ICRP TG108 Workshop

Optimisation of Radiological Protection in Digital Radiology Techniques for Medical Imaging
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Taking account of image quality

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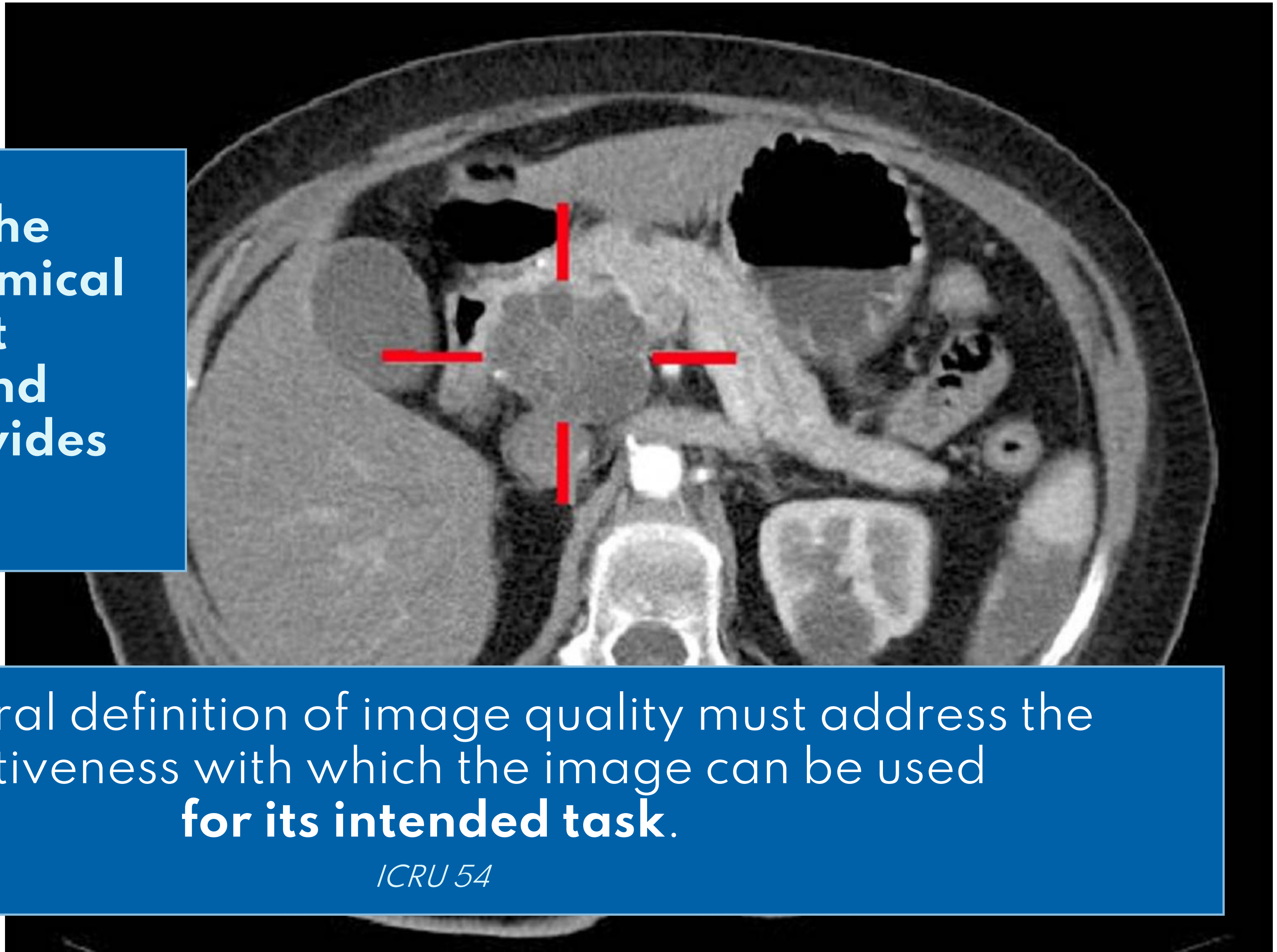
Main objective of image quality



The image quality relates to the capability of providing anatomical or functional information that enables accurate diagnosis and informs care decisions or provides guidance for intervention.

Any general definition of image quality must address the effectiveness with which the image can be used **for its intended task**.

