



# Electronic Oncology Systems

– the Management and the Safety Measures

**Hansen Chen, Director, TDSI**

 **NewYork-Presbyterian**  
 The University Hospital of Columbia and Cornell

TECHNOLOGY  
DEVELOPMENT  
+  
SYSTEM  
INTEGRATION

# Radiation Oncology Department

- People
- Place
- Equipments
- Procedures
- Patients



# Radiation Oncology Staff

*People*

**Oncologist**



**Physicist**



**Dosimetrist**



**Engineer**



**Sim Tech**



**Administrator**



**Therapist**



**Nurse**



**Clerical**



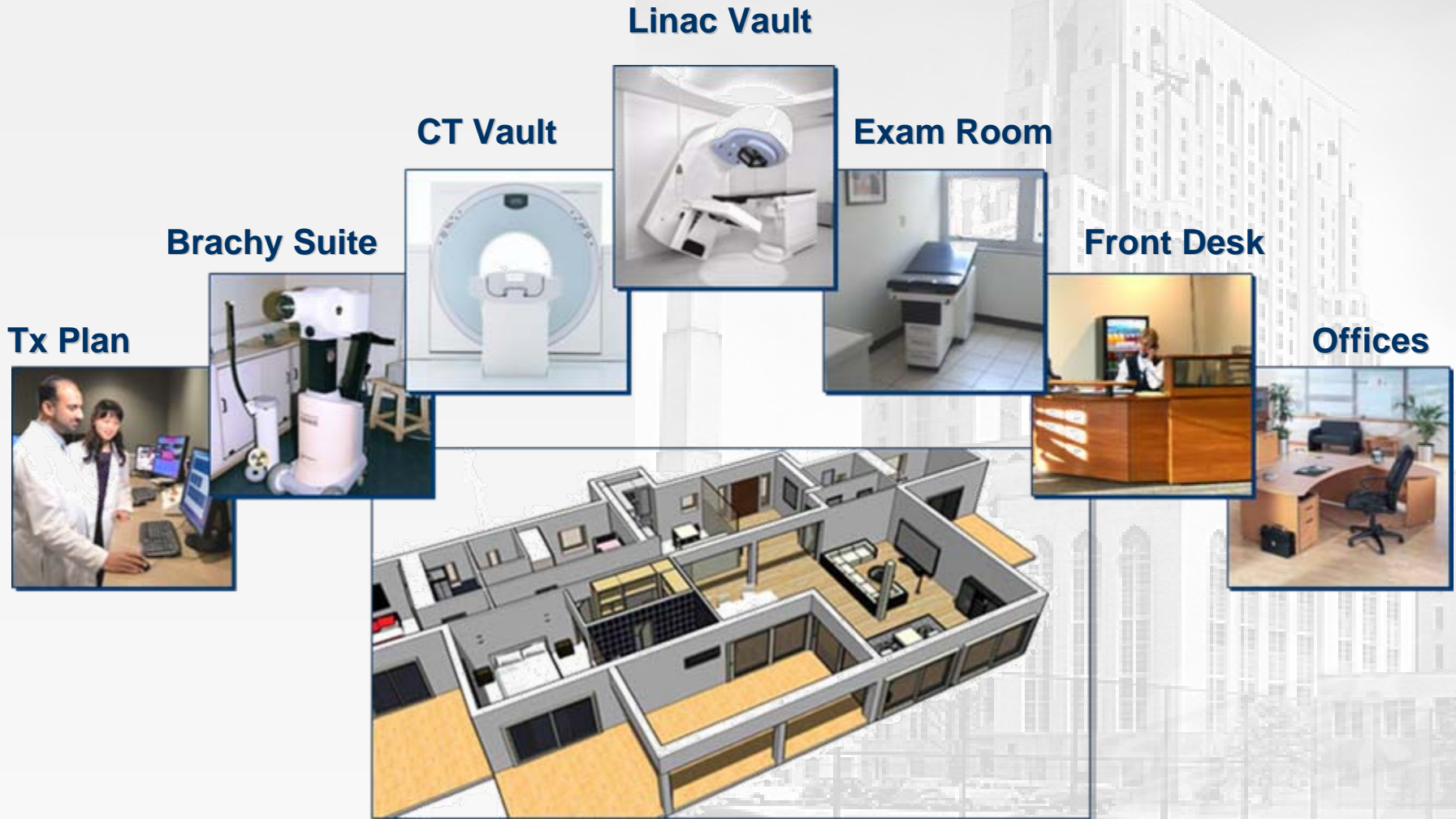
**Billing**



Hansen Chen

# Department Layout

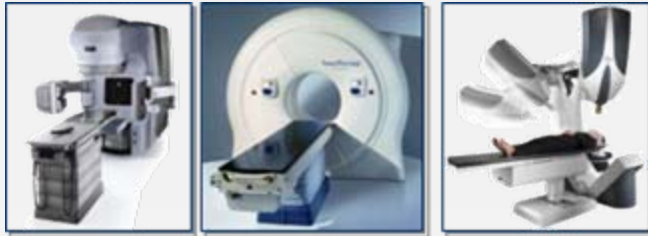
Place



# Machines and Systems

# Equipment

## External Beam Machines



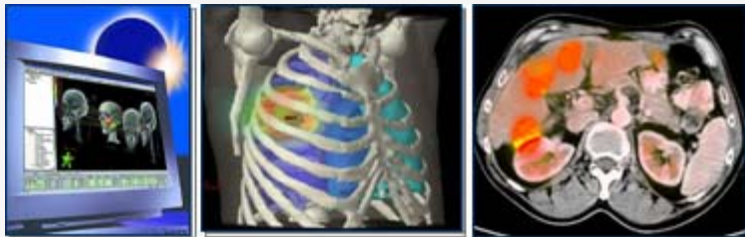
## CT Simulators



## Brachytherapy Machines



## Treatment Plan Systems



## Oncology Info Systems



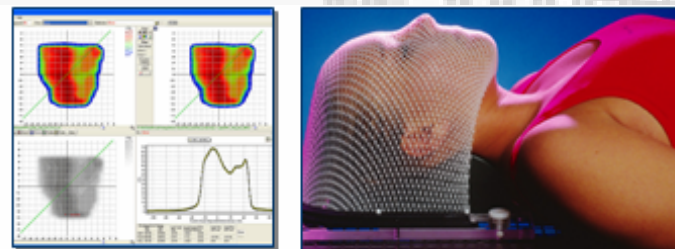
## IT Infrastructure



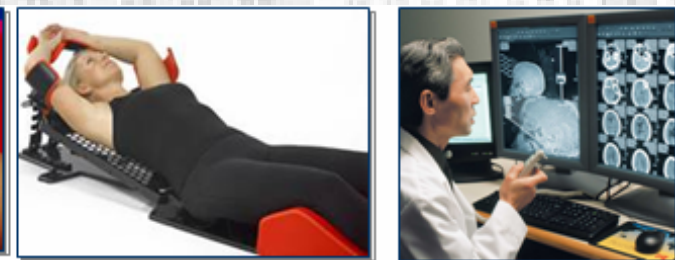
## Calibration Devices



## Treatment Accessories



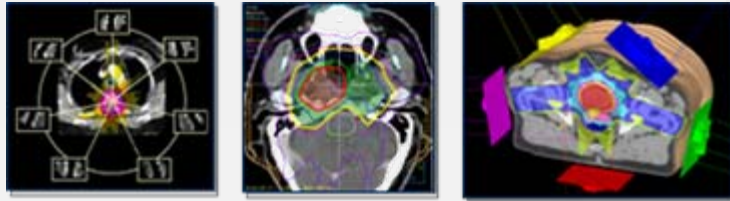
## Oncology PACS



# Clinical Procedures

*Procedure*

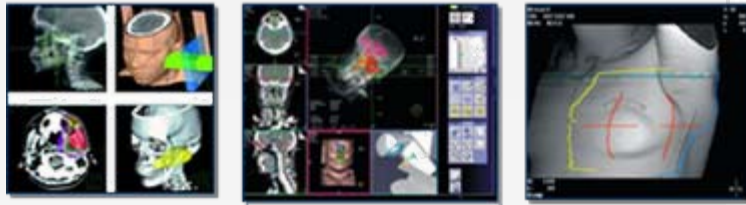
## External Beam IMRT



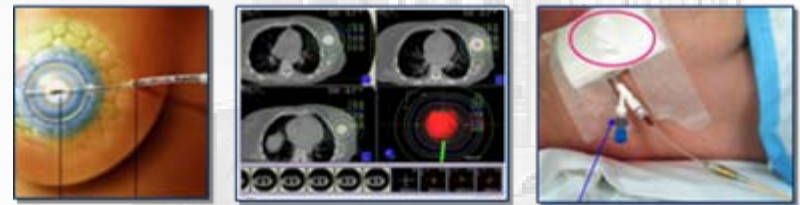
## Image Guided Radiotherapy



## CT Simulation



## MammoSite APBI



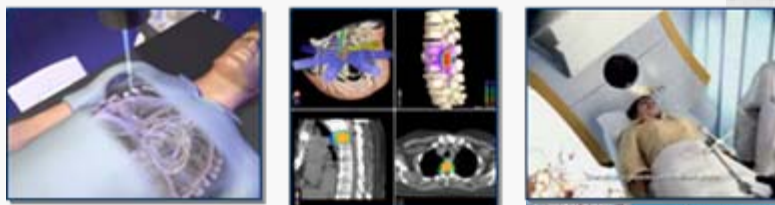
## Stereotactic Radiosurgery



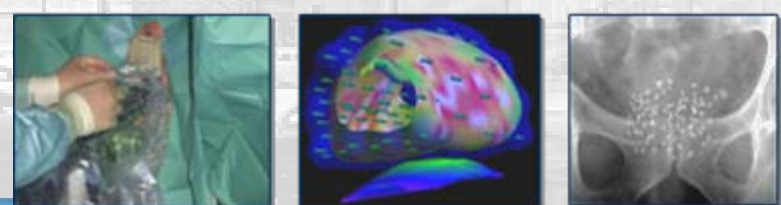
## HDR Brachytherapy



## Stereotactic Body Radiotherapy

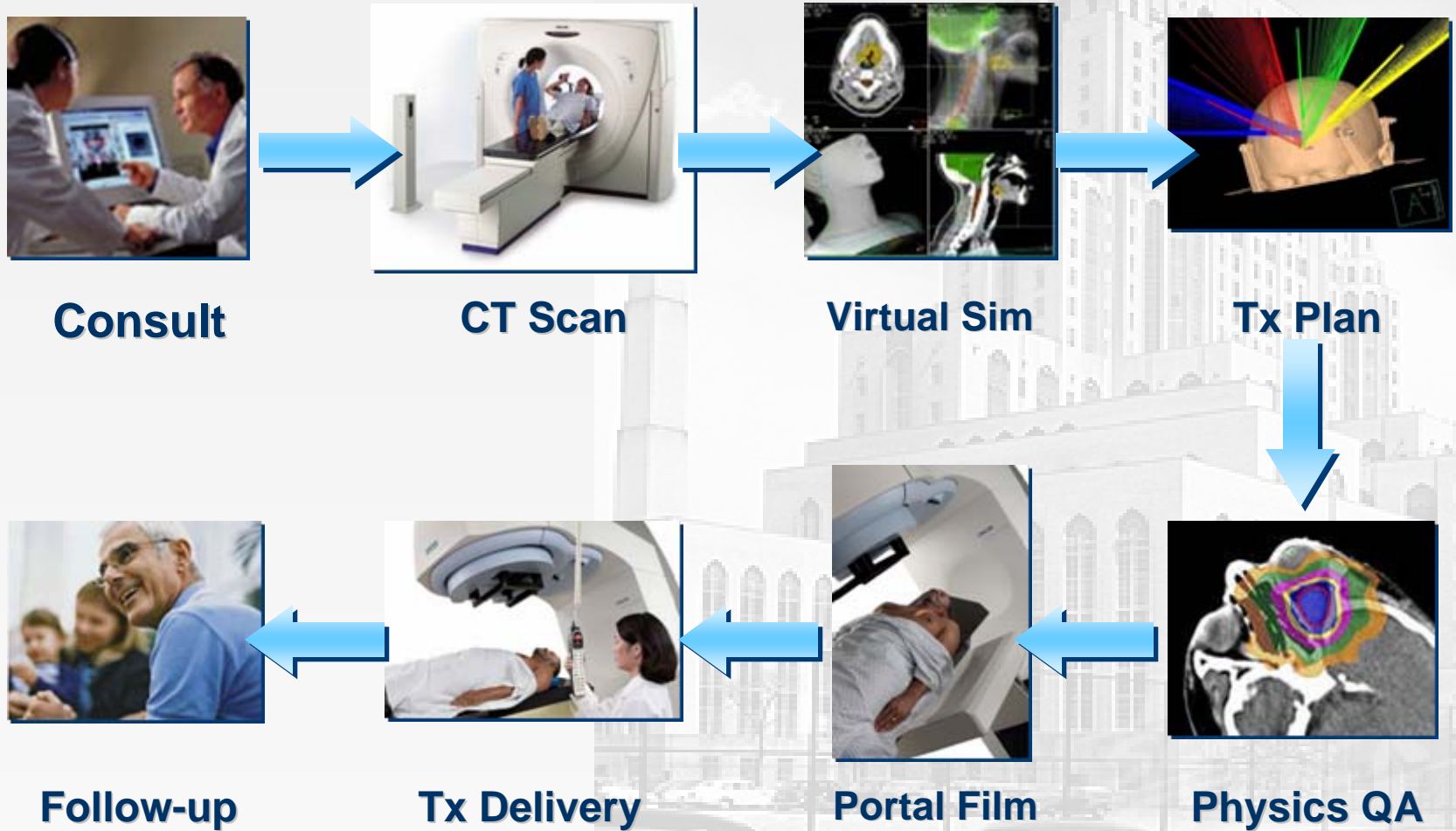


## Prostate Seeds Implant



# Patient Visit Flow (ex. IMRT)

*Patient*



# Yes, It's Quite Complicated Operation!

*People*

*Place*



*Equipment*

*Procedure*



# Mitigation of Potential Errors

- More Manpower
- More Checking Procedures
- More Equipments
- Use of Computer Technologies
- Buy More Liability Insurance...



# What Computer Can Do



## Jaw Treatment Setup Message Downloaded (TSD - JAW)

Patient ID: A050809

Course: 1, Field: '001A', Fraction 0, Attempt: 1

Oper. Mode: 1, Seg. Total: 20, Seg. number: 1, Seg. Attribute: 0x00301000

Mode: X-ray, Energy 6, Technique: Fixed

Dose: 50.0 MU, Dose Rate: 0 MU/Min

# Used: 1, Accessory A: RETIC, Accessory B: ,Accessory C:

Collimator: 90.0, Gantry: 0.0, Arc: 0.0, Direction: CCW

Field Type: 0

Jaw X1: 5.0, Jaw X2: 100.1

Jaw Y1: 5.0, Jaw Y2: 100.1

MLC X1: 10.2, 10.5, 8.7, 6.3, 7.2, 8.1, 9.5, 9.5, 9.6, 9.8, 10.6, 11.3

MLC X2: 7.2, 6.5, 8.7, 6.3, 7.2, 8.1, 9.5, 9.5, 9.6, 9.8, 6.9, 9.3

Table Longitudinal: 0.0, Lateral: 0.0, Vertical: 0.0

Isocentric: 0.0, Eccentric: 0.0

Relative Table Longitudinal: 0.0, Lateral: 0.0, Vertical: 0.0

Isocentric: 0.0, Eccentric: 0.0

Epid Acquisition: 0

Epid Table Longitudinal: 0.0, Lateral: 0.0, Vertical: 0.0

VW Original MU: 0.000000, VW Dynamic Jaw: 0.00

Data Valid 32-Bit Mask: 0x0000f1ef



# What Computer Can NOT Do

- Preparing the
- Potential Error

## Jaw Treatment Setup Message Downloaded (TSD - JAW)

Patient ID: A050809

Course: 1, Field: '001A', Fraction 0, Attempt: 1

Oper. Mode: 1, Seg. Total: 20, Seg. number: 1, Seg. Attribute: 0x00301000

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MLC X2: 7.2, 6.5, 8.7, 6.3, 7.2, 8.1, 9.5, 9.5, 9.6, 9.8, 6.9, 9.3

Table Longitudinal: 0.0, Lateral: 0.0, Vertical: 0.0

Isocentric: 0.0, Eccentric: 0.0

Relative Table Longitudinal: 0.0, Lateral: 0.0, Vertical: 0.0

Isocentric: 0.0, Eccentric: 0.0

Epid Acquisition: 0

Epid Table Longitudinal: 0.0, Lateral: 0.0, Vertical: 0.0

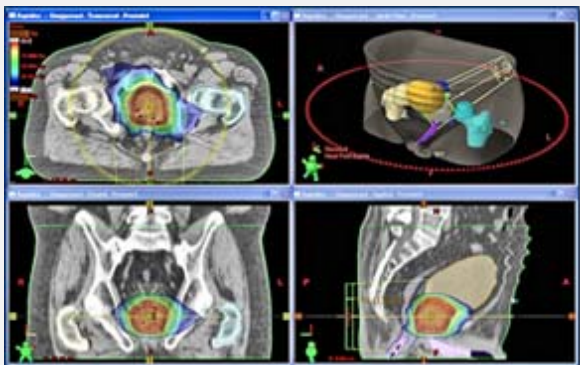
VW Original MU: 0.000000, VW Dynamic Jaw: 0.00

