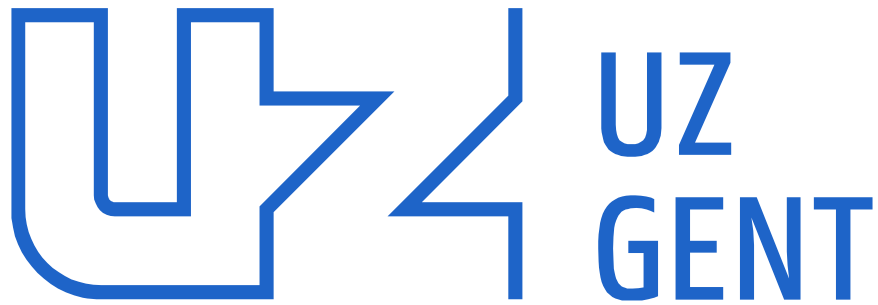
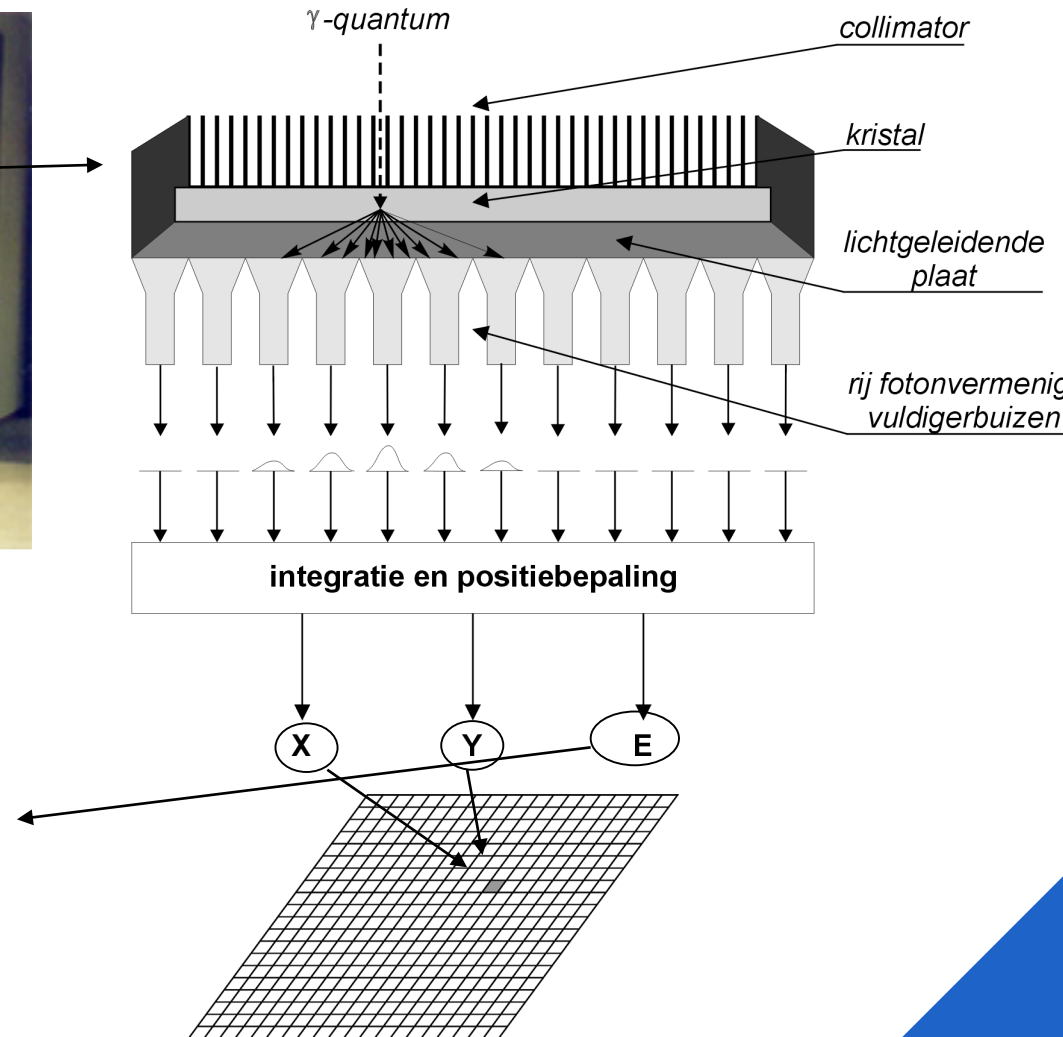


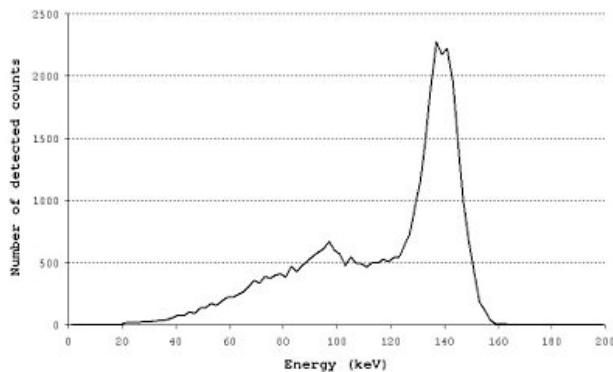


Advances in Nuclear Medicine Imaging Technology: SPECT/CT

Introduction: the gamma camera

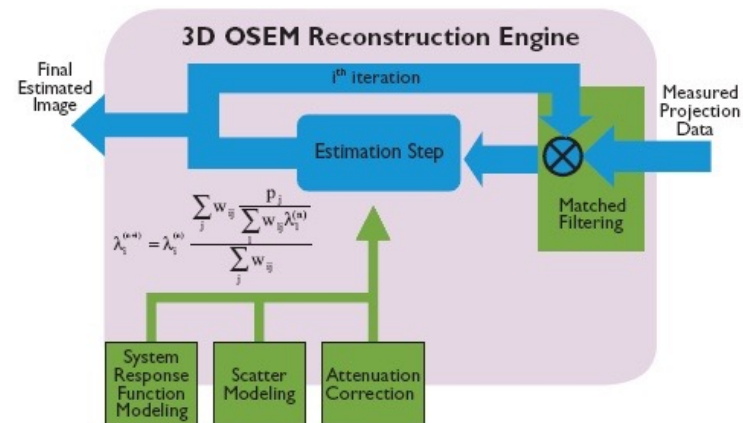
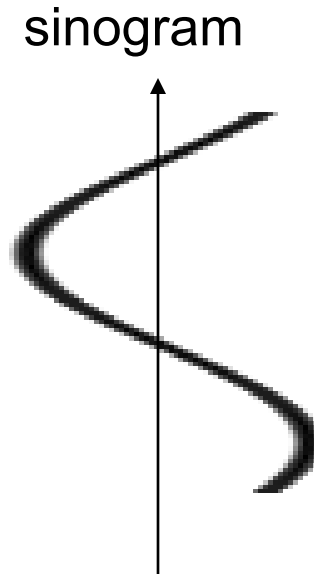


Energy Spectrum



Introduction: the gamma camera

Tomography: measure projections and calculate image



Introduction: the gamma camera

Typical SPECT-system



- ▶ 1 cm spatial resolution @ 10 cm
- ▶ 100 cps/MBq sensitivity
- ▶ 10% energy resolution
- ▶ 50 cm x 40 cm FOV
- ▶ ° 1957 Anger

Preclinical SPECT systems



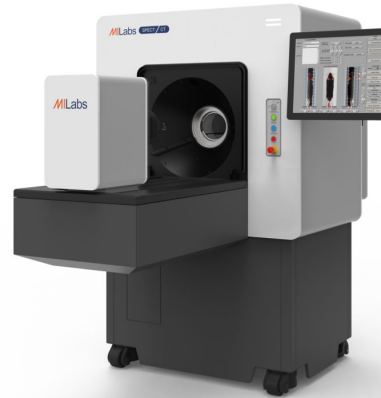
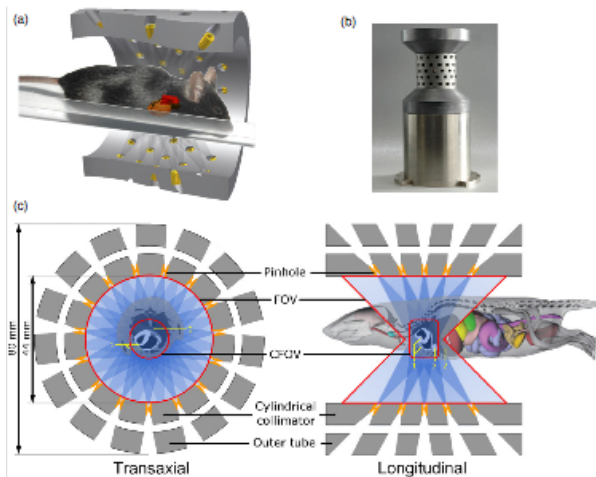
- ▶ 1 cm spatial resolution
- ▶ 100 cps/MBq sensitivity
- ▶ 10% energy resolution
- ▶ 50 cm x 40 cm FOV



