See:
Latte, N., Beeckman, H., Bauwens, S., Bonnet, S., Lejeune, P. (2015)
A novel procedure to measure
shrinkage-free tree-rings
from very large wood samples
combining photogrammetry, high-resolution image processing, and GIS tools.
Dendrochronologia 34, 24-28.

gembloux agro bio tech

Université de Liège

Dendrochronological analysis of large tropical trees: a new approach combining photogrammetry, image processing and GIS tools

9th International Conference on Dendrochronology

13-17 January 2014 | Melbourne Australia

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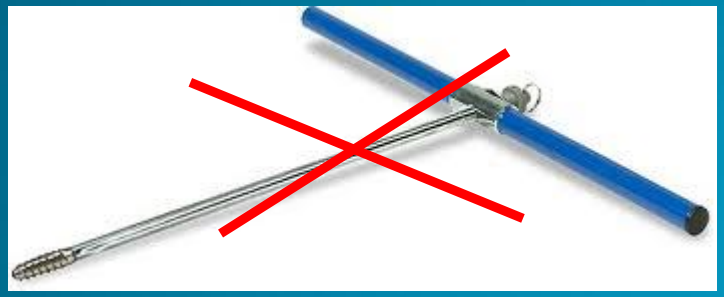
Philippe LEJEUNE
Adeline FAYOLLE

17 January 2014

Large tropical trees



- Core
  - Coring not always possible (wood very dense)
  - Core area may be not sufficient in case of uneasy ring boundary delineation
- Disk
  - Usually, rings measured directly on cross section
  - Heavy and bulky
  - High risk of cracking

➔ Time-consuming and tedious method

Technological developments

http://worldagroforestry.org/

This last decade:

- 64-bits operating system
- High capacity of data storage
- Large range of powerful softwares

➔ Digitized images are more and more frequently used for tree-ring research

New procedure

- Can we digitize large wood sample at high resolution and use big images for ring measurement?

?

- NO with the current dendrochronological softwares because of file size limitation

➔ Development of a new procedure (>10 Gb)

