Vectorised DICOM-RT Regions of Interest as `G4TessellatedSolids`

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GEANT4 User Workshop - 15^{th} April 2011

O V E R V I E W

- DICOM-RT regions of interest,
  - point cloud $\rightarrow$ surface
  - surface $\rightarrow$ tessellated solid via GEANT4 CAD interface
- Amazon EC2/S3,
  - personal cluster
  - 160+ cores on demand (right now!)

M O T I V A T I O N

- Enable visualisation of the actual patient geometry in GEANT4
- Reduce computiation time (money)
- Augment a static CT dataset with motion information from other modalities (4D ultrasound?)

C T or R O I

- DICOM-RT contains two descriptions of patient geometry - voxelised CT data and patient contours or regions of interest (ROI)
- Usually we use the CT dataset only for Monte Carlo simulation
- Can we use the ROI's instead?

DICOM-RT

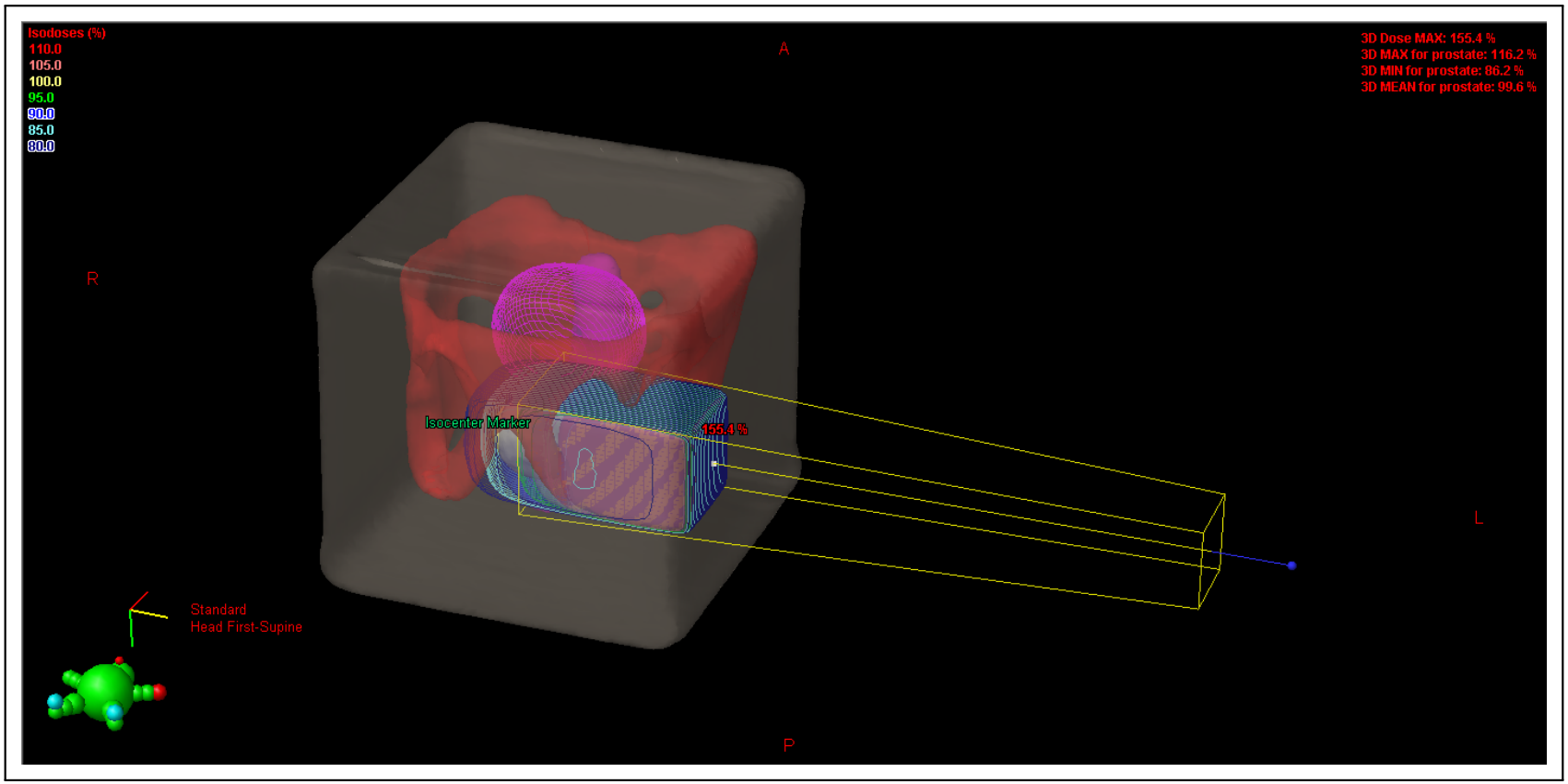
Components

- RT Image
- RT Dose
- RT Plan
- RT Structure

RT Structure

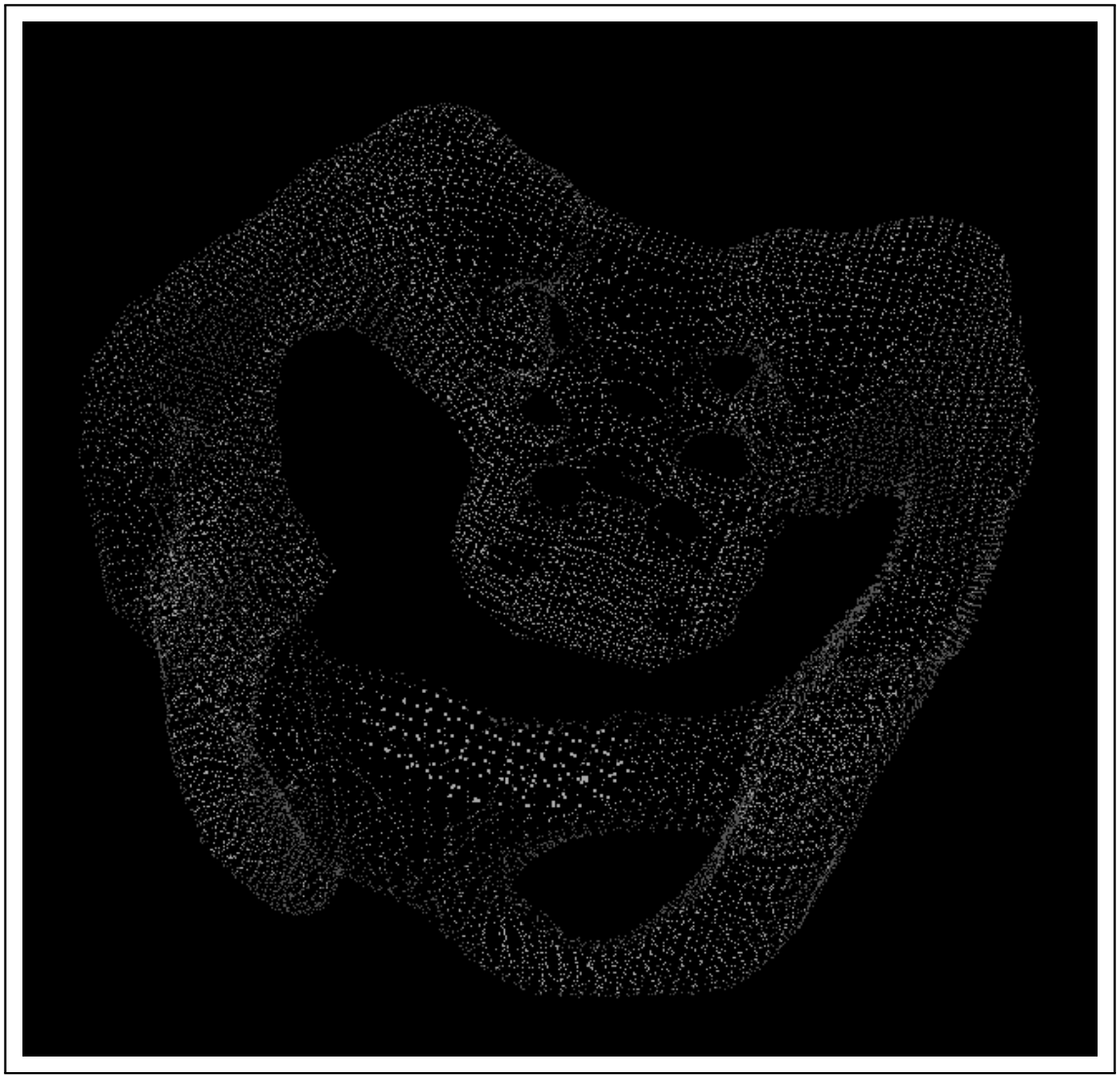
- Point cloud for region of interest
- Associated CT slices
- ROI metadata

