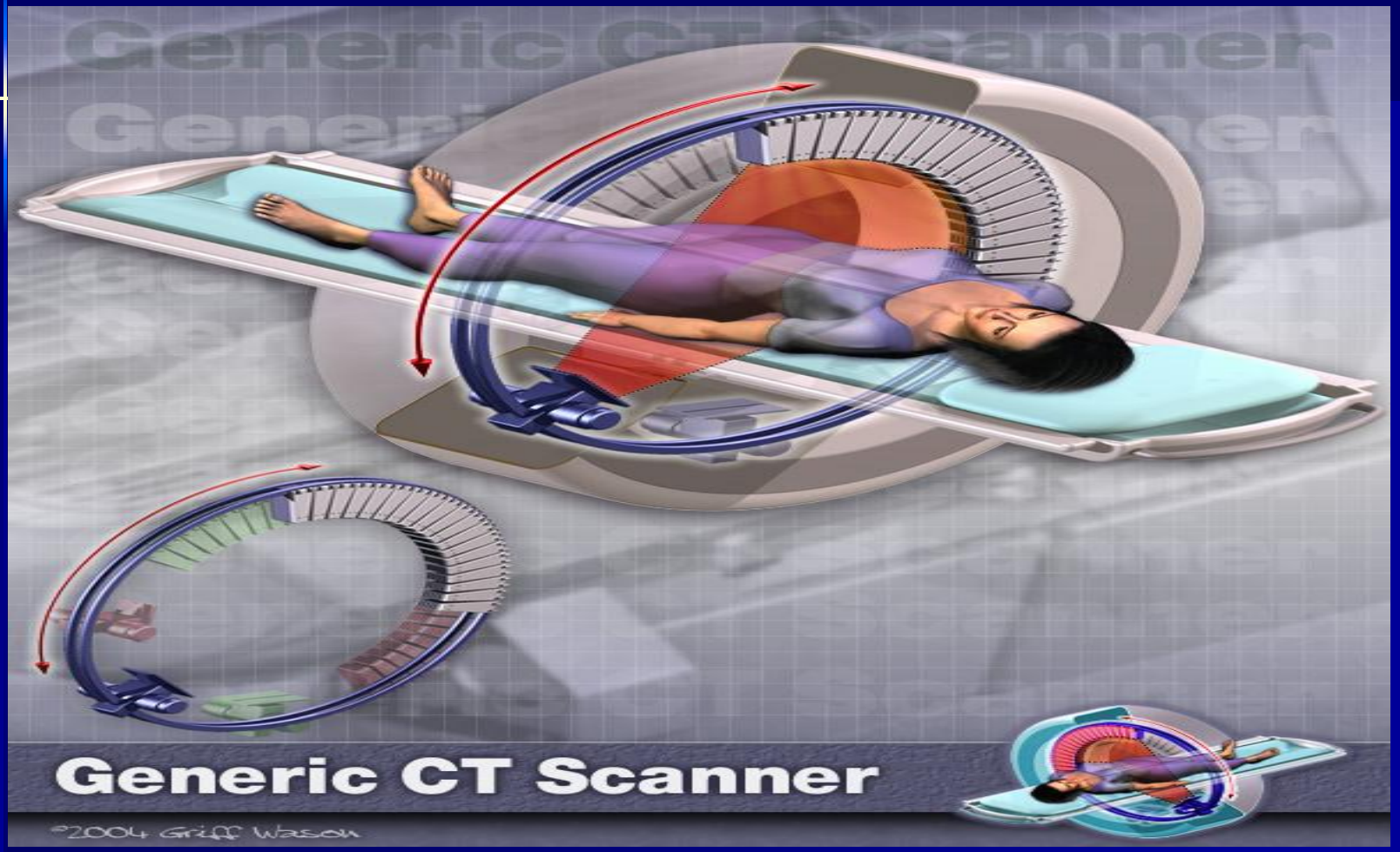

بسم الله الرحمن الرحيم

PHYSICAL PRINCIPLES OF COMPUTED TOMOGRAPHY



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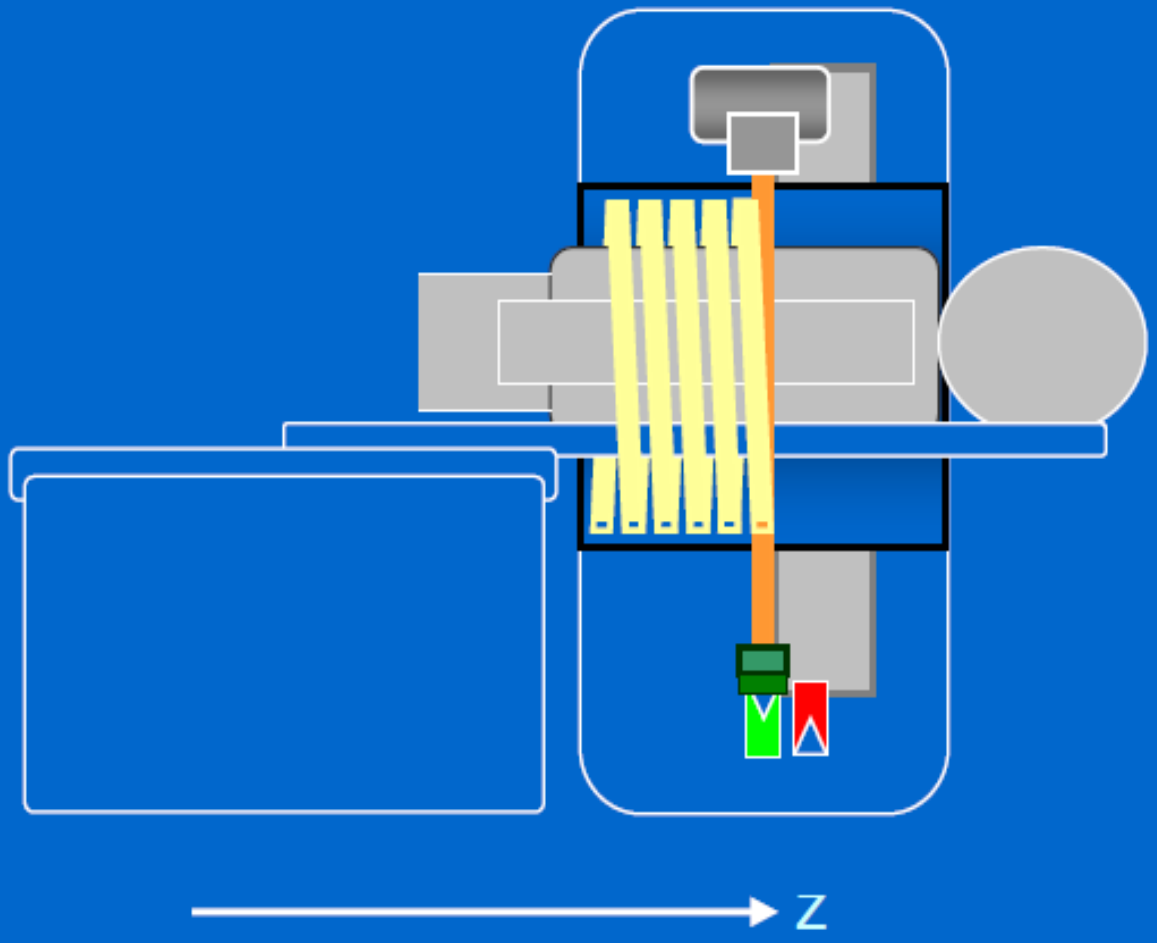
Radiobiology and Radiation Protection MSC

Pitch

The mean of Pitch in CT?

Helical (spiral) scanning - pitch

$$\text{Pitch} = \frac{\text{table travel / rotation}}{\text{X-ray beam width}}$$



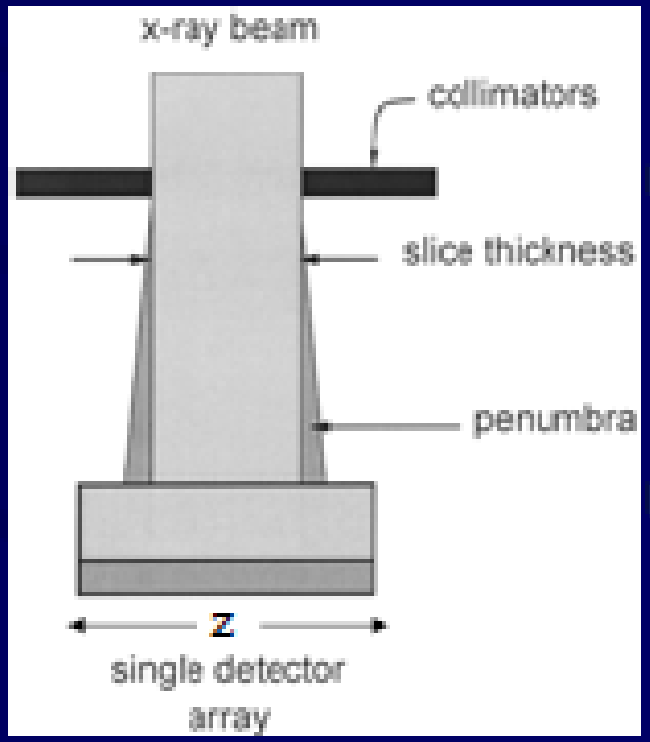
Pitch for Single-Slice CT

- **Image and beam width are same for conventional CT**
- **Pitch = table travel ÷ beam width**
- **Typical pitch values are 0.7 to 1.5**

