Carbon Ion Therapy for Moving Tumors

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- Ion therapy provides a unique possibility to deliver radiation to many tumor shapes while protecting to body from low levels of radiation dose.
- Ion therapy may be the solution for cancers which have poor outcomes when x-rays are used
  
  Lung cancer, liver cancer, and pancreatic cancer all have low survival rates due to treatment complications, tumor recurrence, and tumor spread.

10 Year Cancer Survival Rates

<table>
<thead>
<tr>
<th>Cancer Type</th>
<th>Survival Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Cancers</td>
<td>58%</td>
</tr>
<tr>
<td>Prostate</td>
<td>85%</td>
</tr>
<tr>
<td>Brain</td>
<td>18%</td>
</tr>
<tr>
<td>Kidney</td>
<td>57%</td>
</tr>
<tr>
<td>Pancreas</td>
<td>1%</td>
</tr>
<tr>
<td>Lung</td>
<td>8%</td>
</tr>
<tr>
<td>Liver</td>
<td>14%</td>
</tr>
</tbody>
</table>

Lung, Liver and Pancreatic cancers

- Low survival rates are due to both unsuccessful eradication of the cancer and long term side effects due to low levels of radiation on organ function.
- These cancers are difficult to treat because they move as the patient breathes.
- We need to accurately monitor where the tumor moves inside the patient by tracking how the patient breathes from the outside. Tracking markers (left) are a good option.

Radiation treatment plans for 3 of the 10 cross-sections

1. 10 treatment plans can be created for 10 locations that the tumor moves through during any respiratory cycle (i.e. from beginning of inhale, back to beginning of inhale)
2. Motion tracking markers are used to signal when the tumor has moved into each of the locations.
3. Dose delivery system switches to the appropriate treatment delivery plan.

Comparison of Treatment Strategies

- ~ 2cm tumor amplitude
- 3 fields hypofractionated carbon ion therapy plan

Dose delivery without proper motion handling techniques
Typical lung treatment plans using carbon ions
Our current 4D dose delivery strategy

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