Radiochromic film in the Clinic,

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Contents

- Varian Rapid Arc (RA), Clinical demand for QA
- EBT2 filmdosimetry at VUmc
- Comparison of FilmQA with VUmc method
- Conclusion

Rapid Arc

- RA is “IMRT” in a single rotation
- Different from IMRT by optimization and delivery
  - 1 Arc with variable gantry speed (0.5 – 5.54 degree/sec)
  - Variable dose rate (0 – 600 MU/min (0 – 1000 MU/min on Novalis Tx)), (0.2 – 20 MU/degree)
  - Rapid changing MLC apertures (0 – 2.5 cm/s)
  - Minimization of Monitor Units
  - Direct Aperture Optimization (simulated annealing)
- AAA in Eclips (2.5 mm voxel)
- Inter-digitating MLC
- Highly modulated beam segments

VUmc department Radiotherapy

VU medisch centrum

- 2 Varian 2300 C/D
- 1 Trilogy
- 1 Trilogy Novalis Tx
- 2 Truebeam

Truebeam

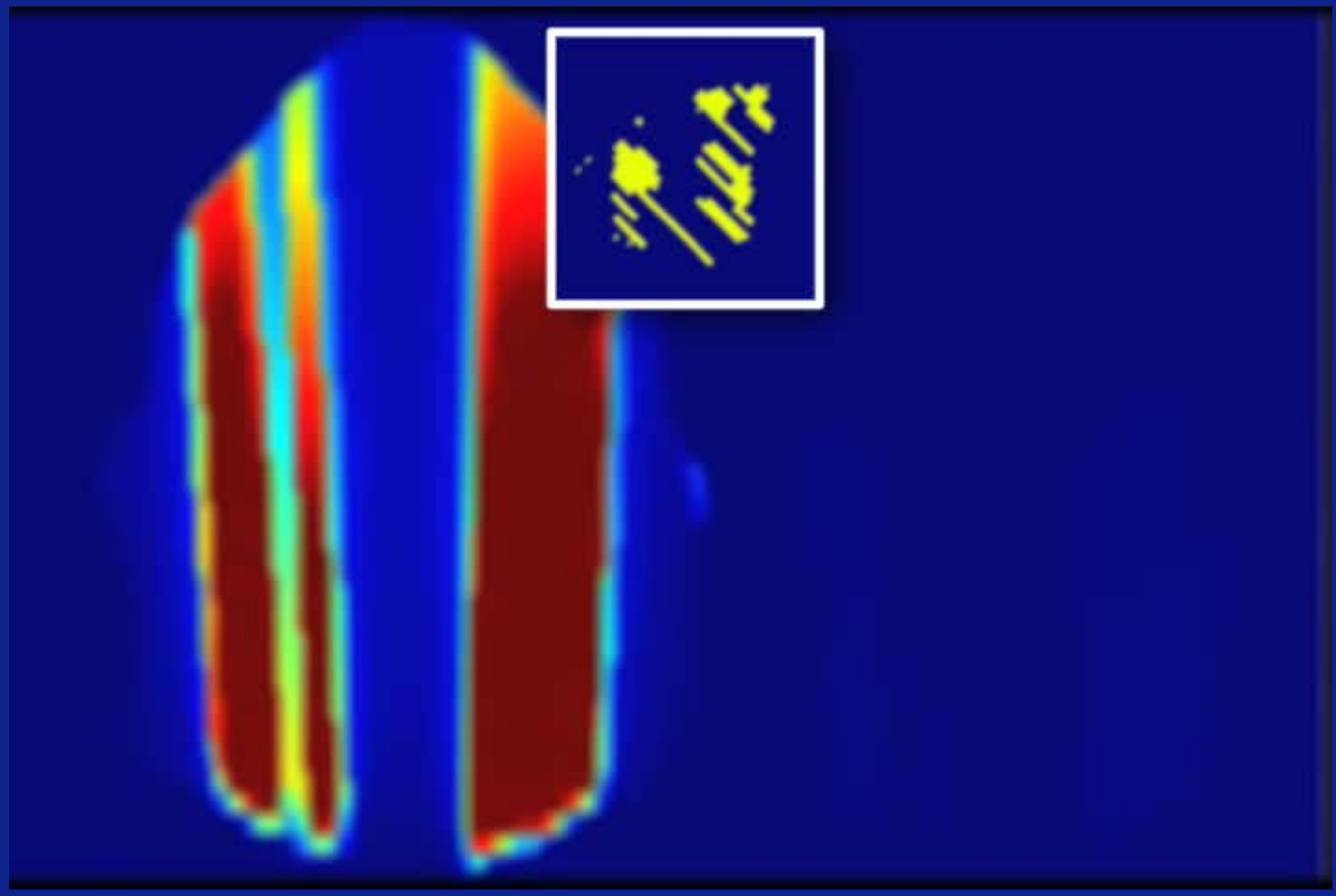
2300 C/D

Implementation Rapid Arc VUmc

- VUmc is one of the first clinical users of RA in Europe (2008)
- Only 6 MV (but also SRS 6 MV 1000 MU/min on Novalis TX)
- 6 accelerators with RA
- 2 arcs per patient (CW and CCW), coll 45 and 50 resp.
- Main indications at VUmc
  - Head and neck
  - Lung
  - Brain
  - Glioblastoma
  - Prostate

→

Fractions x Dose [Gy]
33 x 2 Gy
12 x 5 Gy
4 x 7.5 Gy
1 x 8 Gy
5 x 8 Gy
3 x 9 Gy
5 x 11 Gy
3 x 18 Gy

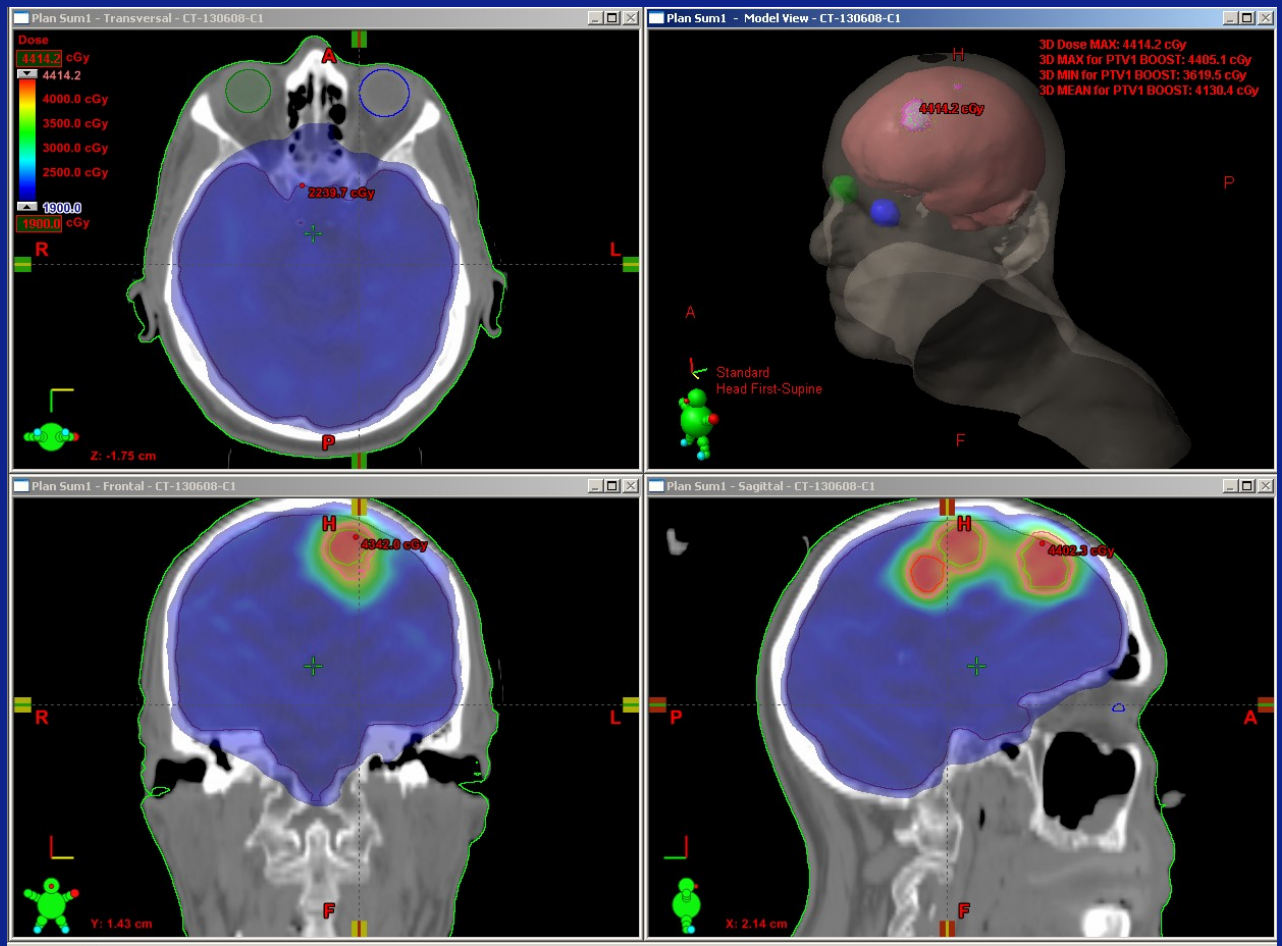


www.varian.com for video

Collimator 45 and 50 degree

VU medisch centrum

WBRT (4 Gy) + mult. metas. (8 Gy)