Conventional Helical CT Detectors

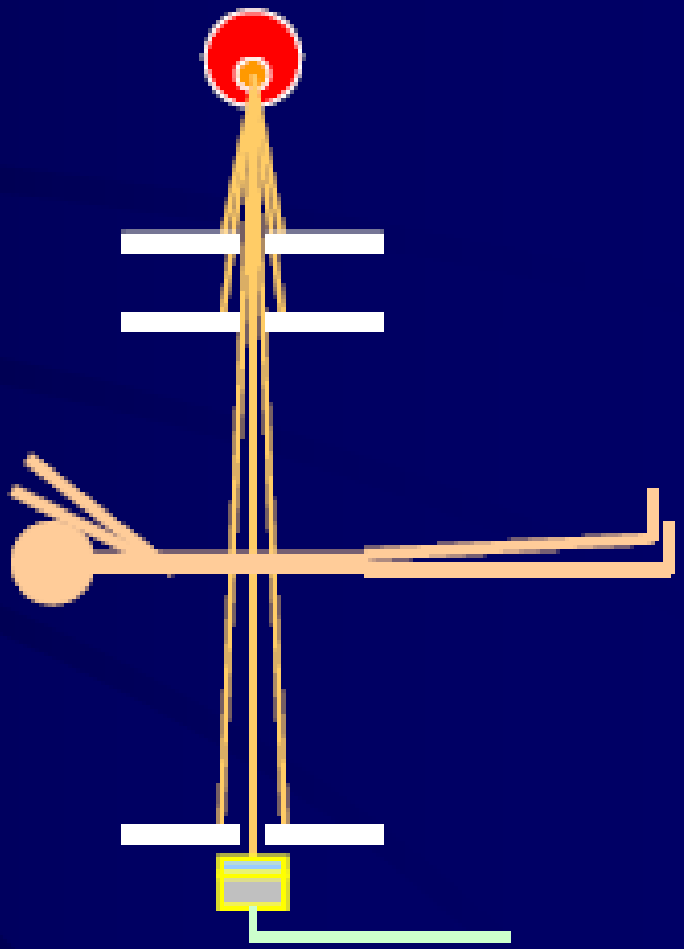
Image width determined by beam thickness

Pitch = table mm / beam mm

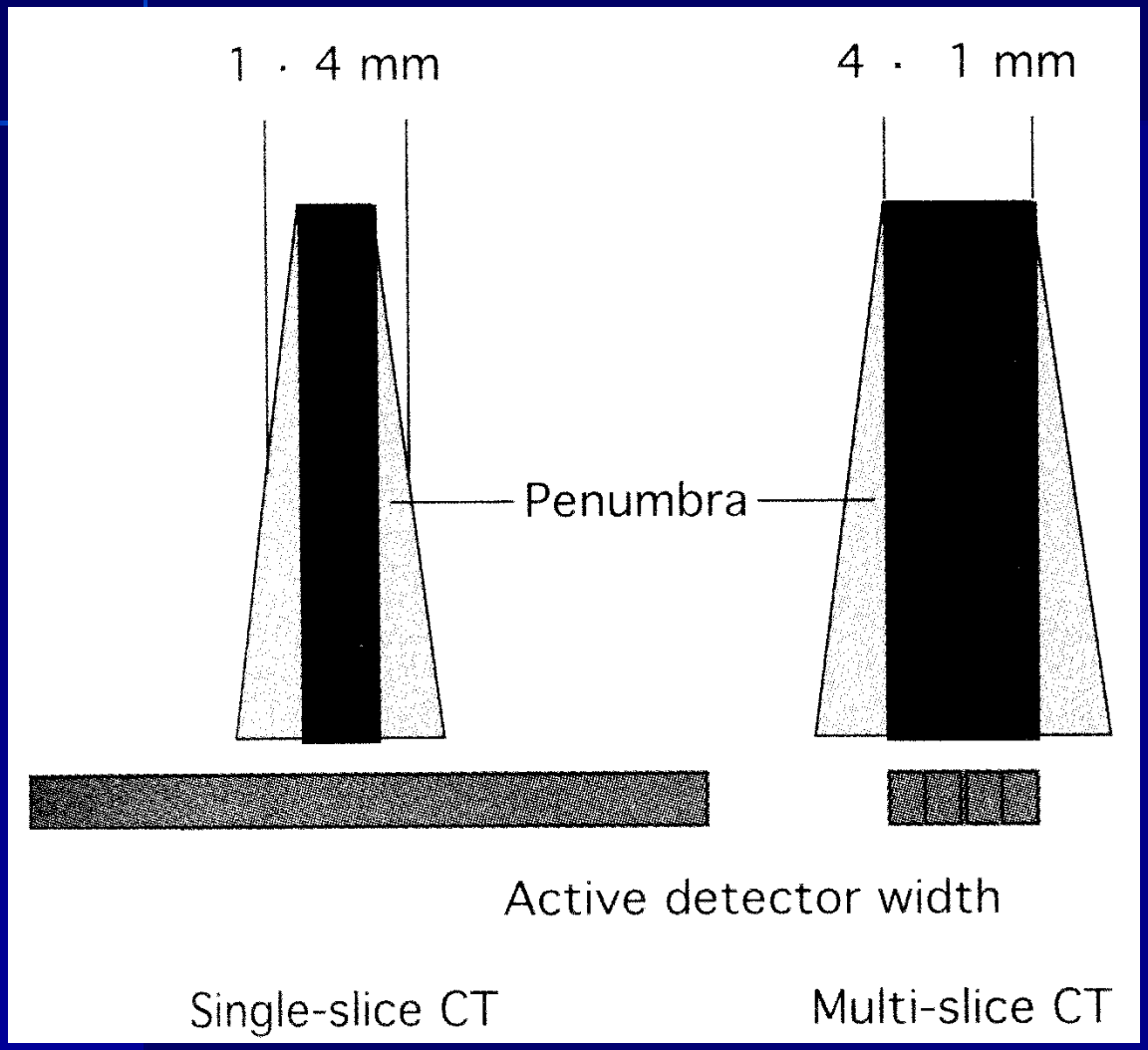


Beam Collimation

- Pre-patient collimators define width of beam in z (all systems)
- "Detector" collimators reduce scatter at detectors (some CTs)

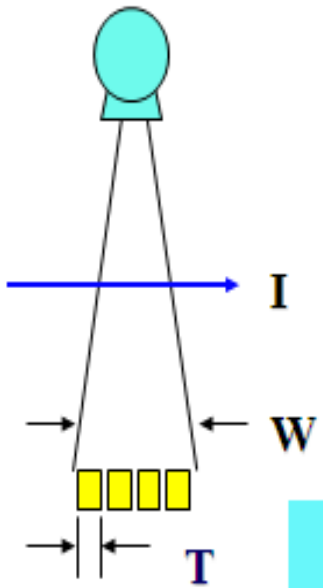


Multi-slice CT



'Over beaming' caused by wider collimator settings to avoid penumbral effects;

Pitch redefined for MDCT



$$\text{Beam Pitch} = \frac{I}{W}$$

$$\text{Detector Pitch} = \frac{I}{T}$$

$$\text{Beam Pitch} = \frac{\text{Detector Pitch}}{N} = \frac{I}{N*T} = \text{Pitch}$$

I - Table feed (mm/rotation)
W - Beam width (mm)
T - Single DAS channel width (mm)
N - Number of active DAS channels

