Automated Plan Quality Check with Scripting

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Outline

- Introduction - BSW
- Automation in Treatment planning
- Eclipse Scripting API
- Script development
- Commissioning and testing
- Clinical implementation

Radiation Oncology: BSW

- Main clinic located at Temple, TX
  - Novalis Tx, Clinac 2100 C/D, Nucletron HDR unit
- Satellite clinics
  - Killeen: Clinac 2100 C/D
  - Waco: Truebeam, Varisource HDR unit
  - Waxahachie: Truebeam, Varisource HDR unit
  - Duncunville: Clinac 2100
- Future satellite clinics
  - Round rock (~ 2017 year end)
  - College station (~ 2016 year end)

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Radiation Oncology @ BSW

- Physician team
  - 9 Physicians
  - 6 Physician residents
- Physics team
  - 9 Physicists
  - 6 Dosimetrists
  - 1 Dosimetry student
  - 4 Physics residents

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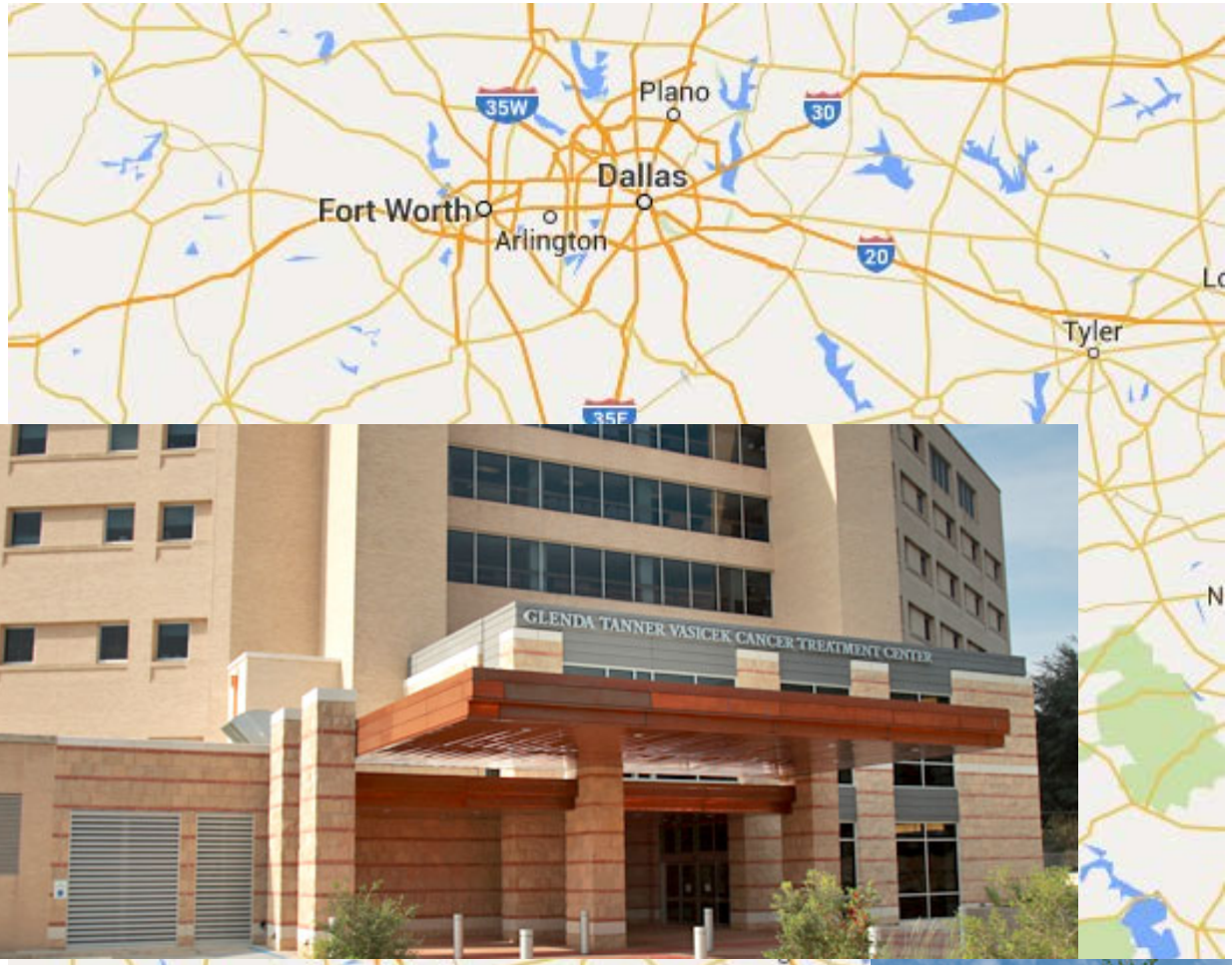
Plano
35W
30
Dallas
Fort Worth
Arlington
20
Tyler
35E
Round Rock
Austin
San Marcos
New Braunfels
10
San Antonio
45

