Implementation of a new free-air ionization chamber as a primary air kerma standard for mammography radiation qualities

**Introduction**

The PK100N is a new free-air ionization chamber standard which has been developed at the Physikalisch-Technische Bundesanstalt (PTB) for the determination of air kerma in mammography. It is designed to measure air kerma in the range of 7.5 kV to 100 kV.

**Free-Air Ionization Chambers**

- Air kerma rate $K_{air}$ at reference plane
- Measurement under charged-particle equilibrium conditions
- Well-defined measuring volume: homogeneous field (electrodes)
- High precision of aperture and electrode

$$K_{air} = \frac{W_{air}}{\varepsilon} \cdot \frac{1}{\varepsilon_i}$$

**Main Characteristics**

- Parallel-plate free-air chamber with two measuring volumes (MV)
- No potential wires crossing the beam line

**Collecting Electrodes**

- Aperture diameter 7.1, 12, 15, 20
- Air path length 32
- Collector height 0.5
- Measuring volume 6281.76
- Polarity voltage /V 1200

**Electric Field**

- Field distribution in the $y$-plane for $x=0$
- Kept constant by ring and guard electrode
- Calculated using SIMION Version 8.1
- Distortion of position of beam openings
- Correction for change in MV due to field distortion $K_{corr}$ calculated using $X_{corr}$

**Monte-Carlo Calculations**

- User code g1p1.nc of the Monte-Carlo simulation code GM245
- Calculation of correction for aperture scatter and transmission $k_{ap}$
- Attenuation $k_{att}$
- Correlation $k_{cor}$
- Scatter $k_{sca}$
- Incoherent calculations from 3 keV to 100 keV

**Uncertainty Budget**

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<th>Type A</th>
<th>Type B</th>
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<tr>
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**Comparison**

Comparison between PK100N and Pantakmex PK (cylindrical design, 20kV-300kV).

- $K_{ax}$ agreement to within 0.3%
- $K_{sd}$ agreement to within 0.5%
- $K_{sd}$ agreement to within 0.5%
- $K_{sd}$ agreement to within 0.5%

**Summary and Outlook**

A new free-air chamber for the determination of air kerma $K_{air}$ of low-energy x-rays has been developed, constructed, and ready to be used as a primary standard at PTB. The measured air kerma rates agree with PTB's other standards (PK100 and PK) to within the uncertainties. Comparisons with other international standards are planned in the near future.

**References**