A 3D Collision Avoidance Tool for External Beam Radiation Therapy Planning

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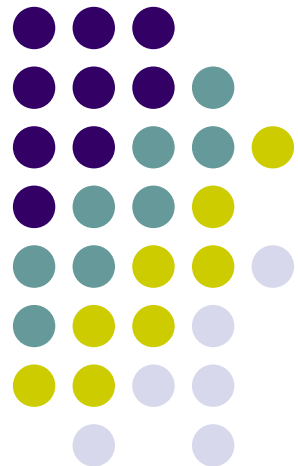

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Motivation

- Most of the currently available treatment planning systems offer little or no information for the treatment planner on possible collision scenarios during the planning process
- Most collision scenarios are found by RTTs during visual treatment verification checks
- Computer Controlled Radiation Therapy (CCRT) requires precise knowledge of the relative positions of all linac components with respect to the patient and to each other. All motions must be verified before use

Motivation

We would like to:

1. Generate a realistic 3D simulation of the treatment room with as much detail and resolution as possible?
2. Virtually move different linac components gantry, table, collimator, ..etc as if you were in the room using a hand pendant?
3. Visualize the beam path, the lasers, and the actual patient external geometries/surfaces on the couch together with add-on/immobilization devices?

If we can, then we have a tool that does off-line virtual simulation of patient-specific external beam plans.

A typical situation from our clinic:

Novalis 7-field H&N IMRT

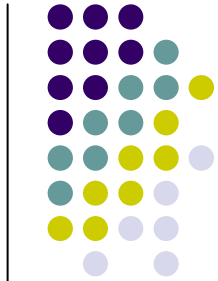
need a new paint job!

Beam Parameters:

Gantry = 245°
Couch = 350°
Collimator = 0°
VRT = 10.0
LAT = **0.0**
LNG = 60

in many cases the collimator is touching the couch, and in some cases re-planning is required

