DPF Task Force on Instrumentation in High Energy Physics

Instrumentation is the great enabler of science both pure and applied. Instrumentation is critical to the mission and culture of High Energy Physics, which is to explore the fundamental nature of energy, matter, space and time. Our field is embarking on a new golden age of discovery with the recent turn-on of the LHC, and with new experiments being planned at existing and proposed new accelerators, deep underground, at the poles, and in space that together will reveal the origin of mass, explain the matter anti-matter asymmetry of the universe, search for extra spatial dimensions, determine the nature of dark matter and dark energy, and may probe the Planck scale. For the very first time we may come to know how our universe was born, how it will evolve and its ultimate fate.

However, we embark on this adventure of discovery with instrumentation that represents both a towering achievement, and, in some cases, a scaled up version of techniques used in the past. We have, for example, gargantuan accelerators equipped with enormous experiments that have tremendous costs associated with them that are outstripping the internationally available public funding for particle physics. The result is often projects with exceptionally long time scales for construction and completion, and major de-scoping of detectors and their capabilities to the detriment of physics reach to match costs. In addition the time scales for our experiments and our large collaborations may have insulated us from instrumentation advances and innovations in industry.

Instrumentation R&D has the power to transform this situation, from novel new acceleration techniques such as plasma wake-field, to novel new detectors that provide enhanced capabilities with significantly reduced cost. However, there has been a decline in DOE and NSF funding for instrumentation research and development during the last two decades at universities and national laboratories. If this funding trend is not reversed declining capabilities will surely lead to a dramatic change in how our field functions, and we will confront a different kind of future for HEP– the golden age of discovery will be stalled and its goals unfilled. Energy, matter, space, and time will remain enigmas.

The field of HEP would clearly benefit from the development of both evolutionary and transformative detector instrumentation that is coordinated across the national laboratories and with the university community and international partners and with other disciplines. Instrumentation R&D is inherently necessary to our scientific future. But because it also has been a priority and strength within High Energy Physics' traditional culture, we believe it is appropriate and necessary now for the DPF to examine instrumentation research and development in its entirety.

Membership of the DPF Task Force on Instrumentation in High Energy Physics

The APS Division of Particles and Fields represents all of High Energy Physics, whether practiced at universities or at national laboratories. University faculty and laboratory scientists face similar challenges, but they do so within very different organizations and with different responsibilities. To that end, it is desirable to have identifiable, joint representation of these two communities within the Task Force leadership and membership.

Membership of the Task Force:

- **Leadership:** Marcel Demarteau and Ian Shipsey will co-chair.
- **Explicit Laboratory Membership:** Each of the five DOE national laboratories have been asked to recommend a senior individual to represent their programs.
- **Explicit University Membership:** We will identify five university faculty who are broadly experienced in the instrumentation issues outlined in this charge.
- **Expert members:** Without allowing the committee to become too large, we will invite a few individuals–without regard to their lab-university affiliation–to join by virtue of their particular expertise or responsibilities.
- **Ex-officio members:** Howard Nicholson and 2010 DPF Chair, Raymond Brock will be ex-officio members.

To ensure an international perspective the Taskforce will consult the European and Asian particle physics communities. Finally, recognizing the inter-disciplinary nature of instrumentation R&D the Taskforce is also encouraged to consult experts in other disciplines, in particular nuclear physics, materials science, condensed matter physics and electrical and computer engineering.

The Task Force Charge, v3.0

The Task Force will recommend a course of action related to each of the questions found below. These recommendations should be in the form of a written report to the 2011 DPF Chair Patricia McBride by September 30, 2011.

Schedule

There are three points on the calendar during which community discussions and, as the year progresses. Task Force ideas should be openly discussed:

- The APS "April Meeting" (http://www.aps.org/meetings/april/index.cfm) is scheduled for April 30-May 3 in Anaheim, California.
- TIPP 2011 (http://conferences.fnal.gov/tipp11/) is scheduled for June 9-14, 2011 in Chicago, Illinois.
- DPF2011 (http://www.hep.brown.edu/~DPF2011/), scheduled for August 9-13, 2011 at Brown University.

