AAPM 2021
JULY 25–29 | VIRTUAL
63RD ANNUAL MEETING & EXHIBITION

CREATIVE SCIENCE. ADVANCING MEDICINE.

Symposium:
In Memoriam of
John Robert (Jack) Cunningham:
Celebrating the Life and Contributions of Jack Cunningham - A "Tour de Force"

Western

MPWB

Speakers/Titles

- Jacob Van Dyk
  - Jack Cunningham and Treatment Planning from the 1960s Through the 2000s
- Jerry J Battista
  - Conceptual Overview of Megavoltage Photon Dose Calculation Algorithms
- David W O Rogers
  - Monte Carlo Modelling for Radiation Dosimetry and Treatment Planning
- Anders Ahnesjo
  - Dose and Beyond in Treatment Planning Calculations
- T Rock Mackie
  - The Future of Treatment Planning

Jack Cunningham and Treatment Planning from the 1960s through the 2000s

Schulich MEDICINE & DENTISTRY Western

Jacob (Jake) Van Dyk
Professor Emeritus
Western University, London, Ontario, Canada
Former President, MPWB

Medical Physics for World Benefit
www.MPWB.org
Working together for effective patient care

28 July 2021

John Robert (Jack) Cunningham, O.C., B.Eng., M.Sc., Ph.D., FCCPM, FAAPM, FCOMP. 1927–2020

- 1927: Born, Regina, Saskatchewan
- 1945-50. B. Eng. Univ. Saskatchewan, Saskatoon
- 1948-50. Operated radon plant, Saskatoon
- 1950-51. Master's degree under Harold Johns
  - Electron range-energy data from betatron
- 1951-53. Grain Research Laboratory, Winnipeg, Manitoba.
- 1953-55. Ph.D. in Physics, Univ Toronto
  - Polymer research using ultrasound
- 1955-58. Canadian Defense Research Board, Ottawa
  - On "Effects of Nuclear Weapons."
- 1958-64. Chief of Clinical Physics, OCI/PMH, Toronto
- 1964-65. Consultant, IAEA, Ceylon (Sri Lanka)
  - Advisor in Medical Physics and Radiation Protection
- 1965-89. Chief, Clinical Physics, OCI/PMH, Toronto
- 1989-98. Consultant, Theratronics Inter'l Ltd/ MDS Nordion, Ottawa
- 1998-2020. Retired

JRC, Contributions, 1958-60

- Developments on cobalt-60 therapy machines

A PRECISION COBALT 60 UNIT FOR FIXED FIELD AND ROTATION THERAPY*

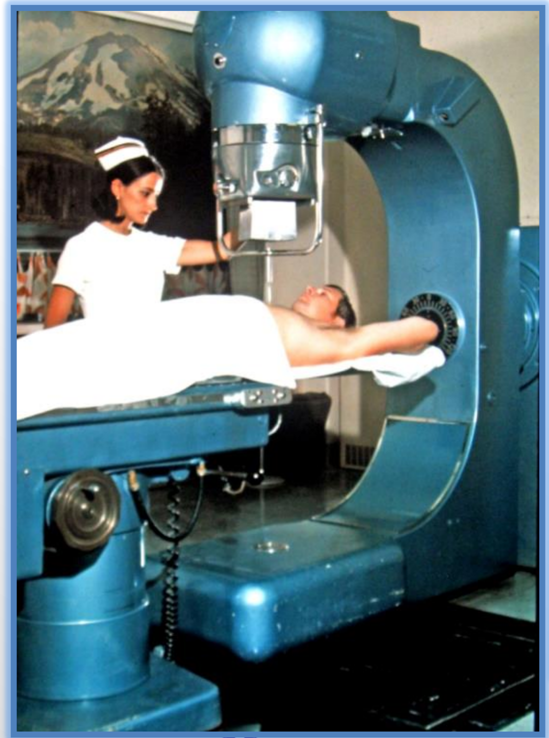
By H. E. JOHNS† and J. R. CUNNINGHAM
TORONTO, ONTARIO, CANADA

Am J Roentgen Rad Therapy & Nucl Med 91: 4-12; 1959

A DOUBLE HEADED COBALT 60 TELETHERAPY UNIT*

By J. R. CUNNINGHAM, PH.D.,† C. L. ASH, M.D.,‡ and H. E. JOHNS, PH.D.§
TORONTO, ONTARIO

Am J Roentgen Rad Therapy & Nucl Med 92: 202-206; 1964



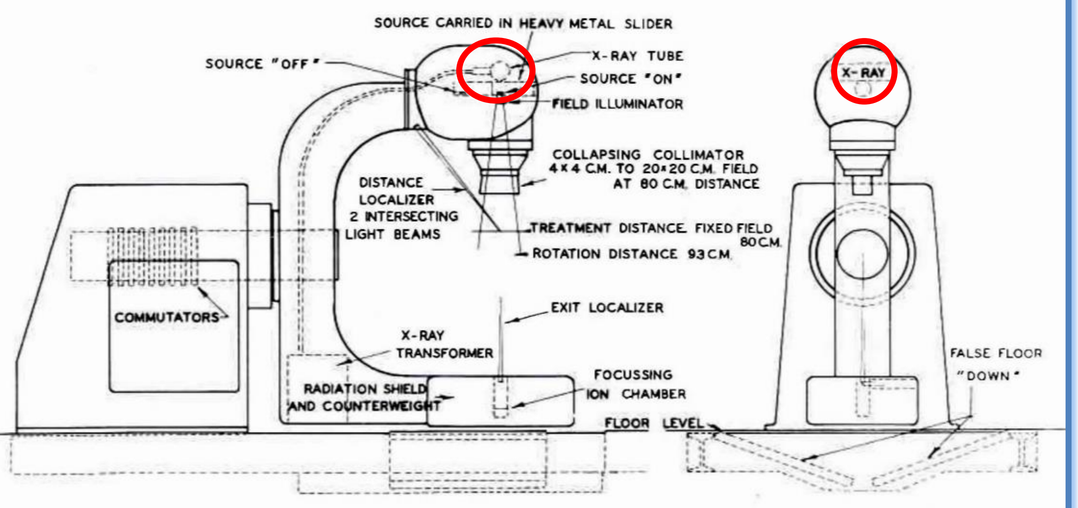
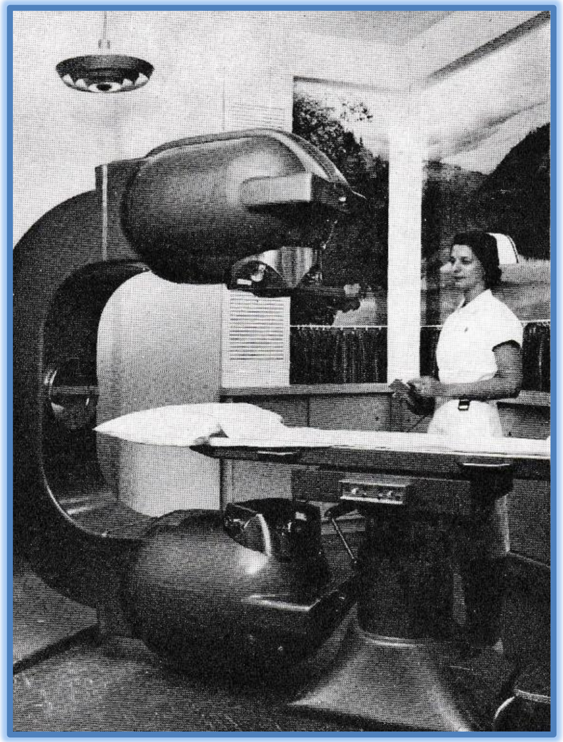


FIG. 1. A schematic diagram of the cobalt 60 unit showing the roentgenographic tube, the collapsing floor and the salient features of the device.

