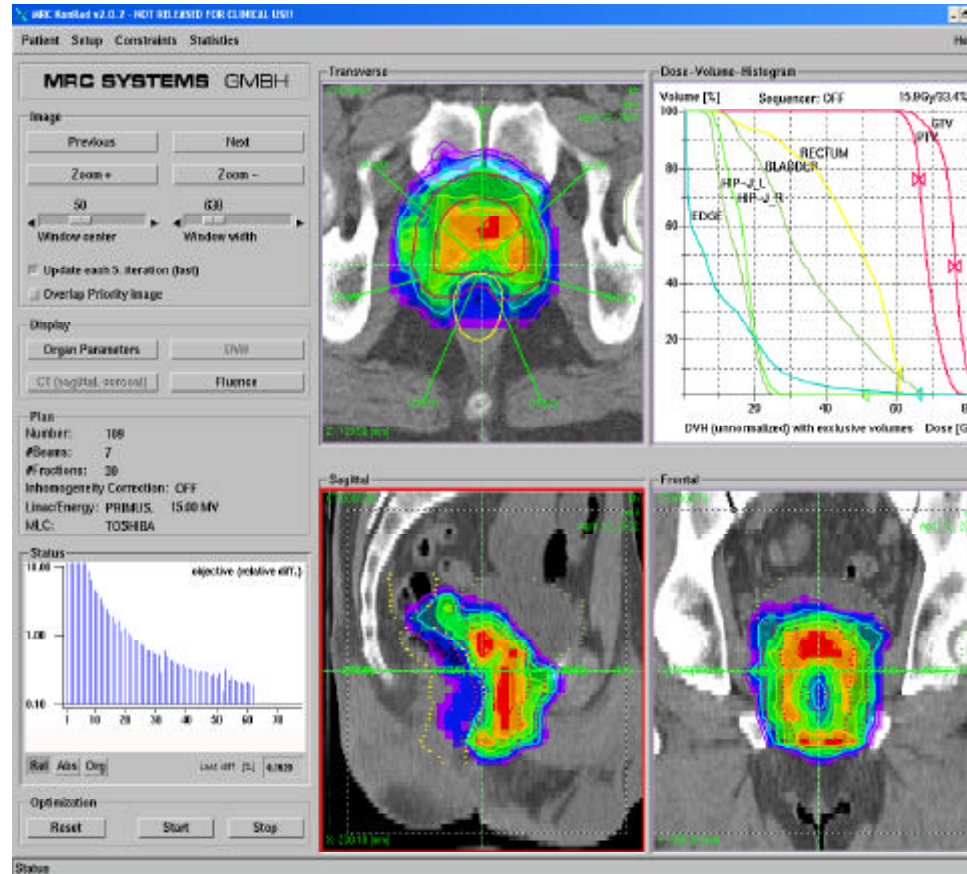




IMRT in der klinischen Anwendung Aktueller Stand und Fragen bzgl. QA und Verifikation



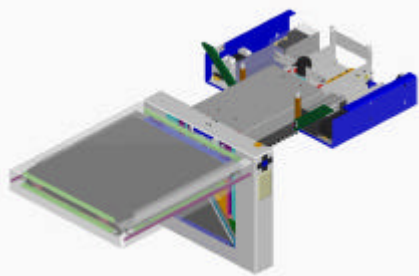
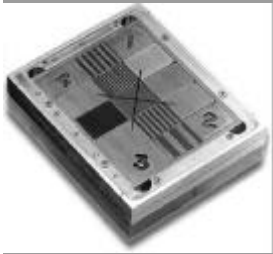
Ulrich Schaller
Oncology Care Systems



COHERENCE Physics Workspace + **WIP** +

Four main tabs will be there:

- Plan review
- Dosimetry Data
Conditioner
- Patient QA
- Machine QA





Patient QA: Independent MU calculation

Parameters	Beam1	Beam2
Beam Number	1001	1002
Treatment Machine	PrimusARoomA	PrimusARoomA
Energy(MV)	6.00	6.00
Collimator Length(mm)	200.00	200.00
Collimator Width(mm)	200.00	200.00
SSD(mm)	900.00	900.00
Depth(mm)	20.00	20.00
Off Axis Distance(mm)	0.00	0.00
Tray Factor(TF)	1.00	1.00
Wedge Factor(WF)	1.00	1.00
% Blocked	10.00	10.00
Bolus Factor	0.00	0.00
Other Factor	1.00	1.00
Prescribed Isodose Line(RxIDL%)	100.00	100.00
FieldDose (MU)	25.00	25.00
SAD(mm)=SSD + Depth	1000.00	1000.00
Equivalent Square Col.	20.00	20.00
Collimator Output Factor(COF)	1.03	1.03
Equivalent Square Field	18.57	18.57
Piston Scatter Factor(PSF)	1.02	1.02
Tissue Max. Ratio	1.00	1.00
TSF = COF x PSF	1.05	1.05
INVSQ = [SCD/SAD] ²	1.03	1.03
Off-Axis Factor, OAF	1.00	1.00
Total Dose Per MU(GY/MU)	1.04	1.04
Planned MU(MU)	40.00	45.00
Calculated Monitor Unit(MU)	23.16	23.16
Percent Error	42.10	48.54
Error Below tolerance?	No	No

Machine Name	PrimusARoomA				
Energy (MV)	6.00				
Depth\ Off-Axis Dist.	0	1	2	3	4
1.5	1.000	1.003	1.007	1.015	
2.5	1.000	1.003	1.006	1.014	
5.0	1.000	1.001	1.006	1.012	
10.0	1.000	1.000	1.004	1.008	
15.0	1.000	1.000	1.003	1.007	
20.0	1.000	0.997	0.997	0.991	