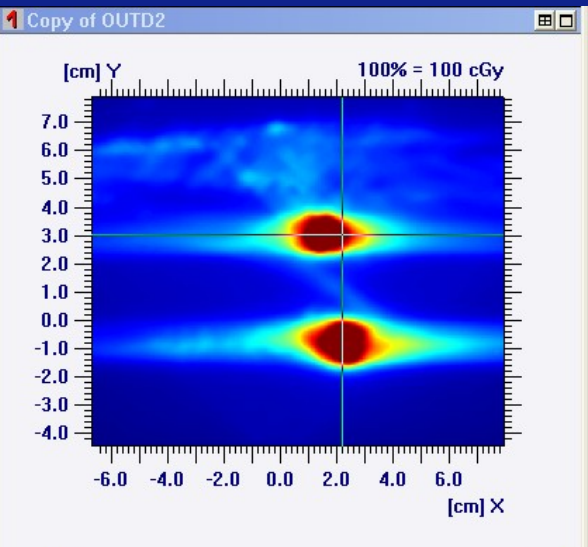
Field Setup | Plan Evaluation

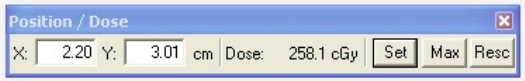
Alignments | Plan Objectives | Optimization Objectives | Dose Statistics | Calculation Models | Plan Sum

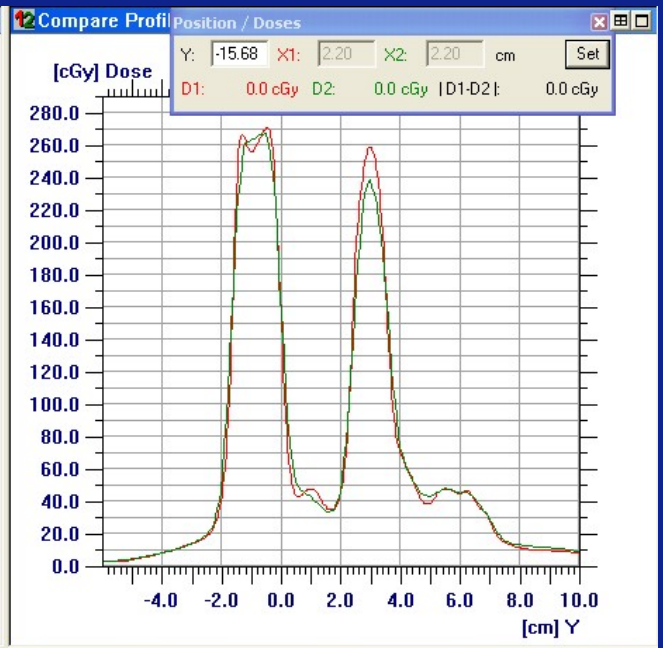
Technique	Machine/Energy	MLC	Field Weight	Scale	Gantry Rtn [deg]	Coll Rtn [deg]	Couch Rtn [deg]	Wedge	Field X [cm]	X1 [cm]	X2 [cm]	Field Y [cm]	Y1 [cm]	Y2 [cm]	X [cm]	Y [cm]	Z [cm]	SSD [cm]	MU	Ref. D [cGy]
ARC-I	F - 6X	Dose Dyn. Arc	1.00	Varian IEC	179.0	45.0	0.0	None	18.8	+9.6	+9.2	18.6	+9.5	+9.2	0.0	0.0	0.0	89.6	680	
ARC-I	F - 6X	Dose Dyn. Arc	1.00	Varian IEC	181.0	40.0	0.0	None	18.8	+9.6	+9.2	18.6	+9.5	+9.2	0.0	0.0	0.0	89.6	724	

