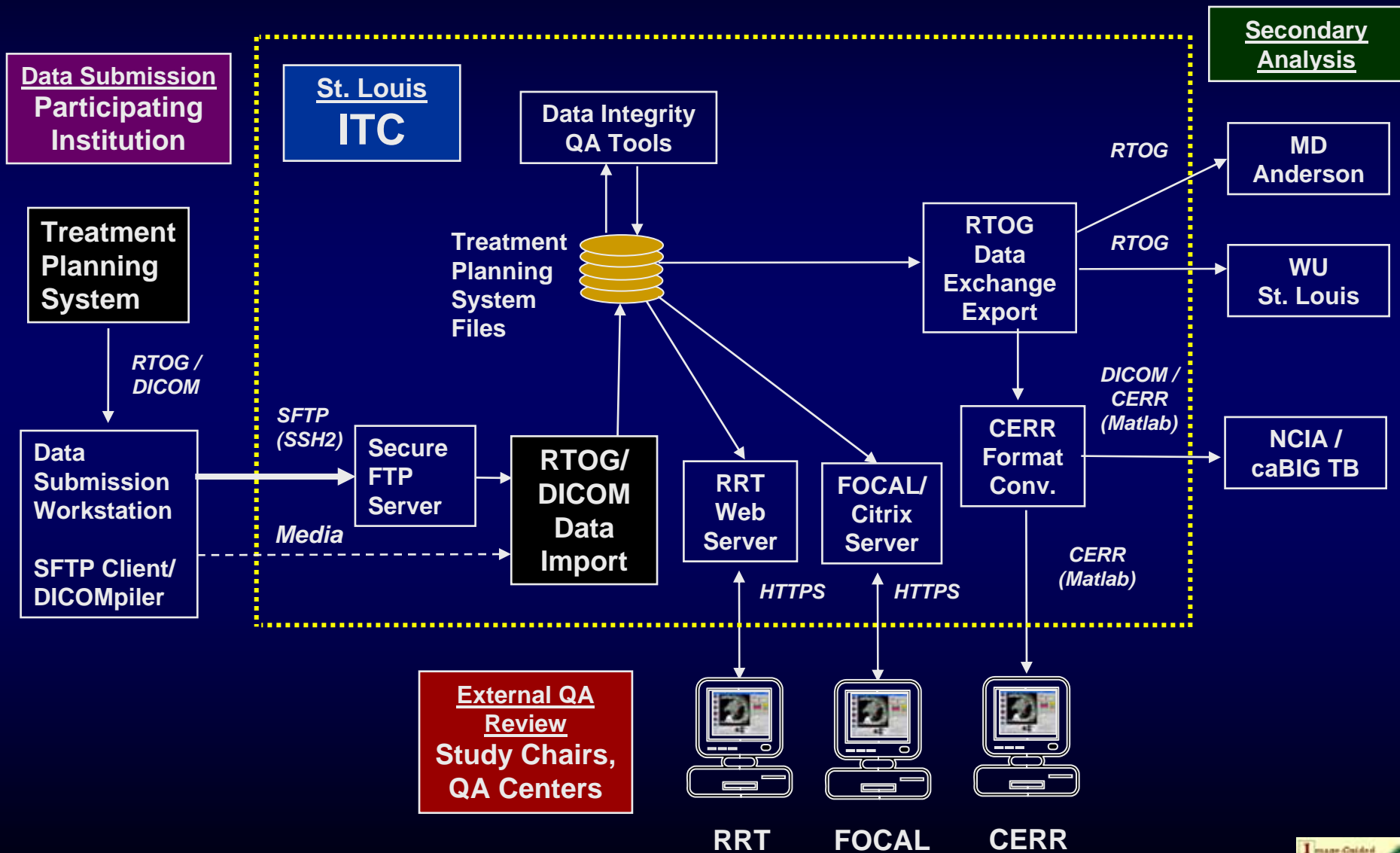# Update on ATC QuASA^{2}R System

Walter R. Bosch, D.Sc.

ATC Meeting

January 17, 2008

San Diego, CA

QuASA²R – *Current Components and Data Flow*

QuASA²R – *Developmental Priorities (1)*

1. Redundant storage (Pillar Data NAS)
   - Stable support for existing review tools (RRT)
   - Extensible foundation for new DICOM Archive
2. DICOM-based RT archive (Teramedica Evercore)
   - Support wide range of imaging modalities as well as RT objects
3. Data format conversion (to CERR, DICOM) using CERR
   - Advanced imaging workstation
   - Gateway for legacy data (RTOG Data Exchange)
   - Format for distributed review
4. Digital Data Integrity QA workflow tools (CERR)
   - DDIQA Server
   - Data anonymization / ID reconciliation
   - Archive loading
   - Case data management (inventory, revision)
   - DICOM consistency checks (DVTk)
   - Structure naming / Structure editing/ Dose summation?

