Effective dose or dose area product as a measure for reference dose values

Calculation of patient dose values from beam quality, tube current, exposure time, exposed area and focus object distance

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DAP and reference levels

- ➔ Reference level = Maximum dose for a given examination at standard conditions
- ➔ Reference level expressed in suitable quantities:
  - – Conventional: DAP or ESD
  - – Mammography: Average Glandular Dose (AGD)
  - – CT: Dose Length Product (DLP) or $CTDI_w$

Factors influencing patient dose

- ➔ Beam quality
  - – kV, filtration, anode material, anode angle
- ➔ Dose rate
  - – mA
- ➔ Exposure time
- ➔ Size of x-ray field and body region irradiated
- ➔ Requirements on image quality
- ➔ Skill of radiologist

What can be done to lower patient dose?

- ➔ Smaller x-ray field (collimation)
- ➔ Compression
- ➔ Match beam quality to sensitivity of detector
- ➔ Better detector system
  - – More sensitive detector (higher DQE)
  - – Better image processing
- ➔ Training of staff (especially radiologists)
  - – Accept lower image quality
  - – Quicker decisions (fewer images, shorter fluoroscopy time)

The DAP concept

- DAP = Dose Area Product
- DAP is a combination of beam quality, mAs and field size

DAP or KAP?

- DAP = Dose Area Product
- KAP = Kerma Area Product
- Kerma = Kinetic Energy Released in Matter by ionising radiation
- For x-ray photon energies:

  Kerma ≈ Dose

  (Range of secondary e^- very short)

DAP meter

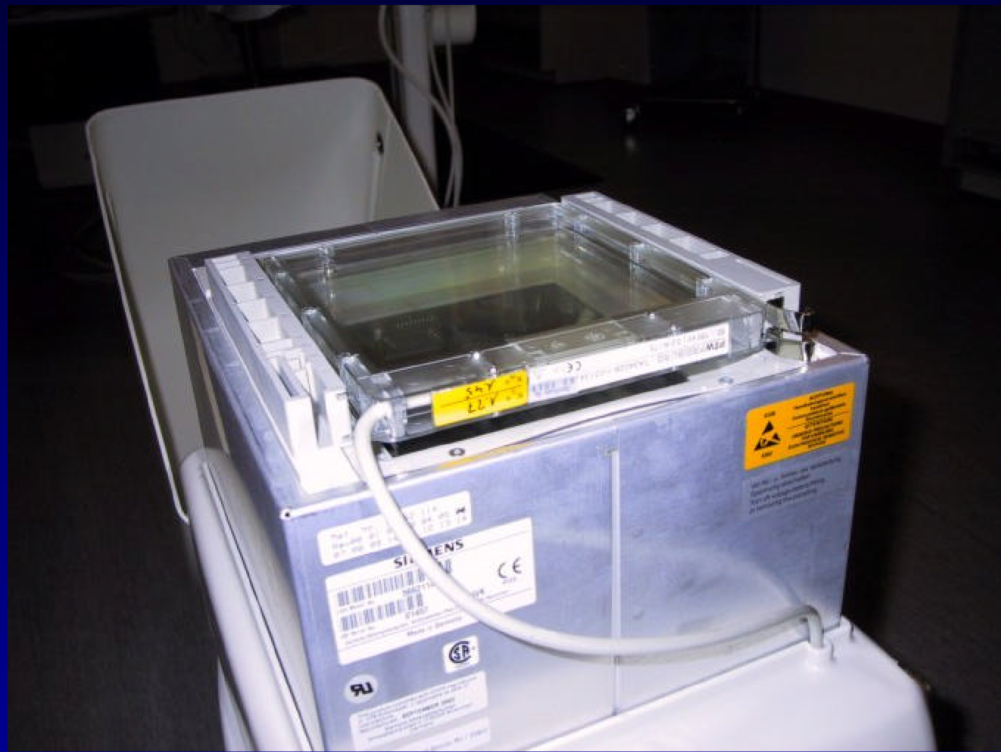
DAP meter

- The DAP meter is a transmission ion chamber
- Collects the charge produced by the x-rays in the chamber
- Produced charge proportional to the dose
- The chamber attenuates ca 10% of the dose

DAP meter mounted on x-ray tube

Other options

➔ Built-in DAP meter



➔ Calculated DAP value based on field size, beam quality and mAs

ESD

- ESD = Entrance Surface Dose
- The dose at the centre of the x-ray field
- Includes back scatter
- Almost independent of field size
- Usually measured with TLD (sometimes with semi conductor)

TLD

- TLD = Thermo Luminiscent Dosimeter
- Small pellets (≈5x5 mm^2), usually LiF
- Integrating dosimeter
- Light proportional to absorbed dose emitted when heated
- Light counted with PM tube in TLD reader

TLD system

TLD pellets (and tooth pick)

TLD reader

Comparison between DAP and ESD

- DAP takes field size into account, ESD does not
- DAP independent of focus-skin distance, ESD is not
- DAP measured with ion chamber
- ESD measured with TLD

DAP meter compared to TLD

+ DAP values can easily be recorded by radiographers
+ Good educational tool – immediate feedback

+/- Requires physicist on site

+ Can be used as many times as needed
+ Easy to handle when mounted (TLD material is poisonous, and sensitive to moisture and dust)

