

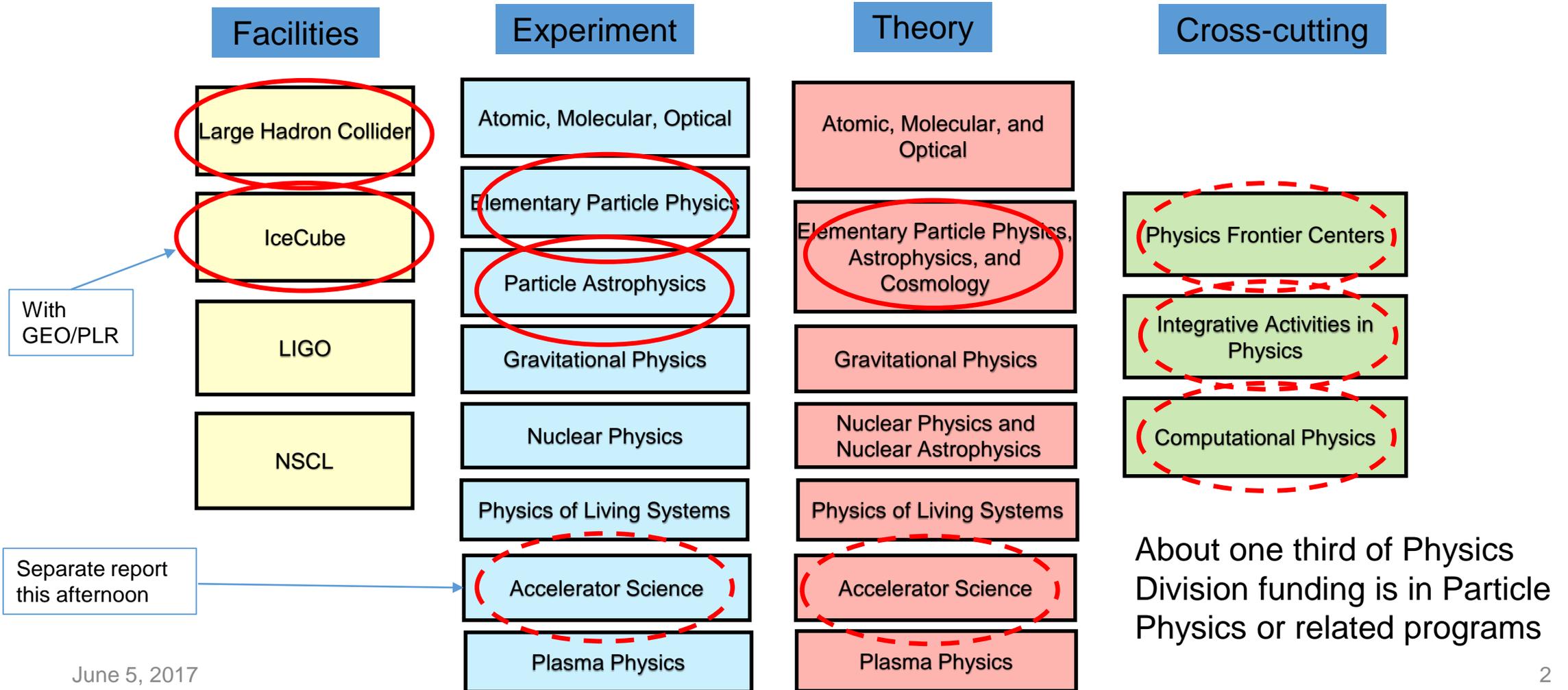


Particle Physics at the NSF

HEPAP Meeting
Gaithersburg, MD
June 5, 2017

Mark Coles, Jean Cottam, Keith Dienes, Saúl González, Randy Ruchti,
Jim Shank, Jim Whitmore

Particle Physics in the NSF Physics Division





National Science Foundation
Summary Table

FY 2018 Budget Request to Congress

(Dollars in Millions)

*FY 2018 President's
Budget Request*

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%

FY 2018 MPS Budget Request



MPS Funding					
(Dollars in Millions)					
	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				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

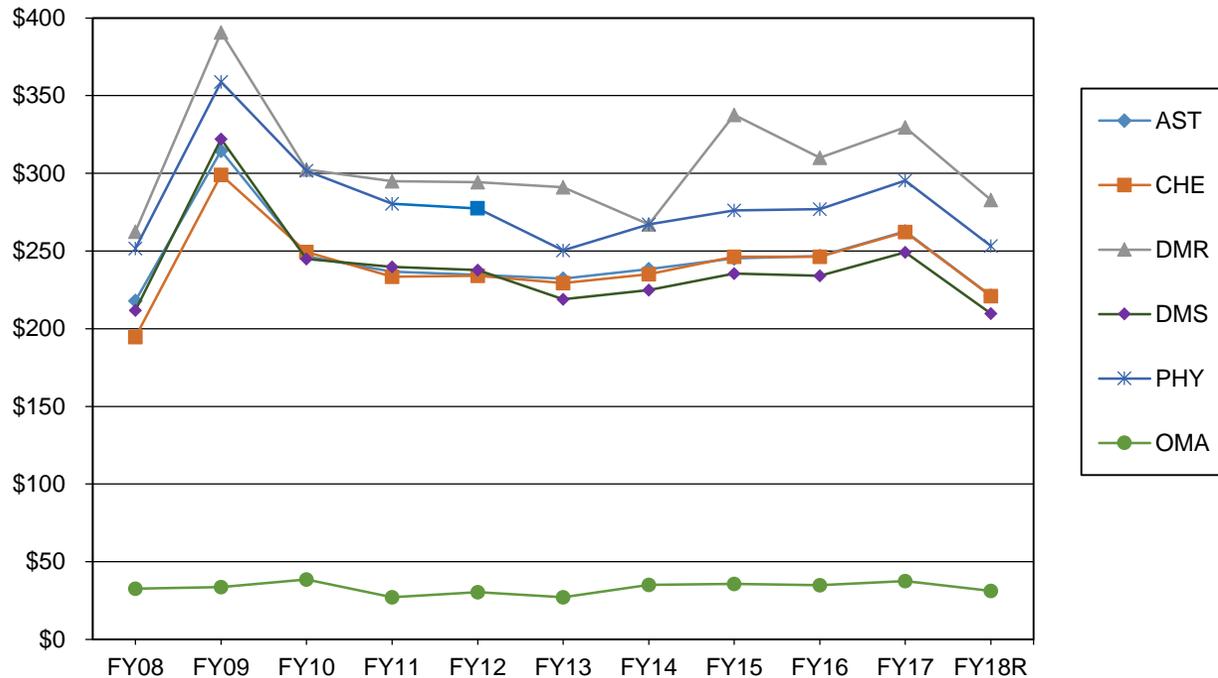


PHY Funding					
(Dollars in Millions)					
	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over	
				FY 2016 Actual Amount	Percent
Total	\$276.91	-	\$253.30	-\$23.61	-8.5%
Research	174.12	-	152.09	-22.03	-12.7%
CAREER	8.12	-	7.30	-0.82	-10.1%
STC: Center for Bright Beams (CBB)	-	-	5.00	5.00	N/A
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)