QuASA²R – *Developmental Priorities (2)*

5. MAX Server implementation at ITC
6. Integrate commercial TP workstations
   - Eclipse
   - Pinnacle
   - CMS
7. Diagnostic image review
   - Hermes
   - MIMVista
8. Grid-enabled CERR for case review
   - Secure download, seamless review
   - Anticipatory data push
9. Server-side review tools
   - Image Digest / QA Report Generator (CERR)
   - Multi-planar (T/S/C) tool for contour and dose review
10. ITC tape backup upgrade

Pillar Data Axiom 500 NAS System

- 10 TB Redundant Disk Array
- Modular design for flexible, affordable system growth
- High-availability system: critical components have duplicate, active backups
  - Redundant disk array (RAID) with error detection/correction
  - Dual, independent (active/passive) storage management units
  - Dual (active/active) storage control units
  - Redundant power supplies and UPS
- Policy-based hardware allocation
- Performance, system health monitoring
- Data management utilities: data migration, snapshots, deltas

NFS Storage for Existing ITC Archive Data

- ITC installation Jan 14, 2008
- Robust storage for existing SFTP server, DDIQA tools, and review tools.
- Current ITC Archive
  - > 9000 Datasets
    - ~ 6500 protocol cases
    - ~ 1900 dry runs
    - ~ 550 phantoms
    - ~ 50 immobilization tests
  - ~ 650 GBytes
 - + 350 GBytes (compressed backup)

ITC TeraMedica Evercore Archive

- Two DELL PowerEdge 2950 Servers, each with quad-core 3GHz Xeon processor, 16 GB RAM, GB ethernet
  - Primary database server, secondary archive server
  - Primary archive server, secondary database server
- Software
  - OS: Windows 2003 Server Enterprise x64
  - Database: MS SQL Server 2005 x64
  - TeraMedica Evercore archive

