

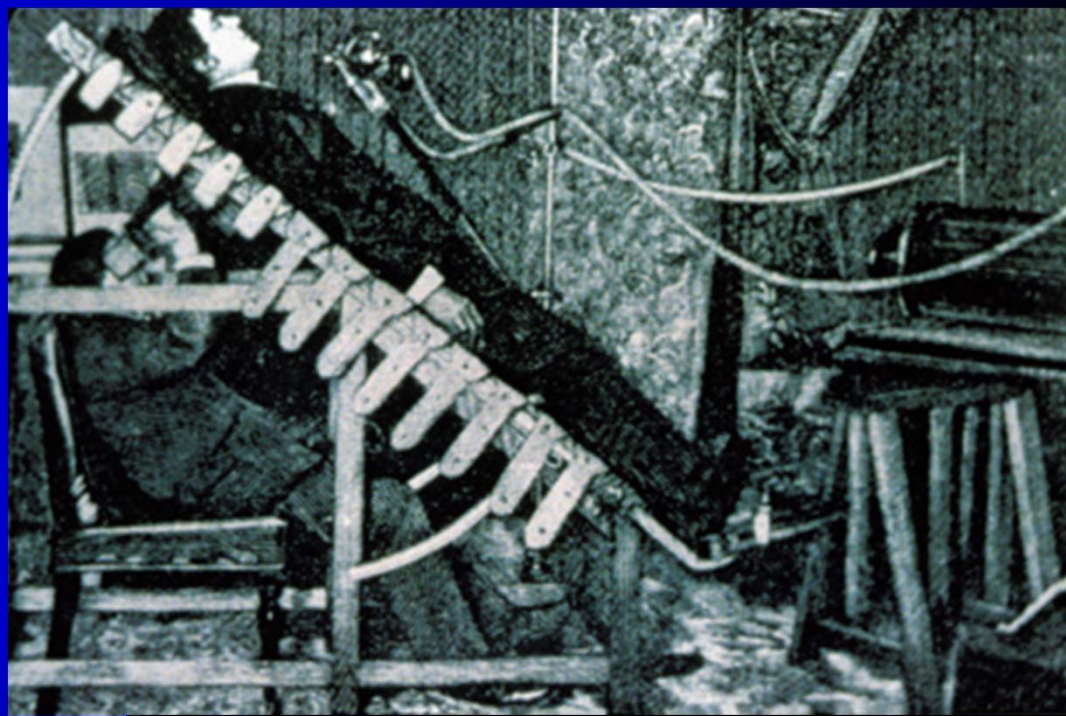
# **Disaster Preparedness for Health Technology Managers: Issues with Radiation-Emitting Devices and Radioactive Sources**

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**Chair, IUPESM Health Technology Task Group**



**International Union for Physical and Engineering Sciences in Medicine**

**Radiological  
equipment has  
changed a bit since  
the early days...**



# Medical Imaging - Today

## X Rays

### Planar Projection Imaging

#### ▲ Radiography

(Film or Digital: CR / DR)

- General
- Mammography
- Dental
- Bone Densitometry

#### ▲ Fluoroscopy

(Image Intensifier or Flat Panel)

- Diagnostic
- Interventional

### Volume (3D) Projection Imaging

#### ▲ Computed Tomography (CT)

#### ▲ Digital Tomosynthesis

*Imaging in Radiotherapy (IGRT)*

## Non-Ionizing Radiation

#### ▲ Magnetic Resonance (MR)

- MRA
- MRS
- fMRI

#### ▲ Ultrasound (US) incl Doppler

## Nuclear Medicine

- Gamma Camera
- SPECT
- PET

## Hybrid Systems

- SPECT/CT
- PET/CT
- PET/MR
- MR/US
- MR/Optical

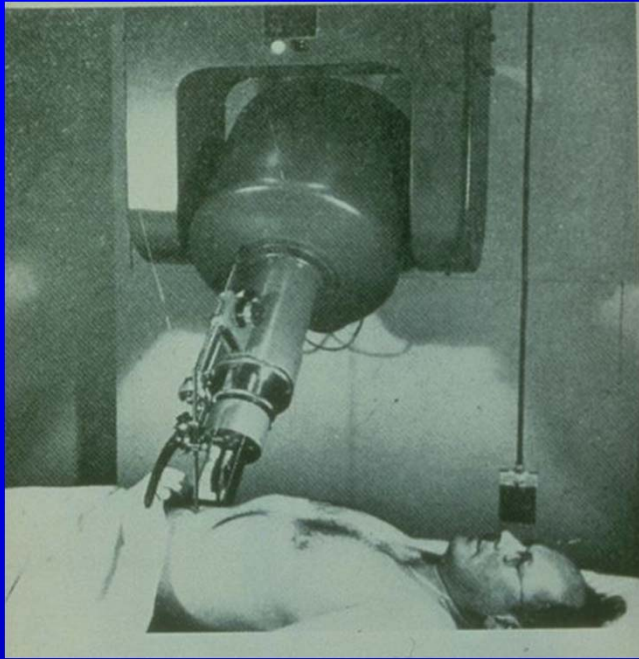
# **RADIATION THERAPY**

- ◆ **External Beam Treatment (Teletherapy)**
- ◆ **Brachytherapy**
  - **Intracavitary**
  - **Interstitial**
  - **Intraluminal**
  - **Inter / Intraoperative**



