NSF PHY Division Status

(HEPAP related)

High Energy Physics Advisory Panel

Newport Beach, CA

December 9-11, 2015

J. Shank reporting for the NSF PHY Division

Overview

- NSF Organization
- Overall NSF Budget
- Recent EPP funding
- Accelerator Science
- Theory
- Particle Astrophysics – covered in Fri. morning session
- Mid-Scale Projects
- The HL-LHC Upgrades
- Computing Opportunities

Division of Physics

Denise Caldwell
Director

Brad Keister
Deputy Director

Facilities

- Large Hadron Collider — *Mark Coles (Saul Gonzalez)**
- IceCube — *Jim Whitmore*
- LIGO — *Mark Coles*
- NSCL — *Ken Hicks*

Experiment

- Atomic, Molecular, Optical — *John Gillaspy*
- Elementary Particle Physics — *(Saul Gonzalez)*, Brian Meadows, Jim Shank*
- Particle Astrophysics — *Jean Cottam-Allen, Jim Whitmore*
- Gravitational Physics — *Mark Coles, Pedro Marronetti*
- Nuclear Physics — *Allena Opper, Ken Hicks*
- Physics of Living Systems — *Krastan Blagoev*
- Accelerator Science — *Slava Lukin, Jim Shank (Saul Gonzalez)**
- Plasma Physics — *Slava Lukin*

Theory

- Atomic, Molecular, and Optical — *Ann Orel*
- Elementary Particle Physics, Astrophysics, and Cosmology — *Keith Dienes*
- Gravitational Physics — *Pedro Marronetti*
- Nuclear Physics and Nuclear Astrophysics — *Bogdan Mihaila*
- Physics of Living Systems — *Krastan Blagoev*
- Accelerator Science — *Jim Shank, Slava Lukin (Saul Gonzalez)**
- Plasma Physics — *Slava Lukin*

Cross-cutting

- Physics Frontier Centers — *Jean Cottam-Allen*
- Integrative Activities in Physics — *Kathy McCloud*
- Computational Physics — *Bogdan Mihaila, Ann Orel*

* On Detail at OSTP

National Science Foundation
Summary Table
FY 2016 Request to Congress

(Dollars in Millions)

NSF by Account	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2016 Request over: FY 2014 Actual Amount	FY 2014 Actual Percent	FY 2015 Estimate Amount	FY 2015 Estimate Percent
BIO	$720.84	$731.03	$747.92	$27.08	3.8%	$16.89	2.3%
CISE	892.60	921.73	954.41	61.81	6.9%	32.68	3.5%
ENG	833.12	892.31	949.22	116.10	13.9%	56.91	6.4%
Eng Programs	*673.13*	*715.20*	*754.86*	*81.73*	*12.1%*	*39.66*	*5.5%*
SBIR/STTR	*159.99*	*177.11*	*194.36*	*34.37*	*21.5%*	*17.25*	*9.7%*
GEO	1,321.32	1,304.39	1,365.41	44.09	3.3%	61.02	4.7%
MPS	1,267.86	1,336.72	1,366.23	98.37	7.8%	29.51	2.2%
SBE	256.84	272.20	291.46	34.62	13.5%	19.26	7.1%
OISE[1]	48.31	48.52	51.02	2.71	5.6%	2.50	5.2%
IA[1]	433.12	425.34	459.15	26.03	6.0%	33.81	7.9%
U.S. Arctic Research Commission	1.30	1.41	1.48	0.18	13.5%	0.07	5.0%
Research & Related Activities	**$5,775.32**	**$5,933.65**	**$6,186.30**	**$410.98**	**7.1%**	**$252.66**	**4.3%**
Education & Human Resources	**$832.02**	**$866.00**	**$962.57**	**$130.55**	**15.7%**	**$96.57**	**11.2%**
Major Research Equipment and Facilities Construction	**$200.00**	**$200.76**	**$200.31**	**$0.31**	**0.2%**	**-$0.45**	**-0.2%**
Agency Operations and Award Management	**$305.95**	**$325.00**	**$354.84**	**$48.89**	**16.0%**	**$29.84**	**9.2%**
National Science Board	**$4.25**	**$4.37**	**$4.37**	**$0.12**	**2.8%**	**-**	**-**
Office of Inspector General	**$13.84**	**$14.43**	**$15.16**	**$1.32**	**9.5%**	**$0.73**	**5.1%**
Total, NSF	**$7,131.39**	**$7,344.21**	**$7,723.55**	**$592.16**	**8.3%**	**$379.34**	**5.2%**

Totals may not add due to rounding.

[1] This table reflects the realignment, expected in FY 2015, of the Office of International Science and Engineering (OISE) and Integrative Activities (IA) as separate budget activities. All data are presented in the FY 2015 structure for comparability.

Mathematical and Physical Sciences (MPS) Funding

(Dollars in Millions)

	FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	Change Over FY 2015 Estimate Amount	Change Over FY 2015 Estimate Percent
Astronomical Sciences (AST)	$238.36	$244.16	$246.55	$2.39	1.0%
Chemistry (CHE)	235.18	243.85	251.20	7.35	3.0%
Materials Research (DMR)	267.09	306.99	315.80	8.81	2.9%
Mathematical Sciences (DMS)	224.97	231.73	235.47	3.74	1.6%
Physics (PHY)	267.09	274.99	277.37	2.38	0.9%
Office of Multidisciplinary Activites (OMA)	35.17	35.00	39.84	4.84	13.8%
Total, MPS	**$1,267.86**	**$1,336.72**	**$1,366.23**	**$29.51**	**2.2%**