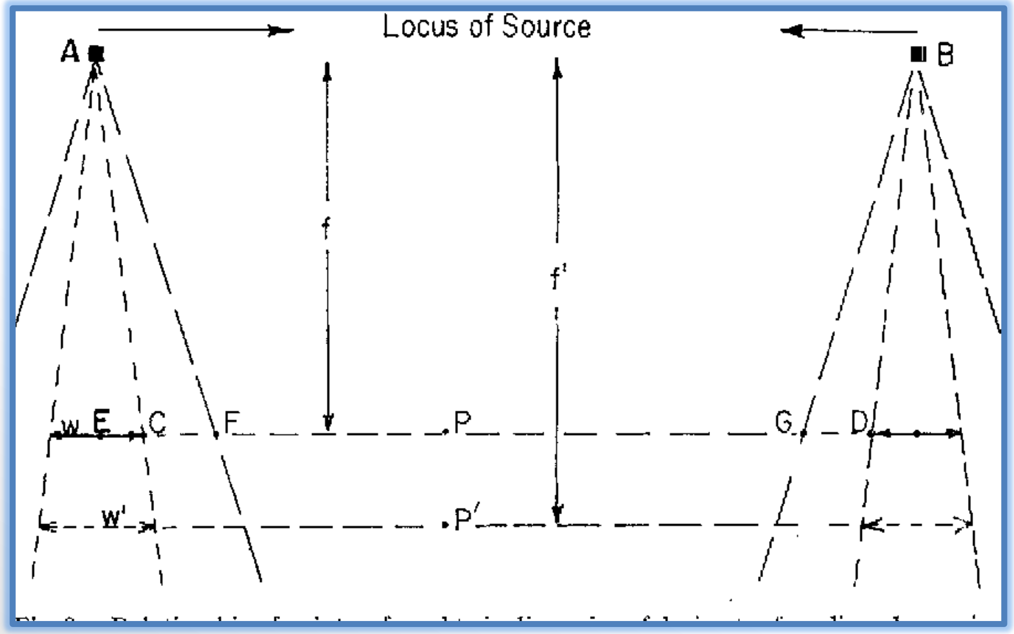


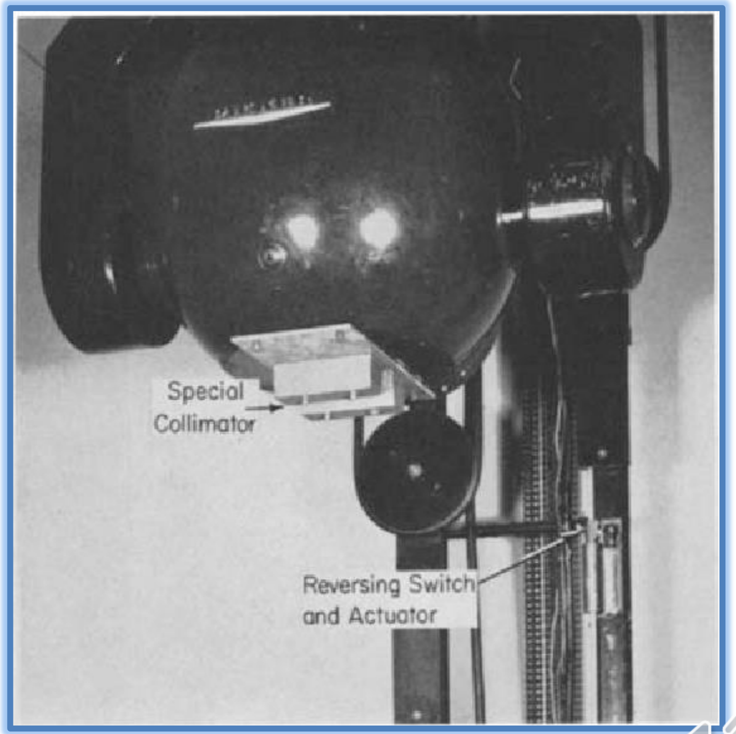
JRC, Contributions, 1962

A Simple Facility for Whole-Body Irradiation

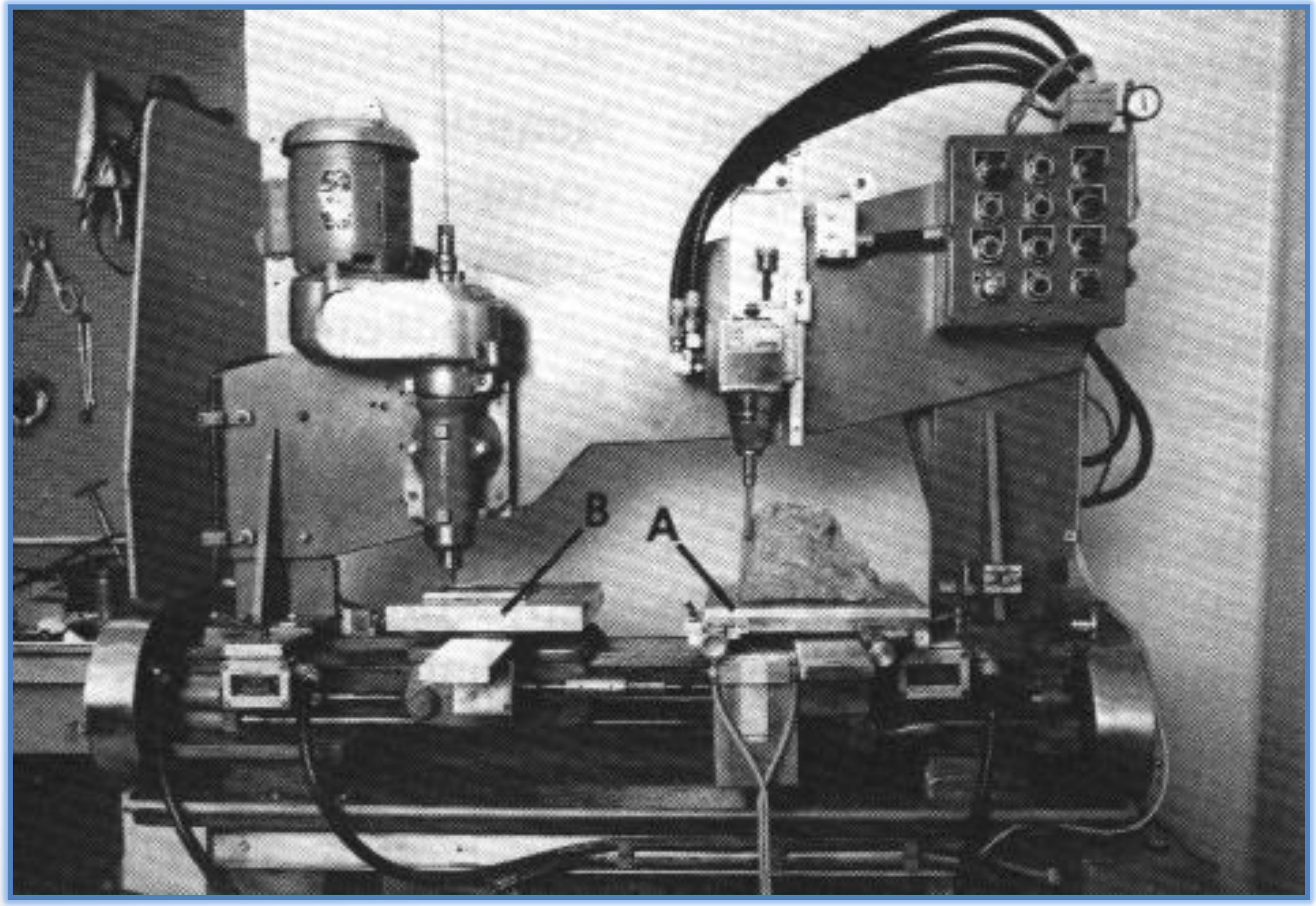
J.R. Cunningham and D.J. Wright

Radiology 78: 941-949; 1962



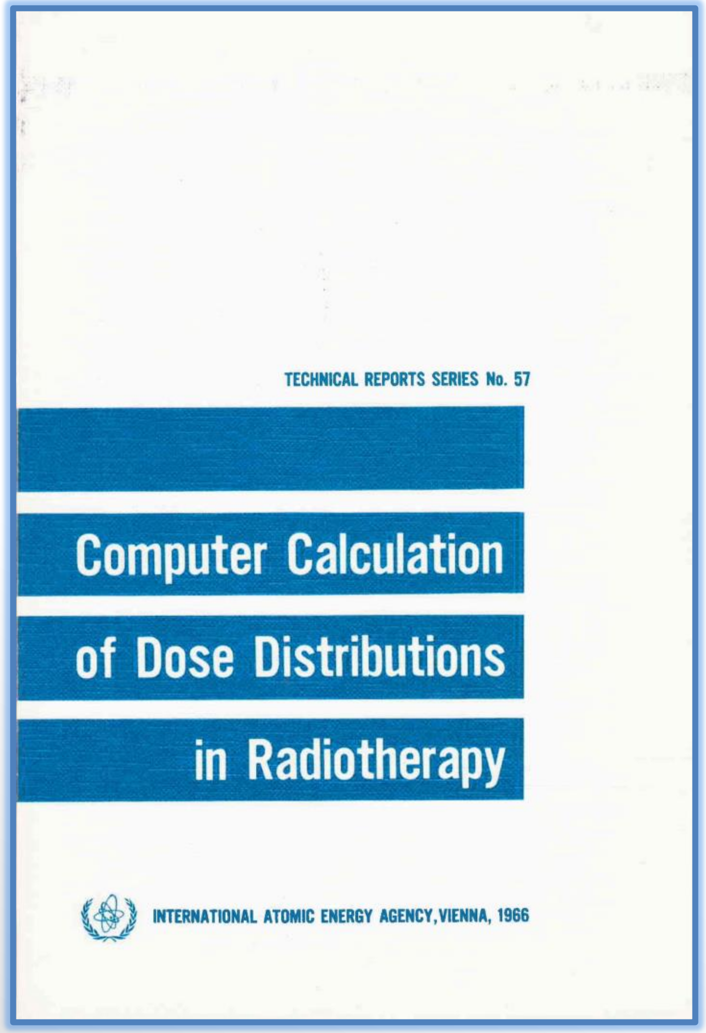


1960s. Compensator Cutter



Cunningham et al. Radiology 82: 130-131; 1964

1966



TECHNICAL REPORTS SERIES No. 57

Computer Calculation of Dose Distributions in Radiotherapy

INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA, 1966

COMPUTATION OF MULTIPLE AND MOVING BEAM DISTRIBUTIONS*

J. R. CUNNINGHAM
PHYSICS DIVISION, ONTARIO CANCER INSTITUTE,
TORONTO, ONT., CANADA

INTRODUCTION

Individual isodose distributions for moving beam therapy treatments are seldom drawn by hand due to the excessive amount of labour involved. Distributions have been produced either by direct measurement in a phantom or by using calculations based on fixed field isodose charts. Representative of the direct measurement technique is the work of Hultberg et al. (1959) who measured a very large number of distributions in a mix D phantom using Sievert ionization chambers.

Rather more numerous have been the attempts to develop a method for calculating the desired distributions. Manual preparation of a complete distribution usually involves the rather tedious procedure of laying a single field isodose chart over a contour at each of a series of angles and noting the contributions to a grid of points. Corrections for variations in SSD (source-to-surface distance) or contour shape must be calculated to weight the contribution to each point. Summation, normalization, interpolation, and curve plotting complete the procedure. Since the whole task must be repeated for each distribution required, this is a problem which lends itself to machine calculation.

Historically, we at the Ontario Cancer Institute embarked on a programme to precalculate sets of rotational isodose distributions in 1962 when it was realized that to study systematically and display the effects of changes in various parameters in rotation therapy it was necessary to use as few sources of primary data as possible and to compute all of the required distributions by a common and self-consistent method. This project was accordingly coupled with the aims of sub-committee III of the IAEA panel on "Physical Data for Dose Distributions with High Energy Radiation" (1960), of which the author was a member, to produce the majority of the isodose charts that are to be included in the Atlas (Tsien et al., in press). The computation method described in this paper is a refinement of the method that was used for that task.

Radiation in a phantom consists of primary and scattered radiation. The primary beam can sometimes be described by a simple analytical model, as in the case of a monoenergetic beam, but the scattered radiation is always complex. Over the years a number of concepts such as depth dose, tissue-air ratio, scatter functions and the extensive use of single-field isodose charts have been developed (Johns, 1961; H.P.A., 1961) to describe care-

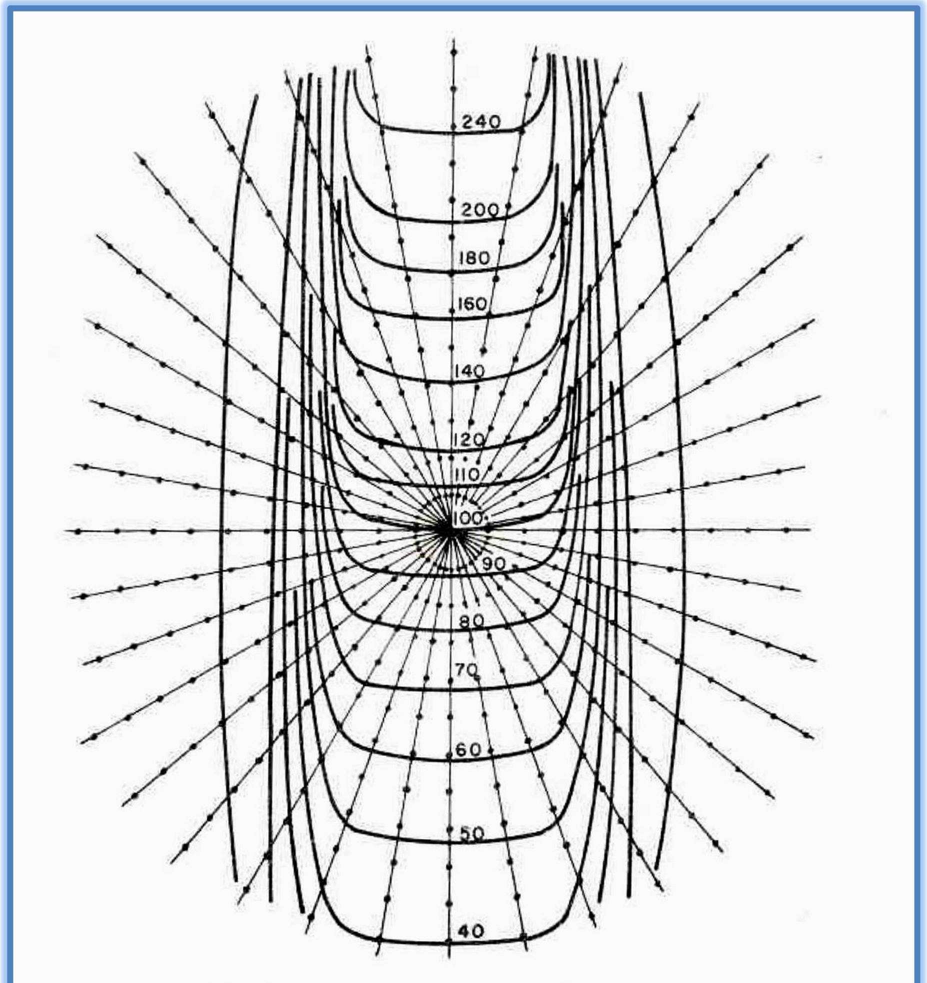


FIG.1. Isodose chart superposed on a polar grid of points

Describes SAR in Appendix

Measurement of tissue-air ratios and scatter functions for large field sizes, for cobalt 60 gamma radiation

By S. K. Gupta, B.A., M.Sc.,* and J. R. Cunningham, B.Eng., M.Sc., Ph.D.

Department of Physics, University of Toronto, and Physics Division, The Ontario Cancer Institute, Toronto, Canada

Br J Radiol 39: 7-11; 1966

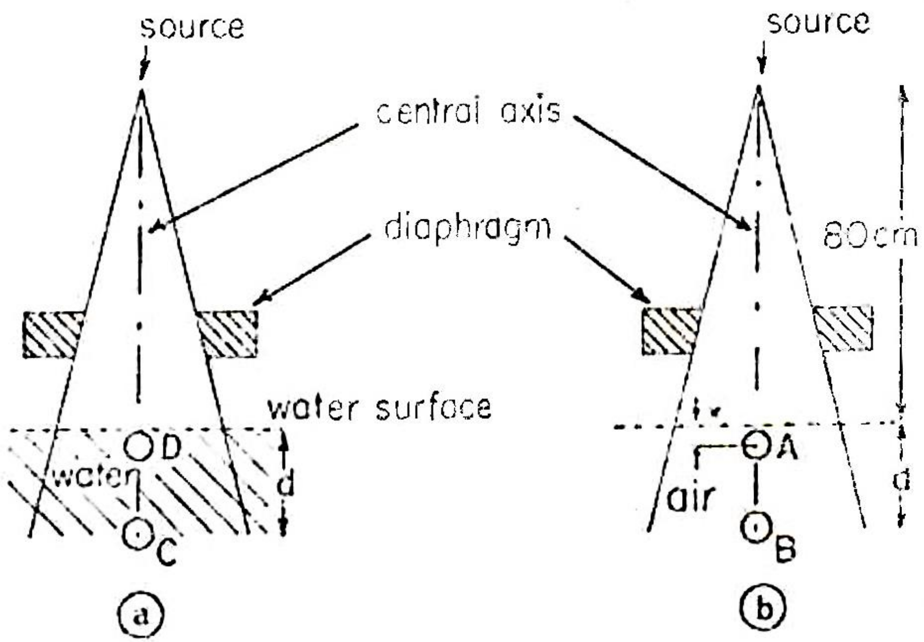
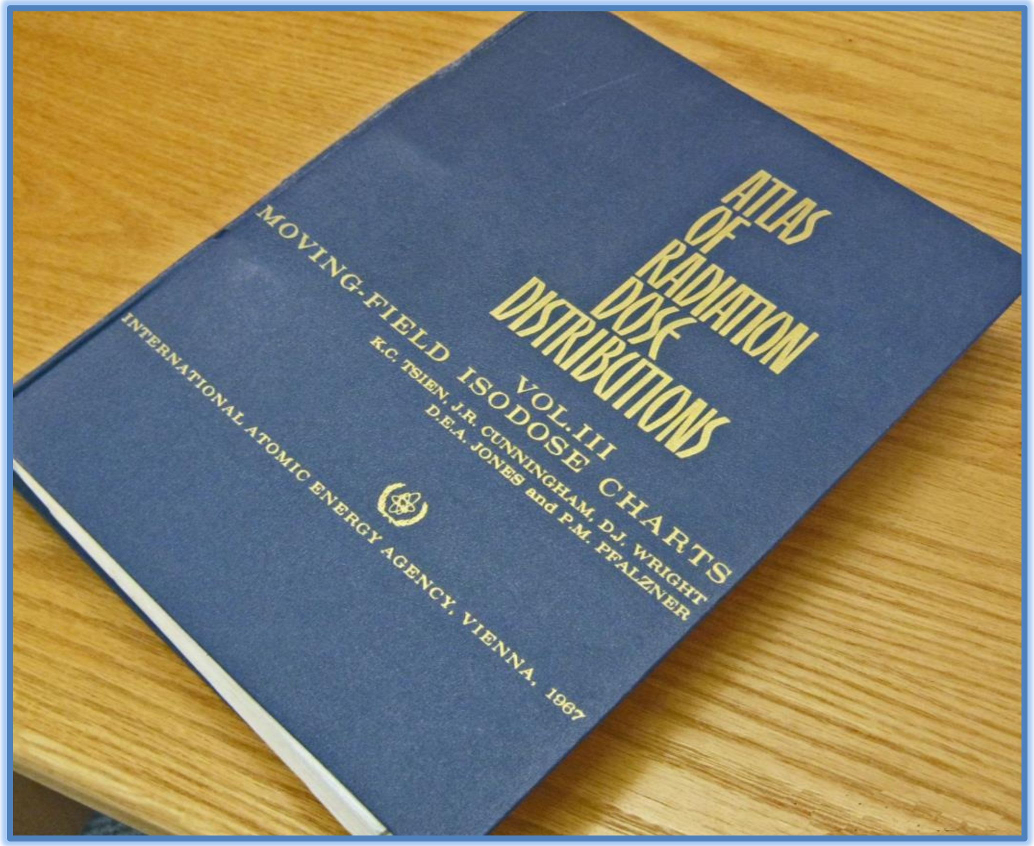


FIG. 1.

(a and b) Diagram showing irradiation conditions for the determination of tissue-air ratio, scatter function and scatter-air ratio.

1967

- IAEA Atlas of Radiation Dose Distributions:
  - Vol. 3, Moving field isodose charts. Tsien, Cunningham, Wright, Jones, Pfalzner, 1967



1967, First Computer for Radiation Therapy

The "PC"
- Programmed Console
- 12K memory

12K !!!

