INFN
LNF
Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali del Frascati

The INFN Frascati facility for X-Ray dosimetry (@ LEMRAP laboratory)

On behalf of the LEMRAP Laboratory

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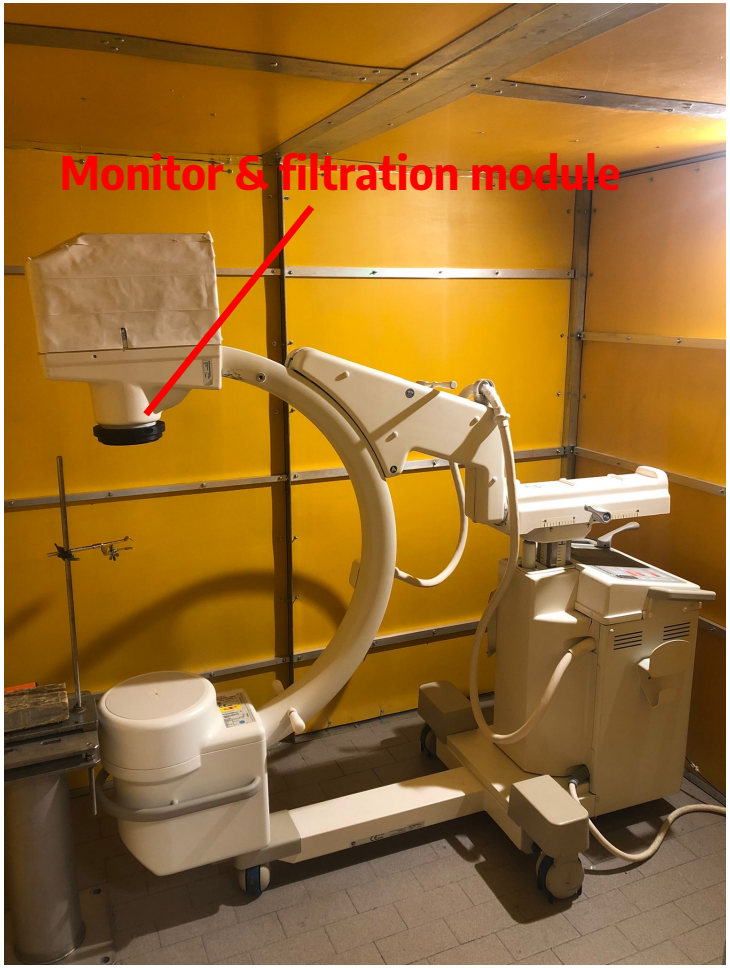
1 The LEMRAP X ray Facility

The X-ray unit & cabinet

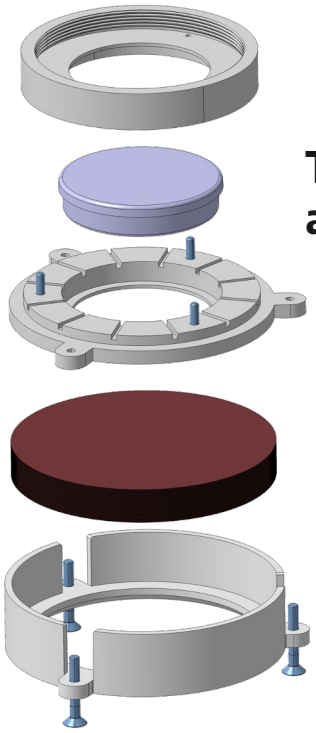
- Bunker 2 mm Pb
  2 x 2 x 2 m3
- door 2 mm Pb
- Interlocked
- Cables in/out



