NSAC Theory Subcommittee

Report to the NSAC

A Vision for Nuclear Theory

Initiatives And Recommendations

Overview

- Committee and Charge
- Present Funding Data
- Community Surveys
- Recent Achievements
- Scientific Opportunities
- Recommendations & Initiatives
- Budget Scenarios
- Benefit Analysis

NSAC Theory Subcommittee

Membership

Joseph Carlson (LANL)
Barry Holstein (U. Massachusetts)
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Gail McLaughlin (NCSU)
Berndt Mueller (Duke) - Chair
Witold Nazarewicz (UT/ORNL)
Krishna Rajagopal (MIT)
Winston Roberts (ODU/Jlab)
Xin-Nian Wang (LBNL)
Richard Casten (Ex-Officio)

Charge to NSAC

- Part of recommendation I of NSAC Long Range Plan:

  "Significantly increase funding for nuclear theory, which is essential for developing the full potential of the scientific program."

- Specific charge for NSAC Theory Subcommittee:

  "NSAC is asked to review and evaluate current NSF and DOE supported efforts in nuclear theory and identify strategic plans to ensure a strong U.S. nuclear theory program under various funding scenarios…."

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Nuclear Theory Funding

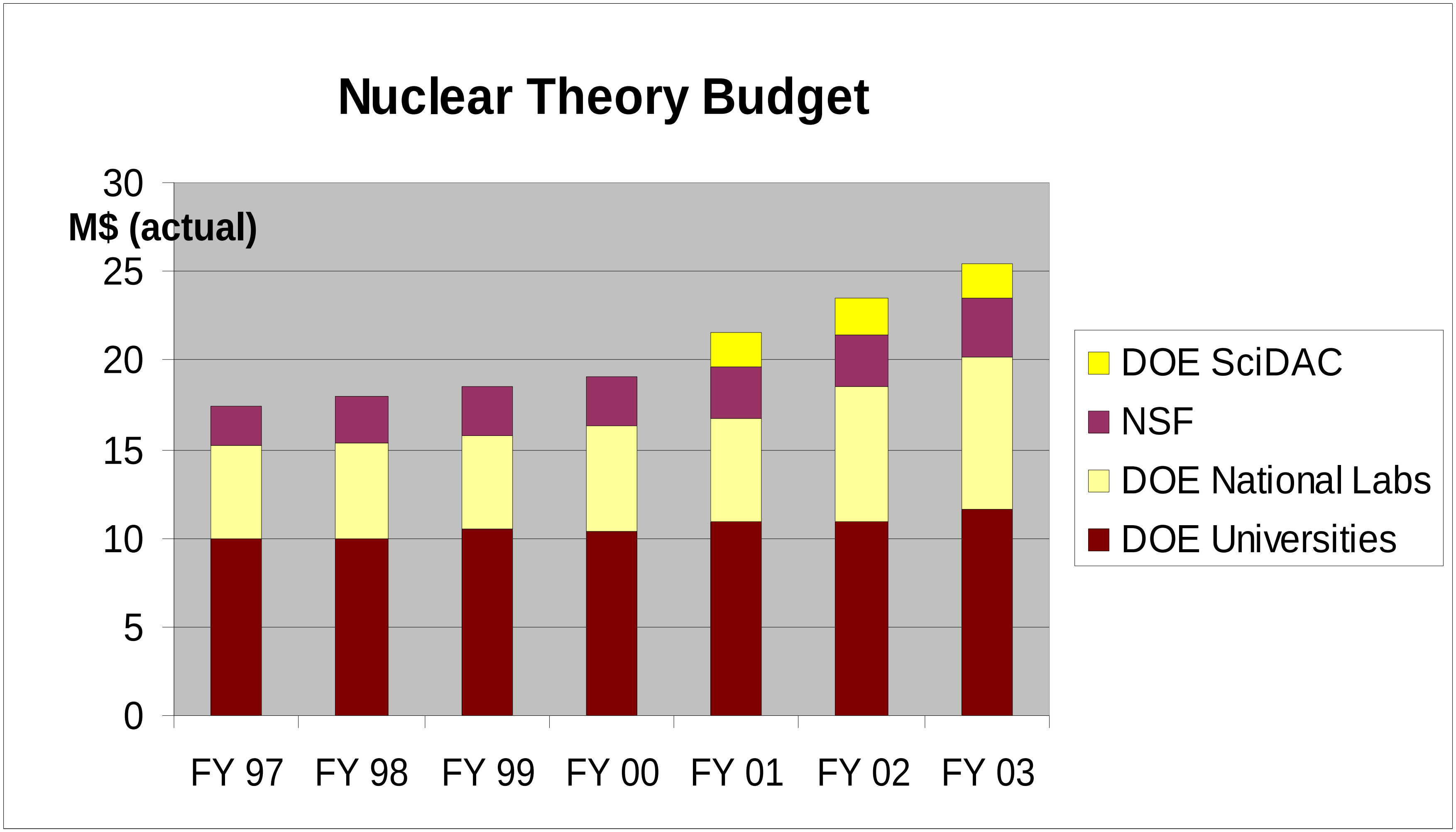

Table 2: Correction

Table 2: DOE Nuclear Theory Support by Subfield (FY03 in k$)

	Universities	Natl. Labs	SciDAC	Total
Hadron structure	3,213	2,674	1,178	7.065
Nuclear structure	3,272	2,698		5,970
Hot nuclear matter	2,816	2,565		5,381
Nuclear astrophysics	952	442	802	2,196
Beyond SM	443	137		580
Total	~~11,723~~ 10,696	8,516	1,980	21,192

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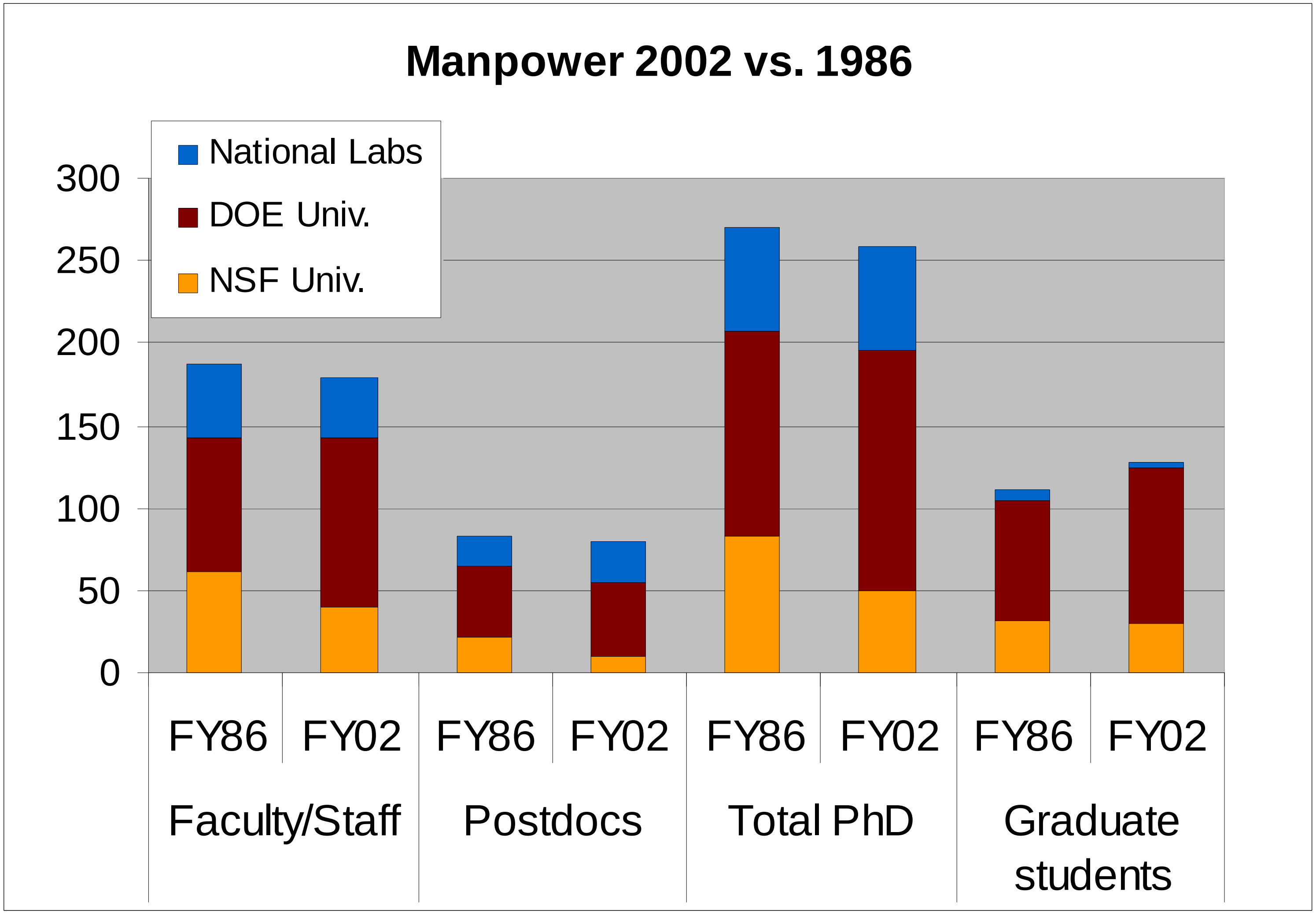
Theory Manpower