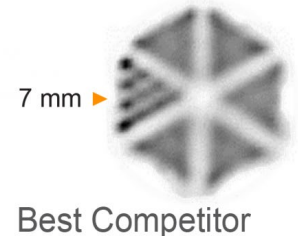
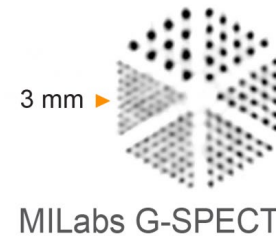
- ▶ e.g. γ -cube
- ▶ 0,5 mm spatial resolution
- ▶ 2000 cps/MBq sensitivity
- ▶ 10% energy resolution
- ▶ 3 cm x 1,5 cm FOV

Preclinical SPECT systems

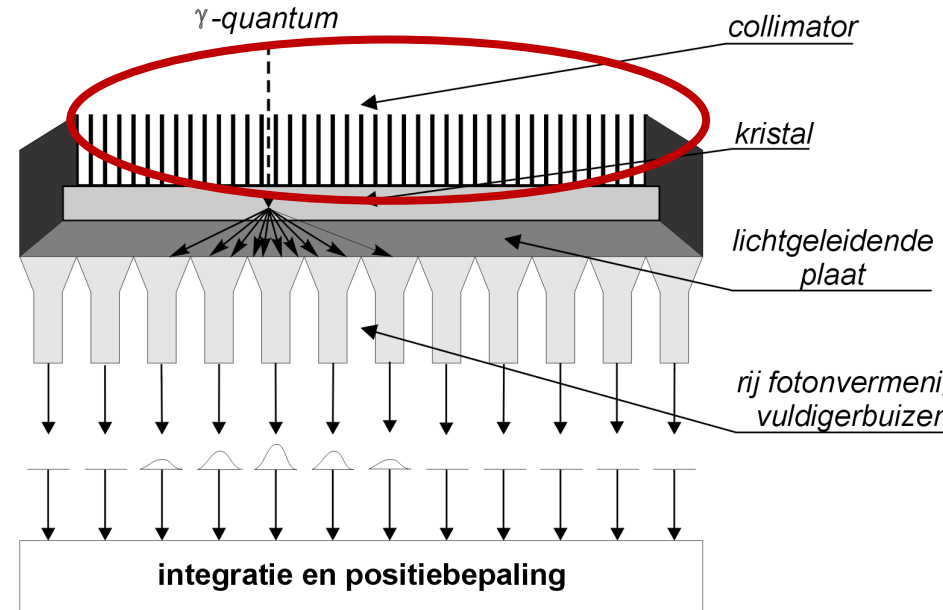
- ▶ Innovative field with concepts that sometimes translate to human scanners



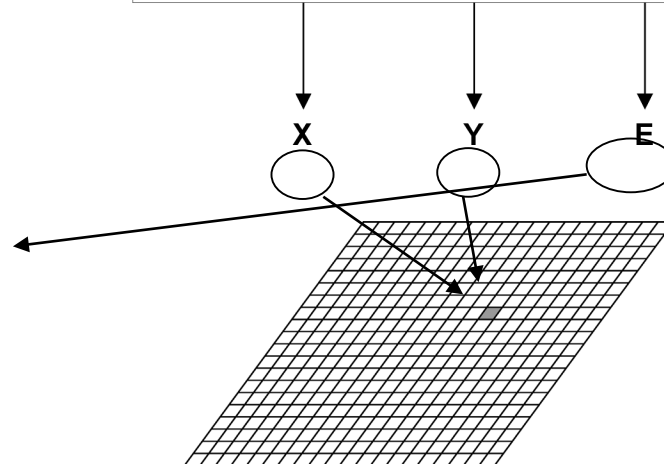
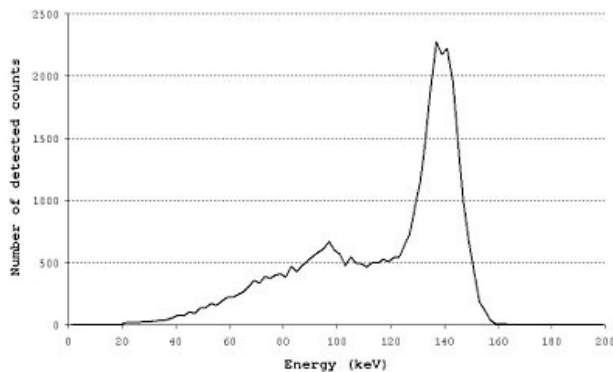
- ▶ e.g. Milabs
- ▶ G-SPECT



Collimator design



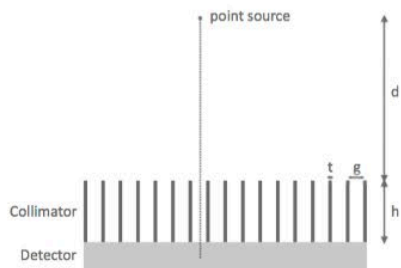
Energy Spectrum



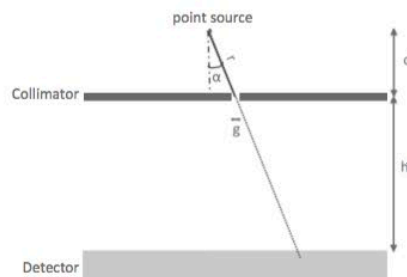
Collimator design

► Different types of collimators

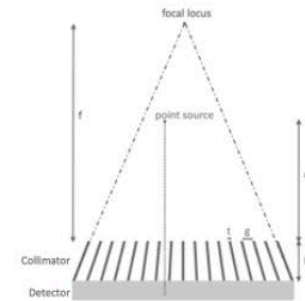
Parallel Hole



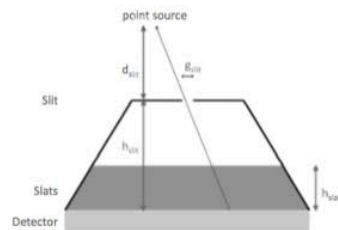
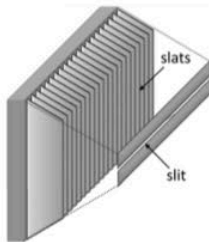
Pinhole



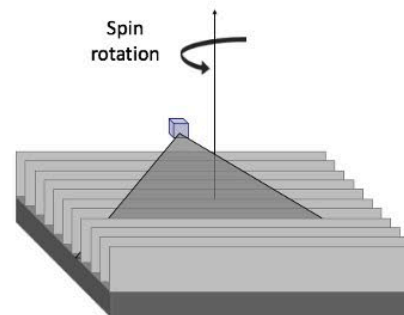
Fanbeam/Conebeam



Slit Slat



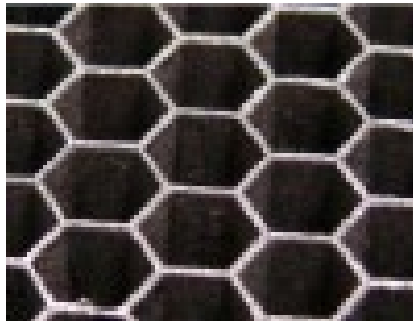
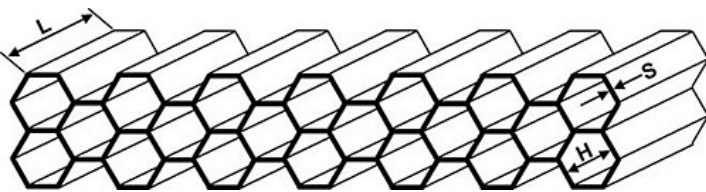
Rotating Slat



