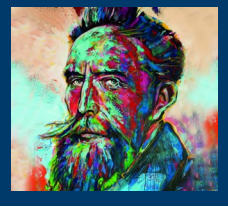
High Precision X-ray Measurements 2025
16-20 June 2025, Laboratori Nazionali di Frascati INFN

Development of a direct-reading dosimeter for eye-lens dose estimation in medical radiology

Preliminary results of the EYEDOS project

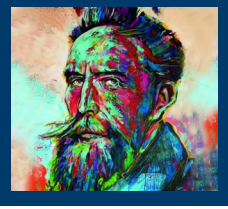
L. Russo, A.I. Castro-Campoy, M.A. Caballero-Pacheco,
F. Lopes Frigi, R. Bedogni

INFN, Laboratori Nazionali di Frascati
LEMRAP Laboratory for Environmental and Medical RAdiation Physics



Contents

- Background
- The operational quantity Hp(3) for eye lens dosimetry
- The Italian case
- Dosimetric studies
- The EYEDOS project
- International Standards
- Preliminary design
- Experimental tests
- Conclusions



Background

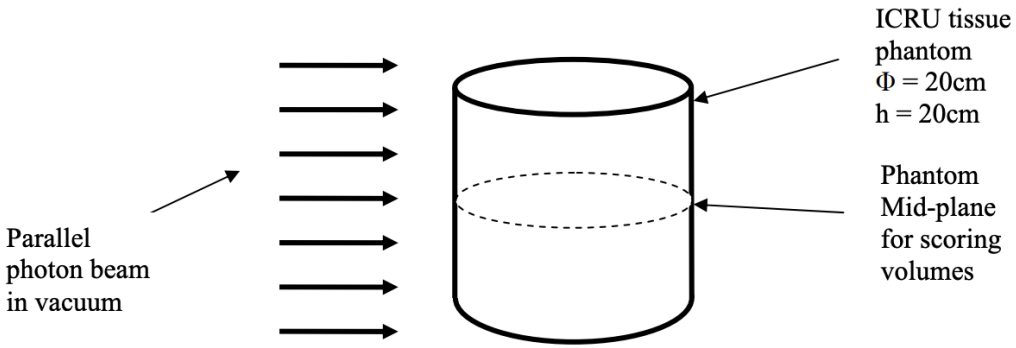
- Interventional radiology / cardiology (IR/IC) very common in clinical practice
- IR/IC vs. traditional radiology: increased exposure for eye-lens
- New epidemiological data
- 2011: Eye lens annual limit reduced from 150 mSv to 20 mSv
- The limit is exceeded in many cases (incorrect habits and postures)
- Radiation protection in IR/IC needs to be improved in terms of
  - Standardisation of the practices
  - Training of the operators
  - Individual radiation monitoring

The operational quantity Hp(3) for eye lens dosimetry

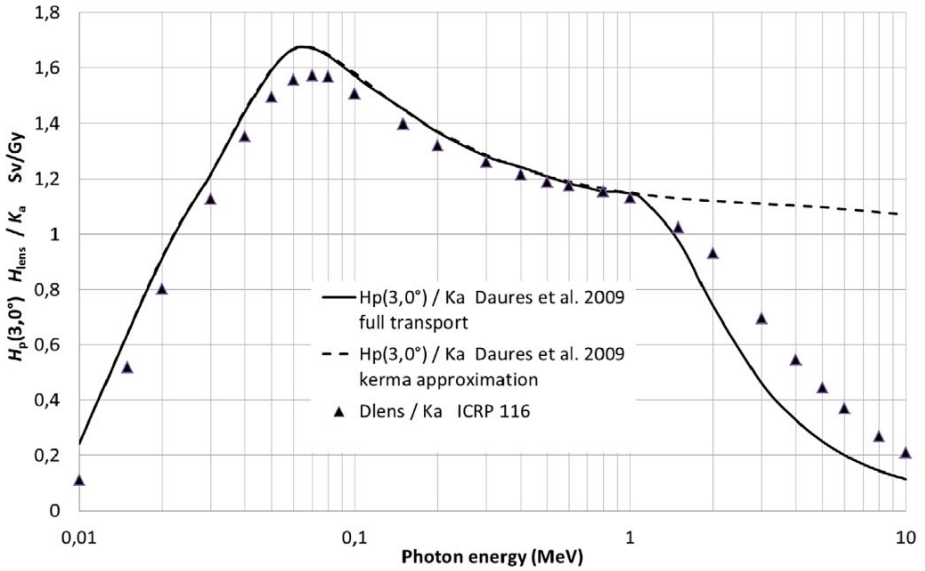
The protection quantity is the equivalent dose to the lens of the eye H_{lens}

