Respiratory Gating with Novalis ExacTrac @ THOCC

George Pavlonnis and Hui Wang

The Hospital of Central Connecticut

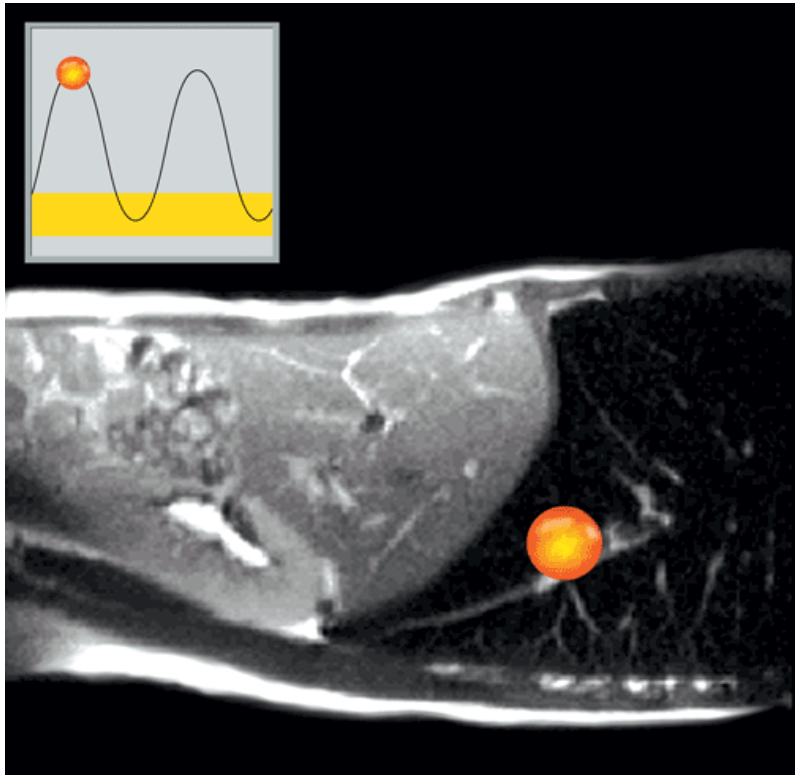
Department of Radiation Oncology

Disclosures

- I don’t know what I am talking about
- I usually make things up as I go
- If you believe anything I say during this presentation you should start making your own disclosure statement!

Why Gating ?

- Target Motion
  - Lung
  - Liver
  - Adrenal glands
- Beam on when target in position



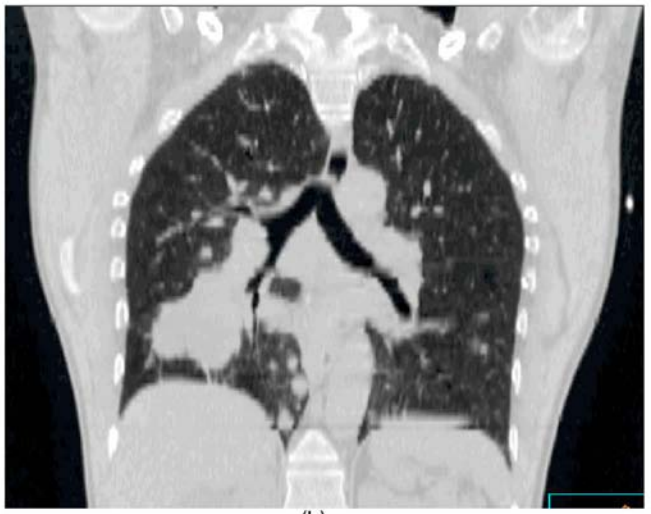
4D CT Simulation

- Surrogate motion tracked with IR camera
- CT slices acquired at different phases of respiratory cycle
- Move couch and repeat acquisition
- Sort images by using phase stamp

Motion Assessment

- Determine extent of target motion
- Determine treatment window
- Generate MIP
- Use treatment window center phase CT for planning.

(a)



(b)

Treatment Planning

- Maximize Beam Utilization
- Minimize Motion (S/I)
  - Lung Motion (2 mm to 18 mm)
  - Liver (10 mm to 28 mm)
  - Renal (5 mm to 24 mm)
  - AP/PA & LT/RT to a much lesser extent
- Beam Orientation and Couch

Imaging Couch Top (ICT)

- Couch Dimensions
- Lack of Skin Sparring
- Number of Beams
- Orientation of Beams

