Systematic Optimization of the DOE Laboratory Components of the HEP Program

November 30, 2017

Office of High Energy Physics
U. S. Department of Energy
Office of Science

Purpose and Outline

The purpose of this talk is to:

1) Inform HEPAP and the community about an extensive, deliberative process developed and executed to position the HEP National Lab Programs to support an outstanding HEP program. The first phase of the process is complete and the decisions taken; neither are open for discussion.

2) Invite HEPAP discussion about how community-based processes can be more proactive in evaluating and helping OHEP maintain an optimized program.

- **Motivation**
- **Development and Timeline**
- **Methodology**
- **Outcomes & Lessons Learned**
- **Maintaining Optimization**

HEP is engaged in three efforts aimed at sharpening the Labs' focus on sustainability and efficiency

Effort 1: Cost of Doing Business Reviews

- Has long been part of the Budget Briefings– as a request to provide detail on laboratory overheads and an analysis of how planned changes in the overheads would impact the lab's ability to maintain staffing in a flat budget
  - Has sharpened in recent years, calling attention to discrepancies between the labs
    - Reduced high pass-through fees at several labs
    - Helped slow overhead growth at one lab
    - Urged several labs to actually look at the ECI before escalating wages
    - Urged labs to identify other, similar labs and compare practices

Effort 2: 7-Year "Sustainability" Planning Exercises

- Initiated in 2015, this is a 7-year core R&D planning exercise that is updated each year at the Budget Briefings.
  - 7-year effort tables, resolved into 21 R&D thrusts, 7 staff types
  - ANL, BNL, LBNL, SLAC participated the first year; plans were of varying quality
  - HEP provided feedback, and at least one lab needed to resubmit
- Repeated again in 2016 and 2017 at the Budget Briefings
  - Quality is better; still some room for improvement

Effort 3: Laboratory Optimization Process – initiated in 2016

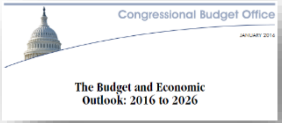
Why is a Systematic Optimization Needed?

Sustainability Issues and Meeting Goals

- **The long-term sustainability of the laboratories is challenged by several factors**
  - Federal funding that is declining in real terms
  - Steadily increasing complexity and cost of experiments
  - An aging workforce
  - Lack of qualified candidates for some positions
- **These meetings aim to identify what solutions can address these challenges and determine a means to implement them**
  - Today's goal will be to define "what"
  - Goal for the year is to get through "how"

U.S. DEPARTMENT OF ENERGY | Office of Science   HEP Laboratory Leadership Meeting: Welcome and Goals - 2/4/2016

As outlined to the labs 2/4/2016



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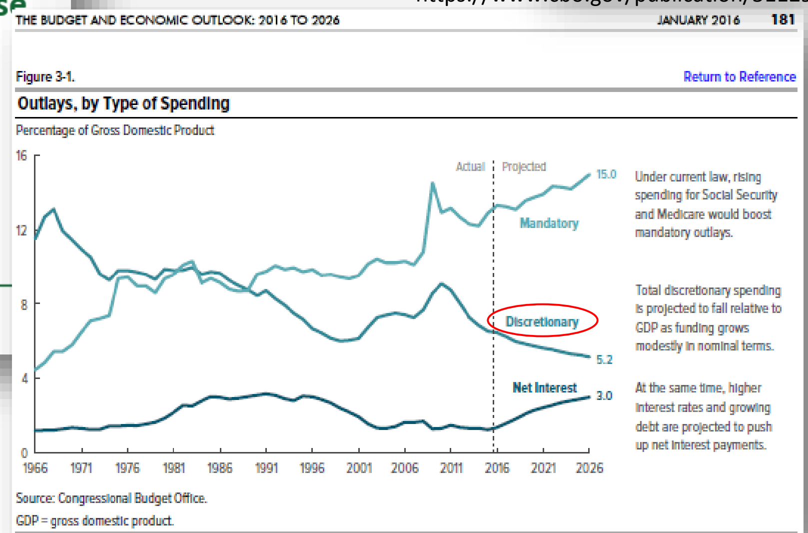


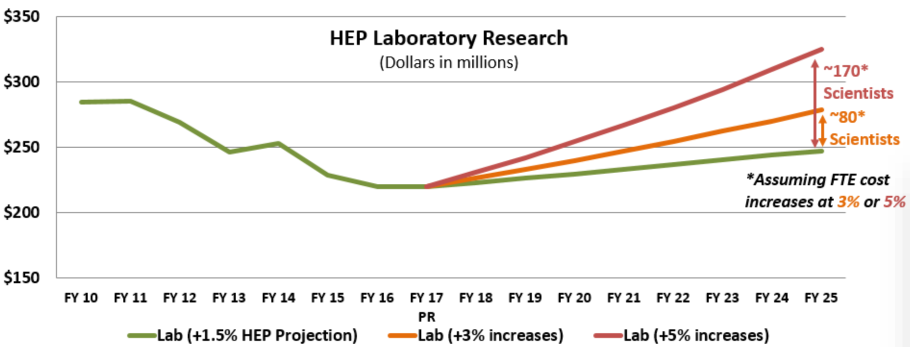
Per 2016 CBO Outlook: GDP Growth ~ 2% and Inflation ~ 2%

Macroeconomic pressures complicate the issues

The Challenge Posed to the Labs February 2016

Research Sustainability

- **HEP plan to increase laboratory research funding is not expected to keep pace with projected cost-of-business increases**
  - Plans must realistically accommodate research FTE reductions while maintaining a viable workforce capable of achieving planned work
    - **Current fully burdened lab PD/Scientist: ~$150k/~$300k**



FY15 Lab Research Funding:

Subprogram Fraction by Laboratory

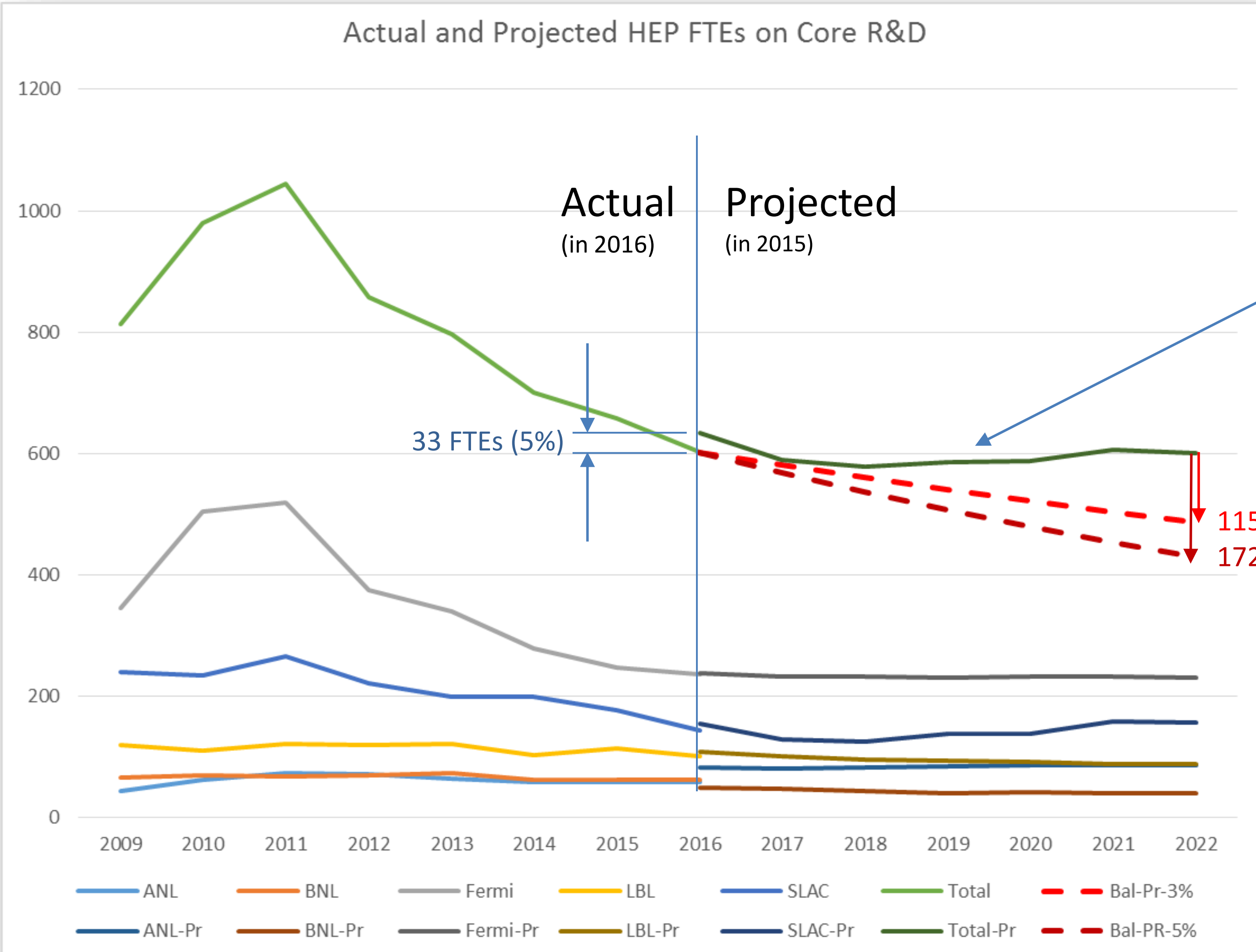
($ in thousands)	ANL	BNL	FNAL	LBNL	SLAC	LLNL	LANL	PNNL	PPPL	TJNAF	Total
Energy Frontier	3,350	6,198	18,752	5,975	3,942	-	-	-	-	-	38,217
Intensity Frontier	2,605	4,105	17,983	1,450	4,495	650	1,008	800	-	-	33,096
Cosmic Frontier	1,940	1,100	9,650	7,846	14,985	895	385	205	-	-	37,006
Theory & Comp.	2,808	3,625	14,190	4,965	9,954	-	400	50	-	-	35,992
Adv. Tech. R&D	6,012	7,282	29,384	17,234	15,639	-	200	-	200	50	76,001
Acc. Stewardship	50	5	20	616	620	200	-	-	-	15	1,526
Lab Totals	**16,765**	**22,315**	**89,979**	**38,086**	**49,635**	**1,745**	**1,993**	**1,055**	**200**	**65**	

** Funding levels include University Service Accounts*

	ANL	BNL	FNAL	LBNL	SLAC	LLNL	LANL	PNNL	PPPL	TJNAF
Energy Frontier	20%	28%	21%	16%	8%	0%	0%	0%	0%	0%
Intensity Frontier	16%	18%	20%	4%	9%	37%	51%	76%	0%	0%
Cosmic Frontier	12%	5%	11%	21%	30%	51%	19%	19%	0%	0%
Theory & Comp.	17%	16%	16%	13%	20%	0%	20%	5%	0%	0%
Adv. Tech. R&D	36%	33%	33%	45%	32%	0%	10%	0%	100%	77%
Acc. Stewardship	>1%	>1%	>1%	2%	1%	11%	0%	0%	0%	23%

– Percentages calculated vs. individual Laboratory totals

One month later, 7-Year sustainability data provided by the labs revealed the disconnect had grown



Early in FY 2016, labs projected moderate growth in Core R&D #FTEs over next 7 years

Cf. "80-170 FTEs by 2025"

Goals of the Laboratory Optimization Process

PROCESS ORDER

- **Raise awareness of systemic issues, align expectations**
- **Agree upon the criteria that define “value to the HEP mission”**
- **Inventory the present capabilities in the system**
- **Develop 10-year visions for the individual HEP lab programs**
- **Assess the value of capabilities in the system**
- **Harmonize projects, operations, and R&D—both in OHEP planning and in the field**
- **Develop a 10-year national vision for HEP lab programs**
- **Identify realignments needed to focus resources on strongest programs**
- **Identify new or repurposed organizational structures needed to drive optimization**
- **Identify near- and far-term implementation strategies**
- **Identify larger (i.e. full ecosystem) issues, and possible routes forward**

