Edinburgh Cancer Centre
Western General Hospital

NHS
Lothian

A step towards Adaptive Radiation Therapy:

Integrating Cone Beam CT with
Transit Dosimetry
for quantitative dose analysis

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Scottish+ Meeting , 01st September 2012, Glasgow , U.K.

Work Flow
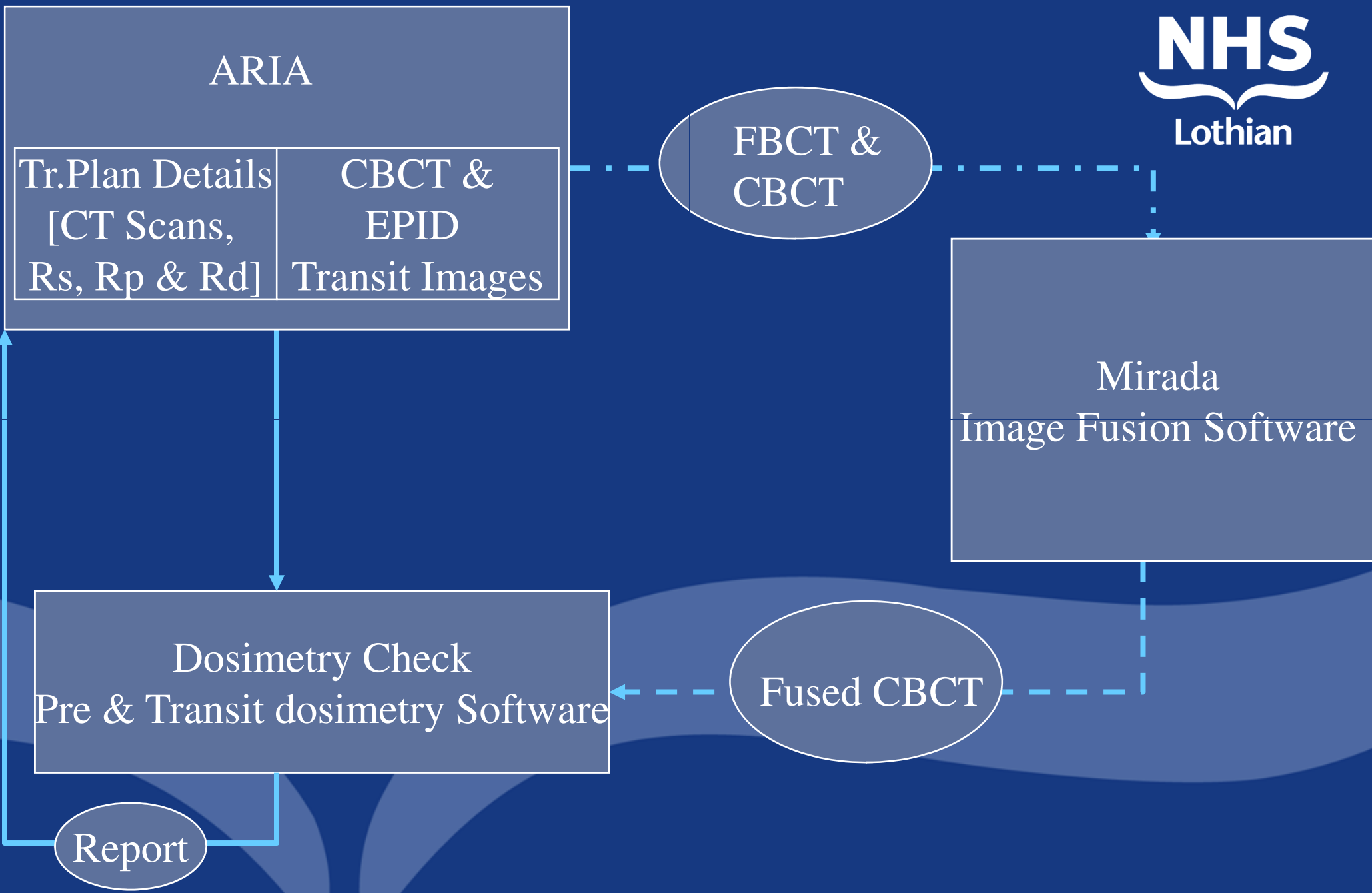
Tr.Plan Details [CT Scans, Rs, Rp & Rd]

