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Klinik und Poliklinik für Nuklearmedizin

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Volume Delineation:

Methods to use

T. Weitzel

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Volume Delineation

Volume ??

Volume !

Implicit assumptions:

- some **inside**
- some **outside**
- some **surface**

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Needs **criterion** to distinguish inside from ouside

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Needs **criterion** to distinguish inside from ouside

e.g.: „inside the skull“

geometric argument, very well defined surface,
but not a simple criterion describing the things inside

b.t.w.: Are the eyes “inside” the skull ?

Volume !

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Needs **criterion** to distinguish inside from ouside

e.g.: „compact object with high X-ray attenuation“

Simple, single valued, measurable property.
Threshold value defines points that are inside.

e.g.: „compact object with high X-ray attenuation“

Simple, single valued, measurable property.
Threshold value defines points that are inside.

Example: Two threshold values allow to distinguish
D(bone) > T1 > D(markers) > T2 > D(towel)

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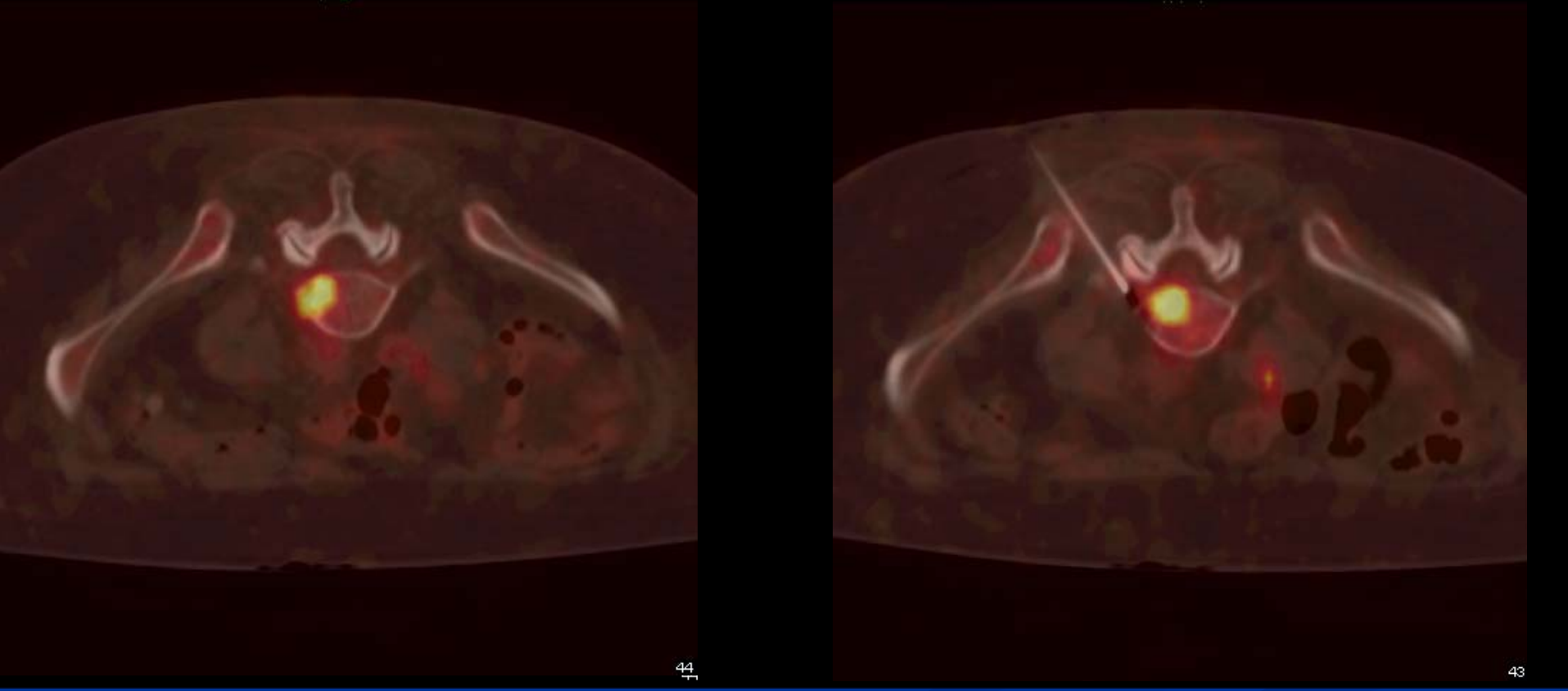
e.g.: „higher accumulation of FDG“ (PET)

Single threshold value defines points that are inside.

Method of measurement has to be very well defined:
A Time-Activity-Curve and other parameters are involved.



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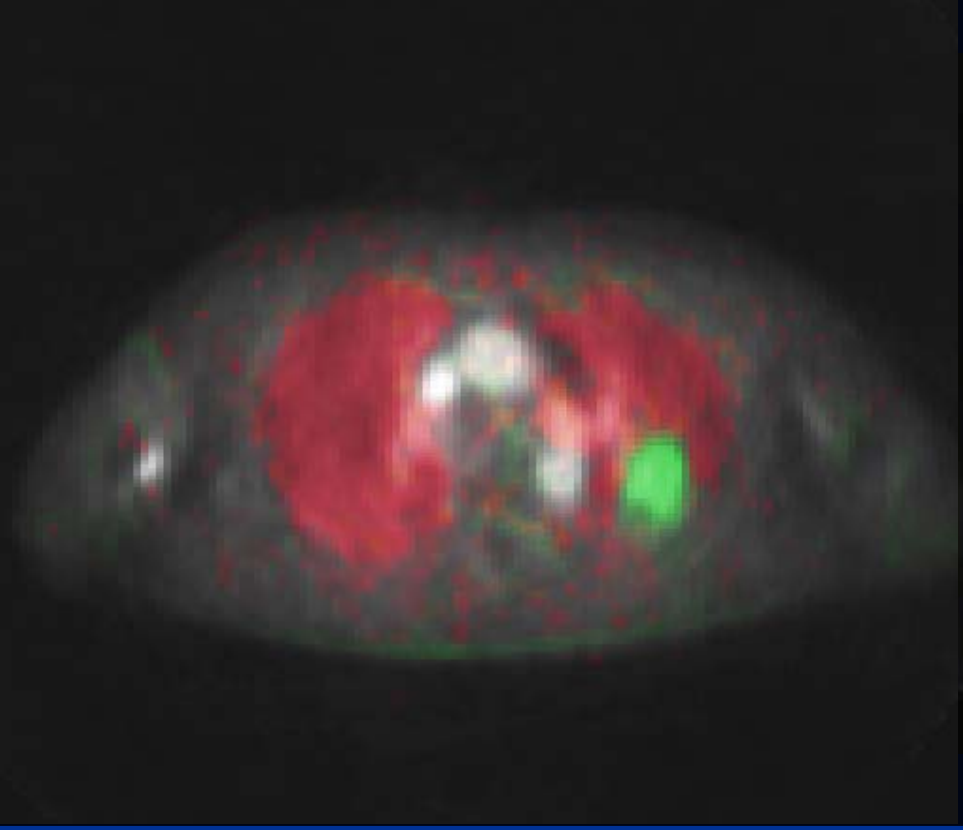
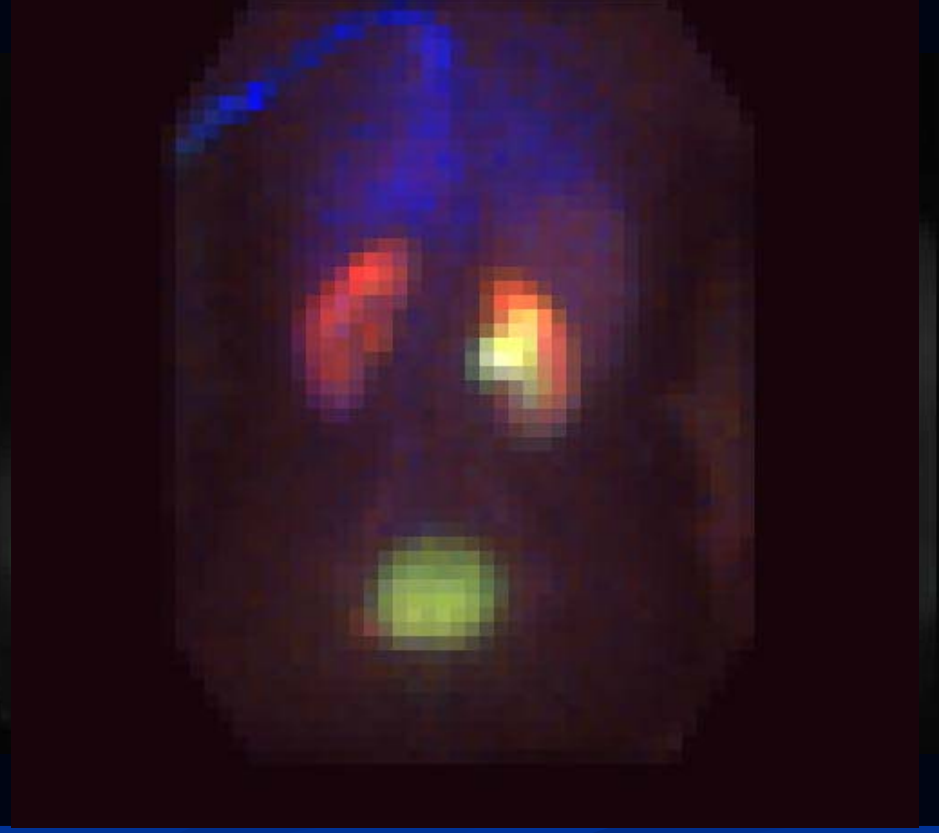
Needs **criterion** to distinguish inside from ouside

e.g.: „characteristic properties of TAC“ (PET)

Points whose measured Time-Activity-Curve shows certain properties are regarded inside.

There is a indefinite range of mathematical possibilities to describe and evaluate such properties.





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Needs **criterion** to distinguish inside from ouside

e.g.: „Multi-modal imaging“ („multi-spectral“ MRI)

Points show a vector of measured values.