Data Valid 32-Bit Mask: 0x0000f1ef

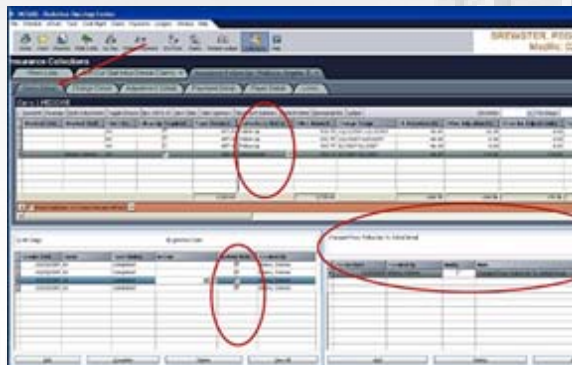


# Electronic Oncology Systems (EOS)

## Treatment Plan System



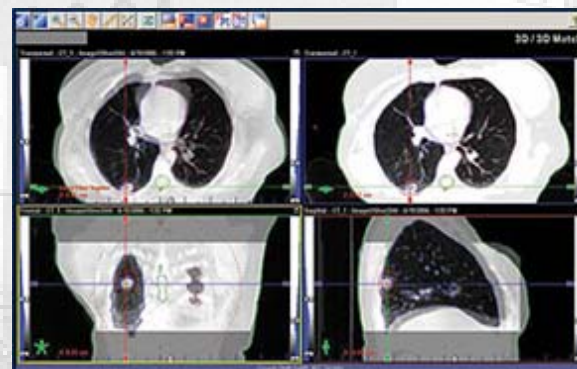
## Oncology Information System



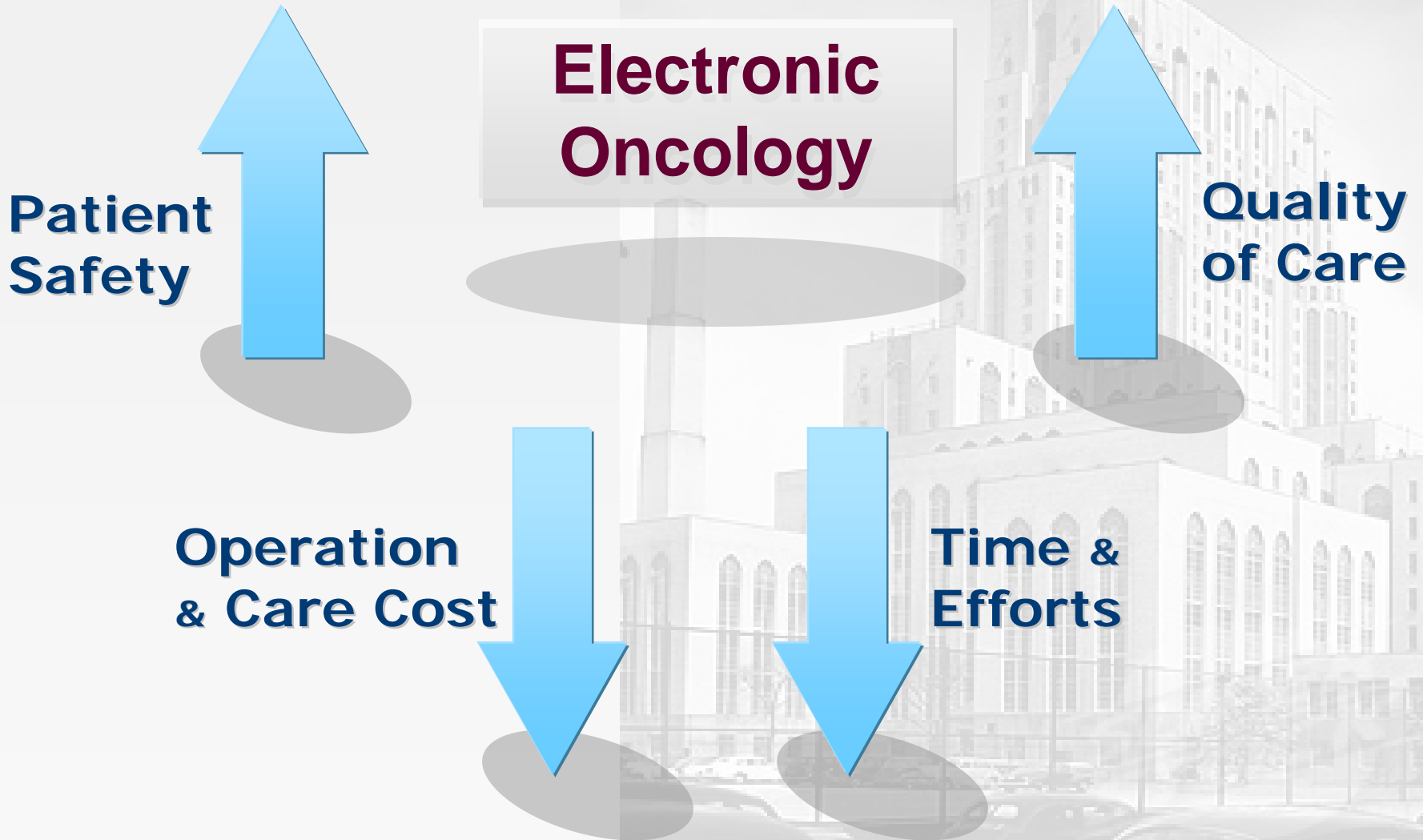
## Treatment Delivery System



## Treatment Verification System



# EOS System Design Guidelines



# Electronic Oncology Systems Management

- IT Infrastructure
  - ❖ Servers and Clients
- Data Safety in Storage
  - ❖ Backup and Archive
- Data Safety in Communication
  - ❖ Data Integrity in Transmission & Execution
- Systems Monitoring
  - ❖ Responsibilities
- Policy & Procedures
  - ❖ System Malfunction etc

