

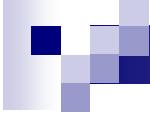
Simulating CT imaging with GATE

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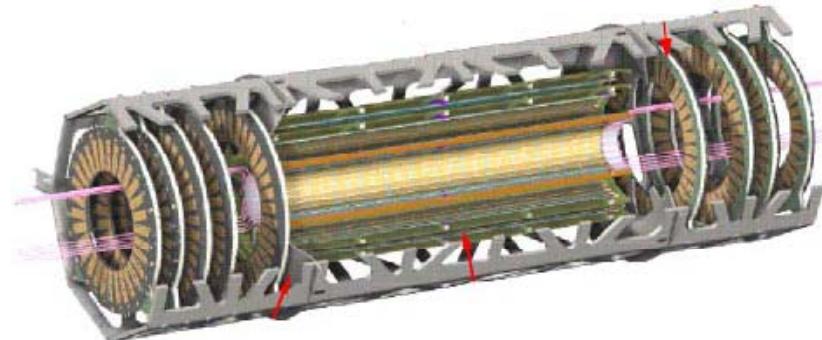




Simulating CT imaging with GATE

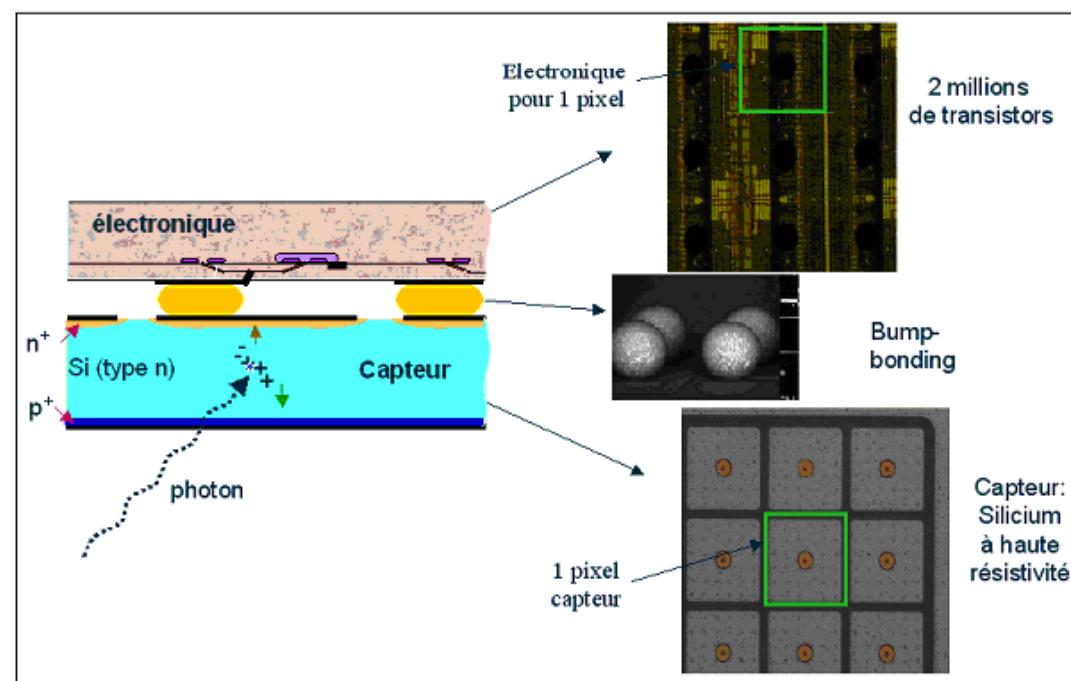
- PIXSCAN, scanner for small animals
- GATE simulation
- data – simulation comparison
- Conclusion
- Outlooks

PIXSCAN

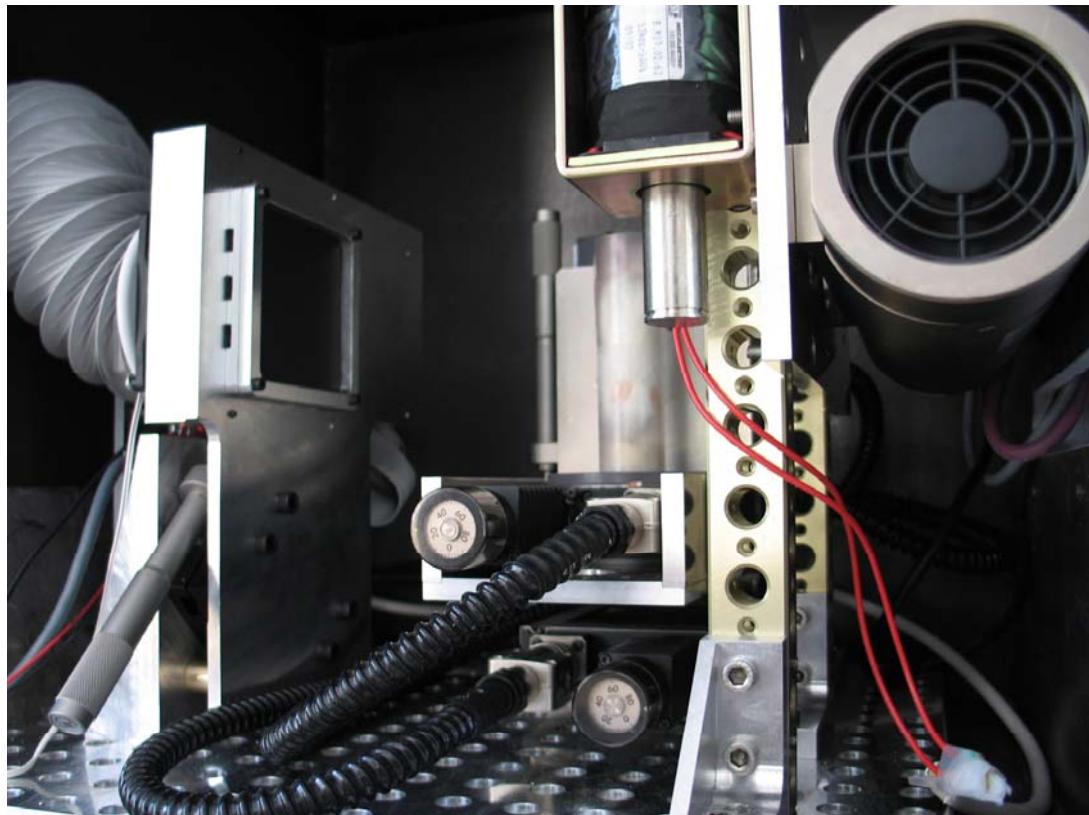


**Single photon counting scanner for small animals
based on hybrid pixels**

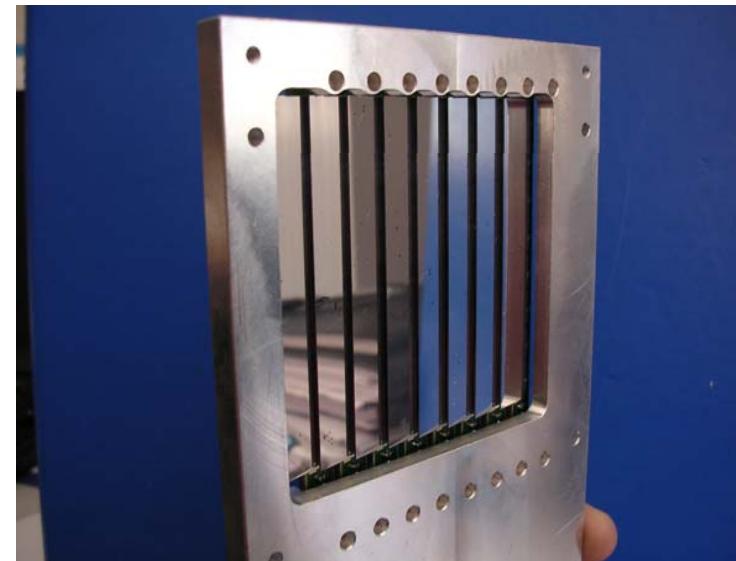
- Low noise
- Energy threshold
- Very high signal dynamic
- Very fast acquisition