Gantry	Measured	TPS (Table Removed)	Difference from Measured	TPS (Including Table)	Difference from Measured
180	85.6	85.4	0.2%	85.4	0.2%
0	78	80.9	-3.7%	78.0	0.0%
10	77.6	80.4	-3.6%	77.5	0.1%
20	76.2	79.2	-3.9%	76.1	0.1%
30	73.7	77	-4.5%	73.6	0.1%
40	69.7	73.2	-5.0%	69.5	0.3%
50	63.5	67.5	-6.3%	63.5	0.0%
60	53.9	58.6	-8.7%	52.5	2.6%
70	50	53.4	-6.8%	51.4	-2.8%

When the 5 cm thick Carbon Fiber table is NOT taken into account in the planning process, the TPS OVER REPORTS the dose by between 3.6 and 8.7%. (The patient will receive less dose than predicted by the TPS)

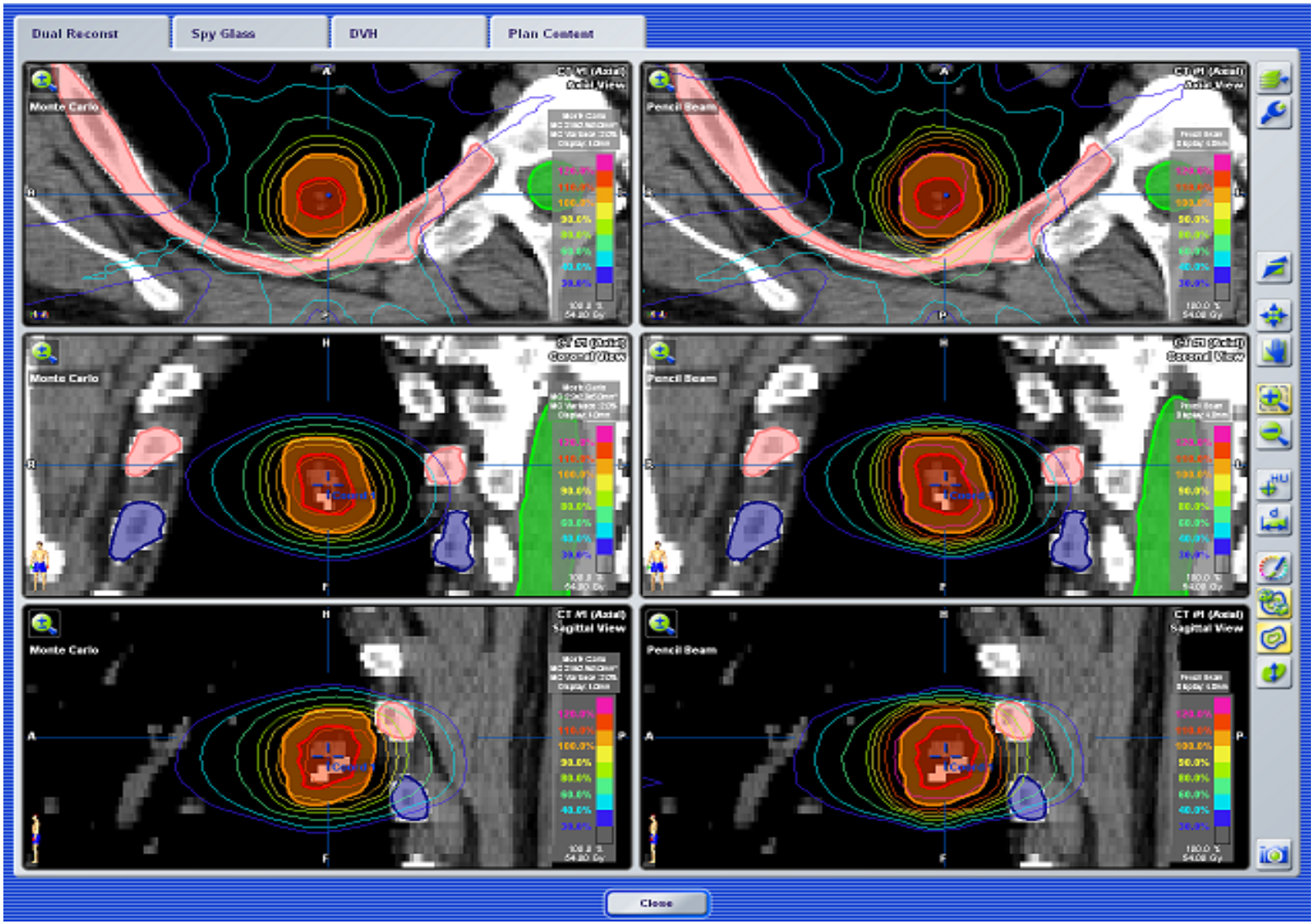
Treatment Planning

- Prescription Doses (Stage I/II NSCLC)
  - Non-centrally located lesions
    - 2,000 cGy/fx x 3 fractions (RTOG 0618)
    - 1,800 cGy/fx x 3 fractions (RTOG 0618 - Hetero)
    - 3,400 cGy (1 Fraction) vs
      4,800 cGy (4 Fractions) (RTOG 0915)
  - Centrally located lesions
    - 1,000 cGy/fx x 5 fractions (RTOG 0813)

