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Clinical Readiness of an MR-Linac: Tips and Tricks

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Objectives

To provide Tips and Tricks On:

- Installation / Commissioning
- Order of Events / Timelines
- Relevant Dosimetry Issues
- QA Devices and Instrumentation
- Relevant Manuscripts

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1.5 T MR-Linac (Elekta Unity System)

- 1.5 T MRI with 7 MV
- Able to run 1.5 T diagnostic Philips exam cards
- Able to be used for functional imaging (ex.DWI)
- 57 cm x 22 cm max field size
- 7 mm projected MLC's
- Flattening Filter Free
- 143.5 cm source to isocentre
- Real-time Beam-On Imaging
- IMRT capability
- MV Flatt Panel Imager

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MR-Linac Room

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Consideration of Adjacent Linacs

Physics and Imaging in Radiation Oncology 4 (2017) 12–16

Contents lists available at ScienceDirect

Physics and Imaging in Radiation Oncology

ELSEVIER

journal homepage: www.elsevier.com/locate/phro

Original Research Article

The impact of a 1.5 T MRI linac fringe field on neighbouring linear accelerators

Thijs Perik*, Jochem Kaas, Frits Wittkämper

Department of Radiation Oncology, The Netherlands Cancer Institute, Plesmanlaan 121, 1066CX Amsterdam, The Netherlands

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Verify Flat/Sym of Adjacent Linacs

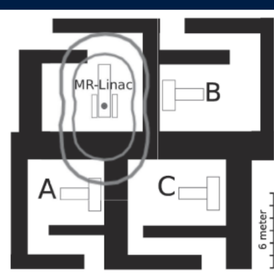

Fig. 1. Layout of the treatment rooms. The MR-Linac is installed in the upper left corner and surrounded by 3 standard linear accelerators, A, B and C at distances of respectively, 7.5, 5.5 and 11 m. The displayed Gauss lines are 0.5 G (Outer) and 2 G (Inner), and are taken from the vendor specifications.

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Order of Events / Timelines

~ **3 weeks**
Set to Work

~ **7 days**
Water tanking with Elekta (suggest extra scans)

2 weeks
Physics Training / Beam Model Check / Acceptance test

Acceptance / Commissioning
(MRI: ~ **2 weeks**)
(Linac: ~ **35 hr**s)
(TPS: ~ **1 month**)
MU Calculator

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Commissioning

- **Linac**
  - AAPM TG - 142 + other (ex Woodings et al, Phys Med Biol. 63(8), 085015, 2018)
- **MRI**
  - Perform AAPM Report 100 + additional beam on tests
  - Tijssen et al. MRI Commissioning of 1.5T MR-Linac – a multi-institutional study. Radiother Oncol 132, 114-120, 2019
- **TPS**
  - IAEA TRS No.430, J Van Dyk et al.
  - AAPM TG-53, Fraass et al.
  - Other (ere effects, surface doses, interfaces)
- **End to End Workflow**
  - MR compatible phantom with chamber required

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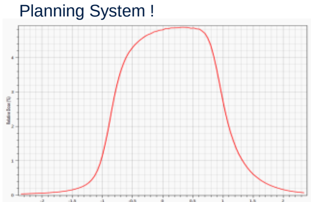
Profiles

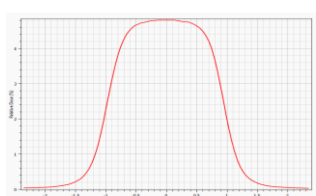
PTW Microdiamond model 60019
PTW SemiFlex model 31021

Verify Direction of Magnetic Field in Planning System !



Cross-plane, dmax, FS=2x2, gantry=0

Skewed



In-plane, dmax, FS=2x2, gantry=0

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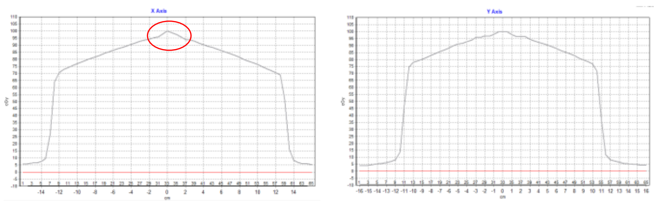
IC Profiler Used as a Surrogate



Kimmy Smit, "Dosimetry for the MR-Linac:, 2015 thesis, Utrecht University

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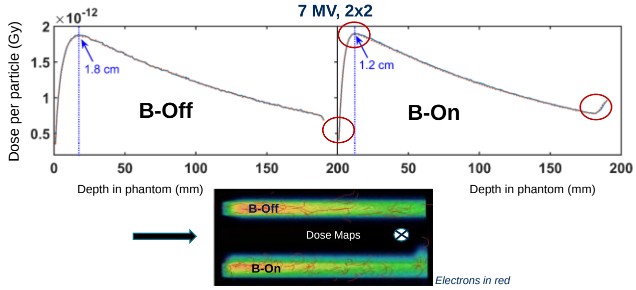
PDD in B-Field



Ahmad S, Sarfehnia A, Paudel M, Kim A, Hissoiny S, Sahgal A and Keller B. Evaluation of a commercial MRI linac based Monte Carlo dose calculation algorithm with Geant4. Med Phys 43(2), 894 - 907, 2016.

