DYNAMIC RESPONSE ANALYSIS OF A SINGLE-DEGREE-OF-FREEDOM (SDOF) INELASTIC STRUCTURE UNDER SEISMIC LOADING WITH UNCERTAINTY USING MONTE CARLO SIMULATION: INCORPORATING BETA PROBABILITY DISTRIBUTION FOR STOCHASTIC PARAMETERS

WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)
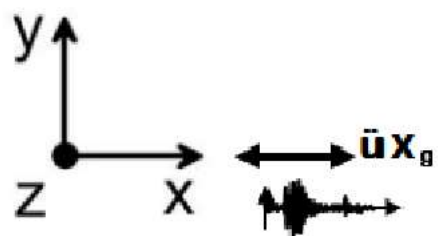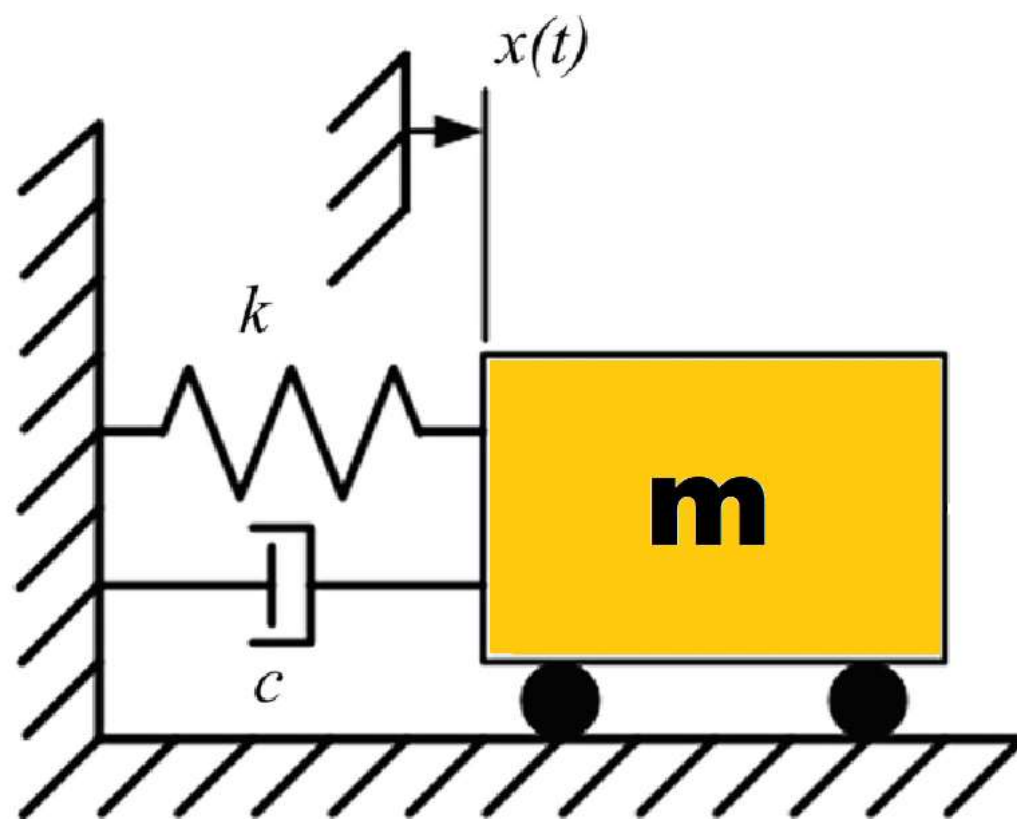
File   Edit   Search   Source   Run   Debug   Consoles   Projects   Tools   View   Help

C:\Users\Dell

C:\Users\Dell\Desktop\OPENSEES_FILES\UNCERTAINTY_SEISMIC\INELASTIC_UNCERTAINTY_SEISMIC_SDOF.py

INELASTIC_UNCERTAINTY_SEISMIC_SDOF.py

```
1  ################################################################################
2  #               >> IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL <<       #
3  #               DYNAMIC RESPONSE ANALYSIS OF A SINGLE-DEGREE-OF-FREEDOM (SDOF)          #
4  #    INELASTIC STRUCTURE UNDER SEISMIC LOADING WITH UNCERTAINTY USING MONTE CARLO SIMULATION:   #
5  #           INCORPORATING BETA PROBABILITY DISTRIBUTION FOR STOCHASTIC PARAMETERS       #
6  #------------------------------------------------------------------------------#
7  # This program models and analyzes the dynamic response of a single-degree-of-freedom (SDOF) structural   #
8  # system subjected to seismic accelerations while incorporating uncertainties in structural properties.   #
9  # The framework supports researchers and engineers in assessing the probabilistic performance of          #
10 # structures under seismic excitation, emphasizing the role of uncertainty in seismic response and        #
11 # design.                                                                        #
12 #------------------------------------------------------------------------------#
13 #               THIS PROGRAM WRITTEN BY SALAR DELAVAR GHASHGHAEI (QASHQAI)              #
14 #                   EMAIL: salar.d.ghashghaei@gmail.com                          #
15 ################################################################################
16 #
17 # Objectives:
18 # 1. Stochastic Parameter Modeling:
19 #    - Use Beta probability distribution functions to generate random values for:
20 #        Stiffness (k)
21 #        Mass (m)
22 #        Damping ratio (ζ)
23 #        Seismic accelerations
24 #    - Provide a statistical representation of uncertainties in structural properties and loading conditions.
25 #
26 # 2. Structural Model Development:
27 #    - Build an SDOF system in OpenSeesPy with stochastic parameters:
28 #        * Variable stiffness, mass, and damping ratio
```