- Program and data storage on cards with magnetic strips
- Contour entry by a "rho-theta" tracing unit

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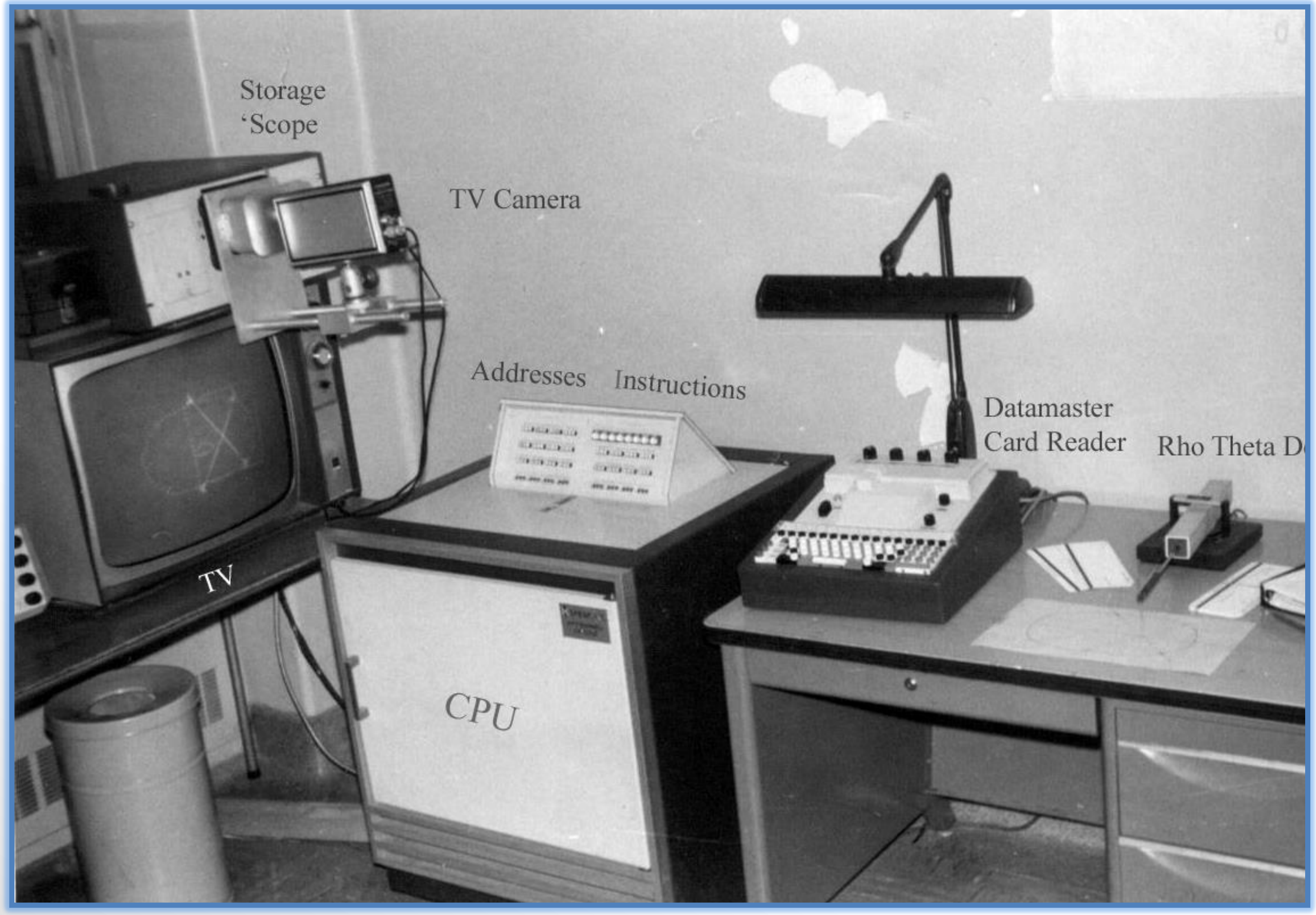
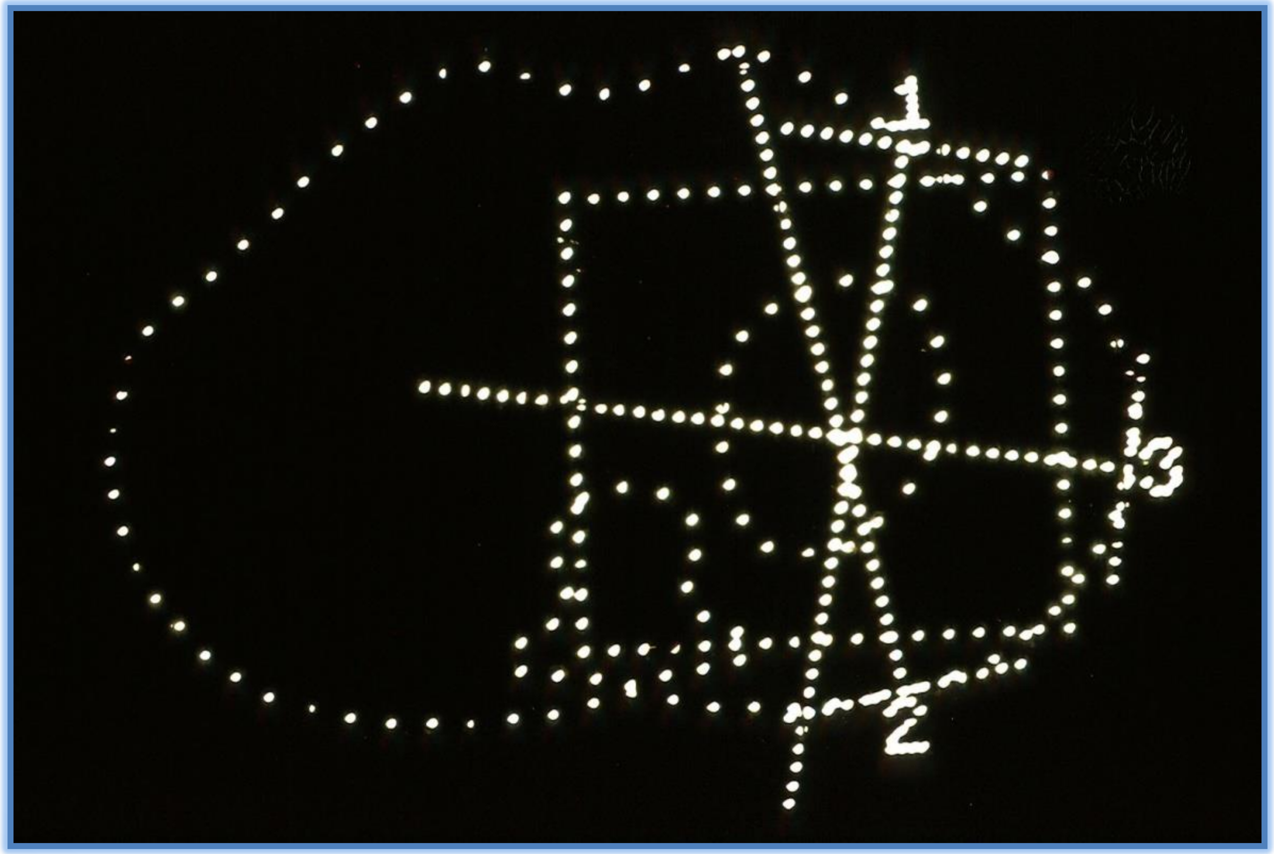
1967, First Computer for Radiation Therapy



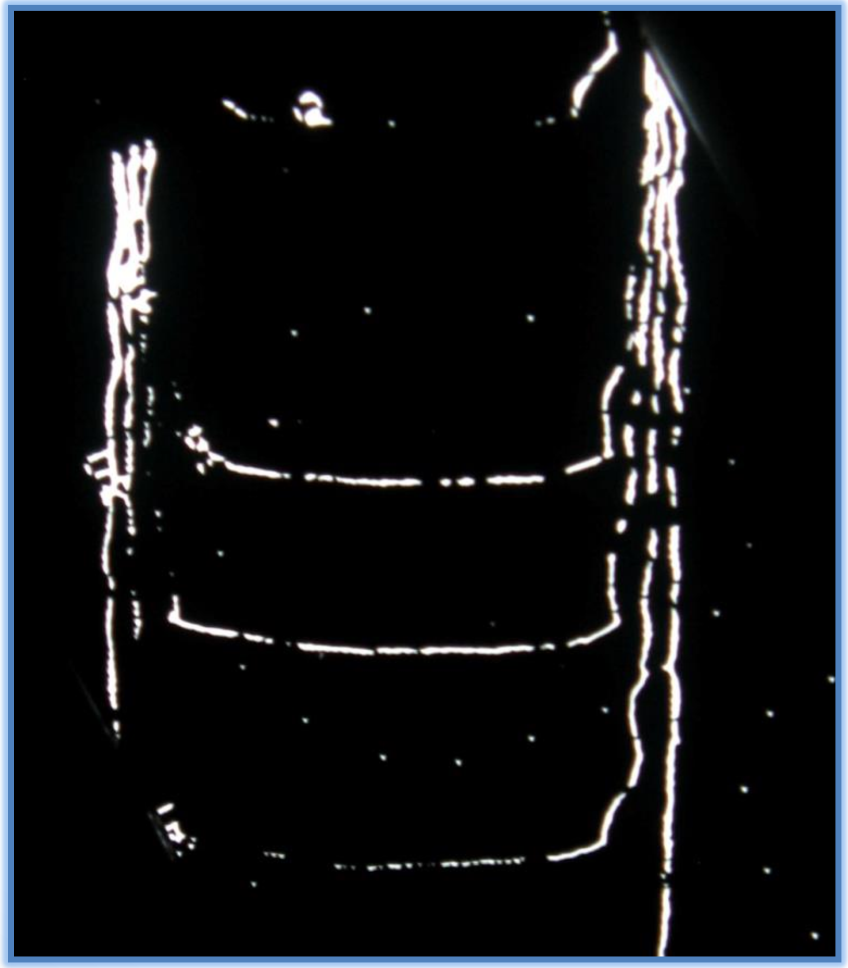
- Programmed Console (PC)
- 12K of memory
- 12-bit word
- Note TV camera for enlarging display

PC, Display for Treatment Planning



- Display of patient’s contour & 3 beam arranged to treat target
- Isodoses are shown within the “viewing window”

PC, Display for Treatment Planning



Display of isodose curves for a single beam

- Plotting was also available

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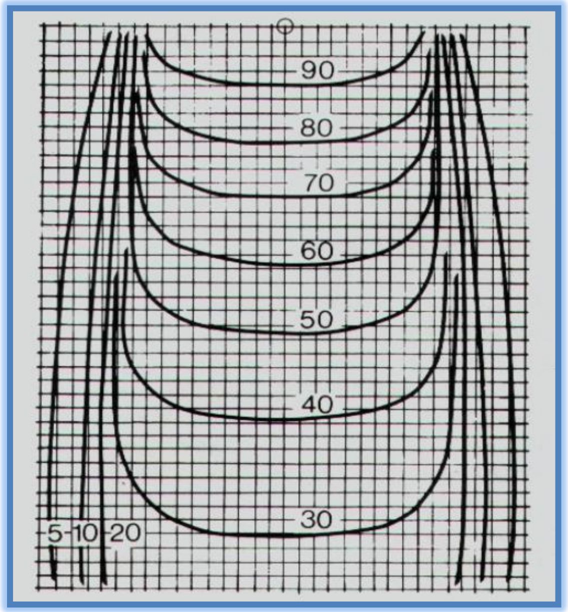
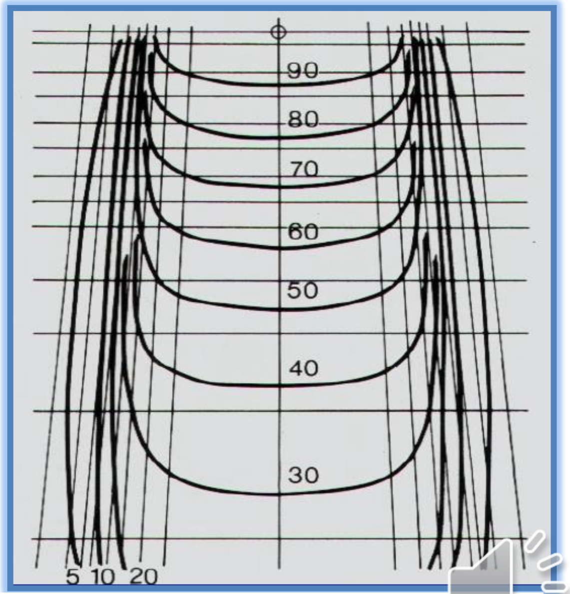
Matrix Representation

- Doses measured and pre-stored on grid
- For treatment planning, interpolate between points
- Make corrections for contour, wedges, inhomogeneities



X-Y Cartesian Grid



Decrement Line Grid

1960s

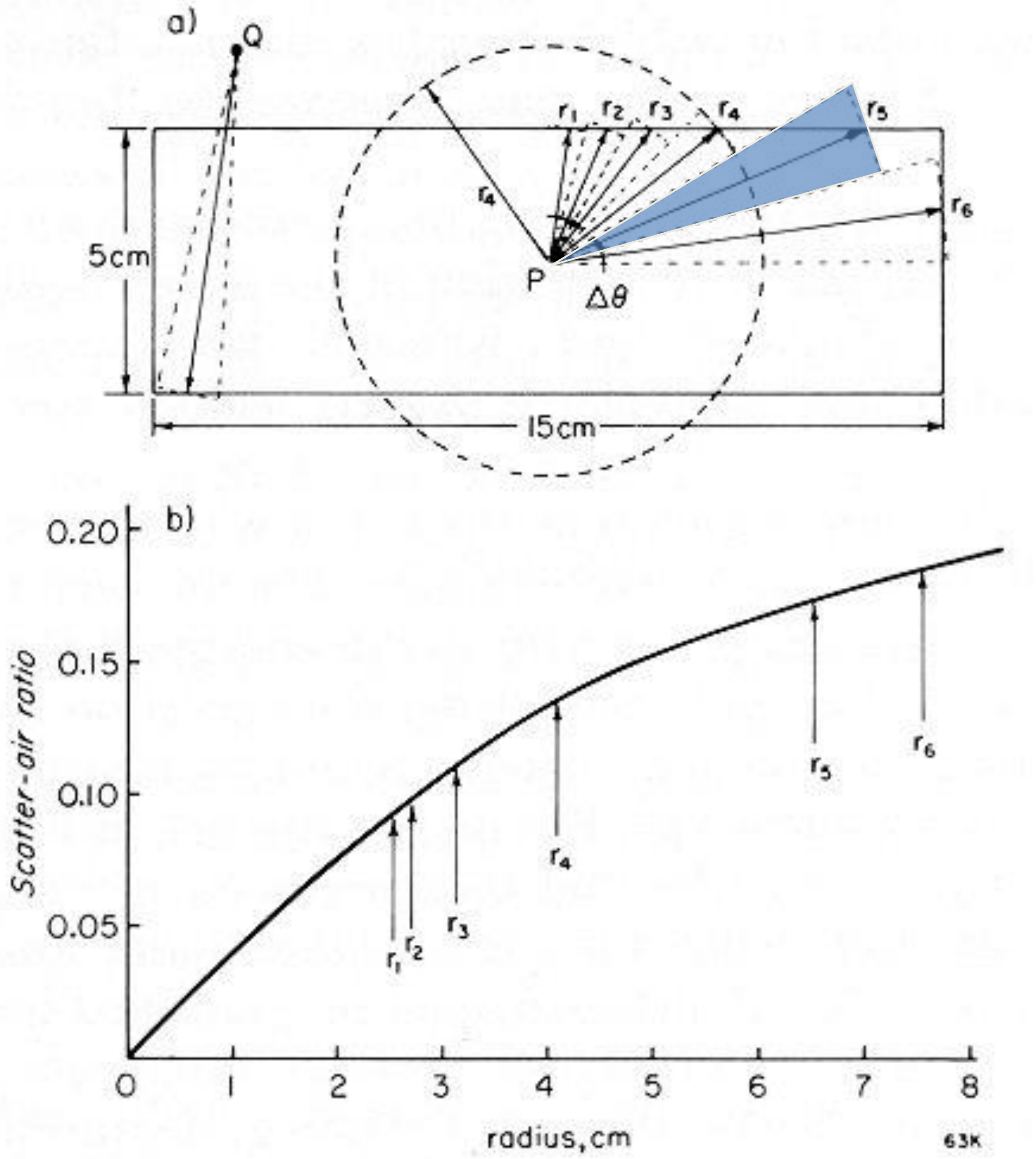
- Development of algorithm summing

$$Primary\ dose + \ Scatter\ Dose$$

- Scatter dose:

