

Acceptance Testing, Commissioning, Data Entry, and QA for Brachytherapy Treatment Planning Systems

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Educational Goals

1. Acceptance Testing and Commissioning recommendations.
2. Data Entry of brachytherapy dosimetry parameters based on AAPM-, manufacturer-, and user-provided data.
3. Quality Assurance, including startup and on-going efforts, towards ensuring a safe and accurate environment.

Summary of AAPM Guidance Documents

TG-40: General Radiotherapy QA

TG-43: Bx Dosimetry Parameters & Dose Calc. Algorithm

TG-53: RTP QA

TG-56: Bx Code of Practice

TG-59: HDR Tx Delivery

TG-64: LDR Prostate Tx Delivery

These reports focus on treatment-related QA

Manufacturer Acceptance Testing Procedures

- Standard practice for linac manufacturers
- Virtually non-existent in Brachytherapy
- Need community to push manufacturers for formally evaluating TPS specs/features
- Expand on TG-64 guidelines

Applicable AAPM TG-40 Guidance

Source strength decay of inventory

Global scaling of dose rate with S_K and Λ

Test source localization tools over range of clinical use

Accuracy / implementation of shield attenuation factor

Impact of grid size

Applicable AAPM TG-43 Guidance

Dosimetry parameters: S_K and Λ , $g_L(r)$, $F(r,\theta)$, and $\phi(r)$
taken from consensus datasets

Parameter units: r [cm] and θ [degrees]
except for β [radians] ensure consistency with RTP

Dosimetry algorithm:

$$\dot{D}(r,\theta) = S_K \cdot \Lambda \cdot \frac{G_L(r,\theta)}{G_L(r_0,\theta_0)} \cdot g_L(r) \cdot F(r,\theta)$$

Applicable AAPM TG-53 Guidance

RTP specs and ATP

Hardcopy printout accuracy

Temporal dose rate correlation with radionuclide decay

Accuracy and consistency of parameter units

Computer systems storage and security

Systematic Approach to RTP QA

Example datasets (from TG-43UXX or published literature)

Methods for data entry (HDR & LDR)

Check RTP for list of key functions

Tests of all RTP field entries (S_K linearity, test of decay, dose superposition, shield attn factor for HDR, etc)

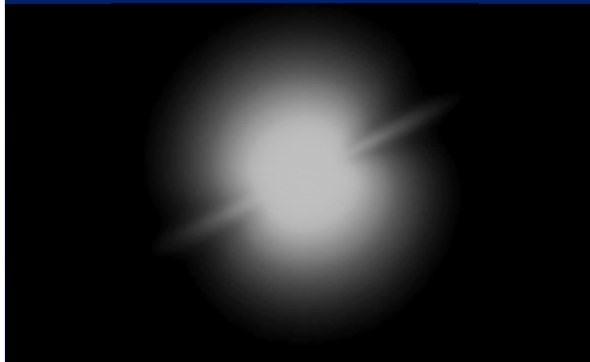
Impact of coarse data grid (interpolation technique & errors)

QA comparison of hand calc with RTP point doses

Compare printed/plotted isodose images

Documentation (use e-records)

Low-Energy Brachytherapy Sources



Example Dosimetry Parameter Dataset

1	r [cm]	g _r (r)	g _p (r)	r [cm]	ph(r)	F(r,g)	0	10	20	30	40	50	60	70	80
2	0.10	0.990	0.582	0.25	1.164	0.05							1.067	0.996	0.985
3	0.25	1.021	0.889	0.5	0.973	0.075					1.050	1.006	0.994	0.996	0.996
4	0.50	1.030	0.998	1.0	0.933	0.1				1.046	0.996	0.990	0.993	0.988	0.999
5	1.00	1.000	1.000	1.5	0.931	0.15			1.039	0.978	0.958	0.977	0.988	0.987	0.996
6	1.50	0.943	0.949	2.0	0.931	0.2		0.987	0.921	0.940	0.960	0.975	0.994	0.998	0.997
7	2.00	0.872	0.879	2.5	0.932	0.25	0.494	0.574	0.795	0.899	0.943	0.967	0.986	0.995	1.000
8	2.50	0.795	0.803	3.0	0.934	0.5	0.610	0.513	0.679	0.808	0.892	0.944	0.974	0.990	0.997
9	3.00	0.717	0.724	3.5	0.935	1	0.580	0.561	0.705	0.813	0.885	0.933	0.967	0.987	0.997
10	3.50	0.643	0.650	4.0	0.937	2	0.652	0.626	0.743	0.830	0.893	0.934	0.967	0.987	0.997
11	4.00	0.573	0.579	4.5	0.938	5	0.690	0.700	0.789	0.854	0.905	0.941	0.968	0.988	0.996
12	4.50	0.508	0.513	5.0	0.938	10	0.709	0.742	0.815	0.872	0.912	0.947	0.972	0.990	0.997
13	5.00	0.448	0.453	6.0	0.939										
14	6.00	0.347	0.351	7.0	0.942										
15	7.00	0.255	0.268	10.0	0.948										
16	8.00	0.201	0.203												
17	9.00	0.151	0.153												
18	10.00	0.114	0.115												