MPS Subactivity Funding
(Dollars in Millions)



FY18 PBR

PHY Division Funding History
(\$M)





Elementary Particle Physics

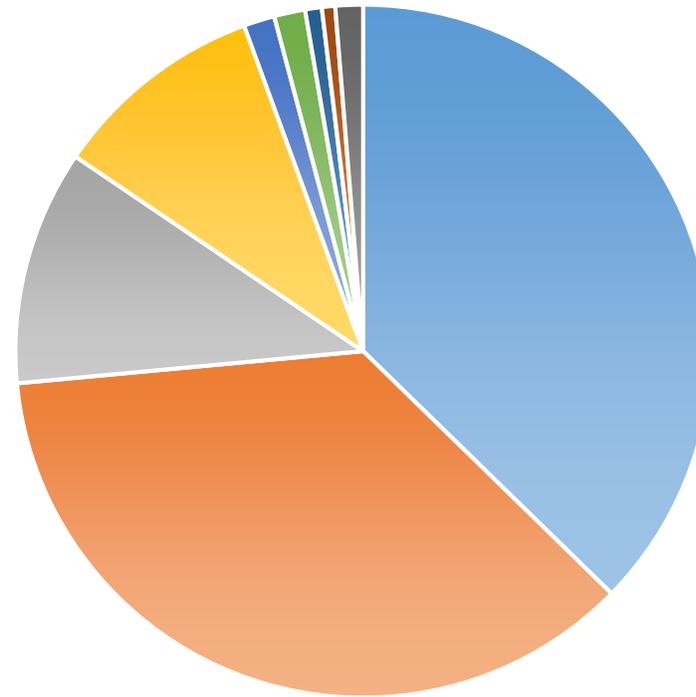
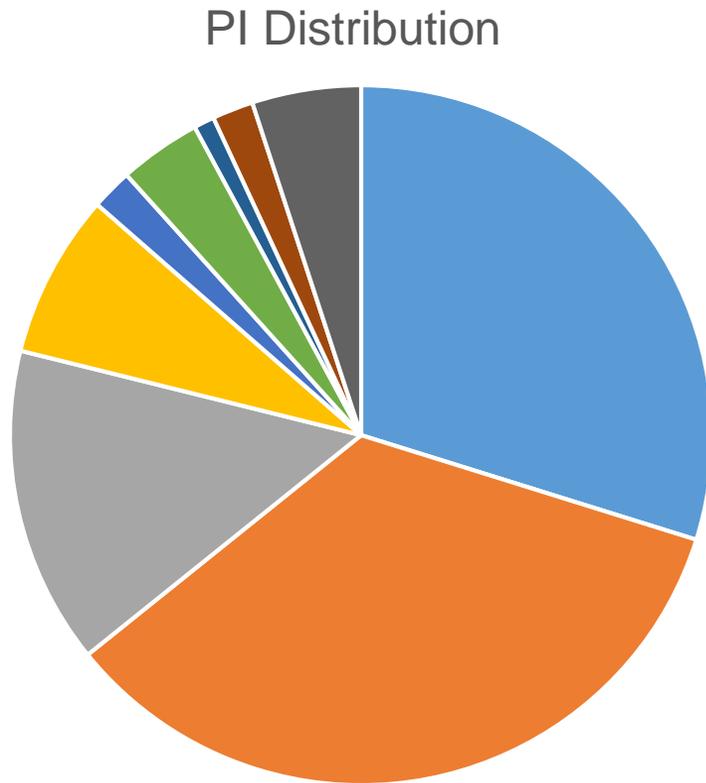
EPP EXPERIMENT