There is a indefinite range of mathematical possibilities to define properties in a multidimensional vector-space.

distinguish

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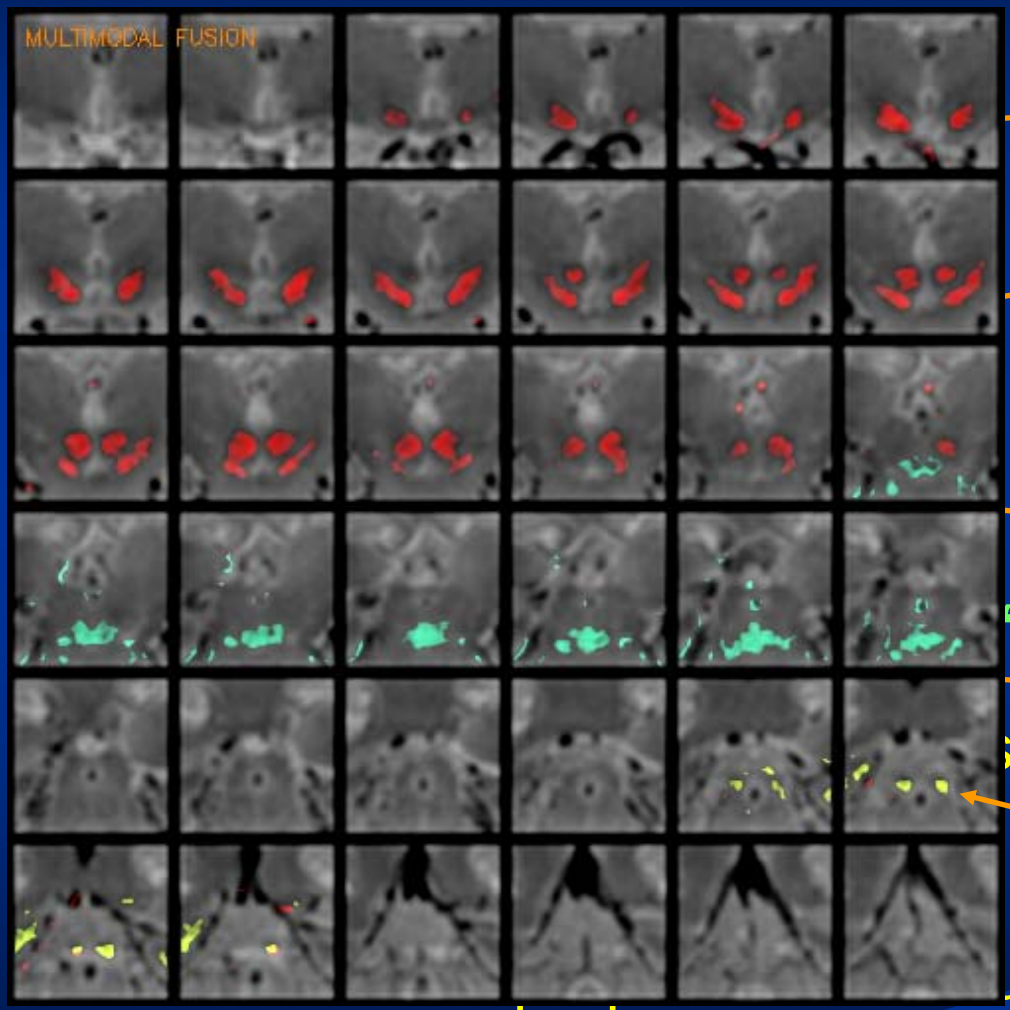
Volume Delineation



36 slices
40mm*40mm*1mm
1mm slice to slice

nucleus subthalamicus

substancia nigra

nucleus ruber

(„multi- spectral“ MRI)

brachium conjunctivum

sured values.

nucleus tegmenti pedunculo pontinus (PPN) (?)

of mathematical possibilities

ultidimensional vector-space.

6D vector measured for each voxel by using different puls sequences

not quite sure, because never seen before in MRI

but now …

… back to the roots !

Illustration using „Phantom“-Data

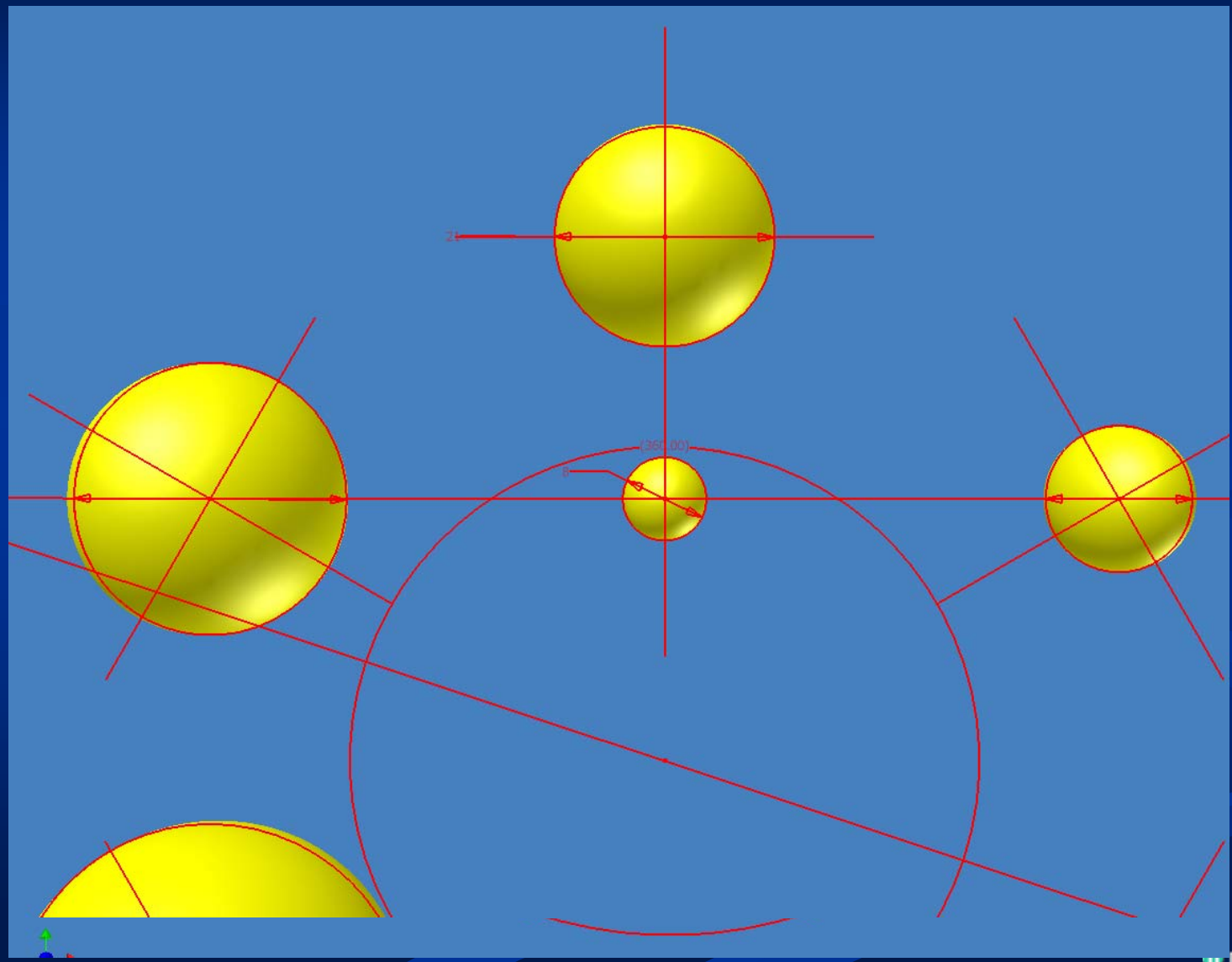
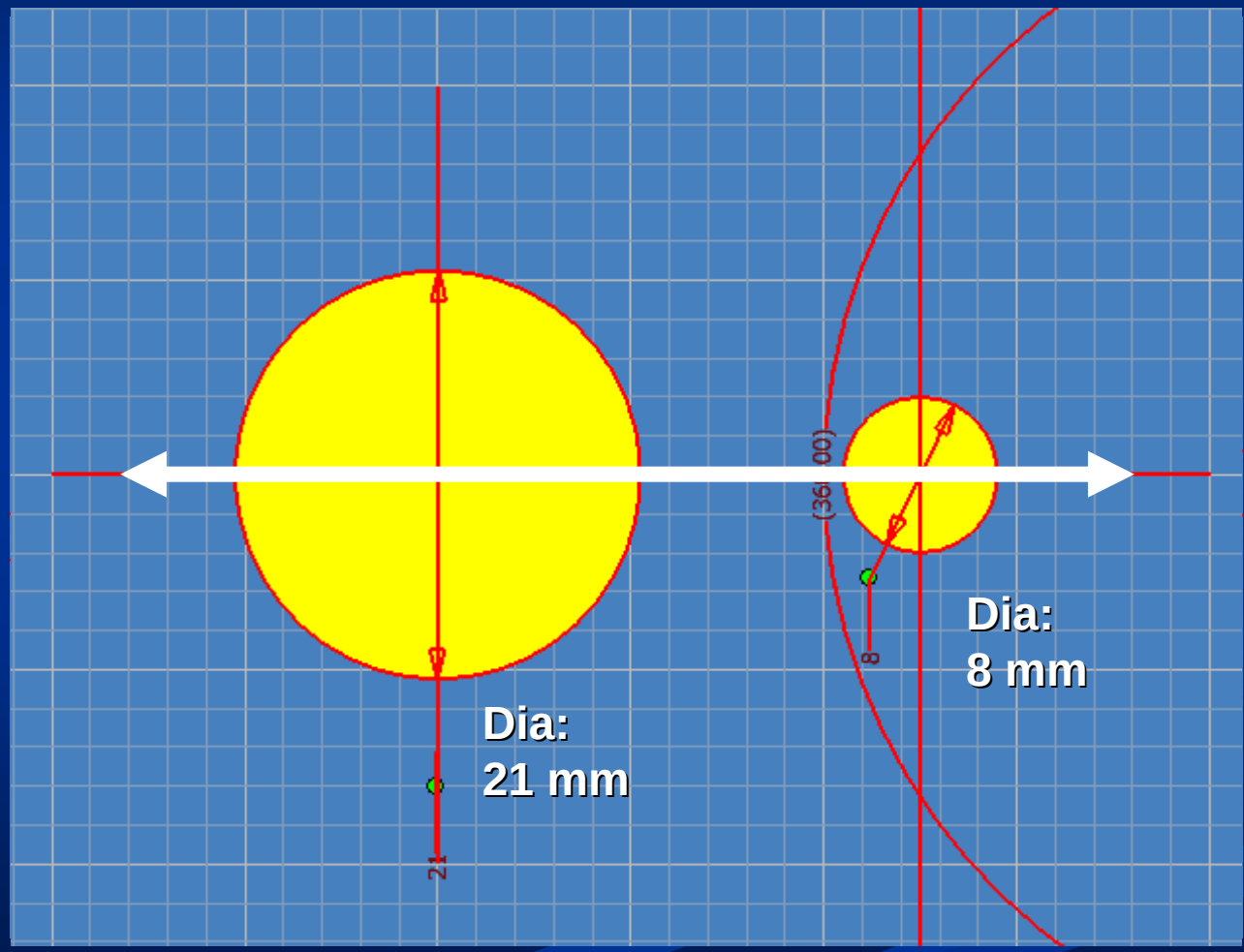
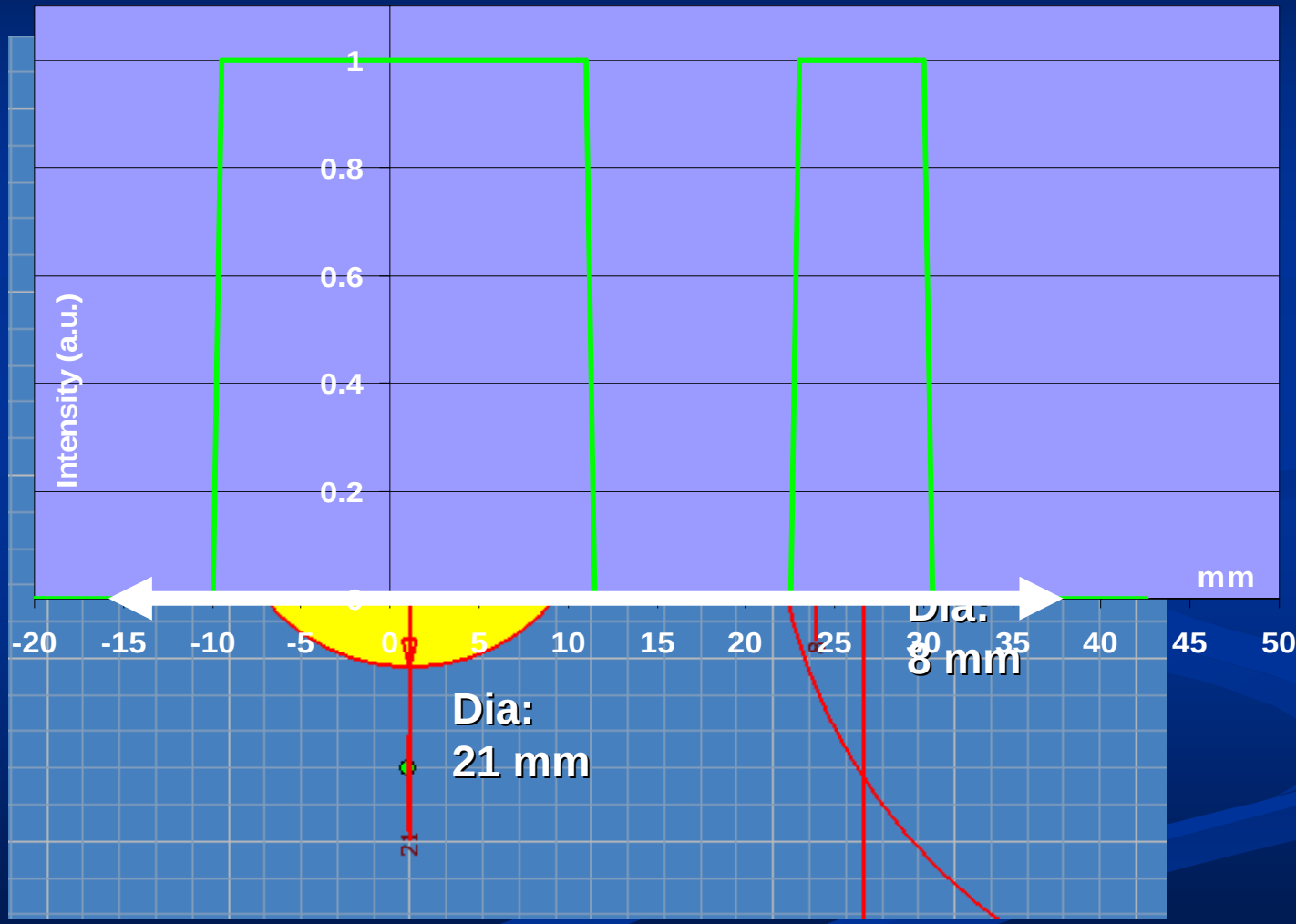


