CURRICULUM VITAE

Soehartati Gondhowiardjo, MD. PhD

Born	: Jakarta, September 1955
Education	
1. GP	: FKUI, 1980
2. Radiologist	: FKUI, 1987
3. Radiation Oncologist	: FKUI / Muenster (Germany) 1990
4. PhD	: FKUI, 1998 (EBV LMP1 and Proliferation in NPC)

Current Positions :

Head of Radiotherapy Department , RSUPN-CM / FKUI
Chairman of Indonesian Radiation Oncology Society
President of South East Asia Radiation Oncology Group

Atomic Energy Regulatory Agency's Role in relation with Advanced Technology in Radiotherapy

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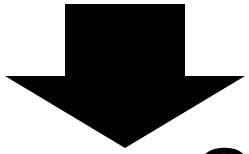
RSCM

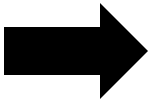
Outline

- Introduction
- Methods of delivery radiation therapy
  - External Radiotherapy
  - Internal Radiotherapy
- Bapeten

Introduction

- The increasing of incidence and prevalence of cancer
- Multidisciplinary cancer treatment
- The role of radiotherapy in cancer treatment
- Milestones of radiotherapy



- Radiotherapy Goal  Therapeutic Ratio

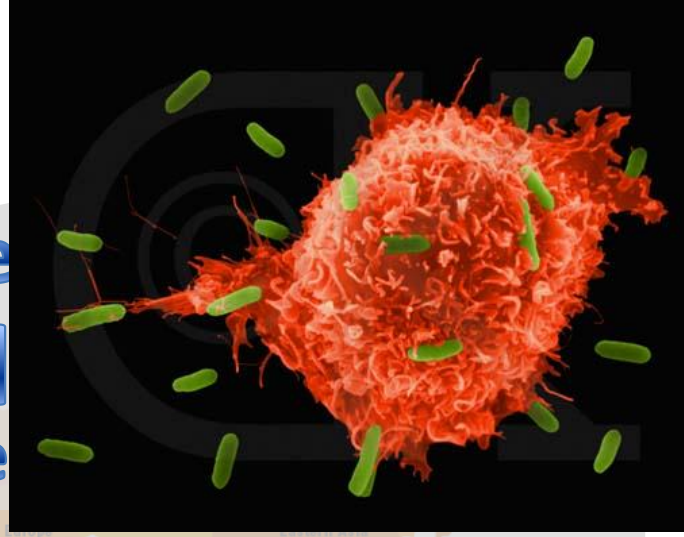
Year 2005:

Cancer kille

Year 2030:

7 mil

People



300%

more people will live with cancer

Cancer will kill more than

70%

of them will be in Developing Countries

23 million

17 million

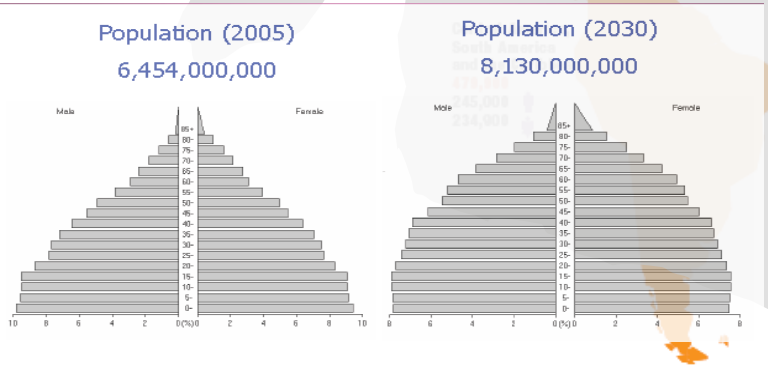
200%

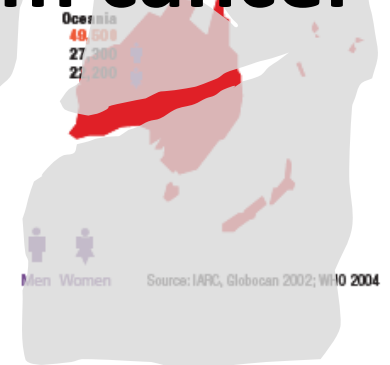
Including

Indonesia

People around the world

more people will die from cancer





11 million

new cases around the world

25 million

People living with cancer

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Cancer Treatment is Multidisciplinary Approach by :

- Surgery (HNB, ENT, Obgyn etc)
- Medical Oncology
- Radiation Oncology
- etc (PM&R, interventional radiologist, pathology, diagnostic radiology)

The role of radiotherapy only as a definitive treatment?

Local Glotic Cancer, Local NPC, Prostate cancer (high risk)

The role of combination chemo-radiotherapy as a definitive treatment?

Locally advanced NPC, cervical cancer, unresectable lung cancer

The role of radiotherapy in the adjuvant setting?

Breast cancer, colon cancer, lymphoma, endometrial cancer, sarcoma

The role of radiotherapy in palliative care?

Pain, uncontrolled bleeding, VCSS, brain metastases

The role of radiotherapy in benign lesion?

Adenoma pituitary, AVM, vestibular schwabomma by Stereotactic Radiosurgery

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TABLE 3
Optimal Radiotherapy Utilization Rate by Cancer Type

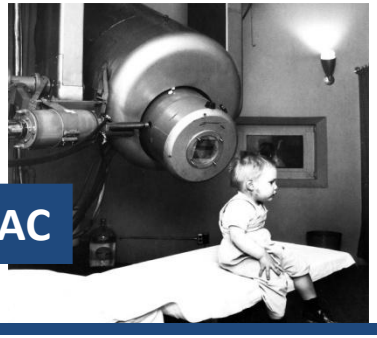
Tumor type	Proportion of all cancers	Proportion of patients receiving radiotherapy	Patients receiving radiotherapy (% of all cancers)	Reference
Breast	0.13	83	10.8	Delaney et al.[12]
Lung	0.10	76	7.6	Delaney et al.[13]
Melanoma	0.11	23	2.5	Delaney et al.[14]
Prostate	0.12	60	7.2	Delaney et al.[16]
Gynecologic	0.05	35	1.8	Delaney et al.[18,19]
Colon	0.09	14	1.3	Delaney et al.[15]
Rectum	0.05	61	3.1	Delaney et al.[15]
Head and neck	0.04	78	3.1	Delaney et al.[17]
Gall bladder	0.01	13	0.1	Delaney et al.[15]
Liver	0.01	0	0.0	Delaney et al.[15]
Esophageal	0.01	80	0.8	Delaney et al.[15]
Stomach	0.02	68	1.4	Delaney et al.[15]
Pancreas	0.02	57	1.1	Delaney et al.[15]
Lymphoma	0.04	65	2.6	Featherstone et al.[20]
Leukemia	0.03	4	0.1	Featherstone et al.[21]
Myeloma	0.01	38	0.4	Featherstone et al.[21]
Central nervous system	0.02	92	1.8	Delaney et al.[22]
Renal	0.03	27	0.8	Delaney et al.[16]
Bladder	0.03	58	1.7	Delaney et al.[16]
Testis	0.01	49	0.5	Delaney et al.[16]
Thyroid	0.01	10	0.1	Delaney et al.[22]
Unknown primary	0.04	61	2.4	Delaney et al.[22]
Other	0.02	50	1.0	See citations in text
Total	1.00	-	52.3	

MILESTONES IN RADIOTHERAPY

IMAGING

- 1950's: Image Intensifier
- 1970's: CT
- 1980's: MRI
- 1990's: PET
- 2000: PET CT
- 2003: 4D PET 4D CT

THERAPY



- 1951: Co-60
- 1952: LINAC
- 1985: MRI Brain
- 1988: CT Body
- 2000: TOMO, IMRT
- 2003: IGRT
- 2004: 4DART

Nuclear & Particle Physics

Computer Science

Imaging

Biotechnology

Radiotherapy Goal

therapeutic ratio

To cause maximum damage to tumor cells, while causing minimum damage to healthy tissue

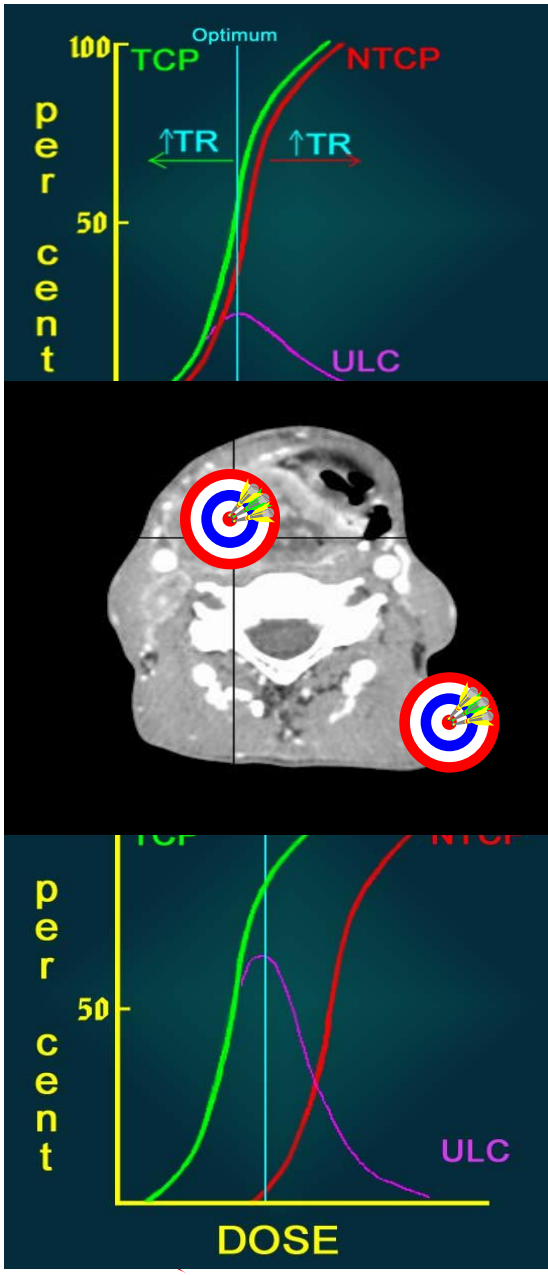
Advances in Technology and Sciences

Physical aspects approach

- Immobilization devices **(Stereotactic Body RT)**
- Technological innovation in radiotherapy delivery **(3 D CRT, IMRT, IGRT, Rapid Arc, 4DART)**
- Implementation of biologic imaging (**PET-Scan)**

Biologic targeted approach

- Altered fractionation scheduling
- Combined modality treatments using chemical or biologic agents - Chemotherapy.
- Targeting molecular processes and signaling pathways – Targeted Therapy.



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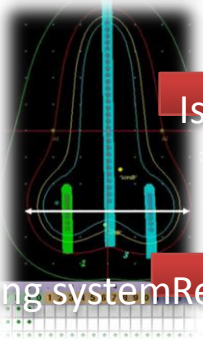
Methods of Delivering Radiation Therapy

High-Dose-Rate Afterloader

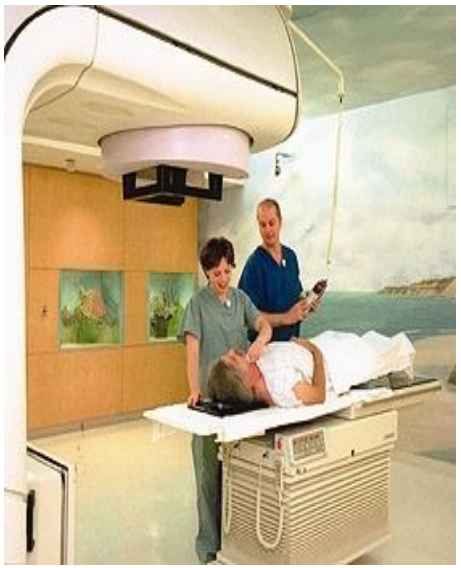
Aplikator



Isodosis

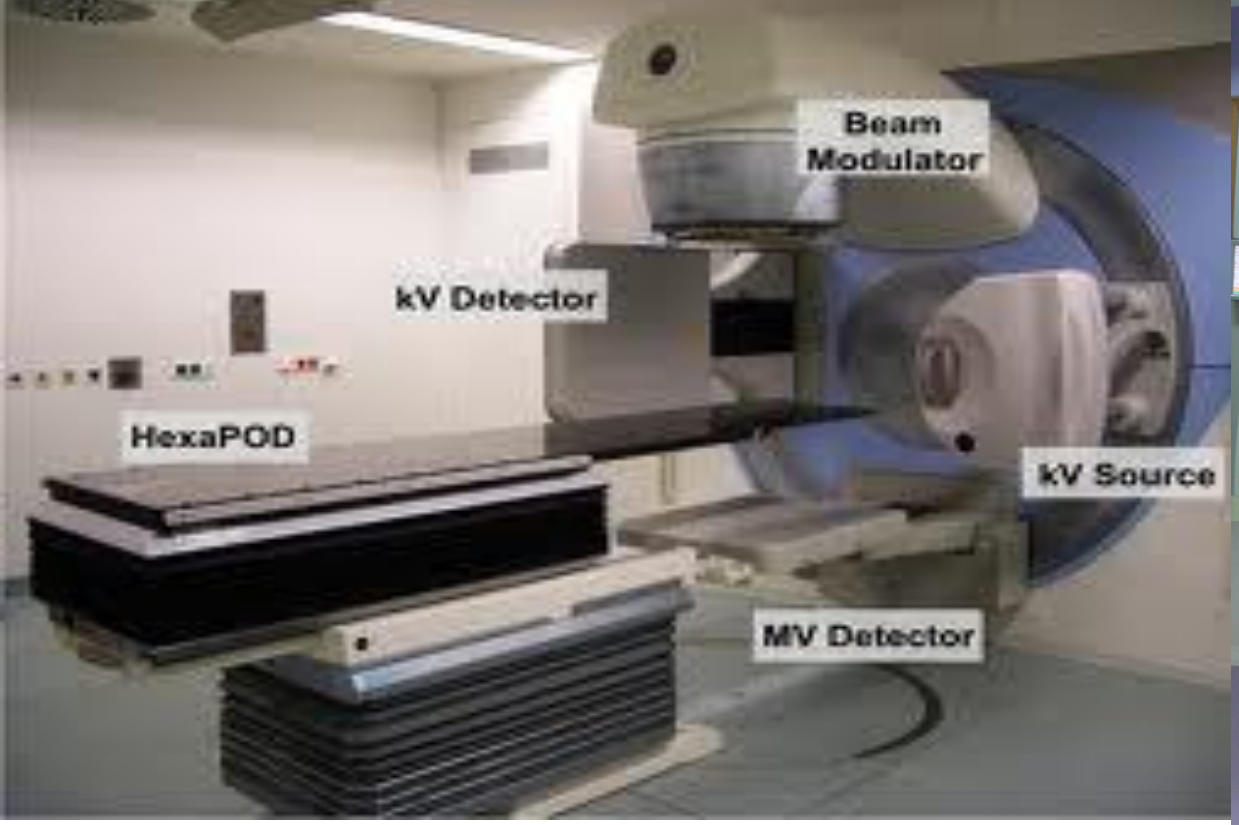
Treatment planning systemRekonstruksi aplikator

