DICOM Correction Proposal

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Correction Number CP-1432
Log Summary: Add Support for Ion Therapy Scanning Modes
Name of Standard PS3.3 2105c
Rationale for Correction: Some manufacturers may support more than one type of delivering beam between control spots during treatment using the Modulated Scanning Mode. This Change Proposal adds Additional Defined Terms to defined the delivery mode and specific the details, how the Scan Spot Position Map (300A,0394)and Scan Spot Meterset Weights (300A,0396) is used. At the time Supplement 102 was devised, the Ion Subgroup Committee felt that each installation would support only one method of delivery with the modulated scanning mode and that the treatment planning system and beam delivery system would have a matched set of information. The Supplement 102 method of transmitting information works for ions delivered only at discrete aiming points, ions delivered continuously along a line between two aiming points, or ions delivered mostly at discrete aiming points but with the beam left on as the aiming point moves quickly between one location and another. The devised method also works for energy stacking before lateral scanning but it is not as efficient. Since Supplement 102 was published, some equipment has been made that supports multiple methods of modulated scanning delivery. It turned out that at least one manufacturer may support more than one method of modulated scanning even between control points, and other may go onto the same path. It was thus identified that a tight definition of scanning modes needs to be inserted into the standard. The members see the need that the use of multiple modulated scanning modes must be explicitly specified, rather than relying on the correct interpretation of the DICOM standard with out-of band information. This CP addressed these concerns by tightening the Scan Mode definitions. An alternative approach to introduce an additional sub-scan-mode attribute is not indicated, since that attribute is not be read by existing applications. Rather than the existing attribute Scan Mode (300A,0308) is a mandatory attribute and though the use of Defined Terms is designed to be extensible exactly for the purpose to address the situation described above, where new advances in technology require tighter and / or additional terms to specify new scan modes. *[Comment: Hologic: add some missing underscore highlighting; remaining questions about why not add "or MODULATED_SPEC" to all attributes instead of just some and different in the two tables?* *U. Busch: Tx for the observation: RESOLVED]*
Correction Wording:

In PS 3.3, modify section C.8.8.25 RT Ion Beams Module, Table C.8.8.25-1

Attribute Name	Tag	Type	Attribute Description
Ion Beam Sequence	(300A,03A2)	1	Introduces sequence of setup and/or treatment beams for current RT Ion Plan. One or more items shall be included in this

			sequence.
>Beam Number	(300A,00C0)	1	Identification number of the Beam. The value of Beam Number (300A,00C0) shall be unique within the RT Ion Plan in which it is created. See Section C.8.8.25.1.
…			
>Scan Mode	(300A,0308)	1	The method of beam scanning to be used during treatment. Defined Terms: NONE = No beam scanning is performed. UNIFORM = ~~**The beam is scanned b**~~**B**etween control points**, the beam is scanned** to create a uniform lateral fluence distribution across the field. MODULATED = ~~**The beam is scanned b**~~**B**etween control points**, the beam is scanned** to create a modulated lateral fluence distribution across the field. **MODULATED_SPEC = Between control points, the beam is scanned to create a modulated lateral fluence distribution across the field. The specific scan mode is defined by Modulated Scan Mode Type (300A,0309).**
>Modulated Scan Mode Type	**(300A,0309)**	**1C**	**Defines the specialization of a modulated scan mode.** **Defined Terms:** **STATIONARY = The Meterset is delivered while the beam spot is at the specified position.** **LEAPING = The delivery of the specified Meterset for the current spot position begins when the spot is at the previous spot position but the spot moves as quickly as possible to the current specified spot position where most of the Meterset is delivered.** **LINEAR = The beam spot is delivered with uniform flux while traveling from one position to the next position (continuous).** **MIXED = Between control points the beam may be delivered by a combination of STATIONARY, LEAPING or LINEAR modes.** **Required if Scan Mode (300A,0308) is MODULATED_SPEC.** **See Section C.8.8.25.X.**
…			
>Ion Control Point Sequence	(300A,03A8)	1	Sequence of machine configurations describing Ion treatment beam. The number of items shall be identical to the value of Number of Control Points

			(300A,0110). See Section C.8.8.25.7.
>>Control Point Index	(300A,0112)	1	Index of current Control Point, starting at 0 for first Control Point.
>>Cumulative Meterset Weight	(300A,0134)	2	Cumulative weight to current control point. Cumulative Meterset Weight for the first item in Control Point Sequence shall always be zero. Cumulative Meterset Weight for the final item in Ion Control Point Sequence shall always be equal to Final Cumulative Meterset Weight.
…			
>>Beam Limiting Device Rotation Direction	(300A,0121)	1C	Direction of Beam Limiting Device Rotation when viewing beam limiting device (collimator) from radiation source, for segment following Control Point. Required for first item of Control Point Sequence, or if Beam Limiting Device Rotation Direction changes during Beam. See Section C.8.8.14.8. Enumerated Values: CW clockwise CC counter-clockwise NONE no rotation
>>Scan Spot Tune ID	(300A,0390)	1C	User-supplied or machine code identifier for machine configuration to produce beam spot. This may be the nominal spot size or some other machine specific value. Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**.
>>Number of Scan Spot Positions	(300A,0392)	1C	Number of spot positions used to specify scanning pattern for current segment beginning at control point. Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**.
>>Scan Spot Position Map	(300A,0394)	1C	The x and y coordinates of the scan spots are defined as projected onto the machine isocentric plane in the IEC GANTRY coordinate system (mm). Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**. Contains 2N values where N is the Number of Scan Spot Positions (300A,0392). **See Section C.8.8.25.X**
>>Scan Spot Meterset Weights	(300A,0396)	1C	A data set of Meterset weights

