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Determination of Defective Central Cylinder on Pinus *radiata (D.Don)* Whorl by means of Gamma Spectroscopy

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Introduction

The research work has as objectives a) to establish a methodology based on gamma radiation for the determination of the diameter of defective central cylinder in a whorl of a pruned tree of *Pinus radiata* (D. Don) that serves as base for scan trees and b) to develop a methodology for the construction of images that allow to integrate the information in the scope of the first log of a tree to obtain the profile of defective central cylinder.

Defective central cylinder (Cilindro central defectuoso, CCD)

It is the confined knotted zone to the center of the log in the pruned region of the tree. Defective Central Cylinder is satisfied when closing itself all the knots lazy by the pruning, being soon all the defects limited in a central knotted zone, including the face of the trunnion, the hard cover, the depth of occlusion and the marrow. In addition, the CCD includes any widening due to the sinuosity of the log at the time of the pruning. (Park, 1982).

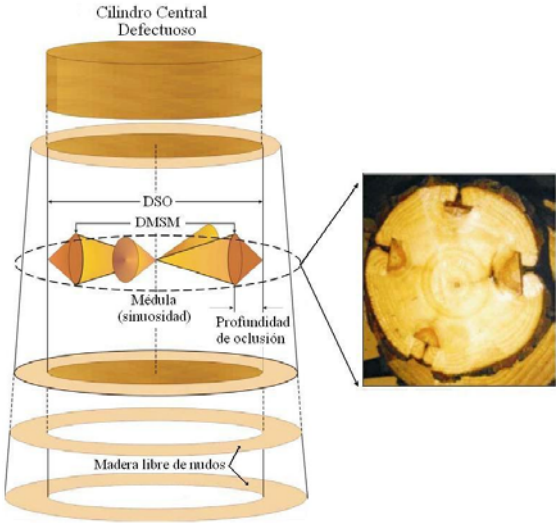
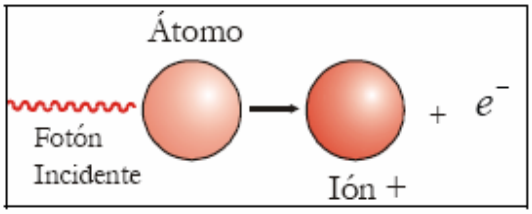


Figure 1. Defective central cylinder

Gamma Radiation

The gamma radiation is a photon beam that is originated in the nucleus of an atom in excited state, which by means of its emission returns to the stable state.

The origin of the radioactivity comes from the attenuation or disintegration of unstable nuclei. Three types settle down: alpha attenuation, beta attenuation and gamma attenuation; each one of which it is characterized to present different throwing power. The Photoelectric effect is the most probable process of attenuation of gamma radiations of low energy (< 1 MeV). (Knoll, 1989)

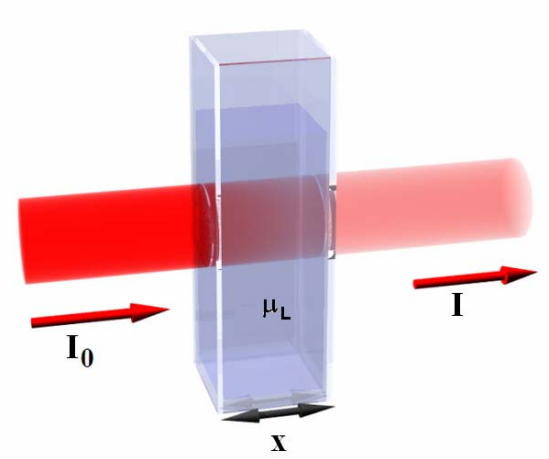


Gamma Attenuation

Fundamental relations

The intensity of the radiation of the beam before happening through the material (I_0), the intensity of the radiation of the beam after pass through the material (I) , the linear attenuation factor (μ_L, in cm^{-1}) and the thickness of the radiated material (x, in cm.) it is related according to one exponential relation, call equation of Beer-Lambert:

$$I = I_0 \cdot e^{\mu_L \cdot x}$$



Coefficient μ_L corresponds to the product between the Mass attenuation coefficient (μ_ρ) and the density (ρ) of the absorbent material.

$$\mu_L = \mu_\rho * \rho$$

The coefficient μ_ρ is a property of the material for a given level of energy. It depends on the chemical composition of the material.