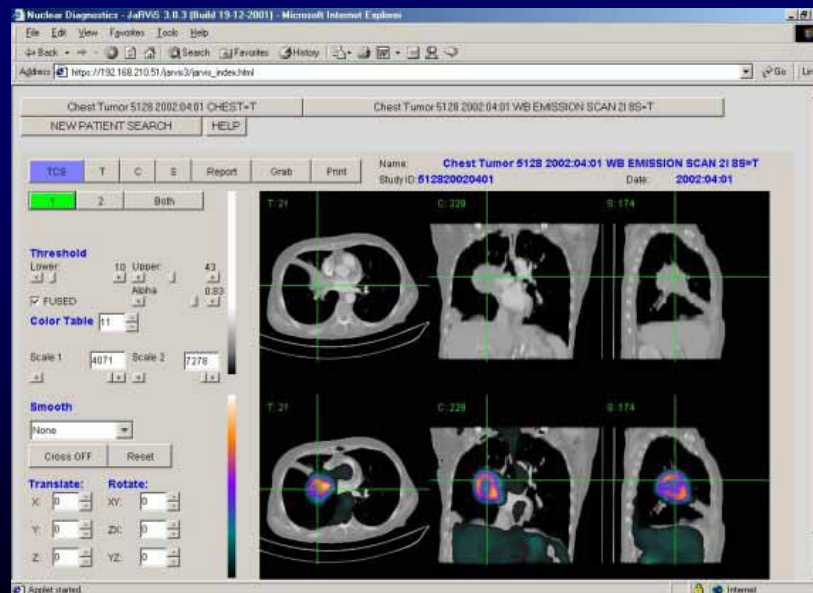# Diagnostic Image Review Tools

- **MIMvista**
  - Multi-modality support: CT, MR, PET, CBCT
  - Automatic/manual registration
  - 3D/Multi-planar contouring
  - Image/contour deformation
  - Atlas-based segmentation
  - IGRT, 4DCT tools
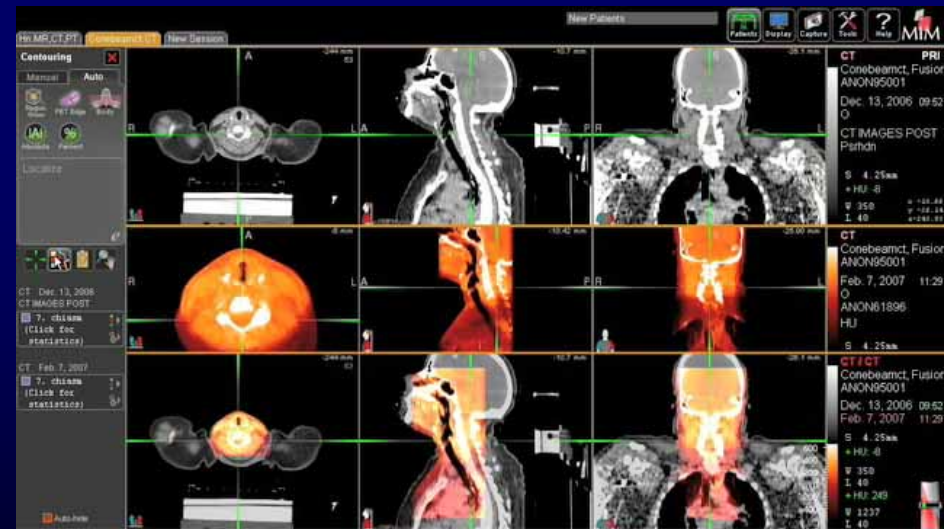
Diagnostic Image Review

- HERMES
  - Diagnostic multimodality workstation & storage server
  - PC based multimodality image viewer
  - Java Remote Viewing Station (JARVIS) – web-based image review
  - Remote access for image review

PET-CT Fusion

Lymphoma case courtesy of Brigham & Women's Hospital, Department of Nuclear Medicine, Boston, MA, USA.

Use of CERR for Treatment Planning Data Format Conversion

- Approximately 50% of data submitted to ITC is in RTOG Data Exchange Format.

- The proportion of DICOM is expected to grow as updated TP systems with DICOM export are installed
  - Pinnacle[3] (7.6 and 8.0)
  - XiO (4.3.x)

Format of Data Submitted to ITC

A bar chart titled "Format of Data Submitted to ITC" with y-axis "Total Yearly Datasets" (0 to 1600) and x-axis "Year" (1995 to 2007). Legend: RTOG (light purple), DICOM (dark red).

- CERR is used to convert RTOG data to DICOM RT for upload to National Cancer Image Archive (RTOG 0522) and to CERR format for RPC Phantom dosimetry.
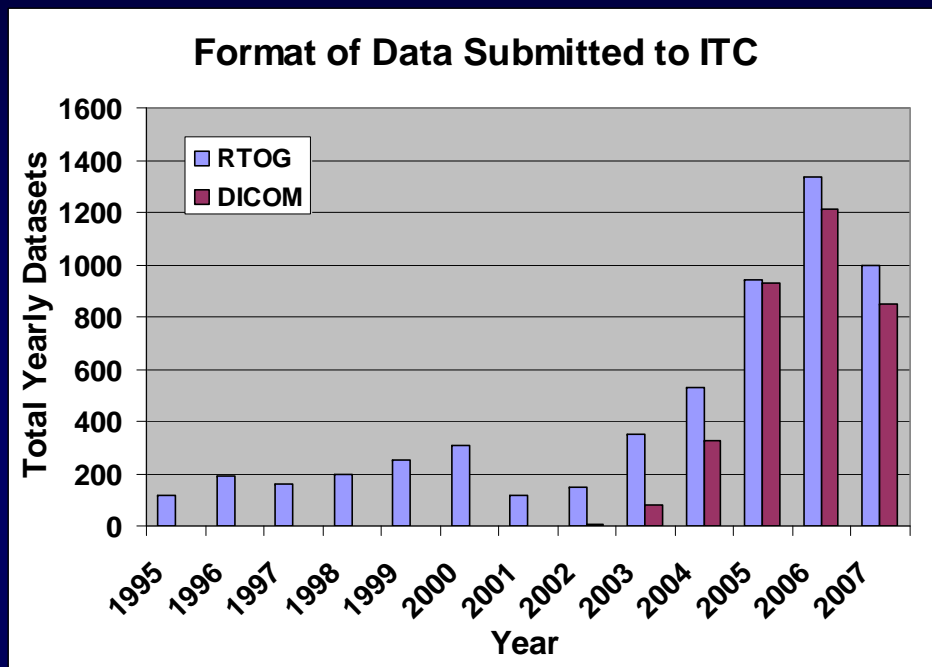
Application of caGrid® Middleware to Facilitate Quality Assurance for Advanced Technology Radiation Therapy Clinical Trials