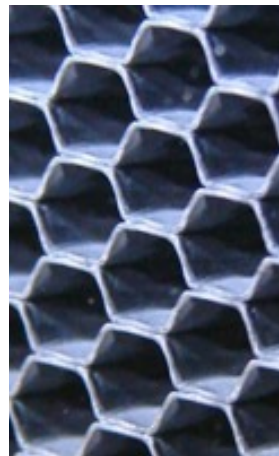
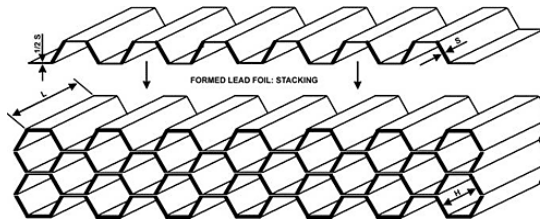
Collimator design

- ▶ Standard production techniques

Casting



Folding

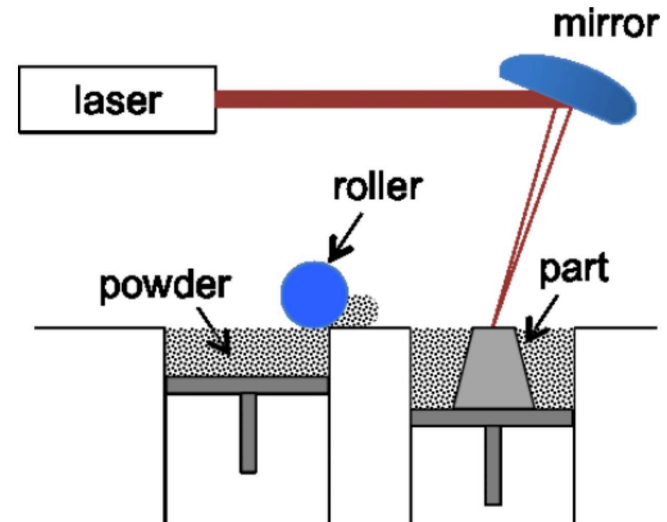
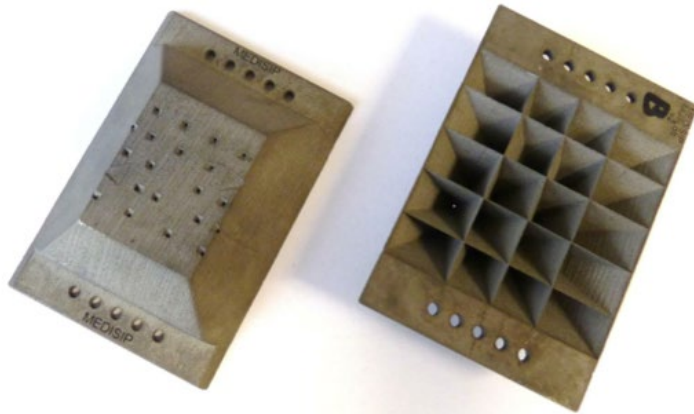
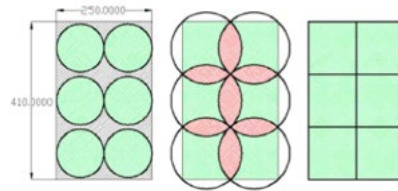
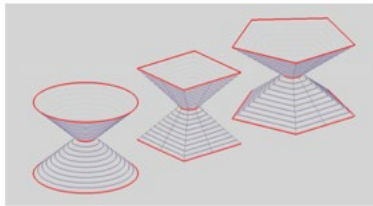


Drilling/Milling



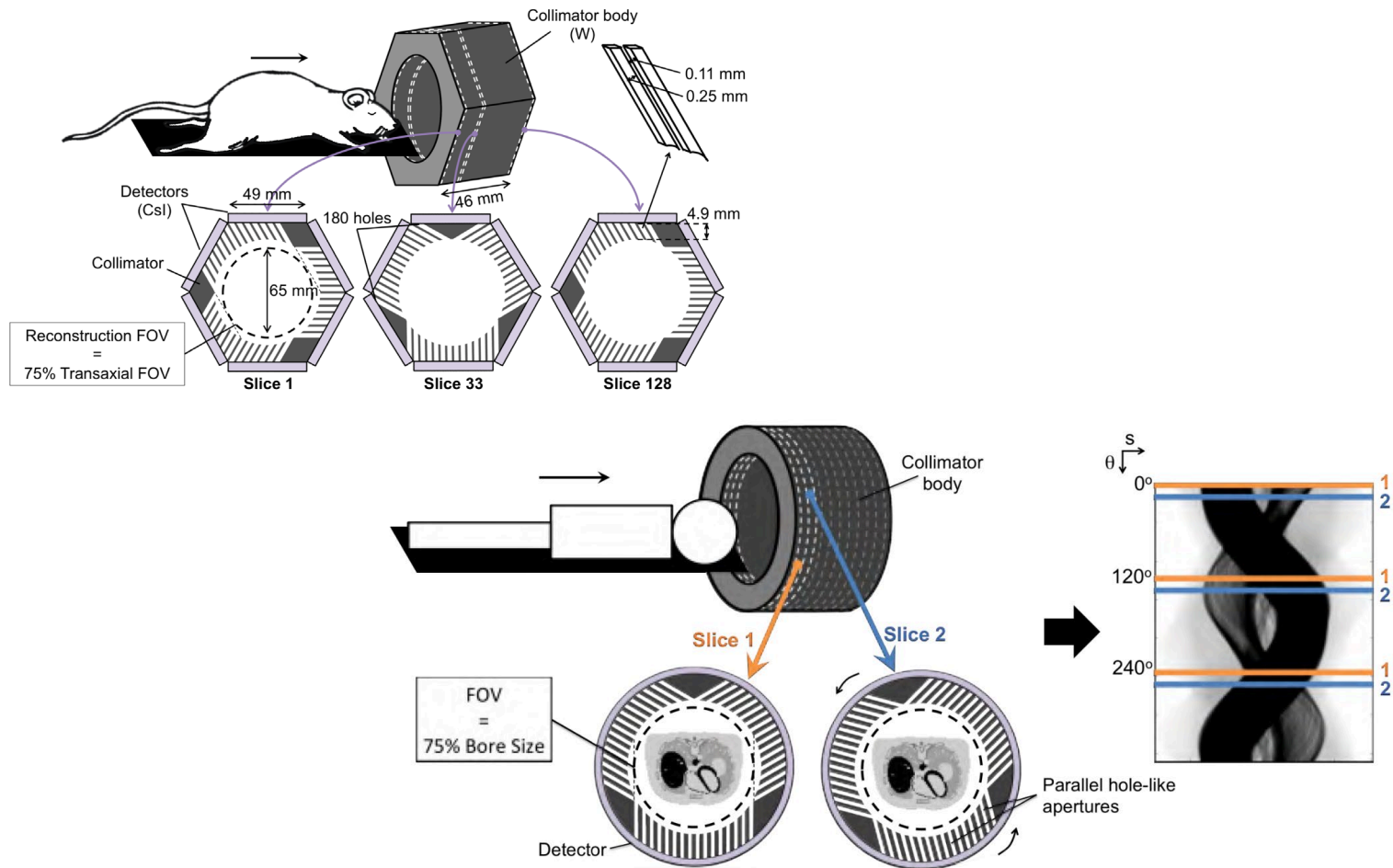
Collimator design

- ▶ New production techniques enable new collimator designs
- ▶ Eg 3D Printing, Additive Manufacturing: lofthole collimator