Console 1/A

```
for more information.

IPython 8.27.0 -- An enhanced Interactive
Python. Type '?' for help.

Restarting kernel...


In [1]:
```
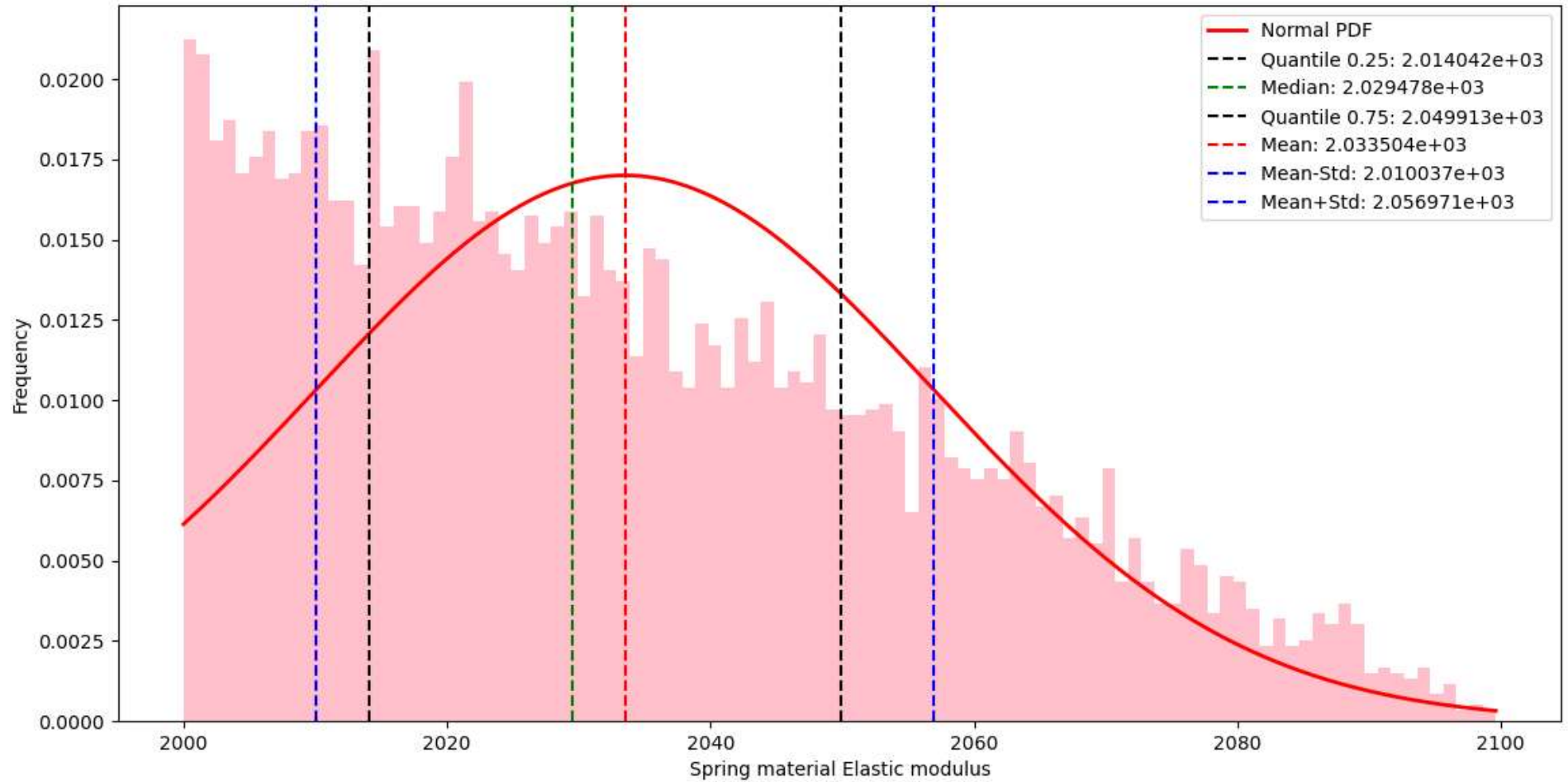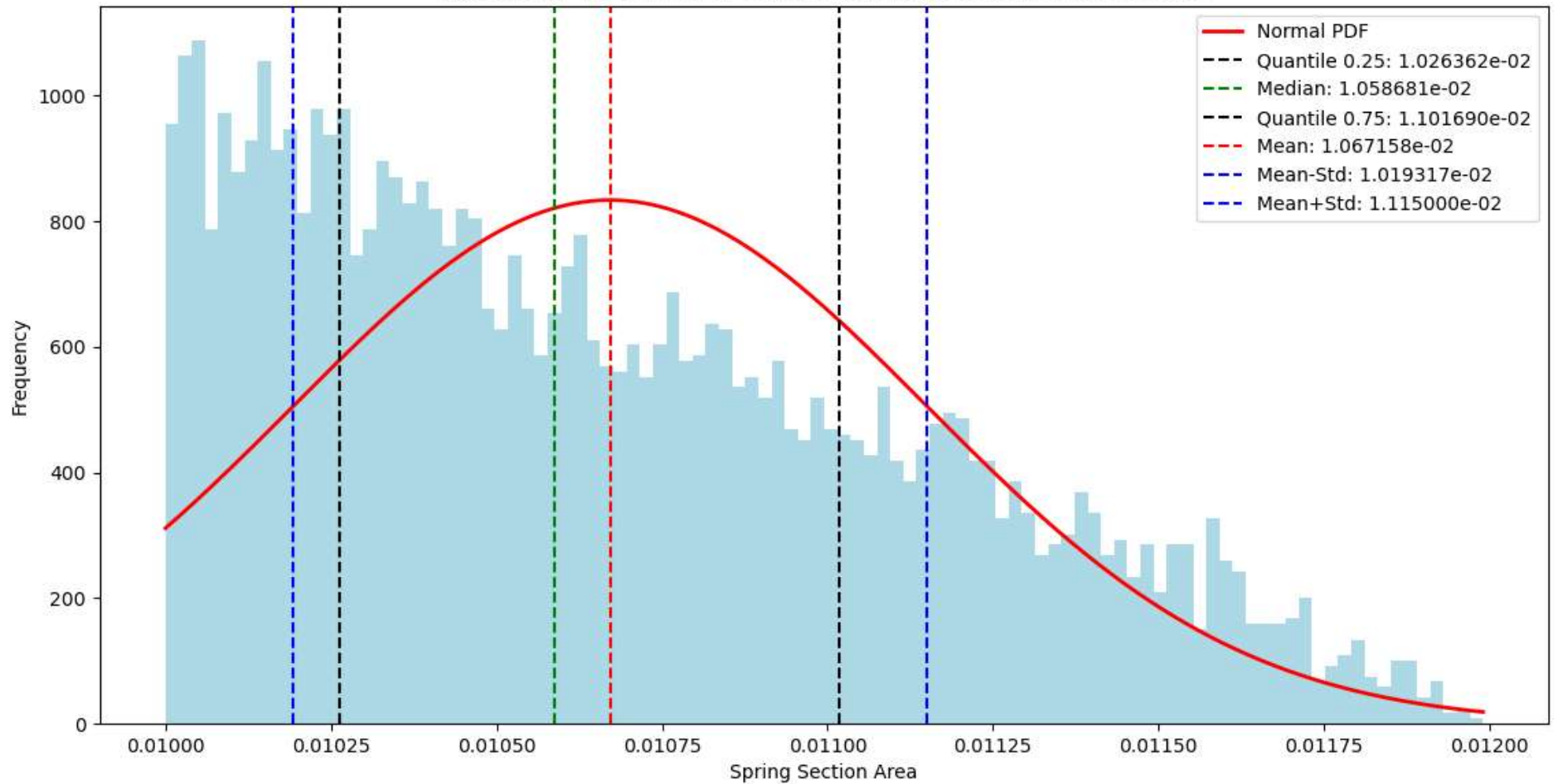
IPython Console   History

Inline   Conda: anaconda3 (Python 3.12.7)   LSP: Python   Line 11, Col 78   UTF-8   CRLF   RW   Mem 38%
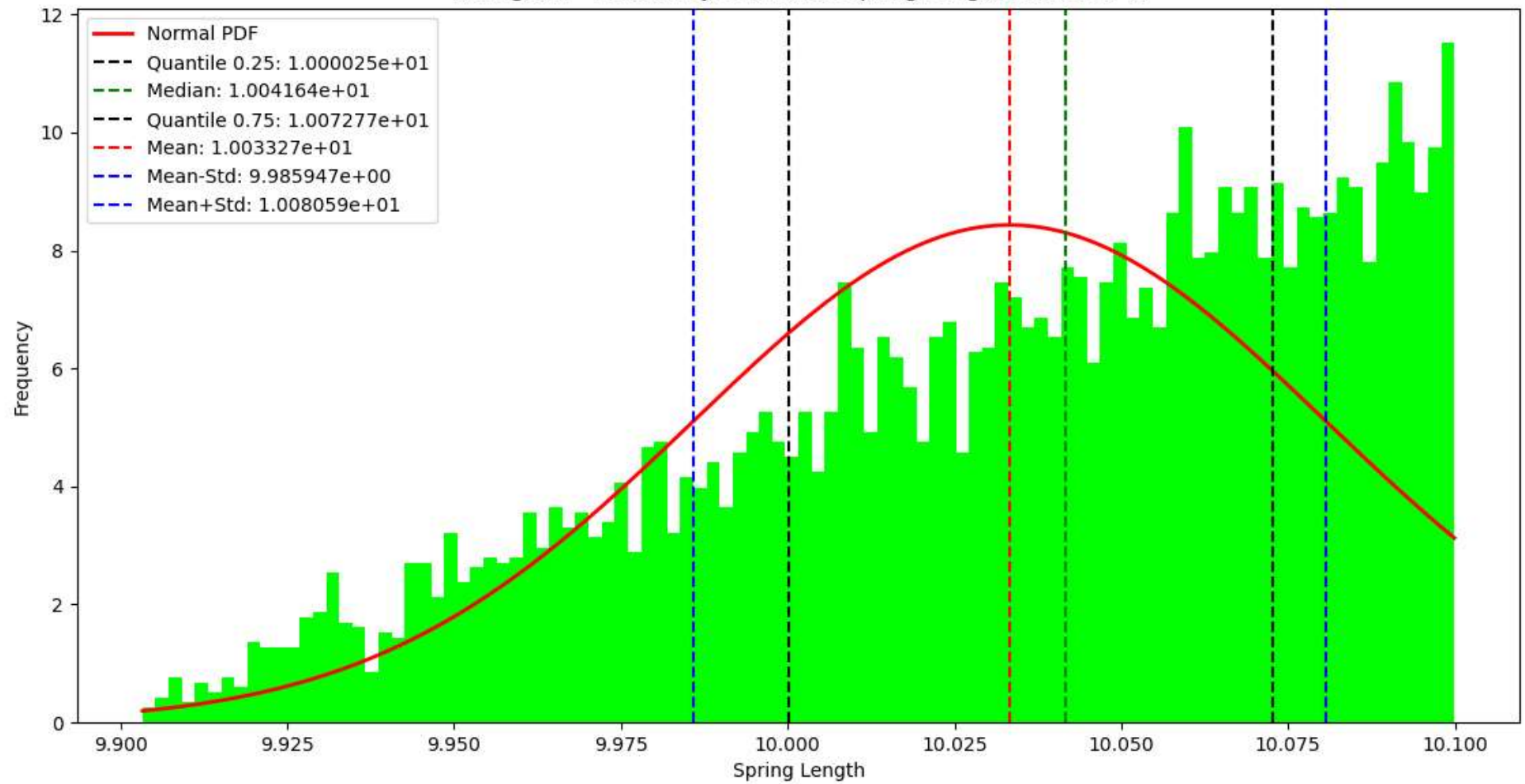
Histogram - Probability of Positive Spring material Elastic modulus is 100.00 %