GLENDA TANNER VASICEK CANCER TREATMENT CENTER


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CANCER CENTER

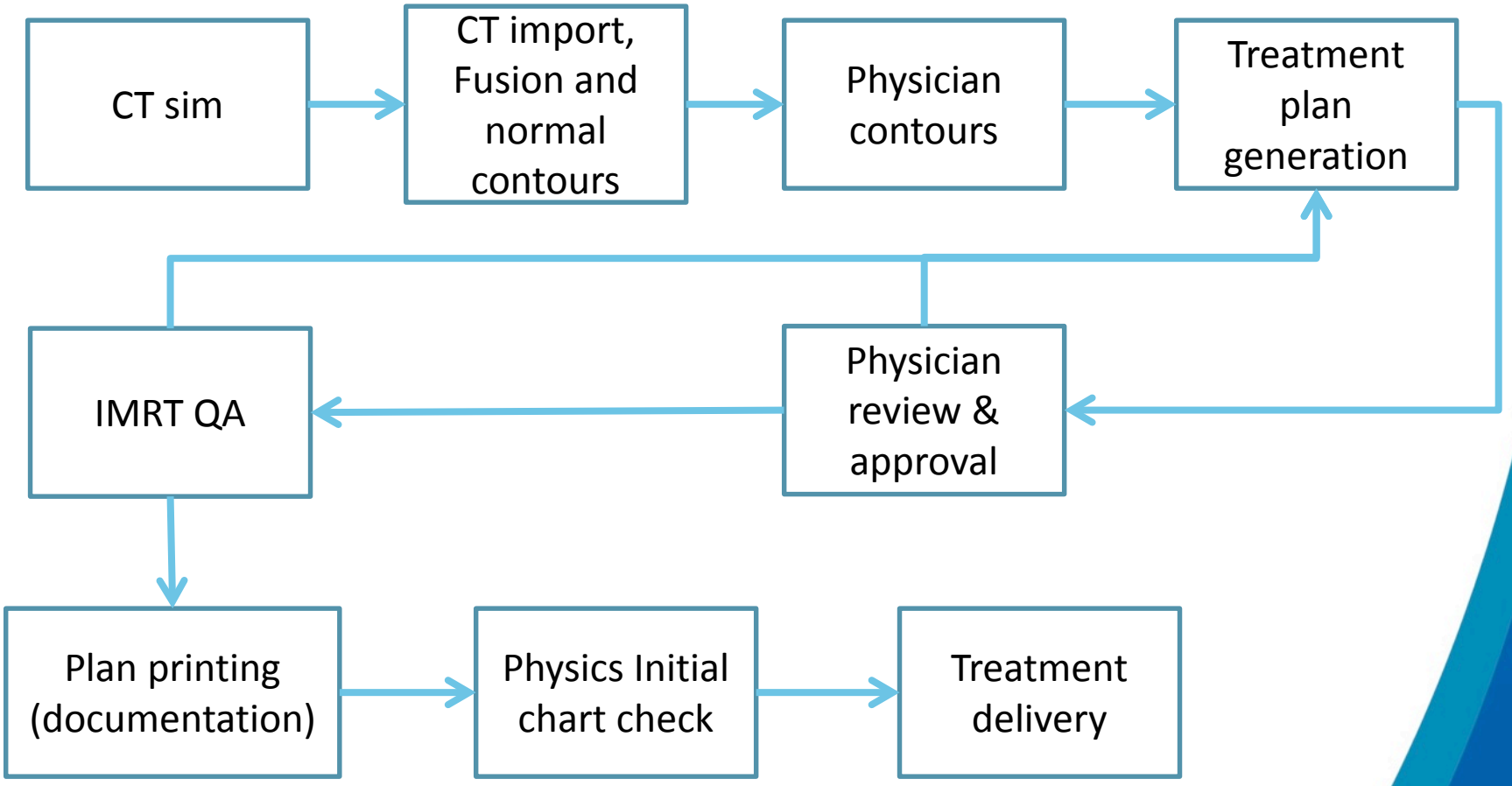
Automation in Treatment Planning

- Benefits of Automation
  - Improved efficiency
  - Reduced human error

} **TIME**

- Components of treatment planning
  - Contouring
  - Beam arrangement and apertures
  - Optimization
  - Dose calculation
  - Constraints check
  - Plan documentation/printing

Treatment Workflow



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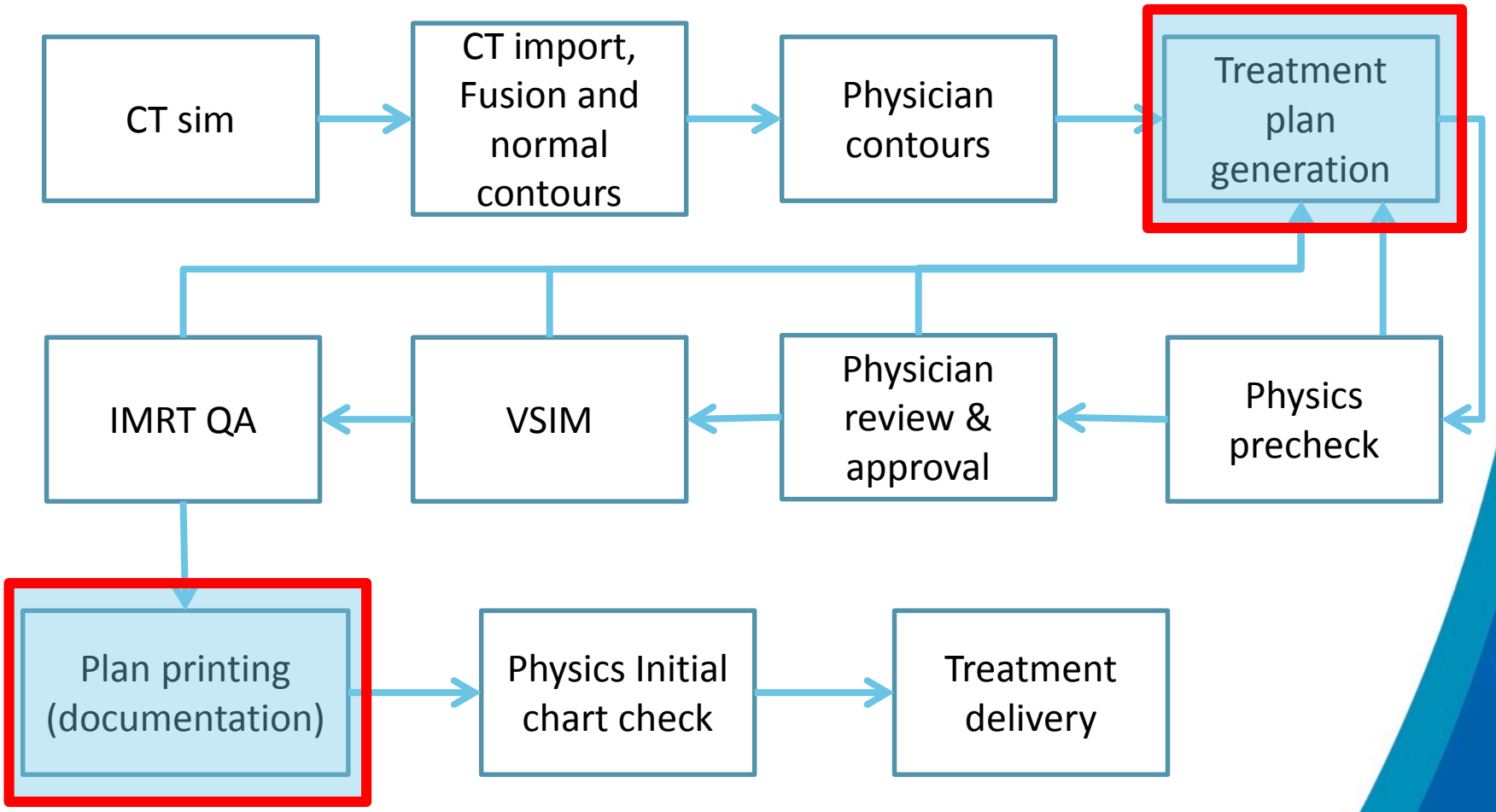
SRS SBRT Treatment Workflow



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Eclipse Scripting API

- The Eclipse Scripting API (application programming interface) allows developers to write C#.NET scripts to access treatment planning information in Eclipse.

- The scripts can be integrated into the Eclipse user interface, or they can be run as stand-alone executables.