Treatment Plan



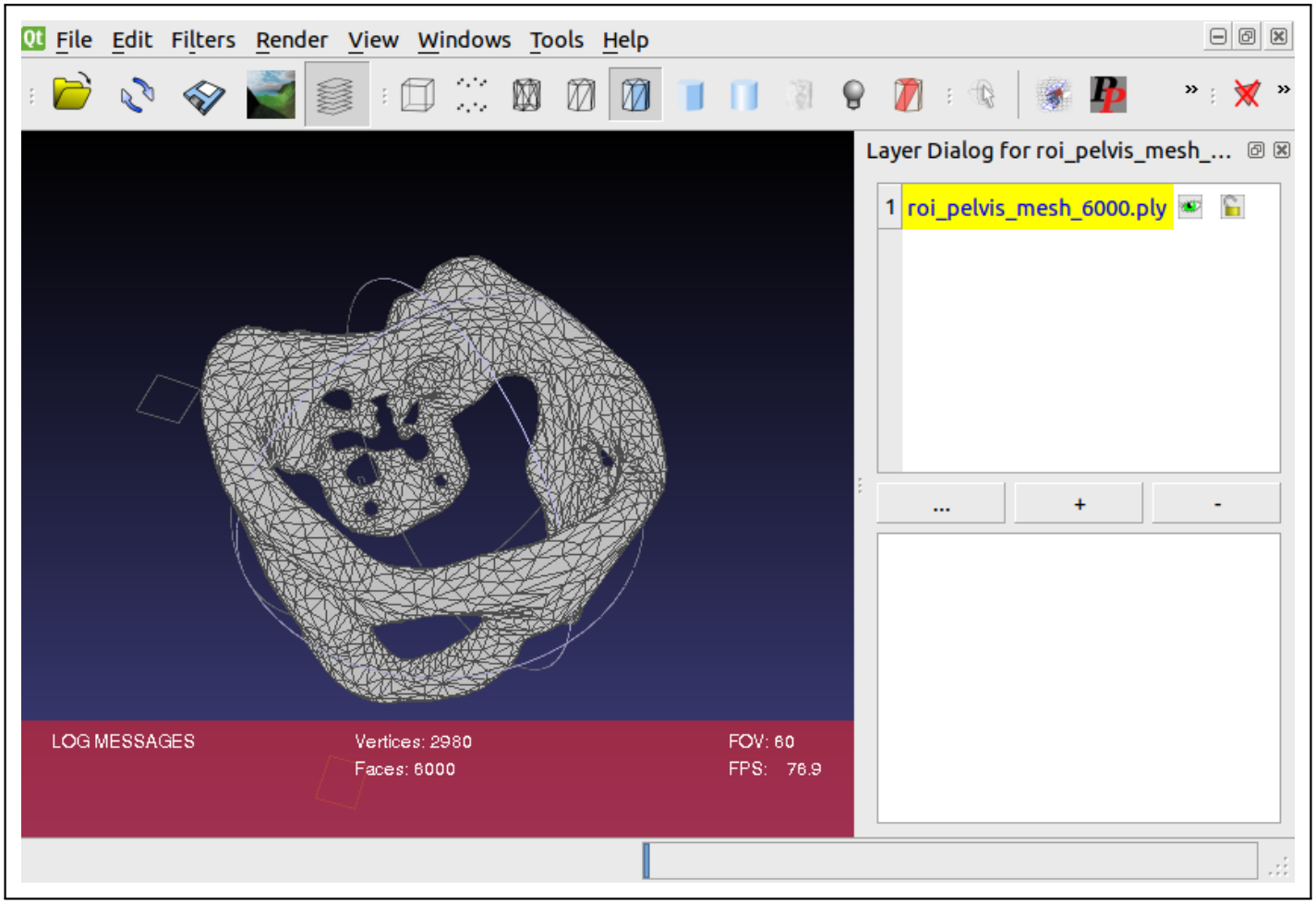
CIRS Pelvic Phantom, Model 048

3D DICOM-RT ROI's as a Point Cloud



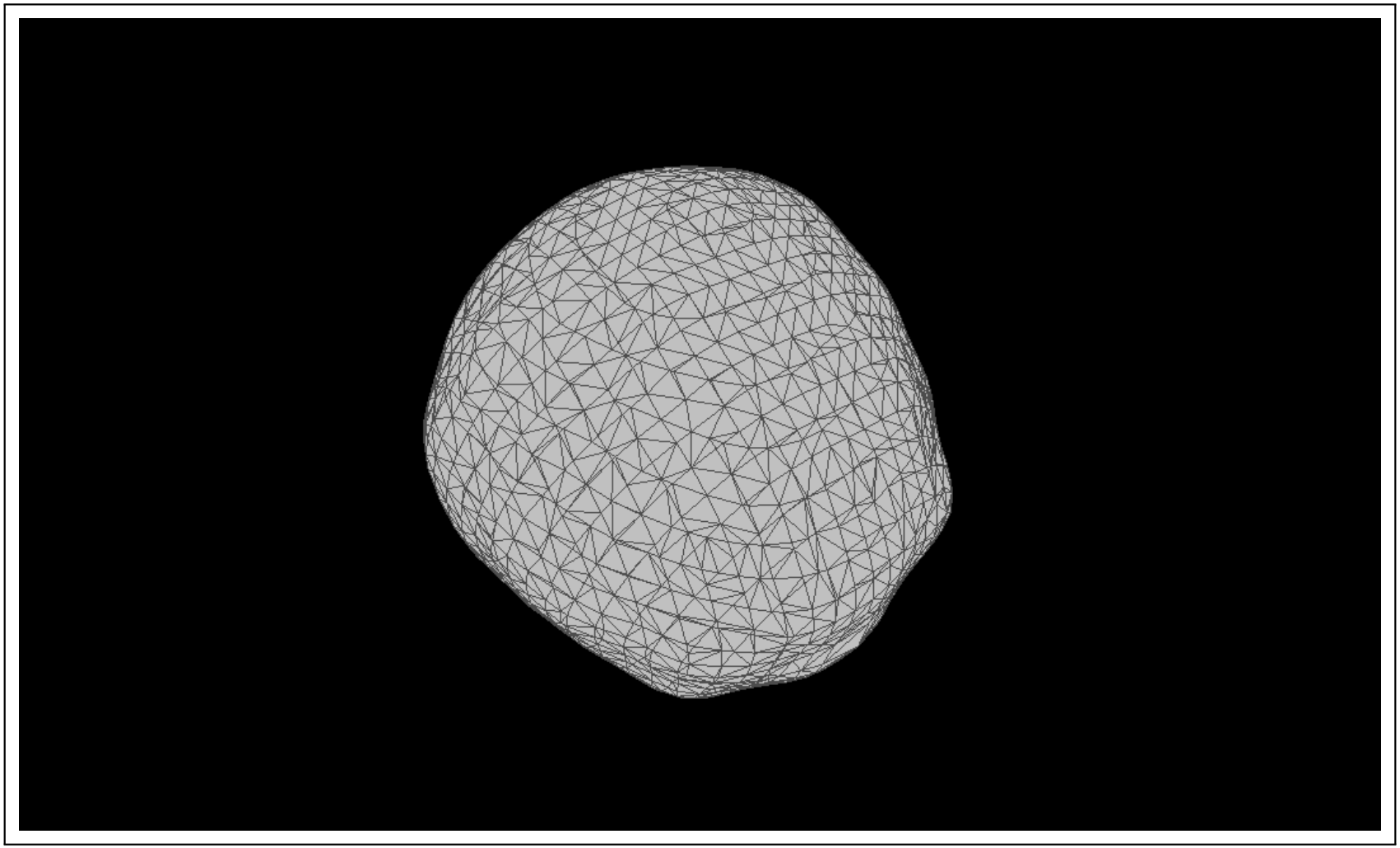
Pelvis ROI - CIRS Pelvic Phantom, Model 048