PIXSCAN prototype

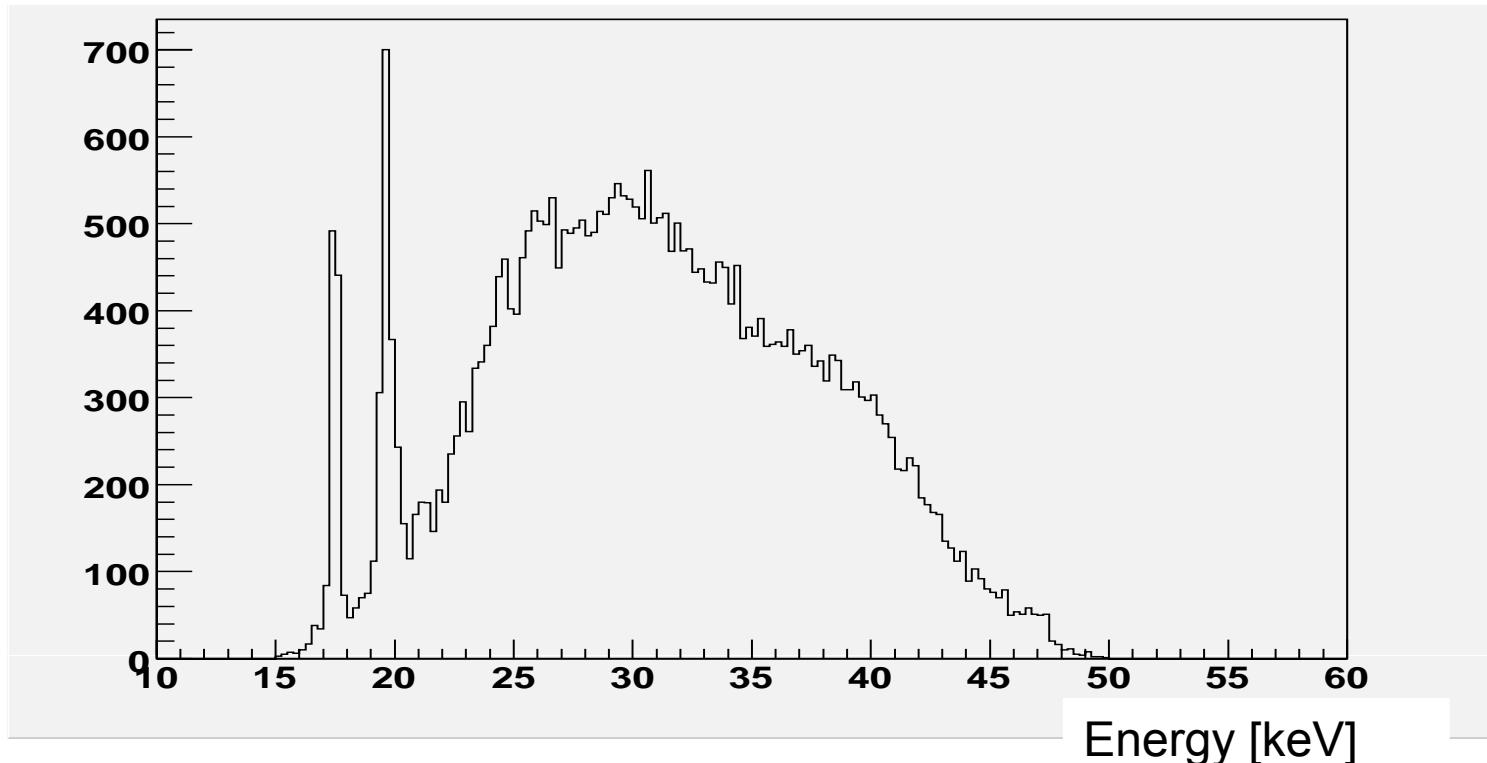


- pixels: $330 \times 330 \mu\text{m}^2$
- 8 tiled modules (9° tilt)
- total size: $6.8 \times 6.5 \text{ cm}^2$
- 206 x 200 pixels
- sensor: Silicon



