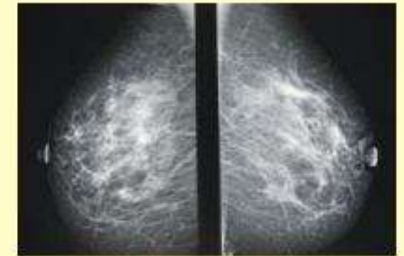


Clinically Embedded Physics Education

A major Factor in Image Quality Assurance and Radiation Dose Management



Perry Sprawls, Ph.D
Emory University
Sprawls Educational Foundation
[**www.sprawls.org**](http://www.sprawls.org)

Clinical Collaborators
Phoung-Anh Duong, M.D.
Debra Monticciolo, M.D.

This presentation available at:
[**www.sprawls.org/ipad**](http://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.

Sprawls

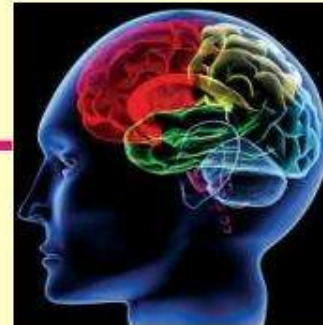
Our Learning Objectives

Clinical Radiology



**Effective
Knowledge Structures**

DO



**Levels
of
Learning**



LEARN PHYSICS



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

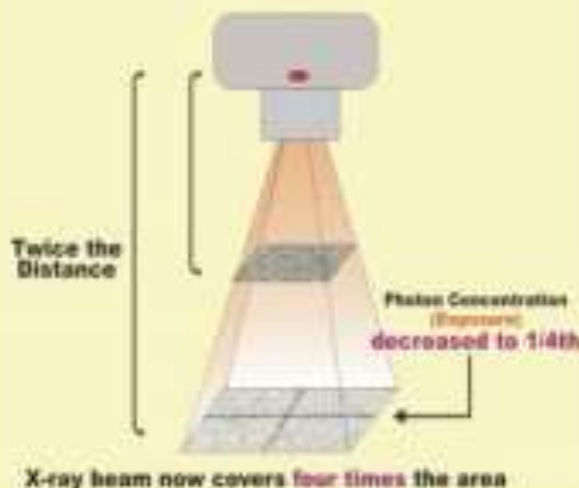
RESOURCES

Sprawls

The Physical Universe



The inverse square law is.....



The Inverse Square Law

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

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

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**

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

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

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

Verbal

**Descriptions
&
Definitions**

Exams



Who needs a knowledge of Physics applied to clinical imaging?

Radiologists, Residents and Fellows

Technologists

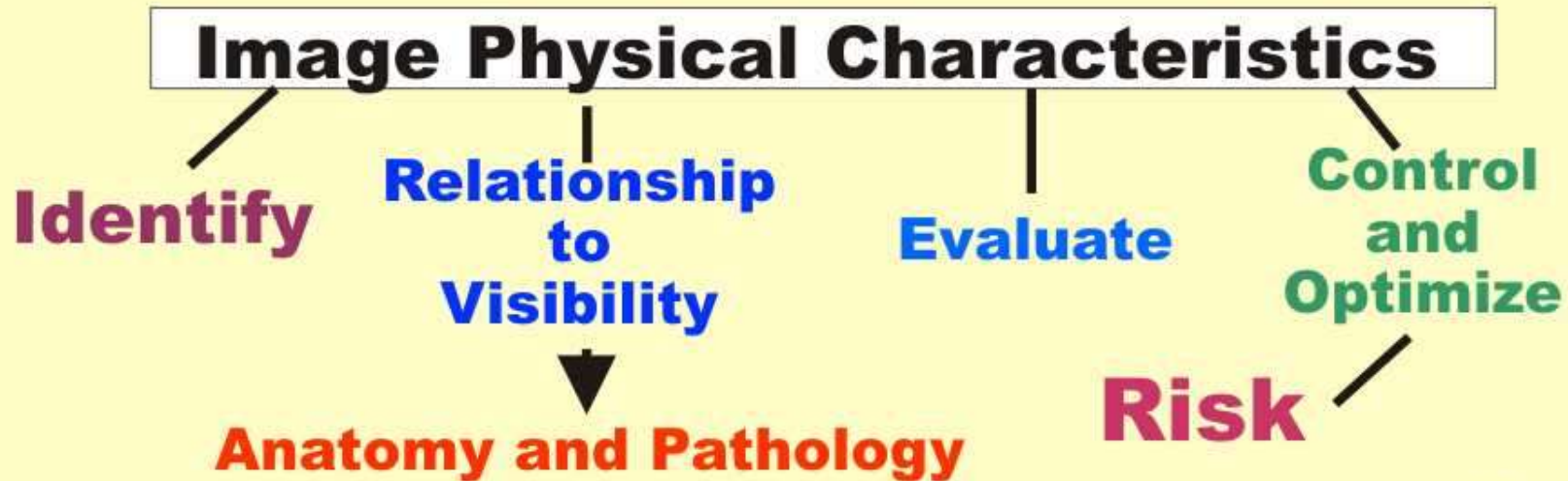
Medical Physicists



Each provides unique challenges and opportunities.

Sprawls

Physics Learning Objectives for Radiologists

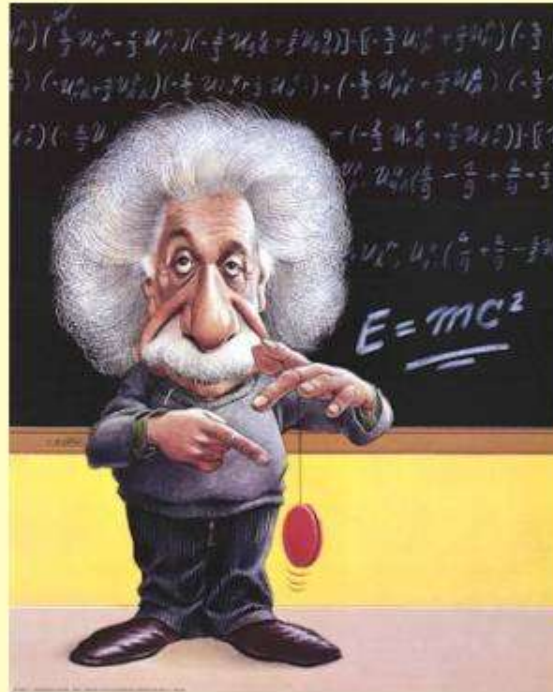


Sprawls

The Physicist as an Educator and Teacher

Our Objectives

***Provide more
EFFECTIVE
learning activities.***



***Be
EFFICIENT
in our
teaching***

Challenges Opportunities

Sprawls

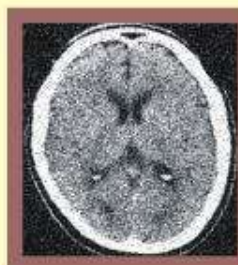


IMAGE QUALITY



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

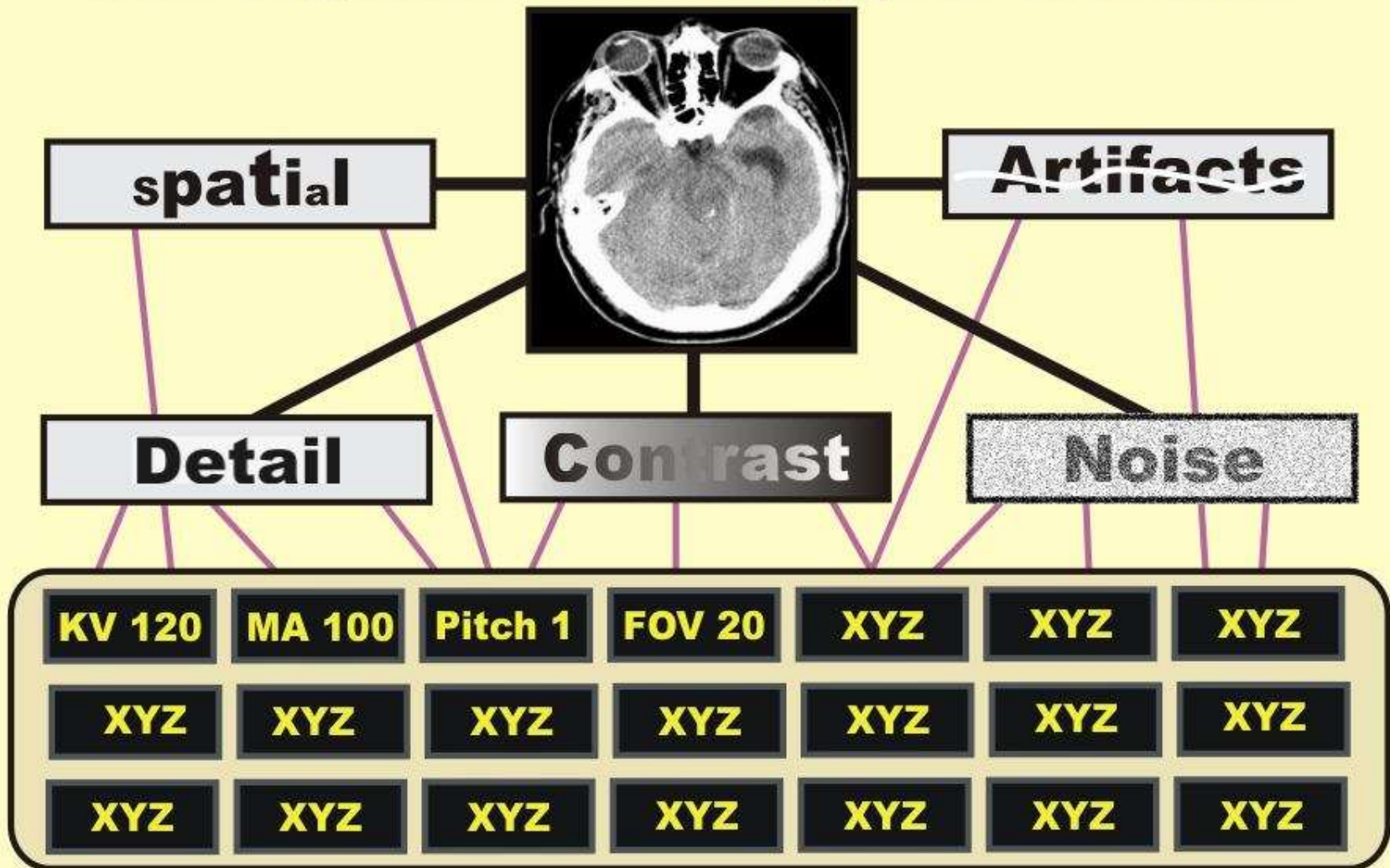
**Design
of
Equipment**
Physics Limitations