PHY
Elementary Particle Physics—Experiment
EPP

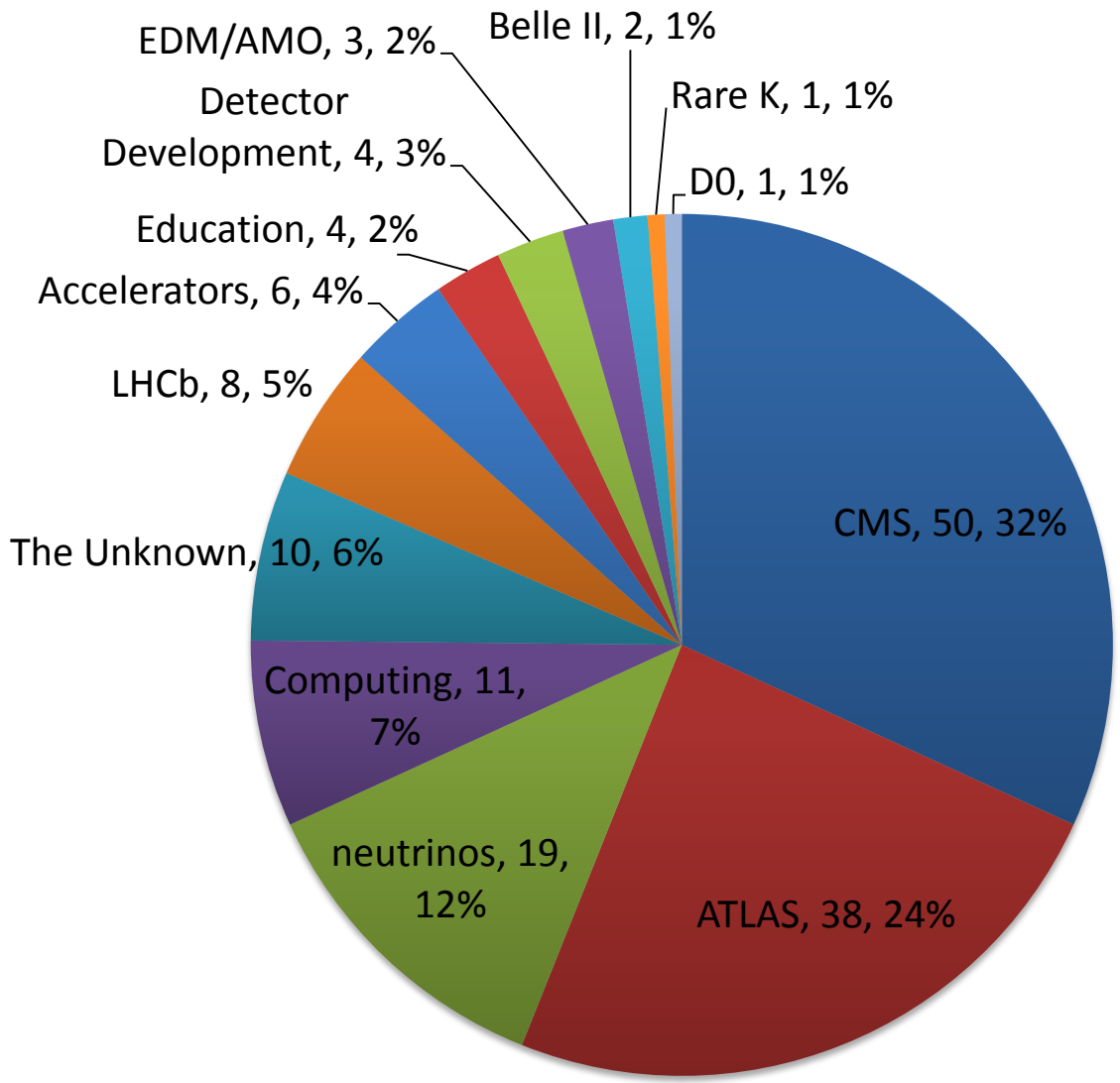
EPP Active Individual Investigator Awards at end of FY2015

Science Thrust	# Awards	$ FY2015	# PI/CoPi	# SP	# PDocs	# GS
CMS	17	$7,440,241	50	40	26	42
ATLAS	17	$7,593,866	38	34	27	34
neutrinos	13	$1,872,377	19	11	7	12
Computing	5	$661,412	11	0	0	0
The Unknown	3	$280,000	10	5	0	4
LHCb	4	$1,865,000	8	8	8	10
Accelerators	3	$67,949	6	1	0	1
Education	2	$655,876	4	0	0	0
Detector Development	2	$120,000	4	2	0	0
EDM/AMO	1	$674,817	3			
Belle II	2	$118,209	2	2	0	1
Rare K	1	$150,000	1	1	0	1
D0	1	$80,007	1	1	0	0
Grand Total	71	$21,579,754	157	105	68	105

