Clinical implementation of Electronic Brachytherapy (eBT)

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BOCA RATON REGIONAL HOSPITAL | EUGENE M. & CHRISTINE E. LYNN CANCER INSTITUTE

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Disclosures

- Speaker for ELEKTA

Current eBT systems

- Intrabeam® by Zeiss Surgical
- Xoft® by Icad Inc.
- Esteya® by Elekta
- SRT-100™ by Sensus Healthcare
- Photoelectric Therapy by Xstrahl Ltd
- Papillon (UK only) by Ariane Medical Systems Ltd

Good reference:
Eaton DJ. Electronic brachytherapy-current status and future directions. Br J Radiol 2015;88: 20150002

Implementation of eBT program

Items to consider for the eBT program

- Room
- Staff/coverage
- Equipment
- Regulatory items
- Acceptance testing
- Commissioning
- Policy and procedures
- QM program
- Staff training
- End to end case (With all staff involved)

Room selection

- Accelerator room (1)
- Sim room (2)
- Exam room (3)
- others

Staffing

- Similar to HDR Brachytherapy staffing
- Dermatologists are purchasing these to be used in their offices (Potential issues with staffing, Q.A., patient safety)

Equipment

- Delivery system and accessories
- Equipment to perform commissioning
- Door interlock system, A/V, intercom
- Emergency buttons installed in the room and outside
- Portable shield (if needed)

Regulatory: check your state regs.

64E-5 Florida Administrative Code 64E-5.1601

Rules 64E-5.1601 — 64E 5.1604 are effective March 12, 2009 and are designated as Revision 9 (R9).

PART XVI

ELECTRONIC BRACHYTHERAPY

Code of Colorado Regulations
Secretary of State
State of Colorado

24.13Electronic Brachytherapy.

AAPM Report 152

AAPM REPORT NO. 152

The 2007 AAPM response to the
CRCPD request for recommendations for the CRCPD's model regulations for electronic brachytherapy

Technical requirements

- Survey for adequate shielding
- Calibrated chamber for the proper energy
- Q.A. check measurements
- Q.M. program: similar to HDR

Authority and responsibilities

- Radiation safety officer
- Authorized User: ***physically present at start and during* patient Tx***; review patient Tx
- Authorized Medical Physicist (AMP): ***physically present at start and during patient Tx***; evaluate eBT output; review calc. prior to Tx; assess each Tx for possible M.E.; establish a Q.A. spot checks

Operating procedures and calibration

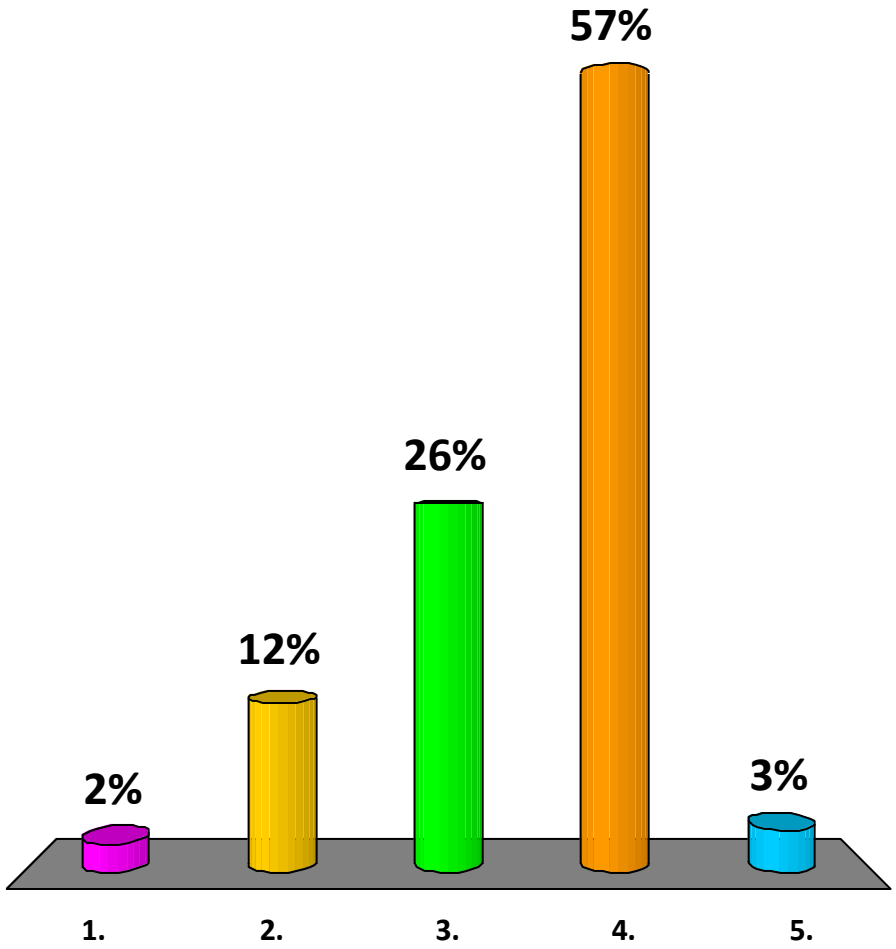
- Unit must be FDA approved
- ***Unit is secured when not in use***
- Operating and emergency procedures in close proximity to the EBT.
- Survey meter
- Calibration: O.F. (**Within 2%**); timer accuracy; evaluation of relative dose distribution (5%)
- Source positioning accuracy within 1 mm within the applicator