$A = 1.011$

$L = 3.7 \text{ mm or } 0.37 \text{ cm}$

Prefer AAPM-recommended datasets

Otherwise rely on published literature and manufacturer

Source Dosimetric Data Entry: Pinnacle

Brachytherapy Physics Tool

Source: Cs-137 (60Co) 2000
Computation Method: TG215
Rad: Cs-137 (60Co) 2000

Physical Length: 2.0 mm
Active Length: 1.50 mm
Curie Diameter: 0.06 mm
Rad: 0.06 mm

Source Type: LDR
Dose Rate Constant: 0.49 cGy/hCi
Reference Dose Constant: 0.49 cGy/hCi
Reference Dose Rate: 0.49 cGy/hCi

Geometry Function: Radial Function
Radial Function: Radial Function
Anisotropy Function: Anisotropy Function
Lookup Table: Lookup Table
Inventory: Inventory

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HDR ¹⁹²Ir Source Dosimetric Data Entry

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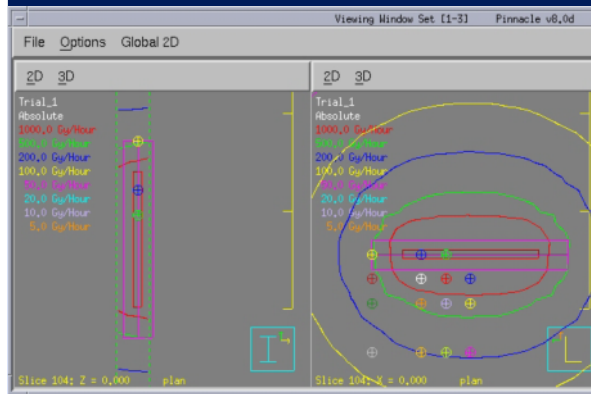
Source: ¹⁹²Ir
Source Type: HDR
Source Length: 3.0 mm
Source Diameter: 0.5 mm
Source Activity: 37.0 GBq
Source Type: HDR
Source Length: 3.0 mm
Source Diameter: 0.5 mm
Source Activity: 37.0 GBq

Source Energy: 0.111 MeV
Half-life: 73.83 days
Decay Constant: 0.00094 day⁻¹
Reference Activity: 37.0 GBq
Reference Date: 2000-01-01

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Source Geometric Characterization

