Atrium Health

Automation in Machine QA

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Objectives

- Explain the use of the Eclipse Scripting API for QA purposes
- Show examples of dose extraction with ESAPI
- Introduce imaging and DICOM manipulation strategies
- Demonstrate treatment planning system QA techniques

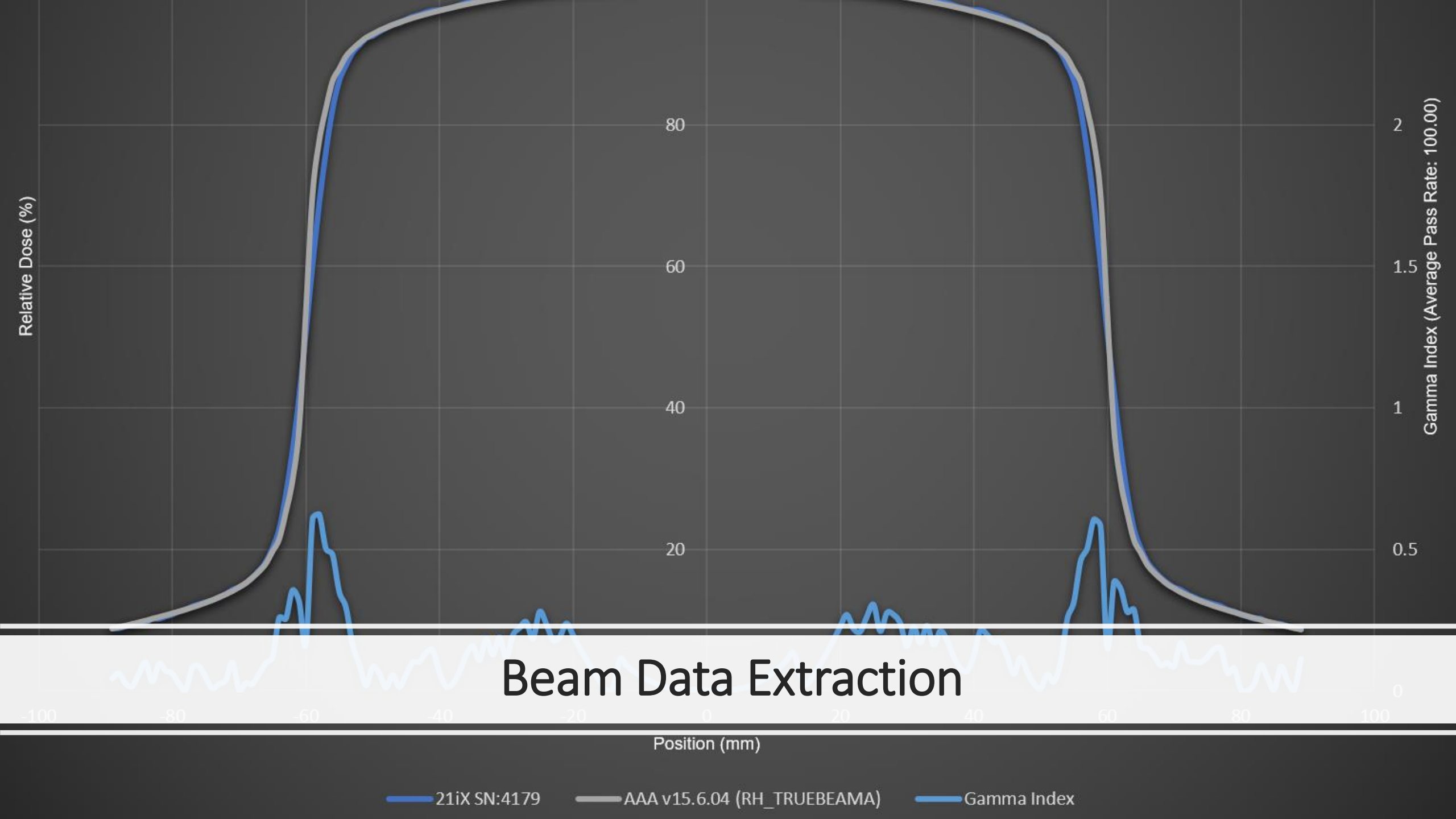
Overview of ESAPI

- The Eclipse Scripting API (ESAPI) is an invaluable tool for Eclipse users
- Not only for clinical automation tools, but can use for machine QA as well
- Beam data extraction, image profiles, plan parameters, and more
- Newer versions allow for automatic plan creation and optimization (15.x and older research versions)

Building Blocks for QA

- A few classes in the API are particularly nice for machine QA
  - Course, Plan, Beam, and Dose classes
    - Can access any field dose
  - Also extract for images
- Can use the following main types of Eclipse Scripting:
  - Plug-in single file
  - Plug-in binary
  - Stand-alone executable
- Also, with newer versions, Visual Scripting

Varian Medical Systems. Eclipse Scripting API Reference Guide (P1021698-003-C). November 2017. Pages 31-32



