Introduction to Positron Emission Tomography
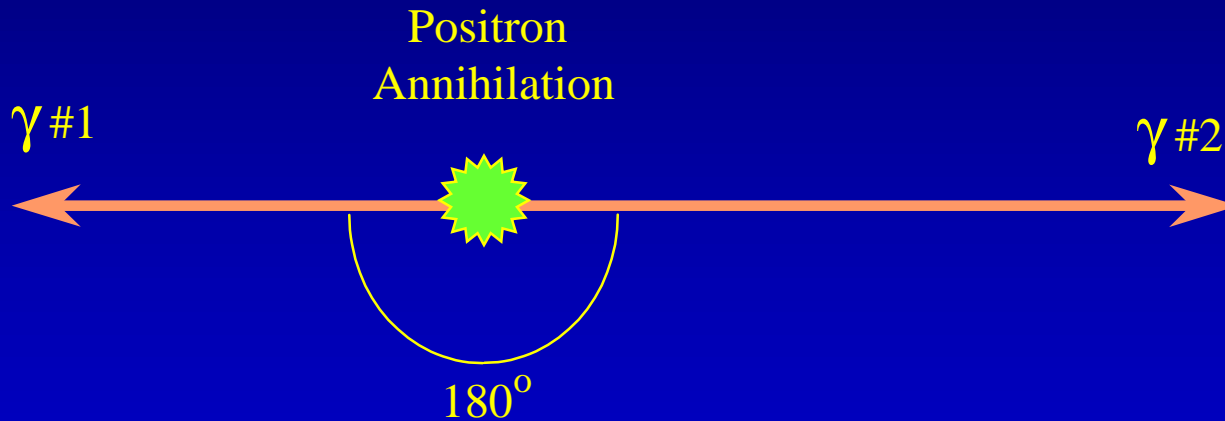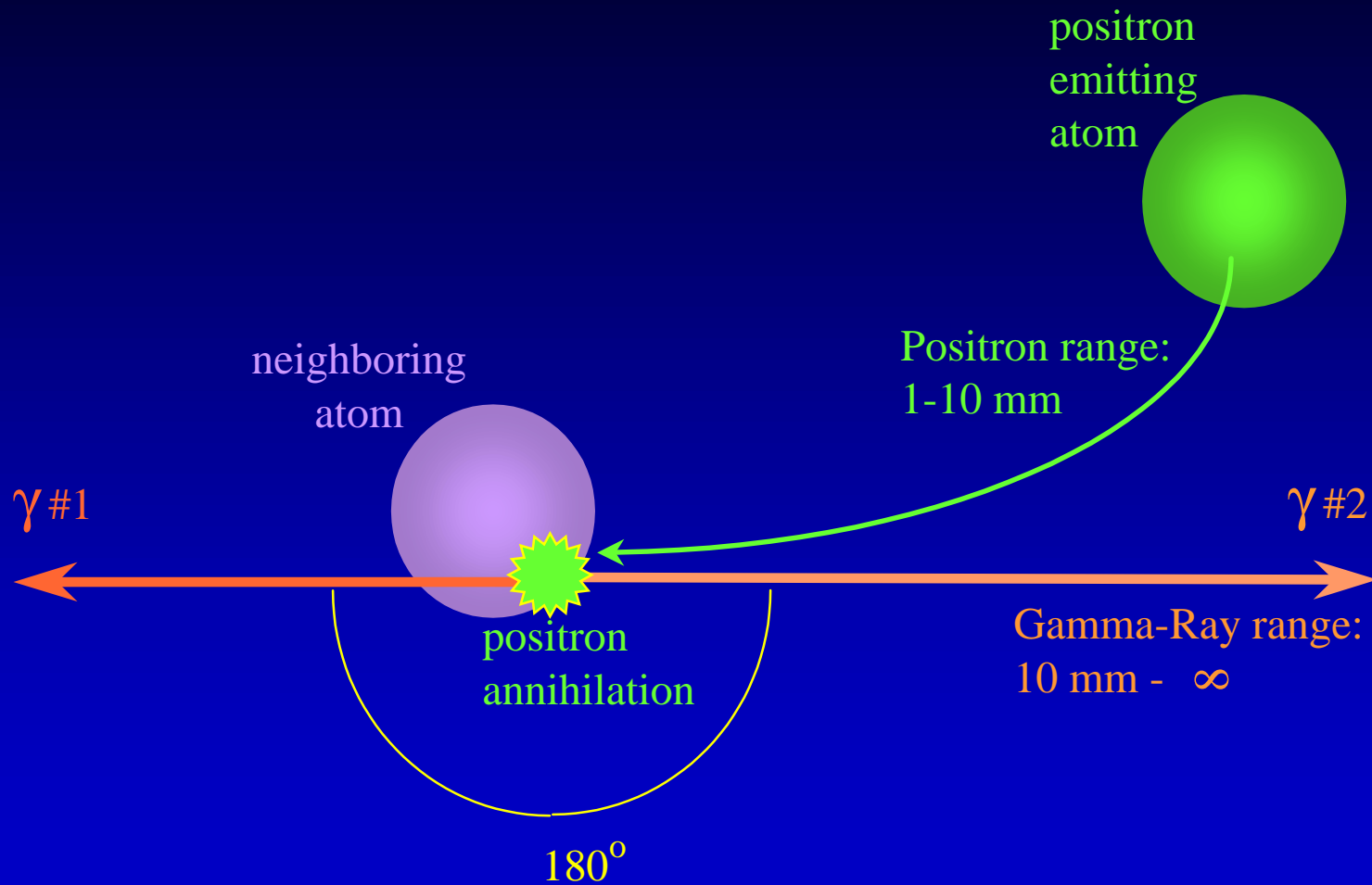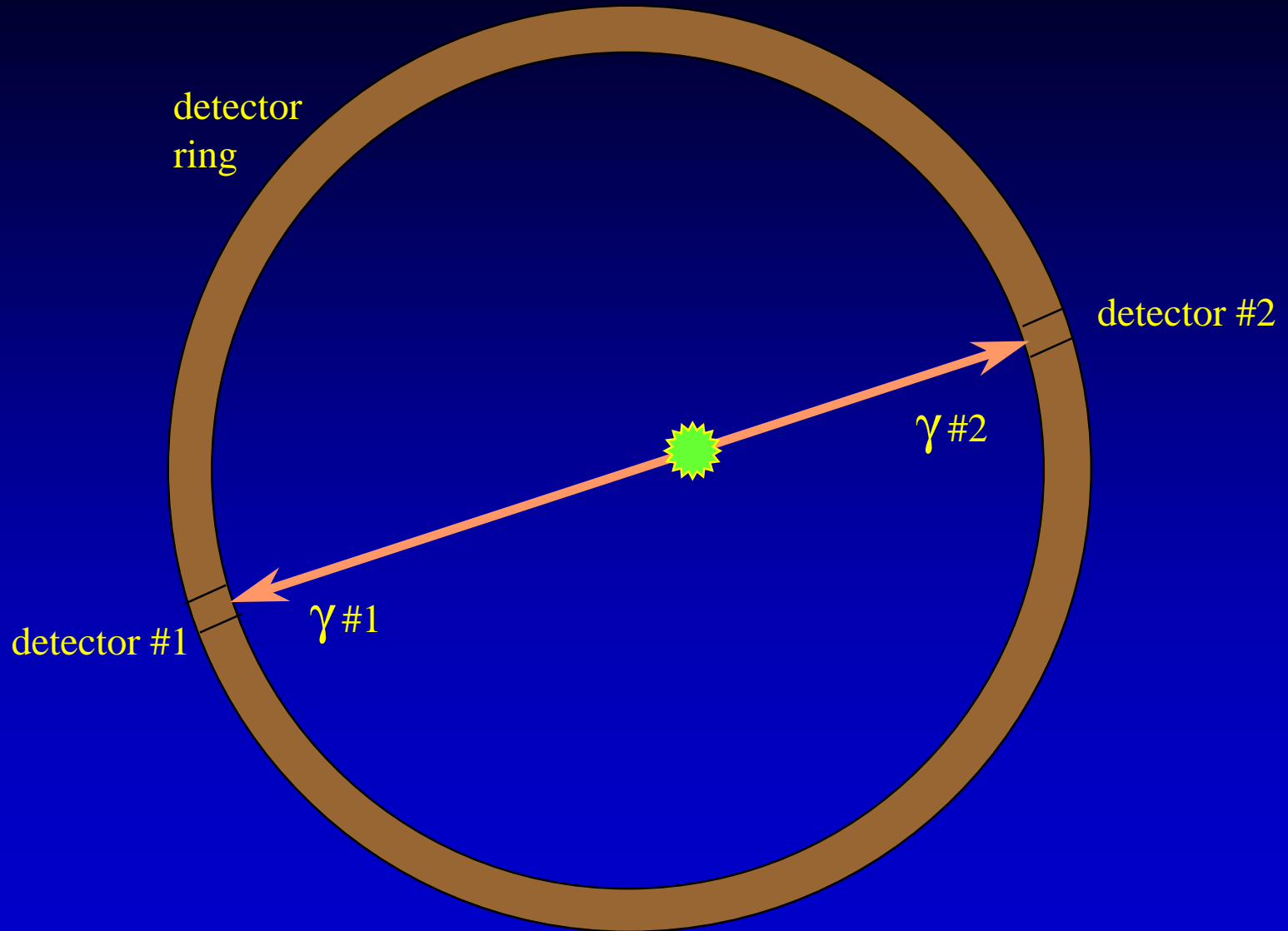
with your host, Terry Oakes

