

ABSTRACT

This study evaluates organ and fetal doses for women undergoing mammography to assess potential risks to organs outside the primary beam.

Using an alpha version of the NCIRF dosimetry system, beam projections for conventional and tomosynthesis mammography were set up. Mammographic spectra were generated in SpekPy and added to the NCIRF library. The study used the NCI adult female phantom and a UF/NCI hybrid pregnant 38-week phantom.

Normalized to a breast dose of 3 mGy, doses to the thyroid, lungs, effective dose, uterus, and 38-week fetal dose were all below 0.5 mGy/view for CC and 0.01 mGy/view for ML. Increased CC doses were due to the absence of breast support and detector attenuation, notably in 38-week 3D CC views.

Despite conservative assumptions and neglecting detector attenuation, doses to non-imaged sensitive organs and fetus are very low. Further modeling and simulation are ongoing.

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Precision dosimetry for female organs and fetal dose estimation in mammography



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INTRODUCTION

Digital mammography and breast tomosynthesis are powerful diagnostic tools for detection of breast diseases. They are considered the gold standard in detecting breast tissue changes before they develop into cancer.

However, since it is an imaging modality that utilizes ionizing radiation, there exists some concern regarding potential exposure to other sensitive non-imaged tissues as well as fetal dose for pregnant women.

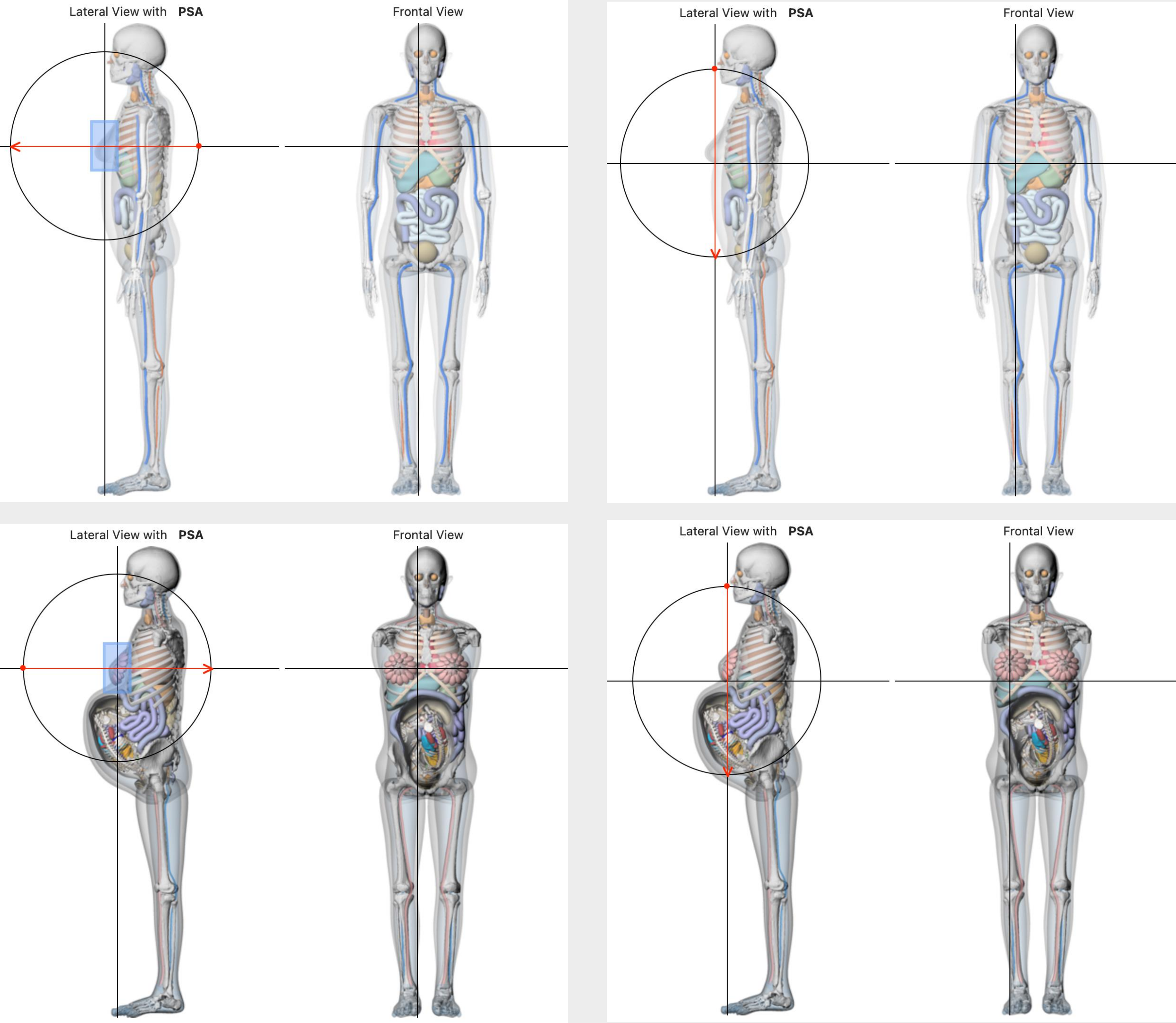
This initial study aimed to quantify these dose levels and put them in perspective.

