Mobius3D

Software based IMRT QA
What is Mobius Medical Systems?

- **Clinical Expertise**
  - Nathan Childress, Ph.D., Founder

- **Software Expertise**
  - Eli Stevens, Chief Technical Officer

- **Support Expertise**
  - Physicists and dosimetrists with real-world clinical experience
What is Mobius3D?

- **Software**
  - Plan Verification
  - Delivery Verification
  - Every patient, every plan, every fraction
Mobius3D: A complete QA system

- Photon calculations
  - IMRT / VMAT
  - EDW / physical wedges
  - SRS cones
  - TomoTherapy
  - Every TPS
- Electron calculations
- Brachytherapy calculations

- MU verifications
- IMRT QA
  - Varian DynaLogs
  - Varian Trajectory Logs
  - Elekta Logs
- Daily patient QA
- MVP measurement phantom
How does it work?

- Computer software with a dedicated server
- Automatically analyzes every patient’s treatment plan
- Automatically analyzes measurements of treatment delivery
- Automatically alerts you to problems
- Easy to use web application
What will Mobius3D do for your clinic?

Mobius3D will vastly improve the:

- Safety
- Efficiency
- Accuracy

of your patient’s treatments
Safer is better!

WARNING
NO LIFEGUARD
ON DUTY
SWIM AT YOUR
OWN RISK
What clinical errors can impact patient safety?

- Systemic TPS problems
- Human errors made during planning
- Data transfer errors (see NY Times)
- Delivery errors
Mobius3D detects systemic TPS problems

- Mobius3D can uncover TPS limitations and commissioning issues
  - Independent beam models and an independent 3D dose calculation
- Mobius3D can reveal deliverability problems before the patient even enters the treatment room
  - Mobius3D checks for gantry clearance and warns of possible collisions
  - Mobius3D alerts you to violations of your accelerator limitations which would result in an interlock when the plan is delivered
Mobius3D detects **systemic TPS problems**

- Incorrect jaw tolerance settings in linac control system (Allegiance Health)
- Dosimetric leaf gap (DLG) incorrect setting in TPS (Lewis Gale)
- Couch rotation error (Gibson Cancer Center)
- AAA algorithm limitations (St. Anthony’s)
- Collision alert on a medial breast setup (St. Anthony’s)
Mobius3D detects human errors made during planning

- Mobius3D can uncover contouring errors
- Mobius3D can draw attention to improper dose grid coverage
- Mobius3D reveals if clinical protocols aren’t followed
Mobius3D detects data transfer errors

- Mobius3D is the only system we are aware of that verifies that the information in the R&amp;V system is exactly what the plan from the TPS specified for every single fraction delivered.
Mobius3D detects data transfer errors

- From 1997 to 2007, the World Health Organization reported 1,732 incidents in radiotherapy were due to data transfer errors.
- A 2007 analysis of the Radiation Oncology Safety Information System (ROSIS) database showed that 49% of events reported had an element of data transfer that caused or contributed to the event.
- Symington reported a corruption of data during transfer of a plan from a different site which was not identified during traditional QA methods but was flagged by Mobius3D.
Mobius3D detects linac delivery errors

- A good plan alone, does not guarantee a successful delivery
  - Mobius3D uses log file measurements from every IMRT/VMAT delivery to verify that the machine successfully delivered the plan
  - If there are any issues, the software shows in full 3D what the difference in dose to the patient was for every target and every ROI

<table>
<thead>
<tr>
<th>What information do log files contain?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fractional MU</td>
</tr>
<tr>
<td>Delivered MU*</td>
</tr>
<tr>
<td>MLC Positions</td>
</tr>
<tr>
<td>Jaw Positions</td>
</tr>
<tr>
<td>Gantry Angles</td>
</tr>
<tr>
<td>Collimator Angles</td>
</tr>
<tr>
<td>Couch Angles*</td>
</tr>
<tr>
<td>Beam Energy*</td>
</tr>
<tr>
<td>Wedge Insertion*</td>
</tr>
<tr>
<td>Other Inserts*</td>
</tr>
</tbody>
</table>

* TrueBeam and Elekta Only
Why trust treatment log measurements?

- Every data source has secondary mechanisms verifying the information.
- The data is written with extremely high temporal and spatial resolution—up to 100 times per second and down to 0.01mm.
- Machine QA, such as that recommended in TG-142 verifies the measurements in treatment logs are accurate.
Mobius3D detects linac delivery errors

- Data from customers have shown that with increasing modulation, greater errors in MLC position occur
  - Research has shown that a 1 mm systematic change in MLC position can result in up to a 12% difference in target doses
- This is especially pronounced in SBRT treatments with small average field sizes
  - One user recently reported several SBRT treatments failed Mobius3D delivery verification, yet their traditional measurements said all was OK
- Recent articles by the Imaging and Radiation Oncology Core at Houston (IROC) have shown that traditional methods are insensitive to many, if not all failures during delivery
About patient positioning and changes in anatomy

- We understand that patient positioning and changes in anatomy are important aspects in safely delivering radiation therapy and log files do not contain this information.