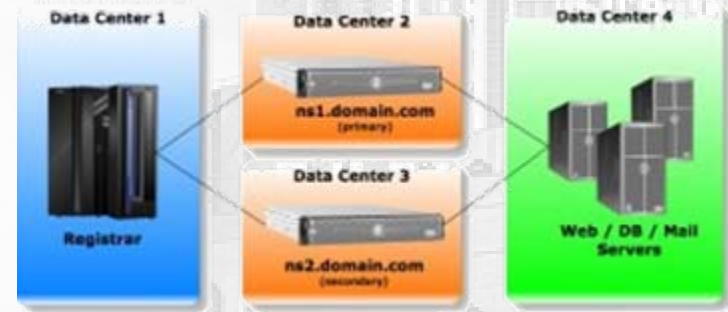


# EOS IT Infrastructure

## Centralized Computing



## System Redundancy



# Systems Infrastructure Before

Columbia Campus



Cornell Campus



**License + Service**

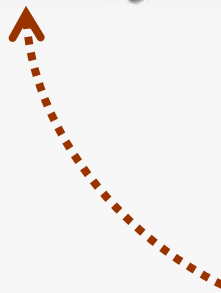


# Centralized System Infrastructure

Columbia Campus

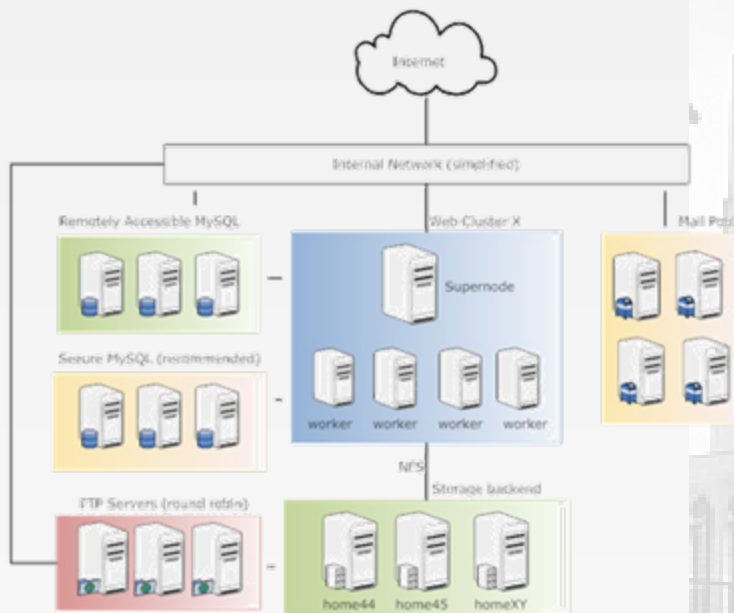


Cornell Campus

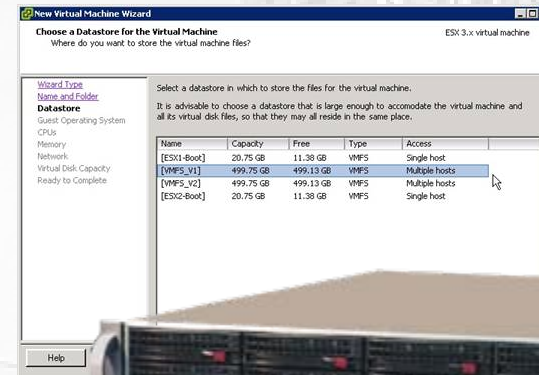


# Systems Redundancy

## Clustered Data Servers

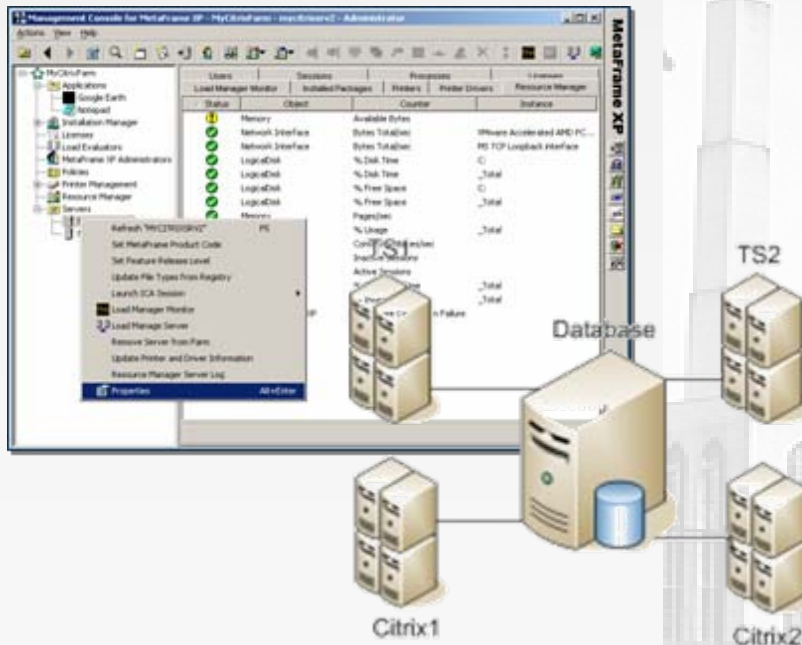


## SAN (Storage Area Network)



# Application Deployment Servers

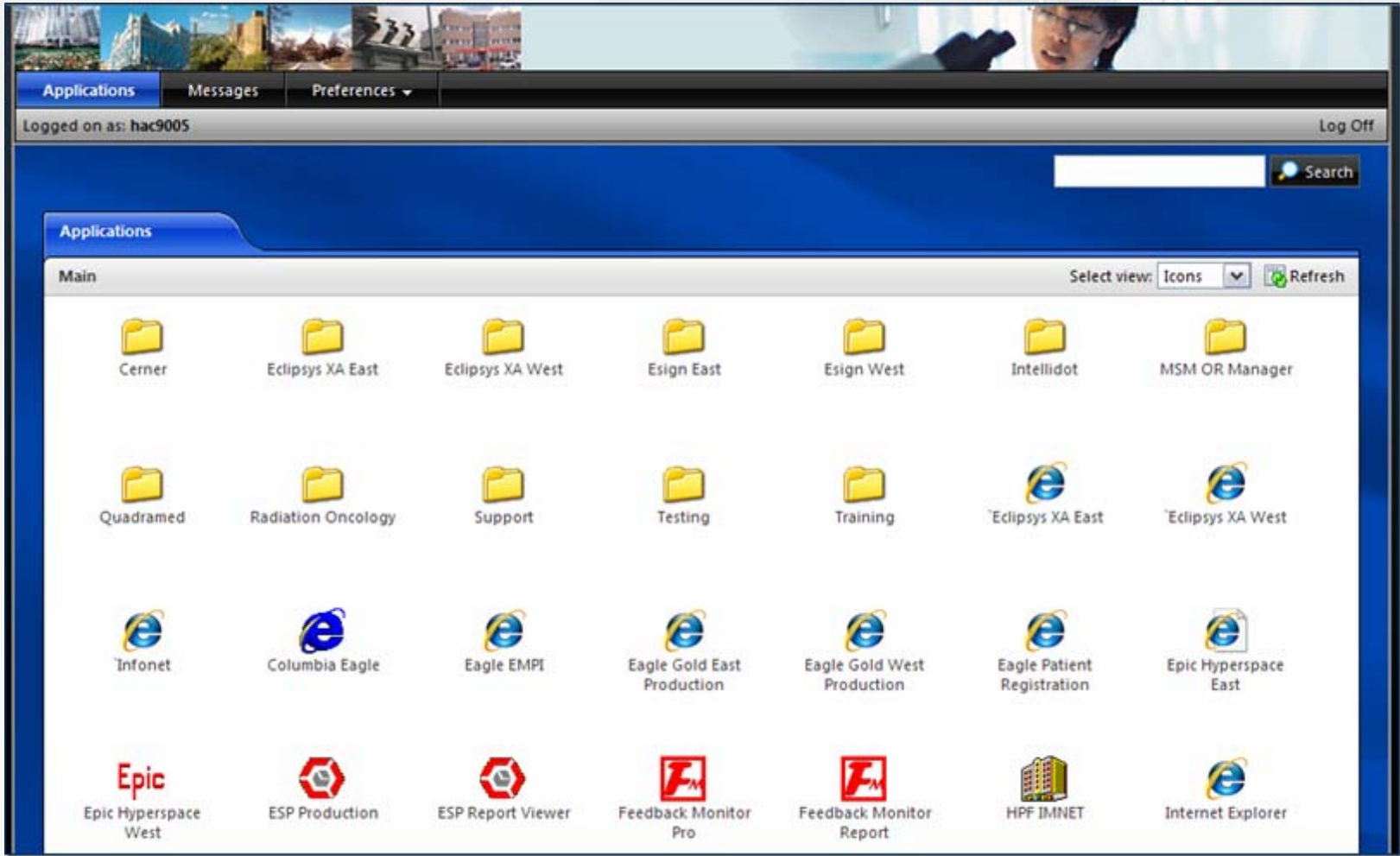
## Citrix Server Farms



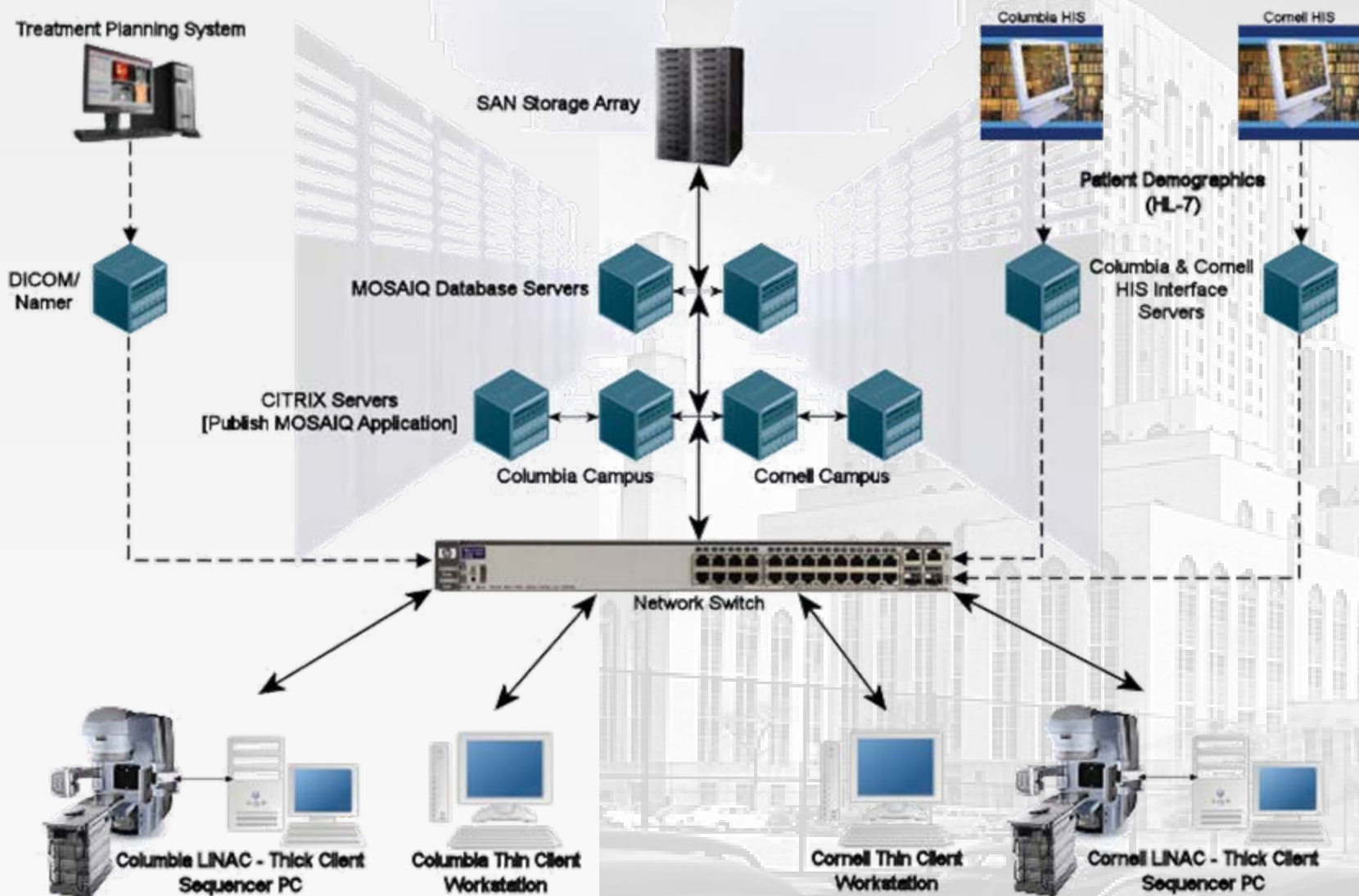
## SunRay Server Array



# Citrix ITA Thin Client Access



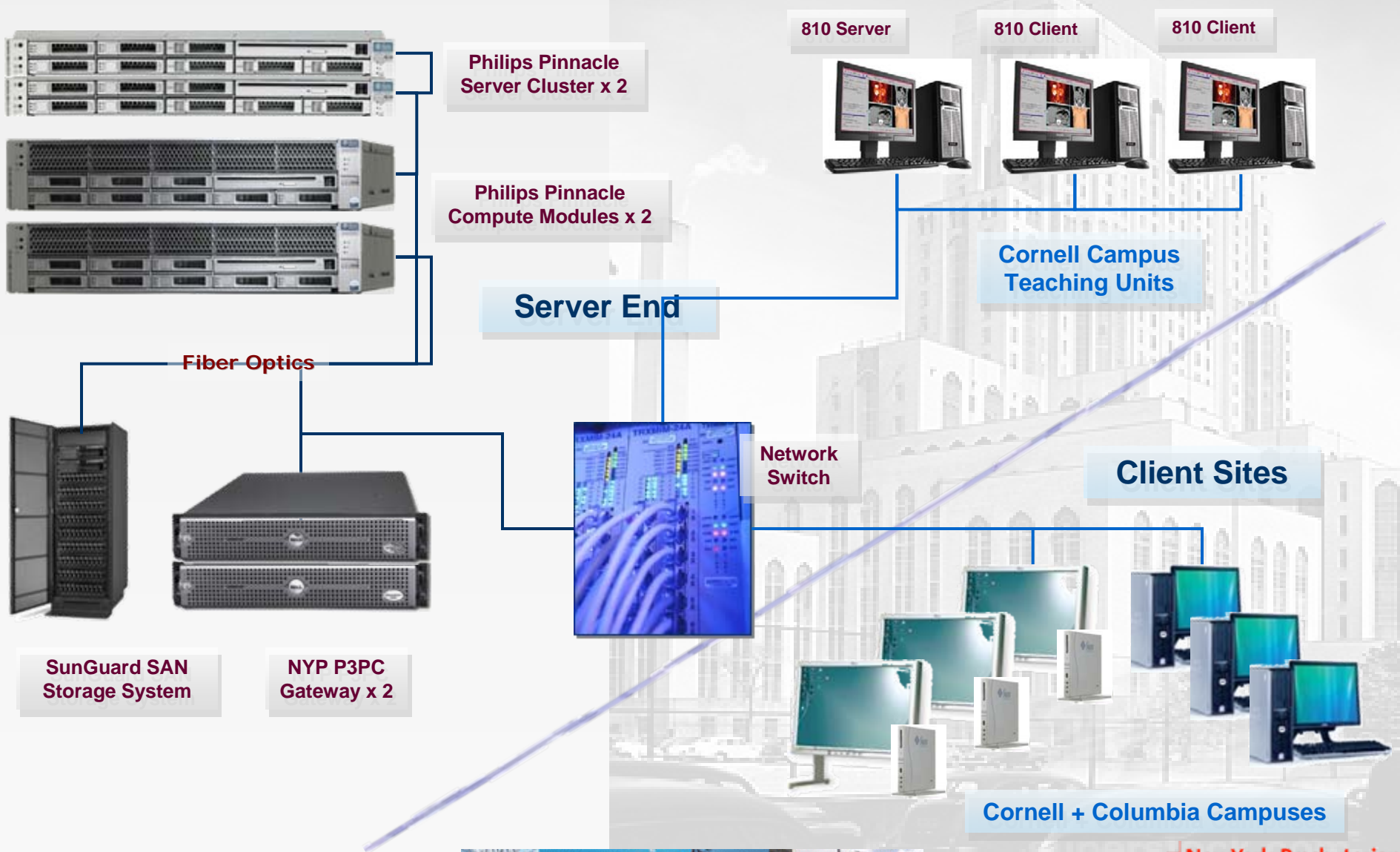
# Oncology Information System Topology



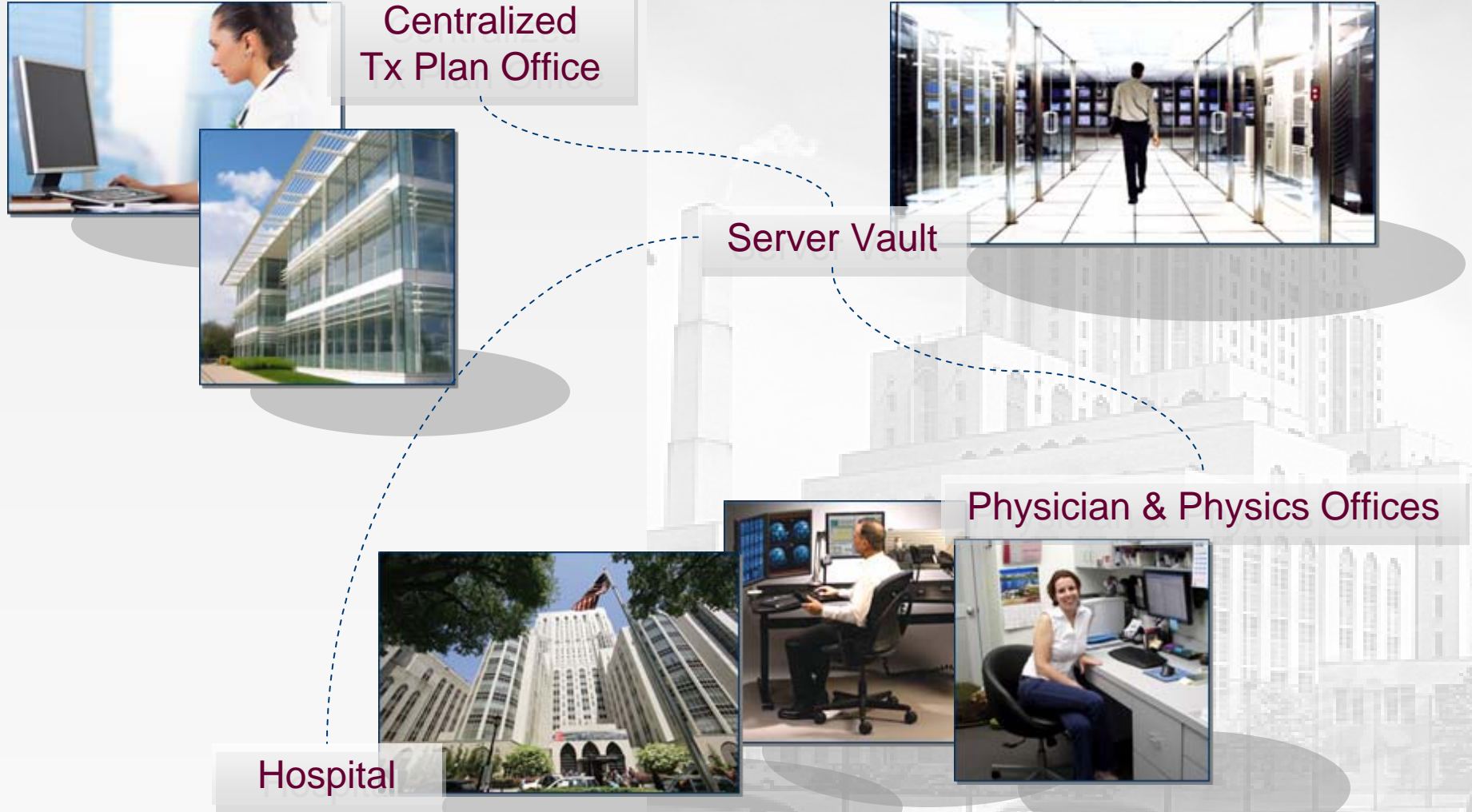
# Pinnacle SunRay Thin Client



# Pinnacle SmartEnterprise Topology



# Centralized Tx Plan Topology





# One Workstation for 10 People



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# Bring Technology to People Not People to Technology



# Contouring

Ho\*Peggy - IKOE --- Fusion and Contouring Tools

File Edit Options Help

standard layout

**Parotid**

Type: Gland

**Function:** Secretes saliva through Stenson's duct into the oral cavity to facilitate mastication and swallowing

**Innervation:** Parasympathetic: secretion of saliva by the parotid gland is controlled by the presynaptic parasympathetic fibres originating in the inferior salivatory nucleus; these leave the brain via the glossopharyngeal nerve (CN IX), travel along the tympanic nerve (of Jacobson), pass through the tympanic plexus and then travel in the lesser petrosal nerve until they reach the otic ganglion. After synapsing, the postganglionic fibers travel as part of the auriculotemporal nerve, a branch of the mandibular nerve (v3) to reach the parotid gland. Sympathetic: sympathetic nerves originating from the Superior Cervical Ganglion

5 mm in all directions

More caudal margin maybe needed for tumor with pharyngeal wall or subglottic extension

