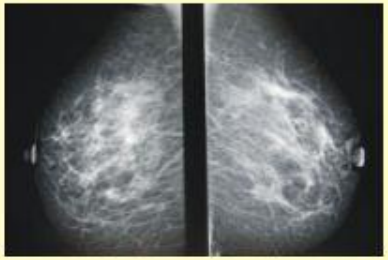
Clinically Embedded Physics Education
A major Factor in Image Quality Assurance and Radiation Dose Management



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Emory University
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Clinical Collaborators
Phoung-Anh Duong, M.D.
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This presentation available at:
www.sprawls.org/ipad

Effective
Medical Imaging Physics Education

Goals & Objectives

Medical imaging professionals with a knowledge of physics that will enable them to perform clinically effective imaging procedures with managed risk to both patients and staff.

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Our Learning Objectives

Clinical Radiology

DO

Effective Knowledge Structures

Levels of Learning

LEARN PHYSICS

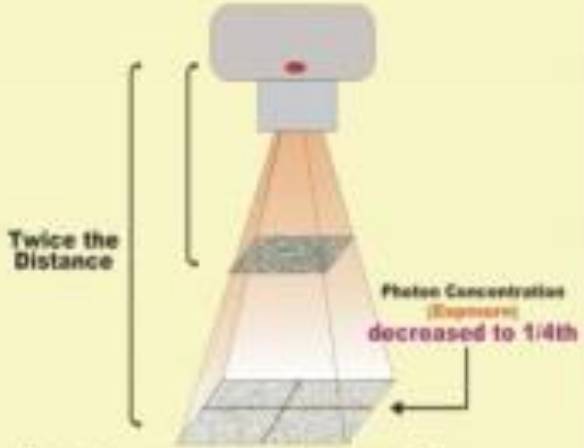
Learning Activities **Effectiveness** and **Efficiency**

RESOURCES

Sprawls

The Physical Universe

The inverse square law is.....



The Inverse Square Law

$$\frac{I_1}{(I_2)} = \frac{(d_2)^2}{(d_1)^2}$$

I_1 is the initial intensity of radiation, d_1 is the initial distance, and d_2 is the final distance, and I_2 is the final intensity.

Verbal

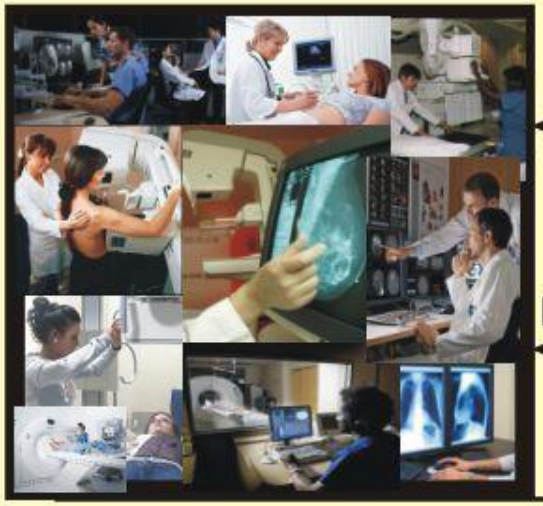
Sensory

Mathematical

Sprawls

Medical Physics Knowledge Structures

Medical Imaging Physics Universe



Learn

Observe

Interact

Sensory Concepts

Apply

Analyze

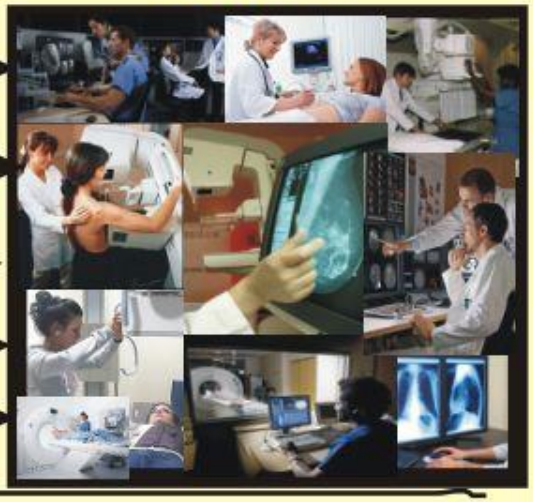
Evaluate

Change

Create

Teach

Medical Imaging Physics Universe



Classroom

Symbols

Mathematical

$$k = \lambda / 2\pi$$

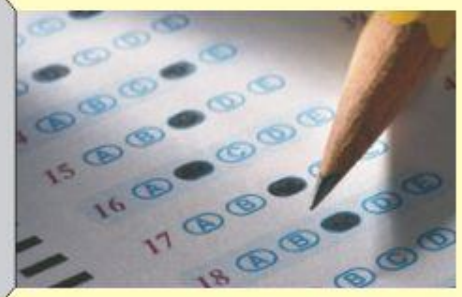
$$\alpha_{hh} = \frac{\varepsilon - 1}{\left(\cos\theta + \sqrt{\varepsilon - \sin^2\theta}\right)^2}$$

$$\alpha_{vv} = \frac{(\varepsilon - 1)\left(\varepsilon + \varepsilon\sin^2\theta - \sin^2\theta\right)}{\left(\varepsilon\cos\theta + \sqrt{\varepsilon - \sin^2\theta}\right)^2}$$

Verbal

Descriptions & Definitions

Exams



Who needs a knowledge of Physics applied to clinical imaging?

Radiologists, Residents and Fellows

Technologists

Medical Physicists

Each provides unique challenges and opportunities.

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Physics Learning Objectives for Radiologists

Image Physical Characteristics

- **Identify**
- **Relationship to Visibility** → **Anatomy and Pathology**
- **Evaluate**
- **Control and Optimize** → **Risk**

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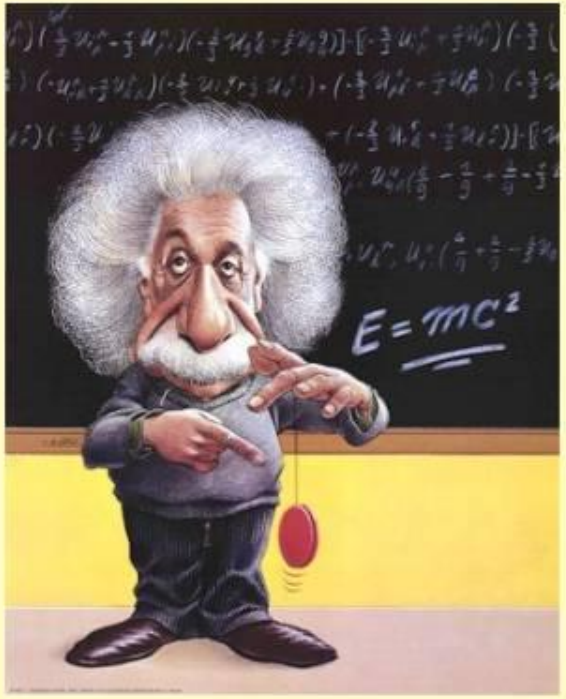
The Physicist as an Educator and Teacher

Our Objectives

Provide more EFFECTIVE learning activities.



Be EFFICIENT in our teaching

Challenges Opportunities

Sprawls

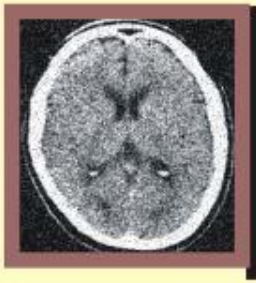
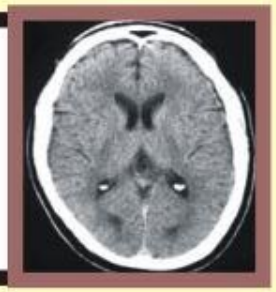


IMAGE QUALITY



Conducting Clinical Procedures

Analyze & Evaluate Image Quality
Selection of Imaging Parameters
Procedure Protocol Optimization
"The Human Factor"

Quality Assurance Procedures
Image Analysis & Evaluation
Verifying Equipment Performance
Calibration

Applied Medical Physics

Research

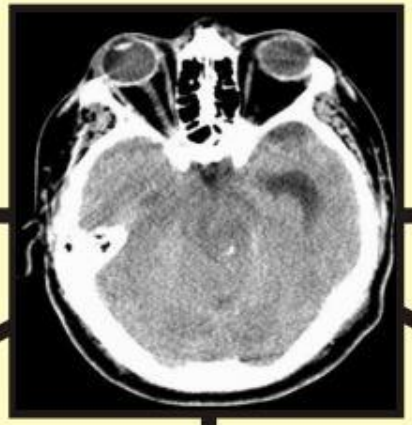
Design of Equipment
Physics Limitations

Development

Sprawls

Image Quality

Visibility of Anatomical Structures and Signs of Pathology or Trauma



spatial

Artifacts

Detail

Contrast

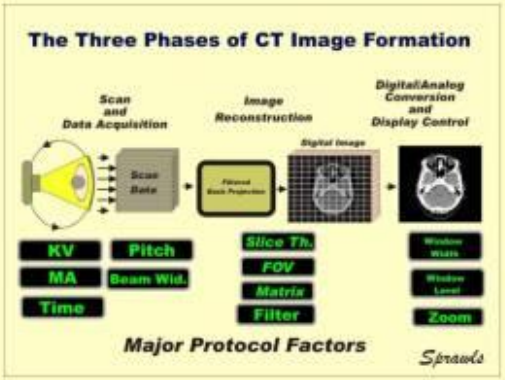
Noise

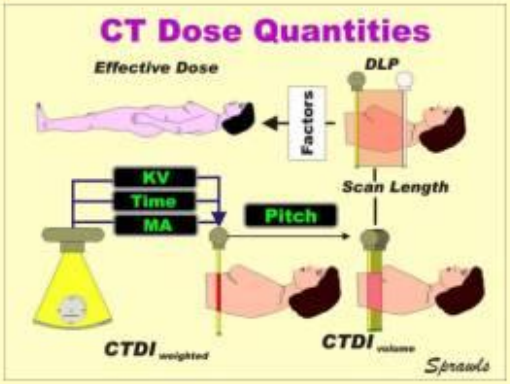
KV 120	MA 100	Pitch 1	FOV 20	XYZ	XYZ	XYZ
XYZ	XYZ	XYZ	XYZ	XYZ	XYZ	XYZ
XYZ	XYZ	XYZ	XYZ	XYZ	XYZ	XYZ

