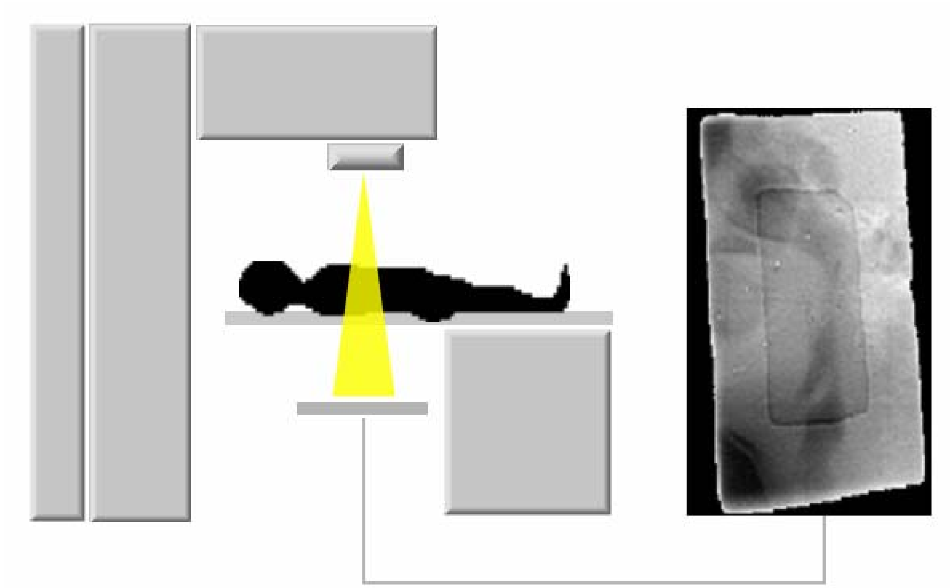
Megavoltage Images in Radiation Therapy



Hamid R. Tizhoosh

Systems Design Engineering

PAMI :: MIAMI :: WIHIR

Content

→ Cancer Statistics

→ Radiation Therapy

→ Patient Setup Verification

→ Megavolatge Images (Portal Images)

Cancer Statistics

Canada 2004:

145,500 new cases of cancer

68,300 Canadians will die

2,798 Canadians diagnosed with cancer every week

1,313 Canadians will die of cancer every week

Source: Canadian Cancer Society

Cancer Statistics

38% of women and

43% of men

will develop cancer during their lifetimes.

Source: Canadian Cancer Society

Cancer Treatment

Surgery

Chemotherapy

Hormone Therapy

Immunotherapy (Biologiocal Therapy)

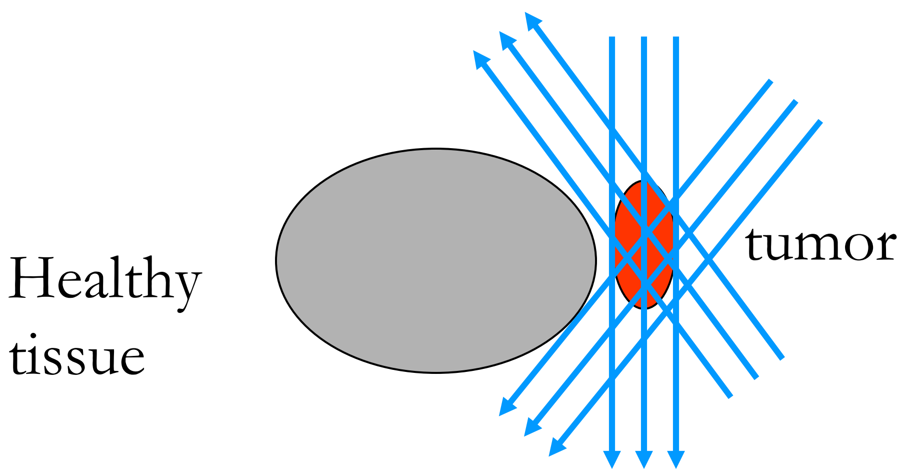
Stem Cell Transplantation

Radiation Therapy

Radiation Therapy

The use of high-energy penetrating rays or subatomic particles to destroy the tumor.

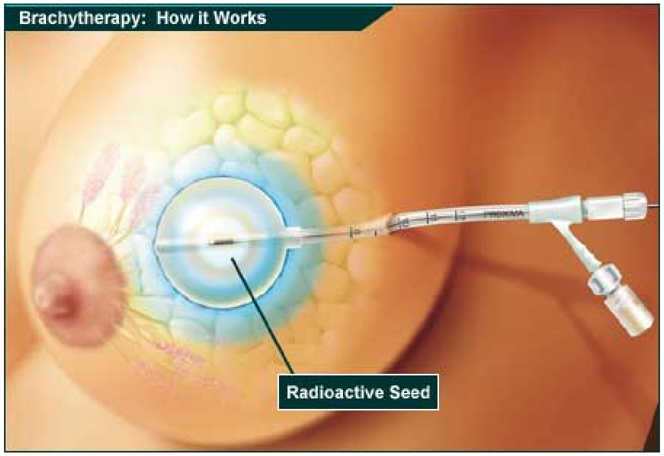
Goal: Killing cancerous cells by delivering a high dose of radiation to the tumor while preserving/sparing healthy tissues



Radiation Therapy

Internal Radiotherapy
(Brachytherapy)

Implanting radioactive material (seed) directly into the tumor or close to it.



