Response to the DOE Office of Nuclear Physics December 8-10 Operations Review of the Argonne Tandem Linac Accelerator System

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Introduction

The facility operations of the Argonne Tandem Linac Accelerator System (ATLAS) were reviewed on December 8-10, 2003. The report was received from DOE Office of Nuclear Physics on 31 March 2004 with a response requested by July 1, 2004.

The overall conclusions of the review were:

- **The ATLAS facility has an outstanding broad-based program, aligned with, and in many areas driving forward, the present and future goals of the low energy nuclear physics field as expressed in the Nuclear Science Advisory Committee (NSAC) 2002 Long Range Plan.**

- **The ATLAS is a first class stable beam facility that is at the low energy nuclear physics forefront.**

- **ATLAS will not be able to sustain the present level of operations with constant effort funding.**

The review validated the high levels of the leadership, scientific program and accelerator and experiment operations of the ATLAS facility. The recognition that the facility is aligned with and in many areas driving forward the present and future goals of the field is particularly satisfying.

The committee's key conclusion is that the present level of funding cannot sustain operations at this high performance level. This matches our own conclusions.

The basis for responding to the review was for the broad ATLAS community to develop a more comprehensive strategic plan and justify performance expectations on the basis of this plan. It was emphasized that this must be a community plan. Following the verbal close-out of the review, we immediately began working with the ATLAS users through the Users Executive Committee. A draft of a strategic plan is given in the next section. An ATLAS user workshop has been scheduled for July 31-August 1 to discuss the visions, opportunities, and priorities with the user community. At the conclusion of this workshop, the Physics Division and the Users Executive committee will work together to finalize this plan by September 2004. It will be available to all, and be updated on a regular basis. We expect this plan to be a principle element of the ATLAS Science and Technology review scheduled for November 2004. For the purposes of this response, the draft strategic plan will be used.

Since this was a facility operations review, it did not include a review of the scientific research of the in-house staff nor the significant involvement of the scientific staff in funded RIA R&D. We provided at the review the current breakdown of resources into accelerator operations, experiment support and research categories. In common with all user facilities, a significant in-house research effort is essential to provide scientific and technical leadership and to attract excellent scientists to maintain the required level of

focused attention to the research goals and the continuing drive to explore the frontiers that can be addressed with ATLAS, and the sustained effort to develop and maintain the experimental systems that is inherent in user support. In our discussions of allocation of resources, we have not included the need to supplement this research activity to address new scientific challenges.

Draft Strategic Plan

This is a draft of the strategic plan based on initial discussions with the ATLAS user community. It will be discussed at the July 31 ATLAS user workshop and a final plan will be published in Fall 2004.

Mission:

The mission for the ATLAS facility at Argonne is to enable research of the highest quality by its users and staff, especially probing the properties of atomic nuclei, through utilizing the capabilities of the accelerator and research equipment in a safe and efficient manner, with the associated responsibility of research and development in accelerator science and in the techniques that are required to accomplish its scientific goals.

This mission requires identifying the highest priority scientific goals, and allocating resources to optimize the research output of the facility. The current scientific goals are fully consistent with those defined in the NSAC 2002 Long Range Plan and the Office of Science 2004 Strategic Plan. The optimization of the research involves the following elements:

1. Effective long-term operation of the accelerator.
2. Development of new accelerator capabilities to enable new high priority research opportunities.
3. Effective support of the experimental program.
4. Development of new experimental capabilities to enable new high priority research opportunities.
5. Encouragement of the scientific and technical base of the low energy research program and helping to develop the high-quality low-energy workforce for future initiatives.

This last element is not discussed explicitly below but is a major factor in the delivery of the entire research program, including the need for young researchers to be involved in equipment development and new research initiatives.

The major scientific goals of the ATLAS research program are: (a) understanding of the stability and structure of nuclei as many-body systems built of protons and neutrons bound by the strong force, (b) exploring the origin of the chemical elements and their role in shaping the reactions that occur in the cataclysmic events of the cosmos, (c) understanding of the dynamics governing interactions between nuclei at energies in the vicinity of the Coulomb barrier, and (d) testing with high accuracy the fundamental symmetries of nature by taking advantage of nuclei with specific properties.

