NSTX-U

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PAC-35 Response, ASC + Operations

S.P. Gerhardt

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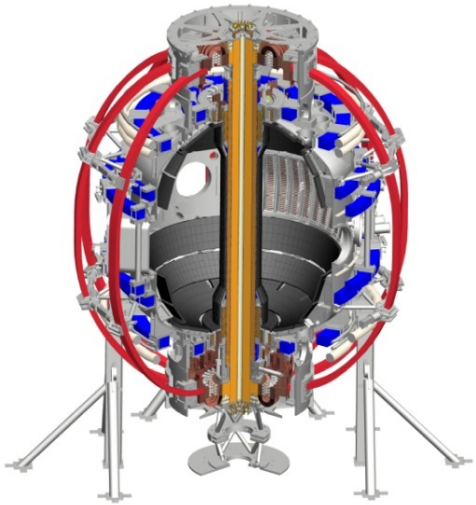

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Scheduling

> The PAC anticipates that the past practice of relatively short-term scheduling is likely to be insufficient now and for the future NSTX-U program. We therefore recommend adopting a new planning process that incorporates a longer term run schedule. This will (1) better support integrated and increased collaborations anticipated for the NSTX-U program, (2) help develop the rationale that drives the hardware schedule, and (3) maximize the productivity of the first year of operation, which clearly has a very tight schedule.

- Agree that a perfect long-term schedule is desirable.
- However:
  - NSTX-U capabilities will likely come on line in a not fully predictable way during the first campaign.
    - Long-term planning will thus likely be more difficult in the first campaign than subsequent ones.
- NSTX was careful to plan ahead for experiments that require collaborator travel
  - and this will continue to be the case.

Importance of Particle Control

> Particle control remains a critical issue in achieving low-collisionality, long-pulse discharges in NSTX-U. The PAC strongly recommends developing a clear plan to understand particle transport and particle sources and sinks to ensure confidence in the design and implementation of the cryo pump. Such a plan will also increase confidence in achieving important metrics such as low collisionality that validate the primary motivation for the Upgrade within the first two years of operation.

- Agree that better understanding of sources and sinks is important.
- Should make this a focus of research in the first year.
- LLNL, UT-K, others will deploy many diagnostics related to this
  - though it is not clear that this will provide a complete picture of the 1st wall+divertor source.
  - Need impurity light, n_e, T_e everywhere along the wall to make complete assessment.

Diagnostics and Wall Conditions

While it is clear there is great eagerness to test the new capabilities of NSTX-U, the PAC urges thorough experimental investigations at each of the operational steps from bare first-wall surfaces to boronization to added lithium. The PAC was presented a very informative time chart (S. Gerhardt) summarizing the readiness of various facility capabilities and diagnostics. We agree that TRANSP analysis capability defines a necessary criterion for research readiness, but it is not sufficient to understand in detail the impact of the various wall conditions and coatings. The PAC recommends more thorough analysis, planning, and preparations that factor in the diagnostic and control capabilities required to support detailed investigation of each of the wall condition operational steps noted above. To support this, we recommend developing metrics for gauging success at each step in wall condition. We also recommend producing a thorough plan and anticipated schedule well in advance of the Research Forum, in part to maximally inform collaborator research proposal preparations. We note that the next opportunity for careful