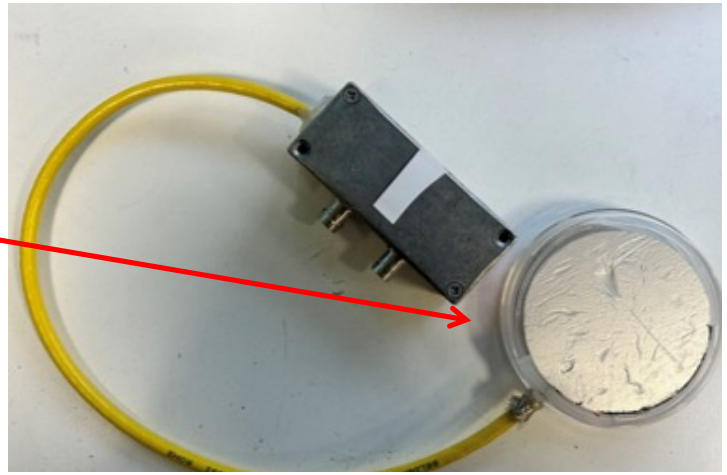
General Electric Stenoscop 9000

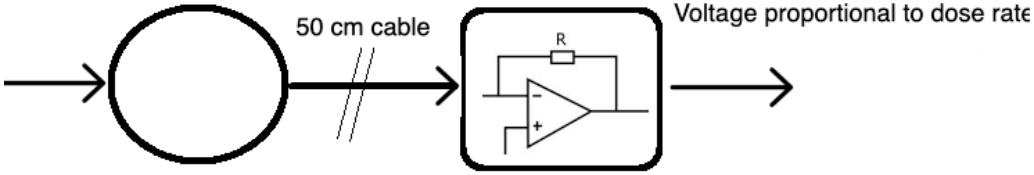
- W anode
- Constant potential
- Filtration 1,5 mm Al + added
- Anode 1,8x1,8 / 0,5x0,5 mm^2
- 40 to 110 kV
- 0.1 to 3 mA

Monitor & filtration module: monitor ion chamber



Transmission air chamber

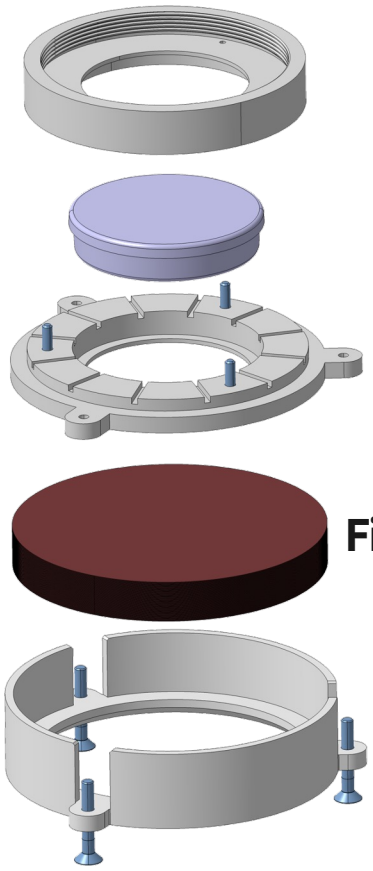




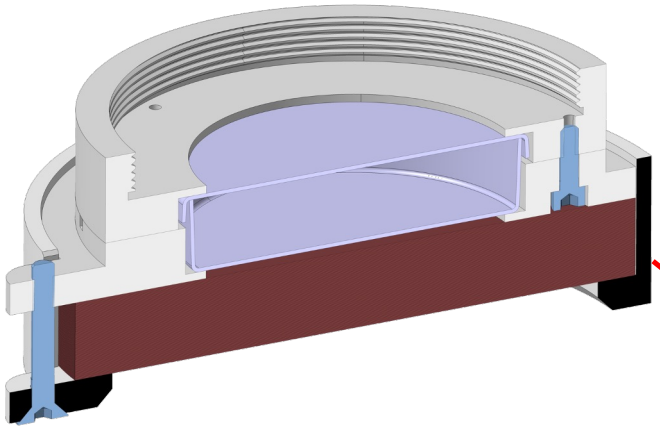
MONITOR CHAMBER

- "Nearly transparent" free-in-air ion chamber allows monitoring the tube output
- Works at +400 V
- Ionisation current amplified through a ultra-low noise amplifier (custom design)
- Linearity range from tens fA up to tens nA ionisation current
- Readout with commercial digitiser up to 250 kS/s

