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Auto Shielding Calculations for CT Rooms

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1. Background-Aim

- Fundamental principles of radiation biology and its effects underscore the necessity for implementing a radiation protection system. Such a system should facilitate the diverse advantageous applications of radiation while concurrently mitigating or preventing adverse radiation effects.
- Every room in which X-ray radiation is utilized must be shielded to control radiation exposure for employees and members of the public within acceptable levels.

- The purpose of this study was to develop a software to perform calculations for the shielding of CT rooms, enabling users to compute the thickness of each barrier with user-selected materials. Furthermore, this software should possess three fundamental characteristics to be fully beneficial for every medical physicist, namely:
  1) user-friendliness,
  2) reliability,
  3) speed.

2. Materials & Methods

For the operation of the software, the DLP method from NCRP Report 147 was used as a method for data processing and calculating the necessary shielding. Indicatively, the transmission B equation was used:

$$B = \left[\left(1 + \frac{\beta}{\alpha}\right) e^{\alpha\gamma x} - \frac{\beta}{\alpha}\right]^{-1/\gamma}$$

This can be transformed to calculate the thickness of the shielding material x (in mm) as:

$$x = \frac{1}{\alpha\gamma} \ln\left[\frac{\left(B^{-\gamma} + \frac{\beta}{\alpha}\right)}{\left(1 + \frac{\beta}{\alpha}\right)}\right]$$

where α, β, and γ are fitting parameters.

Additionally, the Python programming language was employed for the code, in combination with toolkits and libraries such as Tkinter and NumPy, both for the graphical user interface (GUI) and for the necessary computations.

3. Results

This is the window that opens to the user when the program is executed. The user can select the number of barriers for which they wish to calculate the required barrier thickness. Then, the user is required to input the necessary data in each tab, enabling the program to perform all necessary calculations. The data to be entered by the user includes:

- weekly Body Procedures,
- weekly Head Procedures,
- the distance between the point to be shielded and the CT Unit isocenter in meters,
- the corresponding DLP value for body and DLP value for head provided by the manufacturer for the specific CT scanner,
- the kVp value to be utilized,
- the Shielding Design Goal in air kerma in mGy/week and finally,
- the material preference for the desired shielding (either lead or concrete).

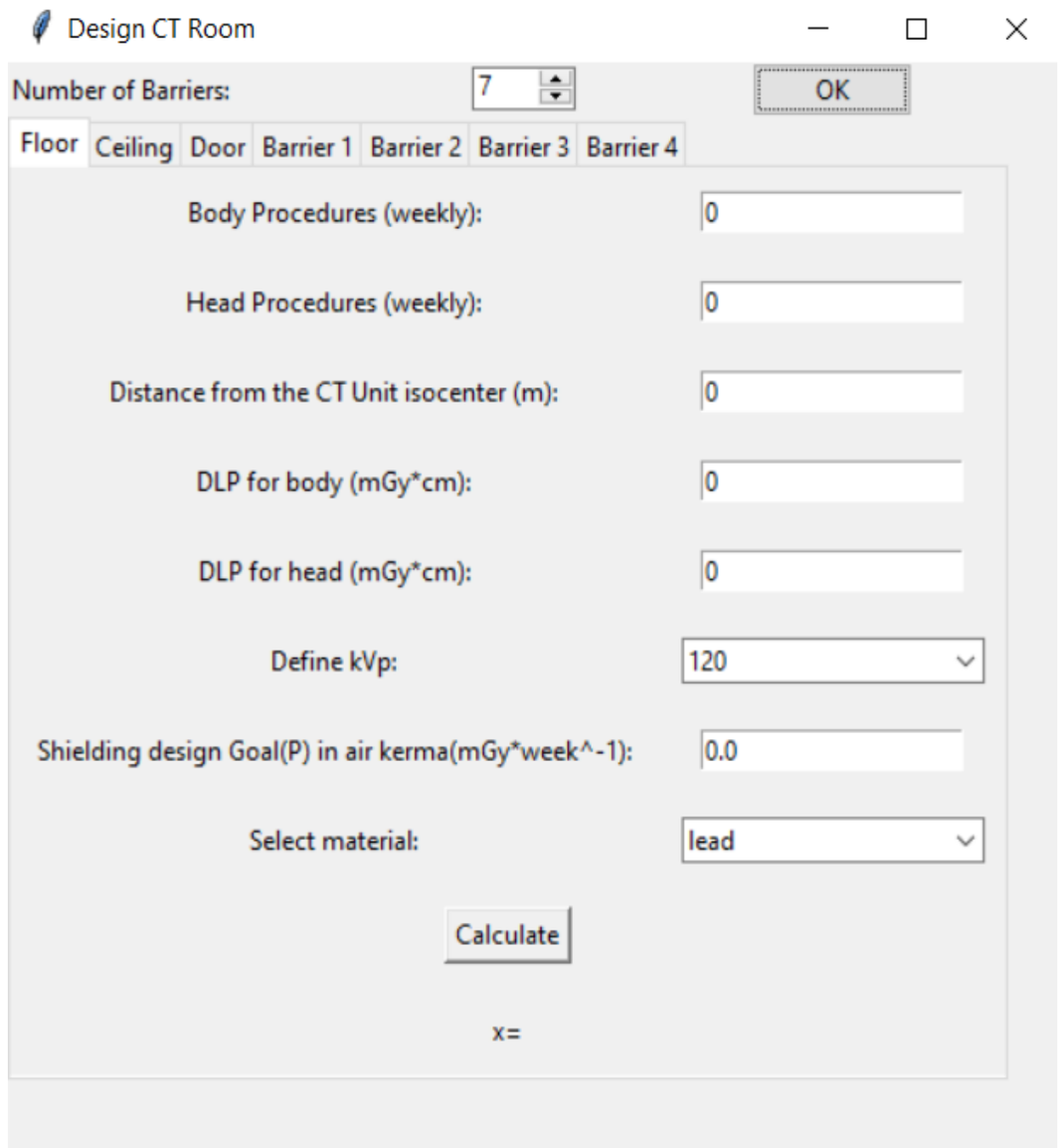

Figure 1: The GUI of the software.

