



HAL
open science

Characteristics of "resonance wood" as viewed by violin makers or by wood scientists: Part 2 – Characterisation and correlations of structural and mechanical properties

Capucine Carlier, Iris Brémaud, Miyuki Matsuo, Eiichi Obataya, Masashi Nakamura, Tancrede Almeras, Joseph Gril

► To cite this version:

Capucine Carlier, Iris Brémaud, Miyuki Matsuo, Eiichi Obataya, Masashi Nakamura, et al.. Characteristics of "resonance wood" as viewed by violin makers or by wood scientists: Part 2 – Characterisation and correlations of structural and mechanical properties. International symposium WoodSciCraft 2014 "Wood Science and Craftsmanship: Cross perspective between Europe and Japan", Sep 2014, Montpellier, France. hal-01960570

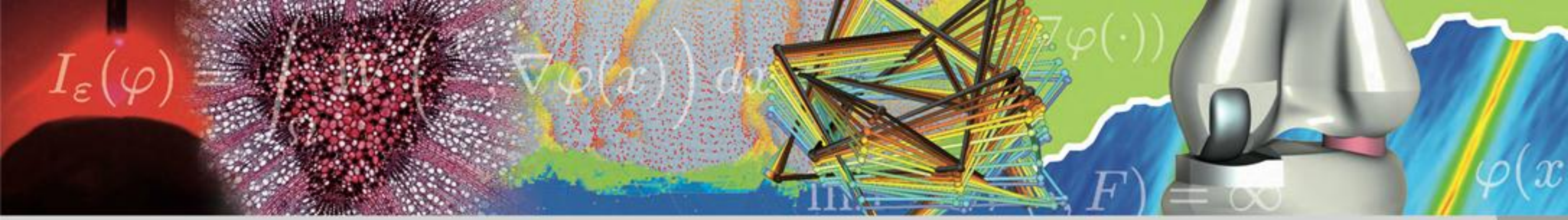
HAL Id: hal-01960570

<https://hal.science/hal-01960570>

Submitted on 19 Dec 2018

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



« CHARACTERISTICS OF "RESONANCE WOOD" AS VIEWED BY VIOLIN MAKERS OR BY WOOD SCIENTISTS: PART 2 – CHARACTERISATION AND CORRELATIONS OF STRUCTURAL AND MECHANICAL PROPERTIES »

CARLIER Capucine¹, BREMAUD Iris¹, MATSUO Miyuki², OBATAYA Eiichi³, NAKAMURA Masashi⁴, ALMERAS Tancrede¹, GRIL Joseph¹

(1)LMGC, UMR 5508, CNRS, UM2, cc048, place E. Bataillon, 34095 Montpellier Cedex5, France

(2)Lab. Of Biomaterials Physics, Graduate School of Bioagricultural Sciences, Nagoya University, Japan

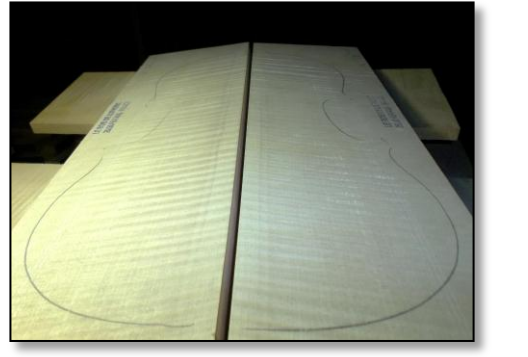
(3)Lab. Of Wood Science and Technology, Graduate School of Life and Environmental Sciences, Tsukuba University, Japan

(4)Lab. of Biomaterials Design, Graduate School of Agriculture, Kyoto University, Japan



1. Introduction

The objective of this study is to improve the understanding of the **interactions** between **physic-mechanical properties** of resonance wood, their **natural variability**, and the actual **expertise of violin makers** in the selection and qualification of their raw material.

