More than Pretty Pictures: 3D Treatment Planning + Conformal Therapy

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CEDARS-SINAI
LEADING THE QUEST

University of Michigan Medical School

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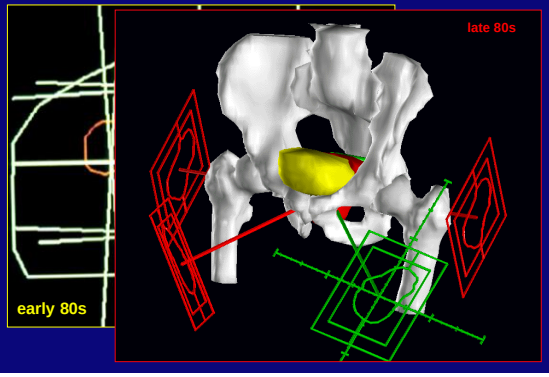
- Previous research and travel funding from Varian, Elekta, Sun Nuclear, Siemens, and others
- UM licensing arrangement with Scanditronix for Scandiplan (early 90s)

Treatment Planning

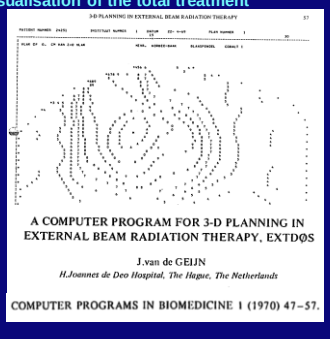


the 60s and early 70s: thinking about dose in 3D

Ted Sterling, H Perry, L Katz: Automation of radiation treatment planning V. Calculation and visualisation of the total treatment volume. Br. J. Radiol. 38: 906-913, 1965.

Jan van de Geijn: The computation of two and three dimensional dose distributions in cobalt-60 teletherapy. Br. J. Radiol. 38: 369-377, 1965

Jack Cunningham: Scatter-air ratios. Phys. Med. Biol. 17: 42-51, 1972.



3-D PLANNING IN EXTERNAL BEAM RADIATION THERAPY

A COMPUTER PROGRAM FOR 3-D PLANNING IN EXTERNAL BEAM RADIATION THERAPY, EXTDØS

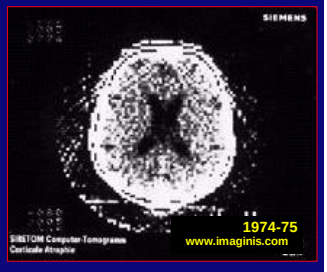
J.van de GEIJN

H.Joannes de Deo Hospital, The Hague, The Netherlands

COMPUTER PROGRAMS IN BIOMEDICINE 1 (1970) 47–57.