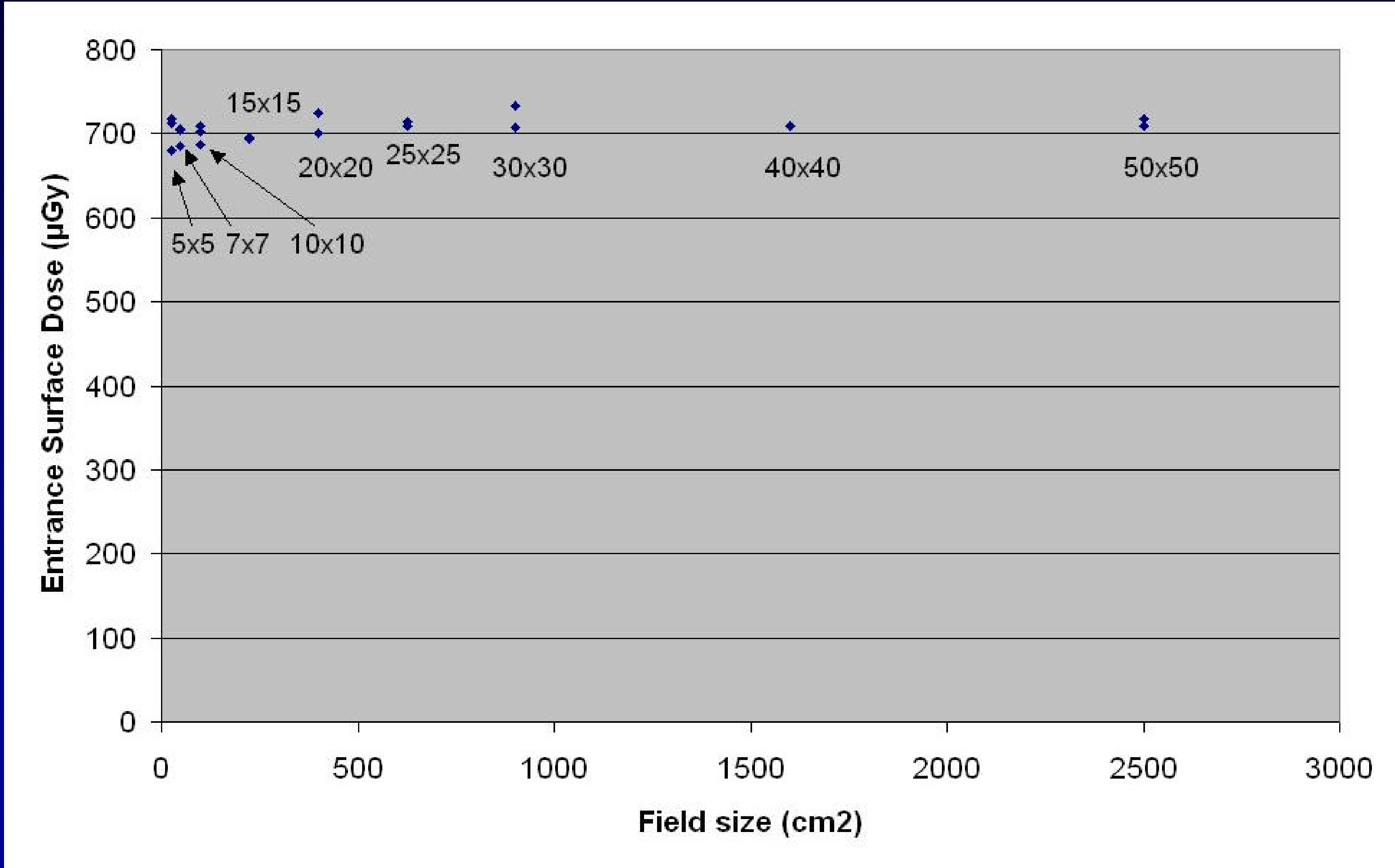
DAP meter compared to TLD

- Two quantities combined (dose and area)
- Calibration procedure more complicated
- Cannot be handled remotely

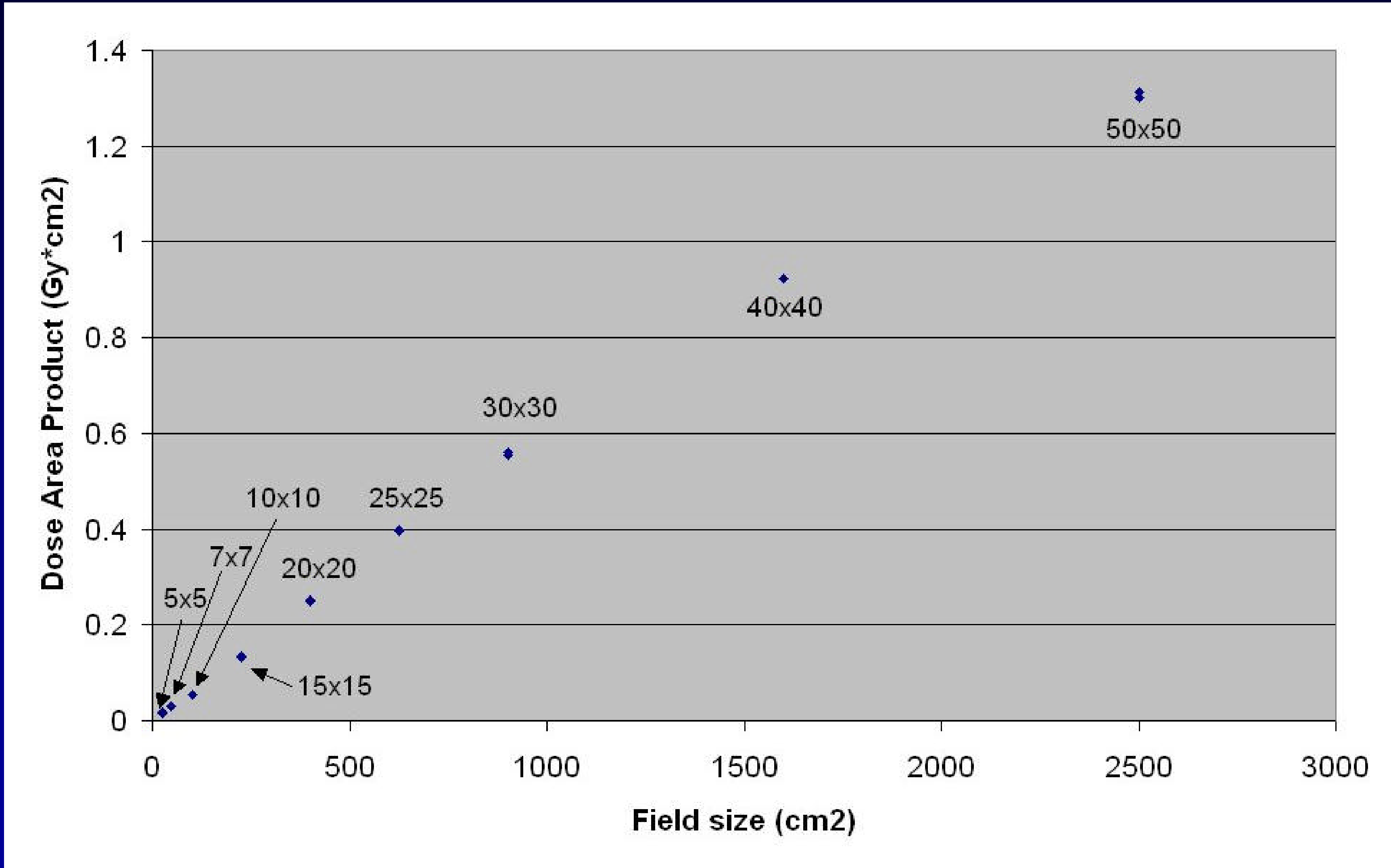
The relevance of DAP with respect to risk

- ➔ Effective dose is proportional to field size: the bigger part of the patient that is irradiated the higher the effective dose (constant mAs)
- ➔ Best way to reduce effective dose (and increase the image quality!) is to reduce the irradiated volume

