2026 JULY 19–22 VANCOUVER, BC
JOINT AAPM | COMP MEETING

Vault Retrofit and Re-Engineering for Varian TrueBeam V3 in a Bunker Originally Designed for Varian Clinac DHX

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ABSTRACT

Purpose: To retrofit a 2009-era Clinac DHX bunker at Square Cancer Centre, Dhaka, for the installation of a Varian TrueBeam V3 (10 MV-FFF) without structural demolition, enabling SRS/SBRT capabilities while establishing a replicable model for similar upgrades.

Methods: Following treatment cessation (November 9, 2024), the Clinac DHX was decommissioned under the supervision of the Radiation Safety Officer (RSO). Infrastructure upgrades included replacement of the maze door with 20 mm borated polyethylene (BP), installation of a 30 mm BP scatter wall, electrical and mechanical system upgrades, installation of a 100 kVA UPS, and isolated grounding. The original concrete bunker remained structurally unchanged. Beam commissioning of the TrueBeam V3 was performed according to the IAEA TRS-398 protocol, including measurements of TPR_{20,10} and PDD₁₀ for 6 MV, 6 MV-FFF, 10 MV, and 10 MV-FFF beams using kQ, kTP, kpol, and ks correction factors. Radiation surveys verified regulatory compliance through Winston–Lutz testing, picket-fence analysis, IMRT/VMAT quality assurance, and gamma analysis (>95% pass rate at 3%/3 mm). Beam calibration was validated by the Secondary Standard Dosimetry Laboratory (SSDL), and the facility was audited and licensed by BAEC. Commissioning and documentation were completed within four weeks, and staff received four days of on-site training..

Results: The retrofit was successfully completed without structural concrete demolition. At a workload of 1000 Gy/week using the 10 MV FFF beam, the measured neutron dose was **0.38 µSv/h**, photon dose was **3.91 µSv/h**, and electron dose was **2.95 Bq/cm²**, all below the limits specified by NSRC-1997 and IAEA. All beam energies satisfied clinical acceptance criteria with appropriate quality assurance metrics..

Conclusion: Strategic borated polyethylene shielding enabled the cost-effective conversion of a Clinac DHX bunker to accommodate a Varian TrueBeam V3. This retrofit approach provides resource-limited radiotherapy centers with a practical pathway for infrastructure modernization while maintaining regulatory compliance and uninterrupted treatment capability..

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Introduction

Square Cancer Centre (Dhaka) replaced its 2009-era **Varian Clinac DHX** (6/10 MV photon, 15 MeV e⁻) with a modern **TrueBeam V3** capable of **10 MV-FFF at 2400 MU/min**, enabling SBRT / SRS. The original bunker was designed under NCRP-49 with no photoneutron-shielding margin.

Why retrofit?

- **FFF beams:** lower mean energy, 10–20% lower head leakage, 2–6× higher dose rate.
- **Neutrons:** appear above 8 MV; DHX showed none, TrueBeam produces 0.003–0.38 µSv/h.
- **Structural fit:** TrueBeam Slim-Stand needs 19′ 4″ × 19′ 4″, 9 ft ceiling.

Methods and Materials

Figure 1: Radiotherapy bunker retrofit workflow diagram

Procedure:

- Decommissioning: Varian team + contractors; RSO Dr. Islam oversight; LOTO documented. Last patient 10 Nov 2024.
- Civil work: PU/Epoxy injection grouting on 220 mm floor; crack & water-leak repairs.
- Neutron shielding: borated PE panels (BP-5000) at maze door + wall lining.
- Calibration: IAEA TRS-398; $TPR_{20,10}$, PDD_{10}; kQ, kTP, kpol, ks.
- Survey: gantry 0°/90°/180°/270° at 10 MV-FF & 10 MV-FFF; W = 1000 Gy/wk.