Spot checks

- Daily spot checks
- AMP to review spot checks within 2 days of completion. Should include indicator lights, cables, catheters or parts of the device
- Dosimetry spot checks: O.F (Dose rate) within 3%; validation of radiation area of the intended area within 1 mm

SAM's Question 1: When daily spot checks are performed on eBT units by someone other than the AMP, the results must be reviewed by the AMP within:

1. Four days
2. One week
3. One day
4. Two days
5. Three days



Answer to question 1

When spot checks are performed by someone other than the AMP, the results need to be reviewed by the AMP within:

1) Four days
2) One week
3) One day
4) Two days
5) Three days

Answer: (4)

Reference: AAPM report 152 page 4; section h

Acceptance testing

- Hardware and software
- Inventory and functionality verification
- Interlocks and radiation detectors
- Basic training
- Manufacturer dosimetric data for comparison

Commissioning

- Calibrated chamber (energy)
- Calibration: in air or water?
- Current calibration:
    - U.S.: in air (NIST)
    - Europe: in water (PTB)

  (TG 61 recommendations for both, not there yet!)
- Measuring tools: chamber holder (air and water), 1D water tank, plastic water, films etc.
- Opportunity to establish daily Q.A. and periodic testing during commissioning

Commissioning

Measurements:

- ✓ Flatness, symmetry, and penumbra
- ✓ HVL
- ✓ Dose rate
- ✓ Virtual source
- ✓ PDD
- ✓ Timer accuracy
- ✓ Others (Depending on the device)

Example: Esteya commissioning

- Both films and chamber were used
- Surface dose rate (In air TG61, A20)
- PDD measurements (Water and film)
- Virtual SSD (Air, A20)
- Dose profiles (F&S, penumbra etc..) with film
- Accuracy of timer (Independent timer)
- HVL (In air, A20)

Device

- Dose rate 2.7 Gy/min @3 mm
- X-ray source 69.5 kV, beam current (0.5, 1.0, 1.6 mA)
- Profiles similar to Valencia applicators
- SSD 60 mm
- Five applicators

QA device (Daily checks)

26 sensors to measure:

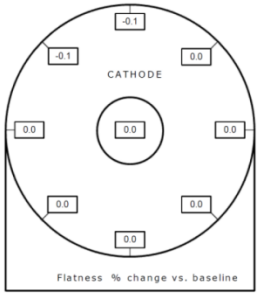
- Dose rate
- Flatness and symmetry at depth
- Percent dose at depth

Validated during commissioning!

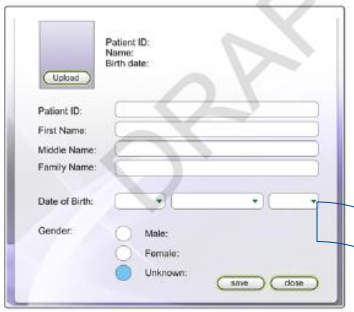
Work flow for Esteya (Opportunity for checklist)