ESD vs. field size



DAP vs. field size



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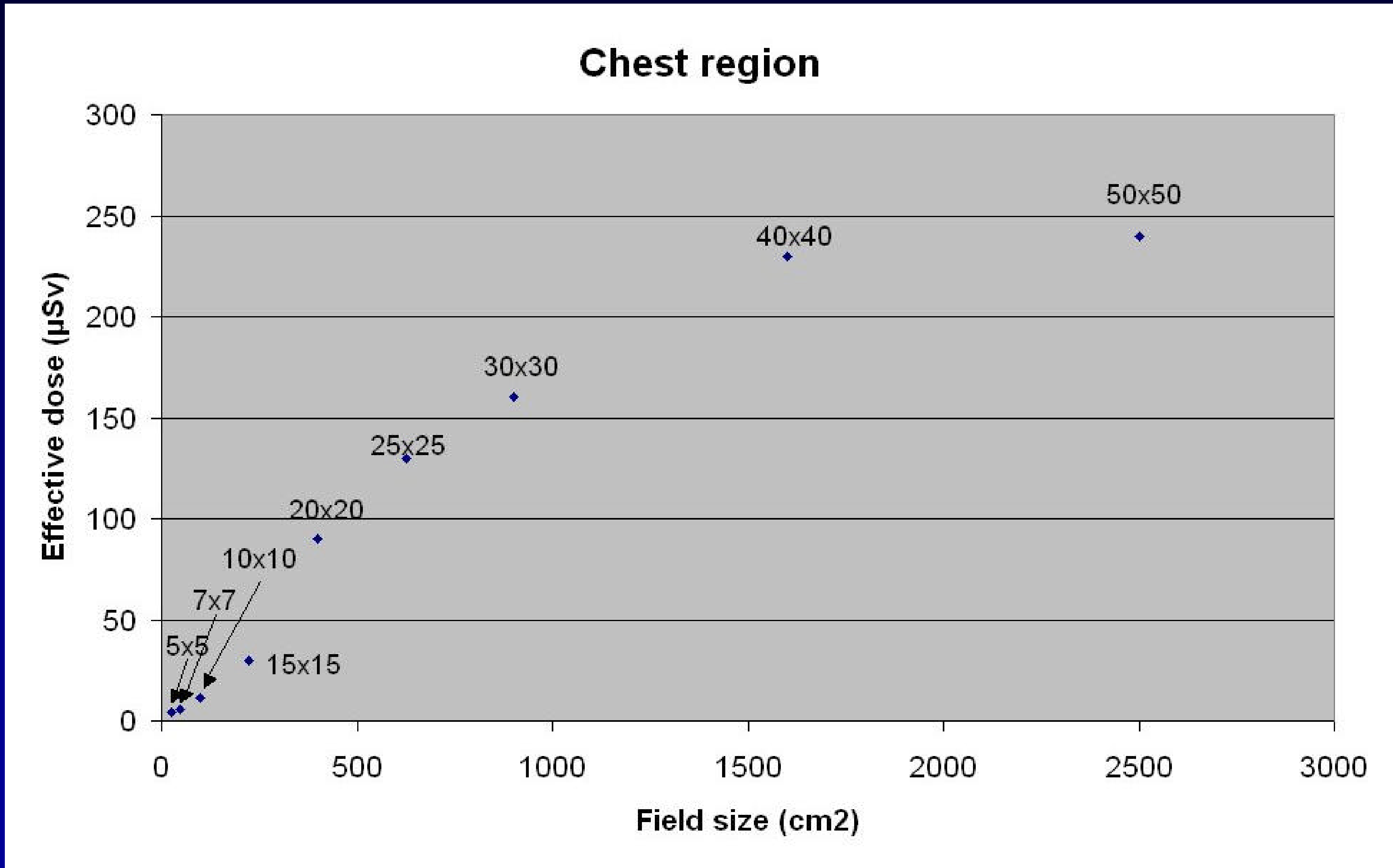
Effective dose vs. field size



Caveats – Lateral chest

- ➔ Normal collimation
- ➔ DAP = 0.5 $Gycm^2$

Caveats – Lateral chest

- ➔ Lax collimation
- ➔ In this case:
  DAP = 0.7 $Gycm^2$

No extra risk for patient!

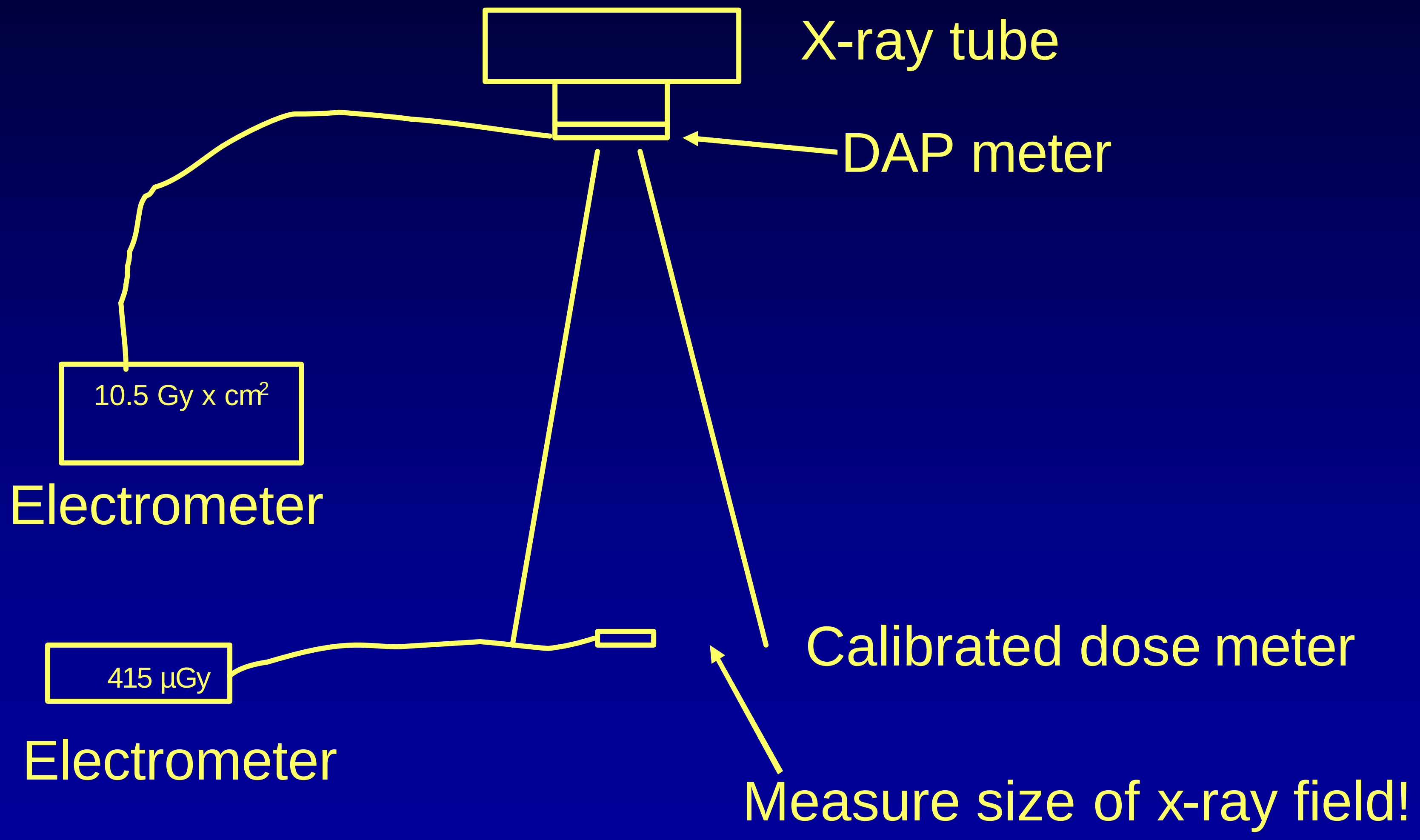
Caveats – Calibration of DAP meter

- ➔ Some DAP meters calibrated with respect to the dose impinging to the chamber
- ➔ Others with respect to the dose coming out of the chamber (thus hitting the patient)
- ➔ The DAP hitting the patient is what we are interested in!

