Update to D.O.E. on AIMS diagnostic development

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on behalf of AIMS and Alcator C-Mod team

24 Jul 14
AIMS diagnostic successfully demonstrated first *in-situ* PFC surface measurements; basis for upgrades

- AIMS uses 1 MeV D+ beam in between plasma shots to interrogate PFCs for D retention, B layer erosion/deposition
  - Successfully demonstrated during FY12 plasma campaign
  - PSI-2014 invited talk,
    APS-DPP 2014 invited talk
    JNM paper submitted
    NF paper being drafted

- Characteristics of FY12 proof-of-principle diagnostic system (*no upgrades*):
  - PFC coverage: ~30 cm x 2 cm strip
  - RFQ accelerator: outdated, limited RF
  - Number of detector: 2 (1 gamma; 1 neutron)
  - Detector location: far from measurement site
  - Measurement times: ~10 min / location
New TF and EF4 magnet power supplies will provide AIMS with ~full poloidal, 60° toroidal coverage

- The TF and EF4 magnet power supplies are being upgraded to provide a steady-state +/- 13kA current for AIMS operation
  - Multiphysics analysis of magnet and and bus system demonstrated feasibility
  - Schematics and buswork design complete
  - Full protection of magnets is being implemented for new supplies

Result for AIMS will be nearly full poloidal and up to 60 degrees toroidal coverage of the first wall and divertor

**Result:** AIMS measurements of ~1/6 total PFC surface area in C-Mod

**Status:** Bid quests to vendors in June. Response from vendors received; resolving outstanding issues with top candidates
New solid-state RF system for RFQ accelerator being installed; will provide stable, high duty-cycle operation.

- The AIMS RFQ is a reused 1980's prototype. We refurbished and partially upgraded it, resulting in substantial cost reductions and successful operation.

- However, the 20 year old vacuum-tube based RF system was out-of-date and difficult to maintain:
  - Replacement tubes, parts not available
  - Providing 10% of design beam current
  - Unstable, unreliable operation
  - Missing / incomplete documentation

- New solid-state RF system from Tomco (AUS) has arrived and is presently being installed:
  - Reliable, consistent RF supply
  - RFQ duty cycle from ~0.2% to ~2%
  - Improved control interfaces

**Result:** Stable, high-current operation, maintainability, ~10x faster measurement

**Status:** RF system received and presently being installed; new control and interface hardware being finished; full tests in Aug.
Advanced detectors are being developed for AIMS; decreased measurement times, operability in B-fields

New detectors based on advanced scintillators and silicon photomultipliers (SiPM) are being developed to enhanced AIMS measurement capability:

- 5x count rate, less volume than current detectors
- Operation in high-B fields
- Radiation hard, robust engineering

**Result:** High performance, advanced detectors with ~5x faster measurement per detector

**Status:** Conceptual designs complete; quotes for hardware received and being reviewed; prototypes being built in laboratory
Translatable reentrant tube for detectors and *in-situ* beam target will significantly enhance capability

- Translatable reentrant tube will be able to move detectors across full major radius
  - Decreased measurement times
  - Improved signal-to-noise
  - Decreased TF, EF4 load

- *In-situ* beam targets will replace 2x2 array of PFC tiles at several locations
  - Beam imaging, optimization
  - Beam code validation
  - Diagnostic validation, calibration

**Result:** Faster measurements with better signal/noise; decreased load on TF

**Status:** Engineering design complete and ready for fabrication; target requires up-to-air install; reentrant tube possibly in up-to-argon
RFQ test stand and new MIT accelerator facility established to support AIMS development and research

- RFQ test stand established outside of C-Mod cell for full characterization of new RF system and optimization of all beam parameters
  - Allows independent ops from C-Mod
  - Beam energy spectrometer built and tested
- In partnership with MIT Nuclear Science and Engineering, a new accelerator facility is now active and will contribute substantially to AIMS:
  - 0.5-3.0 MeV deuteron tandem accelerator, DT neutron generator, shielded vault
  - Development/testing of RFQ beam hardware
  - Development/testing of detectors
  - Development of new ion beam analysis techniques for AIMS
  - Ex-situ measurements of PFC tiles
The AIMS diagnostic on C-Mod is transitioning from a successful prototype to a mature, standard diagnostic.

<table>
<thead>
<tr>
<th>UPGRADE</th>
<th>BENEFIT</th>
<th>TIMELINE</th>
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<tbody>
<tr>
<td>TF, EF4 supply</td>
<td>~Full poloidal PFC coverage</td>
<td>Fall 2014 / Early 2015</td>
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<tr>
<td></td>
<td>~60° toroidal PFC coverage</td>
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<tr>
<td>RFQ RF system</td>
<td>Stable ops; ~10x faster meas't</td>
<td>August 2014</td>
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<tr>
<td>Advanced detectors</td>
<td>Op. in B-field; ~5x faster meas't</td>
<td>Prototypes 2014; Final 2015</td>
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<td>Movable reentrant tube</td>
<td>Optimize meas't environment</td>
<td>FY15 campaign (?)</td>
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<tr>
<td>In-situ beam target</td>
<td>Beam optimization; Exp't calibration</td>
<td>Post-FY15 campaign</td>
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In aggregate, AIMS upgrades and facilities will result in:
- ~10-30x faster, improved meas'ts over ~1/6 total PFC surface area
- Stable, maintainable accelerator (the critical component)
- Fast development, prototyping, and validation in ex-situ facility