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Your Detector Array Just Arrived Update of AAPM TG 312: Acceptance Testing, Commissioning and Periodic Quality Assurance of Ion Chamber and Diode Detector Arrays

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AAPM TG 312 Acceptance Testing, Commissioning and Periodic Quality Assurance of Ion Chamber and Diode Detector Arrays

Purpose

- The purpose of this report is to provide radiation therapy physicists who use multidimensional arrays with a toolset to assess device performance before clinical use as well as over a period of time.

Goals

- Provide a brief description of the detector arrays available during the time when this report was written.
- Describe the multidimensional array characteristics that should be tested for quality assurance purposes.
- Recommend the initial and periodic QA tests that should be performed, including a summary table with recommended frequencies and tolerances.
- Direct the interested reader to relevant published literature on performance testing and clinical use of multidimensional arrays.

Rationale

- The rationale behind this effort was the lack of clarity in terms of the tasks a radiation therapy physicist should perform in order to validate and implement a detector array in the clinic. Moreover, there were no consensus recommendations on periodic QA and expected device performance.

What is our goal

- Not to add unnecessary procedures
- Maximum outcome for effort
- Identify common sources problems and failures

From AAPM TG120

- Detetector arrasy to be validated against a higher resolution device.
- Monthly check of calibration
- Create institutional pass/fail criteria

Medical Physics, 38, 1313-1338 (2011)
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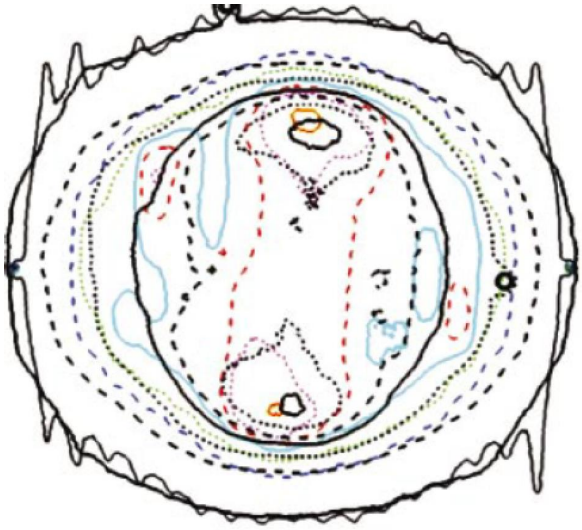
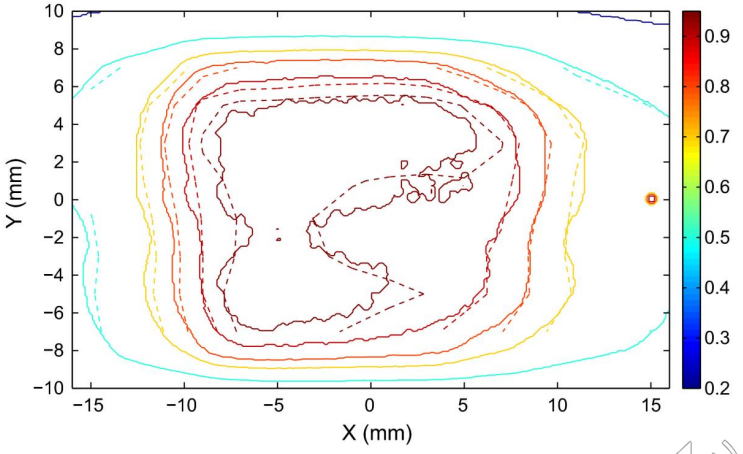
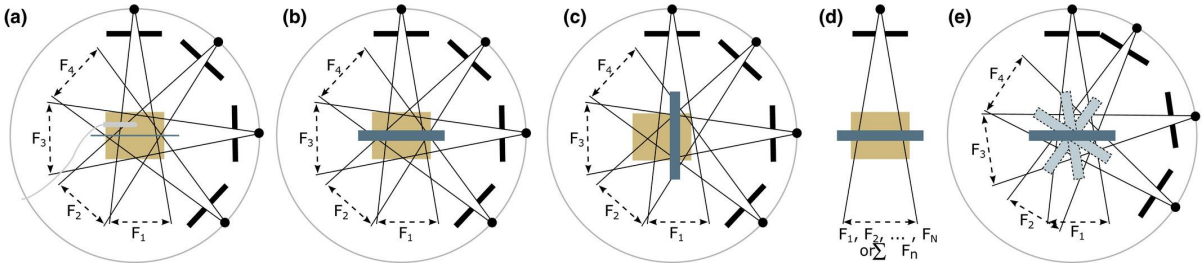




Recommendations

Terminology as it pertains to IMRT QA delivery methods

- Perpendicular field-by-field (PFF) ✓
- Perpendicular composite (PC) ✓
- True Composite (TC) ✓ ✓ ✓