Self test

QA check



Add a new patient



Set up treatment plan

Position on surface

Start treatment

Dose Profiles using film dosimetry for all applicators

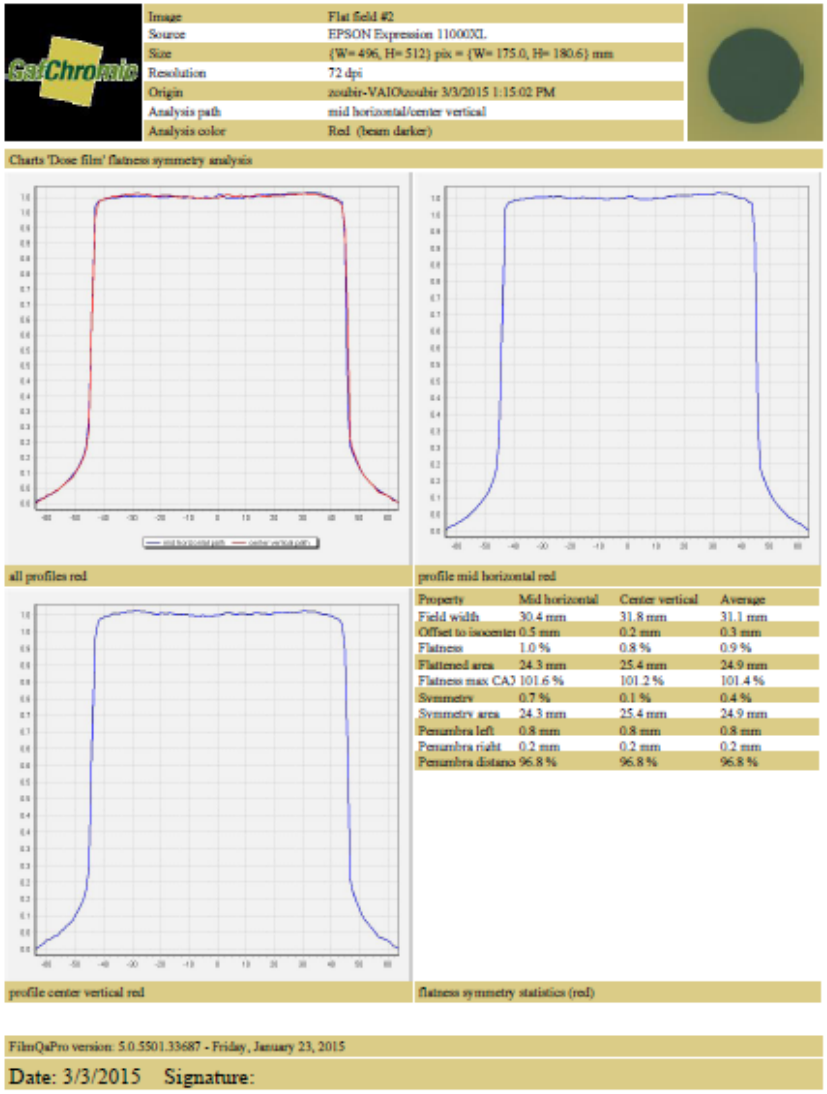


Image	Flat field #2
Source	EPSON Expression 11000XL
Size	(W= 496, H= 512) pix = (W= 175.0, H= 180.6) mm
Resolution	72 dpi
Origin	zoubir-VAIO\zoubir 3/3/2015 1:15:02 PM
Analysis path	mid horizontal/center vertical
Analysis color	Red (beam darker)

Charts 'Dose film' flatness symmetry analysis

all profiles red

profile mid horizontal red

profile center vertical red

Property	Mid horizontal	Center vertical	Average
Field width	30.4 mm	31.8 mm	31.1 mm
Offset to isocenter	0.5 mm	0.2 mm	0.3 mm
Flatness	1.0 %	0.8 %	0.9 %
Flattened area	24.3 mm	25.4 mm	24.9 mm
Flatness max CAX	101.6 %	101.2 %	101.4 %
Symmetry	0.7 %	0.1 %	0.4 %
Symmetry area	24.3 mm	25.4 mm	24.9 mm
Penumbra left	0.8 mm	0.8 mm	0.8 mm
Penumbra right	0.2 mm	0.2 mm	0.2 mm
Penumbra distance	96.8 %	96.8 %	96.8 %

flatness symmetry statistics (red)

FilmQaPro version: 5.0.5501.33687 - Friday, January 23, 2015

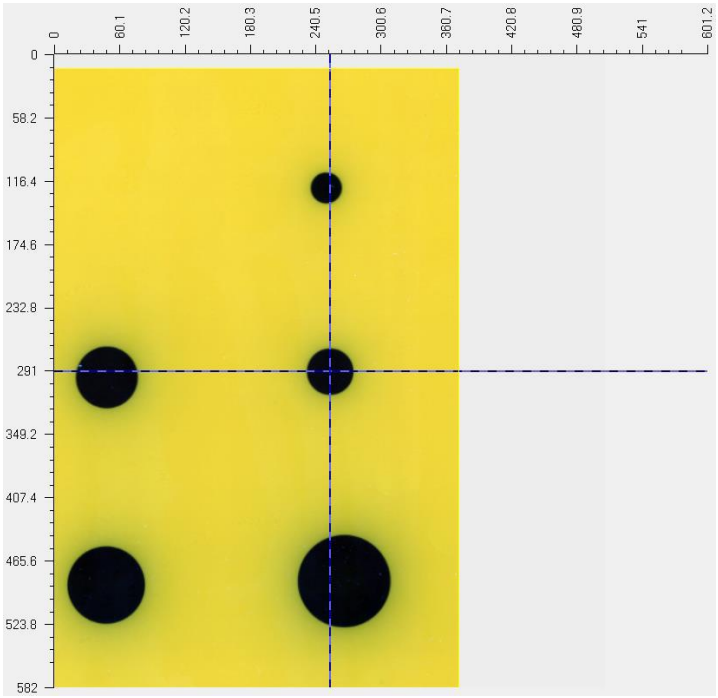
Date: 3/3/2015 Signature:

QA Device

-Dose rate

-Flatness and symmetry√

- Percent depth dose



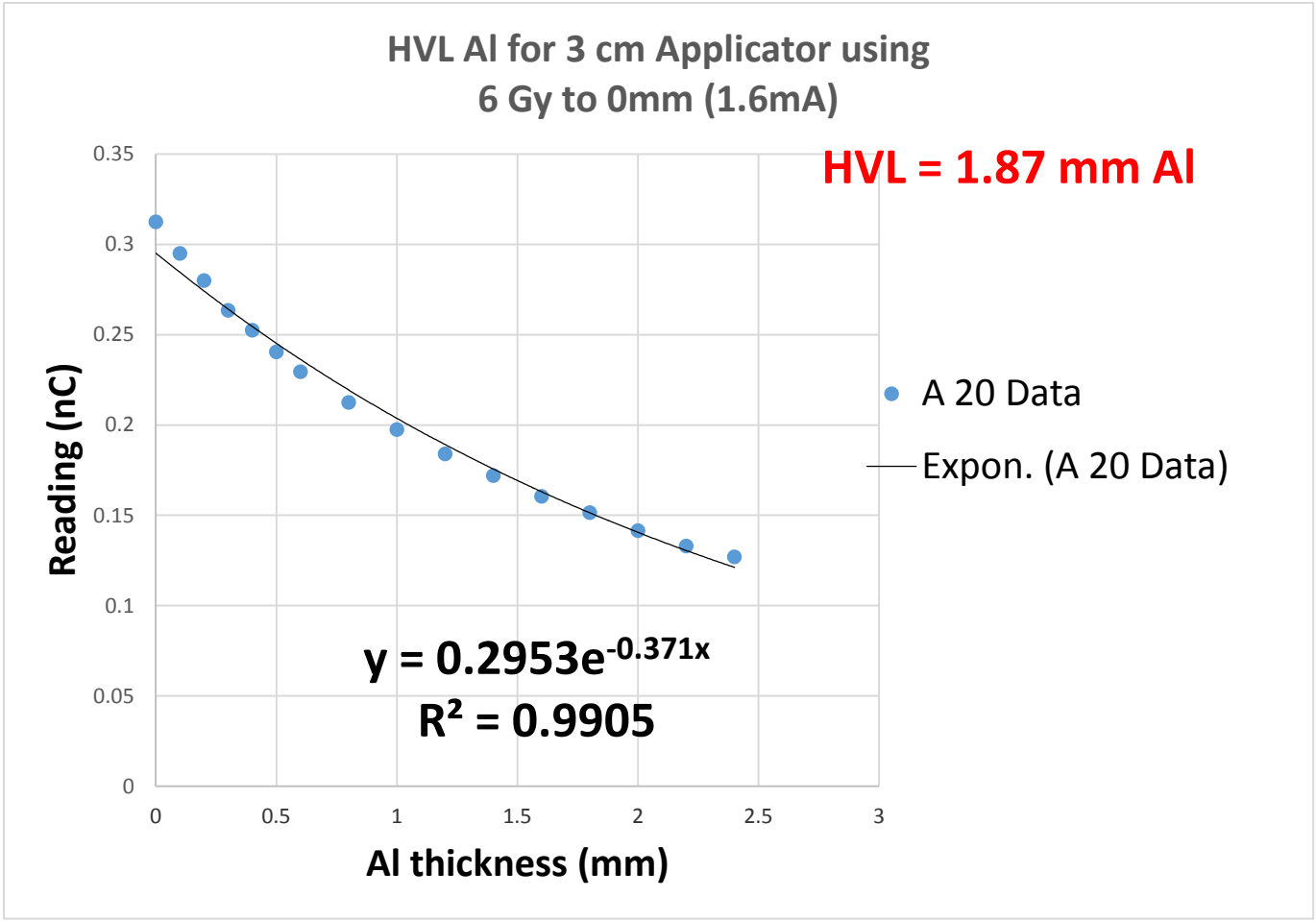
Exradin A20 Chamber vs. TG-61 recommendations

- Parallel-plate chamber with thin window (50.8µm) √
- Small collecting volume is 0.0738 cm^3 √
- Collector diameter is 1.93 mm
- Total wall thickness (Full buildup and reduction of Elec. Contamination(TG61)): 7.72 g/cm^2 vs. 7.3 for 70 kV √ (Table I TG61)
- effective point of measurement is at dc = 1.80 mm depth from the entrance surface (Inverse square corr.) √
- Calibrated for energy* √
- Negligible stem effect