$$SAR(d, r) = [TAR(d,r) - TAR(d,0)]$$

$$SAR'(d, r) = \Delta\Theta/360\ [SAR(d,r)]$$



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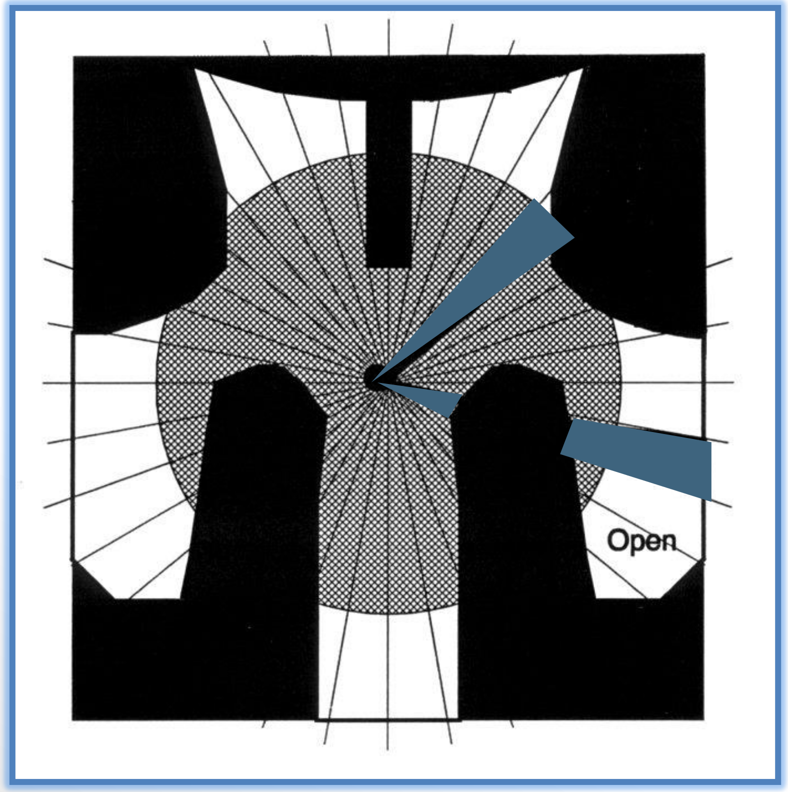
PROGRAM IRREG – CALCULATION OF DOSE FROM IRREGULARLY SHAPED RADIATION BEAMS

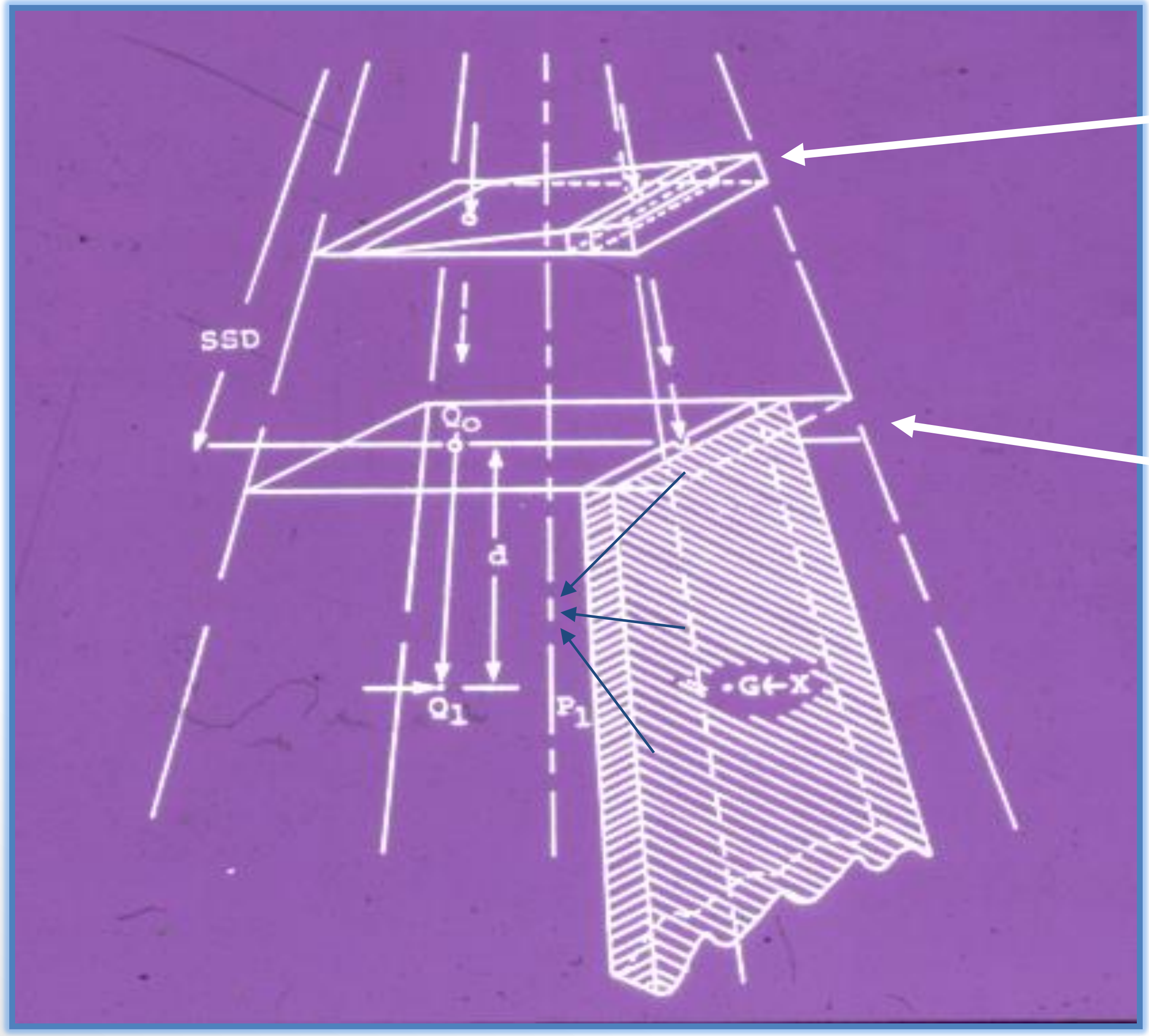
J.R. CUNNINGHAM, P.N. SHRIVASTAVA* and J.M. WILKINSON †
Physics Division, Ontario Cancer Institute, Toronto, Canada

Comput Prog Biomed 2: 192-199; 1972

- Primary plus scatter calculations
  - Using scatter-air ratios



CBEAM Uses Cartesian Slabs

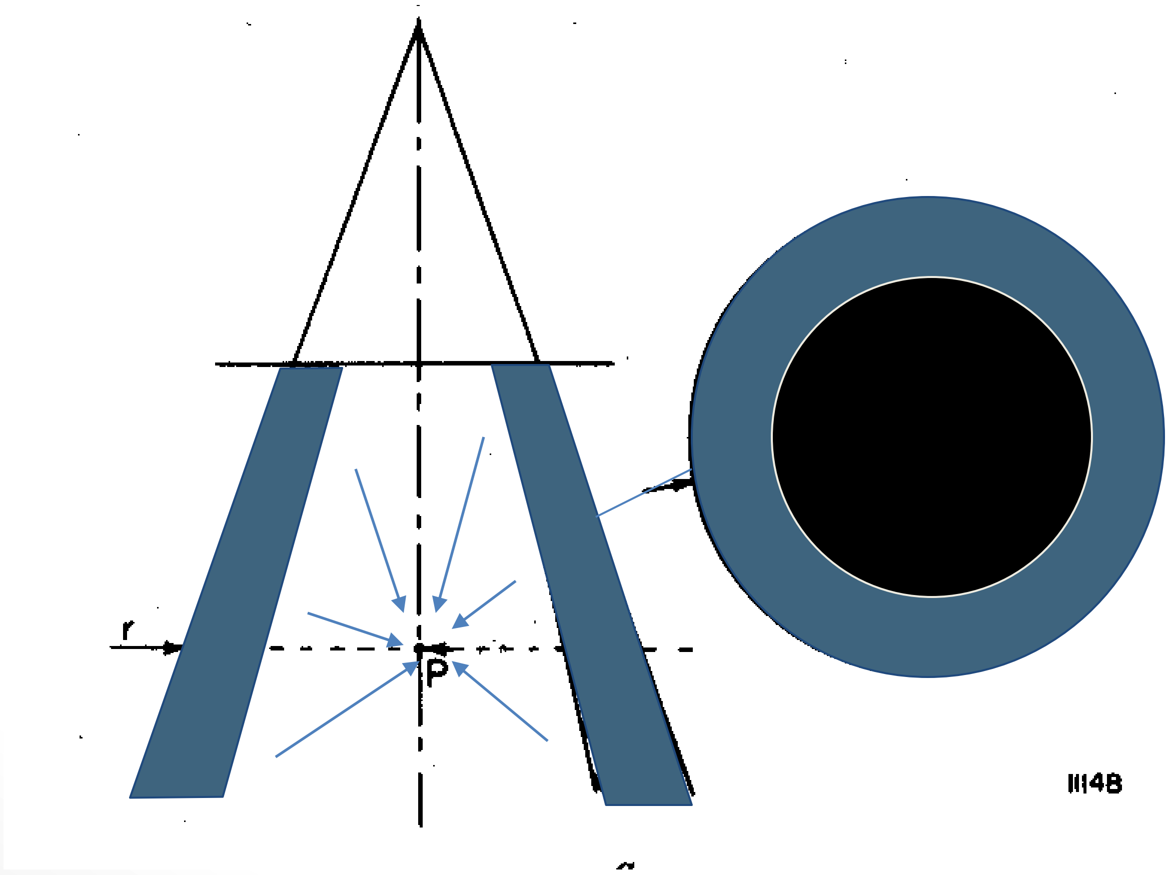


Beam intensity modulated in only one direction

Flat or symmetric contour

Cunningham's CBEAM

Differential SARs



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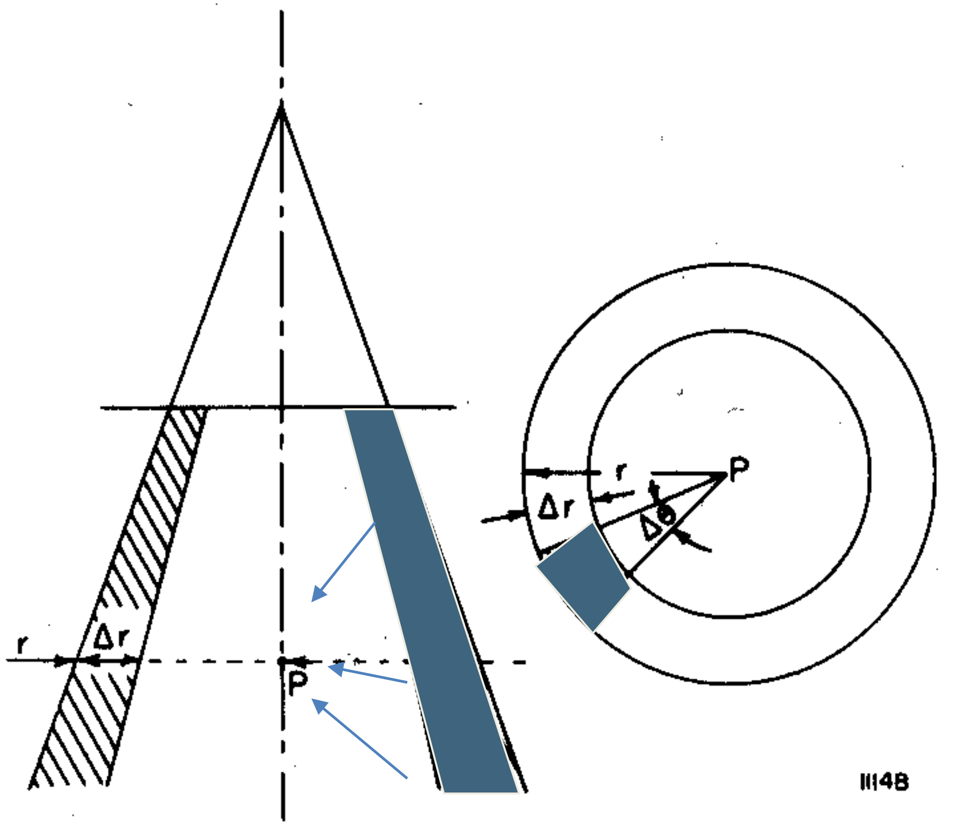
Differential SARs (dSAR) Pencil Beam



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Differential SARs (d^2SAR)