Includes:
8 CAREER
4 RUI
3 MRI

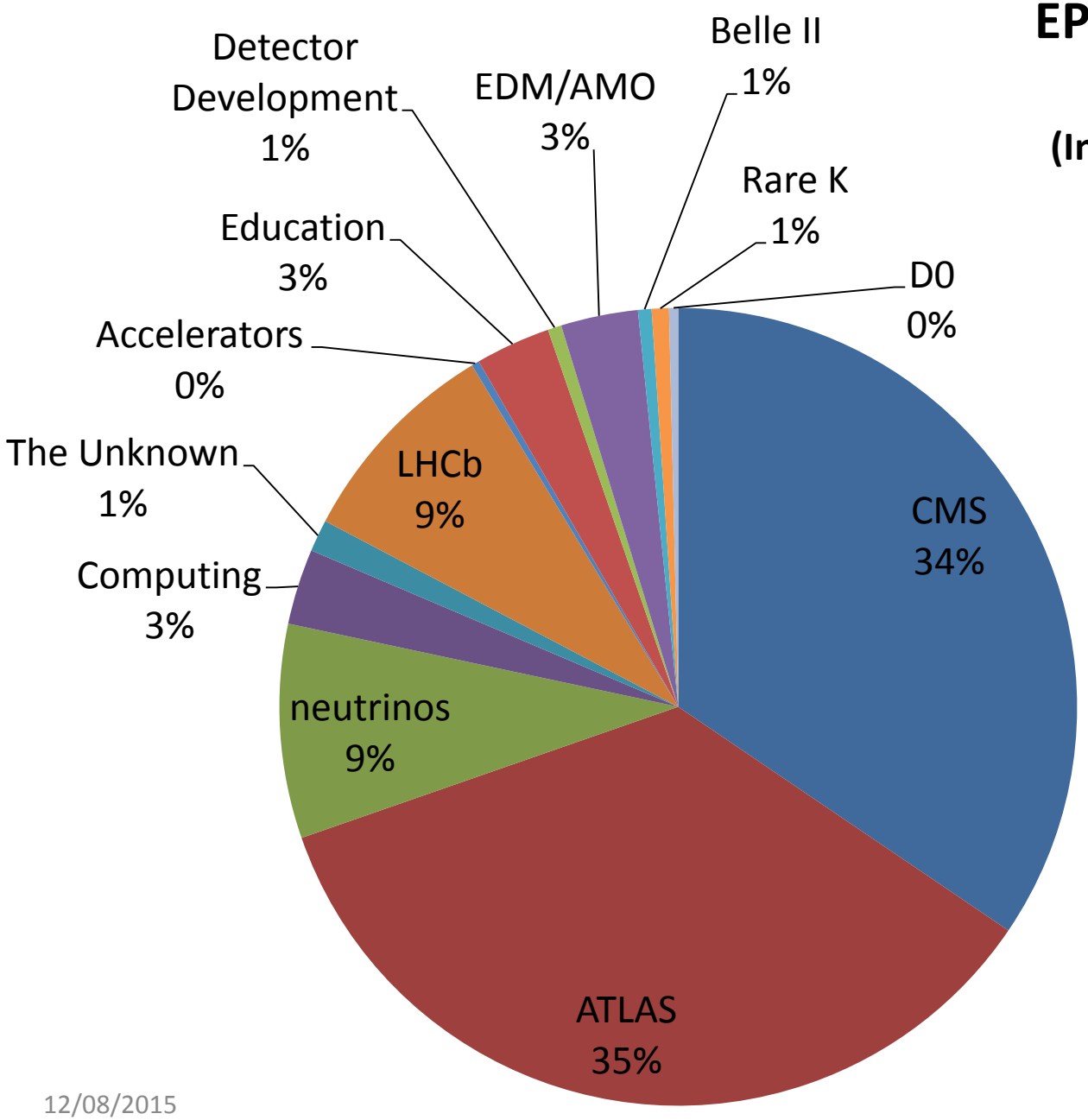
EPP Active Awards in 2015.
Number of PI/CoPI
Total = 157

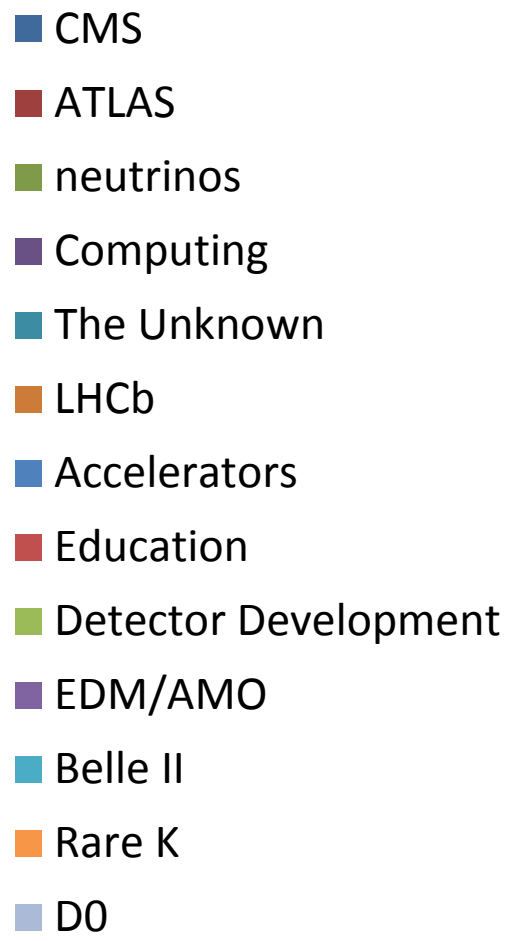
(Individual Investigator awards only)



- CMS
- ATLAS
- neutrinos
- Computing
- The Unknown
- LHCb
- Accelerators
- Education
- Detector Development
- EDM/AMO
- Belle II
- Rare K
- D0

EPP Active Awards $ FY2015.
Total = $21,579,754
(Individual Investigator awards only)