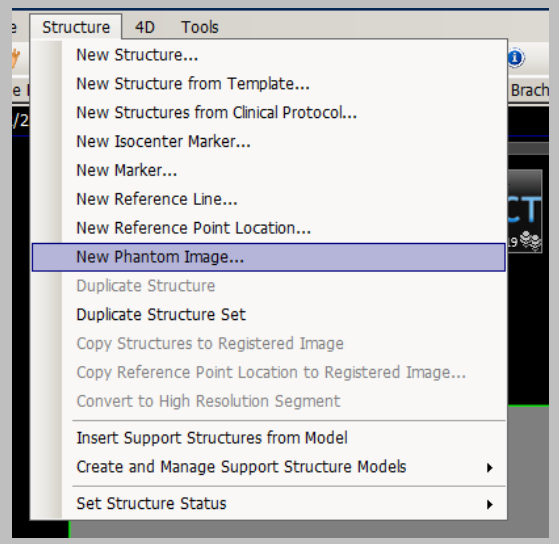
Beam Data Extraction

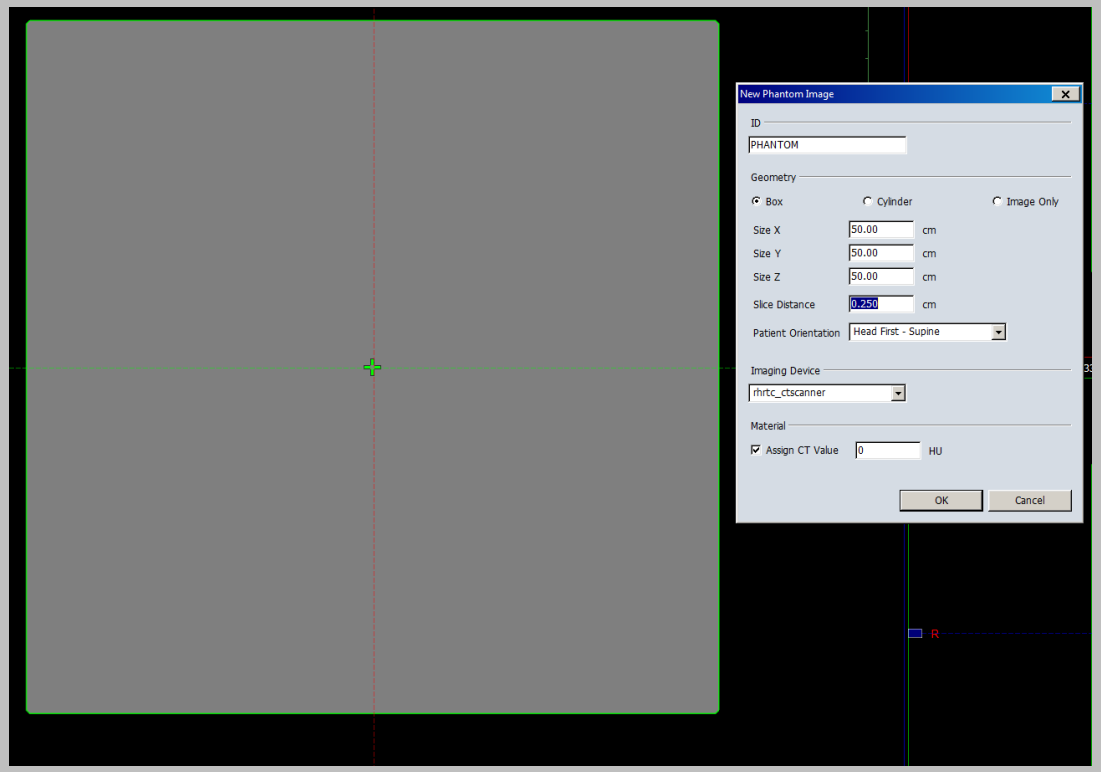
Beam Data Extraction

- Useful for commissioning, annual, and TPS QA
- Extract dose profiles, dose planes, voxels, and fluences from treatment plans
- Point dose extraction available as well

Phantom Creation

- Very easy in Eclipse 13.6 and higher
- Can automate the creation in research versions or 15.x ESAPI





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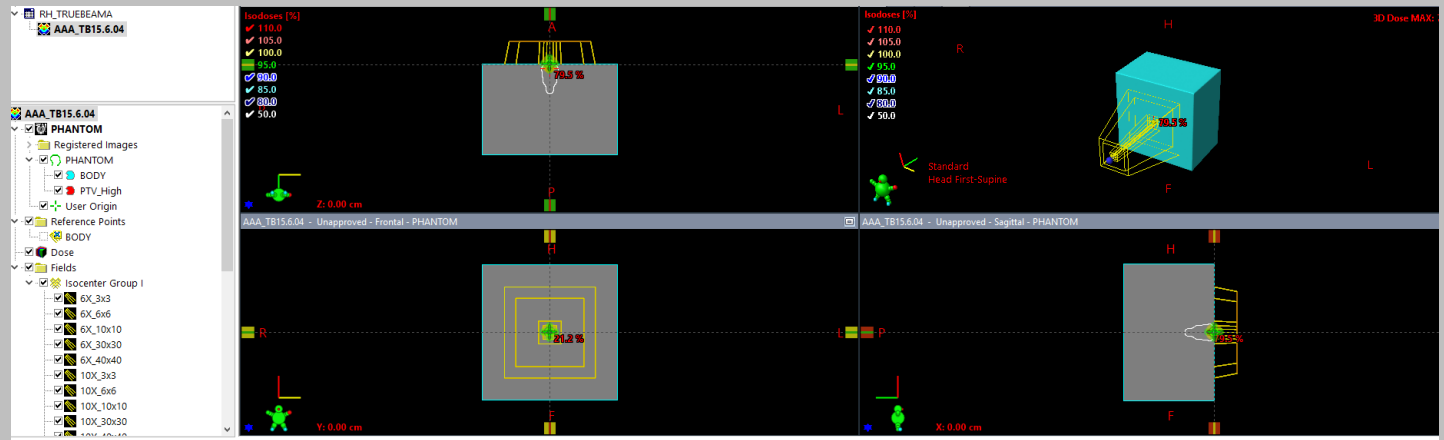
Plan Creation

