Institut de radiophysique

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Annual evaluation report of mammography systems involved in Swiss breast cancer screening in 2021

For anonymity, we assigned a number to each center.

I. Introduction

The Swiss Cancer Screening coordinates all cancer screening programmes organized by the cantons and carries out activities to ensure quality. In this framework, the Institute of Radiation Physics (IRA) of the Lausanne University Hospital (CHUV) is mandated by the cantons of French-speaking Switzerland to perform external audits of the radiological centres involved in the national breast cancer screening programme. The cantons of Ticino and Thurgau have appointed external persons (medical physicists or radiographers) to perform these audits, under the supervision of the IRA. The aim of our mandate is to verify that the status controls carried out by the manufacturers comply with the requirements of the directive of the Federal Office of Public Health (document BAG R-08-02) and the European guidelines (EUREF 4.0). This broad monitoring gives an overview of technical aspects of installations involved in the screening programmes in Switzerland and allows a direct comparison between the different centres on the common basis of image quality and dose. It should be noted however that the evaluation of the image quality by a test object does not take into account ergonomic aspects (such as positioning and compression). The protocol of the audit is designed to ensure that the radiological chain is able to produce mammograms of sufficient quality for the different breast thicknesses while delivering x-ray doses below the EUREF limits. This document presents the results of the controls and measurements performed during the audits in 2021.

II. Material & method

II.a. Inspection protocol

During the audit, the following elements of the radiological chain are checked:

- Weekly stability controls made by the internal staff
- Annual status control of the mammography chain made by the supplier
- Image quality with an anthropomorphic phantom and a human observer
- Detectability of a microcalcification of diameter 0.1 mm in 32, 60 and 90 mm compressed breast thicknesses using a mathematical observer model
- Mean glandular dose (MGD) for compressed breast thicknesses of 32, 45, 60 and 90 mm
- Cleanliness of diagnostic screens
- LUT curve and luminance range of diagnostic screens
- Low contrast detection and display artefacts

The inspection protocol covers four main parts and includes the following items:

II.b. Measurement of detectability

The detectability performance is assessed using a dedicated breast-equivalent tissue phantom (MTM 100), representative of a 45 mm thick breast (Figure II.1). The internal structure of the phantom contains several sets of microcalcifications, masses and filaments of several sizes, as illustrated in Figure II.2.

Figure II.1 – MTM 100 phantom

Aim: Evaluate the clinical image quality (detection performance) from the image of the phantom in routine image acquisition conditions.

Measurement setup

• Positioning the phantom on the bucky with its flat base against the edge of the bucky.
• Selection of the image processing used clinically "Mammo CC".
• The phantom is imaged in the same conditions as a real mammography would be performed (AEC and compression settings).

Data analysis

• The image is displayed on a diagnostic screen.
• The displayed contrast and brightness of the image (window width / level) are adjusted.
• The number of balls visible on both sides of the phantom at the thorax side is determined.
• The number of visible microcalcifications, masses and filaments is evaluated by the person who does the audit.
• The global detection score is the total number of points obtained for the microcalcifications, masses and filaments.

Number of visible objects	*1*	*2*	*2.5*	*3*	*3.5*	*4*	*4.5*	*5*	*5.5*	*6*	*6.5*	*7*
Points	1	2	3	4	6	8	12	16	24	32	48	64

Ranking

The final detection score ranges from 0 to 192, and must be higher than 24. At least 4 microcalcifications, 4 masses and 4 filaments must be detectable.

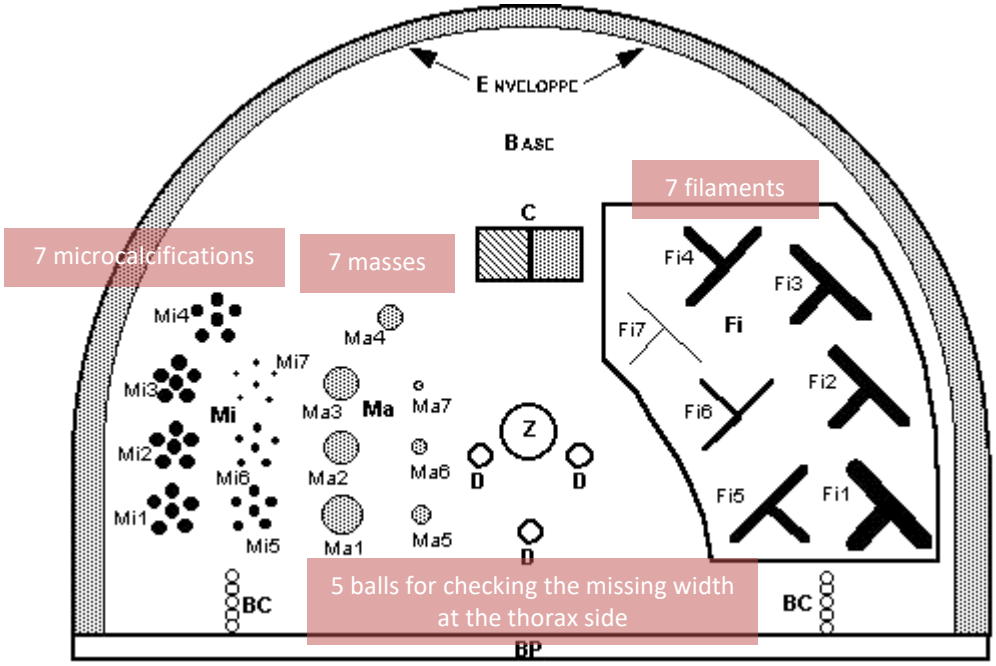


Figure II.2 – Section of the MTM100 phantom

II.c. Measurement of image quality: artefacts and contrast-to-noise ratio (CNR)

The CNR is assessed using a specific setup of Plexiglas blocks and an aluminium foil as illustrated in Figure II.3.

Aim: Check the automatic exposure system works properly, check the absence of artefacts on the images, control the exposure settings and the CNR.

Material

• Plexiglas blocks: 30, 50 and 70 mm PMMA blocks, 24 x 30 cm^2, equivalent to compressed breasts of 32, 60 and 90 mm, respectively.
• Aluminium object: 200 µm thick square of aluminium, 10 x 10 mm^2.

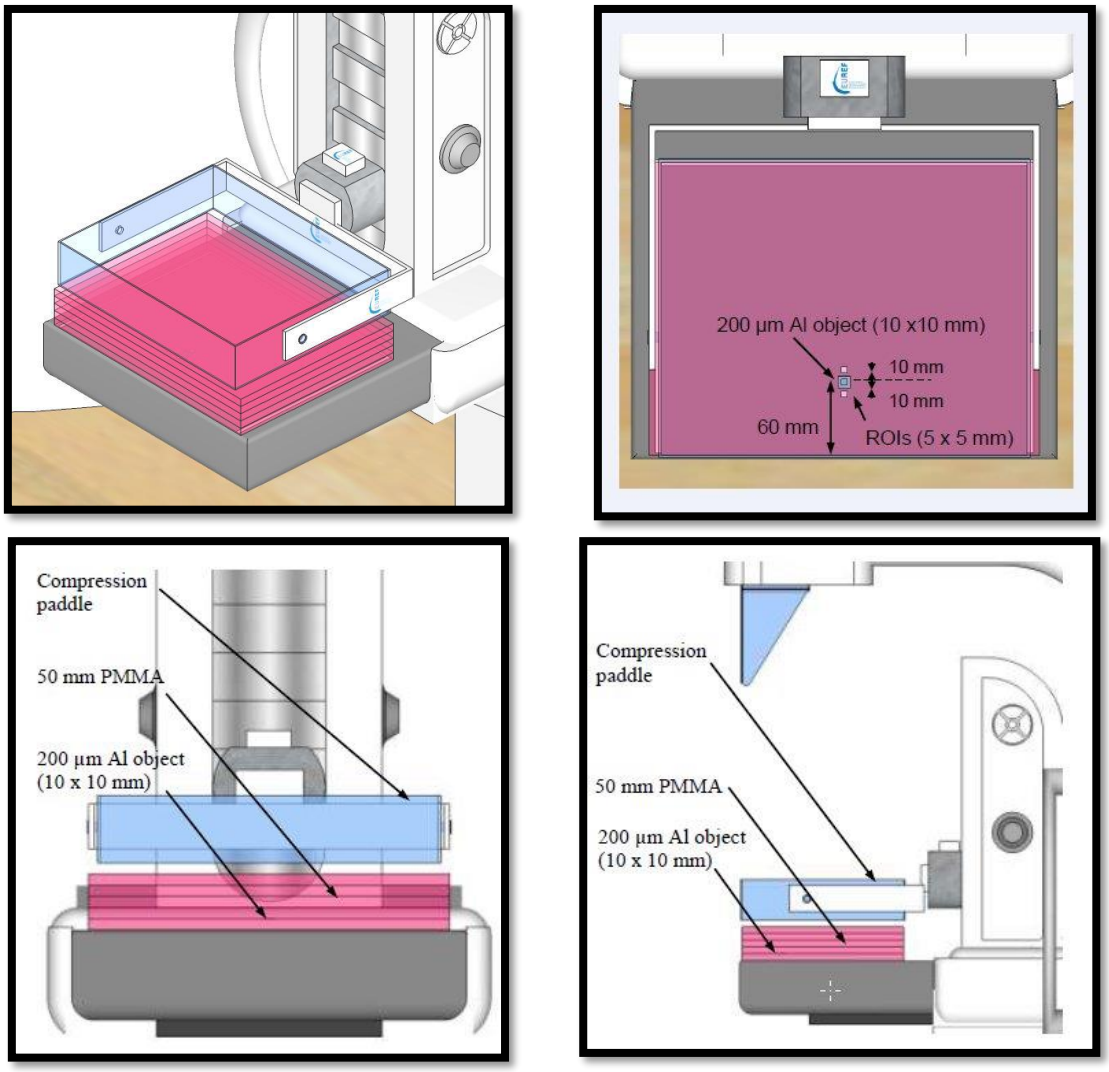


Figure II.3 – Plexiglas blocks imaging

Measurement setup

• All image processing algorithms usually used in routine mammography exams must be disabled (use of the Dicom "for processing" image)
• The Plexiglas block is positioned on the bucky, laterally centred.
• The aluminium object is placed at 6 cm from the edge of the bucky, laterally centred, on 20 mm of Plexiglas.
• The height of the compression plate is adjusted to the equivalent breast thickness. If needed, the plate is compressed on additional small plastic blocks (the additional plastic blocks must be outside the AEC calculation area, small blocks positioned on the left and right

edges).
• The Plexiglas block is imaged using clinical mammography settings (compression and AEC selection).
• This procedure is repeated for all Plexiglas blocks.

Data analysis

• The image is displayed on a diagnostic screen. Track visually "dead pixels" and missing lines and non homogeneity areas. Assess the absence of artefacts in the image. The artefacts are sought by adjusting the width and centre of the display window.
• The CNR is measured in a region of interest (ROI) of approximately 5 x 5 mm^2 in and outside the aluminium object (at 4 sides), and compared to the limiting value.

Ranking

The final score of the image quality of the system is defined as:
• The number of detected dead pixels
• The number of artefacts
• The value of the CNR

II.d. Breast doses

The entrance skin dose (ESD) is measured for the standard breast thickness 32, 45, 60 and 90 mm, as illustrated on Figure II.4. The mean glandular dose (MGD) is calculated from the ESD using the following formula:

$$MGD = g \cdot c \cdot s \cdot ESD$$

The conversion factor *g* corresponds to a glandularity of 50%, the factor *c* corrects for any difference in breast composition from 50% glandularity and the factor *s* corrects for differences due to the choice of x-ray spectrum, as defined in the European guidelines for quality assurance in breast cancer screening and diagnosis (EUREF 4.0 and supplements).

Aim: Ensure that the mean glandular dose (MGD) is compliant for the breast thicknesses

Instrument

• PTW Conny II (PTW Freiburg GmbH)

Measurement setup

• The dosimeter is positioned on the bucky, laterally centred at 6 cm from the edge (Fig. II.4).
• The height of the compression plate is lowered on the dosimeter.
• The same conditions as those obtained with the MTM 100 phantom or Plexiglas blocks are used, but in manual mode (kV, A/F, with the nearest mAs).

Ranking

The measured MGD are compared to the limit values defined by the Federal Office of Public Health (document BAG R-08-02) and European guidelines (EUREF 4.0), reported in the following table.

Breast thickness [mm]	21	32	45	53	60	75	90
Equivalent PMMA thickness [mm]	20	30	40	45	50	60	70
Limiting MGD [mGy]	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**4.5**	**6.5**

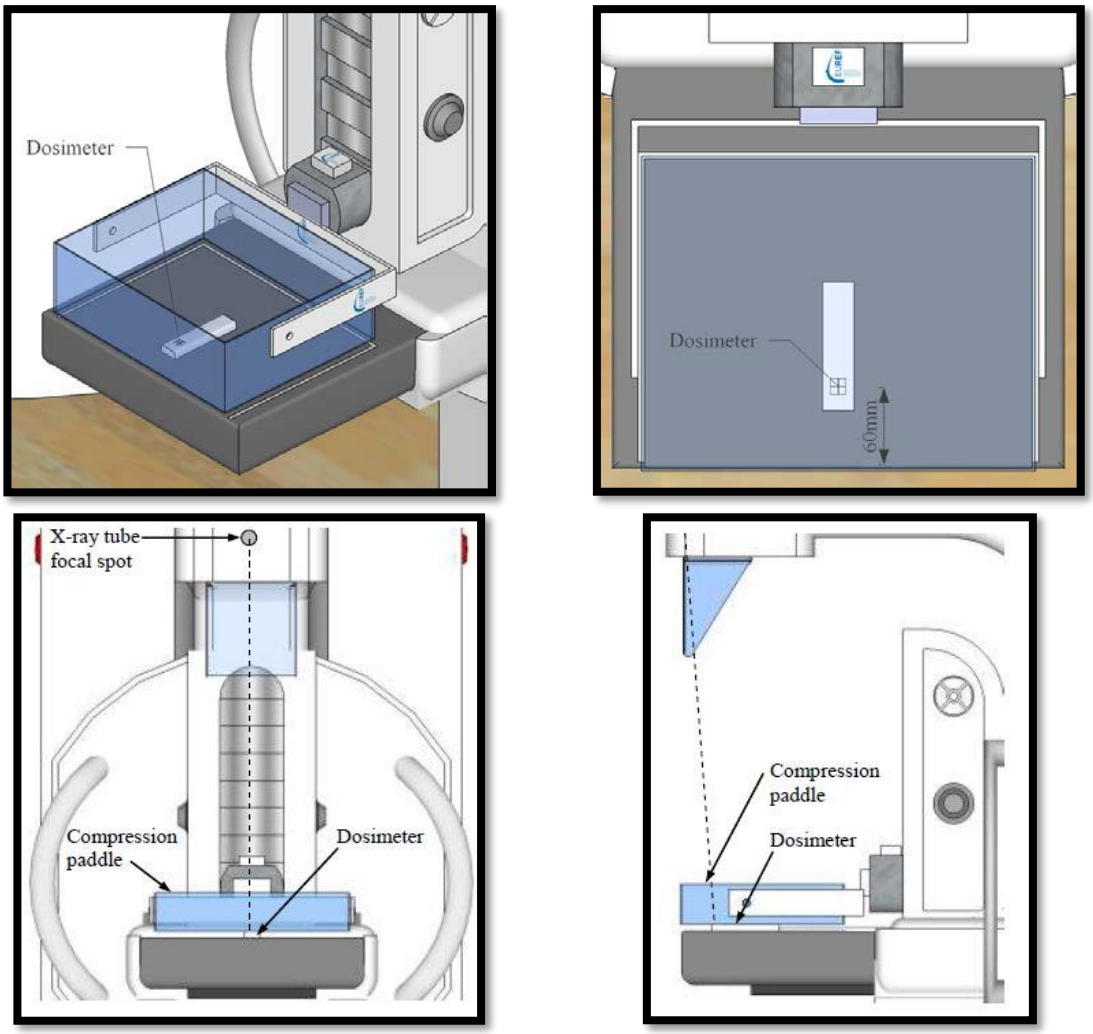


Figure II.4 – Dosimetry scheme

II.e. Control of the diagnostic screens

The control of diagnostic screens includes visual checks on AAPM TG-18 test patterns and a measure of the LUT curve and luminance range. The test is done by following the manufacturer's recommendations, respecting screens heating time before starting the tests.

