

Edinburgh Cancer Centre

Department of Oncology Physics



Portal Dosimetry Check

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11/04/2012

Varian Users Group Meeting , Feb 2011, Edinburgh

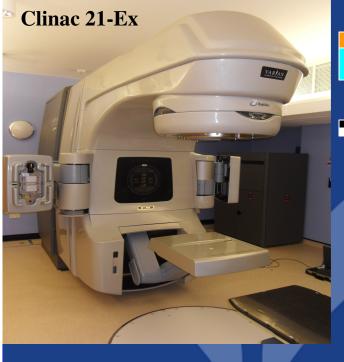
Varian ETIDs IAS 3 : Image Acquisition System - 3

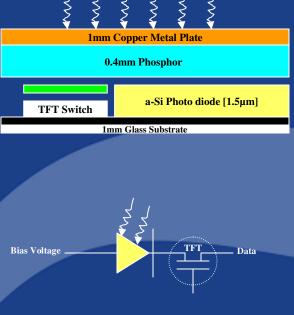
IDU 20 [Image Detector Unit]

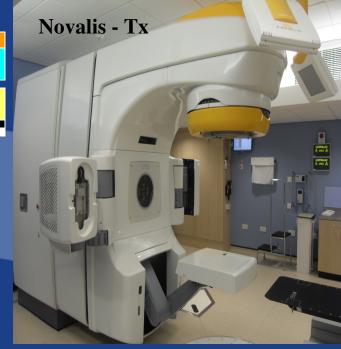
aSi 1000 in E-Arm

FID [cm]	F.Size
	[cm x cm]
100	40 x 30
150	26.7 x 20.0
180	22.2 x 16.7

NHS scotland Resolution: 1024 x 768 [aS 1000] Speed: 2 MHz







Varian EFIDs IAS 3 : Image Acquisition System - 3 NHS SCOTLAND

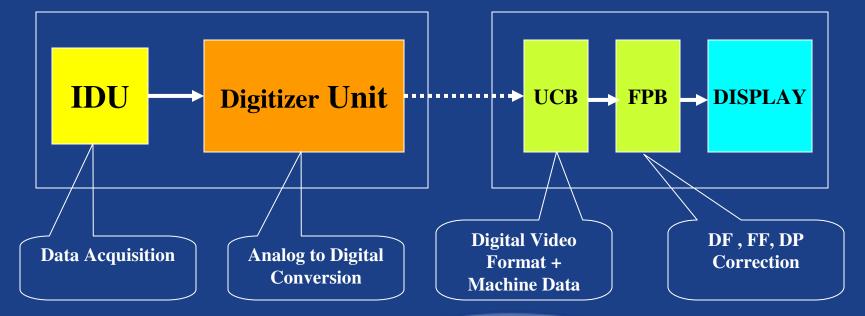


Image Acquisition protocols

Integrated Image

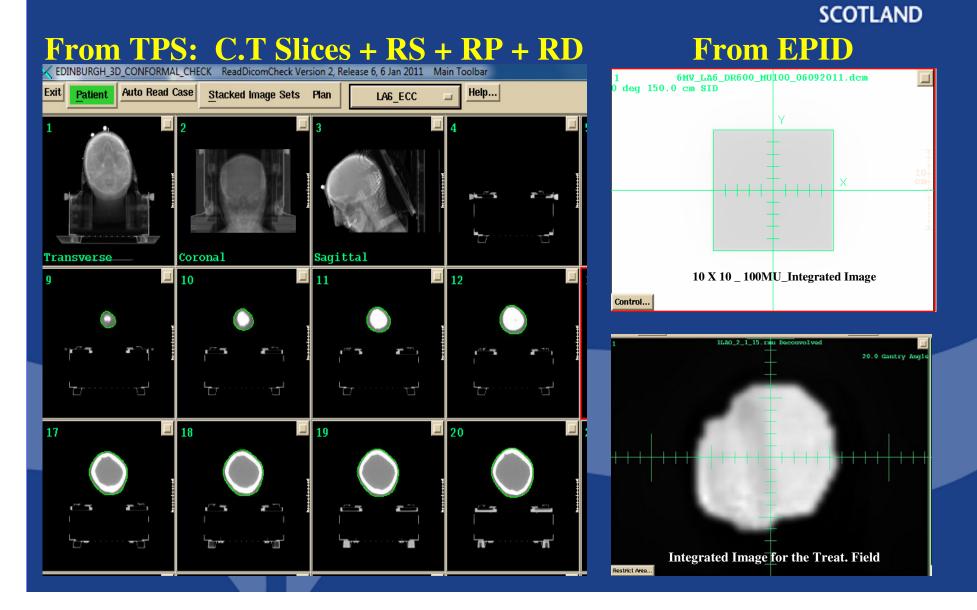
→ Conformal & IMRT

Continuous Acquisition —— **RapidArc**

Dosimetry Check

Dosimetry Check	E	NHS,
X DosimetryCheckTasks		SCOTLAND
Patient Entry		SCOTLAND
New Select	Reset	3 Step Process
— Read in a Patient Case and Plan—	- Read Integrated Beam Images -	Can be used in
Read in Dicom RT protocol files	Varian EPID	Pre-treatment Mode
Read in RTOG pr tocol files	Get Elekta EPID Images	& Transit Mode
	Convert Elekta Images	
	Siemens EPID	
Step 1	Map Check	Step 2
	PTW 729	
	Kodak CR	
	Matrixx	
	IMAT	
Run Dosimetry	Check program	