1970s: CT
A Crucial Development

Early 70s



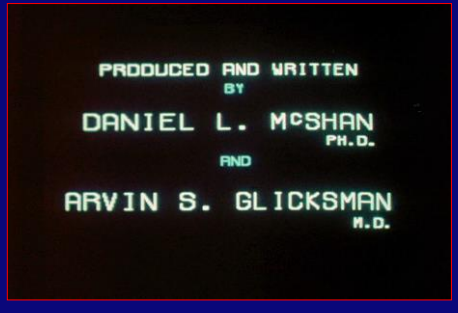
the late 70s

Rhode Island: McShan

the late 70s

Rhode Island: McShan

the late 70s

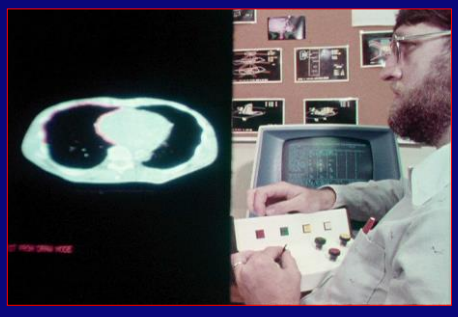


Rhode Island: McShan

the late 70s

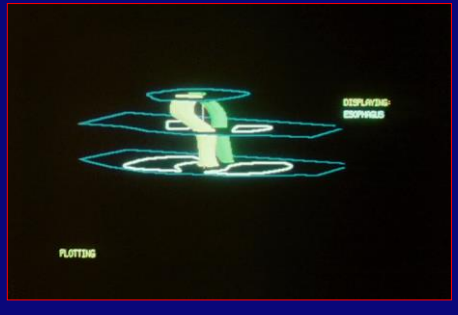
Rhode Island: McShan

the late 70s



Rhode Island: McShan

the late 70s



Rhode Island: McShan

the late 70s

McShan et al: Br J Radiol 52, 478–481, 1979

Rhode Island: McShan

the late 70s: Beam's Eye View

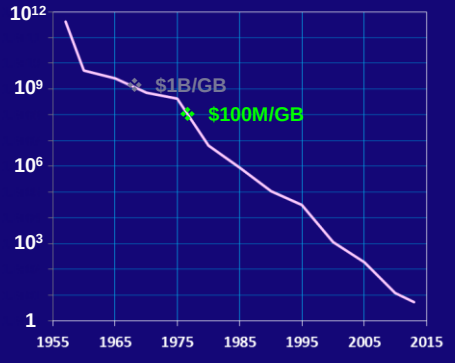
Reinstein, McShan et al: Radiology 127: 259-264, 1978

Rhode Island: McShan

the late 70s: Beam's Eye View

Rhode Island: McShan

Ram Price ($/GB)



http://www.statisticbrain.com/average-historic-price-of-ram/

the late 70s

PDP 11/45

80K words memory

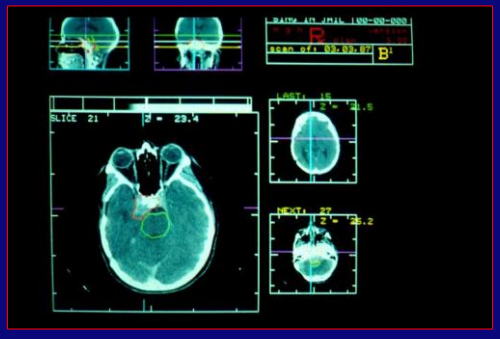
16K overlays

“Large” 116 MB disk

and here’s the mouse!

Rhode Island: McShan

early 80s: Multiplanar Display



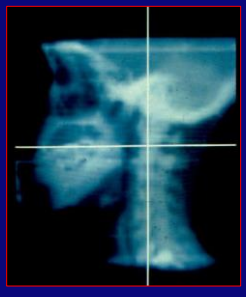
Goitein et al: IJROBP 9:777-787, 1983

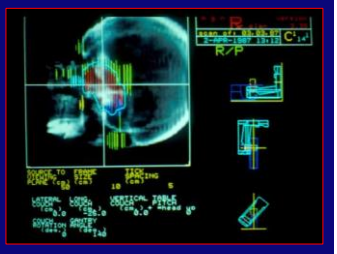
MGH: Goitein

early 80s: BEV w/ Aperture Design

MGH: Goitein

early 80s: DRRs





Goitein et al: IJROBP 9:789-797, 1983

MGH: Goitein

early 80s: DVHs

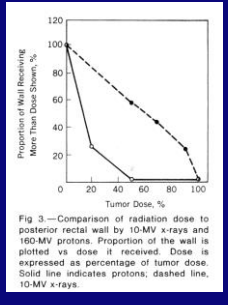
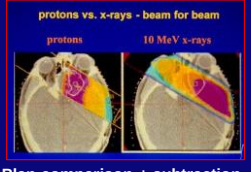


Fig. 3.—Comparison of radiation dose to posterior rectal wall by 10-MV x-rays and 160-MV protons. Proportion of the wall is plotted vs dose it received. Dose is expressed as percentage of tumor dose. Solid line indicates protons; dashed line, 10-MV x-rays.

Shipley WU, et al: JAMA 241:1912-1915, 1979.