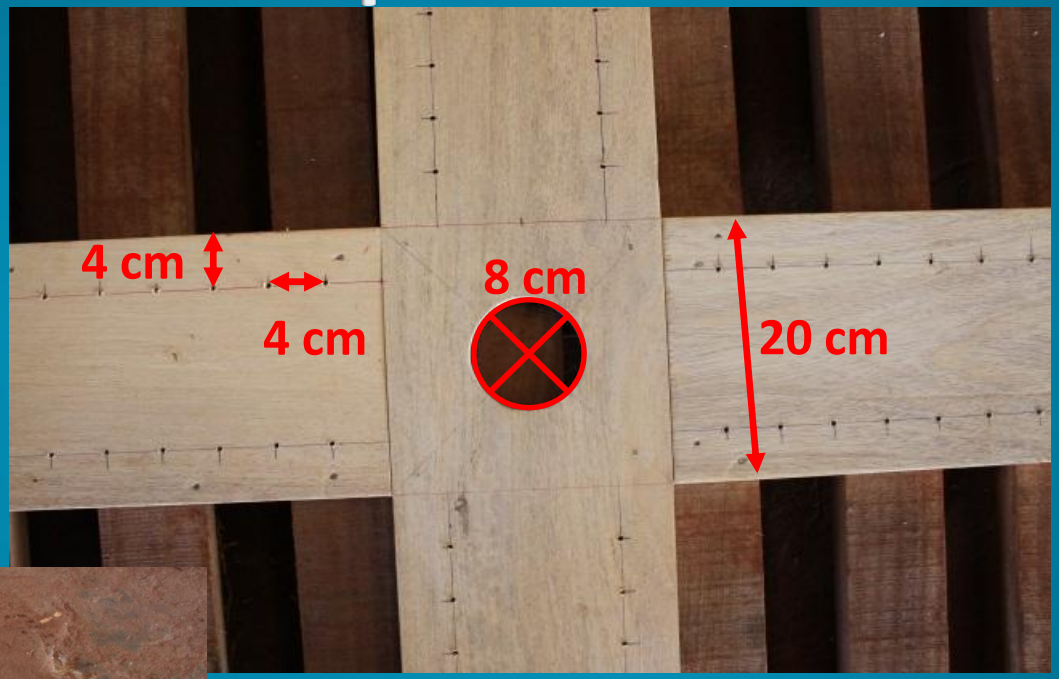
  - Description step by step

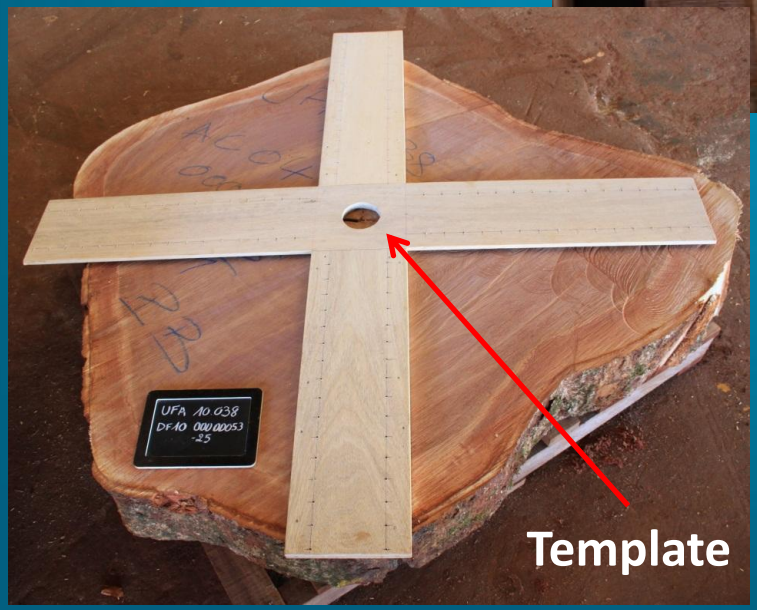
Wood sampling

Control points

Holes of 4 mm using a hand drill

Template for accurate location



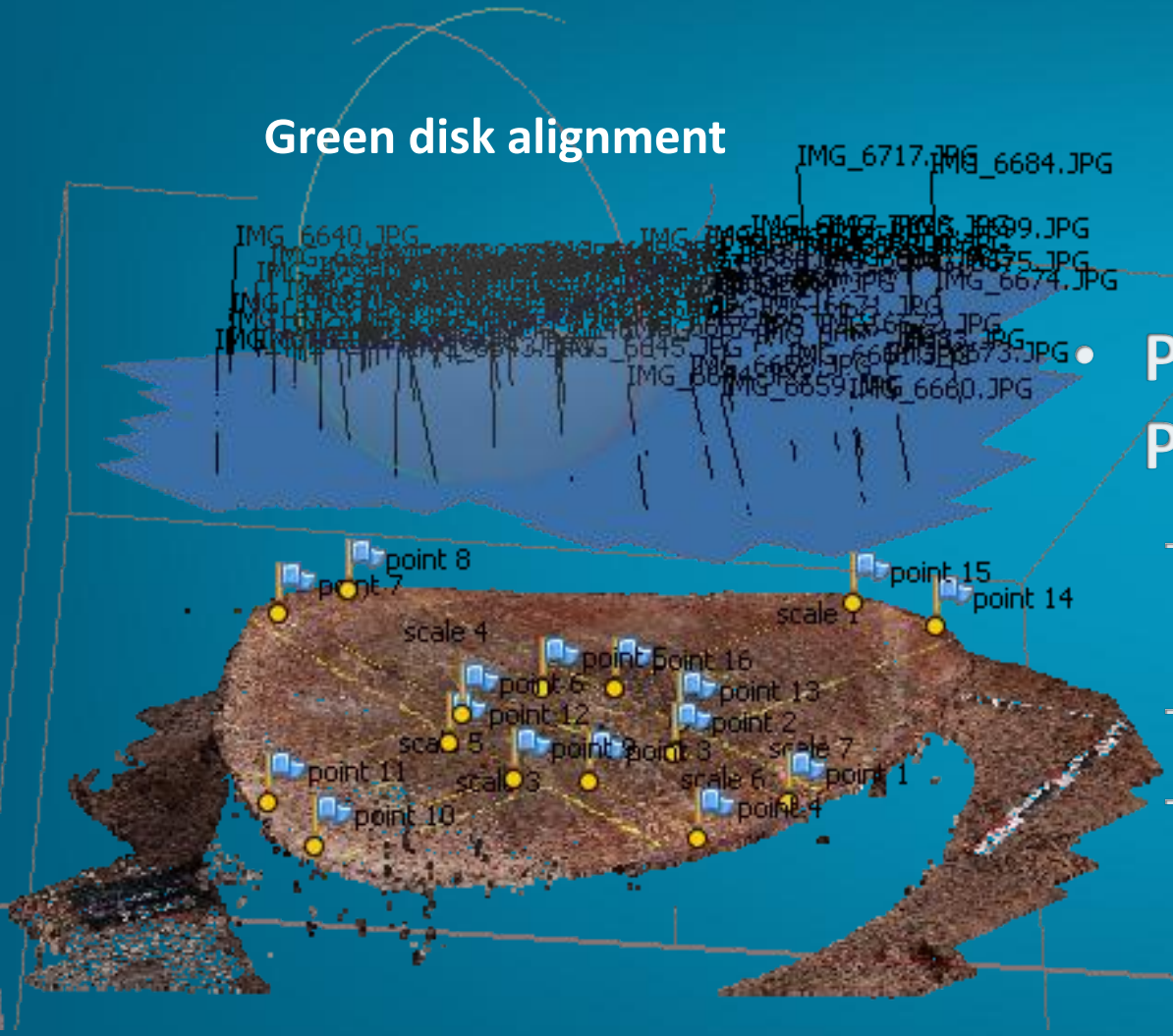


Green wood image

- Disk with control points
- Cleaning with air gun
- Wood sample on the ground
- Photo shooting with an off-the-shelf camera (Canon EOS 50D)
  - From above with at least 1/3 of overlapping

