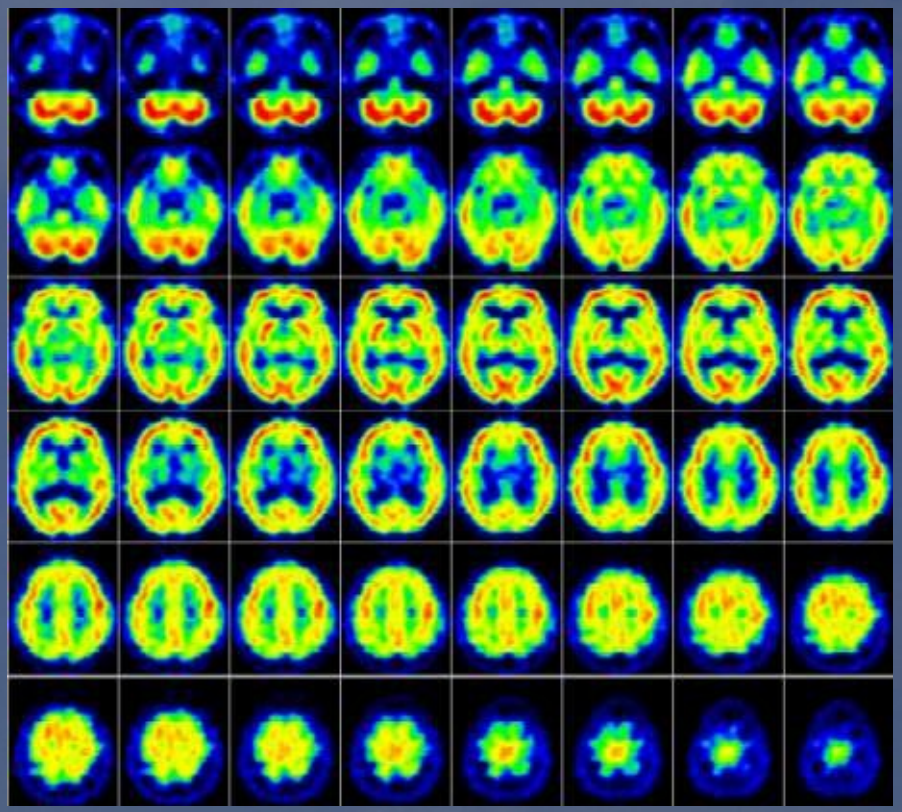
Nuclear Medicine (NM) Images

Prof. Dr. Lucas Ferrari de Oliveira
UFPR
Informatics Department

NM Images



http://www14.plala.or.jp/flrt/alz.html

http://www.sciencephoto.com/media/310546/view

NM Images

- History:
  - Discovered by couple Curie;
    - Pierre Curie (French) and Maria Curie (Polish);
  - The couple isolated two chemical elements from mineral uraninite (Becquerel rays);
    - Polonium and Radio.
  - Radioactivity is derived from element radio (ray emission activity);
  - In NM is used to appoint the radioactive isotopes.

NM Images

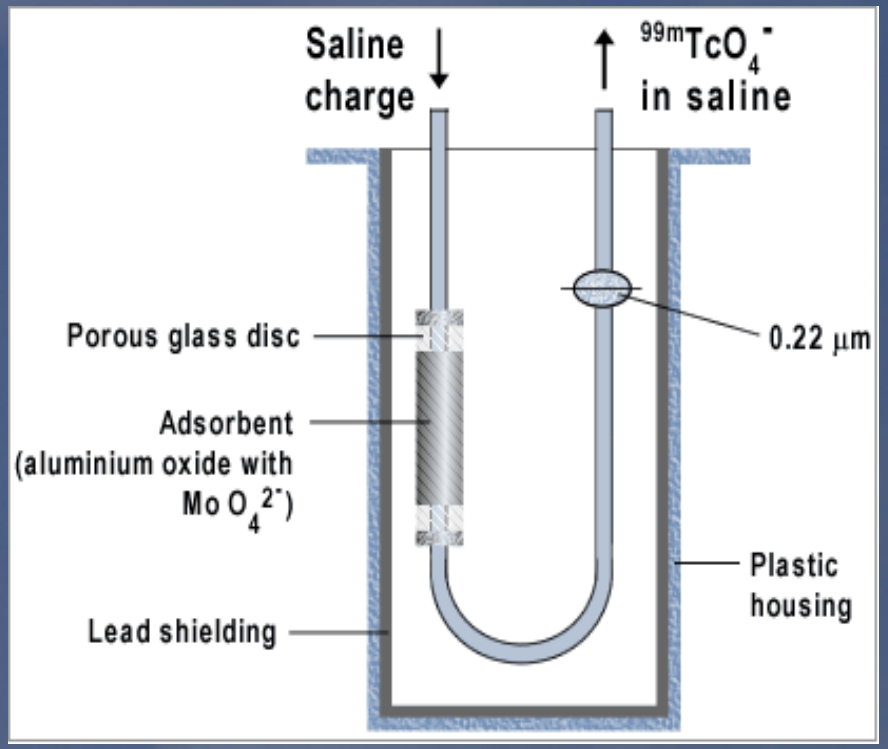
- Isotopes:
  - Variants of a particular chemical element;
  - Same number of protons but different number of neutrons in atom;
  - Carbon-12, carbon-13 and carbon-14 are three isotopes of the element carbon (mass number 12, 13 and 14);
    - The atomic number of carbon is 6 (6 protons), and 6, 7 and 8 neutrons in atom.
  - Radioactivity = nuclear instability.

NM Images

- Radioactive isotopes:
  - Stable isotopes occur naturally on Earth, some are naturally radioactive;
  - ~3000 radioactive isotopes are created in nuclear reactors and in particle accelerators;
  - Many type of radiation:
    - Alfa, Beta Negative (negatrons), Beta Positive (Positrons) and Gama (electromagnetic).
  - Short-lived in the body (short effective half life).

NM Images

- Radioactive isotopes:



NM Images

- Technetium Generator:
  - Molybdenum 99 decays to Technetium 99;
  - Molybdenum is adsorbed onto Alumina;
  - Saline used to elute Technetium 99m;
  - Ideally eluted once every 24h;
  - Usually get one or more generators per week.

NM Images

- Radioactive isotopes:

Isotope	Emission Type	Half Life
Tc-99m	Gama	6 hours
I-131	Gama and Beta	8 days
Ga-67	Gama	3,26 days
Tl-201	Gama	3,04 days
I-123	Gama	13,2 hours
Sm-153	Gama and Beta	1,95 days
F-18	Positron (gama)	109 minutes

NM Images

- Modalities:
  - SPECT (Single Photon Emission Tomography): the camera rotates and acquires data 360º around the patient;
  - PET (Positron Emission Tomography): Positron-emitting radionuclide are administered to the patient. Detector are located in a ring around the patient, and utilize coincidence detection.