Include nodal GTV with 5mm margin in all directions

CTV1 margin around GTV need to be individually determined by physical examination and image studies

If tumor boundary is not descriptive, greater margin may be needed

800  
700  
600  
500  
400  
300  
200  
100  
0

1055  
332

868.60 MB (42.46 %)



# Tx Plan

Planning

File Options Utilities View Setup Contours Points Beams Dose Eval IMRT Inv Plan

Patient: [redacted] Plan: Plan\_0 Rev: R01.P01.D01 final

**Beams**

- g27.6
- g346
- g298.8
- g239

Add Beam  
Delete Beam...  
Control Point: 4

Setup Geometry Modifiers

Name: g27.6 Field ID: [redacted]

Machine: PrimusAB  
Version: 2007-09-05 10:30:21  
Modality: Photons

Final Absolute

- 6300.0 cGy
- 6000.0 cGy
- 5700.0 cGy
- 5400.0 cGy
- 4500.0 cGy
- 3000.0 cGy

Slice 39; Z = 66.450

Final Absolute

- 6300.0 cGy
- 6000.0 cGy
- 5700.0 cGy
- 5400.0 cGy
- 4500.0 cGy
- 3000.0 cGy

Slice 256; X = -0.000

Final Absolute

- 6300.0 cGy
- 6000.0 cGy
- 5700.0 cGy
- 5400.0 cGy
- 4500.0 cGy
- 3000.0 cGy

Slice 256; Y = -74.300

Localization System: Laser Valid

Details...



# Plan Review

**Workflow Panel**

- Open
- Iso Ctr
- Protocol
- Report

**RTSS Panel**

- GTV
- CTV
- PTV
- Cord
- Brain Stem
- Rt Parotid
- Lt Parotid
- Mandible
- Rt Eye
- Lt Eye
- Rt Optic Nerve
- Lt Optic Nerve

**Axial view**

Converted Absolute

- 6321.0 cGy
- 6020.0 cGy
- 5544.0 cGy
- 5292.0 cGy
- 5040.0 cGy
- 4536.0 cGy
- 3528.0 cGy
- 2520.0 cGy
- 1008.0 cGy

HEMERSON, AUDREY

**Sagittal view**

Plan CT

Converted Absolute

- 6321.0 cGy
- 6020.0 cGy
- 5544.0 cGy
- 5292.0 cGy
- 5040.0 cGy
- 4536.0 cGy
- 3528.0 cGy
- 2520.0 cGy
- 1008.0 cGy

Slice 398: X = 37.219 ... HEMERSON, AUDREY

**Coronal view**

Plan CT

Converted Absolute

- 6321.0 cGy
- 6020.0 cGy
- 5544.0 cGy
- 5292.0 cGy
- 5040.0 cGy
- 4536.0 cGy
- 3528.0 cGy
- 2520.0 cGy
- 1008.0 cGy

HEMERSON, AUDREY

**Status**

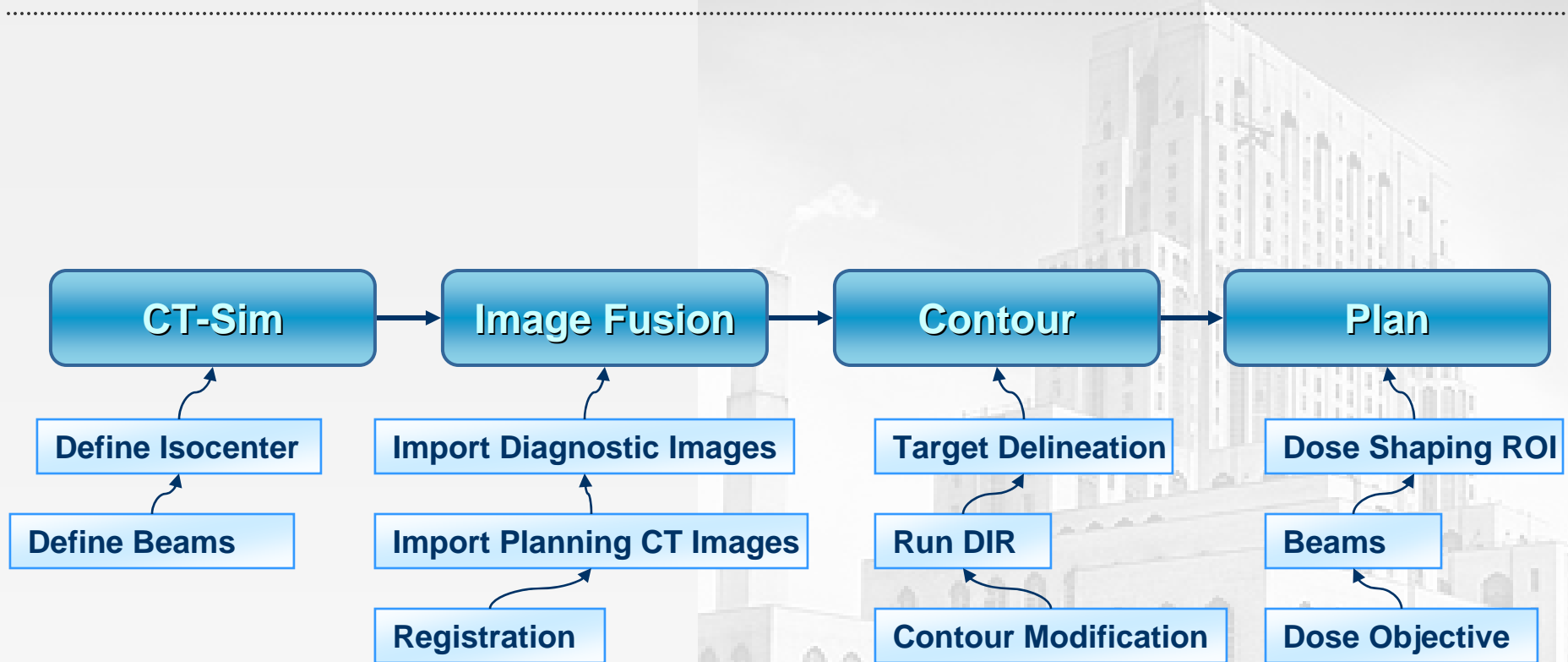
Graph showing dose distribution curves for various structures.

NewYork-Presbyterian Hospital    Workstation: Physics    Login User: Hansen Chen    Software Ver: 1.116



