Actions from PAC-21 Report and Suggestions for Consideration of upcoming PAC and 5-Year Plan (2009-2013)
M. Peng, March 2007

Suggested actions; suggested presentations in upcoming PAC meetings

#	Topic	PAC-21 Comments	5-Year Plan Considerations
1	**T&T**	The PAC feels that it is therefore crucial that NSTX aggressively pursue various high-k diagnostic and measurement possibilities. The NSTX plans for varying plasma parameters (including the temperature ratio Te/Ti and the critical electron temperature gradient) within the context of high-k measurements are on target. The PAC noted that numerical modeling, which is important for interpreting the experimental results, should have the goal of being fully nonlinear, to allow for the possibility that modes that are linearly stable in some discharges might be excited to finite amplitude through nonlinear coupling. As was mentioned in the PAC-19 report, it would be beneficial if NSTX developed the capability to measure both radial and poloidal wave numbers, since the nature of high-k fluctuation anisotropy and its implication for electron-temperature-gradient-driven transport are much debated.	• Aggressively pursue various high-k diagnostic • Numerical modeling should have goal of being fully nonlinear • Develop capability to measure both radial and poloidal wave numbers
2		The PAC notes that emphasis on high-k fluctuations and their relation to electron thermal transport, as well as plans for future emphasis on rotation, understandably limits the extent to which other transport tissues can be pursued. However, these other issues should not be forgotten. Indeed, where appropriate, they should be included in analysis and interpretation. One such area is particle transport, where the low aspect ratio and the collisionality of NSTX allow it to study density peaking relevant to ITER. Studies of impurity transport should be accompanied by analysis of overall particle transport. The PAC recommends that a talk be presented at its next meeting, in which the role of density profiles and their variability in confinement on NSTX are described.	• In additional to planned studies on rotation and momentum transport, low aspect ration and collisionality effects on particle transport should be included in analysis and interpretation, where appropriate • Next PAC – role of density profiles and their variability in confinement
3		the PAC notes that modeling and simulation codes are currently used to help interpret fluctuations and transport measurements. It is important also to develop code validation procedures; this will require active collaboration between experimentalists and modelers.	• Develop modeling and simulation code validation procedures
35	'08-'09 facility & diagnostic	Perturbative experiments with the use of pellet injection indicate that the value of R/LTe is near the critical gradient value and find stiff profile behavior for high-power H-mode plasmas at magnetic field 0.45 T. Heat flux transport studies have indicated that rational surfaces may play a potential role in electron confinement. However, implementation of new turbulence diagnostics has a reduced priority at present.	• Increase priority on new turbulence diagnostics, such as to clarify the effect of rational surfaces on electron confinement

39	'08-'09 research	The PAC feels that the selection of rotation and momentum transport physics as the FY08 Joule milestone is commendable, since it offers exciting possibilities. As with the measurement of high-k fluctuations, NSTX has special features that will allow it to make unique contributions in the investigation of rotation and momentum transport. Traditionally, momentum transport and ion thermal transport have been tightly linked. Now, however, it has been observed that the ion thermal transport is neoclassical while the momentum transport is not well described by neoclassical theory; this might offer new insights into the question of whether momentum transport is neoclassical or anomalous. NSTX could exploit the availability of braking as a tool for rotation and momentum studies. The PAC also notes that research related to edge physics would be desirable for investigations of momentum transport and spontaneous rotation.	• Use breaking as a tool for rotation and momentum studies • Use edge physics research also for investigations of momentum transport and spontaneous rotation
4	**Macro-stability**	It is of interest that realistic geometry must be taken into account in order to obtain quantitative agreement and that shielding of the externally applied error field is significant. The PAC encourages efforts to understand this shielding, particularly in terms of developing a first-principles theory for the effect. The PAC welcomes a move toward more neoclassical tearing mode studies (in line with a PAC-19 recommendation), but at the same time the PAC endorses not compromising the run time for resistive wall mode experiments in favor of neoclassical tearing mode studies in a tight run time schedule, especially in view of the very exciting recent results about resistive wall modes. Neoclassical tearing modes are usually not a showstopper for NSTX, whereas resistive wall modes are—hence the emphasis on the latter. If the schedule were to allow, the proposed neoclassical tearing mode physics studies are reasonable and would yield new insights. For neoclassical tearing modes, the most important studies are the role of the Glasser-Greene-Johnson effect and the seeding process in tight-aspect-ratio machines. Also, it would seem prudent to begin the characterization of neoclassical tearing mode activity in terms of their potential role in a hybrid-type integrated scenario.	• Carry out efforts to understand error field shielding • The most important studies for NTMs are the rile of the Glasser-Johnson effect and the seeing process in tight aspect ratio machines • Begin the characterization of NTM activity in hybrid-type integrated scenario
5		The PAC encourages further NSTX contributions to the worldwide database on disruptions.	• Make further contributions to the worldwide database on disruptions
6		NSTX work on the control of shape and current profiles is geared toward exploring optimum configurations for future spherical torus devices and should be pursued along the lines that are proposed. In particular, the upgrades in the MSE diagnostic and the control system, to enable beta and rotation control, will be necessary in order to push the high-performance scenarios toward steady state.	• Upgrade MSE and control system to explore optimum configurations for future ST devices and to push toward steady state.
