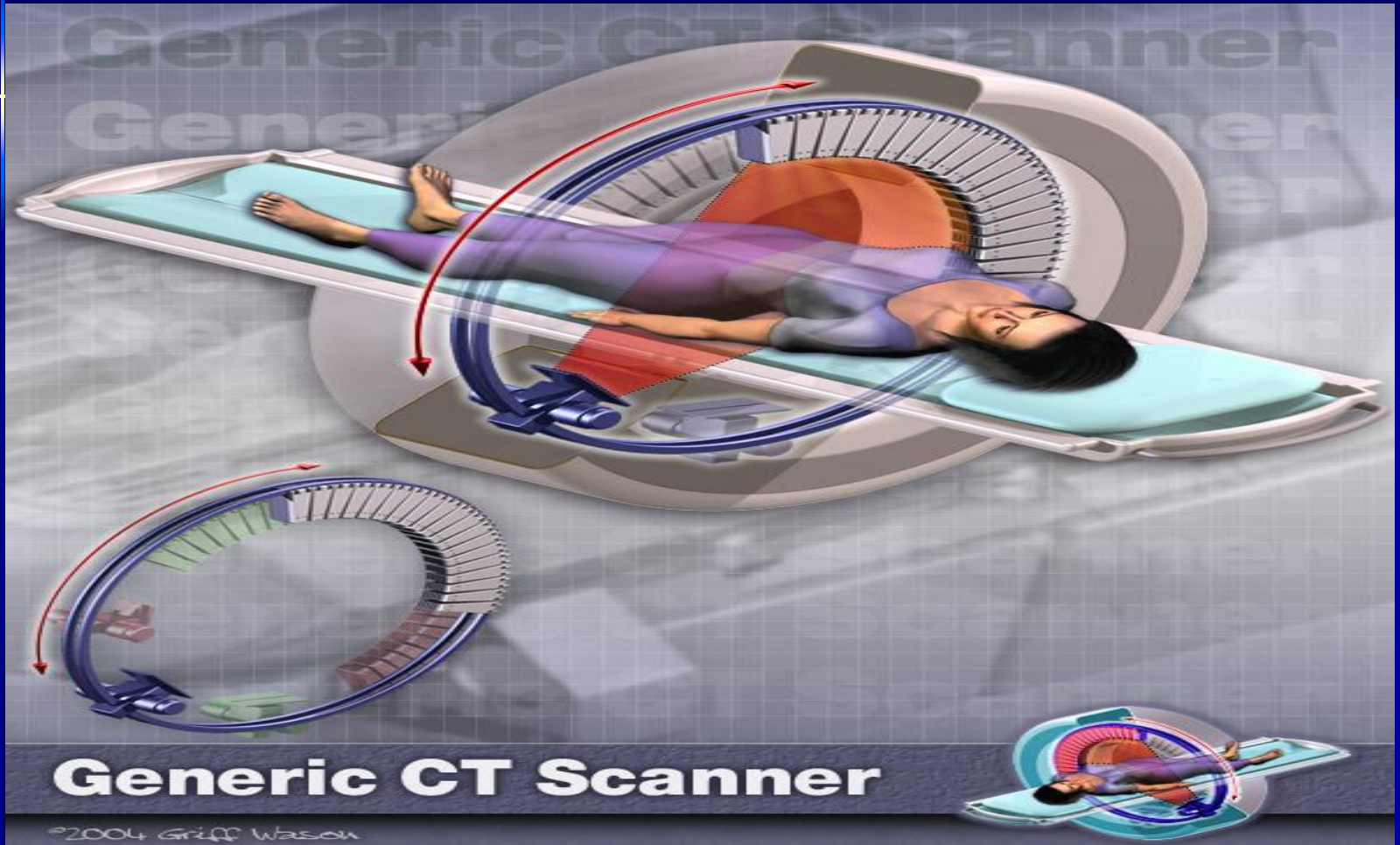


بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

PHYSICAL PRINCIPLES OF COMPUTED TOMOGRAPHY



Presentation: **Mohamad Akbarnejad**
Radiobiology and Radiation Protection MSC

Scan Parameters

- X-ray Tube Voltage (*kVp*)
- X-ray Tube Current (*mA*)
- Scan Time (*s*)
- Slice thickness or Collimation (*mm*)

- ⊙ Table Speed (*mm/rot*)
or Feed per 360 rotation
- ⊙ Pitch
- ⊙ Interpolation Process
- ⊙ Increment (*mm*)

Design considerations

- Scan gantry
 - mechanical stresses
 - data & power feed
- Tubes
 - high currents
 - narrow slices; fast rotations
 - tube cooling
 - generator response
- Detectors
 - responsive
 - efficient
 - small
- Electronics / computers / reconstruction hardware



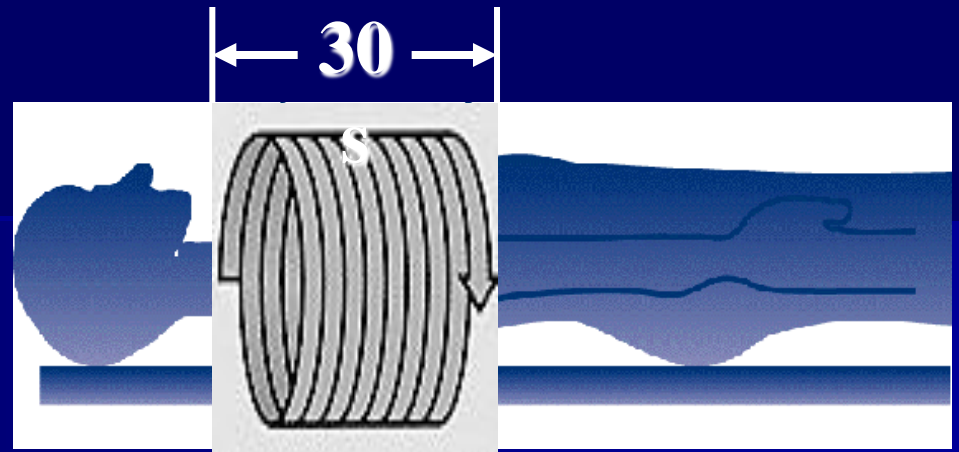
Table Speed & Pitch

Table Speed is defined as distance traveled in mm per 360° rotation

$$\text{Pitch} \Rightarrow \frac{\text{Table Feed per rotation}}{\text{Collimation}}$$

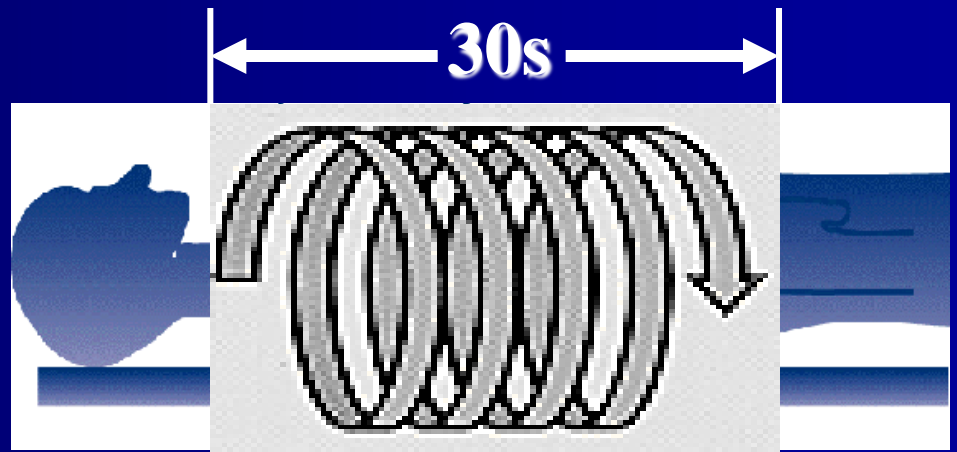
<u>Table Feed</u>	<u>Collimation</u>	<u>Pitch</u>
10 mm/rot	10 mm	1.0
15 mm/rot	10 mm	1.5
20 mm/rot	10 mm	2.0