Lab Optimization Process – overview

2015 and before

- Cost of Doing Business Annual Exercise; Seven-Year Sustainability Exercise

2016

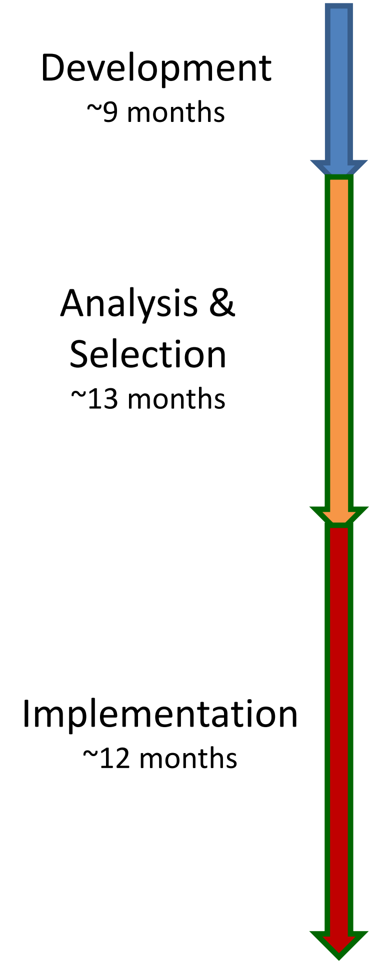
- **February 4, 2016: Inaugural 5-lab meeting**
  - Process discussions with labs & SC-2
- **October 27, 2016: Formal launch of Lab Optimization Process**
  - Initial tests of scoring

2017

  - Data calls
  - Analysis
  - Triage
- **November 29, 2017: Initial roll out to labs**

2018

- **February, March**
  - **Labs present implementation plans at Budget Briefings**
- **October 1, 2018**
  - Initial Fin Plans reflect most Optimization actions
- **Early 2019**
  - Studies completed, remaining actions implemented



Lab Optimization Process—Development (1 of 3)

2015 and before

- **Cost of Doing Business Annual Exercise**
- **Seven-Year Sustainability Exercise**

2016

- **February 4, 2016: Inaugural 5-lab meeting**
  - Showed 10-year planned project profiles, R&D by Thrust and Lab, discussed long-range systemic challenges
    - H-L Diagonalization Process suggested
  - Feedback from lab participants:
    - Meeting: “VERY useful”; “Labs got a sense where they fit, we all saw that a five-year planning horizon is insufficient”; “Scared the [redacted] out of the labs”
    - H-L Process: …” level of trust is not sufficient to have a “pure” Lab driven process”; “[OHEP should] look, but don’t touch [a lab-driven process]”; “Given a national program with international consequences, how best should an independent and objective DOE-HEP deploy its labs?”
- **March: Lab FY 2018 Budget Briefings**
- **April**
  - First OHEP process counterproposal
    - Scope, metrics, thresholds, CBA process
- **June**
  - Second lab process proposal:
    - Develop a 10-Year Vision; framework for evaluating lab capabilities
    - Two 5-lab retreats to reconcile, discuss
- **July, August**
  - Second OHEP process counterproposal
    - Two-panel process:
      - Steering Committee (Information Gathering)
      - Independent Committee (Selection)
- **September**
  - SC-2 brief; instructed to drop second panel
    - Process split:
      - Labs: Vision
      - OHEP: Data gathering, Selection
- **October 27, 2017**
  - **Framework finalized for Lab Optimization Process**
- **November, December**
  - Metrics, scoring methodology developed; internal OHEP trial
  - Labs briefed, asked to comment
  - Initial Lab Capability lists developed

2017

- **January**
  - Activity list, metrics, scoring method finalized
  - Second iteration of lab capability lists

Scope and Definitions

Scope

All R&D capabilities within the HEP Lab Programs [at ANL, BNL, FNAL, LBNL, SLAC], meeting one of the following thresholds:

- A **facility** is a distinct piece of lab physical infrastructure that either (1) has cost HEP $5M or more to construct, or (2) costs HEP $1M annually or more to operate. *While physical co-location of equipment is often a strong determinant in defining a facility, it is more important that the facility be defined by the purpose(s) which the facility serves.*

- A **competence** is a specific scientific or technical competence embodied in multiple employees, of which HEP funds at least 3 FTEs. Use a long-term categorization whenever possible. *Whenever possible, define a competence in terms of its abstracted functions and skills, rather than the specific experiment(s) in which it is currently engaged.*

The generic term "**capability**" refers to either a facility or a competence. The thresholds above are set to limit the total number of capabilities that may be considered in the Optimization Process.

Defining capabilities in a *recognizably interchangeable* manner is central to the process.

Capability Merit Criteria and Scoring

- **Relevance** to HEP Program. Note that capabilities may be applicable in more than one "Type".
  - **Type 1 – World Leading R&D.** This category includes R&D which is not needed to meet P5 projects, but which is relevant for HEP in the longer-term and is world-leading in quality. A high score indicates the results of the R&D are expected to be relevant to HEP beyond the P5 time horizon, and are world-leading in quality.
    - *Examples: Plasma wakefield acceleration, superconducting magnets.*
  - **Type 2 – Necessary for implementing P5.** This category includes capabilities needed for all phases of the "Scenario B" P5 projects, including experimental operations and executing the science. A high score indicates the capability is optimally matched to the needs of the experiment or R&D effort.
    - *Examples: Detector facilities, physics analysis capabilities to carry out the science for each for the P5 experiments.*
  - **Type 3 – Seeding the future program.** This category includes nascent efforts that are not connected with implementing P5, are not yet mature enough to be world-leading, but which are believed to hold potential for transforming HEP. A high score indicates a strong potential to grow into a transformative capability that benefits HEP in the future.
    - *Examples: QIS, advanced instrumentation.*
  - **Type 4 – Non-HEP needs.** This category includes work for others and other non-HEP uses of a capability. A high score indicates the capability is optimally matched to the needs of the non-HEP use.
    - *Example: LCLS-II use of SRF capabilities, industrial use of test facilities.*
- **Impact** (Scientific and Technical Excellence)
  - The quality and impact of the research provided by the capability in the recent past;
  - The scientific significance and merit of research enabled by the capability;
  - The future promise for research enabled by the capability.
- **Synergy & Leverage** with other HEP and non-HEP-funded infrastructure and programs
  - Degree of synergy and leverage available from other HEP and non-HEP efforts at the Lab or at other institutions
  - Opportunity for cross-fertilization and generating new ideas/techniques for HEP through contact or collaboration with other non-HEP efforts at the Lab or at other institutions
    - *Examples: A computation & modeling group jointly funded by multiple Offices; an instrumentation group jointly funded by multiple Offices.*
- **Uniqueness**
  - The extent to which the capability cannot be found anywhere else in the US HEP system (including both national laboratories and universities).

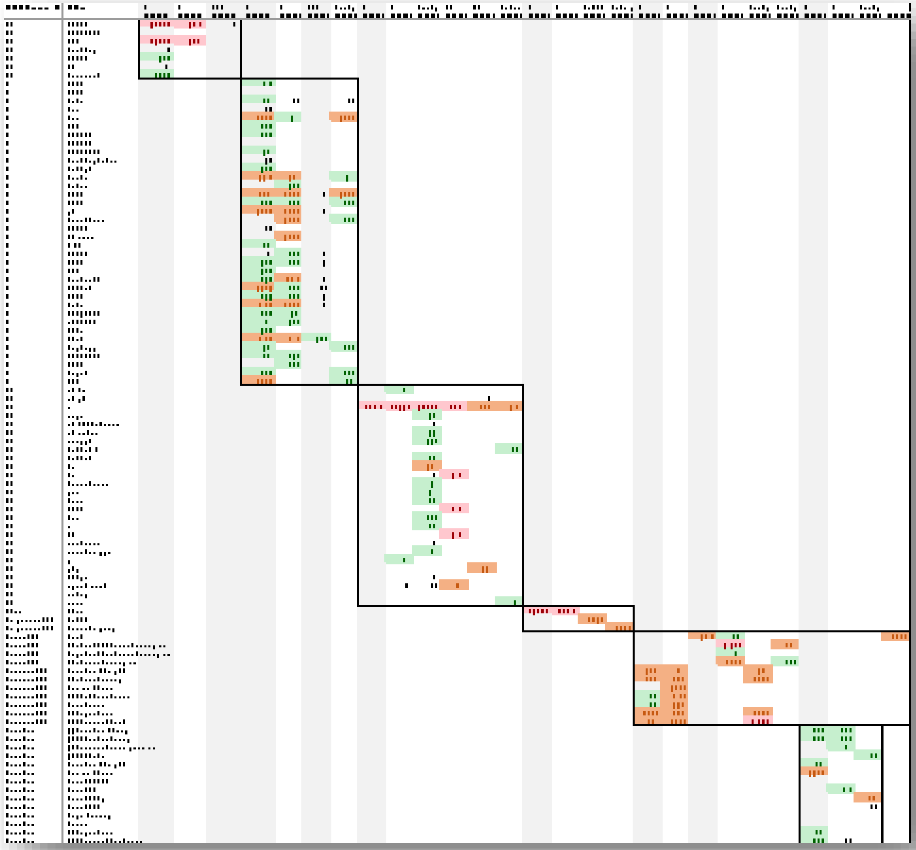
*A note on scoring. Scoring for the above four criteria is 0-5, with 5 being the highest score. Scores should be assigned **in full view of the national set of capabilities in HEP. An average score of "3" means that the capability is as relevant, impactful, beneficially leveraged, and/or unique w.r.t. the end use as any other in the US.** An extraordinary score of "5" should only be assigned if the capability is unmatched in the US w.r.t. the criteria.*

Merit Criteria for the Entire HEP Program

- **Completeness**
  - Can the P5 vision be accomplished with the facilities and capabilities at hand? What is superfluous? What is missing?
  - Will the investments lead to excellence in the decades beyond P5's vision?
- **Diversity & Competition**
  - Is the configuration of lab, university, and industry investments optimized to:
    - Identify and develop innovative ideas, no matter the source;
    - Organize and execute the best ideas as large-scale experiments;
    - Optimally take advantage of the different characteristics (cost, R&D mandate, and proximity of synergistic programs) of each institution; and
    - Educate and train the required workforce?
  - Is there an efficient level of competition? For goals that have significant risk, are there multiple, non-duplicative R&D paths being pursued?

What is the minimal level of detail needed to perform a systematic optimization?

- **Typical Financial View**
  - B&R Codes
    - HEP Program
    - R&D, Ops, Projects
    - Lab, University, etc.
    - Exp or grant, lab, etc.
- **Little is "recognizably interchangeable" at this level**
  - Further detail needed
  - E.g., where are the computing activities?



(FY 2016; Image is deliberately illegible)

Towards a more detailed assessment of the HEP program

- **HEP Program (7)**
  - "Capabilities": Competences (46) or Facilities (23)
    - "Types" or "Tiers" of activities carried out by the C or F (4 Types):
      - "Activities" or "Rating Categories" (52 + "other")
        - » Data: Merit, Cost, FTEs, description, …

Capturing the Connections

- **Most lab capabilities support multiple activities**
  - Capabilities were "homed" in a single program, but could have multiple activities spanning different programs
  - Average ~ 2.8 activities per capability
  - An illustration: BNL's Silicon Detector capability
    - The lab indicated it supported 3 activities (in FY 2016)

Lab	Call T	Capability Name	Tier	Rating Category	Comments
BNL	Lab	Detector R&D: Silicon detector	T3	T3: Energy Frontier	Silicon detector R&D for future collider partially support
BNL	Lab	Detector R&D: Silicon detector	T2	T2: ATLAS Ph 2 Upgrade	passthrough: Univ=$0.8M; add PD
BNL	Lab	Detector R&D: Silicon detector	T1	T1: Detector R&D	

    - Stakeholders provided estimates of future usage:

Respondent	Institution	Use Description	Usage Estimate
Christopher Tully	Detector R&D	LGAD device development for fast timing layer. Design of timing enhanced LGAD devices is vital for this next generation detector technology.	Major LHC Phase-II Project. Approval of this project depends heavily on this competence being available for this project.
Henry Frisch	University of Chicago	LAPPD development and testing	(blank)
Karl Jakobs	International ATLAS Collaboration	Proposed contributions to the ATLAS Phase-II upgrade for the Silicon Strip detector.	Phase-II upgrade time scale (2018 - 2026)
Srini Rajagopalan	US ATLAS	Proposed contributions to the ATLAS Phase 2 upgrades for the Silicon Strip detector. Will be used to readout the Silicon Strip detector during the High Luminosity (HL-LHC) operations.	Potential support for Upgrade projects over next ten years.