Exit Beam Data Utilities Other	Utilities Help	Step 3

Dosimetry Check : Input Data



NHS

Dosimetry Check : Output

Display Tools

* Fraction	un II
Display Evaluate Options * Praction	1341
Display Plan Control	
Display Plan in Current Frame	
Display Plan in Current Screen	
2D Beam Display Control	>
<u>3</u> D Beam Display Control	~
Volumes Active/Inactive	
Make Default Screen	
Make Screen Centered on Volume	~
Make Screen Centered on Point	~
Make Screen Centered on Isocenter	>
Make 2 By Screen Centered on Volume	~
Make 2 By Screen Centered on Point	-
Make 2 By Screen Centered on Isocenter	2
Delete Frame	

Analysis Tools

Dose Volume Histograms...

NHS

SCOTLAND

Je

Evaluate Options	# Fractions/Norma	lize 10
Display Dose in Curre	nt <u>F</u> rame	
Display Dose in Curre	nt <u>S</u> creen	LA6 :
Calculate <u>All</u> Beams 3	D	-
Calculate Matrix Size.		-
2D Isodose Lines		
3D Isodose Surface	• ::	-
Point Doses	>	
Hard Copy	1	Auto Report
Show Point Dose		Print Points
Compare 1D Dose (Pr	ofiles)	Print Points to Queu
Compare 2D Dose (Pl	ane)	Print Queued Jobs
Compare 3D Dose (31) room view)	Delete Queued Jobs
Compare with Gamma	a Method	_
Difference Volume Hi	stogram	-
Show 2D TPS Dose	•	
Show 3D TPS Dose		
Show RMU values		
Show profile in rmu in	nage	
Compare 1D Profile (I	y Beam) 😕	LA6 :
Monitor Unit Check	>	

