Edinburgh Cancer Centre

Department of Oncology Physics

# Portal Dosimetry With Varian Epids

## Use of Dosimetry Check

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# *Varian EPIDs* IAS 3 : Image Acquisition System - 3

**IDU 20**
**[Image Detector Unit]**

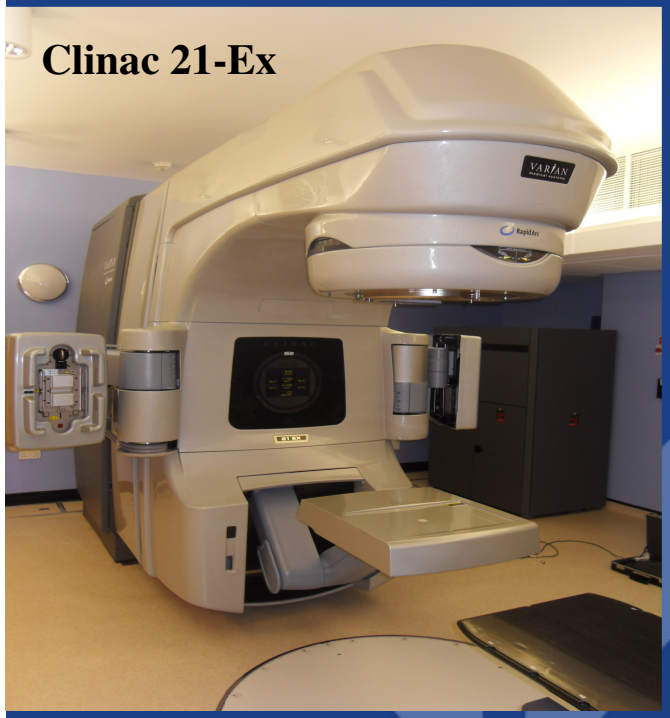
**aSi 1000 in E-Arm**

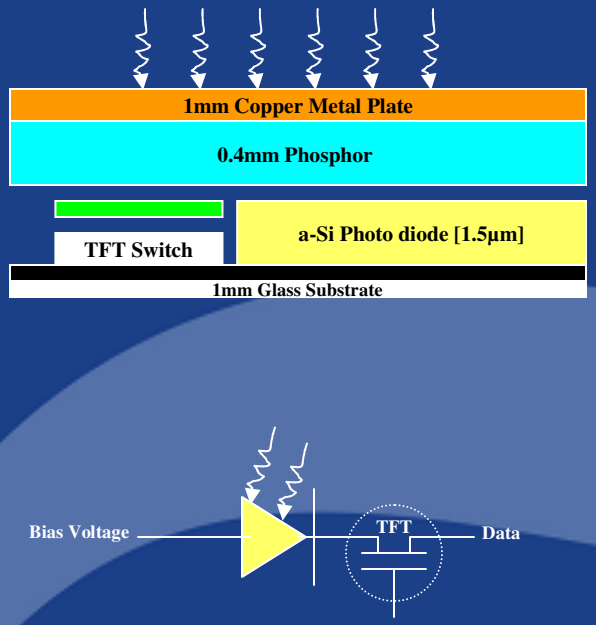
| FID [cm] | F.Size [cm x cm] |
|---|---|
| 100 | 40 x 30 |
| 150 | 26.7 x 20.0 |
| 180 | 22.2 x 16.7 |

