

## THE DESIGN OF NEUTRON BEAMS FOR NEUTRON CAPTURE THERAPY

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Improved Federal support for neutron capture therapy in recent years has brought about a resurgence of activity in this field by researchers in various disciplines. Furthermore, encouraging clinical results from Japan in the treatment of glioblastoma multiforme and melanoma by neutron capture therapy has resulted in renewed enthusiasm for mounting a clinical trial of this treatment modality in the U.S. One area of intense activity world wide is the development of optimal neutron beams for neutron capture therapy for both shallow and deeply seated tumors. In this paper we will review the physical basis for the interaction of neutrons with tissue and the principles underlying the development of neutron beams for neutron capture therapy. In particular, the greater availability of sealed, high-activity  $^{252}\text{Cf}$  sources from US government laboratories has prompted a reappraisal of their suitability for neutron capture therapy.

### INTRODUCTION

Neutron capture therapy (NCT) is a binary form of radiation therapy originally conceived in 1936. It relies on initial targeting of tumor cells by an appropriate drug tagged with the stable isotope  $^{10}\text{B}$ , followed by irradiation of the local tumor site with low energy neutrons. When  $^{10}\text{B}$  absorbs a low energy neutron it ejects an energetic, short-range alpha particle which deposits most of its energy within the cell containing the original  $^{10}\text{B}$  atom. Therefore, if a higher concentration of  $^{10}\text{B}$  exists in tumor cells relative to other normal tissues, a selectively higher dose will be delivered to tumor cells during neutron irradiation.

In addition to the development of  $^{10}\text{B}$  labelled drugs for NCT, an important area of research in the field of NCT over the past years has been the optimization of "thermal" and "epithermal" neutron beams.<sup>1,2,3</sup> Thermal neutron beams (0-0.1 eV) are the original type of neutron beams that were used unsuccessfully in clinical trials of NCT for high-grade astrocytomas in the US in the 1950's and 1960's, and also are currently being used in the Japanese NCT clinical trials for high-grade astrocytomas and melanomas. These more recent clinical trials appear to be demonstrating a more favorable outcome than the earlier US ones.<sup>4</sup>

Unlike the familiar dose distribution pattern in tissue produced by conventional high energy X-ray beams, thermal neutron beams exhibit very rapid fall-off with depth in tissue, with a half-value thickness of approximately 1-1.5 cm, and negligible skin-sparing at the tissue surface. Consequently, the successful use of thermal neutron beams for neutron capture therapy of intracranial tumors generally requires that the tumor be relatively superficial and that normal radiosensitive superficial structures, such as scalp, skull and dura be surgically reflected during treatment. This essentially makes this type of NCT an intraoperative form of radiation therapy. More recently, it has been shown<sup>5</sup> that if

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## **Neutron Beam Design Development And Performance For Neutron Capture:**

*Neutron Beam Design, Development, and Performance for Neutron Capture Therapy* Otto K. Harling, John a. Bernard, Robert C. Zamenhof, 2013-03-08 For this Workshop the organizers have attempted to invite experts from all known centers which are engaged in neutron beam development for neutron capture therapy The Workshop was designed around a series of nineteen invited papers which dealt with neutron source design and development and beam characterization and performance Emphasis was placed on epithermal beams because they offer clinical advantages and are more challenging to implement than thermal beams Fission reactor sources were the basis for the majority of the papers however three papers dealt with accelerator neutron sources An additional three invited papers provided a summary of clinical results of Ncr therapy in Japan between 1968 and 1989 and overviews of clinical considerations for neutron capture therapy and of the status of tumor targeting chemical agents for Ncr Five contributed poster papers dealing with NCT beam design and performance were also presented A rapporteurs paper was prepared after the Workshop to attempt to summarize the major aspects issues and conclusions which resulted from this Workshop Many people contributed to both the smooth functioning of the Workshop and to the preparation of these proceedings Special thanks are reserved for Ms Dorothy K **Energy**