# External Beam Radiotherapy Modalities

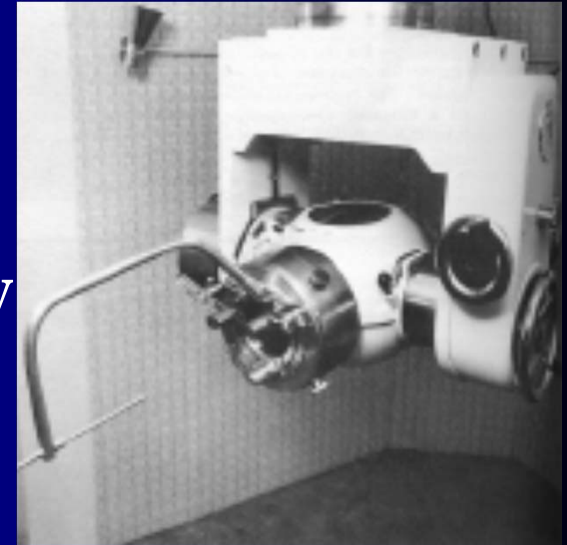
- ▲ **Contact Therapy** + **< 100 kV X Rays**
- ▲ **Superficial Therapy** + **100 to 120 kV X Rays**
- ▲ **Orthovoltage Therapy** + **150 to 400 kV X Rays**
- ▲ **“Teletherapy Units”** + **Cs - 137 and Co – 60**
- ▲ **Megavoltage**
  - **X Rays** + **Linear Accelerators**
  - **Electrons**
- ▲ **Heavy Charged Particles** + **Protons & C, Ar, Ne Ions**
- ▲ **Others** + **Neutrons, Pions**



**First  
Co-60  
Unit  
(1951)**



**Cs-137  
Teletherapy  
(1960's)**



**Orthovoltage X-Ray (1990's)**

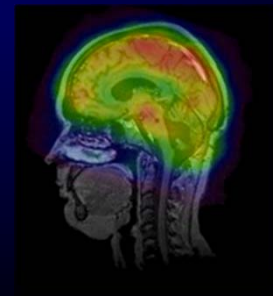
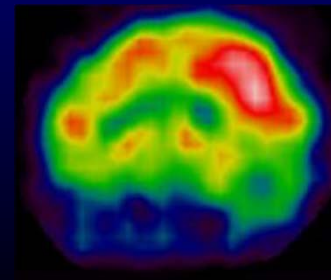
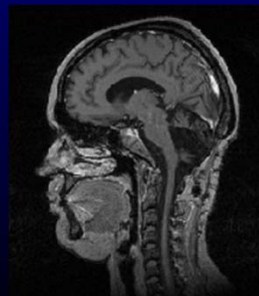


**Linac  
with  
IGRT  
(2000s)**



# 3 - D Treatment Modalities with LINACS

- ▲ Conformal Radiotherapy (3DCRT)
- ▲ Intensity-Modulated Radiation Therapy (IMRT)
- ▲ Intensity-Modulated Arc Therapy (IMAT)
- ▲ Volumetric Modulated Arc Therapy (VMAT)
- ▲ 4-D Radiation Therapy
- ▲ Stereotactic Radiosurgery (SRS)
- ▲ Stereotactic Body Radiation Therapy (SBRT)
- ▲ Image-Guided Radiation Therapy (IGRT)
- ▲ Image Fusion
- ▲ Tomotherapy