Hansen Chen

# Multi-User Environment

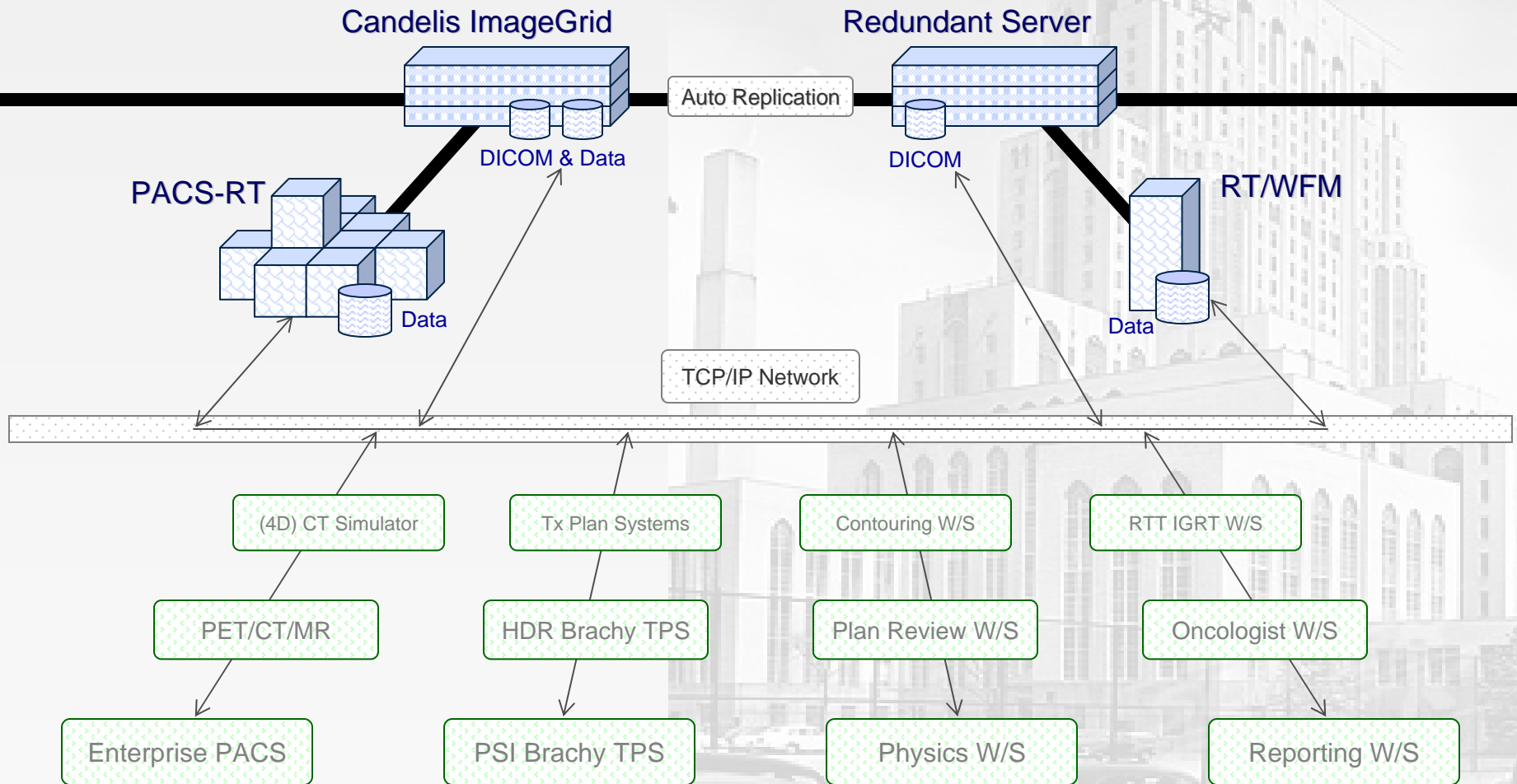


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# Workflow Streamline ≠ a Straight Line