Machine Name: PrimusARoomA
Energy (MV): 6.00

Depth\ Off-Axis Dist. 0 1 2 3 4

1.5 1.000 1.003 1.007 1.015
2.5 1.000 1.003 1.006 1.014
5.0 1.000 1.001 1.006 1.012
10.0 1.000 1.000 1.004 1.008
15.0 1.000 1.000 1.003 1.007
20.0 1.000 0.997 0.997 0.991

Analysis Machine
MC: PrimusARoomA
Energy (MV): 6

OAR TMR wedge factor
tray factor

Approval Status:
 Approve Unapprove Reject

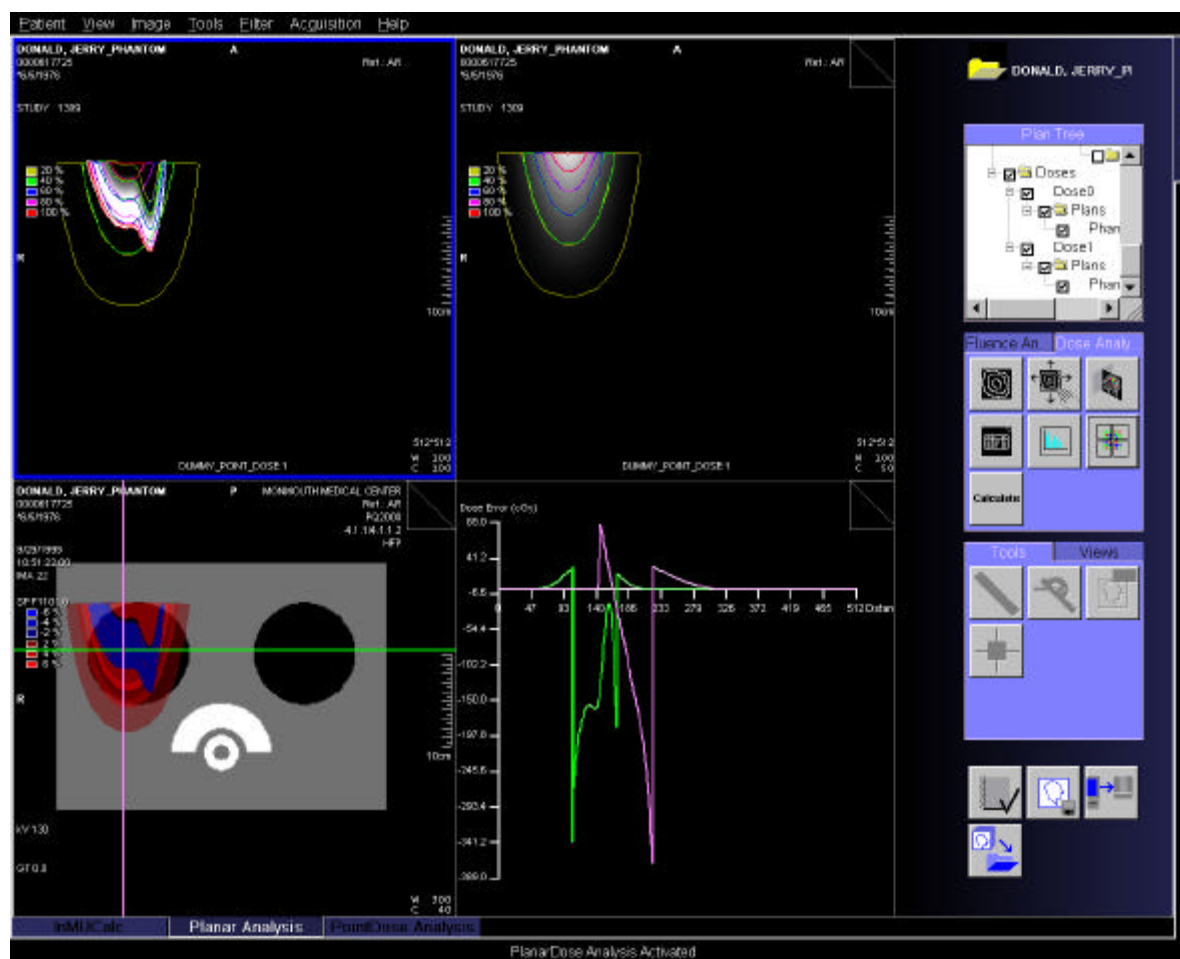
Review Date (mm/dd/yy) _____
Review Time (hh:mm:ss) _____
Reviewer Name _____
Remarks _____

OK Cancel Help

InMUCalc Planar Analysis PointDose Analysis
InMUCalc Activated

**Sub Tab: Planar Analysis, full IMRT in a phantom.**

- Compares Calculated at the RTP isodoses in a plan for the phantom IMRT plan against delivered doses in the phantom.
- Superimposes the error map on the phantom images
- Generates profiles of errors and also histogram





Functional Requirements



Specifications

Accuracy

- penumbra and transmission
- accurate beam projection
- conformality
- clinical resolution and complex shaping
- fast and accurate modulation

Efficiency

- automated shaping
- economy on resources
- economy on material costs
- reduce treatment time
- increase patient clearance
- Number of treatment fields
- Dose escalation (same treatment time)
- Automation, Integration, Control