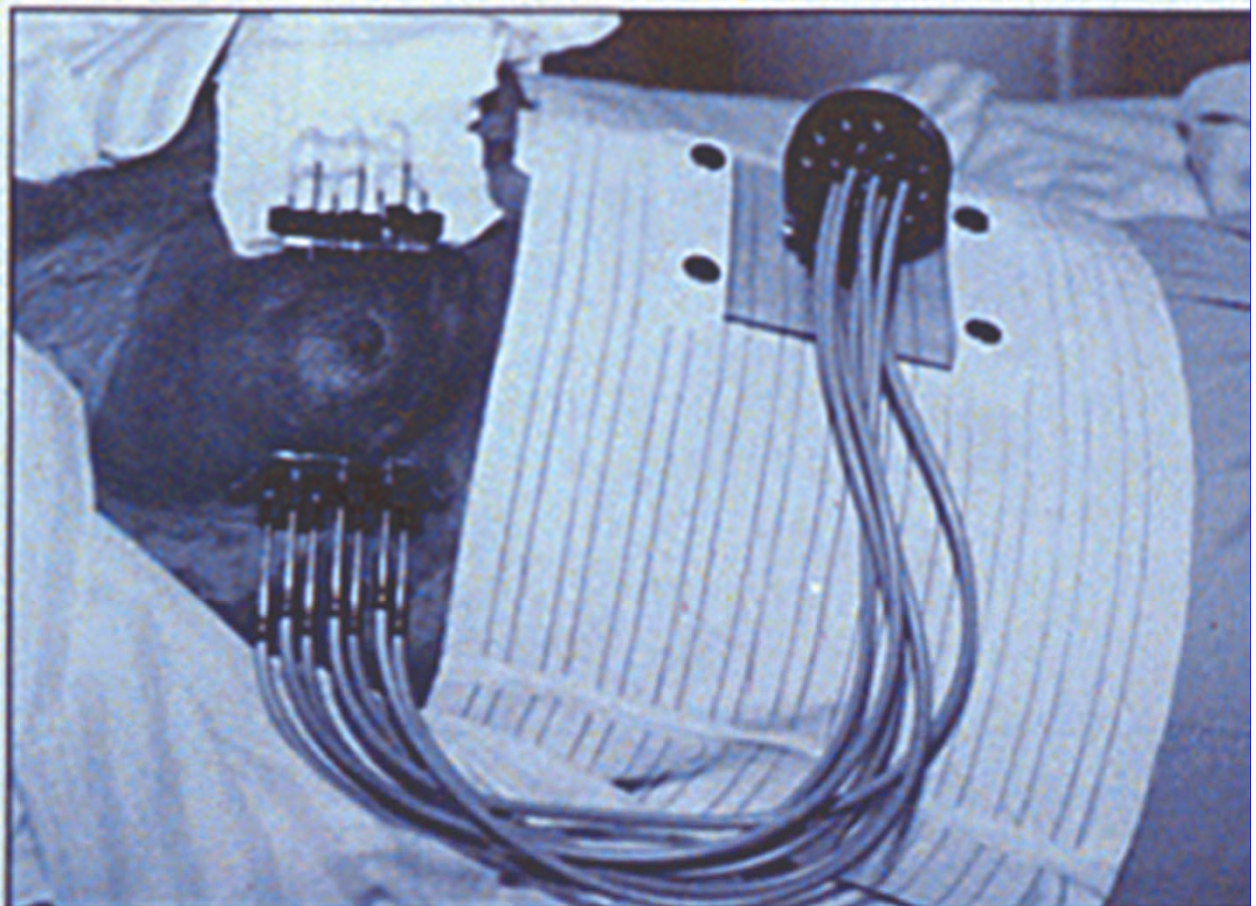


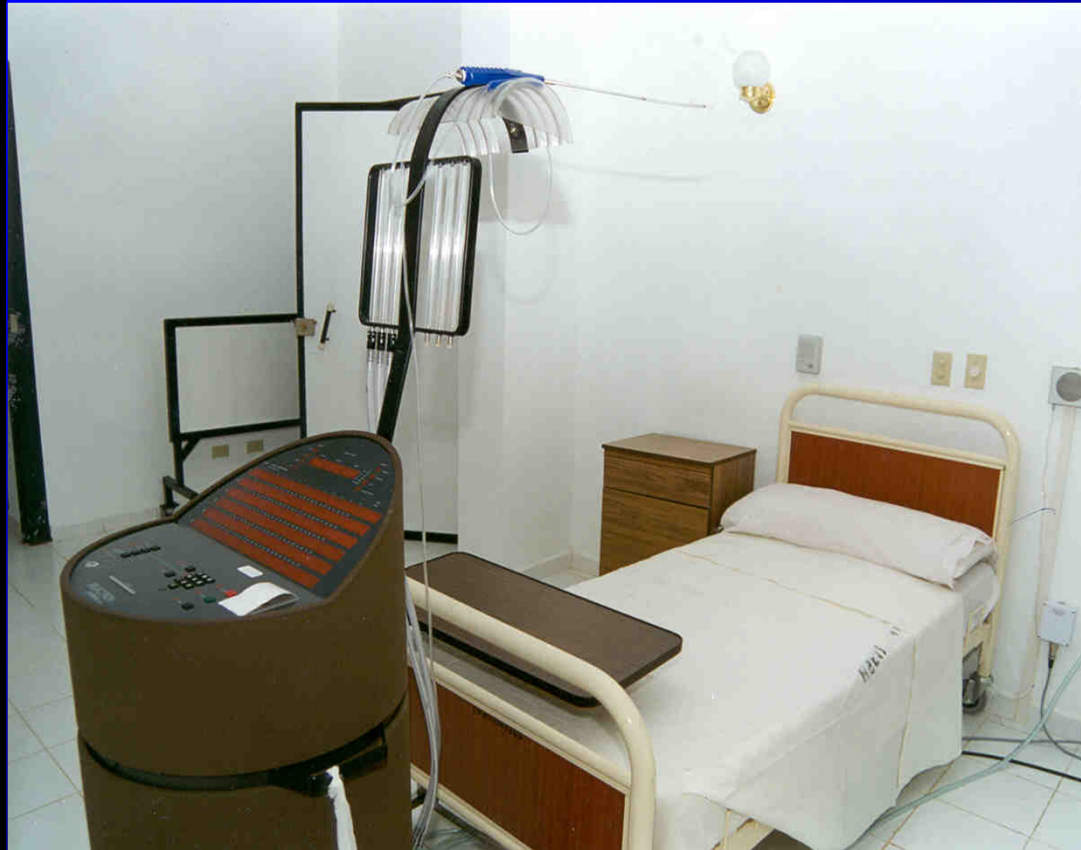




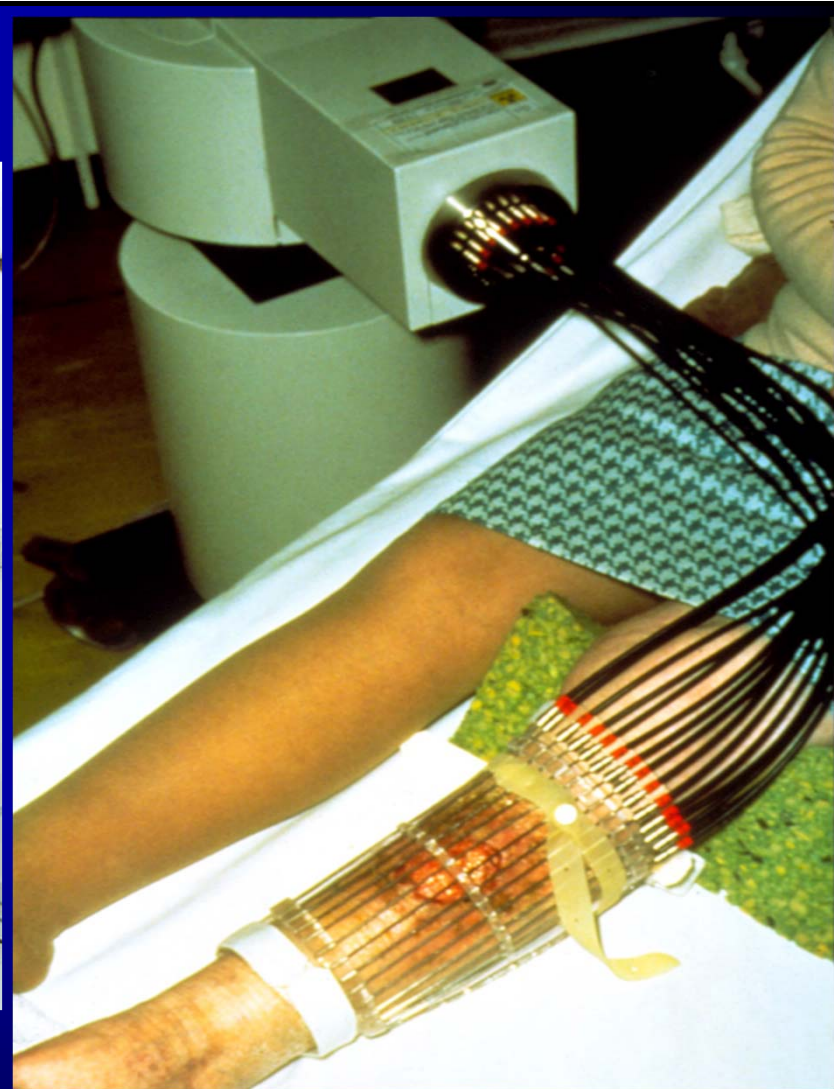
# Changes in Brachytherapy Breast Cancer Treatment