Surface Meshing - Meshlab (http://meshlab.sourceforge.net/)

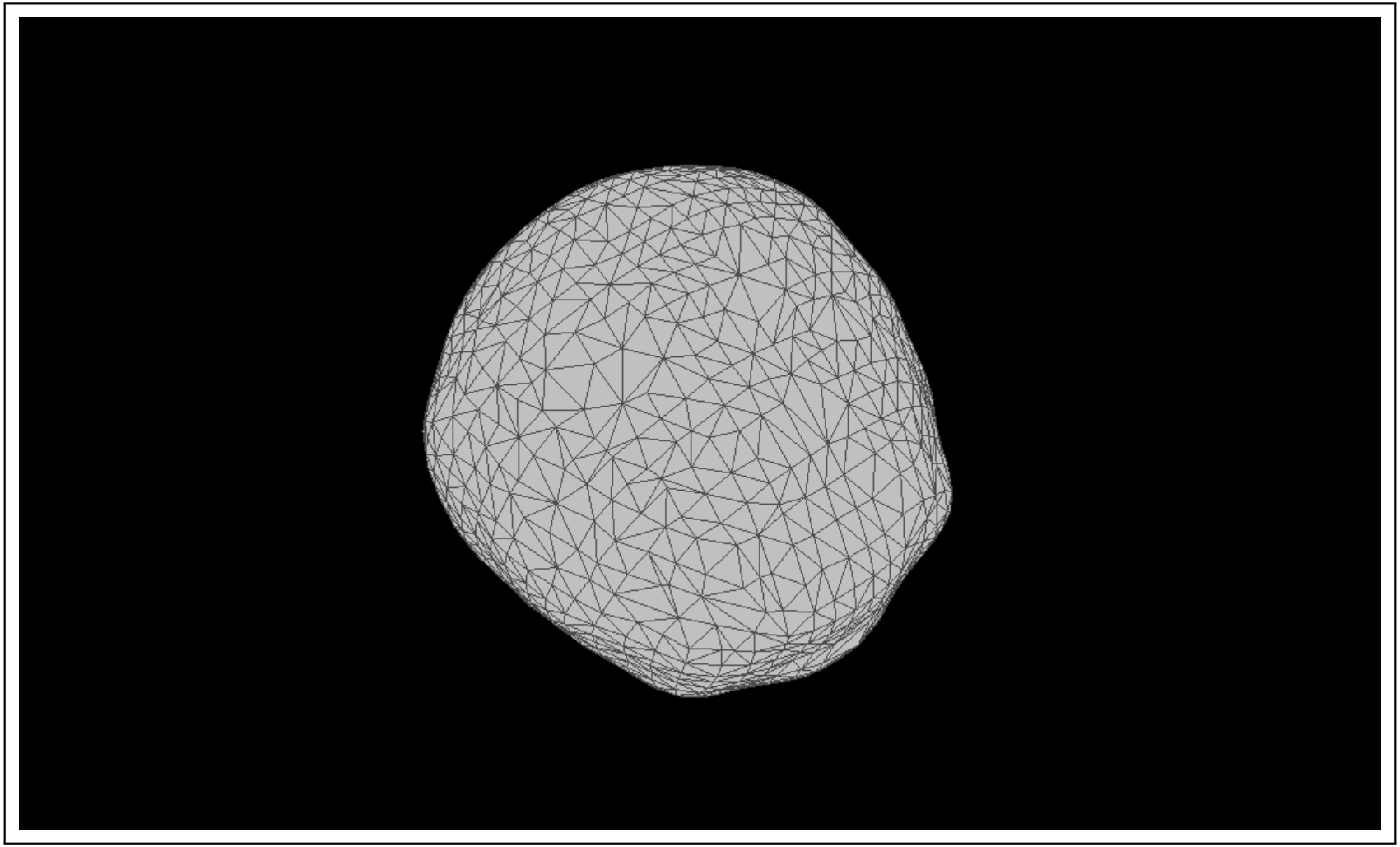


"MeshLab is an open source, portable, and extensible system for the processing and editing of unstructured 3D triangular meshes."