- Can manually create beams, or use 15.x ESAPI to do this programmatically
- Match SSD, Field Size, Energy, Gantry to your scan measurements

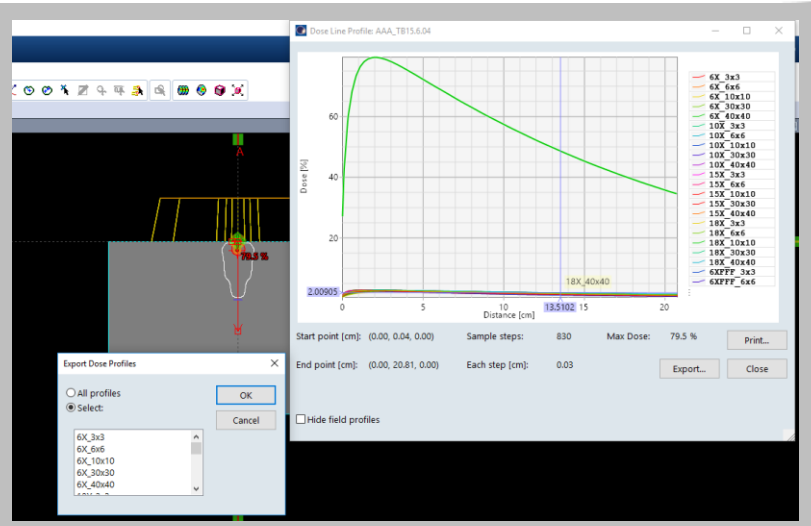


Fields | Dose | Field Alignments | Plan Objectives | Optimization Objectives | Dose Statistics | Reference Points | Calculation Models | Plan Sum

Group	Field ID	Technique	Machine/Energy	MLC	Field Weight	Scale	Gantry Rtn [deg]	Coll Rtn [deg]	Couch Rtn [deg]	Wedge	Field X [cm]	X1 [cm]	X2 [cm]	Field Y [cm]	Y1 [cm]	Y2 [cm]	X [cm]	Y [cm]	Z [cm]	Calculated SSD [cm]	MU	Ref [cG
I	6X_3x3	STATIC-I	RH_TRUEBEAMA - 6X		0.006	IEC61217	0.0	0.0	0.0	None	3.0	-1.5	+1.5	3.0	-1.5	+1.5	0.00	0.00	0.00	100.0	50.0	
I	6X_6x6	STATIC-I	RH_TRUEBEAMA - 6X		0.006	IEC61217	0.0	0.0	0.0	None	6.0	-3.0	+3.0	6.0	-3.0	+3.0	0.00	0.00	0.00	100.0	50.0	
I	6X_10x10	STATIC-I	RH_TRUEBEAMA - 6X		0.007	IEC61217	0.0	0.0	0.0	None	10.0	-5.0	+5.0	10.0	-5.0	+5.0	0.00	0.00	0.00	100.0	50.0	
I	6X_30x30	STATIC-I	RH_TRUEBEAMA - 6X		0.010	IEC61217	0.0	0.0	0.0	None	30.0	-15.0	+15.0	30.0	-15.0	+15.0	0.00	0.00	0.00	100.0	50.0	
I	6X_40x40	STATIC-I	RH_TRUEBEAMA - 6X		0.010	IEC61217	0.0	0.0	0.0	None	40.0	-20.0	+20.0	40.0	-20.0	+20.0	0.00	0.00	0.00	100.0	50.0	
I	10X_3x3	STATIC-I	RH_TRUEBEAMA - 10X		0.005	IEC61217	0.0	0.0	0.0	None	3.0	-1.5	+1.5	3.0	-1.5	+1.5	0.00	0.00	0.00	100.0	50.0	
I	10X_6x6	STATIC-I	RH_TRUEBEAMA - 10X		0.005	IEC61217	0.0	0.0	0.0	None	6.0	-3.0	+3.0	6.0	-3.0	+3.0	0.00	0.00	0.00	100.0	50.0	
I	10X_10x10	STATIC-I	RH_TRUEBEAMA - 10X		0.006	IEC61217	0.0	0.0	0.0	None	10.0	-5.0	+5.0	10.0	-5.0	+5.0	0.00	0.00	0.00	100.0	50.0	
I	10X_30x30	STATIC-I	RH_TRUEBEAMA - 10X		0.009	IEC61217	0.0	0.0	0.0	None	30.0	-15.0	+15.0	30.0	-15.0	+15.0	0.00	0.00	0.00	100.0	50.0	
I	10X_40x40	STATIC-I	RH_TRUEBEAMA - 10X		0.009	IEC61217	0.0	0.0	0.0	None	40.0	-20.0	+20.0	40.0	-20.0	+20.0	0.00	0.00	0.00	100.0	50.0	
I	15X_3x3	STATIC-I	RH_TRUEBEAMA - 15X		0.004	IEC61217	0.0	0.0	0.0	None	3.0	-1.5	+1.5	3.0	-1.5	+1.5	0.00	0.00	0.00	100.0	50.0	
I	15X_6x6	STATIC-I	RH_TRUEBEAMA - 15X		0.005	IEC61217	0.0	0.0	0.0	None	6.0	-3.0	+3.0	6.0	-3.0	+3.0	0.00	0.00	0.00	100.0	50.0	