Wood sampling → Control points → Green image

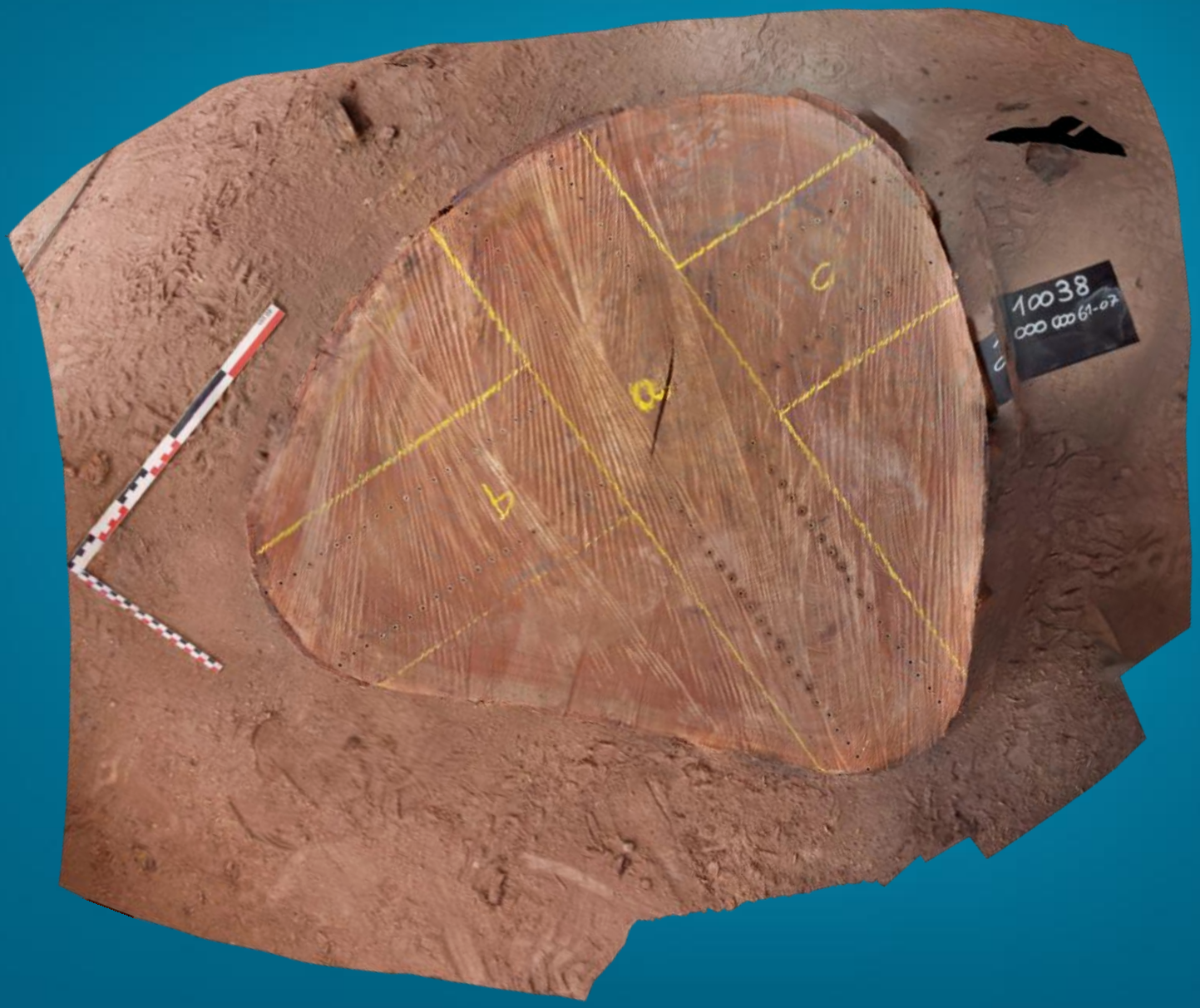
Green disk alignment



- Photos assembly with Photoscan (Agisoft)
  - Alignment with control points as Markers
  - Mesh building
  - Orthophoto (mosaic blending)

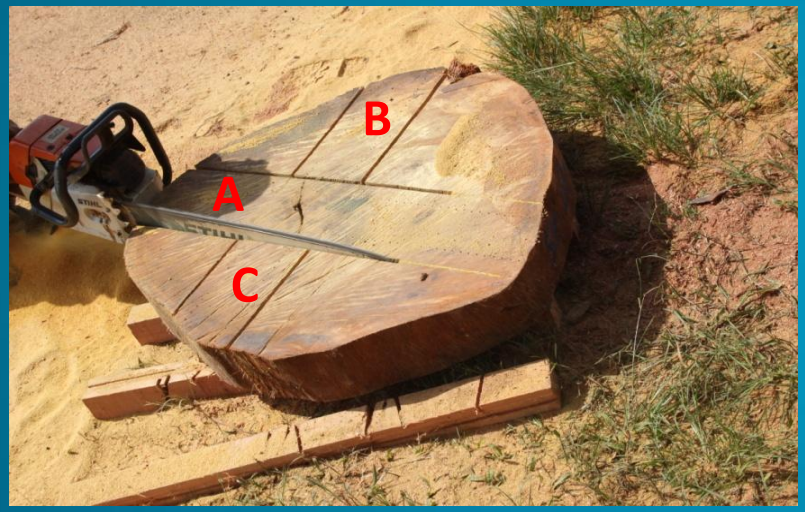
Wood sampling → Control points → Green image