Monitor & filtration module: added filtration

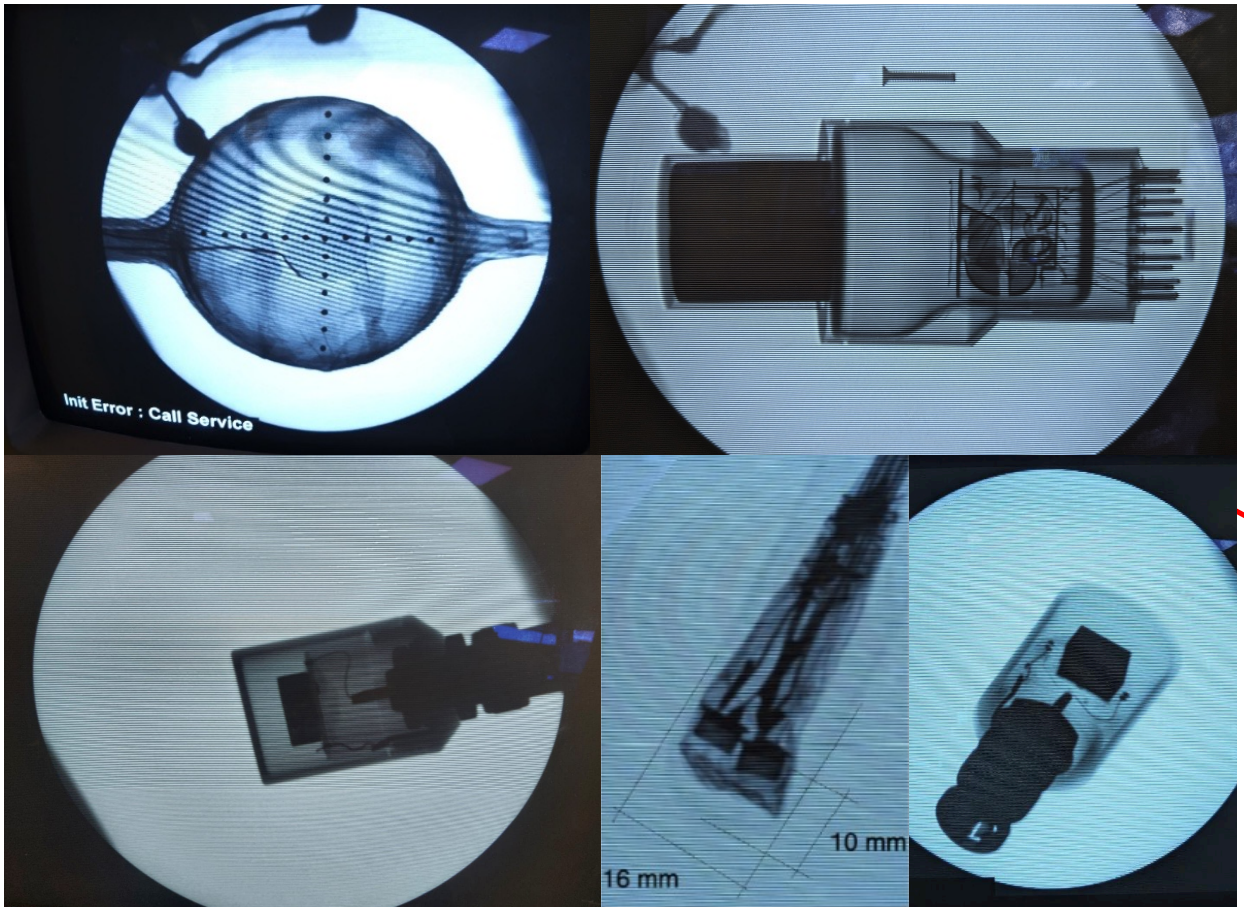


Filters



- 3.3 mm Al = inherent filtration
- 0.7 mm Al added to meet ISO recommendations (4 mm Al)
- Additional filters are added through the module

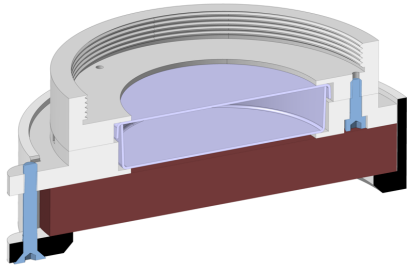
Imaging capability



2 X ray metrology for radiation protection dosimetry

X-ray metrology

Achieving "reference" photon fields



If

- ✓ kV well-known and constant
- ✓ Application of standard filters (ISO 4037)
- ✓ Tube output:
  - Continuously monitored with a transmission free-air ionisation chamber
  - Measured at reference distance in terms of Air kerma (*)with a calibrated ionisation chamber

Then

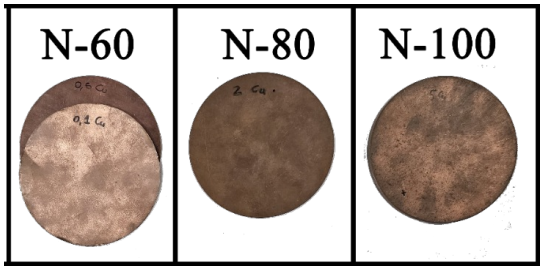
The energy distribution of the photon field is known
The field intensity is known

Air kerma (*) = kinetic energy released by primary photons to secondary electrons per unit mass of air

X-ray metrology

ISO Series “Narrow spectrum” (N)

