

Introduction and overview of MMCTP

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Layout

- 1 pre-MMCTP
- 2 MMCTP
 - Background
 - Current use at McGill
 - McGill RT Format
- 3 Research Software



Why use MC?

What is the effect of more accurate MC dose distributions on patient clinical outcome?

- Need to investigate the correlation of MC calculated dose distributions with clinical outcome (tumor control and normal tissue toxicity)
 - 2003 De Jaeger *et al* demonstrated that the calculated incidence of radiation pneumonitis correlated better with observed incidence when using more accurate dose calculations
- 2006 Siebers *et al* investigated the use of more accurate dose calculations in IMRT optimization (DPEs and OCEs)



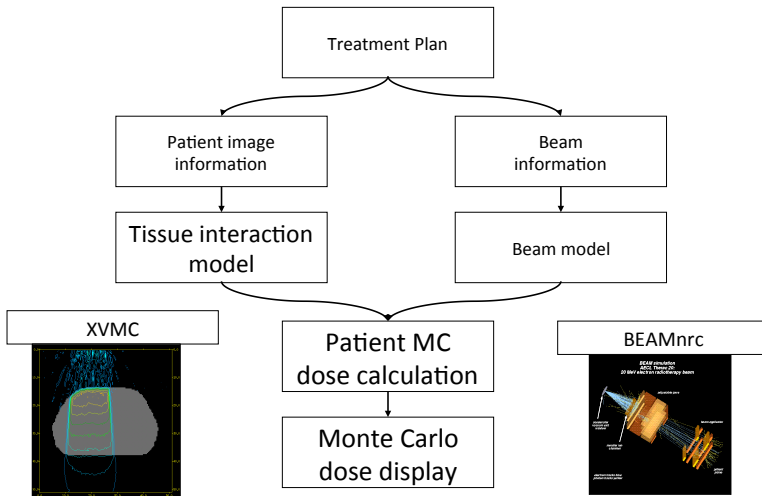
What do you gain from MC?

Clinical TPS are a black box

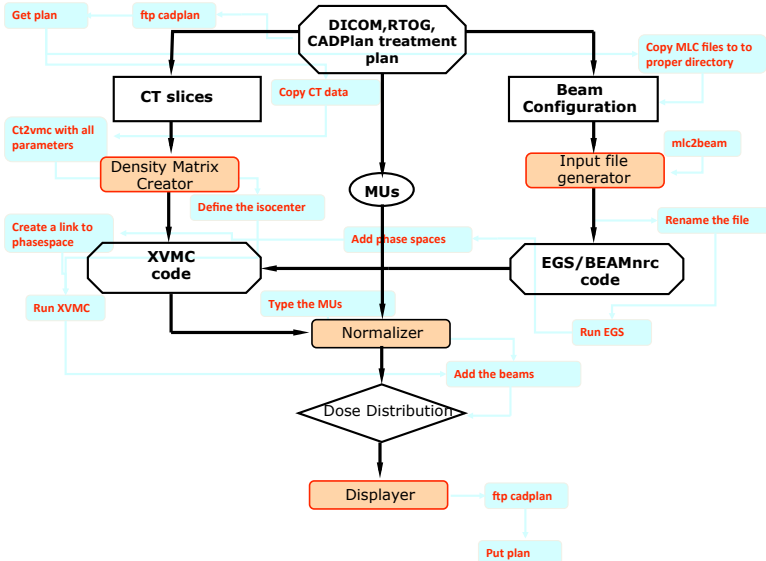
- Research MC codes are fully customizable
- Model detectors
- Model high Z materials in patient
- Model small fields
- Investigate beam vs patient transport differences



Monte Carlo Treatment Planning at McGill



CADPlan MCTP at McGill



Why build MMCTP

- Electron and photon Monte Carlo treatment planning system
- Establish large-scale retrospective studies
- Dose comparison tools
- Combine research projects under one platform



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MMCTP

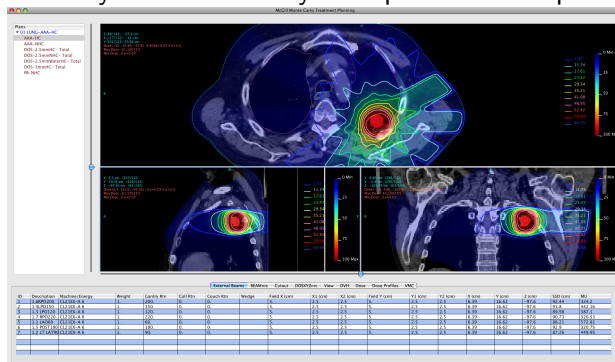
“BEAMnrc without MMCTP is just uncivilized”

Ellis Mitrou



What is MMCTP?

