# JSMP Medical Physics Summer Seminar 2015

**＊JSMP医学物理サマーセミナー2015;**
会場:グリンピアせとうち
会期:2015年9月3日(木)～5日(土)
受付:9月3日(木)12:30-13:00
開校式:9月3日(木)13:10-13:30
閉校式:9月5日(土)11:50-12:10

**＊お知らせ**
**①空港・新幹線広島駅-グリンピアせとうち間送迎バス**を運行致します。
**9月3日(木)**
【JR広島駅発-グリンピアせとうち行き(所要時間約1hr)】
第1便:11:30発
第2便:12:00発
【広島空港発-グリンピアせとうち行き(所要時間約1hr)】
1便のみ:11:40発
**9月5日(土)**
【グリンピアせとうち発-JR広島駅行き】
2便 :12:30発
【グリンピアセトウチ発-広島空港行】
1便 :12:30発 (所要時間約1hr)
参加者各位に送迎バス利用希望アンケートが送付されます。お早目にご回答下さい(8/6)。

②セミナー参加者へのお知らせ
お知らせpdf(バス待合集合場所、他情報)

**③セミナー講義資料ダウンロードについて;**
セミナー参加者は,講義資料を下記URLからダウンロード・印刷し,当日各自で御持参願います。当日の資料配布はありませんのでご注意ください。
https://www.bunken.org/jsmp/seminar/document.php
参加受付番号とe-mailアドレスによるログイン

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| | | Day 1: Thursday Sep 3 |
| 13:10 | 13:30 | Welcome, Course overview |
| 13:30 | 14:50 | Basic Radiation Physics (遠藤 曉) |
| 15:00 | 16:20 | Dosimetric Principles (遠藤 曉) |
| 16:30 | 17:50 | Treatment Planning in External Beam Radiotherapy (齋藤明登) |
| 18:00 | 18:40 | Special Techniques in External Beam Radiotherapy (齋藤明登) |
| 19:00 | | Banquet |
| | | Day 2: Friday Sep 4 |
| 5:30 | 6:30 | Walking |
| 7:00 | 8:30 | Breakfast |
| 8:30 | 9:10 | Special Techniques in External Beam Radiotherapy (齋藤明登) |
| 9:20 | 10:40 | Brachytherapy: Physical and Clinical Aspects (川村慎二) |
| 10:50 | 12:10 | Special Topics (Clinical trial) (木村智樹) |
| 12:10 | 13:10 | Lunch |
| 13:10 | 14:30 | Mathematical Methods for Imaging in Medicine (檜垣 徹) |
| 14:40 | 16:00 | Fusion, Resistration, Deformation (檜垣 徹) |
| 16:00 | 18:30 | Recreation (各種レジャー) |
| 18:30 | 19:30 | Supper |
| 20:00 | | Night session & Informal Q&A (小野 薫・水野秀之) |
| | | Day 3 Saturday Sep 5 |
| 7:00 | 8:50 | Breakfast |
| 9:00 | 10:20 | Conventional X-ray planer imaging (井手口忠光) |
| 10:30 | 11:50 | Motion and Motion Management in Radiotherapy (椎木健裕) |
| 12:00 | | Closing remark, 集合写真撮影 |

## Syllabus

I. Basic Radiation Physics
1. Atomic and Nuclear Structure
(a) Basic definitions of atomic structures
(b) Rutherford model of the atom
(c) Bohr model of the hydrogen atom
(d) Multi-electron atoms
(e) Nuclear structure, including nuclear binding energy, n/p radio, fission, and nuclear bombardment
(f) Radioactivity and modes of decay
2. Classification of Radiations
(a) Basic physical quantities and units used in radiation physics
(b) Types and sources of directly and indirectly ionizing radiations
(c) Description of ionizing radiation fields
3. Quantities and Units Used for Describing Radiation Fields
(a) Fluence and fluence rate
(b) Energy fluence and energy fluence rate
(c) Monoenergetic and polyenergetic spectra
4. Quantities and Units Used for Describing the Interaction of Ionizing Radiation with Matter
(a) Terma, kerma, collisional kerma, radiative kerma
(b) Absorbed dose
(c) Activity
(d) Energy transferred, net energy transferred, energy imparted
(e) Equivalent dose and quality factor
(f) Exposure
5. Indirectly Ionizing Radiations: Photon Beams
(a) X-ray transitions, characteristic radiation, ionization vs. excitation of atoms
(b) Moseley’s law, x-ray line spectra, Hartree’s theory of multi-electron atoms
(c) Radiation from accelerated charge, production of bremsstrahlung, Larmor relationship
(d) X-ray targets, bremsstrahlung yield
(e) Beam quality and filtering
(f) Energy deposition in tissue by photon beams
6. Exponential Attenuation
(a) Simple exponential attenuation
(b) Half-value layer, tenth-value layer, attenuation coefficients, interaction cross sections
(c) Narrow vs. broad beam attenuation
(d) Buildup factor
(e) Spectral effects in attenuation, beam hardening and softening
(f) Reciprocity theorem
(g) Energy transfer coefficient, energy absorption coefficient