Tomographic construction

It is the construction of the image of a cross-sectional of an object from its projections. The section is reconstructed from data of transmission or reflection produced when doing to affect the object, from several directions, the emission of a radioactive source like for example the gamma rays. The used function, in Matlab atmosphere, corresponds to the Inverse Transformed of Radón (Iradón) (Galindo, 2003, 2004)

Material and Method

Testing material

A log of a pruned tree of radiata pine of 1.40 m of length was used and 27,5 cm. of diameter (average), containing 2 whorl distanced in 70 cm. From these tow log obtained cross section corresponding to the zone between whorl to determination of physical properties of material and the resulting log was destined to the test of attenuation of gamma radiation.

Irradiation test

The sample was radiated with a photon beam of 59.5 keV of energy, originating of a radiation source ^{241}Am. (14 mCi of activity). For the detection of photons a detector of Iodide flashing was used of Sodium drugged with Thallium. The figure Nº 2 shows the log of test installed in the set of ample collimation in a central position in the plate carries sample, doing to coincide the center of the log with the center of the plate and the alignment source detector, taking this condition like position zero. The system allows movement in three degrees of freedom so that the log moves in horizontal direction, vertical and angular respect to its central axis. (Knoll, 1989)

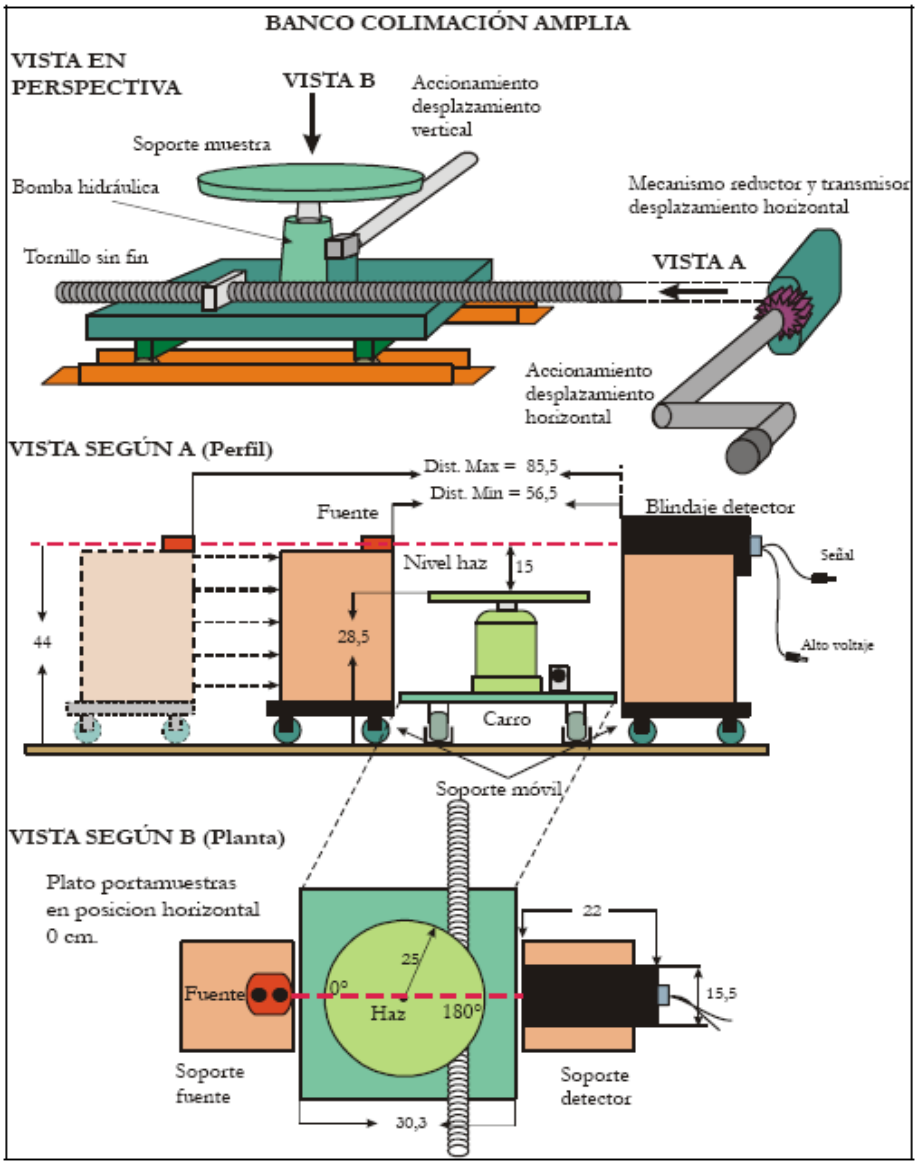


Figure 2. Set of irradiation test

Determination of the physical properties

From the log used for the investigation, it was come to eliminate the 10 cm of each end of such way to annul the condition of edge based on the loss of humidity in this zone. Later 2 were extracted two cross section (R1 and R2), one of each end, approximately 50 mm of thickness with the objective to determine the moisture contents and density of the test material.

From the cross sections mentioned cubical specimens of 2 cm of side were previously obtained. For the identification of these units the matrix nomenclature of such form was applied to be able to assign a position to each specimen.

The determination of the moisture content was made from the gravimetric method. expressed in percentage, with a 0.1% approach, determining the average of the results obtained for the individual specimen. The obtained data is presented in a two-dimensional map of way to observe the distribution of the humidity inside cross section (Figure3).

In order to determine the density of the test material, the same specimens used in the calculation of the moisture content were used. It was determined actual density (D_h) and later it was come to make a tow-dimensional map to observe his distribution in the cross section (Figure 3)

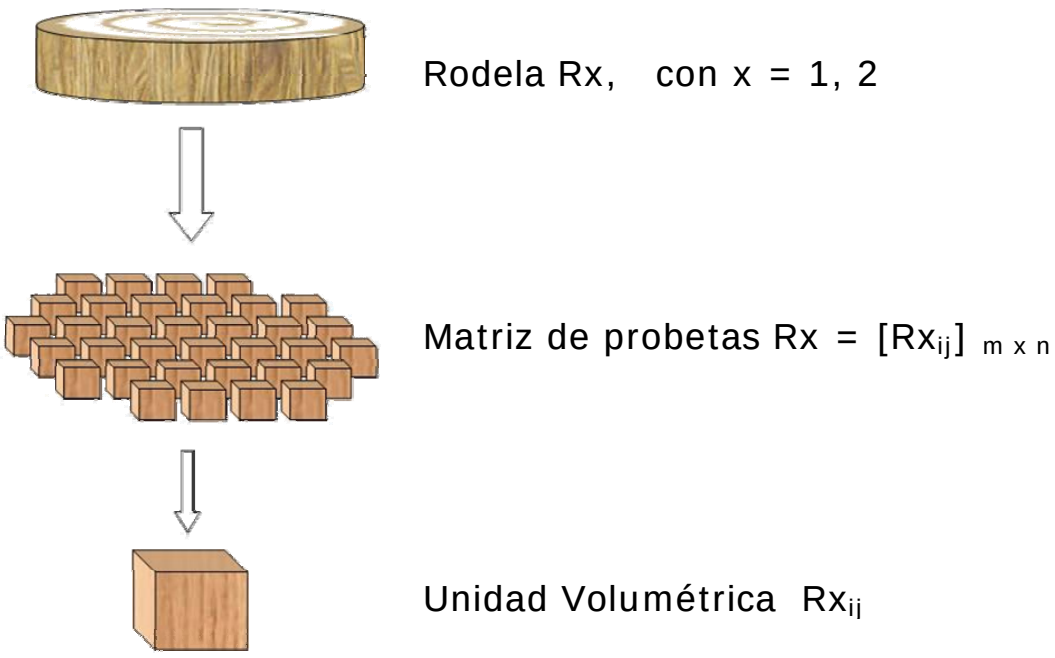
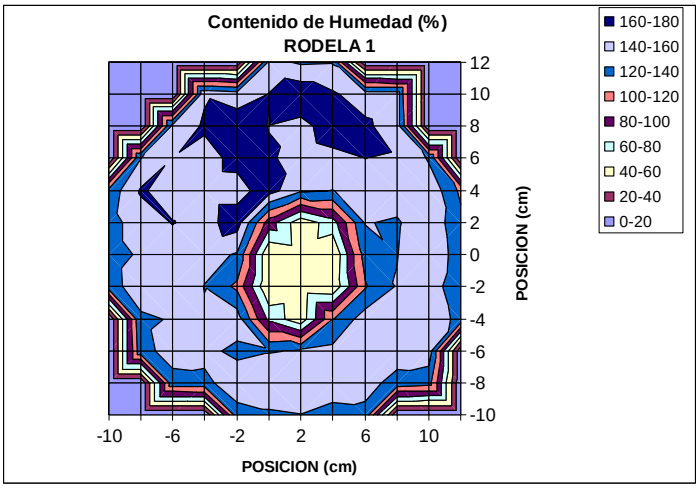
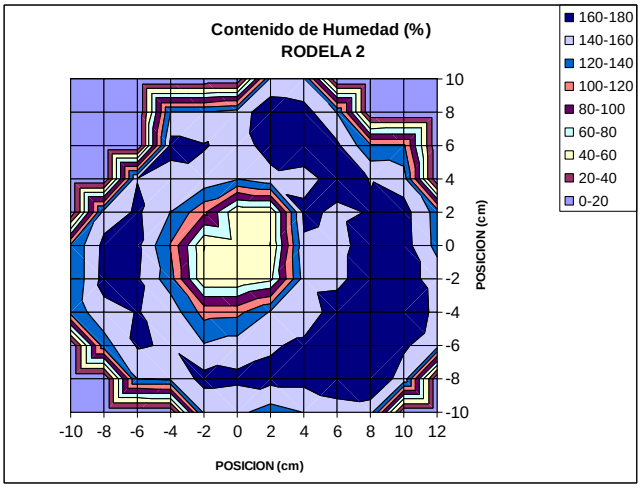


