On the Potential of Machine Learning in Science Operations

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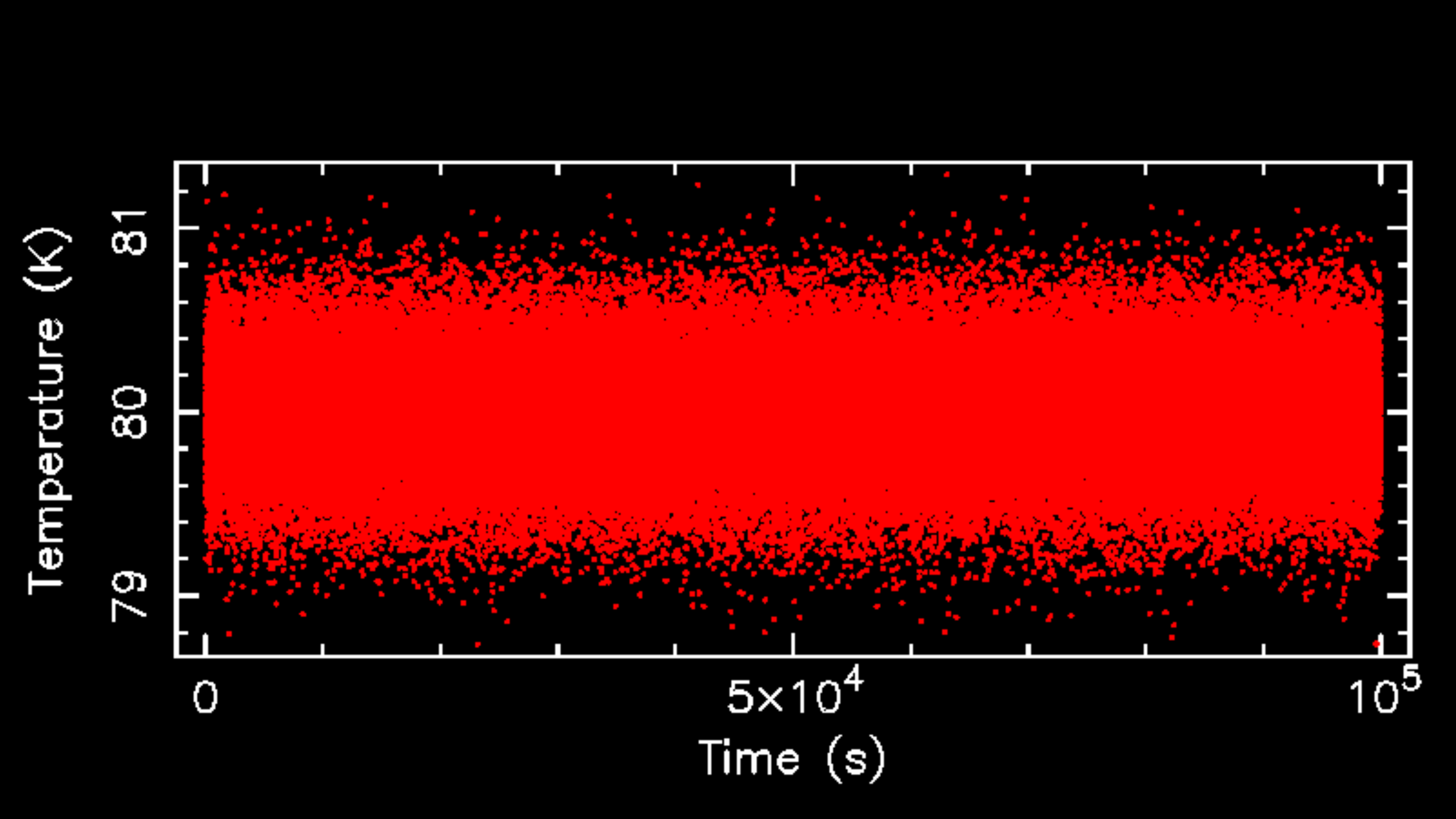
