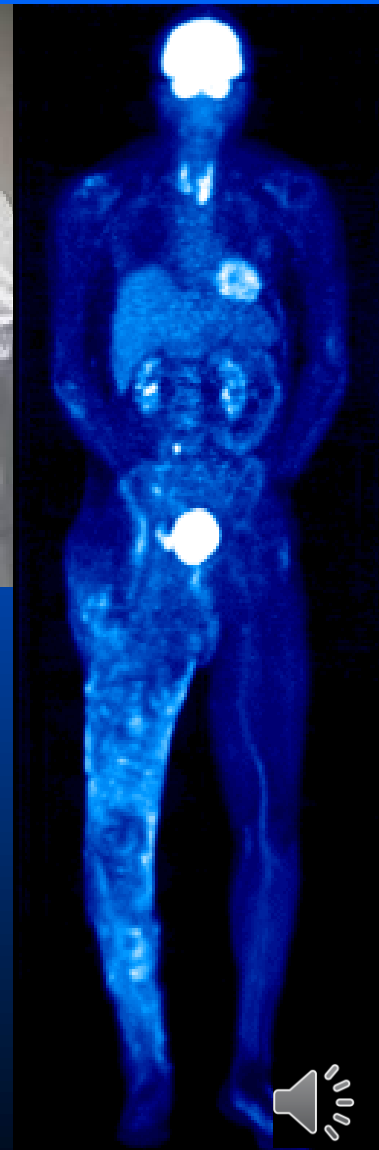
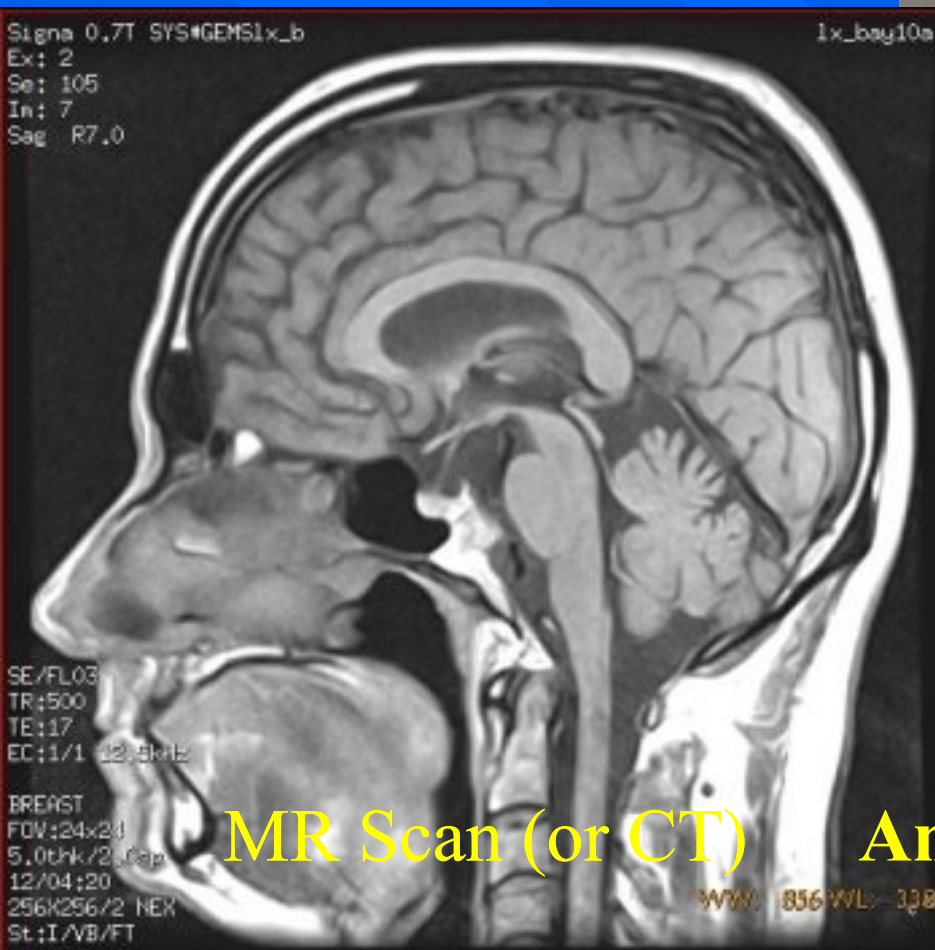
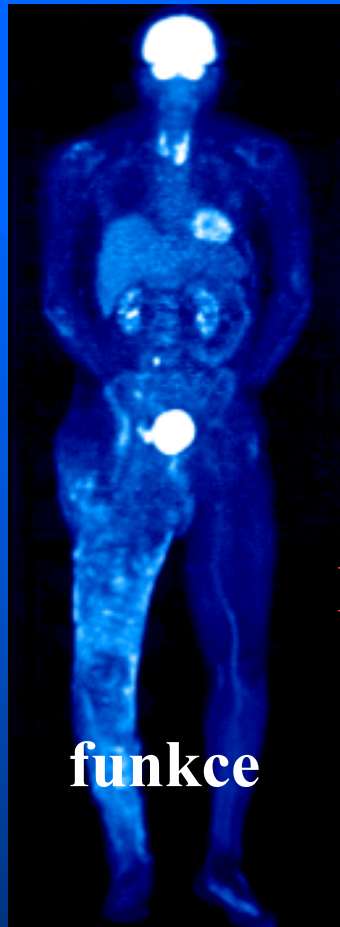


# Positron Emission Tomography

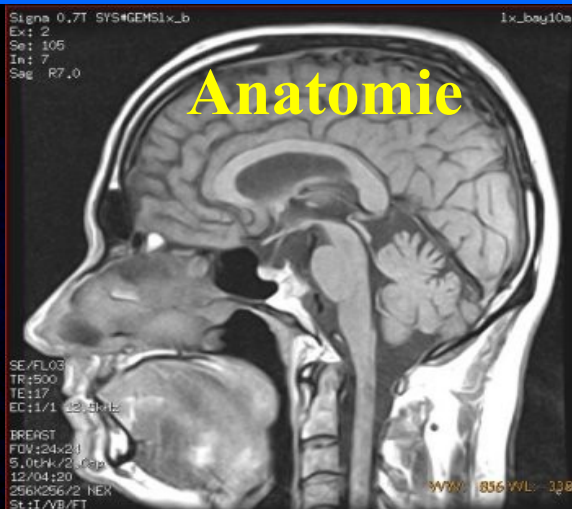


**Anatomický obraz**



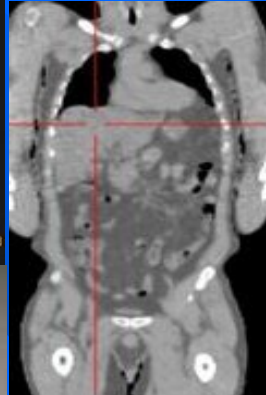
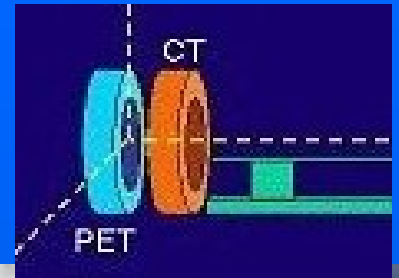


funkce



MR, CT

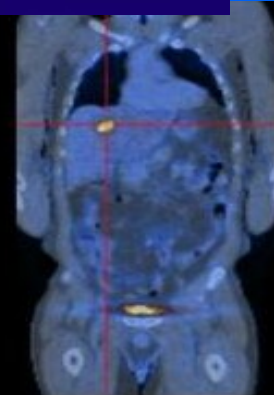
# PET/CT



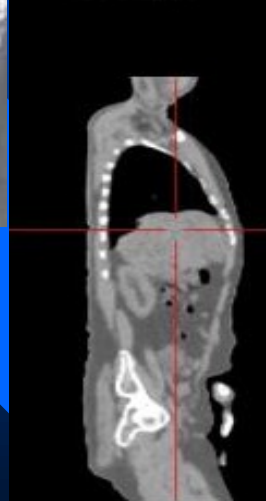
CT Coronal



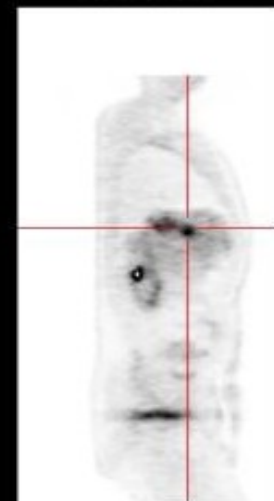
Pet Coronal



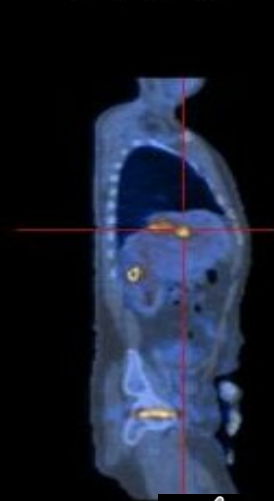
Fused Coronal



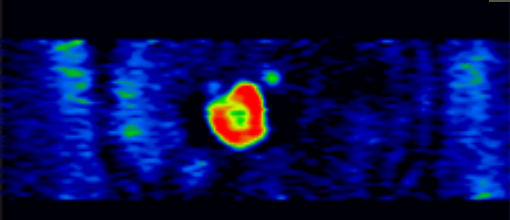
CT Sagittal



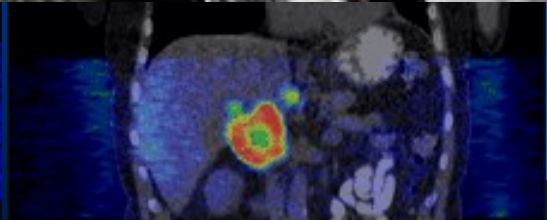
Pet Sagittal



Fused Sagittal



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# Funkční obrazy

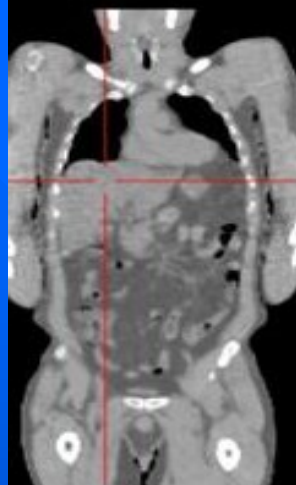
Glucose + Isotope (e<sup>+</sup>)



Injection (~2-5mCi)

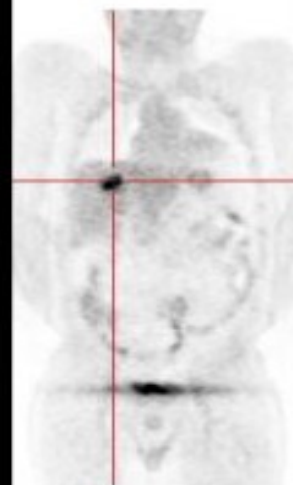


Scan (15-30 minutes)



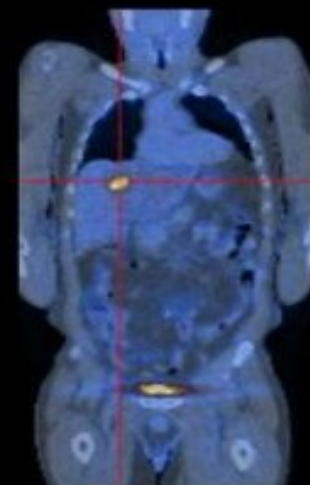
90

CT Coronal



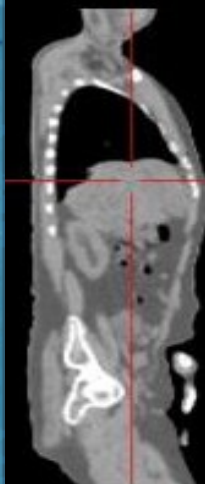
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Pet Coronal



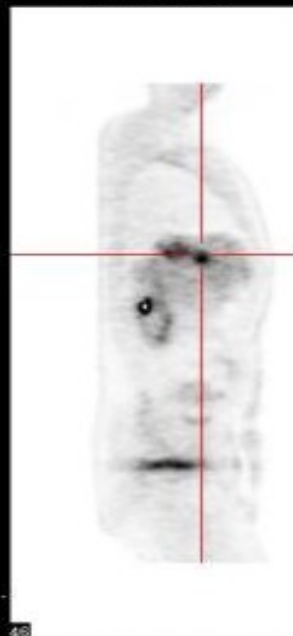
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Fused Coronal



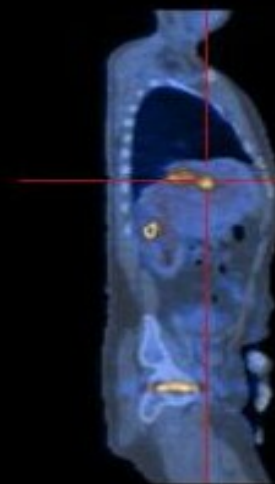
48

CT Sagittal



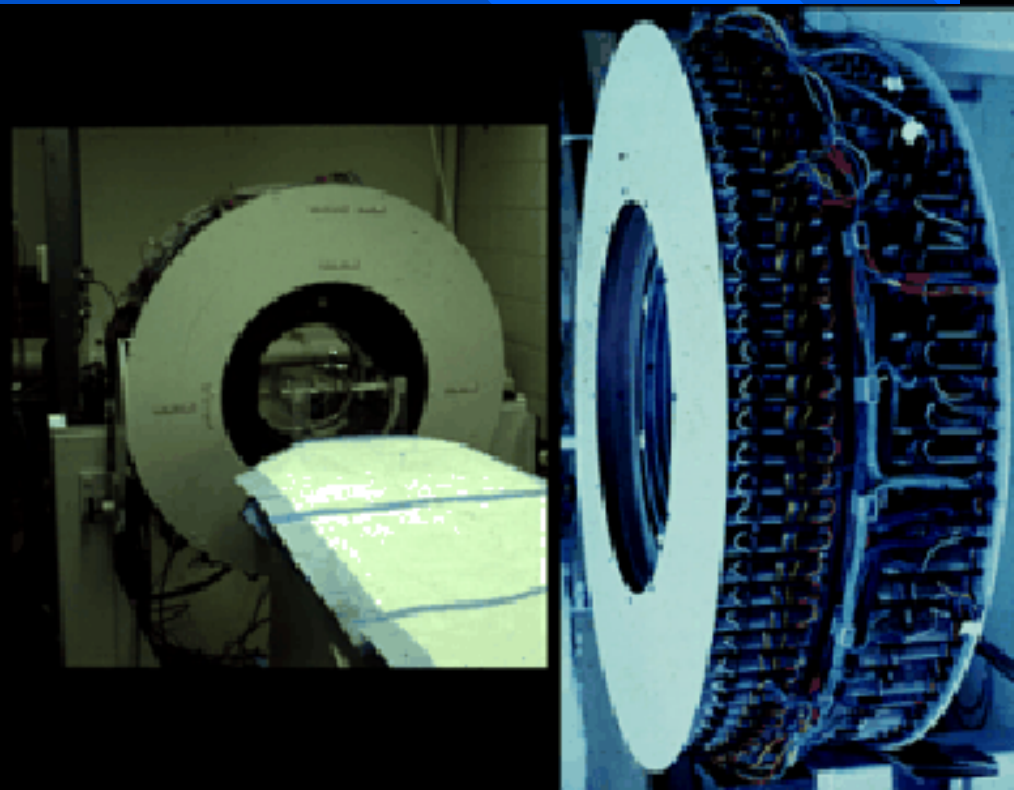
48

Pet Sagittal



48

Fused Sagittal



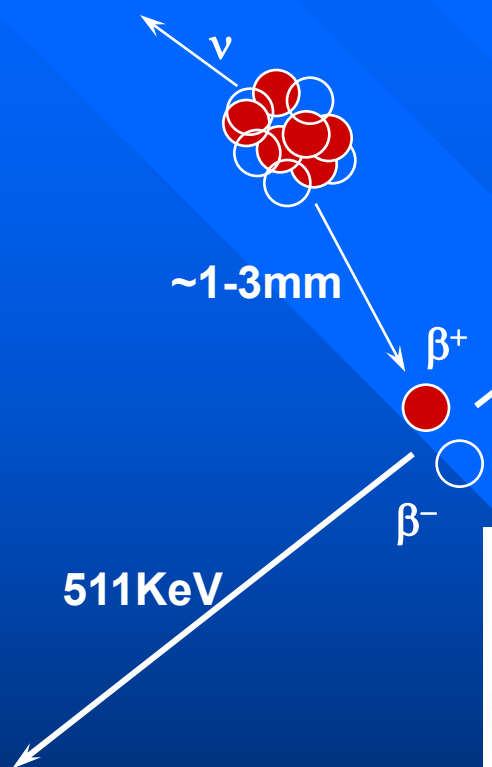
# Co je PET?