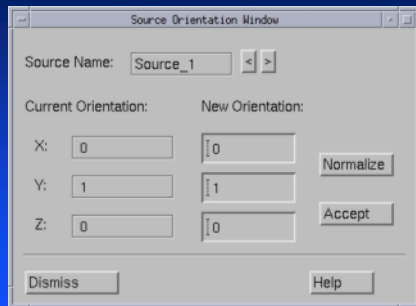


Source Strength Specification

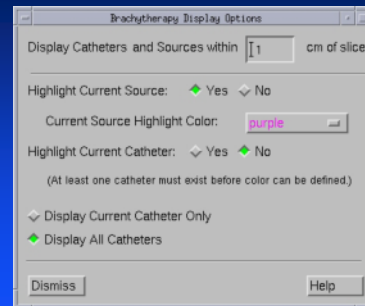
Multiple Source Positioning Entry

Source Inventory

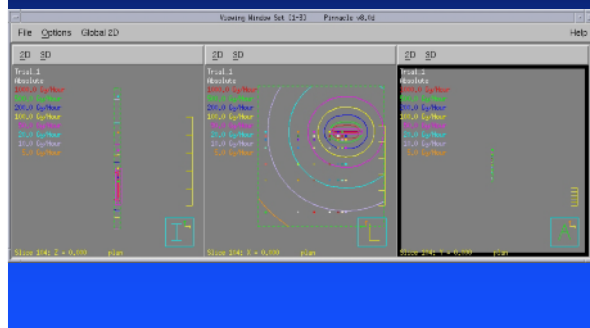
Individual Source Orientation



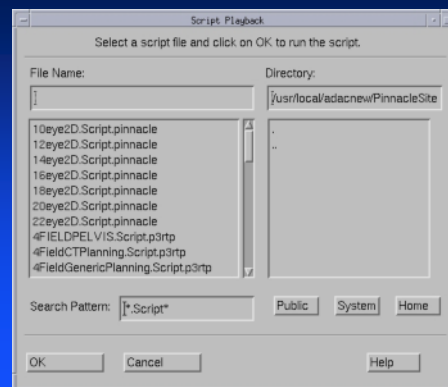
Source Visualization



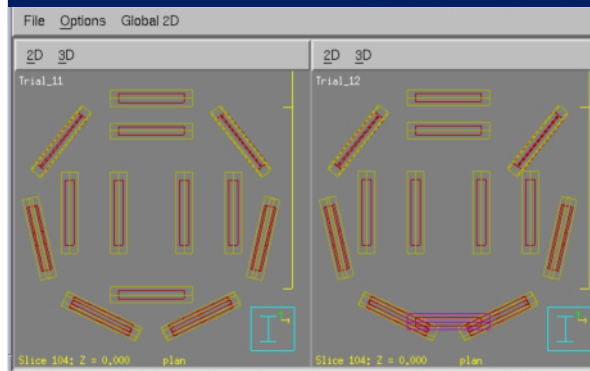
Planar Dose Representation



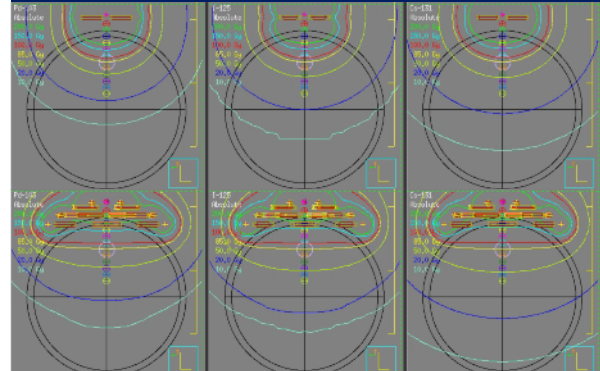
Default Source Entry



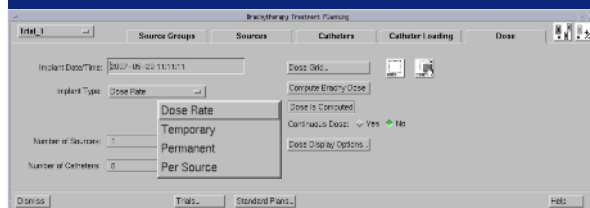
Wrong Source Positioning



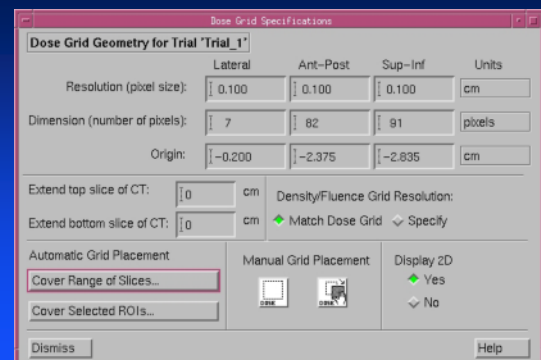
Radionuclide Isodose Comparison



Dose Computation, Implant Selection



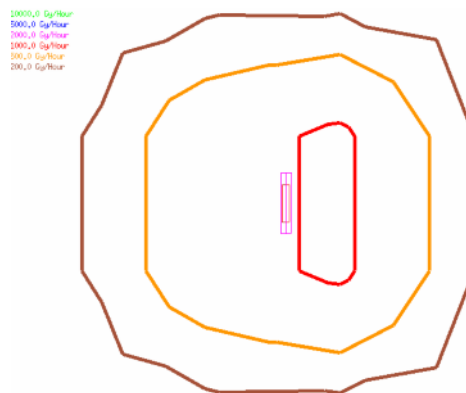
Choice of Dose Grid Specification



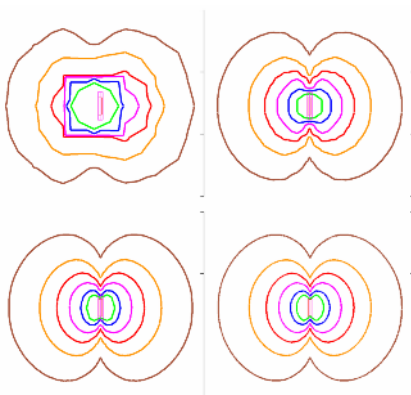
Grid-Dependence of Point Isodoses

		10 mm							
Trial_1		POI_1		POI_2		POI_3		POI_4	
(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)	
(0.00 0.25 0.25) cm		(0.00 0.25 0.00) cm		(0.00 0.50 0.00) cm		(0.00 0.50 0.00) cm		(0.00 1.00 1.00) cm	
Abs (Gy/Hour)		Abs (Gy/Hour)		Abs (Gy/Hour)		Abs (Gy/Hour)		Abs (Gy/Hour)	
