PHOTON BEAM COMMISSIONING – MEASUREMENTS

CONTENTS

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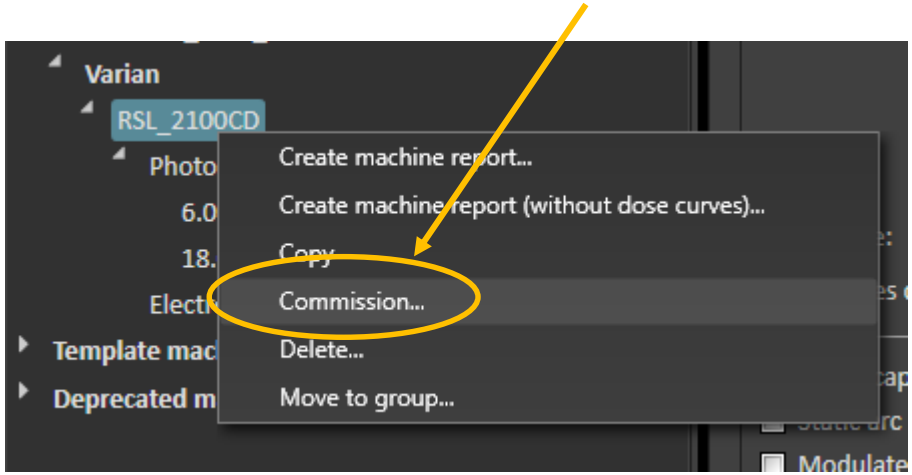
INTRODUCTION TO PHOTON BEAM COMMISSIONING

BEAM COMMISSIONING

- Commissioning means that all parameters that determine the dose computations in the TPS are thoroughly reviewed and validated by measurements.
- Once the review and validation is performed the machine can be accepted for patient treatments and the final commissioning can be executed.



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BEAM COMMISSIONING

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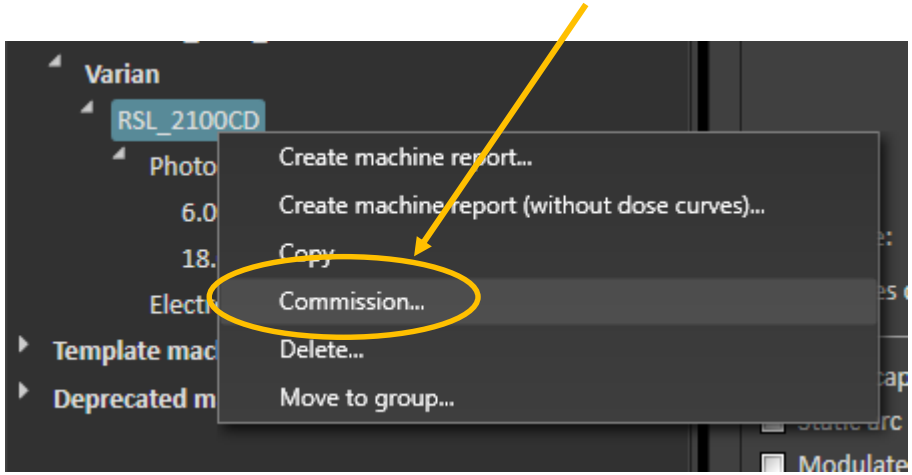

- But first….

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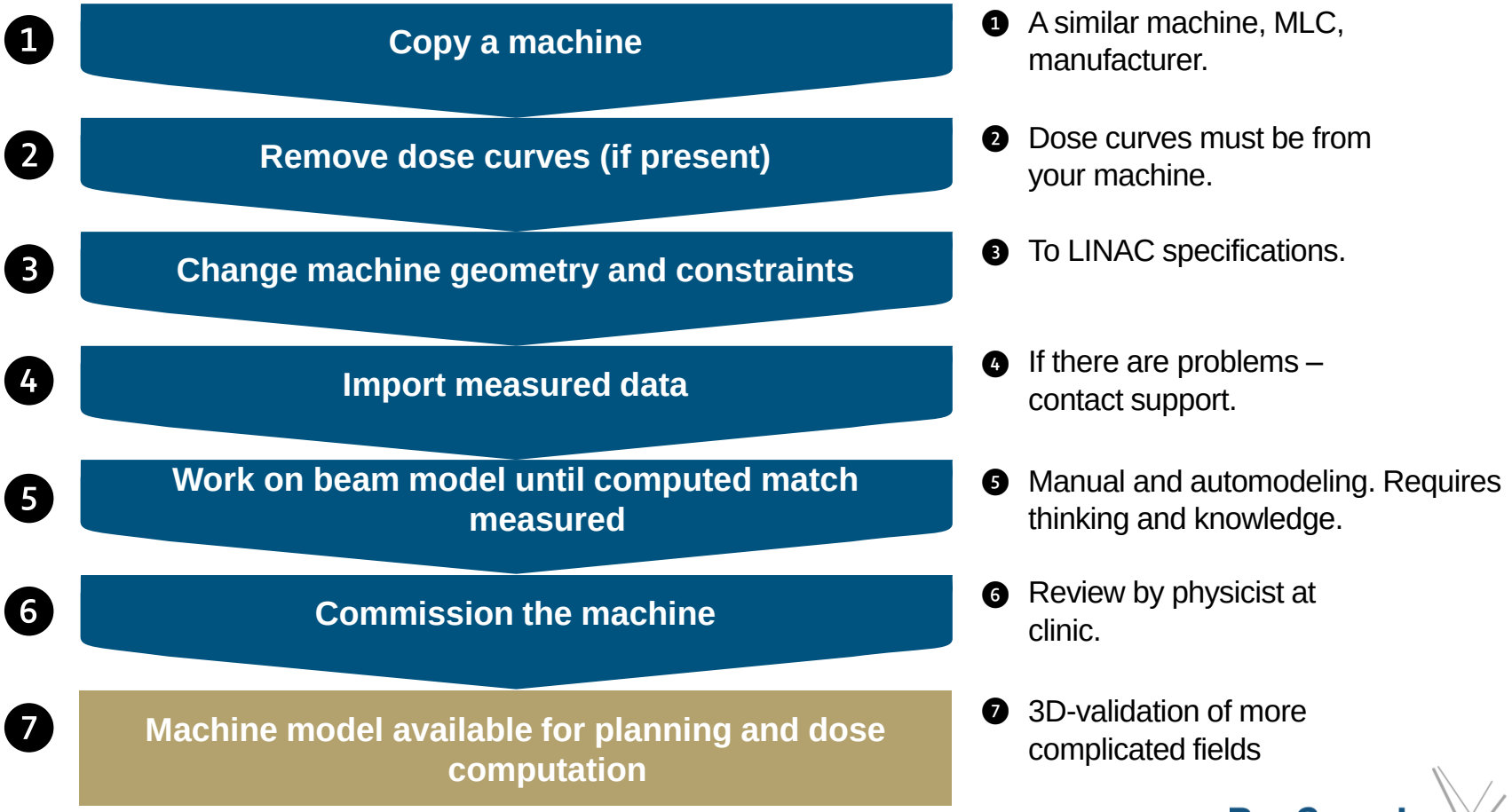
BEAM COMMISSIONING WORKFLOW