Dose Profiles

- The old way
  - Drag profile in Eclipse
  - Hope you start in the correct spot!
  - Export to a CSV file
- The new way
  - Dose class
  - GetDoseProfile(VVector start, VVector stop, double[] buffer)
  - Very precise extraction
  - Automate across the entire data set



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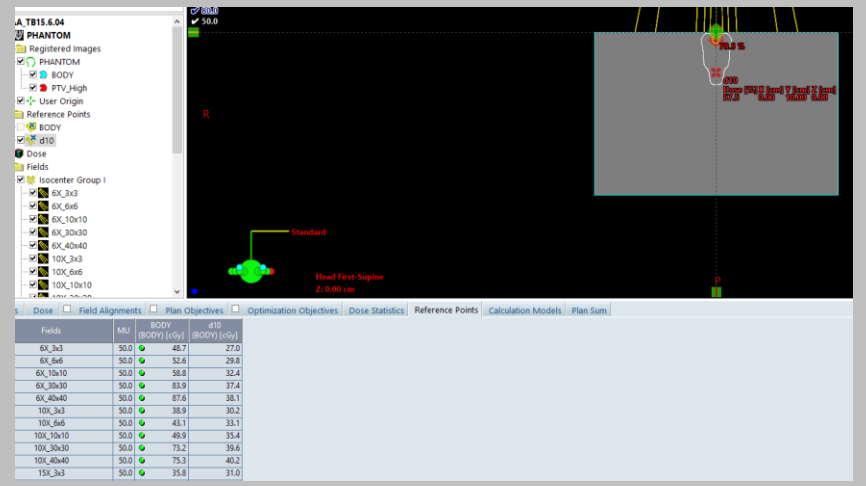
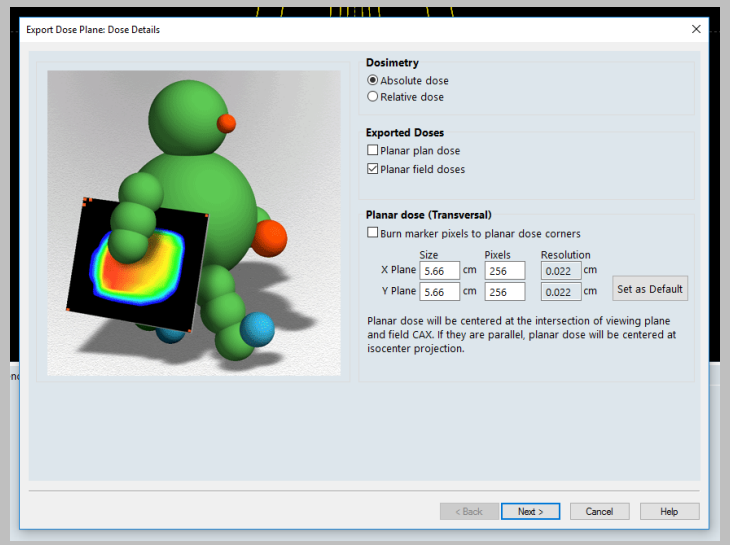
Point Doses

- The old way
  - Create reference point
  - Manually compare field doses at these points
- The new way
  - Dose class
  - GetDoseToPoint(Vvector at)
  - Extract at any point, doesn't have to be a reference point
  - All field doses can be done at once and compared to measured
  - Great for TG-51 verification and spot checks



Dose Planes

- The old way
  - Dose export in Eclipse
  - Very time consuming if doing many fields
  - Need to have the plane selected
- The new way
  - Dose class again
  - GetVoxels(int planeIndex, int[,] buffer)
  - Can create any dose plane by combining slices
  - It does need to match the dose X and Y size of the dose



Putting It All Together

- Standalone program that can search the patient database and extract the curves
- Compare to the measured and report