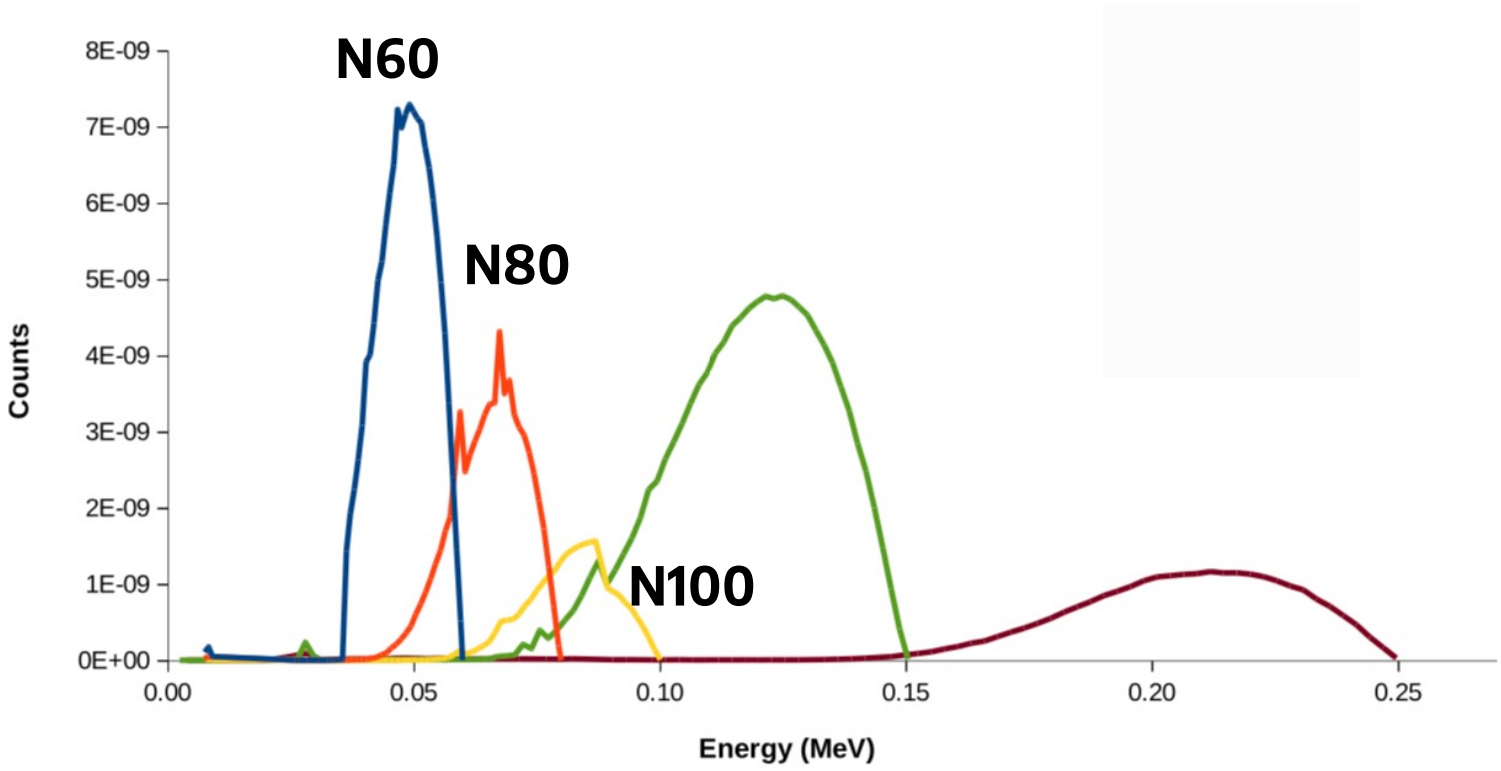
Beam code	kV	filtration	<E> (keV)	dK/dt (mGy/h) 1 mA, 40 cm	dF/dt $cm^{-2}\ s^{-1}$ 1 mA, 40 cm
N60	60	4 Al + 0.6 Cu	47.9	33	3×10^{7}
N80	80	4 Al + 2 Cu	65.0	18	2×10^{7}
N100	100	4 Al + 5 Cu	83.1	9	8×10^{6}



By operating on distance (20 cm to 60 cm) and current (0.1 to 3 mA) the field intensity can be varied **from ÷20 to ×200**