Illustration using „Phantom“-Data

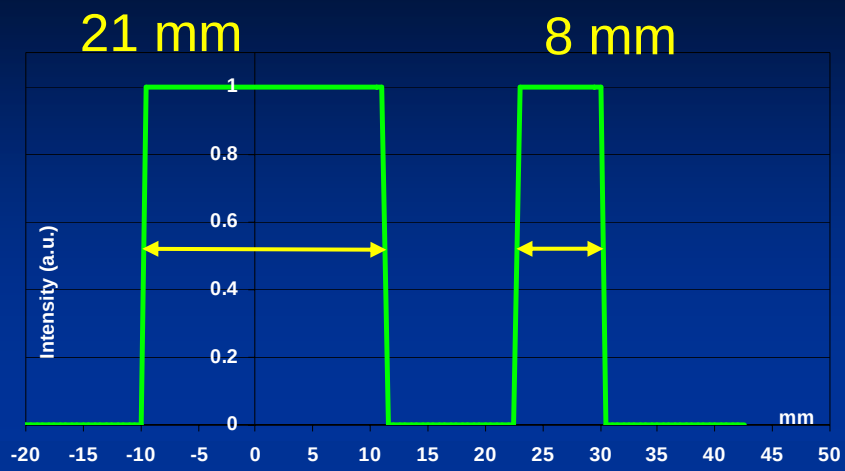


Determining Intensity

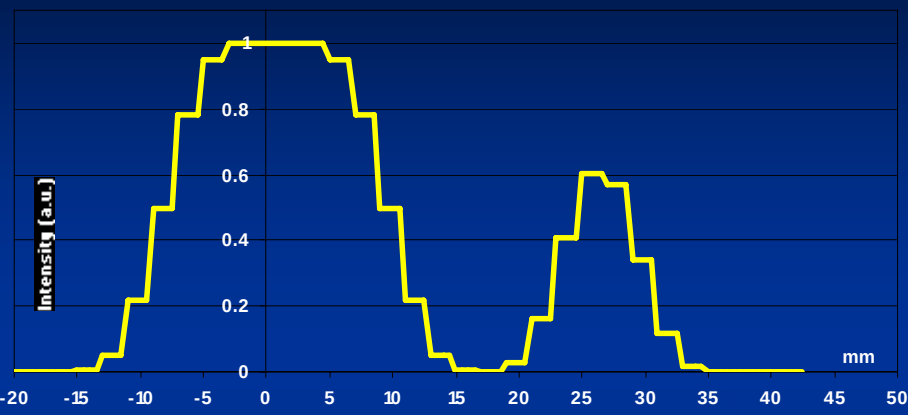


Imaging:

Object



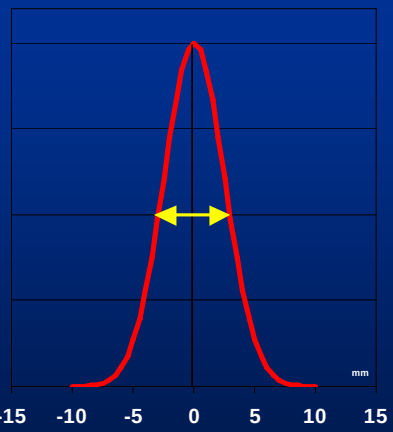
Image

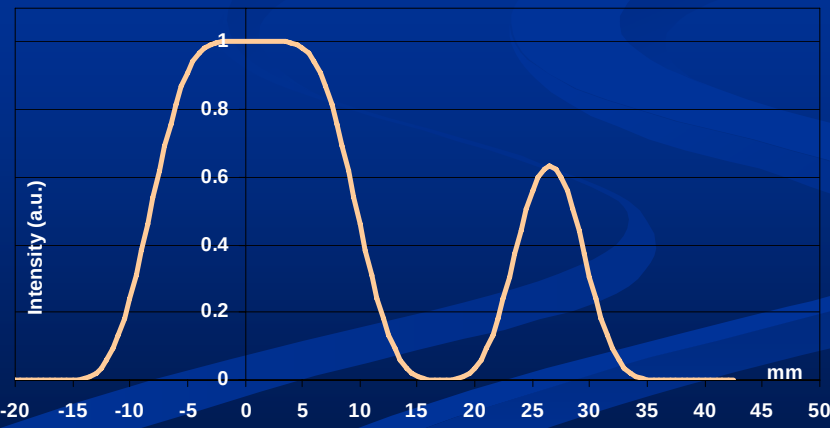


Convolution + Sampling

Transfer Function

FWHM ca. 5.5 mm

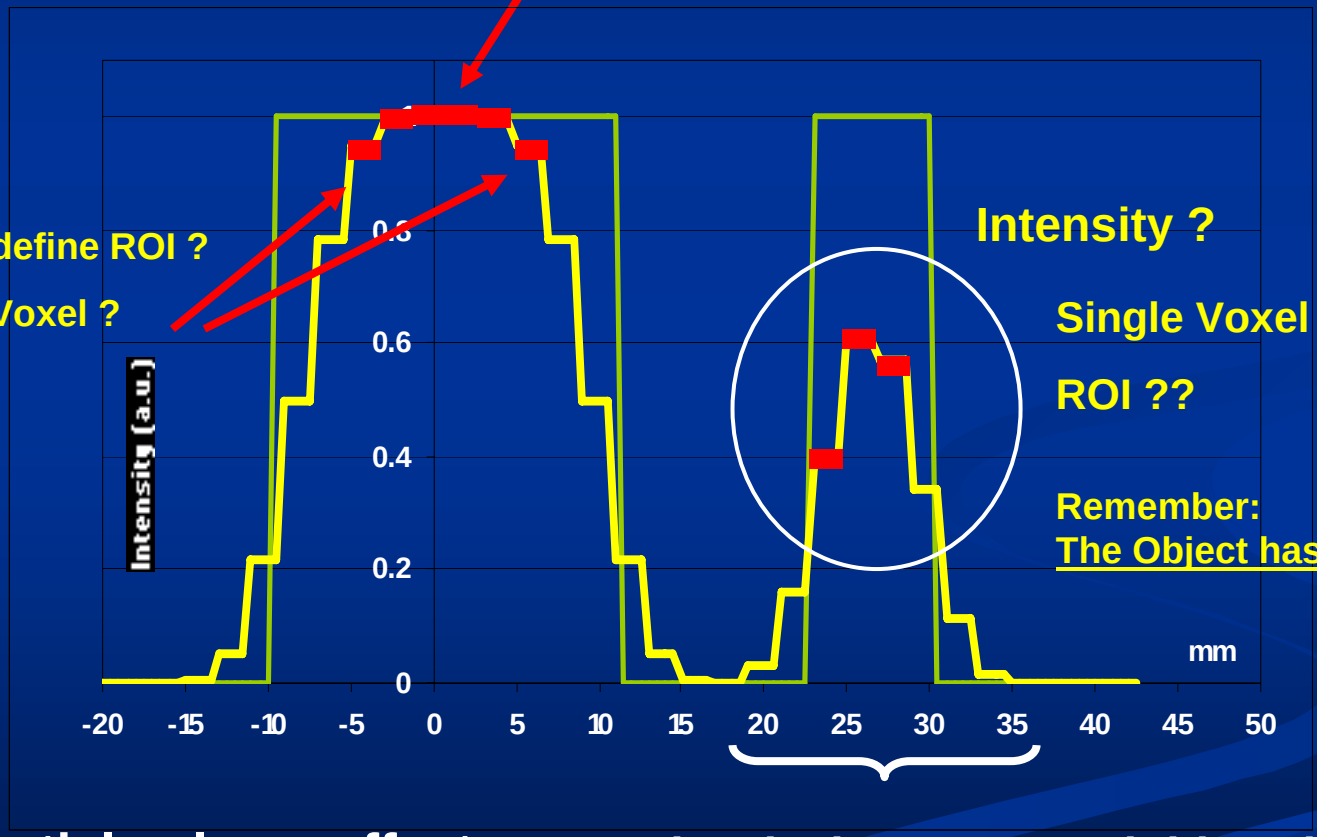




Determining Intensity

Intensity: 4 Voxel reach (almost) full intensity

-> define as ROI and calculate average to determine original intensity ...



How to define ROI ?

Border Voxel ?

Intensity ?