Joel H. Saltz[1], MD, PhD, Ashish Sharma[1], PhD, Tony C. Pan[1], MS,

Walter R. Bosch[2,3], DSc, Joseph O Deasy[3], PhD,

James A. Purdy[4], PhD

[1] Department of Biomedical Informatics, The Ohio State University, Columbus, OH
[2] Image-guided,Therapy QA Center, Washington University, St. Louis, MO
[3] Department of Radiation Oncology, Washington University, St. Louis, MO
[4] Department of Radiation Oncology, UC Davis Cancer Center, Davis, CA

OHIO STATE UNIVERSITY Medical Center

WASHINGTON University in St.Louis SCHOOL OF MEDICINE   SITEMAN CANCER CENTER

QuickTime™ and a decompressor are needed to see this picture.

Grid Computing and RT Clinical Trials

The caBIG In Vivo Imaging middleware is used to deploy existing CERR software as an integrated communication and review tool for Radiation Therapy clinical trials, institutional credentialing, and case quality assurance.

- Simplified distribution of data to reviewers
- Capture reviewer modifications for subsequent analysis
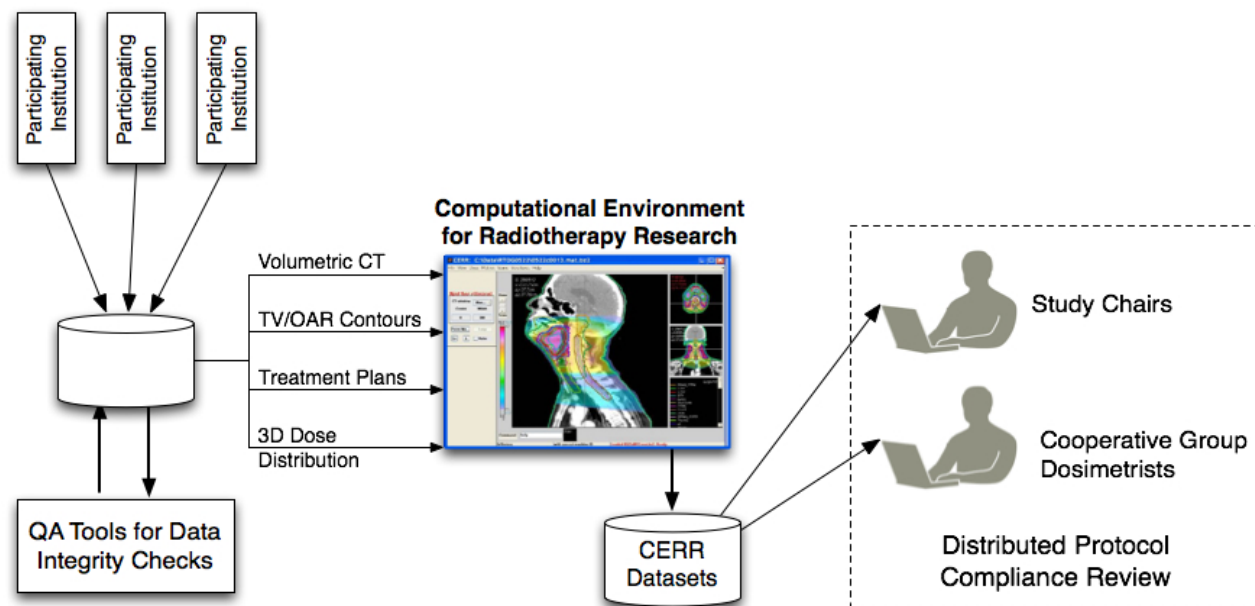
Components of Grid Enabled CERR

- A caGrid data service for storing CERR objects
  - Stores the metadata of the CERR MATLAB objects in a XML database
  - Provides Query and high performance data transfer from/to the client
- CERR client is modified to support grid interactions
  - Grid based Query/Retrieve interface
  - Grid security interface
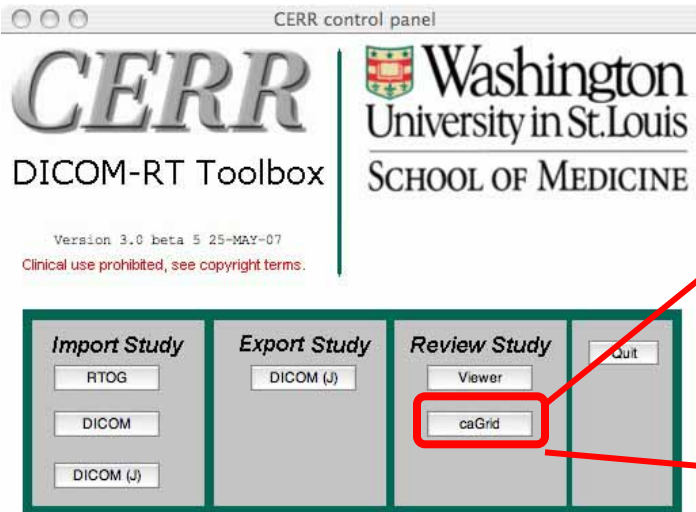
Grid Q/R GUI