NM Images

- SPECT Equipment:

NM Images

- PET Equipment:

NM Images

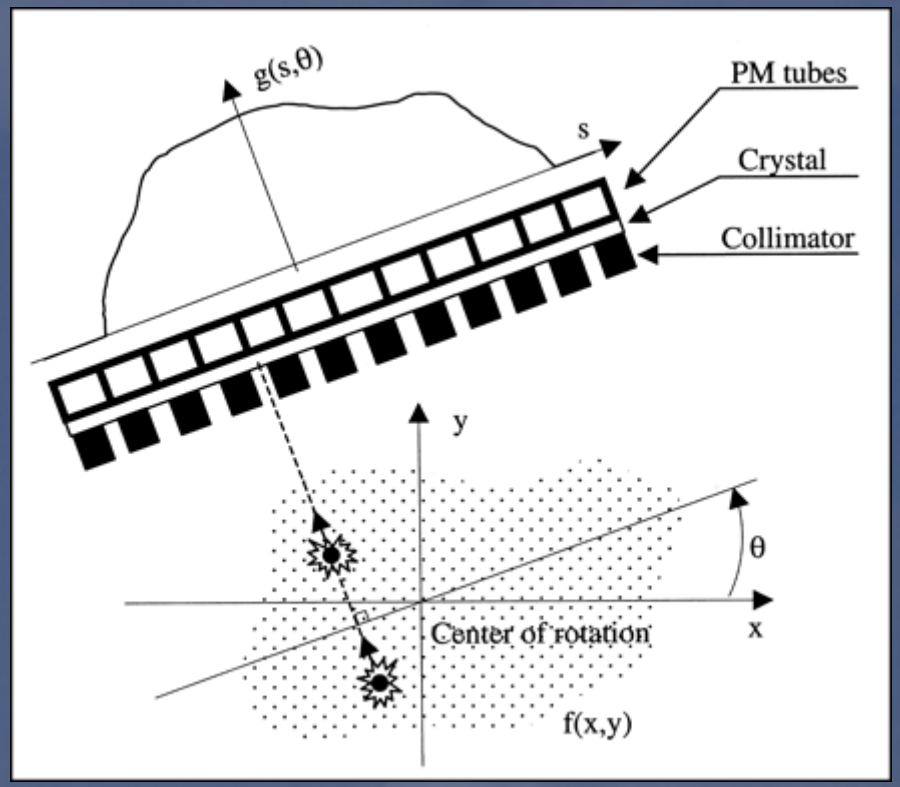
- SPECT Protocol

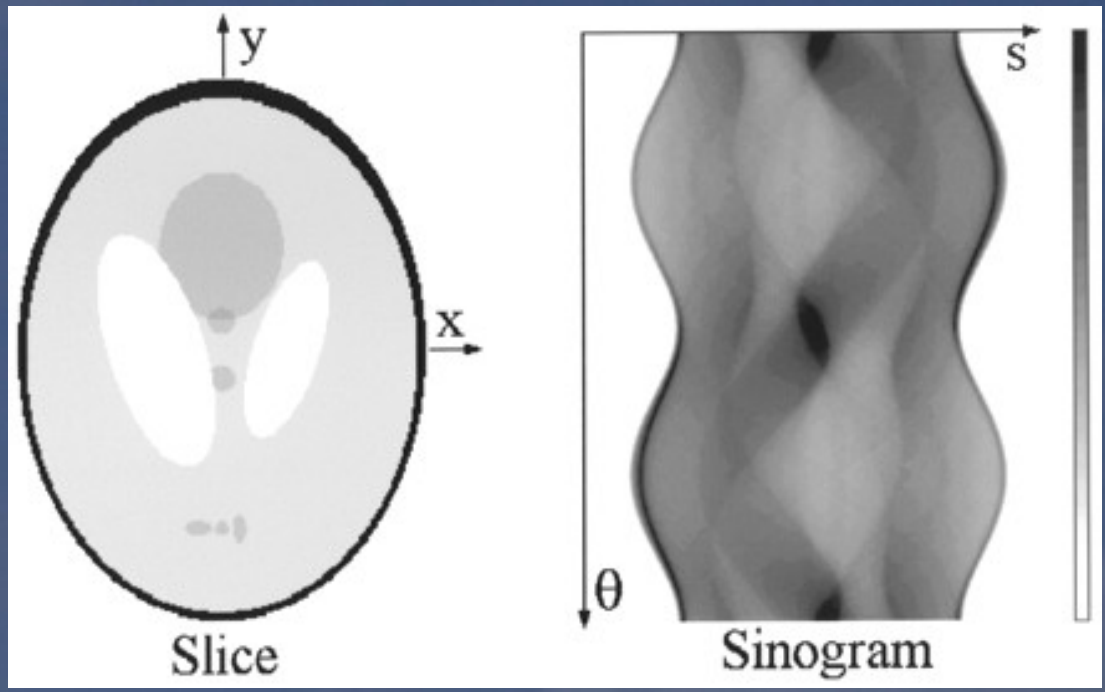
Study	Radioisotope	KeV	Half-life	Radiopharmaceutical	Rotation	Projections	Image Resolution
Bone Scan	Technetium-99m	140	6 hours	Phoshonates / Bisphosphonates	360	120	128x128
Myocardial Perfusion	Technetium-99m	140	6 hours	Tetrofosmin; Sestamibi	180	60	64x64
Sestamibi parathyroid	Technetium-99m	140	6 hours	Sestamibi			
Brain	Technetium-99m	140	6 hours	HMPAO; ECD	360	64	128x128
Neuroendocrine	Iodine-123	159	13 hours	MIBG	360	60	64x64
White cell scan	Indium-111 & Technetium-99m	171 & 245	67 hours	*In vitro* labelled leucocytes	360	60	64x64

http://en.wikipedia.org/wiki/Single-photon_emission_computed_tomography

NM Images

- Image Acquisition:





http://jnm.snmjournals.org/content/43/10/1343.full
J Nucl Med October 1, 2002 vol. 43 no. 10 1343-1358

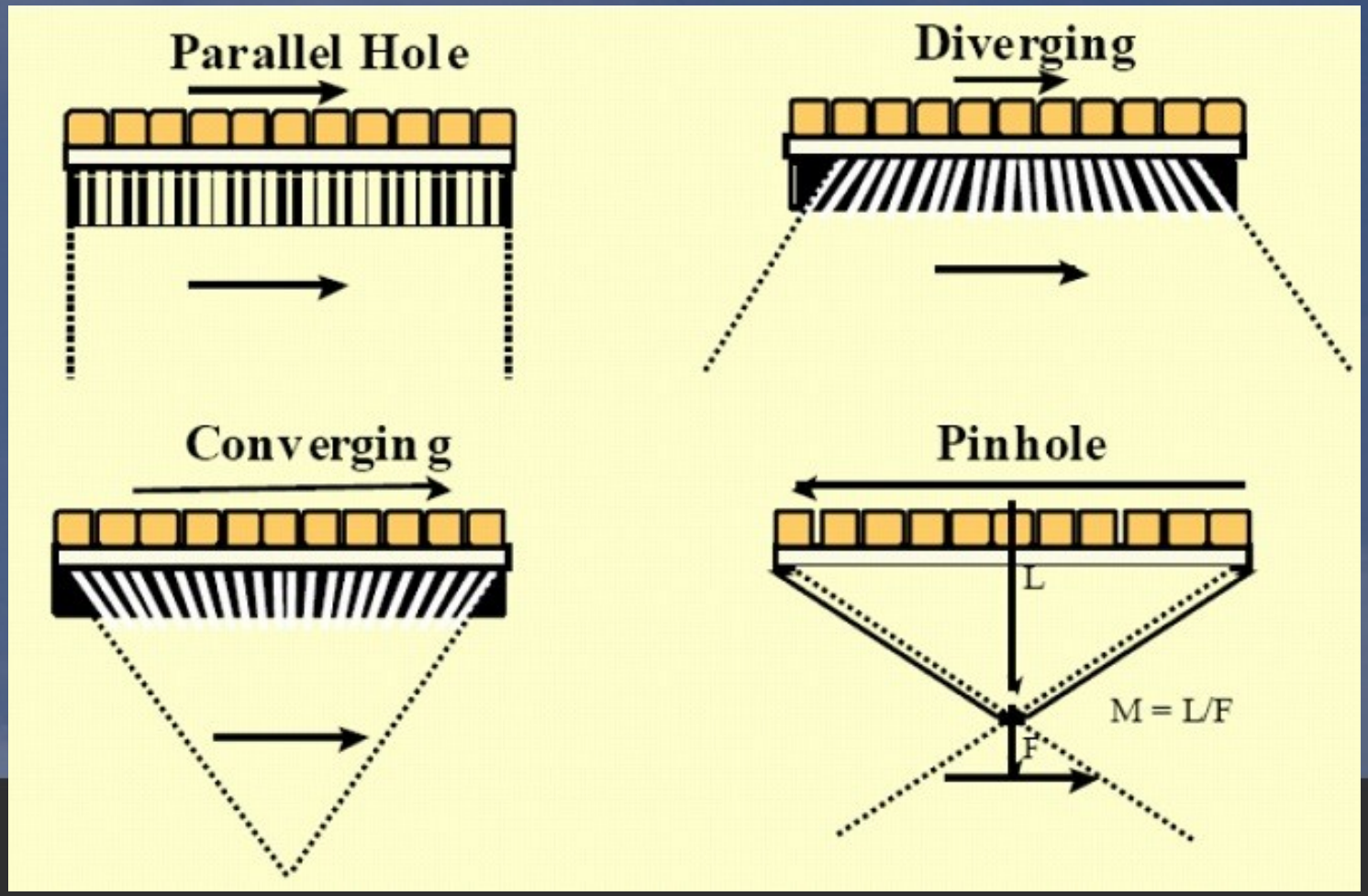
NM Images

- Collimator:

www.orau.org
www.nuclearfields.com
Imablog – Museum: Collimator core blog.imabug.net

NM Images

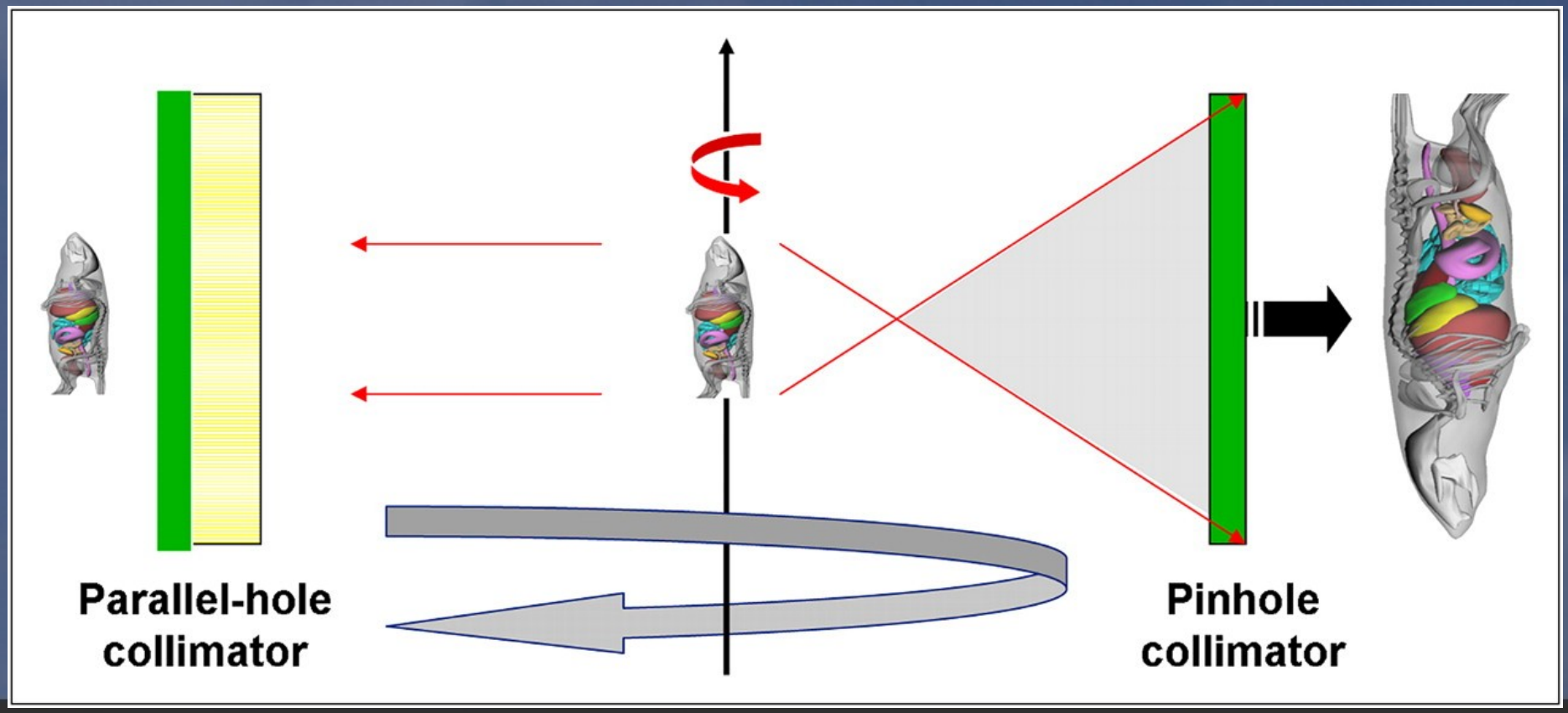
- Collimator:



http://oftankonyv.reak.bme.hu/tiki-index.php?page=Collimators

NM Images

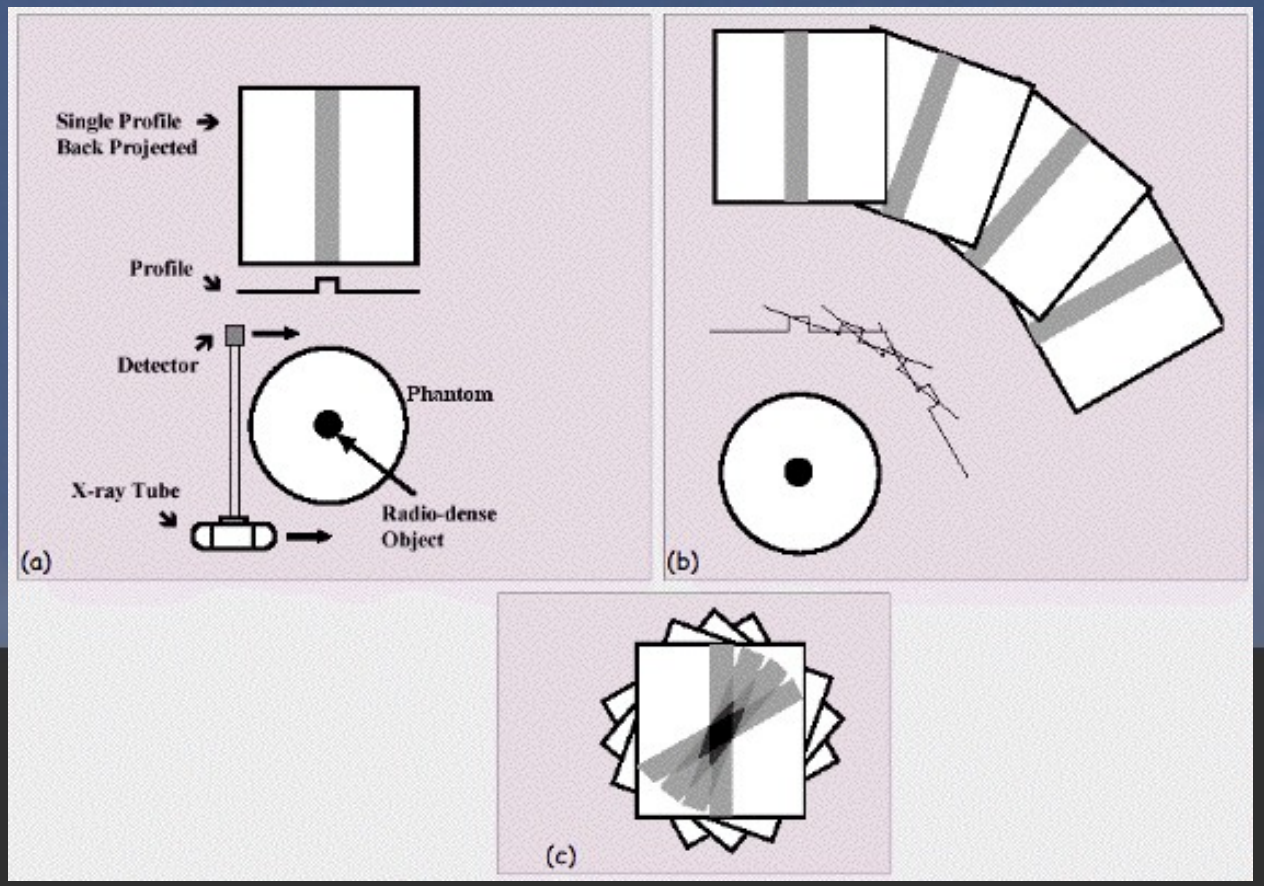
- Collimator:



http://jnm.snmjournals.org/content/51/Supplement_1/18S/F12.expansion.html
J Nucl Med May 2010 vol. 51 no. Supplement 1 18S-32S

