Diagnosi delle carie del legno su piante in piedi mediante tecniche tomografiche

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Incontri Fitoiatrici 2011/2

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Ultrasonic Tomography

What could supply?

- non invasive fast surveying technique
- accurate detection of size and extent of decay
- quantitative determination of ultrasonic velocity distribution in the investigated section

Wood	Longitudinal Wave Velocity m / s
Ash (Along Fiber)	4670
Birch (Along Fiber)	3340
Cork	500
Douglas Fir (Cross Grain)	1400
Douglas Fir (With Grain)	4800
Elm (Wood)	1400
Maple (Along Fiber)	4110
Oak	4470
Pine (Along Fiber)	3320
Poplar (Along Fiber)	4280
Sycamore (Along Fiber)	4460

Equipment and acquisition geometry

- PUNDIT (Portable Ultrasonic Non-destructive Digital Indicating Tester)
- 54 kHz exponential probes
- oscilloscope
- personal computer
- perimeter gage

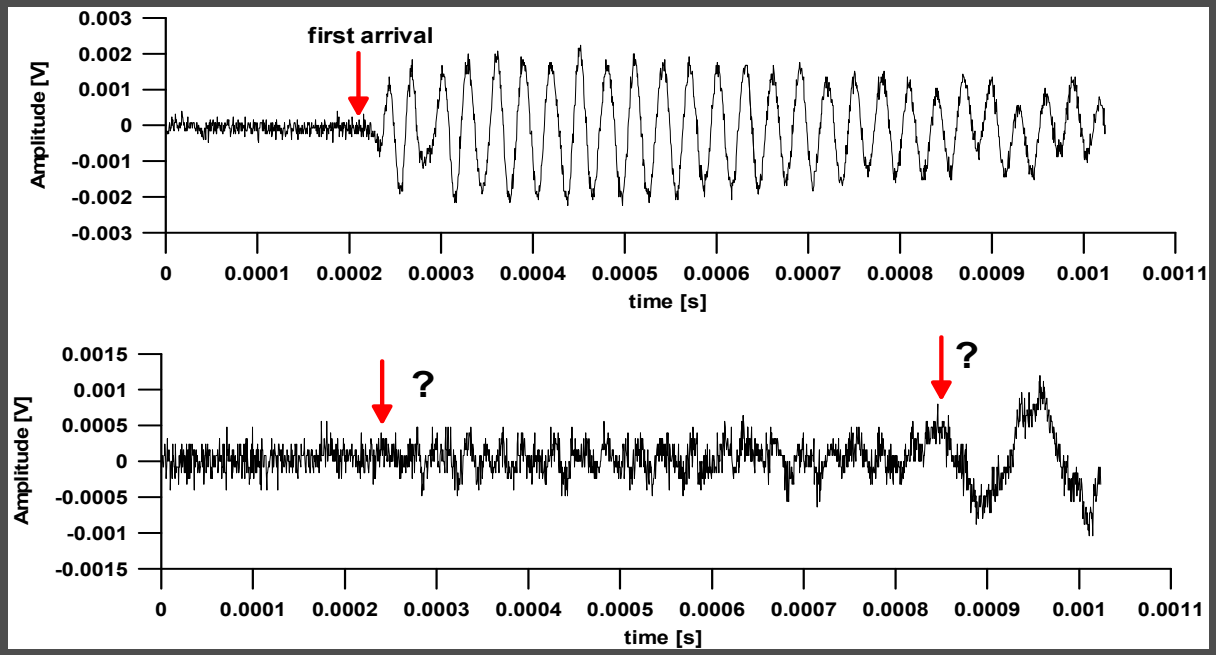
16 equidistant measuring points → 120 indipendent measurements for each investigated section.

Coordinate definition of source and receiver

travel time reading

1° open problem: attenuation

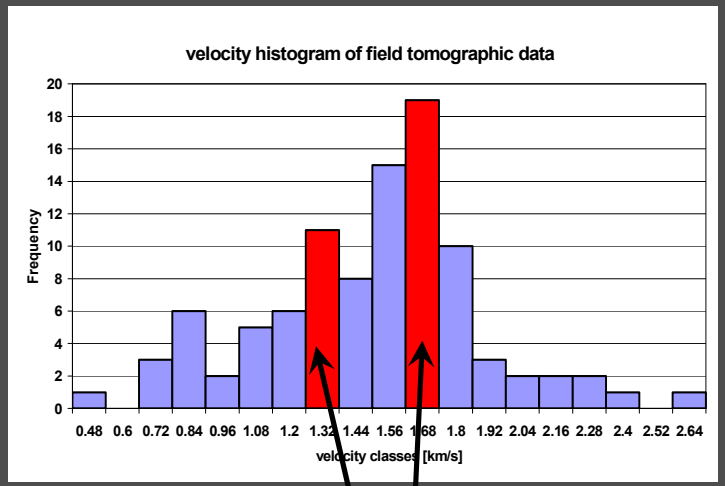
Signal attenuation deeply affect travel time detection reliability and automatic arrival picking is no more adequate

