ELEKTA LUNCH and LEARN

VMAT and SBRT with Monaco

Lori Slack
Manager Medical Dosimetry
Radiation Oncology
Allegheny Health Network
Acknowledgements

This presentation would not have been possible without the help of:

Ellen Day, PhD
Senior Physicist, Allegheny Health Network-
Physicist, co-worker and friend.

A special thank you to Elekta for inviting me to speak today
Disclosures

• No conflict of interest to disclose
• Elekta has partially funded my trip
What are we talking about?

- Monaco 5.1
- SBRT
- VMAT
- Monaco 5.11
Monaco Planning

Utilizes Monte Carlo and Collapsed Cone algorithms
Biological modeling
Multi-Criterial goals
Constrained optimization
Sensitivity Analysis
Bias Dose Planning
Multiple Prescriptions
Forward planning
Dicom recalculation from any RTP
Frozen Dose
Monaco = True Monte Carlo Planning

- Continuous arc calculation (not limited to dose approximations)
- Sharper dose gradients in SRS targets
- Better sparing of critical structures
- Highly conformal dose distribution
- Allows more modulation where required
Monaco 5.1

- Upgraded to 5.1 March 2016
## Monaco 5.1 Benefits of new features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import of MLC Segmented Plans</td>
<td>Ability to import plans from 3rd party TPS systems for recalculation with Monte Carlo Algorithm</td>
</tr>
<tr>
<td>Template Manager</td>
<td>Ability to import/export templates within Monaco systems for sharing, reduce learning curve and speed up the planning time</td>
</tr>
<tr>
<td>Sequencer Improvements</td>
<td>Improved Step and Shoot SSO routine for better plan quality</td>
</tr>
<tr>
<td>Forward Planning Tool</td>
<td>Ability to manually create, edit, and delete segments for static beams</td>
</tr>
<tr>
<td>Multiple Rx</td>
<td>Ability to create multi-modality, composite and integrated bias dose plans from within the same plan file.</td>
</tr>
<tr>
<td>MR Planning</td>
<td>Ability to plan on MR images using bulk density overrides</td>
</tr>
<tr>
<td>Frozen Dose</td>
<td>Ability to recall, edit and retain existing dose and plan integrity when making changes that invalidate dose.</td>
</tr>
<tr>
<td>Anatomical Groups</td>
<td>Ability to create structure templates for import into patients</td>
</tr>
<tr>
<td>Isodose Templates</td>
<td>Ability to save and apply isodose templates</td>
</tr>
<tr>
<td>Point to Point Registration</td>
<td>New registration algorithm for image fusion</td>
</tr>
<tr>
<td>4D Specialty Images</td>
<td>Ability to create MIPs, MinIPs and AVG images from 4D image sets</td>
</tr>
<tr>
<td>Concurrent Sessions</td>
<td>Monaco 5.1 allows 3 concurrent sessions per user</td>
</tr>
</tbody>
</table>
Import of MLC Segmented Plans

Ability to import plans from 3rd party TPS systems for recalculation with Monte Carlo Algorithm.

- This allows the system to acknowledge any dose that was previously given to an OAR or Target and include that dose in the new plan when calculating.
Template Manager (Import/Export)
Forward Planning

![Image of Forward Planning](Image_Calculating.png)

