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A Common Cavity Coordinate System

S. Aderhold*, E. Elsen*, F. Schlander*, L. Steder*

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Abstract

In this report a coordinate system for cavities is defined. The purpose is to establish a standard for common use in order to avoid confusion while communicating features of certain cavities. By the help of this common system, information gained in different inspection processes can be easily compared. An additional projection, used during second sound measurements is introduced as well.

*DESY, Hamburg, Germany

1 Motivation

This note describes a cylindrical coordinate system of the surface of a cavity, be it one with nine or less cells. The coordinate system will serve as common basis for reporting the results of cavity inspection, second sound measurements [1] and all other methods using geometrical references. The documentation thus will help to remove the confusion which arose in the past, when ad hoc coordinates were introduced for every single analysis.

1.1 FLASH Coordinate System

It is known to the authors, that FLASH (Free-Electron Laser in Hamburg) uses a coordinate system as defined in [2]. This system is pretty similar to the here defined one, but the z-axis is pointing into the other direction due to historical reasons.
The approach presented in the following seems to be the most logical option and was therefore chosen for a common definition of a cavity coordinate system.

2 Coordinate System Definition

A right-handed Cartesian coordinate system is defined at the input coupler side (short end group). For TESLA style cavities [3] a cylindrical coordinate system is the obvious choice. The radius is counted from the origin, while the angle ϕ is defined with $0°$ perpendicular to the input coupler flange, as depicted in figure 1. The transformation from Cartesian to cylindrical coordinates is given by

$$x = r \cdot \cos\phi,$$
$$y = r \cdot \sin\phi,$$
$$z = z.$$

The positive angles are counted clockwise seen from the short end group, which is also visible in figure 1.
As third coordinate, z is defined by the longitudinal axis of the cavity structure. The positive z-axis is pointing into the direction of the long end group, as shown in figure 2. In this figure, the naming scheme of the equators and irides is also shown. They are counted along the positive z-axis, which means from the input coupler side on.

2.1 Origin of Coordinate System

In order to define an absolute coordinate system, which is independent from the cavity shape and the end groups, the z position of the origin is chosen to be situated at the equator of the first cell, as depicted in figure 2. This leads (for TESLA style cavities) to z coordinates of the equators of the form:

$$z_n = (n - 1) \cdot 115.4\,\text{mm}$$

[6], where n is the equator number. As a consequence, the region between the input coupler and the first equator has negative z values.

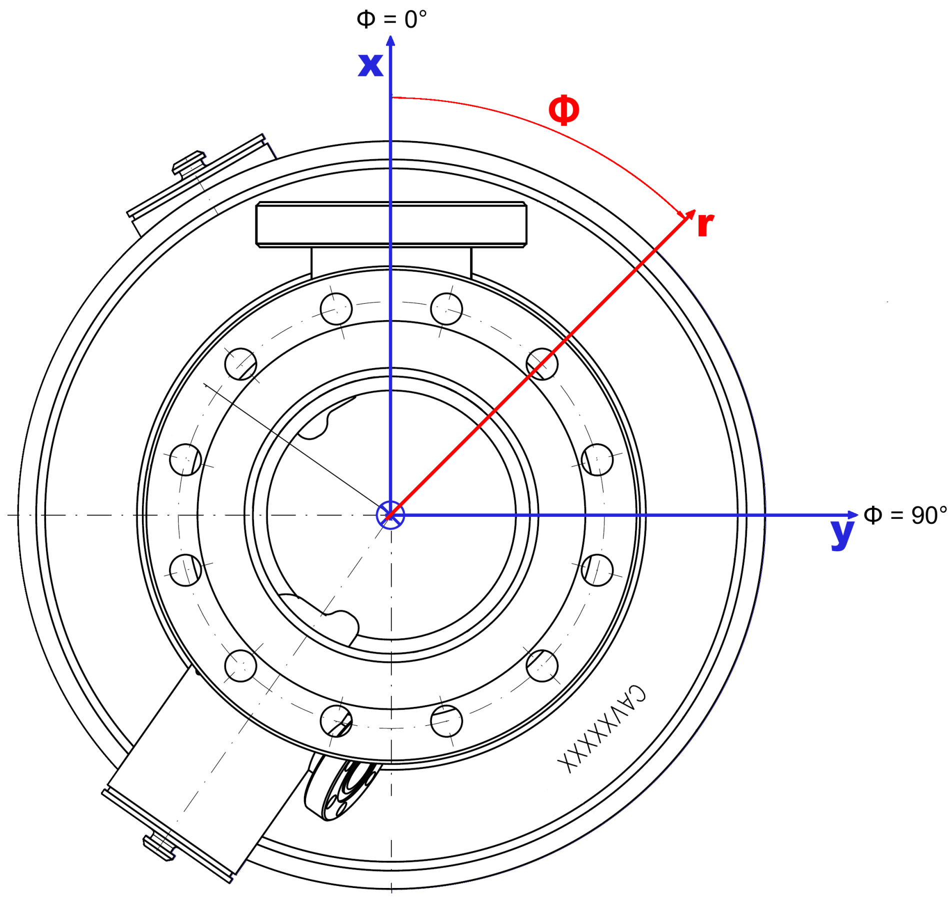

Figure 1: rϕ-plane of cavity with indication of ϕ angles, $\phi = 0°$ defined perpendicular to input coupler flange. The z coordinate is pointing into the cavity [4].