Caveats – Calibration of DAP meter

- ➔ Built-in DAP meters may be calibrated at strange beam qualities
- ➔ Presented DAP up to 2x the real value
- ➔ Obviously very important when measuring diagnostic standard doses

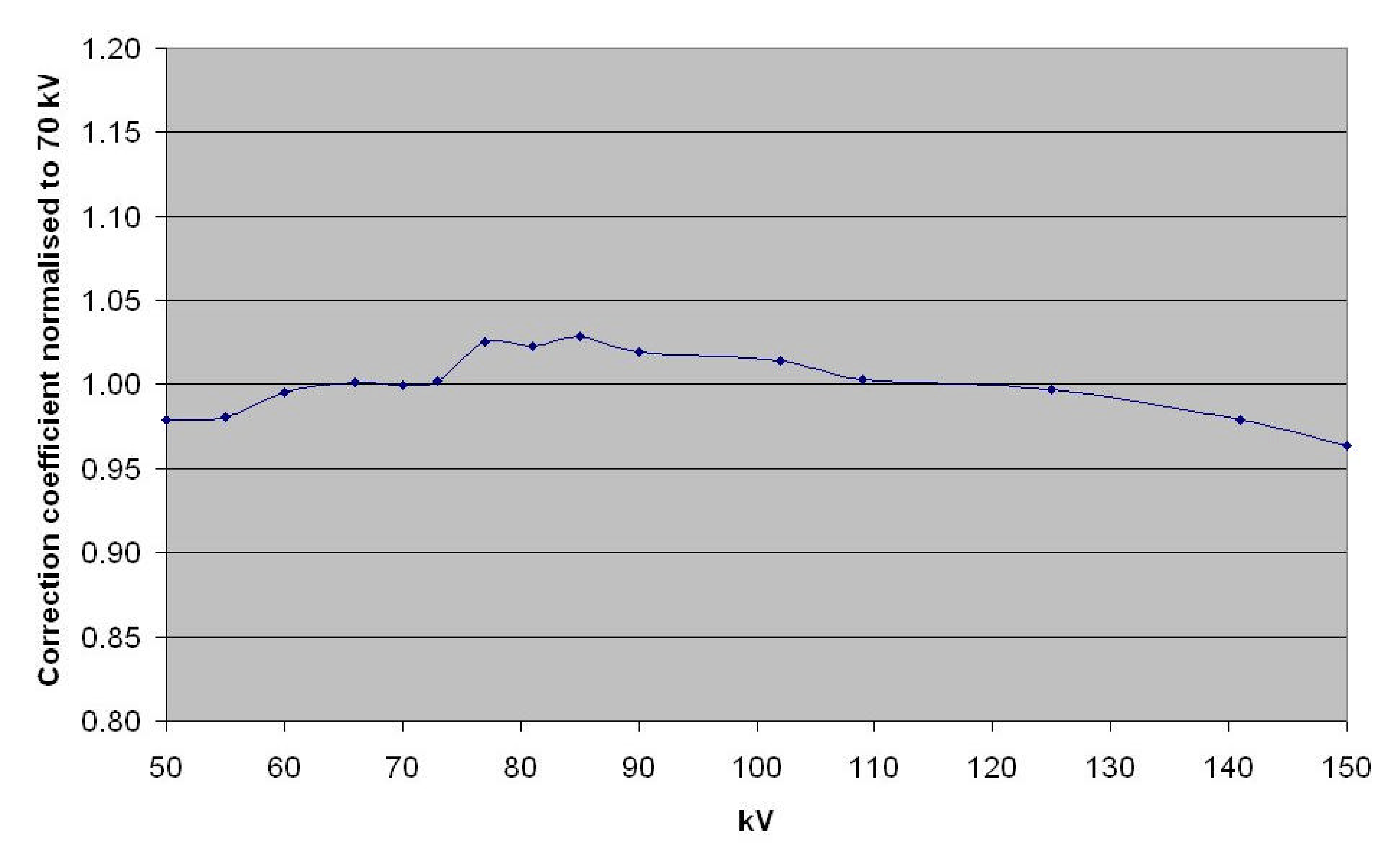
Calibration of DAP meter



Calibration of DAP meter

- ➔ Put DAP meter in position at outside window of x-ray tube
- ➔ Put calibrated dose meter in x-ray field
  - – Calibrated at different beam qualities!
  - – E.g. calibrated semiconductor dose meter
- ➔ Determine response of DAP meter at different beam qualities

Correction Coefficients

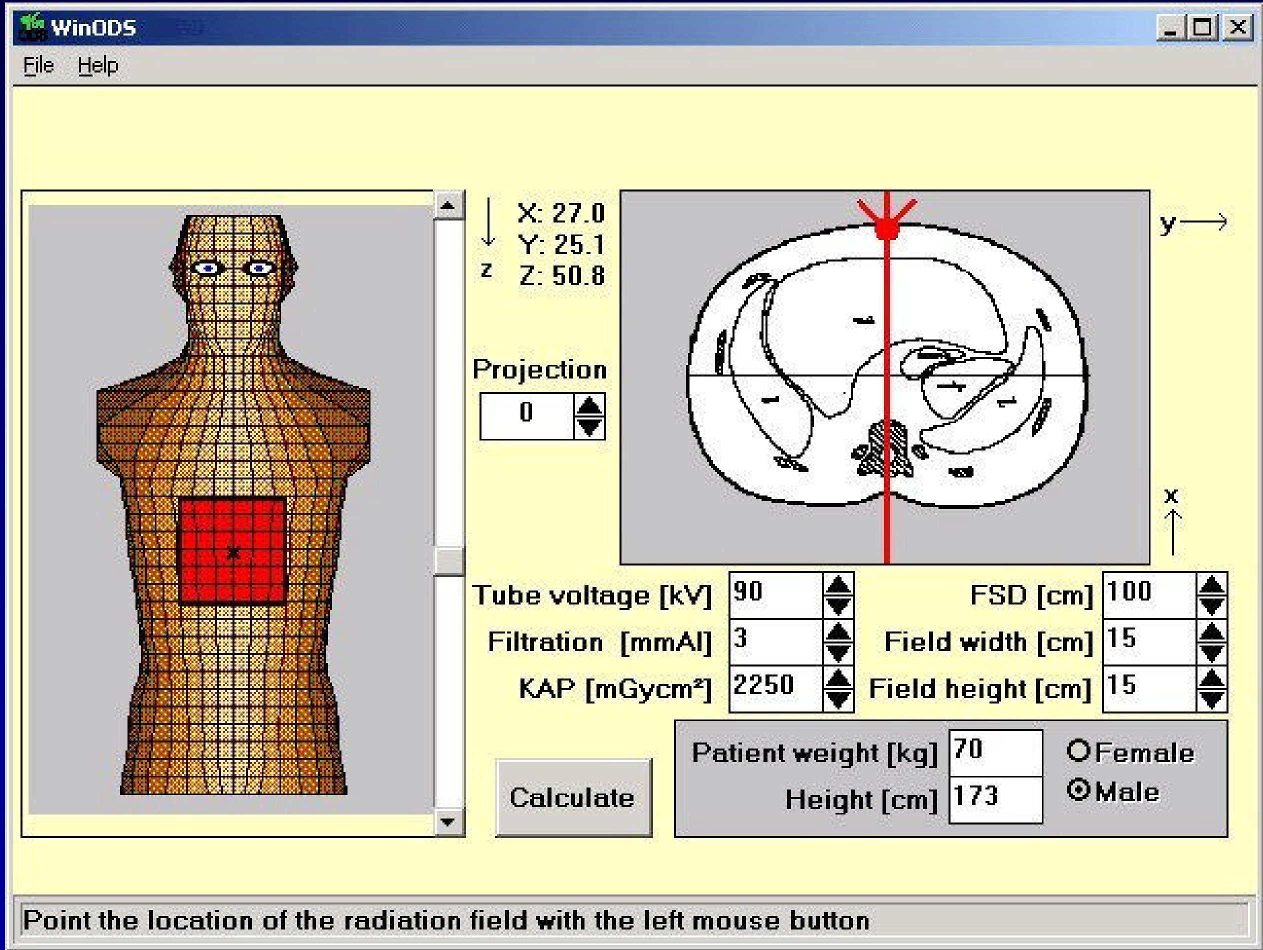


Calculation of effective dose (E)