Early 1950s

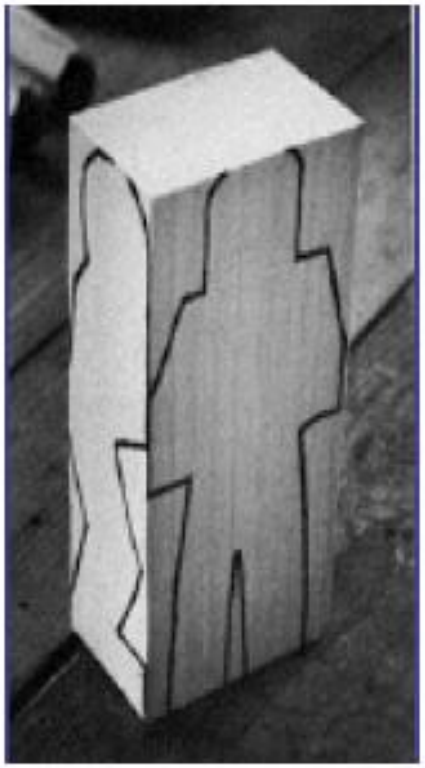


Today

RSCM

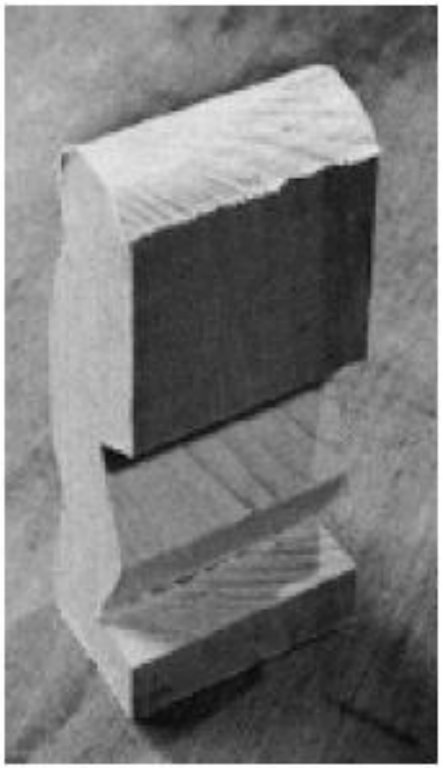


External Beam Radiotherapy



Dose Sculpting

2-D Planning



3-D
Conformal

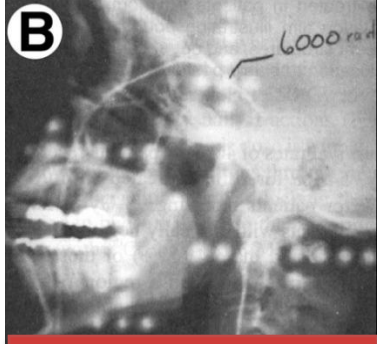
IMRT

What is IMRT?

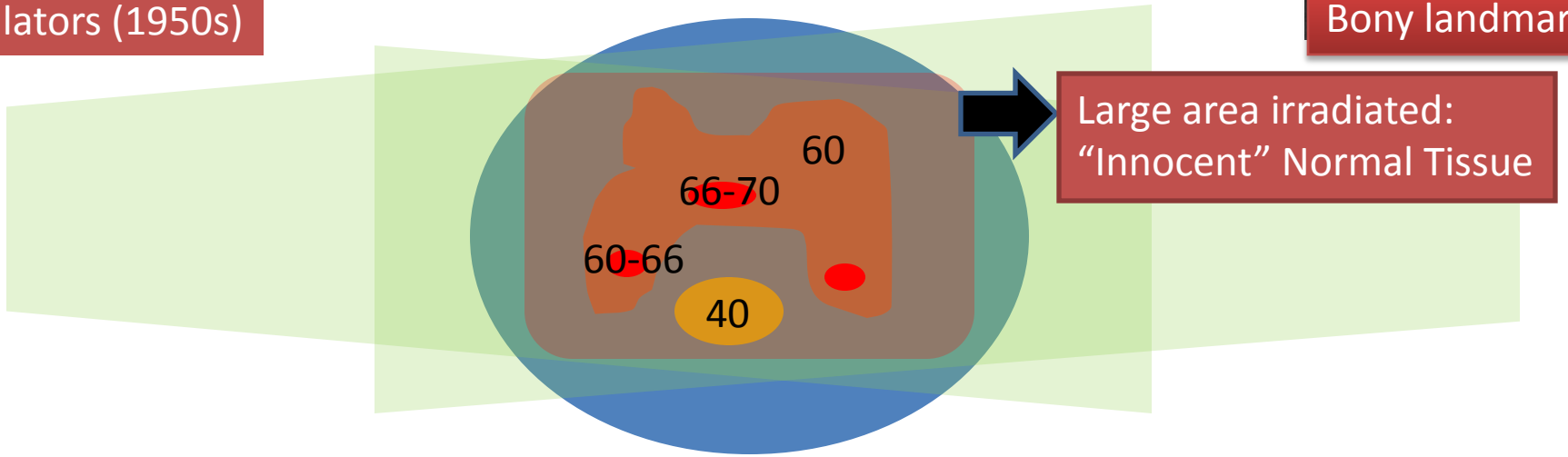
2D RT

(3 phases)

Simulators (1950s)

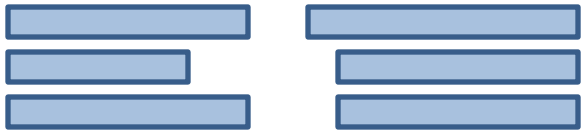


Bony landmarks

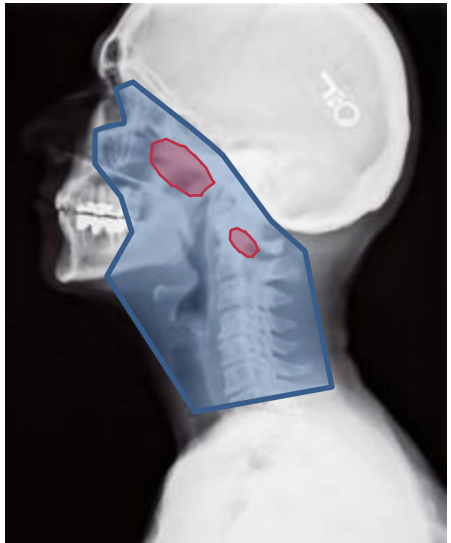


Large area irradiated:
"Innocent" Normal Tissue

Step 1 (40Gy):
Initial large field irradiation



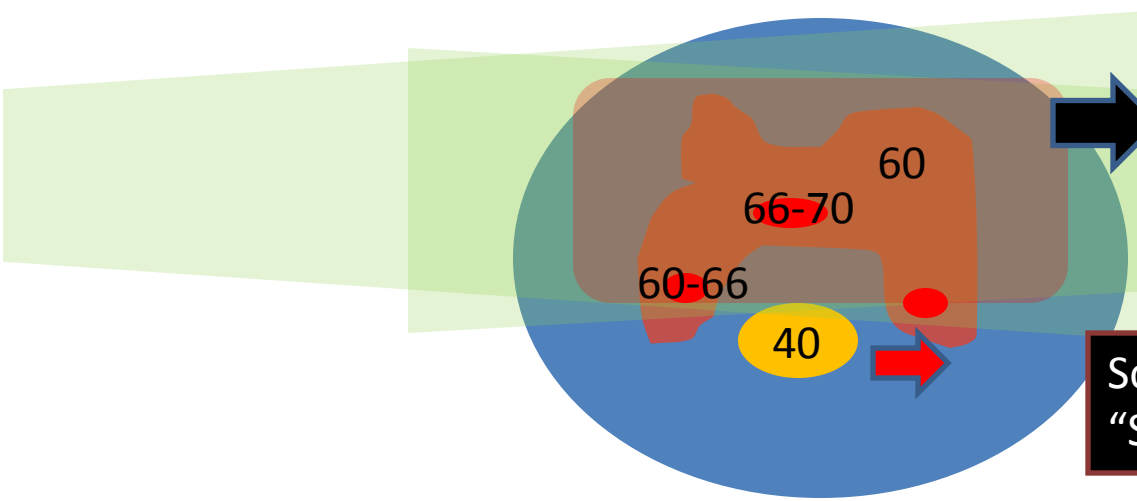
Field shaping with MLC / Blocks



Conventional 2D RT Technique:

Opposed Laterals, geometric field shaping +/- Wedge

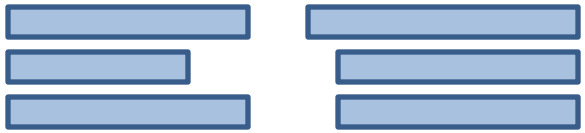
2D RT



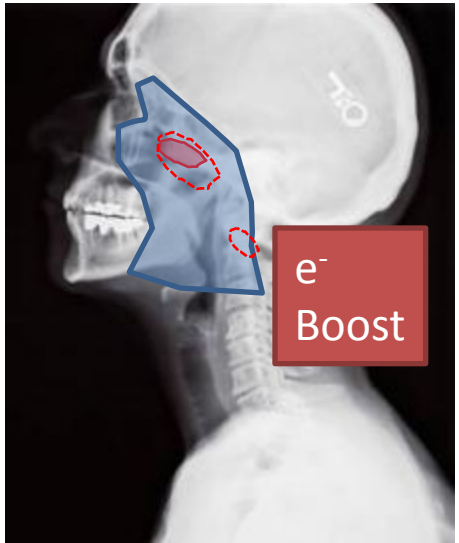
Large area irradiated:
"Innocent" Normal Tissue

Some critical organs limit the dose
"Sacrifices" have to be made.

Step 2 (16-26 Gy):
Off-cord field reduction



Field shaping with MLC / Blocks



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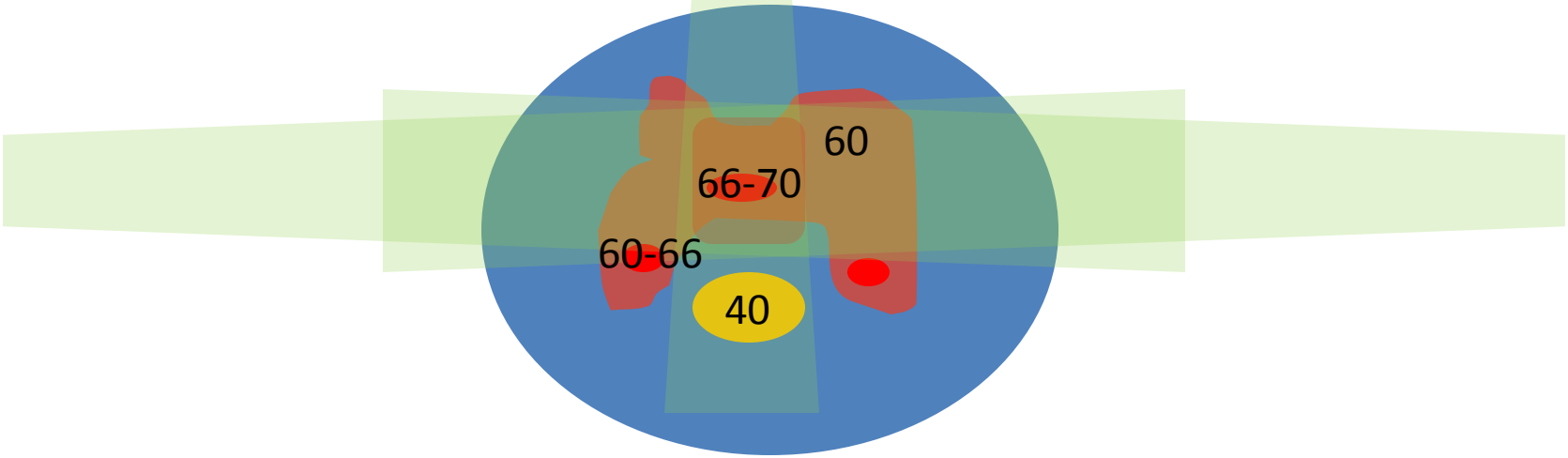
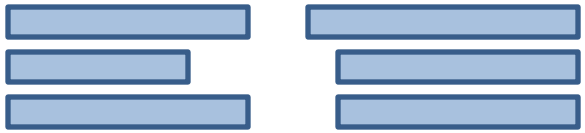
2D RT



