Purpose of this meeting

- Provide chapter authors with some initial “high-level” comments and observations on the status of the chapters
- Highlight some specific positive/negative features from chapters that other chapter authors might want to incorporate/avoid
  - This is first cut at cross-chapter consistency and optimization
- Will hear from chapter author version of perceived status and needs – compare to cross-chapter view
- Plan for next 5 year plan update meeting later this month

- Due date for complete draft chapters: COB December 14

Draft PAC-33 agenda and speakers

PAC dates: February 19-21, 2013

• Program overview	Jon Menard
• Upgrade progress, facility and diagnostic prep, budget	Masa Ono
• Initial Operations Plan, Scenarios and Control	Stefan Gerhardt
• Macroscopic Stability	Jack Berkery
• Non-axisymmetric control coil (NCC) applications	Jong-Kyu Park
• Transport and Turbulence	Yang Ren (or WG)
• Energetic Particles	Mario Podesta
• HHFW and ECH / EBW	Gary Taylor
• Solenoid Free Start-up and Ramp-up	Roger Raman
• Long-term issues and strategy for boundary and PMI	Rajesh Maingi
• Pedestal, SOL, Divertor	Vlad Soukhanovskii
• Cryo-pumping and particle control	John Canik
• Materials and Flowing liquid Li module development	Mike Jaworski

Importance of the plan

- Plan must be:
  - Scientifically relevant and compelling for FNSF, ITER, Demo, toroidal plasma science
  - Innovative, but realizable
  - Strongly supportive of development of predictive capability
    - For this reason, I think explicit inclusion of theory/simulation capabilities to be utilized/developed is a net plus for each chapter, even if it is a bit of extra work (i.e. a good task for the theory TSG deputies)
- Requested facility and diagnostic upgrades must be well-founded and supported in the plan
  - Competition for resources will continue to be intense
- Must satisfy all of the above with:
  - Base budget and associated upgrades
  - Incremental budget (which is much easier)

Comments on plans vs. ideas

- Avoid statements that say we “could” or “might” or “should” do something
  - Need to be concrete in the plans, even in face of budgetary and/or scientific uncertainty
    - Be definitive: we will do “X”, or plan to do “Y”
  - Resources are finite, prioritizations have to be made
    - and of course plans may change after 5 year plan is completed + reviewed
  - Allowable hedges:
    - “(resources permitting)”
    - “(pending incremental funding)”
  - If a research element/plan is not in the base or incremental plan/budget, it effectively does not exist in the 5 year plan

- Make sure your timelines are consistent with text

Comment on granularity of plan years

- Chapters have research plans split into 2 large chunks: years 1-2 and 3-5. This split is ok (as per previous guidance), but without some additional year-by-year detail, this can come across as a plan that is too vague or insufficiently thought-through
- Suggestions:
  - Wherever reasonable, try to give more a more detailed time-line
  - Year-by-year is best for the early years, especially since it's difficult to justify a lack of specificity in years 1-2
    - Example splits: Year 1, 2, Years 3-4, 4-5
    - As stated previously, uncertainty should be placed in the out-years
  - Also ok to have overlapping periods (e.g. years 1-3, 2-4, 4-5)
- Reminder: Assuming the research is still relevant, a significant amount of year 1 and 2 research should incorporate planned research for the FY2011-12 run that was not carried out
  - Can/should use FY11-12 run plan as a resource (and many chapters have)

Macroscopic stability

- Overall thrust definition ok, but content in each thrust comes across as disjointed - Difficult to follow the research threads
- Many sub-sections/sub-thrusts are too short/brief (e.g. 2.2.2.1.2 is only 3 sentences) – should combine some research elements to make fewer larger (but not too large) thrusts
  - 1-3 pages per sub-topic including figures is a reasonable readable size
- Research plan for Thrust 1 is organized by year rather than research carried out – need to change this
- Mixing use of NCC for profile control and passive/active control of RWM.
  - This does not follow delineation of thrusts
  - Either need to change this, or change thrust definition
- NCC details are in separate section at end of chapter.
  - Opinion: since this is important tool for MS (even though incremental), this should come up front, and be woven throughout the chapter, even though there is a separate talk on NCC.