Sprawls

Capability & Complexity

(Computed Tomography)

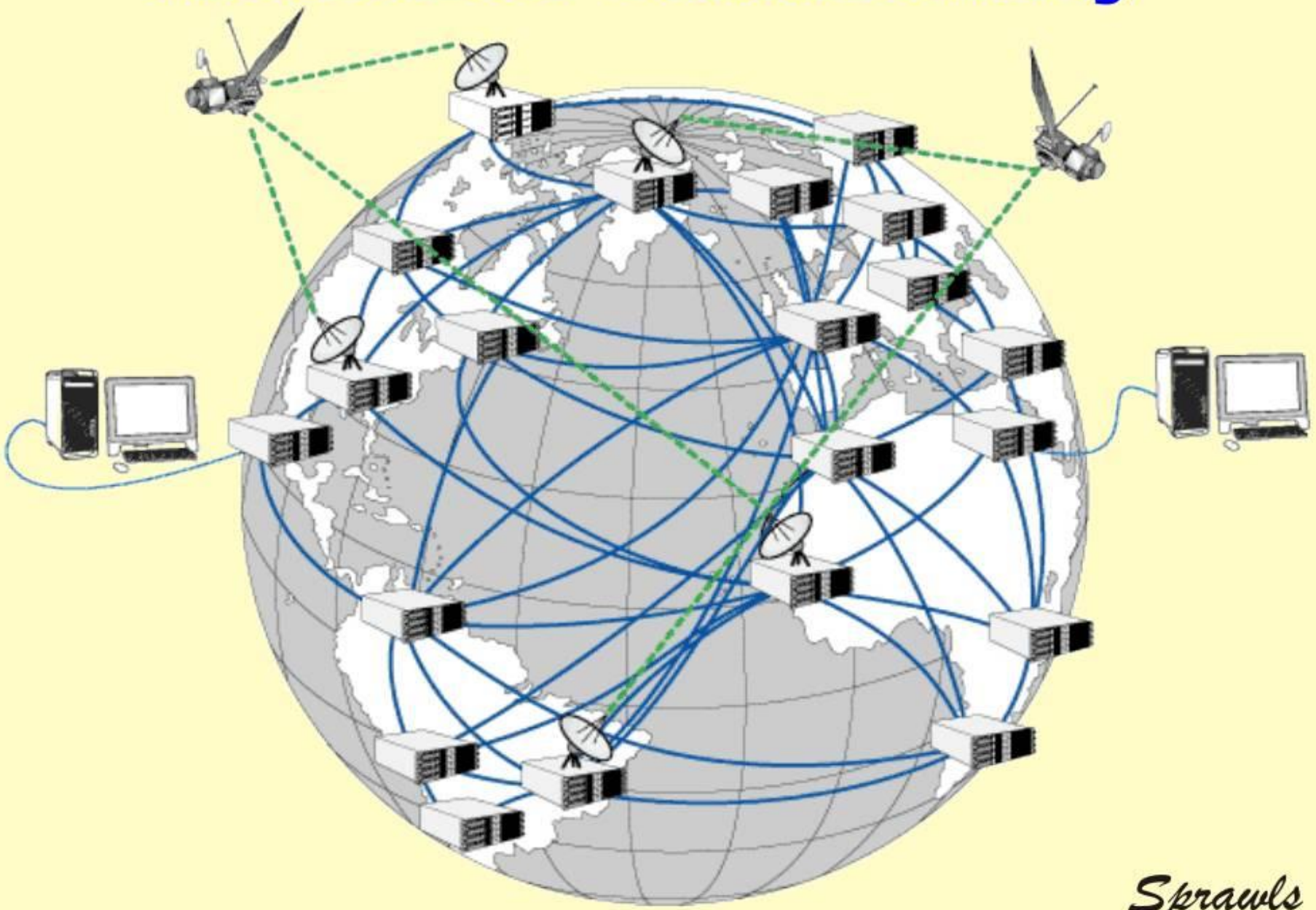




Years

Sprawls

Increased Connectivity



Sprawls

Digital Resources to Enrich Learning Activities

The Web

Connecting and Sharing

Textbooks
Modules

Visuals

Clinical
Images

Modules

References
Teaching Files

Classroom

Clinical
Conference

Small
Group

"Flying Solo"

Sprawls

LEARNING is.....

Building a knowledge structure in the brain.

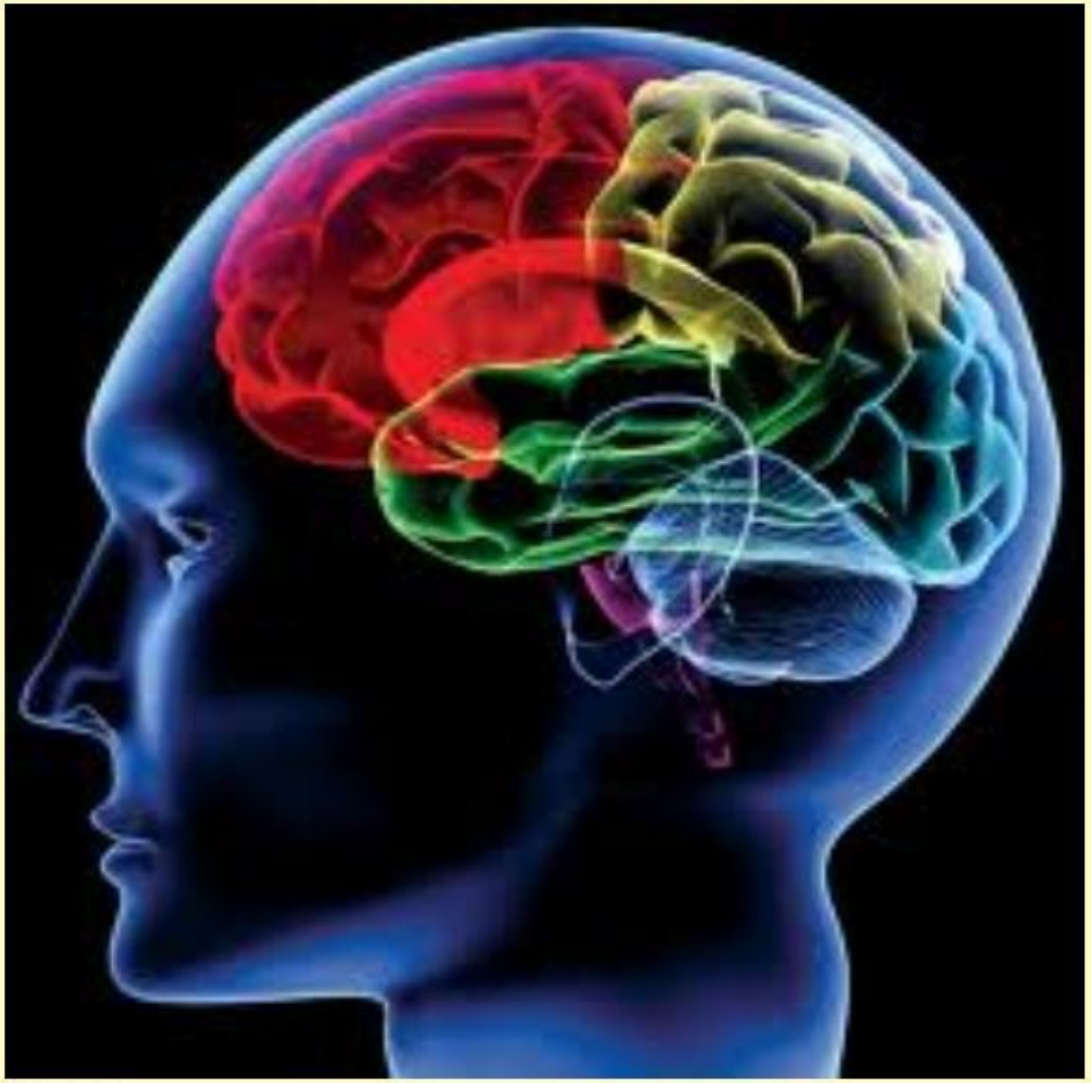


Image from the Web

Sprawls

LEARNING PHYSICS is.....