Jim Shank, Randy Ruchti, Saul Gonzalez

Snapshot: FY 2016 EPP



EPP FY2016 Funding Distribution

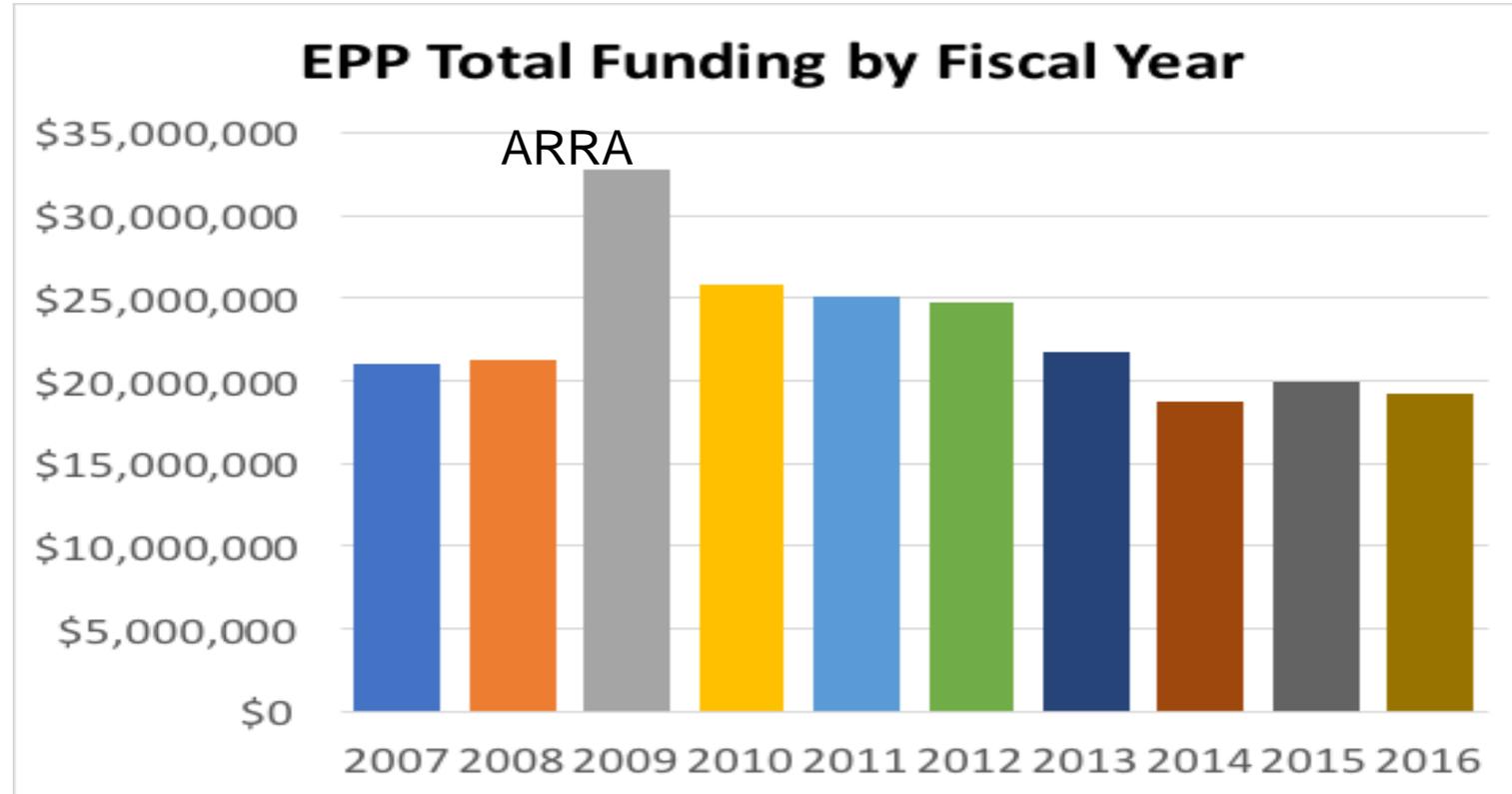


- ATLAS
- CMS
- Neutrinos
- LHCb
- mu2e
- Computing
- RareK
- Detector R&D
- Other

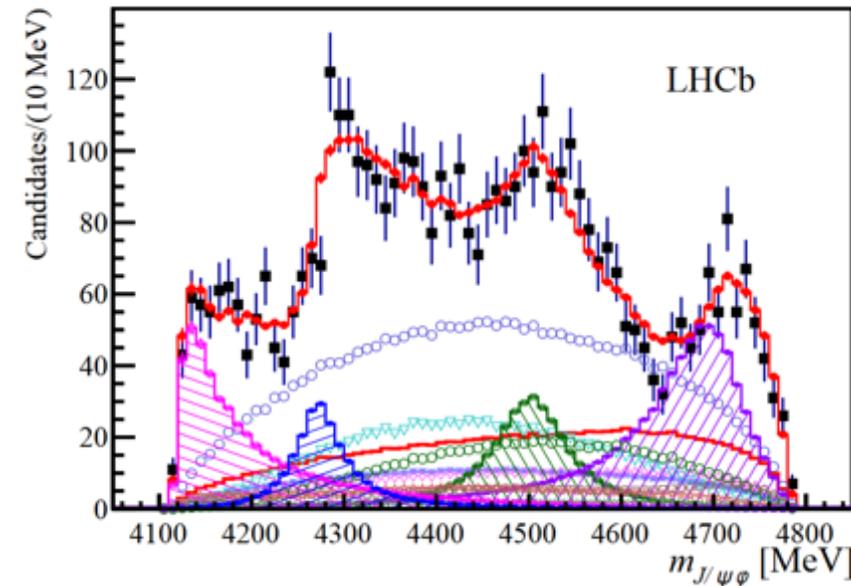
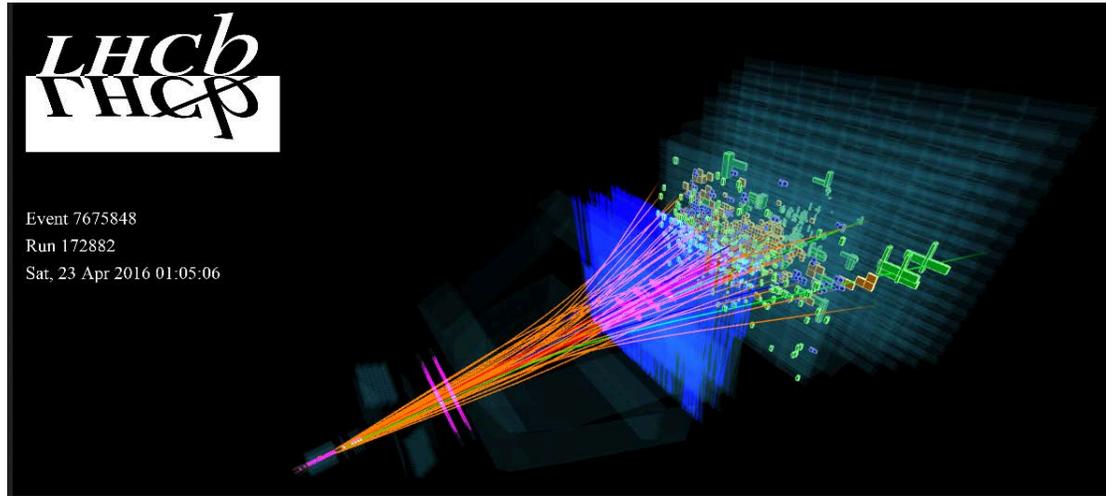
Total Funding
= \$19.4 million