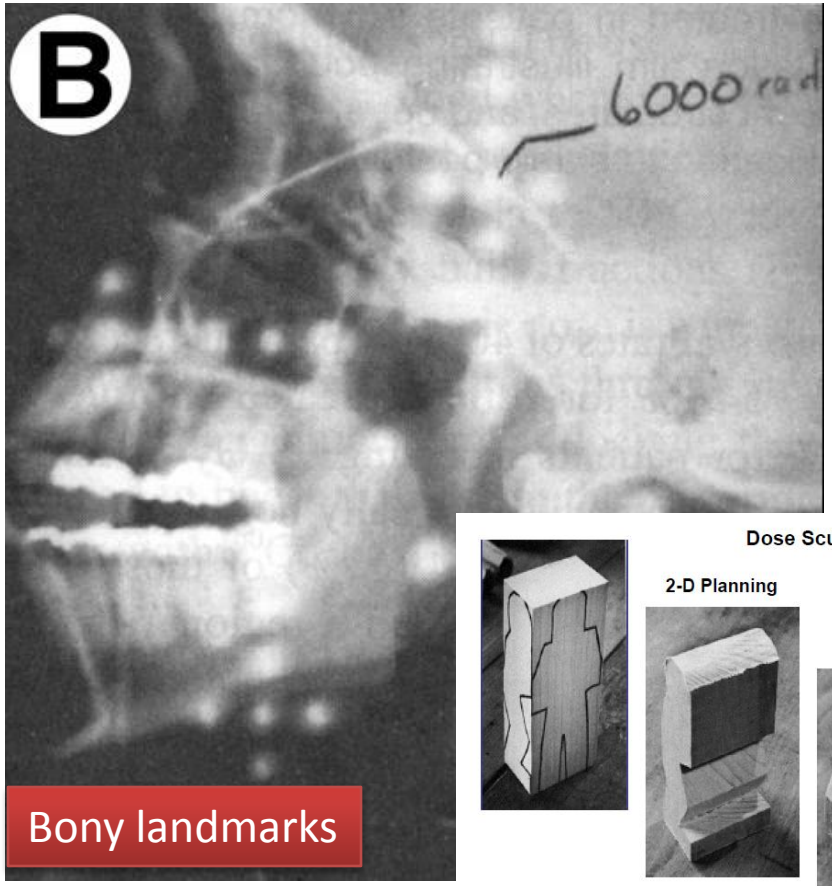
Step 3 (to 70-72 Gy):
Local Boost: 3D-CRT
Brachytherapy



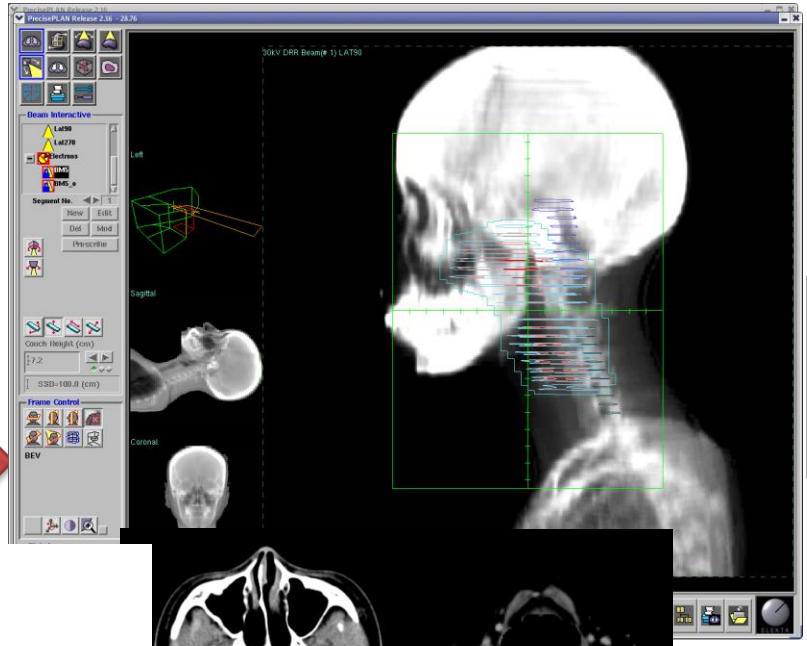
Field shaping with MLC / Blocks

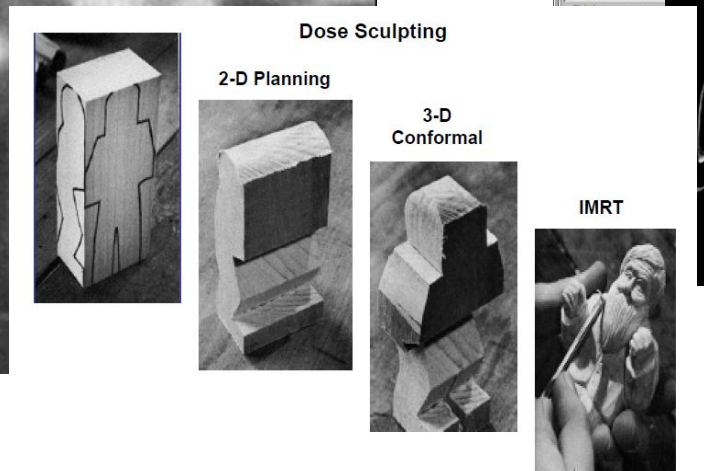
Developments in RT:
What do they mean for the patient?.....

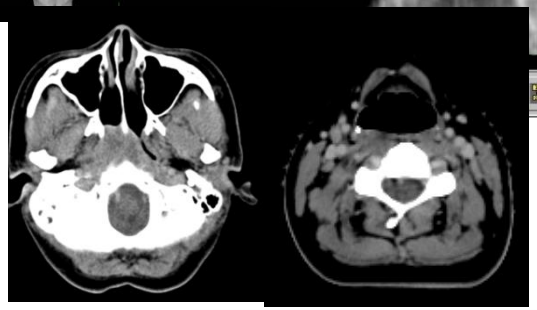
- CTSimulation (1980s-1990s):Targeting & avoidance



Bony landmarks

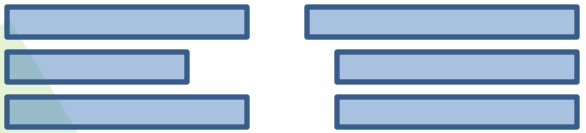






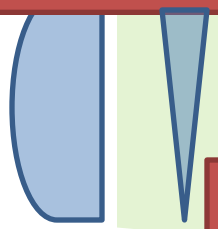
"Slight" customization
No difference in technique
"2D" Conformal

3D-CRT: More Conformal Dose Distribution

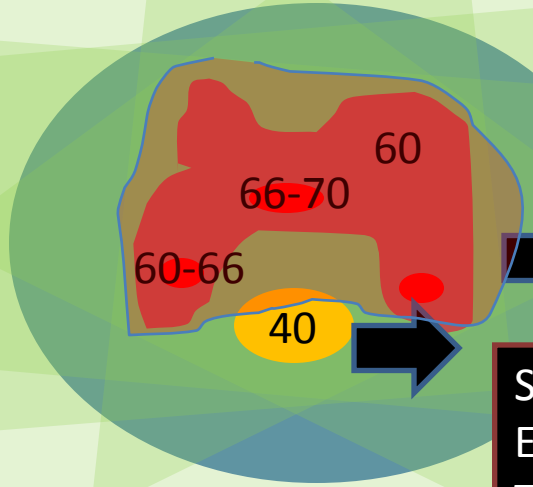


Field shaping with MLC / Blocks

Flat Beam Intensity

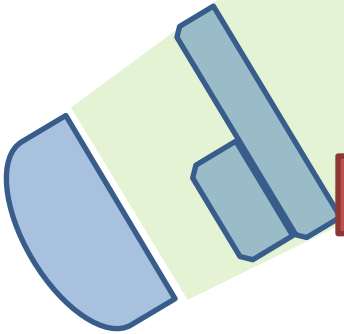


Wedges



More tissue spared

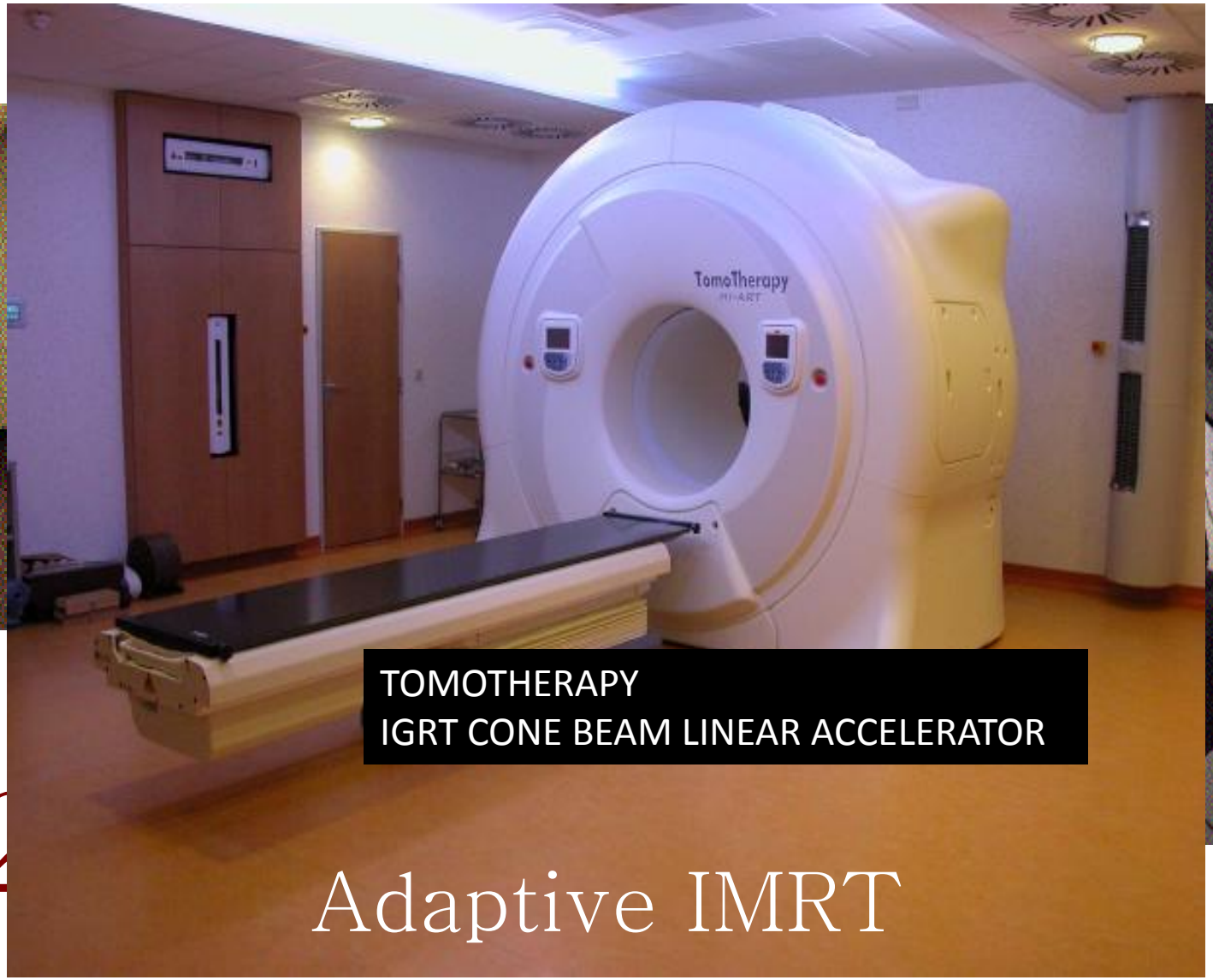
Less risk of "misses"
(3D Imaging is used)



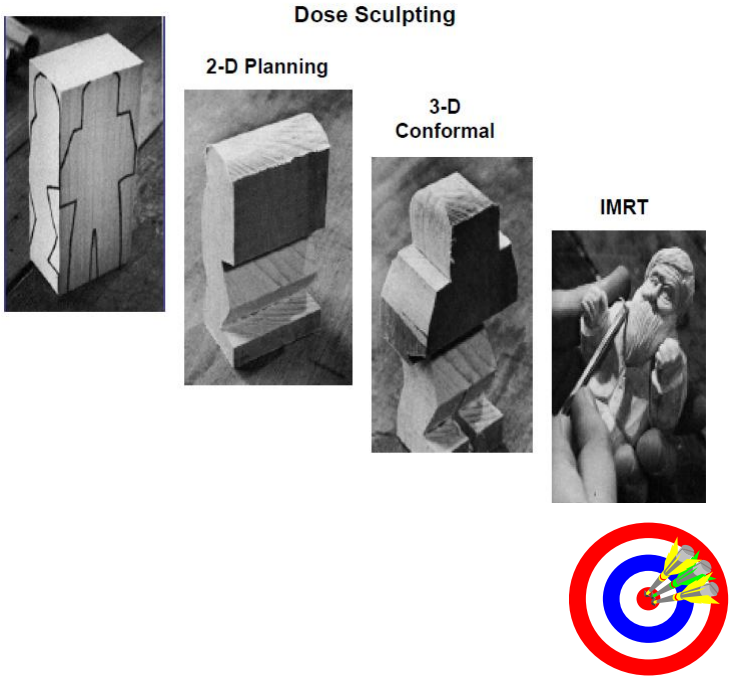
Compensators

Still difficult to avoid normal structures
Extremely difficult for some cases:
T4
Nodes in level V
Base of skull & Clivus

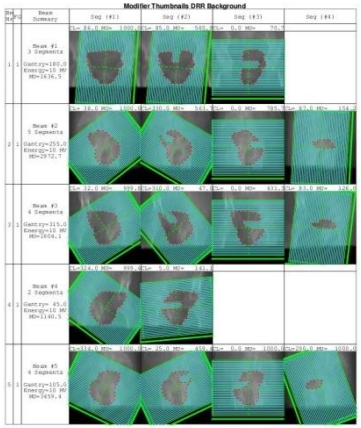
Radiotherapy

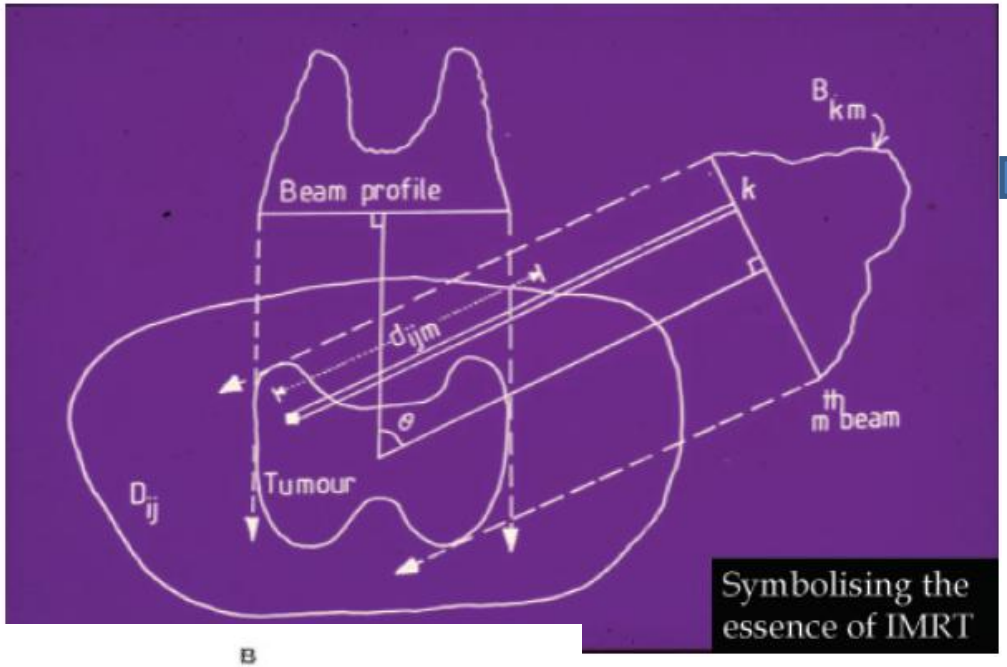


IMRT? ……..HOW?