- **These inputs, together with the OHEP Program Managers' knowledge of the capabilities, were central to understanding the roles and value of each capability in context.**

Detailed Taxonomies: Lab Capability lists

Lab	Program	Activity Class or Facility Class	Facility or Competence	Count of
ANL	Accelerator	Accelerator Beam Test	Facility	1
		Advanced Accelerator Concepts	Competence	1
	Computing	CompHEP	Competence	1
		HPC Hardware	Facility	1
	Cosmic	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Frontier Physics Research	Competence	1
		Software & Computing	Competence	2
	Detector	Detector Electronics, (incl ASICs)	Competence	1
		Detector R&D	Competence	1
			Facility	1
		Detector R&D - TES	Competence	1
		Electronics Assly and Test	Facility	1
		General Use Cleanroom	Facility	1
	Energy	Detector Design and Subsystem Fabrication	Competence	2
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	1
		Software & Computing	Competence	1
	Intensity	Detector Design and Subsystem Fabrication	Competence	2
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	1
	Theory	Theory P5 Higgs	Competence	1
		Theory P5 New Phenomena	Competence	1
		Theory Particle Astrophysics and Cosmology	Competence	1
		Theory Phenomenology Collider	Competence	1
		Theory Phenomenology Dark Matter	Competence	1
		Theory QCD Perturbative	Competence	1
BNL	Accelerator	Accelerator Beam Test	Facility	1
		Advanced Accelerator Concepts	Competence	1
		Magnets	Competence	1
		Superconducting Magnet Fabrication	Facility	1
		Superconducting Magnet Test	Facility	1
	Computing	CompHEP	Competence	1
		HPC Hardware	Facility	1
		SciDAC	Competence	1
	Cosmic	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Frontier Physics Research	Competence	1
	Detector	Detector Electronics, (incl ASICs)	Competence	2
		Detector R&D - Scintillating Liquid	Competence	2
		Detector R&D - Silicon	Competence	1
		Detector Test	Facility	1
		General Use Cleanroom	Facility	1
	Energy	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	3
		Software & Computing	Competence	1
	Intensity	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Frontier Physics Research	Competence	2
		Software & Computing	Competence	1
	other	Project Management	Competence	1
	Theory	Theory Phenomenology Collider	Competence	1
		Theory Phenomenology Dark Matter	Competence	1
		Theory Phenomenology Neutrinos	Competence	1
		Theory QCD Lattice	Competence	1
FNAL	Accelerator	Accelerator Beam Test	Facility	3
		Accelerator Facility Operations	Competence	6
		Beam Physics and Modeling	Competence	2
		Conventional Magnet Testing	Facility	1
		General RF Test	Facility	1
		High Power Target Test	Facility	1
		Magnets	Competence	5
		other accelerator facility	Facility	9
		RF systems	Competence	1
		Sources & High Power Targets	Competence	2
		Superconducting Magnet Fabrication	Facility	1
		Superconducting Magnet Test	Facility	1
		Superconducting RF	Competence	6
		Superconducting RF Fabrication	Facility	1
		Superconducting RF Testing	Facility	2
	Computing	CompHEP	Competence	7
		HPC Hardware	Facility	1
	Cosmic	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	3
	Detector	Detector - other	Competence	1
		Detector Assembly	Facility	2
		Detector Beam Test	Facility	1
		Detector Electronics, (incl ASICs)	Competence	2
		Detector R&D	Competence	1
		Detector Test	Facility	4
	Energy	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	4
	Intensity	accelerator-based facility	Competence	2
			Facility	4
		Detector Commissioning and Operation	Competence	2
		Detector Design and Subsystem Fabrication	Competence	2
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	4
	other	Alignment/Metrology	Competence	1
		Material Science Lab	Facility	1
		other competence	Competence	2
		Project Management	Competence	1
	Theory	Theory Other	Competence	1
		Theory Particle Astrophysics and Cosmology	Competence	1
		Theory Phenomenology Collider	Competence	1
		Theory Phenomenology Dark Matter	Competence	1
		Theory Phenomenology Neutrinos	Competence	1
		Theory QCD Lattice	Competence	1
		Theory QCD Perturbative	Competence	1
LBNL	Accelerator	Accelerator Beam Test	Facility	1
		Advanced Accelerator Concepts	Competence	1
		Beam Physics and Modeling	Competence	1
		General RF Test	Facility	1
		Magnets	Competence	1
		Other Accelerator R&D	Competence	1
		Superconducting Magnet Test	Facility	1
	Computing	CompHEP	Facility	1
		HPC Hardware	Competence	1
	Cosmic	Detector Commissioning and Operation	Competence	3
		Detector Design and Subsystem Fabrication	Competence	3
		Detector Integration and Testing	Competence	3
		Frontier Physics Research	Competence	3
		Software & Computing	Competence	3
	Detector	Detector Assembly	Facility	3
		Detector Electronics, (incl ASICs)	Competence	1
		Detector Test	Facility	1
	Energy	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	1
		Software & Computing	Competence	1
	Intensity	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	2
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	2
		Software & Computing	Competence	2
	other	other competence	Competence	1
	Theory	Theory Other	Competence	1
		Theory Phenomenology Collider	Competence	1
		Theory Phenomenology Dark Matter	Competence	1
		Theory Phenomenology Neutrinos	Competence	1
		Theory QCD Perturbative	Competence	1
SLAC	Accelerator	Accelerator Beam Test	Facility	3
		Accelerator Facility Operations	Competence	1
		Advanced Accelerator Concepts	Competence	1
		Beam Physics and Modeling	Competence	1
		Conventional RF Fabrication	Facility	1
		General RF Test	Facility	1
		RF systems	Competence	1
		Sources & High Power Targets	Competence	1
	Computing	CompHEP	Competence	1
		HPC Hardware	Facility	2
	Cosmic	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	3
		Software & Computing	Competence	2
	Detector	Detector Assembly	Facility	1
		Detector Beam Test	Facility	1
		Detector Electronics, (incl ASICs)	Competence	1
		Detector R&D - Noble Liquid	Facility	1
		Detector R&D - Silicon	Competence	1
		General Use Cleanroom	Facility	1
	Energy	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	3
		Software & Computing	Competence	1
	Intensity	Detector Commissioning and Operation	Competence	1
		Detector Design and Subsystem Fabrication	Competence	1
		Detector Integration and Testing	Competence	1
		Frontier Physics Research	Competence	2
		Software & Computing	Competence	1
	other	other competence	Competence	1
		Project Management	Competence	1
	Theory	Theory Other	Competence	1
		Theory Particle Astrophysics and Cosmology	Competence	1
		Theory Phenomenology Collider	Competence	1
		Theory Phenomenology Dark Matter	Competence	1
		Theory Phenomenology Neutrinos	Competence	1
		Theory QCD Perturbative	Competence	1

N.B.: This is not the full list of 275 capabilities, but a summary!

Detailed Taxonomies: Activity, Thrust*, and Activity/Facility Class

These tables control the pulldown menus for Type and Rating Category entries.

TypeTable

Type
T1
T2
T3
T4

Labs
-all-
ANL
BNL
FNAL
LBNL
SLAC
JLAB
LANL
LLNL
PNNL
ORNL

NeedTable

Type	Need
T1	T1: Energy Frontier
T1	T1: Intensity Frontier
T1	T1: Cosmic Frontier
T1	T1: Theory
T1	T1: HEP Computing
T1	T1: Detector R&D
T1	T1: Accelerator R&D
T1	T1: OTHER (enter name in Column L-->)
T2	ADMX
T2	ATLAS (pre-Ph 1)
T2	ATLAS Ph 1 Upgrade
T2	ATLAS Ph 2 Upgrade
T2	CMB-S4
T2	CMS (pre-Ph 1)
T2	CMS Ph 1 Upgrade
T2	CMS Ph 2 Upgrade
T2	Dark Energy--Future
T2	Dark Matter--Future
T2	DES Operations
T2	DESI
T2	FACET-II
T2	HL-LHC Accelerator
T2	ILC R&D
T2	LBNF
T2	DUNE/protoDUNE
T2	LSST
T2	LZ
T2	Mu2e and g-2
T2	NOvA
T2	PIP-II
T2	SBN Portfolio
T2	Small Projects Portfolio
T2	SuperCDMS-SL
T2	T2: OTHER (enter name in Column L-->)
T3	T3: Energy Frontier
T3	T3: Intensity Frontier
T3	T3: Cosmic Frontier
T3	T3: Theory
T3	T3: HEP Computing
T3	T3: Detector R&D
T3	T3: Accelerator R&D
T3	T3: OTHER (enter name in Column L-->)
T4	T4: OTHER (enter name in Column L-->)

These Tables describe all possible entries in the "**Activity Class or Facility Class**" column

ProgTable

Program
-all-
Energy
Intensity
Cosmic
Theory
Computing
Detector
Accelerator
other

ActFacTable

Program	Comp or Fa	Class
Accelerator	Competence	Advanced Accelerator Concepts
Accelerator	Competence	Superconducting RF
Accelerator	Competence	Normal Conducting RF
Accelerator	Competence	RF systems
Accelerator	Competence	Beam Physics and Modeling
Accelerator	Competence	Magnets
Accelerator	Competence	Sources & High Power Targets
Accelerator	Competence	Other Accelerator R&D
Accelerator	Competence	Accelerator Facility Operations
Accelerator	Facility	Accelerator Beam Test
Accelerator	Facility	Conventional RF Fabrication
Accelerator	Facility	General RF Test
Accelerator	Facility	Superconducting RF Fabrication
Accelerator	Facility	Superconducting RF Testing
Accelerator	Facility	Conventional Magnet Testing
Accelerator	Facility	Superconducting Magnet Fabrication
Accelerator	Facility	Superconducting Magnet Test
Accelerator	Facility	High Power Target Test
Accelerator	Facility	High Radiation Test
Accelerator	Facility	other accelerator facility
Computing	Competence	CompHEP
Computing	Competence	SciDAC
Computing	Facility	HPC Hardware
Cosmic	Competence	Detector Design and Subsystem Fabrication
Cosmic	Competence	Detector Integration and Testing
Cosmic	Competence	Detector Commissioning and Operation
Cosmic	Competence	Software & Computing
Cosmic	Competence	Frontier Physics Research
Detector	Competence	Detector R&D - Silicon
Detector	Competence	Detector R&D - Scintillating Liquid
Detector	Competence	Detector R&D - TES
Detector	Competence	Detector Electronics, (incl ASICs)
Detector	Competence	Detector R&D
Detector	Competence	Detector - other
Detector	Facility	Detector Assembly Facility
Detector	Facility	Detector Beam Test Facility
Detector	Facility	Detector Test Facility
Detector	Facility	General Use Cleanroom
Detector	Facility	Electronics Assly and Test Facility
Energy	Competence	Detector Design and Subsystem Fabrication
Energy	Competence	Detector Integration and Testing
Energy	Competence	Detector Commissioning and Operation
Energy	Competence	Software & Computing
Energy	Competence	Frontier Physics Research
Intensity	Competence	Detector Design and Subsystem Fabrication
Intensity	Competence	Detector Integration and Testing
Intensity	Competence	Detector Commissioning and Operation
Intensity	Competence	Software & Computing
Intensity	Competence	Frontier Physics Research
Intensity	Facility	accelerator-based facility
other	Facility	Material Science Lab
other	Facility	General Laser Test
other	Facility	Cryogenic Test
other	Facility	Alignment/Metrology
other	Competence	Project Management
other	Competence	other competence
other	Facility	other facility
Theory	Competence	Theory QCD Lattice
Theory	Competence	Theory QCD Perturbative
Theory	Competence	Theory Phenomenology Collider
Theory	Competence	Theory Phenomenology Dark Matter
Theory	Competence	Theory Phenomenology Neutrinos
Theory	Competence	Theory Particle Astrophysics and Cosmology
Theory	Competence	Theory Other
Theory	Competence	Theory P5 Higgs
Theory	Competence	Theory P5 Neutrinos
Theory	Competence	Theory P5 Dark Matter
Theory	Competence	Theory P5 Dark Energy
Theory	Competence	Theory P5 New Phenomena
-all-	-all-	-all-
-all-	Competence	Advanced Accelerator Concepts

This Thrust Table (used for the Seven-Year Sustainability Exercise) is displayed here for reference purposes only. No pulldown menu is tied to this table.