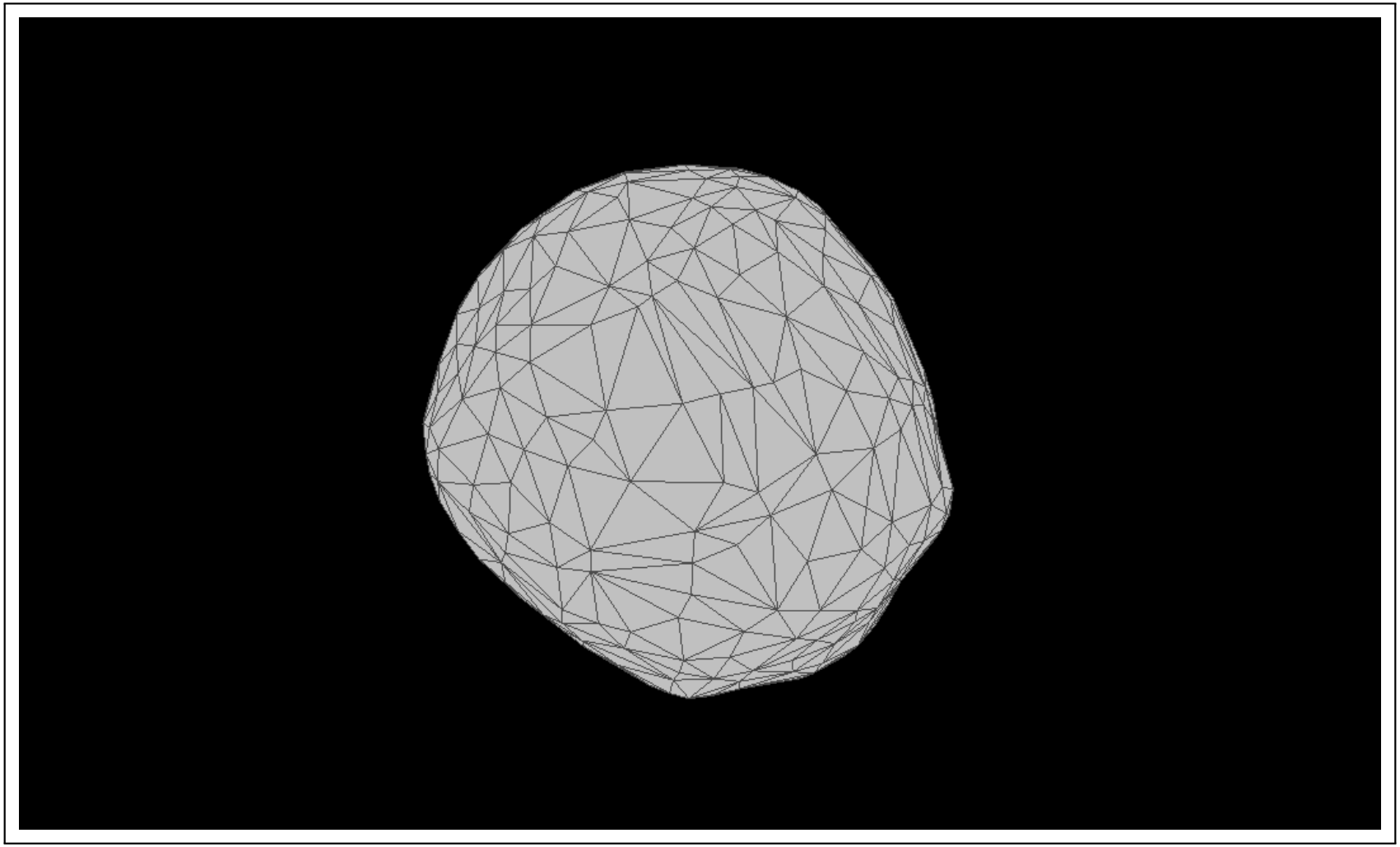
Prostate - 5000 facets



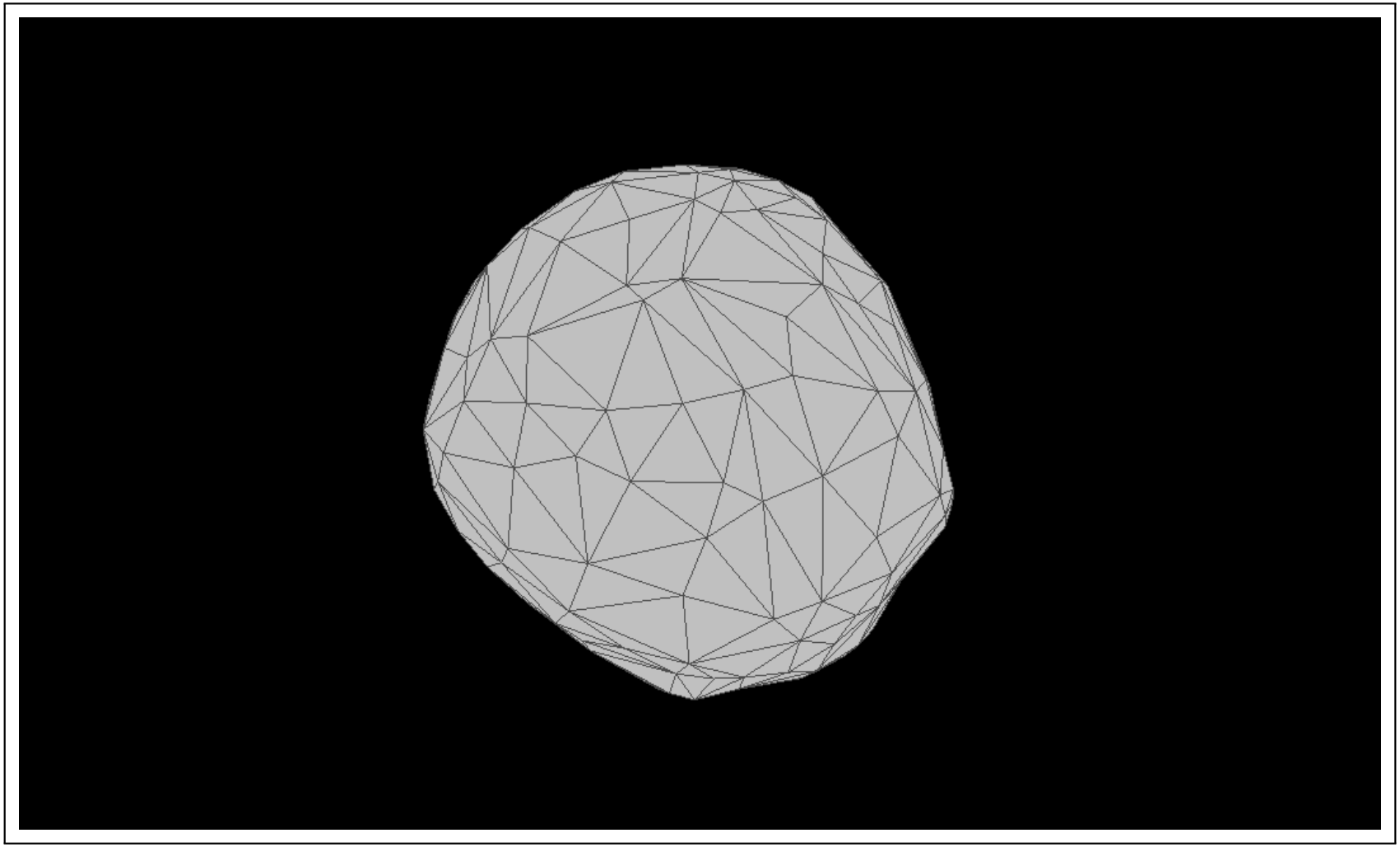
Prostate - 3000 facets



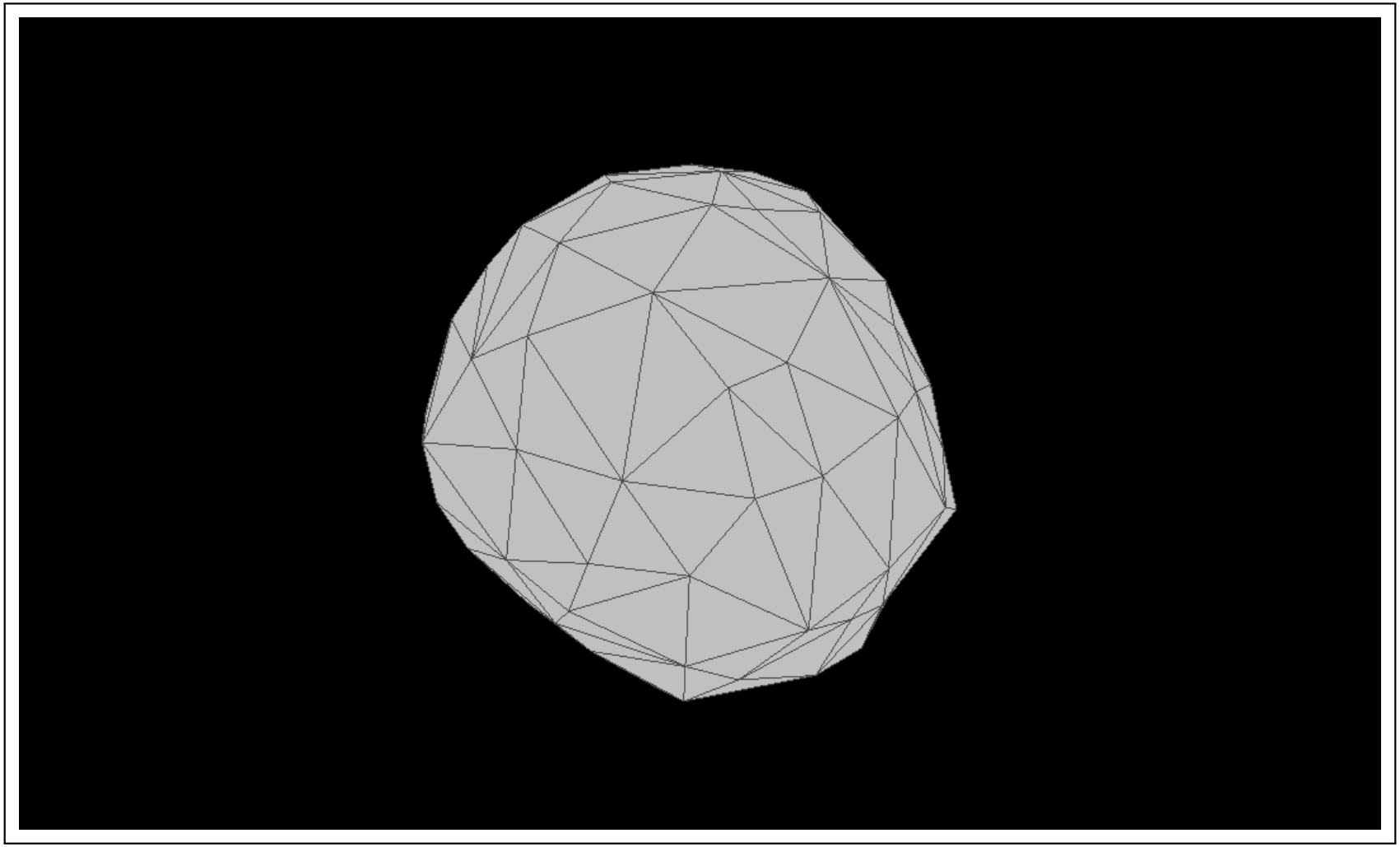
Prostate - 1000 facets



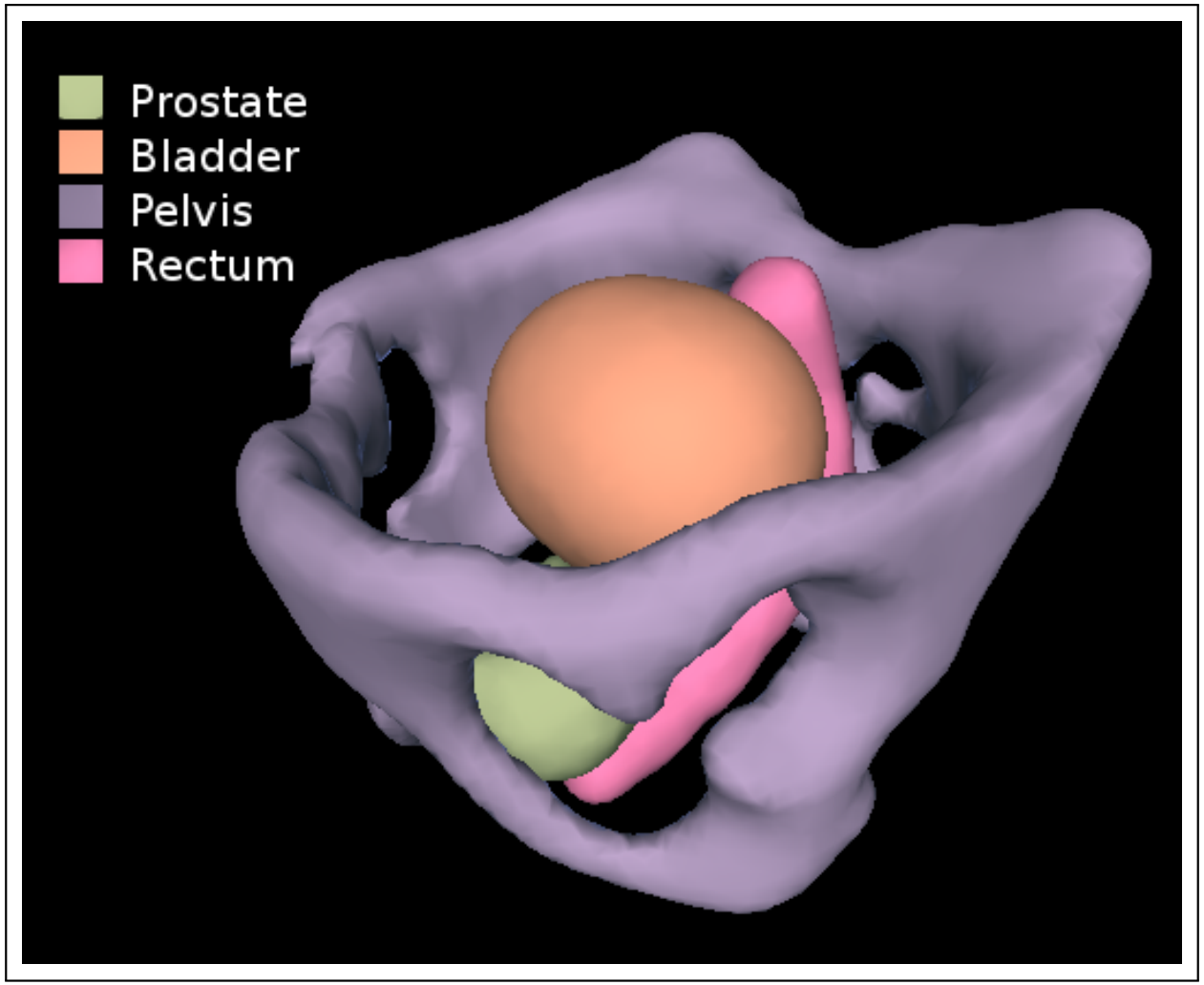
Prostate - 500 facets



Prostate - 250 facets