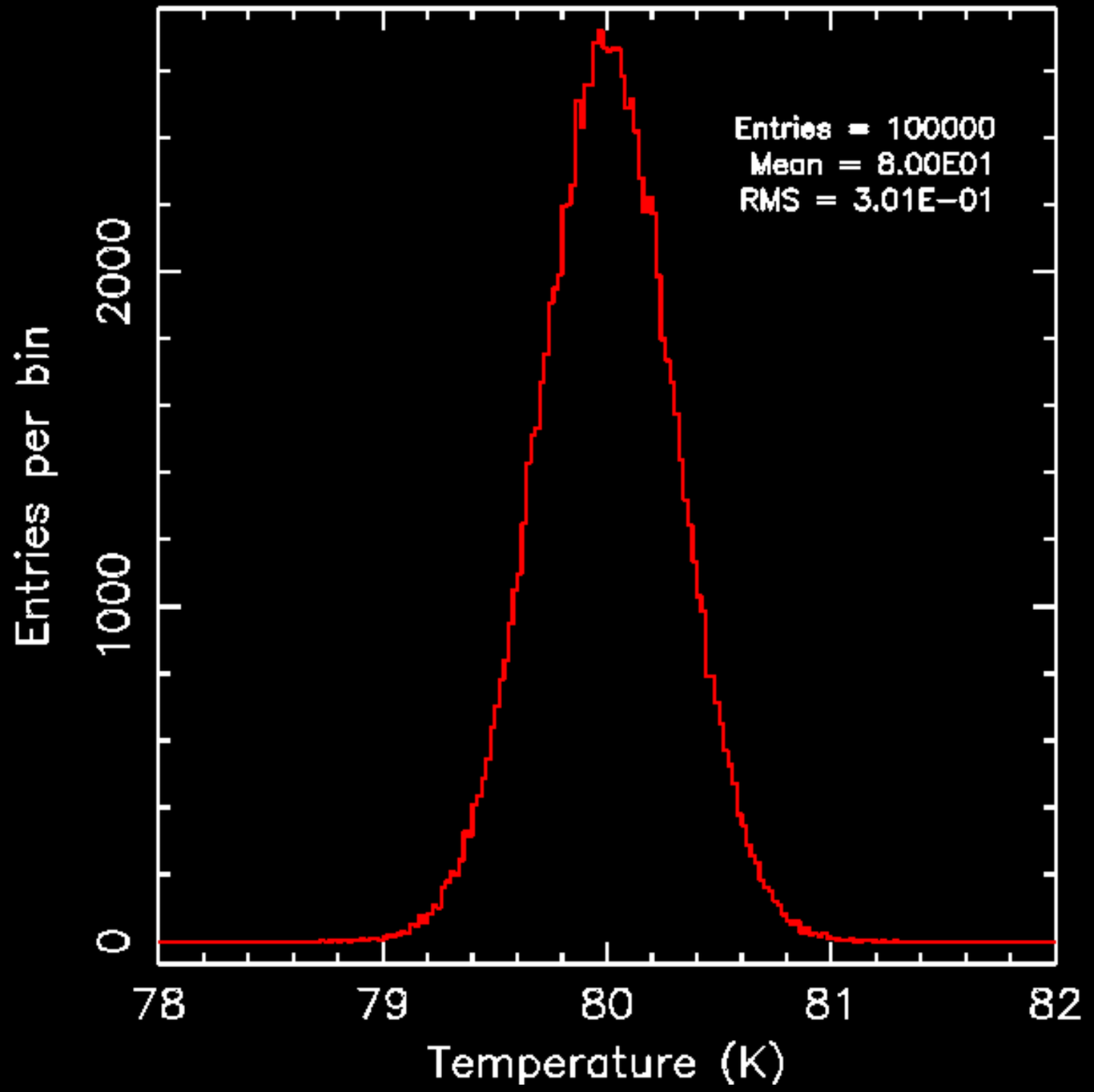
