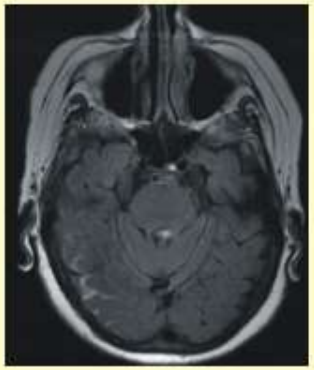
Optimizing CT Image Quality
and
Dose Management
Using
Collaborative Clinically Focused Physics Education



Perry Sprawls, Ph.D
Emory University
Sprawls Educational Foundation

Phuong-Anh T. Duong, M.D.
Emory University

View At
www.sprawls.org/ipad

Effective and Safe Clinical Procedures

Imaging

Radiation Therapy

Require an extensive knowledge of Applied Physics and The Associated Technology

Sprawls

Who needs a knowledge of Physics applied to clinical imaging?

Radiologists, Residents and Fellows

Technologists

Medical Physicists

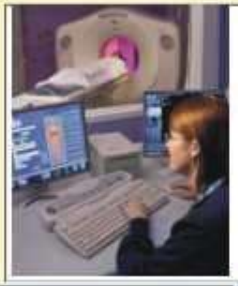
Each provides unique challenges and opportunities.

Sprawls

Computed Tomography

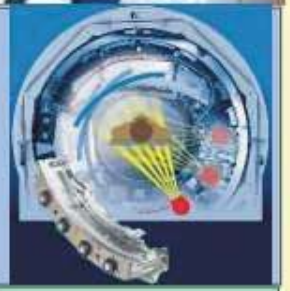
Image Characteristics and Quality

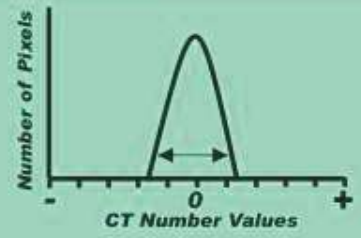
Radiation Dose



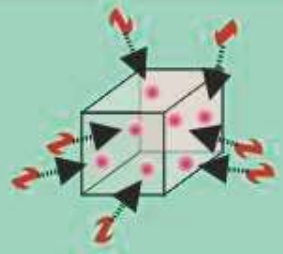
Imaging Protocols

Technology





Physics



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

Clinically Focused Physics Education

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





Learning Facilator "Teacher"

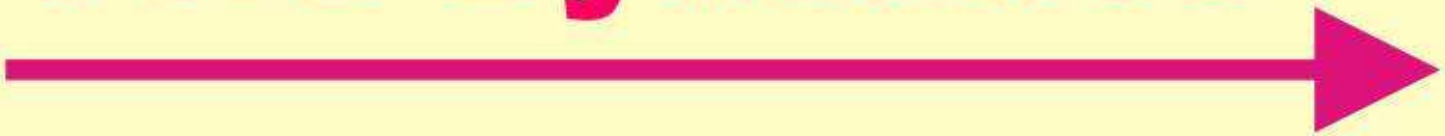
Individual and Peer Interactive Learning

The Goal..

Increase the **EFFECTIVENESS** of each type of learning activity with the **necessary resources** and **understanding of the process** by the Learning Facilators.

Sprawls

Five Dynamics



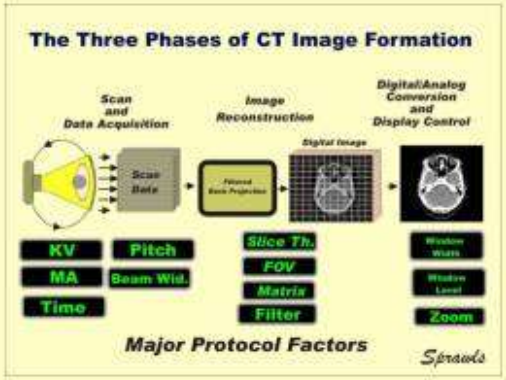
“ It’s a new ball game!”

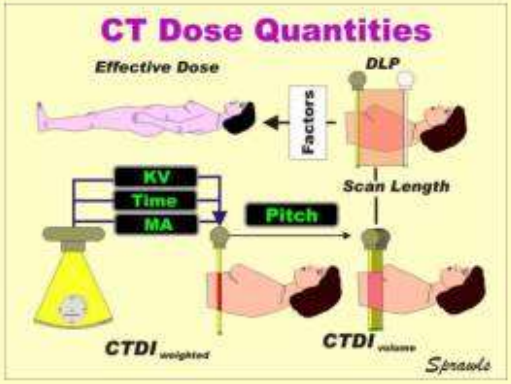
Capability & Complexity
Geographic Dispersion
Learning & Teaching Knowledge
Expanding Educational Resources
Increased Connectivity

Sprawls

Capability & Complexity

(Computed Tomography)





Years

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

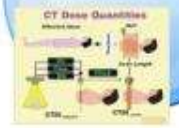
"Flying Solo"

Sprawls

Physics Education to Enhance CT Image Quality Optimization and Dose Management

Physicists With Experience in Clinical CT

Open Access Educational Resources



Visuals

Modules

Global Impact

Teach, Collaborate, Consult

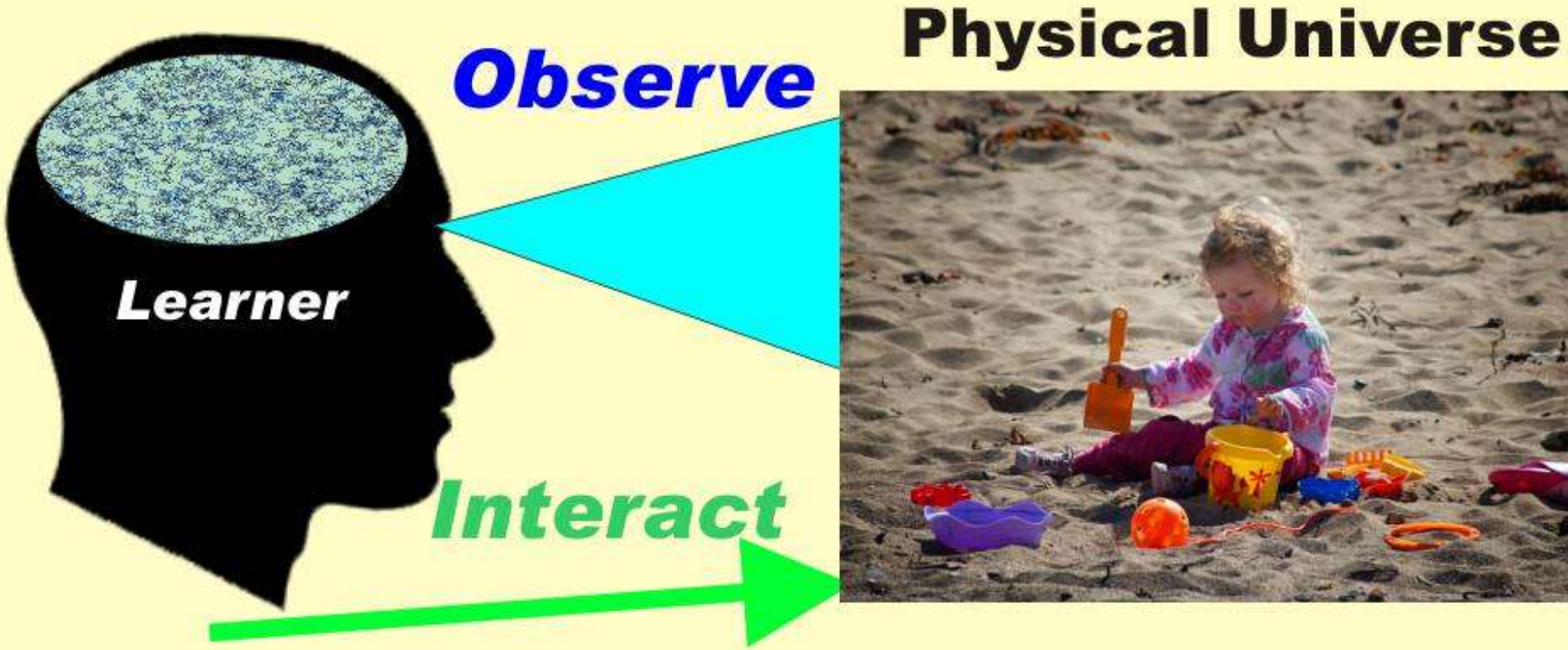
Physicists in Local Institutions

(with Limited Clinical CT Experience)

A resource to enhance the performance of medical physicists in every country of the world.

