Fermilab Accelerator Advisory Committee Meeting
February 6-8, 2013

Final Report

AAC Committee:

Members present: Ilan Ben-Zvi (BNL), Wolfram Fischer (BNL), Steve Gourlay (LBNL), Katherine Harkay (ANL), Mark Hogan (SLAC), Andrew Hutton (JLab), Lia Merminga (TRIUMF) (chair), Peter Ostroumov (ANL), James Rosenzweig (UCLA), Andrei Seryi (JAI)

Tasks/Assignments:

***ASTA Proposal*:** M. Hogan (lead), I. Ben-Zvi, J. Rosenzweig, A. Seryi
FNAL Accelerator complex: K. Harkay (lead), W. Fischer
***Project X*:** P. Ostroumov (lead), A. Hutton
Technology Development: S. Gourlay (lead), L. Merminga
***Muon Accelerator Program*:** A. Seryi (lead), A. Hutton

Contents:

Executive Summary

The AAC was convened from February 6-8, 2013 and asked to assess and provide advice on the plans for ASTA, including a recently completed proposal for an accelerator R&D user facility, and on the progress and plans for the Accelerator Complex, Project X, Technology Development, and Accelerator R&D with emphasis on the Muon Program.

The AAC found that the Accelerator Sector priorities have been clearly defined and they are consistent with its long term vision to establish a world-leading program in intensity frontier. A technology development and fundamental accelerator science strategy have been articulated to realize this vision and meet the long-term goals of the OHEP.

The AAC congratulates the FNAL Accelerator Team for the outstanding progress on multiple fronts in the past year, and their many accomplishments, despite serious funding challenges. The most notable accomplishments are listed in the following sections. These accomplishments indicate the success of defining and communicating a vision for the Accelerator Sector.

The Accelerator Team responded in a thorough and comprehensive way to previous AAC recommendations, and the committee appreciates the effort put into it.

The establishment of a Muon Campus and Muon Department creates a coherent muon effort, and it is strongly endorsed by the AAC.

The AAC strongly encourages FNAL to pursue the ASTA Proposal.

The ASTA facility has unique features and complements the other DOE and international test facilities. Its properties will enable unprecedented experiments in support of the OHEP and the wider DOE missions. Specifically, ASTA addresses needs for R&D towards the Intensity and Energy frontiers, supports the mission of the OHEP for stewardship role of accelerator R&D, and in support of Industry and other society needs.

The ASTA proposal is an impressive document which includes a large collection of experiments, many of which are unique to ASTA. The focus now should shift to sharpening the message: how to organize the proposal and present the experimental program in a way that emphasizes the science that is *unique* to ASTA and differentiates it from the other DOE test facilities.

Regarding the near-term upgrades of the Accelerator Complex: the doubling of the proton beam power at 8 GeV and 120 GeV are of utmost importance for the Fermilab user program over the next few years. The overall plan is plausible; however, open issues remain in the proton operation of the Recycler with intensities an order of magnitude higher than used previously with anti-protons.

Project X is very well planned and executed, and technical challenges are being addressed in a systematic way, with PXIE and other programs. Additional funding is required to keep PXIE on schedule.

The committee is impressed with the superconducting materials program for magnets and cavities, and recent results.

MAP's fresh start under new leadership is a welcome development. Connections with the industrial sector, via IARC, should be proactively explored. AAC is concerned about the SBIR change of policy and its impact on the US muon program.

The committee expresses sincere appreciation to the FNAL directorate for its hospitality during this review.

1. Plans for ASTA

1.1 ASTA Proposal & Science

Is the ASTA proposal well-formulated? Is the Science case strong and are there ways that it can be strengthened?

Observations

The ASTA facility has unique features and complements the other DOE and international test facilities. ASTA provides energy of ~1 GeV, 1 msec long pulses, 3 MHz microbunch structure, high average and peak power, properties that enable unprecedented experiments in support of OHEP and the wider DOE missions.

The facility is highly leveraged with nearly 80% of the facility already completed through a combination of ILC, SRF and ARRA funds.

