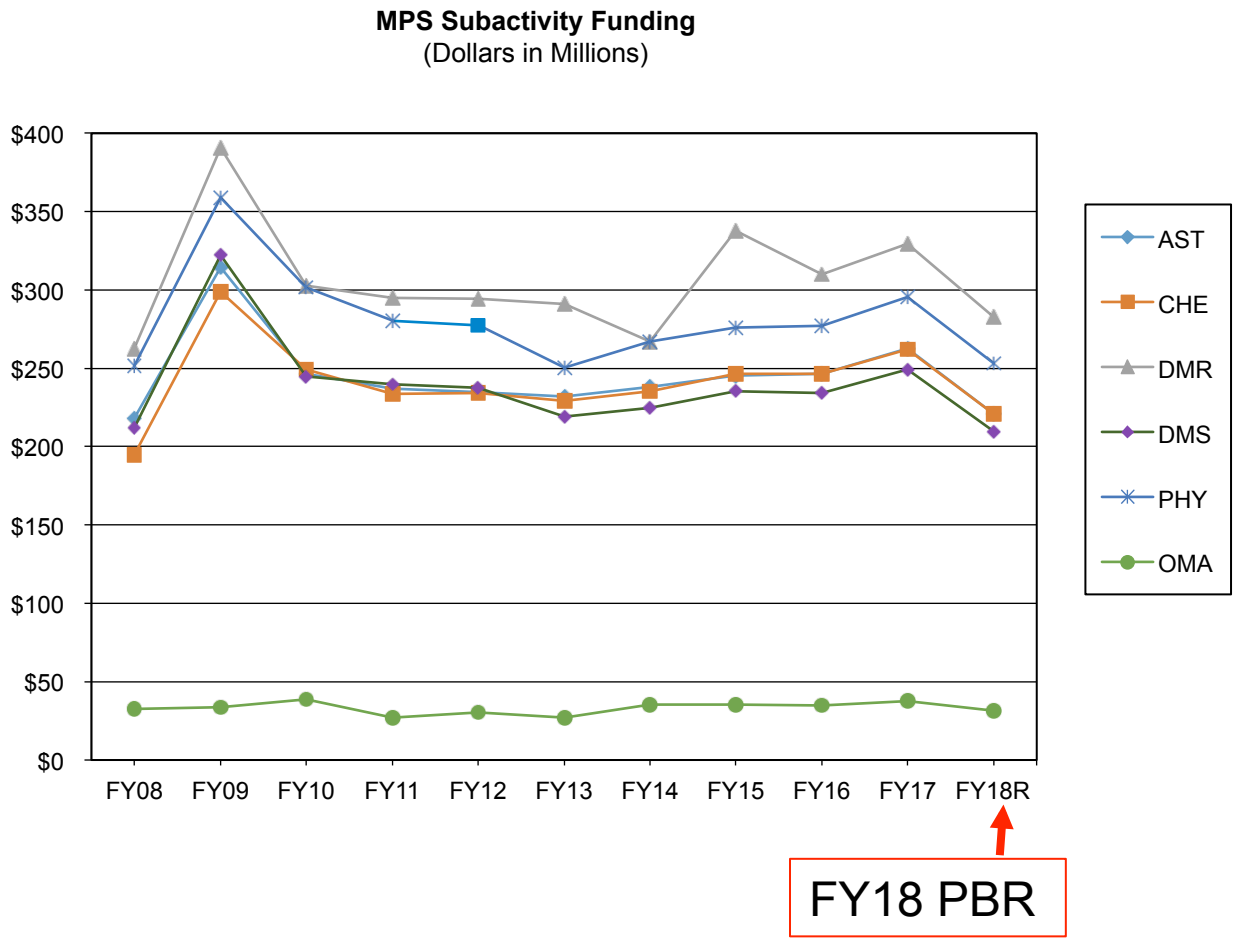
FY 2018 MPS Budget Request

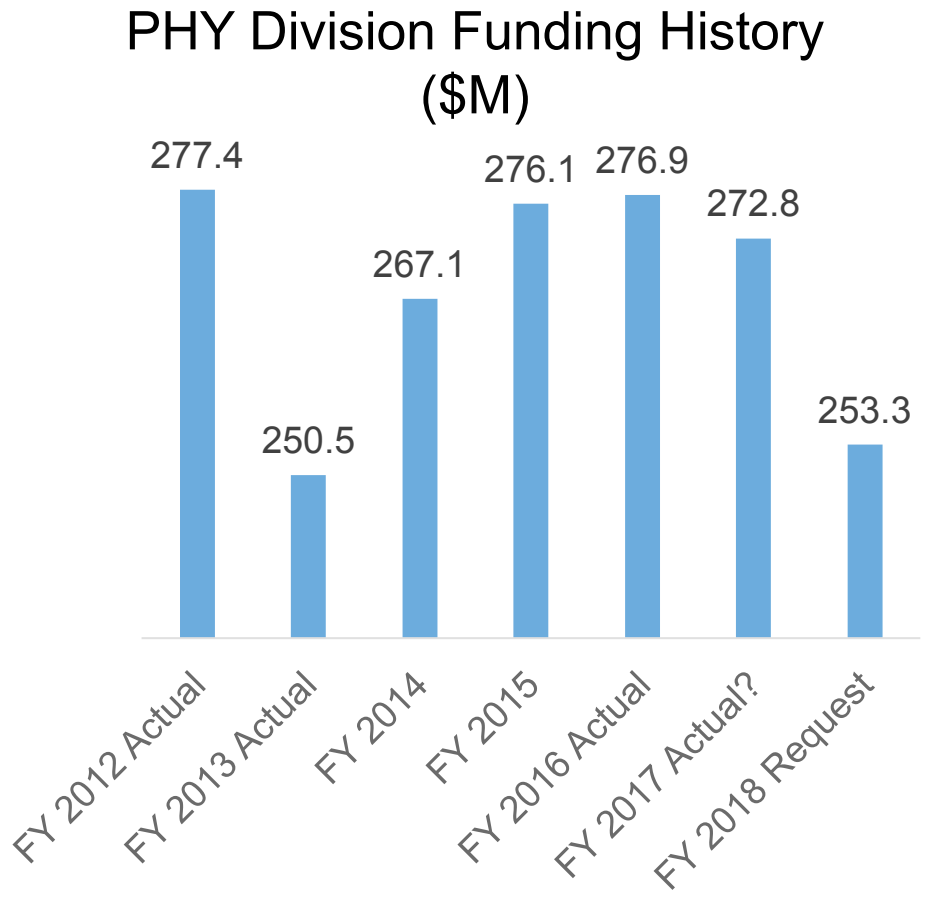
MPS Funding (Dollars in Millions)					
				Change Over FY 2016 Actual	
	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Amount	Percent
Astronomical Sciences (AST)	$246.63	-	$221.15	-$25.48	-10.3%
Chemistry (CHE)	246.52	-	221.05	-25.47	-10.3%
Materials Research (DMR)	309.88	-	282.87	-27.01	-8.7%
Mathematical Sciences (DMS)	233.95	-	209.78	-24.17	-10.3%
Physics (PHY)	276.91	-	253.30	-23.61	-8.5%
Office of Multidisciplinary Activities (OMA)	34.89	-	31.28	-3.61	-10.3%
Total	$1,348.78	-	$1,219.43	-$129.35	-9.6%

FY 2018 PHY Budget Request

PHY Funding (Dollars in Millions)					
				Change Over FY 2016 Actual	
	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Amount	Percent
Total	$276.91	_	$253.30	-$23.61	-8.5%
Research	174.12	-	152.09	-22.03	-12.7%
CAREER	8.12	-	7.30	-0.82	-10.1%
STC: Center for Bright Beams (CBB)	-	-	5.00	5.00	N/A
Education	5.40	-	4.80	-0.60	-11.1%
Infrastructure	97.39	-	96.41	-0.98	-1.0%
IceCube	3.48	-	3.50	0.02	0.6%
Large Hadron Collider (LHC)	20.00	-	16.00	-4.00	-20.0%
Laser Interferometer Gravitational Wave Observatory (LIGO)	39.43	-	39.43	-	-
Nat'l Superconducting Cyclotron Lab. (NSCL)	24.00	-	23.00	-1.00	-4.2%
Midscale Research Infrastructure	10.48	-	8.18	-2.30	-21.9%
Pre-construction planning:	-	-	6.30	6.30	N/A
High-Luminosity LHC Upgrade Planning	-	-	6.30	6.30	N/A

FY 2018 PHY Budget Request (2)