- ➔ Computer software or table
- ➔ Input values:
  - – Exposure parameters: kV, filtration, FSD, field size, DAP or ESD
  - – Examination info: irradiated body region
  - – Patient information: height, weight, sex
- ➔ Output values:
  - – Organ doses and effective dose

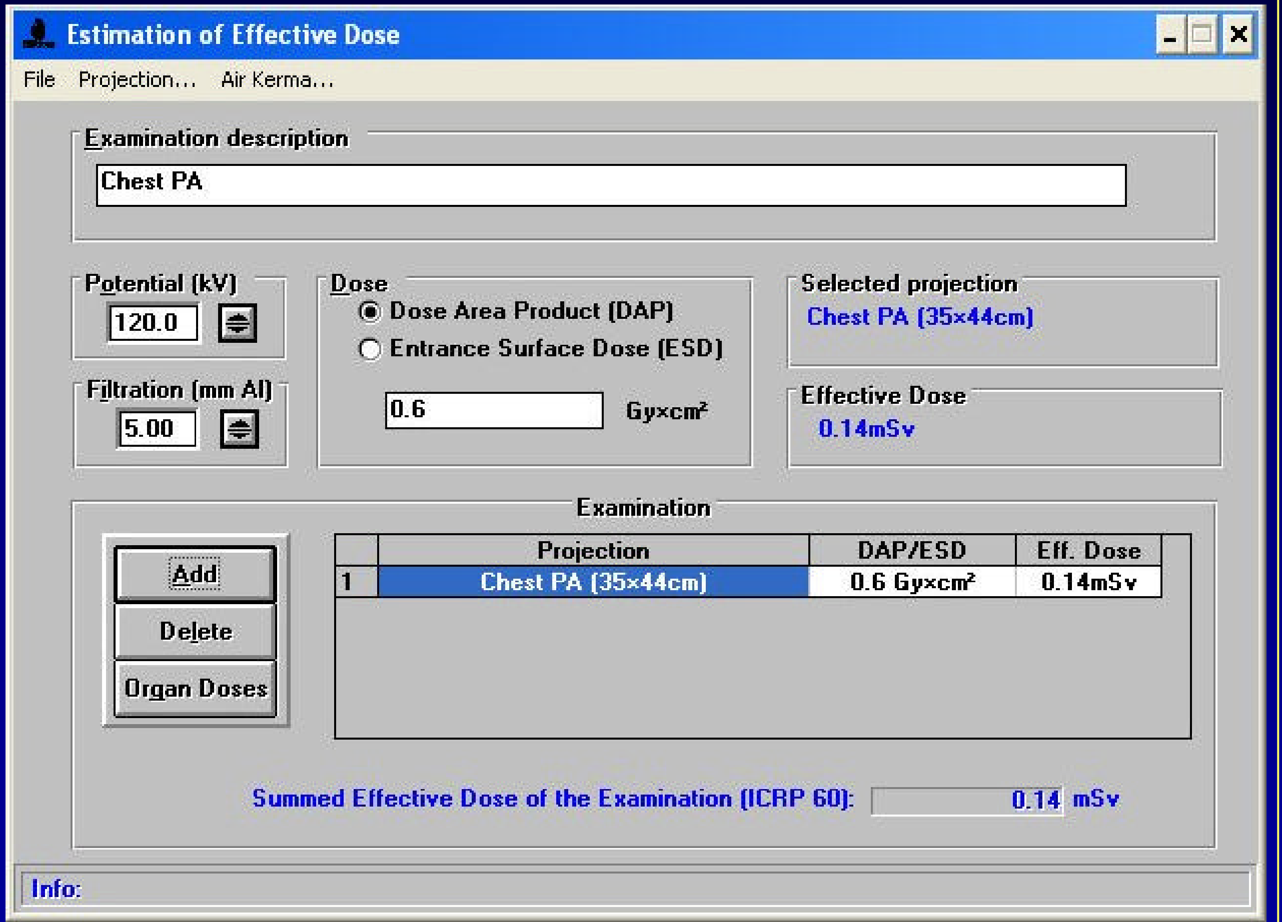
Software packages

➔ WinODS



Software packages

- ➔ NRPB tables (SR 262) and EffDose



Software packages

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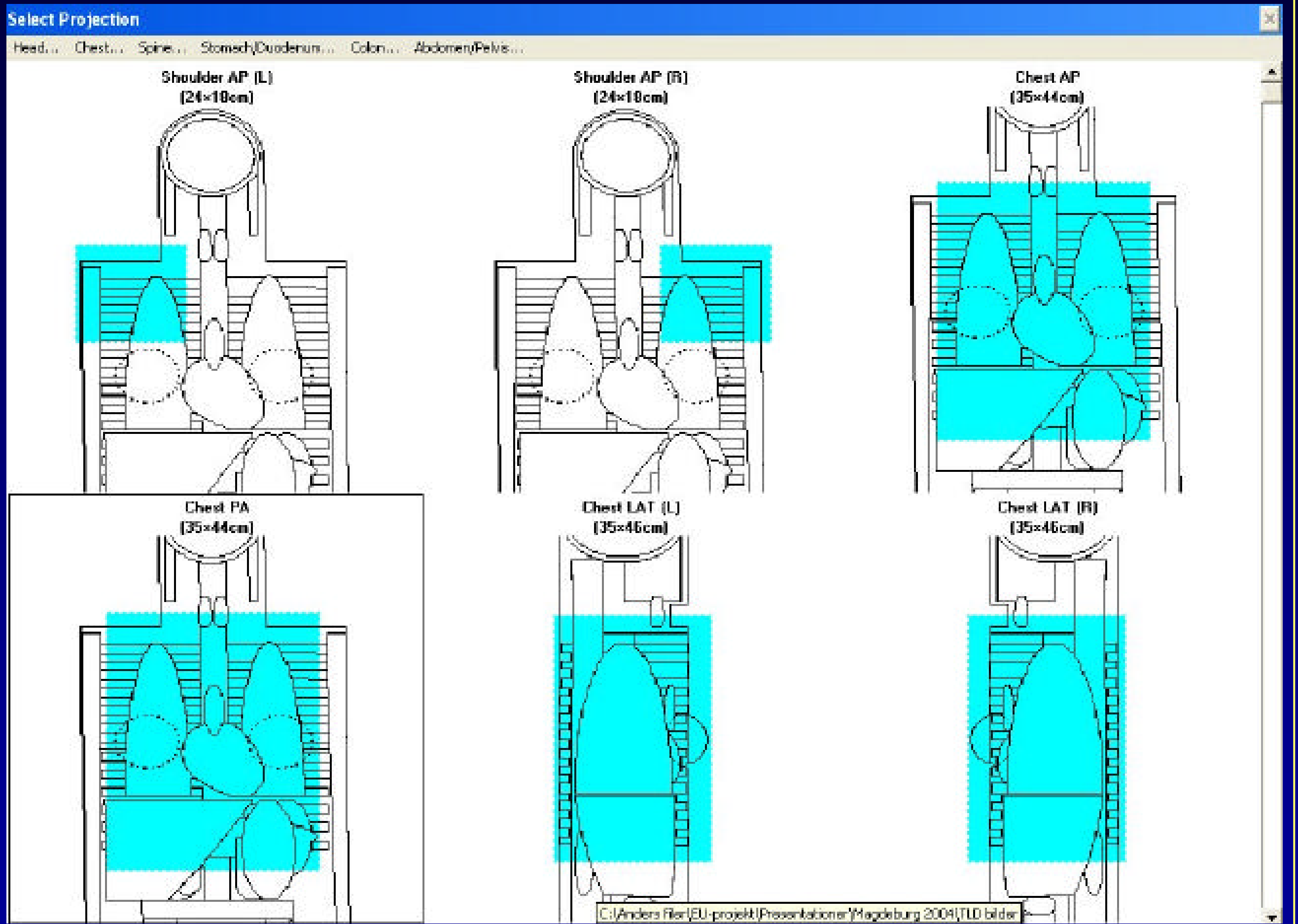

