Comparing dose and image quality of a conventional 400 speed class film/screen system with a CR system by assessing pediatric chest examinations

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Initial situation
(since 1996)

- Conventional X-ray film: Curix HT 1.000G PLUS
- Intensifying Screen: Ortho Regular, AGFA
  Sensitivity class 400

- Programmed settings for all age groups
  - On table (free technique)
  - Bucky table (semi automatic)
  - Thoracomat (semi automatic)
  - Bucky wall stand (semi automatic)
  - Bed examination (free technique)

Known data

- Patient data
  - gender
  - age
  - weight
  - clinical question

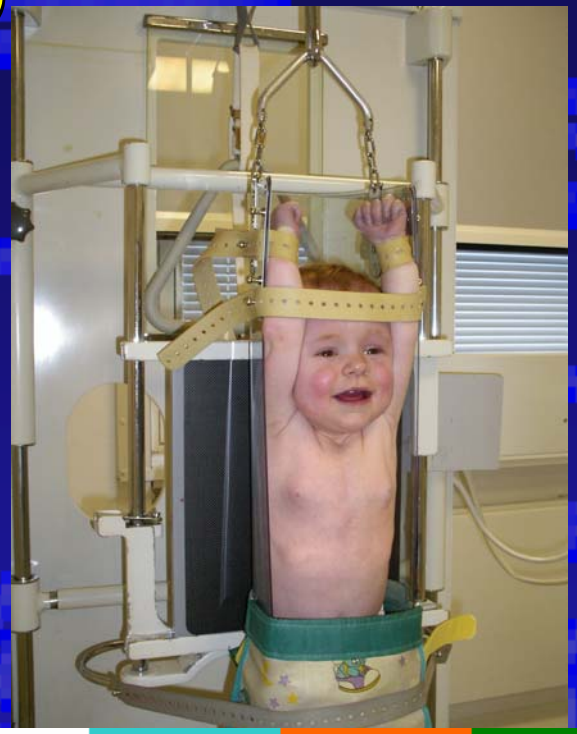
- Exposure settings
  - free technique / Semi automatic
  - anti scatter gridwith / without
  - tube voltage [kV]
  - tube current [mAs]
  - dose area product (DAP)

Basis for SOP: www.uniklinikum-giessen.de/kirad

Settings for chest examinations

(Broselow - Luten - Scale)

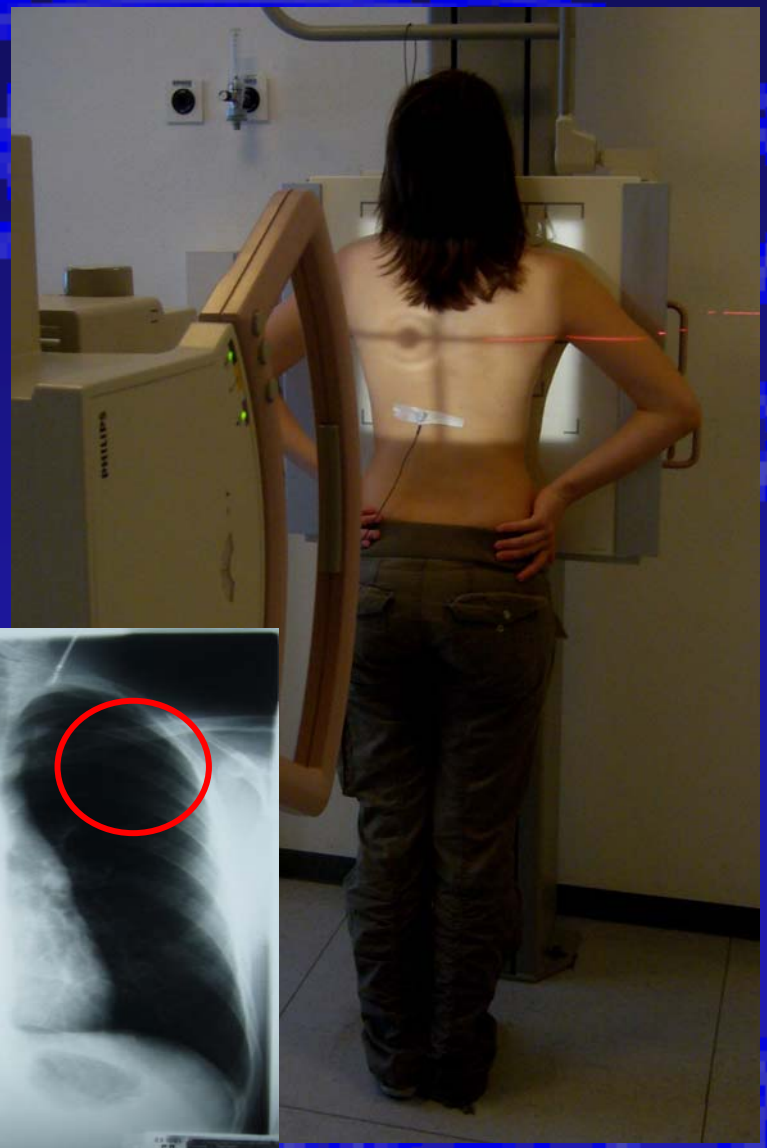
- **Thoracomat**
  - Infants and togglers up to ~ 9 years
  - Nominal focal spot size 0,6
  - Additional X-ray tube filtration:
    1 mm Al + 0,1 mm Cu
  - **ap** – patient orientation
  - **Without** anti-scatter grid
  - Semi automatic
  - Individual position of AEC chamber