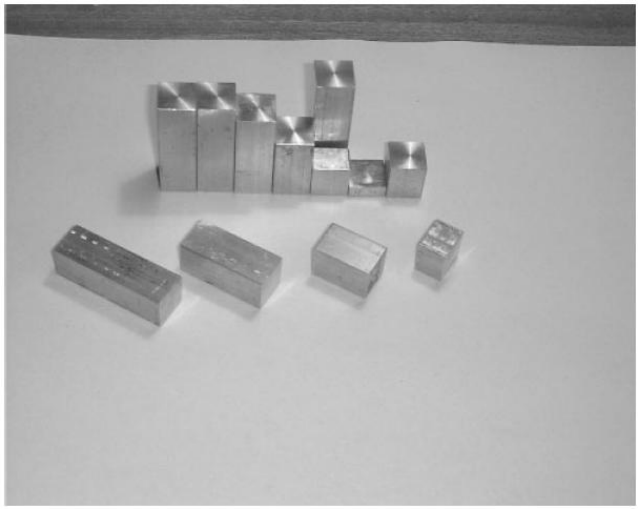


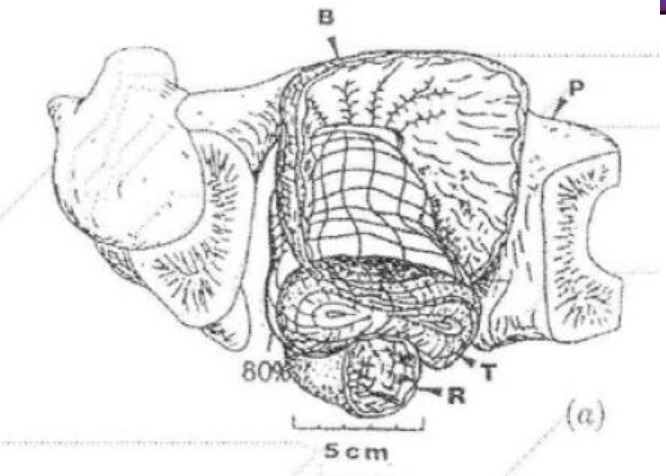
Bending the dose





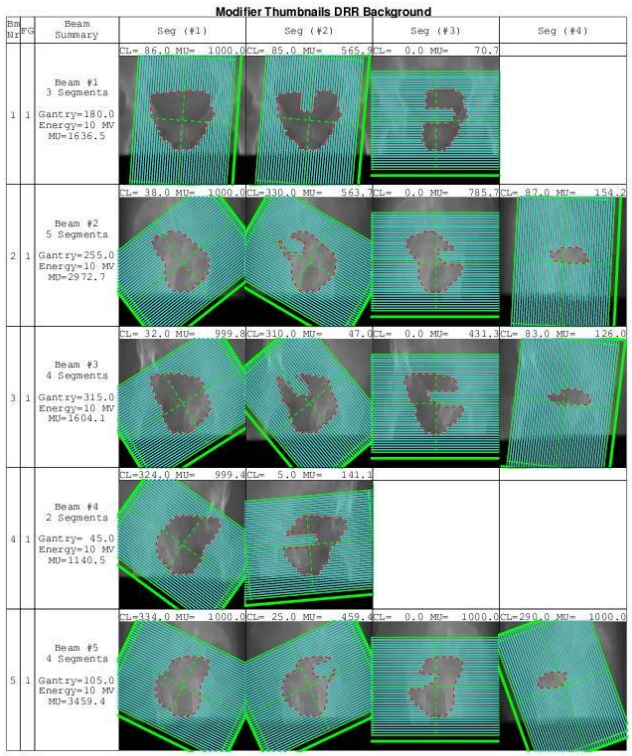
Non-flat beam intensity creates curved dose distributions

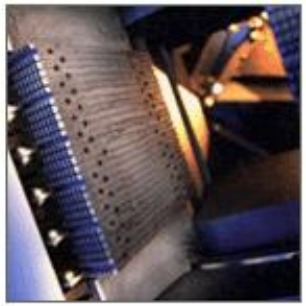


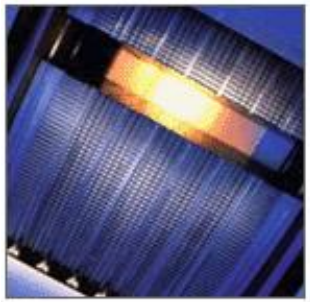


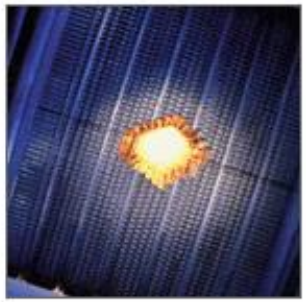
Drawing from Art Boyer, 1993, illustrating the concept of intensity modulation

S Webb, Br J Radiol 2005



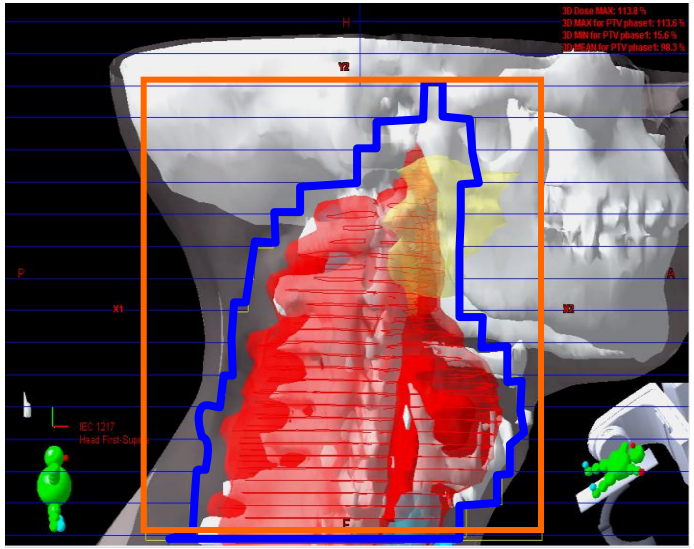


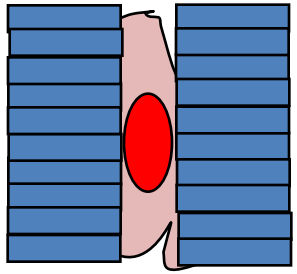




IMRT?

IMRT can be delivered using Multi Leaf Collimator (MLC) to shape dose distributions and to produce non-uniform beam intensity





Rationale : IGRT + CRT / IMRT

- Image Guided Radiotherapy (IGRT) :
  - Increases awareness of motion and setup error
  - Allows delivered dose to be better estimated, providing ultimate "QA" for IMRT
- IGRT, with correction for offsets:

Delivered dose ≈ Prescribed dose

IGRT Technologies

kV Radiographic

Portal Imaging

CYBERKNIFE

TomoTherapy Hi-Art™

MV CT

Elekta Synergy

Varian OBI™

kV Cone-beam CT

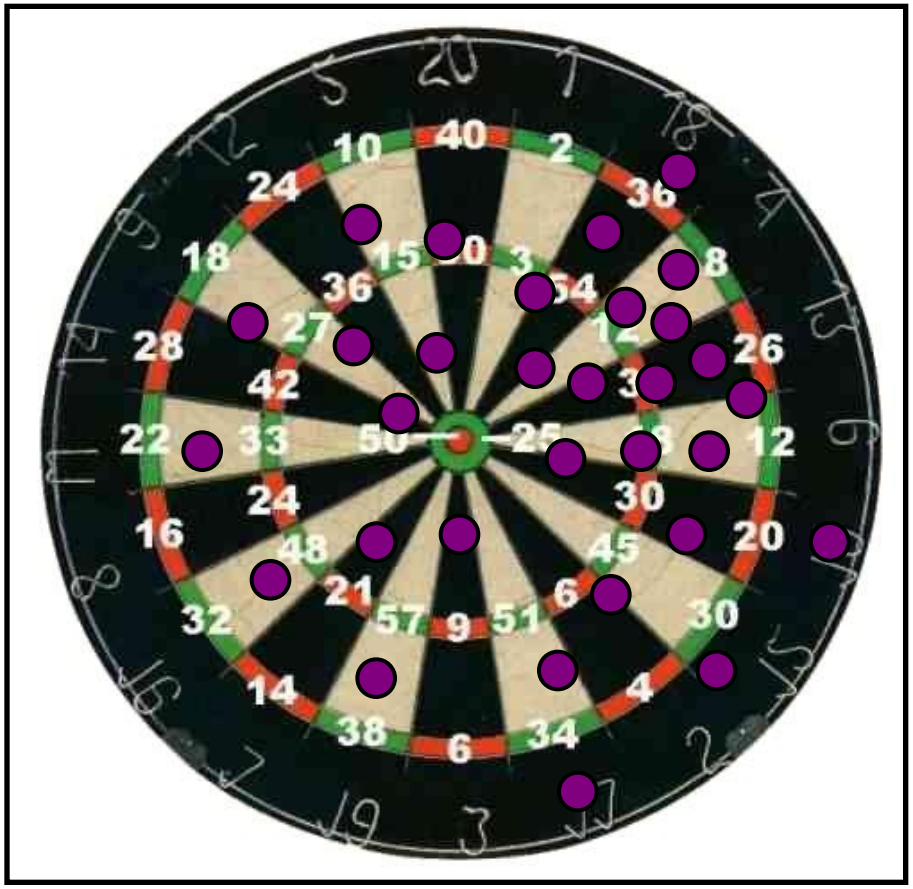
KEY FACTS

- Approximately 40% of people with cancer have radiotherapy as part of their treatment.[1]
- While damaging cancer cells, radiation can also affect surrounding healthy cells if it is not directed with a high degree of accuracy and precision.[1]
- Computerized three-dimensional reconstruction of patient anatomy allows physicians to deliver radiotherapy to cancer patients more precisely.[4]
- Intensity-modulated radiation therapy (IMRT) allows the intensity of the radiation to be changed during treatment, which spares more of the normal surrounding tissue.[6]

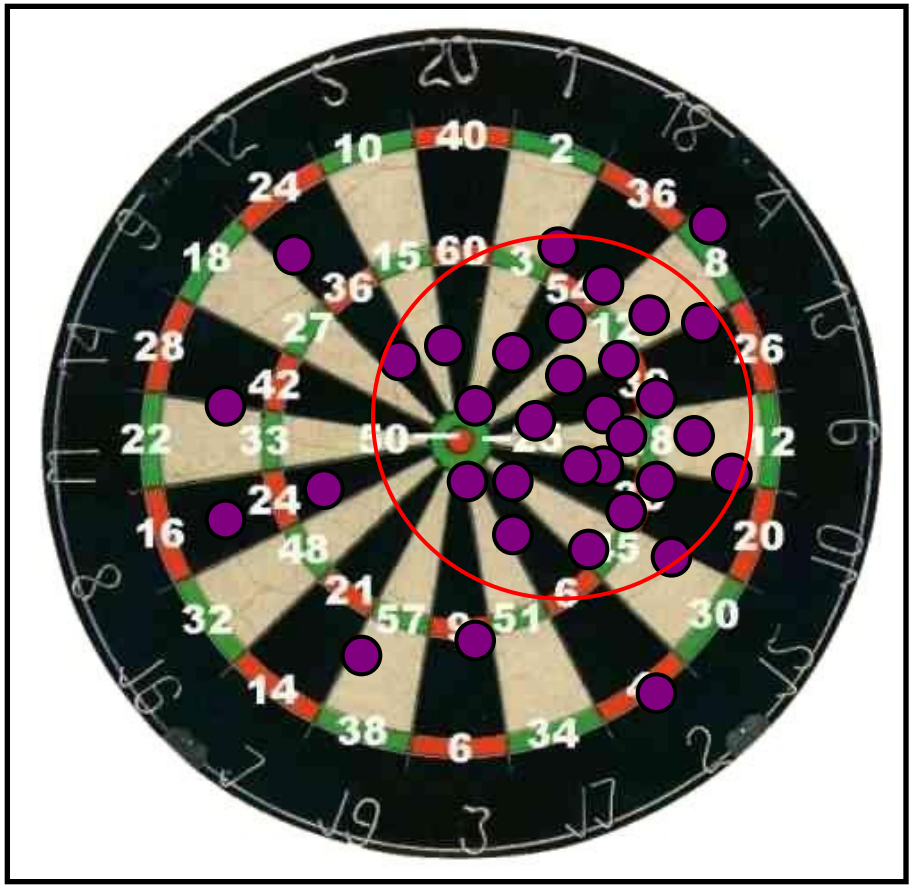
IGRT combines scanning and radiation equipment, to provide images of the patient's organs in the treatment position, at time of treatment, optimizing the accuracy and precision of the radiotherapy.[8]

Where does IGRT Fit In?

