1. Introduction
2. Material
3. Optimization process
4. Results
5. Comments
6. Conclusion
7. Thanks
Plan Competition: opportunity to evaluate our current treatment technique for left sided breast

✓ VMAT with 2 partial arcs
✓ First patient treated in September 2014
TREATMENT PLANNING SYSTEM

- **RayStation (RaySearch) r.5.0**
  - Dose calculation for photon beams
    - Collapsed cone convolution superposition algorithm
    - GPU: Fluence + Convolution
  - Plan Optimization
    - Standard inverse planning
    - Clinical goals
## TREATMENT PLANNING SYSTEM

- Clinical goals

<table>
<thead>
<tr>
<th>Dose</th>
<th>ROI/POI</th>
<th>Clinical goal</th>
<th>Value</th>
<th>Result</th>
<th>% outside grid</th>
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<tbody>
<tr>
<td>Plan dose: Mallex Hugues 2 (CT 1)</td>
<td>BREAST_RIGHT</td>
<td>At most 2.00 Gy dose at 0.3 cm³ volume</td>
<td>11.31 Gy</td>
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<td>BREAST_RIGHT</td>
<td>At most 2.00 Gy dose at 5.00 % volume</td>
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<tr>
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<td>At most 5.00 Gy average dose</td>
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<td>Plan dose: Mallex Hugues 2 (CT 1)</td>
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<td>0 %</td>
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<td>49.80 Gy</td>
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<td>At most 52.00 Gy dose at 50.00 % volume</td>
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<td>SPINAL CORD</td>
<td>At most 8.00 Gy dose at 0.0 cm³ volume</td>
<td>14.08 Gy</td>
<td>✔</td>
<td>0 %</td>
</tr>
</tbody>
</table>
- Versa HD (Elekta)
  - Standard 6 MV
  - MLC Agility
OPTIMIZATION PROCESS

1. Beam geometry
Not guided by dosimetric considerations but by technical constraints:

- **Constraint n°1: CBCT**
  - The isocenter must be placed to avoid collisions
Constraint n°2: CBCT

- The isocenter must be placed to get the entire breast inside the field of view
○ **Constraint n°3: Jaws and MLC maximum opening**

✔ The isocenter must be placed to cover the entire PTV
o No couch rotation

o **Gantry**
  - ✓ Arc 1: 170° → ~ 300°
  - ✓ Arc 2: ~ 300° → 170°

o **Collimator**:
  - ✓ Arc 1: 5°
  - ✓ Arc 2: 355°

o **Grid size**:
  - ✓ Plan Competition: 1,5 mm
  - ✓ Current practice: 3 mm

o **Gantry spacing between 2 CP**: 4°
OPTIMIZATION PROCESS

1. Beam geometry

2. Create additional structures
ADDITIONAL OPTIMIZATION STRUCTURES
ADDITIONAL OPTIMIZATION STRUCTURES
OPTIMIZATION PROCESS

1. Beam geometry

2. Create additional structures

3. Initial objectives
OPTIMIZATION PROCESS

- Initial objectives
OPTIMIZATION PROCESS

- Initial objectives

<table>
<thead>
<tr>
<th>Function</th>
<th>Constraint</th>
<th>Dose</th>
<th>ROI</th>
<th>Description</th>
<th>Robust</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Physical Composite Objective</td>
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<tr>
<td>Uniform Dose</td>
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<td>PTV_TOT_EVAL</td>
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<td>Max Dose</td>
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<td>zc</td>
<td>Max Dose 30.00 Gy</td>
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</tbody>
</table>
OPTIMIZATION PROCESS

1. Beam geometry

2. Create additional structures

3. Initial objectives

PTV criteria OK?
INITIAL OBJECTIVES

- Uniform dose and prescription
  - Usually: 50 Gy to median dose (ICRU 84)
  - in this case: 51,5 Gy to median dose
### INITIAL OBJECTIVES

<table>
<thead>
<tr>
<th>Function</th>
<th>Constraint</th>
<th>Dose</th>
<th>ROI</th>
<th>Description</th>
<th>Robust</th>
<th>Weight</th>
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<tr>
<td>Physical Composite Objective</td>
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<td>Uniform Dose</td>
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<td>Plan</td>
<td>zc</td>
<td></td>
<td>Max Dose 30.00 Gy</td>
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<td>10</td>
</tr>
</tbody>
</table>
1. Beam geometry

2. Create additional structures

3. Initial objectives

   PTV criteria OK?