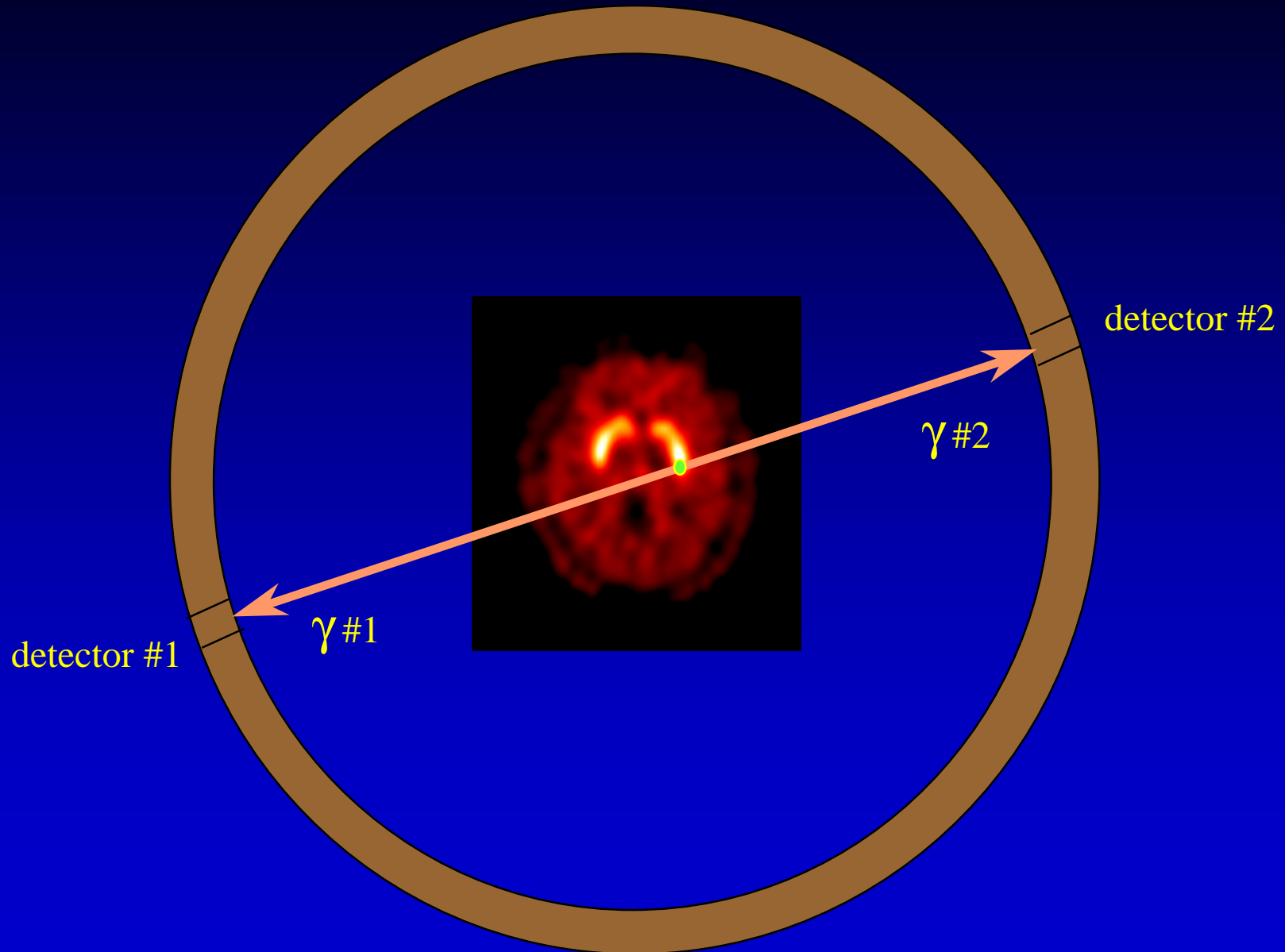Positron
Annihilation

γ #1

γ #2

180°

Positron Annihilation

positron
emitting
atom

Positron range:
1-10 mm

neighboring
atom

γ #1

γ #2

positron
annihilation

Gamma-Ray range:
10 mm - ∞

180°

Positron Emission Tomography

detector
ring

detector #2

γ #2

γ #1

detector #1

Positron Emission Tomography

