U.S. DEPARTMENT OF ENERGY | Office of Science

Theory at DOE-HEP

Dr. Simona Rolli
Program Manager for Theory
DOE Office of High Energy Physics
June 16, 2014
DOE PI Meeting

Introduction

The purpose of this talk is to explain and summarize how the theory program works at DOE, how it is funded, how grant allocations are made, and how the entire process works so that everyone will be on the same page in all future discussions.

(see Snowmass talks in 2013 and HEPAP talk in March 2014)

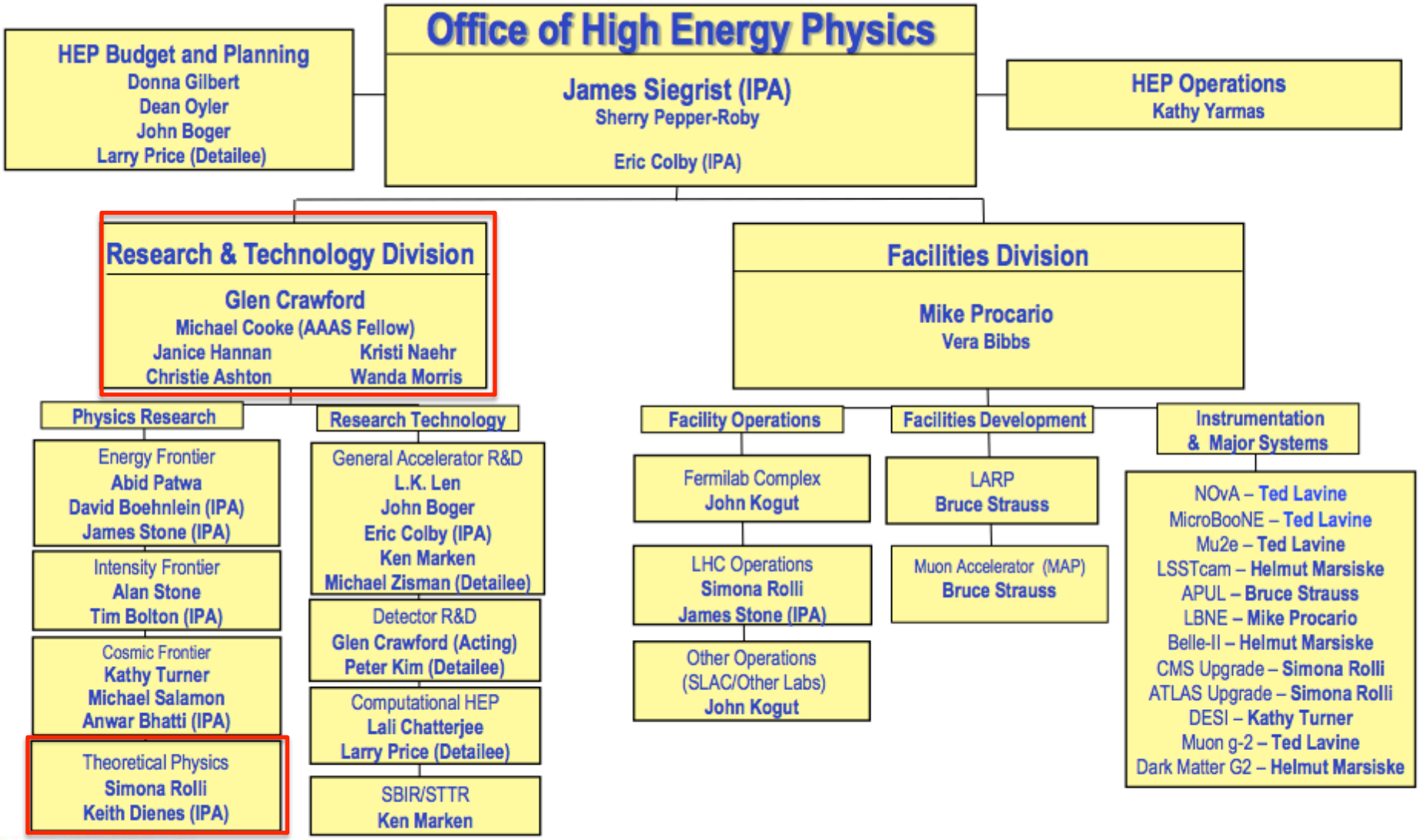
In general, there are two issues that everyone needs to understand:

- How much funding is allocated to the Theory Program *in total*
- How that money is *distributed* across different grant allocations (universities) and across different contracts (laboratory theory groups).

Outline

- The Theory Program at DOE-HEP
- Theory Portfolio and Budget Trends
  - 2009-2014
  - Labs and Universities
- University Comparative Review
  - Funding Issues
    - Bridge Funding
- Laboratory Comparative Review
- Concluding Remarks

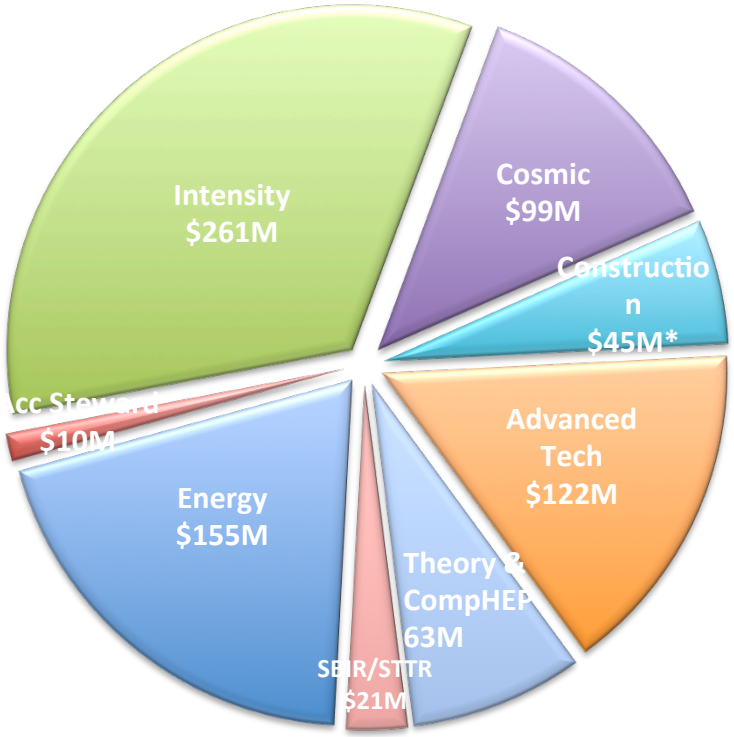
The context



U.S. DEPARTMENT OF ENERGY
Office of Science

The Context

By "Frontier"



The theory budget in DOE is a small fraction (about 6 -7%) of a much larger budget which sustains the entire HEP infrastructure in the US (Energy, Cosmic and Intensity frontier experiments, Accelerator R&D and detector R&D).