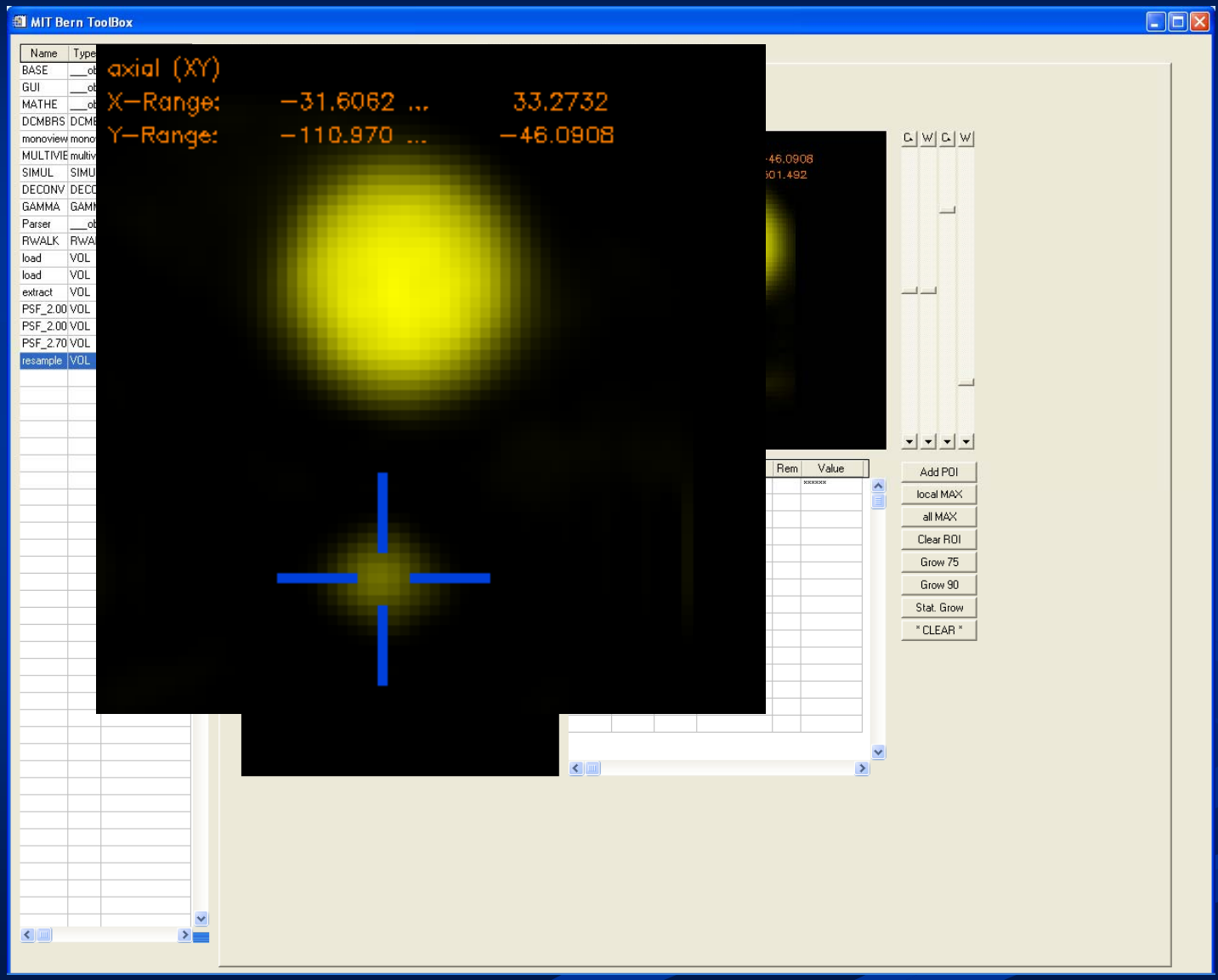
Single Voxel maximum ?

ROI ??

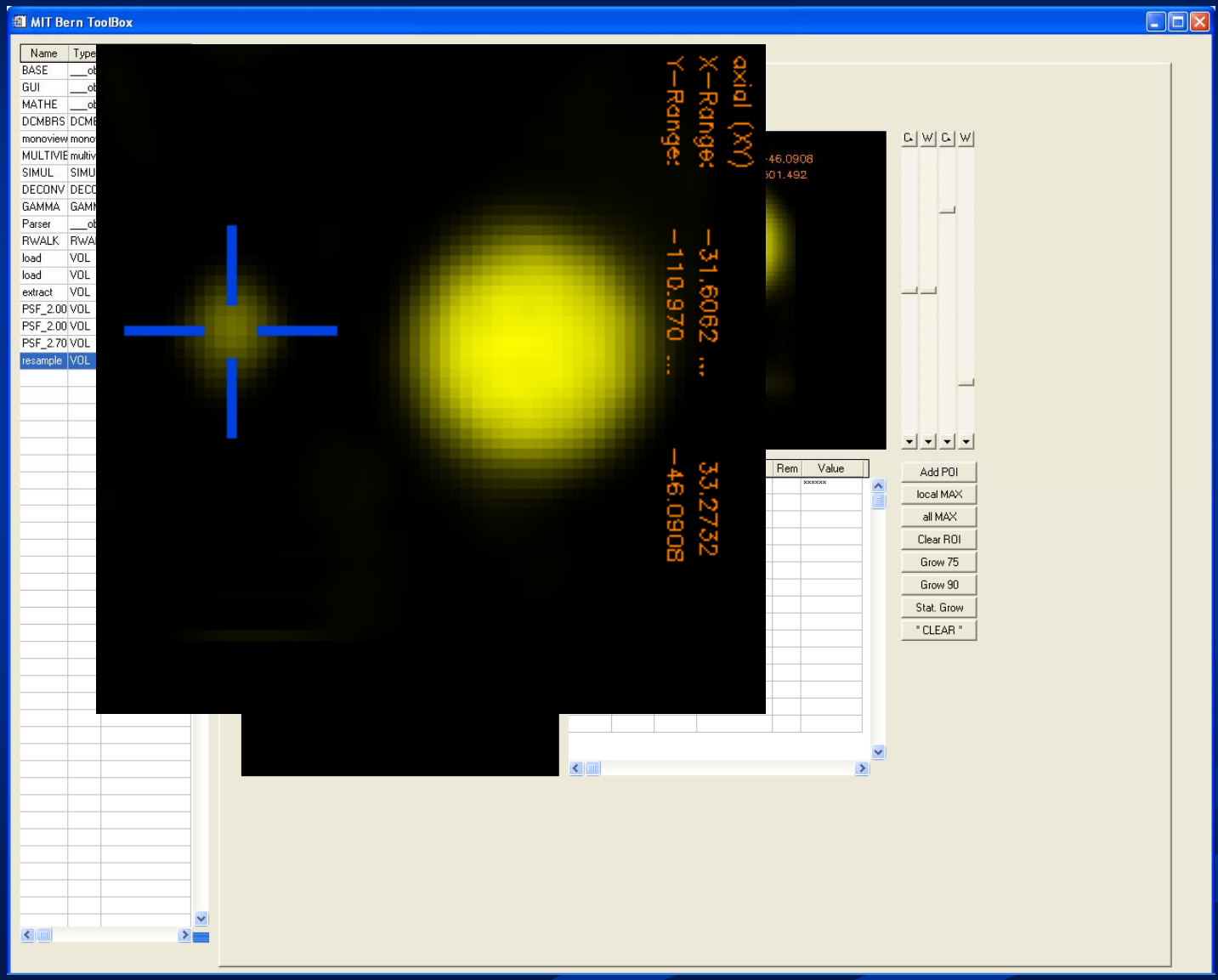
Remember:
The Object has 8 mm in Diameter

Partial volume effect: **Intensity „leaks out“ to neighbouring Voxels in 3 dimensions (!) but is not lost at all ...**

