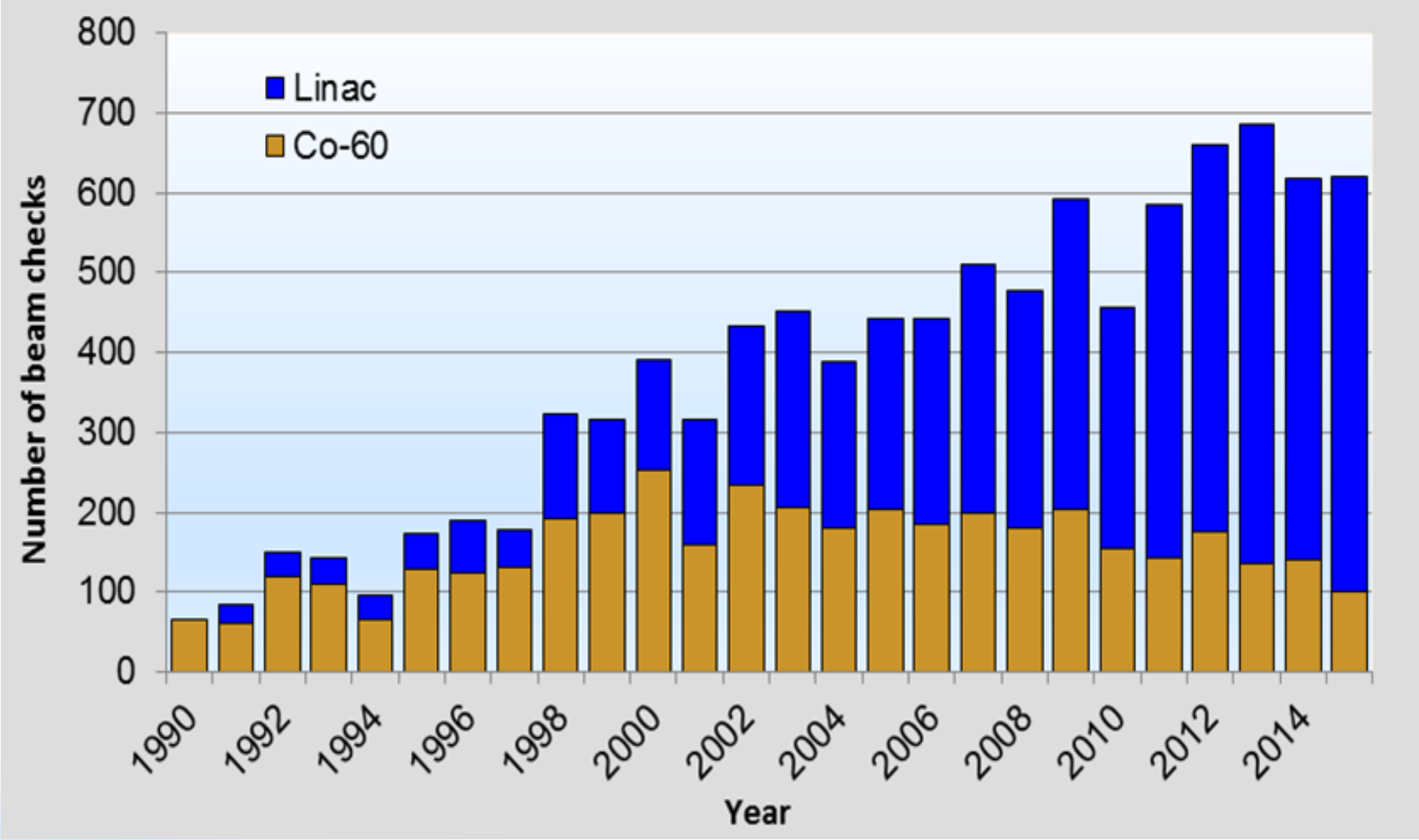
IAEA 60 Years
Atoms for Peace and Development

Design Considerations for Linear Accelerators for Challenging Environment

Machine parameters & machine operational features to satisfy requirements

Ahmed Meghzifene
Head, Dosimetry & Medical Radiation Physics
IAEA

Number of Cobalt-60 and linac beams checked by the IAEA/WHO TLD audit per year



Overview

- Essential requirements for the safe operation of LINAC and limits on degradation of performance of LINACs beyond which a fault condition exists
  - IEC standards
- Requirements for optimum performance
  - IEC
  - IAEA
  - Professional societies (AAPM, IPEM, etc)
  - EC report (RP 162)

Overview

- Accelerators designed to operate in challenging environment **must also fulfil existing standards** that are essential **for their safe operation and for optimum performance.**

Overview

Fulfilment of these conditions is essential to ensure:

