

# DIAMOND™ Product Overview

**DGMP AK IMRT, Hamburg 12.04.2013**

**Marc Damrau**  
Produktspezialist  
und Int. Vertrieb



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- 2 DIAMOND Basics
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- 4 Additional Features
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- 6 DIAMOND Installation
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# General Information

# Recommendations for Plan Verification

## AAPM TG114 Verification of MU calculations for non IMRT clinical RT

- First, a calculation program and/or methodology that is separate from that of the primary calculation should be used.
- Second, the beam data and treatment parameter files should be separate and independent of those used by the primary TPS

## DIN 6875-3 Spezielle Bestrahlungseinrichtungen, Teil 3: Fluenzmodulierte Strahlentherapie

- Wird eine dosimetrische Prüfung des Bestrahlungsplans nicht durchgeführt, so ist in jedem Fall eine vom Bestrahlungsplanungssystem unabhängige rechnerische Prüfung der DOSISMONITORWERTE jedes FLUENZMODULIERTEN STRAHLENFELDES durchzuführen.

## IAEA TRS 430

- Nearly 60% of the reported errors involved a lack of an appropriate independent secondary check of the treatment plan or dose calculation.

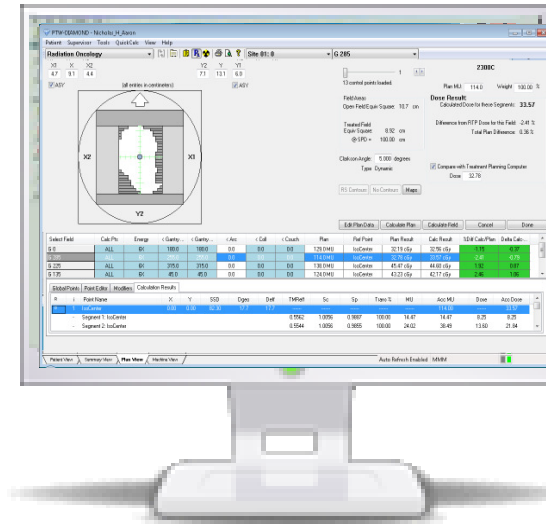
# PTW tools for verification

Verification by measurement...

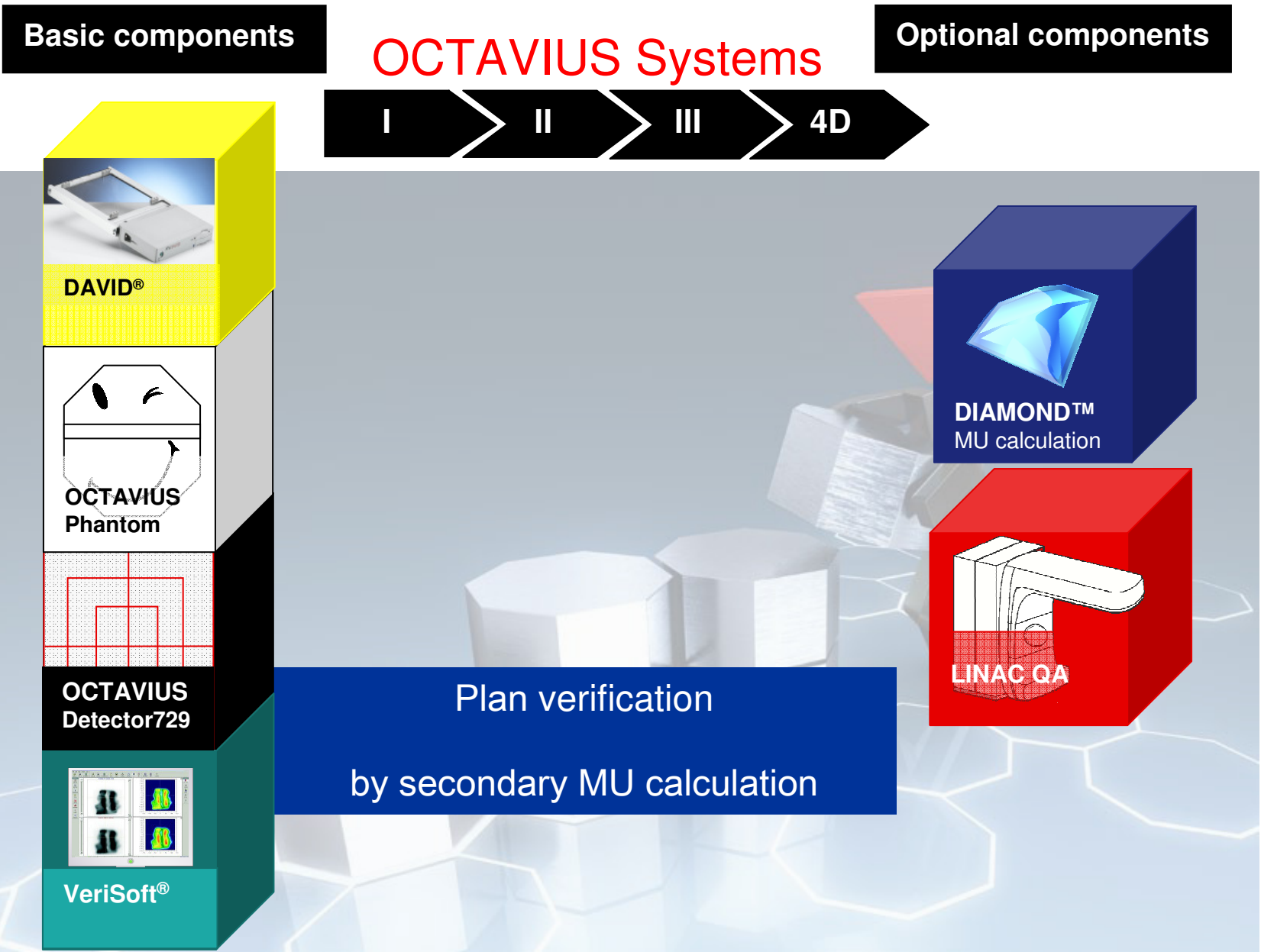
...or Secondary calculation



**OCTAVIUS I – 4D**



**DIAMOND MU Calculation**



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**DIAMOND Basics**

## DIAMOND Software ...

- ▶ does an independent calculation of dose / MU settings
- ▶ uses a set of independent measurements
- ▶ helps finding errors before a plan is approved for treatment
- ▶ is an easy-to-use tool in the daily QA process
- ▶ saves measurement time at the treatment unit



# What is DIAMOND?

DIAMOND is ...