METHODS AND MATERIALS

An alpha version of The National Cancer Institute dosimetry system for Radiography and Fluoroscopy (NCIRF) program¹ was used to setup the correct beam projections for craniocaudal (CC) and mediolateral (ML) conventional and tomosynthesis (15-degree sweep, 15 projections) mammography acquisitions.

Mammographic spectra were generated in SpekPy² (W/Rh 28 kVp @ 0.46 mm Al HVL for 2D, and W/Al 29 kVp @ 0.45 mm Al HVL for 3D) and incorporated into the NCIRF source definition library. Due to the difficulty of modeling the breast support and detector in the lattice geometry, this initial study neglects this added attenuation.

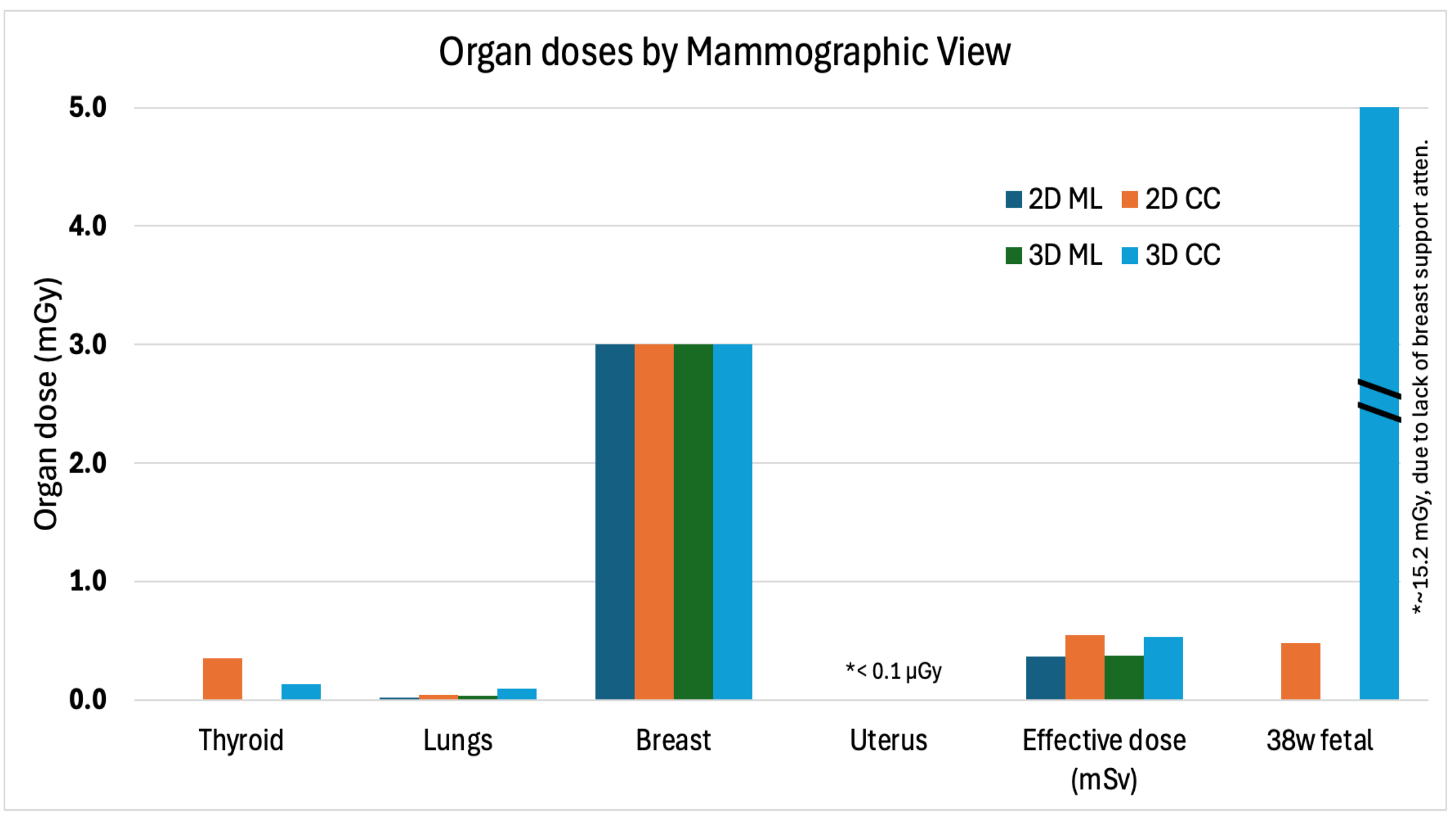
Figure 1. X-ray beam projections in common mammographic exams in the NCIRF GUI (reference female phantom, top panel; 38w GA pregnant phantom., bottom panel); mediolateral (ML) (left) and craniocaudal (CC) (right)



RESULTS

Key female adult organ and fetal organ doses were compared across the NCI adult female phantom and UF/NCI hybrid pregnant 38w in this study. When organ doses are normalized to a breast dose of 3 mGy (max expected breast dose for average breast thickness in clinical practice) female thyroid, lungs, effective dose, uterus dose (fetal dose surrogate for early pregnancy), and 38w GA fetal dose (2D) are all < 0.5 mGy/view (CC) and < 0.01 mGy/view (ML).

Figure 2. Comparison of adult female breast dose with adult thyroid, lung, uterus, effective dose and 38w GA fetal doses, normalized to 3 mGy breast dose per view

