

# CyberKnife and Patient-Specific QA – A case study

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Photo credit: Sam Kittner '85



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# Patient Safety

- Patient safety is a paramount concern
- Receiving increased attention
- Complicated treatments/advanced equipment require extra attention
- Robust QA program a critical component
  - Periodic QA
  - Patient-specific QA

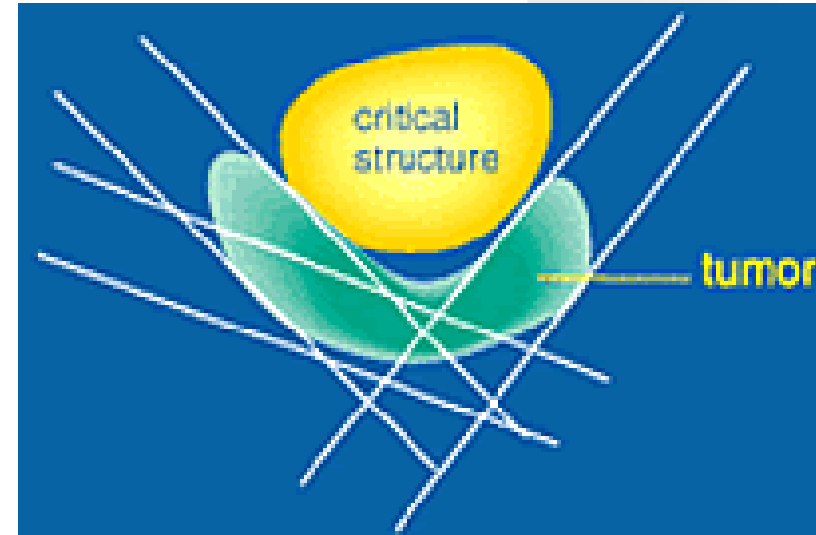


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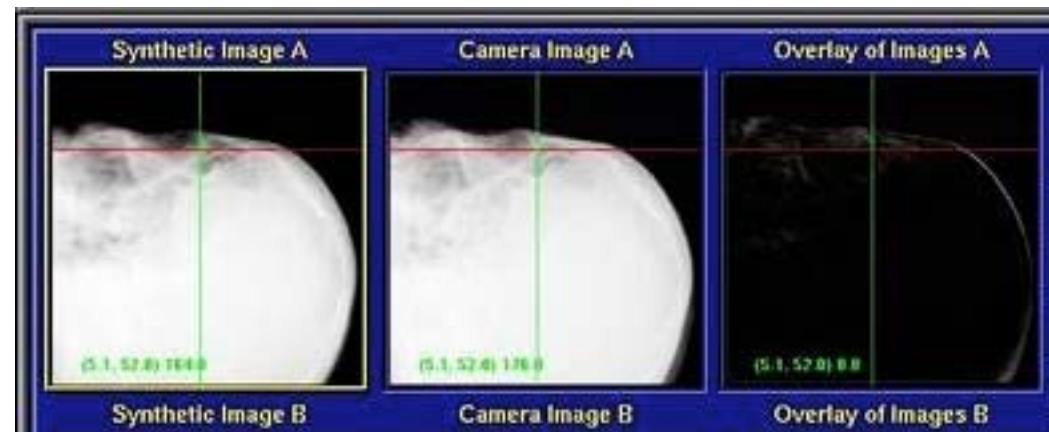
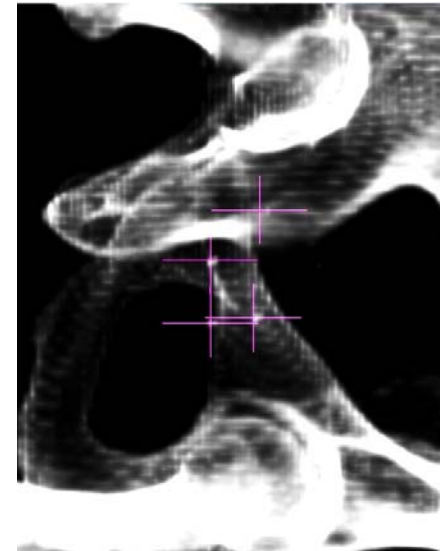
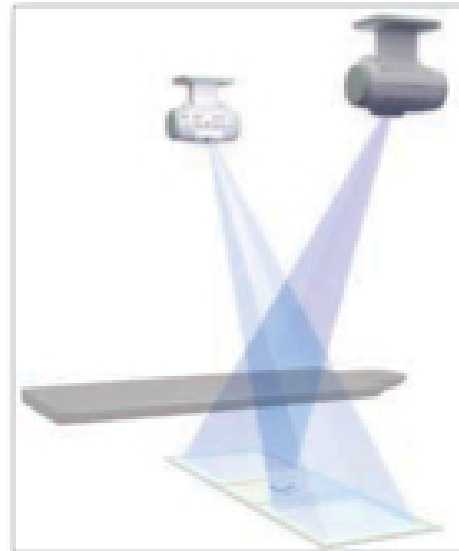
# Case Study: CyberKnife