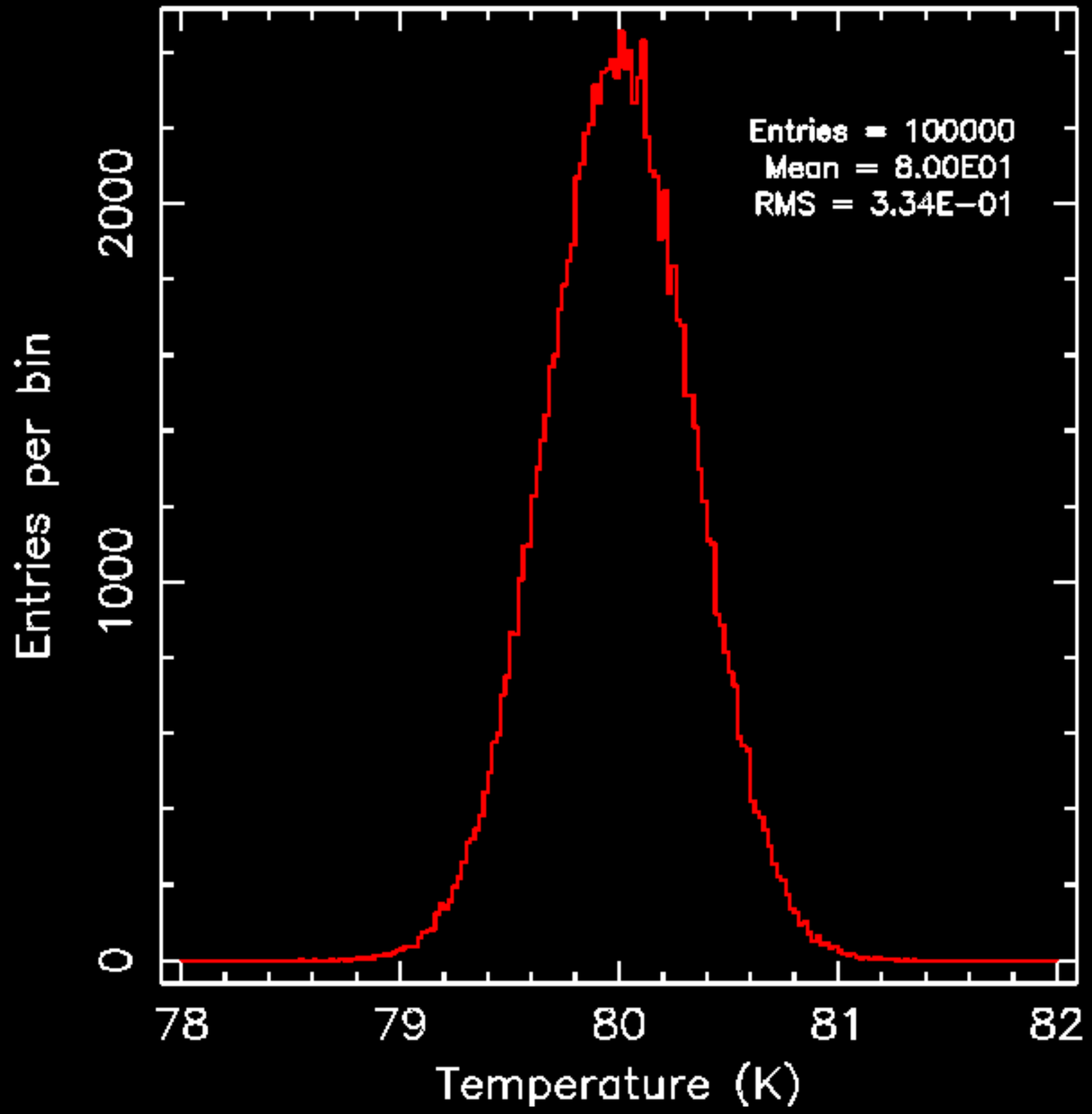
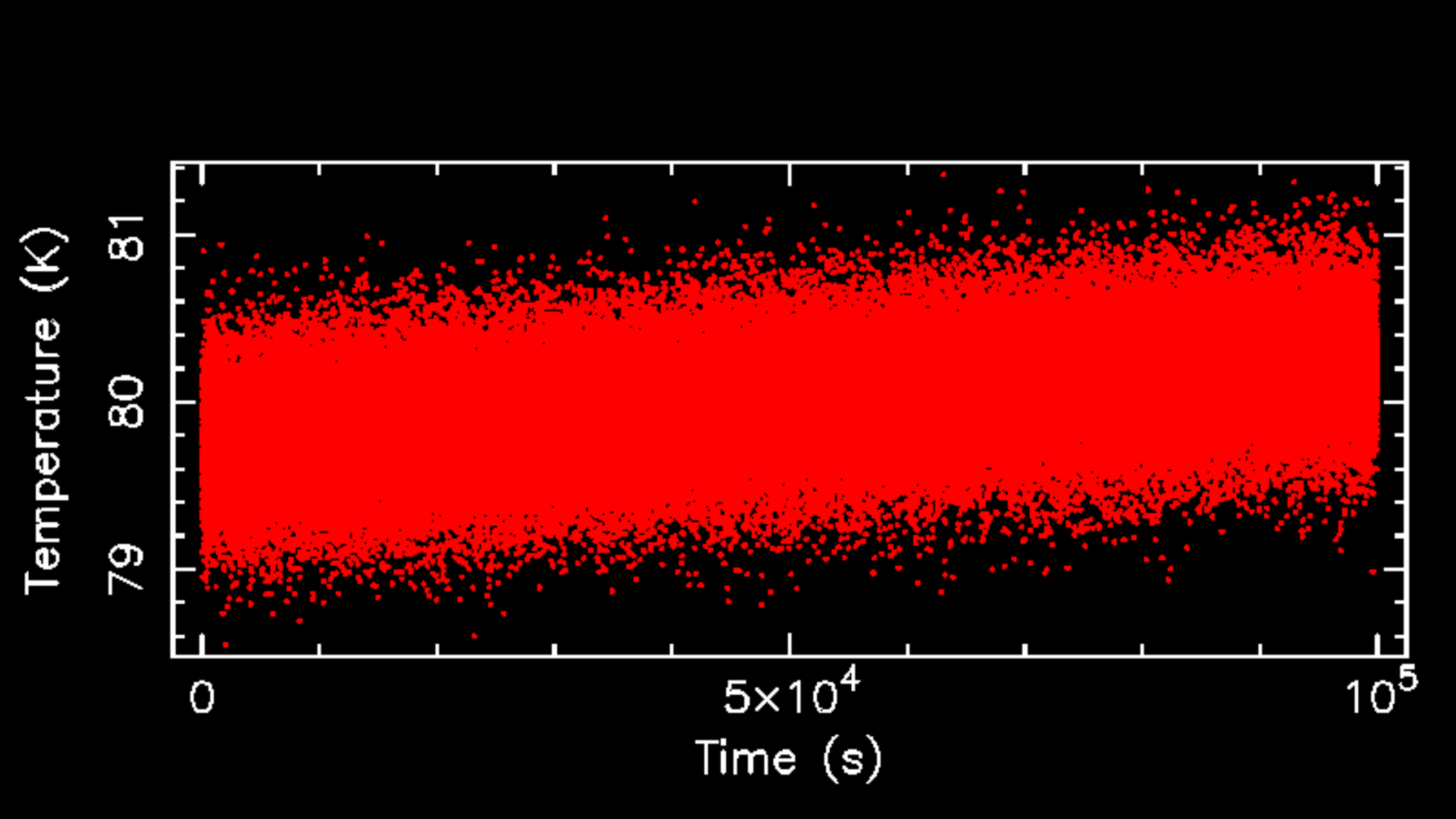