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

EPP Funding History



EPP Highlight: LHCb

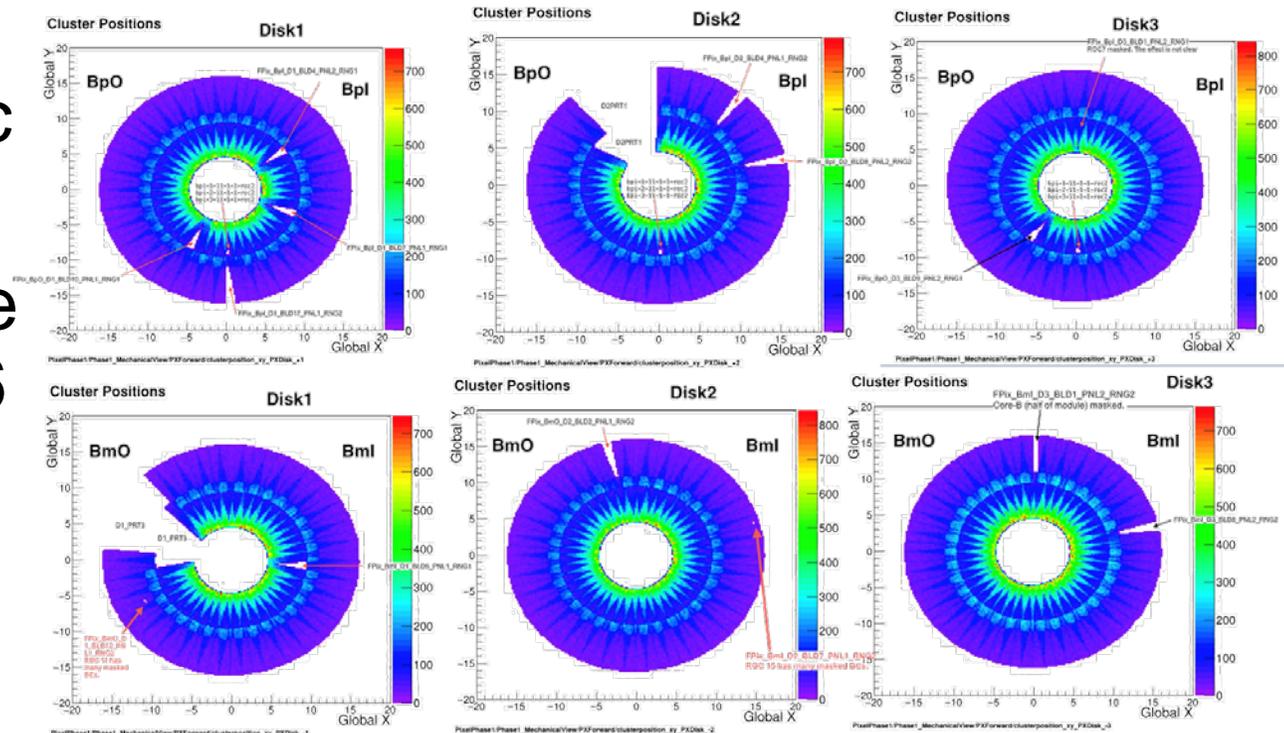


- Recent physics highlights from US groups:
 - Observation of exotic-like particles (Tetraquarks)
 - B^+ meson decays into J/ψ , ϕ and K^+ mesons.
 - The plot shows the J/ψ , ϕ mass spectrum which can only be fit with the inclusion of the four exotic particles at 4140, 4274, 4500 and 4700 MeV. See <https://arxiv.org/abs/1606.07898>
 - Ongoing Lepton Universality test probes physics beyond the Standard Model
 - Recent 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 $\mathcal{L}=2 \times 10^{34}/\text{cm}^2/\text{sec}$ and $\eta < 2.5$.
- 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

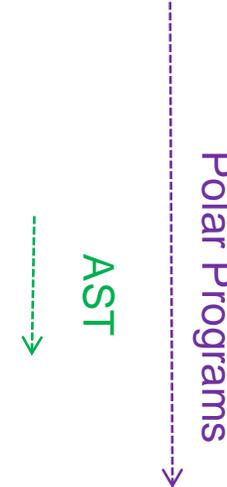
EXPERIMENT

Jean Cottam, Jim Whitmore

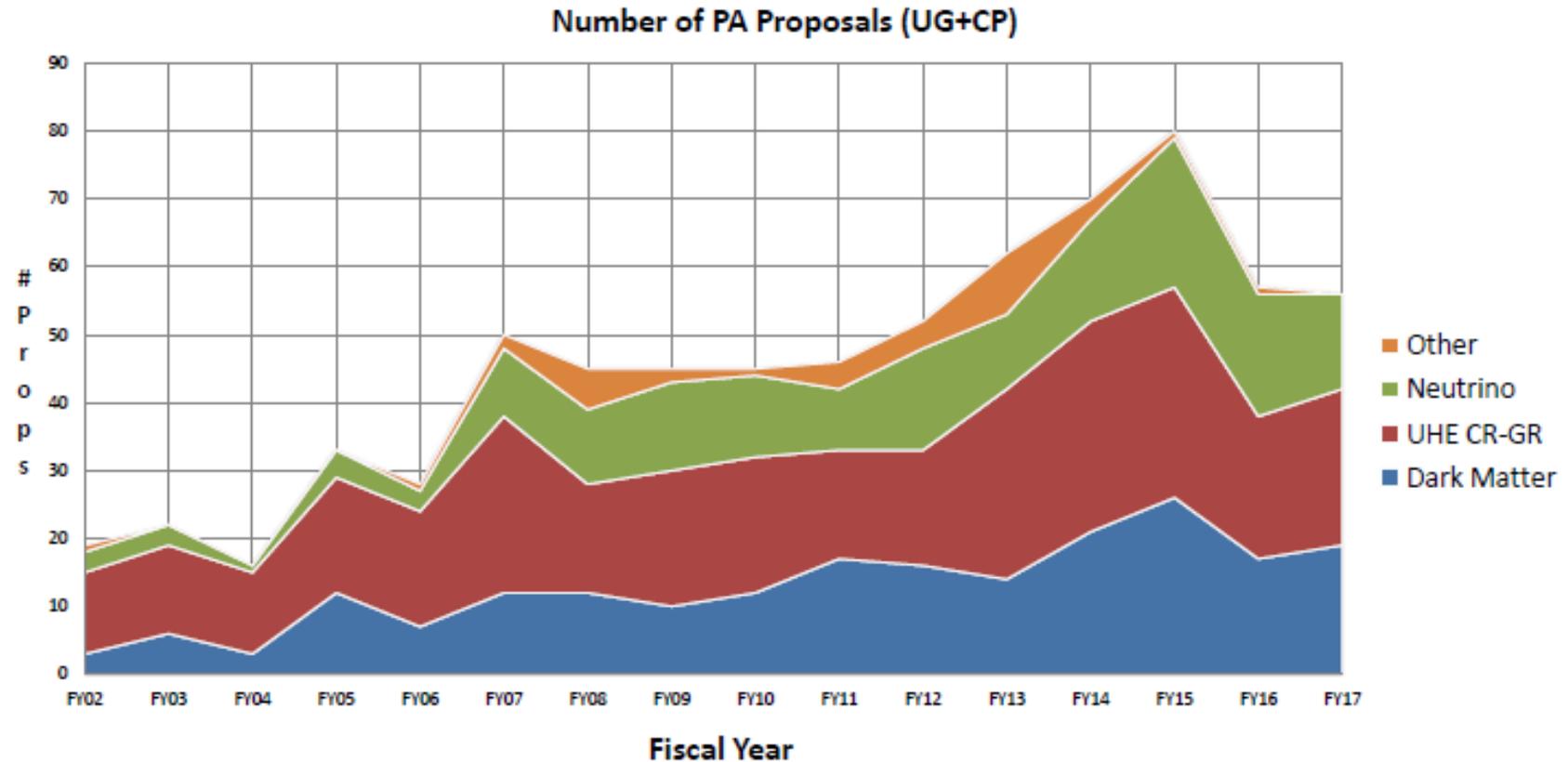
PA Program Scope & Currently Supported Projects