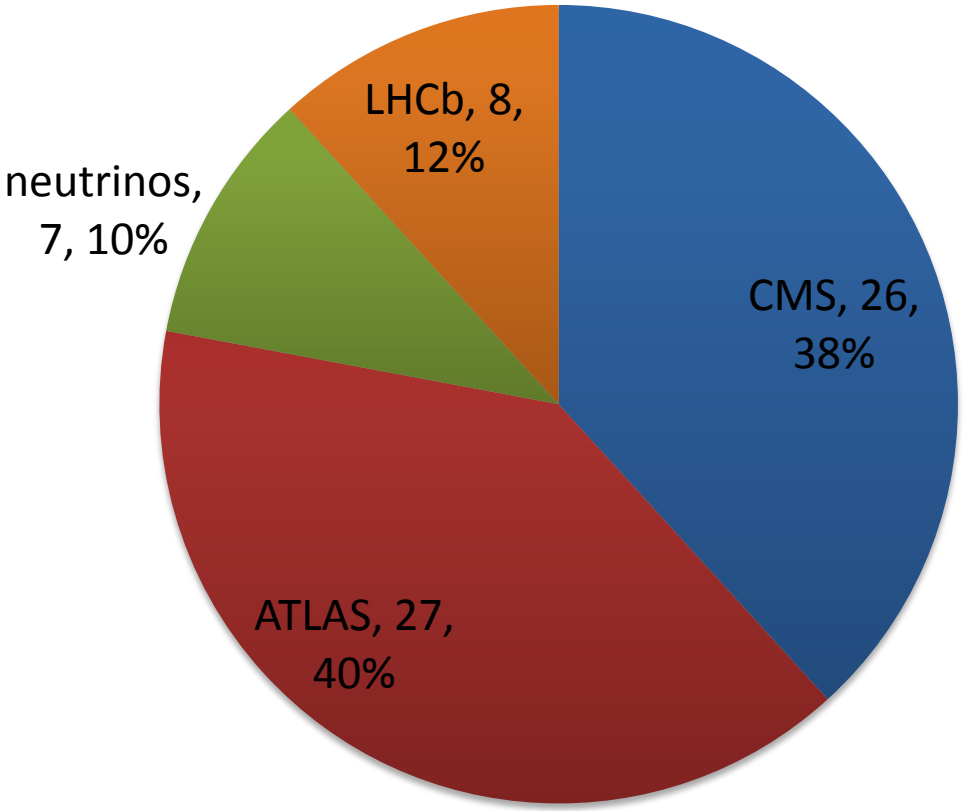




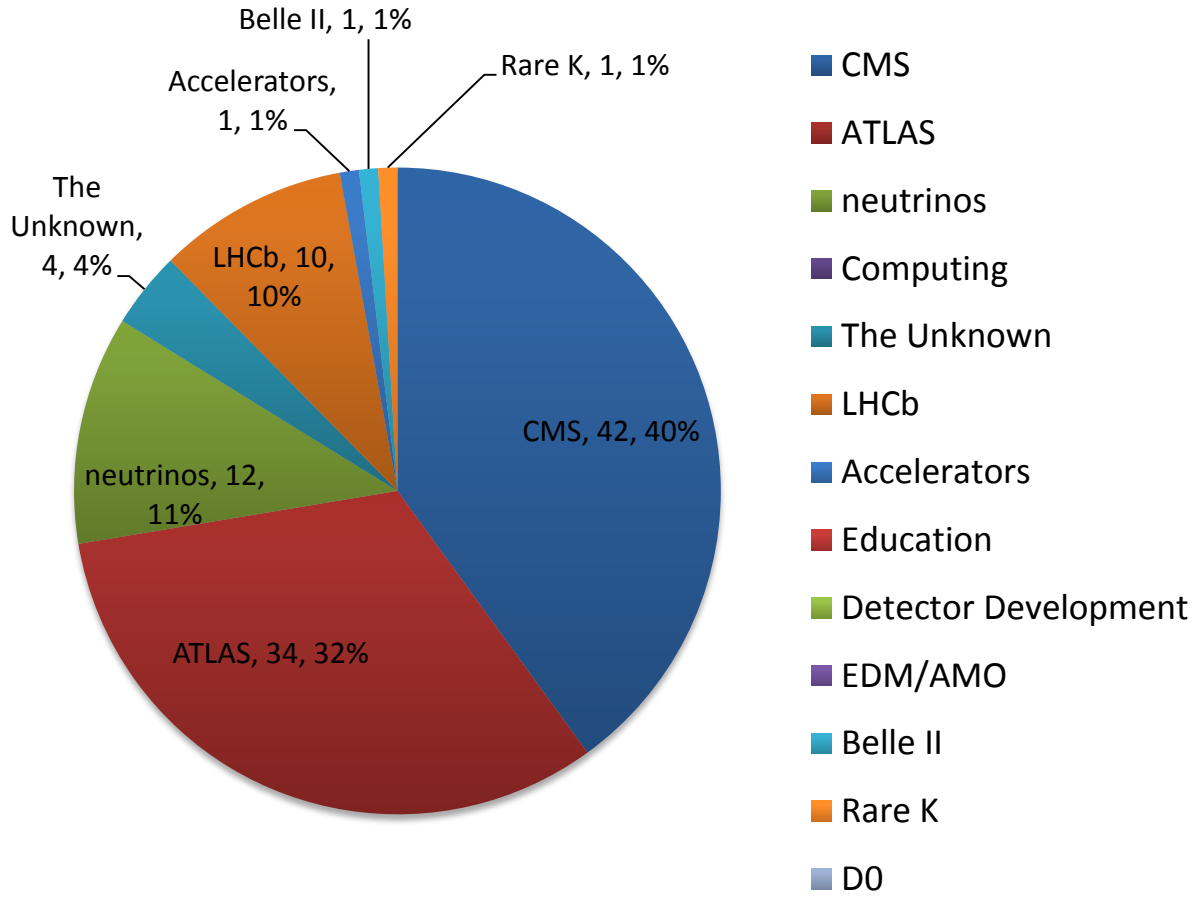
EPP Active Awards FY2015

(Individual Investigator awards only)

Number of Post-Docs



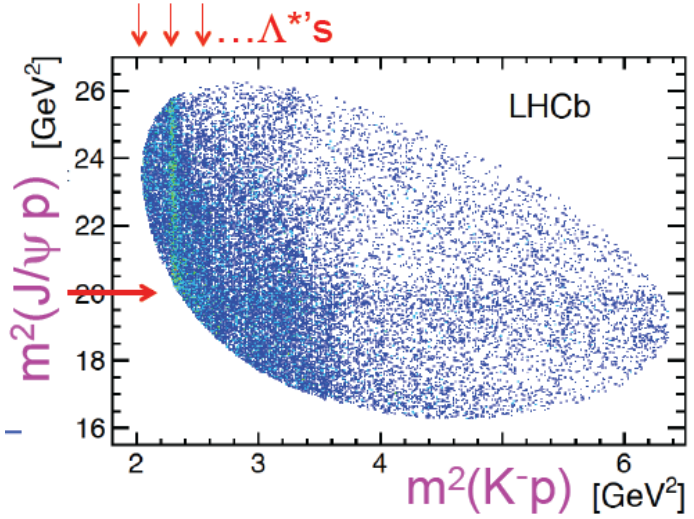
Number of Graduate Students



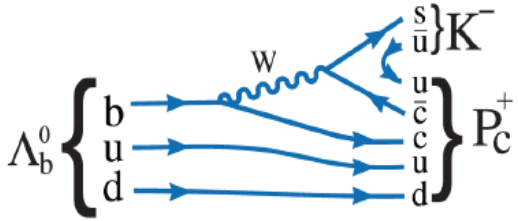
EPP Highlights: US led highlights at LHCb

- NSF support is provided for four university groups:
  - Syracuse U
  - U. Cincinnati
  - U. Maryland
  - MIT
- NSF also supports the LHCb Upgrade Tracker.
- Recent physics highlights from US groups:
  - Observation of hadronic resonances with extra $q\bar{q}$ pairs.
    - Such states were predicted long ago by Gell-Mann (‘64), Zweig (‘64), others later in context of specific QCD models: Jaffe (‘76), Högaasen & Sorba (’78), Strottman (’79), …
  - Confirmed challenge to SM rate for $B \to D^* \tau \bar{\nu}_\tau$ decays (once considered beyond scope of Hadron Machines).