- Every individual is different
- For practical purposes H_{lens} is replaced by $H_p(3)$, *i.e. the dose equivalent in soft tissue, at an appropriate depth d (3 mm), below a specified point on the body*
- Standard "head" phantoms are chosen :

A mathematical phantom in ICRU-tissue for calculating the conversion factors from Air kerma (basic physical quantity) to Hp(3)

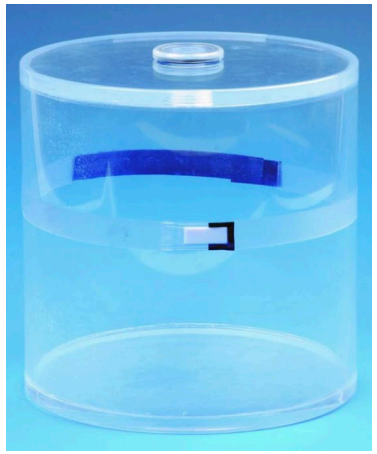


Is Hp(3) a conservative estimation of H_{lens} ?



The operational quantity Hp(3) for eye lens dosimetry

A water-filled phantom is used in metrology laboratories to calibrate personal dosemeters in terms of Hp(3)



Types of personal dosemeters in use for the lens of the eye:

- Thermo-luminescence
- Optically stimulated luminescence
- No active dosemeters are in the market

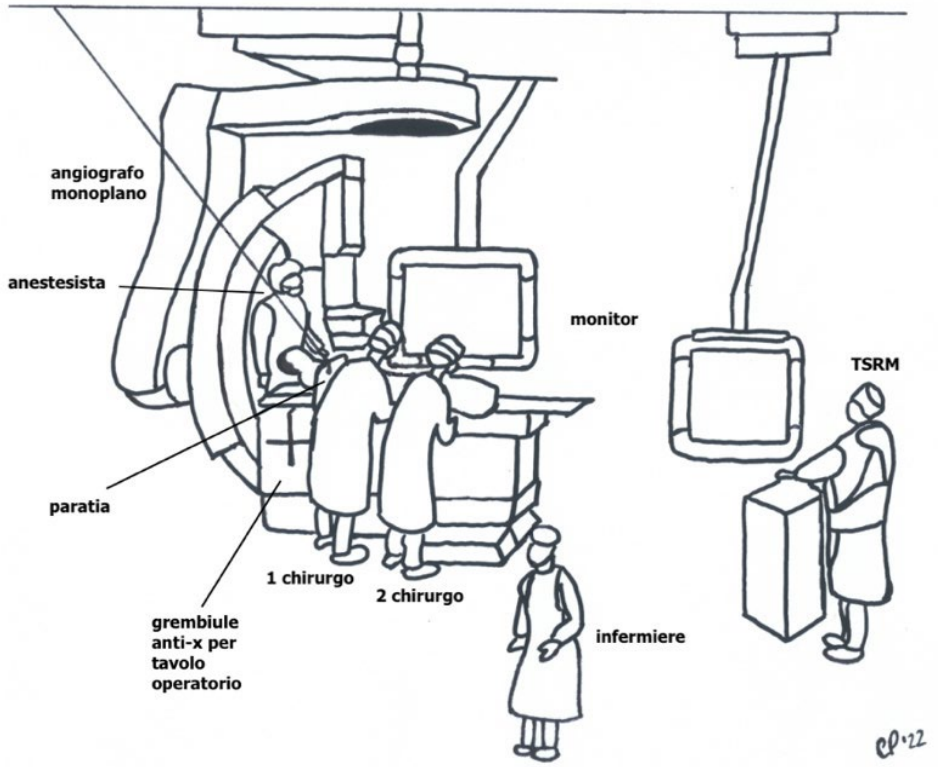
(a) (b)

The Italian case

- **INAIL BRIC Project (2020-2022)**

'Multi-centre study of eye lens radiation exposure of workers in interventional radiology'

- ❑ A dosimeter located near the most exposed eye provides the most accurate eye lens dose estimation
- ❑ Dose received by first operator may vary from tens up to 2500 μSv per procedure
- ❑ Limits can be easily exceeded if personal and collective protective equipment are not correctly used