Pitch factor

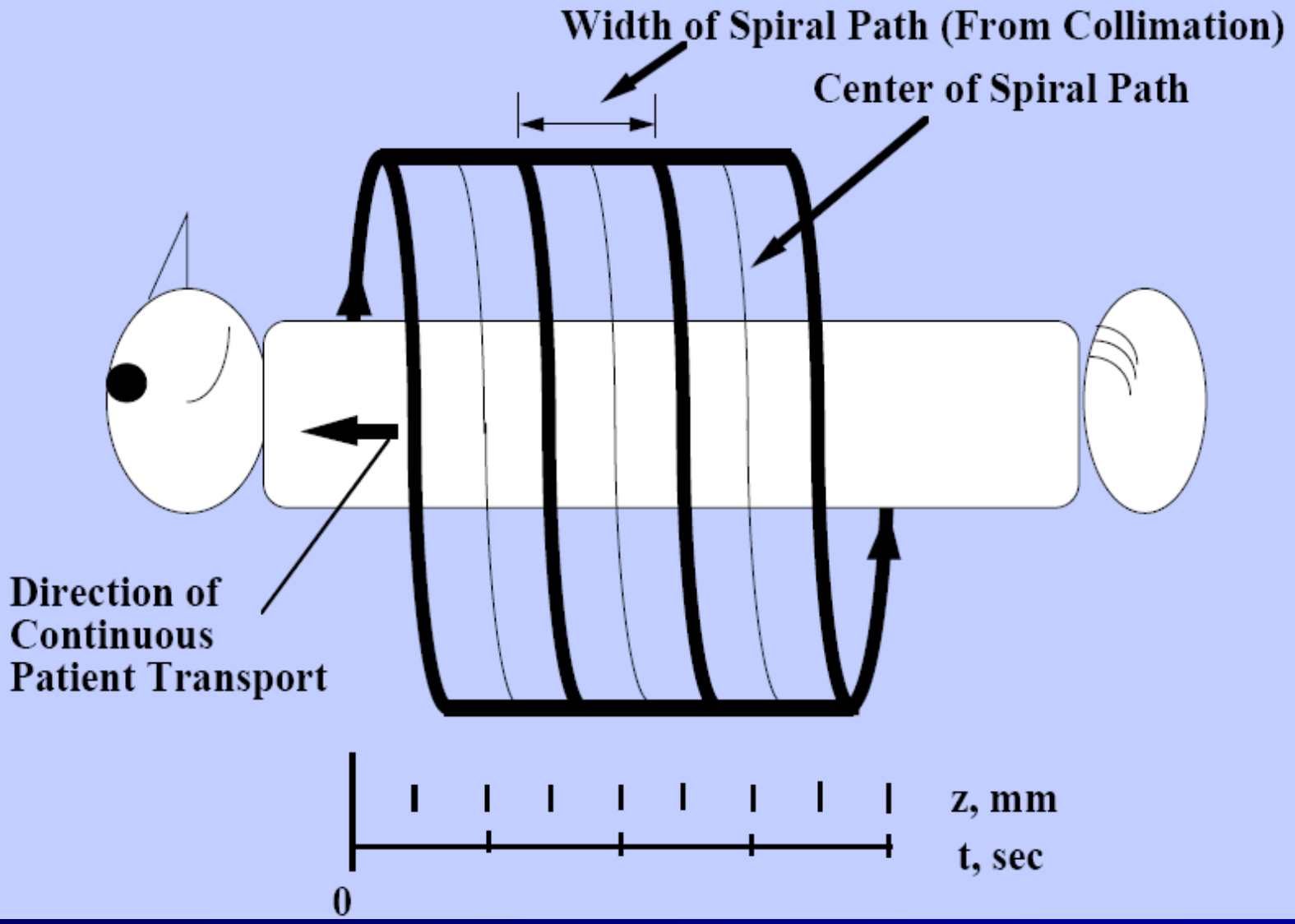
- Inter-slice distance is defined as the couch increment minus nominal slice thickness. In helical CT the pitch factor is the ratio of the couch increment per rotation to the nominal slice thickness at the axis of rotation. In clinical practice the inter-slice distance generally lies in the range between 0 and 10mm, and the pitch factor between 1 and 2.
- The inter-slice distance can be negative for overlapping scans which in helical CT means a pitch < 1.

Data Acquisition

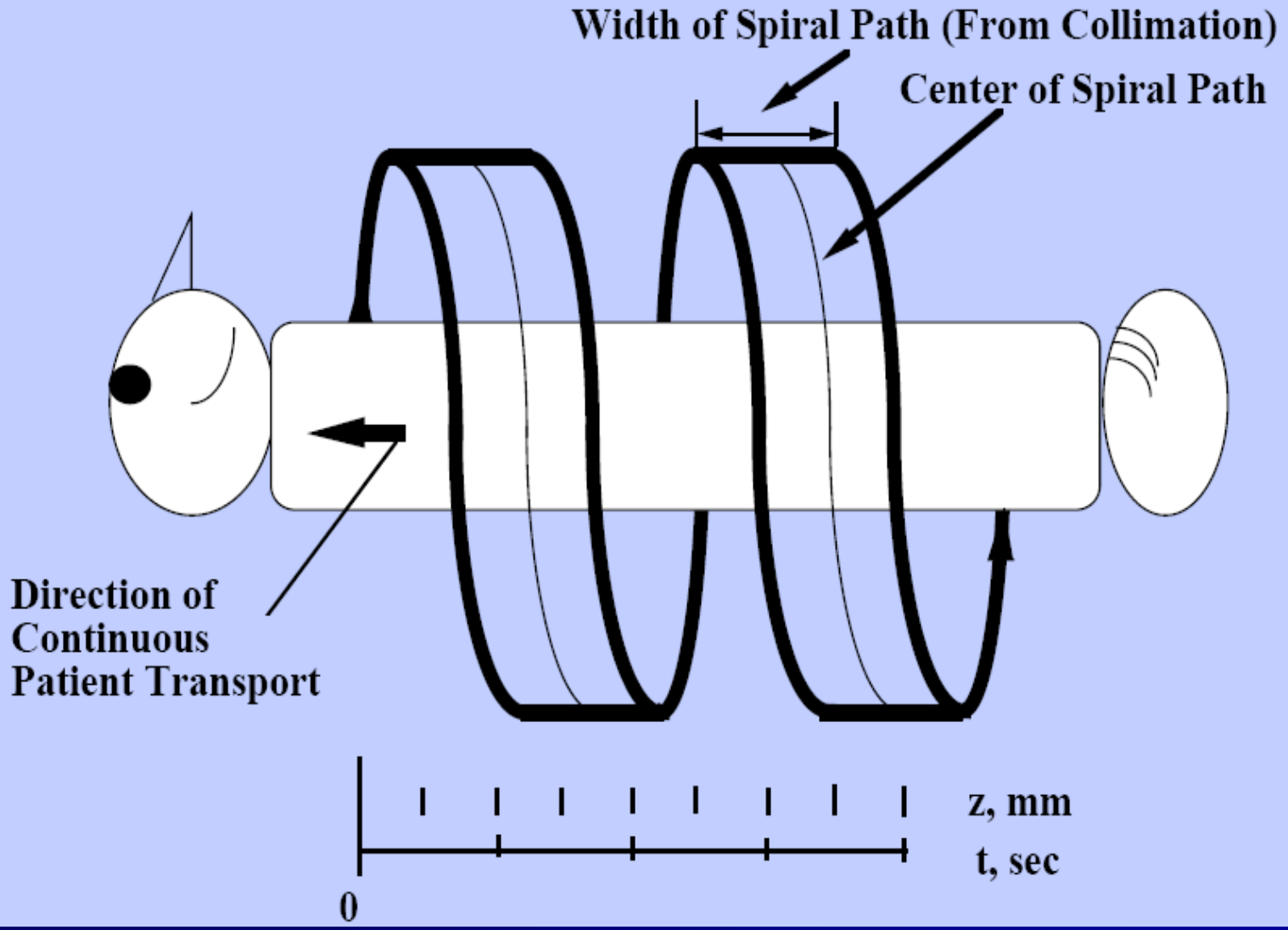
$$Pitch = \frac{\text{Table Movement}}{\text{Collimation}}$$

- Continuous Spiral – Pitch = 1 (10mm/10mm)
- Extended Spiral – Pitch = 2 (20mm / 10mm)
- Overlapping Spiral – Pitch = ½ (5mm/10mm)