1929 vs 1990's





LDR (1970's)



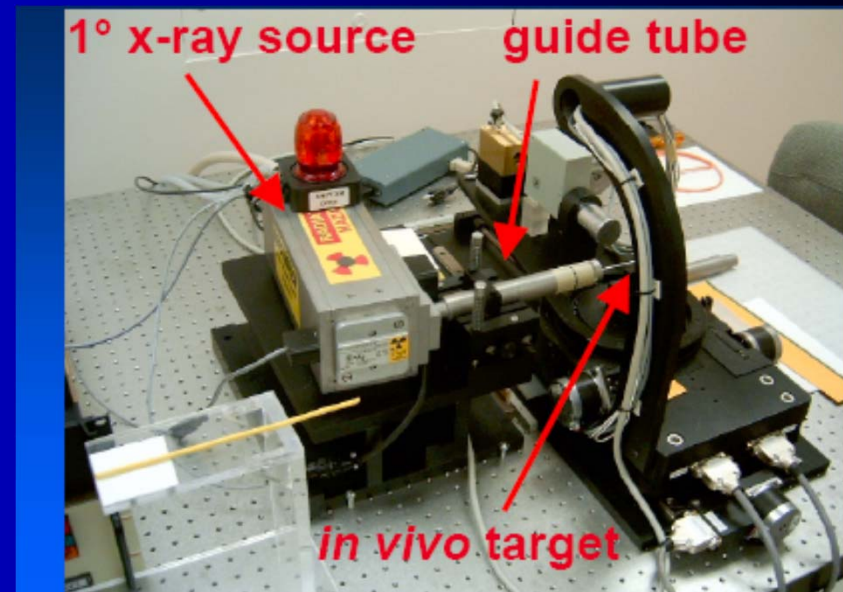
HDR (1990's)

## Remote Afterloading Brachytherapy Units



# Electronic Brachytherapy

Miniature x-ray tubes that can  
yield similar dose distributions  
to LDR I-125 and similar dose  
rates to HDR Ir-192



Reprinted with permission from Sung-Woo Lee and Fang-Fang Yin, ICCR (2004)

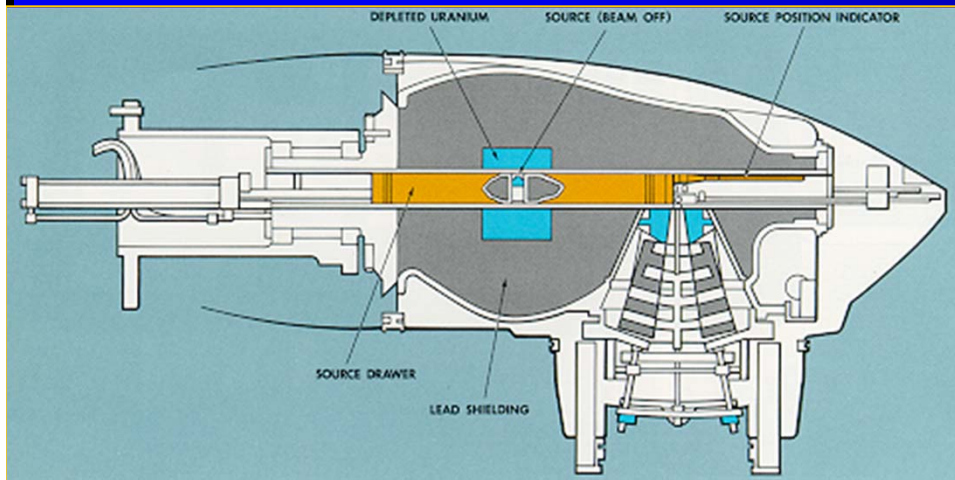


# Disaster Types that Affect Hospitals

- 1. Loss of Radiation Source Control at the Hospital**
- 2. Nuclear / Radiological Event**
- 3. Natural Disasters**
  - a) Fires (do not have to be “natural”, they could be arson)**
  - b) Earthquakes**
  - c) Hurricanes / Typhoons**
  - d) Floods / Tsunamis**