ThrustTable

Program	P5 Driver	Thrust
Energy	Higgs	ATLAS Higgs Boson
Energy	Dark Matter	ATLAS Indirect Dark Matter
Energy	New Phenomena	ATLAS New Physics
Energy	Other	Other ATLAS
Energy	Higgs	CMS Higgs Boson
Energy	Dark Matter	CMS Indirect Dark Matter
Energy	New Phenomena	CMS New Physics
Energy	Other	Other CMS
Energy	New Phenomena	Future Collider
Intensity	Neutrinos	MINOS+
Intensity	Neutrinos	MINERvA
Intensity	Neutrinos	NOvA
Intensity	Neutrinos	SBN Program (incl. MicroBooNE, ICARUS, SBND)
Intensity	Neutrinos	DUNE (incl. ProtoDUNE)
Intensity	Neutrinos	LAr TPC R&D (incl. LArIAT)
Intensity	New Phenomena	Muon g-2
Intensity	New Phenomena	Mu2e
Intensity	Neutrinos	Computing Software & Simulations
Intensity	Neutrinos	Neutrino Beams
Intensity	New Phenomena	Belle, Belle II
Intensity	Neutrinos	Daya Bay
Intensity	Neutrinos	EXO-200
Intensity	Dark Matter	HPS and related Dark Sector R&D
Intensity	Neutrinos	PROSPECT
Intensity	Other	Other Intensity Frontier
Theory	New Phenomena	QCD Lattice
Theory	Higgs	QCD Perturbative
Theory	New Phenomena	Phenomenology Collider
Theory	Dark Matter	Phenomenology Dark Matter
Theory	Neutrinos	Phenomenology Neutrinos
Theory	Dark Energy	Particle Astrophysics and Cosmology
Theory	Other	Other Theory
Cosmic	Dark Energy	Dark Energy Survey
Cosmic	Dark Energy	BOSS, eBOSS
Cosmic	Dark Matter	SuperCDMS-Soudan, SuperCDMS-SNOLAB
Cosmic	Dark Matter	ADMX, ADMX-G2
Cosmic	Dark Matter	LUX, LZ
Cosmic	Dark Matter	DarkSide
Cosmic	Dark Energy	DESI
Cosmic	Dark Energy	LSST
Cosmic	Dark Energy	SPT-3G
Cosmic	Dark Energy	BICEP2, BICEP3
Cosmic	Dark Energy	POLARBEAR, POLARBEAR2
Cosmic	Dark Energy	FGST
Cosmic	Dark Energy	Planck
Cosmic	Dark Energy	SCP, SNfactory
Cosmic	Dark Energy	CMB-S4 R&D
Cosmic	Other	HAWC
Cosmic	Dark Matter	DAMIC
Cosmic	Dark Matter	COUPP, PICO
Cosmic	Dark Energy	Computational Cosmology
Cosmic	Other	Other Cosmic Frontier
Accelerat	Technology	Advanced Accelerator Concepts
Accelerat	Technology	Superconducting RF
Accelerat	Technology	Normal Conducting RF
Accelerat	Technology	RF systems
Accelerat	Technology	Beam Physics and Modeling
Accelerat	Technology	Magnets
Accelerat	Technology	High Power Target
Accelerat	Technology	Other Accelerator R&D
Detector	Higgs	Detector R&D in support of Higgs Boson
Detector	Neutrinos	Detector R&D in support of Neutrino Mass
Detector	Dark Matter	Detector R&D in support of Dark Matter Searches
Detector	Dark Energy	Detector R&D in support of Dark Energy and Inflation
Detector	New Phenomena	Detector R&D in support of New Physics
Detector	Technology	Other Detector R&D for Future Projects
CompHEP	Technology	SciDAC
CompHEP	Technology	Computational HEP
Acc. Stewa	Technology	Accelerator Stewardship
LARP	Technology	LHC Accelerator Research Program
MAP	Technology	Muon Accelerator Program

Rating Categories (Expanded)

Type	Need
T1	T1: Energy Frontier
T1	T1: Accelerator R&D
T1	T1: Cosmic Frontier
T1	T1: Detector R&D
T1	T1: Energy Frontier
T1	T1: HEP Computing
T1	T1: Intensity Frontier
T1	T1: Theory
T1	T1: Various
T2	T2: Accelerator R&D
T2	T2: ADMX
T2	T2: ATLAS (pre-Ph 1)
T2	T2: ATLAS Ph 1 Upgrade
T2	T2: ATLAS Ph 2 Upgrade
T2	T2: CMB-S4
T2	T2: CMS (pre-Ph 1)
T2	T2: CMS Ph 1 Upgrade
T2	T2: CMS Ph 2 Upgrade
T2	T2: CompHEP
T2	T2: Current DE, DM & CMB Expt.
T2	T2: Dark Energy--Future
T2	T2: Dark Matter--Future
T2	T2: DES Operations
T2	T2: DESI
T2	T2: DUNE/protoDUNE
T2	T2: Energy Frontier
T2	T2: FACET-II
T2	T2: HL-LHC Accelerator
T2	T2: ILC R&D
T2	T2: LBNF
T2	T2: LSST
T2	T2: LZ
T2	T2: Mu2e and g-2
T2	T2: NOvA
T2	T2: PIP-II
T2	T2: SBN Portfolio
T2	T2: Small Projects Portfolio
T2	T2: SuperCDMS-SL
T2	T2: Theory
T2	T2: Various
T3	T3: Accelerator R&D
T3	T3: Cosmic Frontier
T3	T3: Detector R&D
T3	T3: Energy Frontier
T3	T3: HEP Computing
T3	T3: Intensity Frontier
T3	T3: Theory
T4	T4: Industry
T4	T4: LCLS-II
T4	T4: OFA
T4	T4: Stewardship
T4	T4: WFO

**Thrust* is a concept used for the Sustainability Exercise

Data Collected: Cost, FTEs, DM, and Utilization

Lab Data Calls:

- **FY 2016 Utilization**
  - (Facilities only) The number of wall-clock hours in FY2016 that this facility was used for this purpose (n.b. not FTE-hours). If needed: assume 100% utilization on a single-shift Monday-Friday operating basis is equivalent to 2080 hours per year.
- **Cost**
  - For a **competence**, this is the fully burdened annual cost of the competence in FY 2016, including associated costs required to carry out the primary activities of the competence:
    - Include labor costs directly associated with the competence,
    - Include M&S costs needed for the competence to carry out its primary activities,
    - Include any pass-through funds to universities,
    - Include overhead charges associated with the above, but
    - *Exclude* LDRD, GPP, and other non-HEP funding sources, but record the amount and source in the Comments column,
    - *Exclude* pass-through funds to other Labs, but record the amount and receiving lab in the Comments column, and
    - Apportion the total of all included costs by Rating Category and by activity type: R&D, Operations, or Project Participation.
    - Record the total number of FTEs represented by this competence on the Staff and Upgrades worksheet.
  - For a **facility**, this is the fully burdened annual operating cost of the facility in FY 2016:
    - Include labor costs for equipment and facility maintenance,
    - Include labor costs for operating the facility,
    - Include the cost of consumables, equipment replacement, and warranties,
    - Include overhead charges associated with the above, but
    - *Exclude* the cost of the R&D activities themselves; this should be reported under a separate competence, and
    - Apportion the total of all included costs by Rating Category and by activity type: R&D, Operations, or Project Participation.
    - Record the total number of FTEs needed to operate the facility on the Staff and Upgrades worksheet, and
    - Record the total estimated cost of deferred maintenance and any upgrades needed to meet P5 obligations on the Staff and Upgrades worksheet.
- **FTEs**
  - The number of FTEs represented by the capability in FY 2016.
    - For a competence, this is simply the total number of FTEs that this competence represented in FY 2016.
    - For a facility, this is simply the total number of FTEs devoted to maintenance and facility operations in FY 2016, but excluding effort spent on the experiments and R&D that used the facility.
    - If a significant change in FTEs has occurred since the end of FY 2016, make a note in the Comments column, and report the current number.
- **Deferred Maintenance and Required Upgrades to meet P5 Obligations**
  - This is the sum of:
    - An estimate of the deferred maintenance costs required to bring the facility up to "nominal" operating conditions, and
    - An estimate of facility upgrades (if any) required to meet both current and currently-anticipated P5 obligations (i.e. meeting a Type 2 end use). Briefly describe the upgrade and the Type 2 end use(s) that require the upgrade in the Comments column.
      - You may describe upgrades to meet a Type 1,3, or 4 end use by listing the purpose and cost in the Comments column, but do not include the amount in Column D.

Stakeholder Data Calls:

- Which capabilities are being used/planned for use in the next 10 years
- Short description of use
- Estimate of utilization

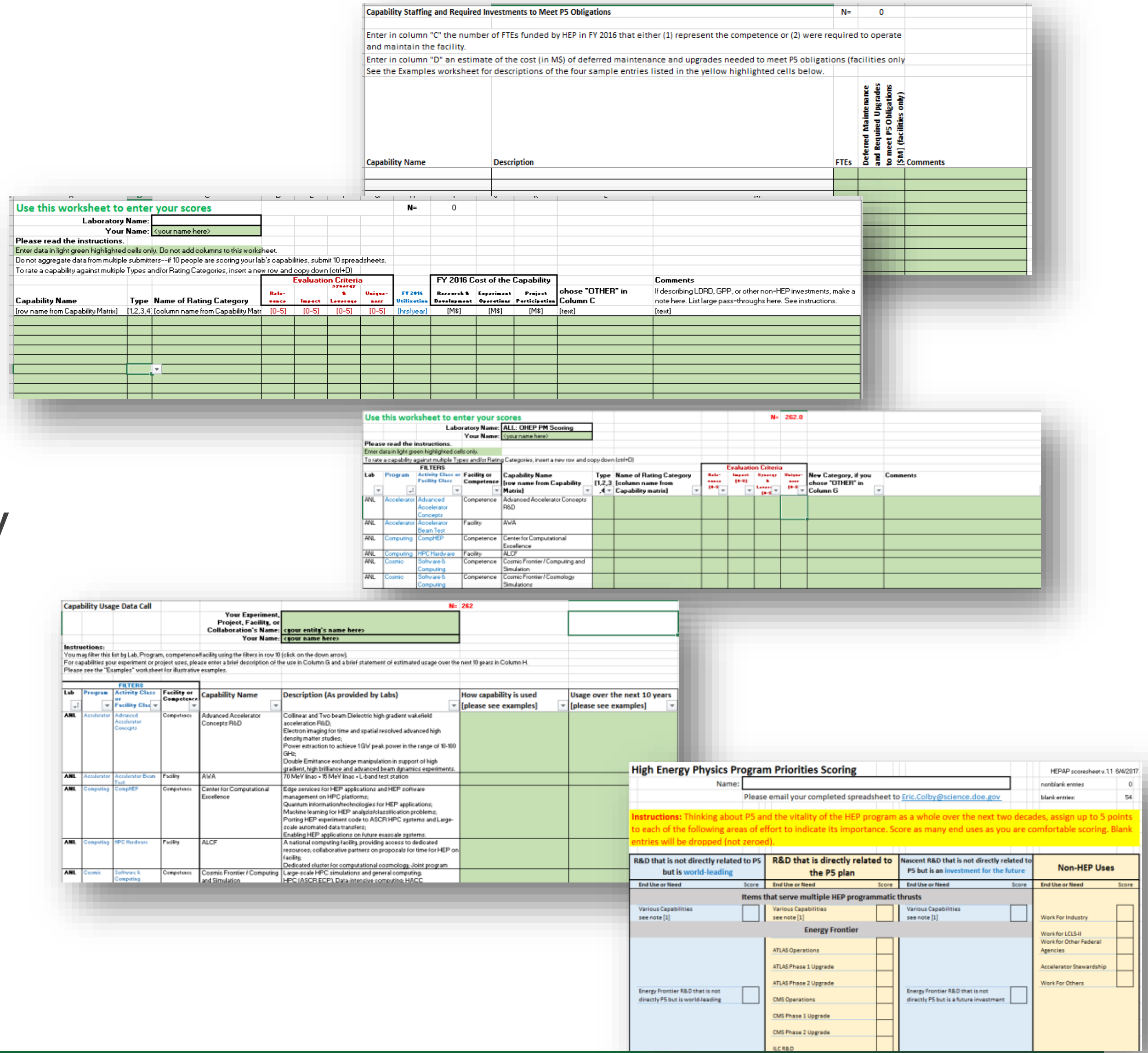
Lab Optimization Process—Calls, Analysis, Selection (2 of 3)

2017

- **January**
  - Activity list, metrics, scoring method finalized
  - Second iteration of lab capability lists
  - Capability lists finalized
  - Lab data call: Merit and cost by capability and activity
- **February, March**
  - OHEP data call: Merit by capability and activity
  - Feedback to labs at budget briefing
  - Stakeholder data call: 10-year use projections by capability
    - 164 OFA PMs, Proj Mgrs, Expt Spokes, Fac Mgrs, Collab Leaders, Senior PIs, …
- **April**
  - Initial database construction, integrity checks
- **May, June**
  - OHEP detailed review of data set; questions to labs
  - OHEP Priority Scoring
- **June**
  - Stakeholder data set released to labs; request to review
  - HEPAP Priority Scoring
- **July, August**
  - Labs Priority Scoring
  - Database cleanup and analysis
- **September, October, November**
  - OHEP deliberates for 8 weeks at a series of triage meetings
    - Capability-by-capability and activity-by-activity, grouped by classes of activity
  - OHEP selects Lab Optimization actions, develops implementation
- **November 29-30, 2017**
  - Initial actions roll out to labs
  - Homework assignments

