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Establishing and Using DRLs for optimisation in Radiography

Sue Edyvean

ICTP-IAEA Workshop on Establishment and Utilization of Diagnostic Reference Levels in Medical Imaging Imaging (smr3333):
18-22 November 2019 **Trieste, Italy**

Acknowledgment for slides from:
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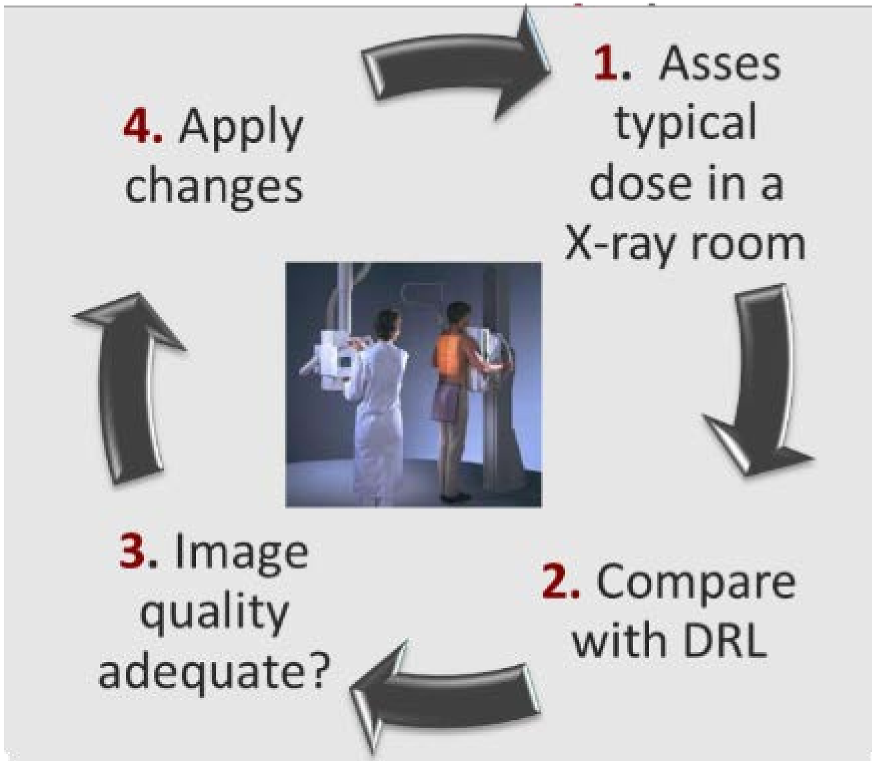
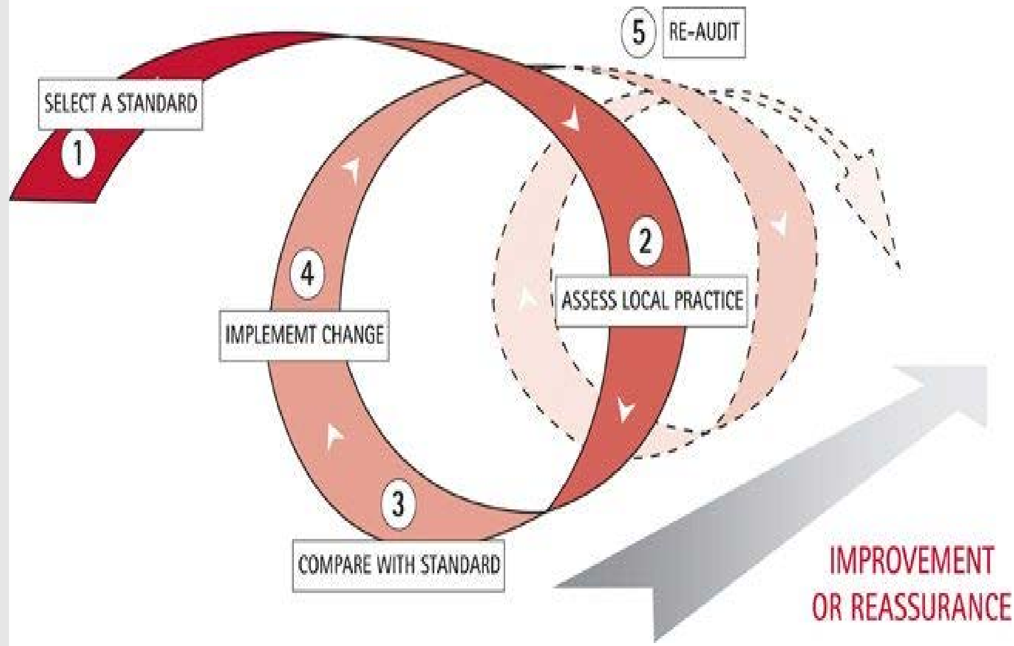
SMITH JENNIFER
55 years F RTH317532
Acc: RBF77696912
17/03/2014
Lumbar-spine
1134x2021
DX
Mag: 0.43x
LEFT
Standing
00454RAD02
"Thunder Platform"
Nuffield Orthopaedic Centre
NORMAL
Im 1/1, #3

Outline

- Radiology dose audit
  - Dose quantities
  - Establishing DRLs
- Optimisation
  - Radiology Equipment
  - Radiographic Practice

Patient dose audit and DRLs





The function of DRLs is to stimulate a continuous cycle of assessment and optimisation of practice

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Designing the dose audit to obtain the DRL

1. Select examination
2. Select patient data
3. Ensure weight is within required range
4. Record the dose index value
5. Review and clean the data
6. Calculate the median value of dose index

Designing the dose audit to obtain the DRL

1. Select examination
    a. High dose
    b. High frequency

Radiography examinations, their relative frequencies and contribution to collective effective dose

Examination	Percentage of total frequency of all radiography examinations (%)	Percentage contribution to collective dose (%)
Chest and thorax	12-29	0.7-5.2
Abdomen, pelvis and hip	7.4-14.3	2.9-14
Spine (thoracic and lumbar)	3.8-12.7	30
Intravenous urography	0.3-2.0	1.2-8.7

EC, 2008. European Guidance on Estimating Population Doses from Medical X-ray Procedures. Radiation Protection No. 154 . European Commission, Directorate-General for Energy and Transport, Luxembourg. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/154.zip (last accessed 10 August 2017).

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- As chest radiography is a very common examination and involves exposure of several radiosensitive organs, it should be included in surveys of radiography.
- The largest contributions from radiography to collective effective dose are examinations of the abdomen, pelvis, and spine, so these should also be included in any radiographic survey.
- If performed with a sufficient frequency, it is recommended that skull X rays should be included, as they involve exposure of the lens of the eye.
- High frequency/low dose exams such as, x-rays of extremities should not necessarily be a high priority:

NHS England 2016
Planar Radiography (from RIS records)

No.	SNOMED-CT code name	Total exam count in 2016	% Total Plain Radiography
1	Plain chest X-ray	7,767,185	37.9%
2	Radiologic examination of knee	1,599,860	7.8%
3	Radiography of foot	1,014,505	4.9%
4	Pelvis X-ray	1,003,500	4.9%
5	Radiography of ankle	843,070	4.1%
6	Radiography of shoulder	778,775	3.8%
7	Diagnostic radiography of abdomen	723,920	3.5%
8	Radiography of hand	673,860	3.3%
9	Radiography of wrist	633,005	3.1%
10	Radiography of hip	632,930	3.1%
11	Diagnostic radiography of lumbar spine	432,400	2.1%
12	Radiography of cervical spine	279,615	1.4%

Selecting Projections/Exams

- First on the high dose and high frequency X-ray (red)
- Next exams of slightly lower dose or frequency (gold)
- Then low dose but very high frequency exams, and low frequency but high dose exams (yellow)
- Providing typical doses for extremity exams (White). Is setting an NDRL appropriate?

If X-ray frequencies are given only by body region then projections and complete exams will need to be chosen.

Choosing an Exam list

- Exam frequency may be determined by several routes: e.g.
  - patient records
  - RIS records
  - National (or subregion) dataset/registry
  - Initial survey

Reasons for not setting KAP NDRL for Extremities

- Usually very low dose exposures, so a low priority
- Exposure extends beyond the edges of body part so collimation of image is a matter of choice.
- KAP is determined from beam size, and hence will vary with collimation, and overestimate the patient's (low) exposure.
- Both hands or both feet can be x-rayed in one image but records can be unclear if both extremities, or only one, was imaged. Where mass data is being retrospectively accessed it is not practical to check this visually.
- Knee KAP DRLs can be criticised for the same reasons.

Dose Audit on first x-ray room

Hospital 1

X-Ray 1 **X-Ray 2** **X-Ray 3** **X-Ray 4**

Designing the dose audit to obtain the DRL

2. Select patient data – how many (as minimum)?

- 20 – 30 patients

3. Ensure weight is within required range

- ICRP 135 ? : ‘standard size’
- Previous advice and a useful starting point
  - Patients between 50 – 90 kg (70kg +/- 20 kg)
  - Giving a mean value f 70 kg +/- 10 kg (or 5 kg)

Dose Audits – Numbers of data and patient size

- (227) If data collection is via paper forms, the number of patients will be limited, but should be at least 20–30. With restricted numbers, information on patient sizes should be recorded, if possible, or at least the range of sizes should be restricted, with very large and very small patients being excluded. This is not a concern when an automated data collection system is used.

ICRP 135

Designing the dose audit to obtain the DRL

4. Record the dose index value
5. Review the data
6. Calculate the median value of dose index

Radiology DRL Quantities

DRL quantity	Air kerma-area product	Entrance surface air kerma
Symbols	P_{KA}	$K_{a,e}$
Recommended Units for DRL^	mGy.cm^2	mGy
Other symbols in common use	KAP	ESAK
Closely similar quantity	Dose-Area product (DAP)*	Entrance-surface dose (ESD)*

^ Recommended by IAEA and ICRP. Note UK uses Gy.cm^2 for DAP NDRLs

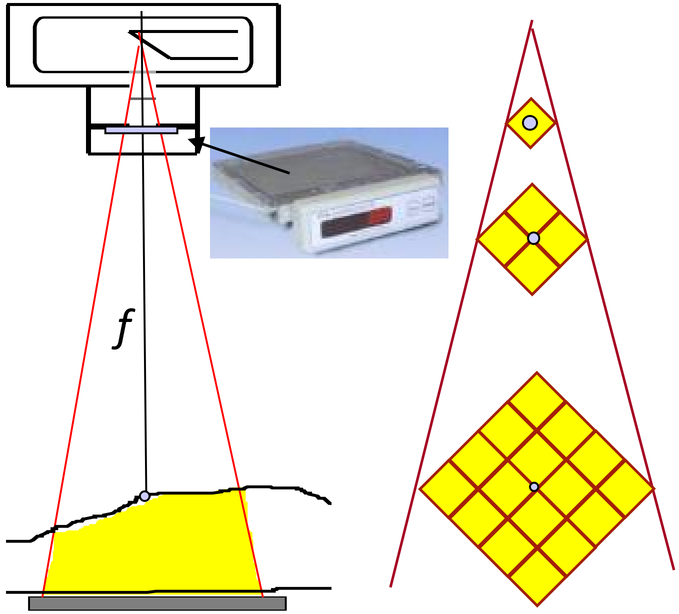
* Because "air kerma" and "dose in air" are numerically equal in diagnostic radiology energy range

1. Measurable dose quantities

Radiography and fluoroscopy

Air kerma-area product, KAP

Also known as Dose Area Product, DAP



Kerma (dose) ~ $(1/f)^2$

Field area ~ f^2

***KAP* is independent on distance from focus**

Unit: Gy·m²

Practical units:

1 μGy.m² = 1 cGy.cm²

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KAP dose units

Radiology system may display KAP doses in many units:

$Gy.cm^2$ | $dGy.m^2$ | $\mu Gy.cm^2$

$cGy.cm^2$ | $cGy.m^2$

$mGy.cm^2$ | $mGy.m^2$

$dGy.cm^2$ (can be displayed as $dGy.cm^2$ or DGYCM2)

$\mu Gy.m^2$ (can be displayed as $\mu GY.m^2$ or as µGYM2)

- Note that 1 $cGy.cm^2$ and 1 $\mu Gy.m^2$ are the same, 1/100 of 1 $Gy.cm^2$.

Machine displays may not use lower case letters, and so display mGy as MGY.

