HEPAP Advanced Accelerator R&D Subpanel

Jay Marx, chair

HEPAP Meeting

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The Charge

- Undertake a comprehensive review of all aspects of the OHEP and NSF accelerator R&D programs with the exception of technical and management review of Linear Collider R&D and LARP

- The review should address:
  - National goals
  - Stewardship
  - Scope
  - Quality
  - Relevance
  - Resources,
  - Management
  - Training

The Subpanel

Mix of accelerator scientists and users of accelerator-based HEP facilities; US, Europe, Asia

- Ilan Ben-Zvi (Brookhaven National Laboratory)
- Jean-Pierre Delahaye (CERN)
- Alex Dragt (University of Maryland)
- Helen Edwards (Fermilab)
- Don Hartill (Cornell University)
- Andrew Hutton (TJNAF)
- Young-Kee Kim (University of Chicago)
- Jay Marx (Lawrence Berkeley National Laboratory, chair)
- Katsunobu Oide (KEK, Japan)
- Nan Phinney (SLAC)
- Jamie Rosenzweig (UCLA)
- Stew Smith (Princeton)
- Harry Weerts (Michigan State University)
- Marion White (Argonne National Laboratory)

Background--Previous AARD Subpanels

- 1980: “Tigner” HEPAP sub-panel
  - Recommended grant-based long-term accelerator R&D program in DOE HEP; 4% of HEP operations funds (not construction)
  - Led to Washington-managed grant-based long-term accelerator R&D program in OHEP (1982)
- 1996: “Marx” HEPAP “composite” sub-panel
  - Address accelerator R&D throughout Office of Science
  - For OHEP, endorsed 4% recommendation of Tigner panel

The Process

- Three multi-day meetings to gather input
  - East coast, mid-west, west coast
  - Each including town meeting coordinated through APS Division of Beam Physics
  - Input from funding agencies, labs, universities, some industry
  - Topical sessions on SCRF, SC magnets
- Other input to subpanel
  - Responses to questionnaires from subpanel for information to labs and university Pis
  - And lots of additional input from community via letters, e-mails, phone calls, etc.

The result--subpanel's report

- Next part of this talk will highlight the most important themes in report
  - Highlight key findings, issues and recommendations
- This talk doesn't touch on everything in the report
  - Other findings, comments and recommendations in report
  - Extensive appendices information compiled by subpanel
    - Background information related to training and education
    - Background information related to short and medium term accelerator R&D
    - Background information related to long term accelerator R&D
    - Summary of accelerator R&D in Europe and Asia

Definitions used by subpanel

- Short-term accelerator R&D is that related to existing or approved accelerator facilities.
  - Mostly ballistic
- Medium term accelerator R&D is that related to envisioned new accelerator facilities.
  - Mostly strategic development and targeted
- Long-term accelerator R&D is exploratory research aimed at developing new and innovative concepts, new techniques and technologies, and advancing fundamental accelerator science
  - Mostly exploratory research

Most important themes in report

- Sustaining and strengthening accelerator science as an important scientific discipline of critical importance to the future of HEP
- Providing needed opportunities for education and training of the next generation of accelerator scientists and engineers
- Sustaining the level and quality of short and medium term accelerator R&D, especially key enabling technologies
- Assuring a healthy and stable program of long-term accelerator R&D in OHEP & NSF
- More coherent management, oversight and planning for the OHEP portfolio of accelerator R&D

Our findings and recommendations are meant to help OHEP and NSF address these topics & strengthen their accelerator R&D programs

Sustaining and strengthening accelerator science

The subpanel finds that there is an urgent need to strengthen accelerator science, technology and education in the US in order to address long-term needs of particle physics, other sciences and the nation.

- To meet the very difficult challenge of future energy-frontier accelerators that must provide extremely high energy and luminosity within a feasible cost to society (construction cost, operating cost, energy usage).

- To continue and expand the contributions of accelerators (and trained people) to other sciences, the economy, security, and other national needs; enhancing recognition of the practical contributions of HEP to society

- OHEP and NSF should recognize this need and become the formal stewards of accelerator science and technology, and of education in these disciplines

Sustaining and strengthening accelerator science

OHEP has had a historical (informal) stewardship for *fundamental* accelerator science and technology.