- ▶ a point dose calculation software
- ▶ an independent secondary check of treatment plans without linac time



## TPS Plan

*Plan creation*

*Dose points included*

DICOM Transfer



## DIAMOND

*Plan verification by*

*independent calculation*

Compares  
single points

# What does DIAMOND do?

## DIAMOND does ...

- ▶ MU calculation for single points
- ▶ Dose or MU comparison for single points

$$MU = \frac{D_{Rx} * \left(\frac{Wt}{100}\right)}{\left[TPR_{EFF}(d, r_d) * S_P * Sc(J_{XY}, MLC, r) * WF(d, f) * OAWR(X_{offaxis}, Y_{offaxis}) * MF * TF * Cal(d) * R_{ref} * P\right]}$$

- $D_{Rx}$  - prescription dose per fraction
- $TPR_{EFF}(d, r_d)$  = Tissue Phantom Ratio from Clarkson (includes POAR)
- $WF(d, f)$  = wedge factor
- $MF$  = modifier factor
- $OAWR(X_{offaxis}, Y_{offaxis})$  = off axis wedge ratio
- $TF$  = tray factor
- $S_P$  = phantom scatter factor based on treated field eq.sq.
- $Sc(J_{XY}, MLC, r)$  = points-eye Sc integration (includes collimator exchange)
- $Cal(d)$  = calibration correction to distance
- $Wt$  = field weighting in percent
- $R_{ref}$  = reference field calibration
- $P$  = penumbra correction (jaw, block or MLC)

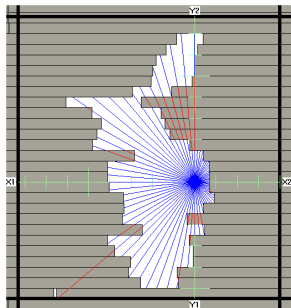
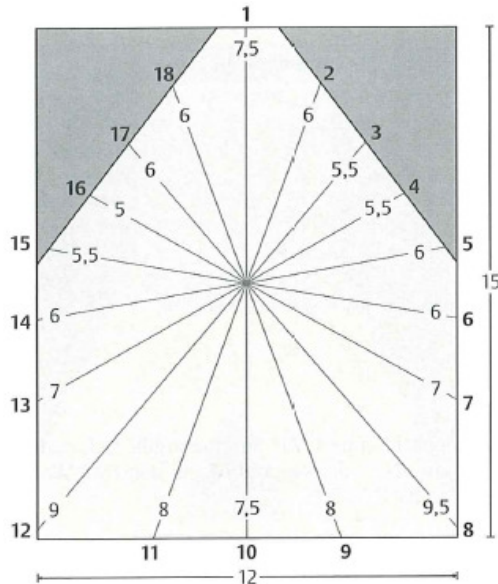
### Planned values

**DIAMOND calculation based on**  
 - independent base data  
 - geometrical plan parameters

**DIAMOND calculation based on**  
 proprietary algorithms

## The Clarkson Integration

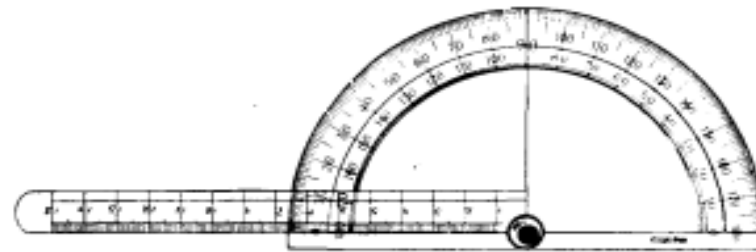
Clarkson's method for dose calculation separates the primary component and integrates the scatter component of the radiation dose to a point.



*J. R. Clarkson*

The combined protractor and steel rule used for radium calculations<sup>4</sup> is admirably suited to these measurements if modified by placing the rule in the position of Fig. 4. Placing the pin at *O* on a diagram of the area, *r* may be measured quickly and accurately for any value of  $\omega$ .

It may be noted that as it is unusual to have measured values of depth doses for areas greater



A NOTE ON DEPTH DOSES IN FIELDS OF IRREGULAR SHAPE

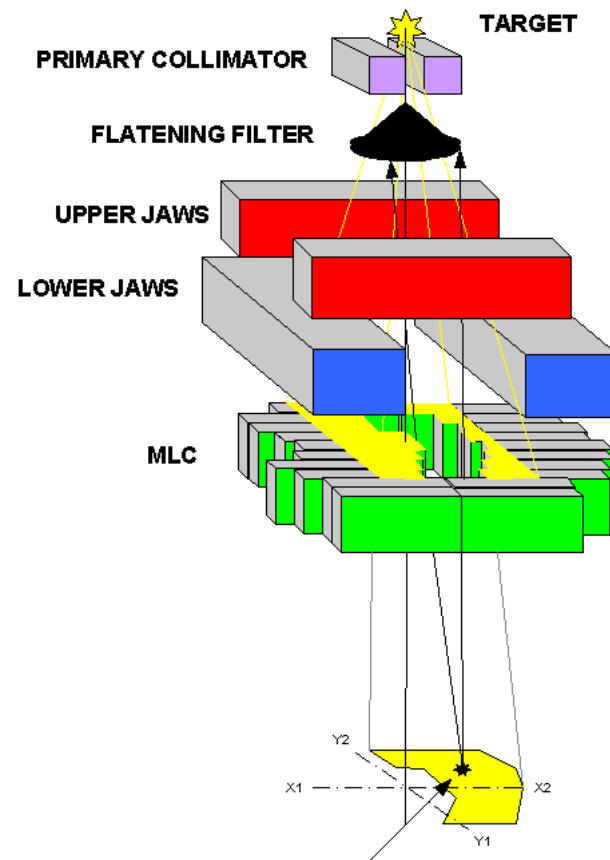
By J. R. CLARKSON, Ph.D.  
Physics Department, Royal Cancer Hospital (Free), London, S.W.3.

**DIAMOND** does the calculation automatically for each segment in IMRT fields

## Points-Eye-View Head Scatter Integration

The “points-eye-view” integration takes into account the point’s view of the source and the flattening filter modified by the windowing effect of the MLC position using measured collimator scatter.