- Robotic Radiosurgery device
- Typical treatment consists of 100-300 beams
- Highly conformal dose distributions



# CyberKnife System

- STRONGLY image guided
- Beam-by-beam tracking based on
  - Bony anatomy
  - Fiducials
  - Lung tumor motion



# CyberKnife QA Program

- No formal guidance yet
  - TG-135 in process
- Most facilities develop own QA from a variety of sources
  - Vendor recommendations
  - TG-40, 42, 51, 142...
  - Do what seems reasonable (lots of variation here)

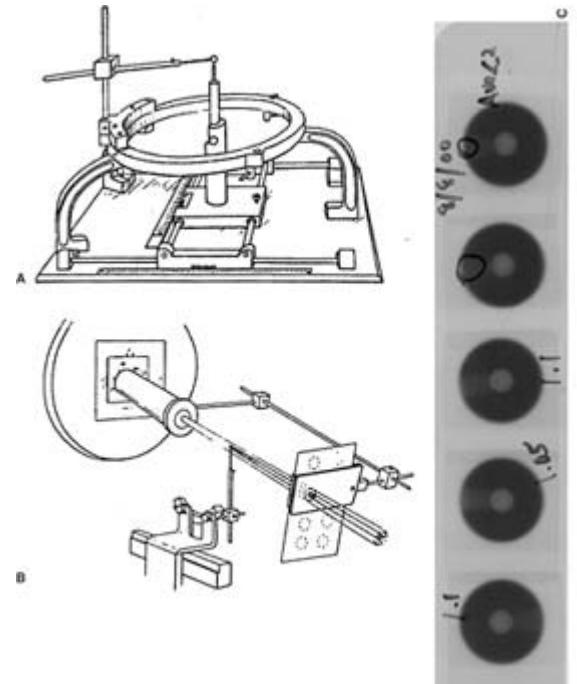


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# Patient-Specific QA?

- CK treatments resembles:
  - Multiple-isocenter SRS
  - IMRT
- Both of these generally use patient-specific QA
- Of course, we would like to do this for CK as well



*Khan, 4<sup>th</sup> Edition, 2010*



*SunNuclear, Inc*

# Strong Motivation

- High doses → High consequences
  - 12-60 Gy
- Fewer Fx → fewer chances to catch errors
  - Typically 1-5 fractions
- Very complicated system

