U.S. DEPARTMENT OF ENERGY | Office of Science

Accelerator R&D Strategic Planning

Michael S. Zisman
Office of High Energy Physics
HEPAP Meeting-Palomar Hotel
March 12, 2012

Outline

- Introduction
- Overview of current SC accelerator R&D program
- The long view
- Summary

Introduction

Accelerator R&D Mission

- Support **world-leading research** in the physics of particle beams and in accelerator technology R&D
  - necessary for advancement of a broad range of scientific disciplines: NP, HEP, photon and neutron science
- Three broad categories:
  - **Near- to mid-term directed R&D** for specific facilities or technologies in support of DOE projects (sometimes captured in project TPC)
  - **Mid-term, facility-inspired R&D** focused on specific concepts or technologies to demonstrate feasibility and engineering readiness
  - **Long-term, proposal-driven research** on fundamental science and technology of particle accelerators and beams to enable break-throughs in size, cost, beam intensity, beam energy, and control
- All SC programs participate in the first two categories
  - the last category is the purview of HEP (stewardship role)

Long Range Accelerator R&D

- **In broad terms, R&D goals are**
  - higher beam quality
  - higher beam intensity
  - more compact size
    - where "compact" is sometimes in the eye of the beholder
- **If one generalizes the concept of "beam" to include not only charged particles, but neutral particles and photons, the overarching R&D goals are unchanged**
  - but the potential customer base broadens considerably
- **Historically, HEP long-range accelerator R&D always implicitly assumed HEP to be its only "customer"**
  - because HEP is a "high-end" consumer, resulting R&D efforts often useful to a broader group
    - "implied" stewardship