Principles Applied to MPS FY 2018 Request

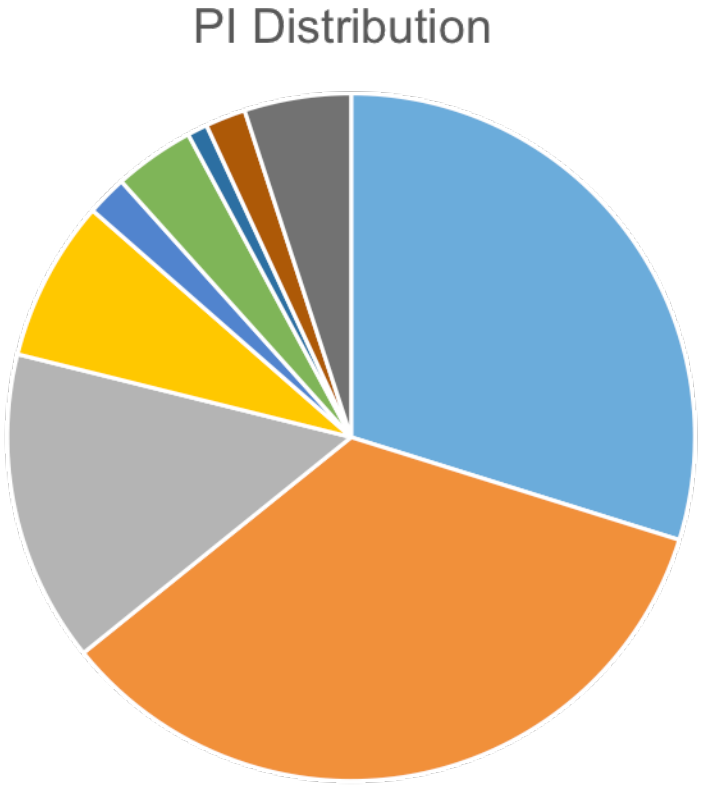
- Support early career
  - CAREER request relatively stable. Targeted REU reductions if undergraduate students could be supported through national facilities and normal research awards. 8,000 graduate students to be supported through research awards.
- Protect the core; cross disciplinary programs
  - Major research facilities are “core” to MPS.
  - Retained flexibility to fund the best science by rolling some cross-disciplinary programs into core programs.
- Strategic and prioritized reductions within directorates
  - Emphasized funding of highest priority facilities; reductions proposed for some facilities in transition.
  - Reduced mid-scale and instrumentation; support individual investigators.
  - Prioritized low-level investments leading to “Big Ideas”.
  - Roll back “accretions” (things scaled up since 2008)