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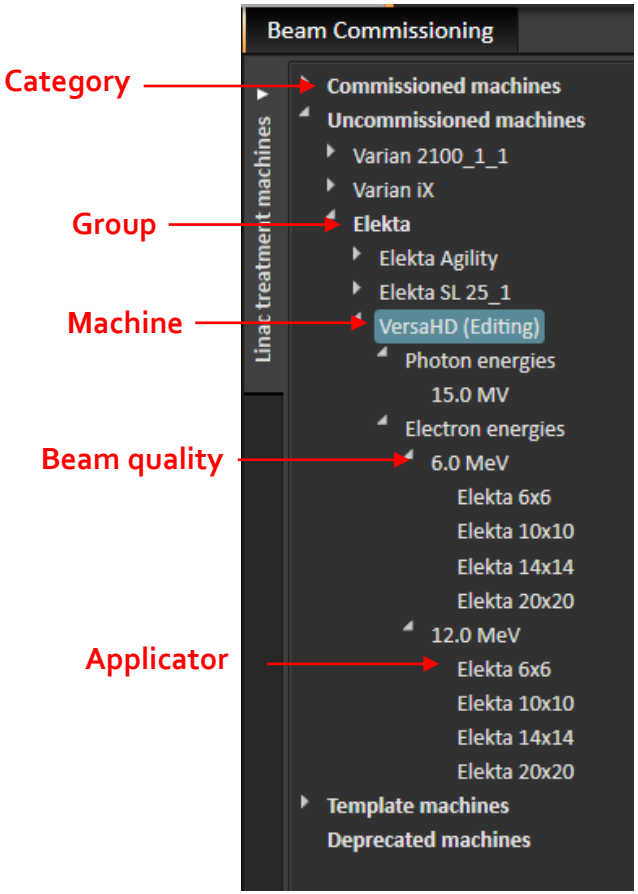
MACHINE TREE VIEW

4 categories:

- ***Commissioned***
- ***Uncommissioned***
- ***Template***
- ***Deprecated***

- A machine must be commissioned to be available for treatment planning in RayStation!
- Templates are only suggestions, always verify all properties
- Name maximum 16 characters (DICOM)
- Unique names, unique commissioning date
- Groups (uncommissioned only)
- Each machine must have at least 1 photon beam quality. Electron beam quality optional.



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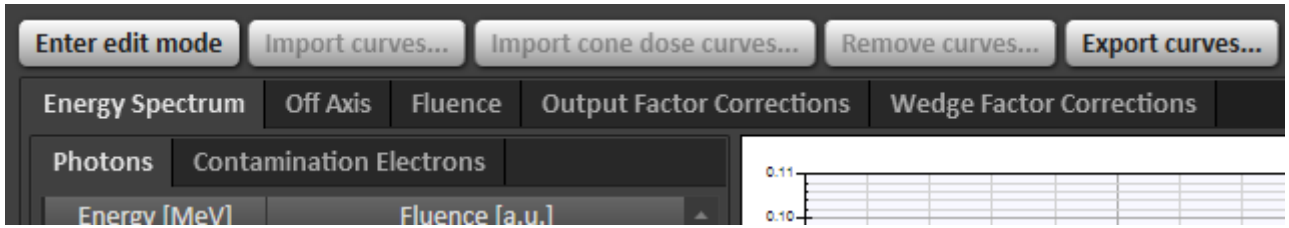
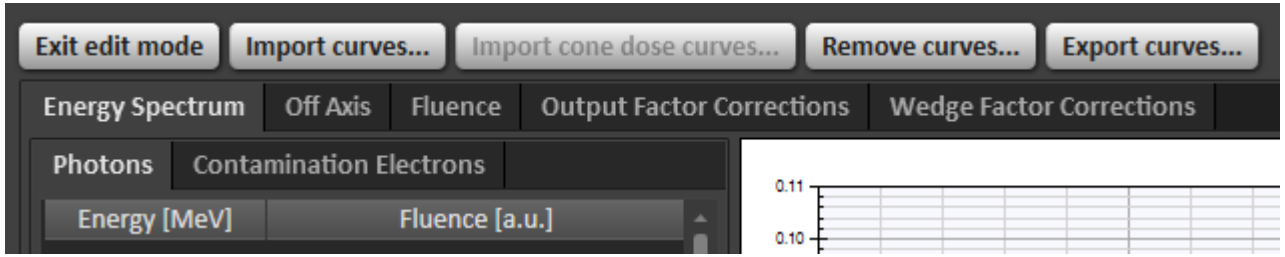
EDIT MODE AND CURVE IMPORT & EXPORT

- Changes can only be made to an uncommissioned machine in Edit mode.



- Measured curves can be imported, removed and exported.
- Computed curves can be exported.



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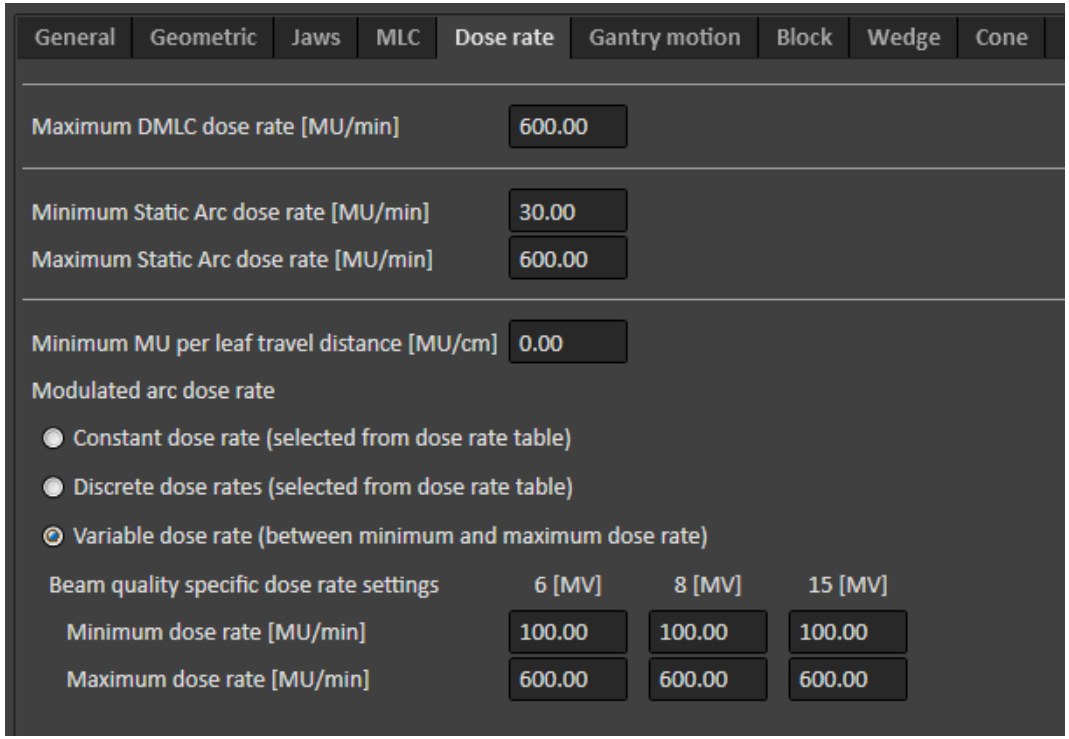
MACHINE GEOMETRY AND CONSTRAINTS