- Isotope production → **CYCLOTRONS**
- Tracer production → **CHEMISTRY SYSTEMS**
- Imaging → **SCANNER**



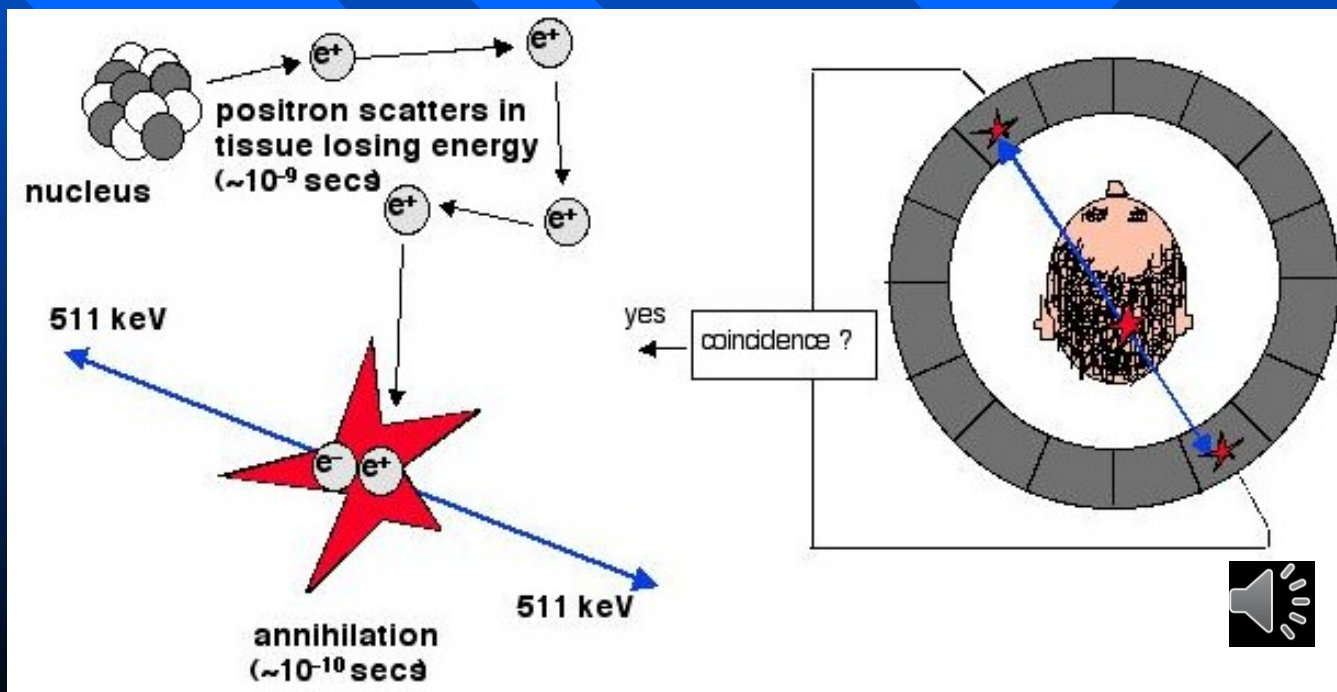
# Fyzikální princip

- Pozitronová dráha 1-3 mm před annihilací (závisí na energii)

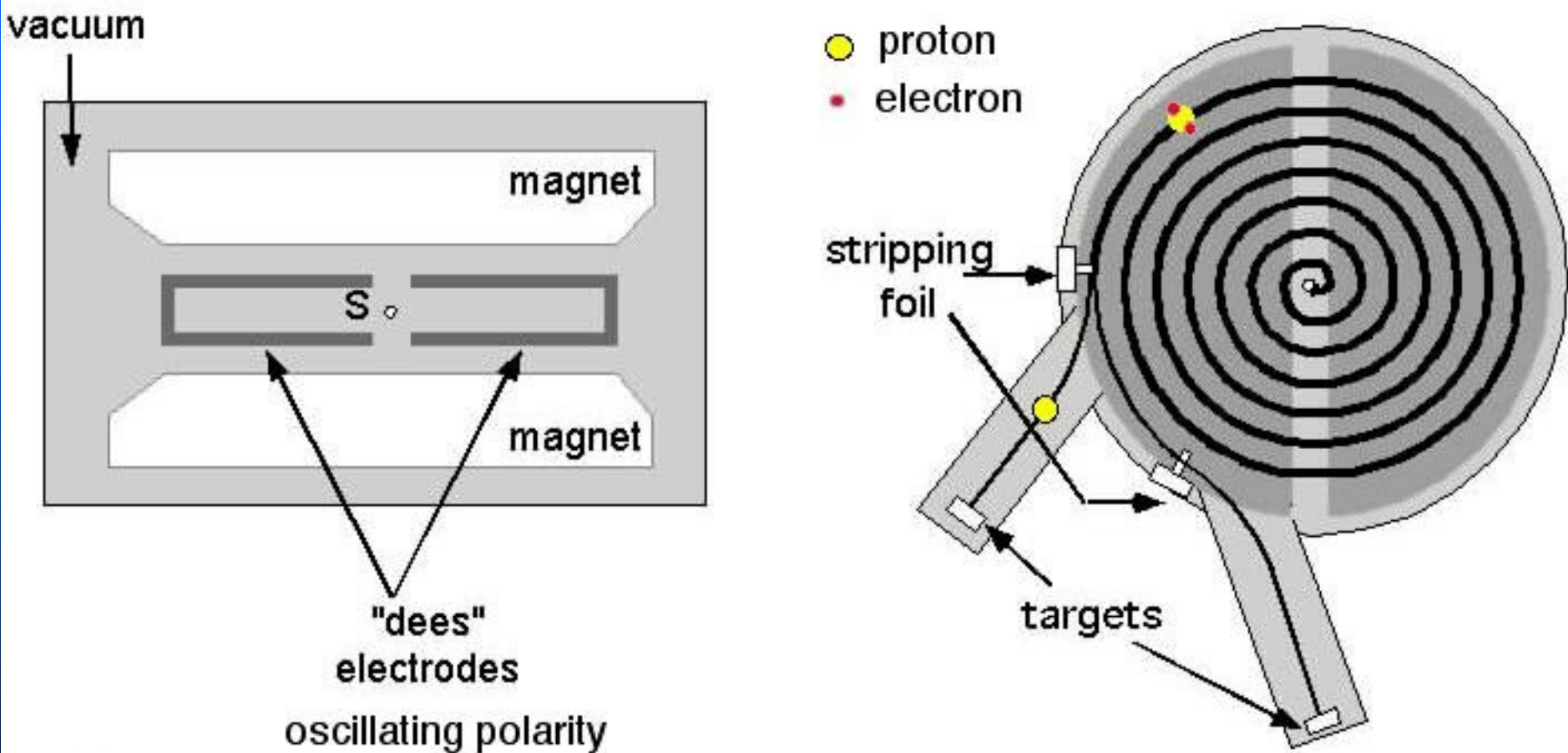


- Zachování energie a momentu - 511 keV fotony a

- **Simultánní detekce dvou 511KeV fotonů** →  
- výsledek je přímka a současný příchod



# Biomedical Cyclotron Negative Ion



# PET-labeled Probes for Biological Imaging

- hemodynamic parameters ( $H_2^{15}O$ ,  $^{15}O$ -butanol,  $^{11}CO$ ,  $^{13}NH_3$ .....)
- substrate metabolism ( $^{18}F$ -FDG,  $^{15}O_2$ ,  $^{11}C$ -palmitic acid....)
- protein synthesis ( $^{11}C$ -leucine,  $^{11}C$ -methionine,  $^{11}C$ -tyrosine)
- enzyme activity ( $^{11}C$ -deprenyl,  $^{18}F$ -deoxyuracil...)
- drugs ( $^{11}C$ -cocaine,  $^{13}N$ -cisplatin,  $^{18}F$ -fluorouracil...)
- receptor affinity ( $^{11}C$ -raclopride,  $^{11}C$ -carfentanil,  $^{11}C$ -scopolamine)



cyclotron

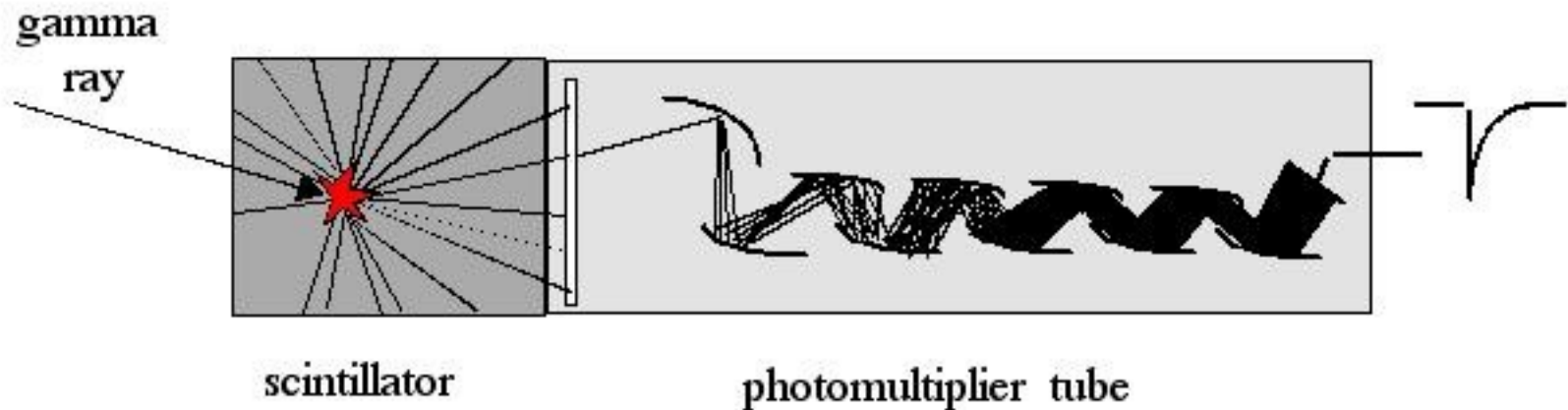
$^{11}C$ ,  $^{13}N$ ,  $^{15}O$ ,  $^{18}F$

## Positron Emitting Radionuclides

Isotope	Halflife	$\beta^+$ fraction	Max. Energy	range(mm)
<b>C-11</b>	<b>20.4 mins</b>	<b>0.99</b>	<b>0.96 MeV</b>	<b>0.4 mm</b>
<b>N-13</b>	<b>9.96 mins</b>	<b>1.00</b>	<b>1.20 MeV</b>	<b>0.7 mm</b>
<b>O-15</b>	<b>123 secs</b>	<b>1.00</b>	<b>1.74 MeV</b>	<b>1.1 mm</b>
<b>F-18</b>	<b>110 mins</b>	<b>0.97</b>	<b>0.63 MeV</b>	<b>0.3 mm</b>
Na-22	2.6 years	0.90	0.55 MeV	0.3 mm
Cu-62	9.74 mins	0.98	2.93 MeV	2.7 mm
Ga-68	68.3 mins	0.88	1.90 MeV	1.2 mm



# The Scintillation Detector



When a gamma ray interacts in a **scintillator**, it produces a flash of visible light. The scintillator thus acts as a converter from high energy to low energy radiation. The **photodetector** converts the visible light into an electrical signal. A photomultiplier tube (PMT) is commonly used as the photodetector. The scintillation detector converts high energy gamma rays into an electrical signal which can be fed into electronics for further processing.



