Planning Next Generation Experiments: the Constraints

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The Size (cost) of Modern Experiments makes them Projects

- HEP has recent successful projects/experiments
  1. LHC Machine Contributions
  2. LHC Detectors
  3. MINERvA
  4. BELLA and FACET
  5. Daya Bay
  6. Double Chooz
  7. DES
- Some are nearing completion
  1. APUL
  2. Nova/NUMI upgrade
  3. HAWC
  4. MicroBooNe
- Other are just starting
  1. Belle-II
  2. Mu2e
  3. LBNE
  4. g-2
  5. LSST
  6. LHC Phase 1 Upgrades
  7. LCH Accelerator Upgrades
  8. Dark Matter G2
- And others have been discussed
  1. bigBOSS
  2. Dark Matter G3
  3. Project-X
  4. LHC Phase 2 Upgrades
  5. Linear Collider

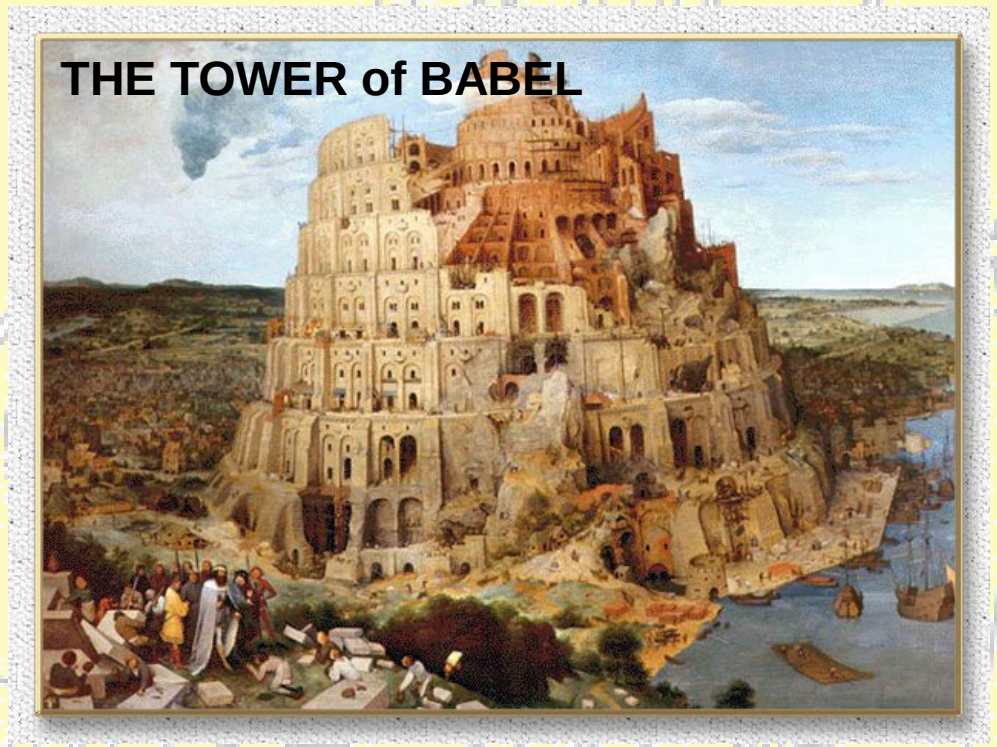
What does it take to join this club?

There is a Long History of trying to Build Big Projects

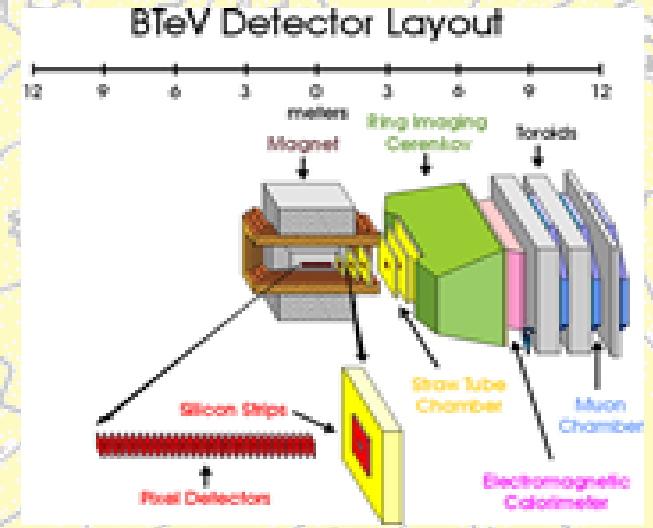
- Projects Need Community Support and a Well Written Proposal

Genesis 11-4: 'Come, let us build us a city, and a tower, with its top in heaven'

- Projects need approval (and resources) from the powers that be



- **Even when started a big project can be suddenly cancelled by a higher power**

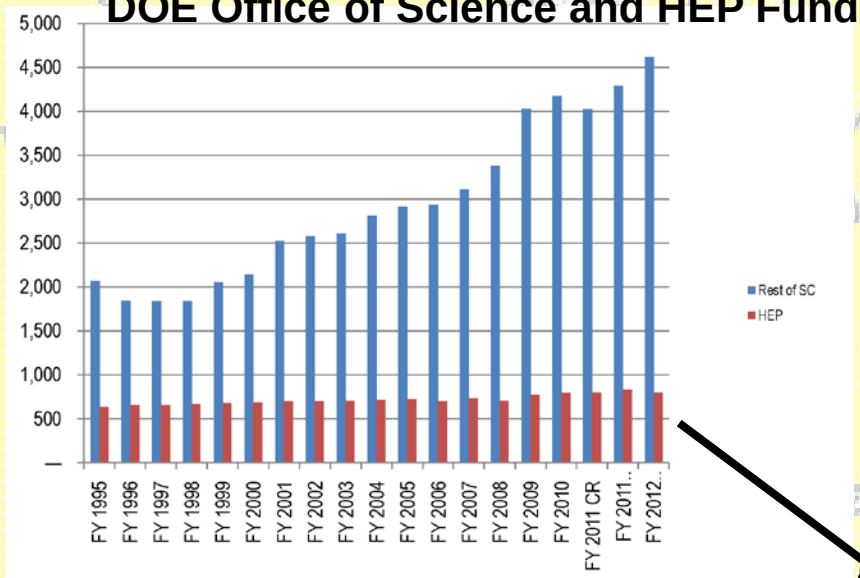


The Constraints

- HEP community experiment portfolio constraints
  1. The size and time scale of modern experiments means they do not exist in a vacuum
  2. Funding levels limit the number of experiments that can be supported in a given time frame
     - The international context must be considered
  3. Community support needs to obtained at both the grass roots and community planning process levels
     - A collaboration needs to be built
     - "Buy in" needs to be obtained among the vast majority of the HEP community
     - The project must be "blessed" by advisory committees.
- Administrative Constraints
  1. Budget Process lengthens the time scales
  2. Agencies have proscriptive guidelines for funding and administering projects
     1. Agency approval requirements lengthens the time scales
- Political Constraints
  1. Overall scientific community "buy in" for expensive projects
  2. For very big projects, societal "buy in"

US HEP Funding

DOE Office of Science and HEP Funding (M$)

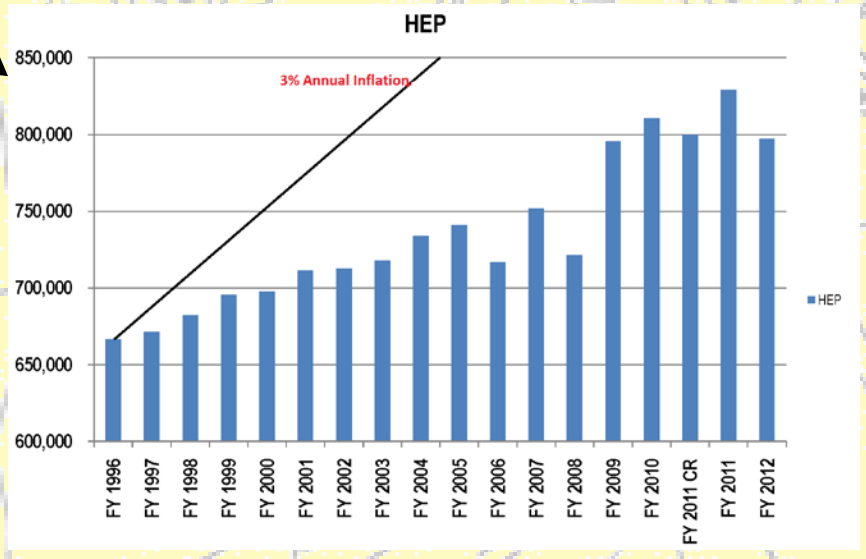


Discovery science is not a high priority

Energy independence and economic competiveness are

HEP is funding is likely to remain flat at best

"$800M is not exactly chicken feed"