<table>
<thead>
<tr>
<th>Segment</th>
<th>%</th>
<th>MU / Fx</th>
<th>Segment Area (cm²)</th>
<th>Width1 (cm)</th>
<th>Width2 (cm)</th>
<th>Length1 (cm)</th>
<th>Length2 (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18.11</td>
<td>7.10</td>
<td>0.000</td>
<td>LW 20.00</td>
<td>RW 20.00</td>
<td>UL 5.50</td>
<td>LL 5.50</td>
</tr>
<tr>
<td>2</td>
<td>16.84</td>
<td>6.60</td>
<td>0.000</td>
<td>LW 20.00</td>
<td>RW 20.00</td>
<td>UL 5.50</td>
<td>LL 5.50</td>
</tr>
<tr>
<td>3</td>
<td>11.73</td>
<td>4.60</td>
<td>0.000</td>
<td>LW 20.00</td>
<td>RW 20.00</td>
<td>UL 0.50</td>
<td>LL 5.50</td>
</tr>
<tr>
<td>4</td>
<td>16.33</td>
<td>6.40</td>
<td>0.000</td>
<td>LW 20.00</td>
<td>RW 20.00</td>
<td>UL -1.50</td>
<td>LL 3.50</td>
</tr>
<tr>
<td>5</td>
<td>23.98</td>
<td>9.40</td>
<td>0.000</td>
<td>LW 20.00</td>
<td>RW 20.00</td>
<td>UL 1.50</td>
<td>LL 0.50</td>
</tr>
<tr>
<td>6</td>
<td>13.01</td>
<td>5.10</td>
<td>0.000</td>
<td>LW 20.00</td>
<td>RW 20.00</td>
<td>UL 4.50</td>
<td>LL 0.50</td>
</tr>
</tbody>
</table>
Multiple Rx

**Prescription**

<table>
<thead>
<tr>
<th>Rx ID</th>
<th>Rx Site</th>
<th>Prescribe To</th>
<th>Rx Dose (cGy)</th>
<th>Number of Fractions</th>
<th>Fractional Dose (cGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Plan Isocenter</td>
<td>X 0.75 Y -122.15 Z 0.84</td>
<td>4500.0</td>
<td>25</td>
<td>180.0</td>
</tr>
</tbody>
</table>

Actual Dose = 4500.0 cGy

**Rescale**

4500.0 cGy

Weight beams by: Dose € MU

**Beam Visibility**

<table>
<thead>
<tr>
<th>Beam</th>
<th>Description</th>
<th>Field ID</th>
<th>%</th>
<th>MU / Fx</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RT LAT</td>
<td></td>
<td>25.00</td>
<td>82.09</td>
</tr>
<tr>
<td>2</td>
<td>AP</td>
<td></td>
<td>25.00</td>
<td>48.99</td>
</tr>
<tr>
<td>3</td>
<td>LT LAT</td>
<td></td>
<td>25.00</td>
<td>78.24</td>
</tr>
<tr>
<td>4</td>
<td>PA</td>
<td></td>
<td>25.00</td>
<td>61.16</td>
</tr>
</tbody>
</table>

Total MU / Fx = 270.48
Multiple Rx

Image of software interface for selecting and configuring radiation therapy plans.
Frozen Dose

- Dose no longer deleted when adding/editing/deleting structure that doesn’t affect dose calculation

The following conditions cause plans to be frozen:

- CT to ED file replaced
- External structure is modified
- Internal Structure with ED is modified
- Assigned bolus or couch structure is modified or assigned/unassigned
- MLCGeometry, MLCDynamics or MLCLeakage are modified (Settings, Physics)
User can choose what to do when loading plan with Frozen Dose:
Frozen Dose

Frozen Dose Warning in T/S/C views and reports
SBRT

(Stereotactic Body Radiation Therapy)
SBRT

• **Why so much SBRT**
  
  • Because your clinic and your Physicians want to do it
  
  • Because you did SBRT lung so you can treat anything SBRT
  
  • Because we want to keep the Physicians happy!
SBRT Monte Carlo

- **Provides an accurate dose representation in the periphery of the tumor**
  - Most algorithms underestimate in this specific area especially in the lung

- **Uses XVMC for accurate dose calculation**

- **Shows the true point maximum doses**
  - Important for serial OARS
History of SBRT at Allegheny Health Network

- **Started treating SBRT in 2007 @ AGH then moved out to the other sites**
- **Siemens Machine**
  - Treat with the Artiste and Primus
    - Artiste 6X only

- **Elekta machines**
  - Resubmitted beam data for small field modelling (September 2015)
    - During validation it was noticed that the small fields needed to be remodeled
  - Received new beams from Elekta and starting to validate (November 2015)
    - Created one model for all three Elekta machines
SBRT at Allegheny Health Network

- **Sites treated with SBRT**
  - Lung
  - Liver
  - Spine
  - Pancreas
  - Prostate (Occasionally)
  - Anything else the Physician wants
SBRT Dose Prescriptions

- **Lung**
  - 1200 x 4
  - Central lesion (800 X 5) OR (900 X 5)