NSF/DOE comparison

TABLE 8 Support per senior Ph.D. (k$)

	FY86 (1986 $)	FY86 (2003 $)	FY03 (2003 $)
NSF	42	70	73
DOE Univ.	71	118	114

Serious discrepancy between NSF and DOE remains.

Community Input

- Detailed survey of nuclear theory PIs and co-PIs:
  - 79 responses from all subfields and age groups
  - Responses confirm our analysis of scientific achievements and opportunities and support our recommendations
  - Most urgent needs: Increased manpower, postdocs, bridged positions
- Questionnaire to experimental PIs
  - 22 responses from different subfields
  - Broad support for increased support for theory addressing critical needs of the national nuclear physics program

Opportunities I

Computational challenges

- Lattice QCD:
  - Methodology (improved actions, domain wall fermions, chiral extrapolations) is in place to calculate important observables with 5% precision or better;
  - $1M/Tflops hardware makes 10+ Tflops facility affordable now;
  - Wide range of program relevant questions are accessible.
- Supernova simulations:
  - Two- and three dimensional simulations of core collapse supernovae with full neutrino transport.
- Many-body theory:
  - Exact solutions of correlated many-body quantum systems

Opportunities II

- JLab and RHIC phenomenology
- Nuclear structure theory
- Nuclear astrophysics
- Tests of fundamental symmetries and search for Beyond the Standard Model physics
- Interdisciplinary Many-Body Physics

Opportunities III

- *Unifying theme:* Controlled precision calculations of quantities of experimental relevance in microscopic theoretical frameworks.

- Important role of theory in providing justification for new experimental facilities: RIA, NUSL, EIC !

Guiding Principles and Aims

- Ensure future excellence of nuclear theory in the U.S.
- Maximize effectiveness of nuclear theory research
- Develop increased manpower required to address scientific opportunities and programmatic needs
- Attract, train, and retain best possible talent
- Reverse decline of nuclear theory in top-rated physics departments
- Build program accountability into major new initiatives

Recommendations: Overview

- Postdoctoral prize fellowships
- Graduate fellowship program
- Enhanced OJI awards
- Topical centers
- Centers of excellence
- Large scale computing initiatives

- Elimination of NSF/DOE disparity
- Increased use of bridge funding
- Leveraged support for sabbaticals
- Nuclear theory at top-ranked universities

Recommendations: Manpower

- Postdoctoral prize fellowships:
  - 5 awards annually for 3-year terms
  - National selection committee (*Hubble model*)
  - Postdocs select host institution
  - Raise visibility of best young nuclear theorists
  - Enhance early career development

- Graduate fellowship program:
  - Seniors or 1st or 2nd year graduate students
  - Selection by national committee

Topical Centers I

- 2-3 centers per year to be awarded competitively on the basis of scientific quality and relevance to the national program, at $300-500k each.
  - Proposals should contain “deliverable” results.
  - Centers to function as hubs of wider networks.
  - Centers could involve staff/faculty bridge funding.
  - Finite lifetime for specific topics.
  - Review and possible competitive renewal after 5 years.
  - Steady state: 10 topical centers in maximal scenario, creating 30-50 new staff/faculty and postdoc positions.
  - Productive staff to either transition into base program or become part of successor centers.