Universality

- applicable to most clinical sites

Safety

- Any leaf position shall be verifiable

leaf travel motion

leaf edge design

collimator to skin distance

leakage through body of leaf

leakage between adjacent leaves

leakage between opposed leaf ends

tracking with backup jaws

optical vs. radiation coincidence (spec)

physical resolution

clinical resolution

Interdigitation

leaf positioning speed (spec)

leaf monitoring method

leaf positioning accuracy (spec)

calibration method

fractional MU control

Integration between Dose and MLC

motor control

Automated Field Sequencing

clearance spec

Control System Integration

Master / Slave relationship

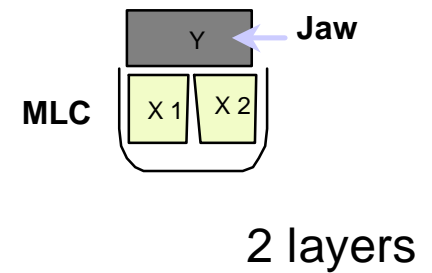
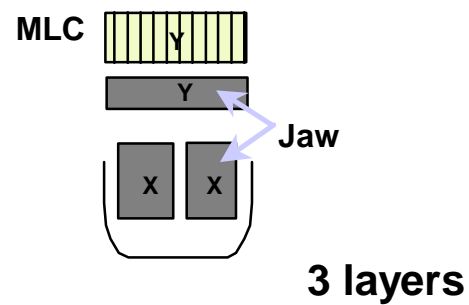
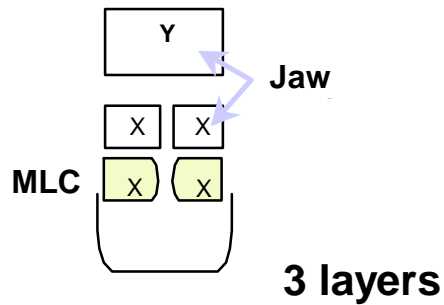
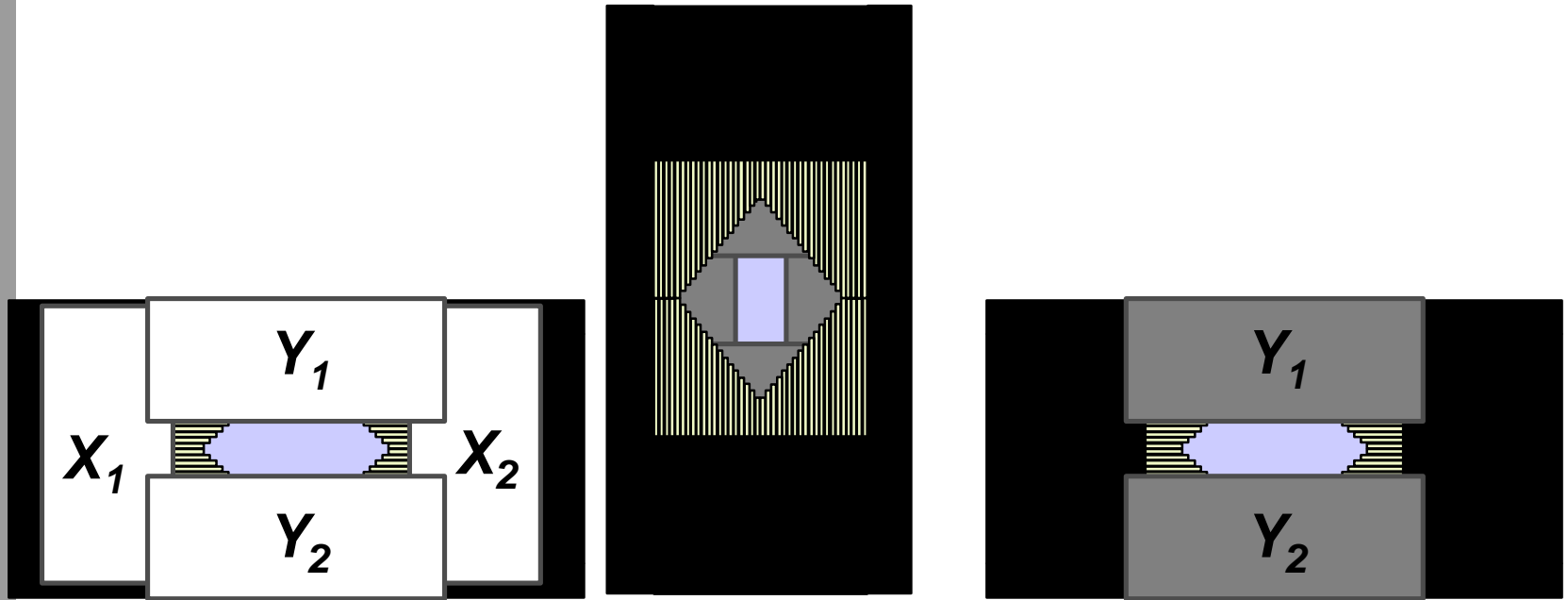
Maximum field size