- Scripts cannot write or change anything in the plan. READ only

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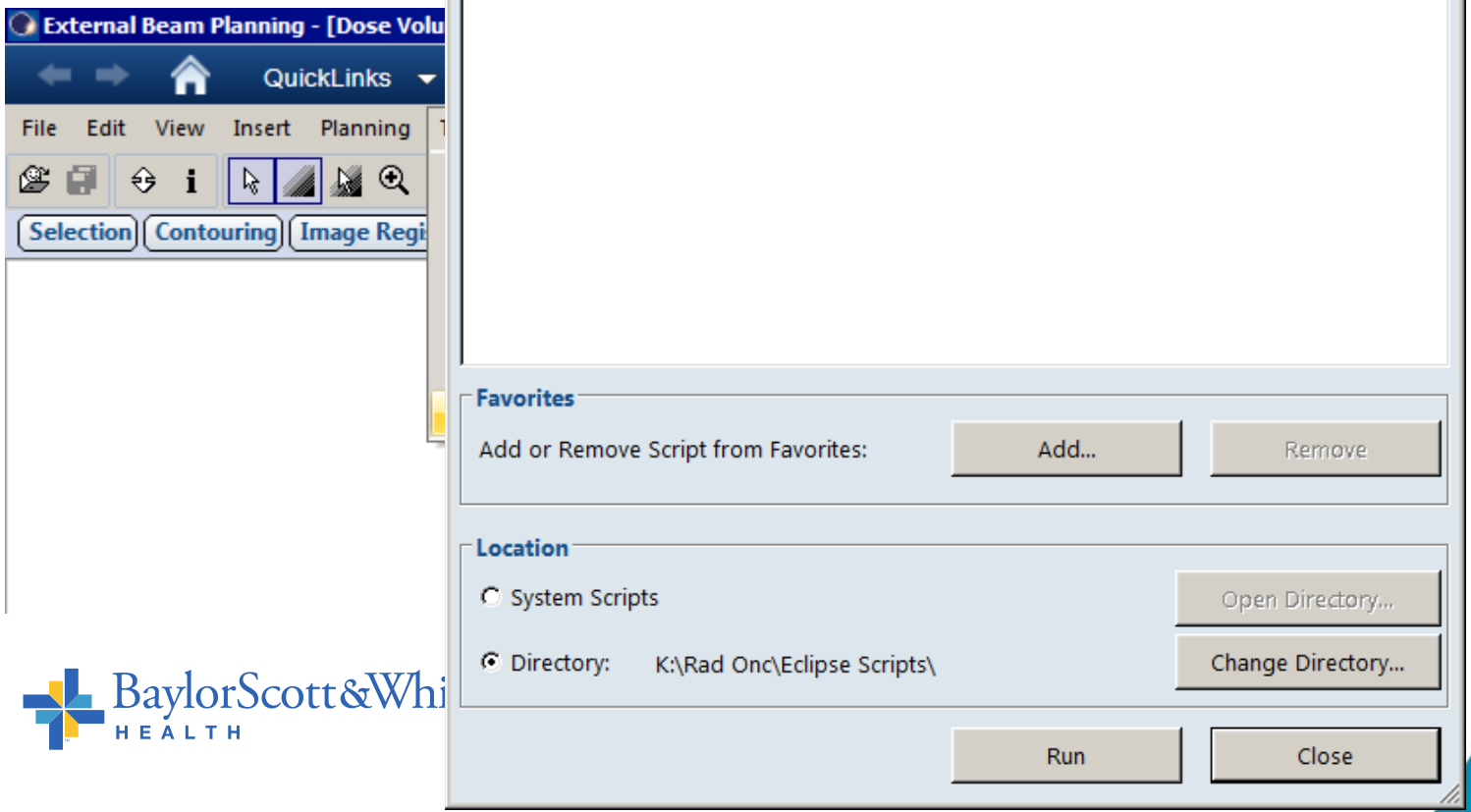
Scripting in Eclipse

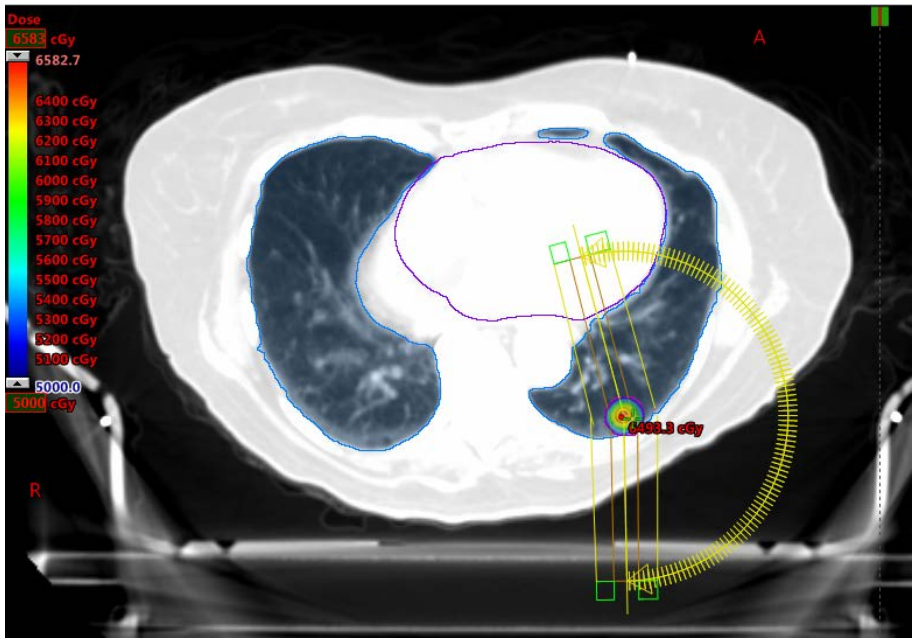
- Available tool – Eclipse v.11 and up
- https://var



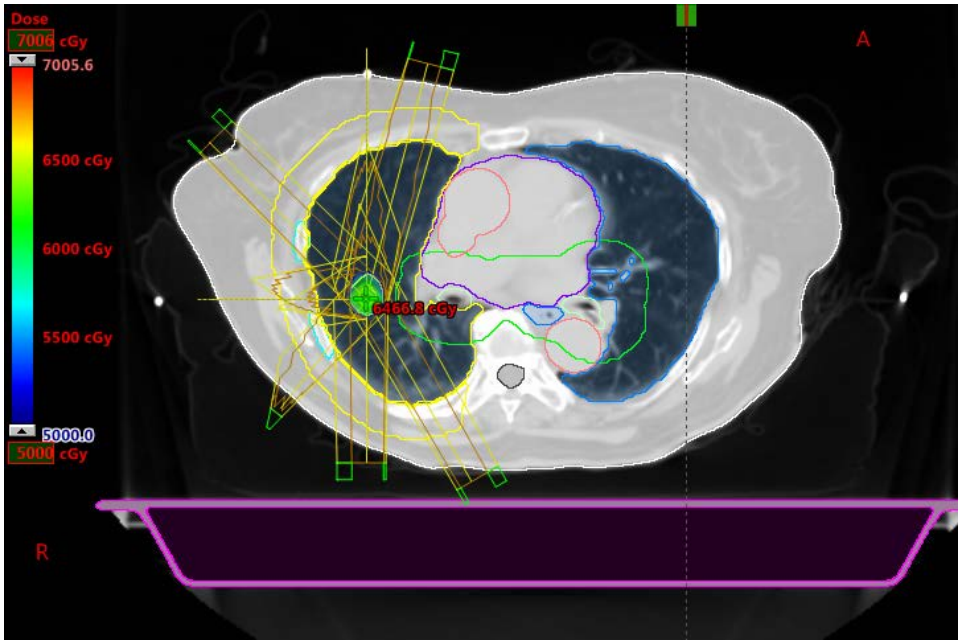
Clinical Implementation

Started using for SBRT and SRS plans
and expanded to all treatment plans at our clinic

