Using DoseLab to Perform TG-142 Imaging QA

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Introduction

Task Group 142 report: Quality assurance of medical accelerators[a)]

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TG-142 is a comprehensive QA protocol

- Covers nearly every aspect of machine and safety QA
- Recommends quantitative results
- Recommends high testing frequencies (ie, monthly imaging QA)
- Essentially requires specialized QA software to perform

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My Background

- 2001–2004
  - Developed open-source DoseLab for PhD at MD Anderson
- 2004–2010
  - Worked at Methodist Hospital as a clinical physicist
- 2008–2010
  - Commissioned a Varian 21iX at a satellite facility
  - Implemented a TG-142 program using PipsPro
- 2010–present
  - Developed DoseLab TG-142 to perform automatic QA
  - Founded Mobius Medical Systems, LP to manufacture and support DoseLab, FractionLab, Mobius3D, and MobiusFX

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My TG-142 Implementation in 2009

- I noticed many inefficiencies
- The software did not extract the maximum amount of results from each image
- Trips inside the vault to setup phantoms were not minimized
- Not all modules stored results in a database, so custom Excel sheets had to be created

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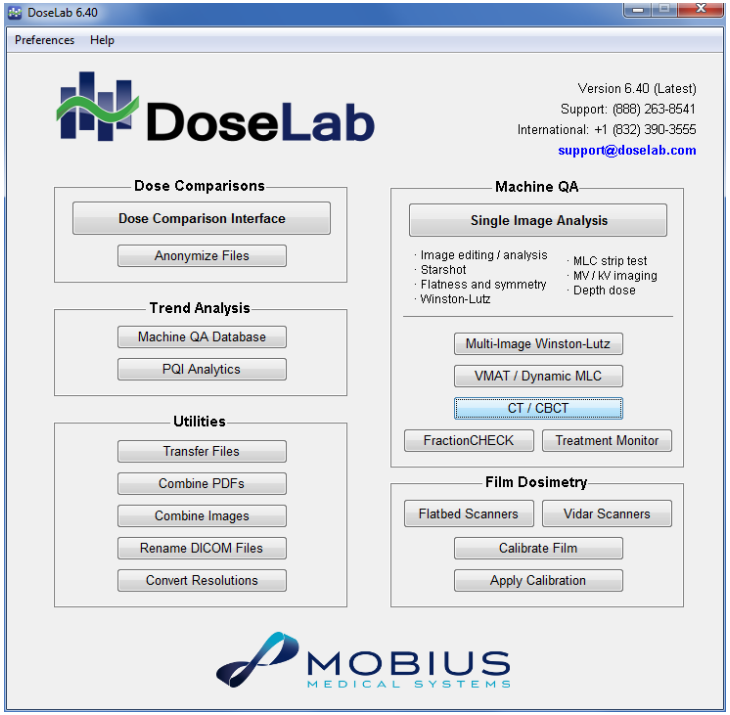
Why Develop DoseLab TG-142?

- Maximize QA efficiency
  - Fewer images & trips to vault
  - Standardized PDF reporting
  - Automatic computations
- Quantify and classify all results
  - Pass/warn/fail tolerances
  - Database trending
- Comprehensive tool set
  - Compatible with EPID, film, CR, etc.
  - Compatible with phantoms from SNC, Standard Imaging, etc.
  - Log file analysis for Varian / Elekta



DoseLab is used by the RPC for on-site TG-142 audits

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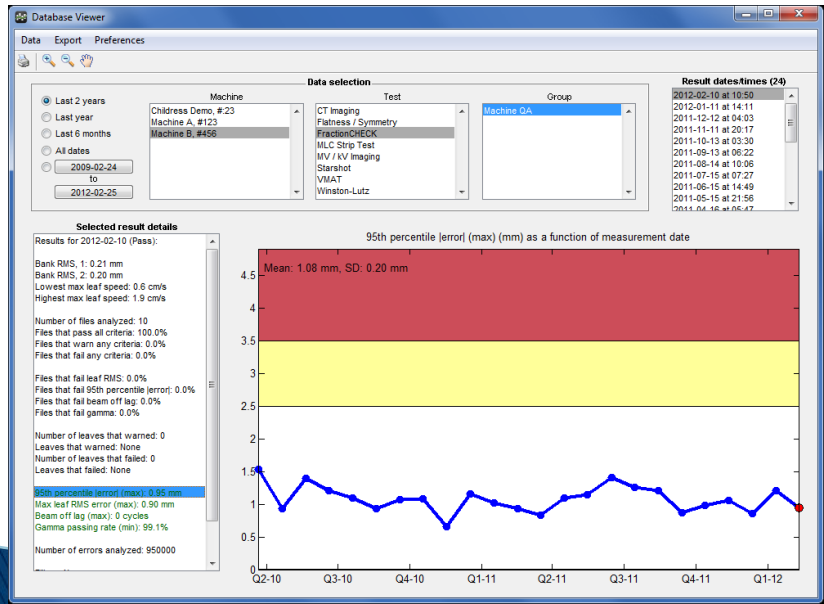
Recommended TG-142 Strategy

