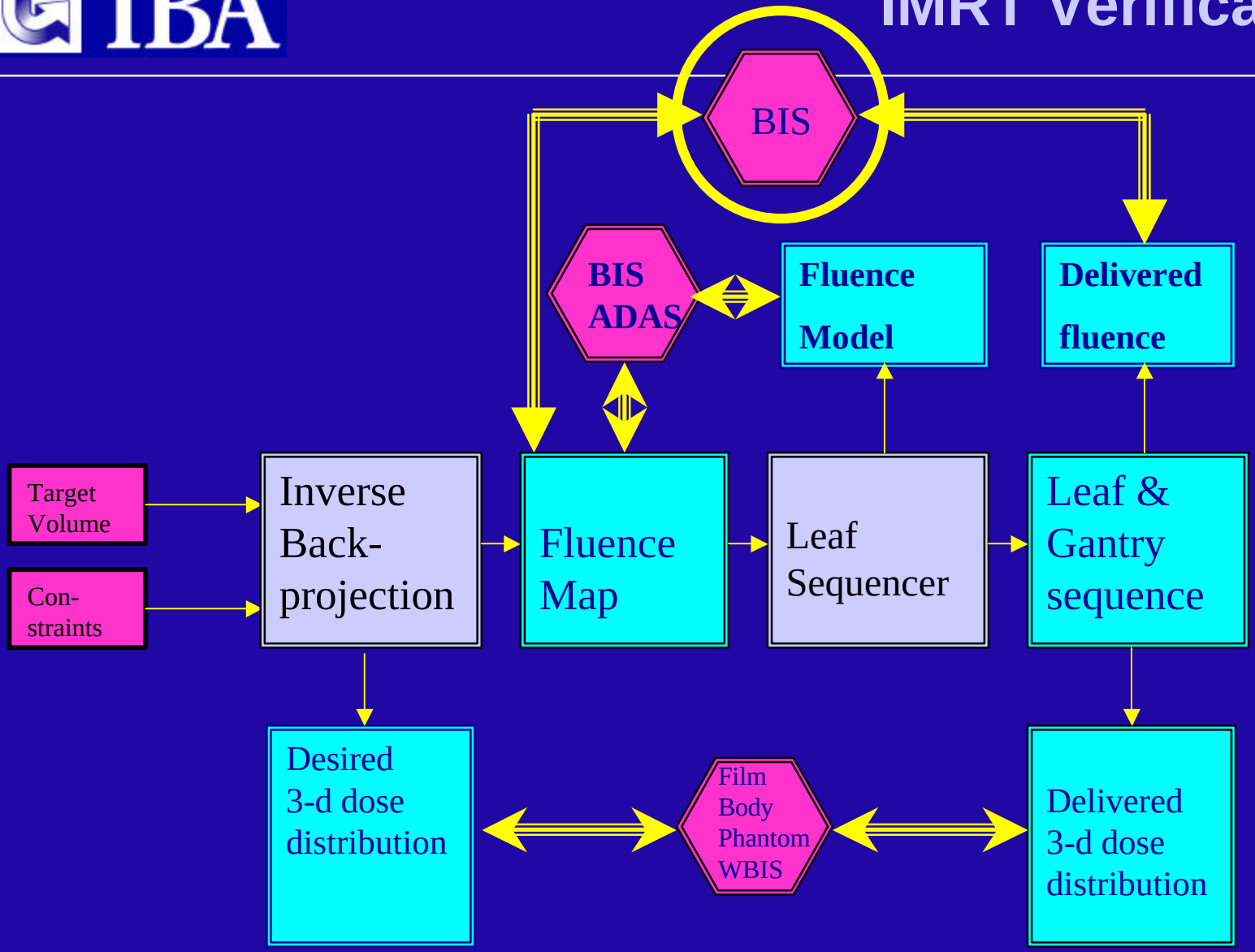
Advanced Radiotherapy

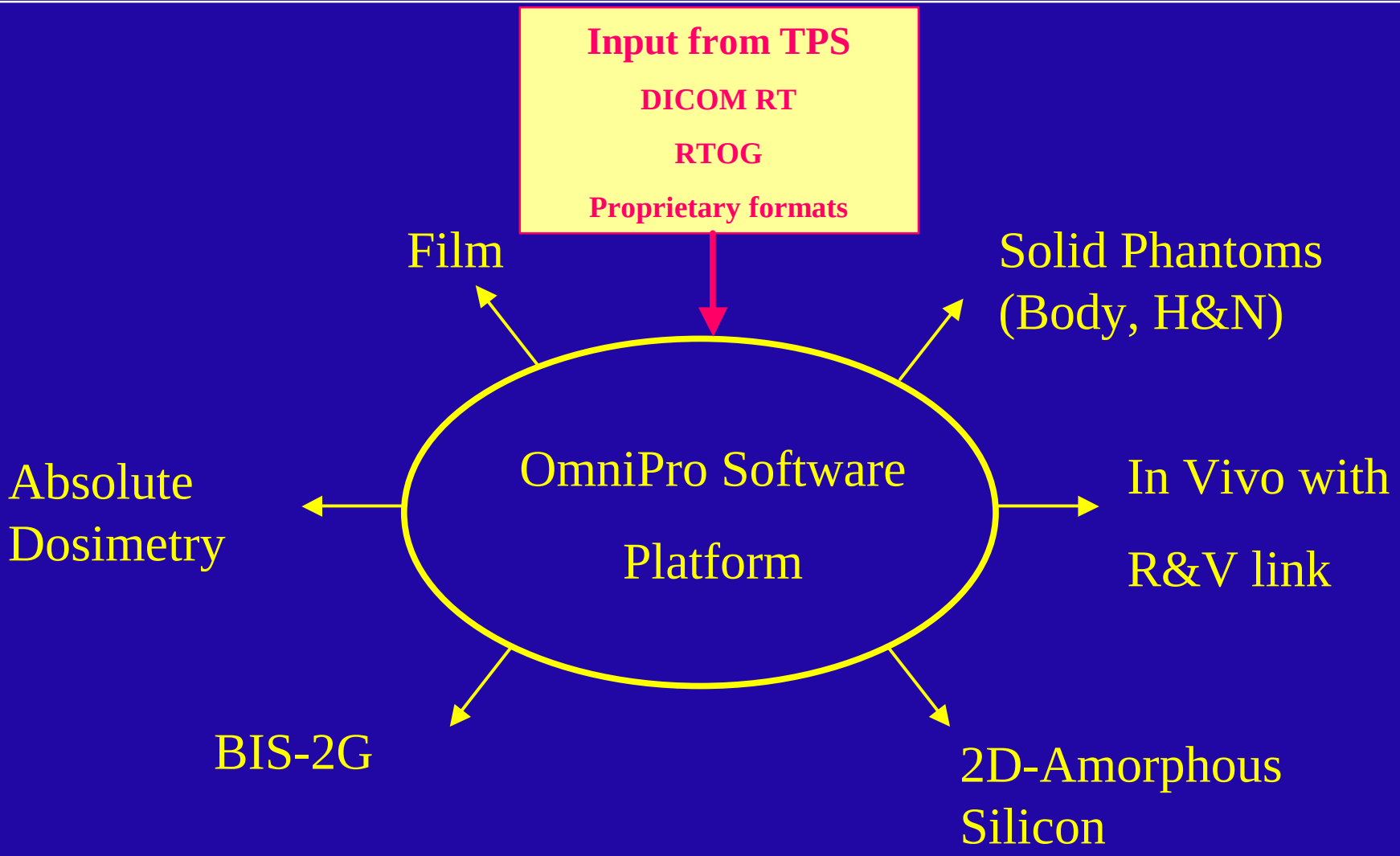
IBA Concept for IMRT Verification

Dr. Lutz Müller

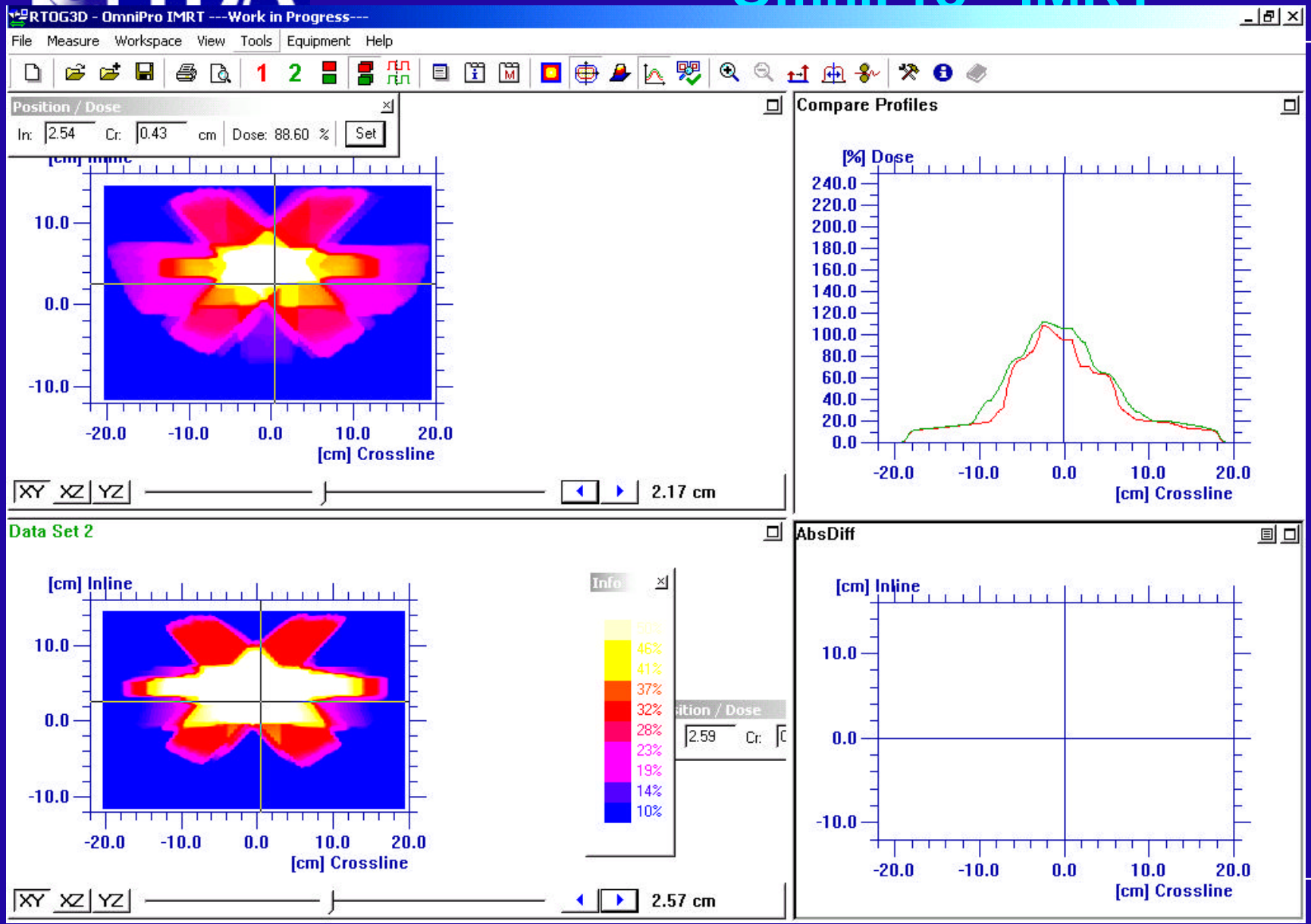
IMRT Verification



Integrated IMRT concept



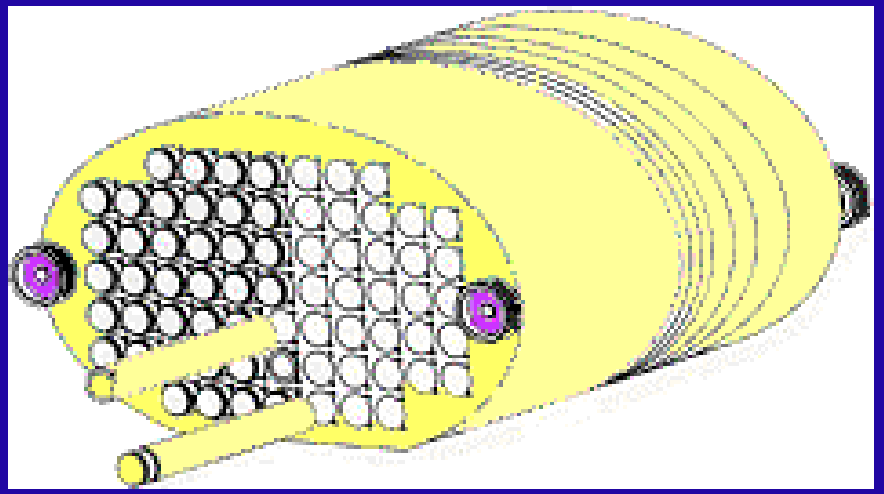
OmniPro - IMRT



Solid-State Phantoms

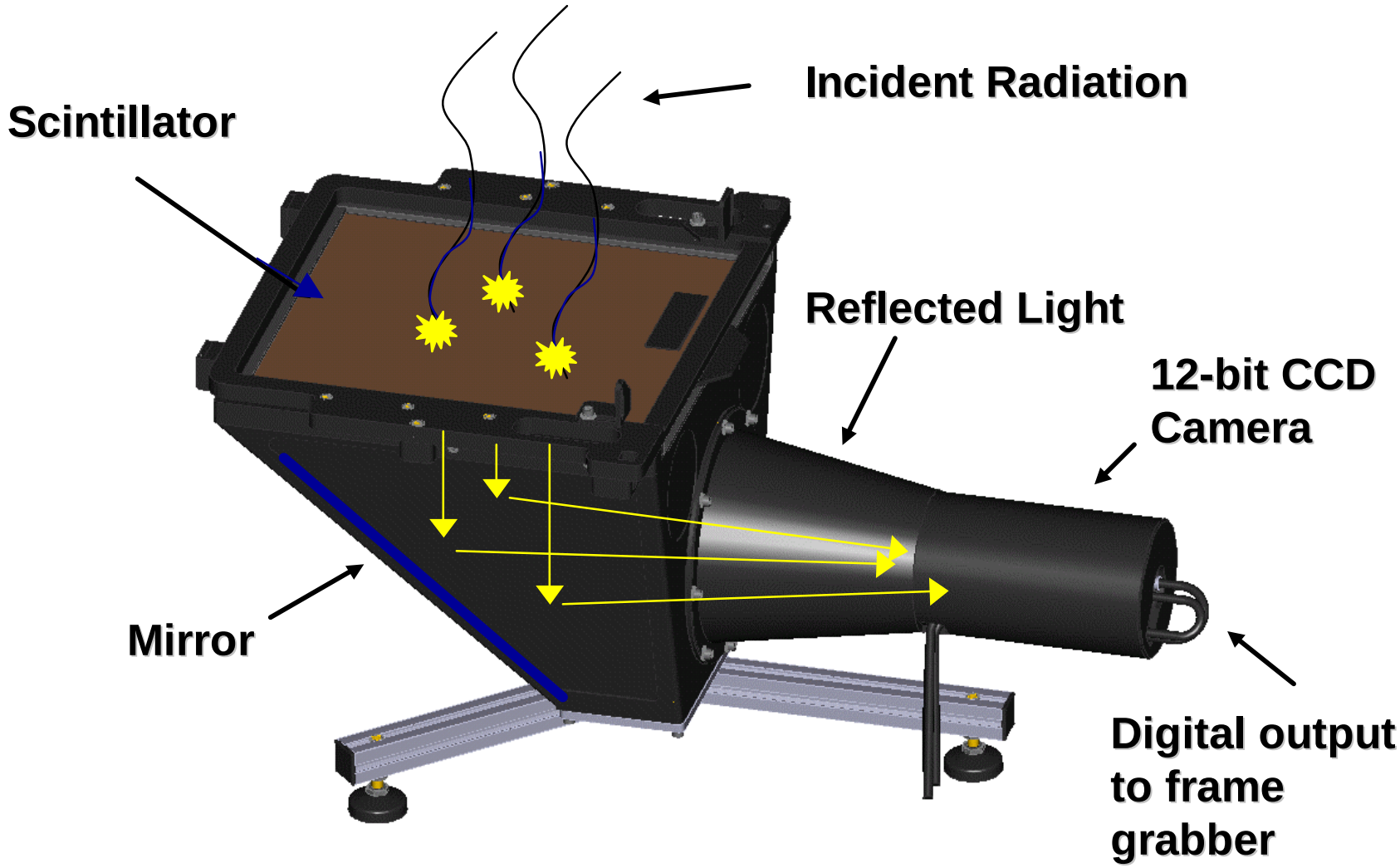
Body Phantom

Head and neck Phantom



Devices:	Film
	Absolute Probes
Applications:	Interface to all common TPS
	Verification of plan
	MU verification

BIS-2G System


Incident Radiation
Scintillator
Reflected Light
12-bit CCD
Camera
Mirror
Digital output
to frame
grabber

Key features

- Fast and simple set-up: less than 5 minutes.
- Positioning on table or in gantry accessory holder.
- Minimum acquisition time: 120 msec per 2D image.