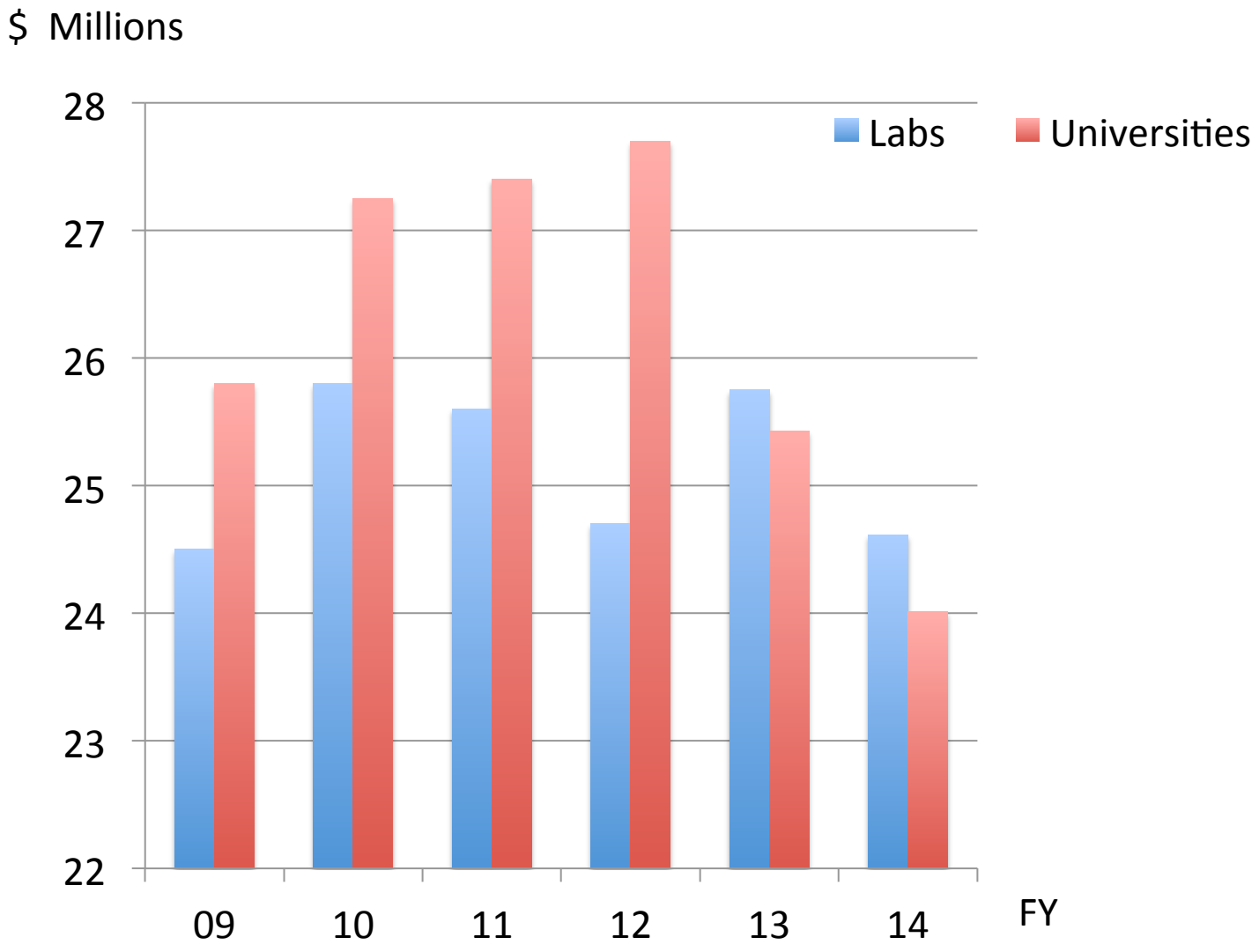
While we all agree that Theory is important, the reality is that the overall primary HEP budget driver is the experimental program (experimental R&D, facilities, etc.). This is an undeniable reality. However, a healthy, well-rounded Theory program is also essential in order to achieve maximum return from these other investments.

* Includes Other Project Costs (R&D) for LBNE

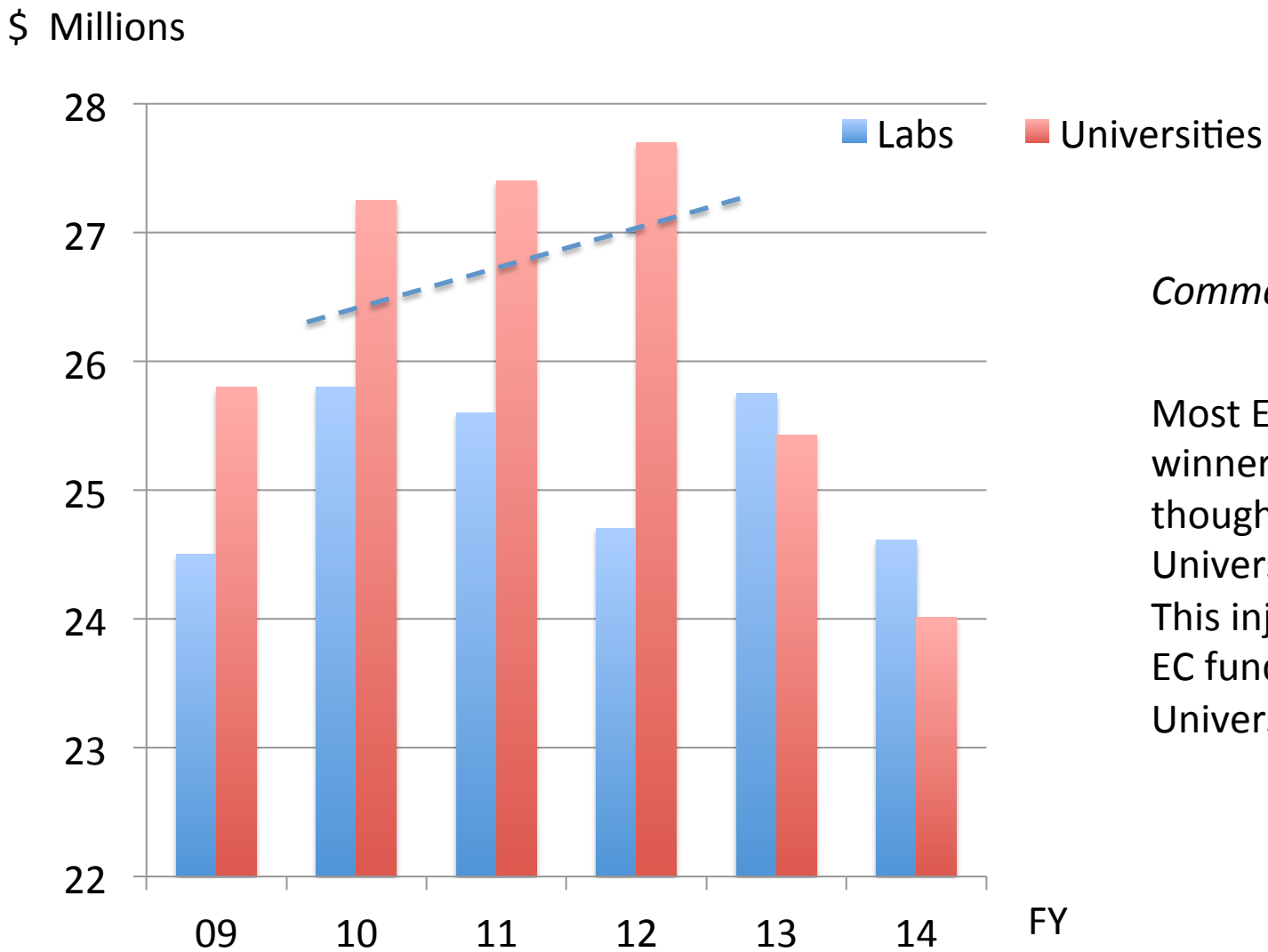
HEP Theory Portfolio

- Topics studied in theoretical high energy physics research *include, but are not limited* to: **phenomenological and theoretical studies that support experimental HEP research at the three frontiers**, both in understanding the data and in finding new directions for experimental exploration; **development of analytical and numerical computational techniques for these studies**; and **construction and exploration of theoretical frameworks for understanding fundamental particles and forces** at the deepest level possible.
- The program is centered across several research areas:
  - 1) **Standard Model Phenomenology**, which involves high precision calculations of Standard Model predictions such as Monte Carlo simulation, higher order calculations of particle production rates and distributions, radiative corrections, and extraction of parton distribution functions;
  - 2) **Beyond the Standard Model Phenomenology**, which studies the experimental consequences of extensions of the Standard Model as well as the search for new particles given their signatures in collider and astrophysical sources, and in rare processes;
  - 3) **Cosmology and Astroparticle** theory, which studies the early universe, inflation scenarios, large scale structure formation, particle models for Dark Matter and prospects for its detection, Dark Energy and its theoretical consequences, quantum gravity and black holes;
  - 4) **Lattice Field Theory**, which involves the study and simulation of lattice models of quantum field theory and its phenomenology;
  - 5) **Formal** and mathematical aspects of quantum field theory, including string theory.