36	'08-'09 facility & diagnostic	For macroscopic stability, the proposed upgrade of the control system is reasonable. This will enable experiments aimed at stable operation with active feedback even closer to the ideal wall limit. The possibility for feedback control of rotation (cf. the PAC-19 report) is foreseen in the program for FY09.	• Upgrade the control system to enable experiments aimed at stable operation with active feedback even closer to the ideal wall limit

7	**EP Physics**	The proposed use of non-resonant braking to separate out the effect of rotation would be interesting for more detailed studies of Alfvén cascade modes. The PAC noted the broad ITER relevance of most of the energetic particle research proposed for FY07. Only one FY07 experiment ("generation of AE quiescent plasmas") is labeled as uniquely ST-specific, with no connection to ITER physics or general tokamak physics. One other FY07 experiment ("ion power balance with modulated NBI") is labeled as relevant to spherical tori and general tokamaks, but not to ITER. Most of the proposed FY07 experiments are relevant in all three respects (viz., spherical tori, ITER, and general tokamak science). The PAC encourages theory and simulations to interpret why the high-harmonic fast wave heating efficiency is maintained in the presence of neutral beam fast ions when the toroidal magnetic field is increased, as was observed during the FY06 campaign.	• Most of the FY07 proposed experiments on energetic particle research should be considered relevant to ST, ITER, and general tokamak physics. • Encourage theory and simulations to interpret why the HHFW heating efficiency is maintained in the presence of neutral beam fast ions when the magnetic field is increased
8		NSTX is uniquely positioned to effectively study the detrimental effects of nonlinear Alfvén eigenmode coupling on energetic particle confinement. The fast ions in NSTX have velocities that can exceed the Alfvén speed and thus strongly resonate with Alfvén waves. Although NSTX does not have ρ^* values as small as in ITER, it is still able to study multi-mode dynamics (such as avalanche phenomena) because its high energetic particle beta can drive the unstable modes to large amplitude so that they overlap. The overlapping modes could lead to an appreciable loss of fast ions. The proposed scan of beam power on NSTX seems a valid approach to assess the effects of Alfvén eigenmode coupling on fast ion confinement. This set of experiments deserves a high priority.	• Assign high priority to study the detrimental effects of nonlinear Alfvén Eigenmode coupling on energetic particle confinement
9		In terms of simulation code validation, the fast particle group for NSTX is pursuing ways to validate M3D and other codes against experimental measurements and use them for developing predictive capability for ITER. This is an important activity that could inform similar efforts in other topical areas.	• It is important to pursue ways to validate M3D and other codes against experimental measurements and use them to develop predictive capability for ITER
10		The capability for variable rotation speeds could make it possible to identify and characterize a large variety of fast ion-driven Alfvén modes in NSTX. The current NSTX research plan emphasizes the characterization of the Alfvén cascade modes and the beta-induced Alfvén-acoustic mode; this is a valuable study. The research plan does not, however, include fishbone modes and fast ion stabilization of the internal kink. NSTX could explore very interesting regimes of both fishbones and m=1 suppression because of its capability for shaping and high beta operation. The reason is that both shaping and high beta can modify—and even reverse—the fast ion precessional frequency. As mentioned earlier, the investigation of the beta-induced Alfvén-acoustic mode is an interesting basic MHD study. Because the plasmas in NSTX have rapid flow, with rotation frequencies on the order of the sound frequency, the BAAE mode structure and frequency could be significantly affected. Therefore it would be of interest to make use of the non-resonant braking capability in NSTX to slow down the plasma and minimize the effect of rotation in this study. Also, after the low-rotation case has been examined, it would be interesting to study the effect of rotation and rotational shear on Alfvén eigenmodes as well as beta-induced Alfvén-acoustic eigenmodes. Theoretical studies have shown that fast rotation can introduce new modes. NSTX is in a unique position to identify such new modes by varying the plasma rotation.	• In addition to identifying and characterizing the variety of fast ion-driven Alfvén modes, explore the very interesting regimes of both fishbones and m=1 suppression using strong shaping and high beta, which can modify and even reverse the fast ion precessional frequency • Use non-resonant braking of rotation to study the effect of rotation and rotational shear on Alfvén eigenmodes and beta-induced Alfvén-acoustic eigenmodes