- **Liver**
  - 1200 x 4

- **Spine**
  - 800 x 3
  - 1350 x 1

- **Pancreas**
  - 500-600 x 5
SBRT - like it a bit better

• **SBRT at Allegheny General.**
  • XiO

• **SBRT on Monaco**
  • **Prior to Monaco 5.1 planning SBRT was so slow**
    • Put your beams on
    • Set your prescription
    • Make sure the calculation properties are correct
    • Run the calculation
    • Modify one leaf, loose the dose
    • Run the calculation, modify one leaf
SBRT Monaco 5.1

- **Move a leaf and the dose stays**
  - This is huge

- **Grid Spacing**
  - 2mm grid for small lesions

- **Calculation Properties**
  - Per Control point
  - Per Calculation
    - Which one do I use
SBRT XiO vs Monaco

XiO

Monaco
SBRT IMRT Spine (L Spinal Neuroma)
1350cGy in 1 Fx
-planned in Monaco due to the bone-tissue interface and the fact that the tumor was so small.
# IMRT Constraints

## HWP Elekta

<table>
<thead>
<tr>
<th>Structure</th>
<th>Cost Function</th>
<th>Enabled</th>
<th>Status</th>
<th>Manual</th>
<th>Weight</th>
<th>Reference Dose (Gy)</th>
<th>Multispectral</th>
<th>Isocentric</th>
<th>Isoeffect</th>
<th>Relative Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV</td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>2.05</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Target Penalty</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>1.85</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum Dose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.21</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cord</td>
<td>Maximum Dose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.27</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cord + 5cm</td>
<td>Maximum Dose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.21</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Kidney</td>
<td>Serial</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.62</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Kidney</td>
<td>Serial</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.81</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient</td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.21</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.21</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.21</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.21</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.10</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## AGH Artiste

<table>
<thead>
<tr>
<th>Structure</th>
<th>Cost Function</th>
<th>Enabled</th>
<th>Status</th>
<th>Manual</th>
<th>Weight</th>
<th>Reference Dose (Gy)</th>
<th>Multispectral</th>
<th>Isocentric</th>
<th>Isoeffect</th>
<th>Relative Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV</td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.30</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Target Penalty</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>1.00</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maximum Dose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cord</td>
<td>Maximum Dose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.04</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cord + 5cm</td>
<td>Maximum Dose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Kidney</td>
<td>Serial</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Kidney</td>
<td>Serial</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patient</td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>Y</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.04</td>
<td>190.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SBRT IMRT Spine  DVH
Questions
VMAT

(Volumetric Modulated Arc Therapy)
History VMAT

January 2011

Monaco was used to treat a VMAT plan at St. James University Hospital in the UK. After fully understanding Monaco, a head and neck VMAT can be completed in two to three hours after contouring,

“Monaco has transformed our IMRT service” Dr. Cosgrove
VMAT at Allegheny Health Network

- **Went live with VMAT March 2016**
- **Biggest hold up**
  - 14 Physicists..
    - DO they know when to stop
- **Created a single beam for all three Elekta LINACS they are matched**
- **Prior to go live**
  - Test plans (~ 25) were created and delivered to a solid water phantom (Cheese) that has different plug locations and a chamber measurement recorded.
  - The test plans were delivered to the ArcCheck device and chamber measurements recorded.
- Use the ArcCheck device from Sun-nuclear with the multiplug for QA of the VMAT plans.
3DVH (Chamber position locator)
ArcCheck
### Verification of VMAT

<table>
<thead>
<tr>
<th></th>
<th>Arc Check 2% 2mm</th>
<th>ArcCheck 3% 3mm</th>
<th>Chamber</th>
</tr>
</thead>
<tbody>
<tr>
<td>L4 L5</td>
<td>95.8</td>
<td>99.5</td>
<td>-1.60%</td>
</tr>
<tr>
<td>Prostate</td>
<td>96.7</td>
<td>99.3</td>
<td>-0.70%</td>
</tr>
<tr>
<td>Prostate</td>
<td>99</td>
<td>100</td>
<td>-0.50%</td>
</tr>
<tr>
<td>Brain</td>
<td>92.6</td>
<td>99.3</td>
<td>-1.70%</td>
</tr>
</tbody>
</table>
What is VMAT

