PregDose: Protocol and Software Structure

Neutron Dose Estimation in Proton Therapy

Developed as part of the SONORA Project
Grant Agreement No. 101061037

July 25, 2025

1 Purpose

PregDose is a clinical tool intended for recalculating proton therapy plans for pregnant patients and estimate neutron equivalent dose to the fetus. It converts DICOM-based treatment planning data into input-files for the TOPAS Monte Carlo simulation tool [1], with the intend to provide clinicians quantitative radiation safety parameters to aid in the treatment planning process.

2 Installation

The software tool can be installed from the GitHub repository directly `https://github.com/Eurados/pregdos` or as a Docker container at XXXX. When installing it from GitHub do:

```
git clone https://github.com/Eurados/pregdos
cd pregdose
python3 -m venv .venv
source .venv/bin/activate
pip install -e .
```

When prompted, select "yes" to install all options.

2.1 System Requirements

- Python ≥ 3.8
- TOPAS (installed and configured)
- Python packages: `pydicom`, etc. (see `setup.py`)

3 Input Requirements

The input directory (`study_dir`) must include the following set of files:

Description	**Format**
DICOM image data	CT`*.dcm`
RTSTRUCT (structure set)	RS`*.dcm`
RTPLAN (treatment plan)	RN`*.dcm`
RTDOSE (TPS dose)	RD`*.dcm`

Here the RTDOSE file can be omitted, but is recommended as the simulations also generate dose files for verifying with the plans from the TPS. The RS structure set, needs to include a structure with the name "fetus" such that relevant neutron specific quantities can be scored correctly.

Besides the required files it is recommended to include additional machine specific information to ensure the most reliable results. These include a beam model, CT or SPR to material conversion and the distance in which the beam model is defined from. Below you find a table on how to includes this in the program and examples of files/values with can be found in the GitHub repository.

Flag	**Description**	**Example**
`-b / --beam-model`	Beam model CSV	`DCPT_beam_model__v2.csv`
`-s / --spr-to-material`	SPR to material table	`SPRtoMaterial__Brain.txt`
`-p / --beam-model-position`	Beam model distance to isocenter (mm)	`500.0`

4 Usage Example

If you have installed PregDos through the GitHub page, you can try the example below to get experince with the program. Note that all necessary files are included in the GitHub repository.

```
PYTHONPATH=. python3 pregdos/main.py \
  -v \
  -b=res/beam_models/DCPT_beam_model__v2.csv \
  -p 500.0 \
  -s=res/spr_tables/SPRtoMaterial__Brain.txt \
  res/test_studies/DCPT_headphantom/
```

This the example plan is a three field plan, the program generates and runs three simulations, one for each field.

- `topas_field1.txt`
- `topas_field2.txt`
- `topas_field3.txt`

These files can be modified by the user prior to running, if needed.

5 Output

PregDose produces one TOPAS input file per treatment field, including:

- Voxelized CT geometry
- Structure definitions (e.g. fetus ROI)
- Field and beam configuration

PregDose reads RTDOSE (TPS dose grids) to allow for Monte Carlo vs TPS dose comparison. This supports:

- QA for simulation accuracy
- Clinical research into fetal dose metrics

6 Command-Line Options

```
usage: main.py [-h] [-b BM] [-s SPR_TO_MATERIAL_PATH] [-p BEAM_MODEL_POSITION]
               [-f FIELD_NR] [-N NSTAT] [-v] [-V]
               study_dir [output_base_path]
```

Option	Required	Description
`study_dir`	Yes	Path to input folder (CT, RS, RN, RD)
`output_base_path`	No	Output base name (default: `topas.txt`)
`-b` / `--beam-model`	Yes	Beam model CSV file
`-s` / `--spr-to-material`	Yes	SPR-to-material mapping file
`-p` / `--beam-model-position`	No	Beam model position (mm)
`-f` / `--field`	No	Export only a single field
`-N` / `--nstat`	No	Number of primary protons
`-v`	No	Verbose output
`-V`	No	Show version and exit

7 Internal Module Structure

Module	Functionality
`pregdos/main.py`	CLI parsing and main execution logic
`import_rtstruct.py`	Handles RTSTRUCT parsing, extracts ROIs
`import_rtplan.py`	Parses RTPLAN and beam geometry
`export_study_topas.py`	Converts study data to TOPAS geometry files
`utils/`	Shared utilities and helpers

8 Licensing and Acknowledgements

This project is part of the **SONORA** initiative, funded by:

> *The European Union's EURATOM research and innovation programme under Grant Agreement No. 101061037 (PIANOFORTE – European Partnership for Radiation Protection Research).*

9 Planned Features

- GPU-accelerated simulation integration
- Automated fetus detection and scoring
- 3D visualization of dose volumes
- GUI-based front-end for clinical researchers

References

[1] J. Perl, J. Shin, J. Schümann, B. Faddegon, and H. Paganetti, "TOPAS: an innovative proton Monte Carlo platform for research and clinical applications," *Medical Physics*, vol. 39, no. 11, pp. 6818–6837, 2012. Publisher: Wiley Online Library.