1. Measurable dose quantities

Radiography and fluoroscopy

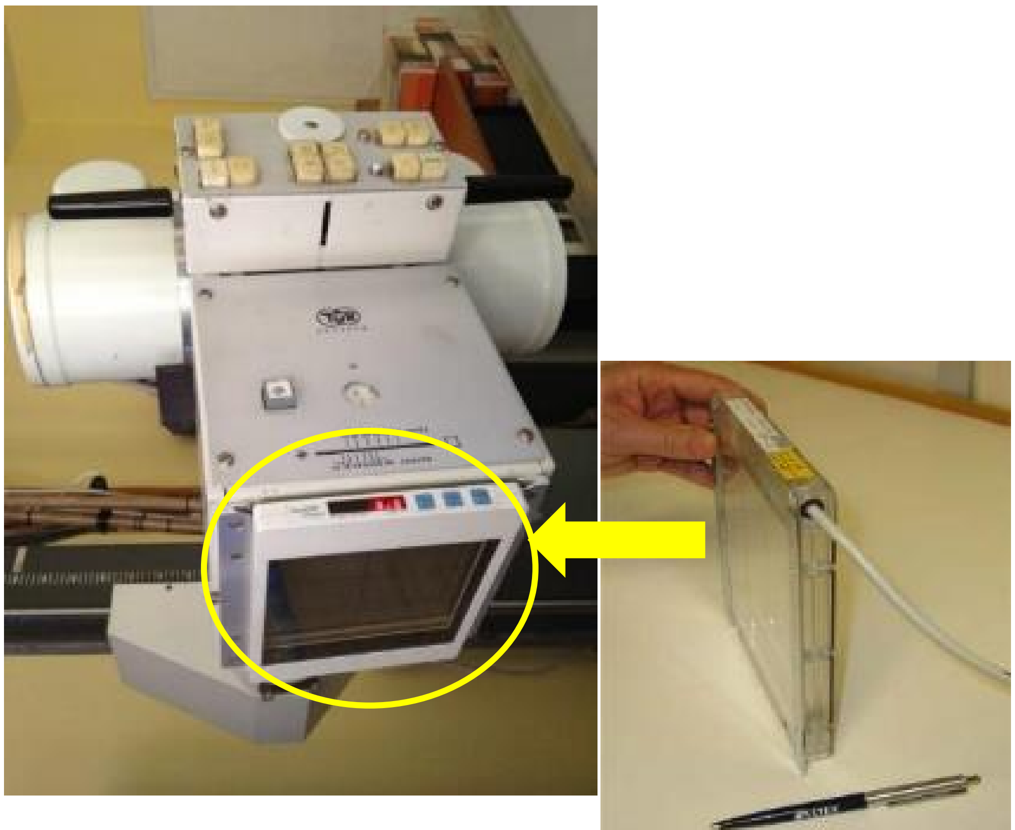

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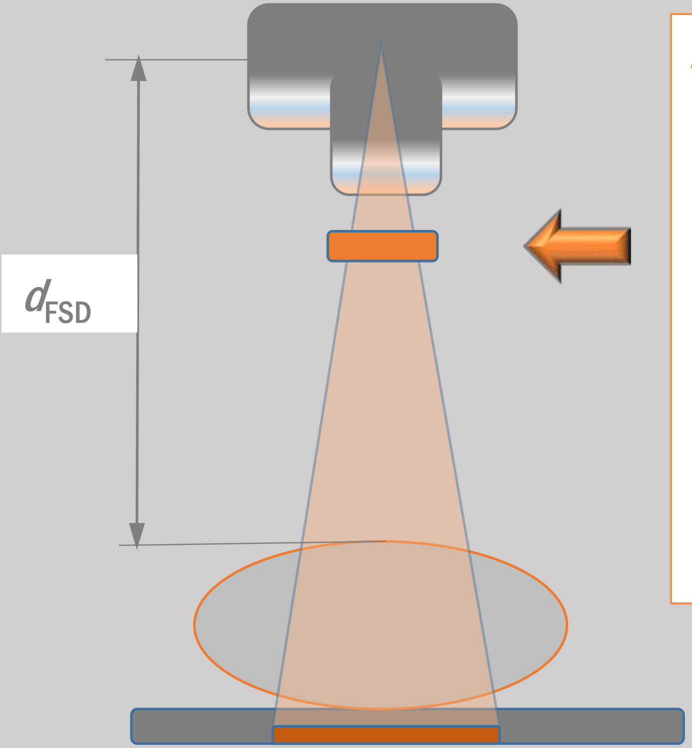
Table 1: KAP Dose Units conversion Table
If your value is currently in the original units and has a value of 1, the table gives its value in the new units (those you want to convert it into).

New Units		µGy m²							
		Gy cm²	dGy cm²	cGy cm²	mGy cm²	Gy m²	dGy m²	cGy m²	mGy m²
Original units									
µGy m²	Gy cm²	1	10	100	1,000	1.E-04	0.001	0.01	0.1
	dGy cm²	0.1	1	10	100	1.E-05	1.E-04	0.001	0.01
	cGy cm²	0.01	0.1	1	10	1.E-06	1.E-05	1.E-04	0.001
	mGy cm²	0.001	0.01	0.1	1	1.E-07	1.E-06	1.E-05	1.E-04
	Gy m²	10,000	1,000	100	10	1	10	100	1,000
	dGy m²	1,000	10,000	1.E+05	1.E+06	0.1	1	10	100
	cGy m²	100	1,000	10,000	1.E+05	0.01	0.1	1	10
	mGy m²	10	100	1,000	10,000	0.001	0.01	0.1	1

Air kerma-area product



Air kerma-area product (P_{KA})

$P_{KA} = K \cdot A$

K – air kerma

A – area

Unit: $Gy \cdot m^2$, $mGy \cdot cm^2$, $cGy \cdot cm^2$, $\mu Gy \cdot m^2$, $Gy \cdot cm^2$ …

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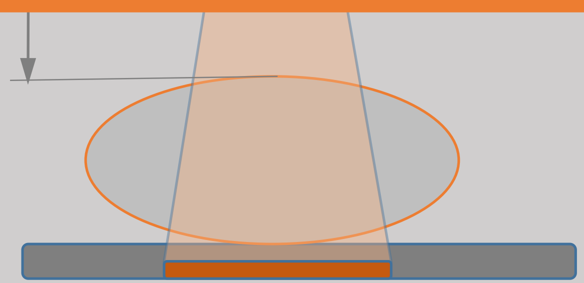
Air kerma-area product

Air kerma-area product (P_{KA})

P_{KA} values recorded by meters, calculated by the equipment, or given by the manufacturers and reported in the DICOM header should be reasonably accurate. Arrangement should be in place to check the calibration of P_{KA} meters and the accuracy of P_{KA} values calculated and displayed by the X ray equipment and recorded in the DICOM header.



Note: *Standard IEC 60580 specifies acceptable limits of uncertainty in the response of P_{KA} meters when individual exposure vary to the maximum likely extent. According to this, the estimated expanded uncertainty of a measurement with P_{KA} meters is 25% at the 95% confidence interval (k = 2).*

References: IAEA TRS 457, IAEA, Vienna, 2007 and Lin, PJ, et. al. Accuracy and calibration of integrated radiation output indicators in diagnostic radiology: A report of the AAPM Imaging Physics Committee Task Group 190, Med Phys, 42: 6815-6829 (2015)

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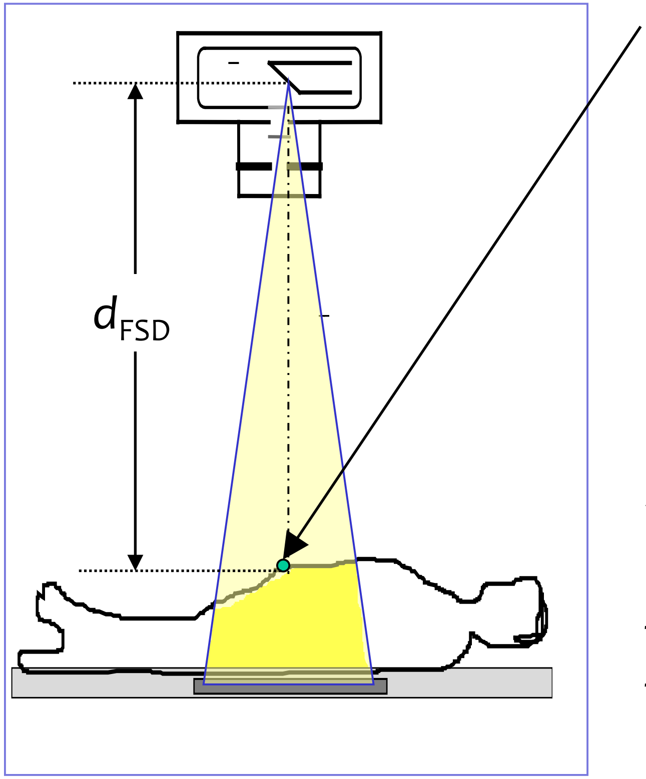
1. Measurable dose quantities

Radiography

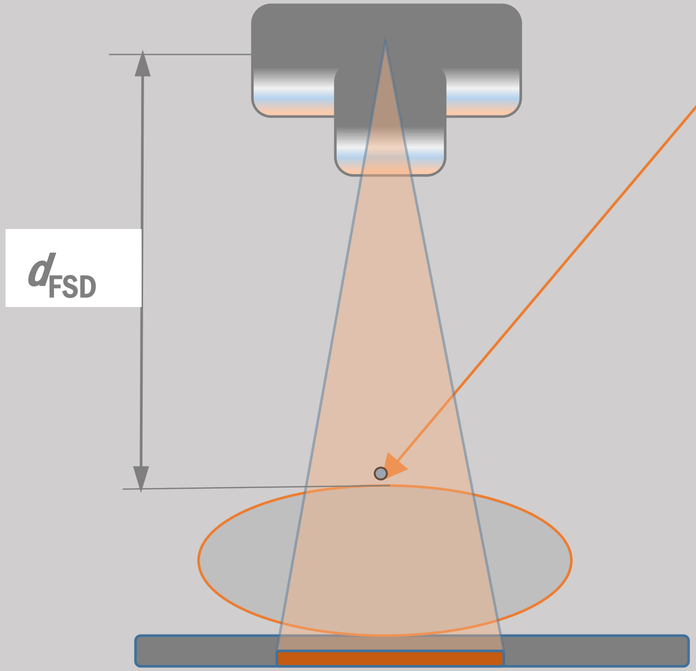


Entrance surface air kerma
K_e [Gy]

Also known as
Entrance surface dose, ESD

1) Measured with phantom
2) With patients:
- Directly measured with TLD
- Calculated from the tube output

Entrance surface air kerma



Entrance air kerma, $K_{a,e}$

$K_{a,e} = K_{a,i} \cdot B$

B – Backscatter factor (1.2 – 1.4)

Unit: Gy

Direct measurement

Calculation from the tube output

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Instructions for calculation of entrance surface air kerma from the x-ray tube output

Definitions

Incident air kerma is the air kerma from the incident beam on the central x-ray beam axis at the focal-spot-to surface distance at the skin entrance plane. Only primary radiation incident on the patient or phantom and not backscattered radiation is included.

Entrance-surface air kerma (ESAK) is the air kerma on the central X ray beam axis at the point where X ray beam enters the patient or phantom. The contribution of the backscattered radiation is included.

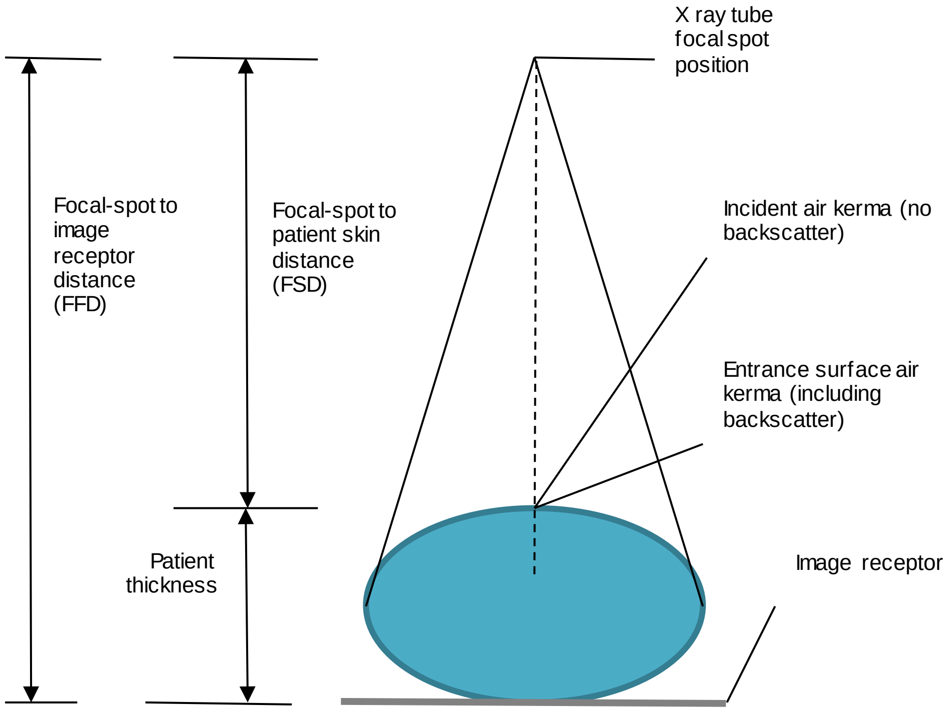

Figure 1. Schematic diagram showing some dosimetric and geometric quantities

ESAK can be established indirectly from incident air kerma using appropriate backscatter factor. Incident air kerma is estimated indirectly for the x-ray tube output at the selected distance and exposure parameters using the inverse square law.

The X ray tube output is air kerma at specified distance from the x-ray tube focal spot, divided by the It (tube-current exposure-time product, in units mAs). It is calculated for the particular tube voltage (U) value.

ESAK units

Radiology machine may display ESAK doses in the following units:

- Gy =1000 mGy
- dGy = 100 mGy
- cGy = 10 mGy
- mGy
- µGy =0.001 mGy

Machine displays may not use lower case letters, and so display mGy as MGY.