Figure 3. Obtaining of specimens for determination of the density

Results

Moisture content

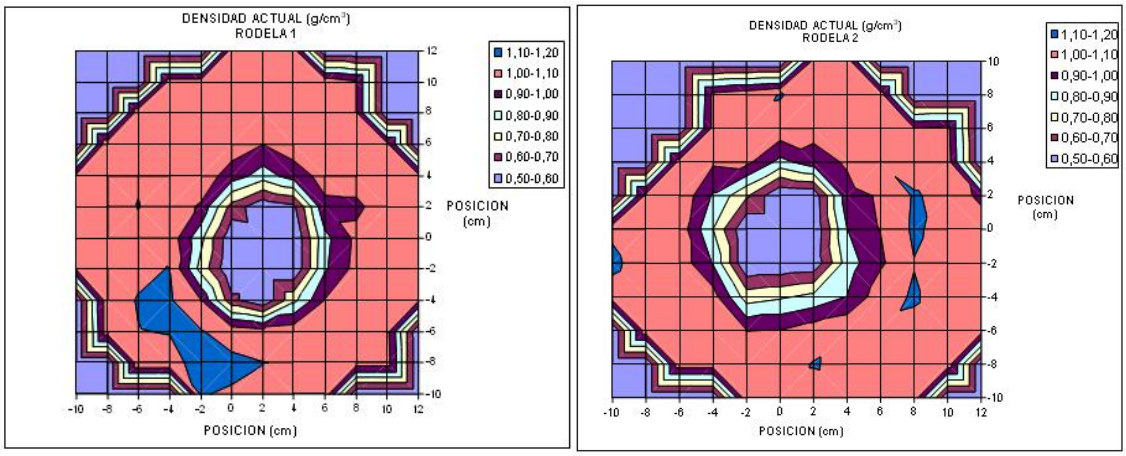




In table Nº 2 appears the values obtained for moisture content, expressed in percentage, indicating its extreme values, average and standard deviation for each cross section.