Two Penta-quark resonances



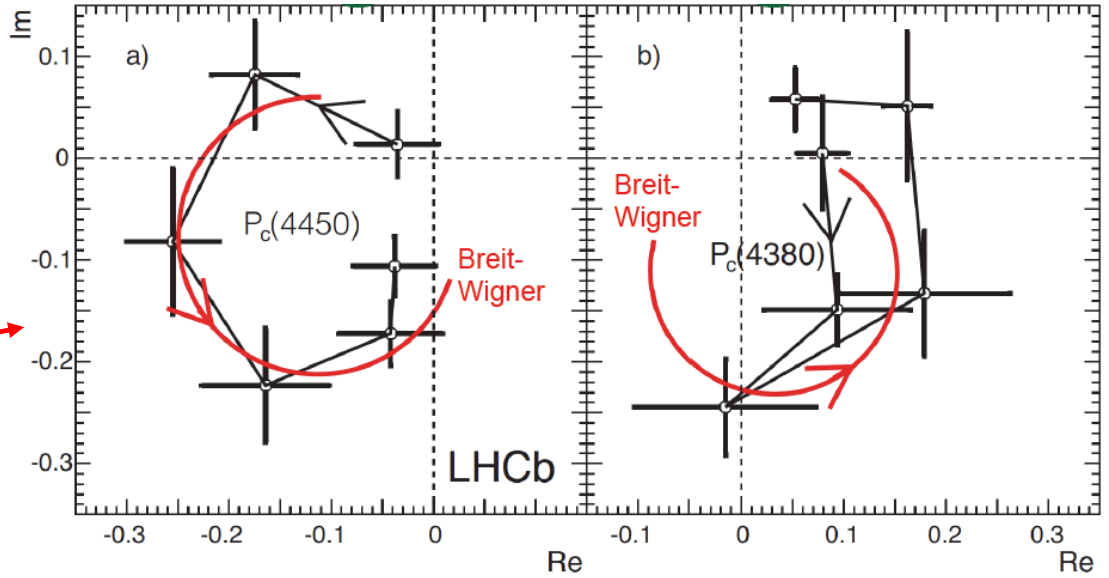
Structure seen in
$\Lambda_b \to J/\Psi p K^-$ Dalitz plot



$\Lambda_b \to P_c^+ K^-$
$\hookrightarrow J/\Psi p$

- Amplitude analysis suggests there are TWO resonant states with $J^P=(3/2^-, 5/2^+)$
- Amplitudes relative to Kp characteristic of resonance

Production Amplitude Argand Plots



Tension in SM in B decays

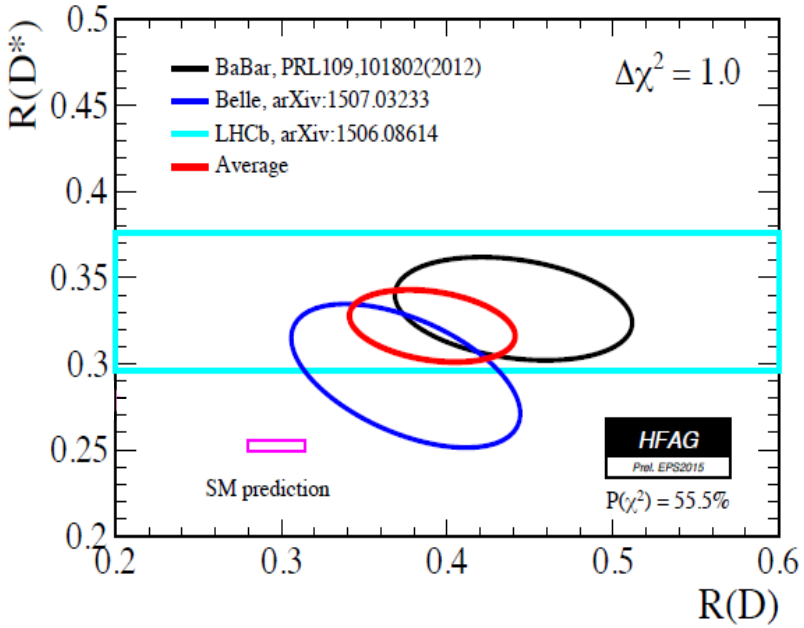
- Form-factor cancellation allows SM to accurately predict the ratio:

$$R(D^*) = \frac{\mathcal{B}\left[\bar{B}^0 \to D^{*+}\tau^-\bar{\nu}_\tau\right]}{\mathcal{B}\left[\bar{B}^0 \to D^{*+}\mu^-\bar{\nu}_\mu\right]}$$

Use $\left[\tau^- \to \mu^-\bar{\nu}_\mu\nu_\tau\right]$ mode to compare identical final states

- Using precise vertex reconstruction and excellent muon ID capabilities, LHCb has been able to make a measurement from data taken in 2011 and 2012. **Previously regarded as beyond scope of hadron machines.**

- Enhances tension found in results from BaBar (now also Belle).



Speculation:

- Breakdown of Lepton universality ??
- Two Higgs Doublet model ??