Pitch=1; Contiguous Spiral



Pitch=2; Extended Spiral

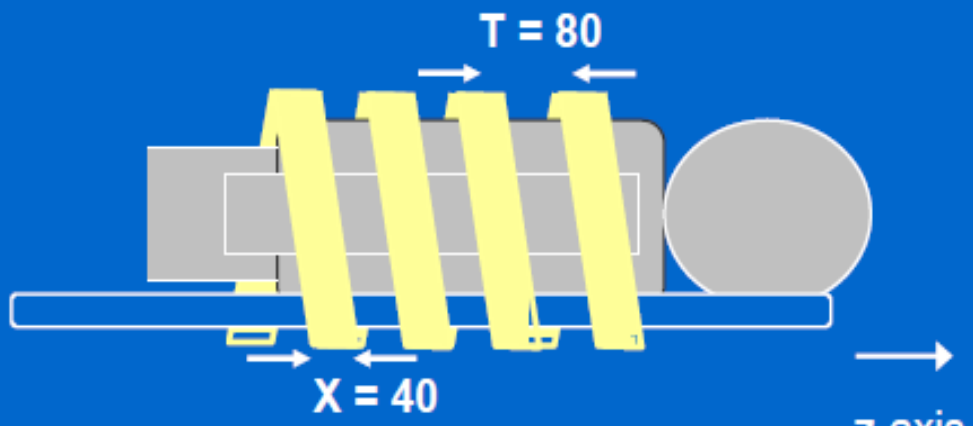


Helical (spiral) scanning - pitch

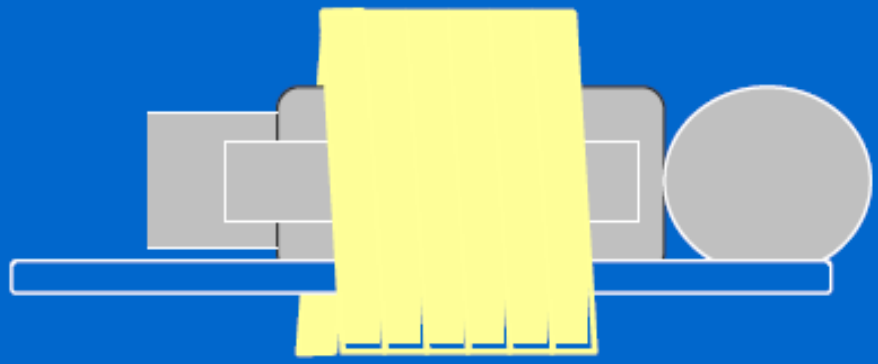
pitch 2

Table travel/rot = 80 mm

Beam width = 40 mm



pitch 1



pitch 0.5

Pitch

Pitch=1
Table Travel = Paint Width
Uniform Paint

Pitch<1
Table Travel < Paint Width
Uniform + Overlapped Paint

Pitch>1
Table Travel > Paint Width
Candy Cane Stripes

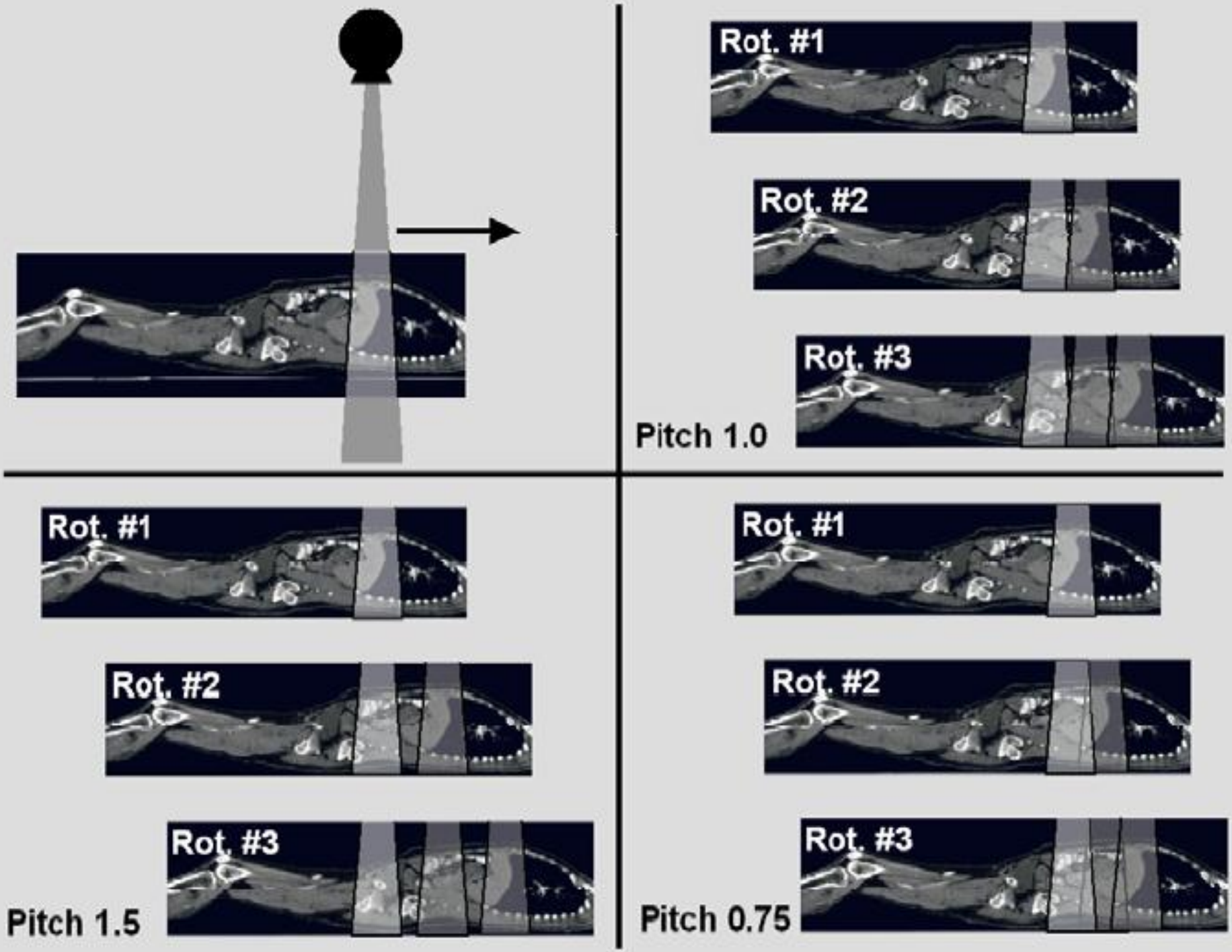

Rot. #1
Rot. #2
Rot. #3
Pitch 1.0
Rot. #1
Rot. #2
Rot. #3
Pitch 1.5
Rot. #1
Rot. #2
Rot. #3
Pitch 0.75

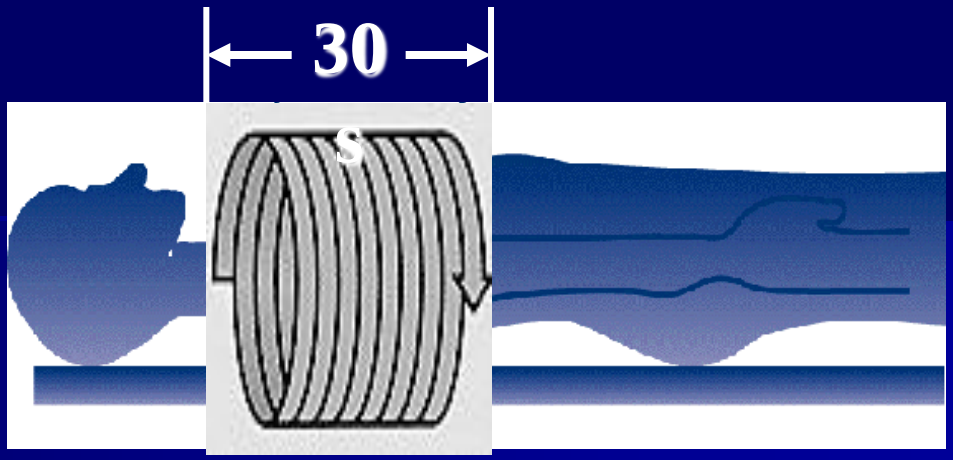
Table Speed & Pitch

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

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

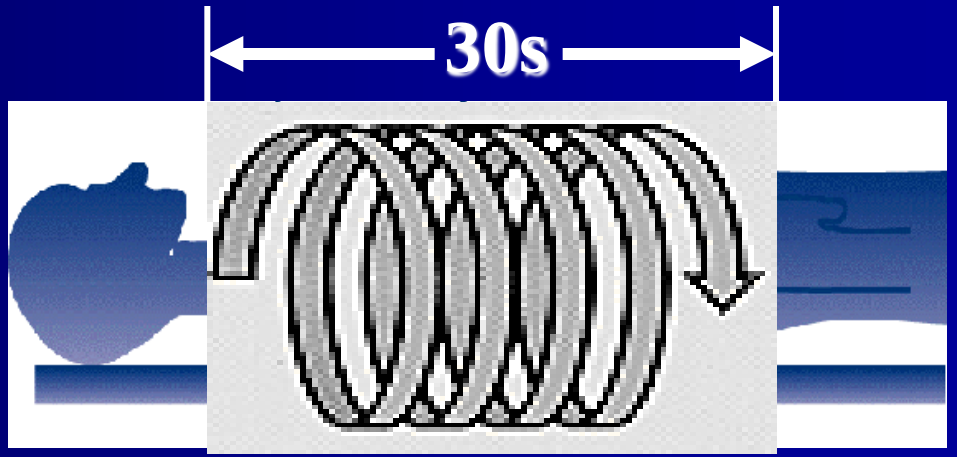
Table Feed	Collimation	Pitch
10 mm/rot	10 mm	1.0
15 mm/rot	10 mm	1.5
20 mm/rot	10 mm	2.0