Building a knowledge structure in the brain

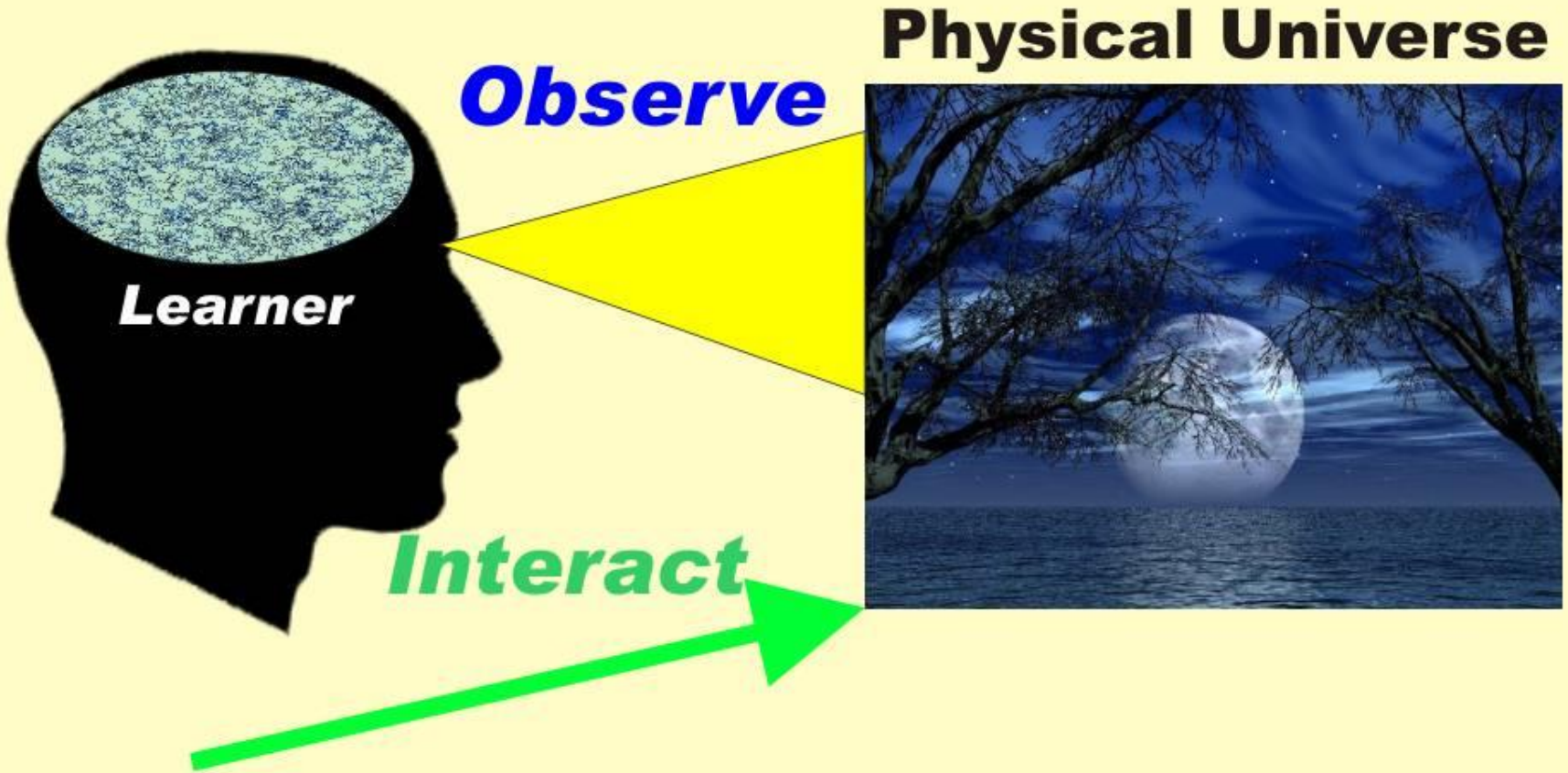
by Encounter and Experience

Physical Universe

Sprawls

Learning is a Natural Human Process

We Learn by Experience

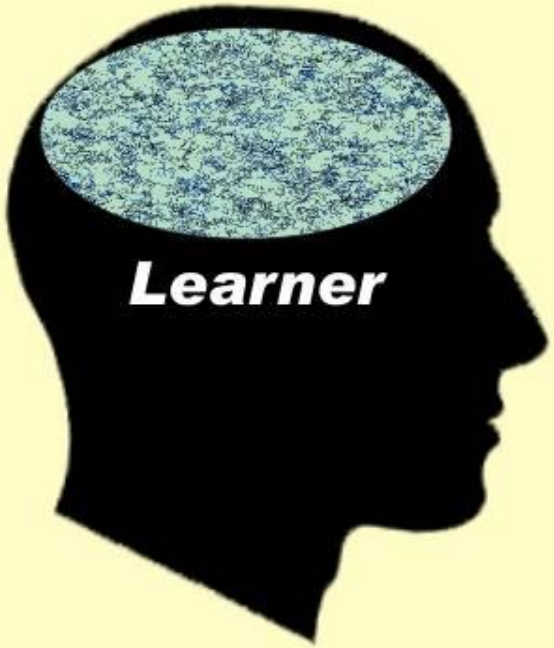


Sprawls

Teaching

is helping someone

Building a Knowledge Structure in the Brain



Physical Universe

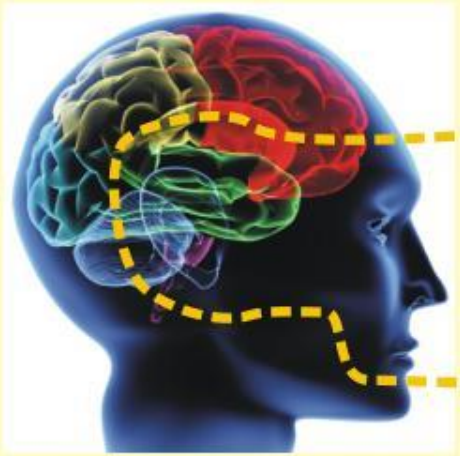
A mental representation of physical reality

Connect Organize Guide

Sprawls

The Elements of
A Highly Effective Educational Session

The Brain



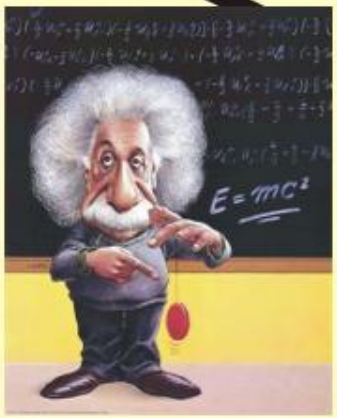
Connection

Observe

Interact

The Physical Universe
(Physics of Medical Imaging)

"Window"



Teacher /Guide

Sprawls

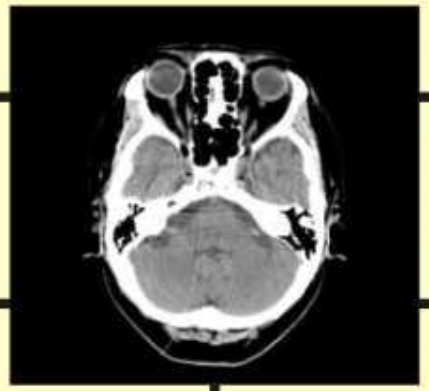
Physics Learning Objectives for Radiologists

Image Physical Characteristics

- **Identify**
- **Relationship to Visibility** → **Anatomy and Pathology**
- **Evaluate**
- **Control and Optimize** → **Risk**

Sprawls

CT Image Characteristics



Spatial

Artifacts

Detail

Noise

Contrast Sensitivity

KV

Pitch

Slice Th.

Window Width

MA

Beam Wid.

FOV

Window Level

Time

Filter

Matrix

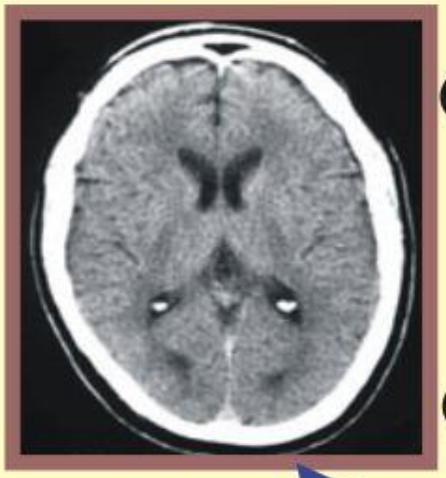
Zoom

Major Protocol Factors

Sprawls

Analyze and Make Decisions

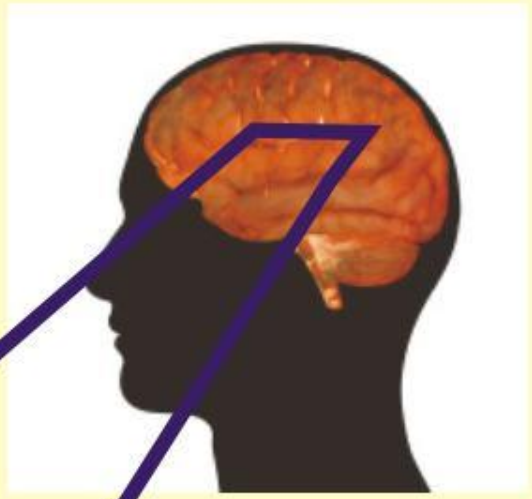
Image



Clinical Characteristics

Physical Characteristics

Radiologist



Physics

KV 120	MA 100	Pitch 1	FOV 20	XYZ	XYZ	XYZ
XYZ	XYZ	XYZ	XYZ	XYZ	XYZ	XYZ
XYZ	XYZ	XYZ	XYZ	XYZ	XYZ	XYZ

Sprawls

Clinically Focused Physics Education

Classroom

Clinical Conference

Small Group

"Flying Solo"

Learning Facilitator
"Teacher"

Individual
and
Peer Interactive
Learning

Each type of learning activity has a unique value.