- 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

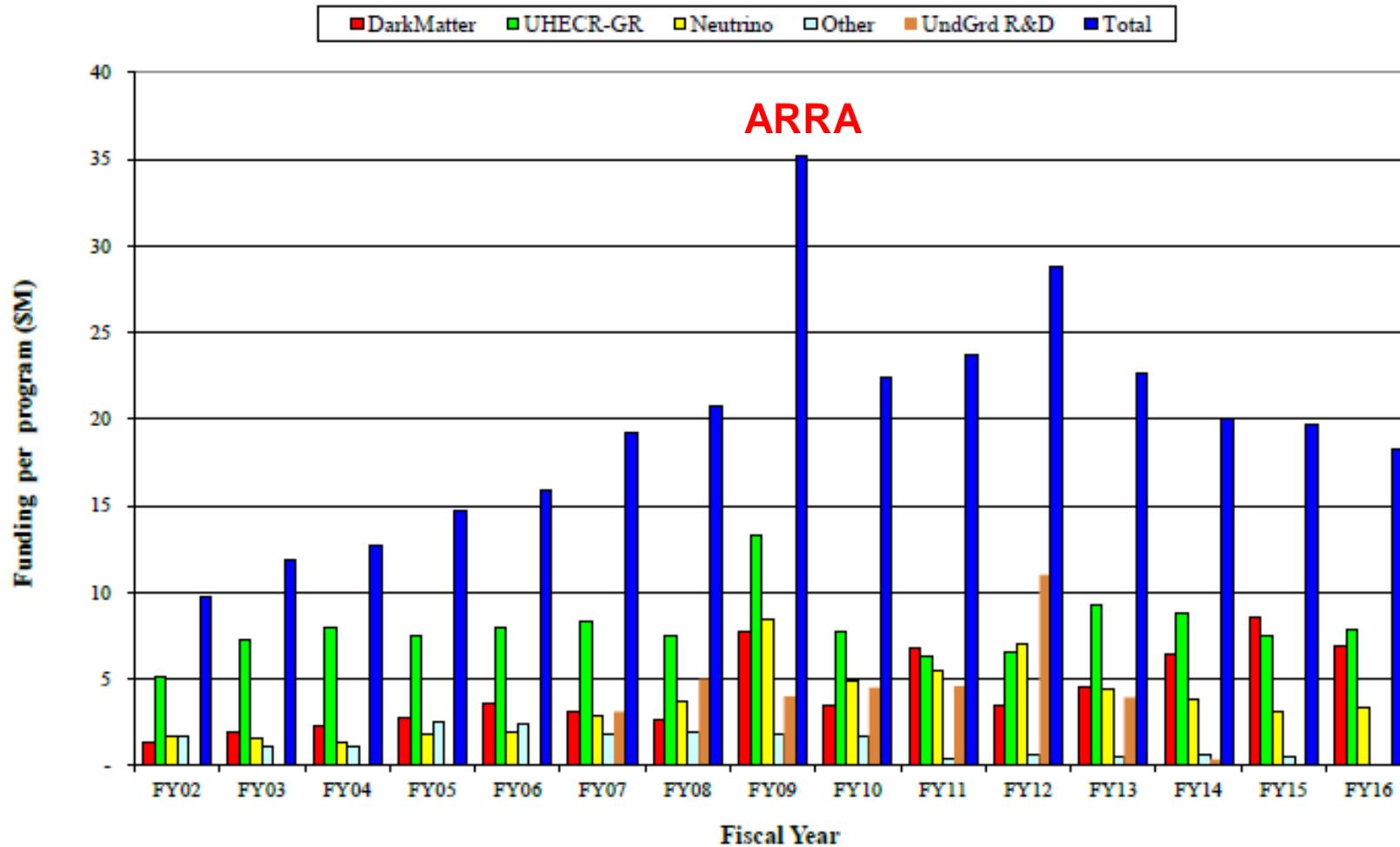


Particle Astrophysics Proposals (FY02-17)

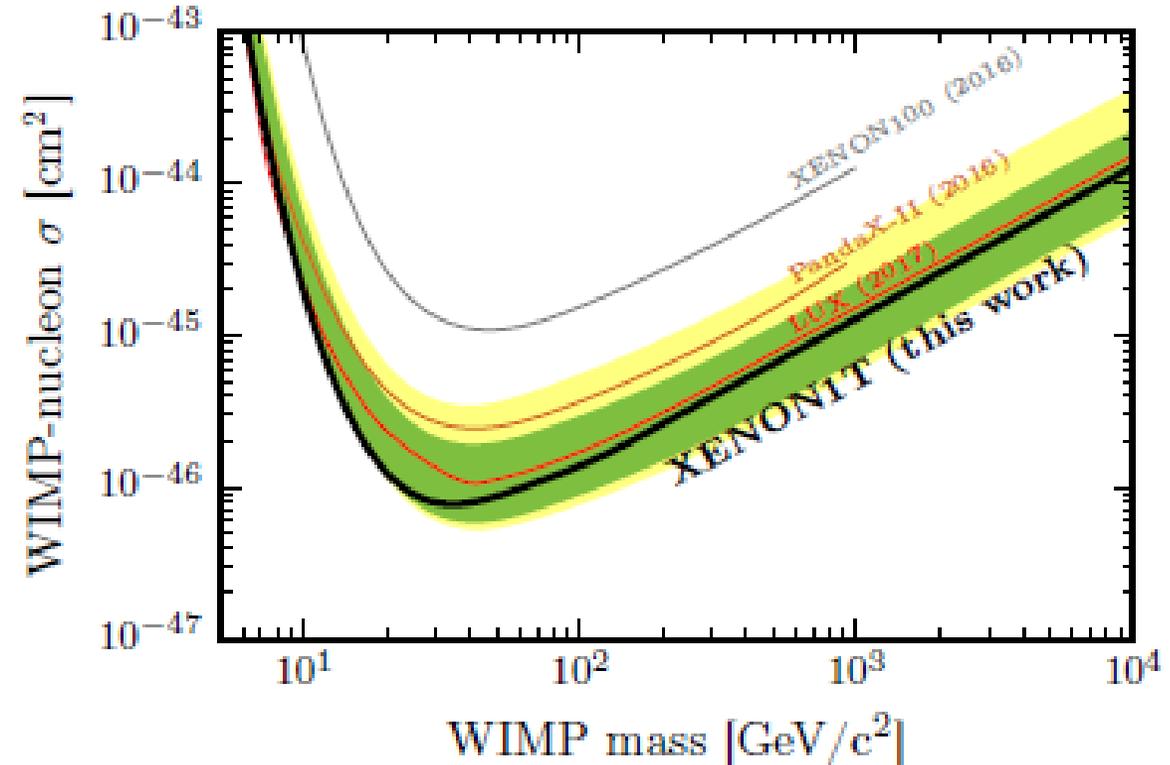


(“Neutrino” includes $0\nu\beta\beta$ for <2015)

