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Respiratory Motion Management

WITHOUT the Bells and Whistles

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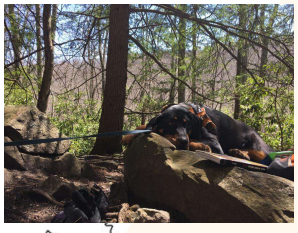

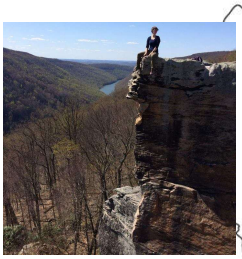

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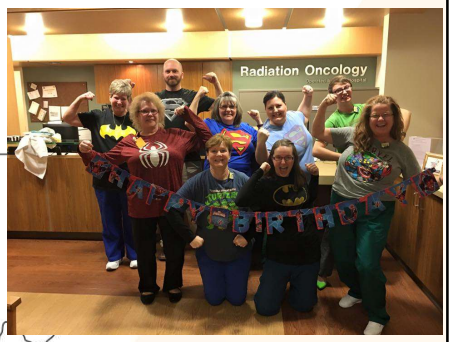
WVU Cancer Institute

4 Facilities: Morgantown,
Fairmont, Parkersburg
Elkins

At Morgantown/ Fairmont:
5 Rad Oncs
5 Physicists
3 Dosimetrists
11 Therapists
5 Rad Nurses



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Dosimetry and Motion Management

- Why you should listen to my talk ☺
  - Motion Management can bring:
    - SBRT
    - Unique margins
    - Unique Contours
    - Multiple Data Sets
    - Gated Treatments
  - AND it *can* make planning easier
    - Motion management → smaller margins → easier to meet constraints

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Report TG-76

- AAPM Task Group: The management of respiratory motion in radiation oncology
- What your physicist should be referencing when creating a gating program

The Management of Respiratory Motion in Radiation Oncology

Report of AAPM Task Group 76

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Motion Management 101

- Patient's breathe during treatment
  - Whether we like it or not
- Anything situated around the diaphragm has potential to move
  - Liver
  - Pancreas
  - Lungs
  - Etc…
- We will focus on Respiratory Motion

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Motion Management 101

- Typical Process
  - Rad Onc consults patient and determines they could benefit from motion management
    - Tumor located near diaphragm
    - Left sided breast
  - Patient receives CT Simulation
    - Breath Hold
      - Left Breast
      - Lung
    - 4DCT
  - Motion analyzed
  - Treatment plan created
  - Treatment delivered
    - Gated
    - Not Gated

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Goals of Motion Management

- Breath Hold
  - Actively have the patient deeply breathe in or out to move the tumor and sensitive structures to a desired location
  - Ex: Deep Inspiration Breath Hold (DIBH) for Left Breasts = patient deeply breathes in, moving the left breast away from the heart
- 4DCT
  - Accurately understand the motion of a tumor
  - This enables us to possibly
    - Up the dose/fx (SBRT)
    - Accurately contour the PTV
    - Reduce dose to sensitive structures

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Motion Management 101

- It's up to your motion management team (Rad Onc, Physicist, CT Techs, Dosimetry, etc..) to answer:
  - 1.) Is motion significant?
    - TG-76 recommends that motion management be implemented for any motion > 5mm
  - 2.) If so, How are we gonna handle it?
    - Contouring
    - Gated Treatment
    - Etc…

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Extent of Motion

Observer/Region	SI Motion (mm)	AP Motion (mm)	LR Motion (mm)
Barnes/Lower	18.5		
Barnes/Upper	7.5		
Ross/ Upper		1	1
Ross/Lower		1	10.1
Plathow/Lower	9.5	6.1	6.0
Plathow/Upper	4.3	2.8	3.4

