

# Thirty years of Varenna's Conferences

## A witness of the progress in nuclear dynamics in the last 30 years

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Leaving after about 30 years the Chairmanship and the Organization of the Varenna Conferences on Nuclear Reaction Mechanisms it seems appropriate to me to briefly remind you the story of this Conference and why it reached its quite outstanding recognition among those who attended it during the years.

The first of these Conferences was organized by Laura Colli Milazzo in 1977 to review the progress made in the experimental and theoretical study of pre-equilibrium reactions. The choice of Villa Monastero was due to its world-wide reputation for high level Physics Conferences and Schools which dates back to 1954 when it hosted a School which was attended by Enrico Fermi a few months before his death.

The Proceedings of this first Conference were published in a unpretentious grey volume which however started with a gem, a paper by Herman Feshbach on the theory of *Statistical Multi-Step Direct Reactions* the first written account of the *direct* part of the famous FKK (Feshbach-Kerman-Koonin) paper which appeared only three years later on *Annals of Physics (NY)*.

Other contributions gave a complete review of the status of art in the field including the measurement and the theoretical interpretation of cross section fluctuations in statistical multi-step reactions, of light ejectile's spectra and of the cross-sections of a large number of reactions induced by light projectiles, up to incident energies exceeding one hundred MeV, and more exotic particles such as pions. This subject remained as a distinctive item in all the subsequent Editions of the Conference up to now. Other important items covered in this first Conference were nucleon clustering (Peter Hodgson gave a review talk on *Alpha Clustering*), giant resonances and fission.

The Conference was really a great success and Laura decided to repeat the experience two years later. The major item was still the study of pre-equilibrium processes and indeed the opening talk was still delivered by Herman Feshbach on *Further Developments of the Statistical Theory of Multi-Step Processes* concerning especially its use at high energies and in heavy ion reactions. As the more detailed exposition of his theory up that time he quoted his previous Varenna lecture. Among the other talks devoted to pre-equilibrium phenomena let me cite that of Harry Holmgren who presented the double-differential spectra of ejectiles measured at the University of Maryland in reactions induced by protons, deuterons and alpha particles at energies varying from 70 to 140 MeV on many nuclei showing one of the first examples of industrial production of data, which was not very usual at the time in nuclear physics. New items made also their appearance. I wish especially mention a talk by Konrad Bleuler (in his first of many comings to Varenna) who spoke of the need of considering the inner structure of nucleons in nuclear theory especially for understanding nucleon - antinucleon interactions. This was followed in the third and fourth Conference by other contributions of the Bonn School on the quantum field theory of nuclear forces.

In 1982 Laura asked me to be responsible of the third Conference. Although in failing health she still actively contributed to the organization and gave a talk on the *Statistical Multi-Step Compound Theory*. She would pass away three years later in January of 1985.

The success of previous editions led to an explosion in the number of participants which doubled those of previous editions. Papers on pre-equilibrium, multistep and break-up processes whose theory was reviewed by P. Hodgson and M. Hussein, still constituted the majority of the contributions to the Conference. However as a major innovation in comparison to previous Conferences two new items were included: the effective interaction in nuclear matter and relativistic heavy ions. The inclusion of the first argument was indicative of the need for a deeper understanding of the interaction

mechanisms. The up to date review of ultra high energy reactions allowed to recognize the significance of the results which were appearing in this research field which was expected to prove a source of invaluable information on nuclear matter at extreme conditions such as those expected at the beginning of Universe. H. von Geramb and A. Molinari gave a great contribution to the organization of the Session devoted to the effective interaction and H. Feshbach and W. Greiner to the organization of the Session on relativistic heavy ions.

It is impossible for me to cite in a well balanced way the many important contributions which were presented. Let me simply cite among the new entries in the Varenna family, as I like to quote the friends that over the years participated many times to the Conference, H. Bucka, A. Budzanowski, N. Cindro, H. Ejiri, J. J. Griffin (the father of the exciton model of pre-equilibrium decay), J. Julien, D. Schutte.

By the fourth Edition in 1985 the Conference was internationally renown and had become the sought occasion for scientists all over the world for coming to Varenna to present their latest results and establish new collaborations. The rather small size of the Conference, the magnificence of Villa Monastero and Varenna itself, the lake of Como at its best beginning June, the usual time for the Conference, create an informal atmosphere most conducive to fruitful discussions and long standing friendships. As I reminded before Laura Milazzo Colli died untimely at the end of January of that year and the Organizing Committee decided to dedicate to her the Conference of that year.