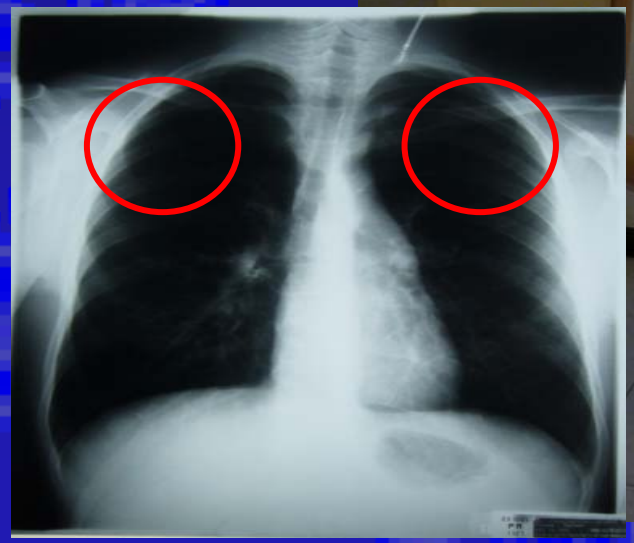
FARBE	GREY	PINK	RED	PURPLE	YELLOW	WHITE	BLUE	ORANGE	GREEN
GRÖßE (cm)	<59,5	59,5-66,5	66,5-74	74-84,5	84,5-97,5	97,5-110	110-120,75	120.75-133,4	133,4-146,5
GEWICHT (kg)	<6	6-7	8-9	10-11	12-14	15-18	19-23	24-29	30-36
ALTER (Monate)	0-1	2-5	5-11	11-19	19-30	30-39,5	39,5-62,5	62,5-83	83-107,5
Aufnahmeart	Thorakomat	Thorakomat	Thorakomat	Thorakomat	Thorakomat	Thorakomat	Thorakomat	Thorakomat	Thorakomat
Strahlengang	ap	ap	ap	ap	ap	ap	ap	ap	ap
Aufnahmeposition	Hängen	Hängen	Hängen	Sitzen	Sitzen	Sitzen	Sitzen	Sitzen	Stehen
Fokus-Film-Abstand (cm)	150	150	150	150	150	150	150	150	150
Streustrahlenraster	nein	nein	nein	nein	nein	nein	nein	nein	nein
Aufnahmespannung (kV)	66	66	66	66	66	66	66	73	73

Settings for chest examinations

- **Bucky wall stand**
  - togglers & adolescents as of ~ 9 years
  - nominal focal spot size 0,6
  - added X-ray tube filtration:
    1 mm Al + 0,1 mm Cu
  - pa – patient orientation
  - With Anti scatter grid (r 8 / 40)
  - semi automatic: AEC measurement
    chambers upper lung fields



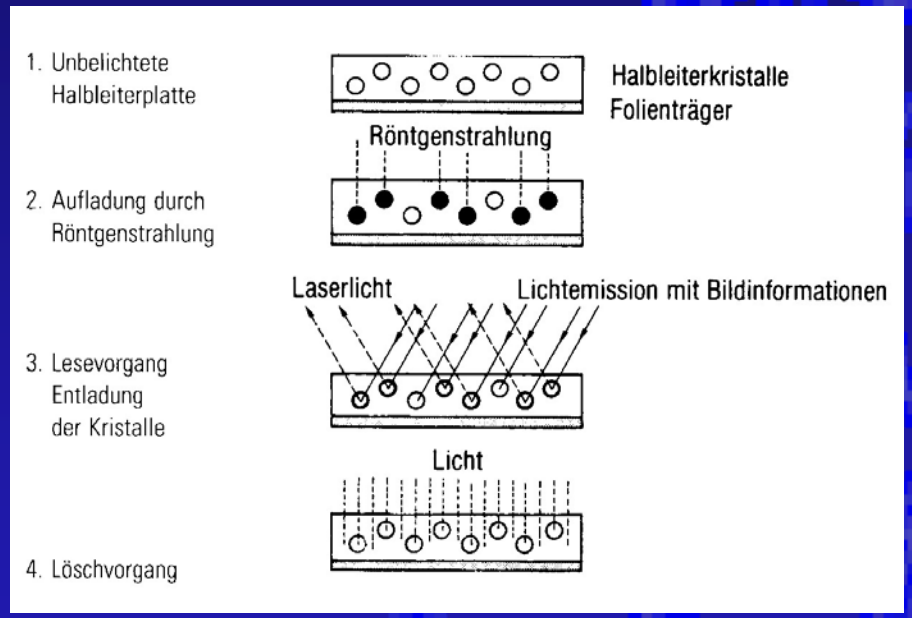
GRÖßE (cm)	>146,5
GEWICHT (kg)	>36
ALTER (Monate)	>107,5
Aufnahmeart	Raster
Strahlengang	pa
Aufnahmeposition	Stehen
Fokus-Film-Abstand (cm)	150
Streustrahlenraster	ja
Aufnahmespannung (kV)	125



Motivation for the study

- Conversion to a digital CR-system
- **DX - S, AGFA**

  (photostimuable luminescence)