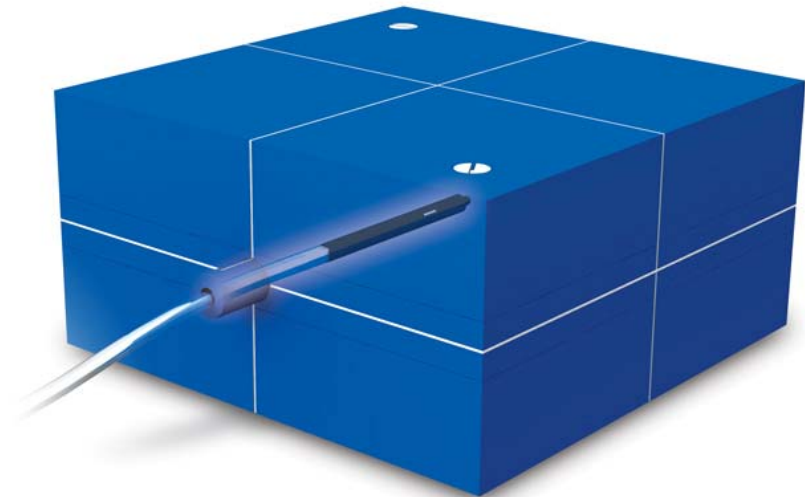


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# Methods

- Generally detector and film measurements in phantoms
  - Standard Imaging SRS phantom
  - Accuray-supplied anthropomorphic head phantom