TG-76 Table 1

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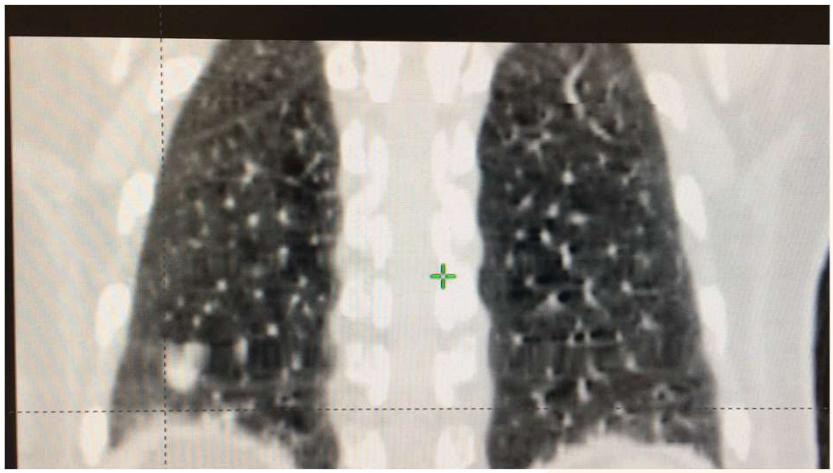
Motion Management 101

They can move A LOT



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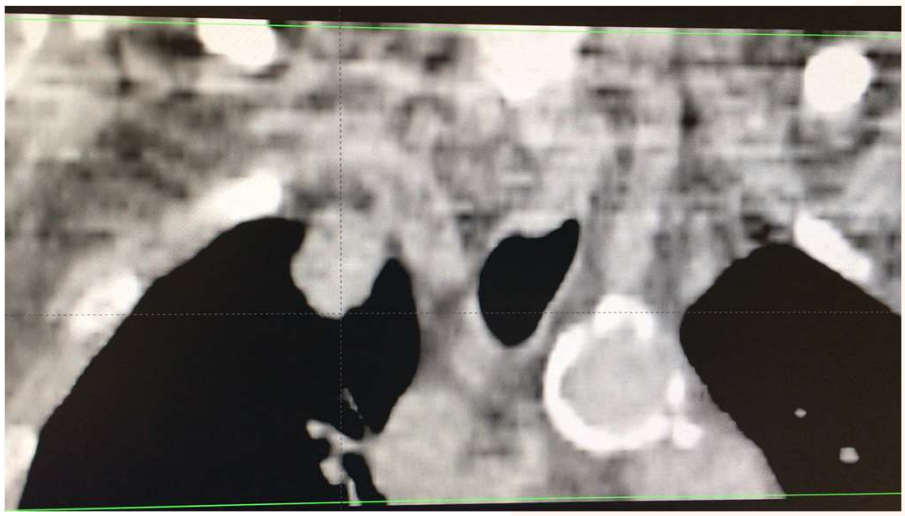
Motion Management 101

They can move a little



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Latest and Greatest Technology Image Acquisition

- Eclipse 13.0
  - Software takes all phases and creates necessary structures, data sets, etc…
- AW Workstation
  - Software - create
- MimVista
  - Import phases into software to create necessary structures, etc…
- GE Scanner
  - Protocols can be set to create AVE, MIN, etc…
- Active Breathing Coordinator
- Varian RPM, fluoro, calypso
- Elekta – Symmetry
- AND MORE

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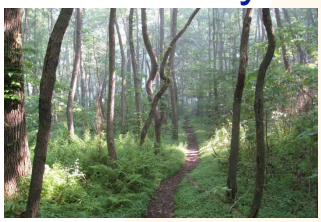
WVU's Motion management Journey

- What we had
  - LB Toshiba Aquilion Scanner
  - Varian RPM system
  - ADW Workstation
  - Eclipse 11

So we had a couple bells and whistles



- What we planned
  - Use CT Scanner to complete 4DCT or Deep Inspiration Breath Hold (DIBH), create Average/MIP's as needed, plan from those, Treat gated if necessary on TrueBeam
- What we found out
  - Toshiba did not create Averages properly
  - We didn't have the proper AW license to create AVE and MIPs
  - We weren't upgrading to eclipse 13 for awhile (still haven't)
  - We weren't getting a new CT anytime soon

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CT - Simulation

- The first part of ANY motion management study starts in the Sim.