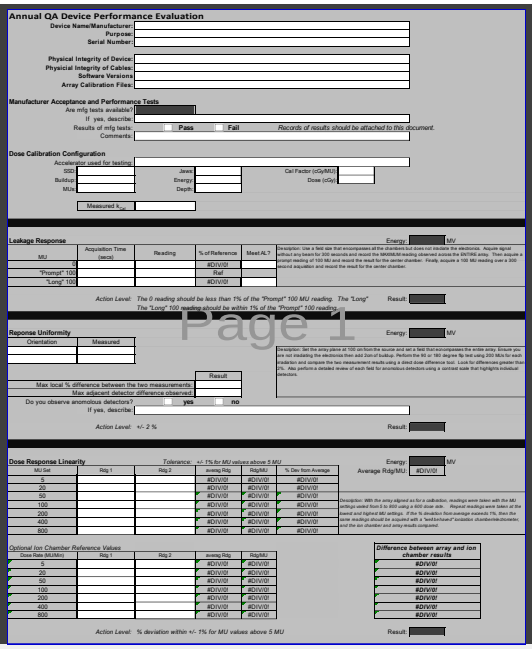
(a) True composite (TC) delivery on a phantom with an IC placed at a specific depth and a radiographic film at a coronal orientation. (b) TC delivery on a stationary 2D array device placed in the coronal direction on the treatment table. (c) TC delivery on a stationary 2D array device placed in the sagittal direction on the treatment table. (d) Perpendicular field-by-field (PFF) or perpendicular composite (PC) delivery on a stationary 2D array device placed in the coronal direction on the treatment table. (e) PFF or PC delivery on 2D array device mounted on the treatment head.

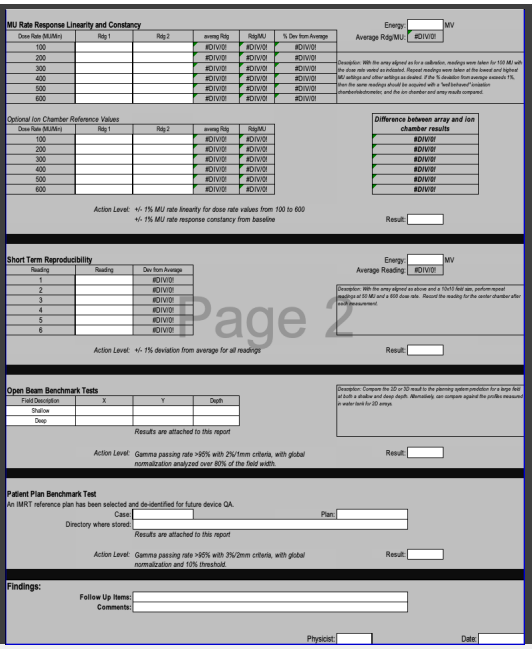
Available multidimensional detetctor arrays

Manufacturer	IBA						PTW		ScandiDos	SI			SNC				
Array Name	MatriXX Evolution	StarTRACK	MatriXX FFF	myQA	Octavius 1500	1000 SRS	StarCHECK	QuickCheck	Delta 4	Beam Checker	Cross Checker	StereoChecker	MapCHECK 3	SRS MapCHECK	ArcCHECK	IC PROFILER	Daily QA 3
Array dimension (cm)	24.4 x 24.4	27 x 27	24.4 x 24.4	25 x 25	27 x 27	10 x 10	25.2 x 25.2	20 x 20	20 x 20	20 x 20	27 x 27	20.5x20.5	26 x 32	7.7 x 7.7	21 x 21	32 x 32	20 x 20
Detector type	Air chamber	Air chamber	Air chamber	Air chamber	Air chamber	Liquid chamber	Air chamber	Air chamber	Diode	Air chamber	Air chamber	Amorphous-silicon (aSi)	Diode	Diode	Diode	Air chamber	Air chamber & diode
Number of detectors	1020	453	1020	125	1405	977	527	13	1069	8	453	1048576	1527	1013	1386	251	25
Detector min dimension (mm)	4.5 (D)	3 (D)	4.5 (D)	2	4.4	2.3	3		1.0 (D)	13.9 (D)	3 (D)	0.2	0.48	0.48	0.8	2.9	9.88 (D) & 13.8 (D) & 0.8
Nominal Detector sensitivity (nC/Gy)	2.4	1.1	1.4	NA	2.0	16	2.0	3.4	5.0	NA	1.1	NA	15	15	32	1.44	10 & 20 & 32
Detector spacing (mm)	7.6	5.0 & 7.0	7.6	Variable	7.1	2.5 & 5.0	3.0 & 5.0	Variable	5.0 & 10.0	75.0	5.0 & 7.0	0.2	7.07	2.47	10	5.0 & 7.07	NA
Buildup (g/cm^2)	0.32	0.32	0.64	0.64	0.80	1.12	0.96	Variable (all detectors >0.5)	Variable	4.3 & 1.9	0.32	2.8	1.5	2.75	3.3	0.94	1.0
Back scatter (g/cm^2)	23.0	23.0	23	NA	1.57	2.35	2.16	4.1	Variable	1.9 & 4.3	23.0	0.7	2.3	2.75	3.3	2.3	1.7
Data sampling rate (ms)	20	10	20	NA	100	100	200	350		2	10	40	50	50	50	125	NA
Weight (kg)	10	10	10		6	5.4	5.5	5.5	27	5	10	16	5.6	1.9	15.4	8.8	5.7
Primary QA application	**Patient**	Machine	**Patient**	Machine	**Patient**	**Patient**	Machine	Machine	Patient / Machine	Machine	Machine	Machine	**Patient**	**Patient**	**Patient**	Machine	Machine