Standard Imaging



Accuray

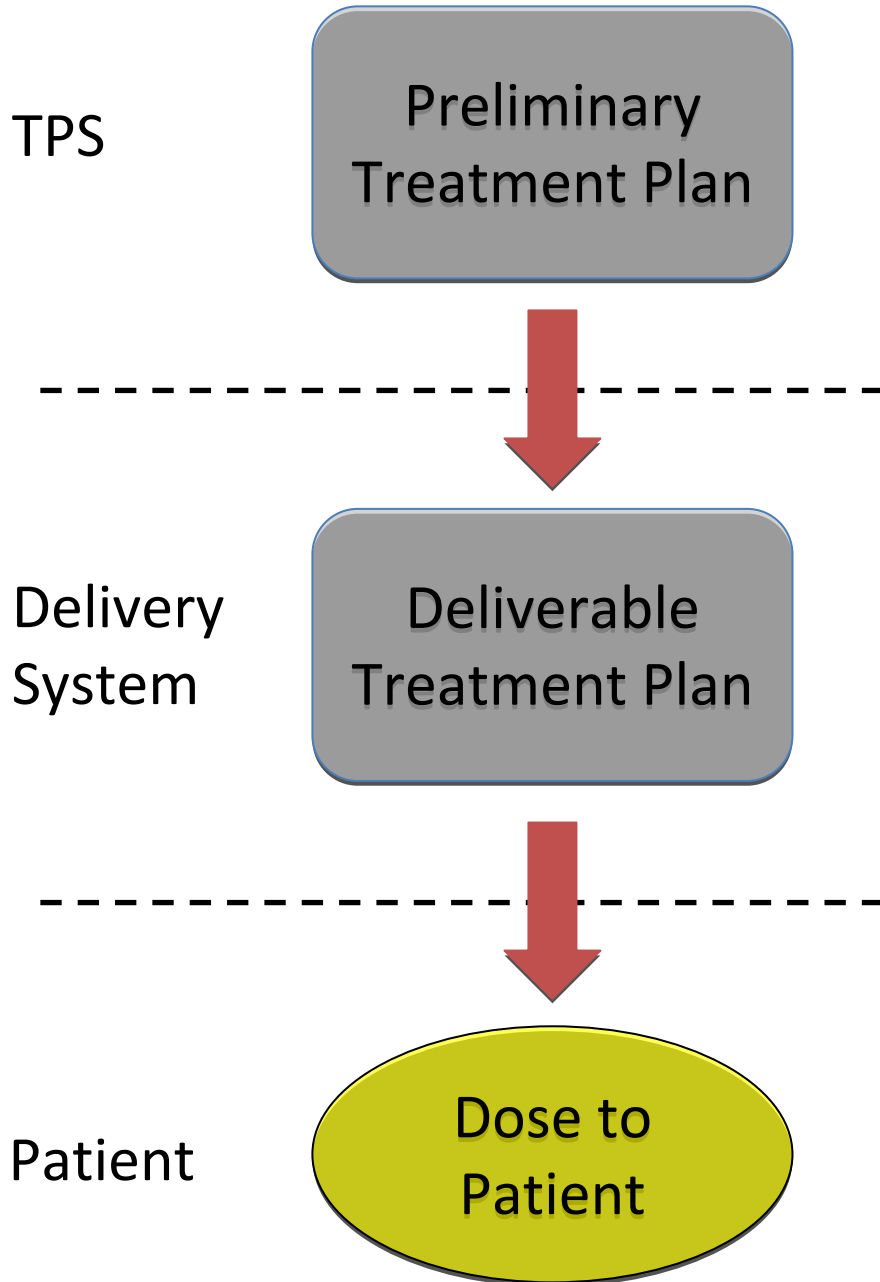
Does this check what we want to  
check



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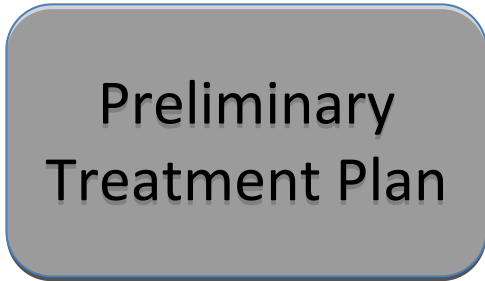
## IMRT QA Workflow



• *Periodic QA* checks the boxes

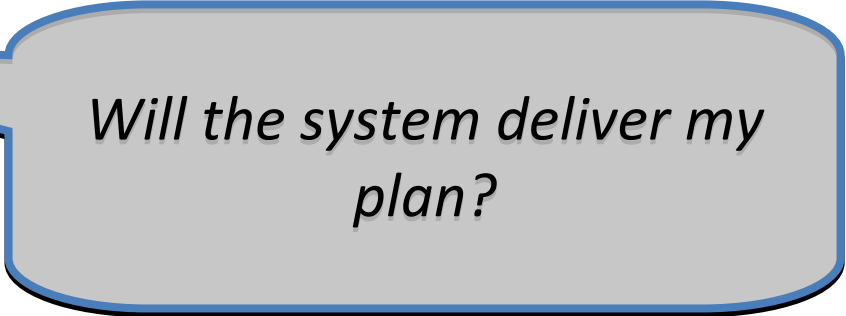
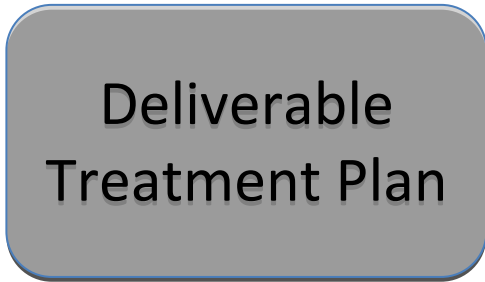
• *Patient-specific QA* checks the arrows