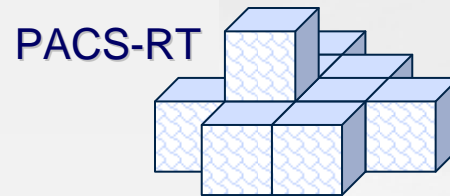


# PACS-RT System

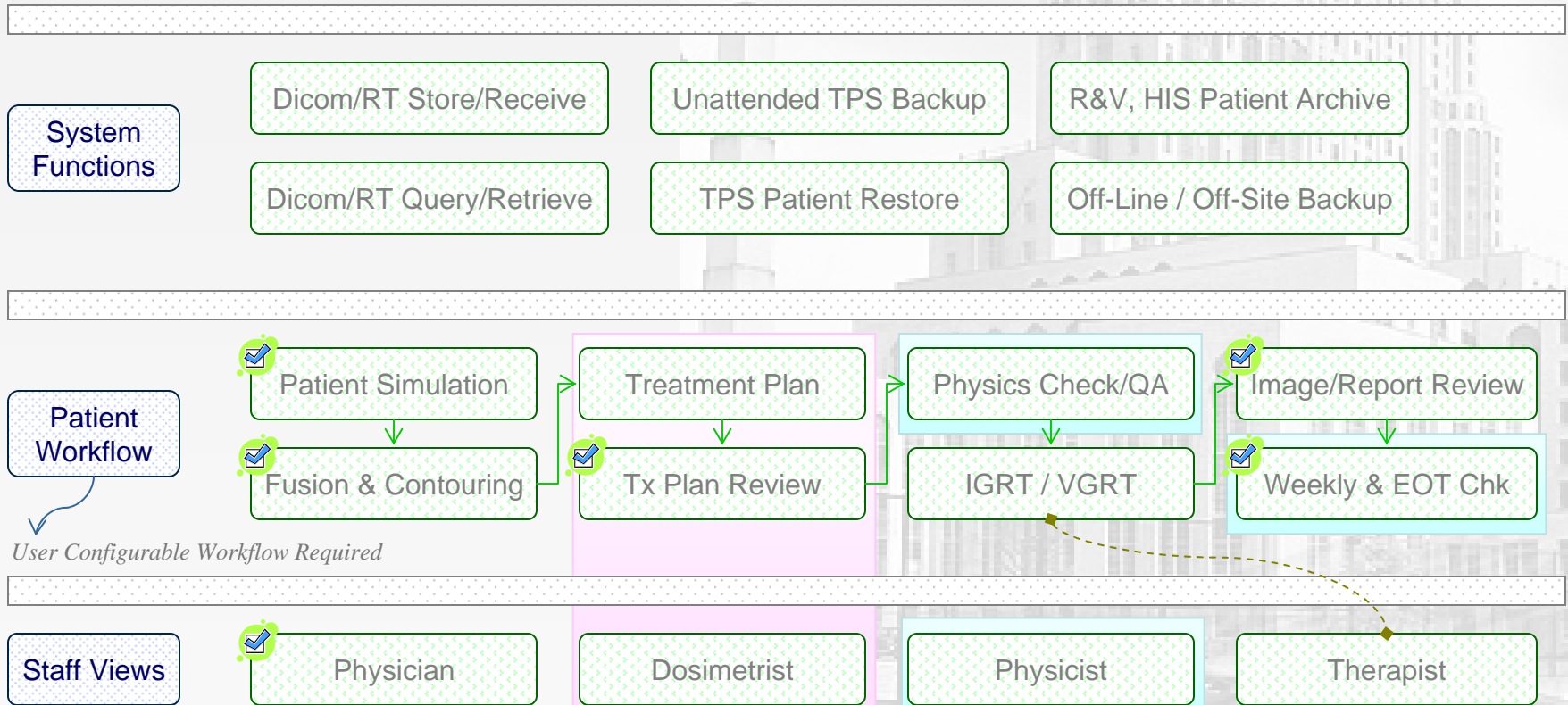




# Workflow Management



Web Based Workflow Manager

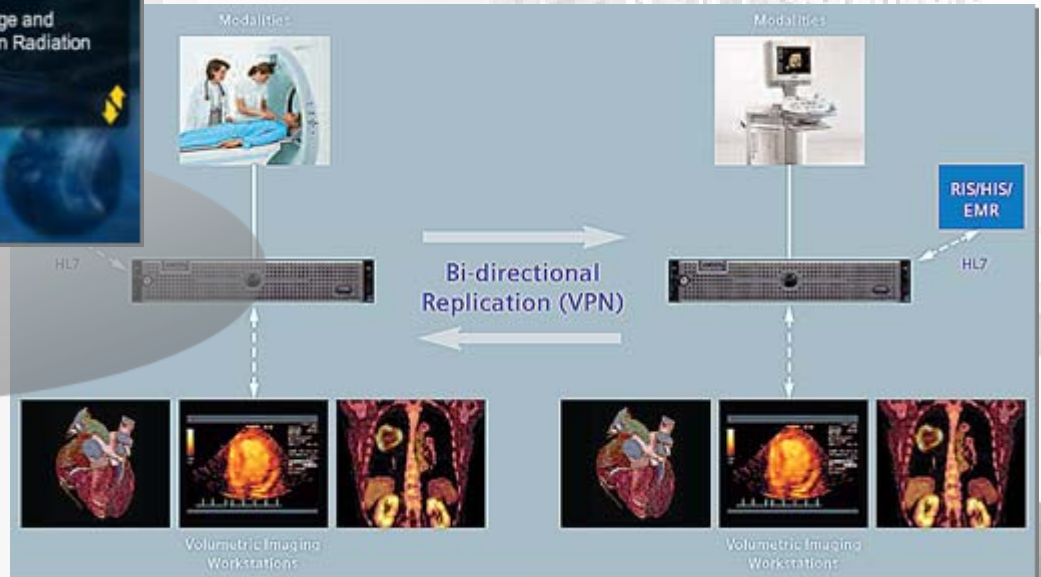


# Oncology PACS Storage

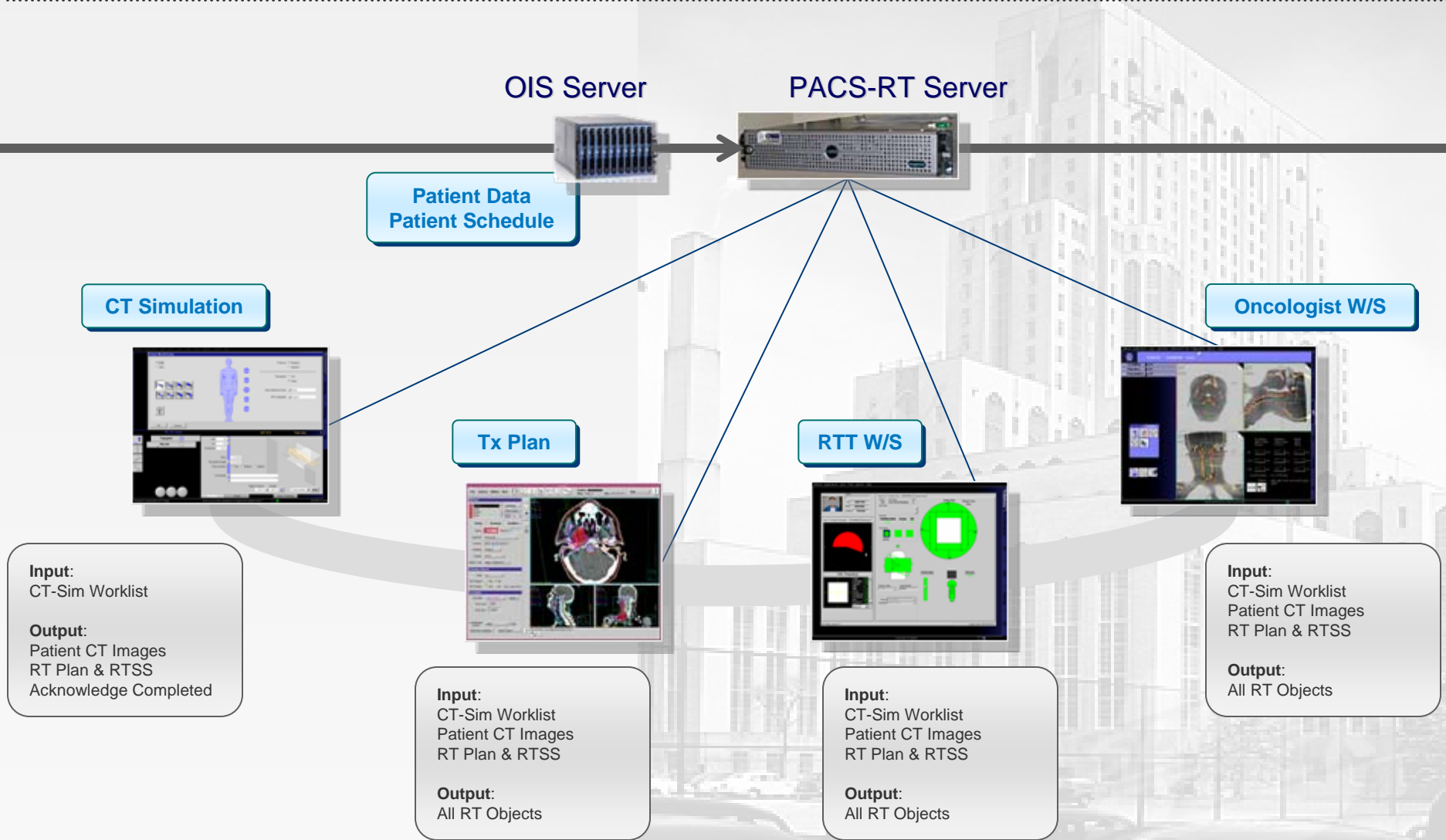


**RADIATION THERAPY**  
Mastering the Data Storage and Visualization Challenge in Radiation Therapy.  
[Read More](#)

**CANDELIS**  
A Technology Revolution

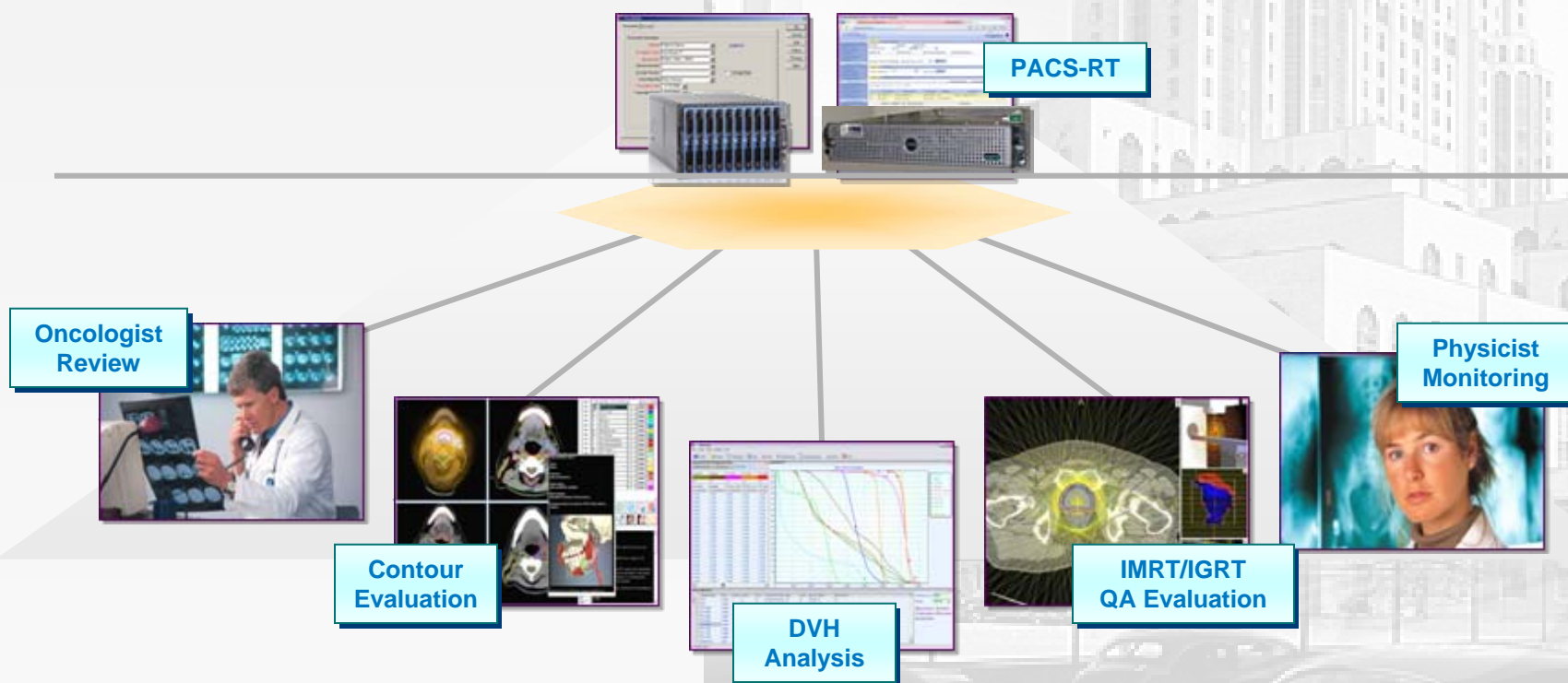


# Centralized PACS-RT Server



# Integration with PACS-RT

- Use of Back-bone PACS-RT Server
  - ❖ Supporting DICOM Query & DICOM Work List



# Data Tsunami

- **Active Data**
  - ❖ Patients Under Care
- **Static Data**
  - ❖ Patient Follow-Ups
- **Data Types**
  - ❖ Medical Records, DICOM Images, DICOM RT Objects



# EOS Safety in Storage

- Online Data Redundancy – Clustered Servers and SAN
  - ❖ Patients Under Treatment
- Near-Line Data Redundancy – Oncology PACS
  - ❖ 6 Months to a Year
- Off-Line Data Redundancy – Enterprise Archive in Different Geometric Locations
  - ❖ Beyond a Year



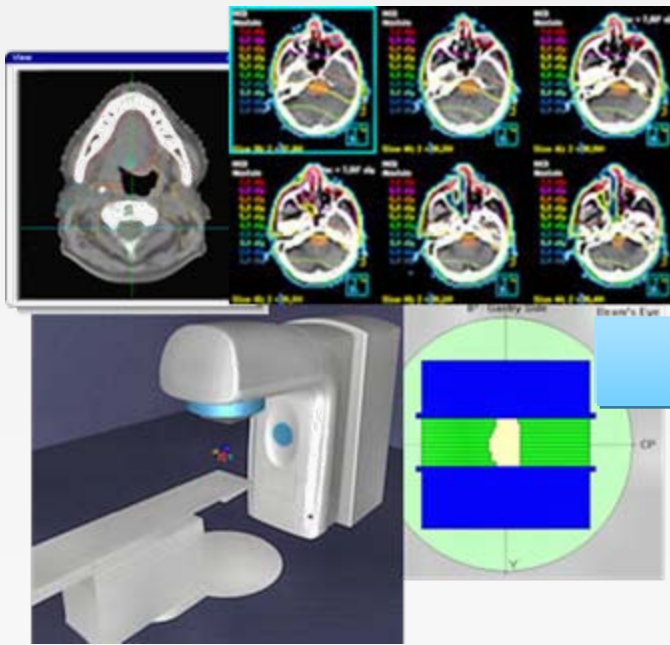
# EOS Safety in Communication

- Adapting from FDA 510K Guidelines
  - ❖ High Level System Description
  - ❖ Architecture Design Chart
  - ❖ Hazard Analysis & Risk Management
  - ❖ System Requirement Specification (SRS)
  - ❖ System Design Specification (SDS)
  - ❖ Hazard Trace Matrix & Traceability Analysis
  - ❖ Operation Environment
  - ❖ Verification and Validation
  - ❖ Unresolved Anomalies