Legend:
- Normal PDF
- Quantile 0.25: 2.014042e+03
- Median: 2.029478e+03
- Quantile 0.75: 2.049913e+03
- Mean: 2.033504e+03
- Mean-Std: 2.010037e+03
- Mean+Std: 2.056971e+03

Frequency

Spring material Elastic modulus

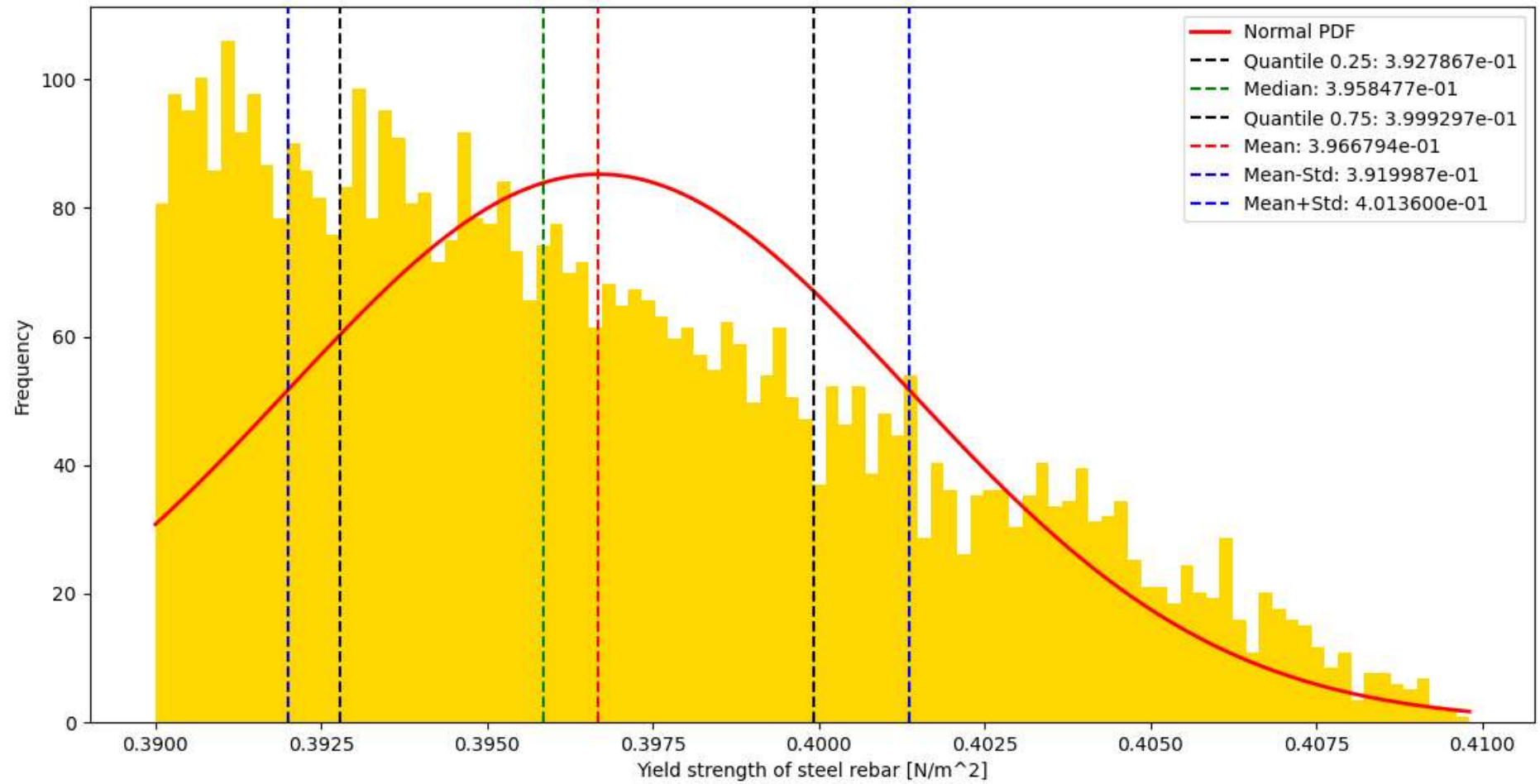Histogram - Probability of Positive Spring Section Area is 100.00 %

Histogram - Probability of Positive Spring Length is 100.00 %

Legend:
- Normal PDF
- Quantile 0.25: 1.000025e+01
- Median: 1.004164e+01
- Quantile 0.75: 1.007277e+01
- Mean: 1.003327e+01
- Mean-Std: 9.985947e+00
- Mean+Std: 1.008059e+01

X-axis: Spring Length
Y-axis: Frequency

Histogram - Probability of Positive Yield strength of steel rebar [N/m^2] is 100.00 %

Frequency

Yield strength of steel rebar [N/m^2]

Normal PDF
Quantile 0.25: 3.927867e-01
Median: 3.958477e-01
Quantile 0.75: 3.999297e-01
Mean: 3.966794e-01
Mean-Std: 3.919987e-01
Mean+Std: 4.013600e-01