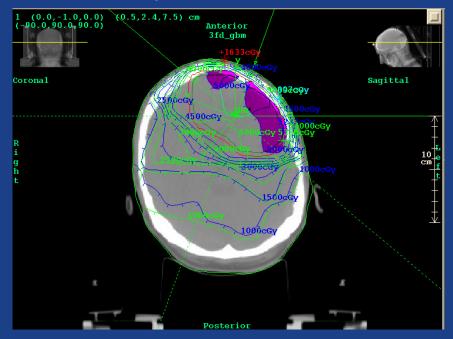
Dosimetry Check : Output

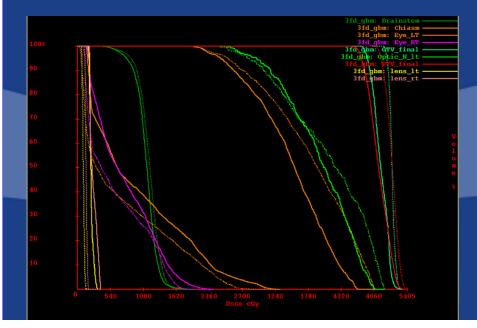
Simple point Dose @ CAX

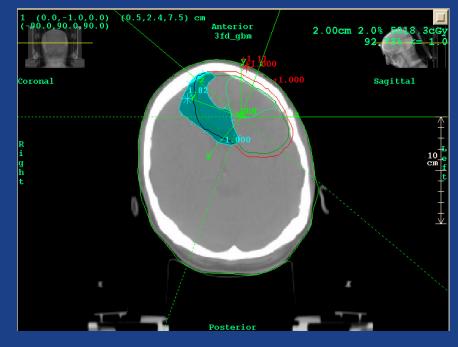
Point Name:	GBM
	x, y, z cm
Coordinates	1.2, 2.4, 12.6
	Dose cGy
1_LAO	1578.5
Machine Name	LA6_ECC
Check Type	Exit-Integration
BEV Coordinates	-0.0, -0.0, -0.0
2_Lt_Lat	1741.6
Machine Name	LA6_ECC
Check Type	Exit-Integration
BEV Coordinates	-0.0, -0.0, 0.0
3_RAO	1459.9
Machine Name	LA6_ECC
Check Type	Exit-Integration
BEV Coordinates	-0.0, 0.0, -0.0
Total Dose cGy	4780.1
Plan Dose cGy	5018.3
Difference %	-4.75% of 5018.3

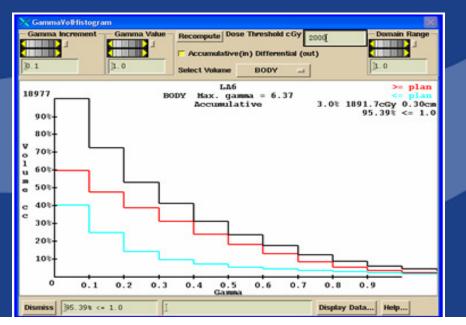


Dosimetry Check : Output







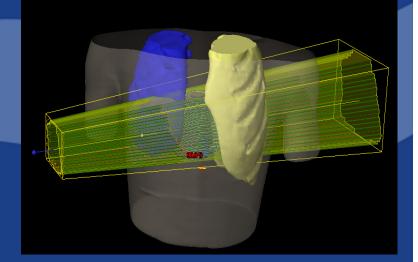


•Area of the beam is divided into pixels in a plane perpendicular to the beam.

- •Each pixel traced back to the X-ray source is a pencil beam.
- •The density of the medium along the path of the pencil beam is noted down and TERMA is computed.

$$T(E,r) = \frac{\mu(E)}{\rho} \psi(E,r)$$





Dose computation at any point inside the patient needs *Intensity* of the radiation beam reaching each pencil.

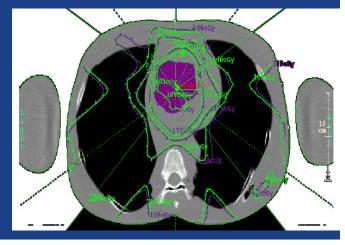
NO SOURCE MODEL IS USED !!

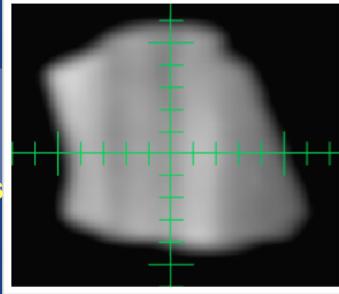
The EPID (film / 2d array system) acquired Image from each beam is used as a primary information for Dose computation.