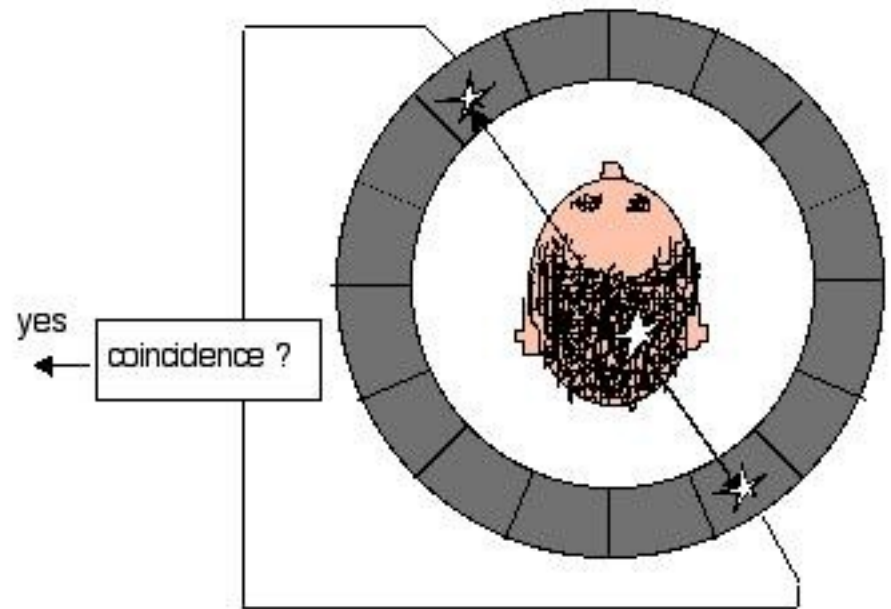


# The PET Scanner

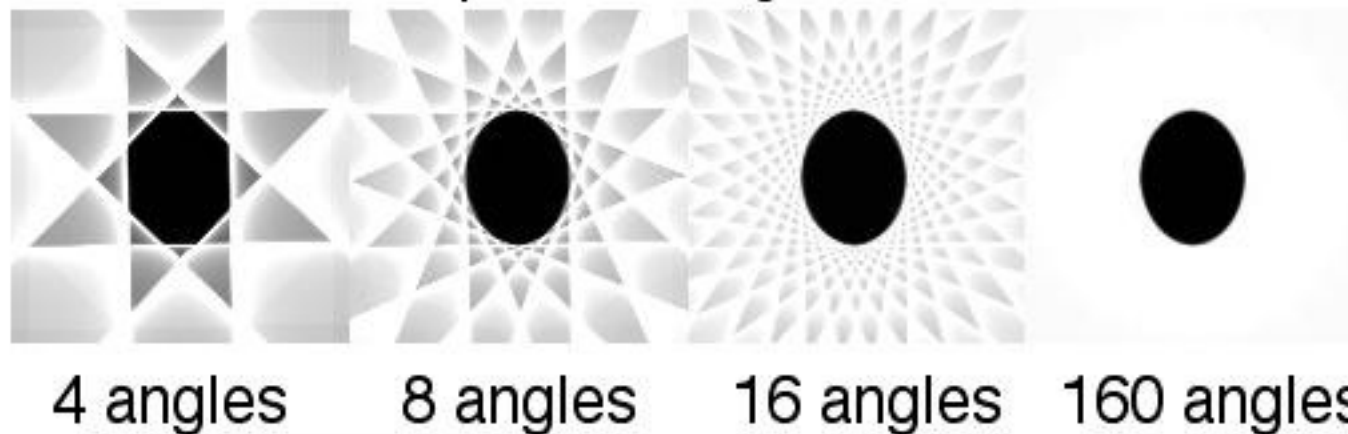
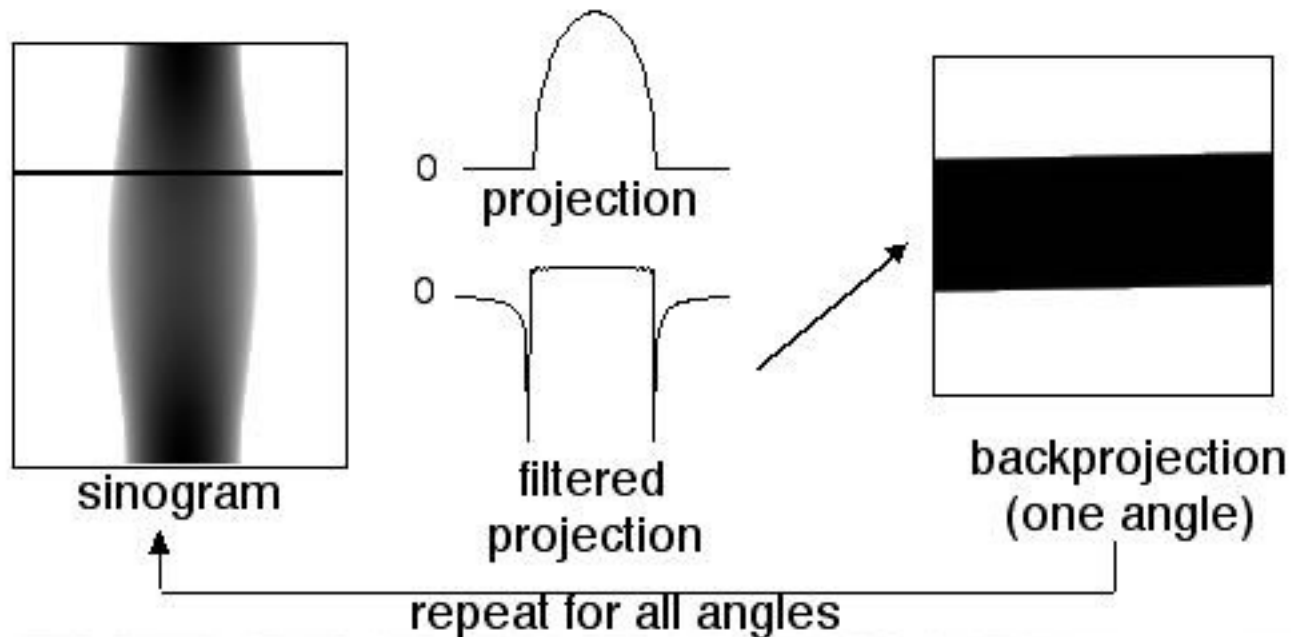
Consists of one or more rings of scintillation detectors.

A valid event occurs when a pair of detectors register an event simultaneously

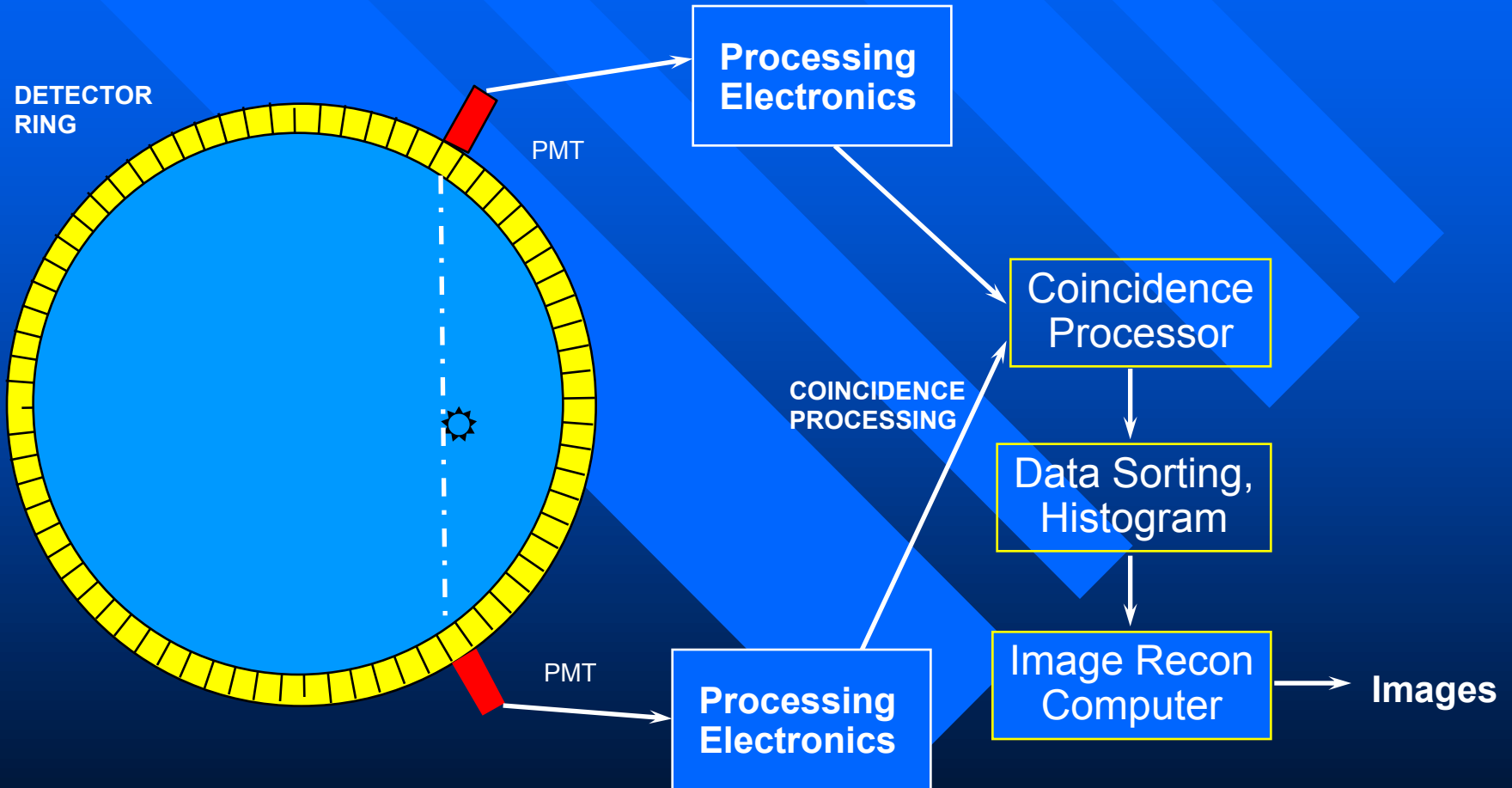
The raw data for a single ring is stored in a 2-D matrix called a sinogram

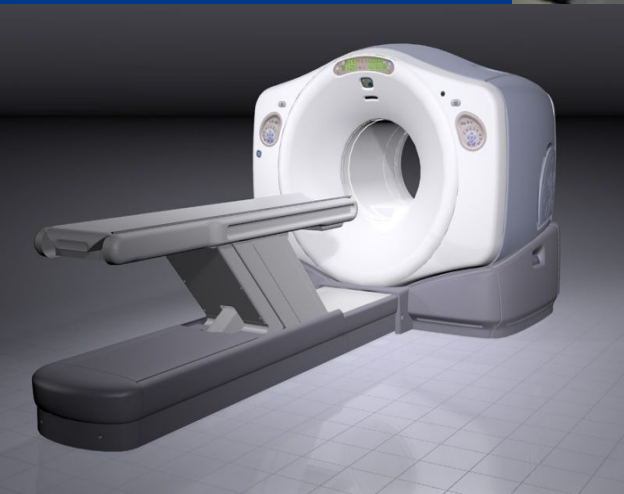
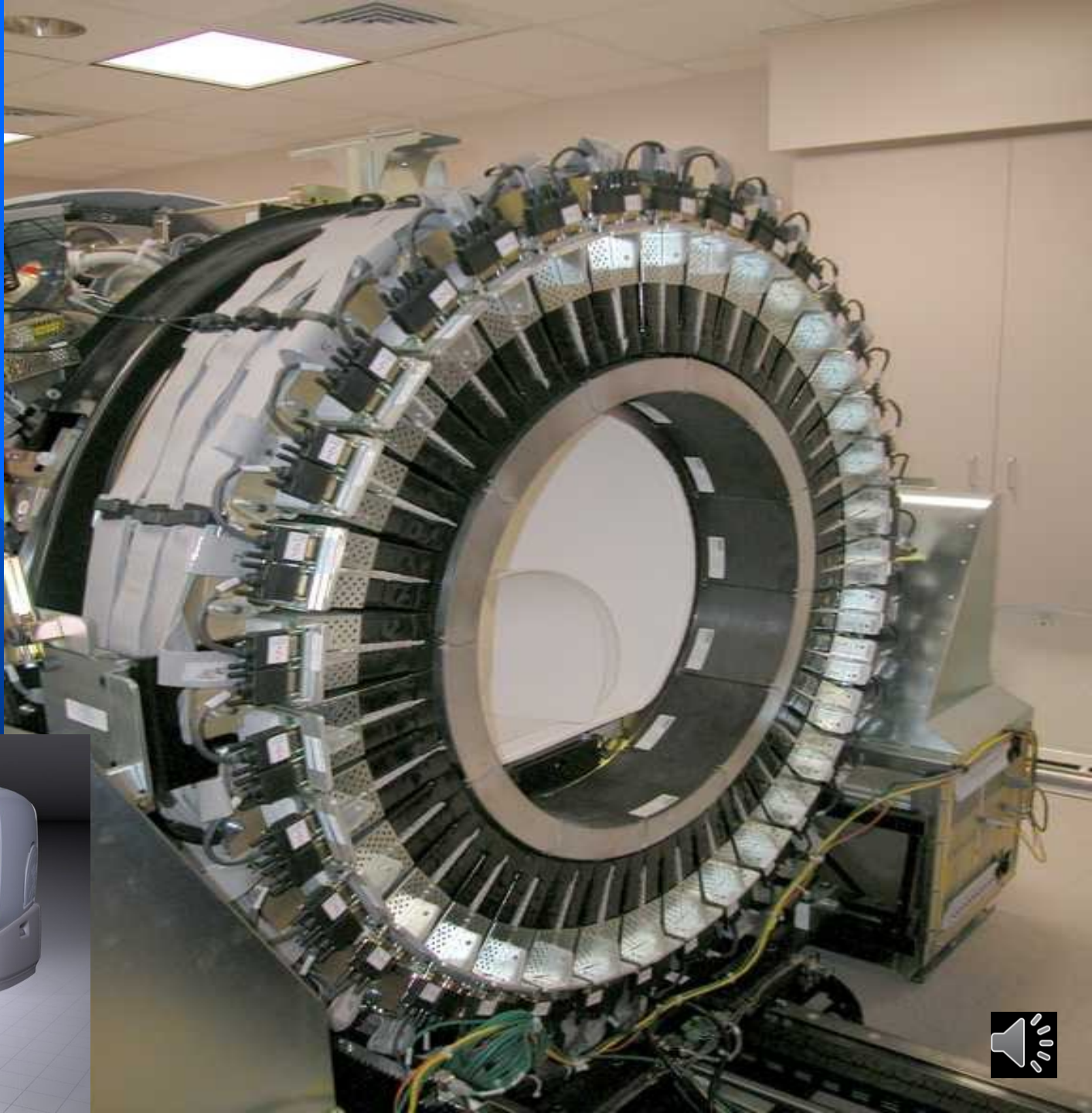