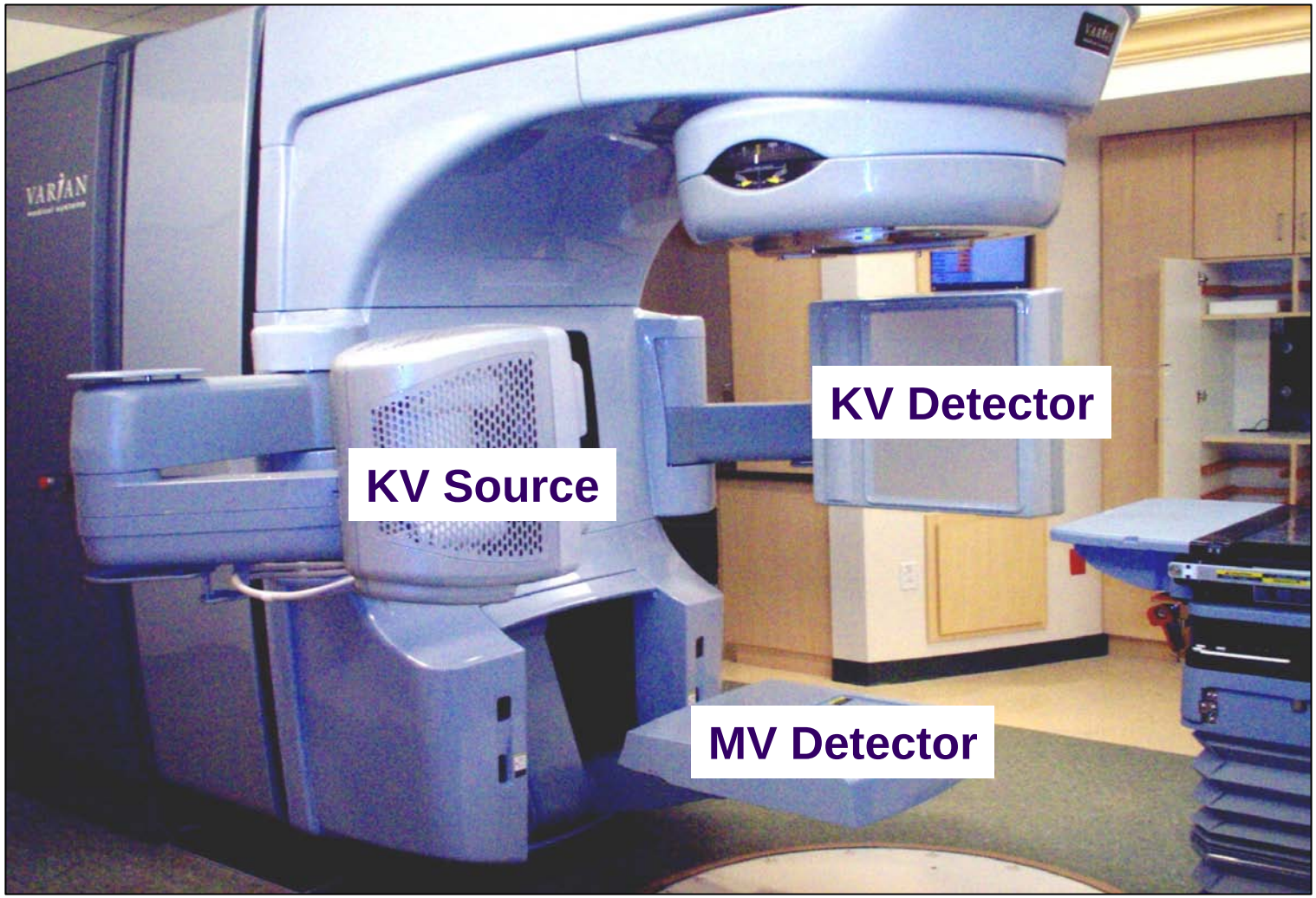
The collision problem



It is an interplay between the following components:

- Linac modules
- Immobilization devices- frames, extensions, boards
- The patient

In addition, the linac may have built-in imaging devices… makes it hard to perform automated setups



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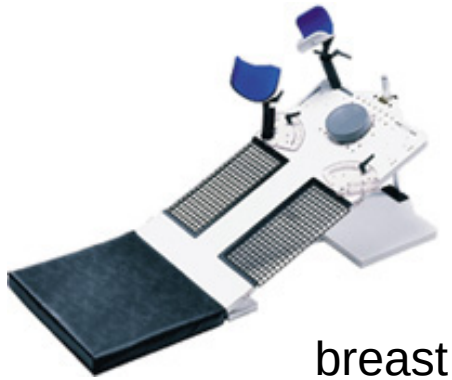
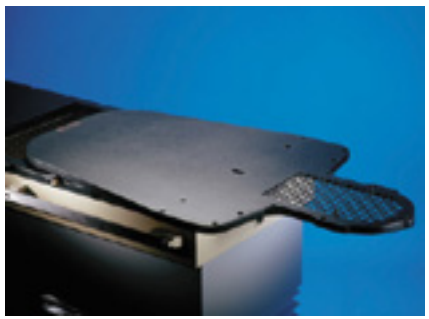
There are many add-ons we need to keep track off and avoid collision with

stereotactic head frames



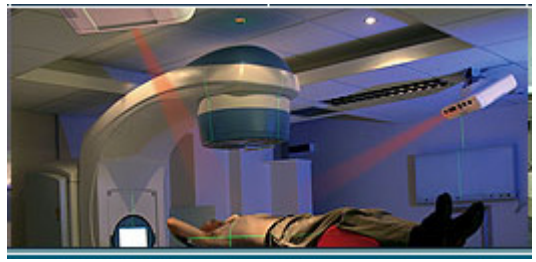
breast boards



head extensions

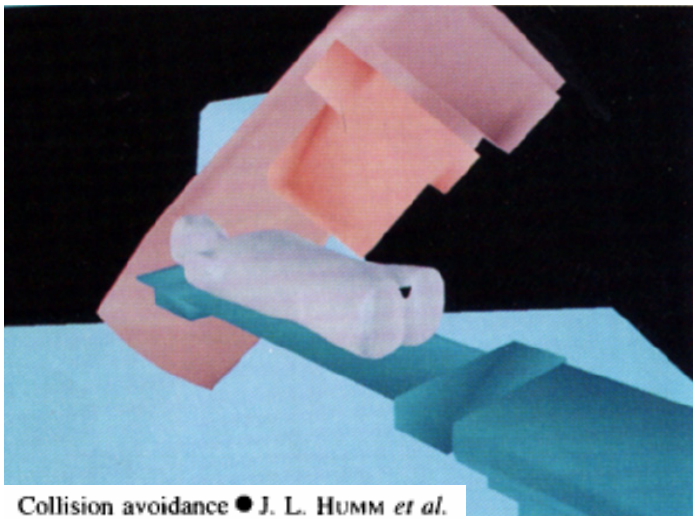
wing boards

CT data provide limited surface information. To map out the entire collision space we need 3D surface model of the entire patient in the treatment position.