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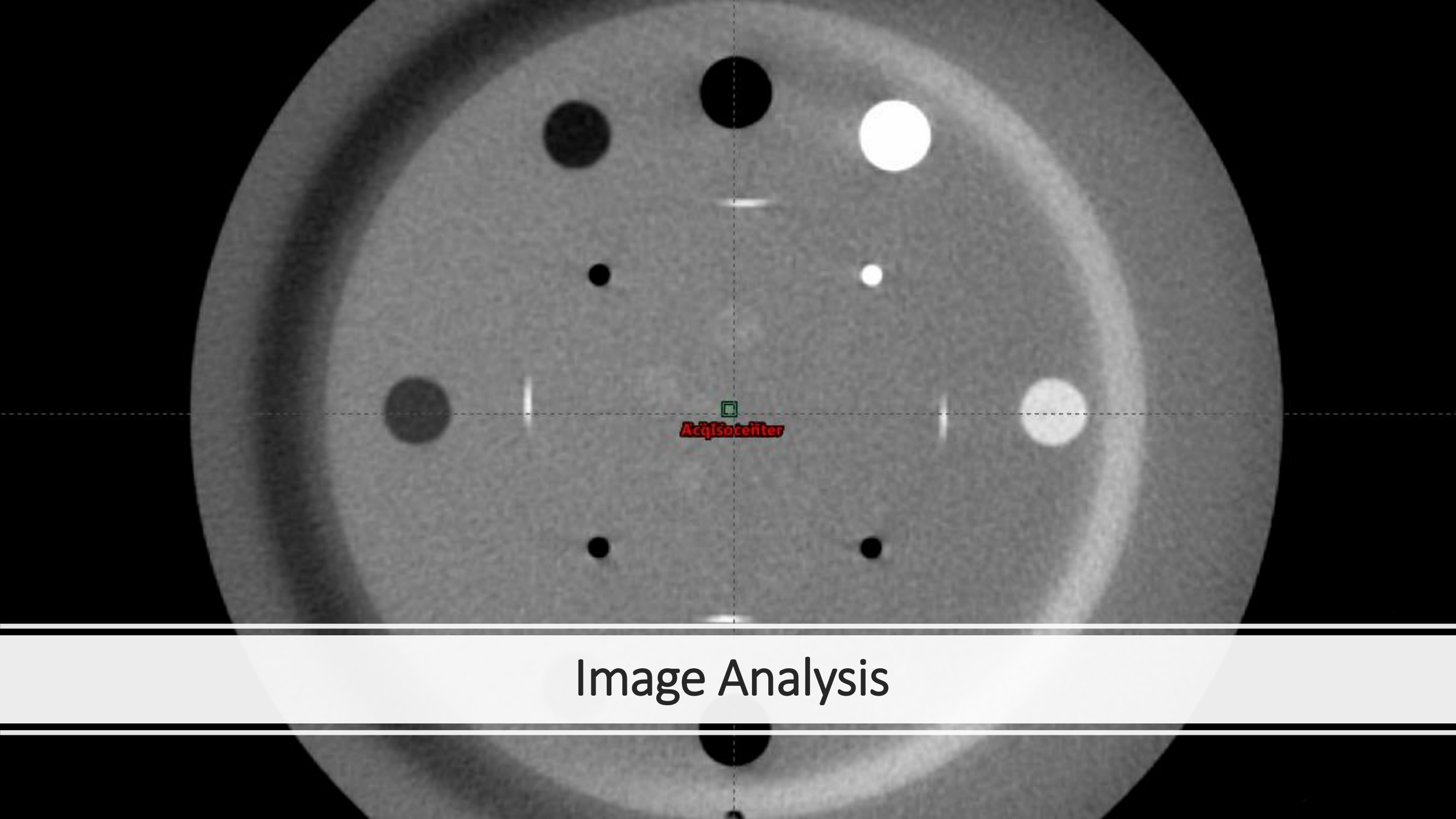


Image Analysis

Catphan®

- Many different models
  - So, some of the tests presented here may be different
- Can use for TG-142 CBCT monthly imaging tests
- Many great commercial tools on the market, but can use ESAPI to help in the absence of these tools

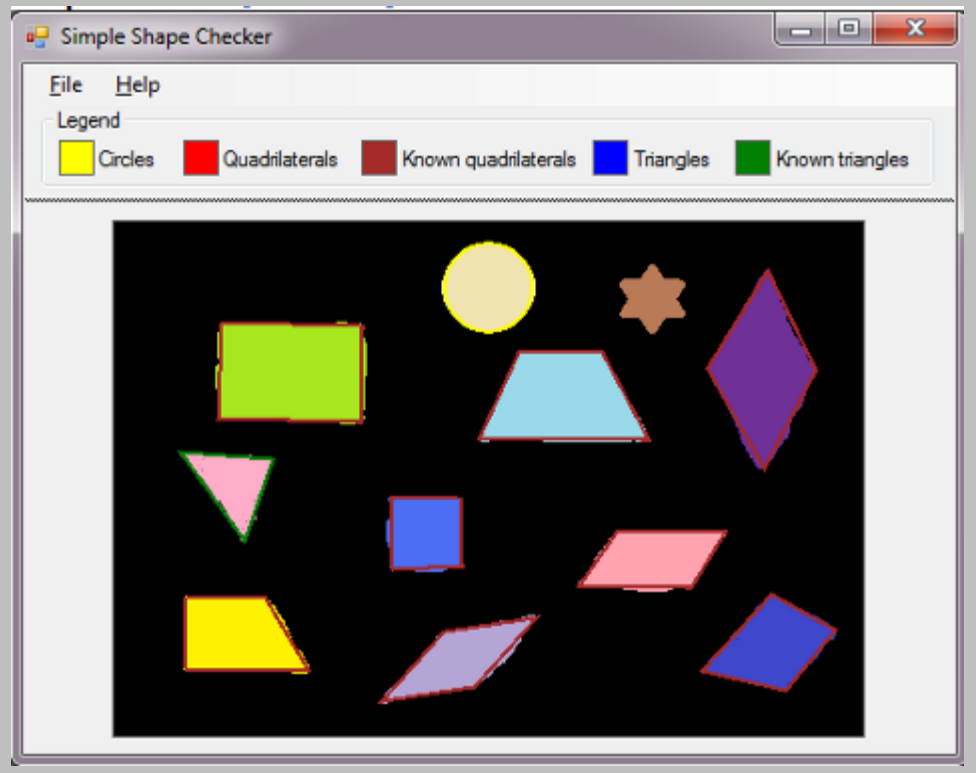
Klein EE, Hanley J, Bayouth J, Yin FF, Simon W, Dresser S, Serago C, Aguirre F, Ma L, Arjomandy B, Liu C. Task Group 142 report: Quality assurance of medical accelerators a. Medical physics. 2009 Sep;36(9Part1):4197-212.