**Pitch 2 covers
2x
distance as Pitch 1**

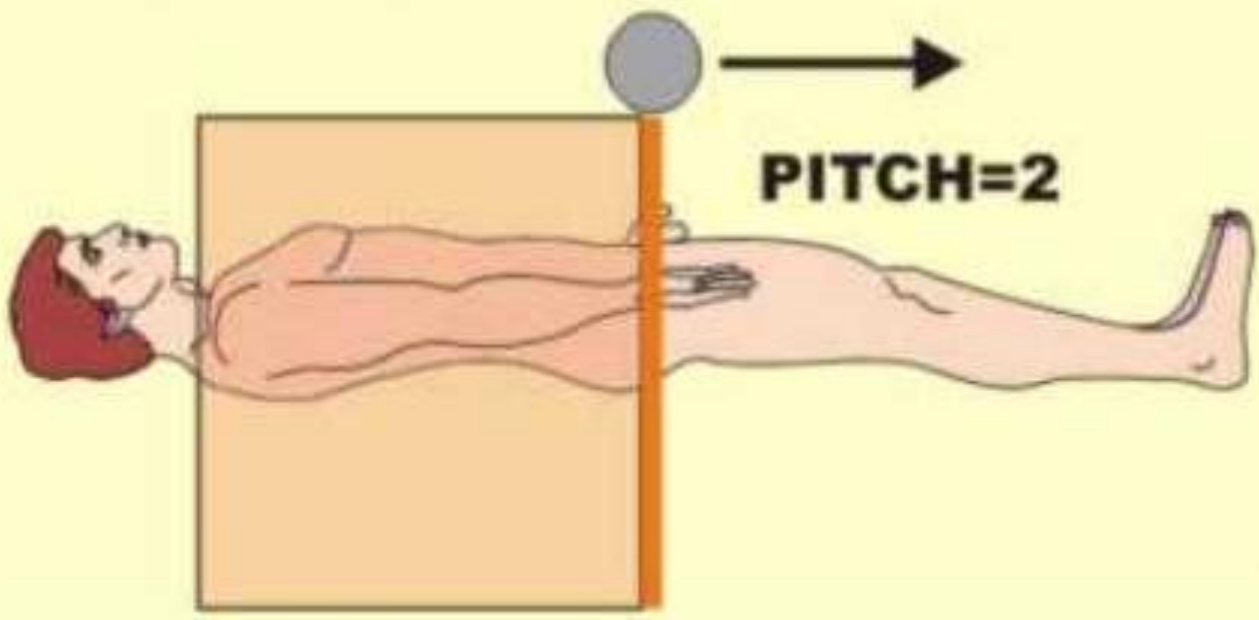
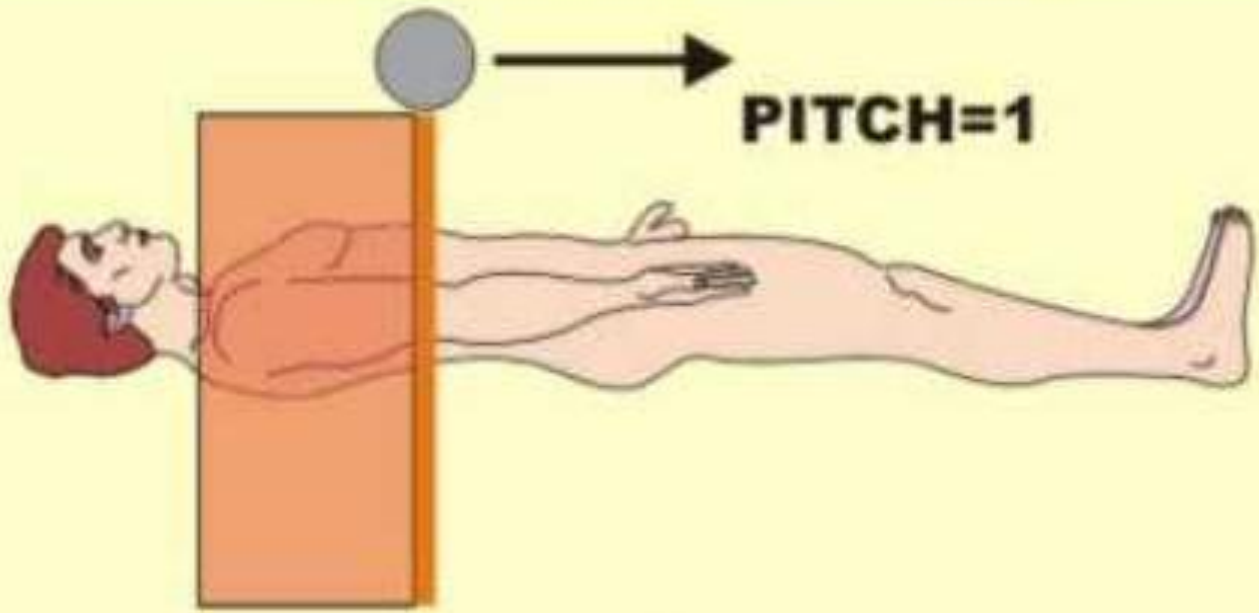