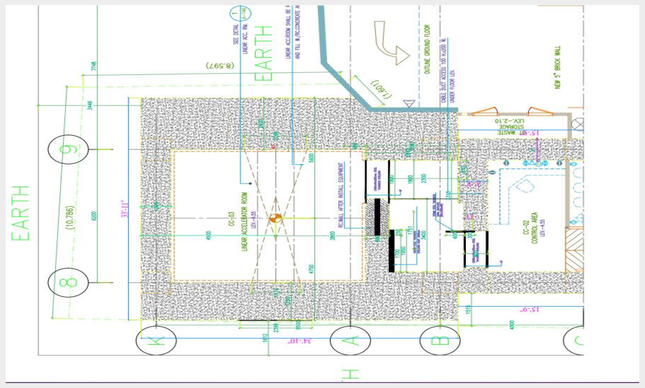


Figure 02. Vault Configuration

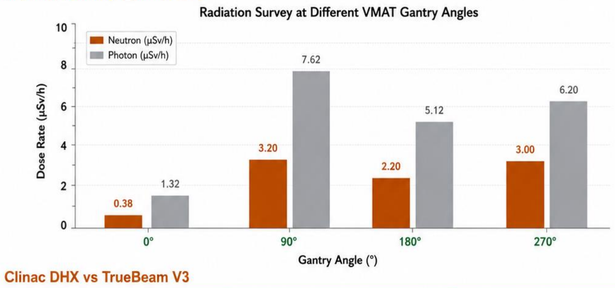
Figure 03: Retrofit Site Documentation

RESULTS

All measurements are within NSRC-1997 / IAEA limits.
This confirms regulatory compliance and patient & staff safety.

0.38 µSv/h	3.91 µSv/h	1000 Gy/week
Neutron (NSRC Limit: 2.5 µSv/h)	Photon (NSRC Limit: 10 µSv/h)	Workload (10 MV FFF)

Radiation Survey @ 10 MV-FFF



Clinac DHX vs TrueBeam V3

Parameter	Clinac DHX	TrueBeam V3
Architecture	Analog	Fully Digital
Photon Energies	6, 10 MV	6, 10 MV, FFF
Max Dose Rate	600 MU/min	2400 MU/min
MLC	Millennium 120	HD MLC (2.5 mm)
Gantry Tilt	Standard	Yes (±180° / ±120°)
Imaging (kV)	None	kV, MV, CBCT
IMRT/VMAT	Limited	Fully Capable

04 DISCUSSION & CONCLUSION

Key Findings

- Bunker retrofit **(2024)** was successfully completed without structural demolition.
- FFF beams **(10 MV)** reduced dose rate, decreased heat load and improved efficiency.
- Neutron dose: **0.38 µSv/h** (3% of NSRC/IAEA limits).
- Photon dose: **3.91 µSv/h** (39% of NSRC/IAEA limits).
- Maintained **reliability** for continuous clinical treatment.

Challenges Faced

Wall strength: Reinforced concrete wall (2350 kg/m³, ~95 cm) originally designed for Clinac DHX required careful evaluation for TrueBeam V3.

Safety margin: Ensured 100% compliance for photon and neutron leakage limits.

Equipment availability: High-purity borated PE and specialized materials had limited local availability.

Project timeline: Retrofit and commissioning completed within 4 weeks.

Patient continuity: Minimized service gap to reduce impact on clinical operations.

Conclusion

The Clinac DHX bunker was successfully retrofitted to accommodate Varian TrueBeam V3 with **10 MV FFF** without structural rebuilding. All measurements met **NSRC-1997 / IAEA** limits, ensuring full regulatory compliance, treatment safety, and uninterrupted service delivery.

Safety Ensured → Regulatory Compliance → Treatment Continuity → Advanced Capability → Cost-Effective Upgrade

Significance & Impact

- Reference model for legacy Clinac DHX bunkers upgrades.
- Cost-effective modernization for resource-limited centers.
- Enables SRS/SBRT and modern IMRT/VMAT practices.

Limitations & Future Work

- Single site study; results may vary for different bunker configurations.
- Follow-up monitoring of neutron dose and shielding performance is ongoing.
- Future work: Multicenter evaluation and optimization of shielding for various workloads.

References

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