Possible solutions:

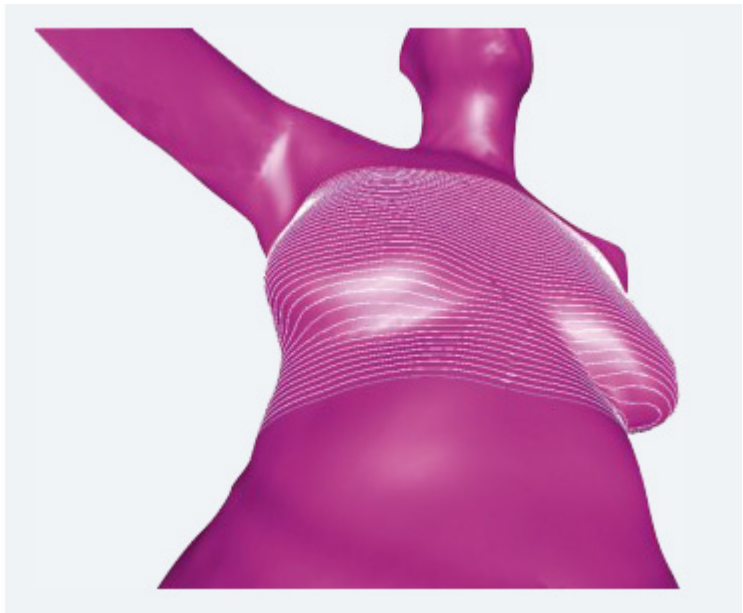
A- Whole body CT of the patient!