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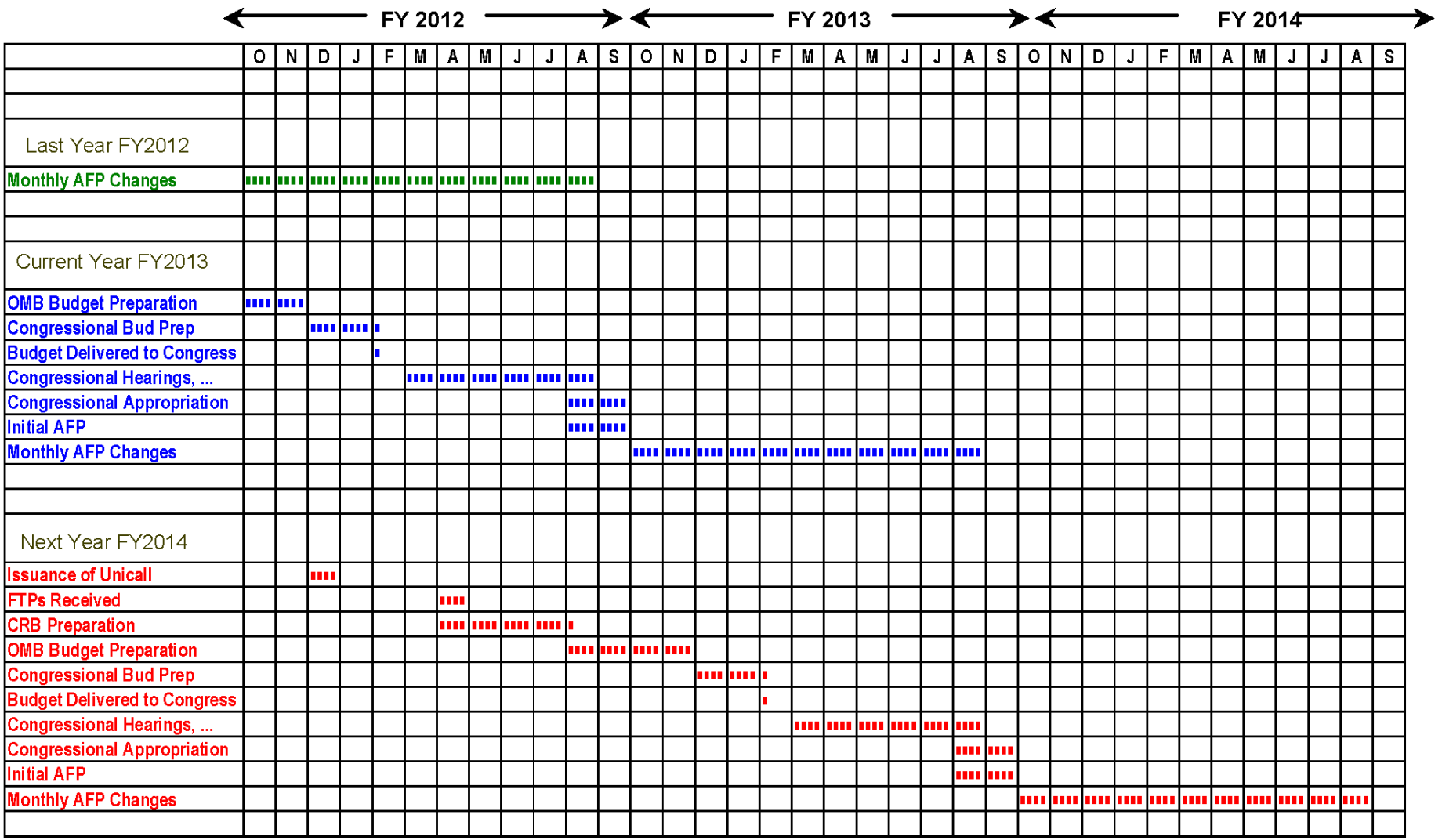
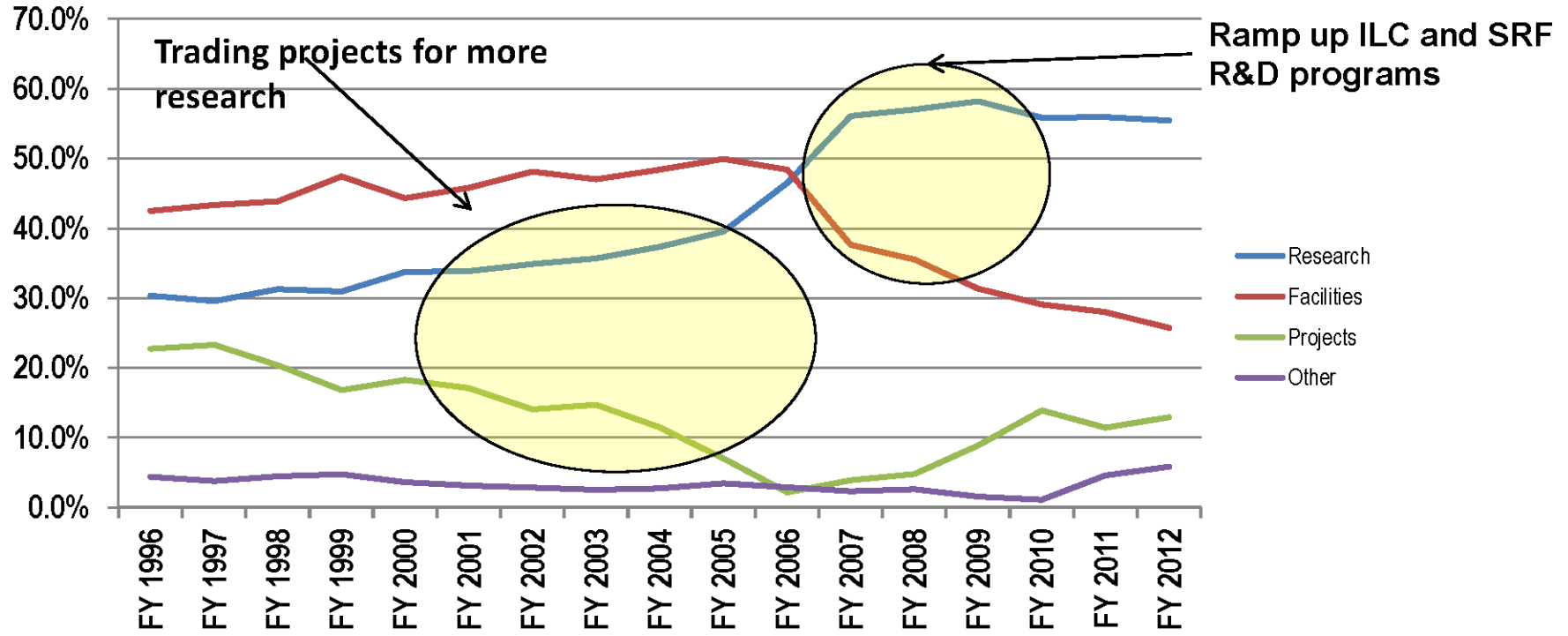
THE DOE/Office of Science Budget Cycle