X-ray metrology

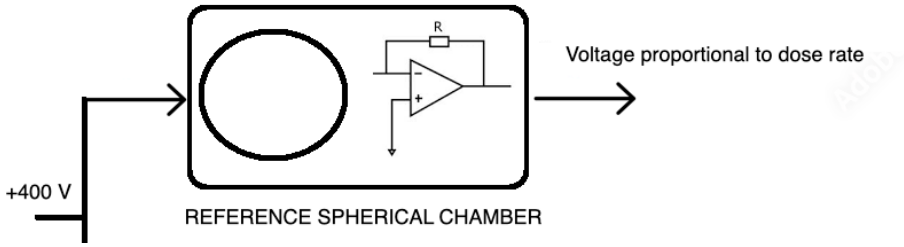
ISO Series “Narrow spectrum” (N)



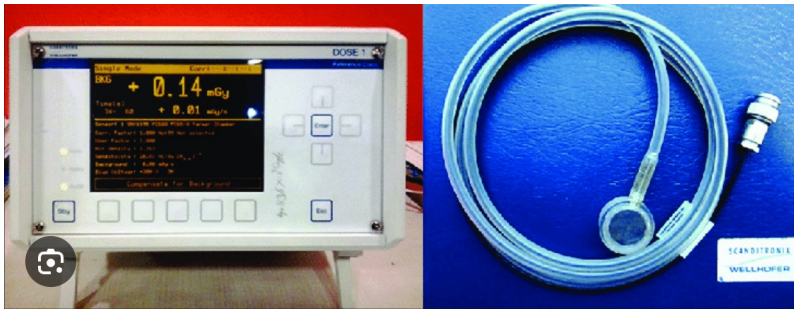
3 Characterising the LEMRAP X-ray unit

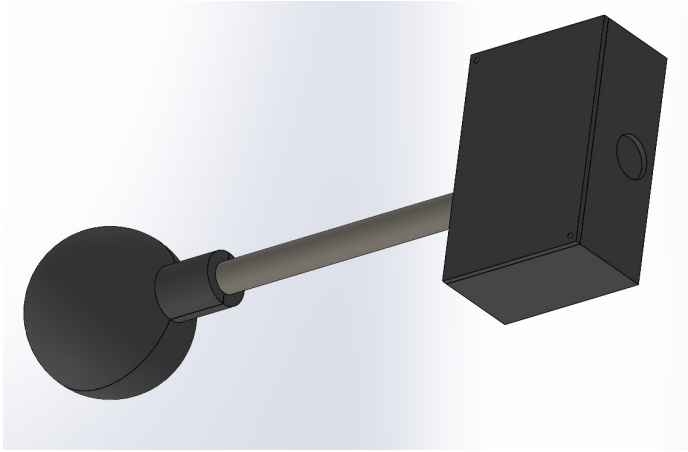
The reference spherical ion chamber

- **Custom design**
- **Isotropic response**
- **Ionisation current amplified through an embedded ultra-low noise amplifier (custom design)**

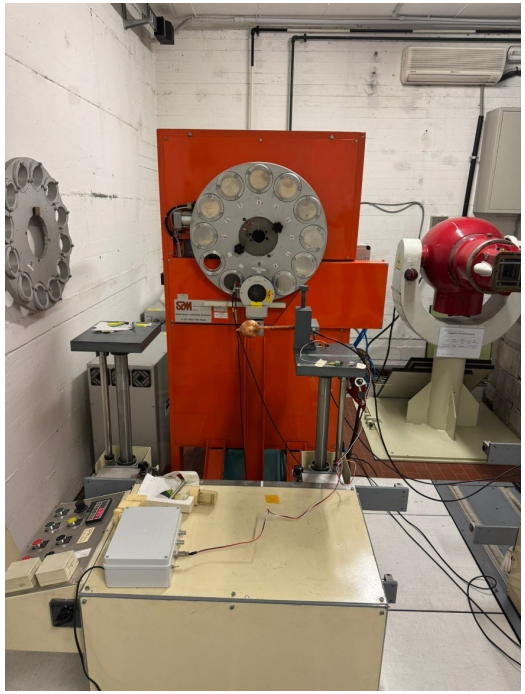


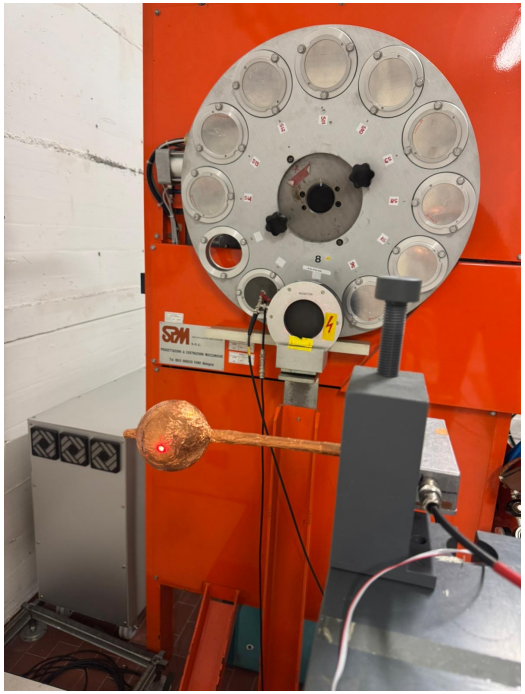
- **Noise and interference REDUCED with respect to state-of-art design**