- Typical acquisition time: 500 msec per 2D image.
- Intensity resolution: 12 bit.
- Acquisition of 2D-images in a sequence.
- Spatial resolution 0.4 x 0.4 mm.
- Field size up to 400 x 400 mm.
- Acquisition and analysis integrated in OmniPro software platform.

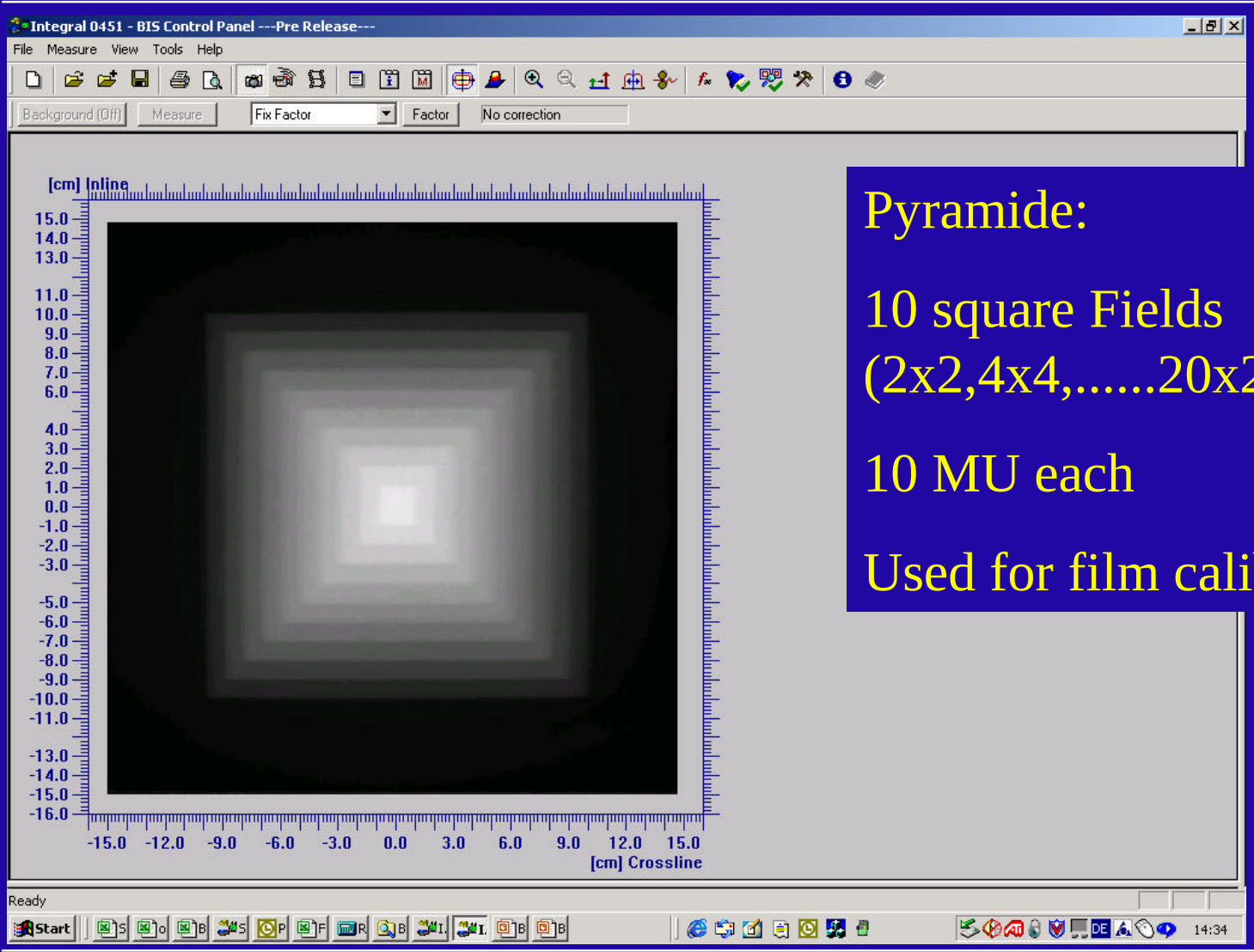
Key applications

- On-line 2D dose distribution (leave movement)
- 2D Fluence measurements
- Verification of complex fields: MLC, dynamic wedge
- Linac start-up behaviour
- Fast daily QA of accelerators (symm.,flatness etc.)
- Leakage of MLC
- Light vs radiation field congruence
- Adjustment of LINAC (on-line 1D inplane+crossplane)

Fluence Verification - Step –and-shoot

Elekta 16 MV
ADAC Pinnacle
Step-and-shoot
BIS
Film
ADAS
EPID (Elekta i-view)
Planar dose from pinnacle

Pyramide



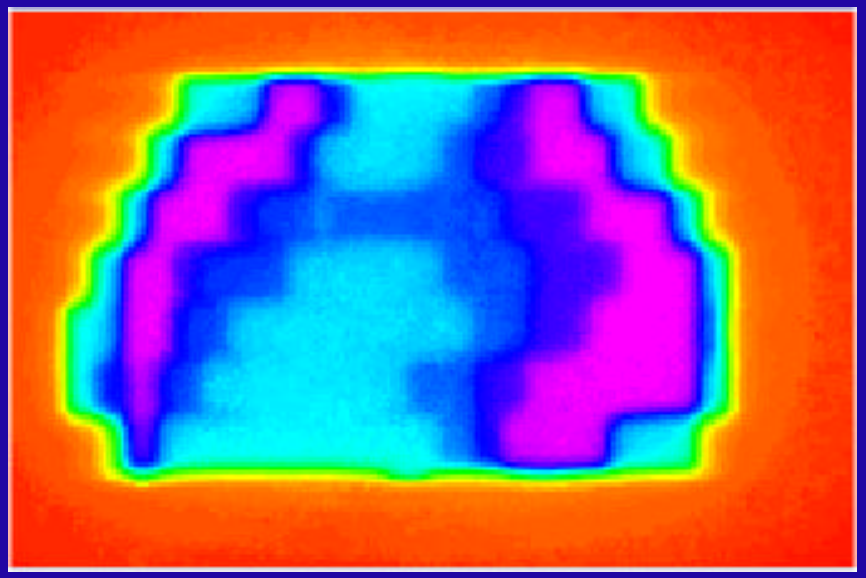
Pyramide:

10 square Fields (2x2,4x4,.....20x20 cm

10 MU each

Used for film calibration

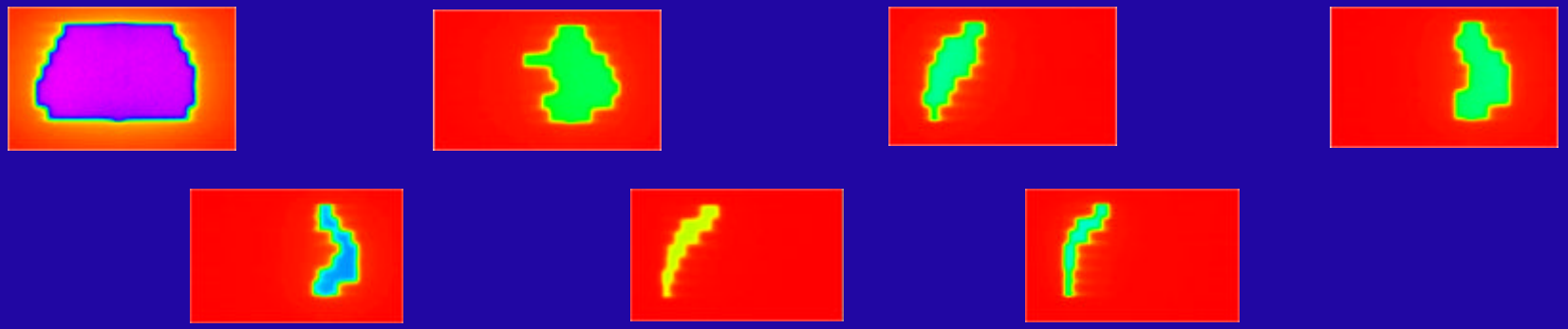
IMRT field



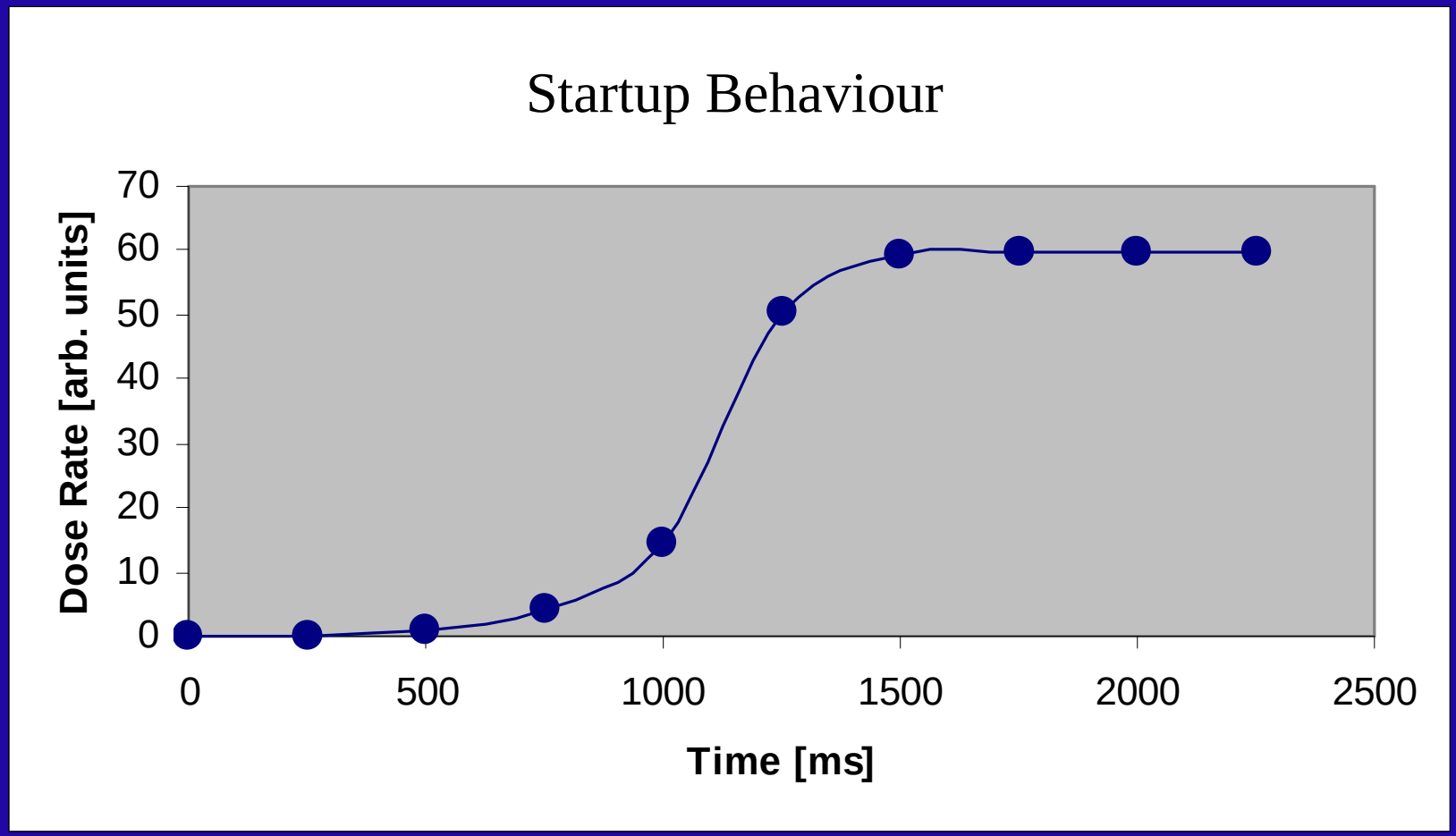
Prostate plan

5 fields

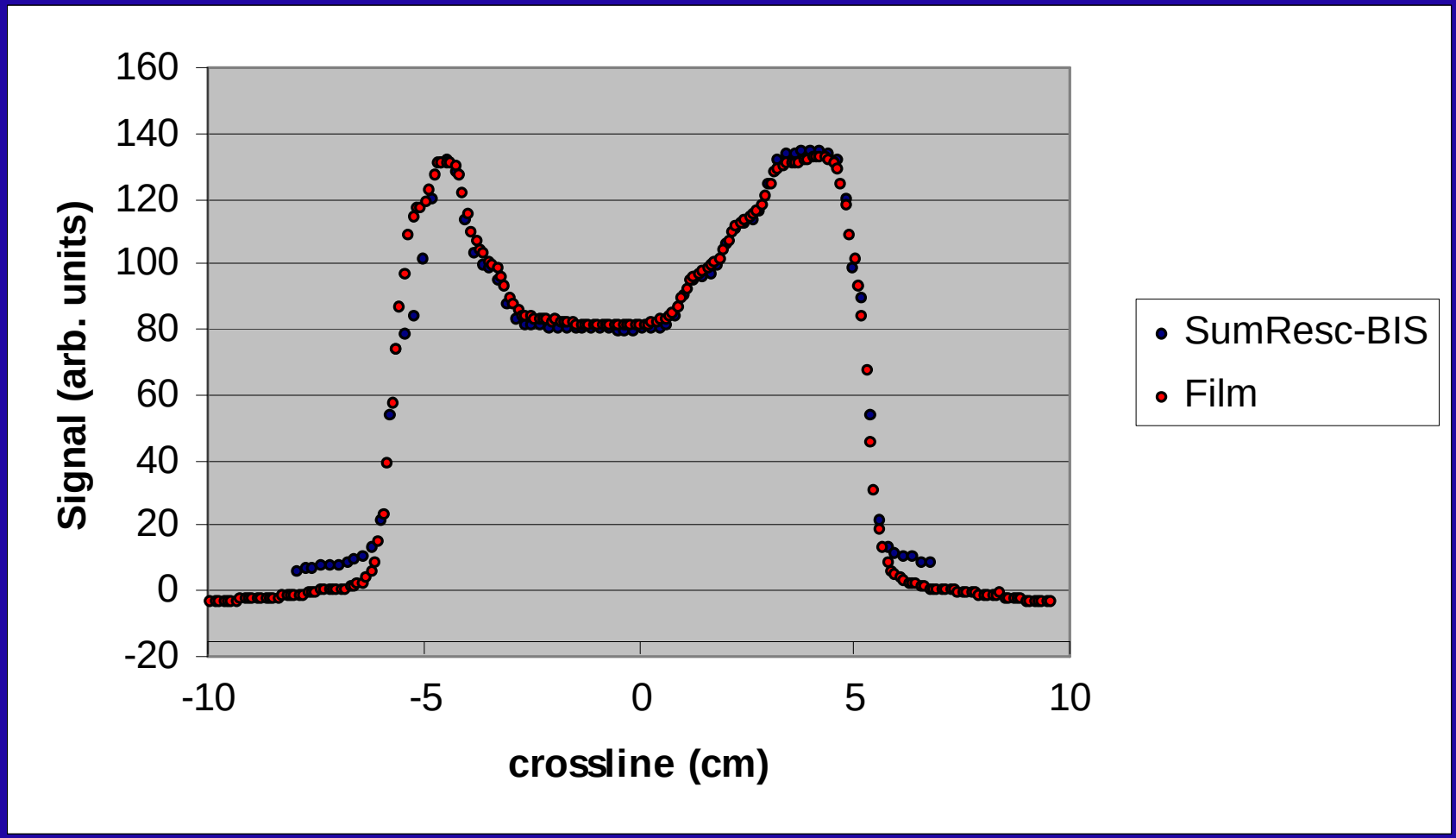
0°: 7 segments



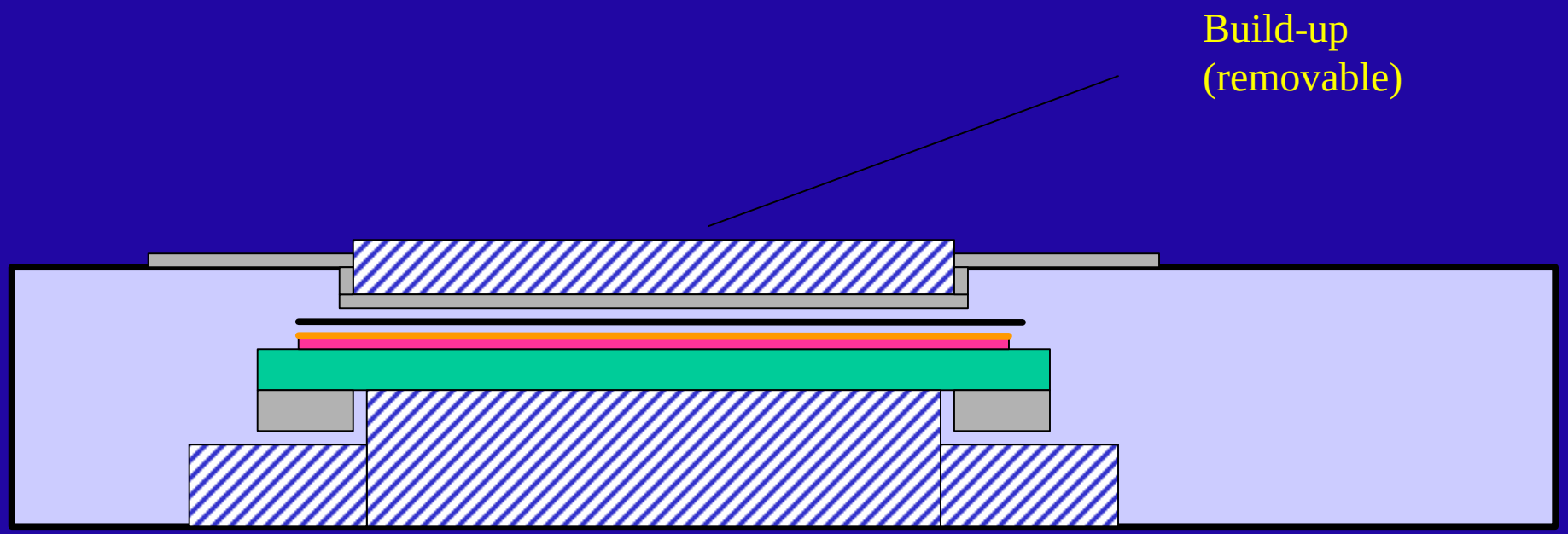
Startup behaviour



BIS vs. Film

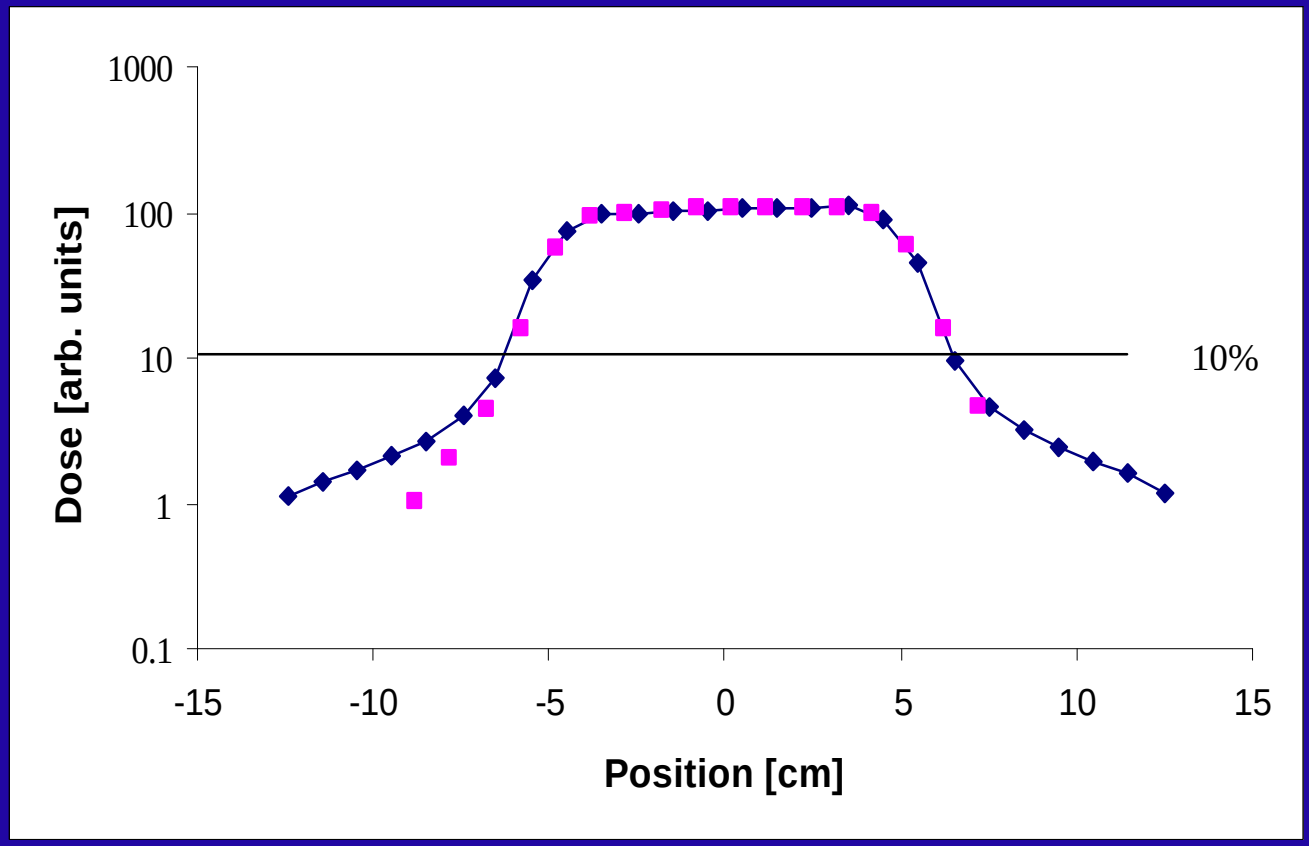

160
140
120
100
80
60
40
20
0
-20
Signal (arb. units)
-10
-5
0
5
10
crossline (cm)
SumResc-BIS
Film