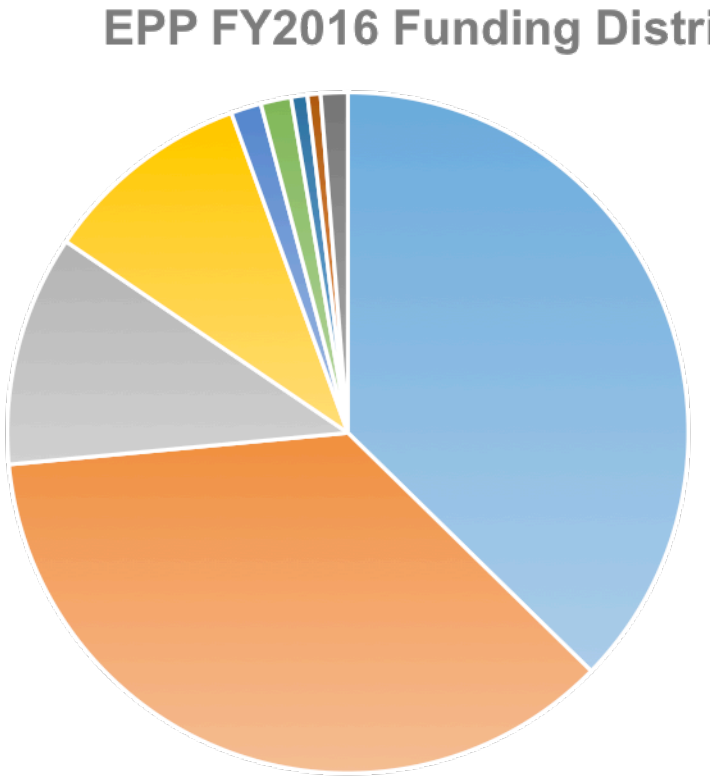
Elementary Particle Physics

EXPERIMENT

Jim Shank, Randy Ruchti, Saul Gonzalez

Snapshot: FY 2016 EPP

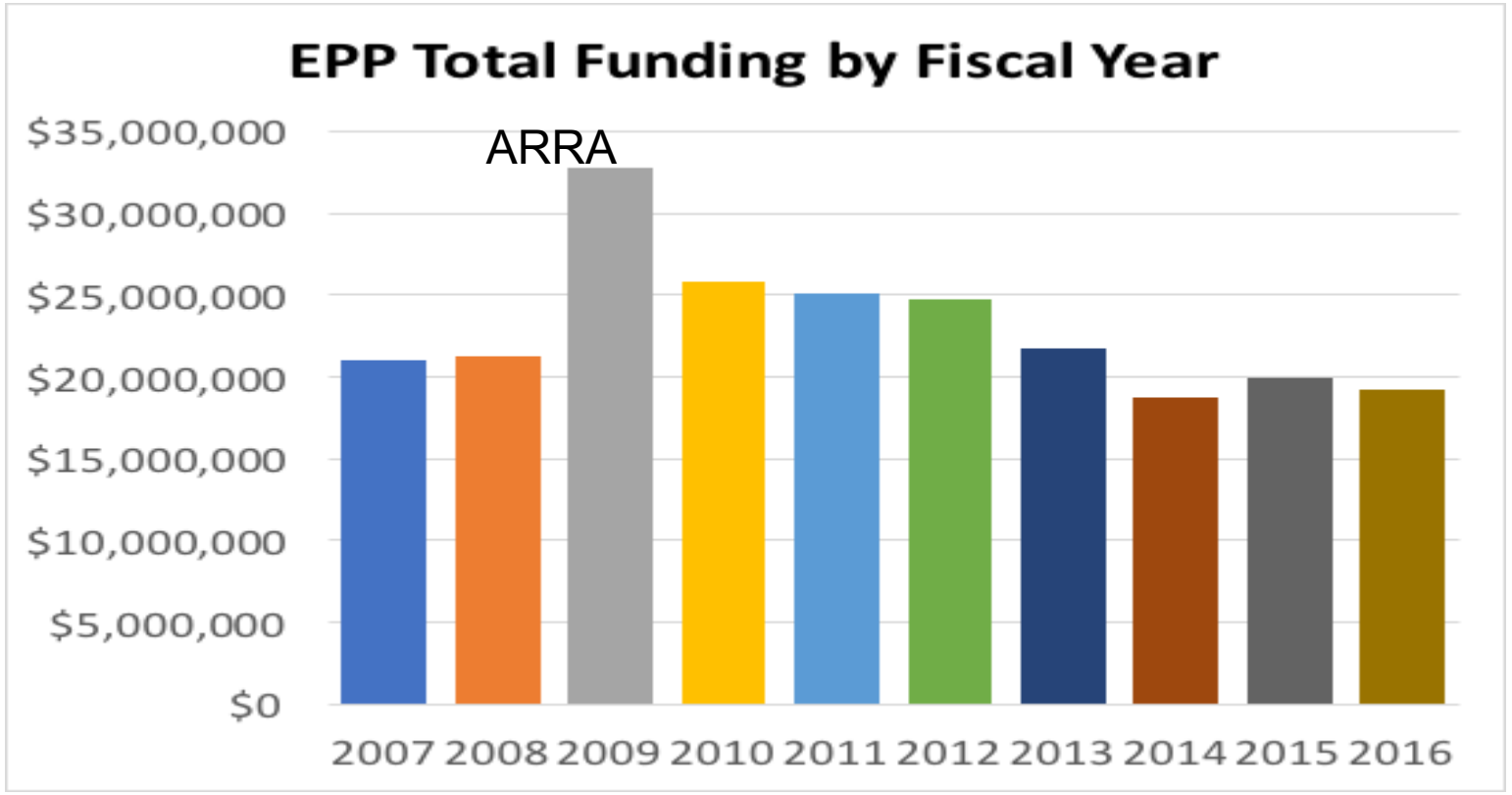




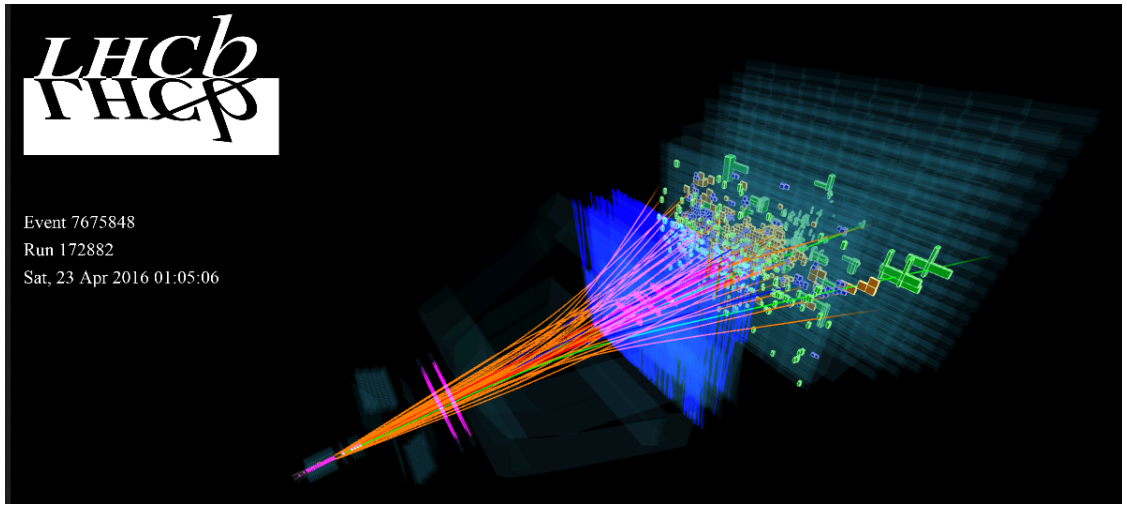
Total Funding
= $19.4 million

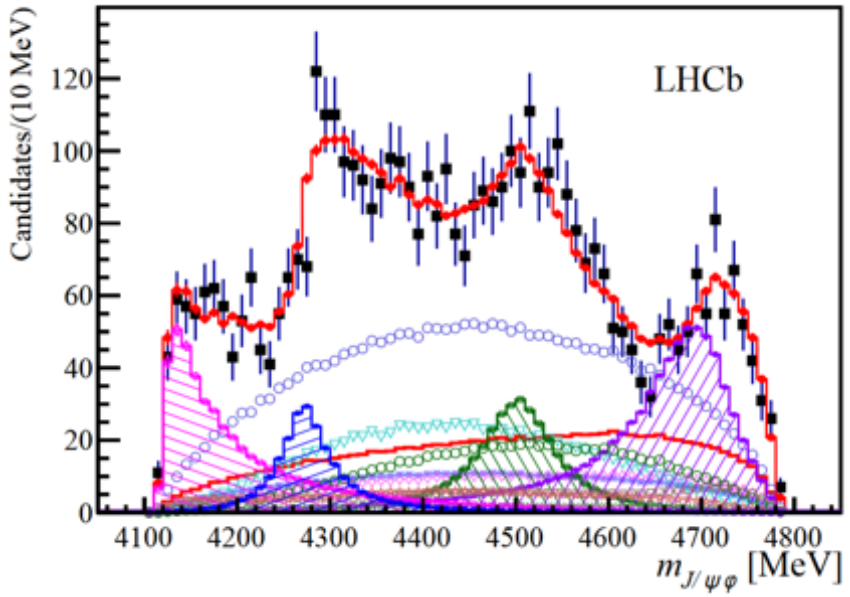
Includes:
eEDM, Belle II, E&O, Einstein, Tevatron legacy, etc.

EPP Funding History



EPP Highlight: LHCb



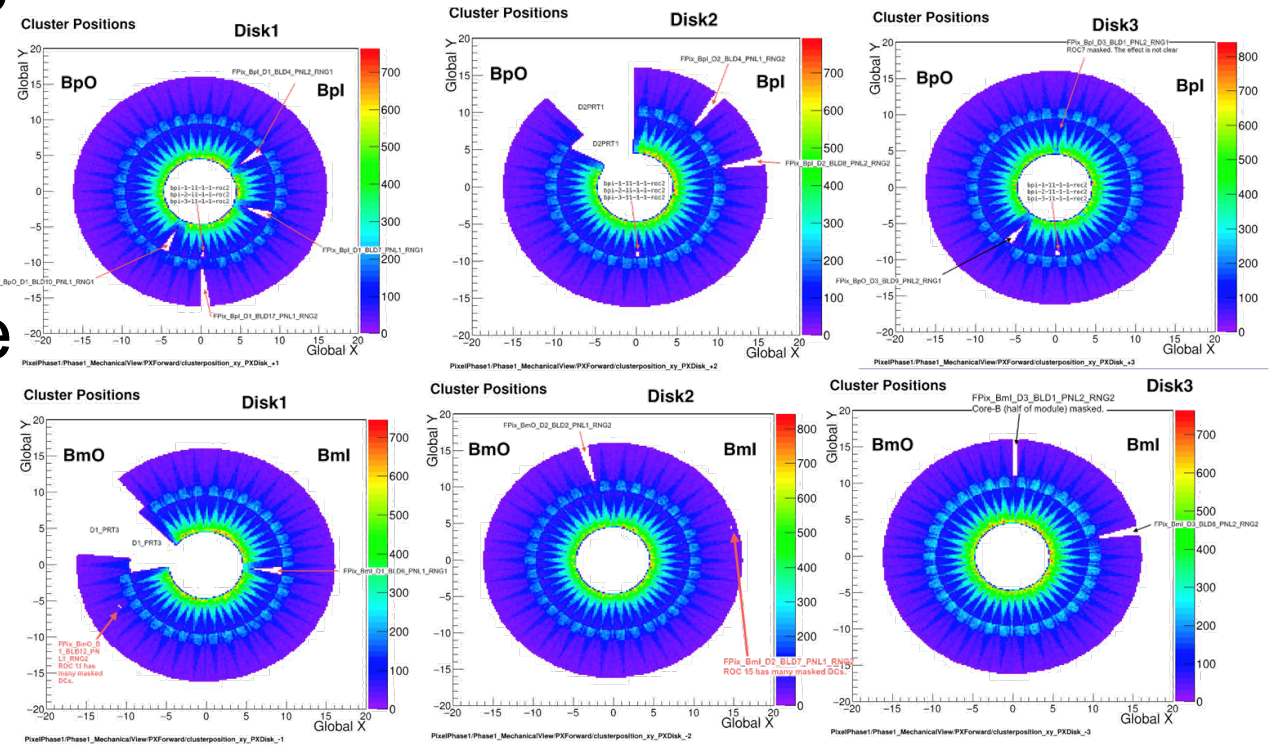


Recent physics highlights:

- Observation of exotic-like particles (Tetraquarks)
  - B^+ meson decays into J/ψ, φ and K^+ mesons.
  - The plot shows the J/ψ, φ mass spectrum which can only be fit with the inclusion of the four exotic particles at 4140, 4274, 4500 and 4700 MeV. See https://arxiv.org/abs/1606.07898
- Ongoing Lepton Universality test probes physics beyond the Standard Model
  - Science article: http://www.sciencemag.org/news/2017/04/physicists-detect-whiff-new-particle-large-hadron-collider

EPP Highlight: CMS Phase 1 Upgrade

- Phase 1 upgrade goal: enhance pixel detector to maintain high efficiency at $L=2x10^{34}/cm^2/sec$ and $\eta < 2.5$.
- Part of NSF scope: replaced the three end-cap disks during the 2016 LHC shutdown (FPIX)
- Verification of operation after resumed LHC operation



