

## Daftar Pustaka

- [1] The International Agency for Research on Cancer (IARC), “Cancer Today,” <https://gco.iarc.fr/today/en>, 2022. <https://gco.iarc.fr/today/en> (accessed Jan. 05, 2025).
- [2] J. Ferlay *et al.*, “Cancer statistics for the year 2022: An overview,” *Int. J. Cancer*, vol. 149, no. 4, pp. 778–789, 2022, doi: 10.1002/ijc.33588.
- [3] Z. Yu *et al.*, “Proton and carbon ion radiation therapy for locally advanced pancreatic cancer: A phase I dose escalation study,” *Pancreatology*, vol. 20, no. 3, pp. 470–476, 2020, doi: 10.1016/j.pan.2020.01.010.
- [4] S. Molinelli *et al.*, “The role of multiple anatomical scenarios in plan optimization for carbon ion radiotherapy of pancreatic cancer: Inter-fraction robustness in CIRT for pancreatic cancer,” *Radiother. Oncol.*, vol. 176, no. November 2019, pp. 1–8, 2022, doi: 10.1016/j.radonc.2022.09.005.
- [5] M. Okamoto *et al.*, “Feasibility and safety of repeated carbon ion radiotherapy for locally advanced unresectable pancreatic cancer,” *Cancers (Basel)*, vol. 13, no. 4, pp. 1–10, 2021, doi: 10.3390/cancers13040665.
- [6] R. L. Foote *et al.*, “The Majority of United States Citizens With Cancer do not Have Access to Carbon Ion Radiotherapy,” *Front. Oncol.*, vol. 12, no. July, pp. 1–5, 2022, doi: 10.3389/fonc.2022.954747.
- [7] W. Tinganelli and M. Durante, *Carbon ion radiobiology*, vol. 12, no. 10. 2020. doi: 10.3390/cancers12103022.
- [8] A. Pompos *et al.*, “National Effort to Re-Establish Heavy Ion Cancer Therapy in the United States,” *Front. Oncol.*, vol. 12, no. June, pp. 1–12, 2022, doi: 10.3389/fonc.2022.880712.
- [9] O. Mohamad *et al.*, “Carbon ion radiotherapy: A review of clinical



- experiences and preclinical research, with an emphasis on DNA damage/repair,” *Cancers (Basel)*, vol. 9, no. 6, pp. 1–30, 2017, doi: 10.3390/cancers9060066.
- [10] H. Ruan and J. Xiong, “Value of carbon-ion radiotherapy for early stage non-small cell lung cancer,” *Clin. Transl. Radiat. Oncol.*, vol. 36, no. March, pp. 16–23, 2022, doi: 10.1016/j.ctro.2022.06.005.
- [11] D. Satoh and T. Sato, “Improvements in the particle and heavy-ion transport code system (PHITS) for simulating neutron-response functions and detection efficiencies of a liquid organic scintillator,” *J. Nucl. Sci. Technol.*, vol. 59, no. 8, pp. 1047–1060, 2022, doi: 10.1080/00223131.2021.2019622.
- [12] T. Furuta and T. Sato, “Medical application of particle and heavy ion transport code system PHITS,” *Radiol. Phys. Technol.*, vol. 14, no. 3, pp. 215–225, 2021, doi: 10.1007/s12194-021-00628-0.
- [13] O. Mohamad, S. Yamada, and M. Durante, “Clinical Indications for Carbon Ion Radiotherapy,” *Clin. Oncol.*, vol. 30, no. 5, pp. 317–329, 2018, doi: 10.1016/j.clon.2018.01.006.
- [14] P. de Vera *et al.*, “Energy Deposition around Swift Carbon-Ion Tracks in Liquid Water,” *Int. J. Mol. Sci.*, vol. 23, no. 11, 2022, doi: 10.3390/ijms23116121.
- [15] Z. Hong *et al.*, “Carbon ion radiotherapy with pencil beam scanning for hepatocellular carcinoma Long-term.pdf.” Wiley, 2022. doi: 10.1111/cas.15633.
- [16] G. Y. Ku and D. H. Ilson, *Cancer of the Esophagus*. 2019. doi: 10.1016/B978-0-323-47674-4.00071-2.
- [17] American Cancer Society, “What Is Pancreatic Cancer? About Pancreatic Cancer - Key Statistics for Pancreatic Cancer,” 2024. <https://www.cancer.org/cancer/types/pancreatic-cancer/about/key->



statistics.html (accessed Jun. 23, 2024).