Sprawls

Elements of Highly Effective
Medical Physics Education

In the Clinic

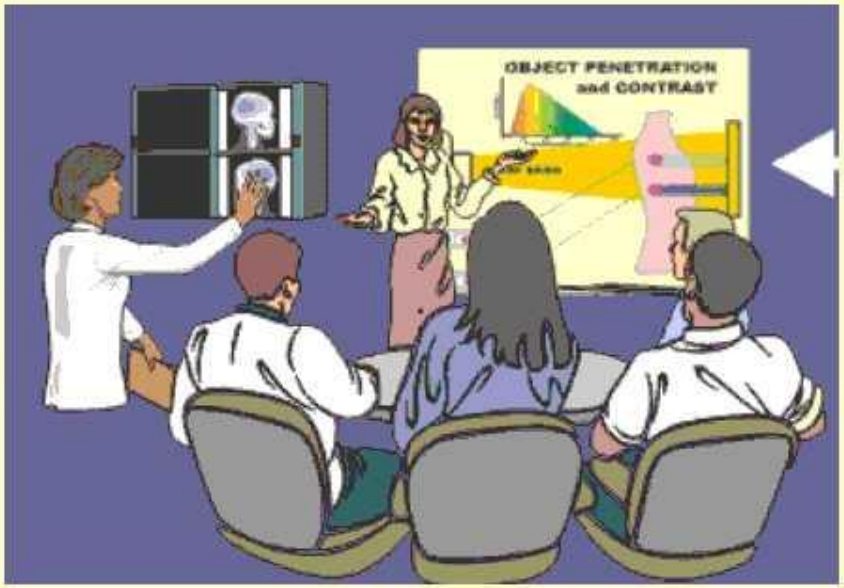
Class/Conference By Physicists

Online Modules

Sprawls

Rich Classroom and Conference Learning Activities

Learning Facilitator "Teacher"



Visuals

Representations of Reality

- **Organize and Guide the Learning Activity**
- **Share Experience and Knowledge**
- **Explain and Interpret What is Viewed**
- **Motivate and Engage Learners**

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Effective Medical Imaging Physics Learning ...In The Clinic

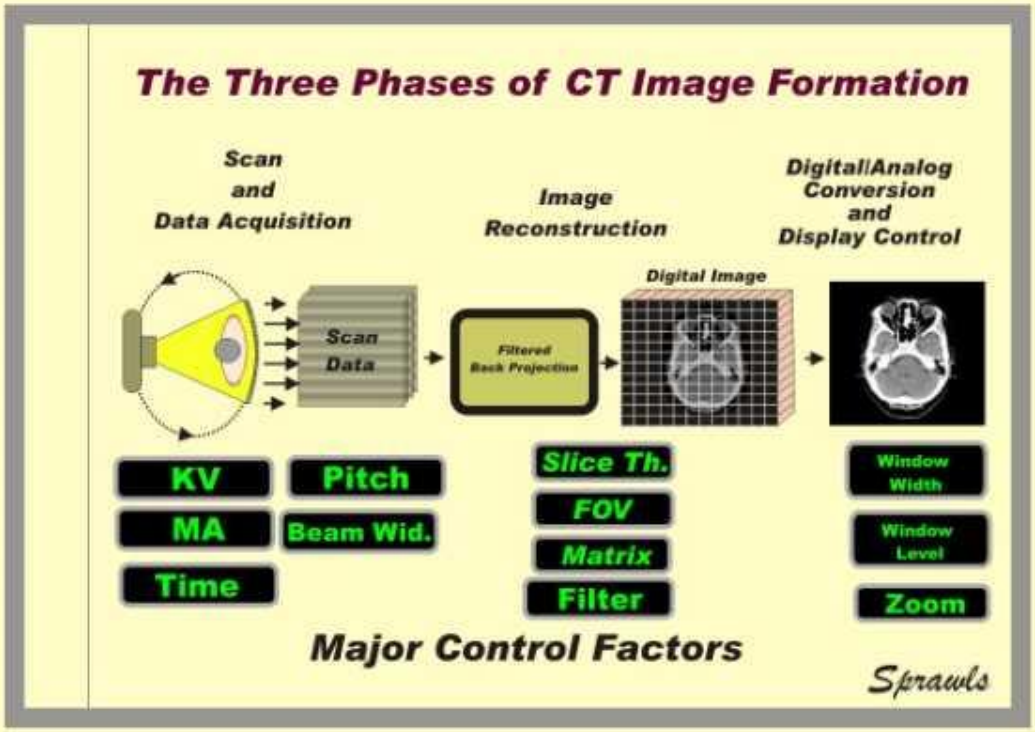
The Real World **Motivating** **Interactive** **Collaborative**

The Physicist Provides:
Learning Modules & Collaboration

Sprawls

Visuals for Learning and Teaching

The Imaging Process



Clinical Images

Sprawls

Visuals

to be used by

Physicists in Classroom and Conference Discussions

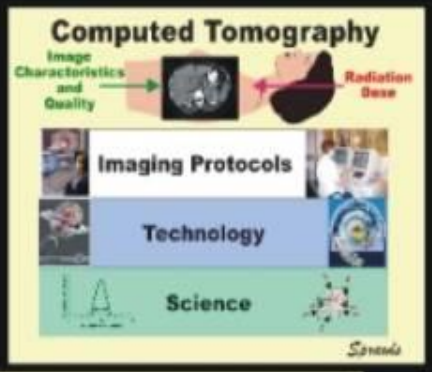
SPRAWLS EDUCATIONAL FOUNDATION
Open Resources for Learning and Teaching
The Physical Principles of Medical Imaging

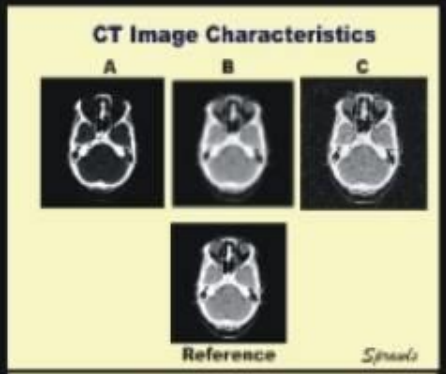
Visuals
for
Classroom, Conference, and Collaborative Learning

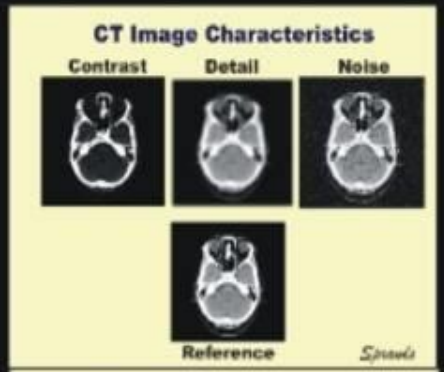
RIGHT CLICK on each visual to download and use in PowerPoint or other display programs.

Computed Tomography Image Quality Optimization and Dose Management

Companion Module
http://www.sprawls.org/resources/CTIQDM/







Modules for Self Study
and
Collaborative Learning in the Clinic

Computed Tomography Image Quality Optimization and Dose Management

Perry Sprawls, Ph.D.

To step through module, CLICK HERE.
To go to a specific topic click on it below.

Introduction and Overview	Image Quality Characteristics	Contrast Sensitivity
Visibility of Detail	Visual Noise	Spatial (Geometric) Characteristics
Artifacts	Identifying Characteristics	Characteristics Identified
Image Quality and Dose	CT Image Formation Process	The Scanning Motions
Views and Rays	Multiple Row Detectors	Helical and Spiral Scanning
Image Reconstruction and Voxels	CT Numbers	Hounsfield Unit Scale
Optimizing CT Procedures	Absorbed Dose	Dose Distribution Within Patient
CT Dose Index (CTDI)	Weighted CTDI	Volume CTDI
Dose for Multiple Slices	Dose Length Product (DLP)	Effective Dose
Summary of CT Dose Quantities	Factors That Determine Dose	Factors Affecting Image Detail
Measuring CT Image Noise	Controlling Image Noise	Voxel Size Compromise


Mammography Physics and Technology
for effective clinical imaging
Perry Sprawls, Ph.D.

How to Use This Resource

Table of Contents and List of Topics

Mammography Physics and Technology
for effective clinical imaging

Perry Sprawls, Ph.D.

Outline	Mind Map	Learning Objectives	Visuals for Discussion		Text Reference

To step through module, CLICK HERE.

To go to a specific topic click on it below

Imaging Objectives	Rhodium Anode	Blurring and Visibility of Detail
Visibility of Pathology	KV Values for Mammography	Focal Spot Blurring
Image Quality Characteristics	Scattered Radiation and Contrast	Receptor Blurring
Not a Perfect Image	Image Exposure Histogram	Composite Blurring
Mammography Technology	Receptor & Display Systems	Magnification Mammography
Imaging Technique Factors	Film Contrast Transfer	Mean Glandular Dose
Contrast Sensitivity	Film Contrast Factors	
Physical Contrast Compared	Film Design for Mammography	
Factors Affecting Contrast Sensitivity	Controlling Receptor (Film) Exposure	
X-Ray Penetration and Contrast	Film Processing	
Optimum X-Ray Spectrum	Variations in Receptor Sensitivity	
Effect of Breast Size	Film Viewing Conditions	

Clinically Focused Physics Education

Classroom | Clinical Conference | Small Group | "Flying Solo"

Highly Efficient

For General Physics and Related Topics

Highly Effective

Clinically Rich Learning Activities

Visuals **Images** **Online Modules**

Resources and References

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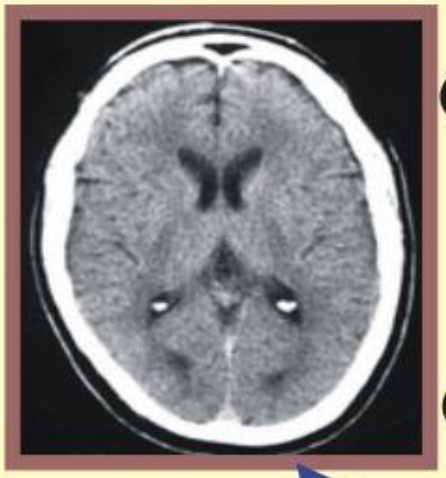
Analyze and Make Decisions