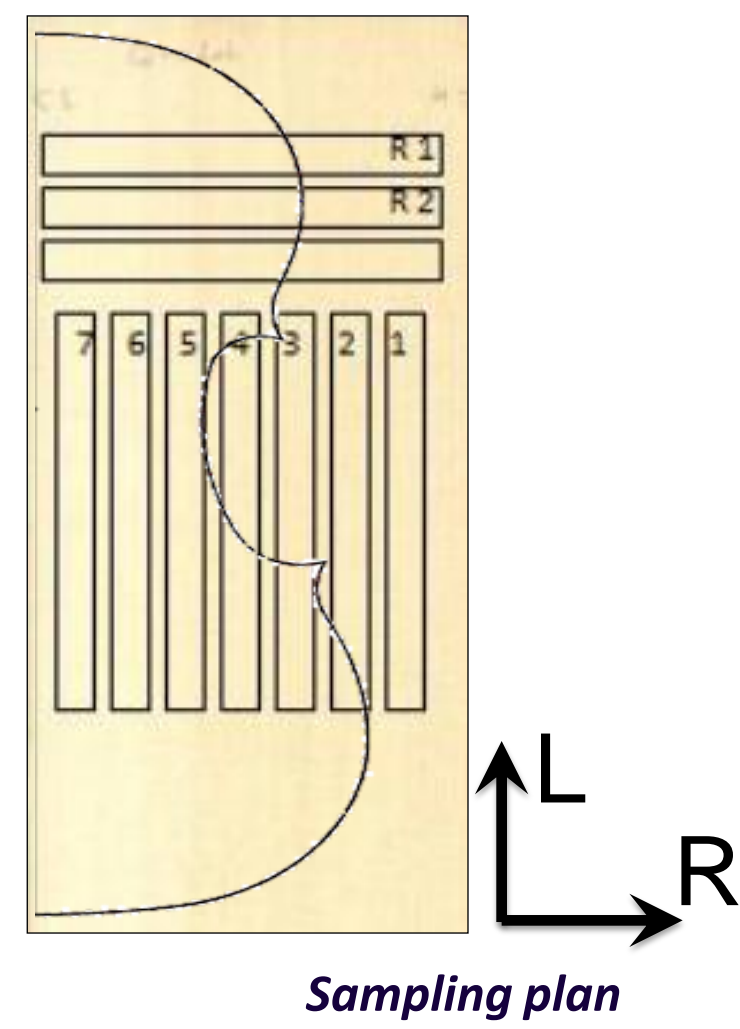


2. Visual and vibrational features of spruce

Material and Methods

o Spruce (*Picea abies* [L.] Karst)

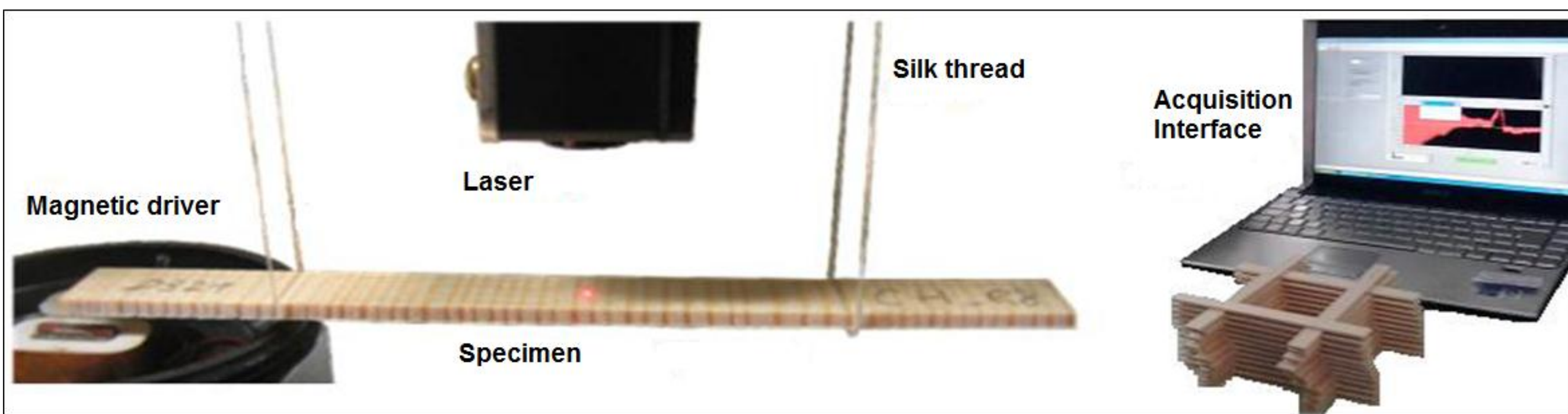
- o 10 Viola and 14 violin soundboard, Quality grades "Excellent" and "Master grade"
- o 72 samples in R radial direction (120 x 2,5 x 12mm, R x T x L) and 177 samples in L longitudinal direction (12 x 2,5 x 150mm, R x T x L).