Learning is a Natural Human Process

We Learn by Experience



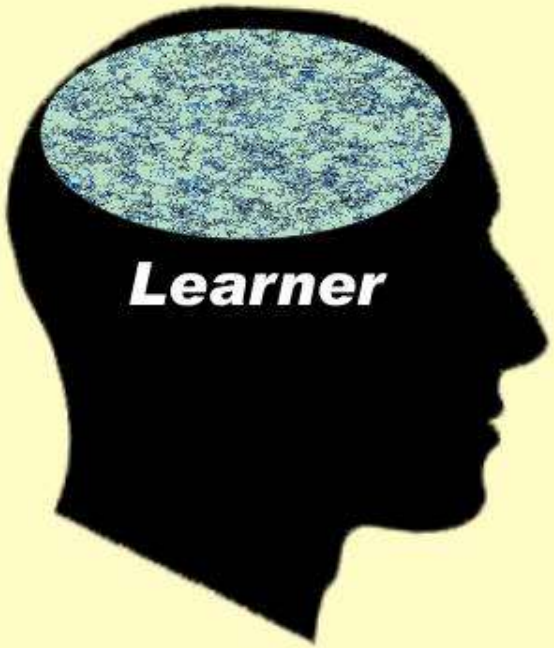
Our Early Physics Learning Activities

Sprouts

Teaching

is helping someone

Building a Knowledge Structure in the Brain



Physical Universe

A mental representation of physical reality

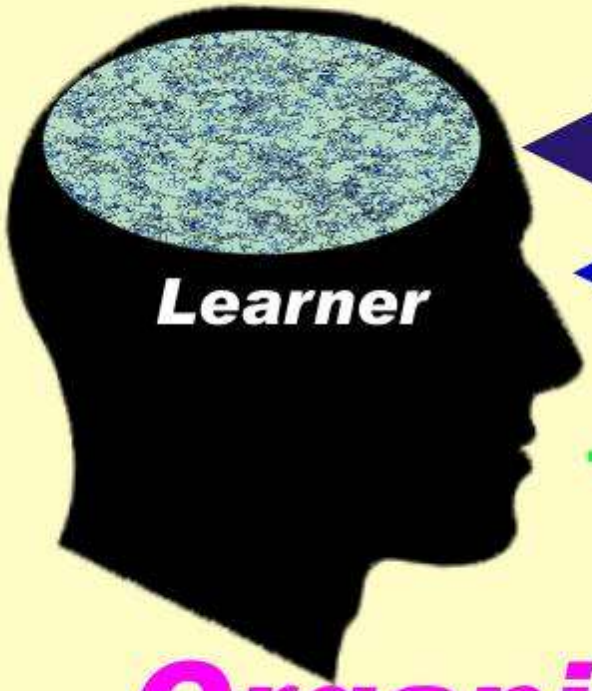
Connect Organize Guide

Sprawls

The Role of Formal Education

Connect

Physical Universe



Observe

Interact

Organize and Guide

The Barrier

Physics Education

Clinical Imaging

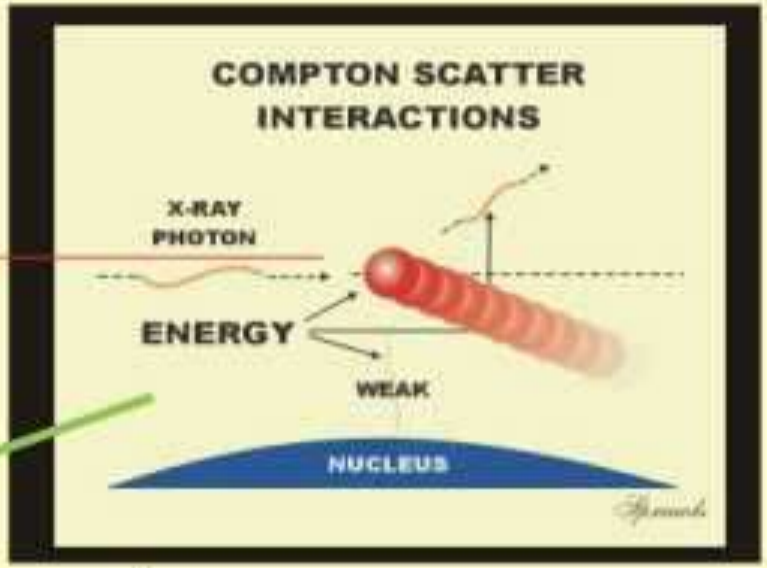
Efficiency

Location, Resources, Human Effort, Cost

Limited Experience

Sprawls

Technology Enhanced Learning



Learning Guide

Learner

Visuals for Classroom

Notes
and
Text

Online
Resources

Sprawls

Visuals

to be used by

Physicists in Classroom and Conference Discussions

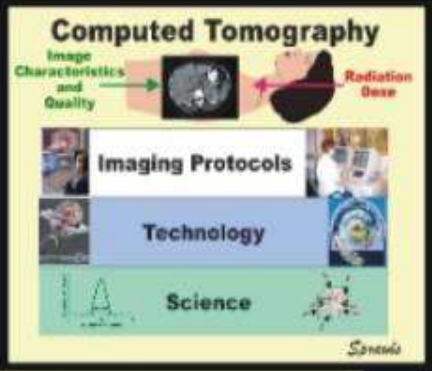
SPRAWLS EDUCATIONAL FOUNDATION
Open Resources for Learning and Teaching
The Physical Principles of Medical Imaging

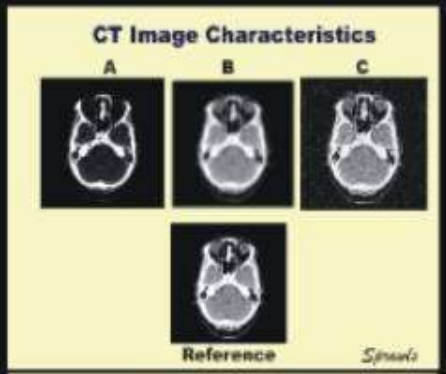
Visuals
for
Classroom, Conference, and Collaborative Learning

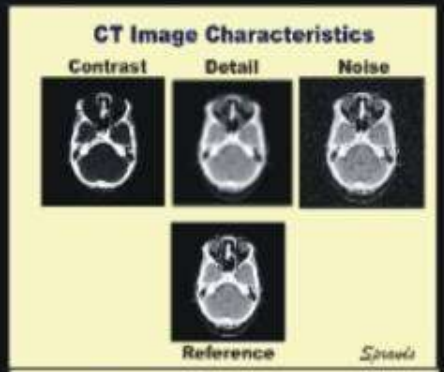
RIGHT CLICK on each visual to download and use in PowerPoint or other display programs.