FPIX Occupancies in Collisions

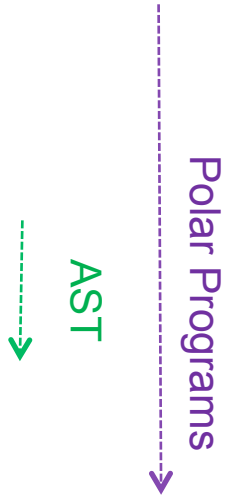
Particle Astrophysics

EXPERIMENT

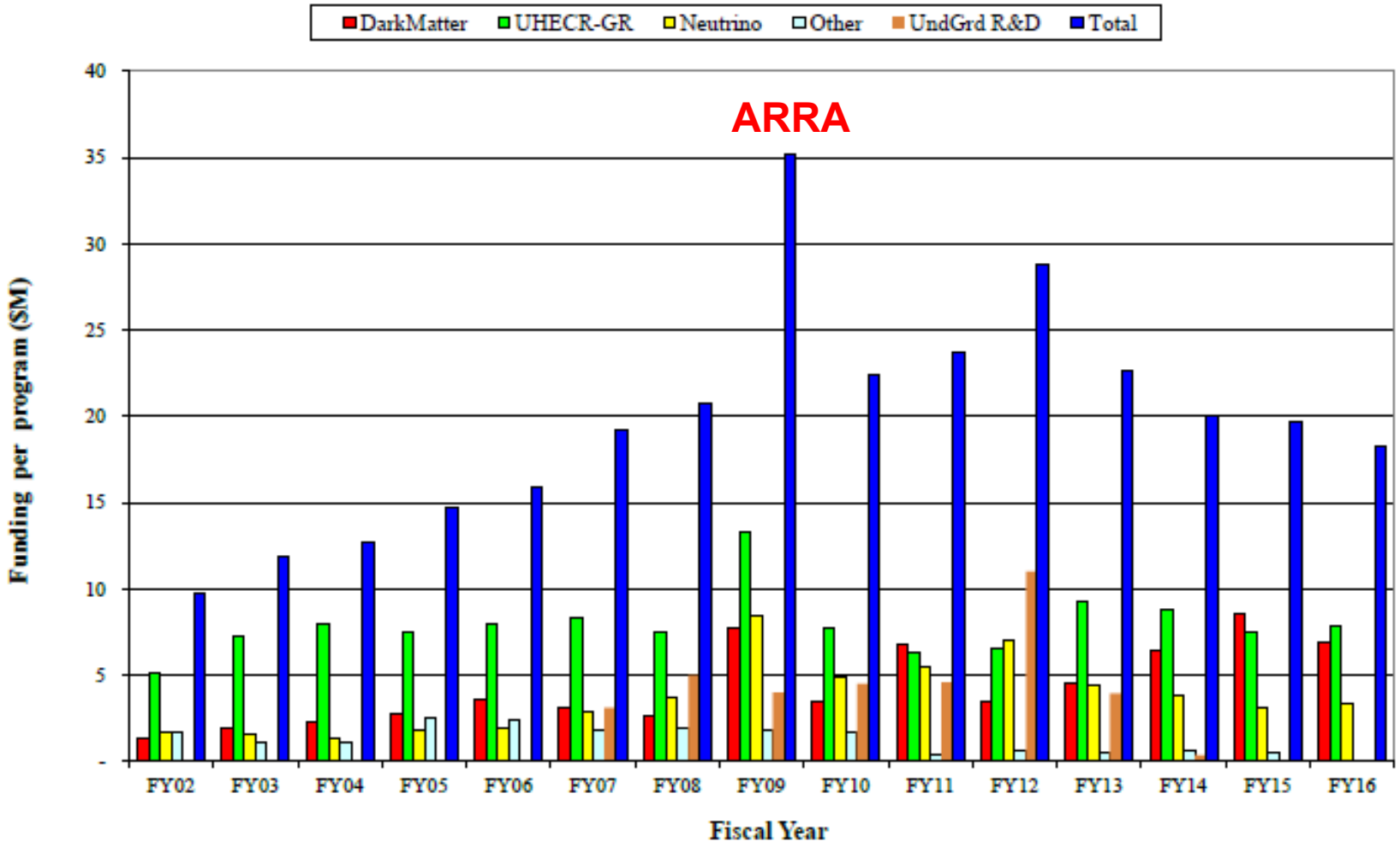
Jean Cottam, Jim Whitmore

PA Program Scope -- Supported Projects

- Direct Dark Matter Detection – WIMP and non-WIMP experiments
  SuperCDMS at SNOLAB, XENON100/1T, LUX, DArkSide-50, PICO, DRIFT, DM-Ice, 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, CTA, 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

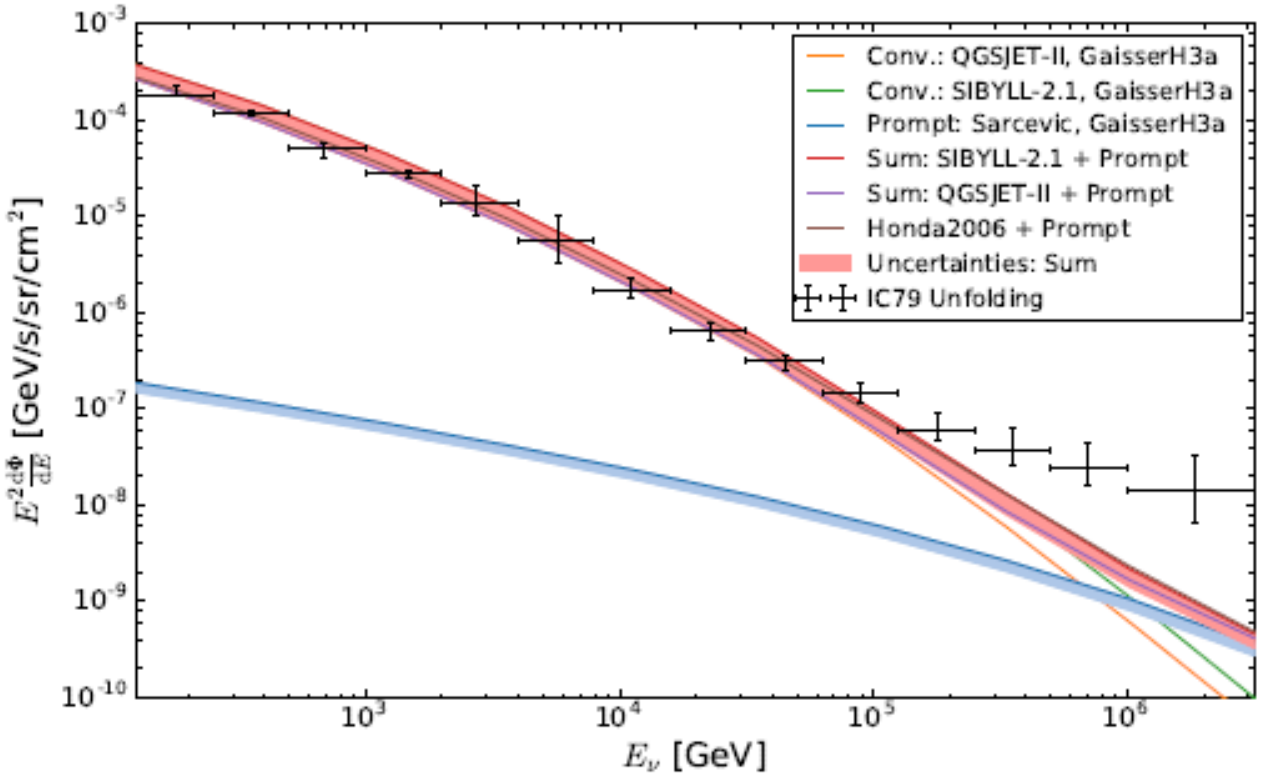


PA Program Funding FY2002-2016



Highlight: Astrophysical muon neutrino

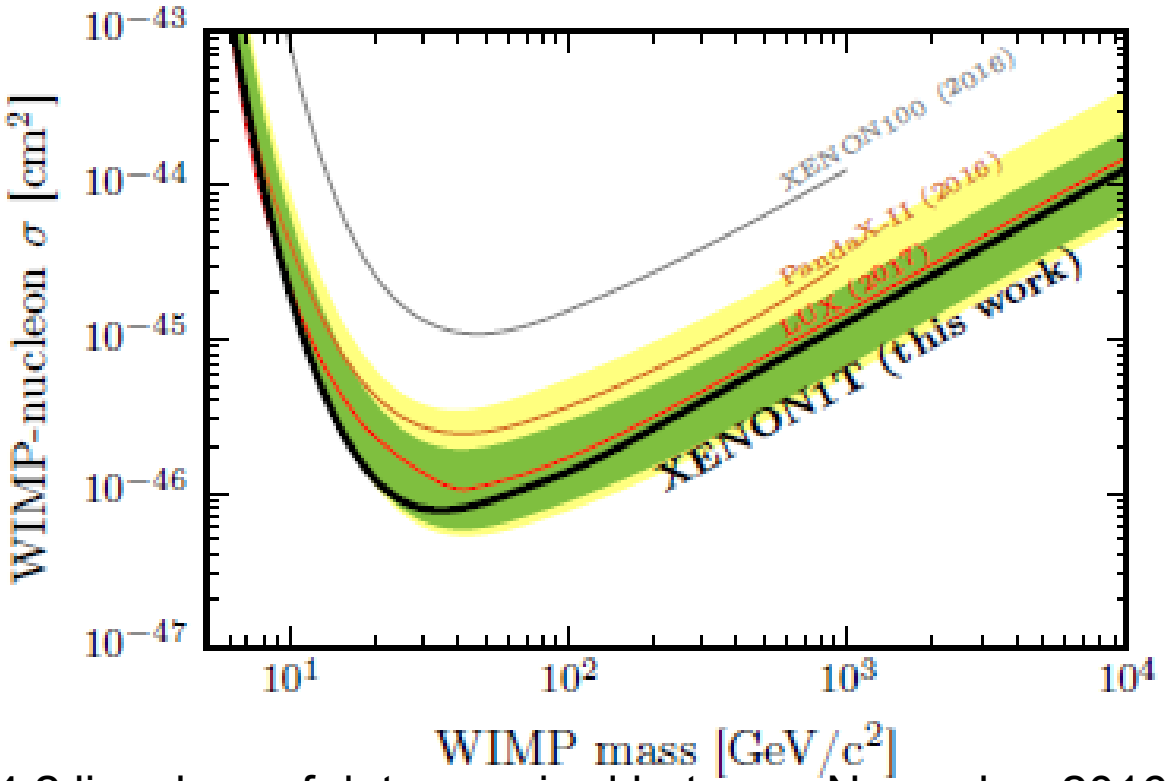
IceCube



Using CC events:
Conventional = from π/K decays
Prompt = from charm decays

A comparison of the unfolded spectrum with theoretical predictions for a purely atmospheric flux shows good compatibility up to energies of E ~126TeV. For energies above 126TeV, however, a flattening of the spectrum is observed, consistent with an astrophysical contribution to the overall spectrum of muon neutrinos. [arXiv:1705.07780v1 (May 22, 2017)]