- Patients have access to the same standard of treatment all over the world including LMICs, and
- Acceptance of the new accelerator by the radiation oncology community, health authorities and patient care organizations

LINACs designed for LMICs ≠ substandard LINACs

Overview

- When equipment manufactured in one country is to be exported into another country with the **IAEA's assistance**, documentary evidence of the national standards of the exporter has to be provided to assess whether the national standards are actually equivalent to the IEC standards

Essential safety requirements

- Three areas of safety are of interest
  - Electrical: protective earthling, leakage, door interlocks, emergency switches, etc…
  - Mechanical: gantry, head, patient support system, etc.
  - Radiation: dose monitoring system, timer, displays, leakage radiation, etc.

To avoid potential serious harm to patients and staff

Essential performance requirements

Dosimetry and dose monitoring system
Depth dose characteristics
Uniformity of radiation fields
Indication of radiation fields
Indication of radiation beam axis
Isocenter
Indication of distance along the beam axis
Zero position of rotational scales
Congruence of opposed radiation fields
Movements of the patient table
Electronic Portal Imaging Device
Etc.…

To ensure optimum treatment of patients

How to ensure compliance?

- **National level**: regulatory agencies are responsible for ensuring/verifying compliance
- **Hospital**: the medical physicist is responsible for conducting acceptance testing (to ensure compliance with equipment specifications) and commissioning (to ensure that LINAC is fit for clinical use)
- In countries where such independent regulatory agencies do not exist? There are no qualified medical physicists?

How to ensure compliance

The IAEA or other organizations can help with acceptance testing and commissioning of LINACs, but:

- Training of radiation oncology staff should be done **before** the commissioning to ensure safe and effective use of LINACs
- Training of a medical physicist goes beyond training on LINAC operation

Boundary conditions in challenging environments

1. Weather conditions
   - Heat, humidity and dust can be taken care of with 24h A/C and flirtation of air. Requires maintenance.
2. Construction
   - How to ensure quality of construction? Lack of independent QC testing in many LMICs.
   - Usually, concrete density is not an issue, if the ratio of cement-sand-gravel is correct
   - Other Items: cable trenches, proper foundations, refrigeration plant, extended maze saves money for the door, bonding between concrete pours to avoid cracks and radiation leakage, …

Boundary conditions in challenging environments

3. Operation
   - High ambient temperatures (30^0 degrees or more) due to poor A/C)
   - Fast turn over of staff - training of new staff
   - Longer working hours/day?
   - Lack of systematic and periodic QC
4. Maintenance
   - Lack of preventive maintenance on LINAC, A/C. …
   - Manufacturers are generally reluctant to train local engineers
   - Taking into account lack of funding and poor planning in some LMICs, there is a need to establish a system to project life span of expensive components: gun, klystron, RF drivers, …

Boundary conditions in challenging environments

Maintenance - Continued

- Manufacturers are reluctant to offer 5 year (or more) maintenance packages
- Multi-leaf Collimators: Failures might happen if leaves are left open after a prolonged week-end, due to faulty resistor track.

5. Remote repair
   - In many LMICs, limited to fault diagnosis via “event log”
   - Already a reality for some machines, but at a high cost
   - Should remote repair enable manufacturers to disable the machine in some cases (non payment)?
   - Requires good quality Internet connection

Most relevant IEC standards

- **IEC 60601-2-1 (2009b):**
  - establishes requirements to be complied with by manufacturers in the design and construction of electron accelerators for use in radiotherapy
  - Identify features of design that are essential for the safe operation of LINACs
  - places limits on the degradation of the performance
  - includes protection against electrical and mechanical hazards and unwanted and excessive radiation hazards (i.e. dose monitoring systems, leakage radiation and stray radiation).

Conclusions

A novel accelerator designed for challenging environments should

- Fulfil existing safety and performance standards
- Be better protected against higher room temperature
- Include an interface for remote diagnosis and adjustments

Conclusions

- Be provided with a 5 or 10 year maintenance package that includes spares, remote support and training of local staff.
- Include a transparent system that allows end-users to plan for the replacement of capital intensive parts (gun, klystron, RF drivers)
- Establish a transparent certification system for maintenance engineers
- Avoid the use of “exclusive” local or regional agents

Most relevant IEC standards

- **IEC 60976** (IEC (2007)) describes test methods and reporting formats for performance tests of medical linacs

- **IEC 60977** (IEC (2008c)) suggests tolerance values, measured by the methods specified in the previous document

Reports on optimum performance

- AAPM TG 142
- IPEM report 81
- IAEA “Setting-up a radiotherapy programme: clinical, medical physics and radiation protection aspects:

Thank you!