Orthophoto = Green wood image



Dry wood image

1 Disk if diam. < 80 cm OR 3 Bars if diam. >80 cm
20 cm wide bars



Disk drying

Bar drying

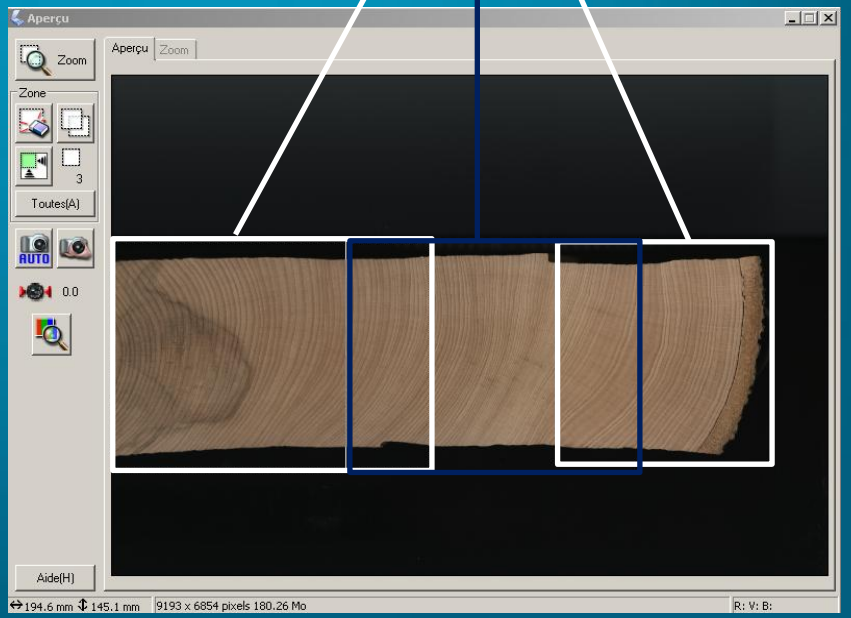
Sanding
Grits 40-120

Grits 200-400

Dry wood image

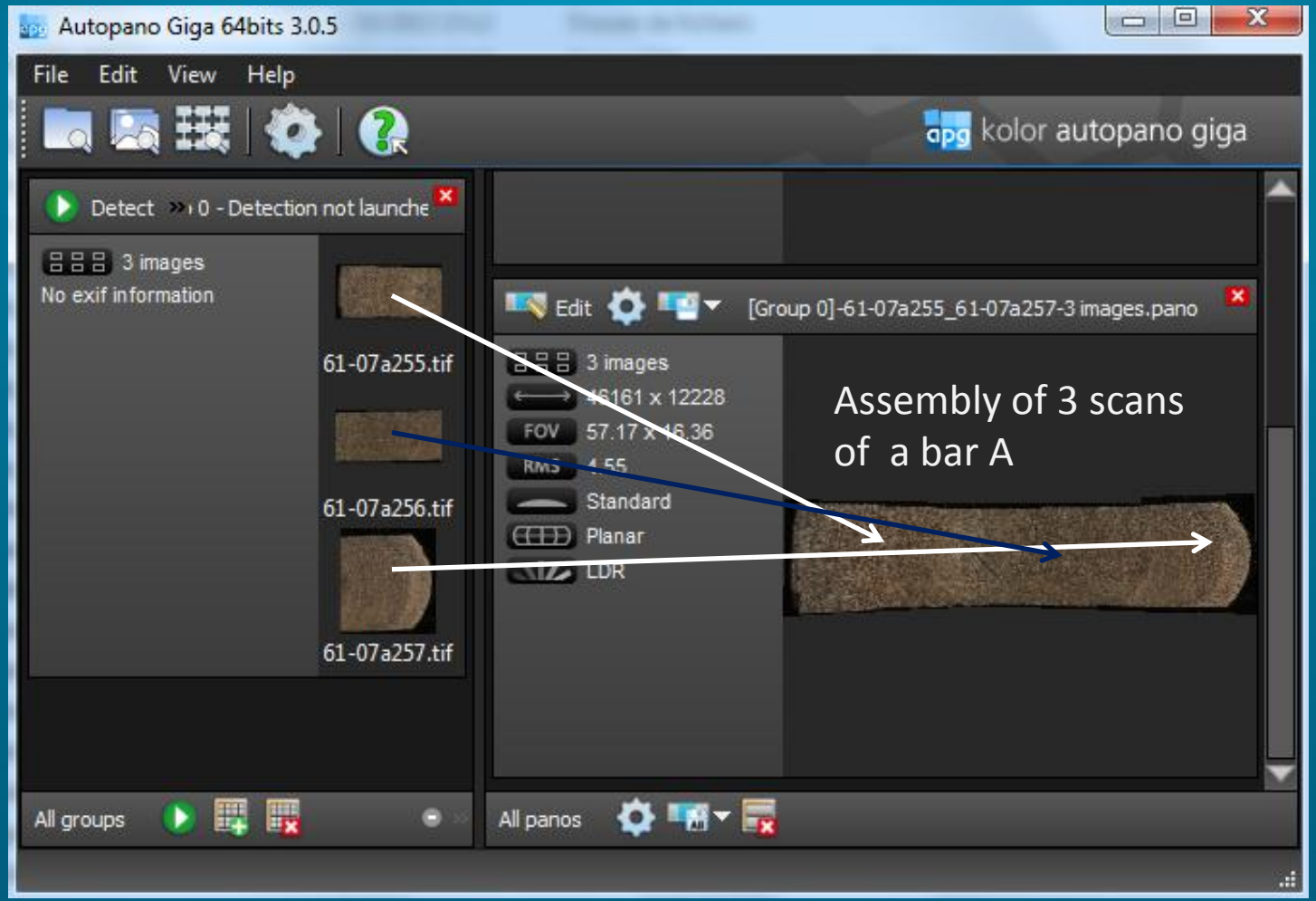
- Scanning with A3 flatbed scanner (Epson Expression 10000 XL)
- Several scans per disk or bar (1200-1800 dpi)
- Several windows and focus per scan to avoid blurry effects
- Overlapping of at least 1/3

3 windows / focus for a scan



Dry wood image

- Scans assembly with Autopano (Giga 3)



Shrinkage-free image

- In a GIS environment (ArcGIS 9.3)
- Dry image rectification (georeferencing)
- Based on control points of the green image

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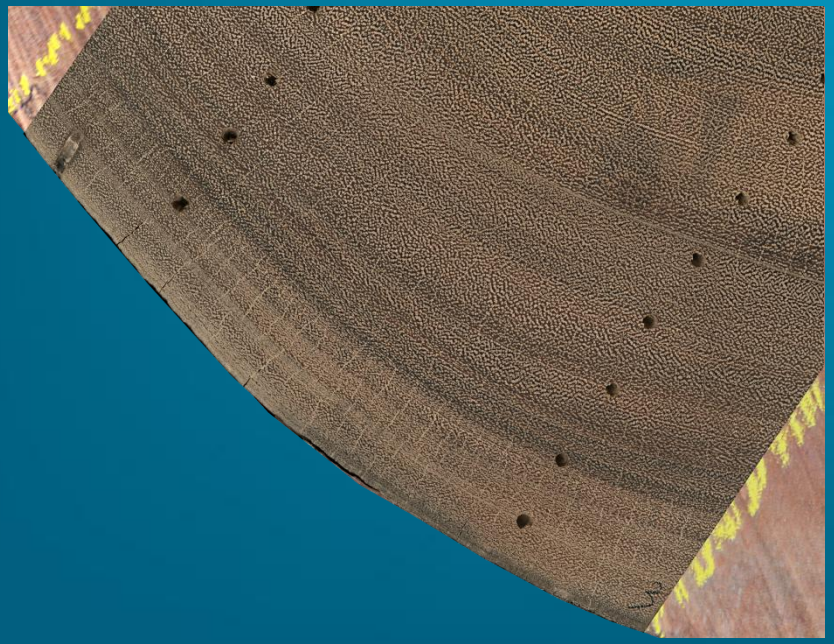

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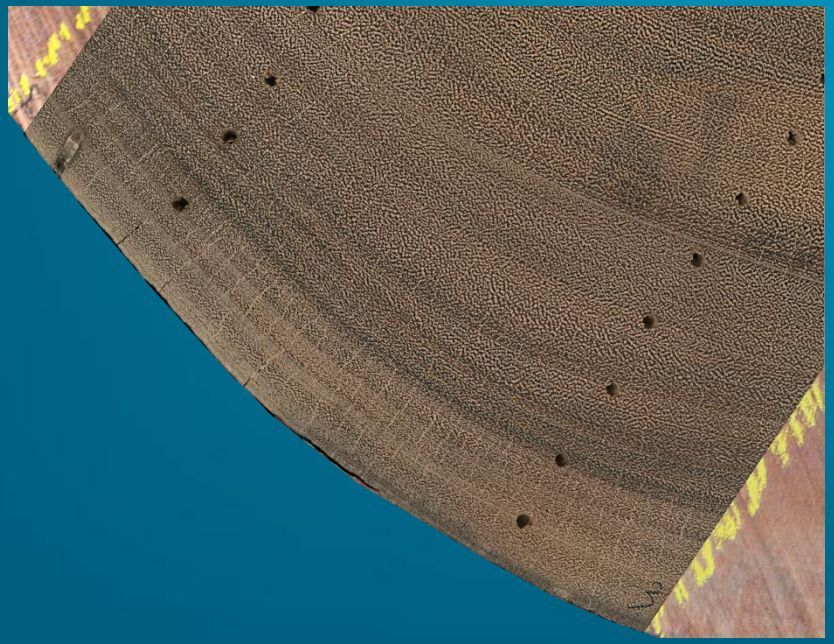

