# PregDose: Protocol and Software Structure
## Neutron Dose Estimation in Proton Therapy

Developed as part of the SONORA Project
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## 1 Purpose

**PregDose** is a clinical tool designed to estimate neutron equivalent dose to the fetus during proton therapy. It converts DICOM-based treatment planning data into input scripts for TOPAS Monte Carlo simulations [1], supporting accurate field-level neutron dose estimation.

## 2 Overview

PregDose:
- Parses a full DICOM treatment study including CT, RTSTRUCT, RTPLAN, and RTDOSE.

- Uses external beam model and SPR-to-material tables.

- Outputs TOPAS-compatible input files for dose simulation.

- Supports field-specific geometry generation and dose verification.

## 3 System Requirements

- Python $\geq 3.8$

- TOPAS (installed and configured)

- Python packages: `pydicom`, etc. (see `setup.py`)

## 4 Installation

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

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

# 5 Input Requirements

The input directory (`study_dir`) must include:

| Type | Description | Format |
|------|-------------|--------|
| CT Series | DICOM image data | CT*.dcm |
| RS File | RTSTRUCT (structure set) | RS*.dcm |
| RN File | RTPLAN (treatment plan) | RN*.dcm |
| RD File | RTDOSE (TPS dose) | RD*.dcm |

Additional required files:

| Parameter | 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 |

# 6 Usage Example

```
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/
```

Generates:

- `topas_field1.txt`

- `topas_field2.txt`

- `topas_field3.txt`

# 7 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 |

## 8   Output

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

- Voxelized CT geometry

- Structure definitions (e.g. fetus ROI)

- Field and beam configuration

## 9   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 |

## 10   Dose Verification

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

## 11   Fetus ROI Scoring

Ensure the fetus ROI is properly defined in the RTSTRUCT file. PregDose will:

- Isolate the ROI using contour data

- Define a scoring volume for neutron dose estimation

## 12   Licensing and Acknowledgements

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## 13   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.