The Constrainers

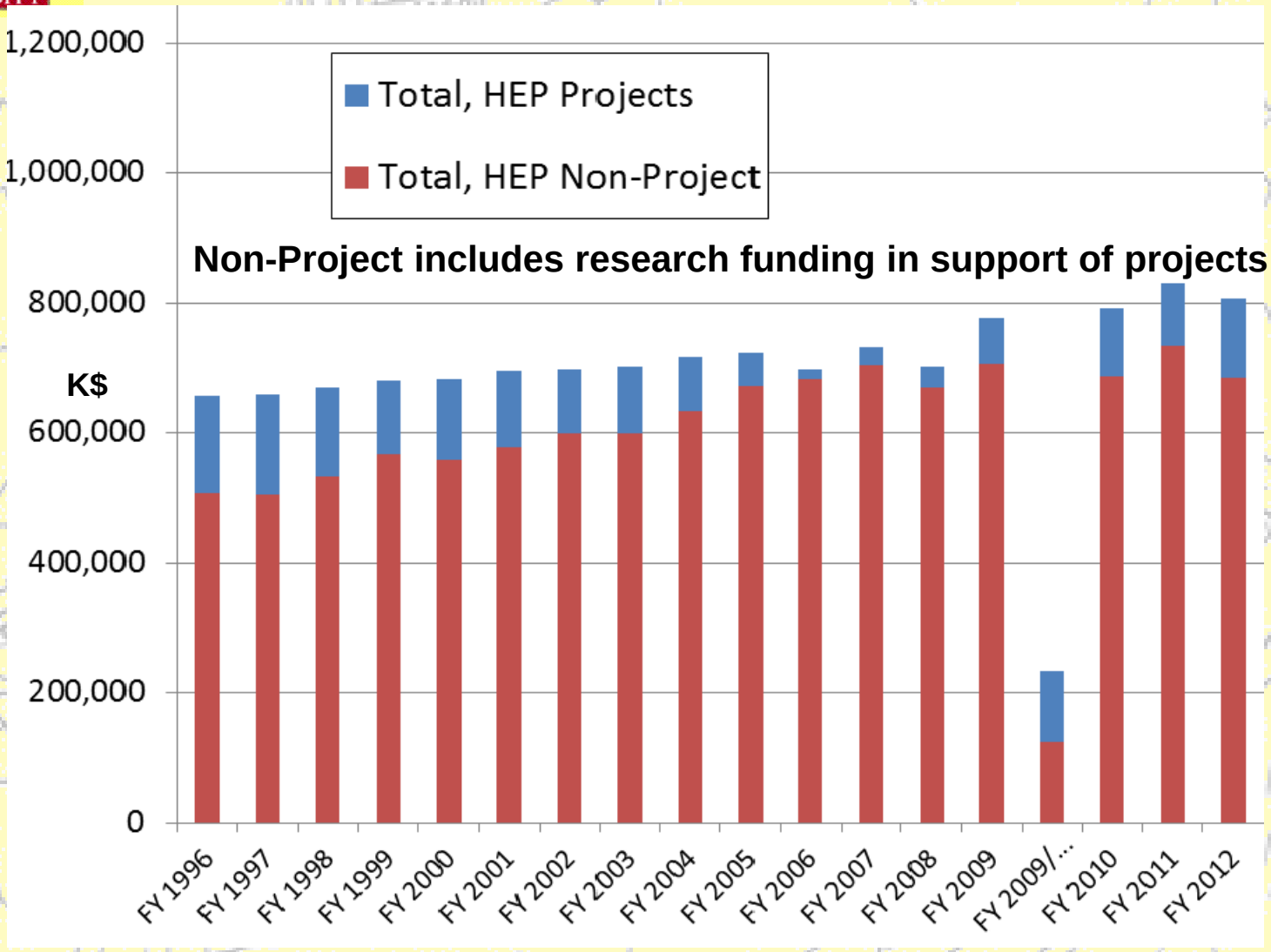
- HEP community
  - Initiate and develop the case for the experiment.
  - Tell the story – get the attention of long-range planning committees (P5, NRC, Decadal Surveys,……)
- Funding Agencies Program Offices (DOE-- OHEP, NSF -- EPP,PNA)
  - Project planning and oversight; align community goals with budget realities
- Funding Agency Management (Office of Science; NSF-MPS, NSB)
  - Oversight, project execution, balance priorities across programs, budget submission
- Office of Science and Technology Policy
  - "Optimize" the U.S. science portfolio to meet the administration's priorities; develop interagency interactions
- Office of Management and Budget
  - See that the budget (incl. science spending) meets the administration's priorities
- Congress
  - Appropriates the budget and sets its own priorities – ultimate budget control
- State Department
  - Major foreign county collaboration; international agreements

However within the funding constraints there is renewed emphasis on projects

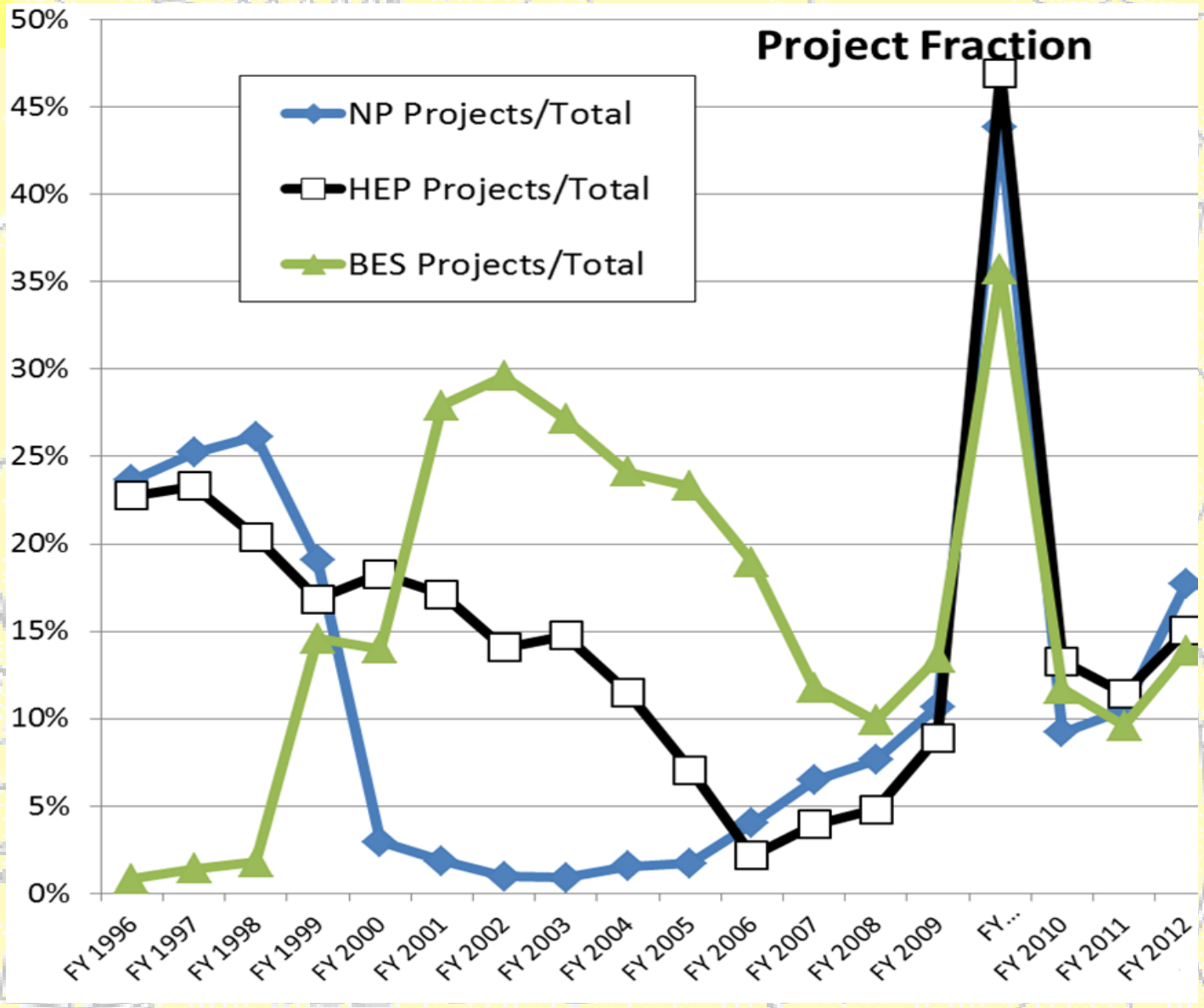


- The 2010 COV recommended an increase in the fraction of the total HEP budget devoted to projects.
- Historically this was ~20% of the budget (~$160M/year in current terms).
- NSF MREFC total budget has been slightly higher than $200M in a single year