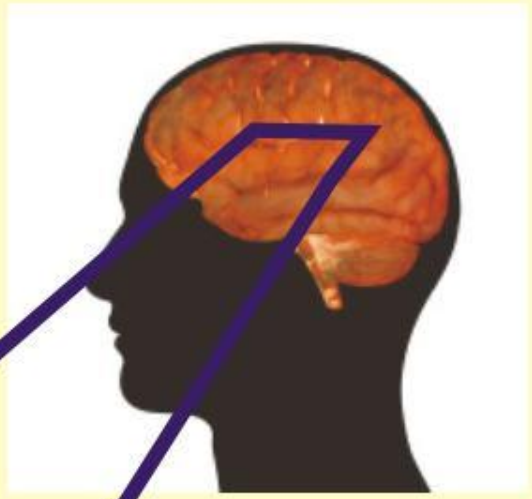
Image



Clinical Characteristics

Physical Characteristics

Radiologist



Physics

KV 120	MA 100	Pitch 1	FOV 20	XYZ	XYZ	XYZ
XYZ	XYZ	XYZ	XYZ	XYZ	XYZ	XYZ
XYZ	XYZ	XYZ	XYZ	XYZ	XYZ	XYZ

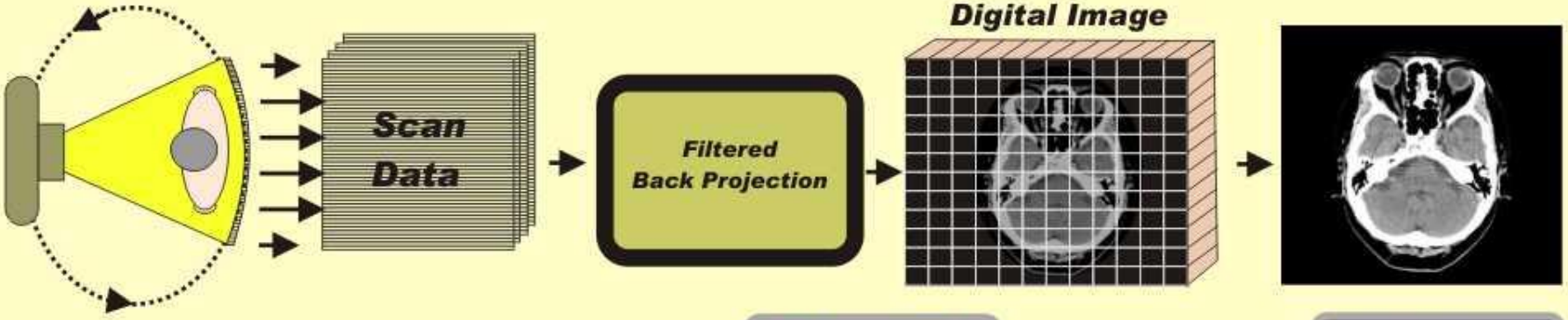
Sprawls

The Three Phases of CT Image Formation

Scan and Data Acquisition

Image Reconstruction

Digital/Analog Conversion and Display Control

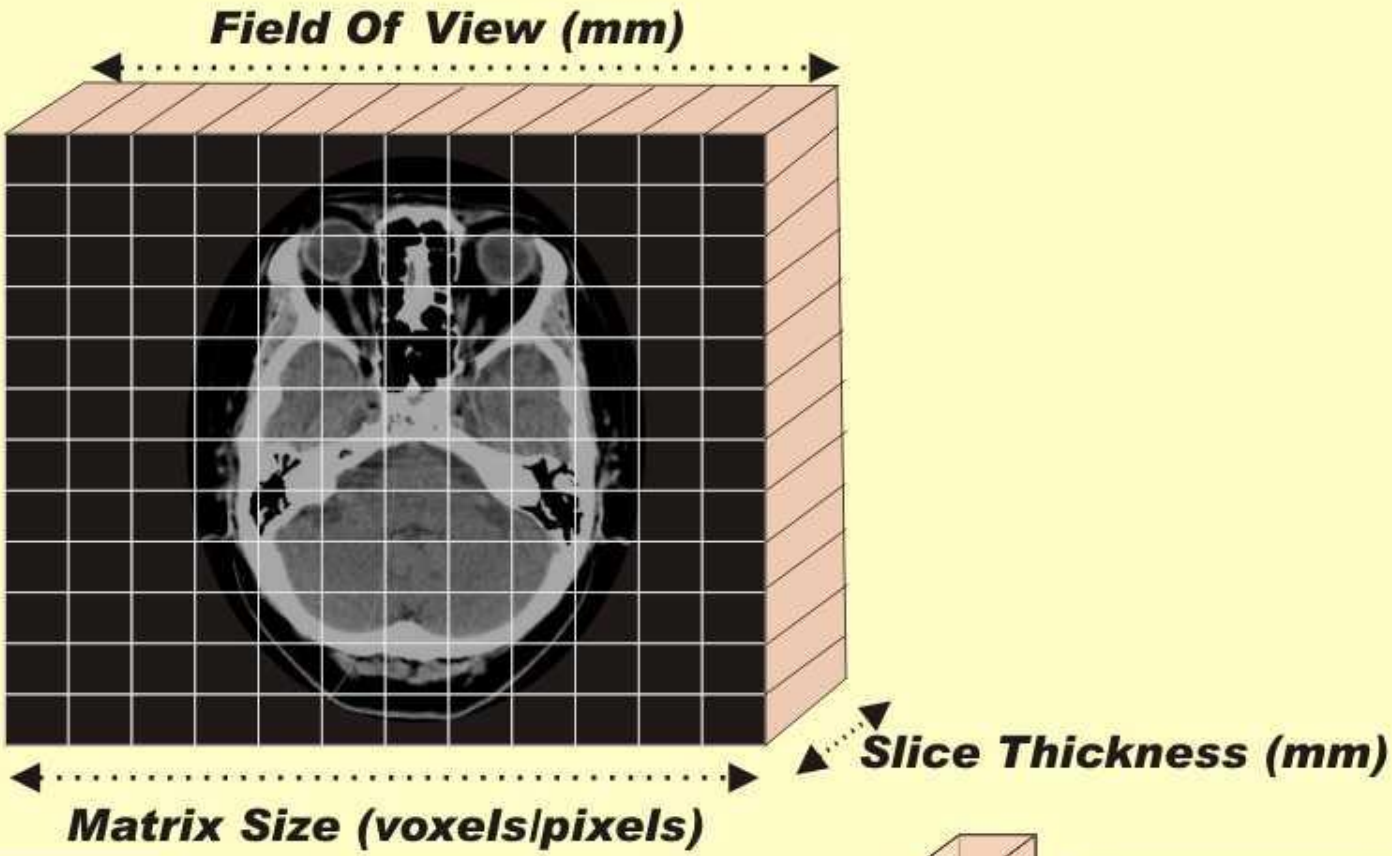


- KV
- MA
- Time
- Pitch
- Beam Wid.
- Slice Th.
- FOV
- Matrix
- Filter
- Window Width
- Window Level
- Zoom

Major Protocol Factors

Sprawls

CT Slice Divided into Matrix of Voxels



Voxel Size Controlled By

Sprawls

X-ray Photons Interact With Tissue in A Voxel

Radiation Dose

determined by

Concentration of Absorbed Energy

per voxel

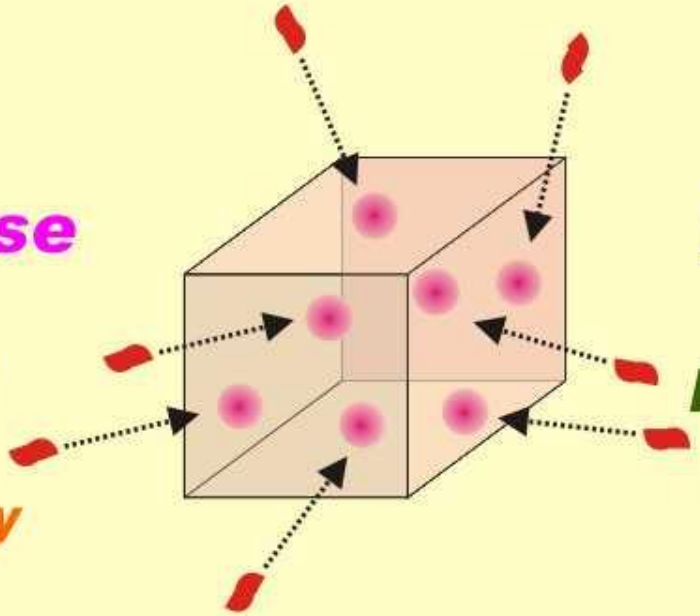


Image Noise

determined by

Number of Photons

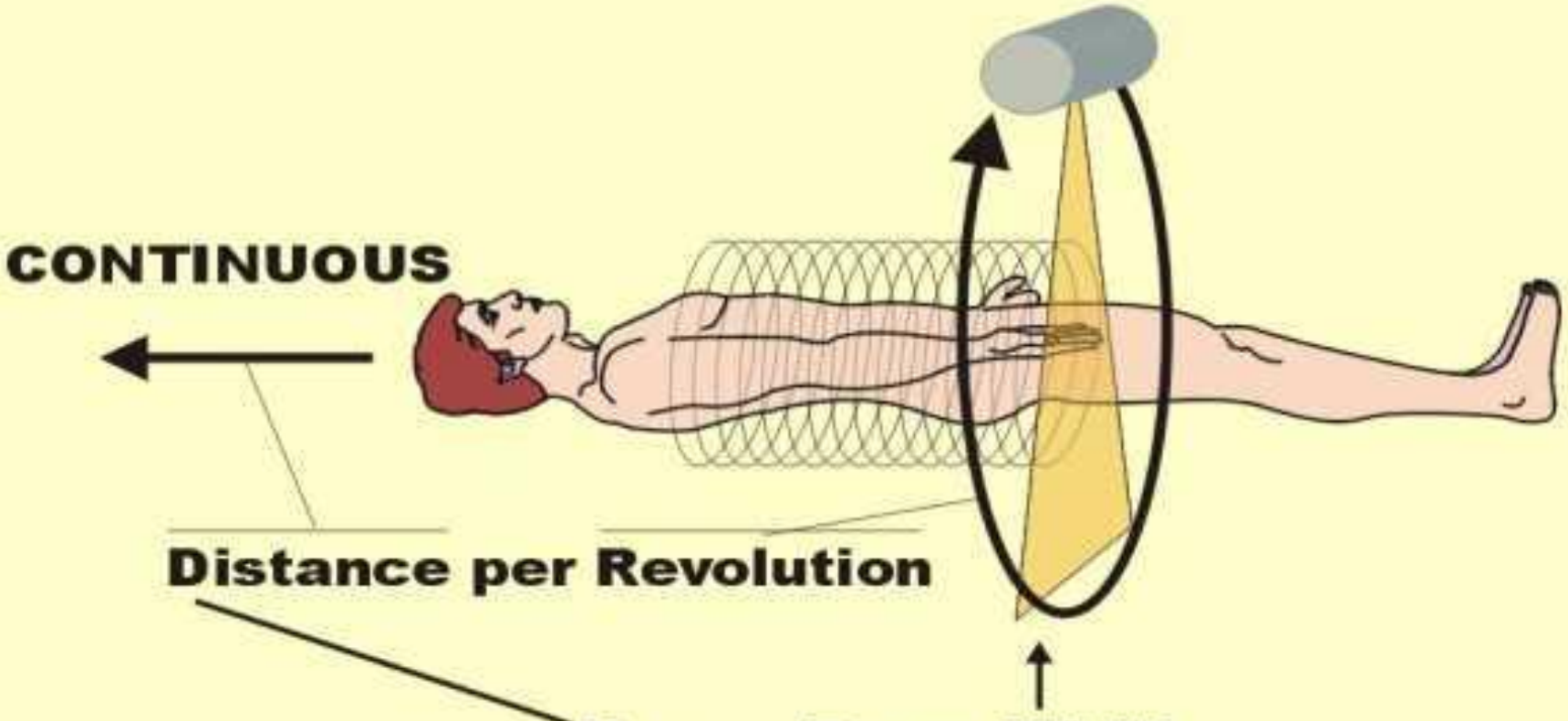
per voxel

Dose is increased by increasing number of photons.