Designing the dose audit to obtain the DRL

1. Select examination
2. Select patient data
3. Ensure weight is within required range
4. Record the dose index value
5. Review and clean the data
6. Calculate the median value of dose index

ID	AP Projection DAP dose *	Patient weight (kg)
1	22	114.3
2	5	50.8
3	9	139.7
4	3	88.9
5	6	44.45
6	7	82.55
7	6	49
8	5	49
9	9	70
10	8	50.8
11	11	75
12	9	68
13	6	57
14	7	65
15	8	70
16	7	70
17	6	82.55
18	11	48
19	11	60
20	9	85.73
21	12	76
22	5	50.8
23	27	114.3
24	7	76.2
mean	9	72.42
median	7.5	70

Designing the dose audit to obtain the DRL

1. Select examination
2. Select patient data
3. Ensure weight is within r… e
4. Record the dose index va…
5. Review and clean the da…
6. Calculate the median val… dex

- "Typical value"

Record ID	AP Projection DAP dose *	Patient weight (kg)
2	5	50.8
4	3	88.9
5	6	44.45
6	7	82.55
9	9	70
10	8	50.8
11	11	75
12	9	68
13	6	57
14	7	65
15	8	70
16	7	70
17	6	82.55
19	11	60
[illegible]	[illegible]	85.73
[illegible]	[illegible]	76
[illegible]	[illegible]	50.8
24	7	76.2
mean	7.6	68.0
median	7.0	70.0

Large and small patients removed

ID	AP Projection DAP dose *	Patient weight (kg)
1	22	114.3
2	5	50.8
3	9	139.7
4	3	88.9
5	6	44.45
6	7	82.55
7	6	49
8	5	49
9	9	70
10	8	50.8
11	11	75
12	9	68
13	6	57
14	7	65
15	8	70
16	7	70
17	6	82.55
18	11	48
19	11	60
20	9	85.73
21	12	76
22	5	50.8
23	27	114.3
24	7	76.2
mean	9	72.42
median	7.5	70

Mean versus Median – Simple tutorial

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Mean versus Median

Mean	Median
Average of values	Same number of data points above and below (50th percentile)
More affected by outliers	Less affected by outliers
Less robust for skewed distributions	More robust for skewed distributions

Nine numbers: 7 9 11 6 13 6 6 3 11			
Put in order	3 **6 6 6** 7 9 11 11 13	Mode	6
Put in order	3 6 6 6 **7** 9 11 11 13	Median	7
Add all	7+9+11+6+13+6+6+3+11 = 72 There are 9 numbers: 72 ÷ 9 = **8**	Mean (average)	8

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Mean versus Median

Mean	Median
Average of values	Same number of data points above and below (50th percentile)
More affected by outliers	Less affected by outliers
Less robust for skewed distributions	More robust for skewed distributions

If highest value is 130 not 13:

Nine numbers: 7 9 11 6 130 6 6 3 11			
Put in order	3 **6 6 6** 7 9 11 11 130	Mode	6
Put in order	3 6 6 6 **7** 9 11 11 130	Median	7
Add all	7+9+11+6+130+6+6+3+11 = 189 There are 9 numbers: 189 ÷ 9 = **8**	Mean (average)	21

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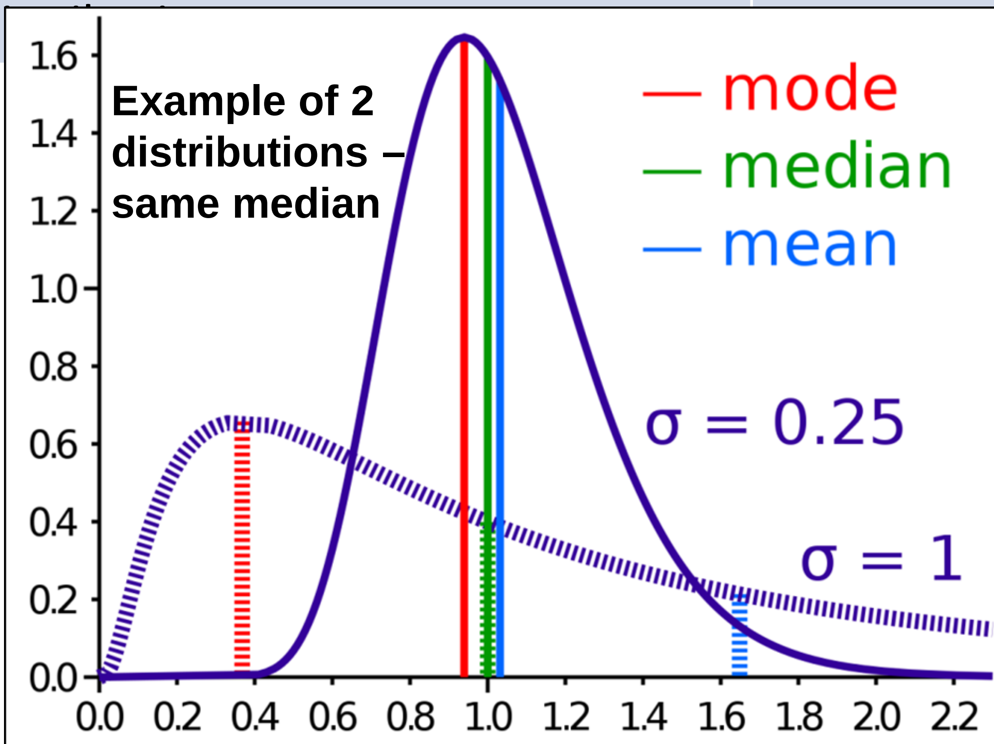
Mean versus Median

Mean	Median
Average of values	Same number of data points above and below (50th percentile)
More affected by outliers	Less affected by outliers
Less robust for skewed d	More robust for skewed distributions

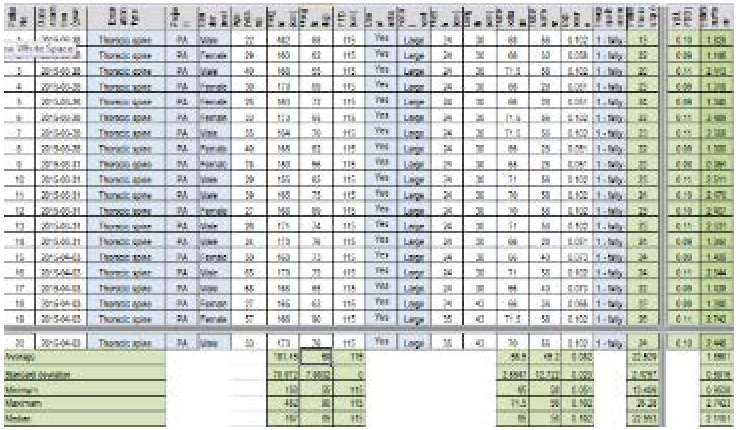


	Nine numbers: 7 9 11 6 13 6 6 3 11	
	Mode	6
	Median	7
= 72 ÷ 9 = **8**	Mean (average)	8

sue.e

Analysis: in a particular X-ray room

- For the most frequently performed exams
- For a particular age/weight group
- Register dose values for a sample of 20-50 patients
- Calculate median/ average dose index
- Typical dose value = median of the sample



<u>Chest X-ray</u>
Adult patient (70 kg)
Range (Min-Max):
(0.01 – 0.10) Gy.cm^2
Median = 0.1 Gy.cm^2

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Analysis in a Hospital

Hospital 1

X-Ray 1 | **X-Ray 2** | **X-Ray 3** | **X-Ray 4** | **…. etc**

Median **Median** **Median** **Median**

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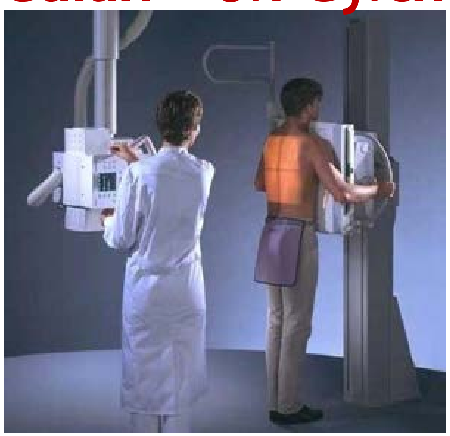
Analysis: in a hospital

Assess typical dose values for all equipment performing the same exams

<u>Chest X-ray,</u> Adult patient (average weight 70 kg)

Room 1:
Median = 0.1 $Gy.cm^2$



Room 2:
Median = 0.05 $Gy.cm^2$

Room 2:
Median = 0.2 $Gy.cm^2$

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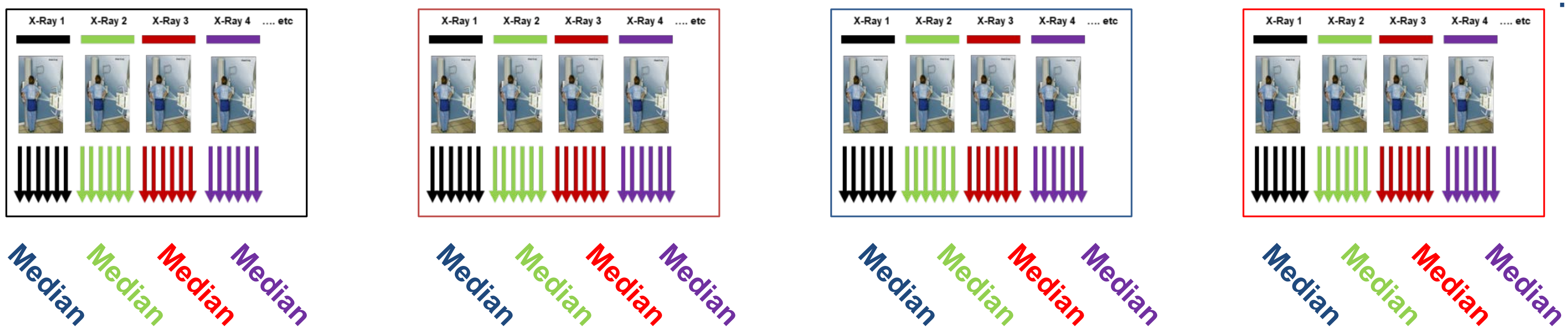
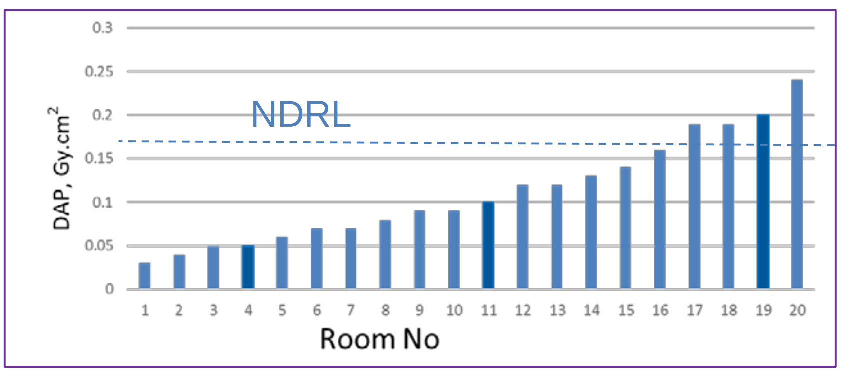
Analysis in a Country / Region - National DRLs

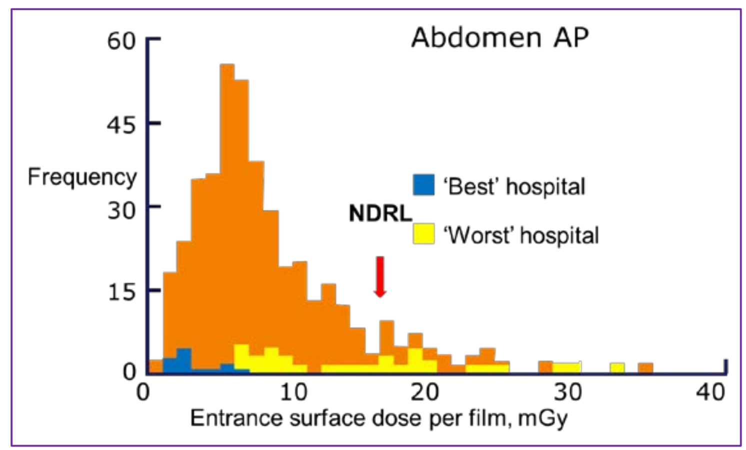
- **Dose index measured for each patient; median for each system obtained:**

Hospital 1 **Hospital 2** **Hospital 3** **Hospital 4** **etc. etc. …….**



- **Show data in two ways (DRL shown in each case – 3rd quartile):**





a) Room versus increasing dose index (DAP in this example)

b) No. of rooms for a given dose index bin (ESD in this example)

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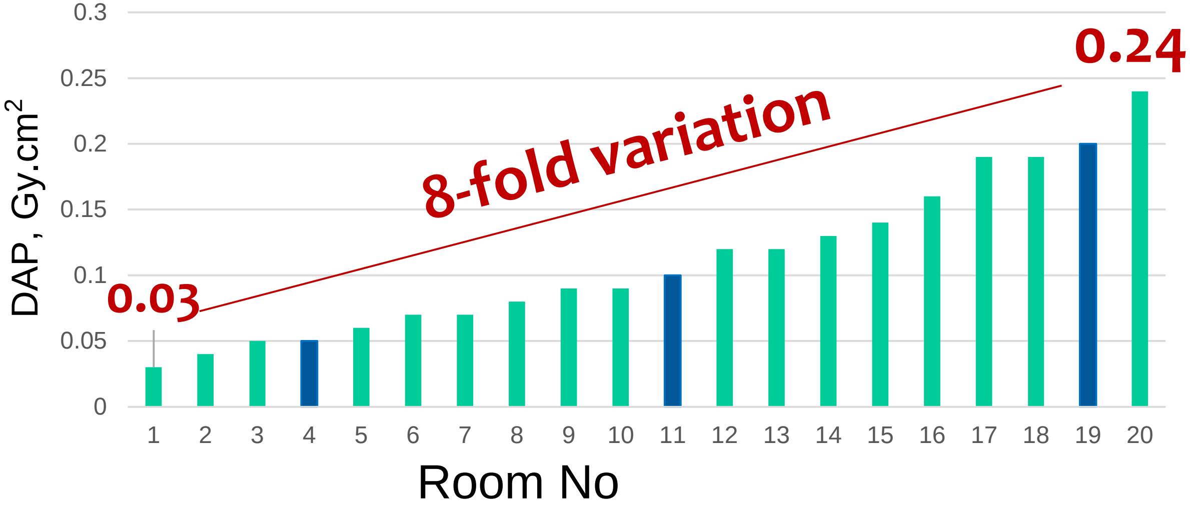
Analysis: in a country/ region

