



Bundesamt  
für Strahlenschutz



# Introduction to the problem of measuring dose-efficiency

**„Approaches to assess image quality in x-ray diagnostics“**

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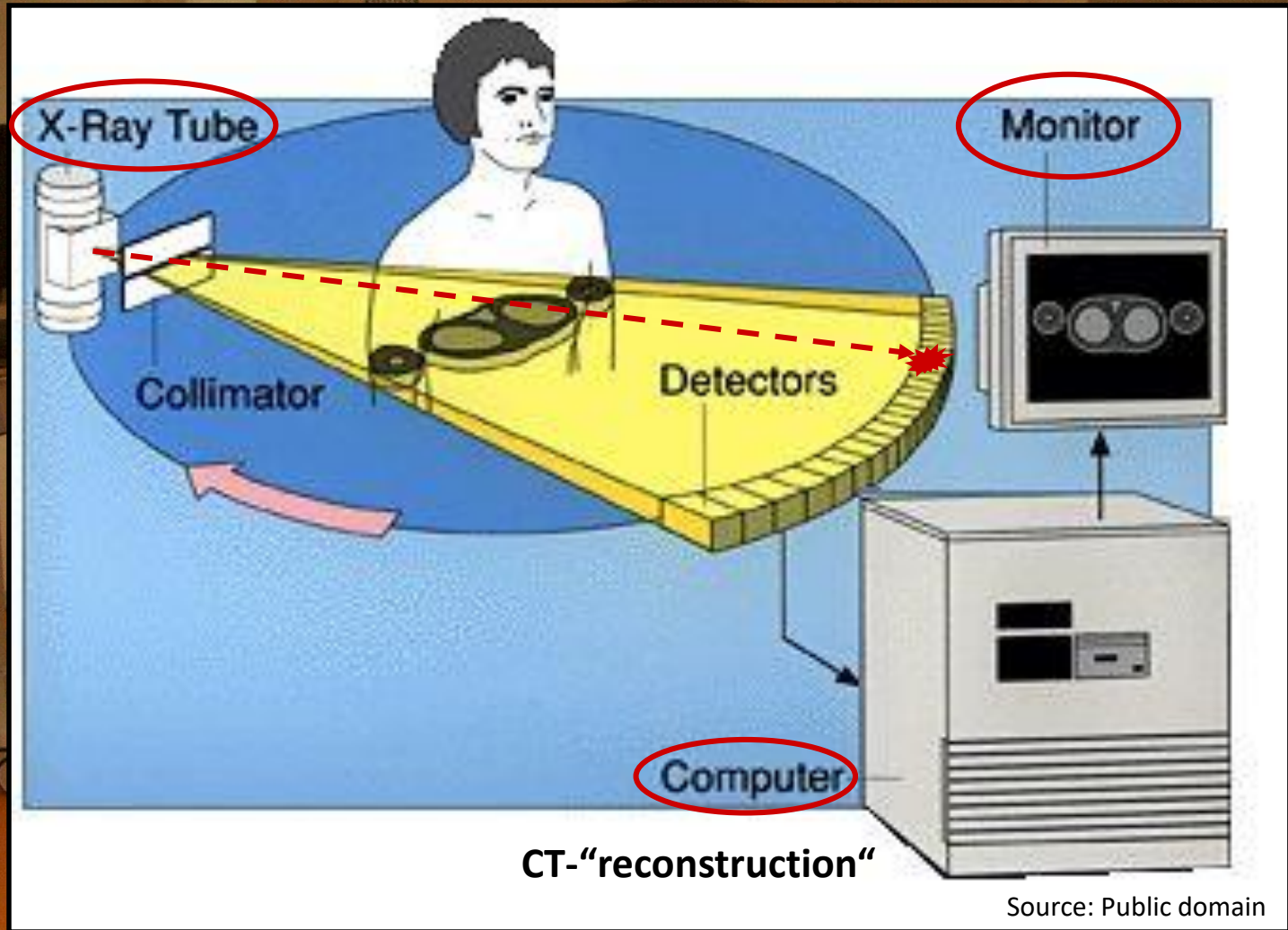
CCRI webinar, 05.11.2024