- Machine-specific tabs
- Enter values from LINAC-specifications.
- Constraints can be hard physical limits, recommended limits in LINAC or R&V (Record and Verify system), or limits with a margin to be sure to have deliverability.
- Some influence dose curve computation (SAD, MLC geometry)
- Some are used to create deliverable plans (motion properties).
- Some properties are per energy level.



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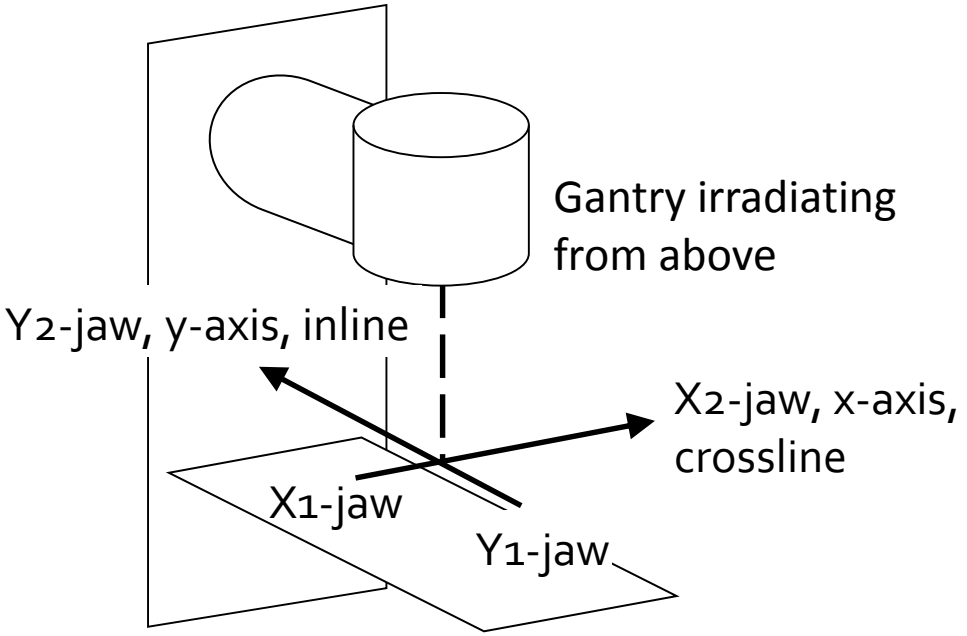
COORDINATE SYSTEM INTERDEPENDENCIES

- Beam model parameter coordinate system (exists only in RayPhysics) independent of coordinate system chosen for the machine (IEC-61217 or other)
- Properties in the machine constraints tabs are affected by the choice of coordinate system for the machine



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MEASUREMENTS

GENERAL MEASUREMENT INSTRUCTIONS

- Measure open or wedged fields (one wedge orientation)
- With flattening filter or flattening filter free
- Use water tank
- Same SSD for all measurements!

Required data:

- Depth dose curves
- Profiles in x and y
- Absolute dose calibration
- Output factors and wedge output factors

- Details in *Beam commissioning data specification* and *RayPhysics Manual*

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PROFILES

- Profiles must have corresponding PDD to allow import
- Profiles at several depths, e.g. D_{max} or d_{ref}, 5 cm, 10 cm and 20 cm.
- Cover clinically relevant fields (Reference field size must be included, 10x10 or close, if 10x10 cannot be used.)
- Field requirements for profiles:
    - Rectangular
    - Centered (by < 1 cm)
    - Crossline (x) or Inline (y) (*not diagonal!*)

Generally [cm]	**Elekta Beam Modulator [cm]**
2x2	1.6x1.6
3x3	2.4x2.4
5x5	3.2x3.2
5x20	4x4
10x10	4.8x4.8
15x15	7.2x7.2
20x5	10.4x10.4
20x20	16x16
30x30	21x16
40x40	4.8x16
	16x4.8

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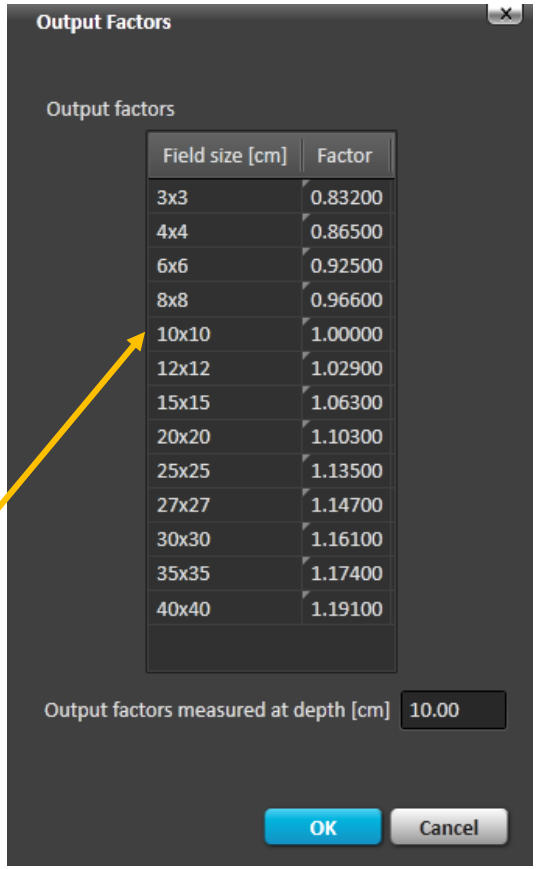
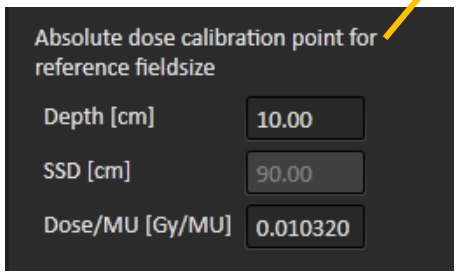
ABSOLUTE DOSE CALIBRATION

- Measured dose curves give relative doses
- Absolute dose calibration needed for reference field size
- Depth dose curve for reference field size normalized in absolute dose calibration point.
- Depth dose curves for other field sizes normalized using output factors and wedge output factors.
- Profiles normalized with the depth dose curve.
- Recommended to measure absolute dose for calibration below electron contamination (at 5 - 10 cm depth)