Data Calls

- **Lab**
  - Capabilities & activities
  - Merit & Cost
  - FTEs, DM
- **OHEP**
  - Merit by activity
- **Stakeholder**
  - 10-year Usage by capability
- **Priority**
  - Ranking of activities



Scope of the Data Received

- **Making CBA projections over the next 10 years requires knowing:**
  - (Everything, everywhere, over 10 years, tagged by: {HEP thrust, tier, activity, class}, measured by: {cost, FTEs, merit, utilization, $ sources, priority, description, DM/RU, …})➔ **$O(10^8)$ entries**
    - Thresholded (>1M$/year cost per capability)
    - Factorized (Longitudinal x transverse; separated Cap, Act, and Util tables)
- **4+1 data calls, 236 input spreadsheets**
    - Lab Data Call: 18,142 data entries
      - Capabilities (Competences, Facilities), merit & cost of each Activity
    - OHEP Scoring: 2,330 data entries
      - Merit of each activity of each capability
    - Stakeholder Data Call: 2,838 data entries
      - Utilization data over the next 10 years for Capabilities
    - Priority Data Call: 4,165 data entries
      - Relative scoring of the importance of Activities
    - Sustainability Data Call: 8,589 data entries

➔ **$O(10^4)$ entries**

- **Gathered in a database of 62 linked tables with 98,195 entries and a set of tools**
    - Automated data aggregation & validation
    - A model linking Optimization & Sustainability data sets to estimate future values
    - A model of capability utilization
    - Priority analysis and MC error estimation
    - Realignment impact estimation

Merit Scoring

- **Average of Labs' scores = 4.5**
- **Average OHEP's scores = 3.9**
  - Guidance: "as good as any other lab in the US" = 3.0

- **Merit Scores were correlated**
  - R = Relevance
  - I = Impact
  - S = Synergy
  - U = Uniqueness
- **Consequently, the four merit scores were combined into a single score: "Benefit"**
  - B = 0.35*R+0.35*I+0.15*S+0.15*U
- **And aggregated as mean-subtracted, scaled (to unit s.d.) scores to partially compensate for rater-to-rater variation**

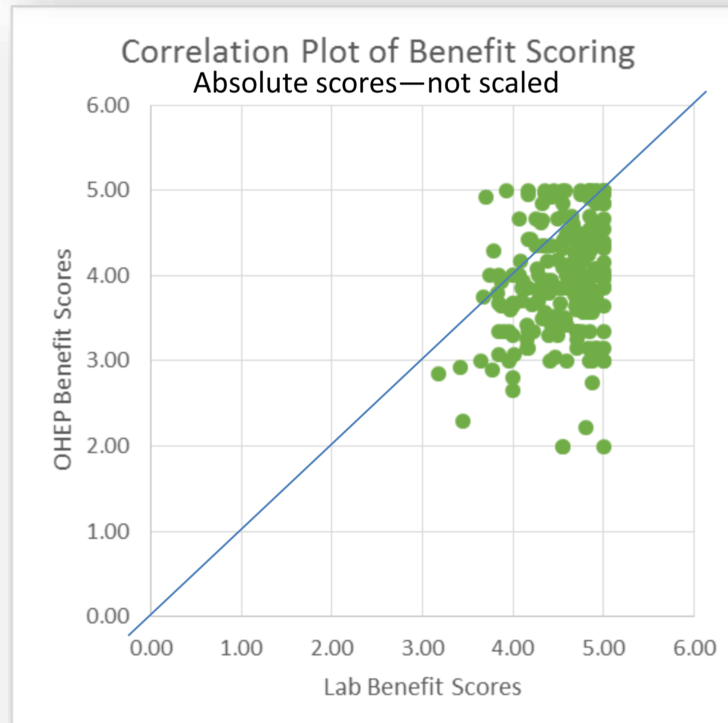
- **OHEP and labs scoring was somewhat correlated (R=0.24)**
  - See plot at right

Merit Score Correlation Matrix

OHEP	R	I	S	U
R	1.000	0.816	0.532	0.707
I		1.000	0.584	0.766
S			1.000	0.574
U				1.000

Merit Score Correlation Matrix

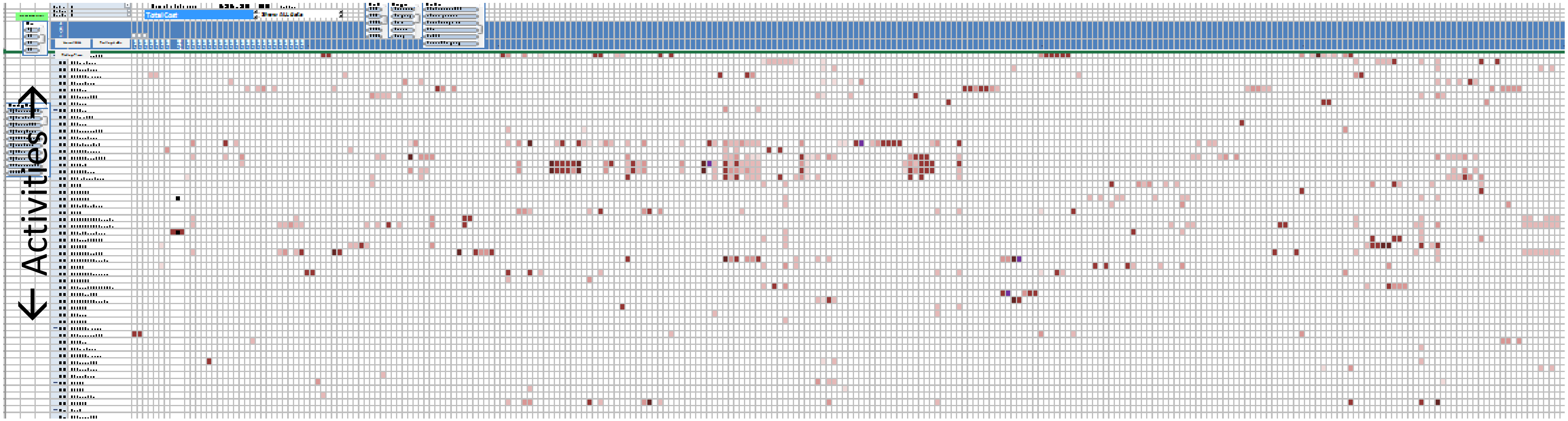
Lab	R	I	S	U
R	1.000	0.555	0.267	0.035
I		1.000	0.424	0.203
S			1.000	0.234
U				1.000

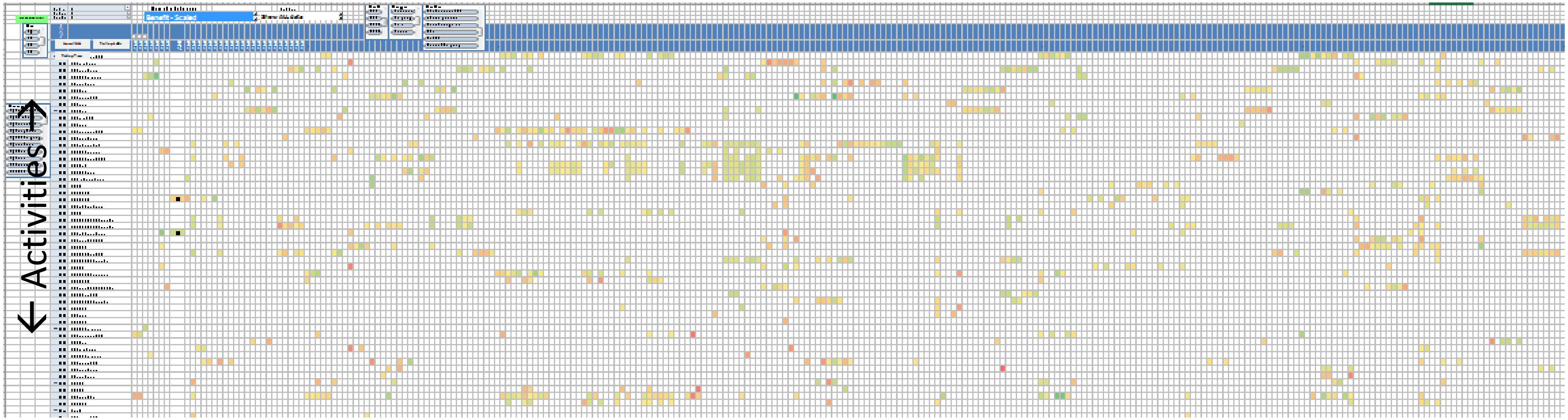


Cost & Merit Data in One Slide

(Illustrations are intentionally illegible—provided to show the scope and density of data)

← CAPABILITIES →





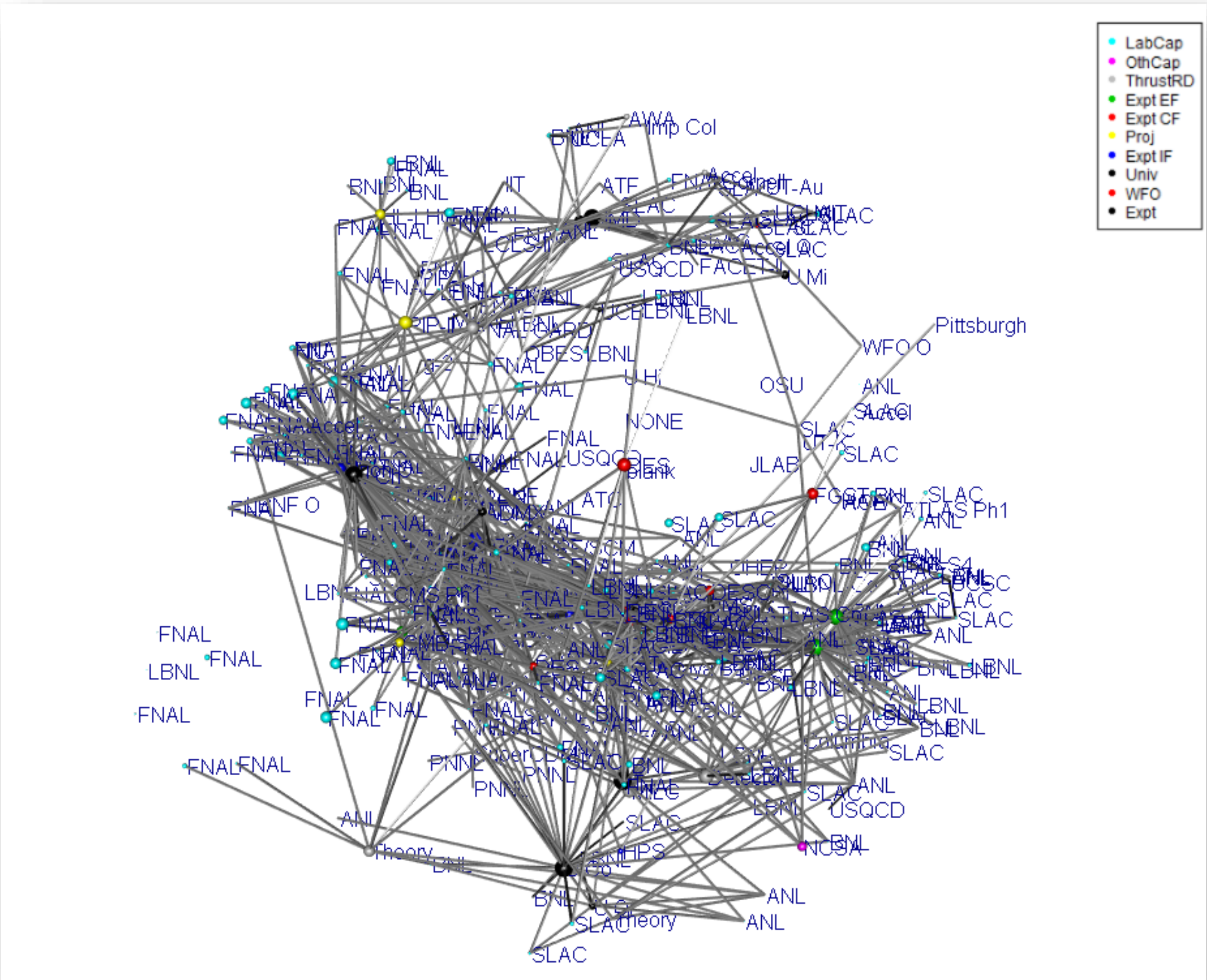
Stakeholder Data Call

To understand the community's use patterns for the capabilities, a Stakeholder Data Call was made

- **Who was asked**
  - A list of 164 entities was generated by the OHEP PMs
    - Collab. leads, Expt. spokes., Proj. mgrs/dirs./sci., fac. mgrs, ctr. coord., PAC Chairs, and senior university PIs
- **Response Rate**
  - 90 responses from 164 requests (~55%)
    - Additional response coordination occurred so coverage is slightly better than 55%
- **What was requested**
  - Which lab capabilities are needed and how much is needed over the next 10 years
- **Statements of usage were then converted into a numerical model of usage**
  - Tagged by: activity, capability, HEP program, activity or facility class, type of source, probable accuracy, and source.