max leaf to leaf separation



MLC Collimators

Important differences between manufacturers

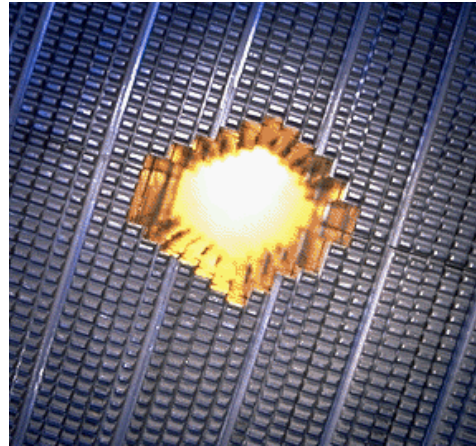


Varian

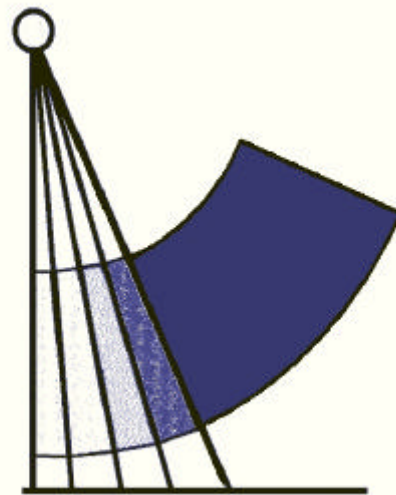
Elekta

Siemens





SOURCE



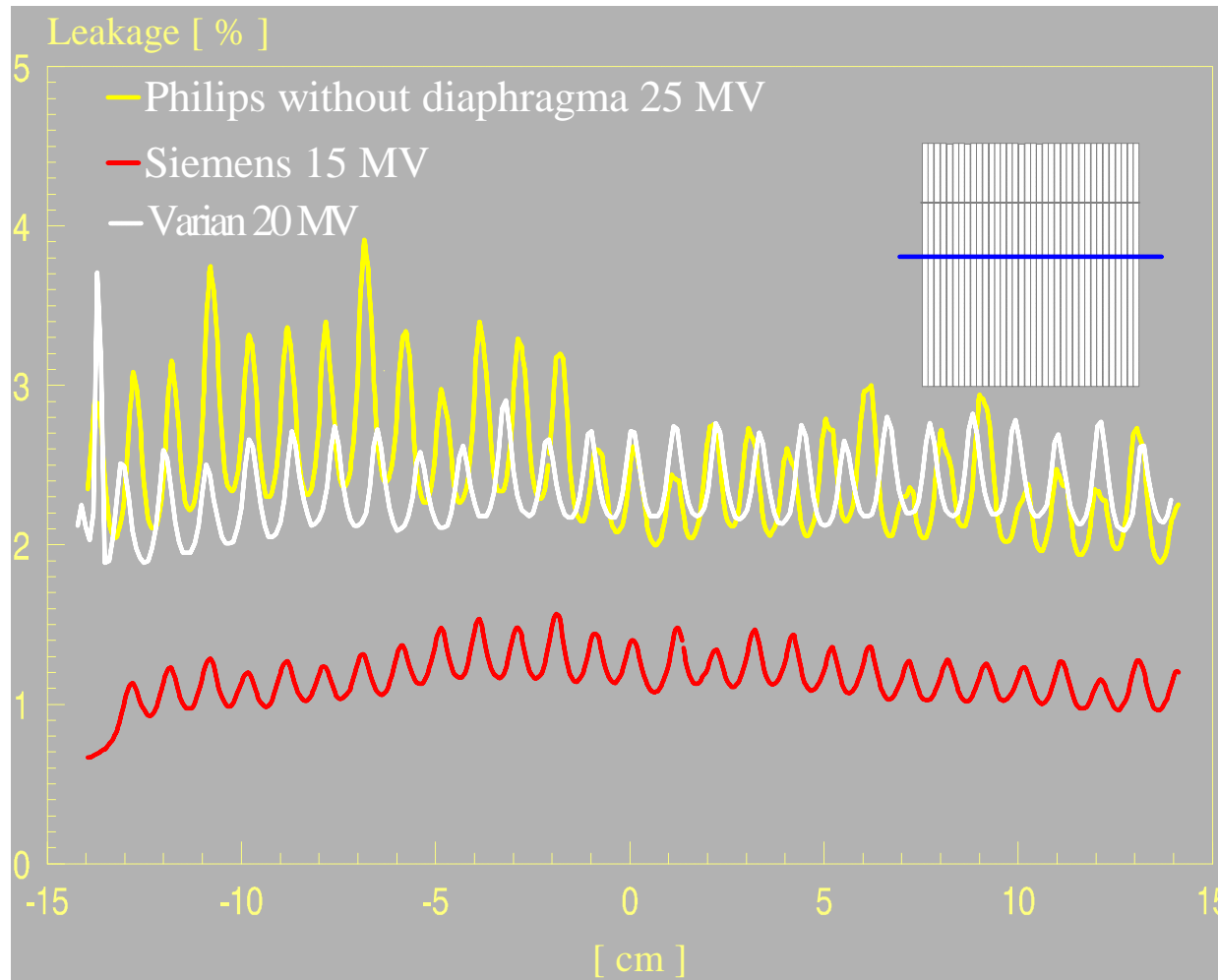
Siemens

- Double focused (Conic geometry)
- Lower leakage
- Minimized penumbra independent of leaf position
- Flat edges (no rounded edges)
- No gap between closed leaves