A-Si Detector

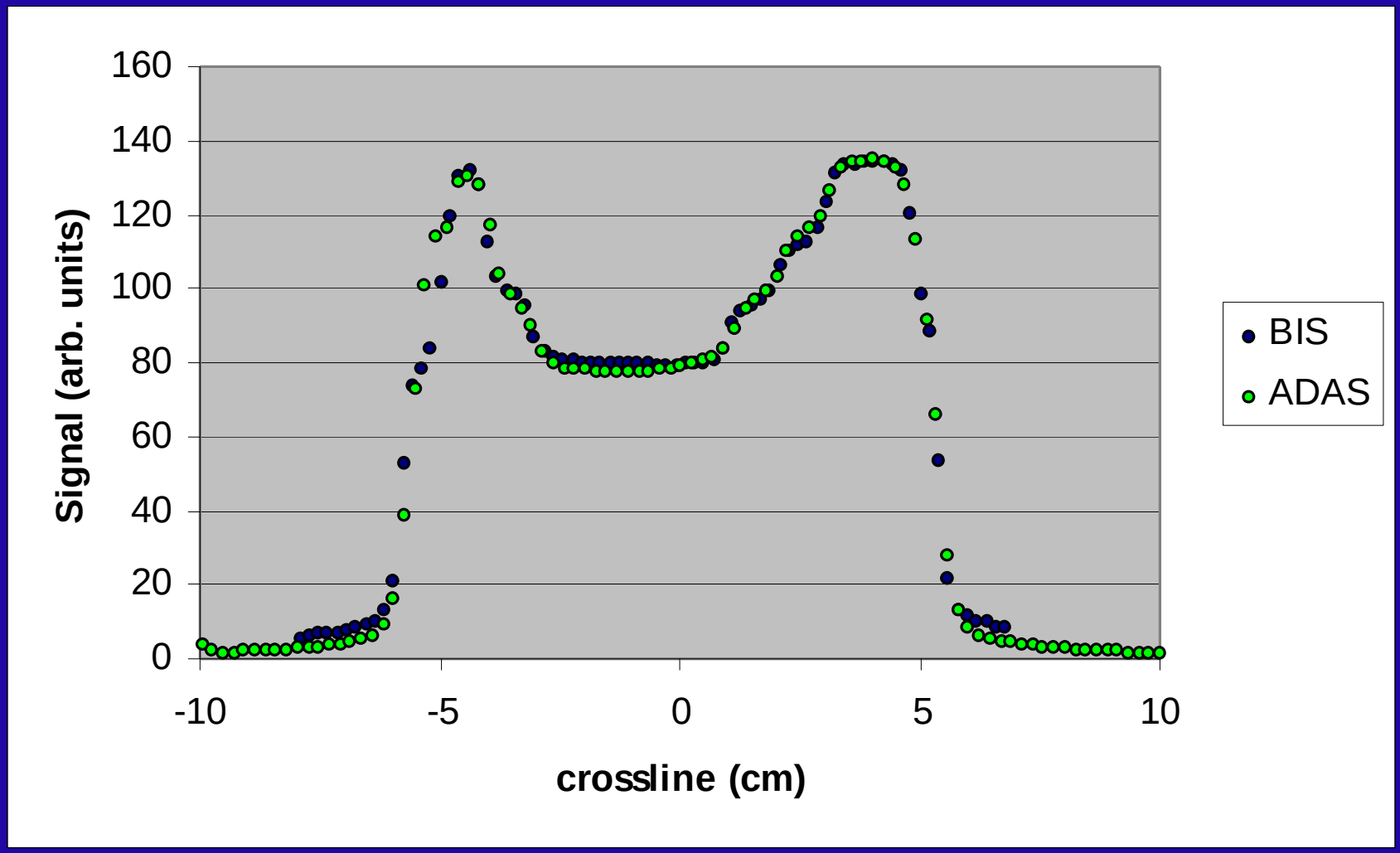


Aluminum **Graphite** **Polyimide** **a-Si** **PC-board**

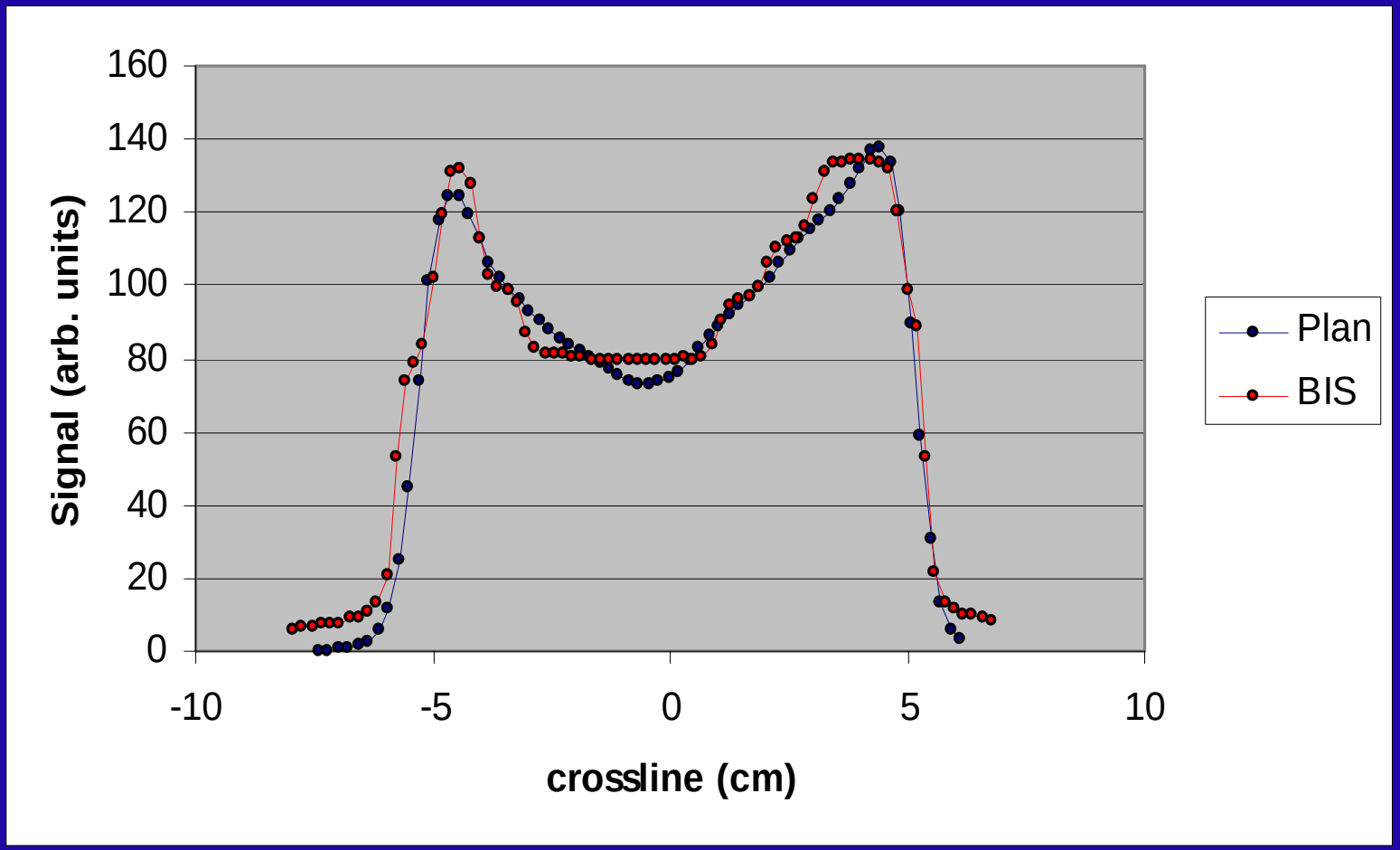
Wedge profile – ADAS vs. WP blue



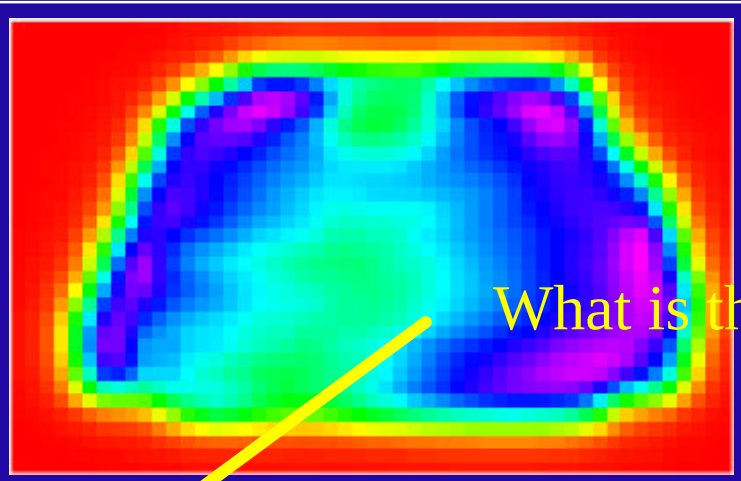
BIS vs. ADAS


160
140
120
100
80
60
40
20
0
Signal (arb. units)
-10
-5
0
5
10
crossline (cm)
BIS
ADAS

BIS vs. Pinnacle planar dose

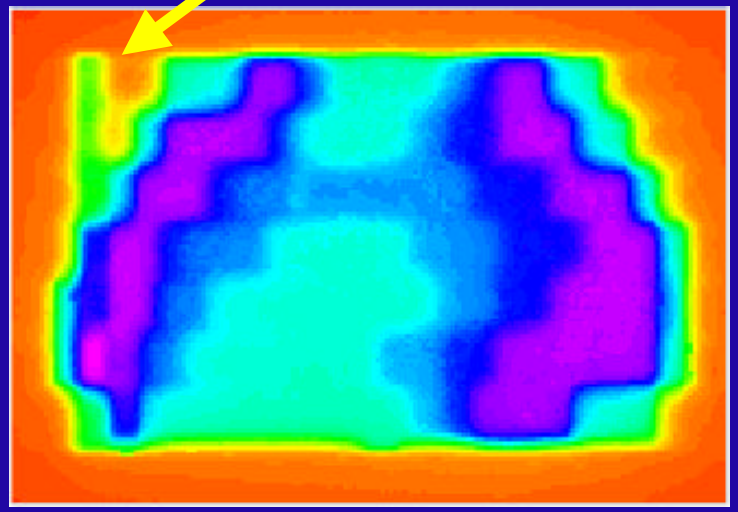


We discovered a delivery error !

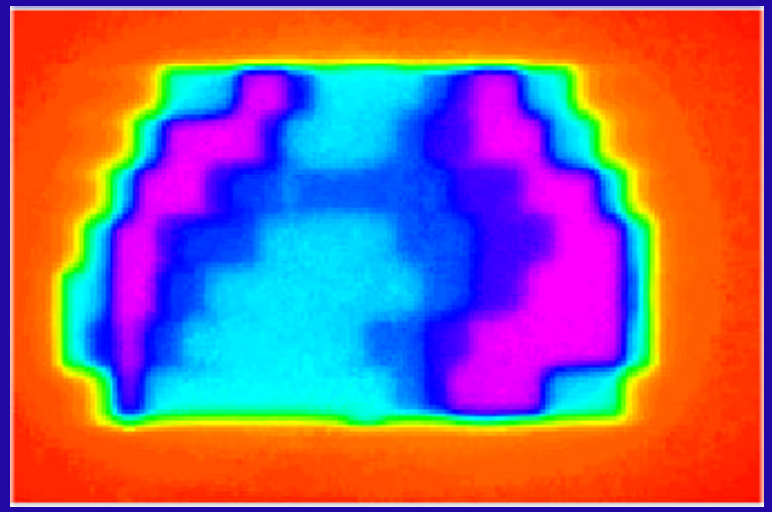


planned

What is that ???