Highlight: First results from XENON1T

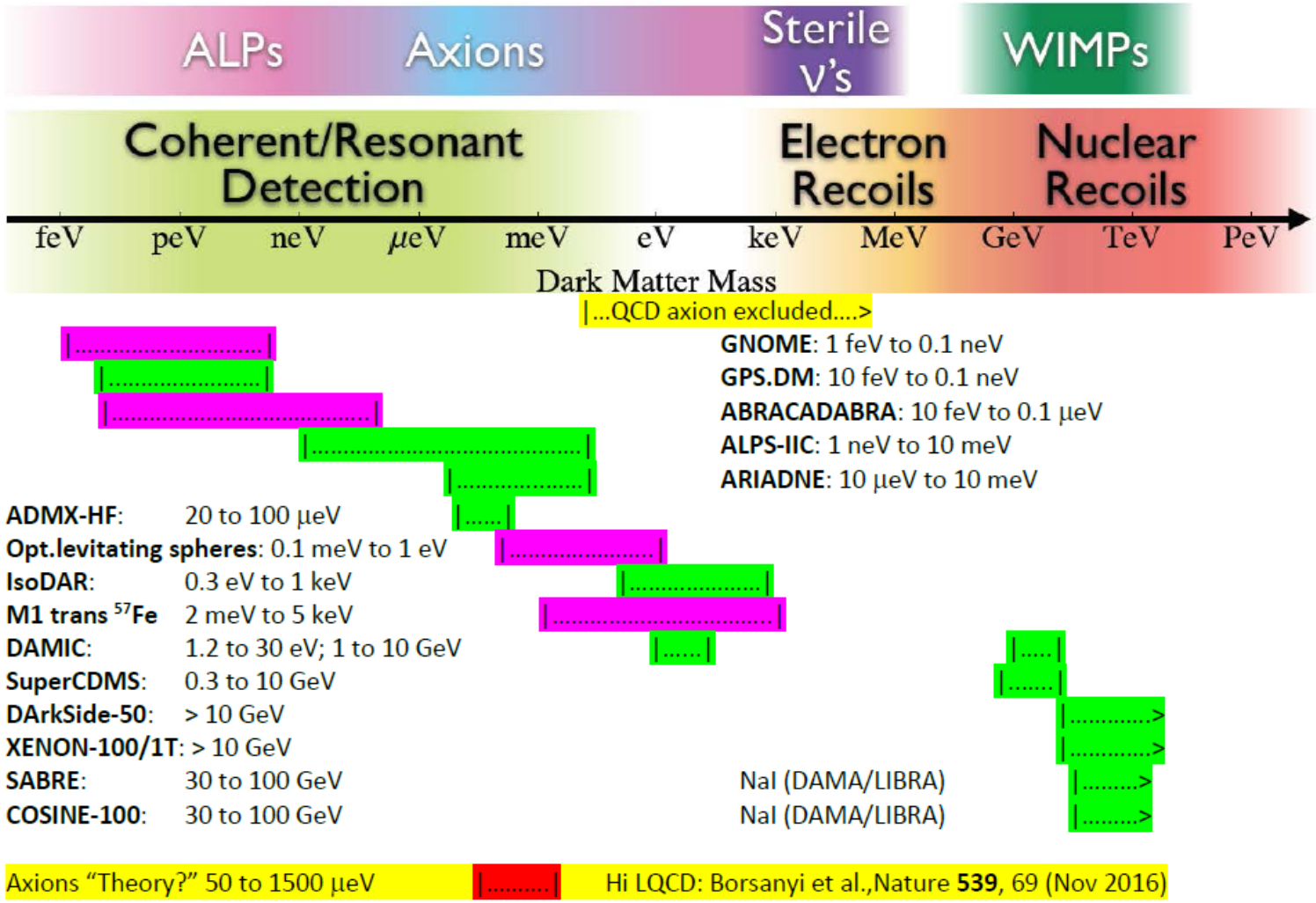


34.2 live days of data acquired between November 2016 and January 2017. They achieved the lowest electronic recoil background in a dark matter detector. The experiment resumed operation shortly after the January 18, 2017 earthquake and continues to record data. [arXiv:1705.06655v2 May 23, 2017]

Look at lower masses for Dark Sector

As WIMPs remain elusive, there is a growing interest in alternatives:

Purple indicates FY2017 awards



Elementary Particle Physics

THEORY

Astrophysics and Cosmology

THEORY

Keith Dienes

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.)

Theory Trends

- FY15-17: three-year absorption of string-theoretic portion of former Mathematical Physics program. Now nearly complete.
- FY16: NSF renews Aspen Center for Physics grant for next five years, expands support and scope into Atomic Physics
- Numbers of proposals received is currently twice what it was only 3-4 years ago.
- Increasing numbers of RUI proposals, particularly in FY17.
- One major challenge affecting Theory is the entrance of non-traditional (private philanthropic) funding sources. NSF has developed new procedures for evaluating overlapping sources of funding and introducing such evaluations into the proposal review process. (See NSF 17-561)

	FY 2015	FY 2016	FY 2017
THY Budget	$13.7 million	$13.2 million	$13.4 million
Proposals receiving awards	28	30	26
CAREER	2	1	2