- Create a QA patient in your R+V system
- Add fields for all needed EPID, kV, and CBCT measurements
- Use all electronic measurements – no film
- Use your R+V system to control the linac and store images
- Export images to TG-142 software and analyze
- This makes future QA easier
  - Open QA patient
  - Deliver fields
  - Export and analyze



Monthly MV and kV Imaging

Daily[a]		
Planar kV and MV (EPID) imaging		
Collision interlocks	Functional	Functional
Positioning/repositioning	≤2 mm	≤1 mm
Imaging and treatment coordinate coincidence (single gantry angle)	≤2 mm	≤1 mm

Monthly		
Planar MV imaging (EPID)		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling[b]	≤2 mm	≤2 mm
Spatial resolution	Baseline[c]	Baseline
Contrast	Baseline	Baseline
Uniformity and noise	Baseline	Baseline
Planar kV imaging[d]		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling	≤2 mm	≤1 mm
Spatial resolution	Baseline	Baseline
Contrast	Baseline	Baseline
Uniformity and noise	Baseline	Baseline

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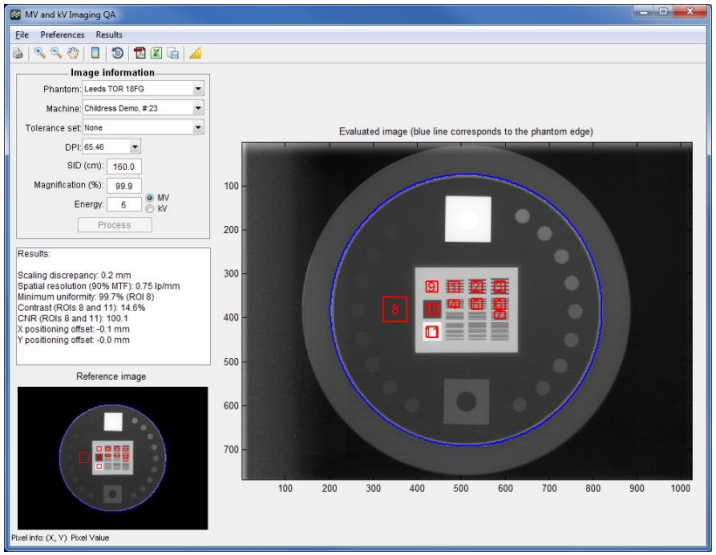
Supported Phantoms

- DoseLab has a unique approach to multiple phantom support
- DoseLab supports all common phantoms:
  - SNC MV and kV ImagePro phantoms
  - Leeds TOR 18FG (included with IGRT linacs)
  - Las Vegas (no spatial resolution, included with linacs)
  - Standard Imaging QC-3
  - Standard Imaging QC-kV1
  - iba DIGI-13
  - PTW EPID QC (no positioning or scaling)
  - User-customizable additions



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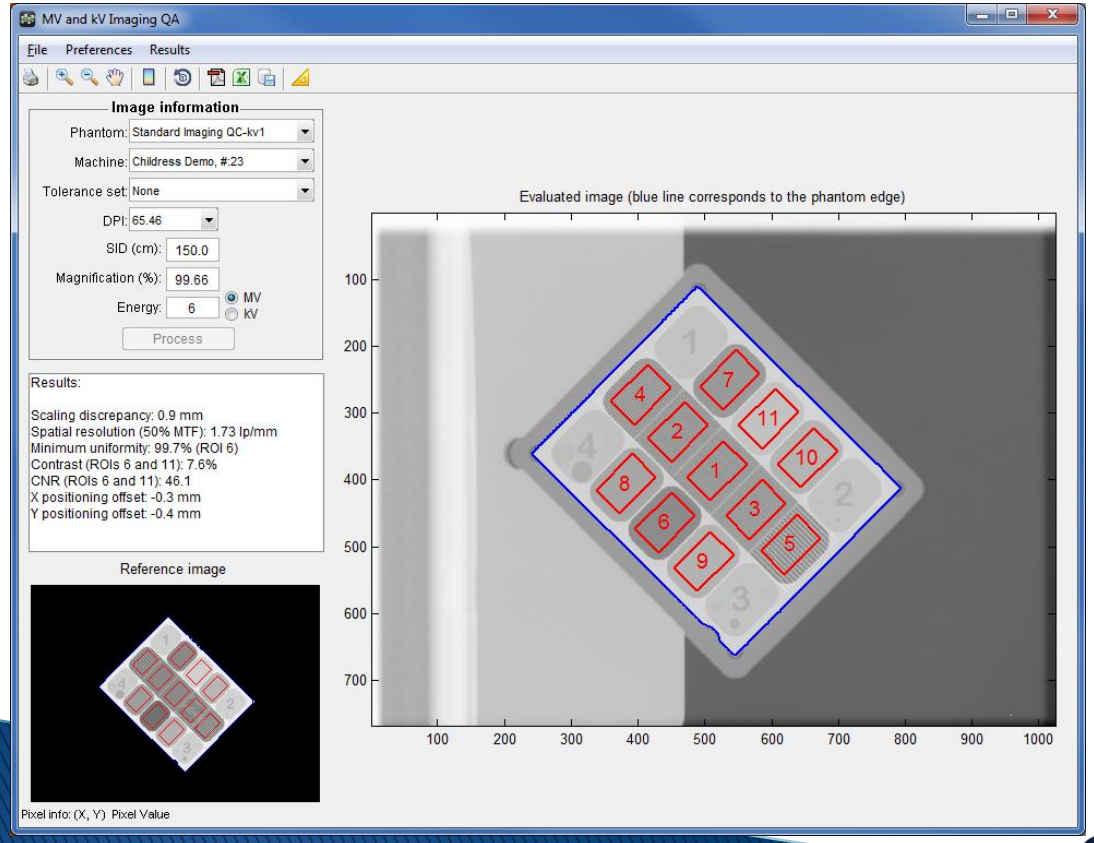
Phantom Selection