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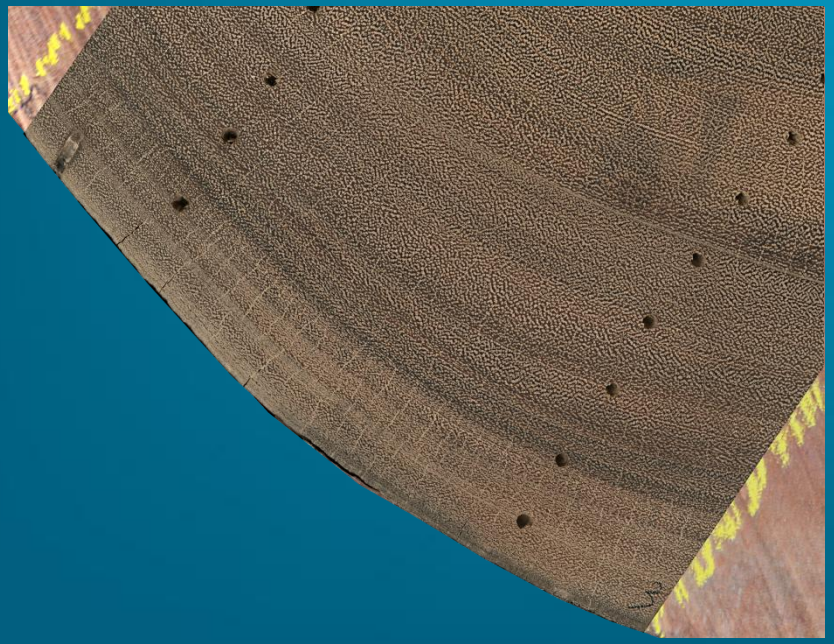


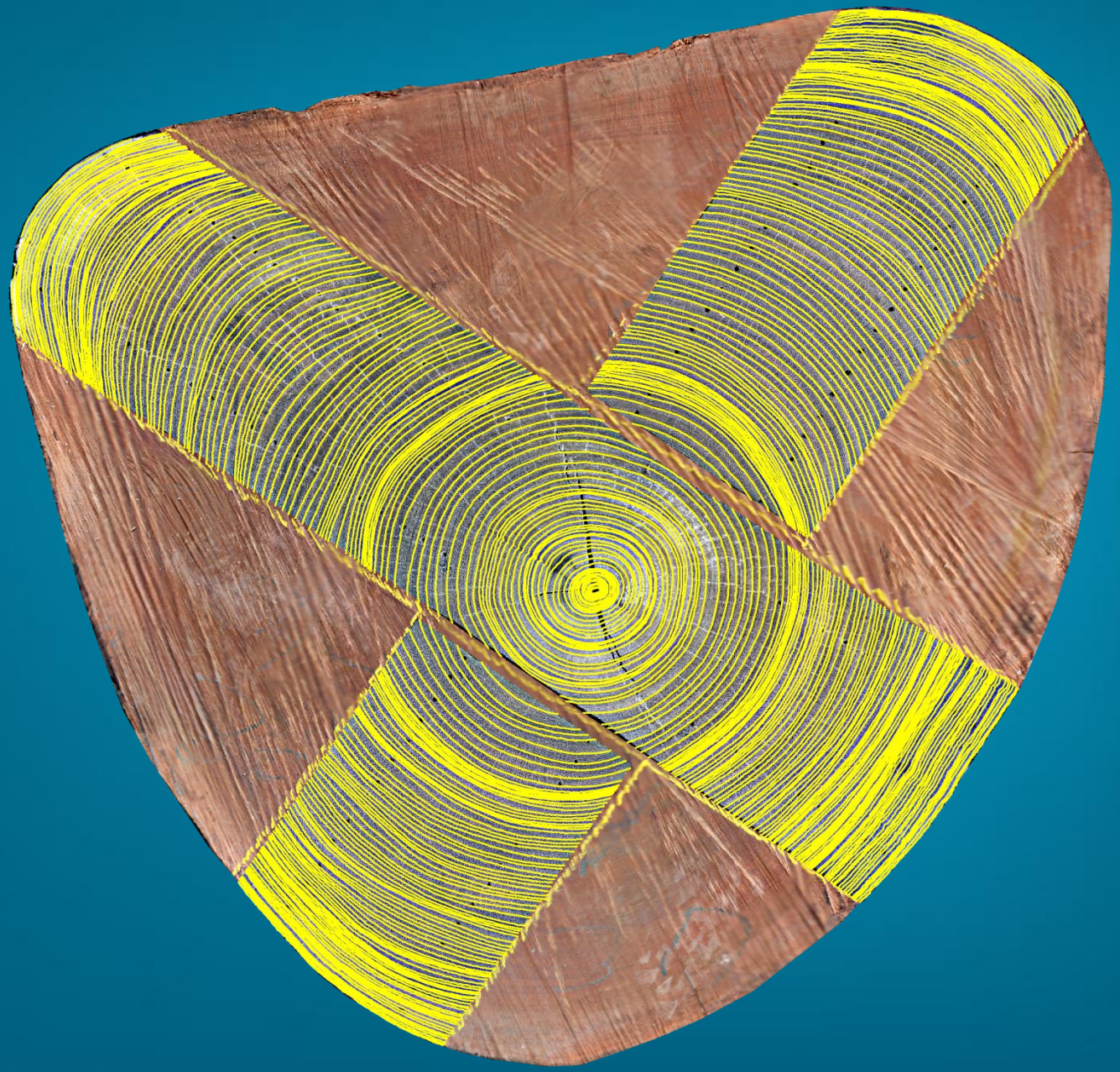
Tree-rings delineation

- Ring boundaries are digitized in ArcGis (9.3)
- Polyline layer (geospatial vector data format)
- Cartesian coordinate system in millimeters