Source: Proxima Therapeutics

Radiation Therapy

External Radiotherapy

Delivering a beam of high-energy x-rays to the tumor. The beam is generated outside the patient by a linear accelerator (LINAC).

Source: Varian

Linear Accelerator

A machine that creates high-energy radiation to treat cancer, using electricity to form a stream of fast-moving subatomic particles.

Also called megavoltage linear accelerator or a **LINAC**.

ONCOR^{TM}, Siemens

Linear Accelerator

LINAC accelerates electrons in a part of the accelerator (wave guide) and then allows these electrons to collide with a heavy metal target.

As a result, high energy x-rays are scattered from the target. A portion of these x-rays is collected and then shaped to form a **beam**.

The beam comes out of a part of the accelerator called a **gantry**, which rotates around the patient.

The Port

Port (also treatment field)

The area of the body through which external beam radiation is directed to reach a tumour.

Conformal Radiation Therapy

Radiation that is shaped, or "conformed“, to the shape of a tumour in all three dimensions.

Accurate shaping of the beam: deliver radiation to the tumour, not to surrounding healthy tissue.

Ionizing Radiation

Radiation of sufficient energy to displace electrons from the atoms of cells and produce ions.

Ionized cells are damaged and will die.

Healthy (normal) cells are able to repair themselves; cancerous cells are not.

Intensity-Modulated Radiation Therapy

→ High-precision radiotherapy

→ Computer-controlled x-ray accelerators

→ Radiation dose conforms to the 3-D shape of the tumor by modulating the intensity of the radiation beam (higher radiation dose to the tumor and minimum radiation exposure of healthy tissues)

Radiation Therapy: Steps

1) Simulation (x-ray images, CT, MRI)
Determining the treatment area, measuring the patient's body, individual set-up

2) Treatment Planning
Software+expert knowledge:

numbers of radiation beams at different angles,
different beam shapes,
beam weightings,
beam energies,
…

Radiation Therapy: Steps

3) Verification

4) Treatment

Aligning the patient on the treatment table (under LINAC)

Immobilizing the patient

Using positioning lasers/field light to accurately set-up the patient in the correct position

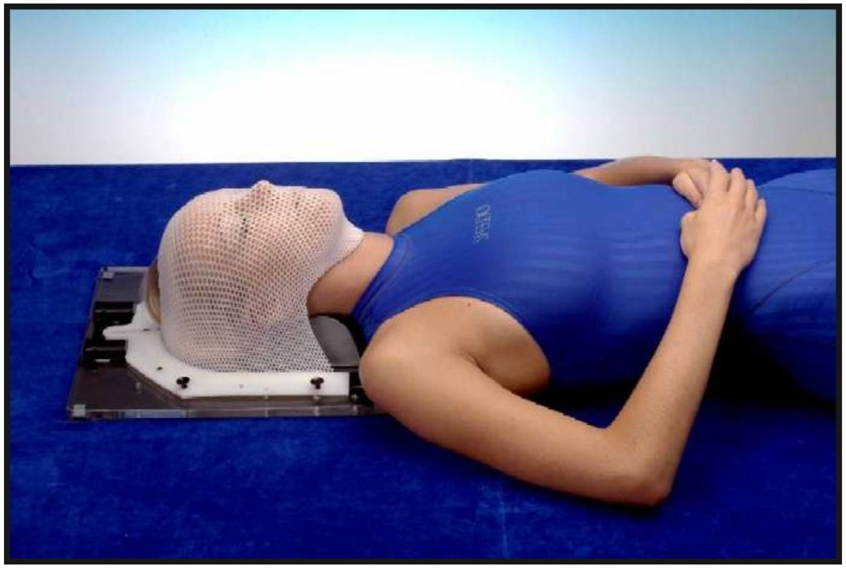
Treatment Duration: 4-6 weeks (fractions of 15-30 minutes)

Patient Positioning & Immobilization

Plastic Mesh (hard plastic that when wet, it conforms to the contour of the treated area. It will dry very quickly.)