The study of pre-equilibrium, multistep and break-up processes remained still the main argument (with important contributions by, among others, K.W. McVoy, D.J. Ernst, A.Iwamoto, T.Udagawa, A. Galonsky, M. Sakai, H. Rebel) together with alpha clustering and giant resonances (with contributions of F. Iachello, J. J. Griffin, A. van der Woude, M.N.Harakeh, H. Ejiri). In that Edition of the Conference a special session was devoted to nuclear structure in the light of new developments of QCD, with contribution by the Bonn Group (K.Bleuler, D.Schutte and H.R.Petry), K.-I.Kubo and H. Toki and H.von Geramb.

For the first time we inaugurated the Wednesday evening Session (which should remain an important characteristic of the Varenna Conferences, with a very fine and moving talk of K.Bleuler on his personal memories of Wolfgang Pauli and Werner Heisenberg and a talk by G.Tagliaferri on *Some historical remarks on the rise of nuclear physics*).

On occasion of the fifth Conference, in 1988, in addition to the usual items, including high energy and intermediate energy reactions, there was a Session devoted to the interaction of electromagnetic probes with nuclei, with a presentation by H. Holmgren of the Continuous Electron Beam Accelerator Facility (CEBAF) of the Thomas Jefferson Laboratory. Among the many talks I wish to mention those of G.Graw, M.Blann, N.Cindro, L.Lassen, J.P.Coffin, S.Okhubo, R.J.Peterson, H.Horiuchi. There was the first talk at the Varenna Conferences of one of our Chairmen, Mark Chadwick who spoke on *Angular Momentum in Multistep Compound Processes*.

Certainly the star of the Conference was still H.Feshbach who after one absence came back to Varenna giving the inaugural talk on *Classical Nuclear Physics* (speaking on super deformed nuclei, nuclear molecules, the nucleon-nucleus force and giant resonances, heavy ion collisions and TDHF theory, multi-step reactions and the coupled channel reaction theory) and one of the two evening talks remembering his *Fifty Years in Nuclear Physics*. The other evening talk was given by K.Bleuler on *Recent Developments on Theoretical Physics*.

In 1991 a large number of talks were once more devoted to decay before equilibration, multistep processes, multifragmentation with talks among others of P. Hodgson, A. A. Cowley (who presented the double differential spectra of protons inelastically scattered by nuclei varying from  $^{58}\text{Ni}$  to  $^{197}\text{Au}$  at incident energies of 100 – 200 MeV, data which allowed a very stringent test of the predictions of the FKK multistep direct reaction theory by the Milano Group of Roberto Bonetti), N. Cindro and J. J. Griffin, H. Rebel, V. V. Volkov. Our group presented for the first time the use of the Boltzmann master equation theory to predict the emission of complex particles in heavy ion reactions. A large number of talks were devoted to the heavy ion reaction dynamics with talks by W. Cassing, H. Horiuchi and V. Strutinsky, to the collective modes of excitations with talks by the Milano group of A.

Bracco, K. Dietrich, M. Frascaria, M. Fujiwara, and to nuclear response to hadronic and electromagnetic probes, with talks by I. Sick, T. Udagawa, V. Metag, H.S.Plendl, R. J. Peterson, T. von Egidy.

Especially interesting was the Session devoted to cluster radioactivity where P. B. Price, V.L.Mikheev and S.P.Tetryakova, and R. Bonetti presented the latest experimental data by Berkeley, Dubna and Milano. D. Poenaru, R. K. Gupta and F. Barranco discussed the theoretical interpretation of this phenomenon by the Frankfurt school of W. Greiner and the Milano group of R. Broglia.

A distinctive feature of the 1994 Conference was in addition to usual items (pre-equilibrium decay, heavy ion dynamics, nucleon correlation ) the large number of talks devoted to the study of the nuclear response to hadronic and electromagnetic probes at intermediate and high energy with the presentation of a large number of experiments made in labs all around the world (Bonn (ELSA), CEBAF (now the Jefferson Lab), CERN (LEAR), COSY, Fermi Lab., GSI, KEK, Lawrence Berkeley Lab., SLAC). Especially important was the presentation made by Otto Schult of COSY and of the experiments which were under way or were planned. I wish to mention a small but representative number of papers on nuclear astrophysics.