Accelerator Science

EXPERIMENT AND THEORY

Vyacheslav (Slava) Lukin, Jim Shank

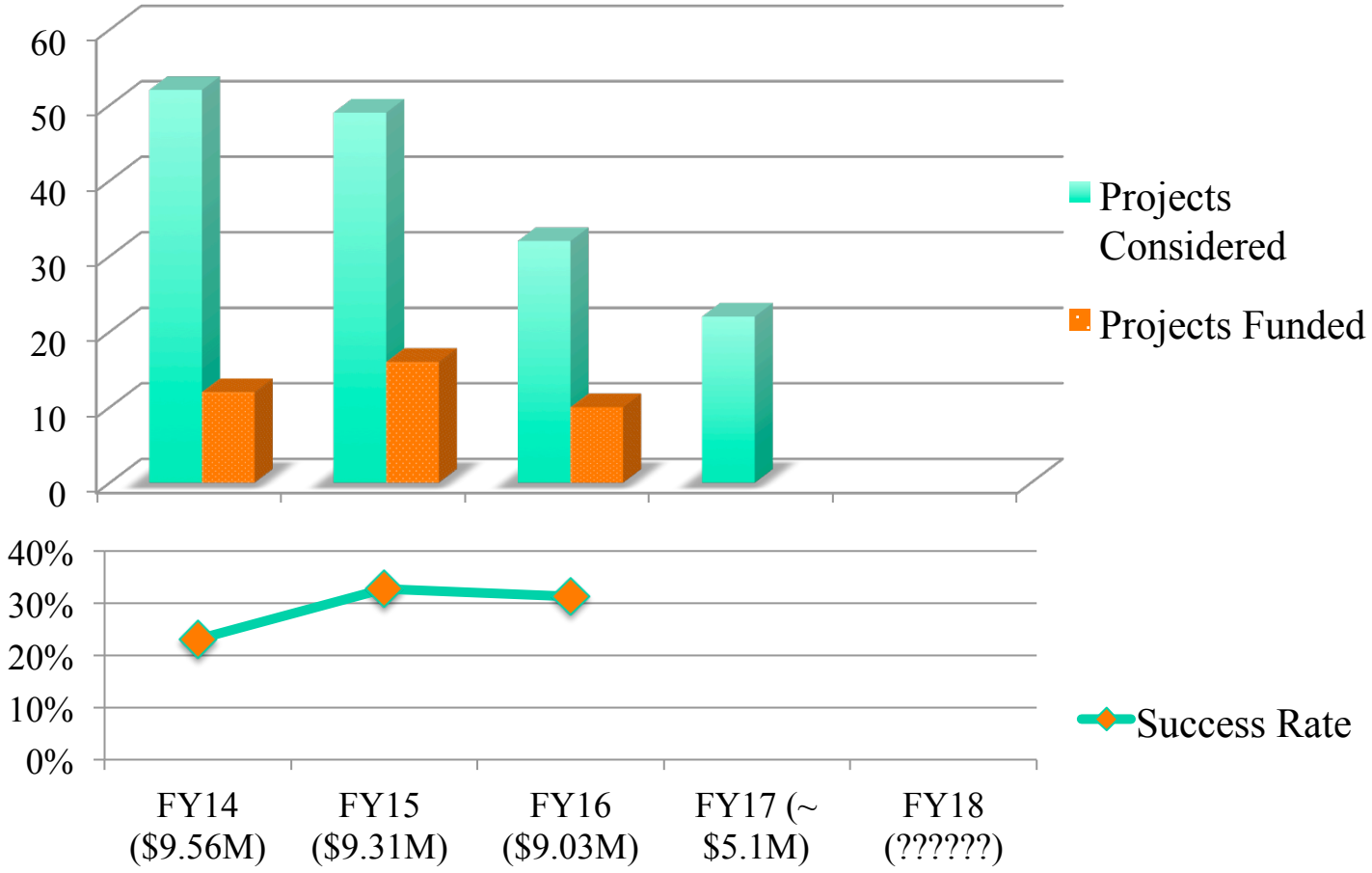
Program Description

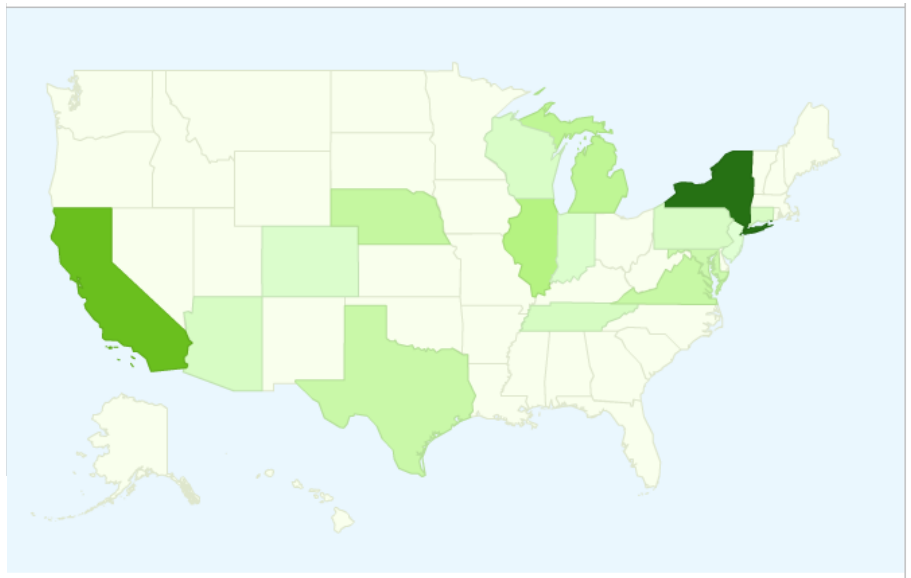
NSF Accelerator Science Program started in 2014

"*The Accelerator Science program supports and fosters research that exploits the educational and discovery potential of basic accelerator physics research at academic institutions. A key goal of the program is* ***to seed and develop research efforts in fundamental accelerator science at colleges and universities*** *that will enable transformational discoveries in this crosscutting academic discipline. In particular, this program seeks to support research* ***with the potential to disrupt existing paradigms*** *and advance accelerator science at a fundamental level…"*

"*This program aims to provide the foundation in knowledge and workforce upon which major advances in accelerator-driven technologies will be based. An important component of the program is the support and training of the next generation of accelerator scientists, including* ***students, postdoctoral researchers, and junior faculty****, who will lead innovations in the field and will form the backbone of the nation's highly trained accelerator workforce.… Priority will be given to those proposals that enable the discovery science supported by the MPS Division of Physics and* ***do not augment ongoing work supported by other agencies****."*

Funding History



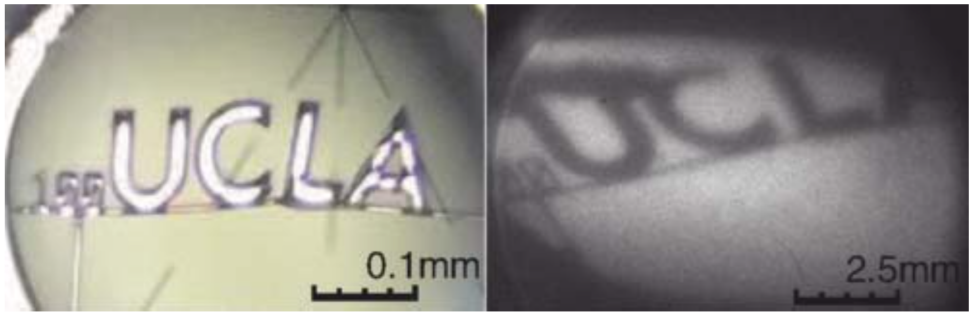


Country - State/Territory	Award Amount
US - New York	$11,491,786
US - California	$6,484,135
US - Illinois	$2,791,941
US - Michigan	$2,112,162
US - Nebraska	$1,749,998

Highlights

Exploring the Limits in Ultrafast High Brightness Electron Beam Generation

PI: Pietro Musumeci, UCLA

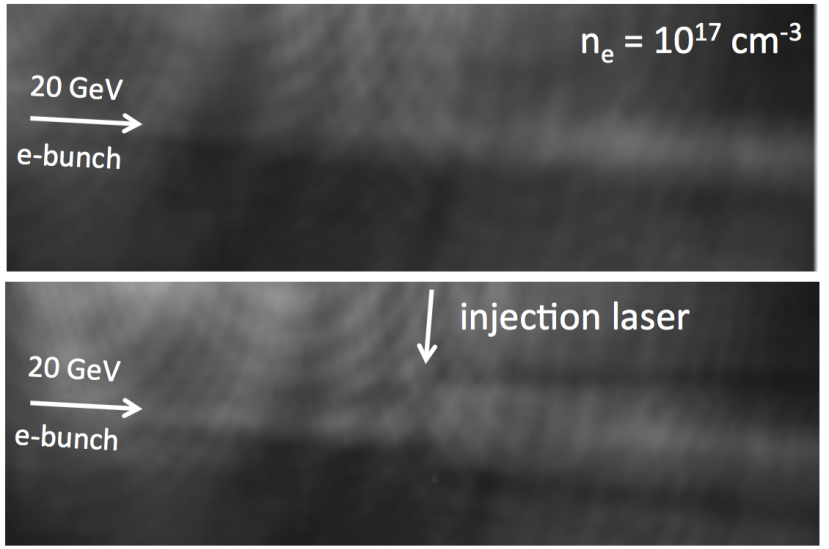


Optical (left) and electron (right) image of the nanofabricated UCLA target. The actual letter size in the target is 100 micron. The image on the right is the first single shot ps-time resolved transmission electron microscopy image using a MeV energy electron beam. (D. Cesar et al. PRL, 117, 024801, 2016)

Tomographic Visualization of Electron-Beam-Driven Plasma Wakefield Accelerators

PI: Michael Downer, UT Austin

Visualization of electron-driven plasma wakefield accelerators (Experiment E224)



Structures generated by intense GeV electron bunches at SLAC/FACET.