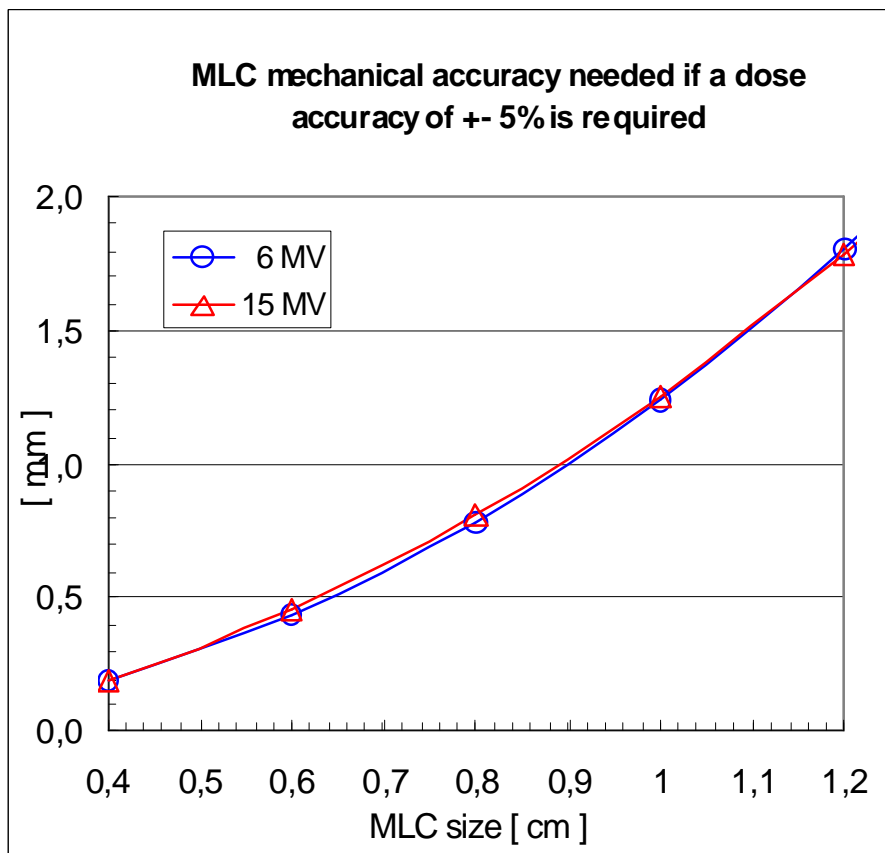
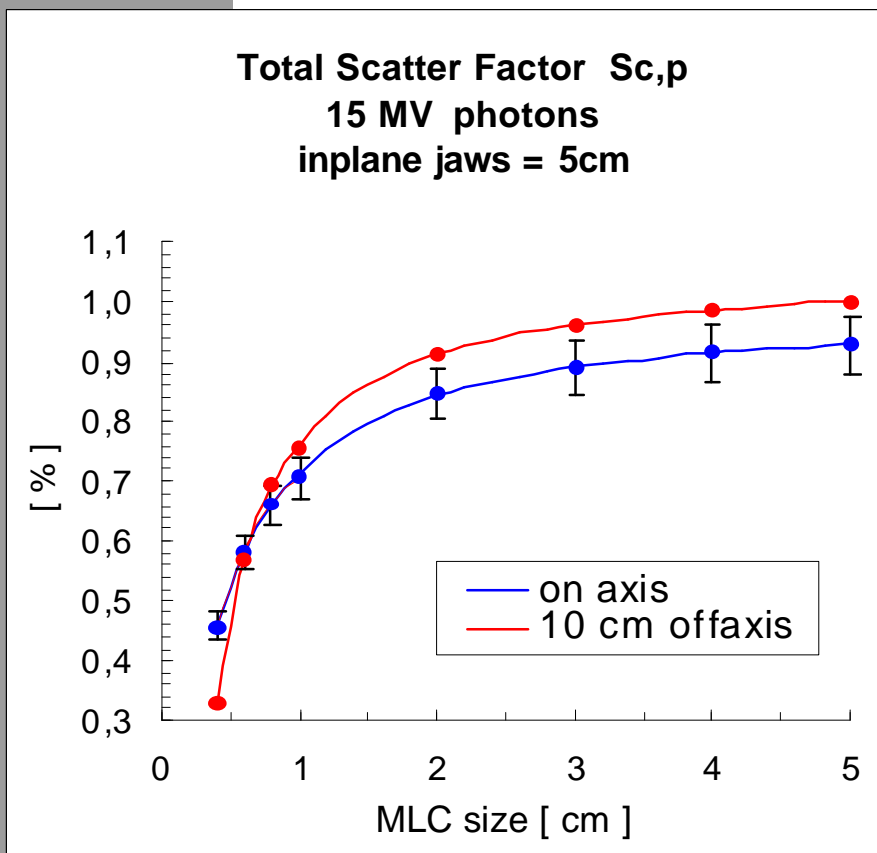
MLC leakage