			corresponding to scan spot positions. The order of weights matches the positions in Scan Spot Positions (300A,0394). The sum contained in all Meterset weights shall match the difference of the cumulative Meterset weight of the current control point to the following control point. Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**. **See Section C.8.8.25.X**
>>Scanning Spot Size	(300A,0398)	3	The Scanning Spot Size as calculated using the Full Width Half Maximum (FWHM). Specified by a numeric pair - the size measured in air at isocenter in IEC GANTRY X direction followed by the size in the IEC GANTRY Y direction (mm).
>>Number of Paintings	(300A,039A)	1C	The number of times the scan pattern given by Scan Spot Position Map (300A,0394) and Scan Spot Meterset Weights (300A,0396) shall be applied at the current control point. To obtain the Meterset weight per painting, the values in the Scan Spot Meterset Weights (300A,0396) should be divided by the value of this attribute. Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**.

…

C.8.8.25.X Scan Spot Maps

The Scan Spot Position Map (300A,0394) and Scan Spot Meterset Weights (300A,0396) shall be used as follows.

The following specifies for each value of Modulated Scan Mode Type (300A,0309) the definition of the map which is included in the Control Point 1 having Cumulative Meterset Weight (300A,0134) = 20, followed by a Control Point 2 having Cumulative Meterset Weight(300A,0134) = 20.

If Modulated Scan Mode Type (300A,0309) is STATIONARY or LEAPING:

Position (X,Y)	**(1.0, 2.0)**	**(3.0, 2.0)**	**(5.0, 2.0)**	**(7.0, 2.0)**	**(9.0, 2.0)**
Meterset Weights	**5**	**4**	**6**	**2**	**3**

Delivery Description:

- **The beam is positioned at Scan Spot Position (1.0, 2.0)**
- **The beam is delivered with a Cumulative Meterset Weight of 5.**
- **The beam is switched off or quickly moved and positioned at Scan Spot Position (3.0, 2.0)**
- **The beam is delivered with a Cumulative Meterset Weight of 4.**

- **The beam is switched off or quickly moved and positioned at Scan Spot Position (5.0, 2.0)**
- **The beam is delivered with a Cumulative Meterset Weight of 6.**
- **The beam is switched off or quickly moved and positioned at Scan Spot Position (7.0, 2.0)**
- **The beam is delivered with a Cumulative Meterset Weight of 2.**
- **The beam is switched off or quickly moved and positioned at Scan Spot Position (9.0, 2.0)**
- **The beam is delivered with a Cumulative Meterset Weight of 3.**

If Modulated Scan Mode Type (300A,0309) is LINEAR:

Position (X,Y)	(1.0, 2.0)	(3.0, 2.0)	(5.0, 2.0)	(7.0, 2.0)	(9.0, 2.0)
Meterset Weights	0	4	6	7	3

Delivery Description:

- **The beam is positioned at Scan Spot Position (1,.0 2.0)**
- **The beam is continuously delivered with a Cumulative Meterset Weight of 4, while being moved from Scan Spot Position (1.0, 2.0) to Scan Spot Position (3.0, 2.0)**
- **The beam is continuously delivered with a Cumulative Meterset Weight of 6, while being moved from Scan Spot Position (3.0, 2.0) to Scan Spot Position (5.0, 2.0)**
- **The beam is continuously delivered with a Cumulative Meterset Weight of 7, while being moved from Scan Spot Position (5.0, 2.0) to Scan Spot Position (7.0, 2.0)**
- **The beam is continuously delivered with a Cumulative Meterset Weight of 3, while being moved from Scan Spot Position (7.0, 2.0) to Scan Spot Position (9.0, 2.0)**

If Modulated Scan Mode Type (300A,0309) is MIXED:

Position (X,Y)	(1.0, 2.0)	(1.0, 2.0)	(3.0, 2.0)	(5.0, 2.0)	(5.0, 2.0)	(7.0, 2.0)	(7.0, 2.0)
Meterset Weights	0	4	6	5	2	0	3

- **The beam is positioned at Scan Spot Position (1.0, 2.0)**
- **The beam is delivered with a Cumulative Meterset Weight of 4 while staying at Scan Spot Position (1.0, 2.0).**
- **The beam is continuously delivered with a Cumulative Meterset Weight of 6, while being moved from Scan Spot Position (1.0, 2.0) to Scan Spot Position (3.0, 2.0)**