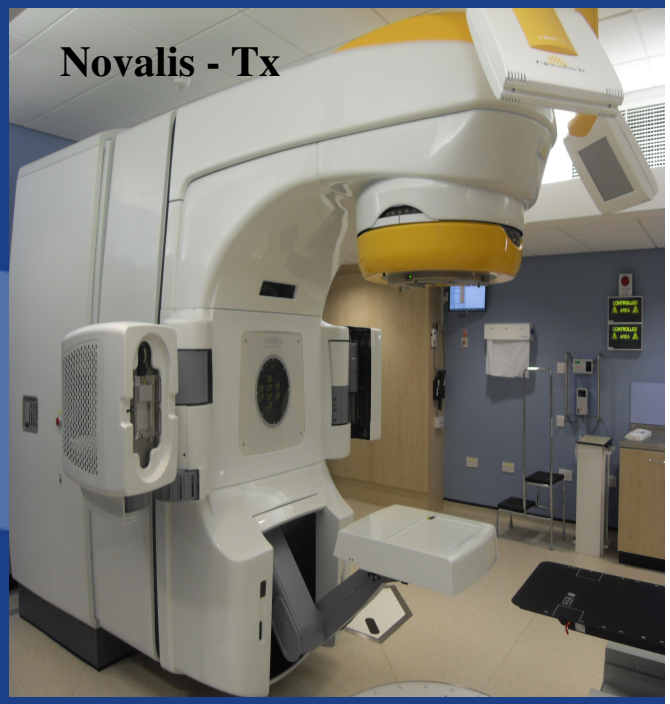
NHS SCOTLAND

**Resolution:**
**1024 x 768 [aS 1000]**

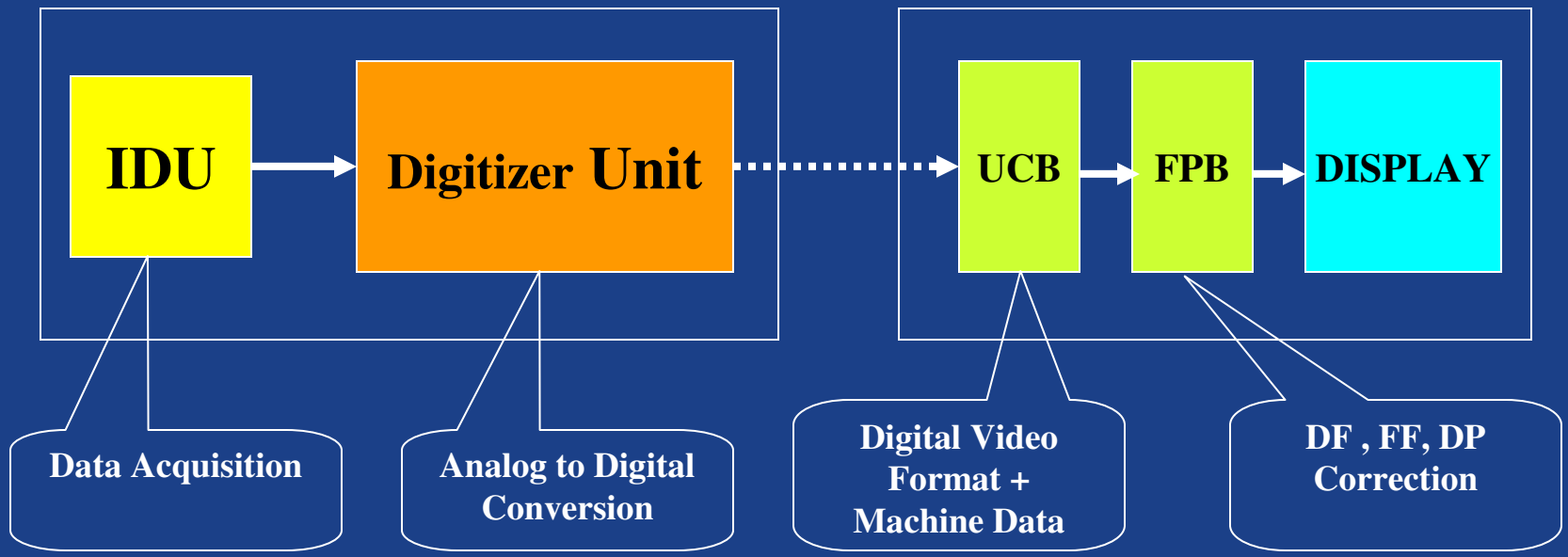
**Speed: 2 MHz**



# Varian EPIDs IAS 3 : Image Acquisition System - 3




## Image Acquisition protocols

Integrated Image ⟶ Conformal & IMRT

Continuous Acquisition ⟶ RapidArc

# Dosimetry Check


**3 Step Process**

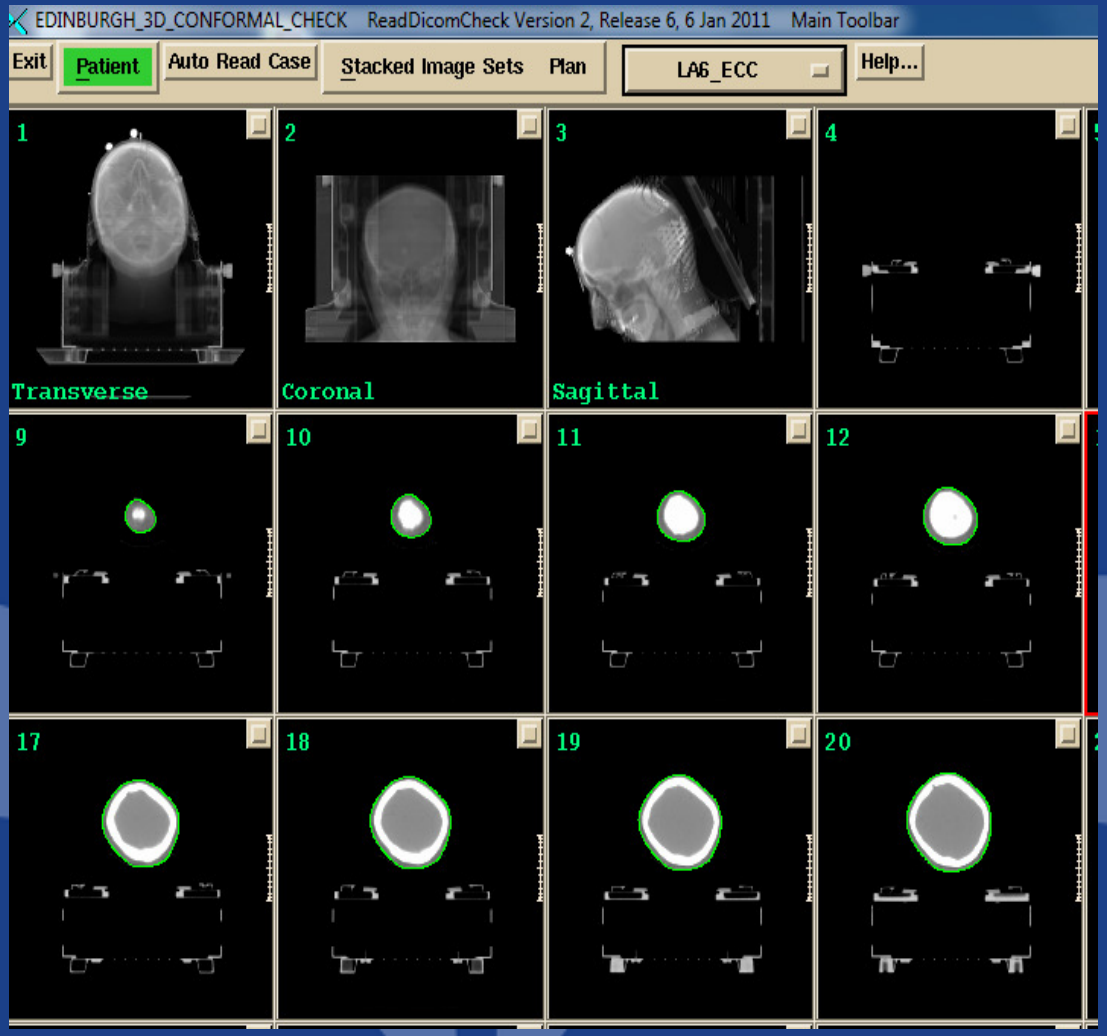
**Can be used in**
**Pre-treatment Mode**
**& Transit Mode**