A full feature treatment planning system that uses various Monte Carlo calculation systems as dose calculation engines which run remotely on one or many multiprocessor computers.



<http://www.medphys.mcgill.ca/~mmctp/MMCTP/Welcome.html>

Alexander et al, Phys. Med. Biol., 2007



MMCTP Features

- 1 Import DICOM RT, RTOG, CADPlan CART
- 2 Export RTOG, DICOM RT Dose
- 3 Visualization options 2D, 3D, images, structures, doses
- 4 Edit treatment planning settings
- 5 Monte Carlo links to BEAMnrc, DOSXYZnrc, Cutout, XVMC
- 6 Dose analysis tools
- 7 Available for MAC, Linux, Windows platforms



What's so special about MMCTP?

This brings the power of customizable MC codes to the fingertips of clinical physicists, researchers and dosimetrists.

- Dose calculations are fully automated by logic scripts which determine when and where to submit MC simulations
 - 1 Local computer or departmental cluster
 - 2 Cloud or remote clusters (West grid, CLUMEQ)



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- Beam commissioning tools for profiles, PDDs, output tables

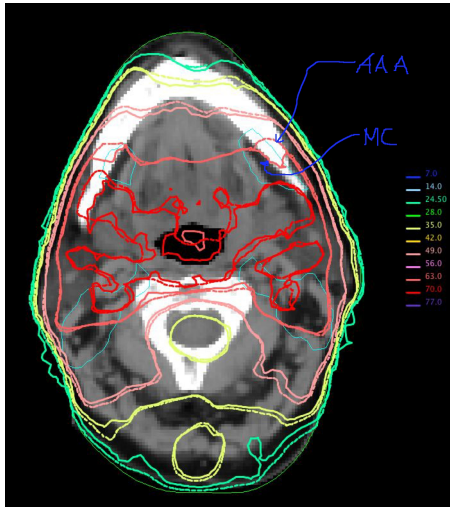


MMCTP Projects at McGill

- 1 Modeling lung toxicity outcome with MC
- 2 Medulloblastoma MC recalculation
- 3 Tomotherapy DQA and patient recalculation
- 4 IMRT QA verification
- 5 Energy and intensity modulated electron therapy (MERT,IMET)
- 6 Clinical MMCTP station
 - MapCHECKTM
 - Head and neck IMRT recalculations
 - SBRT lung MC recalculation



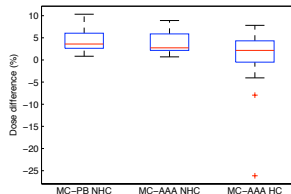
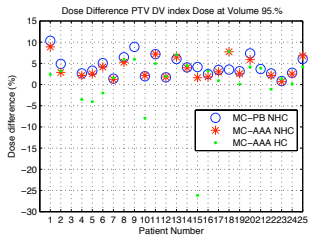
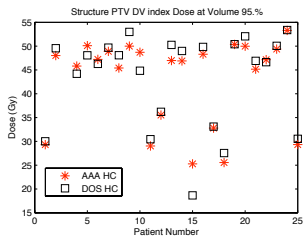
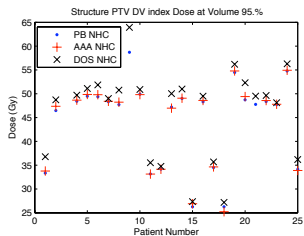
Head and Neck MC recalculation