- All previous systems

  were characterized by the need of an increased dose

Materials and method

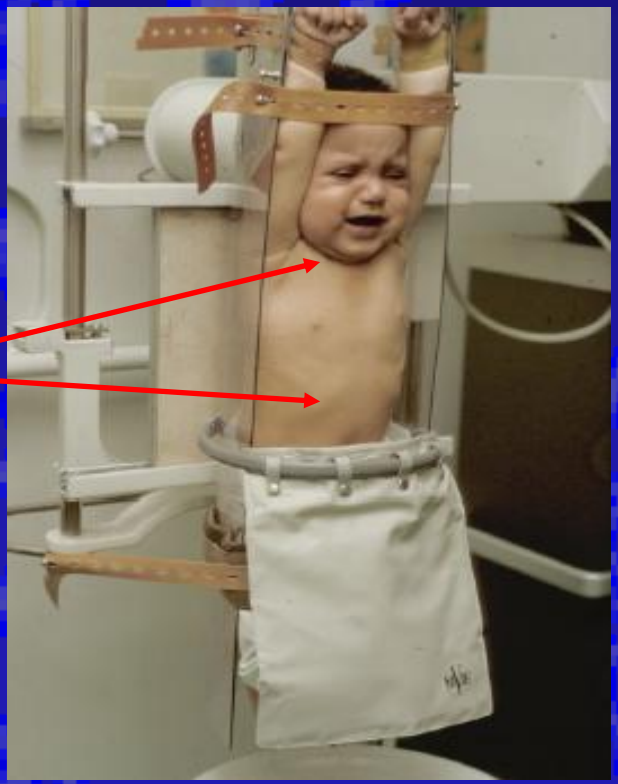
- Additional captured data
  - Body height
  - weight → BMI
  - Sagittal thoracic diameter

- Number of patients n
  - 400 F/S system (film/screen) 82
  - DX - S 79
  - DX - S with dose reduction 65

Materials and method

Dosemetry

- Solid state dose-meter to measure Entrance Surface Dose (ESD)
  UNFORS PSD (patient skin dosimeter)
- Two measuring sensors



Thyroidea

field

Characteristics of UNFORS PSD

- Measuring error ± 6 % (calibration at 90 kV)
- Angle dependency ± 5 % at 45°
  ± 10 % at 75°
- Bandwidth 2,4 Hz, 3 dB
- kV dependency ± 10 % (60 - 120 kV)
  ± 15 % (40 - 150 kV)
  with 6 mm Al
- Temperature dependency none
- Air pressure dependency none
- Dimensions (H x W x L) 4 x 15 x 15 mm

Entrance surface dose (ESD) after conversion to digital CR

F/S system *(Semi automatic)*

0-1 years

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	16	22,7	40,1	29,1	5,2

1-5 years

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	35	17,2	38,4	27,2	4,9

5-10 years

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	23	12,4	30,9	20,8	4,7

10-15 years (grid)

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	8	26,7	59,9	41,6	9,5

DX-S

0-1 years (free technique)

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	17	23,4	31,7	25,3	1,8

1-5 years (free technique)

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	35	21,2	27,6	24,5	1,3

Deskriptive Statistik

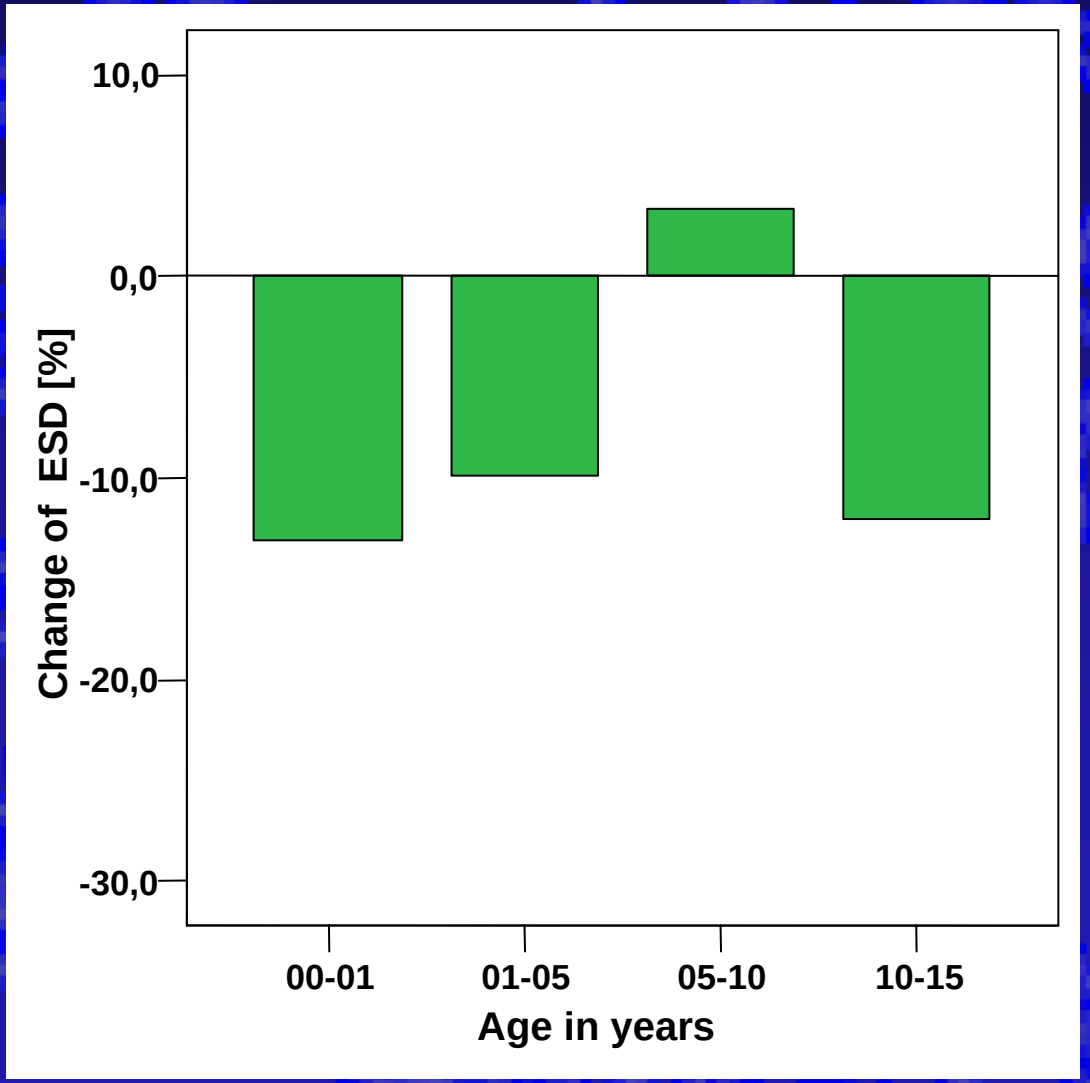
	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	6	20,3	23,4	21,5	1,2