# Filtered Backprojection

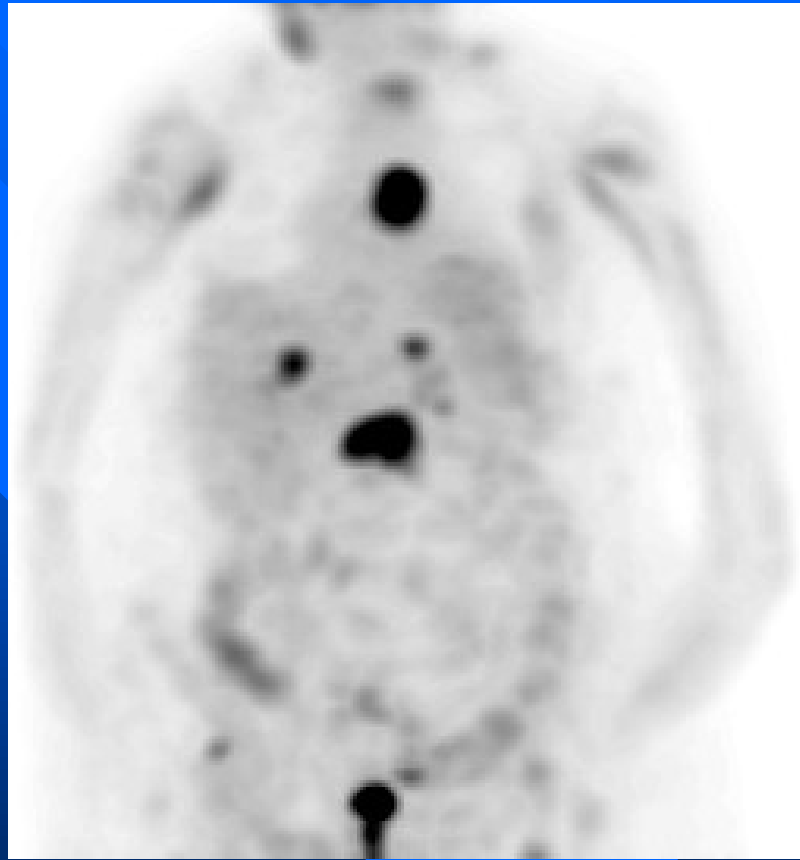


# Projection Data Collection





# PET Image

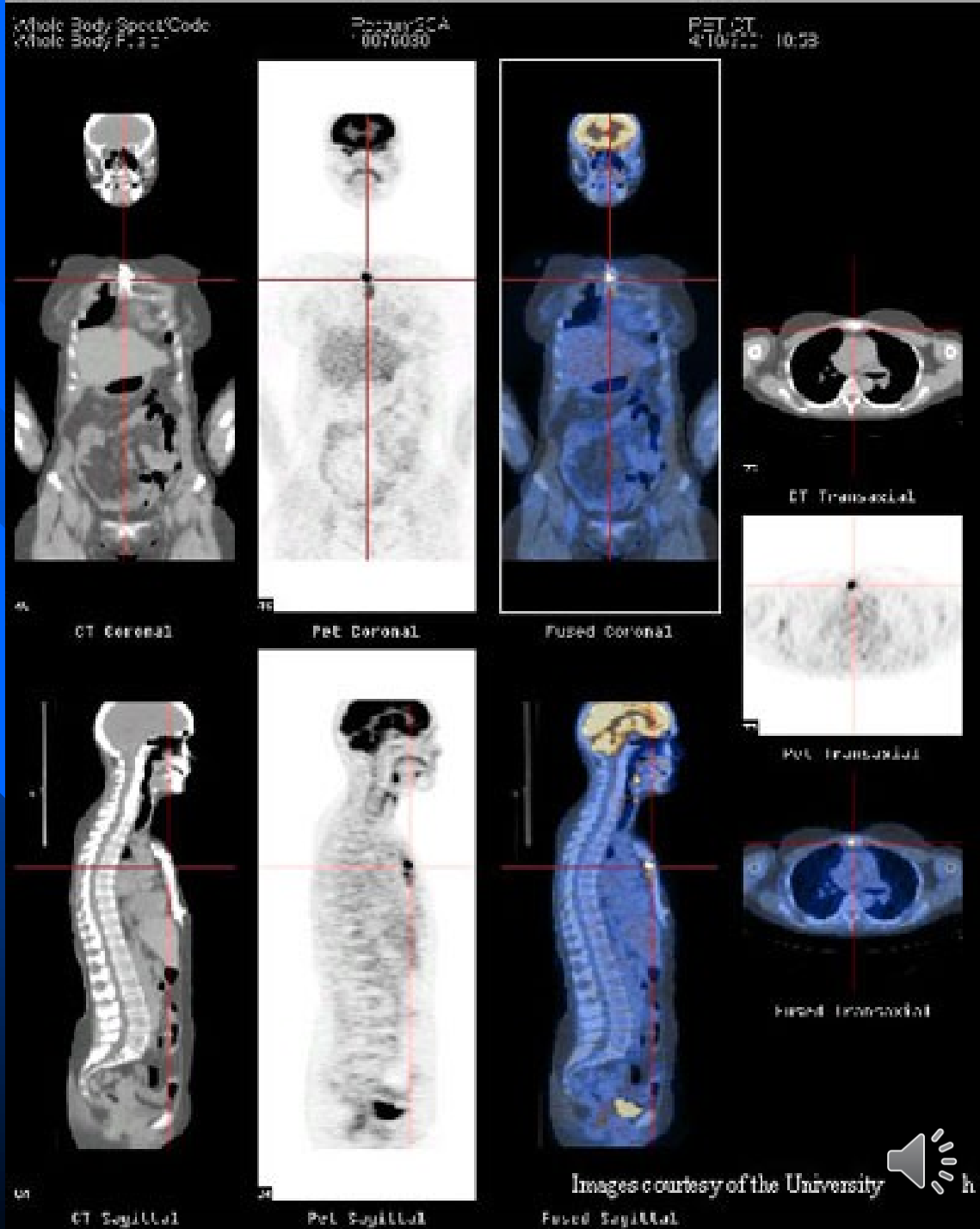
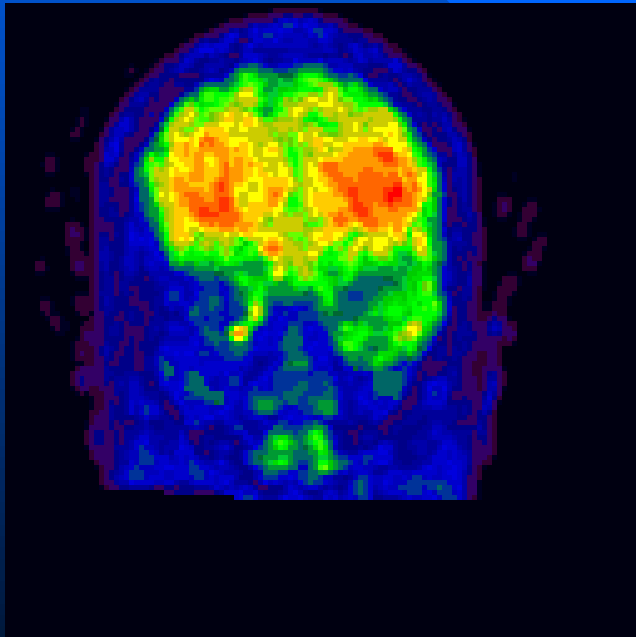


- My Objective → New and better detector design using GEANT4
- Better information to Physicians
  - Better patient care and treatment

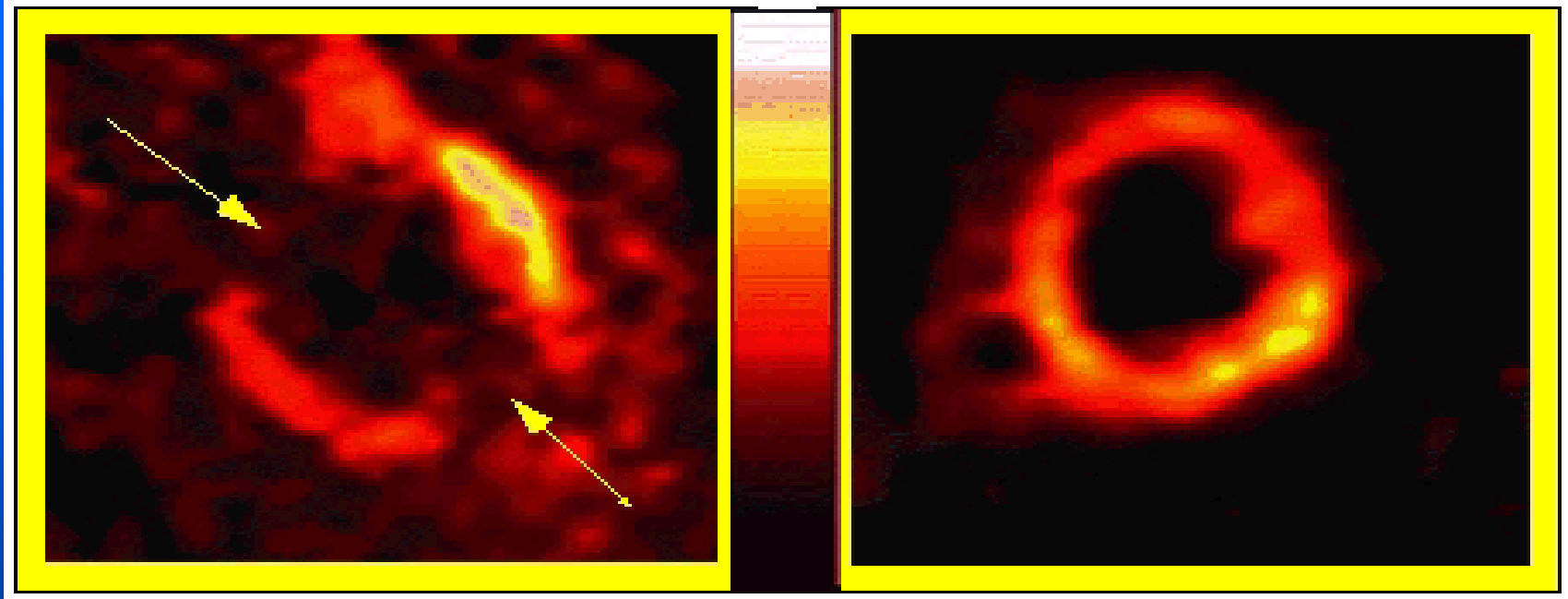


# PET-CT

PET-CT fusion localizes  
Intra-pulmonary lesion



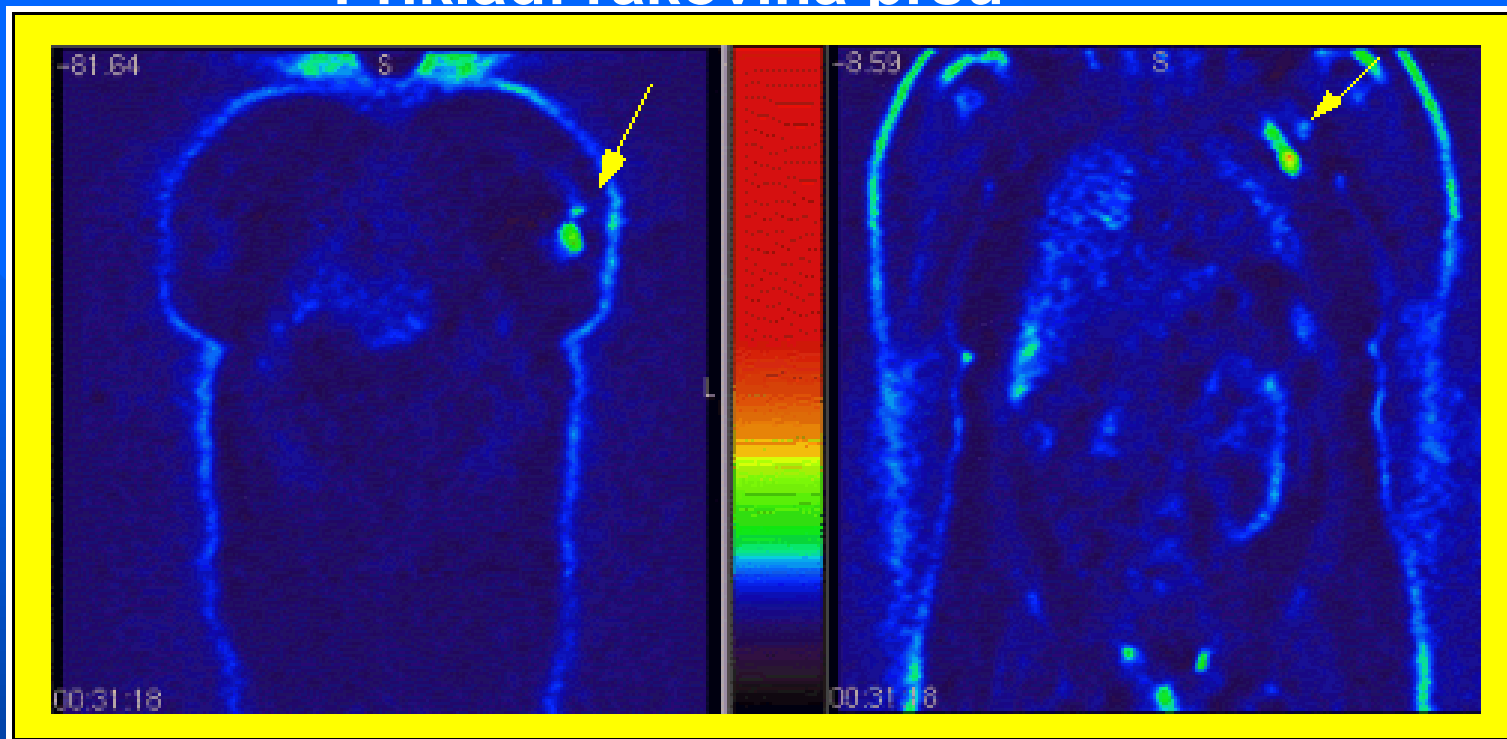
## Příklad : Myokardiální nekrózy



- První srdce má mykardální infarkt. Šipky ukazují poškozené oblasti (‘smrt tkáně’).
- Druhé srdce je normální



## Příklad: rakovina prsu



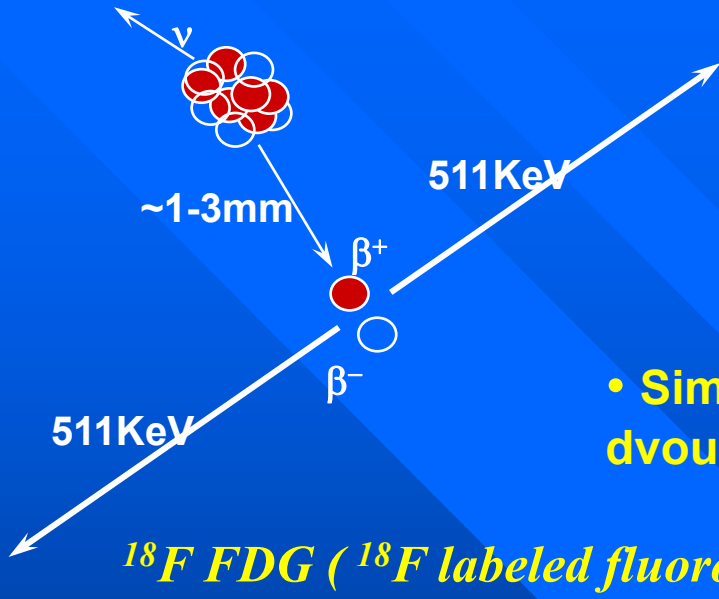
- První obraz ukazuje maligní nádor, který nebyl diagnostikován běžnými zobrazovacími technikami. (CT, MRI, mammogram)
- Druhý obraz již bohužel meta postižení.





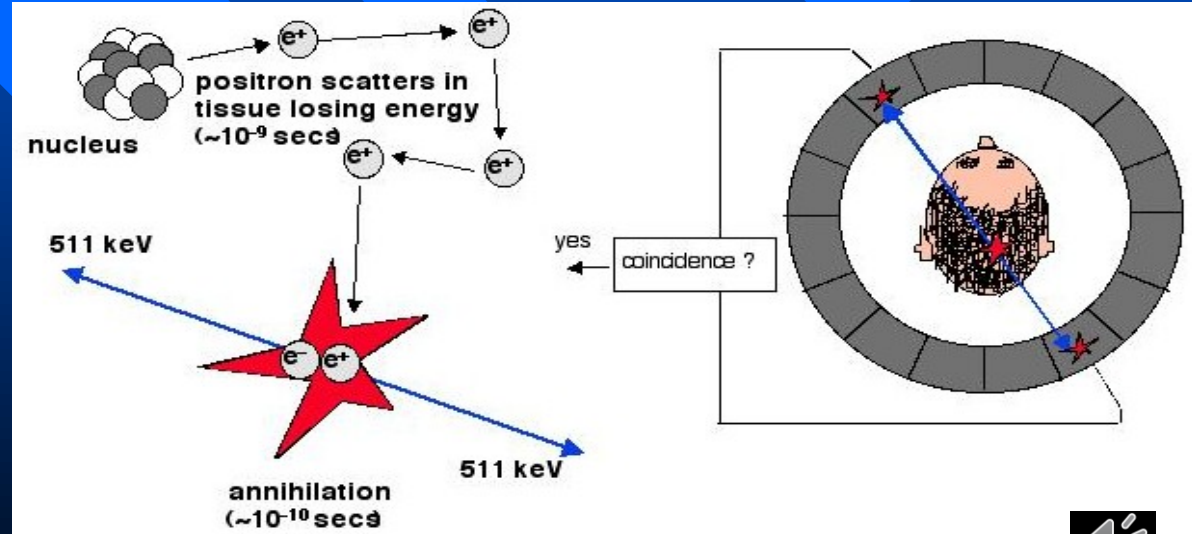
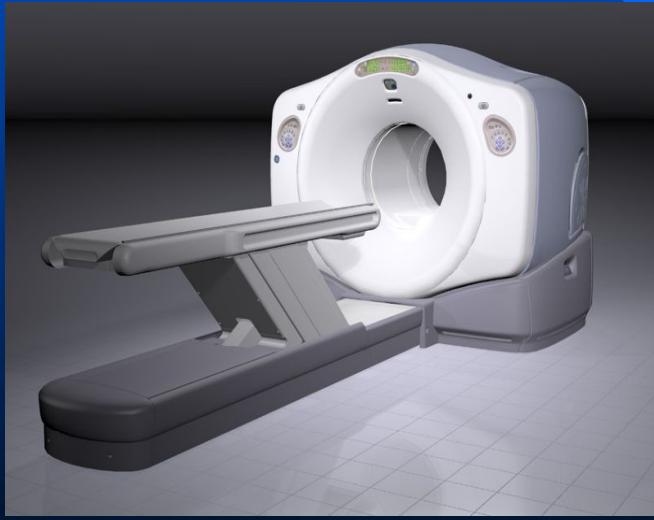
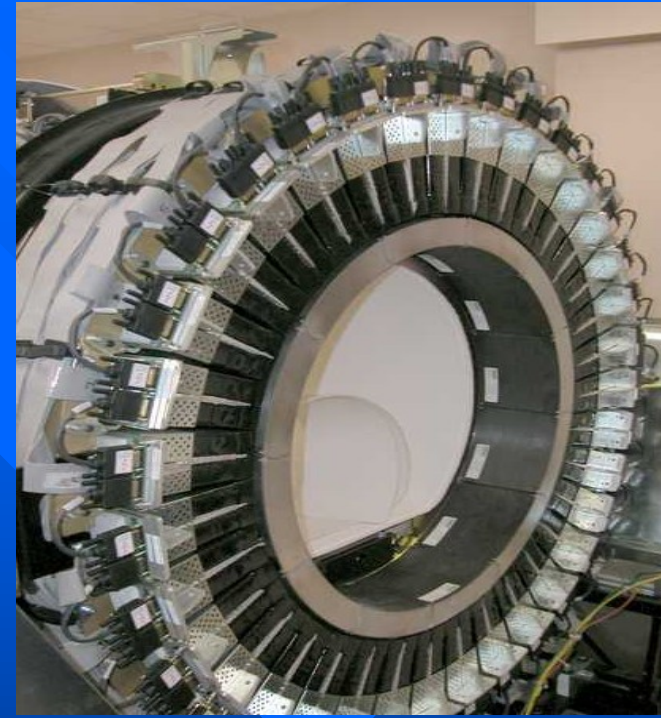
# Fyzikální princip