To reach these goals, major research topics as identified by the scientific community, the Program Advisory Committee and the laboratory include:

- the development of beams of short-lived isotopes and their subsequent use for measurements of astrophysics interest and for nuclear structure and reaction studies;
- the production and characterization of nuclear structure away from the valley of stability including nuclei at the very limits of stability, i.e.; nuclei at and beyond the proton drip-line, on the neutron-rich side of the valley of stability, and in the region with $Z > 100$;
- the study of the nature of nuclear excitations as a function of mass, proton or neutron excess, spin and temperature: characteristics such as nuclear shapes, the interplay between degrees of freedom, changes in shell structure;
- the use of traps for high precision mass measurements for astrophysics and for searches of physics beyond the standard description of the weak interaction.

Smaller scale, complementary efforts exploit the exceptional and often unique capabilities of ATLAS: for example, the irradiation of samples for materials research, developing accelerator mass spectrometry techniques for applications in environmental studies, oceanography, astrophysics, fundamental interactions, and any other area of basic science where they apply, and accelerator research experiments.

As ATLAS is presently the only low energy national user facility focusing on experiments with stable beams, there is an inherent responsibility to make stable beams available to the national community. However, the priorities expressed in the Office of Nuclear Physics performance measures and strategic plan, as well as the scientific goals given above, make it imperative that opportunities with unique radioactive beams at ATLAS continue to be pursued when identified as being important science by the community and endorsed by the Program Advisory Committee as high priority.

Our strategic plan to meet these goals and the mission of ATLAS incorporates the following primary elements:

1. Effective operation of the ATLAS facility at 7 days/week, 5500 – 6000 hours/year: this is a necessary condition to address (a) the large demand for low cross section experiments and for the detection of rare events, (b) the need for flexibility in scheduling and operations of a large number user community, and (c) the need to develop new beams, especially exotic beams, and novel instrumentation.
2. The development of new accelerator capabilities targeted towards these scientific goals:
    a) The energy upgrade of ATLAS: the 30% increase in the maximum energy for ions in the 100-200 mass range is an essential ingredient of a research program probing nuclear states via transfer reactions in inverse kinematics with stable and rare isotopes in the 10 MeV/u range, where the velocities of the nucleons of interest in the projectile and target are well matched.

b) The improvement of in-flight radioactive beams capabilities. This includes the installation of an RF chopper for the in-flight beam program to improve the beam purity for these short-lived, low-intensity beams and enable measurements of lower cross section for nuclear astrophysics.
c) A major upgrade of the reaccelerated radioactive beam capability. The implementation of the so-called “Cf source upgrade” to provide neutron-rich species in the pre-RIA era that are not available elsewhere represents an important, unique step in the exploration of neutron-rich nuclei.

3. Effective support for experimental installation and operation. This includes:
   a) The required scientific and technical support for the user program.
   b) The continued operation of Gammasphere at ATLAS for the foreseeable future: much of the structure program requires the detection of gamma-ray events with large multiplicity for which the array was designed. Until the first tracking arrays become available, Gammasphere will remain the most powerful gamma-ray spectrometer available anywhere and it is essential that it be maintained in optimal operating condition.
   c) Continued development of the target production capability to meet the needs of the scientific program.
   d) Upgrade of data acquisition, analysis and networking capabilities to replace currently unsupported hardware and software.
   e) Experimental support for radioactive beam development

4. Continued operation and development of experimental capabilities. This includes:
   a) Complete the development of the Advanced Penning Trap and continue to exploit the Canadian Penning Trap.
   b) The construction of the X-array: this high resolution, high efficiency array for the focal plane of the FMA is an essential component for the decay spectroscopy of evaporation residues produced with sub-microbarn cross sections such as very heavy nuclei or proton emitters.
   c) The development of the superconducting solenoid: this instrument represents an optimized solution to the challenge of measuring transfer reactions in inverse kinematics at all relevant scattering angles.

Response to Recommendations

Recommendation 1

Generate a mission statement for the ATLAS Facility.

An ATLAS Mission statement is included in the draft strategic plan.

Recommendation 2

Develop a strategic plan with a five to ten year outlook. It should include scientific goals and priorities for the experimental support and accelerator initiatives needed to realize the science. This plan should be available to all, and be updated on a regular basis.

The draft strategic plan is given in Section 2. This plan is consistent with the vision presented at the operations review. The steps to be followed in the future to finalize this plan are:

- An ATLAS user workshop has been scheduled for July 31-August 1 to discuss the visions, opportunities, and priorities with the user community.
- At the conclusion of this workshop, the Physics Division and the Users Executive committee will work together to finalize the plan by September 2004. It will be made available to all on the ATLAS web site , and be updated at least every two years.
- The ATLAS Program Advisory Committee will consider the strategic plan in the Fall of 2004.
- We expect this plan to be a principle element of the ATLAS Science and Technology review scheduled for November 2004.