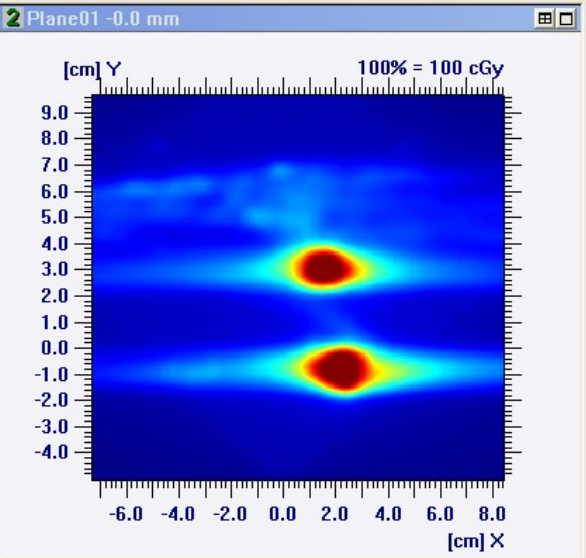
Multiple brain metas: SRT

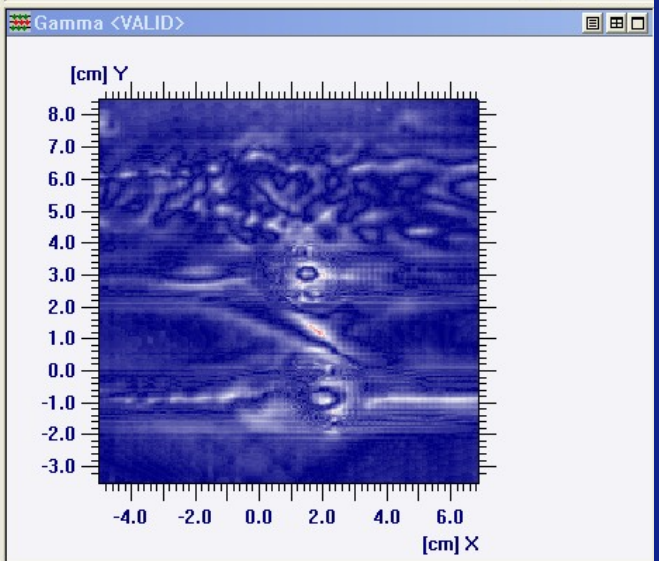
VU medisch centrum

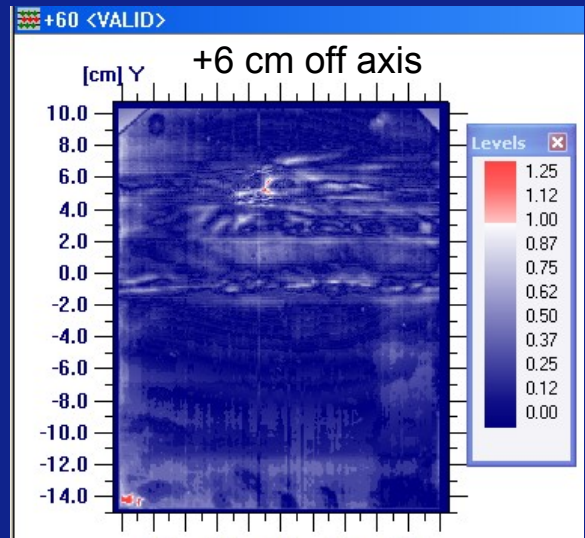


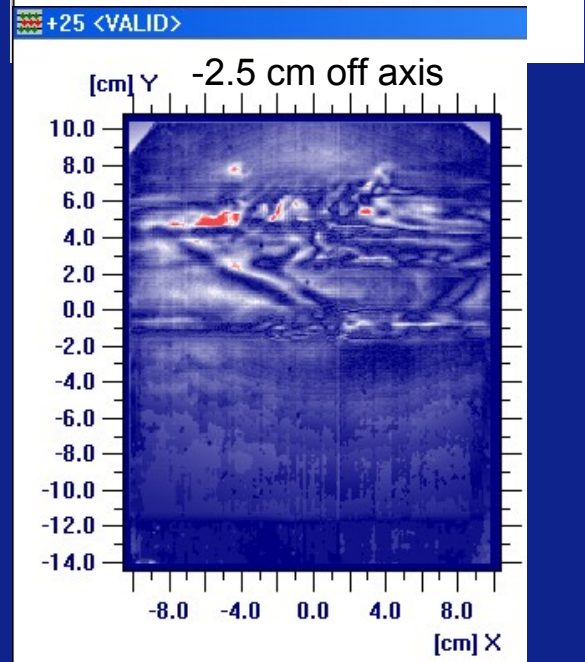










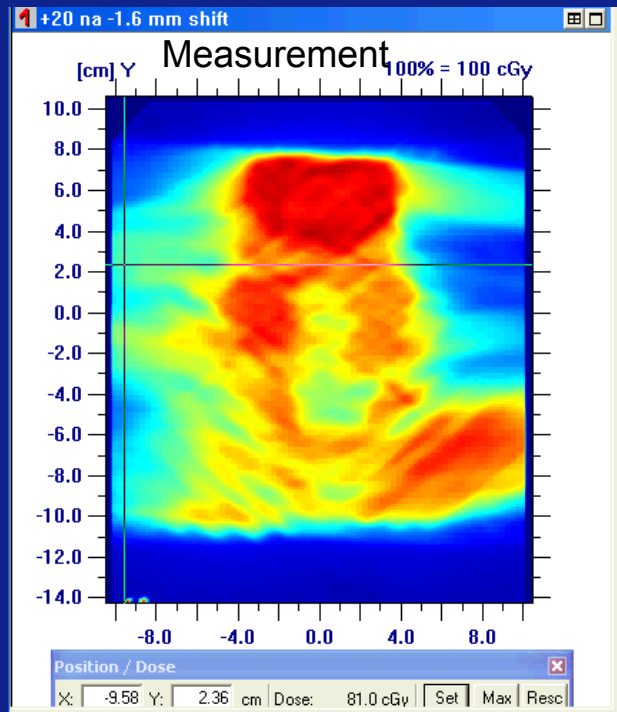


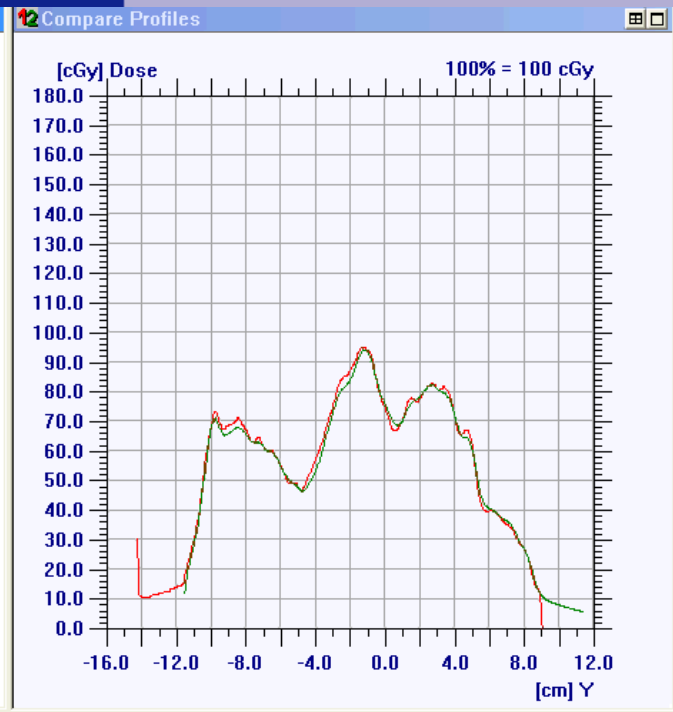
VU medisch centrum

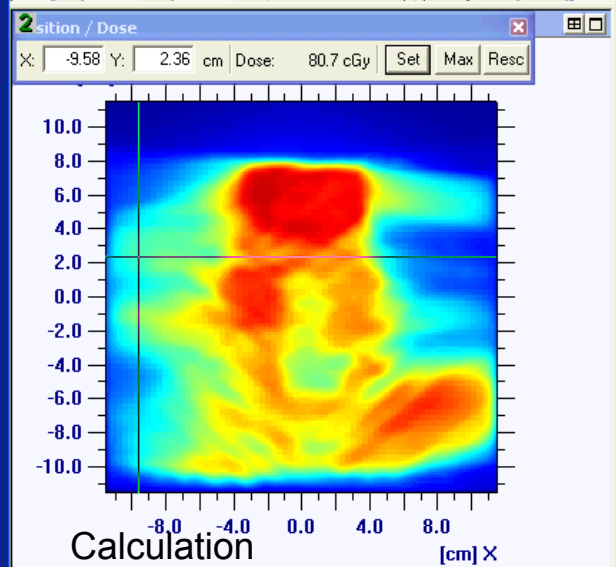
RapidArc optimized plan for Nasopharynx with SIB (56 / 70 Gy)