40	'08-'09 research	Phase-space engineering for energetic ions (i.e., control of their distribution function) is an important topic for spherical torus physics, as well as for ITER and general tokamak science. NSTX intends to devote more attention to this subject in FY08-09. There are plans to add new diagnostics (such as FIDA) that will enable measurements of the energetic ion distribution. The large suite of available simulation codes will also be useful for studying these phenomena.	• Study of phase-space engineering for energetic ions is an important topic for ST, ITER and general tokamak science
11	**H&CD**	During FY06, notable progress was made on electron Bernstein wave and high-harmonic fast wave studies. EBW emission measurements in L- and H-mode plasmas exhibit various features that are not understood, but which have important implications for EBW heating applications. Some, but not all, of these observations are similar to those on MAST; it is essential to understand the differences and similarities. The radiometer and antenna modifications being implemented for FY07, as well as the local gas puffing to investigate collisional effects, are an important element in this effort. Also, a strong theoretical effort will be required to understand and further develop EBW studies. At a future PAC meeting, the NSTX team is encouraged to spell out their efforts in this direction. Close liaison with the MAST team, who are undertaking similar studies, is to be encouraged.	• It is essential to understand the differences and similarities between NSTX and MAST in EBW emission measurements, in close liaison with the MAST team • Will require a strong theoretical effort to understand and further develop EBW studies • Spell this effort at a future PAC meeting
12		Last year effective electron heating by high-harmonic fast waves was demonstrated by operation at higher toroidal magnetic field (0.55 T versus 0.45 T) and higher parallel wave number to reduce edge losses. The mechanism for this B_T dependence should be further elucidated: e.g., whether the dependence can be explained by sheath losses. In addition, NSTX maintained efficient high-harmonic fast wave heating in the presence of low-power neutral beam injection, thus opening up the possibility of making MSE measurements during planned HHFW current drive experiments in FY07.	• The observed improvement in electron heating by HHFW with increased B_T should be further elucidated • Explore making MSE measurements while maintaining efficient HHFW heating in the presence of low-power NBI
13		The initial experimental prioritization for FY07—viz., focusing on HHFW heating and current drive at higher toroidal magnetic field, together with efforts to understand EBW emission—seems appropriate. If HHFW current drive is successful, the NSTX team should consider using one of the contingency days to investigate the effect of alternative antenna phasings, since current drive and ramp-up are critical for the spherical torus concept and not many options may be available. Furthermore, consideration should be given to hydrogen operation in order to probe the reason behind the better heating efficiency at higher magnetic field. There are likely to be other experiments that could also usefully exploit a short period of hydrogen operation.	• Consider using one of the contingency days to investigate the effect of alternative antenna phasing, for current drive and ramp-up • Consider hydrogen operation in order to probe the reason behind the better heating efficiency at higher B_T • Consider other likely useful experiments to exploit a short period of hydrogen operation

14		It would be useful if run time could be found to explore the interaction of HHFW with beam ions at higher beam power. In this respect, the allocation of 3.5 run days seems inadequate to develop HHFW and fully exploit the new, promising results at higher magnetic field (0.55 T). An appropriately increased allocation of contingency days should be considered for HHFW in order to exploit these results. Better MSE should also be available during these upcoming runs. The heating efficiency of HHFW is now 65%, with 40% on the electrons. Available HHFW power far exceeds that to become available with EBW for many years. In addition, an antenna-phasing scenario has been found that produces highly directed wave launch at 13 m-1, where absorption is high. Given the high importance of plasma sustainment to the spherical torus program, more emphasis on HHFW experiments is needed. Heating and current drive with HHFW is a unique NSTX capability.	• Allocate contingent run time to explore the interaction of HHFW with beam ions at higher beam power, 3.5 run days seeming inadequate for the entire HHFW study in FY07 • More emphasis on the uniquely capable HHFW experiments is needed, given the latest success and the high importance of plasma sustainment to the ST program
