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## Spatial vegetation density index from terrestrial laser scanner

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## BACKGROUND AND OBJECTIVES

**Introduction:** Forest monitoring is a key issue in scientific, social and commercial domains. Manual measurements of forests attributes can be tedious and limited. Terrestrial Laser Scanner (TLS) has been introduced in forest monitoring [1]. Vegetation density index is a way to quantify vegetation using voxels from TLS data [2].

**Problem statement:** The vegetation density index is estimated using ray tracing techniques in a 3D voxel grid. This process can be time consuming and can be improved.

### Objectives:

- Decrease the computing time
- Increase the consistency of the calculus

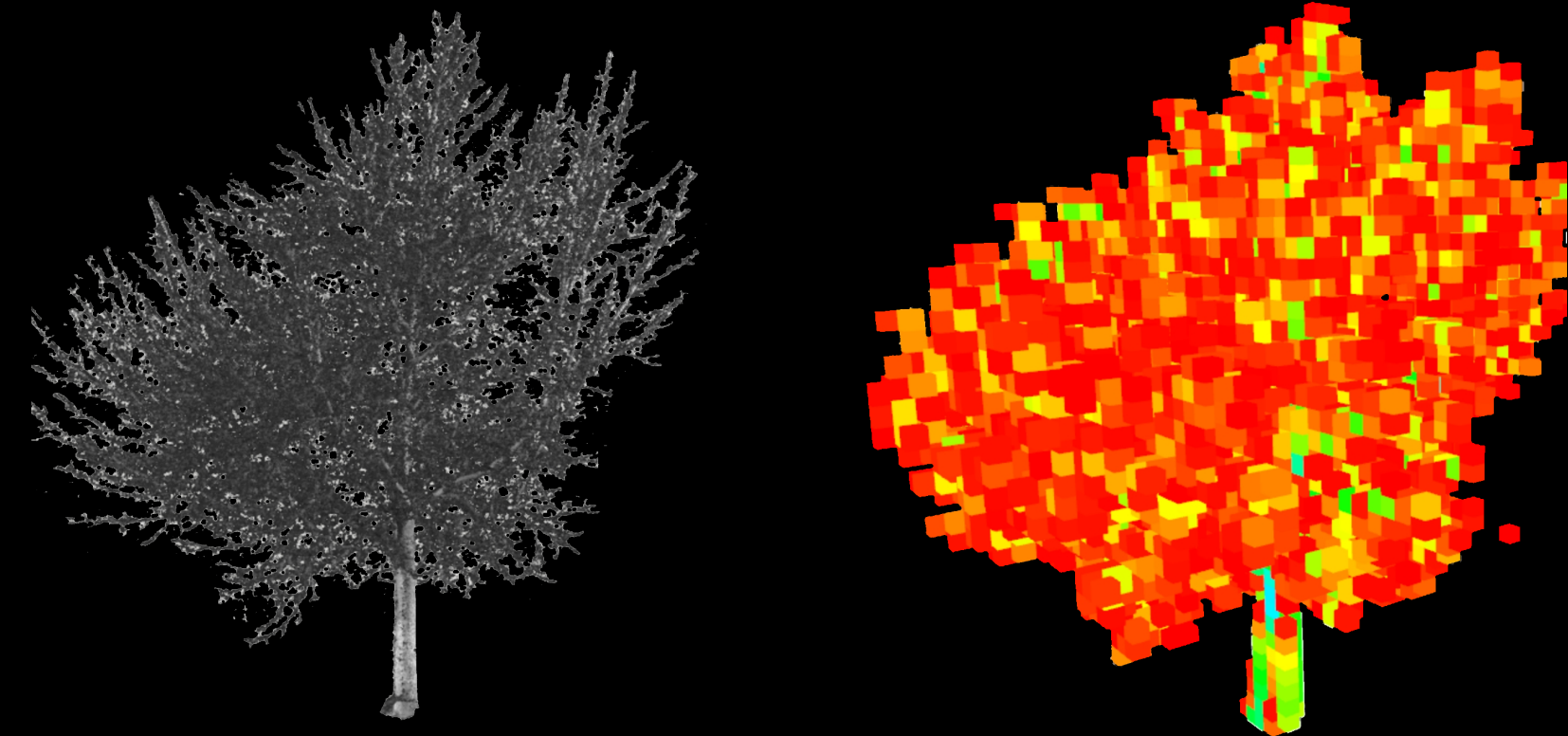


Figure 1: TLS point cloud and voxelisation of a tree

## METHODOLOGY

1. Identify the visible faces of all voxels