• **VMAT = Volumetric Modulated Arc Therapy**

• **Monaco VMAT allows for full or partial arcs and creates the desired radiation field by modulating the gantry speed, MLC speed and direction and dose rate**

• **Beam is broken into Arc segments that are specified at time of planning**

• **All initial arc segments will contain the full number of degrees while the last arc segment will use up the remainder. (100 degrees/20 = 3 full segments of 30 degrees + 1 partial segment which moves 10 degrees)**
Monaco VMAT Algorithm Stage 1

- Optimized fluence maps are produced at a series of discrete beam angles
Monaco VMAT Algorithm Stage 2

- These optimized fluence are then converted into deliverable VMAT arcs with segments
Spot the difference

MLC’s cause a lot of problems but they are a fact of life
VMAT vs IMRT XiO
VMAT vs IMRT

Prostate

![Graph showing dose-volume histograms for prostate with IMRT and VMAT comparison.](image-url)
Constraints

### IMRT Constraints

<table>
<thead>
<tr>
<th>Structure</th>
<th>Cost Function</th>
<th>Enabled</th>
<th>Status</th>
<th>Manual</th>
<th>Weight</th>
<th>Reference Dose (cGy)</th>
<th>Multicentral</th>
<th>Isconstrained</th>
<th>Isocentric</th>
<th>Relative Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1 + FTV1</td>
<td>Target Penalty</td>
<td>On</td>
<td>On</td>
<td></td>
<td>1.00</td>
<td>4900.0</td>
<td>4462.3</td>
<td></td>
<td></td>
<td>++</td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>On</td>
<td>On</td>
<td></td>
<td>0.72</td>
<td>4750.0</td>
<td>70.0</td>
<td>65.6</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td>Rectum</td>
<td></td>
<td>On</td>
<td>On</td>
<td></td>
<td>6.25</td>
<td>3900.0</td>
<td>3925.0</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>On</td>
<td>On</td>
<td></td>
<td>2.34</td>
<td>2900.0</td>
<td>2851.4</td>
<td></td>
<td></td>
<td>++</td>
</tr>
<tr>
<td>Bladder</td>
<td></td>
<td>On</td>
<td>On</td>
<td></td>
<td>2.44</td>
<td>4200.0</td>
<td>4555.1</td>
<td></td>
<td></td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td></td>
<td>On</td>
<td>On</td>
<td></td>
<td>4.19</td>
<td>3220.0</td>
<td>3152.9</td>
<td></td>
<td></td>
<td>+++</td>
</tr>
<tr>
<td>Liver</td>
<td></td>
<td>On</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>4250.0</td>
<td>4224.0</td>
<td></td>
<td></td>
<td>+++</td>
</tr>
<tr>
<td>R. Femur</td>
<td></td>
<td>On</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>3600.0</td>
<td>1593.7</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>L. Femur</td>
<td></td>
<td>On</td>
<td>On</td>
<td></td>
<td>1.12</td>
<td>1600.0</td>
<td>1576.1</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Patient</td>
<td></td>
<td>On</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>4300.0</td>
<td>10.0</td>
<td>9.3</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>On</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>4500.0</td>
<td>10.0</td>
<td>9.3</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>On</td>
<td>On</td>
<td></td>
<td>0.01</td>
<td>4500.0</td>
<td>10.0</td>
<td>9.3</td>
<td>++</td>
<td>+++</td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>On</td>
<td>On</td>
<td></td>
<td>0.12</td>
<td>3600.0</td>
<td>20.0</td>
<td>20.3</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

### Serial

**Required Parameters**
- Equivalent Uniform Dose (cGy): 500.0
- Power Law Exponent: 15.00

**Optional Physical Parameters**
- Shrink Margin (cm): 0.00
- Optimize over all voxels in volume: [ ]
- Multicentral: [ ]

