

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

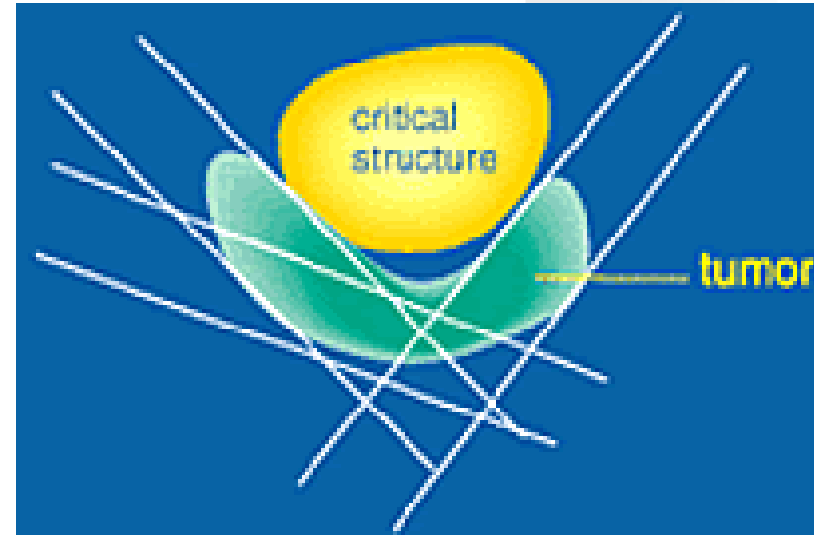


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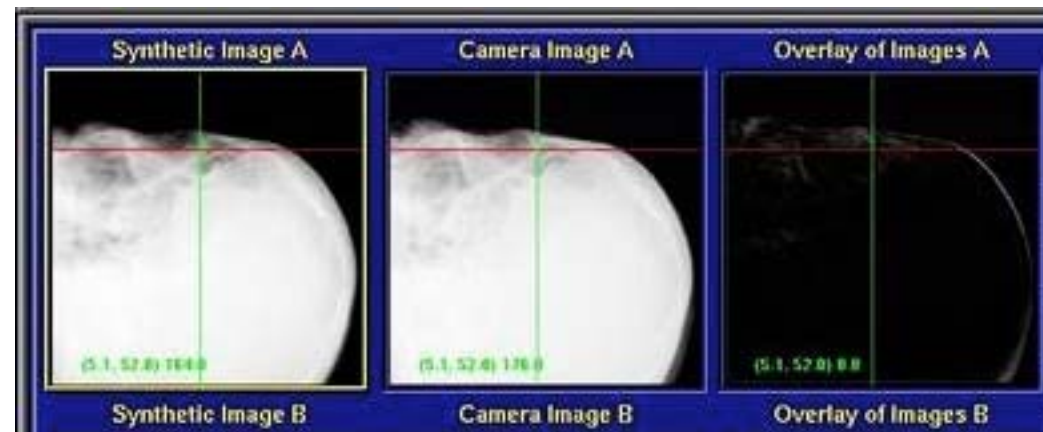
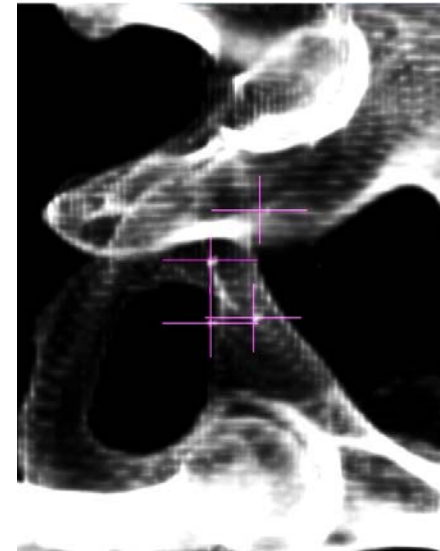
Case Study: CyberKnife

- 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)