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FIRST - Lets talk about Immobilization

- "Cheapest" option to handle motion management.
- Goal = Force Shallow Breathing with Compression
- Great for diaphragm restriction – ex: bile duct
- Advantage – possible reduction in motion
- Disadvantage – can be uncomfortable

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WVUH CT - Options

- Deep Inspiration Breath Hold – Left Breast
- Inhale/Exhale
- 4DCT

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Deep Inspiration Breath Hold (DIBH)

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Breath Hold Process

Left Sided Breast Patients ALL are scanned using the breath Hold technique

- Requirements: Need to be able to hold breath for ~15 seconds to make it through the whole CT

1. Setup patient
2. Free breathing scan
3. Breath Hold Dry-Runs
4. If able – Breath Hold Scan

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Motion Management TIP

- For our breath hold patients we ALWAYS take a regular 3D free breathing scan of our patients
  - WHY?
    - Back up plan if gating cannot/will not be used
      - Collisions, patient fatigue, etc…

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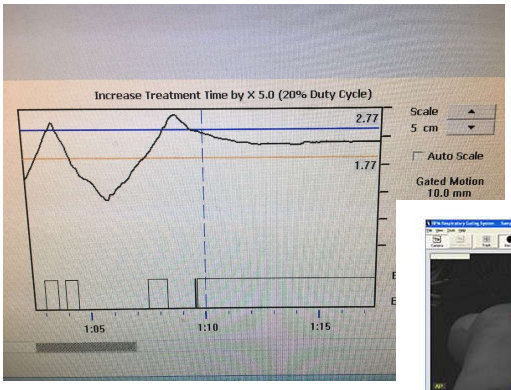
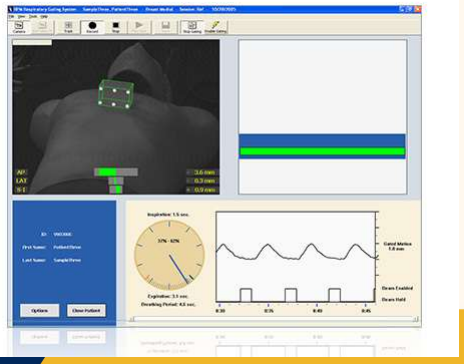
Self – Held Monitoring Breath Hold



"Breathe in .Breathe out. Breathe in. Breathe out. Breathe in. HOLD IT!"



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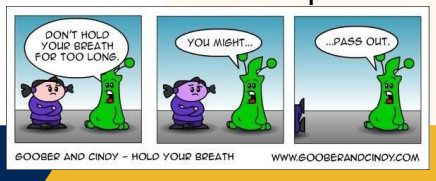
Self-Held No Monitoring

- TG-76
- Patient Voluntarily holds his/her breath during a point in their breathing cycle.
- Advantage: can reduce dose to critical organs for DIBH treatments
- Disadvantage: Relies HEAVILY on patient's ability to understand and reproduce their breath hold.
  - Varian has an added feature – Customer Minor Interlock (CMNR)
- Up to the Rad Onc team to determine adequate margins per patient



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Inhale/Exhale Scans

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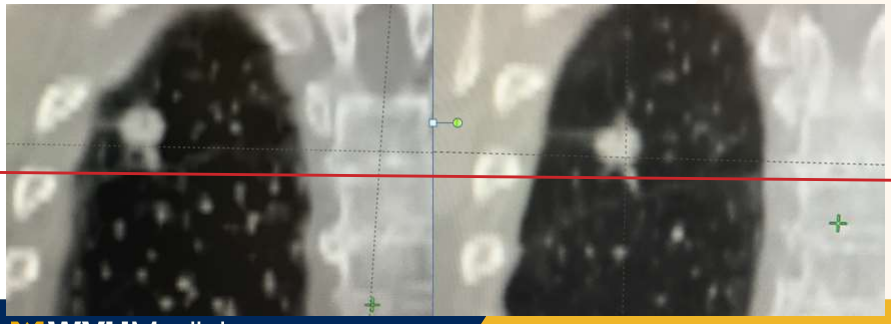
Inhale/Exhale Scan

- Visualize range of motion without the need for a 4DCT scan
  - Irregular breathers
  - Patient's who struggle with coaching