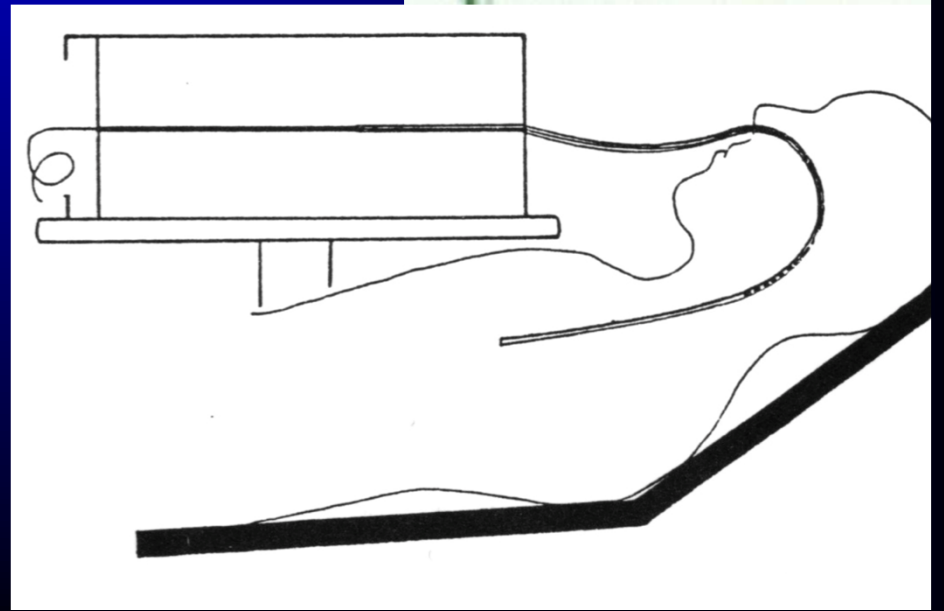
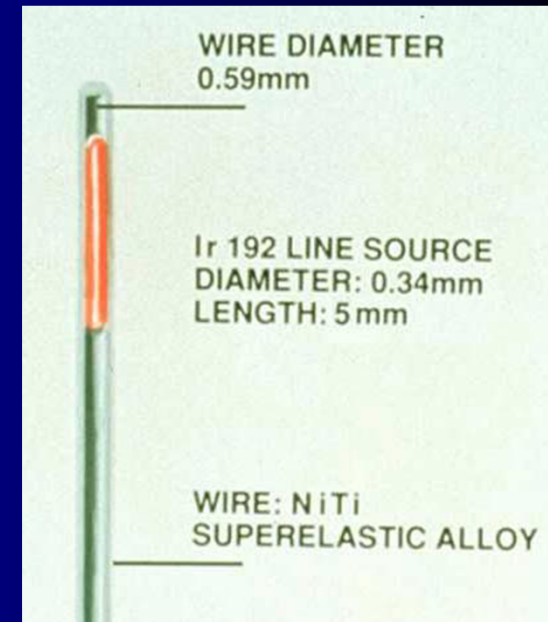
# 1. Loss of Radiation Source Control at the Hospital: Examples



Co-60 Source Stuck



Brachy  
Cable  
Broken



# 1. Loss of Radiation Source Control at the Hospital

- ▲ A BSS-based safety guide for medical applications considers this a contingency not an emergency
- ▲ Medical Physicists/Radiation Protection Officers need to have contingency plans and do periodic drills to test the appropriateness of the responses
- ▲ Medical devices containing radioactive sources, to prevent patient / staff irradiation in case of a power failure (source would not retract), must have a manual retract assembly and/or a UPS

IAEA Safety Standards

for protecting people and the environment

Radiation Protection and  
Safety of Radiation Sources:  
International Basic  
Safety Standards

INTERIM EDITION

General Safety Requirements Part 3  
No. GSR Part 3 (Interim)



**BSS**

## 2. Nuclear / Radiological Event

(Example: Chernobyl radioactive discharges may have affected a hospital in the area)

- ▲ Medical Services may be inoperable if radiation contamination is serious and both patients and staff may have to be relocated
- ▲ Hospital managers should request help from National Agency in charge of Disaster Response
- ▲ Country may need international assistance (See *Joint Radiation Emergency Management Plan of the International Organizations EPR-JPLAN* (2013), published by the IAEA)



Prypiat Hospital in Ukraine. (Carl Montgomery/flickr)



# Joint Radiation Emergency Management Plan

of the  
International Organizations

JOINTLY SPONSORED BY THE CTBTO, EADRCC, EC, EUROPOL, FAO, IAEA, ICAO,  
INTERPOL, IMO, OECD/NEA, PAHO, UNEP, UN/OCHA, UN/OOSA, WHO, WMO



IN CO-OPERATION WITH UNSCEAR

DATE EFFECTIVE: 1 JULY 2013



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APPENDIX A: LEGAL INSTRUMENTS, RESOLUTIONS AND OTHER RELEVANT SOURCES	
APPENDIX B: AUTHORITIES, RESPONSIBILITIES AND CAPABILITIES OF PARTICIPATING ORGANIZATIONS	

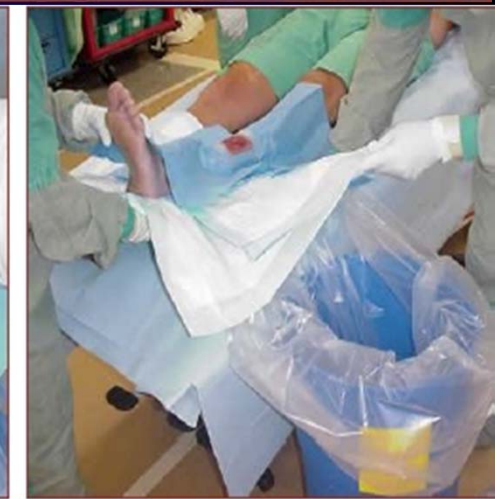
## **2. Nuclear / Radiological Event**

**If the hospital be part of the national / regional network of hospitals providing medical care to irradiated or contaminated patients in a nuclear/radiological emergency**

