Monitoring Progress Report of Industrial Day Events

The **F**ast **A**dvanced **S**cintillation **T**iming is more than a technology shift. It represents a technical revolution with profound impact on feasible applications in particle physics, accelerator physics, medical & biological imaging, non-destructive industrial processing and electronic design issues. An important objective that this action also embarks on is training young researchers in a very innovative approach. We need change agents from every facet of industry, government, academia and healthcare to harness the full potential of **FAST** and to define what is possible.

In the first two years two industrial day events are organized:

- 1st Industrial FAST Workshop @Aachen, Germany Sept. 24th, 2015
- Technology Frontier for Single Photon Detection and Advanced Scintillator Timing @ IEEE NSS/MIC and RTSD in Strasbourg, France Nov. 4th, 2016

These workshops brought together scholars, industry leaders and visionaries from across the world to discuss how academia and industry can partner to address the challenges and the opportunities that scintillator-based detectors with time precision better than 100ps presents.

In the first year we start with the **1st Industrial FAST Workshop at the European Trans Domain COST Action** at Aachen University of Applied Sciences on September 24th. Around **60 participants** from science and industry in part from 16 different countries are coming together for this workshop. A focal point was conceivable applications for ultrafast detection of scintillation light in medicine and biology. The targeted ultrafast picosecond detection provides information on time differences of light in the millimeter range. Future 3D imaging techniques in medicine and biology can thereby be considerably improved.

Presentations from the industry leaders in the field of SiPMs have shown the potential benefit of the new technology with new trenches using new materials. They claim possible applications into High Energy Physics, Medical Imaging, Biology, Security and non-destructive imaging and open for collaborations. In particular the field of medical and biological applications the Fast Advanced Scintillation Timing is more than a technology shift. In addition, to lectures on the development of ultra-fast photosensors and application of scintillation detectors and their potentials, there were many opportunities for conversations. During the round-table discussion, the representatives from industry and science exchanged constructively new ideas of cooperation.

The overall focus of the **2nd workshop in parallel to the IEEE conference at Strasbourg** was on cutting edge technologies addressing the issues that currently limit the use of single photon detectors, including in particular large area readout issues, ultra-fast timing better than 100 ps, radiation hardness, and Ultra-Violet and Vacuum Ultra-Violet sensitivity. In parallel to international IEEE conference on Medical Imaging and Nuclear Science Symposium this event was held in Strasbourg, France. The technologies that are of particular interest include analog SiPMs, SiPMs with embedded digital electronics (monolithic digital SiPMs, 3D-integration, etc.), as well as non-solid state based solutions such as Micro-Channel plates, hybrid photodetectors or gas-based solutions. Scintillation materials and readout

electronics solutions were also be included as a part of the workshop scope.

Nearly 200 participants are registered to bring together scholars, industry leaders and visionaries from across the world to discuss how academia and industry can partner to address these challenges**.** An important objective of this workshop was also to provide training to young researchers in an open and innovative context.

The workshop was subdivided in four sessions:

1. **Challenge and Demand on fast and large area Photon Detection Devices: The point of industrial**
   Performance measurements of the new photon detection devices are done by the manufactures and academia as well. Nevertheless, everyone used their own methods to compare the devices and to benchmark the results on the basics of existing parameterizations. The outcome of this session is to establish a committee of experts to define methods and parameters for standardization of scientific procedures and developments. Their recommendations will be conveyed to a division of NEMA (National Electrical Manufacturers Association).

2. **Performance Measurements of new Photon Detection Devices**
   In the last 2 decades the development of SiPMs has made an enormous progress, and the number of groups working on SiPMs and the number of applications seem to grow exponentially. The same is true for the number of publication, and it is already very difficult, if not impossible, to keep track of them. In addition, in many cases it is difficult to compare the results, as different groups present results in very different ways, and even the definitions of terms and parameters differ frequently. Therefore characterisation, analysis, and calibration of SiPMs for a proper definition of parameters and for the standardization aiming to allow a meaningful comparison of results for different SiPMs as well as for different measurement and analysis methods was the main focus on this session.

3. **Large area photodetectors**
   PMTs remain highly competitive for large area (>1cm^2) applications, such as water Cerenkov detectors for neutrino physics, or noble gas liquid detectors for dark matter searches. Indeed, for large areas, SiPMs suffer from high capacitance per unit area that can pose challenges to the electronic design, and high dark noise rates, which can be alleviated by cooling, or ignored if the noise does not dominate the measurement (e.g. in air shower telescopes). The potential of such detectors to achieve precise timing is of increasing importance for many applications, and the implications of such a radical improvement may bring huge benefits in many areas.

4. **Projects Perspectives for Young Researchers**
   In this session a selection of up to 11 short presentations, especially from early stage researchers were presented in a short time like a pitch to address their projects to the industry and senior scientists. In addition, a discussion with the plenary would provide their ideas.

The result of the industrial day events should be a list of following perspectives:

1. A set up of characterization methods of the new solid state photo detectors, called SiPM (Silicon Photomultiplier Tube), for a proper definition of parameters and to start a standardization process
2. A data base of industrial and academic units has to built with public access which offers dedicated equipment and measurement devices for possible partnerships and cooperations.

We need involvement from every facet of industry, government, academia and healthcare to harness the full potential of what is available and to define what is possible. Responsible and effective transformation will be ushered in through an alliance of industry and academia. The success of the **Industrial Workshops** and the dialogue that we started should continue in the following years.