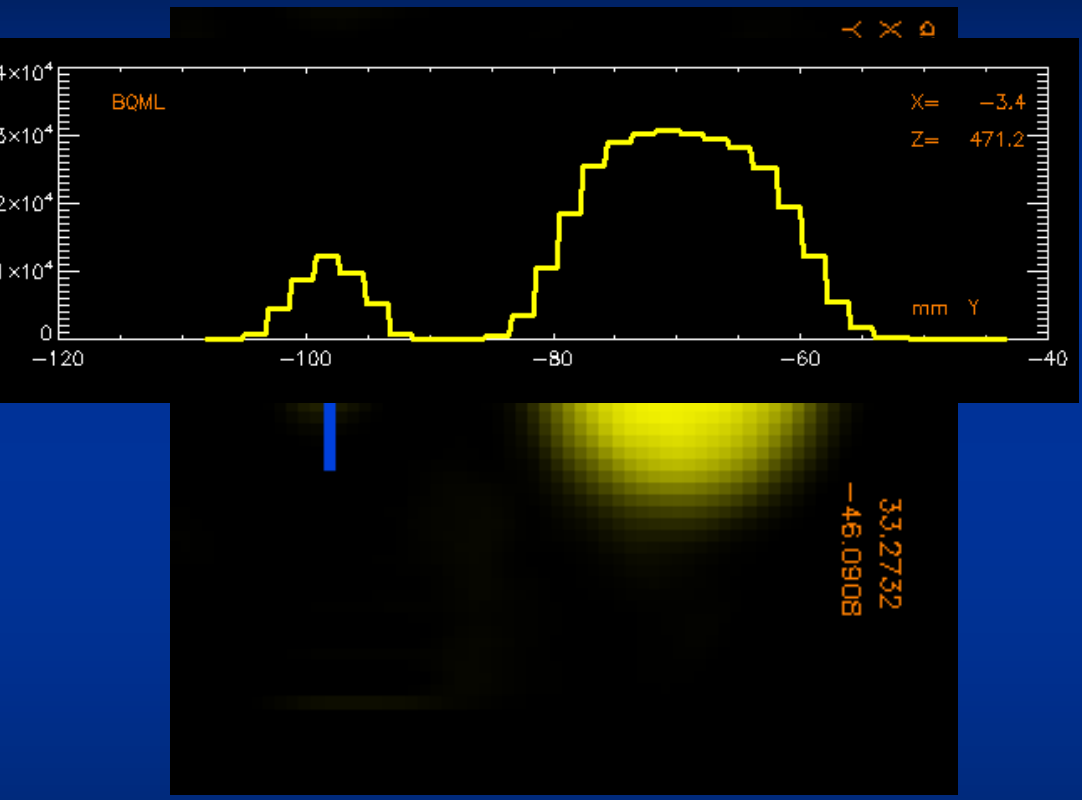
Measurement



Measurement

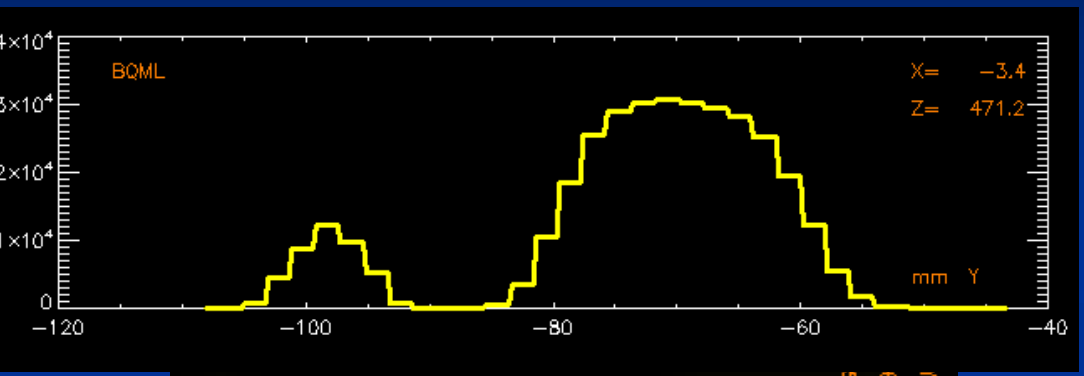


Measurement



Dia. 8 mm

Dia. 21 mm



Convolution ⟺ Deconvolution

Minimal Entropy Deconvolution

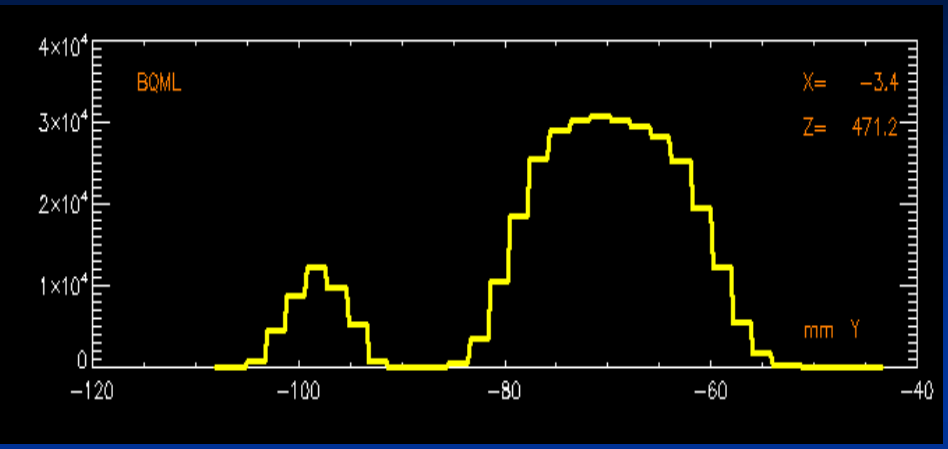
Sampling ⟺ Resampling

Fourier Transform Interpolation

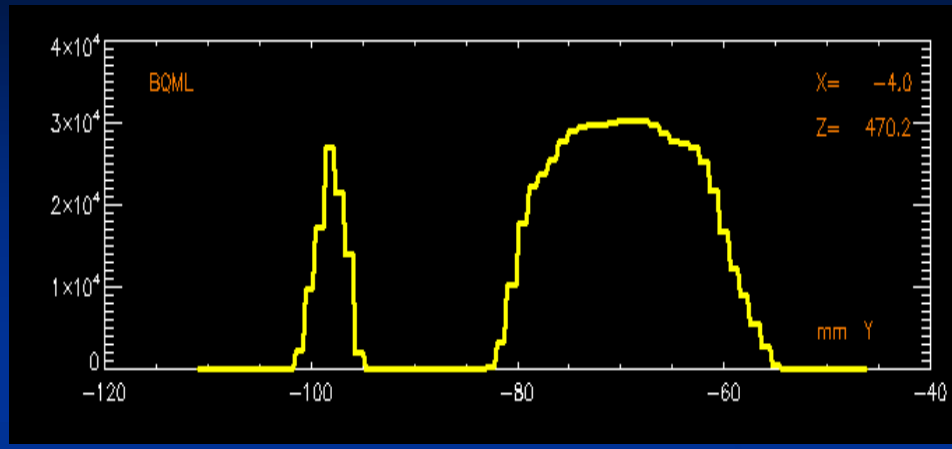
Measurement ⟺ Region Growing

Statistical Region Growing

Image



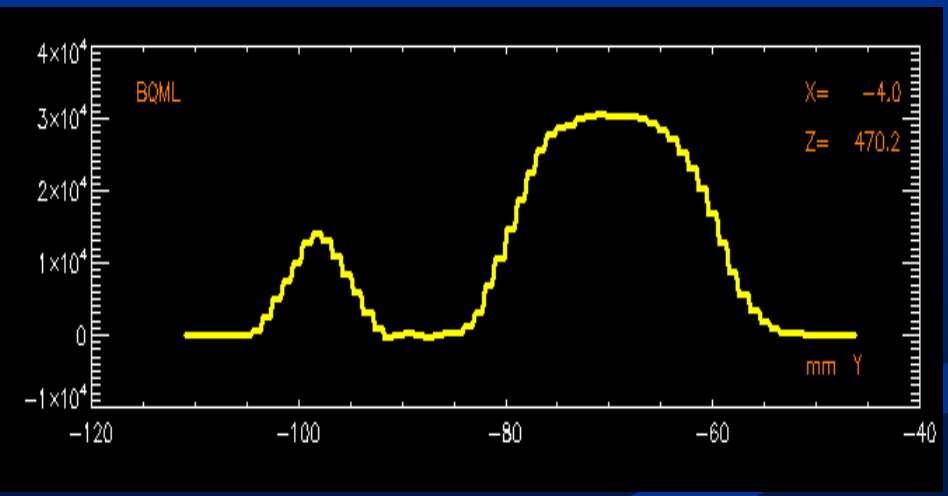
Reconstructed Object

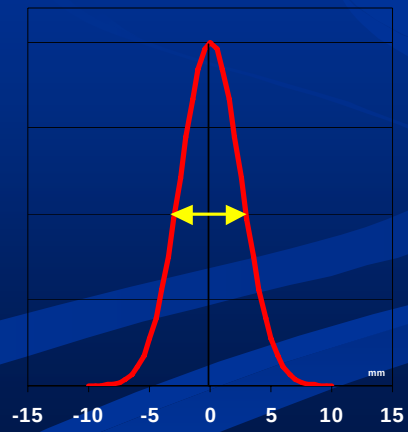


FT Interpolation
(Resampling)

+

Deconvolution

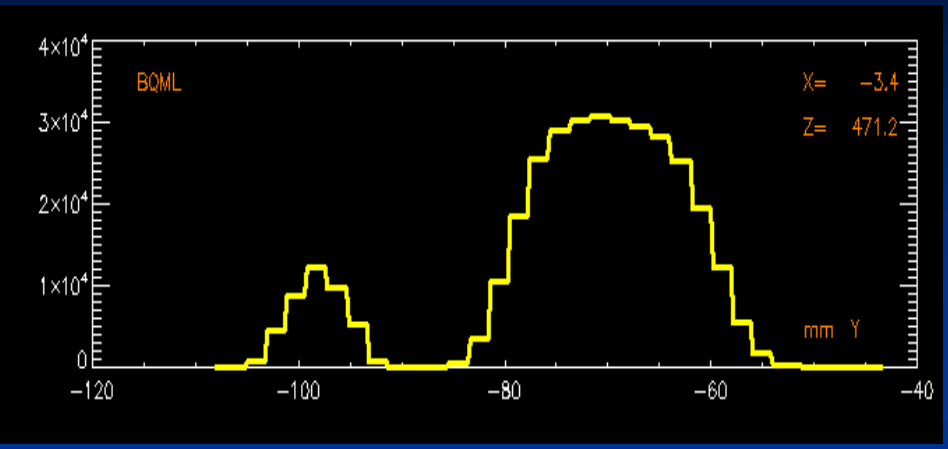




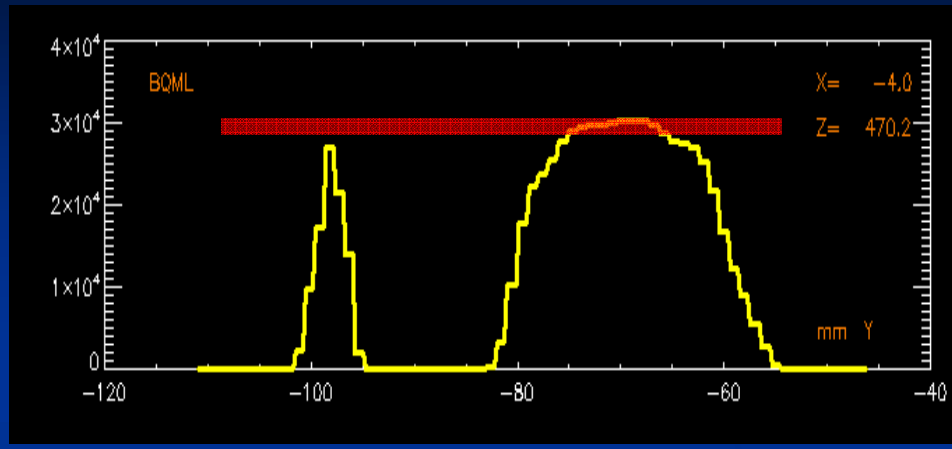
Transfer Function

FWHM ca. 5.5 mm

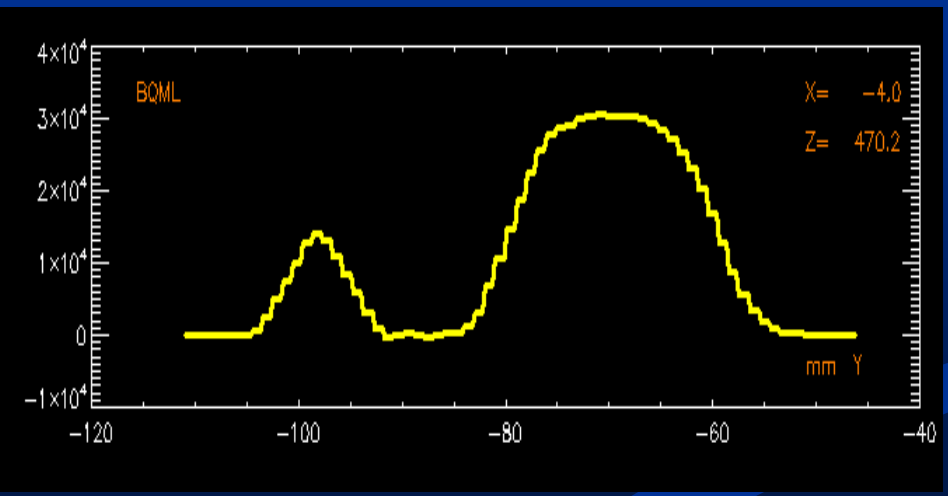
Image

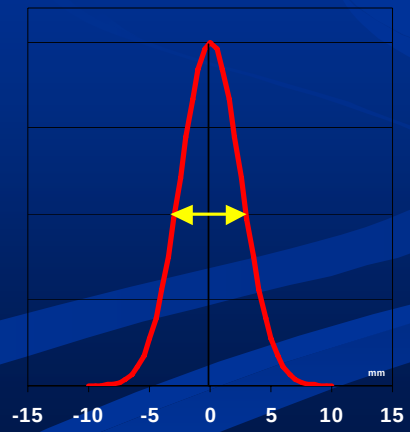


Reconstruction



FT Interpolation (Resampling) + Deconvolution





Transfer Function

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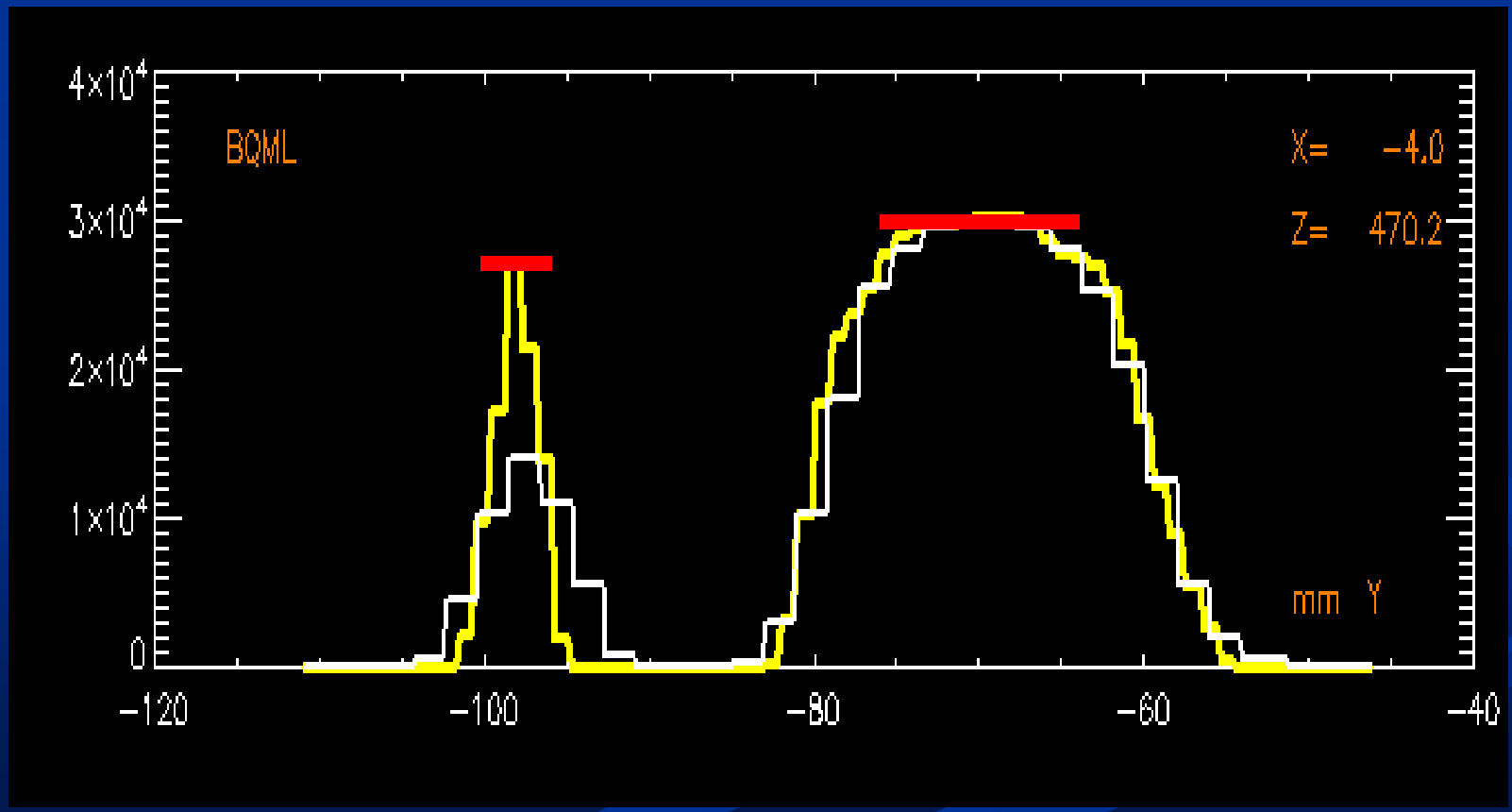
Determining Intensity