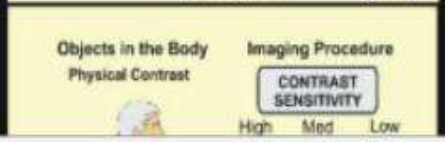
Computed Tomography Image Quality Optimization and Dose Management

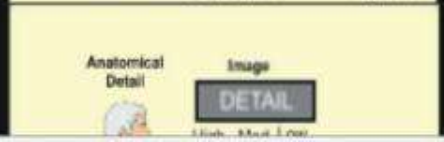
Companion Module
http://www.sprawls.org/resources/CTIQDM/





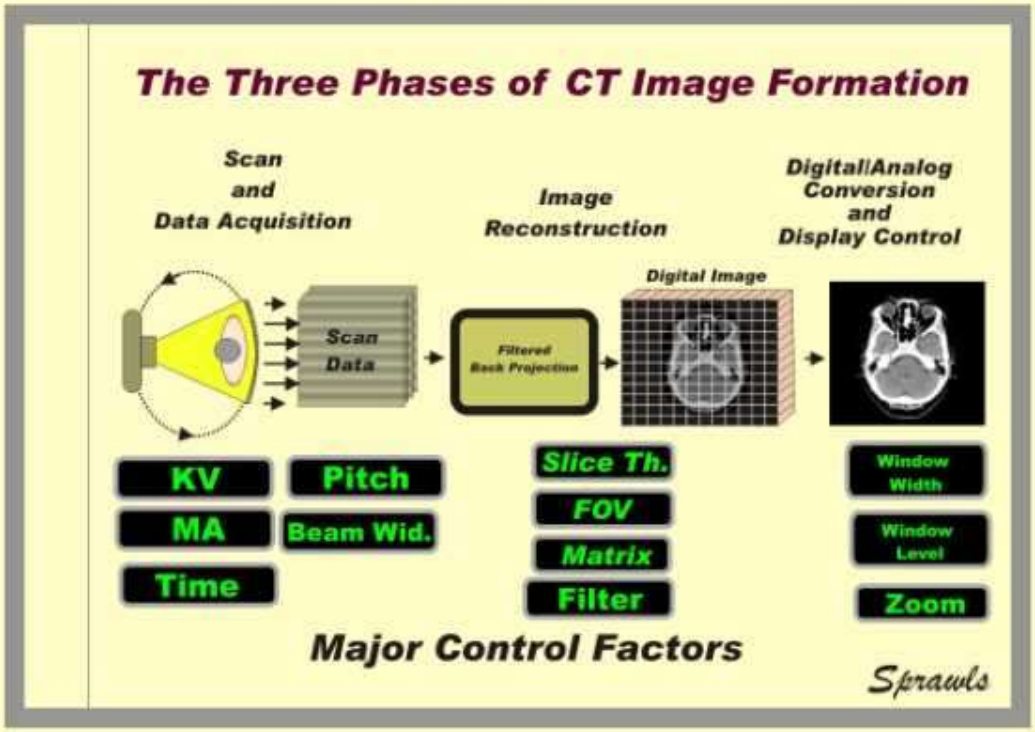






Visuals for Learning and Teaching

The Imaging Process



Clinical Images

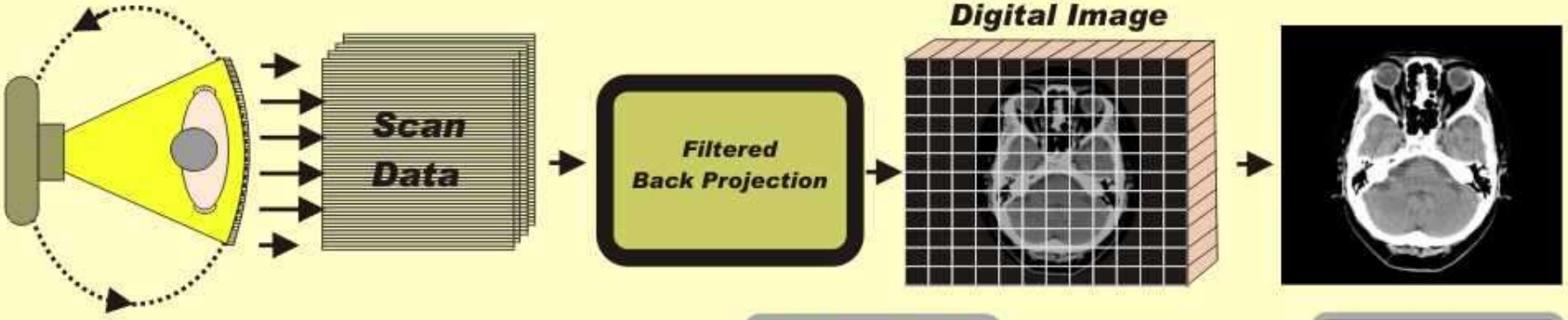
Sprawls

The Three Phases of CT Image Formation

Scan and Data Acquisition

Image Reconstruction

Digital/Analog Conversion and Display Control

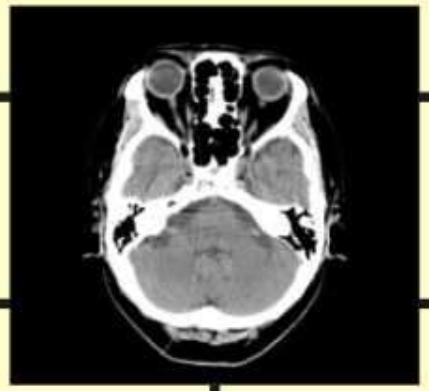


- KV
- MA
- Time
- Pitch
- Beam Wid.
- Slice Th.
- FOV
- Matrix
- Filter
- Window Width
- Window Level
- Zoom

Major Protocol Factors

Sprawls

CT Image Characteristics



Spatial

Artifacts

Detail

Noise

Contrast Sensitivity

KV

Pitch

Slice Th.

Window Width

MA

Beam Wid.