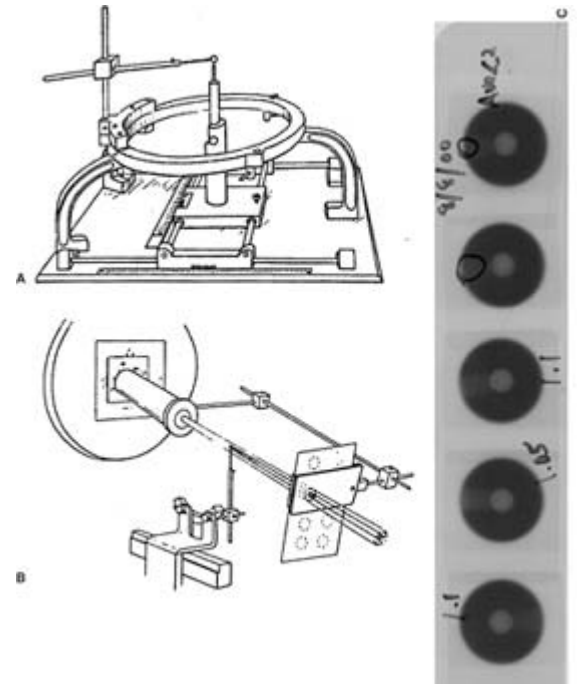


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Patient-Specific QA?

- 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, 4th 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