37	'08-'09 facility & diagnostic	For heating and current drive, the NSTX plan to implement a 28 GHz/15.3 GHz electron Bernstein wave heating system is a reasonable first step, which the PAC strongly encourages. Application of 28 GHz, second harmonic Xmode is compatible with CHI target plasmas (~2×1018 m-3, 20 eV), but single-pass absorption is low. Thus, efforts to increase Te and/or maximize the injected power—utilizing, if possible, the full gyrotron capability of up to 350 kW—are likely to be highly beneficial during start-up. Operation at 15.3 GHz is suitable for EBW studies during the current flat top, but the available power may be marginal. The launcher design is an important task and needs to be advanced in order to permit timely implementation. No details about the launcher design were presented to the PAC.	• Strongly encourage the plan to implement a 28 GHz/15.3 GHz EBW wave heating system • Advance the EBW launcher design to permit timely implementation
38	'08-'09 facility & diagnostic	Electron Bernstein wave (EBW) appears to be viewed as the favored non-inductive current drive technique. It does have the ability to drive off-axis current, which is not easy to do with high-harmonic fast wave (HHFW), but control—not just understanding—of the coupling mechanism is important.	• It is important to also control the coupling mechanism of EBW current
15	**Boundary**	From the run allocations, it appears that the highest priority areas of research in boundary physics are scrape-off layer width scaling, lithium experiments, pedestal scaling, and ELMs. The PAC agrees that these priorities and their allocations are reasonable. In each of these four areas NSTX brings a unique contribution, at least within the US program. The NSTX work with lithium is certainly unique for a divertor and a spherical torus.	• PAC agrees with the run allocations of boundary physics to SOL width scaling, lithium experiments, pedestal scaling, and ELMs

16		NSTX has several lithium approaches, and the PAC feels that the overall balance and cohesion among these approaches should be clarified. The performance so far with lithium is quite good. NSTX should work toward understanding the specific role of lithium, whether the performance is simply due to the pumping function of lithium (and therefore any pump would be sufficient), or whether some other effect is responsible. Within the limited run time, the PAC recommends that NSTX develop a prioritized strategy for using the various lithium techniques. There is a concern that the large number of lithium approaches is somewhat diluting the impact of this research in current experiments and also for a future lithium divertor. The PAC recommends that there be an explicit path for deciding the location of the lithium divertor. The PAC also suggests that NSTX give consideration to implementing an intermediate step such as a small test section.	• Clarify the overall balance and cohesion among the several lithium approaches; develop a prioritized strategy for using these approaches • Work toward understanding the specific role of lithium • Determine an explicit path for deciding the location lithium divertor; consider implementing an intermediate step such as a small test section of the liquid lithium divertor
17		Supersonic gas injection (SGI) is an important tool and should be developed further. It reduces the extraneous gas added to the machine in order to reach a given density, thus decreasing charge exchange losses. NSTX should continue to develop different nozzles and, if possible, injection on the high-field side. Supersonic gas injection is capable of operating at several hundred Hz. Since SGI has been observed to have a significant effect on ELMs, NSTX might consider using SGI in an experiment analogous to pellet pacing.	• Continue developing different SGI nozzles and injection on the high-field side • Consider using SGI in an experiment analogous to pellet pacing of ELMs