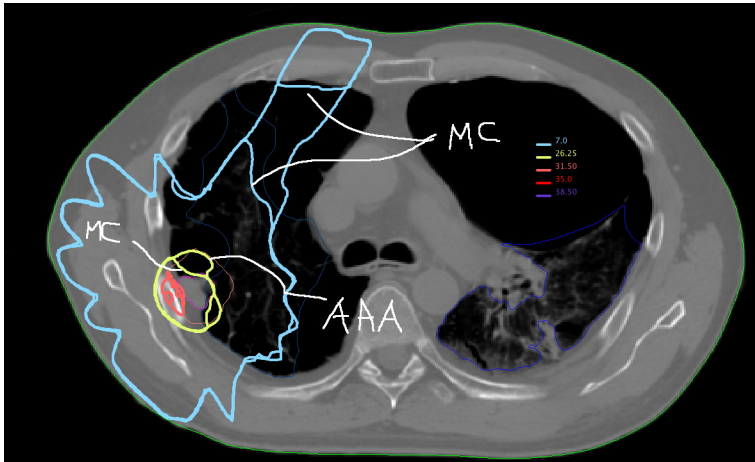
AAA (dashed lines) and MC (solid lines). The PTV60, shown in light blue color, is surrounded by regions of high and low density materials. The MC 63 Gy isodose line deviates from the AAA isodose line in the top right corner. The deviation is believed to be caused by the high density mandible bone adjacent to the PTV60 structure.



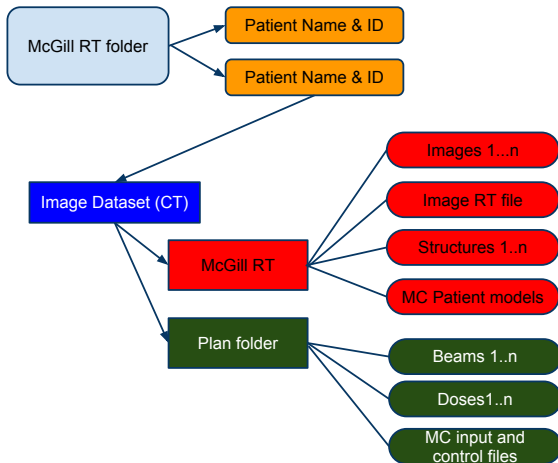
Lung SBRT MC recalculation



Lung SBRT MC recalculation on patient 15 with bullous lung disease



McGill RT Format



- Minimize redundant information
- Minimize number of files edited for save changes
- Use binary or text files when appropriate



Image files

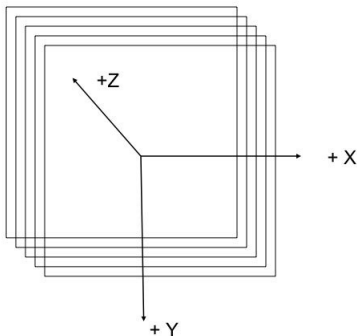
- Image files are named sequentially with the file type as **.img*
- Files are binary, containing a slice Z position and the pixel data
- Image properties text file *RT.dir* stores header info

Table: *RT.dir* file

Patient Name	:= (string)
Patient ID	:= (integer)
IMAGE MODALITY	:= (string)
IMAGE TYPE	:= (string)
SCAN TYPE	:= (string)
CT offset	:= (integer)
Grid unit width	:= (double)
Grid unit height	:= (double)
Number representation	:= (string)
Bytes per pixel	:= (integer)
Size of Dimensions 1	:= (integer)
Size of Dimensions 2	:= (integer)
X offset	:= (integer)
Y offset	:= (integer)
CT-AIR	:= (integer)
CT-WATER	:= (integer)
Slice thickness	:= (cm)
Date	:= (string)
WINDOW LEVEL	:= (integer)
WINDOW WIDTH	:= (integer)



McGill RT coordinate system



- 1st (X, Y) coordinate defines the center of the top right corner pixel
- Z increase into the page
- 1st coordinate Z is the lowest slice



Structure files

- Sequence of three-dimensional coordinates
- Files are text, type **.struct*
- Coordinates are grouped together in Z planes, which coincide with planes on the CT image