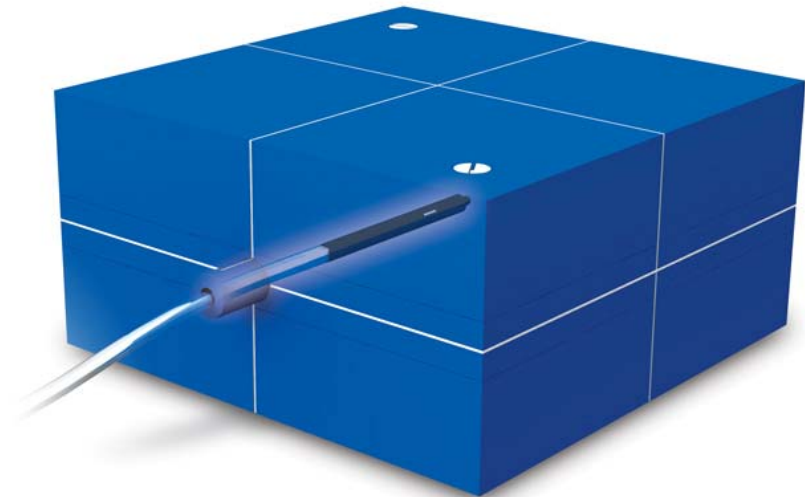


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Methods

- 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

TPS

Preliminary
Treatment Plan

Delivery
System

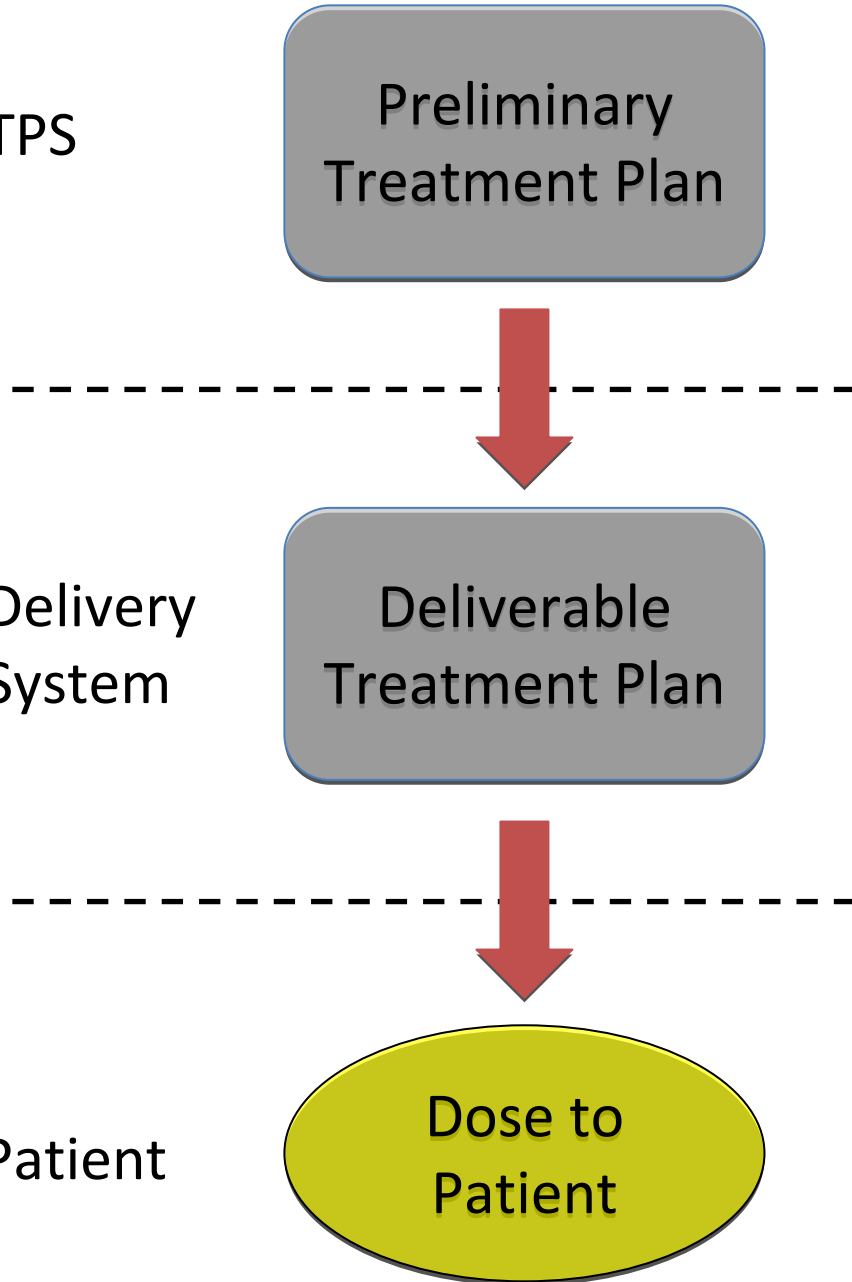
Deliverable
Treatment Plan

Patient

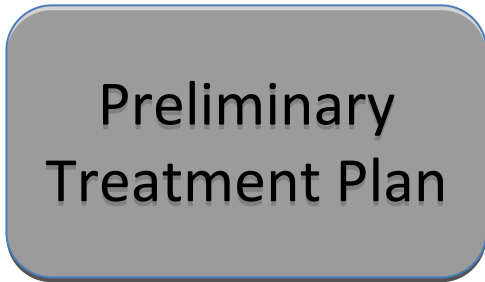
Dose to
Patient

• *Periodic QA* checks
the boxes

• *Patient-specific QA*
checks the arrows

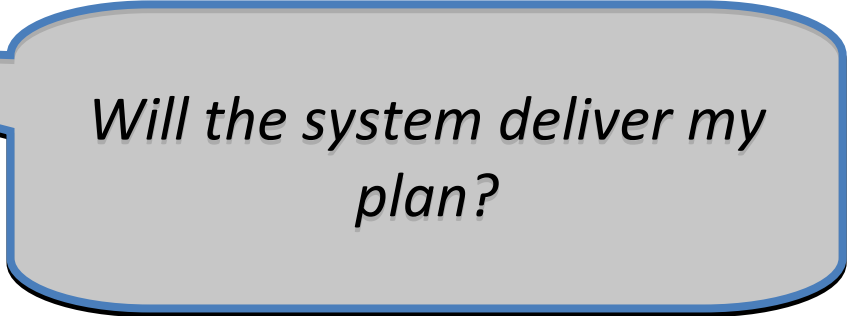
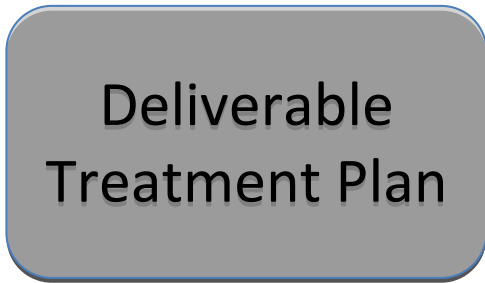