Overview of Current SC Accelerator R&D Program

SC Accelerator R&D – Classification

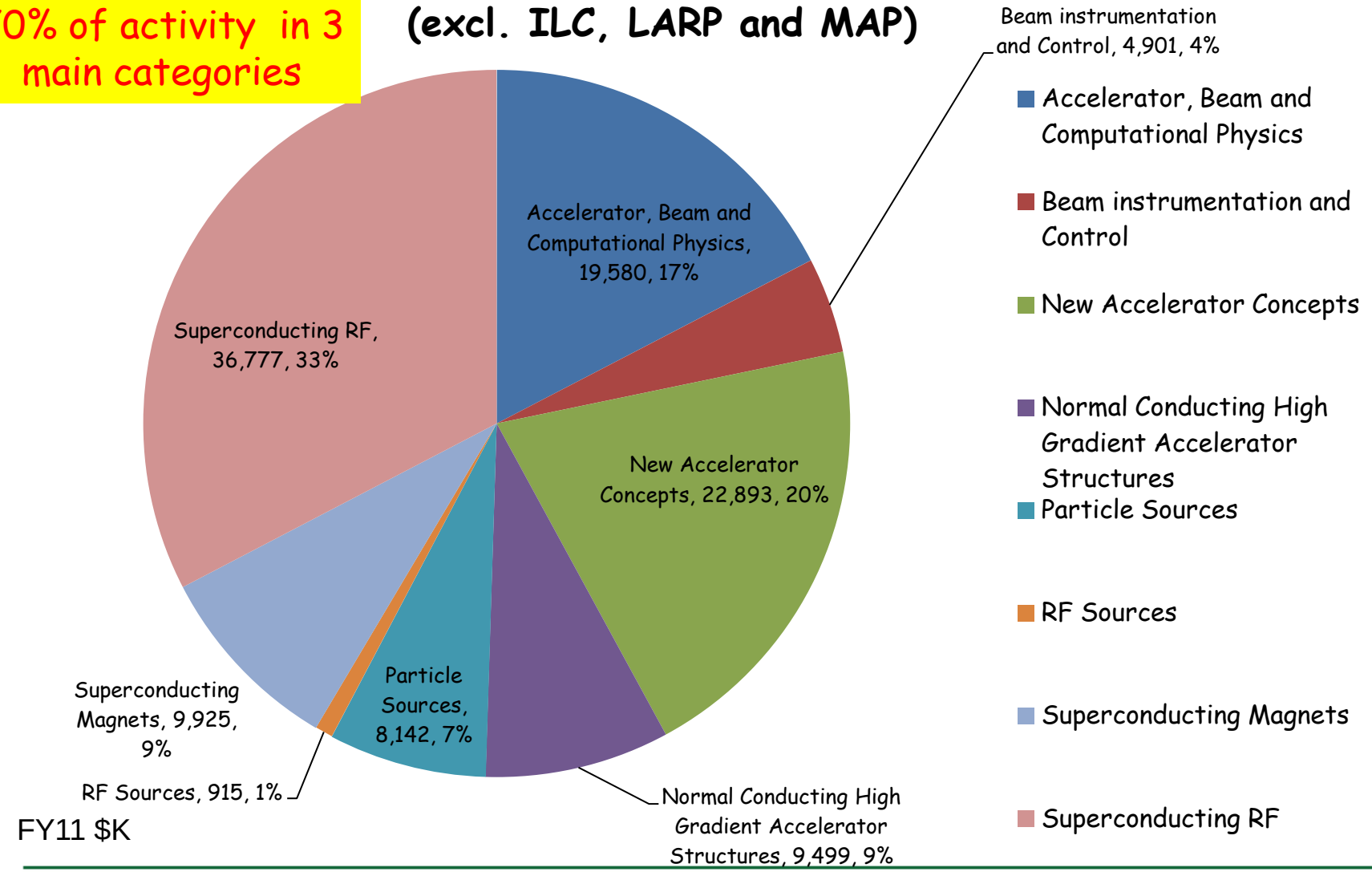
** 8 Core Thrust Areas **

- Superconducting RF
- Accelerator, Beam and Computational Physics
- Particle Sources
- RF Sources
- Beam instrumentation and Control
- Normal Conducting RF
- New Accelerator Concepts
- Superconducting Magnets

SC Accelerator R&D – By Thrust

Total by Research Thrust – Mid and Long Term (excl. ILC, LARP and MAP)

70% of activity in 3 main categories



FY11 $K

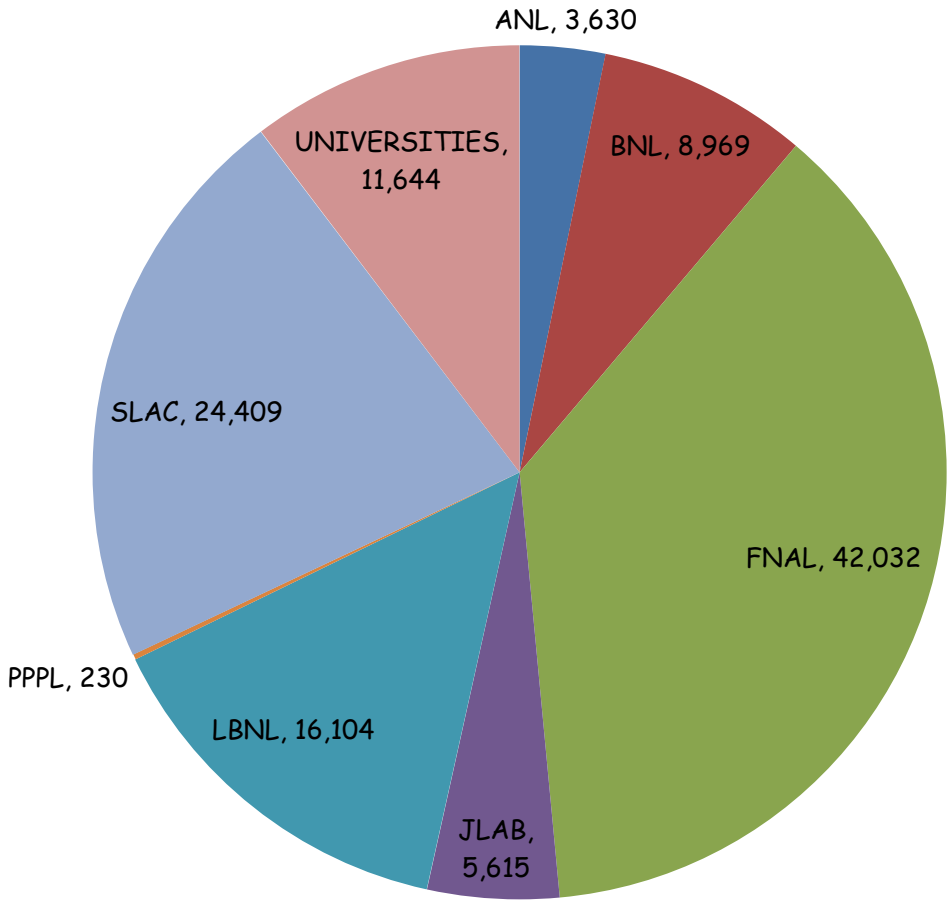
SC Accelerator R&D – Where?