Deskriptive Statistics

	N	Minimum	Maximum	Average	Standard deviation
ESD-field (µGy)	21	23,1	52,8	36,6	8,4

Change of ESD after conversion to DX-S using free technique

- F/S system
  - n = 82
  - Semi automatic
- DX-S
  - n = 79
  - free technique



ESD using additional X-ray tube filtration (1 mm Al + 0,2 mm Cu)

DX-S / 0,1 mm Cu

0-1 years

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	17	23,4	31,7	25,3	1,8

1-5 years

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	35	21,2	27,6	24,5	1,3

5-10 years

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	6	20,3	23,4	21,5	1,2

10-15 years (grids)

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	21	23,1	52,8	36,6	8,4

DX-S / 0,2 mm Cu

0-1 years

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	7	13,9	15,6	14,8	,6

1-5 years

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	27	11,0	16,2	14,6	1,1

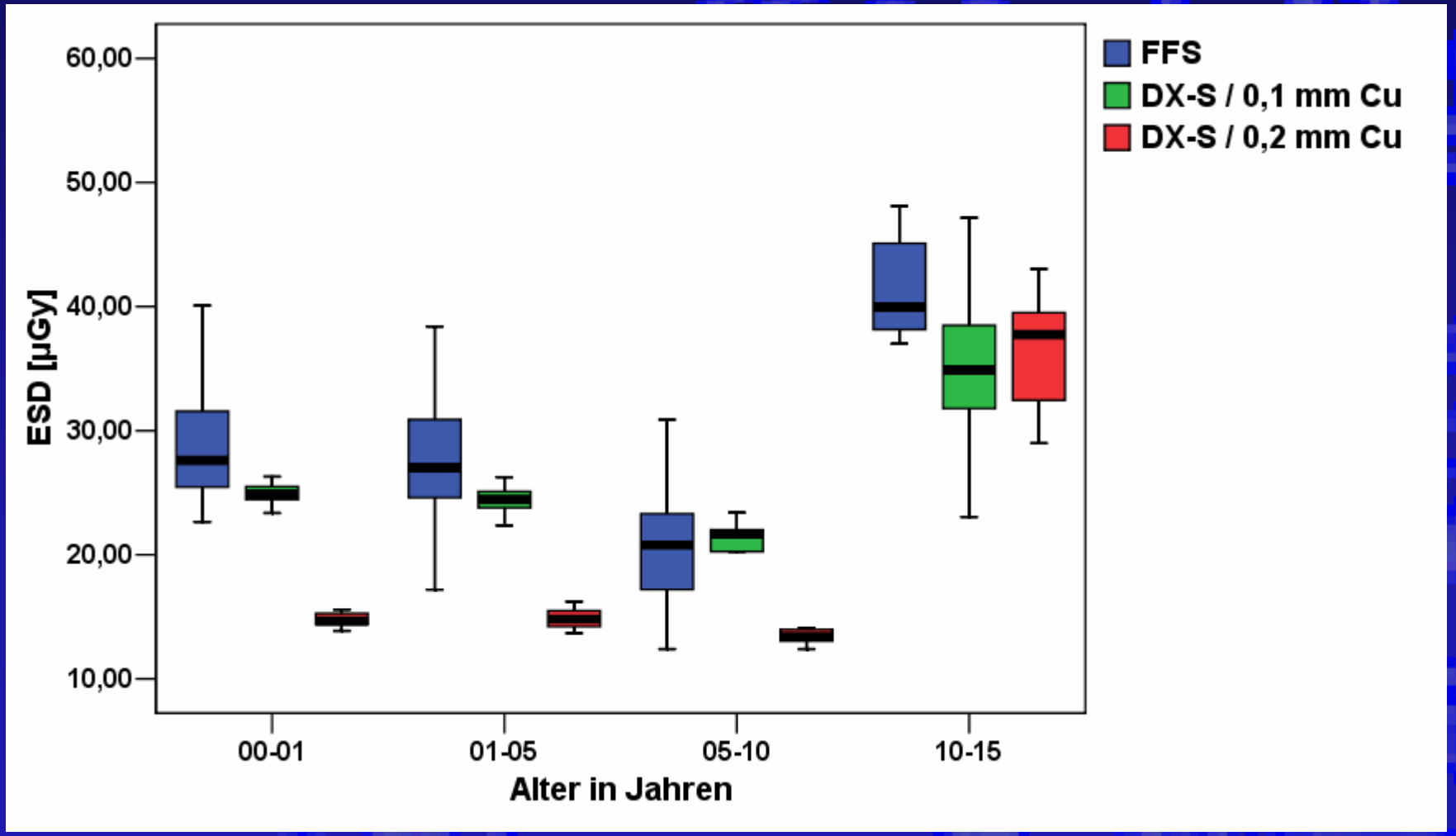
5-10 years

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	10	12,4	17,2	13,7	1,3

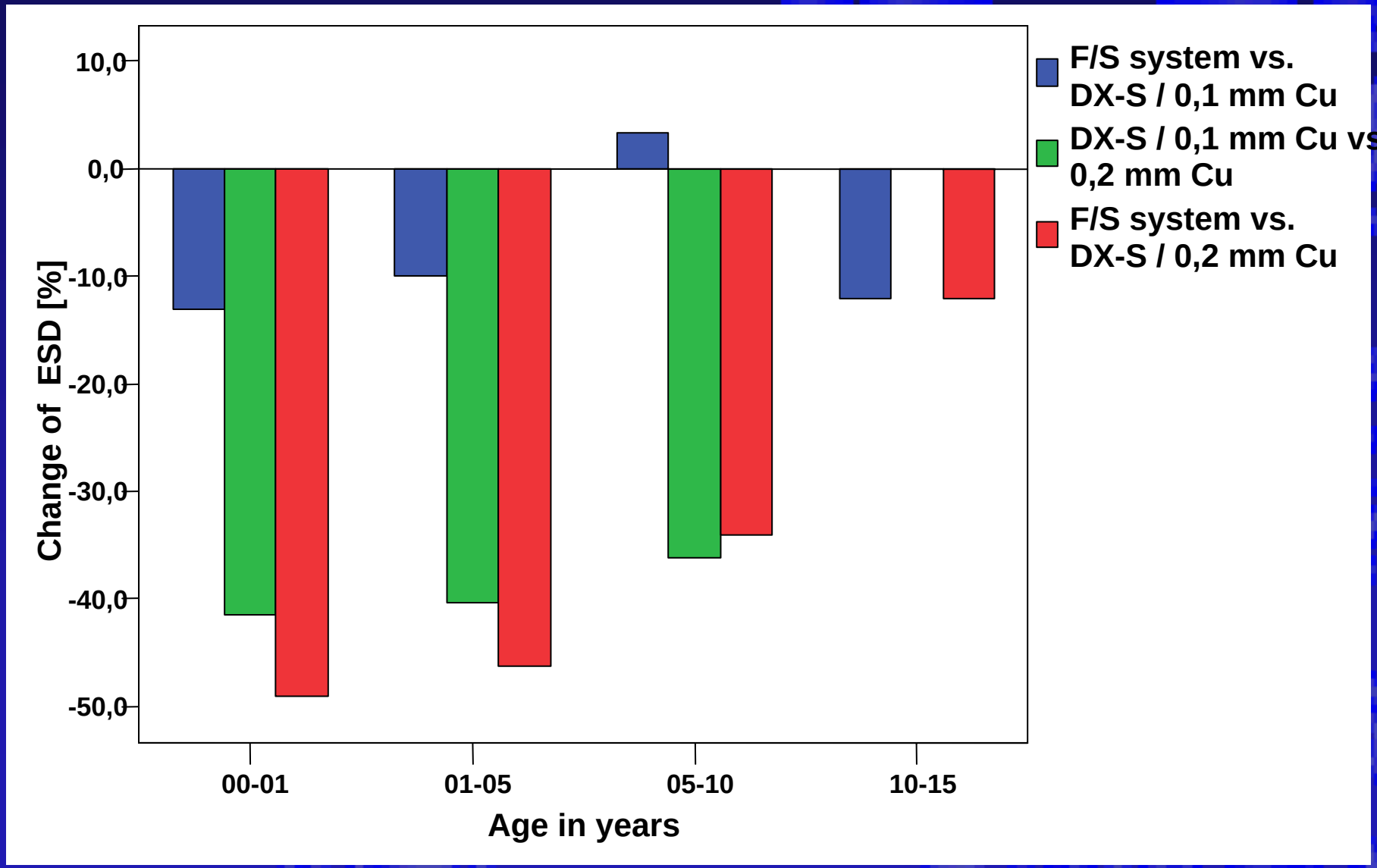
10-15 years (Raster)

	N	Minimum	Maximum	Mittelwert	Standardabweichung
ESD-Feld (µGy)	12	29,0	43,0	36,6	4,6

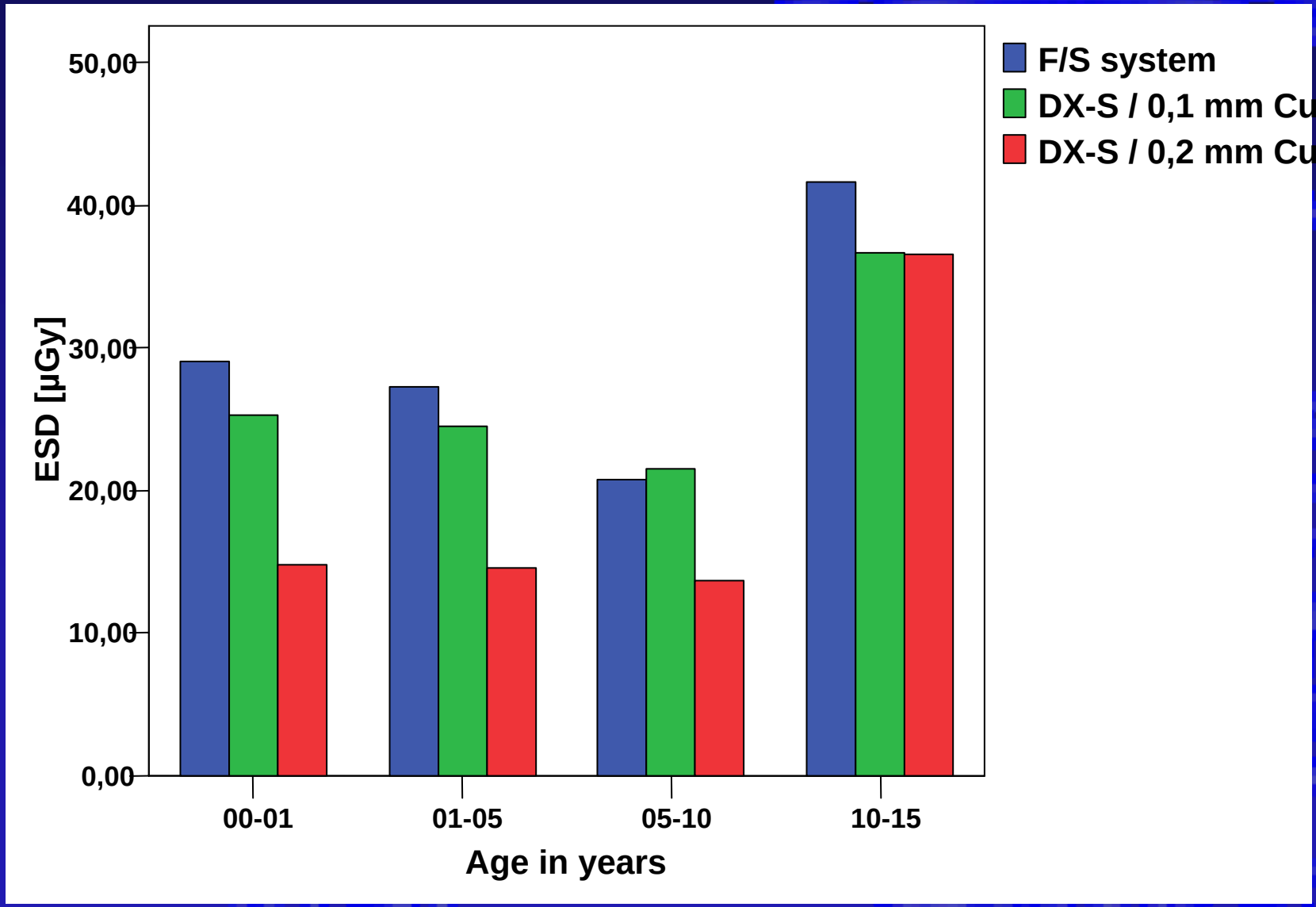
Statistical spread of the ESD Film/screen (F/S) system vs. DX-S