PA Program Funding FY2002-2016



Highlight: First results from XENON1T

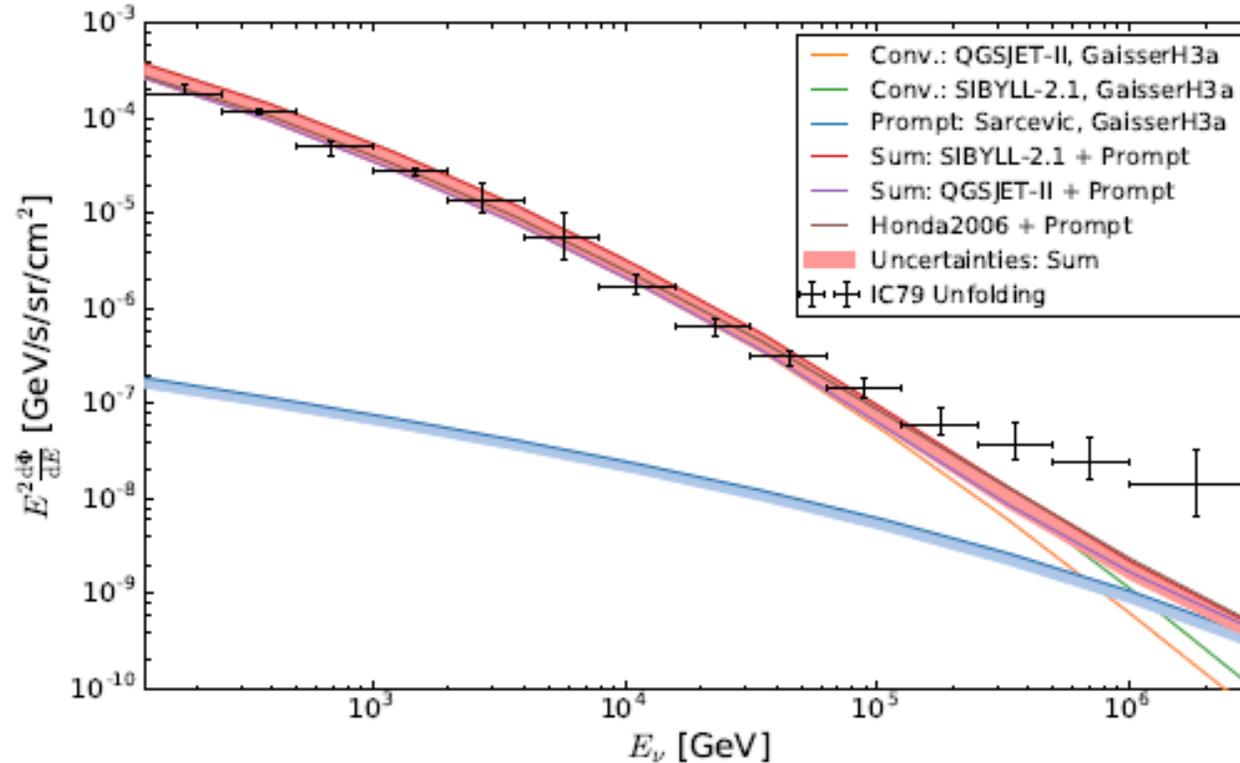


34.2 live days of data acquired between November 2016 and January 2017. They achieved the lowest electronic recoil background in a dark matter detector. The experiment resumed operation shortly after the January 18, 2017 earthquake and continues to record data. [arXiv:1705.06655v2 May 23, 2017]

Highlight: Astrophysical muon neutrino



IceCube



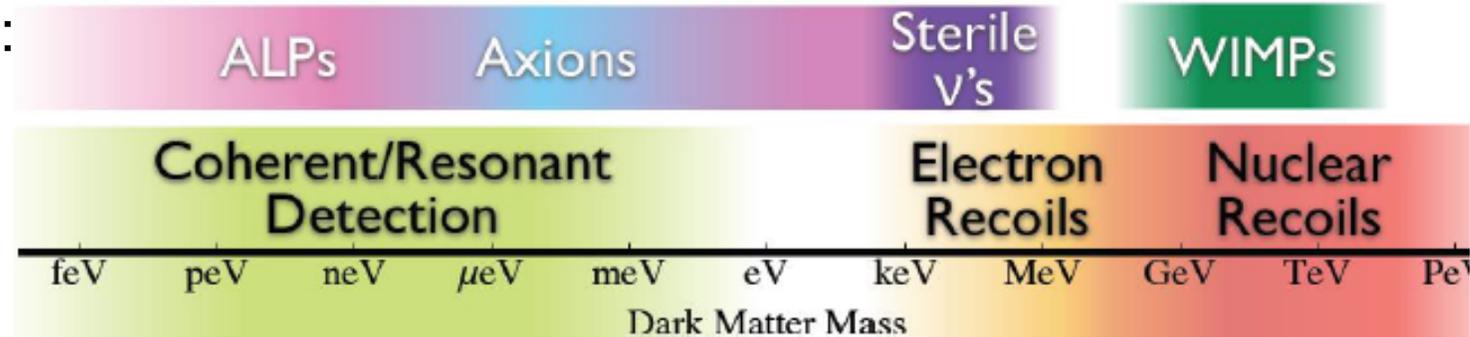
Using CC events:
Conventional = from π/K decays
Prompt = from charm decays

A comparison of the unfolded spectrum with theoretical predictions for a purely atmospheric flux shows good compatibility up to energies of $E \sim 126\text{TeV}$. 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)]