TPS

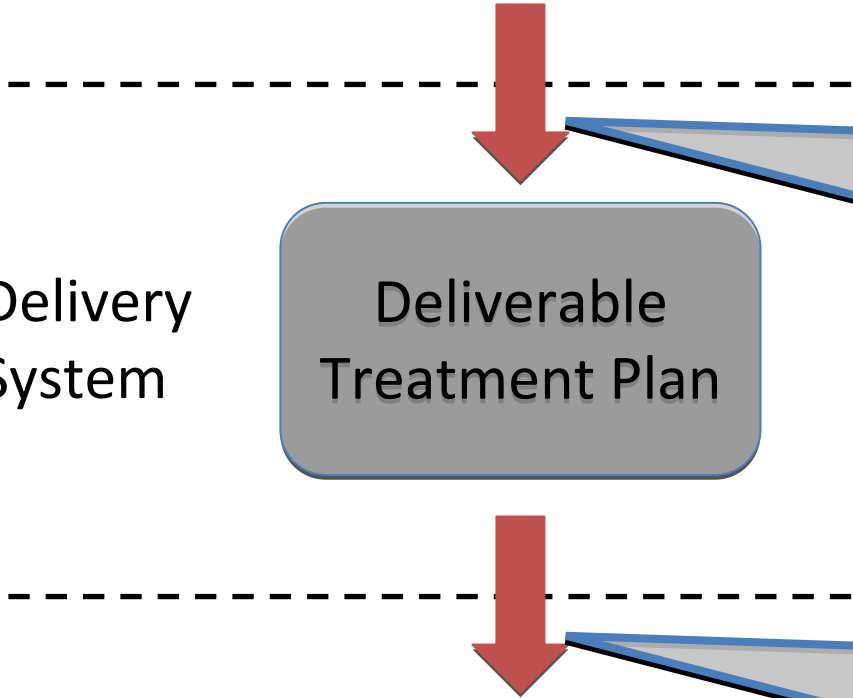
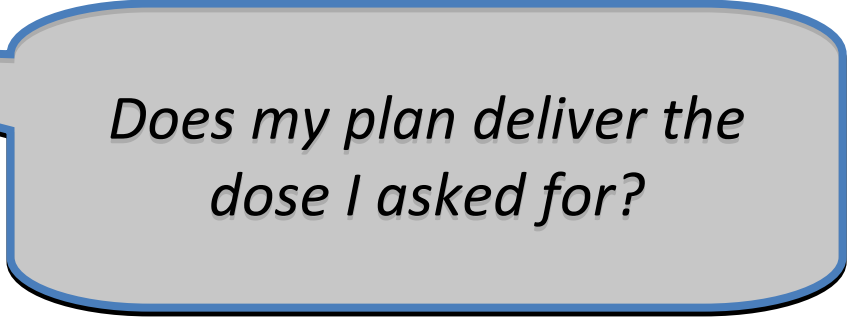


Patient-specific
IMRT QA asks:

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?