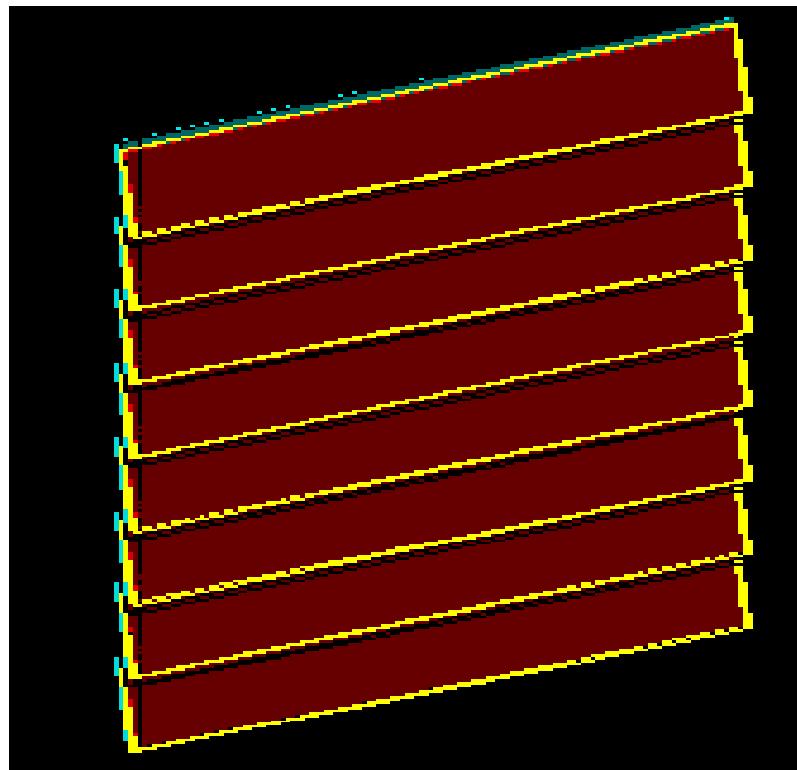
SIMULATION

- Source: Mo anode, 50 kV tube, 0.5 mA
- Filter: 6 mm Al



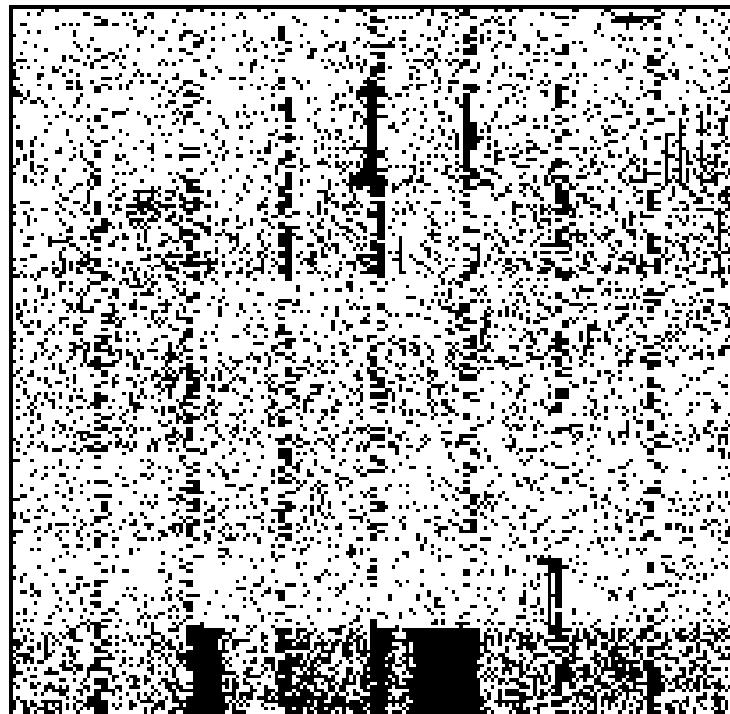
SIMULATION

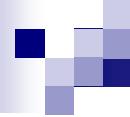
- Detector geometry: tiled modules



SIMULATION

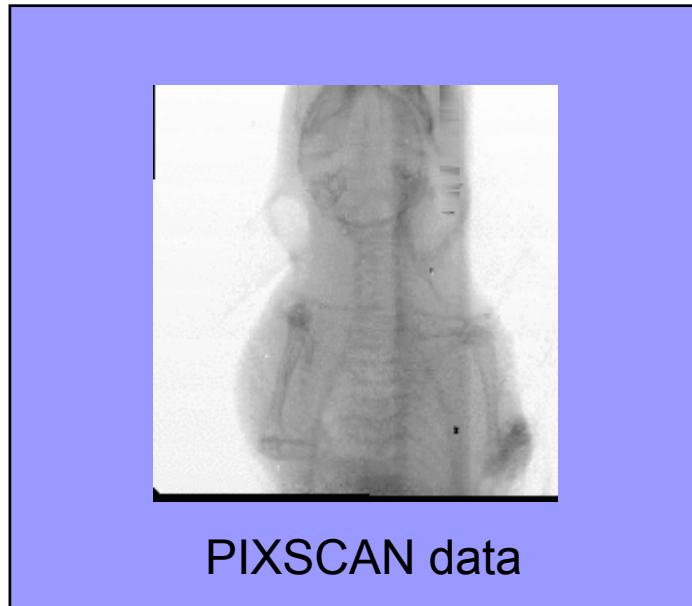
- Digitalization: $E > 15 \text{ keV}$
- Dead pixels added afterwards (~25%)





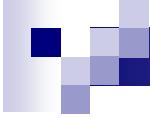
SIMULATION

- Output: 360 projections as for data



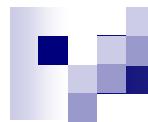
CPU Time:
360 jobs x 2 days:
1000 counts/pixels

Data:
3000-6000 counts/pixels



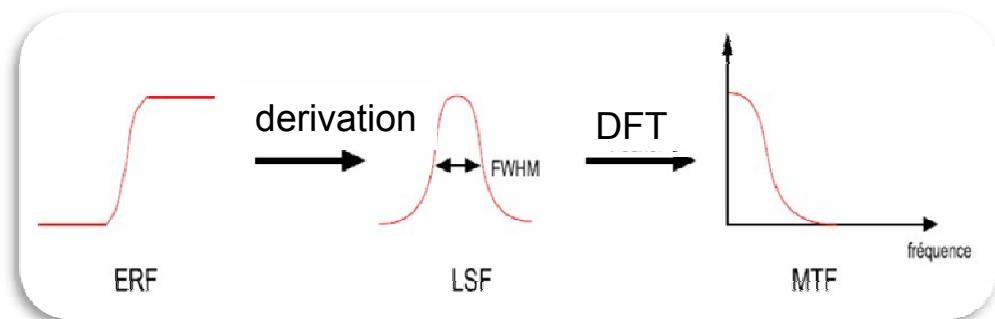
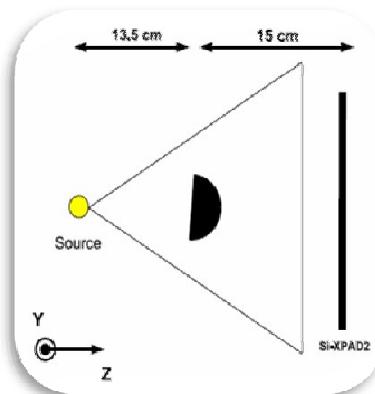
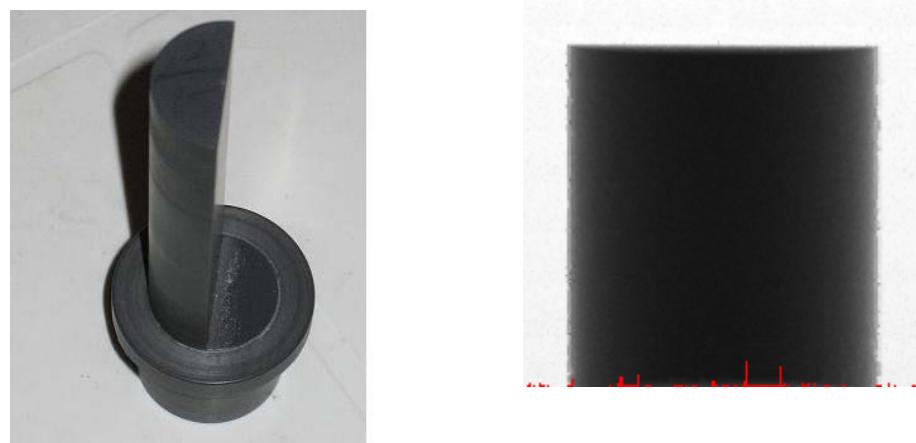
Data – Simulation comparison

- Spatial resolution
- Image noise
- Geometry calibration
- CT linearity
- Tomography's distortions