Pitch 2 covers
2x
distance as Pitch 1



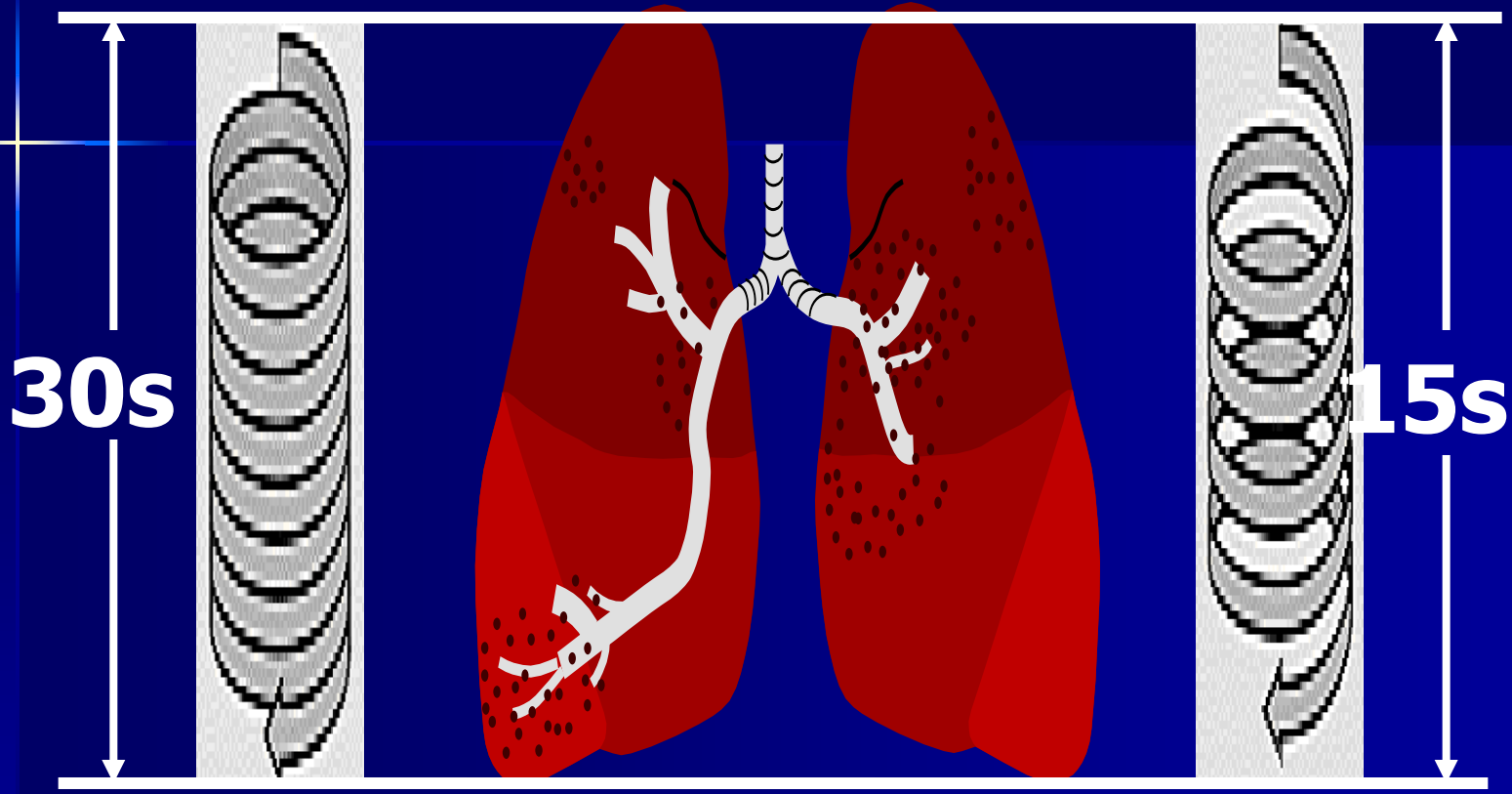
10mm P1

More Coverage in the same time with extended Pitch!!