- ▲ Activate Emergency Plan, that should have been tested in practice drills periodically, and includes coordination with National Disaster Response Agency**
- ▲ Assemble medical/technical/radiation experts team**
- ▲ Prepare hospital to provide staff and rooms / areas for:**
  - Irradiated patients in need of sterile conditions**
  - Radioactivity detection in incoming patients & staff**
  - Decontamination**



**Medical treatment of  
a contaminated  
wound** (*The medical  
aspects of radiation  
incidents, REAC/TS*)



# **3. Natural Disasters**

## **Common Recommendations**

**Device and building should be built to withstand major potential disasters in the area**

**If event occurs when patients are undergoing radiological procedures:**

- **Stop exams, interventions or treatments**
- **Move patients to safe location**
- **Record given doses (mu or time) in case of radiotherapy treatments**



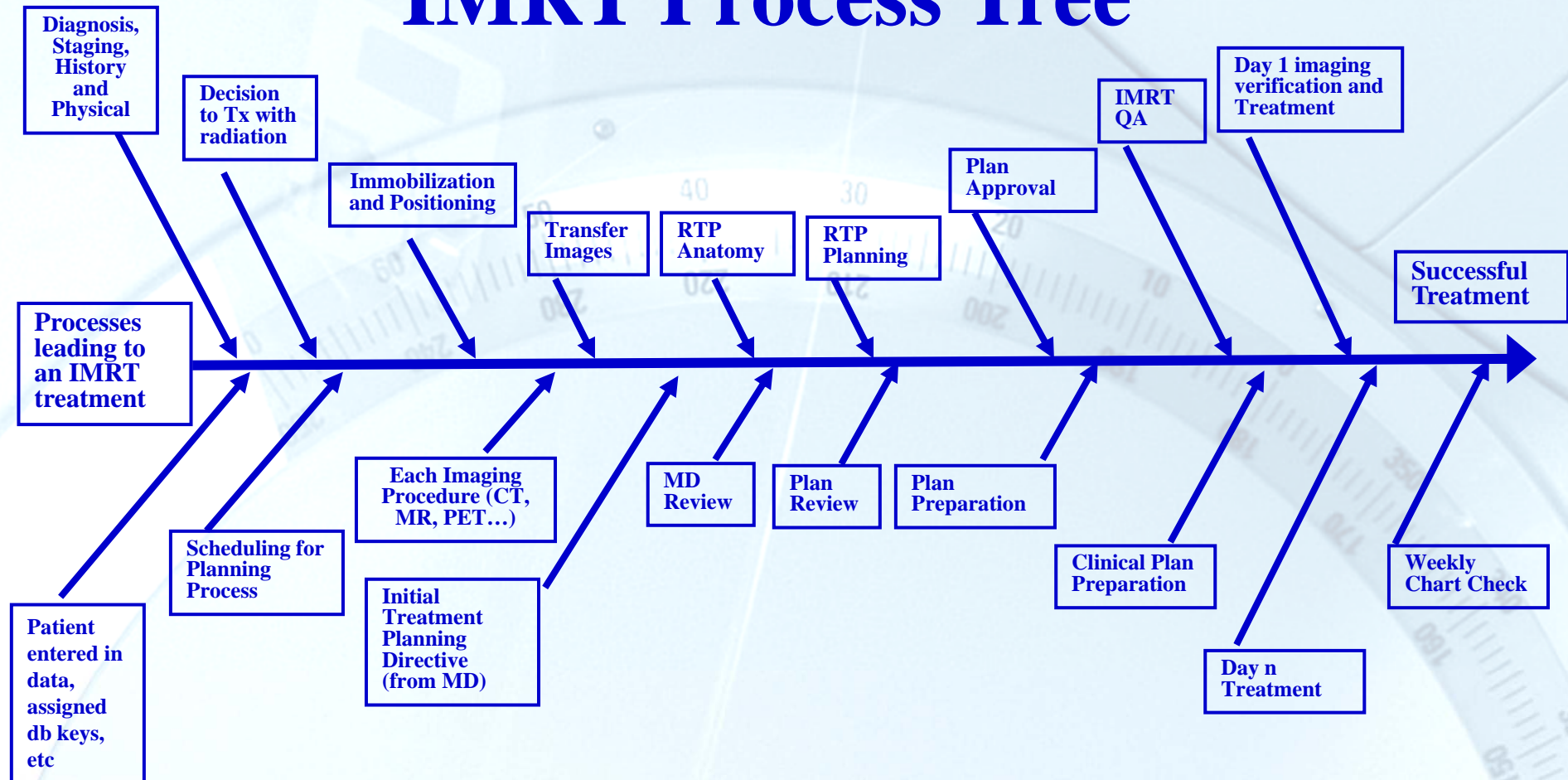
# **3. Natural Disasters**

## **Common Recommendations**

### **After the event**

- ◆ **Check and correct – if possible – the medical device's mechanical and electrical integrity**
  - Components
  - Accessories, including patients' masks, immobilizers...
  - Dosimetry systems and QA phantoms
- ◆ **Assess/repair device's electrical & water supplies**
- ◆ **Assess/repair software and network operability**
- ◆ **Request medical physicist to perform a complete device evaluation before its return to clinical use**

# IMRT Process Tree



# **3. Natural Disasters**

## **Recommendations if Device Contains a Radioactive Source**

### **After the event**

- ◆ **Seal room (prevent access) until radiation protection officer has verified that:**
  - **Source is still in the device or container**
  - **Sealed source encapsulation is intact**
  - **Either no contamination has occurred or**
  - **Contaminated areas have been decontaminated**