Collect data from a representative sample of hospitals performing the same exam

Chest X-ray, Adult patient (70 kg)
Typical DAP values in 20 X-ray rooms



Film-screen data

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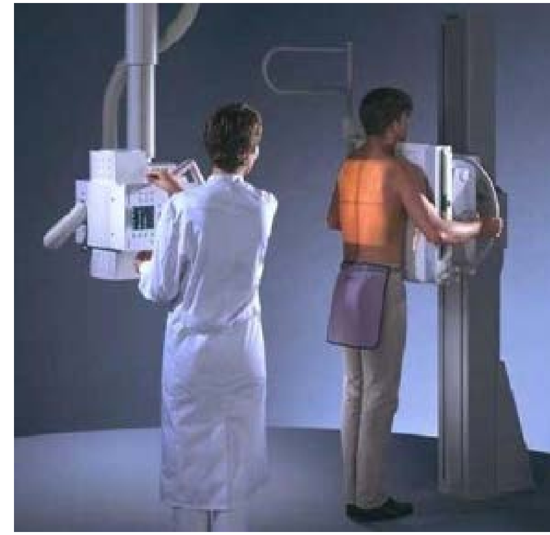
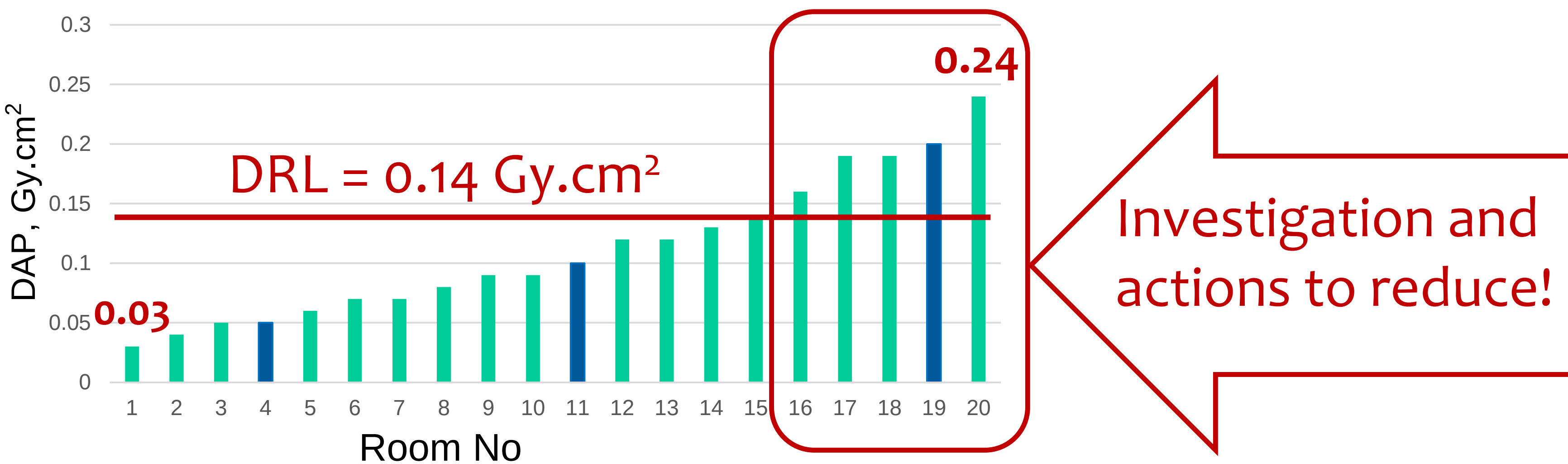
Analysis: in a country/ region

Establish Diagnostic Reference Level (DRL) At 3rd Quartile of dose distribution

Chest X-ray, Adult patient (70 kg)





Film-screen data

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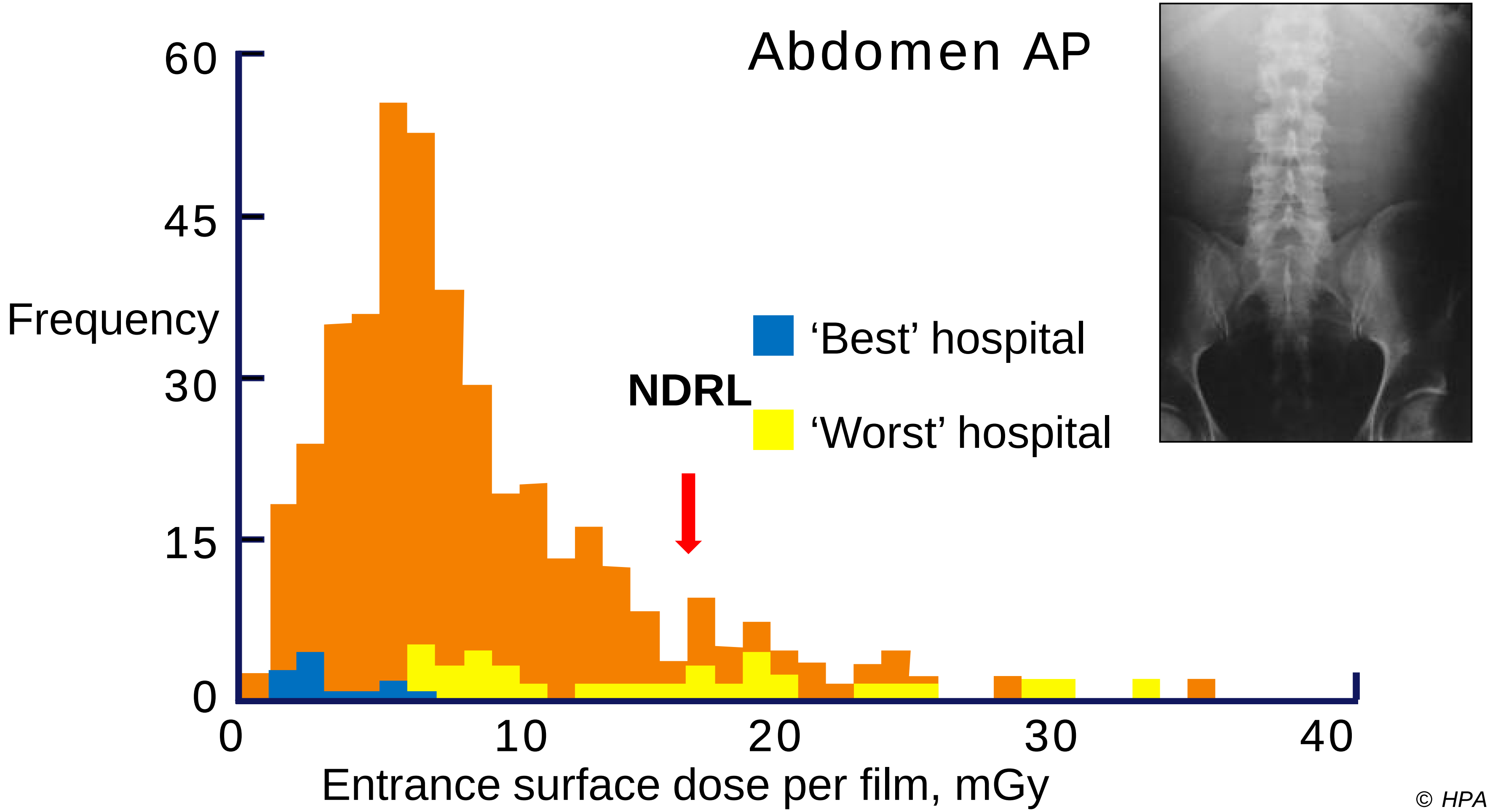
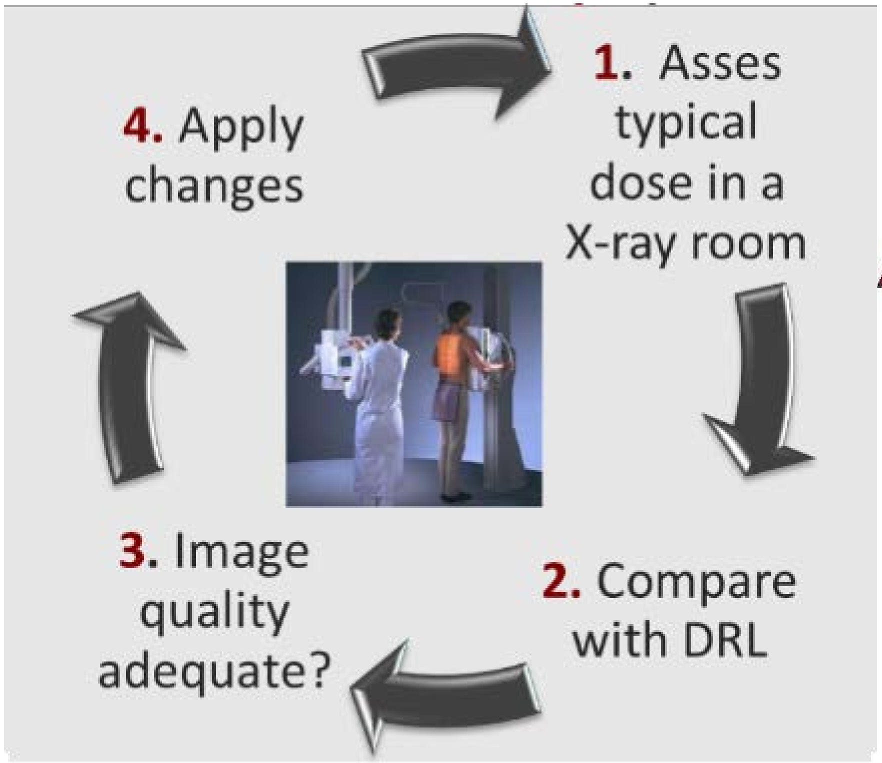
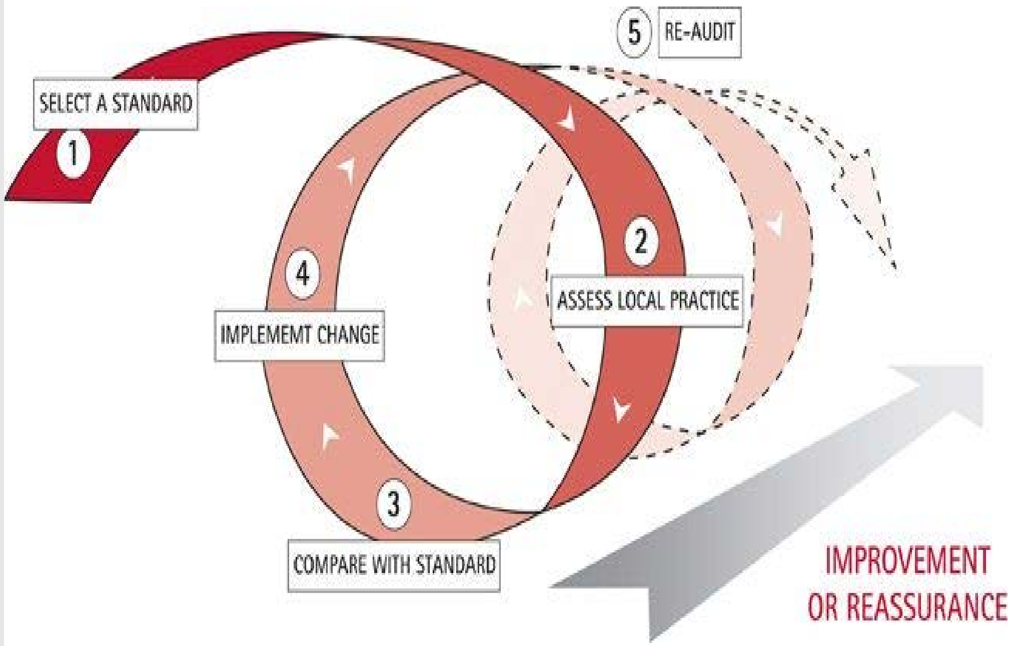
National Reference Dose – National DRL

Early NRPB Patient Dose Survey (England)



Patient dose audit and DRLs





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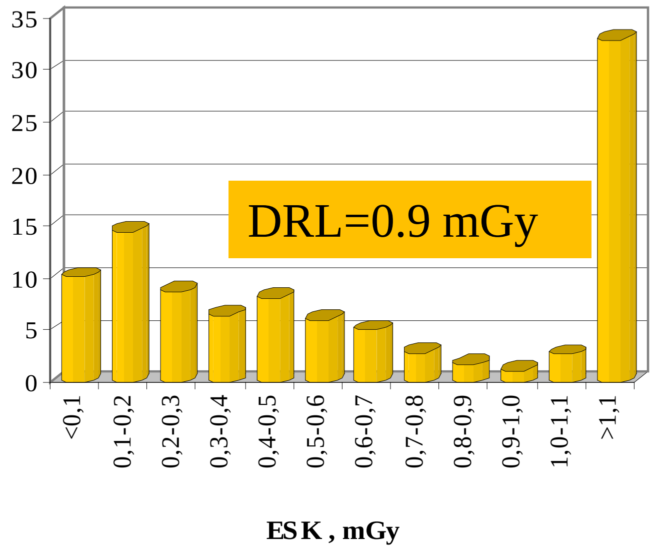
Patient doses - radiography