10mm P1

**More Coverage in
the same time with
extended Pitch!!**

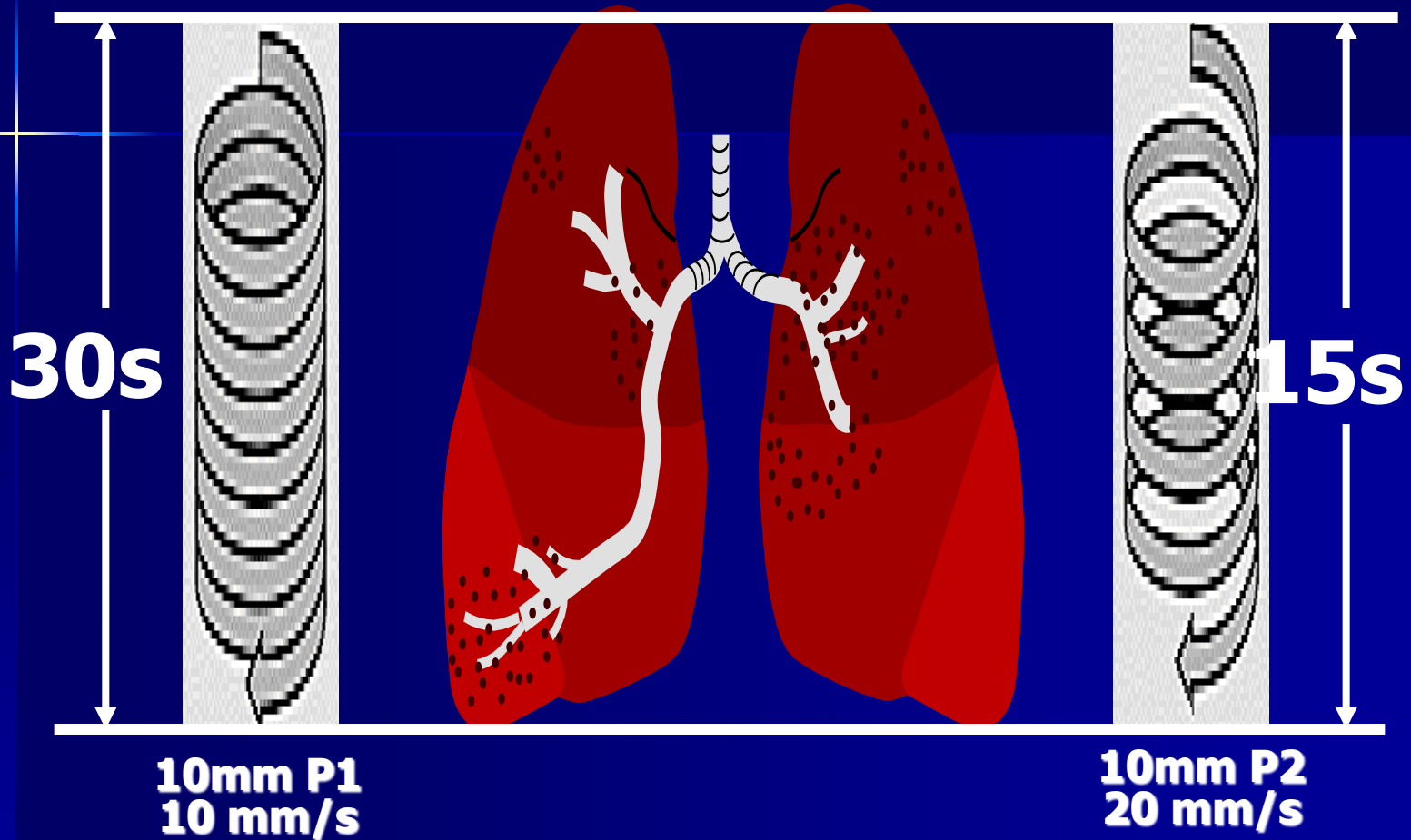


10mm P2



Sprawls

Scan Range = 300mm

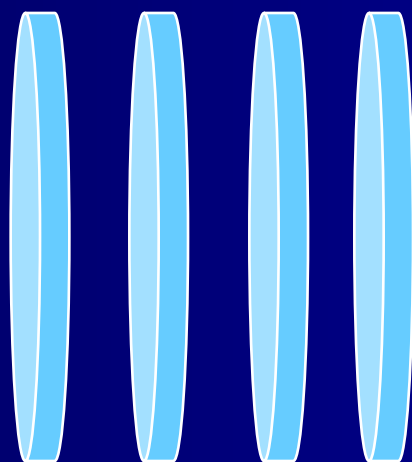
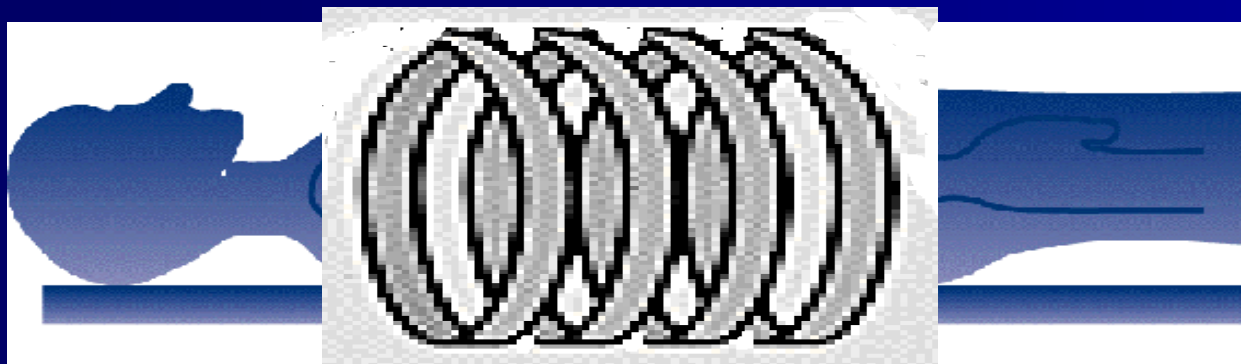


Cover the same volume in shorter time with extended Pitch

Profile:

Slice Sensitivity Profile (SSP)

Conventional

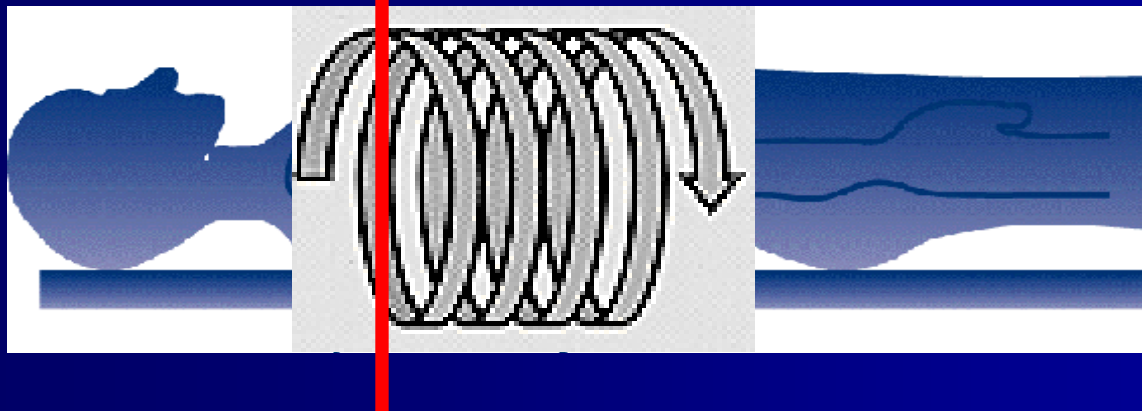


SSP

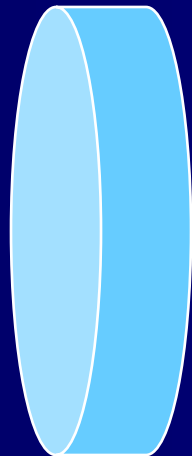
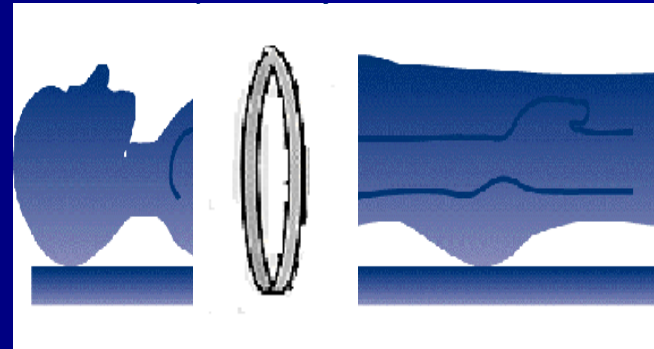
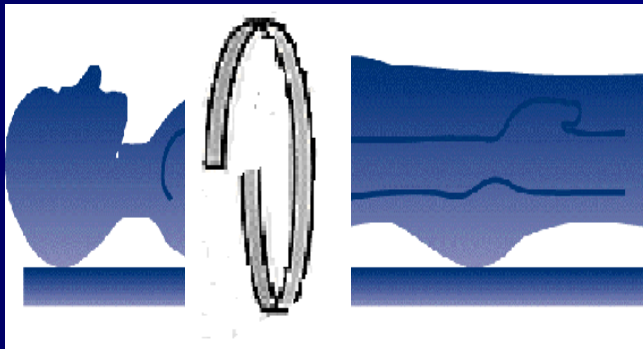