Transport

- Need Thrust 2 contribution from Walter
- Momentum transport research motivation and plan is ~1.5 pages → too short given the importance of the issue
  - Expand on this – for example what is impact of 3D fields on turbulent momentum transport, and what is role of NCC for this research?
- Need to put timeline at end of chapter

Boundary physics

- Entire chapter needs many more (any) figures and references to take credit for what was accomplished on NSTX
- Leading the chapter with "Re-establish reliable H-mode access and operation" is operationally important, but not very compelling
  - Perhaps fold this into section on "Threshold studies and pedestal formation"
- Entire divertor section is missing (!) (under contstruction…)
- Need to start description of pedestal control tools: LGI, EHO
- Edge/SOL physics section focuses primarily on turbulence, whereas a neoclassical transport / drift model appears to capture the leading order dependence of the heat flux width
  - Need more emphasis in research plan on distinguishing between turbulent and collisional diffusion, and where transition from one to the other might occur, and what resources/diagnostics are need to measure this
- Too many examples of things that "could" or "would" be done:
  - "In Year 1-2 a larger electrode and improved diagnostics could be designed…"
  - "A radical solution to the edge/SOL problems of tokamaks would be to move the plasma-facing surfaces through the divertor region…"
  - Need to remove if not in base or incremental budget
- Cryo-pumping section is far too short – doesn't even have figures from last PAC
  - Cryo-pump may be 1 of the 2 major upgrades during 5 year plan period.
  - As written, there is insufficient motivation for the pump

Materials and PFCs

- Intro only states the purported benefits of lithium with no context provided for the alternatives (i.e. high-Z solids)
  - Need to make much better / complete case for liquids and lithium
  - See liquid metal whitepaper sent to Zinkle, last PAC talk
- No figures, graphs, or results from numerous Jaworski presentations (why?)
- The discussion of FNSF needs and relation to present capabilities and/or short-comings is good.
  - Would be better to put this up-front in chapter to motivate the planned research program
- The three thrusts are not well motivated – need more definition and justification up-front – should follow from introduction:
  - These are not thrusts as written: (1) lithium surface science, (2) material migration, and (3) continuous vapor shielding
  - The thrusts should involve some "action" to be taken or new scientific insight to be gained
- Insufficient detail in section on: "staged implementation of high-Z PFCs"
  - There is no discussion of which areas will be covered with TZM tiles, or when.
  - Can't plan liquid metal divertor module w/o first addressing high-Z tile issue since LMD is ill-posed if completely surrounded by C tiles

Energetic Particles

- Good intro section – research motivation by needs of ITER, FNSF, NSTX-U is clear
  - Rest of the chapter also well-written, largely complete
- As suggested early in this presentation, recommend increased granularity in “years 3-5” – need additional some additional detail on what will be done in which year
  - Perhaps finish each section with brief/bulletized year-by-year plans
- Section on code/model usage is good – but make sure to be very clear on how the code physics is relevant to NSTX-U plans/needs.
- Diagnostic info should be kept – but moved to Masa’s facility chapter

RF

- Chapter in good shape
- Recommend increased time resolution in “years 1-3” in many places – need additional detail on what will be done in which year
  - Perhaps finish each section with brief/bulletized year-by-year plans
- Chapter mentions (for example) ion-cyclotron resonant absorption calculations performed, but doesn’t show any of the results (?)
  - In general, if you have specific simulations and plots for NSTX-U, put them into the plan chapter – this strengthens the plan
- Section on code/model usage is good – but make sure to be very clear on how the code physics is relevant to NSTX-U plans/needs.
  - Some sections (AORSA?) may be too long…
- Diagnostic info should be kept – but moved to Masa’s facility chapter