Aim: Ensure that the diagnostic screens meet the standard DICOM 3.14. The following parameters are checked:

- Cleanliness of the display surface
- Artefacts and defective pixels
- Grayscale resolution
- Geometric distortions / artefacts
- Low contrast detection 0 - 5%
- Low contrast detection 95 - 100%
- Display resolution
- LUT curve - Maximum deviation
- Luminance range
- Maximum luminance difference left / right

Instrument

- Photometer Gossen Mavolux (7B34914)

Measurement setup

• The screens surface is visually checked: cleanliness, free of dust and fingerprints.
• The patterns are displayed on the screen as if it were a mammogram.
• The sources of interference light (reflections on screens) are turned off and the ambient light level is set low enough for viewing.
• A visual check is performed using all the tools of the test pattern (Figure II.5).

1. Grids of line pairs
Visibility of the lines pairs without streaking, fading or erasing and visibility of the low contrast lines pairs in the middle and the four corners of the test image.
2. Low contrast squares at 5% and 95%
Visibility of 5% and 95% squares.
3. Letters with low contrast
Visibility of low contrast letters "QUALITY CONTROL".
4. Low contrast squares
Visibility of the four squares in the 4 corners inside the luminance squares.
5. Grid lines
Visibility and linearity of all grid lines.
6. Luminance squares
Distinction of the 16 luminance squares.
7. Progress bar black - white
Continuity of the appearance of the progress bar.
8. Black - white transitions
Black-to-white and white-to-black direct transitions.

• The LUT curve is determined by measuring the luminance of the 18 TG-18 LN patterns using a photometer
• The range of luminance is the ratio between the maximum and minimum luminance

Ranking

The deviation to the LUT must be smaller than 10% and the range of luminance must be greater than 250.

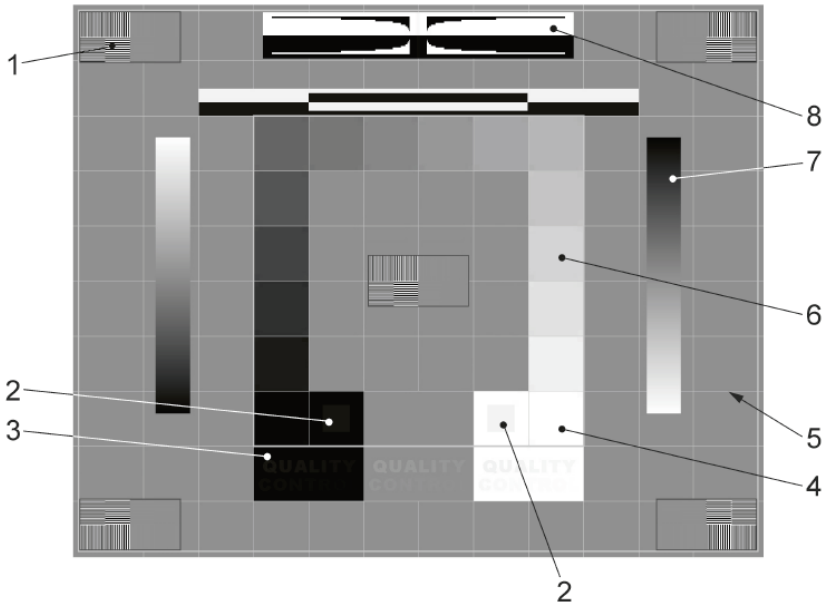


Figure II.5 – AAPM TG18-QC test pattern used for visual checks

III. Overview of the situation

All mammography systems involved in screening programmes in the cantons of French-speaking Switzerland, as well as the cantons of Thurgau and Ticino, have been audited in 2021. This corresponds to 90 mammography systems in 78 radiology centers. All mammography systems are digital radiography (DR) systems based on flat panel detectors (83%) or scanning systems (17%). Three manufacturers are the major suppliers and represent 90% of the market. The breakdown of installations by manufacturer is shown in Table III.1. To facilitate the comparison between centres using the same type of detector, the tables in Appendix A link the number of the controlled installation with the type of system (Figure III.1).

Table III.1 – Distribution of the audited systems by manufacturer

	VD	GE	TI	BEJUNE	VS	FR	TG	Total	Percentage
Hologic	9	8	5	4	3	7	0	**36**	**40.0 %**
Siemens	6	1	2	5	0	0	3	**17**	**18.9 %**
Philips	7	4	0	0	2	2	0	**15**	**16.7 %**
General Electric	4	4	1	1	3	0	0	**14**	**14.4 %**
IMS Giotto	1	0	6	0	0	0	0	**6**	**7.8 %**
Planmed	0	1	0	0	1	0	0	**2**	**2.2 %**
Total	**27**	**18**	**14**	**10**	**9**	**9**	**3**	**90**	**100 %**

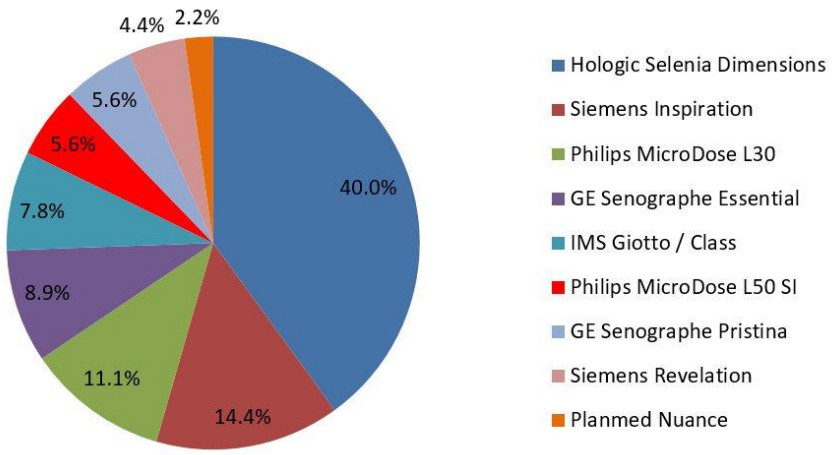


Figure III.1 – Mammography systems audited in 2021

In 2021, auditors reported 9 problems (Table III.2) in 9 radiology centres (10% of audited centres). The number of problems remains within the statistical variability since 2016, as shown in Figure III.2. Four of the nine problems involved diagnostic screens in four radiology centres (difference in luminance between the left and right screens and surface cleanliness). Five issues concerned the weekly stability controls. In three radiology centres, the stability controls of the diagnostic screens were not performed. Two radiology centres were using outdated stability control files. Stability control files must be updated after each annual status control, which is sometimes overlooked.

The non-compliant elements were systematically mentioned in a letter sent to the institutes, with a compliance deadline defined according to the importance of the problem.

Table III.2 – Issues identified during audits in 2021

	VD	GE	TI	BEJUNE	VS	FR	TG	Total
Status and stability controls	0	0	0	1	1	3	0	**5**
Cleanliness of the screens	3	0	0	0	0	0	0	**3**
Maximal luminance of the screens	0	0	0	0	1	0	0	**1**
Total	**3**	**0**	**0**	**1**	**2**	**3**	**0**	**9**

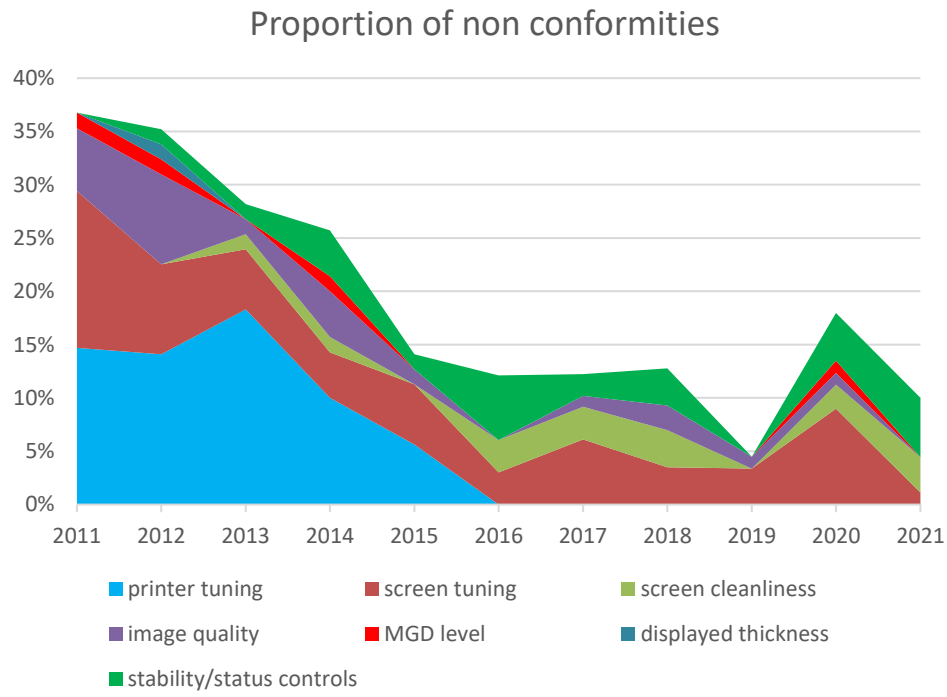


Figure III.2 – Proportion of non-conformities since 2011

IV. Results

IV.a. Measurement of detectability (MTM 100 phantom)

Radiology institutes are compared on the basis of their detectability scores obtained with the MTM 100 phantom (detection of masses, filaments and microcalcifications) that represents a 45 mm thick compressed breast. The image was acquired under clinical conditions, using the full automatic exposure mode (AEC). Appendix A gives the tube voltage and anode/filter combination chosen by the AEC for the MTM 100 phantom.

The figures in Appendix B show the number of groups of microcalcifications, masses and filaments that are subjectively detectable on the image of the MTM 100 phantom. These results are obtained by evaluating the images under controlled reading conditions on a diagnostic screen. The acceptance limit is currently set at the detection of at least 4 groups of microcalcifications, 4 masses and 4 filaments (minimum score of 24).

In 2021, all systems met the requirement. The span of the scores is however rather large, with a range from the best detection performance with 112 points, to the lowest detection performance with only 32 points. The median score of the MTM 100 phantom was 4.5 groups of microcalcifications, 5.5 masses and 5.5 filaments, similar to the results obtained in 2020, with a mean detection score of 61 points (Figure IV.1), stable compared to 2020 (61 points). Note that detection scores should always be related to breast dose, an increase in dose should lead to a higher signal-to-noise ratio (SNR) in images and a higher detection score.

The mean glandular dose (MGD – estimated for glandular/adipose ratio 50/50) obtained for the MTM 100 phantom is also shown in Appendix B. Since the phantom is equivalent (in thickness and composition) to a compressed breast of 45 mm, the MGD must not exceed 2 mGy. Significant differences can be observed between the systems. The distribution of MGD (Figure IV.2) shows a slightly negatively skewed distribution. The lowest MGD value is 0.35 mGy, the highest is 1.66 mGy. The average MGD for the systems audited in 2021 was 1.04 mGy (1.09 mGy in 2020), and the median MGD was 1.17 mGy.

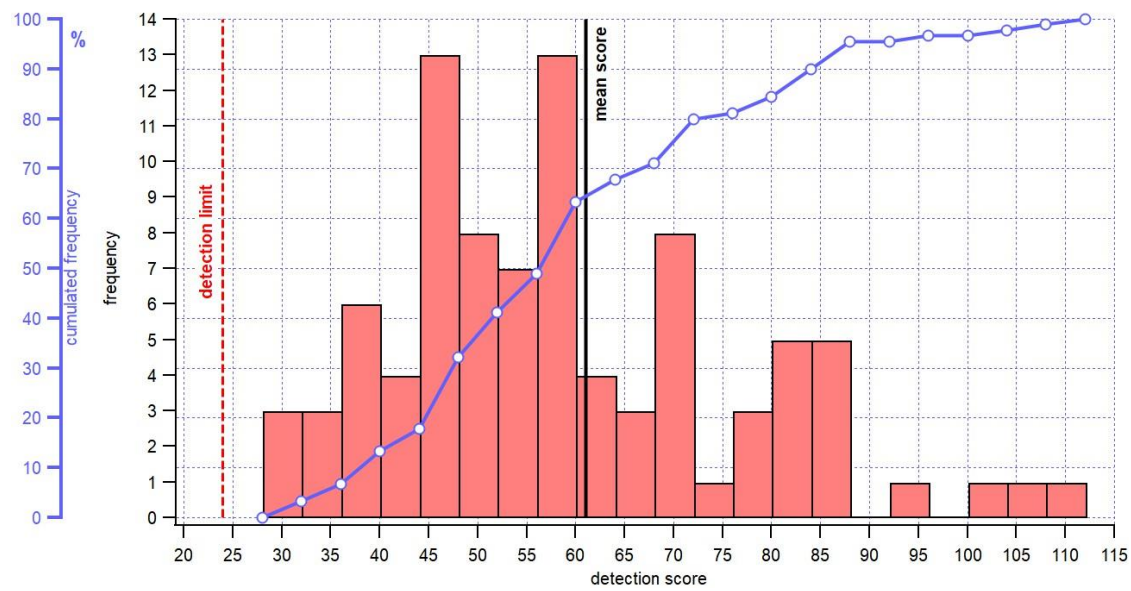


Figure IV.1 – Histogram of detection scores on the MTM 100 phantom

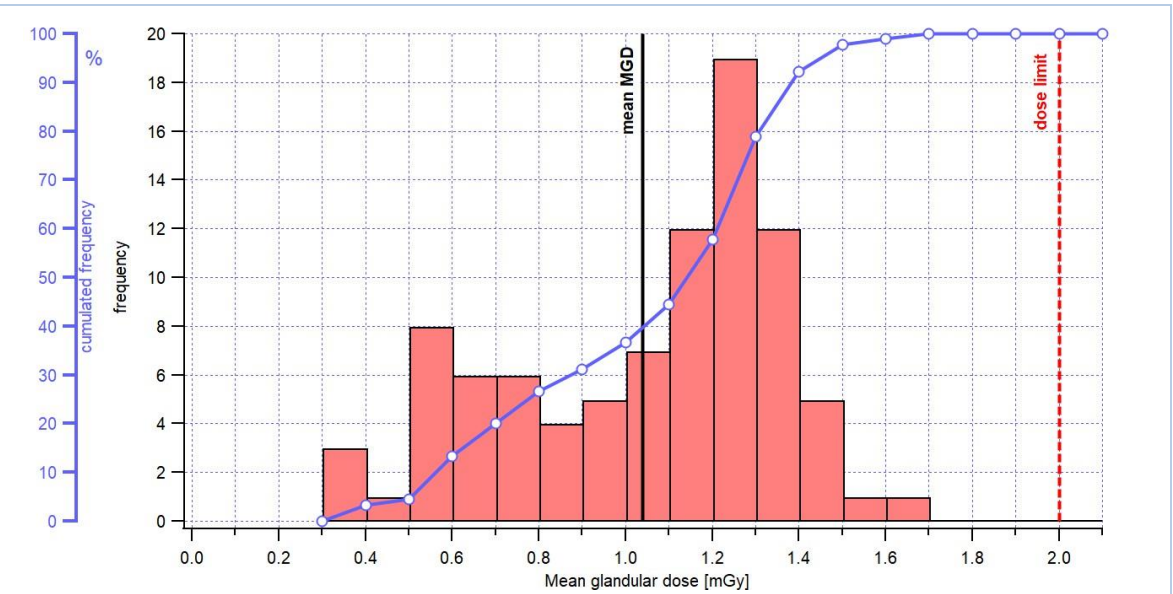


Figure IV.2 – Histogram of MGD for the MTM 100 phantom

Long-term follow-up 2011 - 2021

The mean number of detectable objects in the MTM 100 phantom has varied since 2011 around 4.5 microcalcifications, 5.5 masses and 5.5 filaments (Figure IV.3). Since 2018, the mean number of visible masses has exceeded the mean number of visible filaments on the radiography of the MTM 100 phantom. The number of visible masses tends to increase while the number of visible filaments has decreased slightly.