- Your linac comes with Leeds and Las Vegas phantoms
- Leeds has all required modules to fulfill TG-142, but is difficult to set up for automatic analysis
  - No phantom stand
  - No crosshair marks
- Las Vegas does not have spatial resolution segments
  - And still no phantom stand or crosshair marks
- Most users purchase aftermarket phantoms to overcome these difficulties

Aftermarket Phantoms

- Easy setup – they include a stand and crosshair markings
- Have all required modules to fulfill TG-142
- Work well with automatic analysis



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MV and kV Phantom Setup

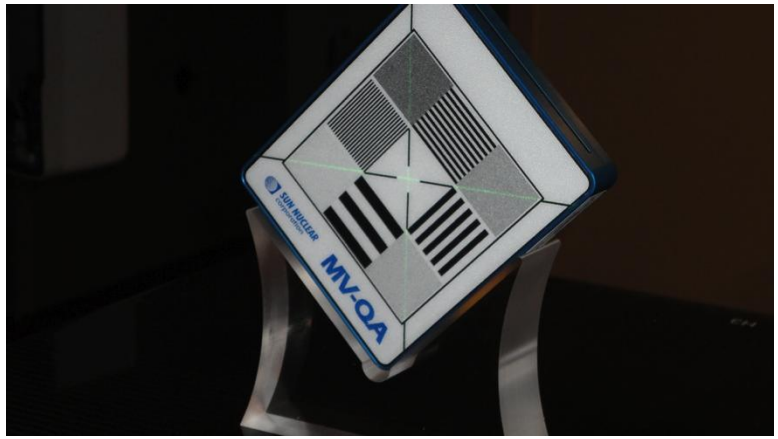

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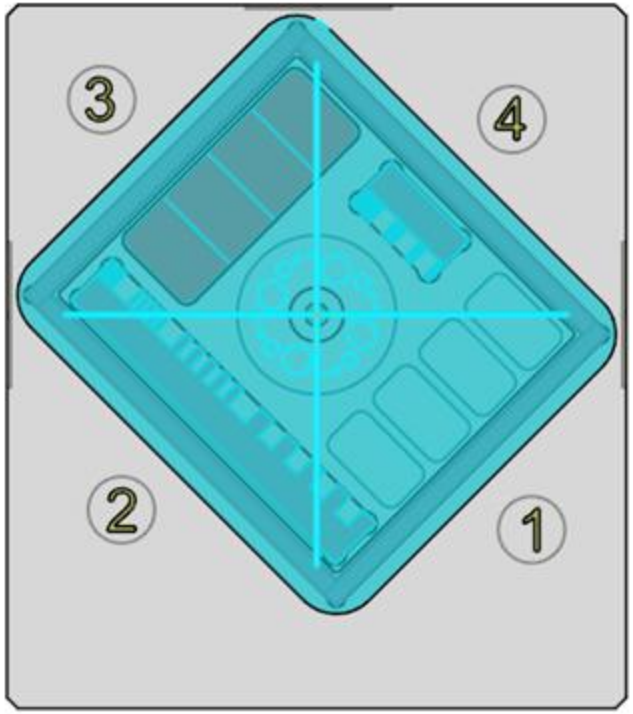
Image Acquisition

- Step 1 – Perform manufacturer's recommended acceptance test to verify correct system performance
- Step 2 – Perform monthly tests using clinical imaging protocols to set baseline values