Image Plane Extraction

- ImageProfile class
  - GetImageProfile(VVector start, VVector stop, double[] buffer)
- Just iterate the vectors down the image plane to get a jagged array of doubles
- Or GetVoxels() method to get int[,]
- Personally like GetImageProfile() to let ESAPI handle subvoxel interpolation

Aforge.NET Framework

- Framework for image processing
- Edge and blob detection algorithms
  - Use to detect objects in a phantom
- Open source
  - Under the GNU LGPL license
- Will come up more in other examples
  - Winston-Lutz
  - Light vs Radiation Field

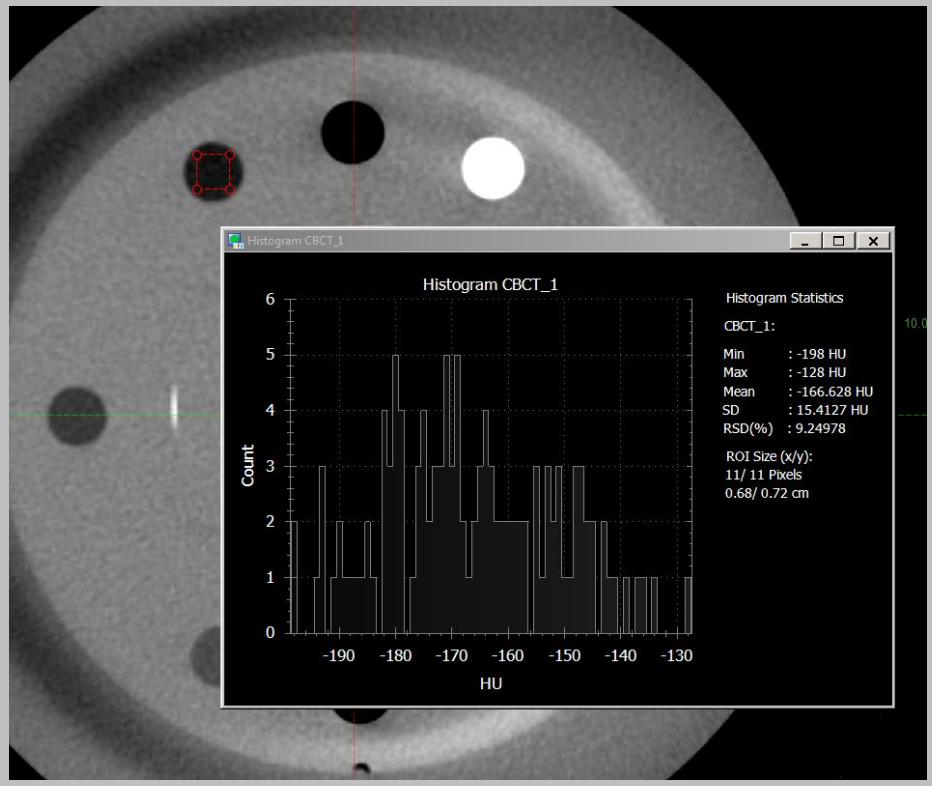


http://www.aforgenet.com/

http://www.gnu.org/licenses/lgpl-3.0.html

HU Detection

- My old way of pulling out HU values
  - Use Histogram tool in Eclipse Contouring
- New way
  - Image built from pixel values in ESAPI
  - Circles detected from BlobCounter class
  - Only looks at the circles
    - Get average values for each detected