Histogram - Probability of Positive Ultimate steel strain [m/m] is 100.00 %

Histogram - Probability of Positive Strain hardening ratio is 100.00 %

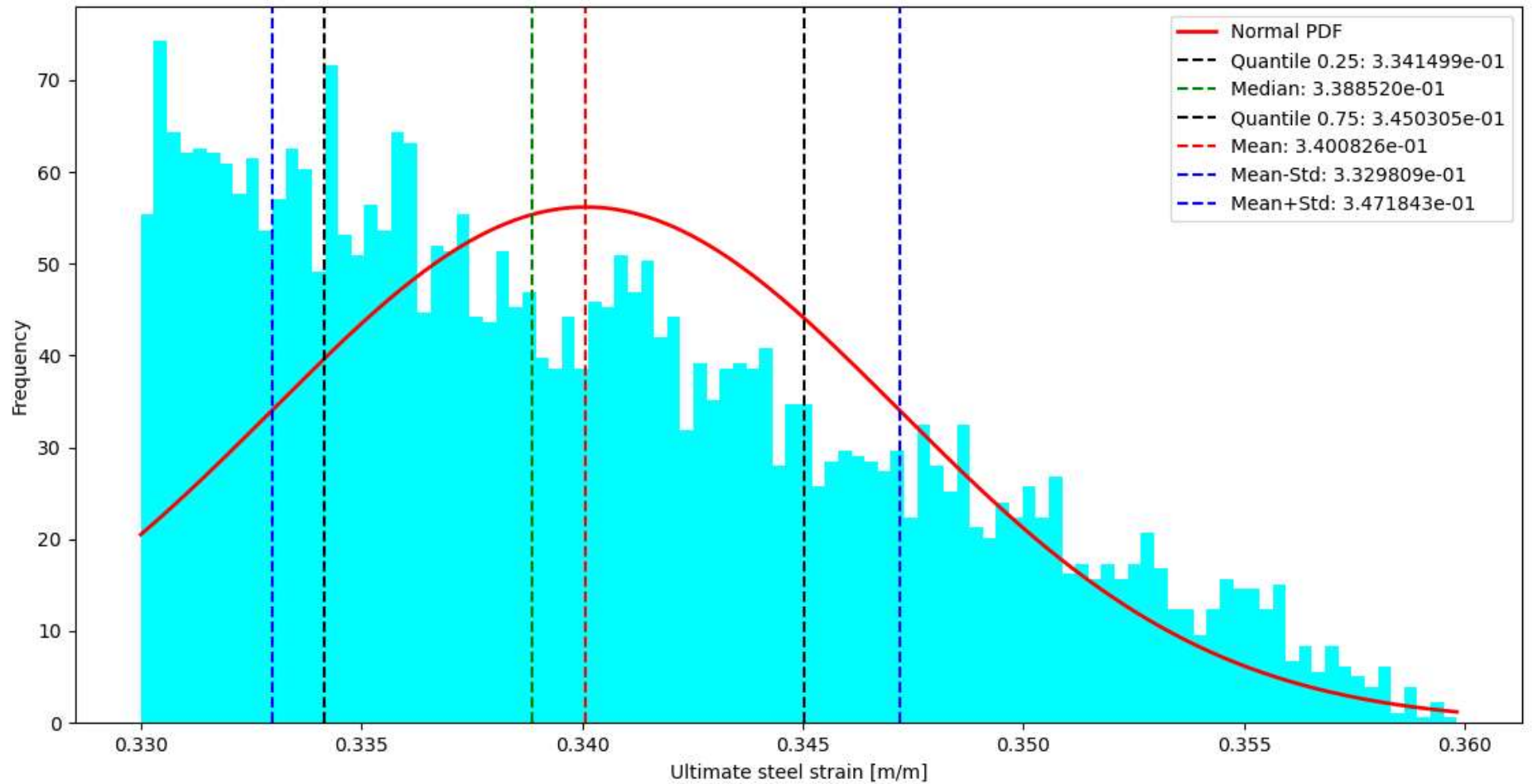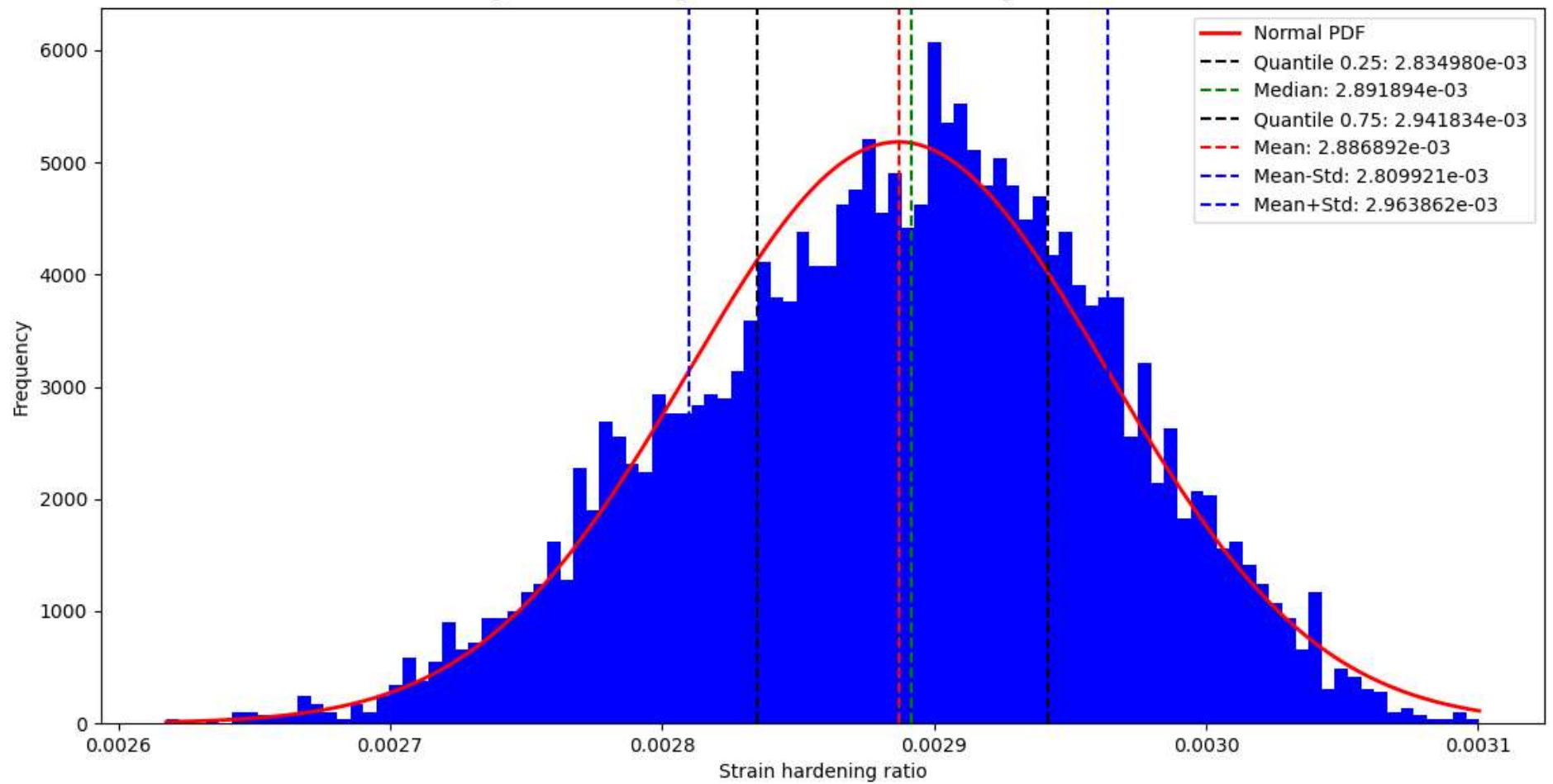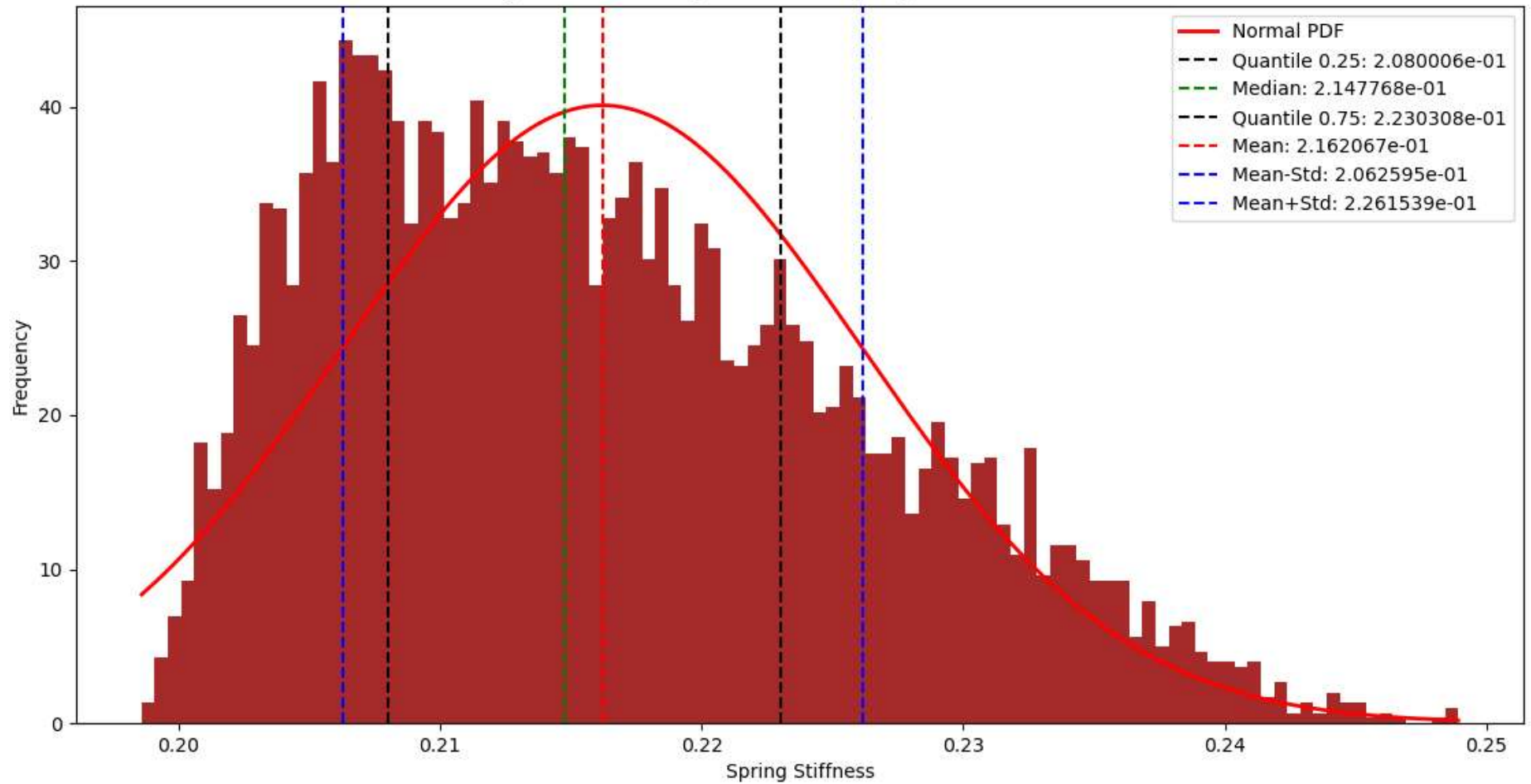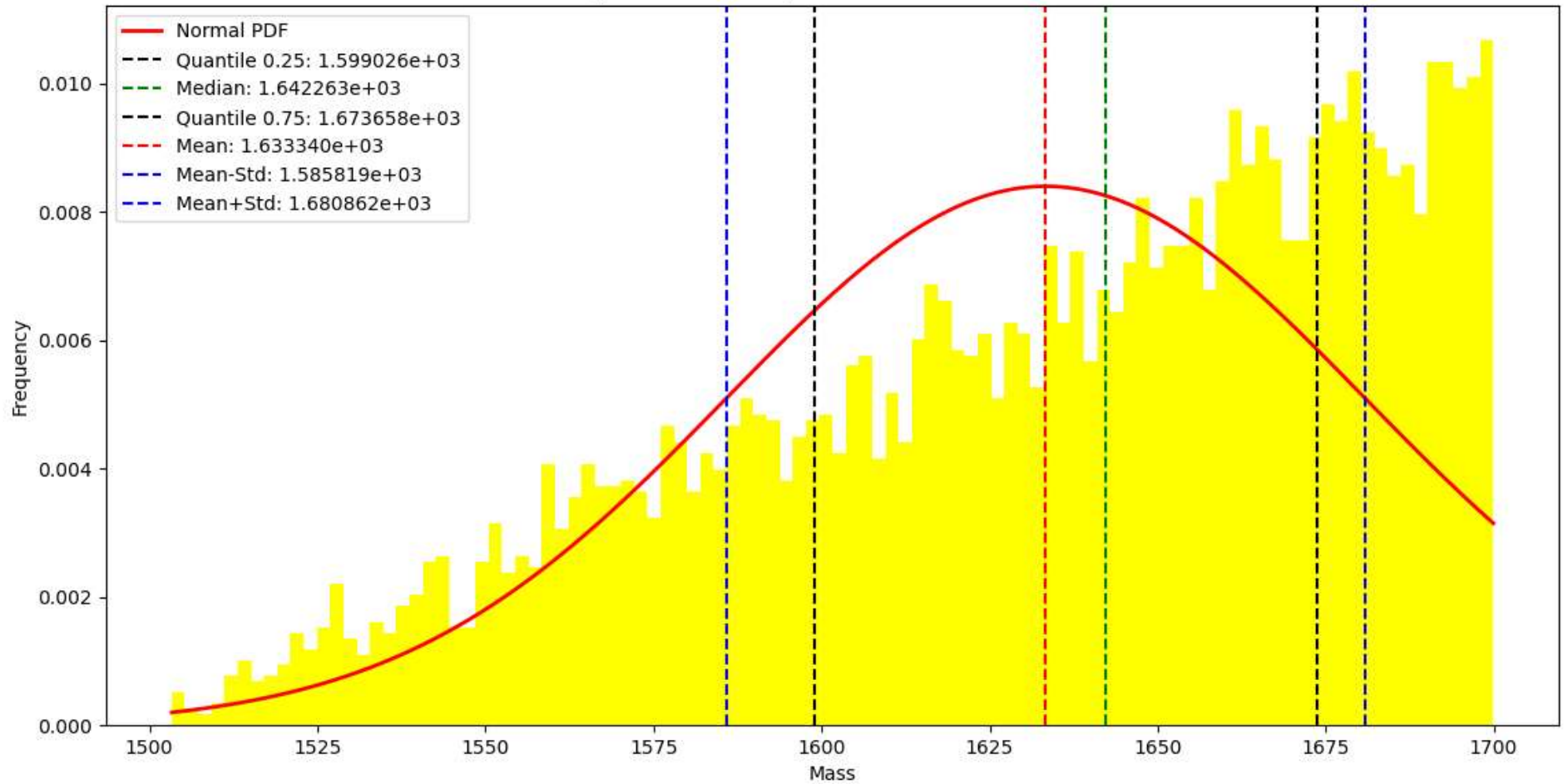Histogram - Probability of Positive Spring Stiffness is 100.00 %