Outlook for Accelerator Science at NSF

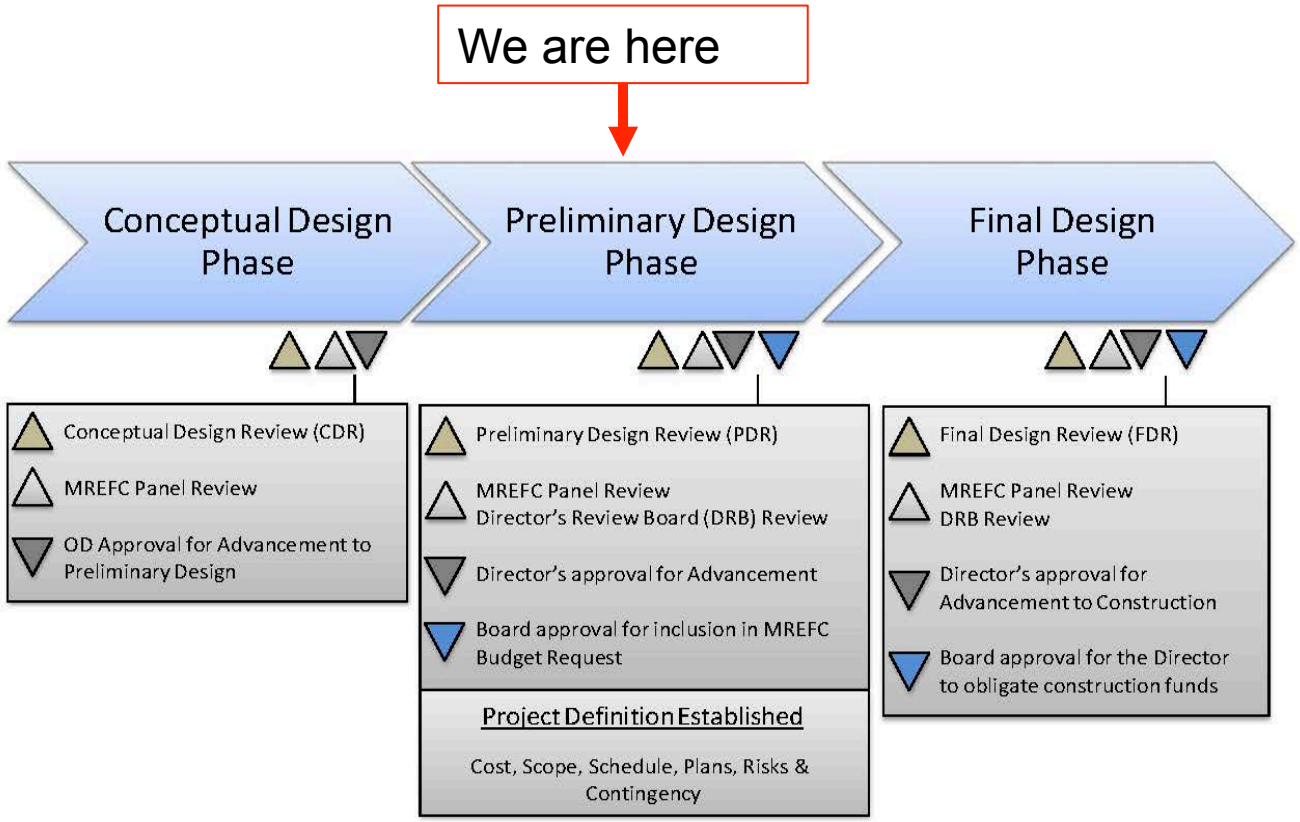
- The Accelerator Science program has not seen a large number of proposals that would fit well under the Program Description
- We have decided not to hold a regular Accelerator Science competition in FY18: recently released NSF PHY Investigator-Initiated Research Projects solicitation 17-561 does not contain a due date for the Accelerator Science program.
- The program will consider proposals submitted to NSF-wide solicitations such as CAREER – we maintain the desire "***to seed and develop research efforts in fundamental accelerator science at colleges and universities***".
- The program intends to be able to entertain supplement requests for graduate student support from PI's whose current awards expire in FY18.

Facilities and Scientific Infrastructure

Mark Coles, Jean Cottam, Saul Gonzalez, Bogdan Mihaila, Jim Shank, Randy Ruchti, Jim Whitmore

High Luminosity LHC Planning

- Conceptual Design (approved initiation Nov 2015)
- Preliminary Design (approved initiation August 2016)
  - "pre-PDR" snapshot review of ATLAS and CMS plans (April 2017)
  - Preliminary Design Reviews in December/17-January/18
- CERN's LHC schedule→ ATLAS, CMS schedules → HL LHC in 2020 NSF MREFC budget request



Instrumentation at the NSF

Project Cost (approx. in $million)		Funding Source			
From	**To**	**R&D/Planning**	**Acquisition / Construction**	**Operations**	**Scope of Competition**
0	1.0	EPP or PA	EPP or PA	EPP or PA	Program (within EPP or PA)
0.2	5.7	n/a	MRI (70%); University (30%)	n/a	PHY (<1.0) NSF (>1.0)
4.0	15	EPP or PA	PHY Research	EPP or PA	PHY
130 (MPS)	--	EPP or PA	MREFC	EPP or PA	NSF

"midscale"

Now $70 million across NSF

(10-15)% of TPC

(10-15)% of TPC *per year*

Computing

- We issued a Software Institute Conceptualization award: "Conceptualization of an S2I2 Software Institute for High Energy Physics" Award 1558216 (Elmer, Princeton) / 1558233 (Sokoloff, Cincinnati) / 1558233 (Neubauer, UIUC)
- Sponsors community workshops and conceptual work to take advantage of the significant data and computing requirements of the Large Hadron Collider as a science driver for next generation high-performance software and sustainability developments. Working together with the HEP Software Foundation to produce a Community White Paper.
- Next meeting: 23-26 Aug, 2017 – S2I2-HEP Workshop (Seattle)
- This effort will inform the future of computing and various software development needs for the HL-LHC era
- We are partnering with NSF's Office of Advanced Cyberinfrastructure
- Working with ATLAS, CMS, and OSG to minimize disruption to U.S. LHC

Outlook

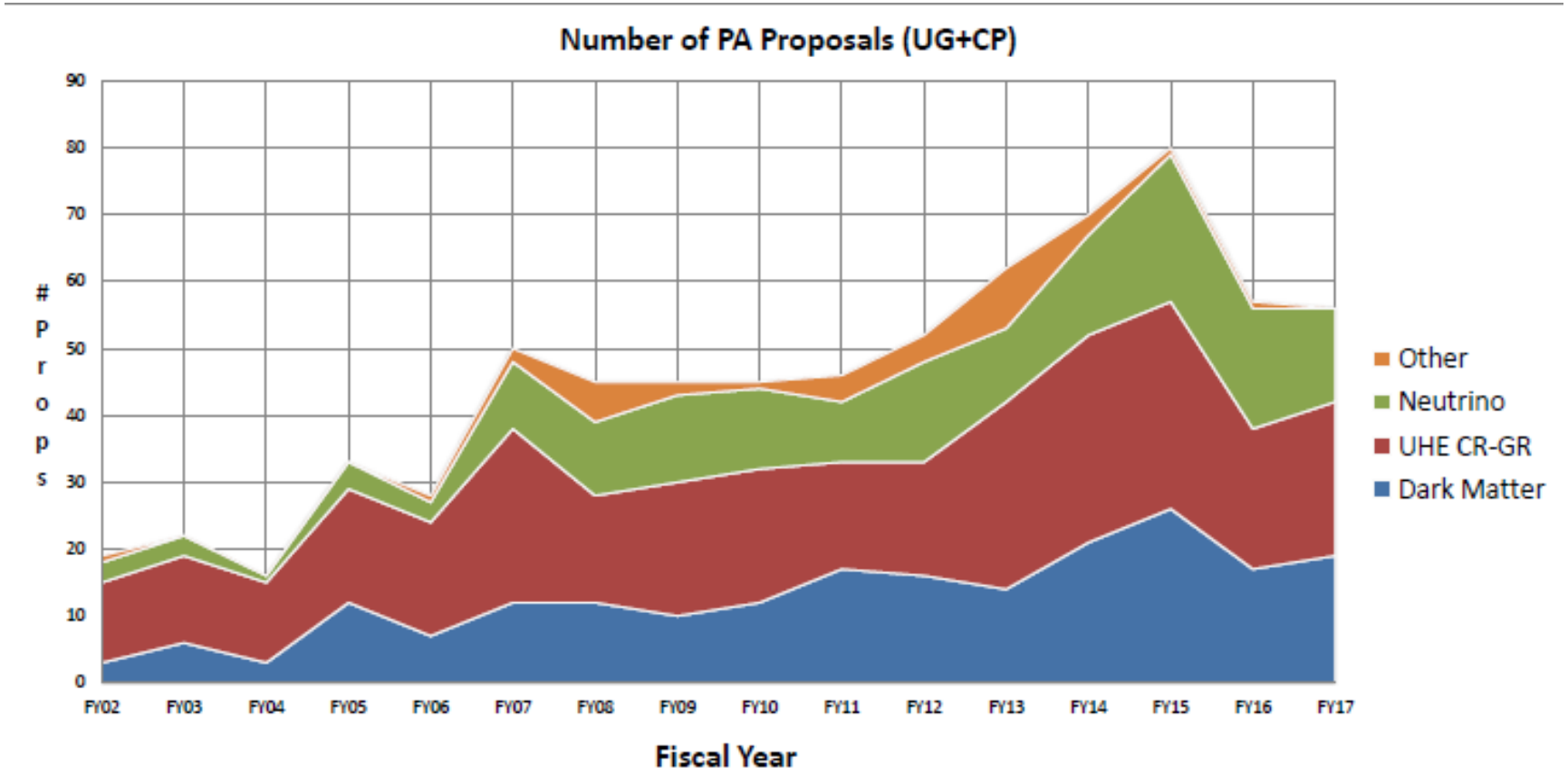
- Particle Physics at the NSF moves forward mindful of the P5 recommendations and aligned to the post-P5 MPS Advisory Committee recommendations
- PHY and the EPP program are committed—to the best of our ability--to the success of the HL LHC. This requires
  - Significant additional research contributions to planning activities
  - Additional reductions to EPP beyond nominal budget envelope
  - Essential to keep the LHC program viable beyond 2025
  - Close coupling between Research and Upgrade programs an issue
- But we are also committed to a diverse scientific portfolio that advances multiple frontiers
- FY18 President's Budget will require a re-baselining of Research Programs