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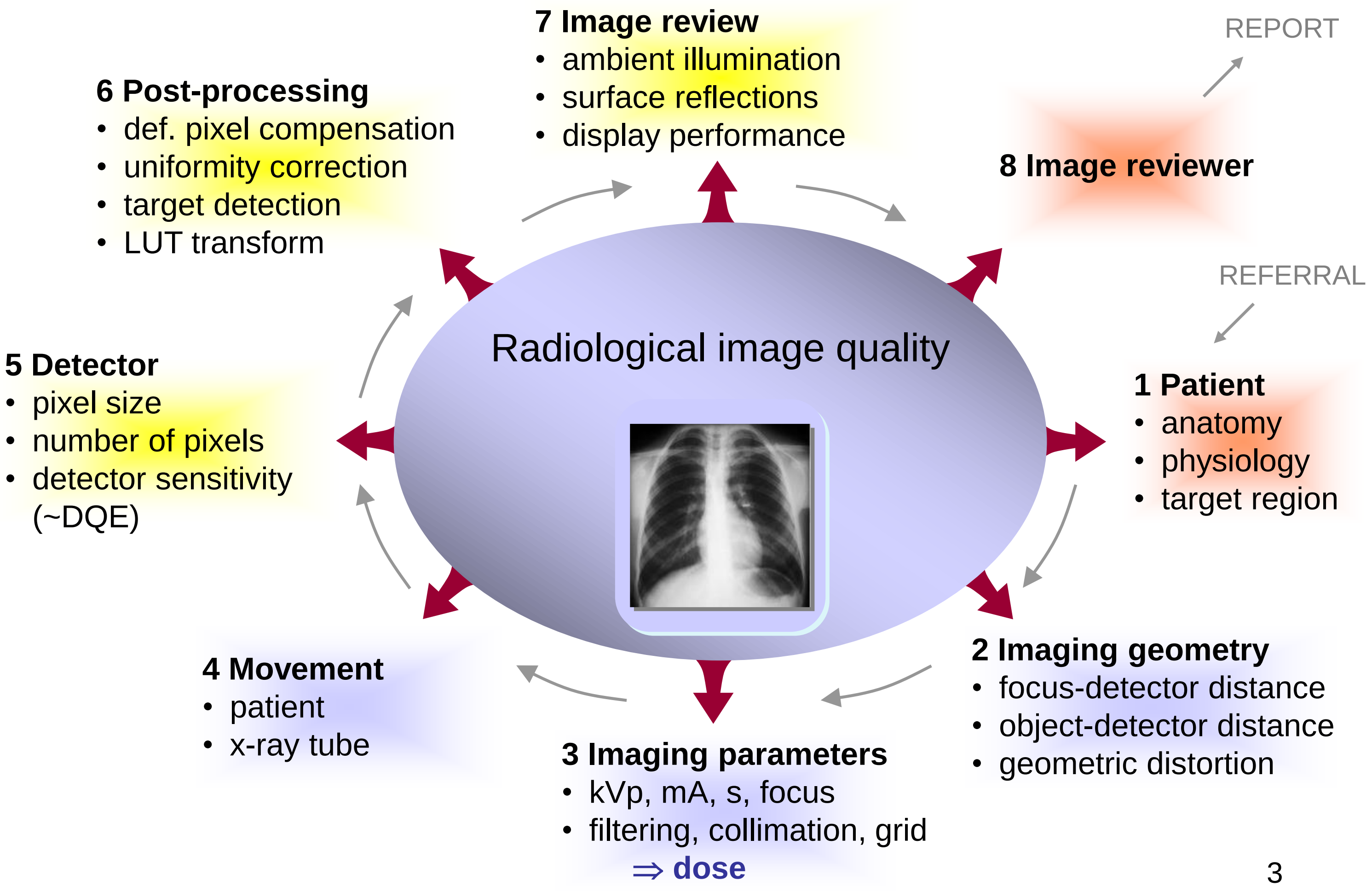
Factors affecting dose and image quality in digital imaging