NM Images

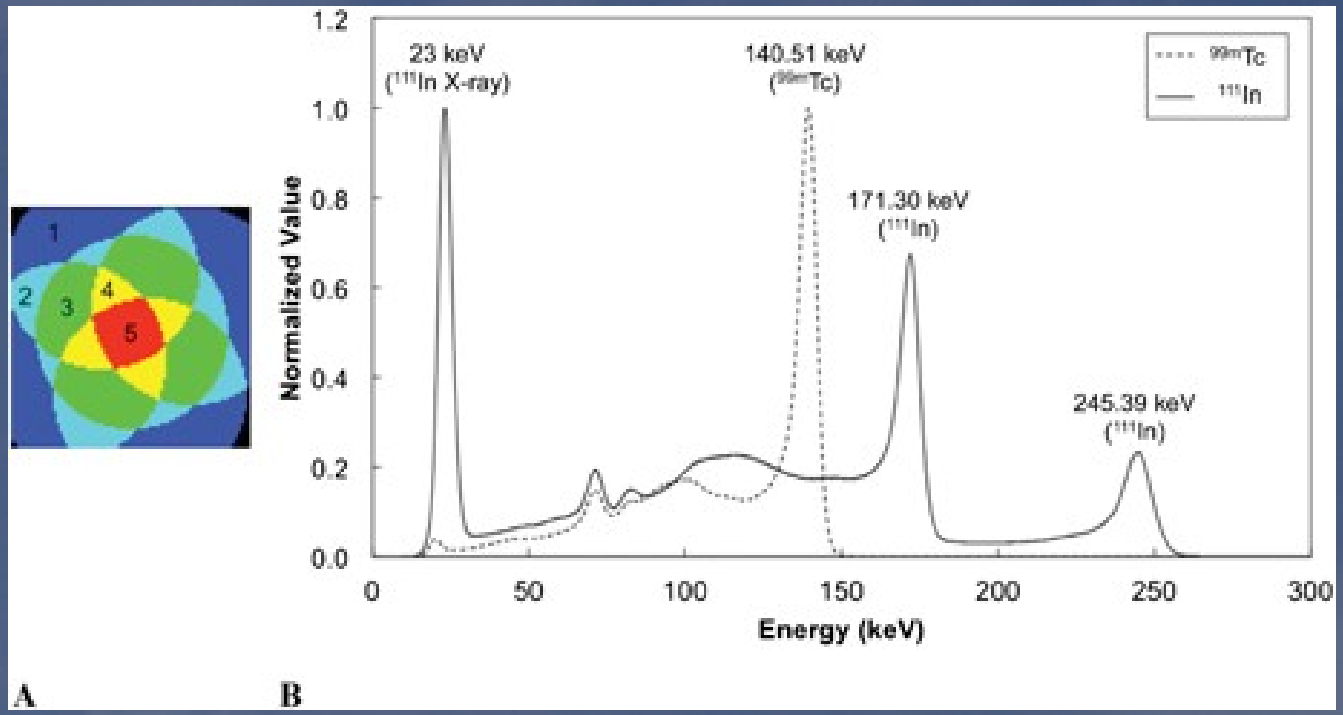
- Image Reconstruction:
  - Many projections;
  - Back projection technique



http://en.wikibooks.org/wiki/Basic_Physics_of_Nuclear_Medicine/X-Ray_CT_in_Nuclear_Medicine