2. Compute their solid angles (eq. 1)
3. Compute the adjustment factor (eq. 4)
4. Compute the density index (eq. 5)

## CONTACT INFORMATION

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## DENSITY INDEX

**Assumption:** The number of laser beams intercepted within a volume is proportional to the density of vegetation.

**Density index:** this index is defined as :

$$D = \frac{N_i}{N_t - N_b} 100$$

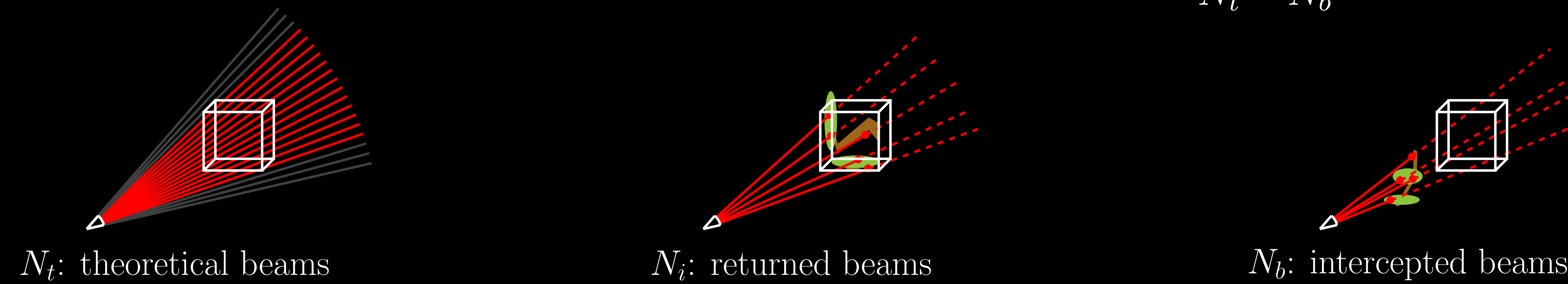


Figure 2: Density index computation using raytracing [3]

## ANALYTIC APPROACH

**Analytic calculus of theoretical number of beams  $N_t$  for each voxel :**

$$\Omega = \sum \Omega_i \quad (1)$$

$$dS = \rho^2 \cdot \sin \phi \cdot d\phi d\theta \quad (2)$$

$$\Delta S = \int_{\theta}^{\theta+\Delta\theta} \int_{\phi}^{\phi+\Delta\phi} dS \quad (3)$$

$$\overline{\Delta S} = \frac{1}{\phi_2 - \phi_1} \frac{1}{\theta_2 - \theta_1} \int_{\theta_1}^{\theta_2} \int_{\phi_1}^{\phi_2} \Delta S d\phi d\theta \quad (4)$$