Acts like a Max

Acts like a Mean

Allegheny Health Network
# Beam Sequencing

## Beam Sequencing Parameters: VMAT

- **Segment Shape Optimization**: 
- **Plot Beamlets**: 
- **Max. Number of Arcs**: 2
- **Max. # of Control Points Per Arc**: 100
- **Target Dose Rate (MU/min)**: 
- **Min. Segment Width (cm)**: 1.00
- **Fluence Smoothing**: Medium

![Beam Sequencing Interface](image)
IMRT vs VMAT
VMAT non vs VMAT
DVH Orbit
VMAT and SBRT combined
DVH

![DVH Diagram]

<table>
<thead>
<tr>
<th>Structure</th>
<th>Cost Function</th>
<th>Enabled</th>
<th>Status</th>
<th>Manual</th>
<th>Weight</th>
<th>Reference Dose (Gy)</th>
<th>Multiplier</th>
<th>Isocentric</th>
<th>Isocentre</th>
<th>Relative Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>PTV1</td>
<td>Target Penalty</td>
<td>On</td>
<td></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td>2000.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quadratic Overdose</td>
<td>On</td>
<td></td>
<td></td>
<td>2.89</td>
<td>2060.0</td>
<td></td>
<td>27.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Coast Equina</td>
<td>Maximum Dose</td>
<td>On</td>
<td></td>
<td></td>
<td>9.83</td>
<td></td>
<td></td>
<td>1800.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Serial</td>
<td>Serial</td>
<td>On</td>
<td></td>
<td></td>
<td>0.01</td>
<td></td>
<td></td>
<td>1600.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Serial</td>
<td>Serial</td>
<td>On</td>
<td></td>
<td></td>
<td>0.01</td>
<td></td>
<td></td>
<td>1450.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>R. Kidney</td>
<td>Serial</td>
<td>On</td>
<td></td>
<td></td>
<td>2.72</td>
<td></td>
<td></td>
<td>600.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>L. Kidney</td>
<td>Serial</td>
<td>On</td>
<td></td>
<td></td>
<td>0.01</td>
<td></td>
<td></td>
<td>700.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Sin Bowel</td>
<td>Serial</td>
<td>On</td>
<td></td>
<td></td>
<td>0.01</td>
<td></td>
<td></td>
<td>1000.0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>Patient</td>
<td>Quadratic Overdose</td>
<td>On</td>
<td></td>
<td></td>
<td>0.01</td>
<td>2000.0</td>
<td></td>
<td>5.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Quadratic Overdose</td>
<td>On</td>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
<td>1500.0</td>
<td></td>
<td>5.0</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Conformal</td>
<td>On</td>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
<td>55.50</td>
<td></td>
<td>0.95</td>
<td>0.00</td>
<td></td>
</tr>
</tbody>
</table>

(click to add a new structure)
Calculation considerations

• IMRT Parameters

- Minimum CT Number: Use with Clear option.
- Auto Flash Margin (cm): 0.20
- Surface Margin (cm): 0.30
- Beamlet Width (cm): 0.20
- Target Margin: Normal (8mm)
- Avoidance Margin: Normal (8mm)
- Bias Contribution: 

OK Cancel
### Treatment Time Comparison

**Average VMAT plan vs. Average IMRT plan**

<table>
<thead>
<tr>
<th>Location</th>
<th>Modality</th>
<th>Arcs/Fields</th>
<th>MU (cGy/MU)</th>
<th>Segments</th>
<th>Treatment Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head and Neck</td>
<td>VMAT</td>
<td>2 Arcs</td>
<td>664.56</td>
<td>169</td>
<td>3 minutes</td>
</tr>
<tr>
<td></td>
<td>IMRT</td>
<td>9 Fields</td>
<td>588.43</td>
<td>132</td>
<td>8 minutes</td>
</tr>
<tr>
<td>Prostate</td>
<td>VMAT</td>
<td>1 Arc</td>
<td>611.2</td>
<td>78</td>
<td>2 minutes</td>
</tr>
<tr>
<td></td>
<td>IMRT</td>
<td>7 Fields</td>
<td>423.7</td>
<td>117</td>
<td>6 minutes</td>
</tr>
<tr>
<td>Prostate</td>
<td>VMAT</td>
<td>1 Arc</td>
<td>533.2</td>
<td>96</td>
<td>2 minutes</td>
</tr>
<tr>
<td></td>
<td>IMRT</td>
<td>7 Fields</td>
<td>428.1</td>
<td>104</td>
<td>6 minutes</td>
</tr>
<tr>
<td>Prostate and Nodes</td>
<td>VMAT</td>
<td>2 Arcs</td>
<td>683.1</td>
<td>154</td>
<td>4 minutes</td>
</tr>
<tr>
<td></td>
<td>IMRT</td>
<td>7 Fields</td>
<td>457.5</td>
<td>126</td>
<td>5 minutes</td>
</tr>
</tbody>
</table>
Monaco 5.1 Summary