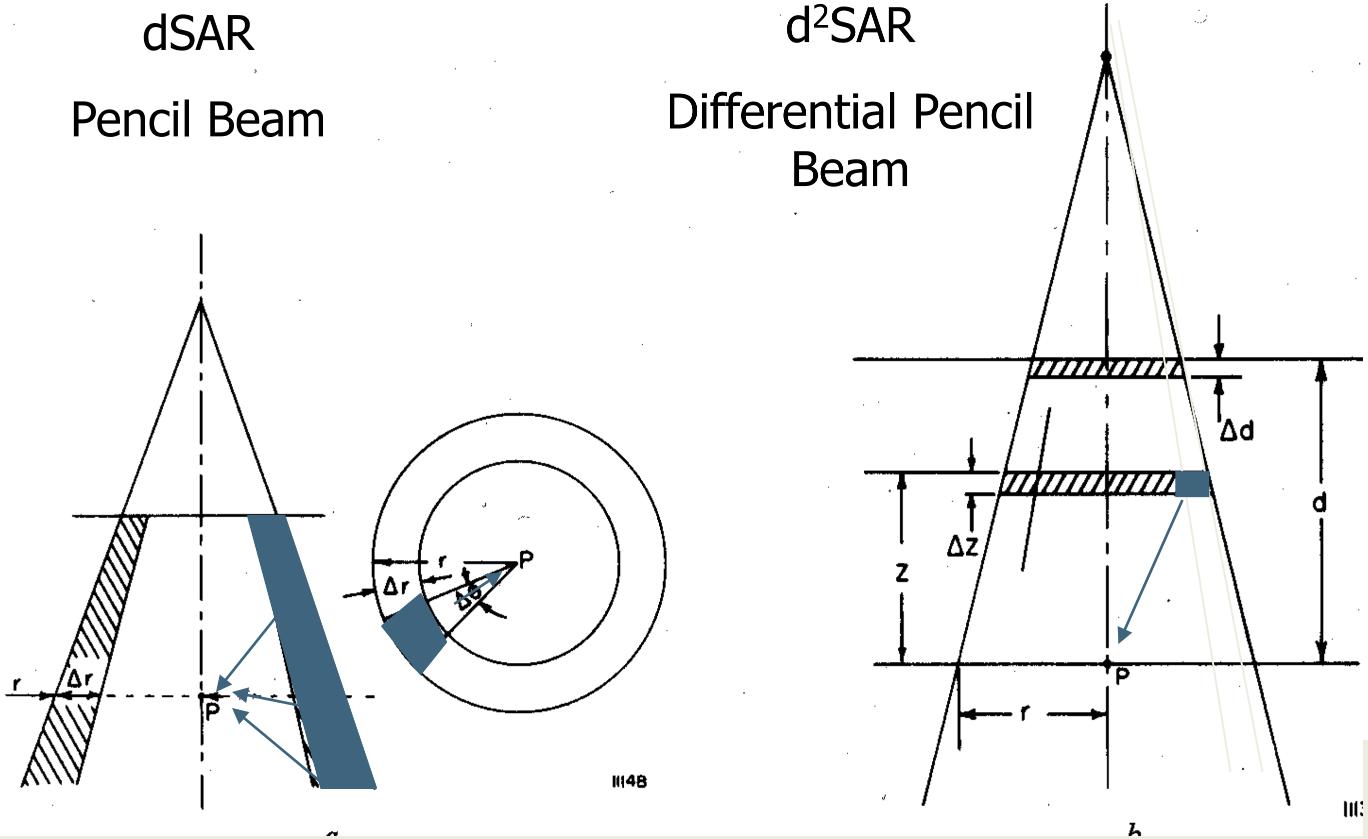
CUNNINGHAM AND BEAUDOIN

dSAR

Pencil Beam

d^2SAR

Differential Pencil Beam



Pencil Beam Concept

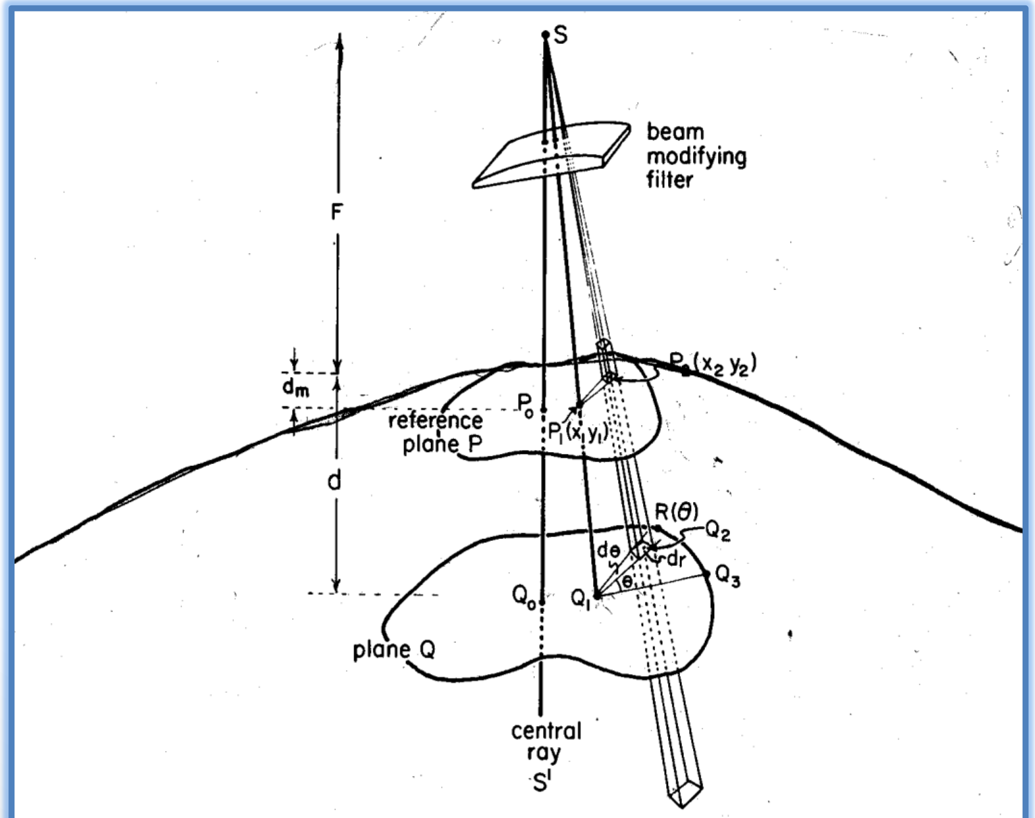
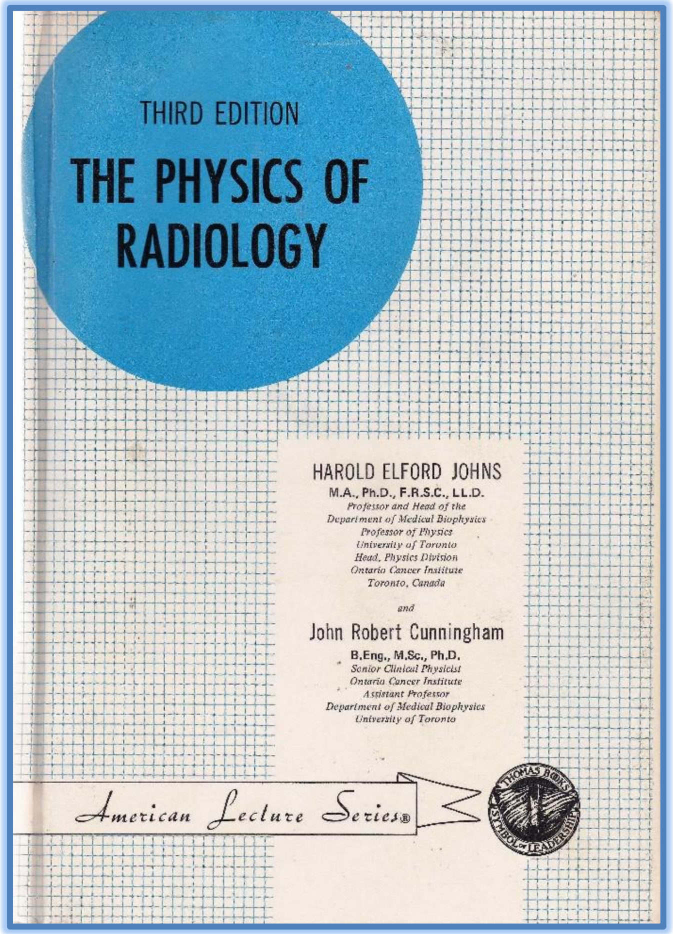


FIGURE X-28. Diagram to illustrate the calculation of the dose to point Q_1 in a plane at depth d below an irregularly shaped field irradiated through a beam-modifying filter.



Johns & Cunningham, 3rd edition, 1969

1969, Canadian Association of Physicists Annual Meeting

- Jack Cunningham
  - Chairman, Division of Medical and Biological Physics, Canadian Association of Physicists

THE PROGRAMMED CONSOLE – A SMALL SPECIAL PURPOSE COMPUTER FOR RADIOTHERAPY

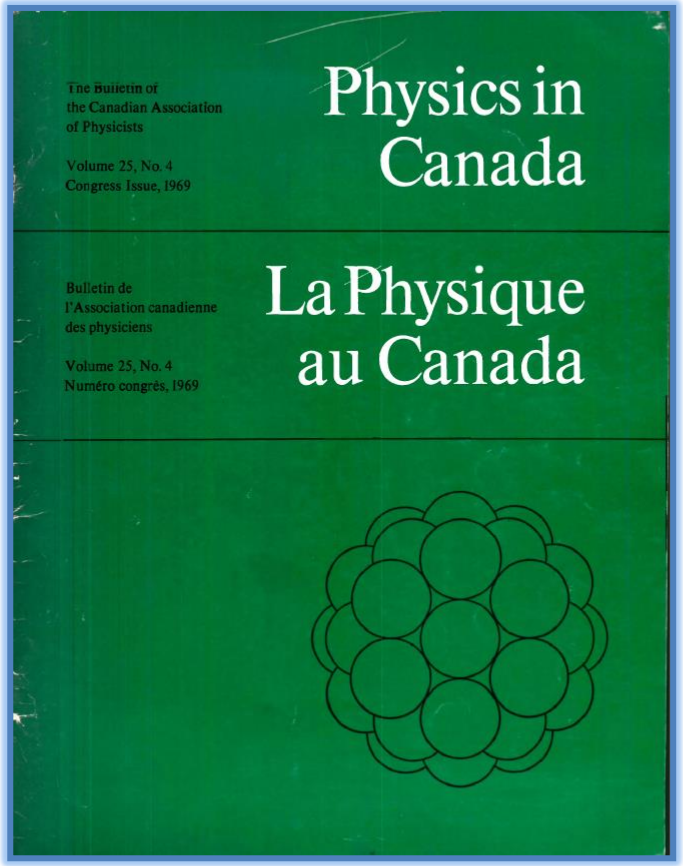
J.R.Cunningham, J.Milan, D.Brinkman and Barbara Seaman
Ontario Cancer Institute, Toronto

EMPIRICAL REPRESENTATION OF BEAM PENUMBRA

J.R. Cunningham
Ontario Cancer Institute, Toronto

WORKSHOP ON COMPUTER APPLICATIONS AND METHODS IN MEDICAL PHYSICS

J.R.Cunningham, R.W.Horsley, R.G. Baker, B.Mee, J.C.F.MacDonald and K.W. Taylor
Ontario Cancer Institute, Toronto



19 eting

- J

THE PROG
SPECIAL
THERAPY
J.R.Cunn
and Barb
Ontario

Western

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Scatter-Air Ratios

- SARs already defined in mid-1960s

PHYS. MED. BIOL., 1972, VOL. 17, NO. 1, 42–51

Scatter–Air Ratios

J. R. CUNNINGHAM, PH.D.

Physics Division, Ontario Cancer Institute, Toronto, Canada

Received (revised version) 26 *April* 1971

ABSTRACT. Scatter–air ratios are empirical quantities derived from tissue–air ratios for use in calculating the dose from scattered radiation at a point in an irradiated phantom. Like tissue-air ratios, for each radiation quality, they depend only on depth and beam cross-section but are independent of the distance from the source. Their use for calculations within uniform and non-uniform radiation beams is outlined and the extension to account for tissue-heterogeneities is discussed.

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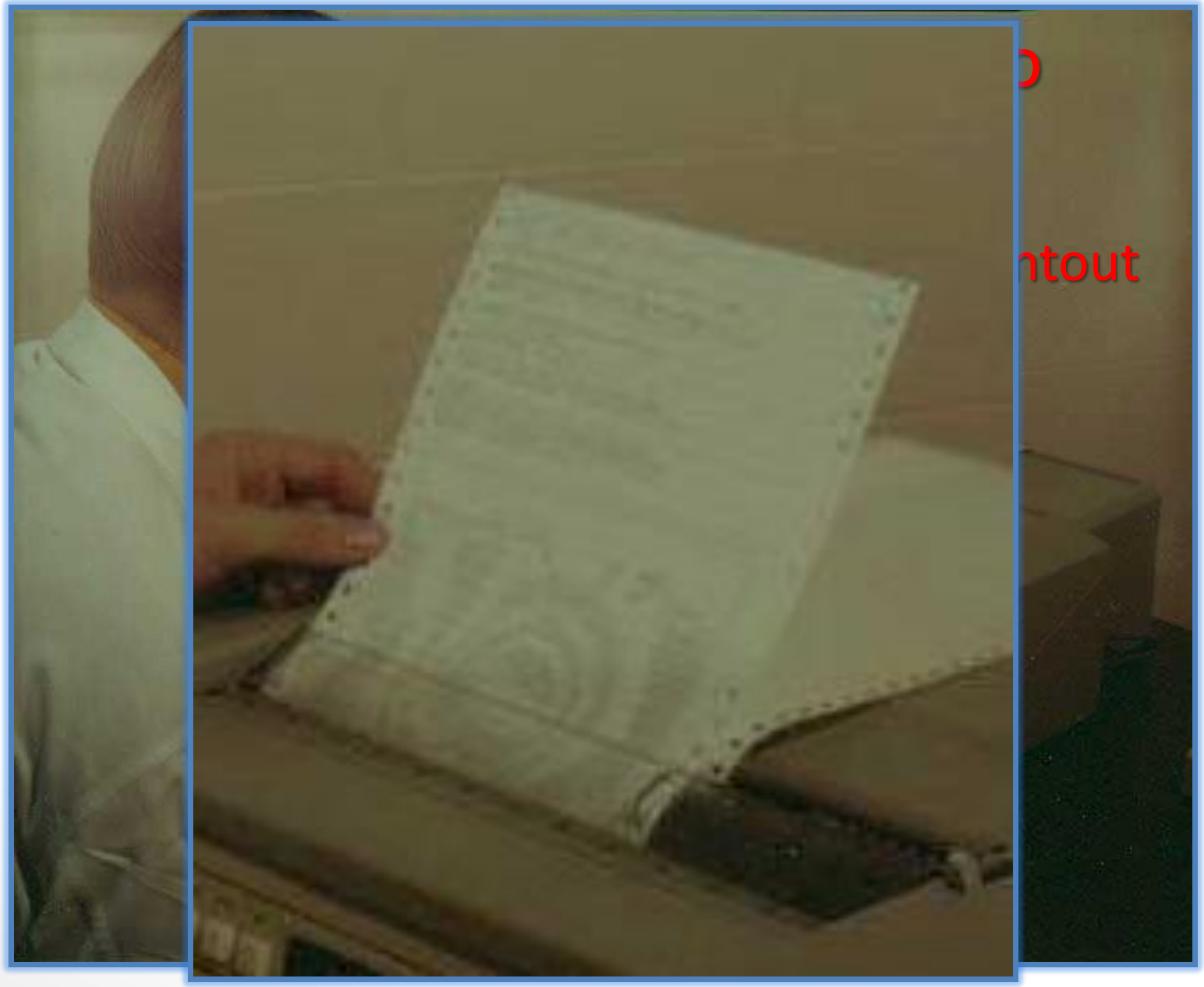
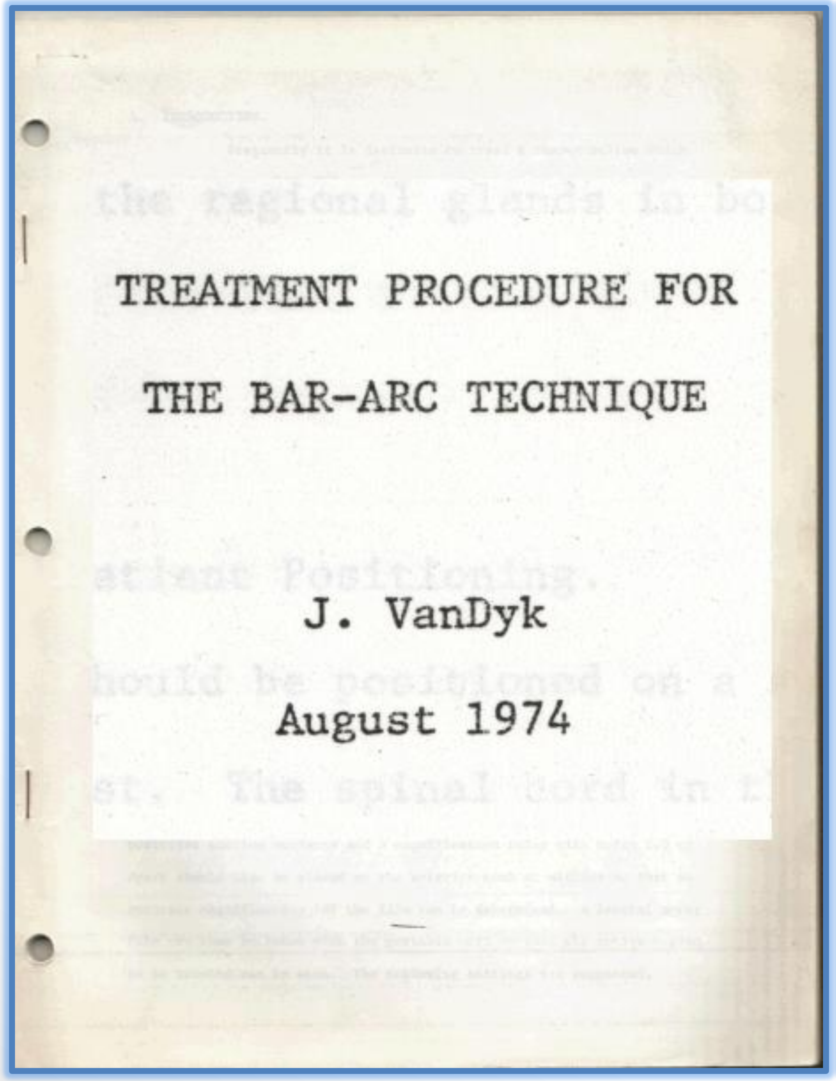
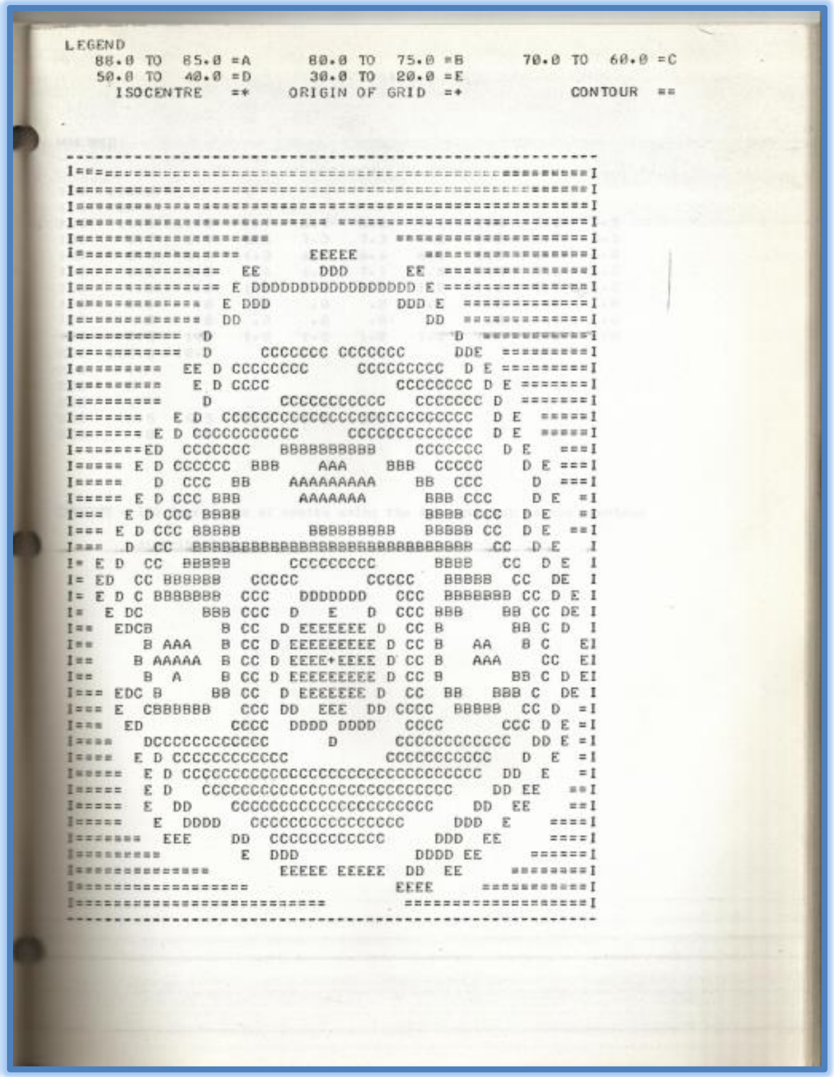
~1972, Timesharing System