Noise is reduced by increasing number of photons.

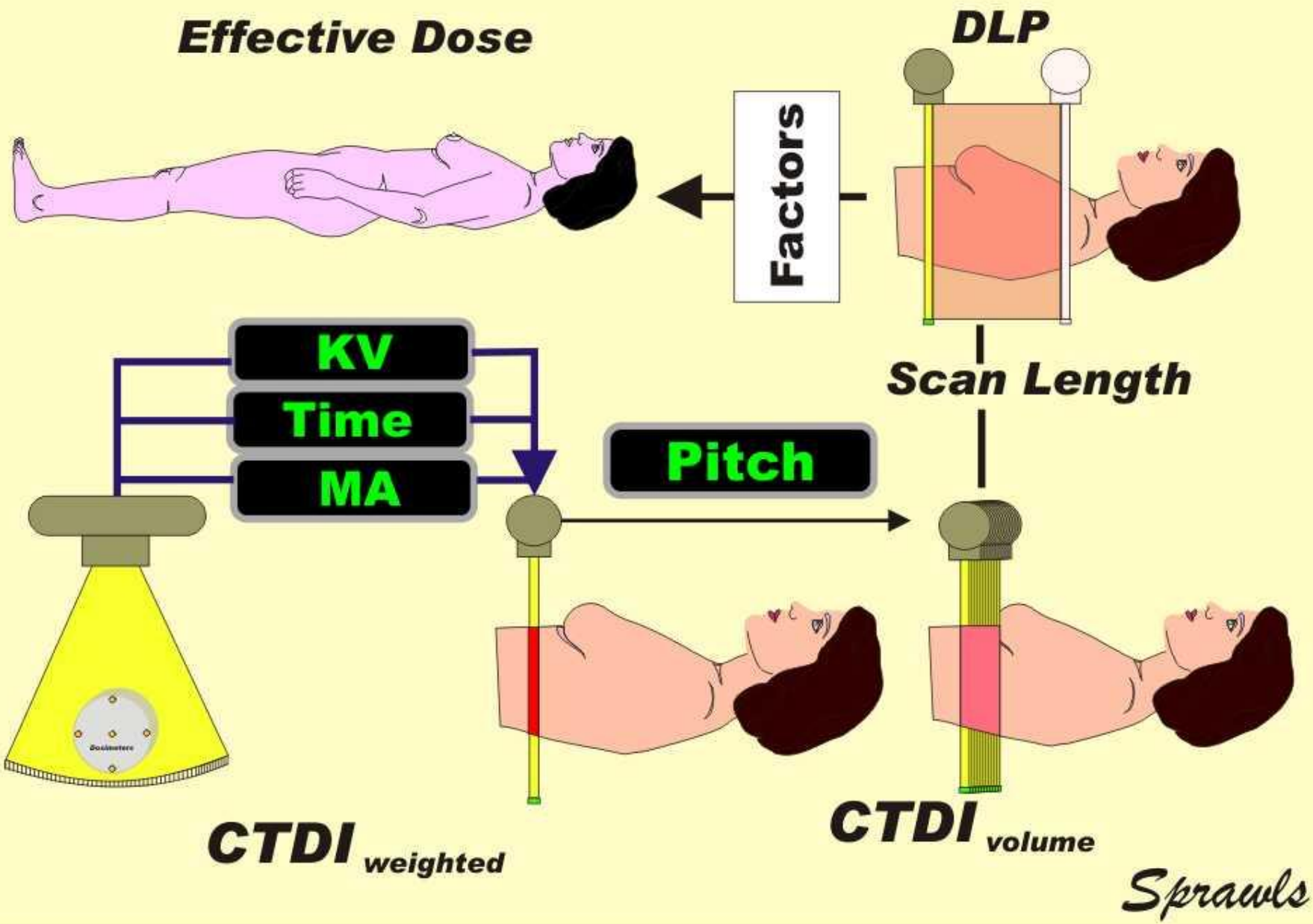
Sprawls

SPIRAL SCAN

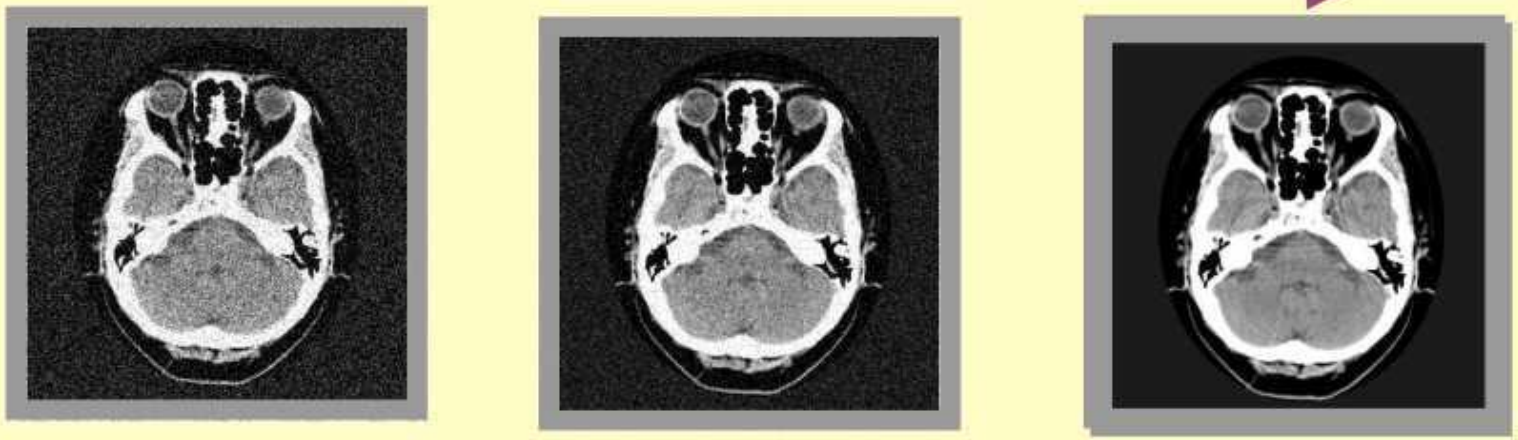


Sprawls

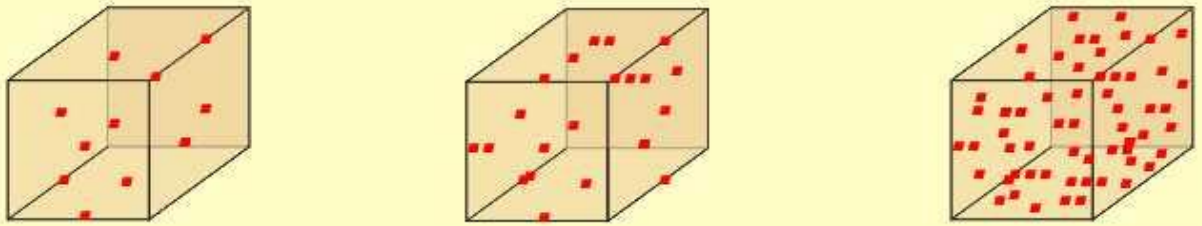
CT Dose Quantities



Decreasing Noise



Requires Increased Photons Absorbed Per Voxel



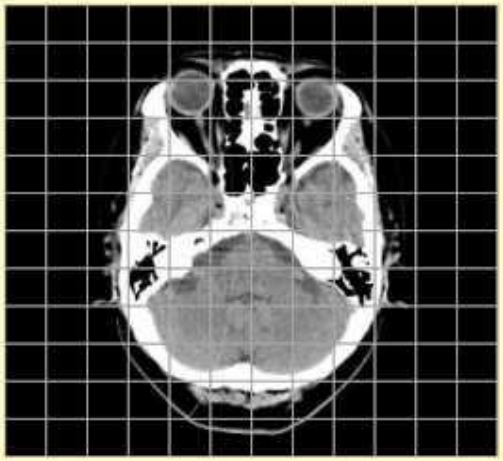
Produces Increasing Dose

Sprawls

Effect of Matrix Size on Image Noise

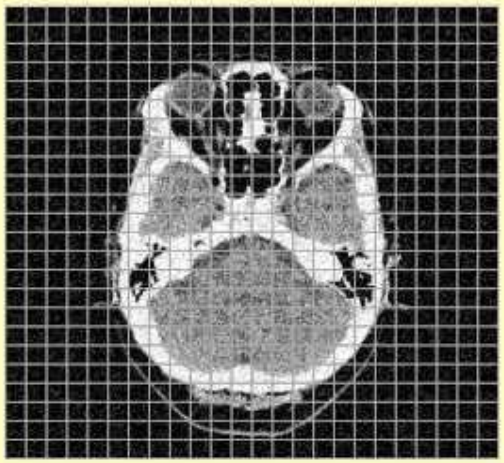
Small **Matrix** ***Large***

Large Voxels



Low Noise

Small Voxels

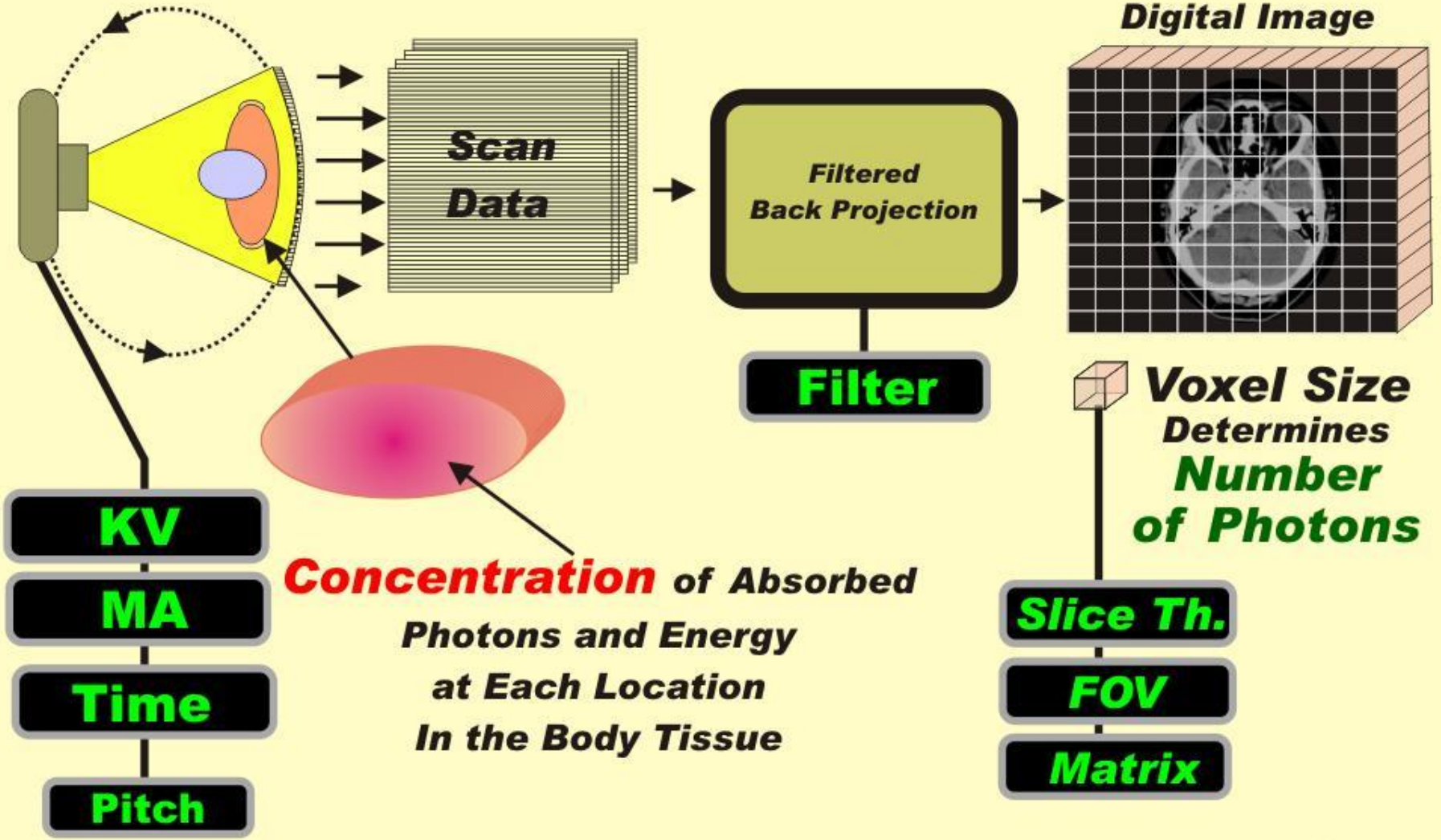


High Noise

The same radiation dose for both images.