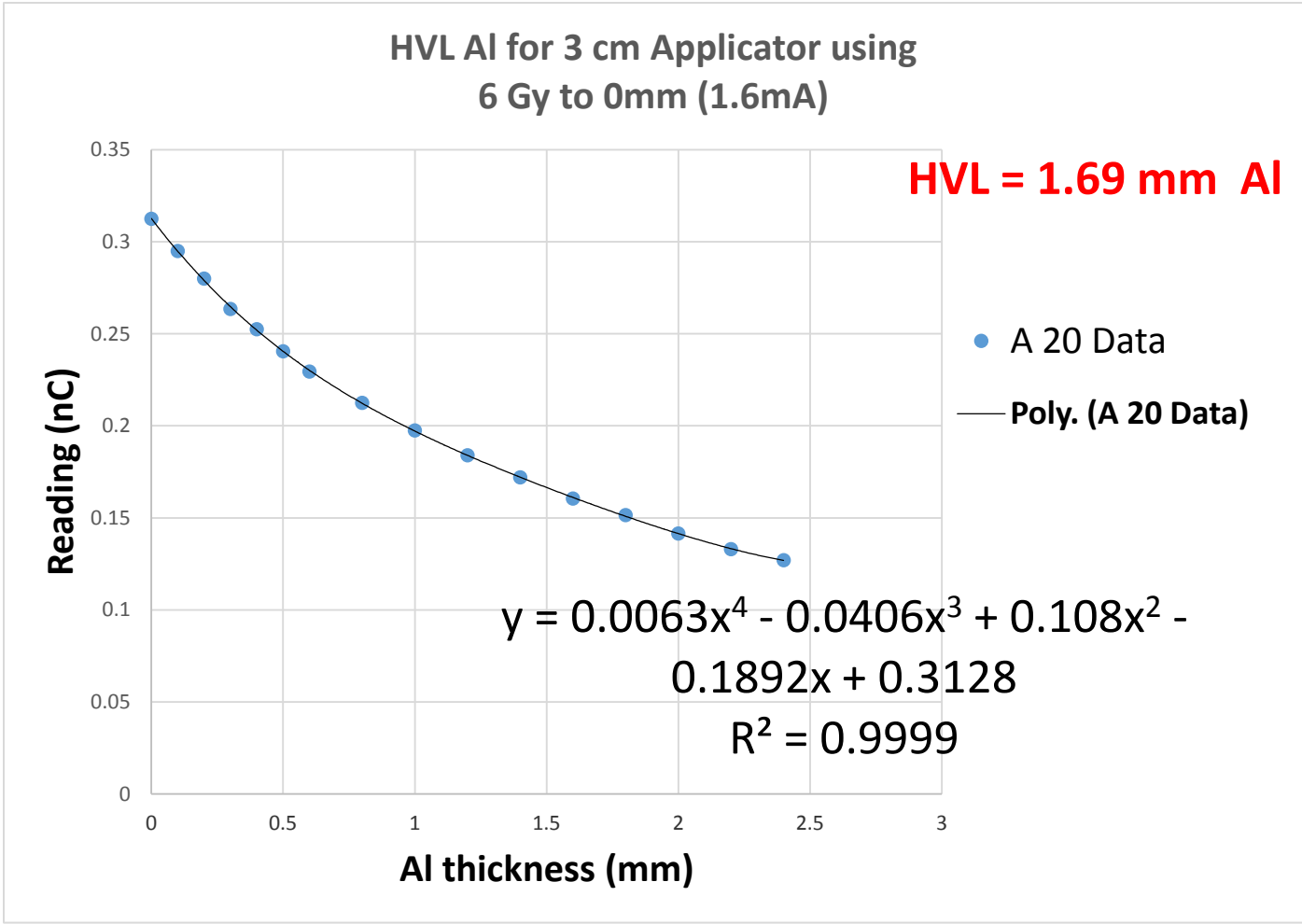
HVL determination

- Using pure Al layers to determine the HVL
- Geometry (II C, TG61)
- Results: consistent with other findings

Exponential fit for HVL value



Polynomial (fourth) fit for HVL

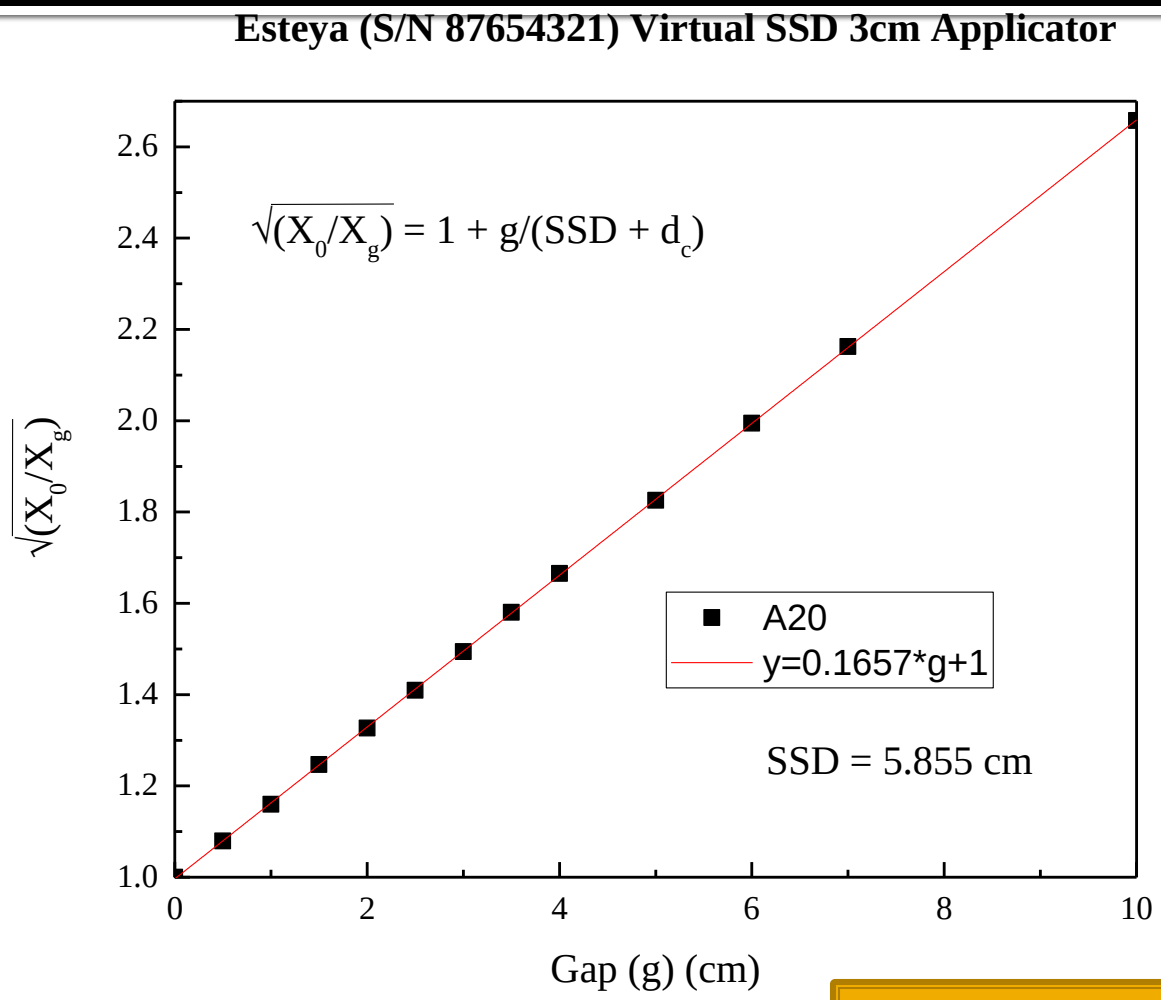


Dose rate measurements (In air TG61) for 1.6 mA

Applicator Size (cm)	Planned Dose Rate (Gy/min)	Measured Dose rate (Gy/min)	% Difference
3.0	3.33	3.41	2.46
2.5	3.29	3.40	3.26
2.0	3.25	3.31	1.85
1.5	3.18	3.23	1.50
1.0	3.11	3.09	-0.50

Measurements performed for other mA settings (1.0, 0.5)