18		In transport studies at the boundary, the PAC encourages NSTX to continue its analysis of turbulence images and its commendable modeling effort. Better comparisons with probe data concerning blob characteristics would be useful, since different measurement techniques have yielded different results. NSTX is one of the few facilities that could undertake such comparisons for blobs (and also ELMs). These comparisons would help pin down blob characteristics (e.g., the parallel extent of blobs) and serve as improved tests for modeling. The reason why the scrape-off layer is anomalously thick also needs to be explored.	• Continue analysis of turbulence images and modeling effort • Improve comparisons with probe data, since different measurement techniques have yielded different results, to pin down blob characteristics and test modeling • Explore the reason why the SOL is anomalously thick
19		The PAC encourages expanding the experiments on deuterium retention. These experiments should include particle accounting (i.e., how much gas is injected versus how much is left in the vessel after a shot), as well as a postmortem analysis of tiles. Experiments should be done with bare walls after a vacuum break (with clean lithium surfaces), and then each shot after a lithiumization.	• Expand experiments on deuterium retention, and include particle accounting and post-operation tile analysis • Carry out experiments with bare walls with clean lithium surfaces after vacuum break and after lithimization

20		ELM studies span the areas of transport, stability, and boundary physics. An interesting aspect of ELM suppression with resonant magnetic perturbations is the different effect on particle and heat transport. With its inherent difference between the ion and electron channels, NSTX may thus provide a special opportunity to probe this effect. Also, type V ELMs may yield useful information about the general applicability of the peeling-ballooning mode theory. The combination of probe and imaging techniques will allow a comparison of various diagnostics for measuring ELM characteristics. Adequate priority should be given to experimental proposals on ELM physics if the run time schedule permits.	• Give adequate priority and run time to XPs on ELM physics
21		As noted above, pedestal scaling is a high priority in the NSTX program. Again, NSTX can make significant contributions across tokamak parameter space for this problem. The PAC would like to learn about details of this research program and its results.	• Present the detail of pedestal scaling research at a future PAC meeting
22		Dust studies appear to be a fairly low priority. The PAC does not disagree. Some of these studies could possibly be carried out piggybacked on other experiments.	• Carry out dust studies piggybacked on other experiments
23		In general, because of its different aspect ratio and field, NSTX can make important contributions in a number of boundary-related areas through its measurements of various plasma characteristics. The PAC continues to encourage NSTX participation in cross-machine comparisons of ELMs, turbulent transport, parallel heat flux e-folding widths, etc.	• Encourage NSTX participation in cross-machine comparisons of ELMs, turbulent transport, and parallel heat flux e-folding widths
24		The PAC also encourages further strengthening the connection with theory and simulation. Examples would be UEDGE simulations of lithium experiments, and comparisons of turbulence and blob experimental data with BOUT and eventually with kinetic simulation tools under development (such as XGC and TEMPEST/ESL).	• Encourage strengthening connection with theory and simulation, such as UEDGE, BOUT, XGC, and TEMPEST/ELS
43	’08-’09 research	With respect to the development of a lithium divertor, the PAC requests that at its next meeting there be a presentation of a detailed plan concerning compatibility—i.e., a careful analysis that installation of such a divertor would not detract from the advancement of spherical torus research. The concern of the PAC is that the presence of a lithium divertor would limit the magnetic configurations and positioning of strike points that are possible in the current NSTX. The investment required for a lithium divertor is considerable, and once it is installed in NSTX the program must be committed to characterizing it and determining if it has merit for a fusion reactor, even if it were not to operate in a desirable way. Thus, there is the possibility that it might be in opposition to the goal of using NSTX to promote the spherical torus as a fusion concept and as a Component Test Facility. The PAC looks forward to hearing such a presentation.	• Make a presentation of a detailed plan concerning compatibility of the lithium divertor with the advancement of ST research, including toward component testing.