Table: Structure file

STRUCTURE NAME	:= PTV2
NUMBER REPRESENTATION	:= CHARACTER
STRUCTURE FORMAT	:= SCAN-BASED
STRUCTURE COLOUR RGB	:= 252/18/41
NUMBER OF SCANS	:= 3
"NUMBER OF LEVELS" 3	(total number of scans)
"SCAN NUMBER" 1	(=1 for first scan, etc)
"# OF SEGMENTS" 0	(number of segments in this level/scan)
"SCAN NUMBER" 2	
"# OF SEGMENTS" 1	
"# OF POINTS" 4	(number of points in first segment)
0, 1.459, 20.86305	(X, Y, Z coordinates of each point)
-0.56, 1.387, 20.86305	
-0.776, 1.387, 20.86305	
-0.848, 1.315, 20.86305	
"SCAN NUMBER" 3	
"# OF SEGMENTS" 0	



Beam files

- Defines an external beam
- Files are text, type **.Beam*
- Two subfiles
 - MLC
 - Collimator

Table: Beam file

BEAM #	:= (beam number in plan)
TREATMENT UNIT	:= (treatment unit name ex CL21EXA)
BEAM MODALITY	:= (electron, photon)
BEAM ENERGY	:= (energy ex 18 MV)
BEAM APPLICATOR	:= (for electrons only)
BEAM DESCRIPTION	:= (text description of beam)
RX DOSE PER TX (GY)	:= (fraction dose)
MUs	:= (number of MUs)
NUMBER OF TX	:= (number of fractions)
FRACTION GROUP ID	:= (id to group beams of common fraction)
BEAM TYPE	:= (static or arc)
COLLIMATOR TYPE	:= (symmetric or asymmetric)
APERTURE TYPE	:= (block or MLC)
WEDGE ANGLE	:= (wedge angle in degrees ex 15)
WEDGE ORIENTATION	:= (wedge orientation ex in,out,left,right)
WEDGE DYNAMIC	:= (dynamic wedge boolean ex true/false)
COLLIMATOR ANGLE	:= (angle in degrees)
GANTRY ANGLE	:= (angle in degrees)
COUCH ANGLE	:= (angle in degrees)
NOMINAL ISOCENTER DIST	:= (isocentre distance in cm)
NUMBER REPRESENTATION	:= (character)
PLAN ID OF ORIGIN	:= (plan ID of beam for grouping beams)

MLC files

- Defines an MLC pattern for one beam
- Files are text, type **.MLC*
- $index(i) - index(i-1)$ is the probability of field i

Table: MLC file

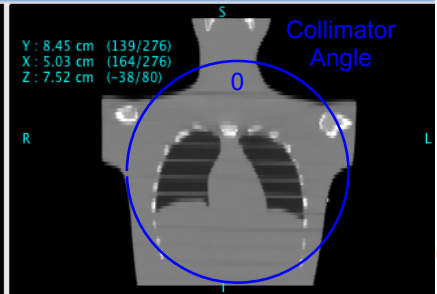
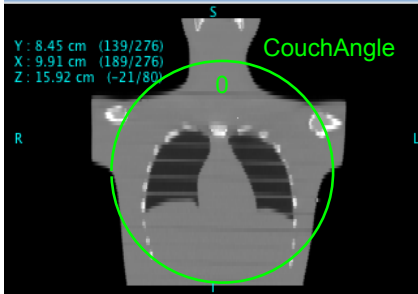
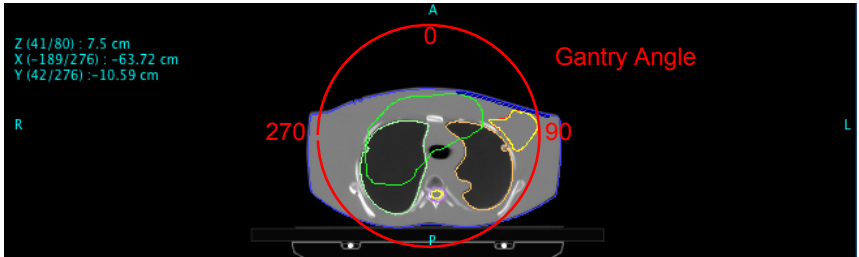
Treatment	:= STATIC
Number of Fields	:= 1
Tolerance	:=
ModelName	:= Varian 120M
ModelType	:= 0
LeafDirection	:= 0

