

Historical perspective on IMRT AAPM Summer School: June 2003

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My view is not the only one

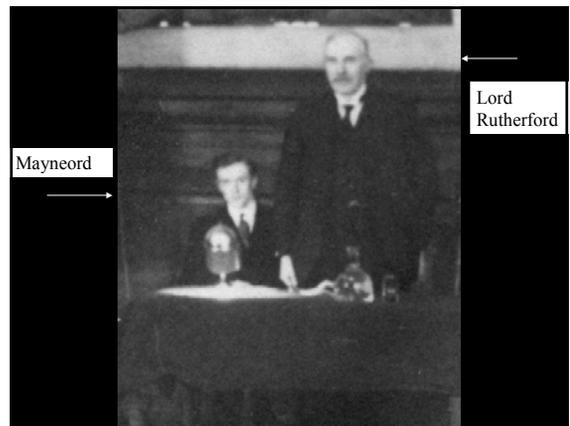
- Disclaimers!
- Writers of history tread dangerously.
- True versus amateur historians.
- Agreement of major landmarks vs controversy on the detail – A.N. Other may tell the story differently.

What is history?

- Egyptians, Kings and Queens of England...IMRT??!!
- Never heard the word until 1996!
- So IMRT is “recent history”.
- “I aM aRT” (Bortfeld/Boyer).
- Everything important has happened in the last 15 years.
- So vast majority of pioneers are (i) alive (ii) still working (iii) probably here!
- If I mention key names do I make instant enemies?

William Valentine Mayneord

- Did no IMRT but....
- made first manual plots of dose;
- invented the Rad;
- Had my job before me for >40 years, so he gets a mention.





Is IMRT “completed”?

- The four sentence history:
- 1988 – one person knew about IMRT – Anders Brahme
- 1995 - main planning and delivery techniques worked out
- 2000 – all major companies offering products
- 2003 – “everyone wants IMRT”.
- So: is there anything left to do? Students, postdocs, managers, bean counters all ask this.
- No! IGRT, non-MLC IMRT, Co-IMRT, MMI applied to IMRT, IMRT and molecular genetics.
- No! Hence this course.

Table 1

1895 The x ray was discovered on November 8th in Germany by Röntgen.

1896 Doctors understood the need to “concentrate radiation” at the target but had means to neither do this nor even to know where the target was precisely.

1950s Takahashi first discussed conformation therapy.

1959 Invention and patenting of the first multileaf collimator.

1960s Proimos developed gravity-oriented blocking and conformal field shaping.

1970s The Royal Free Hospital built the “tracking cobalt unit” and MGH Boston did similar tracking with a linac.

1982 Brahme et al discussed inverse-planning for a fairly special case of rotational symmetry.

1984 First commercial MLCs appeared.

1988 Brahme published first paper on algebraic inverse planning.

1988 Källman postulated dynamic therapy with moving jaws.

1989 Webb developed simulated annealing for inverse planning. So did Mageras and Mohan.

1990 Bortfeld developed algebraic/iterative inverse-planning, the precursor of the KONRAD treatment-planning system.

1991 Principle of segmented-field therapy developed (Boyer / Webb).

1992 Convery showed the dMLC technique was possible.

1992 Carol first showed the NOMOS MIMiC and associated PEACOCKPLAN planning system (now CORVUS).

1993 Tomotherapy (the Wisconsin machine) first described by Mackie.

1994 Stein, Svensson and Spirou independently discovered the optimal dMLC trajectory equations.

1994 Bortfeld and Boyer conducted the first multiple-static-field (MSF) experiments.

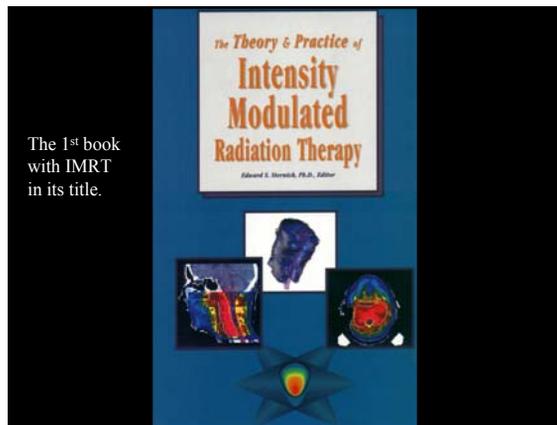
1999 First discussion of possible robotic IMRT.