Foam Cradles (for chest, abdomen and pelvis areas)

Breast Arm Board (for the breast and chestwall areas)



Source: BARKER+

The Dilemma of Patient Set-Up

In spite of immobilization

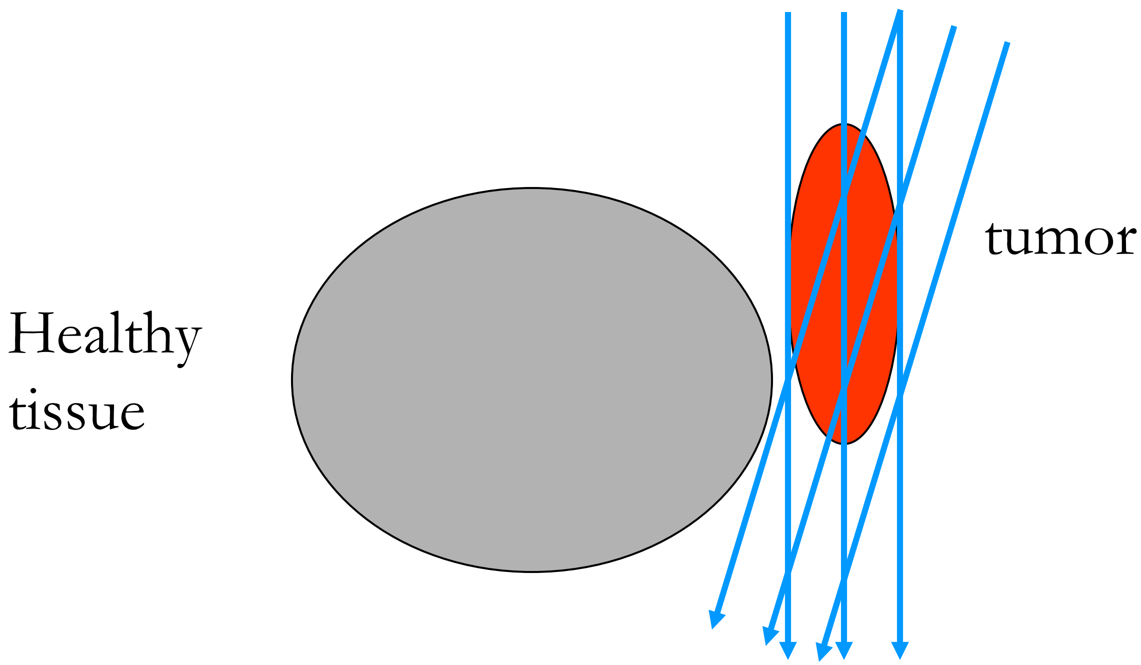
patients move!

→ External motion

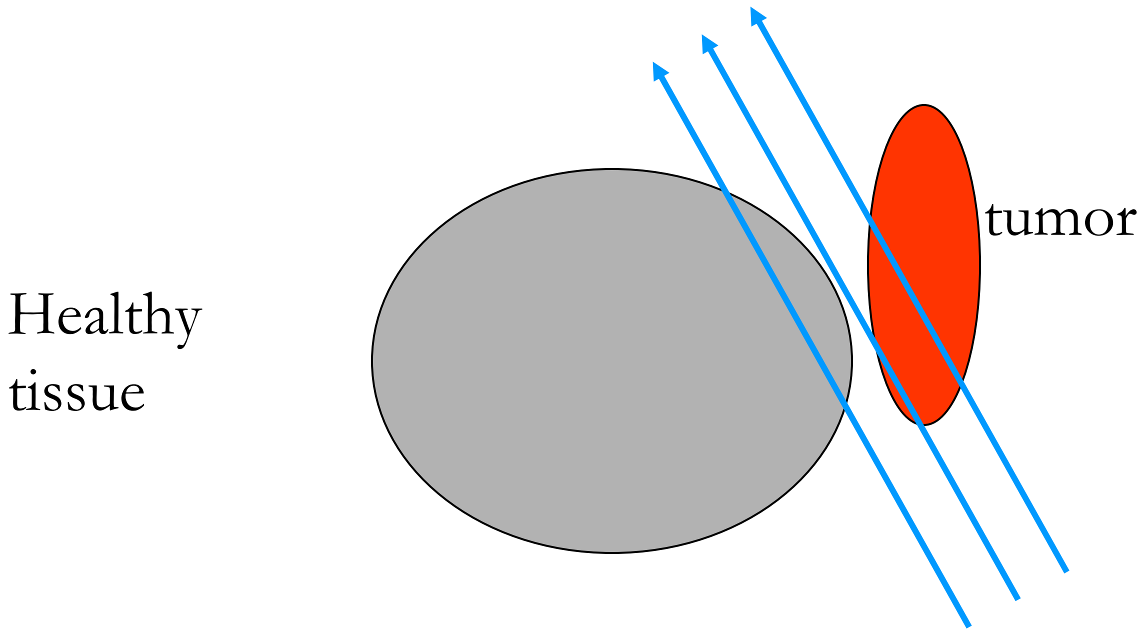
→ Internal (organ) motion

Set-up verification necessary!