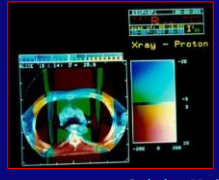
MGH: Goitein

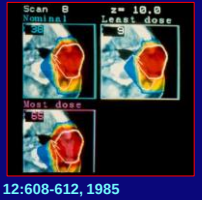
early 80s: Plan Comparison + Uncertainty



Plan comparison + subtraction

Uncertainty analysis

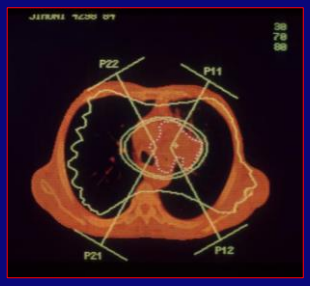




MGH: Goitein

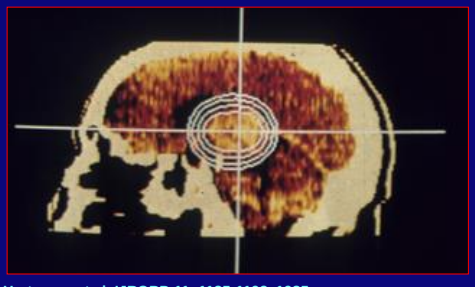
Goitein : Med Phys 12:608-612, 1985

early 80s: DKFZ



W Schlegel et al: Three-dimensional radiotherapy treatment planning using CT-data, in Proc World Congress on Medical Physics and Biomedical Engineering, Bleifeld, Hamburg, 1982, pp 21-27

early 80s: SRS Planning



Hartmann et al: IJROBP 11: 1185-1192, 1985

DKFZ: Hartmann, Schlegel

NCI 3D Treatment Planning Contracts

1982-6: Evaluation of Tx Planning for Heavy Particles
- U Penn/Fox Chase
- LBL/UCSF
- MGH
- MD Anderson

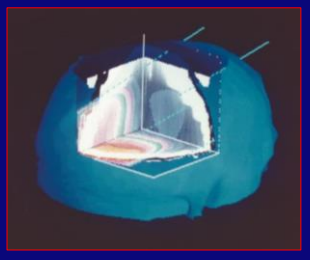
1984-7: Eval. of Tx Planning for Ext. Beam Photons
- U Penn
- MSKCC
- MGH
- Wash U St Louis

1986-9: Eval. of Tx Planning for Ext. Beam Electrons
- UM
- Wash U St Louis
- MD Anderson

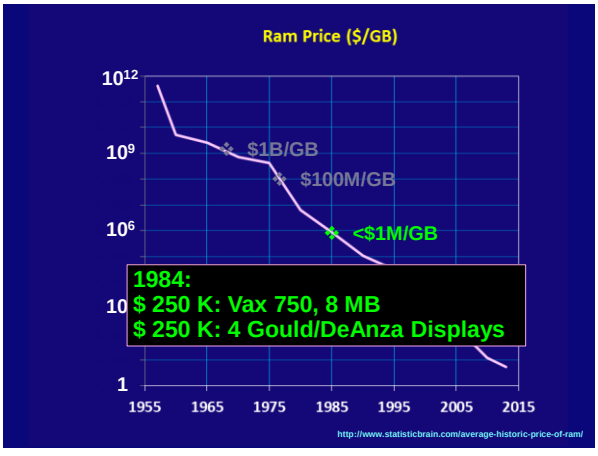
1989-94: Development of RT Tx Planning Tools
- UNC
- Wash U St Louis
- U Washington

The NCI Treatment Planning Contracts Worked!

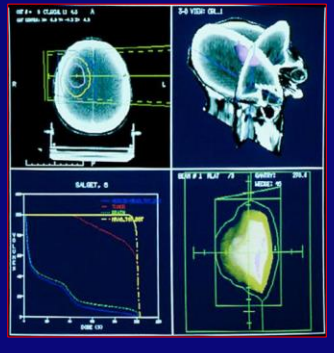
The NCI contracts spurred development of 3-D planning



- RTH, ASL, BAF arrived in AA July 1984, and DLM in Sept. 1984
- Electron contract proposal due: Jan. 5, 1985
- Our 3-D Hogstrom pencil beam algorithm and 3-D display code worked together: Jan 4, 1985