Dosimetric studies

- **Finland**
  - ❑ Dosimeter mounted on lead glasses
  - ❑ Hp(10) can not be generally used as a good estimation for eye lens dose

- **Japan**
  - ❑ Use of protective lead glasses with small OSL dosimeter + additional personal dosimeter on the neck
  - ❑ Dose limits frequently exceeded

- **Switzerland**
  - ❑ Recommeded use of an eye lens dosimeter calibrated in terms of Hp(3) and positioned close to the eye, under the protection equipment

The EYEDOS project

- Limits of passive dosimeters
  - ❑ No real-time response (30-45 days needed)
  - ❑ No alarms available
  - ❑ No time-evolution of dose rate for the operator

- EYEDOS objective
  - ❑ Developing an active dosimeter
  - ❑ Alarm functions
  - ❑ Time evolution of the exposure
  - ❑ For use in:
    - ❑ Routine RP
    - ❑ Training of medical students and staff

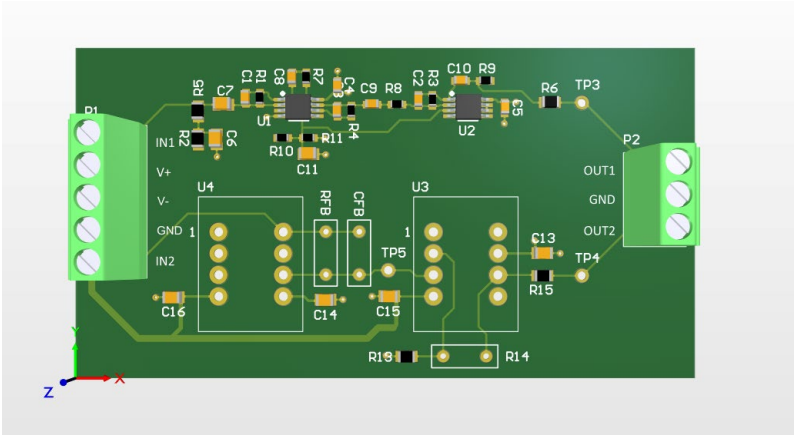
The EYEDOS project

- Main challenges
  - ❑ Dose rate varies from μSv/h up to 10^2 mSv/h
  - ❑ Energy and directional dependence of a radiation sensor generally do not meet those of the Hp(3) quantity

- Recognised standard IEC 61526

  The dosemeter response (measured/true) should vary at most from -29% to +67% when
  - ➢ The energy varies from 30 keV to 250 keV
  - ➢ The angle varies from 0° to 60°

