1. DOE award number, name, and address of the recipient (Institution).
   DE-FG02-06ER46267, West Virginia University, Morgantown, WV 26506
2. Project Title and name of the Principal Investigator and Project Director (if applicable).
   "Laser-induced fluorescence measurements on plasma science experiments at PPPL"
   Dr. Mark Koepke, PI, West Virginia University
   Dr. Philip Efthimion, PPPL Collaborator
3. Date of the report and award period covered by the report with approved budget amount.
   27 Nov 2011; $150,000 /year in FY2006, FY2007, and FY2008 (1Jan2006 – 31Dec2008)
4. Participating National Laboratory: Princeton Plasma Physics Laboratory
5. A brief description (abstract) of project goal and objective.

   Collaborative research between WVU and PPPL is proposed for the purpose of incorporating the sophisticated diagnostic technique known as laser-induced fluorescence (LIF) in the Paul-Trap Simulation Experiment (PTSX). WVU will assemble a LIF system at WVU, transport it to PPPL, help make LIF experiments on the PTSX device, participate in PTSX science, and train PPPL staff in LIF techniques. In summary, WVU will refurbish a non-operational LIF system being loaned from University of Maryland to PPPL and, by doing so, provide PPPL with additional diagnostic capability for its PTSX device and other General Plasma Science experiments. Once the laser system becomes operational, WVU students, staff, and faculty will visit PPPL to collaborate on PTSX experiments.

6. A description of accomplishments over the three-year period and their significance to the field and must include the Progress Report data since the last progress report. References may be outside the page limit.

   6.a. The pulsed-laser, was loaned to WVU from Dr. Richard F. Ellis at University of Maryland, and was refurbished by Dr. Koepke's group at WVU for use at PPPL.
   6.b. The laser system was assembled at WVU, including transmission optics, collection optics, detection instrumentation, specialty-gas handling capability, and halogen-gas safety equipment.
   6.c. Mr. Moses Chung, Princeton University graduate student, visited one week in Morgantown, WV, and completed training at WVU on the practical use of the pulsed-laser system, on safety issues, and on surrogate cw-laser systems at WVU on which LIF data could be acquired and analyzed.
   6.d. The laser system was transported to PPPL in a way that complied with toxic-gas transportation regulations.
   6.e. Dr. Herbert Gunell, WVU postdoctoral research associated, visited one week at PPPL and completed a training session for PPPL staff regarding the practical use of the pulsed-laser system and safety issues.
   6.f. Dr. Efthimion has used the laser system ever since for PTSX and other experiments in the PPPL General Plasma Science program.
   6.g. WVU expertise in LIF techniques, in barium detection by LIF, and in basic plasma science was significant in the successful delivery of a useful laser to the table-top PTSX experiment, which simulates experimentally beam-transport configurations relevant to

hundreds of alternate-gradient quadrupole magnets in an advanced particle accelerator by using oscillating voltages on electrodes and using barium ions to form a beam.
6.h. Detecting halo ions surrounding the ion beam in PTSX, an objective of the project, was not met because an alternative method was used to remedy the drift-tube surface activation problem caused by the scraping of halo ions at the drift-tube boundary. Halo ions can extend radially ten times further from the cylindrical axis of the ion beam than the edge of the ion beam.

7. A list of papers or patents (already published, in press, submitted) in which DOE support is acknowledged.

“Initial Density Profile Measurements using a Laser-Induced Fluorescence Diagnostic in the Paul Trap Simulator Experiment”, M. Chung, E. P. Gilson, R. C. Davidson, P. C. Efthimion and R. Majeski, Proceedings of the 2007 Particle Accelerator Conference, 3666 (2007).

Simulations of a plasmoid penetrating a magnetic barrier, H. Gunell, T. Hurtig, H. Nilsson, M. Koepke, and N. Brenning, Plasma Physics and Controlled Fusion 50, 074013 (2008).

Shear driven waves in the induced magnetosphere of Mars, H. Gunell, U. V. Amerstorfer, H. Nilsson, C, Grima, M. Koepke, M. Fränz, J. D. Winningham, R. A. Frahm, J.-A. Sauvand, A. Fedorov, V. Erkaev, H. K. Biernat, M. Holmström, R. Lundin, and S. Barabash, Plasma Physics and Controlled Fusion 50, 074018 (2008).