Effect of Motion



Effect of Motion



Film-Based Patient Set-Up Verification

1) load a film into a film/screen cassette

2) carry the cassette to the examination room

3) insert the cassette into the x-ray table

4) position the patient

5) make the x-ray exposure

6) carry the cassette back to develop the film

7) check the processed film for any obvious problems

→ takes several minutes : the patient remains immobilized

→ increased chance of localization error (up to 5mm)

Film versus EPI

Conventional x-ray

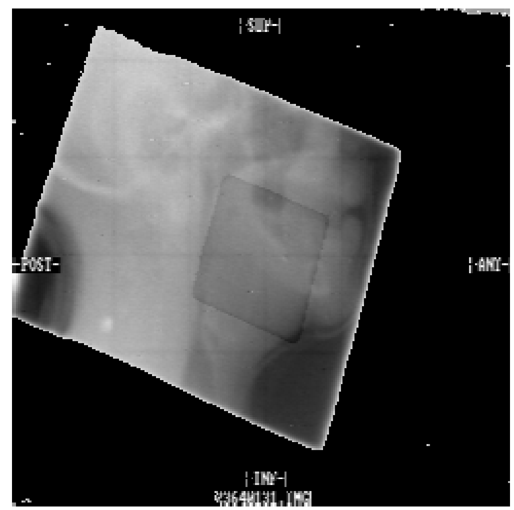
Low energy

High contrast

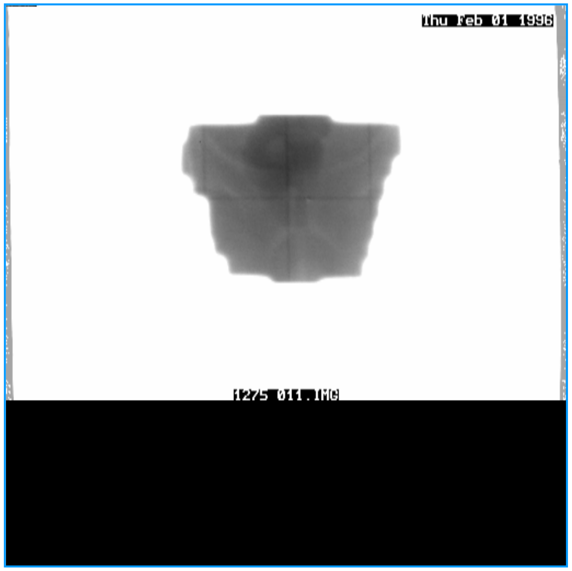
Portal imaging

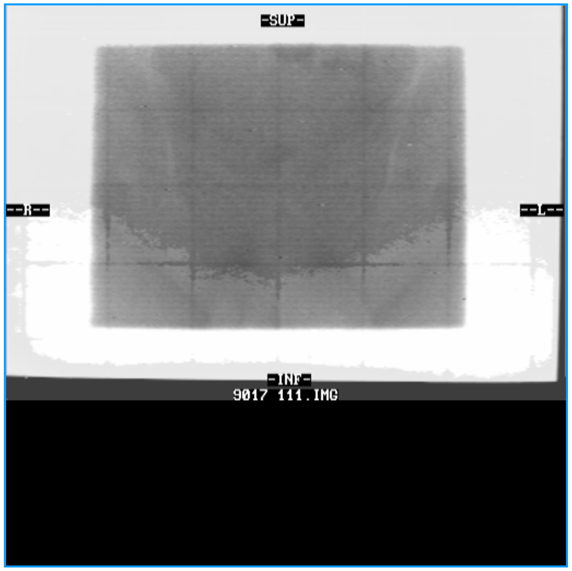
High energy

Low contrast

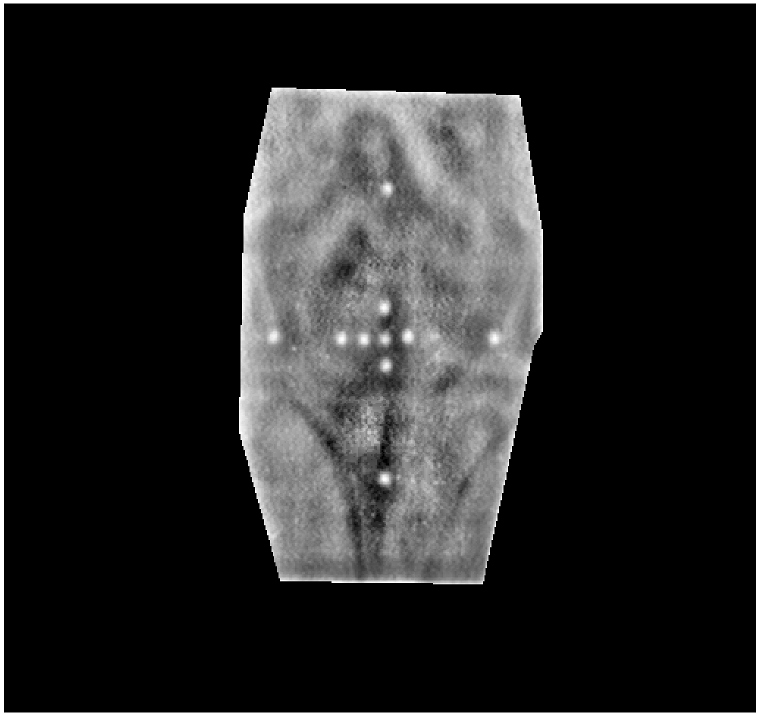


EPIs or Megavoltage Images