FOV

Window Level

Time

Filter

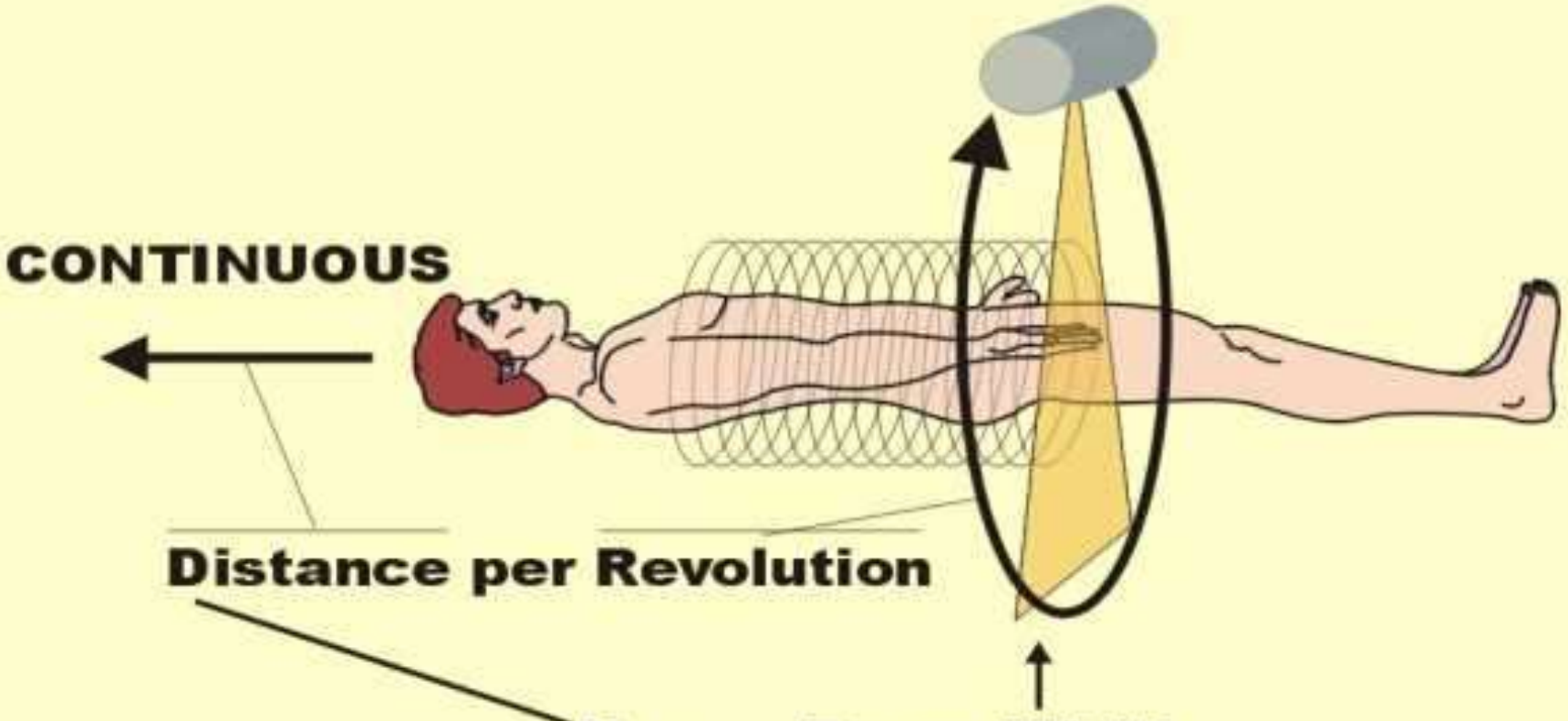
Matrix

Zoom

Major Protocol Factors

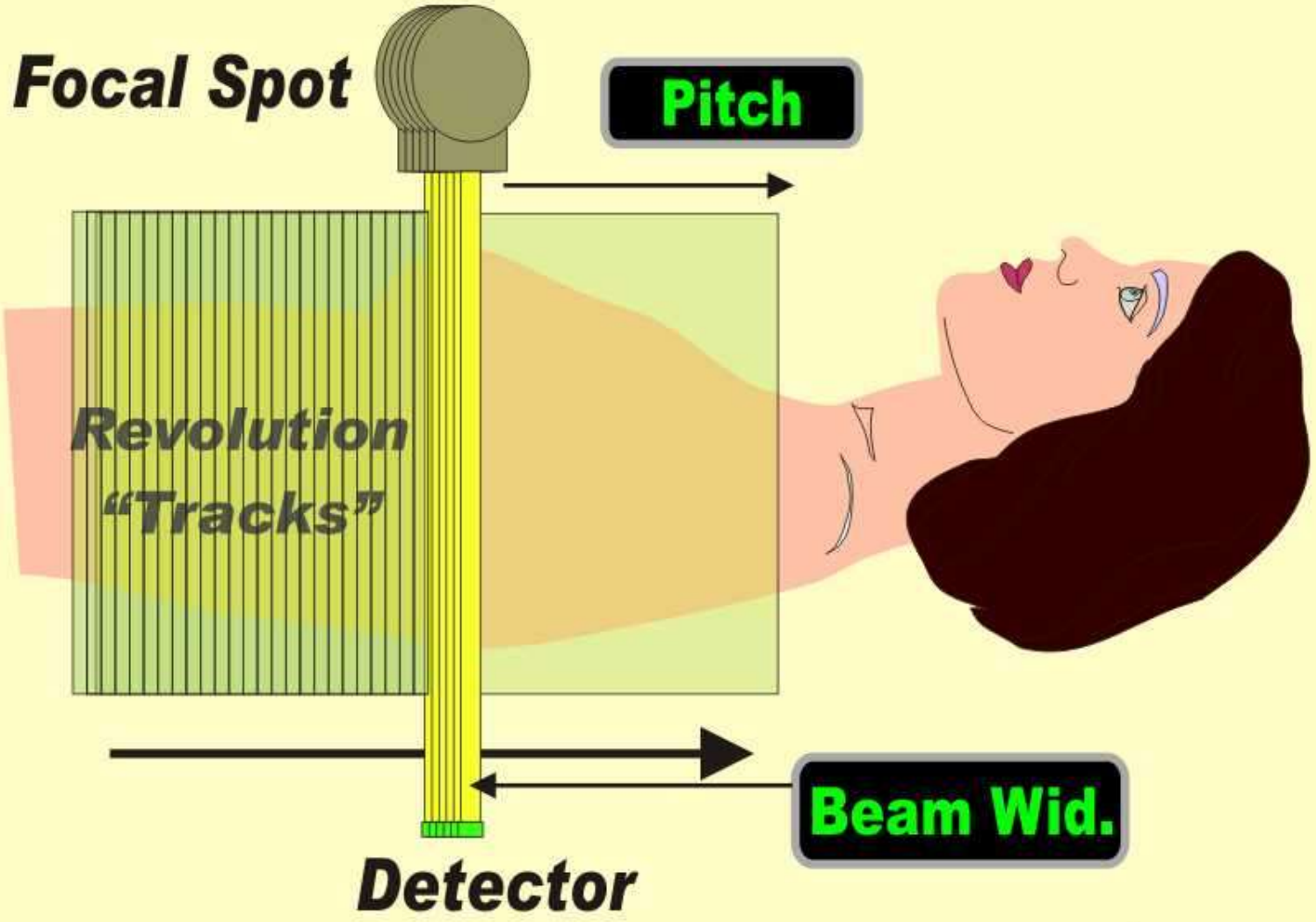
Sprawls

SPIRAL SCAN