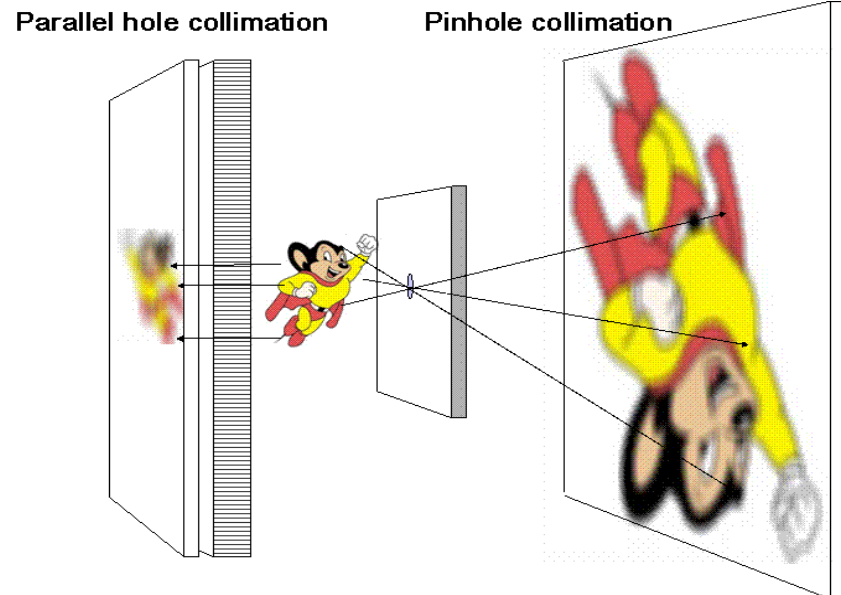
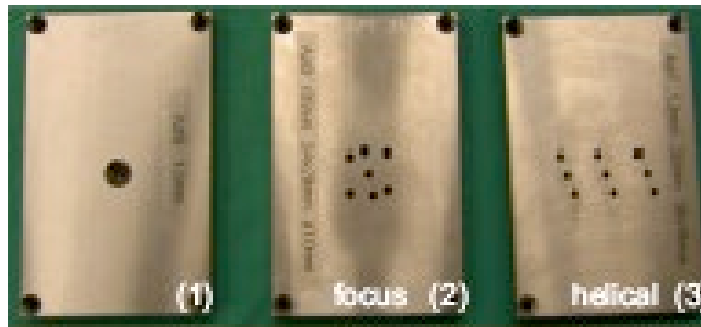
Collimator design

► Spiral-parallel Hole collimator



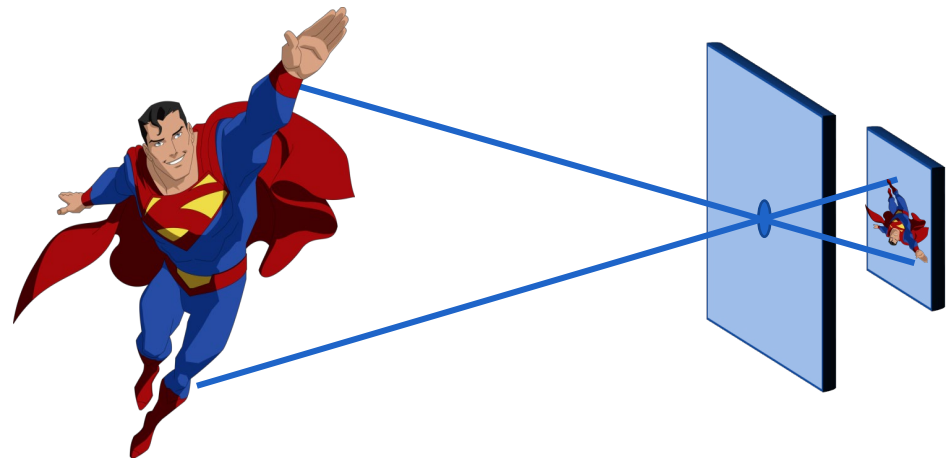
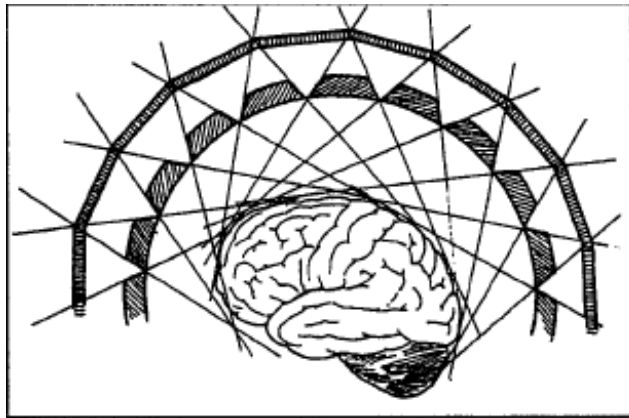
Collimator design

- ▶ Multi-pinhole collimators
 - ▶ Originally used in preclinical SPECT using magnification to improve resolution



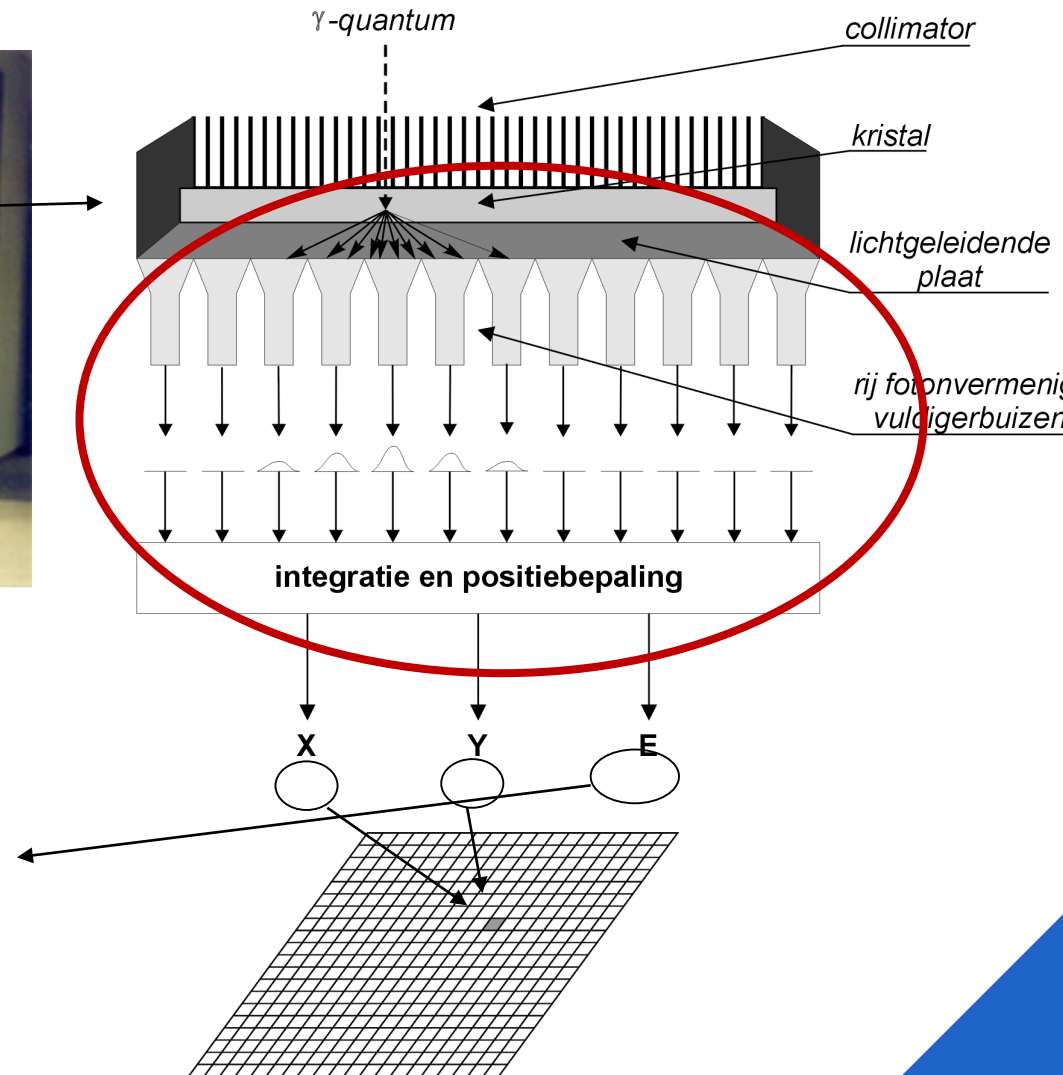
Collimator design

- ▶ Multi-pinhole collimators
 - ▶ Optimize sensitivity by using minification: need good intrinsic resolution