3. Results

Once the user inputs all this data, they can proceed to press the Calculate button. The program will then compute the required lead or concrete shielding in millimeters for the initially selected barrier. This process continues for the remaining barriers by selecting the corresponding tab at the top of the window.

Validation example 5.6.1 from NCRP Report 147:
Body Procedures: 150
Head Procedures: 30
Distance: 3 m
DLP for body: 550 mGy*cm
DLP for head: 1200 mGy*cm
kVp: 120 Hz
Shielding design Goal: 0.02 mGy/week
Material: Lead

Both Example 5.6.1 from NCRP Report 147 and the software, calculate the same necessary shielding, which is **1.5 mm** of lead with precision to one decimal place.

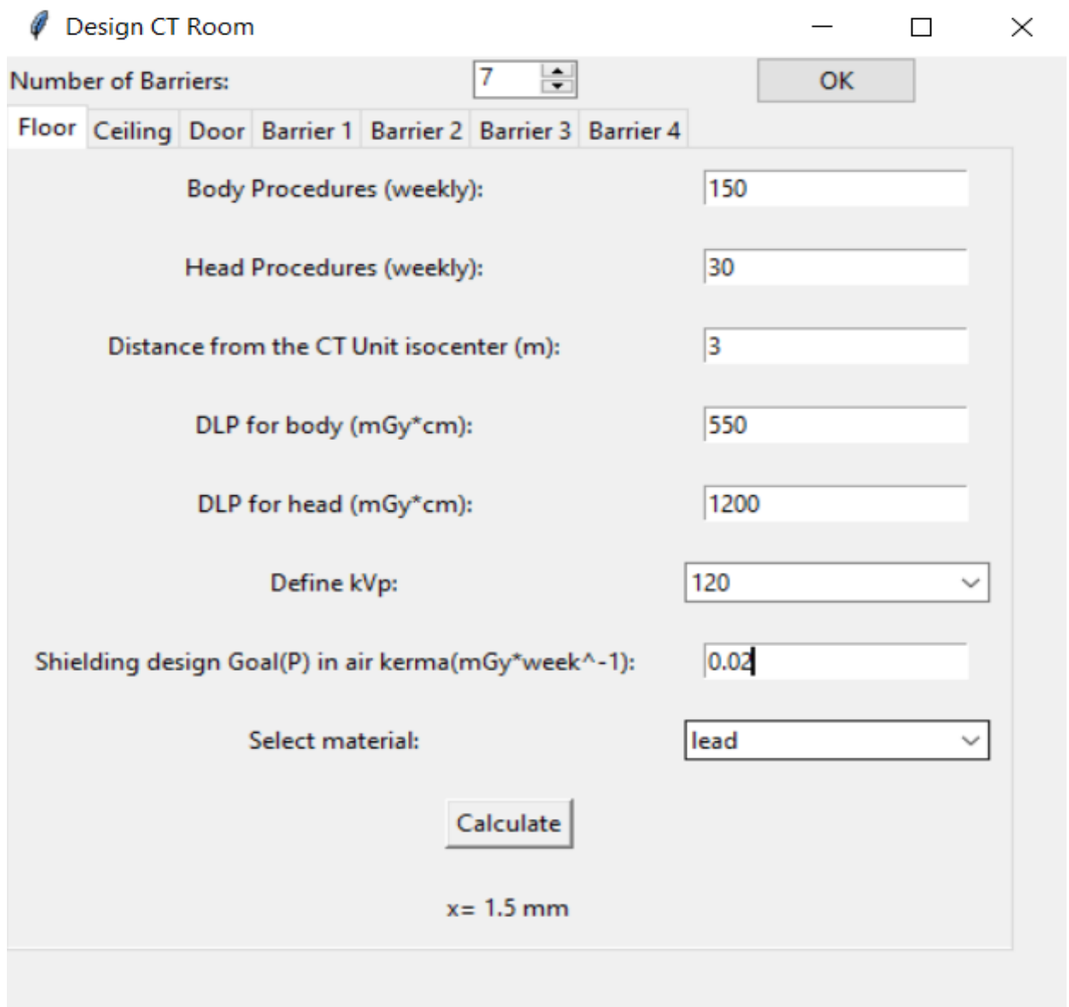

Figure 2: Operation of the software in Example 5.6.1 "Dose-Length Product Method" of NCRP Report 147.

4. Conclusions

The software is designed to assist medical physicists and other professionals in radiation protection with shielding of CT Rooms. Additionally, it may serve as an educational tool for students aspiring to specialize in radiation protection.

In most typical scenarios, the program functions satisfactorily and provides a comprehensive report detailing the necessary thickness of each material chosen by the user through the graphical user interface (GUI) for every barrier within a room.

Limitations:

- Only two materials (lead, concrete) can be selected.
- According to NCRP Report 147, we assume that 40% of the procedures are performed with and without contrast media.

Future Work:

- The limitations mentioned above, could be solved in future updates.
- This program could be integrated with other software programs to calculate the necessary shielding requirements for all spaces utilizing X-Rays, such as Radiology Departments and Radiation Therapy Departments.

5. References

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