

Draft of Report of Interdisciplinary subcommittee to the DPF Instrumentation task force

Subcommittee members:

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The task of this subcommittee is to look at the interdisciplinary aspects of instrumentation, taking into account that we start from a HEP centric view. From that point of view there are two somewhat separate aspects to our task. They are:

1. Development of instrumentation in the HEP community and transfer of that technology/knowledge to other fields of science (“HEP to other sciences”). Here science is used in a somewhat generic way and can range from nuclear physics to photon sciences to national security to industry.
2. Development of instrumentation for HEP specific needs, but using new technologies or breakthroughs from other fields of science or engineering (“Other sciences to HEP”). For example using new materials/techniques developed in material science and applying them to new sensors or detectors for HEP. Again HEP can range from accelerator based physics to astrophysics. This of course assumes shared use of existing equipment/processes at participating institutions

Both of these activities exist in different forms at different institutions. Why they exist and how they exist often depends very much on the environment. For example the instrumentation group at Brookhaven is a good example of their work being driven by the multi disciplinary aspects of Brookhaven, whereas instrumentation development at Fermilab is much more focused on HEP.

Another important observation is that HEP follows a very different approach to instrumentation than nearly all other disciplines in science. HEP defines an experimental measurement and then develops/engineers and builds detector systems to do a particular measurement or live in a certain experimental environment. Nearly all other sciences simply use instruments that are available, mostly from industry. So there is a fundamentally different approach in HEP and other sciences.

The point of resources and access to them keeps coming up. Although in this document we generally refer to all institutions (universities and laboratories), it is clear that universities do not have access to the same resources as labs. There is a strong desire in universities to not only be a purely analysis and software operation, but try to maintain R&D in instrumentation, outside the mainstream umbrella of big experiments.

In the following we will list some areas that should be looked at by the subcommittee or may be these are recommendations for a future “organization” to look at. We will do that separately for the “HEP to other sciences” and “Other sciences to HEP” cases.

Findings/observations for “HEP to other sciences”

- a. This is not a process that can be initiated by HEP. It may be stimulated by HEP, but the need has to arise or be recognized in the other science(s). For example: Photon sciences. We can not tell what they need, they need to tell us.
- b. HEP should reach out to other sciences, explore what they need (See recommendations)
- c. What is the best way to do this?
 - Can DPF and/or APS help?
 - Organization of workshops ?
 - Does the TIPP series do this ? IEEE/NSS/MIC is an excellent example.

Findings/observations for “Other sciences to HEP”

- a. This process needs to be initiated by HEP
- b. Need to make a list of examples where this has happened in the past /is happening now. We need this to see how it works.
- c. It needs to be a two way street: both sides need to benefit from it. HEP should get new sensor/or cheaper sensor and other science should learn something as well.
- d. Can this be organized nationally (At DPF or APS level), encouraged nationally or does it only happen locally because of connections that people have?
- e. Can the *Detector R&D Coordinating Panel* play a role here?
- f. How do such activities start and get initial funding. Can SBIR play a role ?

Before we turn to recommendations, we thought it might be useful to illustrate with some examples where HEP has impacted other fields and where other fields have impacted HEP. Each member of the subcommittee contributed examples and those are listed in the Appendix. We list them simply by topic, the list is incomplete and we avoided attaching institutions to them. A clear observation is that HEP is very enterprising in reaching out to other communities, to solve a problem. This is often done in two ways: trying to find a technology somewhere that exists and can be applied, from a company or another science, or developing something from scratch using developments from other sciences.

It is also evident that a lot of instrumentation developed for HEP has found its way into other areas, either because HEP has moved into that area (astrophysics for example) or others picked up HEP technologies. It should also be noted that not all HEP technologies (ASICs) for example find applications everywhere.

Recommendations

Most of these recommendations are for actions or work to be undertaken by the *Detector R&D Coordinating Panel*.