Eclipse TPS – AAA [Ver. 10.0.28]

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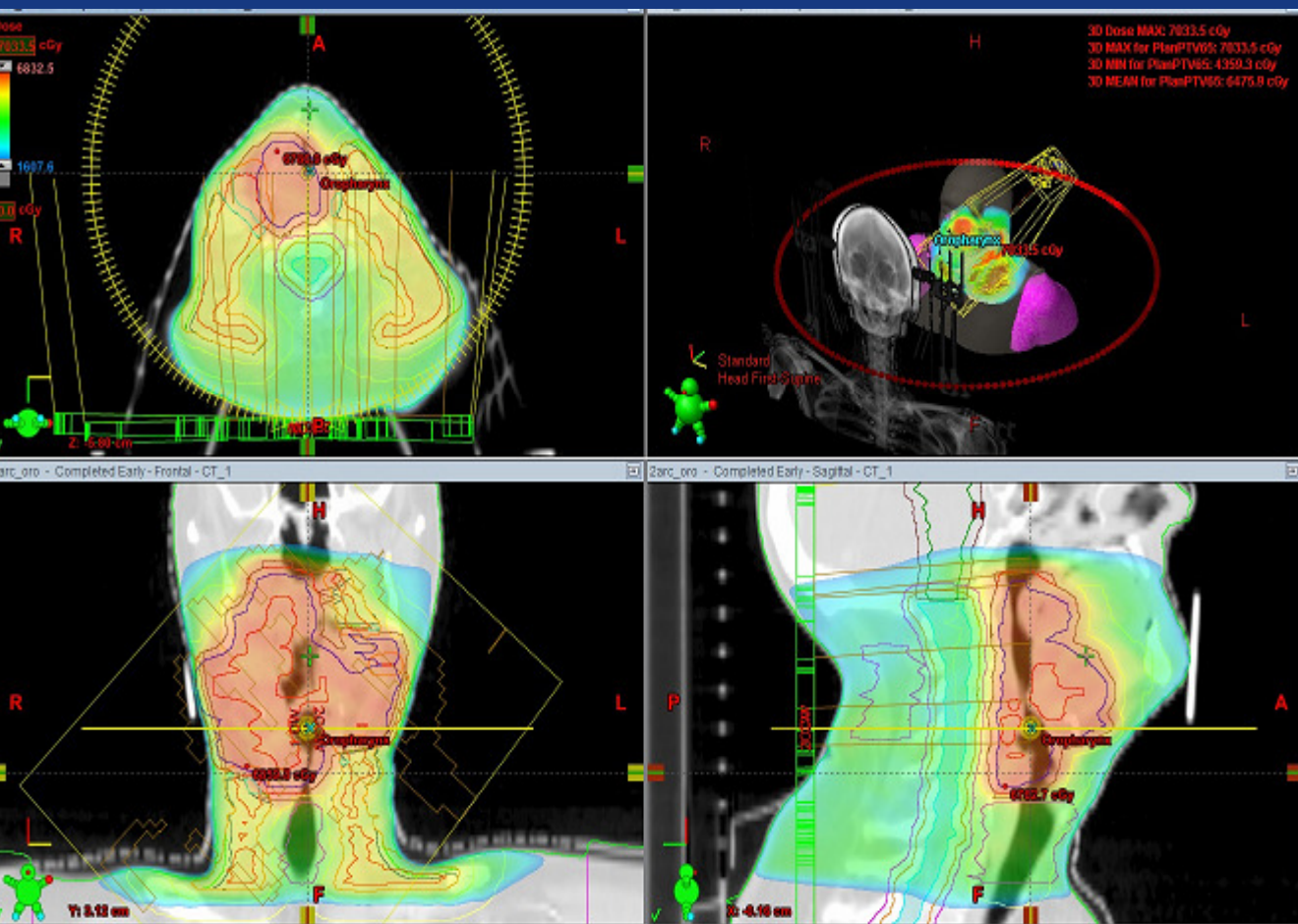
RA – Since Oct 2011
H&N and Prostate