Consider SBRT lung plan case



2 Rapid Arcs

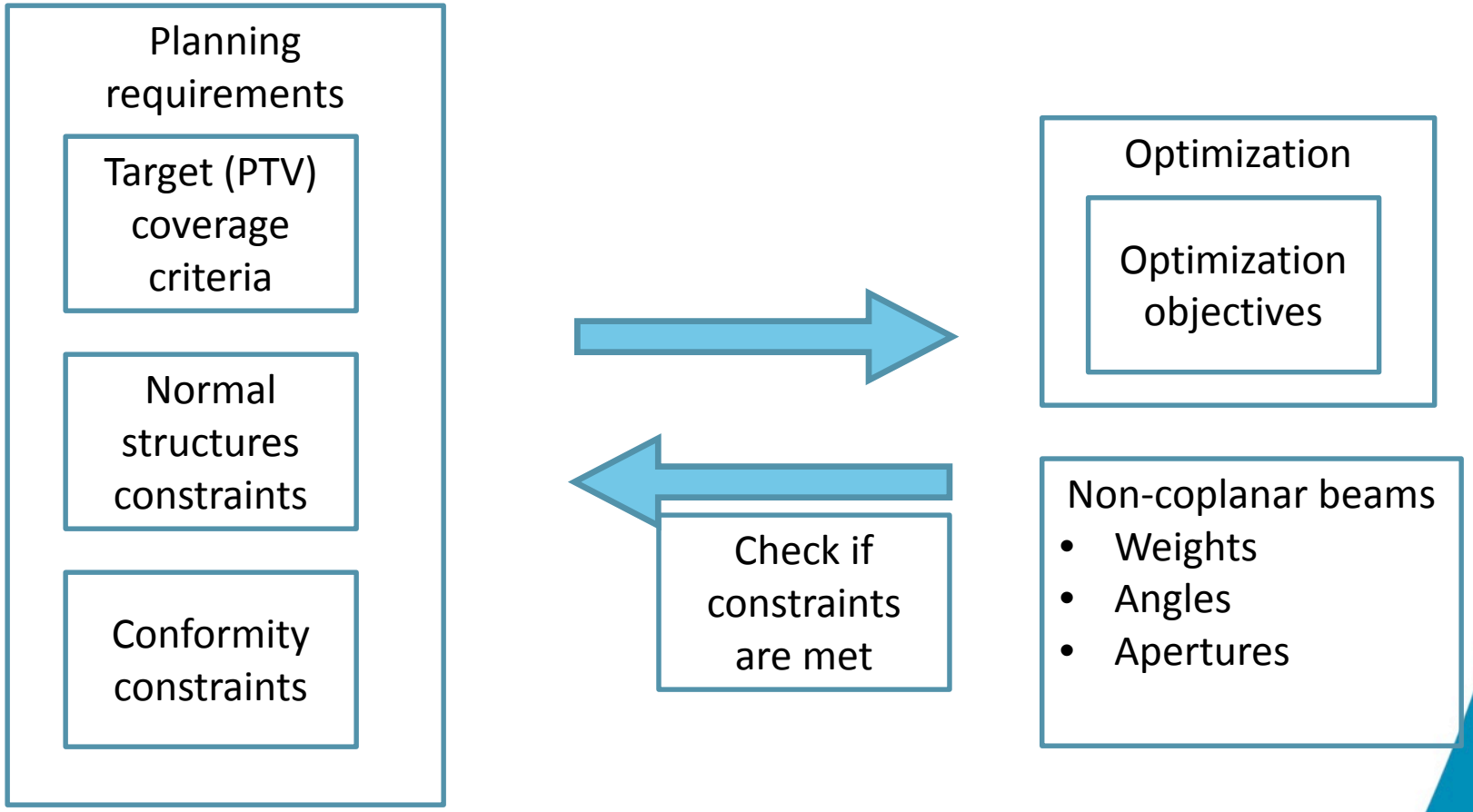


9 non co-planar beams

Four Fractions **Timmerman**

Serial Tissue	Volume	Volume Max (Gy)	Max Point Dose (Gy)**	Endpoint (≥Grade 3)
Optic Pathway	<0.2 cc	19.2 Gy	21.2 Gy	neuritis
Cochlea			18 Gy	hearing loss
Brainstem (not medulla)	<0.5 cc	20.8 Gy	27.2 Gy	cranial neuropathy
Spinal Cord and medulla	<0.35 cc <1.2 cc	18 Gy 13.6 Gy	25.6 Gy	myelitis
Spinal Cord Subvolume (5-6 mm above and below level treated per Ryu)	<10% of subvolume	18 Gy	25.6 Gy	myelitis
Cauda Equina	<5 cc	26 Gy	28.8 Gy	neuritis
Sacral Plexus	<5 cc	26 Gy	28 Gy	neuropathy
Esophagus*	<5 cc	18.8 Gy	30 Gy	stenosis/fistula
Brachial Plexus	<3 cc	24.8 Gy	29.6 Gy	neuropathy
Heart/Pericardium	<15 cc	28 Gy	34 Gy	pericarditis
Great vessels	<10 cc	43 Gy	49 Gy	aneurysm
Trachea and Large Bronchus*	<5 cc	28.8 Gy	34.8 Gy	stenosis/fistula
Bronchus- smaller airways	<0.5 cc	20 Gy	28 Gy	stenosis with atelectasis
Rib	<5 cc	43 Gy	54 Gy	Pain or fracture
Skin	<10 cc	33.6 Gy	36 Gy	ulceration
Stomach	<5 cc	25 Gy	33.2 Gy	ulceration/fistula
Bile duct			38.4 Gy	stenosis
Duodenum*	<5 cc <10 cc	17.2 Gy 14 Gy	24.4 Gy	ulceration
Jejunum/Ileum*	<30 cc	18.8 Gy	30 Gy	enteritis/obstruction
Colon*	<20 cc	26 Gy	32 Gy	colitis/fistula
Rectum*	<20 cc	30 Gy	37.5 Gy	proctitis/fistula
Ureter			43 Gy	stenosis