Integrating the Healthcare Enterprise (IHE)

- IHE is an initiative by healthcare professionals and industry to improve the way computer systems in healthcare share information.

- IHE promotes the <u>coordinated use of established standards</u> such as DICOM and HL7 to address specific clinical needs in support of optimal patient care.

IHE Domains

- Cardiology
- Eye Care
- IT Infrastructure
- Laboratory
- Pathology

- Patient Care Coordination
- Patient Care Devices
- Quality
- Radiation Oncology (2004)
- Radiology

IHE-RO Participants

- **Radiotherapy society participants**

  ASTRO, AAPM, ACR, AROI (India), CARO (Canada), CSRO (China), ECS-RO (Egypt), ESTRO (Europe), JASTRO (Japan), RSNA

- **Equipment manufacturers**

  BrainLab, CMS, Elekta-IMPAC, Mirada Solutions, Nucletron, Philips, Siemens, Tomotherapy, Varian
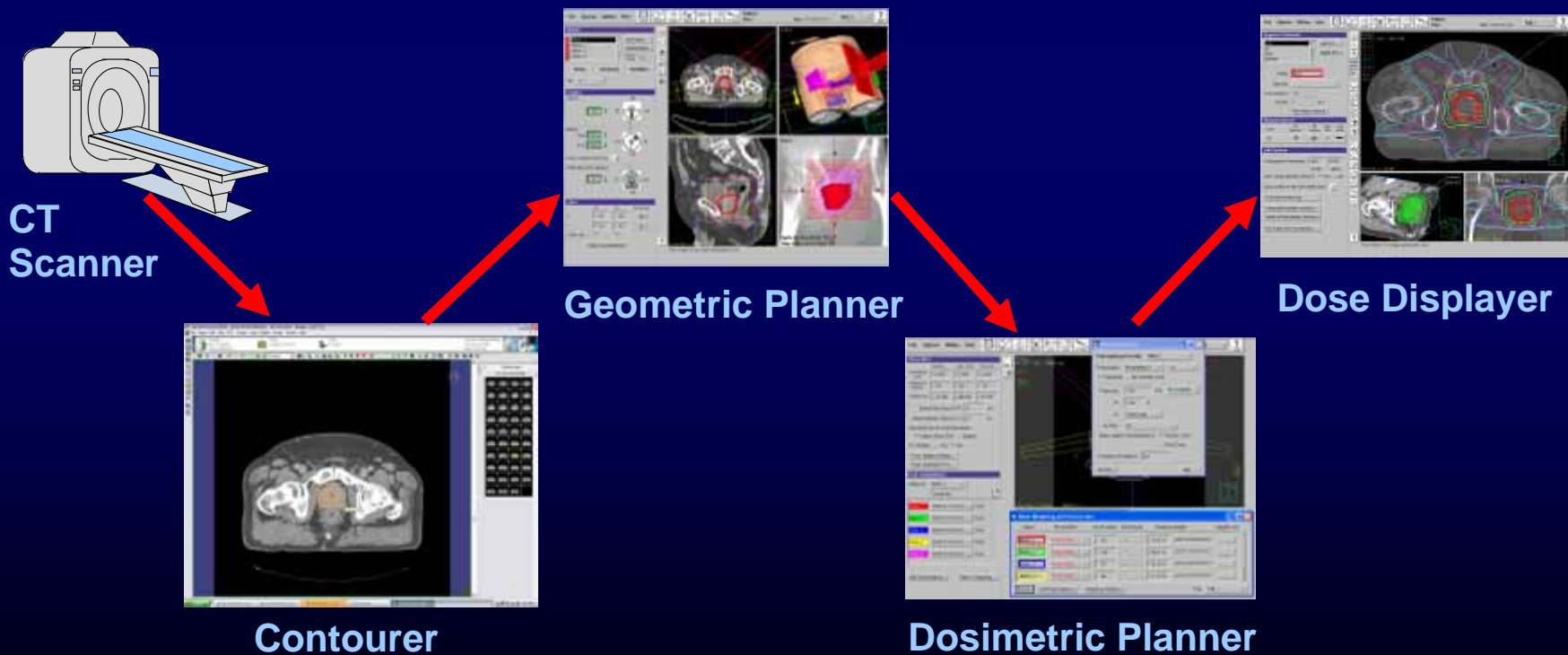
- **Others**

