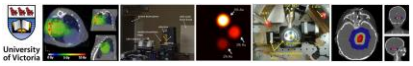
KiloVoltage x-ray beam Arc Therapy (KVAT)

Magdalena Bazalova-Carter, PhD, DABR
Canada Research Chair in Medical Physics
Department of Physics and Astronomy
University of Victoria

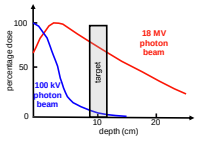


Disclosure

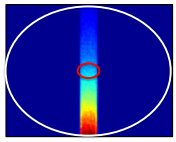
- Precision RT partly funded this work.
- Dylan Breitkreutz and I have a consulting agreement with the Precision RT.

Dylan Breitkreutz did all the work!

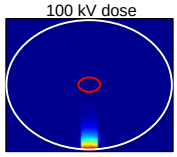
X-ray beam therapy

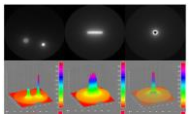


6 MV dose



100 kV dose



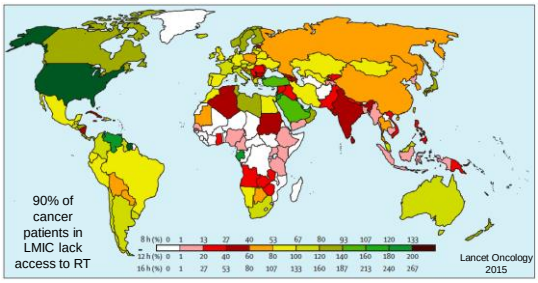


320 kV beam, 4.4 mm Cu

No 7 ft of concrete

Prionas et al., Int J Rad Onc Biol Phys 2012

The need for cost-effective RT

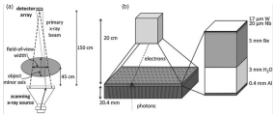


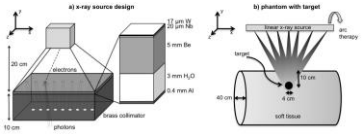
90% of cancer patients in LMIC lack access to RT

Lancet Oncology 2015

Kilovoltage x-ray beam arc therapy (KVAT)

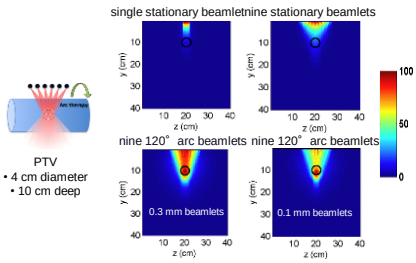
SBDX source



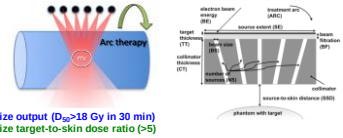


Bazalova-Carter et al. Med Phys 201

KVAT principles



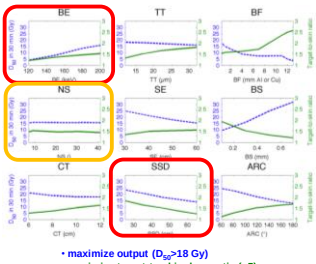
KVAT source parameters



• **maximize output (D_{SK}>18 Gy in 30 min)**
• **maximize target-to-skin dose ratio (>5)**

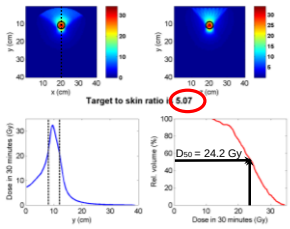
Parameter	Values
beam energy BE (keV)	120, 150, 180, **200**
target thickness TT (μm)	12, **17**, 22, 37, 32
beam filtration BF (mm)	**0.4**, 1, 4, 7 **Al** and 1, 2, 3 Cu
number of sources NS	7, **9**, 21, 41
source extent SE (cm)	30, 40, **50**, 60
beam size at target side BS (mm)	0.1, **0.3**, 0.5, 0.7
collimator thickness CT (cm)	6, **8**, **10**, 12
source-to-skin distance SSD (cm)	25, 35, **45**, 55, 65
treatment arc angle ARC (°)	60, 80, **120**, 160, 180