C.H. (%)	Cross section 1	Cross section 2
Mínimo	40,2	39,6
Máximo	173,1	179,8
Promedio	136,8	143,5
Desv. Estándar	30,9	33,9

Actual Density



Densidad Actual (g/cm^3)	Rodela 1	Rodela 2	Valores Troza
Mínimo	0,490	0,450	0,450
Máximo	1,120	1,120	1,120
Promedio	**0,993**	**0,986**	**0,990**

Test of Irradiation

Figure 4 shows the log of test installed in the set of collimation in a central position in the plate carries sample, doing to agree the center of the log with the center of the plate and the alignment source detector, taking this condition like position zero. The system allows movement in three degrees of freedom so that the log moves in horizontal direction, vertical and angular respect to its central axis.

Attenuation of gamma radiation

The figures 5 to 9 show the obtained profiles of attenuation for each radiated plane.

By virtue of the great amount of obtained data, it is not set of meshes that conform each plane, only acquires knowledge the detail of the meshes obtained in the angular position 0º and 90º, which gives a general vision of the singularity in the log due to their condition of orthogonallity

Figure 4. Log in the set of irradiation.

It is possible to mention that the graphical one shows the disposition of the meshes in a linear perspective of way to facilitate the understanding of the information, but in fact these meshes are arranged at intervals of 5º from 0º to 180º.

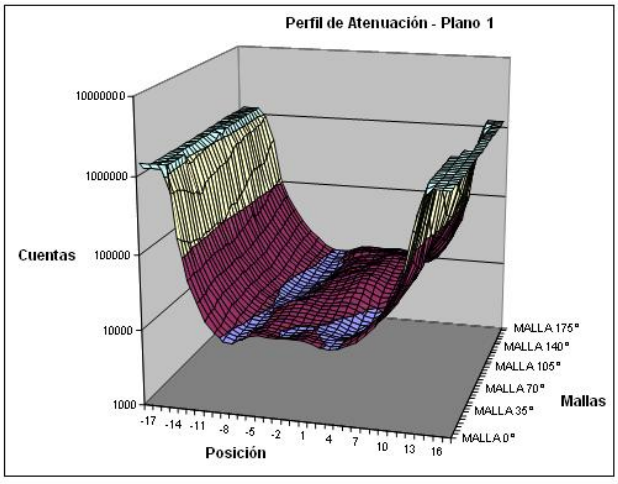


Figure 5. Attenuation profile 1

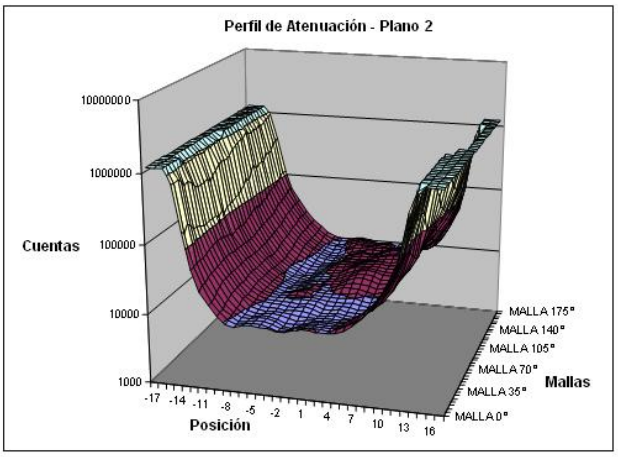


Figure 6. Attenuation profile 2.

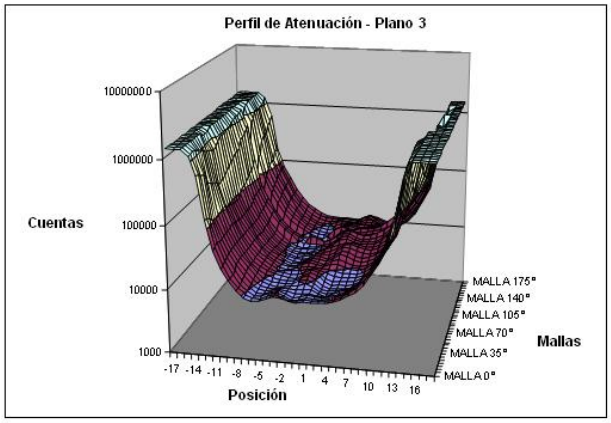


Figure 7. Attenuation profile 3.