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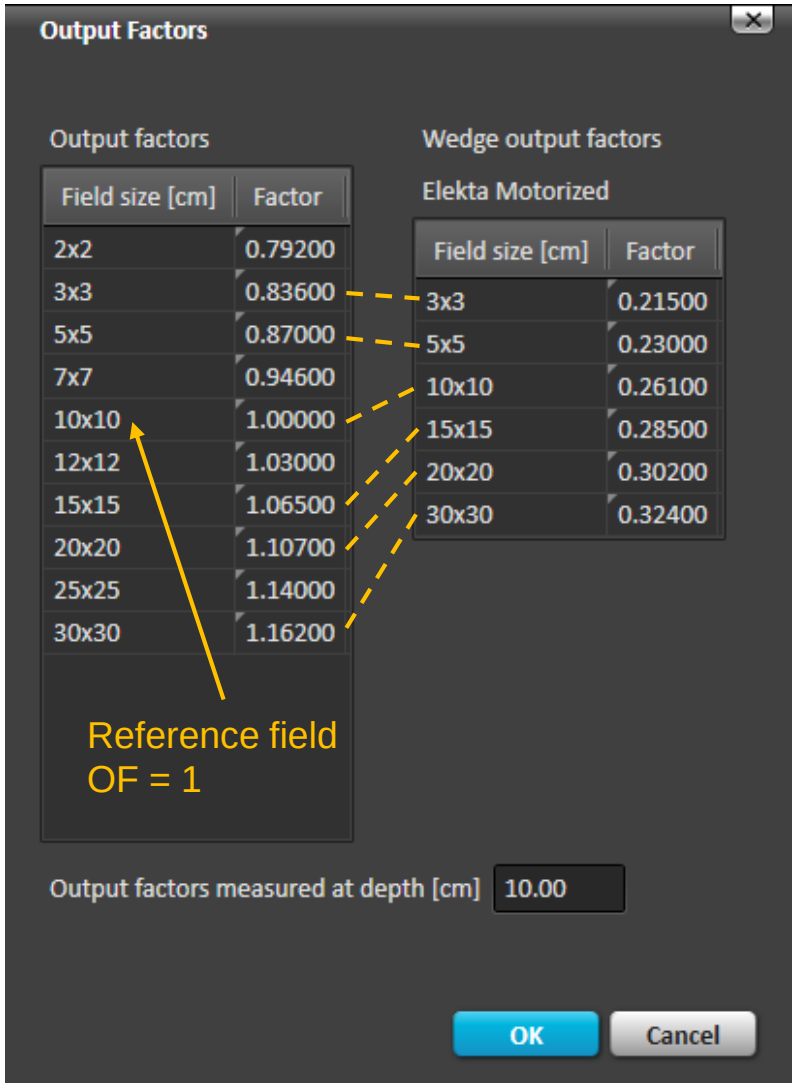
OUTPUT FACTORS AND WEDGE OUTPUT FACTORS



- ***Output factors***: ratio of measured dose in reference point for reference field (typically 10 x10) and the dose in the same point for any other field sixe.
- ***Wedge output factors***: relative to same size open field OFs

  → all field sizes in wedge list must have an output factor also for open field even if no open field curves are included.
- Entered at import (can be changed later)
- *Not part of the beam model/dose calculation, only used for normalization.*
- Recommended to measure OFs and wedge OFs below electron contamination (at 5 - 10 cm depth)

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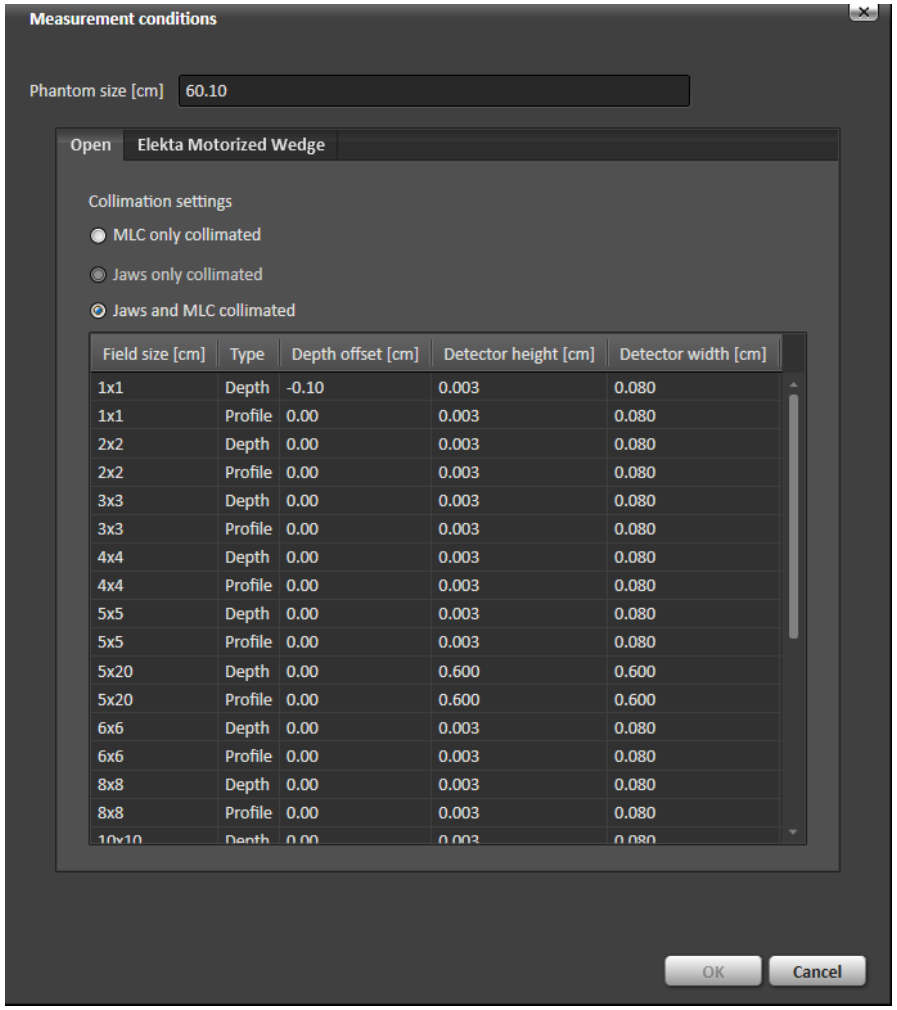
MEASUREMENT CONDITIONS

- ***Phantom size***
- ***Collimation settings***
- ***Depth offset***
- ***Detector height and width***

- Only used in BC dose curve calculation, not for dose calculations in patients.
- Used to make the conditions of the calculated curves mimic the conditions of the dose curve measurements.
- Separate conditions for open and wedged fields.



