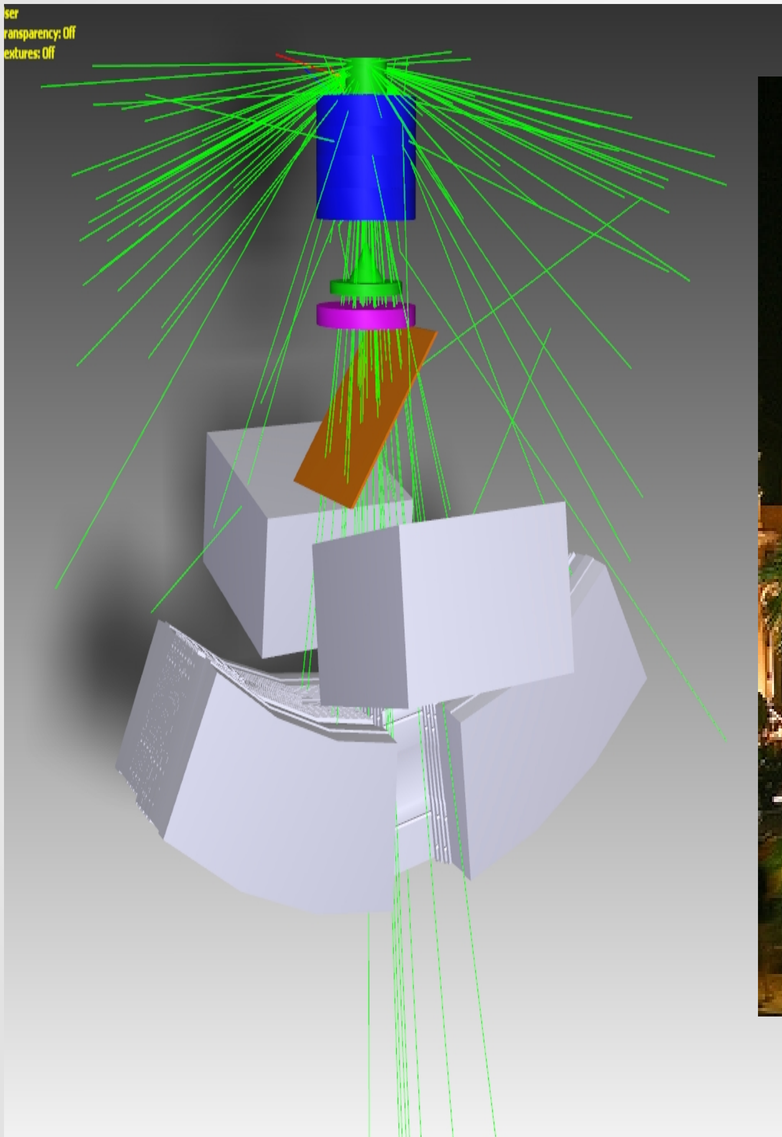
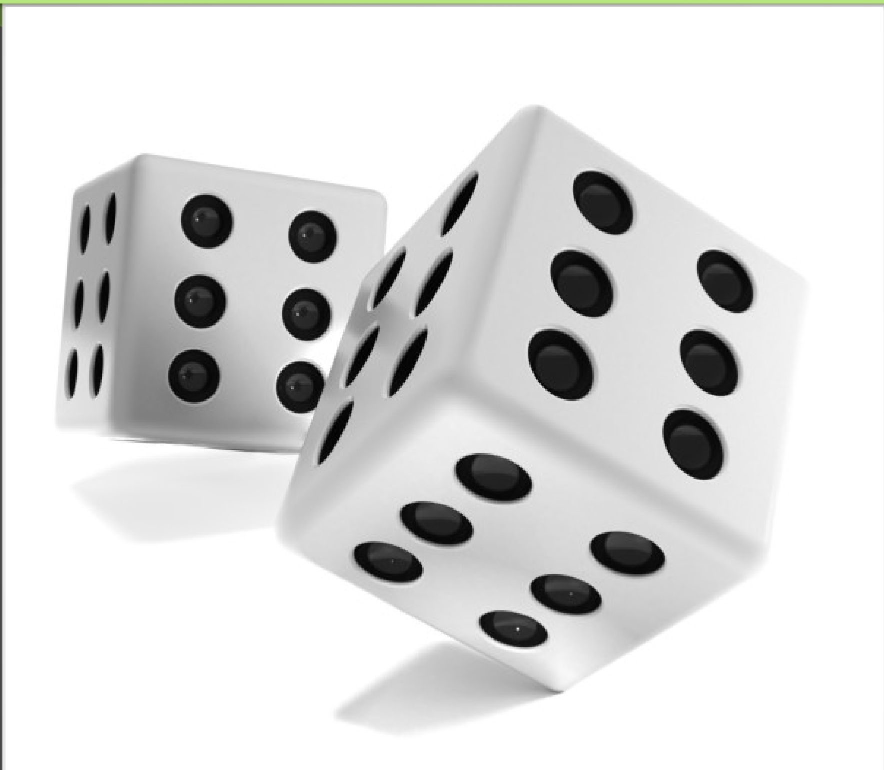
Monte Carlo (klinik) Uygulamaları