Source: Public domain

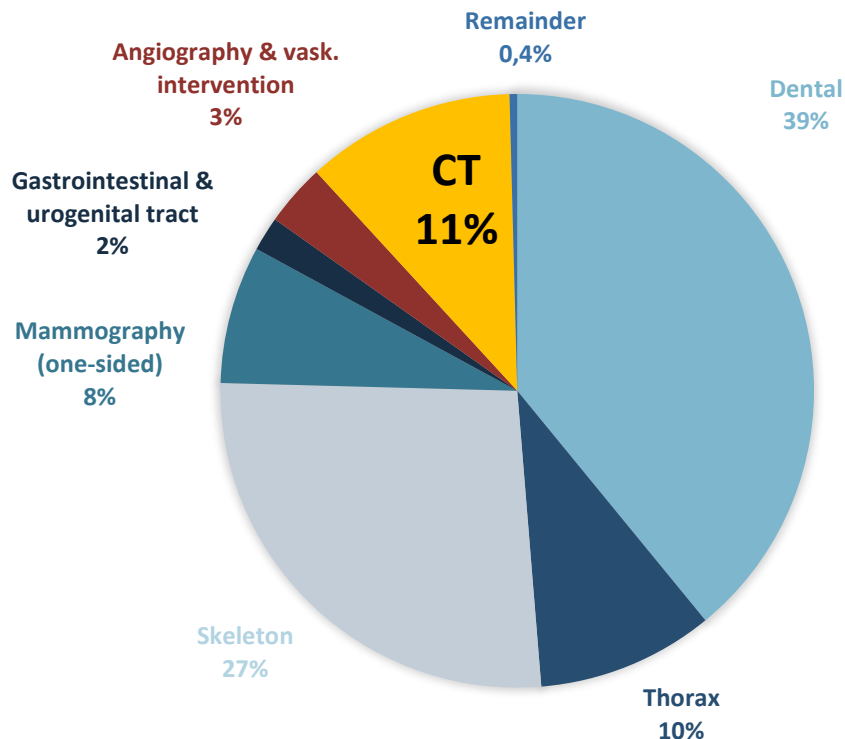
Source: Public domain



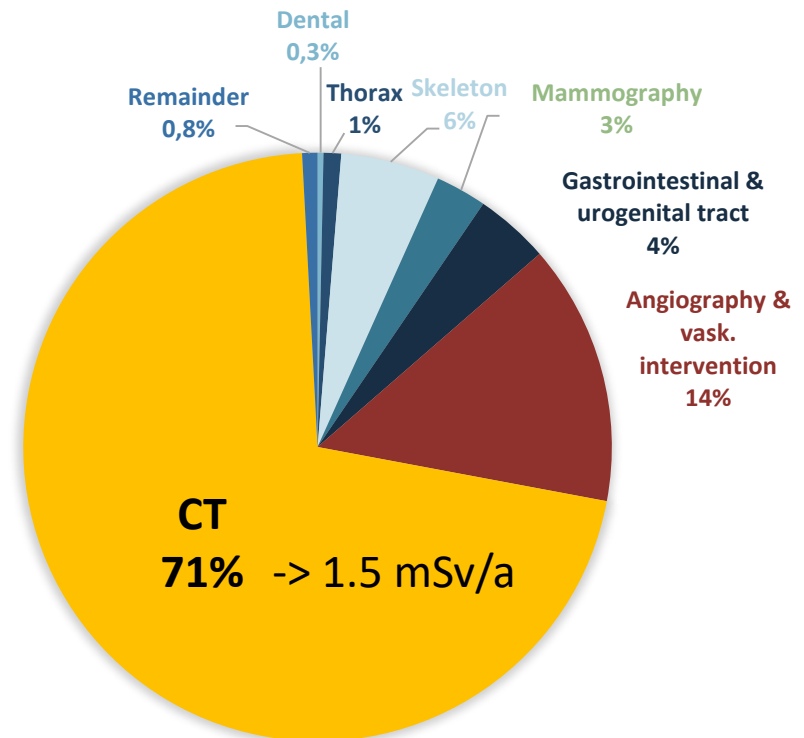


# The largest contribution to **man-made radiation burden** comes from **CT examinations**

## Diagnostic procedures



## Collective effective dose

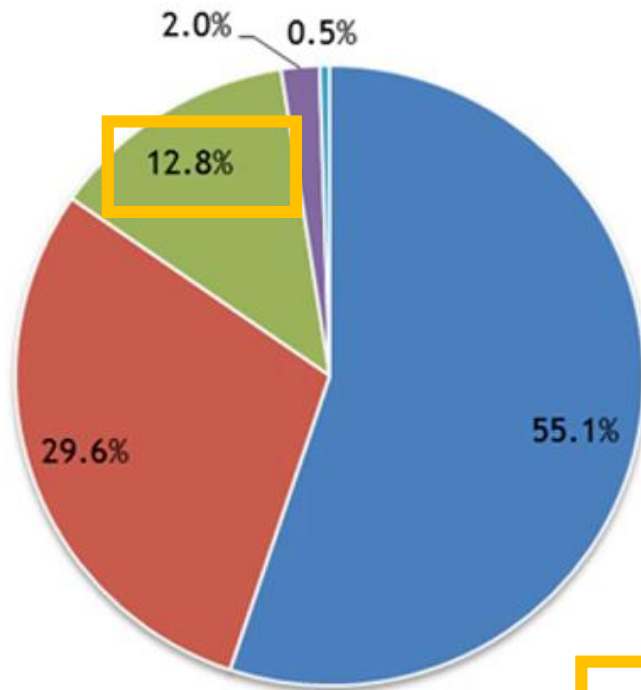