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4DCT

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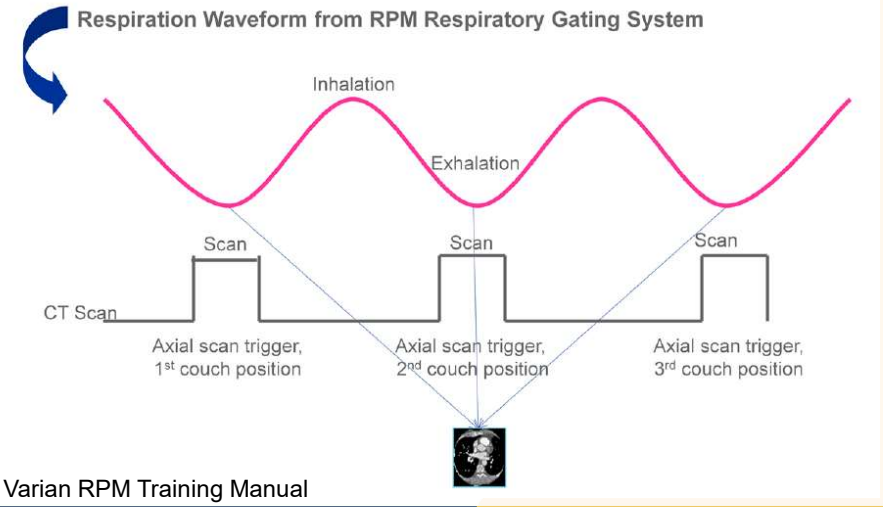
Refresher: CT – Sim Prospective



Varian RPM Training Manual

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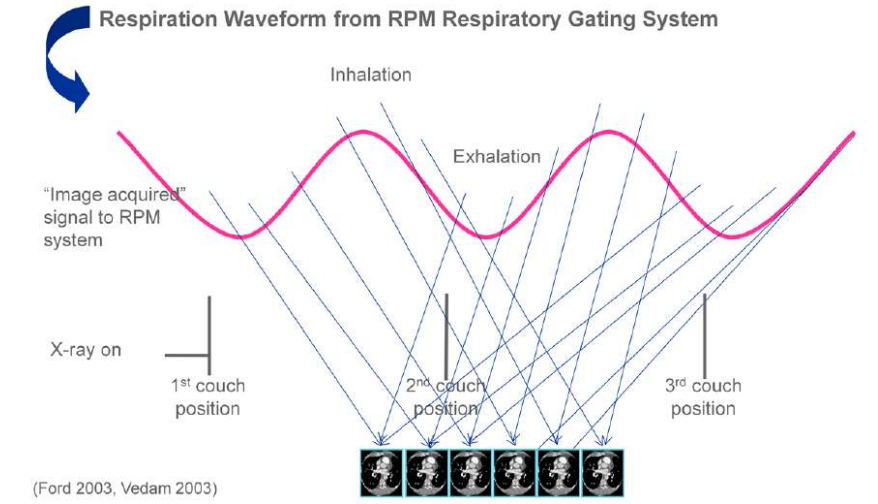
Refresher – Retro Scan



Varian RPM Training Manual

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Average, MIP, MinIP, etc…

- Average = Average CT number found in a given voxel in a set
- MIP = Maximum Intensity Projection = Maximum CT number found in a given voxel in a set
  - Helps reduce blurring
- MinIP = Minimum Intensity Projection = Enables detection of low-density structures in a given volume

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WVU 4DCT process

1. Rad Onc Decides they'd like to 4DCT patient
2. Physics coaches patient in clinical room
3. Patient brought into sim and immobilization setup created
4. 3D Exhale scan
5. 4DCT scan
6. Verify successful Reconstruction
7. Physics analyze motion
8. Physics/Physician discussion of Treatment Plan

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Motion Management TIP

- COACHING!
  - Some CT systems use the patients breathing information to adapt the scanner (GE)
  - Toshiba limits the patients
    - They MUST breathe at least 10 breaths per minute (bpm) or your reconstruction will not work
  - Benefits
    - Eliminates early any patients who aren't capable of being gated (No unnecessary CT Dose)
    - Calms the patients – we are dealing with humans

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WVUH Coaching Process

- Scheduling and Education
  - 15mins before CT is scheduled patient is scheduled in the clinic to meet with a physicist
- Coaching Goals:

Evaluate if the patient is a gating candidate	• **Can they lay down flat** • **Can they take verbal directions**
Evaluate if they will need to be coached or free breathe for the 4DCT	• Are they breathing at least 10 breaths per minute
Evaluate if they can receive an exhale hold CT	• Can they hold their breathe for more than 20 seconds