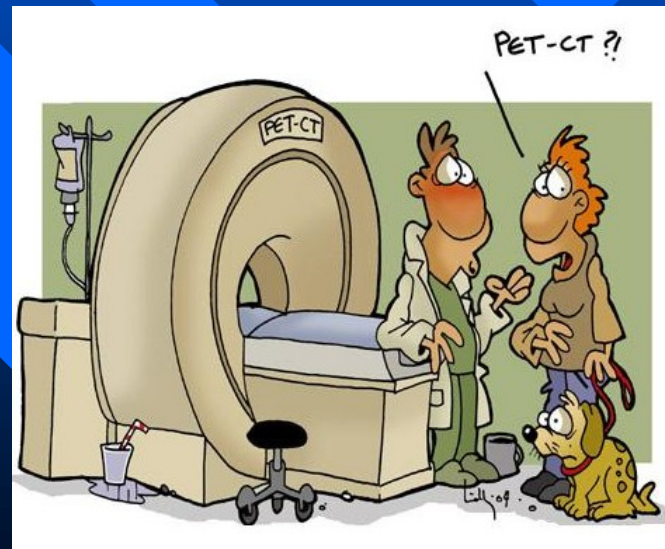
# PET/CT



- Simultánní detekce dvou 511KeV fotonů →

*$^{18}\text{F}$  FDG ( $^{18}\text{F}$  labeled fluorodeoxyglukoza)*



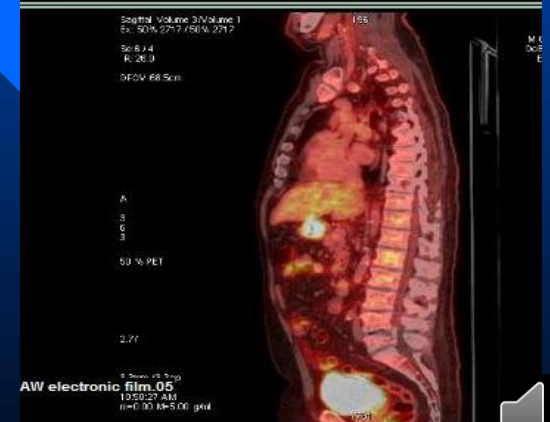
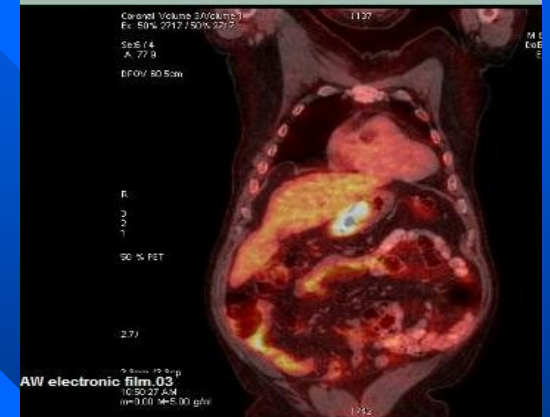
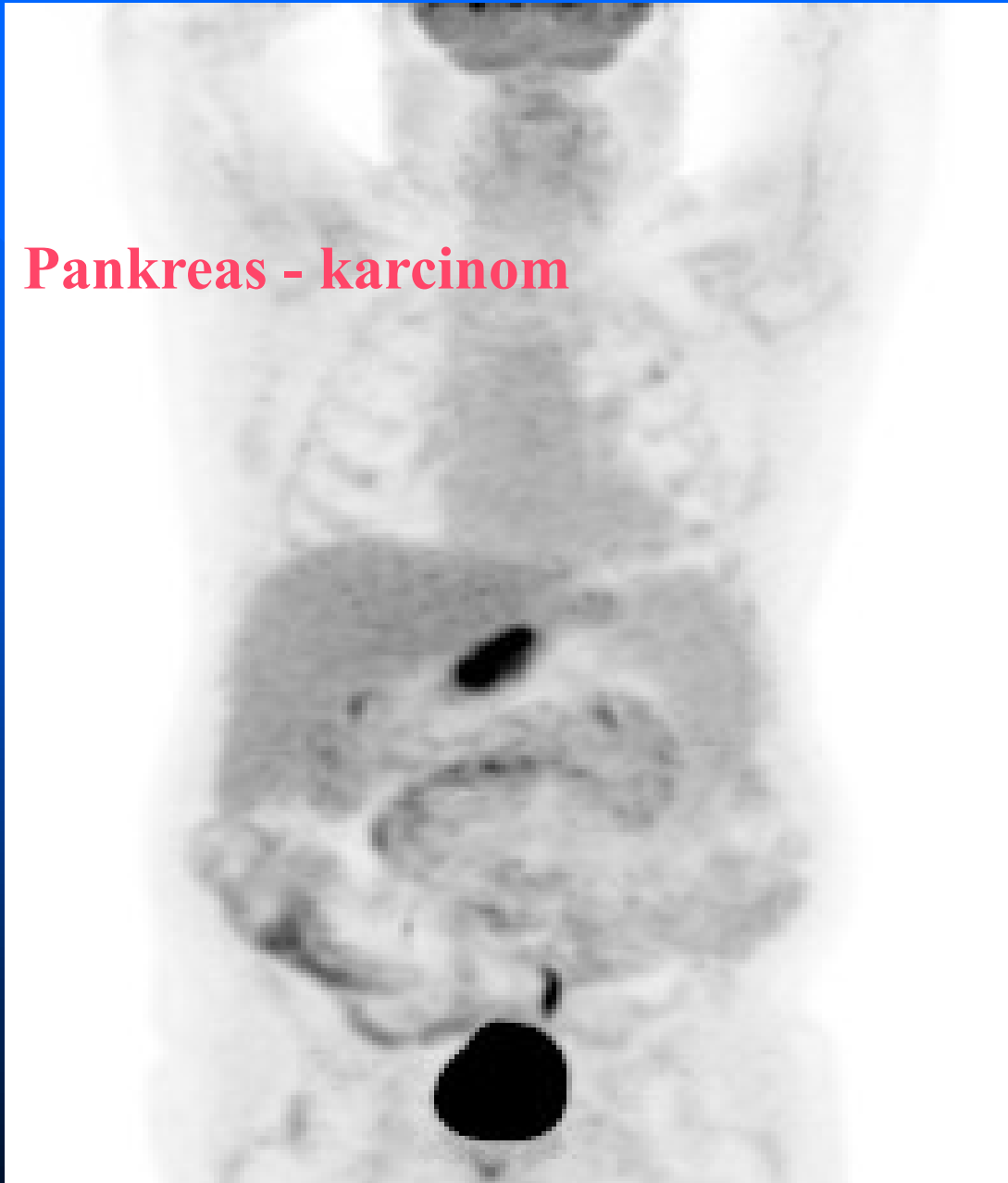




**Žaludek karcinom**



# Pankreas - karcinom



## Activity

$$A = \Delta N / \Delta t \text{ [s}^{-1}\text{]}$$

**A** - activity

**$\Delta N$**  - mean number of radioactive decays

**$\Delta t$**  - time interval

**$1 \text{ s}^{-1} = 1 \text{ Bq (Becquerel)}$**

**$1 \text{ Ci (Curie)} = 3.7 \times 10^{10} \text{ Bq}$**



## Dose

$$D = \Delta\varepsilon / \Delta m \text{ [J.kg}^{-1}\text{]}$$

**D** - dose

**$\Delta\varepsilon$**  - mean energy deposited by ionizing radiation to given material

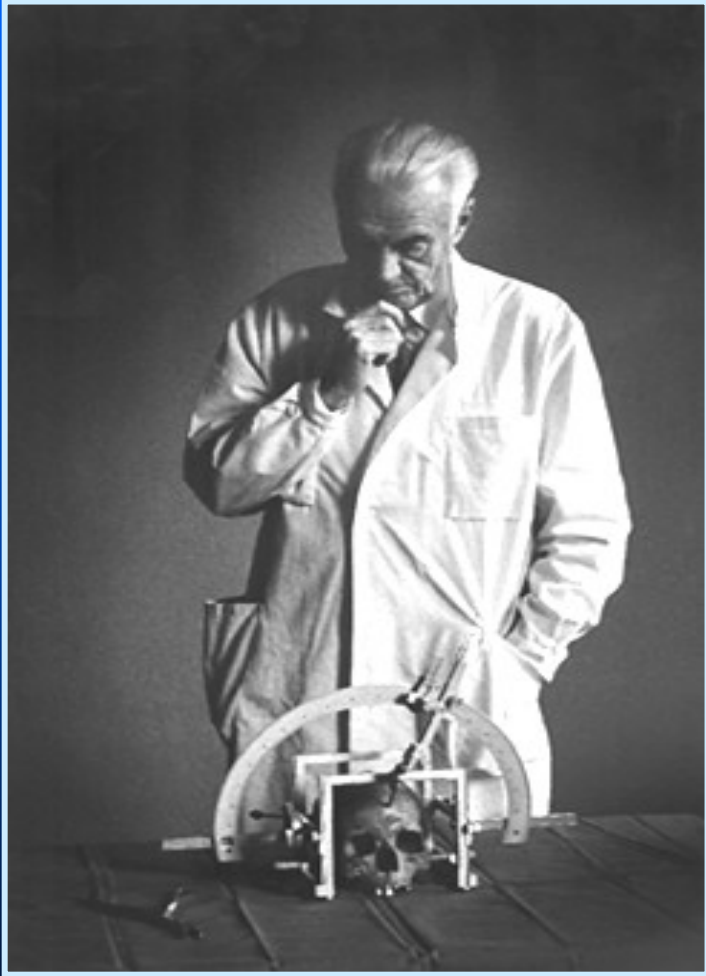
**$\Delta m$**  - mass of material

**1 J.kg<sup>-1</sup> = 1 Gy (Gray)**

**1 rad = 0.01 Gy**



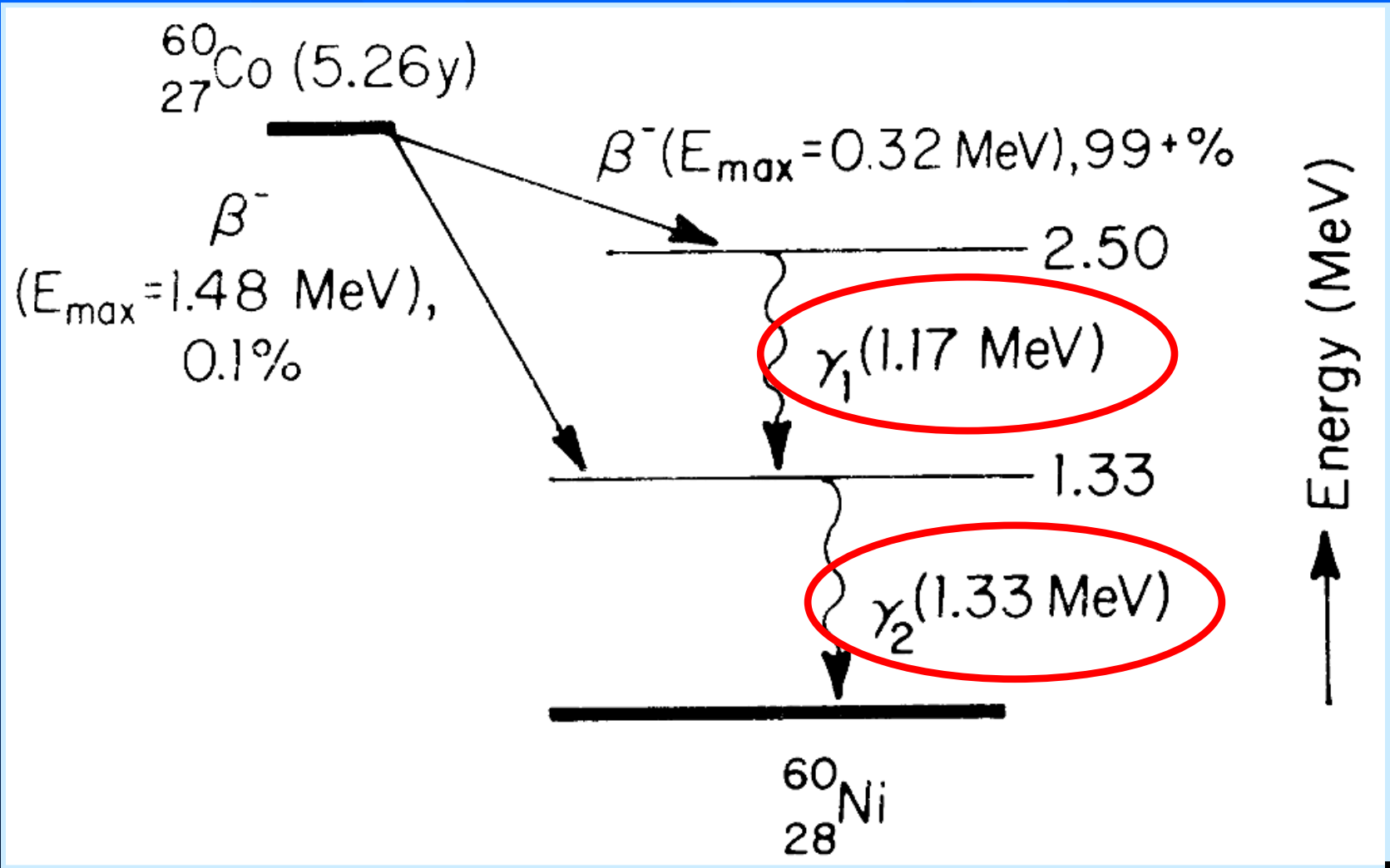
# Basic principles of radiosurgery



The first prototype of the Leksell Gamma Knife was installed in 1968 at Sophiahemmet in Stockholm, Sweden.

