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In Vivo EPID-Dosimetry and Adaptive Radiation Therapy with CBCT

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03.04.17

E P I D

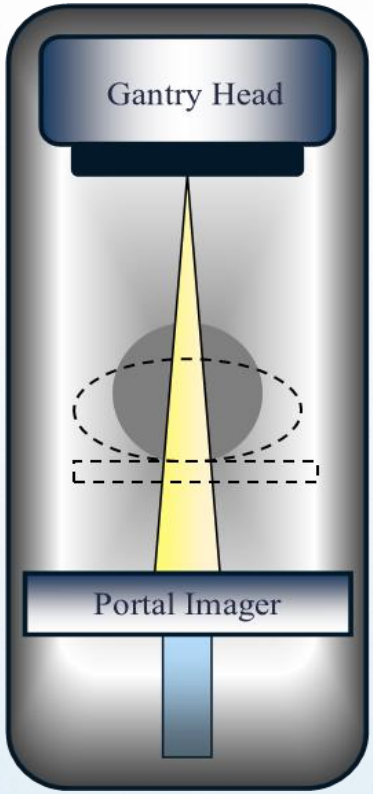
- **Pre-treatment QA**

performed by exposing the treatment plan directly to the EPID, in the absence of the patient or phantom

- **Transit dosimetry**

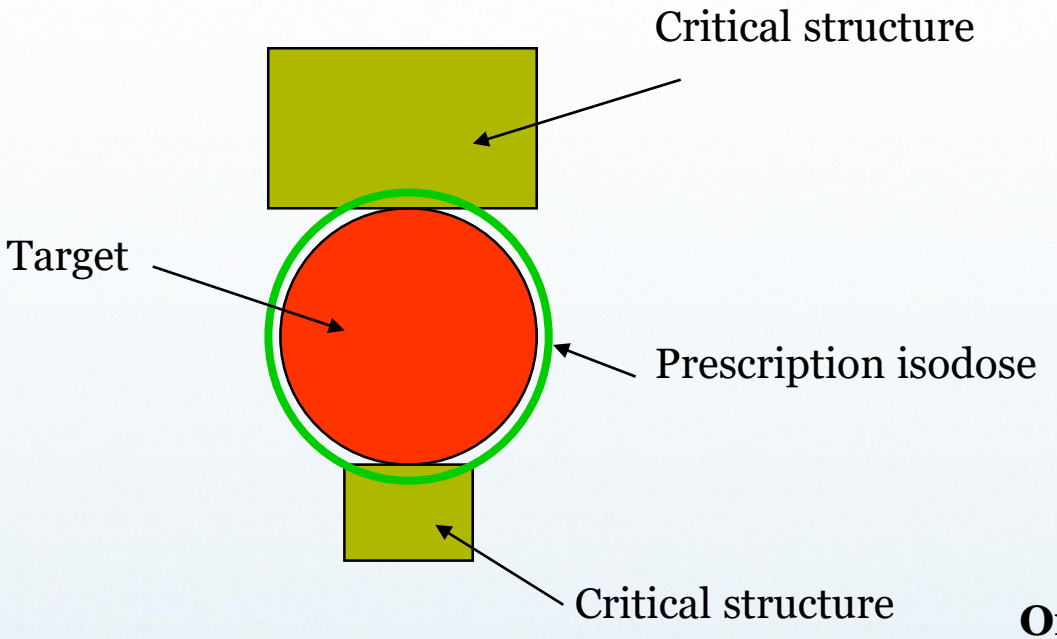
allows in-vivo measurements of patient dose using the portal images acquired during the patient treatment.

EPID dosimetry is the future for performing patient specific QA

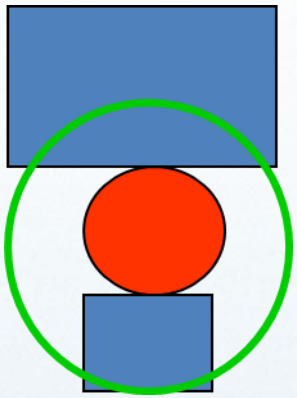


What is ART?

– With **adaptive radiation therapy**, images of the tumor size, shape and location are used to adapt the treatment plan before it is delivered