National surveys in Bulgaria, Chest PA

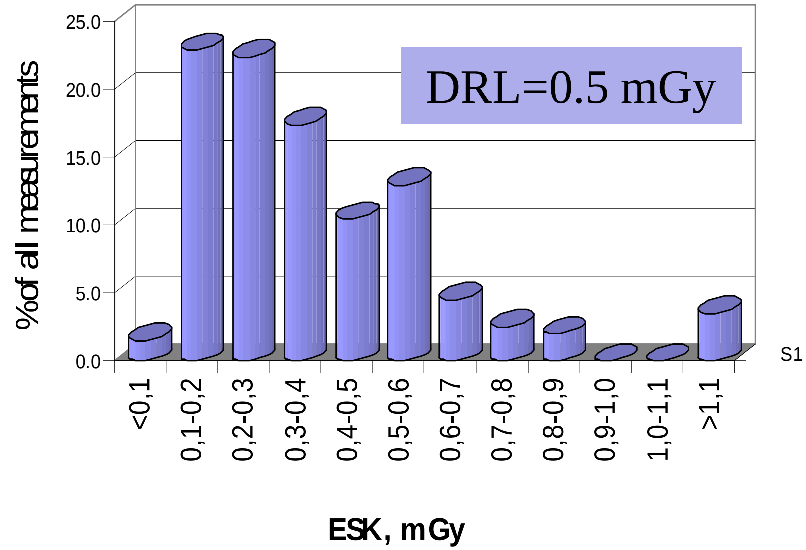
2002-2004



Mean doses: 0.06 – 2.3 mGy **(35 fold)**

Individual doses: 0.03 – 9.3 mGy

2008-2009



Mean doses: 0.1 – 1.3 mGy **(13 fold)**

Individual doses: 0.07 -3.2 mGy

Film-screen data

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Optimising

- Know the Technology
- Look to implement good radiographic practice

Equipment: Detectors Type

- Film
  - Film specification: make, type, speed class, size…
- Computer Radiography (CR) Storage Phosphor techniques
  - Generator settings and dose information not stored on CR panel
- Flat Panel Detectors (DR)
  - May use direct or indirect x-ray conversion to electrical signal
- Charge-coupled device systems
  - Small share of market; image of luminous screen recorded by a charged couple device camera and converted into a digital image
- Photon-counting detector
  - Excellent efficiency and other advantages. Beginning to be used for CT and digital radiography. Being used in mammography.

Radiographic imaging chain

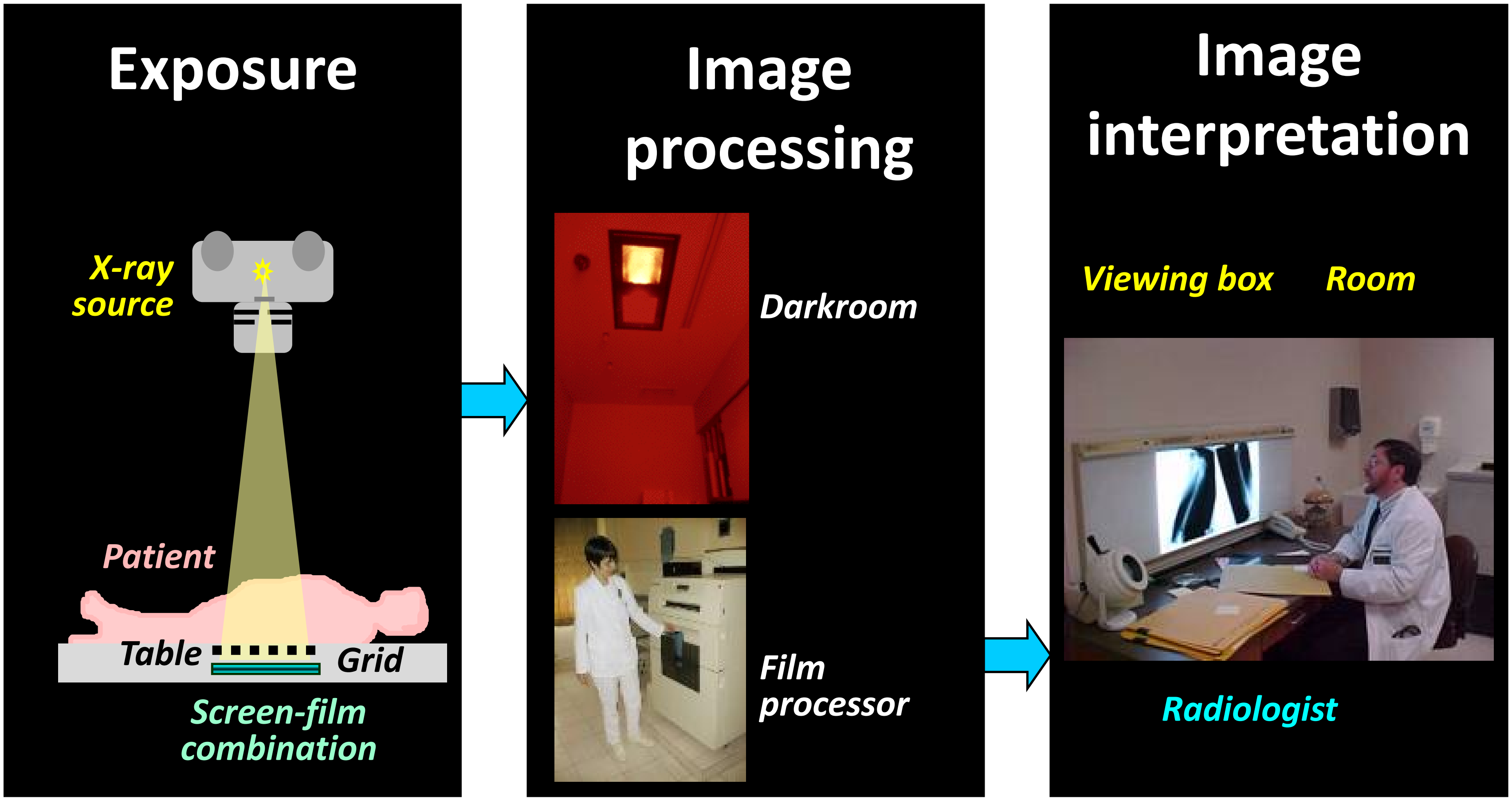

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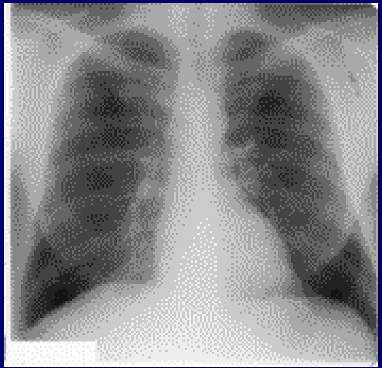
Image formation in radiography

Image processing



Radiographic image

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Public Health England

Equipment: Digital Detectors

- Digital detector systems have high dynamic range
  - Higher doses provide higher quality images without the saturation experienced with film based system.
  - This means that there is not an automatic practical limitation to increasing patient dose as when using film.
  - QA and audit programmes required to ensure optimisation of doses to clinical tasks and to prevent “dose creep”.
- Digital detectors tend to be more sensitive than film
  - Protocols and doses should be set appropriate to the technology being used.
- Different detector technologies have different energy detection efficiency profiles
  - different energy beams and filtration may be used.

Public Health England

Equipment/Protocol

Other information that it may be useful to have includes to determine why doses from different sources differ:

- Machine settings (see next slide)
- Detector arrangement… Is the film/detector directly in contact with the patient or positioned in a bucky (holder) under the bed or in a support frame?
- Field size

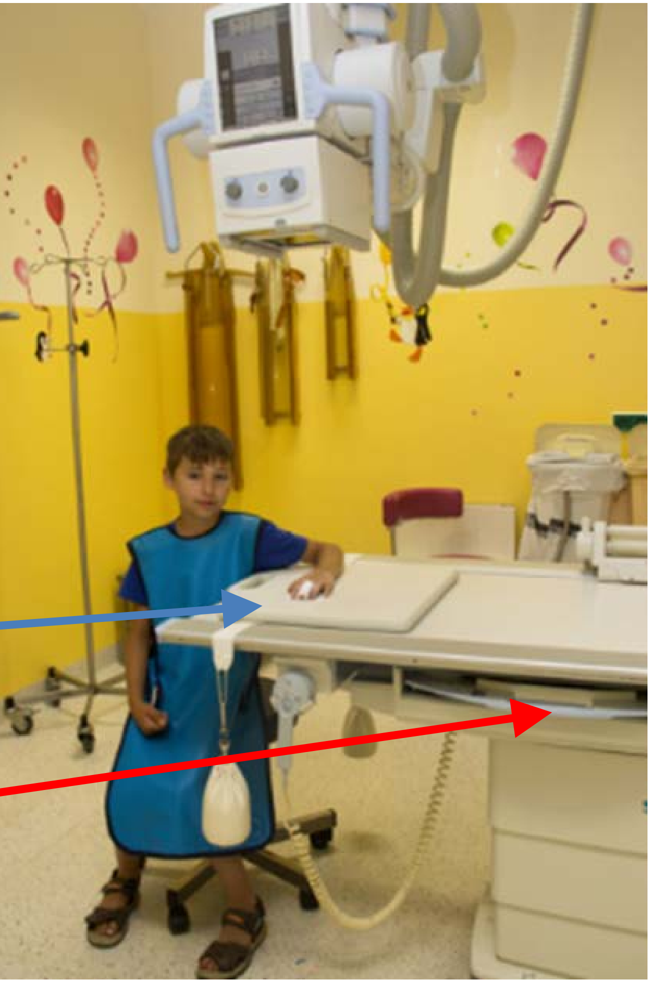

Image formation in radiography

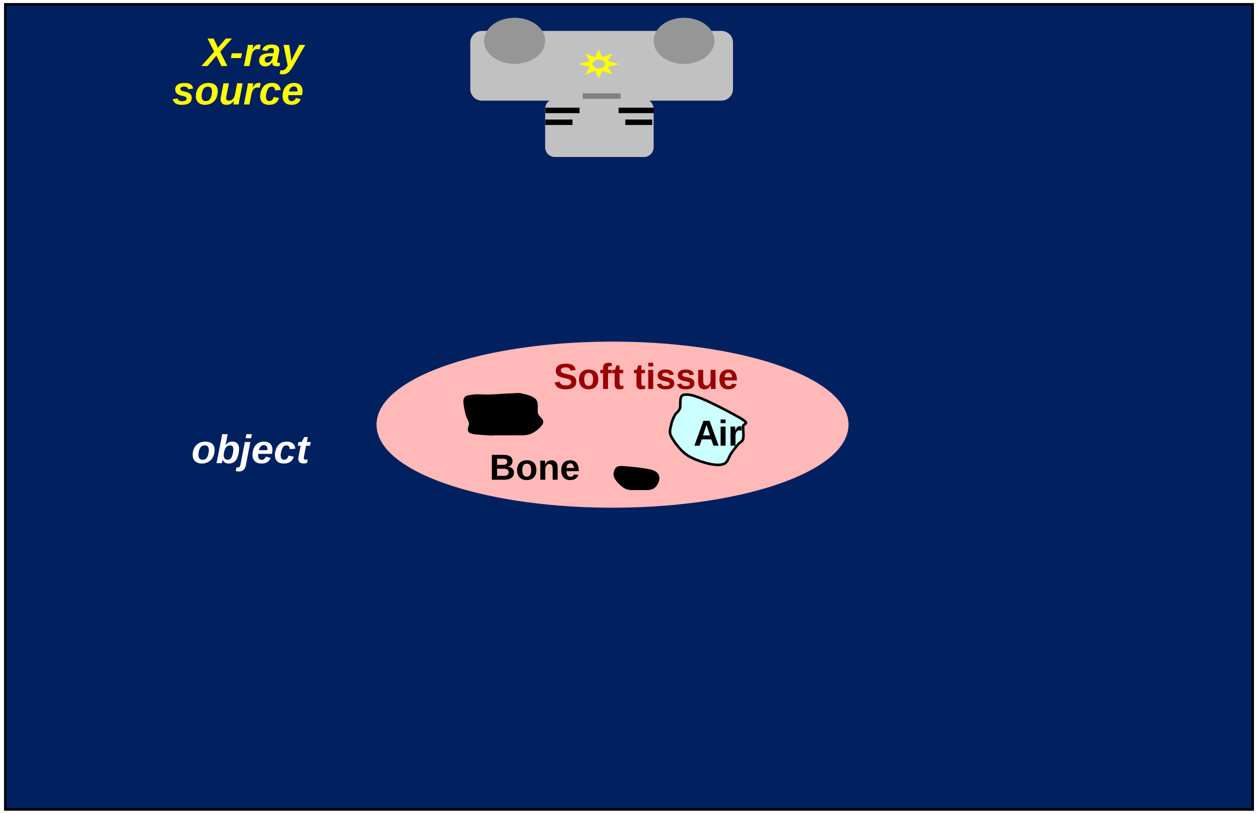

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Image formation in radiography