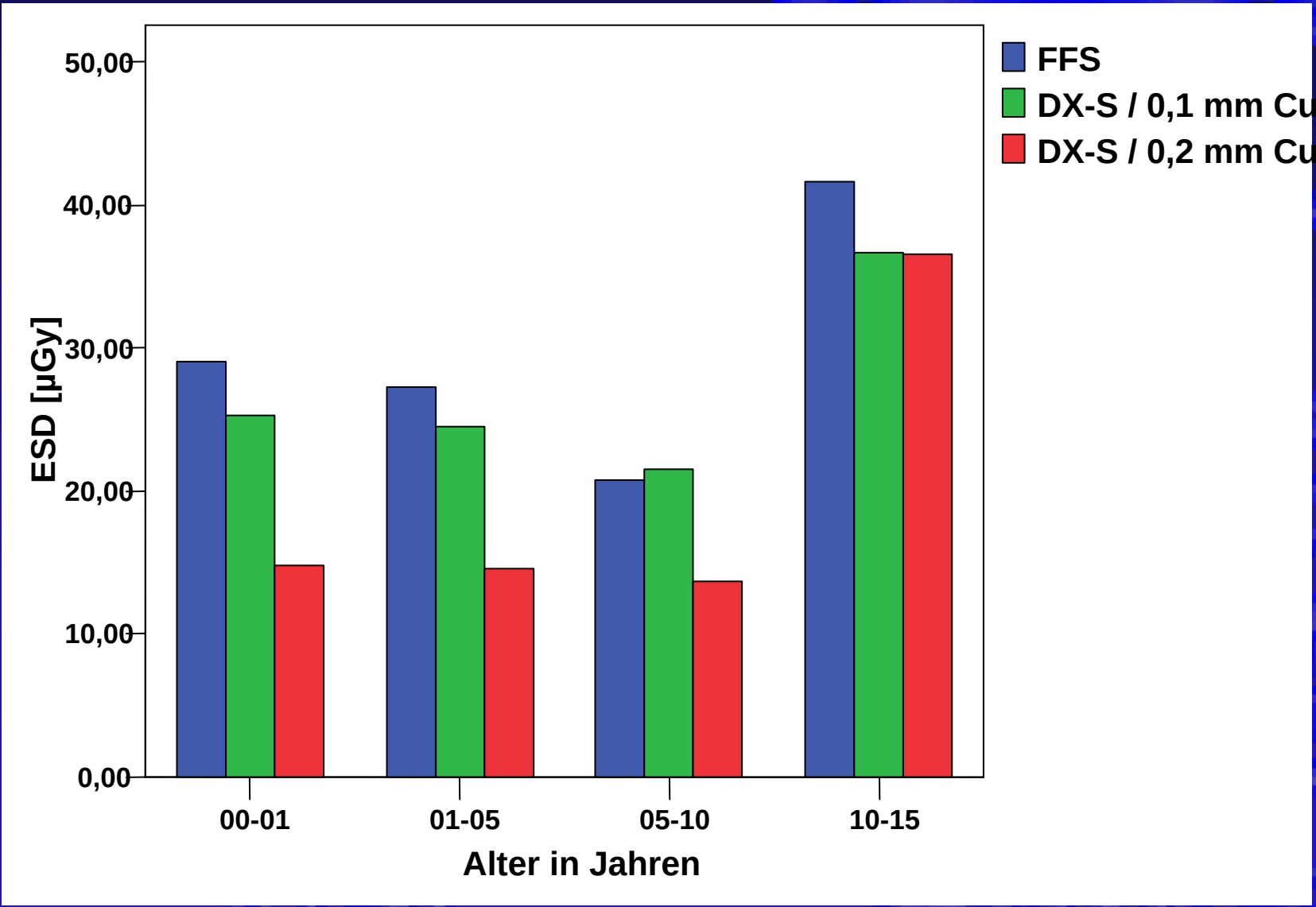
Reduction of ESD by introducing DX-S



ESD for F/S systems vs. DX-S with/without additional X-ray tube filtration



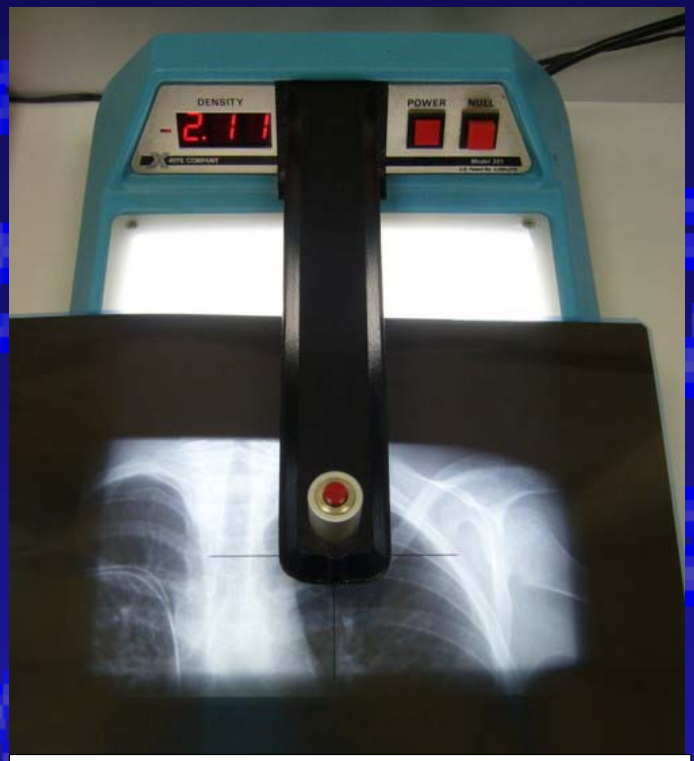
ESD for F/F systems vs. DX-S with/without additional X-ray tube filtration

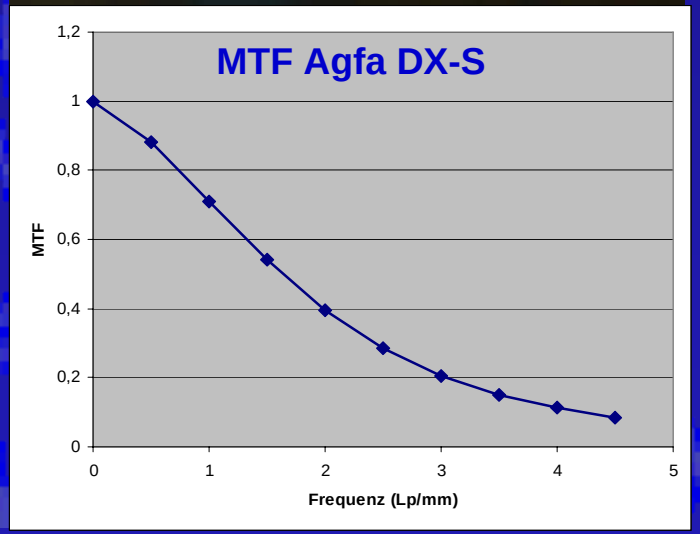


Dose indicators

- Subjective indicators
  - exposure / noise