Legend:
- Normal PDF
- Quantile 0.25: 2.080006e-01
- Median: 2.147768e-01
- Quantile 0.75: 2.230308e-01
- Mean: 2.162067e-01
- Mean-Std: 2.062595e-01
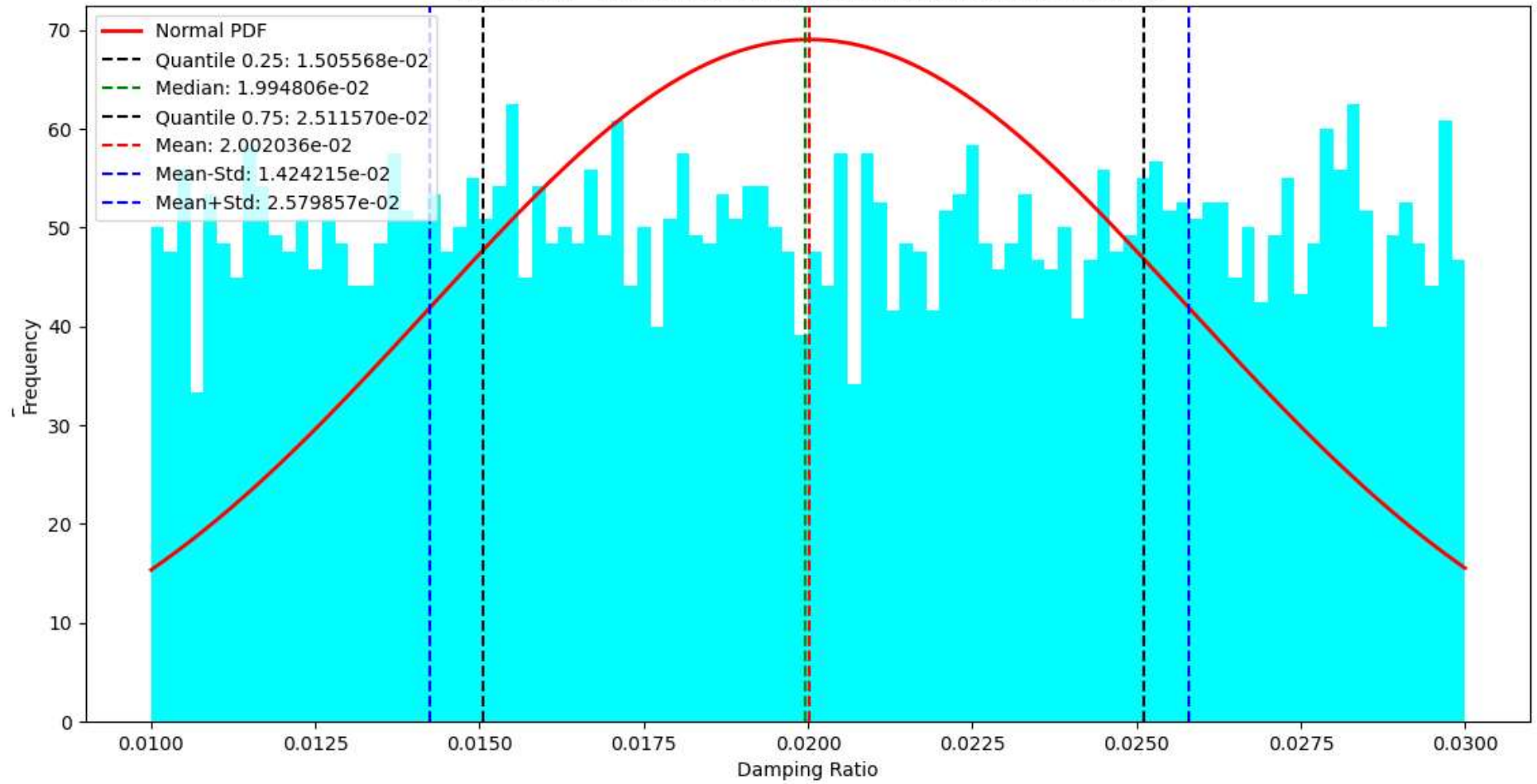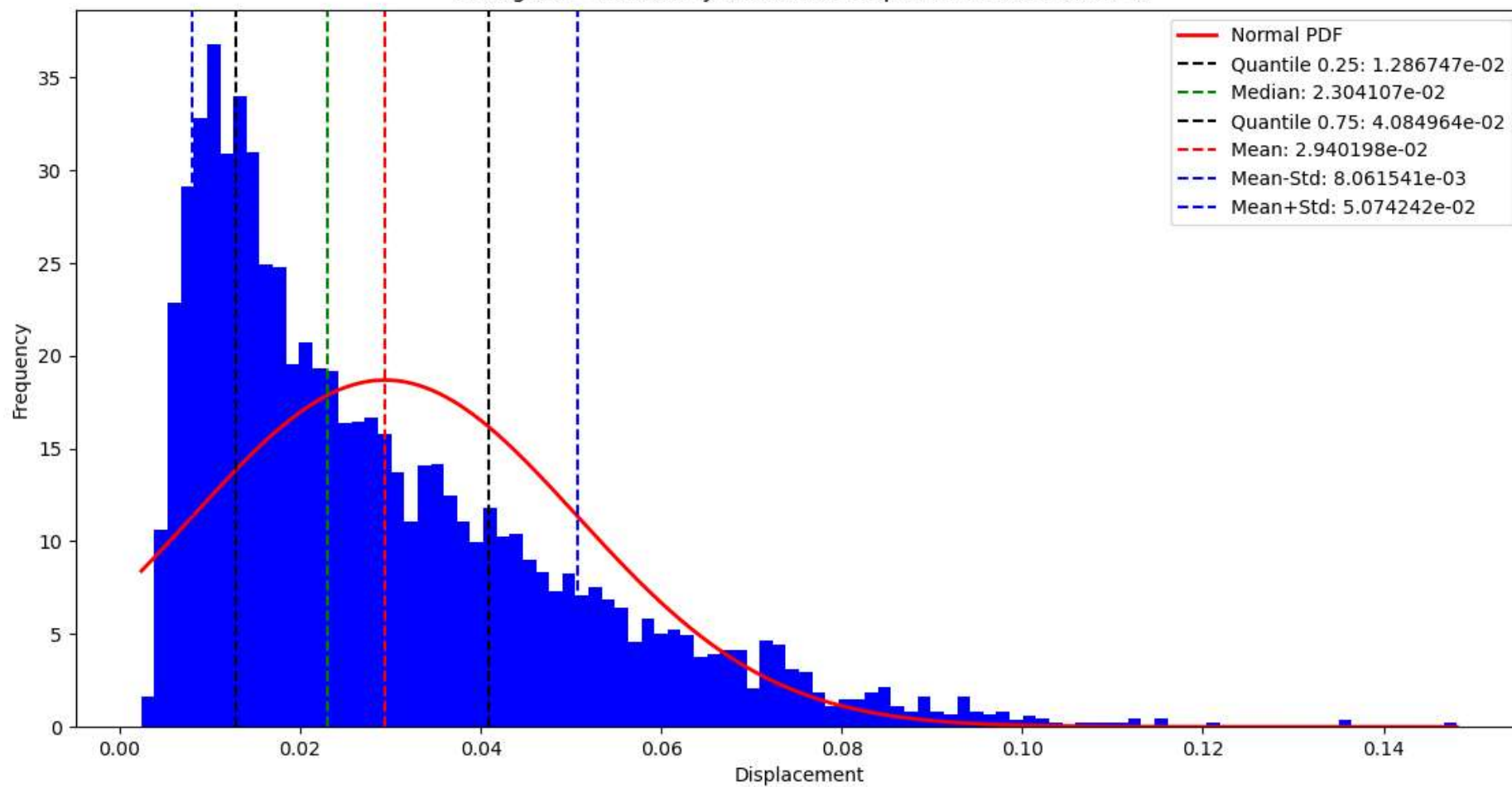- Mean+Std: 2.261539e-01

