Optimization design of photocathode injector assisted by deep gaussian process

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Abstract

To meet the requirement of electron beam characteristics at linac entrance of CEPC. A method of searching in a high-dimensional parameter space was performed using a multi-objective genetic algorithm. A deep Gaussian process was adopted as an surrogate model to solve highdimensional parameter optimization problem. A total of 16 geometric parameters and 10 beam element parameters have been determined to minimize transverse beam emittance and bunch length. At the end, we presented an design optimization for an injector consisting of a L-band radio frequency electron gun, a pair of solenoids, and a traveling wave tube, with an initial charge of 10 nC.

\succ Layout of the entire injector

Block diagram of algorithm





Laser Pulse

the injector layout is composed of L-band normal temperature RF gun, a pair of main and auxiliary surrounds the outside of the gun, and the exit of the gun is connected tsolenoids, and an 18 cell S-band Traveling-wave tube with an acceleration gradient of 30 MV/m. The solenoid o the Travelingwave tube after a drift section.

> Optimization parameters

RF gun cavity parameters & ranges

Parameters	Range & Unit		Parameters	Range & Unit	
Width of nose	[0.5 , 1.5]	cm	Length of gun	[27.0 <i>,</i> 36.0]	cm
Radius of Arc-1	[0.0 , 1.0]	cm	Width of gun	[1.0 <i>,</i> 2.5]	cm
Angle of Arc-1	[0,90]	Deg	Length of first cell	[4.4 ,8.4]	cm
Radius of iris	[3.0 , 5.0]	cm	Length of second cell	[10,12]	cm
Width of iris	[1.0 , 2.6]	cm	Radius of first cell	[8.5 <i>,</i> 9.5]	cm
Angle of Arc-3	[30,90]	Deg			
Radius of Arc-3	[0.5,1.0]	cm			

Initial population is randomly

generated.

Train DeepGP for M effective solutions

from the first t generations.

- Obtain offspring population by selection, crossover, and mutation.
- Offspring population is inputed to the surrogate model
- Get the true offspring population.
- Reply the generation unitl maximum iterations



Results of Pareto-Front



RF gun cavity



Initial beam distribution

Parameters	Value
Total Charge	10 nC
Macronarticles	10000

Beam element parameters & ranges

Parameters	Range & Unit		
Peak gun field	[90,120]	MV/m	
Cavity phase	[0,360]	Deg	
Solenoid 1 peak field	[0.1,0.5]	Т	
Solenoid 1 position	[0.05, 0.2]	Μ	
Solenoid 1 length	[0.05, 0.1]	Μ	
Solenoid 2 peak field	[0.0 , 0.5]	Т	
Solenoid 2 length	[0.05, 0.15]	Μ	
Solenoid 2 radius	[0.02,0.1]	Μ	
Peak TWT field	30	MV/m	
TWT phase	[0,360]	Deg	
TWT position	[0.02, 2.0]	Μ	

Transverse & longitude distribution



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