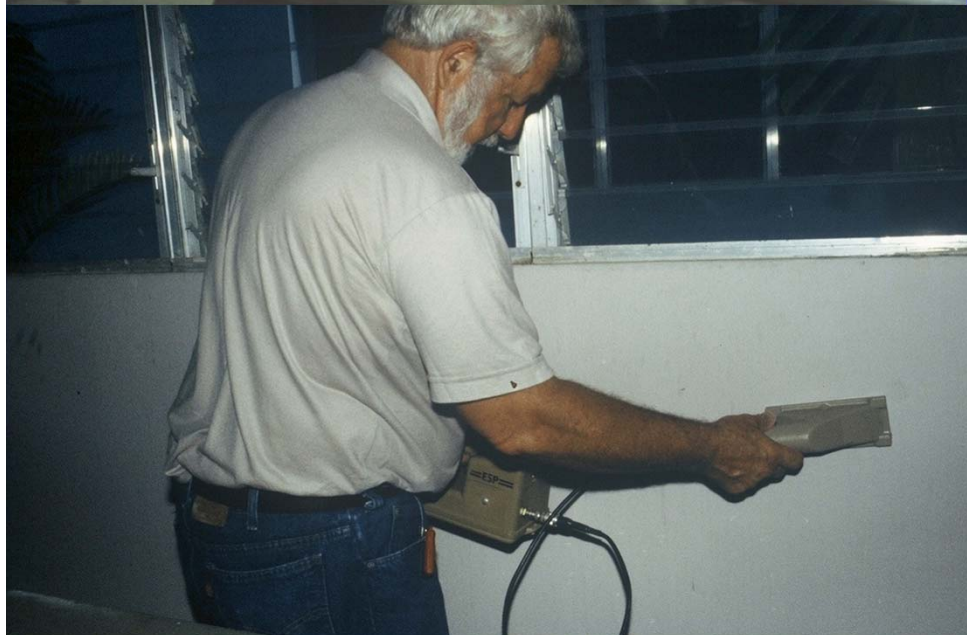
# Checking for Contamination



Radiation Alarm



Leaded safe with  
Ra-226 needles



Goiania, IAEA



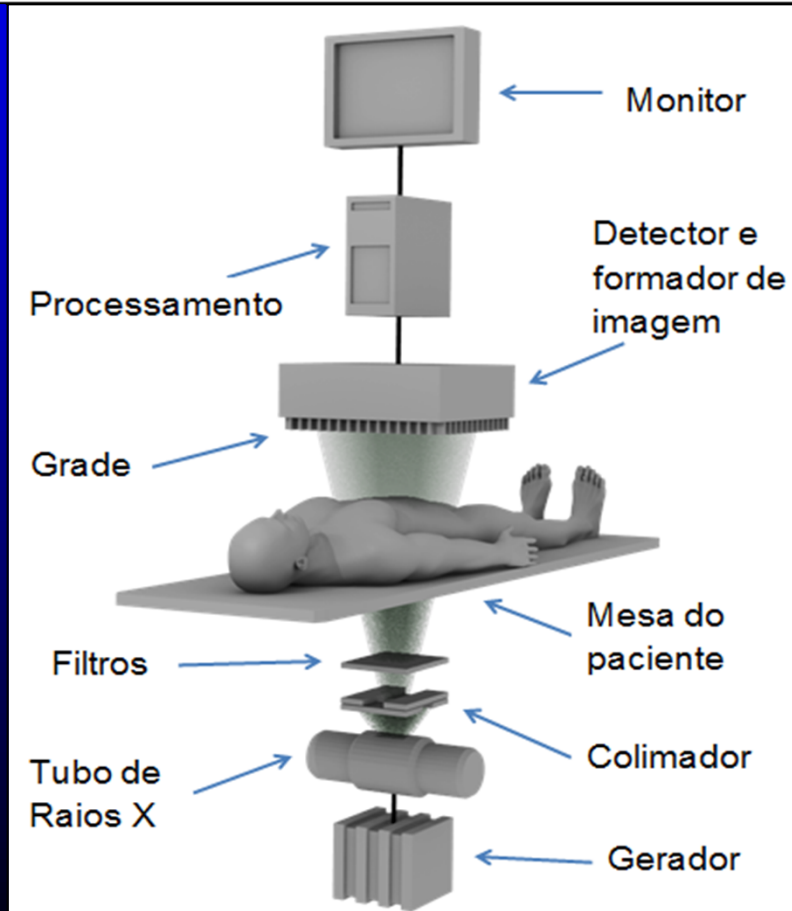
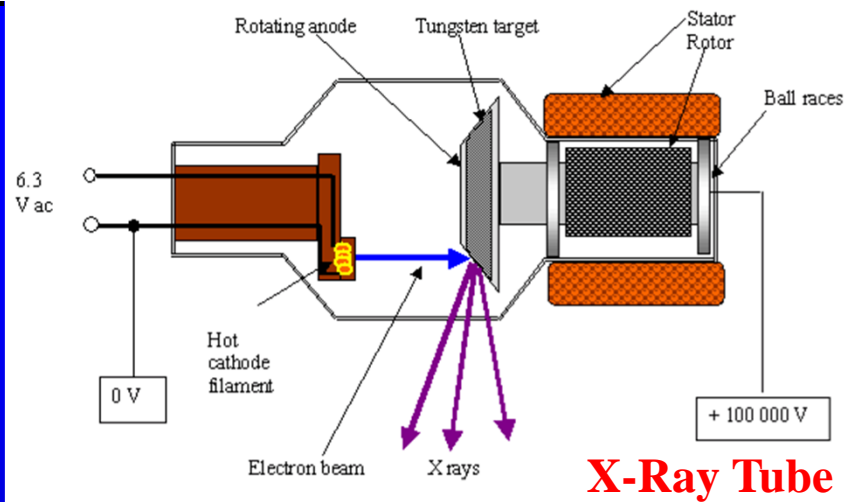
# **Additional Recommendations for Earthquakes**