The mean detection score on the images of the MTM 100 phantom varies between 52 and 66 since 2011 (Figure IV.4). The average detection score is correlated with the average MGD that varies between 0.90 and 1.10 mGy since 2011. A higher dose gives better detection and a higher score.

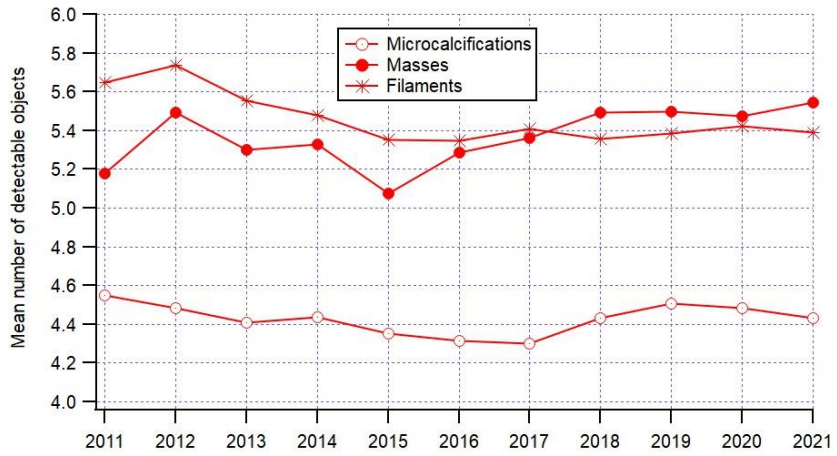


Figure IV.3 – Average number of objects detectable in the MTM 100 phantom since 2011

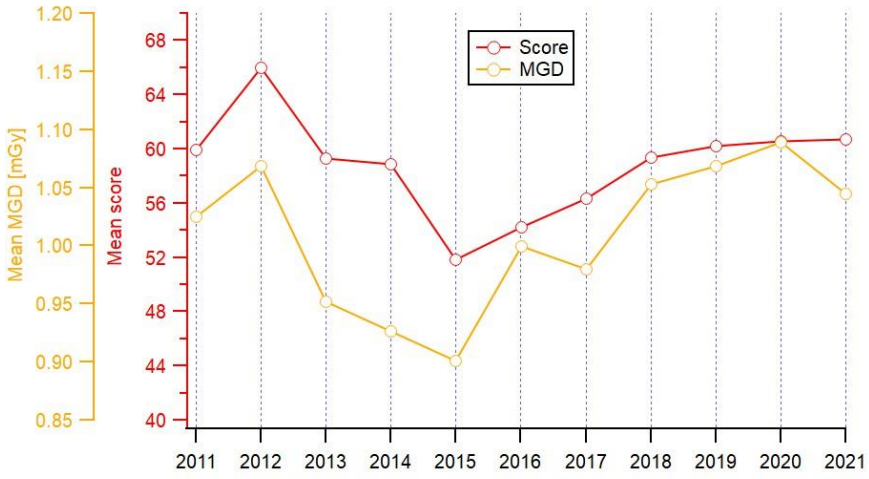


Figure IV.4 – Average score and MGD of the MTM 100 phantom since 2011

IV.b. Measurement of image quality: artefacts and contrast-to-noise ratio (CNR)

Since 2011, all mammography systems in Switzerland must provide at least the detection of a microcalcification of 0.1 mm in diameter with a contrast of 23% in a compressed breast of 60 mm. This probability of detection is linked to the contrast-to-noise ratio (CNR) given by a 0.2 mm thick aluminium foil measured on the images. The ratio between the measured CNR and a reference CNR that provides 50% of correct detection gives a detection index. For example, a normalized CNR of 1.2 means that the probability of detecting such a microcalcification is increased by 20% over the minimum detection threshold of 50%. If this index reaches 2.0, it means that the probability of detection reaches 100%. In order to take into account the increasing difficulty of detection with the breast thickness (loss of contrast and resolution), the minimum limit value of the detection index is adapted to the breast thickness: that is 1.1, 1.0 and 0.9 for compressed breasts of 32, 60 and 90 mm, respectively.

The detection index increases with the dose. Appendices C to E thus represent the detection index as a function of the MGD obtained in clinical mode, for the three compressed breast thicknesses of 32, 60 and 90 mm. Systems in the lower right corner provide inferior image quality while delivering an above-average dose. The settings of these systems should be optimized if possible. At the top right are the systems whose settings favor image quality at the

expense of the dose. Finally, the systems of the lower left sector favor low doses to the detriment of image quality.

In 2021, all the audited installations achieved a sufficient detection index for all breast thicknesses. The average detection indices were 1.88 for 32 mm, 1.52 for 60 mm and 1.21 for 90 mm. These detection indices are compatible with the 2020 data (1.90, 1.55 and 1.22 respectively).

Considering a breast thickness of 32mm, the best detection index is obtained for a MGD of o 0.99 mGy, which is 40% higher than the mean value of 0.70 mGy. In the opposite, the poorest image quality is obtained for a MGD of 0.30 mGy.

Considering a breast thickness of 60mm, the best detection index is obtained for a MGD of 1.47 mGy which is 74% higher than the mean value of 1.47 mGy. In the opposite, the poorest image quality is obtained for a MGD of 0.54 mGy.

Considering a breast thickness of 90mm, the best detection index is obtained for a MGD of 4.06 mGy which is 61% higher than the mean value of 2.53 mGy. In the opposite, the poorest image quality is obtained for a MGD of 2.93 mGy

Long-term follow-up 2011 - 2021

The average detectability index has varied since 2011 around 1.9, 1.5 and 1.2 for the thicknesses 32, 60 and 90 mm, respectively (Figure IV.5). No significant trend in increase or decrease in detectability has been observed for these 10 last years.

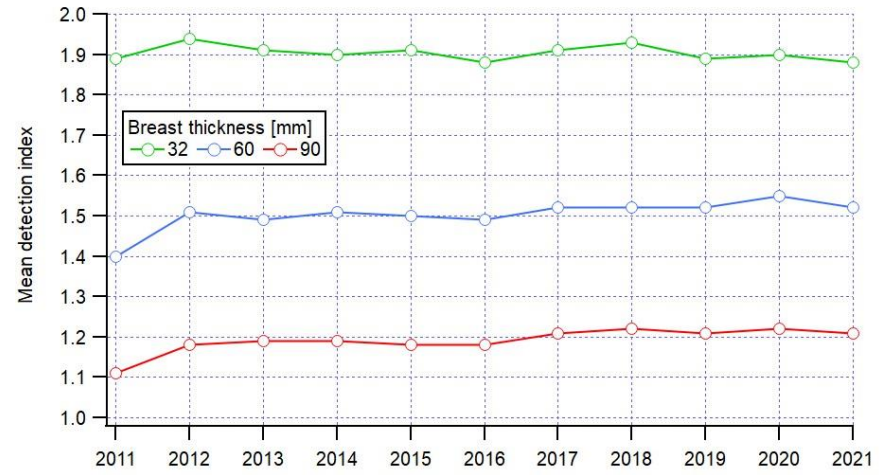


Figure IV.5 – Mean detection indices since 2011

IV.c. Mean glandular dose (MGD)

Radiology centres are compared on the basis of their MGD delivered in clinical mode for 4 breast thicknesses: 32, 45, 60 and 90 mm (Appendices C to E). In 2021, average MGDs were 0.70 mGy for 32 mm, 1.47 mGy for 60 mm and 2.53 mGy for 90 mm, slightly lower compared to 2020 (respectively 0.73, 1.54 and 2.60 mGy for the three thicknesses).

Significant differences of MGD can be observed between systems. The distribution of MGD (Figures IV.6 to IV.8) shows bimodal distributions for the three breast thicknesses. Systems with a low-dose setting differ from the majority of systems that use higher and more conventional MGD values. This type of distribution is very marked for the 90 mm thickness.

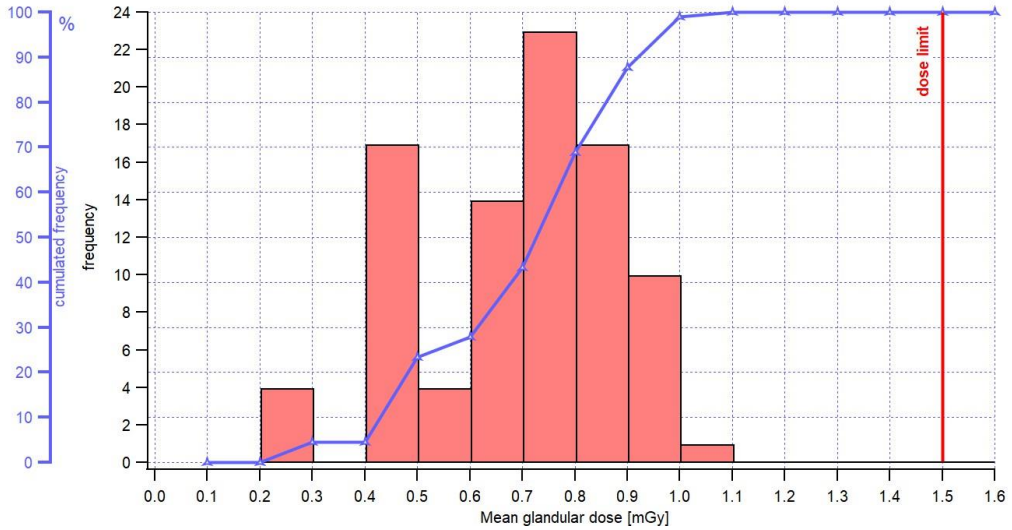


Figure IV.6 – Distribution of MGD for the thickness 32 mm

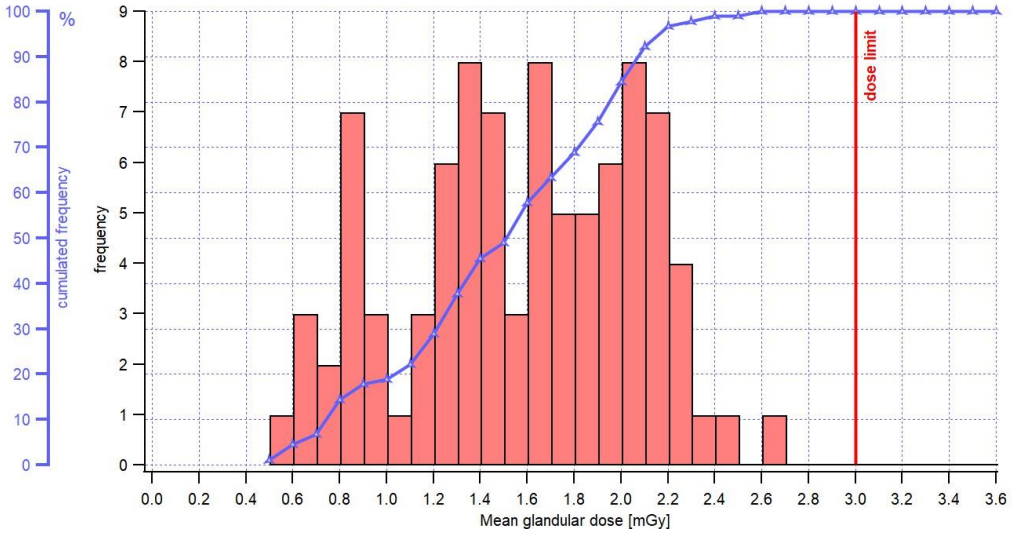


Figure IV.7 – Distribution of MGD for the thickness 60 mm

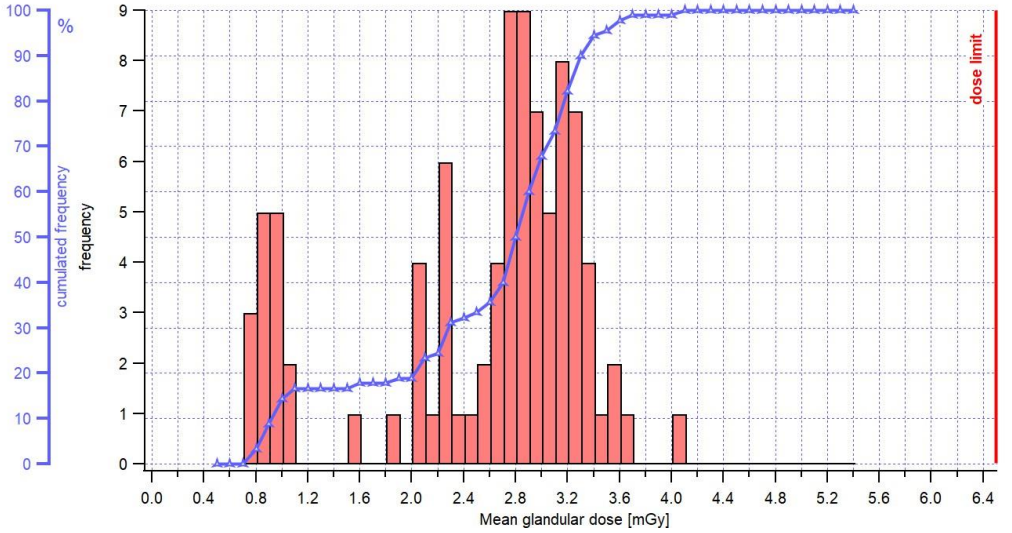


Figure IV.8 – Distribution of MGD for the thickness 90 mm

Long-term follow-up 2011 - 2021

The MGD has varied since 2011 around 0.7, 1.4 and 2.5 mGy for the thicknesses 32, 60 and 90 mm, respectively (Figure IV.9). No long-term trend in increase or decrease in breast dose has been observed for these 10 last years.

