3rd International Symposium on
Energy Challenges & Mechanics
- towards a big picture

7-9 July 2015
Aberdeen, Scotland, UK

Keynote Speaker of Session 11

NUCLEAR ENERGY

Dario Crosetto is the inventor of the 3D-Flow system for the discovery of new particles and the inventor of the 3D-CBS technology (Three-dimensional Complete Body Screening) for early cancer detection. In June 2011, he won the Leonardo da Vinci Prize for the most efficient solution using particle detection for early cancer diagnosis. This competition was held publicly via the web from the University of Pavia, Italy, on its 600 year anniversary. He has 25 years' experience in international collaboration in the field of High Energy Physics (HEP). He has presented numerous seminars and articles at international conferences, universities and research laboratories including CERN, SSC, FERMILAB, BNL, SLAC, NEVIS, BERKLEY, DESY, University of Heidelberg, SACLAY, CPPM, Academia Sinica, etc.

Crosetto worked as a research scientist on physics experiments at CERN, Geneva, for 17 years. His expertise in Digital Signal Processing (DSP) and in designing the Level-2 Trigger for the DELPHI experiment at CERN-LEP accelerator, lead CERN to offer him in 1988 the position of "*Paid Scientific Associate*". It was then that he designed and implemented new instrumentation to accurately measure and focus the beam (Q-measurements) for CERN-SPS (Super Proton Synchrotron) Accelerator Division and designed a new parallel-processing system for trigger and data acquisition (DAQ) for detectors for the Data Handling Division (DD). Invitations followed to lecture at the CERN School of Computing on applications making use of DSP in instrumentation for HEP and to share his expertise at the European Committee for Future Accelerators – ECFA, Large Hadron Collider (LHC) Workshop, 1990.

This lead to an invitation from the Superconducting Super Collider (SSC) in Texas where he was assigned by his boss James Siegrist (who later became the Director of the U.S. Department of Energy –DOE-, Office of High Energy Physics) to solve the most challenging problem in HEP: to design the Level-1 Trigger for the GEM (Gammas Electrons and Muons) experiment to identify all possible rare events (one every 10 billion) generated by collisions between particles occurring at 1 billion per second that cannot be stored without filling every hard drive on the planet in one day. In 1992 less than one year at the SSC, Crosetto reported his 3D-Flow parallel-processing system architecture invention to his boss, Jim Siegrist, (see also video) that would not only solve GEM's problem but also that of its competitor, the SDC experiment at SSC, at the LHC at CERN, and future experiments. The "3D-Flow" superseded the "cabled logic" approach which had been used for 20 years at LHC experiments and still supersedes the "FPGA" (Field Programmable Gate Array) approach currently being implemented to upgrade the LHC experiments for the next 15 years as reported in CERN's 2013 documents. Siegrist favored transparency in science authorizing Crosetto to proceed although it

would give advantages to the competitors and supported Crosetto's presentations at three international scientific conferences in less than one month. Crosetto published three articles on his invention that same year in prestigious scientific journals. Crosetto's invention received many letters of recognition from prestigious universities, leaders of major research laboratories and scientists and leaders of several experiments who were in competition (e.g. from division leaders, group leaders from Atlas and CMS experiments at CERN, from CDF and D0 Experiments at FERMILab, from STAR experiment at BNL).

Transparency in science also took the form of a major public international scientific review of Crosetto's 3D-flow invention requested by the Director of the SSC, lasting an entire day with experts from industry, universities and research centers held at FERMILab in December 1993. The invention's revolutionary value was formally approved by FERMILab review panel in their written report stating that is a *"unique concept"* and "*experimenters would probably think of clever uses not now possible*". A real case "*Beyond imagination of future science*" as solicited by the Chairman of the 2013 IEEE-NSS-MIC-RTSD Conference. The innovative features were later confirmed by simulating 3D-Flow systems with thousands of processors from the top level in C^{++} to gate level, and its feasibility and functionality was proven in hardware by building two modular electronic boards using Altera FPGA, each with sixty-eight 3D-Flow processors able to create systems for detectors of any dimensions for HEP experiments and for Medical Imaging applications. Its technology-independent feature was proven by synthesizing 3D-Flow processors/chip on three FPGAs (ORCA, Xilinx and Altera) and in Standard Cells using Synopsys Synthesis tools. It has the capability to thoroughly analyze each event by executing an "Object Pattern Recognition Technique -OPRT" algorithm for a time longer than the interval between two consecutive events. This technology-independent, programmable, scalable, cost-effective technology can satisfy more stringent requirements should future data input rates and background noise increase due to a higher LHC luminosity.

Crosetto received grants from the Department Of Defense (DOD) and the DOE of approximately $1 million to pursue research in pattern recognition that breaks the speed barrier in real-time applications and the Green Card for permanent resident was granted for "*exceptional ability*". Crosetto's invention was adopted by the SSC-GEM (TDR) experiment and by CERN-LHCb (LOI and TP) experiment.

The "3D-Flow" system's capability to extract all useful information from radiation, besides being a powerful tool for the discovery of new particles, is even more valuable in other fields, including an effective early detection tool for cancer and other anomalous biological processes which are precursors of a disease. Starting in the year 2000, Crosetto worked tirelessly developing new techniques and combining those with known techniques in a unique way to "*accurately capture all possible signals from the tumor markers (specific radiation at 511 keV) at the most economical cost per valid signal captured*". The result was the *ultra-sensitive, low radiation dose, low-cost examination*, 3D-CBS (3-D Complete Body Screening) invention. These three features (ultra-sensitive, low radiation, low-cost examination) achieved at once in a single 3D-CBS device are the result of the synergy of techniques in the field of detector assembly, electronics, coupling of the detector with the electronics, real-time algorithms, etc. It supersedes the performance of all existing PET/CT (or PET associated with any other modality) in functional imaging, opening new doors to research and clinical applications in efficiently detecting cancer at its earliest curable stage, safely and affordably. This would allow repetitive examinations to monitor treatments, and advance research because it can provide more accurate information on minimum anomalies in biological processes and in routine

screening of apparently healthy individuals. The 3D-CBS innovative technology has been presented at and passed many public scientific reviews, including winning the Leonardo da Vinci Prize. The 3D-CBS features are optimized to achieve the maximum reduction of cancer deaths and cost.