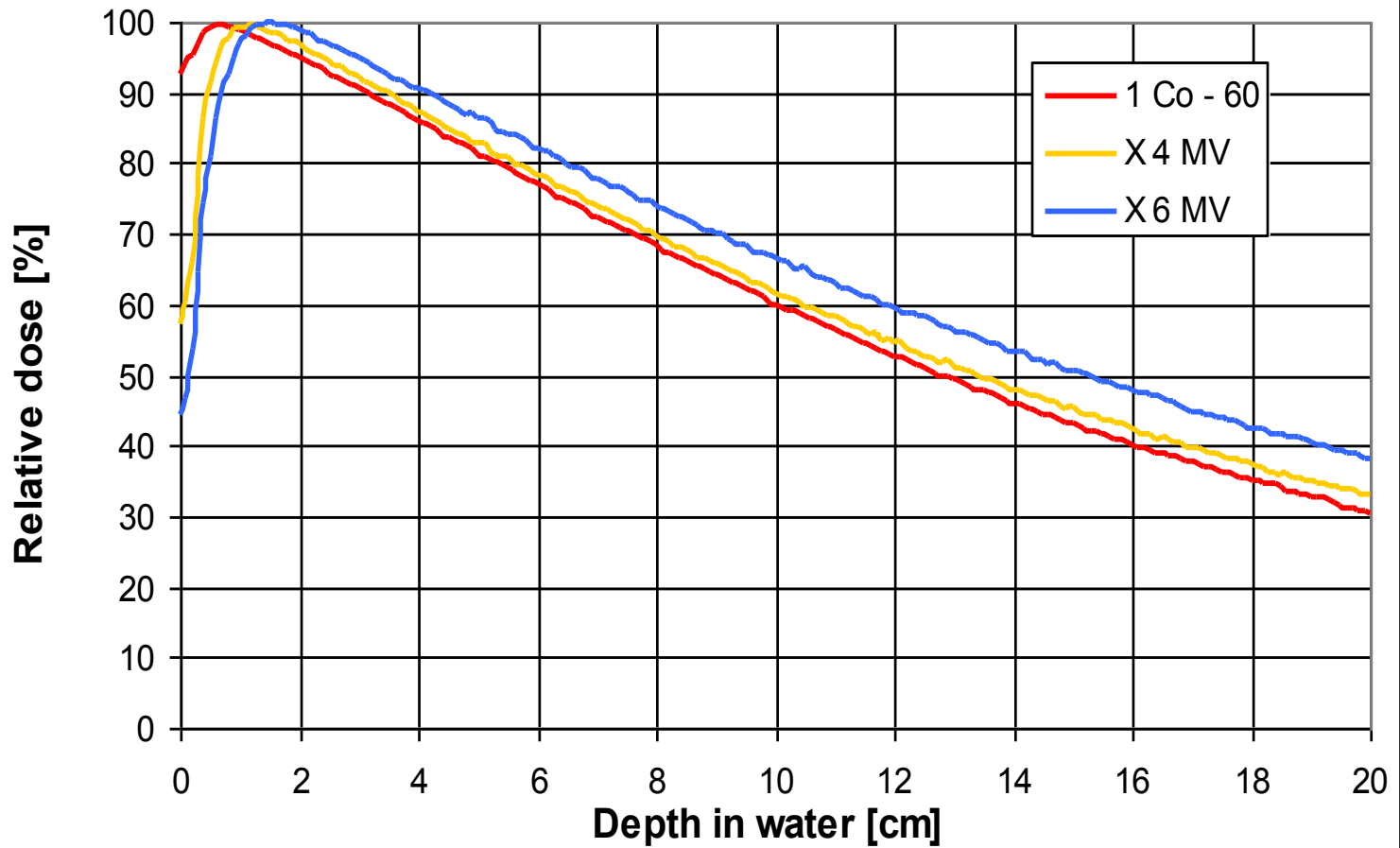


# Diagram for the decay of $^{60}\text{Co}$ nucleus

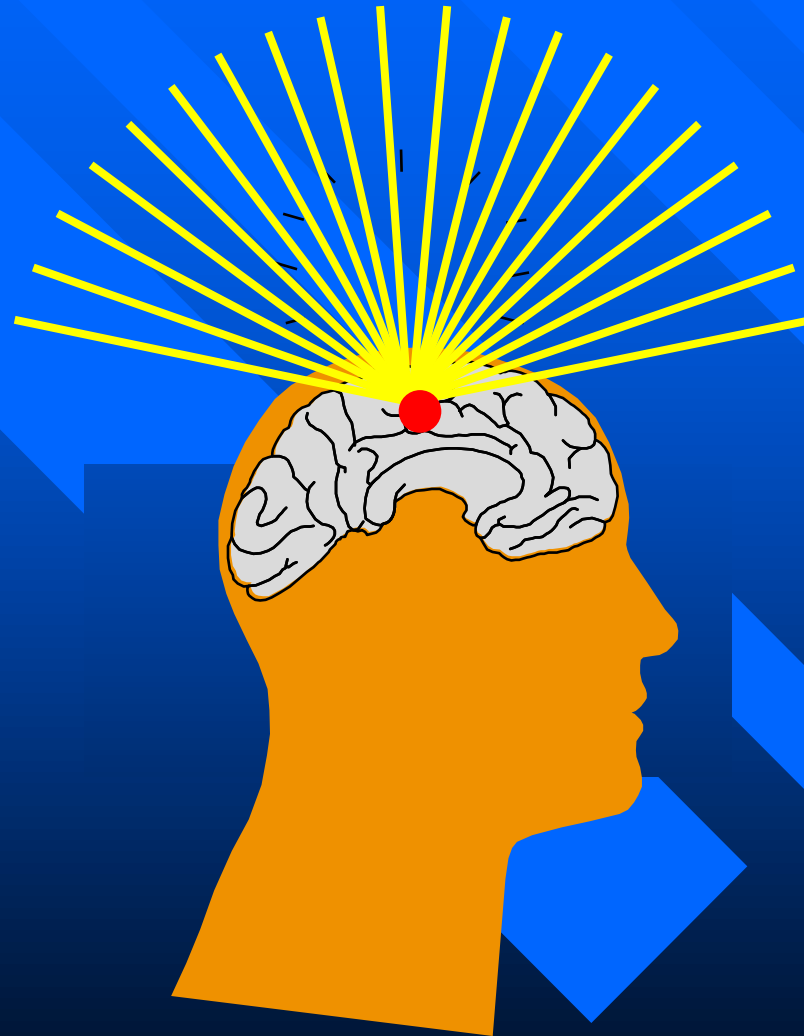




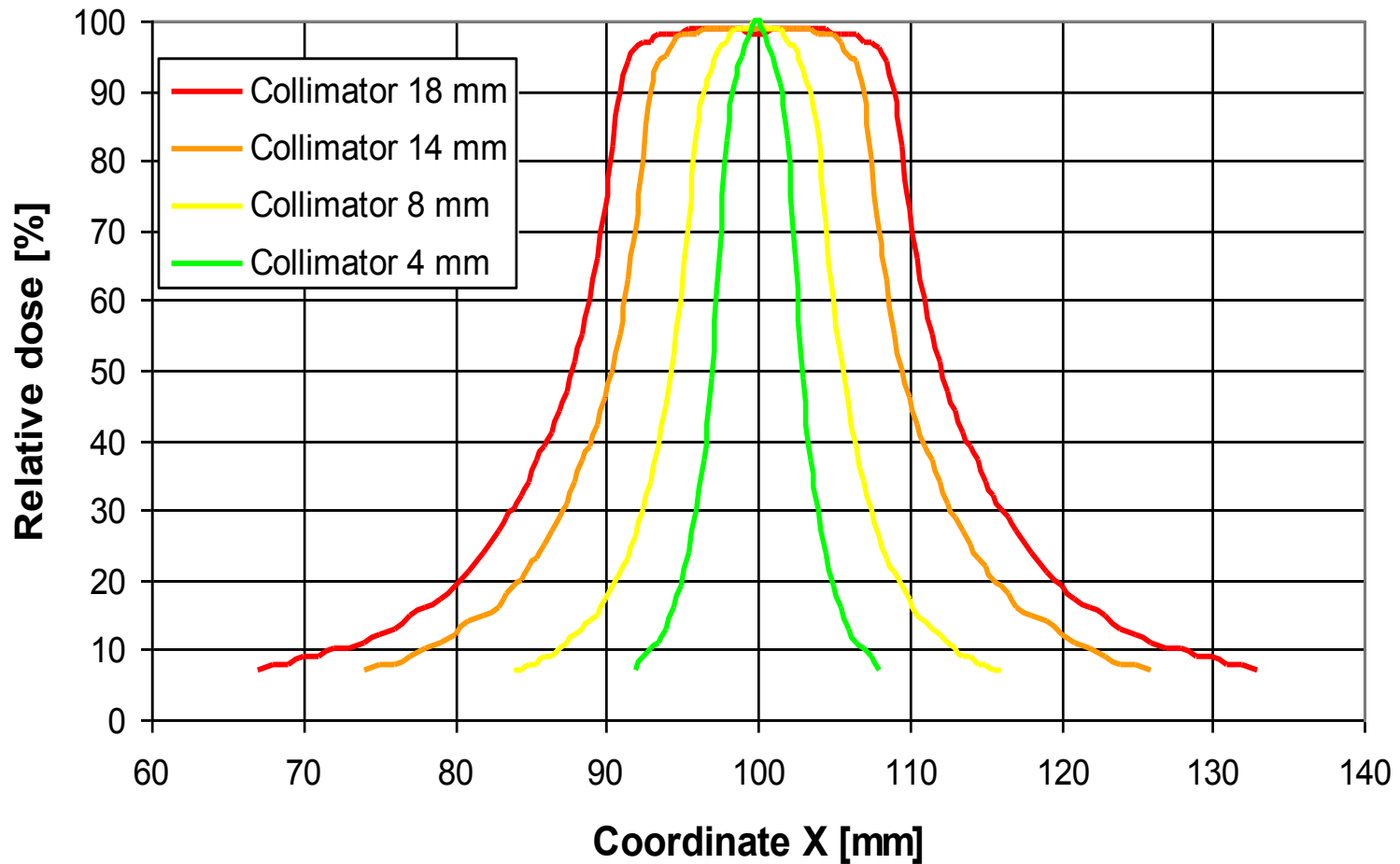
# Photon depth dose curves



# Basic principle of radiosurgery



# Dose profiles for the Leksell gamma knife



# Physical and technical principles

## Leksell gamma knife

**Radiation source:** gamma rays from  $^{60}\text{Co}$

**No. of sources:** 201

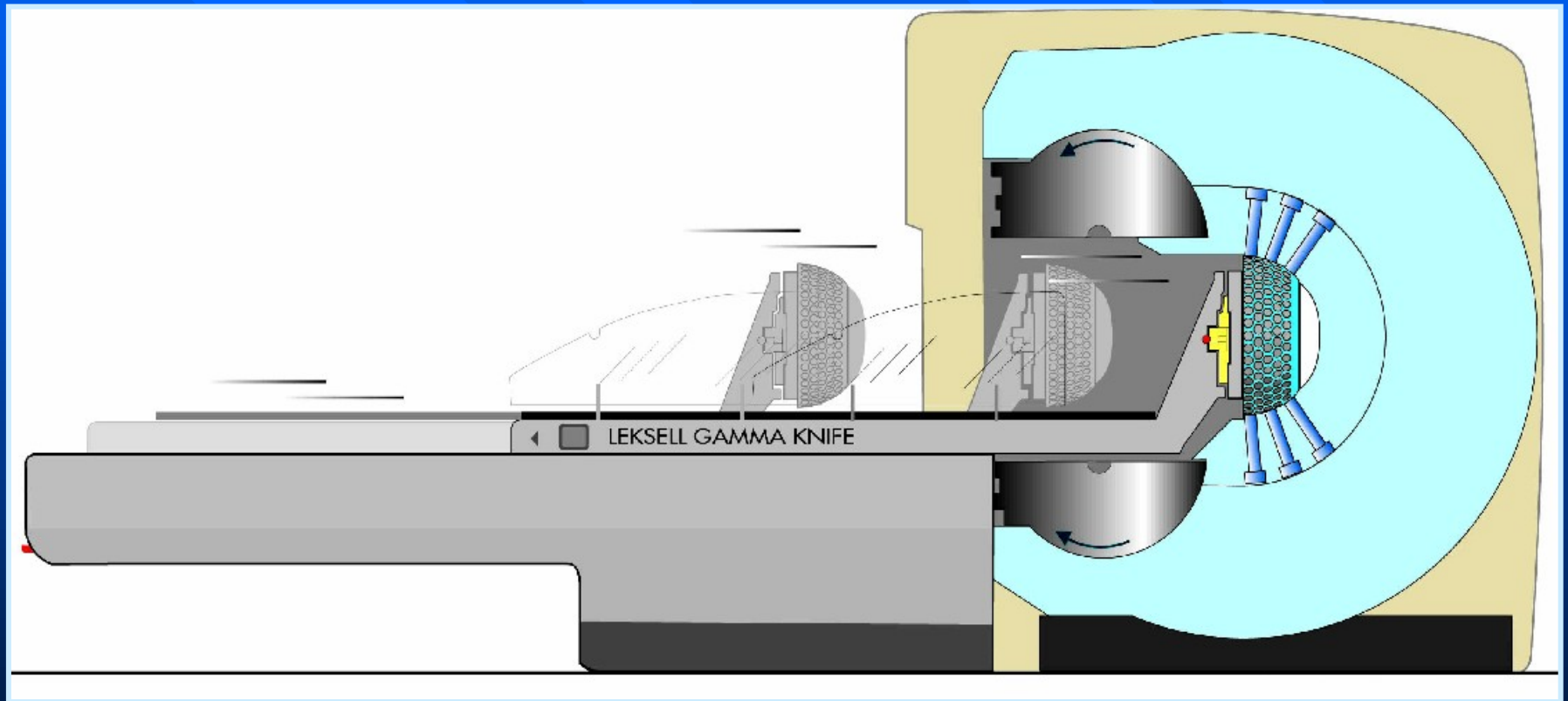
**Collimators:** 4, 8, 14, 18, mm

**Stereotactic target localization:** preferably MRI, CT not necessary,  
angiography



# Physical and technical principles

## Leksell gamma knife



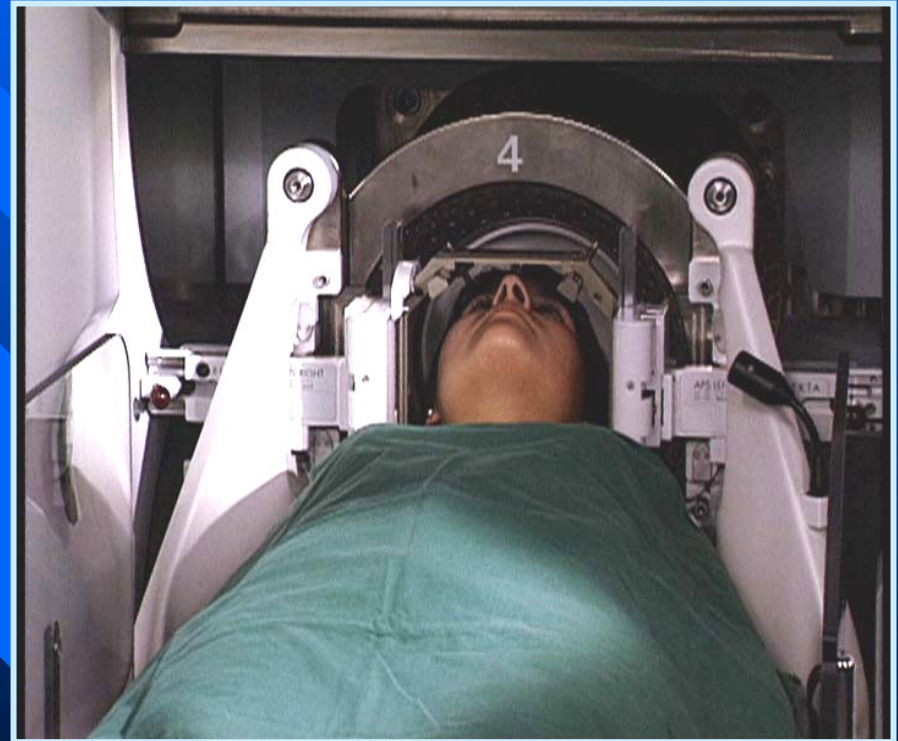
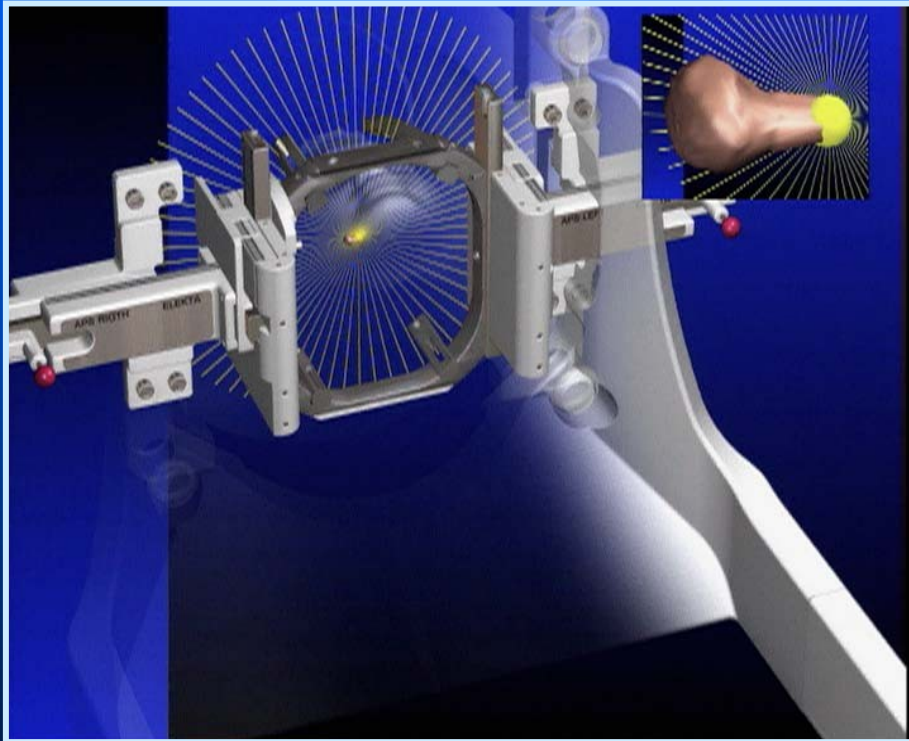
# Physical and technical principles