6 MV X-rays

H&N	Prostate
2 Arcs	1 Arc
250 MU /Arc	600 - 900 MU
(Average)	600 MU /min
600 MU /min	

Total : 107 patients

CBCT & Transit Images

Clinac 21-Ex

Novalis - Tx

CBCT - OBI ver 1.5

H&N – Full Fan mode
Prostate – Half Fan mode

Pixel Matrix : 384 x 384
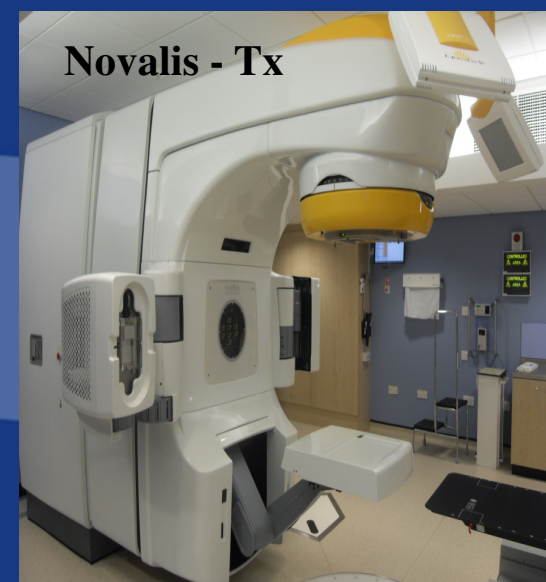
Transit Images

Mode of Acquisition : Continuous

Each image – Avg. of 12 frames
7.5 frames per sec (600 MU/min)
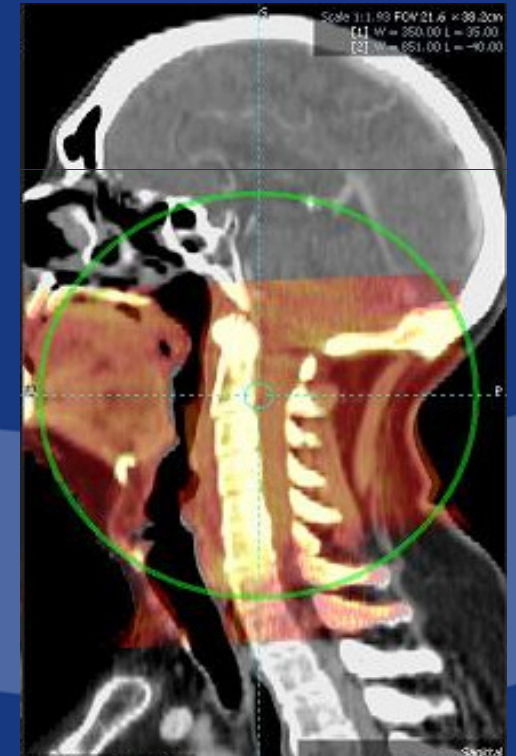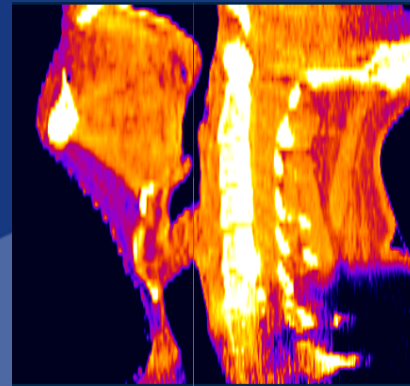Pixel Matrix : 1024 x 768 [Full resolution]
Approx. 40 – 47 images per arc