Theory Funding Profile



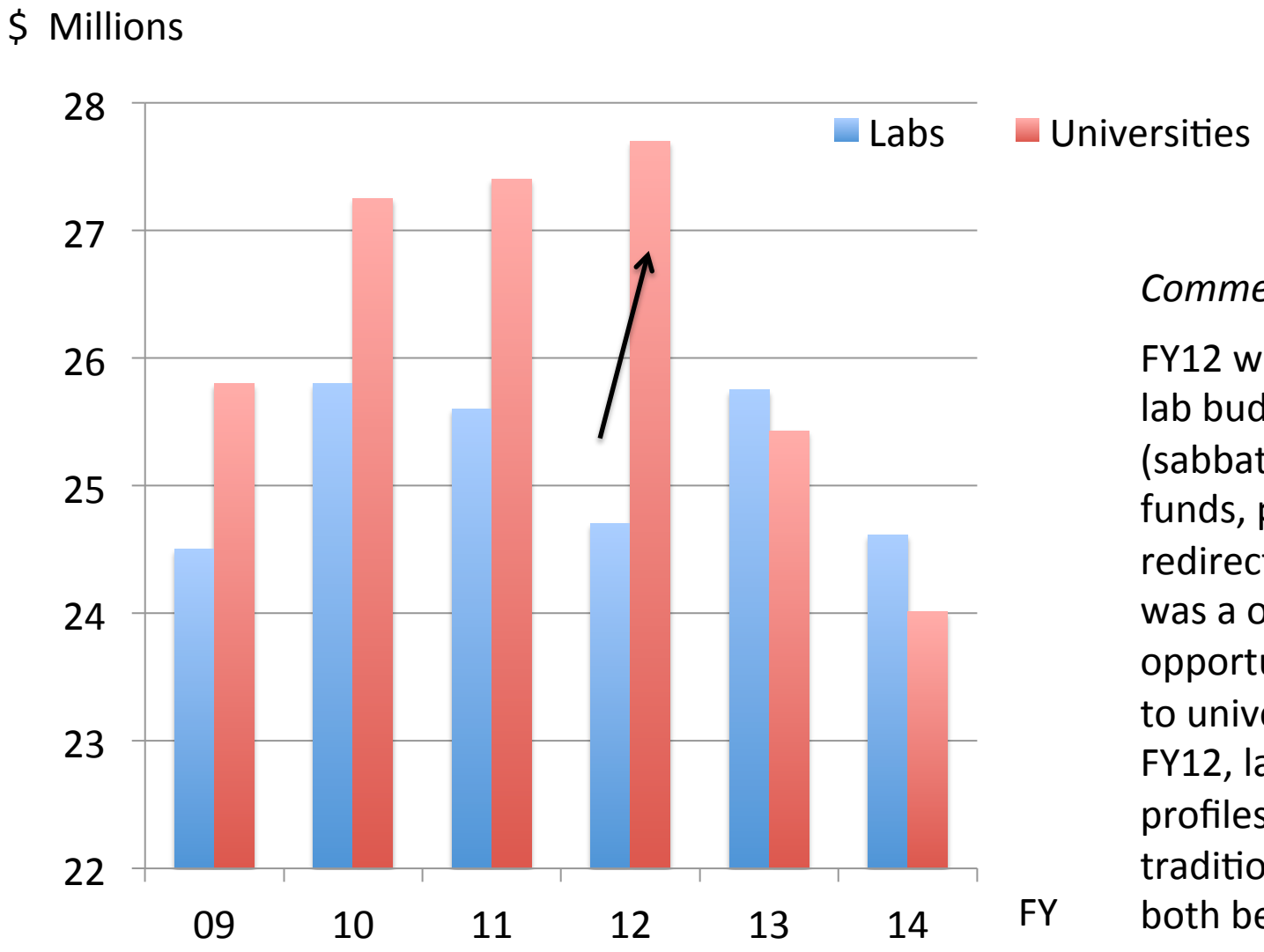
Theory Funding Profile



Comment #1:

Most Early Career winners in FY10 thought FY12 are from Universities, not Labs. This injected one-time EC funds into the University budget.

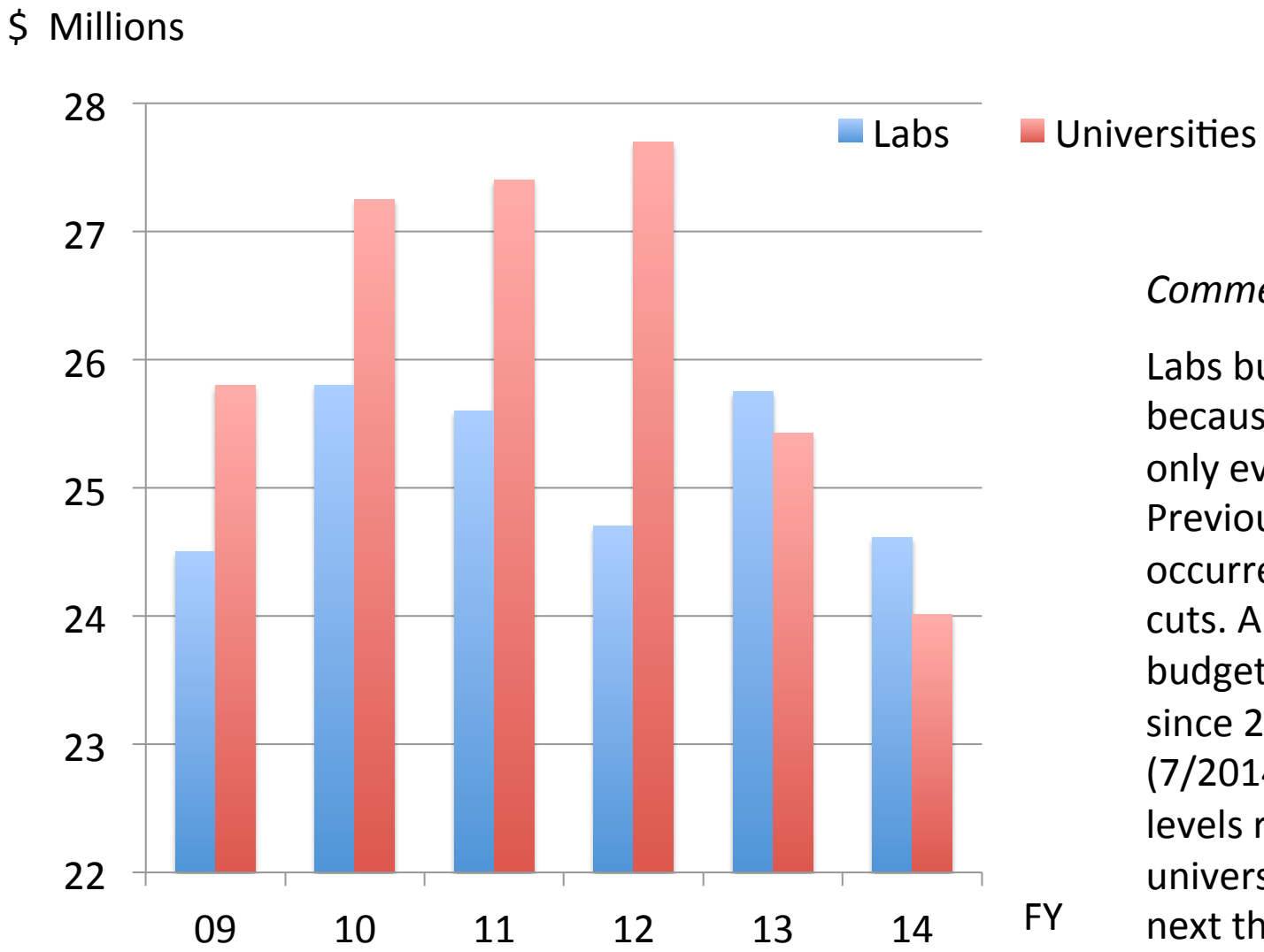
Theory Funding Profile



Comment #2:

FY12 was an anomaly: the lab budget had a surplus (sabbaticals, carry-over funds, personnel redirection, etc.) --- this was a one-time opportunity to shift ~$1M to universities. After FY12, lab and university profiles resumed their traditional balance and both began experiencing cuts.