emin tavlayan

Monte Carlo metodu



a numerical method

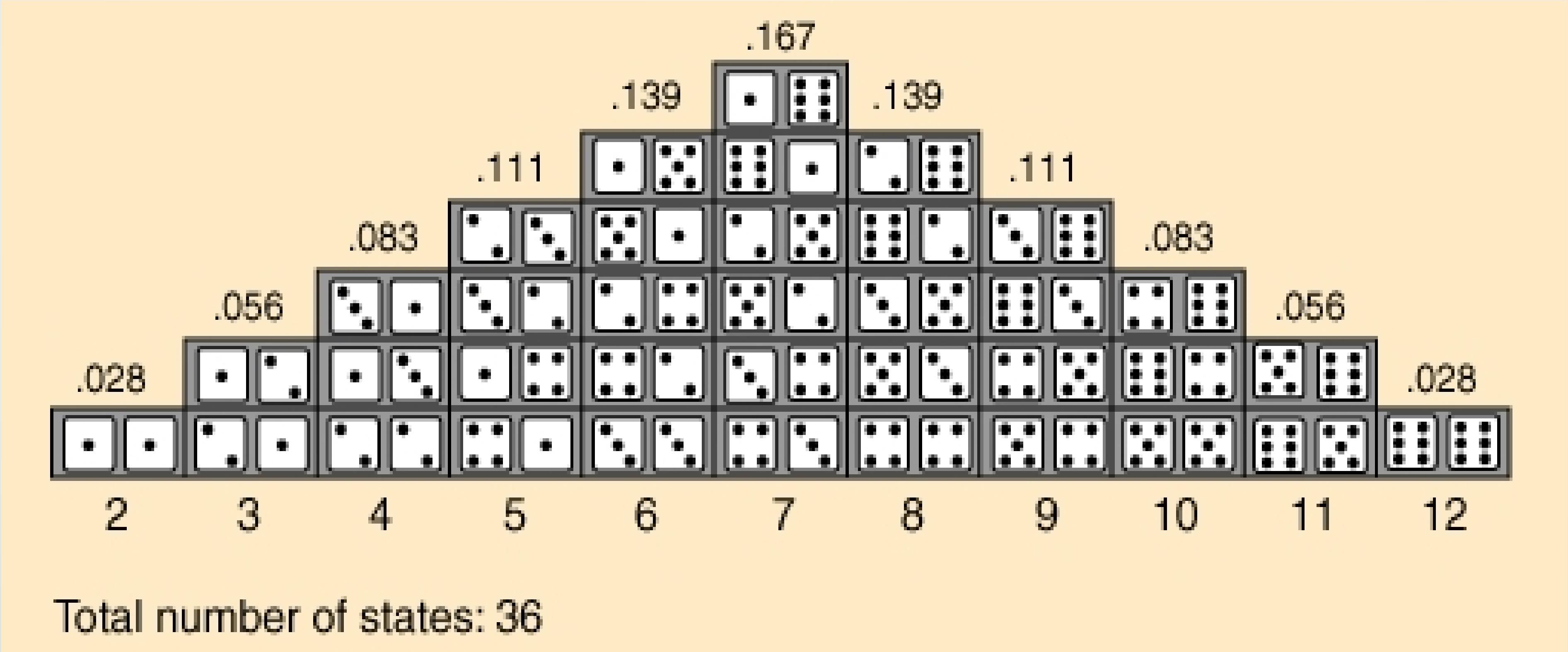
for

statistical simulation

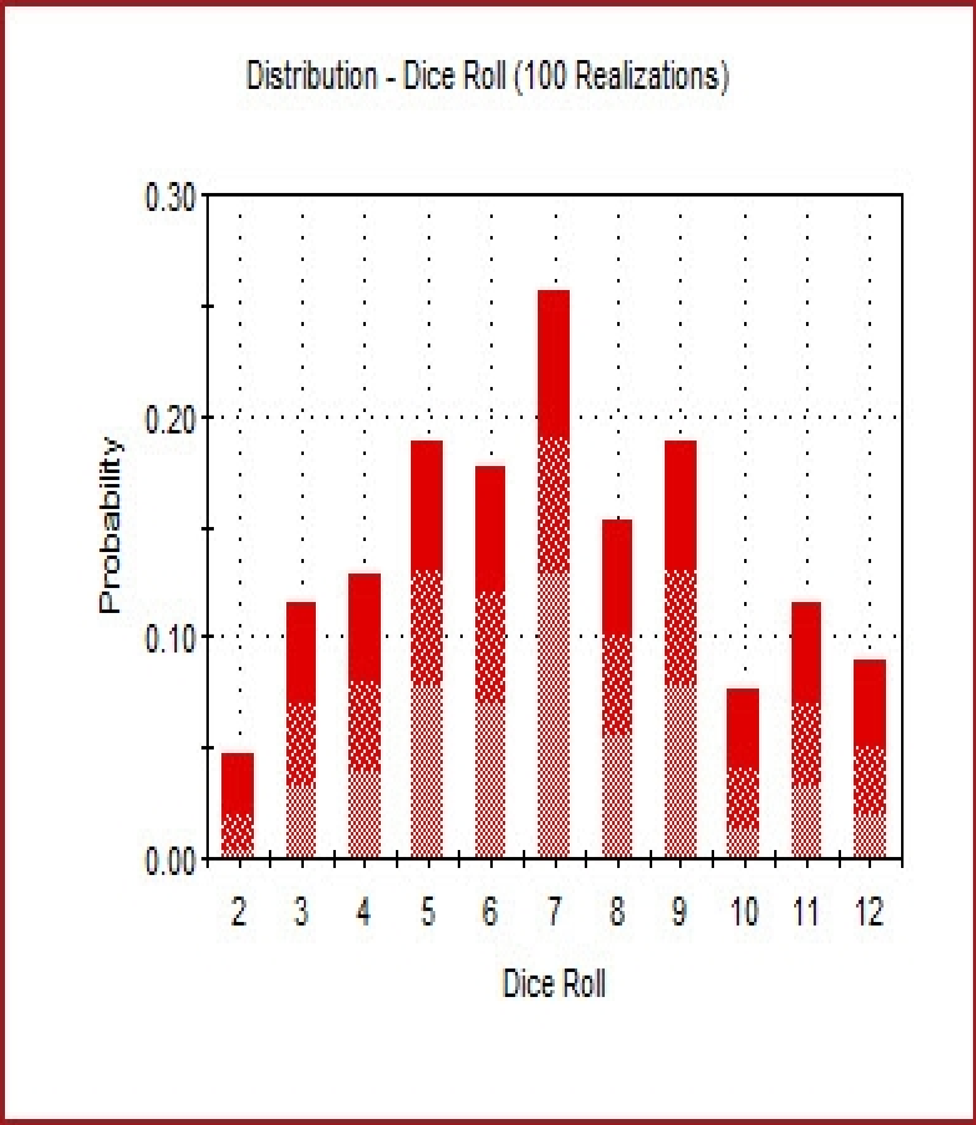
which utilizes sequences of random numbers

Monte Carlo

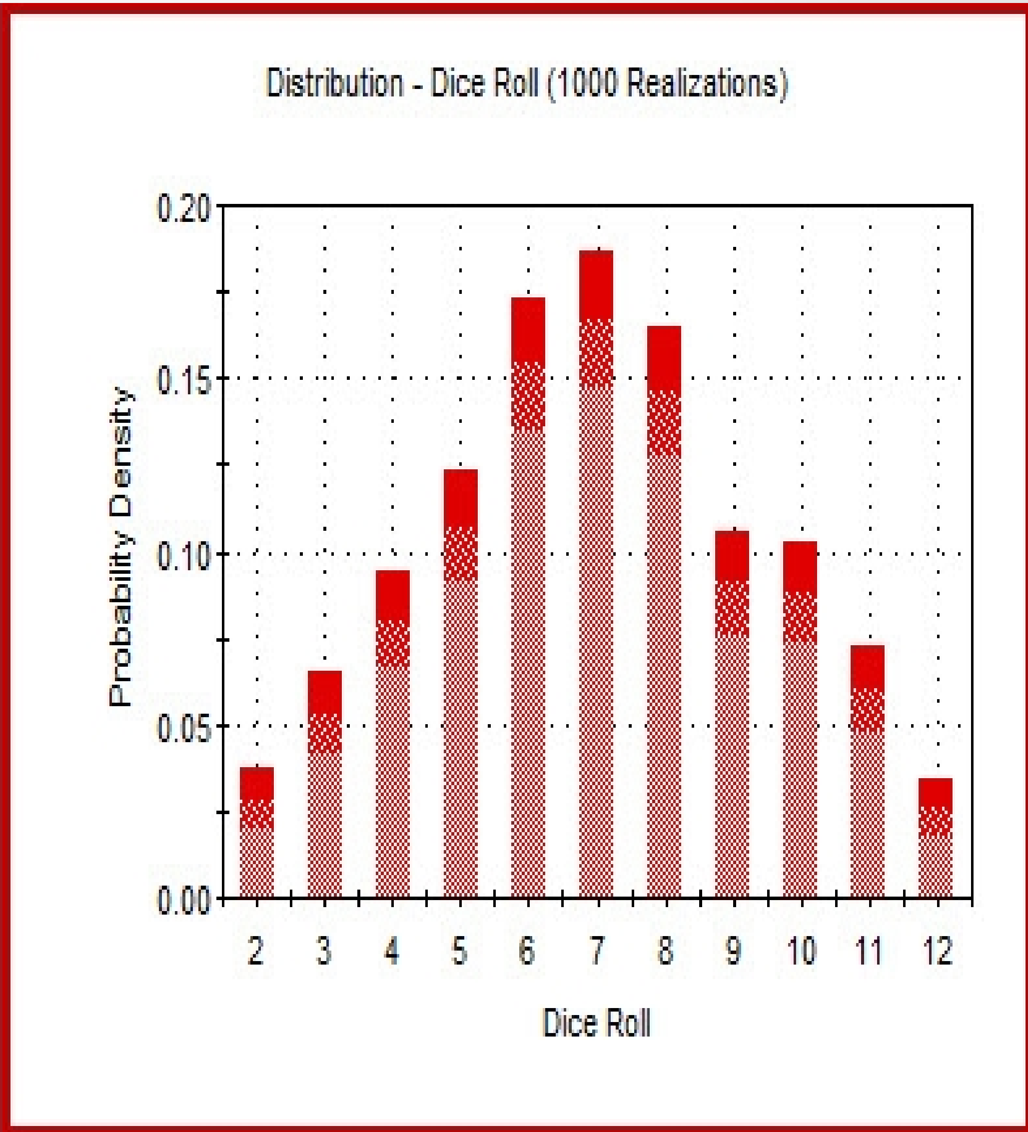
- Toplamı 7 gelme olasılığı   6 / 36 = 0.167.