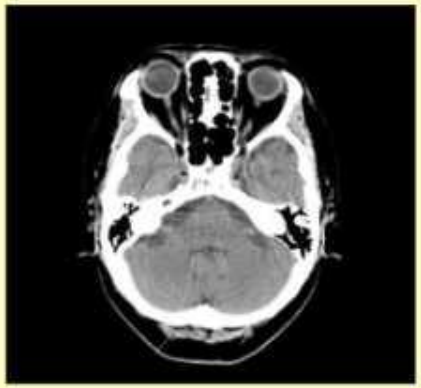
Sprawls

Factors That Determine Image Noise



Sprawls

Two Major Image Quality Goals



High Detail

Low Noise

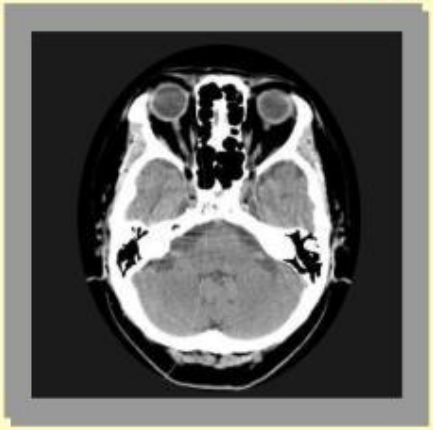
FOV | **Matrix** | **Slice Th.**

Protocol Factors

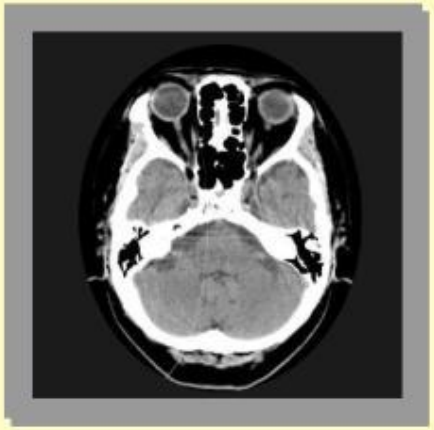
Sprawls

Relationship of Radiation Dose to Image Detail

Lower Dose



Higher Dose

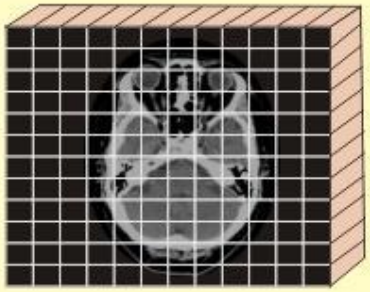


When detail is increased by

- Decreasing **Slice Th.**
- Increasing **Matrix**
- Decreasing **FOV**

Noise Increases

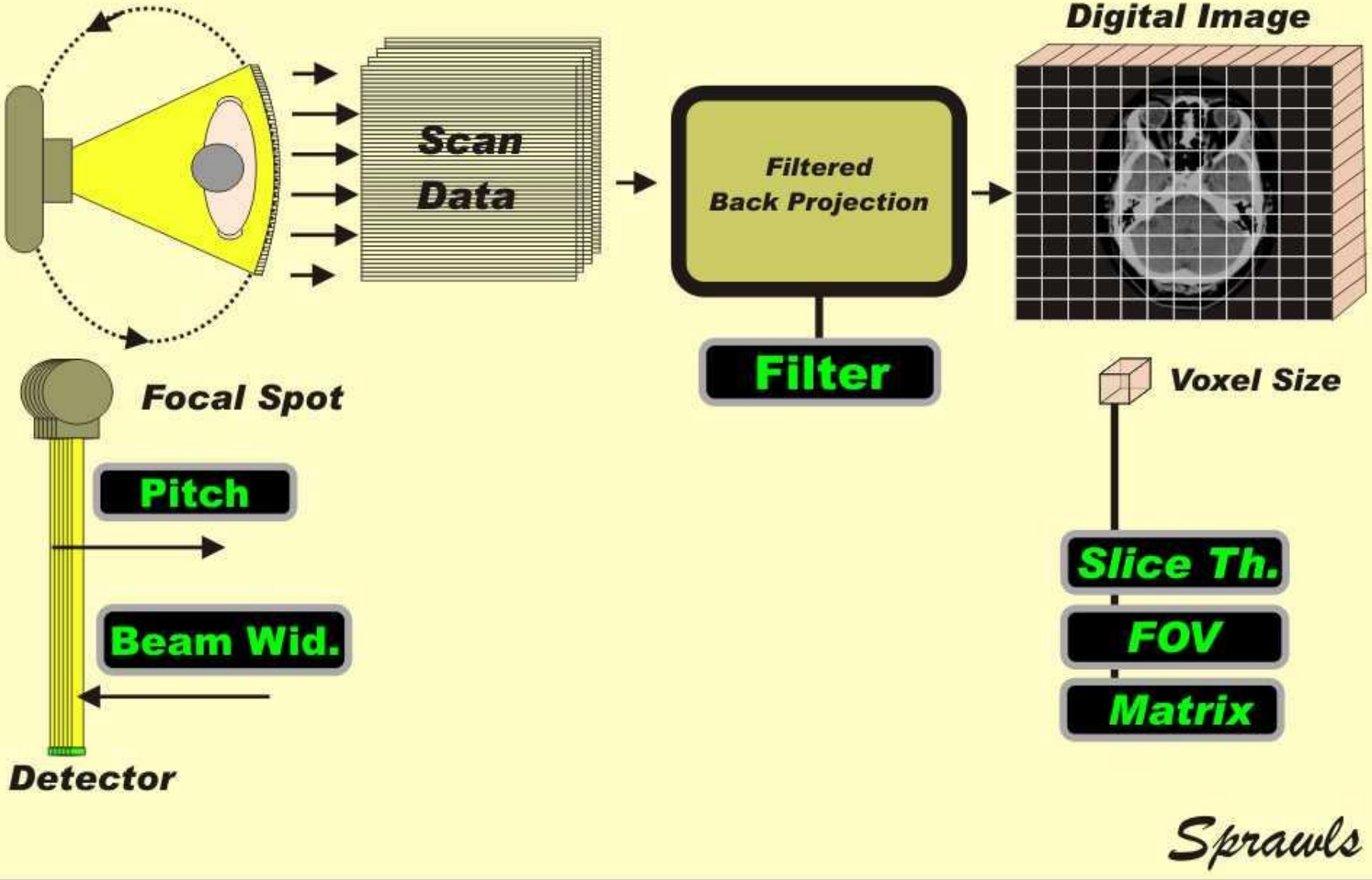
Because of decreased voxel size



Dose must be **increased** to **reduce noise.**

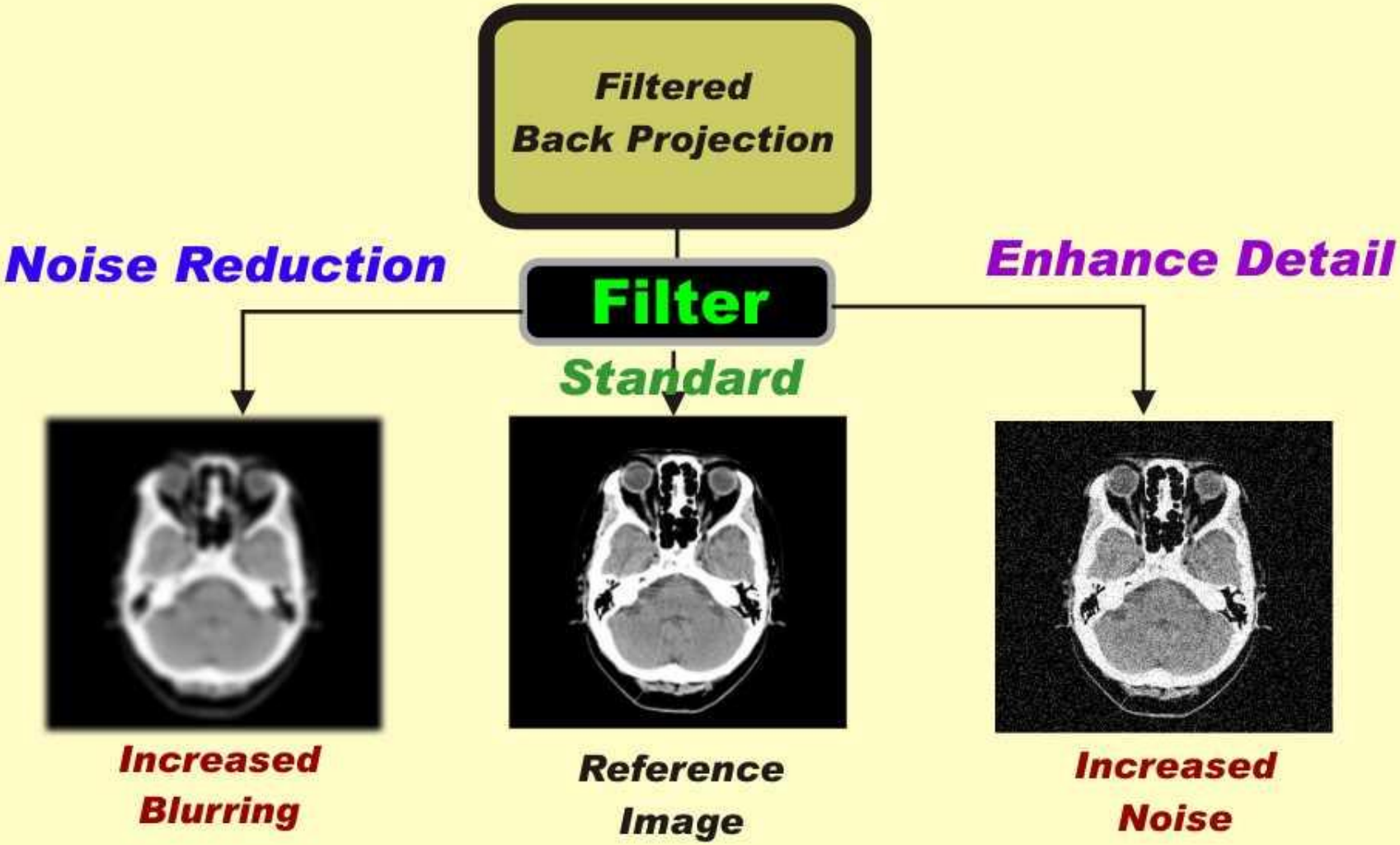
Sprawls

Factors That Determine Image Detail (Sources of Blurring)



Sprawls

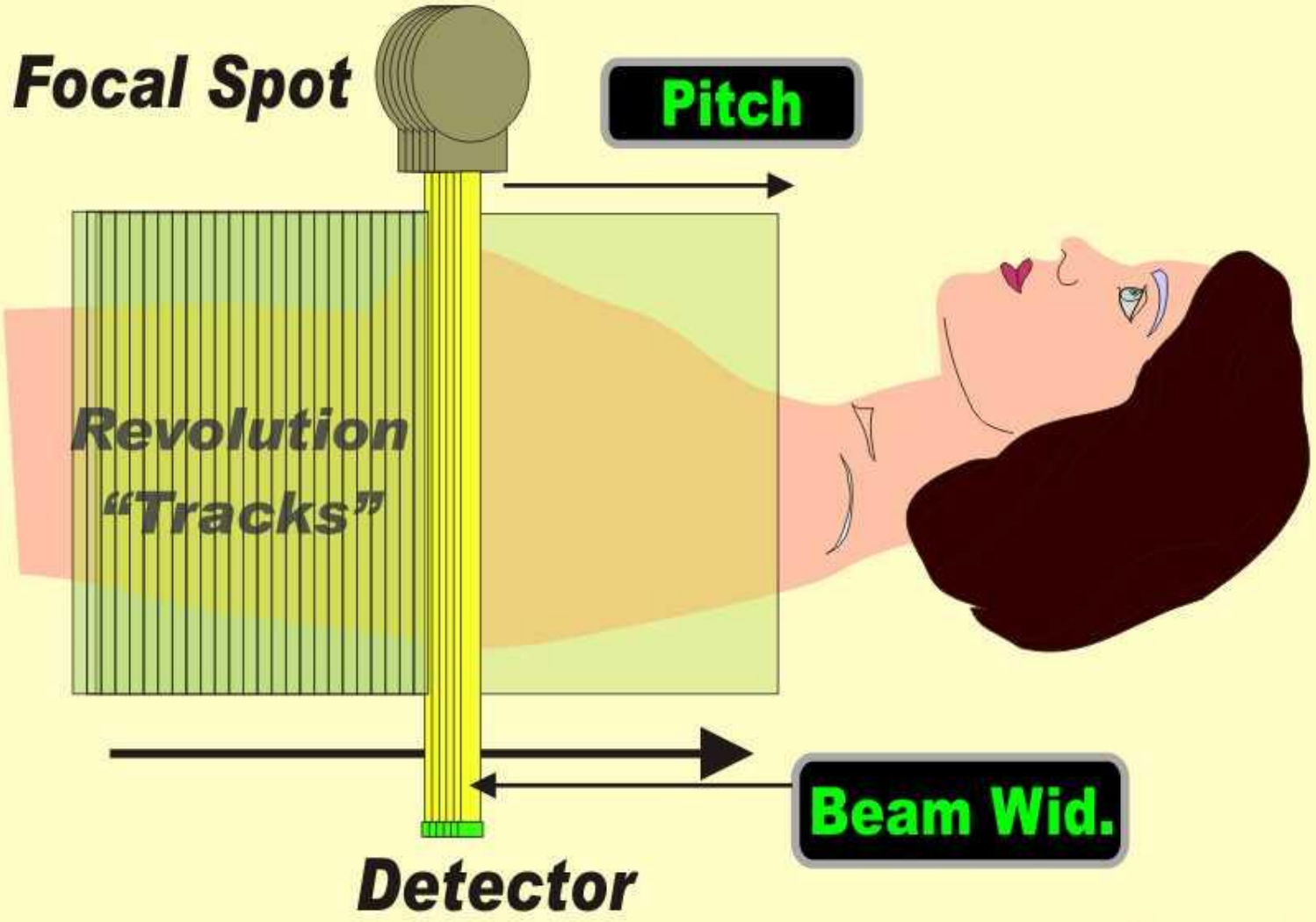
Reconstruction Filter Kernels



(Effects exaggerated for illustration here)

Sprawls

Scan Data Set



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Clinically Focused Physics Education

Classroom

Clinical Conference

Small Group

"Flying Solo"

Learning Facilitator
"Teacher"

Individual