ntout

Bar-Arc Technique – 1974





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1975-79
AECL: TP-11

- Treatment Planning with a PDP-11

1976

ICRU REPORT 24

Determination of Absorbed Dose in a Patient Irradiated by Beams of X or Gamma Rays in Radiotherapy Procedures

ICRU

INTERNATIONAL COMMISSION
ON RADIATION UNITS
AND MEASUREMENTS

Composition of Report Committee Responsible for the Drafting of this Report

Initial work on this report was carried out by the Report Committee on Evaluation of the Absorbed Dose at Any Point in a Patient. Serving on the Report Committee during the preparation of this report were:

J. R. Cunningham, *Chairman*
M. Cohen
A. Dutreix
R. Walstam

and on a collaborating Committee

J. van de Geijn
G. Innes
J. O'Connor
H. Sköldborn

Late 1970s, CT-Based Planning

- Dose dependent on:

1. Release and Spread of Energy
   - Primary and scatter
   - Level of summation or integration
2. Utilization of Patient Anatomical Data
   - Imaging geometry and density data
   - Assumptions of symmetry

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Example of Symmetry Assumptions

2-D

3-D

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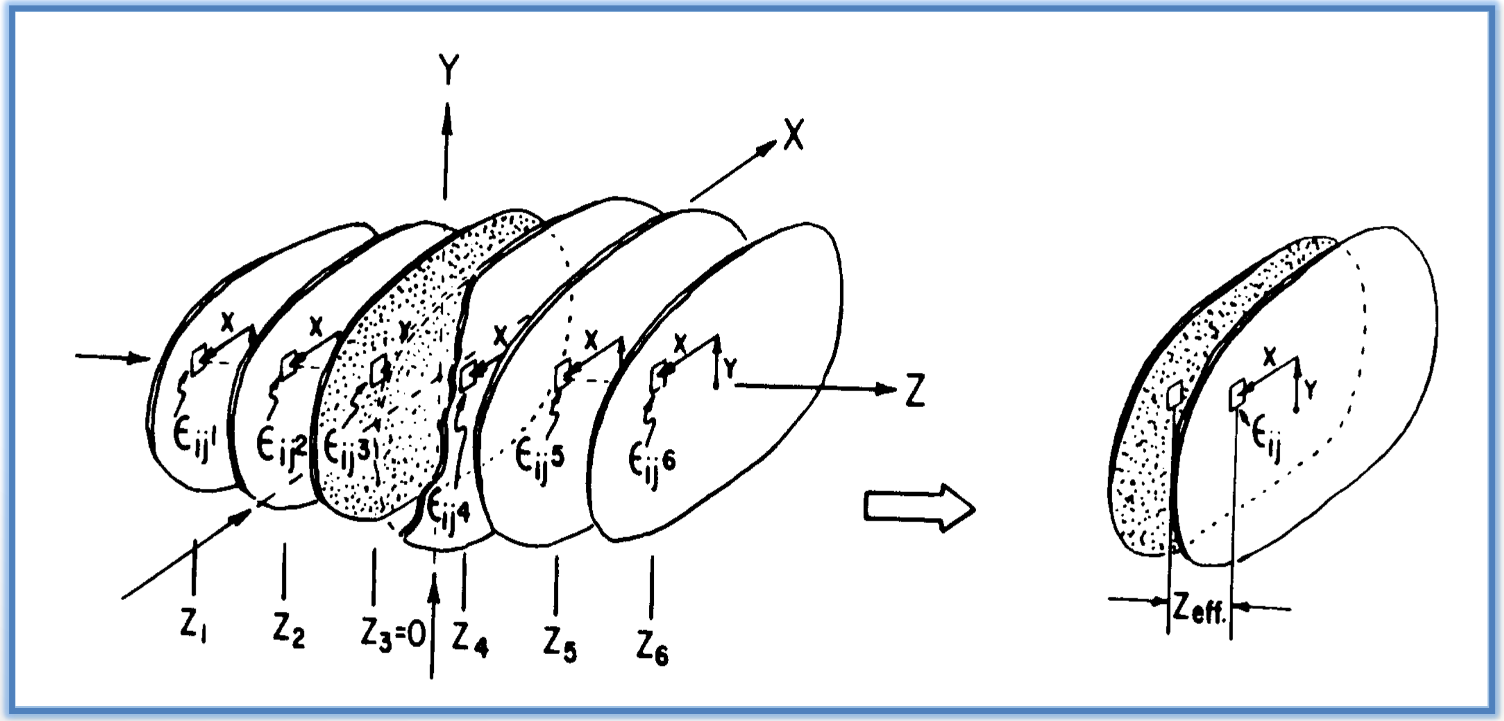
1978, EqTAR Method … "2.5-D"

- For computational speed, adjacent slice data were collapsed to an effective scattering slice

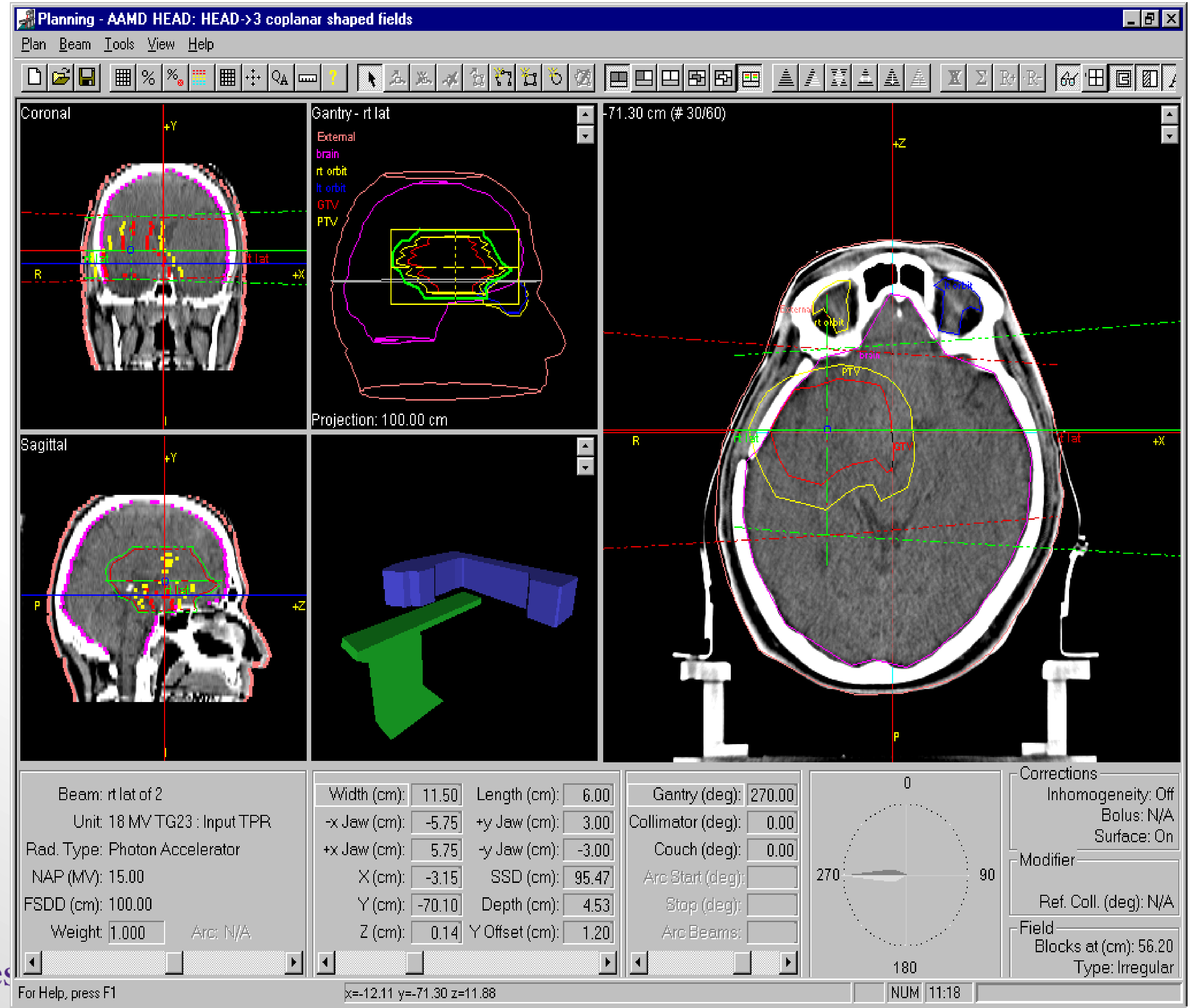


Sontag & Cunningham. Radiology 129: 787-94; 1978

~1979, Theraplan: CT-Based TP

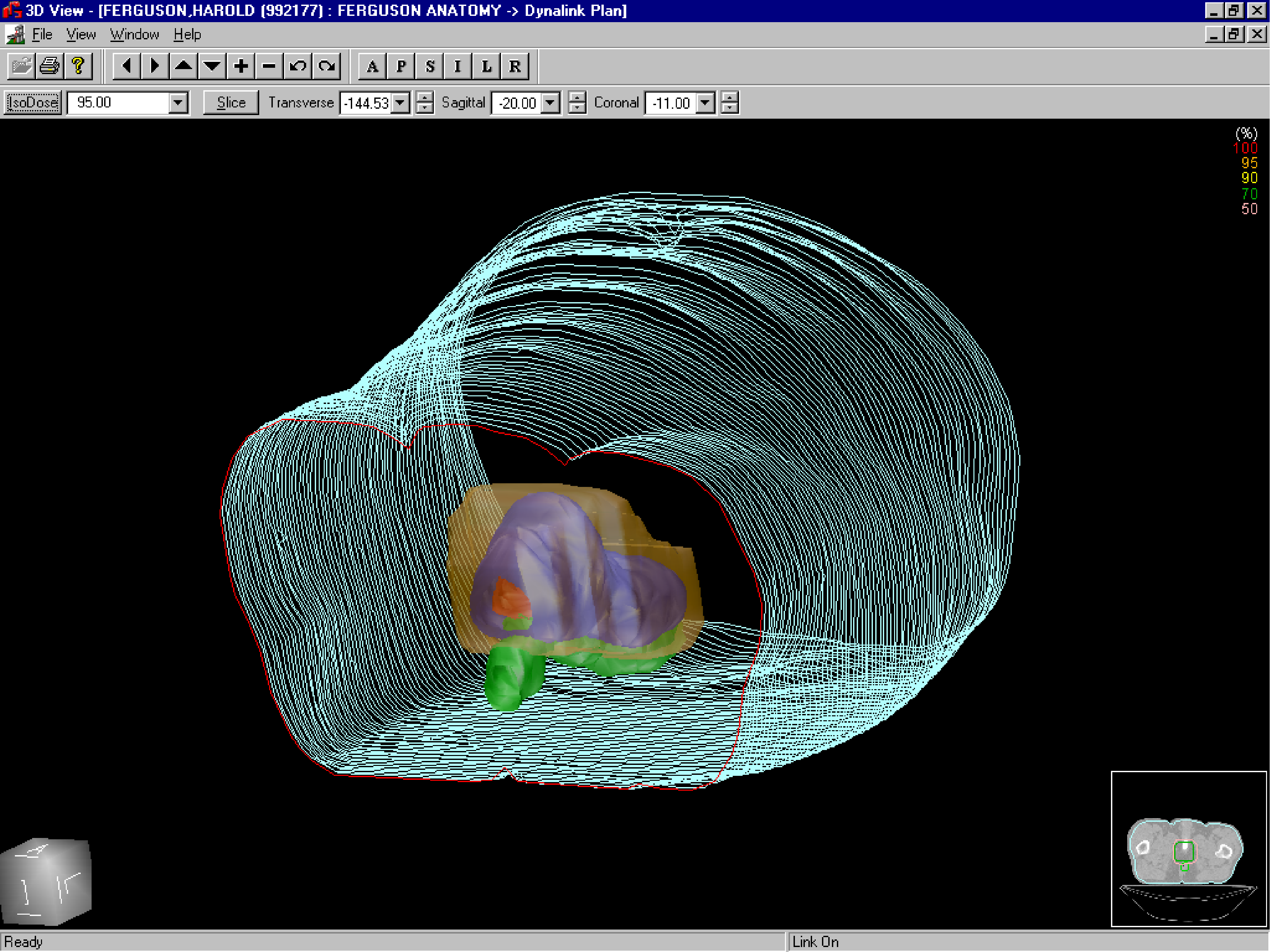
42 years ago!