- [18] S. H. Park and J. O. Kang, “Basics of particle therapy I: physics,” *Radiat. Oncol. J.*, vol. 29, no. 3, p. 135, 2011, doi: 10.3857/roj.2011.29.3.135.
- [19] S. Baatout, *Radiobiology Textbook*. Springer Nature Switzerland, 2023. doi: 10.1007/978-3-031-18810-7.
- [20] A. Baeyens *et al.*, “Basic Concepts of Radiation Biology,” in *Radiobiology Textbook*, 2023, pp. 25–81. doi: 10.1007/978-3-031-18810-7\_2.
- [21] A. C. Kraan, “Range verification methods in particle therapy: Underlying physics and Monte Carlo modelling,” *Front. Oncol.*, vol. 5, no. JUN, pp. 1–27, 2015, doi: 10.3389/fonc.2015.00150.
- [22] G. Battistoni *et al.*, “Measuring the Impact of Nuclear Interaction in Particle Therapy and in Radio Protection in Space: the FOOT Experiment,” *Front. Phys.*, vol. 8, no. February, pp. 1–20, 2021, doi: 10.3389/fphy.2020.568242.
- [23] F. H. Attix, *Introduction To Radiological Physics and Radiation Dosimetry*. Madison: WILEY-VCH Verlag GmbH & Co. KGaA, 2004.
- [24] M. O. E.- Ghossain, “Calculations of Stopping Power, and Range of Ions Radiation (Alpha Particles) Interaction with Different Materials and Human Body Parts,” *Int. J. Physics, Vol. 5, 2017, Pages 92-98*, vol. 5, no. 3, pp. 92–98, 2017, doi: 10.12691/ijp-5-3-5.
- [25] J. F. Ziegler, M. D. Ziegler, and J. P. Biersack, “SRIM - The stopping and range of ions in matter (2010),” *Nucl. Instruments Methods Phys. Res. Sect. B Beam Interact. with Mater. Atoms*, vol. 268, no. 11–12, pp. 1818–1823, 2010, doi: 10.1016/j.nimb.2010.02.091.
- [26] E. M. Zeman, *The Biological Basis of Radiation Oncology*, Fourth Edition. Elsevier Inc., 2015. doi: 10.1016/B978-0-323-24098-7.00001-0.
- [27] A. Kitagawa *et al.*, “Status of Ecr Ion Sources for Carbon-Ion Radiotherapy



in Japan,” pp. 200–202.

- [28] M. Muramatsu *et al.*, “Present Status of Himac Ecr Ion Sources,” *Proc. ECRIS2020*, pp. 140–142, 2019, doi: 10.18429/JACoW-ECRIS2020-WEYZO01.
- [29] M. Muramatsu *et al.*, “Development of an ECR ion source for carbon therapy,” *Rev. Sci. Instrum.*, vol. 73, no. 2 II, p. 573, 2002, doi: 10.1063/1.1429307.
- [30] M. Muramatsu, A. G. Drentje, and A. Kitagawa, “Development of Electron Cyclotron Resonance Ion Sources for Carbon-Ion Radiotherapy,” pp. 10–12, 2015.
- [31] O. Mohamad, H. Makishima, and T. Kamada, “Evolution of carbon ion radiotherapy at the national institute of radiological sciences in Japan,” *Cancers (Basel)*, vol. 10, no. 3, 2018, doi: 10.3390/cancers10030066.
- [32] A. Y. Boytsov *et al.*, “Electron string ion sources for carbon ion cancer therapy accelerators,” *Rev. Sci. Instrum.*, vol. 86, no. 8, pp. 1–6, 2015, doi: 10.1063/1.4927821.
- [33] M. Okamoto *et al.*, “Carbon-Ion Radiotherapy Combined with Concurrent Chemotherapy for Locally Advanced Pancreatic Cancer: A Retrospective Case Series Analysis,” *Cancers (Basel)*, vol. 15, no. 10, pp. 1–11, 2023, doi: 10.3390/cancers15102857.
- [34] Y. Iwata *et al.*, “Superconducting Gantry for Carbon-Ion Radiotherapy,” *IPAC 2018 ninth Int. Part. Accel. Conf.*, pp. 1232–1236, 2018, doi: 10.18429/JACoW-IPAC2018-TUZGBF1.
- [35] H. Tsujii, T. Kamada, T. Shirai, K. Noda, H. Tsuji, and K. Karasawa, *Carbon-Ion Radiotherapy Principles, Practices, and Treatment Planning*. Springer Tokyo Heidelberg New York Dordrecht London t. doi: 10.1007/978-4-431-54457-9.