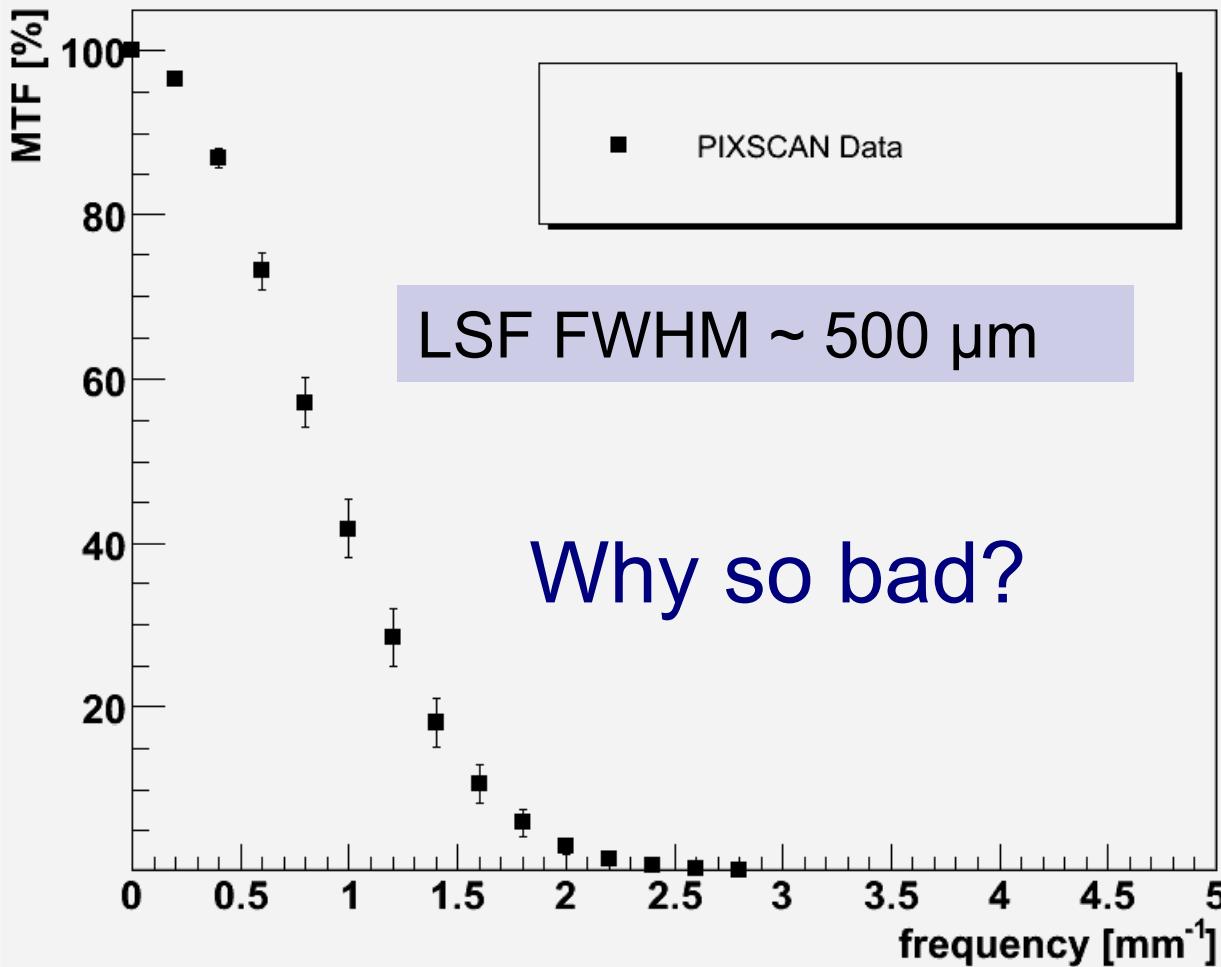
Spatial resolution

- PVC phantom
 $R = 12 \text{ mm}$

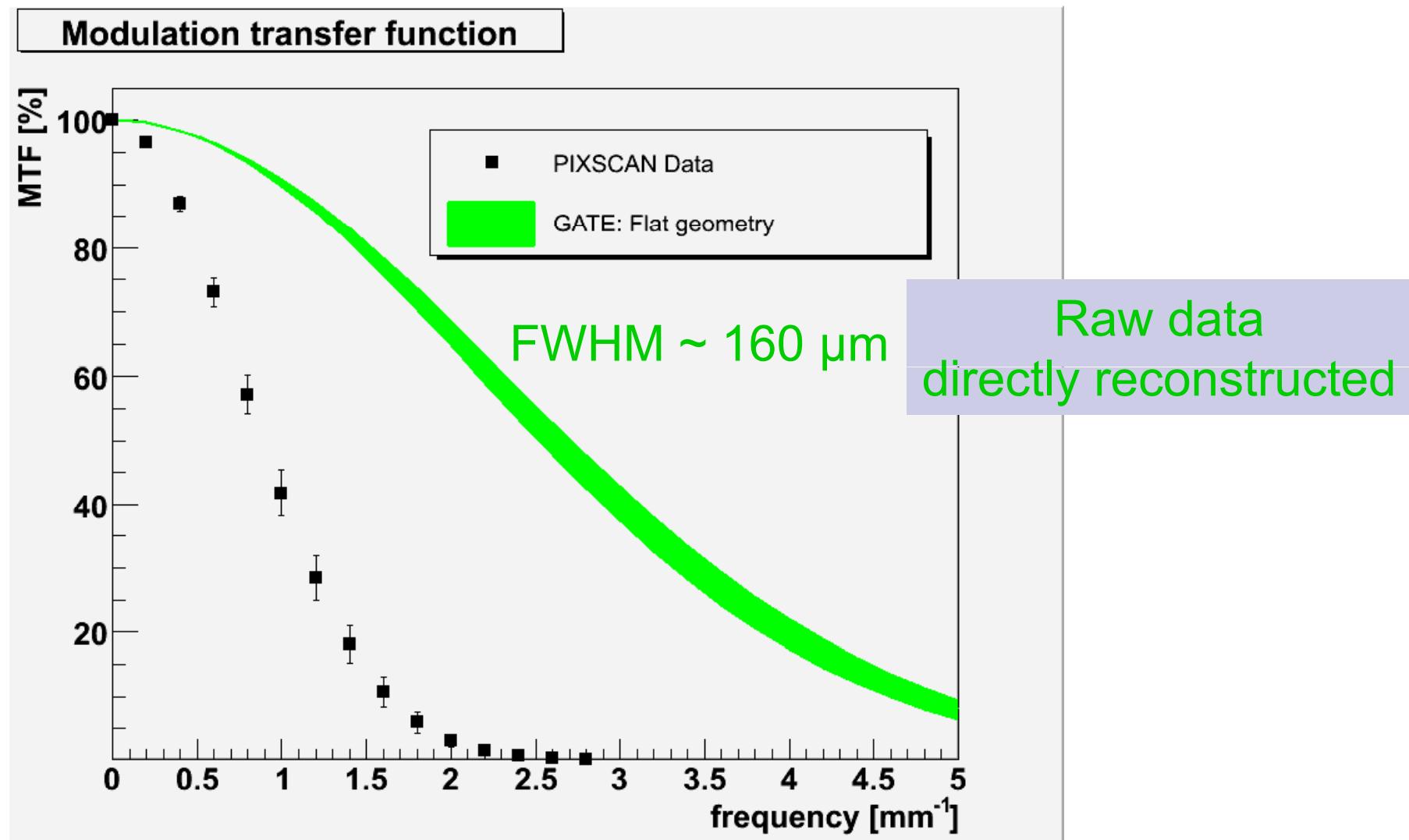


Spatial resolution: DATA

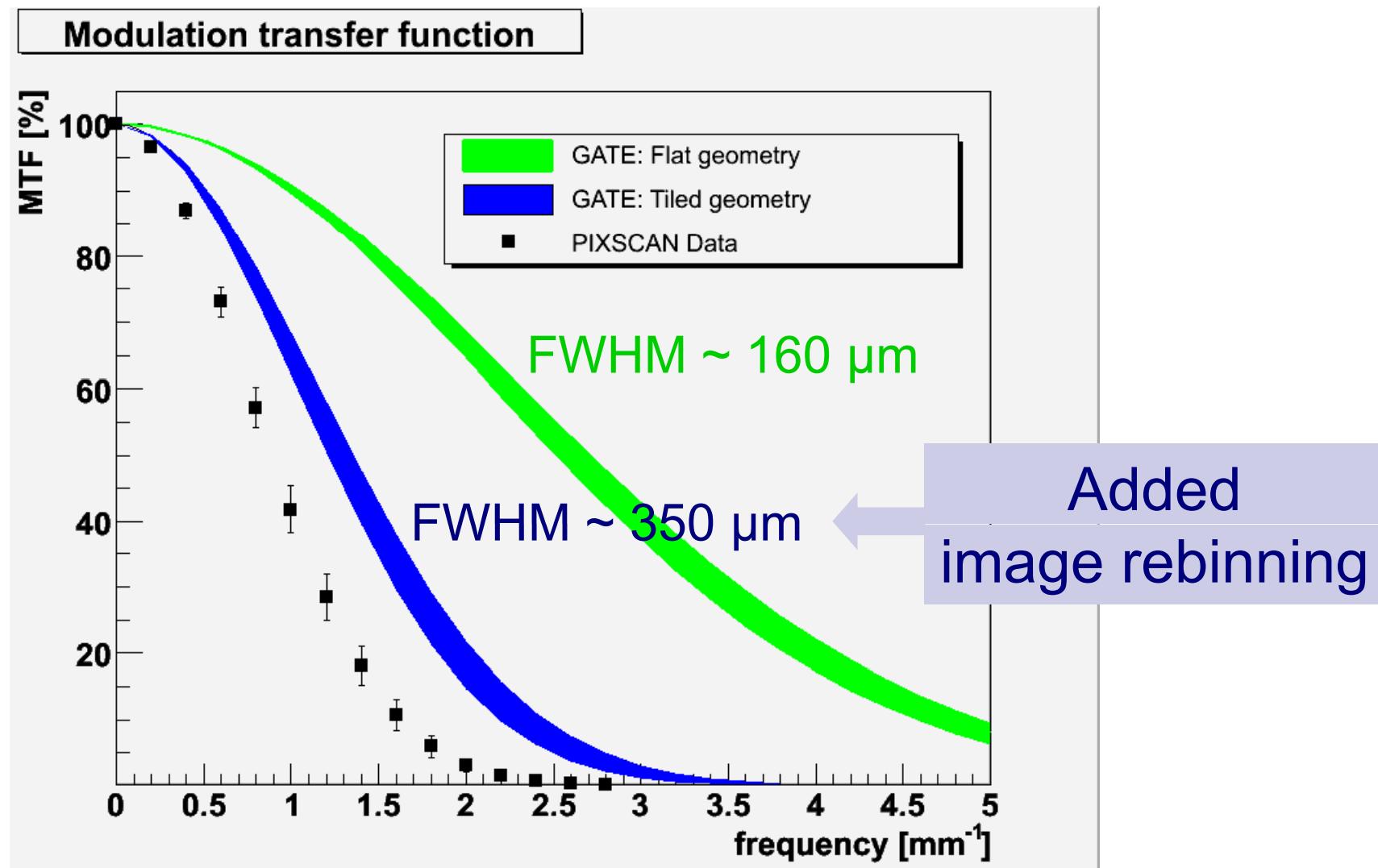