Point Cloud to Closed Surface



CIRS Pelvic Phantom, Model 048

Closed Surface as Geometry in GEANT4

G4TessellatedSolid

- G4Solid defined by a closed surface
- Facets can be triangular or quadrangular

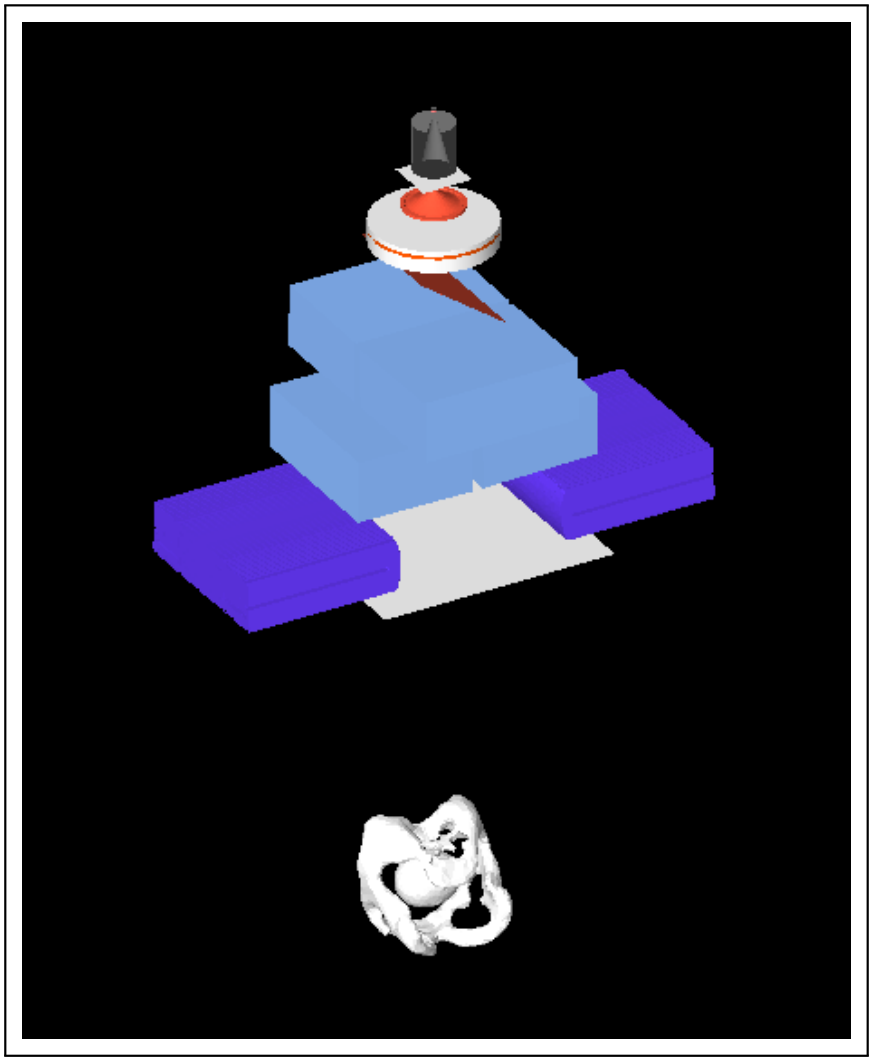
VCGLIB (Visual Computing Lab, ISTI, Italy)