>1980s Theraplan Plus

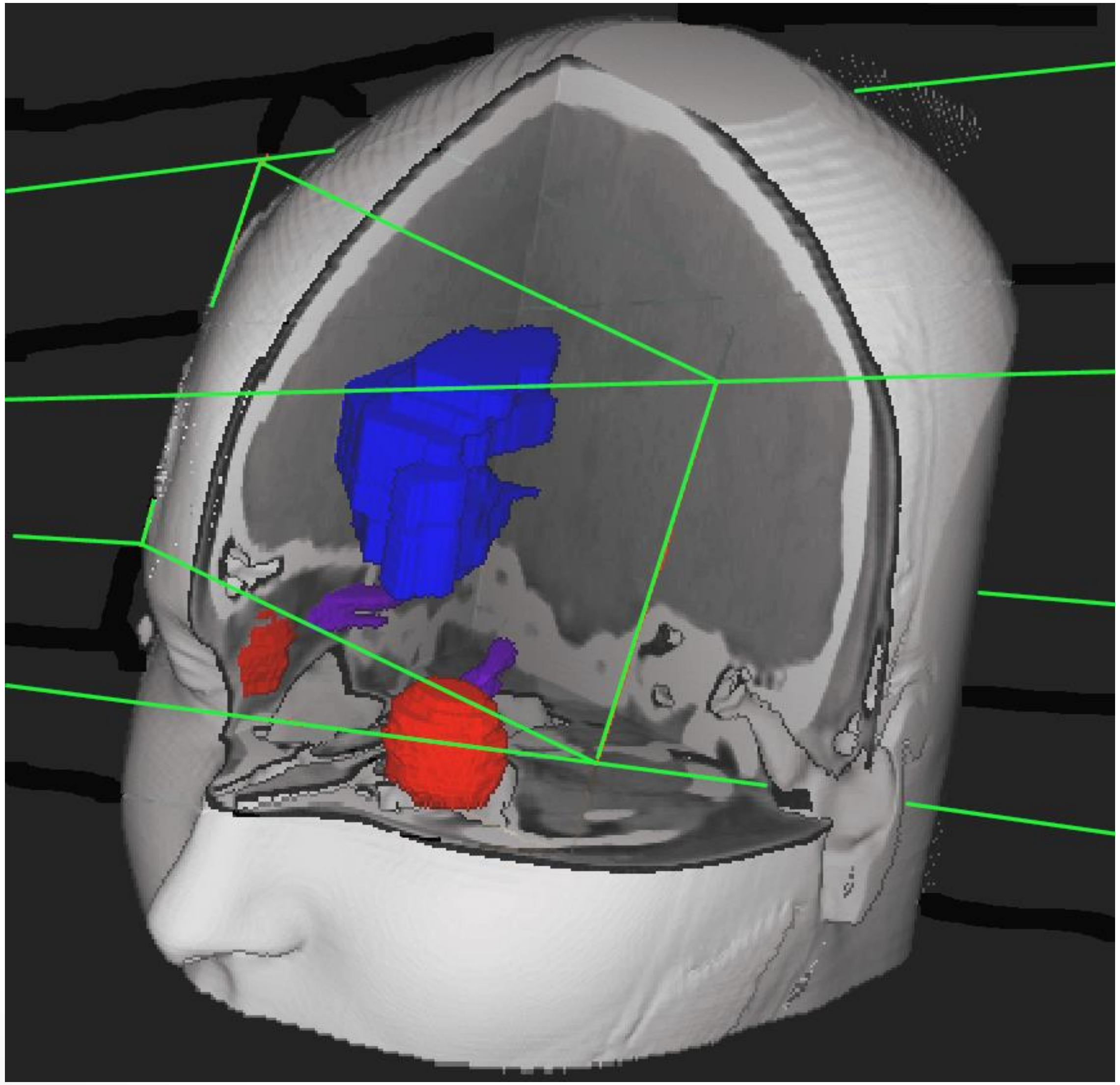


Planning - AAMD HEAD: HEAD->3 coplanar shaped fields
Plan Beam Tools View Help
Coronal
Gantry - rt lat
External
brain
rt orbit
lt orbit
GTV
PTV
Projection: 100.00 cm
-71.30 cm (# 30/60)
Sagittal
Beam: rt lat of 2
Unit: 18 MV TG23 : Input TPR
Rad. Type: Photon Accelerator
NAP (MV): 15.00
FSDD (cm): 100.00
Weight: 1.000
Arc: N/A
Width (cm): 11.50
Length (cm): 6.00
-x Jaw (cm): -5.75
+y Jaw (cm): 3.00
+x Jaw (cm): 5.75
-y Jaw (cm): -3.00
X (cm): -3.15
SSD (cm): 95.47
Y (cm): -70.10
Depth (cm): 4.53
Z (cm): 0.14
Y Offset (cm): 1.20
Gantry (deg): 270.00
Collimator (deg): 0.00
Couch (deg): 0.00
Arc Start (deg):
Stop (deg):
Arc Beams:
0
270
90
180
Corrections
Inhomogeneity: Off
Bolus: N/A
Surface: On
Modifier
Ref. Coll. (deg): N/A
Field
Blocks at (cm): 56.20
Type: Irregular
For Help, press F1
x=-12.11 y=-71.30 z=11.88
NUM
11:18

Wes

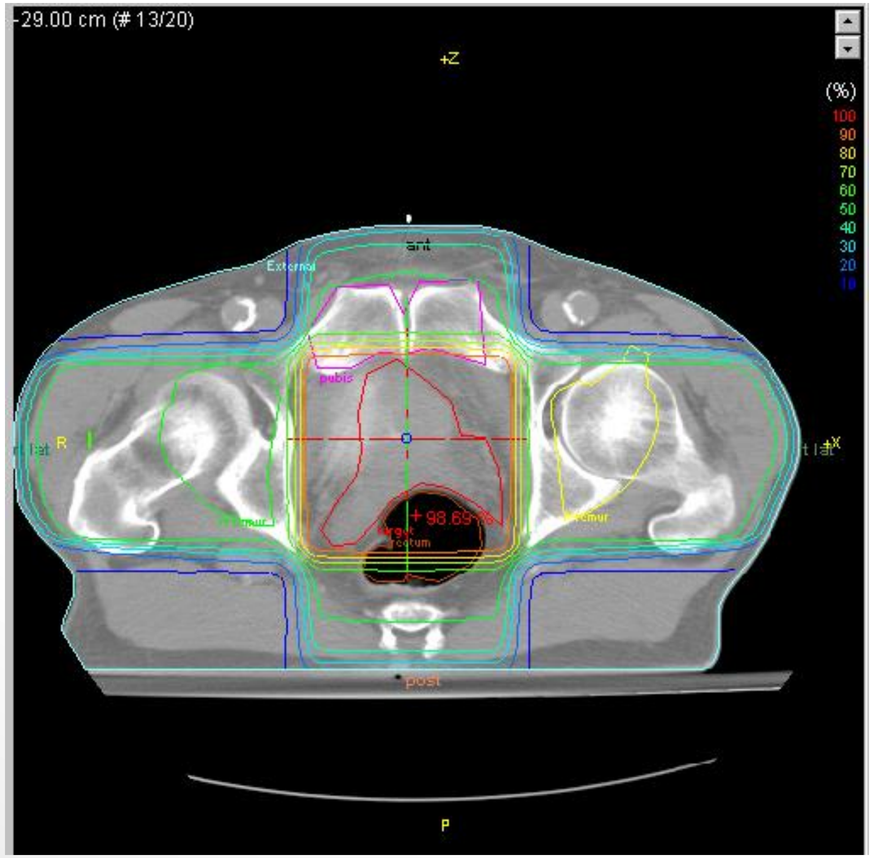

3D View - [FERGUSON,HAROLD (992177) : FERGUSON ANATOMY -> Dynalink Plan]
File
View
Window
Help
A
P
S
I
L
R
IsoDose
95.00
Slice
Transverse
-144.53
Sagittal
-20.00
Coronal
-11.00
(%)
100
95
90
70
50
Ready
Link On