Measurement of physical and vibrational properties and the acoustical indexes of the specimens

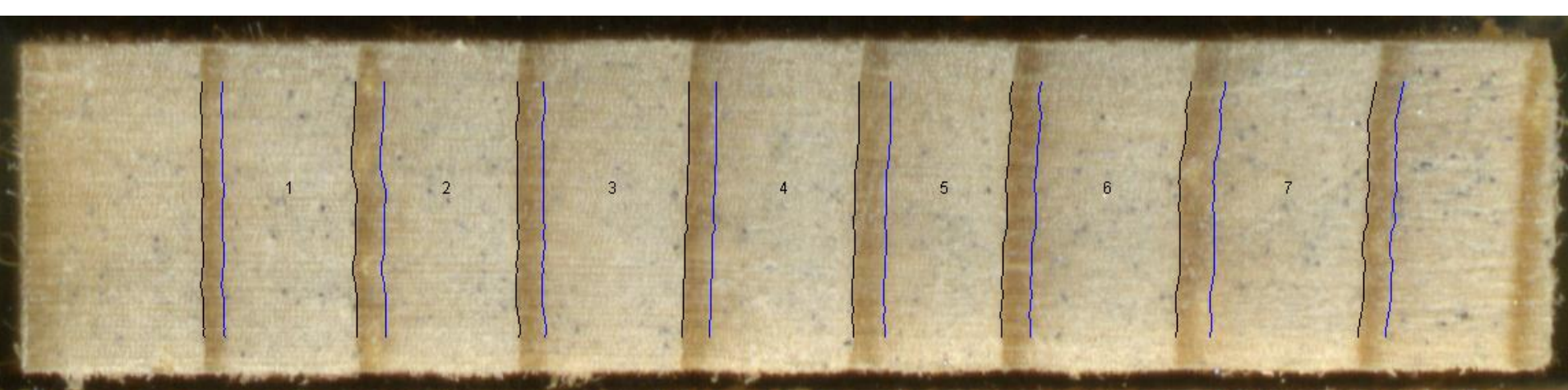
- Specific modulus of elasticity E/ρ
- Damping coefficient / internal friction $\tan\delta=Q^{-1}$
- Characteristic impedance $z = \sqrt{E\rho}$
- Ratio of radiation $R = \sqrt{E/\rho^3}$
- Acoustic conversion Efficiency $ACE = R/\tan\delta$

(Longitudinal and Radial; 3 weeks at 65% relative humidity and 20° C, Frequency range 100-750 Hz)



« Vybris », a device for non contact forced vibrations testing of free-free beams developed in LMGC

Measurement of visual/structural characteristics (growth-ring width, uniformity and percentage of latewood).