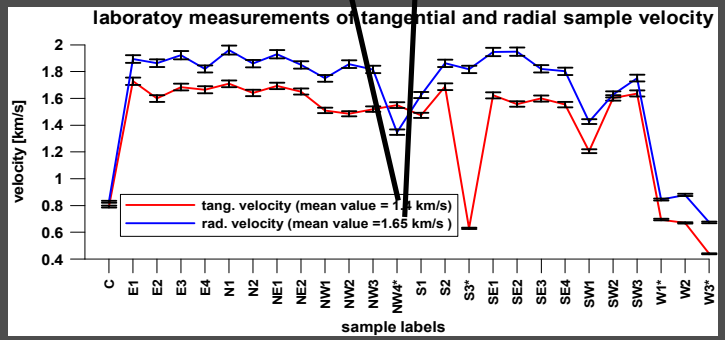


bad signal-noise ratio traces need signal processing technique application for travel time detection and uncertainty determination

statistical pre-processing

2° open problem: anisotropy

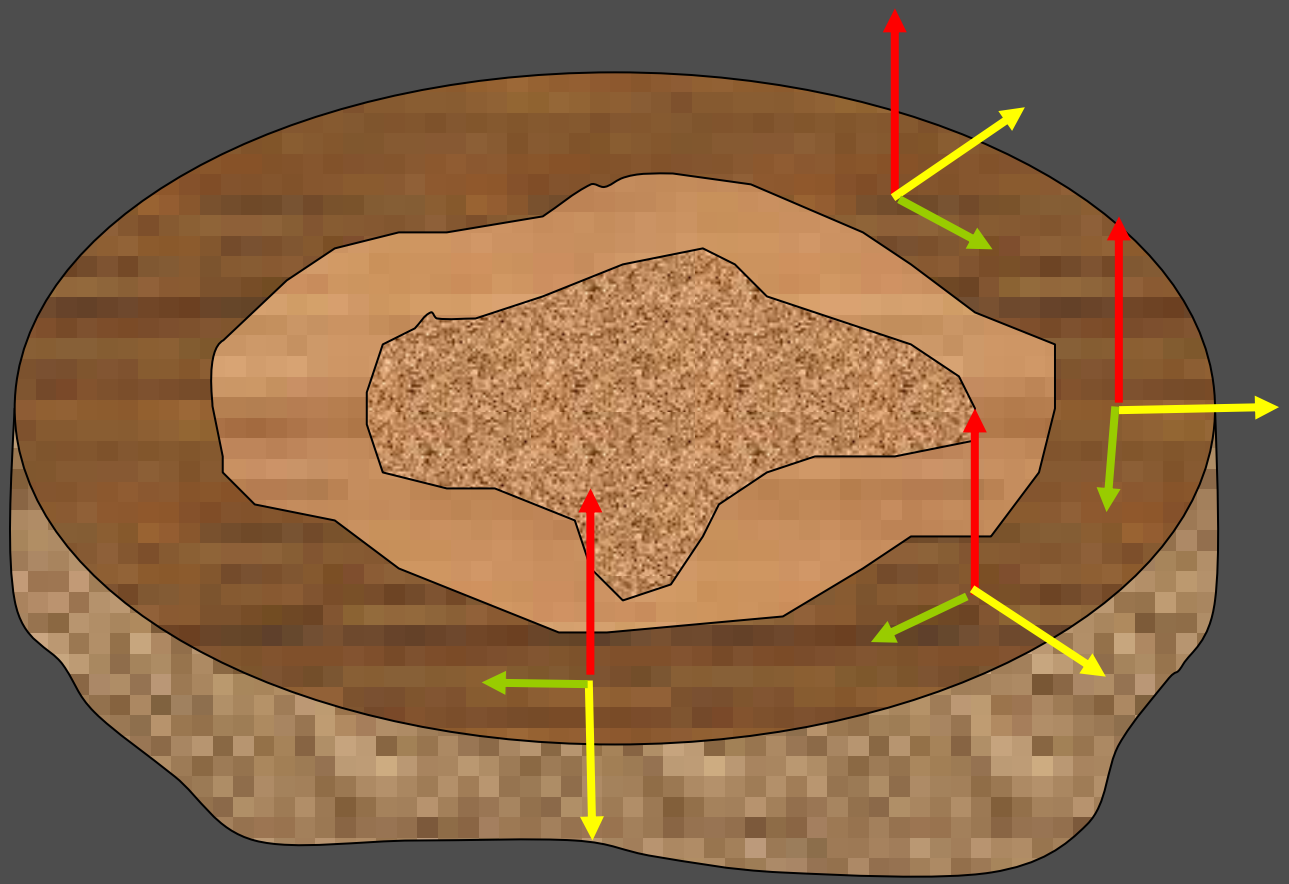




Statistical pre-processing of tomographic data can supply information about anisotropy influence on tomographic results.

Comparison with sample data confirms the validity of the proposed approach.