(Between 1 and 50 mSv per examination)

Source: BfS (Germany, 2021)

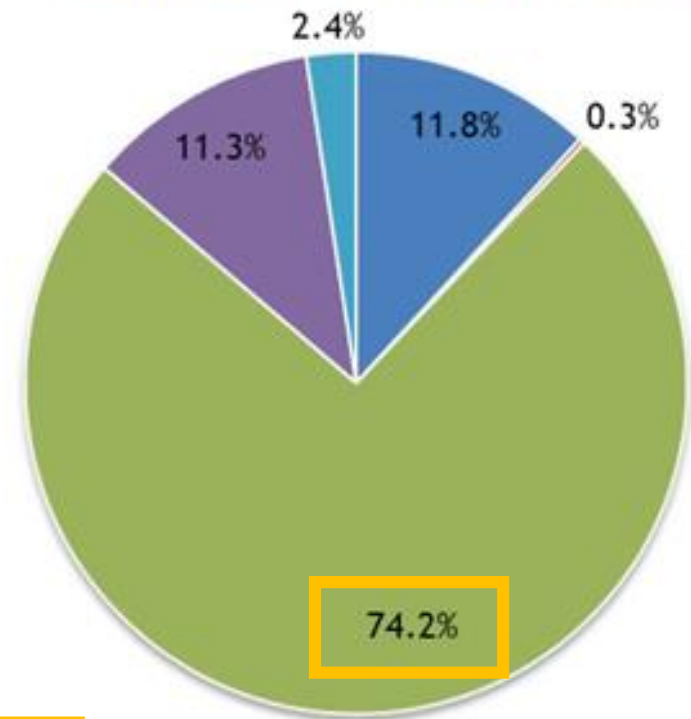
The numbers in **France** are similar (data published in 2021)

## Diagnostic procedures



- Conventional radiology
- Dental radiology
- Computed tomography
- Nuclear medicine
- Diag. interv. radiology