3DCRT vs. IMRT

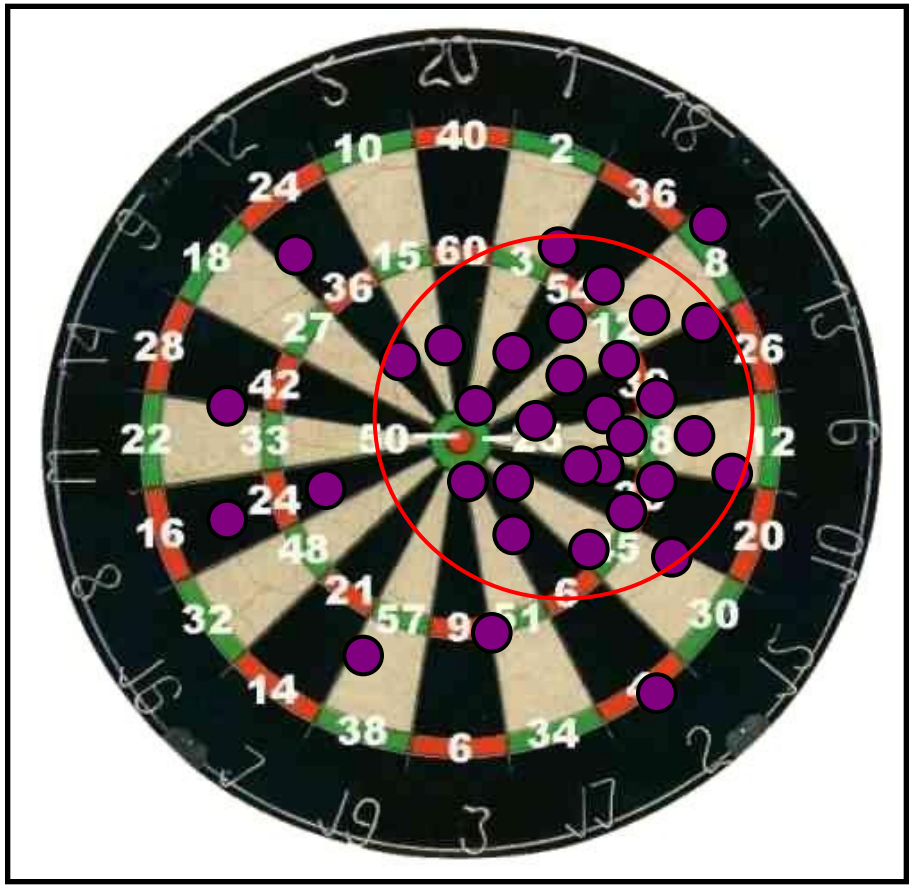


Low precision & accuracy

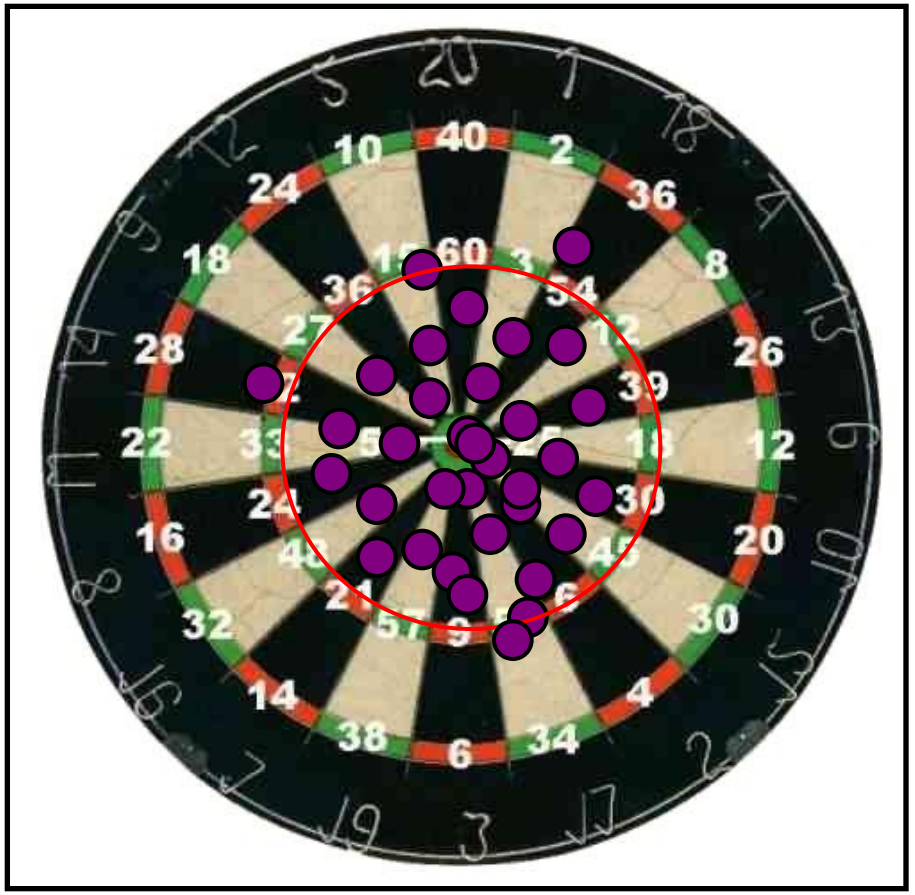


Good *<u>precision</u>* & moderate accuracy

IMRT vs. IGRT

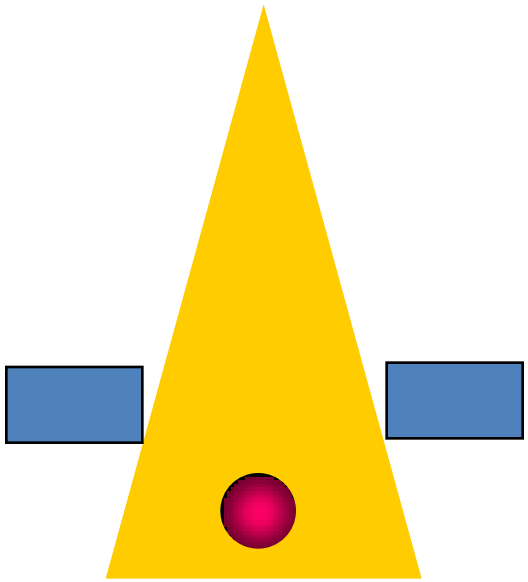


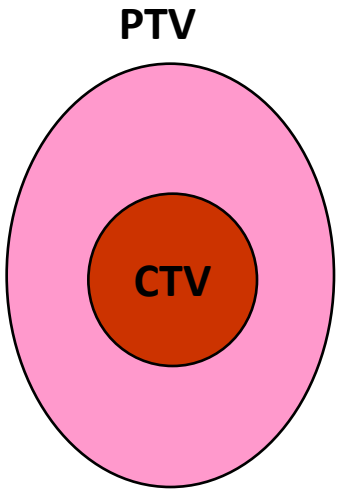
Good *precision* & moderate accuracy



Good *precision* & good *accuracy*

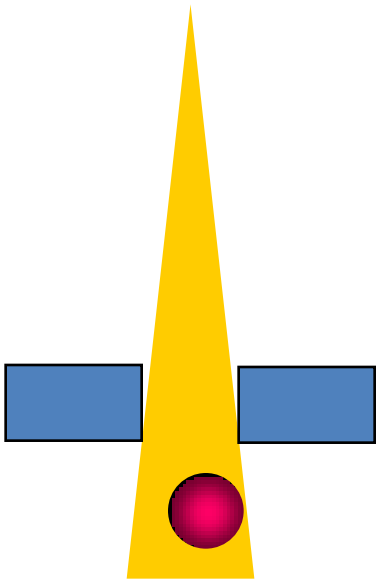
Conventional 3D Conformal Radiation Therapy

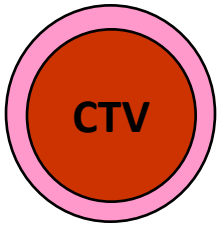




- IRRADIATION TO NORMAL TISSUE AND CRITICAL ORGAN USING STATIC FIELDS AND A MARGIN
- NORMAL TISSUE COMPLICATION PROBABILITY (NTCP) ↑

Reduce Respiratory Organ Motional Range

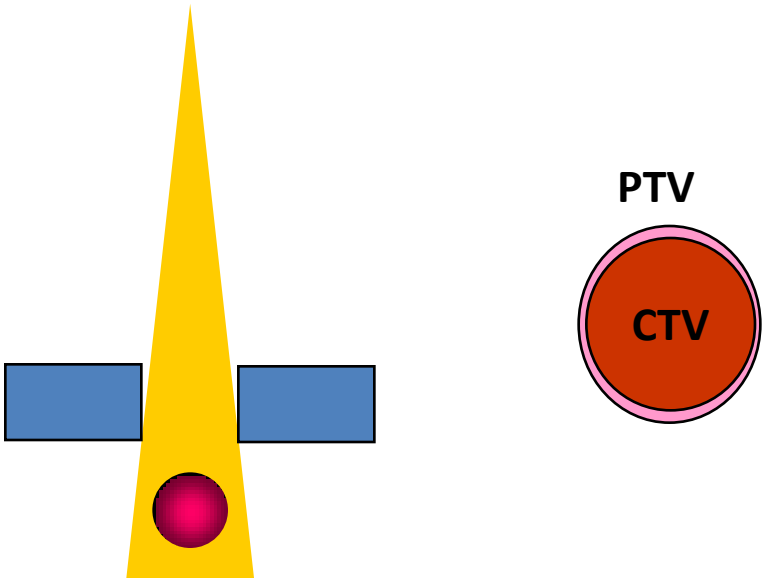




- DIBH (DEEP INSPIRATIONBREATH HOLD)
- ABC (ACTIVE BREATHING CONTROL)

- REQUIRE PATIENT'S COOPERATION
- NOT SUITED FOR ALL PATIENTS

Real-Time Dynamic Tumor Tracking



- IDEAL SOLUTION FOR THE MOTION/SETUP ERRORS
- IMAGE GUIDING IS ESSENTIAL
- COMPLEX & EXPENSIVE

- UNTIL TUMOR TRACKING BECOME MORE AVAILABLE, SOLUTION IN-BETWEEN: ONLINE & OFFLINE IGRT

IGRT

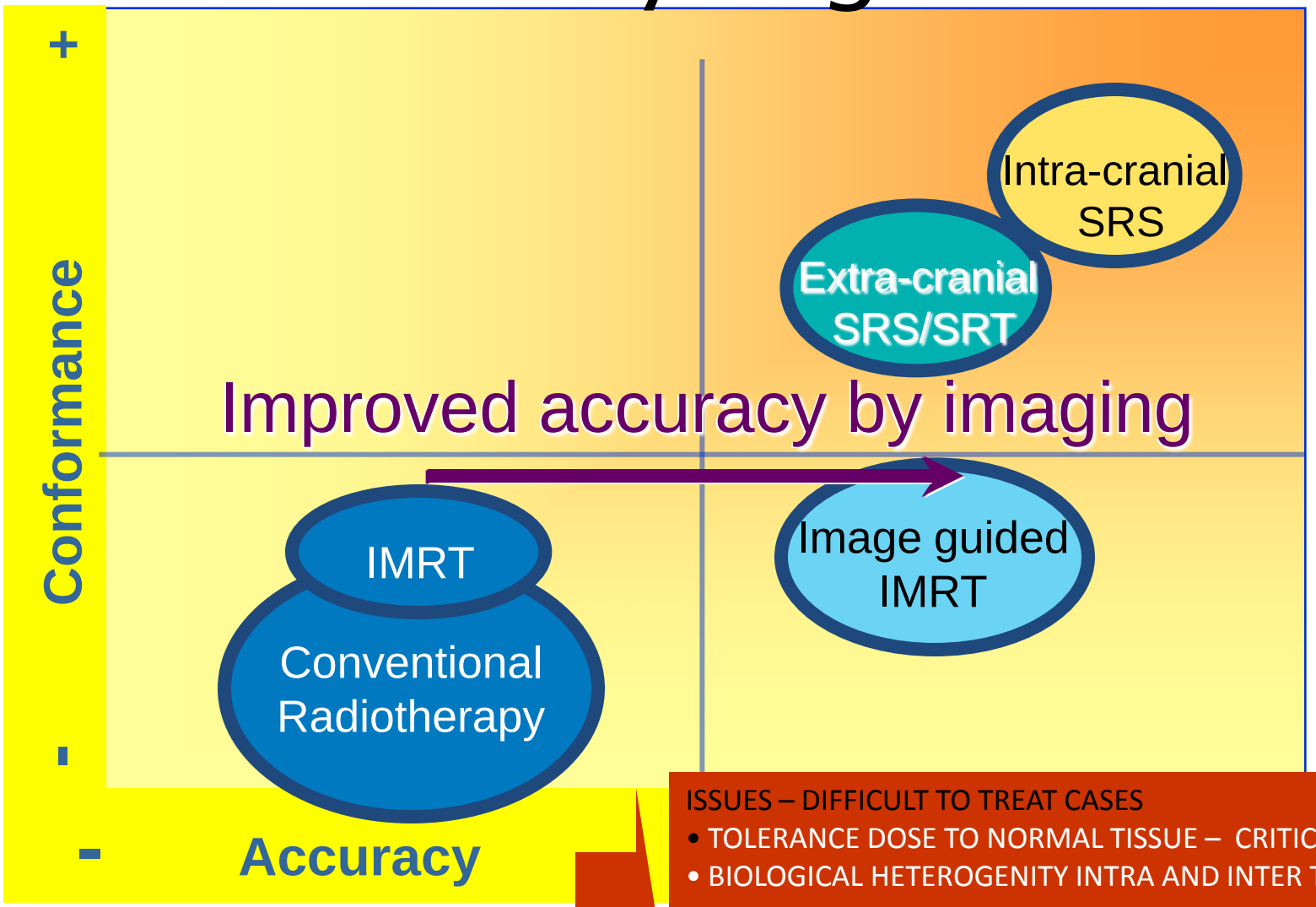
Offline

- PTV adaptation to individual patients
- Reducing the uncertainties due to setup variations
- Leave individualized margins for organ movement
- Time-and-resource efficient
- Larger margin than online
- As in Vargas et al (IJROBP 2005)