(quasi)Cylindrical symmetry of wood anisotropy



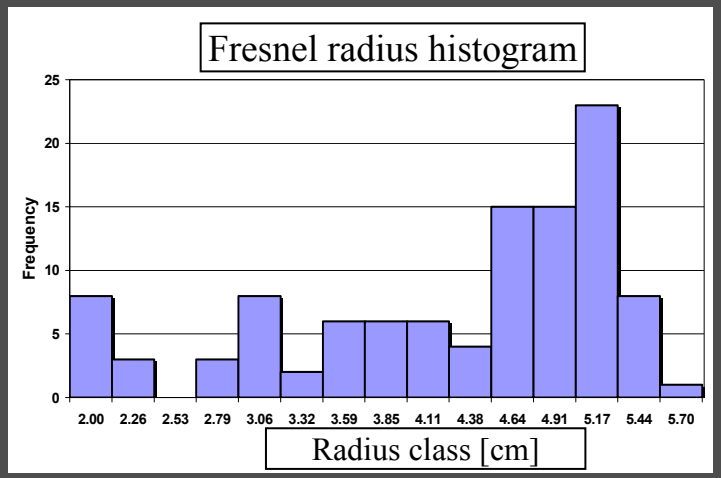
Longitudinal velocity

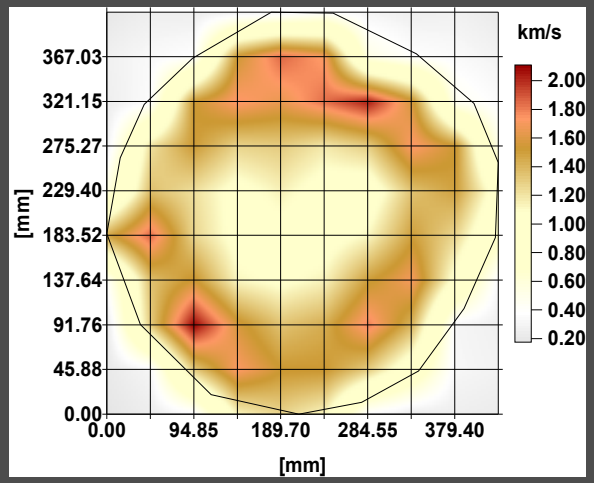
Tangential velocity

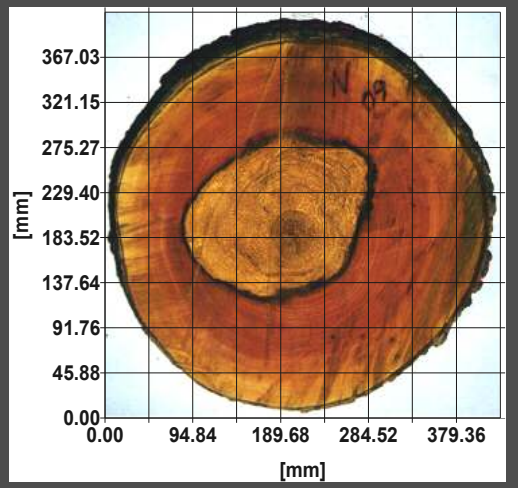
Radial velocity

statistical pre-processing

3° open problem: resolution







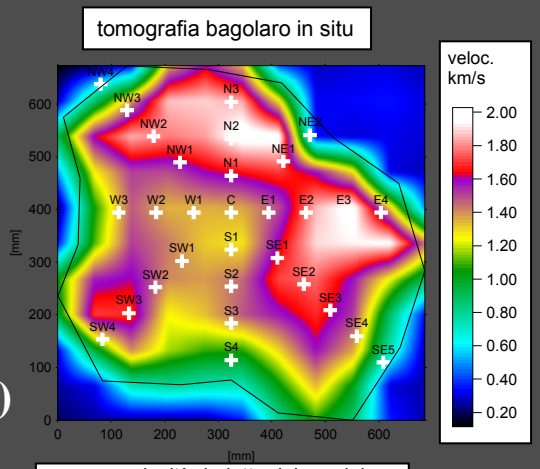
Spatial resolution has been taken into account both from the physical and the mathematical point of view.

Discretisation for tomographic imaging is based on these evaluations.

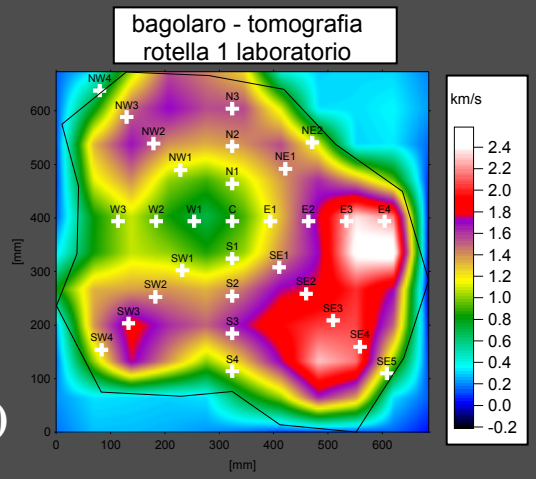
results

a)

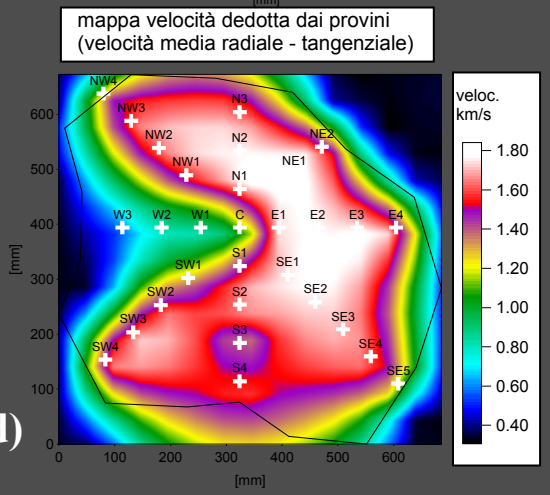
b)



c)



d)