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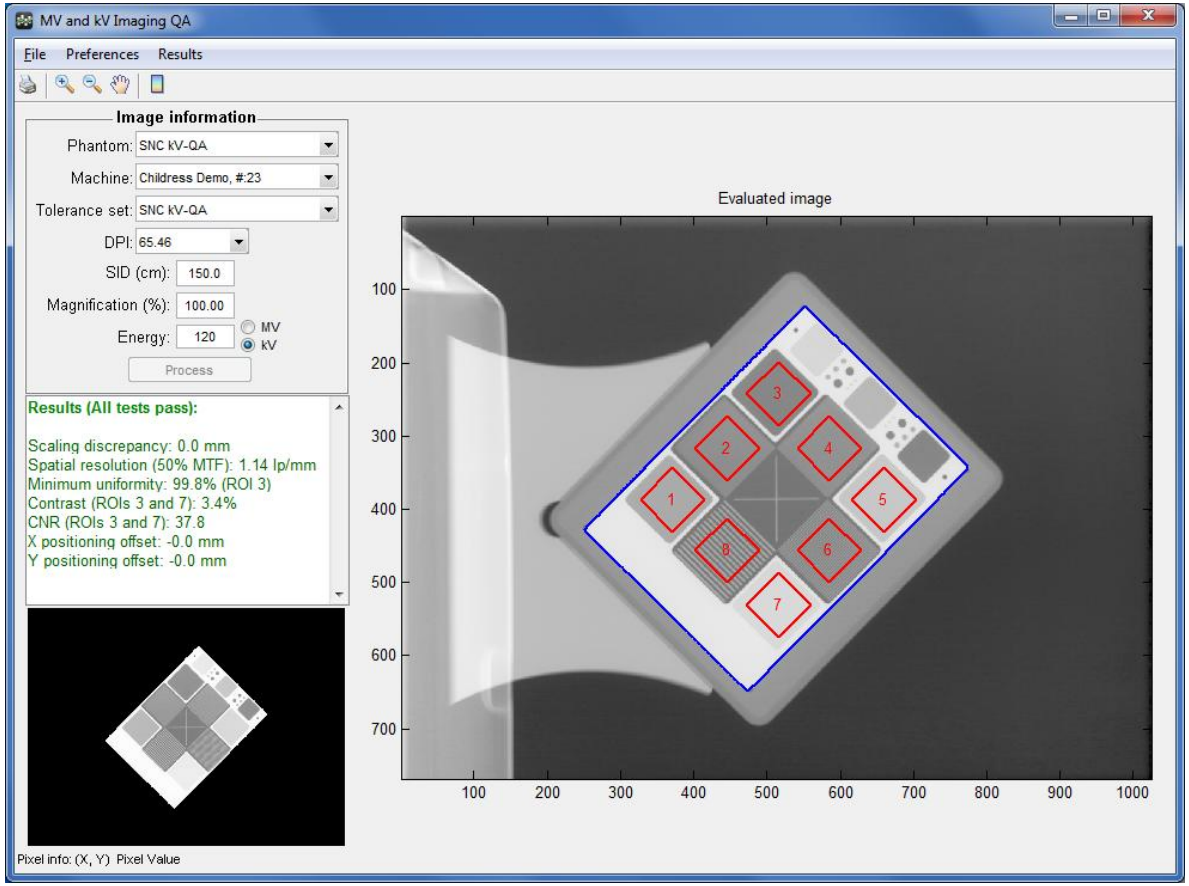
DoseLab MV and kV QA Analysis



- 1 image/imaging energy (2 total)
- MV/kV phantoms
- Analyzes all TG142 parameters
- Includes scaling and positioning, without separate image

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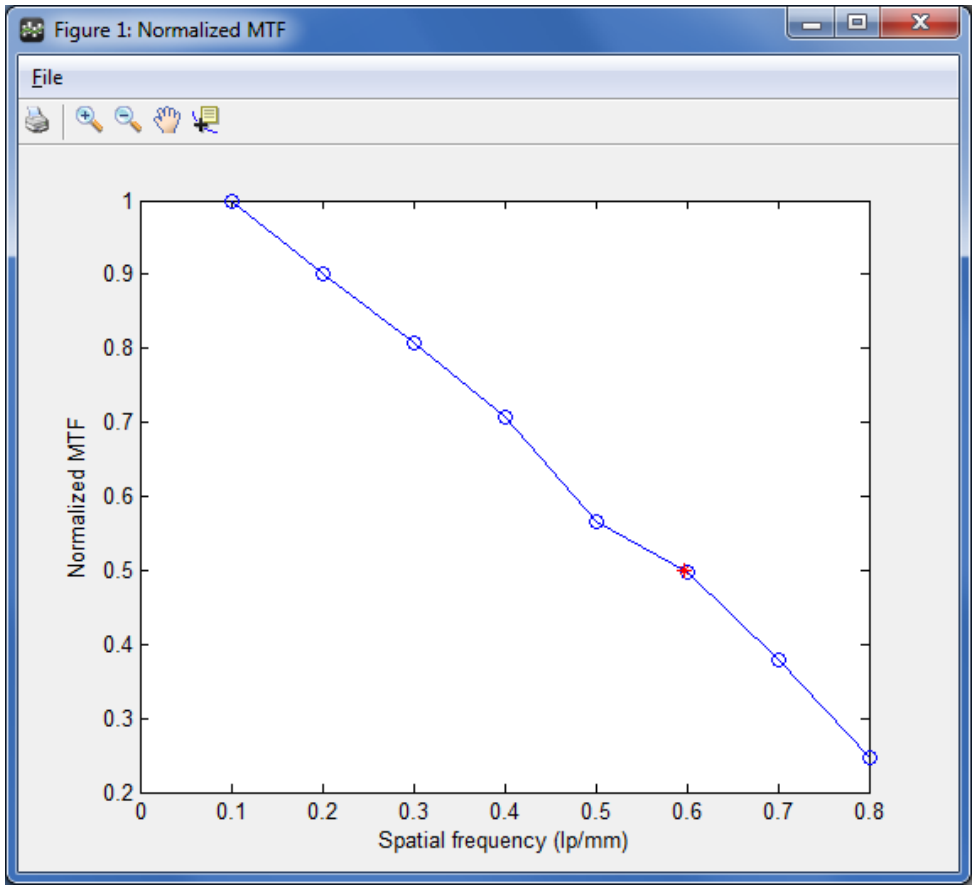
Imaging Calculations