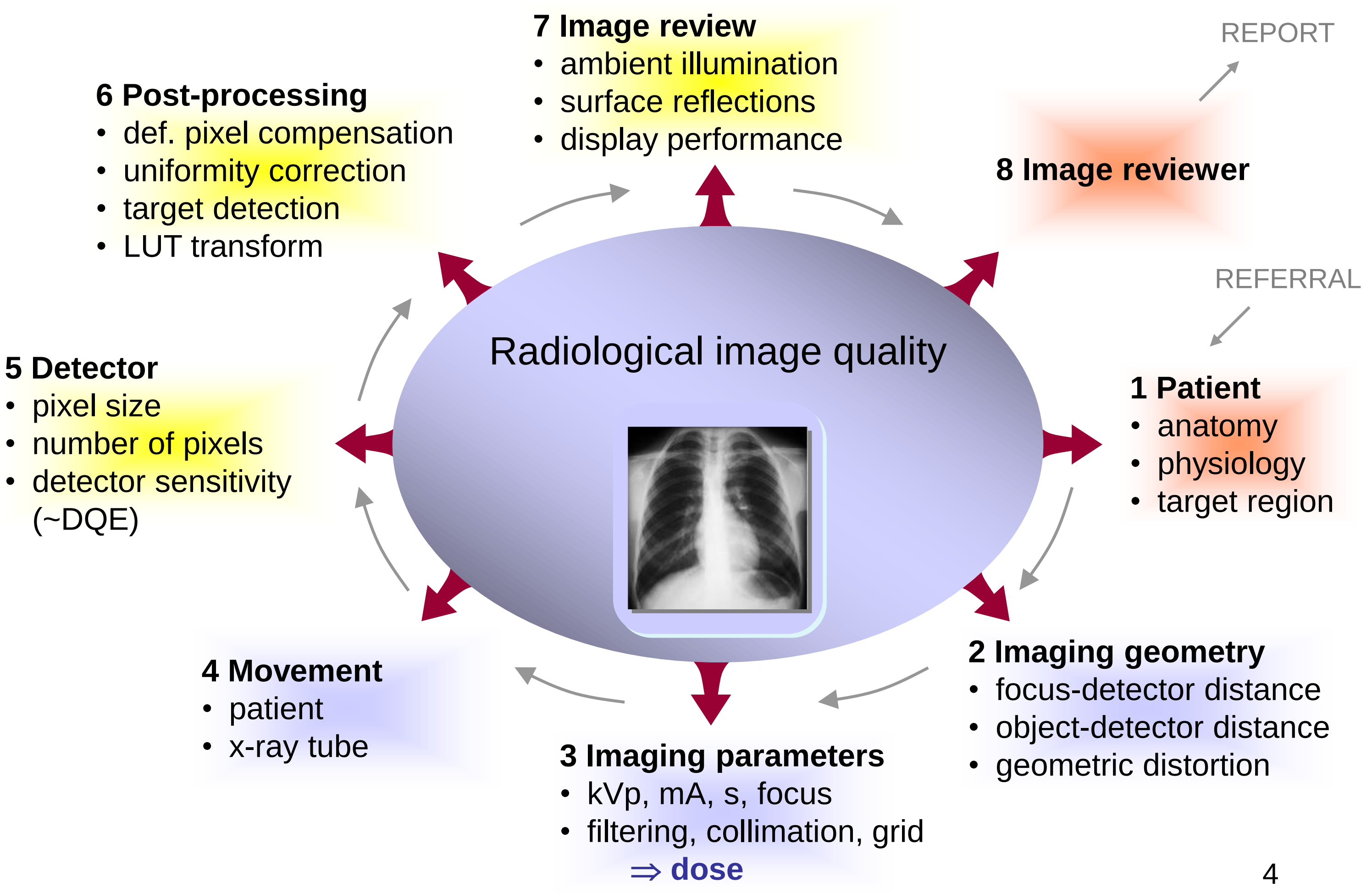
The clinical value of images is dependent on physical characteristics of the imaging method (~medical physicist), image capture and presentation system (~radiographer) and the interpreter (~radiologist).





Factors affecting dose and image quality in digital imaging

- **Subjective expert evaluation of clinical image quality** by radiologists forms part of the routine self-assessment process included in the QA programme.
- The subjective evaluation should be graded based on **image quality criteria** for each modality and clinical indication.
- Ideally this would be paired with patient dose audit.



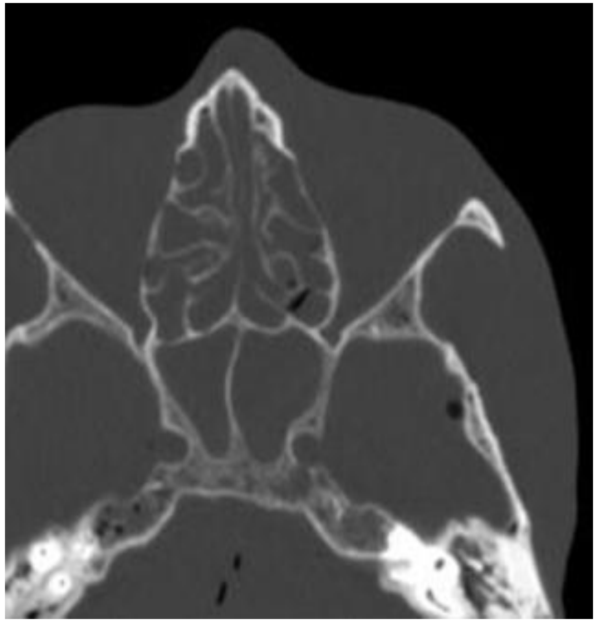
Basic image quality is characterised by contrast, resolution and noise

Spatial resolution or sharpness

= A level of detail that can be seen on an image

TECHNICALLY

Typically assessed on high dose and high contrast conditions so that precise (low noise) results can be achieved.