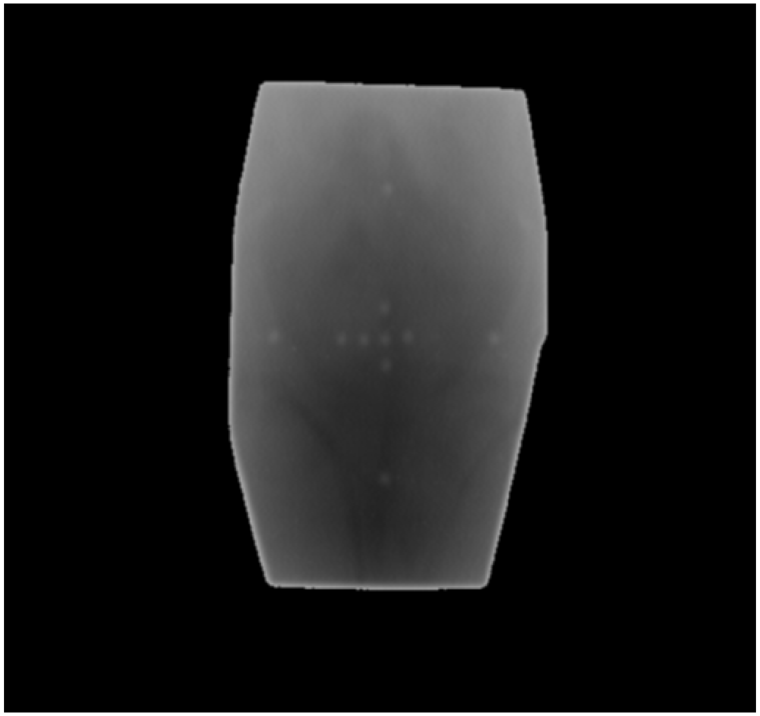


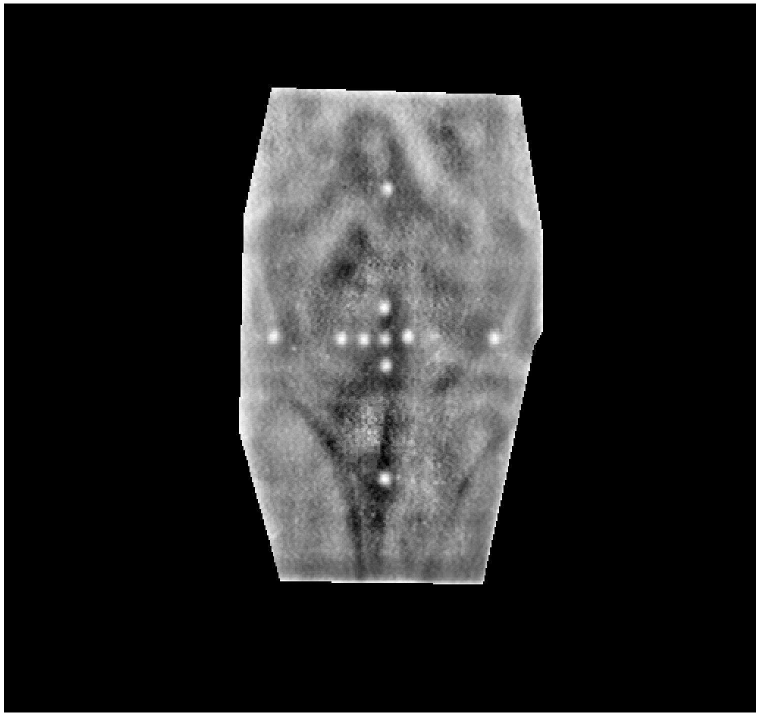


Enhancement of MVIs



Enhancement of MVIs





Electronic Portal Imaging

Fast image acquisition/processing

Lower dose required

Less localization error

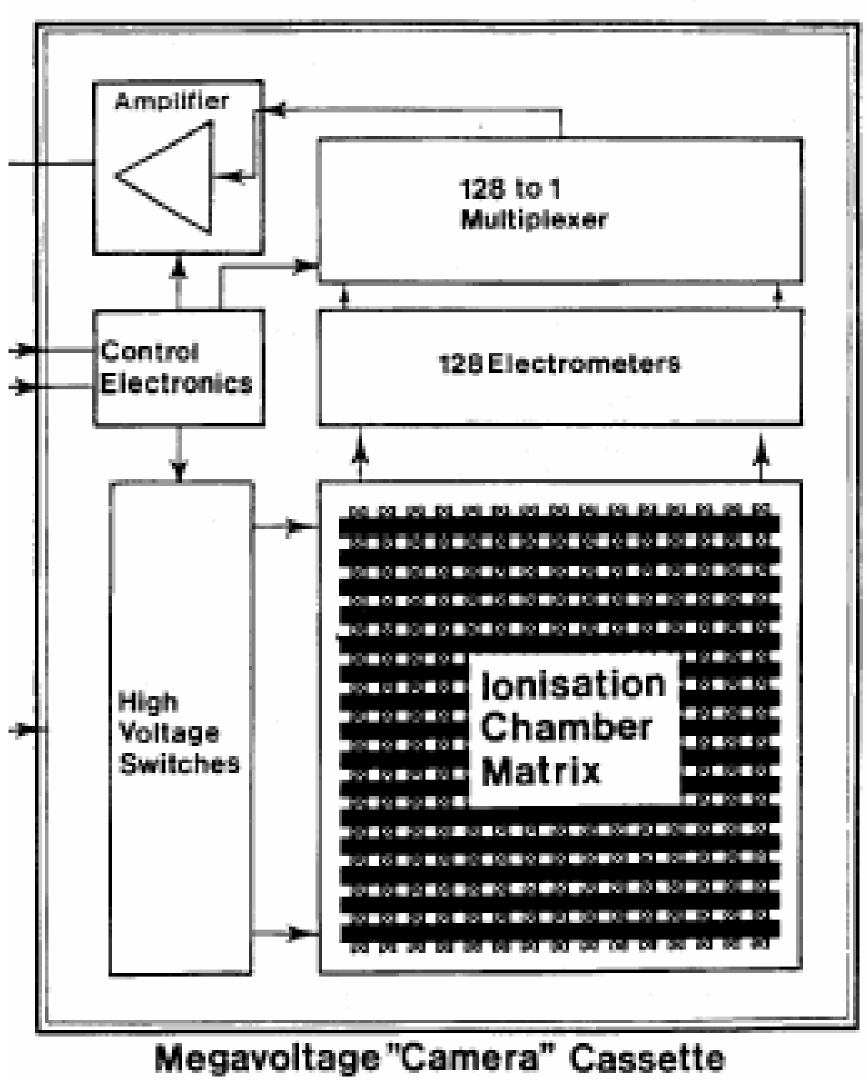
Film versus MVI

	Film	MVI
Speed	- -	++
Information content	++	+(+)
Practicality	+	++
Online	- -	++
Complexity	++	-