- **7 DOE Labs**
  - Argonne National Laboratory
  - Brookhaven National Laboratory
  - Fermi National Accelerator Laboratory
  - Thomas Jefferson National Accelerator Laboratory
  - Lawrence Berkeley National Laboratory
  - Princeton Plasma Physics Laboratory
  - SLAC National Accelerator Laboratory

- **20 Universities and other institutions**
  - ~50 peer-reviewed grants and interagency agreements
    - being comparatively reviewed starting this year

SC Accelerator R&D – By Institution

Total by Institution – Mid and Long Term



FY11 $K

90% of SC Accelerator R&D carried out at National Labs

Expanded NSF involvement broadens university participation and supplies students for stewardship workforce development

Lab-University Complementarity

- **Large-scale efforts make use of National Lab infrastructure, engineering, and fabrication capabilities**
  - SRF technology (Fermilab, Jlab)
  - NCRF technology (SLAC)
  - drive beams (ANL, BNL, Fermilab, SLAC)
  - high-power lasers (BNL (CO_2), LBNL (solid state))
- **Small-scale R&D supported by university grants**
  - promising concepts can be proposed for testing at National Labs
    - ATF (BNL); FACET (SLAC); broadly open
    - AWA (ANL); A0 (Fermilab); LOASIS/BELLA (LBNL)
- **Workforce Development**
  - Lab-University complementarity provides excellent environment for training next generation accelerator physicists
  - ~75 graduate students supported in accelerator R&D across SC
    - NSF universities also provide a strong source of students

SC Accelerator R&D Funding

SC Program Contributions (FY11 $K)