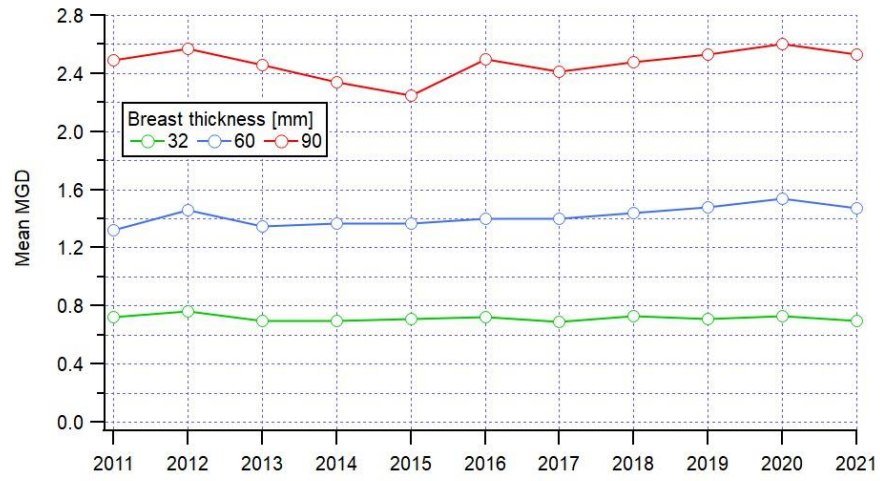


Figure IV.9 – Mean MGD since 2011

IV.d. Control of the diagnostic screens

The diagnostic evaluation of the mammography exam must be made from images displayed on dedicated diagnostic screens that must conform to DICOM GSDF specifications (luminance, contrast, image consistency, grayscale range …). Radiology centres that do not use their own diagnostic screens for the screening programme do not have any measured value for this item.

In 2021, three screens had a dirty surface that needed to be cleaned. Only one diagnostic screen required luminance tuning due to an improper difference of maximum luminance between the left and right screens.

The luminance ranges and LUT deviations are shown in Appendix F. In 2021, all systems met the requirements of minimum luminance range and maximum LUT deviation defined in the directive of the Federal Office of Public Health.

IV.e. Differences between mammography systems

Digital mammography systems can be used over the full range of doses possible for a given breast thickness. This is however only theoretical since these systems must provide a minimum image quality for all breast thicknesses between 20 and 90 mm. The automatic exposure control (AEC) setting is therefore important as it determines the balance between image quality and breast dose. Figures 6a to 6c show how the AEC reacts for the three breast thicknesses 32, 60 and 90 mm.

In general, flat panel systems use similar parameters close to average values regardless of the breast thickness. In comparison, Philips MicroDose systems clearly favor very low doses, for an image quality slightly below the average for the L30. The spectral imaging of the L50 SI highly improves image quality. Scanning systems give lower doses because of the absence of an anti-scatter grid.

It should be noted that for the same mammography model, there can be a certain disparity in terms of parameterization. Some systems offer several curves to adjust the voltage (kV), the

tube load (mAs) and the anode-filter combination, depending on the breast thickness, giving priority to the dose or the image quality. It can also happen that the thicknesses used for the audits (32, 60 and 90 mm) are between two different setting thresholds. A small difference between the displayed thicknesses can thus cause the system to switch to one selection of parameters rather than another.

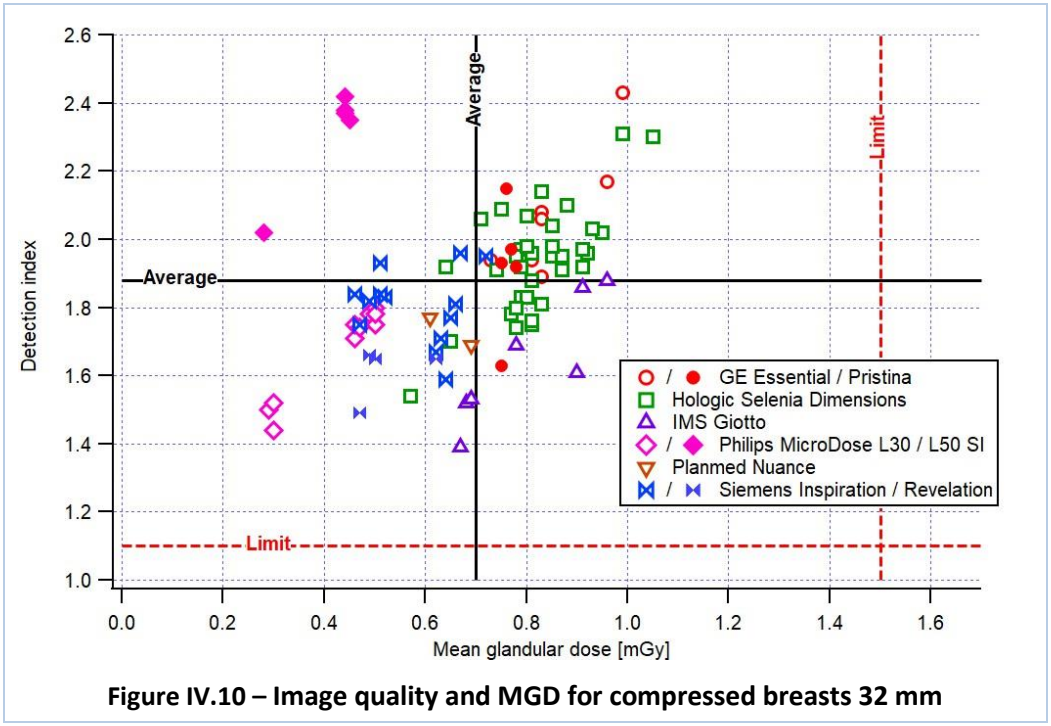


Figure IV.10 – Image quality and MGD for compressed breasts 32 mm

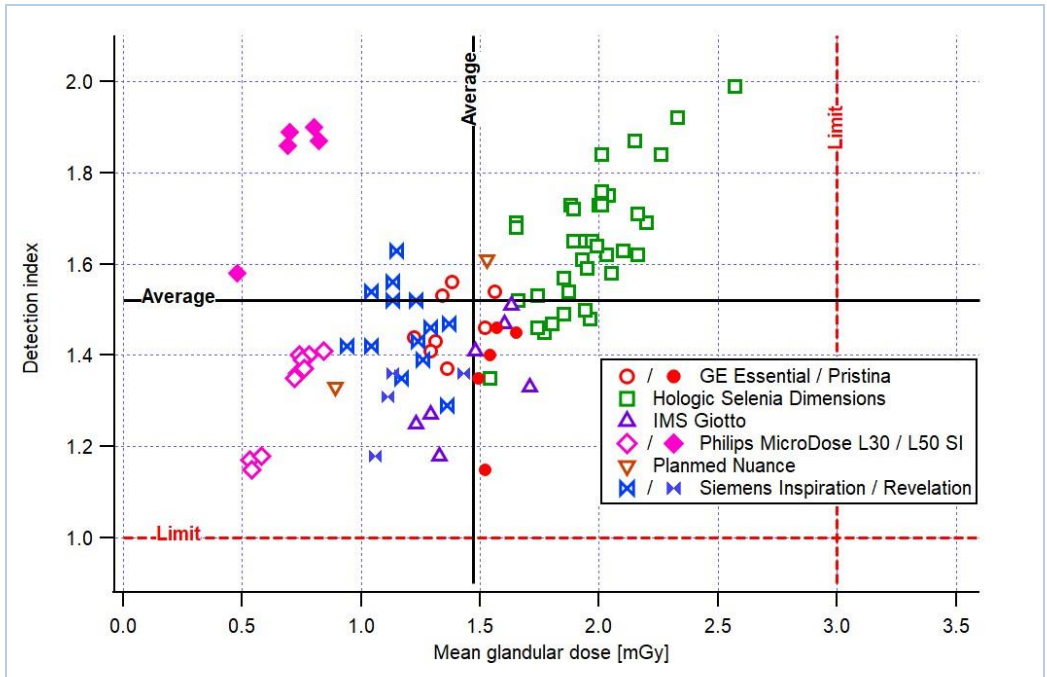


Figure IV.11 – Image quality and MGD for compressed breasts 60 mm

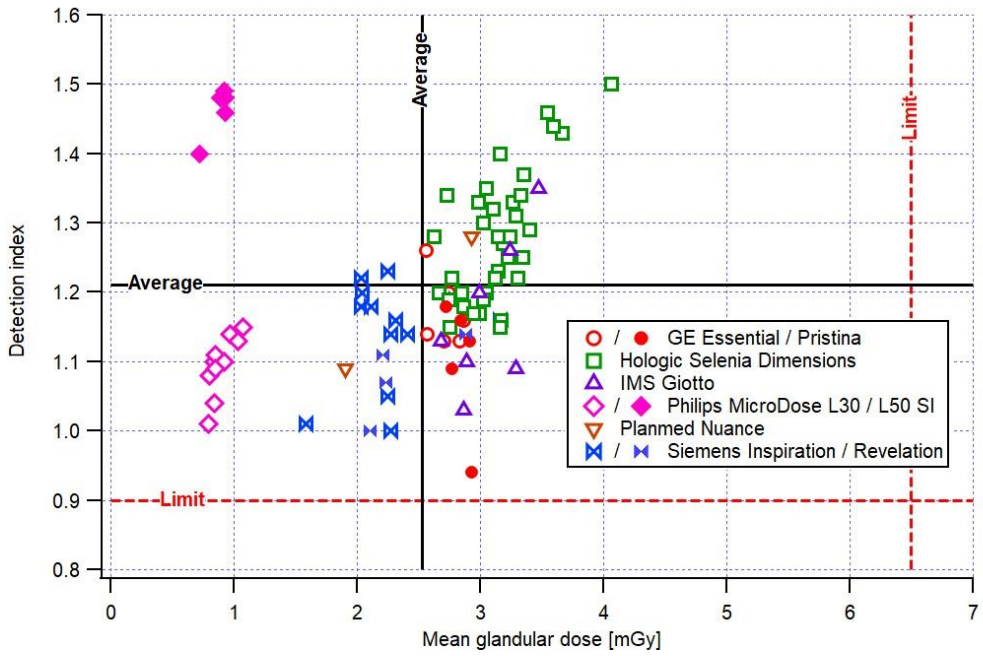


Figure IV.12 – Image quality and MGD for compressed breasts 90 mm

V. Conclusion

The analysis of the image quality-dose balance shows that all the mammography systems audited in 2021 complied with European requirements for image quality and breast dose. The nine problems pointed out at the audits related to stability controls and diagnostic screens. Optimizing the settings of mammography systems according to the thickness of the breast would make it possible to further improve the quality / dose balance. This observation is sometimes also valid for the variability within the same brand or the same model of mammography systems.

Appendix A - List of mammography systems

Vaud			
System		AEC setting (MTM 100)	
		kV	A/F
1	GE Senographe Pristina	34	Rh/Ag
2	GE Senographe Pristina	34	Rh/Ag
3	GE Senographe Pristina	34	Rh/Ag
4	GE Senographe Essential	29	Rh/Rh
5	Hologic Selenia Dimensions	29	W/Rh
6	Hologic Selenia Dimensions	28	W/Rh
7	Hologic Selenia Dimensions	28	W/Rh
8	Hologic Selenia Dimensions	28	W/Rh
9	Hologic Selenia Dimensions	28	W/Rh
10	Hologic Selenia Dimensions	28	W/Rh
11	Hologic Selenia Dimensions	28	W/Rh
12	Hologic Selenia Dimensions	28	W/Rh
13	Hologic Selenia Dimensions	28	W/Rh
14	IMS Giotto Class	28	W/Ag
15	Philips Microdose L30	32	W/Al
16	Philips Microdose L30	32	W/Al
17	Philips Microdose L30	32	W/Al
18	Philips Microdose L30	32	W/Al
19	Philips Microdose L50 SI	32	W/Al
20	Philips Microdose L50 SI	32	W/Al
21	Philips Microdose L50 SI	29	W/Al
22	Siemens Inspiration	28	W/Rh
23	Siemens Inspiration	28	W/Rh
24	Siemens Inspiration	28	W/Rh
25	Siemens Inspiration	28	W/Rh
26	Siemens Revelation	28	W/Rh
27	Siemens Revelation	28	W/Rh

Geneva			
System		AEC setting (MTM 100)	
		kV	A/F
1	GE Senographe Pristina	34	Rh/Ag
2	GE Senographe Essential	29	Rh/Rh
3	GE Senographe Essential	27	Rh/Rh
4	Hologic Selenia Dimensions	28	W/Rh
5	Hologic Selenia Dimensions	28	W/Rh
6	Hologic Selenia Dimensions	28	W/Rh
7	Hologic Selenia Dimensions	28	W/Rh
8	Hologic Selenia Dimensions	28	W/Rh
9	Hologic Selenia Dimensions	28	W/Rh
10	Hologic Selenia Dimensions	28	W/Rh
11	Hologic Selenia Dimensions	28	W/Rh
12	Philips Microdose L30	32	W/Al
13	Philips Microdose L30	32	W/Al
14	Philips Microdose L30	29	W/Al
15	GE Senographe Pristina	34	Rh/Ag
16	Philips Microdose L50 SI	32	W/Al
17	Planmed Nuance	30	W/Ag
18	Siemens Inspiration	30	W/Rh

Ticino			
System		AEC setting (MTM 100)	
		kV	A/F
1	GE Senographe Essential	28	Rh/Rh
2	Hologic Selenia Dimensions	28	W/Rh
3	Hologic Selenia Dimensions	28	W/Rh
4	Hologic Selenia Dimensions	28	W/Rh
5	Hologic Selenia Dimensions	28	W/Rh
6	Hologic Selenia Dimensions	28	W/Rh
7	IMS Giotto	28	W/Ag
8	IMS Giotto Class	28	W/Ag
9	Siemens Inspiration	28	W/Rh
10	IMS Giotto Class	28	W/Ag
11	IMS Giotto Class	28	W/Ag
12	IMS Giotto Class	27	W/Ag
13	IMS Giotto Class	28	W/Ag
14	Siemens Inspiration	28	W/Rh

BEJUNE			
System		AEC setting (MTM 100)	
		kV	A/F
1	GE Senographe Essential	29	Rh/Rh
2	Hologic Selenia Dimensions	28	W/Rh
3	Hologic Selenia Dimensions	28	W/Rh
4	Hologic Selenia Dimensions	28	W/Rh
5	Hologic Selenia Dimensions	28	W/Rh
6	Siemens Revelation	28	W/Rh
7	Siemens Inspiration	28	W/Rh
8	Siemens Inspiration	28	W/Rh
9	Siemens Inspiration	28	W/Rh
10	Siemens Inspiration	28	W/Rh

Valais			
System		AEC setting (MTM 100)	
		kV	A/F
1	GE Senographe Essential	29	Rh/Rh
2	GE Senographe Essential	28	Rh/Rh
3	GE Senographe Essential	29	Rh/Rh
4	Hologic Selenia Dimensions	28	W/Rh
5	Hologic Selenia Dimensions	28	W/Rh
6	Hologic Selenia Dimensions	28	W/Rh
7	Philips Microdose L30	32	W/Al
8	Philips Microdose L50 SI	32	W/Al
9	Planmed Nuance	30	W/Ag

