

Title: Prof.

Lecturer: Ugo Amaldi

Date and Times:

- Friday, 5th August 11:15 am – 12:00 am

Summary of the proposed talk: Particle Accelerators in Cancer Therapy

'Hadrontherapy', or 'particle therapy', is a collective word which covers all cancer therapy modalities which irradiate patients with beams of hadrons.

The most used hadrons are protons and carbon ions. Protontherapy is developing very rapidly: more than 65'000 patients have been treated and five companies offer turn-key centres. Carbon ions, used for about 6000 patients, have a larger radiobiological effectiveness and, being a qualitatively different radiation, require still radiobiological and, in particular, clinical studies to define the best tumor targets.

After a review of the European effort in carbon ion therapy, the two challenges facing the physicists developing the accelerators for hadrontherapy will be described: the construction of 'single-room' facilities for protons and of multi-room facilities not based on synchrotrons, for carbon ions.

Prerequisite knowledge and references: None

Biography

Brief CV:

After his postgraduate studies Ugo Amaldi worked for fifteen years at the Physics Laboratory of *Istituto Superiore di Sanità* (ISS) in Rome, where he became Director of the local Section of INFN (*Istituto Nazionale di Fisica Nucleare*). He dealt with fundamental research problems – in the fields of atomic, nuclear and sub-nuclear physics – as well as with radiation protection of the populations and the use of radiations in tumour therapy.

Following the discovery, made at the ISR accelerator of CERN, of the phenomenon called 'rising proton-proton cross sections', in 1973 Amaldi became *CERN Research Senior Physicist*. For twenty years he devoted himself to physics research in the field of subatomic physics, addressing to the study of the strong and electroweak forces and, in particular, to the problem of their unification.

From 1980 to 1993 he founded and directed as 'spokesman' the *DELPHI Collaboration*, composed of some five hundred physics from forty laboratories of twenty different countries. This collaboration built the big 'particle detector' called DELPHI, which took data at the LEP collider from 1989 to 2000.

More than *450 scientific publications* in the fields of atomic, nuclear, particle and accelerator physics attest his scientific activity. At the end of 2004 (fifty years from the foundation of CERN) the 1991 paper on the unification of the fundamental forces of nature was cited more than thousand times and, as far as citations are concerned, was the seventh of the more than 35'000 papers published by CERN scientists.

In the Seventies he taught radiation physics at the Postgraduate Radiology School of Rome University and, from 1982 to 1991, at Milan University. In 1991 he became full professor in Florence and later in Milan. Till 2006 he taught particle physics and medical physics at the universities 'Milano Statale' and 'Milano Bicocca'.

In 1974 he published the treaty '*Radiation Physics*' (Boringhieri, Turin) on which generations of Italian radiotherapists have been educated. In 1990 Editrice Universitaria, Milan, printed his '*Radiations and molecules*'. Interested at all times in educational and scientific divulgation issues, he published in 1984 with Edoardo Amaldi a physics textbook in three volumes for Italian high schools. Many other editions for scientific, humanistic and industrial high schools followed it. These *thirty text books* have been used by about two million students. At present more than a third of all the Italian high school pupils study physics on his books.

In 1992 the TERA Foundation, of which he is still the President, was created to bring 'hadrontherapy' to Italy and other countries. Hadrontherapy is a radiation technique which uses beams of protons and carbon ions to treat, better than with X rays, deep seated tumours which are close to critical organ and/or 'radioresistant'. For ten years TERA most important project was the design and realization of the *National Centre for Oncological Hadrontherapy* (CNAO) featuring beams of carbon ions and protons. In 2001 he obtained the initial funds from the Italian Health Ministry and the creation of the CNAO Foundation, which has realized in Pavia the therapy centre designed by TERA. The first patient has been treated in summer 2011.

Ugo Amaldi was conferred the title of *Doctor honoris causa* by the Universities of Lyon, Helsinki, Valencia and Uppsala. He is *Distinguished Affiliated Professor* of the Technische Universität München (TUM). He is member of the Italian National Academy of Sciences, of the Science Academy of Turin and of Istituto Lombardo, Academy of Science and Humanities. He is honorary member of the Italian Physical Society (SIF) and of the Italian Association of Medical Physics (AIFM). In 1997 he was decorated with the Russia's Order of Friendship.