1986+: Clinical 3-D Planning Systems

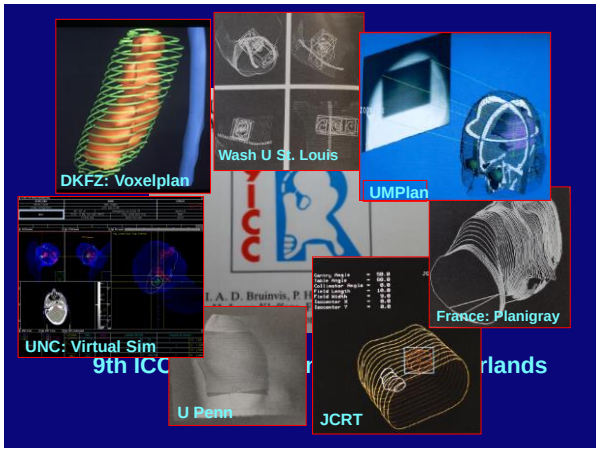


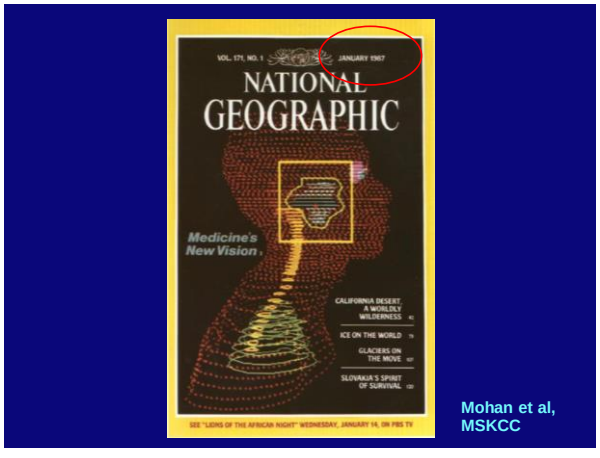
Clinical 3-D systems begin to be introduced

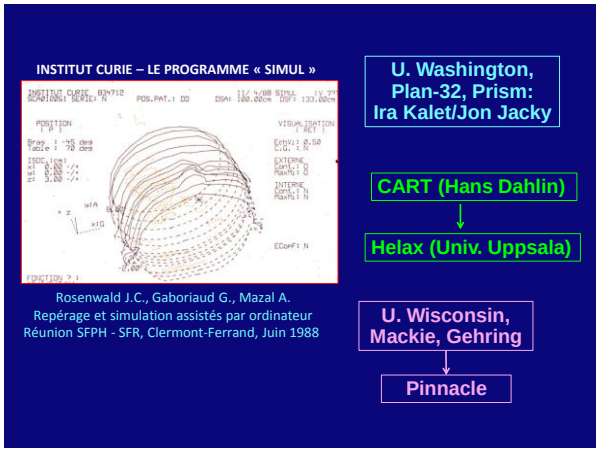
UMPlan, March 1986:

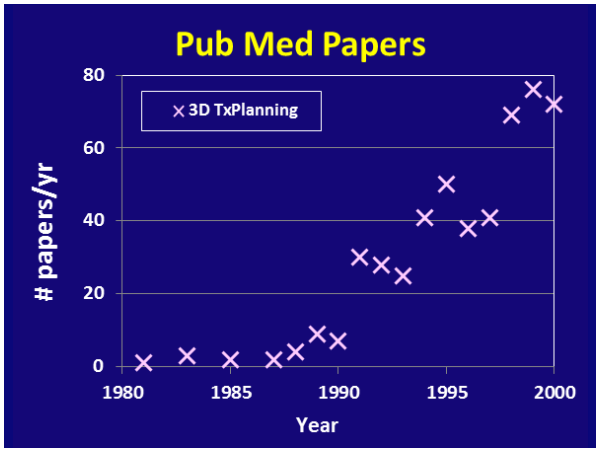
- 3-D anatomy
- CT, MR, PET imaging + dataset registration
- 3-D beams, dose calcs
- DVHs
- BEV, BEV blk design
- 3-D electrons
- 3-D brachytherapy (incl. brain implants)

UMPlan, March 1986


DKFZ: Voxelplan
Wash U St. Louis
UMPlan
UNC: Virtual Sim
France: Planigray
U Penn
JCRT