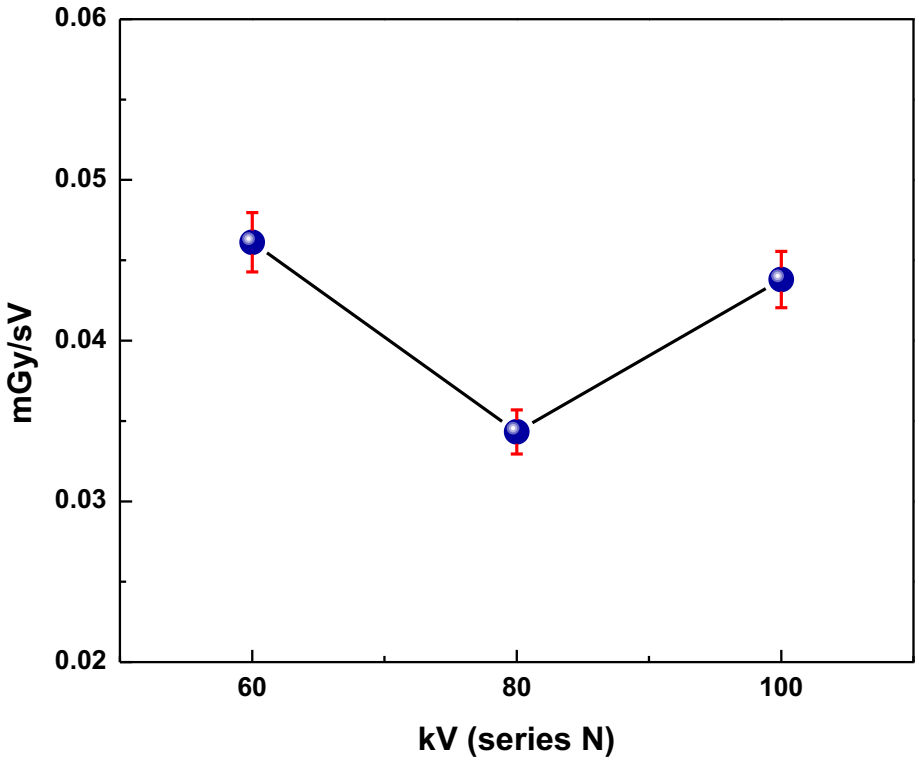




Calibrating the reference spherical ion chamber







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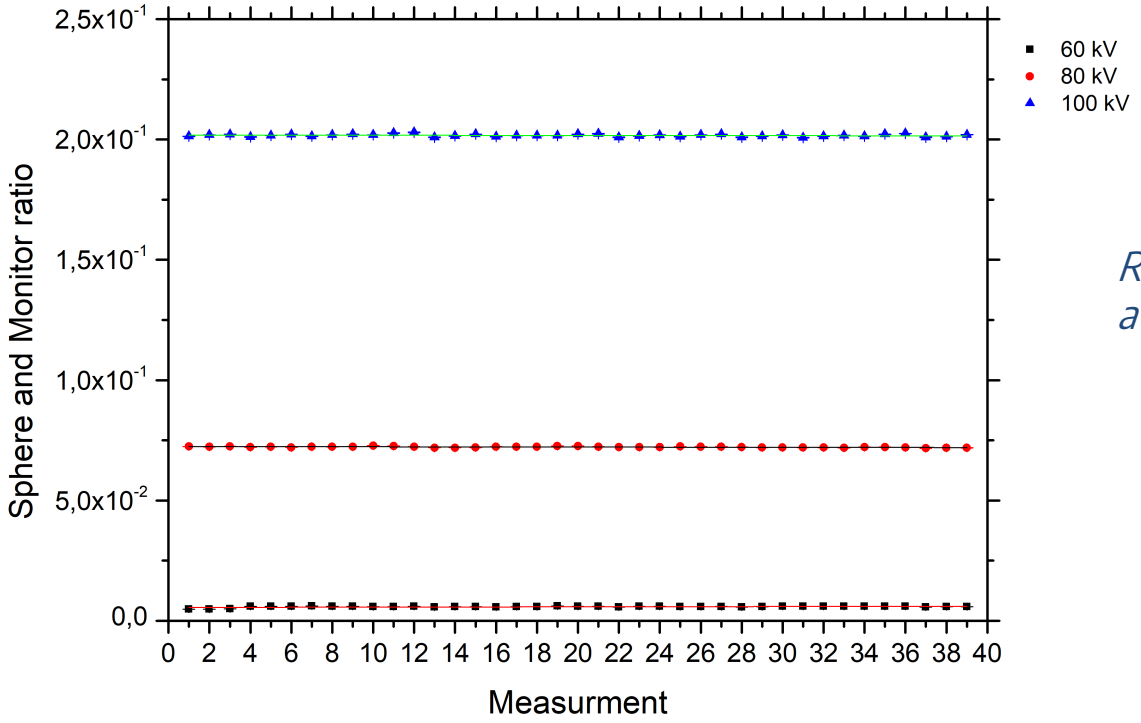
Using the reference chamber to measure the air kerma @ LEMRAP unit