Field size [cm]	Type	Depth offset [cm]	Detector height [cm]	Detector width [cm]
1x1	Depth	-0.10	0.003	0.080
1x1	Profile	0.00	0.003	0.080
2x2	Depth	0.00	0.003	0.080
2x2	Profile	0.00	0.003	0.080
3x3	Depth	0.00	0.003	0.080
3x3	Profile	0.00	0.003	0.080
4x4	Depth	0.00	0.003	0.080
4x4	Profile	0.00	0.003	0.080
5x5	Depth	0.00	0.003	0.080
5x5	Profile	0.00	0.003	0.080
5x20	Depth	0.00	0.600	0.600
5x20	Profile	0.00	0.600	0.600
6x6	Depth	0.00	0.003	0.080
6x6	Profile	0.00	0.003	0.080
8x8	Depth	0.00	0.003	0.080
8x8	Profile	0.00	0.003	0.080
10x10	Depth	0.00	0.003	0.080

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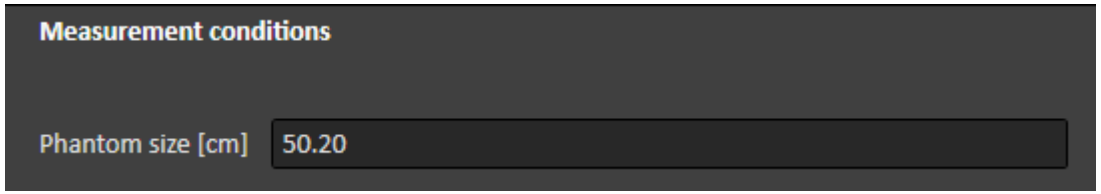
MEASUREMENT CONDITIONS – PHANTOM SIZE



- One value only for the ***Phantom size*** – use some kind of average side length if phantom is a non-square cuboid

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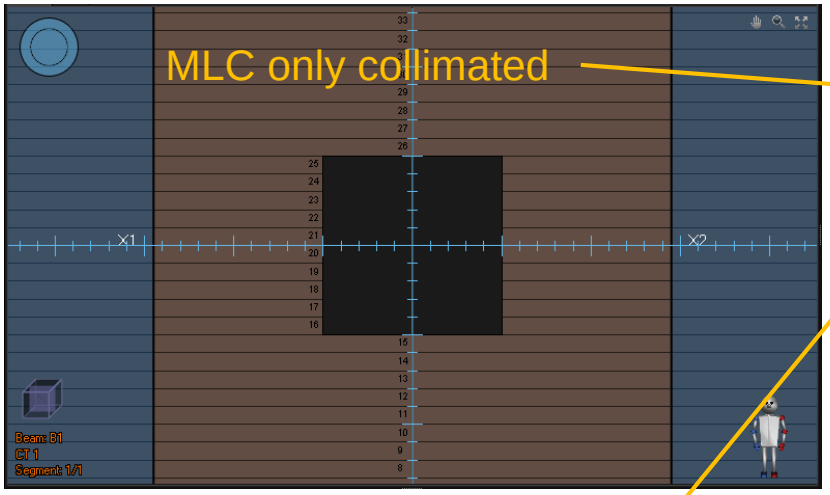
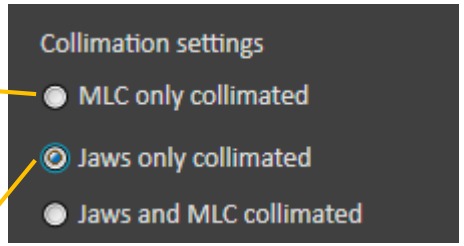
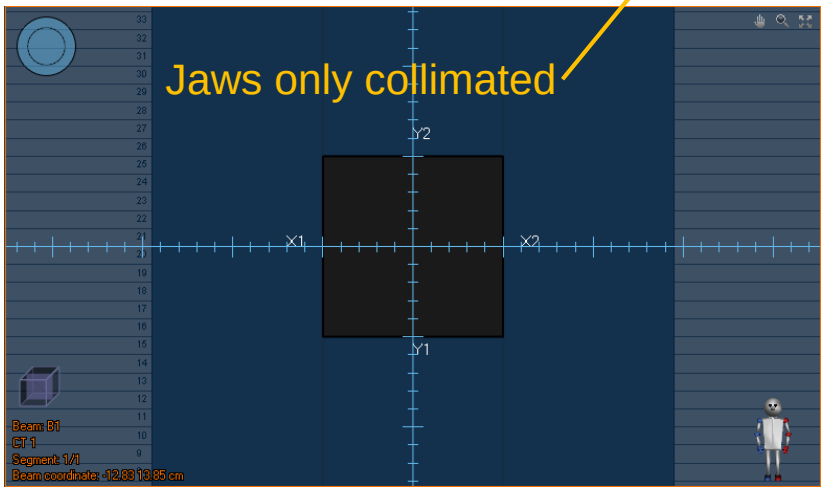
MEASUREMENT CONDITIONS – ALLOWED COLLIMATION SETTINGS







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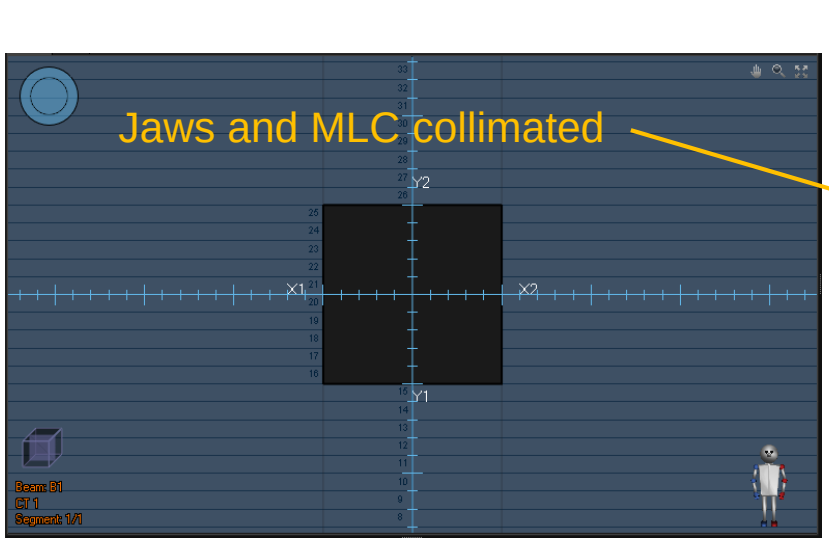