Preliminary design



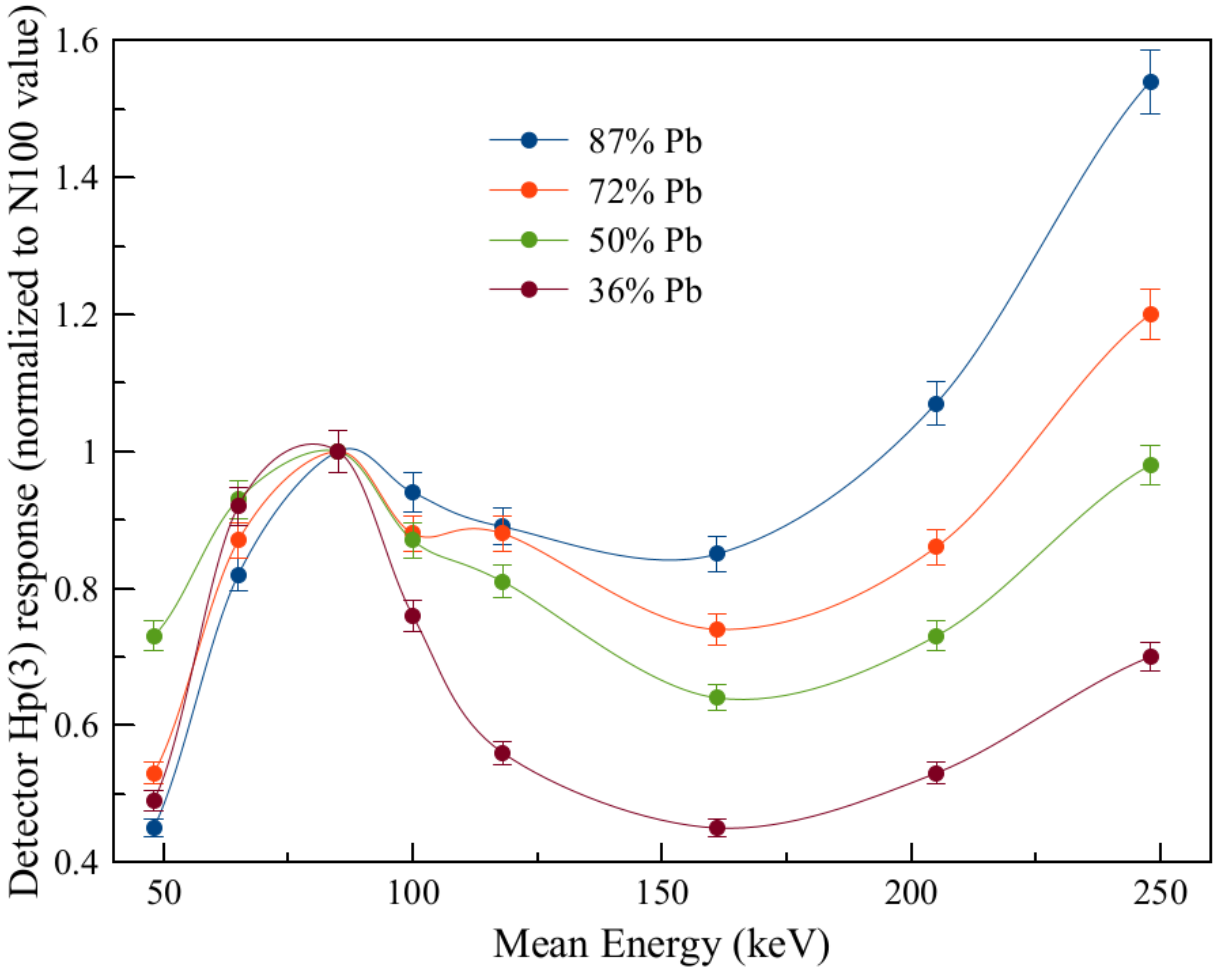
- Silicon P-i-N diodes with “shaped” lead filter
- A 2-channel custom electronics
  - Low dose rate channel: charge sensitive preamp, shaping amp, thresholding & counting
  - High dose rate channel: the radiation-induced inverse current is analysed by a low noise current amplifier
- A “frontal lamp”–type configuration

Experimental tests
Low dose rate channel

- Energy dependence of the response in terms of Hp(3)