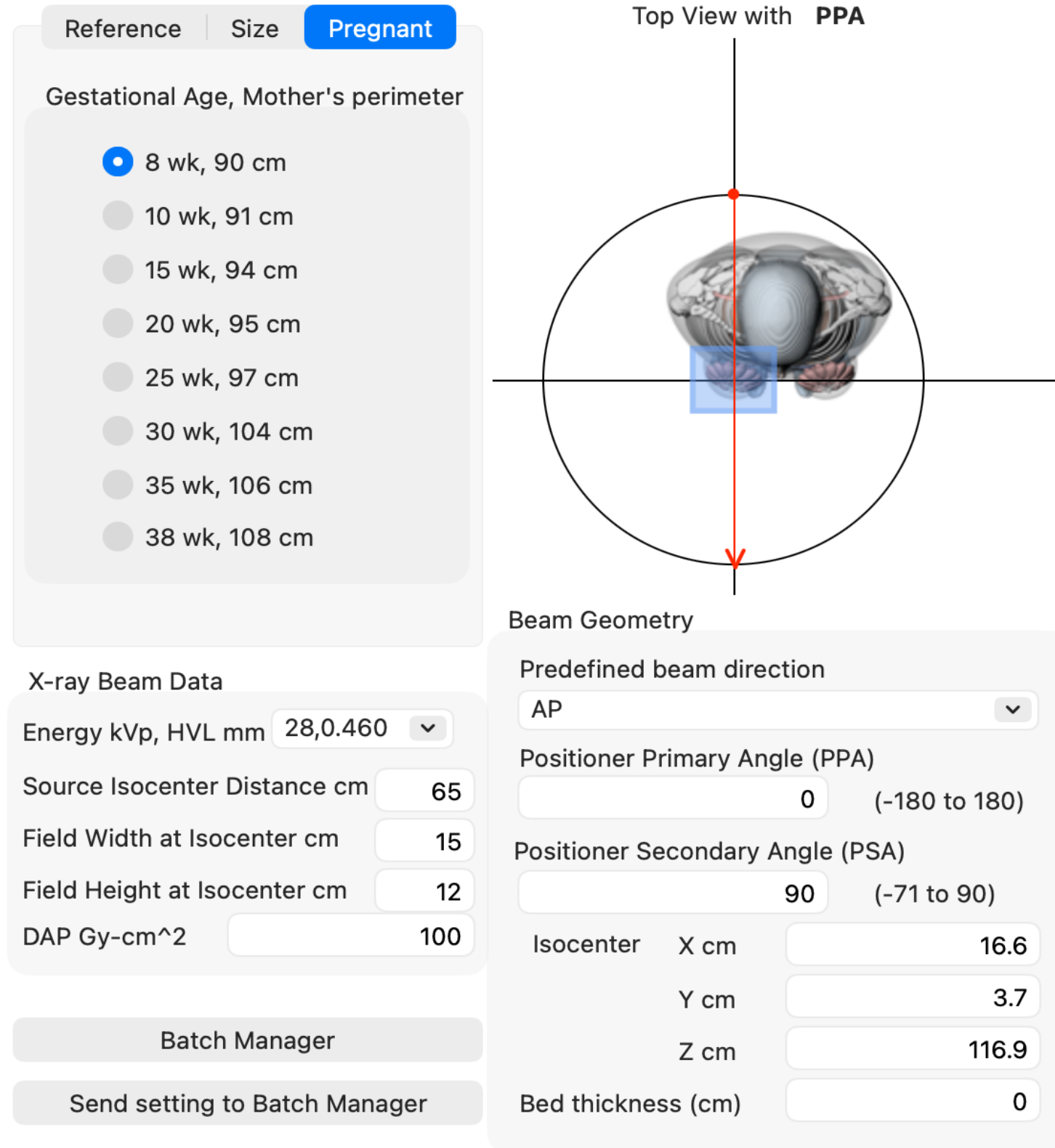


DISCUSSION

Even with the most conservative assumptions, and neglecting detector attenuation, female sensitive organ doses outside of the primary mammography imaging field and fetal doses for (early GA) pregnant women undergoing mammography are less than any level that warrants pregnancy risk (< 10 mGy, ACR-SPR Practice Parameter) discussion or patient shielding.

Increased fetal dose estimates for the CC views are an artifact of neglecting the breast support and detector, resulting in some primary beam exposure. The effects are most pronounced for 3D, due to the 15-degree arc of exposure. It will also result in some contralateral breast exposure for ML views.

Figure 3. New features of NCIRF4, including fetal models, updated spectra and increased PSA angulations



CONCLUSIONS

This work is the first to apply NCIRF to realistic mammography beam geometries and x-ray beam spectra with detailed adult and pregnant women phantoms, providing estimates of maternal organ and fetal dose.

Modeling of the breast support and detector as well as simulating the whole range of pregnant phantoms and exploring impact of breast thickness and higher energy acquisitions, like contrast enhanced digital mammography (CEDM) is in progress.

Since this initial work, NCIRF 4.20260430 has been released, which includes several new features (Figure 3), expanding the applications and exams it can be used for.

REFERENCES

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