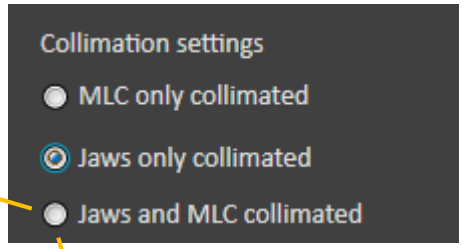

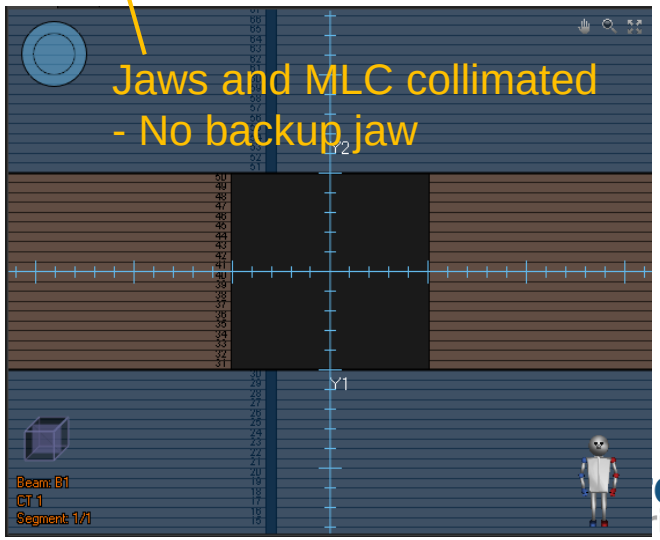

MEASUREMENT CONDITIONS – ALLOWED COLLIMATION SETTINGS

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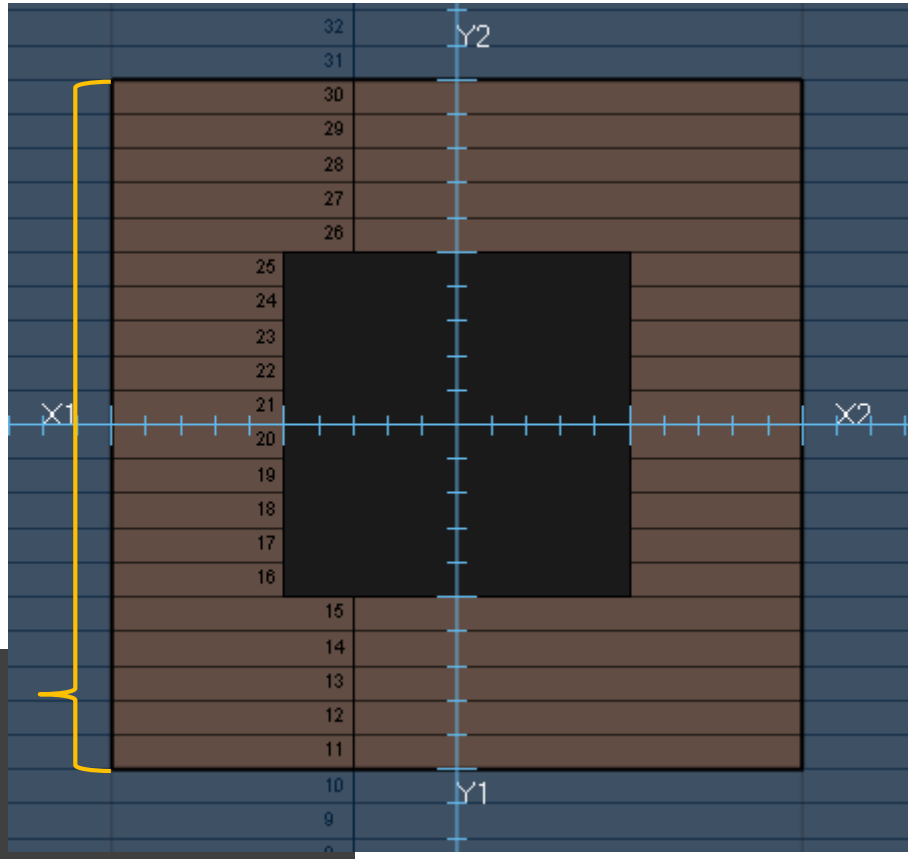
MEASUREMENT CONDITIONS IN RAYPHYSICS - MLC ONLY EXTRA CONDITIONS



Collimation settings

- (•) MLC only collimated — X-profile offset [cm] 0.50
- ( ) Jaws only collimated
- ( ) Jaws and MLC collimated

Jaw Field Size

Field size [cm]	Type	Depth offset [cm]	Detector Height [cm]	Detector Width [cm]	Jaw field size X [cm]	Jaw field size Y [cm]	MLC leaf tip offset [cm]
2x2	Depth	0.00	0.026	0.350	20.00	20.00	3.00
2x2	Profile	0.00	0.026	0.350	20.00	20.00	3.00

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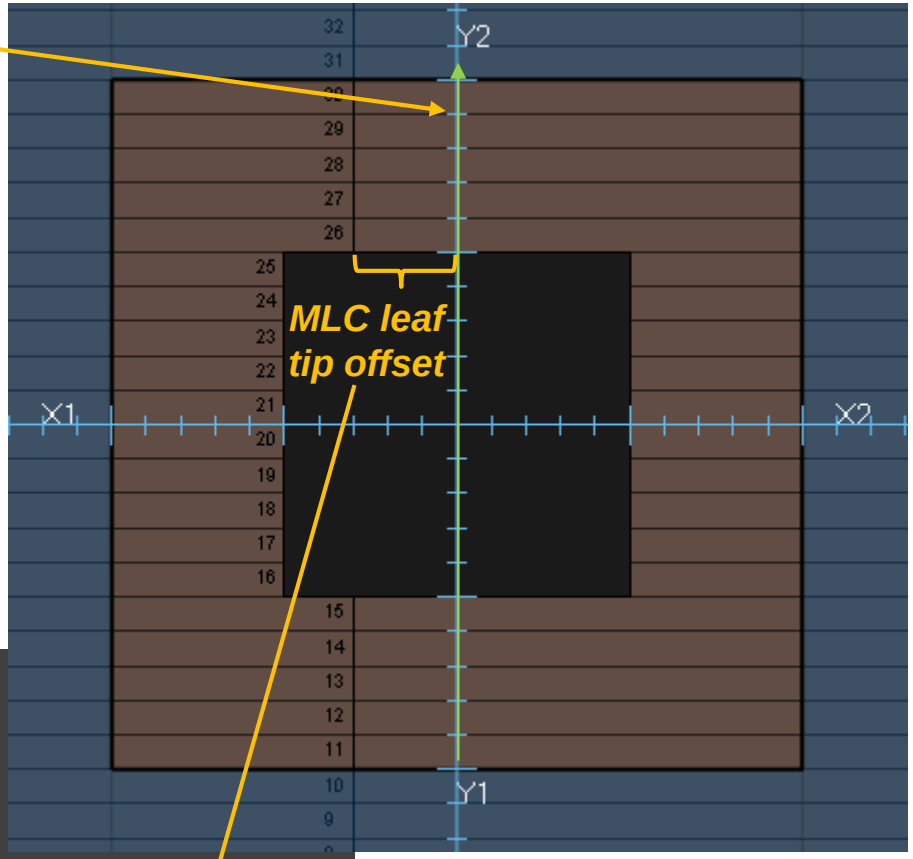
MEASUREMENT CONDITIONS IN RAYPHYSICS - MLC ONLY EXTRA CONDITIONS