Development

Sprawls

Image Quality

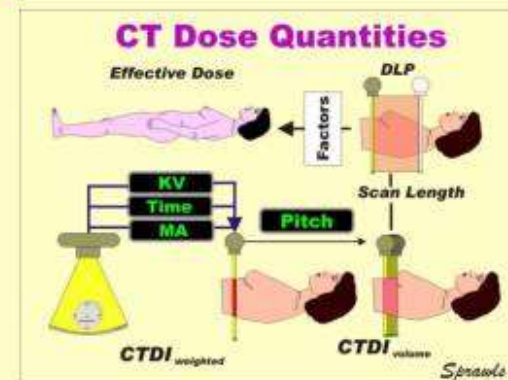
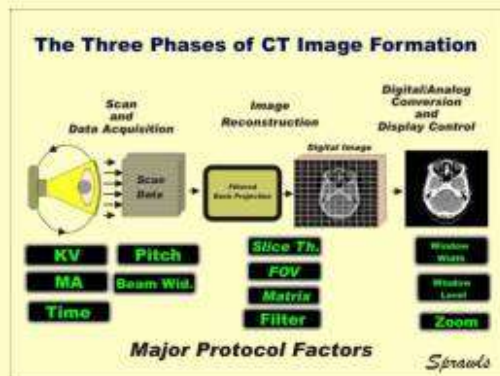
Visibility of Anatomical Structures
and Signs of Pathology or Trauma



Sprawls

Capability & Complexity

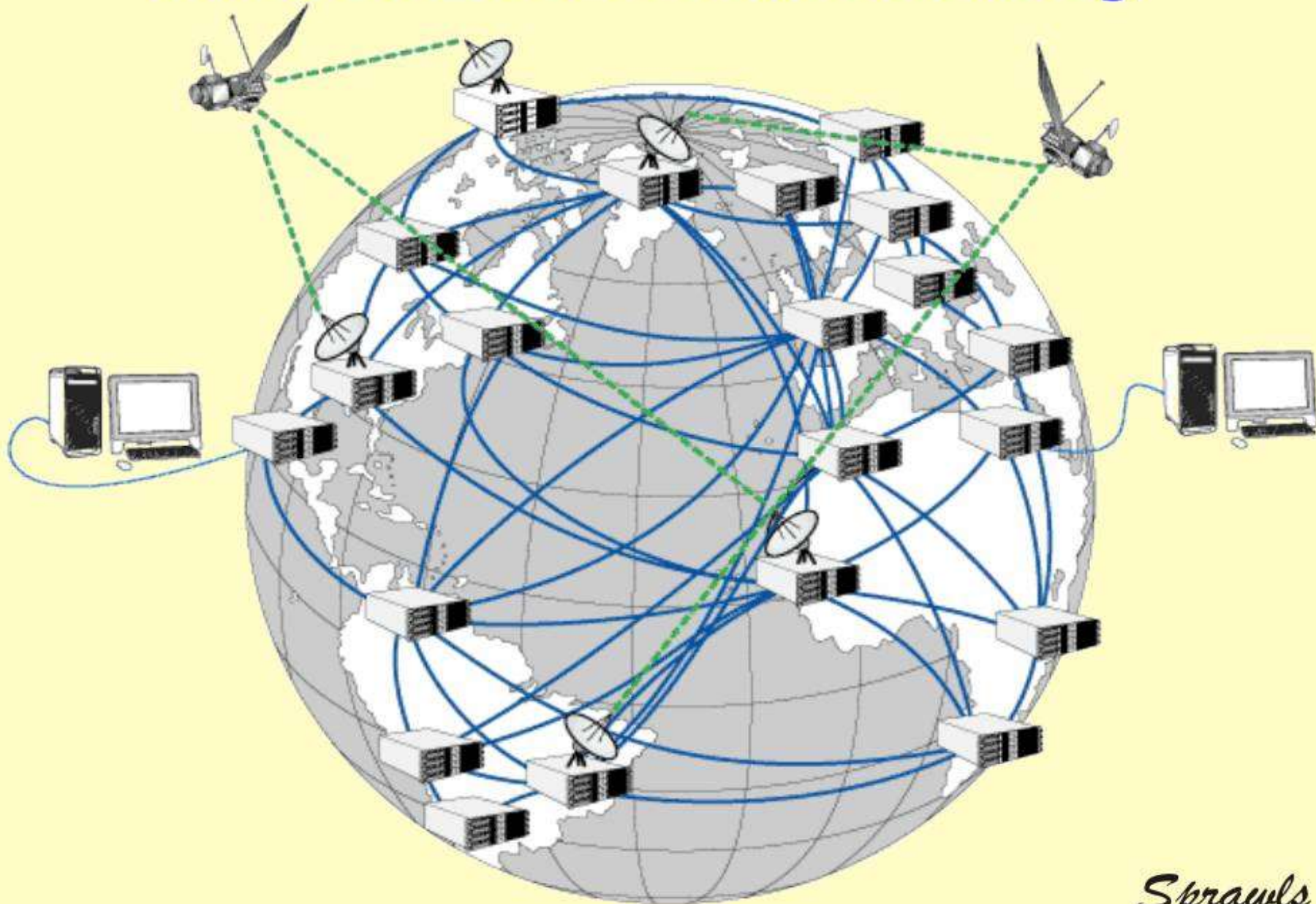
(Computed Tomography)



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.

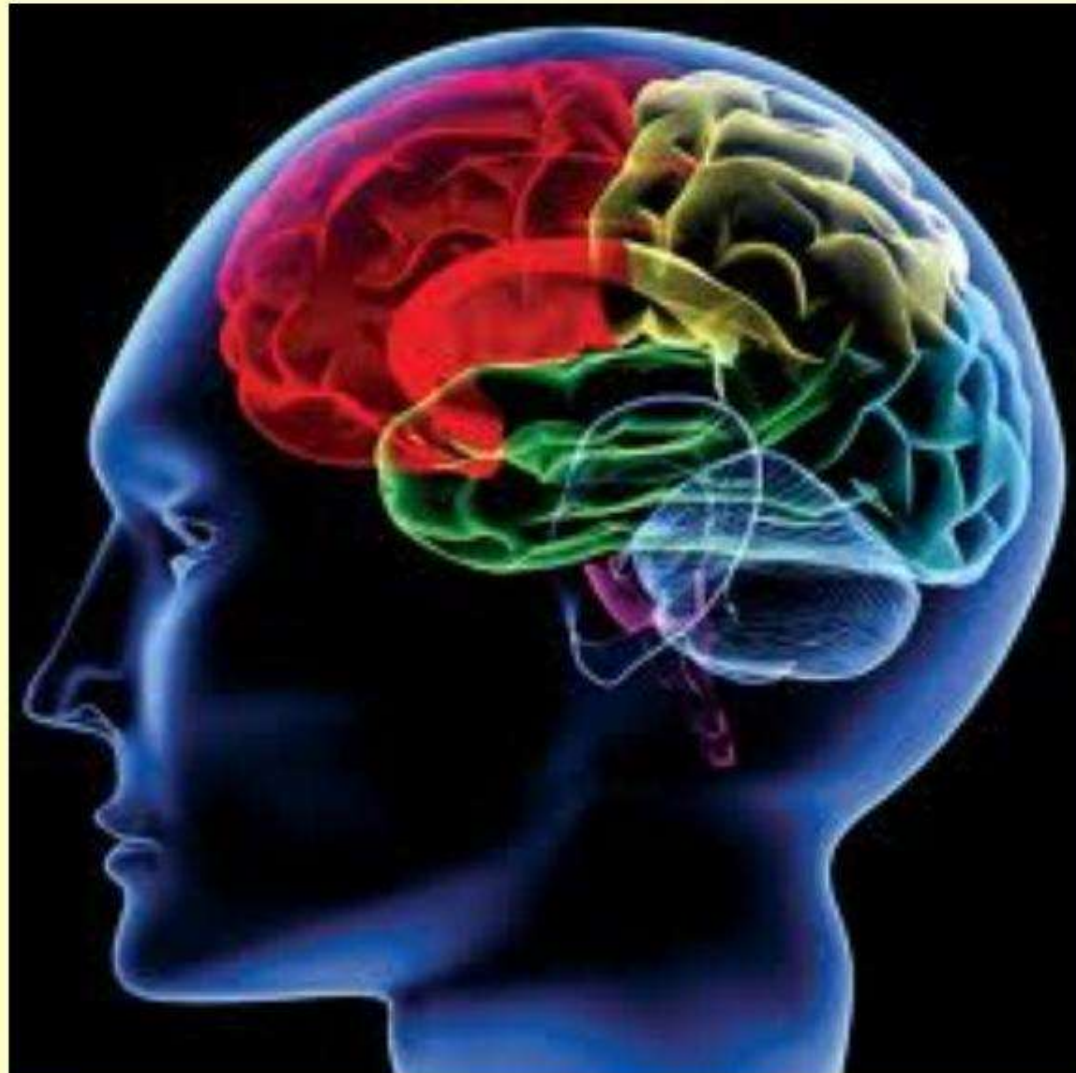
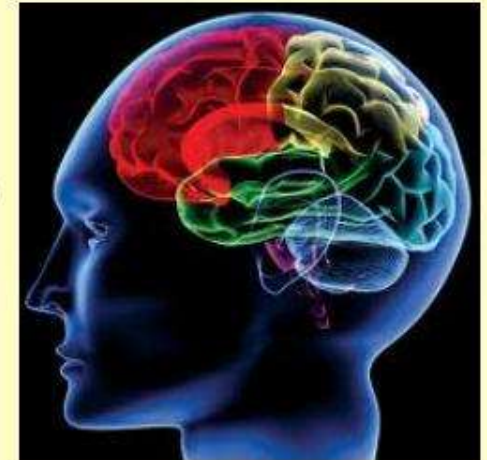
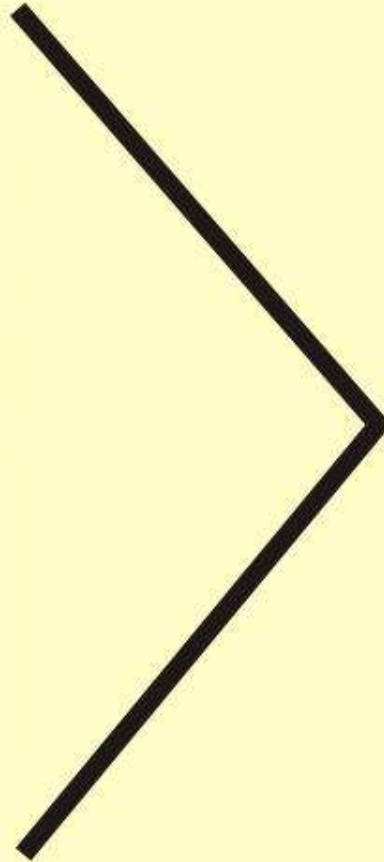