Treatment plan generation



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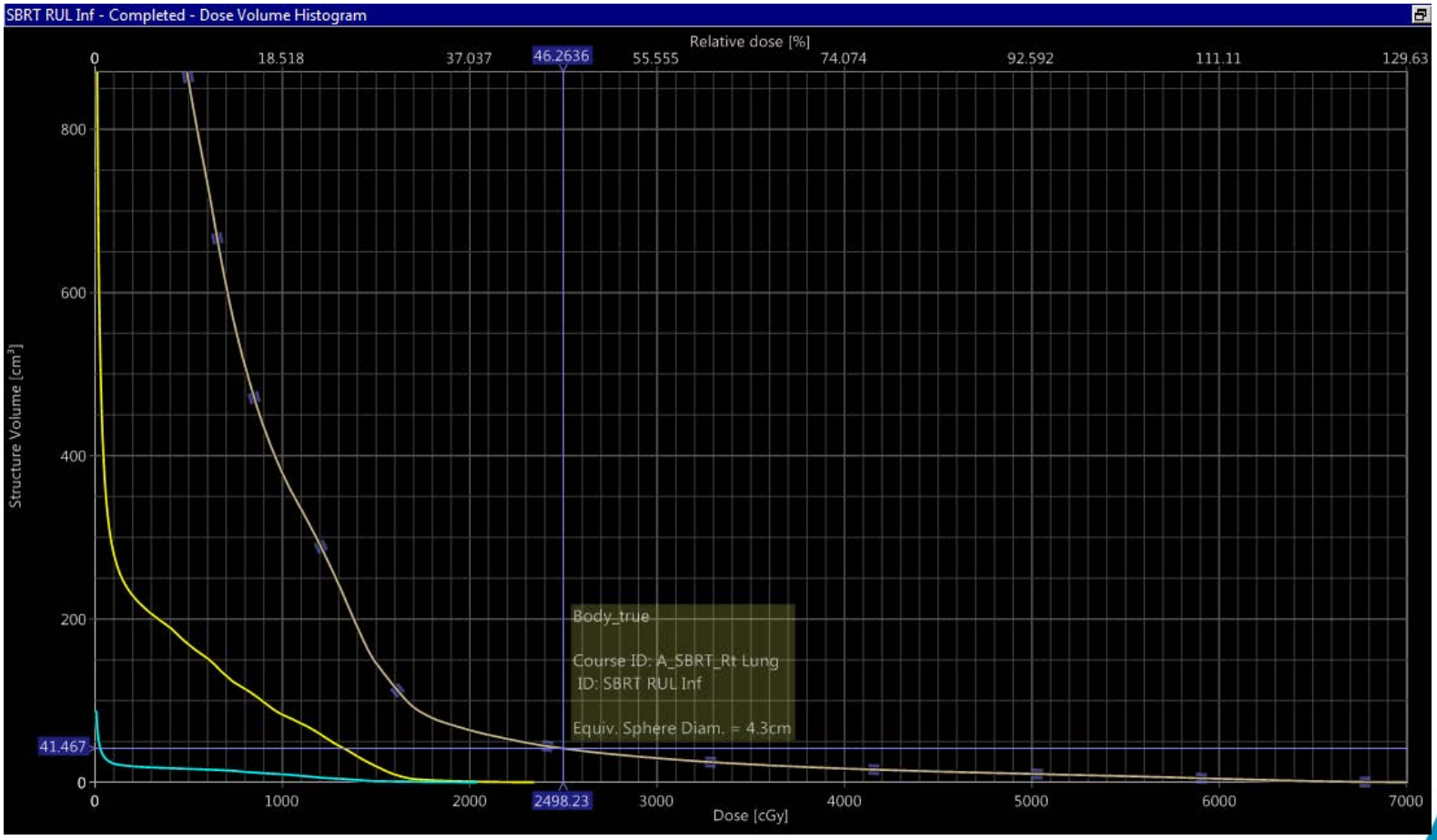
Data lookup from DVH



Dose constraint spreadsheet

Lung SBRT dose constraints	
Patient:	xxxx
MR #:	123
Dose:	5000
Site:	RLL
Date:	6/14/2016

PTV (cc):	30		PLAN	Minor Deviation	Major Deviation
V100 % (cc)		R(100%)	0.00	1.2	1.5
V50% (cc)		R(50%)	0.00	4.4	5.4
D2cm (%Rx)		D2cm (%Rx)	0.0%	56.7%	66.3%
V20Gy (%lung)		V20Gy (%lung)	0.0%	10.0%	15.0%

Legend:	Dose constraint		Volume Constraint
	Pass	At limit	Fail

RTOG 0915

	Volume (cc)	Constraint (Gy)	Plan Max (Gy) or (cc)	
Spinal cord	0.035	26		Gy
	0.35	20.8		cc
	1.2	13.6		cc
Esophagus*	0.035	30		Gy
	5	18.8		cc
Brachial Plexus	0.035	27.2		Gy
	3	23.6		cc
Heart/ Pericardium	0.035	34		Gy
	15	28		cc
Great vessels*	0.035	49		Gy
	10	43		cc
Trachea*	0.035	34.8		Gy
	4	15.6		cc
Skin	0.035	36		Gy
	10	33.2		cc
Stomach	0.035	27.2		Gy
	10	17.6		cc
Rib**	0.035	40		Gy
	1	32		cc

*Avoid circumferential irradiation

**Rib limit may be exceeded if rib structure lies within PTV

Parallel Tissue	Total volume	Dose (Gy)	Constraint (cc)	Value from DVH (cc)	Plan (cc)	
Both Lungs		12.4	1000		0	cc
Both Lungs		11.6	1500		0	cc
Liver		19.2	700		0	cc

Timmerman 2009

	Volume (cc)	Constraint (Gy)	Plan Max (Gy) or (cc)	
Spinal cord	0.035	25.6		Gy
	0.35	18		cc
	1.2	12.3		cc
Esophagus	0.035	30		Gy
	5	18.8		cc
Brachial Plexus	0.035	27.2		Gy
	3	23.6		cc
Heart/ Pericardium	0.035	34		Gy
	15	28		cc
Great vessels	0.035	49		Gy
	10	43		cc
Trachea and Large Bronchus	0.035	34.8		Gy
	4	15.6		cc
Bronchus small airways	0.035	28		Gy
	0.5	20		cc
Skin	0.035	36		Gy

File link

TIME - Measurement Metric

- DVH data look up
- Enter numbers in spreadsheet or
- Verify directly against constraints