Software packages

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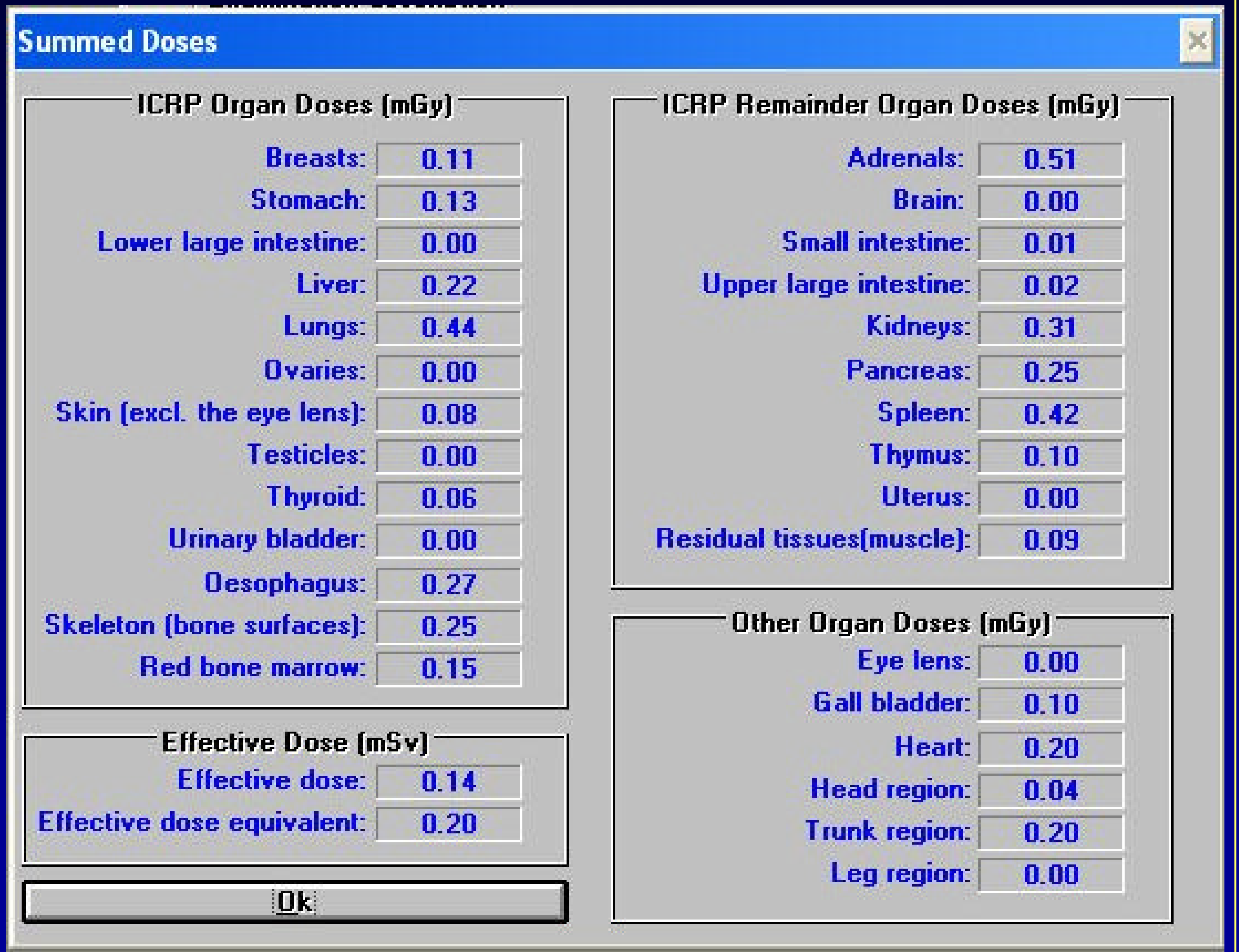