- *The subpanel endorses the importance of this stewardship responsibility and recommends that it be formally recognized in the mission statement of OHEP* by include the following:
  - "The Office of High Energy Physics (OHEP) provides program planning, oversight and funding for research in *fundamental* accelerator science and technology."

The proposed new NSF program, Accelerator Physics and Physics Instrumentation (APPI), will be a major step towards recognition of the value of accelerator science.

- *The subpanel recommends that the NSF Accelerator Physics and Physics Instrumentation (APPI) program should be established and funded.*

Education and Training

The subpanel is concerned that there will not be enough accelerator scientists and engineers to meet future needs.

Biggest challenge- overcoming the issues that limit the number of universities that provide opportunities to study accelerator science/engineering

- Accelerator science and technology is not yet broadly recognized as an essential, vital, and exciting frontier research field.
- In most universities it is not considered as an academic subject worthy of faculty lines.
- Few incoming graduate students are aware of either its existence or its contributions, challenges, and promise

Education and Training-what to do

The importance of accelerator science and technology must be more broadly recognized, starting at the university level (professorships, graduate fellowships, undergraduate internships).

- As a catalyst for new accelerator degree programs the *subpanel recommends that an Accelerator Science Graduate Fellowship program in the DOE and NSF should be given high priority.*
  - Would enhance the visibility and stature of the field and help to attract the best students.
  - Would encourage universities to see the value of a program in accelerator science
- DOE and NSF should encourage expansion of opportunities for education and training in accelerator science-- at universities and labs
  - Given the special role that education plays in the mission of the NSF, a strong commitment to training and research in accelerator science would significantly enhance the recognition of this field in the universities.
- Robust support of the US Particle Accelerator Schools is essential and should be continued.

Assessment of short & medium term accelerator R&D on key enabling science & technology

Subpanel identified key enabling science and technology needed for planned and envisioned particle physics accelerator facilities, as well as facilities for other sciences.

- The overall quality of the R&D on these enabling technologies is very high and the program addresses all of the key topics
- The program is generally well-balanced given the level of available support.
- In the near term, the highest priority will be ILC R&D but in order to advance the enabling technologies needed in the future
  - a balanced R&D program that addresses all of the important topics must be maintained.

Sustaining excellence requires relatively stable funding, modernization of infrastructure when necessary, and a continuous inflow of well-trained new researchers.

Assessment of short & medium term accelerator R&D on key enabling science & technology

- A strong US program in superconducting RF is essential for progress in accelerator science for HEP.
  - As the program develops, it should take account of all relevant available expertise and facilities nationally and internationally and recognize that the US is currently behind Europe and Asia in capabilities, infrastructure and industrialization.
- We are concerned that the support for muon cooling is below what is needed to sustain this program.
  - Support for MICE leaves little for other R&D
  - Without increased support, essential intellectual resources will disappear.
- Within the LARP program
  - Careful consideration should be given to the balance between producing hardware deliverables for CERN and activities (e.g. commissioning) that substantially enhance the intellectual and technical capabilities of the US accelerator community

Assessment of long-term accelerator R&D

A primary focus of the subpanel is the longer-term accelerator R&D programs supported by OHEP and NSF

- A healthy and stable program of long-term accelerator R&D is essential for HEP's future
- The long-term accelerator R&D supported by OHEP and NSF are unique programs that are effective and scientifically valuable
- The overall quality of the US programs in long-term accelerator and technology R&D is very high. Most of these programs are world class and, in many specific areas, world leaders

Long-term R&D on superconducting RF

Subpanel has concern about R&D in long-term SCRF

- Less than 5% of the US effort on SCRF is on long term R&D. This is inadequate given the need for basic understanding of the physics of SRF limitations, materials and surface properties.
- Given the importance of SCRF as a growing technology and its many possible future applications for Office of Science and NSF programs, *we recommend that OHEP and NSF build a healthy program to address the fundamental issues of SRF and cavity properties, materials and surface science.*
  - We believe that support for *fundamental* SCRF research must be increased.