Monte Carlo



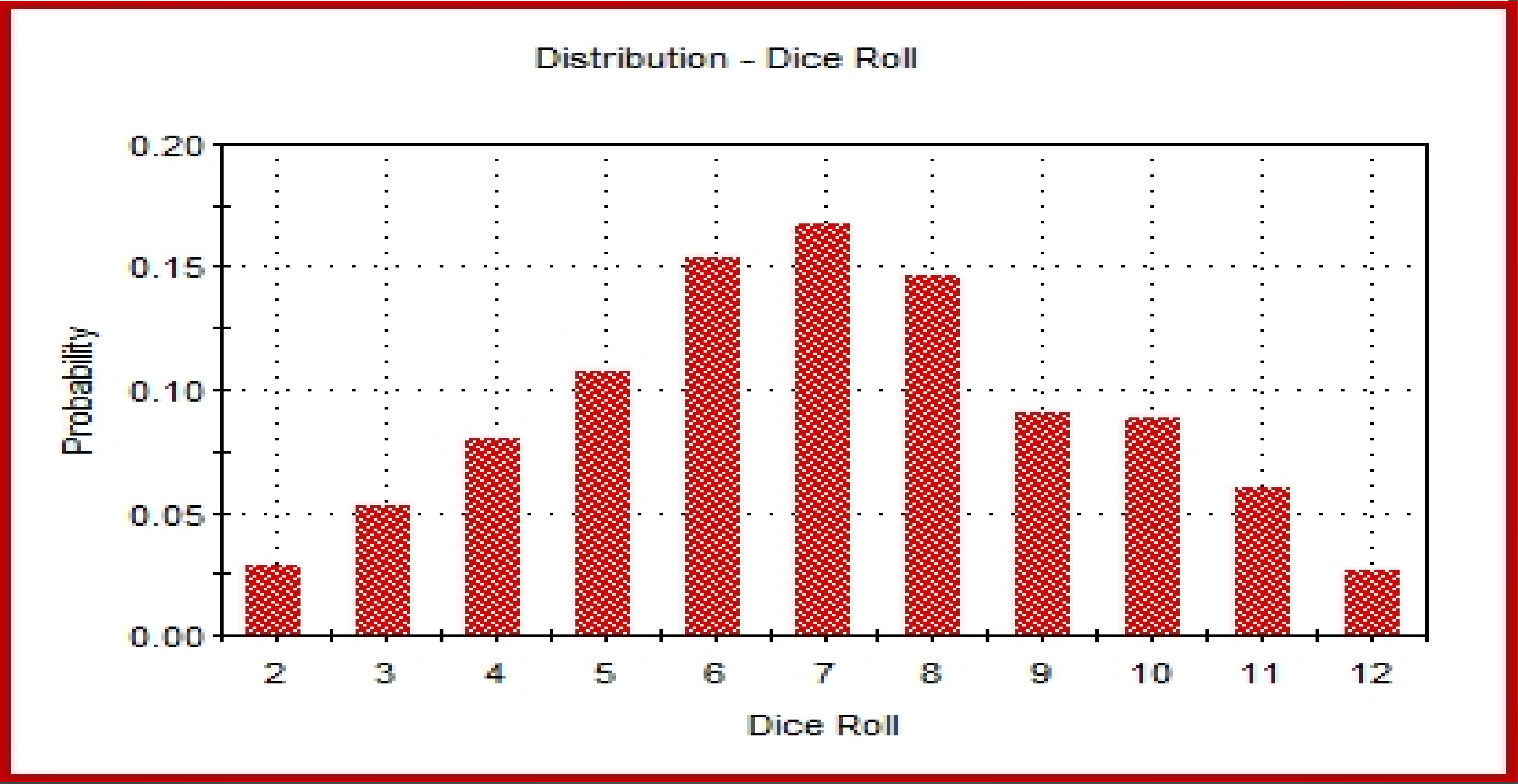
Distribution - Dice Roll (100 Realizations)
0.30
0.20
0.10
0.00
Probability
2
3
4
5
6
7
8
9
10
11
12
Dice Roll



Distribution - Dice Roll (1000 Realizations)
0.20
0.15
0.10
0.05
0.00
Probability Density
2
3
4
5
6
7
8
9
10
11
12
Dice Roll

Monte Carlo

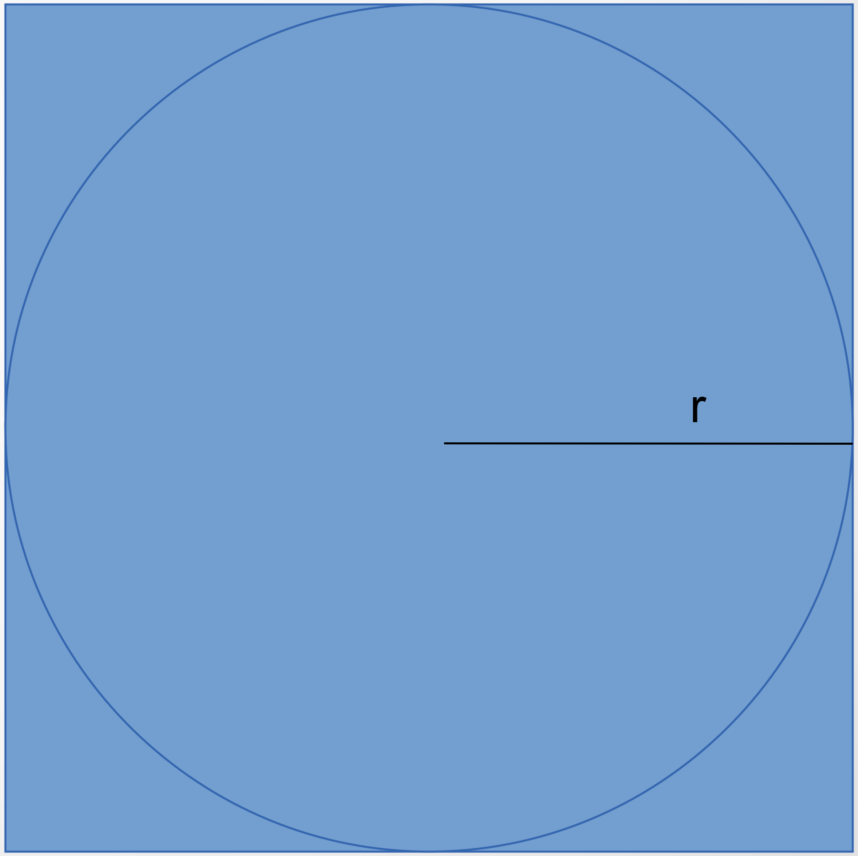
- 10.000



Monte Carlo

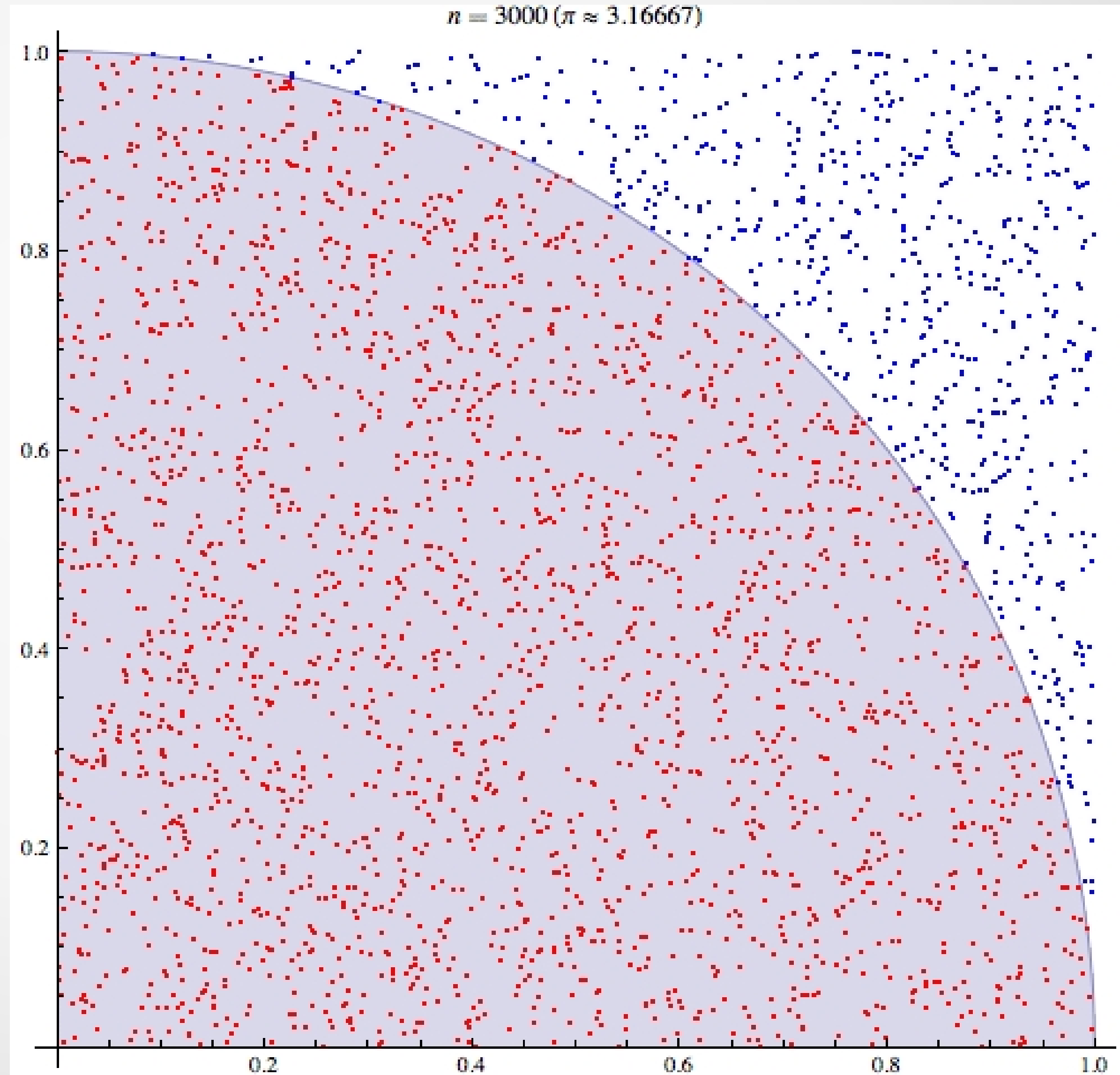
- Daire alanı = pi * r ^ 2
- Kare alanı = (2*r) ^ 2

- Olasılık = pi / 4



Monte Carlo

- Monte Carlo method applied to approximating the value of π.
- After placing 30000 random points, the estimate for π is within 0.07% of the actual value.