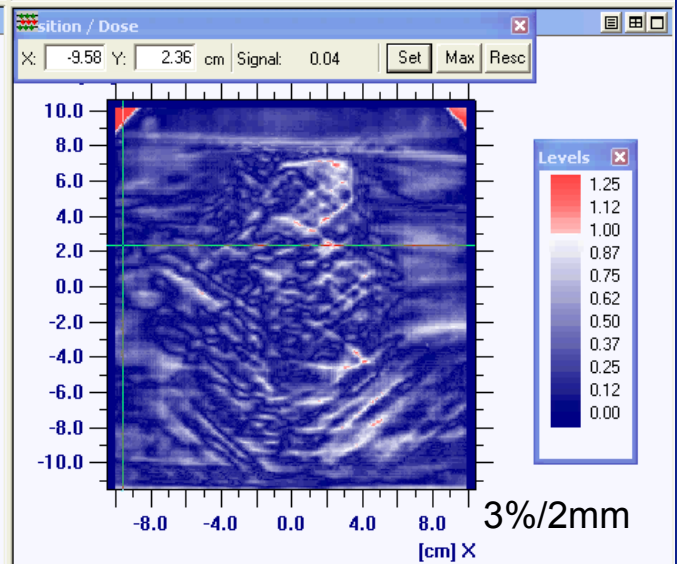
VU medisch centrum

Film analysis for nasopharynx, comparison with calculations





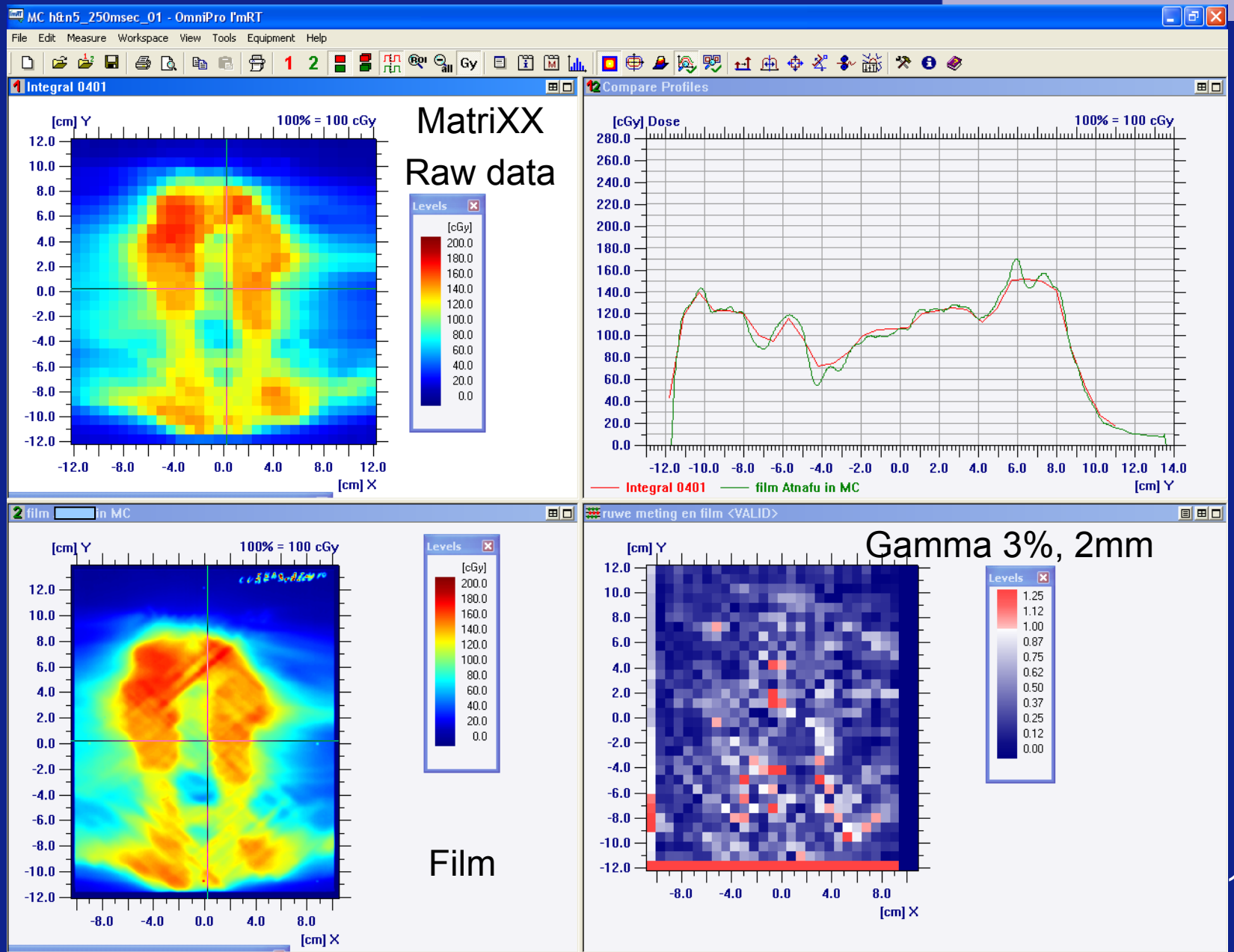




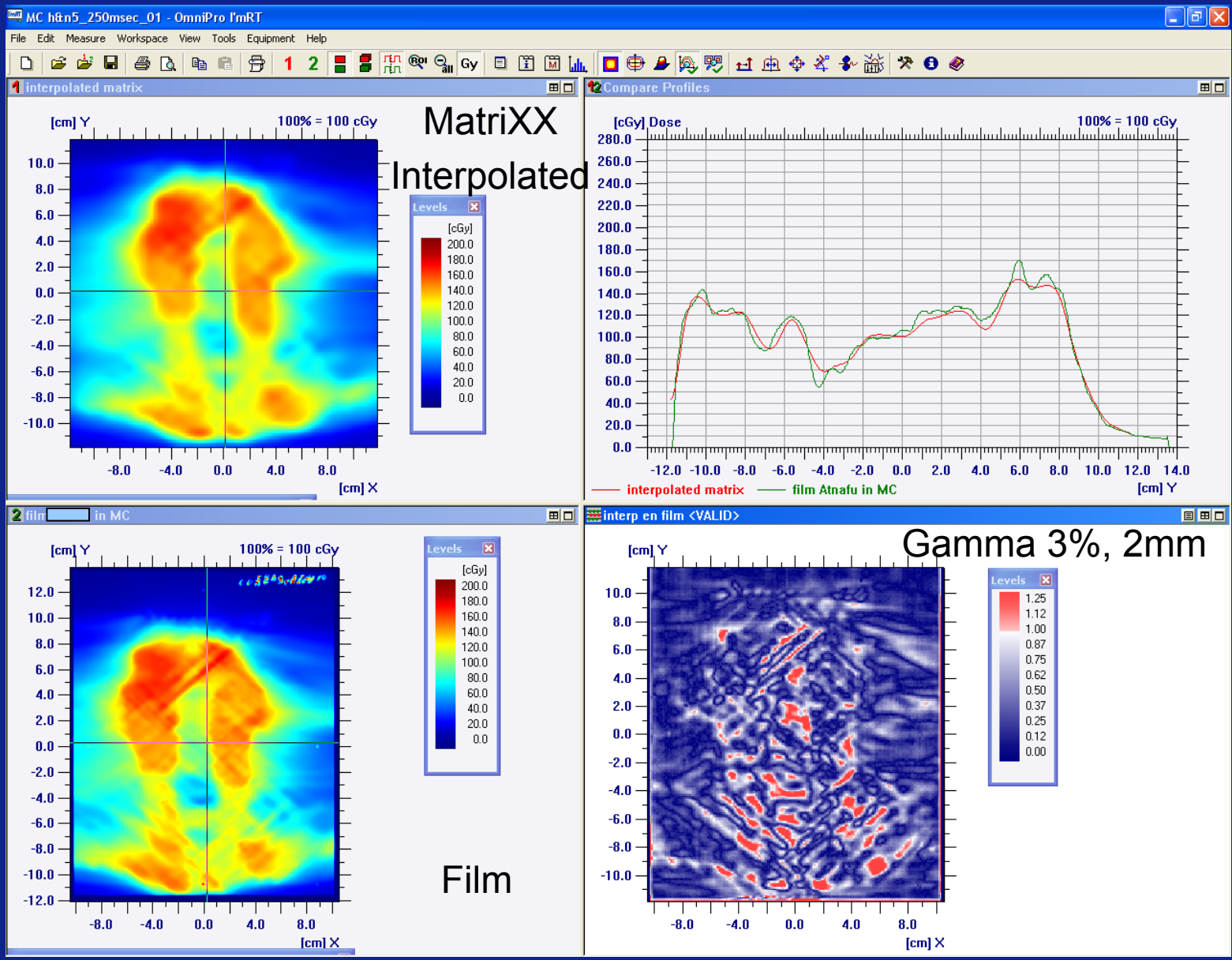
Rapid Arc

Helical MatriXX versus EBT1 film

VU medisch centrum

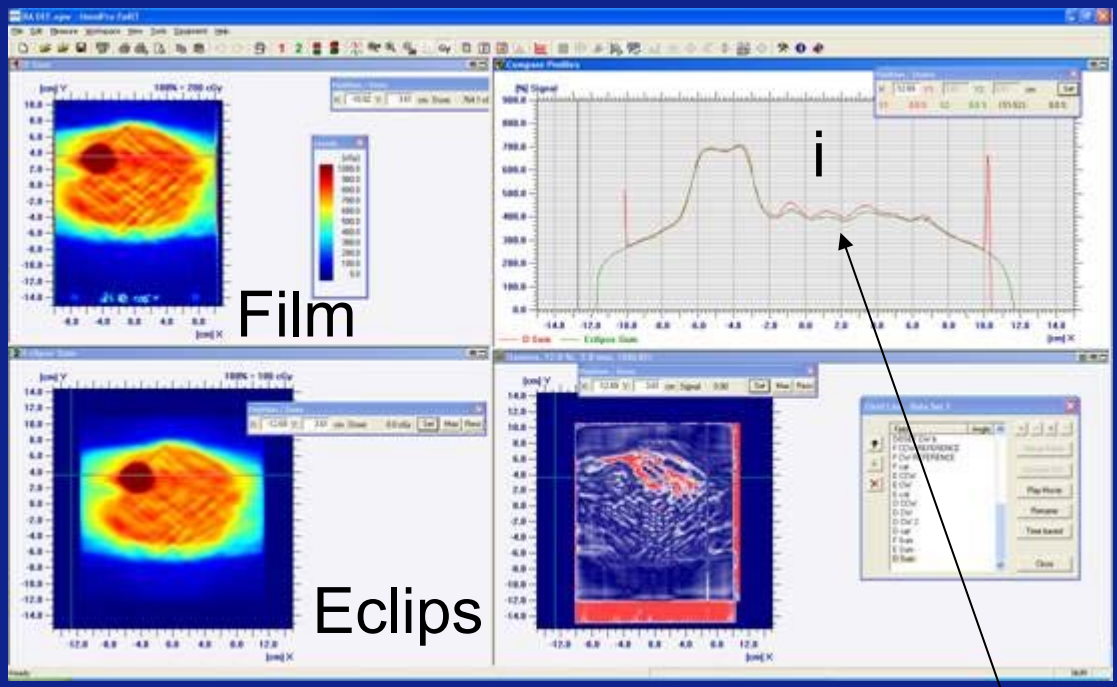


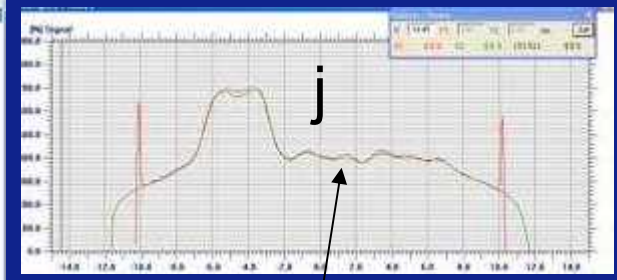
Helical MatriXX versus EBT1 film



GafChromic EBT1 film

VU medisch centrum