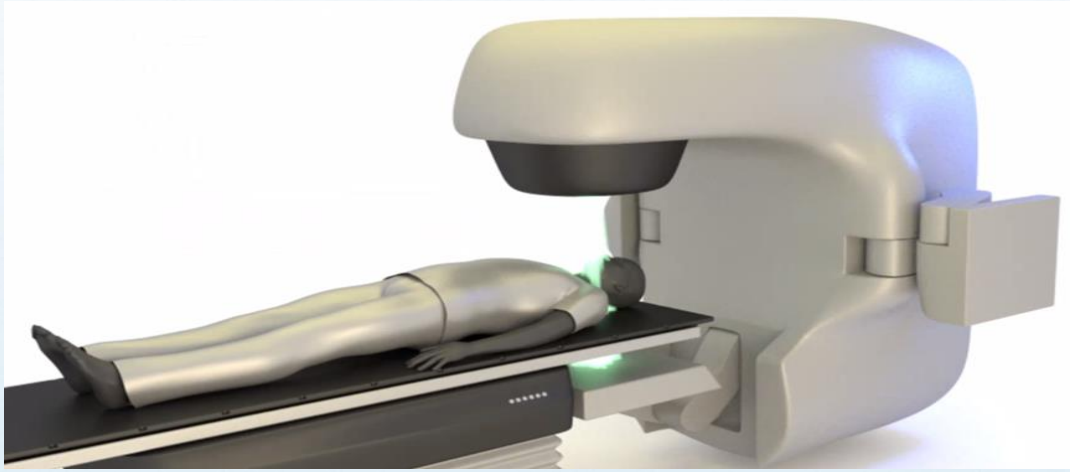
Original treatment plan and anatomy

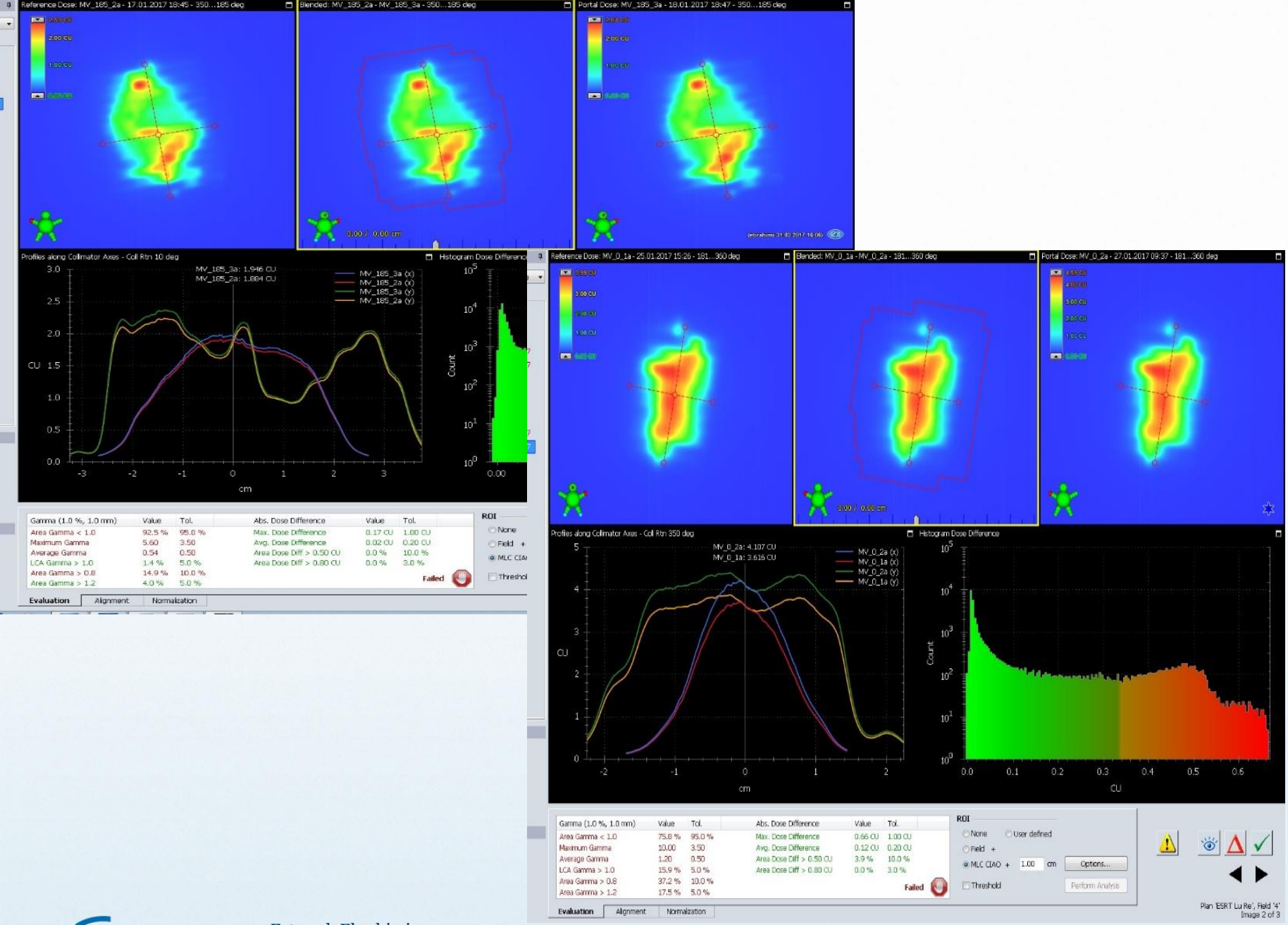


Original treatment plan and new anatomy with tumor shrinkage due to radiation

Step 1

- 50 patients with stereotactic plans (SABR)
- Delivery was carried out on a Varian TrueBeam linac equipped with an aS1000 EPID.
- Continuous portal imaging was performed at each treatment fraction during the delivery of treatment for all beams.
- Daily EPID incident fluence directly compared to EPID ‘s first fraction image
- Gamma analysis