Frequency

Spring Stiffness

Histogram - Probability of Positive Mass is 100.00 %

Histogram - Probability of Positive Damping Ratio is 100.00 %

Histogram - Probability of Positive Displacement is 100.00 %

Legend:
- Normal PDF
- Quantile 0.25: 1.286747e-02
- Median: 2.304107e-02
- Quantile 0.75: 4.084964e-02
- Mean: 2.940198e-02
- Mean-Std: 8.061541e-03
- Mean+Std: 5.074242e-02

Histogram - Probability of Positive Velocity is 100.00 %

Legend	
— Normal PDF	
--- Quantile 0.25: 1.831868e-02	
--- Median: 2.059471e-02	
--- Quantile 0.75: 2.325325e-02	
--- Mean: 2.099227e-02	
--- Mean-Std: 1.729238e-02	
--- Mean+Std: 2.469216e-02	
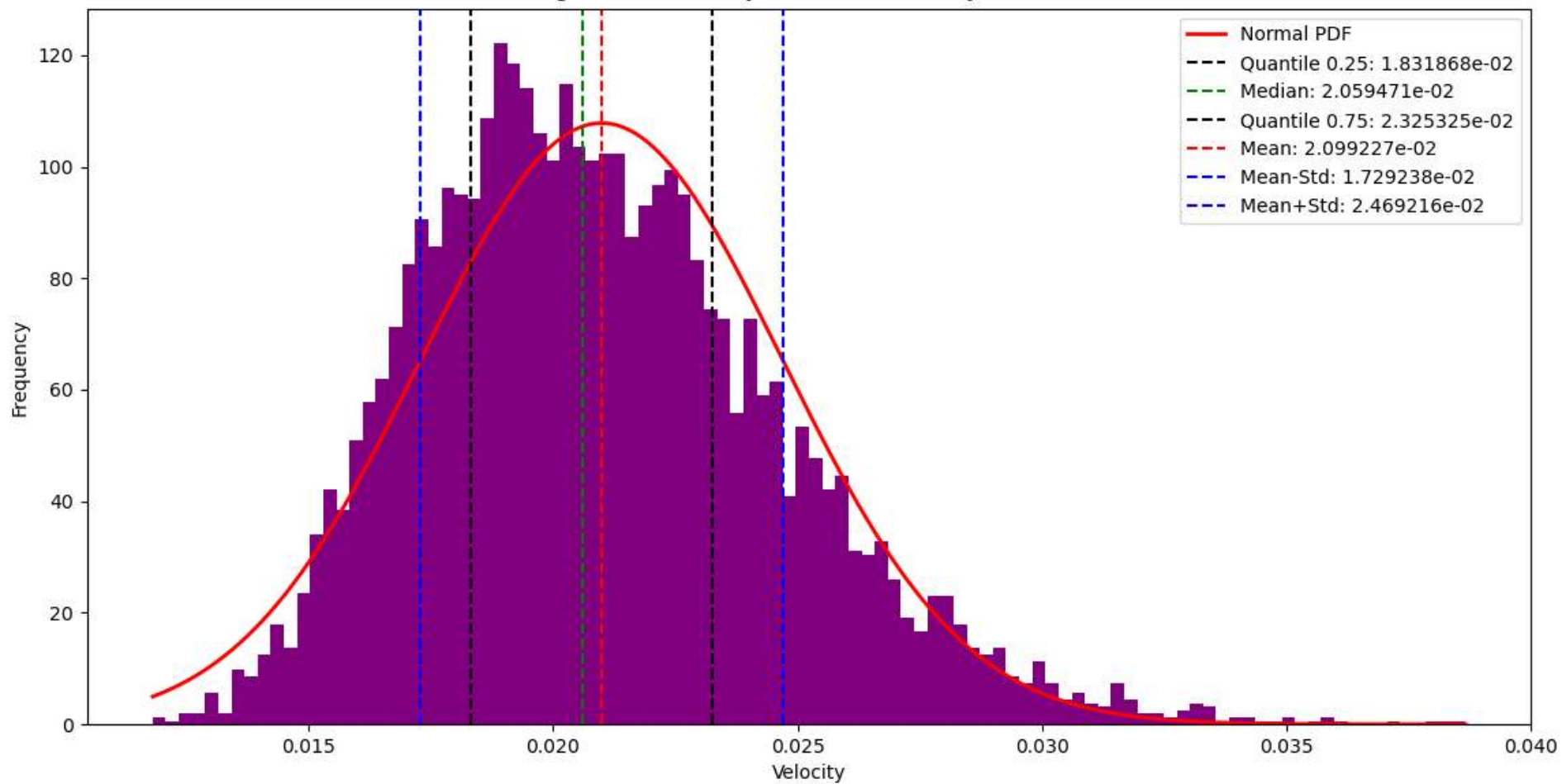
Histogram - Probability of Positive Acceleration is 100.00 %

Legend:
- Normal PDF
- Quantile 0.25: 3.134032e-01
- Median: 3.376891e-01
- Quantile 0.75: 3.661386e-01
- Mean: 3.416368e-01
- Mean-Std: 3.020877e-01
- Mean+Std: 3.811859e-01