- Spatial resolution – uses MTF rather than subjective "How many line pairs can I see?"
- Contrast
- CNR
- Uniformity
- Scaling
- Positioning offset
- CT only:
  - Geometric distortion
  - Slice width
  - HU deviation

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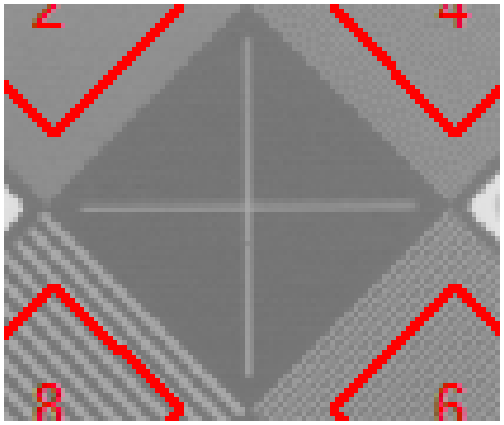
Imaging Parameters: Offsets

- IGRT systems are calibrated to know the isocenter position in each image
- To calculate the offset from expected (radiation or laser isocenter), a target can be placed at isocenter and imaged
- For planar imaging, DoseLab extracts the isocenter location in DICOM tags and compares the phantom position to a baseline position
  - This occurs during image quality analysis



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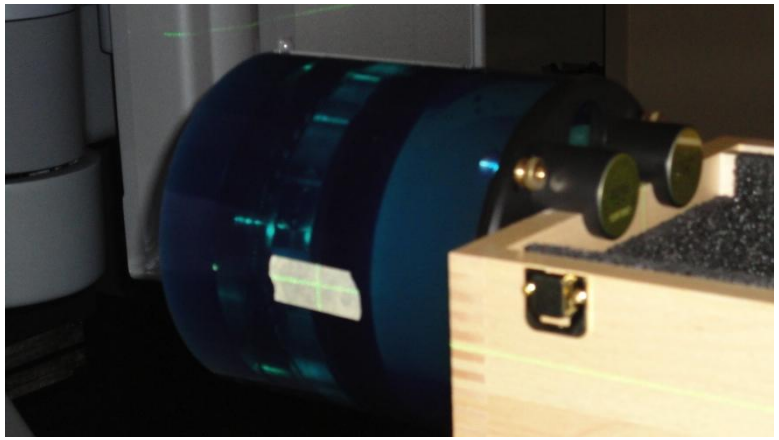
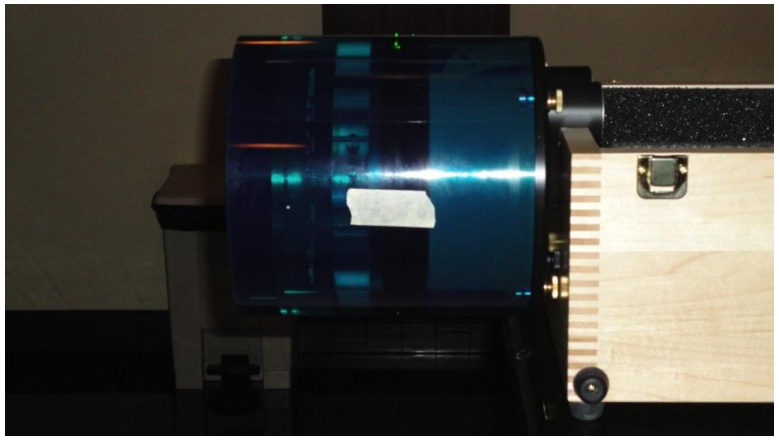
CBCT Catphan Setup