Reference Dose: MV_185_2a - 17.01.2017 18:45 - 350...185 deg
Blended: MV_185_2a - MV_185_3a - 350...185 deg
Portal Dose: MV_185_3a - 18.01.2017 18:47 - 350...185 deg
Profiles along Collimator Axes - Coll Rtn 10 deg
MV_185_3a: 1.946 CU
MV_185_2a: 1.884 CU
MV_185_3a (x)
MV_185_2a (x)
MV_185_3a (y)
MV_185_2a (y)
CU
cm
Histogram Dose Difference
Count
Gamma (1.0 %, 1.0 mm) Value Tol. Abs. Dose Difference Value Tol.
Area Gamma < 1.0 92.5 % 95.0 % Max. Dose Difference 0.17 CU 1.00 CU
Maximum Gamma 5.60 3.50 Avg. Dose Difference 0.02 CU 0.20 CU
Average Gamma 0.54 0.50 Area Dose Diff > 0.50 CU 0.0 % 10.0 %
LCA Gamma > 1.0 1.4 % 5.0 % Area Dose Diff > 0.80 CU 0.0 % 3.0 %
Area Gamma > 0.8 14.9 % 10.0 %
Area Gamma > 1.2 4.0 % 5.0 %
Failed
ROI
None
Field +
MLC CIAO
Threshold
Evaluation
Alignment
Normalization
Reference Dose: MV_0_1a - 25.01.2017 15:26 - 181...360 deg
Blended: MV_0_1a - MV_0_2a - 181...360 deg
Portal Dose: MV_0_2a - 27.01.2017 09:37 - 181...360 deg
Profiles along Collimator Axes - Coll Rtn 350 deg
MV_0_2a: 4.107 CU
MV_0_1a: 3.616 CU
MV_0_2a (x)
MV_0_1a (x)
MV_0_2a (y)
MV_0_1a (y)
CU
cm
Histogram Dose Difference
Count
Gamma (1.0 %, 1.0 mm) Value Tol. Abs. Dose Difference Value Tol.
Area Gamma < 1.0 75.8 % 95.0 % Max. Dose Difference 0.66 CU 1.00 CU
Maximum Gamma 10.00 3.50 Avg. Dose Difference 0.12 CU 0.20 CU
Average Gamma 1.20 0.50 Area Dose Diff > 0.50 CU 3.9 % 10.0 %
LCA Gamma > 1.0 15.9 % 5.0 % Area Dose Diff > 0.80 CU 0.0 % 3.0 %
Area Gamma > 0.8 37.2 % 10.0 %
Area Gamma > 1.2 17.5 % 5.0 %
Failed
ROI
None
User defined
Field +
MLC CIAO +
1.00 cm
Options...
Threshold
Perform Analysis
Evaluation
Alignment
Normalization
Plan 'ESRT Lu Re', Field '4'
Image 2 of 3

Step 2

- 10 MV FFF intensity modulated arc therapy (IMAT) & IMRT & 3DCRT
- CT-scanned Quasar phantom
- TP was done on normal free breathing pattern that it was simulated in an oscillation mode of phantom motion program
- During reproducibility, sensitivity also examined by shifting tumor by a known amount: residual target in a range of -15, -10, 0, 10, 15 mm on static pattern