Remark:

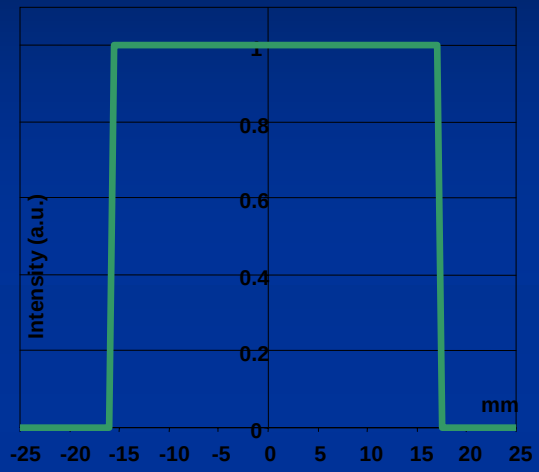
In fact the model just shown
is wrong.

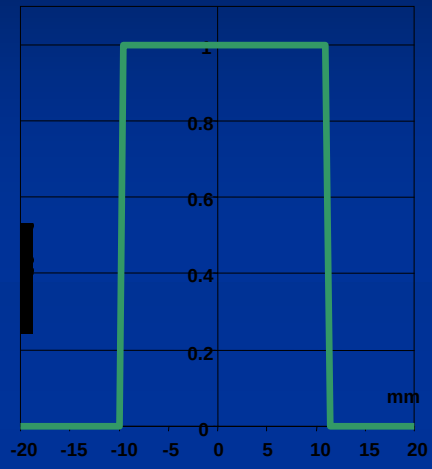
A PET using iterative reconstruction algorithms,
CT based attenuation correction,
superresolution algorithms and
methods to correct for scatter …

… does not have a stable transfer function.

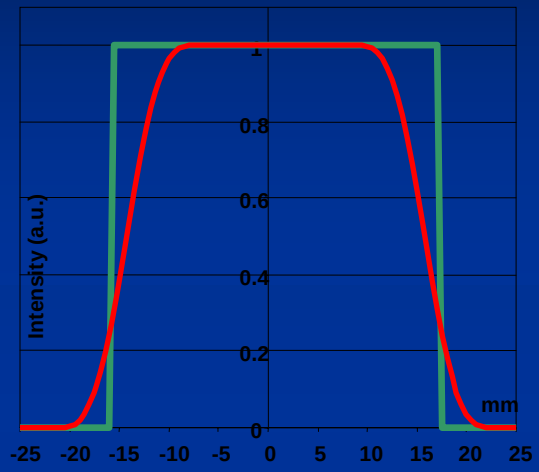
But it looks like it would have …

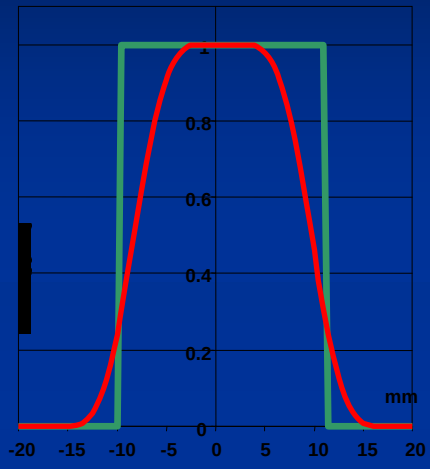
Object,


Intensity (a.u.)
1
0.8
0.6
0.4
0.2
0
mm
-25 -20 -15 -10 -5 0 5 10 15 20 25

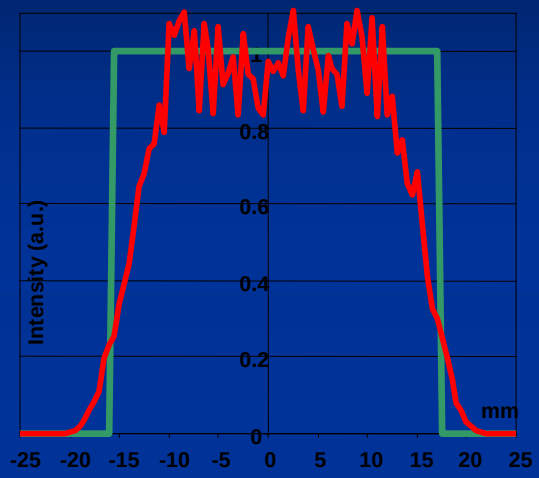

1
0.8
0.6
0.4
0.2
0
mm
-20 -15 -10 -5 0 5 10 15 20

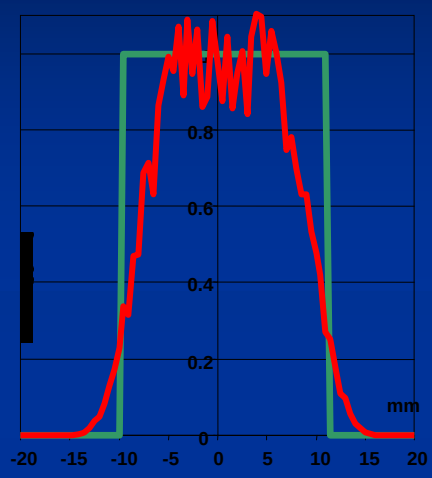
Object, Convolution,



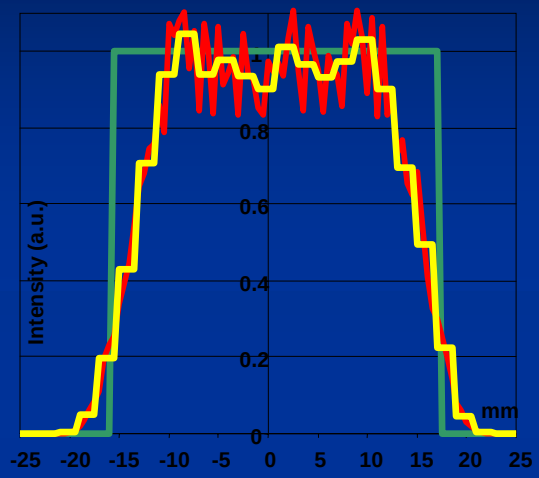


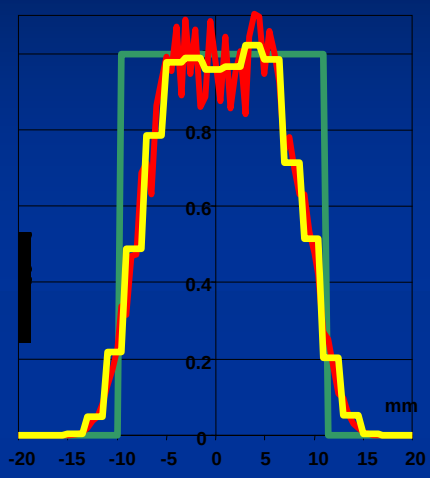
Object, Convolution, **Noise,**



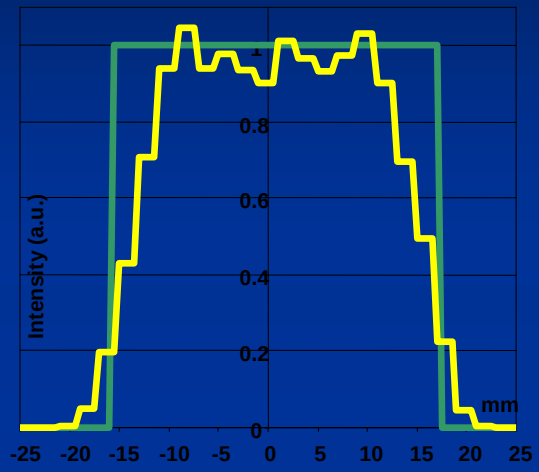


Object, Convolution, **Noise,** Sampling...





-> Signal


Intensity (a.u.)
0.8
0.6
0.4
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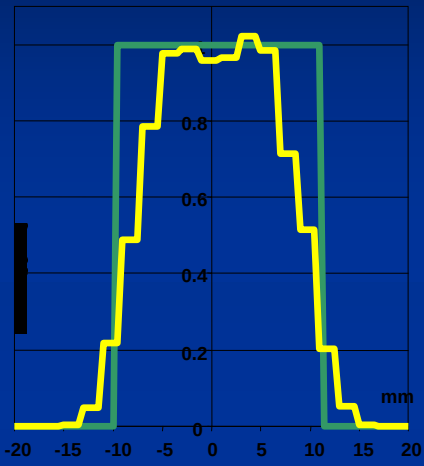
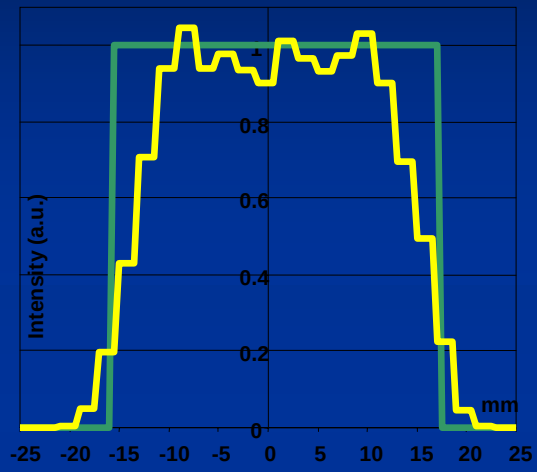
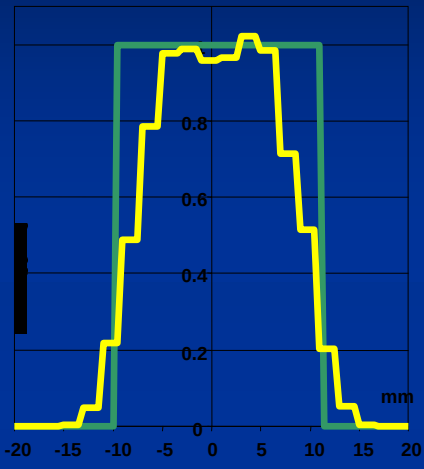
0
mm
-25 -20 -15 -10 -5 0 5 10 15 20 25


