



“Physics in Canada”
Book Review

“La Physique au Canada”
Critique de livre

Basics of PET Imaging: Physics, Chemistry, and Regulations, 2nd Ed. By Gopal B. Saha, Springer, 2010. ISBN 978-1-4419-0804-9; Price: \$50.21.

I have had an opportunity to read through the second edition of this fine text which builds on the market acceptance and simplicity of the first edition, published in 2005. Considering the recent explosion in the global installed base of positron emission tomography (PET) scanners, this revised edition constitutes a timely addition to the scientific literature. The target audience as stated by the author in the preface includes: “nuclear medicine professionals such as physicians, technologists, and residents, along with students [preparing] for their board examinations [or in] training.” To this list I would add diagnostic medical physicists in clinical practice with an interest in PET imaging, medical physics residents in a diagnostic imaging residency, and medical physics graduate students taking an imaging course. An instructor teaching a graduate course in medical imaging – or a specific course in nuclear medicine imaging – may also consider adopting or recommending this text for class use.

This text is a rather compact (237 pages), yet reasonably complete overview of the field of PET imaging. Compared to the more authoritative “*Physics in Nuclear Medicine, 3rd Ed*” by Cherry, Soerensen, and Phelps (523 pages), it is more compact and less mathematically sophisticated. However, Cherry’s text – unlike Saha’s - covers not just PET imaging, but all of nuclear medicine (i.e. SPECT imaging, etc.). This reviewer was pleased to see end-of-chapter questions, which a potential instructor considering adoption for in-class use might appreciate. This additional academic enticement is missing in Cherry’s text. The book contains 12 chapters, and a brief chapter by chapter review follows.

Chapter 1 is a fairly unremarkable introduction to nuclear decay and radiation interaction mechanisms. In chapter 2, the book’s inherent value comes into better focus: here the author makes a careful comparison of the overall system performance for the three most important in - use clinical systems, the Philips Gemini, Siemens Biograph, and General Electric Discovery, systems. This comparison can be of great value to physicists and administrators making acquisition recommendations. An insightful comparison of the physical performance of different scintillator materials currently used by the different manufacturers is also included in this chapter. Chapter 3 is concerned with factors degrading image quality such as photon attenuation. This reviewer found the treatment of scatter vs. random coincidences, i.e. why they occur and how they are corrected for, especially illuminating. Chapter 4 contains a very elemental and summarized treatment of the two most frequently used algorithms for image reconstruction in PET: filtered back projection, and iterative reconstruction. More mathematically formal treatments of these algorithms can be easily found in other imaging texts, i.e. Webb’s *Introduction to Biomedical Imaging*. Chapter 5 is a most condensed (7 page) overview of the

architecture of modern medical imaging platforms and formats, such as the Digital Imaging and Communications in Medicine (DICOM), and the Picture Archival and Communications System (PACS). Chapter 6 is an abbreviated review of the definitions of the main system performance parameters of PET systems, and the recommended quality control procedures; those to be done upon commissioning, and during the clinical life of the system. As the author points out, the interested reader should consult the National Electrical Manufacturer's document NEMA NU 2-2007 which at present is the definitive document regarding this matter. In any case, clinical medical physicists responsible for the commissioning or operation of PET systems should find a review of this chapter rewarding. Chapters 7 and 8 are an introduction to the other side of the PET equation: radiopharmaceutical production and dispensing. Chapter 7 is concerned with the principles of cyclotron operations and the production of the most frequently utilized PET radioisotopes: F-18, C-11, N-13, and O-15. It would be of essentially academic interest to clinical physicists working in PET imaging, since ordinarily the clinical physicist would not be involved with the production of the actual radioisotopes. Chapter 8 introduces elemental concepts of radiochemistry used in the radiolabelling of metabolically relevant molecules. It is aimed primarily at the reader with a background in organic chemistry, and as such, it is of very limited interest to the medical physicist and can thus easily be glossed over without loss of continuity. Chapter 9 is concerned with administrative aspects of PET radiopharmaceuticals, such as obtaining proper governmental clearances to bring a product to market, as well as radiation protection regulations. Since the book's author is based in the U.S., the approach is completely U.S.-centric and would be of limited relevance in a Canadian or international context. Chapter 10 discusses reimbursement procedures for PET studies in the U.S. insurance context, and is therefore completely irrelevant in the Canadian context. Thus, chapters 9 and 10 could easily be skipped by the medical physicist not based in the U.S., without any significant loss. Chapter 11 is an effective presentation of the subject of the design and cost considerations of a PET center, and it does include a section on the design considerations of a cyclotron vault. The reader should be reminded again that not every PET center will be cyclotron equipped. In fact, the vast majority of PET centers do not have a cyclotron on site, but rather rely on a nearby cyclotron for the provision of the radiopharmaceuticals. Parts of this chapter would also be of interest to the hospital administrator contemplating the installation of a PET center at his center. Chapter 12 - the last - is an introduction to the clinical aspects of specific PET procedures, and is therefore better addressed to the technologist or physician, but is still interesting reading for the clinical medical physicist. The book concludes with six appendices which are relevant to the contents of the chapters.

As is to be expected of any text of this type which attempts to cover many aspects of a rapidly evolving technology, it does contain weaknesses and errors. For example, since in the modern radiological imaging environment the electronic management of data is of such import, chapter 5 (on image storage & display) could easily be expanded to review at least in cursory fashion some of the more frequently utilized image processing capabilities. As examples of specific topics that this reviewer would have welcomed are the relevance of different filters for image

reconstruction, window settings, region of interest (ROI) algorithms, standard uptake volume (SUV) algorithms etc. As examples of minor errors that slipped through the editorial review process, in chapter 6 the author states: “*The geometric efficiency of a PET scanner is defined by the solid angle projected by the source of activity at the detector.*” In fact, it is the other way around, the geometric efficiency is defined as the solid angle (divided by 4π) subtended by the detectors as viewed from the source. Also in chapter 6, the author defines image contrast (eq. 6.6) as $C = (A - B)/A$ where A and B are count densities in normal and abnormal tissues respectively. This definition has the inconvenience that negative contrasts can occur and it would have been preferable to give the more frequently given definition $C = |(A - B)|/A$ which obviates this difficulty.

In spite of these minor faults, my overall impression is that this compact text - which is almost a manual - does an excellent job of presenting the most relevant aspects of up to date PET technology to a wide target audience which includes the clinical medical physicist. Perhaps for the medical physicist, the most valuable information presented is not so much the physics of PET as such, but rather those aspects of PET with which the physicist would normally not concern him/herself, such as cost analysis, radiochemistry fundamentals, and clinical patient procedures. Amazon.ca advertises the book for \$50.21 CDN, which this reviewer finds very modest. Any clinical medical physicist considering working in the field of PET would derive some benefit from reading at least some chapters in this book.

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