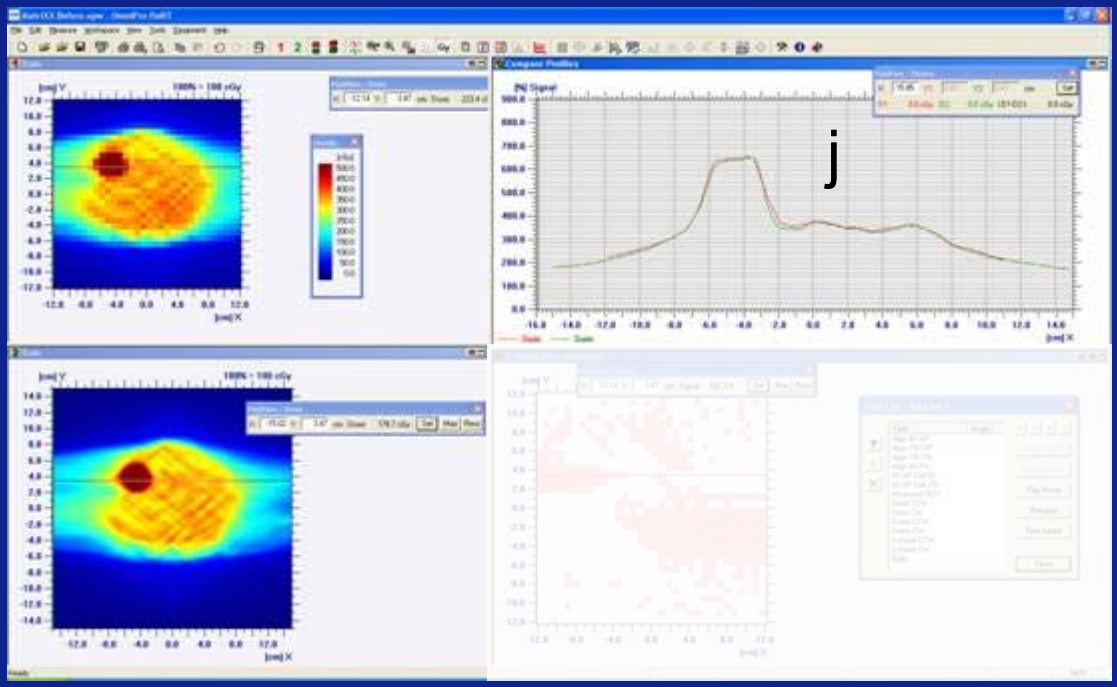


Difference in machine performance (i versus j)

Machines i and j both meet “Varian specs”!
Solved by re-positioning head assembly 0.3 mm

VU medisch centrum

MatriXX

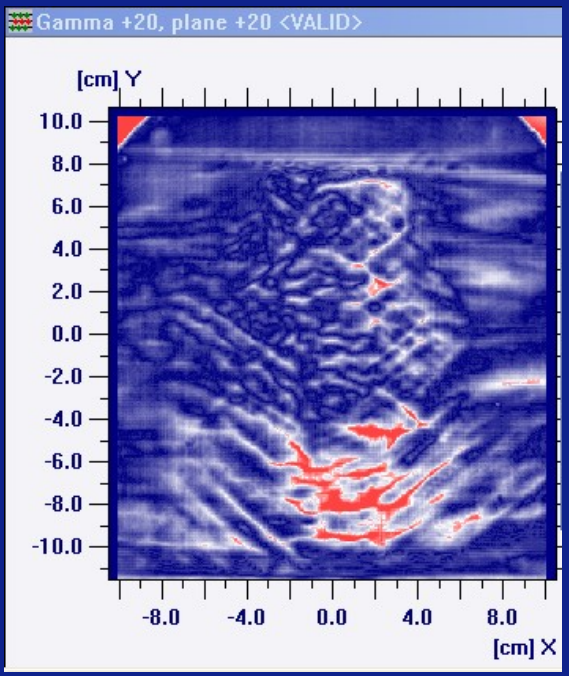


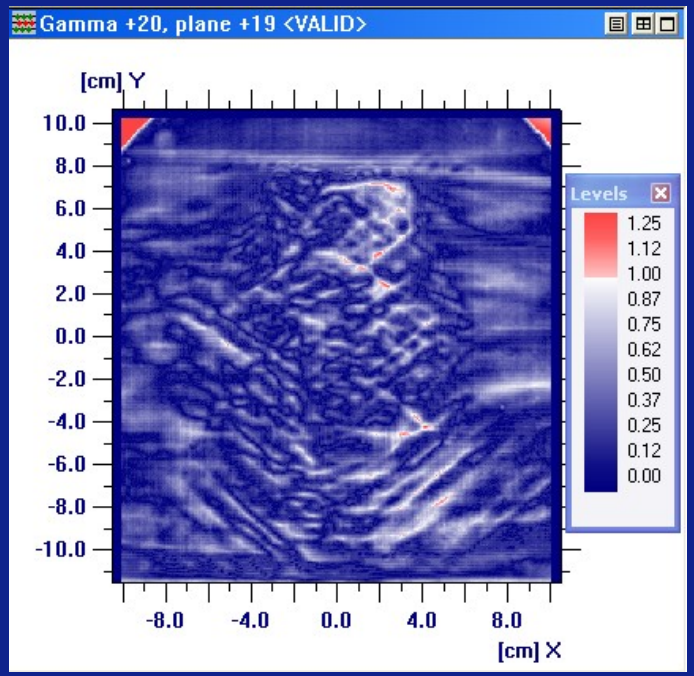
GafChromic EBT1 film

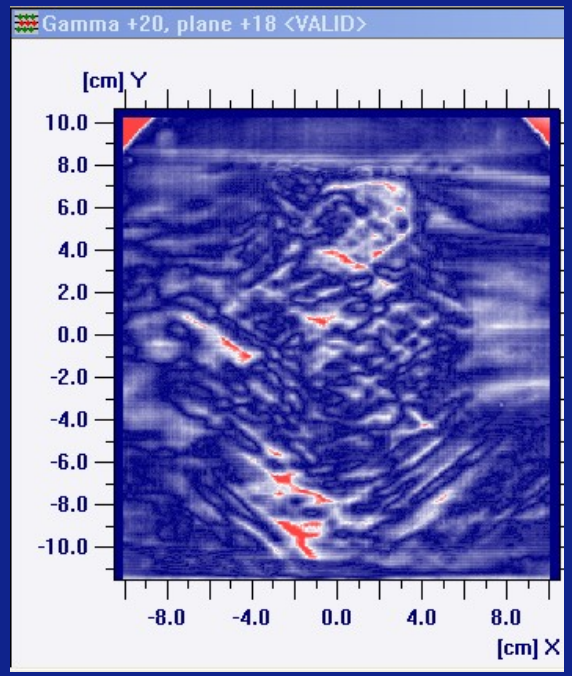
Differences in machine performance not detected with MatrixX only, therefore EBT mandatory!