Field	:= 1
Index	:= 100.
Carriage Group	:=
Operator	:=
Collimator	:=
Leaf 1A	:= 0.
Leaf 2A	:= 0.
Leaf 3A	:= 0.
Leaf 4A	:= 0.
Leaf 5A	:= 0.
Leaf 6A	:= 1.089
Leaf 7A	:= 1.785
Leaf 8A	:= 2.164
Leaf 9A	:= 2.384
Leaf 10A	:= 2.487

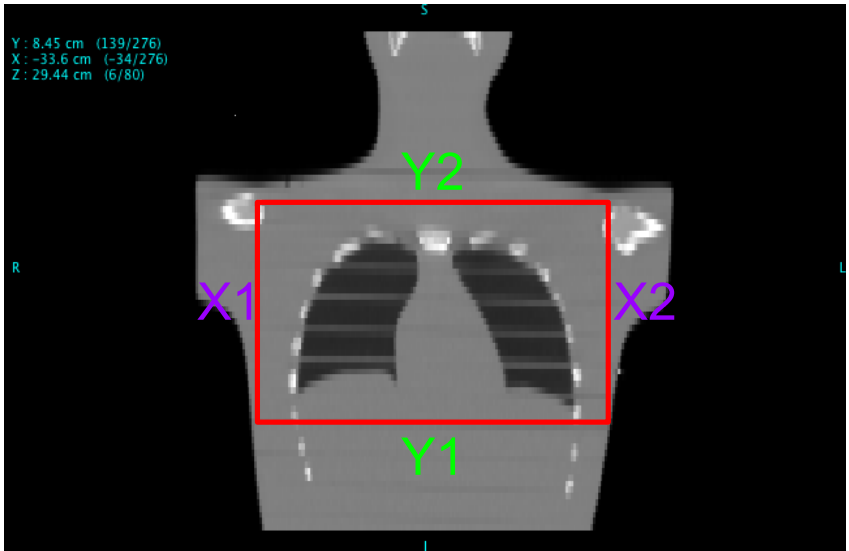
...



Beam angles



Beam jaws



Dose Distribution files

- Sequence of 2D dose planes x, y
- Files are binary, type **.Dose*
- 100 byte header, 4 byte single per dose point
- Additional sequence of uncertainty values

Table: Dose Distribution file

Coordinate X 1st point	:= (cm)
Coordinate Y 1st point	:= (cm)
Coordinate Z 1st point	:= (cm)
Size of Dimension 1	:= (# horizontal points)
Size of Dimension 2	:= (# vertical points)
Size of Dimension 3	:= (# planes)
Horizontal Grid	:= (cm >0)
Vertical Grid	:= (cm >0)
Depth Grid	:= (cm >0)
Dmax	:= (Gy)
Dmin	:= (Gy)
Dose Units	:= (string)



MC control files

- These files keep a record of what has been done and what needs to be done
- per plan, 1 BEAMnrc file and a DOSXYZnrc and XVMC file per patient model
- Each file stores the location of the simulation, progress, CPU time, normalization values etc...
- All input files are stored within the plan file; this keeps a local record of the simulation
- Input files are named by the patient ID # followed by plan # and beam #, ex: 34392_p01b3.egsinp



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MMCTP License

- The Software is licensed as is.
- There are no warranties, whether express or implied, and McGill disclaims all warranties of merchantability and fitness for a particular purpose, and any other warranty implied at law or in equity. McGill makes no representations regarding the use or the results of use of the Software and/or Documentation in terms of corrections, accuracy, reliability, or otherwise.
- Use this Software at your own risk
- The Software is in constant development and there is a non-zero probability that the user will encounter errors.



MMCTP Sites

- Home page `http://www.medphys.mcgill.ca/~mmctp/MMCTP/Welcome.html`
- User google group page
`http://groups.google.com/group/mmctp`
- MMCTP distribution page `http://www.medphys.mcgill.ca/~mmctp/MMCTP/MMCTPDis`