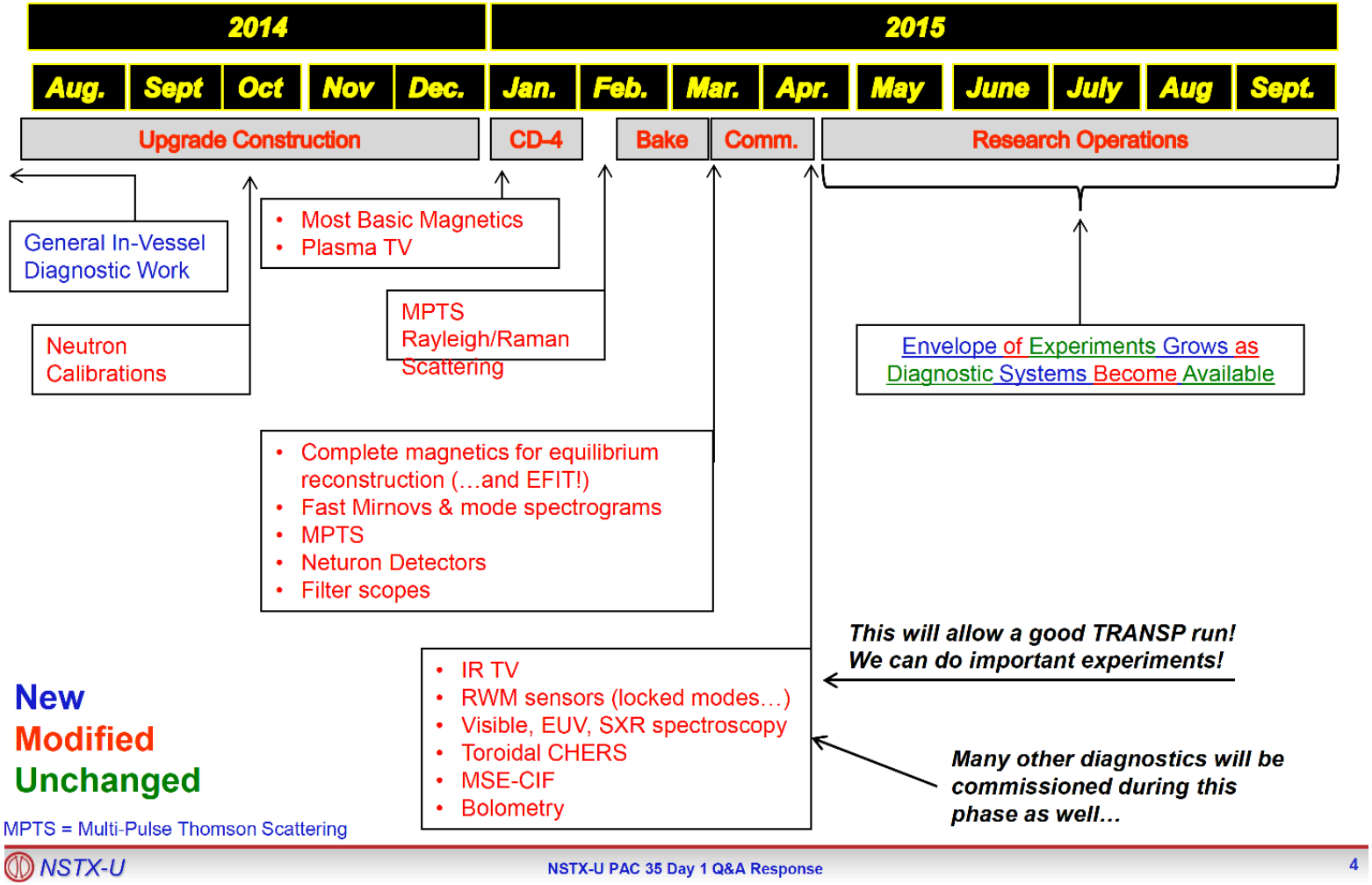
Translation from a PAC member: "Don't go throwing Li in the machine as soon as you get frustrated with the wall conditions."

Diagnostics and Wall Conditions

- My slides also called out that plasma spectroscopy + IR TV would need to be established on the same time-scale as core profile diagnostics.
  - See exact copy on next slide.
- Thesis is that plasma core performance + core impurity content + divertor spectroscopy would be sufficient to assess impact of wall conditions.
  - But this is admittedly not a surface-science point-of-view.
  - Indeed, the PAC seems to want PMI studies, which places a higher standard on the diagnostic status.
- Agree that a set of wall conditioning metrics can/should be defined,
  - Wait two slides….
- I am not sure that the PAC is right in recommending that the wall conditioning program be dictated by fiat at the RF.
  - They want collaborator input in important research decisions after all.
  - Continue to maintain that the proper plan is to maintain flexibility with regard to the introduction of Li.
    - But if the choice is really to impose a date, then it is probably ~2 months into the research program.