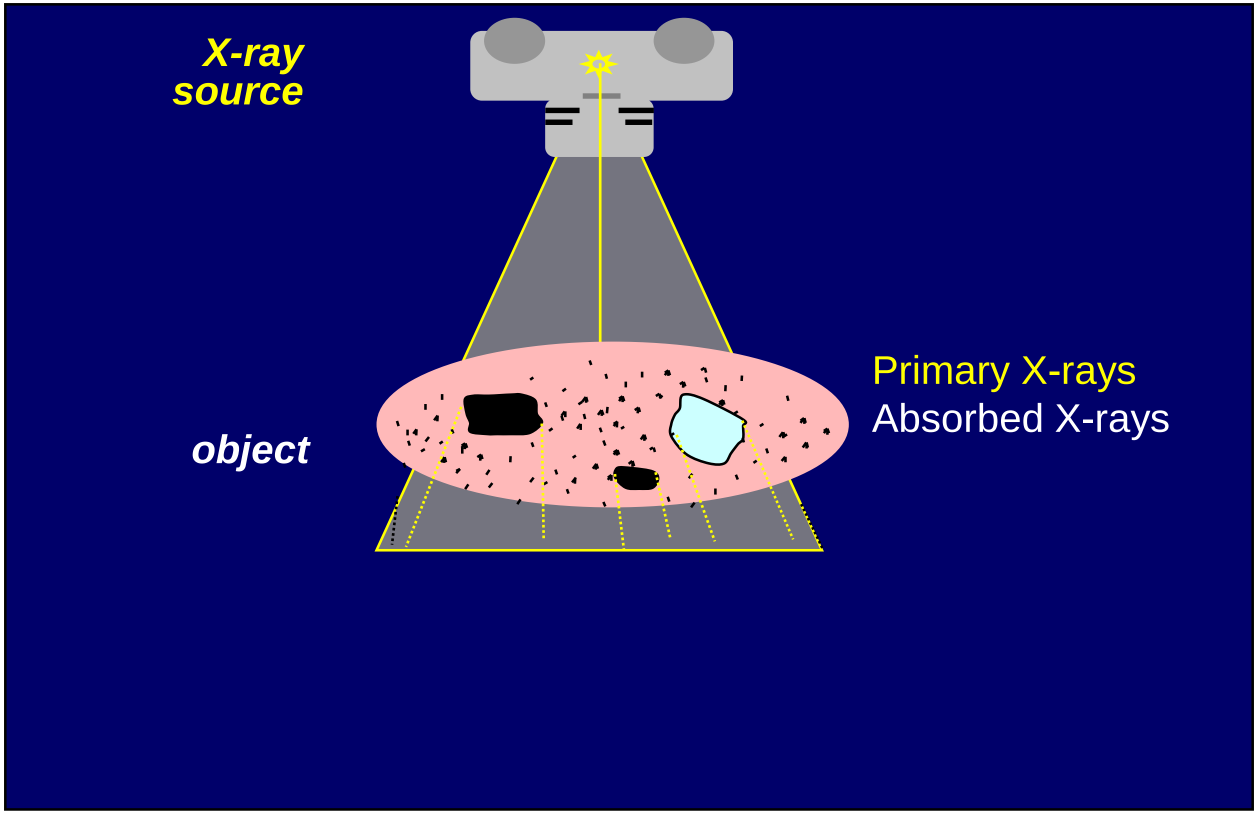

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Image formation in radiography

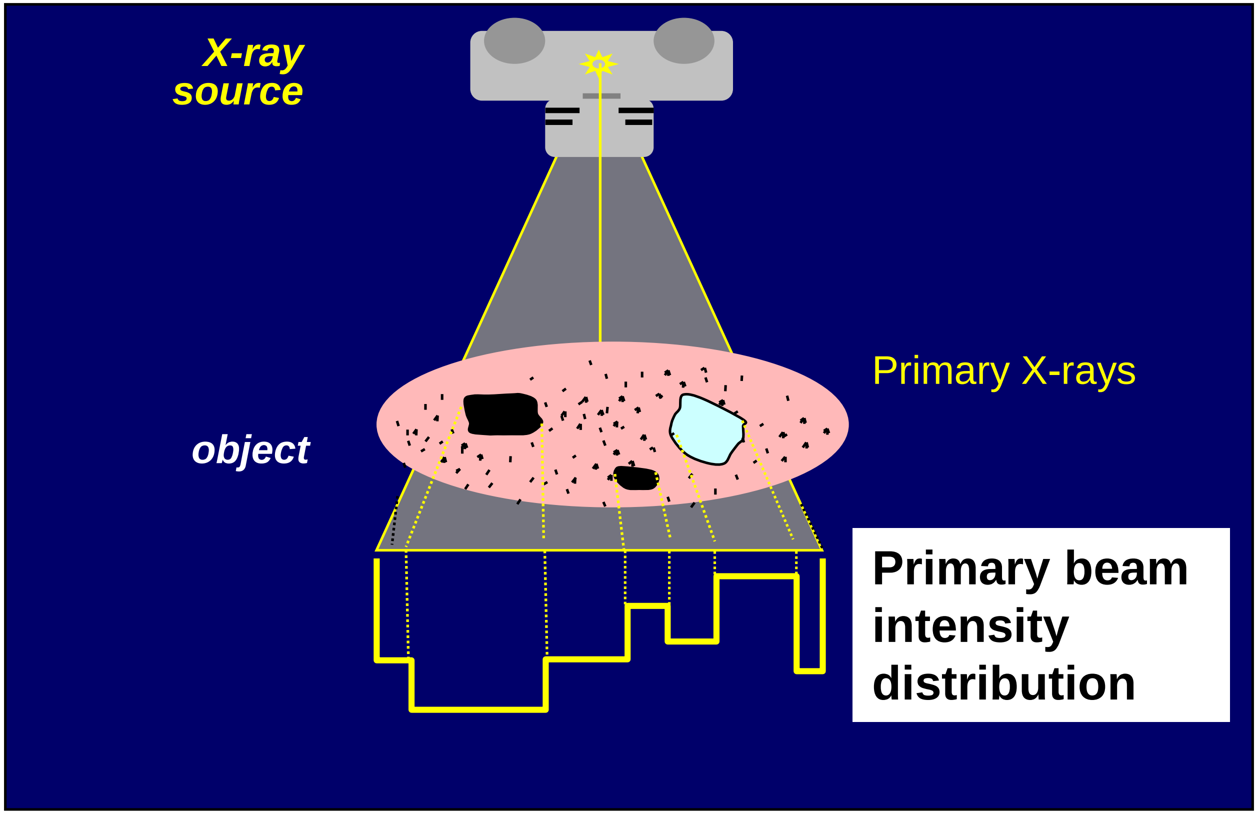

Image formation in radiography

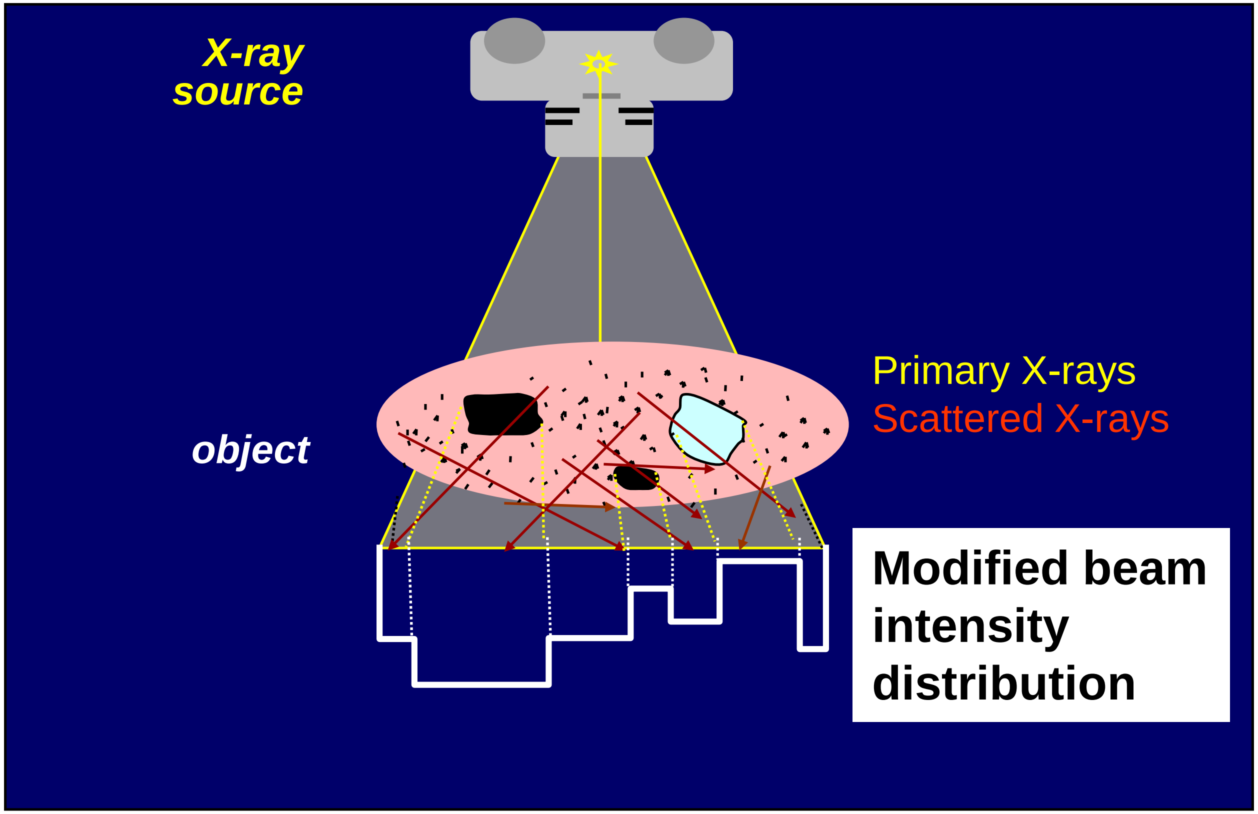

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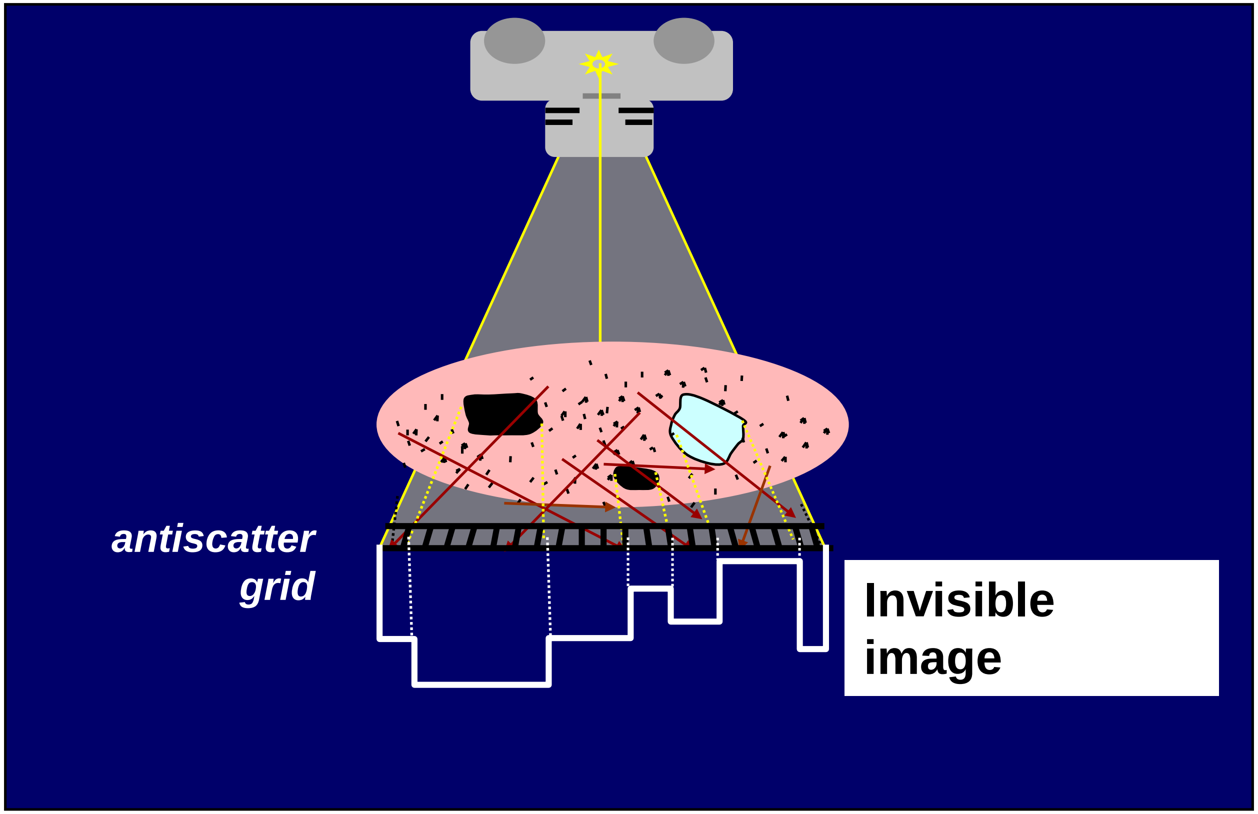
Image formation in radiography