Visual characteristics analyzed by an Image J plugin developed by Tancrede Almeras (LMGC)

Wood properties: variability and correlations

Correlations between visual characteristics and wood properties

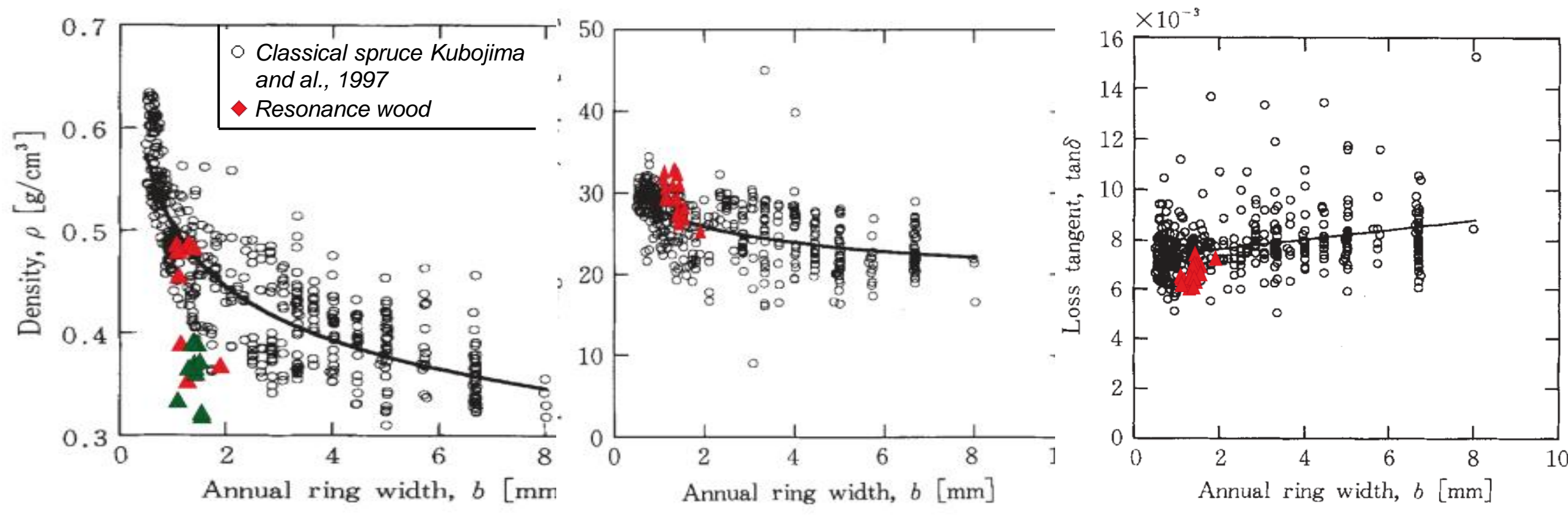
Density is mostly affected by latewood Proportion(Lw). Ring width (Rw) and Lw reflect vibrational properties. Density provides information on the acoustical indexes.

Visual parameters = indicators of wood mechanical properties

Link between specific modulus and density unexpected => microstructural explanation ?

	Rw (mm)	Lw (%) mean	Lw (%) r/r	Density ρ
Density ρ	-0.44	0.78	0.75	
EL/ ρ	-0.63	0.86	0.86	0.69
ER/ ρ	0.69	-0.55	-0.56	-0.36
$\tan\delta$ L	0.58	-0.63	-0.65	-0.28
$\tan\delta$ R	-0.74	0.73	0.73	0.59
zL	-0.51	0.84	0.82	0.98
RL	0.28	-0.58	-0.54	-0.93
ACEL	0.00	-0.25	-0.21	-0.72