The Fermilab Team is to be commended for doing a lot of work in a short amount of time to bring the ASTA proposal together. It is an impressive document which includes a large collection of experiments, many of which are unique to ASTA. However, the proposal does not sufficiently emphasize and exploit the elements of the ASTA facility that are truly unique in the United States: Superconducting technology and associated pulse format with high power and high repetition rate, GeV energy.

The IOTA case is extremely strong and enhances the ASTA proposal. Better integrating IOTA into the proposal, and putting it into a context of intensity frontier experiments that fit in a broader program, will strengthen the proposal.

The ASTA facility is compared to other facilities in the US and to only one facility abroad. However, competition for users, in the present-day integrated world, is international.

The author list has little representation from universities and industry. On the other hand the existence of a large number of support letters indicates that the user community may be significantly larger than the author list.

The proposal does not establish a clear connection between ASTA and the Fermilab IARC center, although this is an obvious opportunity.

ASTA enables an important R&D activity towards Project-X and addresses risks of the pulsed, high intensity linac. Given that the SRF linac is a major cost driver of Project X, the committee agrees it is important to test complete cryomodules with beam.

Comments

In this section, ideas and suggestions for enhancing the “marketability” of the proposal are offered for consideration.

- Describe the proposal review process in detail. For example, name the program committee, explain the ranking process, and outline strategies to engage the user community and attract additional universities and groups. In general, convey an outward looking attitude. Move this section to an early part of the proposal.
- Restructure the proposal to focus the experiments. The committee has two suggestions:

- Leave only a few, e.g. four (for example: a) high-current, high-power, long pulses; b) IOTA; c) beam-phase-space manipulation; d) industrial experiments) flagship experiments in the main body of the text. Move the rest of the proposals to the appendix. In the preamble to the appendix state that these proposals are not yet ranked, but will be ranked and some of these proposals may be rejected, while others will be added.
- The proposal may be better served by organizing around a few themes such as Intensity Frontier, Energy Frontier, FELs, Stewardship and/or Industrial.

- Play to your strengths – emphasize your areas of strength such as IOTA (high intensity rings), EEX (light sources), feedback on long pulse (light sources, ILC, Project-X).

Recommendations

1. Organize the scientific case to clearly articulate the research that is unique to ASTA and how this will impact the field of HEP, other DOE programs, and Industry.
2. Articulate the scientific and programmatic advantages of collocating advanced technology and physics for linear electron accelerators and proton accelerators including rings in a single facility.
3. Proactively engage potential users from more universities and industry, adapting an outward looking attitude. One way to accomplish this is to organize ASTA Users Meetings/Workshops to gather input from the broader community and bolster the scientific case.
4. Proceed to constitute your Program Advisory Committee as soon as possible.
5. Articulate the connection between ASTA and IARC for Industrial applications.
6. Expand comparison of ASTA facility to relevant existing and future facilities abroad.

2. Fermilab's accelerator complex

2.1 Main Injector and Recycler Ring

Are the plans for doubling Main Injector beam power technically sound and achievable?

Observations

The beam power upgrades are of utmost importance for the Fermilab user program over the next few years.

A factor of 2 in beam power is obtained from 2 sources: a shortened injection plateau in the Main Injector, and an increase to 12 Booster batches instead of 11.

The shortened injection plateau is accomplished by storing beam in the Recycler Ring (RR) while the Main Injector (MI) is ramping. This is the more challenging part of the power upgrade, and also requires a doubling of the Booster throughput by increasing the repetition rate from 5 Hz to 9 Hz.

The overall plan is plausible; however, open issues remain in the proton operation of the RR with slip stacking and an intensity that is an order of magnitude higher than previously with anti-protons.

Recommendations

7. Calculate from beam parameters and beam pipe geometry the SEY threshold for e-cloud formation in RR.
8. Continue the efforts to simulate in as much detail as possible the losses in the RR. In addition, investigate options for a collimation system should it become necessary. Modeling tools, such as SYNERGIA, have been validated and should be adequate for this purpose.
9. Develop a contingency plan for the possibility that the titanium sublimation pumps (TSPs) fail in the RR.

2.2 Booster and Linac

Are the plans for doubling the throughput from the Booster technically sound and achievable?

Observations

The increase of the Booster repetition rate to 15 Hz is necessary to serve multiple user programs simultaneously.