The purpose of the collimator

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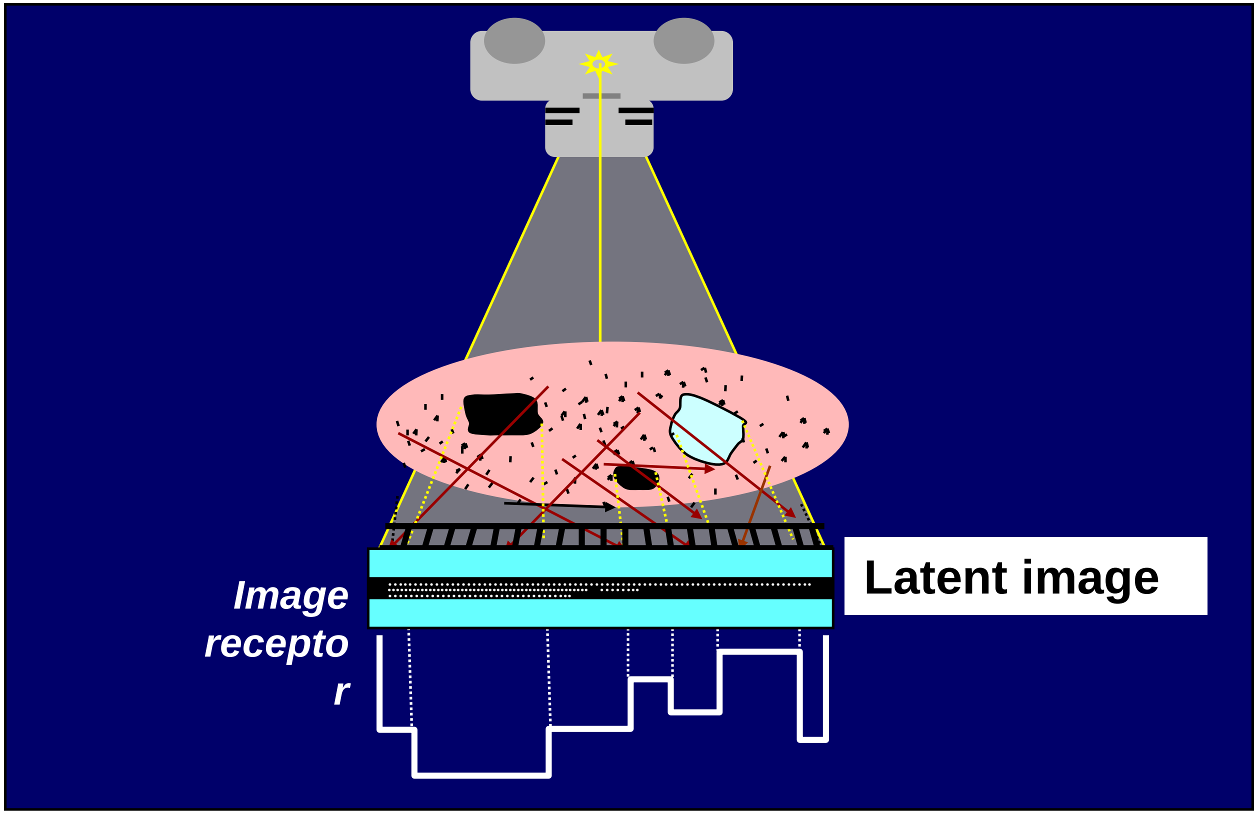
Image formation in radiography



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Optimization: Film-screen radiography

- Projections (AP, PA, Lat)
- Patient positioning, immobilisation / compression
- Technical parameters:
  - The tube potential (kV)
  - Tube current (mA)
  - Exposure time
  - Focal spot size
  - Filtration
  - Source to image receptor distance
  - Choice of anti-scatter device
  - Collimation
  - Image receptor type and size
- Shielding of radiosensitive organs when appropriate

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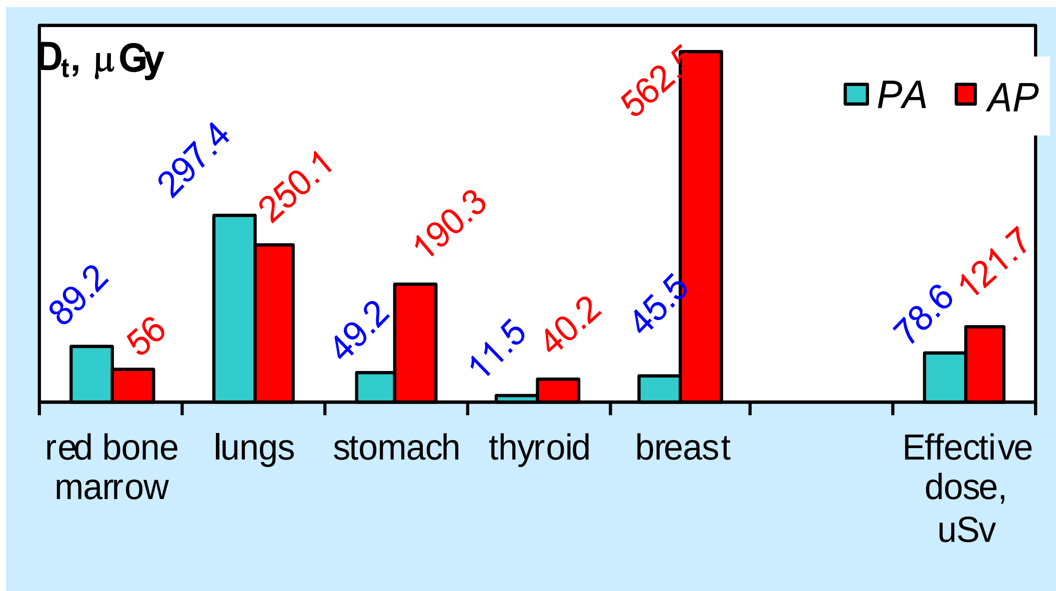
Radiography

Selection of projection

- The most appropriate projection should be adopted, from the patient protection point of view, when the diagnostic information so allows.
  - ✓For pregnant women, PA abdominal projections are preferable to minimize uterus dose
  - ✓For skull examinations eye lenses are better protected in PA projection
  - ✓For chest radiography, PA projection



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Radiography

Patient positioning

- Plays a major role in determining the success of the examination
- Routine positioning may need to be altered in the light of specific clinical circumstances
- Responsibility of the person who is physically directing the examination.
- Use of suitable immobilization techniques
- The use of fluoroscopy for centering the radiation field as a preliminary step of the radiographic image is not considered as a good radiological practice, so that it should be avoided.

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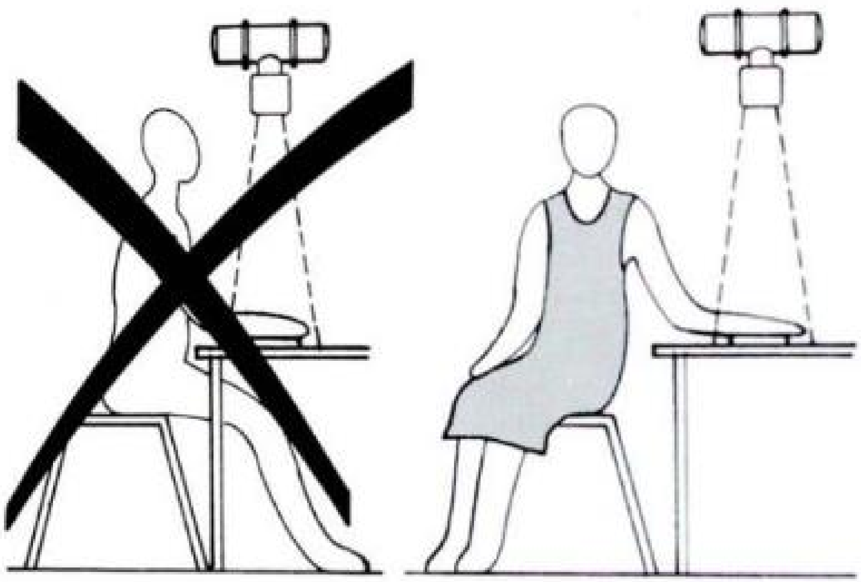
Radiography

Patient positioning



Courtesy E. Sorantin

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Radiography

Patient immobilization and protective shielding

Courtesy D. Koff

Courtesy E. Sorantin

(SE: some countries reviewing advice on patient shielding – for now, stay with IAEA advice)

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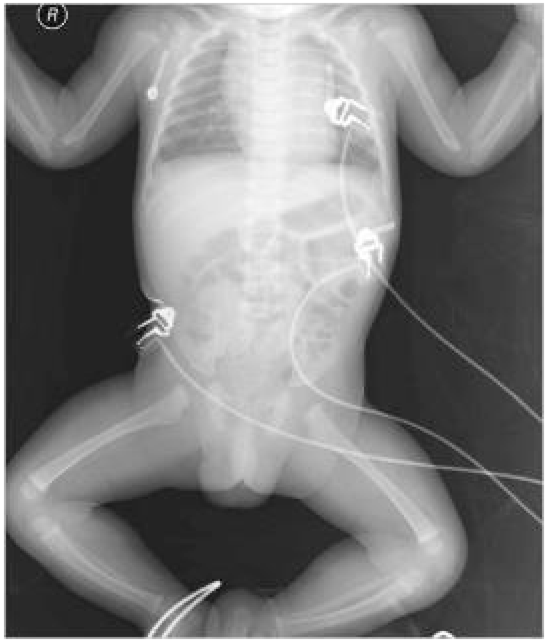
Collimation

- The most important factor for improving image quality whilst also reducing dose
- The most common radiographic fault
- Good collimation/coning is essential to achieve better contrast and avoid exposing unnecessarily other body parts (dose reduction)
- Body parts outside the region of interest should not be in the X-ray field

"Babygram"



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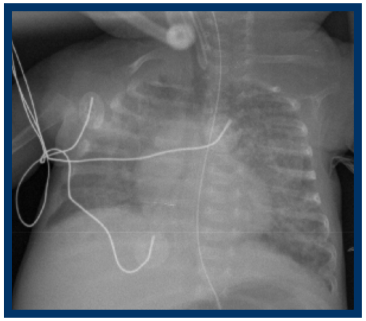
Radiography



- Poor collimation
- Large part of the body is irradiated
- Not seen on digitally cropped image

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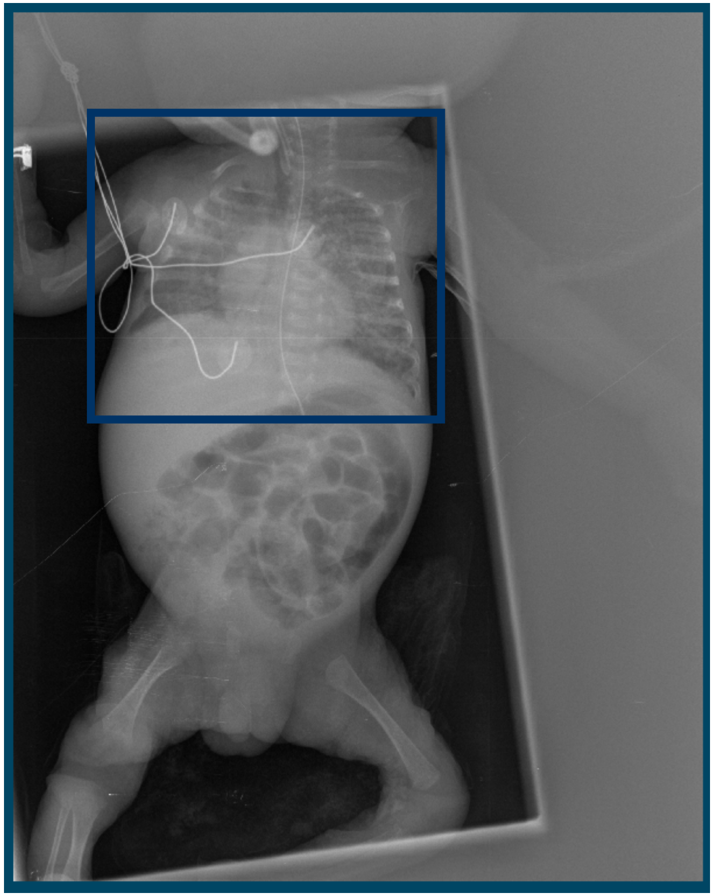
Radiography



- Poor collimation
- Large part of the body is irradiated
- Not seen on digitally cropped image

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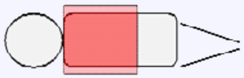
Radiography

- <u>Example</u>. Neonatal chest radiography (real case from my practice)

(Jenia)

Table, f=100 cm, 65kV,
13mAs, 3,5mm Al



Field size	**12x12 cm**	**20x35 cm**
ESD	820 µGy	820 µGy
ovaries	26	525
testicles	1,6	770
red bone marrow	67	201
lung	433	491
stomach	348	532
thyroid	502	743
large intestine	27	537
Effective dose	**209 µSv**	**505 µSv**

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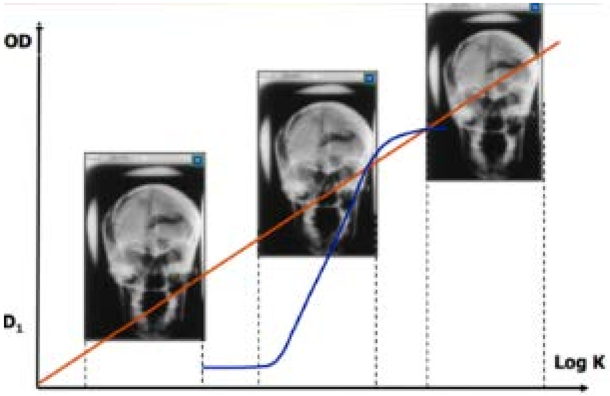
Image receptor

- For analogue image acquisition systems: the type (speed and spectral response) of film–screen combination and film processing conditions (e.g. the chemicals used and developing time and temperature).
- Digital systems can be operated at almost any level of receptor dose: Receptor dose needs to be tailored to the imaging task (decision is made by a responsible radiologist)



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Anti-scatter device

- Anti-scatter grid improves the image quality,
- but ALWAYS increases patient doses.
- It is advisable to evaluate whether the grid is actually necessary in equipment where its use is optional according to procedure (e.g. mammography) or patient characteristics.
- For infants and younger children the use of a grid or other anti-scatter measures is often unnecessary. The examples for good radiographic technique specify when grids are unnecessary.