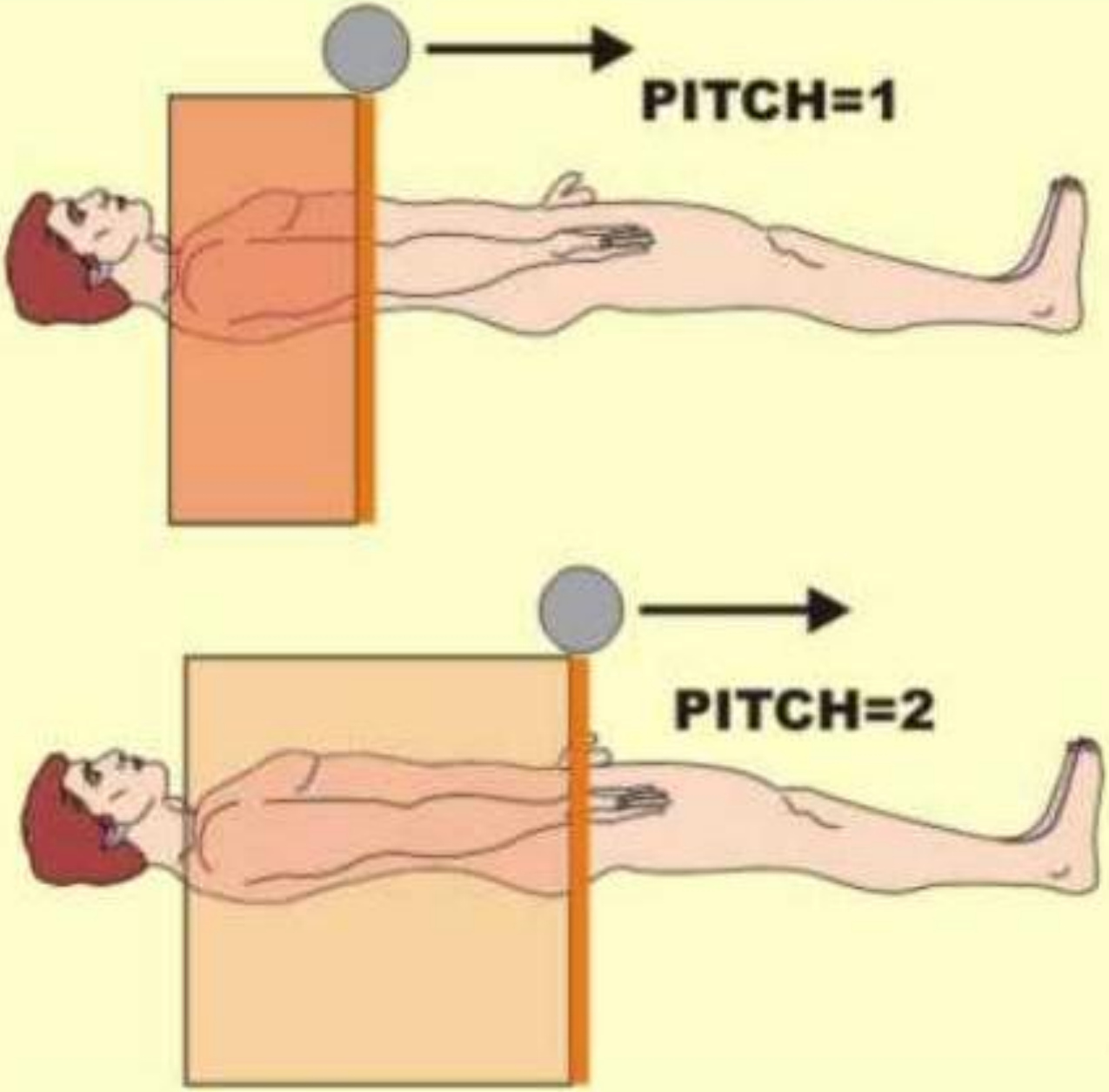


10mm P2

Scan Range = 300*mm*

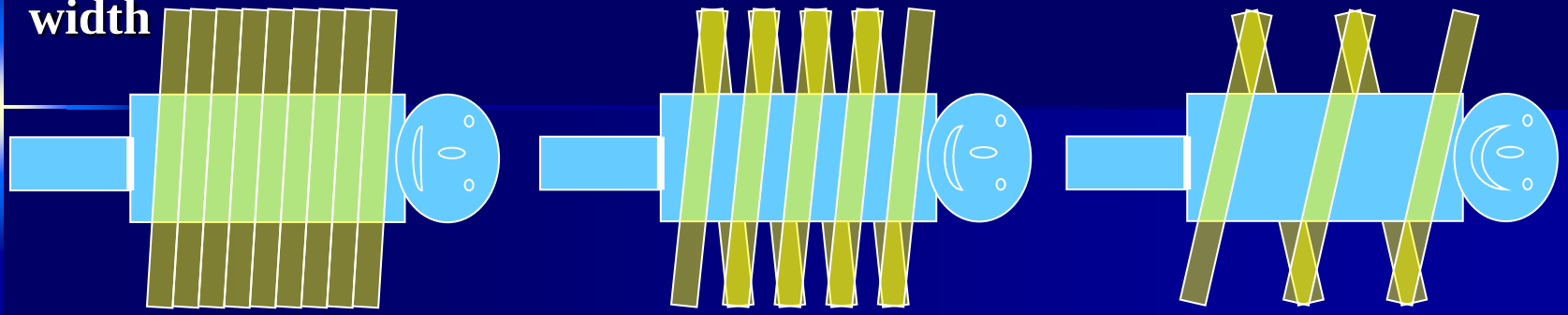


Cover the same volume in shorter time with extended Pitch


PITCH=1
PITCH=2
Sprawls

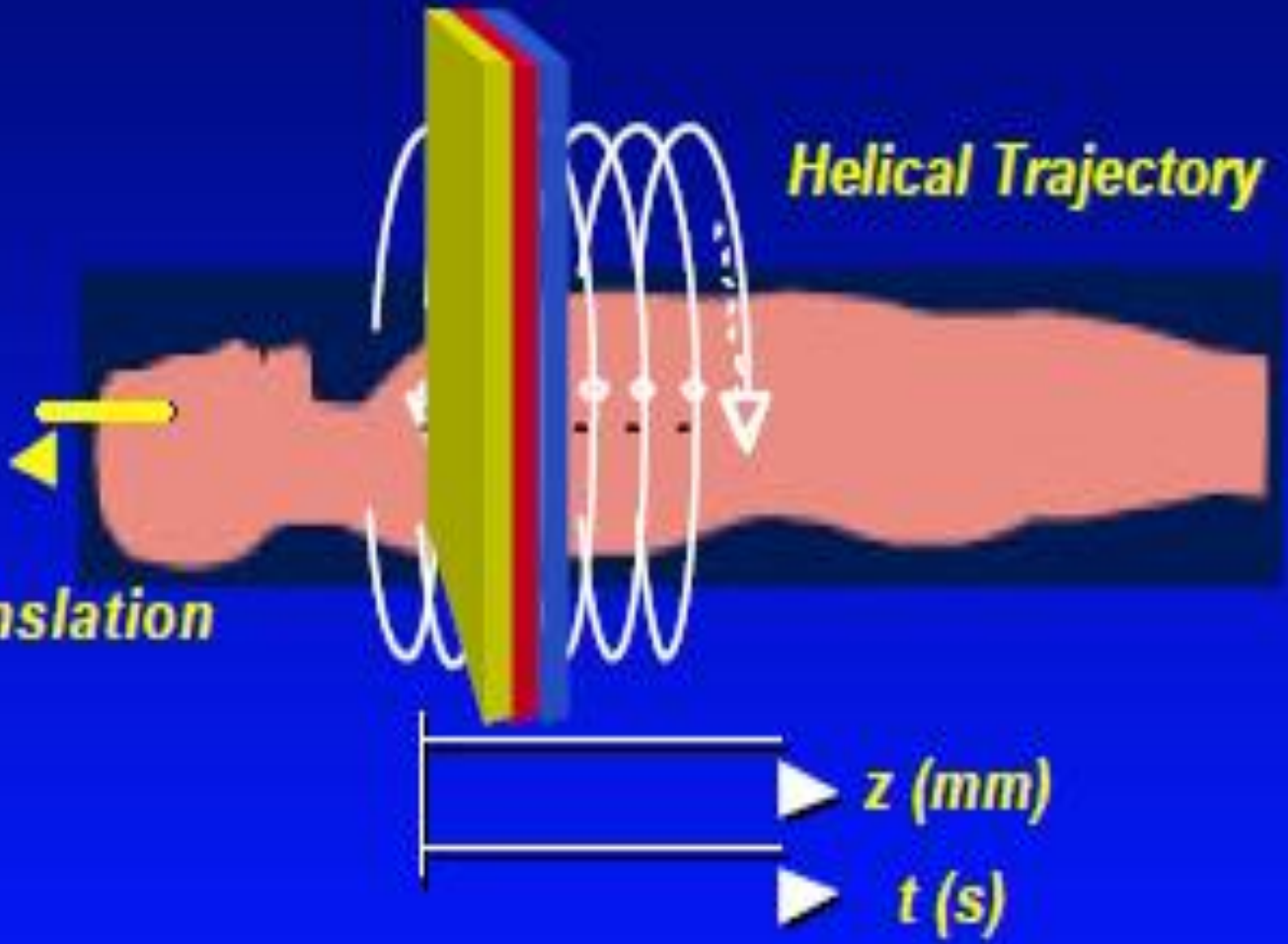
Pitch

ratio of the distance the table travels per rotation to the x-ray beam width



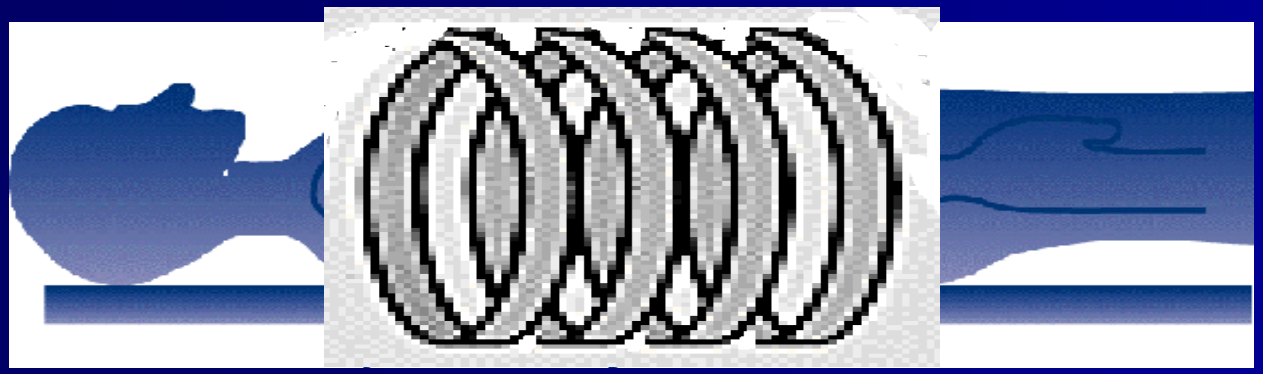
Number rotations	10		5		2.5
Slice thickness	10	10	10	10	10
Table movement per rotation	10	15	20	30	40
Pitch	1	1.5	2	3	4
Dose	10	7.5	5	3.33	2.5