Stakeholders’ View of the HEP Lab Network

(Caveats: This is lab-centric, biased towards “visible” capabilities, and incomplete)



HEP Lab Capability Network in a Fruchterman-Reingold Layout:

- Nodes “repel” but are attracted by the number and weight of the links (edges)
- Minimum “energy” solution produces spatial layout

- Edges
  - weighted by average utilization 2017-2022
- Nodes
  - Nodenames: All 275 lab capabilities truncated to the Lab’s name
  - diameter is
    - log(cost[M$]) for lab capabilities
    - log(Bc) for all else
  - Bc = Betweenness centrality ~ # shortest paths through the node
  - Node color is the object type, as indicated by the legend
    - LabCap = Lab Capability
    - OthCap – Other Capability (e.g. NCSA)
    - ThrustRD = End Purpose is pure R&D in this thrust
    - Expt XX = Named experiment in frontier XX
    - …

T1: Various
T1: Energy Frontier
T1: Intensity Frontier
T1: Cosmic Frontier
T1: Theory
T1: HEP Computing
T1: Detector R&D
T1: Accelerator R&D
T2: Various
T2: ATLAS (pre-Ph 1)
T2: ATLAS Ph 1 Upgrade
T2: ATLAS Ph 2 Upgrade
T2: CMS (pre-Ph 1)
T2: CMS Ph 1 Upgrade
T2: CMS Ph 2 Upgrade
T2: Energy Frontier
T2: DUNE/protoDUNE
T2: LBNF
T2: Mu2e and g-2
T2: NOvA
T2: PIP-II
T2: SBN Portfolio
T2: Small Projects Portfolio
T2: CMB-S4
T2: ADMX
T2: Current DE, DM & CMB Expt.
T2: Dark Energy--Future
T2: Dark Matter--Future
T2: DES Operations
T2: DESI
T2: LSST
T2: LZ
T2: SuperCDMS-SL
T2: Theory
T2: CompHEP
T2: FACET-II
T2: HL-LHC Accelerator
T2: ILC R&D
T2: Accelerator R&D
T3: Various
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T3: Theory
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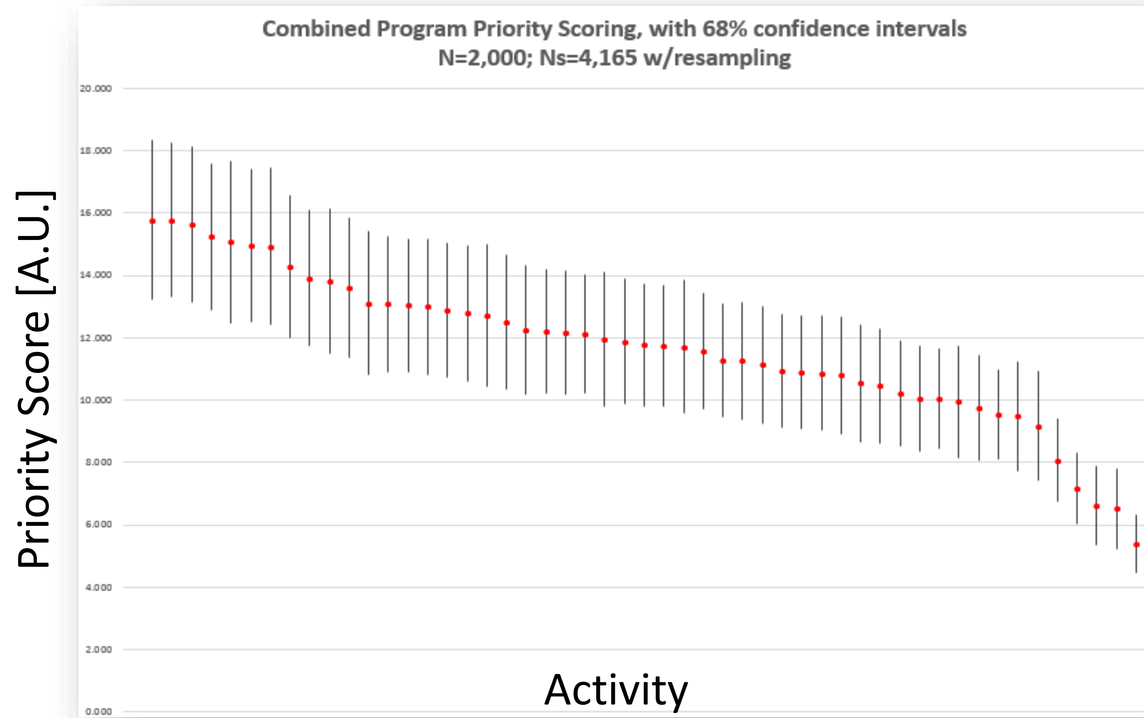
T3: Detector R&D
T3: Accelerator R&D
T4: Industry
T4: LCLS-II
T4: OFA
T4: Stewardship
T4: WFO

Priority ranking of the Activities

Combined ranking of the 52 Activities in the HEP Program

- The 52 Activities of the HEP Program were ranked via the priority scoring exercise
- 93 Respondents from OHEP, HEPAP, and the Labs provided scores of 0-5 for each activity
- The results were combined, and C.I.s estimated by standard bootstrap resampling techniques
- The “resolving power” of this exercise (range/standard deviation) >5



N.B. The ordered list at left does **not** correspond to the abscissa of the plot!

Sample Triage Lists

(Composite of two different triage lists)

Lab	Program	Capability Name	RecID	Capability Description
ANL	Energy	Energy Frontier, Intensity Frontier / Sc	uting:Energy	Data intensive computing, I/O, HPC applicatio
ANL	Computing	ALCF	F:Computing	A national computing facility, providing acce
ANL	Cosmic	Cosmic Frontier / Computing and Sim	tion:Cosmic	Large-scale HPC simulations and general c
ANL	Cosmic	Cosmic Frontier / Cosmology Simula	ions:Cosmic	Advanced statistical methods and machine
ANL	Computing	Center for Computational Excellence	e:Computing	Edge services for HEP applications and HEP
BNL	Computing	LQCD Software	e :Computing	SciDAC and exascale computing project fo
BNL	Intensity	IF Software & Computing	uting:Intensity	Intensity Frontier computing models; support fo
BNL	Energy	EF Software & Computing	puting:Energy	Software for ATLAS and future colliders: fram
BNL	Computing	Software for Distributed Computing	g:Computing	Software development for GRID, cloud com
BNL	Computing	BNL Scientific Data and Computing C	er:Computing	ATLAS Tier-1 computing center, providing US A
FNAL	Computing	Large Scale Distributed Computing an	e:Computing	The expertise, skill, and ability needed to provi
FNAL	Computing	Energy Deposition Calculations and M	e:Computing	The expertise in energy deposition calculatio
FNAL	Computing	Computing Facility Expertise in Desig	s.:Computing	Staff with experience and expertise in archite
FNAL	Computing	Advanced Computer Science, Visualiz	a:Computing	As the lead lab for HEP, Fermilab has signific
LBNL	Cosmic	Cosmic Frontier -CMB, Computing a	ware:Cosmic	Leveraged HPC computign at NERSC for
LBNL	Intensity	Intensity Frontier- Computing and Sof	ware:Intensity	Daya Bay: data transfer from Daya Bay to LB
LBNL	Energy	Energy Frontier, Computing and softw	tware:Energy	Major contributions to ATLAS core soft
LBNL	Computing	Computing facilities: PDSF, NERSC	t:Computing	A national computing facility, providing acces
LBNL	Cosmic	Cosmic Frontier -Dark Energy, Comp	ware:Cosmic	Lead institution for DESI computing; leading
LBNL	Intensity	Intensity Frontier- Muon Physics, Co	ware:Intensity	Design, implement and maintain pattern re
LBNL	Cosmic	Cosmic Frontier -Dark Matter, Comp	ware:Cosmic	LBNL is supporting both LUX and LZ exper
LBNL	Computing	Advanced computing for HEP	P:Computing	Edge services for HEP applications and HE
SLAC	Computing	Simulations - Geant4	4:Computing	Detector Simulations (Geant4)
SLAC	Computing	Stanford Research Computing Cente	r :computing	Joint Research computing effort of the ind
SLAC	Cosmic	Simulations - cosmic	smic:Cosmic	Cosmological Simulations
SLAC	Intensity	Software & Computing - IF	g - IF:Intensity	LArTPC reconstruction and simulation (f
SLAC	Energy	Software & Computing - EF	g - EF:Energy	Databases, scalable analysis data storage
SLAC	Computing	Computing Hardware	re:computing	Accelerator, ATLAS, BaBar, Fermi, KIP
SLAC	Cosmic	Software & Computing - CF	- CF:Cosmic	Computing infrastructure and Analysis sup

Average of OHEP Priority	Average of Lab Priority	Average of Net Priority	Average of Scaled Benefit	Sum of Total Cost	Sum of Delta(Cost)	Sum of Total FTEs - This Use	Projected 5-year Utilization
0.20	0.45	0.25	-0.39	0.00	0.00	0.00	0.00
0.29	0.67	0.26	-0.41	0.89	0.66	3.15	0.00
0.29	0.30	0.26	-0.84	1.75	1.29	3.00	0.06
0.29	0.67	0.26	0.47	2.40	1.76	5.63	0.10
0.32	0.83	0.28	0.42	0.00	0.00	0.00	0.00
0.33	0.43	0.33	-1.14	0.00	0.00	0.00	0.88
0.38	0.44	0.36	-0.01	13.57	0.08	57.17	0.51
0.40	0.50	0.41	-0.49	2.57	0.03	8.46	0.00
0.51	0.56	0.55	0.20	3.64	0.82	14.02	1.34
0.53	0.63	0.61	-1.11	0.00	0.00	0.00	0.00
0.56	0.73	0.63	-0.36	2.80	0.19	7.10	0.60
0.58	0.86	0.55	0.08	7.42	2.01	1.11	0.00
0.58	0.75	0.61	0.20	1.22	0.01	2.50	0.72
0.58	0.53	0.65	0.26	0.00	0.00	0.00	0.00
0.59	0.67	0.62	0.33	3.90	0.74	12.20	1.75
0.60	0.71	0.62	0.54	1.32	0.32	5.00	3.98
0.61	0.64	0.69	-0.63	1.20	0.00	5.00	0.14
0.62	0.60	0.66	0.31	2.81	0.21	12.67	1.07
0.63	0.77	0.66	-0.06	1.80	-0.04	7.80	1.00
0.67	0.64	0.68	0.21	1.26	-0.02	2.50	3.06
0.67	0.91	0.71	0.64	3.40	0.07	9.00	0.25
0.68	0.96	0.67	1.02	3.10	0.85	8.89	1.43
0.68	0.59	0.73	0.41	1.80	0.03	14.12	0.34
0.69	0.68	0.72	-0.07	1.90	0.22	10.00	4.66
0.70	0.78	0.75	0.37	2.20	0.06	5.80	0.34
0.74	0.63	0.78	0.30	0.53	0.00	2.08	1.15
0.75	0.91	0.80	0.46	1.60	-0.03	3.50	1.00
0.75	0.95	0.80	0.43	1.80	0.02	7.10	0.05
0.79	0.95	0.84	0.64	2.70	0.04	10.15	0.71

Triage lists formed the ***starting point*** for discussion about each group of capabilities.