- Meshlab back-end
- Surface meshing, mesh refinement, multi-format

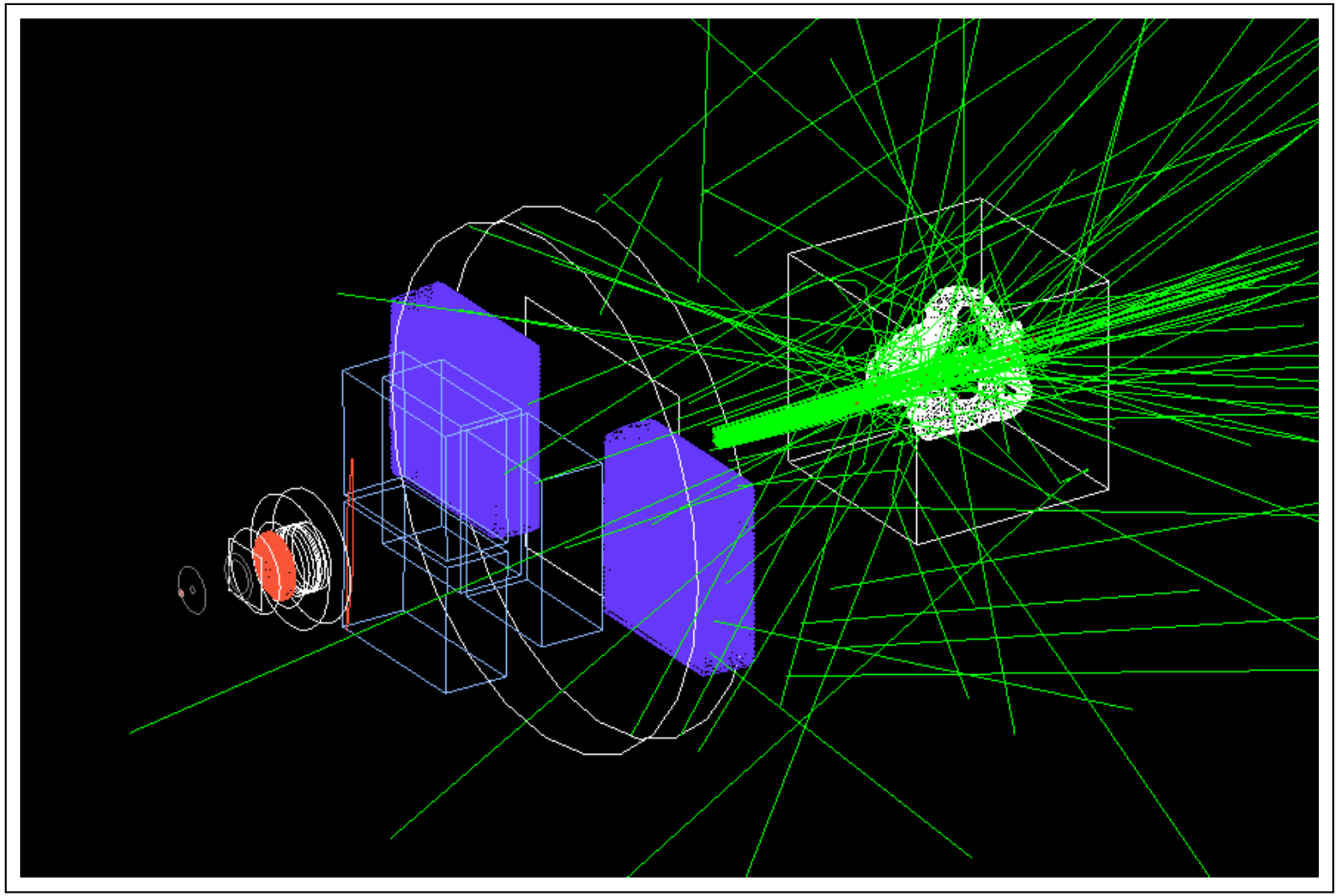
VCGLIB + G4TessellatedSolid = CAD Interface

- Mesh object in VCGLIB provides iterator for random access to facets
- Construct solid through G4TessellatedSolid::AddFacet method