Collision avoidance ● J. L. HUMM *et al.*

Int. J. Radiation Oncology Biol. Phys., Vol. 33, No. 5, pp. 1101–1108, 1995

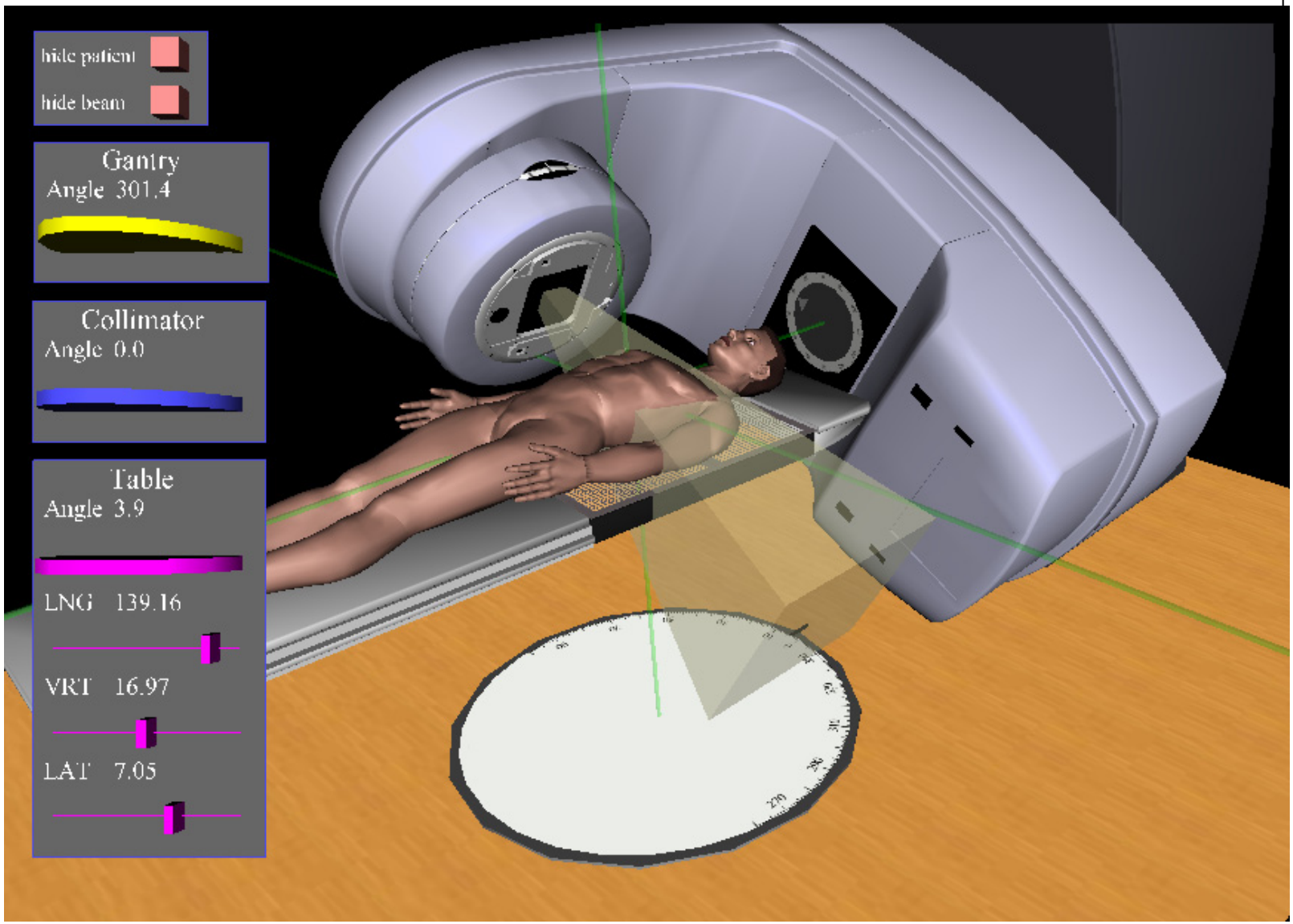
B- 3D surface rendering



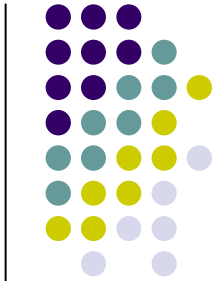
Example of a commercially available “3D” simulation tools …

3DRTT Simulator

- 3D Radiation Therapy Treatment: **Varian 23ix**



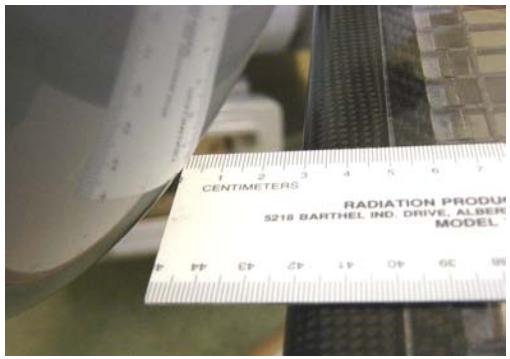
3DRTT Simulator - a few details **-**



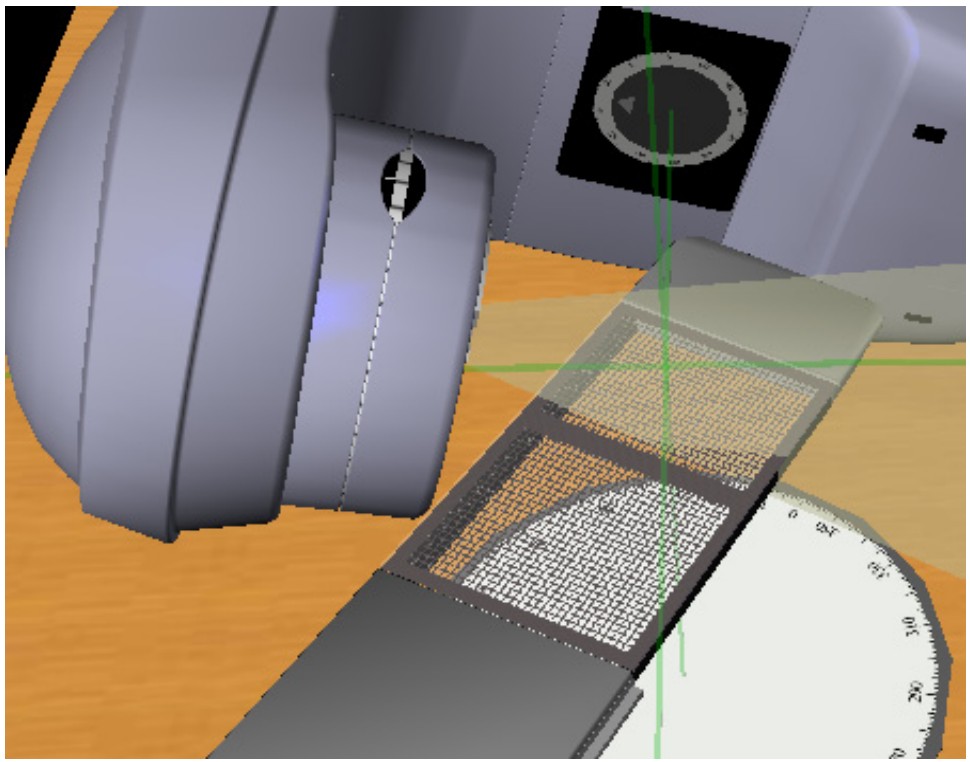
- Software Architecture (3-Tier Scalable)
  - Client-Side: X3D Player in Web-Browser
  - Middle-Tire: Apache Tomcat Server with JSP(Java Server Pages) capability
  - Back-End: 3D database extension capability.
  - GUI (Graphical User Interface) Dual
  - JSP based (servlet engine)
  - X3D event based
  - Adopted IEC
- 3D Linac Model: Varian 23ix
  - **Initially developed from CAD drawings** *(available online)*
  - Later developed in 3DStudio Max (LINAC has approx 12000 polygons) from manual measurements and digital photographs
  - **Gantry and table were cross-scaled through manual measurements**
  - Adopted IEC 1217

