

# From the “Higgs Particle” to Technology, From the Web to the Grid: Fundamental Science, Technology, and International Cooperation

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About a decade ago, the initial decisive ideas emerged from CERN, the European Organization for Nuclear Research based in Geneva, on the World Wide Web that made the Internet globally accessible to everybody in an intuitive way.

Particle Physics is a fundamental science where already 50 years ago resources had to be cumulated between nations to progress at the state of the art. With the LHC, Particle Physics will soon study matter at resolutions of below  $10^{-18}$  m, corresponding to collision temperatures of around  $10^{15}$  °K. Matter in the universe was at that temperature less than  $10^{-13}$  s after the big bang.

To study matter in such an exotic state requires very sophisticated, highly computerized equipment and the most elaborate methods of data acquisition, validation, and analysis. Such studies are typically performed in multinational and multitechnological collaborations, today called “virtual communities,” “collaboratories,” or similar.

At the turn-on of the previous accelerator at CERN, LEP in 1989, the computing environment was multiple vendor and multiple operating systems, PCs, work stations, and mainframes. The need of the scientists to easily exchange documents electronically in this “high tech” and “computer literate” environment was the incentive to develop the “open standard” Web ideas.

The experiments using the next-generation accelerator, LHC, to become operational in 2006/7 will produce analog and digital data at equivalent rates of Petabyte/s at their front-end electronics. Such rates will be reduced online to Petabytes/y for offline analysis by communities of more than 1000 physicists/experiment in dozens of countries and hundreds of institutes.

A worldwide infrastructure of coupled computer centers was envisaged from the beginning to provide to the physicists around the world the access to the data and to the applications. This has turned now to Grids and CERN and collaborating physicists from institutes around the world are involved in a number of grid projects of the EU, in the U.S. and other countries.

Grid computing has emerged in Computer Science from the need to join distributed resources to achieve a particular goal, not achievable through a local resource only, such

as advanced simulation calculations of, for example, car crashes or other highly demanding computing tasks involving a variety of resources.

Particle physics at CERN is adding another dimension to this by trying to use the Grid metaphor for vast amounts of data, stored somewhere around the world, together with complex application programs to be made available to a worldwide community of thousands of scientists who basically dispose of a laptop connected to the Internet.

The particle physics community, apart from original contributions to the grid architecture and middleware, will operate global testbeds with most demanding users and usages and this is probably the only community of scientists that can do this.

Another interest is the operation of vast computer centers made of tens of thousands commodity components to achieve the required throughput at affordable cost.

To science, this will help to open the way to “e-science” or “enhanced science”; and to business, there may be some advances toward true “e-business.”