IMRT

Accuracy requirements for MLC positioning DKFZ Heidelberg - 2002



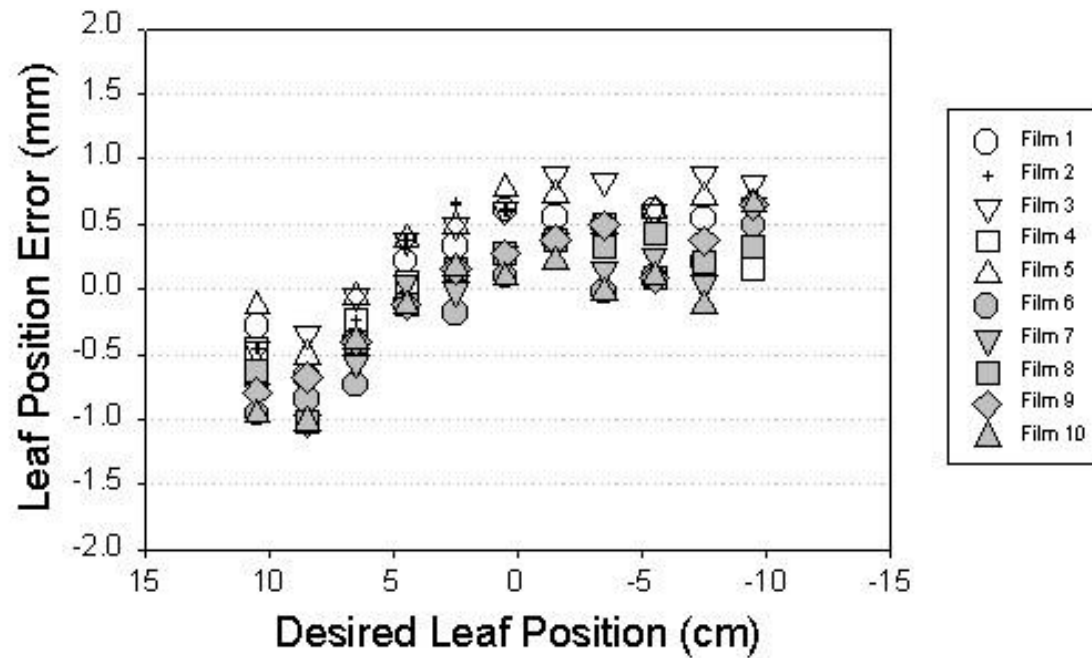


Calibrating the Siemens Primus MLC

Leaf Position Error As Leaf Moves Across Field

Leaf Motion:
Film 1-5, X1 towards X2
Film 6-10, X2 towards X1

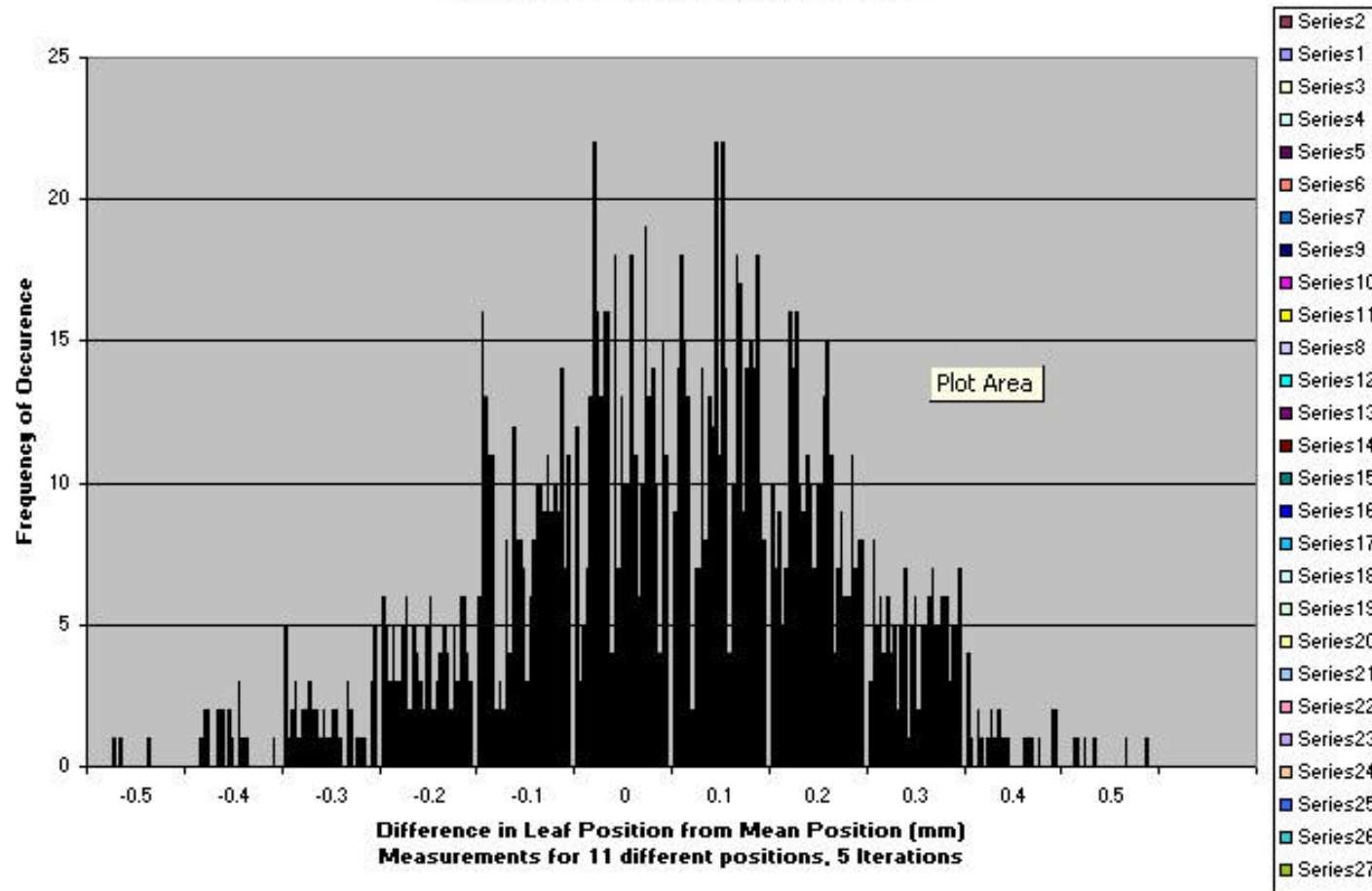
Leaf X1.2





Calibrating the Siemens Primus MLC

Reproducibility of Leaf Position, Bank X1



Courtesy of Dr. Bayouth,
UTMB



EPAC Tool

- + 4-point calibration
- + Speed calibration

Purchase in combination with MLC training



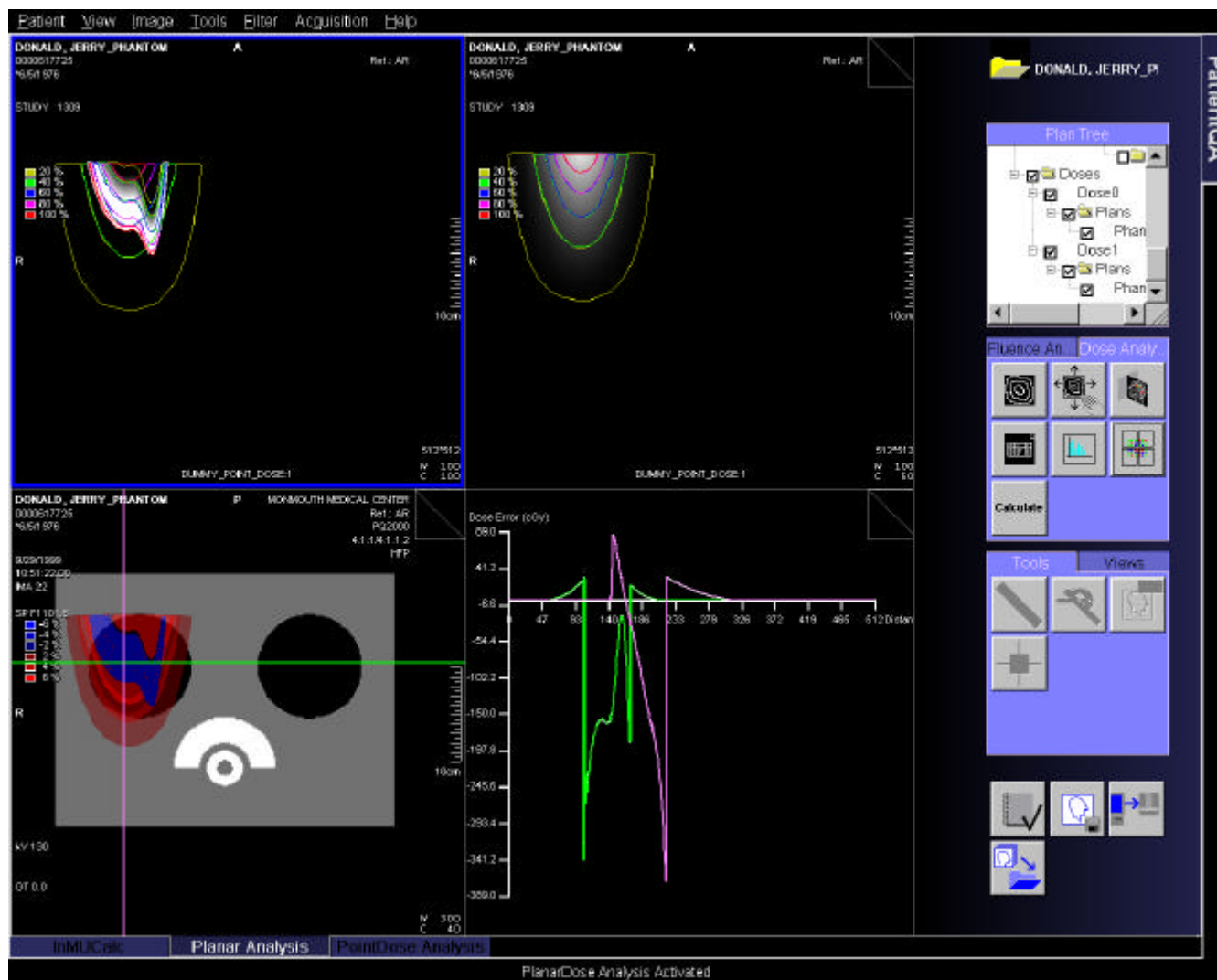
MLC QA – Physics Workspace, WIP

The screenshot displays the MachineQA software interface for MLC QA. It features a grid of MLC positions, a line graph showing error (mm) versus leaf number for MLC #1 and MLC #2, and a data table summarizing the results. The software interface includes various toolbars and a sidebar with navigation options like Plan, Display, Acquire, and MLC.

MLC #1				MLC #2			
Leaf#	Avg Error (mm)	Min Error (mm)	Max Error (mm)	Leaf#	Avg Error (mm)	Min Error (mm)	Max Error (mm)
1	1.3	0.0	3.0	1	6.7	4.0	7.0
2	2.5	0.0	5.0	2	7.7	6.0	10.0
3	2.0	0.0	4.0	3	7.3	6.0	9.0
4	2.0	0.0	4.0	4	7.0	5.0	9.0
5	1.3	0.0	3.0	5	7.3	6.0	9.0
6	1.7	0.0	3.0	6	7.0	6.0	8.0
7	1.3	0.0	3.0	7	7.0	6.0	8.0
8	1.3	0.0	3.0	8	7.3	6.0	9.0
9	1.0	0.0	2.0	9	7.0	6.0	8.0