$$N_t = \frac{\Omega}{\overline{\Delta S}} \quad (5)$$

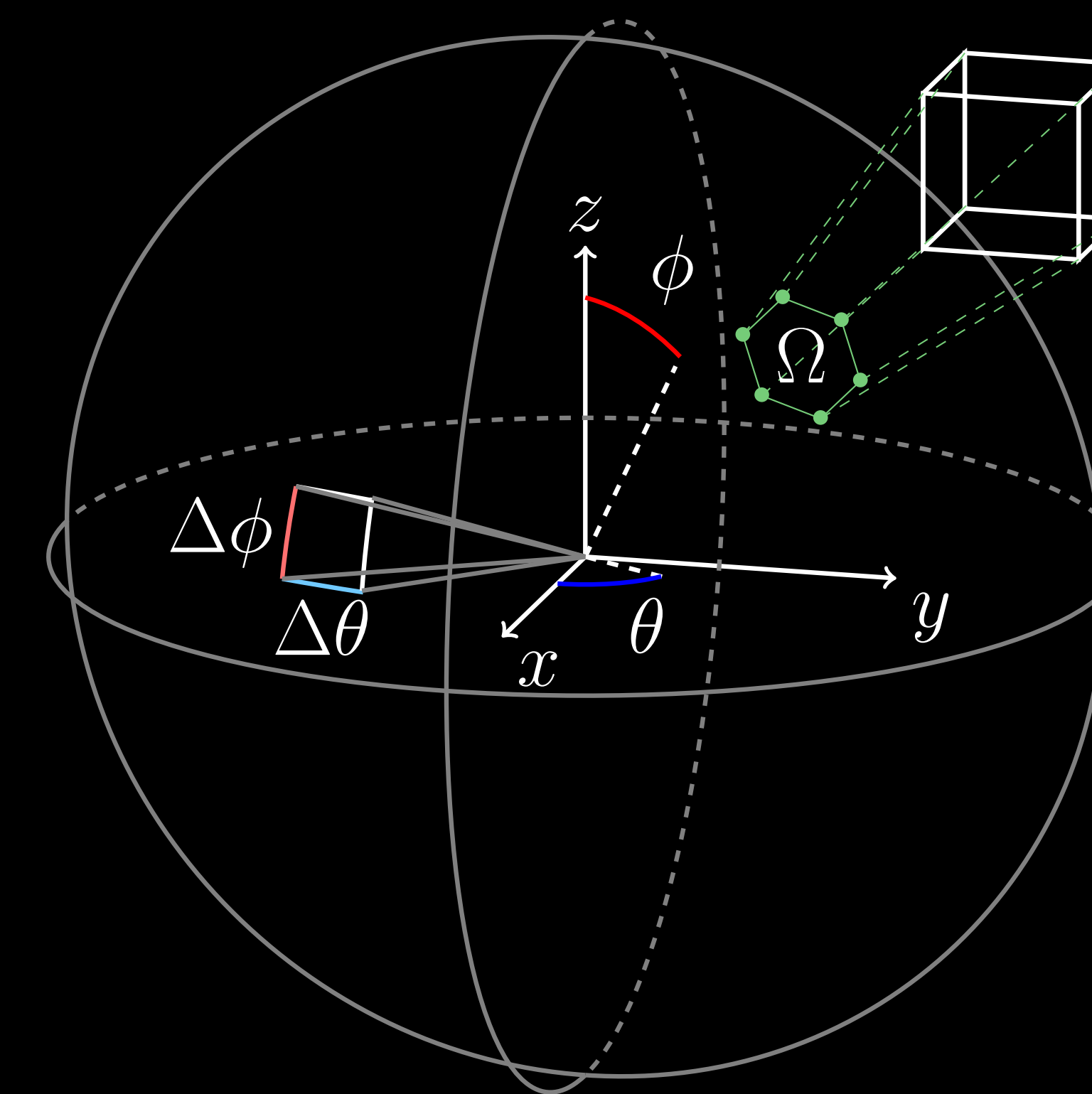


Figure 5: Spherical geometry for the analytic calculus