  ATC, IAEA, NCI, NEMA
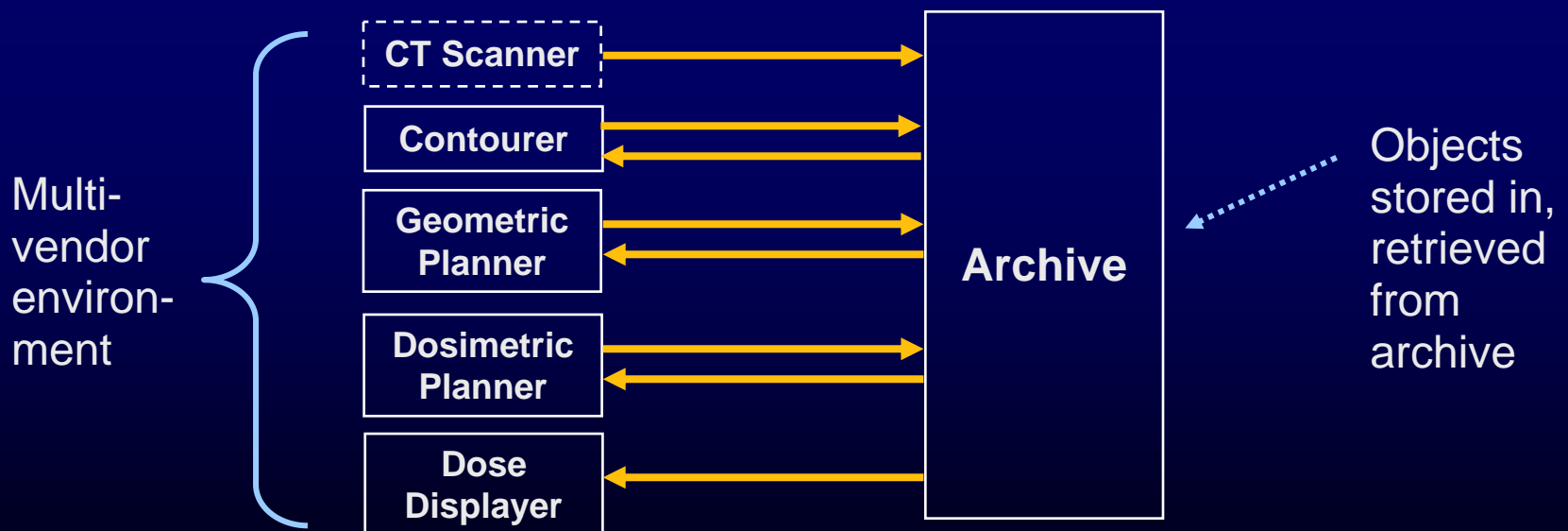
IHE-RO 2007 Profile
Normal Treatment Planning – Simple

- "Normal flow" of clinical data from CT scan through plan review for 3D conformal, external-beam RT
- Actors – abstract functions (products may implement one or more)

CT Scanner

Geometric Planner

Dose Displayer

Contourer

Dosimetric Planner

IHE-RO Goals for 2007

- Reduce ambiguity and improve basic interoperability in the use of DICOM RT <u>objects</u>.

- Emphasis is on <u>consistent interpretation</u> of DICOM objects:
  - Optional features and attributes to be supported.
  - Multiplicity of objects (e.g., contours, blocks, etc.) to be handled.

- Simplifying assumption: all TRANSACTIONS involve exchange of data to/from an RT-capable DICOM Archive.