2002 Commercial tomotherapy began.

2003 Large number of competing IMRT planning systems and systems for delivery. IMRT is well established in several geographically distributed centres. Specialist inverse-planning algorithms continue to appear as one-offs.

Critics of IMRT

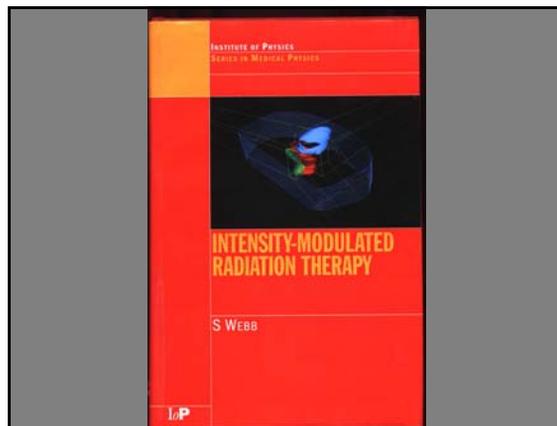
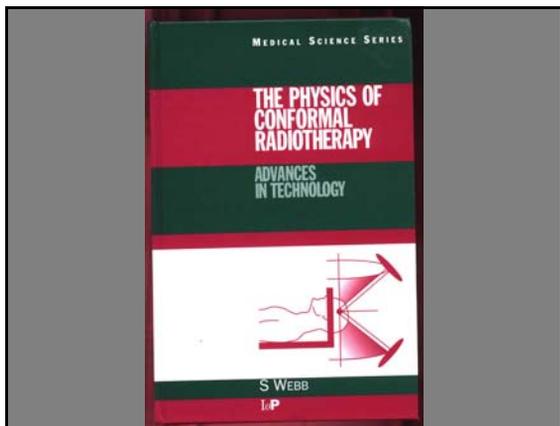
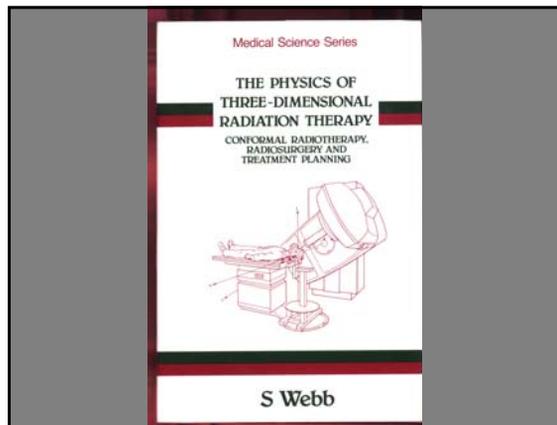
- Is the reimbursement dollar driving the science?
- “If they have it, we must have it”?
- Company influence?
- Unstoppable consequence of human nature.



References:

Reviews of the history of CFRT and IMRT, together with details of inverse-planning algorithms can be found in my three IOPP books.

These form a sequential trilogy and are all different. They contain long reference lists to original papers.



Prehistory

- Hindsight is wonderful.
- What came before 1988?