Mirada
Image Fusion Software

NHS Lothian

XD3 Advanced Image Fusion Ver. 3.4.5.5

Initial Manual Alignment
&
Automatic Rigid

Output : Reformatted CBCT similar to FBCT parameters

Dosimetry Check
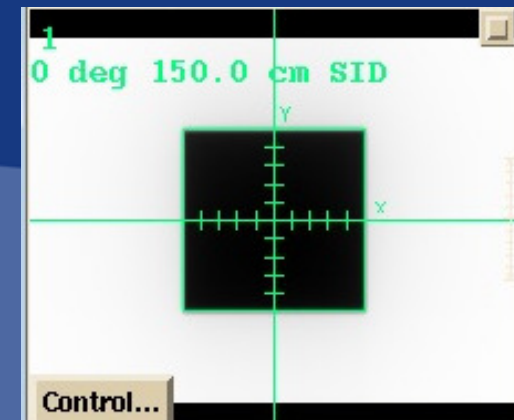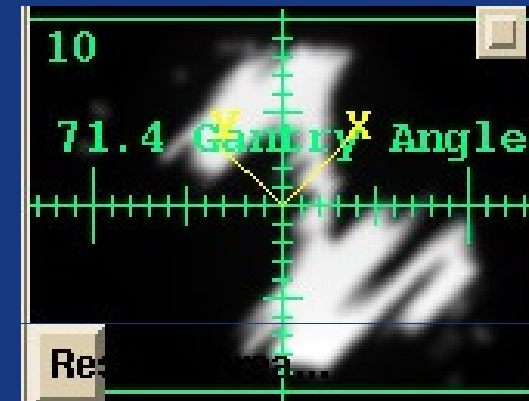## Pre &Transit dosimetry Software

EPID acquired transit Images are used as a primary information for Dose computation.

The pixel values of the 2-d fluence pattern is normalized using a ref. field centre's darkness level corresponding to a ref. MU

Epid Image = $\psi_p^{(x,y)}$ Θ PSF

For different medium thicknesses along the beam path, PSF is needed.

Dosimetry Check
Pre & Transit dosimetry Software

NHS Lothian

Point Spread Function / Kernel

$$k(r) = \sum_{i}^{n} a_i e^{-b_i r}$$

For n = 5, each thickness of the medium will give 10 fitted parameters for the PSF.

Deconvolution of the EPID image will give the <u>intensity in air</u>.

Three-dimensional IMRT verification with a flat-panel EPID

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$$S_{c,p} = S_c \times S_p$$

With the knowledge of CT density and ray tracing,
Dose distribution within the CT volume can be recreated.

Clinical Pathway……..
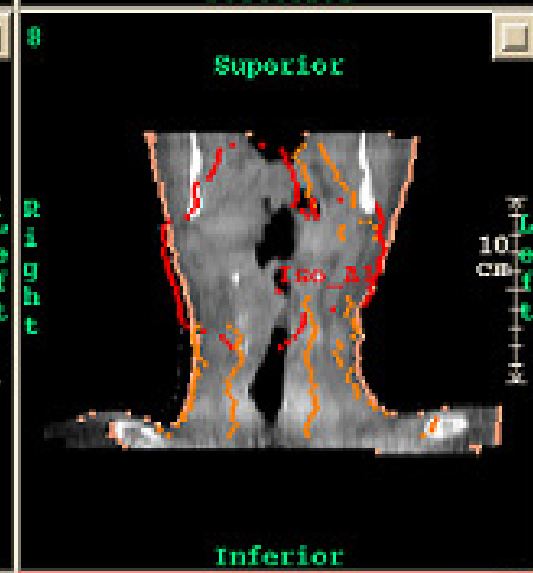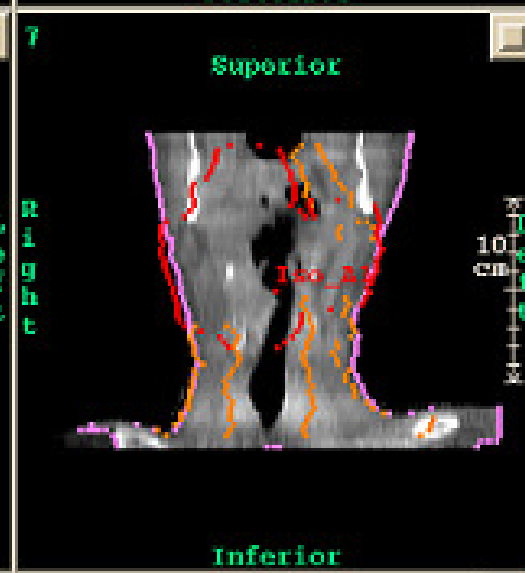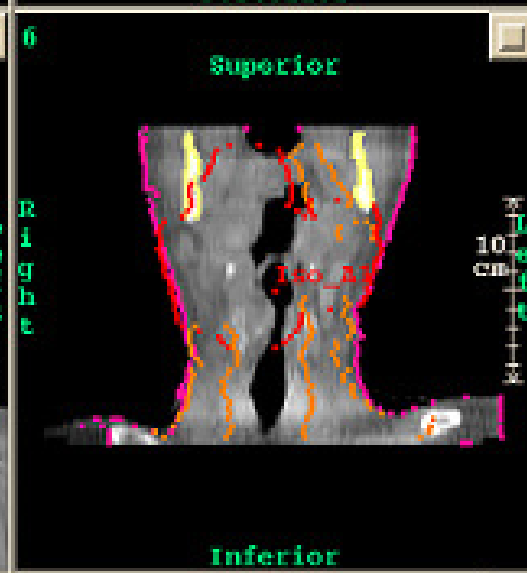
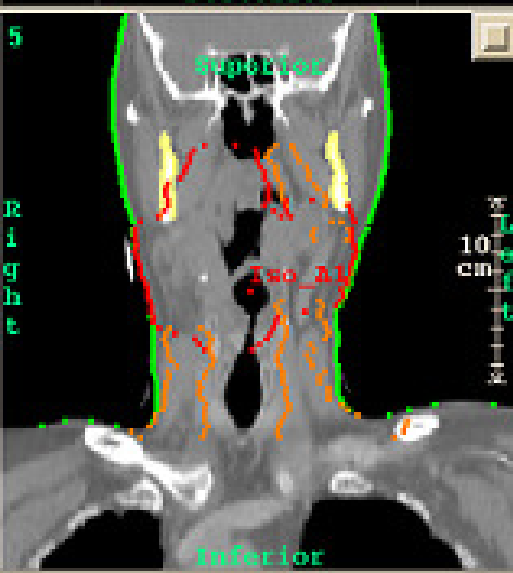## Pre-treatment verification → Day # 0