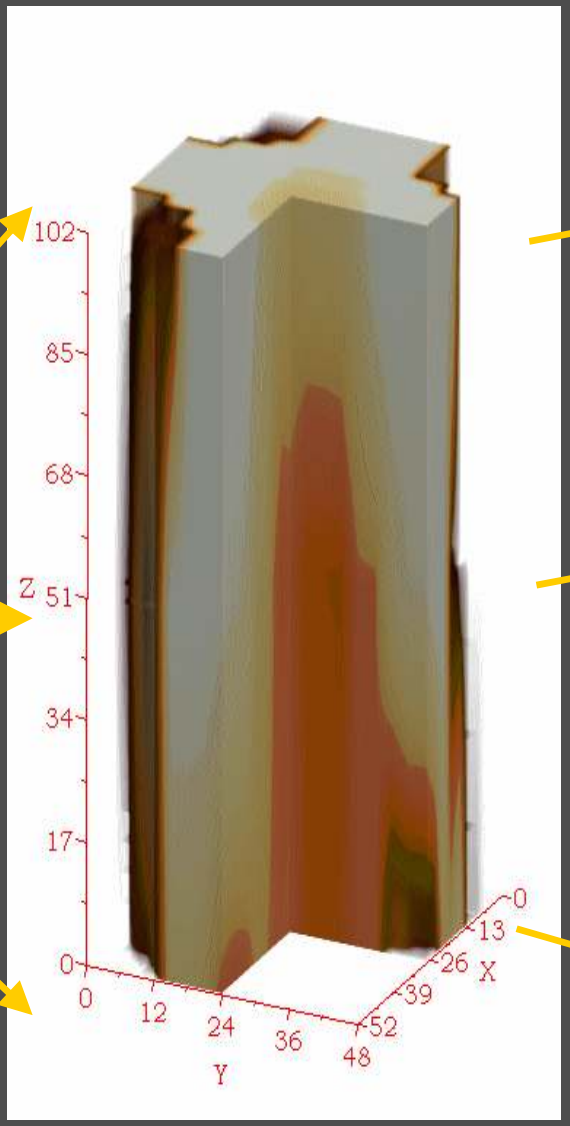
a)investigated section;

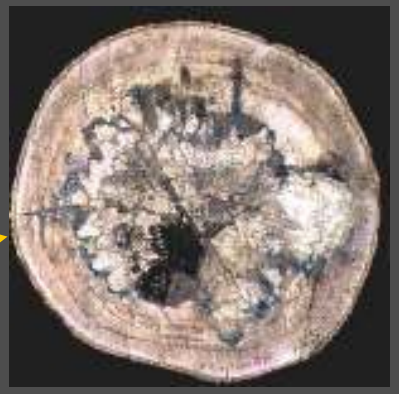
b) in situ tomography;

c) laboratory tomography on a wood disk;

d) velocity map obtained by samples measurements (radial - tangential mean velocity).