Virtual SSD

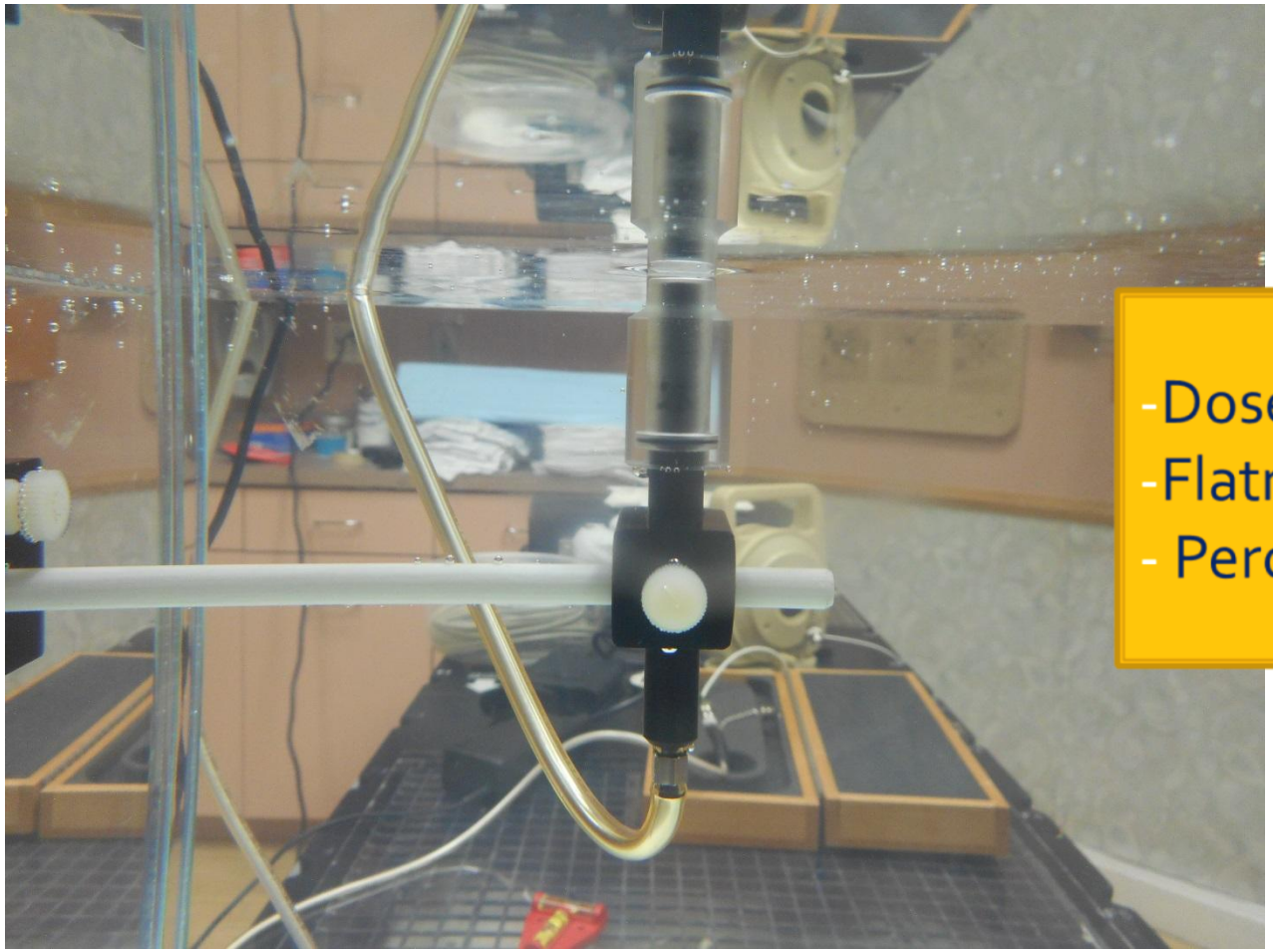


58.6 mm vs. 60 mm

PDD measurements in water and with film

- Using A20 in a 1D water tank
- Film using plastic water*
- Scanner: Epson 11000XL
- Software: Film QA PRO2015 from Ashland
- Films: GafChromic EBT2 and EBT3 radiochromic