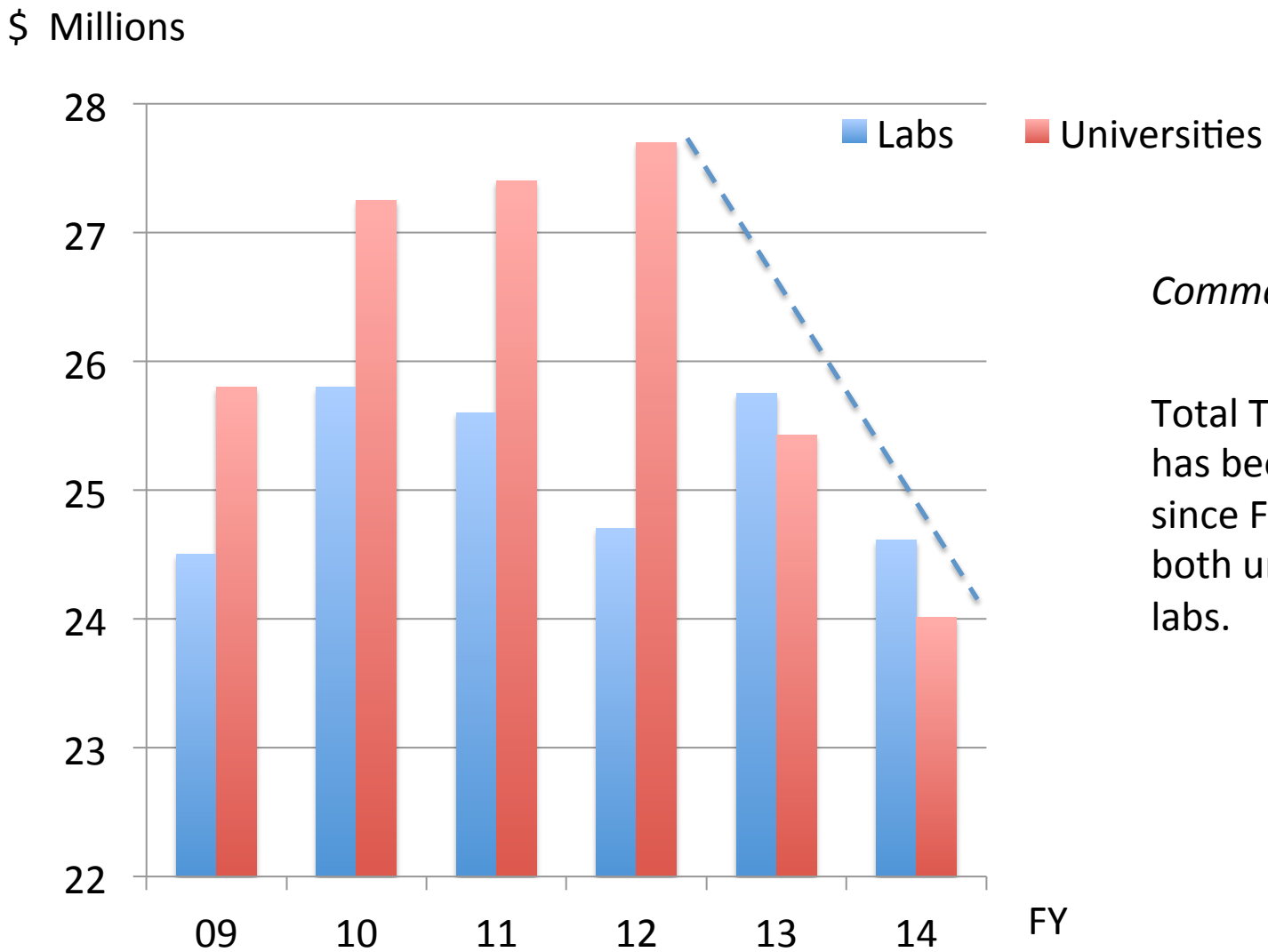
Theory Funding Profile



Comment #3:

Labs budget more stable because reviews occur only every three years. Previous review (2011) occurred prior to recent cuts. Although lab budgets have been cut since 2011, next review (7/2014) will reset lab levels relative to universities levels for the next three-years cycle.

Theory Funding Profile



Comment #4:

Total Theory budget has been declining since FY12 --- affects both universities *and* labs.

Total Theory Budget

EC = Early Career awards

	Universities	Labs	Total
FY10	**27.25M**	**25.83 M**	**53.09 M**
FY11	**27.42M (incl. 450K for EC)**	**25.63 M**	**53.06 M**
FY12	**27.71 M (incl. 900K for EC)**	**24.72 M**	**52.43 M (-1.17%)**
FY13	**25.44 M (incl. 1.2M for EC)**	**25.75 M (incl. 488K EC)**	**51.19 M (-2.4%)**
FY14 *	**24.01 M (incl. 2.0M for EC)**	**24.62 M (incl. 493 EC)**	**48.63 M (-5.0 %)**

*FY14 is not final yet and there may be additional funding provided

COMMENT #1: **Early Career awards are helping to support the the total University base budget, but are reserved for EC winners. Unlike remainder of budget, EC funds are *immune* from all future budget cuts. Total EC Theory awards since inception in FY10: 14 to universities, 2 to labs (not including current year).**

Total Theory Budget

EC = Early Career awards

	Universities	Labs	Total
FY10	**27.25M**	**25.83 M**	**53.09 M**
FY11	**27.42M (incl. 450K for EC)**	**25.63 M**	**53.06 M**
FY12	**27.71 M (incl. 900K for EC)**	**24.72 M**	**52.43 M (-1.17%)**
FY13	**25.44 M (incl. 1.2M for EC)**	**25.75 M (incl. 488K EC)**	**51.19 M (-2.4%)**
FY14 *	**24.01 M (incl. 2.0M for EC)**	**24.62 M (incl. 493 EC)**	**48.63 M (-5.0 %)**

*FY14 is not final yet and there may be additional funding provided

COMMENT #2: **Since FY12, Theory budget has been declining.**

Cumulative cut since FY11: -9.2%.

(Other Frontiers cut equally or worse)

Lab vs. University allocations

- **Universities** are funded through *grants* ("financial assistance"). DOE-HEP can offer a grant or not, based on available budgets. Selection is made through University Comparative Review. Grants typically have three-year cycles; review takes place upon renewal (once per three years).
  - University program includes approximately 80 groups funding approximately 220 PI's, 100 postdocs, 120 grads.

- **Laboratories** are DOE facilities. They are managed/funded through *contracts*, and the laboratory management hire/fire research personnel, including theory personnel. In general, the lab budget pays 100% of the salaries of lab personnel. DOE controls the top-level budget lines, but lab management determines its distribution *within* individual budget lines. Thus, DOE's ability to sculpt/shape profiles of individual lab theory groups is more indirect. Again, assessment is made through Laboratory Comparative Review. All assessments are made simultaneously in a single Comparative Review held every three years (next one: July 2014).
  - Laboratory theory groups with HEP personnel: Argonne, Brookhaven, Fermilab, Lawrence Berkeley Lab, Lawrence Livermore Lab, Los Alamos, SLAC. Total: approximately 50 PI's, 25 postdocs.

Summary of Part I

- This is the overall budgetary situation affecting Theory.

- **Total theory budget is not determined by any individual Program Manager, but at the level of the entire Office of High-Energy Physics, following a game-plan proposed and endorsed by the high-energy physics community through their representatives on the 2008 P5.**

- Whether or not this plan continues to make sense is a valid topic for community discussion through its legitimate feedback mechanisms:
  - HEPAP
  - P5
  - COV (Committee of Visitors, a committee of external physicists which oversees DOE-HEP operations every three years and makes operations recommendations).

- Constructive input from other bodies (e.g., APS/DPF) is also welcome. While comments and suggestions from individuals or groups of individuals are also welcome, those which are constructive, informed, and realistic will have the greatest chance of impact.

Part II

Given an annual Theory budget, the Program Manager (in this case, me) is ultimately responsible for recommending the relative allocations across the entire program.