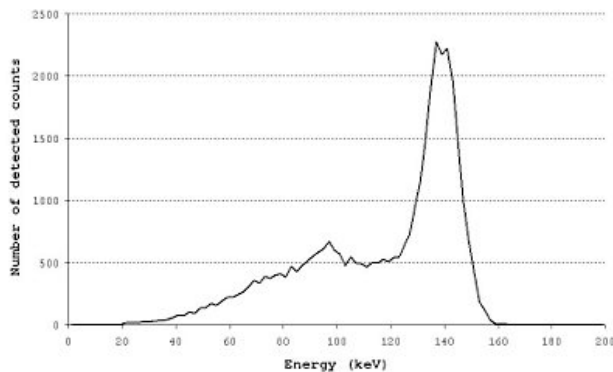


*Rogulski et al. IEEE Trans Nucl Sci
1993; 1123-1129*

New Detectors: Solid State



Energy Spectrum

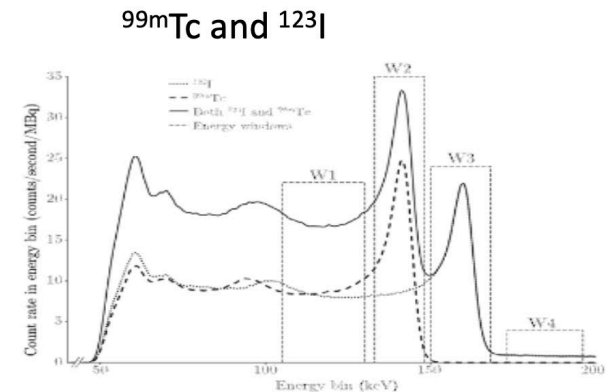
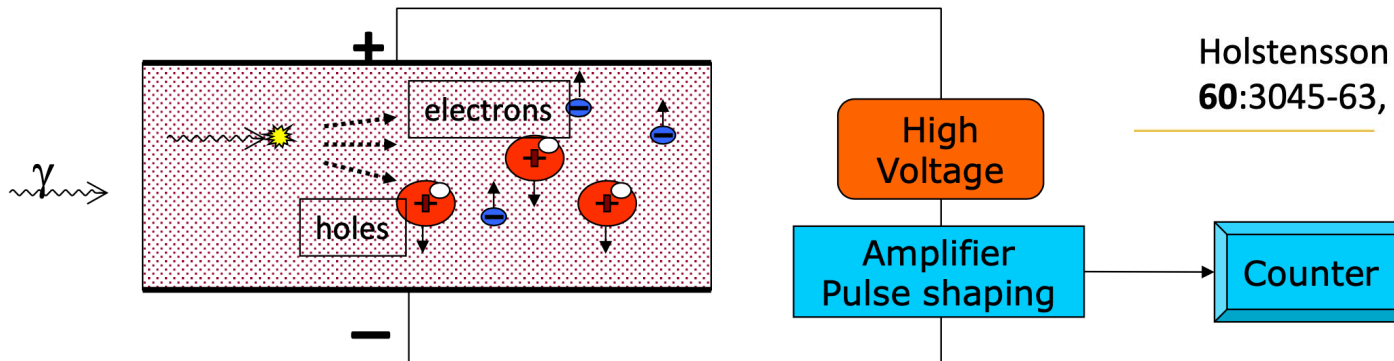


New Detectors: solid state

- ▶ Direct conversion, eg CZT
 - ▶ Indirect conversion: Scintillator + device to replace PMT's (eg SiPMs)
 - ▶ More compact, modular, MRI-compatible
 - ▶ Enables new, flexible designs
- 
- A solid blue triangle is located in the bottom right corner of the slide, pointing towards the top right.

CZT

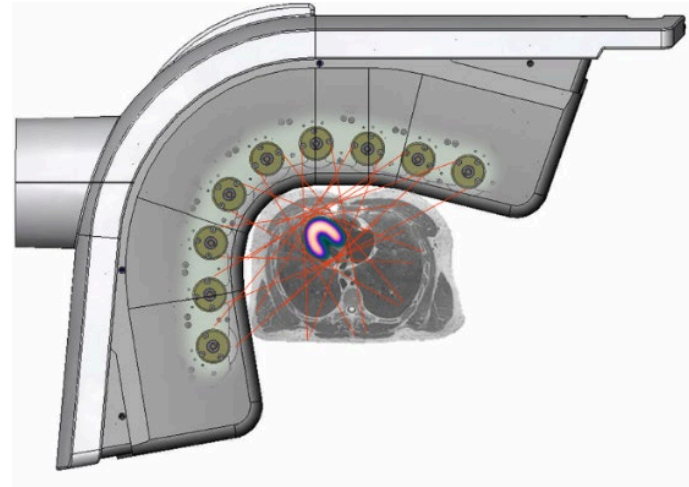
- ▶ Direct conversion of gamma to electrical signal
- ▶ Better energy resolution
- ▶ Good intrinsic resolution



Holstensson et al., *Phys. Med. Biol.*
60:3045-63, 2015

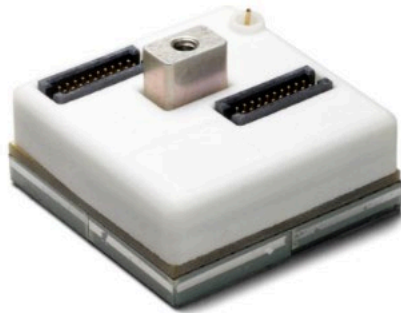
CZT based systems: D-SPECT

- ▶ Dedicated cardiac
- ▶ Detectors rotate around own axis (swivel)
- ▶ Adaptive acquisition
(high sensitivity in heart)



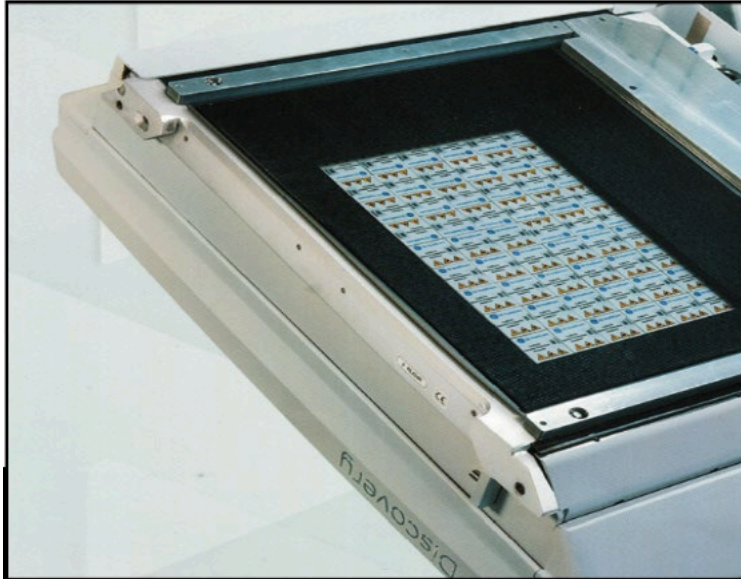
CZT based systems: GE Discovery 530c

- ▶ Dedicated cardiac
- ▶ Detectors fixed focus on heart
- ▶ No detector movement