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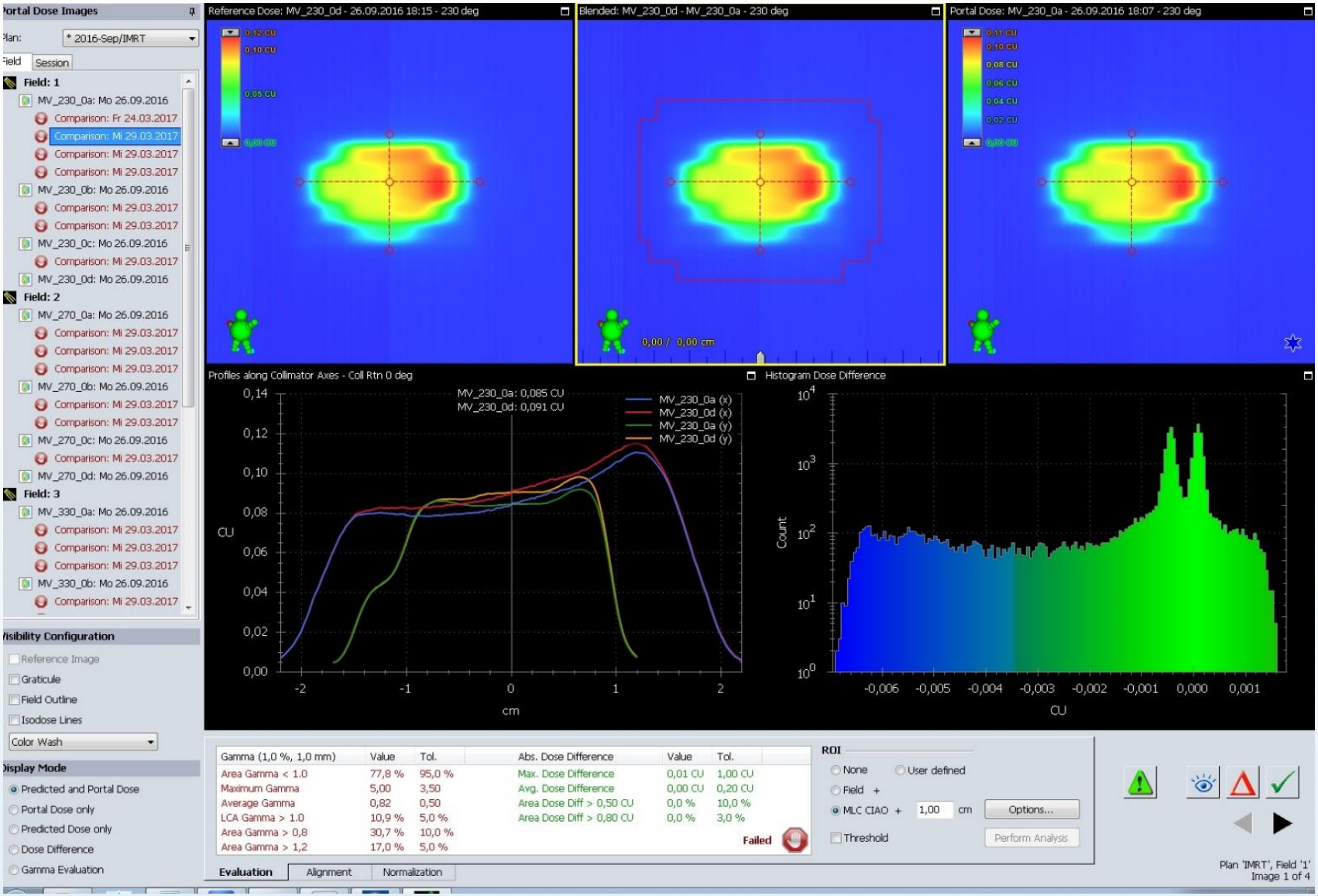
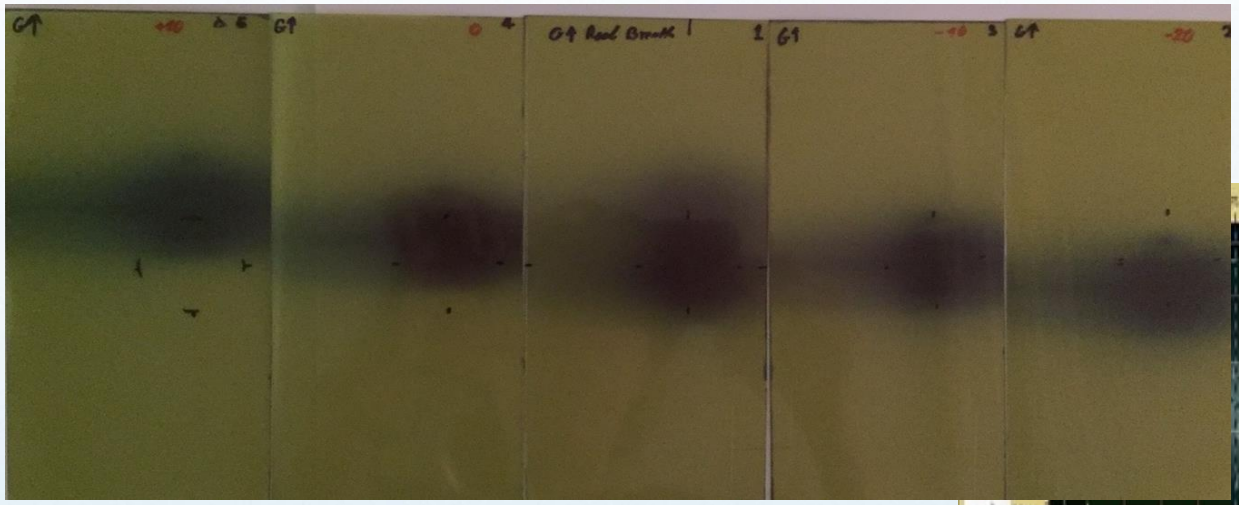
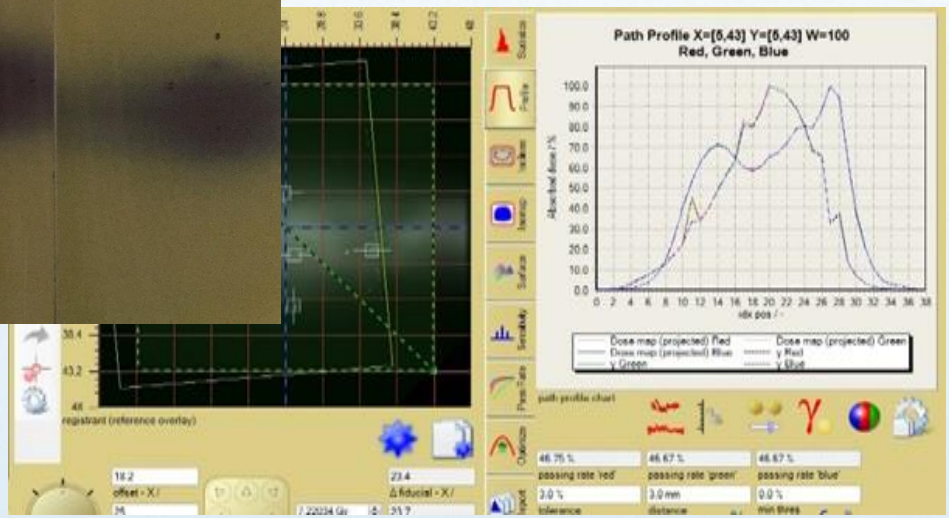