CBCT + Transit →

Session Number	2 arc		Isocheck		
	2CCW	1CW	ISOLat	IsoAP	ISOCBCT
1	CACQ	CACQ	OBI_KV	OBI_KV	OBI_CBCT
2	CACQ	CACQ	OBI_KV	OBI_KV	
3	CACQ	CACQ	OBI_KV	OBI_KV	
4	Integrated I...	Integrated I...	OBI_KV	OBI_KV	
5			OBI_KV	OBI_KV	
6			OBI_KV	OBI_KV	
7			OBI_KV	OBI_KV	
8	CACQ	CACQ	OBI_KV	OBI_KV	OBI_CBCT
9			OBI_KV	OBI_KV	
10	Active		Active (Img)		
			OBI_KV	OBI_KV	
11	Active		Active (Img)		
			OBI_KV	OBI_KV	
12	Active		Active (Img)		
			OBI_KV	OBI_KV	
13	Active (Img)		Active (Img)		
	CACQ	CACQ	OBI_KV	OBI_KV	OBI_CBCT
14	Active		Active (Img)		
			OBI_KV	OBI_KV	
15	Active		Active (Img)		
			OBI_KV	OBI_KV	
16	Active		Active (Img)		
			OBI_KV	OBI_KV	
17	Active		Active (Img)		
			OBI_KV	OBI_KV	
18	Active (Img)		Active (Img)		
	CACQ	CACQ	OBI_KV	OBI_KV	OBI_CBCT

Ca. Oropharynx :