- Objective indicators
  - Optical density (F/S system)
  - LgM (manufacturer specific dose indicator DIN 6868-58)
  - ROI (grey values)
  - SNR
  - MTF



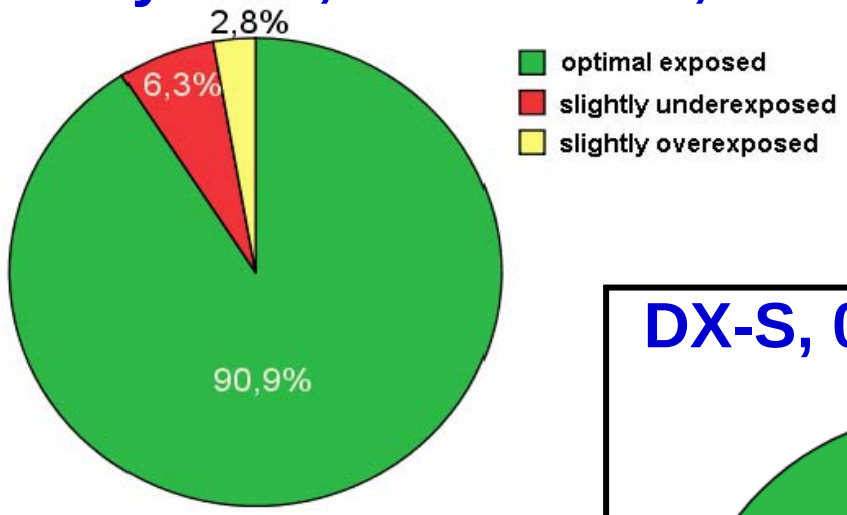


Subjektive assessment of image quality

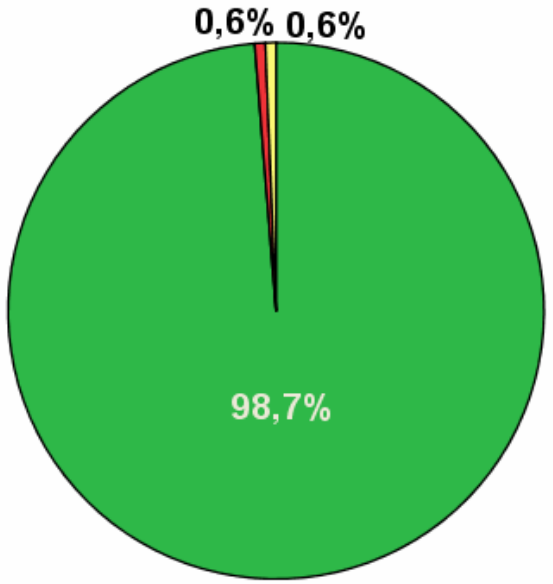
- Assessment by three radiologists
- Three independent assessments
  - exposure
  - collimation
  - centering / positioning