Frequency

Acceleration
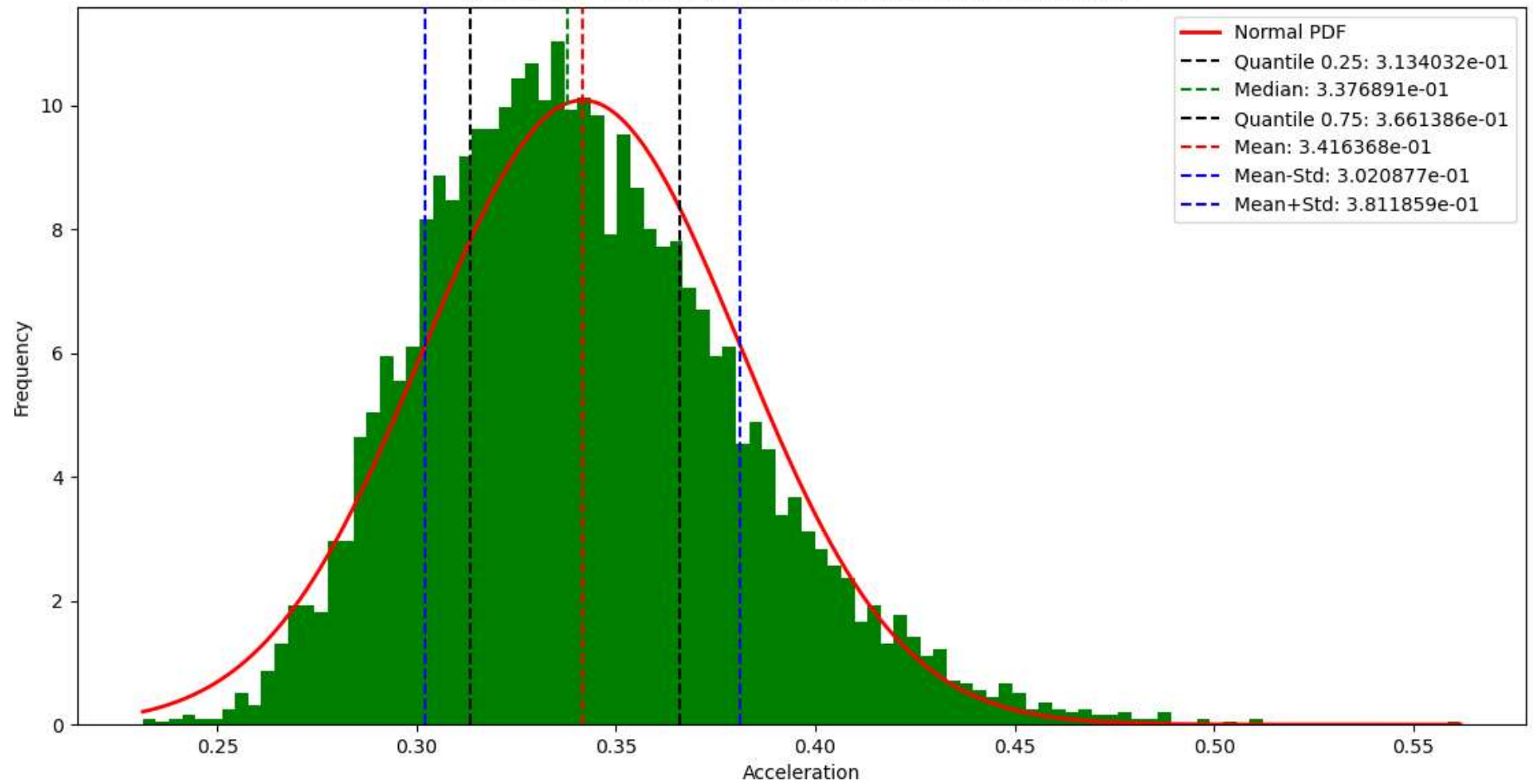
Histogram - Probability of Positive Base Reaction is 100.00 %