## Collective effective dose

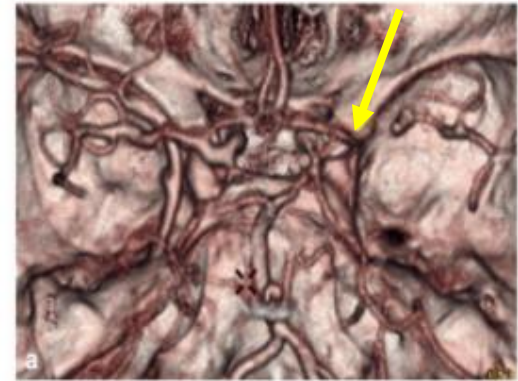


Source: Exposure of the French population to ionizing radiation from medical imaging 2017 (ECR 2021)





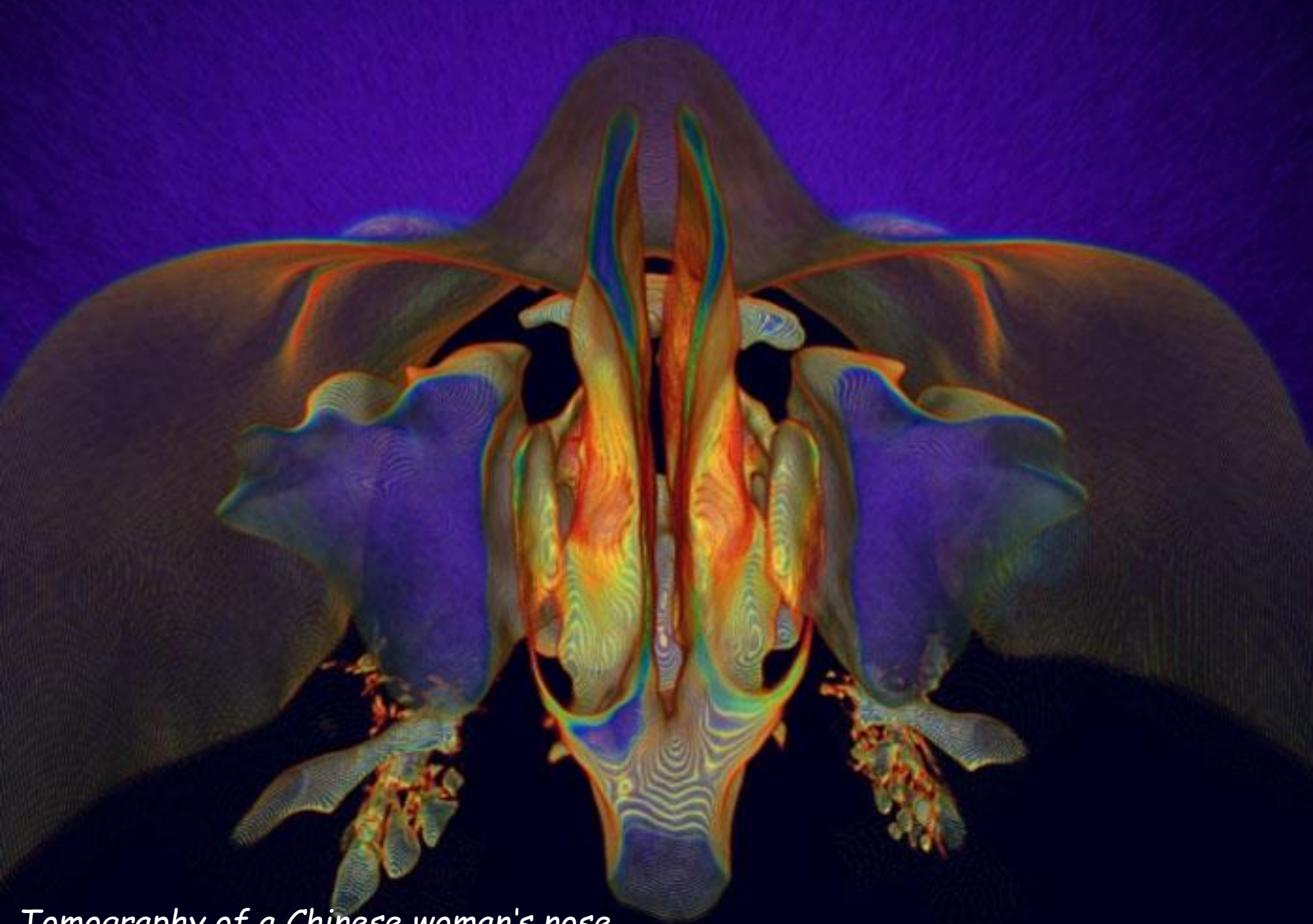
Heart-CT in vivo



Arterial occlusion



Cranial Section



*Tomography of a Chinese woman's nose*  
Winner of the contest "Images in Science 2007" of the journal Science