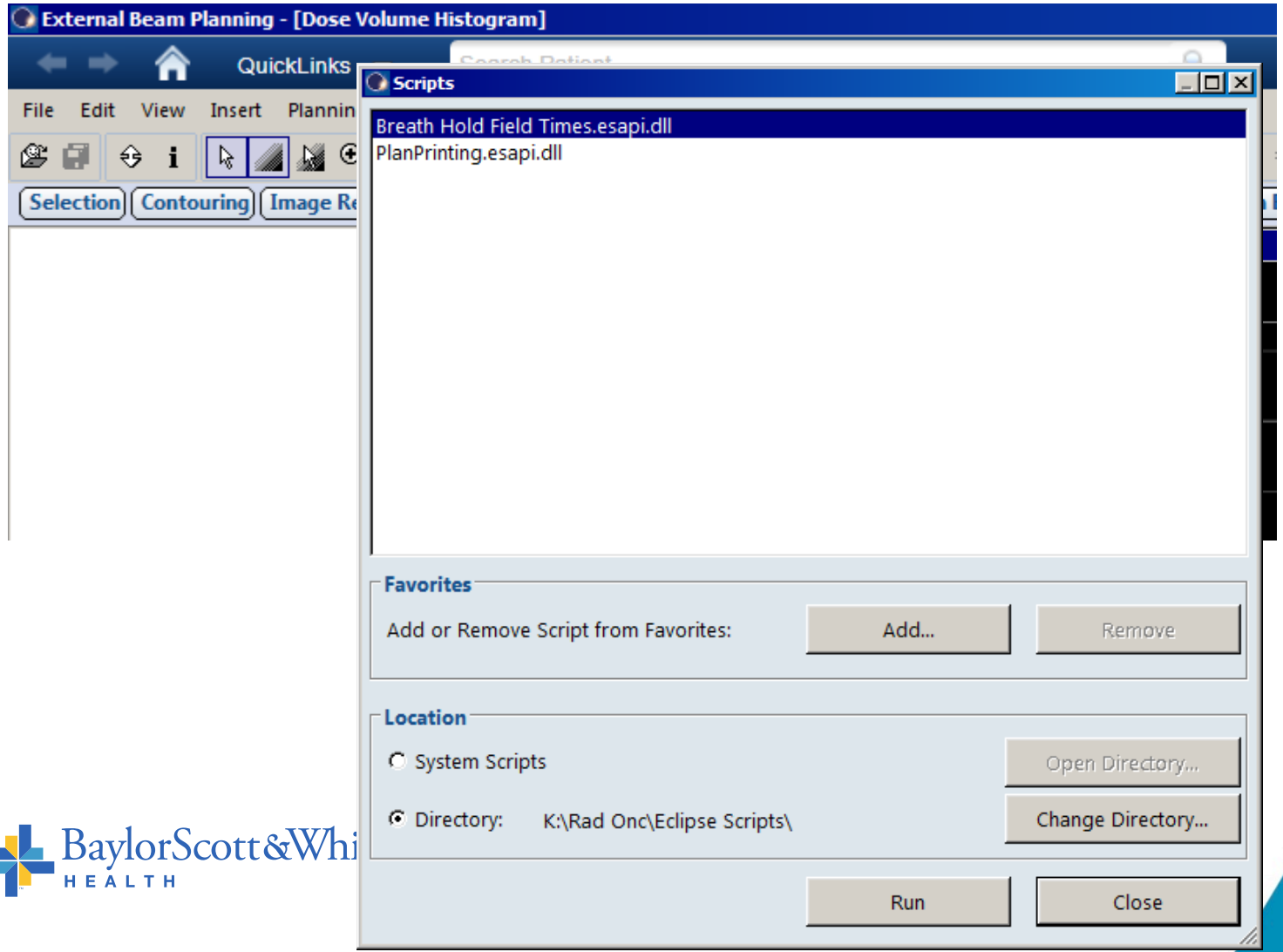
} ~ 8 min

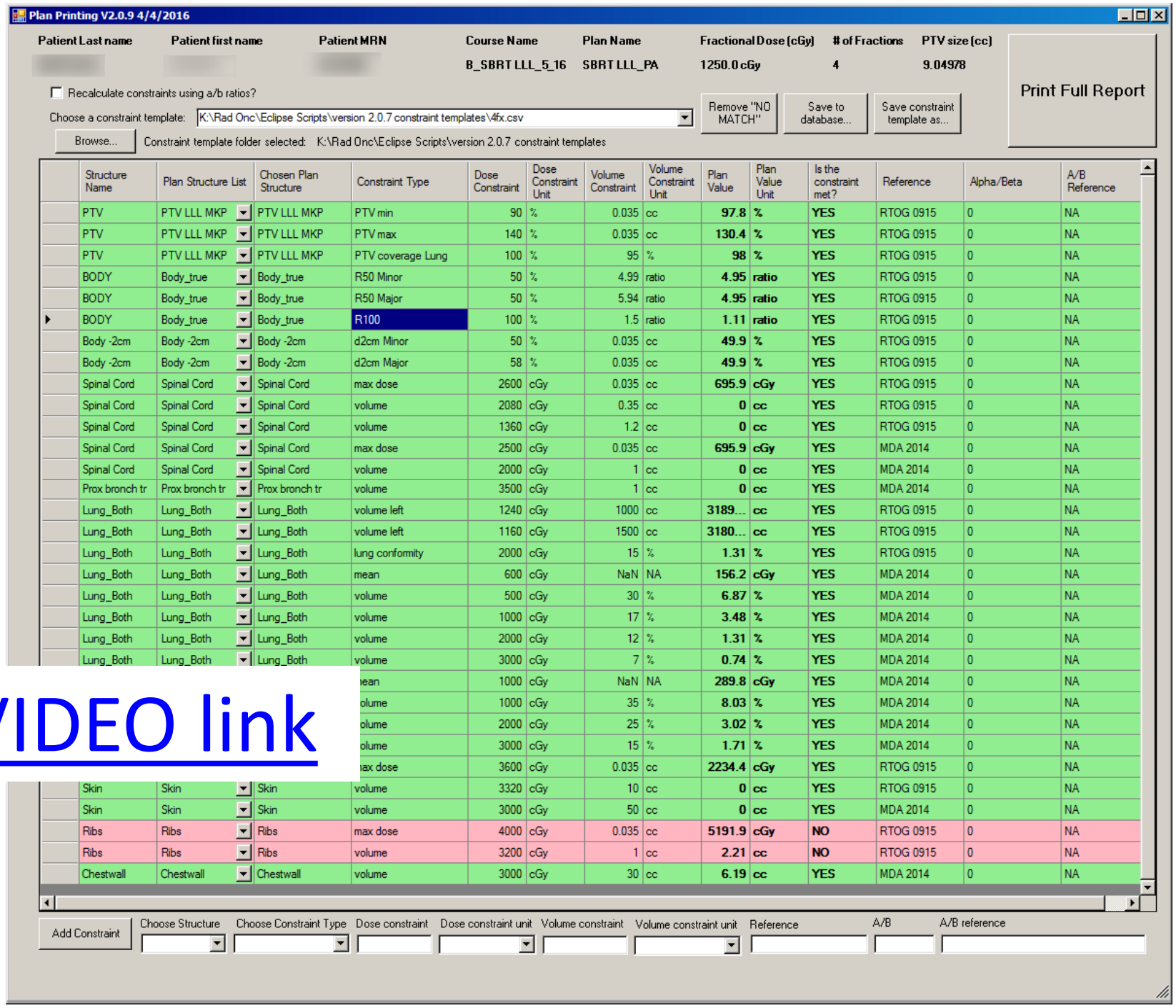
To achieve a desired plan (e.g. SBRT Lung)
~ 3 iterations = ~ **24 min** in DVH data look up

Can we get this done faster ?