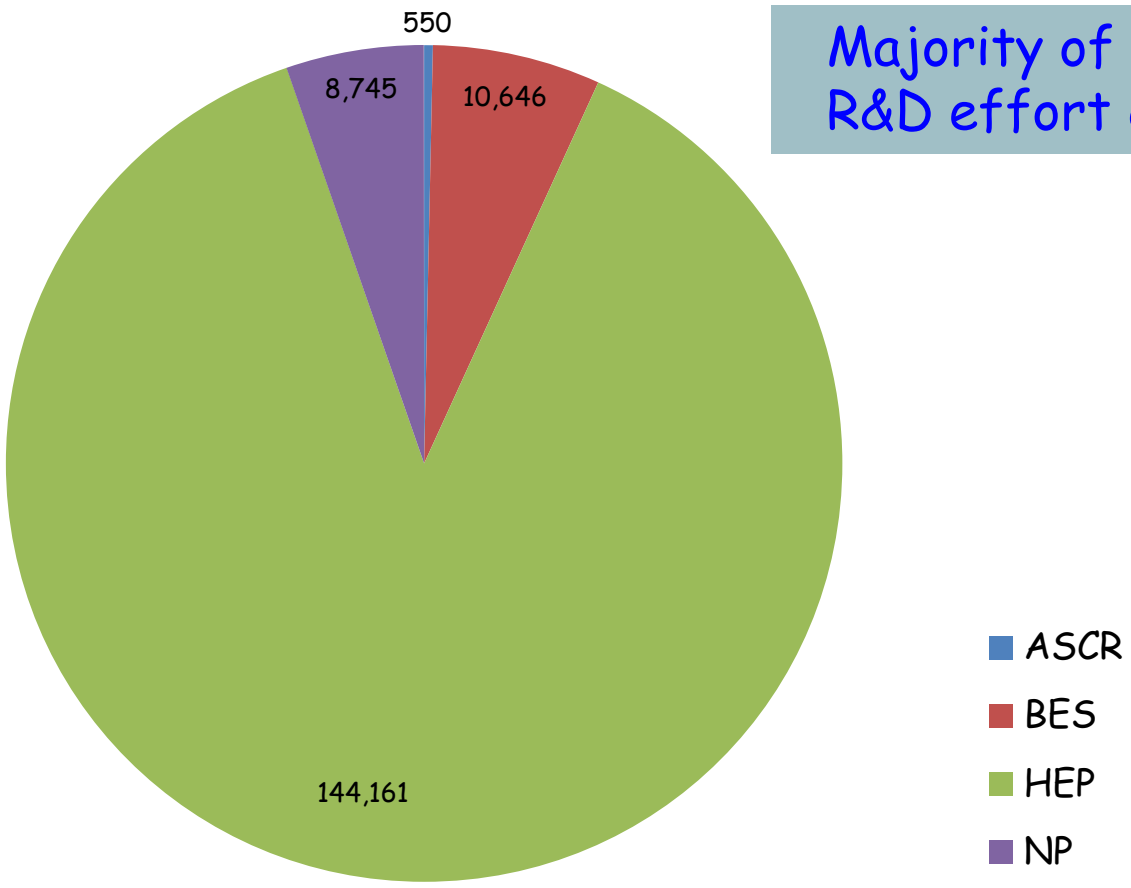
Programs	Mid-term (facility-driven) R&D	Long-term (accel. science-driven) R&D	Directed R&D Campaign	Total
ASCR	550	-		550
BES	10,646	-		10,646
HEP	51,091	41,600	51,521*	144,212
NP	8,745	-		8,745
Total	71,032	41,600	51,521*	164,153

***comprises ILC (28,288), MAP (10,882) and LARP (12,351)**

Does not include very short term R&D done on facility operations budgets.

SC Accelerator R&D – By Program

Total by SC Program – Mid and Long Term



Majority of SC accelerator R&D effort carried out by HEP

FY11 $K

Directed R&D

- **HEP has programs of directed R&D toward specific goals that combine thrusts**
  - International Linear Collider (completing this year)
    - Can an ILC be built at an affordable cost?
    - Superconducting RF, beam physics, instrumentation, particle sources, …
  - LHC Accelerator Research Program
    - How can we contribute to improving the performance of the LHC?
    - Superconducting magnets, beam physics, instrumentation, …
  - Muon Accelerator Program
    - Can muons be made into beams suitable for storage rings?
    - Superconducting magnets, beam physics, normal conducting RF, …
- **Managed as multi-lab programs with clear milestones and deliverables**

SC Accelerator R&D Inventory

SC Program Participation by Institution

Thrust Inst.	Beam Physics	Beam Instr/ctl	New concept	NC high grad. RF	Particle sources	RF sources	SC magnet	SC RF
ANL	⊙◎		●	◉	◉⊙			◉
BNL	◉◎	●	●	◉	◉◉		◉	●
FNAL	●	●			●		●	●◉
JLAB	◉				◉			●●
LBNL	⊙◉●	◉	●		●		●	
PPPL	⊙							
SLAC	⊙●●	◉	●	●	◉	◉		
UNIV.	●●	◉	●	●	◉⊙◎		●	◉

Key: 100<⊙<300; 300<◉<1,000; ●>1,000 **Color code: ■ASCR; ■BES ; ■HEP ; ■NP**

SC Accelerator R&D: Acc./Comp./Beam Phys.