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3D Exhale Scan

- This is the data set we plan on.
- Why do it?
  - Most of our patient's tend to spend most of their time in the exhale
  - Helps reduce motion artifact

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Toshiba Average Issue

- During testing we discovered that what our system called an AVERAGE was actually just the selected phase reconstructed
- I'm still working with Toshiba about creating a true Average
- BUT → We do in fact get 10 distinct phases

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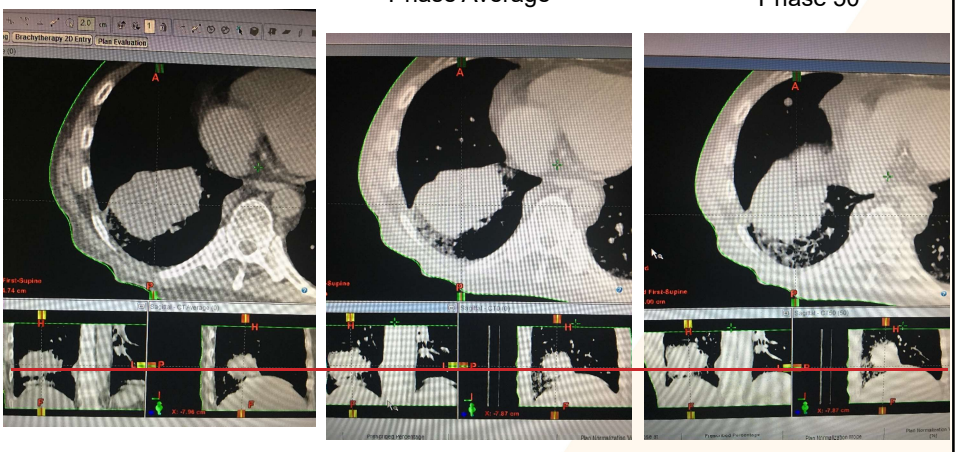
Our "Average"

Phase 0 | Phase Average | Phase 50



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Analyzing

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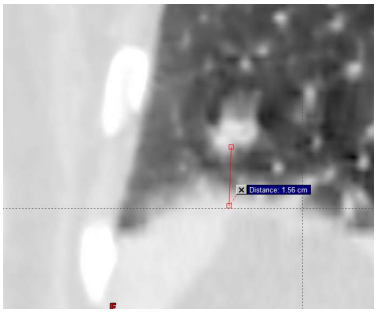
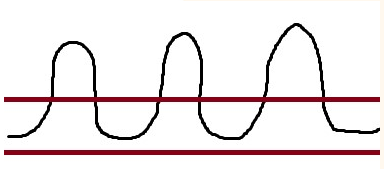
Eclipse 4DCT

- Eclipse TPS can meld the phases from the scan together and blend it into a “movie like” file.
- Physics makes measurements using this set.





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Gating Options at WVU

- All Motion – cutoff for extreme inhale/coughing (VMAT allowed)
  - If a patient is observed to cough, or breathe deeply infrequently during scan this is used as a safety measure
  - ITV created using all phases
- All Motion – cutoff for extreme inhale/coughing (IMRT Only)
  - If a patient is observed to cough or breathe deeply frequently during scan. Saves the Linac from having to "back paddle"
  - ITV created using all phases
- Exhale + margin
  - Tumor moves > 0.5cm
  - Gating plan created to restrict motion of tumor and treatment time
  - Physics and Physician have meeting about this motion
  - ITV created using only selected phases
- Inhale Breath Hold
  - If BH is utilized – Therapist do all documentation – Physics verifies at time of Double Check

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DOCUMENT

Gating Type:

- ☐ All Motion – cutoff for extreme inhale/coughing (VMAT Allowed)
- ☐ All Motion – cutoff for extreme inhale/coughing (IMRT only)
- ☐ Exhale Breath Hold (Upper Threshold of 0.2cm) (IMRT only)
- ☐ Exhale + margin (Upper Threshold defined at time of planning) (IMRT only)
- ☐ Inhale Breath Hold (Breasts Only)
- ☐ No gating to be used during treatment

Gating Parameters 4DCT

Motion Amplitude:
Lower Threshold:
Upper Threshold:

Coached Breathing Information:

Inhale Period:
Exhale Period:

Note: Upper and lower thresholds are decided at the time of planning and may be different for each patient.