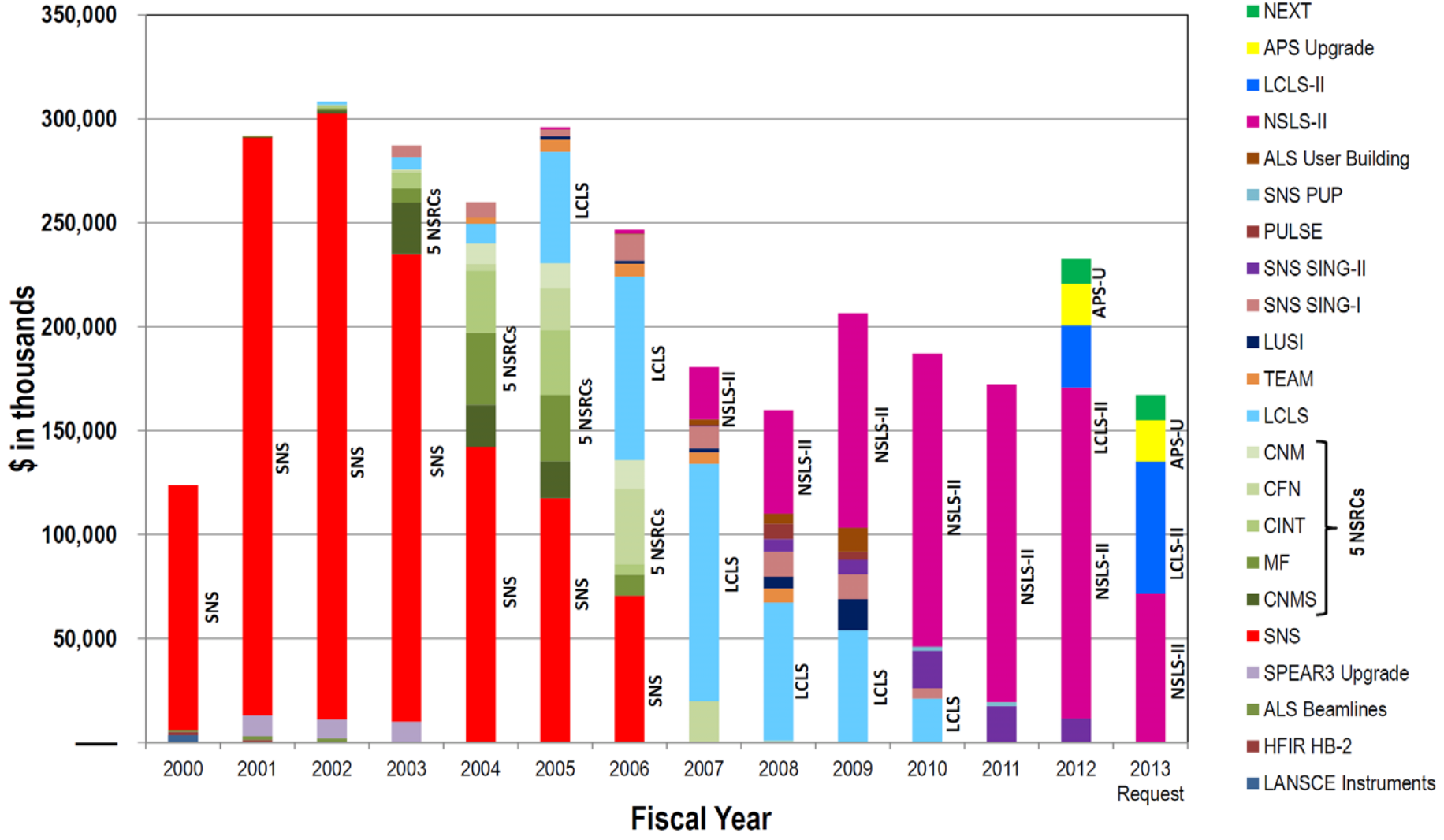
HEP Project Fraction



What is a realistic budget fraction for projects?



What has been successful?
BES Project Portfolio



The path to success

1. **Continuous significant scientific output**
   - **What have you done for us lately?**
2. **A compelling case for the science/project**
   - **The elevator speech**
3. **Community support and panel study endorsements**
   - **Do "wise people" support agree this is important?**
4. **A history of successful project execution**
   - **Can you carry this off?**
5. **A balanced research portfolio**
   - **Can you afford to do this without sacrificing output and ongoing operations?**
6. **Societal impact**
7. **Unique capability and role of the funding agency**
8. **Foreign collaboration/contributions**
   - **If you build it, will they come?**
9. **Political support**

N

Big Projects need lots of endorsements

- Bahcall Committee Report 2001
- Nuclear Physics Long Range Plan 2002
- Connecting Quarks to the Cosmos
- HEPAP Long Range Plan 2003
- Neutrinos and Beyond
- EarthLab
- Physics of the Universe
- The Neutrino Matrix
- Earth Scope
- Discovering the Quantum Universe
- Deep Science
- Nuclear Physics Long Range Plan 2007
- 2008 P5 Report

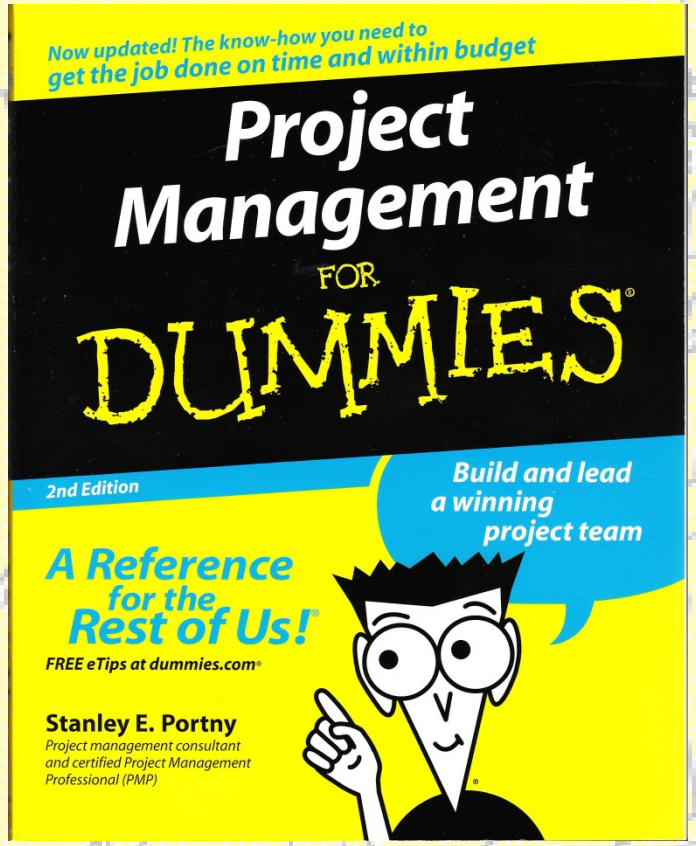
But even that was not enough to save DUSEL

