Update of the CLRP dosimetric database for eye plaque brachytherapy with photon-emitting sources

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INTRODUCTION

- Eye Plaque (EP) dose evaluations traditionally follow the water-based TG43 formalism, however, ocular doses are in error by up to 90%, motivating advanced dose calculations.
- In 2008, EGSnrc BrachyDose-based version 1 of the CLRP EP database (CLRP_EPv1) was published[1] with data for 7 COMS* EPs (10-22 mm) with two radionuclides (^{103}Pd, ^{125}I).
**COMS=Collaborative Ocular Melanoma Study*

AIM

- This work presents CLRP_EPv2, a complete update of CLRP_EPv1 using EGSnrc-application egs_brachy[2].
- CLRP_EPv2 contains new 3D dose distributions for 17 EPs [8 COMS* (10-24 mm), 5 BEBIG-COMS (12-20 mm), and 4 Representative[3] EP models (16 mm)] and 3 radionuclides (^{103}Pd, ^{125}I, ^{131}Cs).
- All EP models will be freely distributed with egs_brachy[2].

METHOD

- Different dose calculation scenarios are simulated:
  i) HOMO: seeds in water with no plaque or interseed effects (TG43 conditions).
  ii) HETERO: seeds fully modelled in EPs, water phantom.
  iii) HETs*i* (BEBIG EPs only): only the *i*th seed is active at a time while all other seeds are inactive. This is repeated for all seeds to enable superposition to obtain "**HETsum**" as the sum of all HETs*i*.
- Doses calculated in (0.5 mm)^3 water voxels; EP dimensions and elemental compositions are online (with CLRP_EPv2)

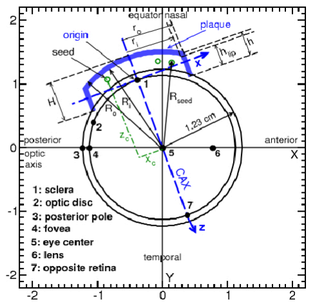

Figure 1.
EP schematic diagram shows eye coordinate system (X, Y, Z), and EP coordinate frame (x, y, z). Some organs at risk (OAR ; points #1 to #7), and plaque geometric parameters (e.g, R_i, R_o, r_i, r_o, h_{lip}, h, H), and seed coordinate (x_c, y_c, z_c) are shown.

RESULTS

- The updated database, CLRP_EPv2, offers new dose distributions for more plaque models and radionuclides, plus lower statistical uncertainties than CLRP_EPv1
- Overall, significant dose reductions for HETERO relative to HOMO doses are observed, due to the attenuation and scattering in the backing/insert material.
- CLRP_EPv2 HOMO and HETERO doses along the CAX for COMS EPs agree within 2% with BrachyDose[1], and within 5% with MCNP published results[4] (Fig. 2a).
- Doses to OARs for treatments with COMS 16 mm EPs in 8 different positions agreed within 2% (BrachyDose) and 3% (MCNP), excepting for the lacrimal gland dose for which MCNP differs by 13% (^{103}Pd), 17% (^{125}I) (Fig.2b).
- HETERO/HOMO dose ratios along the CAX for Representative EPs agreed within statistical uncertainties (up to 4.5%) with BrachyDose results[3] (Fig.2c).
- BEBIG-COMS plaques were successfully modelled for the first time; HETERO and HETsum doses agreed within statistical uncertainties of 0.8% (Fig. 3a).
- On average, the dose (normalized to the dose at z=0.5 cm) for BEBIG EP is 2% lower (z ≤ 0.5 cm) than for the same-diameter COMS EP, and beyond the tumor apex (z> 0.5 cm) doses are about 5% higher (Fig.3b). COMS and BEBIB EPs differ only in elemental composition and density (same geometry)
- HETERO/HOMO dose ratios for smaller plaque sizes are higher than for larger EPs near the plaque (Fig.3c).