At DPF2011 we expect that the report and recommendations will be quite mature and that the discussion at a special session on Instrumentation at that time will inform the final report. More details on community discussions will be available at the conference web site: http://www.hep.brown.edu/~DPF2011/.

Organization of the Charge

The charge considers three broad areas: large scale instrumentation research, small-scale entrepreneurial research, and student and postdoctoral training.

I. A Structure for a National Instrumentation R&D Strategy.

A. National Organization There is a suggestion that DOE and NSF would benefit from coordinated and independent expert community involvement in sorting the many diverse instrumentation R&D proposals. A standing body could be solely reactive to Agency questions, proactively prioritize the many projects, or encourage the community to pursue necessary directions.

Q1. Please comment on the need, merit and process for evaluating and promoting the national R&D program through a standing body. Please indicate possible reporting strategies and suggest the auspices under which such a body might be organized.

B. Upgrades to Existing Experiments and Planning for Future Experiments. Upgrading running experiments often requires considerable instrumentation R&D. Similarly critical and extensive instrumentation R&D programs are required for experiments at future facilities. In some cases the facilities may not yet be approved DOE or NSF projects. Furthermore, there are four kinds of experimental programs, each of which presents different organizational challenges in instrumentation R&D: existing projects at established national laboratories, LHC upgrades, preparation for future lepton colliders, and non-accelerator programs explicitly not at existing national facilities.

Q2. Please comment on the appropriate role for a standing panel on instrumentation in the instrumentation R&D programs for upgrades to existing projects and future projects.

University-laboratory collaboration in all aspects of particle physics has been fundamental to the success of the discipline. Collaboration in the construction of new project specific instrumentation is funded through project arrangements between and among labs and universities jointly administered by either the experiment leadership and responsible laboratories or multi-agency Joint Oversight Boards.

Q3. Please comment on possible models for universities-laboratory large-scale collaborative projects within a national instrumentation program.

Q4. Please comment on the relative importance of developing strategic links to, for example, materials science, condensed matter physics, and electrical and computer engineering both in the academy and in industry to the future of HEP instrumentation as the complexity of our experiments increases. How might these links be developed and

sustained?

II. Models for Entrepreneurial Instrumentation Science.

Infrastructure to conduct instrumentation R&D at our universities is dwindling and non-existent in many cases. This is in stark contrast to the past and one of the bases of concern for the future of instrumentation as a focal point of the Particle Physics enterprise in the United States and for the future of the field as a whole.

While the available personnel and technical infrastructure have shrunk, the intellectual and entrepreneurial spirit among individual university faculty and laboratory scientists fortunately continues. What is best method to continue to encourage and support individual efforts?

Q5. Might targeted resources be established at each of the five national laboratories in order to specifically support particular needs of individual researchers at the universities and the laboratories? This could be in the form of specific needs (e.g., engineering design time) or specific resources for small-scale collaboration among and between university and laboratory scientists. How might such a program be administered?

III. Graduate Student and Post Doctoral Training.

Graduate student training is evolving. In the past graduate students received training in both instrumentation and data analysis. Today the majority of students participate in large experiments where the hardware projects are few and spaced apart by many years. For university groups without local instrumentation R&D programs, students often do not have the opportunity to develop the instrumentation skills that will be necessary to perpetuate the practice of continuous innovation in instrumentation required for the future success of HEP.

Q6. Should instrumentation R&D continue to be a preferred experience in the life of U.S. graduate students, or should only a few students have this experience? What are the implications?

Q7. There are currently a number of few-week, academic, intensive instrumentation experiences for graduate students offered around the world. Should there be an on-going U.S.-based program of instrumentation schools hosted at the national labs and/or well-equipped universities? What might a program look like? Would it instead be preferable to have U.S. events as part of a global instrumentation education program?

Q8. Please comment on the suggestion that a national instrumentation fellowship program be created by the NSF and DOE for Ph.D. students and postdoctoral scholars to encourage and support research in instrumentation.

For each area of the charge the task force should provide a short review of the approach adopted in Europe and Asia.