Thrust / Inst.	Acc./comp/ beam Phys		ASCR	BES	HEP	NP
ANL	⊙◉		SYNERGIA beam dynamics software devel., & integration			Modeling of high intensity ion injector complex
BNL	◉◉			Characterization studies of Inv. Compton Scat. hard X-ray sources		Beam phys./ modeling for **linac-ring** next generation collider
FNAL	●				modeling & dyn.; pt. at FNAL accelerator complex, LHC; USPAS	
JLAB	◉					Beam Phys ./modeling for **ring-ring** next generation collider
LBNL	⊙◉●		Fast Poisson solver for faster beam simulation performance	Hi ni-brightness deling for future urces	PIC code w/ boosted frame; space charge, b-b, e-cloud dynamics	
PPPL	⊙				Theory of space-charge dominated beams	
SLAC	⊙●●		ACE3P code cavity & and w alc.	Laser seeding (enhanced harm. gen.); spectral phase meas. & control	Beam dynamics studies; b-b code development; accelerator design	
UNIV.	●●			Advanced FEL mechanism studies—beam physics in attosecond regime.	Beam dynamics and theory; modeling and simulation; beam labs	

Programmatic efforts are distinct

Key: 100<⊙<300; 300<◉<1,000; ●>1,000 **Color code: ASCR; BES ; HEP ; NP**

SC Accelerator R&D Inventory

SC Program Participation by Institution

Thrust Inst.	Beam Physics	Beam Instr/ctl	New concept	NC high grad. RF	Particle sources	RF sources	SC magnet	SC RF
ANL	⊙◎		●	◉	◉⊙			◉
BNL	◉◎	●	●	◉	◉◉		◉	●
FNAL	●	●			●		●	●◉
JLAB	◎				◎			●●
LBNL	⊙◉●	◉	●		●		●	
PPPL	⊙							
SLAC	⊙●●	◉	●	●	◉	◉		
UNIV.	●●	◉	●	●	◉⊙◎		●	◉

Key: 100<⊙<300; 300<◉<1,000; ●>1,000 **Color code: ■ASCR; ■BES ; ■HEP ; ■NP**

HEP Accelerator R&D: New Concepts

Thrust / Inst.	New concept		ASCR	BES	HEP	NP
ANL	●				Dielectric-loaded wakefield a… concepts (coaxial and two-beam accelerato… g developed at the AWA.	
BNL	●				ATF supports user… ts to develop new accelerator concepts includ… e drive bunches for plasma accelerators… acceleration, radiation generation, etc.	
FNAL						
JLAB						
LBNL	●				…er-driven plasma wakefield accelerators are being developed at LOASIS and BELLA, including experiments for staging multiple modules together.	
PPPL						
SLAC	●				E-beam driven plasma and dielectric wakefield accelerators are being developed at FACET and NLCTA.	
UNIV.	●				Grants support theoretical/simulation/experimental work at or in collaboration with DOE labs. Also development of instrumentation and diagnostic tools needed for these experiments.	

Institutional programs are distinct

Key: 100<⊙<300; 300<◉<1,000; ●>1,000 **Color code: ■ASCR; ■BES ; ■HEP ; ■NP**

The Long View

Stewardship Program Genesis

- **HEP and NP have always invested in longer-term accelerator R&D**
  - advanced acceleration techniques (HEP)
  - superconducting magnets (HEP)
  - superconducting RF (NP, joined more recently by HEP and BES)

- **Such R&D is a recognized part of the HEP portfolio**
  - P5 recommendation (2008):

    "The panel recommends a broad strategic program in accelerator R&D, including work on ILC technologies, superconducting rf, high-gradient normal-conducting accelerators, neutrino factories and muon colliders, plasma and laser acceleration, and other enabling technologies, along with support of basic accelerator science."
    - already doing well in terms of "broad"
      - still need work on "strategic"

