Record of Discussion for FY2014 NSTX-U Research Collaboration Proposals

Key results of discussions between prospective NSTX-U collaborators and a local Research Contact.

Please send completed and signed RoD forms - preferably with scanned or digital signature included in this MS Word document - to Jon Menard (jmenard@pppl.gov) and Masa Ono (mono@pppl.gov).

Questions or comments regarding processing of this form should be forwarded to Thomas Egebo (tegebo@pppl.gov). The NSTX-U Project Fax Number is (609) 243-2222.

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| **Title of Research Activities:** Implementation of Diagnostics for Boundary Physics Research – part of MIT/NSTX-U Collaboration | Collaboration began (mm/yy) or **New:**New |
| **Off-Site Institution:**MIT | **Discussion Dates**Initiated on: 5/1/2013Completed on: 6/13/2013 |
| **Collaboration Principal Researcher:** Name: J. Terry, B. LaBombard, D. WhyteEmail: terry@psfc.mit.edu; labombard@psfc.mit.edu; whyte@psfc.mit.eduTel: 617-253-8637; 617-253-7269; 617-253-1748Signature: scanned_signature2Date: 6/19/2013 | **On-Site Research Contact:**Name: R. Maingi, S. Zweben, R. KaitaEmail: rmaingi@pppl.gov; szweben@pppl.gov; rkaita@pppl.govTel: 609-243-3176; 609-243-3243; 609-243-3233Signature:  Macintosh HD:Users:szweben:Desktop:General:signature.jpgDate: 6/19/2013 |
| **Research Goals:** High level goals: participate in collaborative research in power handling, density and particle control, and integrated core/edge/divertor/PSI solutions. This will involve a number of scientists over a range of topics. The detailed research elements discussed below involve implementation of new diagnostics. 1. Examine local SOL and near-separatrix properties and relation to power and particle flux profiles, including a reciprocating probe using the Mirror Langmuir Probe (MLP) technique
2. Characterize edge and SOL turbulence in existing data from NSTX, in preparation for new analysis and measurements on NSTX-U, including additional Avalanche-PhotoDiode (APD)-based channels to augment the planned gas-puff imaging (GPI) camera-based system
3. Characterize recycling, retention, and surface film evolution, including implementation of the AIMS in-situ accelerator-based diagnostic
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| **MIT Research Tasks (mostly off-site):**1. MLP: develop a complete set of plans for a midplane scanning probe drive. This would involve detailed drawings for all mechanical components (linear motion drive, bellows, servo motor system), with interface to the NSTX-U vacuum vessel, power and data systems and appropriate design review by PPPL. The probe bias and data acquisition system would use the existing mirror Langmuir probe system for C-Mod, if available for loan to NSTX-U. Langmuir-Mach and magnetic probe heads would be designed using proven designs based on experience in C-Mod.
2. GPI: augment the camera-based GPI systems (that existed on NSTX and will be continued for NSTX-U) with the parts of APD-based GPI system on C-Mod, if they become available. This would involve coordination of the finding/sharing of a view of the gas puff, designing the new optics needed to couple the gas-puff-view to the APD-fibers, and laying out space in the test cell for the rack-mounted detectors, power supplies, and digitizers. If it were to become available, the existing C-Mod hardware would be disassembled and prepared for shipment to PPPL; the following Table lists the equipment that would be part of a loan agreement between MIT and PPPL. If unavailable for loan, replacement hardware would need to be acquired.

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|  |  | 90 channel system & 30 channel system |  |
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| item # | number (each) | System component | approx cost ($k) |
| 1 | 4 | D-Tacq ACQ132 digitizer | 32.0 |
| 2 | 1 | D-Tacq DIO2 timing module | 5.0 |
| 3 | 1 | D-Tacq Analog output module | 0.5 |
| 4 | 1 | cCPI chassis | 1.3 |
| 5 | 2 | cCPI power supply | 0.6 |
| 6 | 1 | CAMAC 32-channel (slow) digitizer (for voltage monitor signals) | ? |
| 7 | 1 | Ethernet switchable power strip | 0.3 |
| 8 | 1 | 90-channel imaging APD-based system | 31.3 |
| 9 | 1 | 30-channel imaging APD-based system | 25.5 |
| 10 | 8 | custom interference filters (3 D\_alpha, 4 He I, 1 He II) | 1.5 |
| 11 | 1 | Haake EZ Cool 80 Circulator | 2.2 |
| 12 | 2 | sliding rack-mounted drawer | 0.2 |
| 13 | 1 | 19" standard rack (6 ft) | 1.0 |
| 14 | 1 | electronics power supply | 0.5 |
|  |  | TOTAL | 101.8 |
| *Table 1 – Listing of MIT equipment in the two Avalanche-PhotoDiode (APD)-based GPI systems* |