Image from the Web

Sprawls

LEARNING PHYSICS is.....
Building a knowledge structure in the brain
by Encounter and Experience

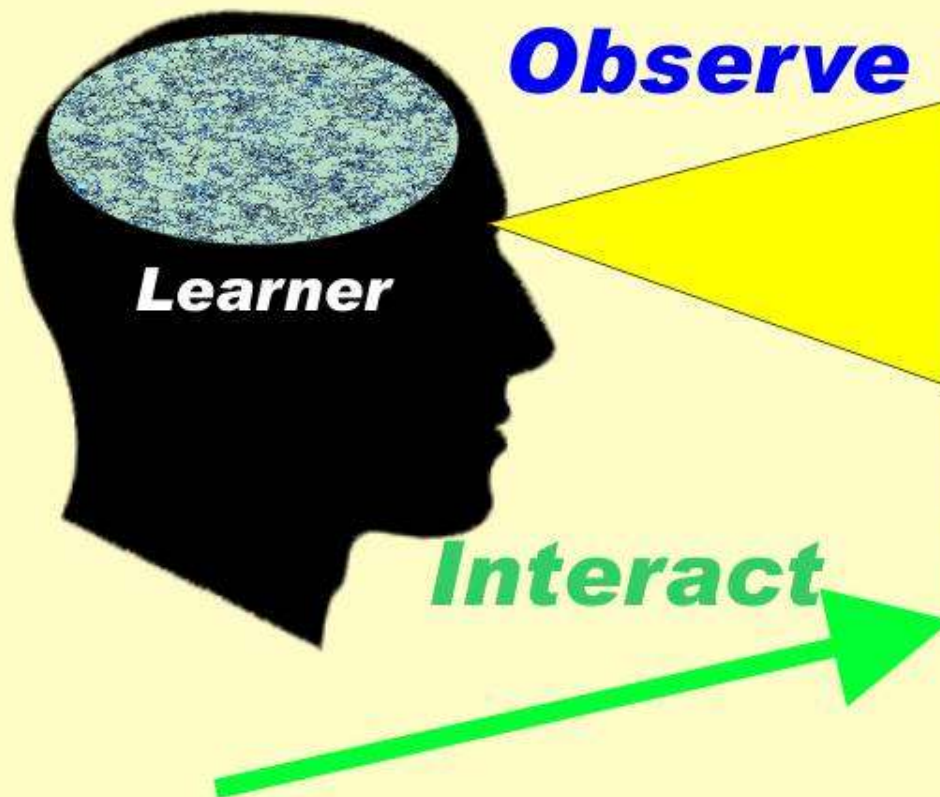


Physical Universe

Sprawls

Learning is a Natural Human Process

We Learn by Experience



Physical Universe

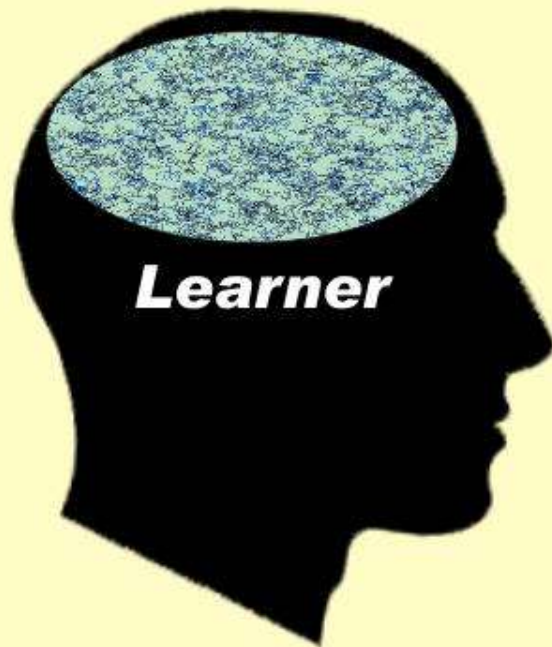


Sprawls

Teaching

is helping someone

Building a Knowledge Structure in the Brain



Physical Universe



A mental representation of physical reality

Connect

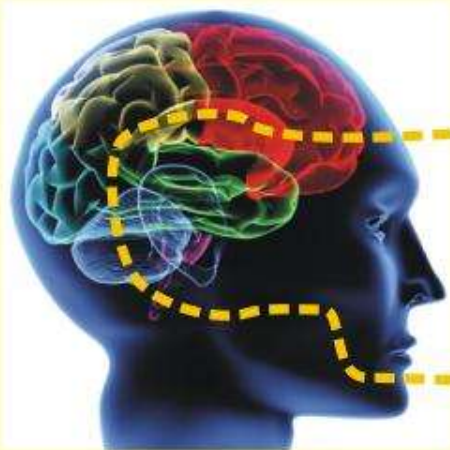
Organize

Guide

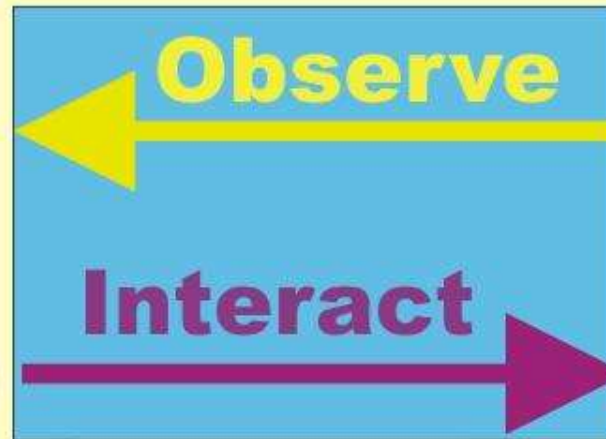
Sprawls

The Elements of A Highly Effective Educational Session

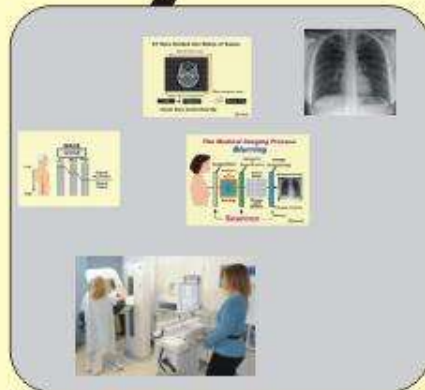
The Brain



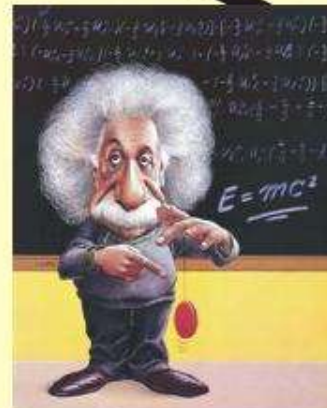
Connection



The Physical Universe
(Physics of Medical Imaging)



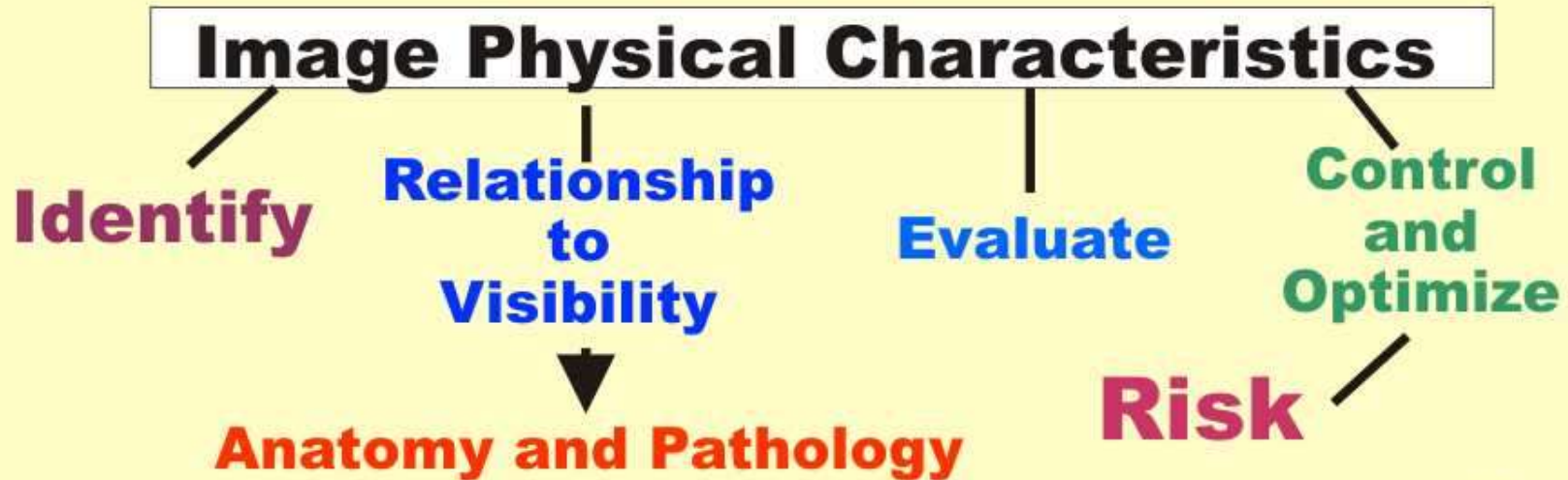
“Window”