BIS



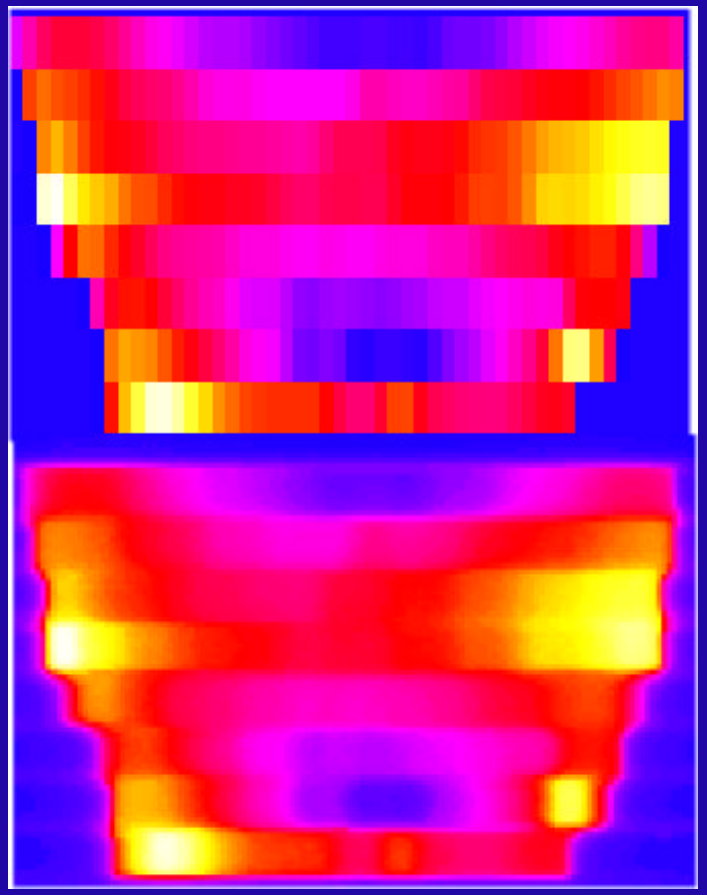
Direct integral

corrected

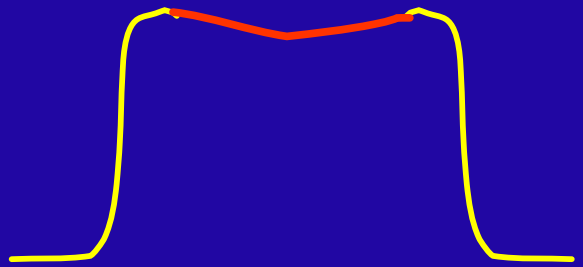
Measurements at Ulm Univ. Hospital

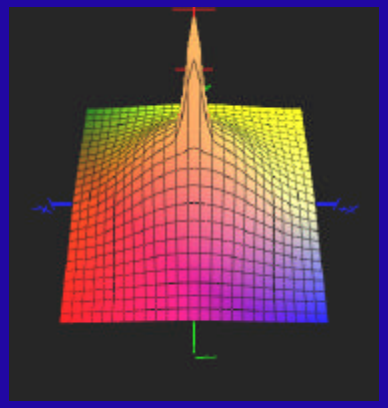
- Dynamic delivery
- Short delivery times (max. ca. 1 min)
- Moderate dose rate (300 MU/min)
- 2 plans: 5-field prostate, 2 field mamma
- Complete movies taken
- Fixed at accessory holder
- 300ms integration time
- 1 GB RAM

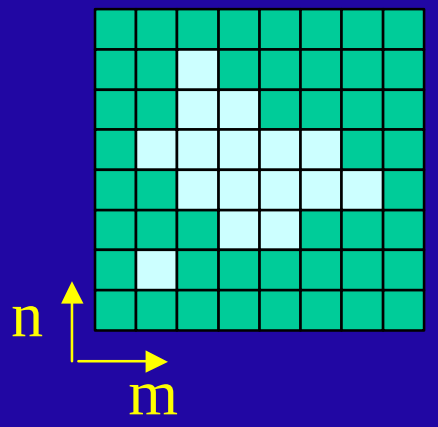
BIS vs. Cadplan



Fluence reconstruction – more complex







$$\Phi_{x,y} = b(x,y)\iint S(x-x',y-y')T(x-x',y-y')dx'dy'$$

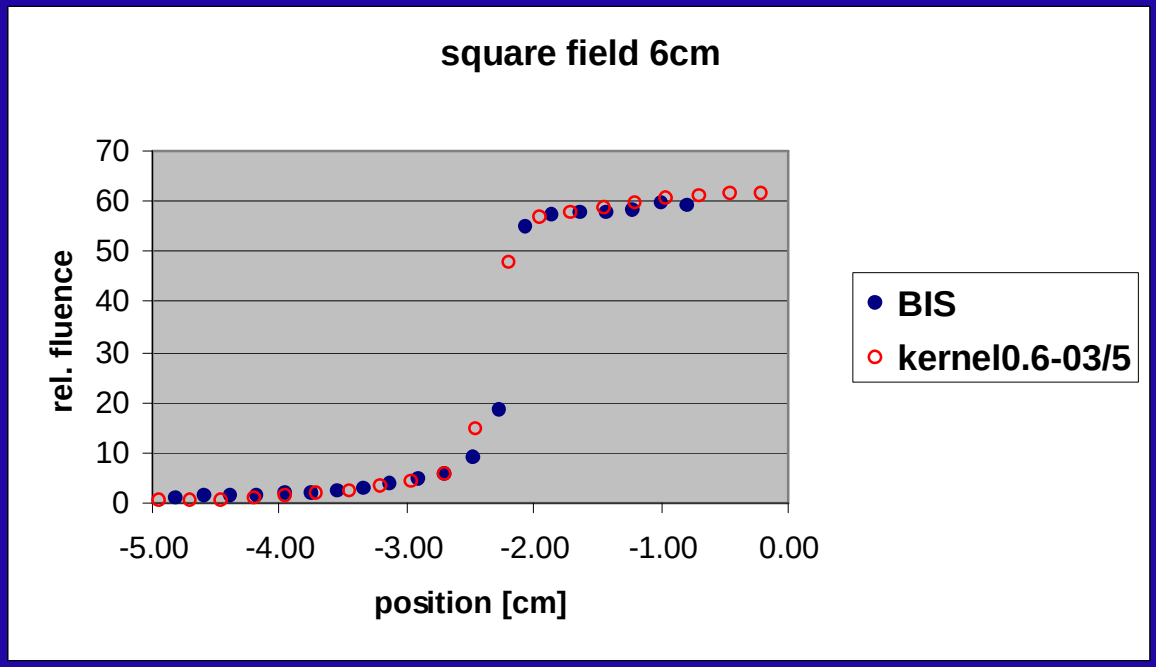
Open field	Double-Gaussian	Transmission
w/o penumbra	Kernel (from penumbra)	through MLC 1 or 0

L.Ma, P.Geis, A.L.Boyer, Med Phys 24(8), 1997

Fit of penumbra region

Double-Gaussian Kernel:

$$I(x_0, y_0) \propto \sum_{x,y} I_0(x,y) \left\{ \exp \frac{-(x-x_0)^2 - (y-y_0)^2}{s_1^2} + e \cdot \exp \frac{-(x-x_0)^2 - (y-y_0)^2}{s_2^2} \right\}$$



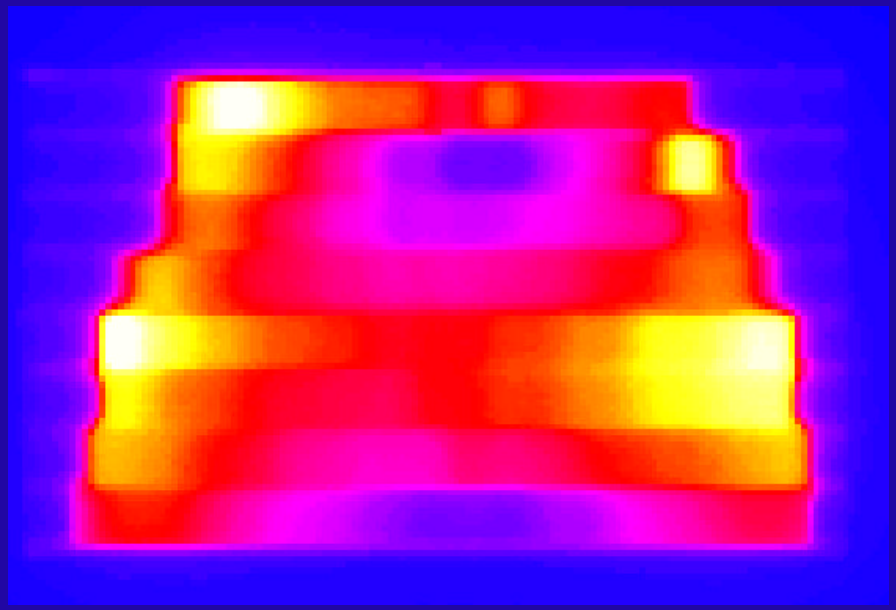
Fit to Penumbra region (square field):