- **The beam is continuously delivered with a Cumulative Meterset Weight of 5, while being moved from Scan Spot Position (3.0, 2.0) to Scan Spot Position (5.0, 2.0)**
- **The beam is delivered with a Cumulative Meterset Weight of 2 while staying at Scan Spot Position (5.0, 2.0).**
- **The beam is switched off or quickly moved and positioned at Scan Spot Position (7.0, 2.0)**
- **The beam is delivered with a Cumulative Meterset Weight of 3 while staying at Scan Spot Position (7.0, 2.0).**

In PS 3.3, modify section C.8.8.26 (RT Ion Beams Session Record Module), Table C.8.8.26-1

Attribute Name	Tag	Type	Attribute Description
Treatment Session Ion Beam Sequence	(3008,0021)	1	Introduces sequence of setup and/or treatment beams administered during treatment session. One or more items shall be included in this sequence.
>Referenced Beam Number	(300C,0006)	1	References Beam specified by Beam Number (300A,00C0) in Ion Beam Sequence (300A,03A2) in RT Ion Beams Module within the referenced RT Ion Plan.
…			
>Scan Mode	(300A,0308)	1	The method of beam scanning to be used during treatment. Defined Terms: NONE = No beam scanning is performed. UNIFORM = ~~**The beam is scanned b**~~**B**etween control points**, the beam is scanned** to create a uniform lateral fluence distribution across the field. MODULATED = ~~**The beam is scanned b**~~**B**etween control points**, the beam is scanned** to create a modulated lateral fluence distribution across the field. **MODULATED_SPEC = Between control points, the beam is scanned to create a modulated lateral fluence distribution across the field. The specific scan mode is defined by Modulated Scan Mode Type (300A,0309).**
>Modulated Scan Mode Type	**(300A,0309)**	**3**	**Defines the specialization of a modulated scan mode.** **Defined Terms:** **STATIONARY = The Meterset is delivered while the beam spot is at the specified position.** **LEAPING = The delivery of the specified Meterest for the current spot position**

			begins when the spot is at the previous spot position but the spot moves as quickly as possible to the current specified spot position where most of the meterset is delivered. **LINEAR = The beam spot is delivered with uniform flux while traveling from one position to the next position (continuous).** **MIXED = Between control points the beam may be delivered by a combination of STATIONARY, LEAPING or LINEAR modes.** **Required, if Scan Mode (300A,0308) is MODULATED_SPEC.** **See Section C.8.8.25.X.**
…			
>Ion Control Point Delivery Sequence	(3008,0041)	1	Sequence of beam control points for current ion treatment beam. One or more items shall be included in this sequence. The number of items shall be identical to the value of Number of Control Points (300A,0110). See Section C.8.8.21.1.
…			
>>Beam Limiting Device Rotation Direction	(300A,0121)	1C	Direction of Beam Limiting Device Rotation when viewing beam limiting device (collimator) from radiation source, for segment beginning at current Control Point. Required for Control Point 0 of Ion Control Point Delivery Sequence (3008,0041) or if Beam Limiting Device Rotation Direction changes during beam administration. Enumerated Values: CW clockwise CC counter-clockwise NONE no rotation
>>Scan Spot Tune ID	(300A,0390)	1C	User-supplied or machine code identifier for machine configuration to produce beam spot. This may be the nominal spot size or some other machine specific value. Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**.
>>Number of Scan Spot Positions	(300A,0392)	1C	Number of spot positions used to specify

			scanning pattern for current segment beginning at control point. Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**.
>>Scan Spot Position Map	(300A,0394)	1C	The x and y coordinates of the scan spots are defined as projected onto the machine isocentric plane in the IEC GANTRY coordinate system (mm). Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**. Contains 2N values were N is the Number of Scan Spot Positions (300A,0392). **See section C.8.8.25.X**
>>Scan Spot Metersets Delivered	(3008,0047)	1C	A data set of Metersets delivered to the scan spot positions. The order of Metersets matches the positions in Scan Spot Position Map (300A,0394). The sum contained in all Metersets shall match the difference of the Delivered Meterset of the current control point to the following control point. Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**. **See section C.8.8.25.X**
>>Scanning Spot Size	(300A,0398)	3	The Scanning Spot Size as calculated using the Full Width Half Maximum (FWHM). Specified by a numeric pair - the size measured in air at isocenter in IEC GANTRY X direction followed by the size in the IEC GANTRY Y direction (mm).
>>Number of Paintings	(300A,039A)	1C	The intended number of times the scan pattern given by Scan Spot Position Map (300A,0394) and Scan Spot Meterset Weights (300A,0396) in the Referenced RT Plan was to be applied at the current control point. Note The actuaxl number of paintings is not known or recorded. The Scan Spot Metersets Delivered (3008,0047) contains the sum of all complete and partial repaints. Required if Scan Mode (300A,0308) is MODULATED **or MODULATED_SPEC**.

In PS 3.6, Section 6, add the following new attributes:

(300A,0309)	**Modulated Scan Mode Type**	**ModulatedScanModeType**	**CS**	**1**