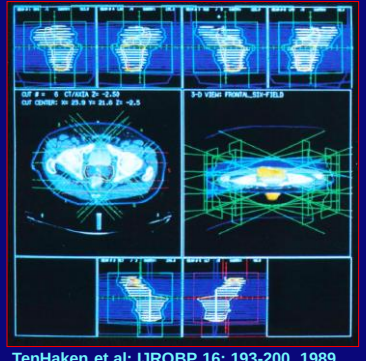

NATIONAL GEOGRAPHIC
Medicine's New Vision
Mohan et al, MSKCC


INSTITUT CURIE – LE PROGRAMME « SIMUL »
Rosenwald J.C., Gaboriaud G., Mazal A.
Repérage et simulation assistés par ordinateur
Réunion SFPH - SFR, Clermont-Ferrand, Juin 1988
U. Washington, Plan-32, Prism: Ira Kalet/Jon Jacky
CART (Hans Dahlin)
Helax (Univ. Uppsala)
U. Wisconsin, Mackie, Gehring
Pinnacle



What do we do with a 3-D planning system?

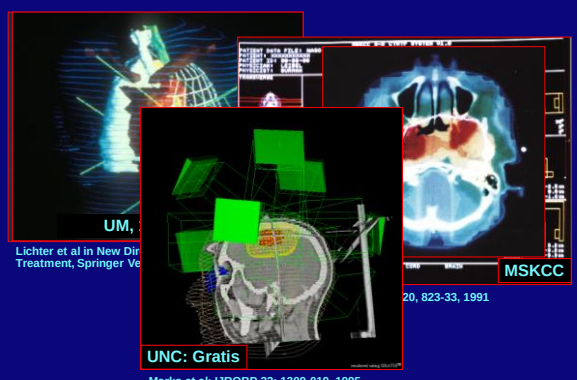
1986: Conformal Treatment of the Prostate



TenHaken et al: IJROBP 16: 193-200, 1989

UM

Late 80s: Learning to Conform

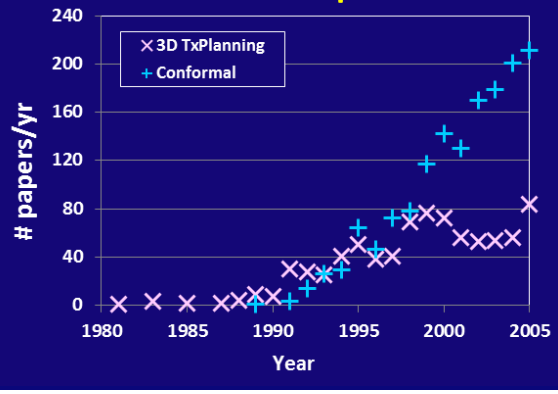


Lichter et al in New Dir
Treatment, Springer Ve

20, 823-33, 1991

Marks et al: IJROBP 33: 1209-019, 1995

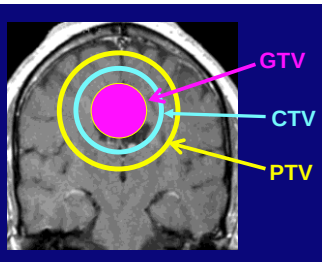
Pub Med Papers



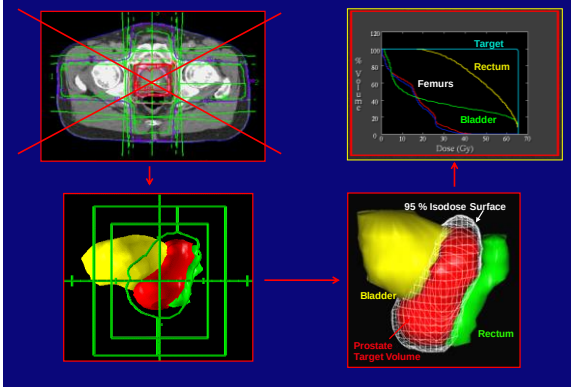
1992: A Crucial Tool: ICRU 50

International Commission on Radiation Units & Measurements

Prescribing, Recording, and Reporting Photon Beam Therapy (Report 50)



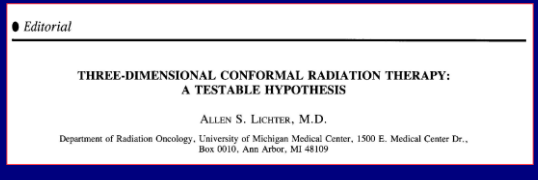
Conformal Therapy → Dose Escalation?