Tests for acceptance, commissioning and periodic QA

Test	Acceptance & Commissioning	Annual	Each Use	Recommended Investigation Level*	Notes
Physical Integrity	M		M	-	No functional defects
Manufacturer acceptance/performance tests	M	O			
Software Settings Verification	M	-	M	-	
Leakage Response	M	M		< 1% of 100 MU reading	Accumulate signal over 5 minutes
Response Uniformity	M	M		+/- 2% for at least 90% of the detectors	180 Flip Test. All detectors within 80% of the field.
Dose Calibration	M	M	M		Performed in conjunction with acquiring normalization data from accelerator (e.g. 10x10cm²)
Dose Response Linearity	M	O		+/- 1% from 2 MU to highest used	Compare against ion chamber
Dose Rate Response Linearity	M	O		+/- 1%	Compare against ion chamber, test from lowest to highest used
Reproducibility	M	M		+/- 1%	Based on 5 repeat readings at 50 MUs
Flatness and Symmetry Assessment (if used for machine flatness and symmetry)	O	O		Metrics within 1% of scanning water tank results.	Compare measured results for a large field at a depth greater thandmax.
Barometer and Thermometer Check (if used)	M	M		+/- 1%	Only required when the array output is not normalized to the accelerator output
Phantom representation in the TPS	M	O	M	Geometrical representation within 0.2cm Density within 1%	Compare the phantom for geometrical accuracy and composition in the TPS against manufacturer's specifications
Open Beam Benchmark Test	M	M		Gamma passing rate >95% with 2%/1mm global, preferably 1%/1mm global criteria.	Compare the 2D or 3D result to the planning system prediction for a large field at both a shallow and deep depth. Alternatively, can compare against the profiles measured in water tank for 2D arrays.
Patient Plan Benchmark Tests (if used for plan QA)	M	M		Gamma > 95%, with 3%/2mm global and 10% threshold	Baseline set during commissioning on highly modulated plan, repeated annually.
Inclinometer Validation (if used)	M	M		+/- 1°	
Energy Dependence	O	O		manufacturer specifications	
Gantry Angle Response i	O	O		manufacturer specifications	





- Template for detector array evaluation

Preliminary results

Pt specific arrays

Test	Ionization Chamber Arrays	Diode Arrays
Leakage	Less than 1.0%	Less than 1.0%
Response Uniformity	Less than 1.0%	Less than 2.0%
Dose Response Linearity	Less than 0.6%	Less than 1.7%
MU rate linearity	Less than 0.2%	Less than 0.6%
Reproducibility	Less than 0.1%	Less than 0.6%

Average time for completion: 5hours

Failure Modes

Mode	Description	Applicable Test	Notes
1	Subtle change in array response / calibration	Dose Calibration, including validation of the dose calibration coefficient	May be one of the more frequent failure modes
2	Subtle shift in individual detector response	Response Uniformity	Individual detector response change may warrant investigation or a uniformity calibration
3	Drifting detector response	Dose Calibration, Response Uniformity, and Reproducibility	Attributable to multiple causes including condensation inside vented ion chambers on humid days
4	Subtle change in response linearity with dose or dose rate	Dose Linearity and Dose Rate Response Linearity	May be seen in combination with other failures such as 2 or 3
5	Catastrophic loss of response in one or several detectors	Response Uniformity	May be due to multiple causes including physical shock, irradiation of the sensitive electronics, etc
6	Catastrophic loss of response in all detectors	NA (failure obvious)	May be due to multiple causes including physical shock, irradiation of the sensitive electronics, etc.
7	Inclinometer failure	Inclinometer Validation	Low likelihood of occurrence and typically detectable with observation
8	Change in energy or angular dependence	Optional Energy Dependence and Gantry Angle Response tests. Dose Calibration may detect change in energy dependence.	Low likelihood of occurrence reported. May be seen in combination with other failures.
9	Change in background signal or leakage	Leakage Response	Low likelihood of occurrence

Recommendations (preliminary)

- Acceptance of the detector arrays should include a physical inspection of the system and its components and communication of all components with the measuring software.
- The QMP should perform the manufacturer's recommended tests and report the results.
- Response uniformity, dose calibration, and leakage should be part of the acceptance testing for the detector array. The system should not be used clinically if these tests exceed the manufacturer's specifications.
- Evaluation of the system components such as inclinometer accuracy, gantry mount sag, and temperature and pressure sensors should be included as part of the acceptance and commissioning before clinical use.

Recommendations (preliminary)

- After the acceptance of the detector system, the QMP should proceed to device commissioning. Although most of the detector array design has been validated in the literature, there are basic validation tests that must be performed by the QMP.
- The commissioning effort should include the measurement and archiving of baseline performance results as well as preparation of a commissioning report.
- Periodic QA is recommended for array devices to include tests at each use as well as an annual performance evaluation.

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