Triage Discussions

- **Capabilities were grouped by activity class and facility class and reviewed together along major topical themes (e.g., accelerator, detector R&D, experiment operations, computing, etc.)**
  - Data was summarized onto triage sheets which formed the *starting point* of the triage discussions
- **For each class of capability, typical discussion questions included:**
  - Of each capability: in what activities is it engaged? How has the activity profile changed since FY 2016 (the year reported in data calls)?
  - Of similar capabilities: which is/are the best? What did the most recent Comparative Review / Institutional Review say about it? Can similar items be consolidated? Does the system have sufficient capacity if X is ramped down?
  - Of "small" capabilities: are any "sub-critical"? What do they leverage?
  - Of capabilities which combine to form a major Core Competence: is the workforce correctly configured and will it evolve to meet the needs of the next decade? What is the condition of the facilities?
  - Of low-utilization and low-priority capabilities: are the low values credible? Why are the scores low? What purpose does this capability serve?
  - …

Triage Outcome and Selection

- **The Triage discussions identified 59 distinct realignment actions**
- **OHEP leadership deliberated over 3 weeks which would be implemented**
  - The overwhelming majority of the actions were selected for implementation
  - Labs were briefed on a subset of these actions on 11/29/2017
  - In several cases, additional steps are needed before realignment actions can be identified and implemented, for example:
    - Lab Thrust Area Comparative Reviews
    - Basic Research Needs Workshops
    - Lab-specific homework
    - OHEP-specific homework (when system-wide)

Lab Optimization Process—Implementation (3 of 3)

- **November 29, 2017: Five Lab Meeting**
  - Initial roll out to labs – actions common to all five labs discussed
  - Timetable, Notables, homeworks discussed
- **November 30, 2017: HEPAP**
  - Inform HEPAP and HEP community; seek advice on future process
- **December**
  - Initial roll out to labs – actions specific to each lab discussed in lab teleconferences

2018

- **February, March**
  - **Labs present implementation plans for initial actions at Budget Briefings**
- **June**
  - Lab FWPs incorporate majority of Optimization Actions
- **October 1, 2018**
  - Initial Fin Plans reflect most Optimization actions

2019

- **Early 2019**
  - All studies completed, actions implemented
  - Additional Notables as needed

2022

- **Ramp-downs for largest actions complete**

Initial Set of Realignment Actions Common to all Five Labs

- **Energy Frontier**
  - Ensure no additional charges for engineering and technical efforts for the CMS and ATLAS Phase I upgrade projects are being charged to research B&R codes. Since Both have passed CD-3, component R&D for the upgrade projects should be complete.
  - Ensure no additional charges for engineering and technical efforts for CMS and ATLAS Phase II upgrades are being charged to research B&R codes after FY 2018.
  - The HL-LHC ATLAS and CMS CD-1 reviews will be charged to evaluate the efficiency of the projects' fabrication plans, e.g., is the number of fabrication sites justified?
- **Theory**
  - Lab management must do a much better job explaining the theory group's integration with lab's program.
- **Computing**
  - An internal OHEP computing WG is examining the HEP computing effort looking for enhanced inter-laboratory collaboration and economies of scale. Please assist with data calls when asked.
- **Detector Facilities and R&D**
  - Optimization analysis for detector capabilities {lab-specific list} indicated relatively low priority and/or projected utilization for these capabilities. Please come prepared to discuss these capabilities at the lab budget briefing with particular attention to how the lab plans to either (1) improve the priority and/or utilization within the HEP portfolio, or (2) provide a long-term view of how these capabilities will impact HEP plans/capabilities.
  - A Basic Research Needs workshop on HEP-oriented long-term Detector R&D is planned. Priority Research Directions and the research roadmap identified at this workshop will inform HEP funding priorities for years to come. Participate!
- **Accelerator Facilities and R&D**
  - Optimization analysis for accelerator capabilities {lab-specific list} indicated relatively low priority and/or projected utilization for these capabilities. Please come prepared to discuss these capabilities at the lab budget briefing with particular attention to how the lab plans to either (1) improve the priority and/or utilization within the HEP portfolio, or (2) provide a long-term view of how these capabilities will impact HEP plans/capabilities.
  - A Basic Research Needs workshop on security applications of accelerators is planned. Priority Research Directions and the research roadmap identified at this workshop will inform HEP funding priorities for years to come. Participate!

What's Next

- **For realignments already defined:**
  - Labs prepare plans to implement actions already defined
    - Discuss plans with OHEP in Feb/Mar 2018 at Budget Briefings
    - Implement in FY 2019, with gradual ramp-in this year
- **For realignments to come:**
  - Homework is needed for some questions that were clearly indicated, but not well resolved by the Lab Optimization process:
    - Accelerator Modernization Review at FNAL
    - Detector Workforce Review at FNAL
    - OHEP Analysis of Computing Workforce
    - …
- **Maintaining optimization**
  - Will come back to this during the discussion

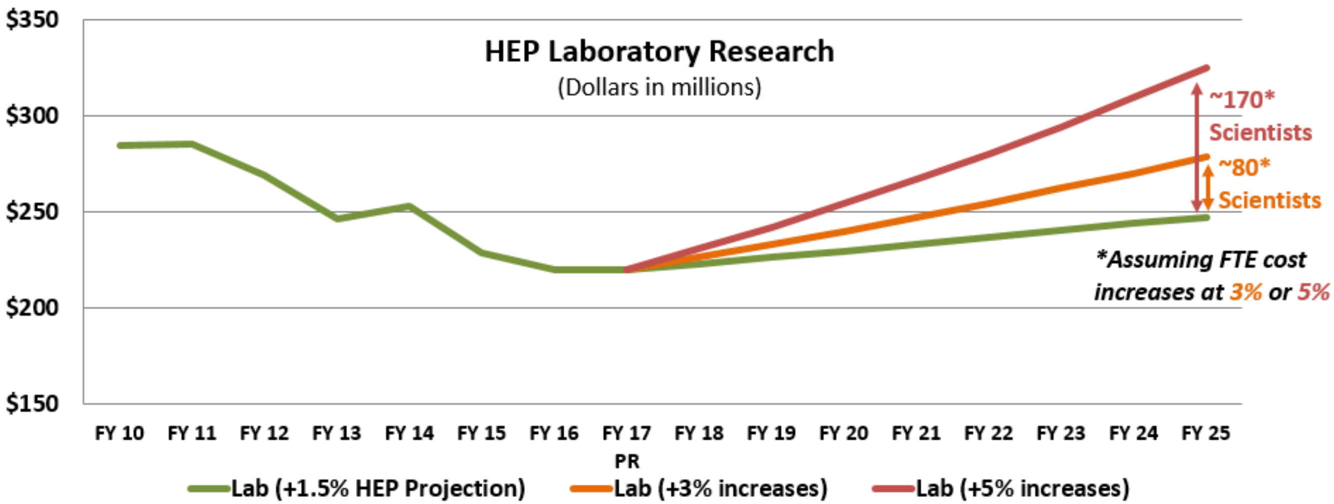
Lessons Learned

- **Further elaboration of the HEP Program into a set of Capabilities and Activities proved quite useful**
  - Labs had quite different ways of conceptualizing their programs!
  - Having a “snapshot” of the cost by capability and activity very useful
    - First time seeing the program as a whole at this level of detail
    - Exposed underlying cross cut activities in detail (e.g. computing)
  - Detailed merit scoring in this large data-call context was not effective
    - Likely a result of repetitive task fatigue
    - Insignificant distinction between R, I, S, and U metrics
- **Stakeholder survey highly informative**
  - Revealed connections, utilization, visibility issues, and more
    - Needs a more structured input process if repeated
- **Priority scoring was an unexpectedly useful exercise**
  - Provided a useful ranking, and insight into the differing priorities of OHEP and the Labs

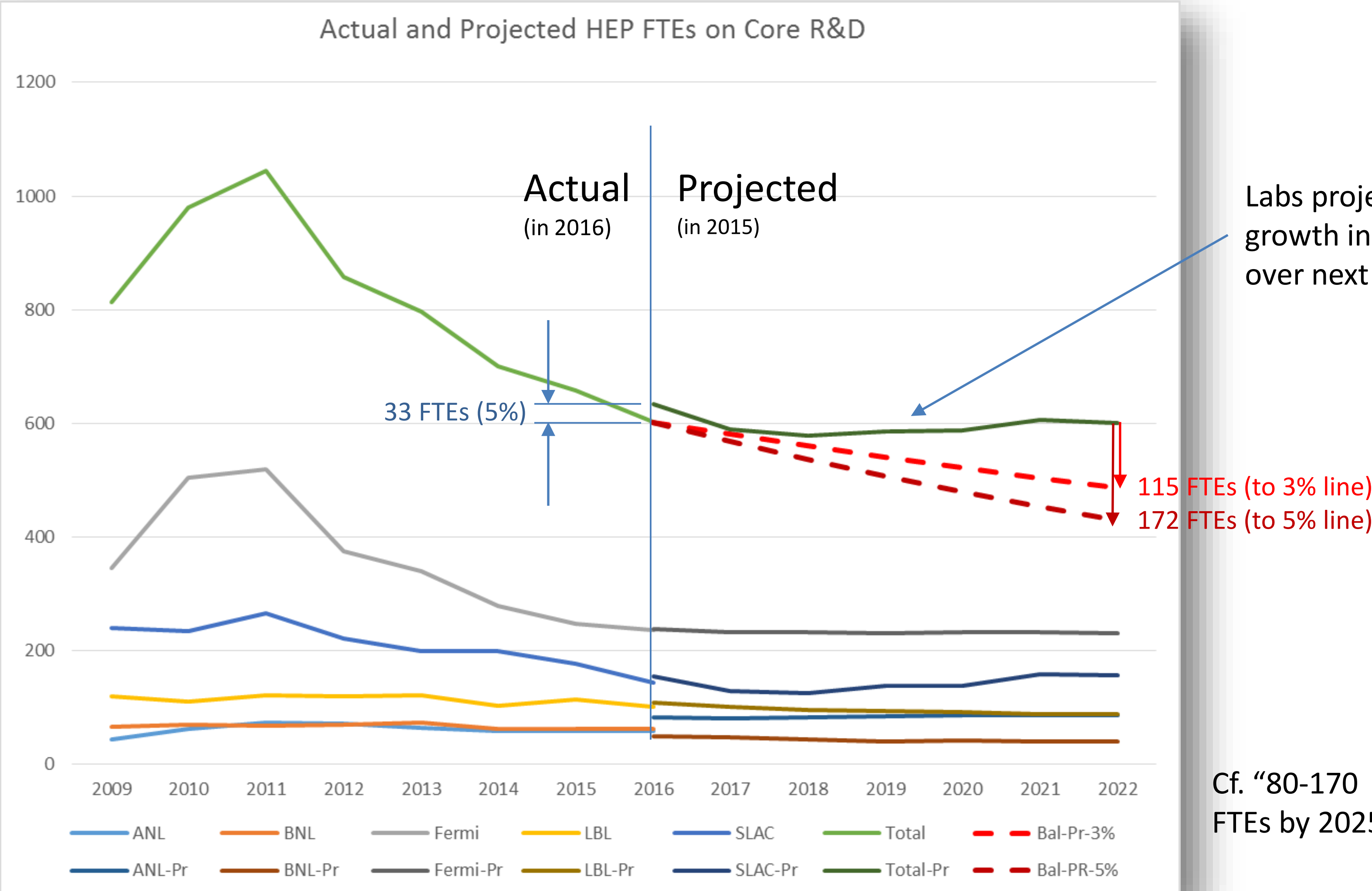
The Challenge Posed to the Labs February 2016

Research Sustainability

- HEP plan to increase laboratory research funding is not expected to keep pace with projected cost-of-business increases
  - Plans must realistically accommodate research FTE reductions while maintaining a viable workforce capable of achieving planned work
    - Current fully burdened lab PD/Scientist: ~$150k/~$300k