25	**Solenoid-free startup**	The demonstration of solenoid-free plasma formation and current ramp-up is one of the defining issues for spherical torus research. Solenoid-free operation is likely to be essential for future development of the spherical torus concept. Conventional-aspect-ratio tokamaks would also benefit.	• Consider the demonstration of solenoid-free plasma formation and current ramp-up one of the defining issues for ST research

26		The demonstration of 150 kA of plasma current by transient coaxial helicity injection (CHI) in FY 2006 was a significant advance over the FY 2005 campaign. Moreover, the technical approach seems to be gaining in reliability and consistency, even though it is not yet fully optimized. As its usefulness for producing current improves, NSTX should consider incorporating CHI into its routine operation. Due to the improved prospects for further increasing the CHI-driven current to a more useful level, it would be helpful if the CHI experiments were fully diagnosed and analyzed, including current profile measurements if possible. For example, understanding the power flow, confinement, and fluctuations and identifying the locations of impurity generation could strongly leverage the plasma quality for follow-on heating and current drive by RF waves, neutral beam injection, and induction. Decreasing (or even eliminating) the “temperature gap” between the CHI generated plasma and a suitable high-harmonic fast wave target plasma would be a very important outcome in this area of research, especially since the electron cyclotron heating/electron Bernstein wave system is not expected to become available until FY 2009.	• Consider incorporating CHI into NSTX’s routine operation • Fully diagnose and analyze CHI driven plasmas, including current profile measurements, to understand power flow, confinement, fluctuations, and impurity generation to enable follow-on heating and current drive by RF (HHFW now), NBI, and induction
27		An important development has been improved density control for CHI by the use of RF ionization in the duct below the divertor gap. The most robust heating scenario for a CHI-generated target plasma would involve maintaining the density below the ECH cutoff. Further optimization (such as low density and low impurities) might also be required.	• Carry out further optimization for low density and low impurity CHI operations
28		The enhanced lithium capability will likely be quite useful in this regard; hence it should be incorporated with CHI experiments if possible.	• Incorporate enhanced lithium capability with the CHI experiment
29		NSTX experiments on inductive startup with the use of poloidal field coils are on hold, pending the availability of better pre-ionization methods (viz., ECH and plasma guns in FY 2009). The PAC encourages identifying synergistic operation of CHI and other solenoid-free techniques. For example, it might be worth reconsidering the use of RF ionization in the divertor gap together with small CHI to pre-ionize the field null region. If successful, the poloidal field-only startup studies could be re-initiated with existing systems.	• Encourage identifying synergistic operation of CHI and other solenoid free techniques, such as the use of RF ionization in the divertor gap together with small CHI to pre-ionize the field null region
30		Finally, the PAC suggests that two-dimensional and/or three-dimensional modeling (e.g., with M3D or NIMROD) of the transient CHI process and follow-on current drive (e.g., through the RF SciDAC project) be considered, in order to understand the processes of current formation and ramp-up.	• Consider 2D and/or 3D modeling (M3D, NIMROD, etc., e.g., through SciDAC) of transient CHI process and follow-on current drive, to understand the process of current formation and ramp-up
31	**ISD**	The choice of research topics for the area of integrated scenarios is appropriate for the long term, although the PAC notes that in the near term the ELM suppression and control studies would benefit from close coupling with both the stability work and also the boundary physics work. The PAC feels that near-term experiments focusing on determining the stability limits in high-elongation plasmas that are closely coupled to the outer conductive wall have been appropriately prioritized, since the presently obtained shape seems to have a reduced stability limit.	• Have close coupling between the near term studies of ELM suppression and control with the stability and boundary physics work

32		The overall balance of the FY 2007 run plan for the area of integrated scenarios appears to be appropriate. In the longer term, the PAC suggests that some consideration be given to increasing the emphasis on the development of techniques for off-axis current drive, since this is a key capability for implementing future fully non-inductive operation in NSTX. In addition, experiments to determine methods for obtaining higher central safety factor q (i.e., less current penetration) in the start-up phase should also receive higher priority, in order to provide access to current profiles that have favorable stability properties. The PAC notes that the proposed installation of a liquid lithium divertor has significant uncertainties associated with the establishment of a fully integrated scenario. The PAC recommends an analysis of the lithium divertor in terms of its benefits and its risks for the development of such a scenario (see associated comments in Section 4).	• Consider increasing the emphasis on the development o techniques for off-axis current drive • Give higher priority to experiments to determine methods for obtaining higher central safety factor in the startup phase • Analyze lithium divertor in terms of its benefits and its risks for the development of steady state scenarios