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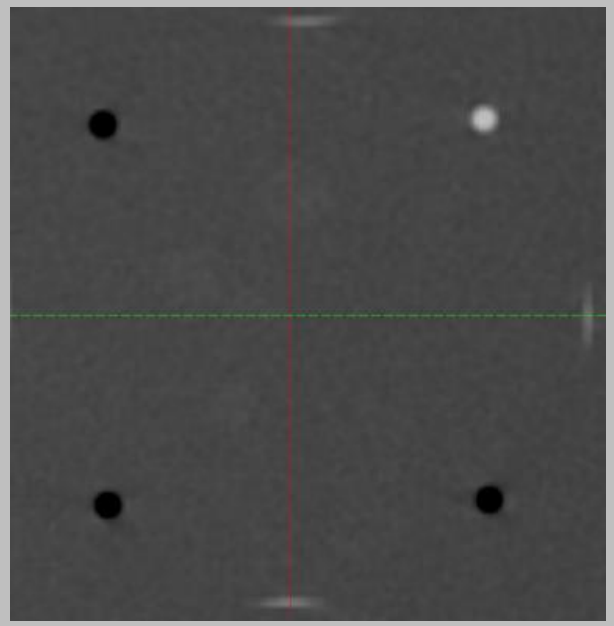
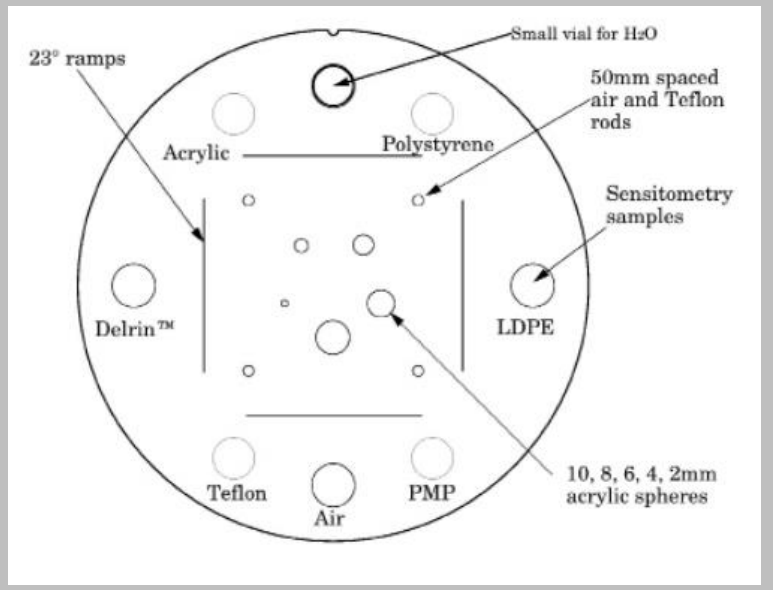
Contrast

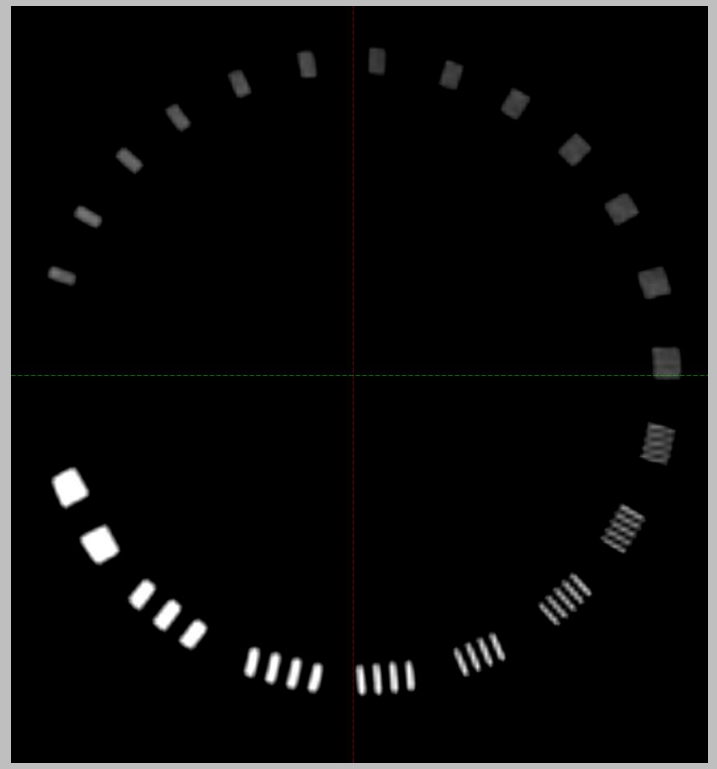
- Use the center of this image plan to look for acrylic spheres of varying size
- Again, ESAPI can help localize, extract, and process for analysis