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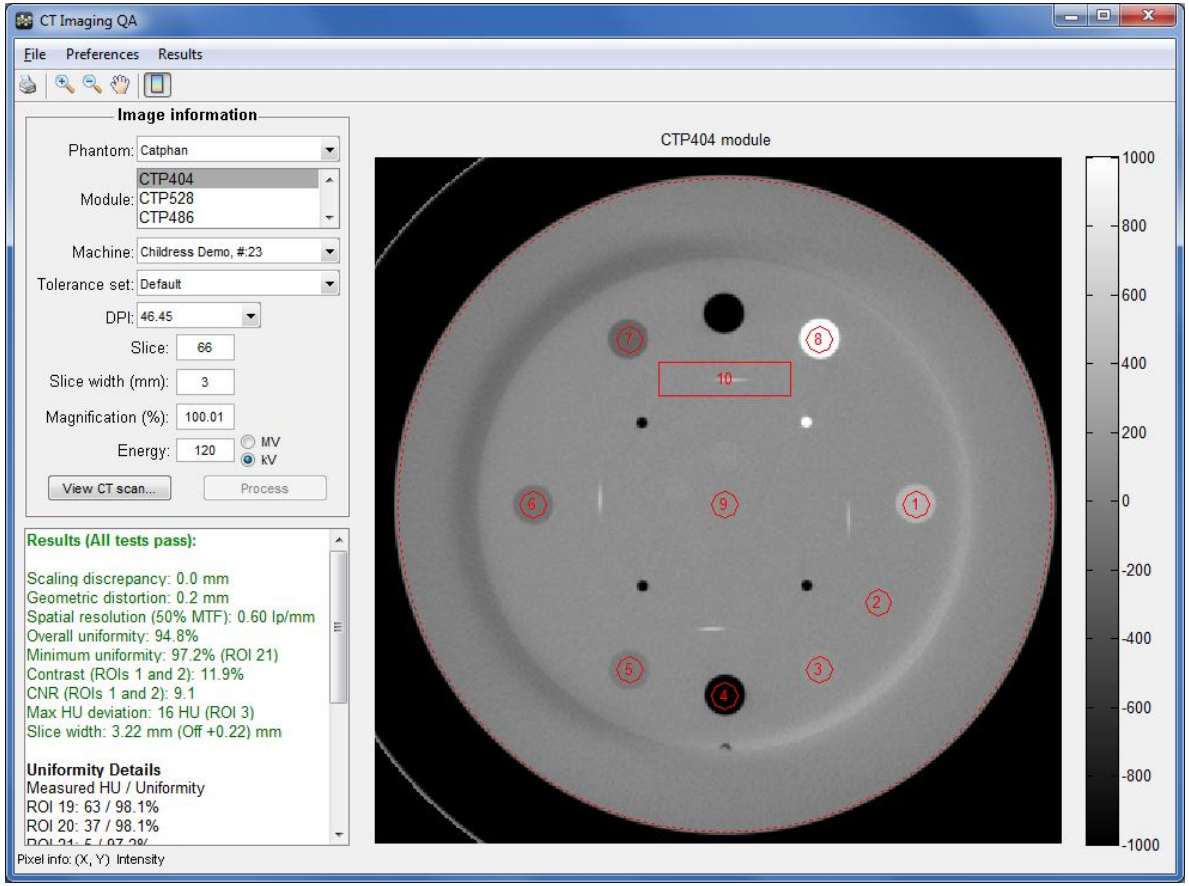
CT and CBCT QA



- 1 image set
- Catphan phantom
- Analyzes all TG142 parameters
- Also supports Gammex, CIRS, and GE phantoms

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Image Quality Tolerances

	Monthly	
Planar MV imaging (EPID)		
Imaging and treatment coordinate coincidence (four cardinal angles)	≤2 mm	≤1 mm
Scaling[b]	≤2 mm	≤2 mm
Spatial resolution	Baseline[c]	Baseline
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- Results depend on many factors
  - Software (several sets of formulas exist)
  - Phantom
  - Imaging technique (kV, mAs)
  - Setup (at isocenter, on panel, through couch)
- Manufacturers / AAPM do not recommend tolerances
- Your clinic's data is used to establish your baseline and tolerance levels

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- Routine QA is used in conjunction with acceptance testing to determine that a system is operating properly and stays operating properly
- Acceptance tests are typically very different than quantitative routine QA tests

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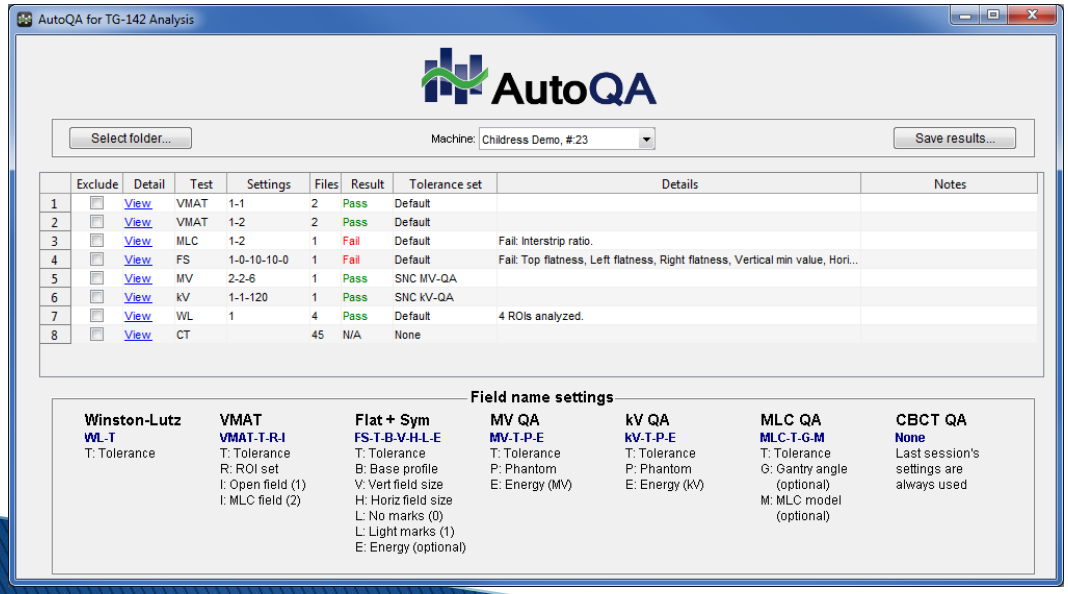
Imaging QA and Non-Standard Formulas