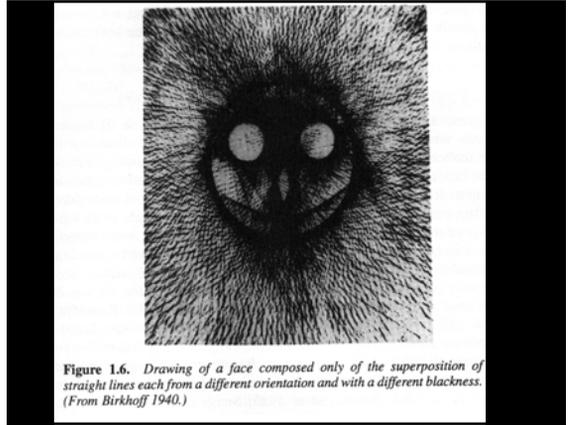
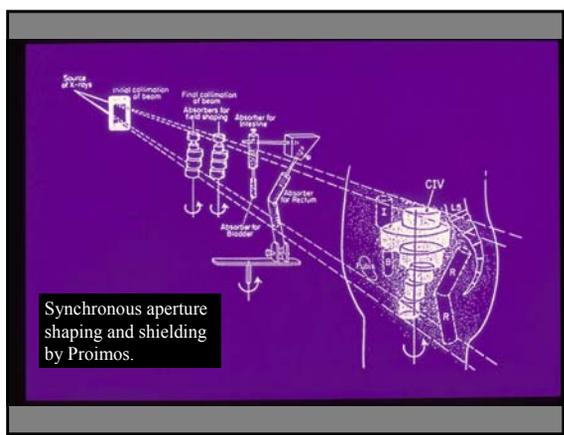


Figure 1.6. Drawing of a face composed only of the superposition of straight lines each from a different orientation and with a different blackness. (From Birkhoff 1940.)



Synchronous aperture shaping and shielding by Proimos.

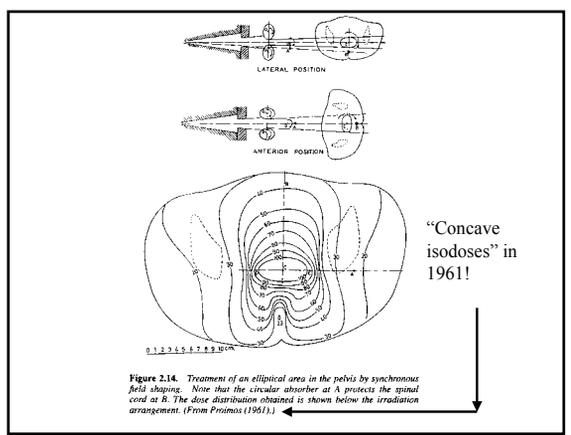


Figure 2.14. Treatment of an elliptical area in the pelvis by synchronous field shaping. Note that the circular absorber at A protects the spinal cord at B. The dose distribution obtained is shown below the irradiation arrangement. (From Proimos (1961).)

“Concave isodoses” in 1961!

What exactly is IMRT?

- Not necessarily via inverse planning
- “moderate” modulation i.e. not wedge, block...

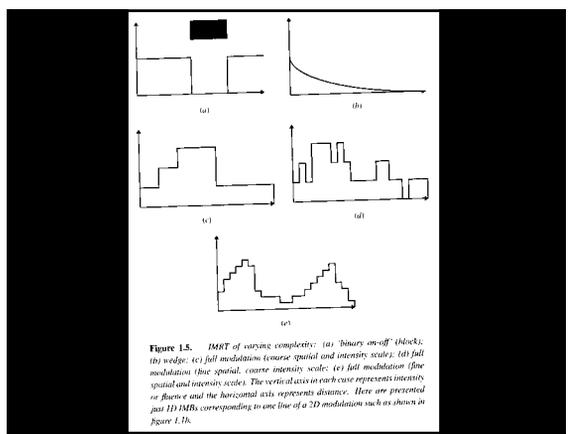


Figure 1.5. IMRT of varying complexity: (a) binary on-off (block); (b) wedge; (c) full modulation (various spatial and intensity scales); (d) full modulation (fine spatial and intensity scales); (e) full modulation (fine spatial and intensity scales). The vertical axis in each case represents intensity or fluence and the horizontal axis represents distance. Here are presented just 1D IMRTs corresponding to one line of a 2D modulation such as shown in figure 1.16.