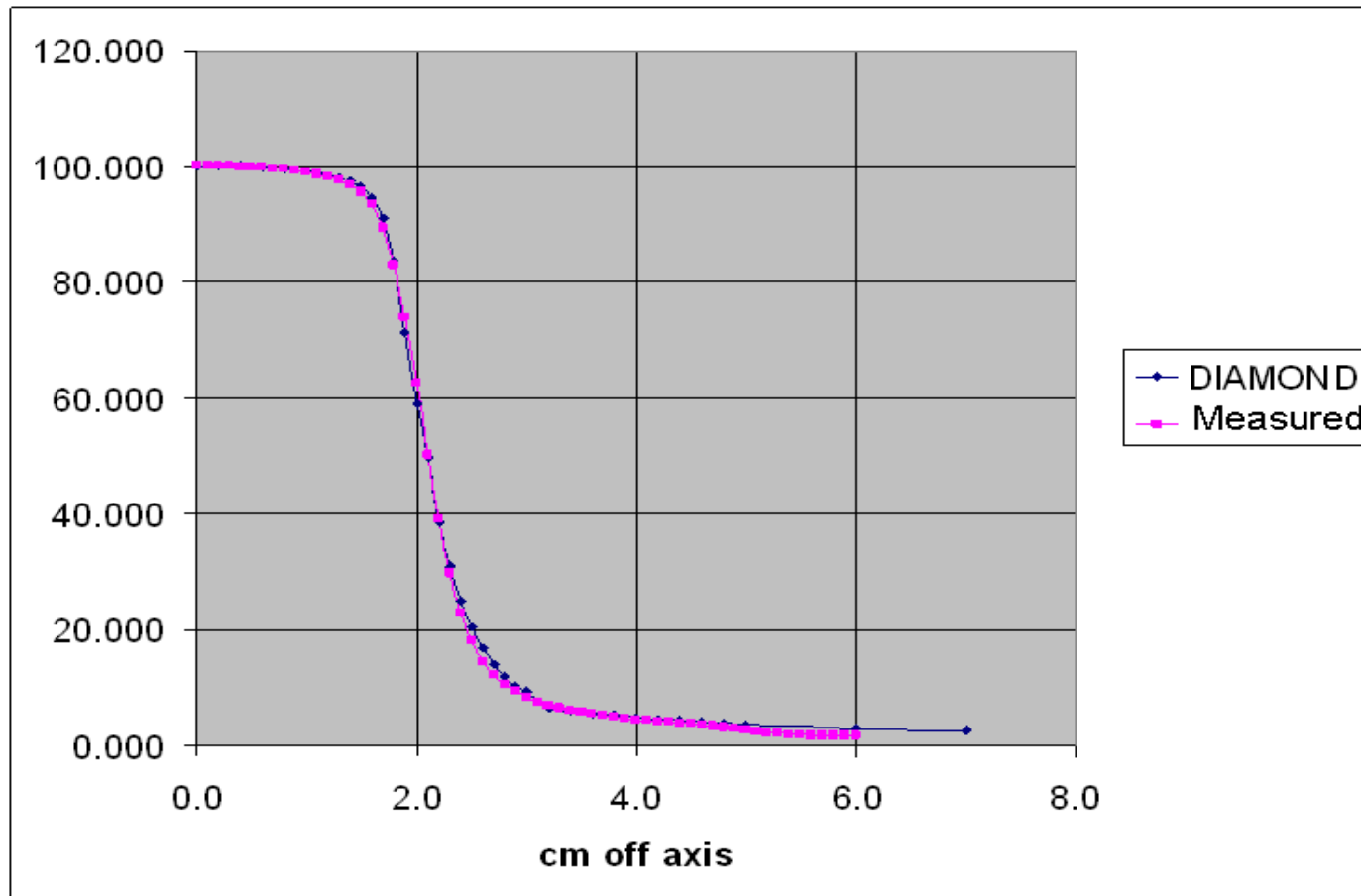
### Points-Eye-View Integration



Points-Eye-View of Flattening filter

### MLC Acu-Trac Model

Proprietary MLC profile model that allows precise tracking of the measured MLC profile



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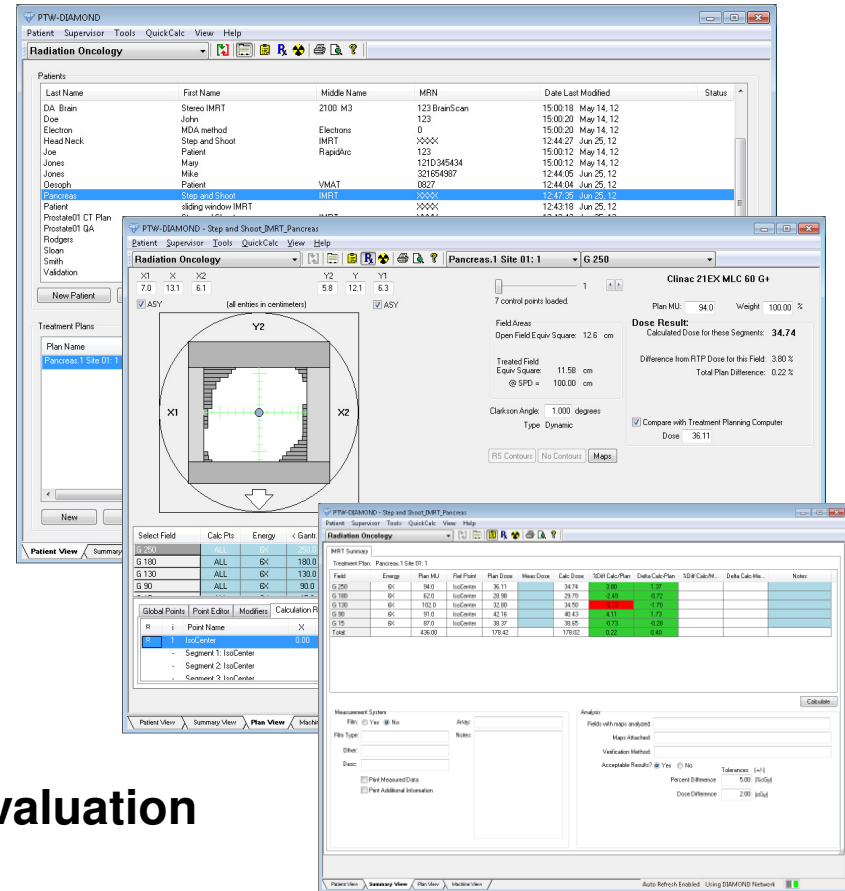
**DIAMOND Workflow**

Plan Import -> Calculation -> Documentation

I.) Add calculation points in plan and transfer it to DIAMOND

II.) Calculate the results

III.) Document the evaluation



# Plan Import

## Patient View: *Patient DB information, demographics, date, plan and fields*

The screenshot displays the PTW-DIAMOND software interface in 'Patient View' mode. The window title is 'PTW-DIAMOND' and the menu bar includes 'Patient', 'Supervisor', 'Tools', 'QuickCalc', 'View', and 'Help'. The 'Radiation Oncology' department is selected. The interface is divided into three main sections:

- Patient Listing:** A table showing patient information. The 'Pancreas' patient is highlighted.
- Treatment Plans:** A table showing treatment plans for the selected patient. The 'Pancreas.1 Site 01: 1' plan is highlighted.
- Calculation Fields:** A table showing calculation fields for the selected plan.

Buttons for 'New Patient', 'Edit Patient', 'Move Patient', 'Delete Patient', 'Find', 'Load Patient', 'Lock Patient', and 'Inactivate Patient' are located below the patient listing. The 'Active Patients' radio button is selected. Below the treatment plans and calculation fields are buttons for 'New', 'Edit', 'View', 'Copy', and 'Delete'. The status bar at the bottom shows 'Patient View' selected, 'Auto Refresh Enabled', and 'Using DIAMOND Network'.

Last Name	First Name	Middle Name	MRN	Date Last Modified	Status
DA Brain	Stereo IMRT	2100 M3	123 BrainScan	15:00:18 May 14, 12	
Doe	John		123	15:00:20 May 14, 12	
Electron	MDA method	Electrons	0	15:00:20 May 14, 12	
Head Neck	Step and Shoot	IMRT	XXXX	12:44:27 Jun 25, 12	
Joe	Patient	RapidArc	123	15:00:12 May 14, 12	
Jones	Mary		121D345434	15:00:12 May 14, 12	
Jones	Mike		321654987	12:44:05 Jun 25, 12	
Oesoph	Patient	VMAT	0827	12:44:04 Jun 25, 12	
Pancreas	Step and Shoot	IMRT	XXXX	12:47:35 Jun 25, 12	
Patient	sliding window IMRT		XXXX	12:43:18 Jun 25, 12	
Prostate01 CT Plan	Step and Shoot	IMRT	XXXX	12:43:42 Jun 25, 12	
Prostate01 QA	Step and Shoot	IMRT	XXXX	15:00:22 May 14, 12	
Rodgers	Mary		FDW45692	15:00:18 May 14, 12	
Sloan	Michael		789456	15:00:30 May 14, 12	
Smith	John		12312343	15:00:16 May 14, 12	
Validation	Machine		XXXX	15:00:18 May 14, 12	

Plan Name	Machine
Pancreas.1 Site 01: 1	Clinac 21EX MLC 60 G+

Field Name	Field ID	Energy	Date
G 250	01	6X	21:27:51 Nov 23, 04
G 180	02	6X	21:27:51 Nov 23, 04
G 130	03	6X	21:27:51 Nov 23, 04
G 90	04	6X	21:27:51 Nov 23, 04
G 15	05	6X	21:27:52 Nov 23, 04



Plan Import -> Calculation

**Plan View:** information on fields, segments, geometry, dosimetry, calculation results

**Beams Eye View**

Display for each segment in BEV

The screenshot shows the PTW-DIAMOND software interface. The top window displays a Beams Eye View (BEV) of a radiation field with a target area and a prescription box. The prescription box is labeled 'Clinac 21EX MLC 60 G+' and shows a Plan MU of 94.0 and a Weight of 100.00%. The Dose Result is 34.74 cGy, with a Difference from RTP Dose of 3.80% and a Total Plan Difference of 0.22%.