CZT based systems: GE Discovery 670

- ▶ Full body detector
- ▶ Matched collimator

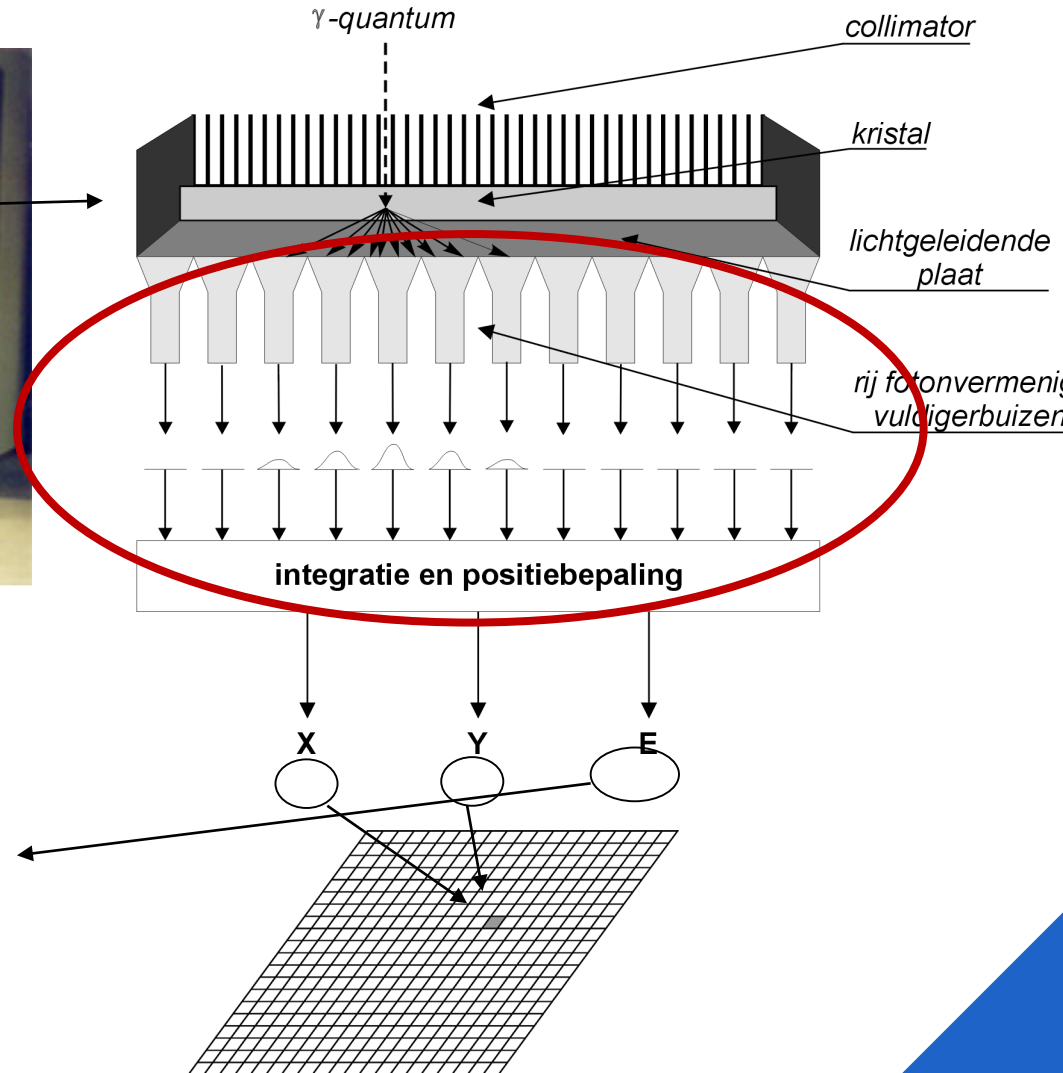


CZT based systems: Veriton-CT

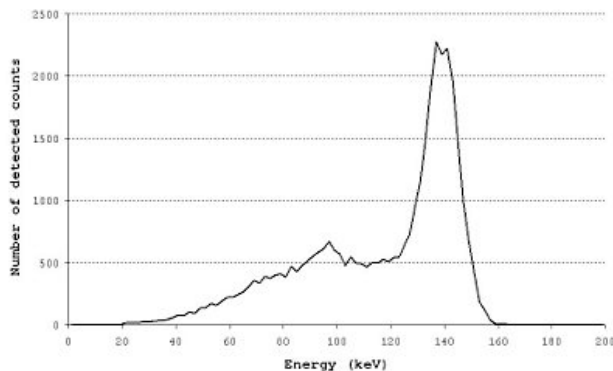
- ▶ Swiveling detectors
- ▶ In and out motion
- ▶ Body contouring
- ▶ Focused imaging



New Detectors: Solid State, indirect

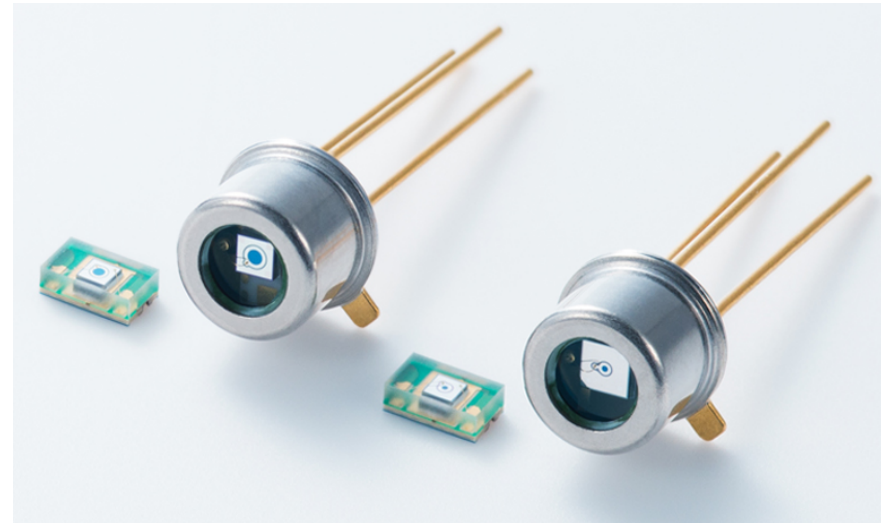


Energy Spectrum



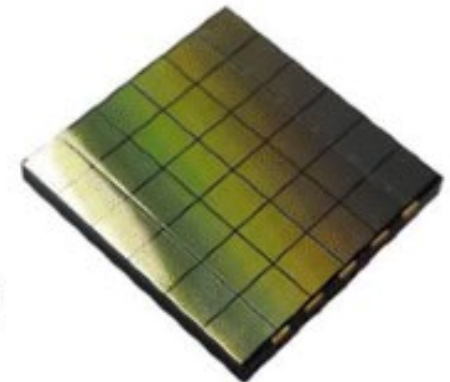
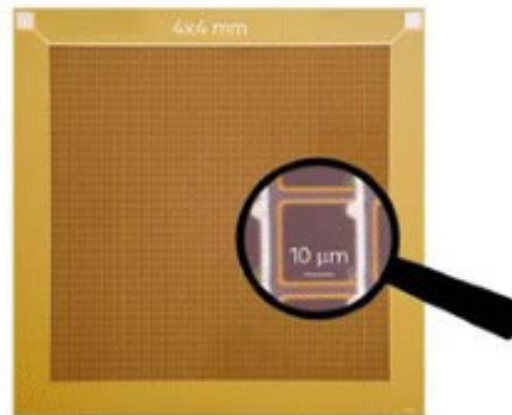
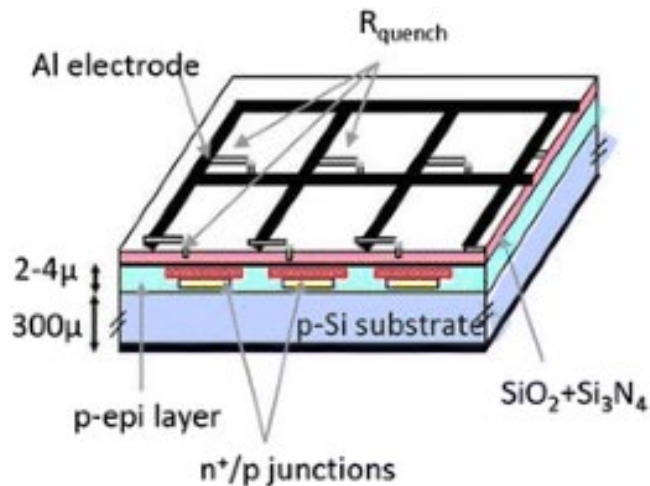
Avalanche Photodiode

- ▶ Converts scintillation light too electrical pulse
- ▶ Replaces PMT
- ▶ Compact and MRI-compatible