**Step 2**

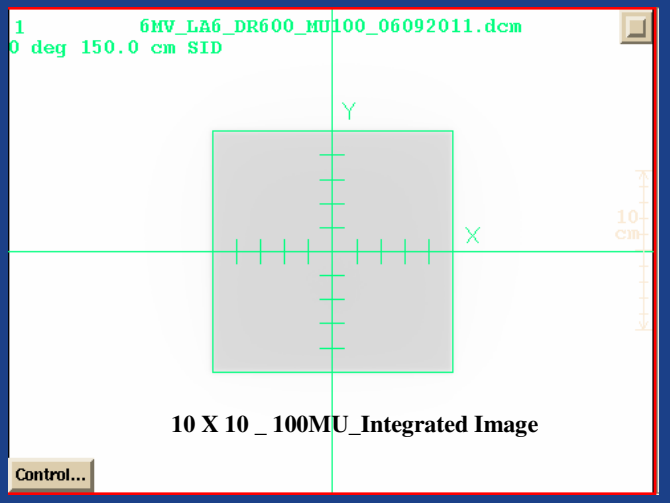
**Step 3**

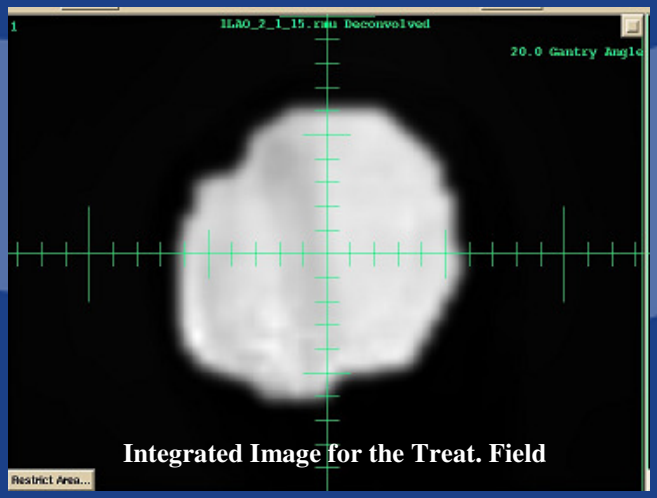
# *Dosimetry Check* : Input Data

## From TPS: C.T Slices + RS + RP + RD



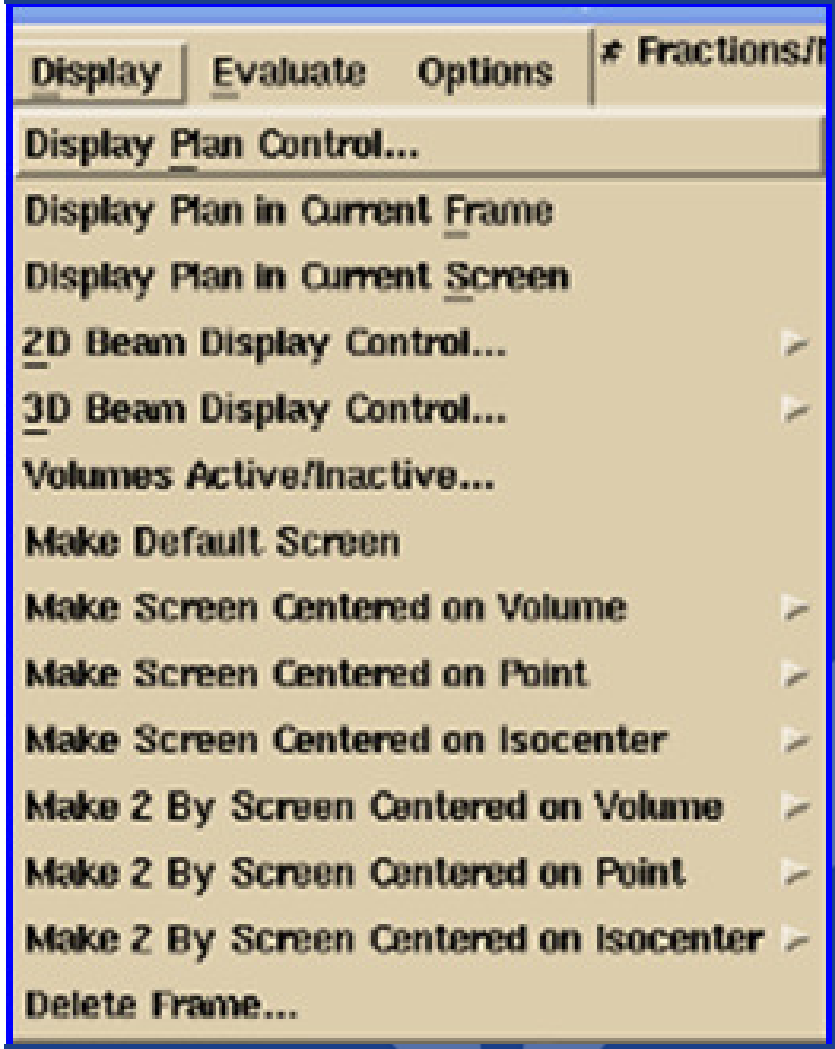

## From EPID



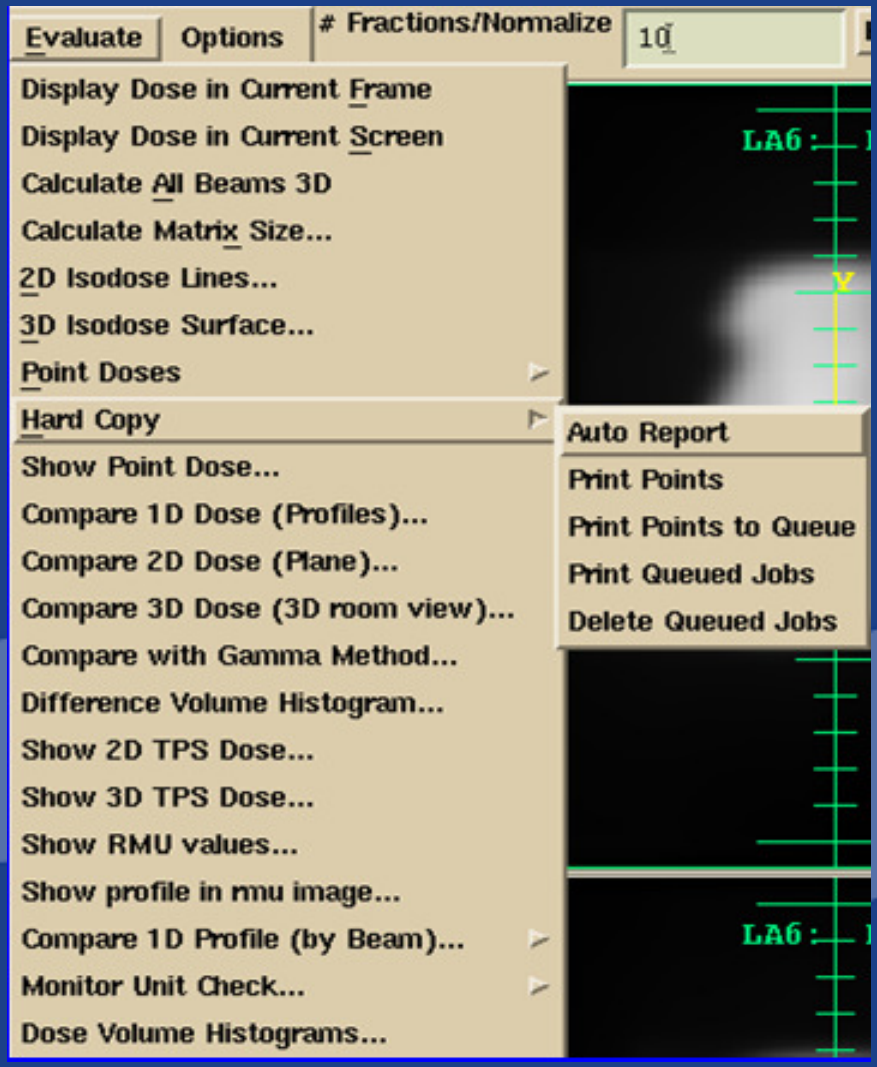



# Dosimetry Check : Output

## Display Tools




## Analysis Tools

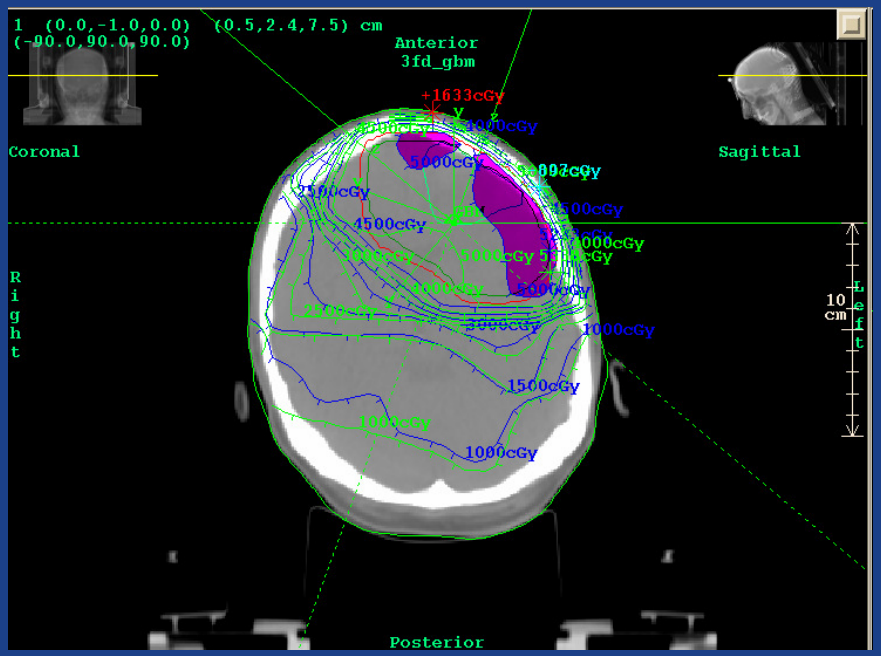


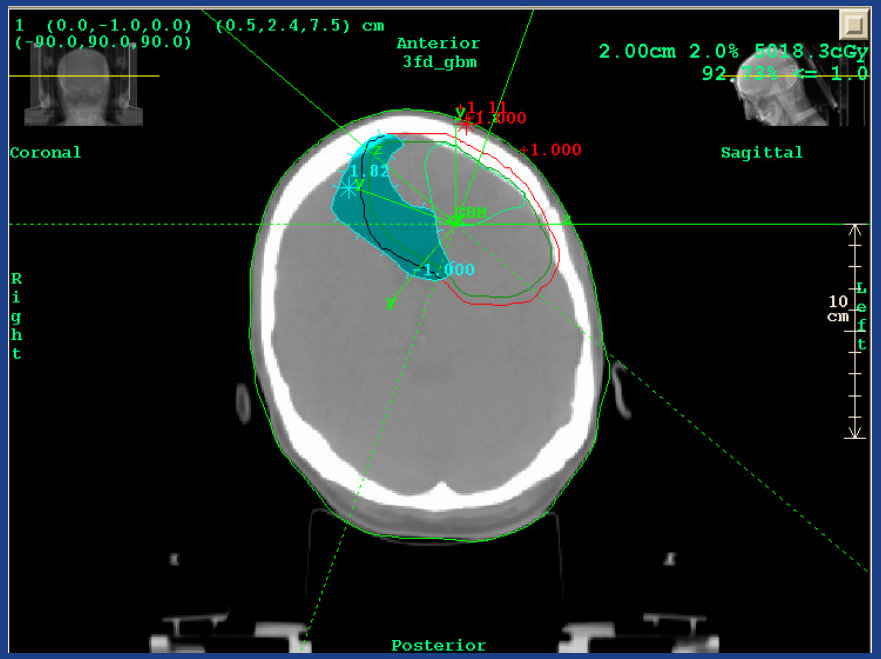
# *Dosimetry Check* : Output

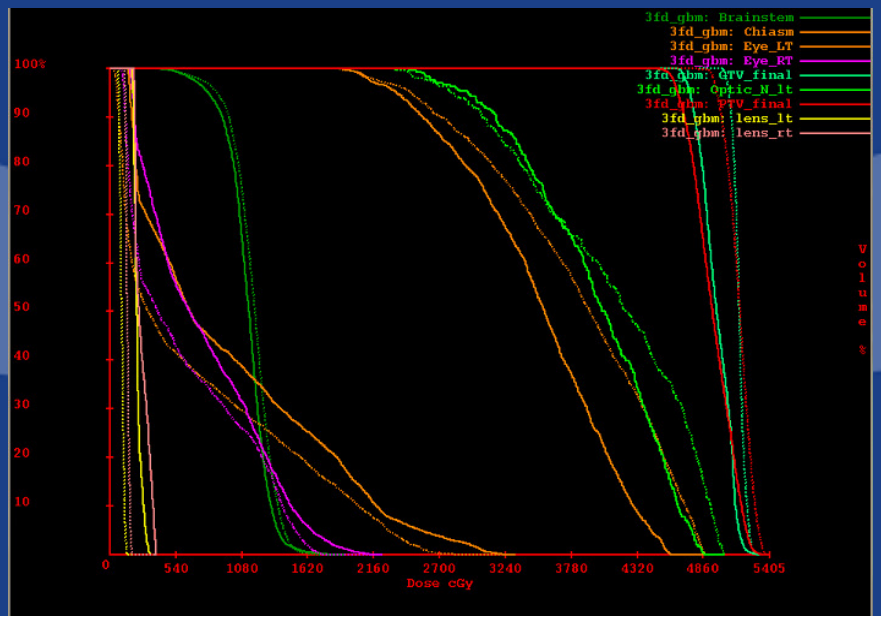
**Simple point**
**Dose @ CAX**

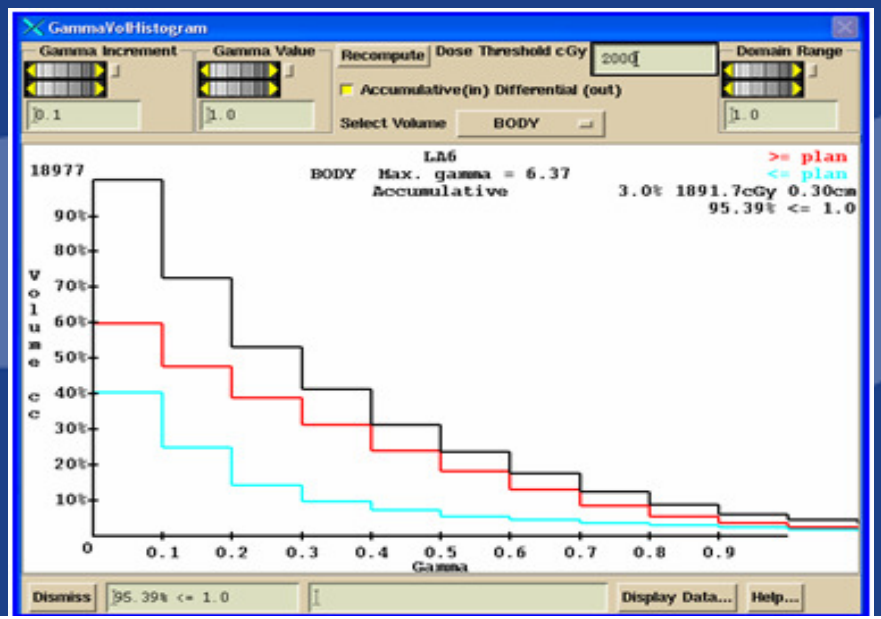