24-bits color

Color stretching for improving contrast

Wood sampling → Control points → Green image → Dry image → Rectified image → Deline-ation



Tree-rings measurement

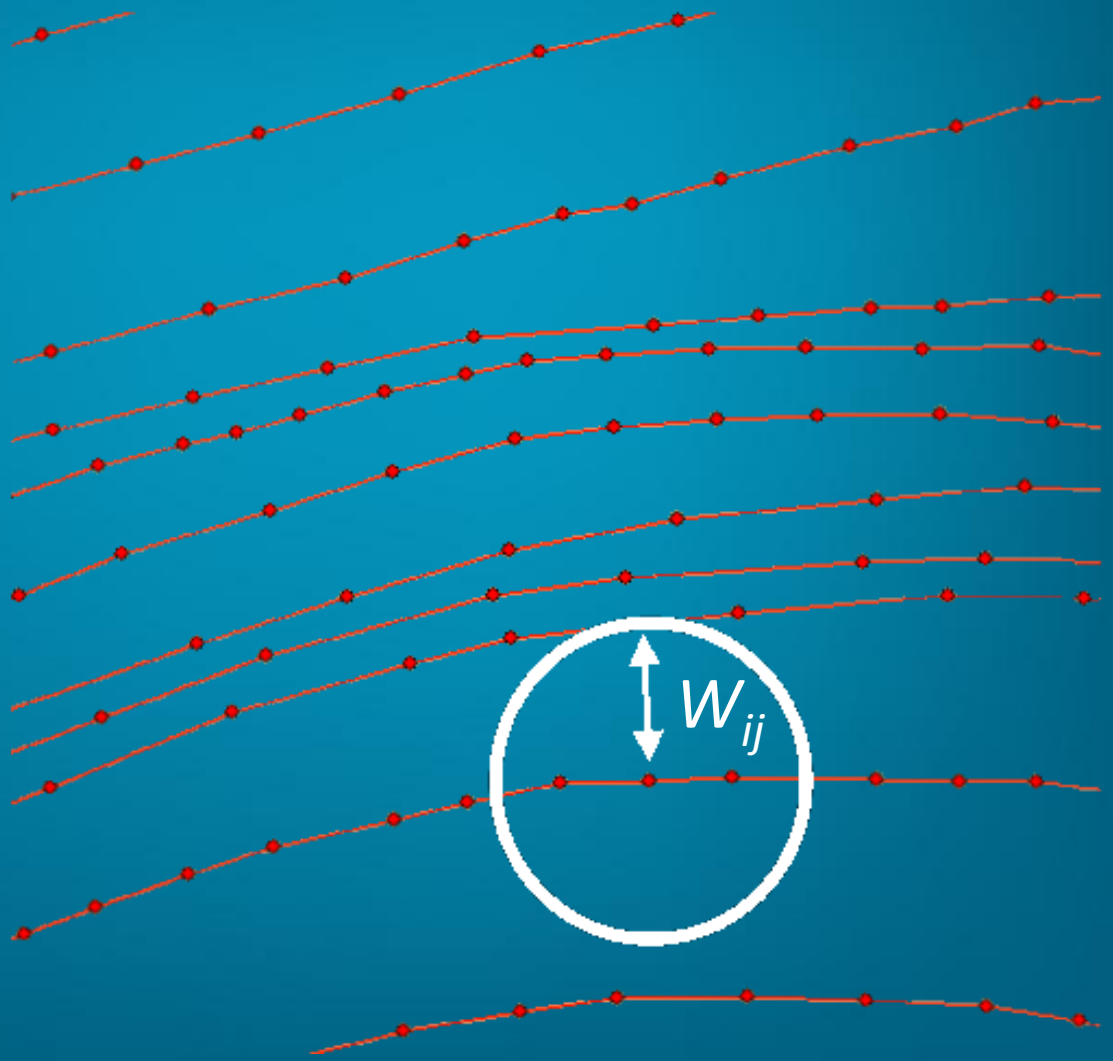
- Automatic measurement from the polyline layer
- Application written in VBA language
- MS Excel® interface
- Control of external components:
  - ESRI® ArcObjects
  - Mapwingis (opensource)

Tree-rings measurement

- Ring-width (mm)

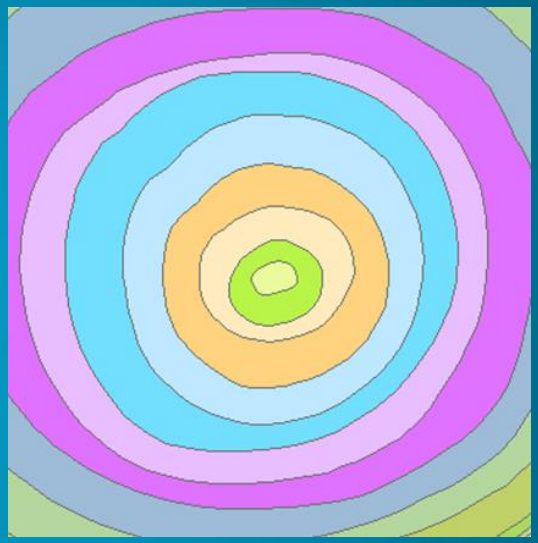
$$w_i = \sqrt{\frac{1}{n}\sum_{j=1}^{n} w_{ij}^{\,2}}$$

Wij:
perpendicular to the tangent of the vertex *j*



Tree-rings measurement

- Ring-area (mm^2)
- Polyline converted into polygon
- Area computation tool of ArcGis