The main upgrade in the Booster is the refurbishment of rf cavities which is a pre-condition for the increase in the repetition rate.

Reliability and availability concerns have led to investigating replacing the linac power tubes; the favored option is to use 200 MHz klystrons.

Recommendations

10. Allocate more labor resources to Booster rf cavities refurbishment.
11. FNAL should ensure that LANL/LANSCE and BNL are aware of a decision to replace the 200 MHz linac rf amplifiers with klystrons, as this decision may impact both.

2.3 Accelerator Upgrades for Muon Program

Are the accelerator modifications and upgrades for the muon program technically sound and achievable?

Observations

The muon program encompasses the two experiments g-2 and Mu2e.

The establishment of a Muon Campus and Muon Department creates a coherent muon effort.

The Mu2e cost reduction exercise has significantly relaxed the demands on the accelerator upgrades.

The upgrade plan is technically sound and achievable. Good use is being made of recycling existing accelerator components.

Recommendations

None

3. Project-X

3.1 Plans

Are the plans well-formulated?

Short answer is "yes".

Observations

The Reference Design of the Project X has been updated to include more technical details and to reflect a new staging plan, and minor technical changes (RFQ frequency, HWRs instead of SSR0).

A staging plan has been developed under DOE guidance. The cost of each stage is below $1B. The following stages were identified:

- Stage I: 1 MW CW beam at 1 GeV
  - Injecting into existing (upgraded) booster
  - Connection to muon campus
  - New high power spallation campus (1 GeV).
- Stage II: 3 MW CW beam at 3 GeV
  - Still injection into booster
  - 20 Hz booster upgrade
  - New high power muon and kaon campus (3 GeV)
- Stage III. Add 3-8 GeV × 1 mA @4.3% duty factor pulsed linac injecting into (upgraded) recycler/MI and provide connection to short baseline neutrino campus.

An R&D program has been developed and is being implemented to mitigate technical, cost and schedule risks.

CD-0 documentation is supported in a continuing state of readiness. Possible timeline for DOE critical decisions has been proposed. The Project X will be ready to initiate construction start in 2017.

Detailed staged physics program with specific requirements to the proton beam has been developed.

Comments

The path to project approval is unclear. At the same time, it is obvious that Fermilab and HEP leadership on the Intensity Frontier strongly depend on the success of Project X. Therefore, the committee strongly supports the efforts towards approval of Project X.

The mission of Project X and its execution plan are very well developed and presented to the AAC. The project team is in place and capable to carry out both the planned R&D work and to execute the project.

The Project X has been broken into three stages. This is a very good idea and it is well executed.

While there are three main areas of R&D, it is clear that the main focus is on PXIE.

Recommendations

None

3.2 Technical Issues

Are the right issues being emphasized? Does the proposed program address the most urgent technical issues?

The answer to both questions is "yes".

Observations

To mitigate technical and cost risks, three main R&D areas have been identified: PXIE, SRF and Project R&D.

Successful completion of PXIE will demonstrate:

- MEBT chopper performance (absorber, extinction level)
- CW RFQ performance
- Performance of SC cryomodules with 2 types of SC cavities
- Acceleration of high power CW beam through the SC section.

SRF is the main cost driver of Project X.

Project R&D includes:

- H-minus injection studies
- High power targetry (lifetime, remote handling)
- Main injector performance
- Booster performance.

Comments

Main focus of the R&D is on PXIE which is the most innovative development and addresses the significant technical risks of Project X. Tremendous progress has been made towards PXIE since the previous AAC meeting. The development of the most critical components of the PXIE such

as ion source, LEBT, RFQ and MEBT stays on original schedule. Unfortunately, due to insufficient funding, the PXIE completion date slipped to 2018 instead of 2016 as was originally proposed. To-date, there is no doubt that PXIE can be commissioned by 2016 if sufficient funding is provided.

SRF is the major driver of the Project X cost. Therefore, the following developments and prototyping should be continued:

- Construction and testing of SSR1 cryomodule for PXIE. The most urgent task is fabrication and installation of the helium vessel for one of SSR1 and its cold testing to confirm the expected performance and controllable microphonics.
- Construction and testing of the third ILC cryomodule.
- Design of 650 MHz cryomodules.