Long--term accelerator R&D at the National Labs

We believe that it is important to encourage and support advanced accelerator R&D at the national laboratories that has the potential for significant long-term impact.

- In recent years such R&D has been increasingly constrained by programmatic and project-related goals.
- The result is a significant decrease in flexibility to pursue new ideas or technologies that could form the basis of a new and important capability in the several decade time-horizon.
- *We recommend that OHEP should accept proposals from the laboratories to pursue long-term accelerator R&D that has the potential for significant impact, and to invest in appropriate research and supporting infrastructure.*

Support of long-term accelerator R&D

Support of long-term accelerator R&D is an investment in the future of the field. It provides opportunities for research with potentially large payoff, enables education and training and sustains accelerator science

- Previous subpanels suggested 4% of the HEP operating budget and emphasized the importance of stable funding.

This subpanel recommends that this accelerator science support be protected at both the agencies and the laboratories to maintain stable levels of funding.

- The need for more educational opportunities, strengthening accelerator science and the difficult challenges ahead-- very high energy & luminosity, affordability, low energy consumption-- lead us to recommend an increased investment over the next decade.

This subpanel recommends that the percentage of the OHEP budget assigned for long-term accelerator science should be 5% in FY07, and increased gradually and smoothly to 6% over the next ten year period.

Increasing coherence of management, oversight and planning across the OHEP portfolio of accelerator R&D

- Within OHEP, oversight for accelerator R&D (medium and long-term) at universities and laboratories should be the responsibility of a single team of program managers.

- Medium and long-term accelerator R&D programs in OHEP should undergo a yearly review by a broad-based committee of accelerator scientists, including members who are cognizant of the possible longer-term accelerator based needs of the other Office of Science and NSF programs. This committee should be appointed with overlapping terms to assure continuity.

- For the long-term R&D-- in addition to the current system, use an expert review process to consider and prioritize all program elements, old and newly proposed should be implemented.
  - This will provide guidance to allow for terminating the worst rated programs while adequately supporting the leading ones.

Strategic Planning for Accelerator R&D

The subpanel believes that OHEP should develop a strategic framework for its portfolio of medium-term and long-term accelerator R&D.

- This framework should be consistent with the overall strategic direction of particle physics and the anticipated needs of the Office of Science, in the context of international efforts.
- An important driver for this strategic framework must be the serious challenge to identify and develop new concepts for future energy-frontier accelerators that can provide the very high energy and luminosity needed for HEP within a feasible cost to society (construction cost, operating cost, energy usage).
- *The subpanel recommends that OHEP develop a strategic plan for medium-term AARD based on the upcoming P5 Roadmap for HEP. This plan should be reviewed (by the committee described on the previous slide) and updated on a yearly basis*.
  - *This plan will be an important tool for priority-setting for medium-term accelerator R&D*

Strategic framework longer-term accelerator R&D

Strategic principles to guide management of longer-term accelerator R&D should be developed; e.g.

- The breadth of long-term accelerator R&D should reflect the stewardship responsibility of OHEP for accelerator science and technology.
- Highest priority should be given to R&D that holds the promise of producing new inventions, techniques, approaches or technologies to extend the reach of accelerator-based physics and to research of the highest quality that addresses fundamental aspects of accelerator science.
- Contributions from the universities, the laboratories and industry should all be encouraged
- Activities that contribute to the education and training of students and postdocs and collaborative activities should be strongly encouraged.

Conclusions

The subpanel emphasizes the critical importance of accelerator science and technology to particle physics, other sciences and to the nation.

We find that there is an urgent need to strengthen accelerator science, technology and education in the US.

- Need to strengthen accelerator science as an important scientific discipline
- Need more opportunities for education and training of the next generation of accelerator scientists and engineers
- Need to sustain the level and quality of short and medium term accelerator R&D, especially key enabling technologies
- Need to assure a healthy and stable program of long-term accelerator R&D
- Need more coherent management, oversight and planning for OHEP portfolio of accelerator R&D

The subpanel, in its report, gives funding agencies information, ideas and advice to help them work towards meeting these needs

Backup slides

Why the % increase for long-term accelerator R&D?