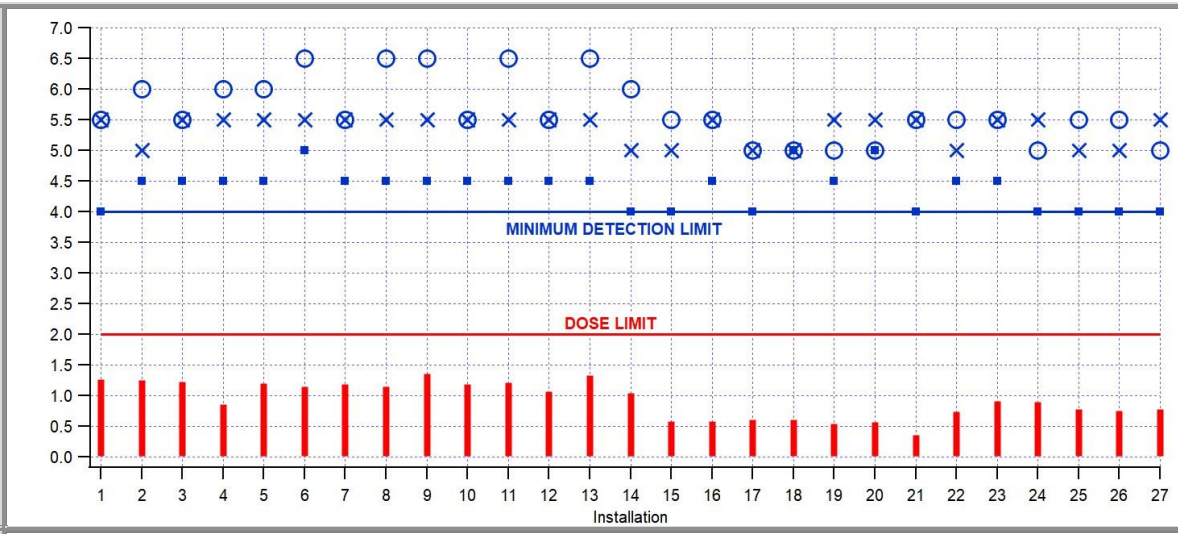
Fribourg			
System		AEC setting (MTM 100)	
		kV	A/F
1	Hologic Selenia Dimensions	28	W/Rh
2	Hologic Selenia Dimensions	28	W/Rh
3	Hologic Selenia Dimensions	28	W/Rh
4	Hologic Selenia Dimensions	28	W/Rh
5	Hologic Selenia Dimensions	28	W/Rh
6	Hologic Selenia Dimensions	28	W/Rh
7	Hologic Selenia Dimensions	28	W/Rh
8	Philips Microdose L30	29	W/Al
9	Philips Microdose L30	32	W/Al

Thurgau			
System		AEC setting (MTM 100)	
		kV	A/F
1	Siemens Inspiration	30	W/Rh
2	Siemens Revelation	28	W/Rh
3	Siemens Inspiration	28	W/Rh

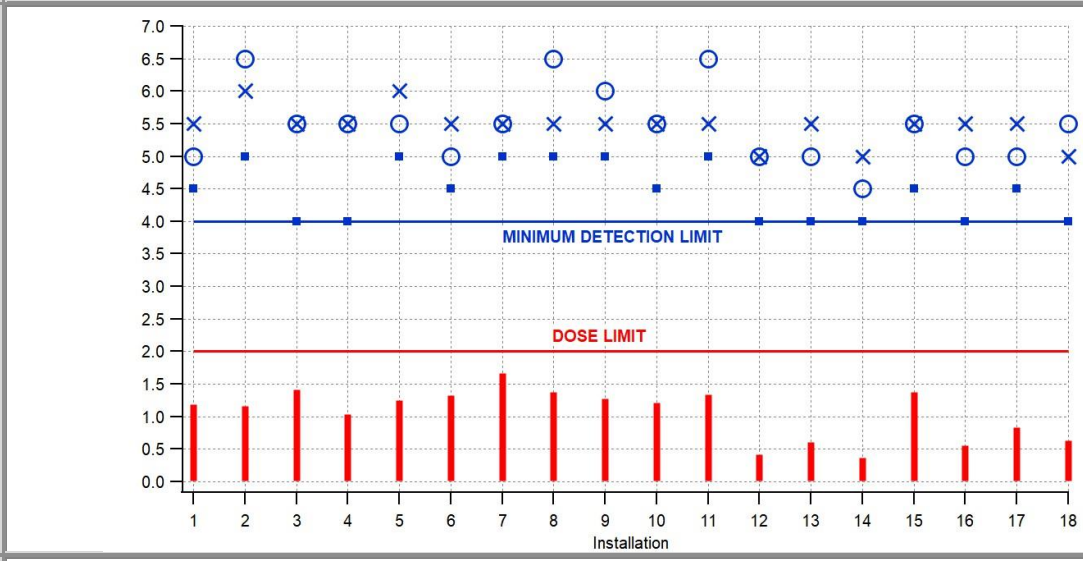
Appendix B - Number of detectable structures on the MTM 100 phantom and MGD