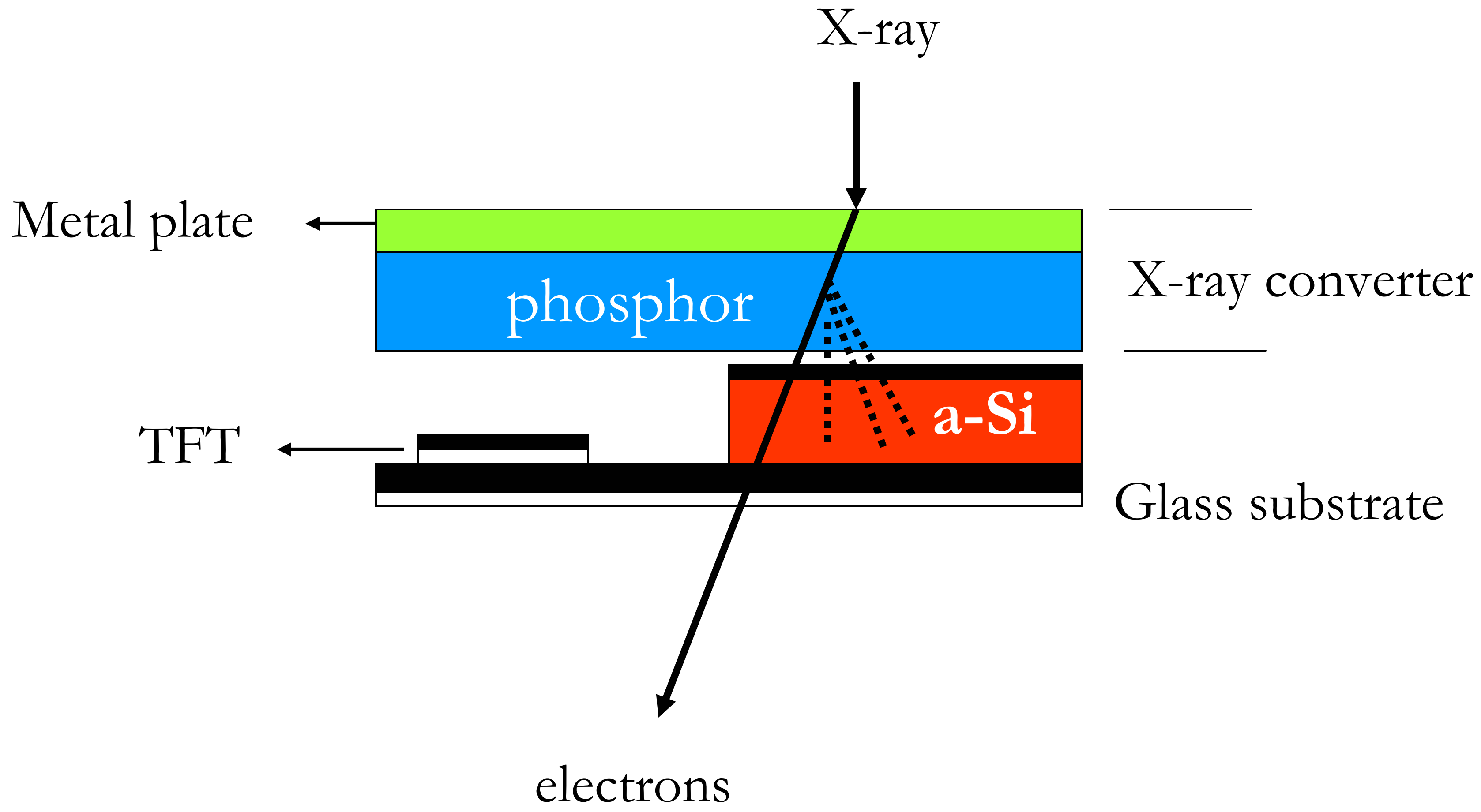
LIC Technology

Liquid-filled Ionization Chamber

Matrix	256×256
Pixel size	1.2 mm
Field size	32 × 32 cm^2



Amorphous Silicon Technology



Flat Panel EPID (a-Si-Based)

In clinical use since spring 2000

Good image quality
(high contrast/spatial resolution, large SNR)

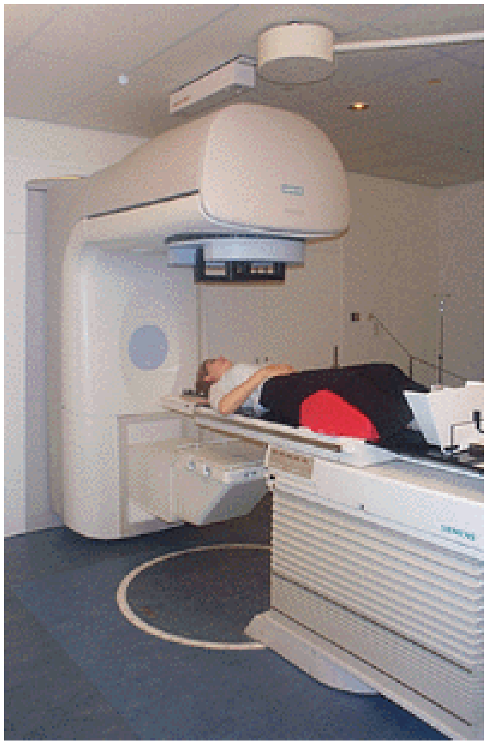
Higher speed (7 Frames/sec)