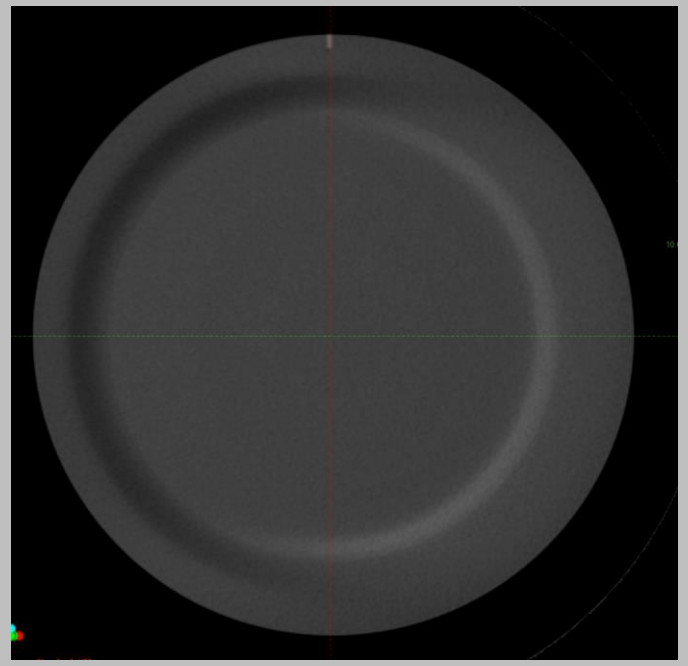
Line Pair Resolution

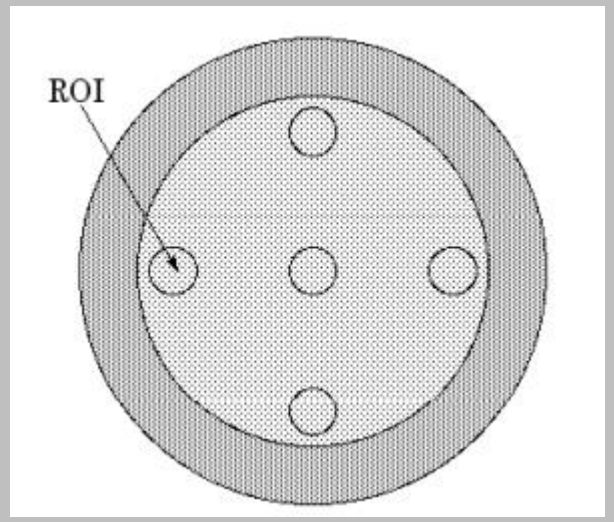
- Visually inspect the line pair for the minimum that can be resolved
- Use ESAPI to extract this slice based on the known position in the phantom
- Can use image processing to automatically threshold the image



Uniformity

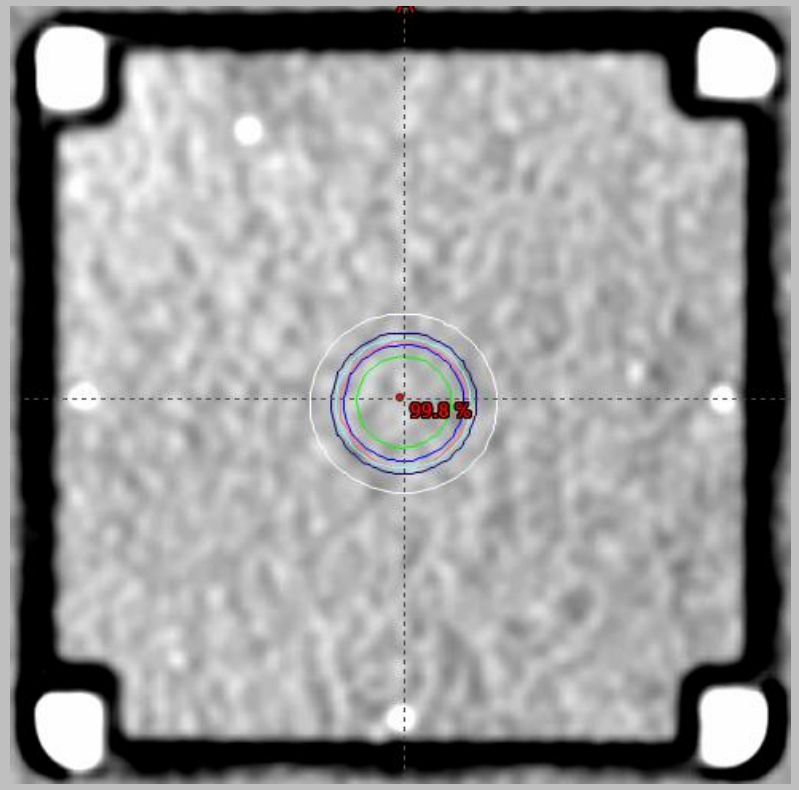
- Automatically locate the uniformity slice
- 5 samples of circular ROIs to get HU values
- Use for HU constancy, noise, and distortion





Gafchromic Film Analysis

- Extract the image profiles out of Eclipse
- Use edge detection for autoregistration to scanned film



DICOM UIDs

- Can use DICOM daemons to C-MOVE objects from the database
- However, need to know the DICOM UIDs for the objects
- ESAPI exposes this for:
  - Series
  - Images
  - Plan
  - Study

Carden, R. (2018). Daemons: A tour through Varian's DICOM API. In J. Pyyry & W. Keranen (Eds.), Varian APIs: A handbook for programming in the Varian oncology software ecosystem (pp.47-48)

Treatment Planning System QA

Treatment Planning System QA

- Use ESAPI to periodically check the TPS for constancy
- Can automate plan creation and compare to a baseline (v15.x)
- Combine this with machine QA to evaluate systematic deviations with the TPS to delivery

Create The Test Plan

- Come up with a clinical case that leverages the algorithms you want included
- Start with a QA patient and create a course
- Point the code that will execute to that patient and course
- Patient class – BeginModification()
- Open the structure set from a CT you want to use
- AddExternalPlanSetup(StructureSet structureSet)

Add Fields and Optimize

- ExternalPlanSetup class
  - AddMLCArcBeam(…)
    - Will add all of the field parameter when you call this method
    - Gantry, collimator, isocenter, etc
    - Can copy from the existing plan
    - Adds an MLC
- Optimize using a set of constraints for the structure set chosen
  - OptimizationSetup class
    - Add your collection of objectives
  - OptimizeVMAT(…)

Calculate Dose and Evaluate

- SetCalculationModel(CalculationType type, string model)
  - CalculateDose()
  - SaveModifications()
- Use the same dose extraction tools as before
- DVH analysis
- Compare extracted dose to measured dose

Conclusions

- ESAPI can greatly improve access to data for efficient machine and TPS QA
- Tasks that were very manual in the past can be automated
- Although programming is often involved (beginners should check out Visual Scripting), there is a very active community
  - https://www.reddit.com/r/esapi/
  - https://varianapis.github.io/
  - https://www.myvarian.com

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Thank You!

Questions?

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