conventional

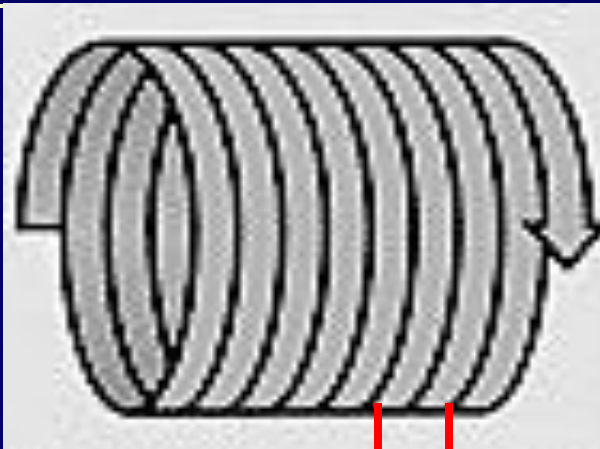
MSCT



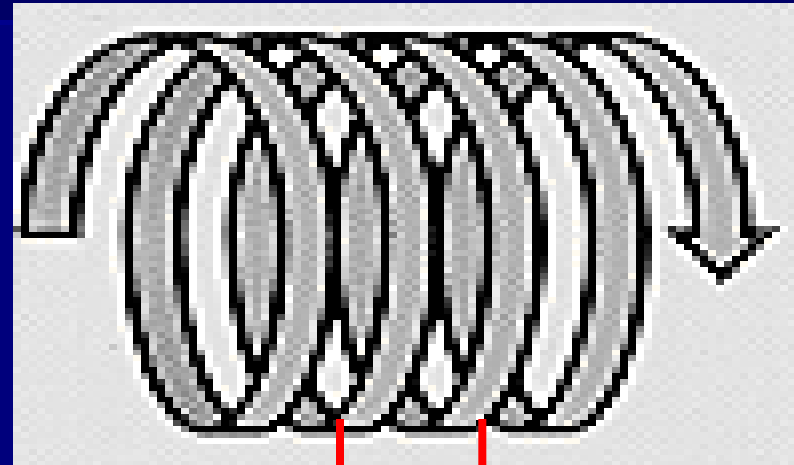
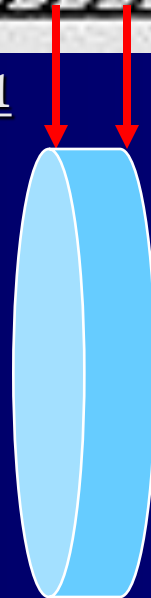
Profile:



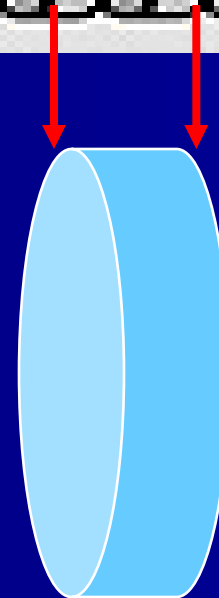
Pitch 2 scanning produces a broader image thickness
Pitch 2 scanning does not increase image noise



PITCH 1



PITCH 2



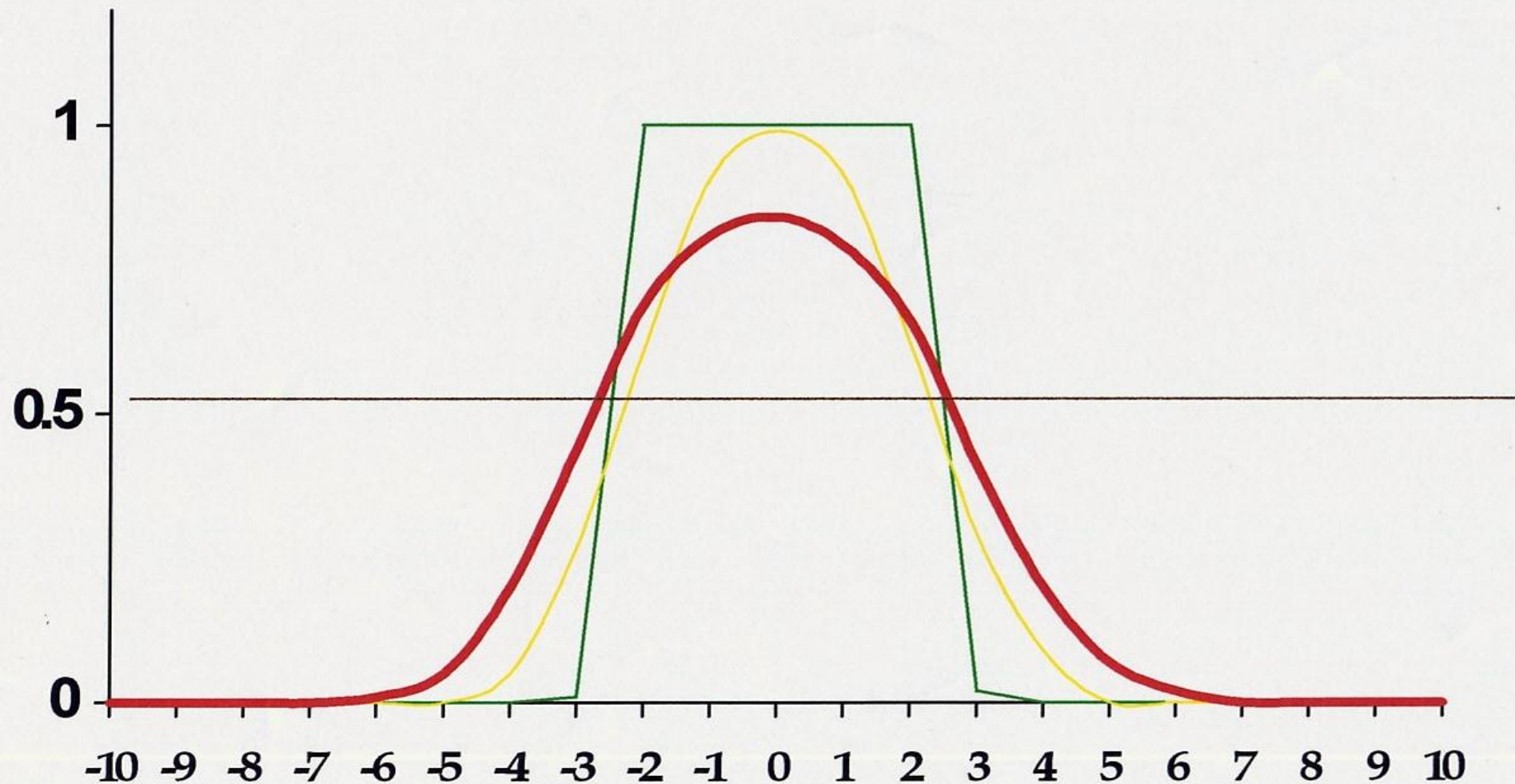
*30% increase in
image thickness
with Pitch 2*

Pitch & Slice Profile

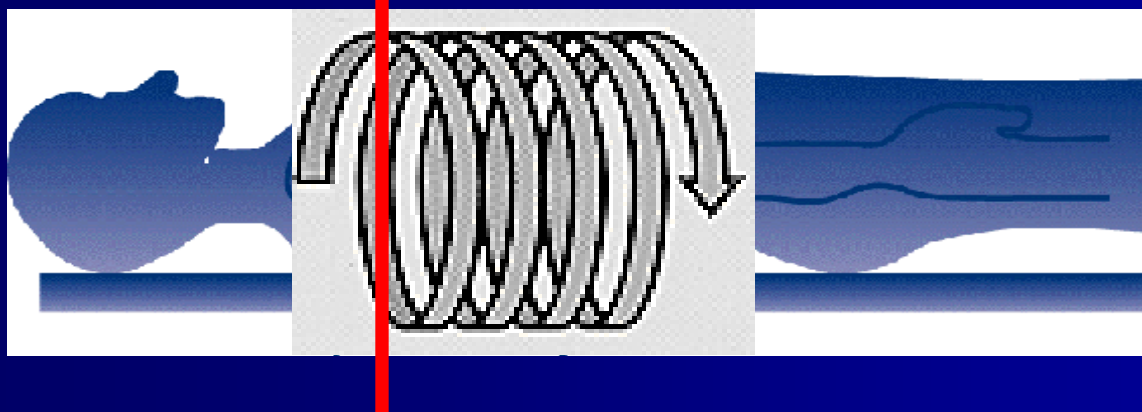
— Standard

— Pitch 1

— Pitch 2



MSCT Interpolation:



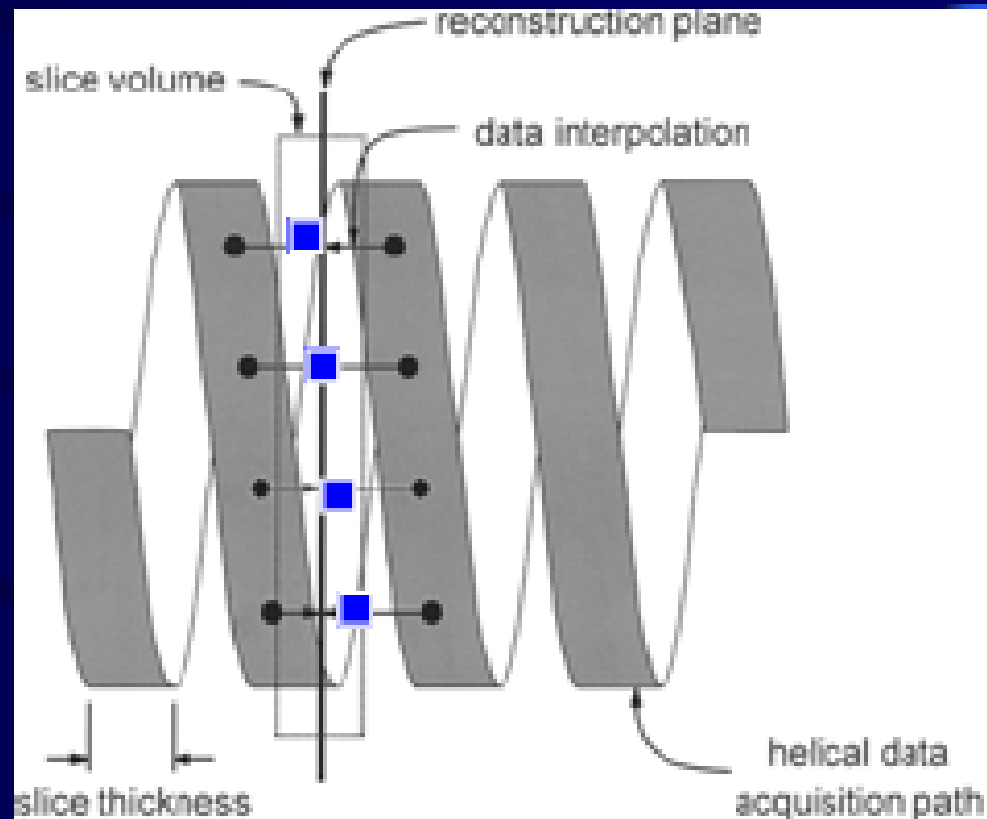
Helical Interpolation

Collect data (black dots)

Rebin to estimate the 180° data (blue squares)

Interpolate to estimate image between collected and rebinned data

Helical CT needs fast computers



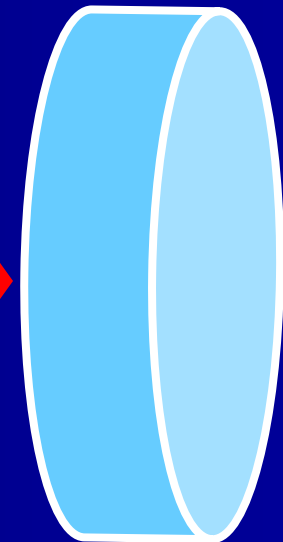
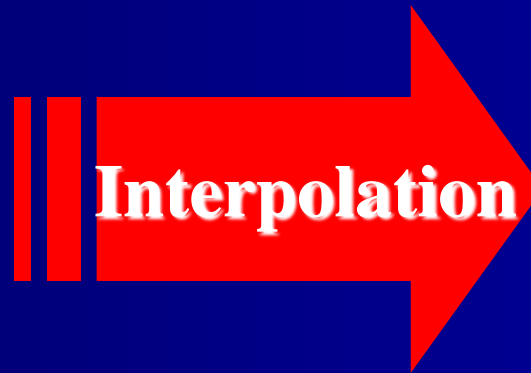
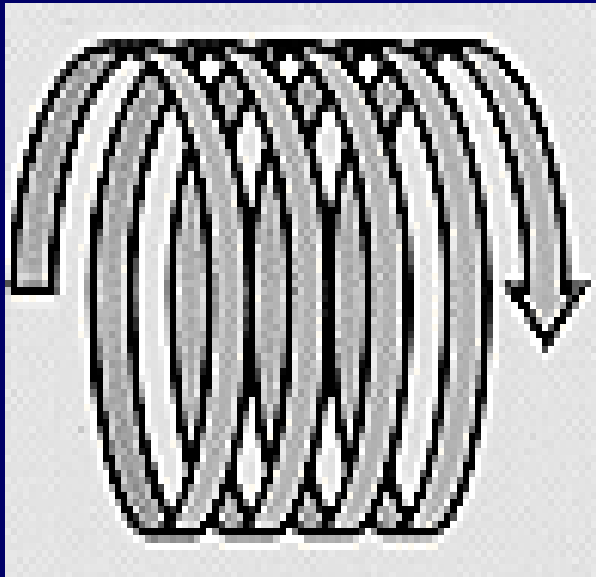
Interpolation:

❖ LI 180

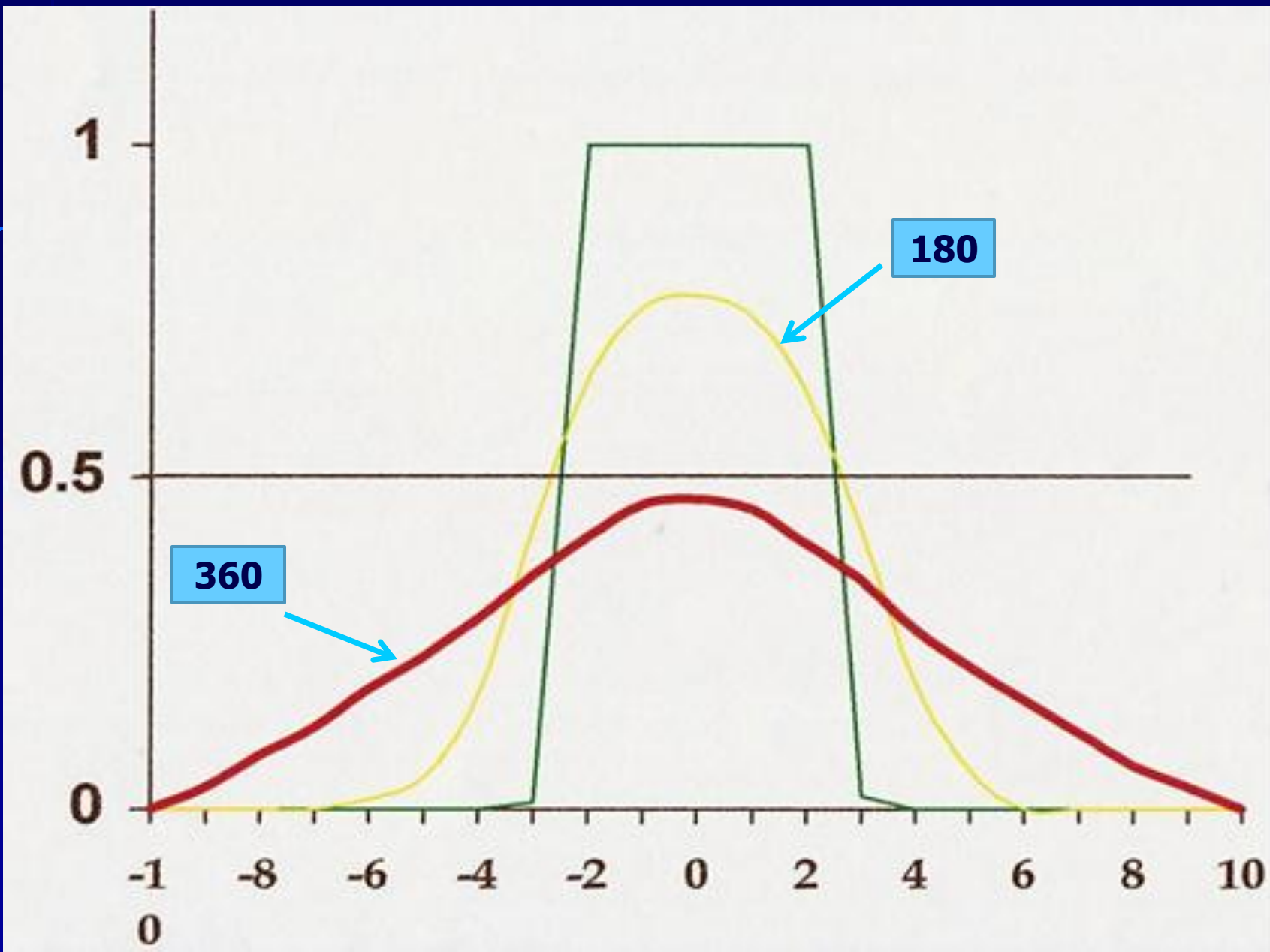
❖ LI 360

Interpolation Algorithm

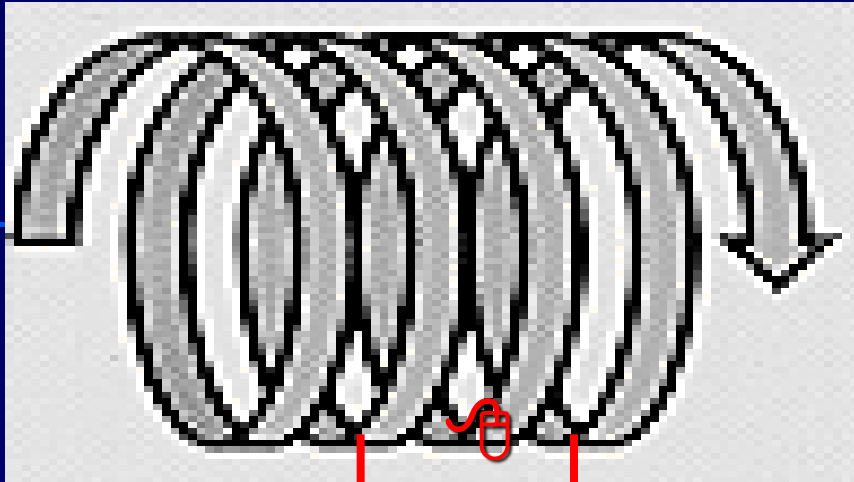
↙ Converts volume data into slice images



To reduce artifacts due to table motion during spiral scanning, we use a special reconstruction process called *INTERPOLATION*

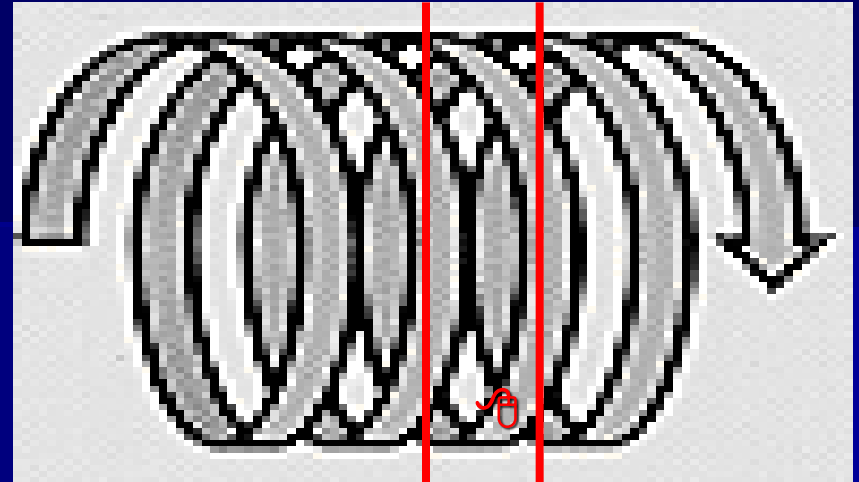


Wide Algorithm



$2 \times 360^\circ$
 $= 720^\circ$
raw data

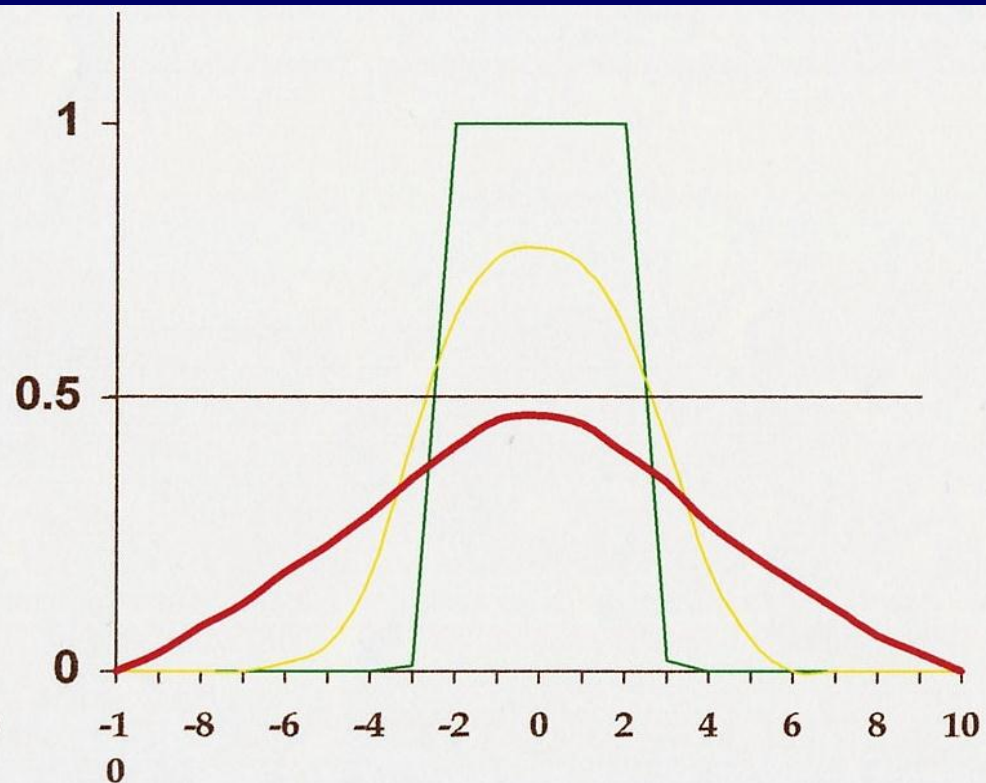
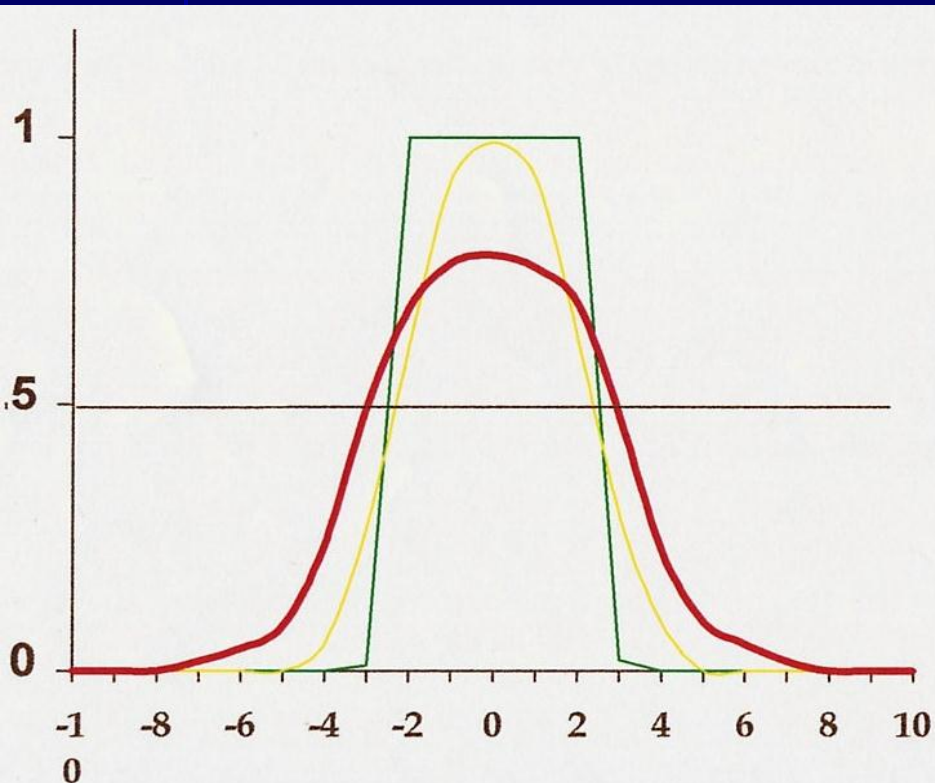
Slim Algorithm