Decisions of Program Managers are not made in isolation ---

- External reviewers are consulted for each proposal.
- Since FY12, members of a Comparative Review Panel also provide assessments and rankings.
- Program Managers also weigh programmatic needs and Office priorities.
- DOE-HEP line of management subsequently must "concur" with all recommendations of Program Managers.

This procedure is not unique to DOE.

For example, for many years NSF has been following exactly these same procedures, as do many grant-giving federal agencies.

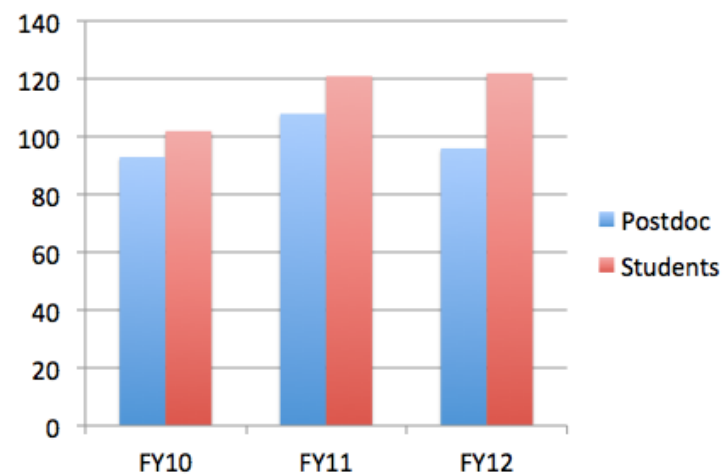
The Annual Budget Process

- I receive an allocation from DOE-HEP leadership = my total budget for that fiscal year.
- First, I make payments for second-year continuations on grants made in previous year (~16%).
- Second, I make payments for third-year continuations on grants made two years earlier (~16%).
- Third, I pay previous commitments for labs (~50%).
- Residual funds are then available for new grants, renewals, supplements, conferences, summer schools, etc. etc. (~16%)
- *Thus, Comparative Review only helps to determine how this remaining piece of the pie is divided.* Commitments from previous years (for both universities and labs) can greatly affect the size of available funds (for both universities and labs). Thus, the Program Manager must aim to balance the program fiscally across many years at once, even in the face of uncertain (and even declining) budgets. **A single-year snapshot is not sufficient.**

Fiscal-Year Timeline & Postdoc Hiring

- HEP budget operates according to a given **Fiscal Year**:
  - **FY12:** Proposals submitted 11/2011, Panel 1/2012, decisions announced 3/2012. Given postdoc hiring season scheduling in Theory, postdocs hired from this money started *Fall 2013*.
  - **FY13**: Proposals submitted 9/2012, Panel 11/2012, decisions announced 2/2013. Postdocs start *Fall 2014*.
  - **FY14**: Proposals submitted 9/2013, Panel 11/2013, decisions announced 1/2014. Postdocs to start *2015*.

- Thus, the 2012 hiring season is the result of FY11 budgets, which *precede* the current round of cuts. Indeed, postdoc and student market was steady through FY12, reflecting the steady total budget that existed through FY11.
- By contrast, decline in total Theory budget which started in FY12 (recall slide #12) can be expected to have significant effects in 2013 and 2014 hiring seasons. Final data does not exist yet, but strong anecdotal evidence suggests a significant decline which indeed matches the decline in the total Theory budget.



Total theory budget vs. Comparative Review

- Note that the decline in the total Theory budget began very soon (one year) after the Comparative Review was implemented.
- **However, these are independent events. "Comparative Review" and "budget cut" are not synonymous.**
- Comparative Review affects *relative* grant sizes, but not their *overall scale*. By contrast, the total theory budget affects the overall scale.

"Bridge" funding

To make matters worse, another (independent) effect entered the scene at roughly the same time: ***the need to synchronize grants to the same start date (April 1) across the entire program***. This affected all programs within DOE-HEP, not just Theory. ***This was done in order to provide long-term stability to the HEP program***, given that final Congressional budget appropriations are not always available prior to this date.

This had a significant effect in FY12, FY13 and FY14, since extra months of funding had to be provided to "bridge" each group to the new start date. This extra bridge funding had to come out of the **same FY allocation** as all other grant actions, further reducing the effective size of the total Theory budget.

- *Example:* Imagine a grant with previous start date of October 1. Upon renewal, their first-year allocation must provide 18 months of funding, not just the usual 12. **This comes out of the single total Theory budget for that fiscal year**. If all grants in the program started October 1, this would represent an effective cut of 33% across the program.
- In reality, different groups had different starting dates. Overall, the net effective cut due to bridge funding turned out to be approx. 15-20% across the program each year (bridge/(new+renewal+bridge)). (Effects were slightly mitigated in FY12 due to one-time lab/university transfer and were worse in FY14 due to other budget constraints.)
- ***This is temporary***, and will no longer be an issue starting next year. All grants are now successfully synchronized.

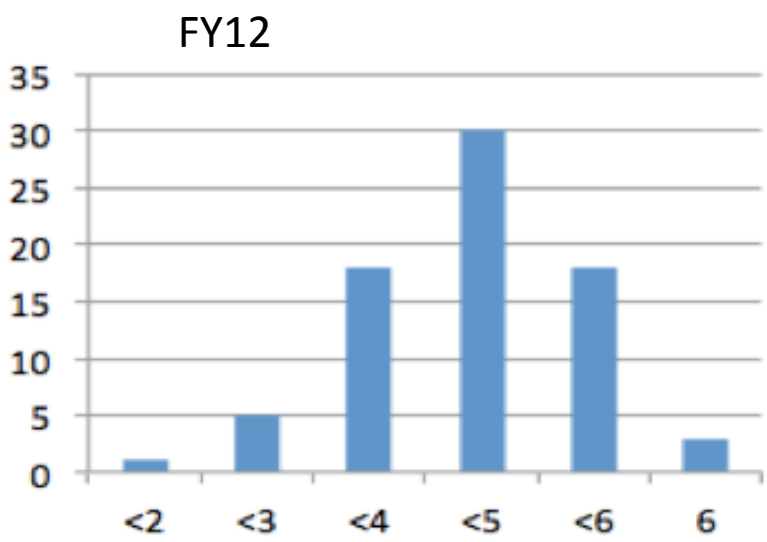
Comparative Reviews

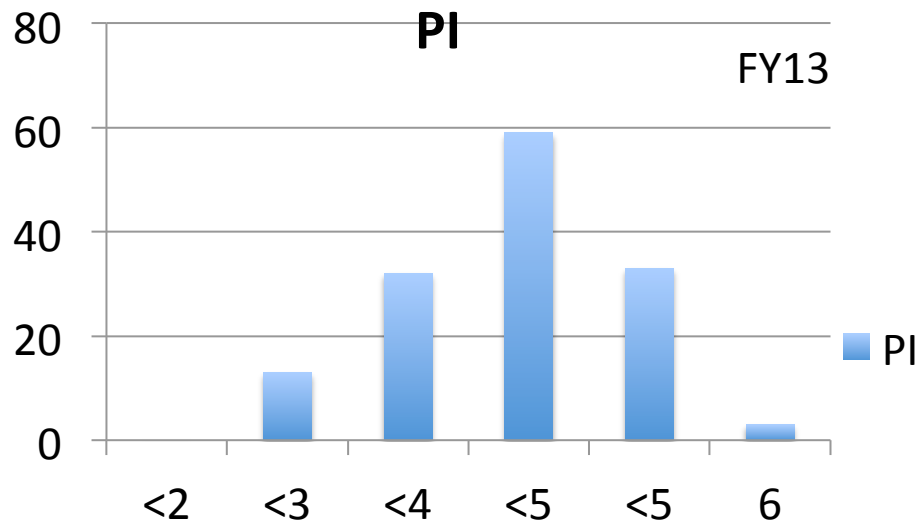
- DOE/HEP started undertaking a round of comparative grant reviews for existing research grants which were scheduled for renewal in FY2012 (+ any new proposals as desired)
  - Existing grants which did not renew in FY2012 ("continuations") were not affected by this change in the 1st round
- Previously all HEP proposals responding to the general Office of Science (SC) call were individually peer-reviewed by independent experts.
- This change in process had been recommended by several DOE advisory committees, including the 2010 HEP Committee of Visitors (COV):
  - "In several of the cases that the panel read, proposal reviewers expressed negative views of the grant, but only outside of their formal responses. Coupled with the trend in the data towards very little changes in the funding levels over time, this suggests that grants are being evaluated based on the historical strength of the group rather than the current strength or productivity of the group. This is of particular concern when considering whether new investigators, new science, or high-risk projects can be competitive. Comparative reviews can be a powerful tool for addressing these issues and keeping the program in peak form."
  - Recommendation: Use comparative review panels on a regular basis.
  - Endorsed by the 2013 COV
  - Routinely used at other agencies (NSF)