Online

- "CTV registration" → PTV adaptation to each treatment
- Eliminating the uncertainties due to setup variations
- Leave individualized margins for organ movement
- Time-and-resource consuming
- Smaller margin
- As in Chung et al (IJROBP 2008)

Delivery segments



ISSUES – DIFFICULT TO TREAT CASES

- TOLERANCE DOSE TO NORMAL TISSUE – CRITICAL ORGAN
- BIOLOGICAL HETEROGENITY INTRA AND INTER TUMOR
- MOVEMENT
- RELAPS

IAEA-TECDOC-1588

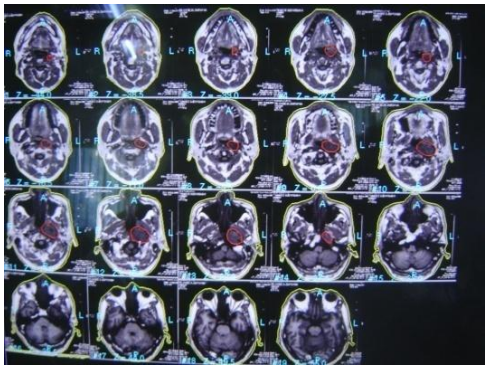
Transition from 2-D Radiotherapy to 3-D Conformal and Intensity Modulated Radiotherapy

IAEA
International Atomic Energy Agency

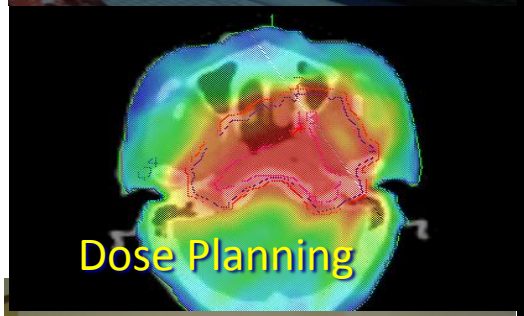
May 2008

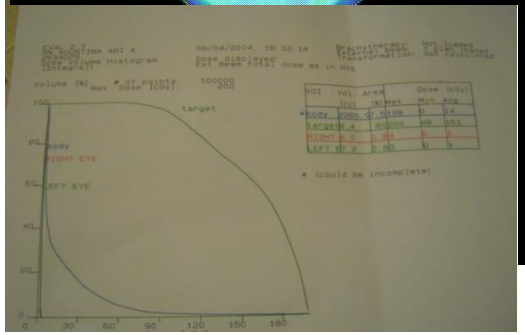
TABLE 1. CLASSIFICATION OF CONFORMAL THERAPY ACCORDING TO THE METHODOLOGY AND TOOLS ASSOCIATED WITH EACH STEP OF THE PROCEDURE

	Level 1 Basic CRT	Level 2 3-D CRT	Level 3 Advanced 3-D CRT
3. Dose calculation and optimization			
Calculation model	1-D or 2-D (slice) ± inhomogeneity	2-D or 3-D with inhomogeneity	3-D or 4-D with inhomogeneity
Evaluation of treatment plans	Isodoses on central slice or several slices	Isodoses viewed in 3-D on computer + DVH	3-D isodose surface + DVH, TCP, NTCP
Treatment plan optimization	Successive trials + visual appreciation	Successive trials + simple optimisation	Inverse planning
4. Treatment verification and execution			
Verification simulation	Normal practice	Useful	Replaced by IGRT on treatment machine
Immobilization (see above)	Desirable	Customized to the patient	Individual cast or stereotactic frame
Aids for positioning	Lasers + light field	Isocentre lasers	Lasers or frameless stereotaxy
Patient positioning	Height above couch + skin marks	Move from anatomical reference or stereotaxy	Daily image guidance
Verification reference image	Simulation film	DRR	CT data compared to cone beam CT
Record and verify system	Desirable	Essential but network is optional	Essential including network transfer
In vivo measurements	Desirable	TLD or diodes recommended	TLD or diodes or EPID transit dosimetry
Beam incidence	Coplanar beams	Several (including non-coplanar) beams	Multiple non-coplanar beams or arcs
Isocentre	SSD or SAD technique	SAD technique (auto centred on target)	SAD technique (auto centred on target)
Beam limiting device	Non-customized shielding blocks	Customized blocks or MLC	MLC or mini MLC
PTV – CTV margin	Shape drawn on simulation films	Protocol margins based on audit	Individual margin based on e.g. 4-D CT



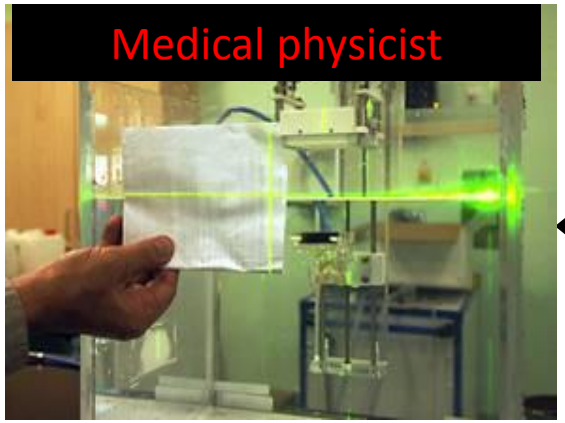
RO + Medical physics





Evaluation

Treatment



Quality Assurance

Immobilization

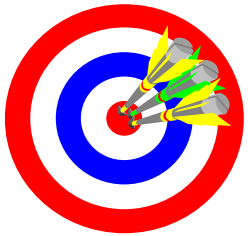
Image Import

BEV
MLC

Radiotherapy Process

TREATMENT PLANNING SYSTEM

BRACHYTHERAPY

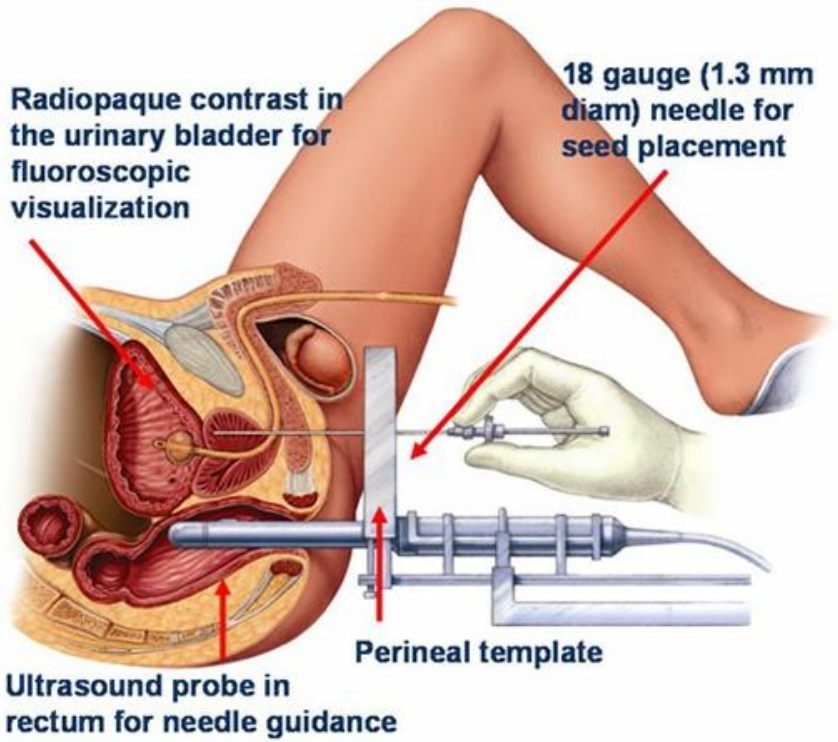


Internal Radiation Therapy

- Places radioactive material into tumor or surrounding tissue.
  - Also called brachytherapy – brachy Greek for “short distance.”
  - Radiation sources placed close to the tumor so large doses can hit the cancer cells.
  - Allows minimal radiation exposure to normal tissue.
  - Radioactive sources used are thin wires, ribbons, capsules or seeds.
  - These can be either permanently or temporarily placed in the body.

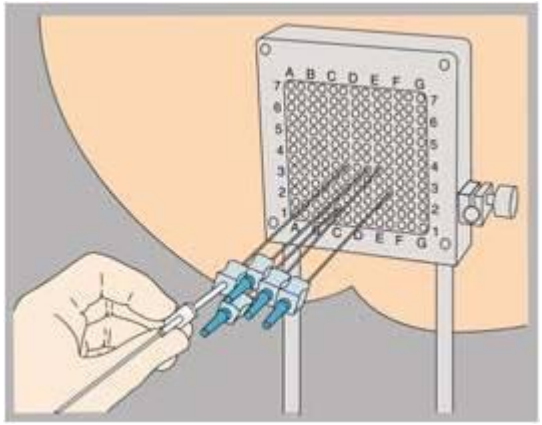
What is prostate brachytherapy? (1)

- Prostate brachytherapy involves the transperineal placement of radioactive seeds directly into the prostate
- This treatment delivers a high dose of radiation directly into the prostate
- During the procedure, rectal ultrasound is used to assess the size and shape of the prostate

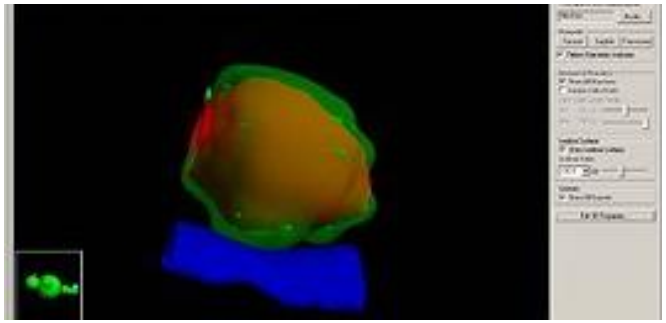


What is prostate brachytherapy? (2)

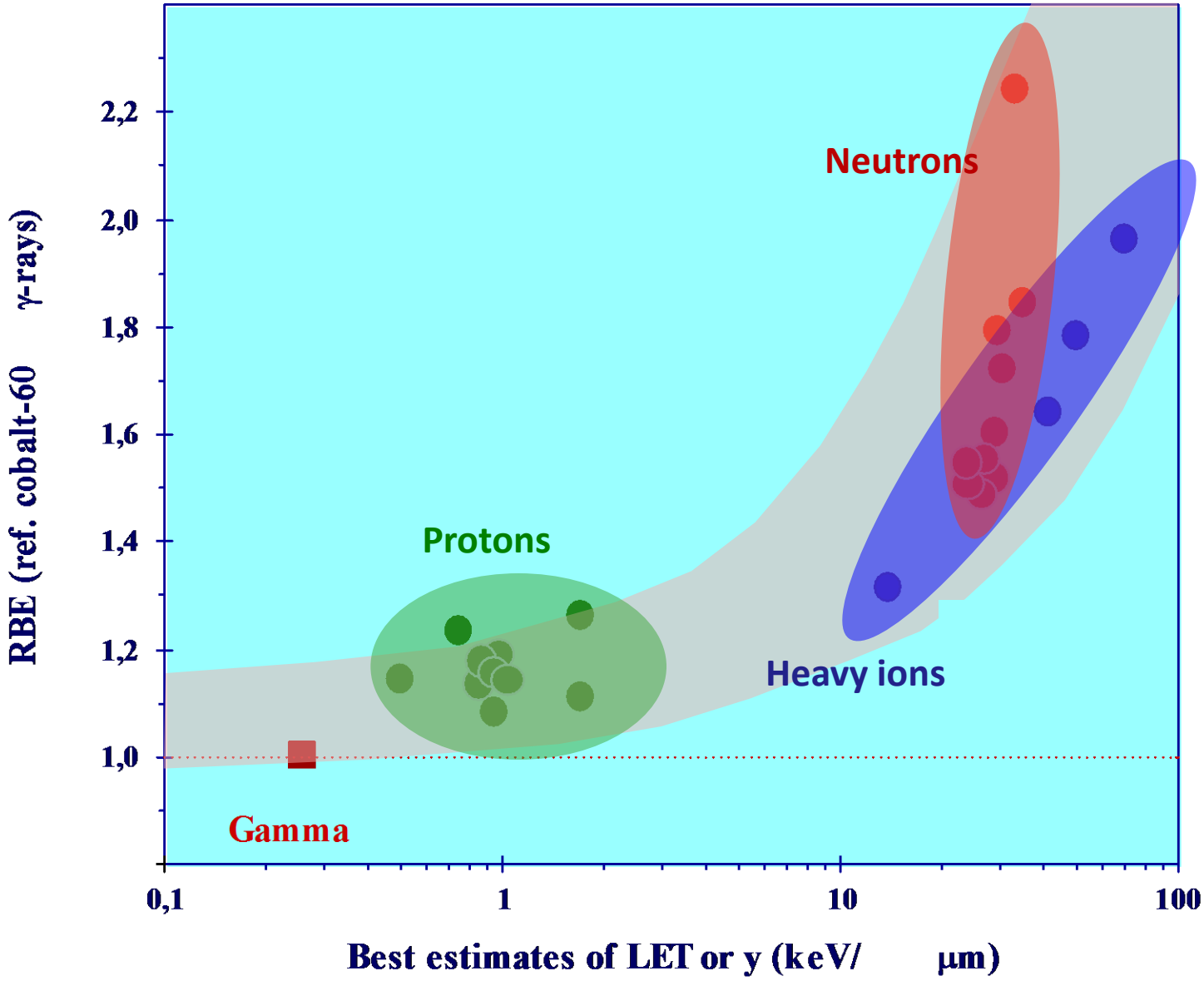
- The seeds are placed into the prostate through fine hollow needles inserted into the perineum
- A grid-like device is used to guide the needles into the correct position