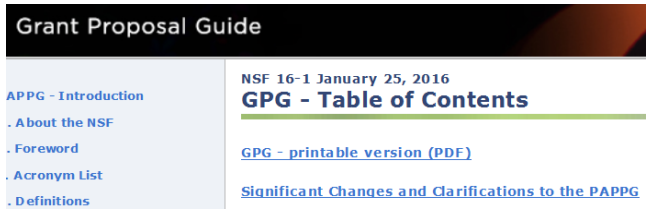
Public Communication: Highlights and interaction with the NSF Office of Legislative and Public Affairs

- The NSF has resources for public outreach and communication:
  - Office of Legislative and Public Affairs
  - NSF CommunicationToolkit
    - Resources including the "Prezi" tool developed by MPS AAAS fellow Greg Mack
- Example: NSF's Pentaquark press release
- Contact your Program Director

The PHY Division Accelerator Science Program

Accelerator Science

- Program description and link to solicitation
  - Link to awards made so far is at the bottom of the page in this link
- Next Deadline: **3 Feb., 2016**
  - **N.B.: New Grant Proposal Guide (NSF 16-1) will be in effect**
  - **If you don't read it all, read the Significant Changes.**
- Budget has been ~ $9M/year
- Expenditures:



2014	2015
$9,565,000	$9,287,000

AS 2015 Awards

Science Thrust	No. of Proposals	FY 15 ($)
AdvAccel	1	$336,051
Beam Dynamics	4	$1,332,259
Instrumentation	1	$200,000
Plasma	4	$1,159,999
Simulation	3	$503,997
Sources	3	$989,781
Grand Total	**16**	**$4,522,087**

PHY Theory

Theory

The NSF Physics Division has two theoretical programs relevant to particle physics:

1. Theoretical High-Energy Physics
2. Theoretical Particle Astrophysics and Cosmology

- Both programs are directed by
  - Keith Dienes, kdienes@nsf.gov.

- FY15 Statistics: 2 CAREER awards, 28 regular awards (including both university groups and individual researchers), total budget approximately $13.7M. Number of proposals received was nearly twice the number from just three years ago.

- Any questions about program emphases, budgets, and proposal submission should be directed to him by email.

PHY Experimental Particle Astrophysics

PA will be covered in the Fri. morning session.

PHY Mid Scale Program

Mid-Scale Instrumentation and Particle Physics

One of the most critical needs of research projects funded through the Physics Division is that of having cutting-edge instrumentation that enables investigators to remain competitive in a rapidly-changing scientific environment.

- The Physics Division has established a Mid-Scale Instrumentation Fund.
    - Dear Colleague Letter: Opportunity to Request Instrumentation Funding for Midscale Level Instrumentation in Physics Division
    - This is not a separate program to which investigators can apply directly. PI's should request funding for specialized equipment as part of a regular proposal to a disciplinary program in the Division. The Program Officer can then request funds be provided through the Mid-Scale Instrumentation Fund.

- Total Project Cost > $4M MRI cap and $ < MREFC threshold (~$140M)
- New program includes well-defined budgetary and competitive selection process
- Selection based on merit review of unsolicited proposals representing exceptional opportunity and of high priority to research community
- Excludes:
    - planning and development funding for future midscale and MREFC candidates
    - O&M for facilities and funds for utilization of constructed/acquired infrastructure
    - Educational/outreach

Mid-Scale Status

- Current funding enables projects on the order of $10M/4-5 years
- Demand is much higher than we can accommodate

- Current projects:
  - LHC Upgrades: LHCb, CMS, ATLAS
  - nEDM
  - SPT, Xenon1T, Super Nemo ➔ done or winding down.
  - Super CDMS, pending baseline cost review.

HL-LHC Upgrade

HL-LHC Upgrade

- The NSF MPSAC subcommittee recommended:
  - "Based on the above considerations, the proper funding mechanism for the NSF investment in the LHC Phase-2 [HL-LHC] upgrades is through the MREFC process"
- MREFC projects require NSB approval