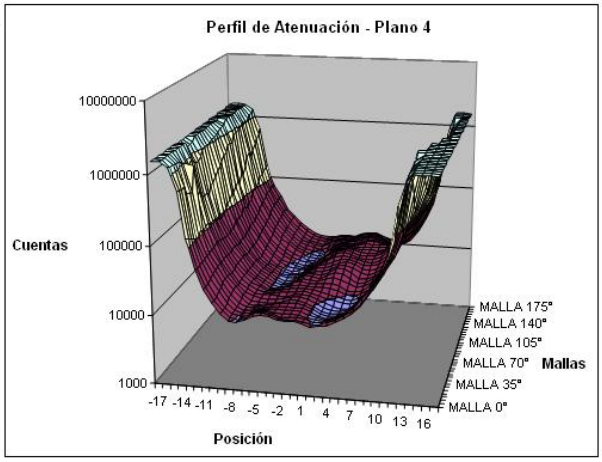


Figure 8. Attenuation profile 4.

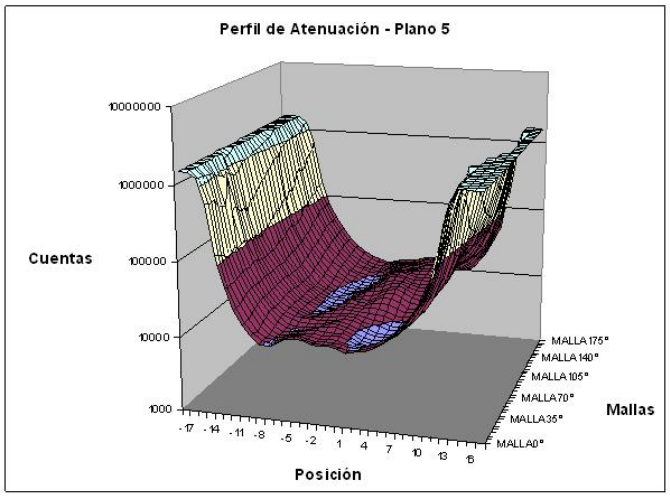


Figure 9. Attenuation profile 5.

