EMWSD team meeting
Notes from the meeting held on 29 November 2021

Present: E. de la Fuente Garcia, C. Zannini, L. Giacomel.
Excused: G. Iadarola.

- **Status of the studies (E. de la Fuente)**

Slides are available here.

- Electric field E_z comparison between Warp and CST
  - *Method to extract fields from CST*: Since the CST tool is not scriptable, a field monitor with enough resolution in the time domain (a timestep equal to the actual simulation timestep) is needed. This results in a rather slow computational time.

    With the field monitor, a 3D field is obtained and for the wake potential computation has to be converted to a 1D array in time for each z position. To do this, the 1D plot option can be used. The 'Evaluate' dialog window is opened to define the position in x, y, z and the time samples that the user wants to include in the 1D extraction of the electric field. The field was then extracted by setting $x = 0, y = 0$ while sweeping through each cell in z. This outputs a .txt file for each time array in every cell in along the z axis, just as needed

    To process this '.txt', the python script 'cst_to_dict.py' was created to read them all and store the electric field in a matrix $Ez[nz, nt]$, which is dumped to a dictionary for latter postprocess.
  - *Method to extract fields from Warp*: The fields from Warp are the result of the simulation performed by the script 'cube_cavity.py' (for local running) or 'cube_cavity_mpi.py' (for parallel running on a server like htcondor). The simulation data is dumped to a dictionary with pickle and can be plotted with the python script 'postproc.py' that performs the comparison with CST and obtains the frequency of the electric field at cavity center.
  - *Comparison*: At first, the Warp simulations were delivering unphysical results, which was solved with an improved definition of the number of macroparticles in the bunch and by fixing a bug in the time profile definition. The injection time and charge of the beam were also changed to match the CST definition.

    A slight change in frequency can be observed, making the resonance in frequency for Warp to be at 4.15 differing from the 4.32 from CST.

    Disussion: This may be caused by Warp's Yee solver that it's dissipative in frequency, thus using the CKC should be explored. This difference in frequency needs to be further studied by comparing the fields in other points of the domain.
- Direct algorithm results
  - From the previous meeting discussion, the Direct algorithm was fixed now using a proper definition of the wake length as:

    $$Wake\_length = timesteps * dt * c - domain\_length - injection\_time * c$$
  - From the wake length, the s vector can be defined with the negative values sampling the $injection\_time$ (time until the center of the bunch enters the domain) with a resolution in meters of $dt * c$. Then the positive values of s sample the wake length starting from 0, with the same resolution $dt * c$.

- The wake potential direct algorithm was proven for both E_z fields extracted from Warp and CST with the scripts 'direct_integration.py' (Warp) and 'direct_integration_cst.py' (CST).

  The results were completely satisfactory for CST field. For the Warp case, a frequency difference after 1ns is observed, together with a larger value of the Wake potential at $s = 0$ that needs to be further analyzed.

- The direct integration was coupled with the k loss factor and impedance calculation. The loss factor obtained for the Warp E_z differed in more than 50% from the benchmark results obtained with the CST tool. The result with the CST field only differed less than 1%. The frequency of the impedance resonance matches for both Warp and CST with the CST computation used as reference. A function to calculate the DFT with the same formula as CST was included but needs to be debugged.

  Discussion: The difference observed in the loss factor is directly related to the amplitude in the wake potential in s=0, and the observed difference in the Warp wake potential might be the cause for this big difference in the loss factor. Warp fields thus needs to be improved more.

– Indirect algorithm results:

- The indirect algorithm has been applied to both Warp and CST E_z fields. The poisson correction calculated in the transverse plane at the cavity and pipe discontinuity has a different order on magnitude (1e9 compared to the ~1 of the wake potential), so a normalization factor might be missing in the reference paper. When the wake potential is normalized, the frequency and shape match perfectly with the CST computation. For the Warp simulation, the poisson solver shows unphysical results.

  Discussion: The unphysical results observed in the Warp poisson computation might be caused by a difference of the E_z field in the discontinuity of the cavity and the pipe. The indirect algorithm should be tested choosing l1 and l2 a few cells inside the pipe, and the E_z fields should be compared at this point too, to understand the big differences shown in the calculation.

– Updated GitHub ImpedanCEI with the new developments.

- **Next steps (all)**

– Fix the poisson computation results from the indirect algorithm. To do so, first compare the fields from Warp and CST in different locations along the z axis. A comparison of the E_z field at the transverse planes at $z = l_1$ and $z = l_2$ (where the poisson is calculated) should be performed as well.

– Compare the indirect integration from CST with the indirect algorithm. The results presented so far use the result from the direct integration method from CST. To be more accurate on the comparison, the indirect algorithm should be compared with the indirect integration method available in CST.

– Try the other CKC solver in Warp to see if the frequency shift and the difference in amplitude in the Wake potential is fixed.

– Perform a convergence analysis to understand how the mesh resolution affects the wake potential and impedance results both in Warp and CST. Compare the computation time as well. Try longer wake length to improve impedance FFT resolution.

– Continue with the transverse Wake potential and impedance through Panofsky-Wenzel

– The studies in EMcLAW are postponed to focus on the Warp-CST comparison.

Minutes by Elena de la Fuente Garcia