Surface Loading effects on the LHC tunnel

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1 Introduction

Some thoughts and a theoretical framework are gathered here to quantify the circumference changes due to surface loading induced deformations of the bedrock.

2 Horizontal deformations due to surface loading

3 LHC circumference changes due to horizontal surface deformations

Assumptions:

- ring is positioned horizontally (it is only approximately horizontal) is)
- Horizontal deformations in and around the ring can be linearized wrt to the center point.

The circumference of the LHC ring, ΔL, may be computed by a path integral over the ring which is deformed from a perfect circle by $\vec{h}(x, y)$:

$$L = \oint_{deformedring} ds(x, y) \tag{1}$$

We parameterize the path of deformed ring in terms of angle α. The infinitesimal path length $ds(x, y)$, can then be linked to $d\alpha$ by:

$$r\alpha = \vec{e}_\alpha \cdot (\vec{e}_s ds) \tag{2}$$

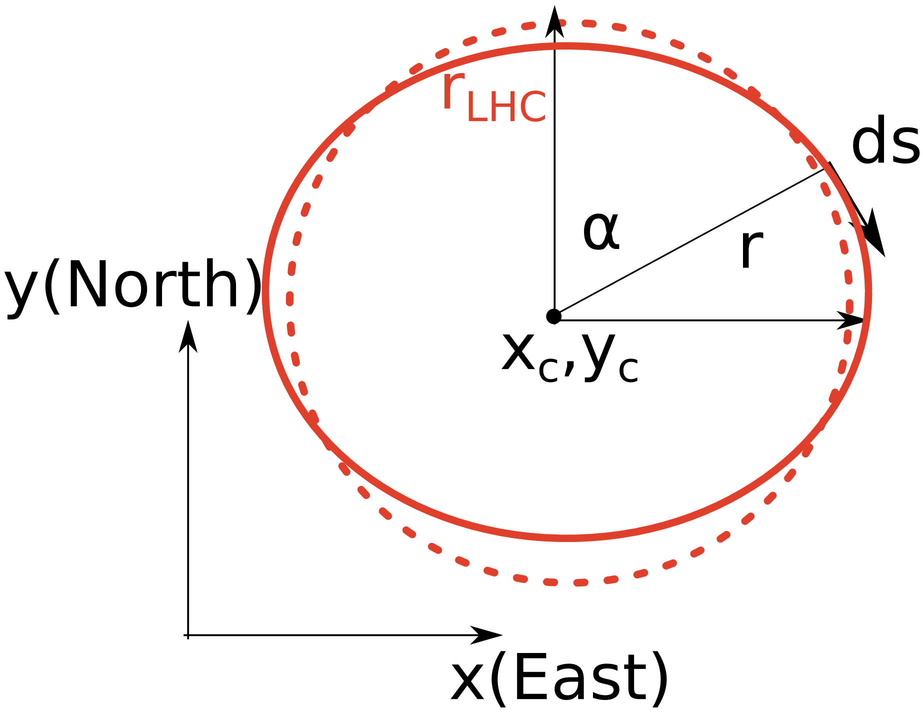
Where $\vec{e}_s$ is the tangential (unit) vector to the deformed ring and $\vec{e}_\alpha$ is a unit vector in the direction of alpha:

$$\vec{e}_\alpha = \begin{bmatrix} \cos\alpha \\ -\sin\alpha \end{bmatrix} \tag{3}$$

The integral above may thus be rewritten in terms of α.

$$L = \int_0^{2\pi} \frac{r}{\vec{e}_\alpha \cdot \vec{e}_s} d\alpha \tag{4}$$

There are several approximations which we can now apply:



- linearize the horizontal deformation field around the center of the ring. (Probably OK, since the deformations are expected to be of large scale (10s of kms').
- evaluate the horizontal deformations at the original ring and not on the deformed ring. This may help in solving the integral in an analytical way.

3.1 Hydrology and atmospheric induced LHC circumference changes from GRACE data

3.2 LHC circumference changes due to water level changes