User Manual for 4D emittance

1. *Importing the libraries*

```
import os
import numpy as np
import matplotlib.pyplot as plt
import easygdf as eg
import math
import pandas as pd
import copy
from sklearn.metrics import mean_squared_error
from time import process_time
```

The aforementioned lines of code in the python code.py will import the required libraries for running the entire python code in the IDE.

2. *Setting up the variables for the run*

```
path_to_folder="C:\\Users\\anura\\Desktop\\VECC\\GPT Input Files\\New folder"
os.chdir(path_to_folder)

sim_prof_file_name="sol100.gdf"
gpt_input_file_name="sol100.in"
meas_prof_file_name="sol100_coupled.gdf"
mr_file_name="Bfac.mr"
input_dist_file_name="particle.gdf"

Bfac_list=[0.2, 0.28, 0.4, 0.45, 0.6, 0.65, 0.78]
hist2d_bound_x=[-0.04, 0.04]
hist2d_bound_y=[-0.04, 0.04]
bin_width=0.0003
num_iter=2
num_initial_particles=len(eg.load_initial_distribution(path_to_folder + "\\" + input_dist_file_name)['ID'])
```

- path_to_folder: Input the folder (the folder uploaded in the drive) address in the given format exactly.
- sim_prof_file_name: Input the name of the simulated profile you desire to generate (generated in the “Simulated” folder) in the given format exactly.
- meas_prof_file_name: Input the name of the measured profile (to be kept in the “Measured” folder) in the given format exactly.

- mr_file_name: Input the name of the ".mr" file to be used (to be kept in the main folder) in the given format exactly.
- input_dist_file_name: Input the name of the initial input particle distribution to be used with a very high emittance (to be kept in the main folder) in the given format exactly.
- Bfac_list: Input the list of all the Bfacs to be used in the run in the given format exactly.
- hist2d_bound_x/hist2d_bound_y: Input the x/y bounds (max x/y and min x/y in a list) for the 2D histogram to be generated (generally keep it such that it covers the whole emittance of the initial particle distribution having a very high emittance) in the given format exactly. It should be provided in metres. So ±40 mm will be inputted as [-0.04, 0.04].
- bin_width: Input the bin width to be kept for the 2D histogram to be constructed in the given format exactly. It should be provided in metres. So a bin width of ±0.25 mm would be inputted as 0.0005.
- num_iter: Input the number of iterations you want to run the simulation for, in the given format exactly.
- Now, run the whole python code in whatever IDE or text editor you are using. The corresponding output and input files will be generated in the designated folders.

3. ***Accessing the Input Particle Distributions of each iteration***

- The input particle distributions of each of the iterations are saved in the "Input" folder.
- The initial particle distribution with a very high emittance is named "particle.gdf" (or the name of the initial input particle distribution used by you) in the "Input" folder.
- The subsequent input particle distributions generated at each of the iterations are named "del_particle4.gdf" and "new_particle4.gdf". "4" represents the input particle distribution generated at the 4th iteration.
- "del_particle4.gdf" is the input particle distribution generated by deleting all the zero weight particles of the previous iteration.
- "new_particle5.gdf" is the input particle distribution generated by generating new particles according to the weights and iteration algorithms after the deletion of the zero weight particles from the previous iteration. This input distribution essentially serves as the main input particle distribution for the next iteration by replacing the "particle.gdf" (or the name of the initial input particle distribution used by you) in the main folder on which the code is run.

4. ***Accessing the Twiss parameters and RMS emittance of measured and simulated profiles***

- The Twiss parameters and the normalized RMS emittance is generated for each of the simulated and measured profiles in the “Simulated” and “Measured” folders respectively.
- The Twiss parameters and the normalized RMS emittance for the simulated and measured profiles are generated as “simulated_profile_analysis3.gdf” and “measured_profile_analysis3.gdf”. “3” here indicates the profile analysis of the 3rd iteration simulated and measured profiles.
- The Twiss parameters and normalized RMS emittance can be investigated as you please in a .gdf file or by importing the data in python using “easygdf” library.

5. Preparing the program for the next run

- Delete all the files from the “Input” folder, just leaving behind "particle.gdf" (or the name of the initial input particle distribution used by you) as that is our initial input particle distribution for the runs.
- Delete all the files from the “Simulated” folder.
- Delete all the files from the “Measured” folder, just leaving behind the measured profile which is taken as an input for the program as the name given in section 2.
- Now, go through section 2 once again to set up or vary the variables for the run.