Parameter study

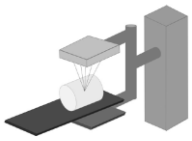


• **maximize output (D_{SK}>18 Gy)**
• **maximize target-to-skin dose ratio (>5)**

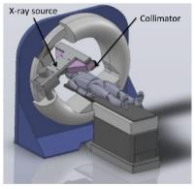
Phantom dose distribution



KVAT machine



UVic design

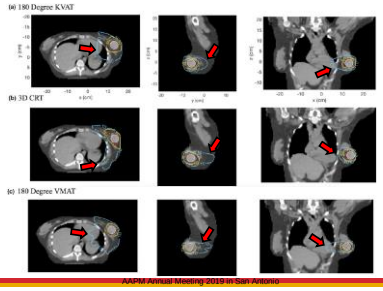


Industrial partner's design

How do dose distributions look in patients?

Bredeloux et al. Med Phys 2017

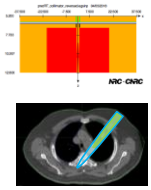
Breast patient



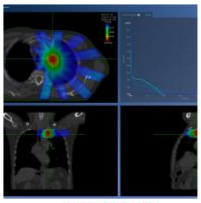
Spherical target
No optimization

Treatment planning

Monte Carlo simulations



Radify



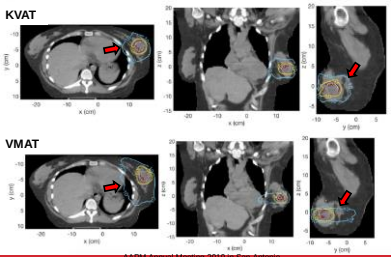
McGill

Breast patient

Total dose 38.5 Gy, total treatment time 28.3 min, 2.8 min/fx.

KVAT

VMAT



Spherical target
With optimization

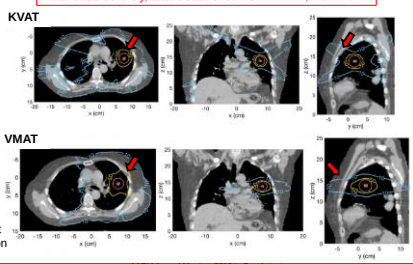
Breedveld et al. Med Phys 2018

Lung patient

Total dose 60.0 Gy, total treatment time 77.1 min, 2.6 min/fx.

KVAT

VMAT

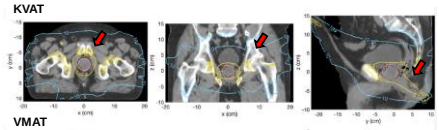


Spherical target
With optimization

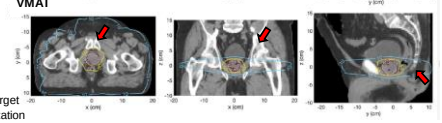
Prostate patient

Total dose 73.8 Gy, total treatment time 223.8 min, 5.5 min/fx.

KVAT



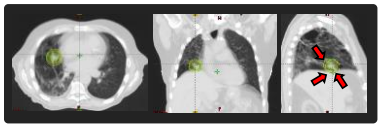
VMAT



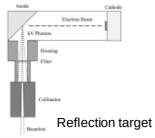
Spherical target
With optimization

Real patient cases

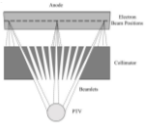
- Real targets are never spherical (unfortunately).