| **Point Name:** | **GBM** |
|---|---|
| | x, y, z cm |
| Coordinates | 1.2, 2.4, 12.6 |
| | **Dose cGy** |
| **1_LAO** | 1578.5 |
| Machine Name | LA6_ECC |
| Check Type | Exit-Integration |
| BEV Coordinates | -0.0, -0.0, -0.0 |
| **2_Lt_Lat** | 1741.6 |
| Machine Name | LA6_ECC |
| Check Type | Exit-Integration |
| 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



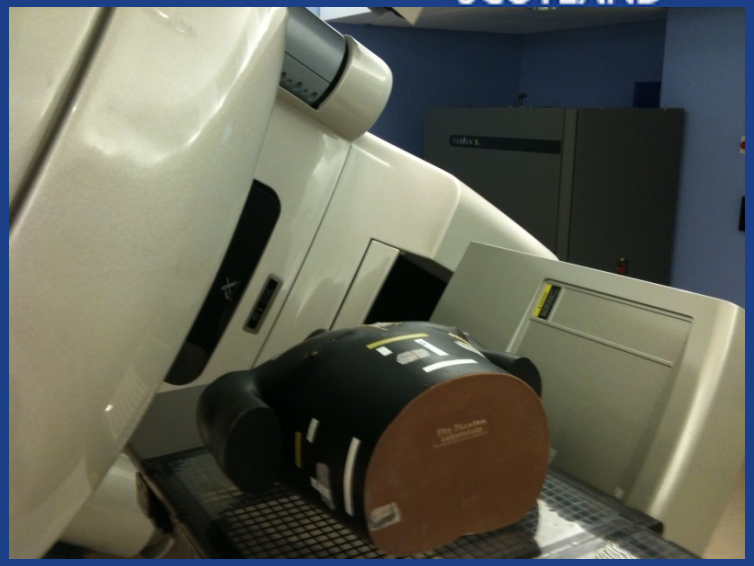



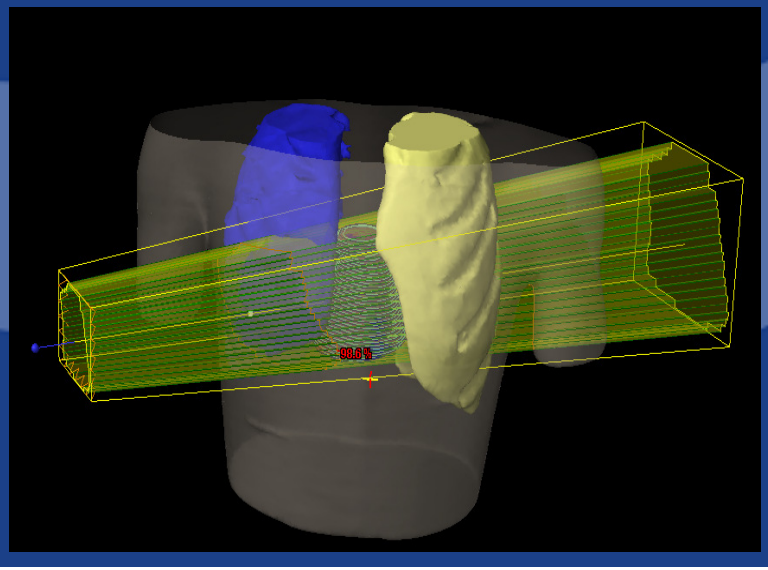



# Dosimetry Check – Physics behind

- 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.