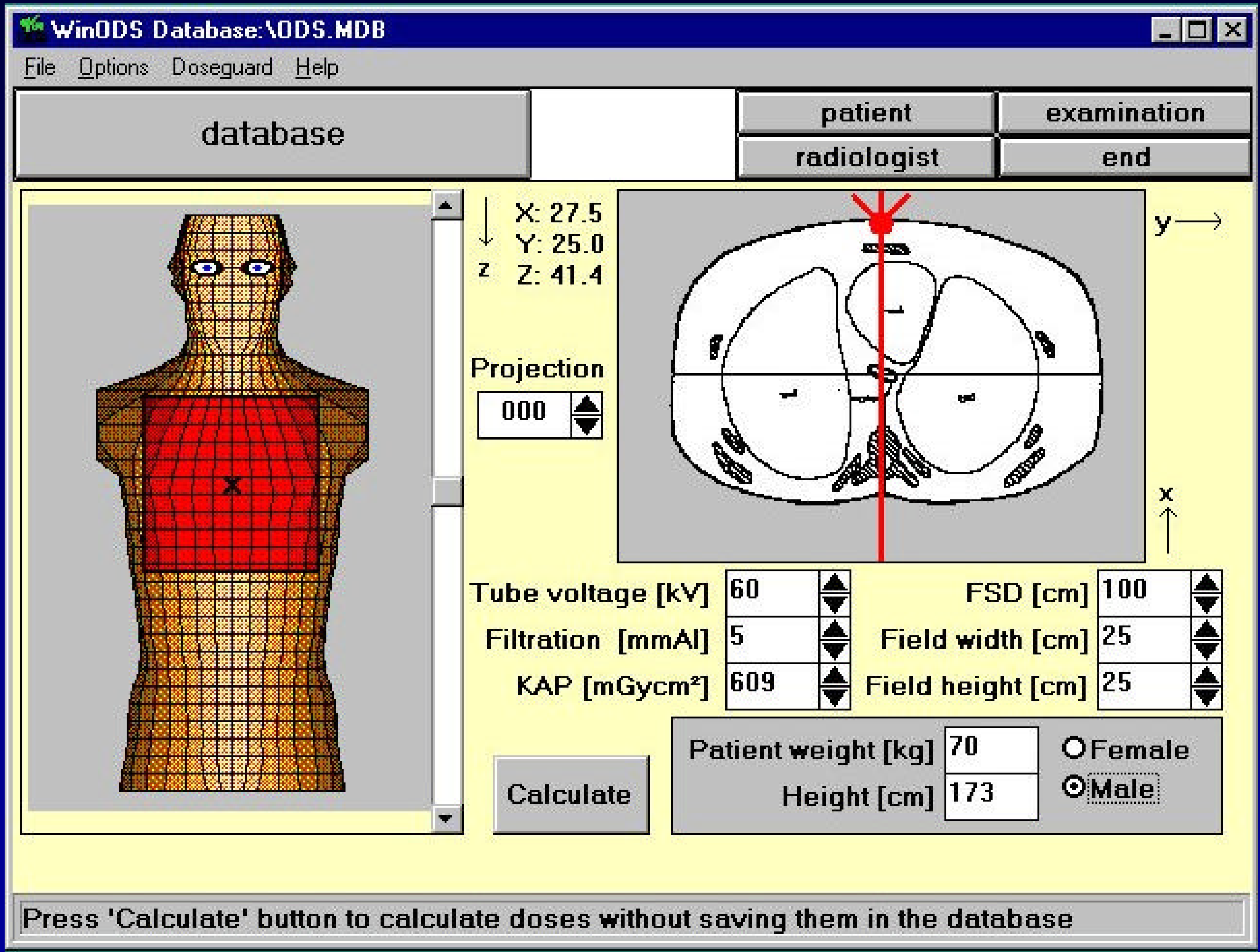
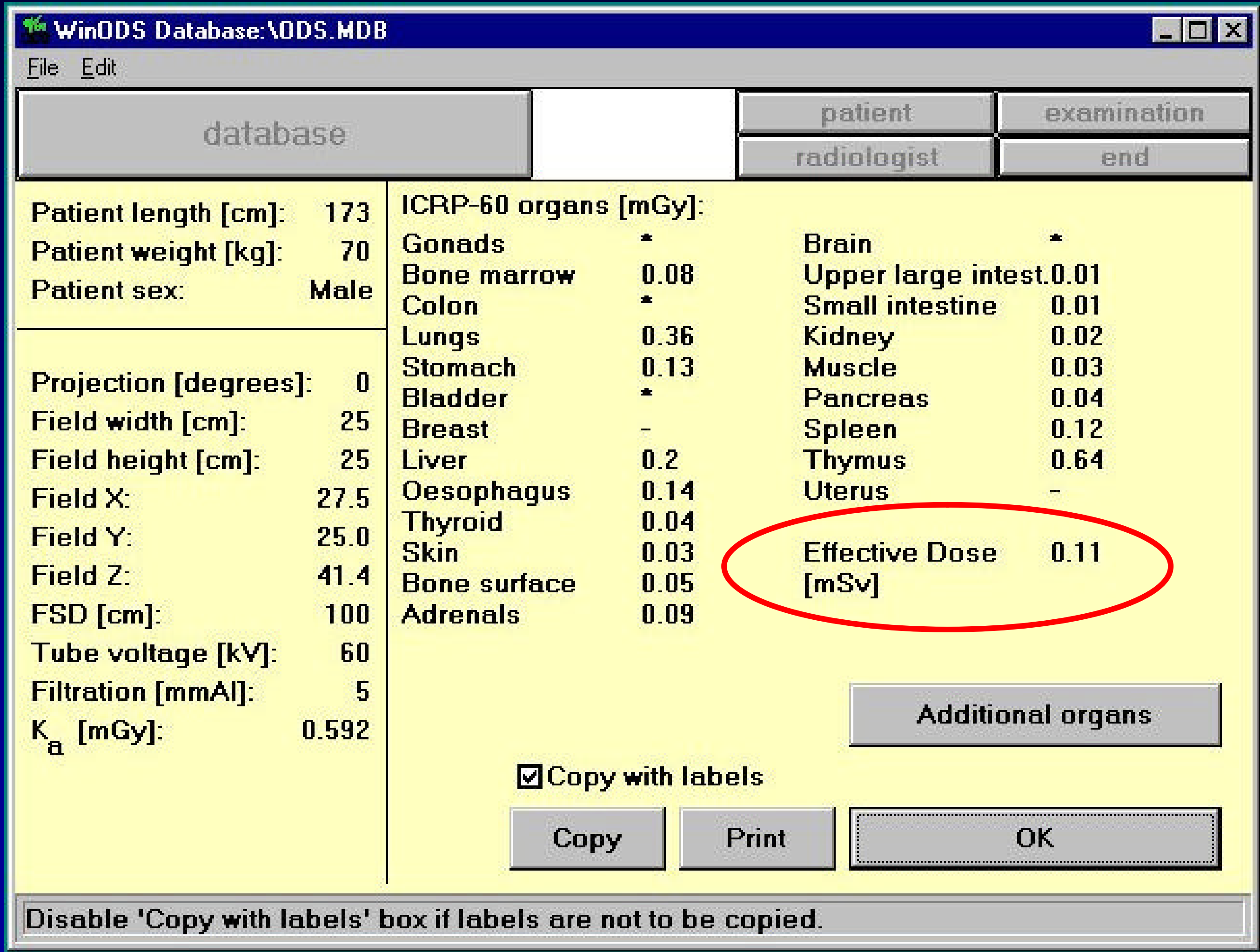