II. Dosimetric Principles
14. Radiation Dosimetry
(a) Types and general characteristics of dosimeters
(b) ICRU (International Commission on Radiation Units and Measurements) definitions of dosimetry quantities and units
(c) Absolute vs. relative dosimetry techniques
(d) Interpretation of dosimeter measurements
17. Cavity Theory
(a) Bragg-Gray cavity theory and corollaries (restricted and unrestricted stopping powers)
(b) Spencer-Attix and Burlin cavity theories
(c) Fano’s theorem
(d) Stopping power averaging
(e) Dose near interfaces
18. Ionization Chambers
(a) Basic configuration of ionization chambers
(b) Standard free air ionization chamber
(c) Cavity (thimble) ionization chamber
(d) Extrapolation chamber
(e) Measurement of chamber current (differential mode) and charge (integral mode) and operation of electrometer
(f) Mean energy required to create an ion pair
(g) Saturation characteristics of ionization chambers: initial and general recombination, diffusion loss (understanding correction factors applied to ion chamber measurement)
19. Calibration of Photon and Electron Beams with Ionization Chambers
(a) Cavity chamber calibration: air-kerma in air and dose in water
(b) Dosimetry protocols: AAPM TG-21; AAPM TG-51; International Atomic Energy Agency Technical Report Series 398 (IAEA TRS-398)
(c) Phantom materials for photon and electron beams

III. Treatment Planning in External Beam Radiotherapy
1. Target Volume Definition and Dose Prescription Criteria (ICRU 50 and ICRU 62)
(a) Gross tumor volume (GTV)
(b) Clinical target volume (CTV)
(c) Planning target volume (PTV)
(d) Dose prescription point, isodose line, or isodose surface
2. Photon Beams: Dose Modeling and Treatment Planning
(a) Single-field dose distribution
(b) Parameters influencing isodose curves and isodose surfaces
(c) Combination of fields
(d) Wedged and angled fields
(e) Corrections for SSD (source-to-surface distance), missing tissue, and inhomogeneities

V. Brachytherapy: Physical and Clinical Aspects
1. Brachytherapy: Basic Physical Characteristics
(a) Radionuclides used in brachytherapy
(b) Source types used in brachytherapy
(c) Sealed-source dosimetry (source strength, air kerma rate, absorbed dose calculation)
(d) Source calibration, assay, and quality assurance
(e) Source specifications and dosimetry
2. Brachytherapy: Clinical Aspects
(a) Brachytherapy techniques: Interstitial, intracavitary; surface applicators
(b) Brachytherapy systems: Direct-loading vs. afterloading; manual vs. remote afterloading
(c) Interstitial therapy: Manchester and Paris systems
(d) Seed implants
(e) Ultrasound-guided prostate seed implants
(f) Gynecological intracavitary therapy
(g) Clinical prescriptions and dose-volume histograms
(h) Remote afterloading machines
(i) Electronic brachytherapy
(j) Radiological models (linear-quadratic model)

VI. Special Topics (Clinical trial)
6. Design of Clinical Studies
(a) Reliability and validity of a study: Internal validity, external validity, etc. Random selection (population inference), random allocation (causal inference)
(b) Design and analysis of randomized controlled studies. Strengths and weaknesses
(c) Design and analysis of case-control and cohort studies. Strengths and weaknesses
(d) Functional status measures. Generic (SF-36). Condition-specific
(e) Data-base studies. Strengths (high external validity) and weaknesses (low internal validity). Data-Mining

VII. Mathematical Methods for Imaging in Medicine
A. Deterministic Aspects
1. Math Background: The complex plane, odd/even functions. The Dirac delta function
2. Introduction to Linear Systems
(a) Fourier’s theorem: Fourier series and the continuous Fourier transform
(b) Properties of the Fourier transform
(c) Gaussian, sinc, rect, sinusoid, and comb functions and essential Fourier transform pairs
(d) The complex transfer function