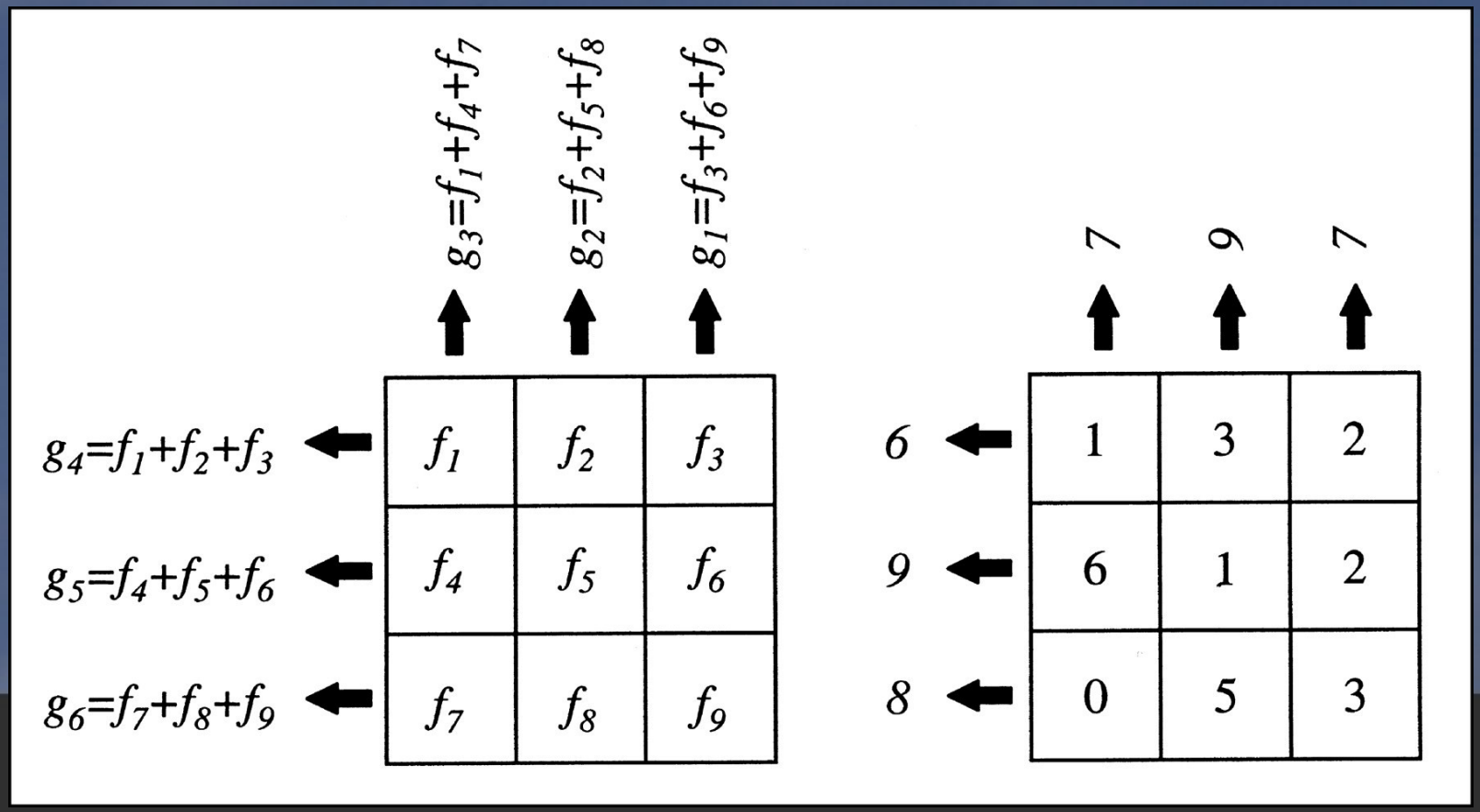
NM Images

- Image Projections



NM Images

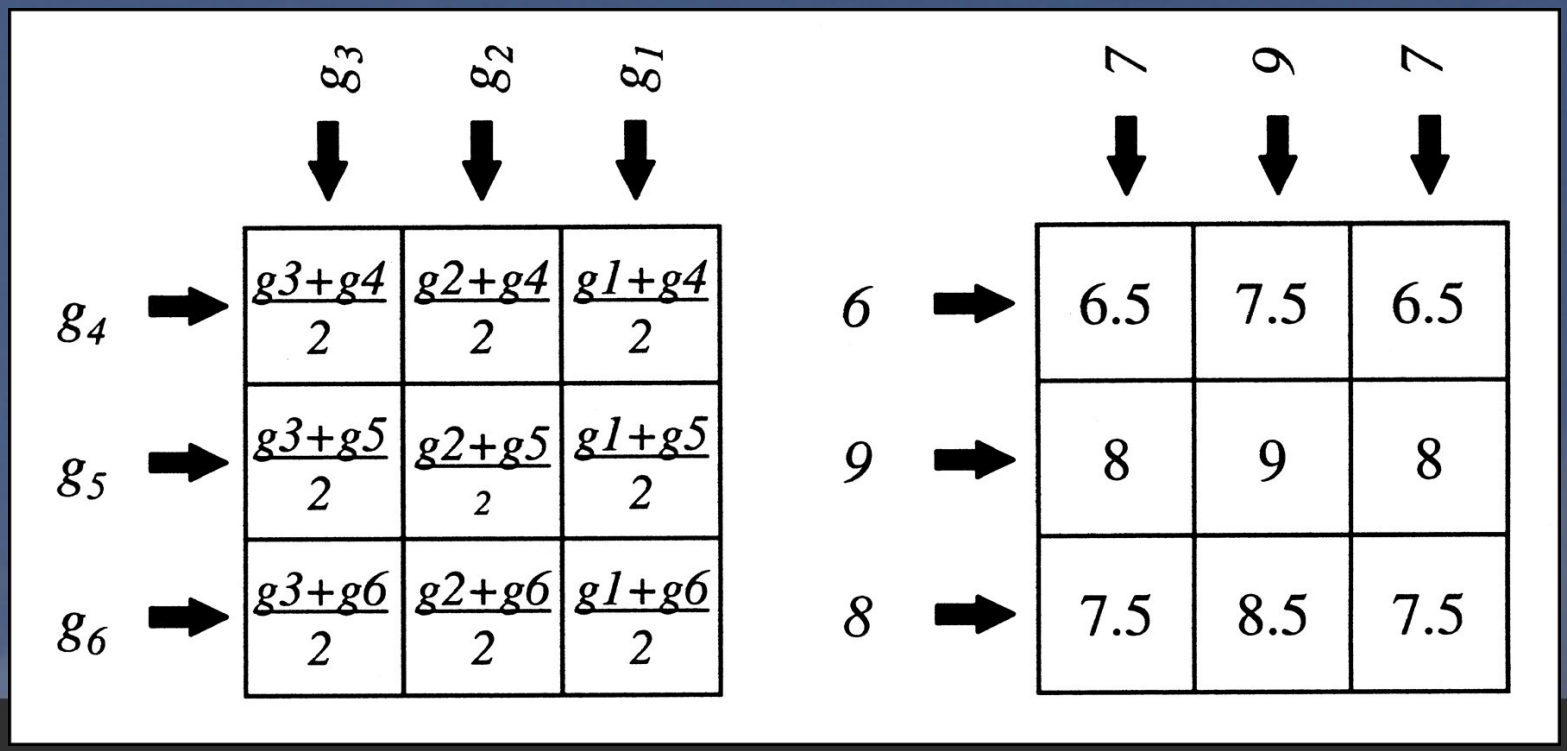
- Image Reconstruction:



http://jnm.snmjournals.org/content/43/10/1343.full
J Nucl Med October 1, 2002 vol. 43 no. 10 1343-1358

NM Images

- Image Reconstruction:

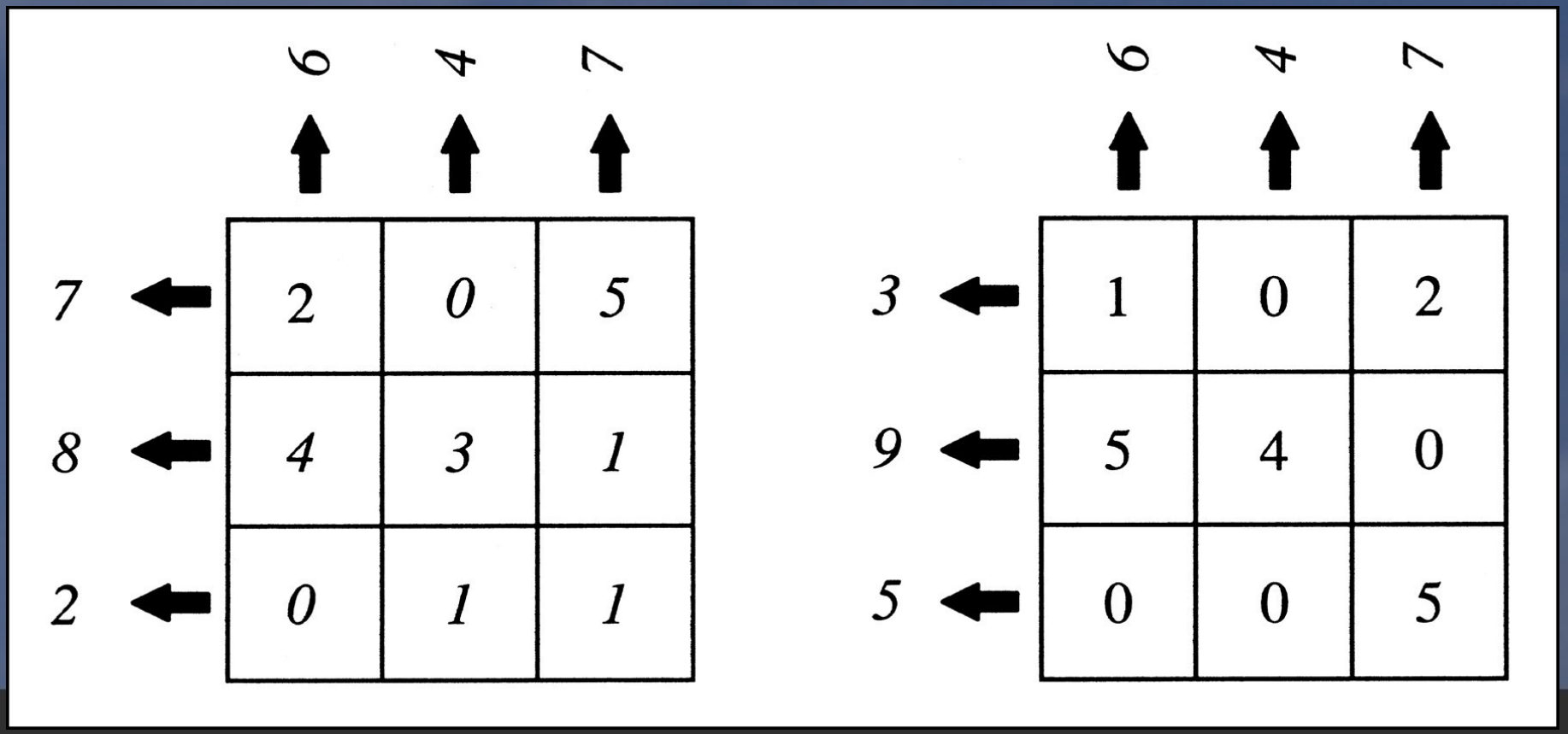


Principle of backprojection for one 2 × 3 sinogram. Value in each pixel is sum of values of bins that, given angle of detector, can receive photons from that pixel and is divided by number of rows of sinogram. (Right) Example: f1 = (g3 + g4)/2 = (7 + 6)/2 = 6.5.