Pts		Pts		Pts		Pts		Pts	
Brachy Dose		1940.88	100.0%	3072.80	100.0%	850.95	100.0%	221.69	
TOTAL		1940.88	100.0%	3072.80	100.0%	850.95	100.0%	221.69	
Trial_3		POI_1		POI_2		POI_3		POI_4	
(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)	
(0.00 0.25 0.25) cm		(0.00 0.25 0.00) cm		(0.00 0.50 0.00) cm		(0.00 0.50 0.00) cm		(0.00 1.00 1.00) cm	
Abs (Gy/Hour)		Abs (Gy/Hour)		Abs (Gy/Hour)		Abs (Gy/Hour)		Abs (Gy/Hour)	
Pts		Pts		Pts		Pts		Pts	
Brachy Dose		1940.88	100.0%	3072.80	100.0%	850.95	100.0%	221.69	
TOTAL		1940.88	100.0%	3072.80	100.0%	850.95	100.0%	221.69	
Trial_10		POI_1		POI_2		POI_3		POI_4	
(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)		(Lateral Ant-Post Sup-Inf)	
(0.00 0.25 0.25) cm		(0.00 0.25 0.00) cm		(0.00 0.50 0.00) cm		(0.00 0.50 0.00) cm		(0.00 1.00 1.00) cm	
Abs (Gy/Hour)		Abs (Gy/Hour)		Abs (Gy/Hour)		Abs (Gy/Hour)		Abs (Gy/Hour)	
Pts		Pts		Pts		Pts		Pts	
Brachy Dose		1940.88	100.0%	3072.80	100.0%	850.95	100.0%	221.69	
TOTAL		1940.88	100.0%	3072.80	100.0%	850.95	100.0%	221.69	