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

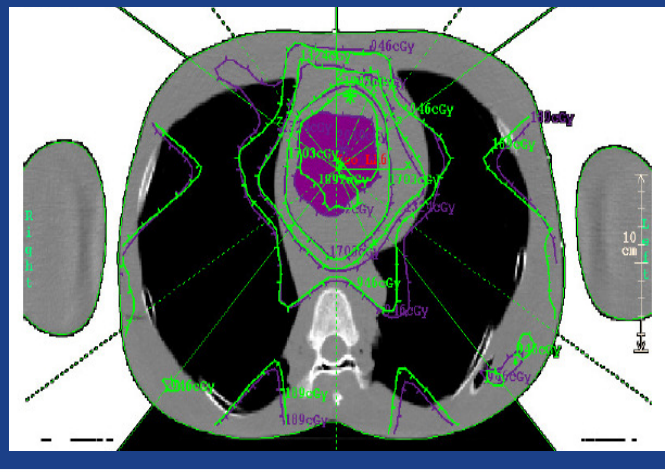




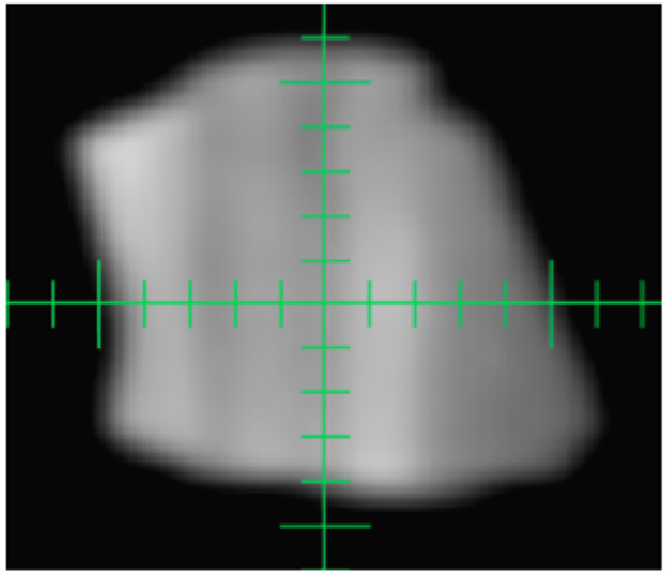
# Dosimetry Check – Physics behind

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

*Effective Monitor Unit ( E.M.U.)*

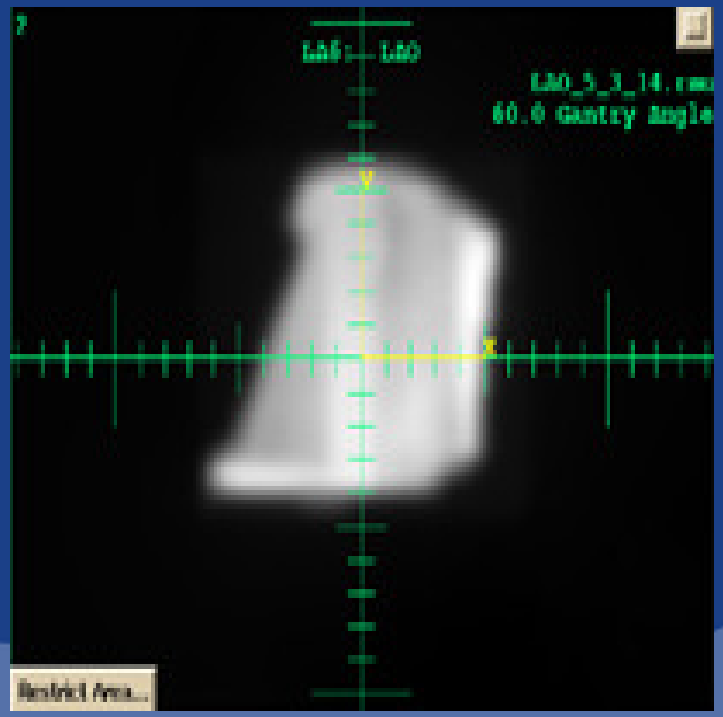
# *Dosimetry Check – Physics behind*

From *R.M.U.* To Dose .....

**Flood field - Remove the horns**

**Scatter – Internal as well as external**

**Epid Image = $\Psi_p^{(x,y)}$ Θ PSF**



***Response of the detector to a point source***

**Point Spread Function / Kernel**

**Dose spread Kernel**

**Glare Kernel**

# Dosimetry Check – Physics behind

## 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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## 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

$$K(q) = \sum_{i}^{n} a_i \frac{2\pi b_i}{(4\pi^2 q^2 + b_i^2)^{3/2}}$$

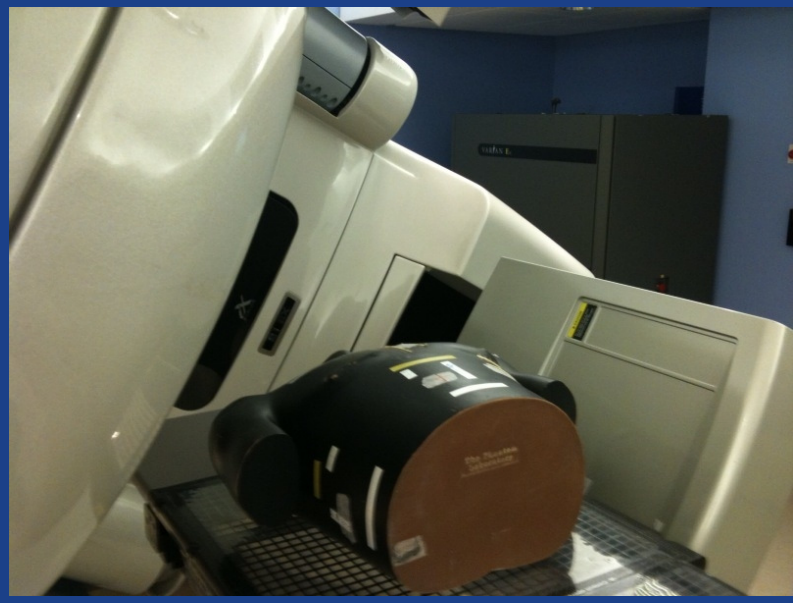
# Dosimetry Check – Physics behind

## Transit Dosimetry

**For different medium thicknesses along the beam path,**

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

**PSF is needed**



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

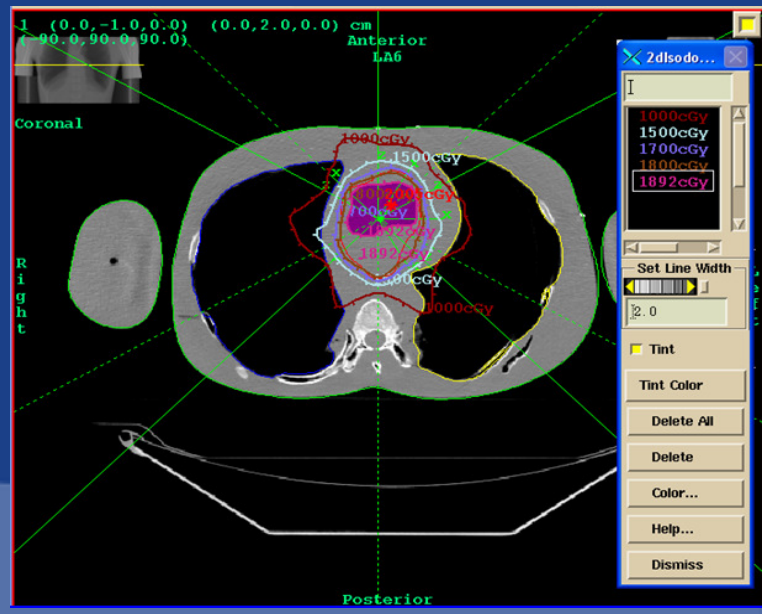
**Deconvolution of the EPID image will give the intensity in air .**

# Dosimetry Check – Physics behind

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

**Which is nothing but collimator scatter (Sc) x M.U.**

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




**With the knowledge of CT density and ray tracing,**

**Dose distribution within the CT volume can be recreated.**

## 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.

# 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 &

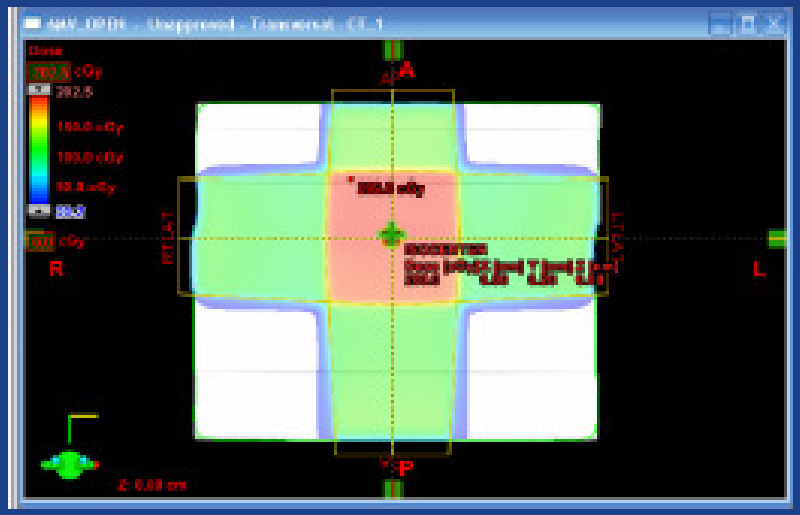
A typical VMAT delivery (72 images) , it will take 11 hrs

to compute the dose.

