Heat-load estimates for the crab cavities (with RF off)

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Many thanks to D. Grote
Outline

Introduction

Fields computations

Heat Loads in a Realistic Geometry
In the CCs there are three contributions to the electromagnetic field:

- RF mode
- beam-induced field
- self-fields of the ECloud
Multipacting in the Crab Cavities (with RF off)

A previous study which has been presented at the 184th WP2 meeting showed that the RF fields tend to suppress beam-induced multipacting. Here we study the ECloud when the cavities are off.

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Warp has a Python wrapper from which we can call routines belonging to other Python packages.

We exploited this feature to interface Warp with PyECloud.

Details can be found in the presentation “Development of WARP simulations for 3D RF structures” given at the Electron Cloud Meeting #73
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Beam field

We compute the beam fields using a boosted-frame approach.

Idea:

- In the comoving frame the protons are quasi-static.
- Poisson solve for the electrostatic potential $\phi'$ in the boosted system
- Transform $\phi'$ back to the lab frame $\phi' \rightarrow (\phi, A)$
- Compute the electromagnetic field $E = -\nabla \phi - \frac{\partial A}{\partial t}$, $B = \nabla \times A$

This solver copes better with complex geometries than the standard FDTD solver.
ECloud space charge

The computation of the ECloud space charge fields with a fully electromagnetic solver is complicated due to:

▶ staircasing
▶ numerical artifacts generated by charge emission from non-conformal boundaries

It would be much easier if we could approximate the ECloud space charge as electrostatic. Can we do that?

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The electrostatic approximation is definitely good enough.
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Realistic Geometry

To study beam-induced multipacting the DQW CC can be simplified a lot. The main differences with the actual design are:

- Sharp edges (no weldings)
- Missing FPC, HOM couplers
- Cylindrical geometry

These simplifications are made to speed up the simulations, but in principle the procedure can be extended to the full model.

In Warp the cavity is modelled as an assembly of cylinders.
We simulated the electron cloud buildup for a 72 bunches train.

- For the heat load estimate we used the last 10 bunches, in order to have a pessimistic estimate (i.e. as if the whole LHC was filled and as if the ECloud was always at saturation)
- Other multipacting studies assume $\delta_{max} = 1.5$ for niobium cavities
Electrons Distribution

The multipacting happens mostly between the cavity poles and in the beam pipes.

MOVIE
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▶ evaluate the goodness of the electrostatic approximations for the ECloud space charge fields in 3D simulations;

▶ modeled a simplified DQW crab cavity starting from primitive solids;

▶ evaluated the heat loads;