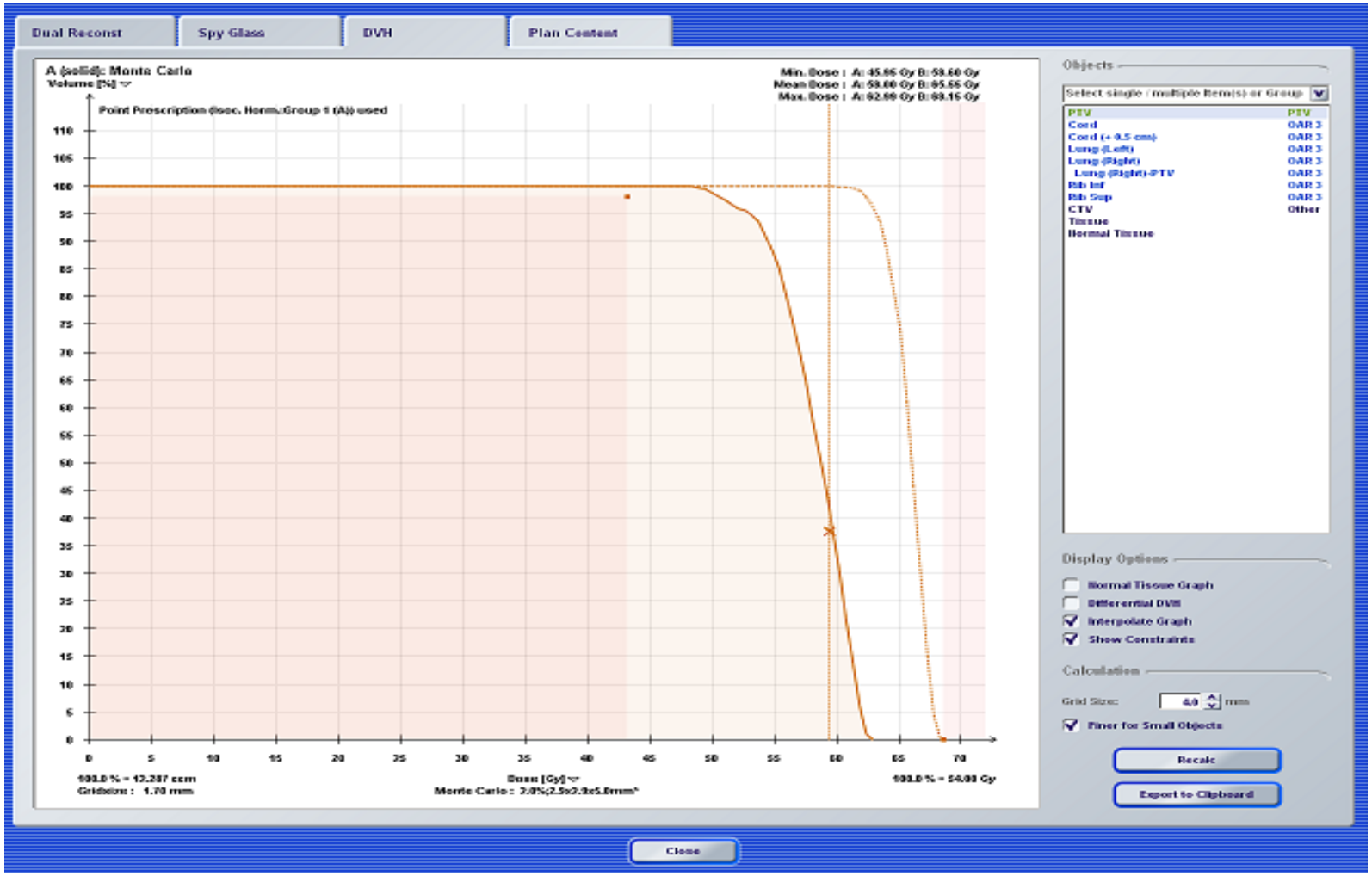
Treatment Planning

- Monte Carlo vs. Pencil Beam

Treatment Planning



Treatment Planning



Treatment Planning

SRS - 3 Fractions

Values from Timmerman are "mostly unvalidated" and based on their SBS/SBRT experience. This table was mostly reproduced from his excellent articl