Among many honours, he received the 'Bruno Pontecorvo' Prize for his works on weak interactions and on the unification of the forces and he was awarded by the President of the Italian Republic the gold medal as 'Benemeritus' of Science, Culture and Arts.

Publications:

UGO AMALDI – Selected Scientific Papers on Hadrotherapy

1. *Per un centro di teleterapia con adroni*, U. Amaldi and G. Tosi, CERN/PPE, **1991**.
2. *Hadrontherapy in Oncology*, U. Amaldi and B. Larsson (editors), Elsevier, Amsterdam-Lausanne-New York,Oxford-Shannon-Tokyo, 1-755, **1994**.
3. *The TERA Project and the Centre for Oncological Hadrontherapy*, Vol 1-2, U. Amaldi and M.Silari (editors), INFN-LNF, Frascati, ISBN 88-86409-29, 1-575, **1995**.
4. *Adroterapia*, in *Enciclopedia Medica Italiana*, Aggiornamento II, Tomo 1, 114-138, **1998**.
5. *The RITA network and the design of compact proton accelerators*, Amaldi, U., Grandolfo, M. and Picardi, L. (editors), INFN-Laboratori Nazionali, Frascati, ISBN 88-86409-08-7, 1-501, **1996**.
6. *The National Centre of Oncological Hadrontherapy at Mirasole*, U. Amaldi (editor), INFN-Laboratori Nazionali, Frascati, ISBN 88-86409-29-X, 1-363, **1997**.
7. *Advances in Hadrontherapy*, U. Amaldi, B. Larsson and Y. Lemoigne (editors), Elsevier, Amsterdam- Lausanne-New York,Oxford-Shannon-Tokyo, 1-547, **1997**.
8. *Design of a centre for biologically optimised light ion therapy in Stockholm*, A. Brahme, R. Lewensohn, U. Ringborg, U. Amaldi, F. Gerardi, S. Rossi , Nucl. Instr. Methods B184, 569-588, **2001**.
9. *Slow neutrons at via Panisperna: the discovery, the production of radioisotopes and the birth of nuclear medicine*, U. Amaldi, Fisica in Medicina, 32-45, January-March **2002**.
10. *Hadrontherapy in the world*, U. Amaldi, in *Nuclear science in Europe: impact, applications, interaction*, D. Guerra, J. Åystö, D. Guillemaud-Muellr, G.-E Körner (editors), NUPECC-ESF, 115-125, **2002**.
11. *LIBO—a linac-booster for protontherapy: construction and tests of a prototype*, U. Amaldi et al. - Nucl. Instrum. Methods A521, 512-529, **2004**.
12. *Radiotherapy with beams of carbon ions*, U. Amaldi and G. Kraft, Reports Progr. Phys. 6, 1861, **2005**.
13. *Recent applications of synchrotrons in cancer therapy with carbon ions*, U. Amaldi and G. Kraft, Europhys. News 36/4, 114-118, **2005**.
14. *Physics and Society*, U. Amaldi, in *The new Physics for the twenty-first century*, G. Fraser (editor), Cambridge University Press, Cambridge, 505-531, **2006**.
15. *CLUSTER: A high-frequency H-mode coupled cavity linac for low and medium energies*, U. Amaldi et al., Nucl. Instr. Methods A, **2007**.
16. *European Developments in Radiotherapy with Beams of Large Radiobiological Effectiveness*, U. Amaldi and G. Kraft, J. Radiation. Res., 48: Suppl., A27-A41, **2007**.
17. *High frequency linacs for hadrontherapy*, U. Amaldi et al, Review of Accelerator Science and Technology, 111-131, **2009**.
18. *Accelerators for hadrontherapy: From Lawrence cyclotrons to linacs*, U. Amaldi et al., Nuclear Instruments and Methods in Physics Research A 620, 563–577, **2010**.
19. *The Path to the Italian National Centre for Ion Therapy*, U. Amaldi et al., Edizioni Mercurio, 4-393, **2011**.
20. *Present challenges in hadrontherapy techniques*, U. Amaldi and S. Braccini, European Physical Journal Plus, in print.