http://jnm.snmjournals.org/content/43/10/1343.full
J Nucl Med October 1, 2002 vol. 43 no. 10 1343-1358

NM Images

- Image Reconstruction:



http://jnm.snmjournals.org/content/43/10/1343.full
J Nucl Med October 1, 2002 vol. 43 no. 10 1343-1358

NM Images

- Image Reconstruction:

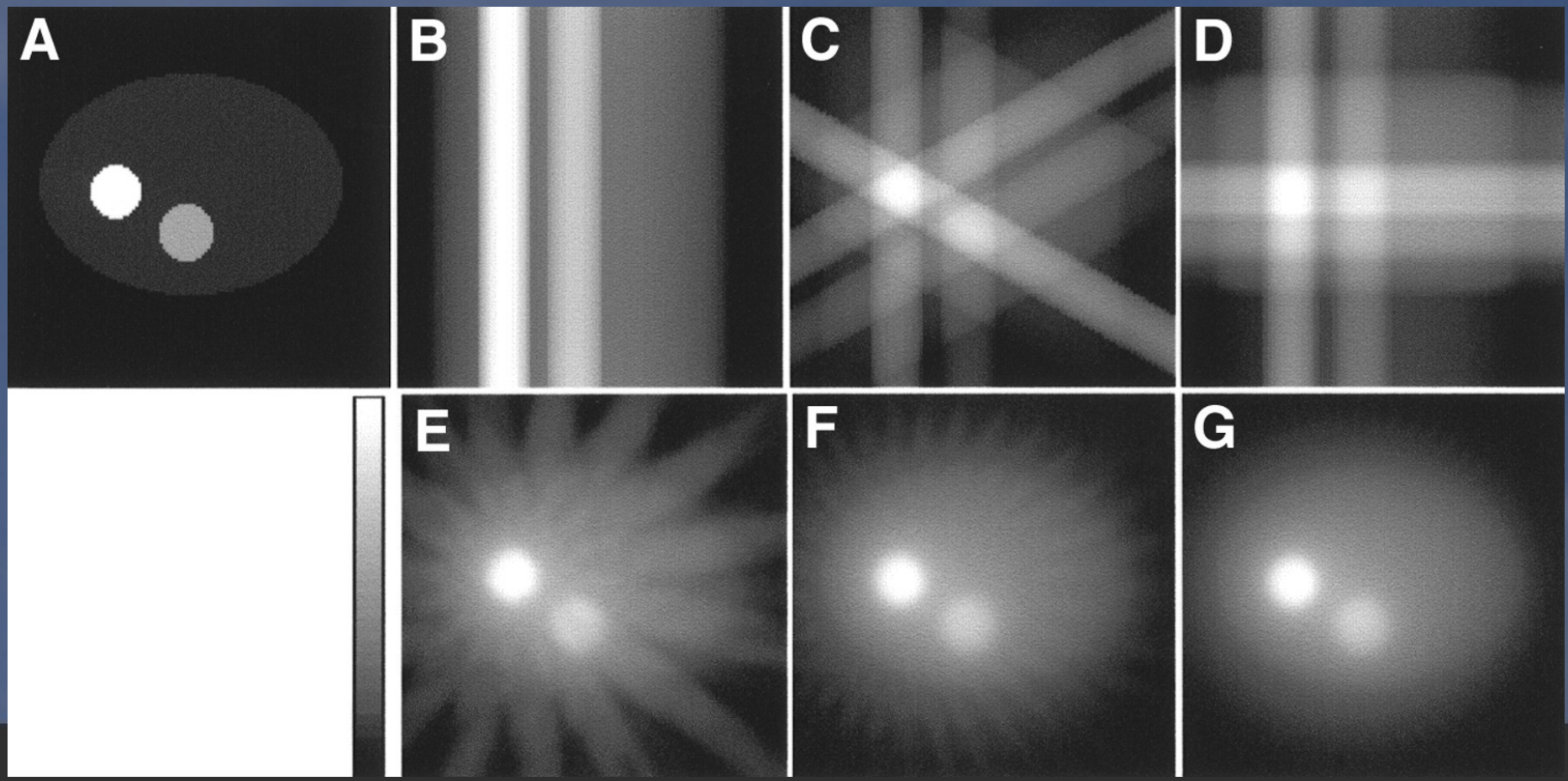
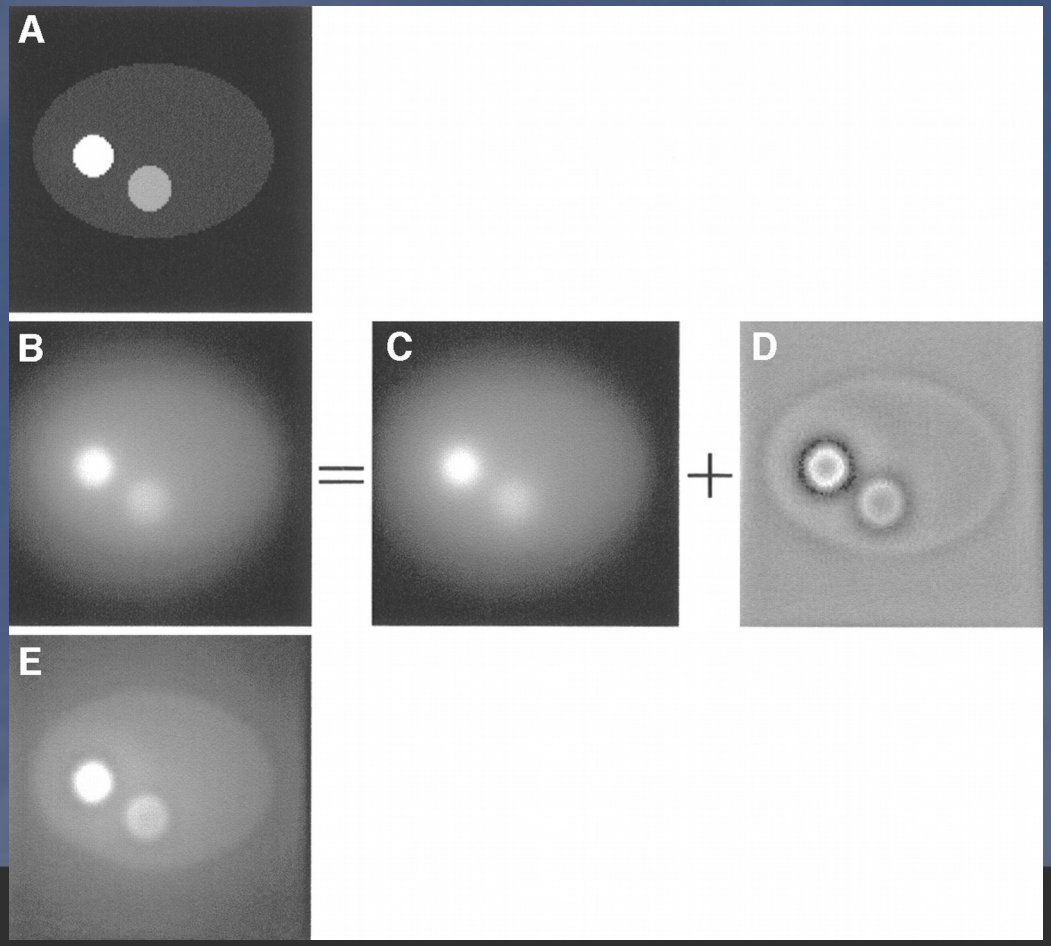