detector #2

γ #2

detector #1

γ #1

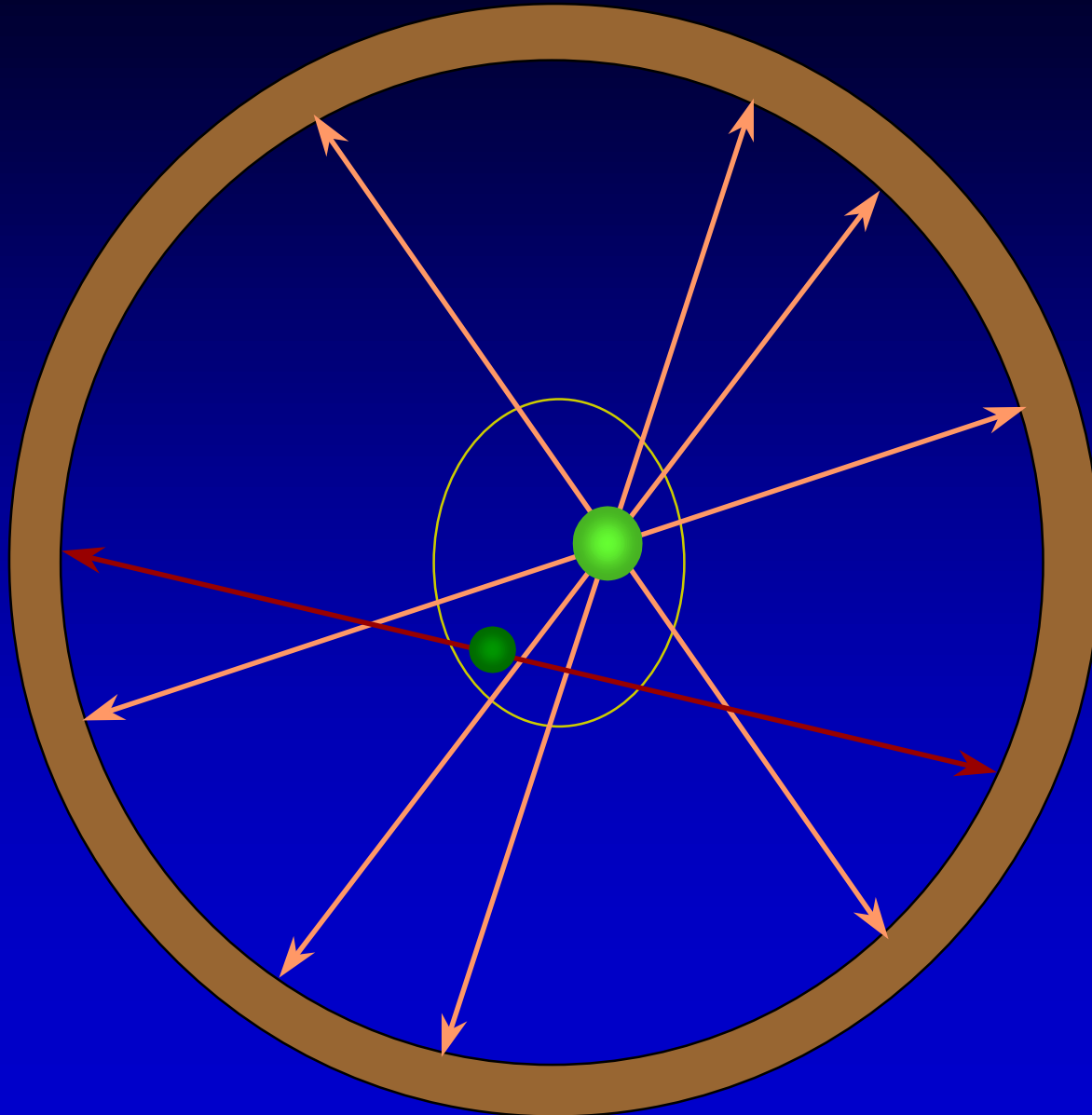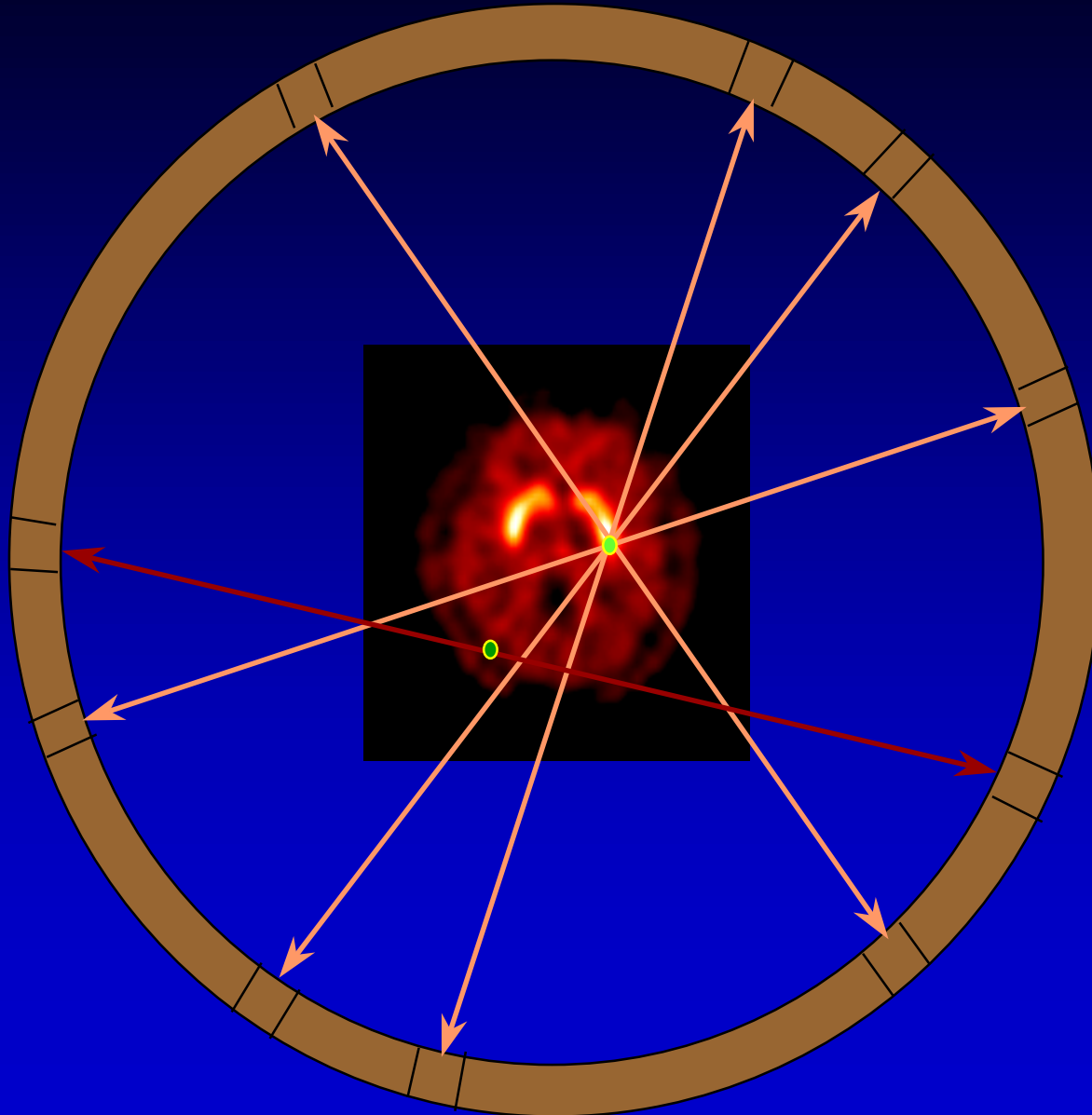# Positron Emission Tomography
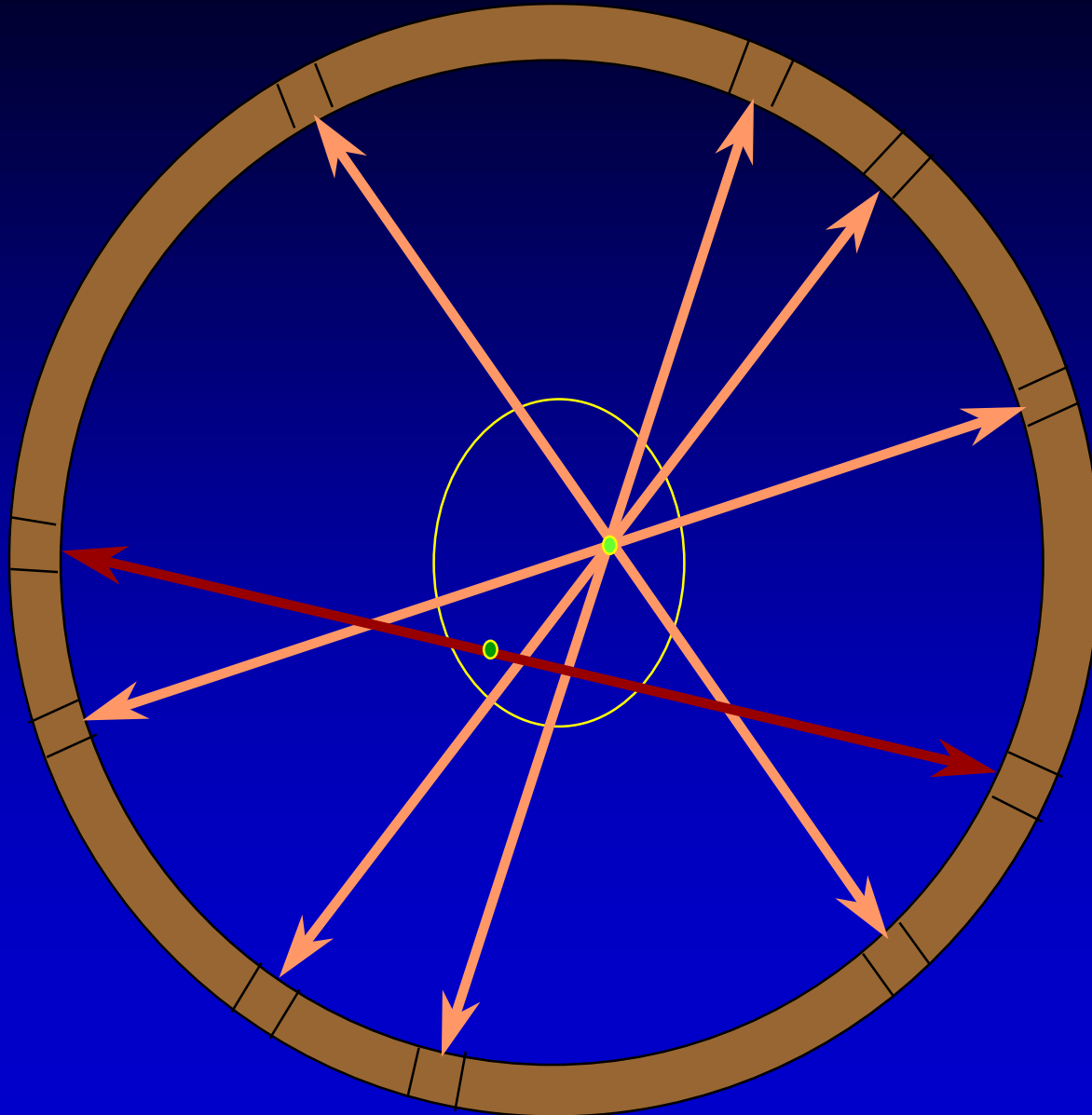
# Positron Emission Tomography

Positron Emission Tomography

P.E.T. measures Concentration of Radioactivity

1) Gamma-rays escape from body:
External detection possible.