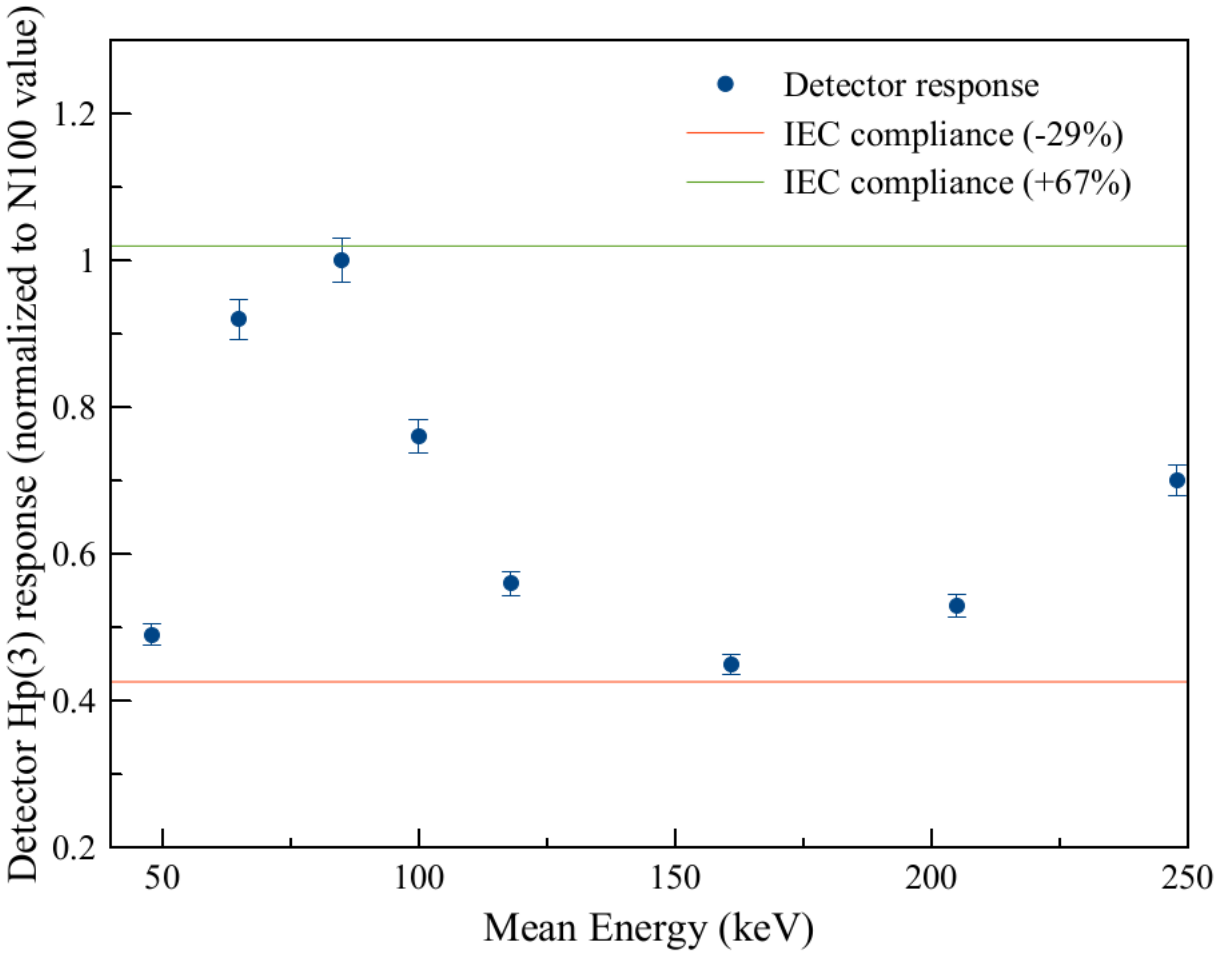
  (energy range 60 -300 keV)

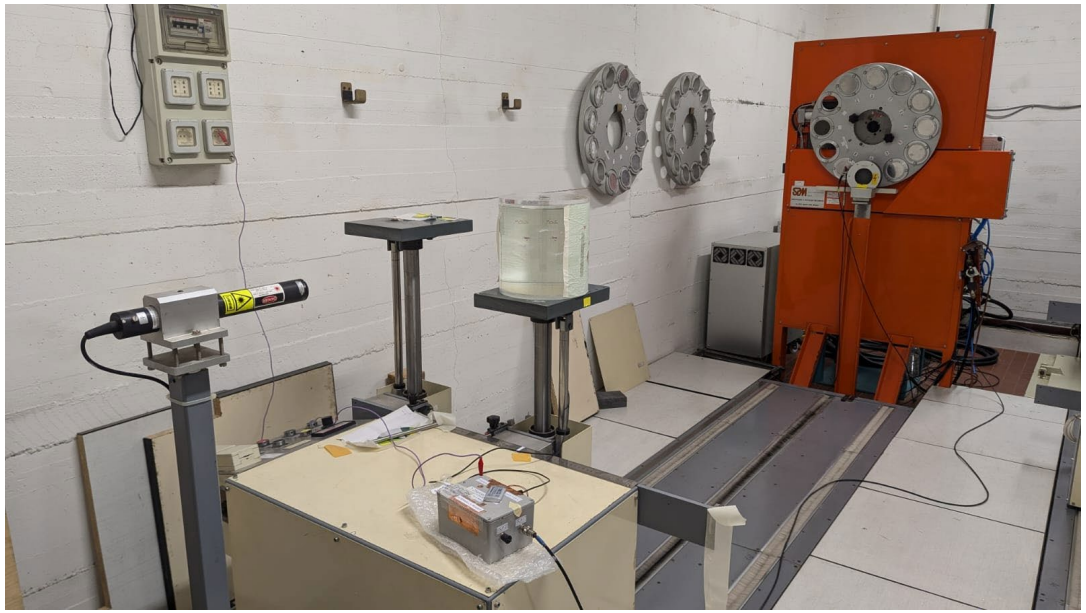
- Dosemeter exposed on a 20 cm high x 20 cm diameter water filled cylindrical phantom