“The first IMRT paper”

- Only analytically soluble problem

Solution of an integral equation encountered in rotation therapy

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Received 30 March 1981, in final form 4 December 1981

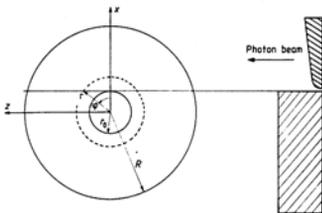


Figure 1. The irradiation geometry and coordinate system used in the calculations. The origin of the rectangular and polar coordinate systems is located at the isocentre of the therapy machine. The location of the beam block and the non-linear wedge-shaped filter is also indicated.

Brahme's 1988 paper

Webb 1989 simulated annealing

- Similar work at MSK (Mageras and Mohan).
- Two-weights per field (1992).

1990 Bortfeld's inverse-planning method

1991 Boyer cone-beam inverse-planning and “field-within-field”

1992 Mark Carol

- Geneva WHO meeting.
 - MEDCO and NOMOS.
 - The MIMiC.
 - Peacockplan.
 - CORVUS.
 - Not announced until 100% (well 99%) ready.
- Hook up and start; 4 years lead on dMLC; integrated planning and delivery.
- Durango and the Strater Hotel



142 Methods to create intensity-modulated beams (IMBs)

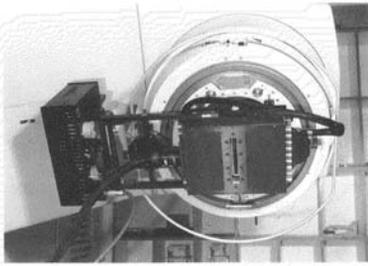


Figure 2.23. Shows the NOMOS MIMiC collimator attached to a Philips SL25 linear accelerator at the Royal Marsden NHS Trust, Sutton, UK. The two sets (banks) of leaves (or vanes) can be seen with some open and some shut. (Loan of MIMiC courtesy of the NOMOS Corporation.)

1993 Rock Mackie and tomotherapy

- Radiotherapy in a box.
- 10 years from publication to clinical prototype – development under community gaze.
- Swerdloff; relationship with NOMOS.

Other key workers

- Kallman 1988.
- Convery 1992.
- Kijewski 1978.
- Takahashi 1965.
- Note the MLC was patented in 1959.

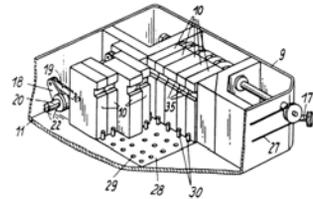


Figure 5.5. A schematic view of Gscheidlen's multileaf collimator patented in 1959, showing just two of the four sets of leaves. The actuating mechanism and the template for setting the field shape may be seen, as well as some of the guide bars (see text for description). (From Gscheidlen (1959).)

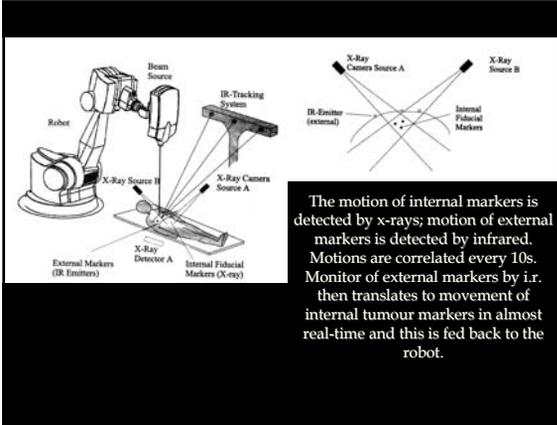


Ultramodern history

- When does history become review?

The Cyberknife





We have come a long way from....



Where next (that's for the course....)

- Racetrack microtron?
- IMAT?
- Shuttling MLC?
- Jaws + mask?
- Cobalt IMRT?

“No-one has ever been treated with a concept”

- Clinical IMRT will prove its worth.
- I've included concepts as well as actualities (otherwise major omissions).
- Hard to track clinical IMRT history – what is meant by 1st?