- microcalcifications
- masses
- filaments
- **Mean glandular dose [mGy]**

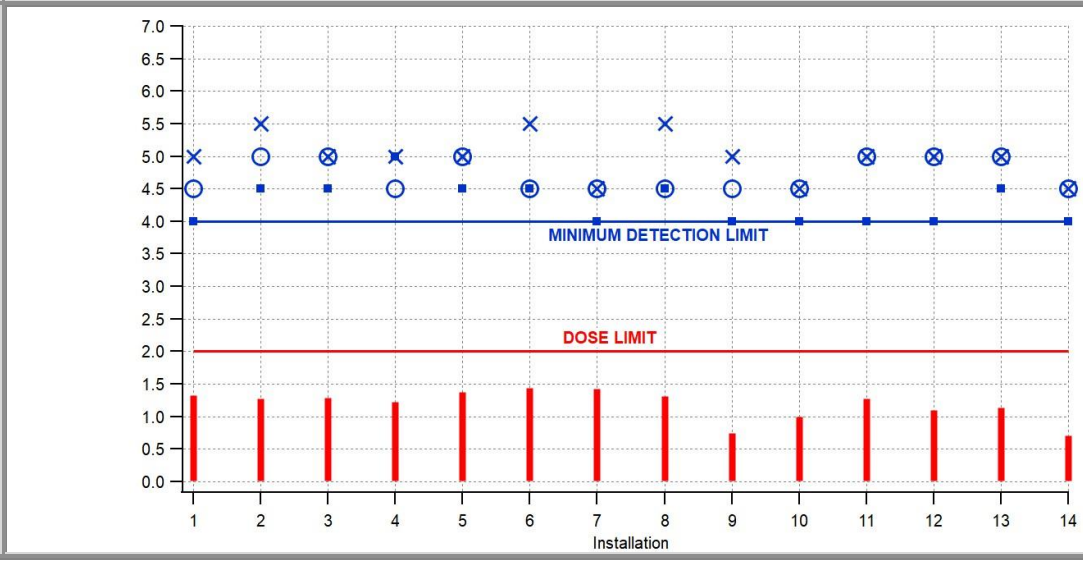
VAUD



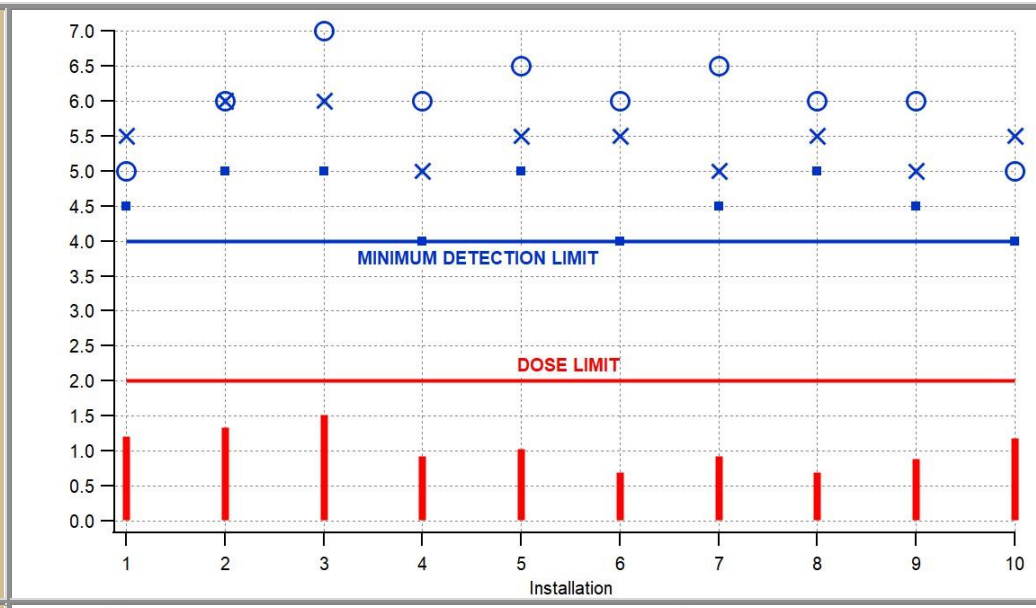
GENEVA



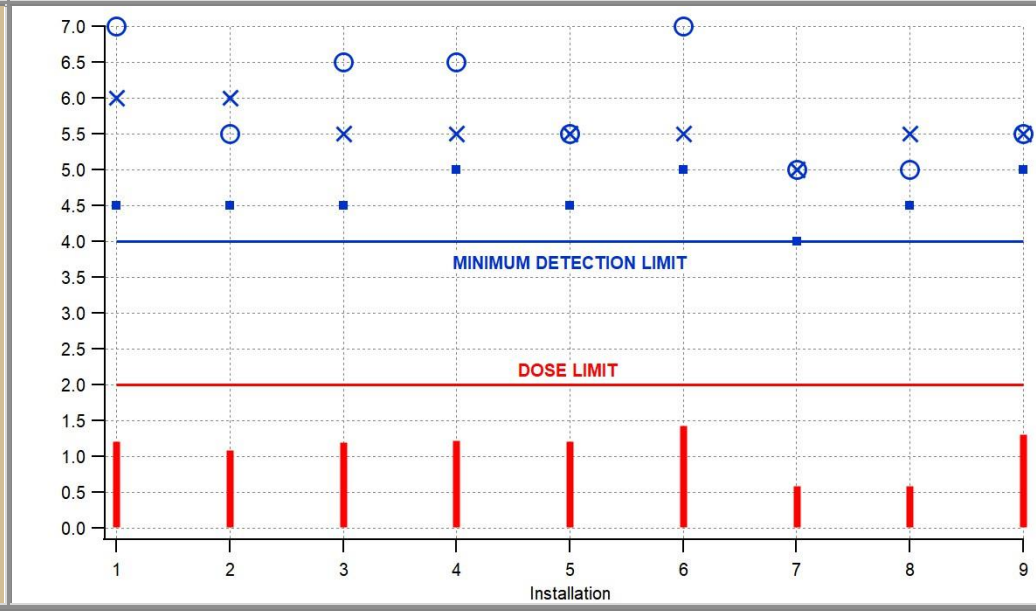
TICINO



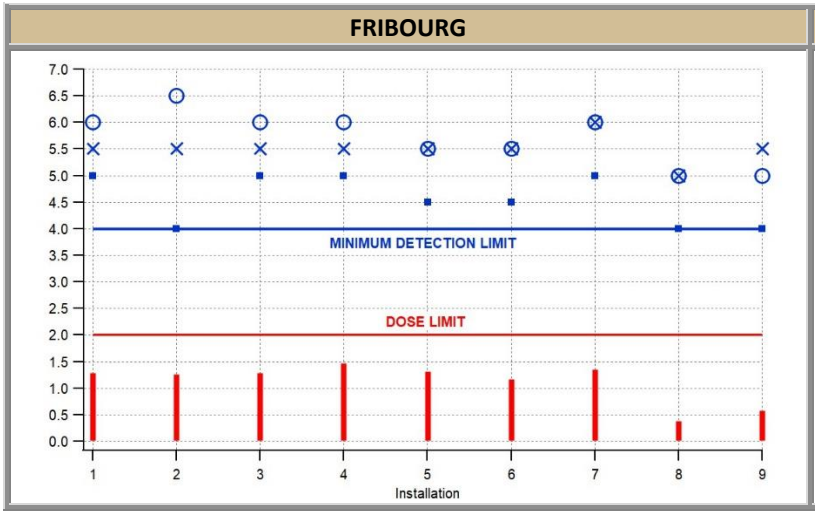
BEJUNE



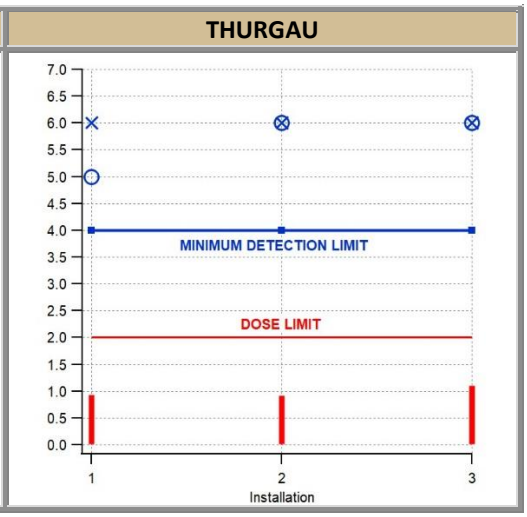
VALAIS



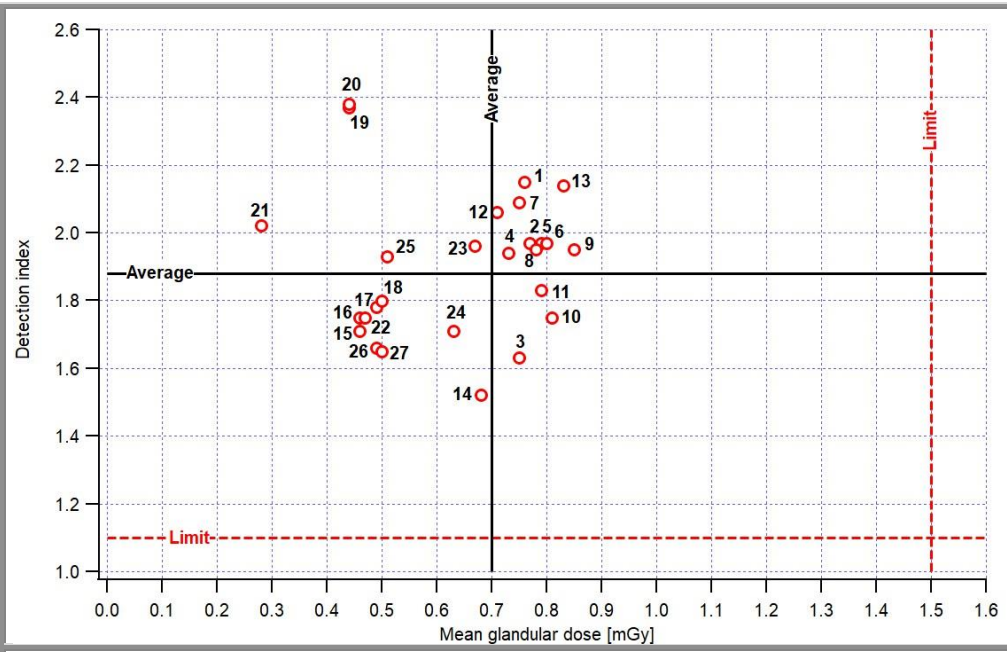
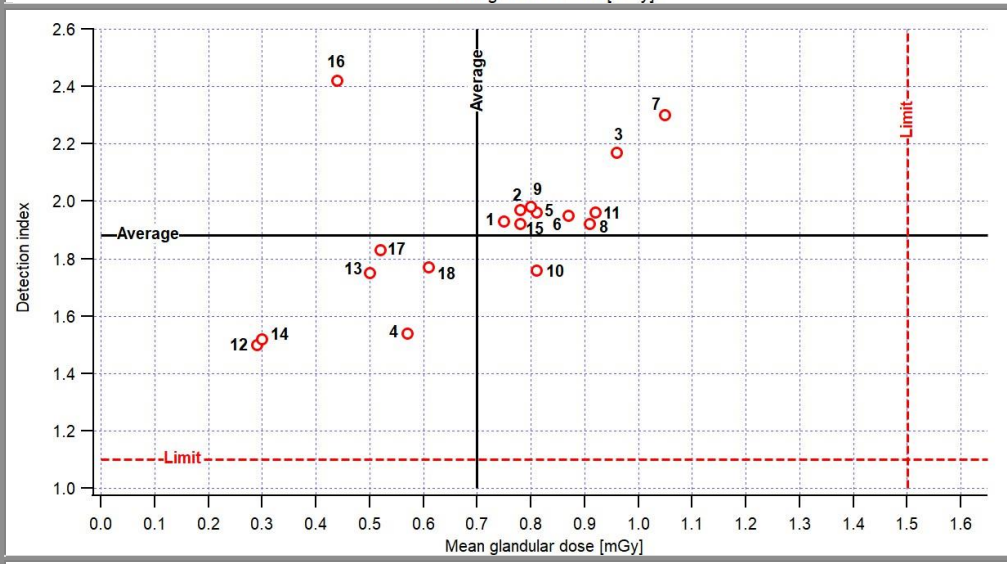
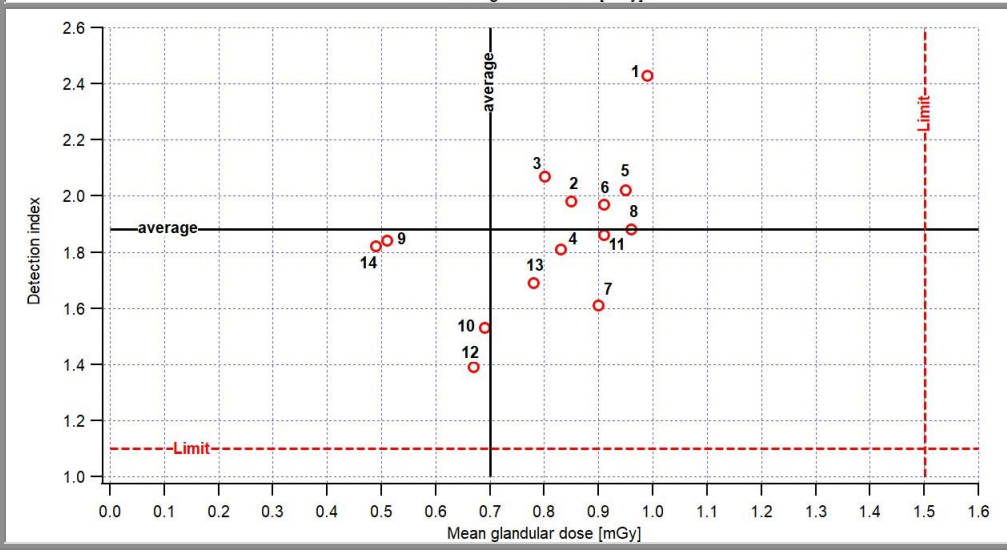
FRIBOURG



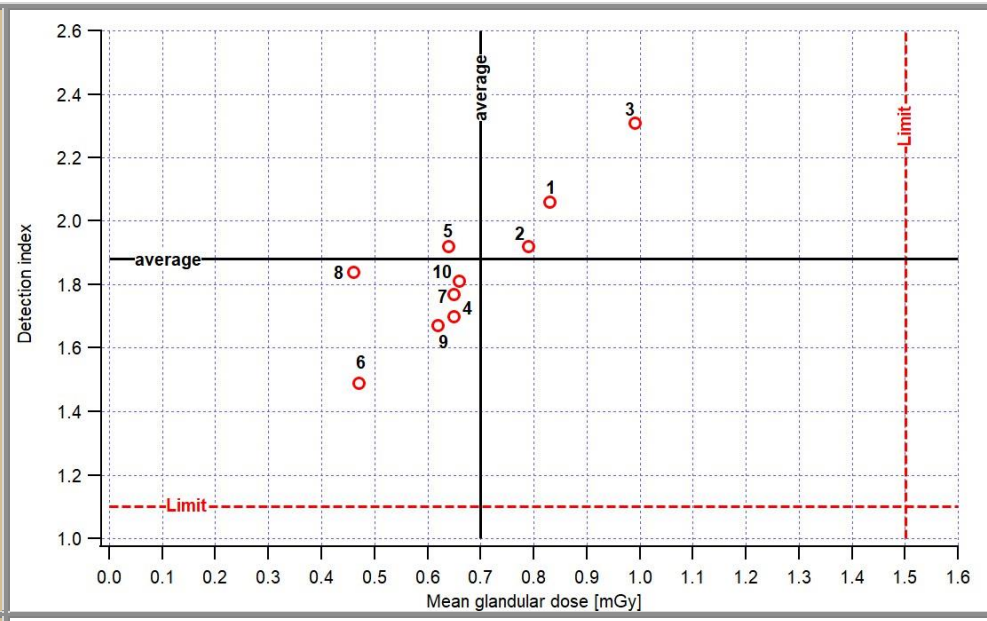
THURGAU



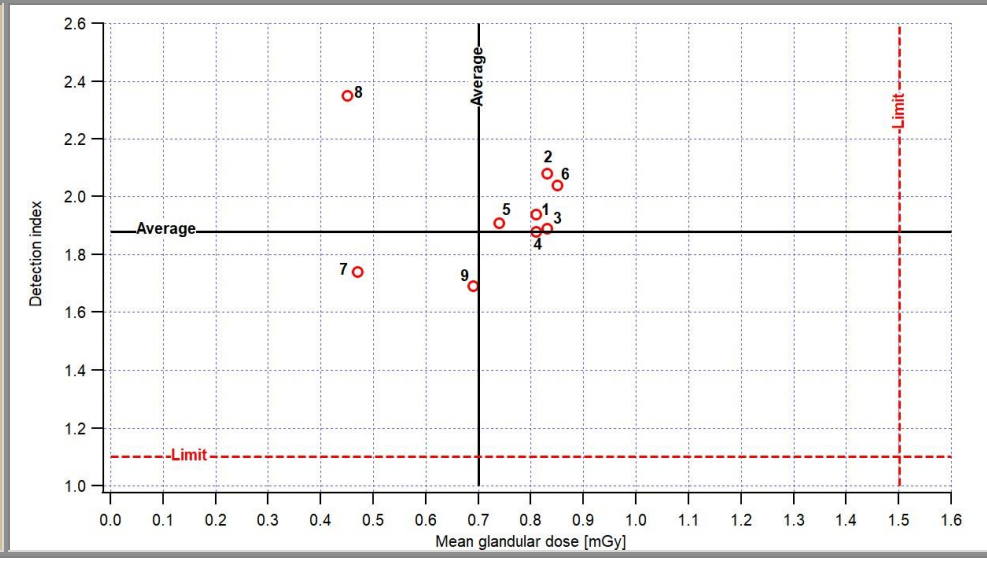
Appendix C – Detection index and mean glandular dose (MGD) for a 32 mm compressed breast

VAUD	
GENEVA	
TICINO	

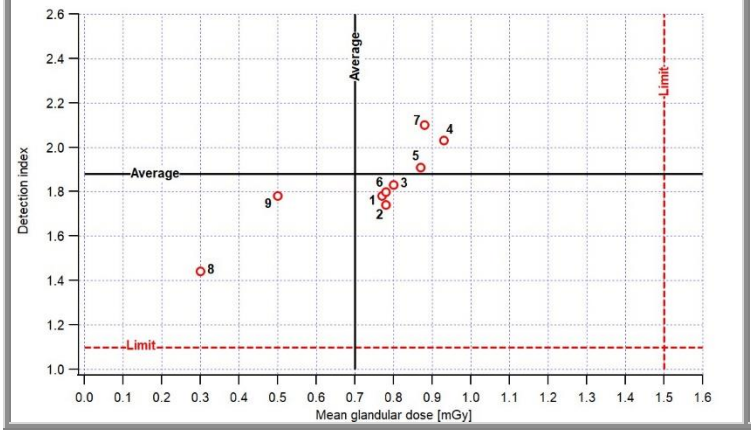
BEJUNE



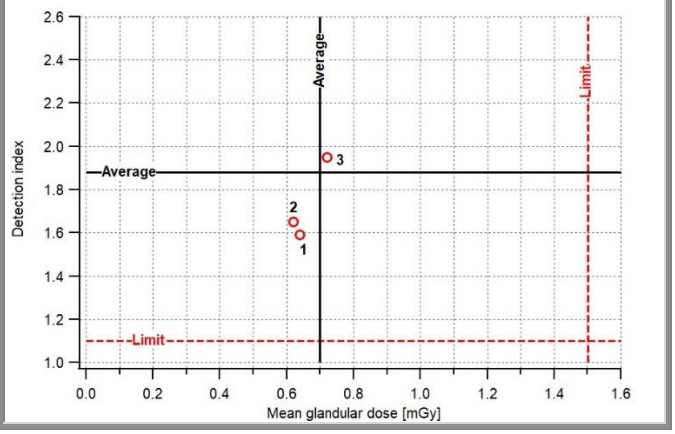
VALAIS



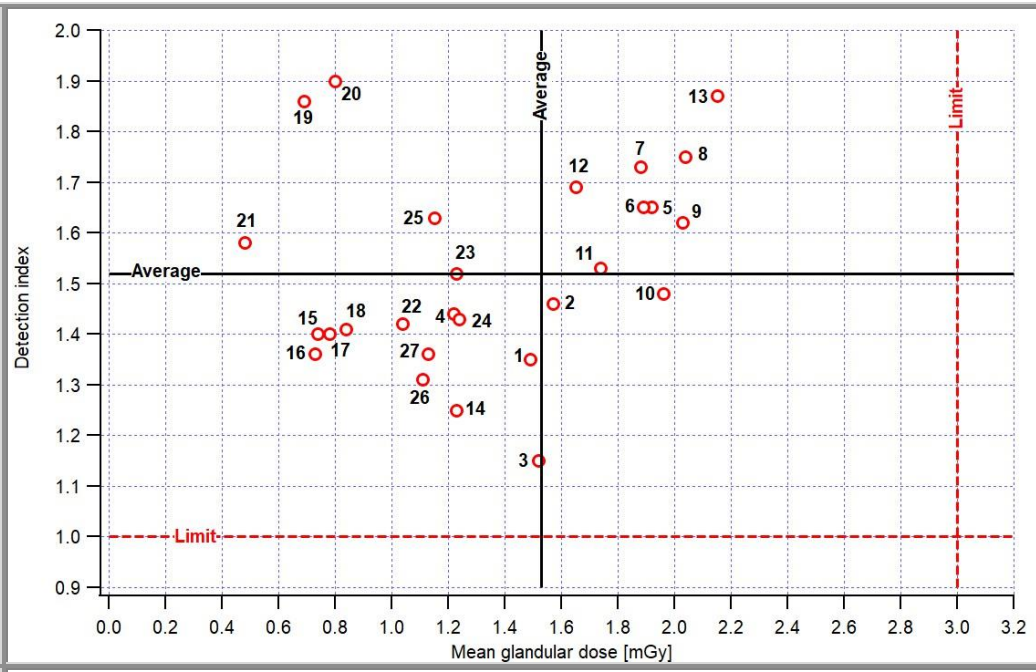
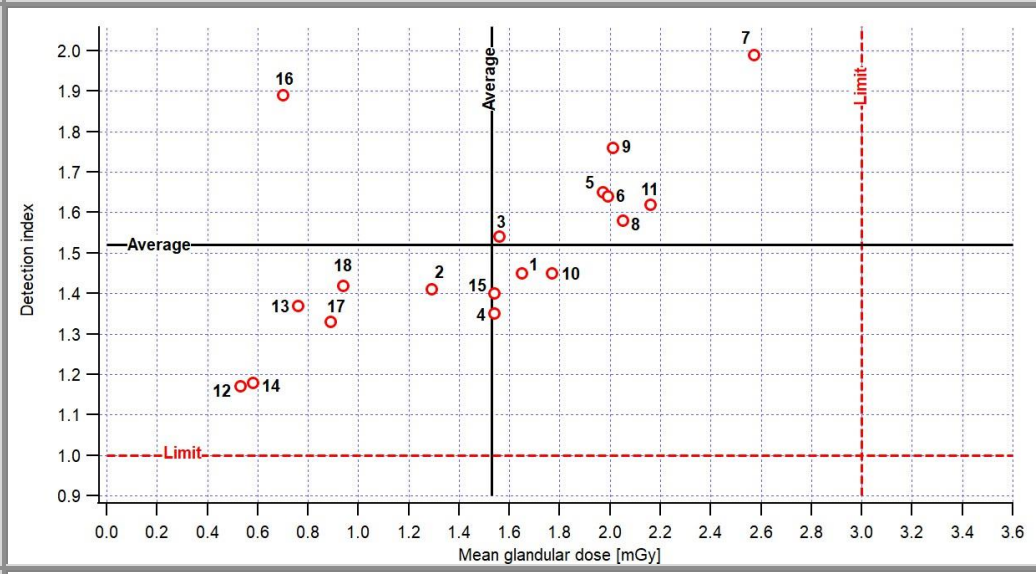
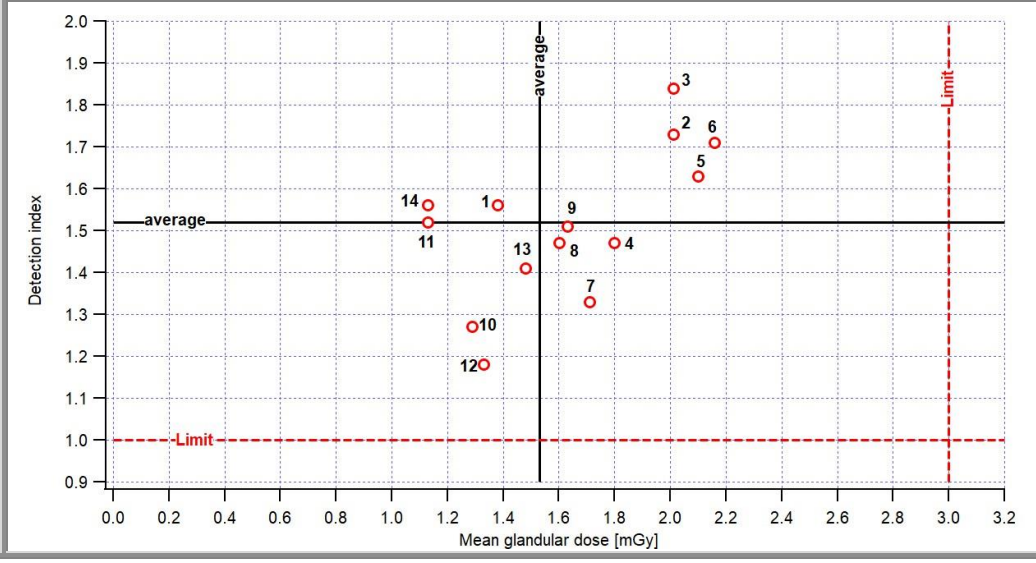
FRIBOURG