A complete response to the recommendations of the review requires this finalization of the strategic plan. For the purposes of this response, the draft strategic plan will be used, with the understanding that if the interactions with the community result in any changes in priorities, this will be addressed at the Science and Technology review.

Priorities: Prudent scientific planning requires the consideration of commitment to delivery of accelerator beams, both in scheduled hours and choice of beams, the support for users, innovative new science and constant investment in the future. Experience has demonstrated that the time scale for experiments in this area of physics is about one year. ATLAS proposals consistently request twice as much beam time as is available and the Program Advisory Committee regularly concludes that they are forced to turn away excellent science proposals The PAC is regularly consulted about the relative importance of longer experiments, development opportunities, or a larger number of shorter experiments. Our priorities are explicitly discussed in recommendations 3-5.

Recommendation 3

Make the case for the distribution of available funds, optimized to the needs of your strategic plan and balanced between facility operating and M&S, capital equipment facility base, accelerator improvement projects and research. Consider requesting splitting of research into experimental support funding and research funding into separate B&R accounts.

Our strategy had historically been based on maximizing the number of running hours and PAC approved experiments. Even with this focus, approximately half the research proposals cannot be accommodated. The consensus of the operations review appears to be that the ATLAS facility has overemphasized operations and support for users at the expense of overworking the technical staff, postponing maintenance and delaying new capabilities.

ATLAS is a complicated accelerator requiring considerable specialized expertise for reliable operation. Our only flexibility in accelerator operations is a reduction in the operating hours and flexibility in the research program, with a possible decrease in the number of accelerator operators and a small reduction in M&S costs or a reduction in the variety of specialized beams. This latter option will mean that fewer high priority PAC approved experiments could be accommodated. Any action must be accompanied with an increase in accelerator maintenance and restoration of necessary accelerator R&D activities to the ATLAS budget.

A reduction in the experiment support staff would have the consequences that

- experiments with new detection systems cannot be mounted effectively,
- specialized target requirements cannot be fully met,
- laboratory cybersecurity requirements could not be met and an archaic data acquisition system cannot be replaced,
- Gammasphere, a ten year old system, cannot be maintained at its full capability nor improved to enable new classes of experiments.

The bottoms-up distribution of accelerator and experimental support activities was presented at the operations review. With the high priority given to new scientific opportunities including the ability to use Gammasphere effectively on two beam lines, experiments with new radioactive beams and the need to push detection abilities further from the valley of stability, we conclude that the most effective strategy is to reduce overall accelerator operations by 20% to 5.5 day operation. This will allow us to operate and maintain the accelerator with the current accelerator operations staff, reduce the load on experiment support including target making and experiment installation, and focus resources on the highest priority experiments. It will only begin to allow us to fully address accelerator maintenance and new capabilities as additional M&S funds are still

required so difficult choices remain. Limited 7 day operation for periods up to a month could be accommodated on a case-by-case basis for specific experiments which the PAC identifies as requiring longer data taking runs.

Given the integrated requirements on the experimental program, the planning process, and the relatively short one-year time scale for experiments compared to national funding cycles, we see no particular advantage to splitting the funding for experiment support from that for research into separate B&R accounts. Our current experimental staff is fully integrated into both experiment support and research activities at roughly a 50-50 level and our technical support resources are devoted to experiment support at the 70% level. However, on a year-to-year basis depending on the approved scientific program, individuals and M&S resources frequently shift between support and research functions so such a split is inherently artificial. We do not believe it is appropriate to adopt a longer-term program cycle characteristic of larger accelerators such as RHIC or CEBAF and the acknowledged scientific productivity of the ATLAS program supports this conclusion. However, if the Office of Nuclear Physics concludes such a split would allow them to manage the program more effectively, we can accommodate it, with the recognition that the lines between accelerator operations, experiment support and research must remain flexible.

Recommendation 4

Perform an analysis on the impact of sustaining seven day operations in the out years with constant level of effort funding and the trade-offs to accomplish this.