Portal Dose Images
Plan: * 2016-Sep/IMRT
Field Session
Field: 1
MV_230_0a: Mo 26.09.2016
Comparison: Fr 24.03.2017
Comparison: Mi 29.03.2017
Comparison: Mi 29.03.2017
Comparison: Mi 29.03.2017
MV_230_0b: Mo 26.09.2016
Comparison: Mi 29.03.2017
Comparison: Mi 29.03.2017
MV_230_0c: Mo 26.09.2016
Comparison: Mi 29.03.2017
MV_230_0d: Mo 26.09.2016
Field: 2
MV_270_0a: Mo 26.09.2016
Comparison: Mi 29.03.2017
Comparison: Mi 29.03.2017
Comparison: Mi 29.03.2017
MV_270_0b: Mo 26.09.2016
Comparison: Mi 29.03.2017
Comparison: Mi 29.03.2017
MV_270_0c: Mo 26.09.2016
Comparison: Mi 29.03.2017
MV_270_0d: Mo 26.09.2016
Field: 3
MV_330_0a: Mo 26.09.2016
Comparison: Mi 29.03.2017
Comparison: Mi 29.03.2017
Comparison: Mi 29.03.2017
MV_330_0b: Mo 26.09.2016
Comparison: Mi 29.03.2017
Visibility Configuration
Reference Image
Graticule
Field Outline
Isodose Lines
Color Wash
Display Mode
Predicted and Portal Dose
Portal Dose only
Predicted Dose only
Dose Difference
Gamma Evaluation
Reference Dose: MV_230_0d - 26.09.2016 18:15 - 230 deg
Blended: MV_230_0d - MV_230_0a - 230 deg
Portal Dose: MV_230_0a - 26.09.2016 18:07 - 230 deg
0,00 / 0,00 cm
Profiles along Collimator Axes - Coll Rtn 0 deg
MV_230_0a: 0,085 CU
MV_230_0d: 0,091 CU
MV_230_0a (x)
MV_230_0d (x)
MV_230_0a (y)
MV_230_0d (y)
CU
cm
Histogram Dose Difference
Count
CU
Gamma (1,0 %, 1,0 mm) Value Tol.
Area Gamma < 1.0 77,8 % 95,0 %
Maximum Gamma 5,00 3,50
Average Gamma 0,82 0,50
LCA Gamma > 1.0 10,9 % 5,0 %
Area Gamma > 0,8 30,7 % 10,0 %
Area Gamma > 1,2 17,0 % 5,0 %
Abs. Dose Difference Value Tol.
Max. Dose Difference 0,01 CU 1,00 CU
Avg. Dose Difference 0,00 CU 0,20 CU
Area Dose Diff > 0,50 CU 0,0 % 10,0 %
Area Dose Diff > 0,80 CU 0,0 % 3,0 %
Failed
ROI
None
User defined
Field +
MLC CIAO + 1,00 cm
Options...
Threshold
Perform Analysis
Evaluation
Alignment
Normalization
Plan 'IMRT', Field '1'
Image 1 of 4

Step 3

- dose distribution was measured by a Gafchromic EBT2 film
- films were placed inside the lung inset of phantom
- Monitoring TV received dose
- Quantitative analysis of gamma function distributions and dose profile comparisons were analyzed for each breathing phase.





Step 4

Worst case scenario:

lung inhomogeneities, respiratory motion, no gating….

What we need

provides a complete view into the daily and cumulative dose delivered to your patients as patient setup, patient geometry, and tumors change during treatment.

Daily and cumulative 3D dose analysis

Quantifies how changing anatomy and setup variations affect a patient's treatment