## Leksell gamma knife



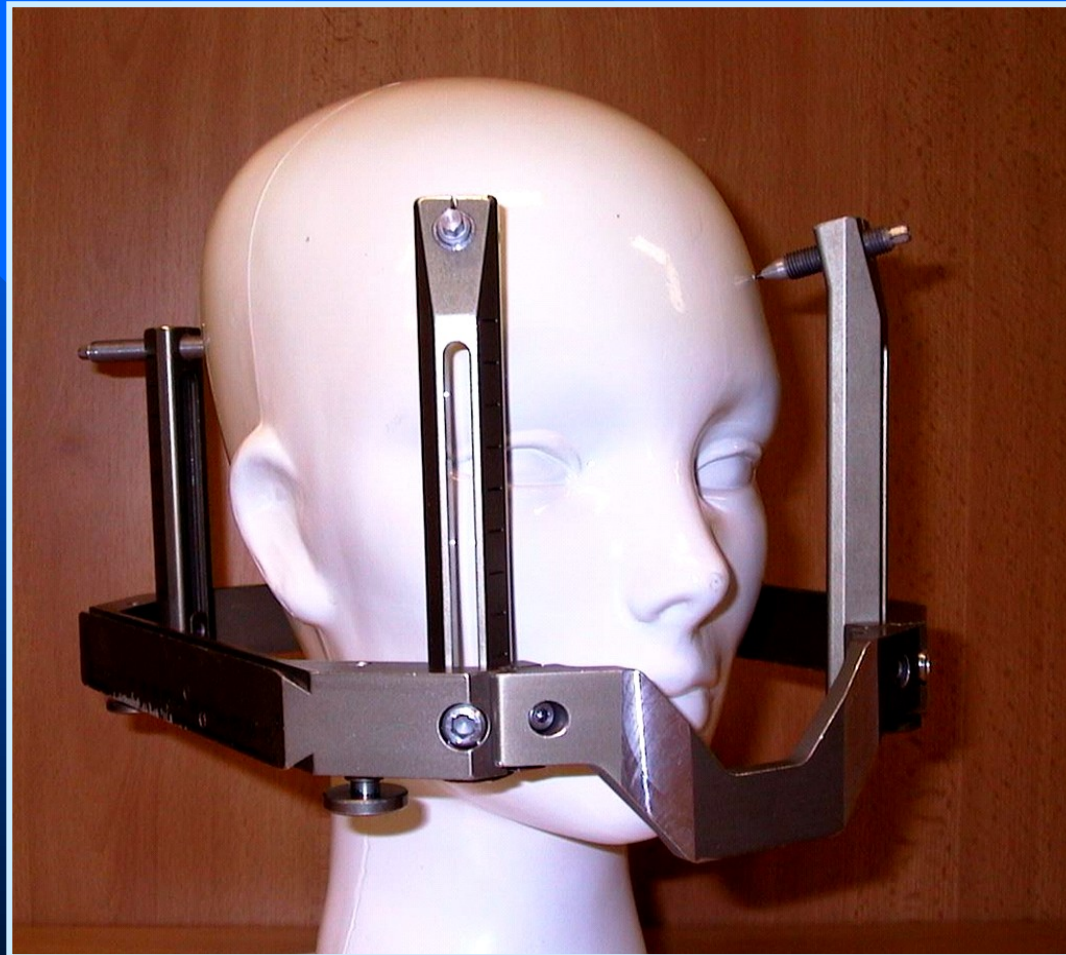
# Physical and technical principles

## Leksell gamma knife



# Physical and technical principles

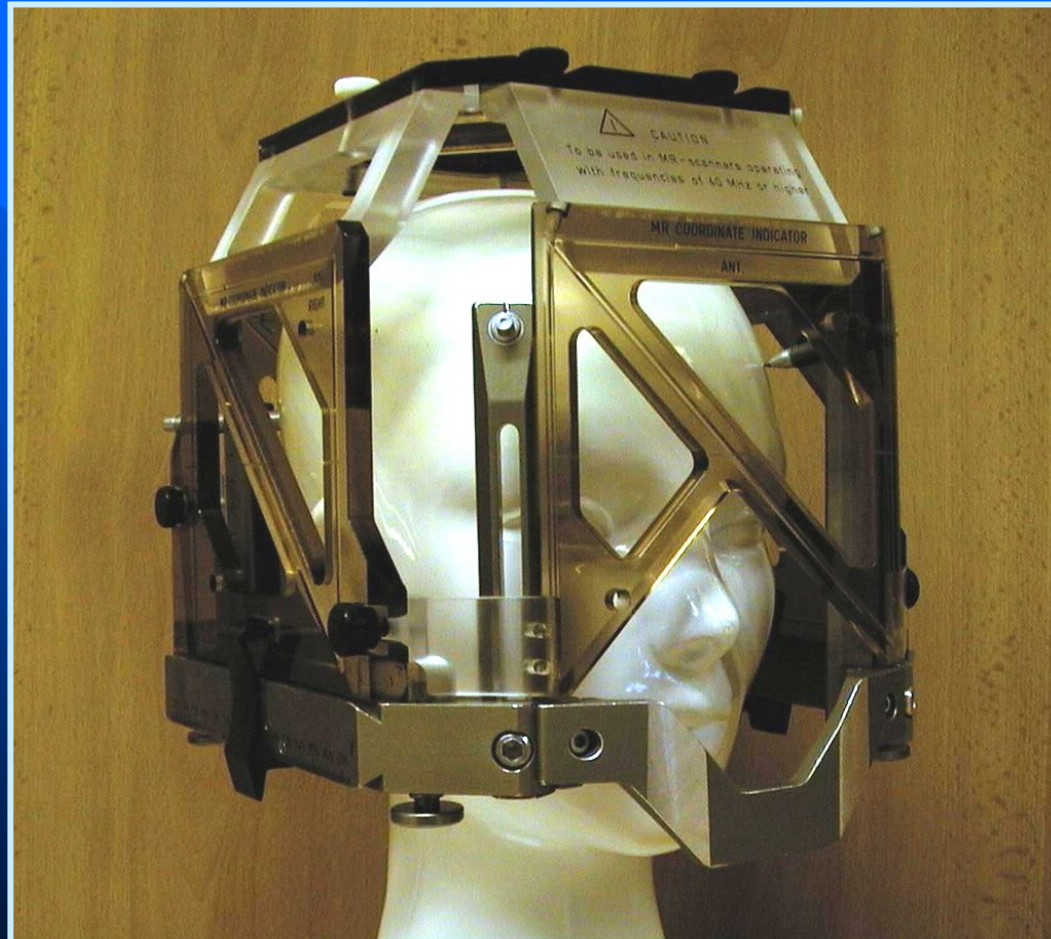
## Leksell gamma knife





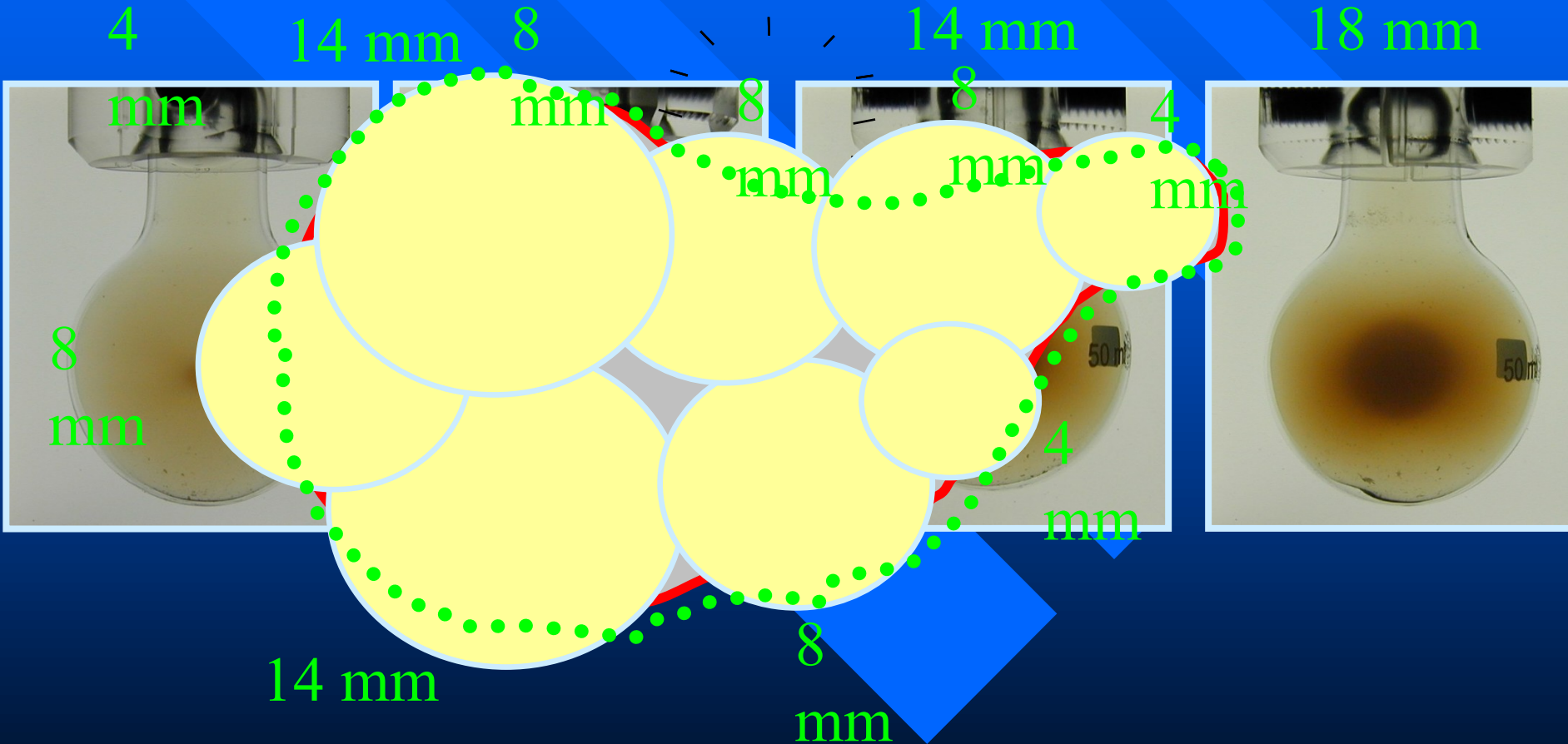
# Physical and technical principles

## Leksell gamma knife



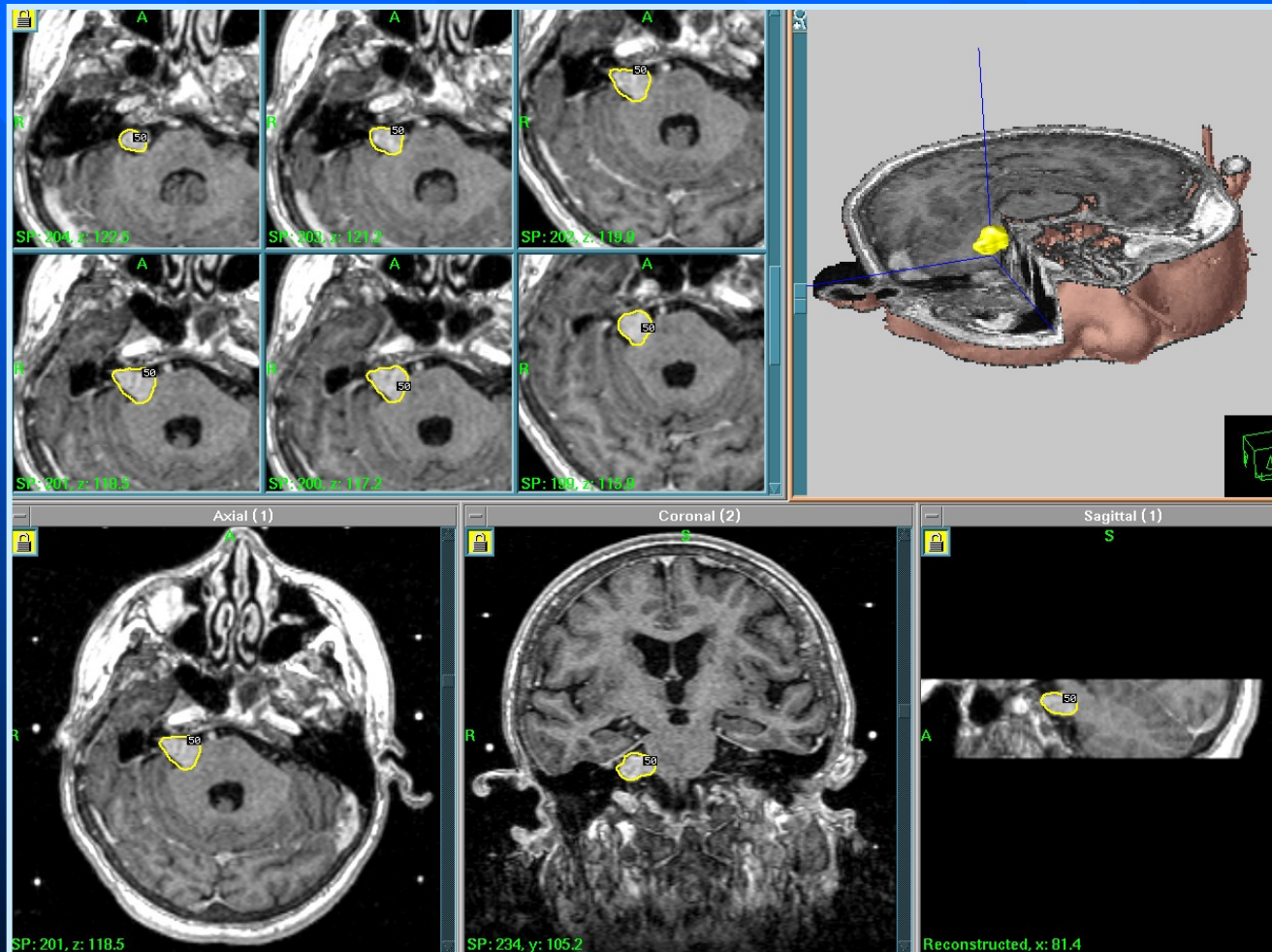
# Physical and technical principles

## Leksell gamma knife



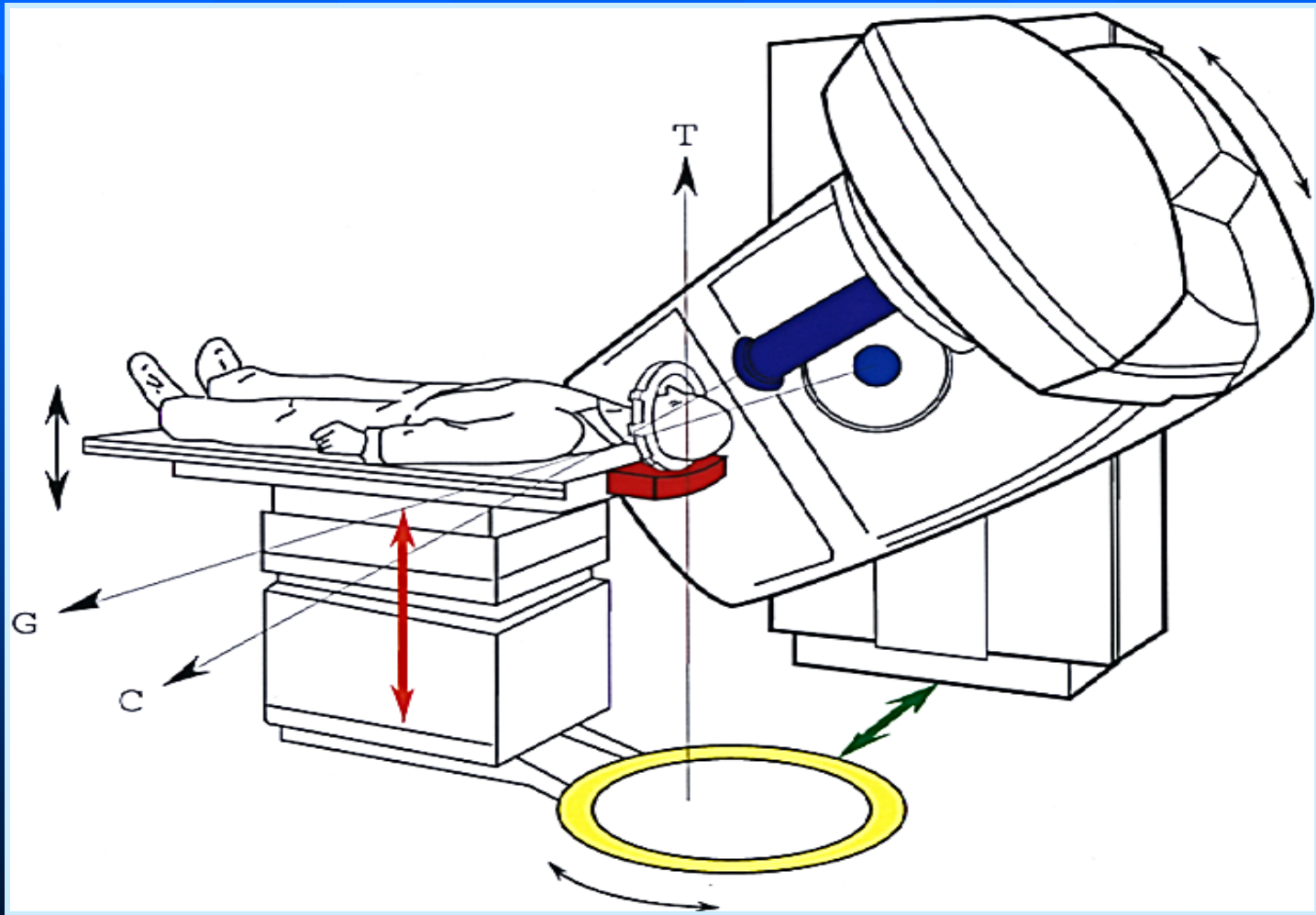
# Physical and technical principles

## Leksell gamma knife



# Physical and technical principles

## Linac radiosurgery or radiotherapy (BrainLAB system)



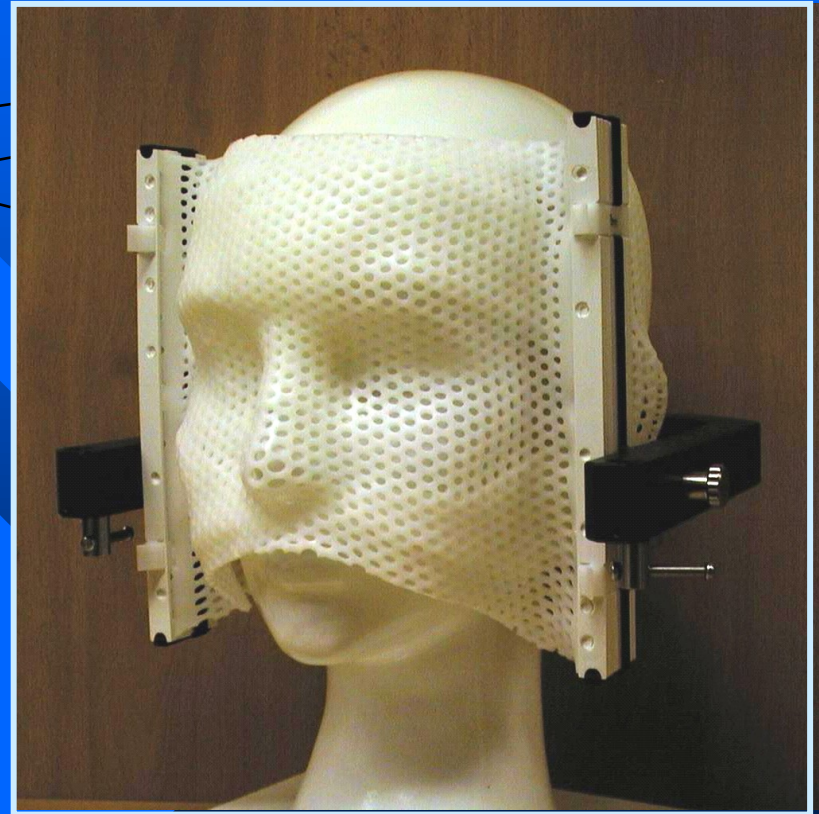