4. Add OAR objectives (weight = 1)
OAR CRITERIA

- 2 types of criteria for OAR:
  - maximum dose
    - Right breast
    - Spinal cord
  - Parallel organs
    - Heart
    - Left lung
    - Right lung
MAXIMUM DOSE CRITERIA

- Maximum dose:
  - Right breast
    - BREAST_RIGHT: At most 2.00 Gy dose at 0.3 cm³ volume
    - BREAST_RIGHT: At most 2.00 Gy dose at 5.00 % volume
  - Spinal cord
    - SPINAL CORD: At most 8.00 Gy dose at 0.0 cm³ volume
MAXIMUM DOSE : OAR OBJECTIVES

- Additional structures
  - Breast right + 2 mm
  - Spinal cord + 2 mm

<table>
<thead>
<tr>
<th>Structure</th>
<th>Max Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast right + 2 mm</td>
<td>1.80 Gy</td>
</tr>
<tr>
<td>Spinal cord + 2 mm</td>
<td>7.80 Gy</td>
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</tbody>
</table>
PARALLEL OAR CRITERIA

- Parallel OAR
  - Heart
    - HEART: At most 4.00 Gy average dose
    - HEART: At most 15.00 % volume at 15.00 Gy dose
    - HEART: At most 20.00 Gy dose at 5.00 % volume

- Left Lung
  - LUNG_LEFT: At most 9.00 Gy average dose
  - LUNG_LEFT: At most 15.00 % volume at 20.00 Gy dose
  - LUNG_LEFT: At most 30.00 % volume at 10.00 Gy dose
  - LUNG_LEFT: At most 50.00 % volume at 5.00 Gy dose
PARALLEL OAR CRITERIA

- Parallel type OAR dosimetric criteria
  - Right Lung:
PARALLEL OAR OBJECTIVES

- Only one objectif by OAR

<table>
<thead>
<tr>
<th>HEART</th>
<th>Max DVH 4.00 Gy to 12% volume</th>
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</thead>
<tbody>
<tr>
<td>HEART</td>
<td>At most 4.00 Gy average dose</td>
</tr>
<tr>
<td>HEART</td>
<td>At most 15.00 % volume at 15.00 Gy dose</td>
</tr>
<tr>
<td>HEART</td>
<td>At most 20.00 Gy dose at 5.00 % volume</td>
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</table>

<table>
<thead>
<tr>
<th>LUNG_LEFT</th>
<th>Max EUD 10.00 Gy, Parameter A 1.95</th>
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<td>LUNG_LEFT</td>
<td>At most 9.00 Gy average dose</td>
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<tr>
<td>LUNG_LEFT</td>
<td>At most 15.00 % volume at 20.00 Gy dose</td>
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<tr>
<td>LUNG_LEFT</td>
<td>At most 30.00 % volume at 10.00 Gy dose</td>
</tr>
<tr>
<td>LUNG_LEFT</td>
<td>At most 50.00 % volume at 5.00 Gy dose</td>
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</tbody>
</table>

- Initial weight: 1
3. Initial objectives (PTV, ring)

4. Add OAR objectives (weight = 1)

5. Fine-tune parallel OAR objectives

clinical goals OK ?

6. increase the weight of the OAR objectives

End
HOW TO PUT THE MAXIMUM DOSE INSIDE DE CTV-LUMPECTOMY

- Additional structure:
  - PTV – (CTV-LUMPECTOMY)

- Add objectives:

<table>
<thead>
<tr>
<th></th>
<th>Max Dose</th>
<th>Plan</th>
<th>PTV without CTV-LUMPECTOMY</th>
<th>Max Dose 51.60 Gy</th>
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<td>Plan</td>
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RESULTS
## Results

### Physical Composite Objective

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<tr>
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<th>Constraint</th>
<th>Dose</th>
<th>ROI</th>
<th>Description</th>
<th>Robust</th>
<th>Weight</th>
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</thead>
<tbody>
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<td>Max EUD</td>
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<td>1</td>
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</table>

Better!
DELIVERY TIME

- Delivery time:
  - ✓ Arc 1: 1’13”
  - ✓ Arc 2: 1’18”
PATIENT-SPECIFIC QA
PATIENT-SPECIFIC QA
COMMENTS: INTERFRACTION MOVEMENT
COMMENTS: INTERFRACTION MOVEMENT

- **How to take this into account?**
  - ✓ For fixed fields: skin flash

- ✓ VMAT?
COMMENTS: INTERFRACTION MOVEMENT

- Virtual bolus
Optimization: 2 step process

1) With virtual bolus: Optimization on the PTV OUTSIDE

2) After having removed the virtual bolus: Optimization on the PTV without modifying the shape of the segments
COMMENTS: INTERFRACTION MOVEMENT
In our current technique, we use additional objectives for:

- Larynx
- Thyroid
- esophagus
Some (humble) recommendations:

- Well-defined methodology
  - learning curve
  - homogeneity of practices
- As simple as possible:
  - 2 arcs
  - No couch rotation
  - As few objectives as possible for optimization
- Use of Virtual bolus
THANKS

✓ Ahmad Nobah
✓ Radiation Oncologists
✓ Medical Physics team
✓ RaySearch
✓ My Family