Studies of charged particle beam dynamics on the Paul Trap simulator experiment pure ion plasma, Chung, Moses, PhD dissertation, Princeton University, supervisor: R.C. Davidson, Sept. 2008

7.a. A list of papers in which Chung’s dissertation is referenced in a relevant way to the goal’s of this grant, DOE support is acknowledged, but not specifically this grant.
“Experimental Investigation of Random Noise-Induced Beam Degradation in High-Intensity Accelerators Using a Linear Paul Trap”, M. Chung, E. P. Gilson, R. C. Davidson, P. C Efthimion, and R. Majeski, Physical Review Special Topics on Accelerators and Beams 12, 054203 (2009).

“Use of a Linear Paul Trap to Study Random Noise-Induced Beam Degradation in High-Intensity Accelerators”, M. Chung, E. P. Gilsom, R. C. Davidson, P. C Efthimion, and R. Majeski, Physical Review Letters 102, 145003 (2009).

“Recent Advances in the Physics of Collective Excitations in the Paul Trap Simulator Experiment”, E.P. Gilson, M. Chung, R. C. Davidson, M. Dorf, P.C. Efthimion, A. B. Godbehere, and R. Majeski, Nuclear Instruments and Methods in Physics Research A 606, 48 (2009).

"Experimental Studies of Random Error Effects In High-Intensity Accelerators Using the Paul Trap Simulator Experiment (PTSX)", M. Chung, E. P. Gilson, R. C. Davidson, P. C. Efthimion and R. Majeski, Proceedings of the 2009 Patricle Accelerator Conference, in press (2009).

8. A total list of people who worked on the project –number of graduate and undergraduate students, postdocs, visitors, technicians, etc, during the total funding period. Please indicate for each person whether they received full or partial support under this award. In case of partial support indicate percentage of support.

8.a. Mark Koepke, PI, partial support, 1 month/year for 3 years
8.b. Herbert Gunell, postdoctoral research associate, partial support, 6 months/yr for 3 yrs
8.c. Eric Reynolds, graduate research assistant, full support, 12 months/year for 2006
8.d. Saikat Chakraborty, graduate research assistant, one-third support for 2006
8.d. Sean Finnegan, graduate research assistant, full support for spring 2006
8.d. Mattias Tornquist, graduate research assistant, half support for summer 2008
8.d. Jeff Walker, graduate research assistant, full support for 0.5 year (2008)
8.e. Stephanie Sears (full support from US Fusion Fellowship – not this grant)
8.f. Princeton University graduate student Moses Chung (no support from this grant)

9. An updated list of other support (current and pending, federal and non-federal.) For each, indicate the overlap, if any, and/or distinctiveness with the DOE-supported project.

No past, current, or pending support during 2006-2008 had any overlap with ER46267. This included one grant in the NSF-DOE Partnership in Basic Plasma Science and one grant in the DoD-EPSCoR program.

9.a. No overlap at all with ER46267
Project/Proposal Title: Predictive Control of Plasma Kinetics: Multi-Phase and Bounded Systems (PI: V. Demidov)
Source of Support: DoE-Fusion Energy Sciences, Plasma Science Centers program
Total Award Amount: $ 711,800
Total Award Period Covered: 08/15/09 - 08/14/14
Person-Months Per Year Committed to the Project: 3.6
Support: Current

9.b. No overlap at all with ER46267
Project/Proposal Title: High-Spatial-Resolution Magnetically Insulated Baffled Probe Technique for NSTX Plasma-Edge Diagnostic (PI: Koepke)
Source of Support: DoE-Fusion Energy Sciences, NSTX collaborator program
Total Award Amount: $ 741,204
Total Award Period Covered: 05/16/12 - 05/15/16
Person-Months Per Year Committed to the Project: 1 (summer)
Support: Pending

9.c. No overlap at all with ER46267

Project/Proposal Title: Stationary Inertial Alfven Wave: Experiment, Observation, Computation (PI: Koepke)
Source of Support: NSF-DoE Partnership in Basic Plasma Science and Engineering
Total Award Amount: $ 363,900
Total Award Period Covered: 05/16/12 - 05/15/15
Person-Months Per Year Committed to the Project: 1 (summer)
Support: Pending

10. Cost status: Approved budget for the full budget period and actual costs incurred were aligned. For cost-sharing, breakout by DOE share, recipient share and total costs. Financials Statements should be reported to DOE Chicago Operations as requested.