Multi-vendor environ-ment

CT Scanner → Archive
Contourer ⇄ Archive
Geometric Planner ⇄ Archive
Dosimetric Planner ⇄ Archive
Dose Displayer ← Archive

Objects stored in, retrieved from archive

IHE-RO Technical Framework Document

Actors	Transactions	Optionality	Vol II/III section
Contourer	Single/Contoured Series Image Retrieval [RO-1]	R	3.1
	Structure Set Storage [RO-2]	R	3.2
	Multi-Series Image Retrieve [RO-6]	R	3.6
	Structure Set Retrieval [RO-7]	R	3.7
	Resampled/Combined CT Series Storage [RO-11]	R	3.11
Geometric Planner	Geometric Plan Storage [RO-3]	R	3.3
	Structure Set Retrieval [RO-7]	R	3.7

Defines a set of Actors and the Transactions in which they participate

Specifies how the DICOM standard is to be used in Transactions

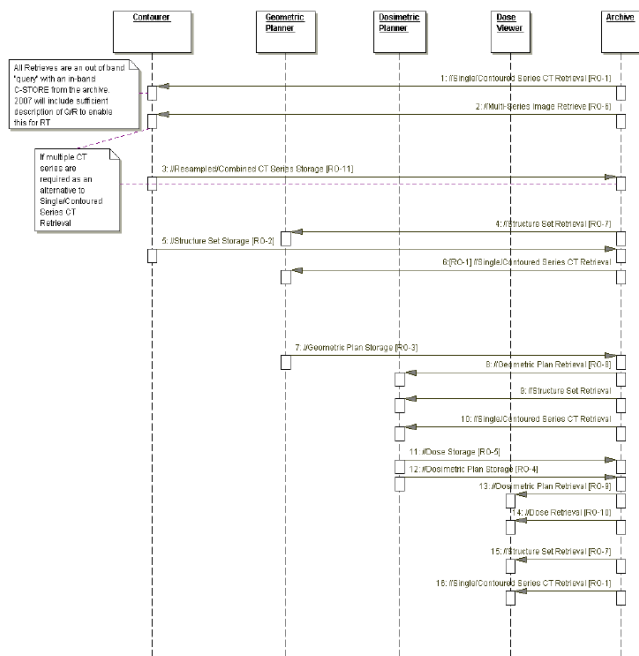### 3.2 RT Object Process Flow

Sequence Diagram

IMAGE PLANE MODULE ATTRIBUTES

Attribute	Tag	Type	Attribute Note
Image Orientation (Patient)	(0020,0037)	R+*	This element shall be present in every RT Dose IOD. For IHE-RO 2006, this element shall be restricted to AXIAL images only. For an axial image, direction cosines shall be (±1, 0, 0, 0, ±1, 0) with an angle tolerance of 0.001 radians (~0.057 degrees)
Slice Thickness	(0018,0050)	O+*	Shall not be relied on.
Slice Location	(0020,1041)	O+*	Shall not be relied on.
Pixel Spacing	(0028,0030)	O+*	For CT, non-isotropic pixels are outside the scope of the profile. For RT Dose, pixel spacing may be non-isotropic

IHE-RO 2007 Formal Connectathon Aug. 27-31, 2007, at ASTRO HQ

- Pre-testing (offline) with test tools and test data to qualify for participation in connectathon

- Formal connectathon (private) to qualify for public demonstration

- Public demonstration at ASTRO for systems able to interoperate with 3+ others

Elekta

Impac

CMS

Tomotherapy

Brainlab

Philips

Nucletron

Varian

Demonstration of Interoperability

- Test fan-in and fan-out of each actor.

- Example of retrieval of TP data for dose viewer using web interface of DICOM RT Archive

- Dosimetric Plan (DC on GP on CE):
  - Dosimetric Plan – CMS
  - Geometric Plan (CT Sim) – Philips
  - Contourer – Elekta

Demonstration of Interoperability

- Six vendors demonstrated interoperability of one or more actors and were invited to participate in the IHE-RO Demonstration at ASTRO 2007

- Examples cases from 2007 Connectathon:

  - **"We were able to take a head and neck patient CT, draw contours on Brainlab, place a non-co-planar beam on Brainlab, dose plan on Philips, dose display on Varian, archiving and distributing with Impac."**

  - **"For the prostate patient CT, we drew contours on TomoTherapy, beam placement and dose plan on CMS, and displayed on Elekta."**

- Right: example dosimetric plan data generated on Tomotherapy TPS – CT images, structure contours, and dose viewed on Elekta (upper) and Varian (lower)
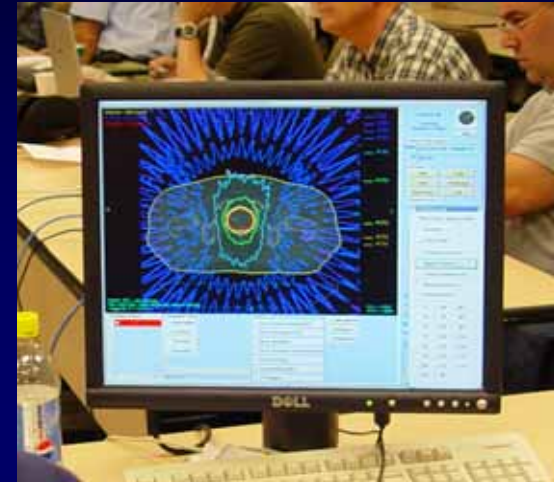
2007-8 Development Cycle