Planning CT :14/05/2012
First Treatment: 04/06/2012

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Planning FBCT

04/06/2012_CBCT

14/06/2012_CBCT

20/06/2012_CBCT
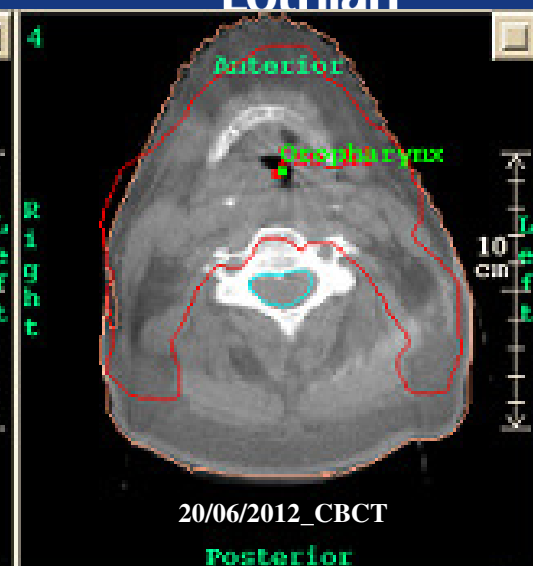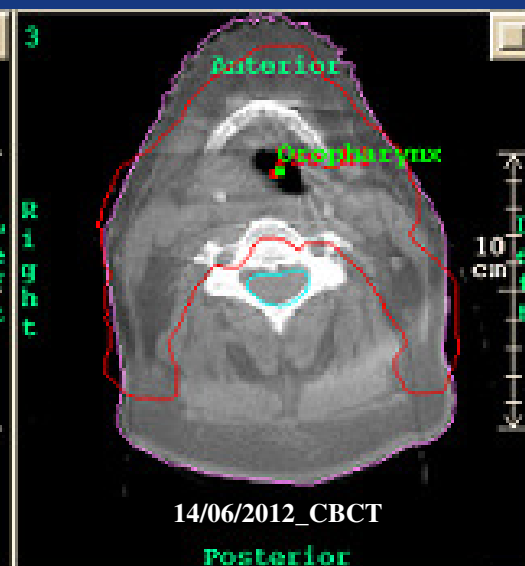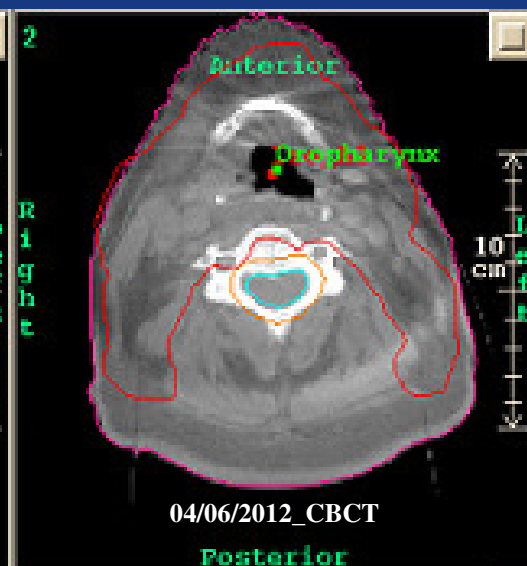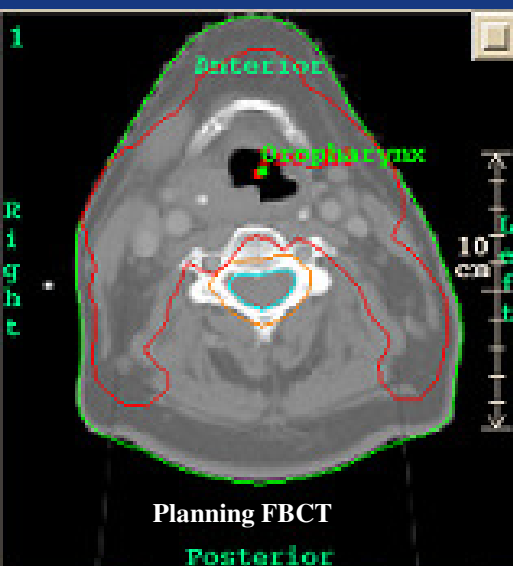
ARIA – Image Registration Result