Surface, Target, Critical Tissues, Beam

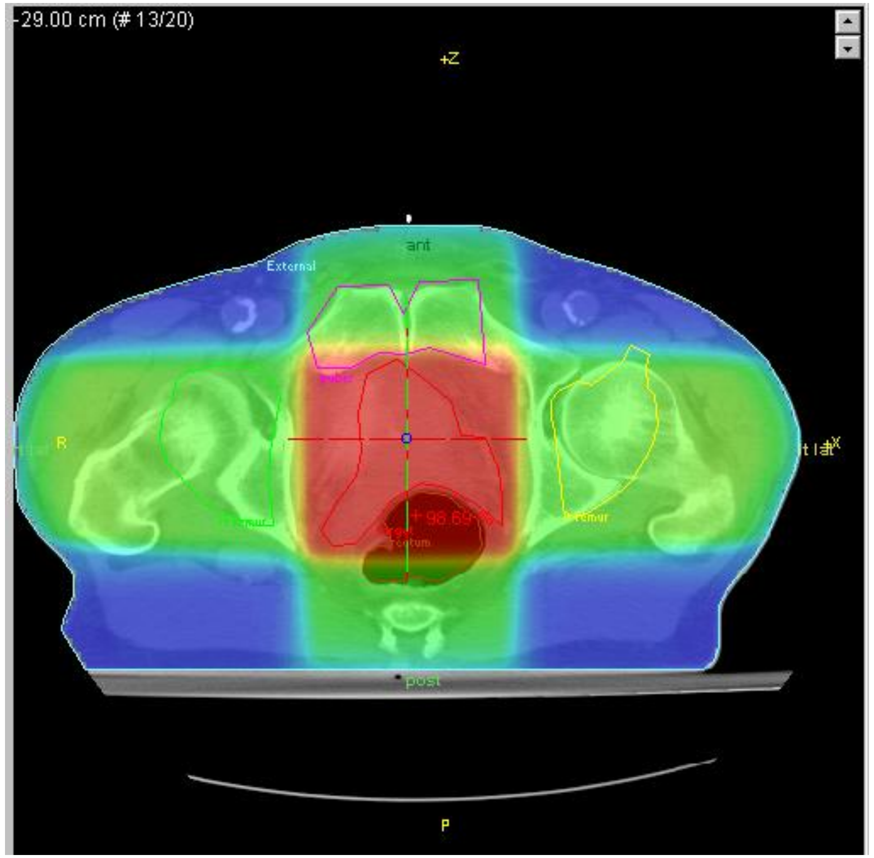


Isodose Displays

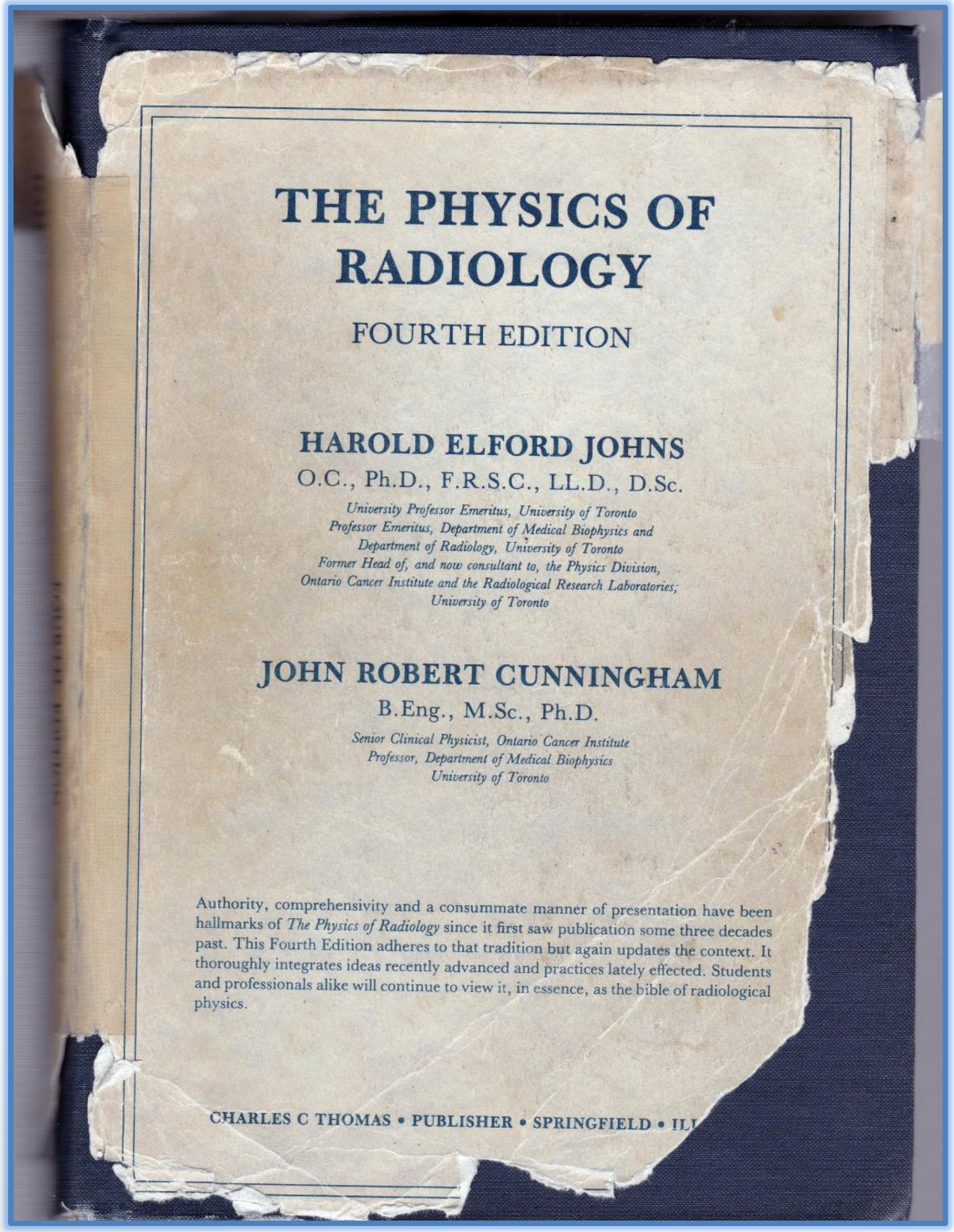
Isodose lines

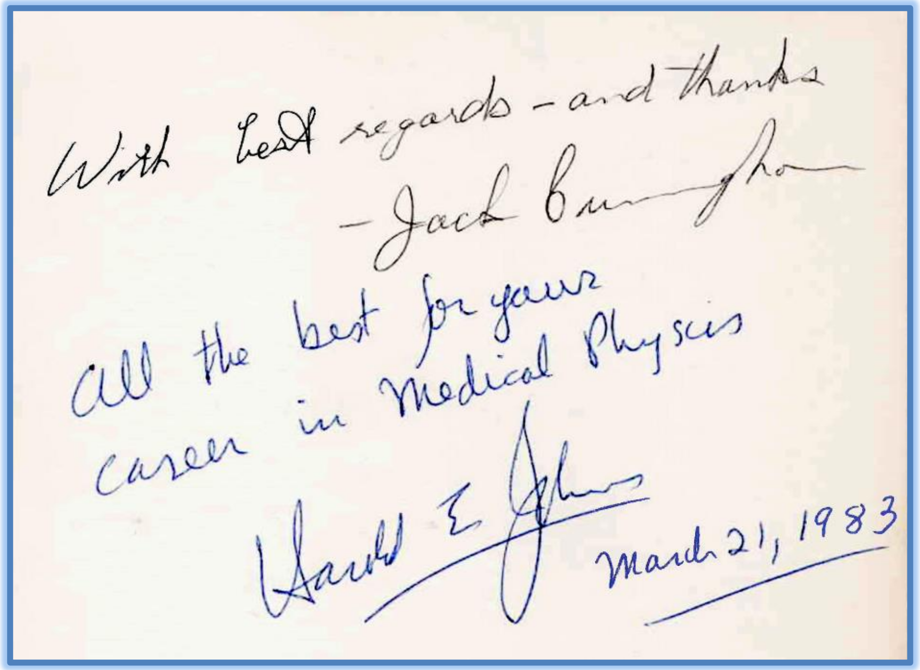


Isoshades

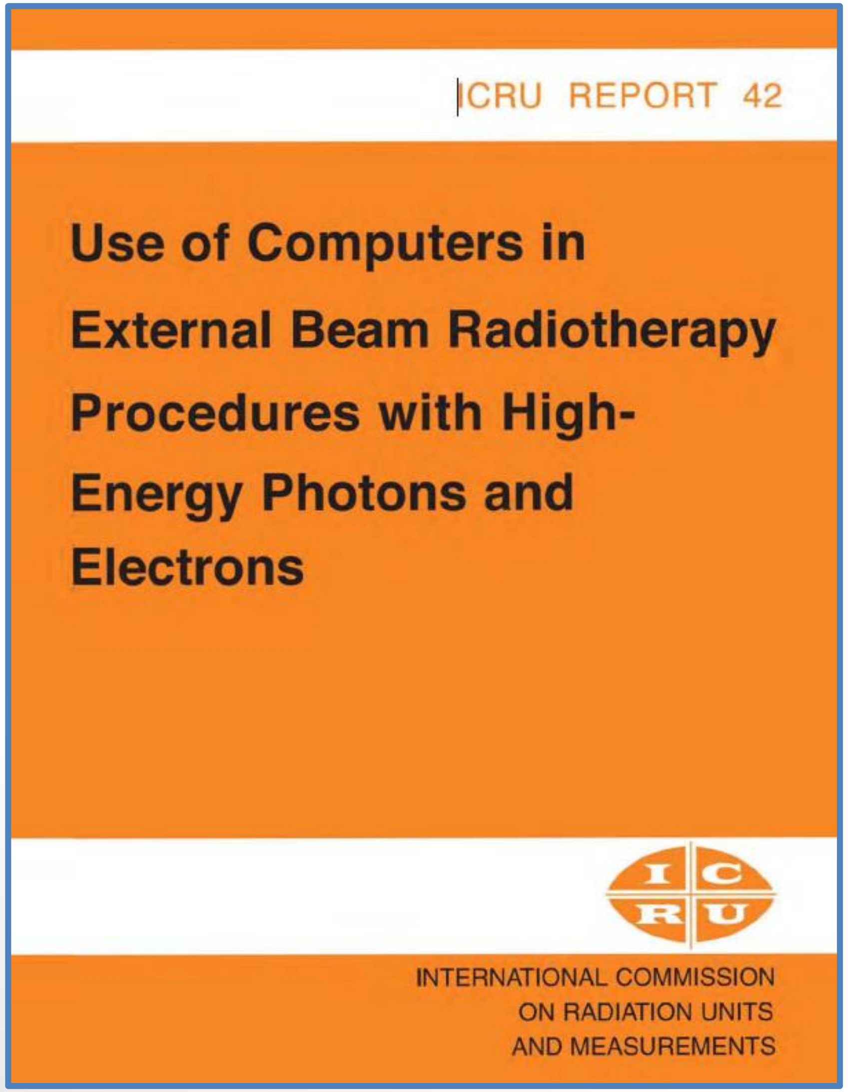


1983


THE PHYSICS OF RADIOLOGY
FOURTH EDITION
HAROLD ELFORD JOHNS
O.C., Ph.D., F.R.S.C., LL.D., D.Sc.
University Professor Emeritus, University of Toronto
Professor Emeritus, Department of Medical Biophysics and Department of Radiology, University of Toronto
Former Head of, and now consultant to, the Physics Division, Ontario Cancer Institute and the Radiological Research Laboratories; University of Toronto
JOHN ROBERT CUNNINGHAM
B.Eng., M.Sc., Ph.D.
Senior Clinical Physicist, Ontario Cancer Institute
Professor, Department of Medical Biophysics
University of Toronto
Authority, comprehensivity and a consummate manner of presentation have been hallmarks of The Physics of Radiology since it first saw publication some three decades past. This Fourth Edition adheres to that tradition but again updates the context. It thoroughly integrates ideas recently advanced and practices lately effected. Students and professionals alike will continue to view it, in essence, as the bible of radiological physics.
CHARLES C THOMAS • PUBLISHER • SPRINGFIELD • ILL

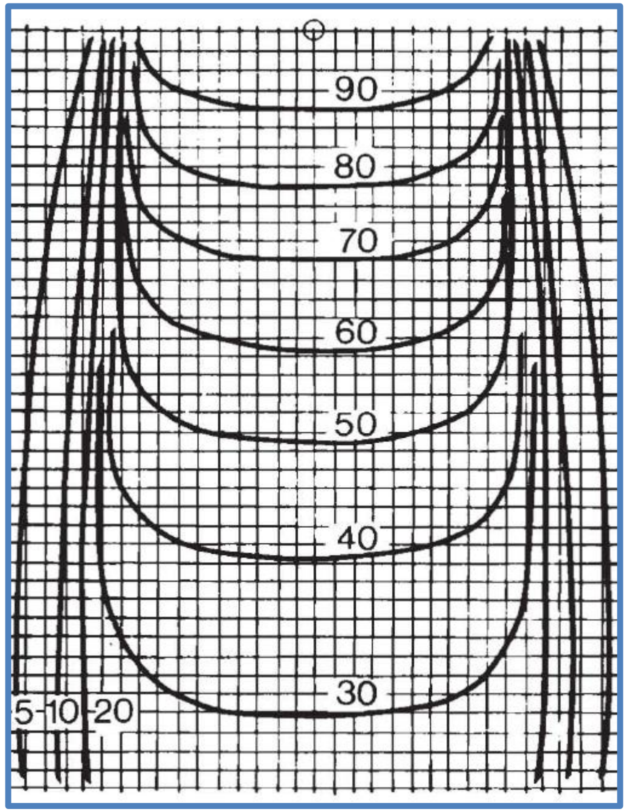

With best regards - and thanks
- Jack Cunningham
All the best for your
career in Medical Physics
Harold E Johns
March 21, 1983

1987



Tabular/Matrix Format

- Cartesian
- Polar
- Fan line
- Decrement line
- Fast … correct for contours
- Much data
- Not too accurate



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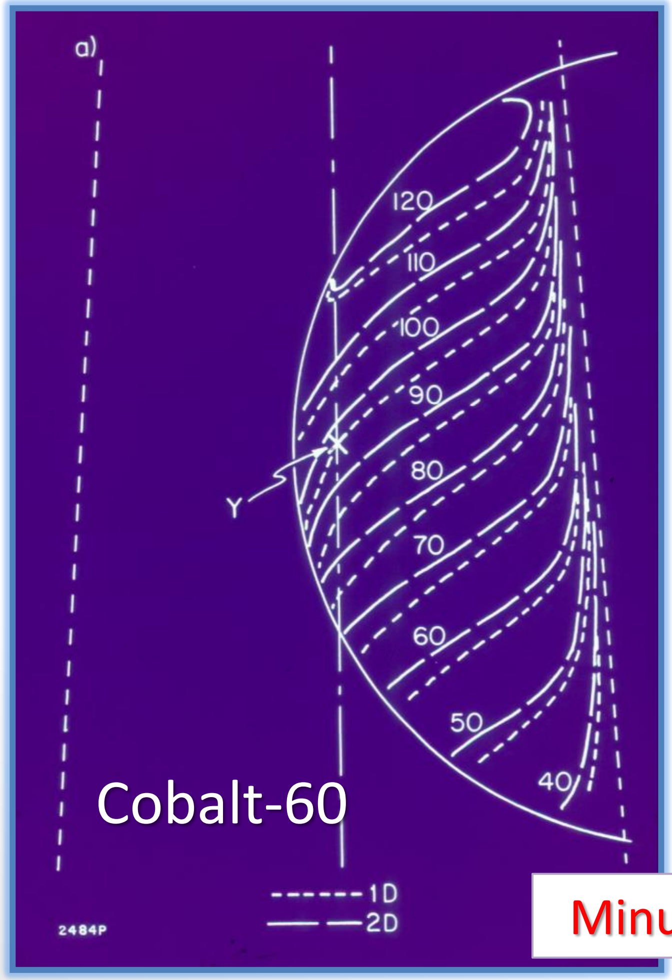
1-D vs 2-D vs 3-D Comparison

Sphere



Minus ~4%

Sphere

Minus ~ 8%

1988, AAPM Coolidge Award

- San Antonio, TX
- Joint AAPM-IOMP

AAPM News

COOLIDGE AWARD INTRODUCTION

President Barnes, Chairman Laughlin, distinguished guests, ladies and gentlemen.

As Dr. Laughlin has indicated, the Coolidge Award was established 16 years ago to recognize one of its members who has established a distinguished career in medical physics. The AAPM Awards and Honors Committee has decided that the seventeenth winner of this pre-eminent award is John Robert Cunningham. Having known Jack as a close associate for 17 years, it is now my privilege and personal pleasure to briefly summarize for you the specific attributes that have made his career, a career of distinction.

Jack Cunningham's first introduction to Medical Physics occurred when he was involved in the operation of a Radon Plant for the Saskatchewan Cancer Commission, Saskatoon, Saskatchewan, Canada between 1948–1950. This work was carried out on a part-time basis during his undergraduate studies. In 1950, Jack entered graduate school and received an M.Sc. decree under the supervision of Dr. Harold Johns. The resultant paper published with H. E. Johns and L. Katz was entitled—*Range of High Energy Electrons in Aluminum* (Phys. Rev. **83**, 952–954, 1951). Jack then left the field of Medical Physics for approximately 7 years during which time he worked as a physicist at the Grain Research Laboratory in Winnipeg, Manitoba; he obtained his Ph.D. in physics at the University of Toronto and he worked for the Canadian Defense Research Board in Ottawa. In 1958, Harold Johns enticed Jack to return to Medical Physics at the Ontario Cancer Institute in Toronto. Except for a year leave of absence in 1964–65 to work under the auspices of the IAEA as an Advisor in Medical Physics and Radiation Protection to the government of Ceylon, he has continued to work at the Ontario Cancer Institute (OCI) until the present. Since 1965

who have had personal contact with him. I, for one, work with him on a daily basis and can attest to this fact which is rare for an individual of his expertise and stature. With these professional, scientific, and personal qualifications, I would like to present to you the 1988 winner of the William D. Coolidge Award: John Robert Cunningham.

Jake Van Dyk

COOLIDGE ADDRESS, AAPM 1988

Mr. President, Dr. Laughlin of the Awards and Honors Committee, fellow members of the AAPM and IOMP. I am honored, flattered, and pleased to be chosen for this year's Coolidge Award. There have been sixteen before me and I feel very privileged to join this eminent group. I know most of them and consider them to be friends. I would also like to thank Jake Van Dyk for his flattering and somewhat exaggerated remarks.

My friend, Colleague, and mentor, Harold Johns won this award twelve years ago. It was at the meeting in Ottawa and like this one it was a combined AAPM and IOMP conference. I consider this award to me to be in a very real way a second award to Harold Johns. I have told him this.

Impact of Jack's Programs?

- No. of TP11s & Theraplans sold: ~1500
- Average lifetime: ~ 7 years
- Average cancer center: ~1,000 patients/year
- Average no. of patient plans:
- 1500 X 7 X 1,000 =

  >10 million patients impacted by these programs

Thanks to discussions with J. Battista

Western

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2005, Order of Canada

Governor General: Michaëlle Jean

OBITUARY

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Obituary: John Robert (Jack) Cunningham, O.C., B.Eng., M.Sc., Ph.D., FCCPM, FAAPM, FCOMP 1927–2020

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further demonstration of his generosity is that his home was often offered as a temporary residence for new graduate students, international visitors and visiting professors. A further description of his personality and humour is well exemplified by the entertaining 300-page memoir that Jack wrote, entitled *And I Thought I Came From a Cabbage Patch!*[49]

Jack is survived by his wife of 68 years, Sheila, three daughters, Susan, Joan, and Karen and their partners and two sons, Ian and Clifton and their partners along with 9 grandchildren and 3 great-grandchildren. We in the Medical Physics community of Canada and beyond extend our sincere condolences to them.

Jack will be greatly missed, but his influence will live on.

Jacob (Jake) Van Dyk
Jerry J. Battista

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