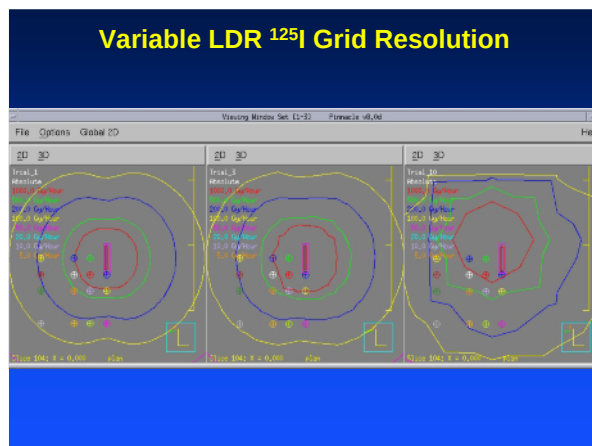
LDR ^{125}I with 10 mm grid



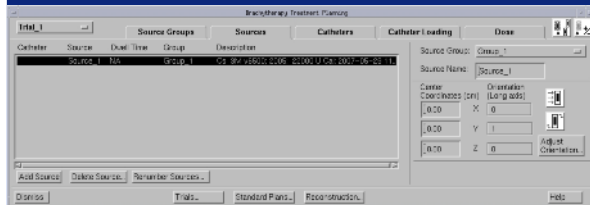
LDR ^{125}I with 5, 2, 1, 0.1 mm grids



Variable LDR ^{125}I Grid Resolution



Individual Source Coordinates



Shielding and QA

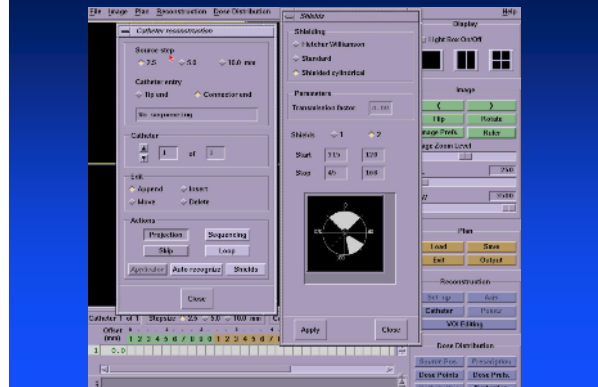


Image Input and Data Transfer

Recommendations dispersed in TG-53/56/59/64

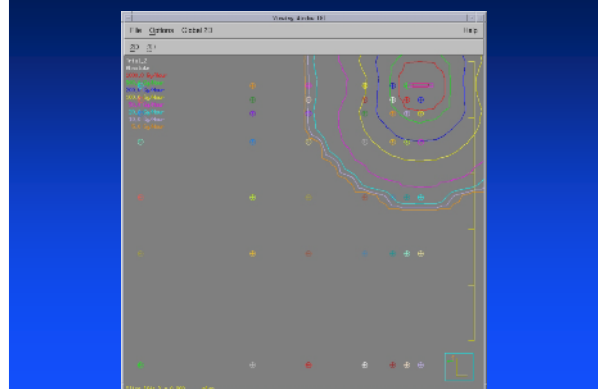
Scan phantoms with internal fiducials

Evaluate XYZ dimensions, slice width, FOV

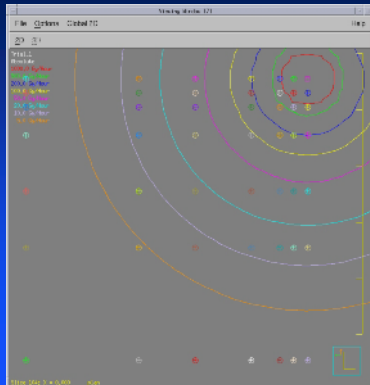
Define input/output scope, set tolerances

Document tests, writeup procedures, reflect

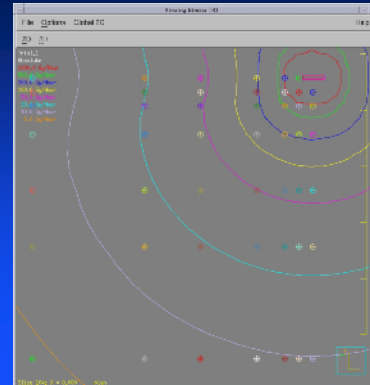
Limited Dataset Specification



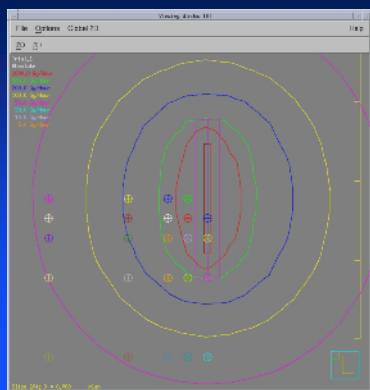
1-D Dosimetric Low-E_γ Characterization



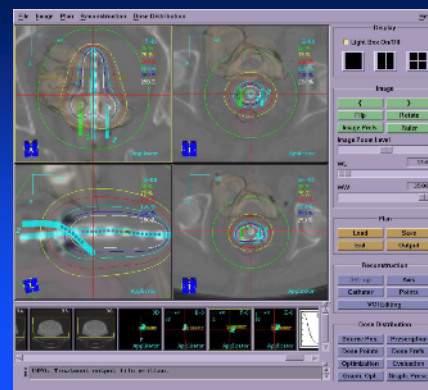
HDR ¹⁹²Ir Isodose Distribution



LDR ²⁵²Cf Neutron Isodose Distribution



HDR ¹⁹²Ir Isodose Distributions



Summary

Demand ATP procedures from manufacturers

Garbage-in, garbage-out with RTP source data entry

Cover range of RTP variables for clinical use

Document tests, update QA documents as-needed