Body Volume Change

FBCT_Pre-treat 04/06/2012_CBCT+TRANSIT 14/06/2012_CBCT+TRANSIT 20/06/2012_CBCT+TRANSIT
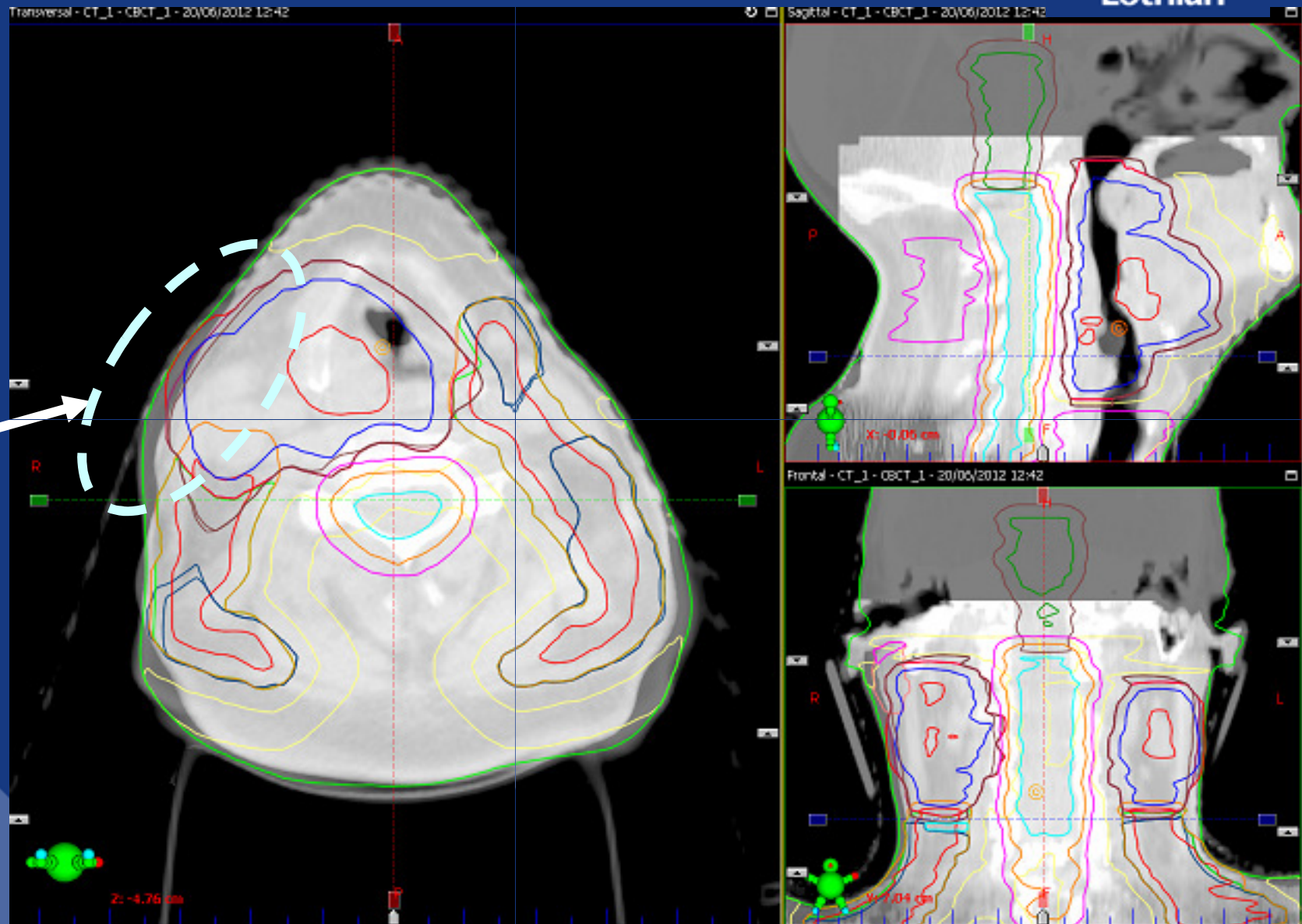
Dose – Volume Histogram : Comparison