## RESULTS

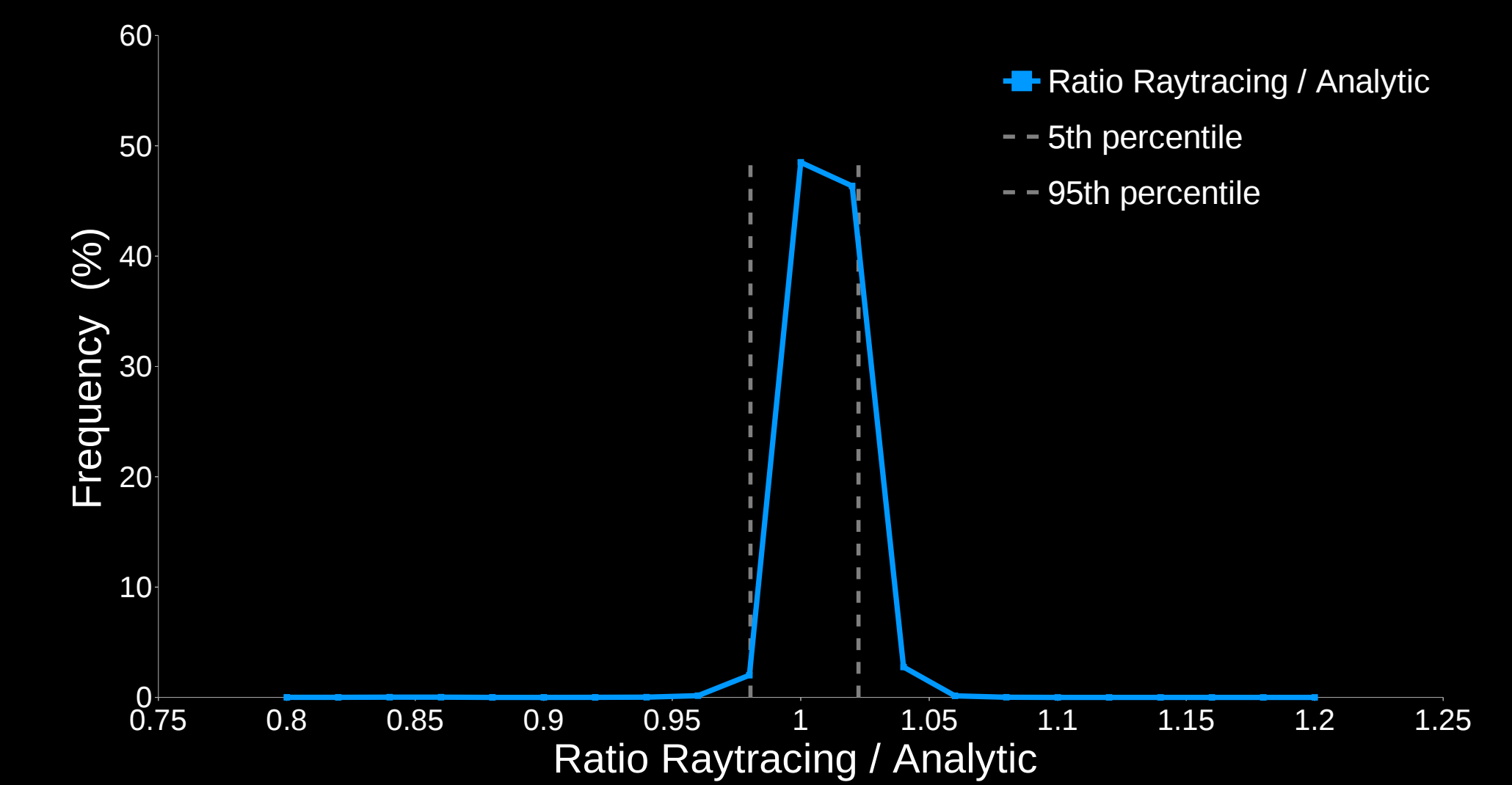


Figure 3: Comparison of density index between raytracing technique and analytical solution