2.5 D gamma evaluation?

- Measured plane with 3 calculated planes, 1 mm apart:
  20 mm 19 mm 18 mm

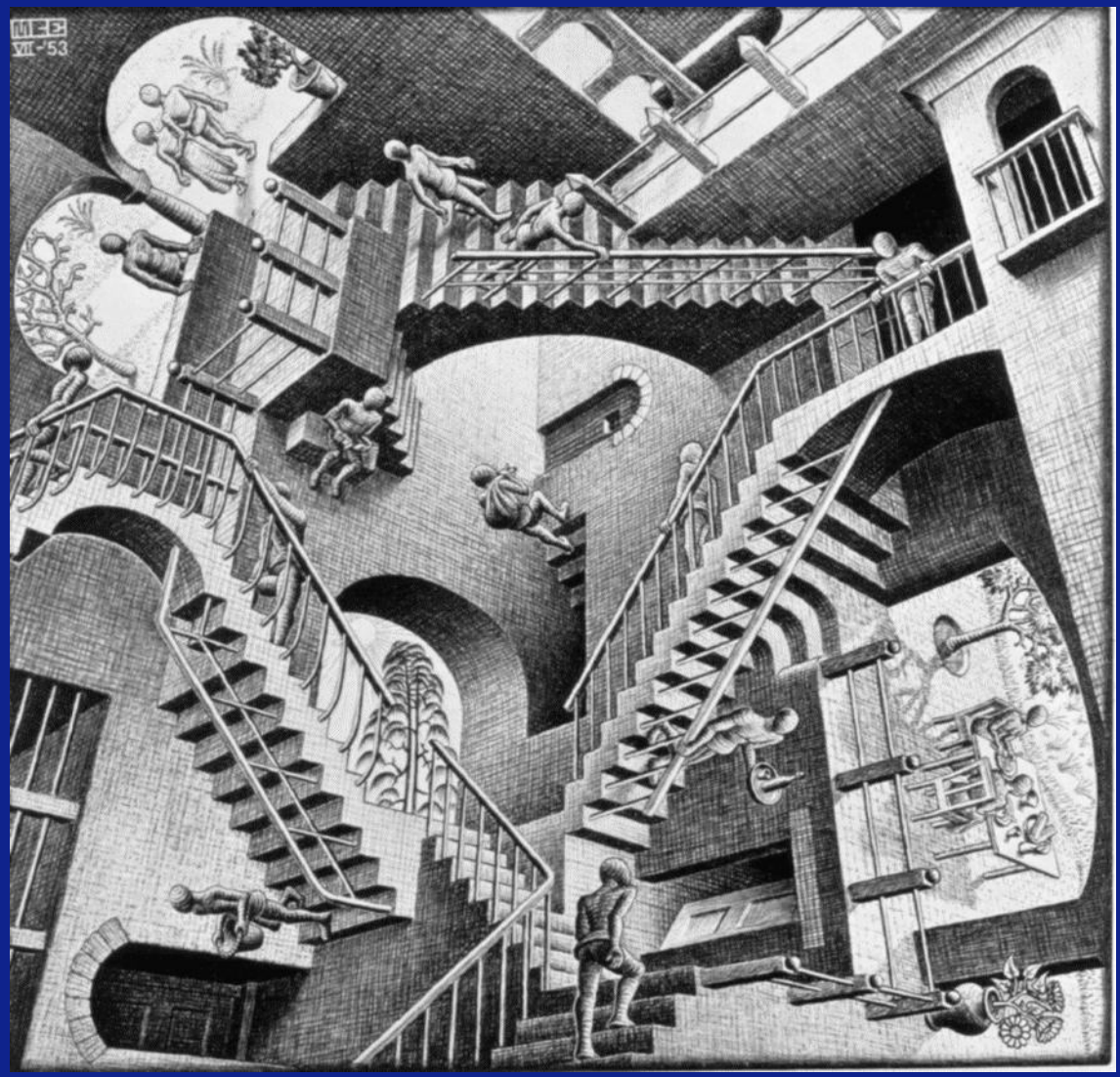






- Uncertainty in phantom positioning
- Highly varying spatial dose distributions (within 95-107%)

