TOPAS

Tool for Particle Simulation

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TOPAS
TOol for PArticle Simulation

Model nozzle
Import patient CT
Transport in an all particle code
Score dose, fluence, etc.
Save/Replay Phase space
Advanced graphics

Fully 4D:
- moving parts of nozzle,
- beam current modulation,
- time-varying fields for beam scanning, etc,
- patient motion

Why TOPAS

While Monte Carlo particle transport has proven useful for design of nozzles, scanning, shielding, treatment planning,... fully flexible MC codes have been too hard to learn.

Learning process wastes staff time, incorrect or outdated habits are passed from user to user, new users make many mistakes

Solution: a purpose-built proton therapy MC simulation tool. Layered cleanly on top of an already established general purpose MC (as BEAMnrc and DOSxyz are layered on top of EGSnrc for e- & photon).

We start from Geant4, whose accuracy has already been shown, and whose flexibility is unmatched. We then make it easier to use for particle therapy and make it harder to make mistakes.
Who is TOPAS
Aims

Build TOPAS
Validate
Speed Up
Distribute

Currently at Yr 1.75 of a 4 year R01

Built the basics and Validated at our own proton centers.
Why Talk Now

Our project plan depends on early and frequent feedback.

TOPAS is for all of you: Researchers, Clinicians, Engineers, Vendors.

Your feedback will help us make sure the architecture encompasses all of your needs.
Parameters System

Users configure everything about their simulation:
Geometry (nozzle, patient, dosimetry or imaging components)
Particle Sources
Physics
Scoring
Graphics
Time Features
from a set of simple yet powerful files we call the Parameters System.

Handle a wide variety of particle therapy simulations with no required knowledge of Geant4 or programming languages

Mindful of the way scientists really work.
Makes it easy to hold many parameters constant while you vary just one or two.
Geometry

Simple Components

Specialized Components
compensator
aperture
range mod wheel
wire chamber
propeller
magnet
patient

Or make your own

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TOPAS Tool for Particle Simulation
J. Perl
Particle Sources

Parameterized source

Phase Space Input (IAEA plus extensions)

Later will even include Brachytherapy seeds
Physics

Defaults to standard best Geant4 physics as already validated at MGH.

But can exploit the full rich physics of Geant4.

We are cleanly layered on top of Geant4.  
Ease of use, but no restrictions on Geant4’s inherent flexibility.
Scoring

Dose, Fluence, Surface Current, etc. All with statistical information.

Phase Space Output (IAEA plus extensions)
Wide range of graphics options from Geant4.

Again all the same nice filtering.

gMocren, from the PTSim collaboration.
Time Features

Consistent, comprehensive handling of all time-dependent quantities.

Motion
Modulation
Fields
Scoring
4D Patient
Sequencing

Overall control of what to read, how many histories to run, etc.
Beamlines Modeled

Have accurately modeled the MGH gantry treatment delivery system, the MGH radiosurgery delivery system and the UC Davis eye treatment delivery system.
Match to Measurement at UC Davis
Patient Calculation

The bottom line is accurate patient dose calculation.

Energy Deposit
Gamma index for 2mm and 2%
TOPAS vs previous MGH Geant4
Next Aim: Speed Up

Why we rarely get there:

The Post Doc Life Cycle / Variance Reduction mismatch

Speedup is hard. Requires computer science expertise: difficult to get right information on where speed is going.

Requires clinical judgement: what cases are relevant, what defines acceptable accuracy.
Schedule

Talking to as many of you as possible to understand use cases.

Taking the time to get the code right.
Given the complexities of geometry and scoring supported by our time features, we know it’s one thing to validate our MGH and UCSF setups, quite another to declare TOPAS good enough for other users.

We succeed through close collaboration of clinical and research medical physicists and Geant4 software experts

Alpha Release already began in March:
Small number of users who keep in close touch, mostly at our home institutions.

Summer 2012: Beta release.
Any brave users who want to try the unfinished version.

To use Monte Carlo transport for particle therapy today, one must be both an expert in Monte Carlo and an expert in medical physics. With TOPAS, it will be sufficient to be an expert in medical physics.

TOPAS is by:
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Jan Schümann
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Bruce Faddegon
Harald Paganetti

Thank You
NIH !!!!

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