7. Photon Interactions with Matter
(a) Thomson scattering
(b) Rayleigh scattering
(c) Photoelectric effect
(d) Compton scattering
(e) Pair production, triplet production
(f) Photonuclear reactions
(g) Relative predominance of individual effects as a function of energy and atomic number
(h) Effects following individual photon interactions, fluorescence yield, Auger effect
(i) Contributions of individual effects to the attenuation coefficient, energy transfer coefficient, and energy absorption coefficient
8. Indirectly Ionizing Radiations: Neutron Beams
(a) Neutron types by kinetic energy
(b) Neutron sources
(c) Neutron beam specifications
9. Neutron Interactions with Matter
(a) Neutron interactions including scatter, absorption kinematics, and cross sections
(b) Shielding consideration for neutrons
(c) Neutron kerma and absorbed dose calculations
(d) Absorbed dose in a body phantom
(e) Gamma-neutron mixed field dosimetry
(f) Neutron quality factor
10. Directly Ionizing Radiations
(a) Types of charged particle beams used clinically
(b) Sources of charged particle beams
(c) Energy deposition in tissue by charged particle beams
11. Interactions of Directly Ionizing Radiations with Matter
(a) Stopping power (collisional and radiative), scattering power, range, straggling
(b) Restricted stopping power, linear energy transfer
(c) Orbital electron interactions
(d) Nuclear interactions
(e) Energy distribution of electrons in matter (charged particle spectrum)
(f) Calculation of absorbed dose in charged particle interactions
12. Radioactive Decay
(a) Total and partial decay constants
(b) Units of activity
(c) Mean-life and half-life
(d) Parent-daughter relationships
(e) Transient and secular equilibrium
(f) Harvesting of daughter products
(g) Radioactivation by nuclear interactions
(h) Exposure rate constant and air-kerma rate constant
13. Charged Particle and Radiation Equilibrium
(a) Radiation equilibrium
(b) Charged particle equilibrium (CPE)
(c) Relationships between absorbed dose, collisional kerma, and exposure under CPE
(d) Conditions that enable CPE or cause its failure
(e) Transient CPE

(f) Dose specification and normalization
3. Photon Beams: Treatment Planning
(a) Acquisition of isodose data
(b) Computer hardware
(c) Common algorithms: Convolution, superposition, pencil beam
(d) Dimensionality (2D, 2.5D, and 3D treatment plans)
(e) Non-coplanar plans
(f) Treatment planning with asymmetric collimators
(g) Treatment planning with wedges (hard, dynamic, and virtual)
(h) Treatment planning with multileaf collimators (MLCs)
(i) Compensator design
(j) 3-D treatment planning
(k) Forward vs. inverse treatment planning
(l) Inverse planning objectives and techniques. Optimization methods
(m) Treatment planning with Monte Carlo techniques
(n) Quality assurance of treatment planning systems
(o) Biological modifiers/optimization
4. Clinical Photon Beams: Patient Application
(a) Patient data acquisition
i. Contours
ii. Images: Plain film, electronic portal imaging device (EPID), computed radiography (CR)
iii. Computed tomography (CT), ultrasound (US), single photon emission tomography (SPECT), magnetic resonance imaging (MRI), positron emission tomography (PET)
(b) Conventional simulator techniques
i. Positioning/immobilization
ii. Use of contrast, markers, etc.
iii. Image parameters/optimization
(c) Accessory devices and techniques
i. Block cutting
ii. Compensators
iii. Bolus
(d) CT-simulator techniques
i. Scout view images
ii. Virtual simulation
iii. Digitally reconstructed radiographs (DRRs)
iv. CT number and (electron) density relation and calibration
(e) Special considerations
i. Skin dose
ii. Field matching
iii. Integral dose
iv. Dose-volume histograms (DVHs): Differential (direct) and integral (cumulative)
5. Clinical Electron Beams: Dose Modeling and Treatment Planning
(a) Effects of patient and beam geometry
i. Air gap
ii. Beam obliquity
iii. Irregular patient surface
iv. Internal heterogeneities: bone, fat, lung, air
(b) Dose algorithms
i. Analytical algorithms (e.g., Fermi-Eyges based pencil beam)
ii. Monte Carlo algorithms
iii. Clinical commissioning
iv. Quality assurance of treatment plans
(c) Treatment planning techniques
i. Energy and field size selection
ii. Bolus: Constant thickness and shape
iii. Collimation: Inserts, skin, internal
iv. Field abutment techniques
v. Photon-electron mixed beams
(d) Special electron treatment techniques
i. Total skin irradiation
ii. Total limb irradiation
iii. Electron arc therapy
iv. Intraoperative electron therapy
v. Total scalp irradiation
vi. Craniospinal irradiation
vii. Conformal therapy