Feature Importance
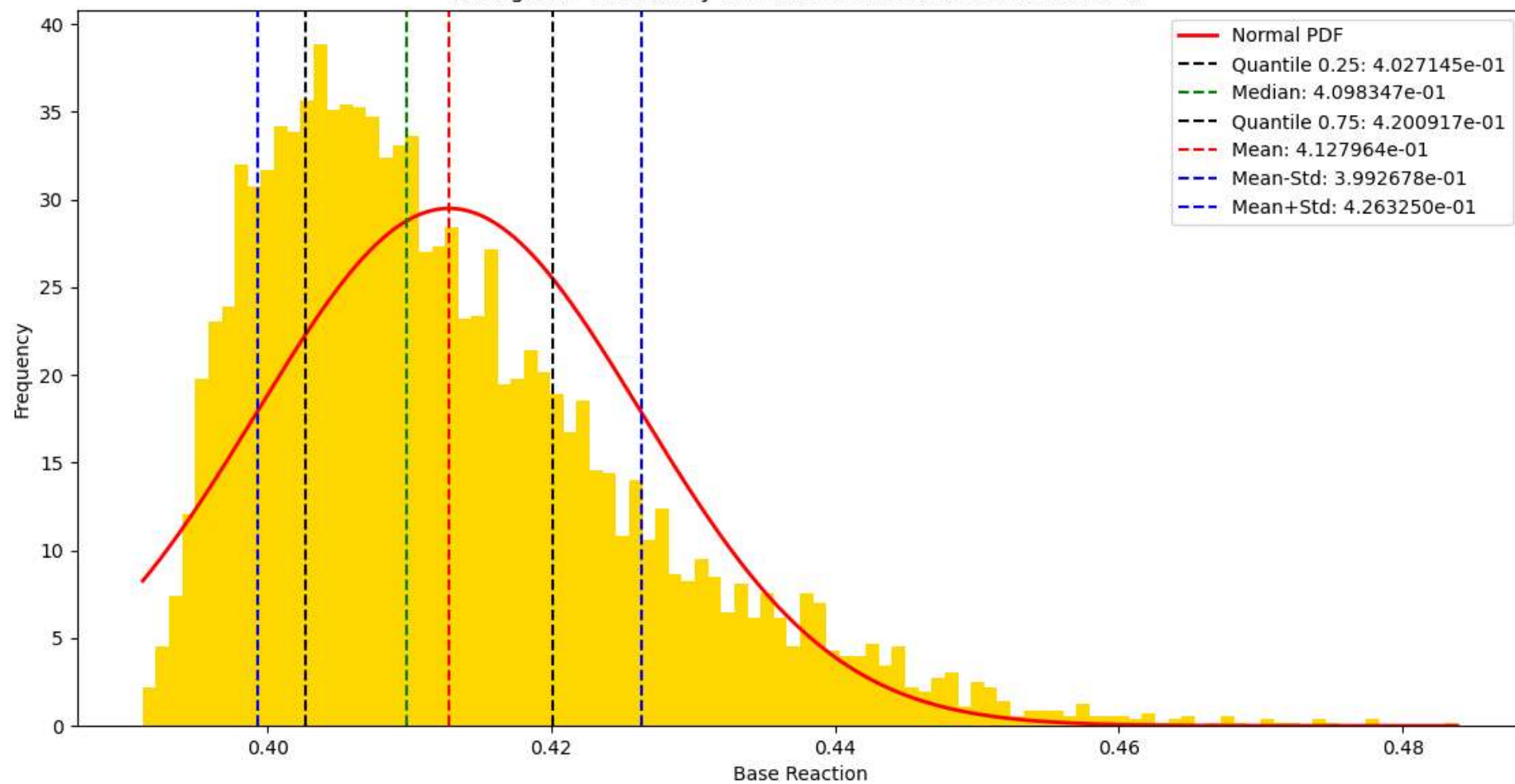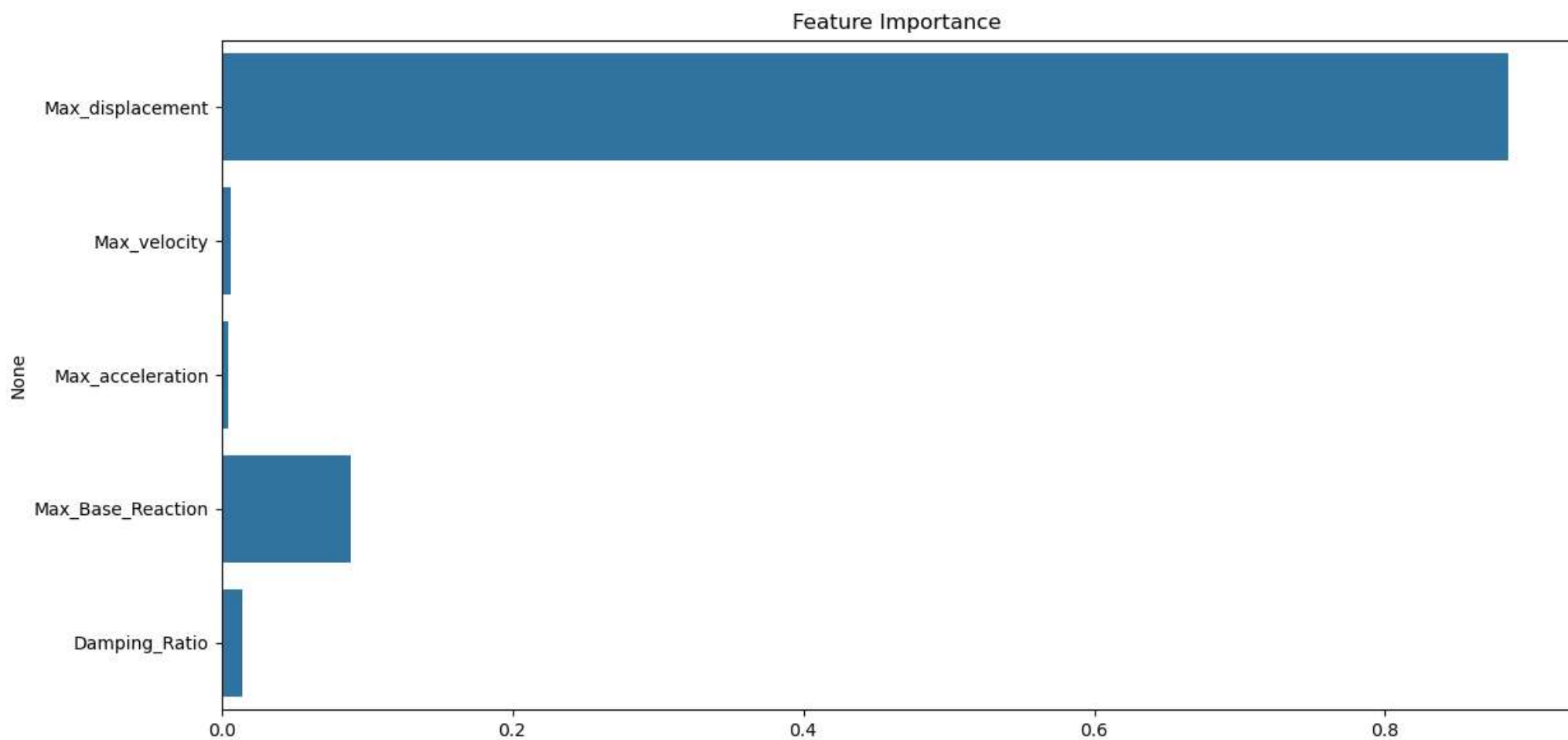
MACHINE LEARNING: LONG SHORT-TREM MEMERY (LSTM) METHOD - Predicted [[0.33985257]]
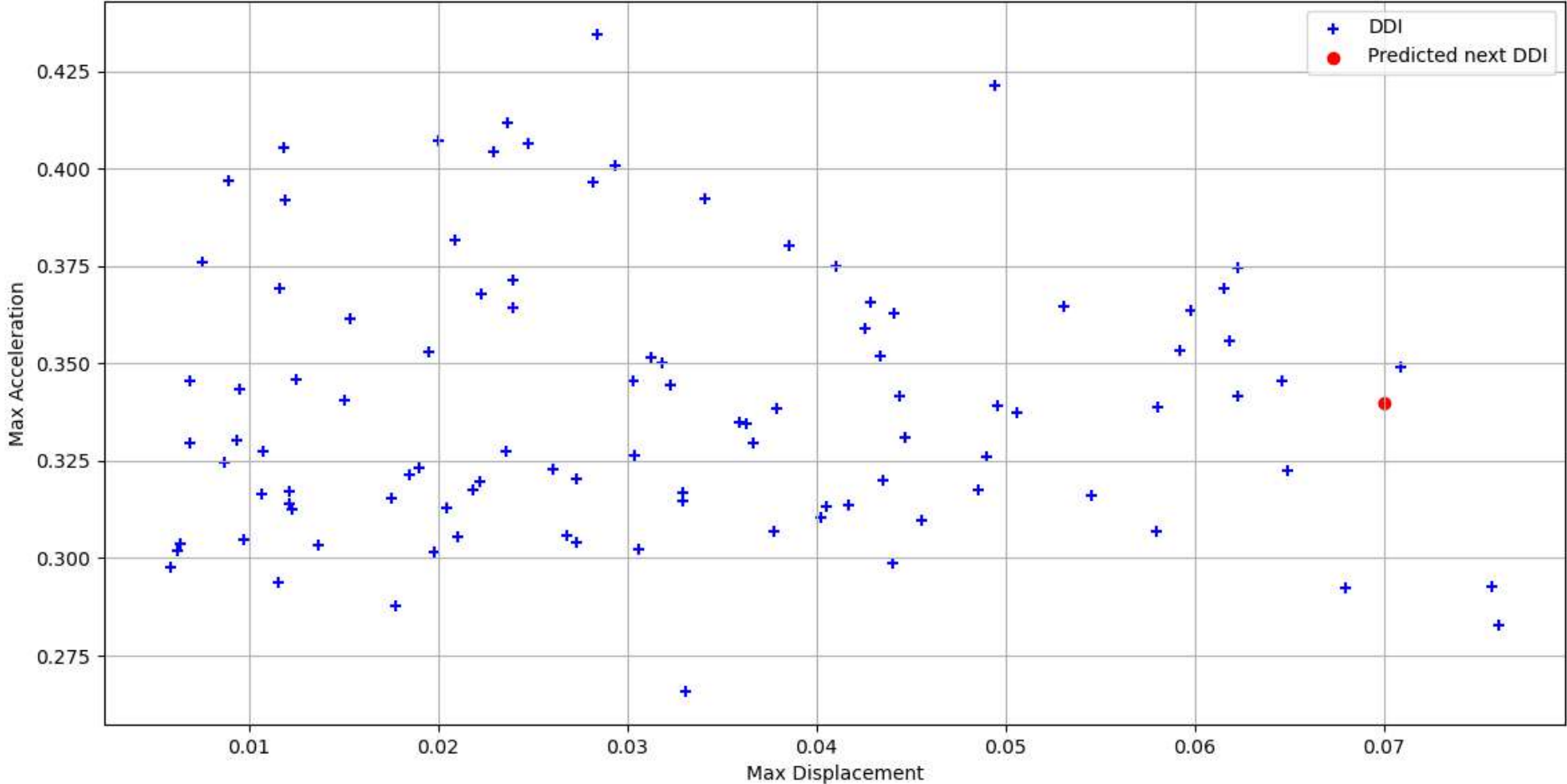
```
                          OLS Regression Results
==============================================================================
Dep. Variable:         Max_displacement   R-squared:                       0.870
Model:                              OLS   Adj. R-squared:                  0.870
Method:                   Least Squares   F-statistic:                 1.005e+04
Date:                 Mon, 27 Jan 2025   Prob (F-statistic):               0.00
Time:                        21:54:48   Log-Likelihood:                  20694.
No. Observations:                6000   AIC:                         -4.138e+04
Df Residuals:                    5995   BIC:                         -4.135e+04
Df Model:                           4
Covariance Type:            nonrobust
==============================================================================
                      coef    std err          t      P>|t|      [0.025      0.975]
------------------------------------------------------------------------------
const               -0.5806      0.003   -186.047      0.000      -0.587      -0.574
Max_velocity         0.0368      0.032      1.134      0.257      -0.027       0.100
Max_acceleration     0.0077      0.003      2.551      0.011       0.002       0.014
Max_Base_Reaction    1.4677      0.007    197.801      0.000       1.453       1.482
Damping_Ratio        0.0370      0.017      2.152      0.031       0.003       0.071
==============================================================================
Omnibus:                      130.948   Durbin-Watson:                   2.044
Prob(Omnibus):                  0.000   Jarque-Bera (JB):              119.377
Skew:                          -0.297   Prob(JB):                     1.20e-26
Kurtosis:                       2.646   Cond. No.                         372.
==============================================================================
```