- [36] Y. Iwata *et al.*, “Design of a superconducting rotating gantry for heavy-ion therapy,” *Phys. Rev. Spec. Top. - Accel. Beams*, vol. 15, no. 4, pp. 1–14, 2012, doi: 10.1103/PhysRevSTAB.15.044701.
- [37] K. Sato, A. Miyamoto, D. Kameda, and S. Takayama, “Carbon-ion synchrotron accelerator and raster scanning irradiation system,” *Adv. Accel. Med. Phys.*, pp. 111–127, Jan. 2023, doi: 10.1016/B978-0-323-99191-9.00018-9.
- [38] J. Soltani-Nabipour and G. Căta-Danil, “Monte Carlo computation of the energy deposited by heavy charged particles in soft and hard tissues,” *UPB Sci. Bull. Ser. A Appl. Math. Phys.*, vol. 70, no. 3, pp. 73–84, 2008.
- [39] A. N. Golovchenko *et al.*, “Erratum: Total charge changing and partial crosssection measurements in the reactions of 110–250 MeV/nucleon  $^{12}\text{C}$  in carbon, paraffin, and water,” *Physical Review C - Nuclear Physics*, vol. 66, no. 3. American Physical Society, p. 399011, Sep. 01, 2002. doi: 10.1103/PhysRevC.66.039901.
- [40] J. Kim, J. M. Park, and H.-G. Wu, “Carbon Ion Therapy: A Review of an Advanced Technology,” *Prog. Med. Phys.*, vol. 31, no. 3, pp. 71–80, 2020, doi: 10.14316/pmp.2020.31.3.71.
- [41] M. Durante and J. Debus, “Heavy Charged Particles: Does Improved Precision and Higher Biological Effectiveness Translate to Better Outcome in Patients?,” *Semin. Radiat. Oncol.*, vol. 28, no. 2, pp. 160–167, 2018, doi: 10.1016/j.semradonc.2017.11.004.
- [42] S. Valable *et al.*, “Impact of hypoxia on carbon ion therapy in glioblastoma cells: Modulation by let and hypoxia-dependent genes,” *Cancers (Basel)*, vol. 12, no. 8, pp. 1–15, 2020, doi: 10.3390/cancers12082019.
- [43] M. Gérard *et al.*, “Hypoxia Imaging and Adaptive Radiotherapy: A State-of-the-Art Approach in the Management of Glioma,” *Front. Med.*, vol. 6, no. June, 2019, doi: 10.3389/fmed.2019.00117.