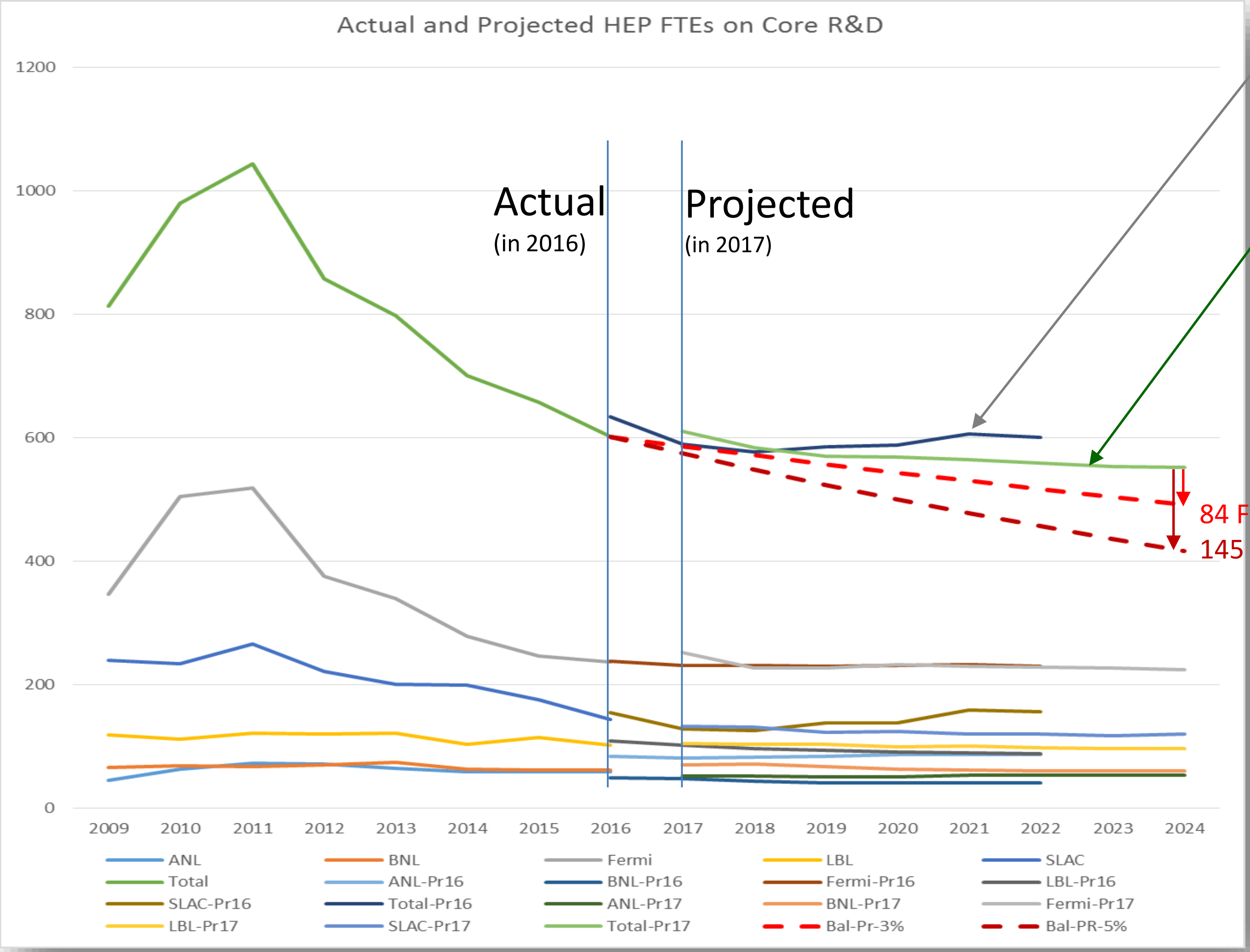
One month later, 7-Year sustainability data provided by the labs revealed the disconnect had grown



Labs project moderate growth in Core R&D #FTEs over next 7 years

Cf. “80-170 FTEs by 2025”

Silver Linings: One year later, 7-Year sustainability data provided by the labs revealed the disconnect had **improved**



In 2016, labs projected moderate growth in Core R&D #FTEs over next 7 years

In 2017, labs projected moderate contraction in Core R&D #FTEs over next 7 years

N.B. Offset projections assume a fixed workforce (no attrition, no hires).

Silver Linings: Fermilab is implementing Capability and Activity-level tracking in the lab's strategic planning process

Lab Activities in the Strategic Planning Database

- Lab Activity:
  - Work done by the laboratory to accomplish lab objectives. Research-, project-, or operations-funded lab activities are aligned with HEP thrusts.
  - Lab activities include overhead-funded activities (i.e. activities associated with lab management systems).

Edit	LA-ID	Lab Activity	Activity Group
⊞ **DOE-SC Core Capability : Accelerator Science and Technology** (28)			
⊞ **DOE-SC Core Capability : Advanced Computer Science, Visualization and Data** (9)			
⊞ **DOE-SC Core Capability : Large Scale User Facilities / Advanced Instrumentation** (24)			
⊞ **DOE-SC Core Capability : Mission Support** (28)			
⊞ **DOE-SC Core Capability : Particle Physics** (55)			

For FY 2017 the lab has 144 lab activities (lab activities for each core capability shown on the left).

- Lab activities have significant overlap with lab capabilities
  - The lab activities database served as a starting point for defining lab capabilities for the HEP Lab Optimization Process.

Fermilab

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Improvement Plan for Workforce Planning

- The **lab capabilities database** will be key feature for future workforce planning framework by linking to existing databases in the lab's framework.
- Critical and endangered skills database
  - Divisions and sections identify critical and endangered skills
  - Estimate needs for the next 3 years
  - Action plan (e.g. crosstrain, contractor, new hire, outsource, retrain, etc.)
- Employee skills database
  - Employee self assessment of skills
  - Annual lab-wide "skills talent review"
  - Enables identification of personnel skills across the lab
- Budget Planning System
  - Oracle cloud resource budgeting system – startup in FY17
  - Projects upload resource needs for duration of project
  - Divisions upload projected labor supplied to projects
- Lab wide risk management
  - Early identification and tracking of potential resource risks

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Goals of the Laboratory Optimization Process

Status

- **Raise awareness of systemic issues, align expectations**
- **Agree upon the criteria that define "value to the HEP mission"**
- **Inventory the present capabilities in the system**
- **Develop 10-year visions for the individual HEP lab programs**
- **Assess the value of capabilities in the system**
- **Harmonize projects, operations, and R&D—both in OHEP planning and in the field**
- **Develop a 10-year national vision for HEP lab programs**
- **Identify realignments needed to focus resources on strongest programs**
- **Identify new or repurposed organizational structures needed to drive optimization**
- **Identify near- and far-term implementation strategies**
- **Identify larger (i.e. full ecosystem) issues, and possible routes forward**

Concluding Remarks

- **Labs engaged frankly and constructively throughout a long, high-stakes process**
  - Many constructive discussions and inputs during process definition and execution
  - Easily 1-2 FTE-years invested in data gathering alone
  - Actions total 5-10% of FY2016 funding
- **The labs maintain an outstanding commitment to excellence on an international scale**
  - Unanimous commitment to providing outstanding science for the taxpayer dollar
  - Commitment to the idea that optimization on a system-wide basis is necessary and beneficial, when done properly

Opportunities for Improvement

(For HEPAP discussion)

- **Opportunities for improvement**
  - Competition + reduced probability of success ➔ labs "diversify" hoping to keep a hand in each game
    - More aggressive system-wide management of "initiatives"?
  - Visibility issues➔ inefficient exploitation of technology investments
    - MIE Project process documentation and review reforms?
  - Expensive infrastructure and niche skills replicated multiple places; complicated by episodic demand
    - System-wide management of key infrastructure and skills sets?
  - Many capabilities are funded with the long-term remit of a 'core competence'
    - What part of the competence or facility must be treated this way? Why?
    - What part should be funded by the work scope?
    - When is a "Center" model an appropriate funding mechanism to foster collaboration and broad use?

- **Maintaining optimization is an ongoing task**
  - Need to regularly assess the program system wide and generate actionable information to keep it optimized
    - Maintain an elaborated list of P5-traceable R&D objectives
    - Maintain an up-to-date picture of the state of the art
    - Maintain a global view of what tools and resources are available and how to best to deploy them
    - Maintain a national view of how the workforce must evolve to handle ever more complex experiments
  - Mechanisms for input, evaluation, and advice
    - Via multi-institutional task forces?
    - Through organized actions of APS-DPF, -DPB, etc.?
    - Via targeted NAS studies?
    - Through HEPAP topical subcommittees?
    - By repeating the Lab Optimization process following each P5?
    - …?

- **Additional Materials**

Summary for the Minutes

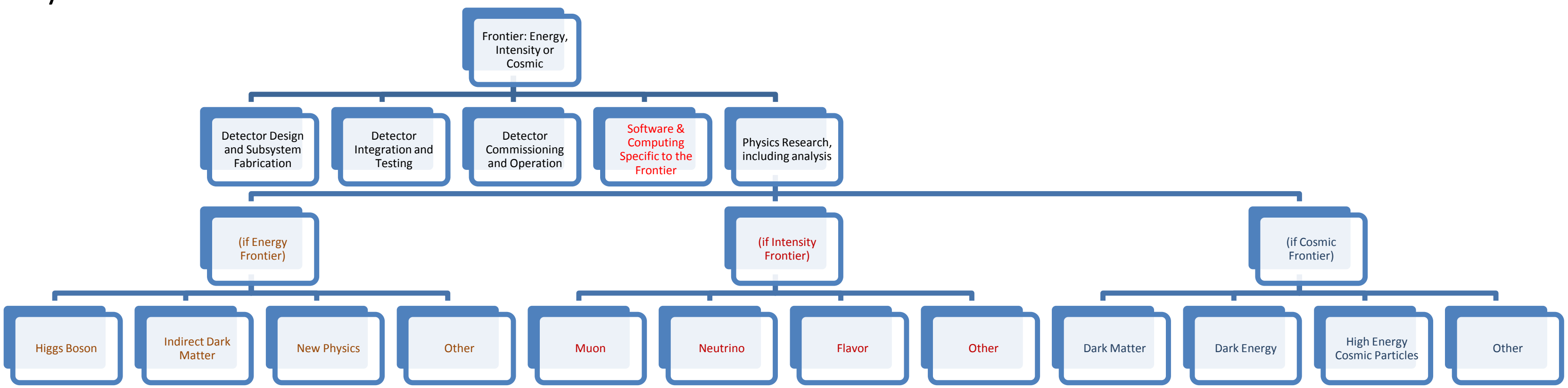
Systematic Optimization of the DOE Laboratory Components of the HEP Program

A deliberative 2-year long process undertaken jointly between OHEP and the five largest DOE Lab programs has resulted in a set of actions to strengthen the HEP program. The lab HEP programs at ANL, BNL, FNAL, LBNL, and SLAC were resolved into 275 distinct capabilities. The activities of these capabilities were then inventoried by cost, merit, utilization, priority, and other factors, with data inputs collected from the Labs, the HEP community, and other key stakeholders. Over the course of two months of triage and selection meetings, realignment actions designed to strengthen the HEP program were identified, and important system-wide issues requiring further input and study were identified. In total, the realignment actions involve an estimated 5-10% of the five labs' DOE OHEP funding, and will impact every aspect of the HEP program. Implementation of the actions will ramp up in FY 2018, and be complete within a few years. The labs' full and constructive engagement in this high-stakes process is compelling evidence of their continuing commitment to deliver outstanding science.

Capability Partitioning Scheme for Frontier R&D

(Use of this scheme is mandatory; use "other" with caution)

Hierarchy



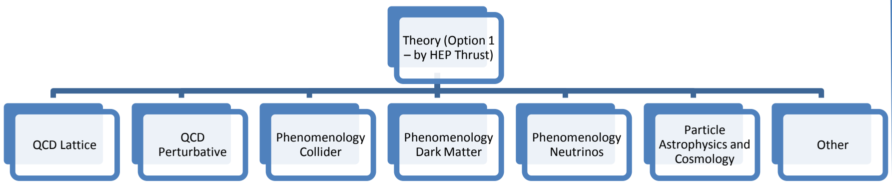
List of all possible competences

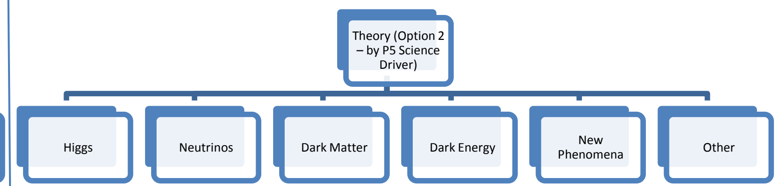
Energy Frontier Detector Design and Subsystem Fabrication	Intensity Frontier Detector Design and Subsystem Fabrication	Cosmic Frontier Detector Design and Subsystem Fabrication
Energy Frontier Detector Integration and Testing	Intensity Frontier Detector Integration and Testing	Cosmic Frontier Detector Integration and Testing
Energy Frontier Detector Commissioning and Operation	Intensity Frontier Detector Commissioning and Operation	Cosmic Frontier Detector Commissioning and Operation
Energy Frontier Software & Computing	Intensity Frontier Software & Computing	Cosmic Frontier Software & Computing
Energy Frontier Higgs Physics Research	Intensity Frontier Muon Physics Research	Cosmic Frontier Dark Matter Research
Energy Frontier Indirect Dark Matter Physics Research	Intensity Frontier Neutrino Physics Research	Cosmic Frontier Dark Energy Research
Energy Frontier New Physics Searches	Intensity Frontier Flavor Physics Research	Cosmic Frontier High Energy Cosmic Particle Research
Energy Frontier Physics Research -- Other	Intensity Frontier Physics Research -- Other	Cosmic Frontier Physics Research -- Other

Capability Partitioning Scheme for Theory

(Use of exactly one of these schemes is mandatory; use "other" with caution)

Hierarchy—pick one organizational scheme only





List of all possible competences—pick one list only

QCD Lattice	Higgs
QCD Perturbative	Neutrinos
Phenomenology Collider	Dark Matter
Phenomenology Dark Matter	Dark Energy
Phenomenology Neutrinos	New Phenomena
Particle Astrophysics and Cosmology	Other
Other	