Project X is heavily based on ILC technology; therefore, the Project X team has established tight collaboration with the virtual ILC laboratory (GDE) to carry out mutually beneficial developments.

ASTA will provide R&D in support of one of the critical elements and the cost driver of Project-X.

Recommendations

12. Aggressively pursue current plans on PXIE and work with DOE/HEP to avoid any schedule delays due to the lack of funding.
13. Continue R&D work on performance improvement of 650 MHz SC cavities including the studies of microphonics.
14. Consider the impact on Project X and the SRF Program of possible ILC developments.

4. Technology Development Programs

Are the plans for SRF and superconducting magnet development well-formulated and is adequate progress being made? Are the right issues receiving the required attention?

4.1 Plans & Progress

Observations

The Materials program is excellent, and has considerable breadth, ranging from very practical applications to potentially paradigm changing ideas.

The magnet program responded to recommendations from the last review by increasing focus on the 11 T program and launching into focused development of radiation-hard materials for impregnation. Both programs are making good progress.

It is not yet determined if the 11 T dipole will be included as part of the scope of the LHC upgrade. See additional comments below.

The conductor program seems relatively well aligned with other efforts in the community.

A significant but appropriate amount of work is going into Bi-2212 development but the powder supply is uncertain.

Significant and impressive achievements were made on reduction of surface resistivity of SRF cavities, a critical issue for the CW part of Project X.

Recommendations

15. LARP needs a crab cavity down-select plan. Define performance criteria so proponents know what to aim for.
16. Clearly define scope of the 11 T program in the near term. Need a clear definition of success.
17. The rad-hard materials effort is excellent but needs a well-defined end-point.
18. Work with the community to develop alternate sources of BSCCO powder.
19. Continue with SRF material studies to improve cavity performance that affect the cost driver of the Project X linac.

4.2 Program scope

Are they adequately supporting the HEP community's plans?

Observations

The focus of SRF cavity materials R&D more on reduction of surface resistivity, and less on gradient, will directly and significantly benefit CW and long pulse SRF linacs (such as Project X, NGLS, ERLs), which are in the HEP and Light Source community's plans.

The magnet and materials programs play well to Fermilab's traditional strengths; focus on technology development for near to mid-term applications.

Decision from CERN on the magnet aperture has allowed LARP to move ahead with the plan to transition from program to project. This seems to be well underway.

The 11 T program will generate timely experience that will be very important for the LHC Luminosity Upgrade. This can be viewed as a positive response to the increased pressure by the DOE on the Accelerator R&D program to support LARP. It is not clear if the program funding allows this work to be continued without direct LARP support.

Recommendations

20. Fermilab's participation in HL-LHC is critical to the success of the LHC Upgrade Project. It is important to have a clear projection of resources given current and future commitments.

5. Accelerator R&D Program

5.1 Muon Accelerator Program

Is the Muon Accelerator Program properly focused and making adequate progress?

Observations

The Muon Acceleration Program is now managed by Mark Palmer – the committee is pleased with this appointment.

The management and execution plans for MAP have been reviewed and updated, maximizing the efficiency of the program and its opportunities. The committee was pleased to hear recent developments to analyze a muon-based Higgs factory.

The MAP program is planning to select baseline technologies (in 2013-15) as well as alternatives, aiming at technical demonstration of baseline technologies by FY16-18.

The program aims to be ready in about six years to provide technical information to the community, enabling and facilitating a decision to proceed to CDR of either a neutrino factory or a muon collider.

The technological part of MAP is making impressive progress.

The program is challenged by the available funding profile.

Recent reconfiguration of SBIR program effectively further reduced the available budget of the program. The committee acknowledges that Fermilab is engaged in the analysis of the effects of SBIR reconfiguration.

The program is suffering from weak connection to international physics community.

Recommendations

21. Seek connections between MAP technology program and IARC where appropriate – based on impressive and often world-record devices and systems developed as part of the program.
22. Evaluate quantitatively the impact of SBIR reconfiguration on MAP schedule and progress, and discuss possible mitigations with DOE.