33		In the boundary integration area, the PAC feels that appropriate priority has been placed on the ELM suppression experiments. Although NSTX is not unique in being able to conduct such experiments, its demonstration of suppression capability would reinforce the complementary work on DIII-D and provide a new platform for developing the physics basis for ELM suppression in ITER.	• Use ELM suppression capability to reinforce the complementary work on DIII-D and provide a new platform for developing the physics basis for ELM suppression in ITER
41	'08-'09 research	In view of the needs for establishing the physics basis for a Component Test Facility, the PAC feels that the demonstration of highly elongated, wall-stabilized plasma operation is an appropriate long-term goal for NSTX. The PAC is encouraged to see the NSTX team carrying out integrated scenario modeling for full non-inductive operation. The modeling suggests that fully non-inductive operation is possible, but requires extension of the operating space, namely, β_N>7, electron temperature 60% above presently obtained values in similar discharges, moderate density control, and current profiles with q_0>2. This scenario would require the integration of several different parts of the program—stability (ideal limits at high elongation), electron transport, heating and current drive, boundary (lithium), and resistive wall mode stabilization. The PAC feels that a plan to systematically integrate these issues should be developed and articulated, with identification of the highest priority items on the development path. At a future meeting, the PAC would like to have a discussion of such a plan. Because of the complexities involved in integrating these elements, the opinion of the PAC is that the FY09 research milestone in physics integration should be delimited in scope, for example, to a demonstration of high-beta operation at elongation κ>2.8.	• Develop a plan to systematically integrate these issues (higher β_N, Te, density control, high q_0, etc.) with identification of the highest priority items on the development path and articulate the plan at a future PAC meeting.
42	'08-'09 research	Also, attention should be given to understanding the redistribution of beam ions by MHD instabilities. And, in the context of a Component Test Facility, consideration should be given to the compatibility of very highly shaped plasmas with tolerable divertor heat fluxes.	• Give attention to understanding the redistribution of beam ions by MHD instabilities • Consider the issues of compatibility of very highly shape plasmas with tolerable divertor heat fluxes

34	**'07 run**	Last year NSTX had a full schedule of activities. For FY 2007 another very full schedule—especially in view of the available run time and manpower—is again proposed. The PAC feels that the assignments adopted by NSTX for "highest" priority objectives versus "high" priority objectives are reasonable. There are contingency run days, and the PAC recommends that some of these days be allocated to boundary physics and high-harmonic fast wave studies. Of course, it may be possible for a number of the second-priority experiments to be carried out by piggybacking on run days assigned to first-priority experiments. The PAC thinks that having only ten weeks of run time in FY 2007 hampers the progress of the program. Not exploiting a large existing machine is a non-optimal use of resources. Incremental funds to enable more run time would lead to substantial gain.	• Recommends that some of the contingency run days be allocated to boundary physics and HHFW studies • Carry out a number of second priority experiments by piggybacking on the first priority experiments
44	Program direction	Moreover, PPPL has put forth a good vision for the future of the spherical torus program. However, the PAC feels that the process of aligning and adjusting the allocation of NSTX experimental run time to make this vision a reality should be better articulated by NSTX management.	• NSTX management articulate better the process of aligning and adjusting the allocation of NSTX experimental run to make the vision for the future of ST program a reality
45	Program direction	Finally, at its next meeting, the PAC would like to hear more details about the proposal for alternate-year operation of NSTX and NCSX. Questions arise whether such alternating operation is realistic, in terms of manpower sharing and the difficulties entailed in bringing up a machine that has been down for a year; what the true cost savings would actually be; and what the drawbacks are. The PAC feels that NSTX has done a credible job of responding to the DOE directive to study this option for the case of a flat budget, but also that it should be made clear that this is not the ideal way to operate high-performance facilities. The PAC suggests consideration of a period of alternation shorter than a year; for example, ASDEX and Wendelstein used alternate-week operation, although for NSTX and NCSX alternate-month operation might be preferable in order to avoid too-frequent power supply switchovers.	• Present a the next PAC meeting more details about the proposal for alternate-year operation of NSTX and NCSX