Measurements of PDD in water



QA Device

-Dose rate√

-Flatness and symmetry√

- Percent depth dose√

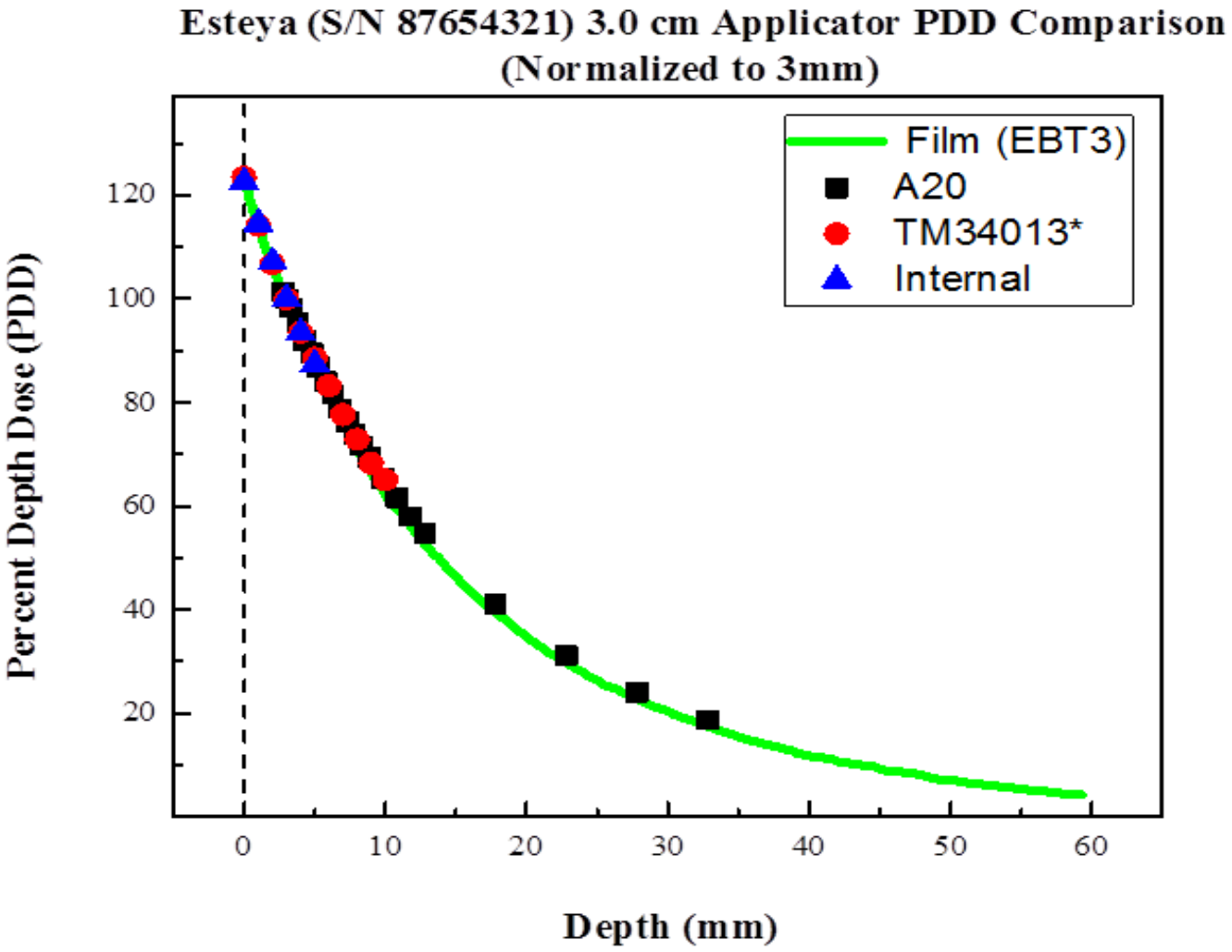
PDD results and comparison (3.0 cm applicator)

Film: 0-60 mm

A20: 2.8-33 mm

TM34013: 3-10 mm

Internal: 0-5 mm



SAM's Question 2: The A20 chamber meet TG 61 requirements because of the following reason.

8%	1.	Chamber orientation
2%	2.	Published stem effect data
33%	3.	Can be calibrated in air or water
2%	4.	Does not require Inverse square law corr.
55%	5.	Small collecting volume, negligible stem effect, adequate total wall thickness

Answer to question Sam's question 2

The A20 parallel chamber meet TG 61 requirements because of the following reason:

1. Chamber orientation
2. Published stem effect data
3. Can be calibrated in air or water
4. Does not require inverse square law corrections
5. Has a small collecting volume, negligible stem effect, adequate wall thickness

Answer: (5)

Reference: AAPM TG 61, Section V.

Sources of uncertainties

- Film positioning vs. applicator
- Film measurements (PDD): surface dose
- Chamber and applicator positioning for water and air measurement
- Overall uncertainty for dose rate measurement: 3%

Q.A for eBT

- Daily Q.A for all components (Cable, applicators, caps, emergency button, Applicator interlock, etc..)
- Establish a method of verification for Tx time
- Which data to use for Q.A.: own or internal?
- Compliance form (Presence of AU and AMP)
- Have a template for simulation information to avoid errors (Manual entry)
- Pacemaker verification
- Others

Independent Tx time verification

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Independent calculation for EBT (Esteya) procedure

Patient: _____ Date: _____

Treatment Area: _____ Field#: _____

Radiation Oncologist: _____ Physicist: _____

Applicator identification (please circle appropriate size):

10 mm 15 mm 20 mm 25 mm 30 mm

Hand calculation for treatment time

Use the equation below, the dose per fraction, measured dose rate (Table1), and measured PDD (Table 2) to determine the calculated treatment time.

$$Calc.\ Time = \frac{Fraction\ Dose\ (Gy)}{Measured\ Dose\ Rate\ \left(\frac{Gy}{min}\right) x\ Measured\ PDD} = Min$$

Treatment planning time (from ESTEYA) = *Min*

Treatment planning time/calculated time X 100=

Acceptable (ratio less than 3 %): Y N

Calculated by: Date:

Esteya measured data for 1.6 mA

Applicator diameter (mm)	Dose rate (Gy/min) at 0 mm
10	3.109
15	3.179
20	3.248
25	3.330
30	3.330

Table 1. Measured dose rate for ESTEYA S/N 87654321

	Applicators sizes(cm)				
Depth (mm)	3	2.5	2.0	1.5	1.0
0.0	1.000	1.000	1.000	1.00	1.000
0.5	0.968	0.964	0.962	0.967	0.959
1.0	0.937	0.931	0.925	0.935	0.919
1.5	0.906	0.900	0.890	0.904	0.881
2.0	0.877	0.871	0.856	0.874	0.845
2.5	0.849	0.844	0.824	0.845	0.811
3.0	0.821	0.818	0.794	0.818	0.778