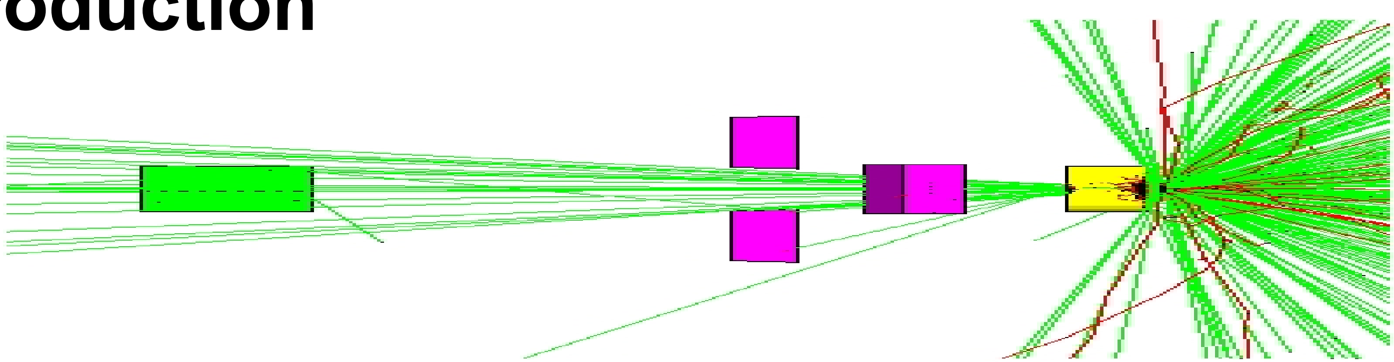
Monte Carlo

Processes

Multiple scattering
Bremsstrahlung
Ionisation
Annihilation
Photoelectric effect
Compton scattering
Rayleigh effect
γ conversion
e^+e^- pair production

Particle

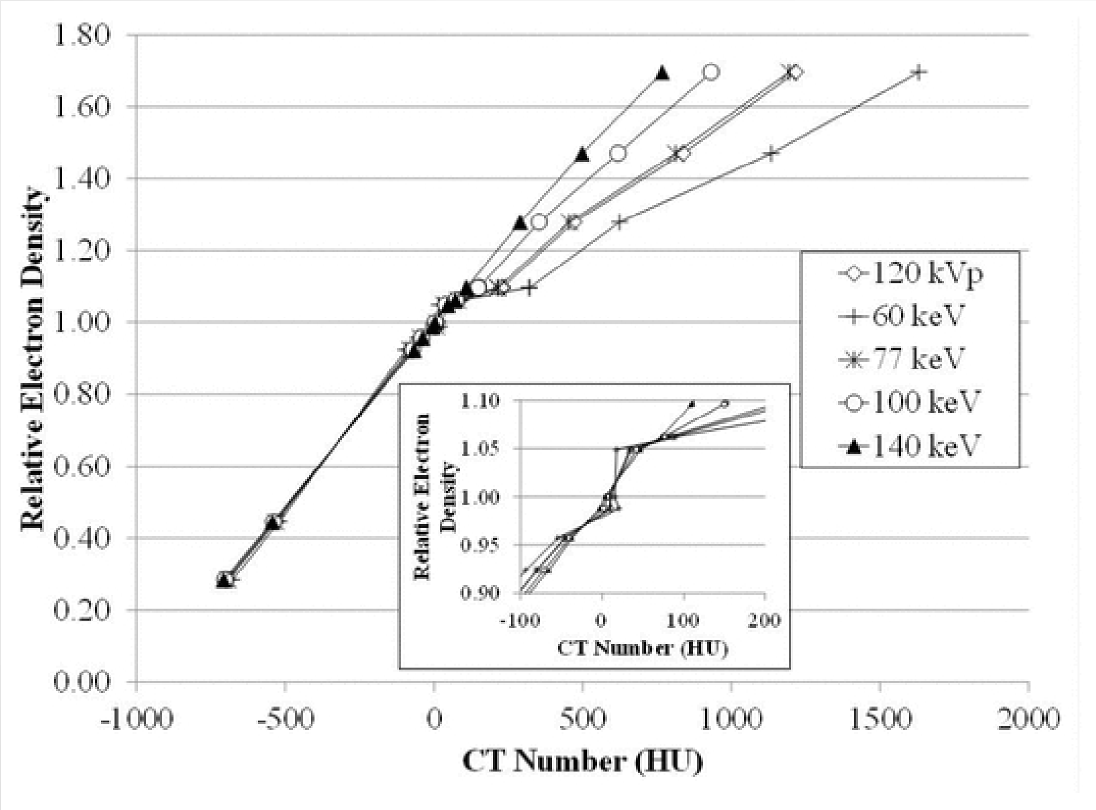
e-
e+
γ

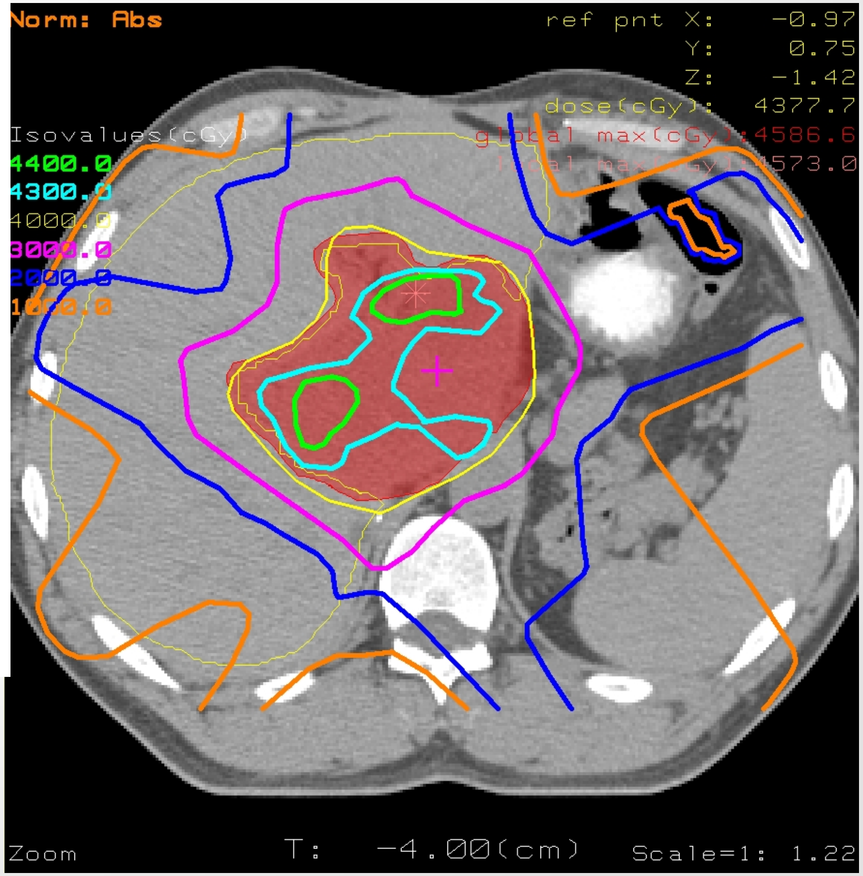


Monte Carlo

Monte Carlo

- Dicom (Hava, Yağ, Kemik, Implant...)





Neden MC?