**Teacher
/Guide**

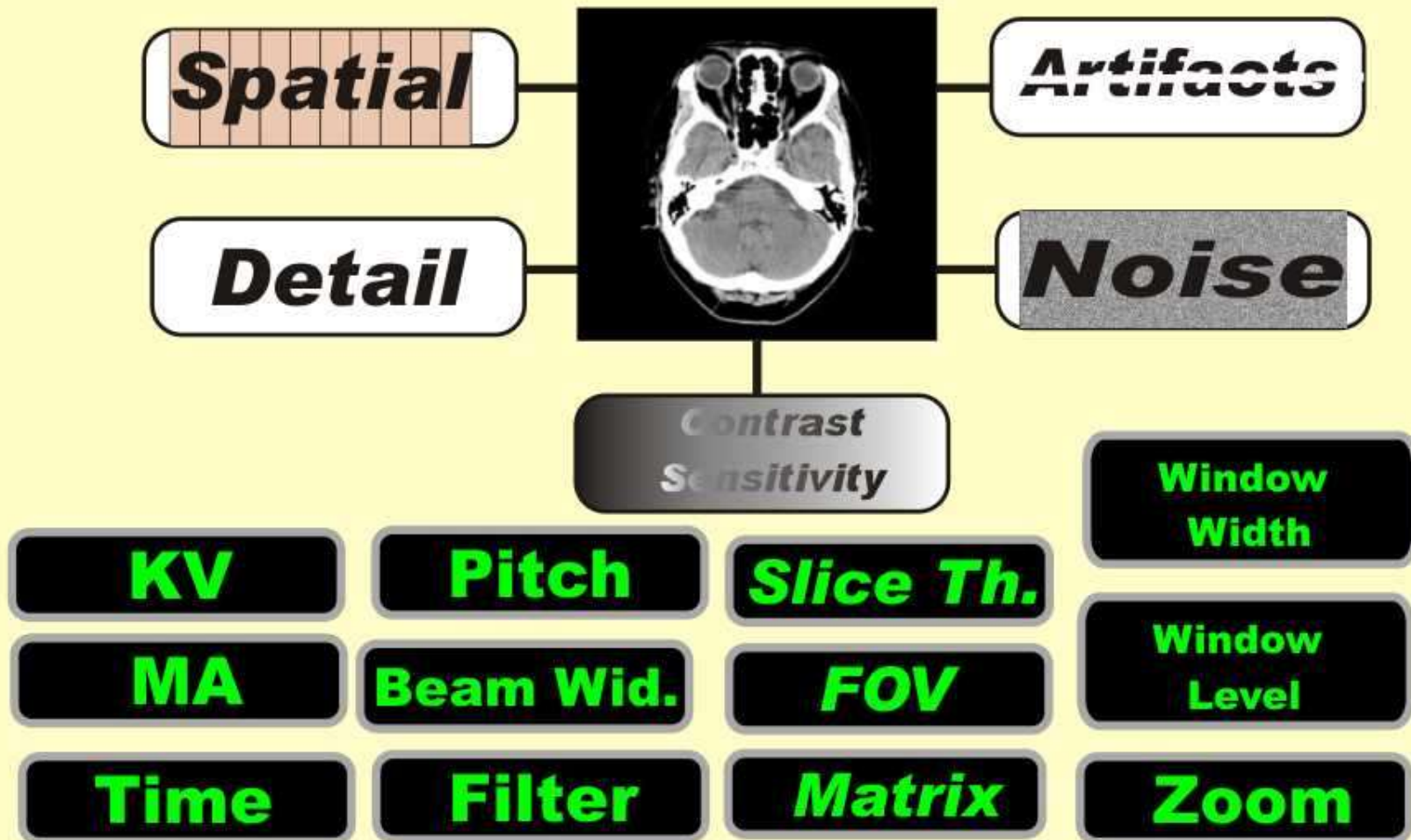
Sprawls

Physics Learning Objectives for Radiologists



Sprawls

CT Image Characteristics



Major Protocol Factors

Sprawls

Analyze and Make Decisions

Image

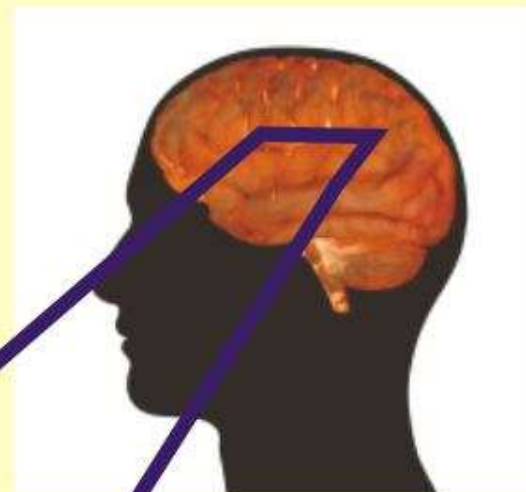


**Clinical
Characteristics**

**Physical
Characteristics**

Physics

Radiologist



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**

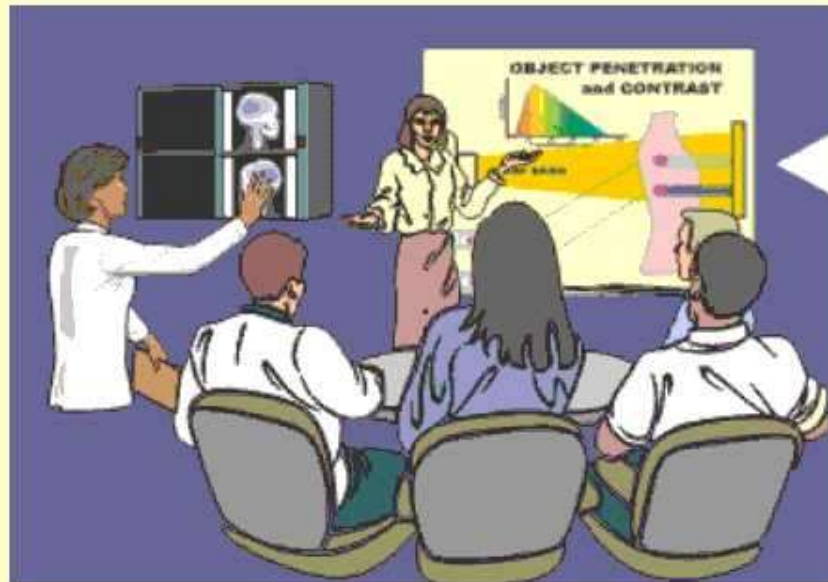


Online Modules

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

Sprawls

Effective Medical Imaging Physics Learning **...In The Clinic**

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



The Physicist Provides:
Learning Modules & Collaboration

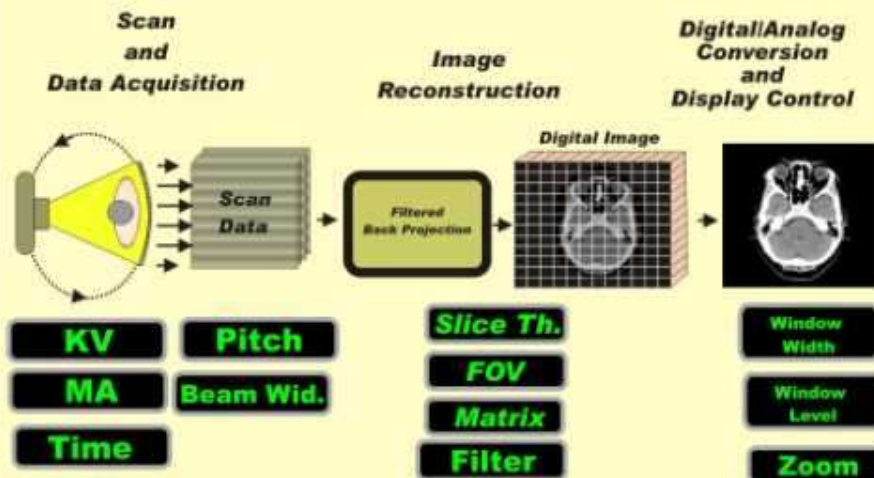
Sprawls

Visuals for Learning and Teaching

The Imaging Process

Clinical Images

The Three Phases of CT Image Formation



Major Control Factors

Sprawls



Sprawls

Visuals

to be used by

Physicists in Classroom and Conference Discussions



Visuals

for

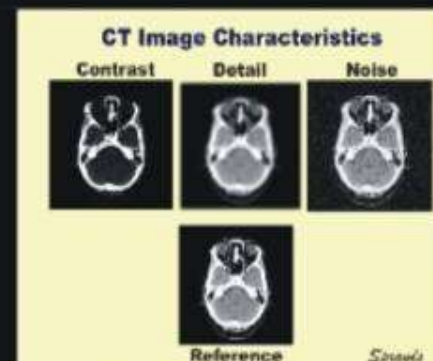
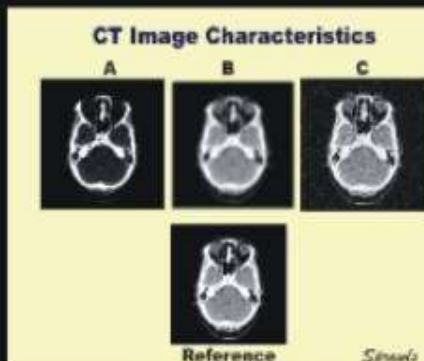
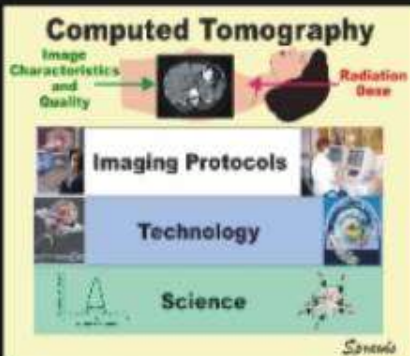
Classroom, Conference, and Collaborative Learning