- [44] H.-G. Menzel, *International Commission on Radiation Units and Measurements*, vol. 15, no. 1–2. Oxford University Press, 2015. doi: 10.1093/jicru\_ndy011.
- [45] K. Berberoğlu, “Use of Positron Emission Tomography/Computed Tomography in Radiation Treatment Planning for Lung Cancer,” *Mol. Imaging Radionucl. Ther.*, vol. 25, no. 2, pp. 50–62, 2016, doi: 10.4274/mirt.19870.
- [46] J. Liermann *et al.*, “Carbon ion radiotherapy as definitive treatment in non-metastasized pancreatic cancer: Study protocol of the prospective phase II PACK-study,” *BMC Cancer*, vol. 20, no. 1, pp. 1–7, 2020, doi: 10.1186/s12885-020-07434-8.
- [47] T. Pawlicki, D. J. Scanderbeg, and G. Starkschall, *Hendee’s Radiation Therapy Physics*, 4th ed. Canada: JohnWiley & Sons, Inc., Hoboken, New Jersey, 2017.
- [48] ICRP, “ICRP PUBLICATION 103 The 2007 Recommendations of the International Commission on Radiological Protection,” *Radiat. Phys. Chem.*, vol. 188, no. 24, pp. 1–337, 2007, [Online]. Available: [www.mdpi.com/journal/diagnostics](http://www.mdpi.com/journal/diagnostics)[http://www-pub.iaea.org/MTCD/publications/PDF/Pub1609\\_web.pdf](http://www-pub.iaea.org/MTCD/publications/PDF/Pub1609_web.pdf)[http://www.vomfi.univ.kiev.ua/assets/files/IAEA/Pub1462\\_web.pdf](http://www.vomfi.univ.kiev.ua/assets/files/IAEA/Pub1462_web.pdf)<http://www.ncbi.nlm.nih.gov/pubmed/16168243>
- [49] E. Hiswara, *Proteksi dan Keselamatan Radiasi*. 2023.
- [50] C. Rangacharyulu, *Physics of Nuclear Radiations Concepts, Techniques and Applications*. CRC Press, 2014.
- [51] A. F. Bielajew, “Fundamentals of the Monte Carlo method for neutral and charged particle transport, The University of Michigan,” *Ann Arbor*, no. October 2001, p. 346, 2001.
- [52] T. Sato *et al.*, “Particle and heavy ion transport code system, PHITS,



- version 2.52,” *J. Nucl. Sci. Technol.*, vol. 50, no. 9, pp. 913–923, 2013, doi: 10.1080/00223131.2013.814553.
- [53] Y. Iwamoto *et al.*, “Benchmark study of the recent version of the PHITS code,” *J. Nucl. Sci. Technol.*, vol. 54, no. 5, pp. 617–635, 2017, doi: 10.1080/00223131.2017.1297742.
- [54] T. Sato *et al.*, “Features of Particle and Heavy Ion Transport code System (PHITS) version 3.02,” *J. Nucl. Sci. Technol.*, vol. 55, no. 6, pp. 684–690, 2018, doi: 10.1080/00223131.2017.1419890.
- [55] T. Furuta *et al.*, “Implementation of OpenMP and MPI hybrid parallelization to Monte Carlo dose simulation for particle therapy,” *IFMBE Proc.*, vol. 39 IFMBE, pp. 2099–2102, 2013, doi: 10.1007/978-3-642-29305-4\_551.
- [56] H. Nose *et al.*, “Improvement of three-dimensional monte carlo code PHITS for heavy ion therapy,” *J. Nucl. Sci. Technol.*, vol. 42, no. 2, pp. 250–255, 2005, doi: 10.1080/18811248.2005.9726386.
- [57] S. Yonai, N. Matsufuji, and M. Namba, “Calculation of out-of-field dose distribution in carbon-ion radiotherapy by Monte Carlo simulation,” *Med. Phys.*, vol. 39, no. 8, pp. 5028–5039, Aug. 2012, doi: 10.1118/1.4736823.
- [58] T. Sato and Y. Furusawa, “Cell survival fraction estimation based on the probability densities of domain and cell nucleus specific energies using improved microdosimetric kinetic models,” *Radiat. Res.*, vol. 178, no. 4, pp. 341–356, Oct. 2012, doi: 10.1667/RR2842.1.
- [59] Y. Iwata *et al.*, “Design of a compact superconducting accelerator for advanced heavy-ion therapy,” *Nucl. Instruments Methods Phys. Res. Sect. A Accel. Spectrometers, Detect. Assoc. Equip.*, vol. 1053, no. June 1994, p. 168312, 2023, doi: 10.1016/j.nima.2023.168312.
- [60] J. Liermann, E. Ben-Josef, M. Syed, J. Debus, K. Herfarth, and P. Naumann, “Carbon ion radiotherapy as definitive treatment in locally