Centers of Excellence

- Interdisciplinary centers at universities or national labs targeting areas benefiting from intense interactions with scholars from other communities (astrophysics, CM physics, HE physics, etc.).
  - Broad and curiosity driven research agenda.
  - Flexible specific structure to accommodate special circumstances.
  - Funding $0.5-1M/year; faculty bridge support and graduate students should be important components.
  - 3-5 centers nationally.
  - Review and competitive renewal after 5 years.
  - Leverage is part of award criteria.

Computing

- Aggressive investment in computational nuclear science with the goal of solving problems of core importance to the physics program:
  - Urgently needed investments include >10 teraflops scale national facilities to capitalize on immediate scientific opportunities: precise lattice QCD calculations of the structure of hadrons and dense matter, realistic simulations of supernova dynamics, and *ab initio* solutions of quantum many-body problems.
  - The opportunities are so compelling that even when new external resources, such as SciDAC, are unavailable or inadequate, a minimal sum of $3M/year from the nuclear science budget should be allocated to computational nuclear physics with an appropriate share being borne by the nuclear theory program.
  - Start longer term planning for >100 teraflops facility.
  - Utilize synergies with HEP initiatives.

Revitalization

- Bridge positions:
  - Expand existing practice of bridging new faculty and staff positions & use centers for institutional leverage
  - Peer review of proposals
- OJI / CAREER programs:
  - Continue very successful OJI program, but
  - Increase OJI grants to =100k/year budget
  - Allow national lab staff to compete
- Graduate students:
  - Graduate fellowships & support through centers
  - Develop new REU programs led by nuclear theorists
- Sabbatical leaves:
  - home inst. 50%, host inst. 25%, agency 25%

Base Program

- NSF base program:
  - Raise $70k/PI funding to DOE level (>$110k/PI) even in a constant level of effort scenario
    - Make best theory groups and single PIs more effective
    - Make NSF program more attractive to best young theorists
    - Raise competitiveness of NSF nuclear theory program with respect to other theory areas.
  - Aim at 50% growth of NSF nuclear theory funding

- DOE base program:
  - Modest reprogramming required in constant level of effort scenario
  - Protect core program in growth scenarios

Priorities for Growth

"Bundled" priorities to optimize program:

1. Full funding of initiatives, 50% increase NSF
   corresponds to 55% overall increase.
2. Full funding of initiatives, except centers at 2/3, 33% increase NSF
   corresponds to 39% overall increase.
3. Full funding of initiatives, except centers at 1/3, 20% increase NSF
   corresponds to 23% overall increase.

Constant Level of Effort Scenario

- Postdoc and graduate fellowships at half level; one center (either topical or excellence); computing initiative as tax on NP program; enhanced NSF grant size.

Benefits: *Increased visibility and leverage; more effective and focused program in support of LRP.*

Drawbacks: *Painful for many researchers; many critical problems of LRP program will not be addressed.*

Hope: *More effective program will justify growth.*

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Budget Scenarios I

Initiative	CLE	Option I	Option II	Option III
Postdoc Fellows	0.6	1.2	1.2	1.2
Topical Centers	0.25*	1.0	2.5	4.0
Centers of Excellence	0.25*	1.5	2.5	3.5
Computing	0.2	1.0	2.0	3.0
Graduate students	0.0	0.0	0.0	0.0
Enhanced OJIs	0.0	0.5	0.5	0.5
Total initiatives	(1.3)#	5.2	8.7	12.2
Change NSF budget	0.0	0.6	1.0	1.5
Total	0.0	5.6	9.7	13.7
Current NP Theory	25.0	25.0	25.0	25.0
Future NP Theory	25.0	30.8	34.7	38.7
Increase (%)	0	23	39	55