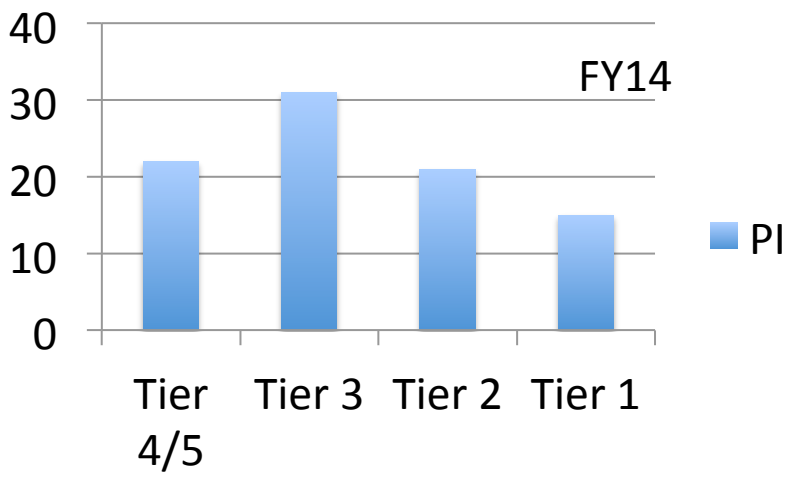
Statistics

Proposals Reviewed	Proposals Funded	Proposals Declined	Young PI Funded	Young PI not funded	PI Not previously funded
FY12					
37 (66 PI)	22	15	3	5	8
FY13					
53 (146 PI)	35	18	13	2	11
FY14					
33 (89 PI)	16	17	2	2	1

PI ranking


FY12
35
30
25
20
15
10
5
0
<2
<3
<4
<5
<6
6


PI
FY13
80
60
40
20
0
<2
<3
<4
<5
<5
6
PI


FY14
40
30
20
10
0
Tier 4/5
Tier 3
Tier 2
Tier 1
PI

Funding Allocation & Comparative Review

- Comparative Review Panels are a new procedure for DOE-HEP. Therefore, the manner in which funding allocations were determined (in relation to Panel rankings) evolved somewhat during the period from FY12 to FY14.

- ***Ultimately, in FY14, a method was used which mirrors that employed at NSF, and which determines grant sizes according to the ranking of the individual PI's involved, regardless of the PI's previous history. This makes sense for a theory program, given that there are no fixed equipment costs and only salaries are involved.***
  - ***As a result, theorists who are ranked higher are given more funds, per PI, than theorists who are ranked lower. Theorists whose rankings were below a certain cutoff were defunded completely, as recommended by the Panel, in order to provide more funding at the top.***

- Even though FY13 allocations had not been determined this way, the funding allocations for FY13 were reviewed using the FY14 procedures and it was verified that no large variations exist. In particular, only two groups out of the 35 groups funded in FY13 received a level of funding more than 20% below what would have been provided according to FY14 procedures. Similar for FY12.
- FY14 procedures will now guide future decisions. In this way, all groups are treated equitably and fairly according to current perceived scientific merit, as judged by external Panel of experts.

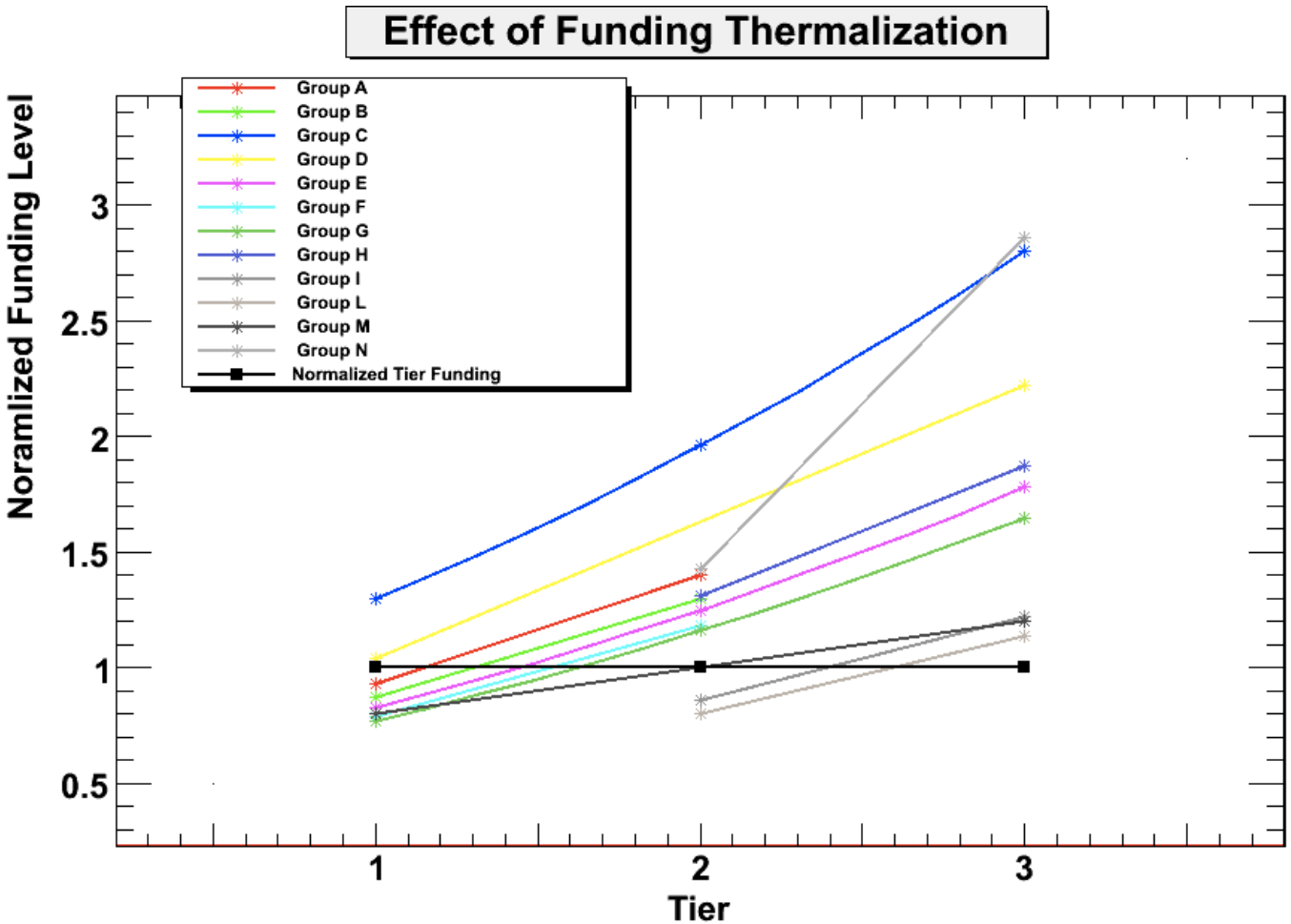
Funding Allocation & Comparative Review

- **<u>Note that previous funding levels are irrelevant in Comparative Review. Everyone "recompetes" from zero in each new competition, based on current merit and current budget baselines</u>**.
  - Thus, the program remains flexible and dynamic.
  - Allowances are made in (rare!) cases of large fluctuations, where grads or postdocs might otherwise be stranded, **<u>but this is only to soften a strong derivative.</u>**