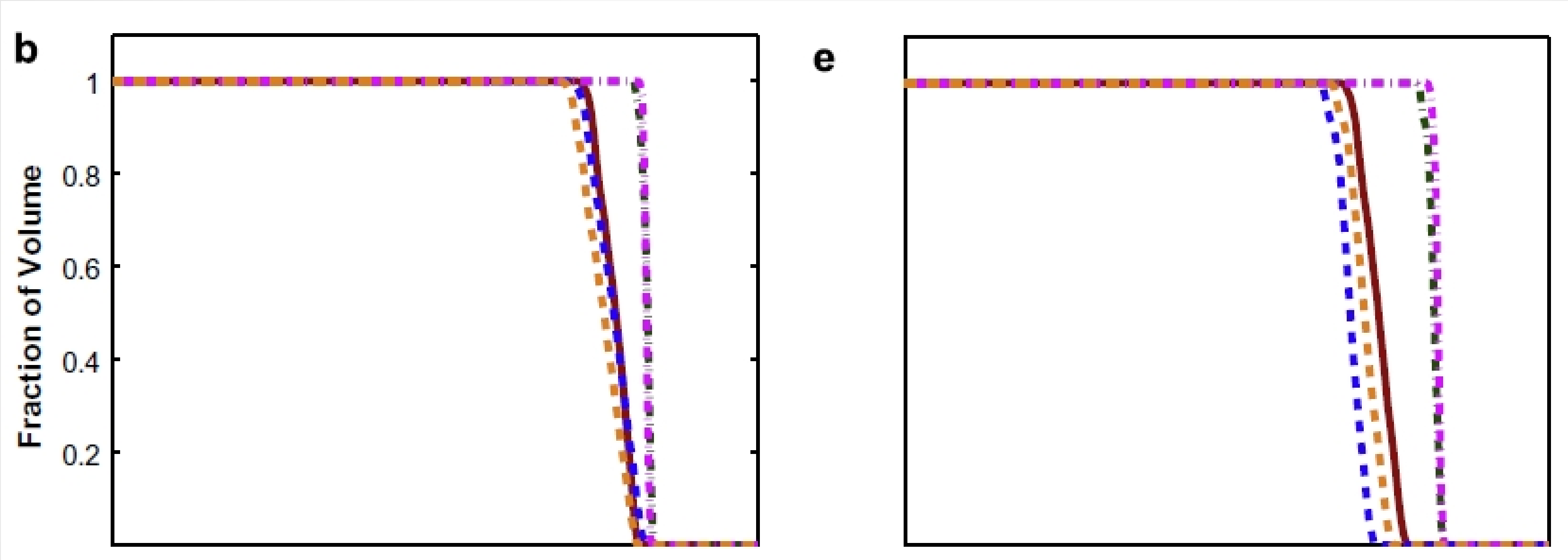
Neden MC?

Neden MC?

Neden MC?

Neden MC?

Neden MC?



Genel Amaçlı Kodlar

- Beam Model
  - BEAMnrc
  - MCNP
  - GEANT4
  - Penelope

- Hasta dozu için özelleşmiş
  - Peregrine
  - VMC/XVMC
  - DPM
  - MCDose

Ticari Sistemler

- CMS Monaco

Algorithm: source model. 3D conformal, IMRT (SMLC & DMLC) and VMAT . No wedges

- Accuray Multiplan

Algorithm, source model. Radiosurgery specific

- Brainlab iPlan

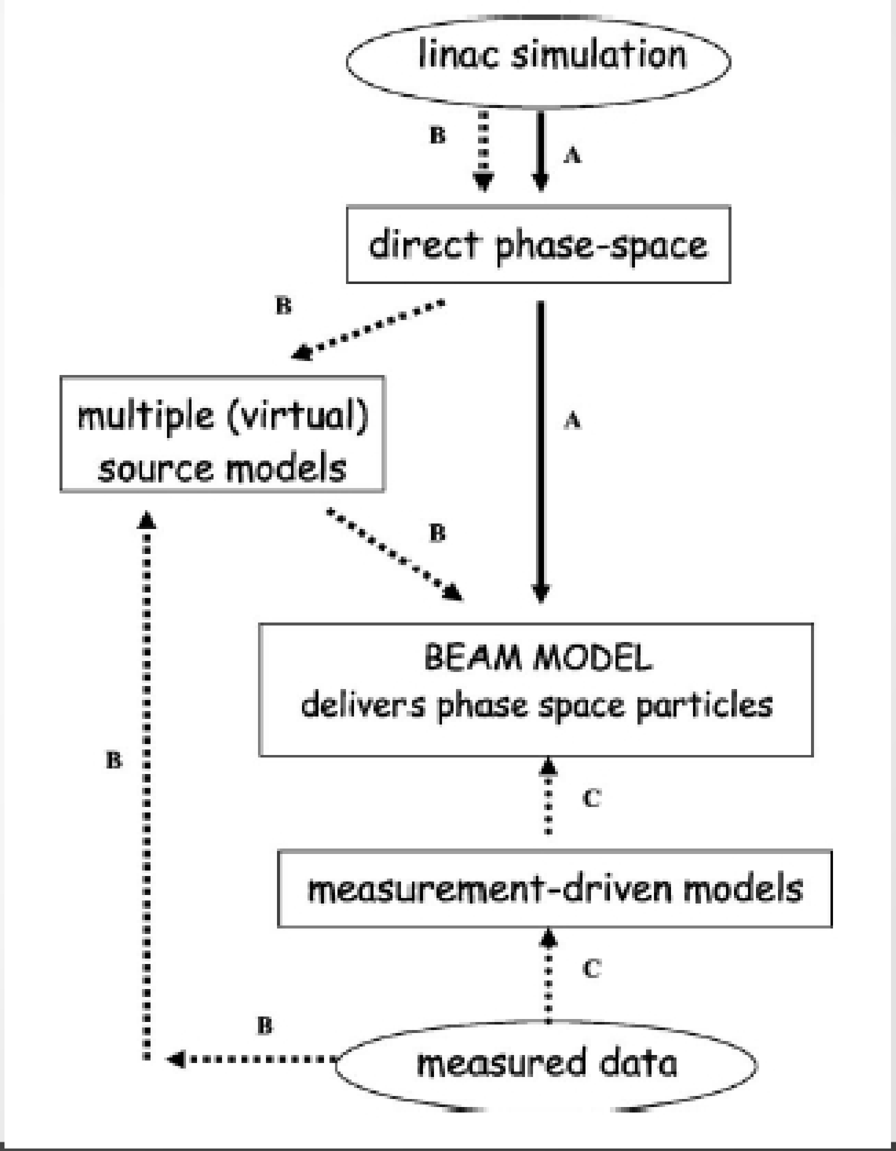
Algorithm: source model 3D conformal, IMRT (SMLC & DMLC) and VMAT. No wedges

Linac Beam Modelling

- Direkt Faz Uzayı Sim.
- Virtual source model

  (Faz Uzayı Simülasyonu)
- Virtual source model

  (Ölçümler)



Commissioning

Data for beam Characterization specified by the vendor

(Fraass et al, AAPM TG-53, Das et al, AAPM TG 106)

- CAX pdd & profile scans in water: square fields (1x1 to 40x40

  cm2), rectangular fields, Diagonal profile scans in water

- Output factors in water

- Absolute dose in water (linac calibration geometry)

Commissioning

İki Aşamalı Test

1. Radiation output from the linear accelerator

   - Işın (kare alanlar, doz verimi,)