$2 (180+52)$
 $= 464^\circ$
raw data

Wide algorithm produces a broader image thickness
Wide algorithm uses more raw data => less image noise

Slim vs Wide – SSP Comparison



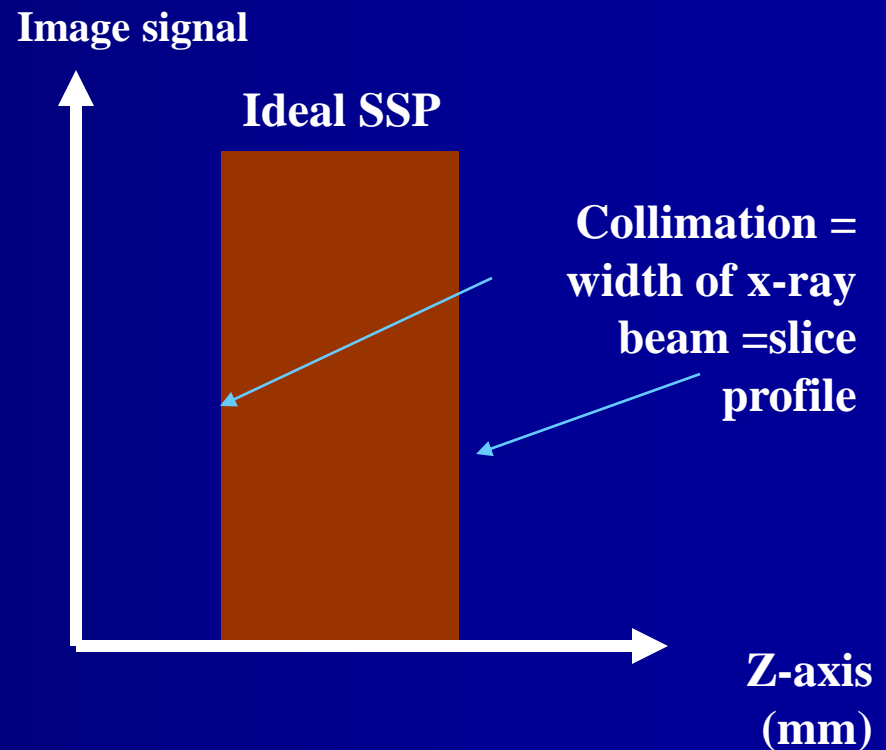
Slice Profile	Slim	%Broaden	Wide	%Broaden
Pitch One	5.0 mm	0	6.3 mm	26
Pitch Two	6.5 mm	30	10.8 mm	116

Slice Sensitivity Profile (SSP)

SSP describes the **effective slice thickness** of an image and to what extent anatomy within that slice contribute to the signal



All points within the slice contribute equally & points outside of the slice do not contribute to the image at all .



Slice Profile (SP)

Effective slice thickness of an image

↑ Slice Profile ↓ Resolution

Factors influencing Slice Profile

- Collimation
- Pitch
- Interpolation algorithm (360° or 180°)

Factors influencing SSP

- **Collimator width**



Spiral CT

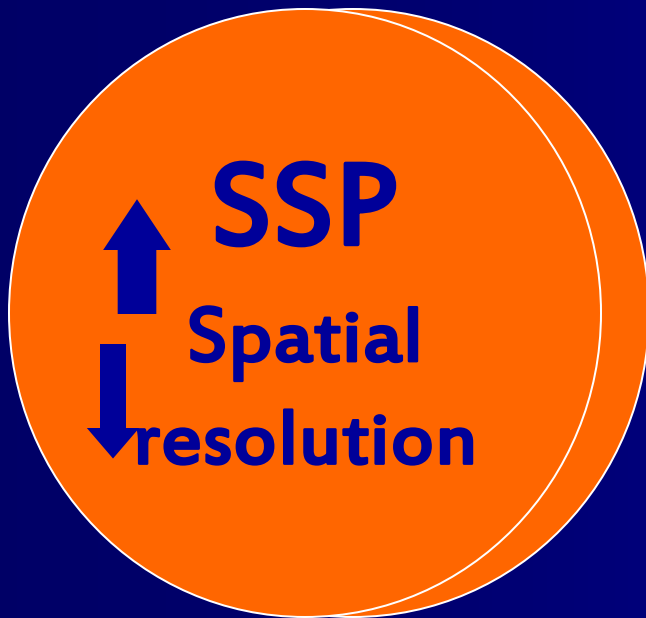
- **Table speed or Pitch**

- **Interpolation Algorithm**

=> mathematical process required to reconstruct axial images from the spiral volume data set

WIDE

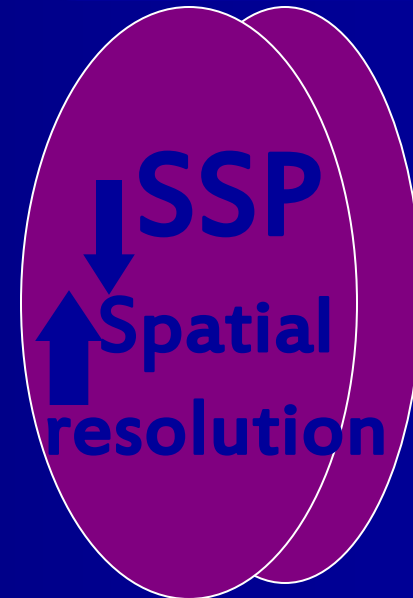
720 degree
More photons



Smoother image

SLIM

464 degree
Less photons



Noisier image

Slim - Advantages

- **Improved Z – Resolution**
- **Reduced partial volume artifacts**
- **Slim + extended Pitch**
 - **Longer coverage**
 - **Same coverage with shorter scan time or thinner slices**
 - **Less radiation dose**