TPS

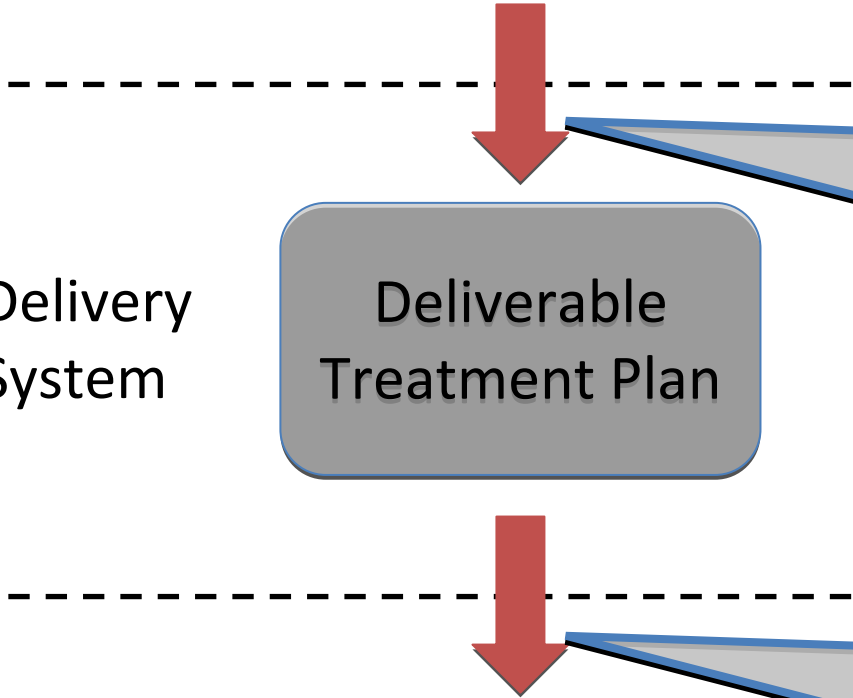
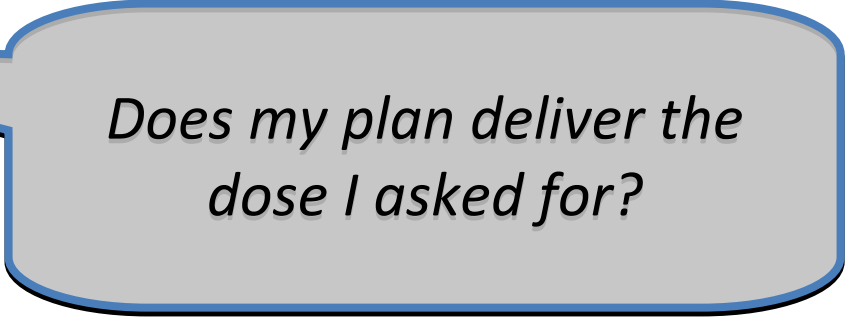
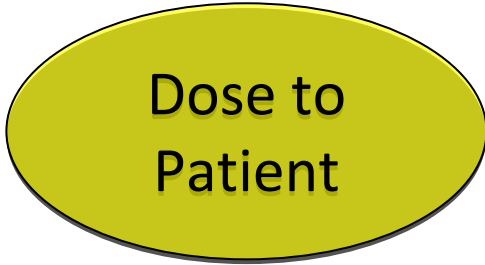


Patient-specific  
IMRT QA asks:

Delivery System



Patient



# Important Distinction for CyberKnife

- Most systems deliver dose to region in space
- CK delivers dose to coordinate system that is:
  - Moving
  - Deforming
  - Patient Specific
- Impossible to deliver plan without intended target



TPS

Preliminary  
Treatment Plan

What are the  
consequences of  
this?