Some Early Conformal Therapy Clinical Dose Escalation Studies

Site	Institution	Start	Dose(Gy)
Prostate	UM	1986	60 → 80.4
Liver	UM	1987	30 → 90
Prostate	MSKCC	1988	64.8 → 75.6, +
Brain	UM	1989	60 → 70,80,90
Lung	UM	1991	60 → 102.9

The 3-D Hypothesis



Editorial

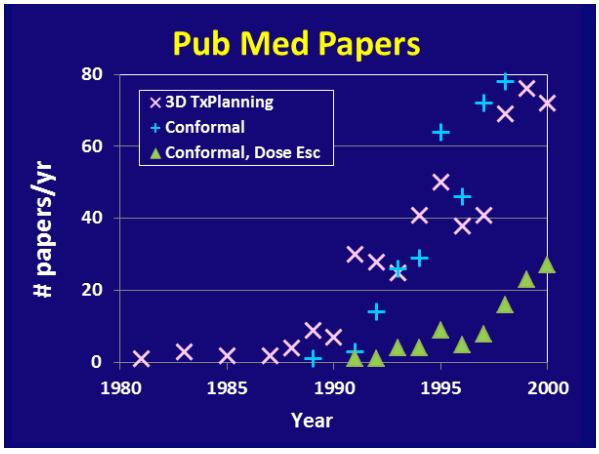
THREE-DIMENSIONAL CONFORMAL RADIATION THERAPY:
A TESTABLE HYPOTHESIS

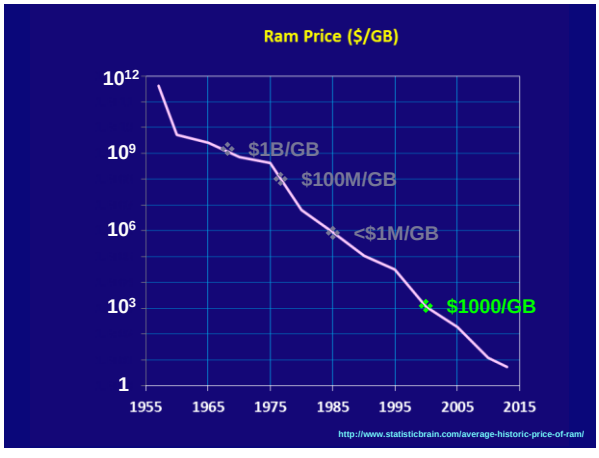
ALLEN S. LICHTER, M.D.

Department of Radiation Oncology, University of Michigan Medical Center, 1500 E. Medical Center Dr., Box 0010, Ann Arbor, MI 48109

By tightly conforming the shape of the high dose volume to the shape of the target, one could increase target dose without increasing complications

AS Lichter: Int J Rad Onc Biol Phys 21: 853-855, 1991





2000s: 3-D is the State of the Art

Finally,

- We have 3-D planning capabilities
- We know how to treat patients conformally
- We have clinical data on dose escalation and/or minimization of normal tissue toxicity
- Cost for computer systems continues to fall
- Commercial planning systems provide some 3-D planning capabilities

Widespread acceptance of 3-D and conformal therapy: it's now time for computer-controlled machines and IMRT, as well as the next talk !

Summary

3-D planning was made possible by

- Development of CT (and other imaging)
- Continually increasing computer power + decreasing costs
- A lot of smart and clever people
- Vision of the improvements in therapy that the new capabilities would make possible
- Careful implementation and clinical studies which led to real improvements in clinical use and improved outcomes for patients

Acknowledgments

Dan McShan PhD	RIH, UM
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Radhe Mohan PhD	MSKCC, MDACC
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Michael Goitein PhD	MGH, PSI
Wolfgang Schlegel PhD	DKFZ
Jean-Claude Rosenwald PhD	Institut Curie
Anders Murman	Helax, RaySearch
Tomas Bortfeld PhD	DKFZ, MGH