CLINICALLY

Clinical detection is done with typically lower clinical contrast level and with lower dose according to optimization.

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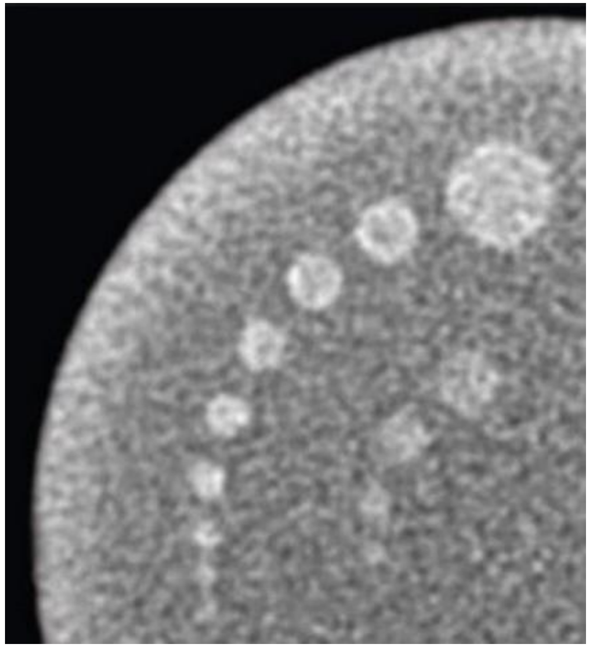
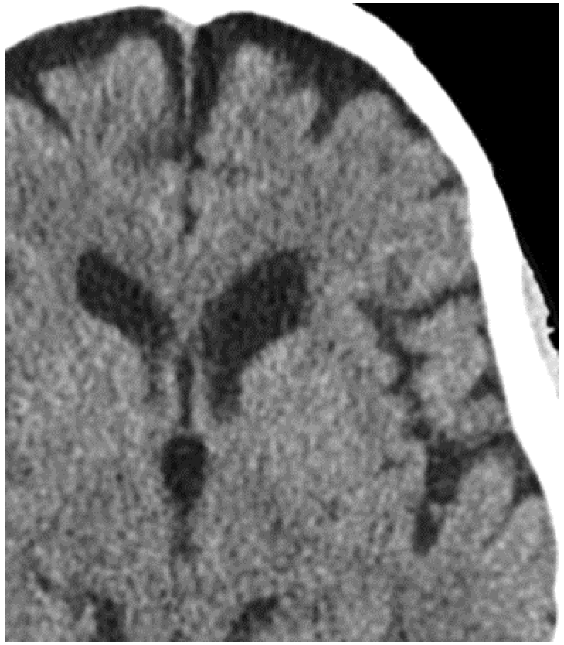
Contrast resolution