Below the BEV view is a table of field calculation results:

Select Field	Calc Pts	Energy	< Gantr...	< Gantr...	< Arc	< Coll	< Couch	Plan	Ref Point	Plan Result	Calc Result	%Diff Calc/...	Delta Ca...
G 250	ALL	6X	250.0	250.0	0.0	180.0	180.0	94.0 MU	IsoCenter	36.11 cGy	34.74 cGy	3.80	1.37
G 180	ALL	6X	180.0	180.0	0.0	180.0	180.0	62.0 MU	IsoCenter	28.98 cGy	29.70 cGy	-2.49	-0.72
G 130	ALL	6X	130.0	130.0	0.0	180.0	180.0	102.0 MU	IsoCenter	32.80 cGy	34.50 cGy	-5.19	-1.70
G 90	ALL	6X	90.0	90.0	0.0	180.0	180.0	91.0 MU	IsoCenter	42.16 cGy	40.43 cGy	4.11	1.73

Below the field table is a table of segment calculation results:

i	Point Name	X	Y	SSD	Dgeo	Defl	TMRref	Sc	Sp	Trans %	MU	Acc MU	Dose	Acc Dose
1	IsoCenter	0.00	0.00	84.50	15.5	15.5					94.00			34.74
	- Segment 1: IsoCenter						0.6309	1.0088	1.0182	100.00	19.83	19.83	13.24	13.24
	- Segment 2: IsoCenter						0.6297	1.0088	1.0158	100.00	19.81	39.64	13.17	26.41
	- Segment 3: IsoCenter						0.6089	1.0016	0.9798	100.00	7.47	47.11	4.60	31.01

**Dose Prescription**

imported Dose and MU

**Fields**

With geometric information and calculation results

**Segments**

With calculation results for each control point

Plan Import -> Calculation -> Documentation

**Summary View:** Overview of results, remark area, documentation

**Results**  
Comparison  
for each beam

PTW-DIAMOND - Step and Shoot\_IMRT\_Pancreas

Patient Supervisor Tools QuickCalc View Help

Radiation Oncology

IMRT Summary

Treatment Plan: Pancreas.1 Site 01: 1

Field	Energy	Plan MU	Ref Point	Plan Dose	Meas Dose	Calc Dose	%Diff Calc/Plan	Delta Calc-Plan	%Diff Calc/M...	Delta Calc-Me...	Notes
G 250	6X	94.0	IsoCenter	36.11		34.74	3.80	1.37			
G 180	6X	62.0	IsoCenter	28.98		29.70	-2.49	-0.72			
G 130	6X	102.0	IsoCenter	32.80		34.50	-5.19	-1.70			
G 90	6X	91.0	IsoCenter	42.16		40.43	4.11	1.73			
G 15	6X	87.0	IsoCenter	38.37		38.65	-0.73	-0.28			
Total:		436.00		178.42		178.02	0.22	0.40			

**Total Difference**  
Total dose difference  
for the complete plan

Measurement System  
 Film:  Yes  No  
 Array:   
 Film Type:   
 Notes:   
 Other:   
 Desc:   
 Print Measured Data  
 Print Additional Information

Analysis  
 Fields with maps analyzed:   
 Maps Attached:   
 Verification Method:   
 Acceptable Results?  Yes  No  
 Tolerances (+/-)  
 Percent Difference: 5.00 (%cGy)  
 Dose Difference: 2.00 (cGy)

**Documentation remarks**  
Comments for analysis criteria

Patient View **Summary View** Plan View Machine View

Auto Refresh Enabled Using DIAMOND Network

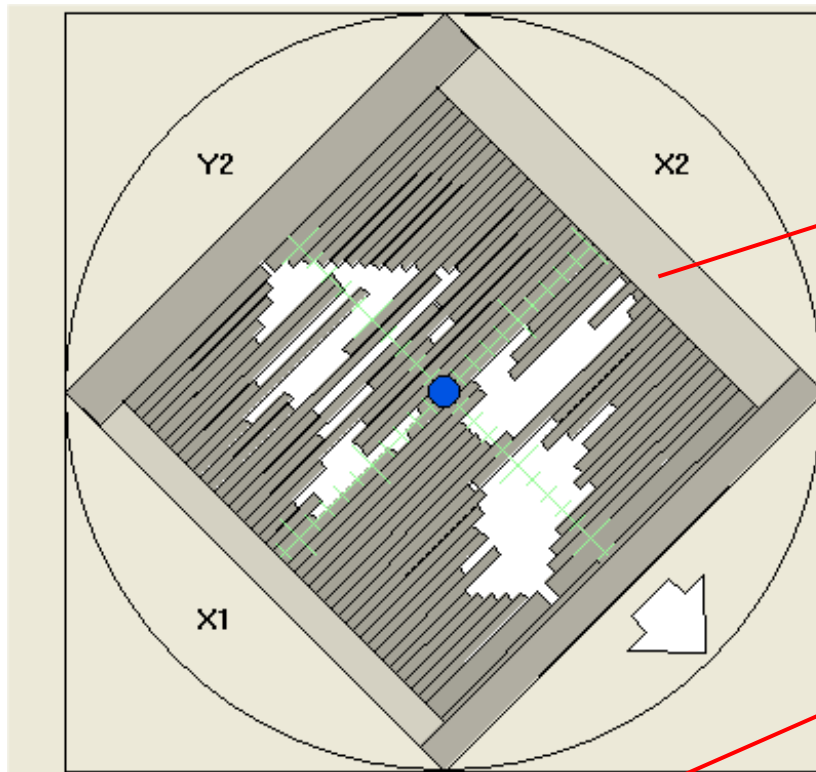
**Deviations**  
% and abs. difference  
for each beam

## VMAT Plan Import -> Calculation

Two steps for full **multiple arc** calculation:

- ▶ Import the plan as DICOM RT Plan
- ▶ Import a DICOM RT Structure Set

# VMAT Step I: DICOM RT Plan Import



**Plan Import**  
*Beams Eye View*

**Multiple Arc**  
*Arc beams with geometric and MU information*

Select Field	Calc Pts	Energy	< Gantry Start	< Gantry End	< Arc
1Arc1	ACP	6X	179.9	180.1	359.8 CC..
1Arc2	ACP	6X	180.1	179.9	359.8 CW