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	Visual Sinus Compensation



SPRAWLS EDUCATIONAL FOUNDATION

Open Resources

for

Learning and Teaching

The Physical Principles of Medical Imaging



[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**

Sprawls

Analyze and Make Decisions

Image

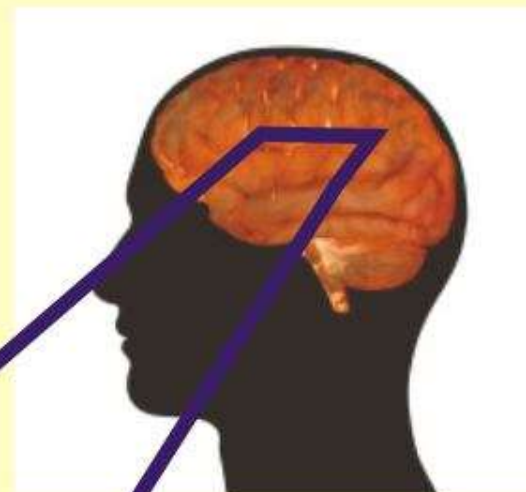


Clinical
Characteristics

Physical
Characteristics

Physics

Radiologist



KV 120

MA 100

Pitch 1

FOV 20

XYZ

XYZ

XYZ

XYZ

XYZ

XYZ

XYZ

XYZ

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XYZ