0.8
0.6
0.4
0.2
0
mm
-20 -15 -10 -5 0 5 10 15 20

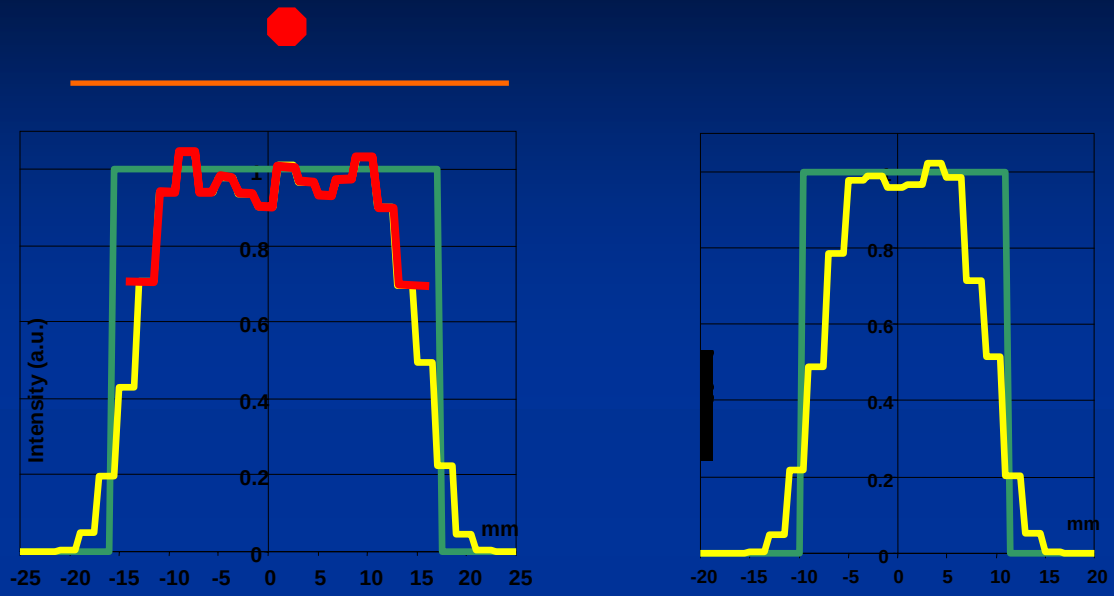
Region Growing conventional





1: choose a point within Region of Interest
2: „grow“ by including all neighbors with (e.g.) Intensity > 80%

Region Growing conventional

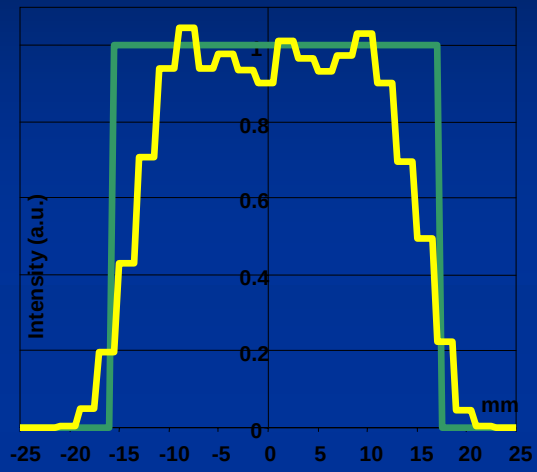


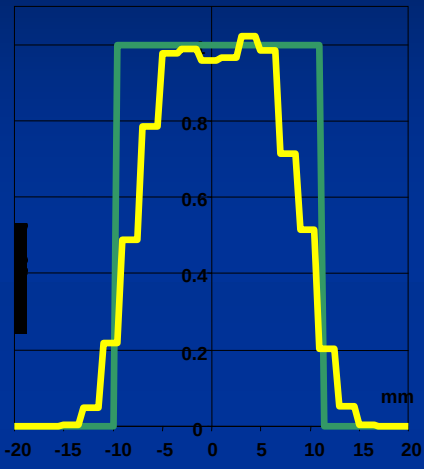
1: choose a point within Region of Interest
2: „grow“ by including all neighbors with (e.g.) Intensity > 80%

=> (-) result depending on arbitrary starting point

=> (-) not suitable for very small regions

Region Growing, statistical, local

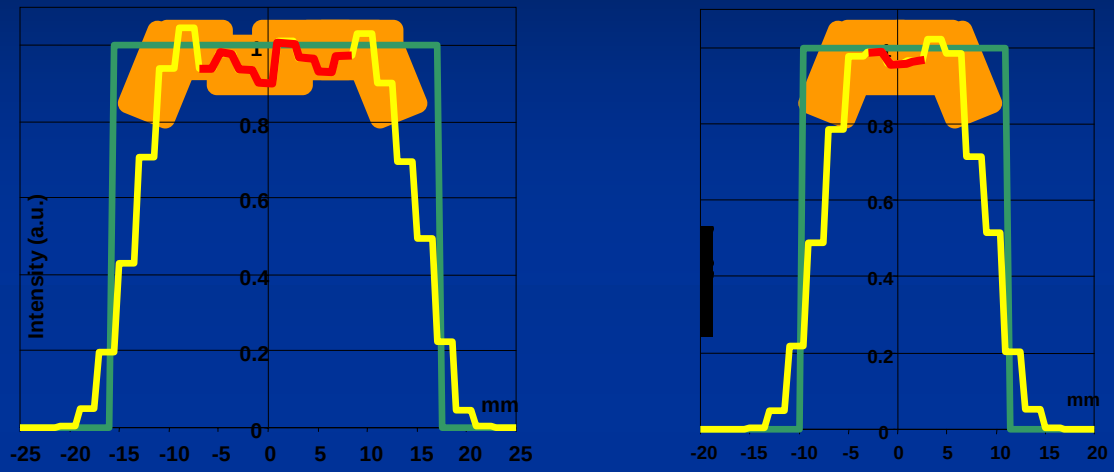




1: choose a point within Region of Interest

2: „grow“ by including all neighbors having a „flat“ environment (e.g.) standard deviation in local surrounding below a limit

Region Growing, statistical, local



1: choose a point within Region of Interest

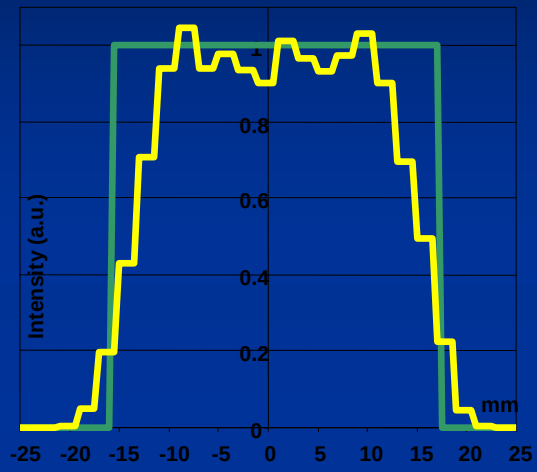
2: „grow“ by including all neighbors having a „flat“ environment (e.g.) standard deviation in local surrounding below a limit

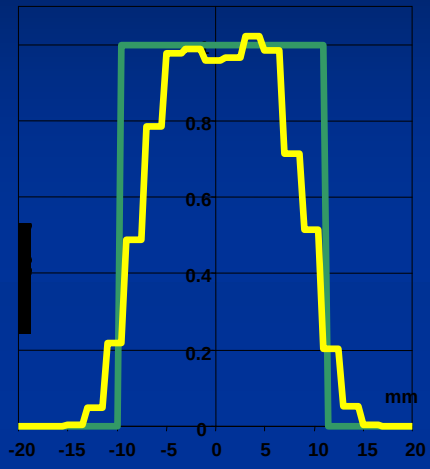
=> (+) result does not depend on starting point

=> (-) border of area is missing

=> (-) tendency to grow out of ROI via potential „smooth“ pathways

Region Growing, statistical, full region





1: choose a point within Region of Interest

2: „grow“ by including neighbors if the <u>overall</u> variance of the total resulting new region stays within given limit.

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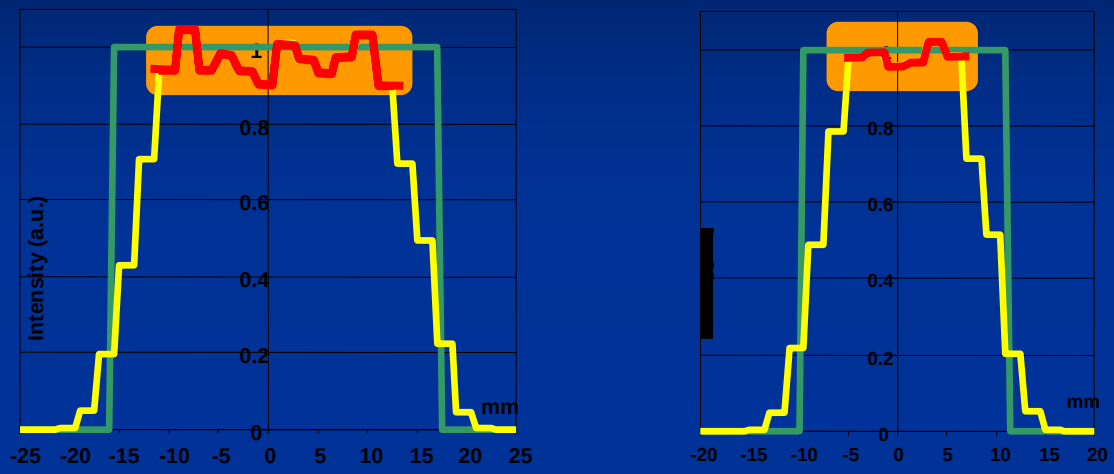
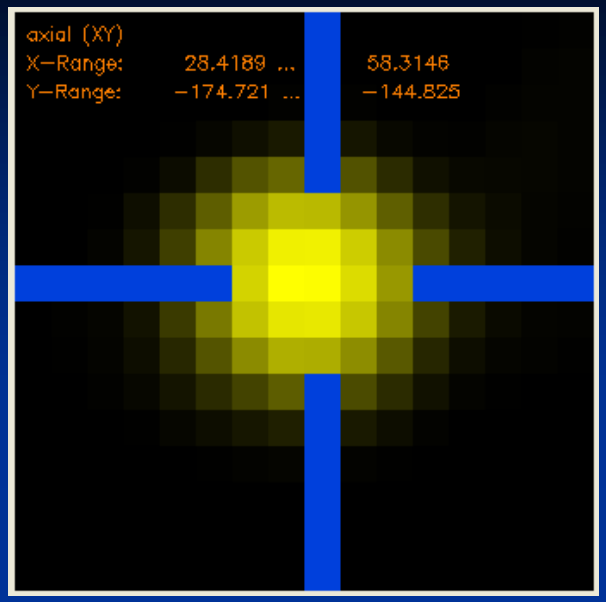


1: choose a point within Region of Interest

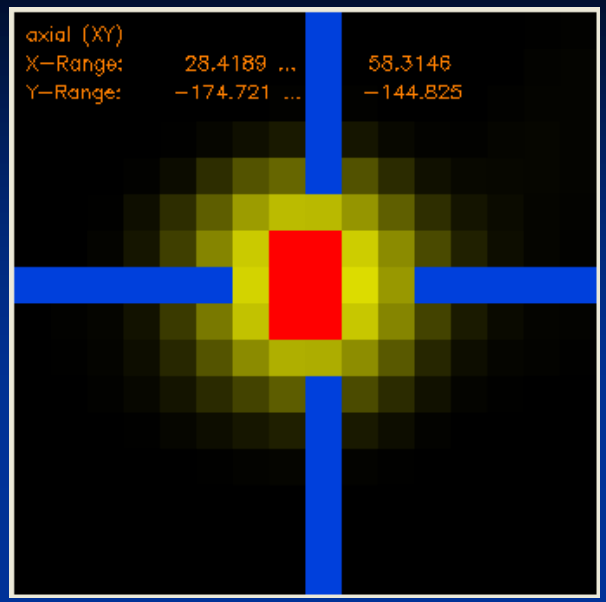
2: „grow“ by including neighbors if the overall variance of the total resulting new region stays within given limit.