2) Two gamma rays emitted
at 180° when a positron
annihilates:
**The annihilation occured
somewhere between
the two detectors.**

3) Regions with greater
radioactivity levels
produce more LORs:
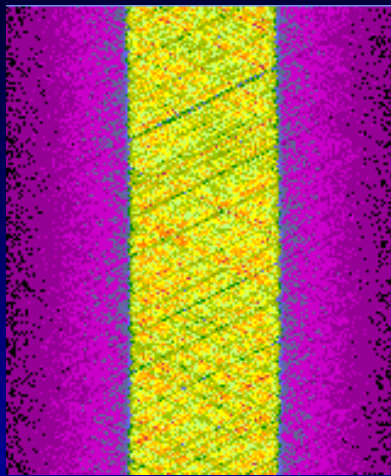**Concentration of radioactivity
can be measured and quantified.**
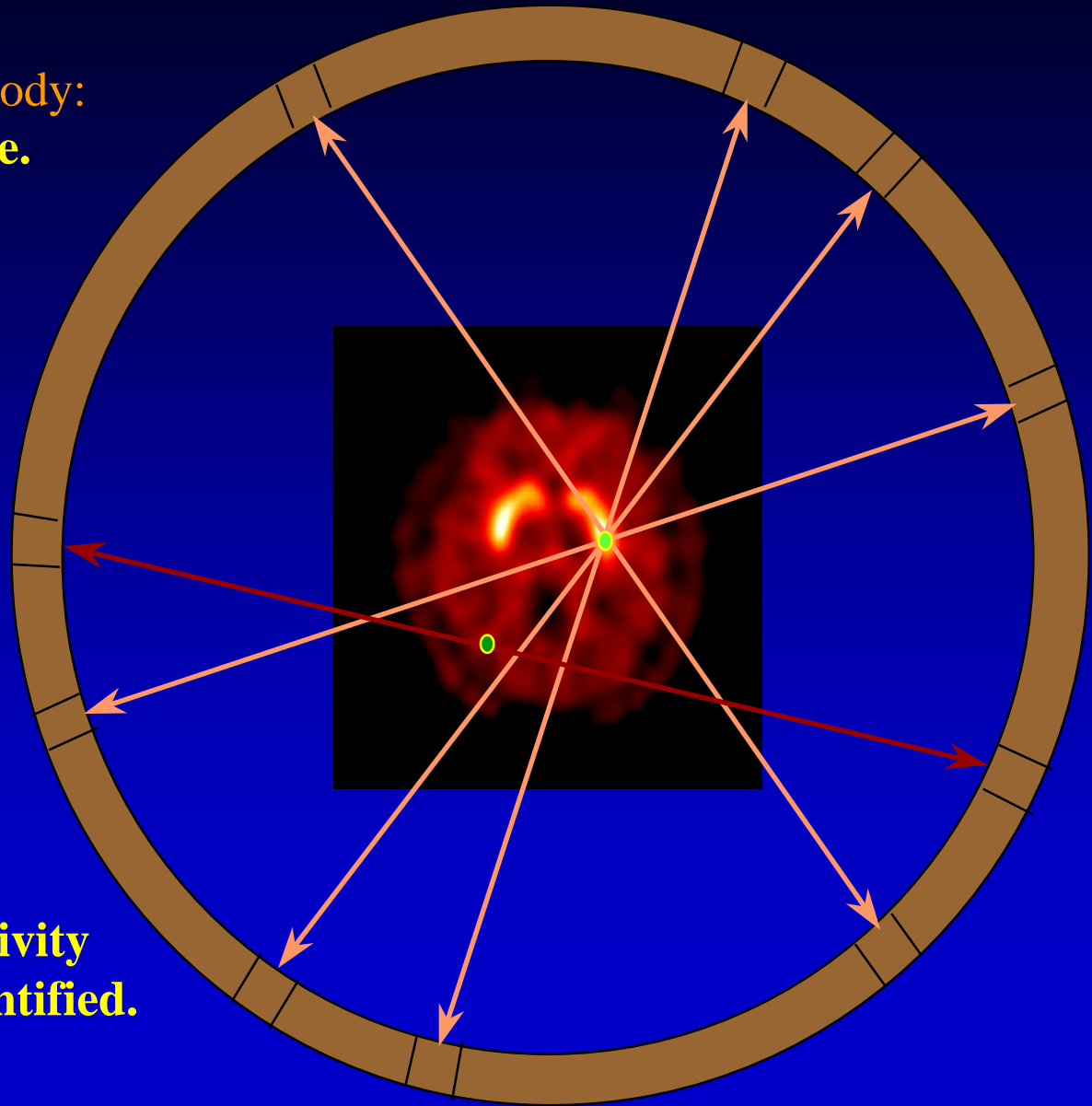
P.E.T. yields Quantitative results.
(μCi/cc tissue)

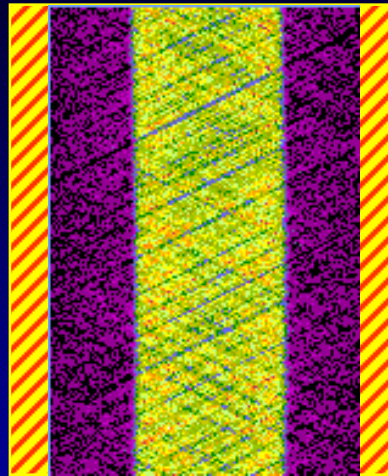**Corrections must be applied to raw data:**
- 1) Dead-time, Random events
- 2) Calibration
- 3) Normalization
- 4) Scatter-correction
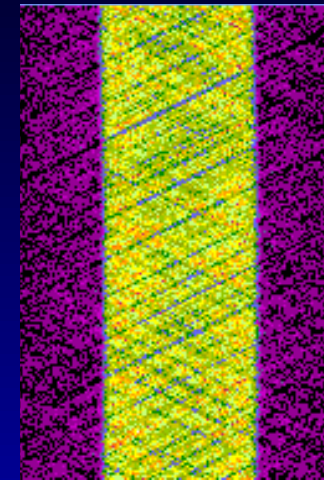- 5) Attenuation correction
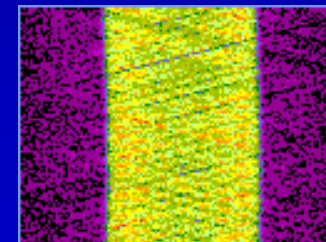- 6) Reconstruction
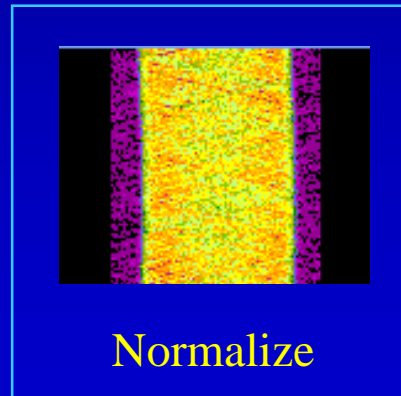
Corrections to Sinograms
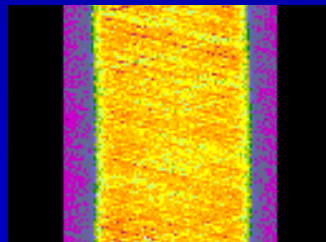
raw sinogram
(20 cm cylinder)

trim
(remove edges)

Scatter-Correct

Normalized,
without Scatter-Correction

Normalize

mash
(combine angular views)