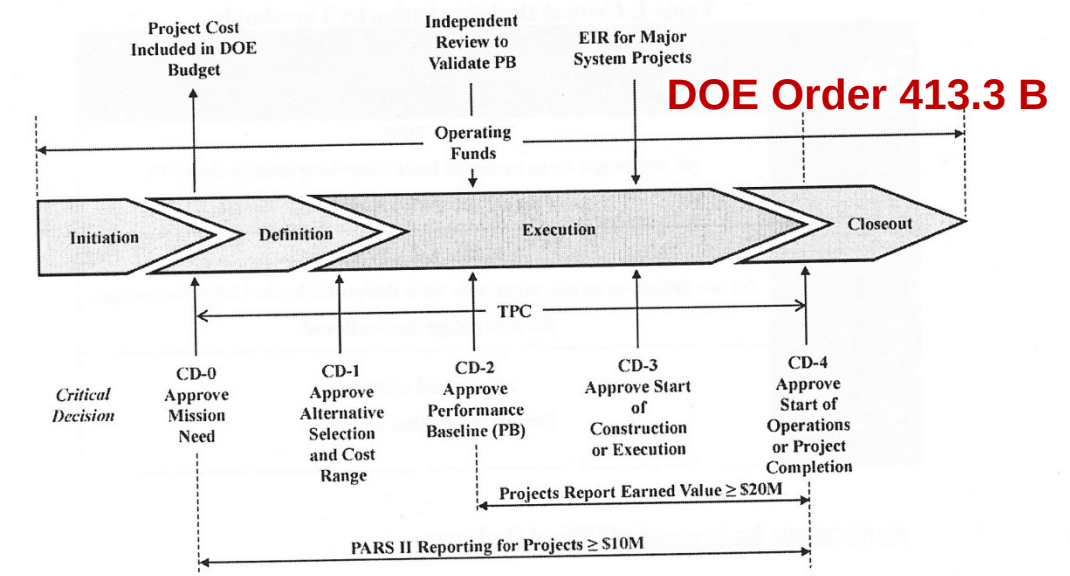
N

Major Recommendations of P5

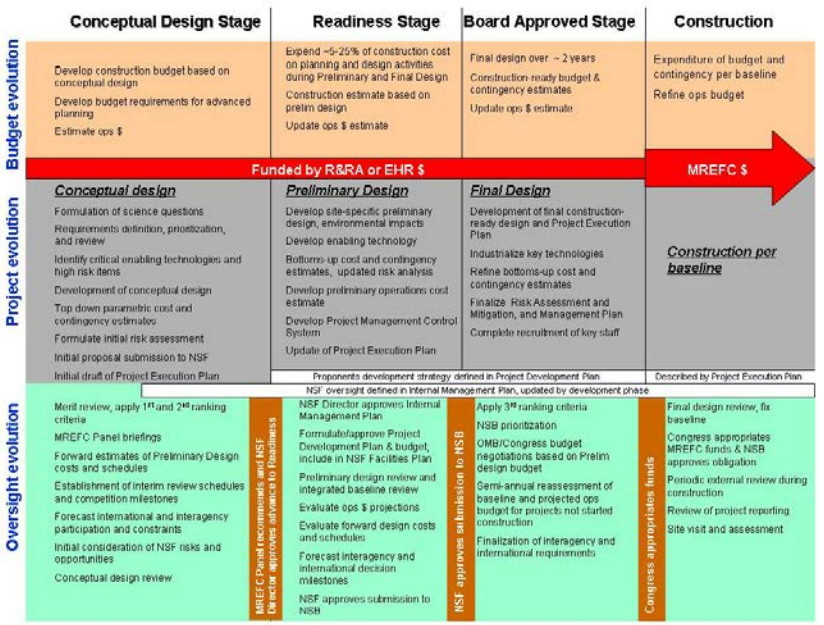
- The panel recommends that the US maintain a leadership role in world-wide particle physics. The panel recommends a strong, integrated research program at the three frontiers of the field: the Energy Frontier, the Intensity Frontier and the Cosmic Frontier.
- The panel recommends support for the US LHC program, including US involvement in the planned detector and accelerator upgrades. (highest priority)
- **The panel recommends a world-class neutrino program as a core component of the US program, with the long-term vision of a large detector in the proposed DUSEL and a high-intensity neutrino source at Fermilab.**
- The panel recommends funding for measurements of rare processes to an extent depending on the funding levels available… (Mu2e)
- **The panel recommends support for the study of dark matter and dark energy as an integral part of the US particle physics program**.
- The panel recommends a broad strategic program in accelerator R&D, including work …, along with support of basic accelerator science.

How to get a project through the agencies



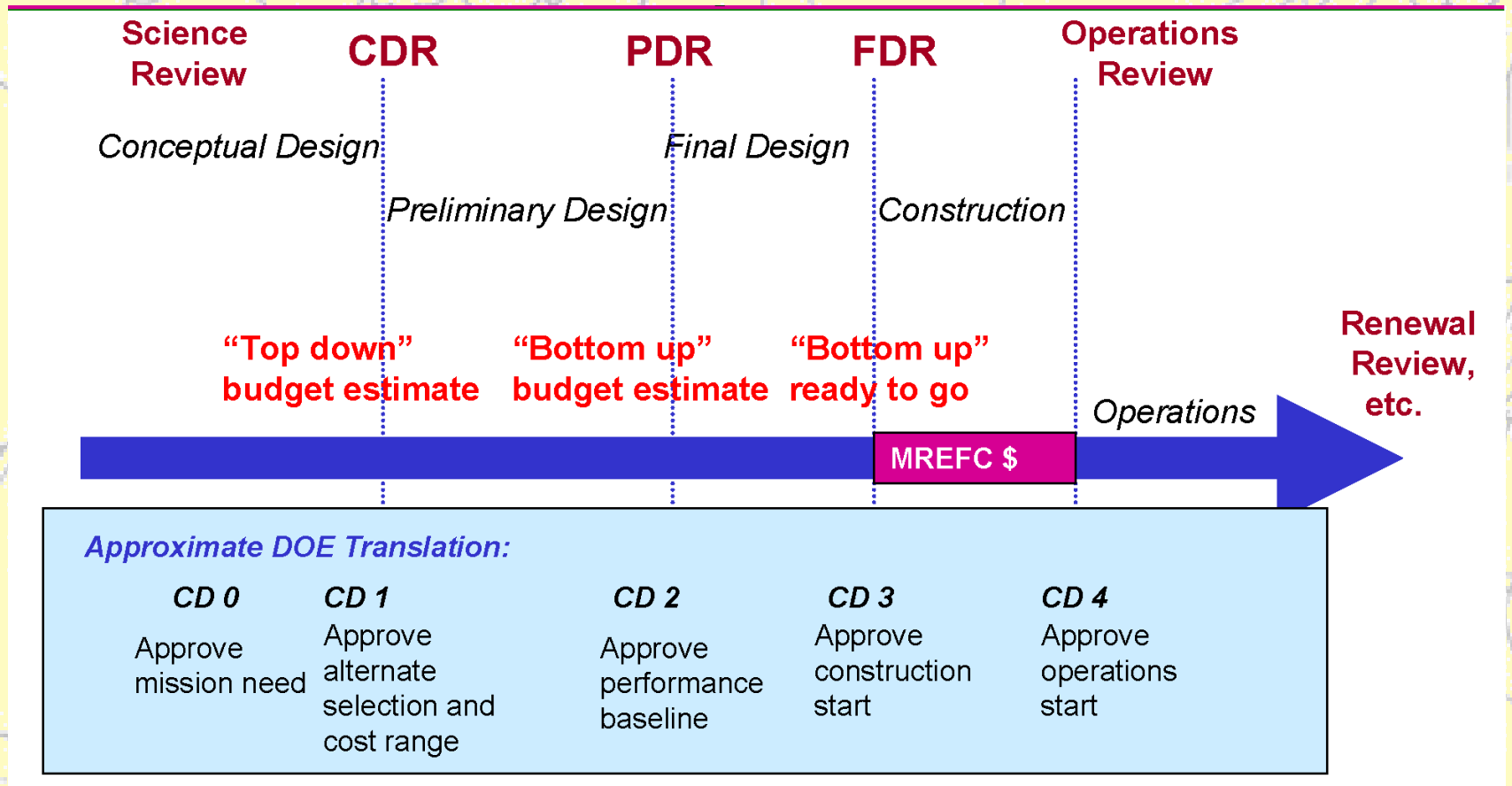


DOE Order 413.3 B



NSF Large Facilities Manual

The Project Process II



CD-n approval is given through the Energy Systems Acquisition Advisory Board

Size Matters

The cost of a project indicates the level of scrutiny and constraints it will be subject to

Total Project Cost	
> $2M	MIE line item in budget
> $5M	Triggers CD Process
> $10M	Monthly Project Assessment and Reporting required
> $20M	Strict Earned Value Accounting reporting
> $750M	Approval by Deputy Secretary Required