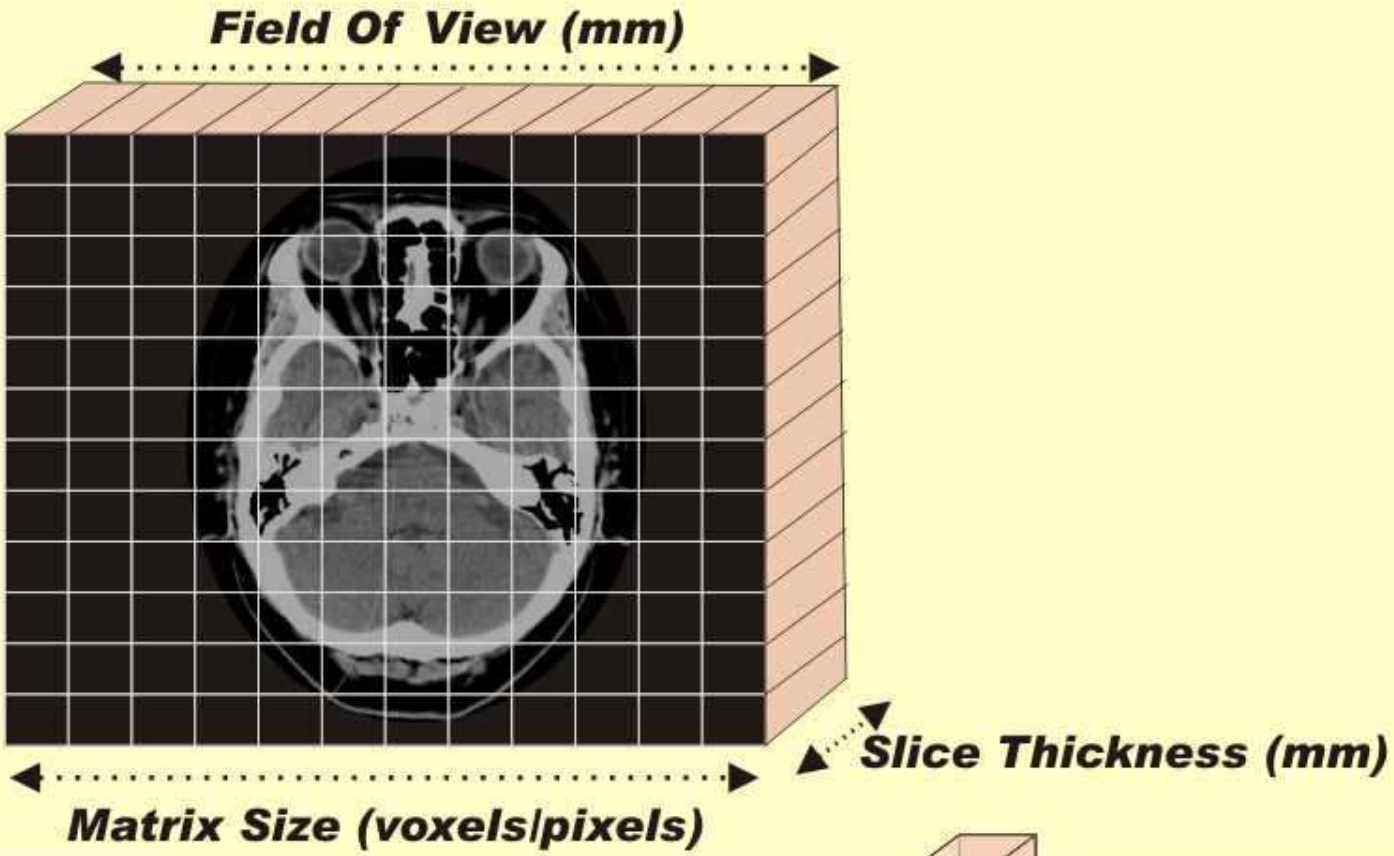
Sprawls

Scan Data Set



Sprawls

CT Slice Divided into Matrix of Voxels

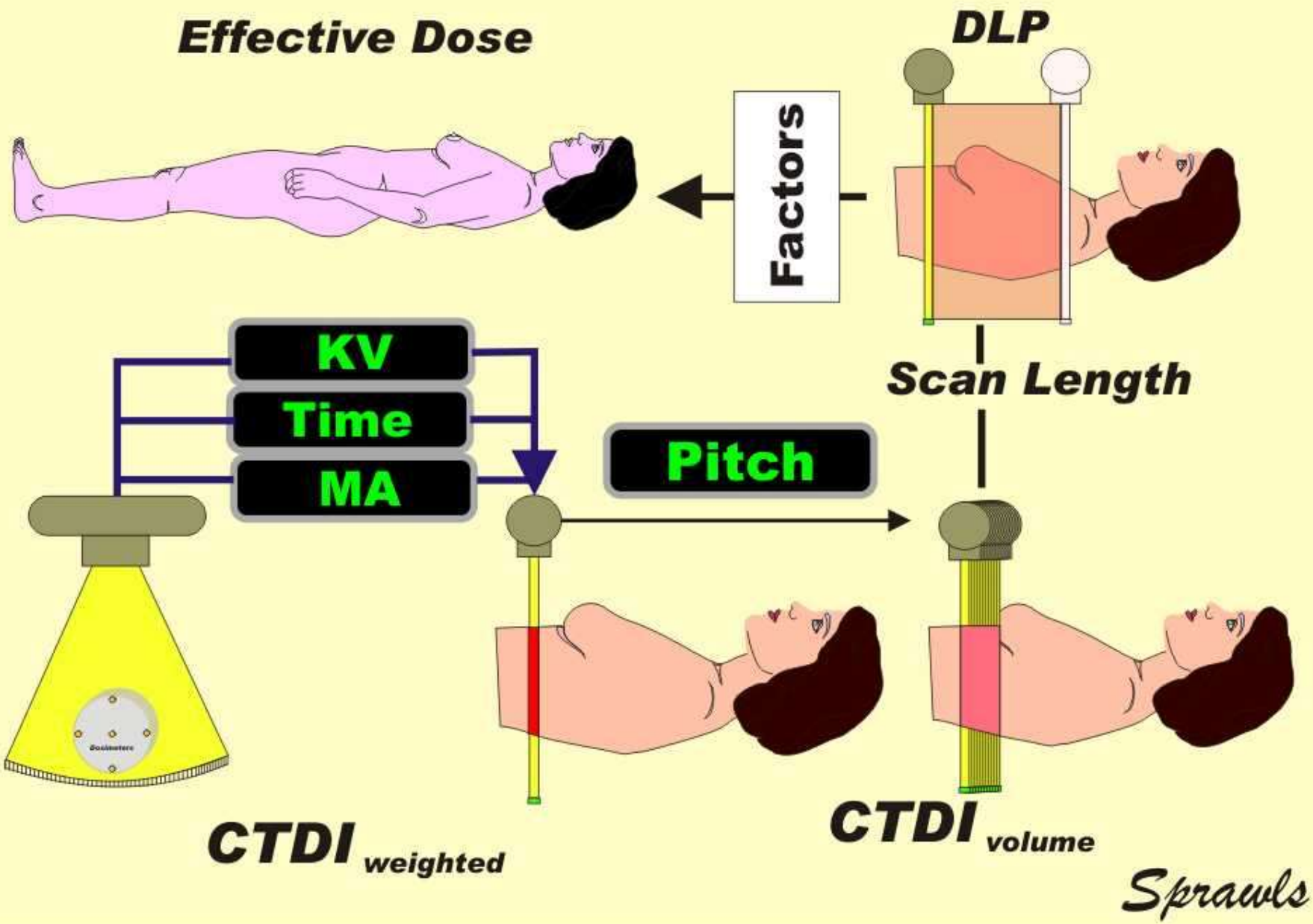


FOV ÷ Matrix ····· Slice Th.