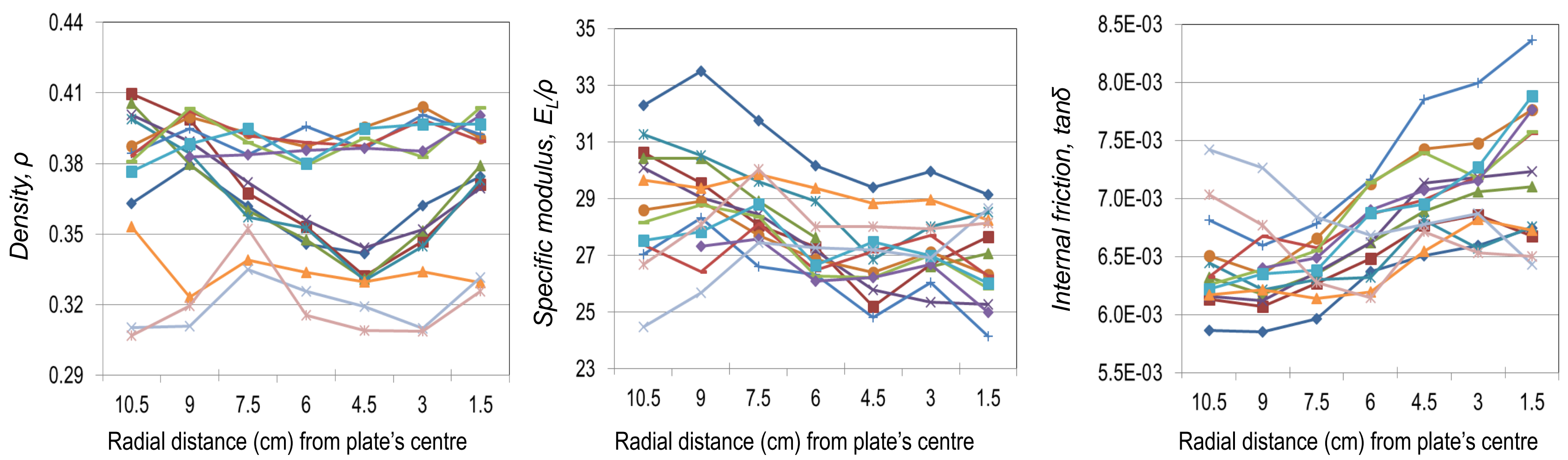
Correlations between properties, acoustical index and visual characteristics of wood



Relation between visual characteristics of spruce wood and its properties

=> Is the confidence of luthiers for their suppliers coming from the pre-selection of an uncommon material?