This is what they saw…

Implementation Schedule for Diagnostics



Metrics for Wall Conditioning -> Implications

- Assumptions
  - we will not try to run for long periods, or at all, before boronization.
  - we have a fiducial shot established, maybe ~1 MA, ~6-8 MW, ~0.5-0.6 T, higher triangularity.
- Track the following during some period of the shot:
  - P_{rad}, dP_{rad}/dt -> Luis' new Bolometer
  - $<Z_{eff}>$ -> New Z_{eff} chords on Bay G and the CHERS background
  - Divertor impurity sources -> VIPS, DIMS, EIES
  - Global confinement -> CHERS, MPTS, EFIT, Z_{eff}
  - Core impurities -> XEUS, MONaLISA, LoWEUS
  - df_{GW}/dt, assuming that we are fueling to the same f_{GW} -> MPTS
  - Required fueling
- Repeat the same measurements:
  - After boronizations with different numbers of gas inlets are used?
    - Three TMB inlets are in the preliminary design.
  - After boronizations with different GDC pressures?
  - After each lithiumization?
    - And then for each type of impurity control technique (ELM pacing,…)?

The Schedule

> Especially for scenario development and their control, the commissioning schedule prior to FY15 operation is aggressive and has the potential for significant delays. Hence, the scheduling of the 18 week run plan in FY15 should continue to take into account completion of key systems. Providing a best estimate for when systems become available during FY15 and FY16 is essential for optimum use of NSTX-U. Key would be prioritizing to make sure critical systems are ready to meet their high level objectives.

- The schedule is aggressive because there are no other options.
- Agree that we should prioritize key systems.
  - Though this seems like a bit of a platitude.
- Not entirely sure what key systems are being considered here:
  - DCPS? LITERs? MPTS? Beams? Granule injector? PCS Algorithms?

On NBCD and Heat Flux Control

opportunities at NSTX-U. Validation of NBCD should be given high priority in the first two years of operation, starting at 600-800 kA using (initially) inductive ramp-up of the plasma. Power control with strike point control, radiation control and snowflake control are key new developments, but care should be taken not to fragment the research in the area of heat flux control.

- NBCD is called out in both the ASC and WEP programs, and will be part of the JRT in 2015…will get plenty of attention.
- Agree that the heat flux control program is multi-faceted
  - partly because the tools are more readily in hand than in the area of particle control.
- That said, I think that individual initiative will allow this all to work out.

More on Particle Control

> Particle and density control at NSTX-U will have new capabilities such as gas valves under real-time control, impurity seeding and new real-time density measurements. However, the cryopump will not be available until at least FY17, and it is not yet known whether lithium alone will provide adequate particle removal. The preparation (algorithms) for real-time density control (including its profile) is not clear. For the experimental program in FY15 and FY16 priority should be given to documenting what can be used to provide active particle control long pulse, high power plasmas. A second priority should be developing the necessary basis for the design of a cryopump for NSTX-U in combination with new the capabilities of the device, such as the snowflake divertor.

- We never promised anything related to closed loop density profile control.
  - But agree that the meaning of "density control" was not clearly given.
  - Algorithm will likely be simple PID…doesn't really rise to the level of a PAC presentation.
- Agree that the first two years will need to creatively use all available tools
  - "improved" boronization vs. Li.
  - Pellet pacing via granules & 3D fields.
  - Optimized fuelling with SGI and improved CS injectors.
- Cannot rely on data collected in summer/fall 2015 for the cryopump design if it is to be installed in summer 2017.
  - It can at best validate design assumptions.

DIII-D Collaboration

In their presentations to the PAC, the NSTX-U team did not provide details on the study, optimization, and control of NBCD at NSTX-U in collaboration with DIII-D. This area is well coordinated; DIII-D has announced a second national campaign that includes a joint experiment with PPPL for "testing the prospects of neutral beam current drive to produce fully non-inductive and current overdrive in preparation for follow-on experiments on NSTX-U." Sufficient priority should be given to this collaboration during the first 2 years of operation.

- Sure, my mistake.