= Ability to detect intensity or grayscale differences on an image

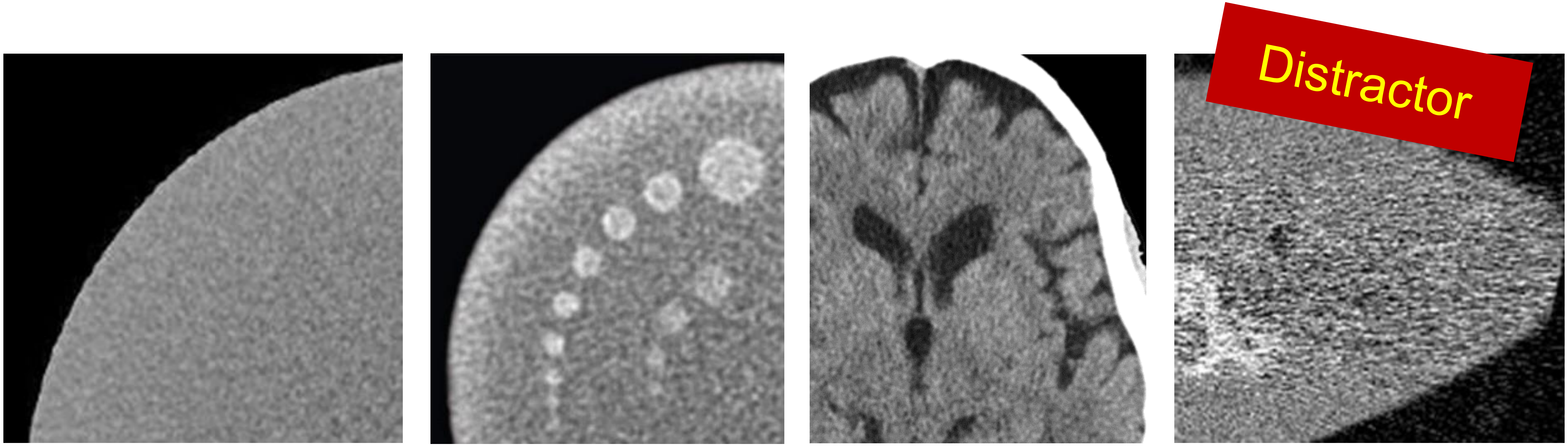




In DR: arbitrary units, in CT: calibrated contrast scale in HU units based on water attenuation $\mu(E)$.

Noise

= Fluctuations of image intensity values around their mean and interfering with contrast & detail detectability

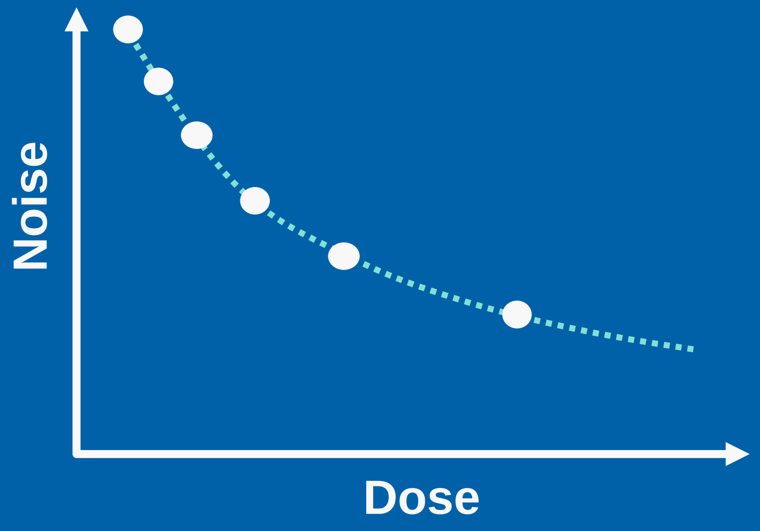


- *Statistical/random and structured*
- *Non-correlated (white) and correlated*

Image noise vs radiation dose

$$\boldsymbol{noise} \propto \sqrt{\frac{1}{\boldsymbol{dose}}}$$

Poisson statistics: If dose is doubled, noise is decreased by 30% (1/√2).



ATOM 705D paediatric anthropomorphic phantom
- Noise simulation

Target visualisation depending on size, contrast and noise levels

Five targets

Can you see them?