Additional Details:

Reminders: *Use default settings to create new, amplitude based gated session. The periodicity filter should be set to zero. Uncheck all coaching boxes. Once the parameters have been set, record the session by clicking start, waiting for a minute, and clicking stop. After clicking OK at the very bottom of the gating screen, the system will let you continue with the gated treatment fields.*

BreathHold Parameters

Upper Threshold:
Lower Threshold:

Additional Details: Delay=1.5s, Threshold =0, Scale = 5 cm.

Reminders: *Use default settings to create new, BreathHold Amplitude based gated session. Time Delay = 1.5. Uncheck all coaching boxes. Once the parameters have been set, record the session by clicking start. Upper and lower Thresholds should be 1cm apart. Make sure breathhold is reproducible. When completed export breathing pattern from RPM desktop.*

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Planning

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Planning a Gated Patient

- The nice thing is, for the most part planning approach doesn't change.
- You will still use the same techniques for IMRT/VMAT/3D
  - For Eclipse the big change is whether or not you check the Gating Box

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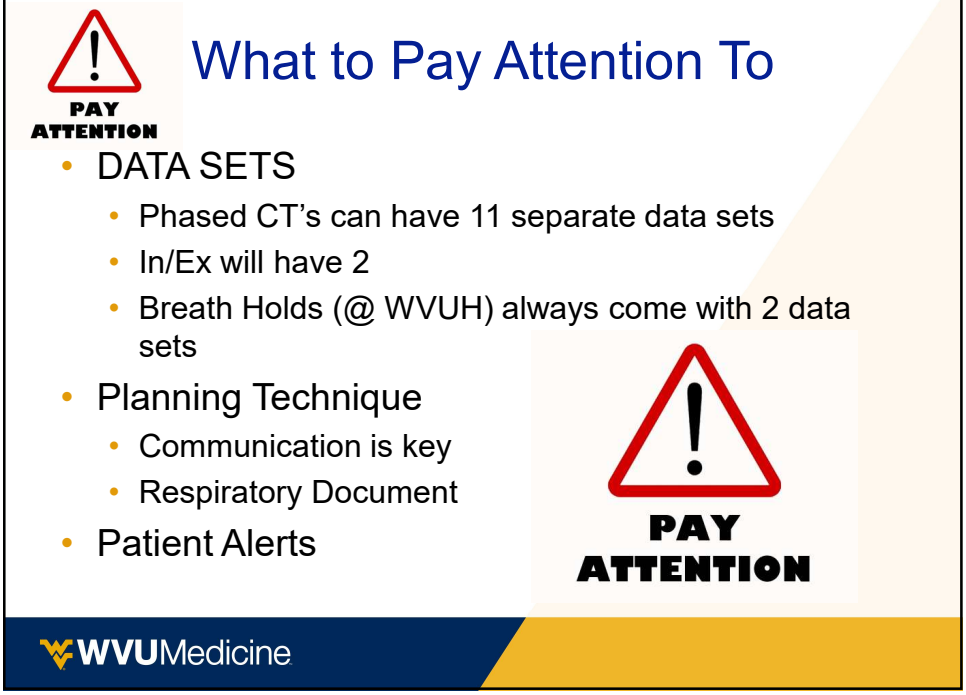
PAY ATTENTION
What to Pay Attention To
DATA SETS
Phased CT's can have 11 separate data sets
In/Ex will have 2
Breath Holds (@ WVUH) always come with 2 data sets