Engelmann et al., Radiologe 2001, 41 (5)

F/S system,1 mm Al + 0,1 mm Cu



DX-S, 0,1 mm Cu



DX-S, 0,2 mm Cu

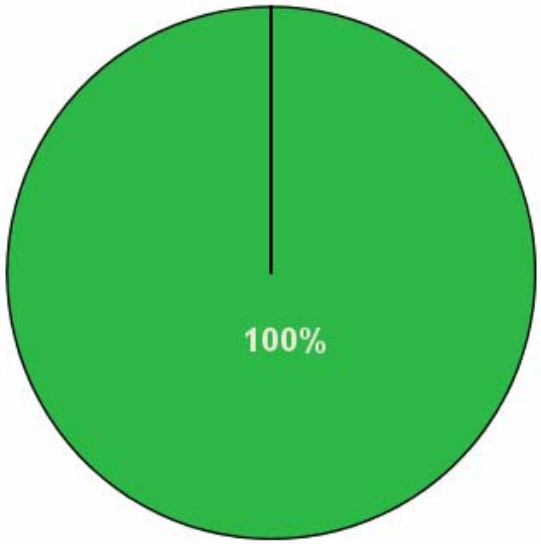
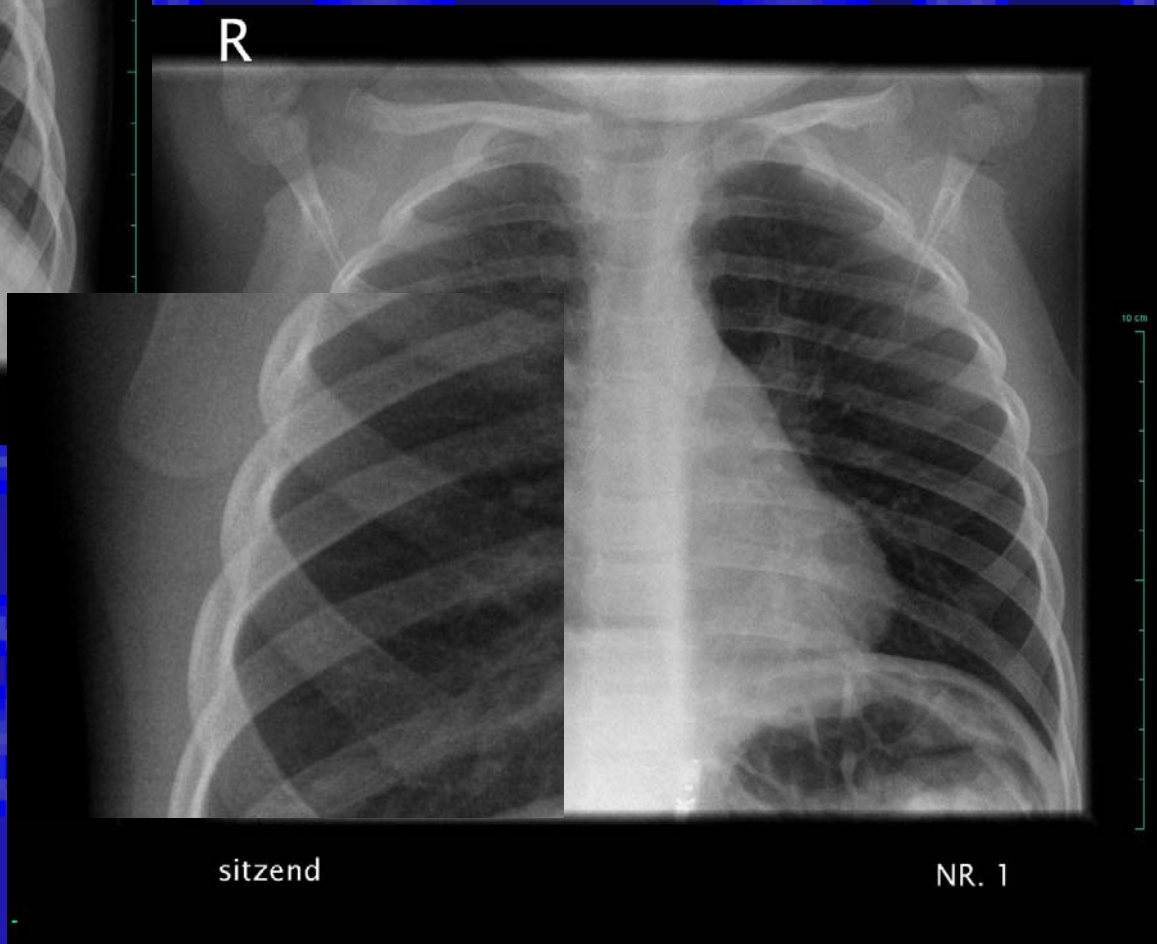


Image quality

DX-S, 1 mm Al + 0,2 mm Cu



DX-S, 1 mm Al + 0,1 mm Cu

Conclusions I
Dose

- DX-S allows a dose reduction up to 50 % without any perceptible constraints in image quality
- Semi automatic operation causes increased fluctuations in ESD
- Up to now infants and togglers benefit the most from conversion to DX-S
- For examinations on bucky wall stand further dose reduction can be realized without loss in quality

Conclusions II
Image quality

- DX-S leads to a more consistent image perception
- CR does not know under/over exposure
- The shortfall of the recommended LgM - value of 1,9 up to 1,7 does not result in a decline of quality

- This study resulted in significantly improved settings for thoracic examinations (positioning, collimation)