# High Level Systems Description

## Approved Tx Plan



## Daily Tx Delivery



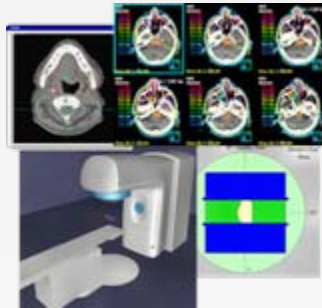


# Architecture Design Chart

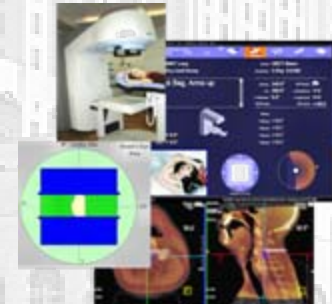
## 2.2 Product Perspective Processes I/O Table

Process	Inputs			Input Data Description	Outputs
	User Input	Process Input	Default Data		

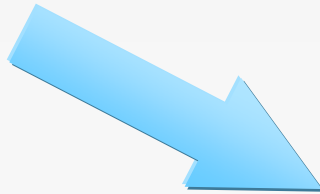
**Approved Tx Plan**



**Daily Tx Delivery**



**R&V System**

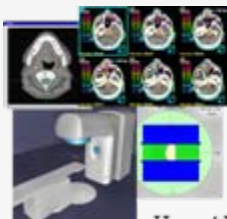


# Hazard Analysis & Risk Management

		Severity			
		I Major	II Moderate	III Minor	IV Negligible
Likelihood	A-frequent	I-A	II-A	III-A	IV-A
	B-probable	I-B	II-B	III-B	IV-B
	C-occasional	I-C	II-C	III-C	IV-C
	D-remote	I-D	II-D	III-D	IV-D
	E-improbable	I-E	II-E	III-E	IV-E
	F-incredible	I-F	II-F	III-F	IV-F

Intolerable risk
Undesirable risk
Tolerable risk
Negligible risk

## Approved Tx Plan



Hazard ID: 2.2.1

Cause	Loading patient
Risk Index prior to mitigation	II-B
Mitigation	Software user in the whole sets of
Risk Index after mitigation	IV-F

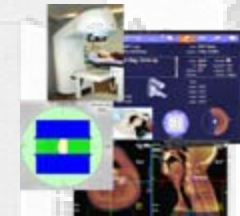
## R&V System



Hazard ID: 2.2.1

Cause	Loading patient
Risk Index prior to mitigation	II-B
Mitigation	Software user in the whole sets of
Risk Index after mitigation	IV-F

## Daily Tx Delivery



# SRS & SDS to Mitigate the Risks

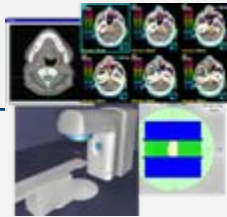
- Extensive Bit-to-Bit Data Check by Human is Too Much Work
- Designing a Computer Software Tool to Mitigate the Risks
- A Computer-Aided Tx Data Auditing Software to Improve the Efficiency
- A Software which can Automatically Monitor Tx Data being Delivered