Effect of Corrections on Images

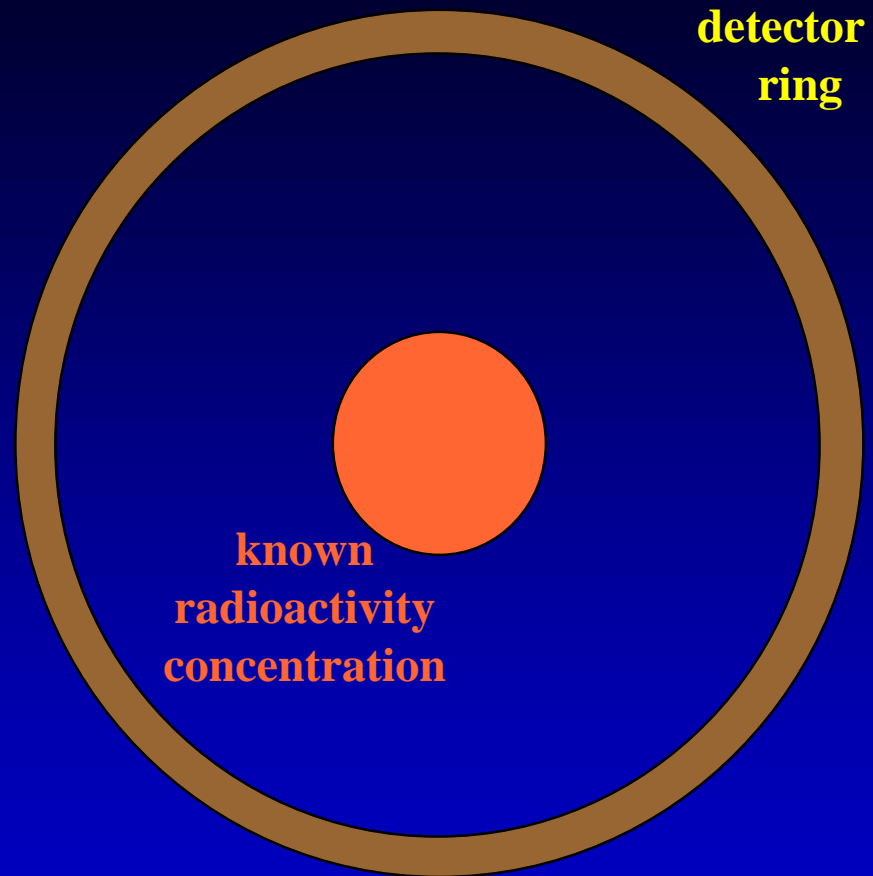|				
Scatter-corrected		X	X	X
Normalized	X		X	X
Attenuation-corrected	X	X		X
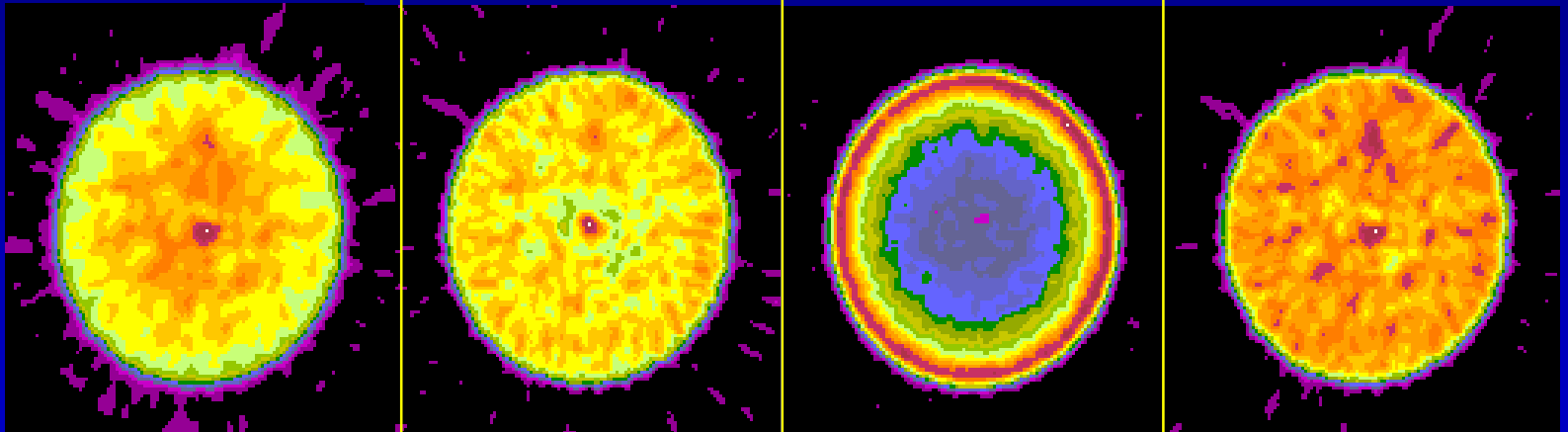
Uniform
20 cm cylinder

color scale

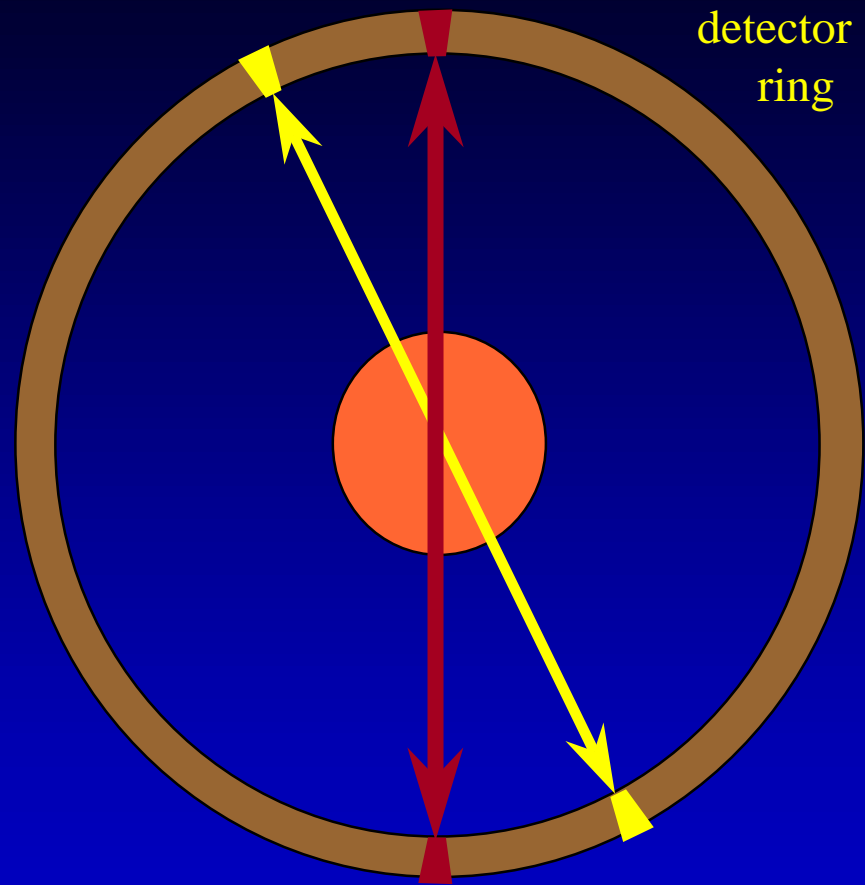# Calibration

Converting
"counts/pixel"
to
"microCi / cc tissue"

Measure response of
the PET scanner to a
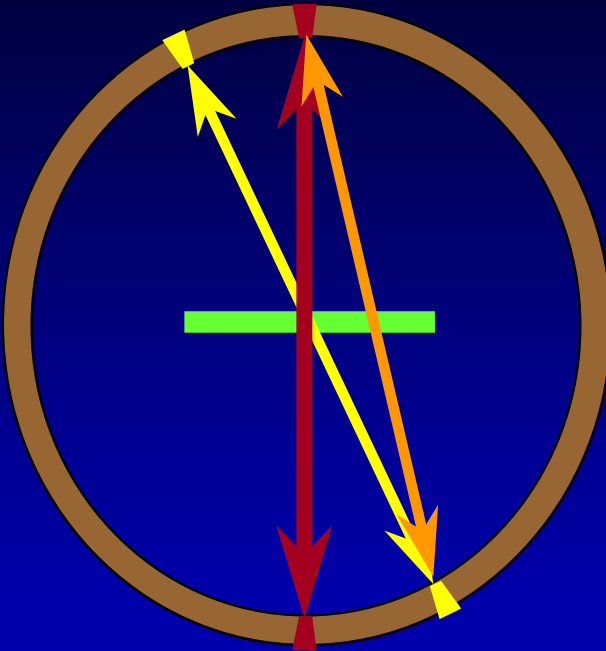known concentration
of radioactivity.