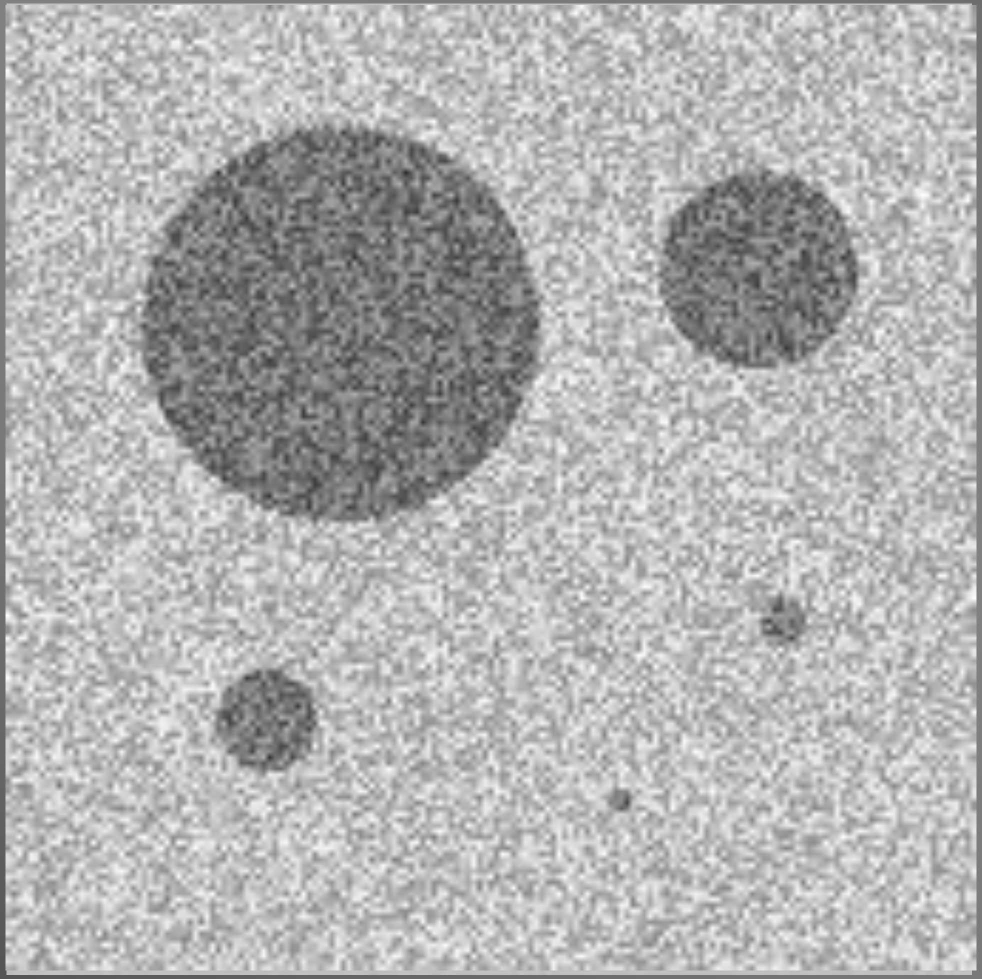
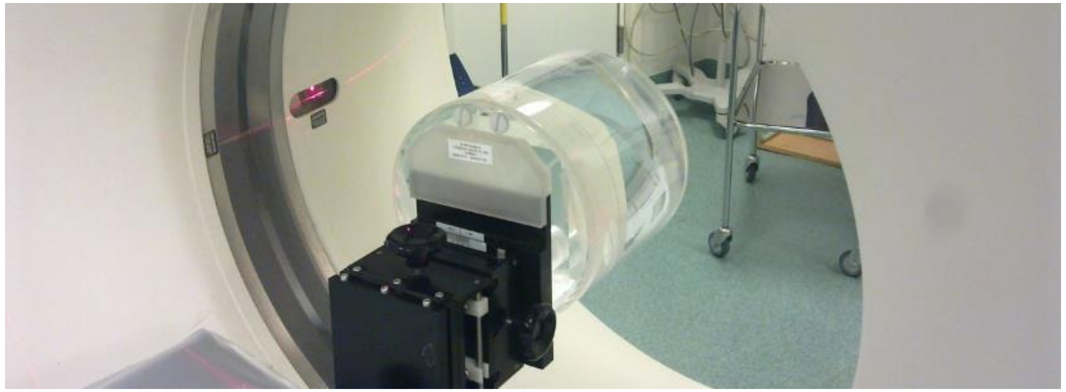


Image quality related metrics and implementation levels D: Pre-optimisation level (basic infrastructure)



- Availability of vendor phantom for basic image quality assessment for all imaging modalities
- Availability of simple protocols to test system performance with such phantoms, following the vendor guidelines, simple visual scoring, use of vendor software or freeware for basic image analysis.
- Purchase of phantoms for image quality evaluation

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Image quality related metrics and implementation levels C: Basic (level D, plus)

- Availability of simple protocols to test system performance with vendor phantoms, simple visual scoring and basic image analysis.
- Evaluation of clinical images through regular reporting by trained radiologist.
- Subjective clinical image quality evaluation should be a part of routine self-assessment and paired with patient dose audits.
- Utilisation of clinical image data in simple assessments by using contrast and noise measurements.
- Using specific geometric phantoms for image quality assessment in the image domain – contrast, noise, spatial resolution, artefacts, uniformity, geometry, image collimation and centring, detector exposure index (EI) – as measured manually and evaluated visually.
- Diagnostic monitor QC in the form of a visual test image review.