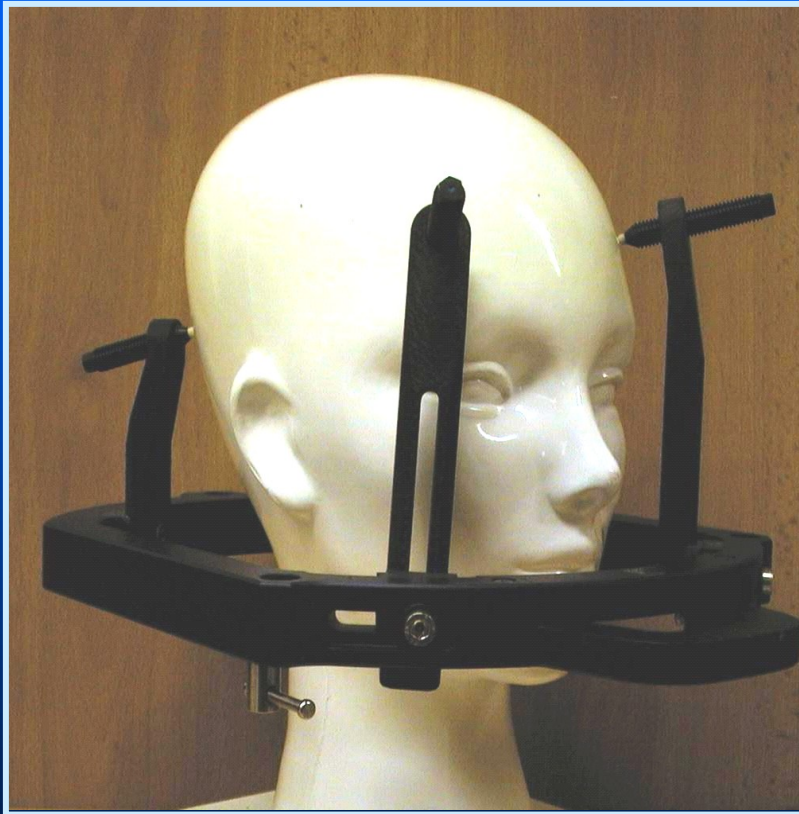
# Physical and technical principles

## Linac radiosurgery or radiotherapy (BrainLAB system)



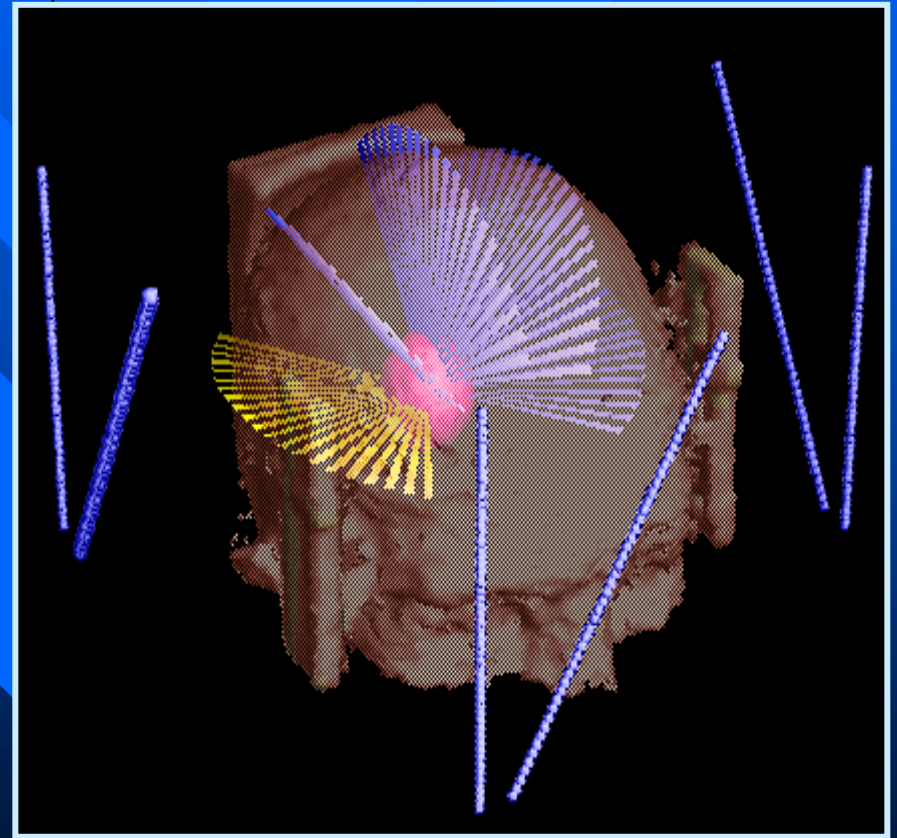
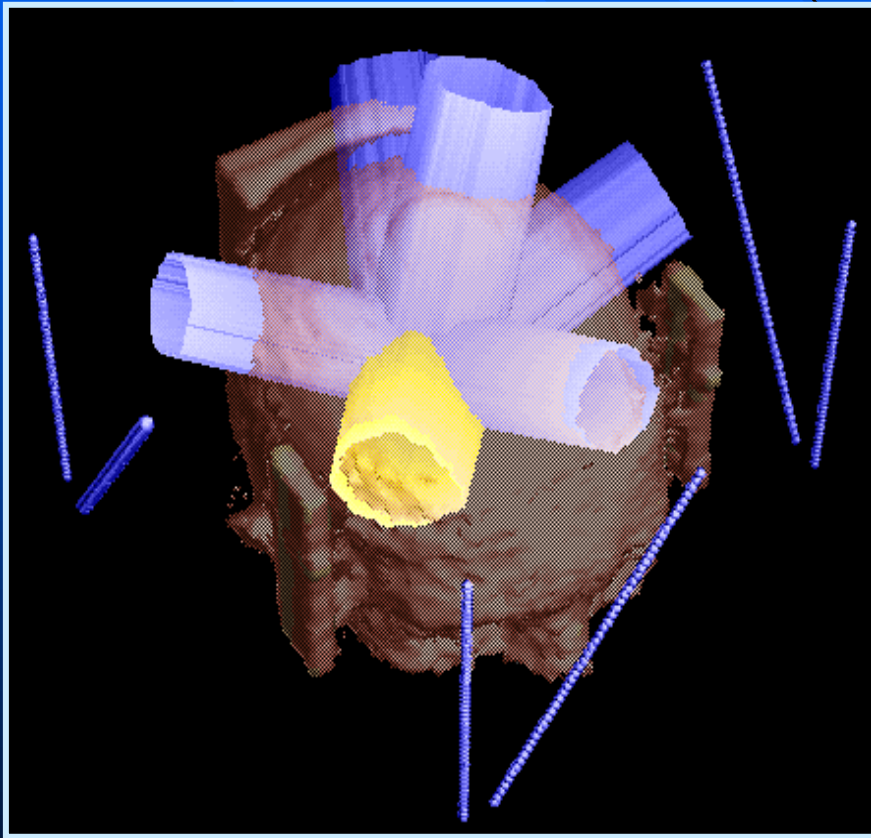
# Physical and technical principles

## Linac radiosurgery or radiotherapy (BrainLAB system)

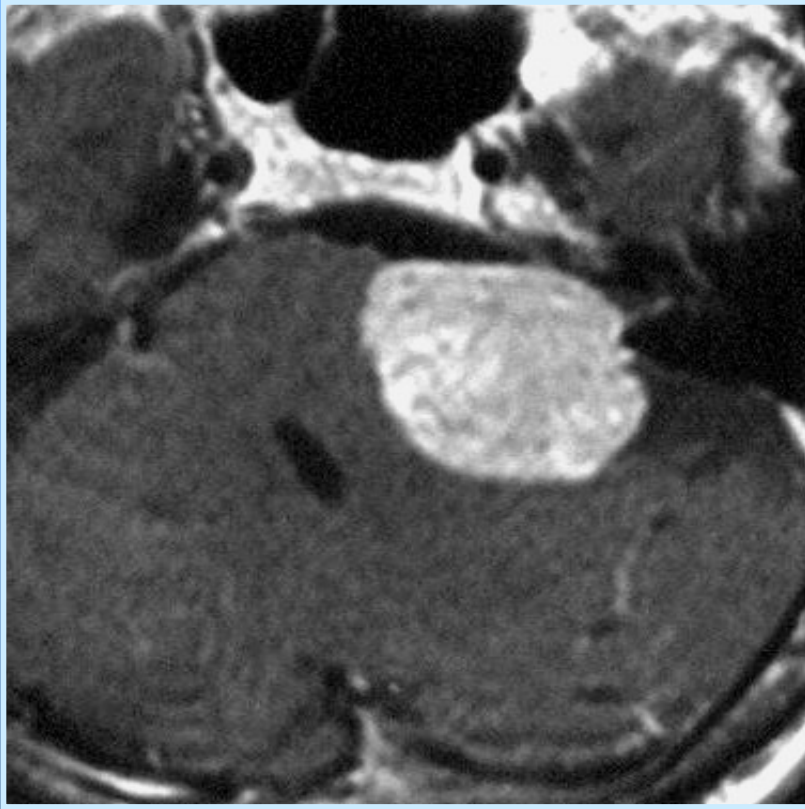


# Physical and technical principles

## Linac radiosurgery or radiotherapy (BrainLAB system)



# Clinical applications-acoustic neuroma



during LGK irradiation



3 years after LGK irradiation

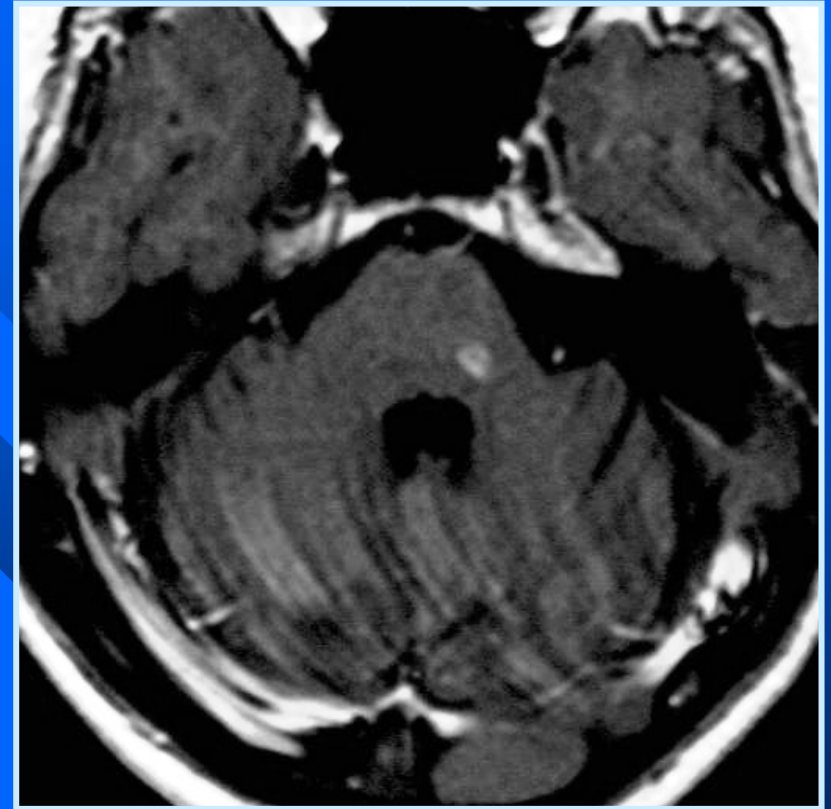




# Clinical applications-metastasis



during LGK irradiation



6 years after LGK irradiation