No geometrical distortions

Quasi-linear dose response

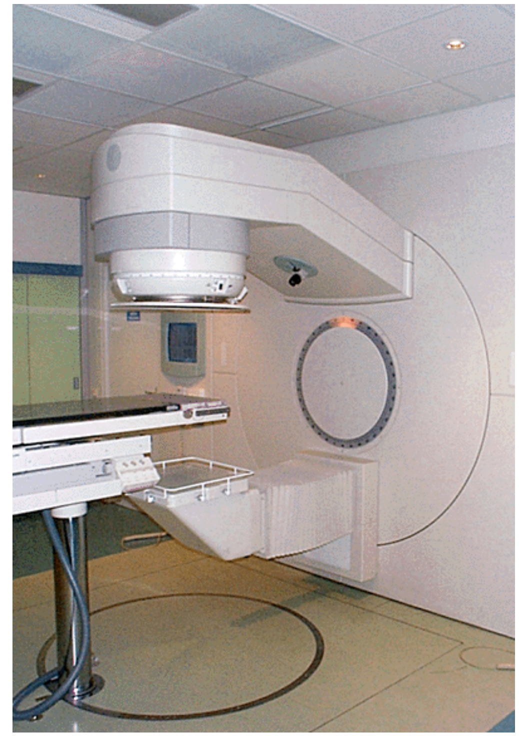
Disadvantage: cost & „dead pixels“

Electronic Portal Imaging Devices



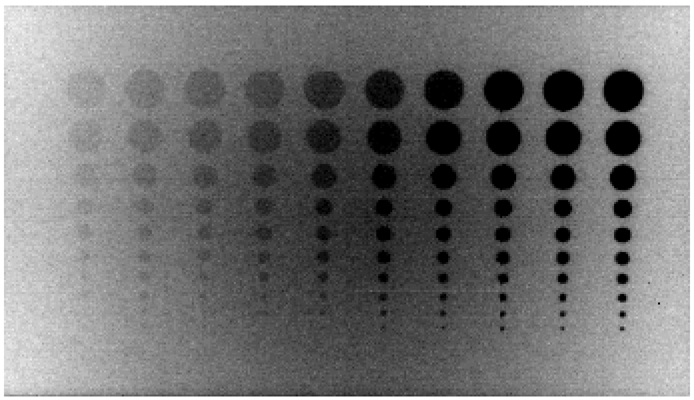
Siemens

Varian

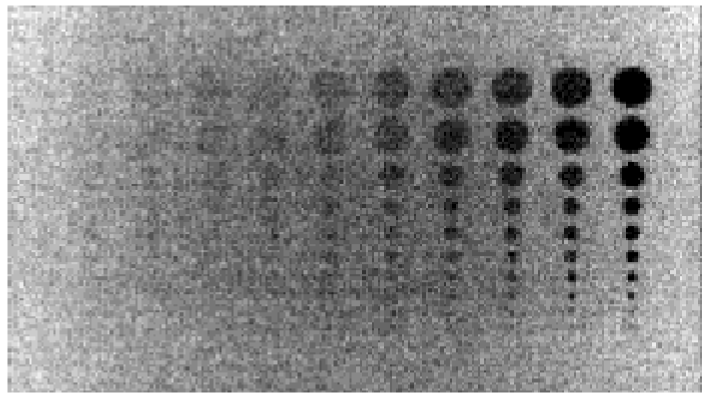


Theraview
(Elekta LINAC)

EPIDs: Phantom Images

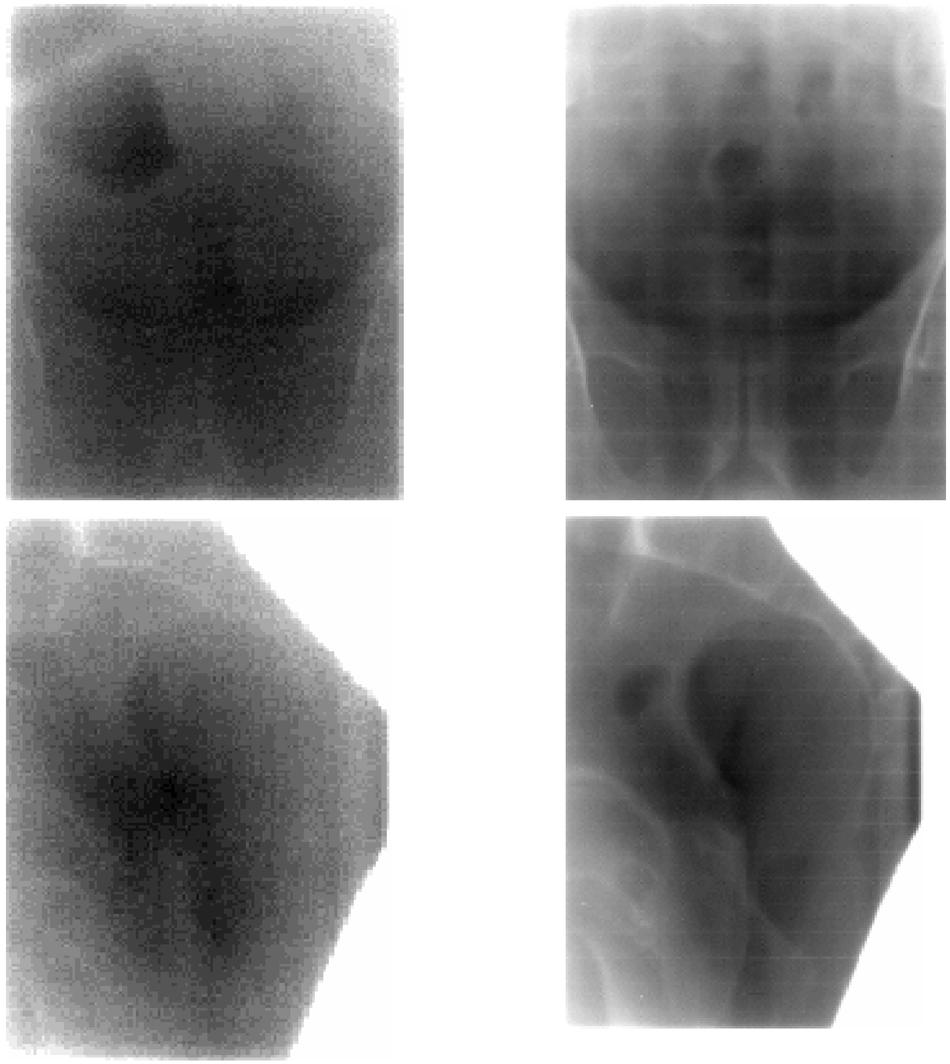


a-Si



LIC

EPIDs: LIC versus a-Si



EPI-Based Online Verification