ADDITIONAL SLIDES

Other Items

- Workshop on “Table-top experiments with Skyscraper reach” (Aug 9-11, MIT): *“...to bring together a diverse set of scientists from the particle physics, nuclear physics, and AMO communities to discuss new ideas for small-scale experiments that can search for new physics beyond the Standard Model*
- CPAD 2017, University of New Mexico, October 12-14
- NSF Physics Division Solicitation (Investigator-initiated Research Projects) 17-561 Deadlines:
  - October 25, 2017 (EPP-experiment, PA-experiment)
  - December 7, 2017 (EPP-Theory, PA & Cosmology-Theory)

Particle Astrophysics Proposals (FY02-17)



("Neutrino" includes $0\nu\beta\beta$ for <2015)

2016 STC at Cornell U.

- CBB's goal is to increase the intensity ("brightness") of beams of charged particles by two orders of magnitude while decreasing the cost of key accelerator technologies.
- CBB will promote significant advances in scientific disciplines ranging from physics to chemistry to biology by enhancing the capabilities of the accelerators essential to research in these fields.
- It will conduct collaborative research with national laboratories and companies, leveraging their diverse expertise, and will transfer technology to them.
- It will help integrate the research into instruments that advance the frontiers of knowledge in life sciences, materials science, condensed matter physics, particle physics, and nuclear physics.

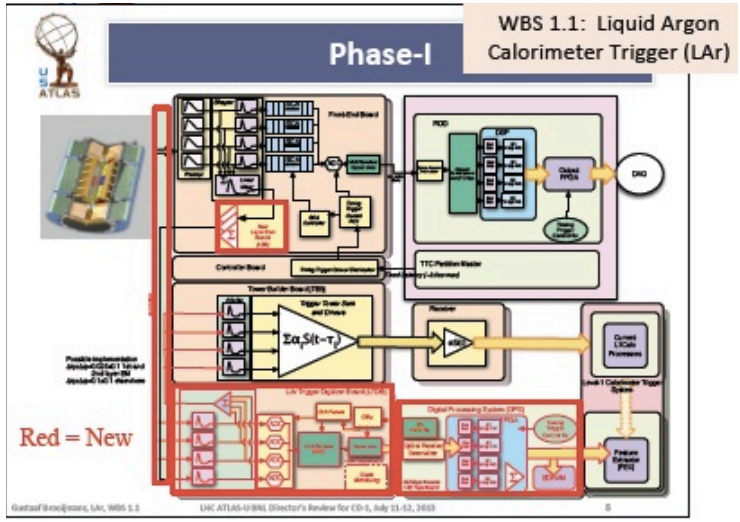
Major Research Instrumentation (MRI)

- Up to $4 million from NSF for development or acquisition proposals
- Cost-sharing at the level of 30% of the *total project cost* is required for Ph.D.-granting institutions and non-degree-granting organizations. *Cost-sharing is not required for non-Ph.D. granting institutions.*
- Submission limit - Three (3) per organization: *If three proposals are submitted, at least one of the proposals must be for instrument development.*
- Merit Review - At the time of submission, PI's are asked to identify an NSF division(s) to review proposal. NSF reserves the right to place proposals in the appropriate division(s) for review.
- Very competitive and supported mostly with non-PHY funding
- EPP and PA communities have leveraged many $million over the years
- MRI solicitation is evolving

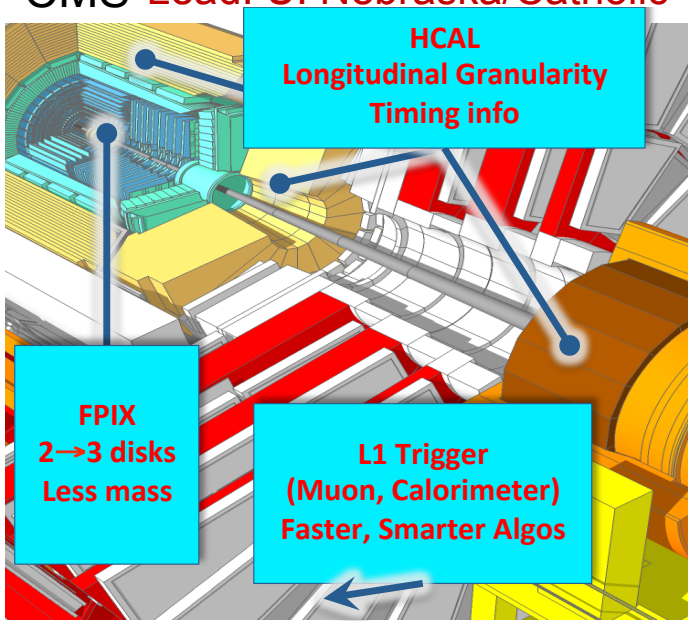
Midscale Instrumentation

- Design and Construction *or* Acquisition of Instrumentation
- ~ $4M < TPC < ~ $15M; PHY funding over multiple years
- Currently 6 Midscale projects (see PHY Solicitation 17-561)

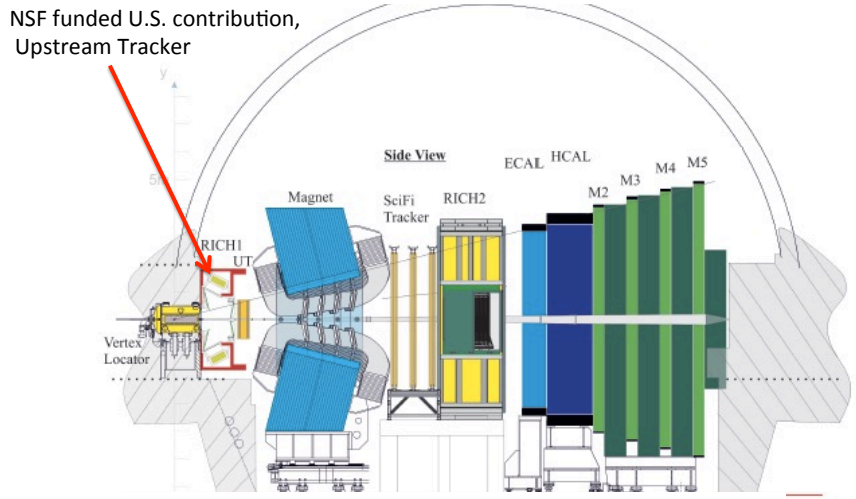
ATLAS Lead: SUNY-Stony Brook



CMS Lead: U. Nebraska/Catholic



LHCb



Leads: Syracuse,Cincinati, MIT, UMd

Update: Major Research Equipment & Facilities Construction

National Science Foundation
Office of the Director
Arlington, VA 22230

~$130 million threshold (MPS) → $70 million

Notice No. 138 **November 30, 2016**

IMPORTANT NOTICE TO
PRESIDENTS OF UNIVERSITIES AND COLLEGES
AND HEADS OF OTHER NATIONAL SCIENCE FOUNDATION
GRANTEE ORGANIZATIONS

SUBJECT: **Revision of the Major Research Equipment and Facilities Construction (MREFC) Eligibility Threshold.**

Following open discussion at the National Science Board meeting on November 8th and 9th, NSF has established the Total Project Cost (TPC) eligibility threshold for potential inclusion in the Major Research Equipment and Facilities Construction (MREFC) account at $70M. This adjustment responds to emergent scientific research opportunities and addresses the gap that previously existed between smaller instrumentation and major facility projects. Further details on MREFC account eligibility will be included in the FY 2017 revision of NSF's *Large Facilities Manual* which will be published in December and made available on the Large Facilities Office website (https://www.nsf.gov/bfa/lfo/index.jsp). The scientific community should incorporate this change in their long range portfolio planning and prioritization efforts.

France A. Córdova
Director