- A computer program ensures that the right dose of radiation is delivered to the prostate and that other organs are unaffected
- The seeds stay in the prostate permanently and remain radioactive for 3-9 months



What lies in the future? Heavy Ions



Uncharged	Charged	
X rays γ rays	e^- p^+ He^{2+}	Low LET
Neutrons	C^{6+} Ne^{10+} Si^{14+} Ar^{18+}	High LET

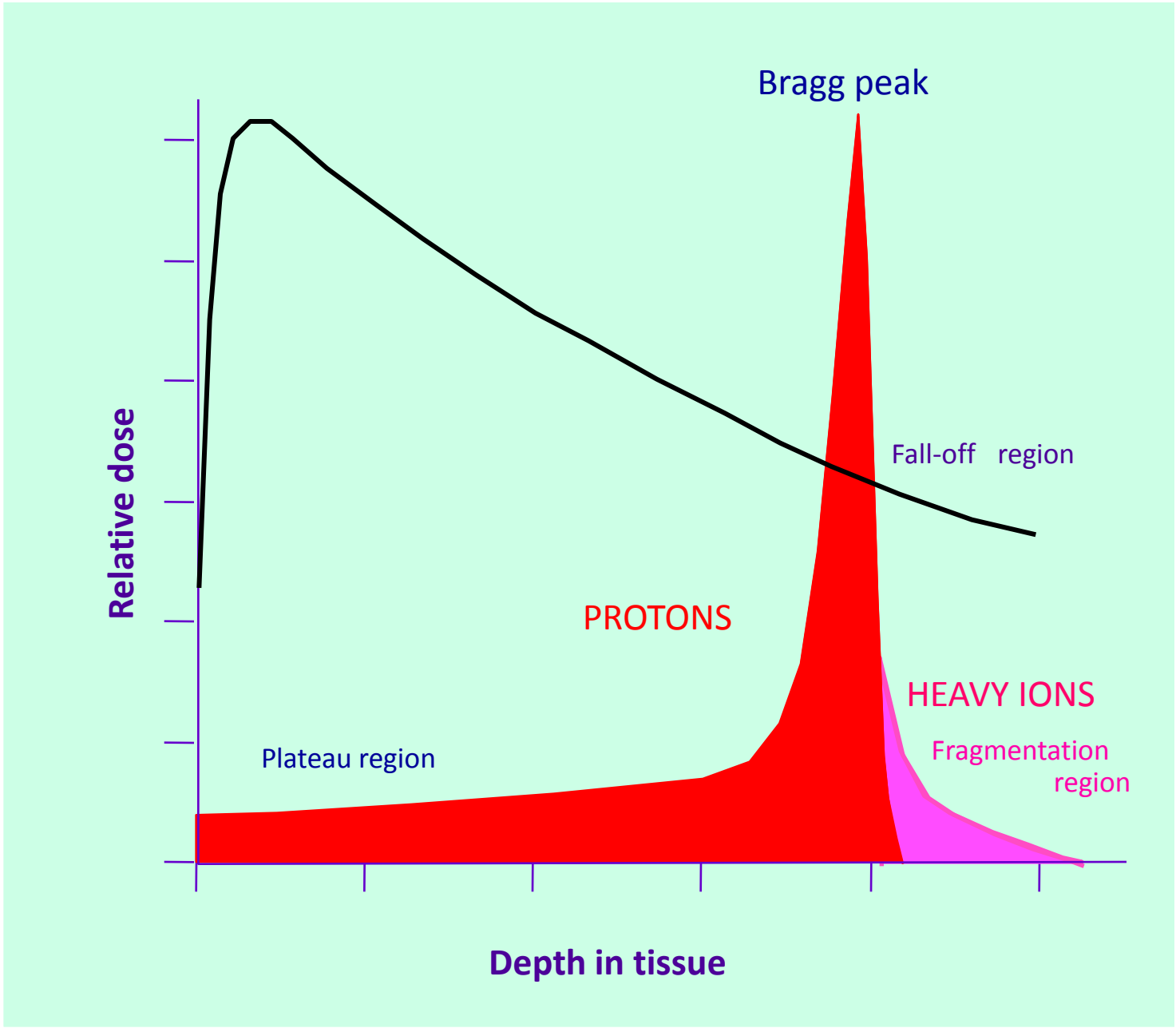
Heavy Ions: Why?

Ballistic selectivity

Increasing the dose to the tumour while reducing the dose to the surrounding normal tissues

Differential effect

Compared to conventional radiations, the effect is relatively more marked on the tumour than on the normal tissues (RBE)

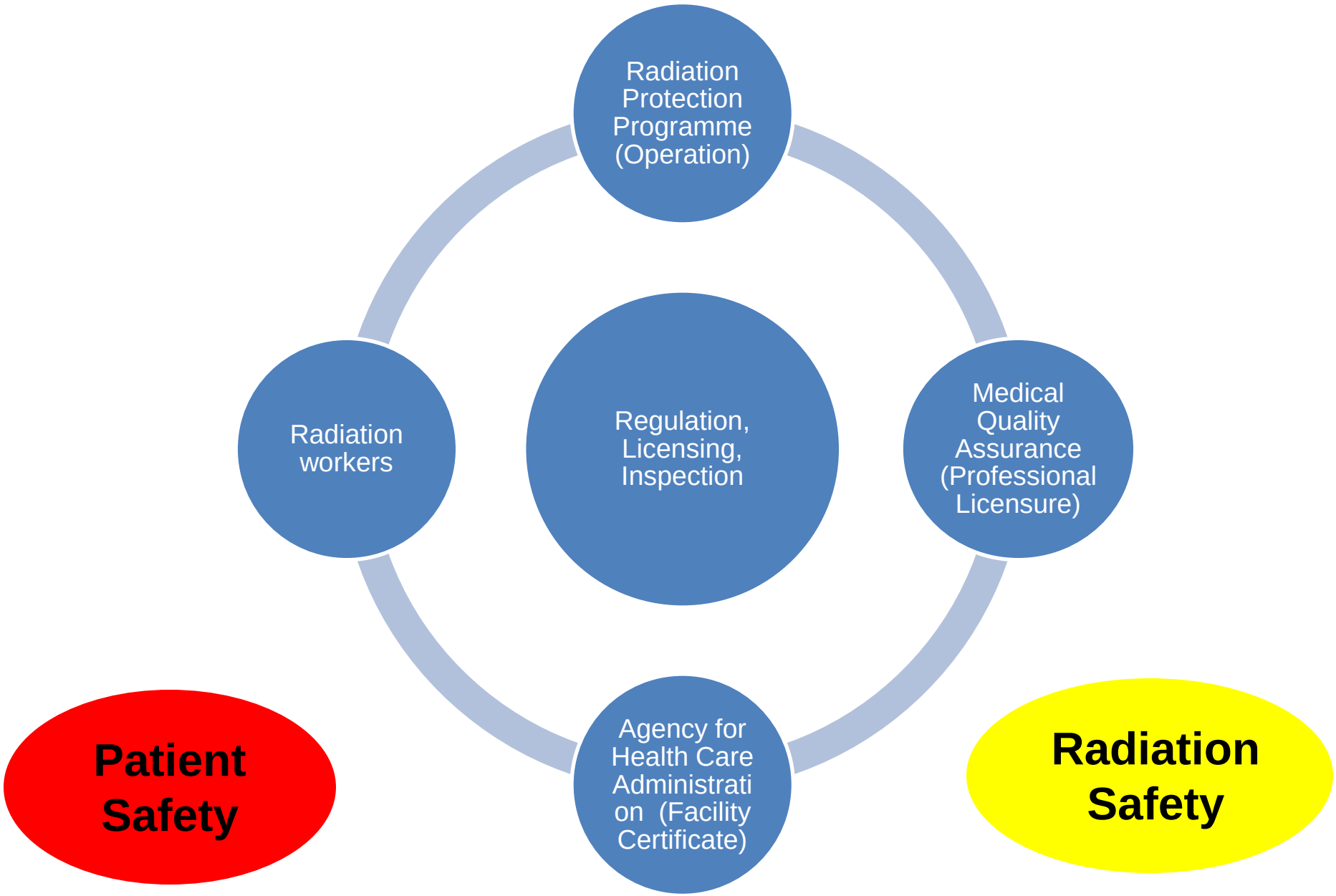

Bragg peak
Relative dose
Fall-off region
PROTONS
HEAVY IONS
Plateau region
Fragmentation region
Depth in tissue

Outline

- Introduction
- Methods of delivery radiation therapy
  - External Radiotherapy
  - Internal Radiotherapy
- Bapeten

BAPETEN


INSTALASI
- Konstruksi
- Peralatan
- Fungsi & Ketahanan
- Infrastruktur & Manajemen Proteksi Radiasi
Pengaturan, Perijinan, Inspeksi
OPERASI
- Kegiatan
- Program Manajemen Kualitas
- Kesiapsiagaan Nuklir
- Manajemen Limbah
PEKERJA
- SIB
- Pengontrolan Petugas
- Kinerja Petugas
- Petugas Proteksi Radiasi


Radiation Protection Programme (Operation)
Medical Quality Assurance (Professional Licensure)
Agency for Health Care Administrati on (Facility Certificate)
Radiation workers
Regulation, Licensing, Inspection
Patient Safety
Radiation Safety

Regulations affect radiation oncology practice in United States of America

These include the regulations set forth by

a) The state over the operation of radiation producing equipment for medical use.

b) **Nuclear Regulatory Commission** or agreement state over the medical use of byproduct materials.

c) Environmental Protection Agency (EPA) over the release of materials,

d) Department of Transportation (DOT) over the transport of radioactive materials.

e) Food and Drug Administration (FDA) over the use of radiopharmaceutical in humans, and

f) FDA and Center for Devices and Radiological Health (CDRH) over the use of medical devices.

Any non-compliance to these regulatory guidelines can result in a penalty and an eventual loss of license to practice or operate the equipment.

As such, **QA program** must incorporate compliance with the regulatory guidelines.

http://www.biij.org/2008/3/e48

Setting Up a Radiotherapy Programme:

Clinical, Medical Physics, Radiation Protection and Safety Aspects

IAEA
International Atomic Energy Agency

Setting Up Radiotherapy Programme

- Staff requirements for a radiation therapy programme
- Radiotherapy Facility Design
- Equipment
- Quality Assurance of the radiation therapy programme
- Radiation Protection of the patient
- Radiation Protection and safety of sources

➡ Patient and Radiation safety

Safety Reports Series

No. 38

Applying Radiation Safety Standards in Radiotherapy

Jointly sponsored by

IAEA
International Atomic Energy Agency

Rules and Procedures

Radiation Safety Reports Series No. 38

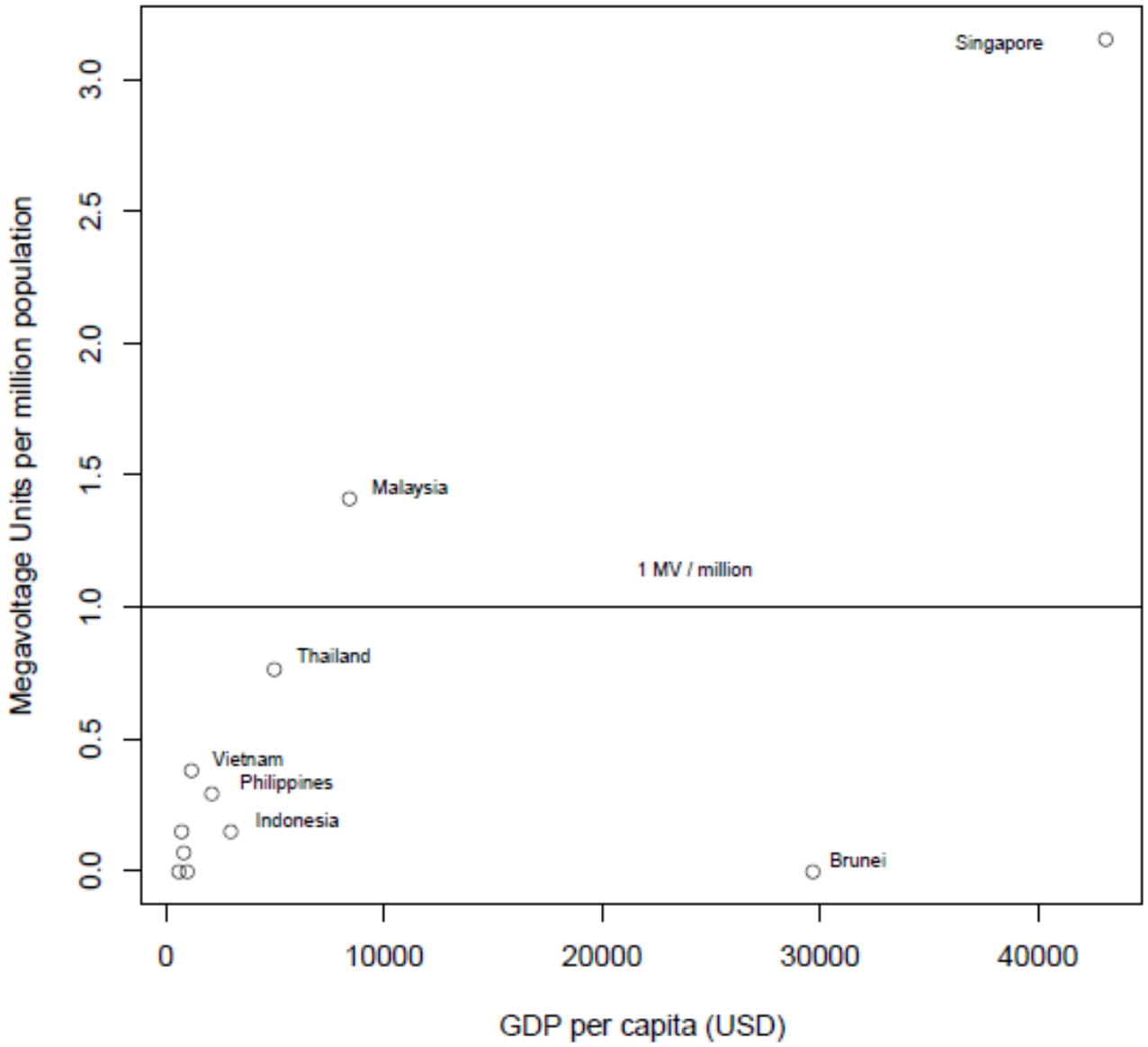
- Purchasing radiation sources and radiotherapy equipment (preparation of technical specifications before purchasing, who should be involved and who provides the internal clearance);
- Receipt, storage and disposal of radioactive sources;
- Use of radiotherapy equipment, including safety devices;
- Individual exposure monitoring (see occupational protection);
- Workplace monitoring (see occupational protection);
- Leak testing;
- Communication of safety critical issues;
- Maintenance and repair of radiotherapy equipment, including obligatory notification to the qualified expert in radiotherapy physics before resuming use (for a decision whether beam measurements are necessary before resumption of treatments);
- **Moving radiation sources and patients with sources within the hospital**