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XYZ

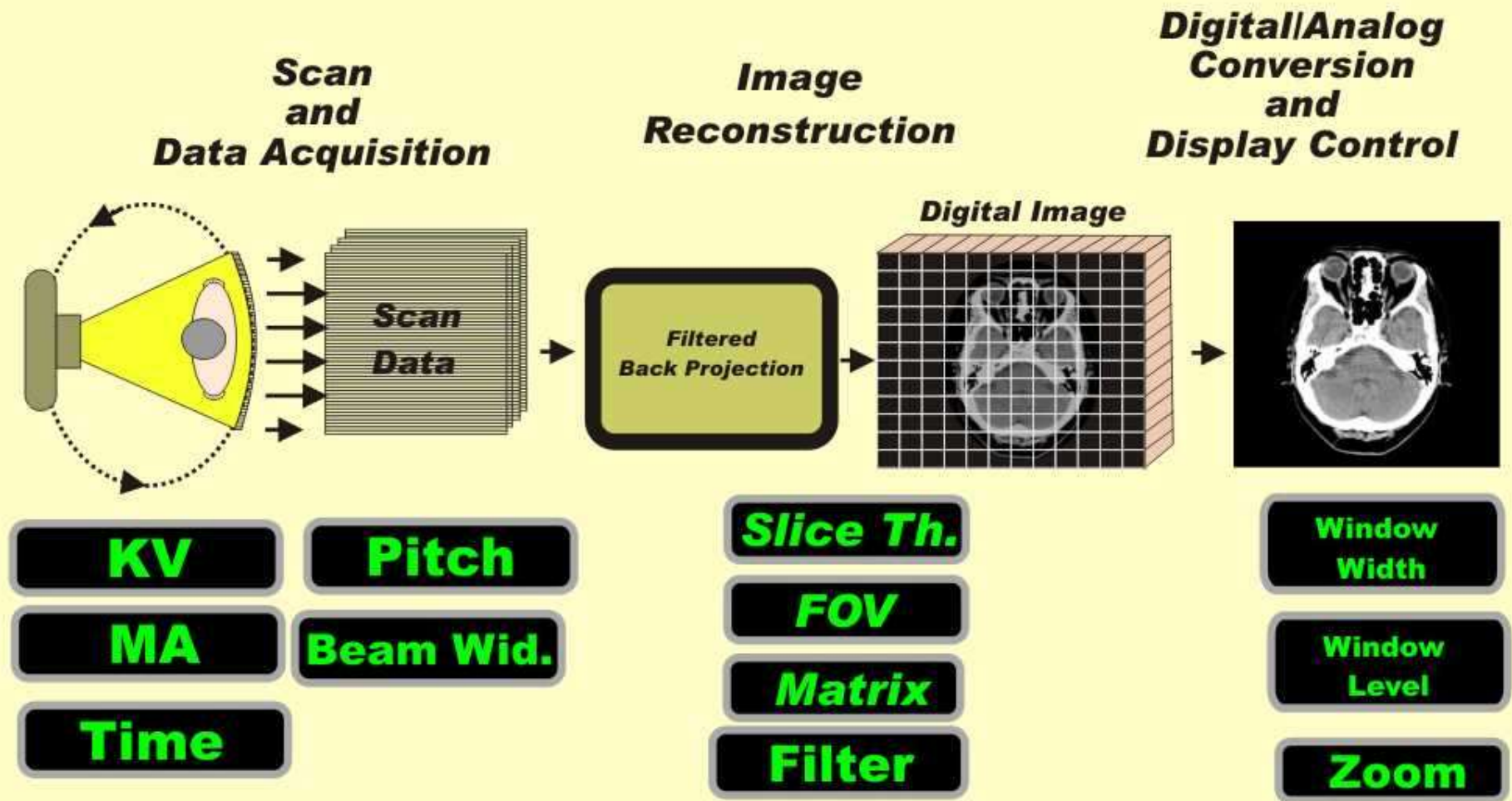
XYZ

XYZ

XYZ

Sprawls

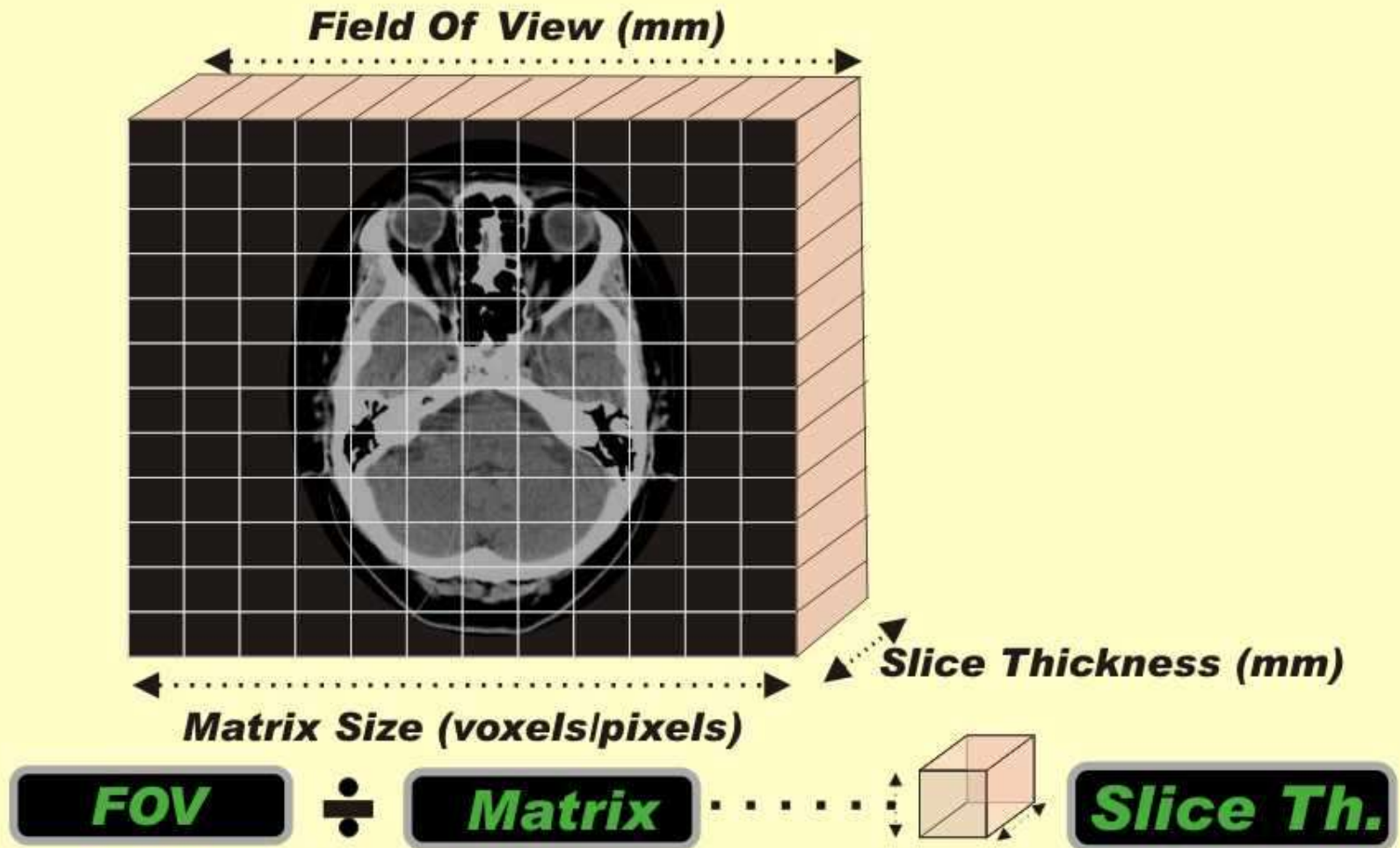
The Three Phases of CT Image Formation



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

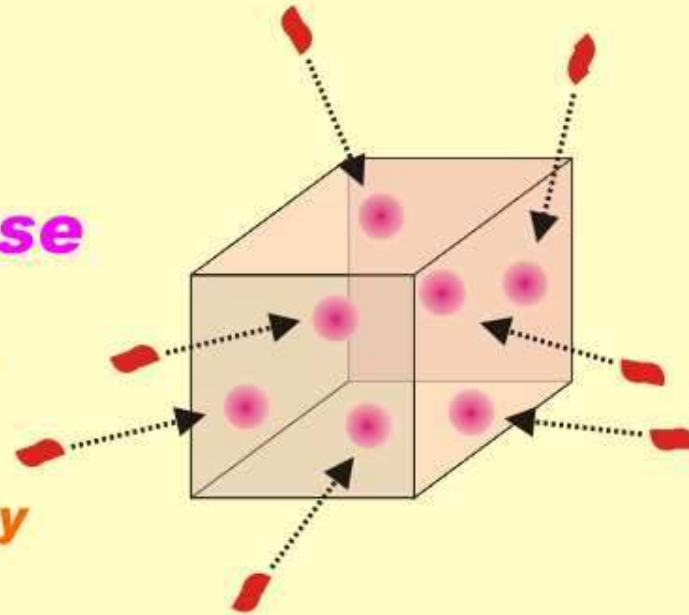


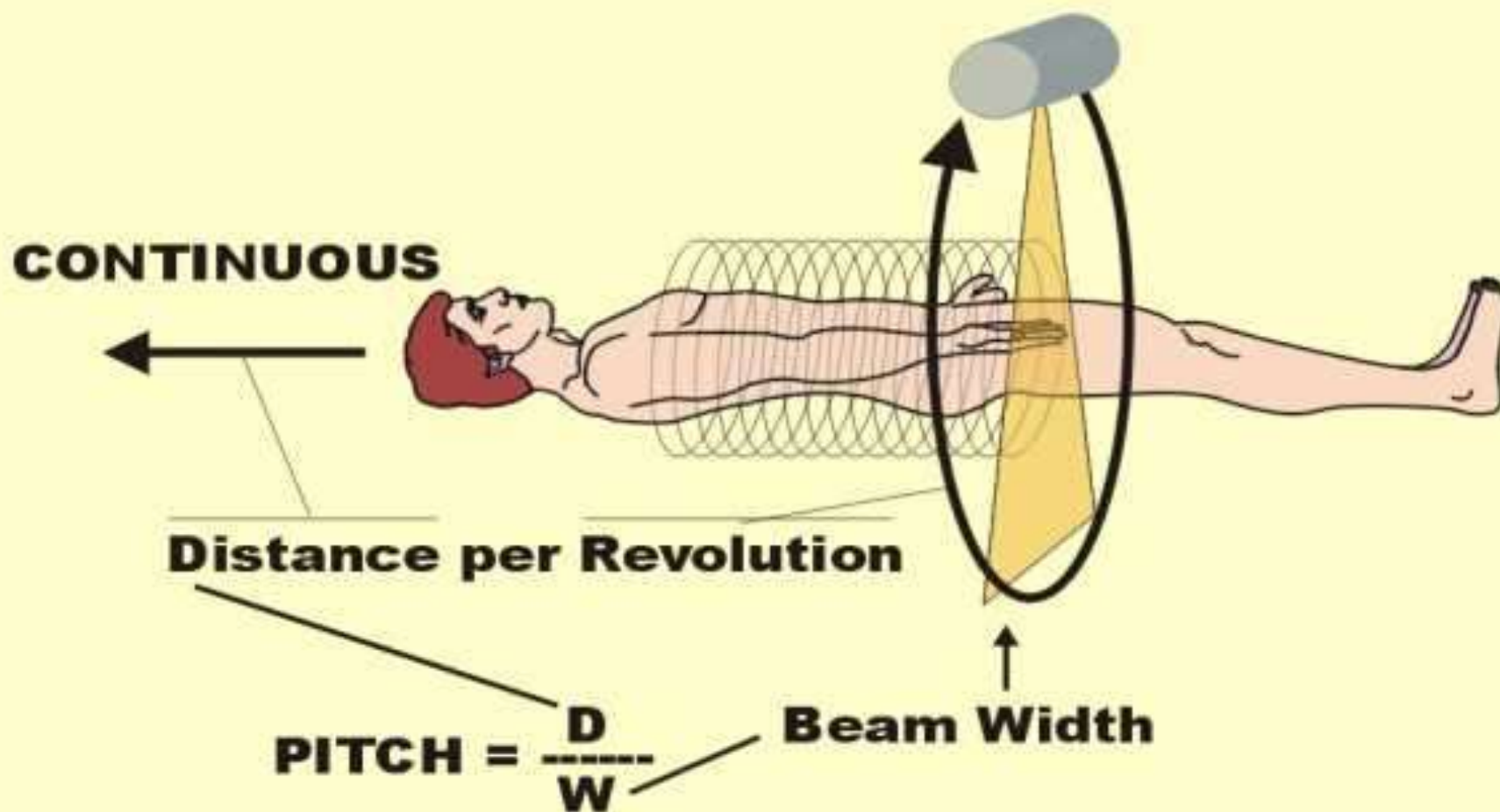
Image Noise

determined by
Number of Photons
per voxel

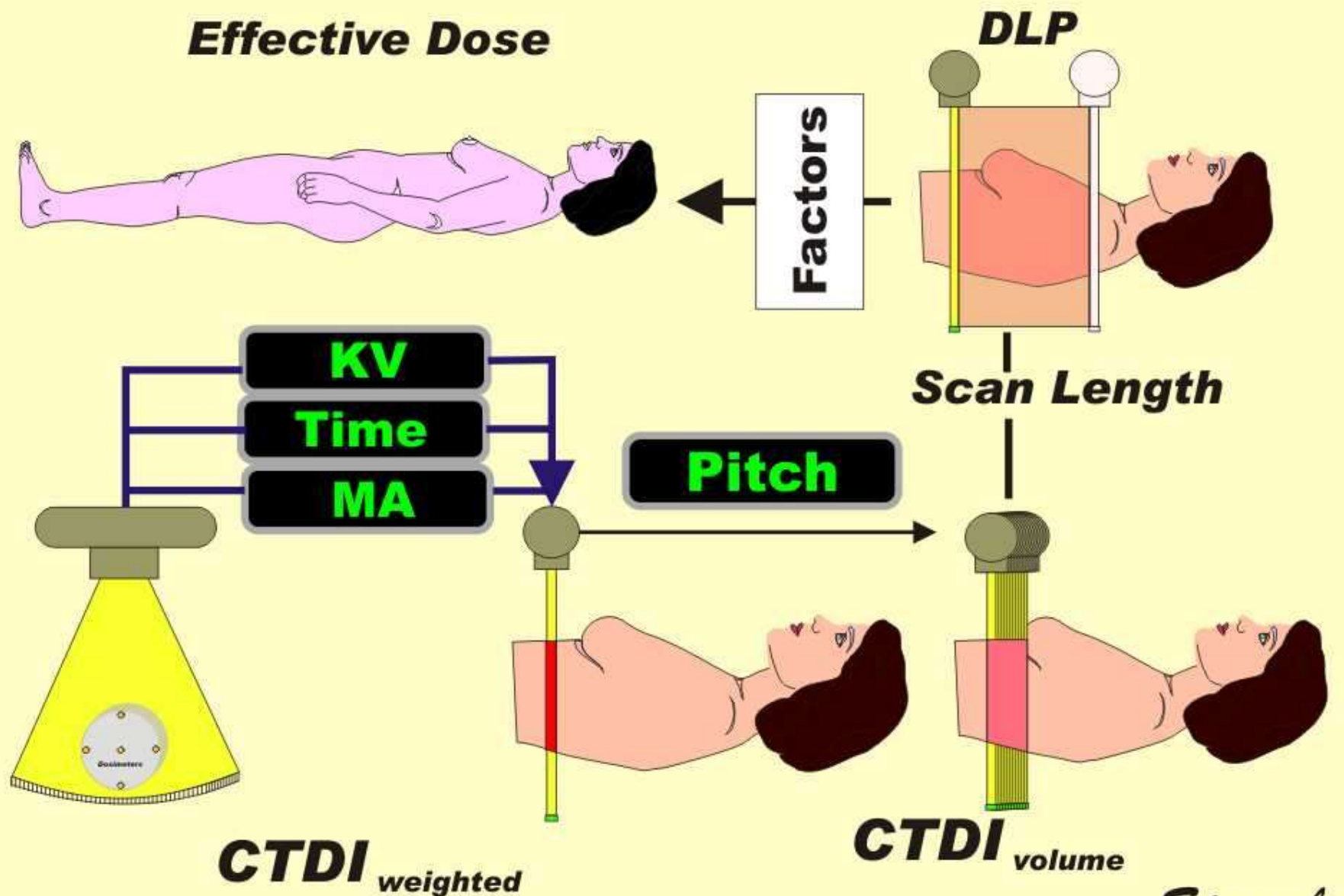
Dose is increased
by
increasing number
of photons.

Noise is reduced
by
increasing number
of photons.