FIGURES

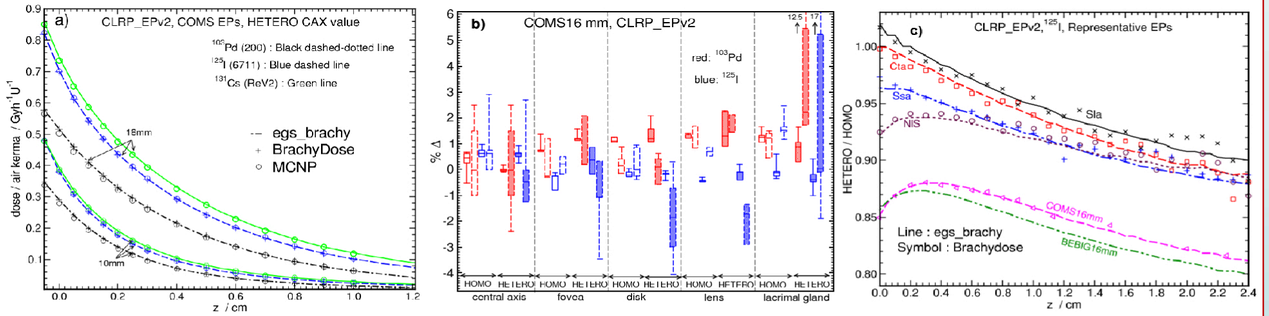

Figure 2. ***a)*** *Comparison of COMS HETERO doses along the CAX for egs_brachy with BrachyDose[1] and MCNP[4]. **b)** COMS 16 mm, Box-and-Whisker plot of the percent dose difference (%Δ) along the CAX and for some OARs in the eye (Fig1) for HOMO & HETERO between egs_brachy and BrachyDose (solid boxes), and egs_brachy and MCNP (dashed boxes). **c)** HETERO/HOMO dose ratio along the CAX with egs_brachy and BrachyDose[3] for 4 Representative EPs (Cta=COMS-thin acrylic; Sla=Short lip-acrylic; Ssa=Stainless steel-acrylic; NIS=No lip-Silastic), COMS 16mm, and BEBIG-COMS 16mm for ^{125}I seeds.*

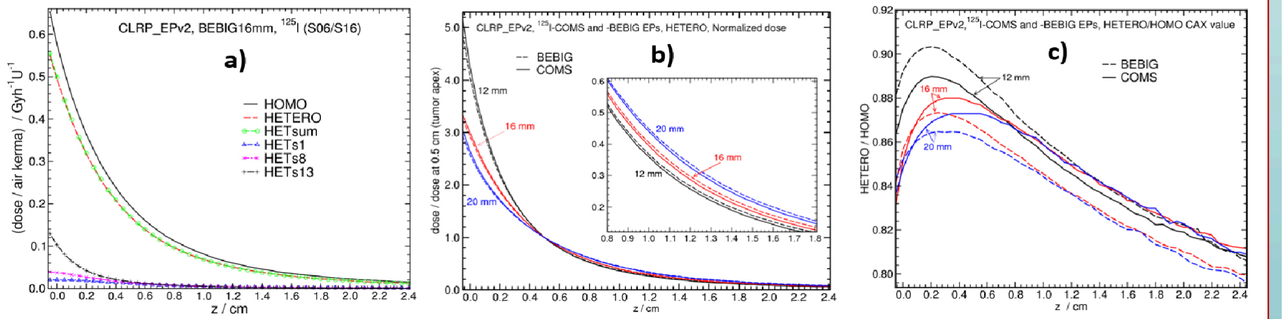

Figure 3. ***a)*** *Dose per unit seed air kerma for BEBIG 16mm EP along the CAX for scenarios indicated. Comparison of **b)** normalized doses and **c)** HETERO/HOMO dose ratios along the CAX between some BEBIG and COMS EPs. Statistical uncertainties < 0.04%.*

CONCLUSIONS

- CLRP_EPv2 database provides accurate 3D reference dose distributions and benchmarked EP models; complementing the benchmarked seed models freely distributed with egs_brachy.
- The database will be distributed at https://physics.carleton.ca/clrp/eye_plaque_v2, enabling advanced MC dose calculations for ocular brachytherapy research, dosimetry, and clinical practice. egs_brachy is freely distributed: https://physics.carleton.ca/clrp/egs_brachy; https://github.com/clrp-code/egs_brachy/

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