Example of E calculation



Example of E calculation



Diagnostic reference level, DRL

- ➔ Dose level determined by government for a given examination
- ➔ If DRL is exceeded, actions should be taken to lower the dose

DRL, cont'd

- Mean value for a number of patients
- Does not apply to an individual patient!
- Value of DRL is set arbitrarily – often the the 75% level of the distribution within a country is selected

Diagnostic standard dose, DSD

- ➔ Dose level determined at the radiology department for a given examination, measured in the same way as for the DRL

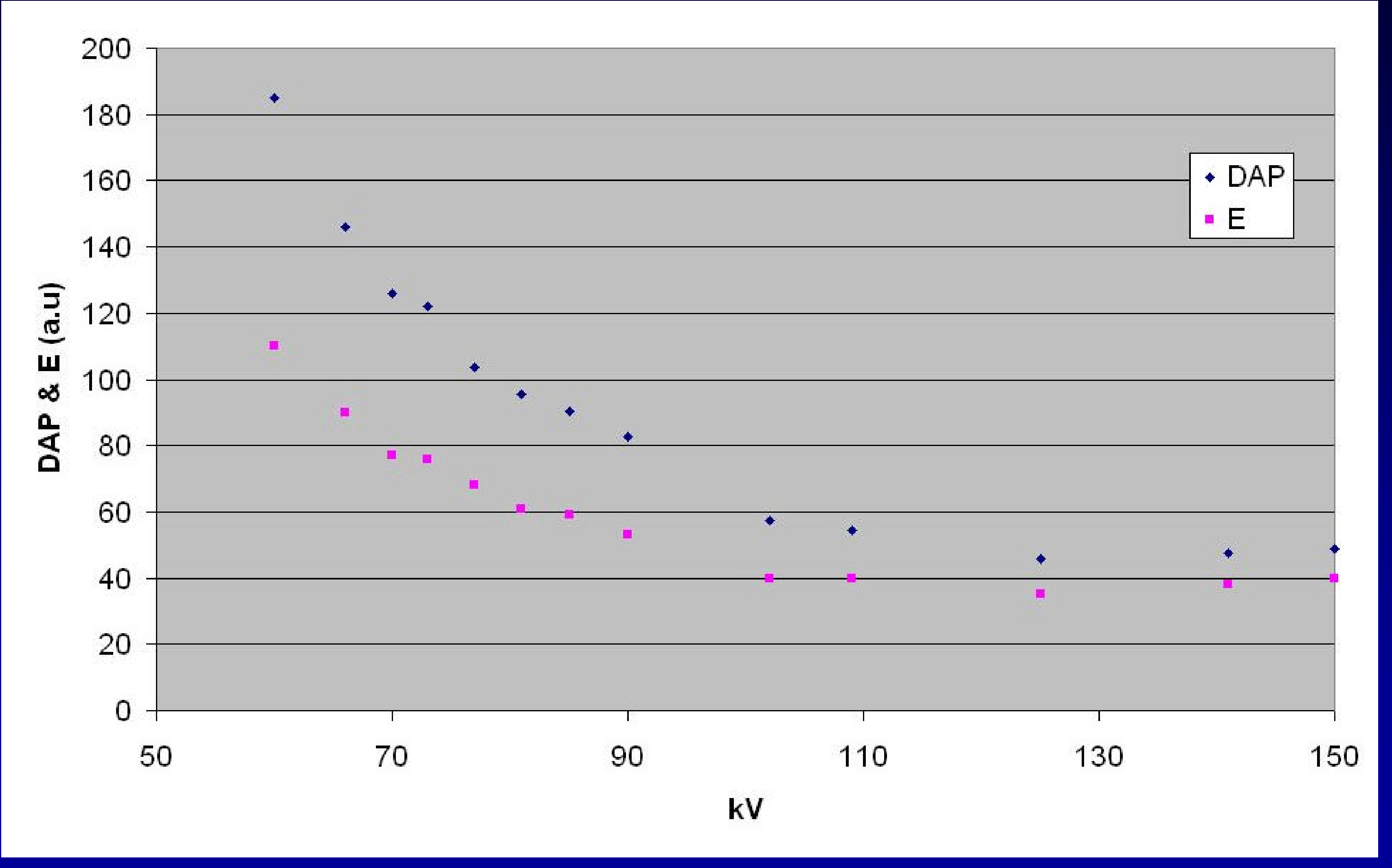
Purpose of DRL

- ➔ Identify bad procedures
- ➔ Comparisons
- ➔ National (and international) dose surveys
- ➔ Encourage radiation protection and dose consciousness

How to measure DSD, for a given examination

- ➔ Mount DAP meter at x-ray tube
- ➔ Provide technicians with measurement protocols (preferably digital)
- ➔ Instruct technicians and radiologists carefully
  - – Put someone in charge of the measurements
- ➔ Be patient…
- ➔ Repeat procedure for each x-ray stand

DAP & E vs. kV (AEC)



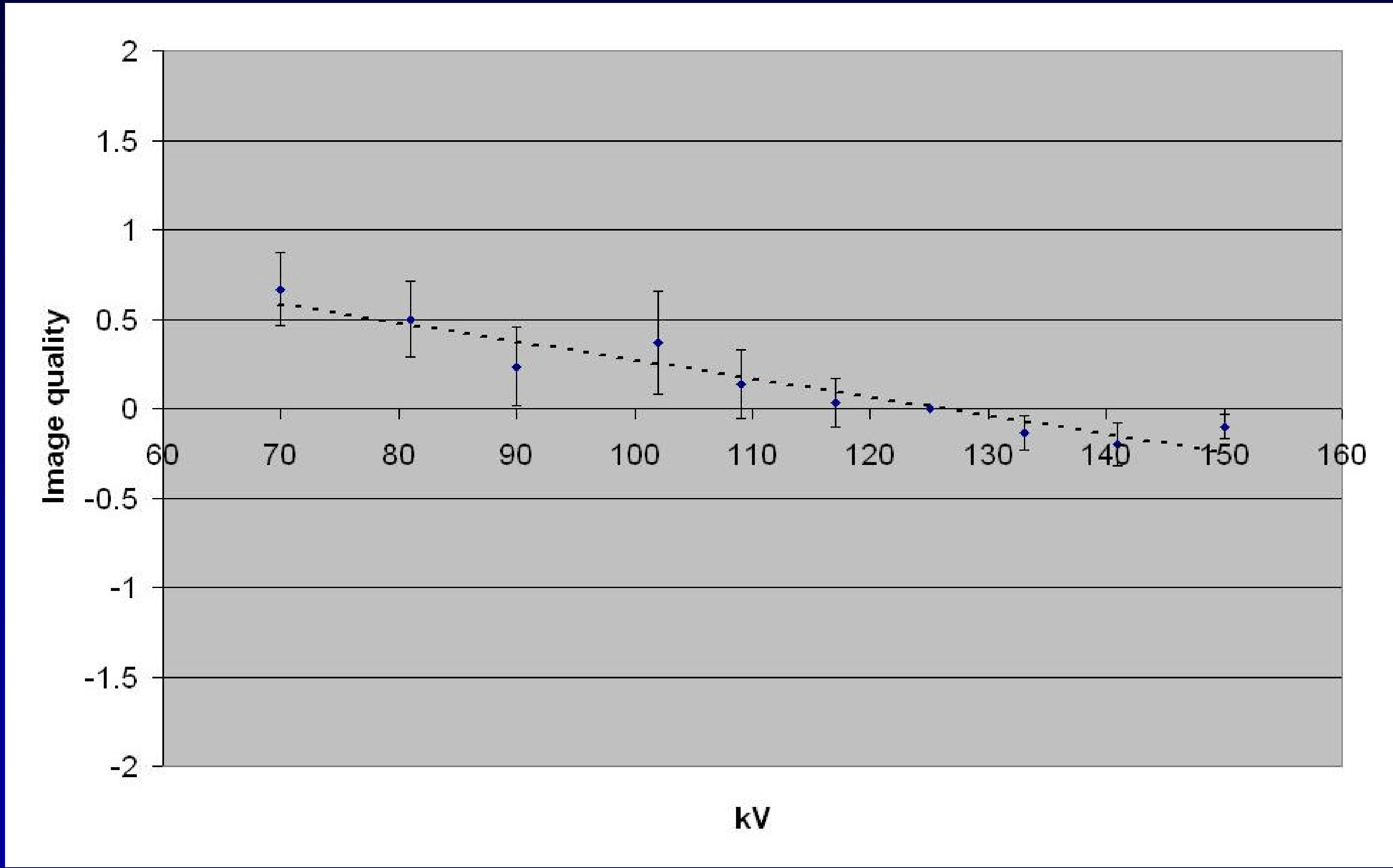
DAP vs. E

- E is not linear to DAP
- Another example:
  - Chest PA normal field size vs. small field size
  - Same beam quality and DAP
  - Normal field: 0.23 µSv
  - Small field: 0.27 µSv

Digital detector (Fuji CR)

- ➔ Vary kV
- ➔ Adjust mAs so that E is constant
- ➔ Have radiologists evaluate images
- ➔ What happens to image quality?

Chest radiography



DAP or E as the measure for reference level?

- ➔ DAP is easy to measure
- ➔ But E is not linear to DAP
- ➔ Only if beam quality, field size etc. is the same, then E is linear to DAP
- ➔ However, E has to be calculated (cannot be measured)

DAP or E as the measure for reference level?

- ➔ E depends on beam quality, field size, irradiated body region and DAP
- ➔ E is *the* important quantity with respect to risk

- ➔ E should (according to my point of view) be the quantity to use for the reference levels

Diagnostic reference levels for image quality

- ➔ DRL for patient dose huge step forward for optimising dose in hospitals
- ➔ But optimisation work also needs to deal with image quality
- ➔ Desirable to find DRL for image quality!

Summary

- ➔ DAP more useful quantity than ESD
- ➔ E more appropriate than DAP
- ➔ DRL very useful tool for medical physicists!

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Go Sweden!

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