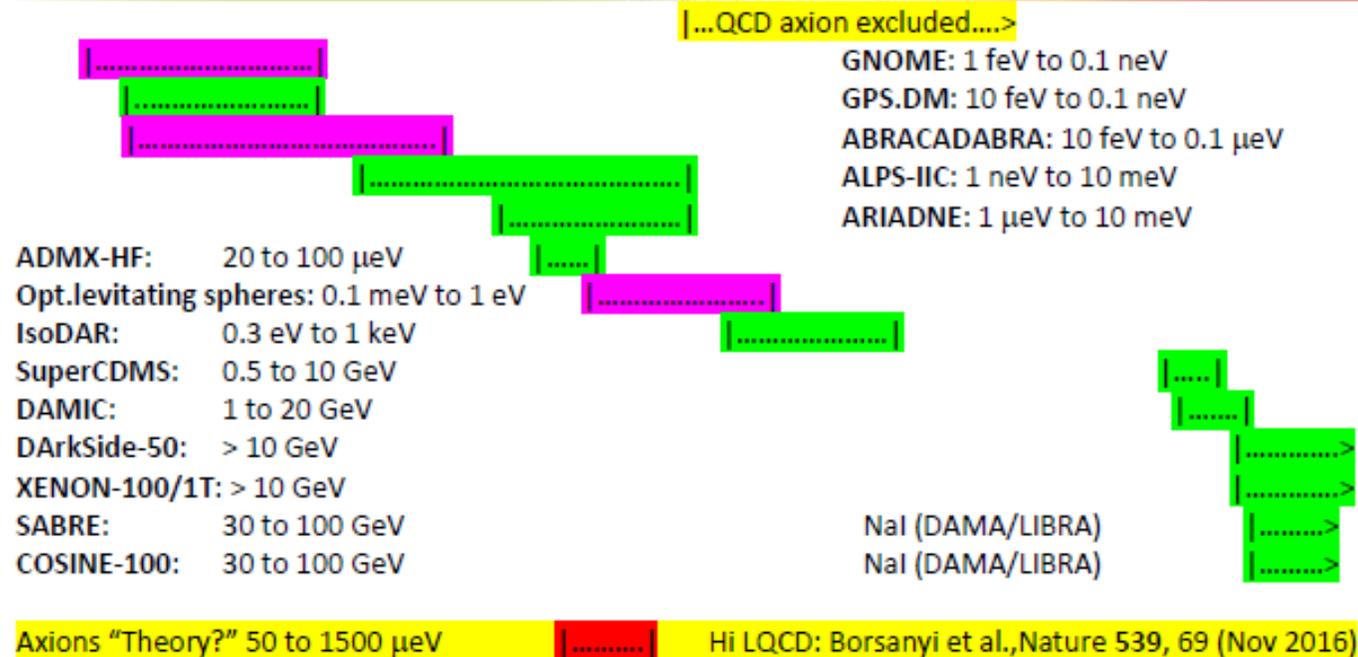
Look at lower masses for Dark Sector



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 therefore strive to capitalize on the immense 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.

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



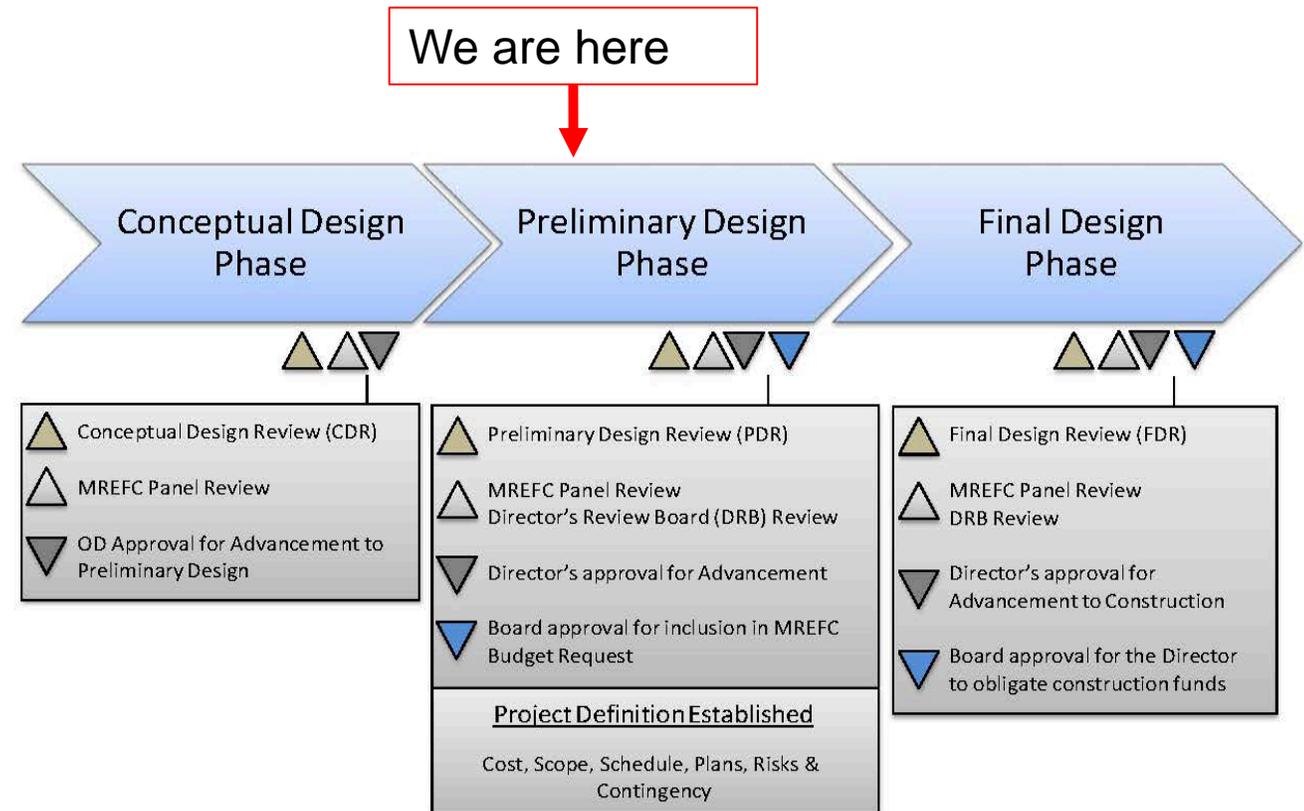
Facilities and Scientific Infrastructure

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 (if approved) in 2020
MREFC budget request (2018)





- 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: 26-30 Jun, 2017 - HEP Software Foundation Workshop *LAPP (Annecy)*
- 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

Major Research Instrumentation (MRI)

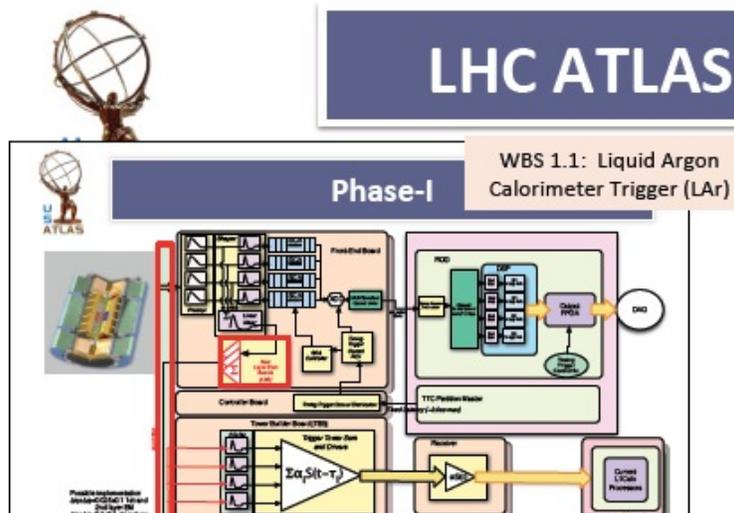


- Up to \$4 million from NSF for development or acquisition proposals
- Cost-sharing at the level of 30% of the *total project cost* is required for Ph.D.-granting institutions and non-degree-granting organizations. *Cost-sharing is not required for non-Ph.D. granting institutions.*
- Submission limit - 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