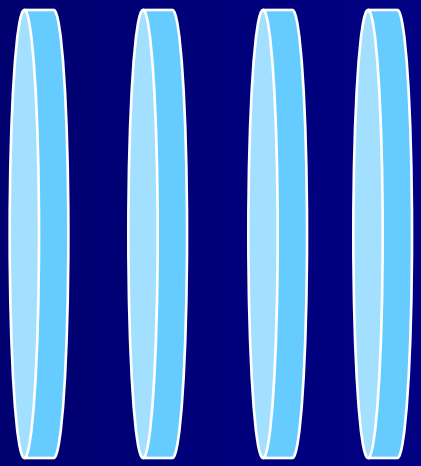
Helical Single-Section Mode



Interpolation using samples from single row detector ring

Conventional

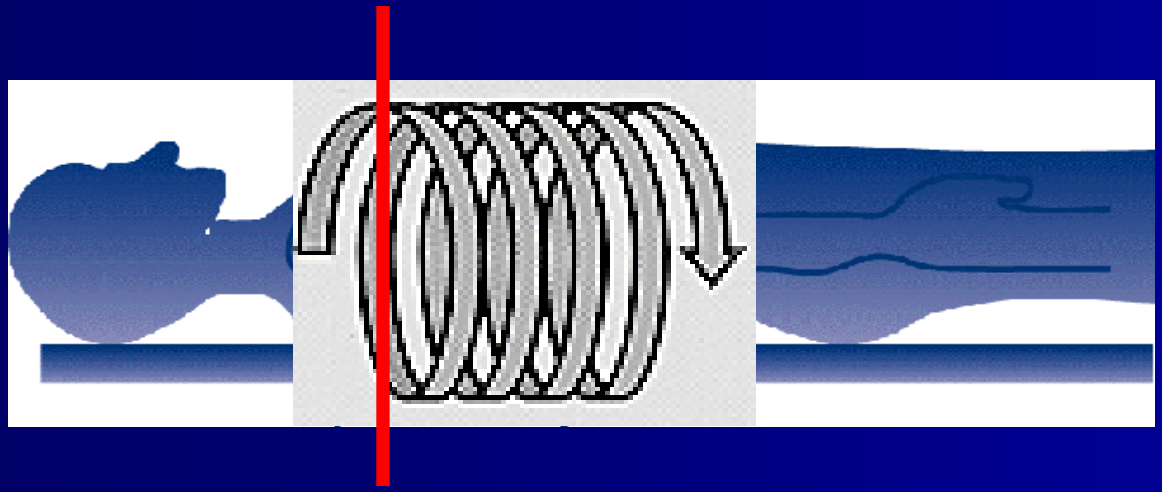




SSP

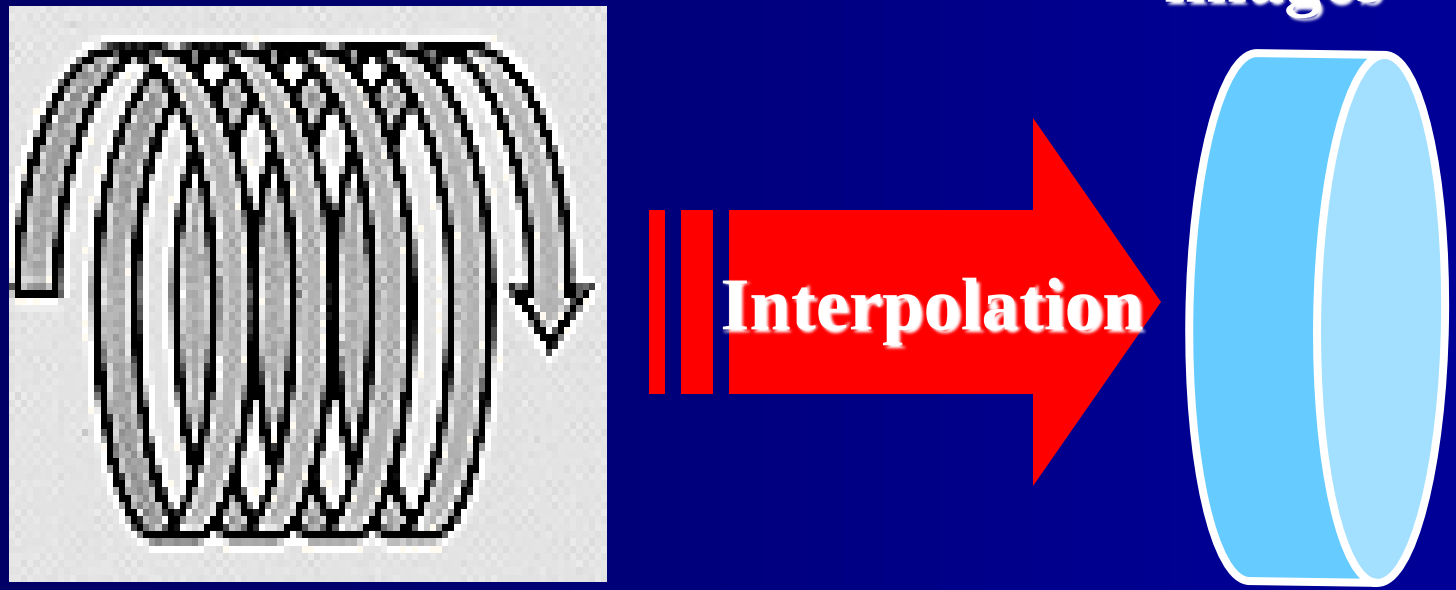
conventional

MSCT



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*

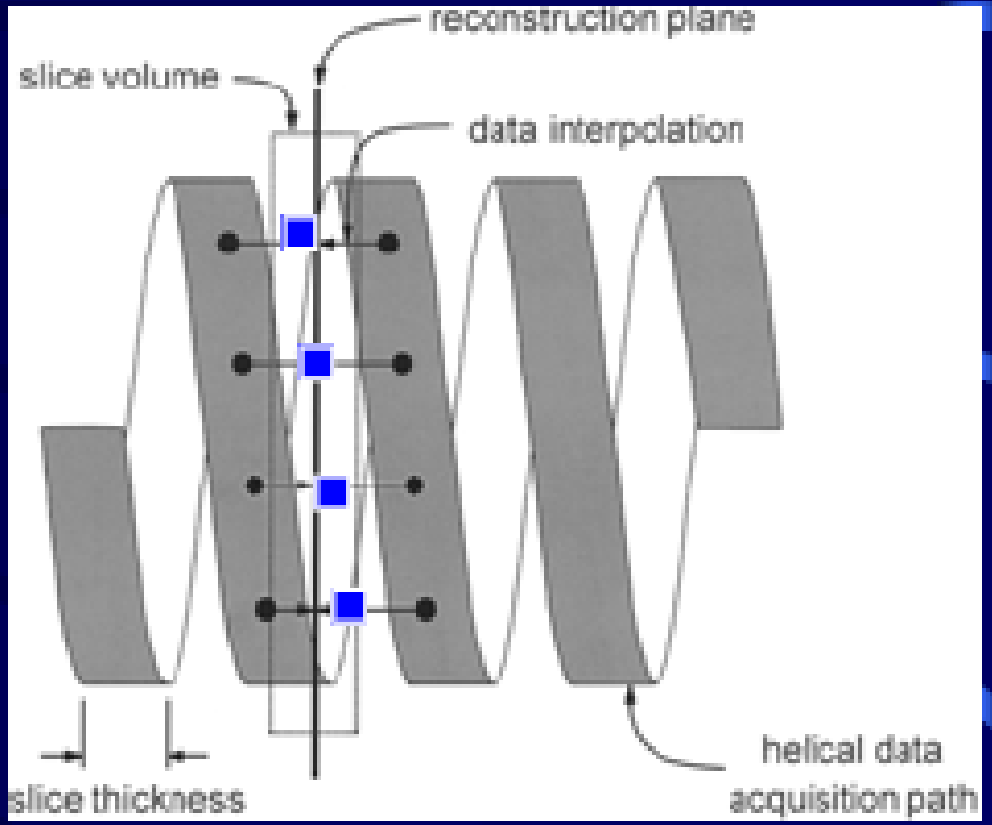
Helical Interpolation

Collect data (black dots)

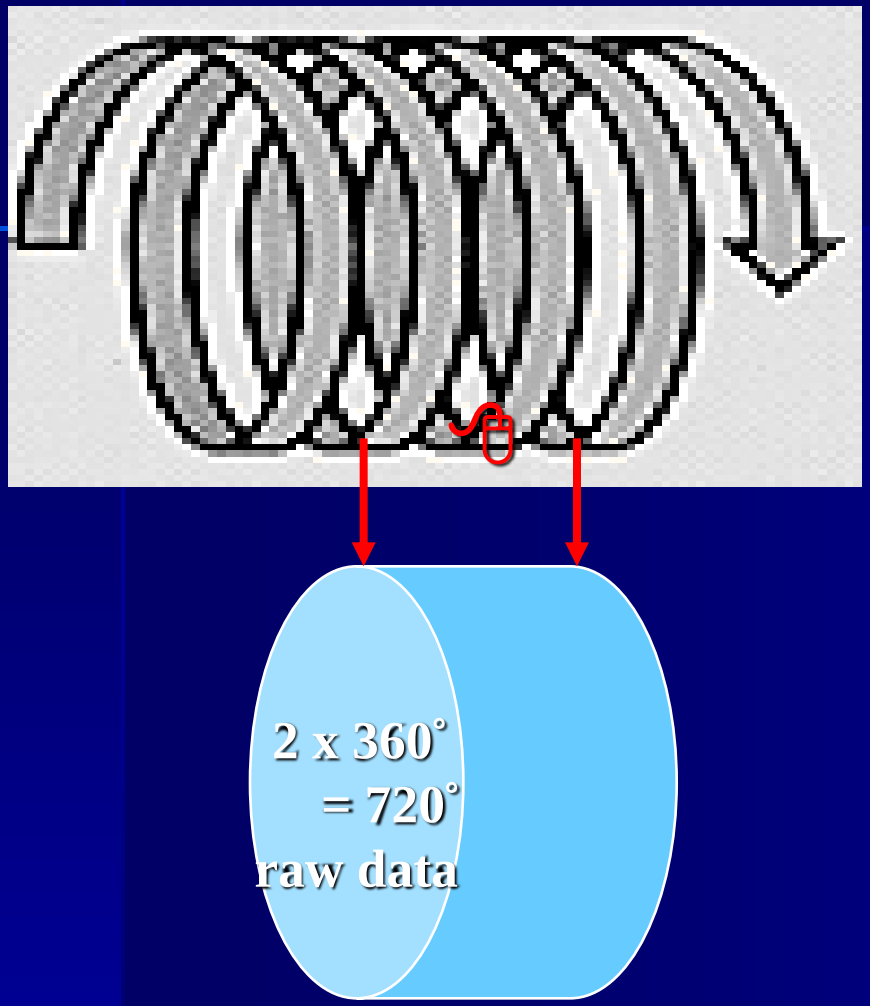
Rebin to estimate the 180° data (blue squares)