**Research Abstracts** ,1990 Proceedings of the 23rd Pacific Basin Nuclear Conference, Volume 2 Chengmin Liu, 2023-05-16 This is the second in a series of three volumes of proceedings of the 23rd Pacific Basin Nuclear Conference PBNC 2022 which was held by Chinese Nuclear Society As one in the most important and influential conference series of nuclear science and technology the 23rd PBNC was held in Beijing and Chengdu China in 2022 with the theme Nuclear Innovation for Zero carbon Future For taking solid steps toward the goals of achieving peak carbon emissions and carbon neutrality future oriented nuclear energy should be developed in an innovative way for meeting global energy demands and coordinating the deployment mechanism It brought together outstanding nuclear scientists and technical experts senior industry executives senior government officials and international energy organization leaders from all across the world The proceedings highlight the latest scientific technological and industrial advances in Nuclear Safety and Security Operations and Maintenance New Builds Waste Management Spent Fuel Decommissioning Supply Capability and Quality Management Fuel Cycles Digital Reactor and New Technology Innovative Reactors and New Applications Irradiation Effects Public Acceptance and Education Economics Medical and Biological Applications and also the student program that intends to raise students awareness in fully engaging in this career and keep them updated on the current situation and future trends These proceedings are not only a good summary of the frontiers in nuclear science and technology but also a useful guideline for the researchers engineers and graduate students Neurosurgical Standards, Cerebral Aneurysms, Malignant Gliomas Kurt Pisco, Margareta Klinger, Mario Brock, 2012-12-06 Three topics of major interest for neurosurgeons are covered in this volume of the Advances in Neurosurgery series as the title suggests First neurosurgical standards of diagnosis and treatment are

viewed from several points of view including the legal one Second the many aspects of aneurysm surgery are dealt with timing and grading monitoring during the operation postoperative vasospasm Doppler sonography and new research in subarachnoid hemorrhage Third the diagnosis and treatment of malignant gliomas are discussed there are preliminary reports on interstitial laser assisted thermal therapy immunotherapy and radiopharmaceutical substances as well as the standard forms of neurosurgical and radiation treatment *Current Catalog* National Library of Medicine (U.S.),1991 First multi year cumulation covers six years 1965 70 *High-Grade Gliomas* Gene H. Barnett,2007-11-21 This is truly an exciting time in the field of neuro oncology particularly in the area of hi grade gliomas The management of patients with high grade gliomas has historically been one of the most challenging and disheartening fields in medicine where failure is the rule and longevity is the exception The jaded often state that despite purported advances in surgical and radiotherapeutic techniques and a myriad of clinical trials of medical therapies the s vival statistics for glioblastoma have not changed in the last three decades The nihilism associated with these tumors is such that some practitioners still advise against treatment or even biopsy recommending palliative care with the diagnosis based only on history and an MRI scan If the current state of the art in the diagnosis and management of high grade gliomas was truly so bleak there would be no reason to compile and publish a monograph on the subject The fact is that we have recently entered an era where real progress is being made in our understanding and treatment of high grade gliomas that is directly benefiting some patients We are slowly but surely chipping away at this problem One approach has exploited correlations between particular molecular markers and therapeutic response The first such breakthrough in high grade glioma was the observation that loss of chromosomes 1p and 19q uniformly predict chemosensitivity in anaplastic oligodendrogliomas 1 **Frontiers In Boron-based Medicinal Chemistry** Yinghuai Zhu,2023-04-14 Boron has long occupied a privileged role in chemistry as a catalyst component and human health as a micronutrient In 1951 boron science took a momentous leap forward with its application in clinical cancer research The seventy or so years since have witnessed exciting developments in the technology now known as Boron Nuclear Capture Therapy BNCT a binary form of radiotherapy that lethally combines two separately non lethal constituents a boron based radiosensitizer and non ionizing neutron radiation *Frontiers in Boron based Medicinal Chemistry* is a one stop resource on the current state of BNCT and promising works in the pipeline It begins with an introduction to general boron chemistry with extensive discussion on important boron compounds including boranes boronic acids carboranes and FDA approved boron drugs Chapter 2 looks at BNCT in clinical trials while Chapter 3 describes emerging next generation agents such as boron based nanoparticles and dendrimers The penultimate chapter summarizes the currently used and emerging imaging techniques in BNCT namely PET CT MRI and fluorescence microscopy The book concludes with a technically heavy chapter on neutron sources and dosimetry The cutting edge information contained in this authoritative volume will be a valuable resource for all those involved in mankind s endless struggle against cancer **In Vivo Body Composition**