10	1.0	0.0	2.0	10	7.3	6.0	9.0
11	1.0	0.0	2.0	11	8.0	6.0	11.0
12	0.7	0.0	1.0	12	8.7	8.0	10.0
13	0.7	0.0	1.0	13	8.7	8.0	10.0
14	1.0	0.0	2.0	14	8.7	8.0	10.0
15	1.0	0.0	2.0	15	8.7	8.0	10.0
16	0.7	0.0	1.0	16	8.3	7.0	10.0
17	0.7	0.0	1.0	17	8.3	7.0	10.0
18	0.7	0.0	1.0	18	8.3	7.0	10.0
19	0.7	0.0	1.0	19	8.7	7.0	10.0
20	1.0	0.0	2.0	20	8.0	6.0	10.0
21	1.0	0.0	2.0	21	8.3	7.0	10.0
22	1.0	0.0	2.0	22	8.0	7.0	9.0
23	1.0	0.0	2.0	23	8.0	6.0	10.0
24	0.7	0.0	1.0	24	8.0	7.0	9.0
25	0.7	0.0	1.0	25	7.7	7.0	8.0
26	0.7	0.0	1.0	26	8.3	7.0	10.0
27	1.0	0.0	2.0	27	8.0	6.0	10.0
28	1.0	0.0	2.0	28	7.7	6.0	9.0
29	1.3	0.0	3.0	29	8.0	6.0	10.0



Planar Analysis, full IMRT in a phantom, Physics Workspace, WIP





• OPTIFOCUS MLC

- 82 Leaf-MLC
- 1cm width, isocenter
- **Accuracy +/-1mm**
- Auto-Initialization and Autocalibration
- Full field, low leakage collimation
- Higher positional accuracy
- Enabler for IMRT

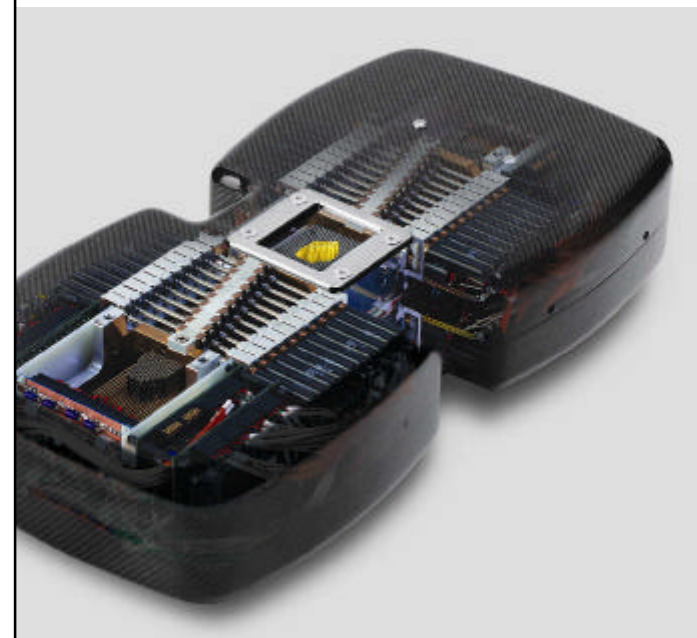




Siemens Medical
Solutions that help

ModuLeaf: optimized for IMRT

- number of leaf pairs 40
- leaf width* 2,5 mm
- max. field size* 10x12 cm²
- max. overtravel* 5,5 cm
- Max. leaf speed 2 cm/sec
- **Positioning accuracy 0,5 mm**
- Leaf design focusing
- penumbra (80/20%) 3 mm
- mean/max. leakage 1-1,5%/ 2,5%
- Automatic „step and shoot“ IMRT
- weight 40 kg (88lb)