- EPID measurements contain this information, but they fail to produce results that are sensitive, specific, and actionable.

- The clear choice for patient position and anatomy analysis for the next-generation QA system is CBCT data and research is underway to transform your CBCT data into a useful quantitative check and include this capability in Mobius3D.
EPID Transit Dosimetry vs. CBCT

EPID images showing (a) correctly delivered 90° prostate field, (b) phantom shifted 2 cm longitudinally (99.4% 3%/3 mm gamma passing rate), (c) phantom shifted 2 cm vertically (98.6%), and (d) 2 cm bolus added to phantom (100%).

Images from CBCT analysis currently being researched. The vertical 2 cm shift in the prostate case results in clear differences in the images and significantly reduced passing rates.
More efficient is better!
What are some sources of clinical inefficiency?

- Time consuming measurement setup
- Non-automated data collection and entry
- Complicated and poorly designed analysis software
- No identification of the root causes of errors
Mobius3D reduces QA measurement setup time

- No manual or detailed setup of a device
- Treatment log measurements happen automatically with each delivered fraction resulting in the elimination of setup time
- Mobius3D imports data automatically removing manual data entry that takes time and adds risk
Mobius3D software is designed for efficiency

- Most QA software for radiation oncology is confusing and inefficient in design
- Mobius3D:
  - Has user-friendly workflow
  - Is accessible via a web browser
  - Allows electronic sign-offs
  - Quickly alerts you to problems
  - Allows for detailed analysis if needed
Mobius3D identifies root causes

- Other QA systems may indicate a problem, but they do not identify the root cause. This leads to frustration and delay.
Mobius3D identifies root causes

- Mobius3D saves you time by identifying:
  - whether a problem is TPS-calculation or delivery based
  - what linac component failed (e.g., MLC, gantry, collimator)
  - what IMRT segment of the delivery failed

- Root cause identification improves troubleshooting, which can increase safety also
Mobius3D’s brings Efficiency to the clinic

- MD Anderson realized a ~70% reduction in QA time when switching to Mobius3D for IMRT/VMAT QA.
- One clinic in the Netherlands reported an over 75% reduction in clinical time spent on QA after implementing Mobius3D.
- A site in Canada had not been able to implement VMAT throughout their clinical practice due to the bottlenecks created by traditional QA methods. Mobius3D allowed them to begin performing VMAT on six machines.
More accurate is better!
What are some sources of clinical inaccuracy?

- Older dose calculation algorithms
- Low-resolution measurements
- Measurements conflated by too many variables
How does accuracy affect safety and efficiency?

- If an inaccurate system generates a false passing result, this is a **SAFETY issue**. The patient will be treated when there is really an unknown problem.

- If an inaccurate system generates a false failing result, this is an **EFFICIENCY issue**. The effort to identify and fix what is really a non-existent problem will be a waste of time.

- These are the reasons that accuracy was one of the core tenets when designing Mobius3D.
How does Mobius3D ensure accuracy?

- Advanced and independently verified collapsed-cone convolution superposition algorithm for dose calculation

*Algorithm* (noun.)

Word used by programmers when... they do not want to explain what they did.
How does Mobius3D ensure accuracy?

- Treatment log files measurements provide high resolution (both temporal and spatial)
- Up to 100 times the accuracy of other QA systems
How does Mobius3D ensure accuracy?

- Mobius3D’s measurements are not fouled-up by the patient’s body or treatment couch
- Mobius3D’s measurements do not rely on complex calibrations or spectral-dependent issues (i.e., for EPID dosimetry)
Mobius3D brings Accuracy to the clinic

- MD Anderson compared the Mobius3D dose calculations and their customized Pinnacle beam model calculations to measurements and found that Mobius3D was more accurate.

- Epworth in Australia checked more than 850 plans and found the mean dose difference between their TPS and Mobius3D to be 0.00%! with a standard deviation of only 1.31%.