*Radiation Overdoses Point Up  
Dangers of CT Scans*

October 15, 2009 (206 cases of overdose)

**The New York Times**





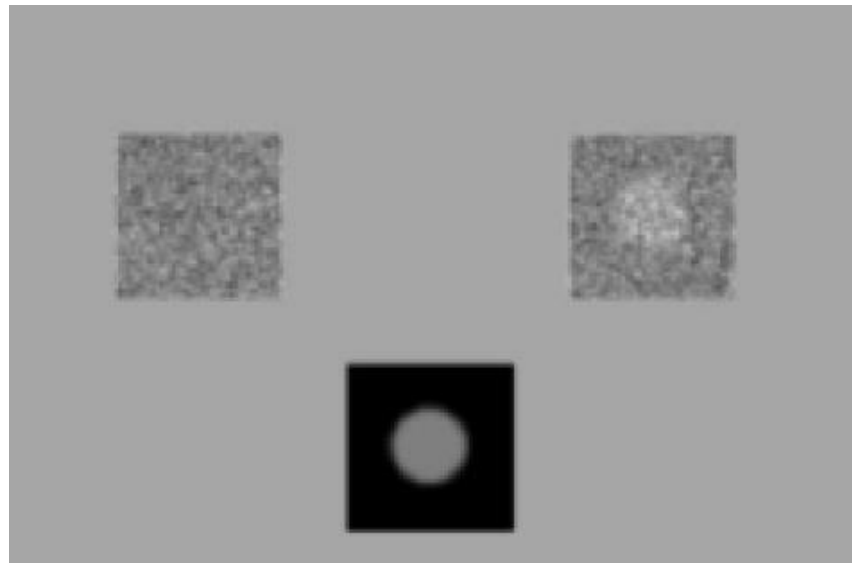
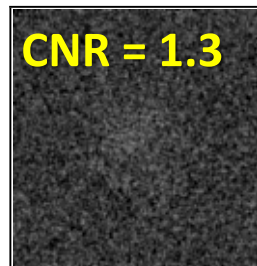
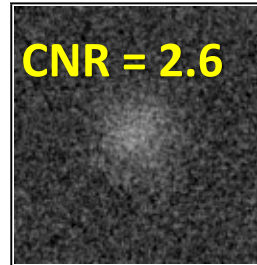
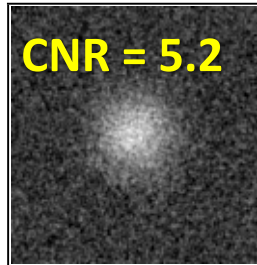
-> The issue with the **structure** of noise