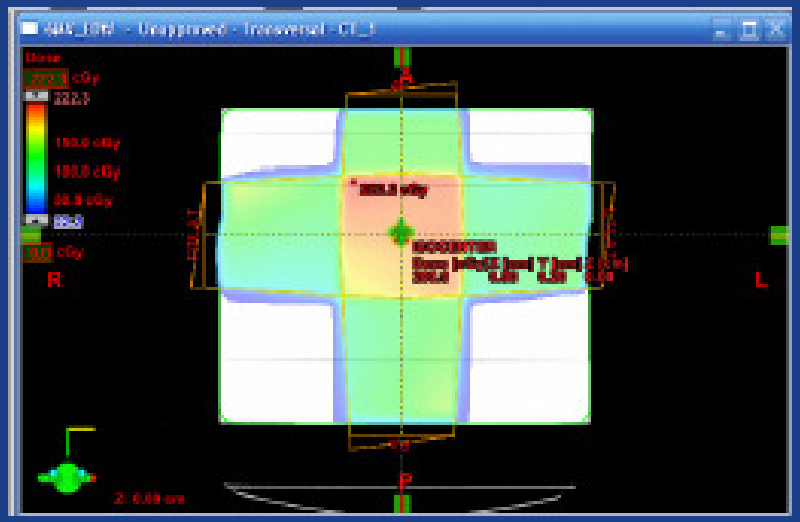
Another algorithm is used to simplify the process which ends up only 3 secs to compute the dose from each image.

# What's studied so far with Dosimetry Check ?

## Open Fields [RMI]



## Wedge Fields [RMI]

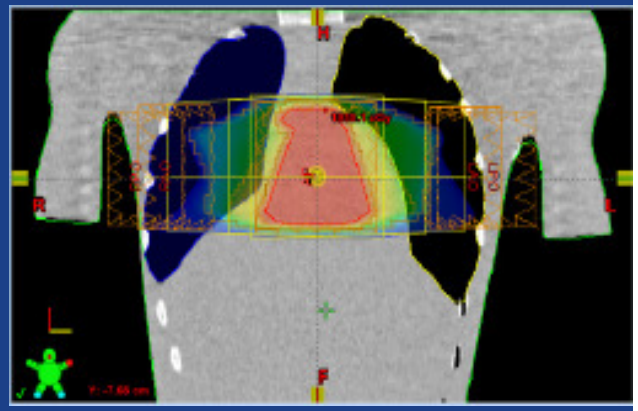


| | TPS (cGy) | Pre (cGy) | Diff (%) | Transit (cGy) | Diff (%) | Chamber (cGy) | Diff (%) |
|---|---|---|---|---|---|---|---|
| Open | 200 | 197.6 | -1.19 | 209.9 | 4.94 | 199.4 | -0.003 |
| EDW | 200 | 198.0 | -0.98 | 209.7 | 4.85 | 199.1 | -0.005 |

# What's studied so far with Dosimetry Check ?

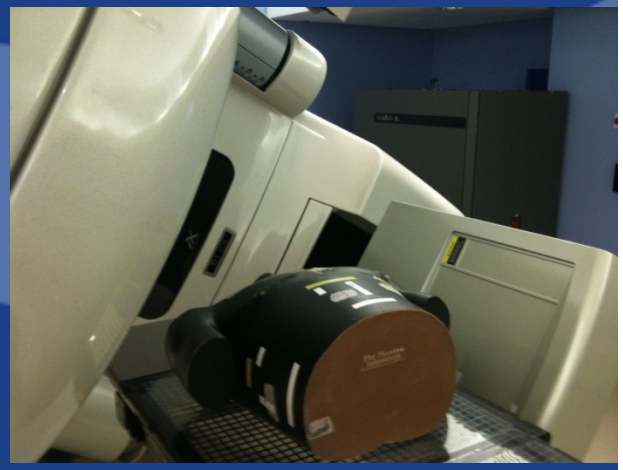
## Reproducibility Study [ Fixed gantry IMRT ]