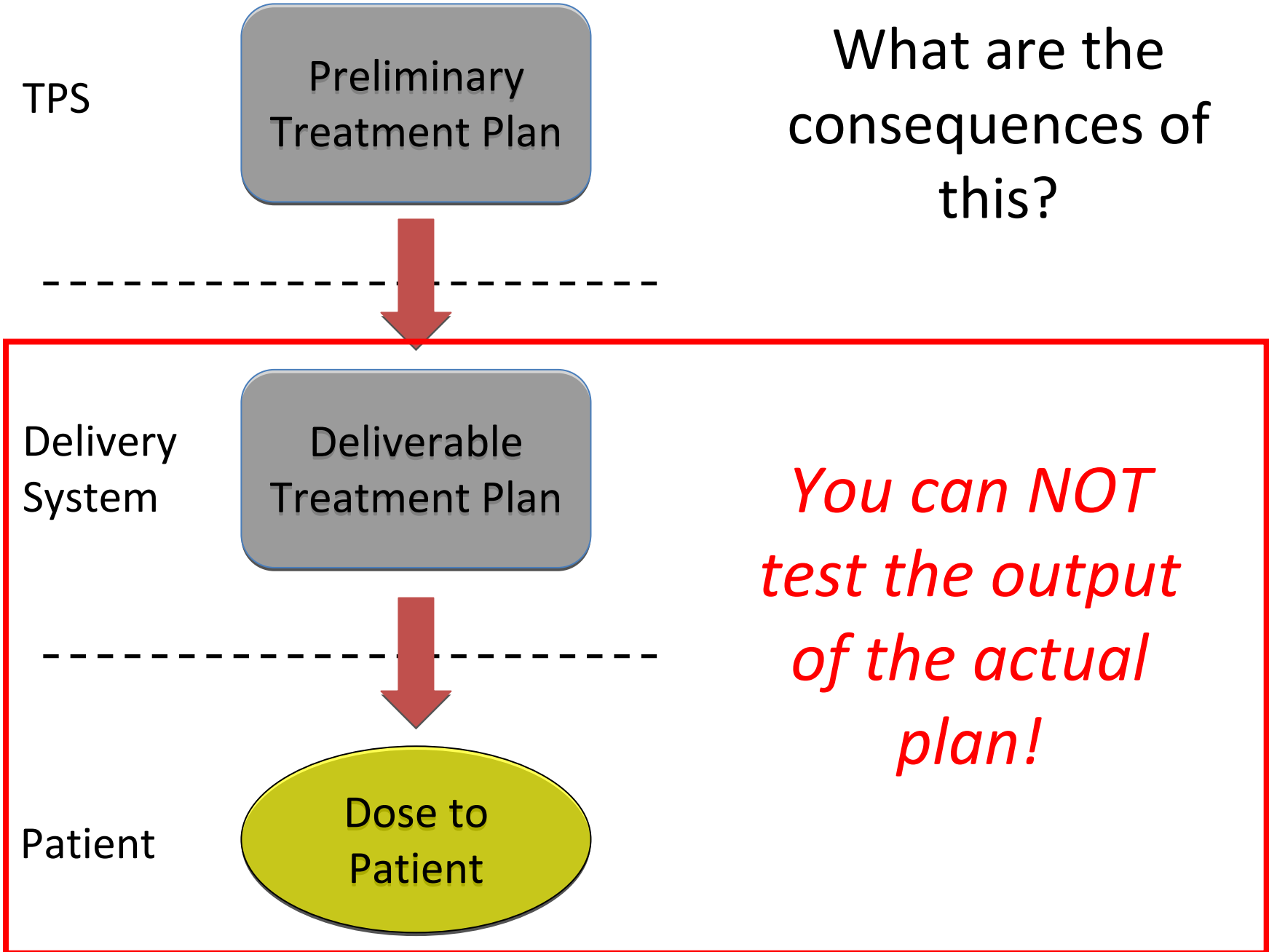
Delivery
System

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



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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?*

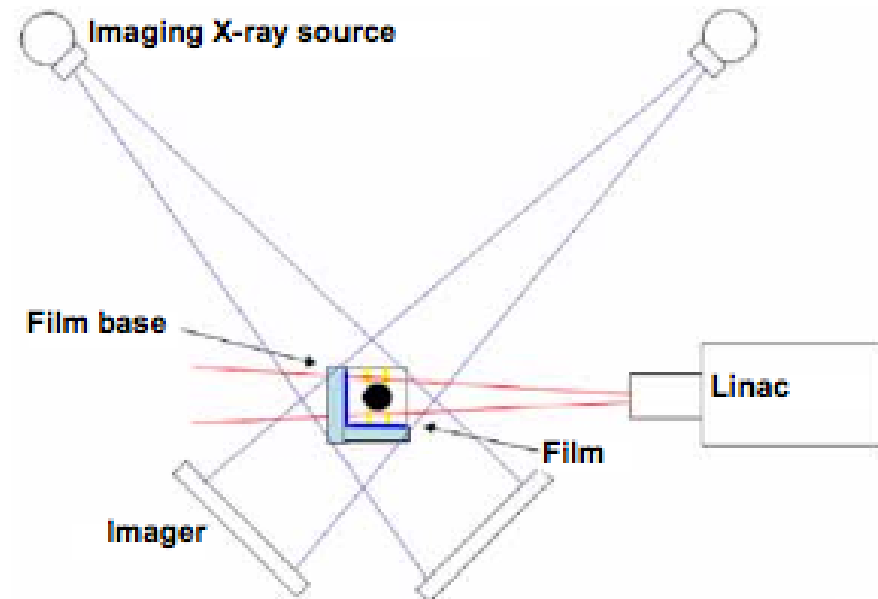
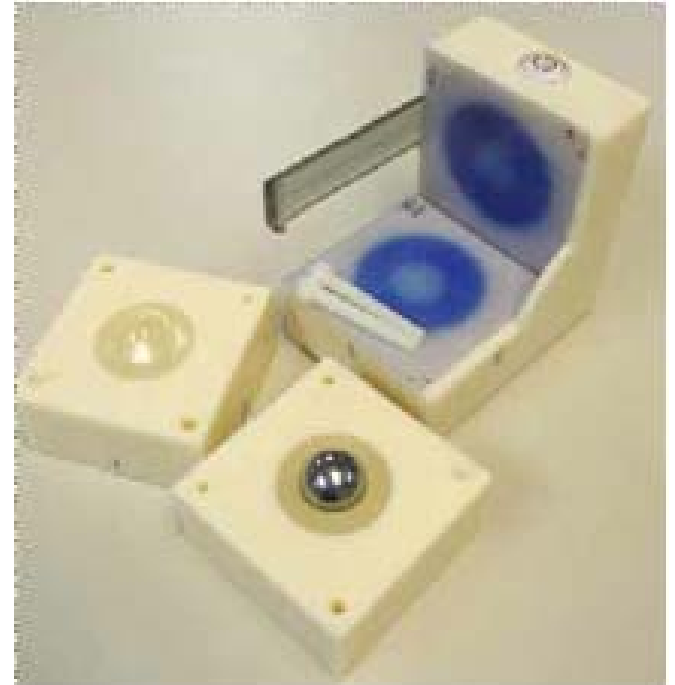


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CyberKnife QA

- 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