Modulation transfer function



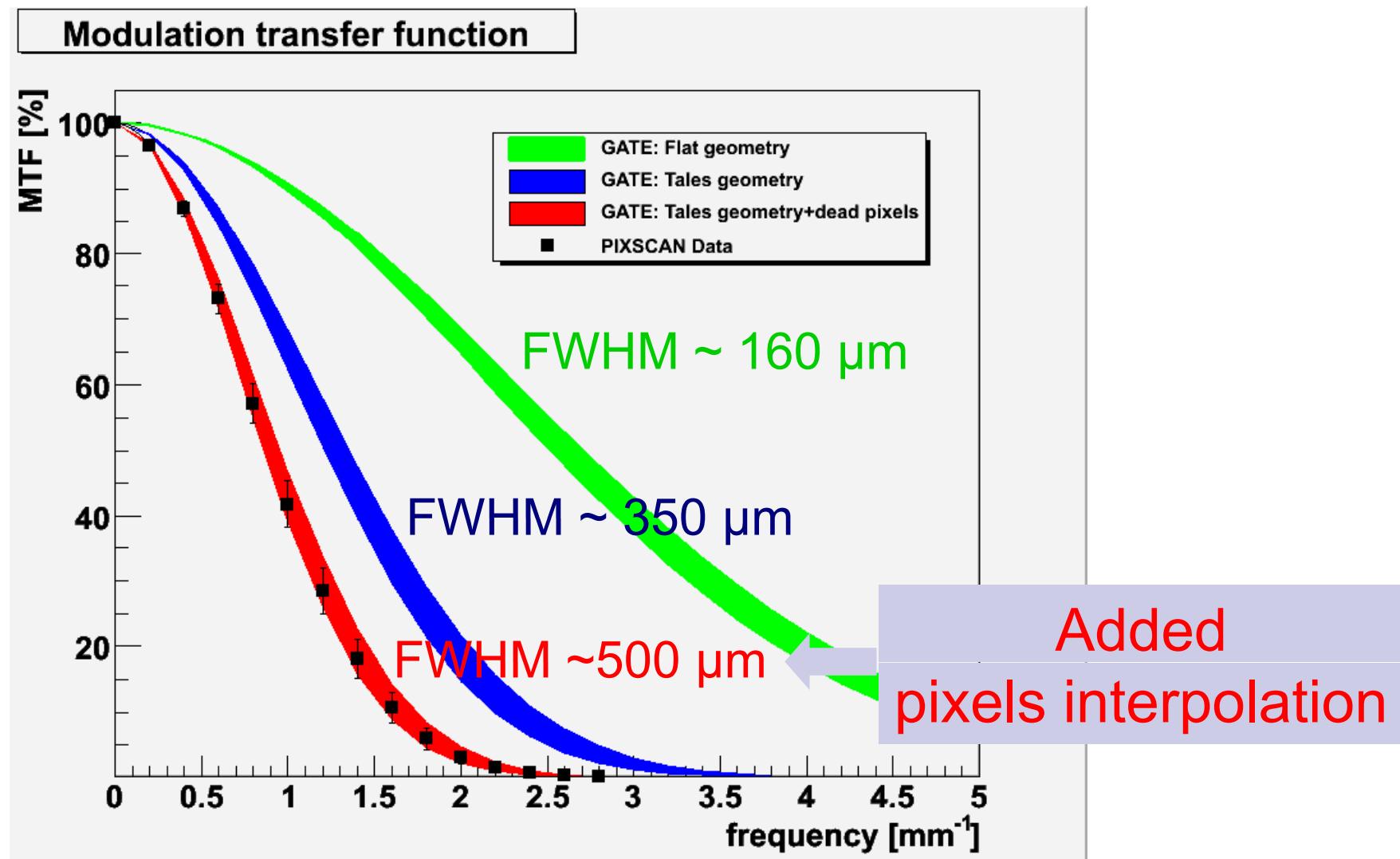
Spatial resolution: FLAT modules



Spatial resolution: TILED modules

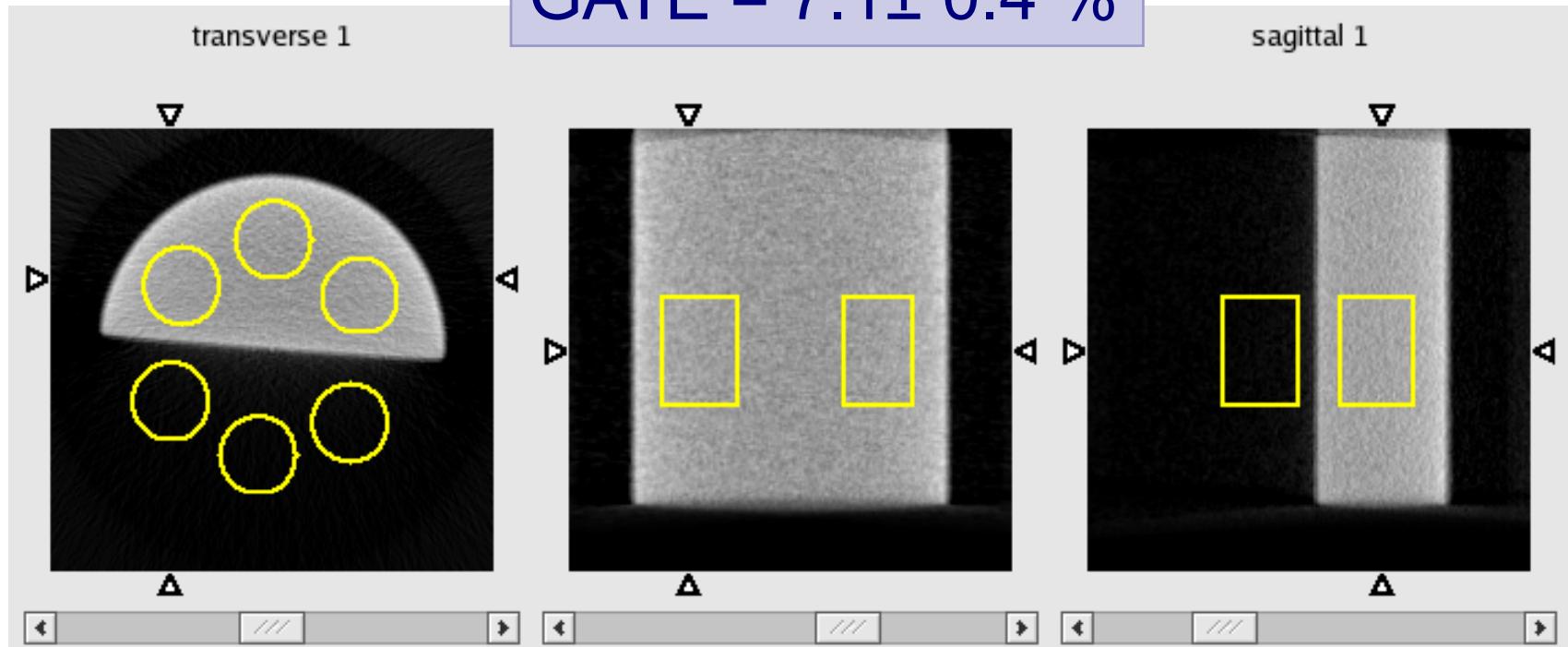


Spatial resolution: + DEAD PIXELS