# VMAT Step II: DICOM Structure Set Import

## Transversal Slice

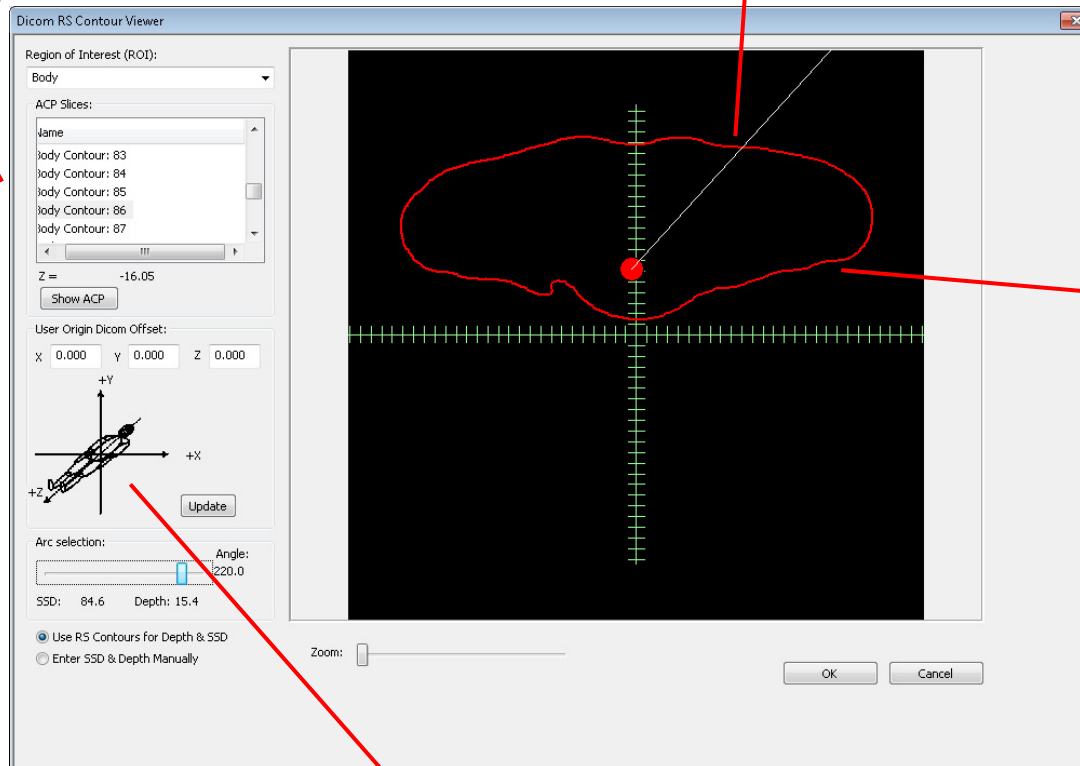
*Automatic detection of transversal slice*

## SSD calculation

*For each control point SSD is calculated*

## Contour

*Body Contour*



## Patient Coordinate System

*Preconfigured for each TPS*

4

Additional Features

# Analysis Tools

**Distance to Agreement Setup**

Radius:  millimeters  Modify Eff Depth

**Distance to Agreement: Results**

X	Y	Geo Depth	Eff Depth	MU	%Diff	Abs Diff
0.50	0.00	10.60	9.80	31.54	-0.46	0.15
-0.50	0.00	10.60	9.80	31.46	-0.22	0.07
0.00	0.50	10.60	9.80	29.70	5.37	-1.69
0.00	-0.50	10.60	9.80	31.69	-0.94	0.30
0.00	0.00	11.10	9.80	31.32	0.21	-0.07
0.00	0.00	10.10	9.80	31.37	0.05	-0.02

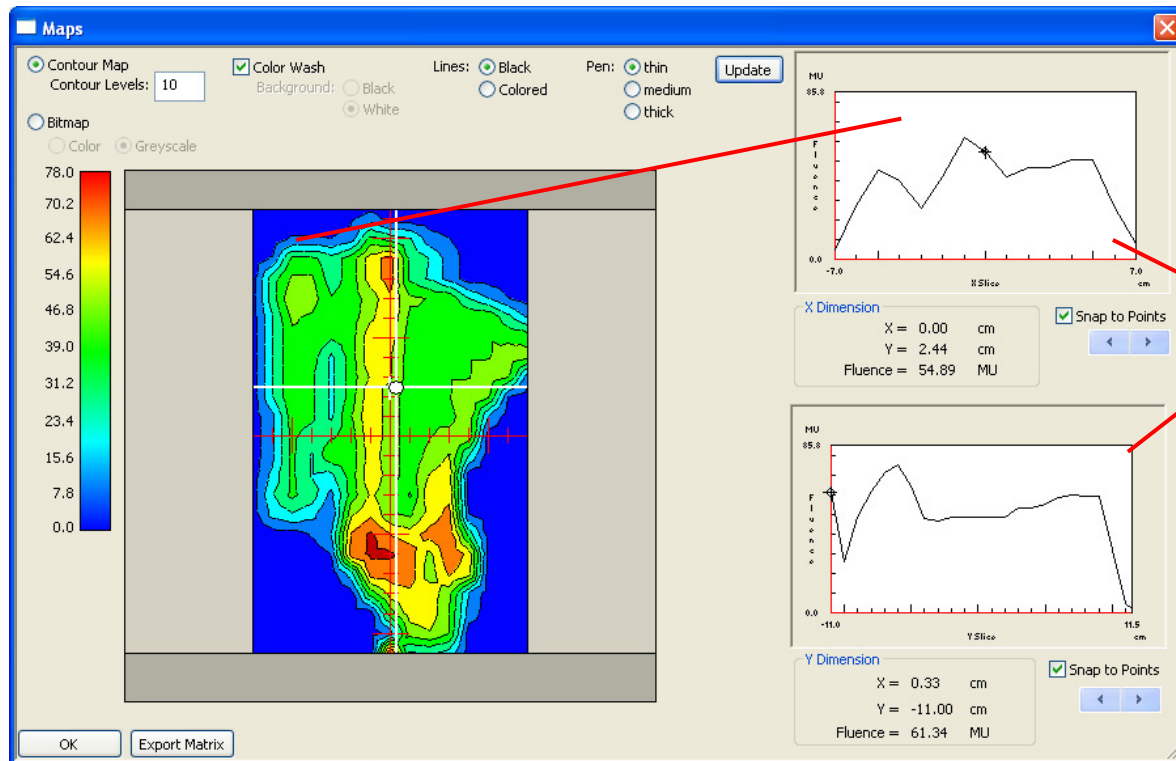
Closest match found at (x,y): (0.000000,0.000000)  
Distance to Closest Match: 0.000

Create a new Active Calc Point and transfer the selected coordinates to it.

# Fluence- and Dose Map Calculation

## Fluence Map

User defined resolution, Possible at block tray level, Different view possibilities



**Profiles**

Single values visible

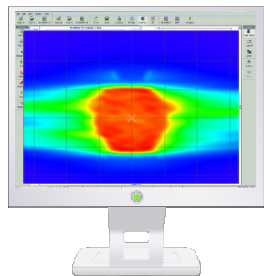
**Export**

As file

Interface to VeriSoft for map comparison



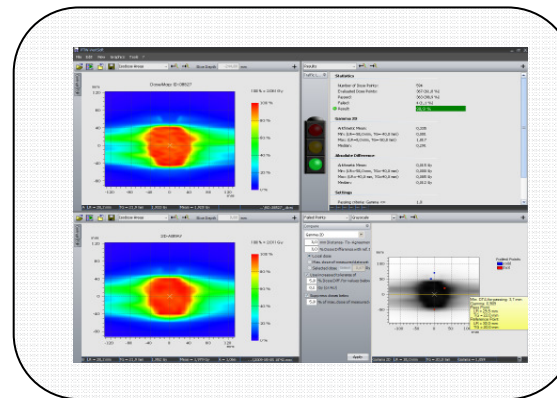
# Fluence- and Dose Map Comparison



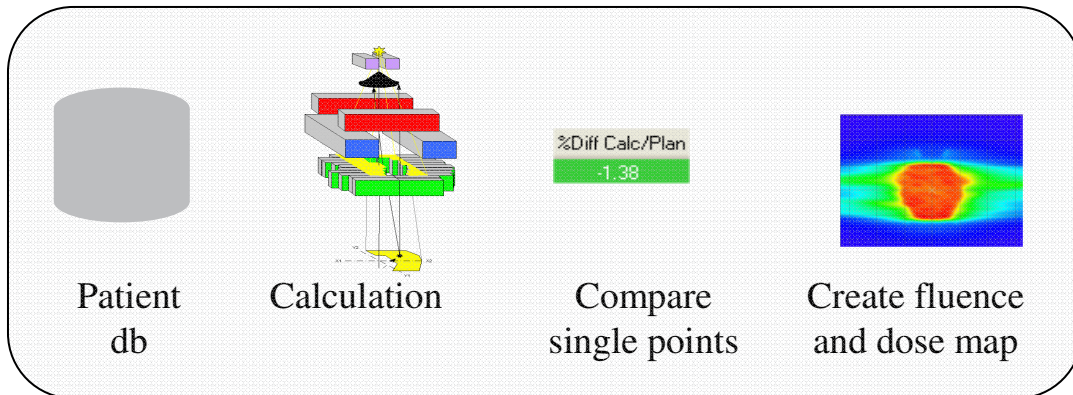
**TPS Plan**

DICOM RT Plan  
DICOMRT Structure

DICOM RT Dose



↑ **VeriSoft**



**DIAMOND**

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# Electrons

## Electrons

### Electron calculation levels:

- ▶ Standard – OF for each applicator
- ▶ Extended – OF versus equivalent square values
- ▶ MDA Electron Calculation (Option) –  
Includes electron depth dose data  
and electron air gap data for each energy