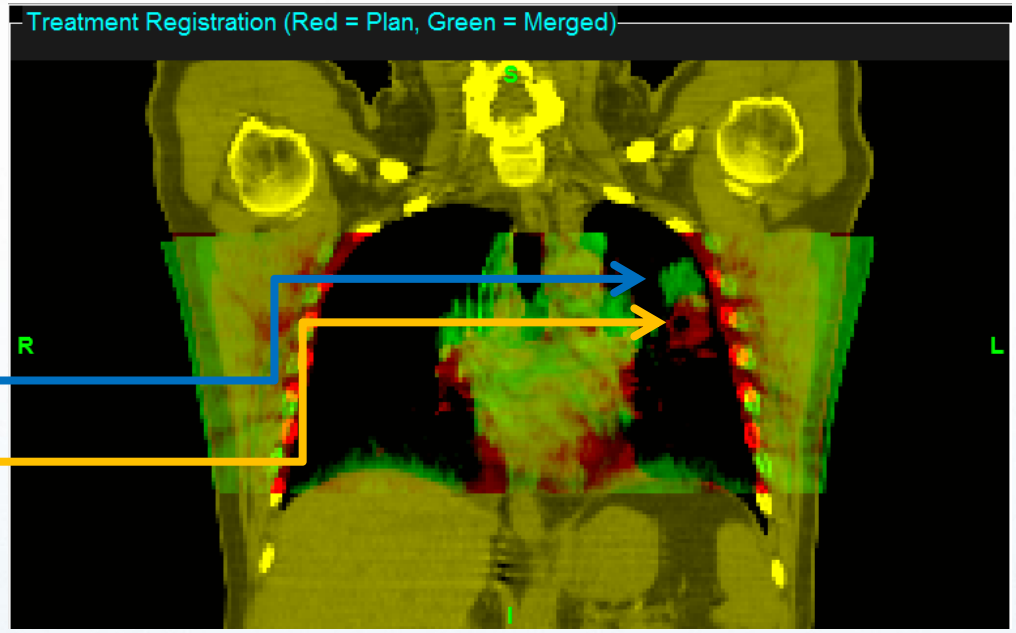
Case study: Lung

Patient misaligned on fraction 18

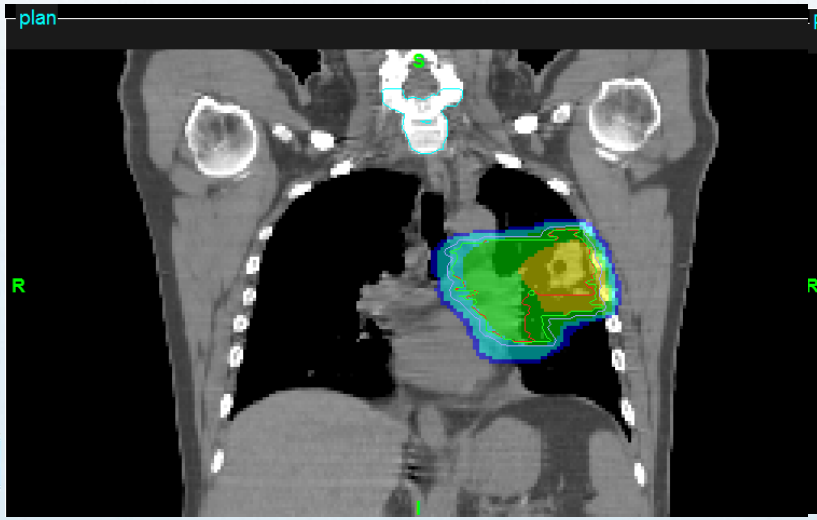
Adaptive module showed:

Today's tumor location

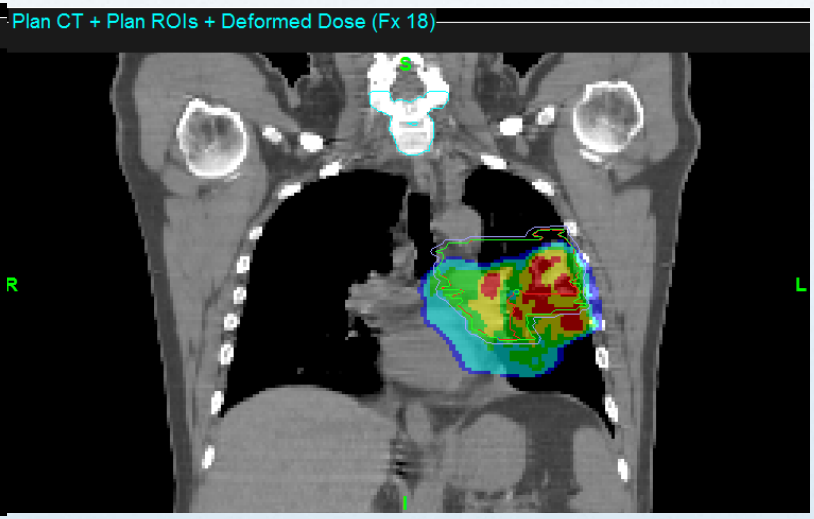
Planned tumor location



Planned dose:

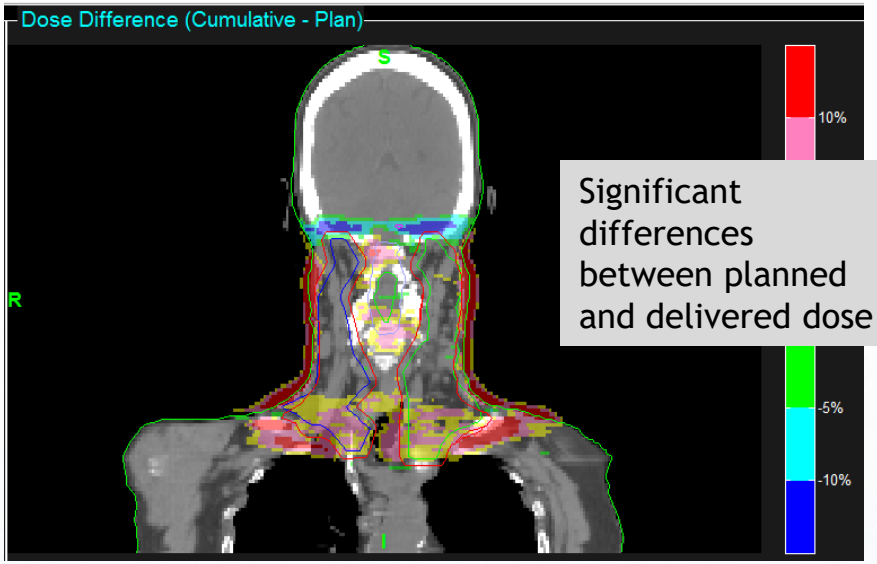


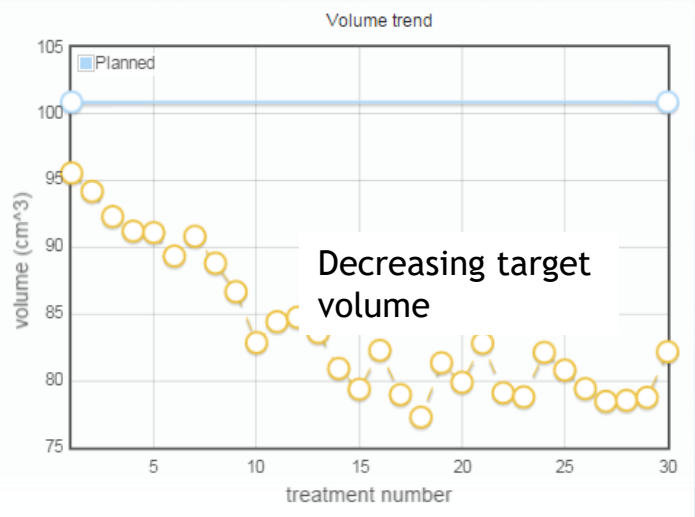
Fraction 18 dose:

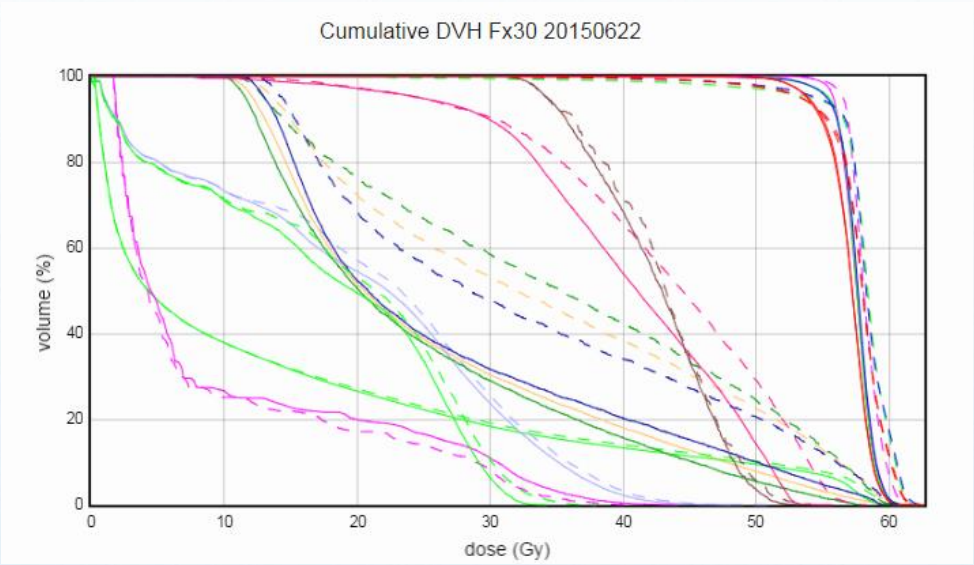


Case study: H&N

- Patient lost weight throughout treatment
- Mask was poorly made: inconsistent daily setup
- Effect of these changes were tracked