Reference chamber at the working distances of 40 cm, 55 cm, and 75 cm

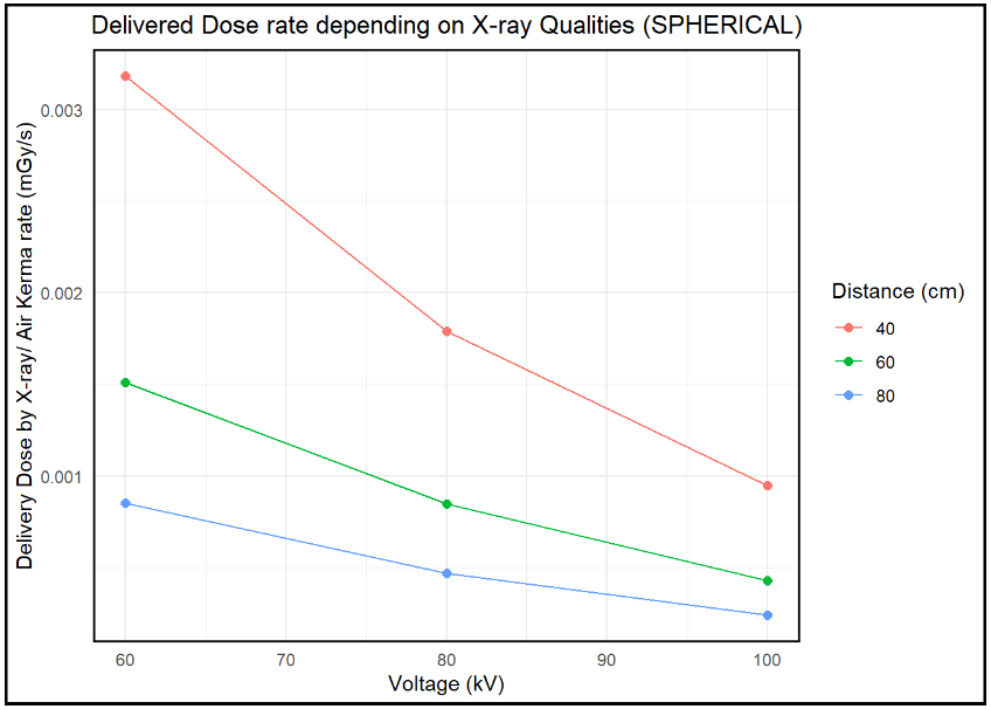
Reproducibility of the Ion Chamber

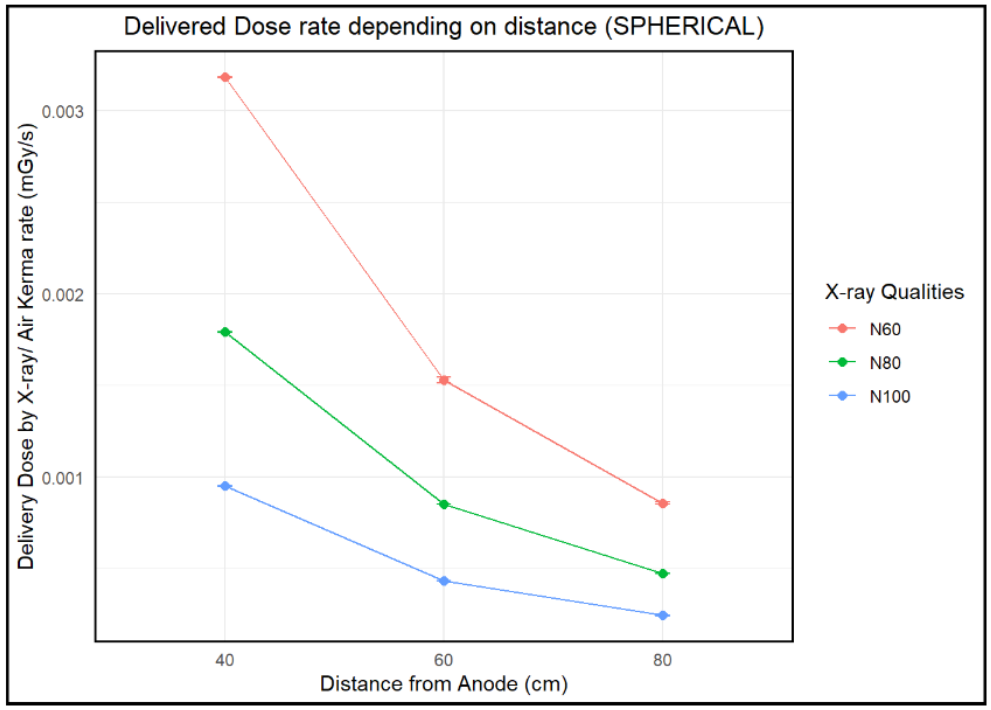


Reproducible (1 %) at a 55 cm distance

Reproducibility of the Ion Chamber on the X-ray tube

Dose rate capabilities





Delivered Dose rate depending on X-ray Qualities (left) and per distance (right) of the Spherical Ion Chamber

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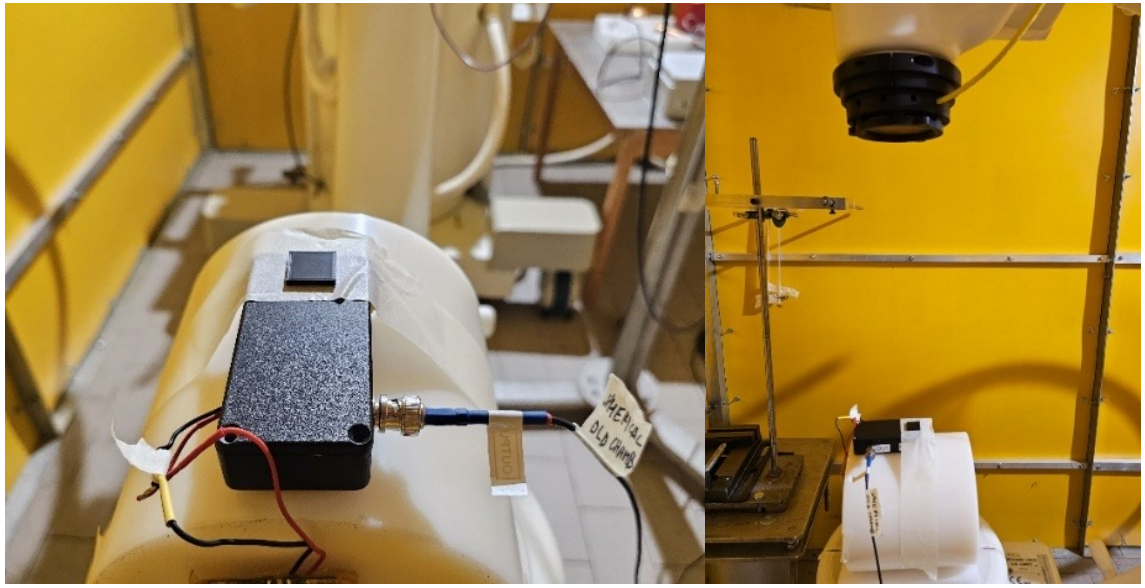
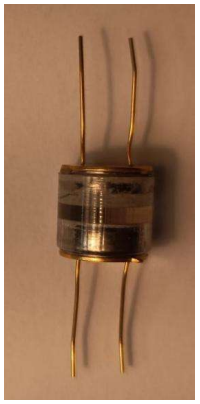
4 Lab activities and Potential applications

Lab activities and potential apps

Testing new sensors for clinical dosimetry or nuclear physics





5 Conclusions

- The LEMRAP X-ray facility produces X-ray fields with know energy distribution and air kerma

- Various activities within collaborations with Institutions and private companies

  - Developing active and passive sensors for X-ray dosimetry
  - Calibrating X-ray dosemeters
  - Evaluating the X-ray sensitivity of sensors used in nuclear physics

Thank you for your attention