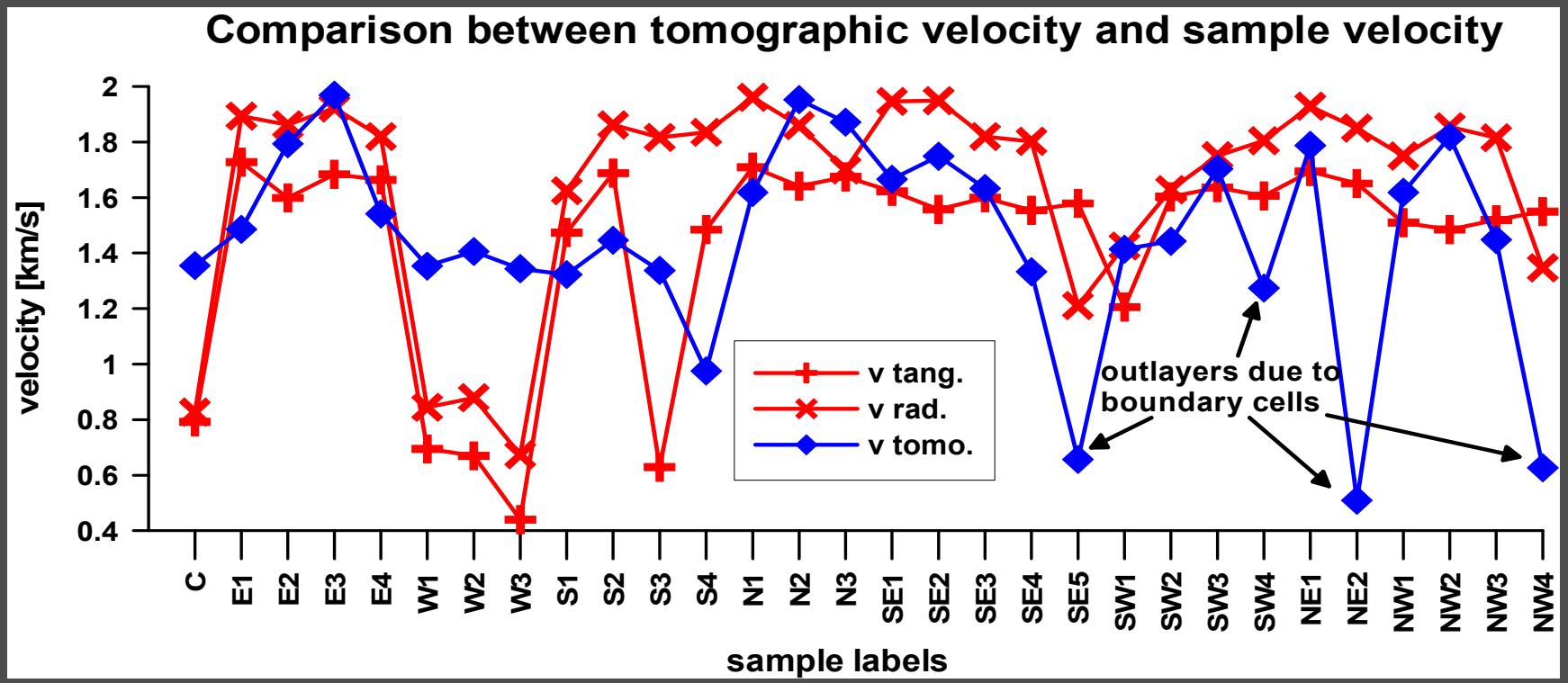
results



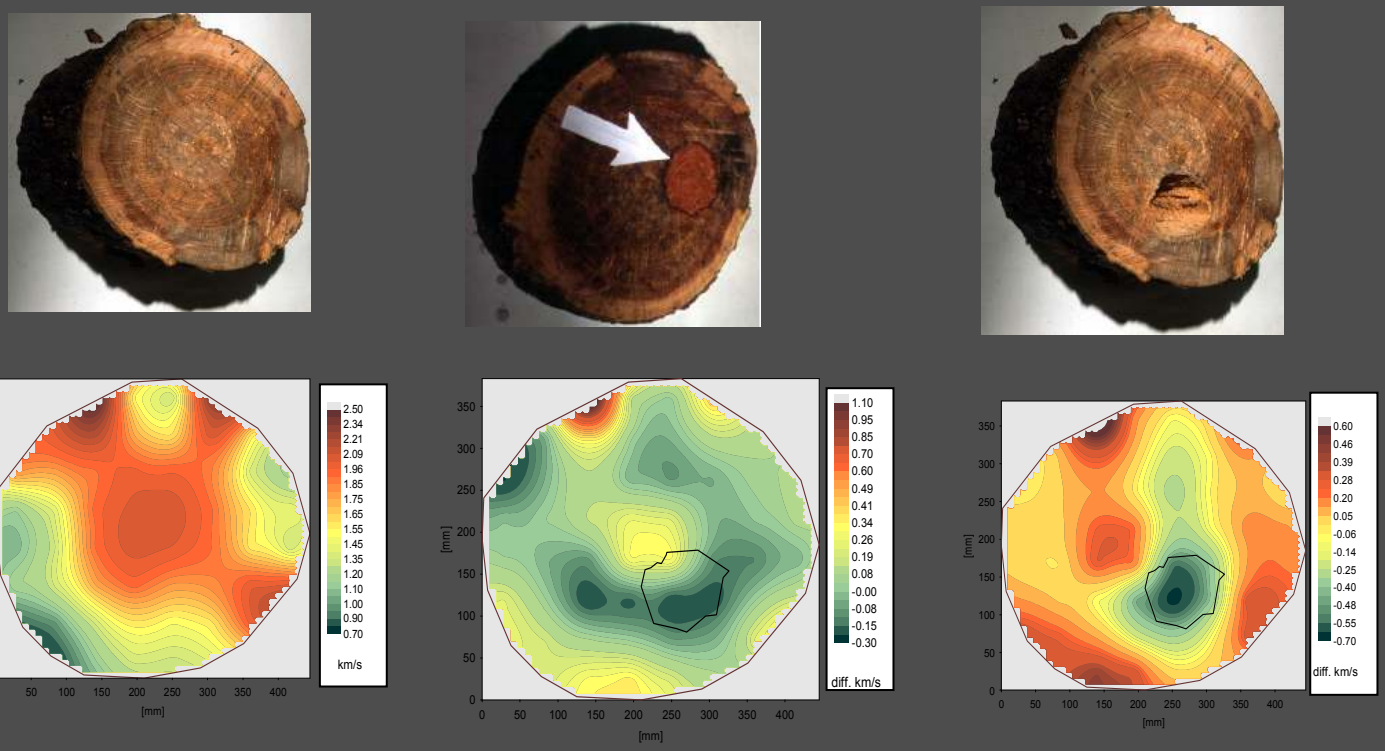


result comparison

4° open problem: underestimation of velocity contrast



Time lapse tomography



Evolving condition monitoring tested with laboratory measurements of velocity variation maps.

resuming: advantages

- totally non invasive;
- good accuracy and reliability in determination of size and extent of decay;
- quantitative results;
- possible automation of the acquisition and processing for non expert end-users.

resuming: open problems

estrinsic problem (could be solved by engineering improvement):

- attenuation;
- spatial resolution;
- ~~anisotropy;~~ **SOLVED ! Maurer et al. 2006**

intrinsic problem:

- anisotropy;
- underestimation of velocity contrasts;