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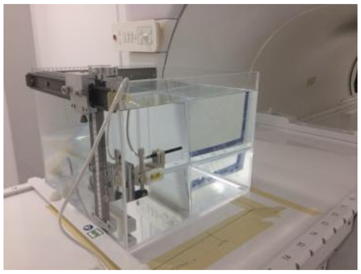
Reference Dosimetry (TG-51)



Setups Vary
Across Centers

Center	1	2	3	4	5	6	7
Gantry Angle	90°	0°	90°	0°	90°	90°	90°
SSD (cm)	138.5	133.5	138.5	133.5	133.5	133.5	133.5
Depth (cm)	5	10	5	10	10	10	10

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Reference Dosimetry (TG-51)

1 / **Monte Carlo study of ionization chamber magnetic field correction factors as a function of angle and beam quality**

Victor N. Malkov[a] and D. W. O. Rogers
Carleton Laboratory for Radiotherapy Physics, Physics Dept, Carleton University, Ottawa, ON, Canada

(Received 30 August 2017; revised 31 October 2017; accepted for publication 25 November 2017; published 5 January 2018)

$$D_W^Q = Mk_Q N_{D,w}^{60Co}.$$ (no B-field)

$$D_W^Q = Mk_Q k_B N_{D,w}^{60Co}.$$ (with B-field)

2 / **Experimental measurement of ionization chamber angular response and associated magnetic field correction factors in MR-linac**

Viktor Iakovenko[a], Brian Keller, Arjun Sahgal, and Arman Sarfehnia
Odette Cancer Centre, Sunnybrook Health Sciences Centre, Toronto, ON, M4N 3M5, Canada
Department of Radiation Oncology, University of Toronto, Toronto, ON, M4N 3M5, Canada

(Received 19 August 2019; revised 6 January 2020; accepted for publication 7 January 2020; published 19 February 2020)

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Beware of Small Air Gaps Affecting Dosimetry

Med Phys. 2017 July ; 44(7): 3830–3838. doi:10.1002/mp.12290.

Monte Carlo study of the chamber-phantom air gap effect in a magnetic field

Daniel J. O'Brien[a] and
Department of Radiation Physics, The University of Texas MD Anderson Cancer Center, Houston, Texas, 77030
Gabriel O. Sawakuchi[b]
Department of Radiation Physics, The University of Texas MD Anderson Cancer Center, Houston, Texas, 77030 and The University of Texas MD Anderson Cancer Center UTHealth Graduate School of Biomedical Sciences, The University of Texas, Houston, Texas, 77030

Results—Differences in the chamber dose of 1.6% were observed for asymmetric air gaps just 0.2 mm thick. No effect greater than 0.5% was observed for the symmetrical air gaps investigated

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Beware of Small Air Gaps Affecting Dosimetry

The effect of very small air gaps on EBT3 film in a 1.5 T MR-Linac

Thijs Perik, Jochem Kaas, Ton Vlasveld, Frits Wittkämper.
The Netherlands Cancer Institute, Amsterdam, The Netherlands.

NETHERLANDS CANCER INSTITUTE ANTONI VAN LEEUWENHOEK

CONCLUSION
- The use of EBT3 film is possible but caution is necessary to avoid small air gaps
- Air gaps up to 0.49 mm cause an increase of measured dose of up to 8%
- Air gaps can be prevented by using water or other liquids between film and phantom

Master Thesis, University of Heidelberg, Germany, 2017

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Chamber in Water Indexed to Table

Preference is to Irradiate in Water

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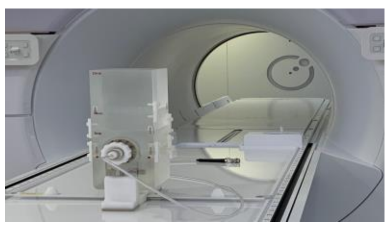
Surrogate for Energy Check

Energy Check Surrogate



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QA Equipment *

Purpose of QA Device	QA Device
Profile Surrogate Device	SNC IC Profiler MR PTW Starcheck max MR
Patient Specific QA Devices	SNC ArcCHECK MR PTW Octavius 1500 MR
Daily Output Check Device	Flatt Panel Central Detector Ionization Chamber in water Phantom with chamber (no air gaps) Central Chamber on IC Profiler Diode Device

** Equipment used by some consortium site members, but not an exhaustive list*

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QA Equipment

Purpose of QA Device	QA Device
Point detectors	PTW microdiamond (60019) PTW Semiflex (31021) Exradin A1SL (XW172482) Exradin A19 (XAQ100622)
Water Tanks *(reference dosimetry, TPR's, Output factors, PDDs, Profiles)*	PTW Manual MP1 MR 1D water tank PTW 3D Beamscan MR In house if possible
MRI QA	Modus MRID(3D) geometric distortion phantom Philips Geometric Distortion Phantom PIQT Phantom ACR MR-MV test phantom (Elekta provided)

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QA Equipment

Purpose of QA Device	QA Device
Surface Dose / Patient Skin Dose	Optically stimulated luminescence dosimeters **
End to End tests	CIRS STEEV Modus Quasar MRI motion phantom

*** Surface and near-surface dose measurements at beam entry and exit in a 1.5 T MR-Linac using optically stimulated luminescence dosimeters. Kim et al. Phys Med Biol 65(4), 045012, 2020*

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