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

Sfelictive Monitor Unit (R.M.U.)







From R.M.U. To Dose

Flood field - Remove the horns Scatter – Internal as well as external

Epid Image = $\Psi_{p}^{(x,y)} \Theta PSF$

Response of the detector to a point source

Point Spread Function / Kernel





Dose spread Kernel

Glare Kernel

Point Spread Function / Kernel

$$k(r) = \sum_{i}^{n} a_{i} e^{-b_{i}r}$$

Three-dimensional IMRT verification with a flat-panel EPID

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(Received 2 July 2004; revised 5 November 2004; accepted for publication 9 November 2004; published 3 February 2005)

Fast Fourier Transform

$$I_{EPID} = I_{fluence} \otimes k(r)$$

Inverse Fourier Transform

$$I_{fluence} = F^{-1} \{ F(I_{fluence}) * [F(k(r)) / F(k(r))] \} = F^{-1} \{ F(I_{fluence}) \}$$

2 d Frequency Transform

$$K(q) = \sum_{i}^{n} a_{i} \frac{2\pi b_{i}}{\left(4\pi^{2}q^{2} + b_{i}^{2}\right)^{3/2}}$$
 12

Transit Dosimetry

For different medium thicknesses along the beam path,

$$k(r) = \sum_{i}^{n} a_{i} e^{-b_{i} r}$$

PSF is needed



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

Deconvolution of the EPID image will give the intensity in air.

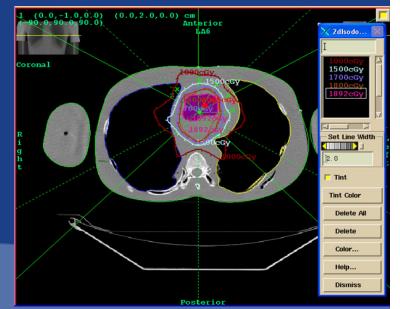
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Beam Intensity in air is represented as R.M.U.,

Dosimetry Check – Thysics behind

Which is nothing but <u>collimator scatter (Sc) x M.U.</u>

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



NHS

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With the knowledge of CT density and ray tracing,

Dose distribution within the CT volume can be recreated.

KNOWN LIMITATIONS :



Scatter (from patient) in the detector panel is considered uniform throughout the plane, which is not true.

The accuracy of dose estimation decreases if the EPID images are acquired at a different FID compare with deconvolution setup.

Not possible for field sizes larger than the imager dimensions.

The inside story of Dosimetry Check

BLACK BOX



If each pixel in the EPID image is applied with the appropriate kernel parameter and deconvolve to get the In-air beam intensity,

Using 1.81 GHz Intel processor,

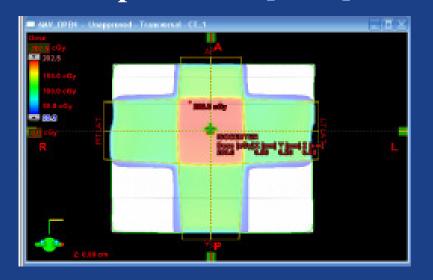
For a 7 field IMRT case, it will take approx. 1 hr &

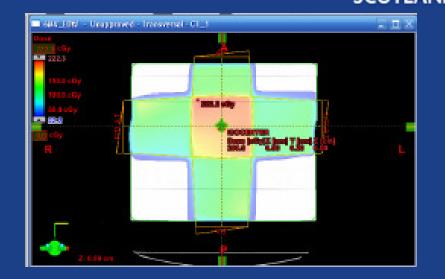
A typical VMAT delivery (72 images), it will take 11 hrs

to compute the dose.