- HEP should reach out to other communities.
 - This should start somewhat locally in science by establishing a better relationship with NP and BES in the Office of Science. The specific recommendation here is a workshop or a series of workshops intended to bring those communities closer and foster interaction

and collaboration so each benefits. This should also include NSF (in a multidisciplinary way) to get the ARPA (?) program rejuvenated.

- Ultimately this outreach/better connections should extend to the medical community, NASA and national security. All this should take into account existing relationships.
- It is recommended that the *Detector R&D Coordinating Panel* have input on which topics in instrumentation should be encouraged in SBIR/STTR proposal calls. Each year DOE requests input for these calls.
- As the examples on interdisciplinary activities in “Other Sciences to HEP” illustrate there are many examples of such work, resulting often in new directions or development of new capabilities. It is recommended that the *Detector R&D Coordinating Panel* establish a repository of such examples or even better a repository of possible new developments in other fields that might benefit the development of new sensors or instrumentation in general.

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Appendix:

A (incomplete) sample of activities falling under “**HEP to other sciences**”

- Application of active pixel devices to electron microscopy (LBL, UK)
- Development of Silicon-on-Insulator based X ray imaging sensors (with KEK)
- Collaboration with Upstate Medical (data acquisition infrastructure, using xrays to check cable connectivity).
- Collaboration with small high tech companies (CMA) mirror development, and now novel thin RF foil development.
- HEP/NP incubate talent in detector R&D for national security and probably medical R&D - this is a political point that could strengthen HEP/NP funding for detector R&D that is likely under-utilized.
- There has been a 30-40 year synergy between Radio-analytical chemistry and physics and between basic HEP research and applied environmental radioisotope measurement research. HEP has contributed better instrumentation resulting in less need for chemistry and faster processing. Chemistry has helped remove unwanted materials from detectors for DM searches
- ASICs from HEP. There is great synergy in Europe between medicine and HEP - much more so than in the US. Because of high cost and limited access to resources other fields(for example NP) shy away from the leading edge HEP technologies, often because of cost and complexity arguments. Can/should HEP's national capabilities be more available to interdisciplinary communities.
- Conventional HEP already has well established connections and already contributed to developments in astrophysics and even astronomy. Examples: AMS, GLAST, DES,

A (incomplete) sample of activities falling under “**Other sciences to HEP**”

- Development of doped water based scintillator.
- Development of TES for B-mode polarization of CMB. Required identifying and characterizing a superconducting material and make sensor out of it with correct noise characteristics.
- Development of large area, flat panel, pico second photo-detectors based on being able to make cheap micro-channel plates from glass and functionalize them i.e. turn them in electron amplification devices (gain 10⁵) with Atomic Layer Deposition (ALD).
- Development of new photo-cathode materials for accelerators and photo-detectors
- Willingness to re-invent photo-detectors and redevelop forgotten technologies and/or replace them with new ones.
- Initial development of CCD's
- Development of new photo sensitive materials for photocathodes for accelerator sources of photo-detectors.
- Developments in the silicon based area:

- wafer thinning and backside laser annealing process (with Cornell Materials Science department and university Nanofab).
 - 3D electronics and sensor integration (with MIT-LL, BNL and commercial firms)
 - Silicon-on-Insulator integrated electronics and detectors (in-progress SBIR).
 - Development of 3D and active edge silicon sensors (with University Nanofabs)
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- Development of cold electronics in collaboration with university (N. Carolina?) EE departments
 - HEP/NP incubate talent in detector R&D for national security and probably medical R&D - this is a political point that could strengthen HEP/NP funding for detector R&D that is likely under-utilized.
 - Dzero silicon flex cables were produced at Kansas City Plant, a dedicated NNSA facility. Many of the CMMs at FNAL came out of NNSA facilities and were repurposed for HEP. While some linkages exist between those realms I think it would help HEP to strengthen them .
 - We also believe that the original radiation hard electronics for HEP were developed on the coat tails of enormous investments made in the weapons program (NNSA) and for satellites (NASA).