| | 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 |

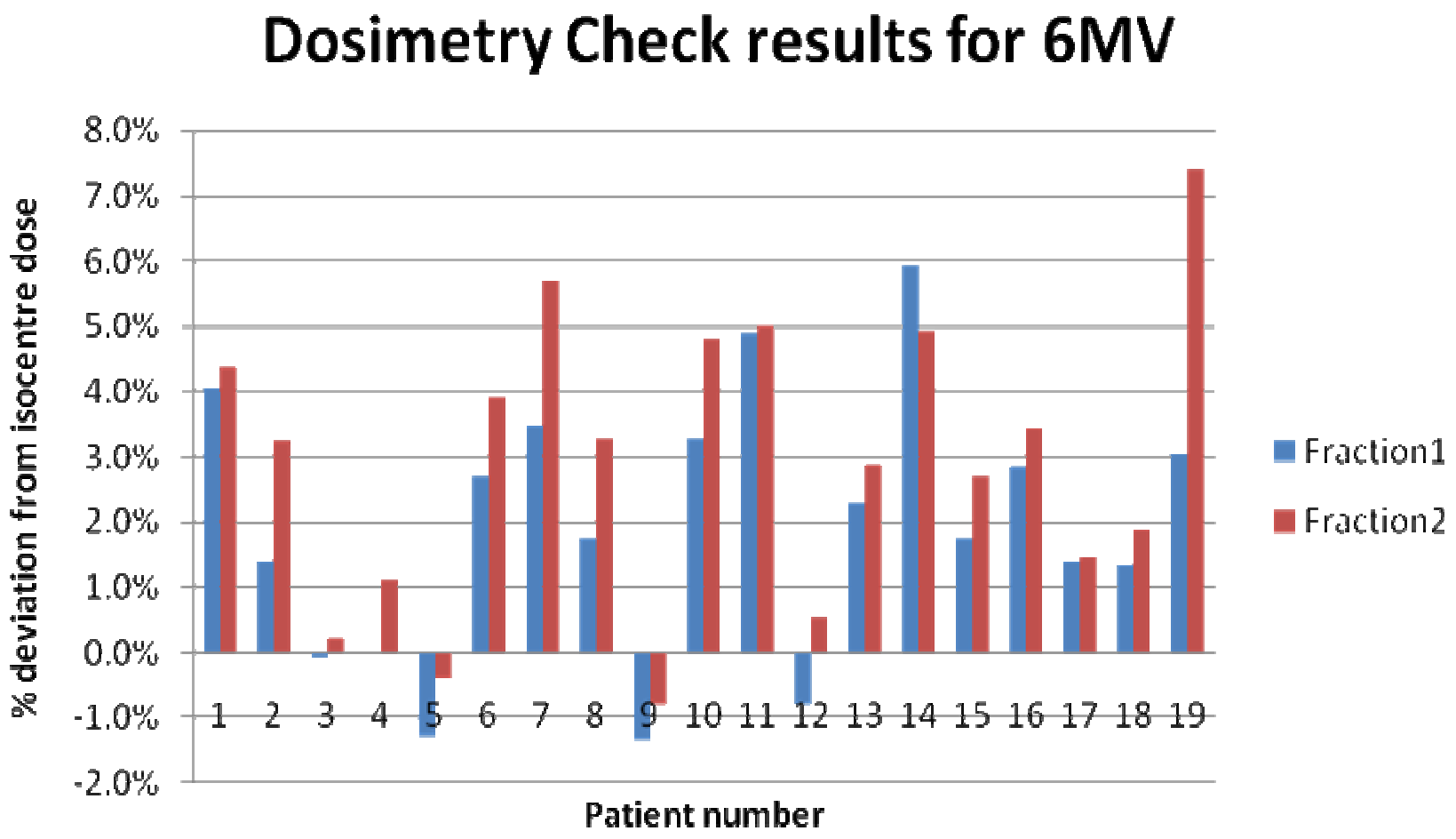


# What's studied so far with Dosimetry Check ?

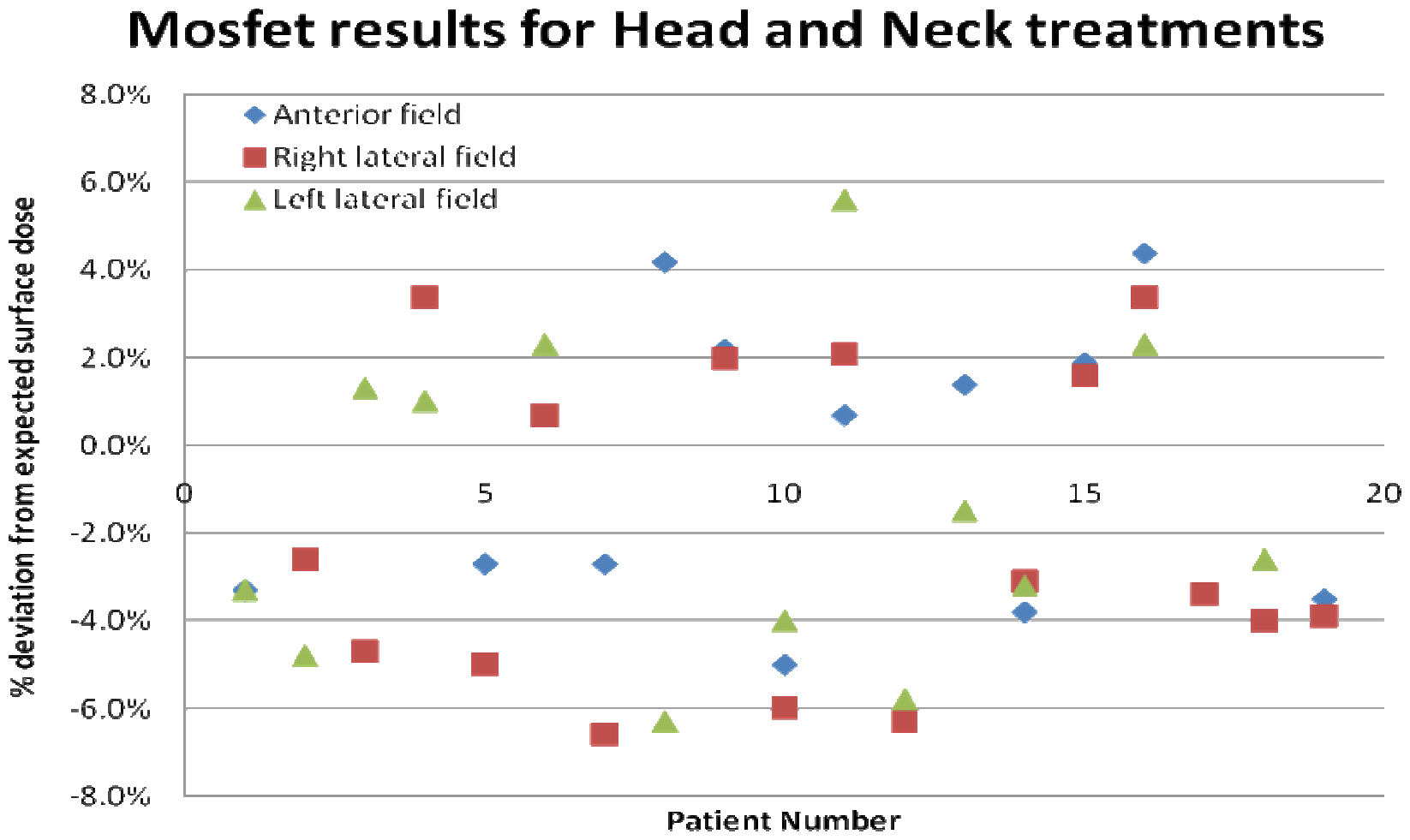
## Clinical Study – LA 6 _ 6MV  Ca. Lung patients

| 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 |

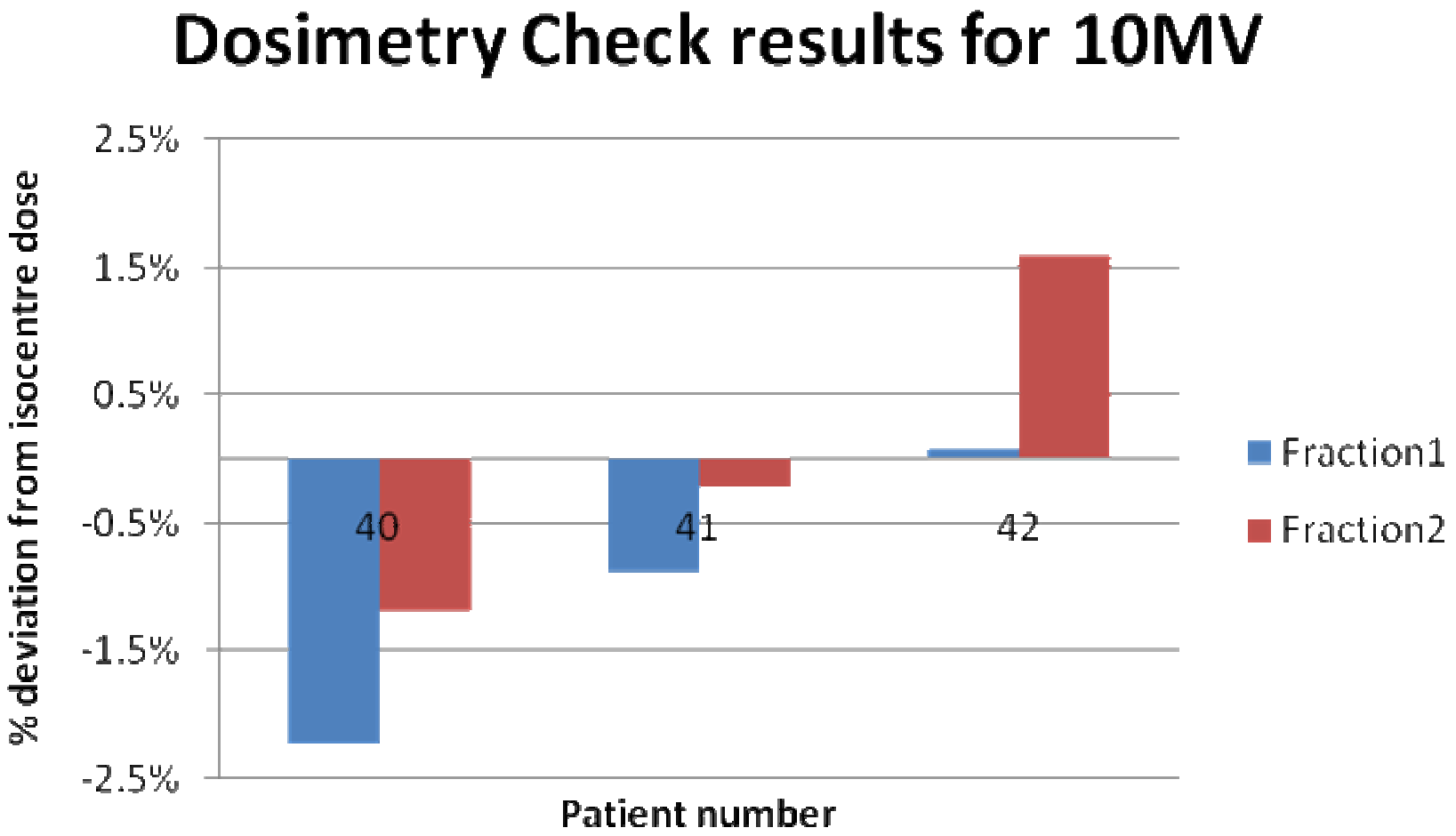
# LA 7 : H& N Conventional Conformal technique