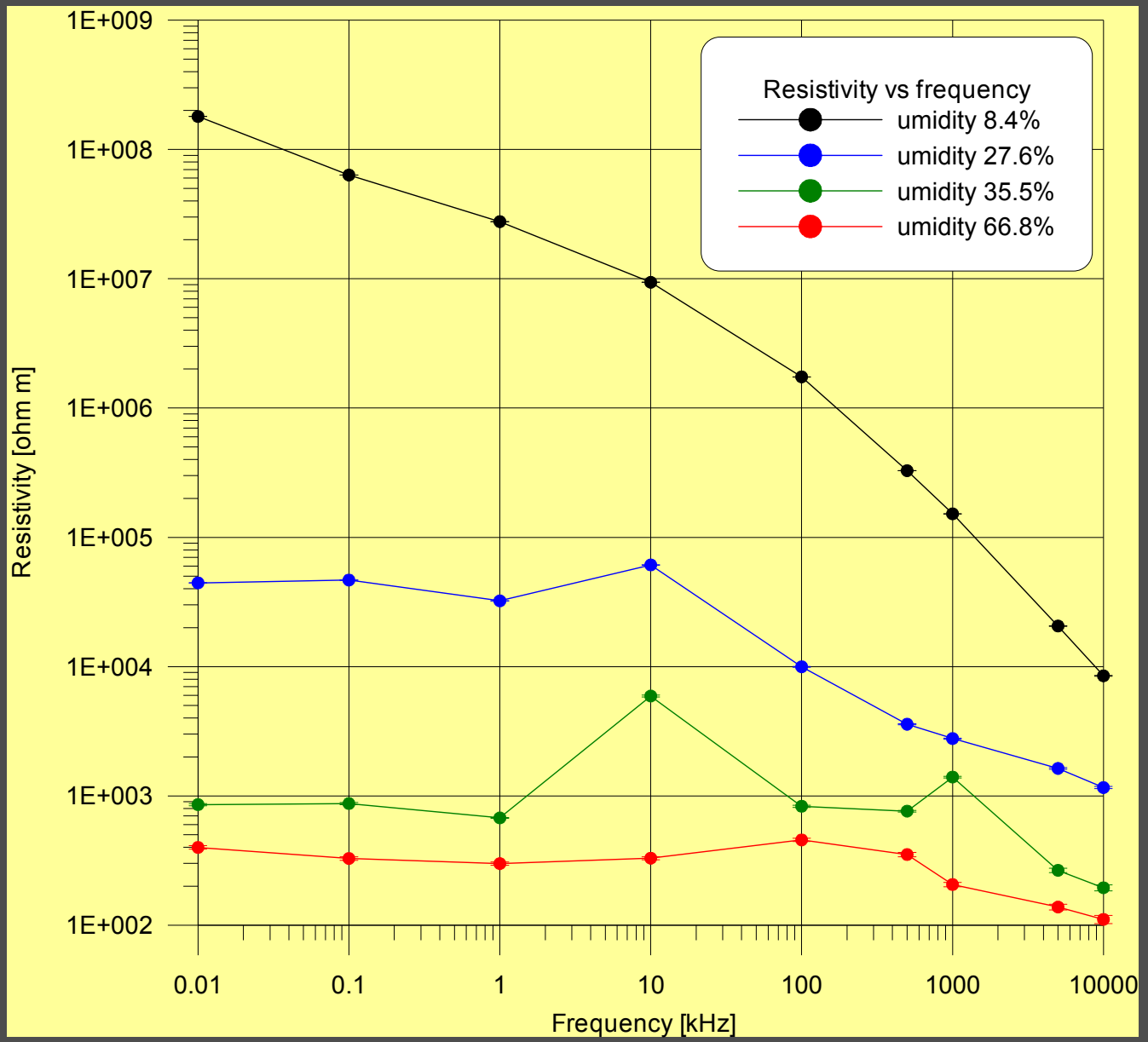
further development: technical

- multi-channel ultrasonic equipment and "instrumented belt" to speed up the acquisition;
- measuring device for accurate sensors positioning;
- amplified and sharp energising pulse for good s/n ratio signals and autopicking procedure;
- automation of statistical pre-processing and tomographic imaging;