FBCT_Pre-treat

04/06/2012_CBCT+TRANSIT

14/06/2012_CBCT+TRANSIT

20/06/2012_CBCT+TRANSIT
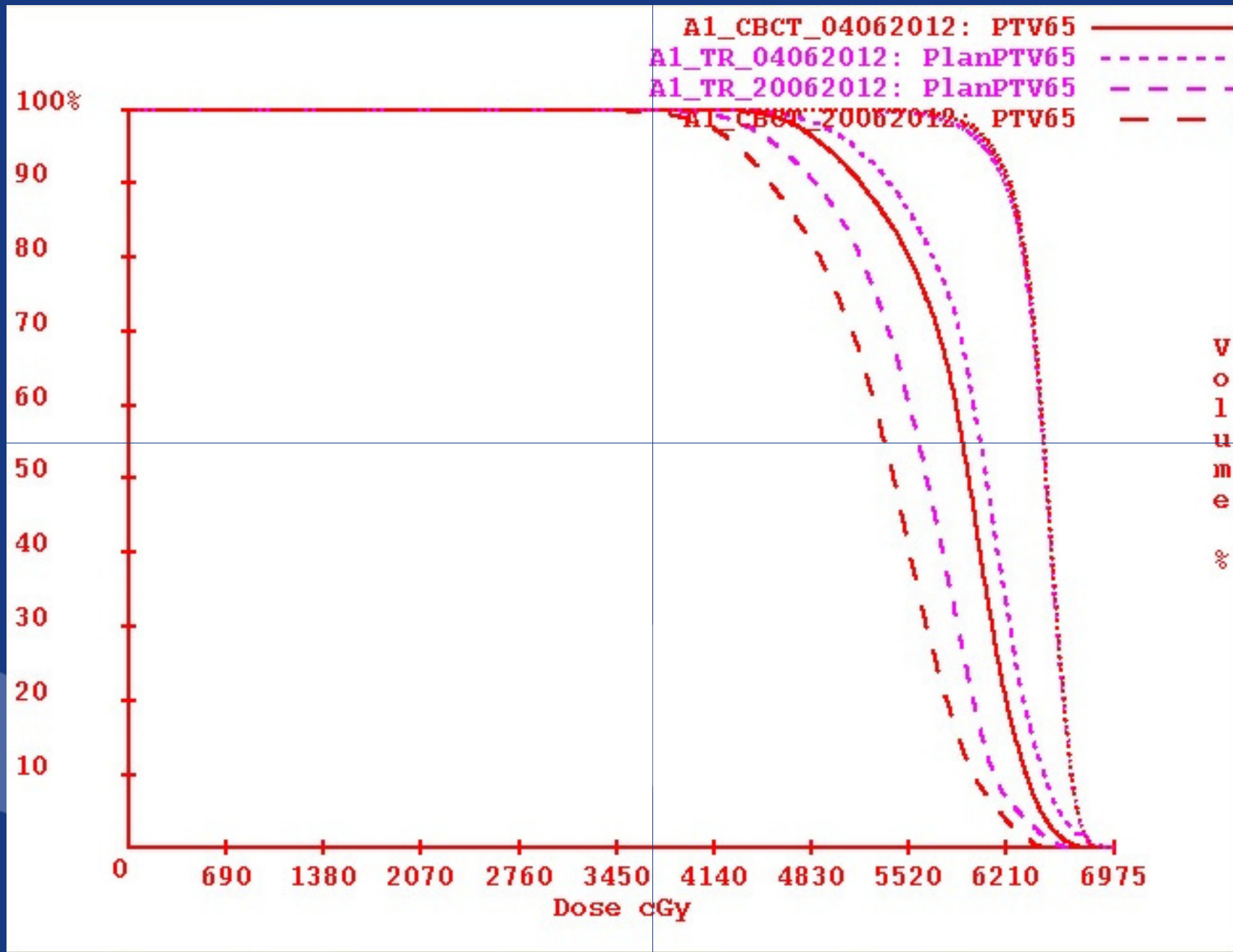
Point Dose Results - Summary

Verification Type	ISO	Oropharynx
Pre-verification	2.0%	2.3%
Transit_FBCT_04062012	1.7%	2.6%
Transit_FBCT_05062012	3.8%	4.2%
Transit_FBCT_07062012	-3.3%	-2.3%
Transit_FBCT_14062012	-3.3%	-2.1%
Transit_FBCT_20062012	-6.5%	-5.4%
Transit_CBCT_04062012	0.6%	1.5%
Transit_CBCT_14062012	-5.6%	-4.5%
Transit_CBCT_20062012	-6.4%	-5.2%

Uncertainties

CBCT Image Quality

Fusion Algorithm's accuracy

Eclipse AAA vs DC Pencil Beam

Limitations

CBCT's FOV (24.0 cms)

EPID Imager dimensions

Resources

ADVANTAGES

Potential replacement for external 2d/3d array based Pre-treatment verifications

Systematic approach on Quality Treatment

Reliable in-vivo tool

Possibility to estimate Radiobiological Outcomes

REFERENCES

Thank You