σ_1=0.6mm

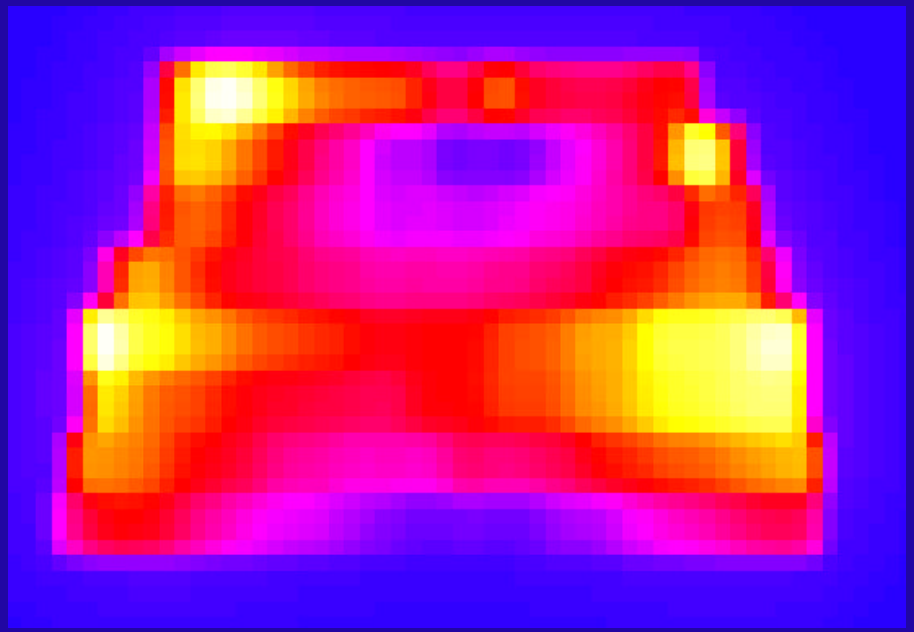
σ_2=3 mm

ε=0.3

Double-Gaussian Kernel

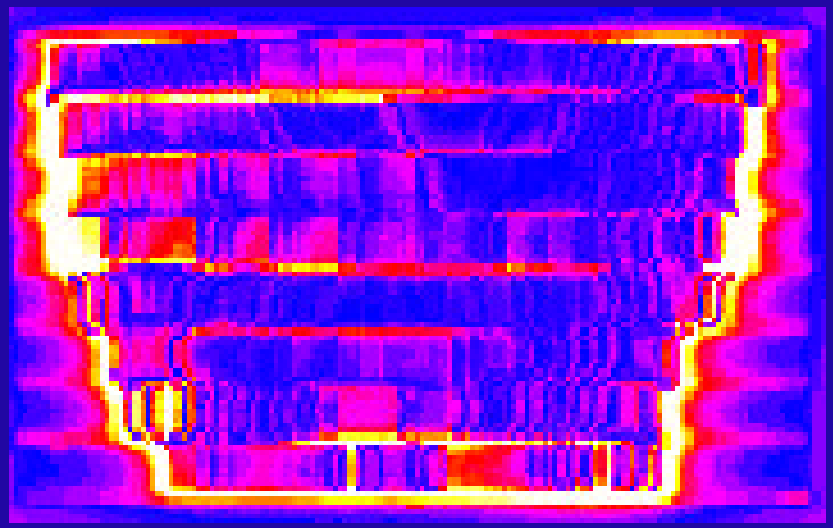


BIS measured

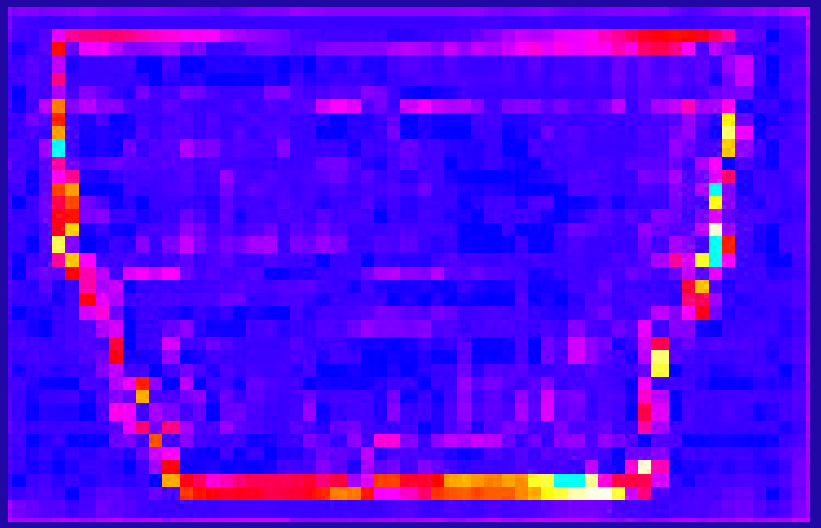


Cadplan / double gaussian kernel

Gamma Index

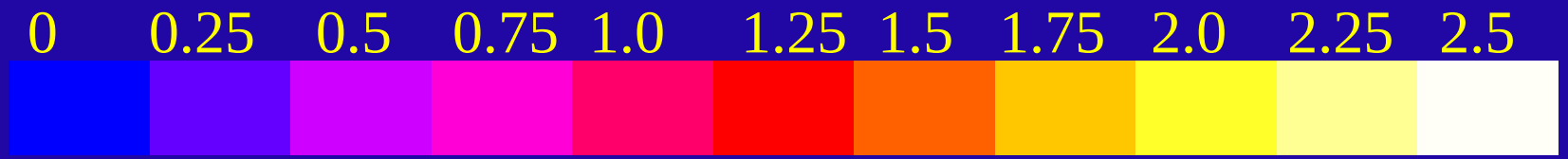


Cadplan raw fluence

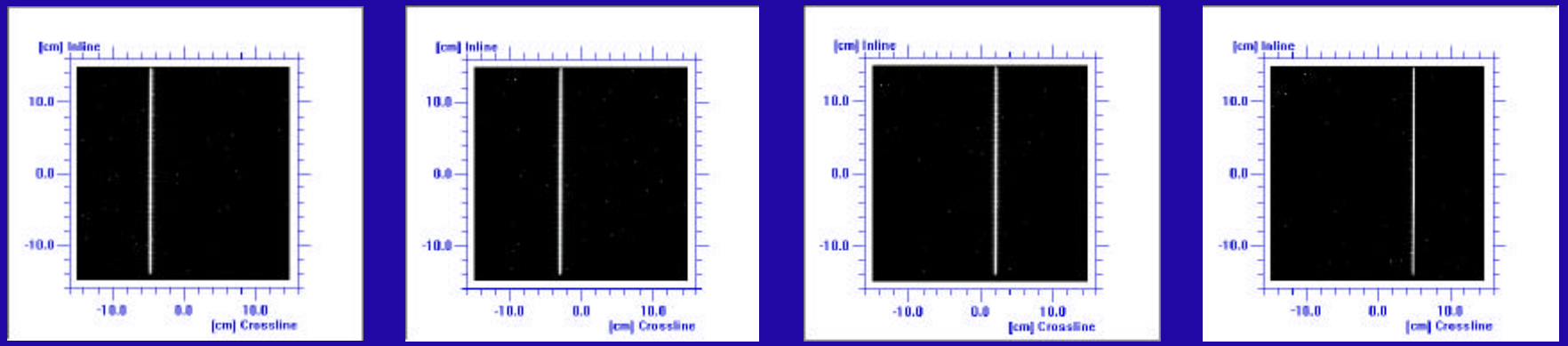


Double Gaussian Kernel

$\Delta x = 3mm, \quad \Delta D = 3\%$

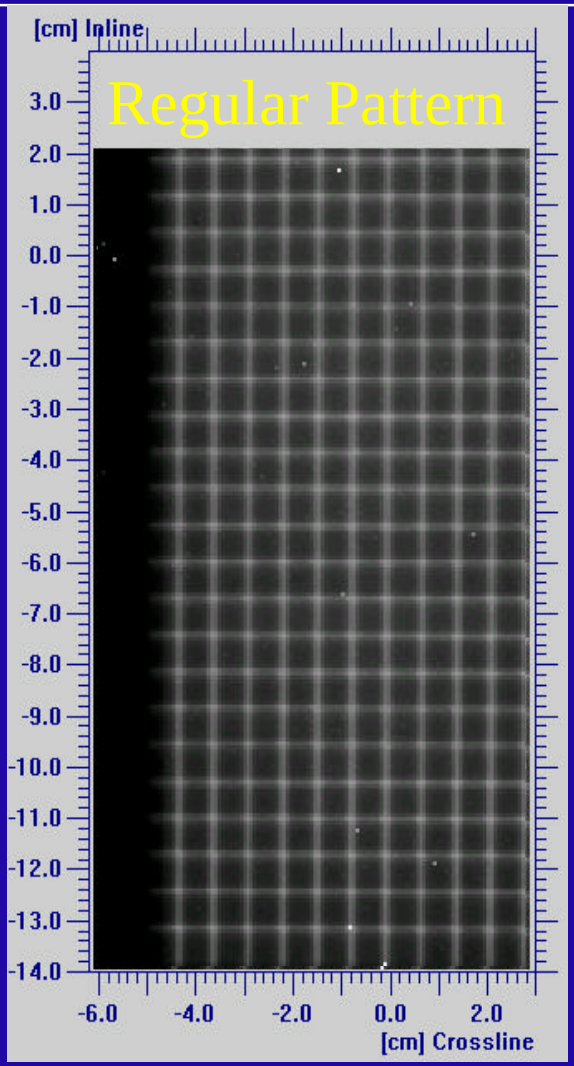


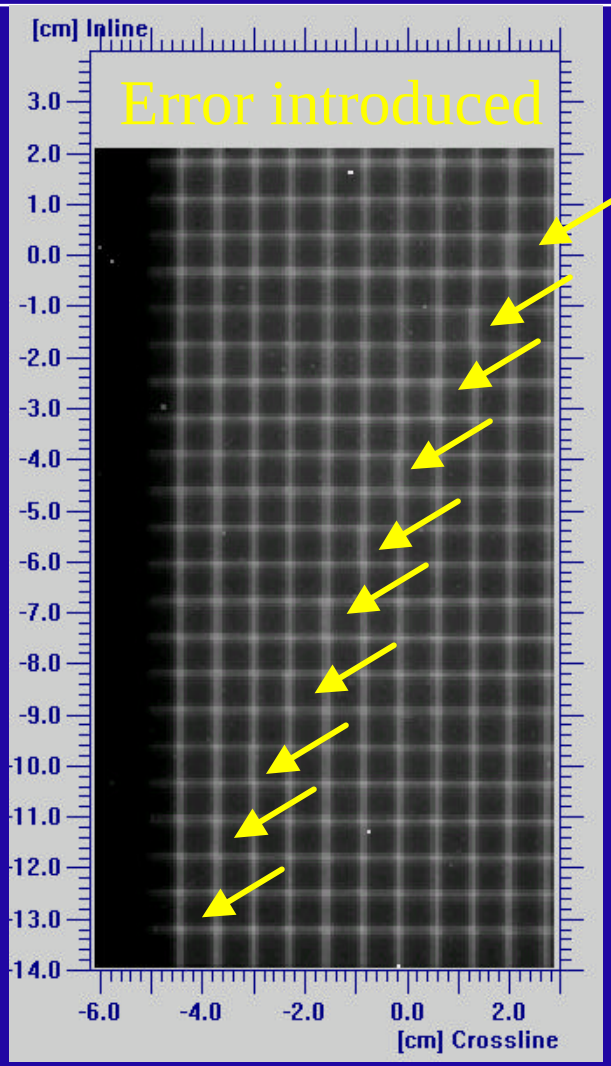
MLC QA - ‚Garden Fence‘



MLC pairs form a narow slot moving across the field, stopping and reaccelerationg at predefined positions

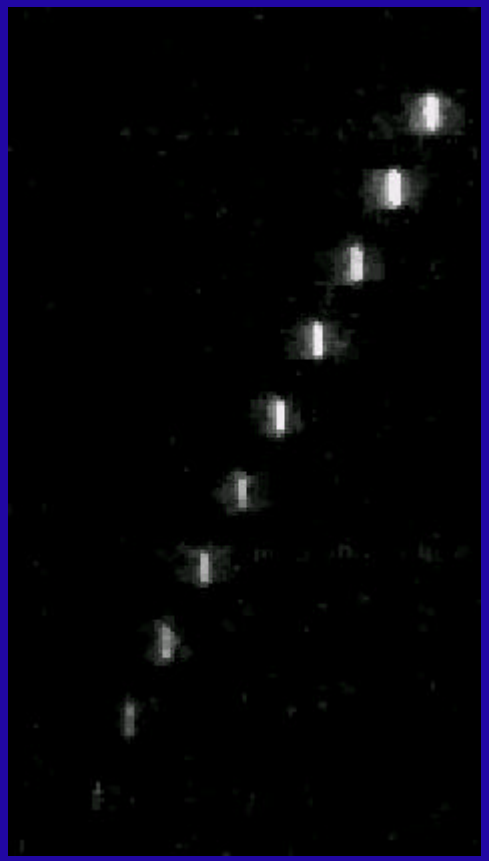
MLC QA – ‚Pickett Fence‘





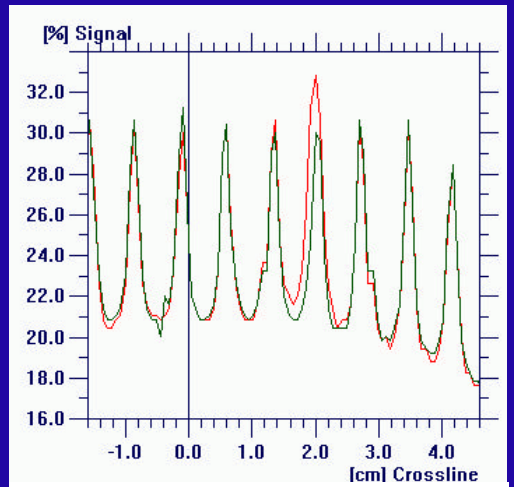
1.0 mm
0.9 mm
0.8 mm
0.7 mm
0.6 mm
0.5 mm
0.4 mm
0.3 mm
0.2 mm
0.1 mm