Experimental tests
Low dose rate channel

- IEC compliance of the Hp(3) response

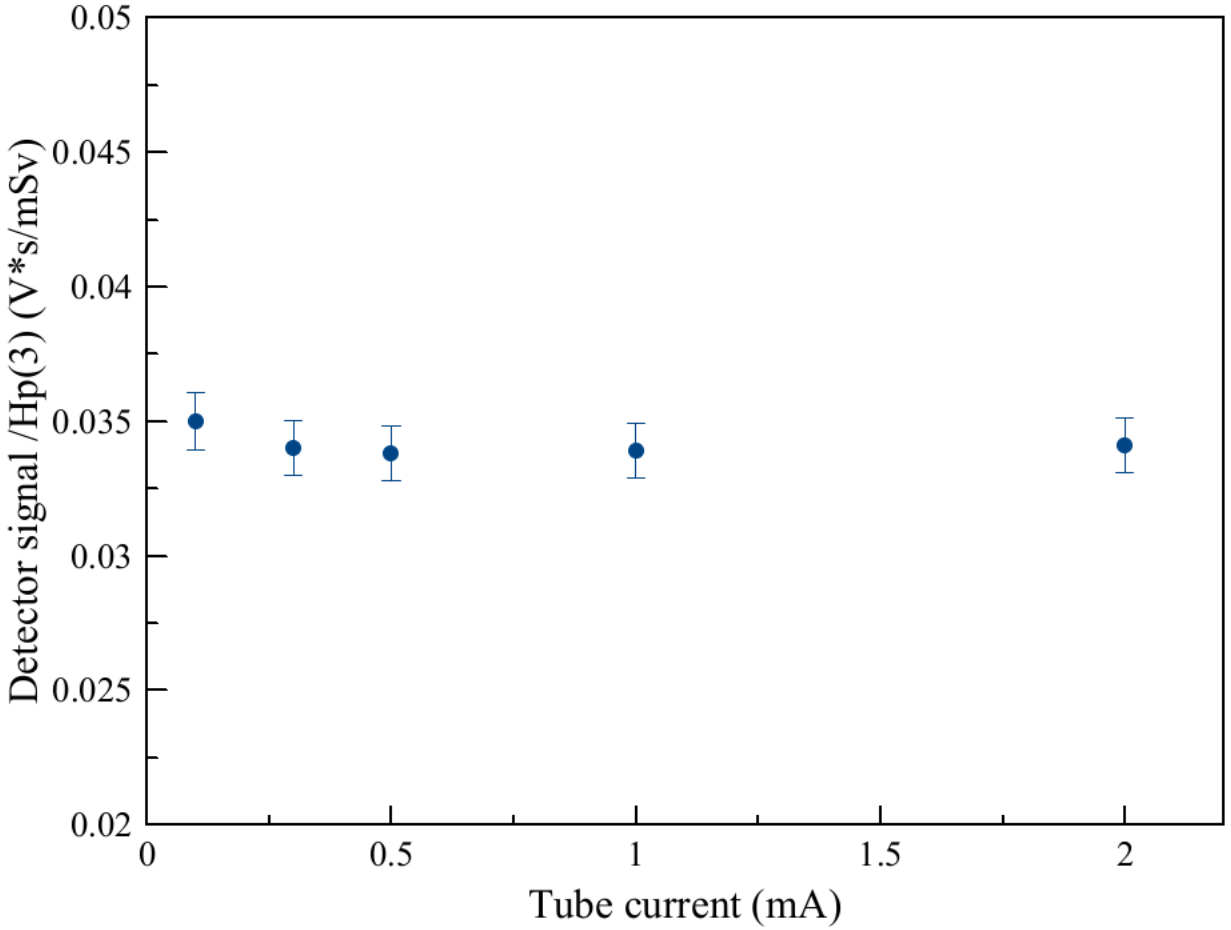




- Angular dependence of the Hp(3) response (from 0° to ±60°)
  - +/- 35% @ N60
  - +/- 30% @ N300