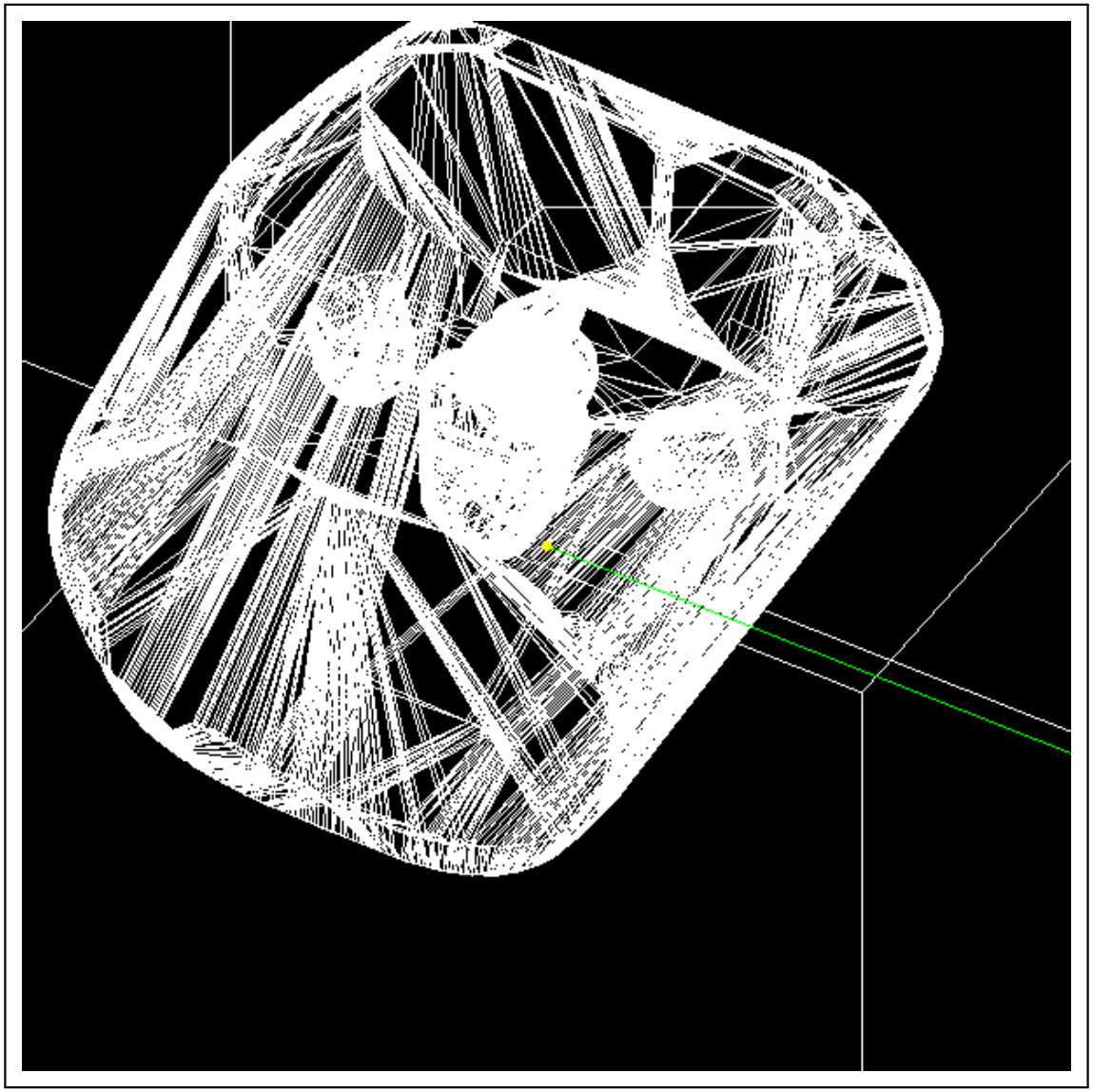
Closed Surface as Geometry in GEANT4



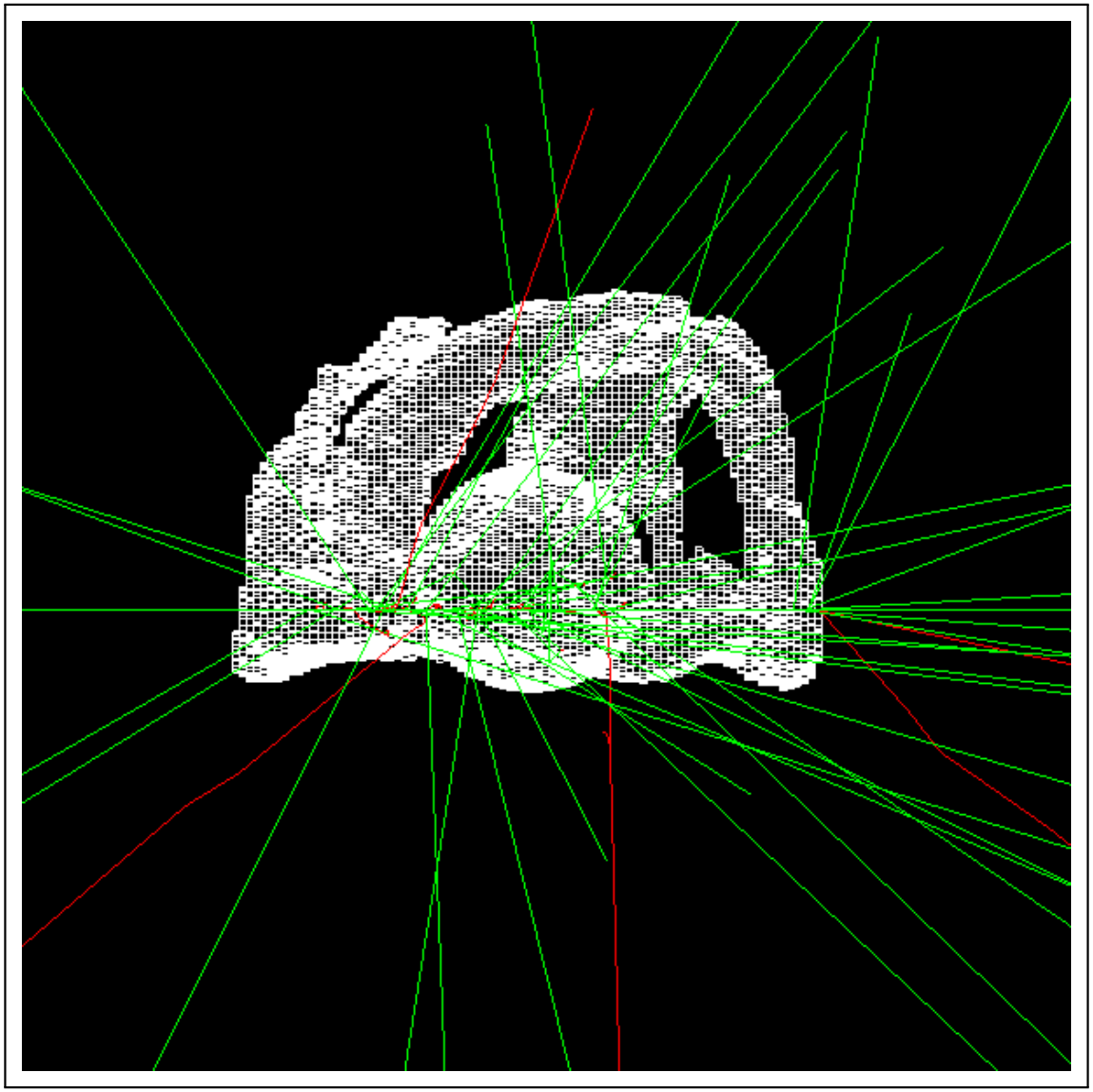
Closed Surface as Geometry in GEANT4



Closed Surface as Geometry in GEANT4



Extruded Solids?



Geometry in GEANT4

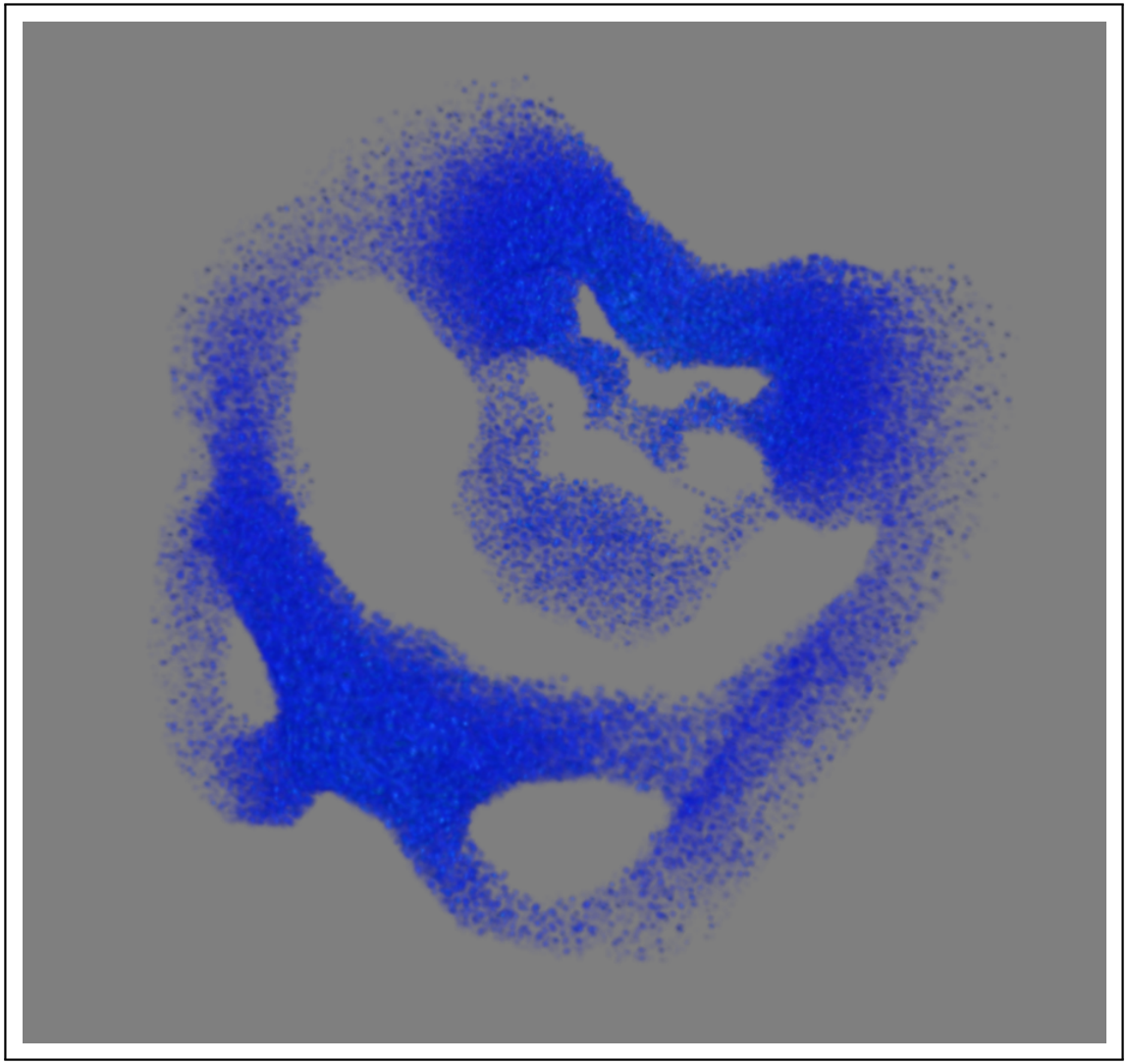
Material Properties

- For each volume a CT number histogram is calculated
- Use this to assign a mean/median/modal CT number/density
- OR assign a default material (G4_SOFT_TISSUE for example)

Geometry Definition

- A single scoring histogram for all volumes or a separate scoring histogram of each volume
- Time dependent geometry - evaluate dose consequence of motion
  - Adjust geometry guided by pre-treatment alignment images
- Include or exclude bodies - prosthesis for example