DOE/SC Requirements vs. Cost

DECISION / REQUIREMENTS[1] / APPROVAL[2] \ TOTAL PROJECT COST (TPC)			$750M or more	Less than $750M to $400M	Less than $400M to $100M	Less than $100M to $50M*	Less than $50M* to $20M	Less than $20M to $10M** Delegation Allowed
Prior to CD0, Approve Mission Need Statement			Reviewed by SC-28 (OPA) Approved by SC-1	Reviewed by SC-28 Approved by SC-1	Reviewed by SC-28 Approved by SC-1	Reviewed by SC-28 Approved by SC-1	Reviewed by SC-28 Approved by SC-1	Reviewed by SC-28 Approved by SC-AD
PRIOR TO CD-4--PROJECT COMPLETION			Reviewed by SC-28 Approved by SC-1	Reviewed by SC-28 Approved by SC-1	Reviewed by SC-28 Approved by SC-2	Reviewed by SC-28 Approved by SC-AD	Reviewed by SC-28 Approved by SC-AD	Reviewed by SC-28 Approved by SC-AD
CRITICAL DECISIONS	CD-0--APPROVE MISSION NEED		S-2 (CD-1 to 4 delegated, see below)	SC-1	SC-1	SC-AD	SC-AD	SC-AD
	CD-1--APPROVE ALTERNATIVE SELECTION AND COST RANGE		S-4	SC-1	SC-1	SC-AD	SC-AD	SC-AD
	CD-2 --APPROVE PERFORMANCE BASELINE		S-4	SC-1	SC-2	SC-AD	SC-AD	SC-AD
	CD-3--APPROVE START OF CONSTRUCTION		SC-1	SC-1	SC-2	SC-AD	SC-AD	SC-AD
	CD-4--APPROVE START OF OPERATIONS OR PROJECT COMPLETION		SC-1	SC-1	SC-2	SC-AD	SC-AD	SC-AD
BASELINE MANAGEMENT	Changes to TPC	Deviations	If performance, scope, schedule, or cost baseline at CD-2 cannot be met, then SC-1 and SC-2 must be notified & a determination made to terminate the project or establish a new performance baseline.					
		New Performance Baseline Approval	S-4	SC-1	SC-2	SC-2	SC-2	SC-2
		Directed Change	Project changes caused by Policy Directives that have the force and affect of law and regulation, or Regulatory, or Statutory action and are initiated by entities external to the Department.					
	No TPC Change / Routine Project Changes/ Control	Program	SC-AD	SC-AD	SC-AD	SC AD	SC AD	SC AD
		Project	Prog. Mgr., SOM or FPD	Prog. Mgr., SOM or FPD	Prog. Mgr., SOM or FPD	Prog. Mgr., SOM or FPD	Prog. Mgr., SOM or FPD	Prog. Mgr., SOM or FPD
		Contractor	Contractor	Contractor	Contractor	Contractor	Contractor	Contractor
REVIEWS	Mission Validation Independent Review		SC-AD	SC-AD	SC-AD	SC-AD	SC-AD	SC-AD
	Design Review Prior to CD-1, CD-2, & CD-3		Team External to Project	Team External to Project	Team External to Project	Team External to Project	Team External to Project	Team External to Project
	Conduct Independent Project Review or External Independent Review prior to CD-0 to 3		ICE or ICR by OECM with OPA	ICE or ICR by OECM with OPA	ICE or ICR by OECM with OPA	Prior to CD-1 to CD-4 by SC-28	Prior to CD-2 & CD-3 Tailored by SC-28	Prior to CD-2 & CD-3 Tailored by SC-28
	SC-AD Request Annual Peer Reviews by PMSO Post CD-2		SC-28	SC-28	SC-28	SC-28	SC-28 Tailored	SC-28 Tailored
	Performance Baseline Deviation Reviews after CD-2		SC-28	SC-28	SC-28	SC-28	SC-28	SC-28
	EVMS Review--Certification Prior to CD-3 & Bi-annual Surveillance (annual by contractor)		SC-28	SC-28	SC-28	SC-28	SC-28	N/A
	ORR/RA--Operational Readiness Review/Readiness Assessment Prior to CD-4		Team External to Project	Team External to Project	Team External to Project	Team External to Project	Team External to Project	Team External to Project
	Technology Readiness Assessment (TRA) prior to CD-2 and 3 by SAE or AE		N/A	N/A	N/A	N/A	N/A	N/A
	Project Definition Rating Index (PDRI) by OECM		N/A	N/A	N/A	N/A	N/A	N/A
	Hazard Cat. 1,2,3 Nuclear Facility--Technical IPR Prior to CD-2		*PSO*	*PSO*	*PSO*	*PSO*	*PSO*	*PSO*
REPORTING	Monthly PARS II Reporting (EVMS for Projects>$20 M)		Project Status After CD-0 and EV After CD-2					Monthly Project Status After CD-0
	Monthly or Quarterly Project Reporting (QPR) or Meeting after CD-0		SC-AD Invite SC-1 and SC-28	SC-AD Invite SC-1 and SC-28	SC-AD Invite SC-2 and SC-28	SC-AD to invite SC-28	SC-AD to invite SC-28	SC-AD to invite SC-28

It Starts with the Mission Need

CD-0 = Mission Need Approval

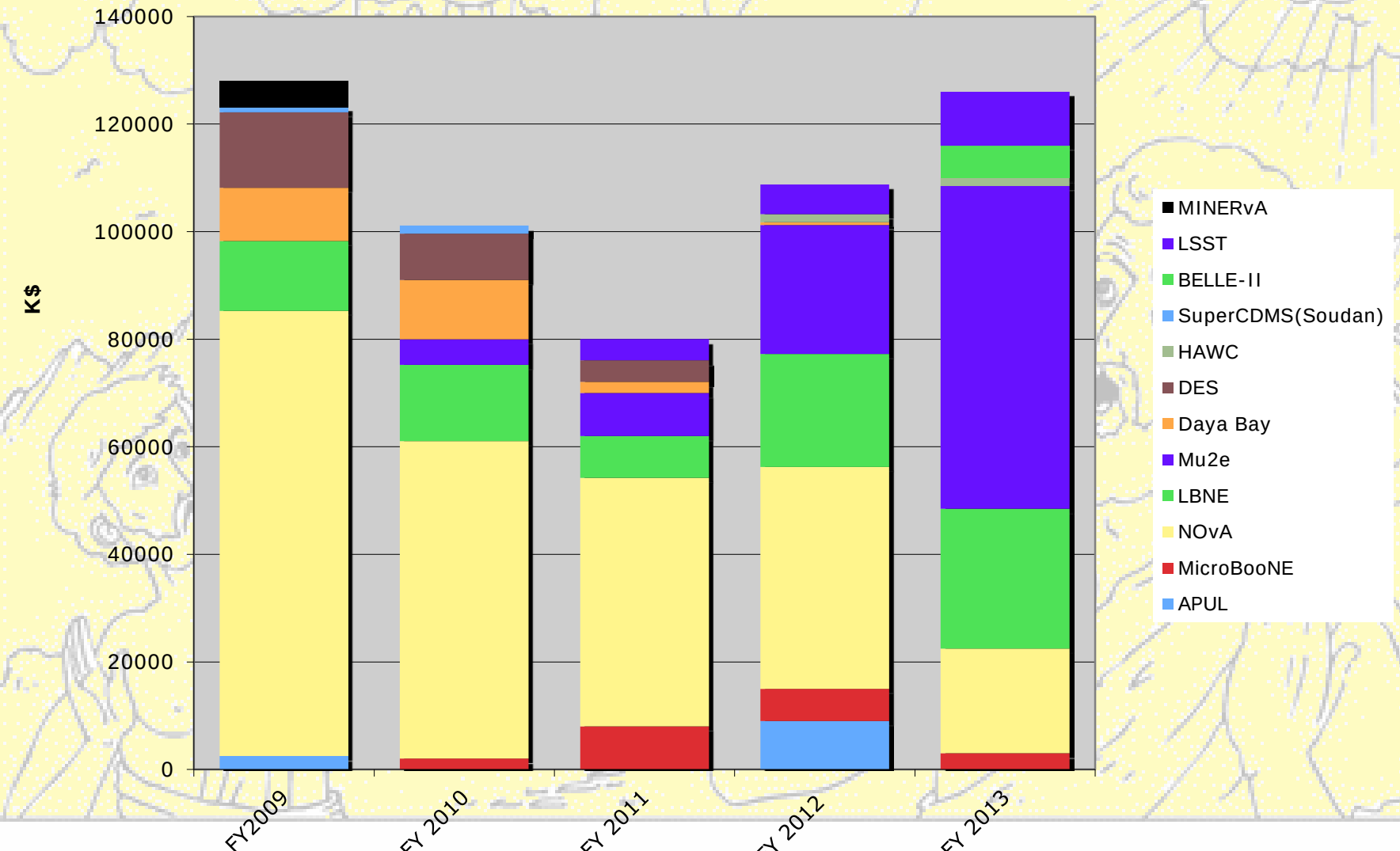
This is high level, concise statement designed for non-experts in HEP. It summarizes the process used to evaluate and define the need.

