ELI-NP----a Game Changer

Toshiki Tajima†
Faculty of Physics, Ludwig Maximilian University
Garching, Germany
†Blaise Pascal Chair, ENS

We have emphasized that Extreme Light Infrastructure (ELI) is a game changer in the 21st Century science. This is first because ELI will change the way we conduct the fundamental scientific investigation we established in 20th Century with the fashion of the extrapolation of the current technology to ever larger sizes. An example is the accelerator to investigate high energy phenomena that is the most successful hallmark of 20th Century basic research tool. ELI will look for radically different ways to seek fundamental physics via photons, rather than charged particles in high energies. Secondly, ELI, unlike many other large scientific instruments, are not only for analysis, but also for synthesis, encompassing many disciplines ranging from high energy physics, nuclear physics, plasma physics, solid state physics, chemistry, biology, medicine, nuclear engineering, etc. and will serve to integrate these disparate disciplines, rather than to narrowly isolate a single discipline. Third, significantly, it involves a new participation from a geographical region that has never hosted a major international scientific installation. Not only is it significant for geopolitics, but also

the new blood is good for the possibility to open doors to new entries with less constraints by the establishment approach and philosophy that may have been stuck, leading to opportunities for wide-open breakaway developments.

The ELI Science was designed based on the scientific recommendation by ELI SAC [1], which recognized four scientific missions of ELI: High field science, laser accelerated beam lines, photonuclear science, and attosecond science. It turned out that ELI Pillars are consisted of the above four scientific missions and that each Pillar is centered in so far three countries (Czech, Romania, and Hungary) for each of the three scientific missions, respectively, other than high field science listed above. The high field science pillar will be considered finally in 2012. The high intensity frontier is ELI's chief guiding direction. It will seek the highest laser intensity ever, which enables us to explore physics frontiers of the above four missions. Beneath this guiding direction is the Laser Intensity-Pulse Duration Conjecture stating that the shortest pulses of radiation come from the highest intensity of the driving laser [2]. Because of this we now learn that the discipline of ultrafast optics and that of high field science are tied. (It is also getting obvious that in order to create highest intensity, larger energy lasers are needed.) Thus the three distinct disciplines of ultrafast optics, high field science, and large energy lasers science are all tied. We now see that the attosecond pillar of ELI and other pillars are interrelated through this Conjecture.

On top of these characters of ELI as a game changer, ELI-Nuclear Pillar (ELI-NP) is unique. ELI-NP represents Nuclear Photonics, an emerging brand new discipline to explore and control nuclei by photons. Unlike the standard approach in the present nuclear physics where charged particle beam (or beams) bombards these charged particles to spew out deep interior secrets of the constituent particles through the large penetrating momenta, our approach is through photons, chargeless massless particles. At ELI-NP, we employ both high intensity lasers and large energy gamma beams, two elements of extreme light. With these two extreme light elements we should begin to explore and manipulate nuclei, just the invention of laser in 1960 has immediately begun the establishment of the new discipline of optics and spectroscopy of atoms. Chargeless gamma particles can penetrate the nucleus without deflection by the nuclear charge. It can precisely resonate with the internal structure of the nucleus if the energy of the gamma is chosen appropriately. With the large amplitude laser, we may be able to excite and/or break up the nucleus. With these new tools, a large amount of new ideas and topics have been suggested. For example, the energy specific gamma beam is capable of exciting specific nuclear levels (or isomers) so that we can make use of these levels as a marker or an energy releaser, thus possibly as a diagnosis, and a cancer killer, yielding a new genre of nuclear medicine. The nuclear resonance fluorescence by the gamma beam should be able to identify the precise information of the specific nuclei at hand without contact and thus in safety and convenience with speed. Subsequently we witness many new participants with broad backgrounds taking action in this field. We have also begun to see ELI-NP developments will bring hopes to new classes of beneficiaries such as patients with metastasized tumors and IAEA nuclear inspectors.

As Professor S. Gales has told us, the impact of progress of nuclear physics will be felt on the way to make progress in nuclear engineering such as the nuclear waste monitoring and management. Even though Fermi has made an impressive beginning of nuclear energy and engineering, few breakthroughs that rival his have happened. This is why I have been advocating the importance of what I called 'toilet science' as opposed to the predominant conventional efforts in 'kitchen science', where the latter focuses on the upstream side of energy and matter while the former on the downstream. In other words, the former tries to understand the science how best we can clean up what the nuclear energy production brings out. The new headway in this direction can only come with a brand new approach such as ELI-NP employs and new ideas and discoveries that it might bring out. In retrospect of the recent catastrophic development pertaining nuclear reactors after the most powerful earthquake in the recorded history of Japan, I believe that it is even more urgent to make further progress in 'toilet science' of nuclear energy. ELI-NP research can make such a contribution to the society.

In conclusion ELI-NP is a game changer in nuclear physics and engineering as well as in fundamental science and its applications of a broad range. We are hoping that a broad international partnership and participation will enjoy the fruit of these potentials to become reality.

[1] ELI Scientific Advisory Committee Report (2009), www.extreme-light-infrastructure.eu
[2] G. Mourou and T. Tajima, Science **331**, 41 (2011).