## Electrons – Standard / extended calculation

$$MU = \frac{D_{Rx} * 100}{[\%DD * EOF_{SSD} * MF * GC_{VSSD}]}$$

where,

$D_{Rx}$  = prescription dose per fraction

$\%DD$  = percent depth dose of treatment

$MF$  = modifier factor

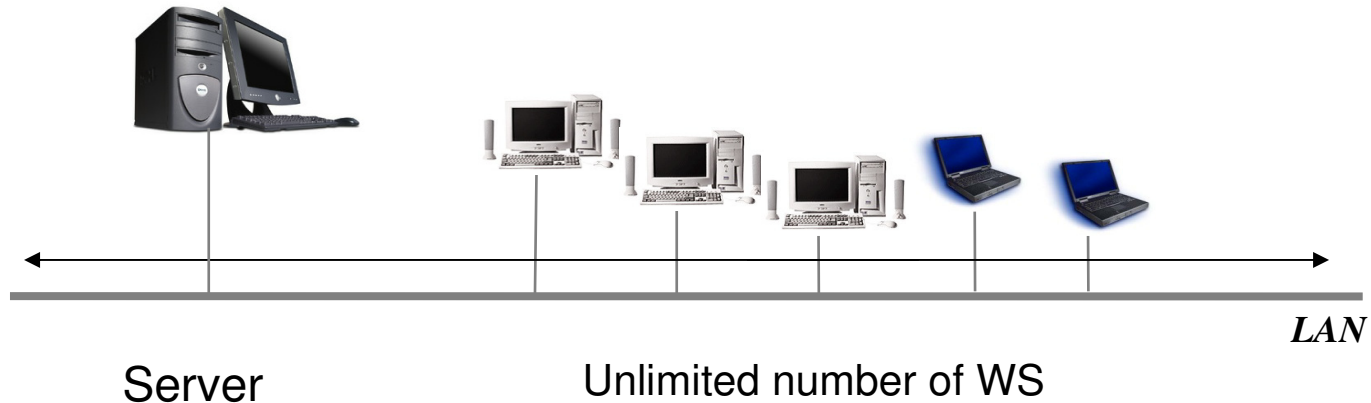
$EOF_{SSD}$  = electron output factor at selected SSD

$GC$  = gap correction using virtual SSD

**6**

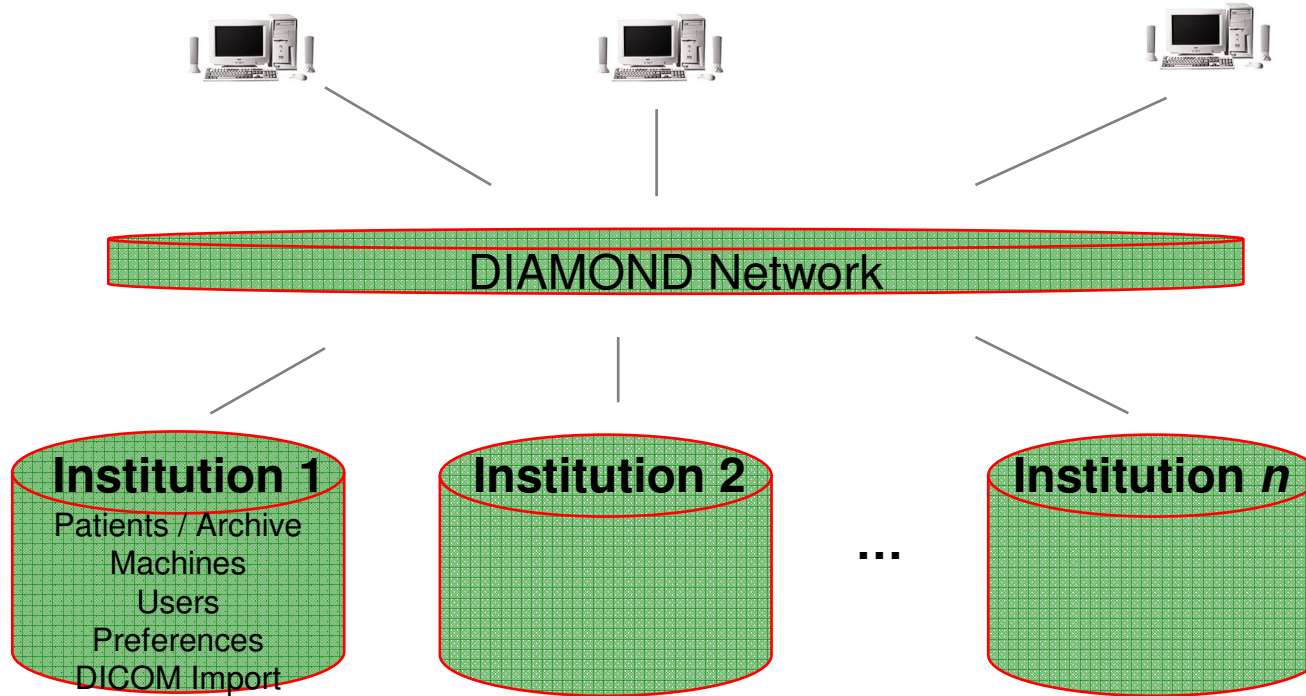
**DIAMOND Installation**

## DIAMOND Installation



- ▶ Stand alone on notebook or desktop
- ▶ Networked with the patient and machine data on a server
- ▶ User management integrated (user / supervisor)
- ▶ Provided with DICOM SCP server

# DIAMOND Configuration



- ▶ Several Institutions can be integrated in a network setup
- ▶ Each institution with preferences, machines and patients
- ▶ Inactive patients can be archived