Table 2. Measured PDD (Film dosimetry) for ESTEYA S/N 8765321 normalized at 0 mm

Example:

Dose/fraction: 7Gy at depth of 3 mm

Applicator size: 30 mm Used current: 1.6 mA

Esteya calculated time: 2:34.3 which is equivalent to = 2.57 min

Calculated time: Dose/ (Measured Dose Rate x measured PDD)

7/ (3.330 x 0.821) = 2:33.6 (MIN: S.SS) which is: 2.56 min

(Calculated –Esteya)/calculated x 100 = -0.4%

Esteya time vs. calculated time*
7 Gy at 3 mm depth

Applicator Diameter (cm)	Actual Treatment Time	Calculated Treatment Time* (min)	% Difference
3.0	2.57	2.56	-0.45
2.5	2.61	2.57	-1.53
2.0	2.65	2.71	2.30
1.5	2.73	2.69	-1.21
1.0	2.80	2.89	3.24

* Using ***measured*** dose rate and PDD

Daily treatment verification/Compliance form

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Daily Treatment Q.A. for Esteya skin Brachytherapy

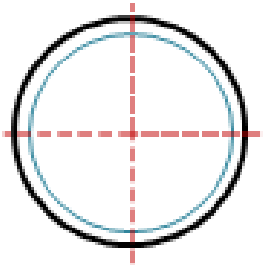
Patient Name:

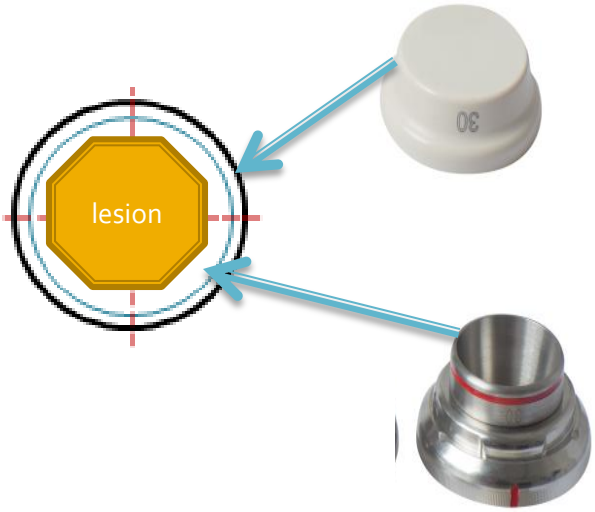
Physician:

Applicator selection (circle appropriate applicator):

	Fraction #1	Fraction #2	Fraction #3	Fraction #4	Fraction #5	Fraction #6
Therapist Physics						
Physician						
Date						

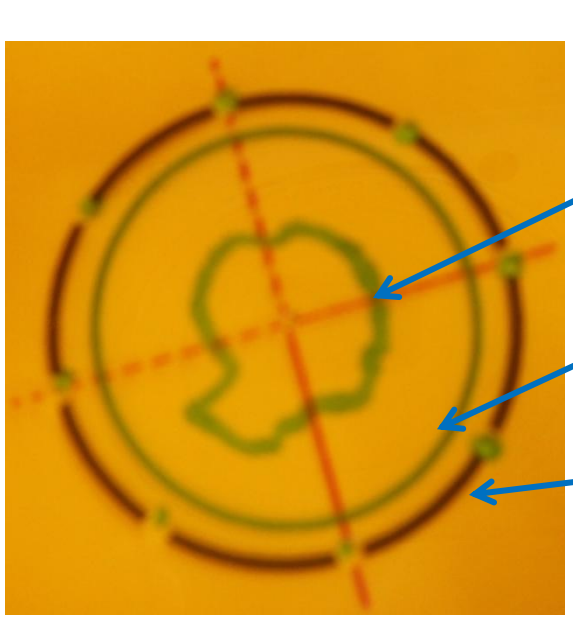
Useful beam and geometric miss





Idea from the Valencia group (Jose Perez-Calatayud)

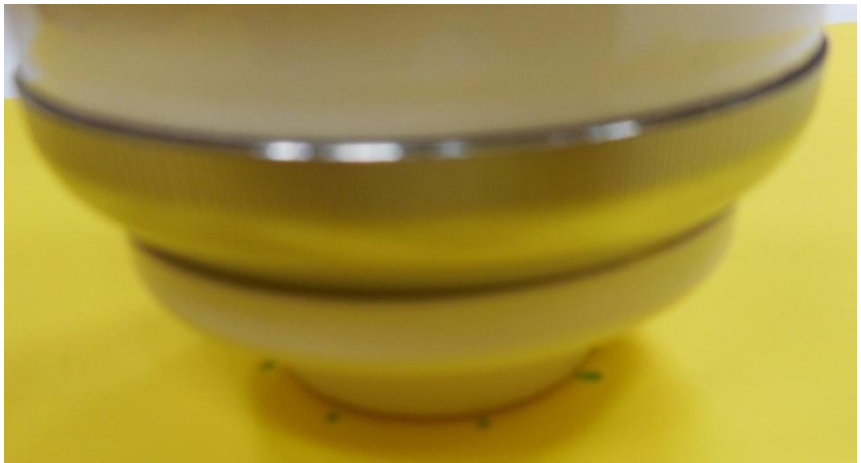
Simulation



Lesion

Useful beam

Plastic cap



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