 Preparation of this equipment for shipping to PPPL is estimated to be ~2 man weeks, as it must be removed from in-vessel connections within C-Mod, the two systems must be consolidated within one rack, and the components secured for safe shipment. J. Terry believes that the filled rack would be trucked to PPPL. 1. The Accelerator-based In-situ Materials Studies (AIMS) is a newly developed method for interrogating plasma-facing surfaces during plasma operations. A MeV deuteron beam is injected into the torus between discharges and magnetically steered to different poloidal and toroidal locations. AIMS has demonstrated measurement of boron, oxygen and deuterium in Alcator C-Mod, and is ideally suited to measure carbon and lithium as well. Initial activities would scope out the requirements for port access on NSTX-U for the compact accelerator, neutron/gamma detector location and port allocation, and between-shot B field requirements for beam steering. A full set of computational tools has been developed to perform this analysis, which would be adapted to the NSTX-U environment. A very complete simulation tool, ACRONYM, is also available to produce synthetic pulse-height spectra from AIMS on NSTX-U which has a full physics model to calculate the effects of neutron/gamma scattering and detection in the complex tokamak geometry. The near-term effort in late FY 2013 and FY 2014 is aimed at assessing the steps that would be required to implement AIMS on NSTX-U. The first set of issues includes: (a) to assess if beam injection from a port at the top of NSTX-U can be used to image the bottom divertor; (b) to document local power requirements; (c) assess required pit space, rack space, and candidate ports for the beam injection and detectors.
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| **On-Site Research Support Tasks:** 1. A PPPL researcher (e.g. M. Jaworski) effort will be needed to support installation of MLP on NSTX-U: 0.5

man-months.1. PPPL researcher (S. Zweben) will arrange minor modifications to the existing ex-vessel GPI hardware at Bay B: 0.5 man-months.

 a. a beam-splitter will be added to the GPI optical bench with a ferrule for holding the 90-ch.  APD array fibers, which will be mounted onto the bench on one side of the beam-splitter. b. drawings for the GPI re-entrant optics will be supplied by PPPL so that MIT can design  and built a holder for the APD fibers which can be inserted into the re-entrant port when needed to get more light to the diodes (coordinated with T. Munsat and R. Maqueda) c. an external mounting shelf will be made for the 30 ch. APD array to view the center-stack  through an existing port at Bay B (i.e. the 6” window at the 3:00 position)3. PPPL staff (0.2 man-month) will provide information to MIT staff to aid in the AIMS implementation assessment. Specifically (a) provide port drawings and access from the top divertor; (b) determine if documented power requirements are available or can be made available at NSTX-U; (c) provide port drawings for detector locations, and pit maps toward assessment of pit and rack space.**Estimated Researcher Effort Required (Man-Months):** 1.2 man-months per year |
| * **On-Site Engineering Support Tasks:**

For Task 1 above (support installation of MLP on NSTX-U):* 1. Specify PPPL requirements for MLP; coordinate required design reviews.
	2. Reserve 6” diameter port with gate valve at 4:30 position on Bay J flange for MLP diagnostic.
	3. Perform preliminary and final design of re-entrant guide tube to support MLP inside NSTX-U vacuum vessel. (Note: guide tube will be designed to be installed from outside vacuum vessel.)
	4. Perform preliminary design of stand to support MLP from NSTX-U platform.
	5. Designate rack space for MLP bias and control electronics and data acquisition system.
	6. Designate cable trays to be used for MLP cables between MLP and rack.
	7. Designate Ethernet connection(s) to interface MLP data acquisition system to NSTX-U data acquisition system.
	8. Specify required interfaces between MLP and NSTX-U safety interlocks.

Work with MIT to specify requirements for MLP data archiving in NSTX-U MDS Plus tree.For Task 2 above: 1. MIT APD fibers will be run about 7-8 meters from the Bay B GPI to a dedicated rack nearby, or to an MIT rack which will be mounted on the floor within this distance. The location of this rack will be discussed in an upcoming peer review, including determination if a new rack is required. An APD chiller also needs to be mounted in or near that rack, an a small igloo may be needed for radiation shielding of the APDs.
2. Fibers for cPCI Ethernet and timing will be run to that APD rack and the data from the APDs (~400 MB/shot) will be sent to MDSplus storage using segmented data.

For Task 3 above: none envisioned in FY14**Engineering Effort Required (Man-Months):** For Task 1 above:1. Mechanical Engineer: 1.5 man-months
2. Electrical Engineer: 1 man-months
3. CAD designer: 2 man-months
4. Software Engineer: 0.25 man-months

For Task 2 above: 1 man month for computer division to interface APDs to data system, 1 man month for running fibers and making required drawings 1 man month engineering effort if new rack required (TBD at peer review)For Task 3 above: none**Estimated Hardware Cost Required ($k):** For Task 1 above: $0 (design effort only in this RoD)For Task 2 above: $10k – for optical components, opto-mechanical components, fiber tapers $5k – for machining of mounting and support structuresFor Task 3 above: $0 (design effort only in this RoD) |
| **Collaboration Researcher Questions and Issues:**1. All covered by ongoing discussions

**etc.**  |
| **Responses by On-Site Research Contact and Task Manager:**1. N/A

**etc.**  |
| **Additional Collaboration Researcher’s Comments (if any):****1)** N/A |
| **Additional On-Site Research Contact and Task Manager Comments (if any):**1. N/A
2.
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| **Review and Comment:** **NSTX-U Program Director**Electronic signatureDate: June ??, 2013 | **Review and Comment:** **NSTX-U Project Director, Concurrence**Electronic signature Date: June ??, 2013 |