The relative size of the "cut" for any given group (relative to their previous history) reflects three things:

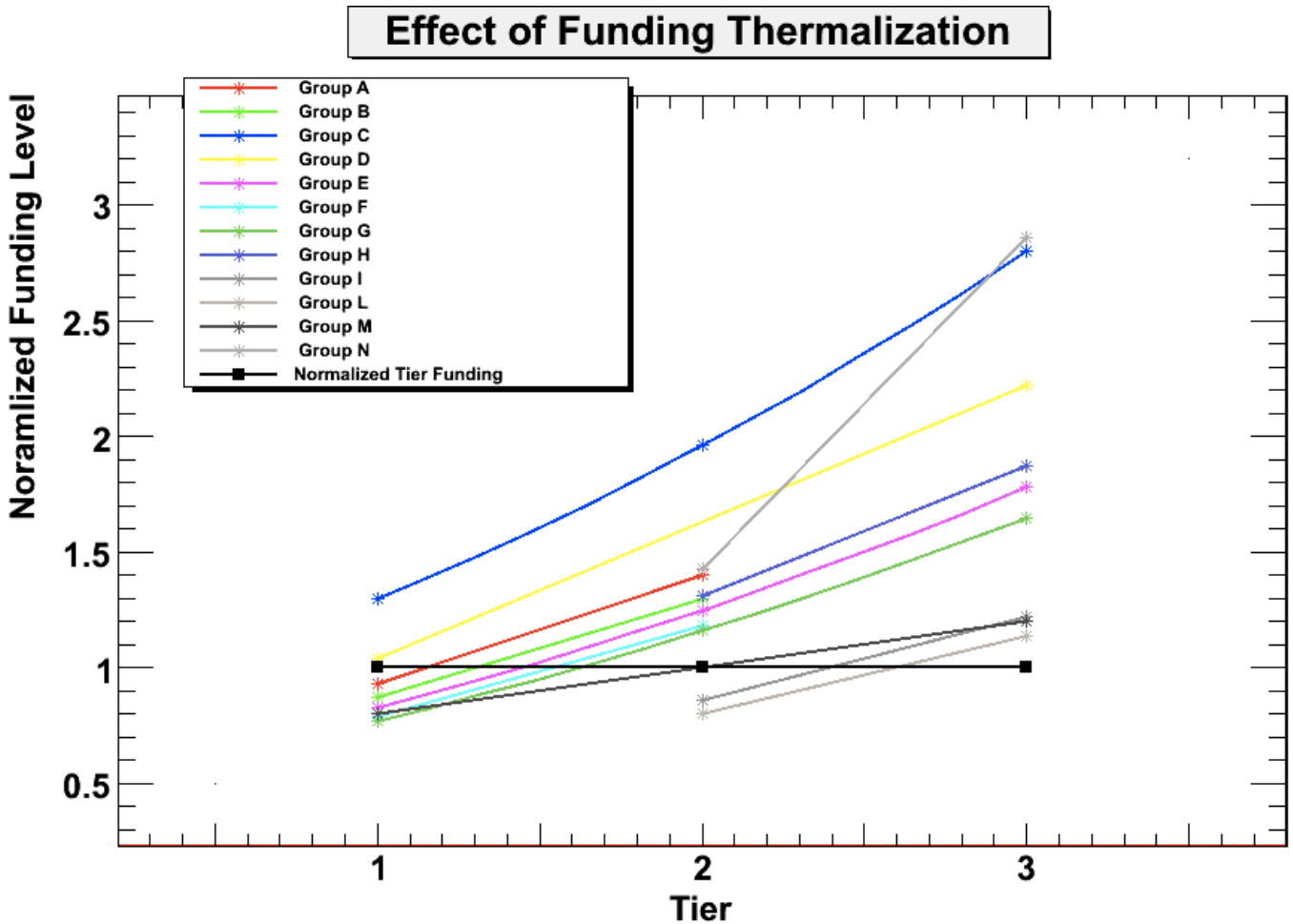
- The size of the cut experienced by the total Theory program (including bridge funding during this first round).
- The perceived *current* scientific merit of the group, as evaluated *today*.
- The degree to which the group's historical funding profile might have been out of synch with the rest of the program … a situation which is no longer sustainable in today's budget climate.

Funding levels are now "thermalized" to merit



- Each PI is ranked in a "Tier" with similarly ranked PI's, and allocated a funding level associated with that Tier (normalized to 1) = black line.
- For each tier, we also show (color) the spread of *previous* normalized funding levels for the PI's in that tier.
- This spread in funding levels is historical, has no basis in current comparative merit within a given tier, and has now been eliminated.
- Lines are connected across different tiers to indicate different groups.

Funding levels are now "thermalized" to merit



Comments:

- In top tier (Tier 1), "thermalization" has brought the majority of PI's up, but a few down.
- In lower tiers (2 and 3), thermalization has tended to reduce funding levels for most PI's.
- Not shown are Tiers 4 and 5, which were defunded completely.
- Reductions of funding levels in lower tiers reflects the cut in the total funding level for the entire Theory program.
- As evident, effort was made to shield the top-ranked PI's from these cuts.

Laboratory Comparative Review

- **All Laboratory Research Groups** (experimental frontiers, Theory, and Detector R&D) have been undergoing Comparative Review **since 2008**.
- In particular, **Theory groups** at Labs were evaluated in **2008** and **2011**. Their next review is scheduled for **Summer 2014**.
- Panels evaluate all laboratory theory groups at once and make recommendations on how to best allocate resources to labs, indicating areas of weakness and strength.

"Several important components of the laboratory theory group mission are: support for experimental programs at the laboratory; support and development of infrastructure, including software, and its exploitation; leadership in defining the national and international strategy for the HEP program; and training of the next generation of theorists in the context of a mission-oriented approach to research. The HEP Program requires theorists in this role."
(Laboratory Groups Theory Review 2011 --- Final Report)

- The recommendations of the Lab Comparative Review Panel are forwarded to lab management for implementation, and the DOE-HEP budget line is adjusted accordingly.

- **Laboratory groups have been affected by budget cuts in ways similar to University groups.** *For example:* At one prominent lab there has been a 30% reduction in Postdocs between FY12 and FY14; 9.5% reduction in permanent personnel; 20% reduction in student support.

Concluding Remarks

- The Theory program at DOE-HEP is an integral part of a much larger portfolio sustaining the entire HEP infrastructure in the U.S.;
- The Research Budget has been declining in the last 3 years, due to priority shifting of resources to projects;
- The Theory budget has been cut, together with the budget for research in all other experimental frontiers.

Do Research Program % cuts have disproportionate impact on Theory?

It is plausible though not proven that many Theory groups were operating "close to the edge" (budget-wise) prior to budget cuts to the Research Program. Traditional HEP funding per PI in Theory is less than Experimental HEP by 30-40%, and previously supported on average PI + 1/2 postdoc + 1 grad student. Inflation has eroded this purchasing power over the years and PIs have been forced to rely more heavily on TAs and other sources of funding.

Experimental HEP groups (particularly Energy Frontier) have taken similar cuts in FY12-14 but have on average managed better, likely a combination of having more "cushion" and PI's discretion on how to allocate resources.