Solenoid-Free Start-up

- Bulletized list of expected improvements for transient CHI in NSTX-U vs. NSTX is good
- Good incorporation of results and plans from Pegasus
  - Would be good have Pegasus presentation to NSTX team to update us on status of conceptual design, future plans/needs
- Minor critique that chapter reads more like research paper than a plan – sometimes difficult to keep track of what research elements will be carried out.
  - Plans too well blended with results? Maybe delineate a bit more.
- Some of the theory and modelling discussion may be redundant with RF chapter, for example "GENRAY-ADJ for EC/EBW Heating and Current Drive"
  - Also, is this best chapter to cover TRANSP / PTRANSP?
- Diagnostic and hardware info should be kept – but moved to Masa's facility chapter

Advanced Scenarios and Control

- Bulletized list of both ST and (especially) ITER relevance of research thrusts is good
  - Similar simple/concise lists emphasizing both ST/FNSF and ITER are perhaps something to be emulated in other chapters where appropriate (i.e. in MS, T&T, BP, EP, RF chapters)
- Need to finish "Advanced Boundary and Position Control" section
  - Person(s) with initial(s) EK or DG need to write something
  - Same comment for profile control section
- Can/should probably move "9.2.2.4: Deuterium Inventory Control" to particle control section of BP chapter
- Need to see more complete "Pedestal control" section of BP chapter before deciding fate of "9.2.4.3: Optimization of Pedestal Control Tools"

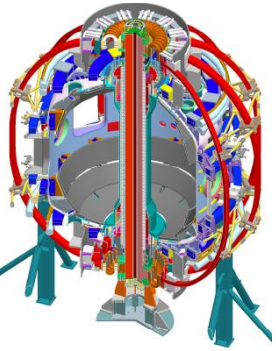
Strawman/draft upgrades to be in place by 2018 assuming base budget

2014	2015	2016- 2018					

Upgrade Outage | **1.5 → 2 MA, 1s → 5s**

Masa+Stefan+Bob+Brent need to ID which FY11-12 capabilities will be ready for 1st full year of NSTX-U ops

New center-stack



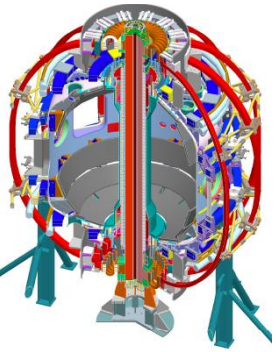
2nd NBI

Start-up and ramp-up	Upgraded CHI	ECH/EBW 1 MW
Boundary physics		Divertor cryo-pump
Materials and PFCs		U or L Mo divertor
Lithium	Li granule injector	Upward LiTER
MHD	MGI disruption mitigation tests	Enhanced RFA/RWM sensors
Transport & turbulence	High k_θ	Polarimetry and DBS
Waves and Energetic Particles		HHFW limiter upgrade
Scenarios and control		Control: rotation, snowflake, divertor radiation, q_{min}

5-8 year plan upgrades with ~10-15% increment

2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Upgrade Outage	1.5 → 2 MA, 1s → 5s				Advanced PFCs, 5s → 10-20s				

New center-stack



2nd NBI

Start-up and ramp-up	0.3-0.5 MA CHI	0.5-1 MA CHI	0.2-0.4 MA plasma gun	up to 1 MA plasma gun	ECH/EBW	1MW → 2 MW	Extend NBI duration or implement 2-4 MW off-axis EBW H&CD		
Boundary physics	Divertor cryo-pump	Divertor Thomson	Diagnostics for high-Z wall studies						
Materials and PFCs	U or L Mo divertor	U + L Mo divertor	All High-Z PFCs	Hot High-Z FW PFCs					
Lithium	Li granule injector	Upward LiTER	Flowing Li divertor or limiter module	Full toroidal flowing Li divertor					
MHD	MGI disruption mitigation tests	Enhanced RFA/RWM sensors	NCC coils	NCC SPA upgrade					
Transport & turbulence	High k_θ	δB polarimetry	DBS	PCI or other intermediate-k					
Waves and Energetic Particles	HHFW limiter upgrade	HHFW straps for EHO, *AE	Dedicated EHO or *AE antenna						
Scenarios and control	Rotation control	Snowflake control	Divertor radiation control	q_{min} control	Control integration				

U.S. FNSF conceptual design including aspect ratio and divertor optimization