Previous Efforts

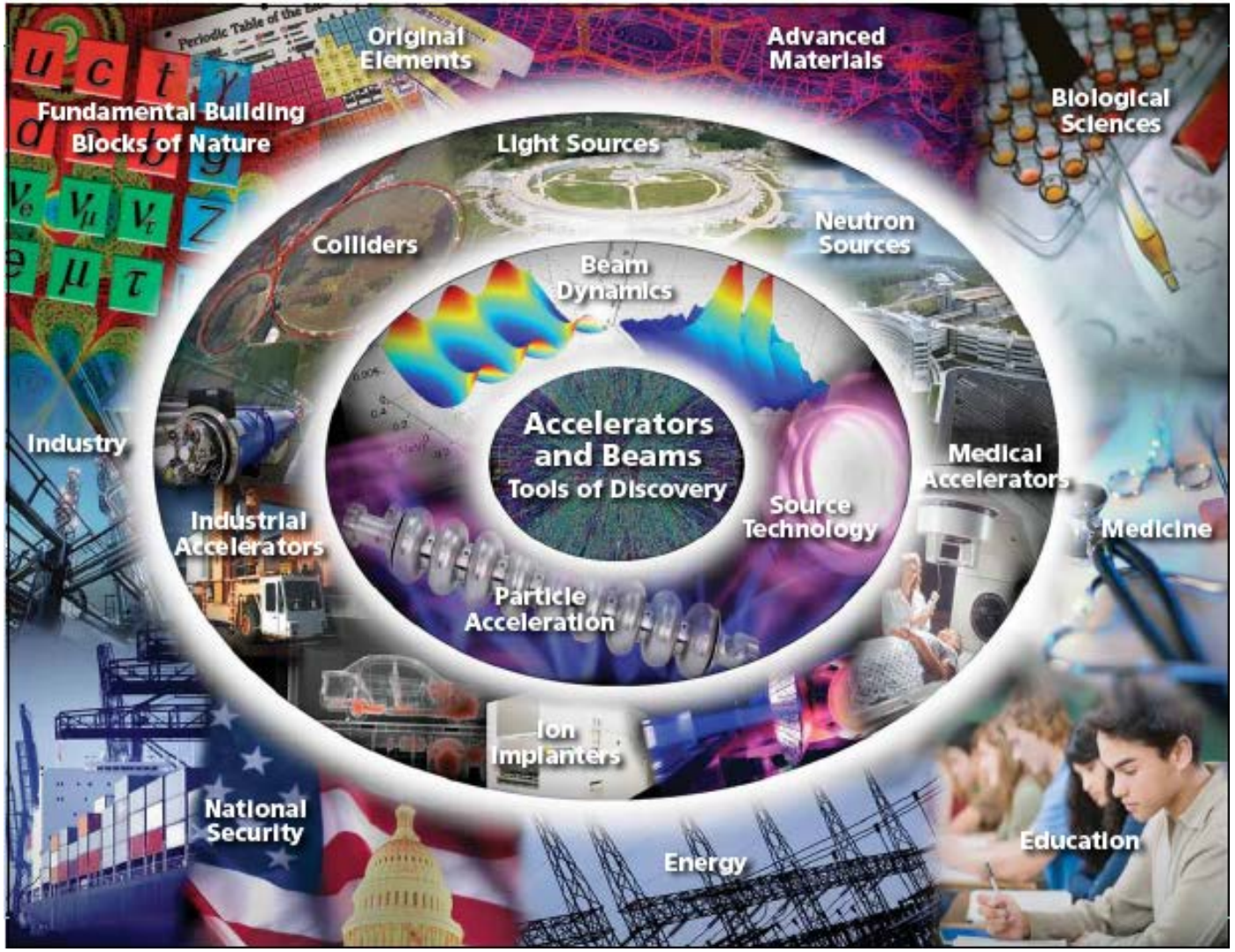
- **Past efforts to make accelerator technology more available have been undertaken**
  - example: design/construction/commissioning of Loma Linda medical accelerator (Fermilab)
  - other methods used include CRADAs and SBIR solicitations
    - partnerships with industry to deliver required components
      - Superconducting cavities (Fermilab, Jlab)
      - Klystrons and modulators (SLAC)
      - Insertion devices (APS, NSLS, ALS)
      - Superconducting magnets (BNL)
- **These have been successful…in the sense of technology transfer**
  - but, need stronger, ongoing partnerships to develop new concepts and capabilities that further scientific and commercial needs beyond the traditional areas of SC programs

Stewardship Program Request

- **Excerpt from recent Senate Appropriations Committee language encourages more proactive approach to stewardship task**
  - along with a deadline for doing so!