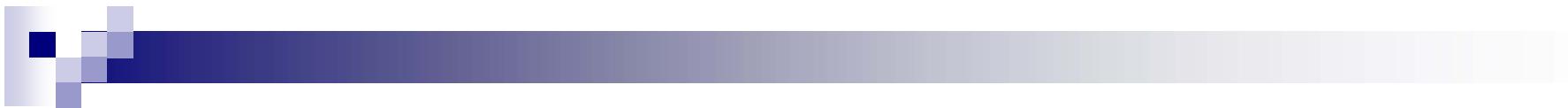


Noise

For 3000 ph/pixel:
Data = 7.1 ± 0.1 %
GATE = 7.1 ± 0.4 %



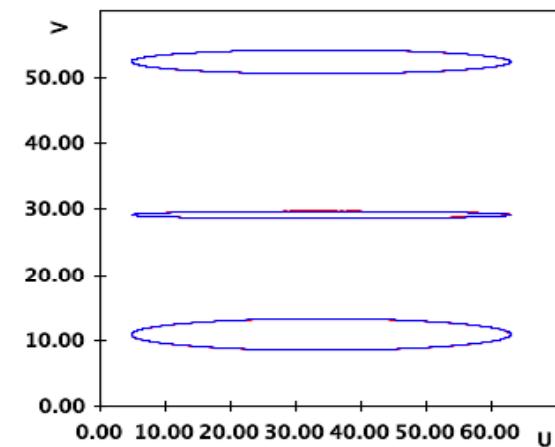
$$\% Noise = \frac{\sigma_{cyl}}{CT_{cyl} - CT_{air}} \times 100$$