Wide - Advantages

- **Noise Reduction**

⇒ **Smoother image**

⇒ **Useful for scanning huge patient**

Only for scanning at

Pitch One

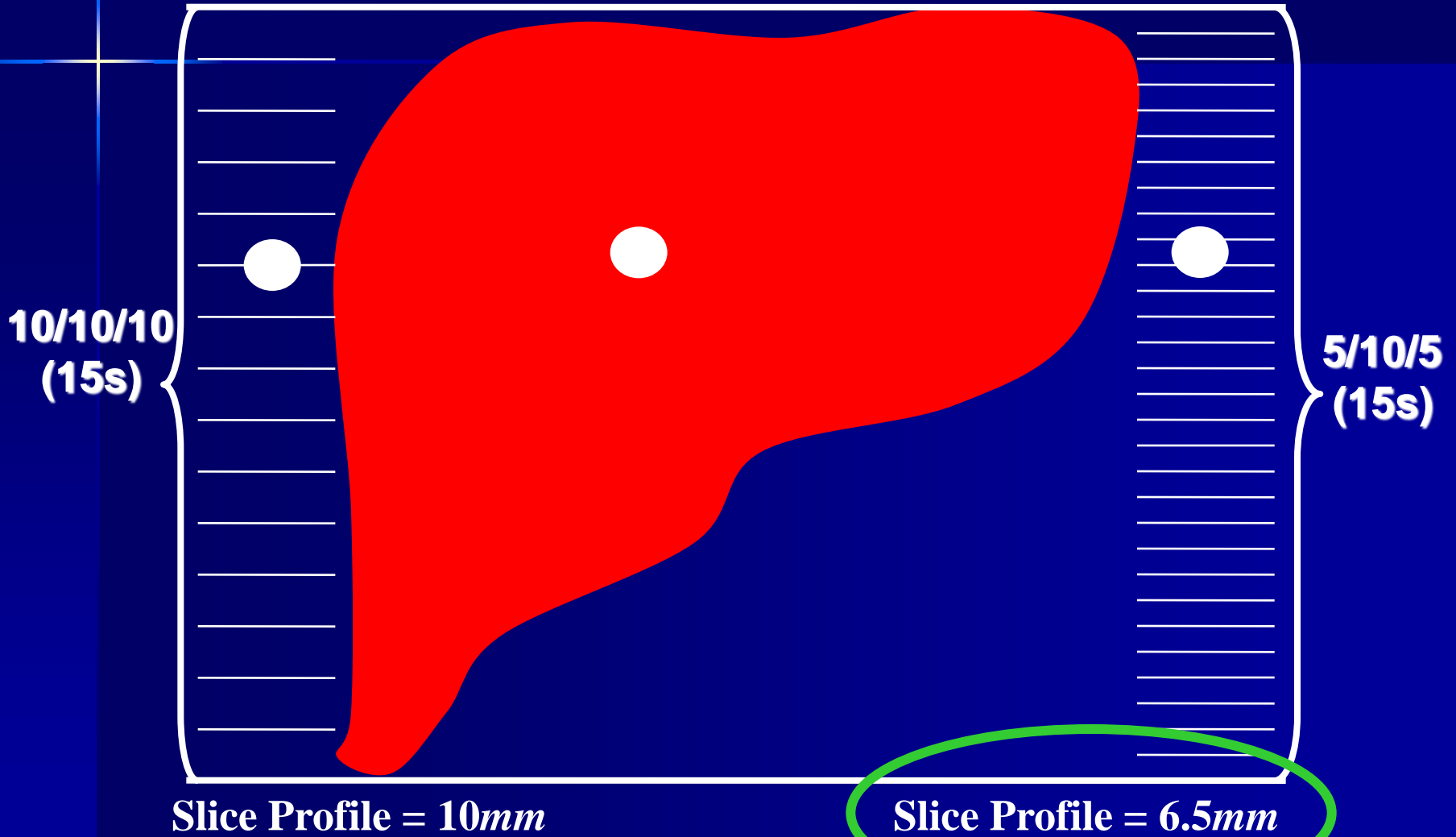
Slice Profile Comparison

Collimation 5.0 mm	Wide Interpolation	Slim Interpolation
Pitch 1.0	6.3 mm	5.0 mm ✓
% Broadened	26	0
Pitch 2.0	10.8 mm	6.5 mm
% Broadened	116	30

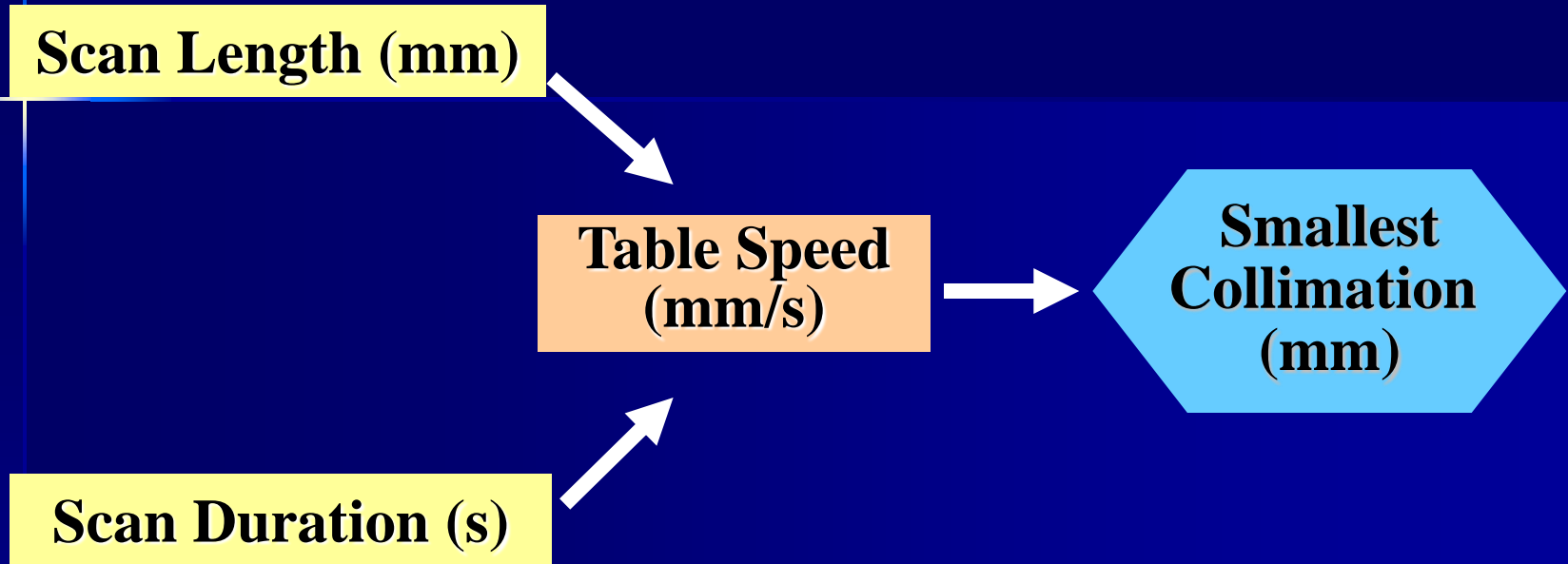
Optimizing the Scanning Parameters

SCAN RANGE = 150mm

Lesion ● smaller than 1cm



Smallest Possible Effective Slice Thickness



Scan Duration

Depends on the scan length & patient's breath-hold compliance

**Table Speed
Pitch Factor**

$1 < \text{Pitch} < 2$
↙ to cover the whole volume in one breath-hold