Structure	Volume (cc)	Total Dose (Gy)	Dose per Fraction (Gy)	Max Point Dose (Gy)	Max Point Dose per Fraction (Gy)	Endpoint	Notes
Brachial plexus (ipsilateral)	3	22.5	7.5	24	8.0	Neuropathy	
Bronchus (ipsilateral)	4	15	5.0	30	10.0	Stenosis/fistula	Avoid circumferential radiation
Esophagus	5	21	7.0	27	9.0	Stenosis/fistula	Avoid circumferential radiation
Great vessels	10	39	13.0	45	15.0	Aneurysm	
Heart/pericardium	15	24	8.0	30	10.0	Pericarditis	
Liver	>700	17.1	5.7	-	-	Basic liver function	Parallel structure, spare at least this volume*
Lung (right and left)	15%	20	6.7	-	-		Minor deviation
Lung (right and left)	10%	20	6.7	-	-		Ideal
Lung (right and left)	>1000	11.4	3.8	-	-	Pneumonitis	Parallel structure, spare at least this volume*
Lung (right and left)	>1500	10.5	3.5	-	-	Basic lung function	Parallel structure, spare at least this volume*
Sacral plexus	3	22.5	7.5	24	8.0	Neuropathy	
Skin	10	22.5	7.5	24	8.0	Ulceration	
Spinal cord	0.25	18	6.0	22	7.3	Myelitis	
Spinal cord	1.2	11.1	3.7	22	7.3	Myelitis	
Stomach	10	21	7.0	24	8.0	Ulceration/fistula	
Trachea	4	15	5.0	30	10.0	Stenosis/fistula	Avoid circumferential radiation

RTOG 0618 only lists Max Point Doses, so all Volume/Dose points are from Timmerman

Timmerman: Robert D. Timmerman, "An Overview of Hypofractionation and Introduction to This Issue of Seminars in Radiation Oncology," Sem Rad Onc 18, 215-222 (2008).

*For parallel structures, subtract the volume that receives the listed dose from the total size of the organ and verify it is less than the volume listed. For example, a patient's liver is 2000 cc. An int receives 17.1 Gy. This means (100%-55%=) 45% of the liver has been spared from 17.1 Gy. 45% of this patient's liver is 900 cc, which is more than the listed 700 cc volume, so the plan would meet that the DVH point you would use for IMRT optimization in this case would be (2000-700)/2000 = 65% volume and 17.1 Gy dose.

Delivery

- Team Approach
  - RTT's, Physics & Physician
- Typical time ~ 30 minutes
- Challenges
  - Amplitude modulated surrogate
  - Nomenclature

How It’s Done

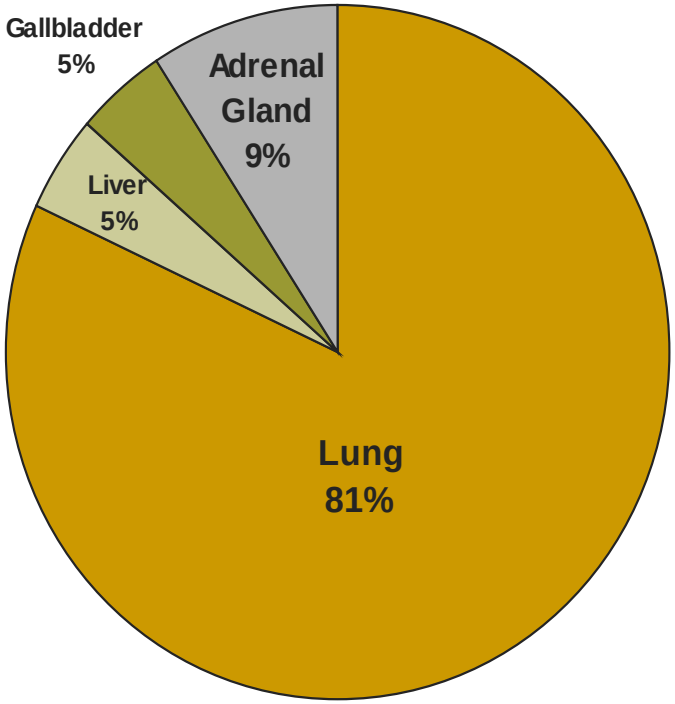
- Track surrogate motion with IR cameras

How It's Done

- Correlation of internal target motion and external surrogate motion
- Set target on isocenter at the center of the beam-on time window with robotic couch
- Determine Beam On Time
- Snap Imaging

Distribution of Cases

- 22 Cases Since February 2009



Pros and Cons

- Pros
  - Reduced Margin
  - Sparing of Healthy Tissue
  - More Accurate Tumor Delivery

- Cons
  - Longer Treatment Time
  - Potential Pneumothorax from Marker Placement
  - Potential Skin Reaction from 6D Couch
  - Potential Rib Fractures