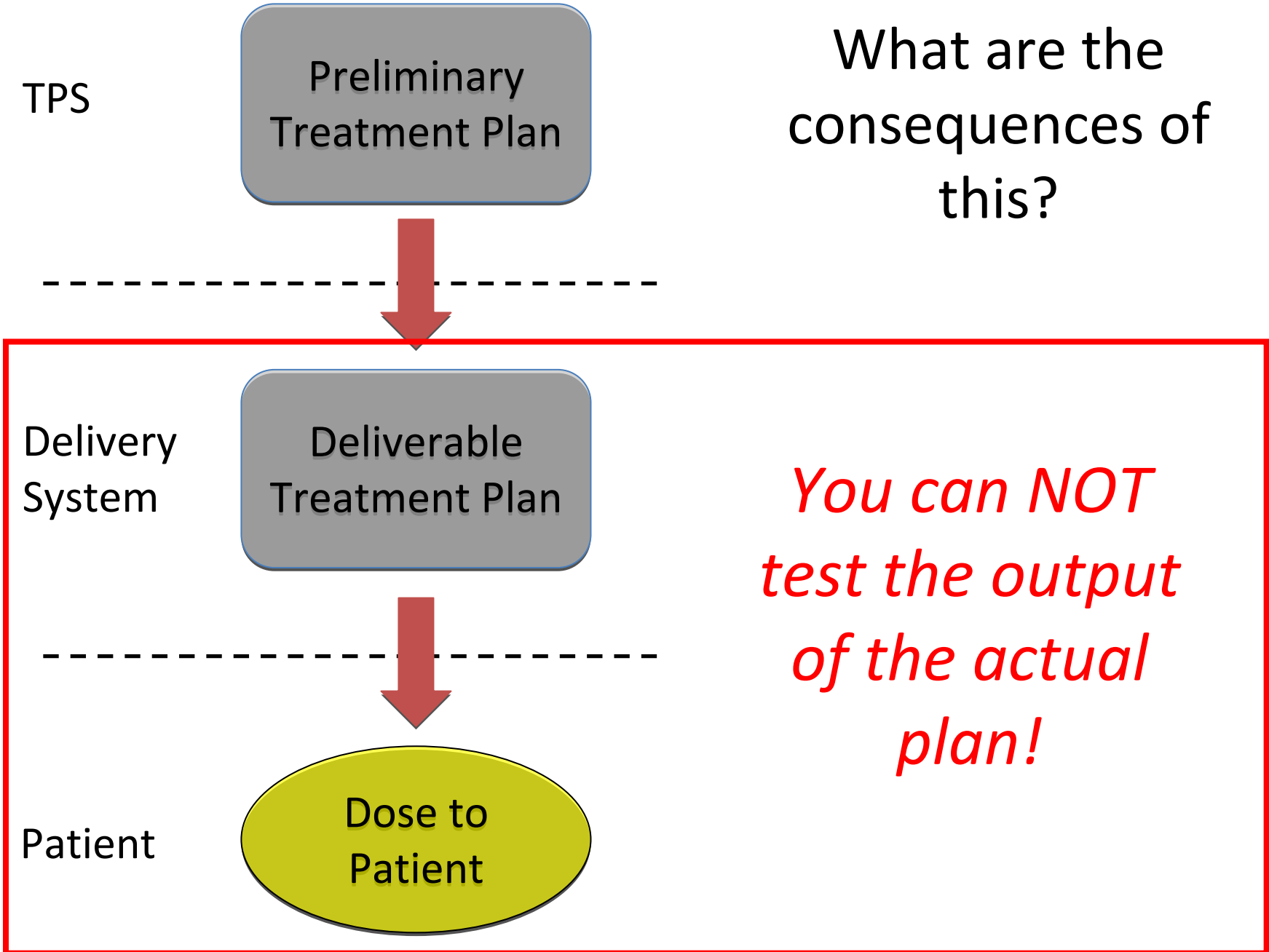
Delivery  
System

Deliverable  
Treatment Plan

*You can NOT  
test the output  
of the actual  
plan!*

Patient

Dose to  
Patient



TPS

Preliminary  
Treatment Plan



Preliminary  
*Phantom* Plan

Delivery  
System

Deliverable  
Treatment Plan



Deliverable  
*Phantom* Plan

Patient

Dose to  
Patient

Dose to  
*Phantom*



Does  =  ?

- Delivery System:
  - Would not necessarily catch the big errors
    - File corruption, Bad targeting
- Patient:
  - Dose to static target  $\neq$  Dose to moving target
  - Dose to phantom  $\neq$  Dose to patient
  - You've tested A plan, but not THE plan
    - Plus, you already tested A plan in daily QA



# Conclusions and Thoughts

- Current CK patient-specific QA does not really test what we need it to test
- We are NOT arguing against doing patient-specific QA
  - Patient-specific QA would be desirable for CK
  - Not clear that current techniques can really do that.



# What would work?

- Possibilities include
  - Phantom-less QA?
  - Exit dosimetry?
  - Motion tracking of linac head?
- May require working with vendor



# Conclusions and Thoughts

- Increased focus on patient safety
- Limited physics resources available
- Resources must be applied where they can do the most good
- Not simply ***MORE*** QA, but ***SMART*** QA



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# CK Case Study Demonstrates...