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Radiography

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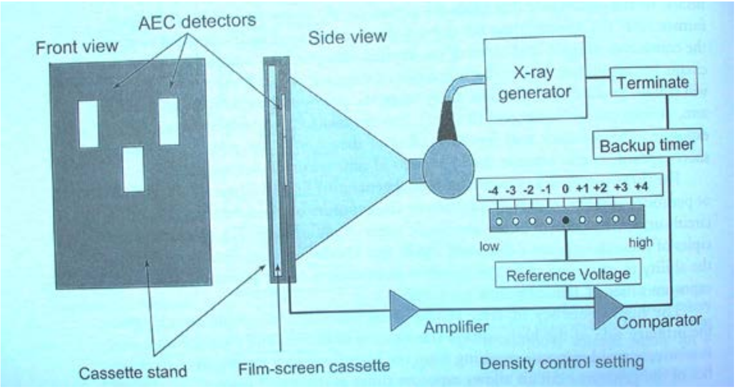
- Suitably calibrated and maintained automatic exposure controlled systems (AEC) should be used when available and appropriate.
- AEC systems are calibrated based on the radiation exposure at the detector required to produce the desired level of optical density (OD) for film-screen systems or a pre-determined acceptable level of signal to noise ratio (SNR), or surrogate, for digital systems.
- For digital systems, users need to understand how the selection of "exposure index" (or similar term for exposure indicator) affects patient dose.



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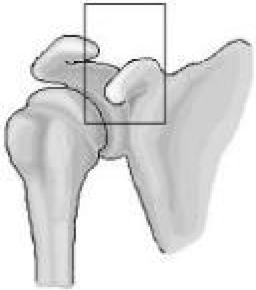
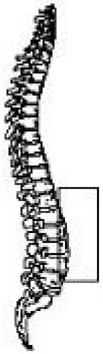
Radiography

Automatic Exposure Control

- Inappropriate selection of automatic exposure control settings might lead to incorrectly contrasted images (too dark or too clear).
- Then the automatic exposure control device should **ALWAYS** be checked, in particular when the sensitivity of the screen-film combination has been changed.
- The correct operation of the AEC device requires, for each projection, the selection of the chamber or detector closer to the area of interest, so that this area be best contrasted.
- Generally not appropriate for small children





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Radiography

Exposure parameters (example from the First survey in Bulgaria)

Example: the same type of x-ray system in 8 facilitiees

Chest radiography, PA, standard adult patient

ESD, mGy	U, kV	FSC	Grid factor
0,18	80-100	800	7
0,25	100	400	7
0,3	65-80	800	7
0,44	70-80	400	7
1,04	100	100	7
1,92	70-85	100	7
1,94	85	100	7
2,38	70-75	100	15

13 fold!

SE note: Film-screen systems

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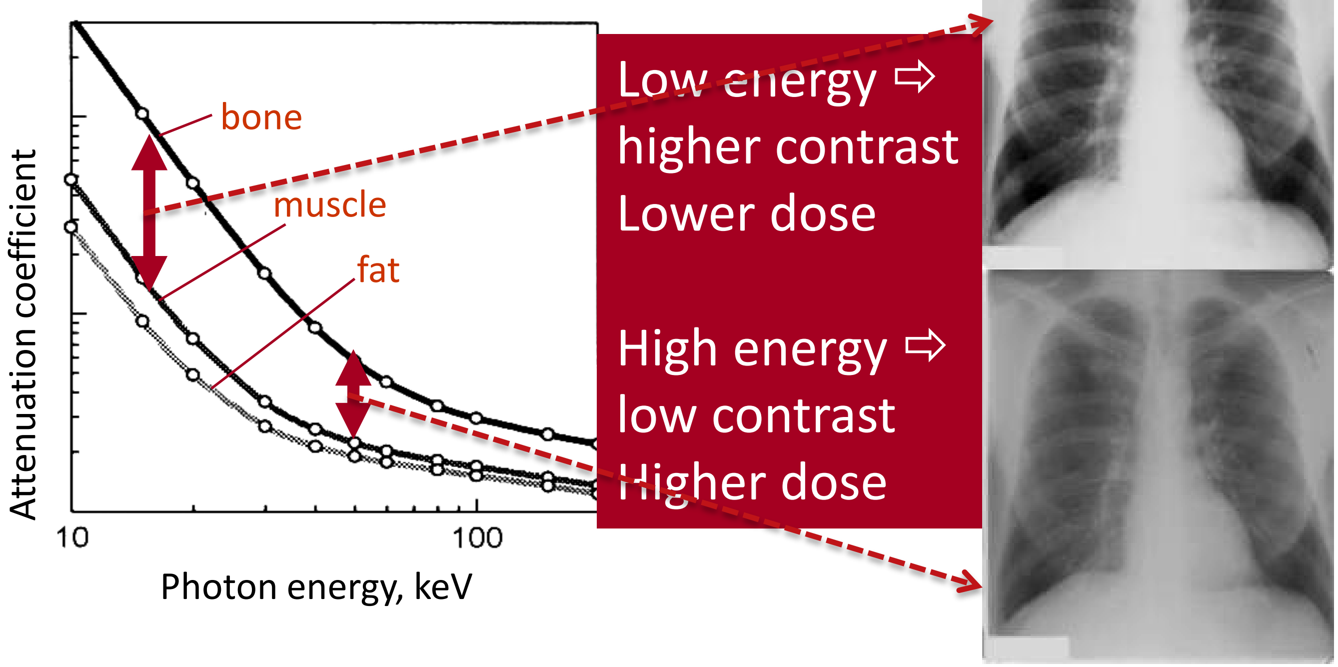
Radiography

Image contrast and patient dose

- Absorption depends on photon energy
- The image contrast depends on the energy



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Radiography

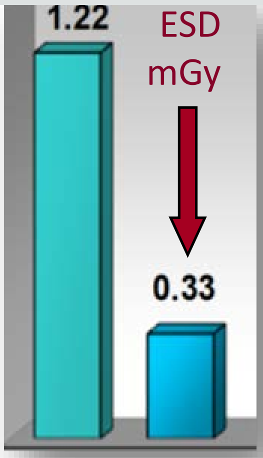
Example: Chest radiography with old radiography system

Chest wall; Bucky *r=7; f* = 150 cm; filtration 3 mm Al

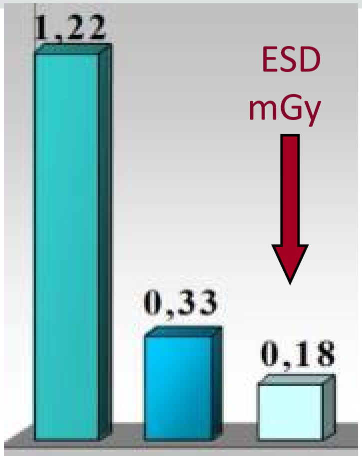
U = 70 - 80 kV; speed class 100

Increased speed

class 100 → 400



Increased kVp and filtration
70 kV →100 kV,
1 mm Al + 0.1 mm Cu



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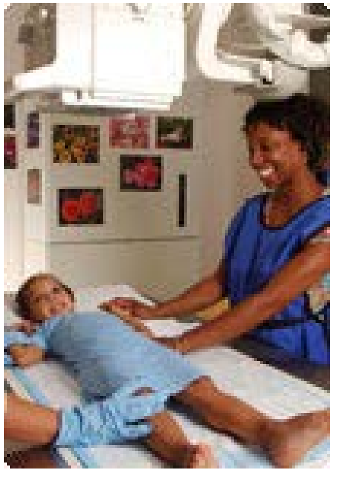
Radiography

Added filtration

Added filtration	0 mm Al	3 mm Al
Examination	Mean ESD (μGy)	Reduction
Abdomen AP 10 months (62 kVp)	200	30 %
Chest AP 10 months (55 kVp)	64	40 %
Pelvis AP 4 months (50 kVp)	94	51 %



From: Mooney and Thomas : Dose reduction in a paediatric X-ray department following optimization of radiographic technique, BJR (77) 1998:852-860

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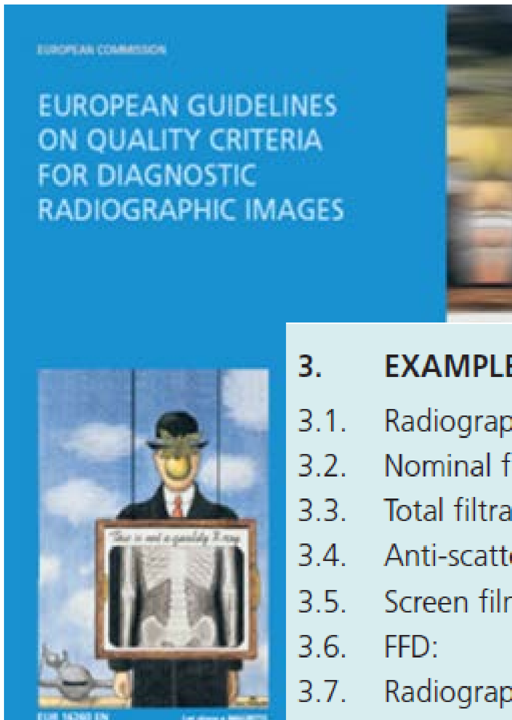
IAEA

Radiography

Good radiographic technique



3. EXAMPLE OF GOOD RADIOGRAPHIC TECHNIQUE

3.1.	Radiographic device:	vertical stand with stationary or moving grid
3.2.	Nominal focal spot value:	≤ 1.3
3.3.	Total filtration:	≥ 3.0 mm Al equivalent
3.4.	Anti-scatter grid:	r = 10; 40/cm
3.5.	Screen film system:	nominal speed class 400
3.6.	FFD:	180 (140-200) cm
3.7.	Radiographic voltage:	125 kV
3.8.	Automatic exposure control:	chamber selected — right lateral
3.9.	Exposure time:	< 20 ms
3.10.	Protective shielding:	standard protection

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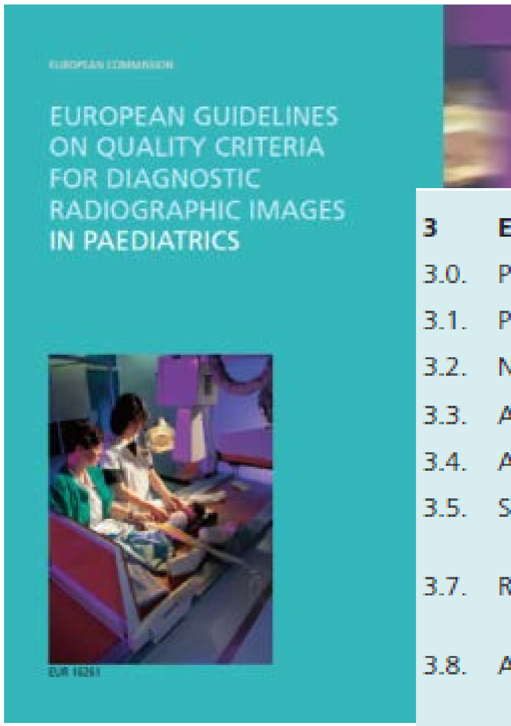
Radiography

Good radiographic technique



PA/AP PROJECTION
(Beyond the newborn period)

For co-operative patients PA projection;
AP projection for non-co-operative patients.

3	**EXAMPLE OF GOOD RADIOGRAPHIC TECHNIQUE**	
3.0.	Patient position	: upright, supine position possible
3.1.	Padiographic device	: table or vertical stand, depending on age
3.2.	Nominal focal spot value	: 0.6 (≤1.3)
3.3.	Additional filtration	: up to 1 mm Al + 0.1 or 0.2 mm Cu (or equivalent)
3.4.	Anti-scatter grid: r = 8; 40/cm	: only for special indications and in adolescents
3.5.	Screen film system	: nominal speed class 400 - 800 3.6 FFD 100 - 150 cm
3.7.	Radiographic voltage	: 60 - 80 kV (100 - 150 kV with grid for older children)
3.8.	Automatic exposure control	: chamber selected - lateral; preferably none in infants and young children
3.9.	Exposure time	: <10 ms
3.10.	Protective shielding	: lead-rubber coverage of the abdomen in the immediate proximity of the beam edge

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Designing the dose audit to obtain the DRL

1. Select examination
2. Select patient data
3. Ensure weight is within required range
4. Record the dose index value
5. Review and clean the data
6. Calculate the median value of dose index

Public Health England

Optimising

- Know the Technology
- Look to implement good radiographic practice

Establishing DRLs gives a benchmark in order to optimise equipment and practice

Public Health England

Protecting and improving the nation's health

IAEA International Atomic Energy Agency

Establishing and Using DRLs for optimisation in Radiography

Sue Edyvean

ICTP-IAEA Workshop on Establishment and Utilization of Diagnostic Reference Levels in Medical Imaging Imaging (smr3333):
18-22 November 2019 **Trieste, Italy**

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