# LA 7 : H& N Conventional Conformal technique



# LA 7 : Pelvic site - Conventional Conformal technique



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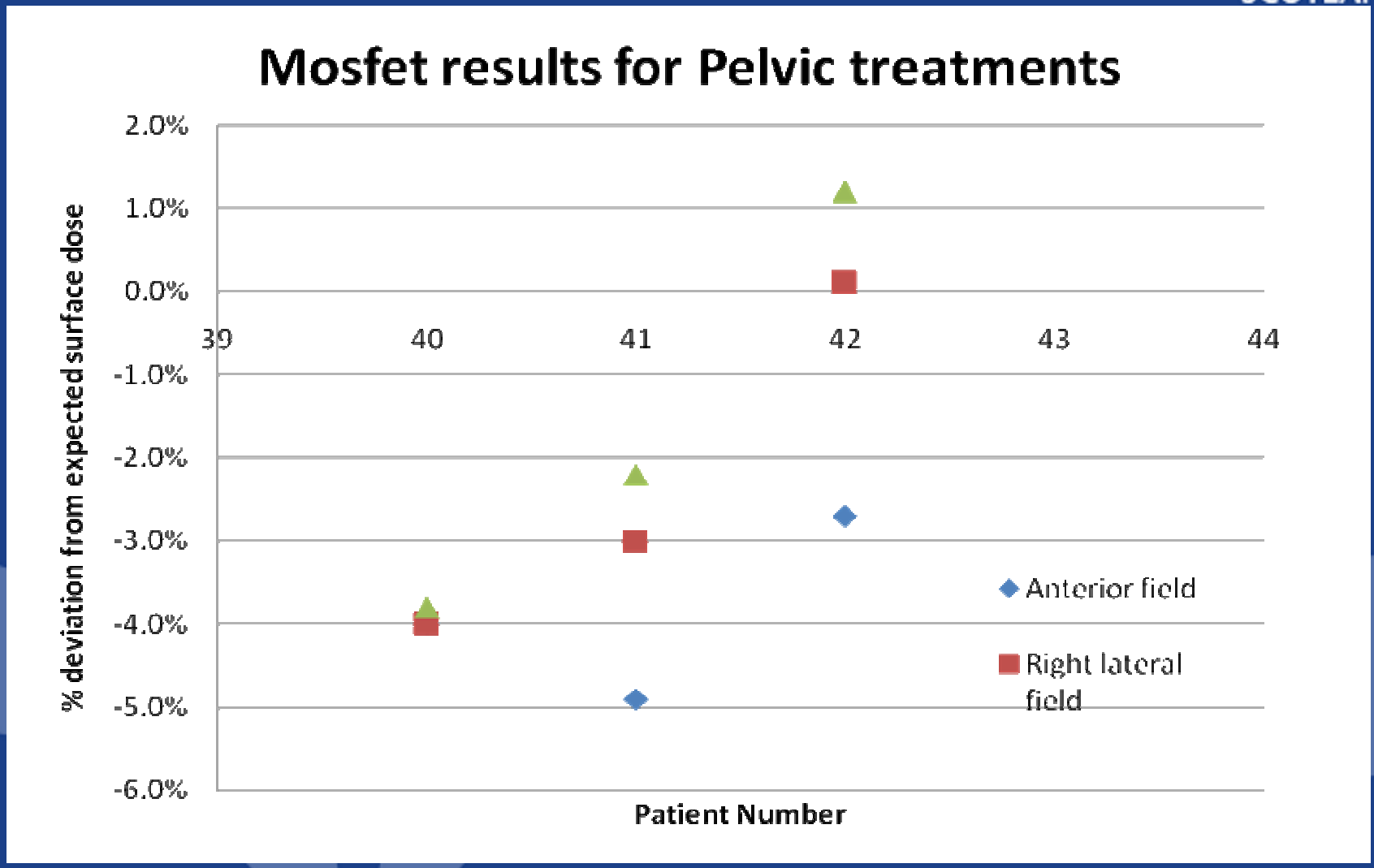
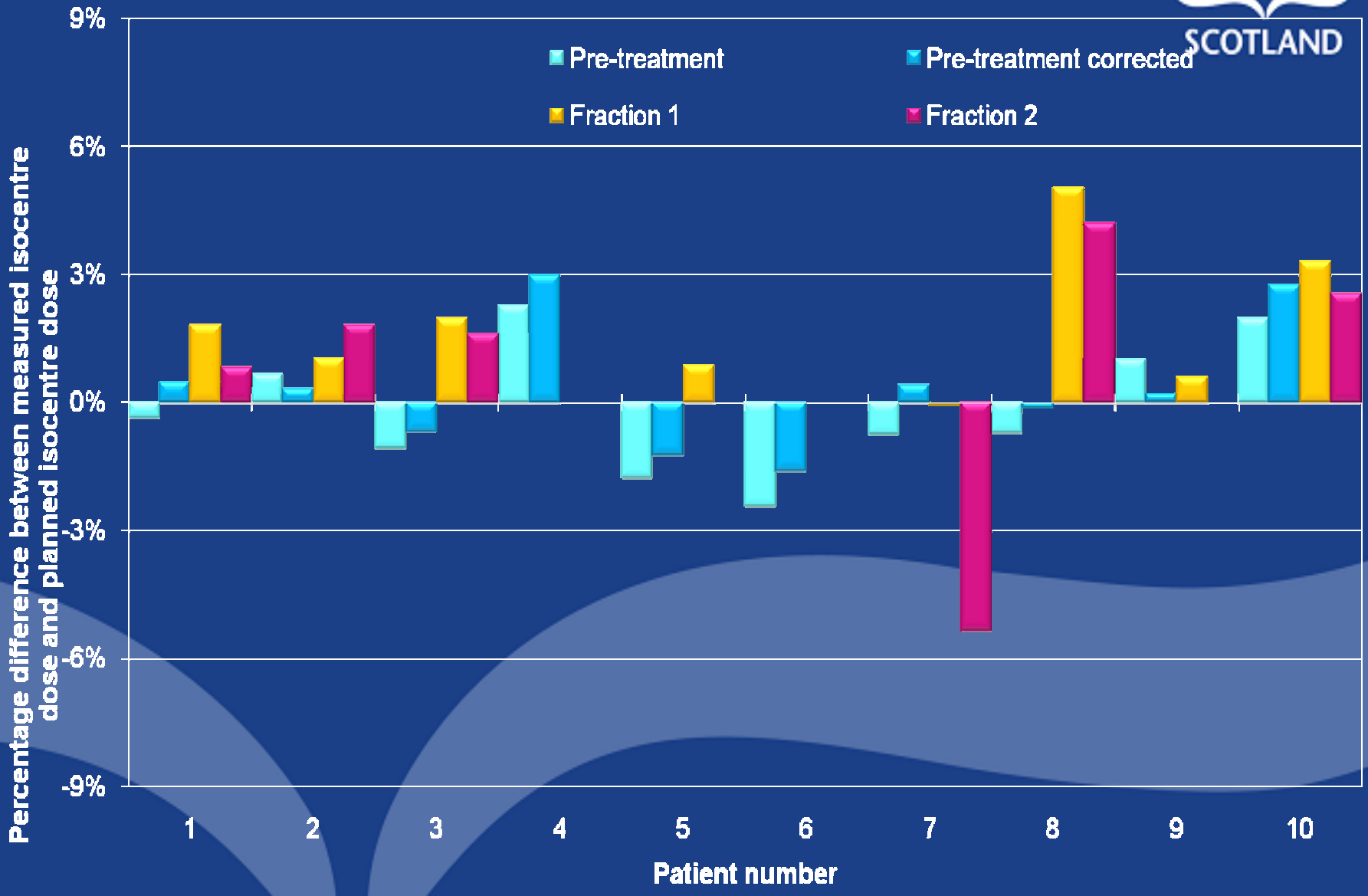


# RapidArc patients



# *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