YES

Use of Eclipse Scripts




Plan Printing V2.0.9 4/4/2016
Patient Last name
Patient first name
Patient MRN
Course Name
Plan Name
Fractional Dose (cGy)
# of Fractions
PTV size (cc)
B_SBRT LLL_5_16
SBRT LLL_PA
1250.0 cGy
4
9.04978
Print Full Report
Recalculate constraints using a/b ratios?
Choose a constraint template:
K:\Rad Onc\Eclipse Scripts\version 2.0.7 constraint templates\4fx.csv
Remove "NO MATCH"
Save to database...
Save constraint template as...
Browse...
Constraint template folder selected: K:\Rad Onc\Eclipse Scripts\version 2.0.7 constraint templates
Structure Name
Plan Structure List
Chosen Plan Structure
Constraint Type
Dose Constraint
Dose Constraint Unit
Volume Constraint
Volume Constraint Unit
Plan Value
Plan Value Unit
Is the constraint met?
Reference
Alpha/Beta
A/B Reference
PTV PTV LLL MKP PTV LLL MKP PTV min 90 % 0.035 cc 97.8 % YES RTOG 0915 0 NA
PTV PTV LLL MKP PTV LLL MKP PTV max 140 % 0.035 cc 130.4 % YES RTOG 0915 0 NA
PTV PTV LLL MKP PTV LLL MKP PTV coverage Lung 100 % 95 % 98 % YES RTOG 0915 0 NA
BODY Body_true Body_true R50 Minor 50 % 4.99 ratio 4.95 ratio YES RTOG 0915 0 NA
BODY Body_true Body_true R50 Major 50 % 5.94 ratio 4.95 ratio YES RTOG 0915 0 NA
BODY Body_true Body_true R100 100 % 1.5 ratio 1.11 ratio YES RTOG 0915 0 NA
Body -2cm Body -2cm Body -2cm d2cm Minor 50 % 0.035 cc 49.9 % YES RTOG 0915 0 NA
Body -2cm Body -2cm Body -2cm d2cm Major 58 % 0.035 cc 49.9 % YES RTOG 0915 0 NA
Spinal Cord Spinal Cord Spinal Cord max dose 2600 cGy 0.035 cc 695.9 cGy YES RTOG 0915 0 NA
Spinal Cord Spinal Cord Spinal Cord volume 2080 cGy 0.35 cc 0 cc YES RTOG 0915 0 NA
Spinal Cord Spinal Cord Spinal Cord volume 1360 cGy 1.2 cc 0 cc YES RTOG 0915 0 NA
Spinal Cord Spinal Cord Spinal Cord max dose 2500 cGy 0.035 cc 695.9 cGy YES MDA 2014 0 NA
Spinal Cord Spinal Cord Spinal Cord volume 2000 cGy 1 cc 0 cc YES MDA 2014 0 NA
Prox bronch tr Prox bronch tr Prox bronch tr volume 3500 cGy 1 cc 0 cc YES MDA 2014 0 NA
Lung_Both Lung_Both Lung_Both volume left 1240 cGy 1000 cc 3189... cc YES RTOG 0915 0 NA
Lung_Both Lung_Both Lung_Both volume left 1160 cGy 1500 cc 3180... cc YES RTOG 0915 0 NA
Lung_Both Lung_Both Lung_Both lung conformity 2000 cGy 15 % 1.31 % YES RTOG 0915 0 NA
Lung_Both Lung_Both Lung_Both mean 600 cGy NaN NA 156.2 cGy YES MDA 2014 0 NA
Lung_Both Lung_Both Lung_Both volume 500 cGy 30 % 6.87 % YES MDA 2014 0 NA
Lung_Both Lung_Both Lung_Both volume 1000 cGy 17 % 3.48 % YES MDA 2014 0 NA
Lung_Both Lung_Both Lung_Both volume 2000 cGy 12 % 1.31 % YES MDA 2014 0 NA
Lung_Both Lung_Both Lung_Both volume 3000 cGy 7 % 0.74 % YES MDA 2014 0 NA
1000 cGy NaN NA 289.8 cGy YES MDA 2014 0 NA
1000 cGy 35 % 8.03 % YES MDA 2014 0 NA
2000 cGy 25 % 3.02 % YES MDA 2014 0 NA
3000 cGy 15 % 1.71 % YES MDA 2014 0 NA
3600 cGy 0.035 cc 2234.4 cGy YES RTOG 0915 0 NA
Skin Skin Skin volume 3320 cGy 10 cc 0 cc YES RTOG 0915 0 NA
Skin Skin Skin volume 3000 cGy 50 cc 0 cc YES MDA 2014 0 NA
Ribs Ribs Ribs max dose 4000 cGy 0.035 cc 5191.9 cGy NO RTOG 0915 0 NA
Ribs Ribs Ribs volume 3200 cGy 1 cc 2.21 cc NO RTOG 0915 0 NA
Chestwall Chestwall Chestwall volume 3000 cGy 30 cc 6.19 cc YES MDA 2014 0 NA
VIDEO link
Add Constraint
Choose Structure
Choose Constraint Type
Dose constraint
Dose constraint unit
Volume constraint
Volume constraint unit
Reference
A/B
A/B reference

SBRT SRS Treatment Plans

- SBRT plans
  - Lung
  - Spine
  - Pancreas
  - Liver
  - Rectum
- SRS plans
  - Brain mets
  - Acoustic Neuroma

	2015	2016
Jan	6	11
Feb	9	11
Mar	9	14
Apr	18	9
May	15	11
Jun	9	4
Jul	7	
Aug	6	
Sep	13	
Oct	5	
Nov	9	
Dec	16	
TOTAL	122	60

24 min of DVH data look up

122 plans × 24 min = 2928 min

122 × 3 × 0.5 min = 183 min

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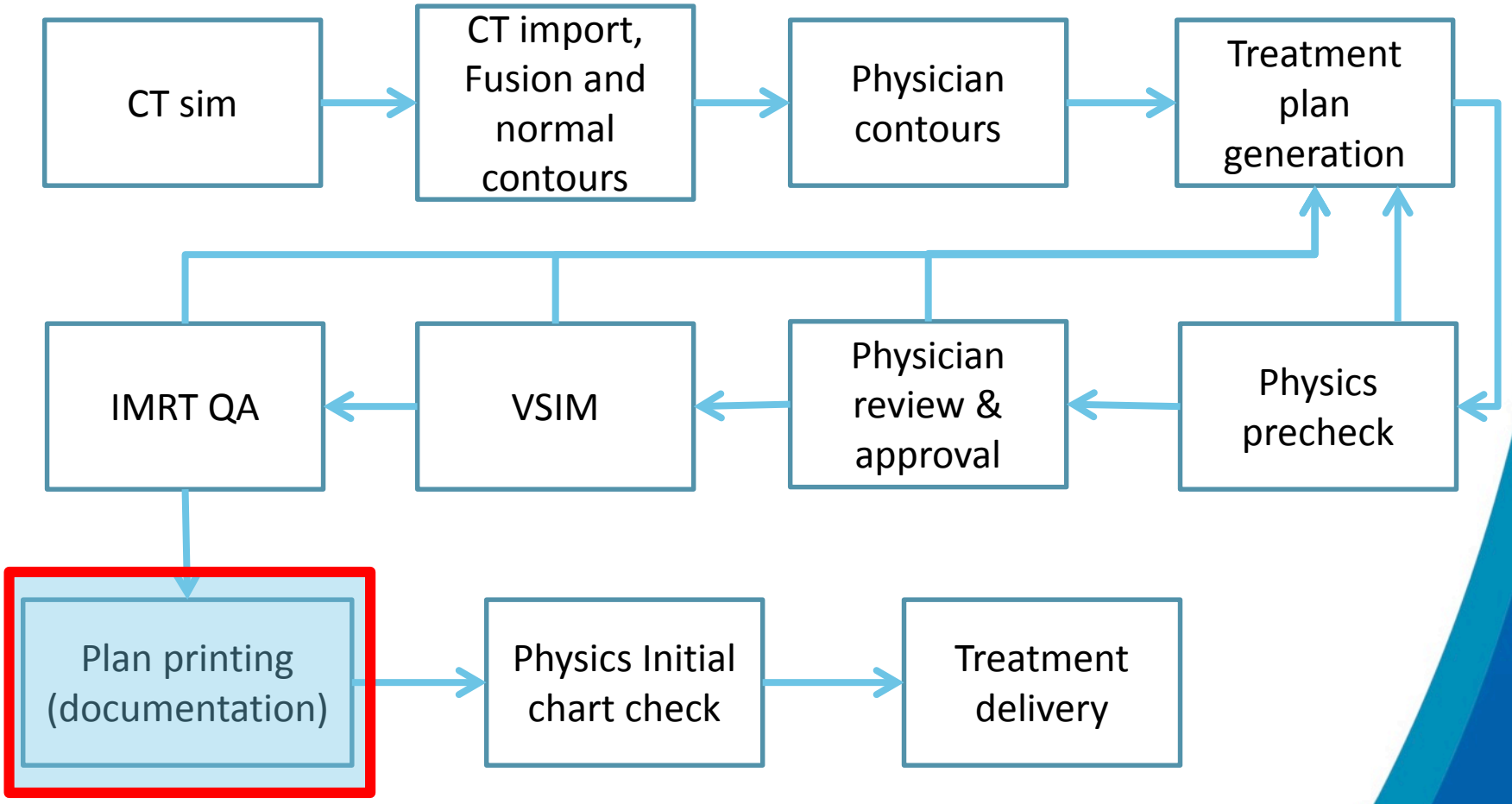
Commissioning of Scripts