"The Committee understands that powerful new accelerator technologies created for basic science and developed by industry will produce particle accelerators with the potential to address key economic and societal issues confronting our Nation. However, the Committee is concerned with the divide that exists in translating breakthroughs in accelerator science and technology into applications that benefit the marketplace and American competitiveness. The Committee directs the Department to submit a 10-year strategic plan by June 1, 2012 for accelerator technology research and development to advance accelerator applications in energy and the environment, medicine, industry, national security, and discovery science. The strategic plan should be based on the results of the Department's 2010 workshop study, Accelerators for America's Future, that identified the opportunities and research challenges for next-generation accelerators and how to improve coordination between basic and applied accelerator research. The strategic plan should also identify the potential need for demonstration and development facilities to help bridge the gap between development and deployment."

In a Nutshell



From: "Accelerators and Beams - Tools of Discovery and Innovation," the APS Division of Physics of Beams

Strategic Stewardship Plan

- **HEP currently leading development of a strategic plan for accelerator stewardship to respond to national needs**
  - *Accelerators for America's Future workshop* (2009) identified needs
    - also identified potential representatives for the various constituencies
  - recent actions
    - additional accelerator science program manager (Fed position) hired
    - HEP program manager for stewardship planning is on-board and currently helping to formulate strategic plan
    - Task Force set up to provide community input on possible strategy (Holtkamp's talk)
      - DOE will carefully consider this input in arriving at its plan
- **Formal plan will be coordinated by HEP in close consultation with other relevant SC program offices**
  - response to Senate will be submitted at SC level
    - stewardship activities likely require partnerships with other programs
      - not all the right people will reside in HEP

Evolution of Program (1)

- **Accelerator Task Force has provided input on how HEP might effectively broaden its long-range accelerator R&D portfolio to explicitly consider needs beyond HEP**
  - and beyond just Office of Science (SC)
- **Possible approach**
  - designate representatives from the various stakeholders to meet regularly and advise/evaluate the accelerator stewardship program
    - other SC programs
    - other agencies (NSF, NIH, ONR,…)
    - medical community
    - national security/defense community
    - industrial users
      - need both large and small companies; perspectives are different

Note: both programmatic and end-user perspectives needed

  - targeted community workshops could be used to assess progress and solicit future needs
    - decision-making process must be seen as transparent and fair

Evolution of Program (2)

- **Within HEP**
  - envision creating separate B&R code for stewardship activities
    - designate program manager for activity (reporting to HEP AD)
    - allocate a portion of long-range accelerator R&D funds for stewardship
      - expect initial phase to be mainly a relabeling of ongoing HEP work
      - successful program will ultimately grow based on demand
        - ♦ e.g., more emphasis on lasers
- **Within SC**
  - have regular briefings with cognizant programs and SC management
- **Beyond DOE**
  - have regular meetings with "Board of Stakeholders"
    - they will help to evaluate and prioritize promising directions
      - final decisions must be made by HEP AD
        - ♦ cannot manage a program via a committee
  - coordinate workforce development/training with NSF