Y-profiles must be measured without offset in x!
Instead use ***MLC leaf tip offset.***



Collimation settings

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- ( ) Jaws only collimated
- ( ) Jaws and MLC collimated

Field size [cm]	Type	Depth offset [cm]	Detector Height [cm]	Detector Width [cm]	Jaw field size X [cm]	Jaw field size Y [cm]	MLC leaf tip offset [cm]
2x2	Depth	0.00	0.026	0.350	20.00	20.00	3.00
2x2	Profile	0.00	0.026	0.350	20.00	20.00	3.00

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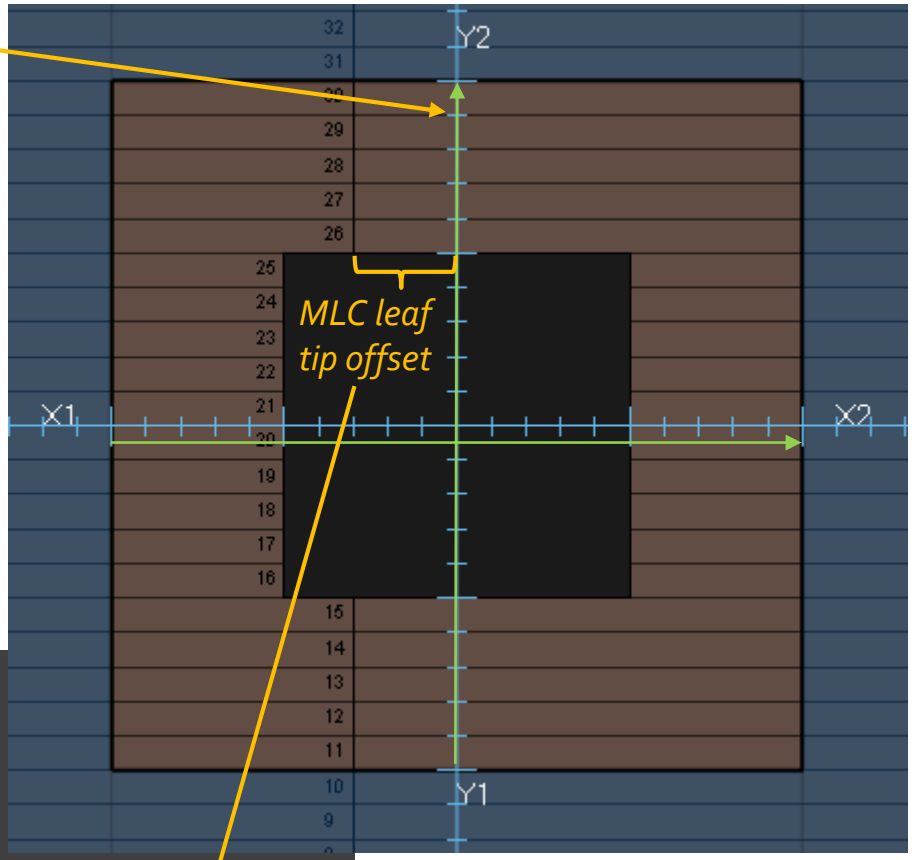
MEASUREMENT CONDITIONS IN RAYPHYSICS - MLC ONLY EXTRA CONDITIONS

Y-profiles must be measured without offset in x!
Instead use ***MLC leaf tip offset.***



X-profile offset in y detected automatically at import and cannot be changed in RayPhysics.

Collimation settings

MLC only collimated X-profile offset [cm] 0.50

Jaws only collimated

Jaws and MLC collimated

Field size [cm]	Type	Depth offset [cm]	Detector Height [cm]	Detector Width [cm]	Jaw field size X [cm]	Jaw field size Y [cm]	MLC leaf tip offset [cm]
2x2	Depth	0.00	0.026	0.350	20.00	20.00	3.00
2x2	Profile	0.00	0.026	0.350	20.00	20.00	3.00

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MEASUREMENT CONDITIONS – DETECTOR CHOICE

- Ionization chamber – resolution effects
- Diode – energy sensitive
- Recommended protocol:
  - Ionization chambers for large fields
  - Diodes or pinpoint chambers for small fields (< 4 cm)
  - Use same detector for output factor measurements as for PDDs.

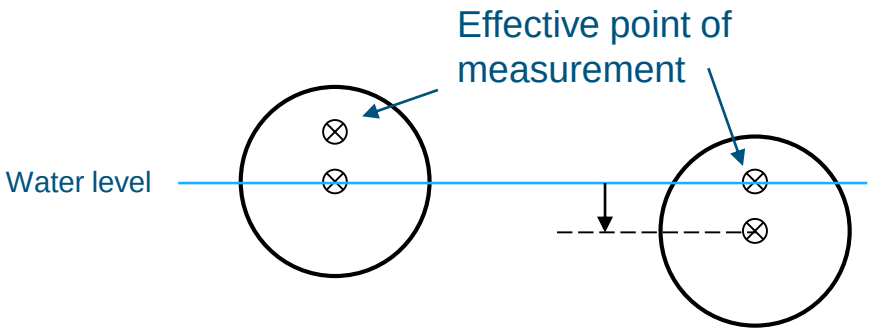
MEASUREMENT CONDITIONS – DEPTH OFFSET

- The center of the detector is not necessarily the effective point of measurement.
- Detector position is thus shifted to the effective point of measurement.
- If measurements were ***NOT*** performed by positioning detector in effective point of measurement, a depth offset corresponding to the shift must be entered in RayPhysics.

Field size [cm]	Type	Depth offset [cm]
2x2	Depth	0.10
2x2	Profile	0.10
3x3	Depth	0.10
3x3	Profile	0.10
5x5	Depth	0.10

See Figure 6 in:

Das *et al.*: TG-106: Accelerator beam data commissioning
Med. Phys. 35 (9), September 2008



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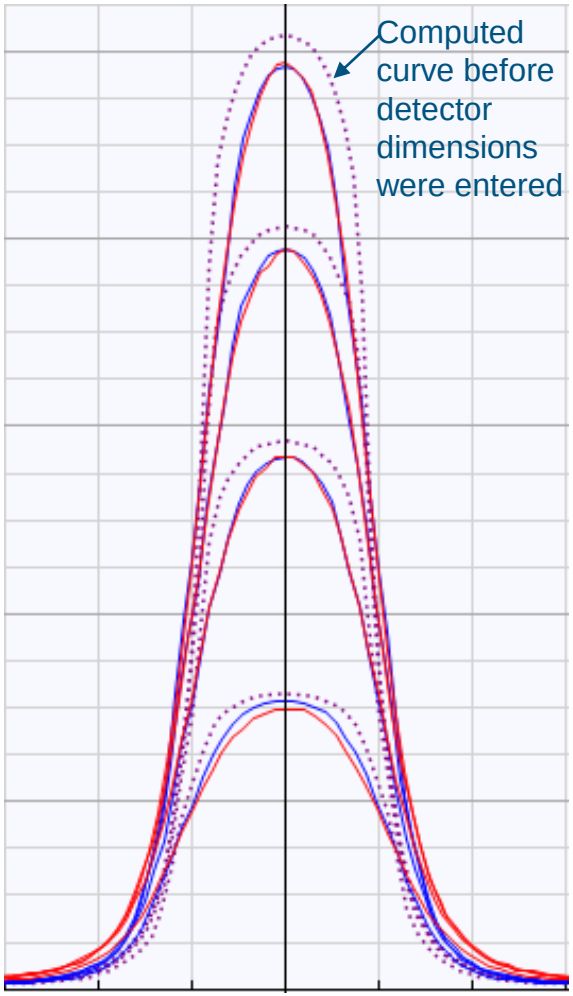
MEASUREMENT CONDITIONS - CONVOLUTION