- Old QA methods don't necessarily apply to new systems
- With new technology, we must carefully assess:
  - *What do I want to check with my QA?*
  - *Does my QA test really check what I want it to?*

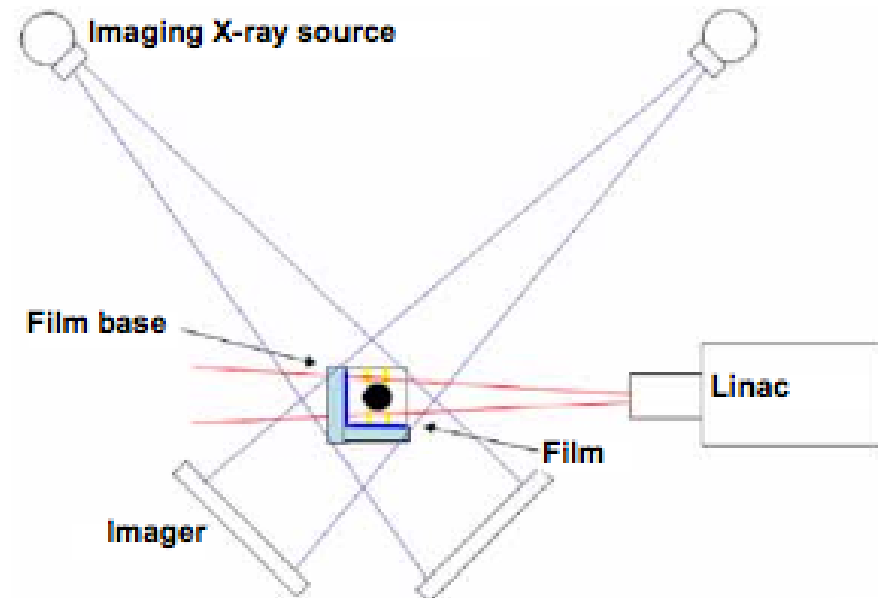
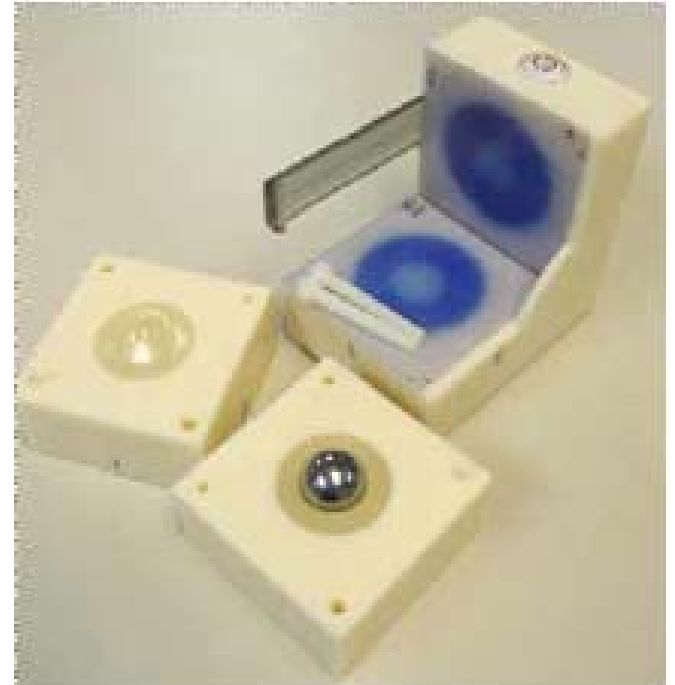


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# CyberKnife QA

- Standard Measurements
  - Mechanical
  - Beam (dose rate, energy)
- CK-specific Measurements
  - Daily and Monthly film-based delivery



# Monthly – E2E

- Full treatment delivery
  - New plan every time
  - All modalities
- Analyze shape and position
- Tolerance
  - 0.75 mm any direction
  - 0.95 radial