Another algorithm is used to simplify the process which ends up <u>only 3 secs</u> to compute the dose from <u>each image.</u>

What's studied so far with Dosimetry Check? Open Fields [RMI] Wedge Fields [RMI]_{COTLAND}

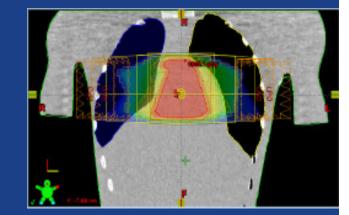




	TPS (cGy)	Pre (cGy)	Diff (%)	Transit (cGy)	Diff (%)	Chamber (cGy)	Diff (%)
Open	200	197.6	-1.19	209.9	4.94	199.4	-0.003
EDW	200	198.0	-0.98	209.7	4.85	199.1	-0.005

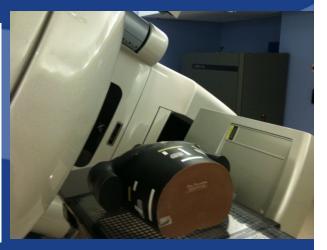
What's studied so far with Dosimetry Check? NHS Reproducibility Study [Fixed gantry IMRT]

	Normalised Mean	Std Dev.
Transit - FID 140cm	1.04	±0.007
Transit - FID 150cm	1.02	±0.006
Pre-Treatment	1.02	±0.004



Sensitivity Study [Fixed gantry IMRT]

FID (cm)	Shift (cm)	Mean Δ%	Std Dev.
140	2	1.77	±0.18
140	5	7.49	±0.28
150	2	2.04	±0.48
150	5	6.58	±0.80



What's studied so far with Dosimetry Check?



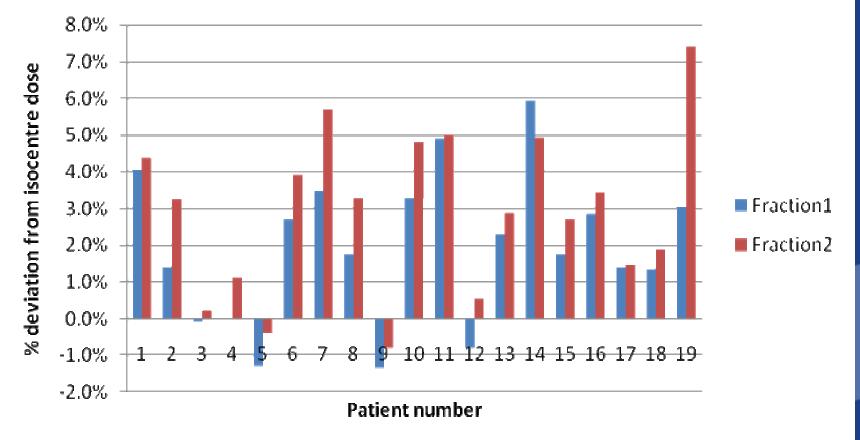
Clinical Study – LA 6 _ 6MV Ca. Lung patients

Patient	Pre-Treatment (%)	Transit #1 (%)	Transit #2 (%)	Transit #3 (%)
1		5.81		
2	3.49	0.45	0.09	-6.45
3	0.20	7.68	1.91	6.00
4	1.92	0.43	3.69	
5	4.47	-4.89	-5.86	1.00
6	1.41	-2.93	-7.09	1.09
7	3.43	4.66	6.97	1.33