Siemens Medical
Solutions that help

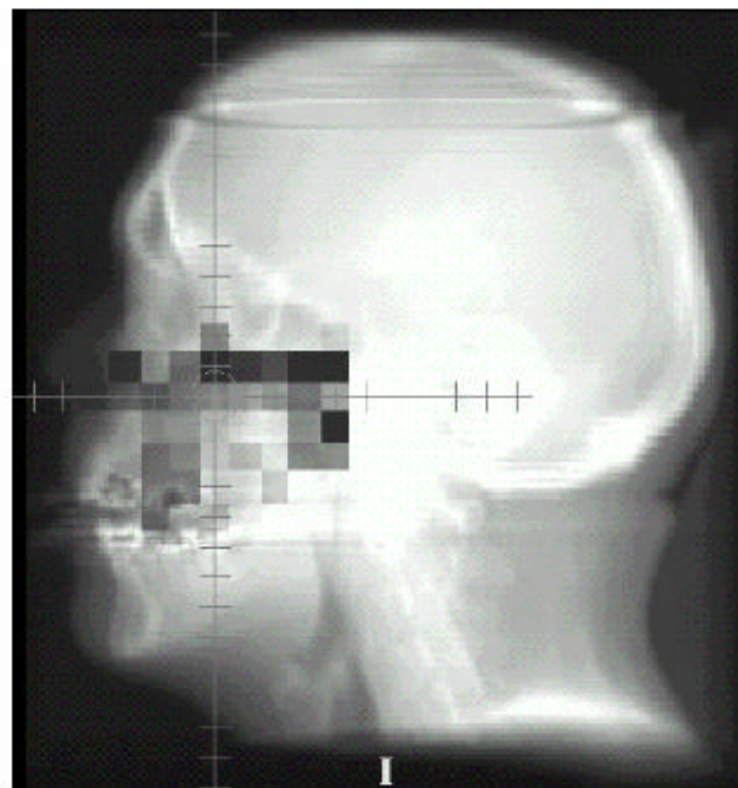
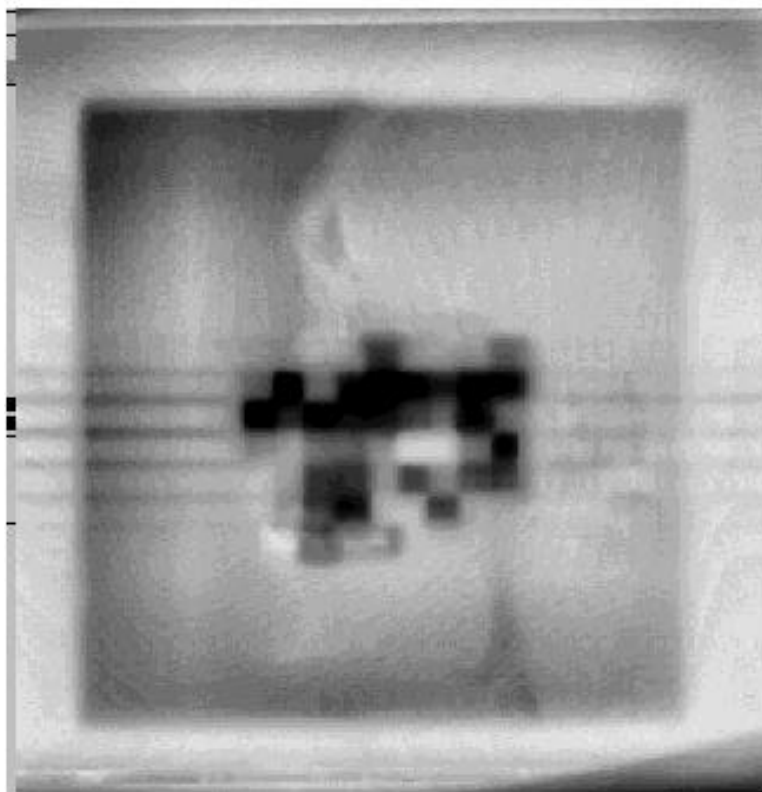


Dose Grid Associated OK
Dose Calculation 100% Done, Status OK
Dose Display Ongoing, Please Wait ... 33%



IMRT Intensity Map Test

- Visualization of intensity map correlated to the map superimposed on the DRR from planning system
- Checking the beamlets by intensity comparison





QA process

		Dynamic Sliding	Cinematic Siemens
Phantom QA Patient plan	Segment by Segment	not possible	possible
	Field by Field	possible	possible
	Total plan	possible	possible
Machine QA Dose MLC	Linearity low MU	Important	Important (good)
	Dose Rate	Critical	Not relevant
	Symmetry and Flatness	Important	Important (good)
	Leaves accuracy	Important	Important
	Leaves speed	Critical	Not relevant
	Leaves acceleration	Critical	Not relevant
	Carriage	Important	Not
	Carriage sag	Important	Not





S

DGMP AK IMRT Wü.20-02-04

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Siemens Medical Solutions that help

Siemens Medical
Solutions that help

The Continuum of Oncology Care