Starting from 1997 the Organizing Committee decided to dedicate every subsequent Conference to a scientist for his outstanding contribution to Nuclear Physics. That year, the Conference was dedicated to Peter Hodgson, on occasion of his retirement. Peter gave important contributions to the Conference. He participated to all the Editions from the first up to the 10<sup>th</sup> in 2003 and during all this period as a member of the International Advisory Committee he contributed to the organization with enlightening comments and suggestions. As mostly of you presumably know Peter passed away at the end of last year. In another contribution to the Conference I give a short account of his many achievements which have been a source of inspiration for many of us.

It is almost impossible for me to select a few contributions among the many outstanding reports which all together represented an impressive review of the most recent results in nuclear dynamics studies ranging from rather low up to high incident energies. The number of talks on the astrophysical applications of nuclear physics increased quite considerably anticipating the growing importance in subsequent editions of the Conference of the talks on interdisciplinary studies and applications of nuclear physics in many fields which concur to illustrate the different perspectives of Nuclear Physics: the ever increasing accuracy and completeness of the experiments and of the theoretical interpretation of nuclear properties, the contribution to basic knowledge through the study of matter in extreme conditions, the contribution to the study of fundamental problems which usually one associates to other fields of knowledge and finally its use in applications useful to mankind.

The 9<sup>th</sup> Conference was dedicated to J. P. F. (Friedel) Sellschop on occasion of his 70<sup>th</sup> birthday. Friedel was a very remarkable man. In addition to Nuclear Physics he gave important contributions to many fields of Physics. In mid sixties, a collaboration leaded by him and F. Reines discovered the atmospheric neutrinos. He was a worldwide authority of Diamond Physics. Prof. Connell discussed in present Conference an application of PET for identifying raw diamonds avoiding the risk of breaking them during extraction. This work originated by Friedel's last researches which he pursued with relentless effort even in his last days when he was near to death. He was also a Statesman of Science in South Africa and greatly contributed as an advisor of Nelson Mandela to preserve the high standard of research in this Country when Madiba become President of South Africa.

The inaugural talk of the Conference was delivered by Arthur Kerman who spoke on *Open Problems and Perspectives of Multistep Direct Theories*. Walter Greiner spoke on *Perspectives of Nuclear Physics from Superheavies via Hypermatter to Antimatter*. Ken Amos and Alex Brown and many other speakers showed how formal nuclear theories allow to achieve an ever increasing accuracy in reproducing large sets of data. These and the discussion of the data collected in experiments from many of the most important Labs in the world (CERN, COSY, GANIL, JLAB, IJNR, KEK, Saturne) showed once more the enormous spread of Nuclear Physics research and the significant contribution it can still afford to basic knowledge. It would be ungenerous to quote only some of these important contributions, however I like to cite the talk by Mark Chadwick in which he spoke of *Nuclear*

*Reaction Mechanisms in Hadron Radiotherapy* anticipating the enormous growth of research in this field of so great relevance for mankind.

The 10<sup>th</sup> Conference was dedicated to R. A. Ricci. Prof. Ricci was alumnus of one of the most prestigious University Institutions in Italy, the Scuola Normale Superiore di Pisa, and after graduation completed his studies under Louis De Broglie and Frederic Joliot-Curie. He introduced in Italy the experimental study of nuclear spectroscopy and gave numerous and important contribution to this field.

He was one of the leaders of the experiments made at CERN with the antiproton beams and started there the relativistic heavy ion physics. Not less important has been his activity as Administrator of Science, as President of Italian and European Physical Societies, as Director of Legnaro National Laboratories, as Vice-President of the National Institute of Nuclear Physics and Chairman of many other important

Institutions and Committees.

The dominant contributions to the Conference were the discussion of the perspectives open by radioactive beams and the physics of the exotic nuclei and a quite exhaustive review of the intranuclear cascade models and transport codes and their use both in basic research and in interdisciplinary fields and applications showing once more that one must not underestimate the contribution which our research field may provide to other fields of knowledge and to applications useful to mankind. This is especially important since nuclear physics from its very beginning with the discovery of radioactivity dealt both with fundamental questions and applications which may be at the same time beneficial and harmful for humanity.