Intra and inter soundboard variability

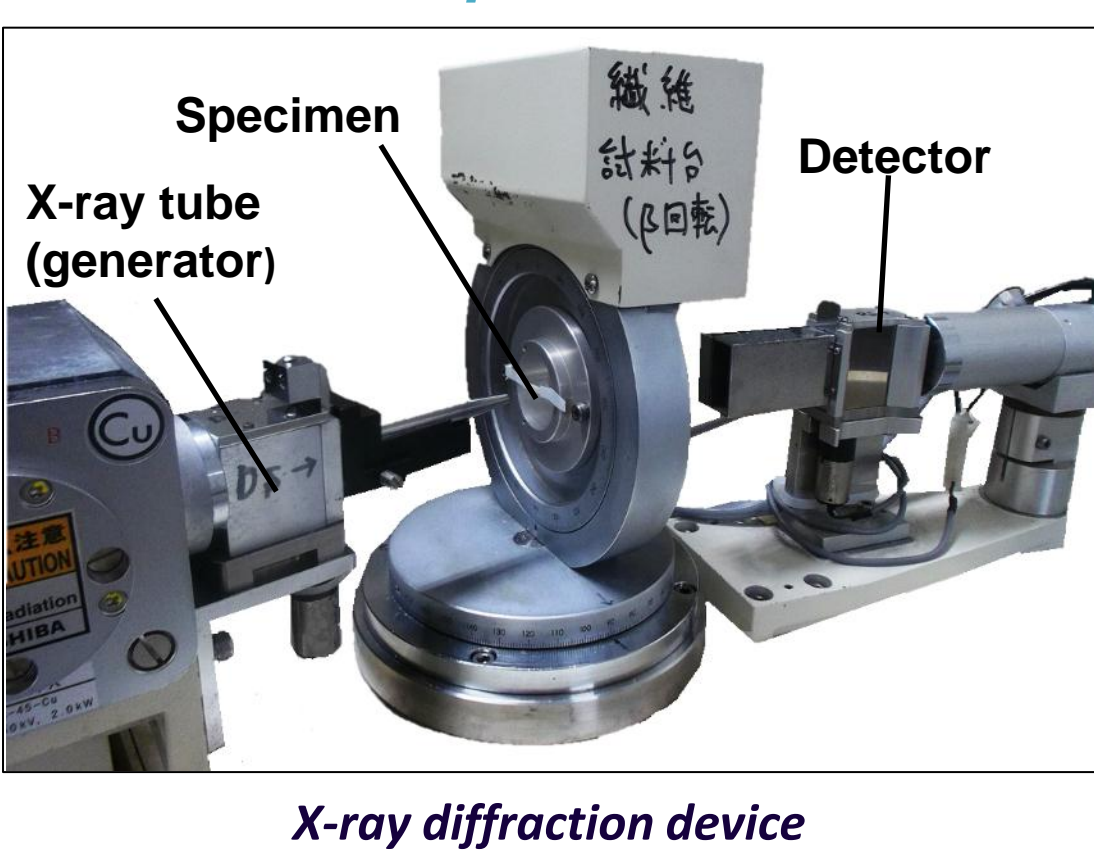


Evolution of density, specific modulus and damping within the radial direction of violins soundboards

High variability within and between plates → a single specimen may not be representative of the properties of the entire board. => Necessity to construct a model to evaluate the properties of a full violin plate from sampling fabrication offcuts

3. To go further : Work in progress

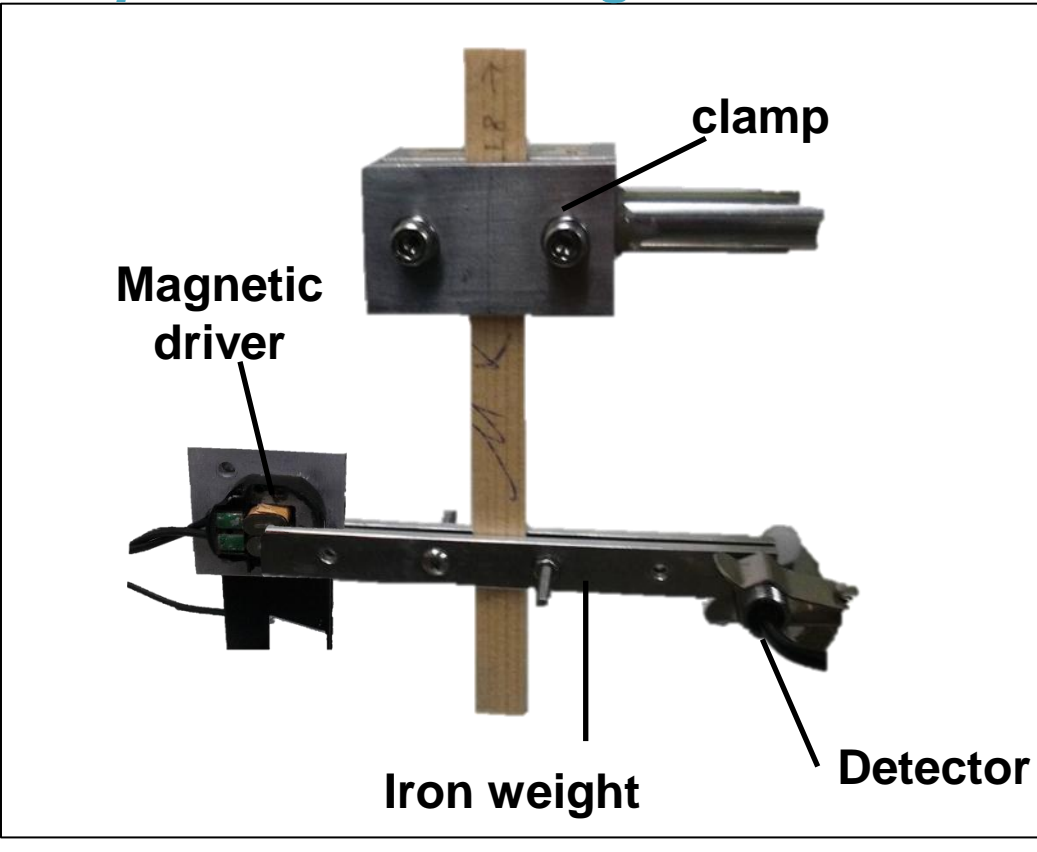
Can the microstructure of wood (microfibril angle) be the cause of the specificities of resonance wood ?