SPIRAL SCAN

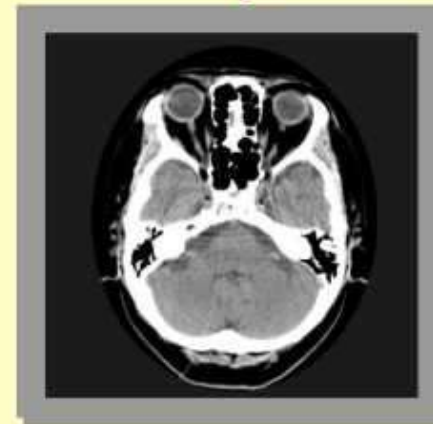


CT Dose Quantities

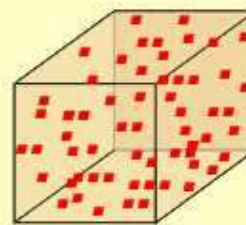
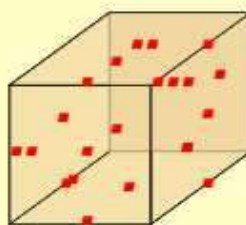
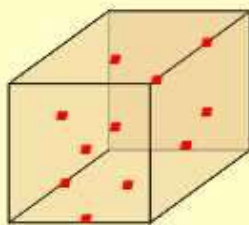


Sprawls

Decreasing Noise



Requires Increased Photons Absorbed Per Voxel



Produces Increasing Dose

Sprawls

Effect of Matrix Size on Image Noise

Small

Matrix

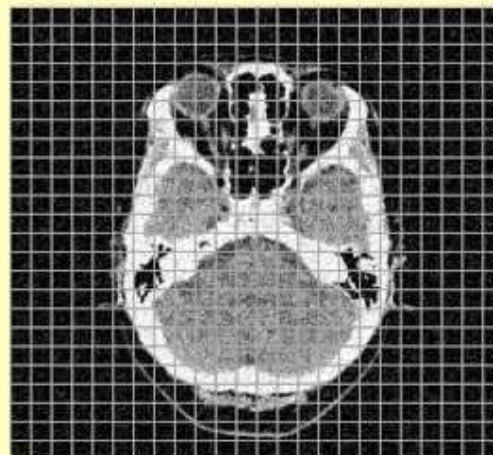
Large

Large Voxels



Low Noise

Small Voxels

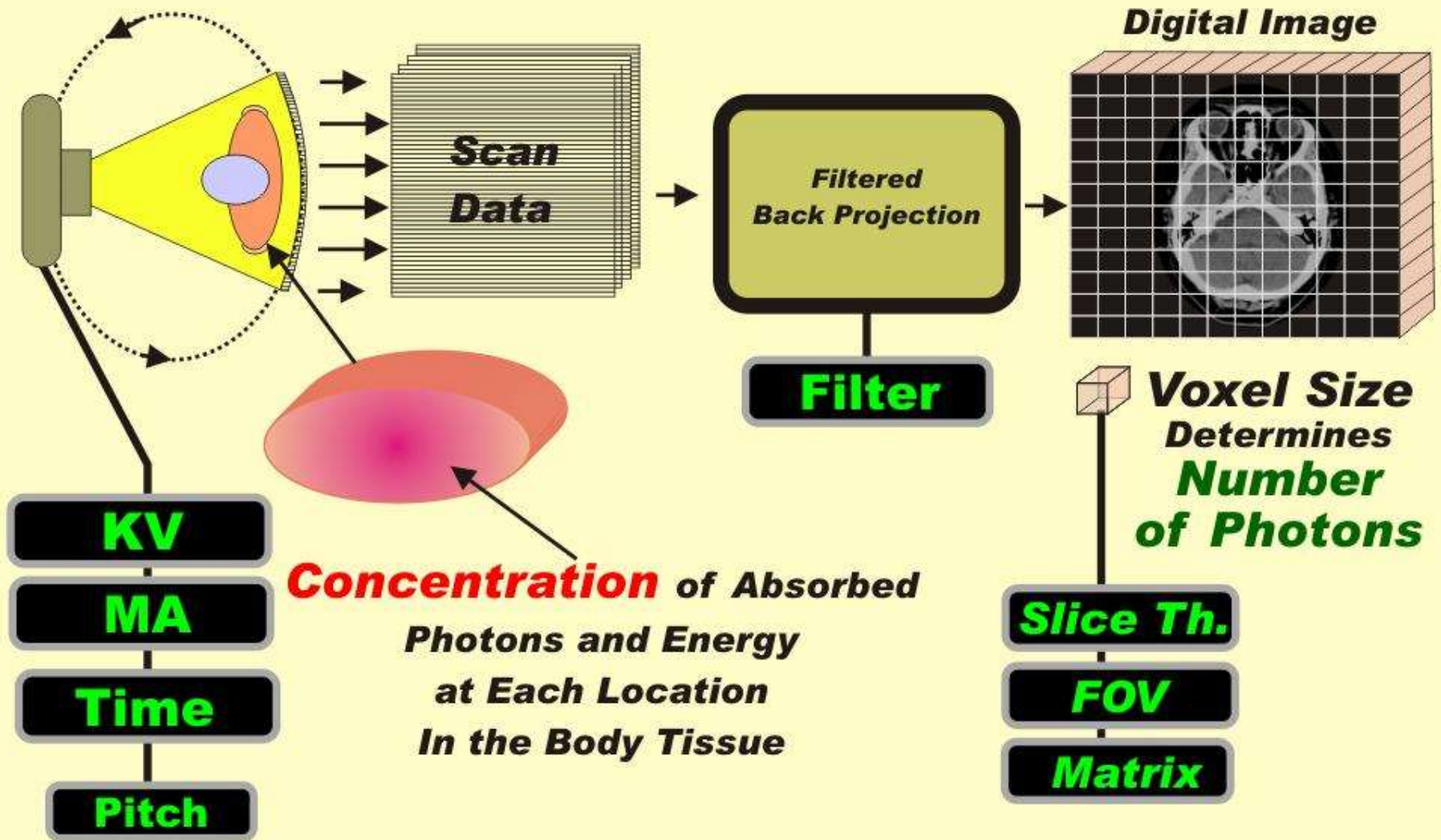


High Noise

The same radiation dose for both images.

Sprawls

Factors That Determine Image Noise

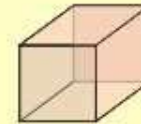


Two Major Image Quality Goals

High Detail



Low Noise



Small

Voxel Size

Large

FOV

Matrix

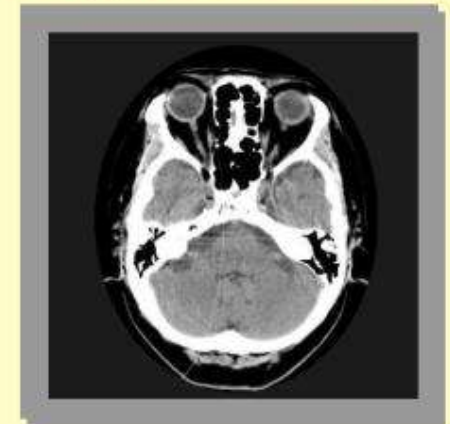
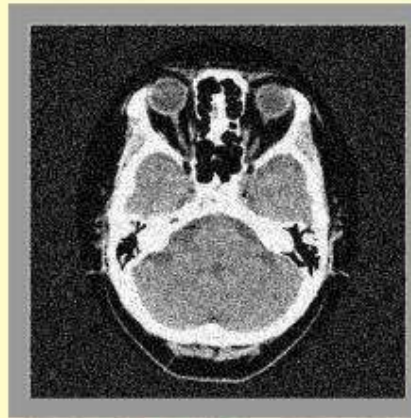
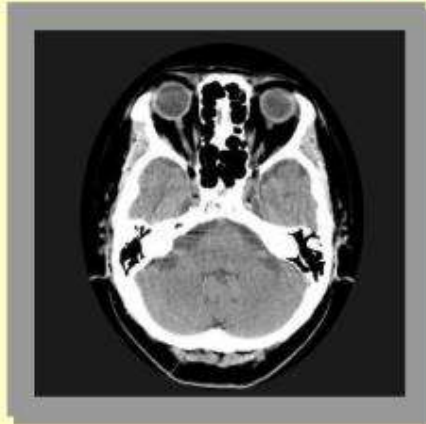
Slice Th.

Protocol Factors

Sprawls

Relationship of Radiation Dose to Image Detail

Lower Dose **Higher Dose**



**When detail
is increased
by**

Decreasing

Slice Th.