Our perception of images is **strongly influenced by „frequencies“**





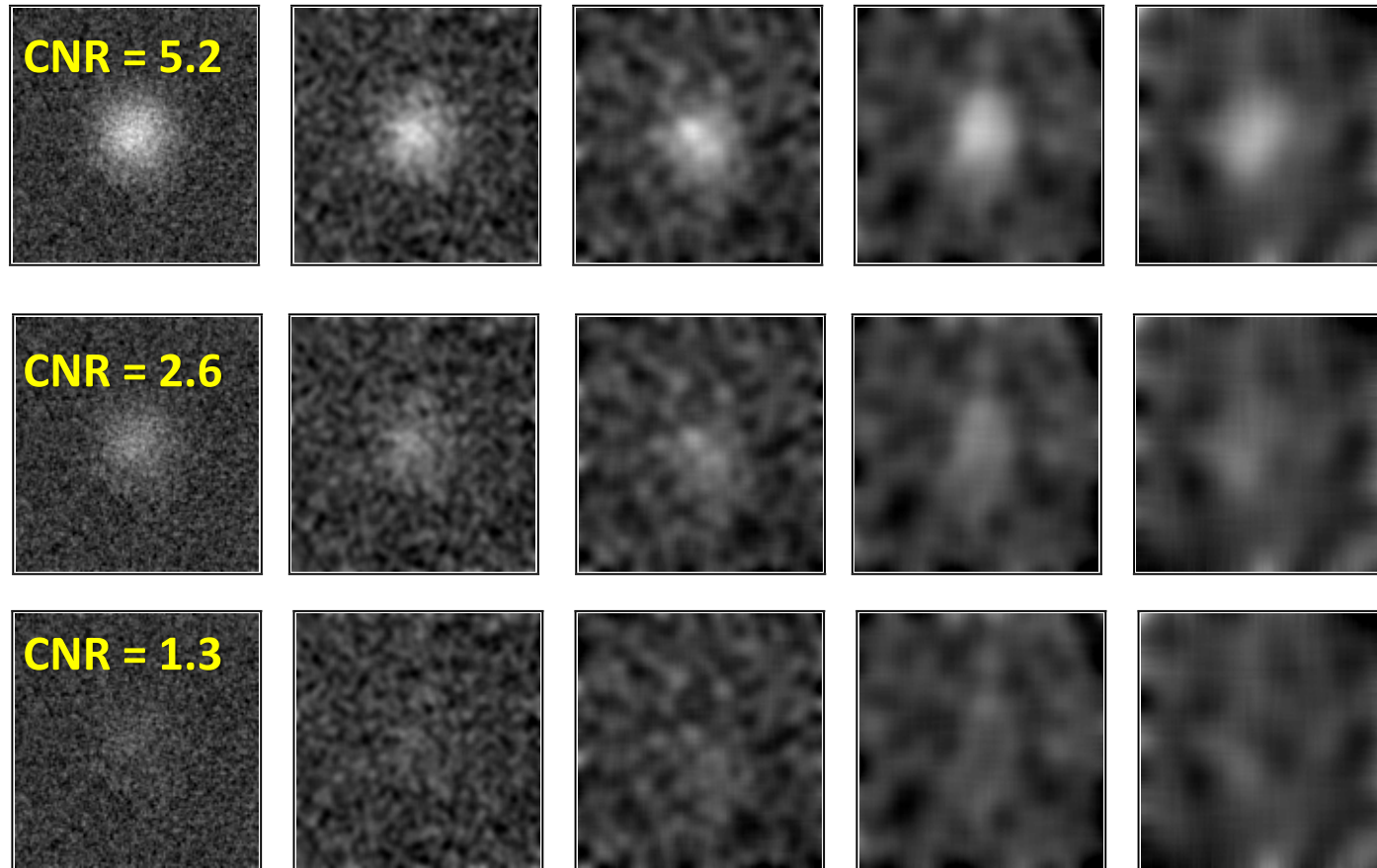
The **detectability of signals** (such as tumors)  
is thus also strongly **dependent on frequencies... of image noise**



Changing the frequency of noise



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is thus also strongly **dependent on frequencies...** of image noise