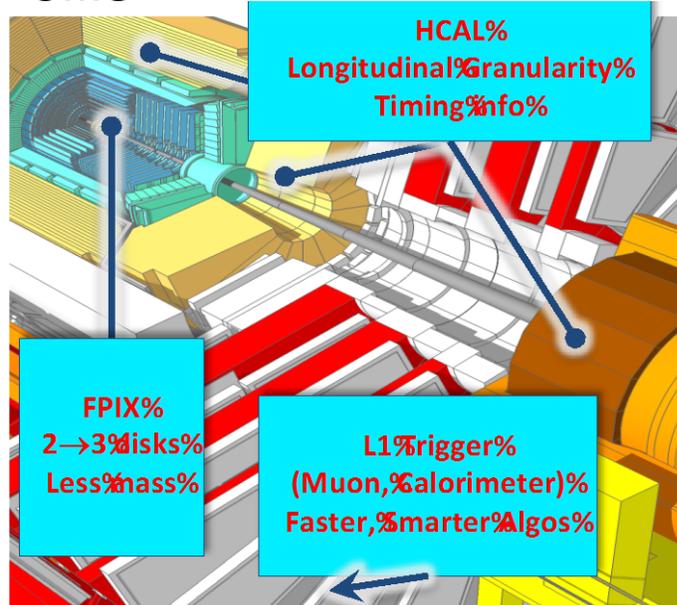
Midscale Instrumentation

- 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

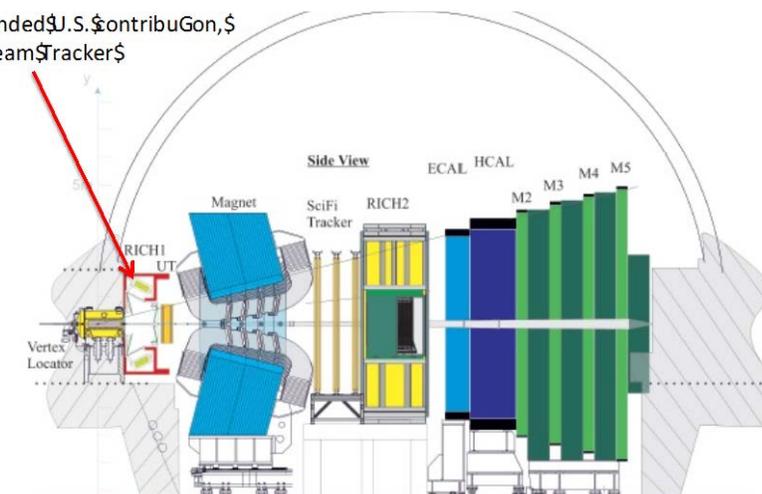


CMS Lead: U. Nebraska/Catholic



LHCb

NSF funded U.S. contribution, \$ upstream Tracker



Leads: Syracuse, Cincinnati, 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. Córdoba
Director

Summary: 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*

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 Budgets imply a re-baselining of Research Programs

New 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.

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)
- Career Program Solicitation 17-537 Deadline: July 21, 2017

We are moving this summer

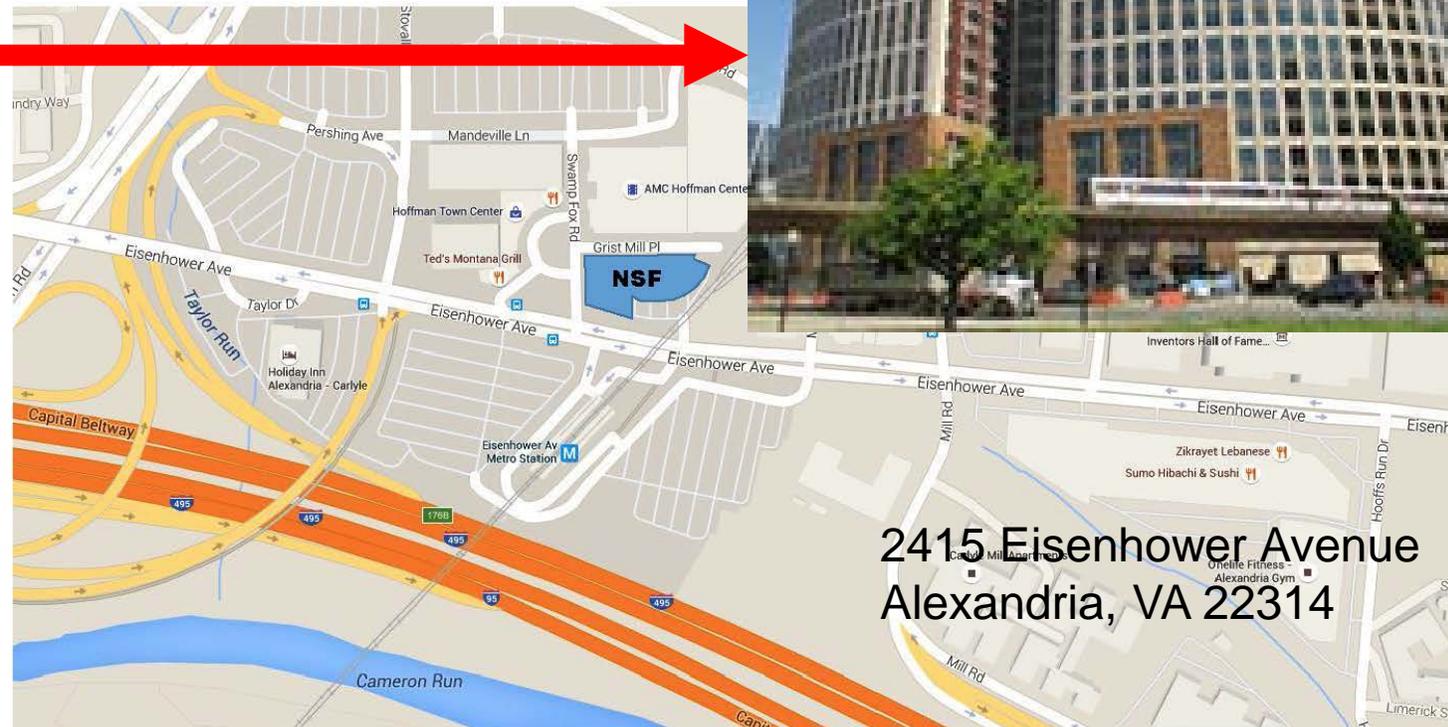


25 mins to/from DCA



4201 Wilson Boulevard
Arlington, VA 22230

10 mins to/from DCA



2415 Eisenhower Avenue
Alexandria, VA 22314