=> (+) result does not depend on arbitrary starting point

=> (+) process includes the „bordersurface“ i.e. even very small regions are captured

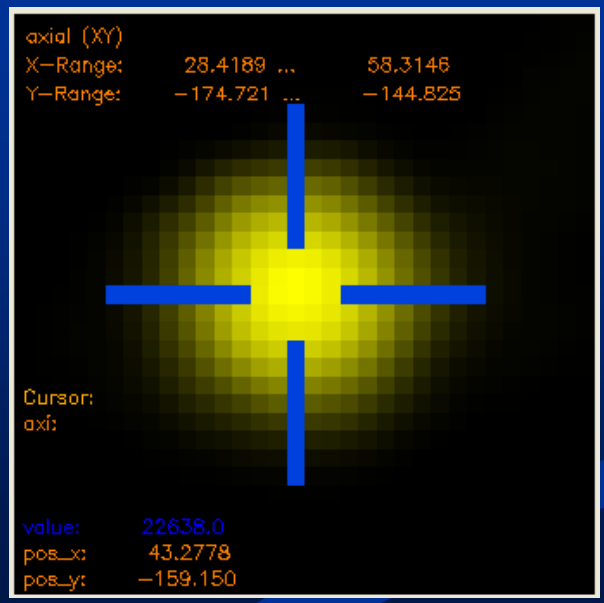


Reg.Grow
90 %

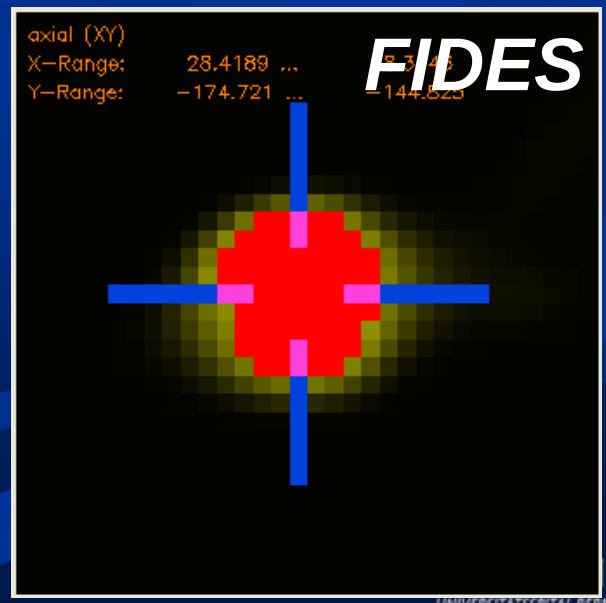


FTI

Deconvol.



Stat.Grow
„0.05“



Volume Delineation:

The simple case:

- More or less homogeneous region of interest …
- .. inside of another more or less homogeneous region
- Region is big compared to spatial resolution and sampling period,
  i.e. combined volume of „surface voxels“ is small compared to total volume of region of interest.
- Measured values inside region show a significant difference to values outside

Use one of the standard methods:
Select a Voxel inside,
then region growing using a suitable threshold

Volume Delineation:

The not so simple case:

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- Low spatial resolution

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- Low signal to noise

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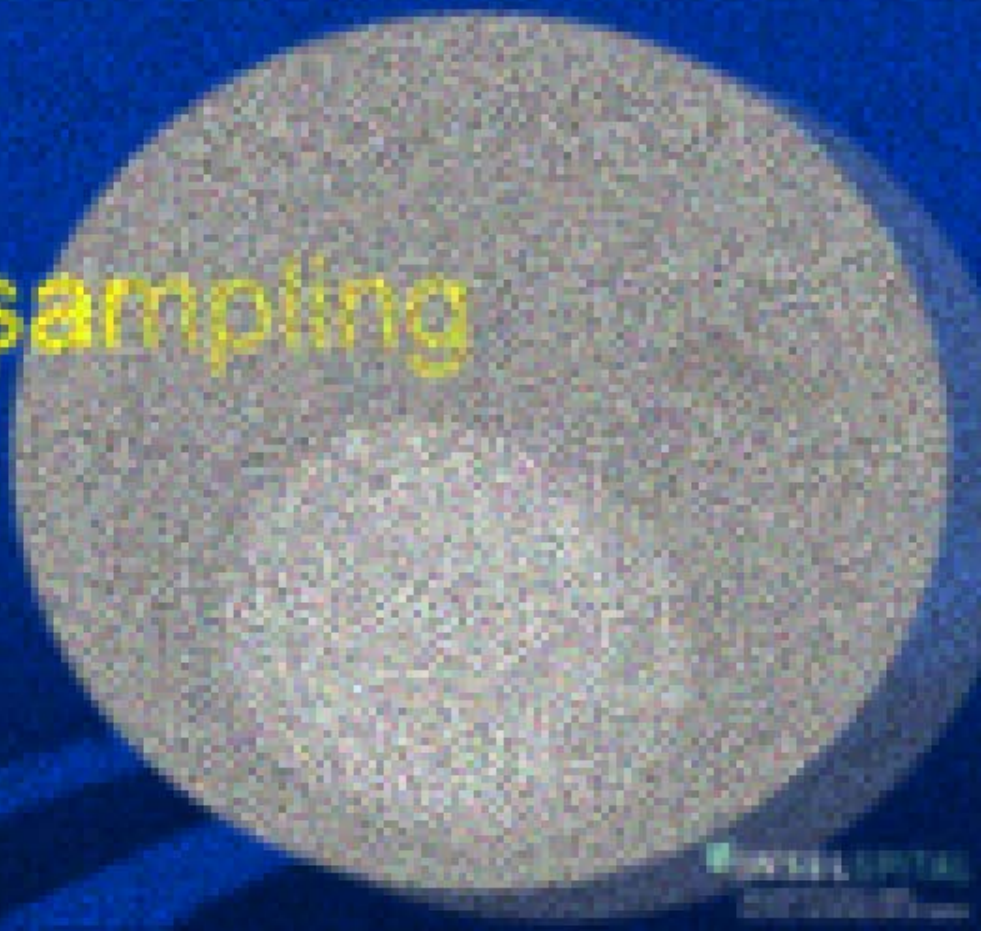

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The not so simple case:

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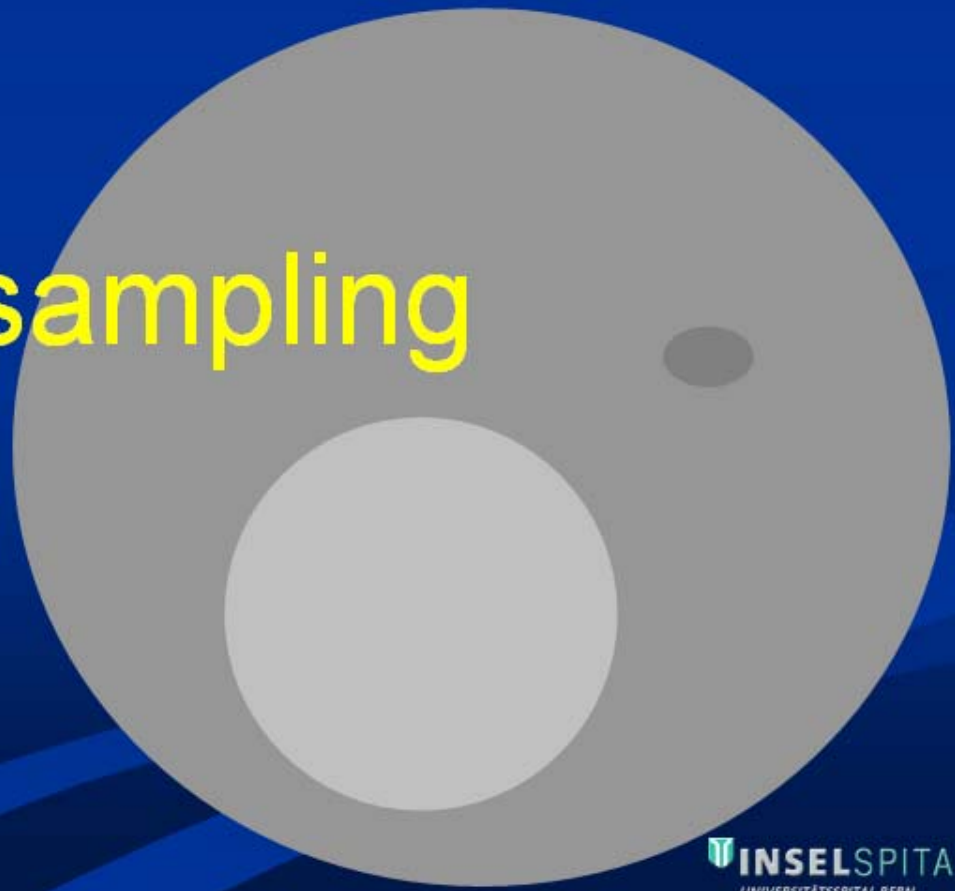
- Low signal to noise
- artifacts
- low spatial sampling frequency



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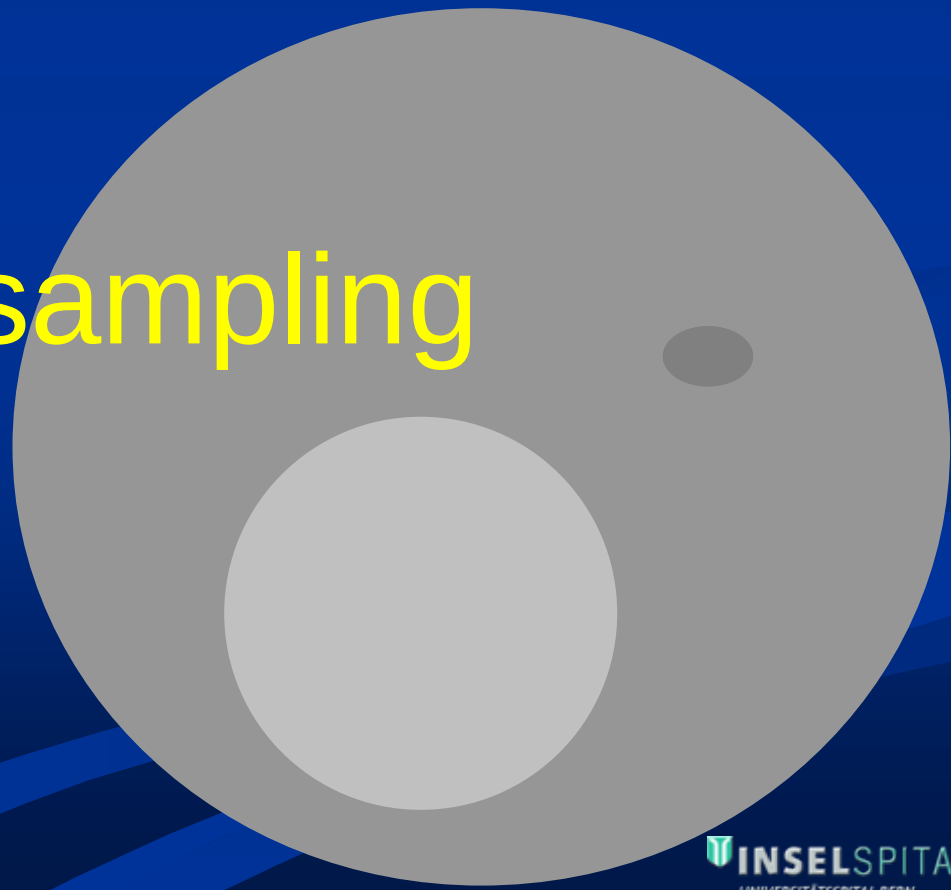

Conclusion

- Use established, standardized methods
  to evaluate your data

Contradiction

- Use physical and mathematical sound methods,
  i.e. numerical calculations,
  to check for validity and to improve your results

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