Changing the frequency of noise







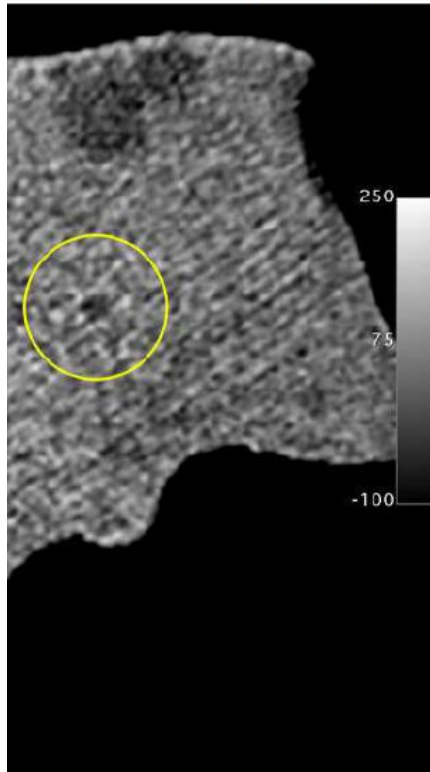
# A clinical example from CT

**Current CT-reconstruction algorithms** affect the **structure** of noise (i. e. its frequency spectrum) – and thus also **detectability of lesions!**