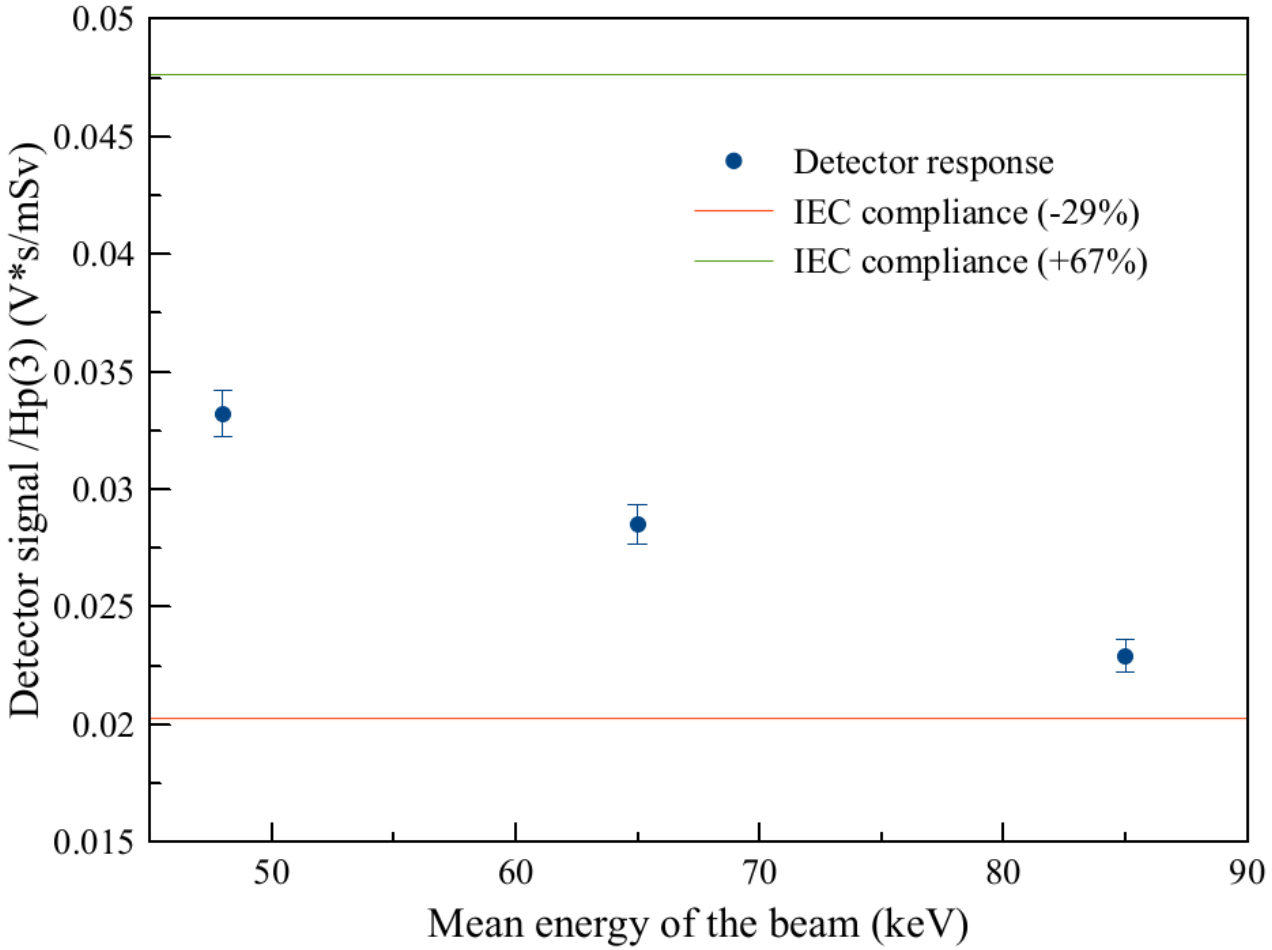
Experimental tests
High dose rate channel

- LEMRAP X-ray calibrated facility
  - Response Linearity



Experimental tests
High dose rate channel

- LEMRAP X-ray calibrated facility
  - Energy dependence of the response - IEC compliance



Conclusions

- Clinical and regulatory need for an active dosimeter for eye lens

- EYEDOS has the right features:

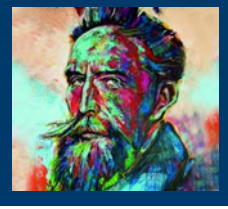
❑ Reduced energy dependence (within international standards)

❑ Linearity

❑ Able to work in an extended dose rate range (from μSv/h up to 10^2 mSv/h)

❑ Real-time dose values

❑ Alarm if a critical dose rate value is exceeded




Thank you
For your
Attention
Adobe Stock | #421999134