IV. Special Techniques in External Beam Radiotherapy
1. Special External Beam Radiotherapy Techniques: Basic Characteristics, Historical Development, Quality Assurance (Equipment and Treatment), Diseases Treated
(a) Total body irradiation (TBI)
(b) Total skin electron irradiation (TSEI)
(c) Stereotactic radiosurgery
(d) Stereotactic radiotherapy
(e) Endorectal irradiation
(f) Electron arc therapy
(g) Intraoperative radiotherapy
(h) Hyperthermia
(i) Hyperfractionation and Hypofractionation
(j) Pulse Low Dose Rate (PLDR)
2. Intensity-Modulated Radiotherapy (IMRT)
(a) Dose delivery systems
i. Single-slice collimators

(e) The convolution principle
(f) The edge response function
(g) Auto and cross-correlation
3. Discrete Signal Processing
(a) The sampling theorem
(b) Sampling and restoration
(c) The Discrete Fourier Transform (DFT)
(d) Apodizing and aliasing
(e) Approximate restoration from sampling (pixels)
4. 2D Digital Image Processing
(a) Pixel transformations: the 2D affine transformation
(b) The anti-aliasing affine transformations
(c) Image registration: normalized mutual information, Woods algorithm
(d) Filtering and image compression
5. Image Reconstruction
(a) Line and edge responses: The Central Slice Theorem
(b) Imaging from projections: The sinogram
(c) Analytic and iterative reconstruction methods
(d) Image registration in sinogram space
(e) Compartmental modeling: Physiological and biochemical parametric mapping
B. Stochastic Aspects
1. Random Number Generators, Probability Density, and Distribution Functions
(a) The binomial, Poisson, and Gaussian distributions
(b) Moments: Expectation, mean, and variance
(c) Fourier relationships: The characteristic function and the central limit theorem
(d) Introduction to elementary decision theory
(e) Signal-to-noise ratio
(f) The Rose Model and the pre-whitened matched filter
(g) Detective quantum efficiency and noise equivalent quanta
2. Decision Theory
(a) Negative and positive predictive value; effect of noise on decision criteria
(b) Joint and conditional probabilities; Bayes' theorem
(c) Receiver Operating Characteristics (ROC)
(d) Free-response receiver operating characteristics (FROC) [journal article]
3. Noise Averaging and Filtering
(a) Principles of noise averaging: The covariance concept
(b) Autocovariance and power spectrum concepts [Noise graphs]
(c) Filtering: The inverse, Metz, Wiener, matched, and Wiener-Hellstrom filters [figures]
(d) The propagation of error and the covariance matrix
4. Maximum Likelihood
(a) Linear regression
(b) The correlation coefficient
(c) Eigenstructure of the covariance matrix
(d) Optimization. The Levenberg—Marquardt and Nelder—Mead approaches
(e) Expectation—maximization
(f) OSEM and iterative deconvolution techniques
5. Tests of Significance
(a) Chi-squared, t-test, F-test, statistical power
(b) Analysis of variance
(c) Statistical parametric mapping (SPM)

VIII. Fusion, Resistration, Deformation
(a) Algorithms for fusion
(b) Algorithms for registration
(c) Multimodality imaging treatment planning
(d) Treatment planning and motion

IX. Conventional planar X-ray imaging
6. Radiographic Receptors
(a) Screen functions
(b) Receptor sensitivity
(c) Image blur
(d) Image noise
(e) Artifacts
7. The Photographic Process and Film Sensitivity
(a) Film functions
(b) Optical density
(c) Film structure
(d) The photographic process
(e) Sensitivity
(f) Processing quality control
8. Film Contrast Characteristics
(a) Contrast transfer
(b) Film latitude
(c) Film types
(d) Effects of processing
(e) Film fog

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|---|---|---|
| | ii. Multileaf collimators<br>iii. Tomotherapy<br>iv. Volumetric arc therapy<br>(b) Dose delivery techniques<br>i. Step-and-shoot<br>ii. Sliding window<br>(c) Patient-specific QA | 10. Blur, Resolution, and Visibility of Detail<br>(a) Visibility of detail<br>(b) Unsharpness<br>(c) Resolution<br>(d) Modulation Transfer Function (MTF)<br>11. Radiographic Detail<br>(a) Object location and magnification<br>(b) Motion blur<br>(c) Focal spot blur (geometric unsharpness)<br>(d) Receptor blur<br>(e) Composite blur<br>12. Image Noise<br>(a) Effect on visibility<br>(b) Quantum noise<br>(c) Receptor sensitivity<br>(d) Grain and structure noise<br>(e) Electronic noise<br>(f) Effect of noise on contrast<br>(g) Effect of blur on noise<br>(h) Image integration<br>(i) Image subtraction<br><br>X. Motion and Motion Management in Radiotherapy<br>(a) Musculoskeletal motion<br>(b) Cardiac motion<br>(c) Breathing motion<br>(d) Gastrointestinal motion<br>(e) Treatment margins, systematic and random errors<br>(f) Margin reduction strategies: on-line, off-line, adaptive |