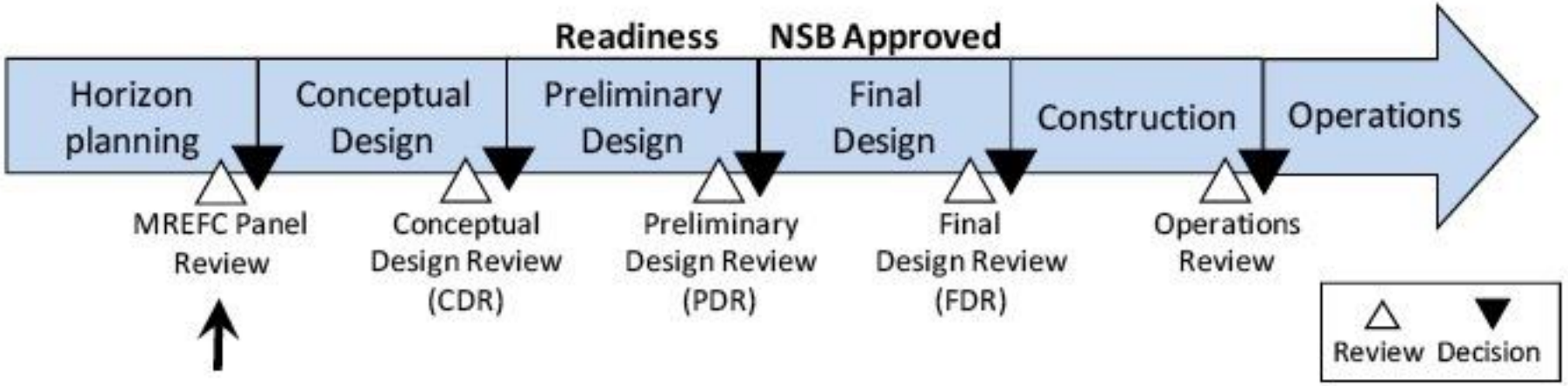
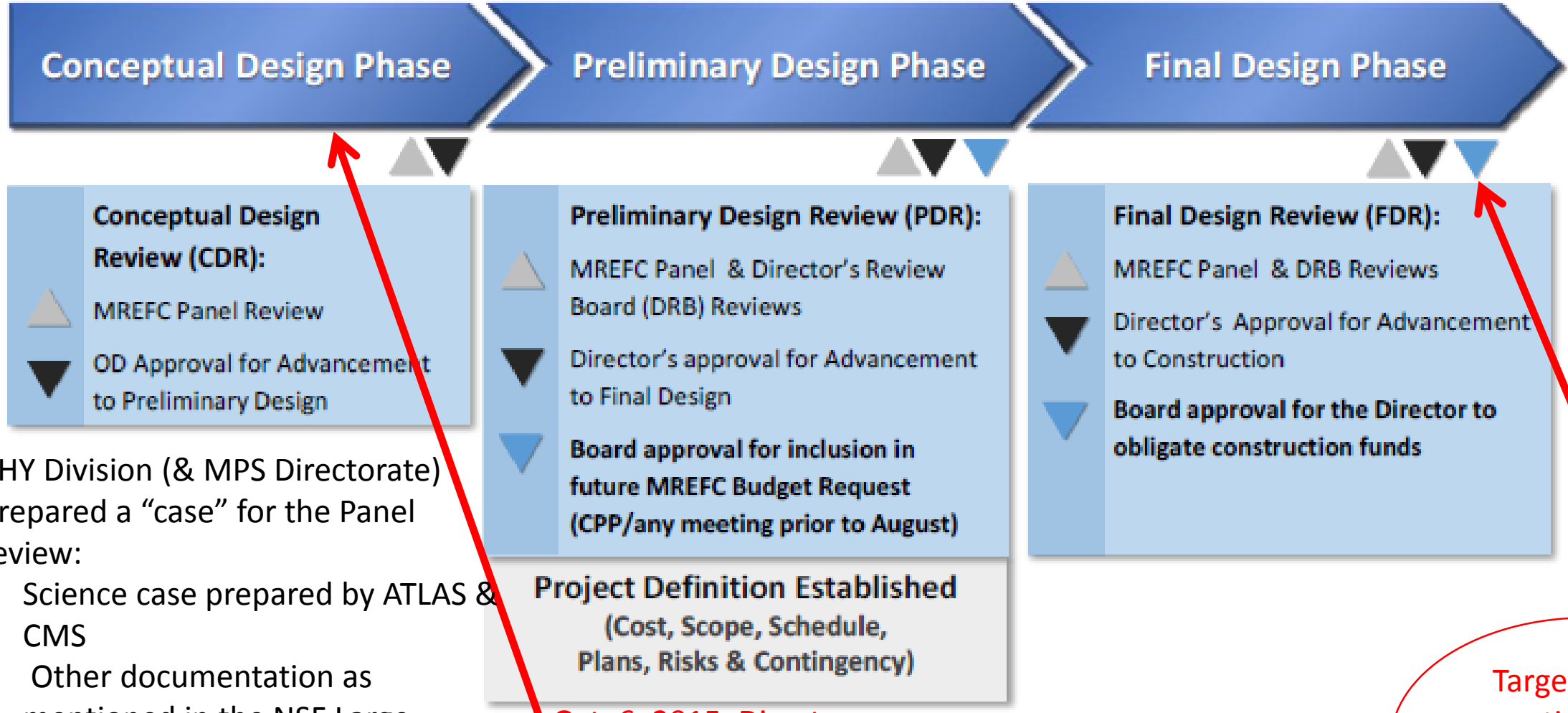


Figure 2.1.3-2 Progressive Phases in the Life Cycle Design Stage, showing review and decision points for advancement to the next phase and NSB approvals for budgeting and award.



PHY Division (& MPS Directorate) prepared a "case" for the Panel review:

- Science case prepared by ATLAS & CMS
- Other documentation as mentioned in the NSF Large Facility Manual

Panel members are the AD's of all of NSF. Panel Review took place 6 Oct.

Oct. 6, 2015. Director Cordova approves advancement to CDR. NSB notified 19 Nov.

Target is 2020 contingent on NSB approval at each phase

The MREFC Process

- Towards a Conceptual Design Review in early 2016
- If CDR successful, we expect a project planning proposal from each experiment with the goal of funding the effort to go to Preliminary Design using FY17 and FY18 money
- PDR in late fall of 2017

NSF Computing

NSF Computing Opportunities

- In MPS/PHY
  - Computational Physics
    - All Physics Division computing related proposals go through this solicitation
    - CP is the program through which the Physics Division participates in the CDS&E program.
    - 2016 deadline just passed: December 3rd ,2015
      - Next deadline Dec 1, 2016

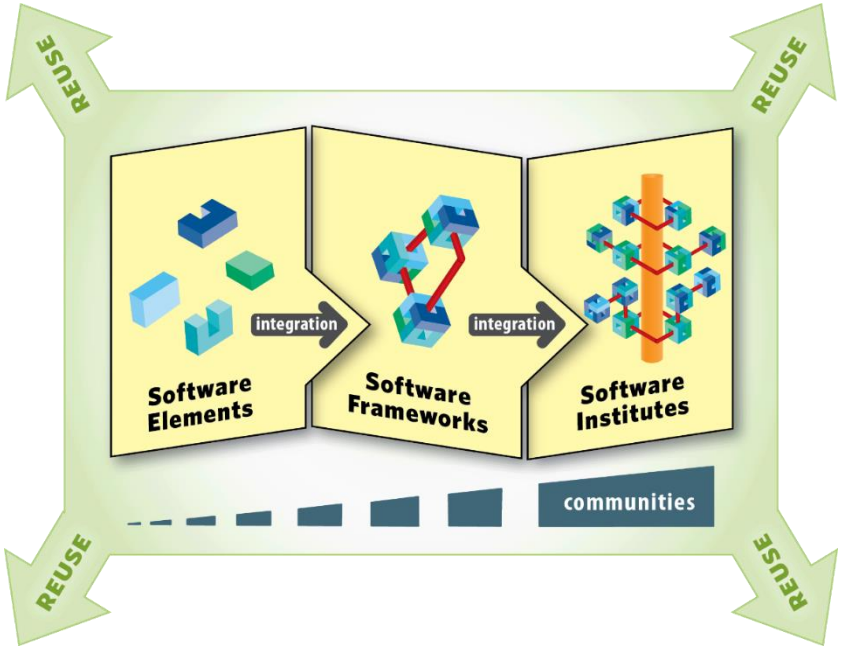
- CDS&E, Computational and Data-Enabled Science and Engineering