MLC QA – ‚Garden Fence‘

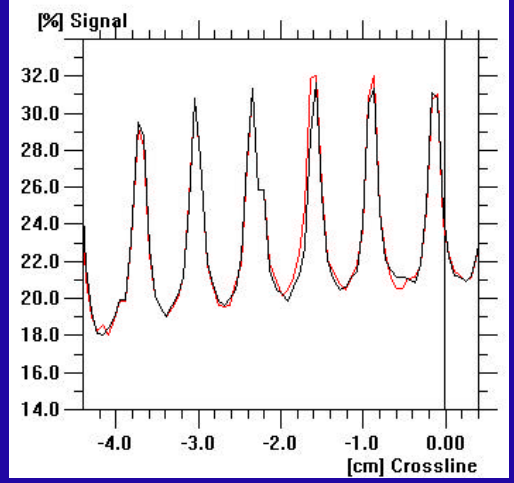


1.0 mm
0.9 mm
0.8 mm
0.7 mm
0.6 mm
0.5 mm
0.4 mm
0.3 mm
0.2 mm
0.1 mm

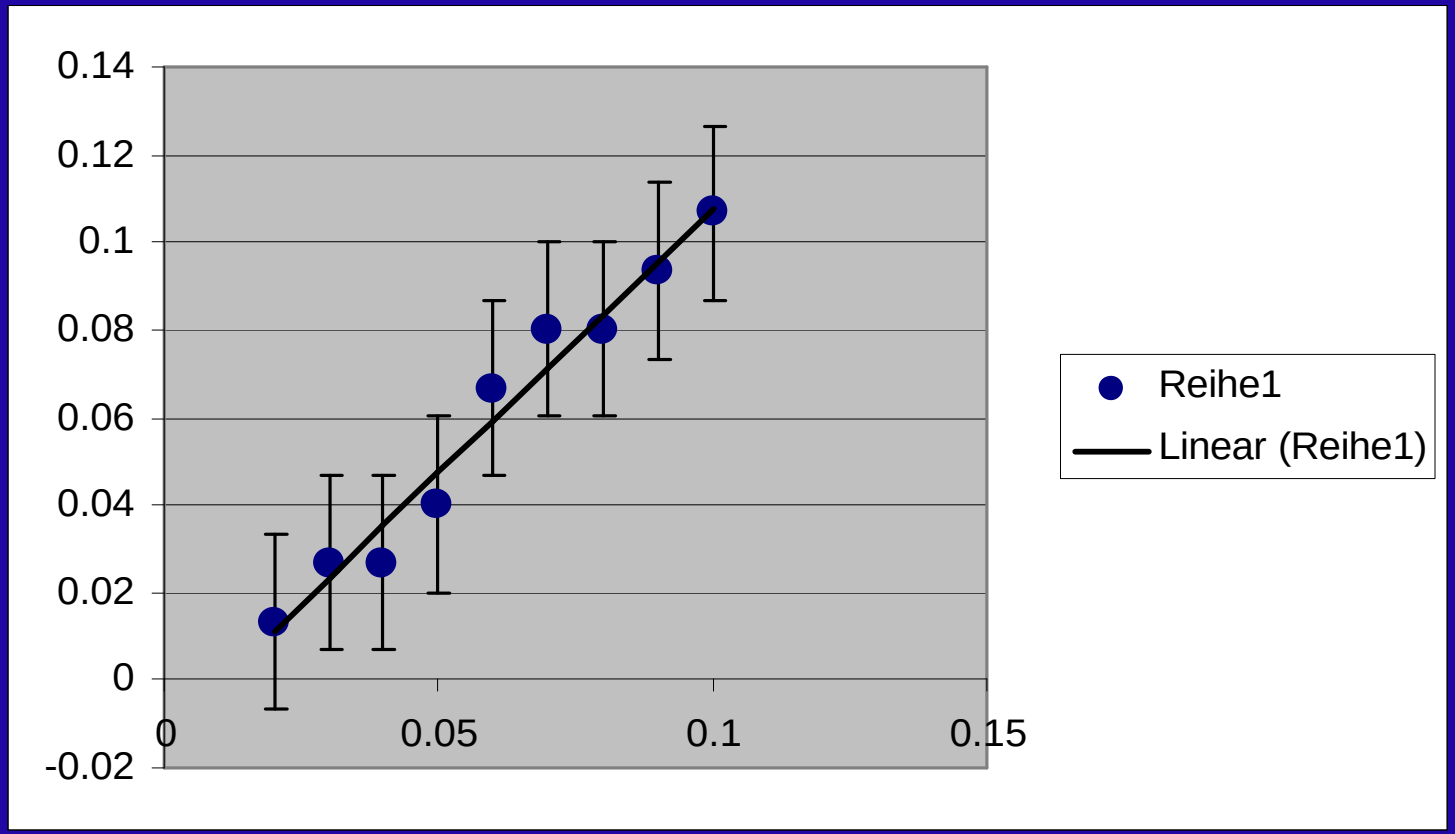
1.0 mm



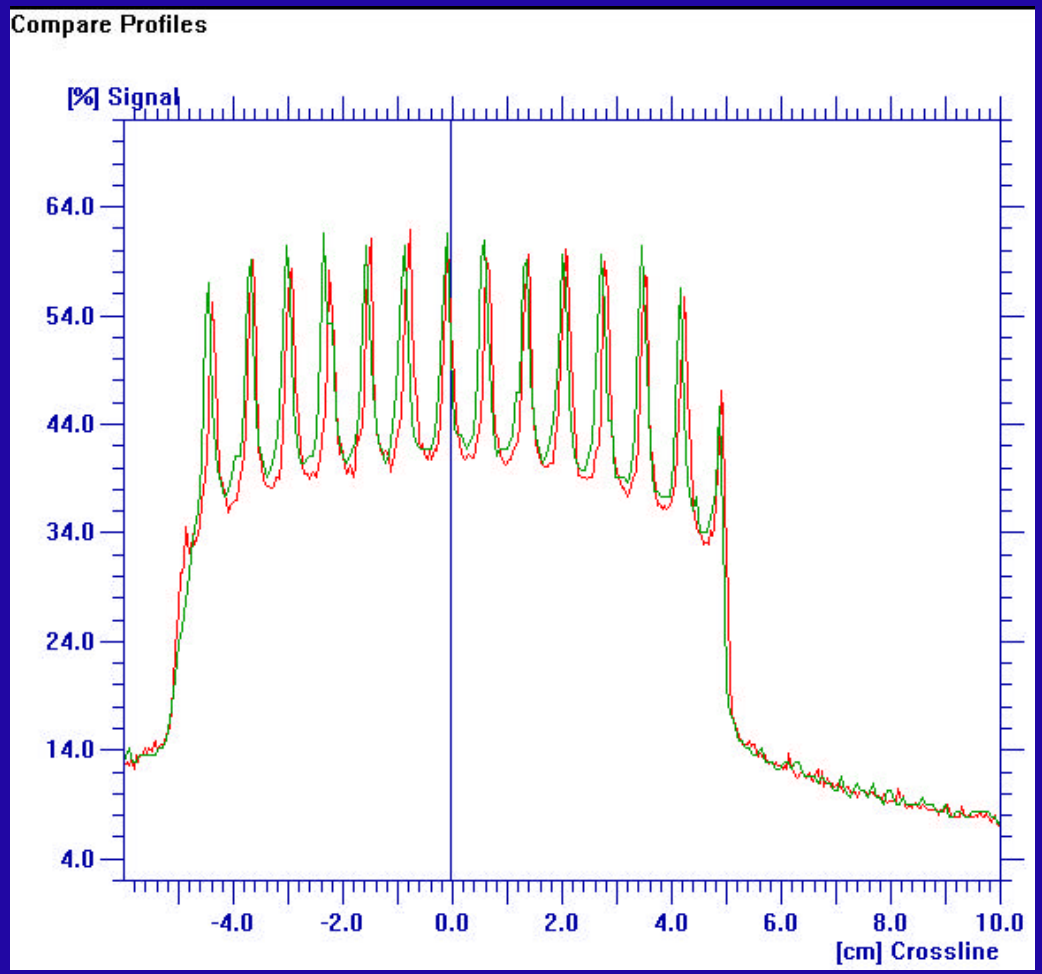
0.5 mm



Gap Error

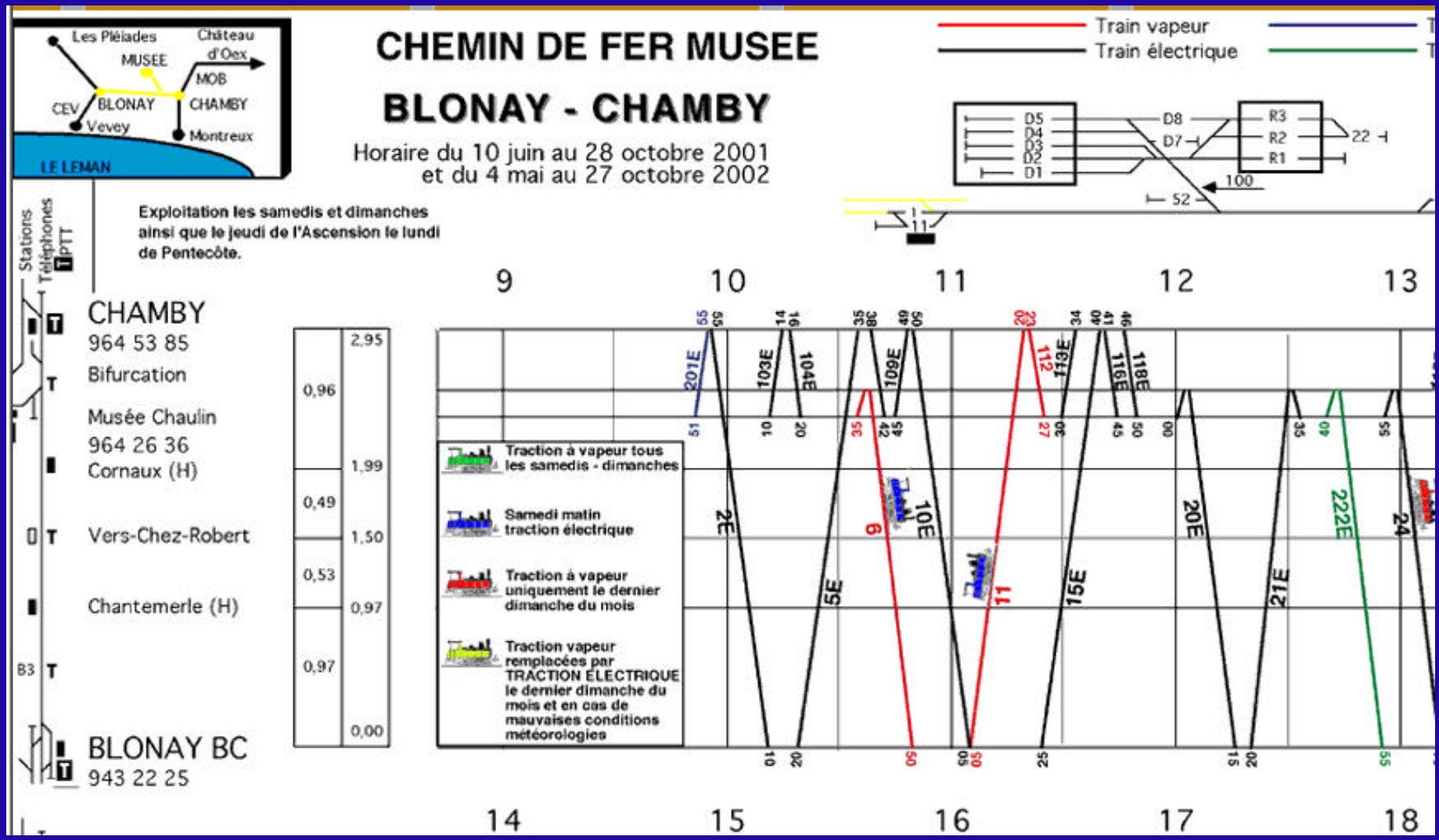

0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
-0.02
0
0.05
0.1
0.15
Reihe1
Linear (Reihe1)