Illustration of star (or streak) artifact. (A) Slice used to create projections. (B–G) 1, 3, 4, 16, 32, and 64 projections equally distributed over 360° are used to reconstruct slice using backprojection algorithm. Activity in reconstructed image is not located exclusively in original source location, but part of it is also present along each line of backprojection. As number of projections increases, star artifact decreases.

http://jnm.snmjournals.org/content/43/10/1343.full
J Nucl Med October 1, 2002 vol. 43 no. 10 1343-1358

NM Images

- Image Reconstruction:

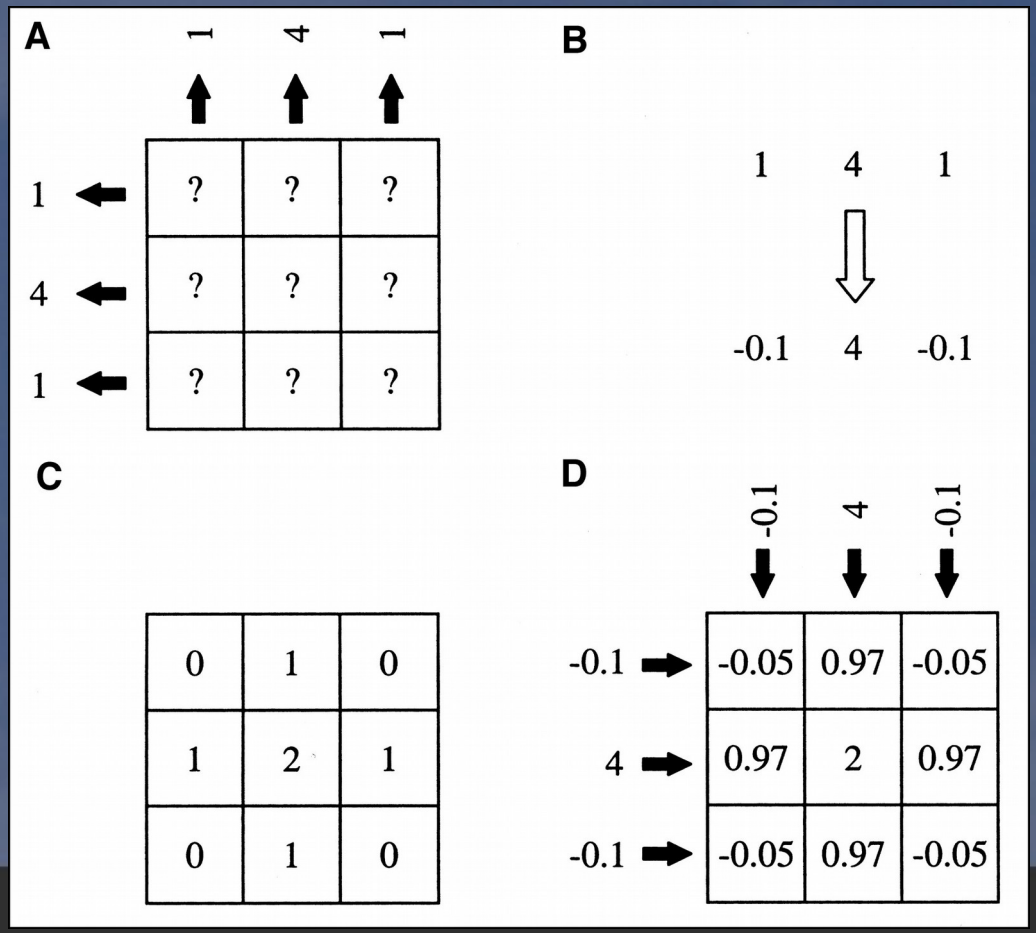


Simplified illustration of filtering process. (A) Model (128 × 128 pixels). (B) Image obtained after backprojection of 128 projections. (C) Low-frequency component of image presented in B. Only overall aspect of image is visible. (D) High-frequency component of image presented in B. Edges are emphasized. Dark rings correspond to negative pixel values. Sum of images in C and D yields image in B. (E) Images in C and D are added, but after C is given low weight to reduce amplitude of low-frequency component.

http://jnm.snmjournals.org/content/43/10/1343.full
J Nucl Med October 1, 2002 vol. 43 no. 10 1343-1358

NM Images

- Image Reconstruction:

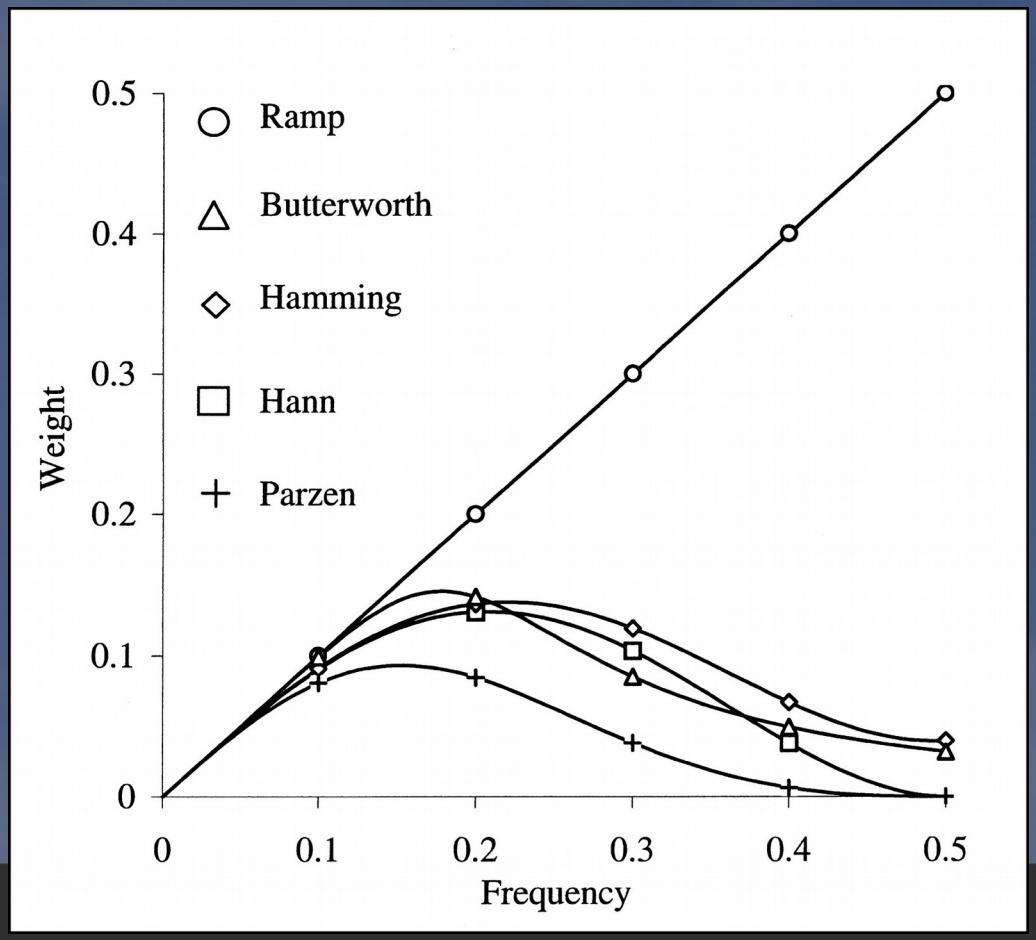


(A) Two projections are same as in Figure 8. (B) Filtering of projections using ramp filter yields negative values. (C) Original image. (D) Image obtained after backprojection of filtered projections. Note how negative and positive values substantially cancel each other, yielding result closer to original image that can be seen in D.