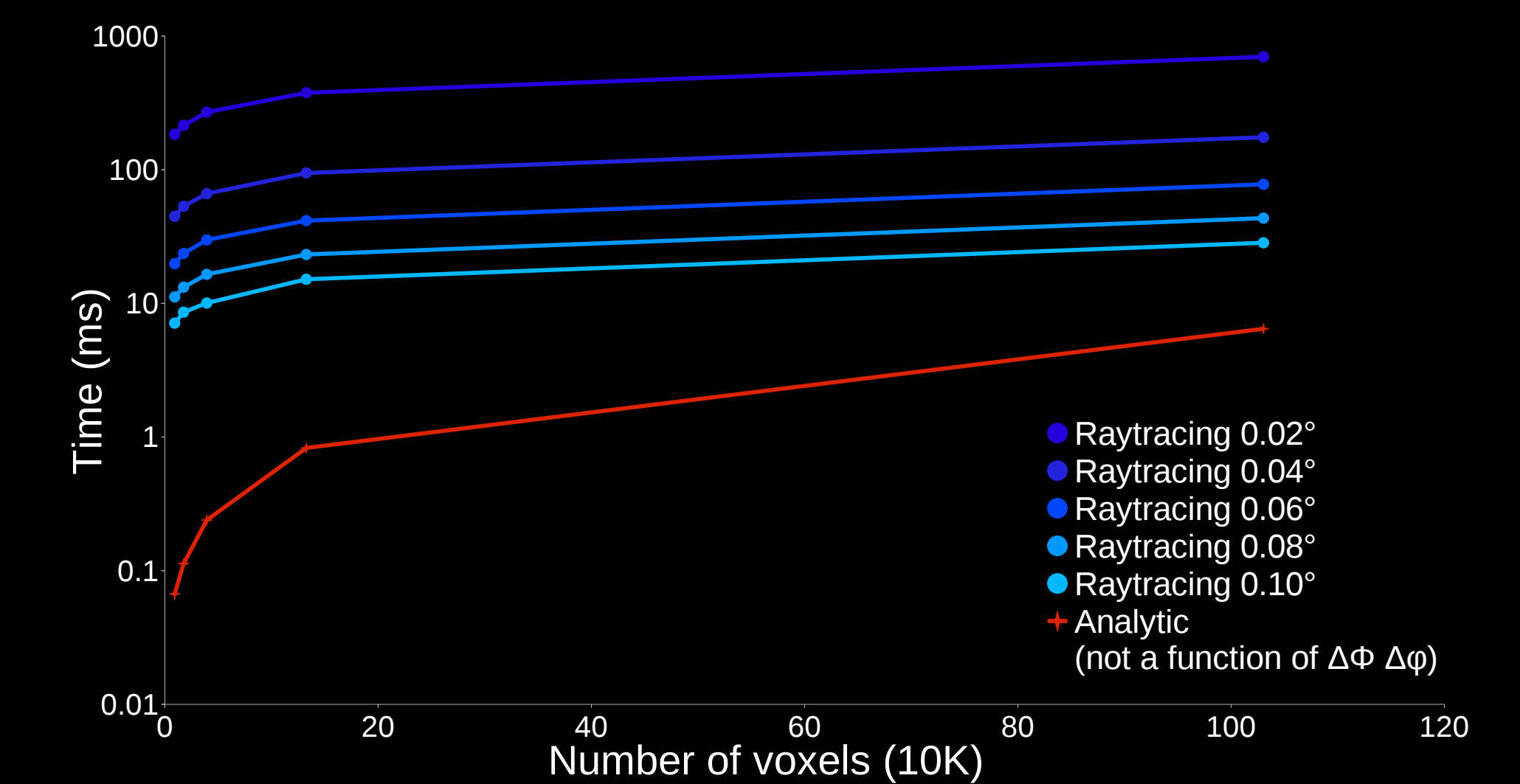


Figure 4: Computational time for both approaches

## CONCLUSION

- Raytracing and analytic process give **similar results**
- The analytical calculus represents an **important gain of time**
- **Parallel processing** is easy to set up

## FUTURE RESEARCH

**Characterizing the limits and conditions** that need to be fulfilled while using our methodology.

**Provide an analytical calculus** for the average distance covered by a beam inside a voxel.

## REFERENCES

- [1] Dassot, Constant, and Fournier. The use of terrestrial LiDAR technology in forest science: application fields, benefits and challenges. *Annals of Forest Science*, 68(5):959–974, July 2011.
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- [3] Amanatides and Woo. A fast voxel traversal algorithm for ray tracing. In *Proceedings of EUROGRAPHICS*, volume I, pages 3–10, 1987.