X-ray diffraction device

- o Spruce (*Picea abies* [L.] Karst)
- o 9 violin soundboard, 4 ≠ quality grade
- o 10 samples of Ew + 10 samples of Lw by table
- o MFA by Xray diffractometer

Vibrational tests: beyond indicators of "amplitude and response", how to get indicators of "timbre"?

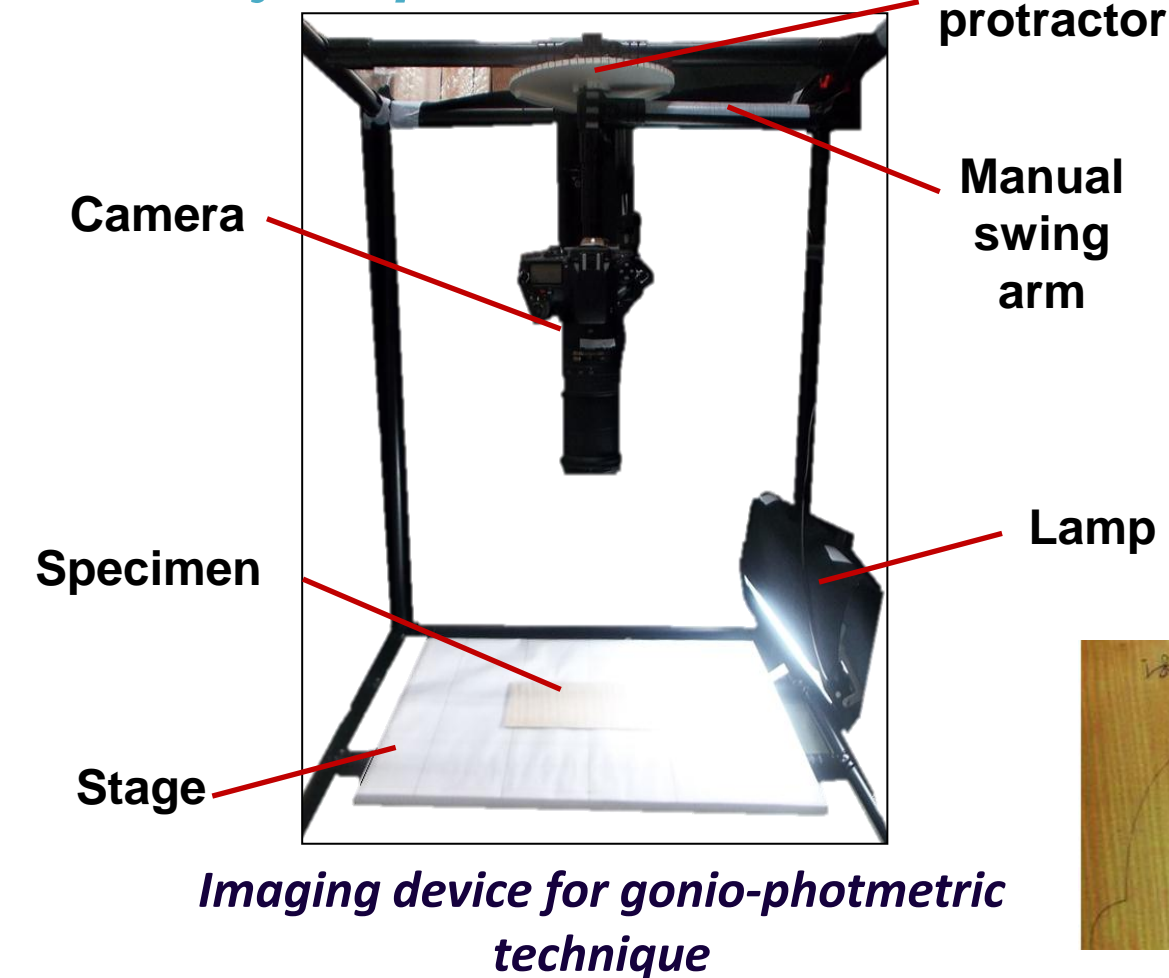


Torsional vibration device

- o Spruce & Maple (*Acer pseudoplatanus* L.)
- o 9 spruce soundboards + 8 maple back plates, 4 ≠ quality grade
- o 4 small specimens per plate
- Determination of shear (torsion) modulus G , and damping $\tan\delta_G$ (+density ρ)

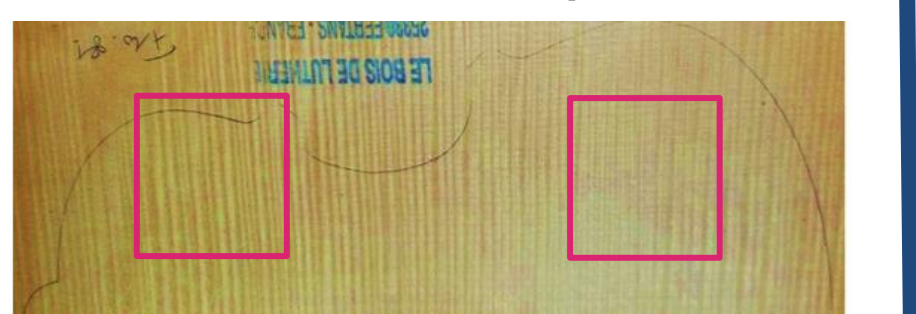
- G_{Acer} (maple) > G_{Picea} (spruce)
- **Spruce:** G from high quality plates are clearly lower than G from low quality plates (0.7 for 1st quality to 1.2 for 4th quality)
- No clear trend for $\tan\delta$

How can we determine the appearance of wavy grain of curly maple ?



Imaging device for gonio-photometric technique

- o Maple
- o 8 back plates, 4 different quality grades
- o 2 areas observed for each plate



- Noticeable features are changing by the lighting azimuth.
- Calculating differences of the lightness in local 3x3 area (local contrast) everywhere at every filter size

Analysis in progress

4. Conclusion and perspectives

This study shows the peculiarity of spruce "resonance wood" in regards to classical softwoods. Empirical choice by violin makers, based on perceptual criteria that can be visual, physico-mechanical, auditory, are relevant to the acoustic properties measured

⇒ Perspectives

- To construct a model to evaluate the properties of a full violin plate from sampling fabrication offcuts.
- To analyze microstructural features of resonance wood in regards to visual characteristics and wood properties
- To enlarge the study to 'fiddleback' maple.

⇒ Acknowledgments

The authors gratefully thank Daniel Guibal in CIRAD, Montpellier for the assistance during the experiments and Bernard Michaud for his time and help to choose our wood. The support of CNRS-INSIS, of Région Languedoc-Roussillon and of the Japan Society for the Promotion of Sciences (JSPS) is gratefully acknowledged.