- Results plotting in Excel

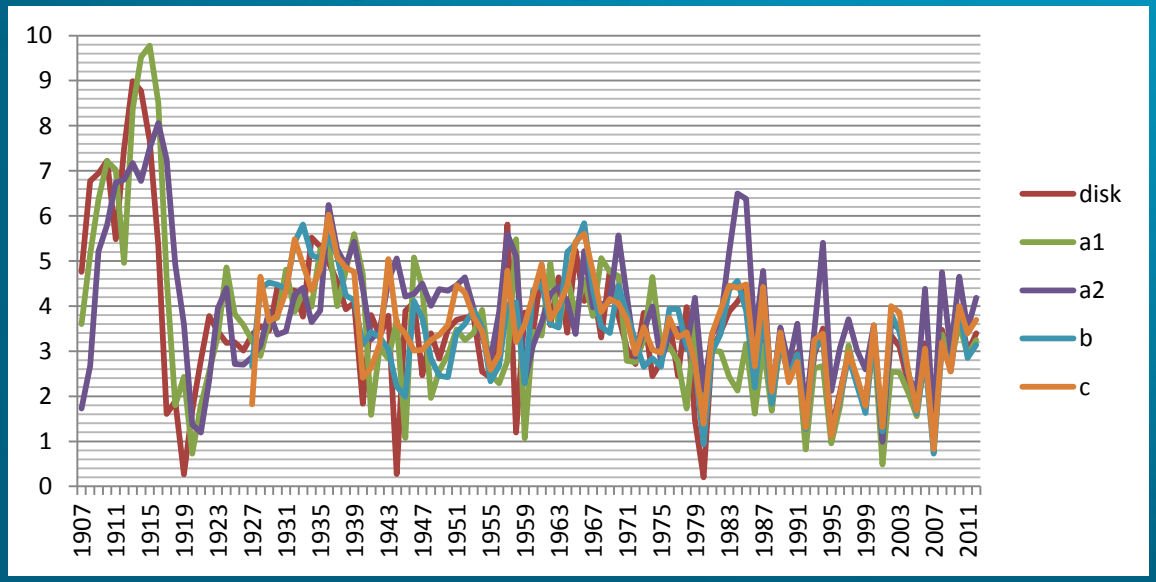
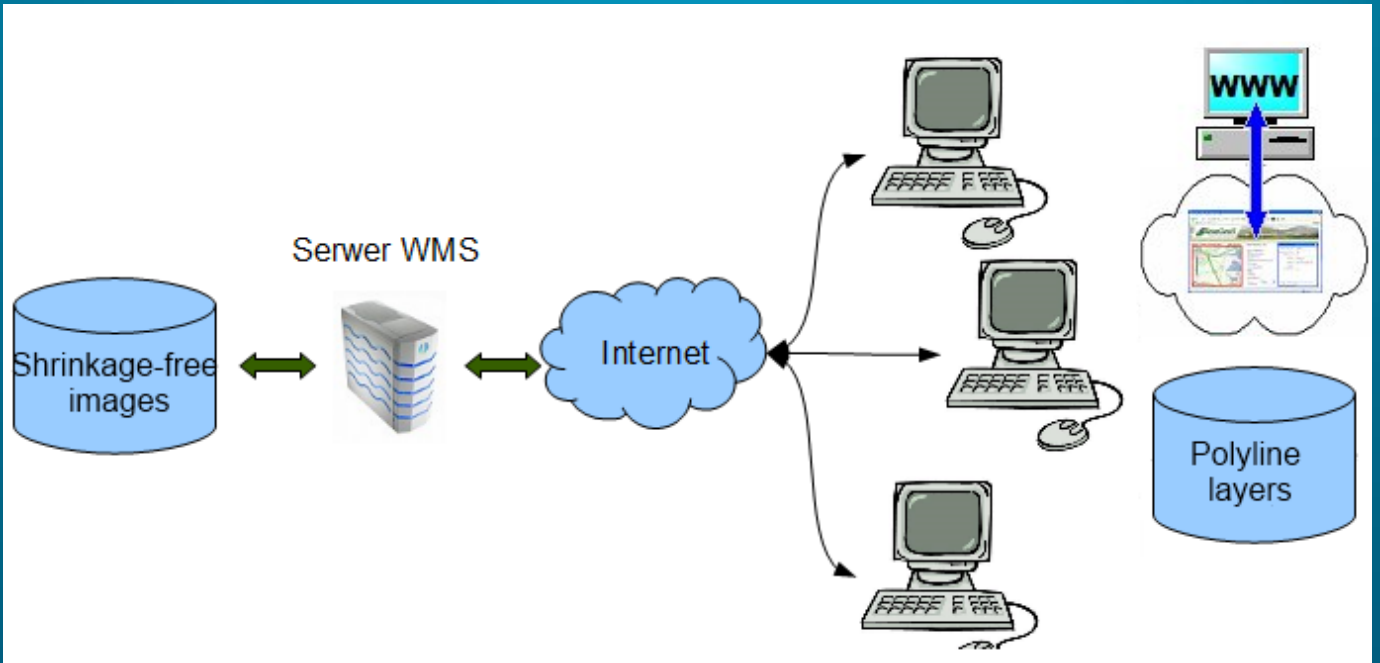


Image viewer

- Display digitized images online (without having to download all the data)
- Wep Map Service - GeoServer (opensource)
- Image viewing and ring delineation in a GIS environment



Conclusions

- New dendrochronological procedure adapted for large tropical trees
- High resolution shrinkage-free images with various possible uses:
  - Growth modeling
  - Tree-ring (intra-annual and inter-annual),
  - Wood anatomy in some extend
- Automatic ring measurement

- Partnerships
  - Pallisco & Mindourou Industrial and Forestry Centre (CIFM) in Cameroun
  - Royal Museum for Central Africa – Tervuren in Belgium
  - NATURE+

- Tree species
  - Sapelli: *Entandrophragma cylindricum*
  - Tali: *Erythrophleum ivorense*
  - Assamela: *Pericopsis elata*
  - Moabi: *Baillonella toxisperma*