- Critical testing was conducted
  - Patient information
  - Prescription
  - Auto listing of contours
  - Naming conventions
  - DVH data look up
  - Conformity criteria interpolation
  - Constraint type look up
  - Color coding (pass fail marginal-pass)
  - For different fractionations
  - Point dose vs. pixel dose
  - Constraint reference information
  - Custom constraints
  - Etc
  - Tested on multiple plans (diff sites, fractionations, and patients)

Script Based Plan Constraints Check

- All types of plans
  - 3D, IMRT, Rapid Arcs, SBRT, SRS, etc
  - Physician specific dose constraints tables
  - References for dose constraints
  - Customizable constraints tables
  - PDF print of the constraints verification table

SRS SBRT Treatment Workflow



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Treatment Plan Documentation

Standard template

1. Treatment planning note

2. 3-plane screenshot with beam arrangement on the body contour
   - Absolute dose with isodose lines
   - Fields tab shown with all tx fields and their parameters visible
   - 3D view of body contour with treatment fields shown
   - PTVs and major organs displayed

3. BEVs for each treatment field

4. DVHs. 5 Curves maximum per page

5. IF SRS/SBRT – Conformity/constraint spreadsheet

6. Long treatment plan report

7. Short treatment plan report

8. Plan Sum 3-plane screenshot with beam arrangement on the body contour

9. DVHs (Plan Sum). 5 Curves maximum per printout

Treatment Plan Documentation

- Possible issues in Manual Method
  - Incorrect order of documents
  - Missing sections
  - Incorrect sections
  - Rework
- All of the above lead to extra **TIME** to fix.

Plan printing time's

	Treatment Site	# of Plans	Plan sum printed	Printing time (min)	Average time/plan
Planner 1	Rectum Boost	1	yes	25	**15 min**
	Prostate	1	no	23	
	Prostate	1	no	16	
	Whole Brain	1	no	16	
	pelvis 4 field	1	no	16	
	RAO/LPO	1	yes	25	
	chestwall (tangents+supraclav+PAB)	3	yes	55	
Planner 2	Rectum boost	1	no	12	**12 min**
	Head & Neck replan	1	no	12	
	Pelvic nodes	1	no	14	
	GBM Brain	1	no	9	
Planner 3	3 arc pelvis	1	no	10	**11 min**
	Prostate Boost	1	no	12	
	pelvis	1	no	10	
	Lt Breast	1	no	11	
	Prostate Boost	1	no	11	
Planner 4	Whole Brain	1	no	5	**10 min**
	Rt Breast	1	no	13	
	Rt Breast	1	no	8	
	Whole Brain	1	no	8	
	Rt Lung 3D	1	no	12	
	GBM RA	1	no	18	
	chestwall (tangents+tangents with bolus+supraclav+PAB)	4	yes	36	
	Pelvis 3D	1	no	15	
	Breast Boost	1	no	8	
	Pelvis	1	no	10	

Treatment plans - 2016

	Temple	Killeen	Waco
Jan	108	36	49
Feb	84	42	46
Mar	71	19	36
Apr	72	32	39
May	89	25	36
Total (2016)	424	154	206

Grand total = 784 → ~ 784 x 12 min = 9408 min of documentation preparation time

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Plan printing with Eclipse Script video

SBRT Rt Lung printed plan

Whole Brian printed plan

Rt Lung IMRT

Printing time with Eclipse script

- One click documentation – PDF format
- Typical printing time is ~ 1 min for one plan
- Standard order for all plans
  - ~~Incorrect order~~
  - ~~Missing sections~~
  - ~~Incorrect /irrelevant information~~

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Commissioning of Plan Printing Script

- Critical testing was conducted
  - Patient information
  - Prescription
  - Naming conventions
  - Dose constraints verification table
  - Beams eye view: orientation, MLC apertures, annotations, etc.
  - DVH plots
  - MU calculation point data
  - Treatment and set-up field data
  - Couch shifts
  - Calculation algorithms information
  - Tested on multiple plans (diff sites, fractionations, and patients)

Future

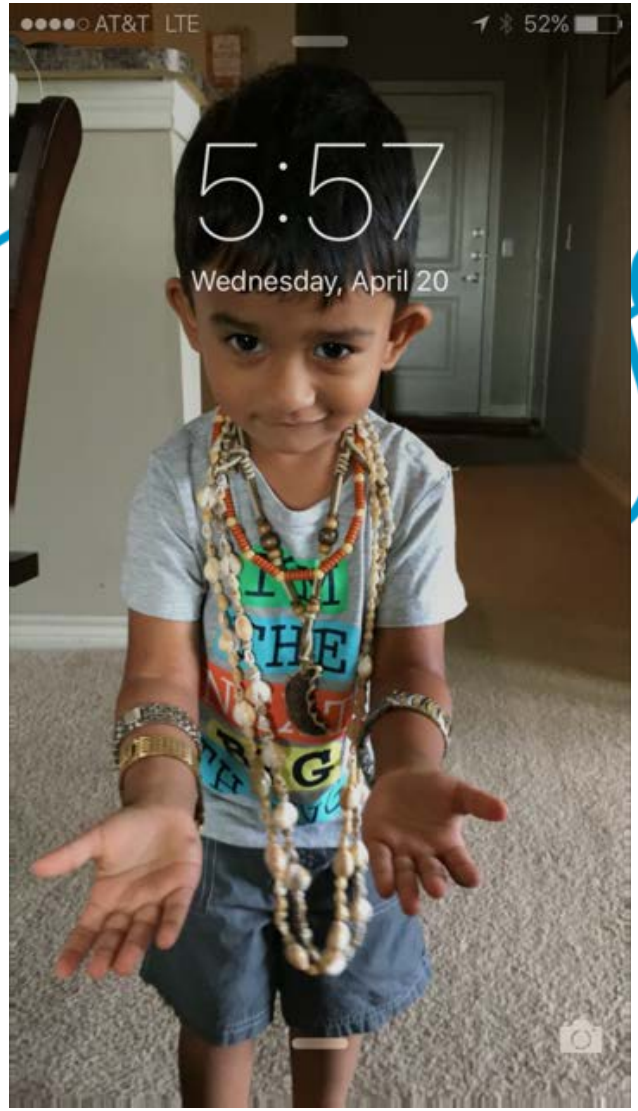
- Plan Sums
  - Script for DVH analysis
  - Script for plan sum documentation
- Plan check program
  - Verify contour naming convention
  - Verify contours
- Updating current scripts in tandem with Eclipse TPS upgrades

Conclusions

- Automation works
- Scripting tool
  - very effective
  - Avoids human error
  - **TIME**
- Morale
  - Dosimetrists, physicists and physicians love the tool
  - Path towards effectiveness of team members

Acknowledgements

- Andrew Morrow
  - Chief of Treatment Planning @ BSW
  - Script developer/programmer
- Dharanipathy Rangaraj
  - Chief of Physics Division @ BSW



you!

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