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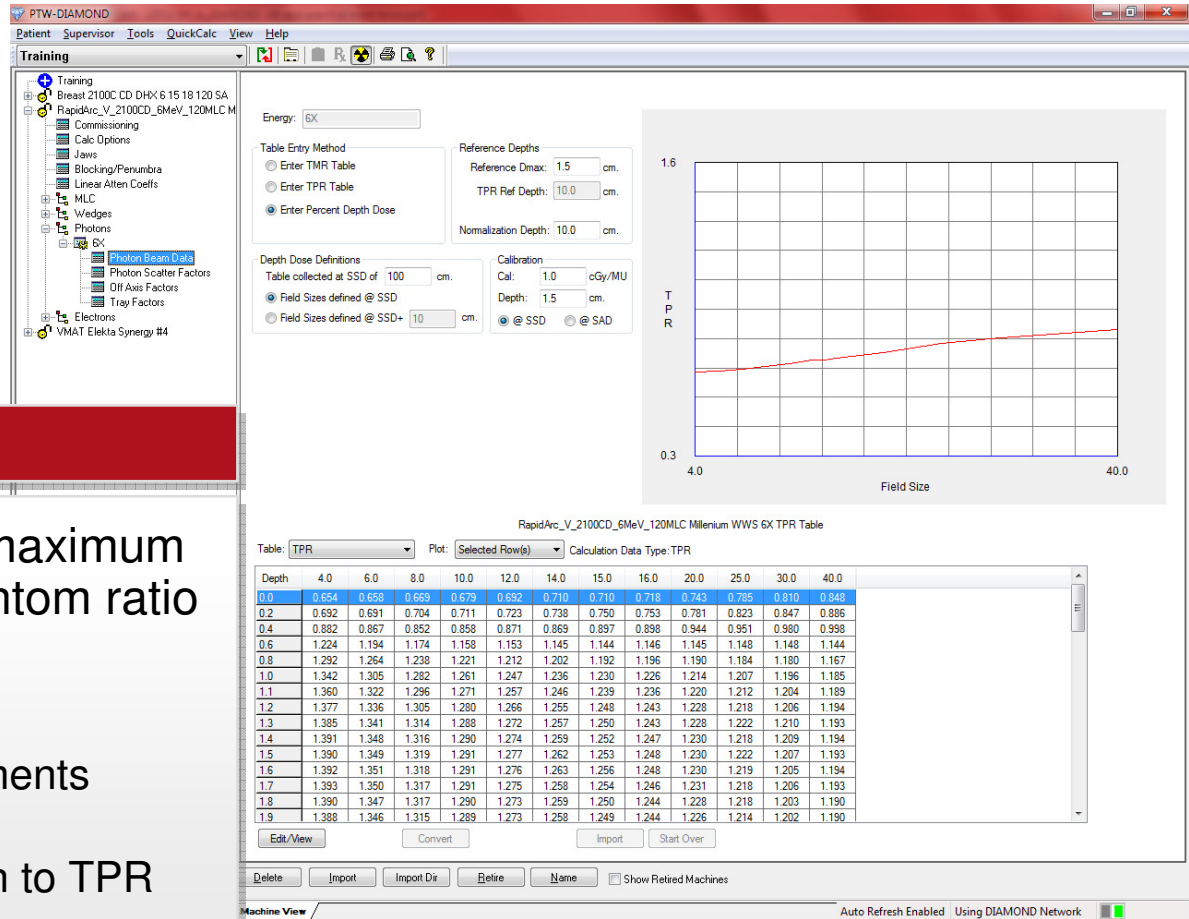
Machine Setup



## Support and Machine data requirements

- ▶ Support for Start with DIAMOND includes:
  - we offer a 90-days SW test – full version
  - we provide a (similar) machine data-set for local Linear-accelerator
  - we offer support for the measurements
  - we support the commissioning of the first local machine data-set
  
- ▶ Machine data requirements:
  - Machine / MLC type / Geometrical parameters
  - Most important data for each photon energy:
    - PDDs for squared field sizes
    - Head and phantom scatter
    - Off-axis profiles for largest field size
    - Wedge factors
    - Wedge profiles for largest field size
  
- ▶ A template can be used (Mephysto), data can be imported by copy and paste

# Setup of machine data



## Photon Beam Data: PDD

- ▶ DIAMOND needs tissue maximum ratio (TMR) or tissue phantom ratio (TPR) charts
- ▶ Recommendation:
  - ▶ Import PDD-measurements
  - ▶ Add scatter factors for subsequent conversion to TPR

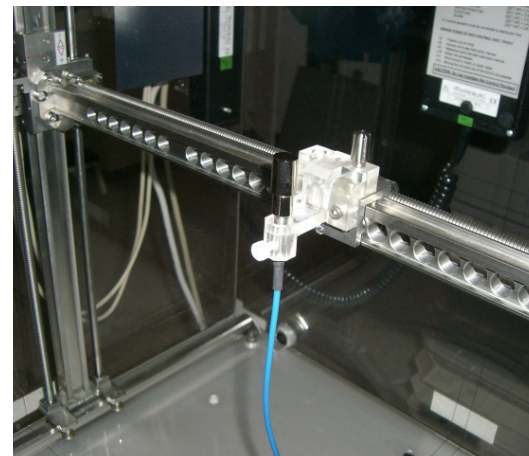
# Setup of machine data

## Photon Beam Data: Scatter Factors

- ▶ Measurements in water and in air
- ▶ Measuring depth at 10 cm is more precise because of unproblematic secondary electron contamination
- ▶ Source-Phantom-Distance at 90 cm



- ▶ Effective measuring volume as small as possible
- ▶ Axial detector orientation



# Setup of machine data

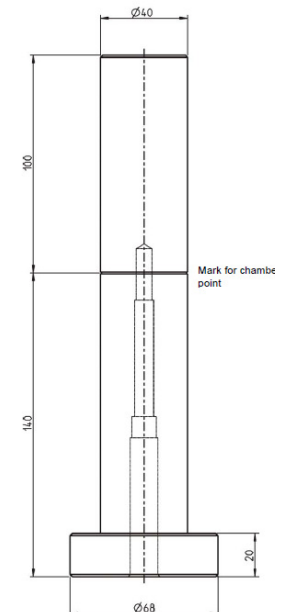
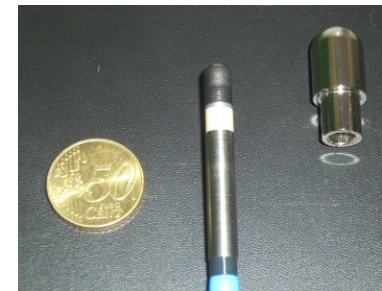
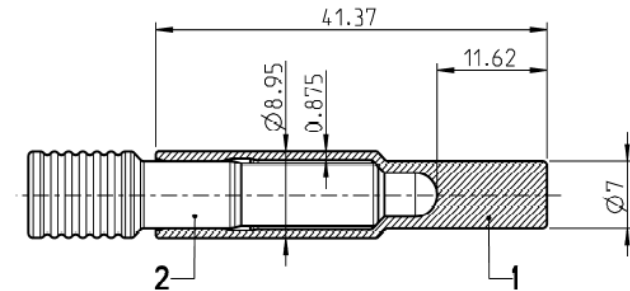
## Recommended detectors for FS up to 4x4 cm<sup>2</sup>

- ▶ 3D-PinPoint chamber together with AAPM TG74 Brass mini phantom of type T31016.1.300
- ▶ Dosimetry Diode T60012 with a sensitive volume of 1 mm<sup>2</sup> x 2.5 μm