Sequencer Improvements
- Step and Shoot sequencer overhaul
- Hyperion code re-factor (performance improvements)

3 Instances of Concurrent Session Planning

Template Manager (Import/Export) for workflow speed

HP Z840 28 core processor with K40 GPU
Monaco 5.1 on Z820 24C vs. New Release on Z820 24C vs. New release on Z840 28C

- **HeadNeck_Air (S&S IMRT)**: 0:36:13, 0:25:58, 0:25:27
- **Prostate_Air (S&S IMRT)**: 0:45:38, 0:22:06, 0:16:12
- **Lung_Air (S&S IMRT)**: 0:56:38, 0:14:44, 0:28:41

- **HeadNeck_Air (VMAT)**: 0:12:57, 0:13:44, 0:06:10
- **Prostate_Air (VMAT)**: 0:20:20, 0:15:20, 0:10:20
- **Lung_Air (VMAT)**: 0:42:51, 0:28:41, 0:36:05

- **Prostate_Norm (S&S IMRT)**: 0:08:00, 0:10:01, 0:12:28
- **Prostate_Norm (VMAT)**: 0:42:22, 0:10:20, 0:11:44
Monaco – Speed Improvements

<table>
<thead>
<tr>
<th>Case</th>
<th>Monaco 5.10 on Z820 24C (hh:mm:ss)</th>
<th>New Patch on Z840 28C (hh:mm:ss)</th>
<th>Savings (hh:mm:ss)</th>
<th>Total Speed Up (Times Faster)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head Neck_Air (S&amp;S IMRT)</td>
<td>0:36:13</td>
<td>0:05:55</td>
<td>0:30:18</td>
<td>6.12</td>
</tr>
<tr>
<td>Head Neck_Air (VMAT)</td>
<td>0:25:58</td>
<td>0:08:43</td>
<td>0:17:15</td>
<td>2.98</td>
</tr>
<tr>
<td>Prostate_Air (S&amp;S IMRT)</td>
<td>0:25:27</td>
<td>0:04:22</td>
<td>0:21:05</td>
<td>5.83</td>
</tr>
<tr>
<td>Prostate_Air (VMAT)</td>
<td>0:45:38</td>
<td>0:10:01</td>
<td>0:35:37</td>
<td>4.56</td>
</tr>
<tr>
<td>Prostate_Norm (S&amp;S IMRT)</td>
<td>0:22:06</td>
<td>0:08:00</td>
<td>0:14:06</td>
<td>2.76</td>
</tr>
<tr>
<td>Prostate_Norm (VMAT)</td>
<td>0:14:44</td>
<td>0:10:20</td>
<td>0:04:24</td>
<td>1.43</td>
</tr>
<tr>
<td>Lung_Air (S&amp;S IMRT)</td>
<td>0:56:38</td>
<td>0:12:28</td>
<td>0:44:10</td>
<td>4.54</td>
</tr>
<tr>
<td>Lung_Air (VMAT)</td>
<td>0:42:51</td>
<td>0:11:44</td>
<td>0:31:07</td>
<td>3.65</td>
</tr>
</tbody>
</table>

- Average **4x** faster - New patch on Z840 28C compared with Monaco 5.1 release on Z820 24C

- Speed improvement comes from **both** hardware improvements and software code change
In Conclusion:

As we expand our department and increase our ease with Monaco planning, I am looking forward to using this system exclusively.

Our SBRT and VMAT programs continue to expand rapidly and our dosimetrists are embracing the challenge of learning and perfecting the plans that they are producing.
Questions?
Thank You