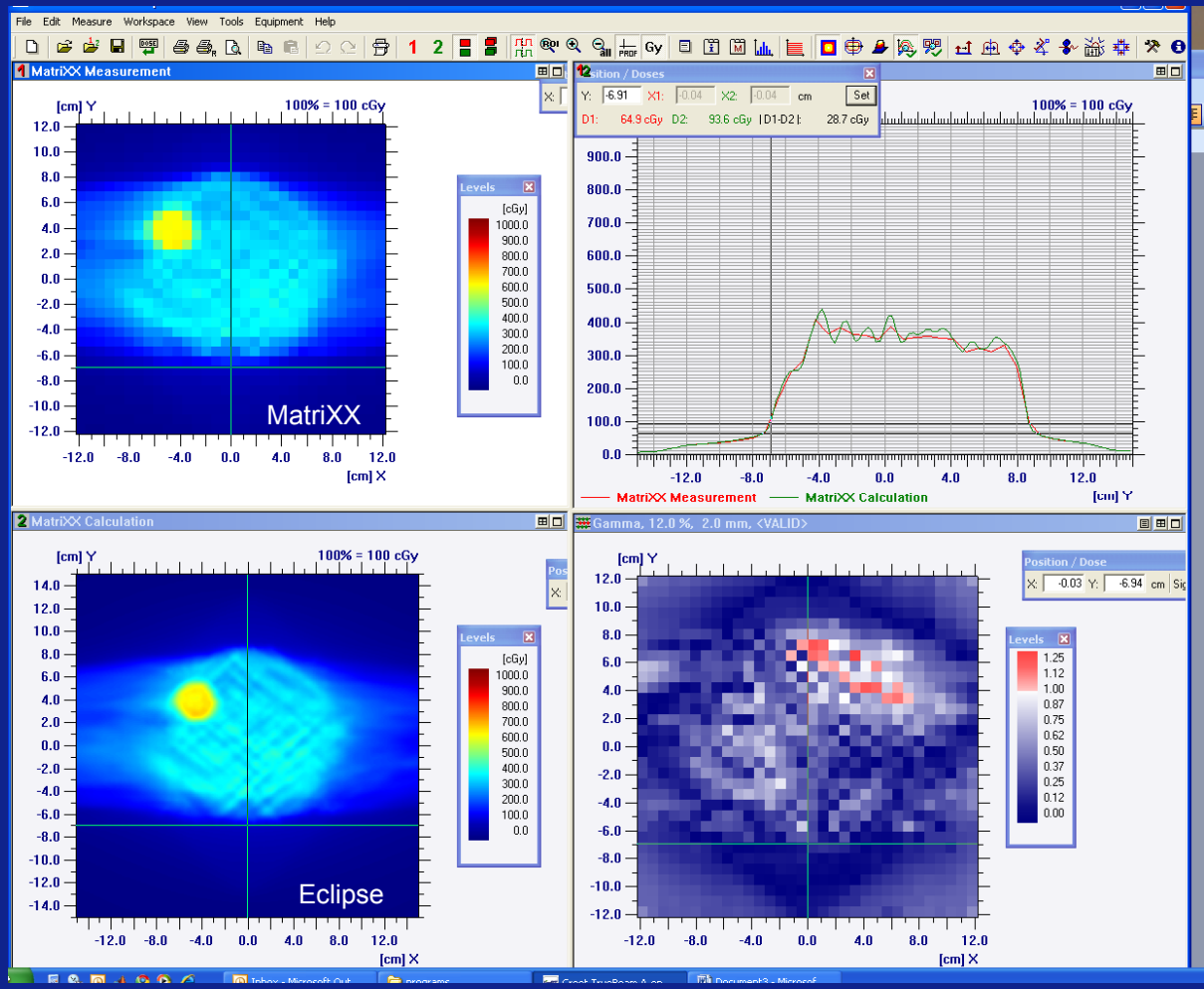
2D ≠ 3D

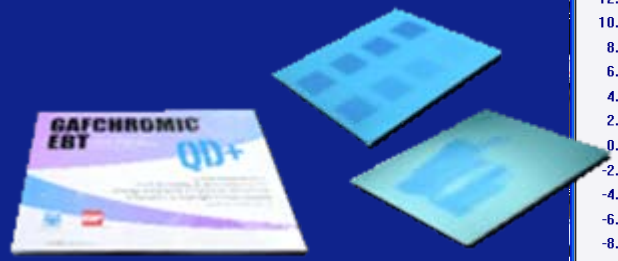


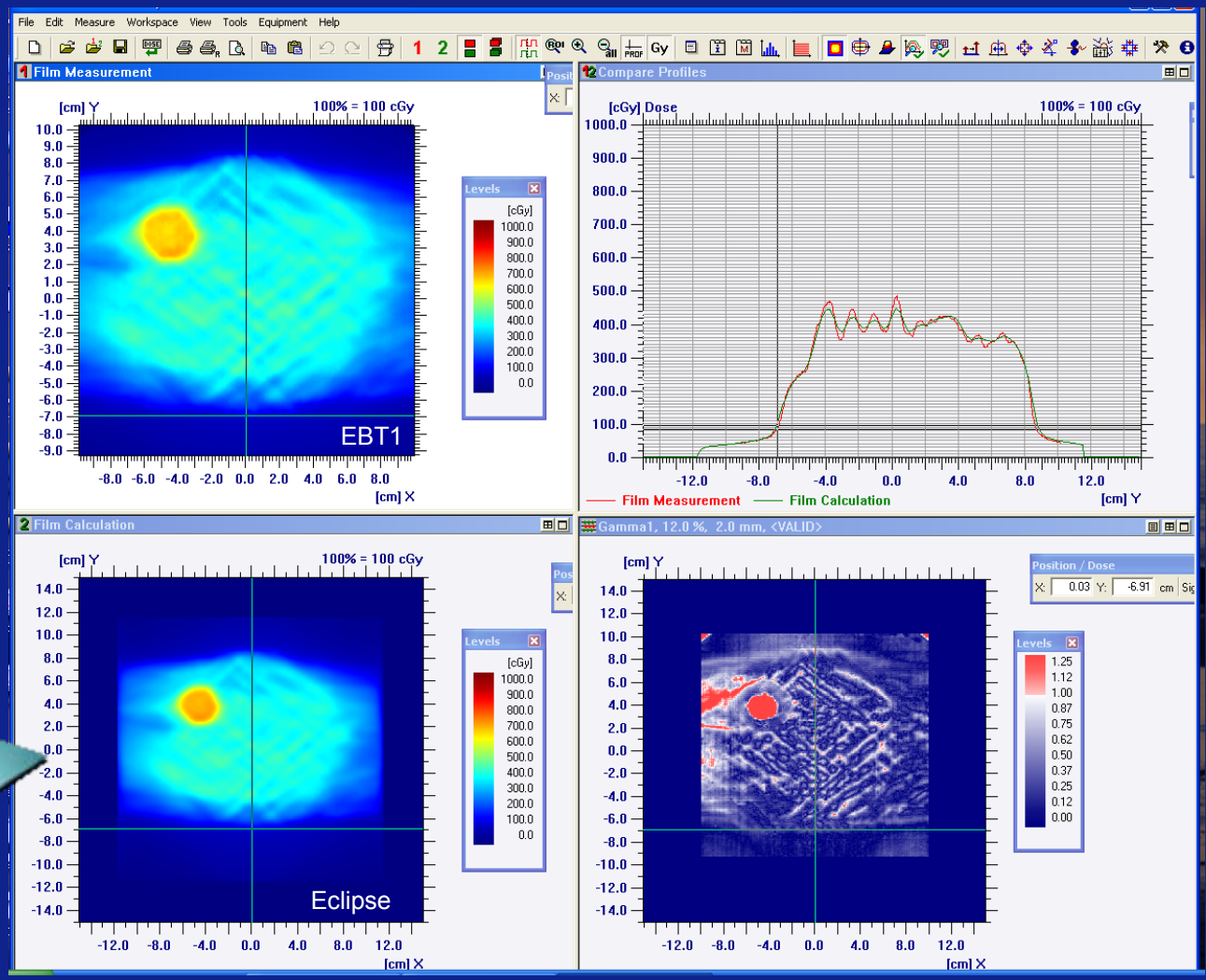
Relativity 1953 M.C. Escher

Observation: Eclips calculates higher intensity modulation

MatriXX in VUmc phantom







Films shows that accelerator produces higher intensity modulation than calculated

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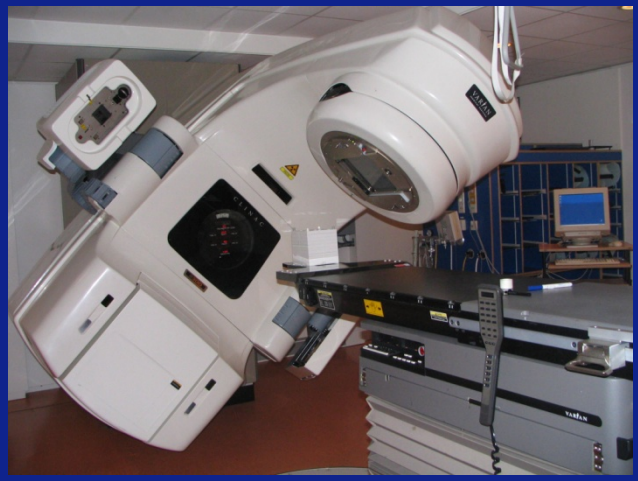
GafChromic Film Dosimetry at VUmc

VU medisch centrum



Van Battum et al Med.Phys 35(2) 2008
and Van Battum et al ESTRO poster 394 2009

VUmc

- Need for high resolution detector with 3% accuracy (1 SD)
  - Especially for commissioning, research, start-up RA, QA, …….
  - EBT1 not available anymore → EBT2 (2008)
  - Film workload too big for routine pre-treatment verification, but
    - method of choice for in-homogeneous phantoms (lung)
    - method of choice in Quasar phantom
    - On demand….
  - Routine RA-QA with MatriXX (10 – 15 patients starting per week)
  - About 10 RA patients with MatriXX; 1½ hr at linac
  - Need for fast QA with good resolution and accuracy

GafChromic filmdosimetry at VUmc

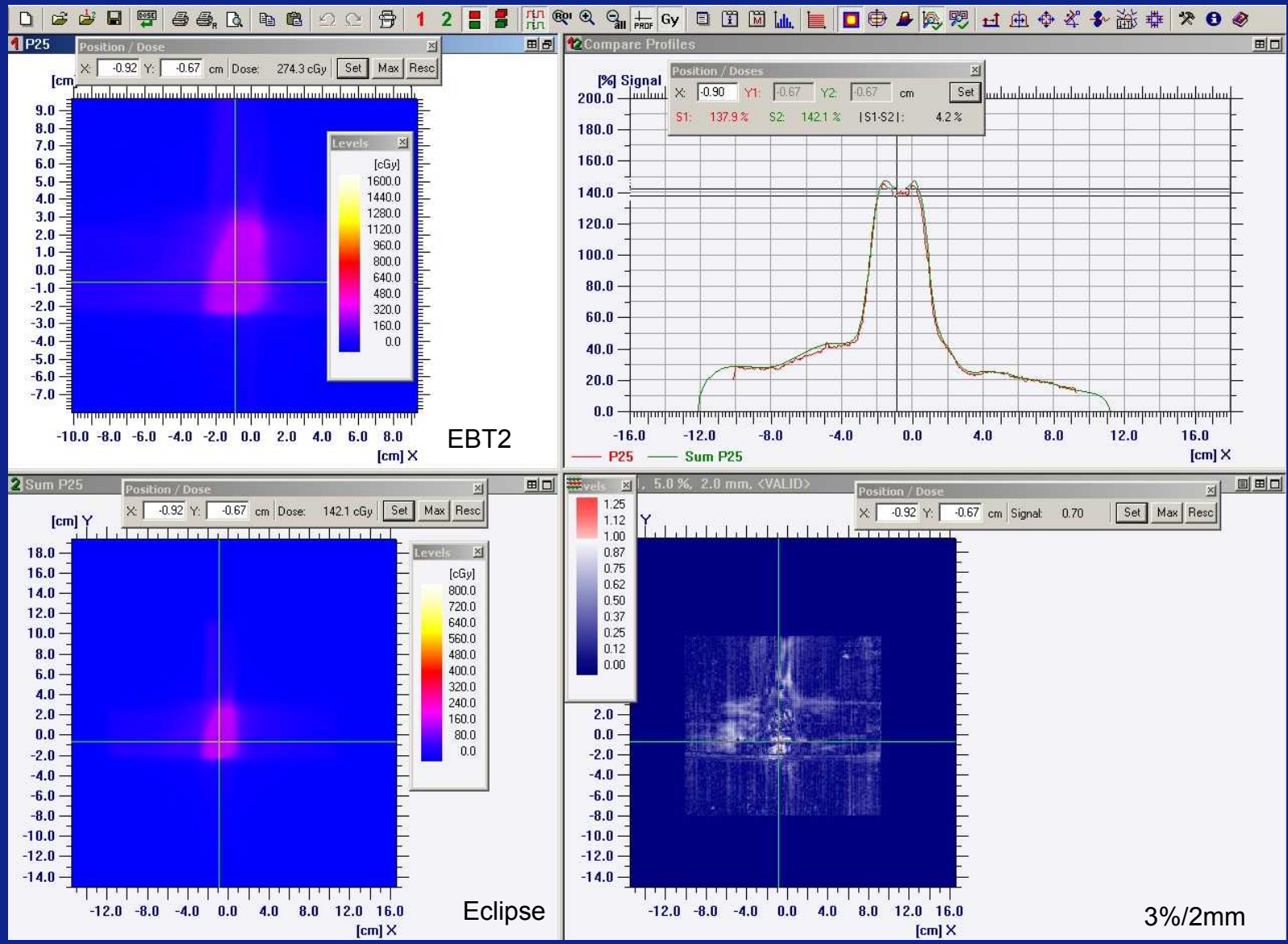
- Dose plane in absolute dose
- No extra ionization chamber measurement
- Average 2 films per dose plane (*Van Battum et al Med.Phys 35(2) 2008)*
- Each pre-treatment verification; 2 calibration films
- 'Step-shaped' calibration film
- Derive OD to dose information (with Matrixx data)
- Home made Matlab routine (GClab)

Double exposure technique;

- To improve accuracy of EBT2;
  - Scan un-irradiated film (red channel only)
  - Irradiate film with e.g. 100 MU
  - Scan film again
  - Irradiate pre-treatment plan
  - Final scan
- Corrects for local sensitivity variations !!!