The operations review concluded: "ATLAS will not be able to sustain the present level of operations with constant effort funding." To maintain seven day operations under constant funding would require a significant reduction in scientific and technical support staff for experimental operations. Examples of the consequences would be

1) Significantly reduce the operating efficiency of Gammasphere and postpone the replacement of obsolete parts and user-requested upgrades.
2) Eliminate several research avenues endorsed by the Program Advisory Committee and the users, especially in the areas of experiments with expensive isotopes, either beams or targets, or unique radioactive beams. This includes research that is identified as part of the Office of Nuclear Physics performance milestones and Strategic Plan.
3) Elimination of the development of selected new capabilities in order to provide funding for increased maintenance.
4) A significant reduction of our ability to address broader needs of the low energy community in target preparation and Gretina development and construction.

Our conclusion is the community and the Office of Nuclear Physics are better served by scaling back the entire ATLAS program to 5.5 day per week operation. This conclusion is not simply based on convenience. While it will significantly reduce the quantity of ATLAS research and will compromise some opportunities available to the user community, it will allow the facility to focus on the highest priority research opportunities as identified by the Program Advisory Committee. A return in status from 5.5 day back to 7 day per week operation requires approximately a 9 month operator training period.

Recommendation 5

Develop a request for incremental funding in the context of the strategic plan, integrating the needs for seven day operations, experimental support staff, and new experimental and accelerator initiatives.

From a reduced operating scenario of 5.5 days per week, the highest priority increment is to immediately return accelerator operations and experiment support to seven day per week operations with proper maintenance. This requires items I) and II) and is consistent with the first priority recommendation (section 4.3) of the review report:

I) Increase accelerator operations and experimental support manpower (elements 1, 2a, 3c and 3d of the strategic plan):

Accelerator Operations:	2 additional operators and an engineer ($530k)
Experimental Support:	1 Target Maker and 1 Computer support ($380k)

The additional operators allow full staffing of two operator shifts, increasing our flexibility in accommodating beam and energy changes and our maintenance capacity during operations. The additional engineer would substantially improve our maintenance capability and provide timely support to complete the ATLAS energy upgrade AIP project. The additional target maker is necessary to provide the range of targets needed for the experimental program. It would have the additional benefit of providing requested additional capacity to provide some specialized targets nationally to the entire U.S. program. The additional computer support personnel would allow us the flexibility to satisfy increasing DOE cybersecurity requirements, replace our existing out-dated data acquisition system and provide required user computing support.

II) Increase ATLAS accelerator operations M&S by $200k and experimental support M&S by $350 (elements 1, 2b, 4a and 4b)

These increases would allow us to cover ongoing maintenance costs with operating funding, freeing base capital equipment to cover some upgrades of the radioactive beam capability and experimental equipment.

III) Fund construction of a solenoid detector system for transfer reactions in inverse kinematics (element 4c) over two years.

IV) Fund the Cf upgrade AIP project over three years (element 2c)

V) Make long-term 7 day a week operations and installation secure (element 1, 2c, 3a, 3e).

Accelerator Operations: 1 operator and 1 engineer ($380k)

Experimental Support: 1 engineer ($230k)

VI) Add a research scientist to support radioactive beam development, tuning and experiments (element 3e, $230k).

Recommendation 6

Develop the case for the proposed Californium source AIP project. Generate a proposal that has input from the general community and has been carefully vetted for cost, schedule and feasibility.

A draft proposal for the Californium source AIP project is being prepared for the July ATLAS User Workshop. Following the workshop, we will have a independent technical review of the proposal to address the cost, schedule and feasibility and plan to submit the proposal to DOE in the Fall of 2004.

Summary

ATLAS provides a unique scientific resource for the national and international low energy nuclear physics community. The operations review noted the outstanding broad based program, superb publication record, alignment with the present and future scientific goals of the fields and the effective synergy of a strong local scientific staff, excellent support staff, an extensive group of active users and innovative accelerator physics group. The review concluded that the present level of operations can only be sustained with increased resources for operations and support activities in the future. The review pointed out the need for more visible long term planning and we have outlined the process we are engaged in to implement this. Our draft strategic plan is fully consistent with the plan presented at the operations review.

The operations review specifically recommended an increase in budget to provide for greater than 6000 hours of beam on target for users. We look forward to working with the

Office of Nuclear Physics to achieve this. We conclude by reiterating our commitment to delivering the highest quality science at ATLAS and in meeting the scientific objectives outlined in the NSAC Long Range Plan and the DOE Strategic Plan and milestones.