- **Image Registration Integration Profile**
  - DICOM Registration Information Object, resampled images
  - Supports CT, MR, PET
  - Actors: Registrator, Registered Display, Registered Contourer, Registered Dose Display

- **Treatment Delivery Workflow Profiles**
  - Discrete Positioning and Delivery Profile
    - Patient Positioning Systems acquires positioning images/data, performs registration of acquired data with desired position, adjusts patient position accordingly
    - Treatment Delivery Device performs delivery and internal verification
  - Integrated Positioning and Delivery Profile
    - Single system Patient Positioning and Delivery System acquires images/data, performs registration, adjusts position, delivers treatment

ATC Participation in IHE-RO

- ATC is fully committed to supporting the mission and vision of IHE in Radiation Oncology.
- Dr. Bosch's participation in IHE-RO Technical Committee meetings has been sponsored by ASTRO.
  - Data preparation and evaluation as part of Test Committed for 2006 Informal Testing and 2007 Formal Connectathon
  - Approx. four Technical Committee meetings per year 2005-2007
  - Next meeting: Mar 3-12, 2008, Munich (Informal testing of 2008 profiles, begin draft of 2009 profiles)
- IHE International is working toward non-profit incorporation in Mar 2008
  - Principles of Governance adopted Oct. 2007
  - ATC has applied to become a voting member of IHE International

IHE-RO Timeline

- Dec 2004 (RSNA) – Organizational Meeting
- Jan 2005 (NEMA) – Identify Use Cases
- Apr 2005 (NEMA) – Identify Actors
- Aug 2005 (IMPAC) – Define Transactions
- Oct 2005 (ASTRO) – Joint PC/TC Meeting
- Jan 2006 (AAPM) – Review Transactions Document
- Apr 2006 (ITC) – 2006 Demo, 2007 Use Cases
- Aug 2006 (AAPM-HQ) – Connectathon Planning
- Sep 2006 (ASTRO-HQ) – 2006 Informal Testing
- Jan 2007 (IMPAC) – Identify 2008 Actors, Transactions
- Apr 2007 (Madison, WI) – Draft 2008 Reg, Workflow profiles
- Jul 2007 (AAPM) – Finish 2008 Profile drafts
- Aug 2007 (ASTRO-HQ) – 2007 Formal Connectathon
- Sep 2007 (ASTRO) – Joint PC/TC Meeting
- Mar 2008 (Munich) – Informal testing, begin work on 2009 TF
- Jul 2008 (Houston) – 2008 Formal Connectathon

ATC – Advanced Technology Consortium
Providing support in quality assurance and data management for radiation therapy clinical trials

DICOM: 2nd Generation RT Objects

- Some limitations of current DICOM RT objects
  - Complex referential structure means changes in one object may necessitate changes in others objects just to maintain referential integrity.
  - Difficulty in retrieving a collection of RT objects for a given phase of a patient's treatment
  - New DICOM objects offer better representation for image segmentation
  - Multiple uses of RT Plan for prescription, plan development, approval, delivery.
  - Complex conditions of a common RT Plan object used in multiple contexts, many optional attributes

DICOM WG-7 Activities

- New RT objects (larger number of smaller objects)
  - Workflow instructions
  - Physician Intent, RT Planning Prescription objects
  - RT Course ("container") object – support for unmanaged workflow, clinical trials submissions
  - Use new DICOM segmentation (surface, volume) and registration (rigid, deformable) objects
  - Radiation Set (fraction group)
  - Separate radiation delivery objects per treatment modality: C-arm Photon Beam, C-arm Electron Beam, C-arm Ion Beam, Tomotherapeutic Photon beam, Non-isocentric Photon Beam

DICOM WG-7 Meeting Schedule

- 2007 meetings addressing the design of 2nd - generation DICOM RT objects
  - Los Angeles (ASTRO) - Oct 30 – Nov 2, 2007
  - Las Vegas - Dec 10-14, 2007
- WG-7 Meetings Scheduled for 2008
  - April 22-25, 2008 – NEMA HQ
  - June 16-19, 2008 – Albuquerque
  - Oct. 21-24, 2008 – Tampa