Stewardship Challenges

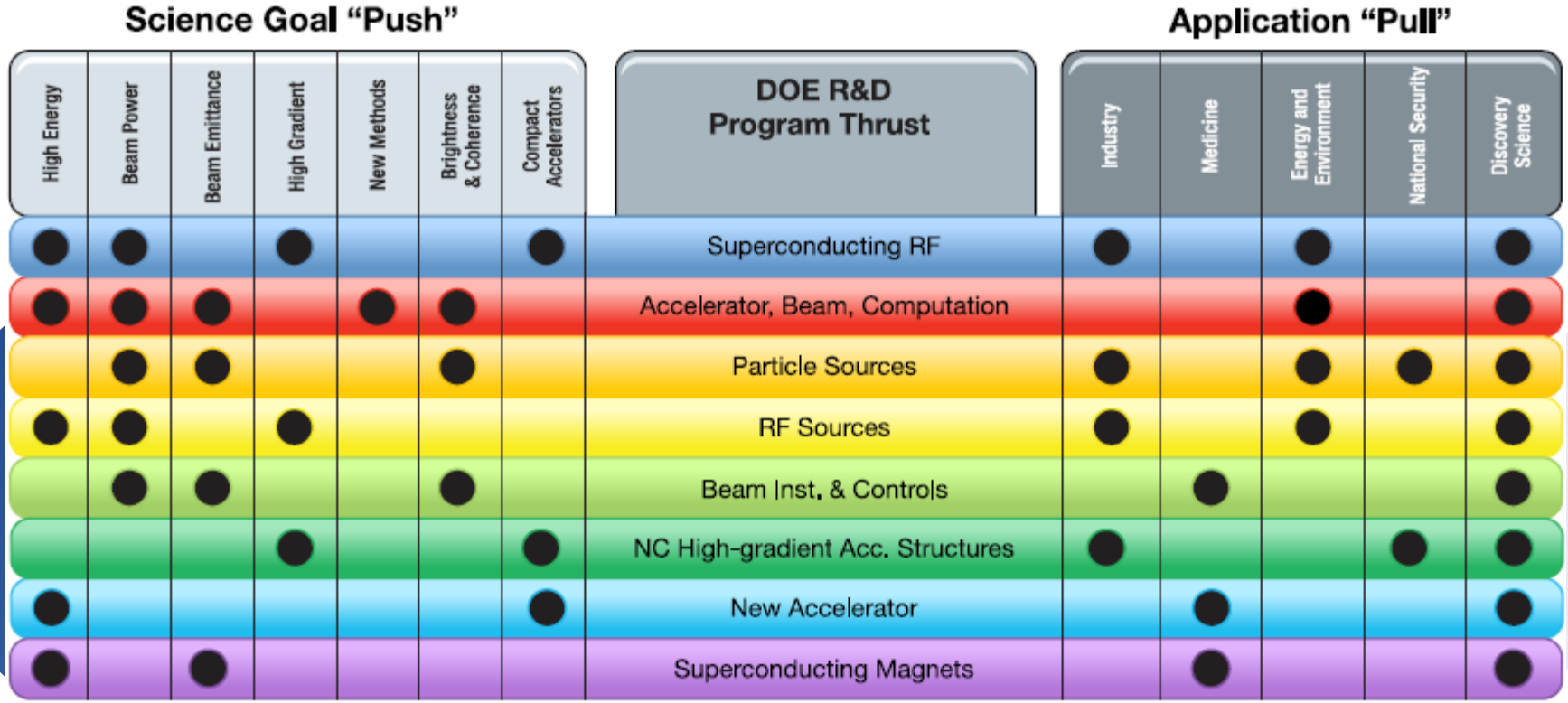
- **Successful program must address challenges identified at the AfAF workshop:**

1. difficulty of stakeholders to identify cognizant federal "owner" when requirements cut across agencies
2. need to address (funding) gap between bench-scale demos and full deployment of new technologies
3. need for technology advances to increase reliability and reduce construction and operation costs
4. need to maintain and improve core competency in accelerator design and construction via education and training
    - of these, item 2 is the most challenging

- **Additional challenges associated with collaboration between industry and national labs must also be handled**
    - time scales, intellectual property, up-front funding requirement…

Evolution Mechanism

- Over time, R&D program needs will modify the science goals and, as necessary, the program thrust areas



Summary

Take-Home Message

- SC programs already maintain a broad accelerator R&D program that leverages unique expertise and test facilities at different labs and universities
- Near and mid-term program-specific R&D is being carried out by various SC programs
- HEP continues its historical support of long-term R&D in accelerator science and technology
- HEP currently leading development of a strategic plan for accelerator stewardship
- Goal is to have world-leading program in accelerator R&D not only for SC applications but serving all of the nation's accelerator needs
  - it is a worthy goal, but will not be easy