Obtain
Calibration Factor
applicable for all scans.
(CF ~ (μCi/cc)/counts)

detector
ring

known
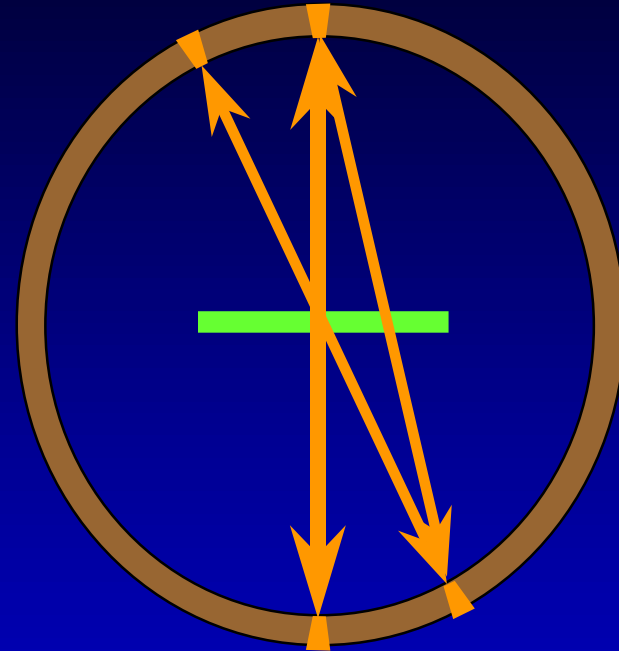radioactivity
concentration

Normalization

detector
ring

Normalization

**Individual detectors respond differently to the same level of radioactivity.**

Normalization produces a uniform response to the same level of radioactivity.

Attenuation Correction

Gamma-ray attenuation proportional to:
  1) density of object
  2) pathlength through object

Attenuation can be corrected with a density-weighted map of the object.

gamma-ray attenuated

rotating radioactive line-source
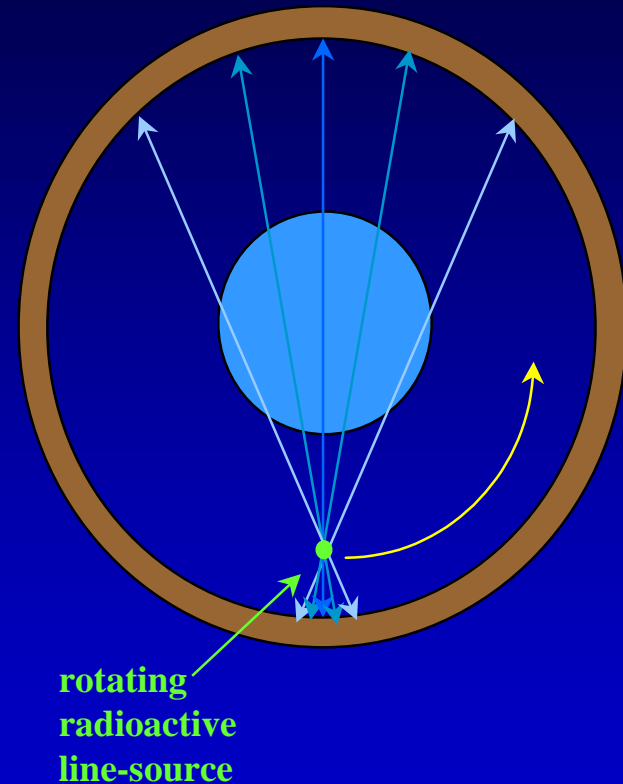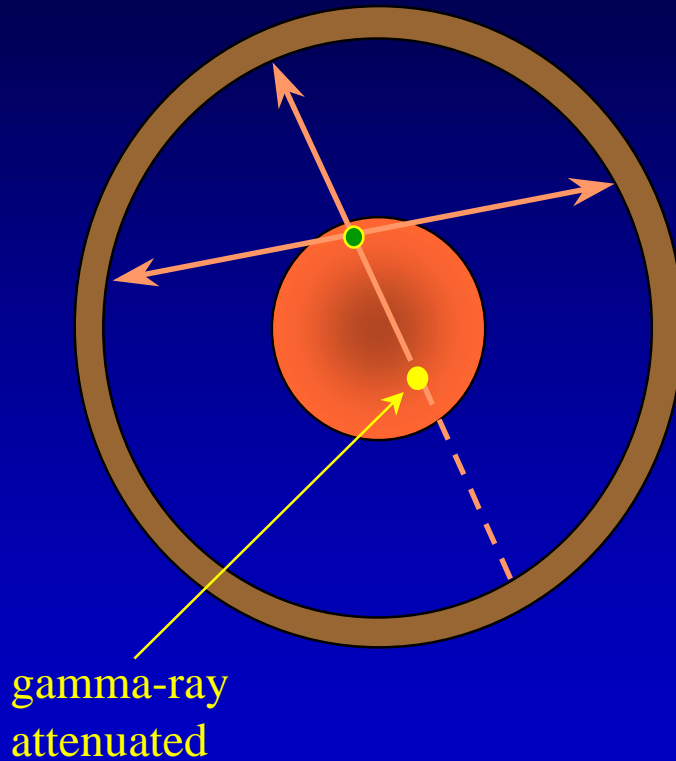
**Attenuation causes a non-uniform loss of events;
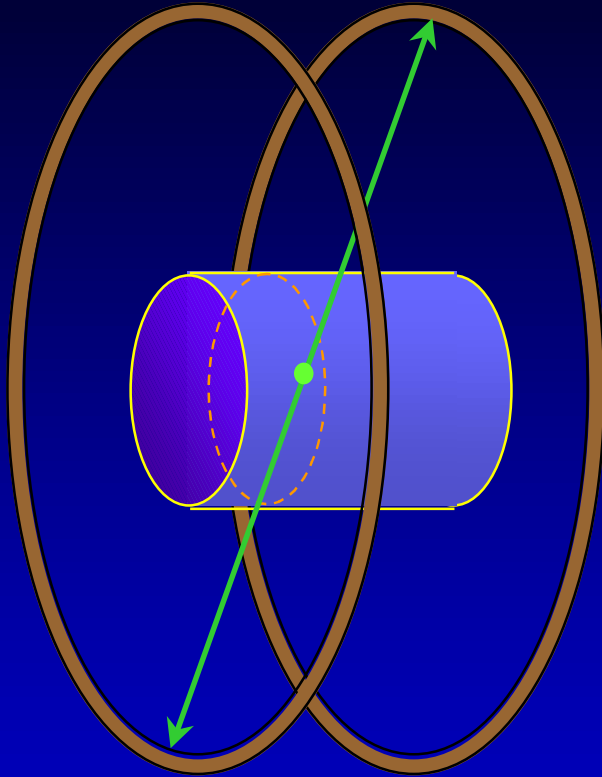more gamma rays passing through the middle of the object are lost.**

Scatter Correction

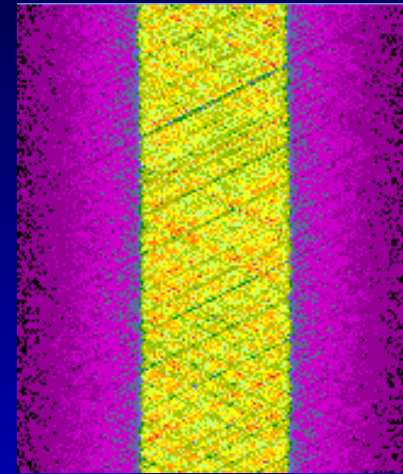Scattered gamma rays cause
recorded events to be mispositioned.