**Studies** Seiichi Yasumura, Joan E. Harrison, 2012-12-06 This book is the compilation of papers presented at the International Symposium on in vivo Body Composition Studies held at the University of Toronto Ontario Canada June 20 23 1989 The purpose of this conference was to report on advances in techniques for the in vivo measurement of body composition and to present recent data on normal body composition and changes during disease This conference was the most recent of several meetings on body composition studies and follows two successful such meetings one at Brookhaven National Laboratory in 1986 and at Edinburgh in 1988 The large number of excellent research papers and posters presented at these conferences demonstrates the rapid growth of the field and the broad interest in the subject of in vivo body composition studies The proceedings of the Brookhaven meeting In Vivo Body Composition Studies is published by The Institute of Physical Sciences in Medicine London Both the Brookhaven and the current Toronto meeting emphasized the clinical applications together with the techniques employed The Edinburgh meeting placed more emphasis on the methodological problems and design of instrumentation Because of the number of papers presented at the meeting it was necessary to ask the authors from the same institution to combine their presentations into a single paper where appropriate The editors wish to thank the authors for their cooperation and for graciously accepting the minor revisions made to each manuscript National Library of Medicine Current Catalog National Library of Medicine (U.S.), 1991

**Computational Medicine, Public Health And Biotechnology: Building A Man In The Machine - Proceedings Of The First World Congress (In 3 Parts)** Diana J Vincent, Matthew Witten, 1996-07-03 This three volume series represents a selected and refereed collection of papers contributed by the participants of the First World Congress on Computational Medicine Public Health and Biotechnology held in 1994 at Austin Texas Over 500 individuals from 30 countries attended this meeting In addition this collection contains a number of papers from the Australian CSIRO High Performance Computing Meeting held that same year

**Nuclear Science Applications**, 1981 **Nuclear Technology**, 1992 Tumor Response Monitoring and Treatment Planning A. Heuck, P. Lukas, P. Kneschaurek, M. Mayr, 2013-12-11 Medical imaging progressed to a standard undreamt of not very many years ago The advances are due to continuous development of radiological techniques and the introduction of magnetic resonance imaging With the improved and new methods three dimensional target volumes for radiation therapy can be defined with hitherto unknown precision This leads to an improvement in irradiation techniques and as a consequence to a higher likelihood of tumor control and a lower risk of normal tissue complications Besides the improvement in irradiation techniques the new imaging methods may enable great strides in tumor response monitoring not only in the detection of morphological alterations but also by showing physiological changes in the tumor during and after treatment by means of MRI and PET This not only leads to better prognostic information but may also allow early evaluation of the response to treatment It may then be possible to individualize the radiation dose but also the alternative treatment for non responders This is certainly a future direction for radiation oncology

**Nuclear Science Abstracts**, 1974 Neutron Dosimetry H.

G. Menzel,1997      *Fusion Energy Update* ,1983      Hadrontherapy in Oncology Ugo Amaldi,Börje Larsson,1994 This text provides an overview and analysis of the present state of research and development in hadrontherapy with the intention of promoting the clinical introduction of ion accelerator technology for the benefit of cancer patients in various parts of the world      Journal of Nuclear Science and Technology ,1995 Includes English language abstracts from Japanese articles in Nihon Genshiryoku Gakkai Shi Journal of the Atomic Energy Society of Japan      **International Conference on Neutrons and Their Applications** Themis Paradellis,1995      **Periodica Polytechnica** ,1993

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