- IROC-Houston studies showed that even non-customized beam models in Mobius3D were more accurate than most center’s treatment planning systems.
Conclusion

Just a couple more slides, I promise!
This is our expertise

- Clinical – Founded and run by a medical physicist with a PhD from UT – MD Anderson and six years of clinical experience
- Software design – A dedicated team of 8 software engineers with over 70 years of experience including time at Yahoo!, Cisco Systems, and Oracle
- Support – Our extremely responsive group currently includes four medical physicists and two dosimetrist who understand the need for quick and accurate answers to keep your clinic running smoothly
Conclusion…

- Improved Safety
- Improved Efficiency (with a lot more root cause data)
- Improved Accuracy
- Proven!
Thank You
What Our Users Are Saying…

- “Mobius 3D’s workflow saves our clinic valuable time and removes limitations on patient throughput. The software also played a pivotal role in the commissioning of an otherwise difficult to verify delivery and gave valuable insights into areas we cannot realistically measure due to detector/phantom issues”  
  David Jolly, MS, CMPS, QMPS, MACPSEM, Medical Physicist, Epworth Hospital, Australia.

- “One of the only unanimous decisions made by Physics, Physicians, Dosimetrists, and Management in the history of our facility.”  
  James P. Nunn, MS, CHP, DA BR, LewisGale Hospital, Pulaski, VA

- “Mobius Medical’s products are finally giving clinical medical physicists the tools needed to do our jobs intelligently and efficiently!”  
  Philip Silgen, M.S., D.A.B.R., Chief Medical Physicist, HealthEast Cancer Care

- “Mobius is a second physicist, or a second set of eyes, for us.”  
  James Monroe, PhD, D.A.B.R., Chief Medical Physicist, St. Anthony’s Medical Center
Be aware of total cost of ownership

- Besides yearly software maintenance there are no hidden costs with ownership of Mobius3D
- EPID based solutions will most likely require replacement of EPID panels as they get damaged by radiation
- Other devices that are placed in the beam will also suffer damage and require replacement over time
Mobius vs. EPID - Cost Comparison

**Mobius QA Software**
- Mobius3D
  - $50,000 first linac
  - $25,000 additional linacs
- BrachyTherapy License
  - $4,950
- SRS Cone License
  - $4,950

**Sun Nuclear PerFraction**
- PerFraction 3D*
  - Approx. $35,000 per linac
- EPID Replacement
  - Approx. $58,000 per linac every 24 months

*Mobius3D and MobiusFX are proven as the most accurate, most efficient, and safest plan verification and machine performance tool on the market.*

*Sun Nuclear PerFraction 3D is not released or available for purchase on the market.*
1.10 Radiation Hardness: aSi based portal imaging systems supplied by Varian or Varian Medical Systems have been in routine clinical operation since 1998. During this time, the detectors have proven excellent reliability and stability and have not shown additional significant deterioration in image quality. Using the system under standard clinical conditions¹, the detector (panel and surrounding electronics) lifetime is expected to be \( \geq 4 \) years.

¹ Definition of standard clinical conditions: working week with approximately 150 treatment fields with electronic portal imaging, 75% of fields \(<12 \times 12 \text{ cm}^2\), 250 cGy/week or 130 Gy/year on the surrounding electronics.
3.2.1.5 A Word of Caution

The PortalVision Image Detection Unit is an extremely sophisticated piece of hardware containing high-precision electronics. The detector is designed such that only the rectangular window of \( 40 \times 30 \text{ cm}^2 \) may be fully exposed to the beam for any length of time. The two wide areas along two edges of the sensitive rectangle should never be exposed directly to the full beam.

If the field is larger than the sensitive square, the PortalVision image detector may not be used or the lateral/longitudinal movements of the support arm must be activated to move the detector such that the field only covers the sensitive square.

The following table shows the relation between maximum Focus Detector Distance (FDD) and the maximum field size.

<table>
<thead>
<tr>
<th>FDD [cm]</th>
<th>Max. field size [cm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>40 x 30</td>
</tr>
<tr>
<td>110</td>
<td>38.4 x 27.3</td>
</tr>
<tr>
<td>120</td>
<td>33.3 x 25.0</td>
</tr>
<tr>
<td>130</td>
<td>30.8 x 23.1</td>
</tr>
<tr>
<td>140</td>
<td>28.6 x 21.4</td>
</tr>
<tr>
<td>150</td>
<td>26.7 x 20.0</td>
</tr>
<tr>
<td>160</td>
<td>25.0 x 18.8</td>
</tr>
<tr>
<td>170</td>
<td>23.5 x 17.6</td>
</tr>
<tr>
<td>180</td>
<td>22.2 x 16.7</td>
</tr>
</tbody>
</table>

Table 1: Maximum field size depending on FDD
Automatic Brain Metastases Planning

- Single isocentre with up to 10 arcs over 5 table angles.
- Automated template based planning.
- Optimization engine aims to reduce conformity index for each individual met.
- Results in volumetric dynamic conformal arcs with more than 1 met treated with each sweep.
- 6X (iPlan PBC Profile).
- IGRT with ExacTrac and 6D couch.
- Fast and efficient treatment.

Slide courtesy of D Jolly

Pictures courtesy of BrainLab