LA 7 : H& N Conventional Conformal technique



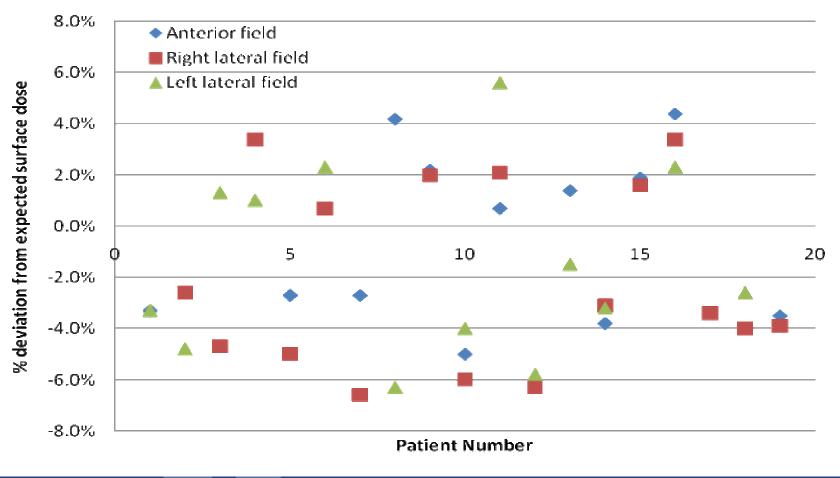
Dosimetry Check results for 6MV



LA 7 : H& N Conventional Conformal technique



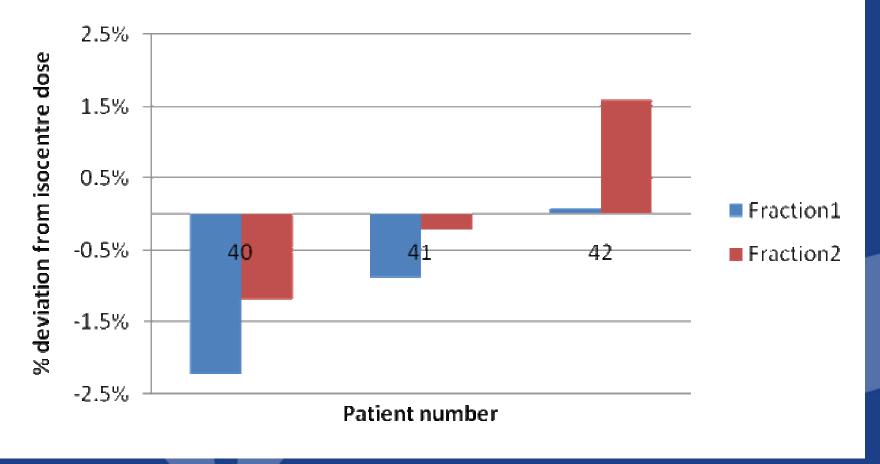
Mosfet results for Head and Neck treatments



LA 7 : Pelvic site - Conventional Conformal technique NHS

Dosimetry Check results for 10MV

SCOTLAND



LA 7 : Pelvic site - Conventional Conformal technique NHS

2.0% 1.0% % deviation from expected surface dose 0.0% 39 40 41 42 43 44 -1.0% -2.0% A -3.0% Anterior field -4.0% Right lateral field -5.0% -6.0% **Patient Number**

Mosfet results for Pelvic treatments

SCOTLAND

RapidArc patients NHS **9%** Pre-treatment corrected SCOTLAND Pre-treatment Fraction 1 Fraction 2 6% Percentage difference between measured isocentre 3% -9% 2 3 4 5 6 7 8 9 10 **Patient number**

What data is needed for commissioning?

If we use Varian's GBD, the process is very simpler. Deconvolution kernels are available for 4, 6, 10, 15, 16, 18 & 24 MV X-rays.



- 1. Absolute output definition : (1cGy / MU) for 10 x 10 cm field size @ dmax and FSD = 100.0 cm
- 2. Total Scatter factor $S_{c,p}$ for all rectangular field sizes
- 3. In air OAR value from a diagonal profile for largest f.size
- 4. In water OAR value from a diagonal profile for largest f.size
- 5. CAX PDD values for various field sizes
- 6. Deconvolution images for various f.sizes and phantom thicknesses
- 7. C.T. calibration graph

Future Developments



Montecarlo based calculation
Improvement with the scatter kernel
More user friendly GUI

11/04/2012