Interpolate to estimate image between collected and rebinned data

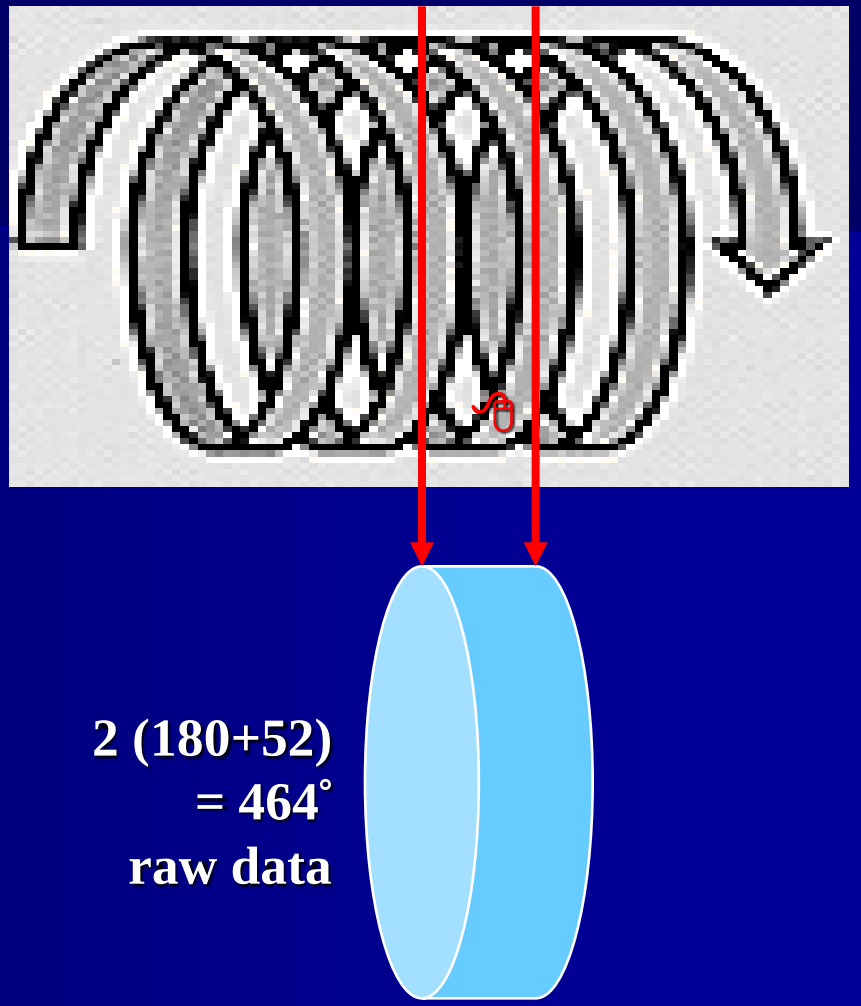
Helical CT needs fast computers



Wide Algorithm



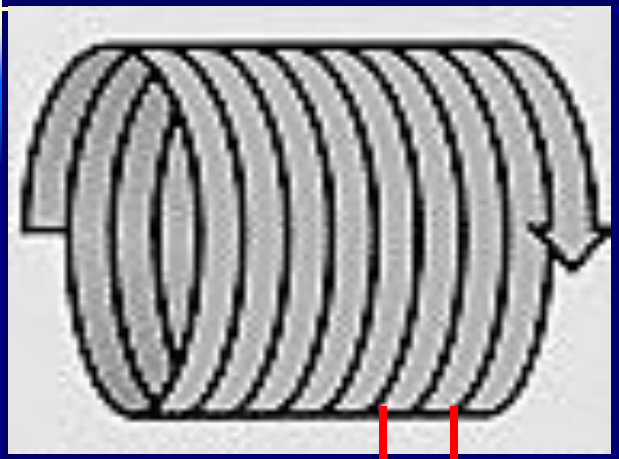
Slim Algorithm



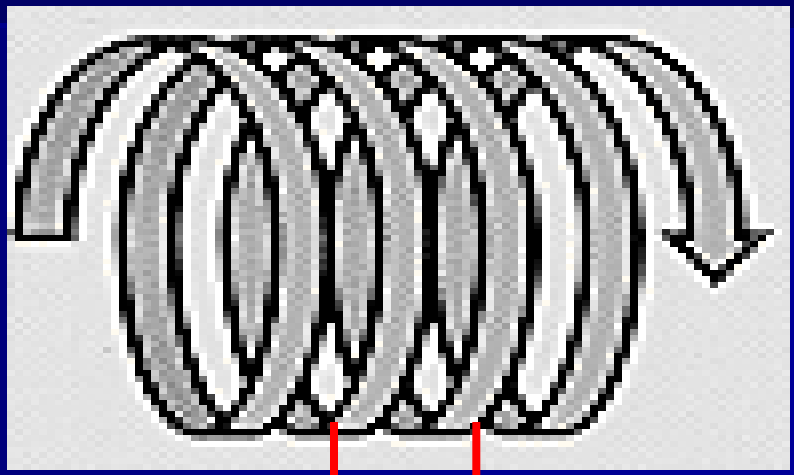
Wide algorithm produces a broader image thickness

Wide algorithm uses more raw data => less image noise

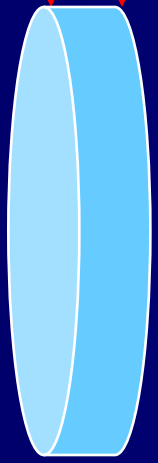
Pitch 2 scanning produces a broader image thickness
Pitch 2 scanning does not increase image noise

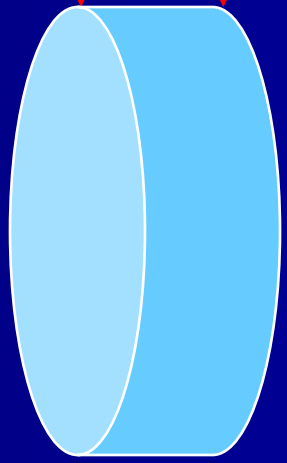


PITCH 1



PITCH 2





30% increase in image thickness with Pitch 2

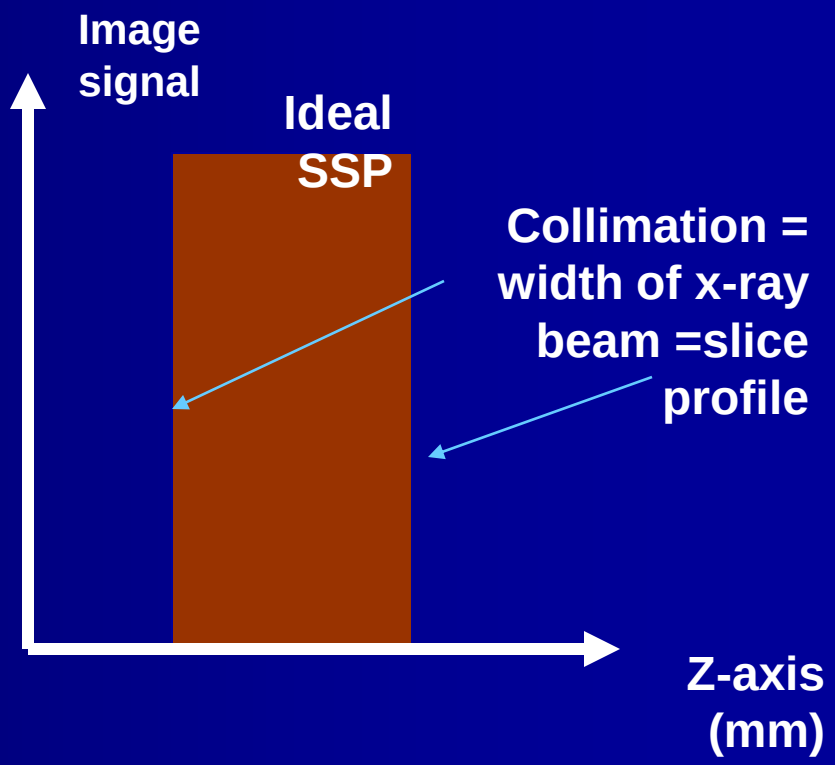
Slice Sensitivity Profile (SSP)

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

RESOLUTION

SSP

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**

Resolution

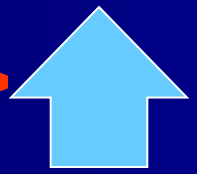
Slice Profile

Factors influencing Slice Profile

- **Collimation**
- **Pitch**
- **Interpolation algorithm (360˚ or 180˚)**

Factors influencing SSP

- **Collimator width**

 **collimation =>**  **SSP**

Spiral CT

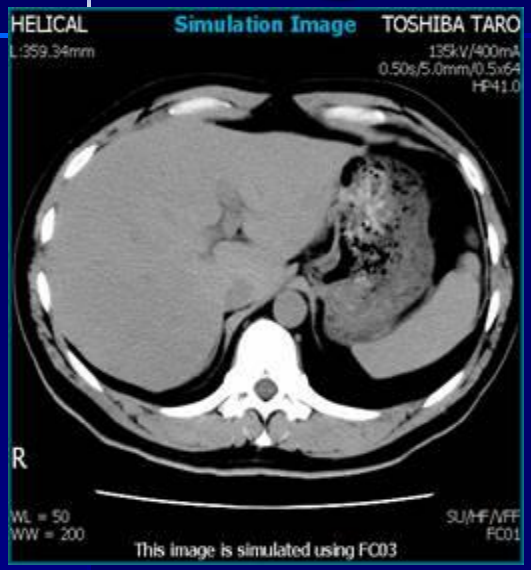
- **Table speed or Pitch**
- **Interpolation Algorithm**

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

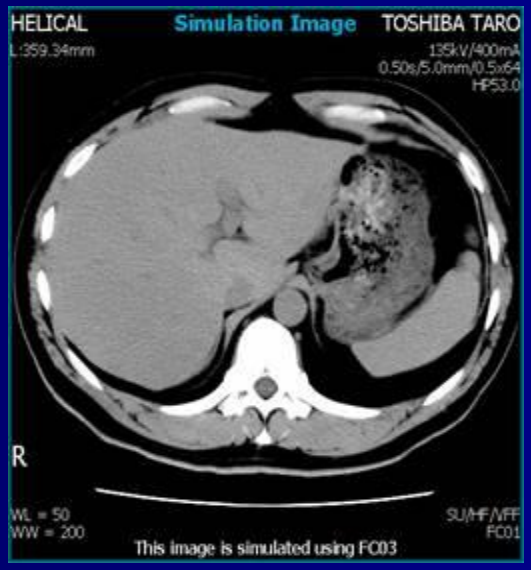
Smoother
image

Noisier
image

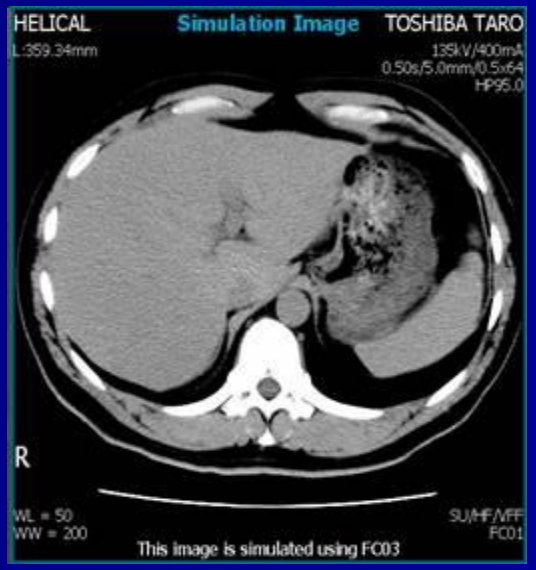
Effect of Pitch on Dose and Image Quality



P = 0.64
CTDI = 47.8 mGy
30% higher



P = 0.83
CTDI = 37 mGy



P = 1.48
CTDI = 20.6 mGy
45% lower


Thank you for your attention!