The 11<sup>th</sup> Conference of the series was dedicated to D. Brink. I think that every body knows the many seminal contributions of David starting from the Axel-Brink hypothesis for explaining the dipole resonances and the theory of fluctuations of statistical reaction cross sections. A paper on kinematical effects in heavy ion reactions in 1972 allowed to explain the observed selectivity in the population of high angular momentum states in heavy ion transfer reactions and led to a semi classical model for neutron transfer to bound states and to the continuum. His semi-classical methods led also to the explanation of the ALAS phenomenon in alpha scattering and to path-integral methods. Other seminal contributions have been the use of Skyrme's effective interaction for Hartree-Fock calculations, the semi - classical theory of collective motion in nuclei and the use of sum rules with Skyrme's interaction.

All those who participated to the Conference cannot forget the real enthusiasm of his many former students and collaborators in greeting him. All was organized with real love and devotion by Angela Bonnacorso.

A sad occurrence was the news of the death during the preparation of the Conference of Ken – Ichi Kubo an old fellow of Varenna Conferences. As a member of the International Advisory Committee he provided an invaluable help until his death. He was a bright example of dedication to Science with profound and extensive knowledge also in other aspects of life. Prof. Kubo gave important contributions to nuclear reaction theory. His first significant contribution was a DWBA computer code for the analysis of direct reactions which was widely used. His main interest was in spin theory and gave many significant contributions to various fields of research. A special Session in honour of Ken-Ichi was held in the last day of the Conference and Prof. Toki gave a talk in which he presented Ken-Ichi's last research on *Dynamical Spin Polarization of Hadrons in High Energy Hadron-Hadron Interactions*.

As usual the Conference program covered a very broad range of subjects ranging from basic nuclear reaction theory and light and heavy ion reactions at low and intermediate energies to the high energy hadron, electromagnetic and weak interactions, from exotic nuclei and decays to nuclear astrophysics and nuclear effects in neutrino interactions. Strengthening the trend of previous Conference it also included contributions discussing the applications of nuclear physics in civil security, medicine and archaeology, the creation of data bases of relevance for these subjects and the development of comprehensive reactions codes for describing the many different reactions which contribute to a

nuclear interactions of which one must give a reasonably accurate description for understanding their effects on matter.

I cannot end without remembering another sad occurrence: the untimely death by a car accident, just two years ago, of Roberto Bonetti, one of the most influential members of the Conference's Organizing Committee since its beginning.

Roberto was a very outstanding physicist with broad interests both in basic and applied research. His more known contributions pertain to the study of multi-step reactions by the FKK theory which he made usable developing a widely known computer code. Not less important have been his investigations on cluster radioactivity and proton radioactivity, and on nuclear interactions occurring at very low energy in stars. Very important have also been his uses of nuclear physics dating methods in geology and archaeology. The many quotations I made of his contributions show how important was his work and advice for our Conferences.

One may imagine that the Organization of the Varenna Conferences was an heavy duty. It was not. I could enjoy over the years the continuous collaboration of my wife Enrica, the help of members of my group and of my many students, but chiefly the support of many friends who helped with well done advices and suggested arguments and speakers. Among these I wish to mention Peter (Hodgson) with whom I collaborated for more than twenty years, K. Bleuler who always showed a special interest in the Conference, N. Cindro, whose knowledge and sharp judgment were a continuous stimulus for me. A. Molinari and H. von Geramb greatly helped in the organization of Session devoted to special arguments. For many years H. Feshbach and W. Greiner have been inspiring headlights.

However great and important have been these aids, the more important support was given by the Varenna family itself, the many friends that year after year would participate to the Conference. I never had troubles in calling for participation. At soon as I gave the announcement of a forthcoming Conference I would receive a continuous flow of mails mostly from previous participants and their new collaborators. Once Jerry Peterson told me, as I wrote above, that Varenna and the size of the Conference are ideal for the exchange of ideas, bringing in new collaborations and projects.

I really hope that this will continue and future organizers might say as I may that Varenna was a great and enlightening experience who greatly helped them and those who attended in their research bringing in new enthusiasm and ideas.