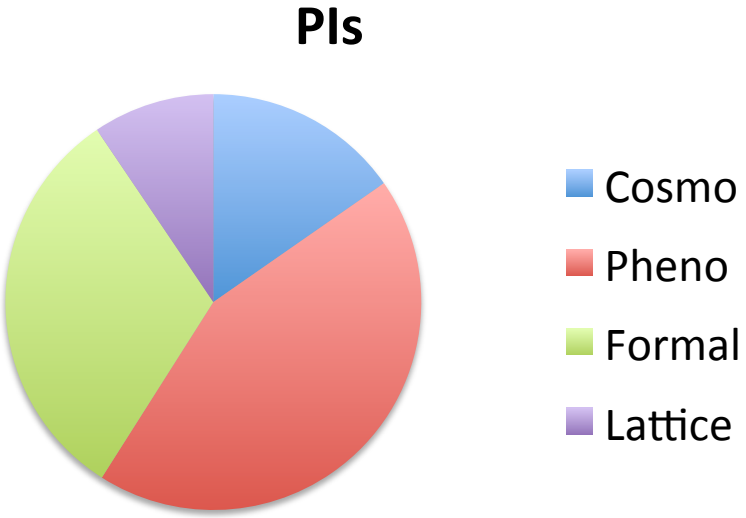
Backup Slides

Demographics Universities (FY12)

Postdocs: 95 FTE (0.43/PI)
Students : 122 FTE (0.55/PI)

Total: 221 PI
Cosmo 34
Pheno 97
Formal 70
Lattice 20

- Comp Rev 2012: 45 PI
  - Cosmo 12
  - Pheno 16
  - Formal 16
  - Lattice 1
- Comp Rev 2013:114 PI
  - Cosmo: 16
  - Pheno 57
  - Formal: 31 passed
  - Lattice 14 passed
- Comp Rev 2014: 58 PI
  - Cosmo 6
  - Pheno 24
  - Lattice 5
  - Formal 23

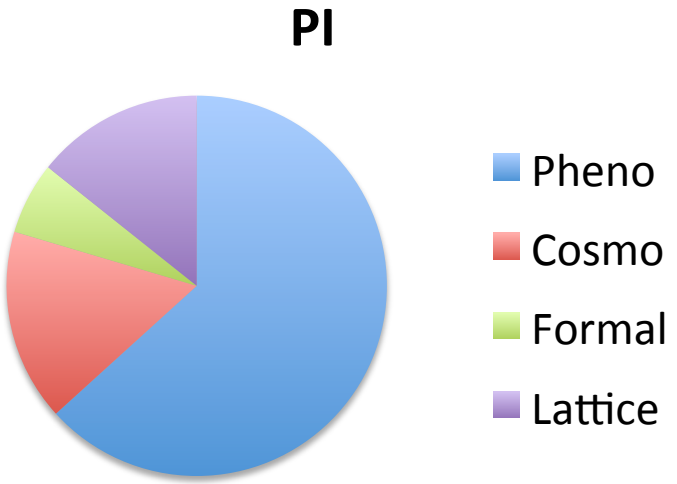


Demographics Labs (FY12)

Postdocs: 28.5 FTE (.58/PI)
Students: 7.4 FTE (0.15/PI)

Total: 49 PI
Pheno 31
Cosmo 8
Lattice 7
Formal 3

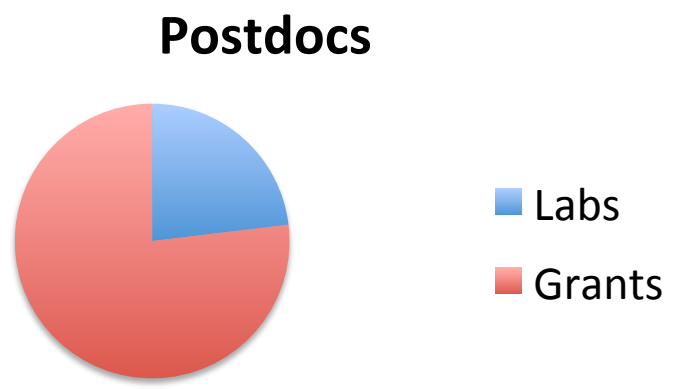
- FNAL
  - Astro 5 (3 RA)
  - Particle Physics (8 RA)
    - Pheno 12
    - Lattice 3
- SLAC
  - KIPAC 3 (1.5 FTE) (1.5 RA, 1.4 GS)
  - Particle Physics (7 RA, 7 GS)
    - Pheno 6
    - Formal 3 (2)
- BNL (3 RA)
  - Lattice 3 (+1)
  - Pheno 4
- LBNL (2 RA)
  - Pheno 3
- ANL (4 RA)
  - Pheno 6
  - Formal 1 (phased out)

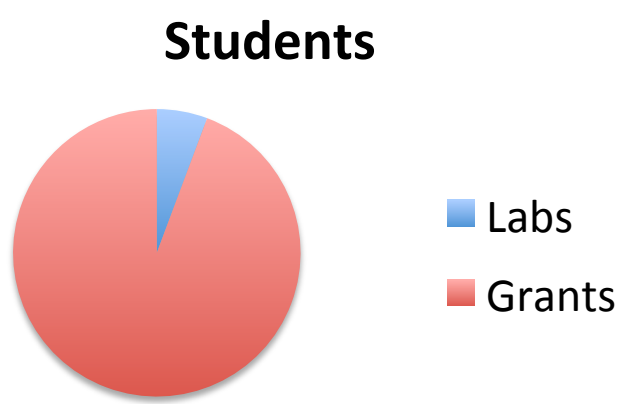


Students and PD at Universities

- Comp rev 2012 group
  - Students 30 FTE
  - PD 21.65 FTE
- Comp rev 2013 group
  - Students 52.6 FTE
  - PD 47.46 FTE
- Comp rev 2014 group
  - Students 39 FTE
  - PD 26.07 FTE

Total Students : 122 FTE
Total Postdocs: 95 FTE



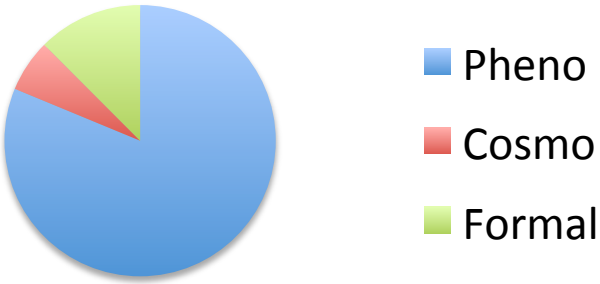


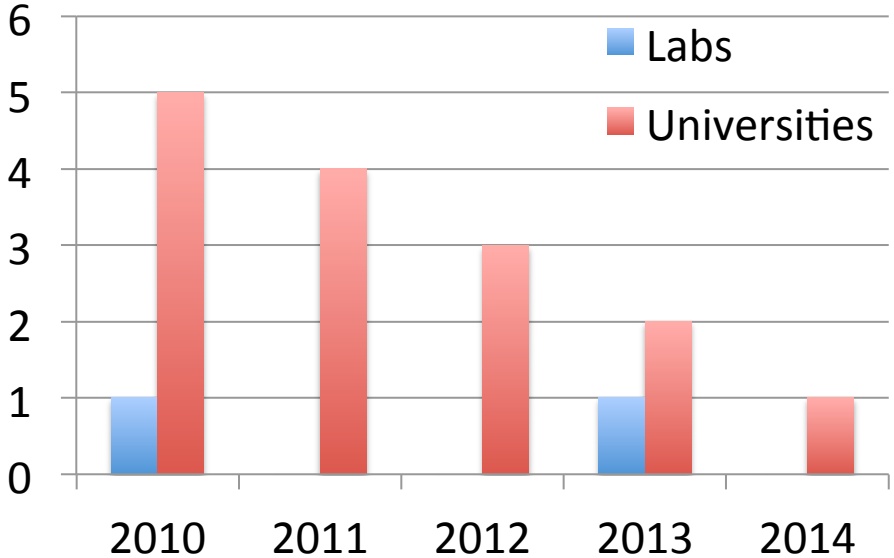
Demographics numbers refer to FY12
1FTE = 12 months

Early Career Awards (17)

- 2010: 6 awards (out of 43)
  - 5 Universities (first 4 years from ARRA 5th year to be taken from theory budget
  - 1 Lab (fully forward funded for 5 years - ARRA) 500k
  - Pheno 6
- 2011 : 4 awards (out of 45)
  - 4 Universities 600k
    - Pheno 2
    - Cosmo 1
    - Formal 1
- 2012 : 3 awards (out of 23)
  - 3 Universities 450k
    - Formal 1
    - Pheno 2
- 2013: 3 awards (out of 20)
  - 1 Lab 500k
  - 2 Universities 300k
  - 2 Pheno, 1 Cosmo
- 2014: 1 award (out of 22)

PI





The most successful Frontier in the HEP Office!