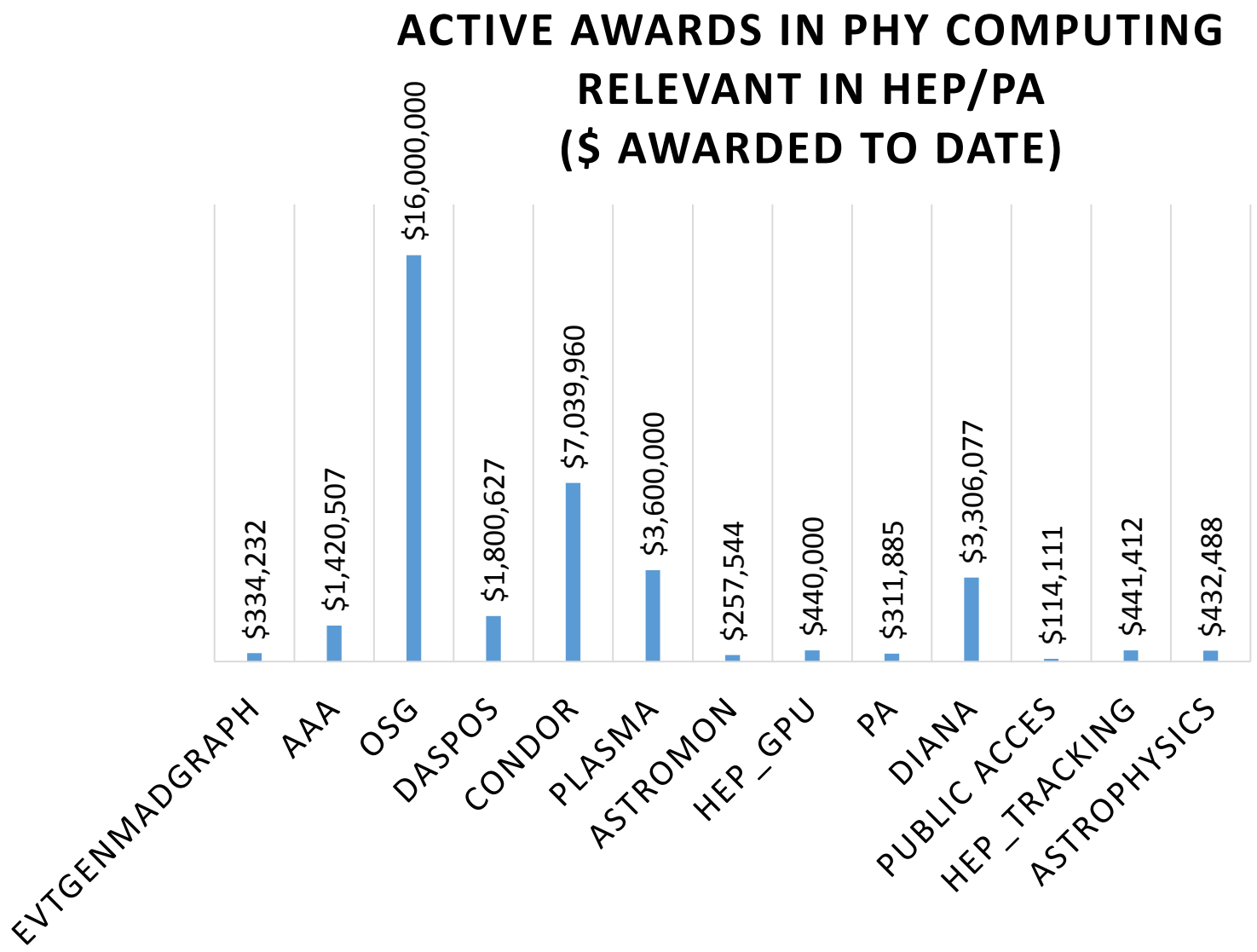
  - **Physics**: ideas at the interface between scientific frameworks and computing capability that enable advances well beyond the expected natural progress of either activity, including development of science-driven algorithms to address pivotal problems in physics and efficient methods to access and mine large data sets.

CISE/ACI, Advanced Cyberinfrastructure

- CIF21, Cyberinfrastructure Framework for the 21st Century
  - A Vision and Strategy for Software for Science, Engineering, and Education (NSF 12-113)
  - Implementation of NSF Software Vision

- In CISE/ACI (Advanced Cyber Infrastructure)
  - Co-funded with MPS (PHY, OMA)
  - SI2, Software Infrastructure for Sustained Innovation
    - SSE, Scientific Software Elements -- TBA
    - SSI, Scientific Software Integration -- TBA
    - S2I2: Scientific Software Innovation Institutes
      - Conceptualization Proposals (accepted anytime)
    - Reuse
  - DIBBs, Data Infrastructure Building Blocks
    - Now part of Campus Cyberinfrastructure - Data, Networking, and Innovation Program (CC*DNI) program. Solicitation: 15-534





See next slide for definitions of these

Synergistic Computing Awards

- EvtGenMadgraph - Web-Based High-Energy Particle Physics Event Generation
- AAA - Any Data, Anytime, Anywhere
- OSG – Open Science Grid
- DASPOS – Data Preservation
  - ATLAS, CMS, TeVatron,…
- Condor - Flight-Worthy Condor: Enabling Scientific Discovery
- Plasma - SI2-SSI: Particle-In-Cell and Kinetic Simulation Center
- Astro M.O.N - The Astrophysical Multi-messenger Observatory Network
- HEP – GPU - Enabling High Energy Physics at the Information Frontier Using GPUs and Other Many/Multi-Core Architectures
- PA - CDS&E: Investigating a Self-Assembling Data Paradigm for Detector Arrays
- DIANA - SI2-SSI: Data-Intensive Analysis for High Energy Physics (DIANA/HEP)
  - ATLAS, CMS, LHCb
- Public Access - Workshop Series to Gauge Community Requirements for Public Access to Data from NSF-Funded Research
  http://mpsopendata.crc.nd.edu/
- HEP Tracking - Particle Tracking at High Luminosity on Heterogeneous, Parallel Processor Architectures
- Astrophysics – SI2-SSE: A Software Element for Neutrino Radiation Hydrodynamics in GenASiS