- recurrent pancreatic cancer,” *Strahlentherapie und Onkol.*, vol. 198, no. 4, pp. 378–387, 2022, doi: 10.1007/s00066-021-01827-9.
- [61] O. Tanaka *et al.*, “Effect of stomach size on organs at risk in pancreatic stereotactic body radiotherapy,” *Radiat. Oncol.*, vol. 17, no. 1, pp. 1–7, 2022, doi: 10.1186/s13014-022-02107-1.
- [62] Y. Cao *et al.*, “Dose evaluations of organs at risk and predictions of gastrointestinal toxicity after re-irradiation with stereotactic body radiation therapy for pancreatic cancer by deformable image registration,” *Front. Oncol.*, vol. 12, no. January, pp. 1–12, 2023, doi: 10.3389/fonc.2022.1021058.
- [63] U. S. Customs, B. Protection, D. Nuclear, and D. Office, “Compendium of Material Composition Data for Radiation Transport Modeling,” 2011, [Online]. Available: [www.pnnl.gov/main/publications/external/technical\\_reports/pnnl-15870rev1.pdf](http://www.pnnl.gov/main/publications/external/technical_reports/pnnl-15870rev1.pdf)
- [64] PNNL, “Data Mining Analysis and Modeling Cell: Compendium of Material Composition Data for Radiation Transport Modeling,” no. April, pp. 1–298, 2021, [Online]. Available: [www.pnnl.gov/main/publications/external/technical\\_reports/pnnl-15870rev1.pdf](http://www.pnnl.gov/main/publications/external/technical_reports/pnnl-15870rev1.pdf)
- [65] ICRP and ICRU, *Annals of the ICRP: Adult Reference Computational Phantoms ICRP PUBLICATION 110*. Elsevier.
- [66] R. L. Maughan, P. J. Chuba, A. T. Porter, E. Ben-Josef, and D. R. Lucas, “The elemental composition of tumors: Kerma data for neutrons,” *Med. Phys.*, vol. 24, no. 8, pp. 1241–1244, 1997, doi: 10.1118/1.598144.
- [67] Y. Kusano *et al.*, “Robust treatment planning in scanned carbon-ion radiotherapy for pancreatic cancer: Clinical verification using in-room computed tomography images,” *Front. Oncol.*, vol. 12, no. August, pp. 1–



14, 2022, doi: 10.3389/fonc.2022.974728.

- [68] J. Liermann, M. Shinoto, M. Syed, J. Debus, K. Herfarth, and P. Naumann, “Carbon ion radiotherapy in pancreatic cancer: A review of clinical data,” *Radiother. Oncol.*, vol. 147, pp. 145–150, 2020, doi: 10.1016/j.radonc.2020.05.012.
- [69] L. C. Lin *et al.*, “Evaluating dosimetric constraints for carbon ion radiotherapy in the treatment of locally advanced pancreatic cancer,” *Radiat. Oncol.*, vol. 15, no. 1, pp. 1–9, 2020, doi: 10.1186/s13014-020-01515-5.
- [70] L. Rezaee, “Design of spread-out Bragg peaks in hadron therapy with oxygen ions,” *Reports Pract. Oncol. Radiother.*, vol. 23, no. 5, pp. 433–441, 2018, doi: 10.1016/j.rpor.2018.08.004.
- [71] B. K. S. M. Physicist, and C. Gleneagles Global Hospitals, “Radiotherapy Prescription Dose and Normal Tissue Tolerance Dose Protocol,” no. November, pp. 0–20, 2022.
- [72] W. Farhiyati, R. Subroto, I. W. A. Makmur, N. Qomariyah, and R. Wirawan, “Treatment Planning System (Tps) Kanker Payudara Menggunakan Teknik 3Dcrt,” *ORBITA J. Kajian, Inov. dan Apl. Pendidik. Fis.*, vol. 6, no. 1, p. 150, 2020, doi: 10.31764/orbita.v6i1.2115.
- [73] D. Mirza, I. P. E. Juliantara, and C. Amelia, “Analisis Dosis Radiasi Paru Pada Pasien Radioterapi Kanker Payudara Dengan Teknik 3D-Crt Berdasarkan Grafik Dvh,” *J. Med. Malahayati*, vol. 7, no. 4, pp. 1172–1181, 2024, doi: 10.33024/jmm.v7i4.12596.