and
Peer Interactive
Learning

Each type of learning activity has a unique value.

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Elements of Highly Effective
Medical Physics Education

In the Clinic

Class/Conference By Physicists

Online Modules

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Digital Resources to Enrich Learning Activities

The Web

Connecting and Sharing

Textbooks
Modules

Visuals

Clinical
Images

Modules

References
Teaching Files

Classroom

Clinical
Conference

Small
Group

"Flying Solo"

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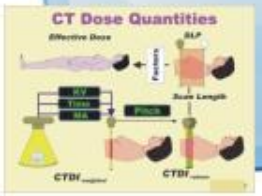
The Sprawls Resources

Sharing the Emory Experience with the World
With Emphasis on the Developing Countries

Emory

www.sprawls.org/resources

Open Access
Educational Resources

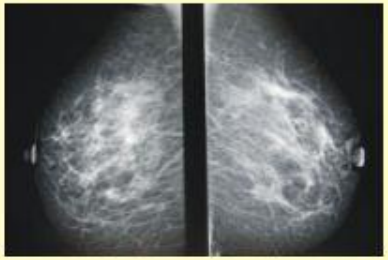


Visuals **Books** **Modules**

Global Impact

Enhancing Radiology Education
in Every Country of the World

Clinically Embedded Physics Education
A major Factor in Image Quality Assurance and Radiation Dose Management



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