Thank you for your attention

Disk vs. Bars

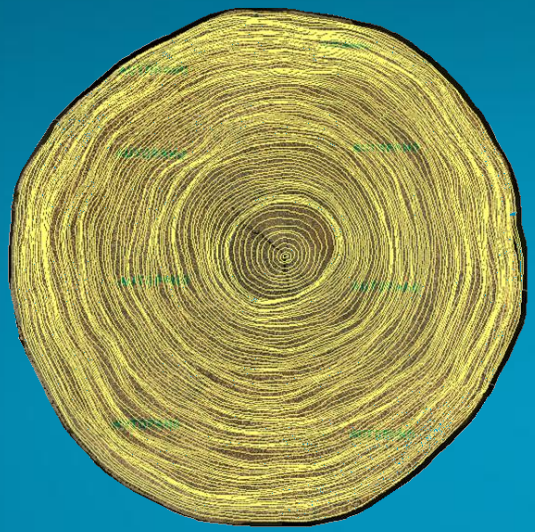
- Full information
- Exhausting handling
  - ±120kg
    (1m diameter; 0.15m thickness)
- Slow drying in room
- Risk of cracking

- Reduced information:
  - Selection of the most representative parts without wood defect
  - Compensate possible information lost:
    - More samples

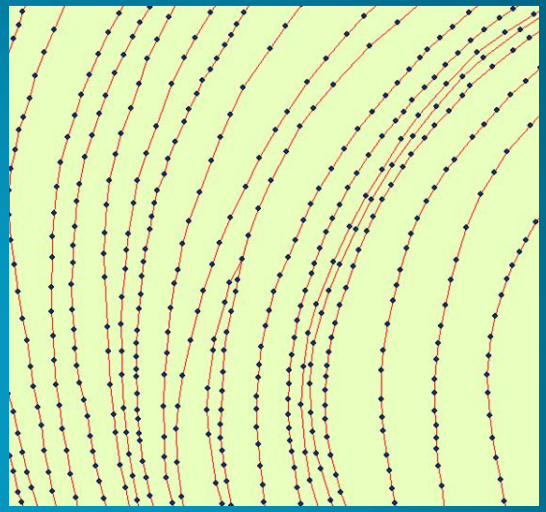
    OR
    - A few disks in combination with bars
- ±60kg for 3 pieces
- Suited dimension for fast drying (in small oven) and sanding (industrial sander)
- Good dimensional stability

Dry wood image

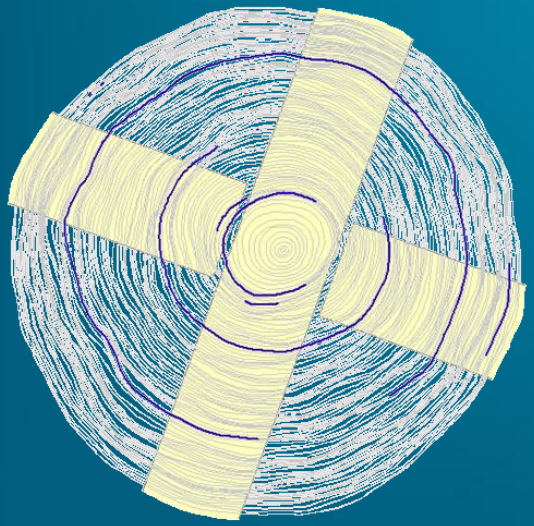
Rings delineation (GIS)



Polyline shapefile

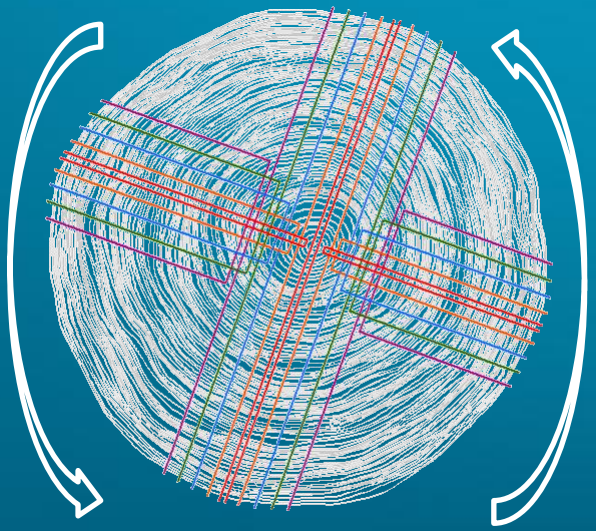


Partial rings

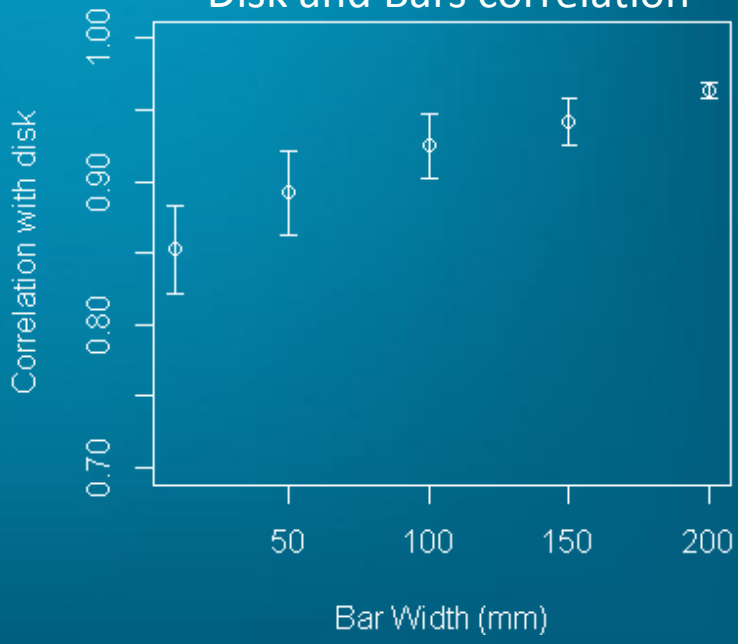


Bars simulation

- Several widths
- 5 by 5 degrees



Disk and Bars correlation




Wood sampling
Control points
Photos shooting
Photos assembly
=> Green wood image
Drying / Sanding / Scanning
Scans assembly
=> Dry wood image
Dry image rectification
from control points
=> Shrinkage-free image
Tree-ring delineation and
measurement in GIS environment
Image viewer
Web Map Service