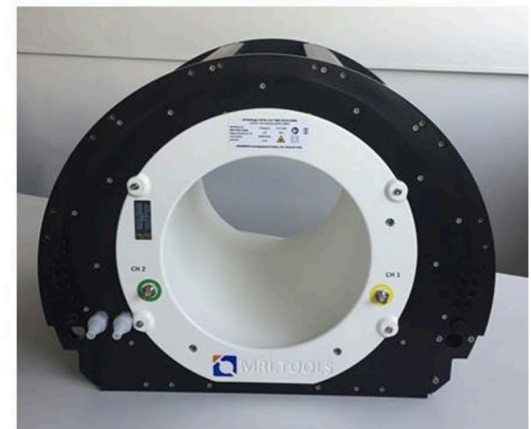
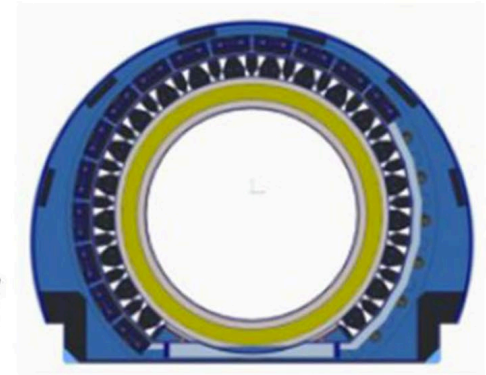
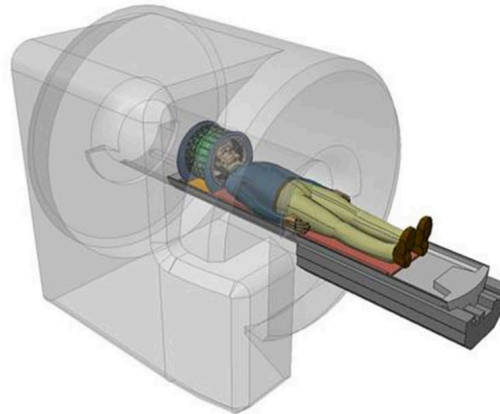
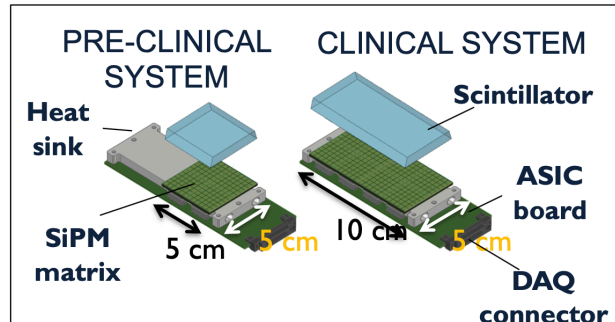
SiPM (Silicon Photomultiplier)

- ▶ Array of APD's in Geiger mode
- ▶ Gain similar to PMT
- ▶ Compact and MRI-compatible
- ▶ Used in PET



SPECT/MRI

- MRI compatible SPECT insert based on SiPMs

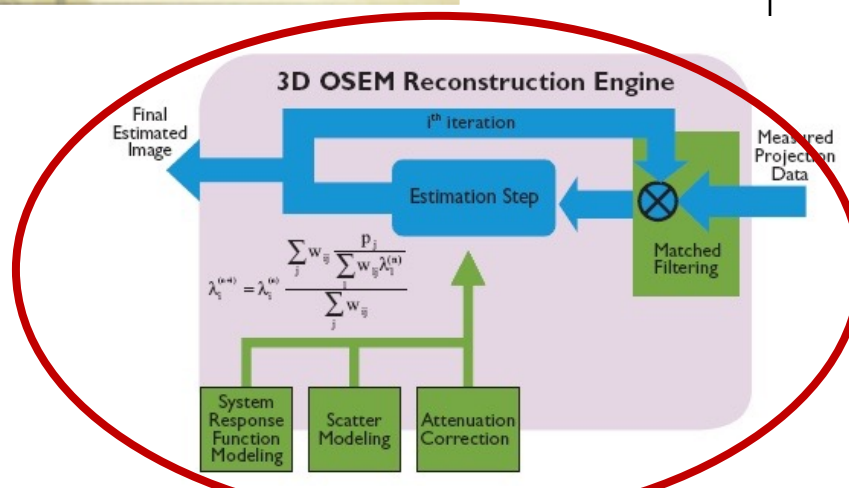
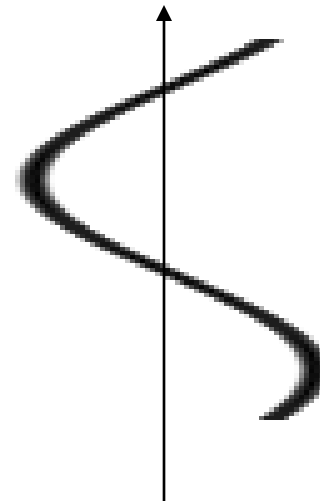


Introduction: the gamma camera

Tomography: measure projections and calculate image



sinogram

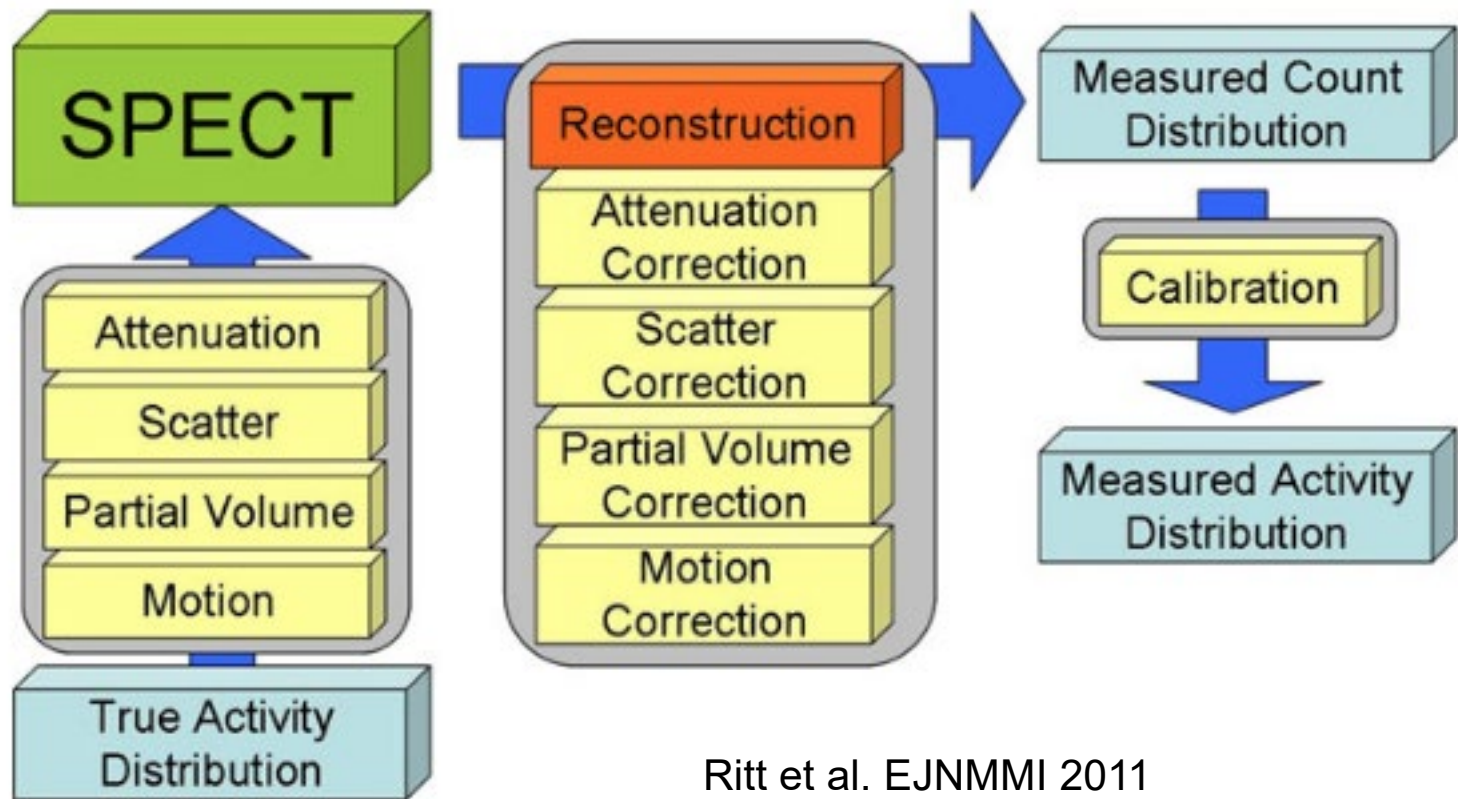


Quantitative SPECT

- **Historically, PET regarded as quantitative, and SPECT non-quantitative**
 - SPECT as “hot spot imaging”
 - “... PET is superior to SPECT in both sensitivity and spatial resolution. Furthermore, PET enables quantitation of tissue radioactivity concentrations.” (JNM 2012)
 - PET attenuation correction more straightforward
- **With SPECT-CT and iterative reconstruction, routine quantitative SPECT becomes realistic**