   - Işın şekillendiriciler

2. Homojen ve Heterojen Geometriler ile Doz Doğrulanması

Commissioning

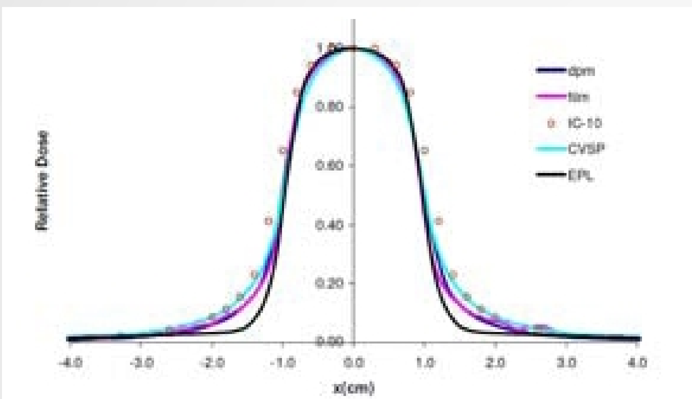
Build-up

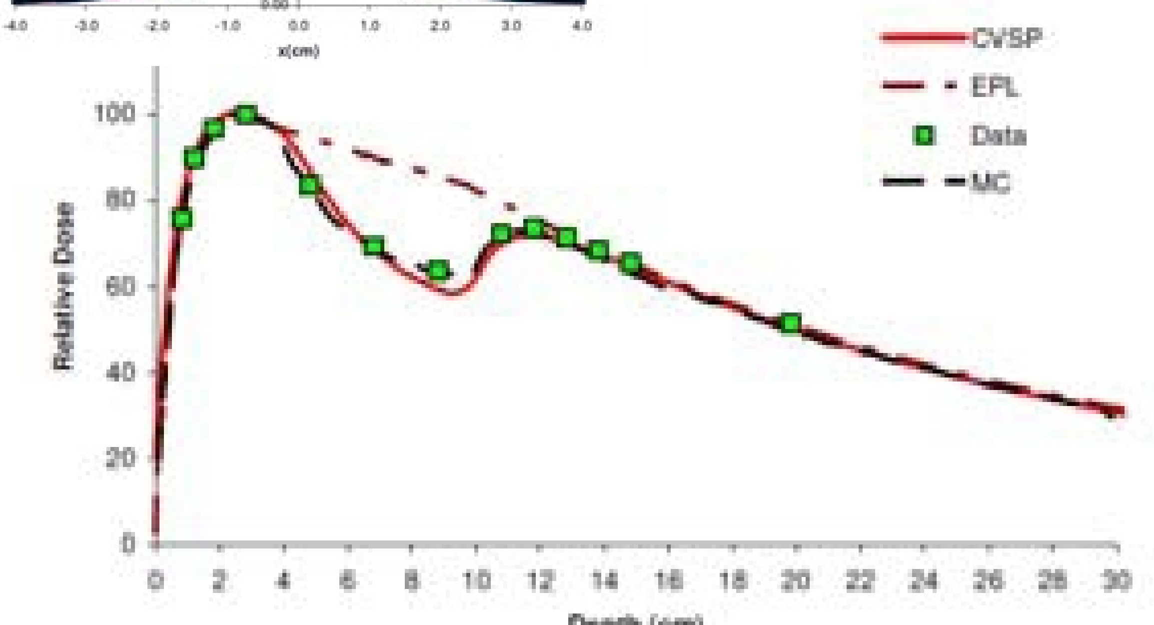
Build-up

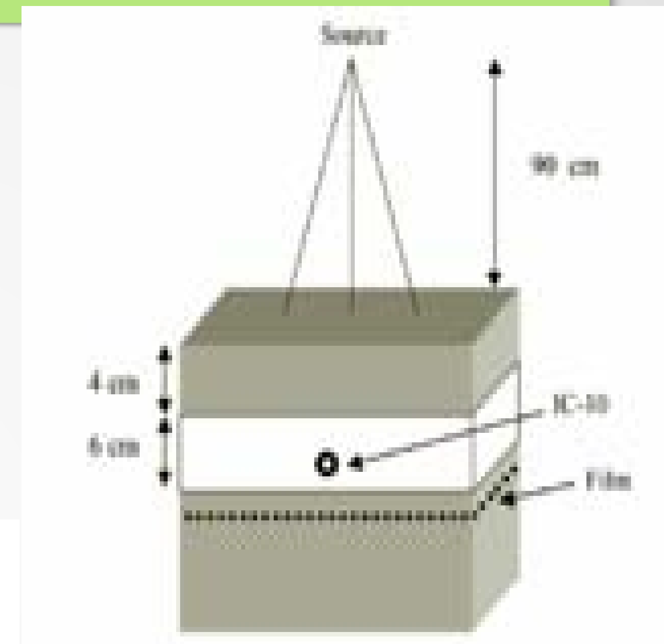
Heterojen Fantom

Heterojen Fantom

- Tyagi et.al Phys. Med. Biol. 2006







Nerelere gidelim?

- NCI Report

Fraass et al, “Summary and recommendations of a National Cancer Institute workshop on issues limiting the clinical use of Monte Carlo dose calculation algorithms for megavoltage external beam radiation therapy”,

Med Phys 30 (12), 3206-16 (2003)

Med Phys. 2003 Dec;30(12):3206-16.

Summary and recommendations of a National Cancer Institute workshop on issues limiting the clinical use of Monte Carlo dose calculation algorithms for megavoltage external beam radiation therapy.

Fraass BA[1], Smathers J, Deye J.

Author information

[1]Department of Radiation Oncology, University of Michigan, Ann Arbor, Michigan, USA.

Abstract

Due to the significant interest in Monte Carlo dose calculations for external beam megavoltage radiation therapy from both the research and commercial communities, a workshop was held in October 2001 to assess the status

Nerelere gidelim?

- AAPM Task Group Report 105

  Chetty et al, “Issues associated with clinical implementation of Monte Carlo-based treatment planning: Report of the AAPM Task group No 105”, Med Phys (Med. Phys. 34, 2007)

Report of the AAPM Task Group No. 105: Issues associated with clinical implementation of Monte Carlo-based photon and electron external beam treatment planning

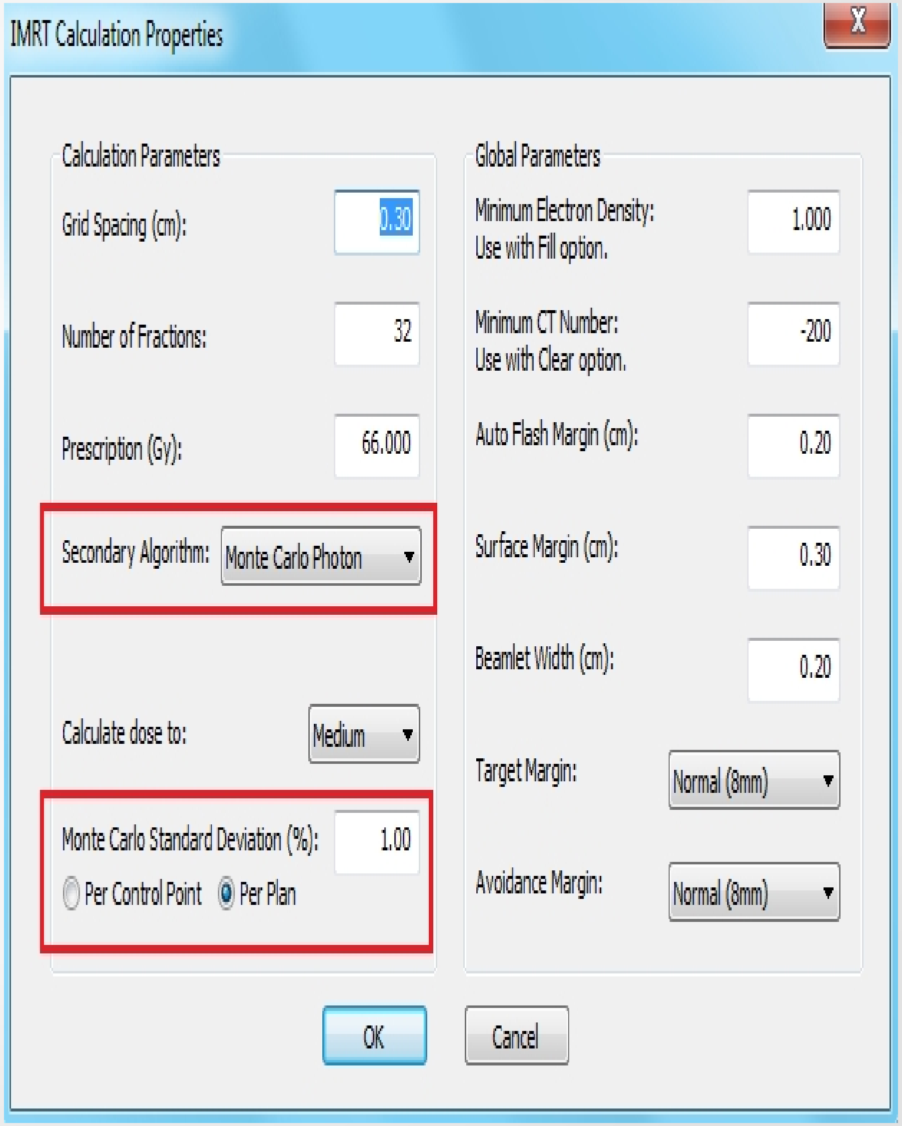
Indrin J. Chetty[a)]
University of Michigan, Ann Arbor, Michigan 48109
and University of Nebraska Medical Center, Omaha, Nebraska 68198-7521

Bruce Curran
University of Michigan, Ann Arbor, Michigan 48109

Joanna E. Cygler
Ottawa Hospital Regional Cancer Center, Ottawa, Ontario K1H 1C4, Canada

Ticari Sistemler

- Girdiler
  - Voxel boyutu
  - Dose 2 water /
    Dose 2 medium
  - Belirsizlik
    (segment veya plan)



İstatistik Belirsizlik

- Belirsizlik Kaynakları
  - Tedavi Kafasından kaynaklananlar

    (sadece Faz Uzayı tabanlı modeller)
  - Hasta datasından kaynaklananlar

İstatistik Belirsizlik

HU – materyal dönüşüm

- Konvansiyonel TPS algoritmaları HU – relatif elektron dansitesi dönüşüm tabloları üzerinden çalışırlar

- MC simülasyonlarındaki parçacık etkileşimleri için hem materyal dansiteleri hem de kompozisyonları iyi bilinmelidir.