Only partially solved

Resistivity Tomography

Variation of electric properties with frequency and degradation

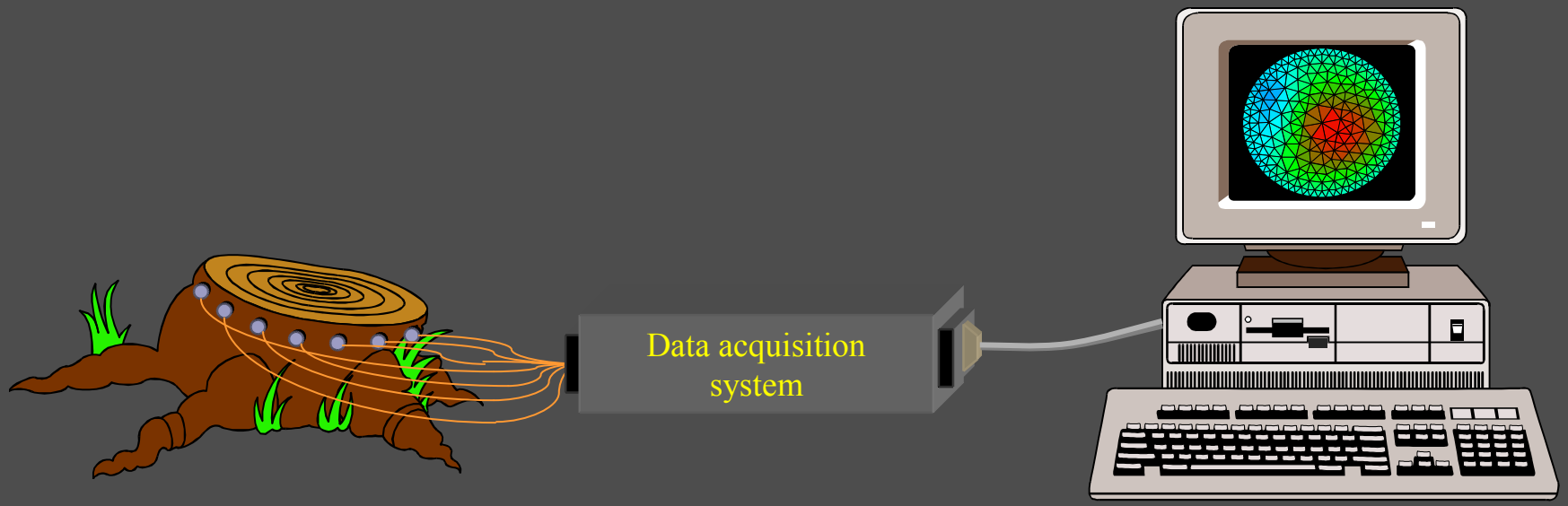


Some resistance * values of Douglasia under mushrooms attack

		Settimane di incubazione			
Tessuto	fungo	2	4	8	16
		Resistenza * elettrica del legno (in kΩ)			
Alburno	Nessuno	275	195	240	190
	Carie bianca	72	70	52	26
	Carie bruna	75	73	72	35
Durame	Nessuno	>500	>500	>500	>500
	Carie bianca	168	70	63	30
	Carie bruna	142	62	80	34

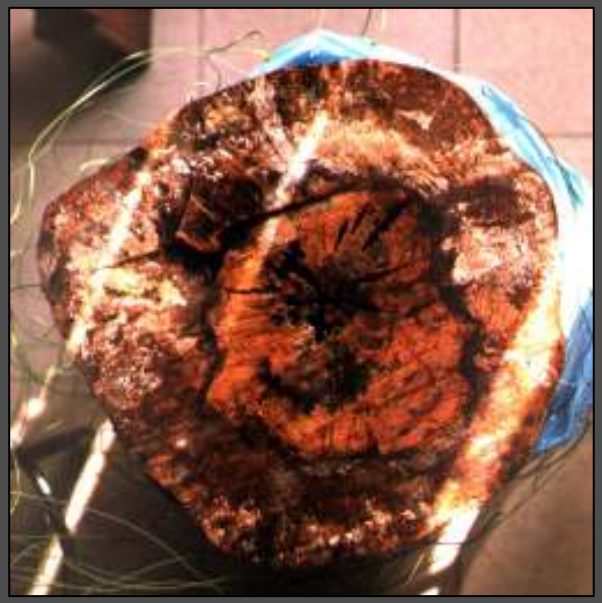
* In literature one can often find resistance as there is a kind of standard measuring device