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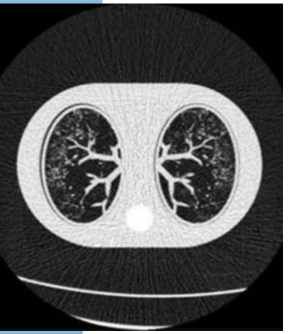
Image quality related metrics and implementation levels B: Intermediate (levels C and D, plus)

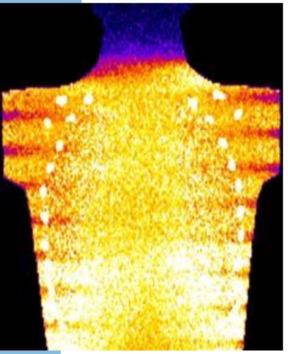
- Expansion of image quality evaluation to more versatile phantoms – geometric phantoms that mimic the total attenuation and/or shape of the patient to test image quality closer to the clinical situation.
- Comprehensive and systematic QA programme covering all imaging modalities with anthropomorphic phantoms for selected clinical protocols.
- Comprehensive display monitor and illumination measurements.

Optional progressive steps towards A level:

- Simple model observer evaluations – detectability of low contrast objects in phantoms in selected optimisation tasks involving image quality assessment.

Image quality related metrics and implementation levels A: Advanced (levels B, C and D, plus)

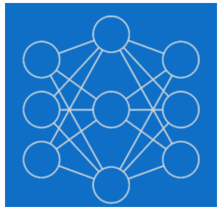




- Use of anthropomorphic phantoms for dosimetry, visual IQ tests and clinical image quality self-assessment, artefact check, protocol dose check compared to standard patients, and basic IQ tests in the image domain.
- Systematic and wide scale monitoring of image quality measured on phantom images for the main imaging modalities, combined with radiation exposure monitoring.

Optional (A+):

- Application of model observers, based on indication specific task functions. These models should be used in combination with anthropomorphic phantoms.
- IQ metrics applied directly from patient clinical image data possibly AI/ML/DL based methods.



Further development:

- Connection of objective and quantitative IQ follow-up applications with comprehensive and on-line quality management and patient safety monitoring system, and linked to continuous hospital wide audit process (also accounting for management and systematic continuous improvements at an organisational level).

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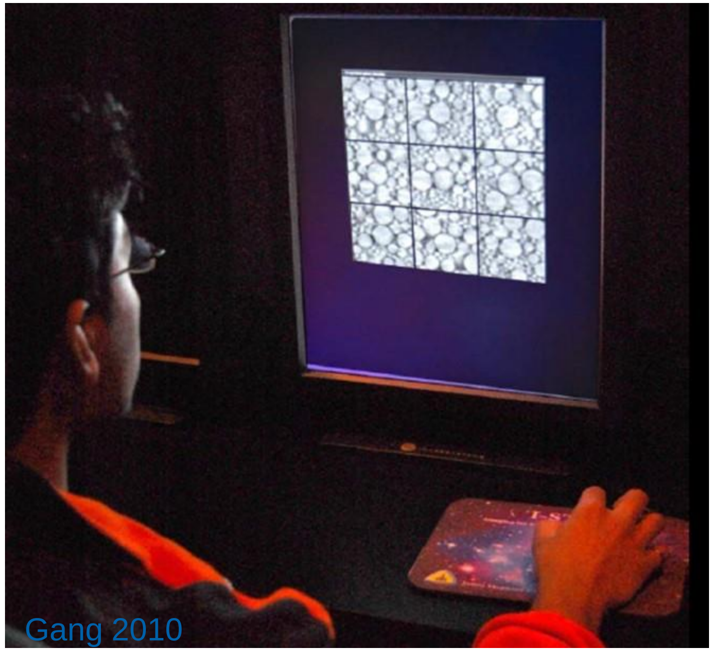
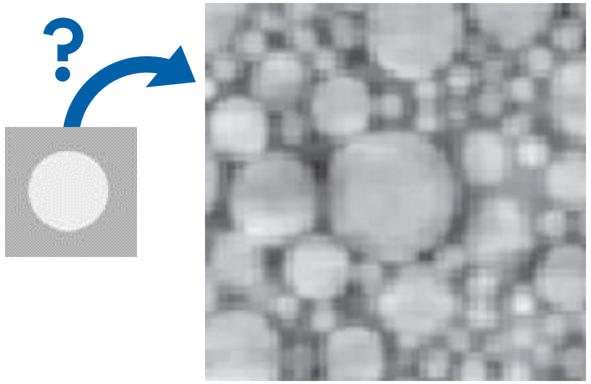
Coming back to basic definitions

Image quality = effectiveness by which an image can be used for its intended diagnostic task

⇒ What is the ability of an observer to detect a targeted lesion?