Quantitative SPECT

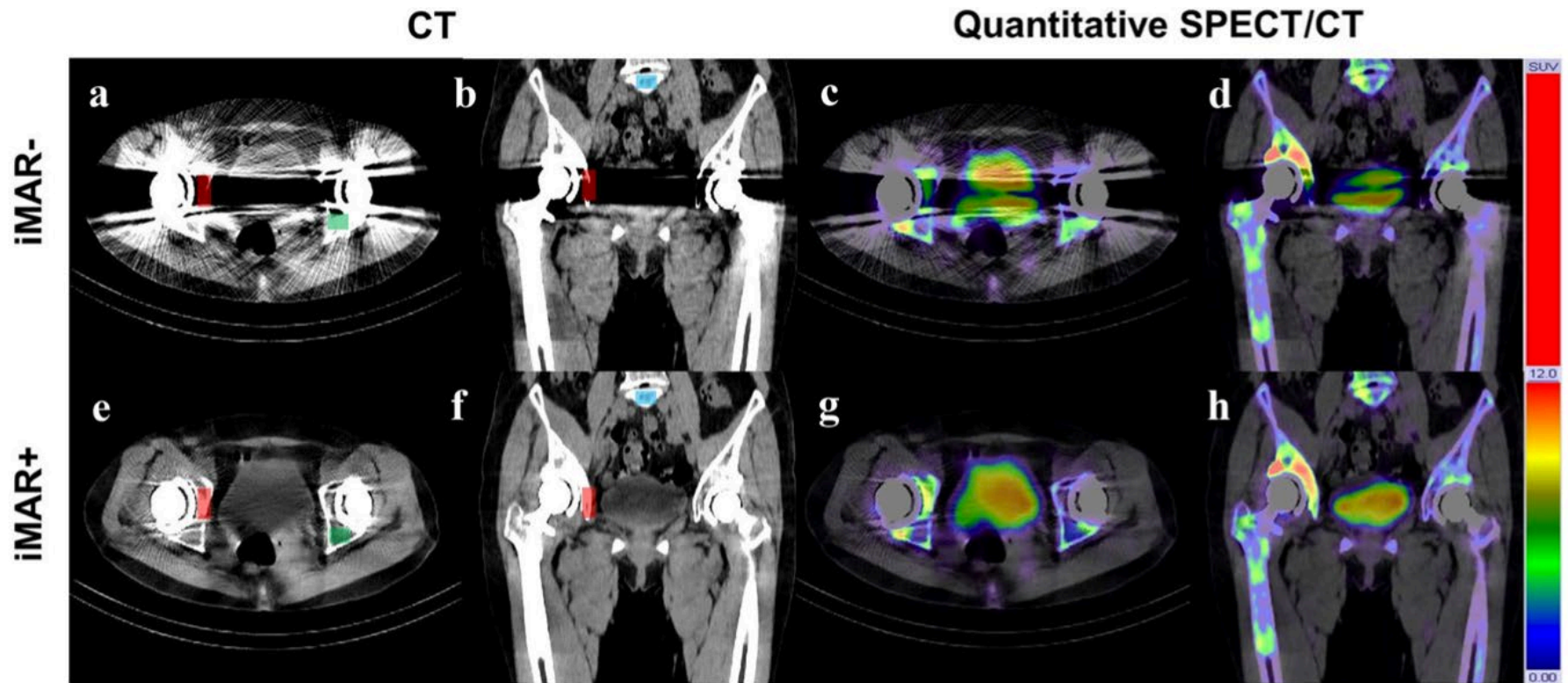
- SPECT Image formation chain**



Ritt et al. EJNMMI 2011

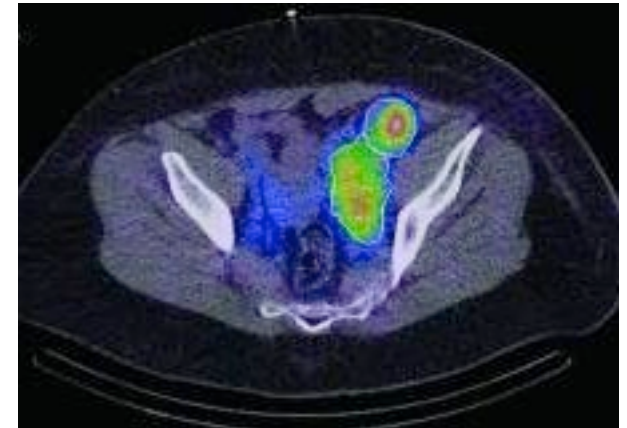
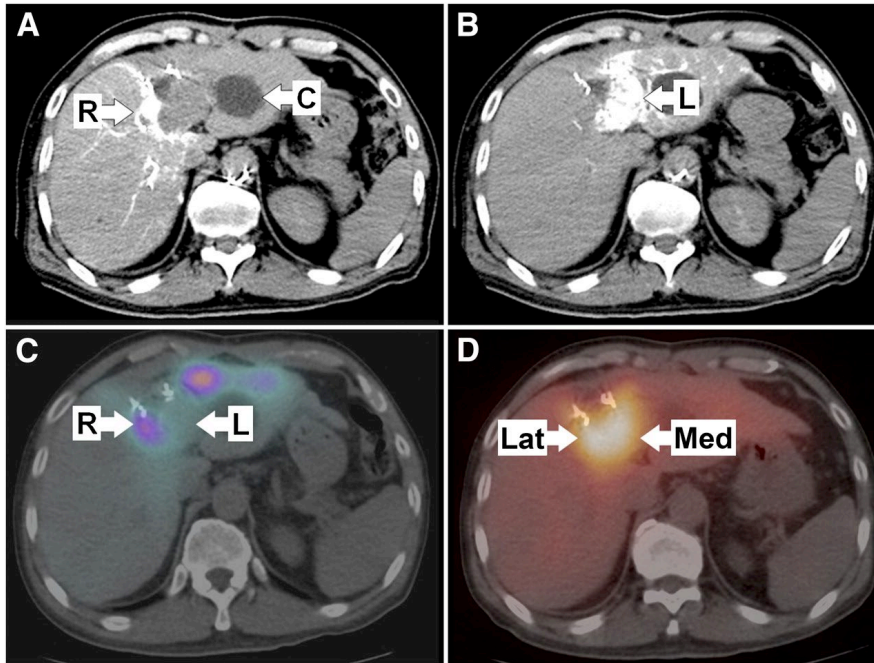
Quantitative SPECT

- Importance of metal artefact reduction



Applications

- ▶ Why Quantitative SPECT?
 - ▶ Use quantitative SPECT to assess disease progression and therapy response
 - ▶ 3D in vivo dosimetry



Applications

TABLE 2
List of Potential Uses for Quantitative SPECT

Radiopharmaceutical/imaging test	Application
Planning/treatment (e.g., ^{111}In , ^{123}I , and ^{177}Lu)	Theranostics using quantitative SPECT for targeting and dosimetry planning in monoclonal antibody, peptide, receptor, or other radionuclide therapy (e.g., tositumomab, ibritumomab tiuxetan, and ^{177}Lu -octreotate) (31,50,51)
$^{99\text{m}}\text{Tc}$ myocardial perfusion imaging	Regional myocardial blood flow in $\text{mL}\cdot 100\text{ g}^{-1}\cdot \text{min}^{-1}$ (52) or myocardial SUV for detection of left main artery or balanced triple-vessel disease; measurement of coronary flow reserve
$^{99\text{m}}\text{Tc}$ functional lung scanning (ventilation or perfusion)	Preoperative assessment of lobar function before surgical resection (53)
$^{99\text{m}}\text{Tc}$ -macroaggregated albumin	Treatment planning and measuring lung uptake (54) plus estimation radiation dosimetry (55) in selective internal radionuclide therapy for liver cancer before radioembolization
$^{99\text{m}}\text{Tc}$ bone scanning	Quantitative measurement of uptake in metabolic bone disease (56)
^{123}I -iodoamphetamine for regional cerebral blood flow	Baseline/acetazolomide challenge in regional cerebral blood flow (34)
^{123}I -labeled neuroreceptor tracers	Neurotransmitter brain imaging of receptor density and occupancy (57,58)
^{123}I -iodide thyroid uptake	Determination of individualized doses for subsequent radioiodine (^{131}I) therapy and monitoring uptake in follow-up
^{131}I in thyroid cancer	SUV in metastatic thyroid cancer and monitoring response to treatment
^{201}Tl myocardial perfusion imaging	Dynamic analysis of myocardial perfusion to derive kinetic parameters K_1 and distribution volume (36)
General imaging	Use of quantitative SPECT to monitor serial scans to assess disease progression or response to treatment (e.g., ^{67}Ga in infection)
Measuring radionuclide biodistribution and dosimetry	More accurate assessment of 3-dimensional biodistribution and radiation dosimetry from new radiopharmaceuticals (31)

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Volg ons op