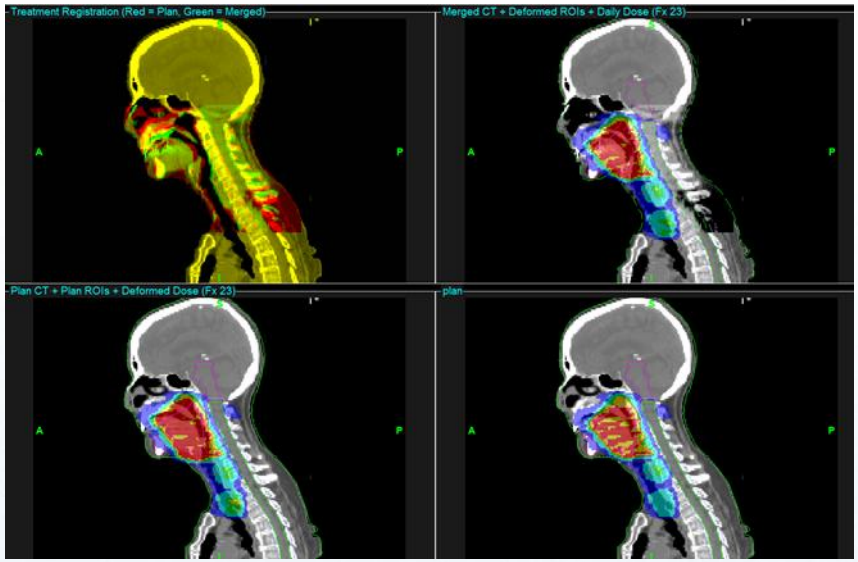


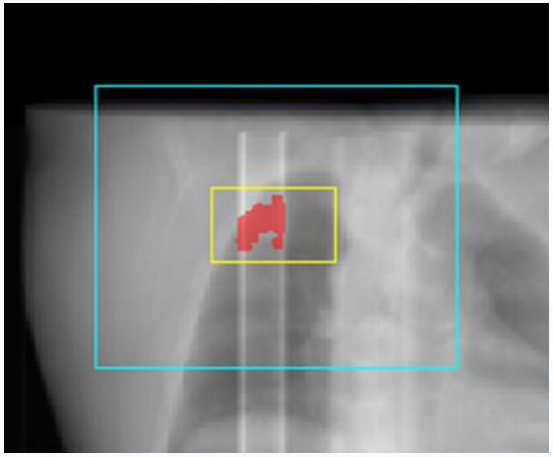


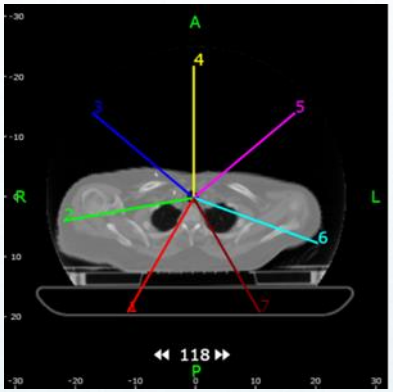
DVH differences between planned and delivered cumulative doses

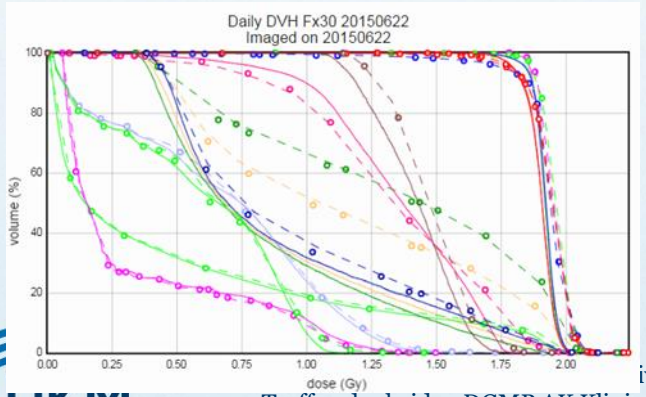
Thank You

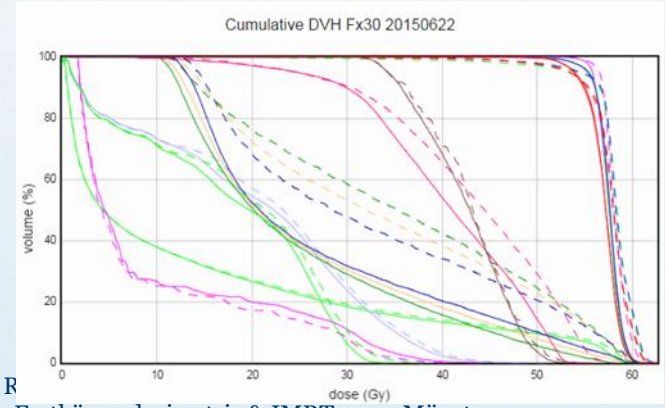
Adaptivo™


Treatment Registration (Red = Plan, Green = Merged)
Merged CT + Deformed ROIs + Daily Dose (Fx 23)
Plan CT + Plan ROIs + Deformed Dose (Fx 23)
plan

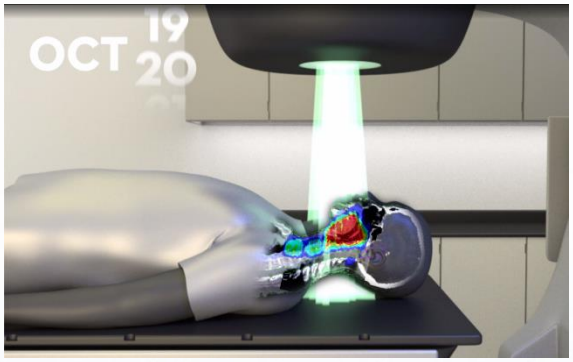



A
4
3
5
R
L
2
6
118
P


Daily DVH Fx30 20150622
Imaged on 20150622
volume (%)
dose (Gy)


Cumulative DVH Fx30 20150622
volume (%)
dose (Gy)

Adaptivo™



- ✓ Streamlines and automates pre-treatment QA
- ✓ Provides daily treatment delivery monitoring
- ✓ Determines both daily and cumulative delivered dose
- ✓ Automates calculation and notification
- ✓ Provides a complete integrated solution

Better dose tracking,

Better treatments.