Charge

February 6-8, 2013

The Fermilab Accelerator Advisory Committee is asked to assess and provide advice on the following topics:

1. **The plans for ASTA**. DOE/HEP directed Fermilab to suspend activities associated with the buildout of ASTA, and to submit a Proposal for its completion and subsequent operation as a user facility for accelerator R&D. Is the Proposal well-formulated? Is the Science Case strong and are there ways that it can be strengthened?
2. **The plans for Fermilab's Accelerator Complex in the near-term.** Are the plans for doubling the Main Injector beam power technically sound and achievable? Are the plans for doubling the throughput from the Booster technically sound and achievable? Are the accelerator modifications and upgrades for the muon program technically sound and achievable?
3. **The progress and plans for Project-X and its R&D program**. Are the plans well-formulated? Are the right issues being emphasized? Does the proposed R&D program address the most urgent technical issues?
4. **The progress and plans for the Technology Development programs**. Are the plans for SRF and superconducting magnet development well-formulated and is adequate progress being made? Are the right issues receiving the required attention? Are they adequately supporting the HEP community's plans?
5. **The progress and plans for Fermilab's Accelerator R&D program.** Is the Muon Accelerator Program properly focused and making adequate progress?

Agenda

Fermilab Accelerator Advisory Committee Meeting February 6-8, 2013

Start	Duration	End	Speaker	Topic
Wednesday Feb. 6, 2013				
Overview and ASTA				
11:30	1:00	12:30		*Executive Session*
12:30	0:30	13:00	S. Henderson	Overview and Strategy
13:00	0:15	13:15		*Discussion*
13:15	0:30	13:45	S. Henderson	ASTA Introduction
13:45	0:30	14:15	V. Shiltsev	ASTA Science Justification and Program Overview
14:15	0:15	14:30		*Discussion*
14:30	0:25	14:55	M. Church	Status, Commissioning and Operations plans
14:55	0:25	15:20	P. Piot	ASTA Physics
15:20	0:25	15:45		*Coffee Break*
15:45	0:25	16:10	S. Nagaitsev	IOTA
16:10	0:20	16:30	J. Leibfritz	ASTA Scope, Cost, Schedule
16:30	0:30	17:00		*Discussion*
17:00	1:00	18:00		*Executive Session*
Near-term Plans for the Accelerator Complex				
Thursday Feb. 7, 2013				
8:30	0:30	9:00	P. Derwent	NOvA Accelerator Upgrades
9:00	0:30	9:30	W. Pellico	Proton Improvement Plan
9:30	0:30	10:00	J. Annala	Accelerator Upgrades for the Muon Program
10:00	0:20	10:20		*Discussion*
10:20	0:25	10:45		*Coffee Break*
10:45	0:30	11:15	I. Kourbanis	Beam Dynamics Issues for NOvA Operation
11:15	0:30	11:45		*Discussion*
11:45	1:00	12:45		*Lunch*
LARP and the SC Magnet and Materials Programs				
12:45	0:30	13:15	E. Prebys	LARP Plans
13:15	0:30	13:45	A. Zlobin	SC Magnet Program
13:45	0:30	14:15	L. Cooley	SC Materials R&D
14:15	0:30	14:45		*Discussion*
14:45	0:25	15:10		*Coffee Break*
Project X and the SRF Program				
15:10	0:30	15:40	S. Holmes	Project-X
15:40	0:30	16:10	V. Lebedev	Project-X Injector Experiment (PXIE)
16:10	0:40	16:50	S. Yakovlev	Superconducting RF Program
16:50	0:40	17:30		*Discussion*
17:30	1:00	18:30		*Executive Session*
Friday February 8, 2013				

Muon Accelerator Program				
8:30	0:30	9:00		*Follow-up with Committee*
9:00	0:40	9:40	M. Palmer	Muon Accelerator Program
9:40	0:25	10:05	A. Bross	Fermilab MICE Activities
10:05	0:25	10:30	Y. Torun	MTA Status and Progress
10:30	0:30	11:00		*Coffee Break*
11:00	1:00	12:00		*Discussion*
12:00	0:30	12:30		*Lunch*
12:30	3:00	15:30		*Executive Session*
15:30	1:00	16:30		*Closeout*