Increasing

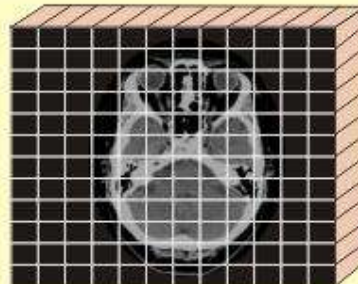
Matrix

Decreasing

FOV

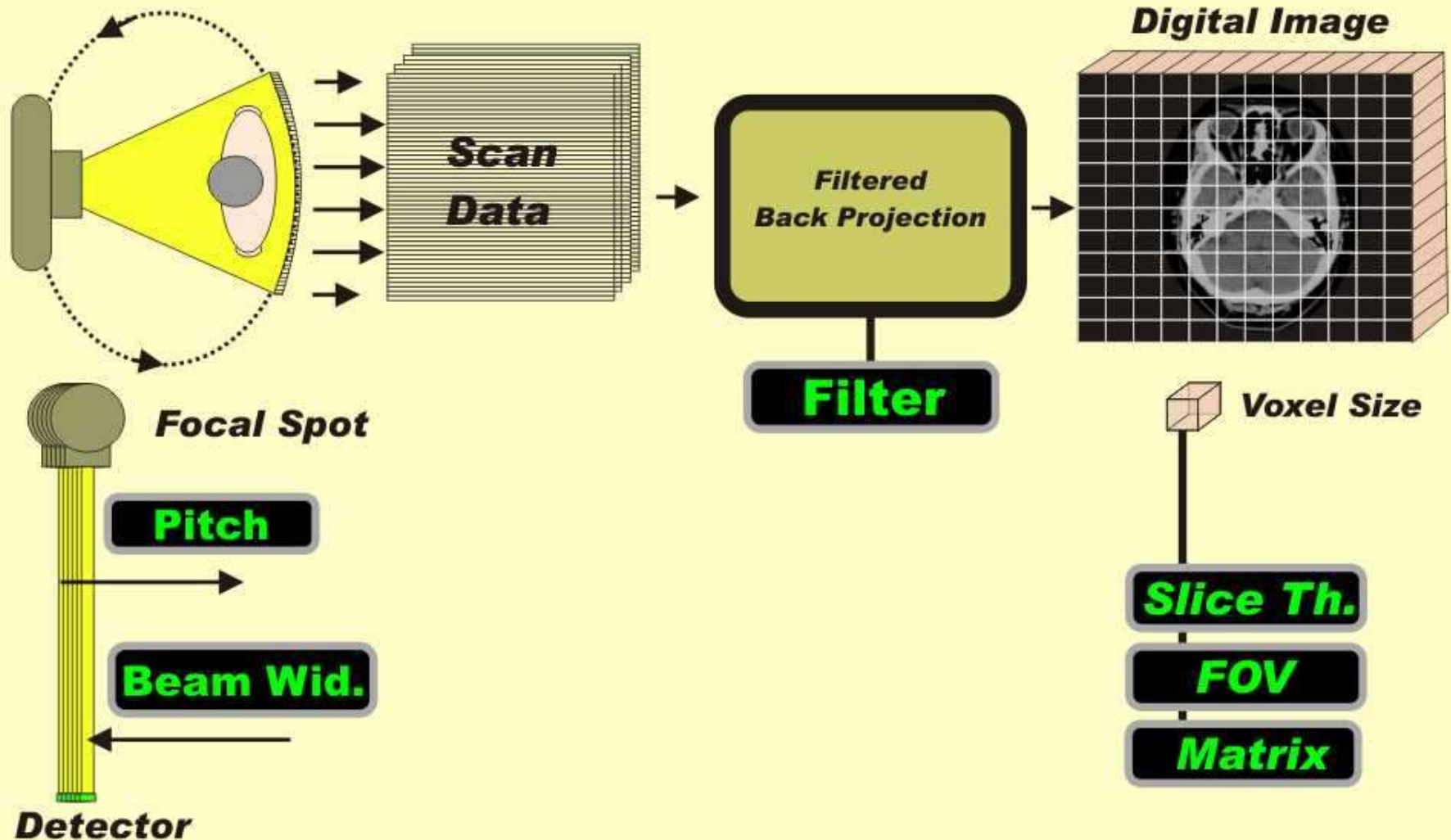
**Noise
Increases**

**Because of
decreased
voxel size**



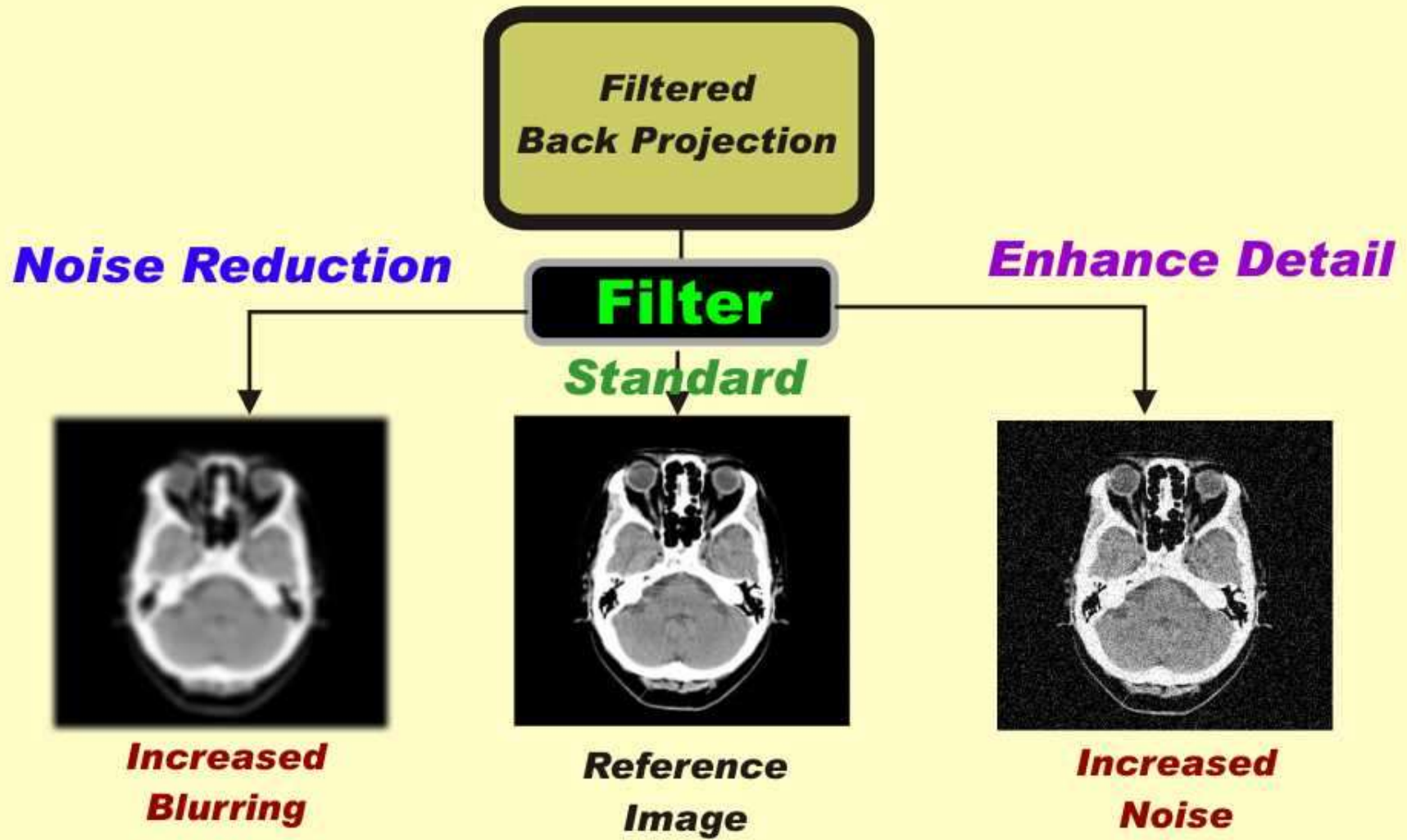
**Dose
must be
increased
to
reduce noise.**

Factors That Determine Image Detail (Sources of Blurring)



Sprawls

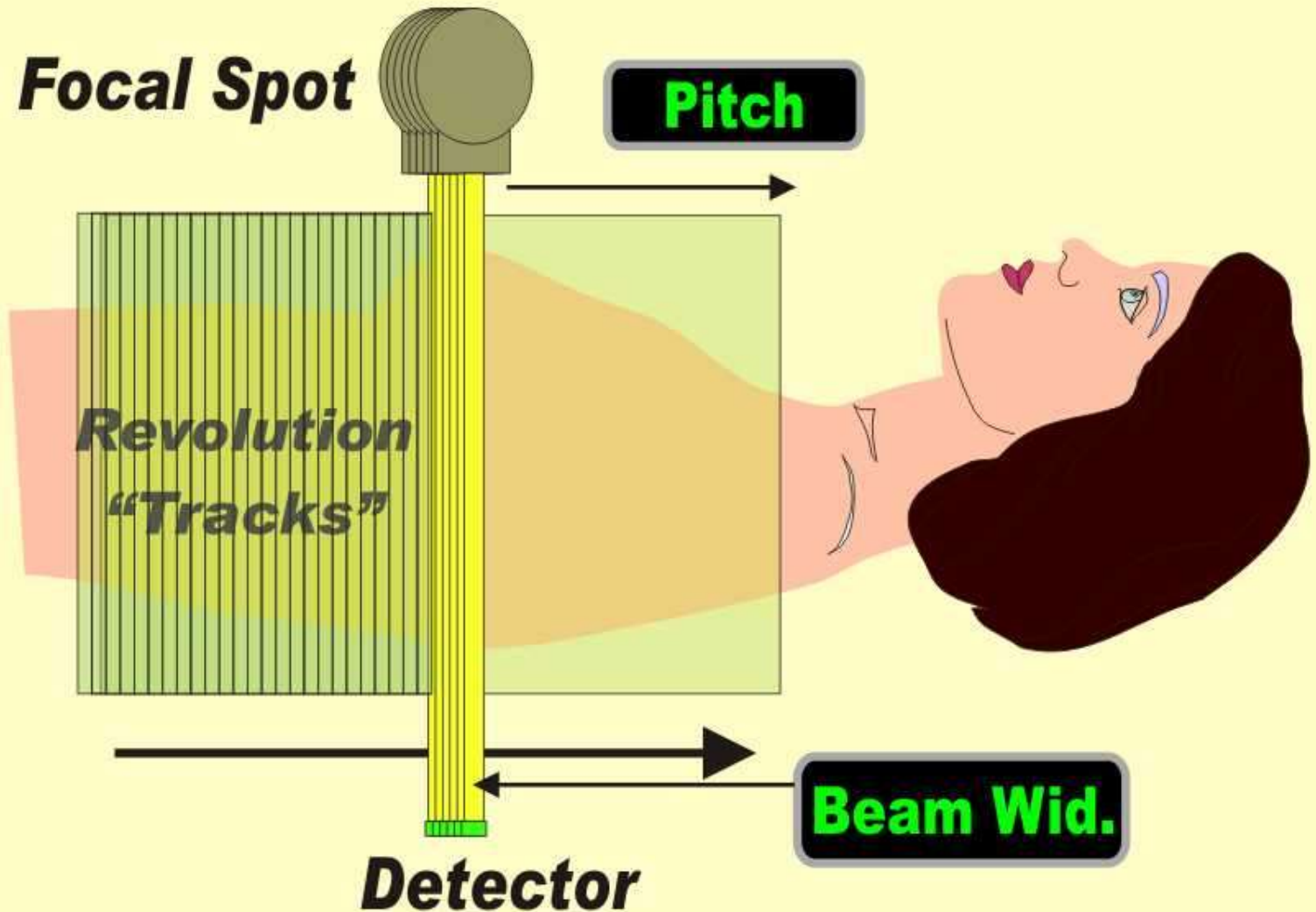
Reconstruction Filter Kernels



(Effects exaggerated for illustration here)

Sprawls

Scan Data Set



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

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

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

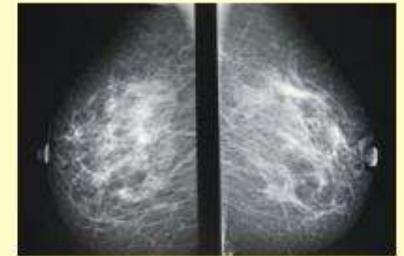
Global Impact



**Enhancing Radiology Education
in Every Country of the World**

Clinically Embedded Physics Education

A major Factor in Image Quality Assurance and Radiation Dose Management



Perry Sprawls, Ph.D
Emory University
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Clinical Collaborators
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This presentation available at:
[**www.sprawls.org/ipad**](http://www.sprawls.org/ipad)