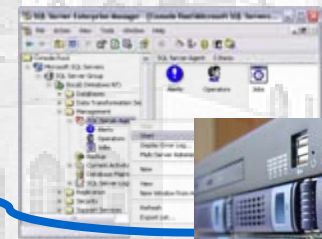
# SRS & SDS to Mitigate the Risks

## Module A: New Plan Checks

Approved Tx Plan



R&V System

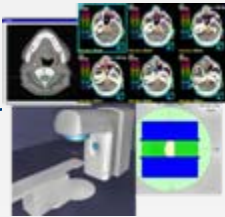


New Software for  
Tx Data Checking

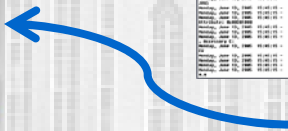
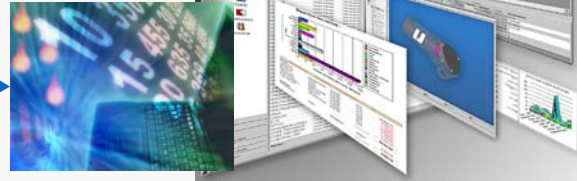
# SRS & SDS to Mitigate the Risks

## Module B: Daily Tx Log Checks

Approved Tx Plan



Daily Tx Delivery



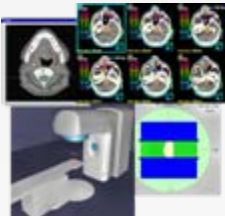
New Software for Tx Data Checking



# Hazard Traceability Analysis

Hazard ID	Cause	Risk Level Before Mitigation	Risk Level After Mitigation	Risk Control Method(s)	Requirement ID	Test ID	Test Result
2.2.1	Loading patient DICOM images failed.	II-B	IV-F	Software user interface will not display the patient and library images unless the whole sets of DICOM images are loaded.	P01V02-SDS433	P01V02-VET533	Passed

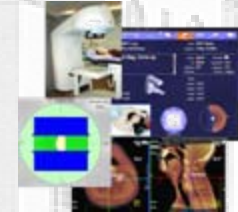
## Approved Tx Plan



## R&V System



## Daily Tx Delivery



# Electronic Oncology System Monitoring

## ➤ Whose Responsibility?



# Whose Fault?

## RAID 5 Array Failing



System Unit Storage System

Refresh

Fan 1	Fan 2	Fan 3	Fan 4	Power Supply1	Power Supply2	System	CPU
3600 RPM	3600 RPM	3600 RPM	3600 RPM	Ok	Ok	66°F/18°C	121°F/49°C

System Unit Storage System Head (32) Enclosure (7)

Refresh [Click for Help](#)

BBU Firmware	Serial #	BBU Status	Backup Capacity	Last Test Date
DLKR174	163	Ok	1092 Hours	07-26-2009

Unit #	Configuration	Stripe	Capacity	Mode & Progress
0	Raid 5	64KB	2.73 TB	Normal

Drive Information

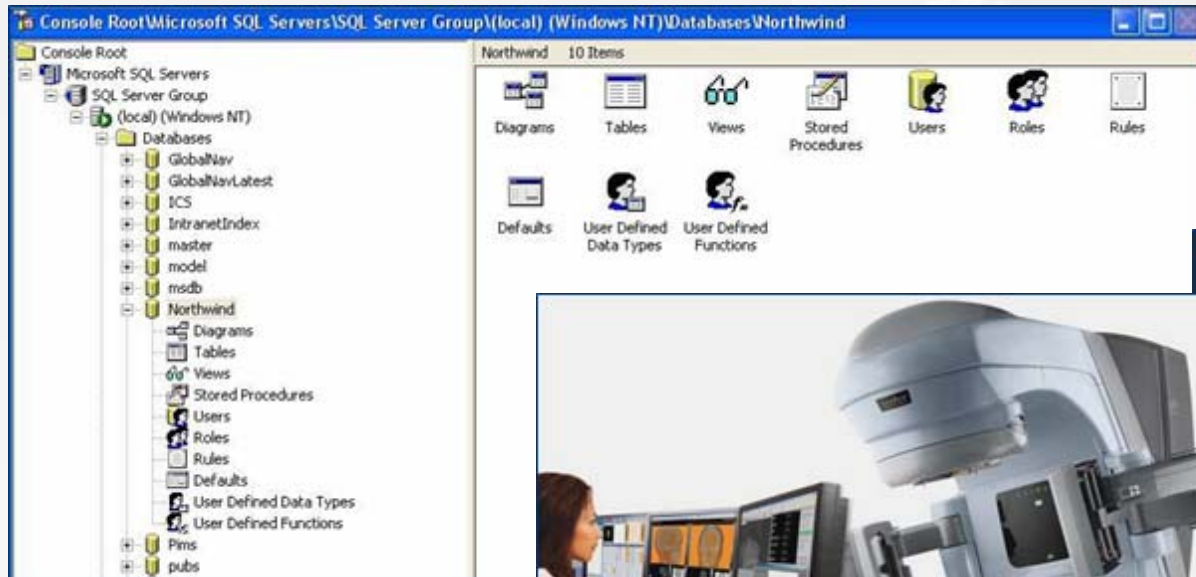
Slot	Unit	Model	Serial #	Capacity	Usage
1	0	ST37506305S	9QK2HCS3	698.12 GB	Data



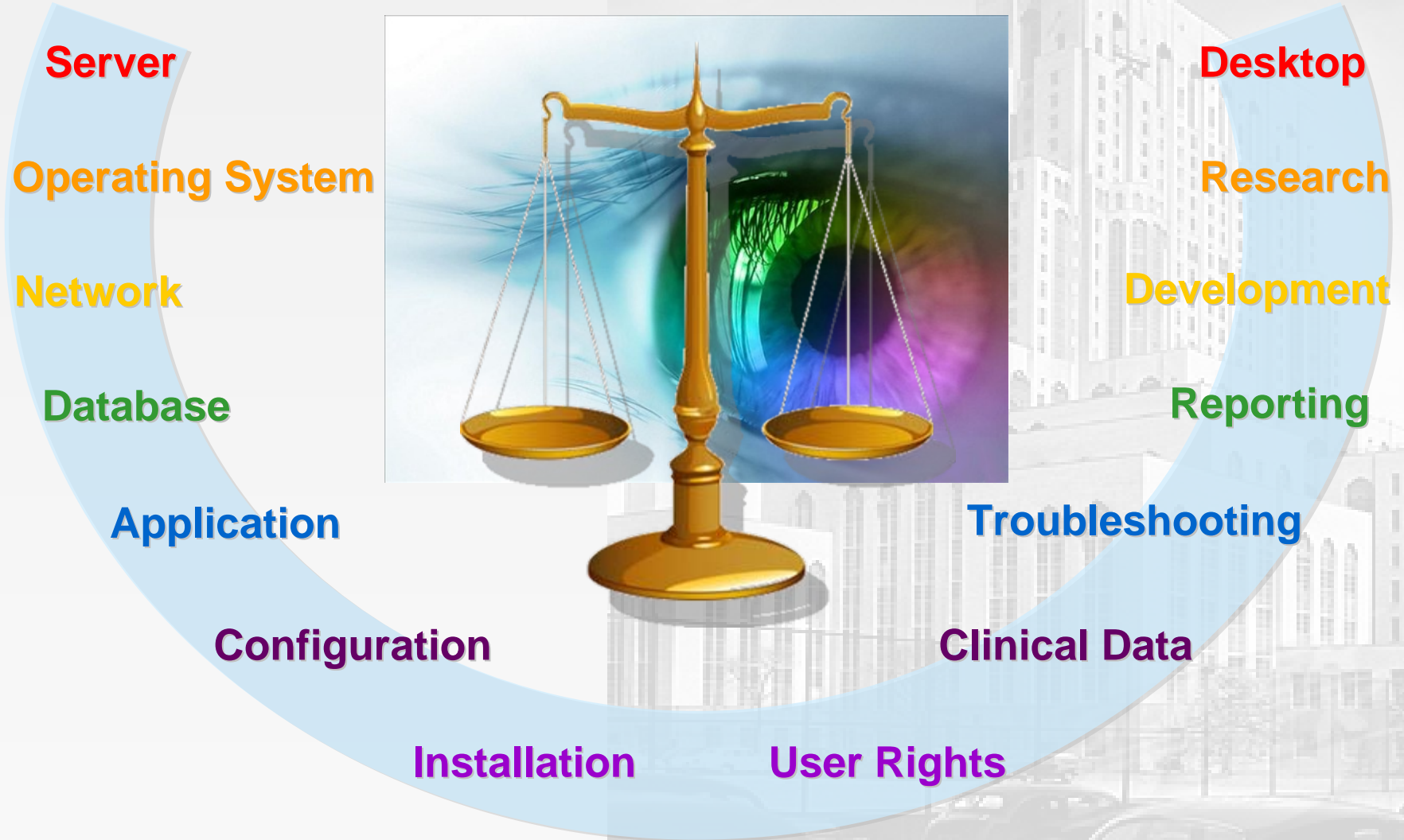


# Whose Fault?

## Restarting a Database Service



# Balance with True Colors



# Policy & Procedures

## ➤ When Server is Down

- ❖ Should off-line treatment be carried out?
- ❖ Off-line data roll back integrity checks

## ➤ Overwrite

- ❖ Staff role and their rights for overwriting
- ❖ Quality auditing for overwritten data

## ➤ User Rights

- ❖ For each staff group, plus “senior” staff
- ❖ Who can define user rights
- ❖ Generic user account?



# Policy & Procedures

- Paperless Chart / Electronic Medical Record
  - ❖ Patient medical record accessibility by other medical staff
  - ❖ Paper signing off vs. electronic signature
- Login & Logout
  - ❖ Login & logout enforcement
  - ❖ User activity logging
- System Continuity
  - ❖ Configuration change policy
  - ❖ System update policy



# Summary

- Electronic Oncology System (EOS) is playing an essential role in today's Radiation Oncology service
- EOS Management Considerations
  - ❖ IT Infrastructure
  - ❖ Data Safety in Storage
  - ❖ Data Safety in Communication
  - ❖ Systems Monitoring
  - ❖ Policy & Procedures



# Conclusion

- The emerging radiation therapy technology has become more and more complicated with increased clinical procedures and equipments
- Electronic Oncology System provides one solution to such complicated environment
- Well designed EOS management from its infrastructure to the implementation is important
- Safety measures for EOS is by no means critical to the Radiation Oncology practice



# Thank You

TECHNOLOGY  
DEVELOPMENT  
+  
SYSTEM  
INTEGRATION



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