Gang 2010



Evolving image quality parameters and model observers

Detectability (d’)

Clinical task function

Eye response function

Physical image quality (NEQ or DQE (MTF, NPS))

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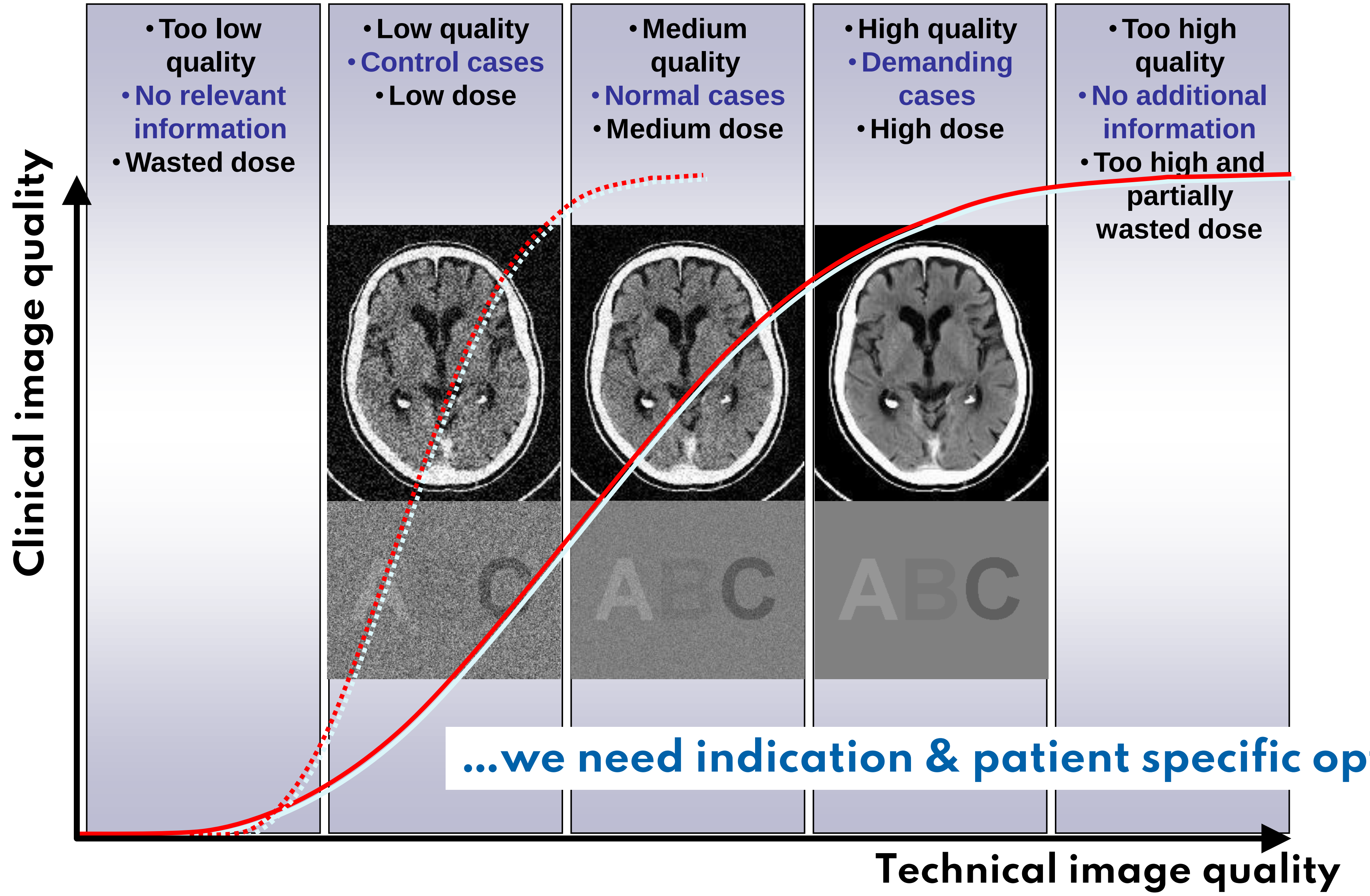
Evolving image quality parameters and model observers

TECHNICAL

CLINICAL

Clinical image quality – finding the right level

Optimisation process should involve the multi-professional team of technicians / radiographers, medical physicists and radiologists



…we need indication & patient specific optimisation

I acknowledge contributions from the members of

ICRP Task Group 108

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Dina Husseiny	David Sutton
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Thank you for your attention

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