- There is no industry standard set of basic formulas in diagnostic imaging or radiation therapy
- DoseLab, like nearly every other software package, uses its own set of imaging QA formulas
- DoseLab's formulas were designed to produce consistent results for automatically-placed ROIs



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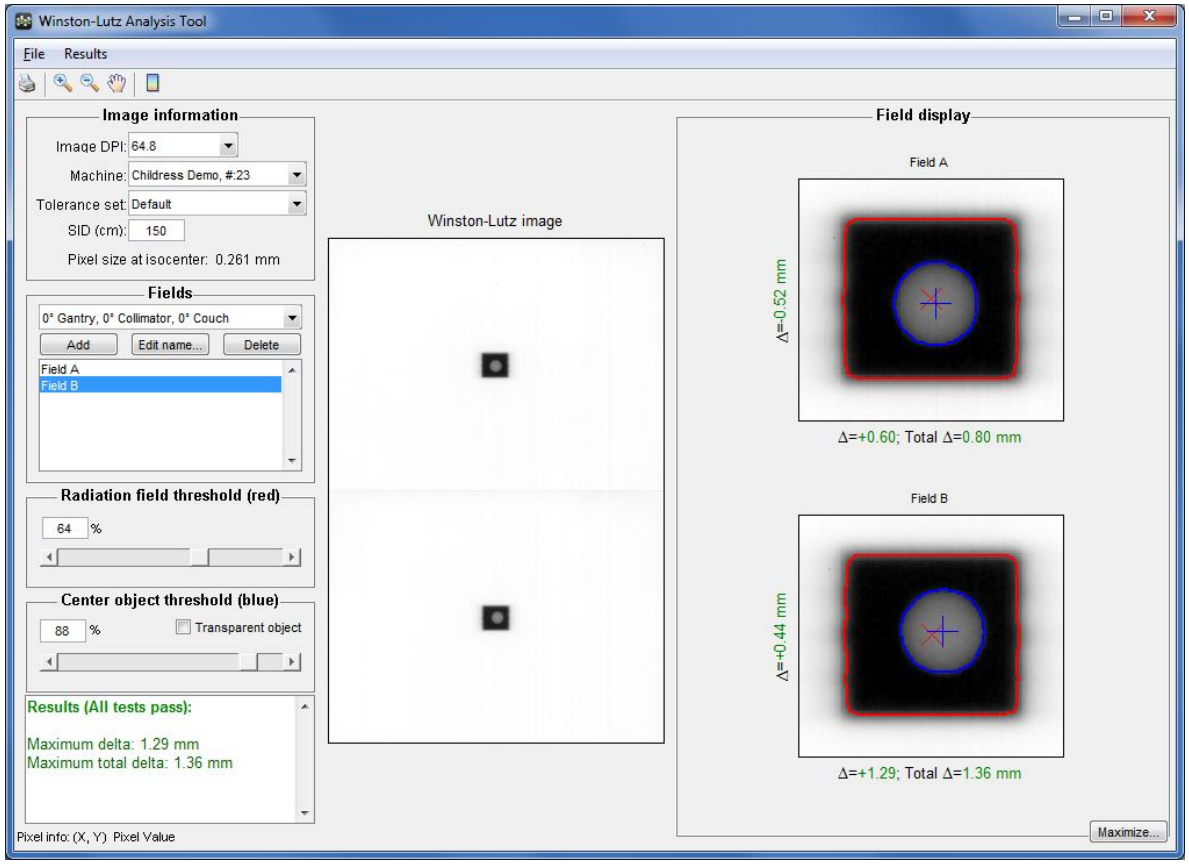
Comparing Imaging QA Results

- In therapy, we are used to being able to directly compare performance data between machines and hospitals
- This is absolutely not the case with imaging QA, due to results depending on formulas, phantoms, setup, imaging techniques, etc.
- Even holding these parameters constant between different machines can lead to quantitative differences that do not indicate performance issues
- TG-142 recommends comparing results to “Baseline”

CBCT Positioning



- 2 EPID images after CBCT positioning
- WL-QA phantom
- Many ways to accomplish this
- WL is easy (<5 min) and accurate within 0.1 mm
- Can be repeated daily for frameless SRS / SBRT