HU – materyal dönüşüm

INSTITUTE OF PHYSICS PUBLISHING PHYSICS IN MEDICINE AND BIOLOGY

Phys. Med. Biol. **50** (2005) 937–946 doi:10.1088/0031-9155/50/5/016

Sensitivity study for CT image use in Monte Carlo treatment planning

Frank Verhaegen and Slobodan Devic

Medical Physics Department, McGill University, Montreal General Hospital,
1650 Cedar Avenue, Montreal, Québec H3G1A4, Canada

- 6MV fotonda %10
- 18MeV elekt. %30

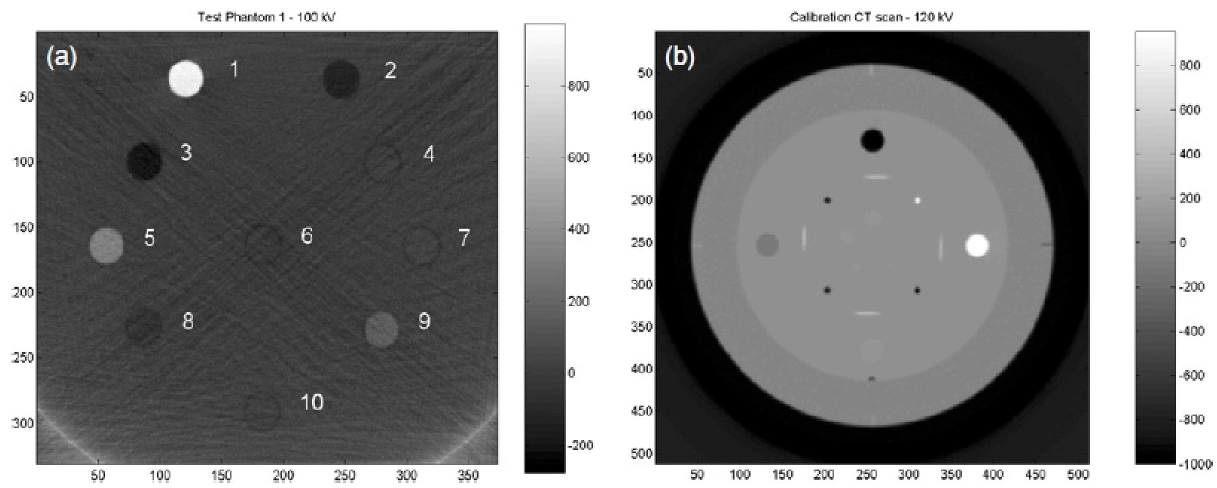


Figure 1. Test phantom (a) and calibration phantom *Catphan* (b) used in this work. The *Catphan* phantom consists of water equivalent material with cylindrical insets. In this work, the four large cylinders were used for calibration which consist of (clockwise starting from top) air, Teflon ($\rho = 2.16$ g cm^{-3}), PMMA ($\rho = 1.18$ g cm^{-3}) and low-density polyethylene ($\rho = 0.92$ g cm^{-3}).

HU – materyal dönüşüm

INSTITUTE OF PHYSICS PUBLISHING PHYSICS IN MEDICINE AND BIOLOGY

Phys. Med. Biol. **52** (2007) 539–562 doi:10.1088/0031-9155/52/3/001

Conversion of CT numbers into tissue parameters for Monte Carlo dose calculations: a multi-centre study

Barbara Vanderstraeten[1], Pik Wai Chin[2], Michael Fix[3], Antonio Leal[4], Grisel Mora[5], Nick Reynaert[1], Joao Seco[6], Martin Soukup[7], Emiliano Spezi[8], Wilfried De Neve[9] and Hubert Thierens[1]

- D2M / D2W

clinical patient cases in a European multi-centre study. The observed local relative differences in dose to medium were mostly smaller than 5%. The dose–volume histograms of both targets and organs at risk were comparable, although within bony structures D_{14} was found to be slightly but systematically higher than D_5. Converting dose to medium to dose to water (D_{14} to D_{14wat} and D_5 to D_{5wat}) resulted in larger local differences as D_{5wat} became up to 10% higher than D_{14wat}. In conclusion, multiple bone bins need to be introduced when Monte Carlo (MC) calculations of patient dose distributions are converted to dose to water.

HU – materyal dönüşüm

HU – materyal dönüşüm

IOP PUBLISHING PHYSICS IN MEDICINE AND BIOLOGY

Phys. Med. Biol. 53 (2008) 2439–2456 doi:10.1088/0031-9155/53/9/015

Dual-energy CT-based material extraction for tissue segmentation in Monte Carlo dose calculations

Magdalena Bazalova[1], Jean-François Carrier[2,3], Luc Beaulieu[4,5] and Frank Verhaegen[1]