http://jnm.snmjournals.org/content/43/10/1343.full
J Nucl Med October 1, 2002 vol. 43 no. 10 1343-1358

NM Images

- Image Reconstruction:



Some filters currently used in FBP and their shape. Value on y-axis indicates to what extent contribution of each frequency to image is modified by filters. These filters, except ramp filter, simultaneously reduce high-frequency components (containing much noise) and low-frequency component (containing blur introduced by summation algorithm).

http://jnm.snmjournals.org/content/43/10/1343.full
J Nucl Med October 1, 2002 vol. 43 no. 10 1343-1358

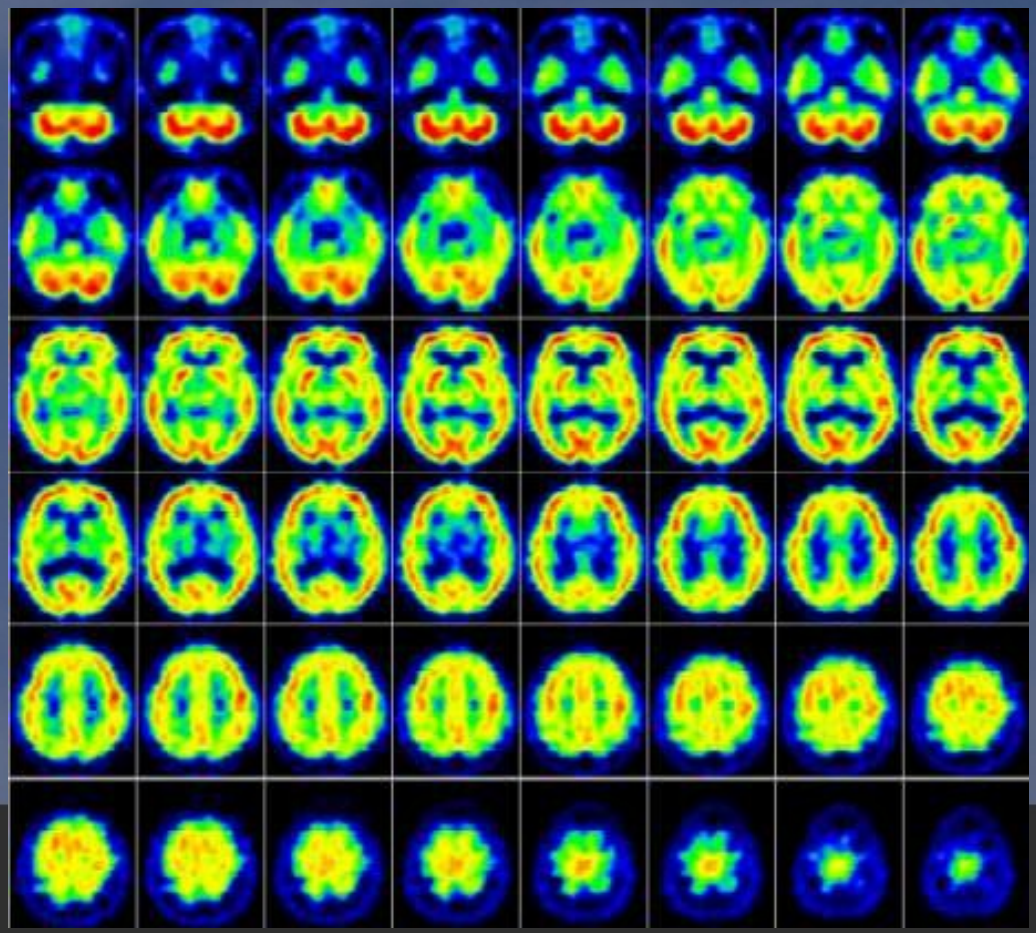
NM Images

- SPECT Images:
  - Bone Scan

http://www.jupitermed.com/nuclear-med

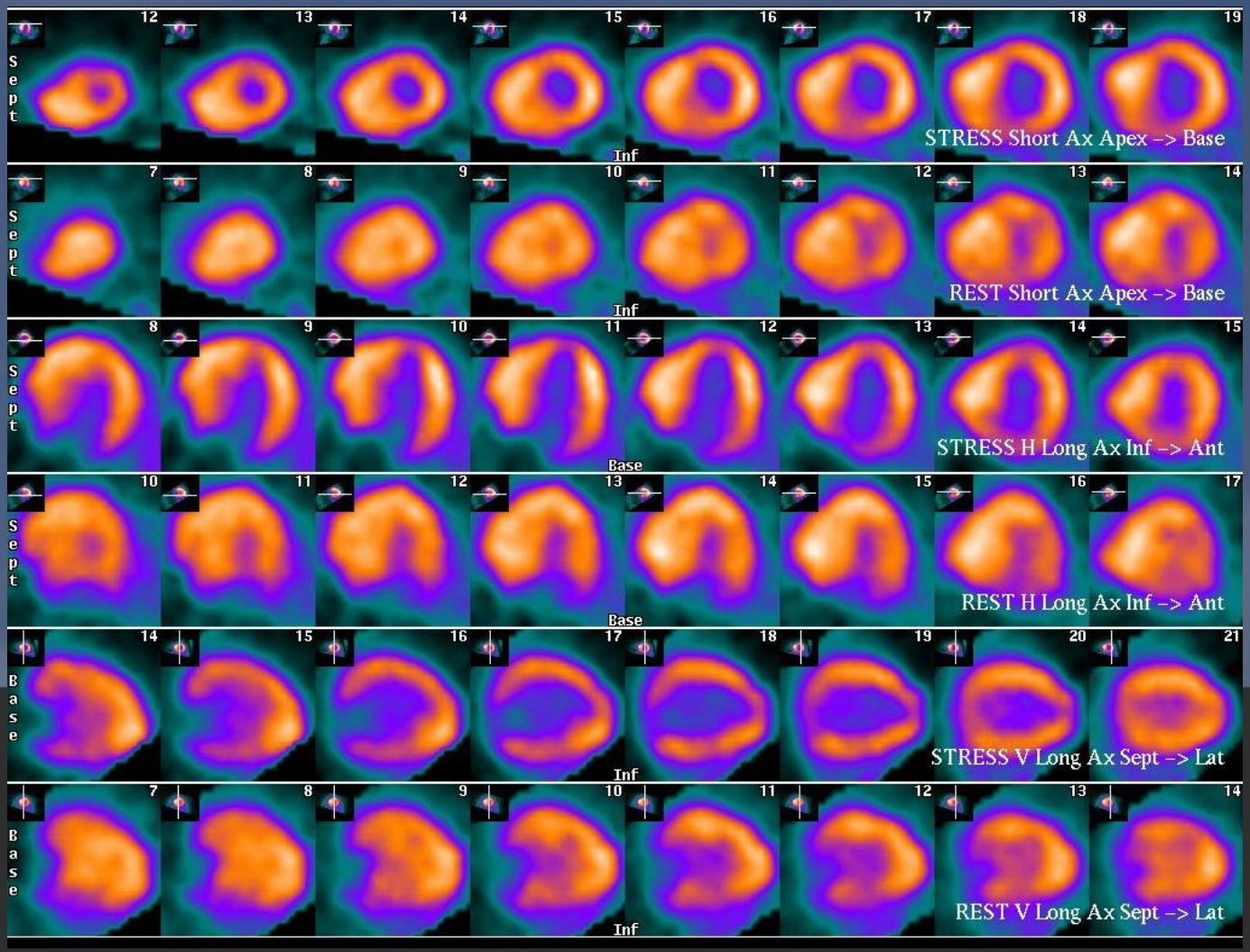
NM Images

- SPECT Images:
  - Brain



NM Images

- SPECT Images:
  - Cardiology



NM Images

- PET Images:
  - PET/CT

http://www.sciencephoto.com/media/255254/enlarge