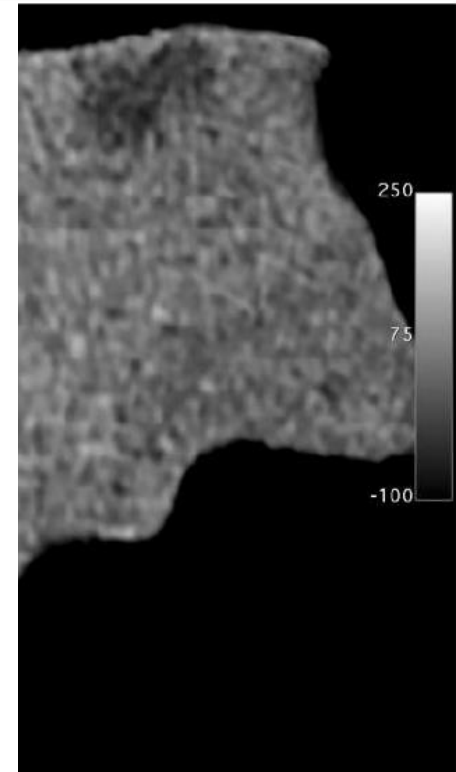
### FBP

### Iterative reconstruction (2012)

*Liver phantom with cystic lesions*



CNR = 5.1 CTDI = 10.6 mGy

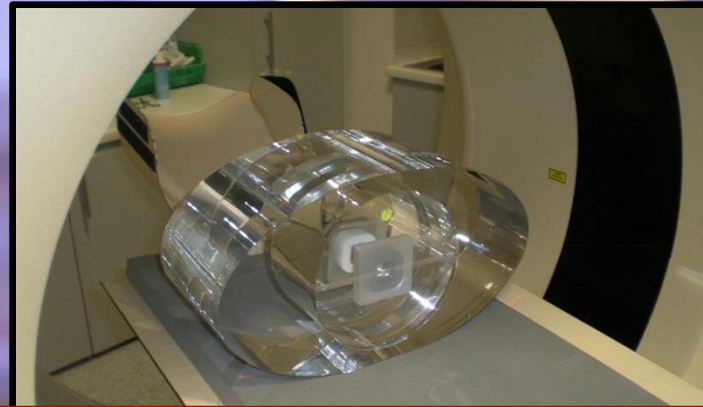


CNR = 5.3 CTDI = 1.6 mGy

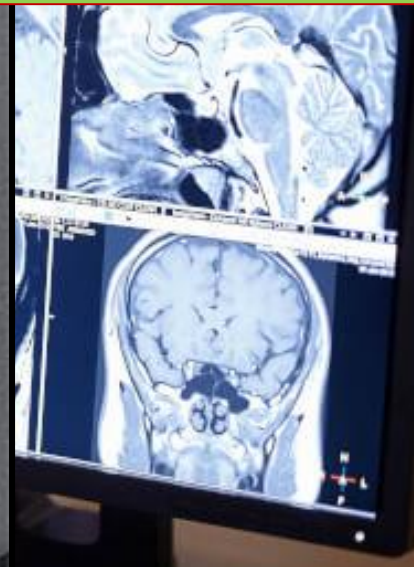
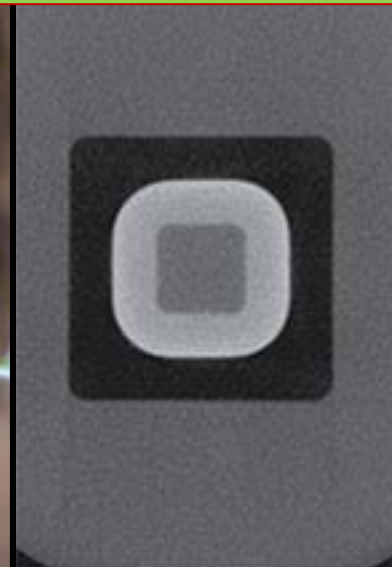
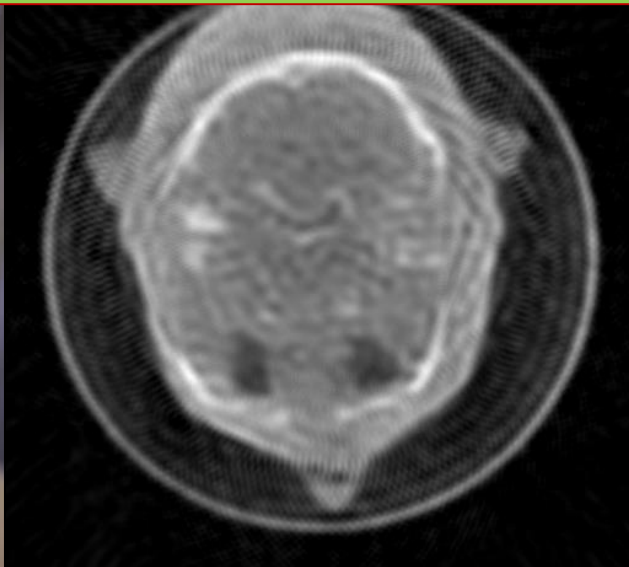




# How does **quality assurance** in **CT** work?



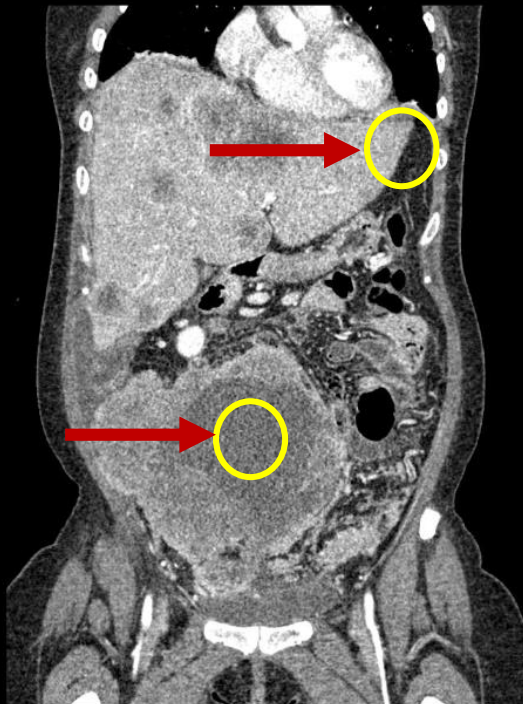
Before „iterative reconstruction“ arrived (around 2010), assumptions of **linearity** and **shift-invariance** were granted



... But modern algorithms are **local and non-linear**

Reduction of noise (blurring)...

...and preservation of edges  
(without blurring!)



Filtered backprojection  
(since ca. 1980)



Iterative reconstruction  
(since ca. 2012)



Deep-learning based  
(since 2022)

⇒ **Assumptions for traditional QA do not hold!**



# So... how can we update quality assurance?

- M. Göppel

BfS: Federal Office for Radiation protection

- M. Anton

PTB: National Metrology Institute



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für Strahlenschutz**

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