**Depending on the magnitude, earthquakes may  
affect the alignment of the radiation beam**

**After the event**

**For medical imaging devices, check:**

- ▲ The congruence of the radiation and light fields**
- ▲ The alignment of the whole imaging chain,  
including displays and networks (RIS, PACS)**



## Fluoroscope with Flat Panel Detector



## Fluoroscopic Imaging Chain

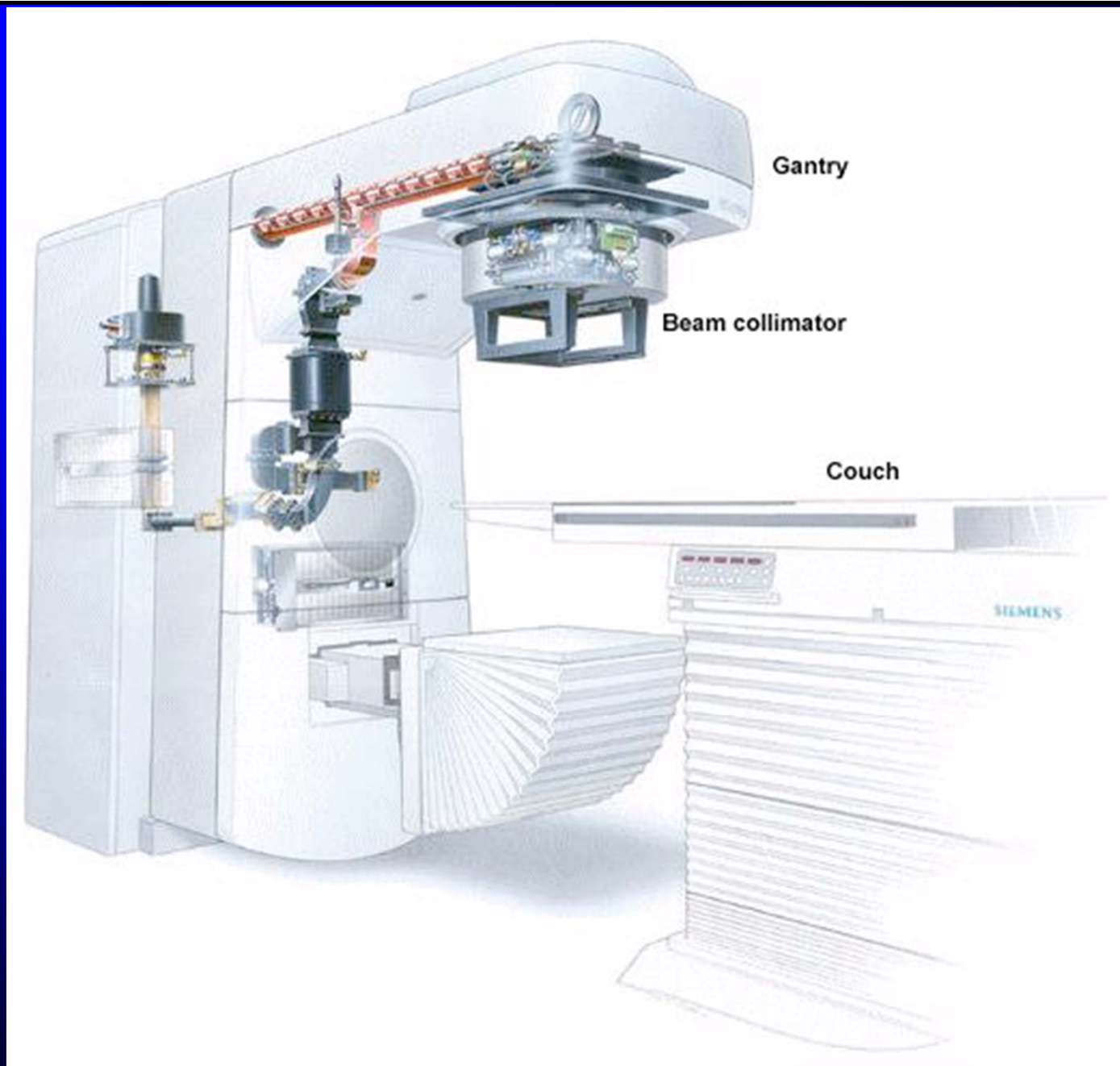
# **Additional Recommendations for Earthquakes**

## **After the event**

**For external beam radiotherapy devices, especially  
linear accelerators, check:**

- ▲ Position of collimator, gantry & table isocenters**
- ▲ Field flatness and symmetry**
- ▲ All dosimetry and treatment planning systems**
- ▲ In-room imaging devices (IGRT)**
- ▲ The record and verify network**
- ▲ Patient accessories**





Schematics of a medical linear accelerator (State University of Campinas, Brazil)

# Conclusion

- ▲ **Medical devices in medical imaging and radiation therapy are very vulnerable to disasters due to their design complexity.**
- ▲ **Prevention and response measures should take into account the medical device itself and its role in the whole radiological process.**
- ▲ **Hospital staff should be prepared to cope with disasters through frequent drills of a well-developed emergency plan which encompasses the phases before, during and after the disaster, and that includes radiation protection considerations.**