Record Dose in Separate Volumes



Computational Performance

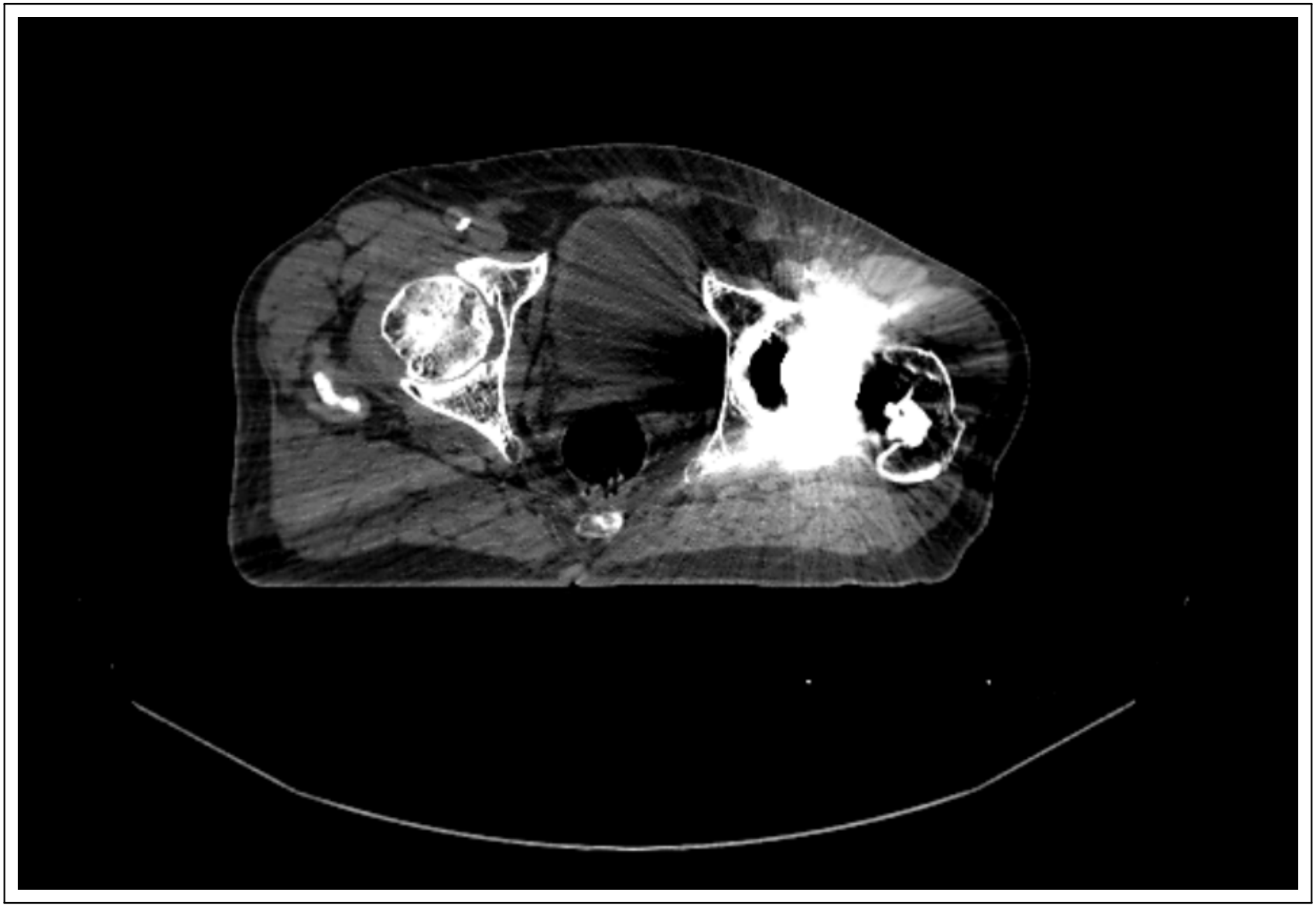
CT Benchmark

- Linear increase in computation time with increase in facet count
- For same number of histories, computation time same as CT dataset at 10,000 facets
- 420 MB RAM for CT dataset, 110 MB RAM for ROI's (including scoring histogram)

Amazon EC2 - Elastic Compute Cloud - Out-sourced HPC

- One EC2 compute unit equivalent CPU capacity of a 1.0-1.2 GHz 2007 Opteron or 2007 Xeon processor
- $\$0.68c/hr$ for 7 GB of memory, 20 EC2 Compute Units (8 virtual cores with 2.5 EC2 Compute Units each), 1690 GB of local instance storage, 64-bit platform
- Fixed hourly rate for on-demand instances, spot market to bid on unused network capacity (cheaper)

Uses: Monte Carlo with Foreign Body (corrupted CT)



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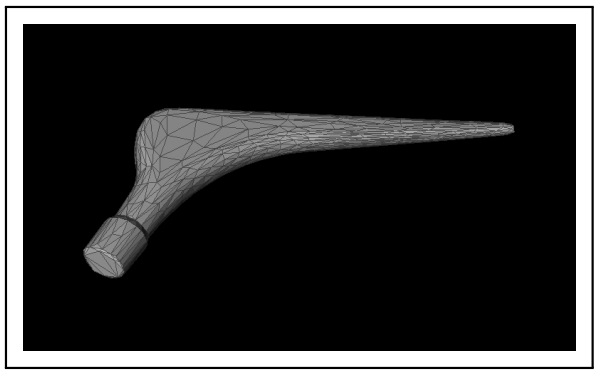

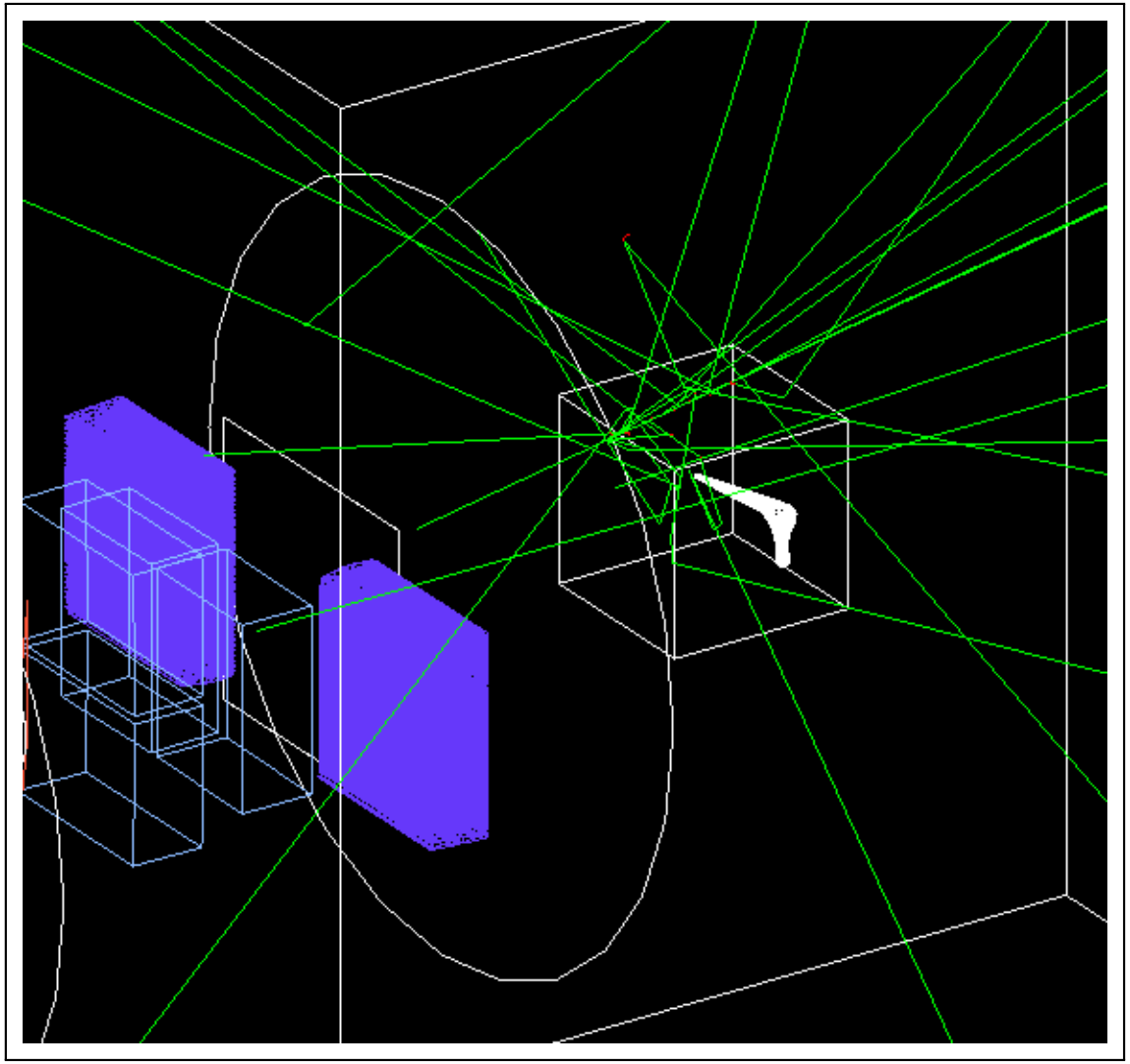

Prosthesis model, L Wilson (QUT)

N E X T ...

- Compare results to measurements - anthropomorphic phantom?
  - Any difference between MC with CT dataset and ROI's?
- Simulate treatment with foreign body (CT versus ROI's), does it agree with measurement?