MLC QA – ‚Garden Fence‘

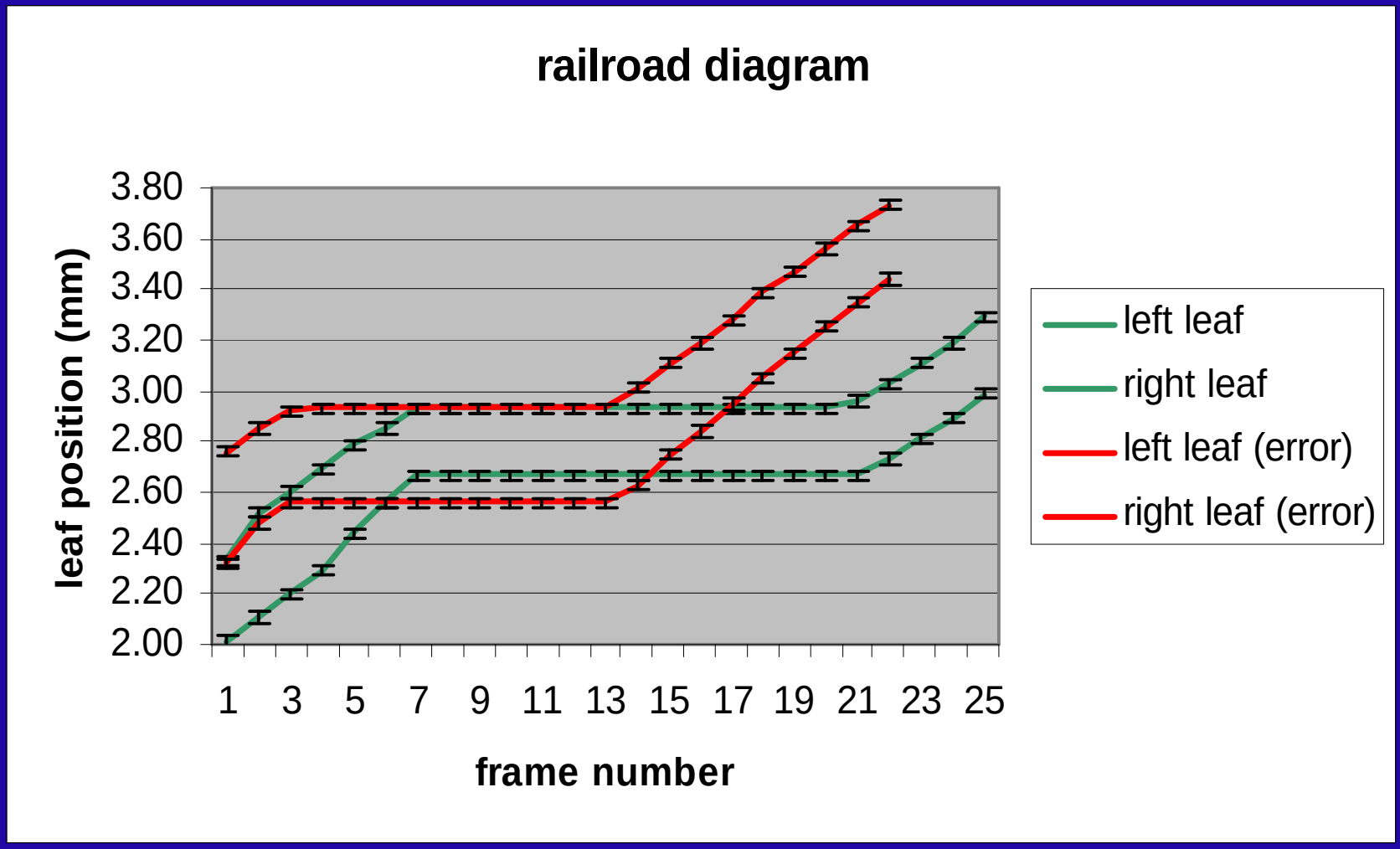


90° Gantry Orientation vs. 270° Gantry Orientation

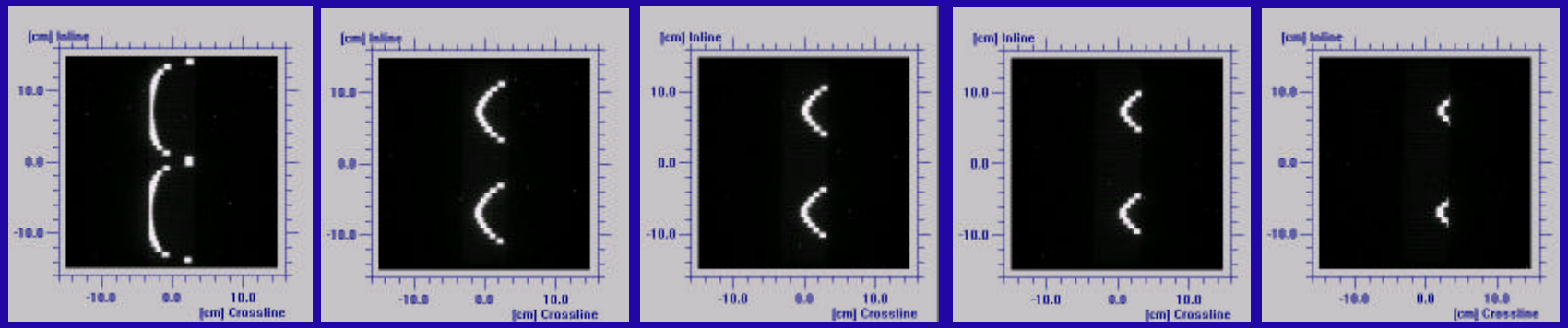
Graphic railway schedule



‚Railroad diagram‘

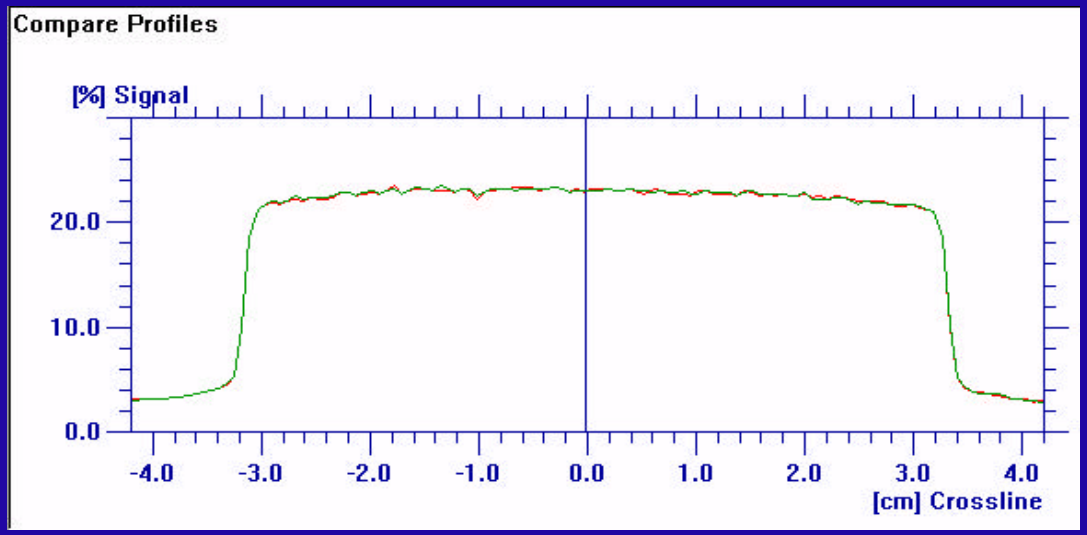


MLC QA - Leaf Speed Test

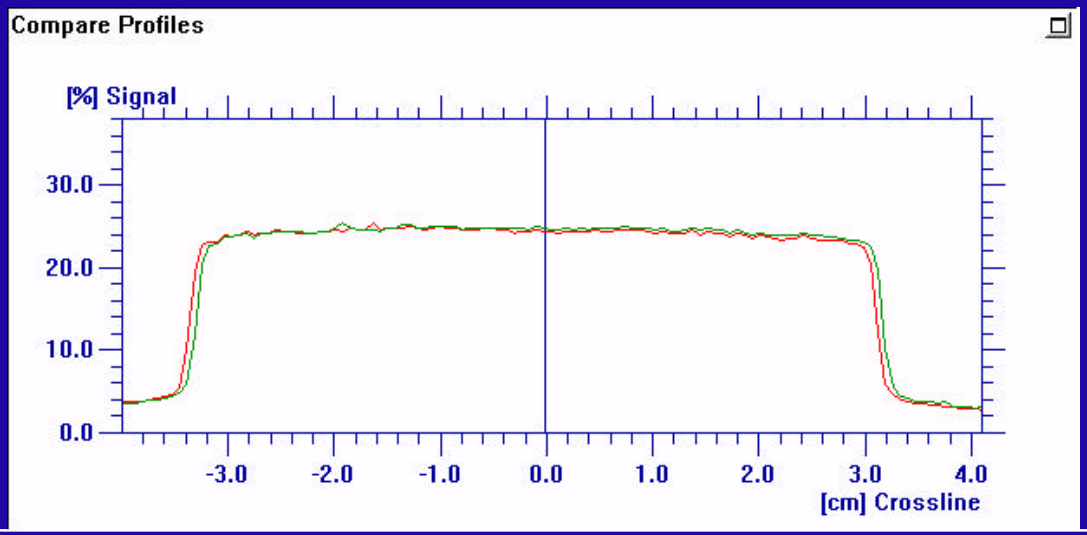


Leaf pairs form gaps moving with different speed

MLC QA – Leaf Speed test

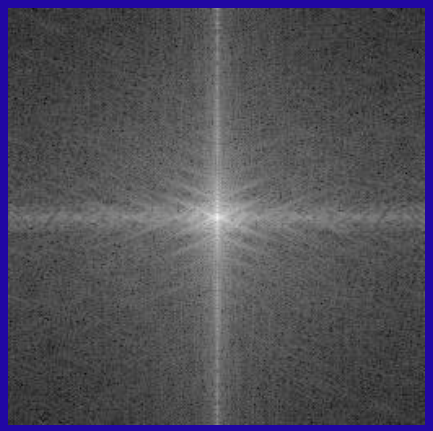


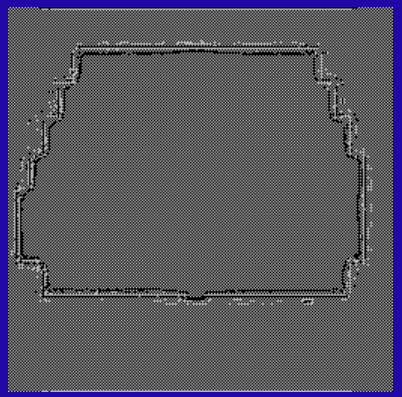
Delivery with beam interrupts

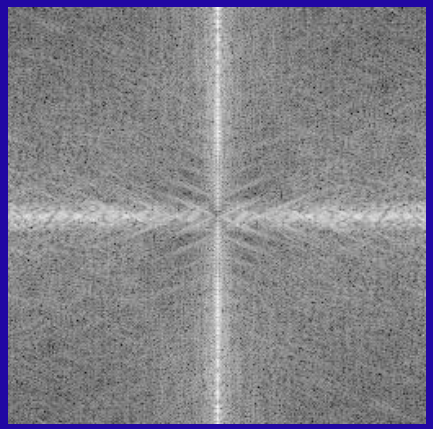


90° Gantry Orientation vs. 270° Gantry Orientation

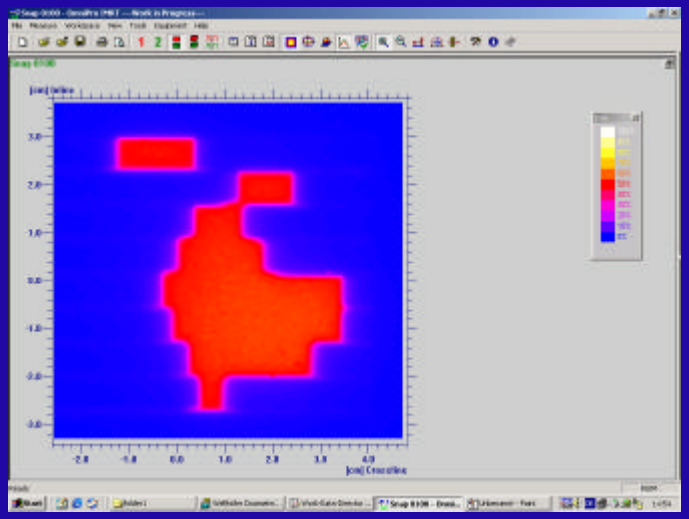
Edge filter-fast fourier transform

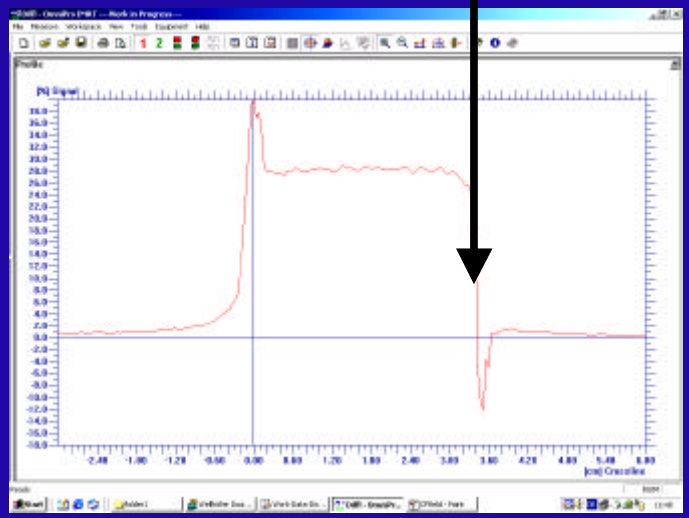






Constant-fraction approach



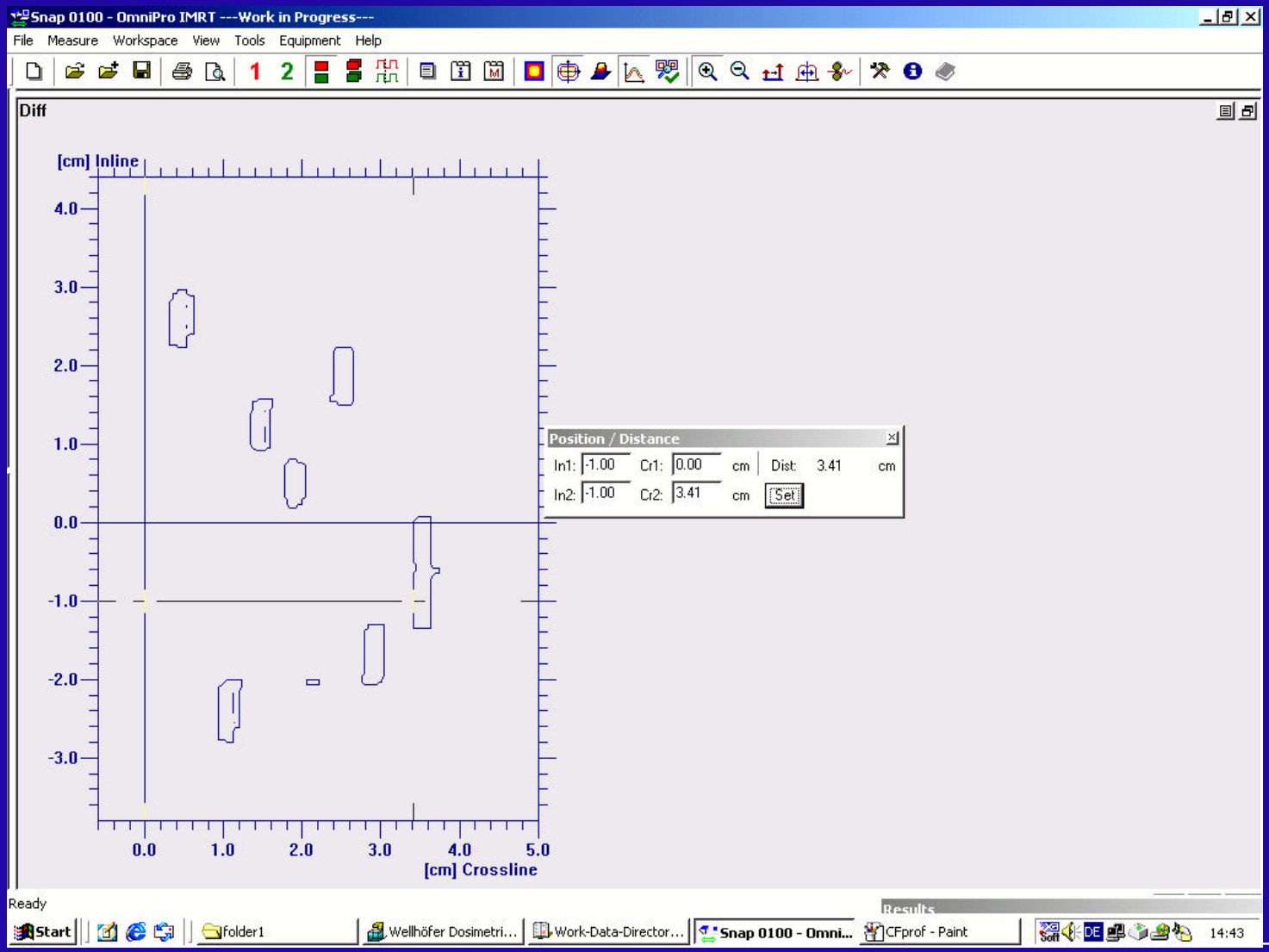


Original field

-shifted,
attenuated field

Zero crossing

Right edge positions




IBA