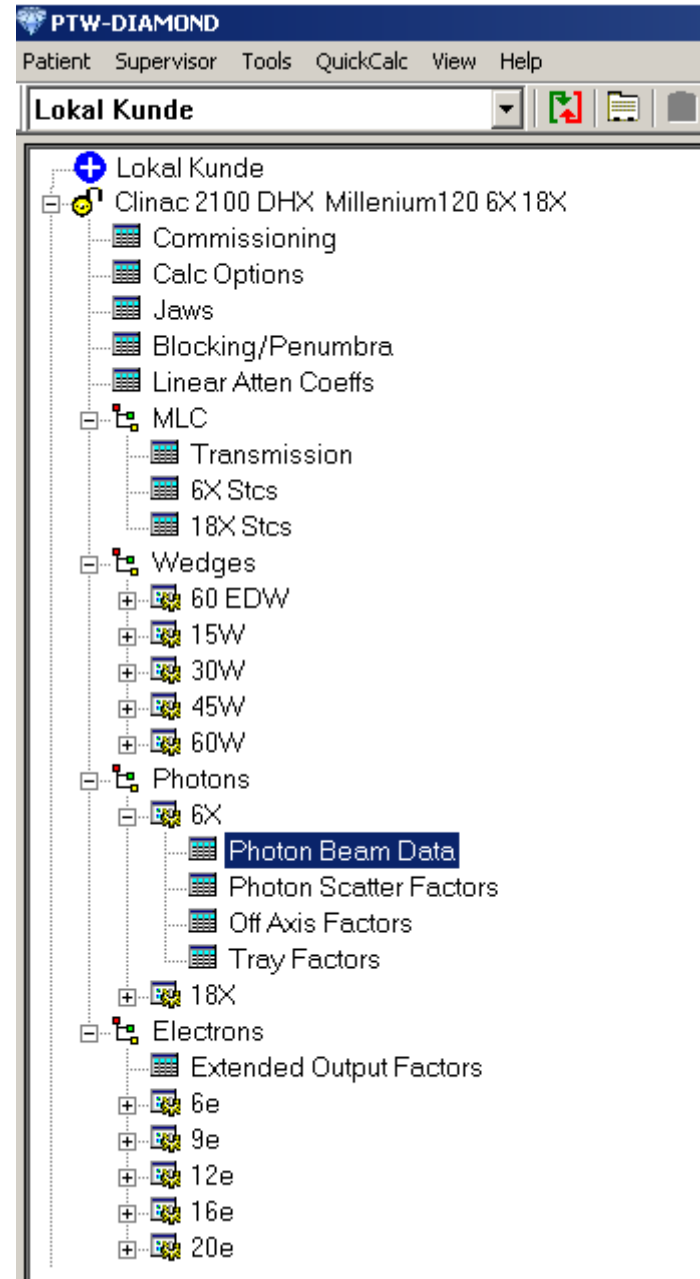
## Recommended detectors for FS larger 4x4 cm<sup>2</sup>

- ▶ Semiflex ion chamber T31010 with a sensitive volume of 0.125 mm<sup>3</sup>
- ▶ ESTRO mini phantom of type T40036.1.020

Correlate measurements with cross calibration



# Setup of machine data



# Setup of machine data

## TPR data

The screenshot displays the PTW-DIAMOND software interface. The left sidebar shows a tree view of training data, with 'Photon Beam Data' selected. The main window contains several configuration panels:

- Energy:** 6X
- Table Entry Method:** Enter TPR Table (selected), Enter TMR Table, Enter Percent Depth Dose
- Reference Depths:** Reference Dmax: 1.5 cm, TPR Ref Depth: 10.0 cm, Normalization Depth: 10.0 cm
- Depth Dose Definitions:** Table collected at SSD of 100 cm, Field Sizes defined @ SSD (selected), Field Sizes defined @ SSD+ 10 cm
- Calibration:** Cal: 1.0 cGy/MU, Depth: 1.5 cm, @ SSD (selected), @ SAD

Below the configuration panels is a graph of TPR vs Field Size. The y-axis (TPR) ranges from 0.3 to 1.6, and the x-axis (Field Size) ranges from 4.0 to 40.0. A red curve shows the TPR increasing from approximately 0.65 at 4.0 cm to 0.85 at 40.0 cm.

Below the graph is a table titled 'RapidArc\_V\_2100CD\_6MeV\_120MLC Millenium WWS 6X TPR Table'.

Depth	4.0	6.0	8.0	10.0	12.0	14.0	15.0	16.0	20.0	25.0	30.0	40.0
0.0	0.654	0.658	0.669	0.679	0.692	0.710	0.710	0.718	0.743	0.785	0.810	0.848
0.2	0.692	0.691	0.704	0.711	0.723	0.738	0.750	0.753	0.781	0.823	0.847	0.886
0.4	0.882	0.867	0.852	0.858	0.871	0.869	0.897	0.898	0.944	0.951	0.980	0.998
0.6	1.224	1.194	1.174	1.158	1.153	1.145	1.144	1.146	1.145	1.148	1.148	1.144
0.8	1.292	1.264	1.238	1.221	1.212	1.202	1.192	1.196	1.190	1.184	1.180	1.167
1.0	1.342	1.305	1.282	1.261	1.247	1.236	1.230	1.226	1.214	1.207	1.196	1.185
1.1	1.360	1.322	1.296	1.271	1.257	1.246	1.239	1.236	1.220	1.212	1.204	1.189
1.2	1.377	1.336	1.305	1.280	1.266	1.255	1.248	1.243	1.228	1.218	1.206	1.194
1.3	1.385	1.341	1.314	1.288	1.272	1.257	1.250	1.243	1.228	1.222	1.210	1.193
1.4	1.391	1.348	1.316	1.290	1.274	1.259	1.252	1.247	1.230	1.218	1.209	1.194
1.5	1.390	1.349	1.319	1.291	1.277	1.262	1.253	1.248	1.230	1.222	1.207	1.193
1.6	1.392	1.351	1.318	1.291	1.276	1.263	1.256	1.248	1.230	1.219	1.205	1.194
1.7	1.393	1.350	1.317	1.291	1.275	1.258	1.254	1.246	1.231	1.218	1.206	1.193
1.8	1.390	1.347	1.317	1.290	1.273	1.259	1.250	1.244	1.228	1.218	1.203	1.190
1.9	1.388	1.346	1.315	1.289	1.273	1.258	1.249	1.244	1.226	1.214	1.202	1.190

At the bottom of the interface, there are buttons for 'Open', 'New', 'Copy', 'Delete', 'Import', 'Import Dir', 'Retire', 'Name', and a checkbox for 'Show Retired Machines'. The status bar at the bottom indicates 'Auto Refresh Enabled' and 'Using DIAMOND Network'.



# Setup of machine data

## Off Axis and Tray Factors

The screenshot displays the PTW-DIAMOND software interface. The main window shows a tree view on the left with 'Off Axis Factors' selected. The central area contains a graph of Depth vs. Radius and a table of Off Axis Factors. A smaller window in the foreground shows a detailed view of the 'Tray Factors' table.

**Off Axis Factors (Depth vs. Radius)**

Radius	1.5	5.0	10.0	20.0	30.0
-23.0	0.073	0.085	0.106	0.143	0.156
-22.5	0.073	0.085	0.106	0.143	0.164
-22.0	0.073	0.085	0.106	0.143	0.178
-21.5	0.073	0.085	0.106	0.143	0.194
-21.0	0.073	0.085	0.106	0.143	0.210
-20.5	0.073	0.085	0.106	0.155	0.230
-20.0	0.073	0.085	0.106	0.169	0.290
-19.5	0.073	0.085	0.106	0.185	0.489
-19.0	0.073	0.085	0.113	0.205	0.718
-18.5	0.073	0.085	0.126	0.263	0.786
-18.0	0.073	0.092	0.142	0.498	0.808
-17.5	0.076	0.102	0.162	0.765	0.829
-17.0	0.084	0.115	0.219	0.835	0.842
-16.5	0.093	0.139	0.498	0.859	0.858
-16.0	0.110	0.282	0.844	0.877	0.870
-15.5	0.249	0.751	0.918	0.891	0.884
-15.0	0.757	0.955	0.939	0.903	0.892
-14.5	0.999	0.984	0.953	0.917	0.903
-14.0	1.022	0.947	0.962	0.927	0.912

**Tray Factors**

Description	Factor
Block Tray	0.969

# Zusammenfassung

## DIAMOND prüft Patientenpläne rechnerisch ...

- ▶ für statische, dynamische und VMAT Techniken
- ▶ mit Berücksichtigung der Inhomogenitäten über eff. Tiefen
- ▶ über einfache aber transparente und sehr schnelle Berechnungsmethode
- ▶ als validiertes Medizinprodukt mit Integration des klinischen Arbeitsablaufes
- ▶ ohne Linac-Zeit und damit besonders interessant für Kliniken hoher Auslastung

**Vielen Dank!**