Argonne NATIONAL LABORATORY
www.anl.gov

Advanced Photon Source
Bldg. 401/Rm A4115
Argonne National Laboratory
9700 S. Cass Ave.
Argonne, IL 60439 USA
apsinfo@aps.anl.gov ◦ www.aps.anl.gov

# THE ADVANCED PHOTON SOURCE

## A Dedicated Fuel-Spray Beamline at APS 7-BM

"The evolution of fuel sprays plays a defining role…in determining both combustion efficiency and the formation of…pollutants...The overall research goal is to develop methodologies to computationally predict and design optimally shaped sprays for engine combustion of new fuels based on their physical and chemical characteristics."

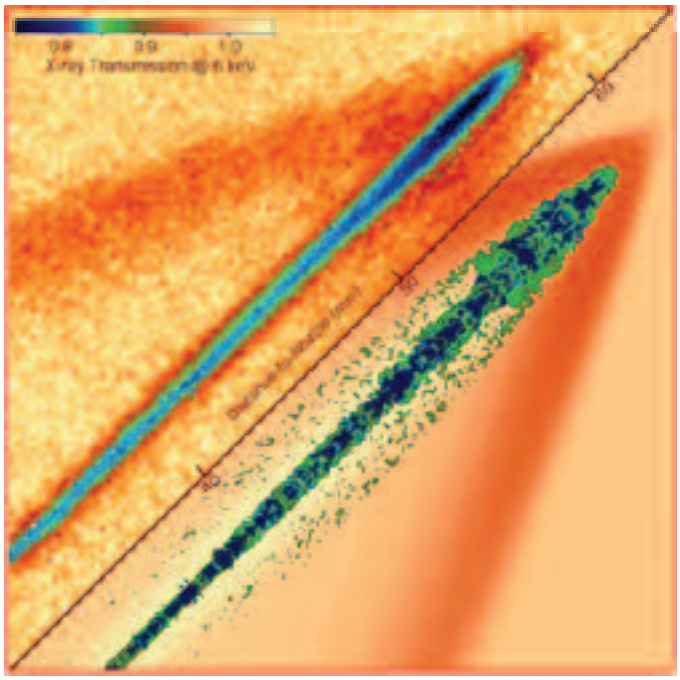
*Basic Research Needs for Clean and Efficient Combustion of 21st Century Transportation Fuels.* Report from the U.S. Department of Energy Office of Basic Energy Sciences Workshop on Clean and Efficient Combustion of 21st Century Transportation Fuels, October 29-November 1, 2006.

High-pressure, high-speed fuel sprays are a critical technology for many applications, including engine fuel-injection systems where the structure and dynamics of the fuel sprays are key to increasing fuel efficiency and reducing pollutants. But because liquid sprays are difficult to image with conventional (optical) techniques, particularly in the region close to the nozzle, quantitative information on the structure of these sprays has been elusive.

Research on this critical subject has been ongoing at the Advanced Photon Source (APS) for several years. The primary technique for these investigations has been ultrafast x-radiography carried out mainly at X-ray Operations and Research (XOR) Sector 1 at the APS and at the Cornell High Energy Synchrotron Source, with microsecond x-ray tomography also being employed.

Results, which have seen wide circulation in several peer-reviewed journal articles, have yielded information on quantitative fuel mass distribution, and high-speed spray and combustion models. Perhaps the most (to date) intriguing result has been capturing the propagation of spray-induced shock waves in a gaseous medium (MacPhee et al., Science **295**[5558], 1261 [2002]; Powell et al., J. Synchrotron Rad. **7**, 356, [2000]; K.-S. Im et al., Phys. Rev. Lett., in press). The researchers have engaged with an ever expanding roster of academic, industrial, and federal-lab partners in order to improve injector system design in areas such as optimizing spray timing and air/fuel mixing.

The time has now arrived for the creation of a dedicated, ultrafast-imaging facility on the Sector 7 bend magnet beamline at the APS. This facility will provide a centralized resource for transportation engine technologies, offering high-throughput measurement capabilities for the user community. The Vehicle Technologies Program in the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy, working through the Argonne Transportation Technology R&D Center, spurred the project to existence with a significant investment in rebuilding the beamline, where two research stations and major beamline components were already in place.



*Shock wave in high-speed fuel spray measured by μs-radiography (top) and simulated with computational fluid dynamics (bottom). (K.-S. Im et al., Phys. Rev. Lett., in press.)*

The beamline will provide ultrafast (μs) x-radiography, ultrafast (μs) x-tomography, high beam intensity, a wide-bandpass monochromator ($10^{13}$-$10^{14}$ ph/s, tunable from 6 to 12 keV), and flexible beam size. Instrumentation includes a sagittal focusing double-multilayer monochromator, a harmonics rejection mirror for use with area detectors, a secondary Kirkpatrick-Baez focusing mirror for use with point detectors, modular sample stations, pressurized spray chambers, and rapid-compression machines. Major emphasis is placed on safe operation of fuel injection under high-pressure, high-temperature conditions. Ultrafast x-ray framing detectors are to be available through a collaborative effort between researchers from Cornell and the APS.

Construction is on schedule. The beamline control system was completed and major x-ray optics components installed in January 2009. Commissioning is scheduled for February and March 2009, and dedication of the facility in May 2009.

*For more information contact: Jin Wang, wangj@aps.anl.gov*

### CALL FOR APS GENERAL-USER PROPOSALS

General-user proposals for beam time during Run 2009-3 are due by Friday, July 10, 2009

Information on access to beam time at the APS is at http://www.aps.anl.gov/Users/apply_for_beamtime.html
or contact Dr. Dennis Mills, DMM@aps.anl.gov, 630.252.5680

Argonne is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC
The Advanced Photon Source is funded by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences

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