Double Exposure technique: clinical example Oct. 2010 Truebeam

VU medisch centrum



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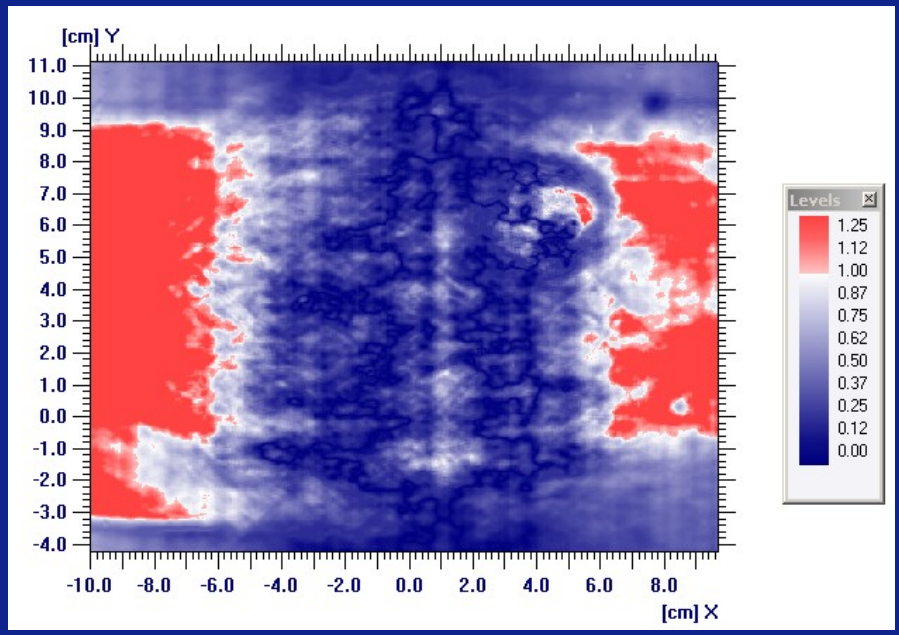
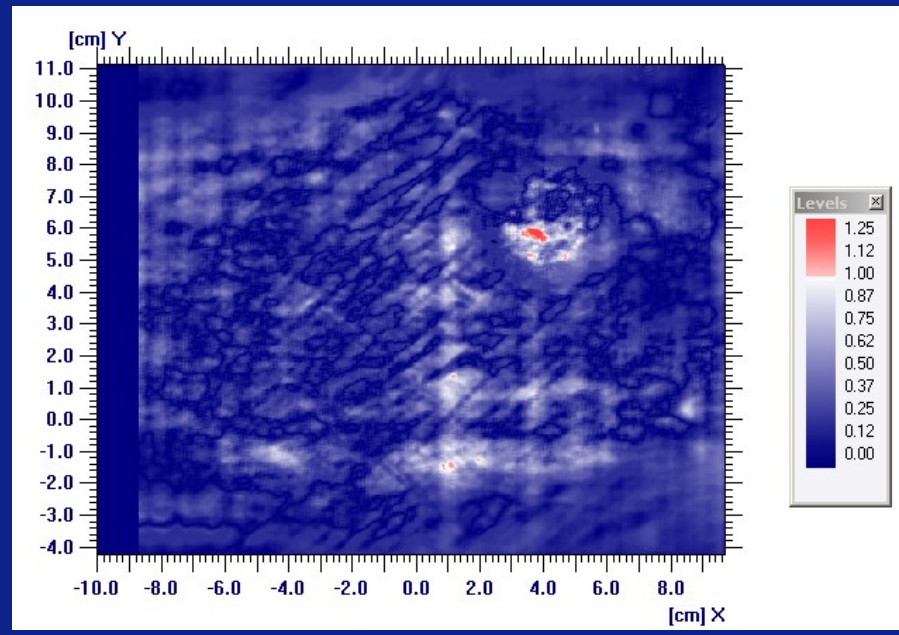
GCLab vs. FilmQA (LCCR)



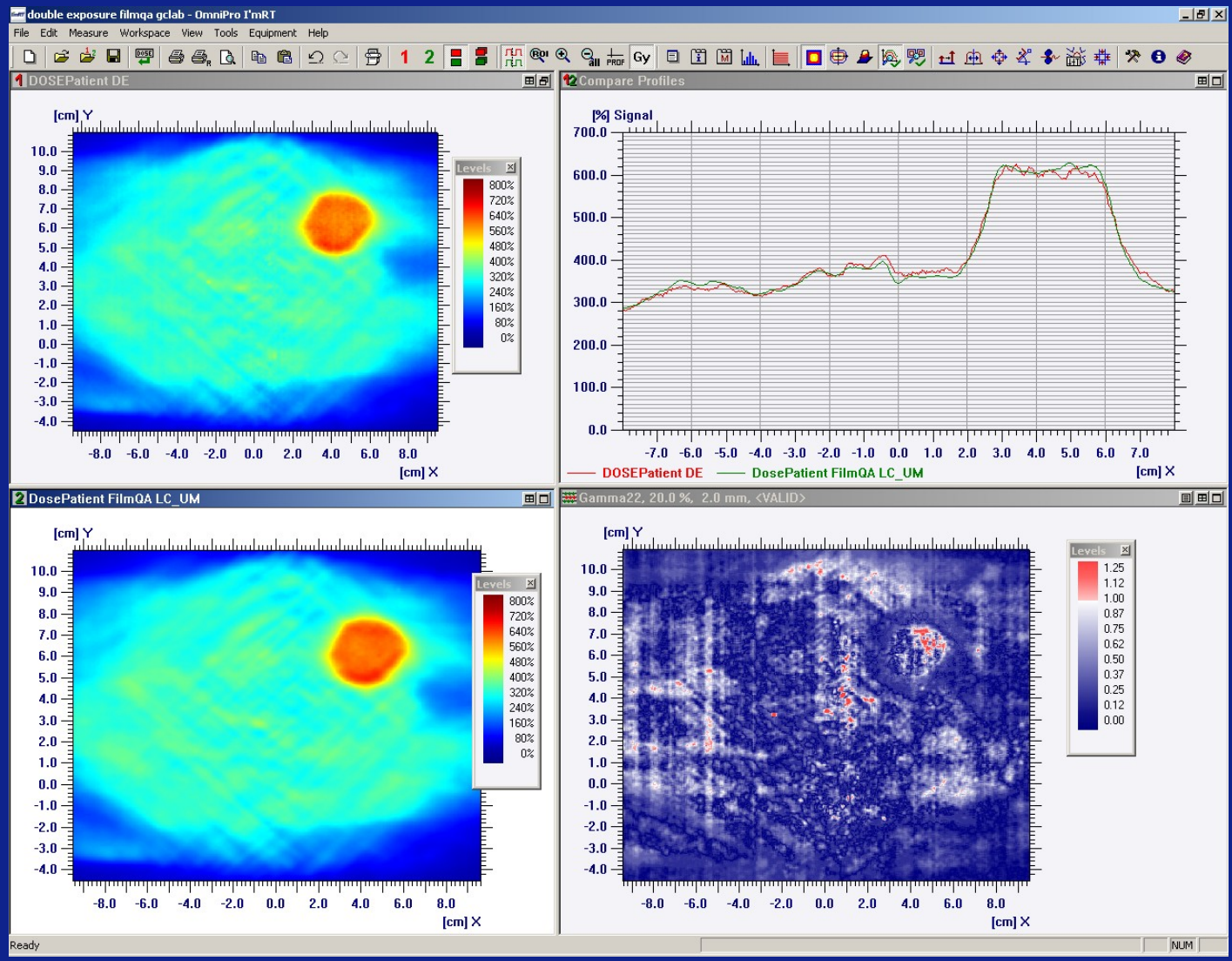
Gamma of GCLab vs. 'FilmQA lateral uncorrected'



Gamma of GCLab vs. FilmQA (LCCR) corrected

Gamma 3%, 2mm

EBT2
GCLab DE vs. FilmQA with lateral correction



Remarks for Double exposure

- Film dosimetry with Double exposure is;
  - Cumbersome
  - Only applicable for one or two patients a week (complex, SRS)
  - For routine QA we have to check 10-15 patients per week
  - Time available in accelerator is limited (<2 hrs per QA slot)
  - MatriXX information on Dose is OK (spatial resolution is poor)
  - Dose range EBT2 limited (<10Gy) (Green channel??)
  - How about absolute dose information????? (Future work)

Remarks of Matrixx

- Spatial resolution poor
- Gantry sensor (corrects for directional dependence)
- One single plane per patient *(central phantom)*

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Conclusions

- Rapid Arc accurately delivers the planned dose distr.
- Higher spatial dose modulation observed with film
- Eclipse calculates smoother dose distributions than measured
- Dosimetry verification with film preferred over MatriXX
- 2.5D gamma evaluation would give better agreement

- Pre-treatment verification
  - Discussion if every patient needs to be measured
  - If so, with what accuracy (detector)
  - Epid (Epiqa, Civco, home made?)
  - Risk analyses
  - Total QA program; ongoing process….

Conclusions

- Film dosimetry for spatial resolution!
- Local QA strategy
- Film-QA gives excellent agreement in comparison to Matlab
- Workload at VUmc limited
- For Varian users Film is a powerful tool
- Absolute dose information is important

Thank you for your attention

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