- If measured curves were <u>not deconvolved</u>:
  - The ***detector width*** and ***height*** should be entered to RayPhysics during import.
  - Computed curves will then be convolved with a square well function to better match the measured curves.
  - The RayPhysics square well convolution will convolve TERMA for photons and depth dose for contamination electrons.

- If measured curves were <u>deconvolved</u> before import:
  - Set detector sizes to 0.
  - No convolution is then applied by RayPhysics.
  - To get a smoother curve in the build-up region, detector height can be set to something small like 0.1 cm.



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MEASUREMENT CONDITIONS - DETECTOR HEIGHT

- ***Detector height*** mainly affects the buildup region of the depth dose curves.

Field size [cm]	Type	Depth offset [cm]	Detector Height [cm]
2x2	Depth	0.10	0.026
2x2	Profile	0.10	0.026
3x3	Depth	0.10	0.026
3x3	Profile	0.10	0.026
5x5	Depth	0.10	0.026

See Figure 10 in:

Das *et al.*: TG-106: Accelerator beam data commissioning
Med. Phys. 35 (9), September 2008

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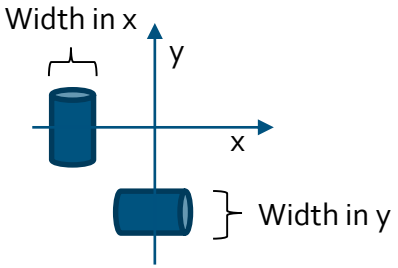
MEASUREMENT CONDITIONS – DETECTOR WIDTH

- ***Detector width*** affects penumbra steepness.
- Detector orientation determines the effective detector width in scanning direction.
- Be careful to use the same orientation in x and y!



- ***Detector width*** also affects the measured output of small fields.

Field size [cm]	Type	Depth offset [cm]	Detector Height [cm]	Width [cm]
2x2	Depth	0.10	0.026	0.350
2x2	Profile	0.10	0.026	0.350
3x3	Depth	0.10	0.026	0.350

See Figure 11 in:

Das *et al.*: TG-106: Accelerator beam data commissioning
Med. Phys. 35 (9), September 2008

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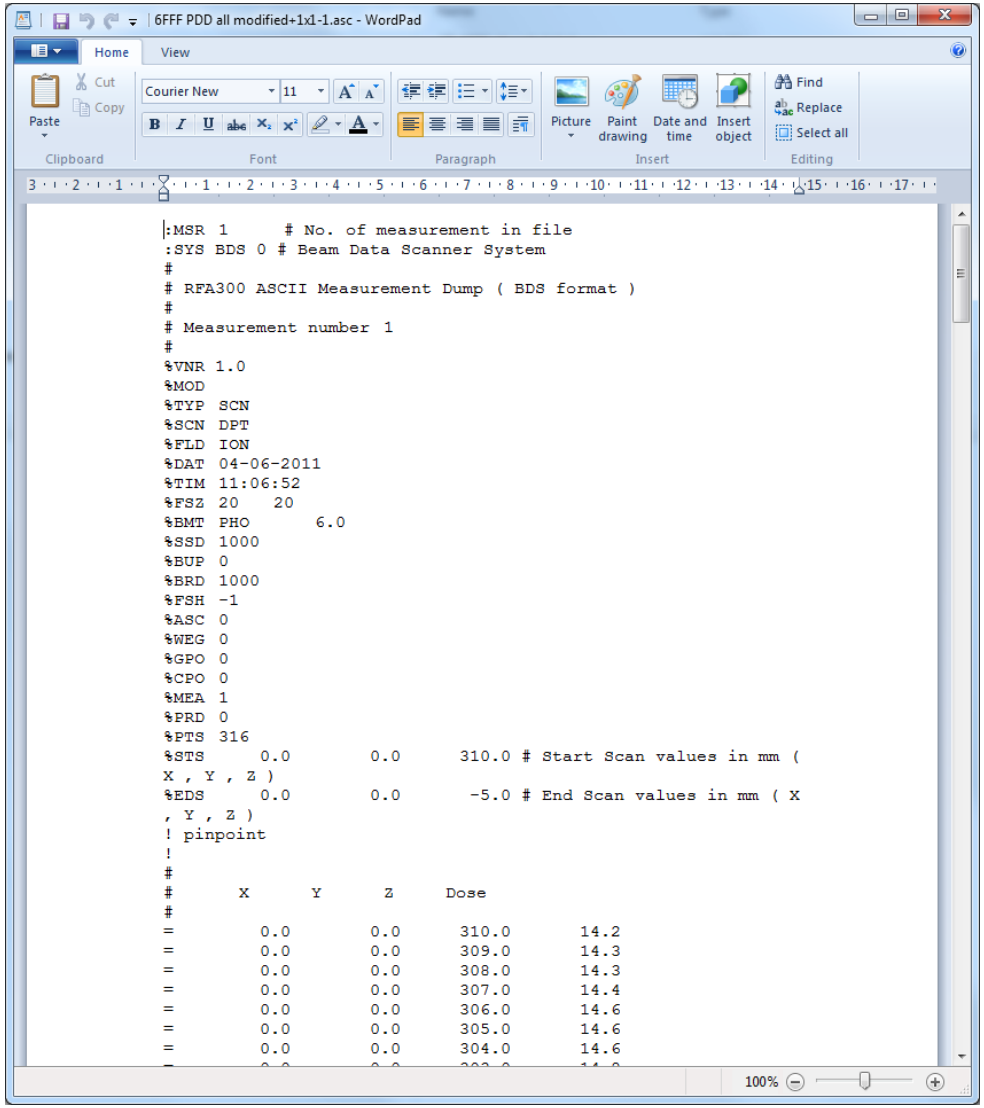
SUPPORTED CURVE FORMATS



- All supported formats are simple text files with tags and values:
  - Comma-separated values (.csv)
  - RFA (.asc)
  - MEPHYSTO (.mcc)
  - SNC (.snctxt)
  - Brainlab MC (.xmcdat)
- For further format requirements see *RayPhysics Manual Appendix B*.

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