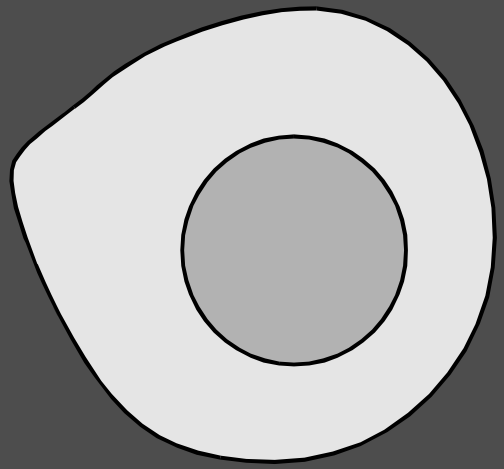
Electric tomography device

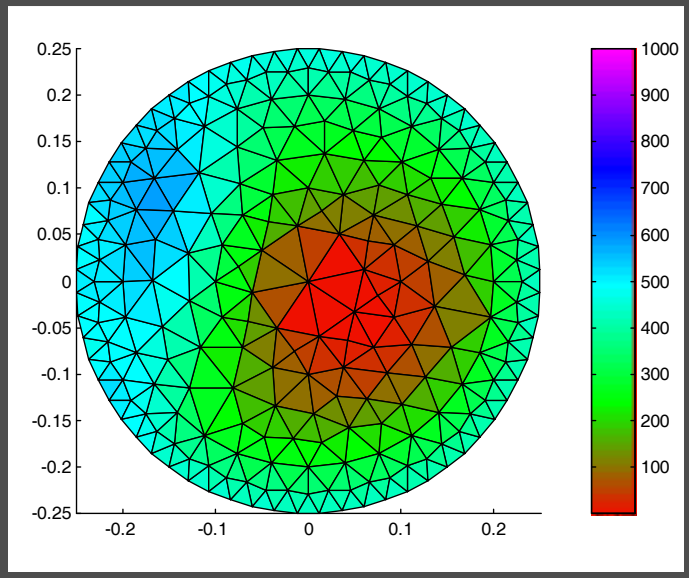


Test on wood in laboratory

Test on wood in laboratory

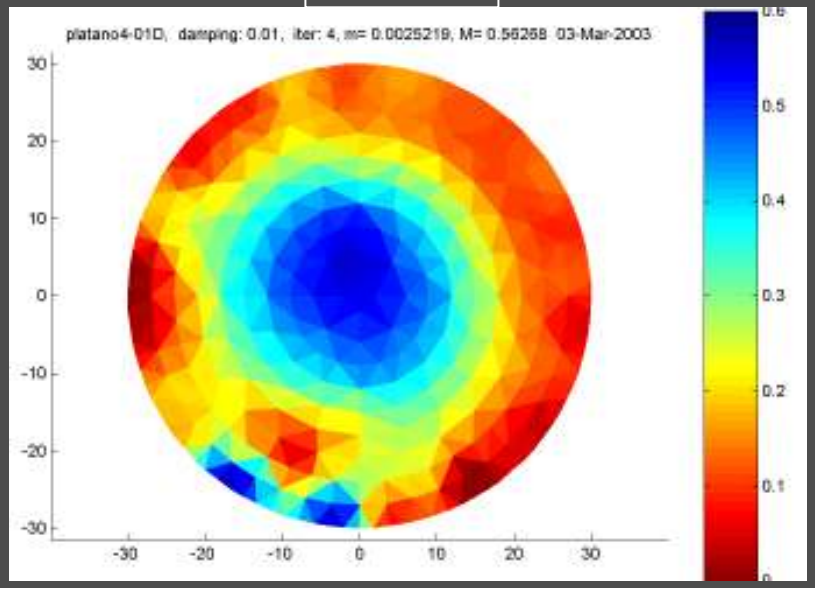




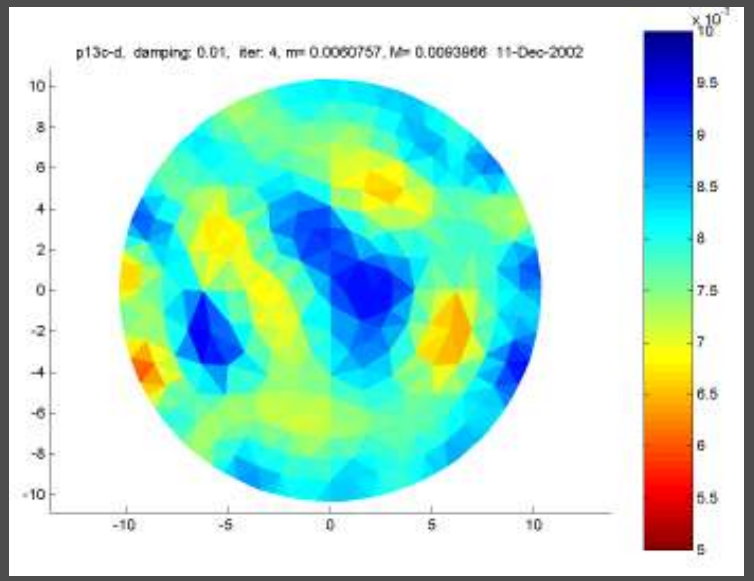


Test on trees in field

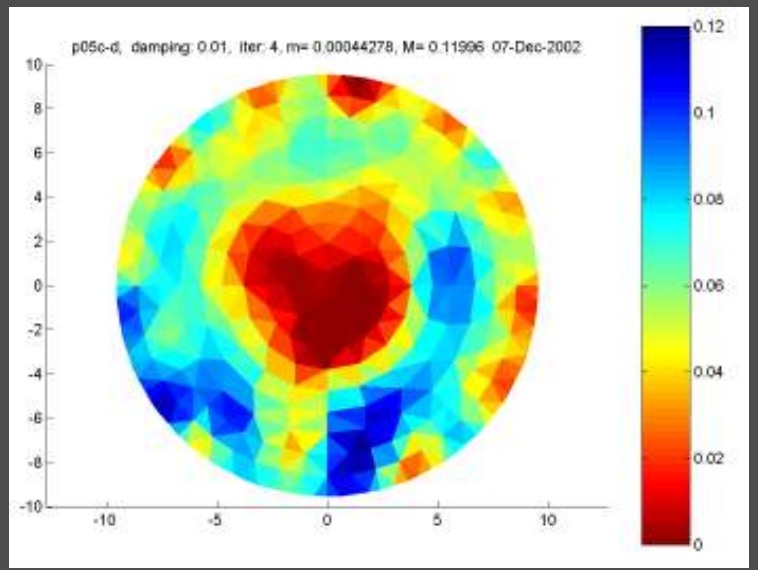
Test on trees in field



Test on poles in field



Sound



Decayed

resuming: advantages

- fast;
- reduced sensors-wood coupling problems;
- sensitive to humidity and ionic concentration;
- possible automation of the acquisition and processing for non expert end-users.

resuming: open problems

- partially invasive;
- partial accuracy and reliability in determination of size and extent of decay;
- season dependent;
- some ambiguities in interpretation.

MARTINIS R.; SOCCO L.V.; SAMBUELLI L.; NICOLOTTI G.; SCHMITT O.; BUCUR V. (2004).
Tomographie ultrasonore pour les arbres sur pied.
ANNALS OF FOREST SCIENCE, vol. 61; p. 1-9, ISSN: 1286-4560
15 CITATIONS

SOCCO L.V.; SAMBUELLI L.; MARTINIS R.; COMINO E.; NICOLOTTI G. (2004).
Feasibility of ultrasonic tomography for nondestructive testing of decay on living trees.
RESEARCH IN NONDESTRUCTIVE EVALUATION, vol. 15; p. 31-54, ISSN: 0934-9847
13 CITATIONS

NICOLOTTI G; SOCCO L. V.; MARTINIS R.; GODIO A.; SAMBUELLI L. (2003).
Application and comparison of three tomographic techniques for detection of decay in trees.
JOURNAL OF ARBORICULTURE, vol. 29; p. 66-78, ISSN: 0278-5226
41 CITATIONS

SAMBUELLI L.; SOCCO L.V.; GODIO A.; NICOLOTTI G.; MARTINIS R. (2003).
Ultrasonic, electric and radar measurements for living trees assessment.
BOLLETTINO DI GEOFISICA TEORICA E APPLICATA, vol. 44; p. 253-279, ISSN: 0006-6729
4 CITATIONS

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