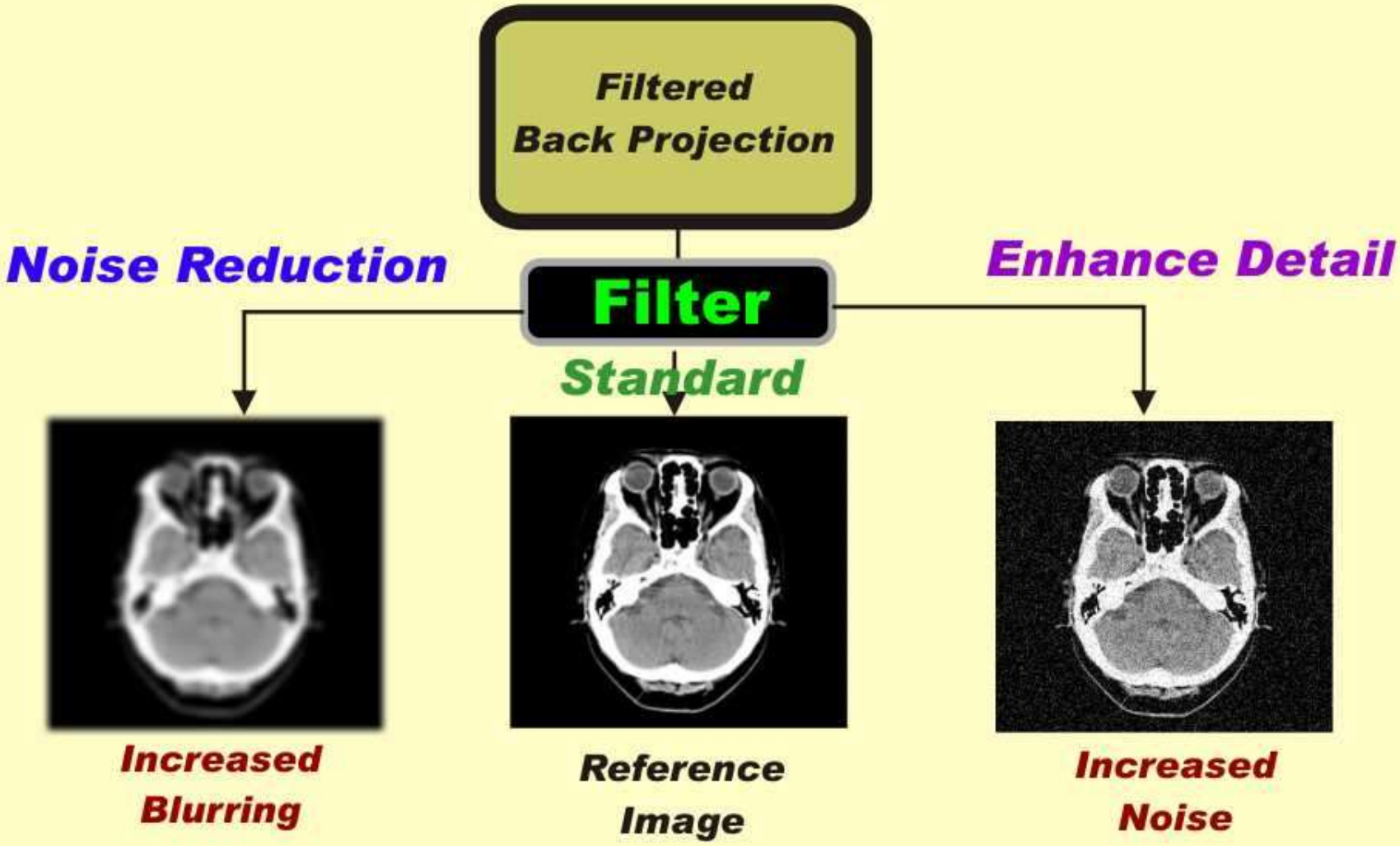
Voxel Size Controlled By

Sprawls

CT Dose Quantities



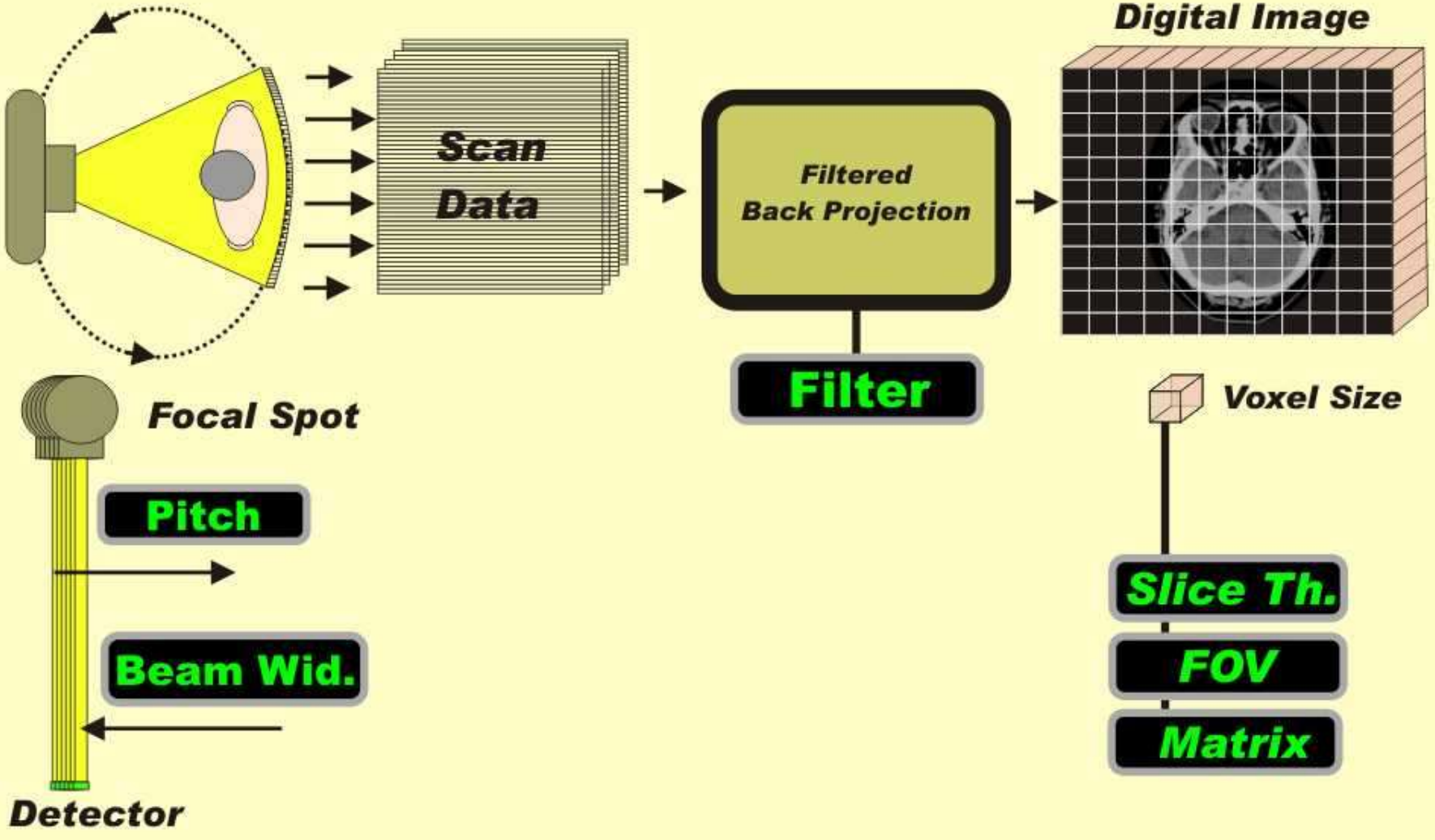
Reconstruction Filter Kernels



(Effects exaggerated for illustration here)

Sprawls

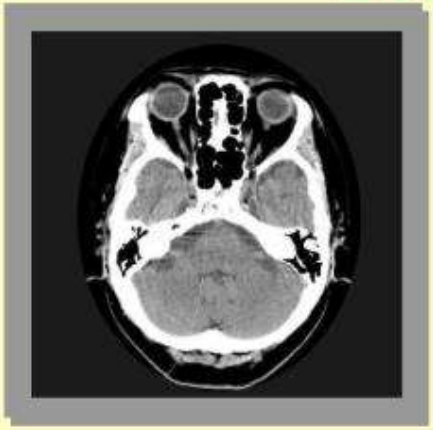
Factors That Determine Image Detail (Sources of Blurring)



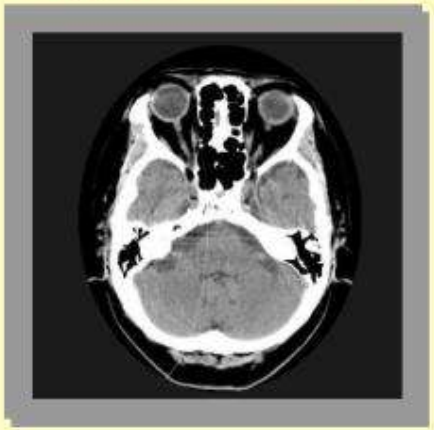
Sprawls

Relationship of Radiation Dose to Image Detail

Lower Dose



Higher Dose

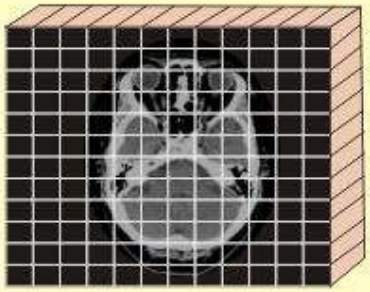


When detail is increased by

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

Noise Increases

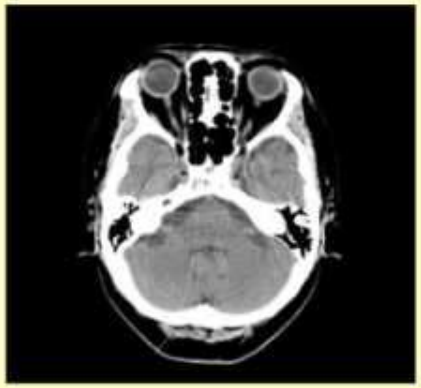
Because of decreased voxel size



Dose must be increased to reduce noise.