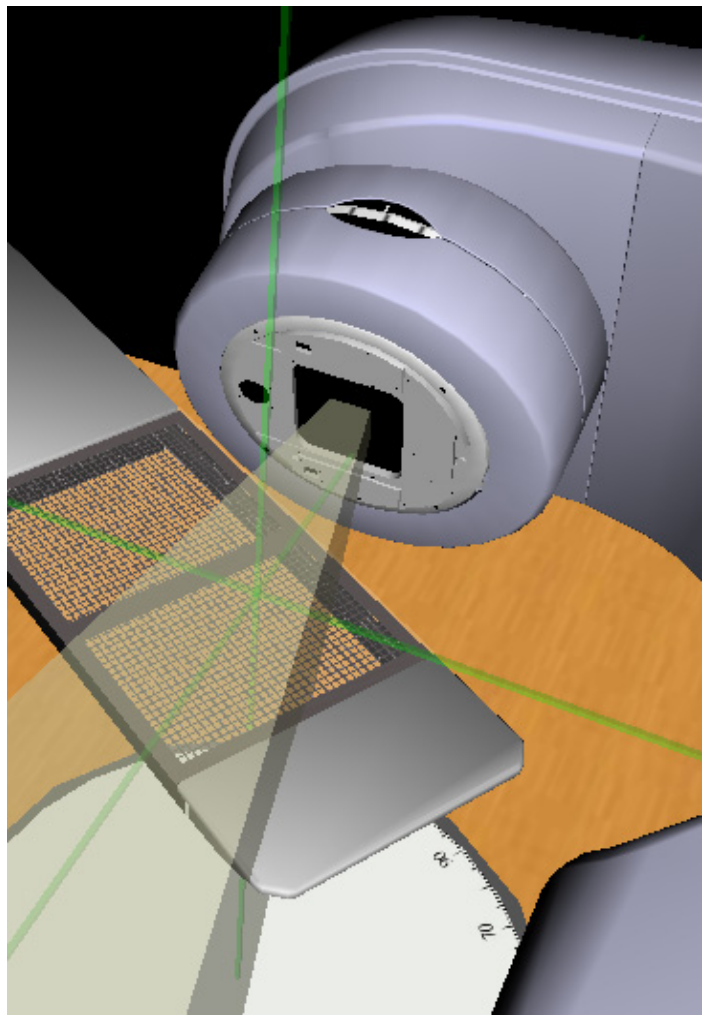
3DRTT Simulator

- A validation example



Coll Rtn	90.0
Gantry Rtn	285.2
Couch Vrt	12.0
Couch Lng	118.7
Couch Lat	0.0
Couch Rtn	30.3





3DRTT Simulator

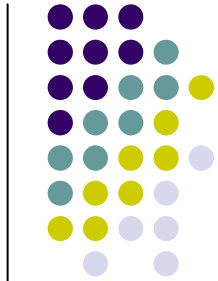
- 3D Radiation Therapy Treatment

- **Features**:
  1. **Web-based** simulator (using latest X3D technology standards)
  2. Friendly GUI (Graphical User Interface)
  3. **Easy setup** and is platform independent
  4. Uses **freely available software components** (web browser, x3d player)
  5. To experience **immersive 3D visualization** use red/blue glass pair

Work in progress …

- Automatic generation of 3D patient external geometries from CT scans and total-body 3D surface scans followed by automatic registration with the linac isocenter
- Automatic calculation of the most efficient plan delivery sequence by optimizing gantry/table motion while incorporating translational speeds
- Model linac geometry to within a few millimeters accuracy using high-resolution 3D laser scanners
- For indexed tables, the tool should predict the optimal position for patient on the treatment couch

Conclusions



- The simulation tool allows for accurate 3D representation of the all linac components and allows the user to perform virtual 3D simulation of the delivery.
- The current version allows for visual detection of collision scenarios to within a few centimeters average accuracy
- With increased model resolution including add-on devices and patient-specific external contour volumetric data, the tool may serve as a verification check for CCRT deliveries.
- The tool can be used as a training tool for RTTs, dosimetrists, and physics residents

Thank you

http://hyperion.armstrong.edu:8080/3DRTT