Enhanced Validation of Performance-Defining Physics through Measurement Innovation

R. Boivin (GA), M. Austin (UT), T. Biewer (ORNL), D. Brower (UCLA), E. Doyle (UCLA), G. McKee (UW), P. Snyder (GA)

The advancement of fusion science and plasma science relies on accurate comparison of detailed measurements with theoretical predictions and computational simulations. Plasma diagnostics open windows on the science, revealing intricate, yet essential, details. The U.S. Fusion program is a recognized world leader in developing the understanding of fusion plasmas, due in part to our pioneering work in plasma diagnosis, combined with recent, rapid advances in computer simulation. Our understanding of plasmas is derived from well-diagnosed experiments, a fundamental component of model validation. The introduction of new diagnostics often brings scientific breakthrough. It is crucial that we strive to maintain and expand the highly productive development and utilization of new diagnostic systems for fusion research. It is time to renew the impetus in long-term diagnostic development in order to face the current and future research needs in plasma science. That situation is especially critical in the U.S., where traditional expertise and leadership in this domain are eroding at an alarming rate.

The improved capability in the modeling of plasma performance and in theoretical interpretation drives new measurement requirements to advance fusion research. Inadequate investment in diagnostic development jeopardizes the success of many present and future undertakings. A comprehensive set of diagnostics is essential for maximizing scientific output and realizing full utilization of any research facility. The level of effort should be commensurate with the potential for leading-edge scientific accomplishment, and applied to large and small experiments alike.

There are two overarching aspects of deficiencies in scientific measurements. First, there are measurement techniques that already exist and are critical to the physics program, but cannot be implemented with existing resources for a given experiment. Second, there are needs for which no established techniques exist or have not been fully demonstrated. The long-term health and potential for plasma science research requires that, at some reasonable level, resources be made available for the development of more innovative, higher risk, new diagnostics. Historically, a development time of five years or more is needed for a new diagnostic technique to mature from conceptual to full demonstration level.

Research and development in diagnostics is also a key area for training and educating the next generation of researchers. The challenges of a new technique and to excitement of new scientific discoveries give opportunities for young scientists to participate and contribute in the exciting field of plasma science. It strengthens the vital link between smaller facilities, usually found in universities, and major research laboratories.

Hence, we propose a new, comprehensive initiative to support plasma diagnostic innovation and development to benefit the U.S. national program:

1) We recommend that an infusion of new funds on the order of $10M/year be made available to assist in the short and long-term development and implementation of new diagnostics. A proper allocation between conceptual, proof-of-principle, and full implementation stages should be envisioned following a standard competition process.
2) We recommend that some minimal provision (e.g., seed funds) be made to support new proposals between official solicitation periods, which typically cover a three to five year cycle.
3) Finally, a coordination of efforts should be maintained in relation to the formation of a new overall model validation initiative. However, it is clear that the present needs in the diagnostics area far exceed the goals and requirements of that initiative alone.