Sprawls

Two Major Image Quality Goals



High Detail

Low Noise

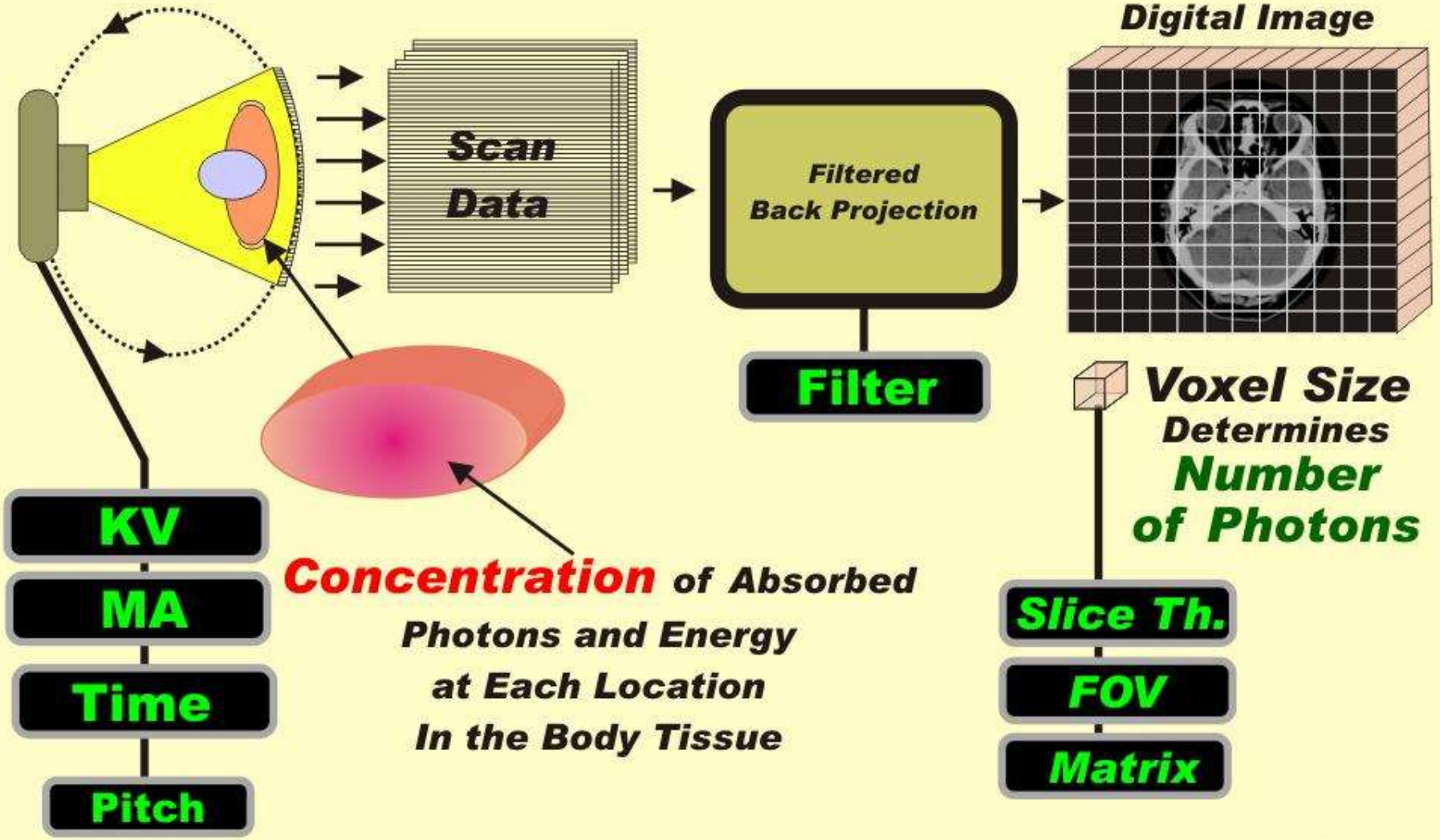
Voxel Size

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

Protocol Factors

Sprawls

Factors That Determine Image Noise



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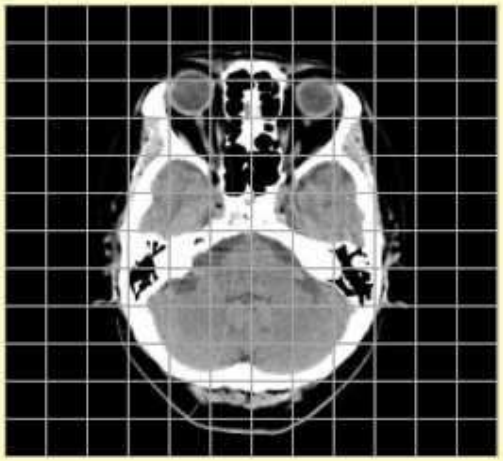
Effect of Matrix Size on Image Noise

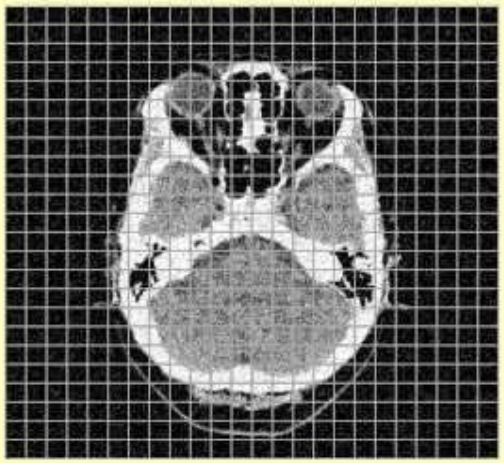
Small **Matrix** ***Large***

Large Voxels



Low Noise

Small Voxels



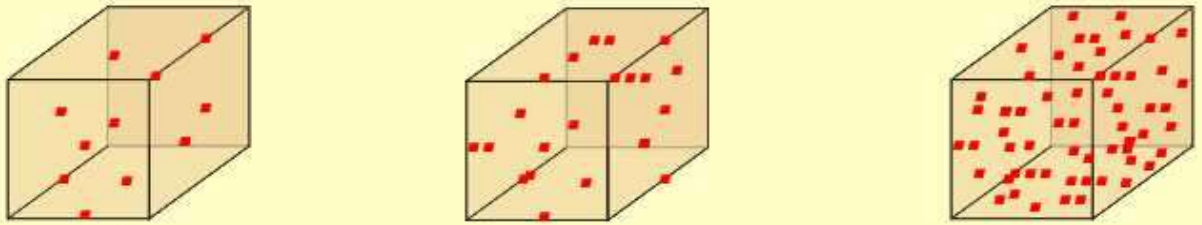
High Noise

The same radiation dose for both images.