Geometry

Several parameters to be estimated

GATE used to validate our calibration procedure



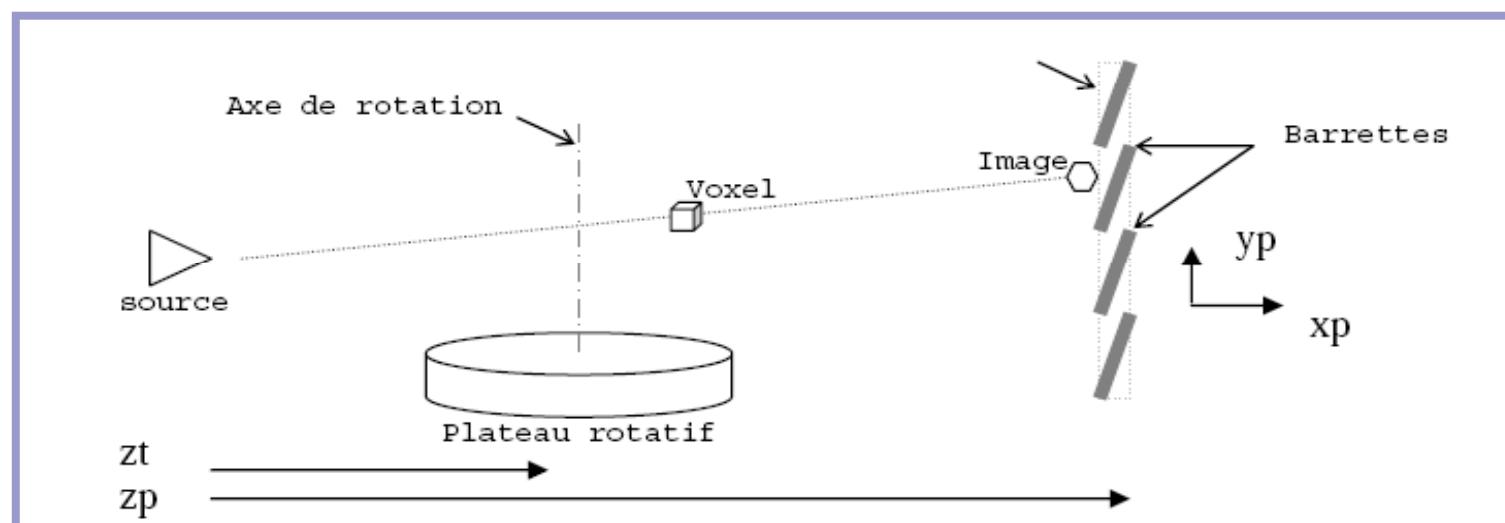
Geometry

GATE input

xp = -33.990 mm
yp = -34.712 mm
zp = 284.000 mm
alpha = 0
zt = 135.000 mm

Calibration output

xp = -34.344 +/- 5.447 mm
yp = -34.305 +/- 0.437 mm
zp = 284.397 +/- 5.497 mm
alpha = -0.0001 +/- 0.001 rad
zt = 135.11 +/- 2.585 mm





CT linearity

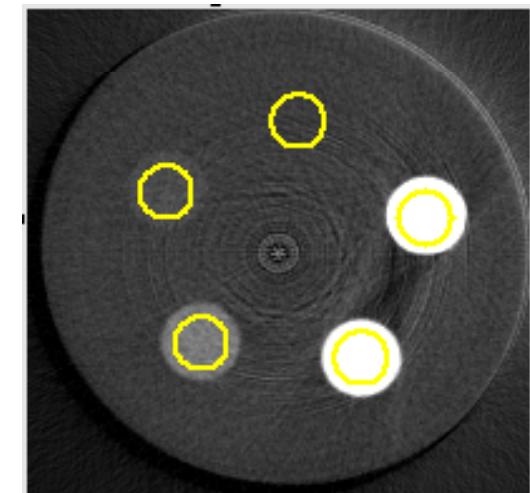
■ Simulation of a linearity phantom:

Base = epoxy resin (1.15 g/cm^3)

Inserts = calcium hydroxyapatite $\text{Ca}_5(\text{PO}_4)_3(\text{OH})$

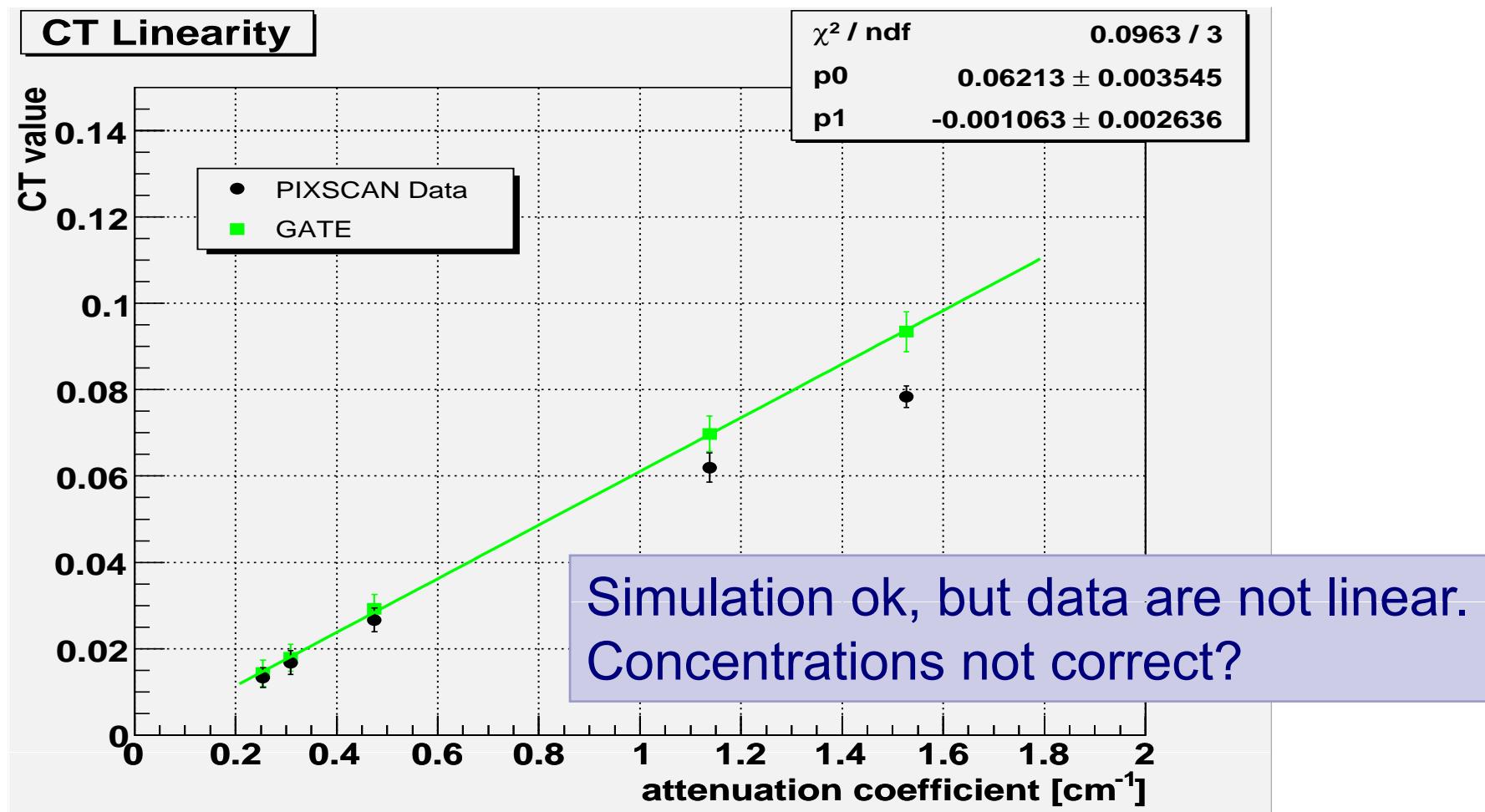


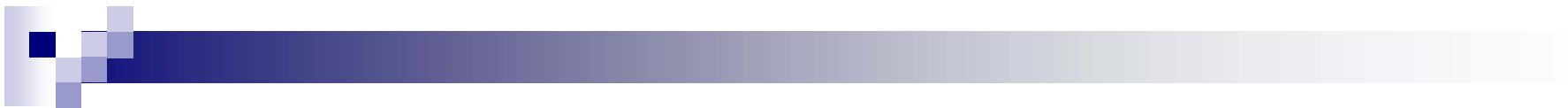
Insert	ρ_{HA} g/cm^3	ρ_{tot} g/cm^3
5	0.00	1.15
4	0.05	1.16
3	0.20	1.26
2	0.80	1.66
1	1.20	1.86