Scatter tends to increase the concentration
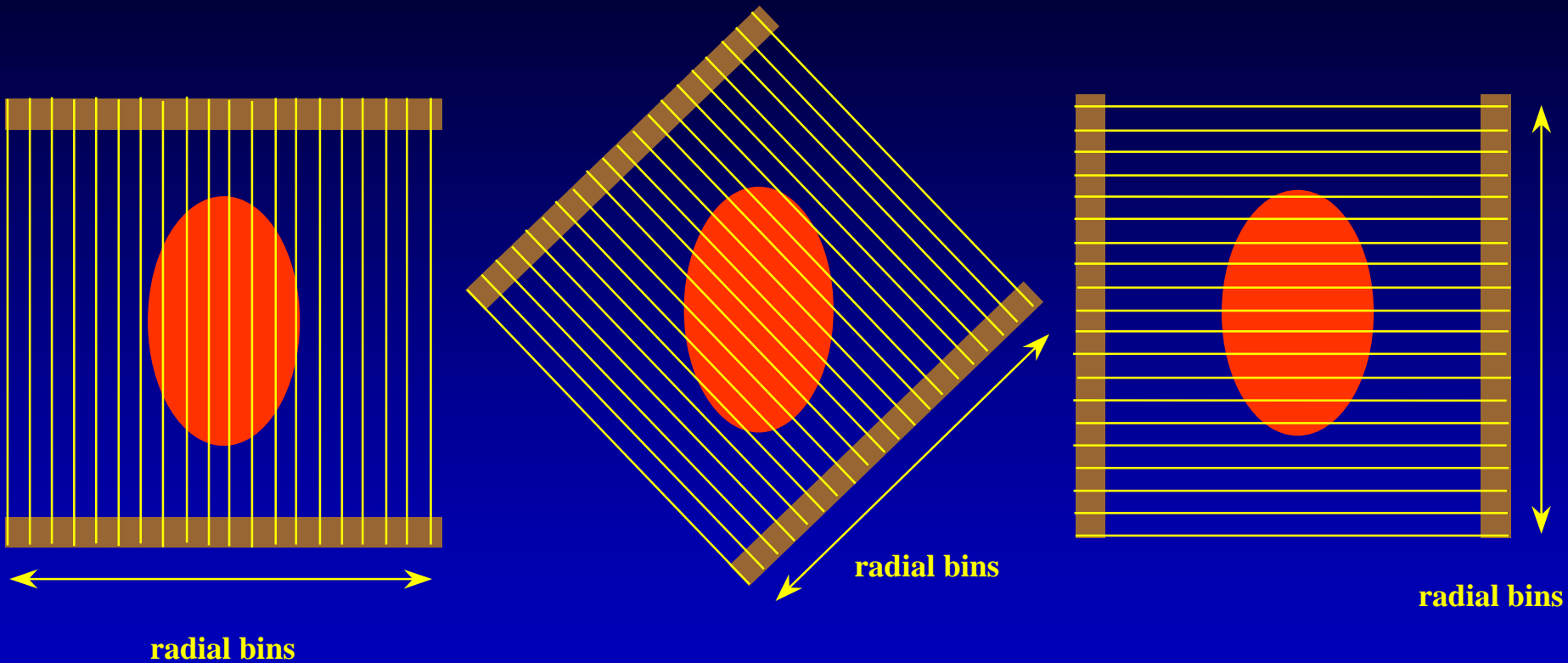measured toward the center of the object.

gamma-ray
scattered

unscattered
(true) events

scattered
events

number of events

radial bin
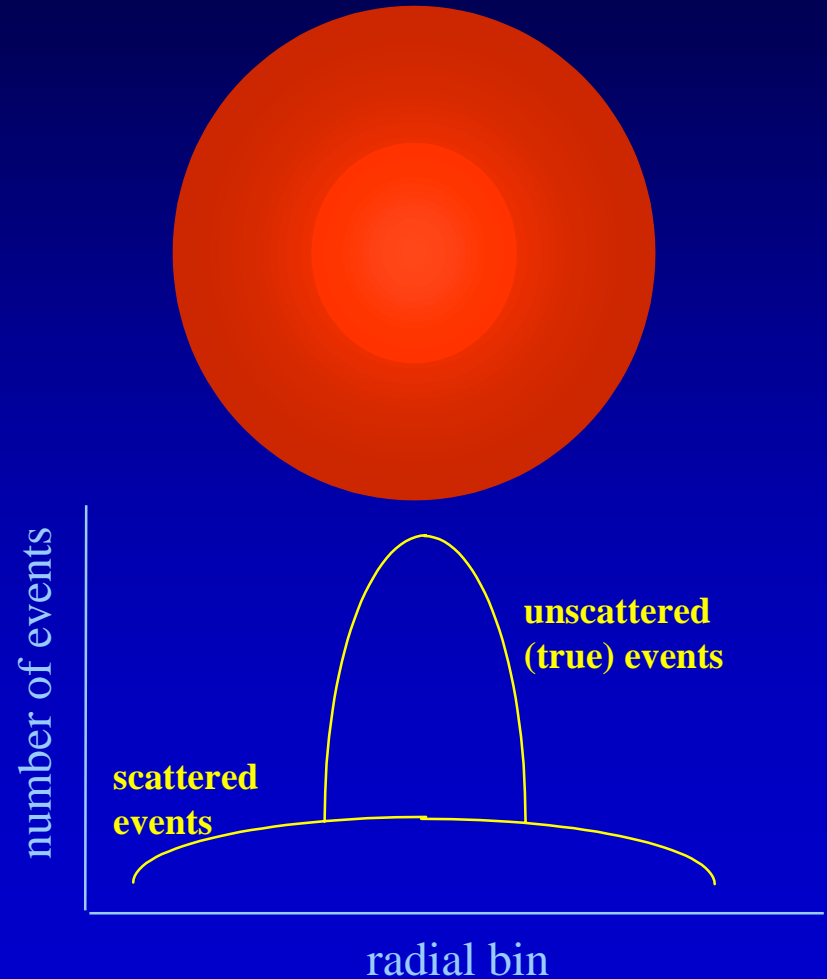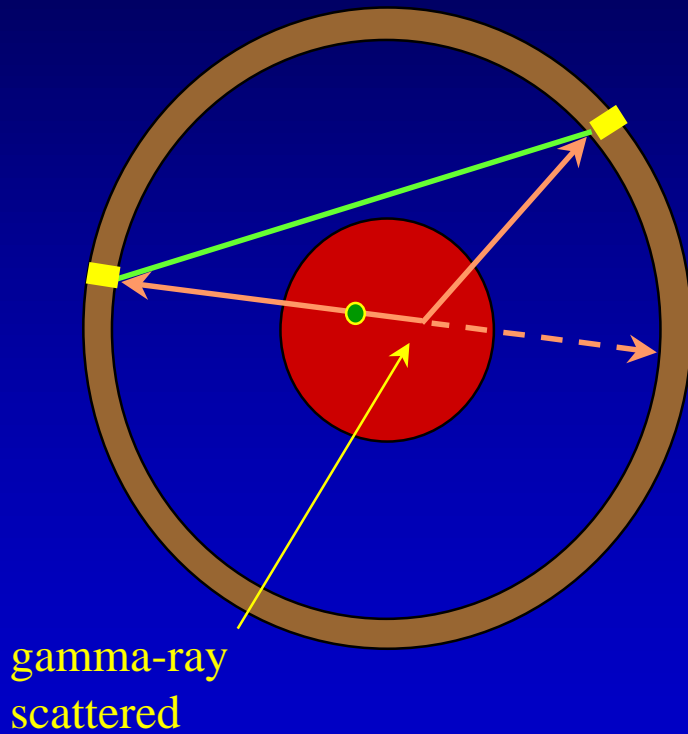
PET Data Acquistion