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Monthly QA Summary

- 2 photon energies with IGRT, CBCT, and VMAT
  - 15 images analyzed (1 is a CBCT set)
  - 5 phantoms
  - 7 software modules (Or 1 module – AutoQA)
  - 13 PDF reports (can be merged into one)
  - 170 numerical values written to database
  - Everything can be performed with EPID / kV imagers
- ~70 minutes, after clinic's initial setup period
  - Machine time: 45 minutes
  - Export images from R+V system: 10 minutes
  - DoseLab / FractionCHECK analysis: 15 minutes

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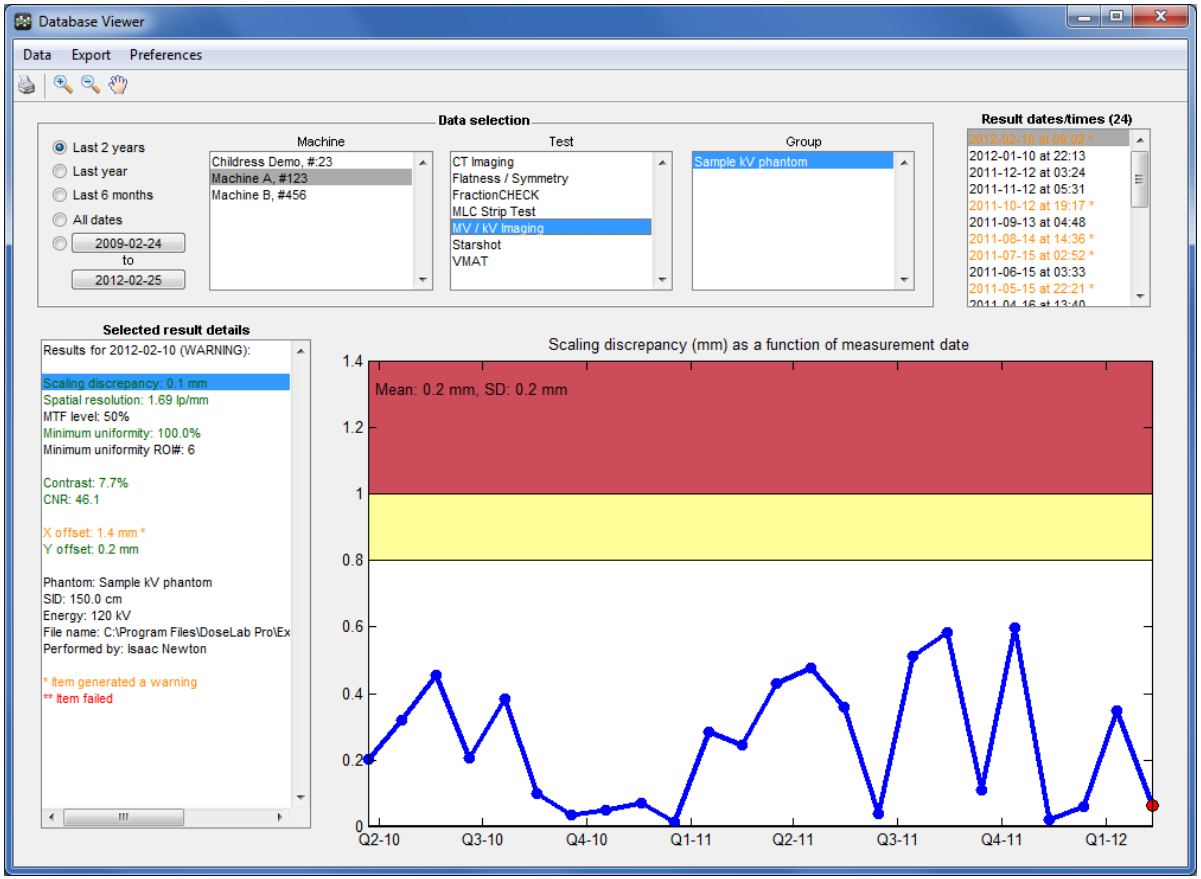
Result Documentation



- Documentation is essential
- PDF reports can show original image and ROIs
- Database can save and trend numeric results

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Issues Discovered During TG-142

- Scaling discrepancy >3 mm: Imager SID needs recalibration
  - May also affect CBCT positioning
- Contrast or uniformity issues: Imaging panel needs recalibration (dark field / flood field recalibration)
- Several bad pixels: Recalibrate or replace imaging panel
- Pin cushion distortion in image: Replace imaging panel
- CBCT imaging issues typically indicate need to recalibrate

Web Resources

- "A Practical Guide to TG-142 QA"
  http://www.medphysfiles.com/
  - 50 page TG-142 procedure guide
  - XLS file of TG-142 tables
  - Written by Jimmy Jones
- "Modified Winston-Lutz Test for IGRT Setups"
  http://www.medphysfiles.com/
  - CBCT Winston-Lutz Guide
  - Written by Nathan Childress

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Summary

- TG-142 requires a lot of QA
- Specialized software is necessary to be TG-142 compliant
- Imaging QA is very different from therapy QA
  - Results difficult to compare
  - Nearly everything based on deviation from baseline
- Software can automate tasks:
  - Analysis of all results
  - Documentation
  - Database saving and trending

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