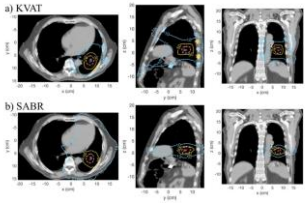
- Our collimators are designed to deliver spherical dose distributions => sphere packing is applied to cover irregular targets (similar to CyberKnife of GammaKnife)

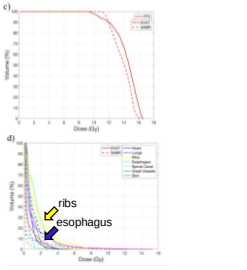


Reflection target



Lung patient 1

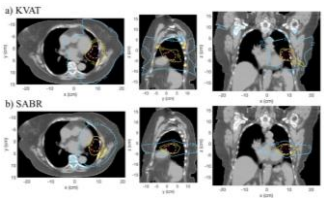


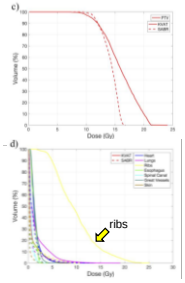


Treatment time for 12 Gy/fx: 49 minutes (3 subvolumes).

Breedveld et al. Biomed Phys Eng Express 2018 (under review)

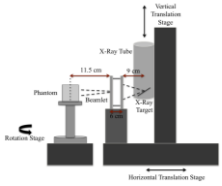
Lung patient 2



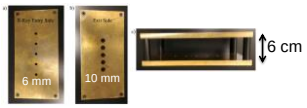


Treatment time for 12 Gy/fx: 65 minutes (3 subvolumes).

Proof-of-concept experiment

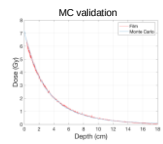


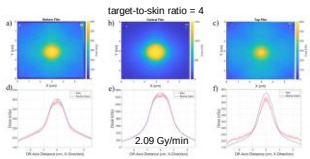
160 kVp, 13 mA, 5 minute irradiation

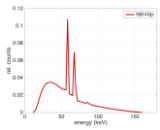


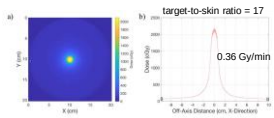
Brekkestø et al. Med Phys 2019 (under revi

Proof-of-concept experiment







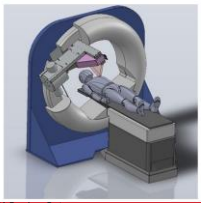


Industrial translation of KVAT

ImaTrex

HOME · PRODUCTS · ABOUT US · TEAM · CONTACT

Precision RT - Low Dose Radiotherapy



The Precision RT system is truly revolutionary in its design, capabilities and performance. Most important is that it can be marketed at a price 10 times less than conventional RT systems.

The benefits of using the SIRIUS Radiation Therapy system include:

- Most cost effective Radiation Therapy system in the world
- Systems effectiveness that matches and is better than most conventional Radiation Therapy systems
- Minimizes dose to healthy tissue by using the TumoTrak™ System – providing real time feedback on the location of the tumor
- Small footprint
- Designed to be used in conventional x-ray rooms
- Does not require a specially shielded and fabricated therapy room
- Designed for low and middle income regions

KVAT conclusions

- By means of MC simulations, we have demonstrated dosimetric properties of KVAT plans.
- KVAT might be a suitable cost-effective radiation treatment modality for small tumors in the breast and lung (plans met RTOG dose constraints).
- Dose to bone is the limiting factor in some cases.
- Treatment times are long, but the system might be capable of online imaging.
- The first prototype has been constructed, but runs at low beam currents.

Acknowledgements



Dylan Breitkreutz

Nolan Esplen

Henry Baxter

Sergei Zavgorodni


Marc Renaud

Jan Seuntjens


Ted Graves
ImaTrex

Michael Weil

Douglas Boyd
TRIPLE RING

Brian Wilfley
NSERC CRSNG
Canada Research Chairs
INNOVATION.CA
Canada
BC Knowledge Development Fund

Thank you!