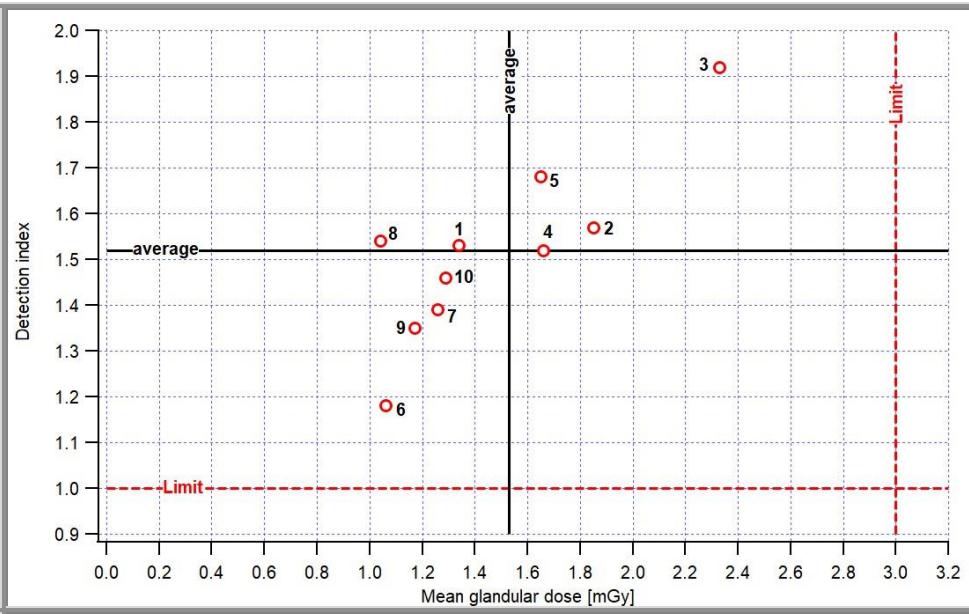
THURGAU



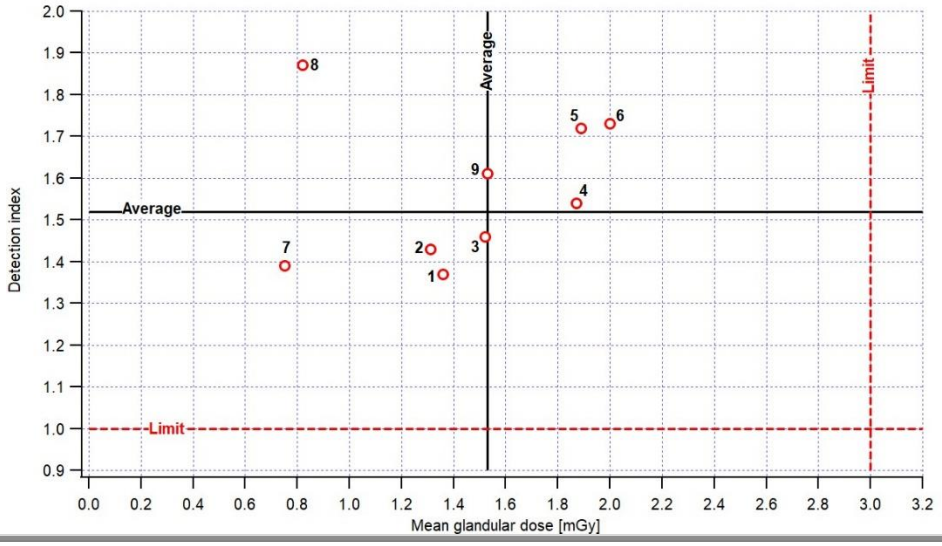
Appendix D – Detection index and mean glandular dose (MGD) for a 60 mm compressed breast

VAUD	
GENEVA	
TICINO	

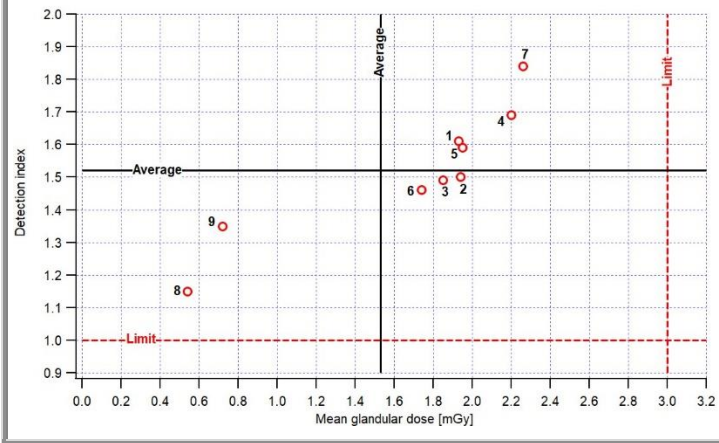
BEJUNE



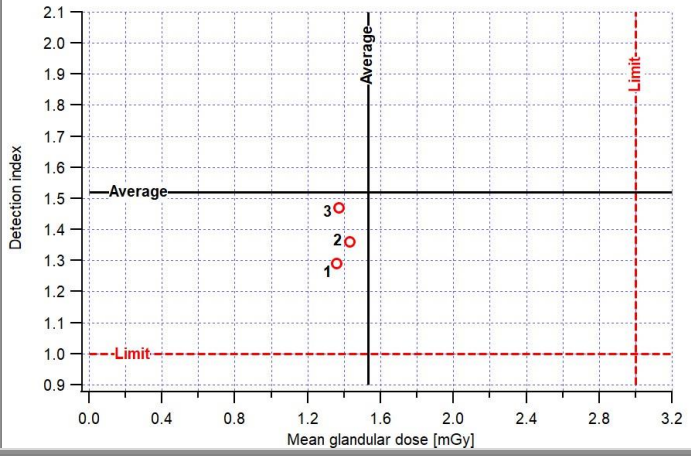
VALAIS



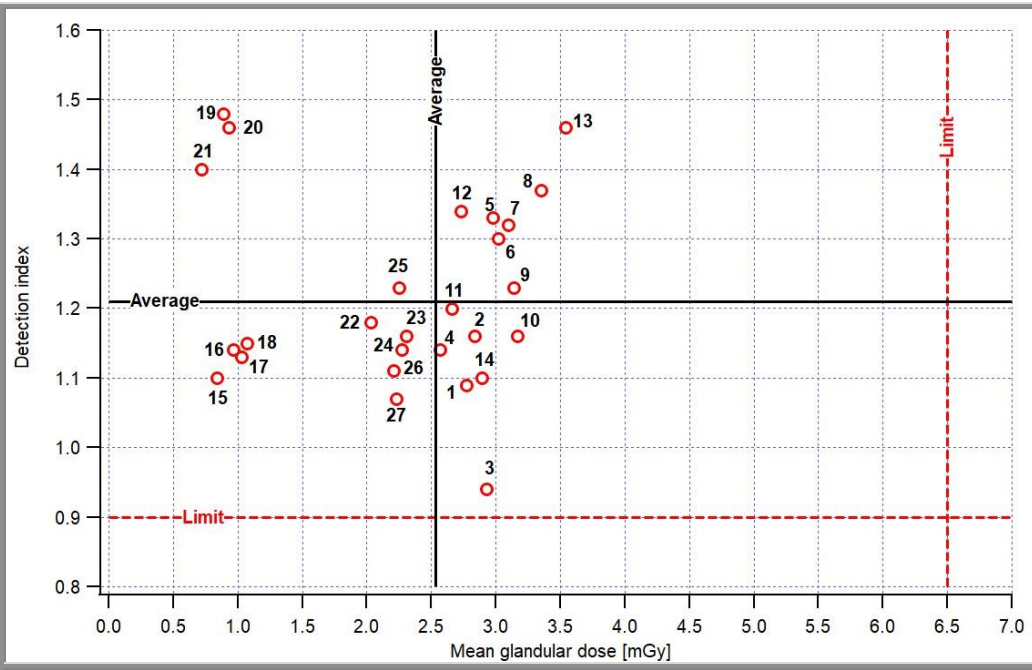
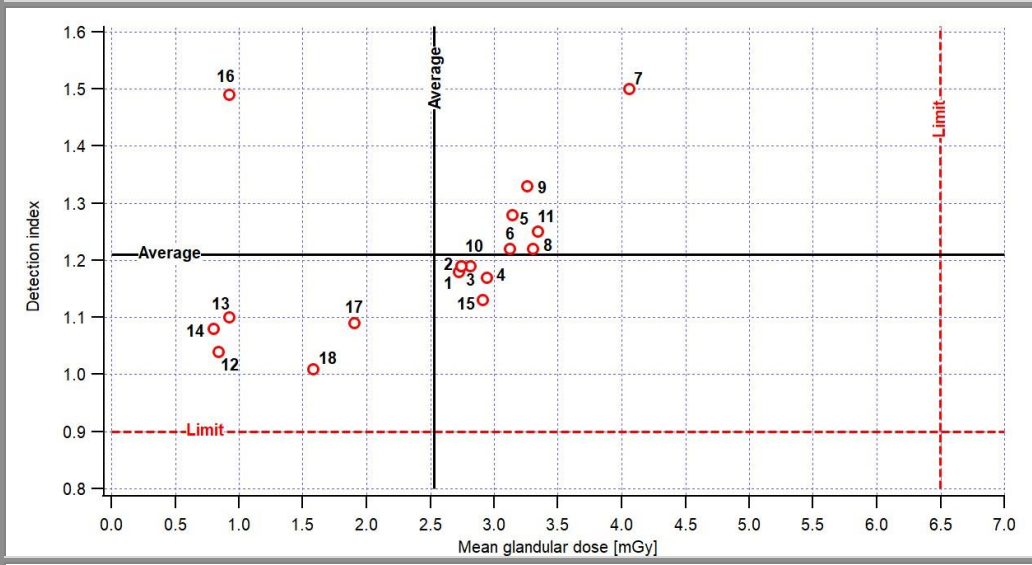
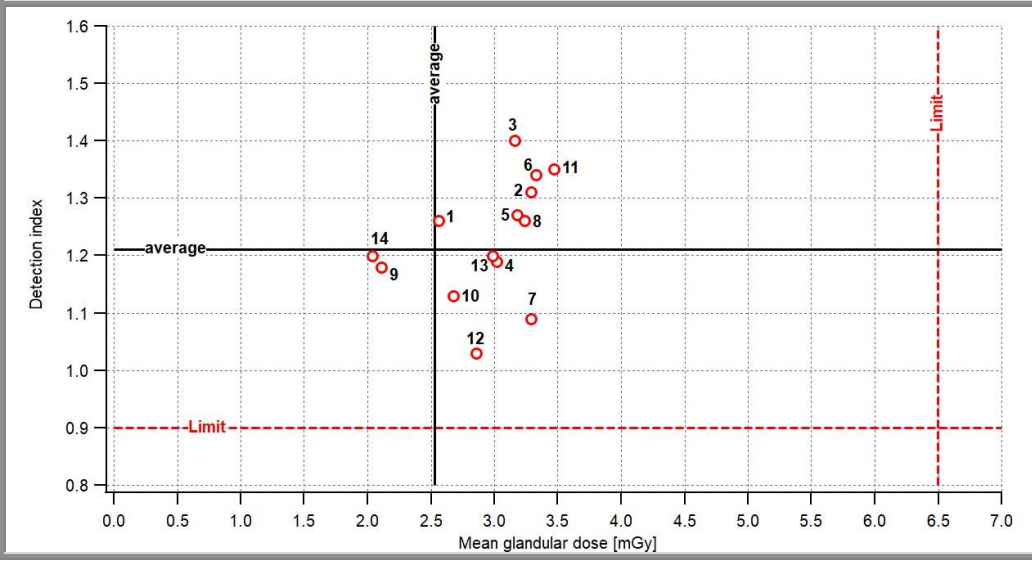
FRIBOURG



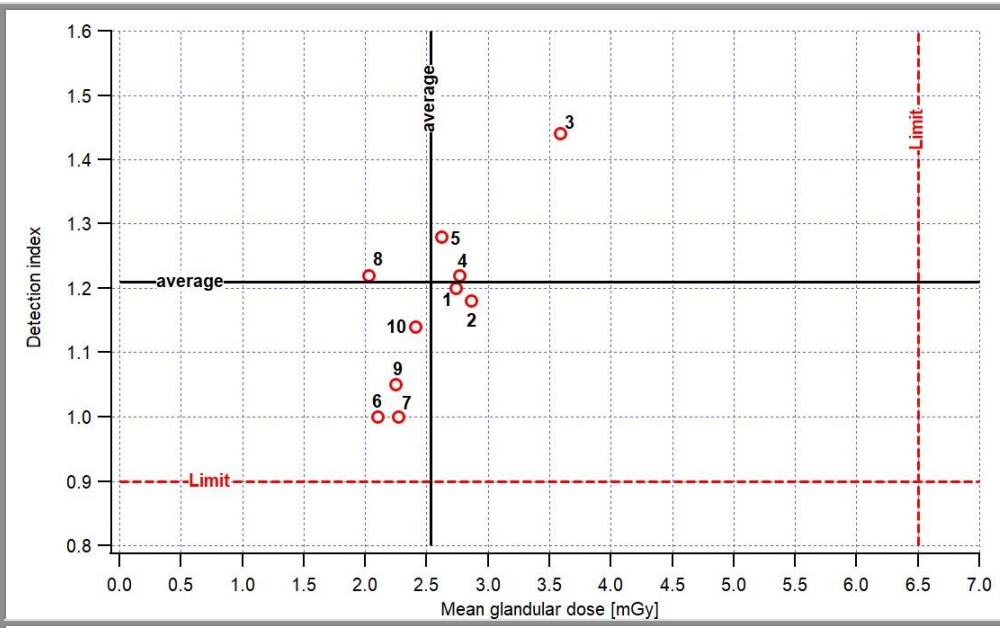
THURGAU



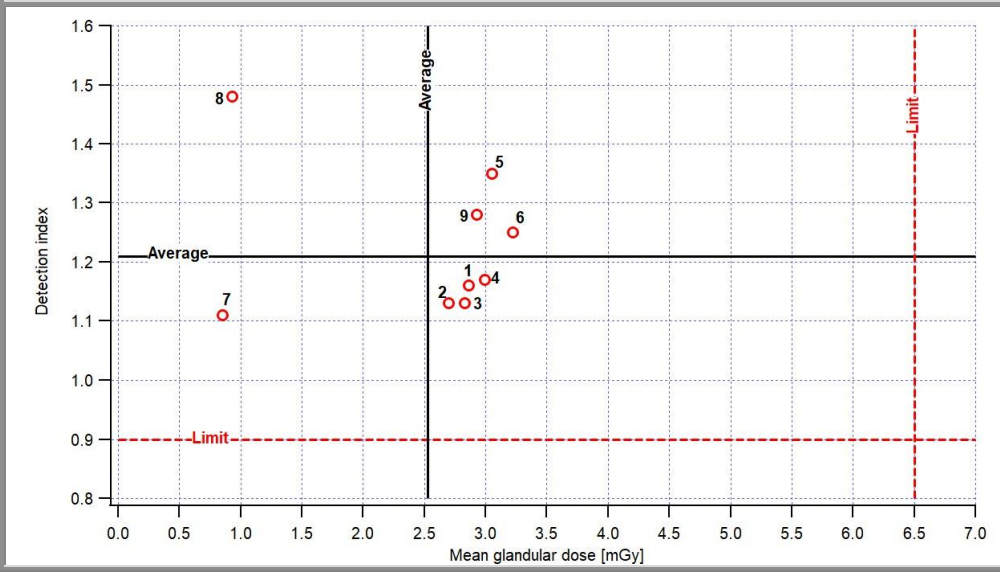
Appendix E – Detection index and mean glandular dose (MGD) for a 90 mm compressed breast