1. How does the project fit into the overall agency and programs strategic plan? What are the internal or external drivers?
2. The capability gap or why can't we live without this project.
   - Why won't existing facilities do?
   - Why can't someone else (another agency, another country,…) do it?
3. What has been or will be analyzed as potential strategies to meet the mission need
   1. Do we need something new or will an upgrade/improvement to an existing facility meet the need?
4. Cost range and schedule ranges

Does not contain site specific data

Site selection is part of the CD-1 Alternative Analysis

Recent and Current HEP Projects
(approximate)



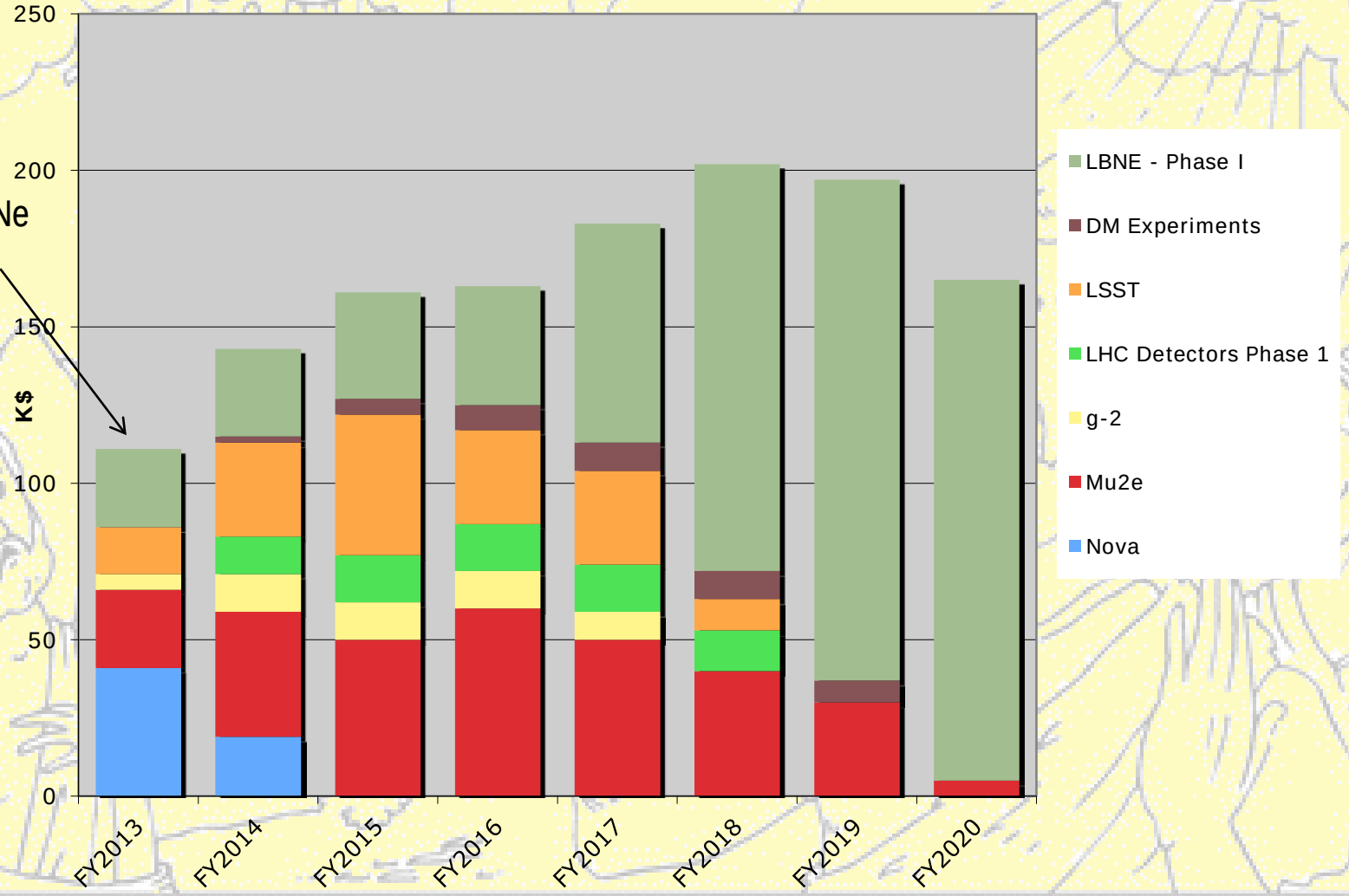
Predicting the future

1. **HEP Budgets will be flat at best for the next 4 years and perhaps even longer**
2. **The maximum fraction of the budget for projects is 20-25%. ($160M-$200M).**
3. **Based on historical data $200M is probably an optimistic best case**
4. **Choose your mix of projects and chose your spending profile.**
5. **Add U.S. contributions to off-shore projects**
   - **HyperK**
   - **Daya Bay II**

An example

with no Project-X; no LHC Accel Contrib; no LHC Phase-II Upgrades; no off-shore participation other than LHC

HAWC
MicroBooNe
Missing



The first steps are in your hands

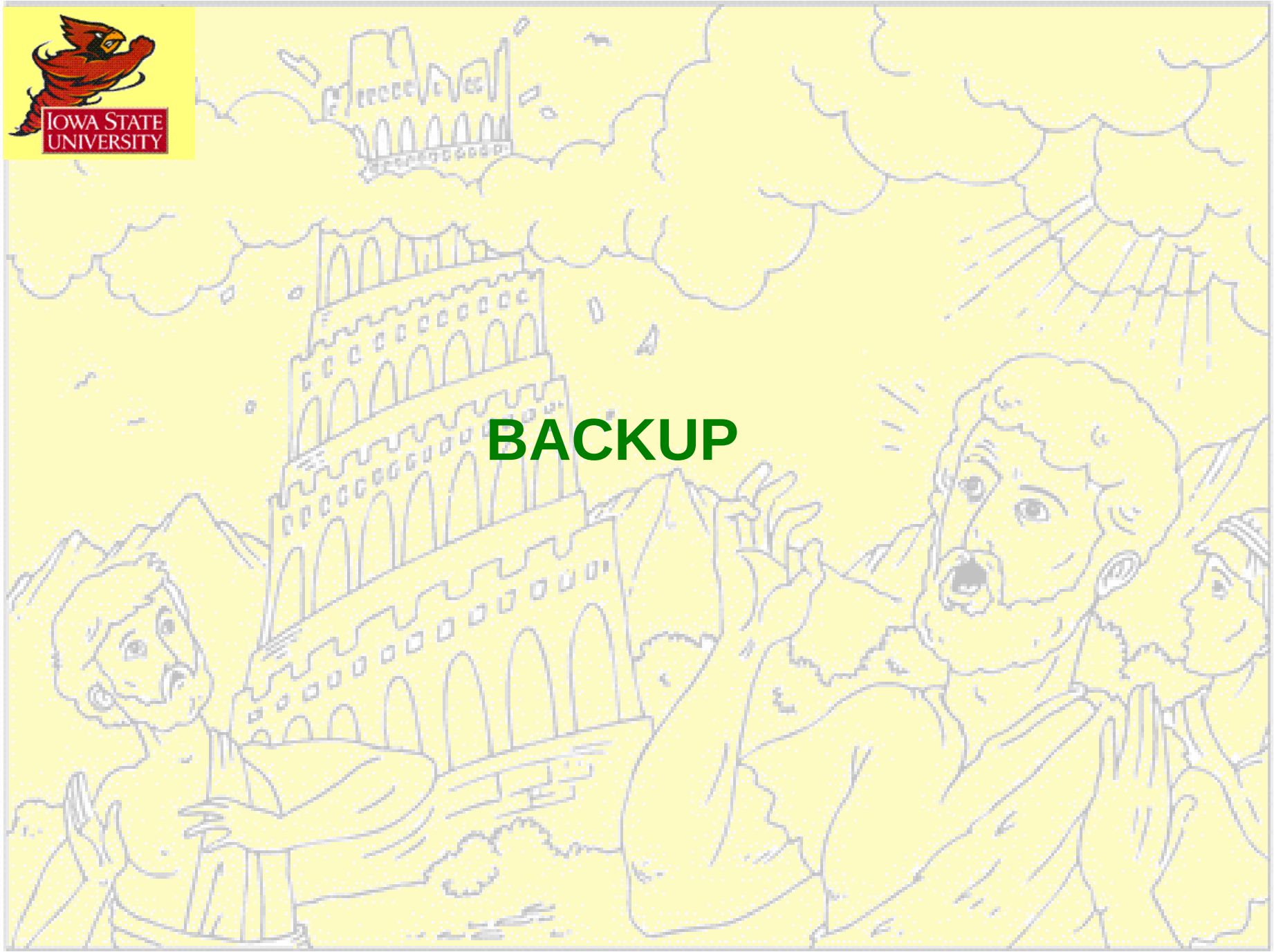
The community planning effort is an opportunity to get things started

- **What is the project you want**
  - **Need a coherent science case from and by the community**
  - **Need a well defined goal with a defined end point**
  - **PR is everything**
    - **Well articulated explanations**
    - **Simplified overall package that can capture the imagination of non-experts (think NASA)**
    - **What are the possible broader impacts – find some**
- **How can you get it done (process)**
  - **Look at what has worked and been funded**
  - **Look outside HEP; talk to colleagues**
  - **Look for a novel approach; interdisciplinary is the rage**