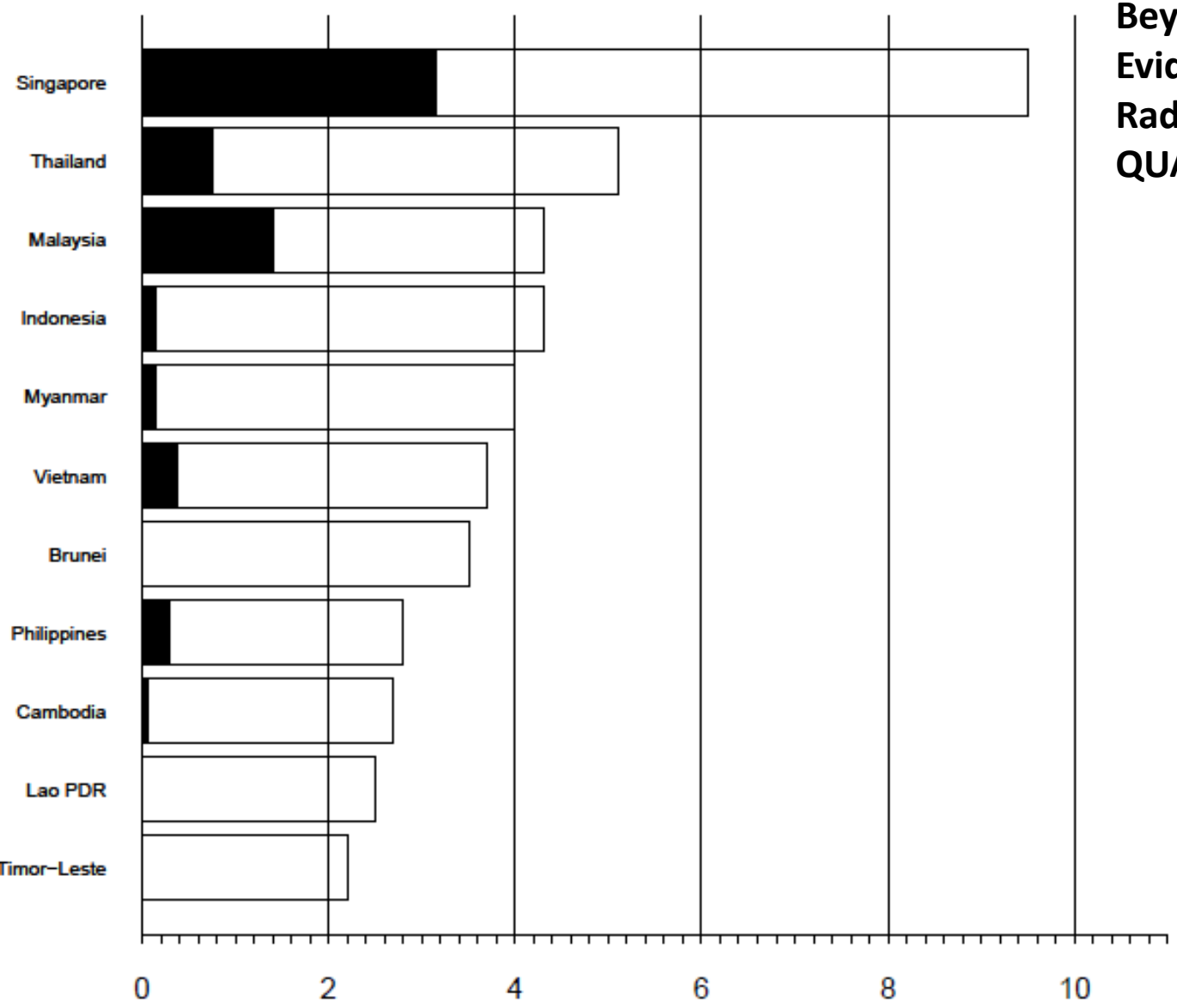
RADIOTHERAPY CENTER IN INDONESIA, 2010

Total		**: 22 centers**
Primary	**(EBRT CO 60 + INTRACAVITARY BT)**	**: 6 centers**
	(EBRT LINAC + INTRACAVITARY +/- INTERSTITIAL BT)	**: 15 centers**
Secondary	**(EBRT + IMRT or IGRT or SRT or SRS + BT INTRACAVITARY +/- INTERSTITIAL**	**: 0 centers**
Tertiary	**(IMRT+IGRT+SRT+SRS+ INTRACAVITARY + INTERSTITIAL BT)**	**: 1 centers**

2010
LEVEL 1 □ 3D CRT WITH INTRACAVITARY BT
LEVEL 2 □ IMRT AND / OR SRS WITH INTRACAVITARY WITH / WO. INTERSTITIAL BT
LEVEL 3 □ ALL SERVICES

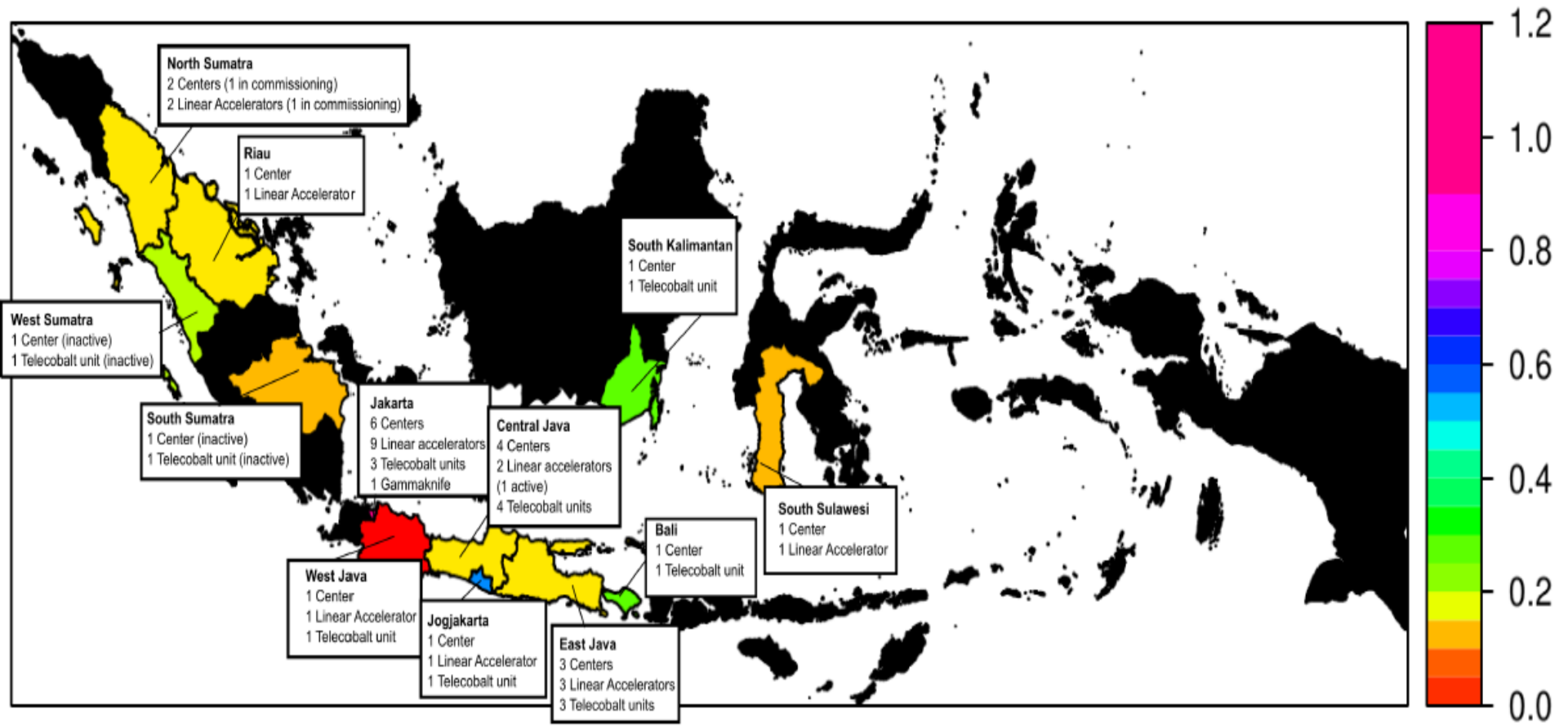
Radiotherapy in Indonesia: Adequate?





Beyond 1 MV/million: Evidence-based estimates of Radiotherapy Needs (ESTRO QUARTS & CCORE)

Megavoltage Units per Million Population, 2012



The number of new radiotherapy center is expected to increase rapidly within the next 5-10 years

To avoid discrepancy with the capacity of regulatory agency, BAPETEN needs to be ready for such an increase.

Problems for BAPETEN

External Beam Radiotherapy

- Radiation Protection (Teletherapy bunkers that is suitable for advanced conformal RT: New, reconditioned, ?)
- Radioactive Waste: Production, Storage, Disposal (Telecobalt-60)

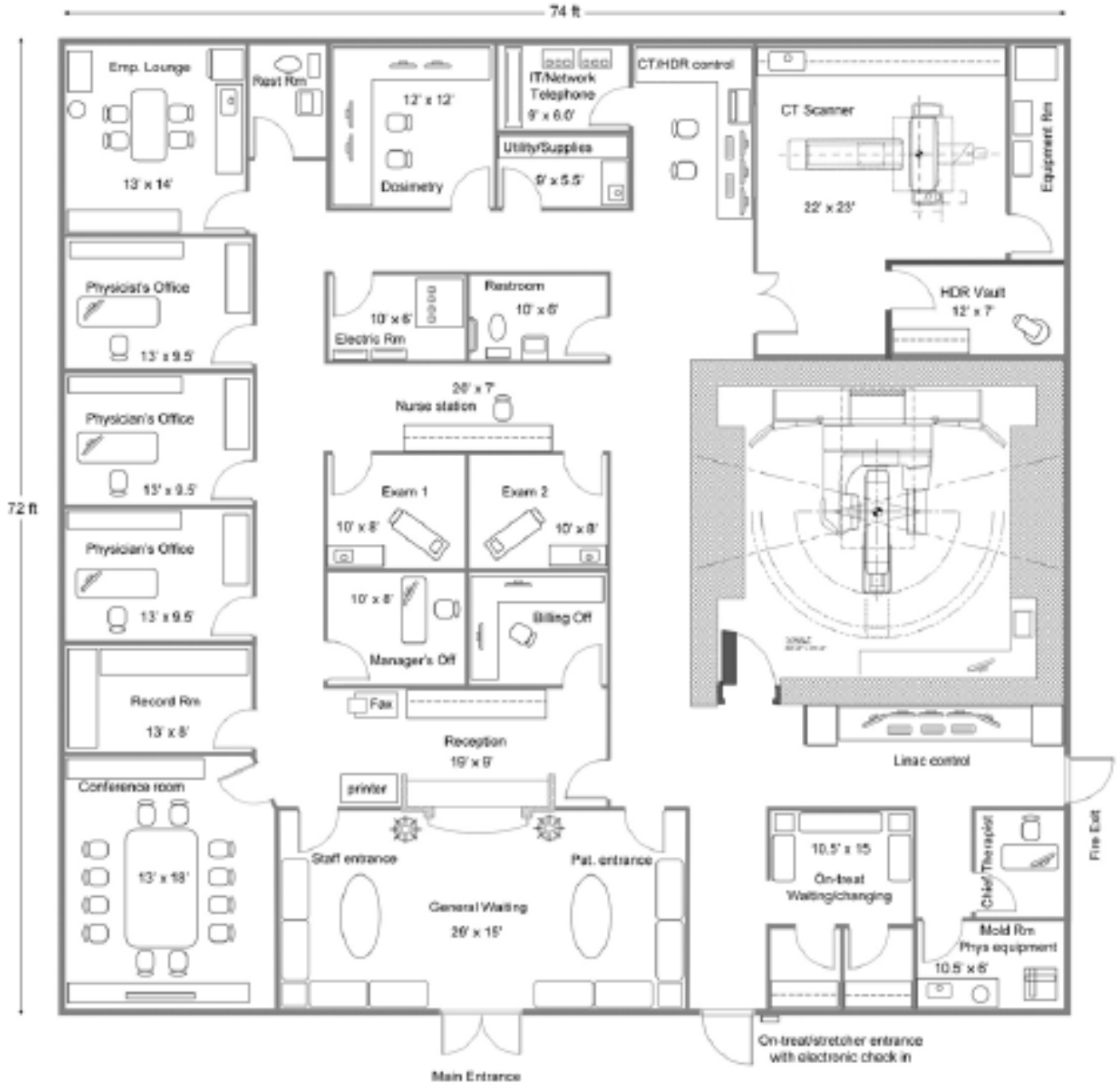
New technologies:
Cyberknife
Tomotherapy
Heavy ion & particles

Brachytherapy

- Radiation Protection (brachytherapy bunkers)
- Radioactive Waste: Production, Storage, Disposal (iodine-125, Iridium-192)

New regulations needed:
"Non source brachy"
(Intrabeam, etc)
Brachytherapy seeds:
Security, Public Protection

Courtesy of dr. Angela Giselvania



Example Space program of a 1-linac, 1-HDR radiation therapy facility