* Only one center

Reprogramming of existing funds

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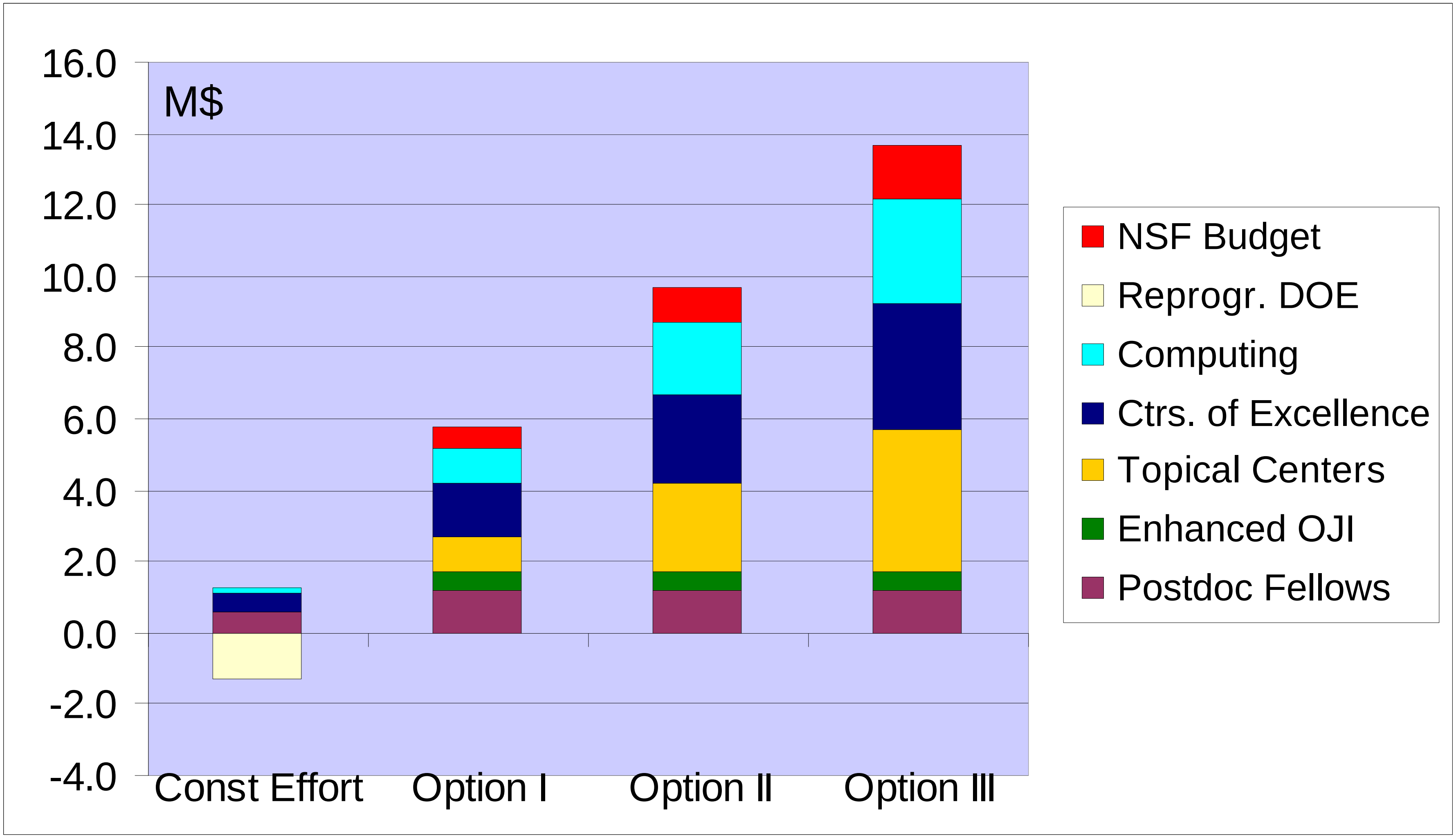
Budget Scenarios II



Benefit analysis

- Programmatic manpower needs
  - Quantity and quality
- Enhanced visibility and effectiveness of young scientists
- Accountable focus on programmatic priorities
- Visibility of nuclear theory in institutions and in the nation
- Leverage provides by centers
- Revitalization of NSF NT program
- Showcase function