data

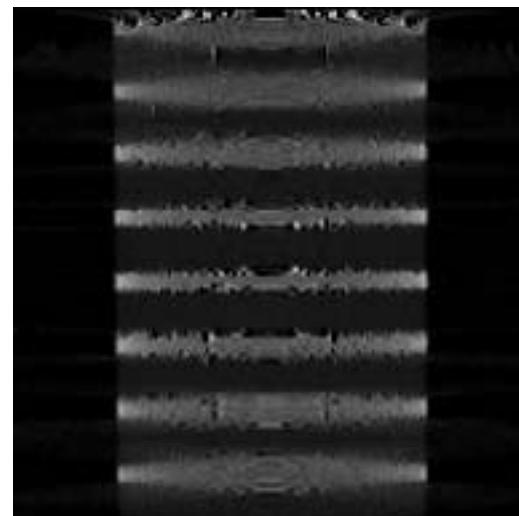
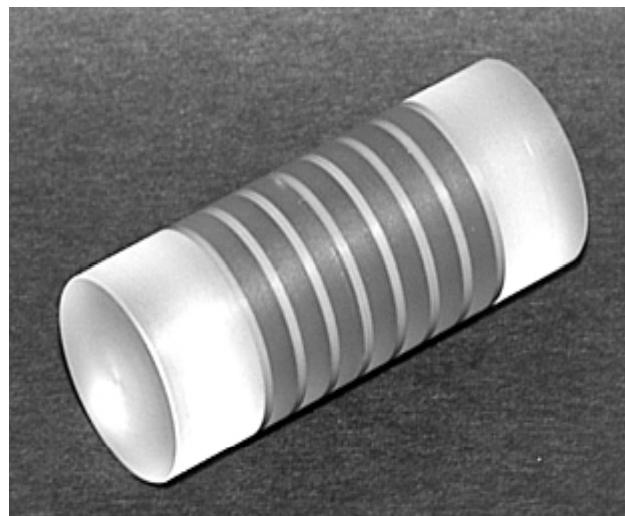
CT linearity



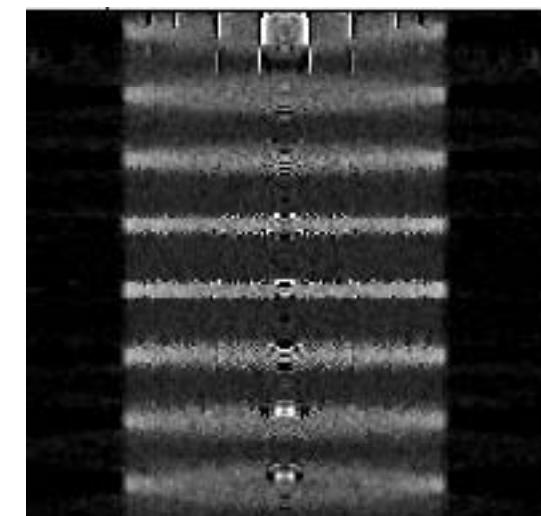


Tomography's distortions

- Simulation of a phantom after Defrise

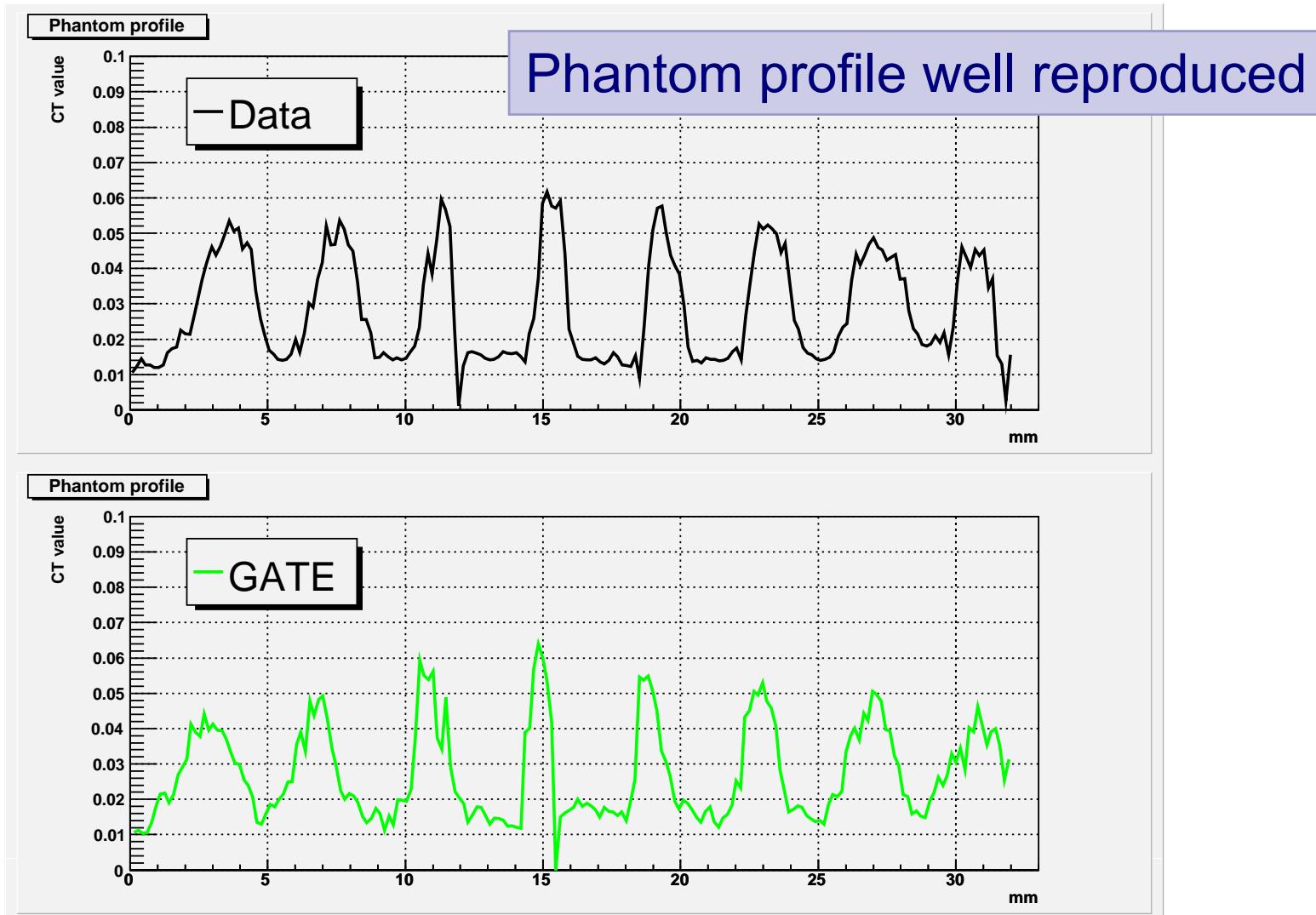


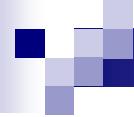
Data



Gate

Tomography's distortions





Conclusion

- GATE could reproduce several figures of merit of our CT scanner:
 - Spatial resolution
 - Noise
 - Linearity (for low densities)
 - Tomography's distortions
- The geometry calibration procedure could be validated
- Weak points of our image treatment could be identified (image rebinning)

Outlooks

GATE will help us in the following analysis:

- Optimization of the next PIXSCAN geometry :
new chip with pixels of $130 \times 130 \mu\text{m}^2$
- Dose estimations
- Contrast studies based on simulated animal phantoms
- Design of a simultaneous CT-PET scanner