Sprawls

Decreasing Noise

Requires Increased Photons Absorbed Per Voxel



Produces Increasing Dose

Sprawls

Modules for Self Study
and
Collaborative Learning in the Clinic

How to Use This Resource

Table of Contents and List of Topics

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

During the reconstruction process mathematical filters are used to change some of the image characteristics. These might be referred to by different names such as algorithms or kernels but their effects are the same.

Each CT system has many different filters that the operator can select from for a specific clinical procedure. The filters that are appropriate for the various clinical procedures have been determined from experience and are typically included in the established protocols for a facility.

We are not going into the characteristics of all of the filters here but focusing our attention on their effects of the two image characteristics, noise and detail as illustrated here.

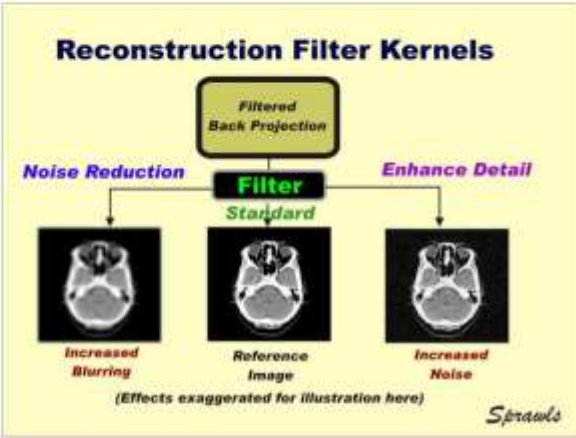
Some filters can be selected to reduce noise in an image. However, the reduction of noise by digital image processing usually increases the blurring in the image and reduces the visibility of detail.

Filters that are selected to increase or enhance detail typically increase the visibility of image noise.

This is all part of the compromise between image detail and image noise.

In general noise is reduced by increased blurring (voxel size, filter, etc) but that reduces image detail.

That is all part of the process of developing an optimized imaging protocol.



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

Effective Medical Imaging Physics Learning ...In The Clinic

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

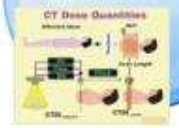
The Physicist Provides:
Learning Modules & Collaboration

Sprawls

Physics Education to Enhance CT Image Quality Optimization and Dose Management

Physicists With Experience in Clinical CT

Open Access Educational Resources



Visuals

Modules

Global Impact

Teach, Collaborate, Consult

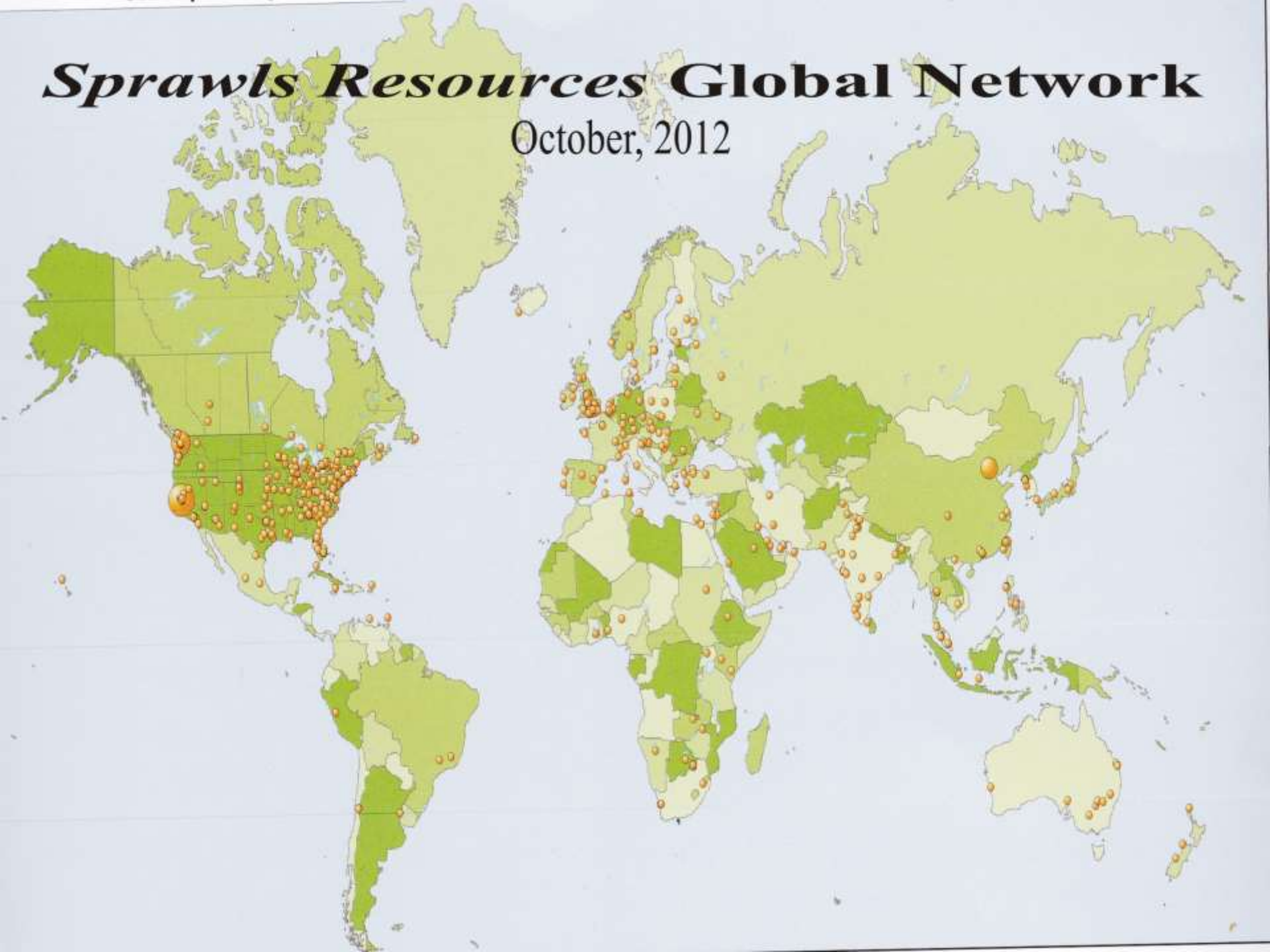
Physicists in Local Institutions

(with Limited Clinical CT Experience)

A resource to enhance the performance of medical physicists in every country of the world.

Sprawls Resources Global Network

October, 2012



References and Resources

MEDICAL PHYSICS INTERNATIONAL Journal, vol.1, No.1, 2013

.www.mpijournal.org

EFFECTIVE PHYSICS EDUCATION FOR OPTIMIZING CT IMAGE QUALITY AND DOSE MANAGEMENT *WITH OPEN ACCESS RESOURCES*

P. Sprawls[1], P-A. T. Duong [2]

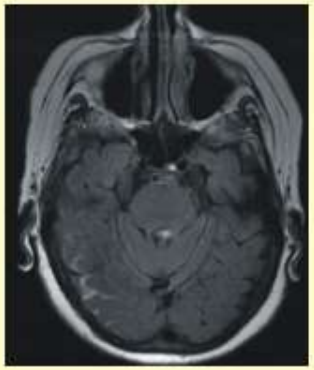
[1] Sprawls Educational Foundation and Emory University/Department of Radiology and Imaging Sciences, Montreat, USA
[2] Emory University/Department of Radiology and Imaging Sciences, Atlanta, USA

Visuals and Module

www.sprawls.org/resources

E-mail:sprawls@emory.edu

Optimizing CT Image Quality
and
Dose Management
Using
Collaborative Clinically Focused Physics Education



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Emory University

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