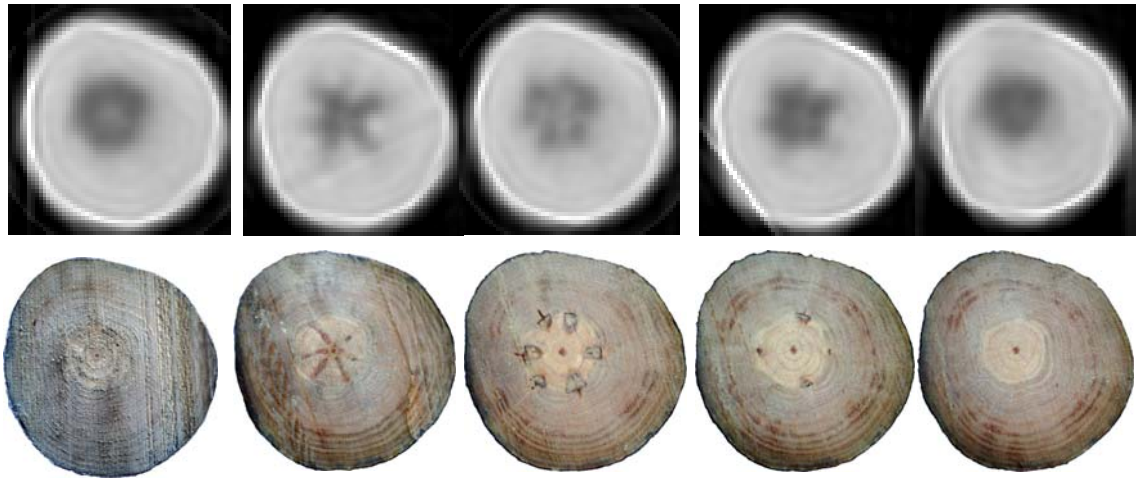
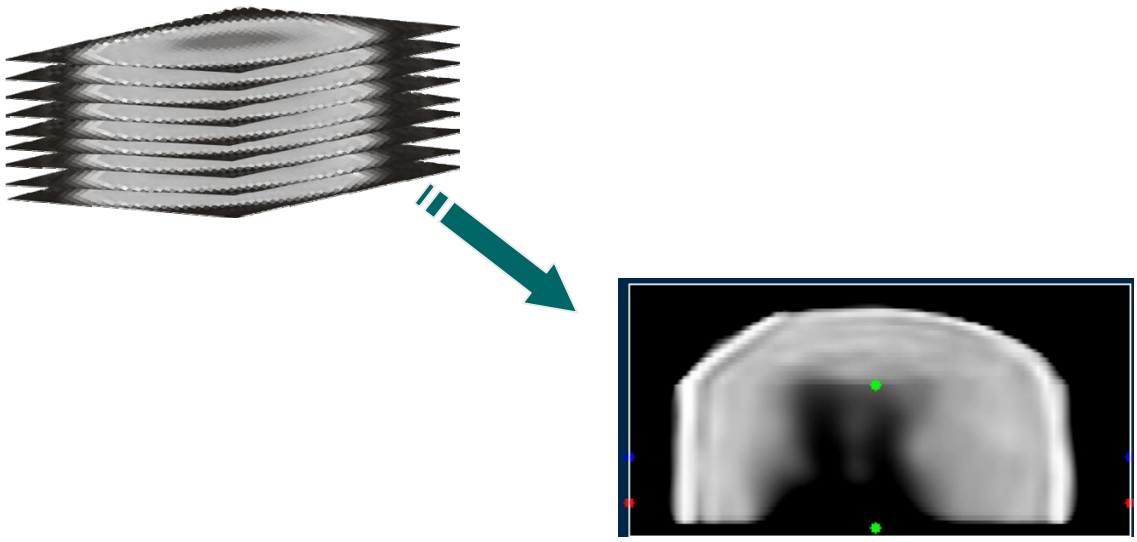
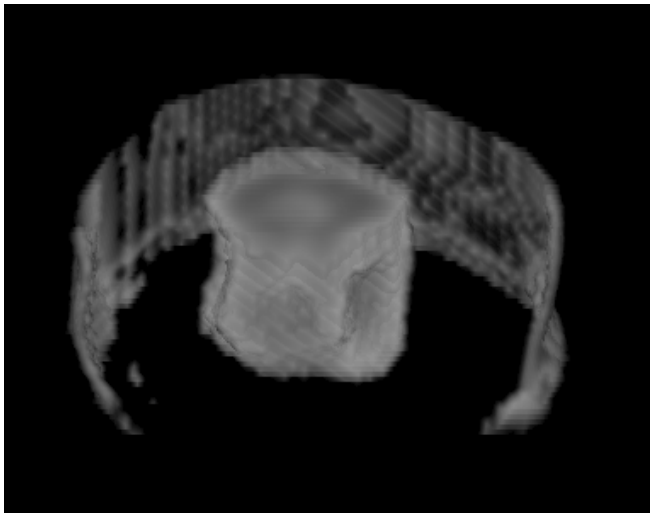


Figure 10. Tomographic construction of irradiated planes

Three-dimensional image construction



Volume-Rendering of irradiated whorl



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In the quantification of the CCD one obtained a difference of 4.8% in smaller diameter and 8.4% in the greater diameter, of the whorl analyzed.
Consequently, the underestimation average of the diameter of whorl is of 6.6 %. The estimation from the tomographic construction of the CCD of whorl gives a difference of 7% when underestimating the volume.

Conclusions

The obtained results demonstrate that the used methodology allows the detection, identification and quantification of the CCD in whorl.

The resulting image has a direct relation with the amount of data collected in the attenuation process, but the most preponderant factors correspond to the knot/wood relation and the adapted mathematical implementation, for example functions filter.

The methodology allows to model a three-dimensional image of the CCD, whose volume is measurable.

References:

GALINDO, S. 2004. Principios Matemáticos de la Reconstrucción de Imágenes Tomográficas. Revista Ciencia Ergo Sum. Universidad Autónoma del Estado de México. Toluca. México. Vol. 10 (3): 271-281 p.

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PARK, J. 1982. Occlusion and the defect core in pruned radiate pine. New Zealand Forest Service. Fri Bulletin Nº 2. 15 p.