- Historically---The level of 4% of the HEP operating level (non-construction part of overall budget) recommended by the Tigner panel seems to have been well-targeted in that the field has been able develop the accelerator science and technology needed for the cutting edge accelerator-based capabilities for the several decades since.
- Funds exploratory research-- hard to make a programmatic analysis of how much is enough.
- Is the past indicative of future needs?

- The subpanel regards the need for strengthening accelerator science, more opportunities to train the next generation of accelerator scientists and engineers and the difficult and increasingly complex technical challenges to be faced in the decades ahead at the energy and luminosity frontiers—achieving extremely high energy and luminosity with a cost that society can bear with low energy consumption during operation—as indicative of the need for increased investment in fundamental long-term accelerator R&D over the next decade.
- This has need been recognized in the increased funding for this R&D in the President's FY07 Budget Request. (from ~4% to ~5%)

- The subpanel regards the increase recommended during the coming decade as relatively modest and very important.

Why has the subpanel not set priorities among sub-elements of the accelerator R&D program?

- Short-term-- ballistic; focus is on operating facilities
- Long-term-- high priority; need stable, robust program of exploratory research; seed corn to protect.
- Medium term- aimed at approved/planned facilities--
  - Priorities between elements (e.g work on enabling technologies vs. time) is, of course a good idea.
  - Must be done in the context of the overall priorities and roadmap for the field (e.g P5 Roadmap in preparation) taking account of when results of R&D is needed (e.g. when targeted facilities would be designed, constructed). Then can develop R&D priorities between different R&D tasks vs. time.
  - This is the strategic plan for medium term R&D we recommend; but now is a bit too early (wait for P5)
  - The charge wisely didn't asked us to set such priorities

Funding for long-term **accelerator R&D in OHEP**

- FY05:
  - At labs ~$20.6M in FY05
  - At Universities (+ some industry & non-DOE labs)-- ~$11.4M in FY05 (grant-based program)
- This (~$32M) is ~4% of OHEP budget

- For FY07 President's budget has additional $5M for long-term accelerator R&D
  - Inflate FY05 numbers to FY07 ~$34M; add $5M= $39M
- For FY07 get up to ~5%

- And portion of SBIR and STTR

Enabling science and technology

- Accelerator theory
- Computer simulations
- Superconducting RF cavities
- High-power RF sources
- RF controls and feedback systems
- High gradient warm RF cavity systems
- Cryogenics
- Electron/positron sources
- Beam diagnostics and instrumentation
- Lasers
- Superconducting magnets
- Energy recovery and efficiency
- Muon cooling
- Technology development and infrastructure to support R&D

What falls under stewardship?

the criteria is the fundamental importance of the accelerator science and technology being addressed as well as the potential impact on particle physics and on other DOE research. Not research that has a narrow focus towards short or medium term applications, unless the particular research topic is fundamental.

Long-term R&D on superconducting magnets

The long-term superconducting magnet R&D program represents an important national asset and so should be supported at a vigorous level.

- It is essential that a well-coordinated, optimized research program be developed to avoid duplication of effort. There may be opportunities to redirect production capacity at the laboratories for a more effective use of resources.

Muon cooling

- US commitment to MICE requires most of the available funding in the US for work on muon cooling. As a result there are other aspects of the problem that are not able to be addressed due to limited funding. Given the long time horizon of a muon collider or storage ring, it is hard to maintain the attention, commitment and focus of researchers who wish to work on some of these topics unless there is some funding available.
- Answer best determined by in-depth depth of the muon cooling R&D tasks that need to be addressed, the effort and equipment needed, and the opportunities for addressing them (e.g. people who are interested in doing the work as well as the balance between support for MICE and the other aspects of the muon cooling program. This type of review would be best organized and carried out by the OHEP program manager for the muon cooling effort.
- Perhaps a reasonable scale would be to restore the funding to the level of four or five years ago which is about twice the current funding level of 3.6 M$ from DOE. In addition there was 1.2 M$ from the NSF during that period.