Planning Technique
Communication is key
Respiratory Document
Patient Alerts
PAY ATTENTION
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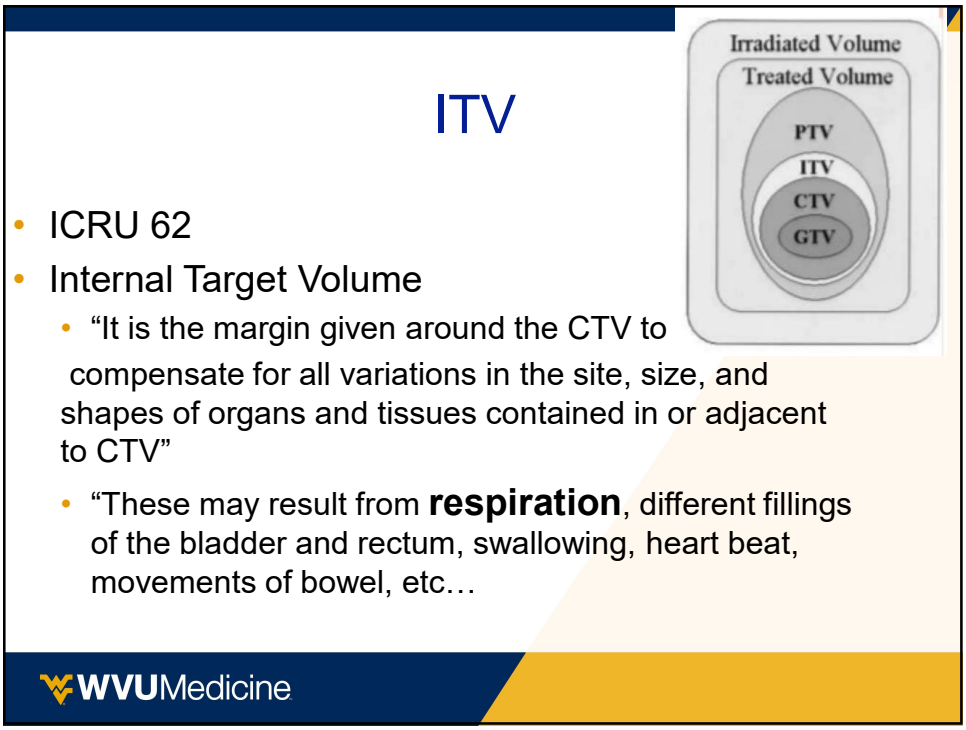
ITV
Irradiated Volume
Treated Volume
PTV
ITV
CTV
GTV
ICRU 62
Internal Target Volume
"It is the margin given around the CTV to compensate for all variations in the site, size, and shapes of organs and tissues contained in or adjacent to CTV"
"These may result from **respiration**, different fillings of the bladder and rectum, swallowing, heart beat, movements of bowel, etc…
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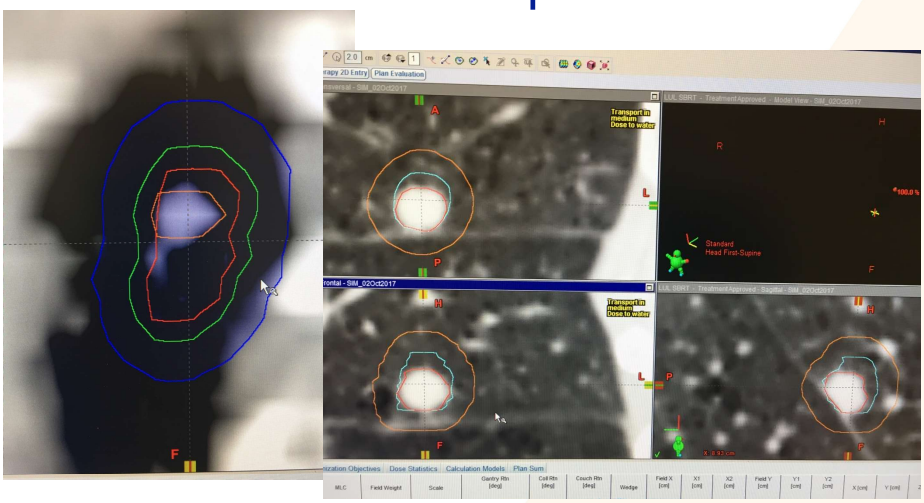
ITV Examples



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Treatment

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Treatment

- At this point it's all about - VERIFYING
  - Breathing Cycle
  - Breathing Amplitude
  - Gating versus not
- Documentation is KEY

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Take Away's

- Figure out what technology you have
- Figure out how it works
- Figure out how your department wants to use it
- Just because you don't have the latest and greatest technology doesn't mean you aren't allowed to offer this to your patients
  - Creativity can help
- TG-76 is your friend

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THANK YOU!!

- Any Questions??
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- 215-713-8656
- 304-293-1351

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