Radioactive source
in PET scanner

raw sinogram

P.E.T. data are acquired as discrete Lines of Response (LORs)
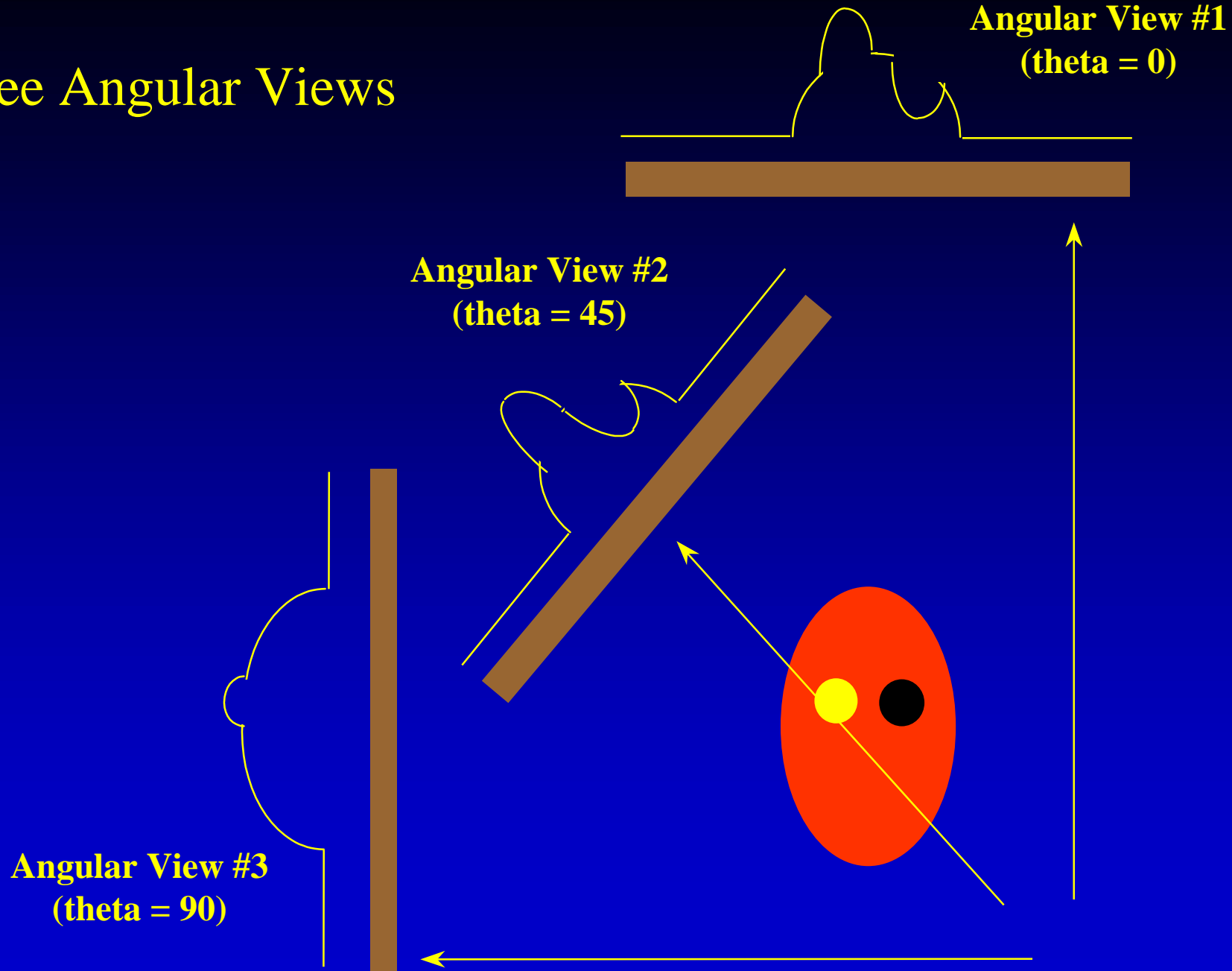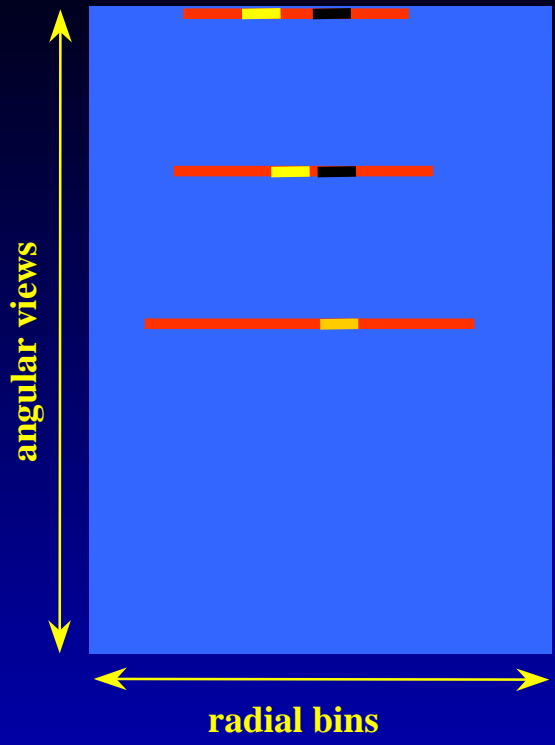

radial bins

radial bins

radial bins
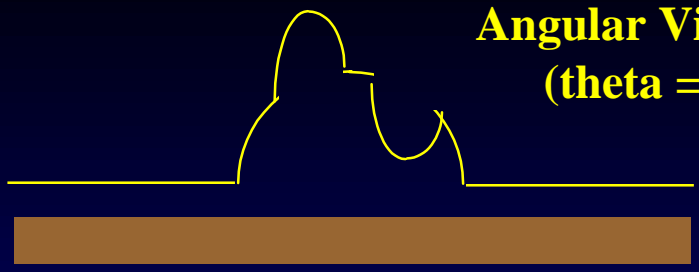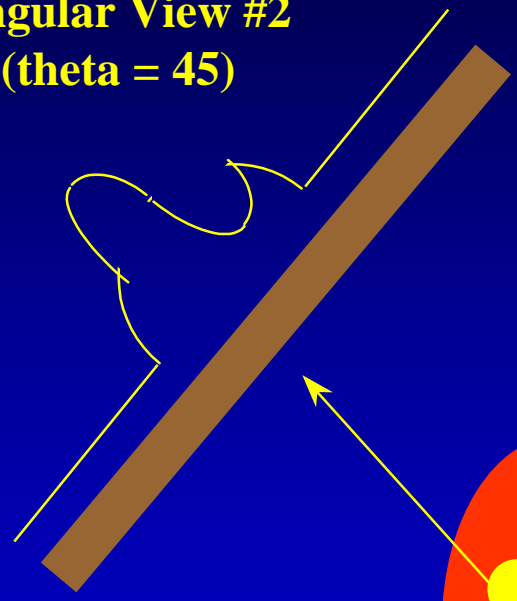
Angular View #1
(theta = 0)

Angular View #2
(theta = 45)

Angular View #3
(theta = 90)

Three Angular Views

Angular View #2
(theta = 45)

Angular View #3
(theta = 90)

Sinogram

#1

#2

#3

angular views

radial bins

Angular View #1
(theta = 0)

Angular View #2
(theta = 45)
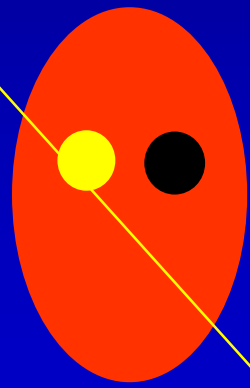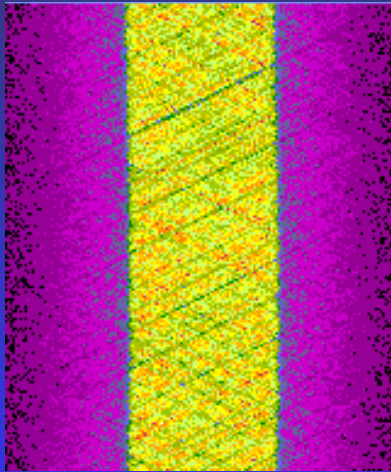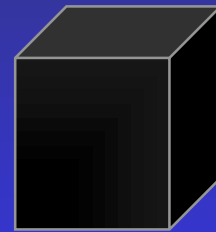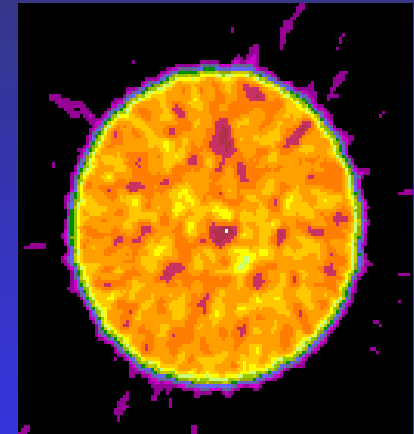
Angular View #3
(theta = 90)

Image Reconstruction

raw sinogram

it's magic!

Reconstructed Image