VAUD	
GENEVA	
TICINO	

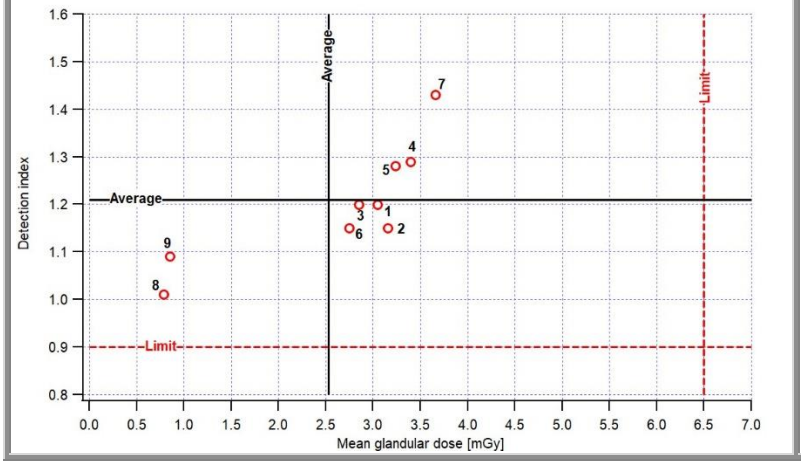
BEJUNE



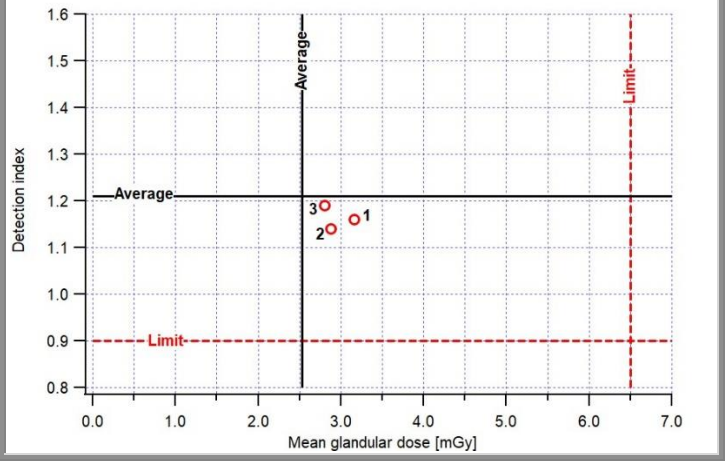
VALAIS



FRIBOURG

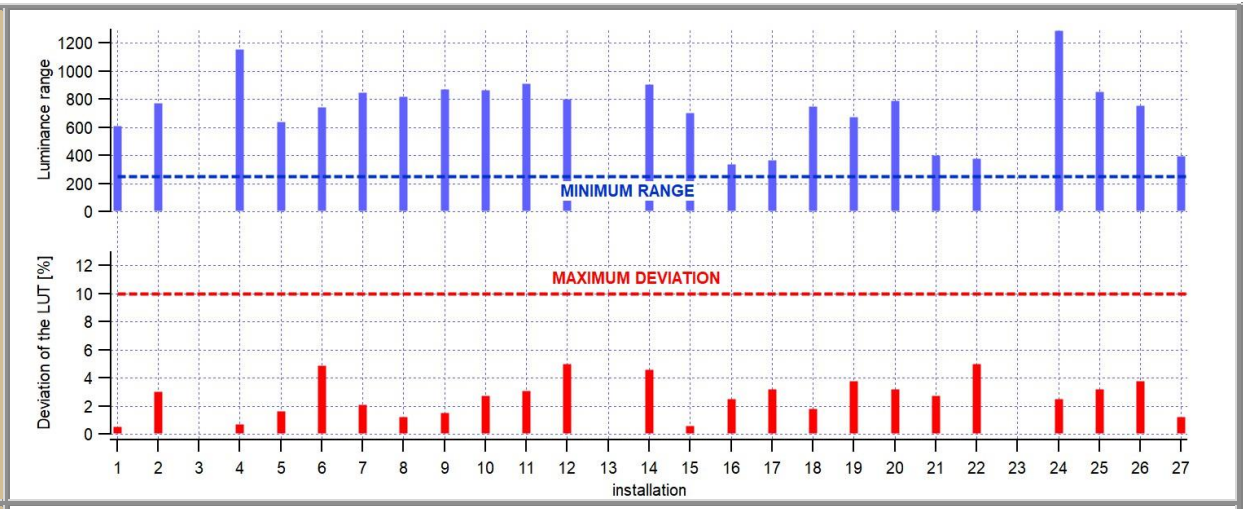


THURGAU

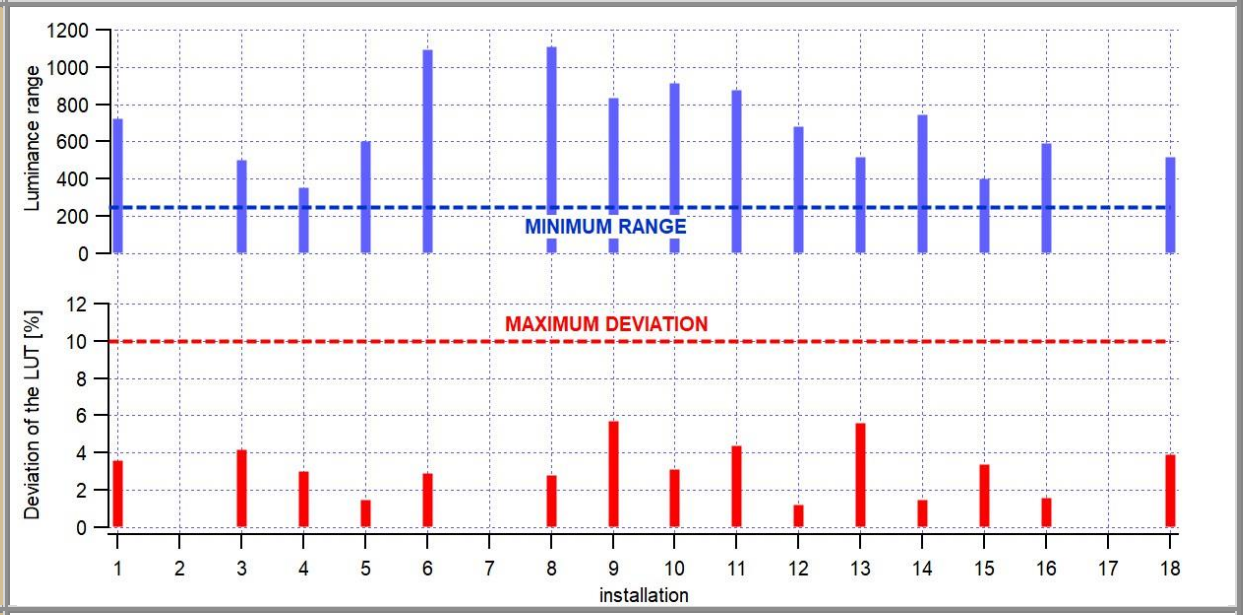


Appendix F - Luminance range and deviation of the LUT curve of diagnostic screens

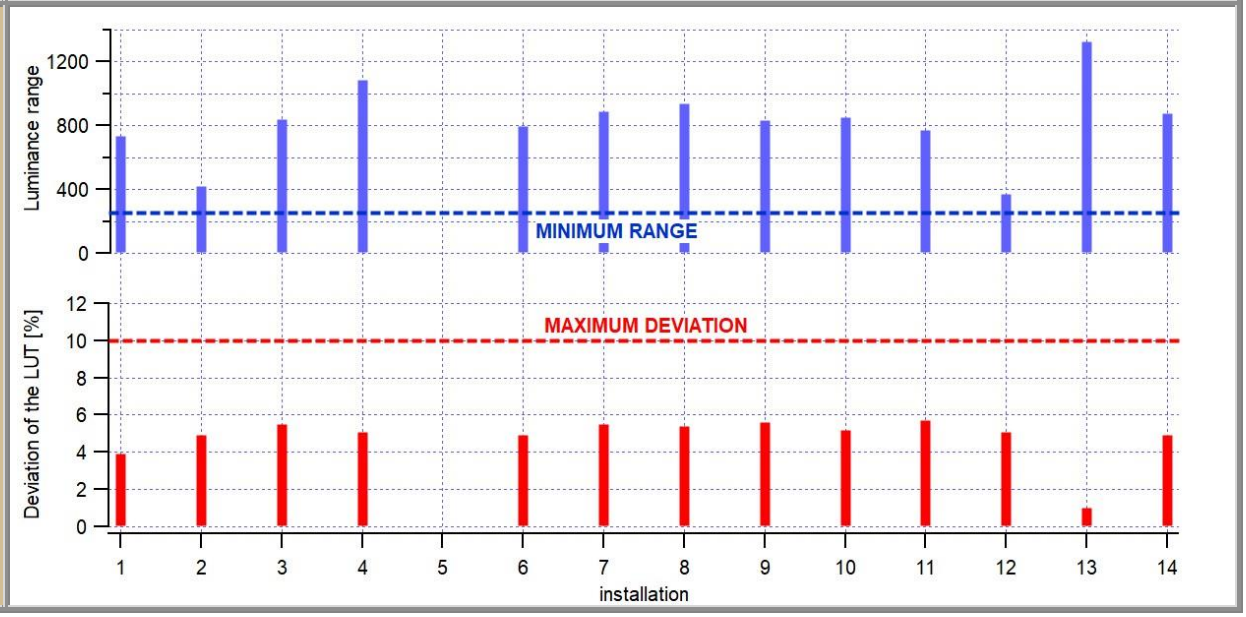
VAUD



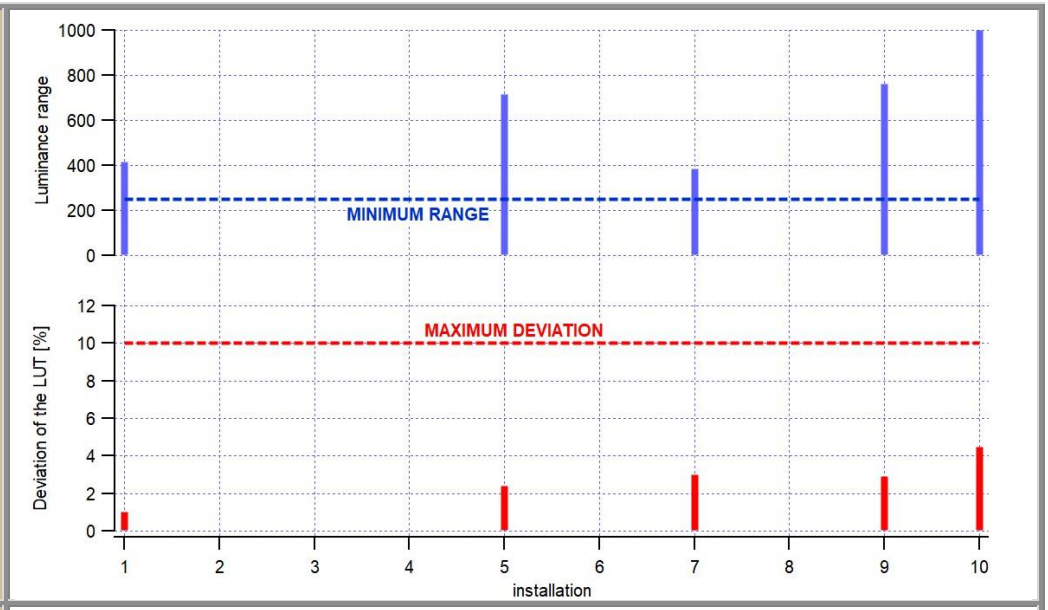
GENEVA



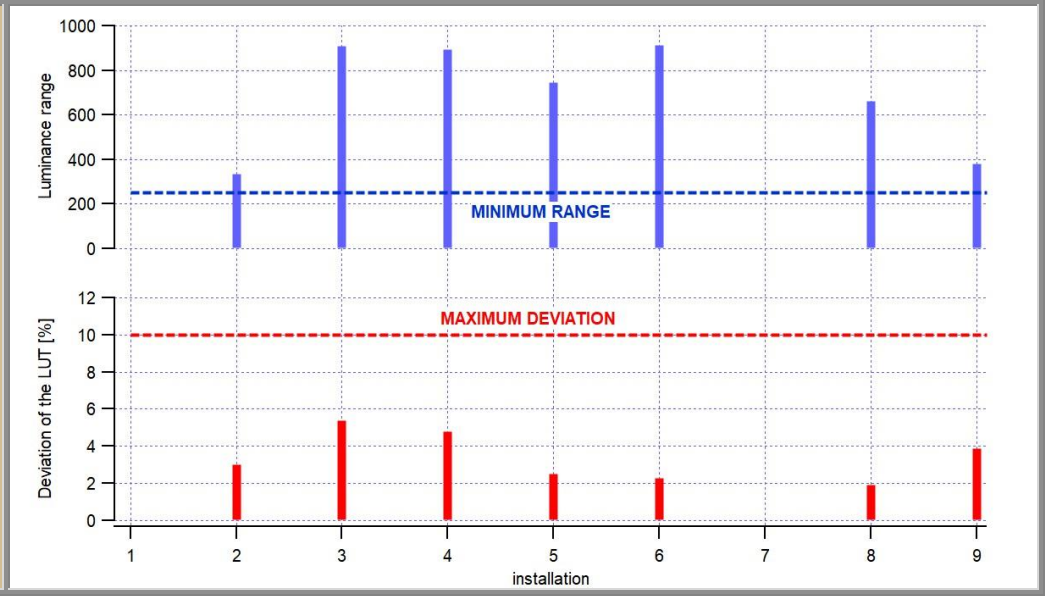
TICINO



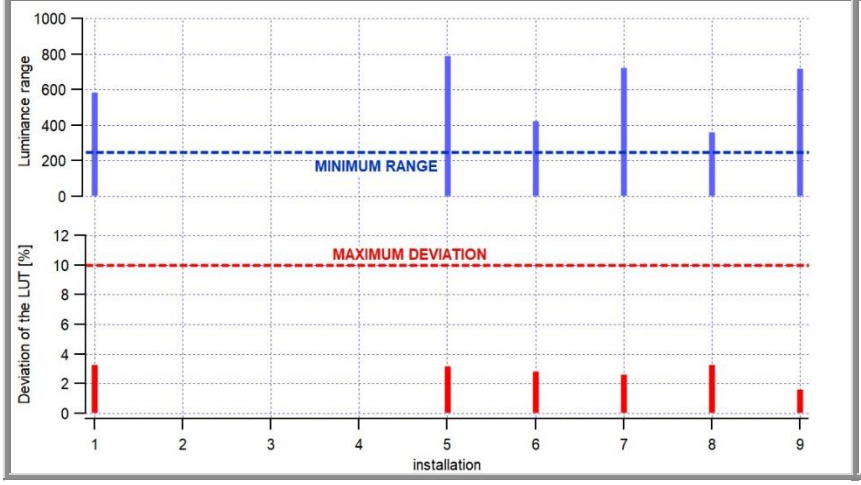
BEJUNE



VALAIS



FRIBOURG



THURGAU