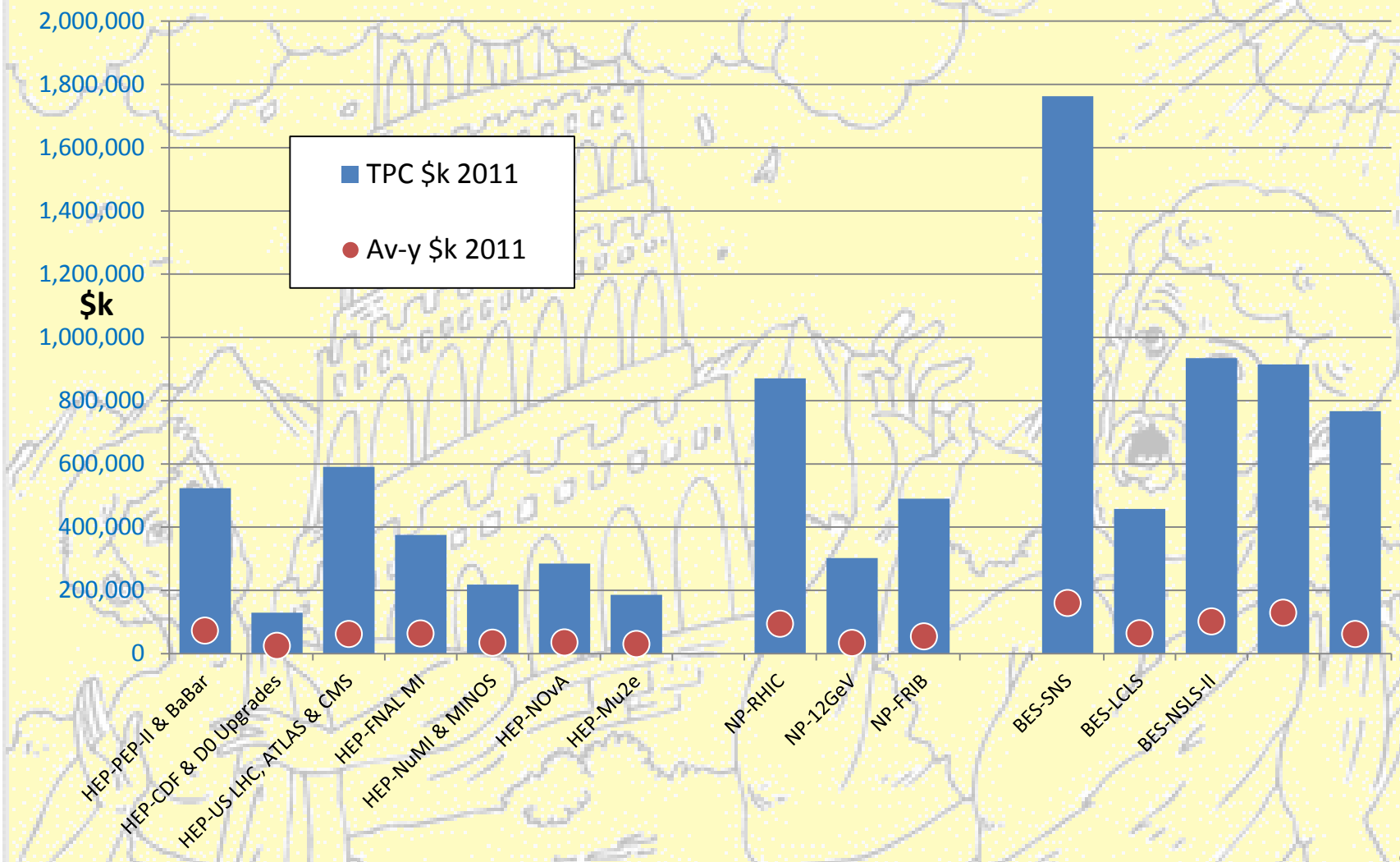
How will this fit into an overall picture for both HEP and the science community

But it is a long, continuing process

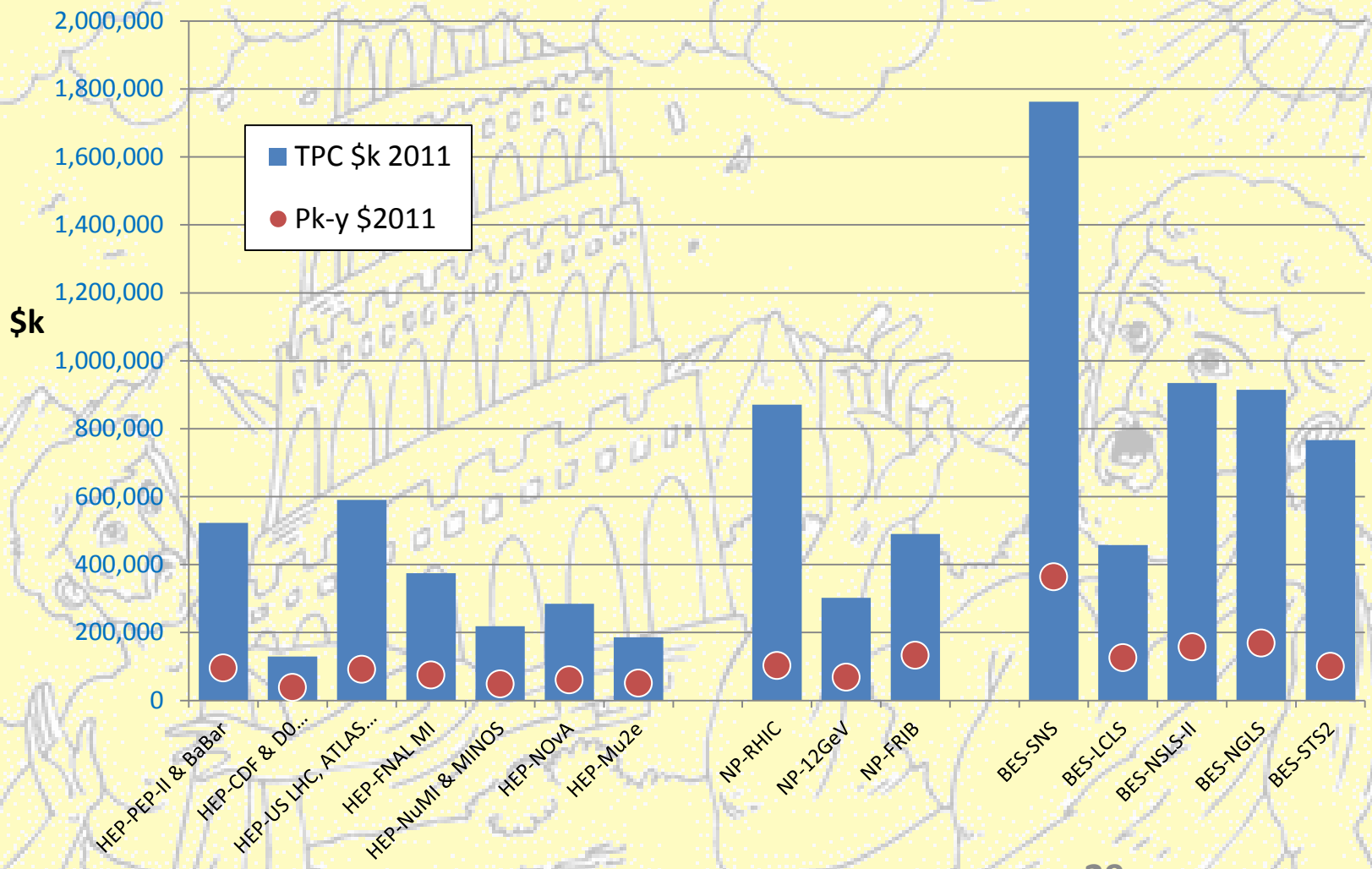
- Getting a well-defined community supported project is the first step.
- As shown in the process slides, the project must be “sold” up the DOE food chain. This is true even if the budget will support the project and you meet the mission need requirements.
- There is competition within the Office of Science and you need to show why the HEP project is important to our field.
- You then need to convince OSTP and OMB. This is a continuing process even when a project is “on the books.”
- And then there is congress…….
- This is a continuous process – the longer the time scale the greater the need to educate and re-educate all the players.


BACKUP

Average funding per year on projects



The HEP Mission

The High Energy Physics program's mission is to understand how our universe works at its most fundamental level, which is done by discovering the elementary constituents of matter and energy, probing the interactions between them, and exploring the basic nature of space and time itself.

Historical Project Peak-yr Funding