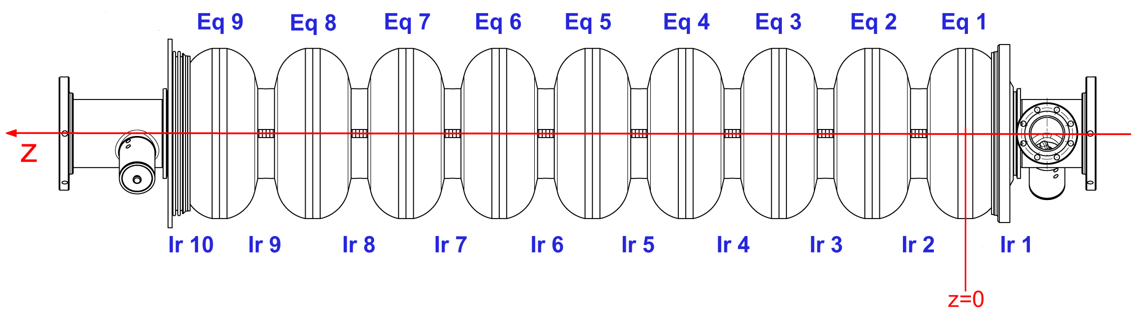

Figure 2: rz-plane of cavity with naming scheme of equators and irides [5]. The origin of the coordinate system is situated at the z-axis, in fact at the first equator.

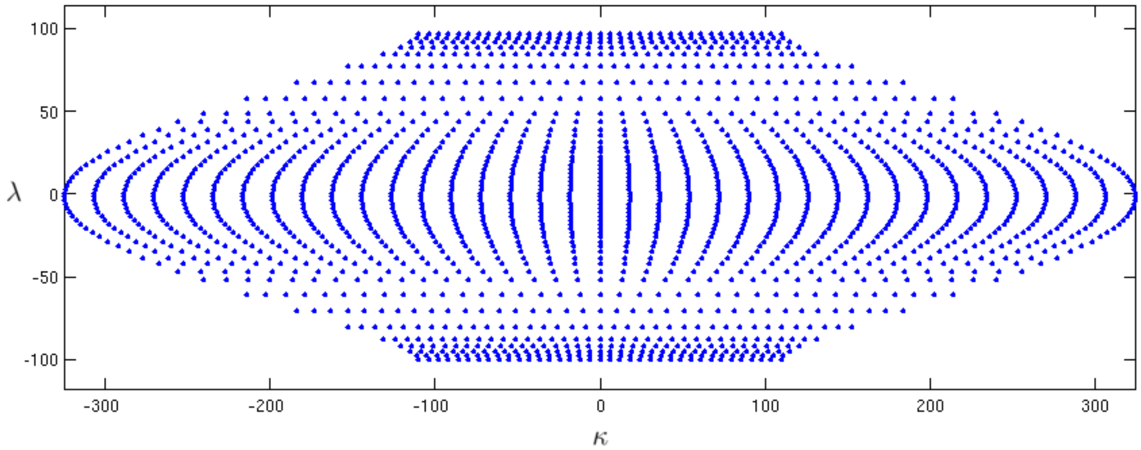

Figure 3: Non-isometric projection of a 1.3GHz cell to the $\kappa\lambda$-plane.

2.2 Defect Localization

Within a single cavity cell r, z and ϕ are also used to determine the position of for example a defect. The radius r is a function of the z position r(z), due to the periodical structure of a cavity. Hence, only the absolute z value and the ϕ information is needed to localize a certain spot within one cell.

2.3 Two-Dimensional Cavity Projection

The calculation of the shortest path between to points along the surface requires yet another coordinate system. Such a 2-dimensional projection of the cavity is shown in figure 3, which introduces the coordinates $\zeta = z + \Delta z$, κ and λ.

$$\kappa = 2\pi r(\zeta) * (\phi - 180^\circ)/360^\circ$$

$$\lambda = \int_{\zeta_1}^{\zeta_2} \sqrt{\left(\left(\frac{dr}{d\zeta}\right)^2 + 1\right)} d\zeta$$

with $\lambda = \lambda(\zeta, \phi = \text{const.})$.
Such a calculation is necessary to correlate the measurements of the quench induced second sound [1] propagation time with the origin of the quench.

Acknowledgment

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References

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[5] based on DESY drawing EDMS No. D*791745

[6] DESY drawing – EDMS No. D*797725