- 100 ve
- 140 kvp

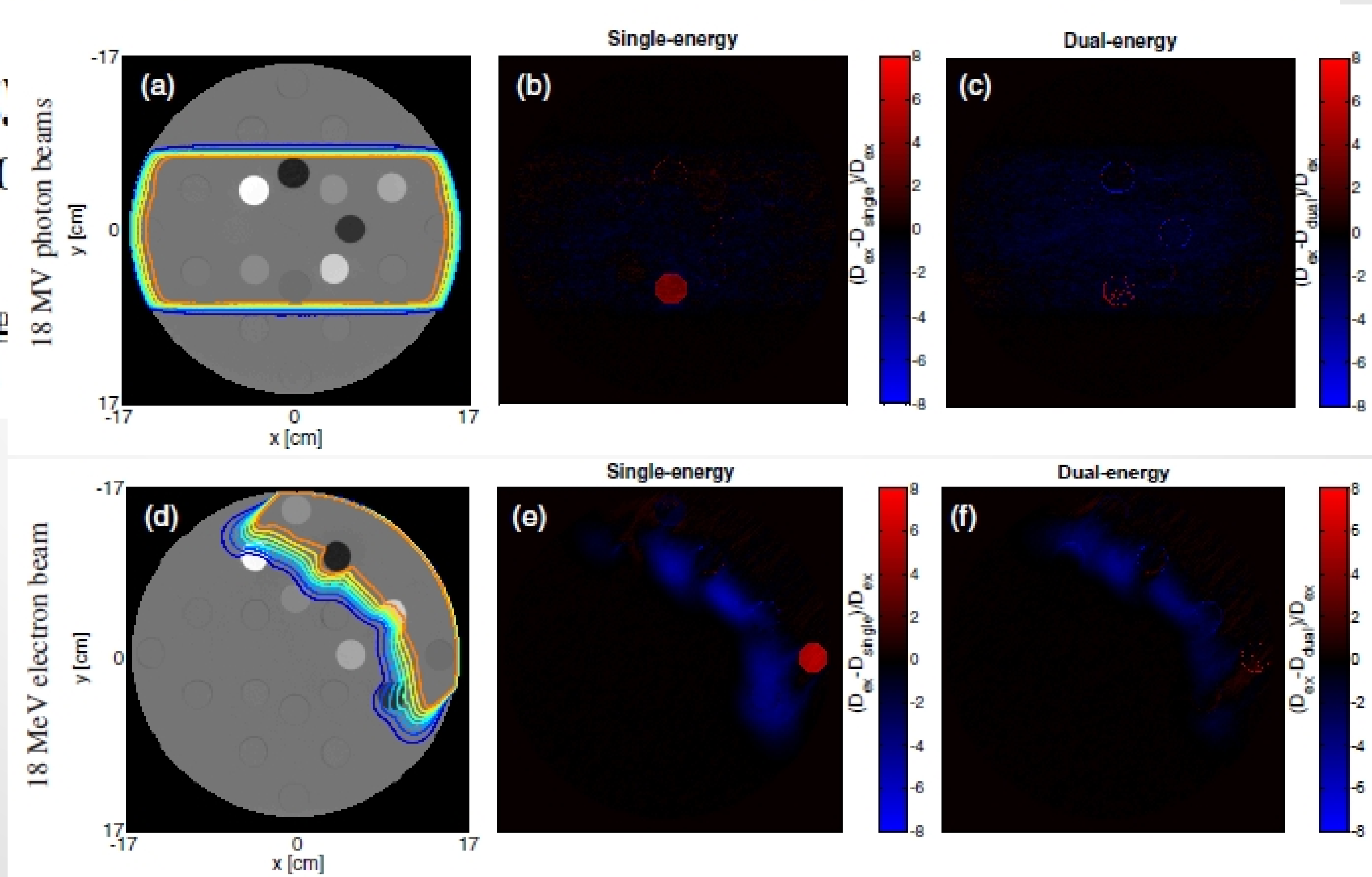
HU – materyal dönüşüm

IOP PUBLISHING PHYSICS IN MEDICINE AND BIOLOGY

Phys. Med. Biol. 53 (2008) 2439–2456 doi:10.1088/0031-9155/53/9/015

Dual-energ
segmentati

Mag
and



- 100 ve
- 140 kvp

Dose to Medium

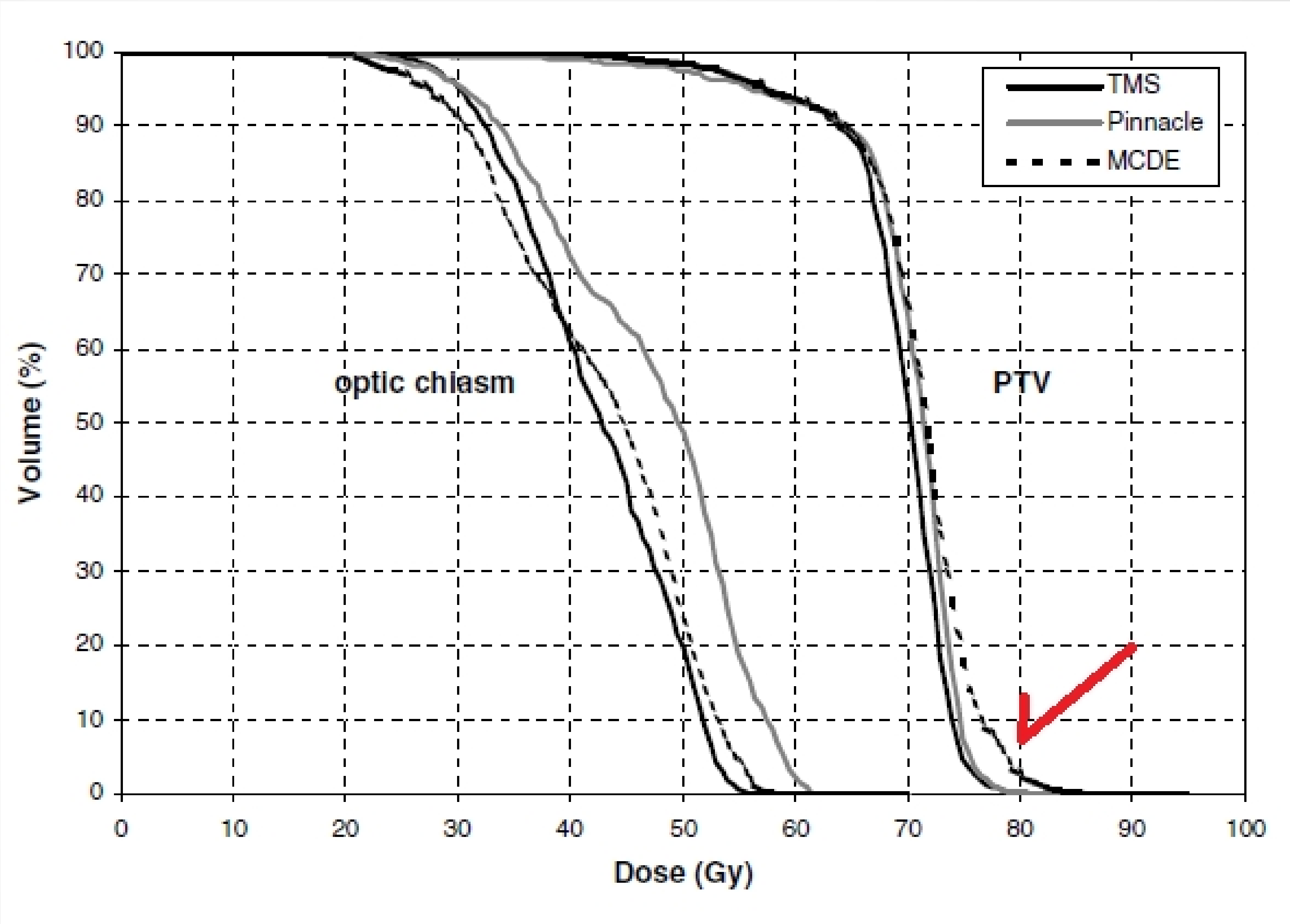
Dose to Medium

Dose to Medium

Klinik Önemi

Klinik Önemi

- Sp conv, MCDE
- Kuyruk, sıcak nokta



Klinik Önemi

Klinik Önemi

Klinik Önemi

Klinik Önemi

Monte Carlo

Monte Carlo

Monte Carlo

Monte Carlo

Monte Carlo

Monte Carlo

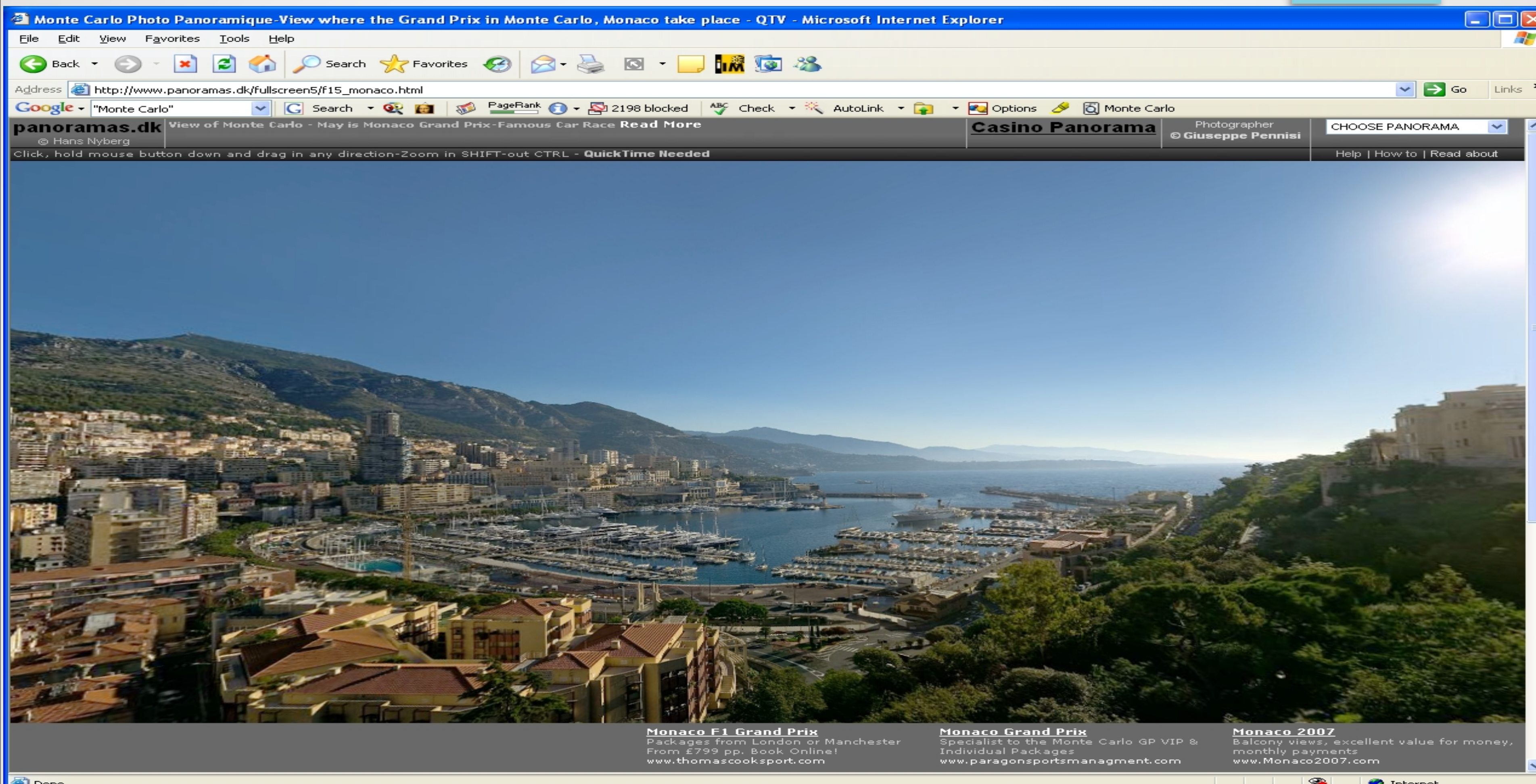
Özgür yazılımlar

Özgür yazılımlar

Sonuç

- Klinik uygulama bakış açısından Monte Carlo metoduna, diğer tüm konvansiyonel doz hesaplama algoritmaları ile aynı şekilde yaklaşılmalıdır.
- Klinikte çalışan fizikçilerin algortimanın temellerini anlamaları ve klinik uygulamada karşılaşılabilecek eksiklerden haberdar olmaları gerekmektedir.

Monte Carlo



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