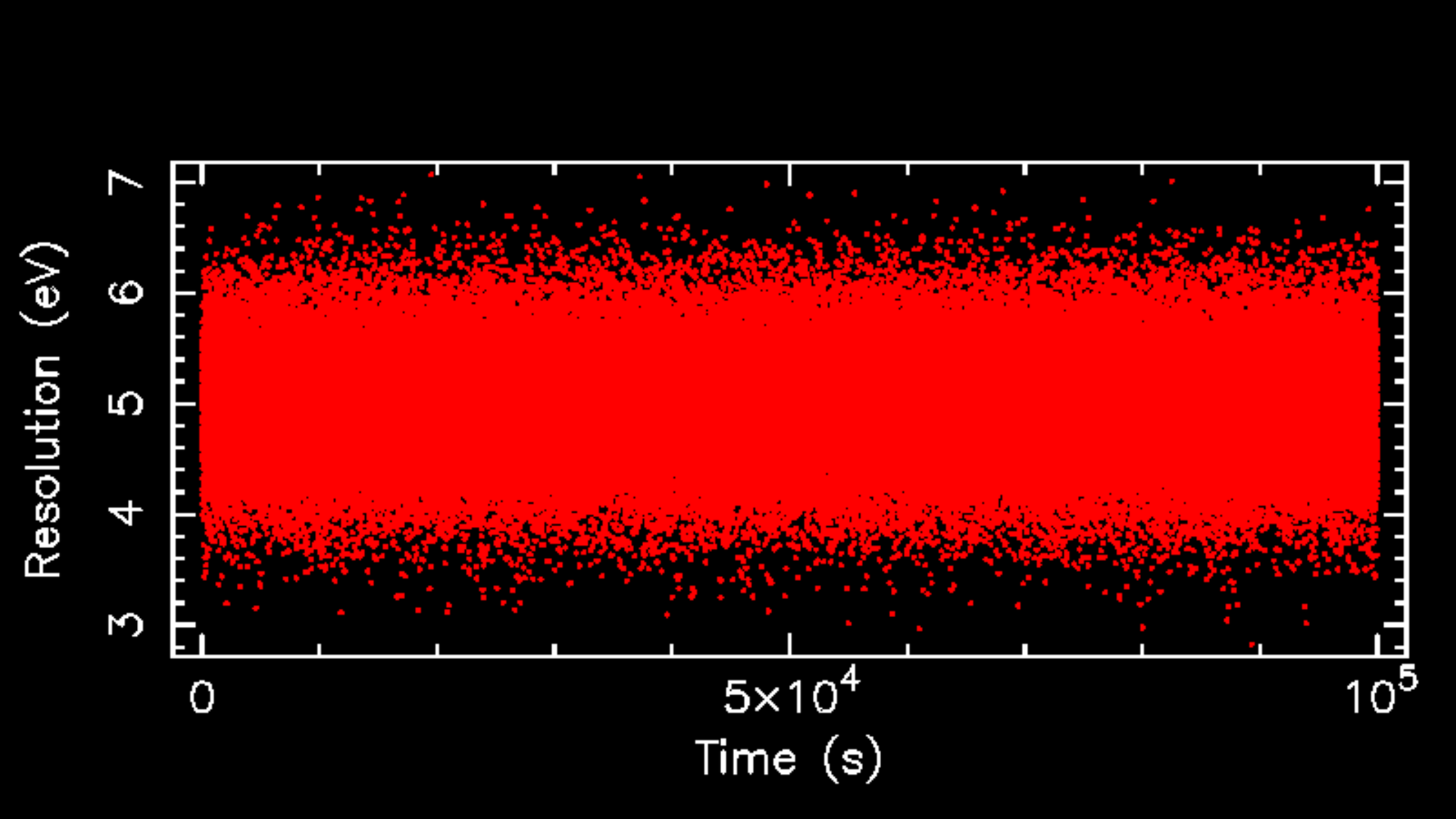
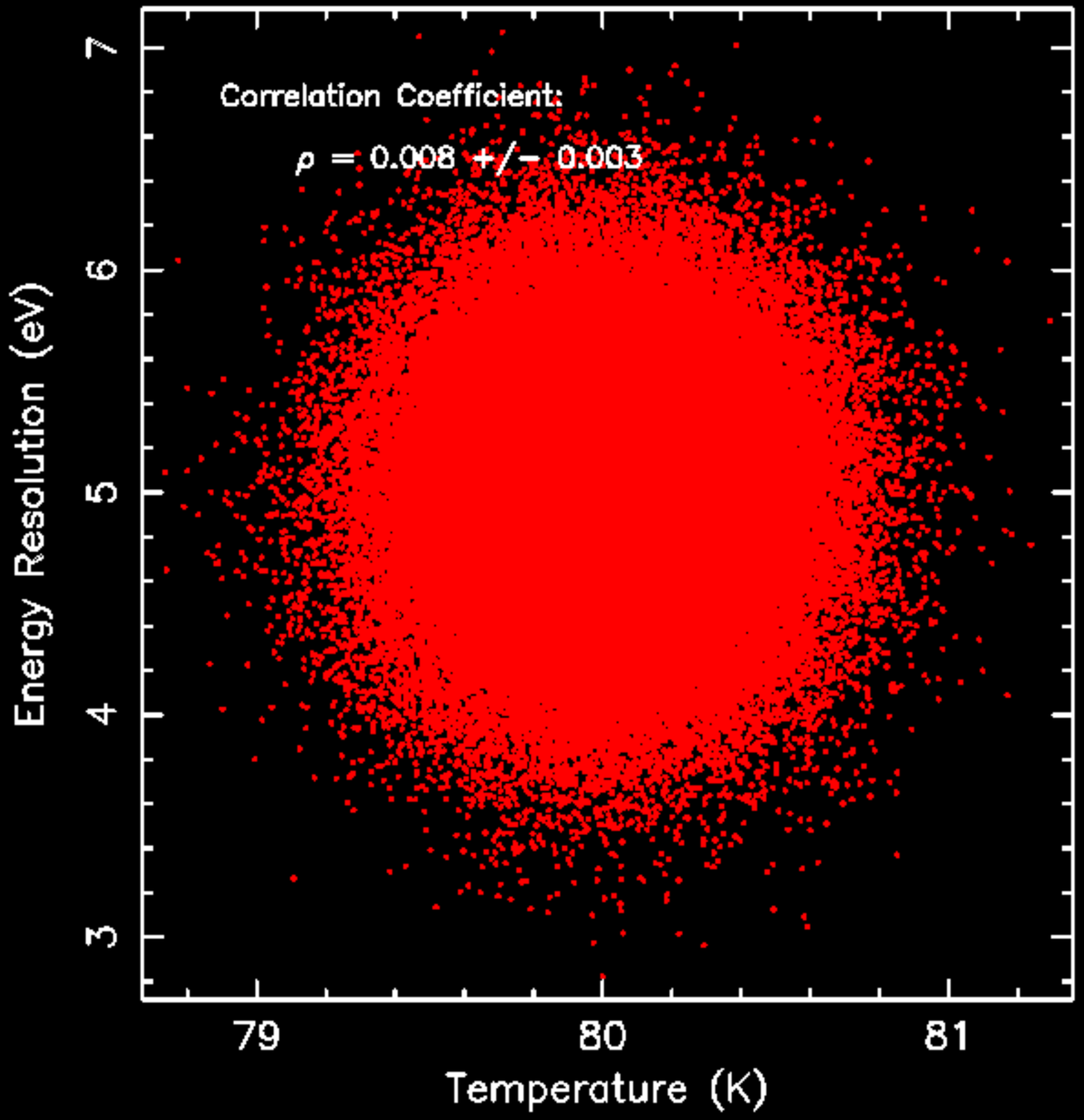

Temperature (K)
79
80
81
0
5×10^4
10^5
Time (s)

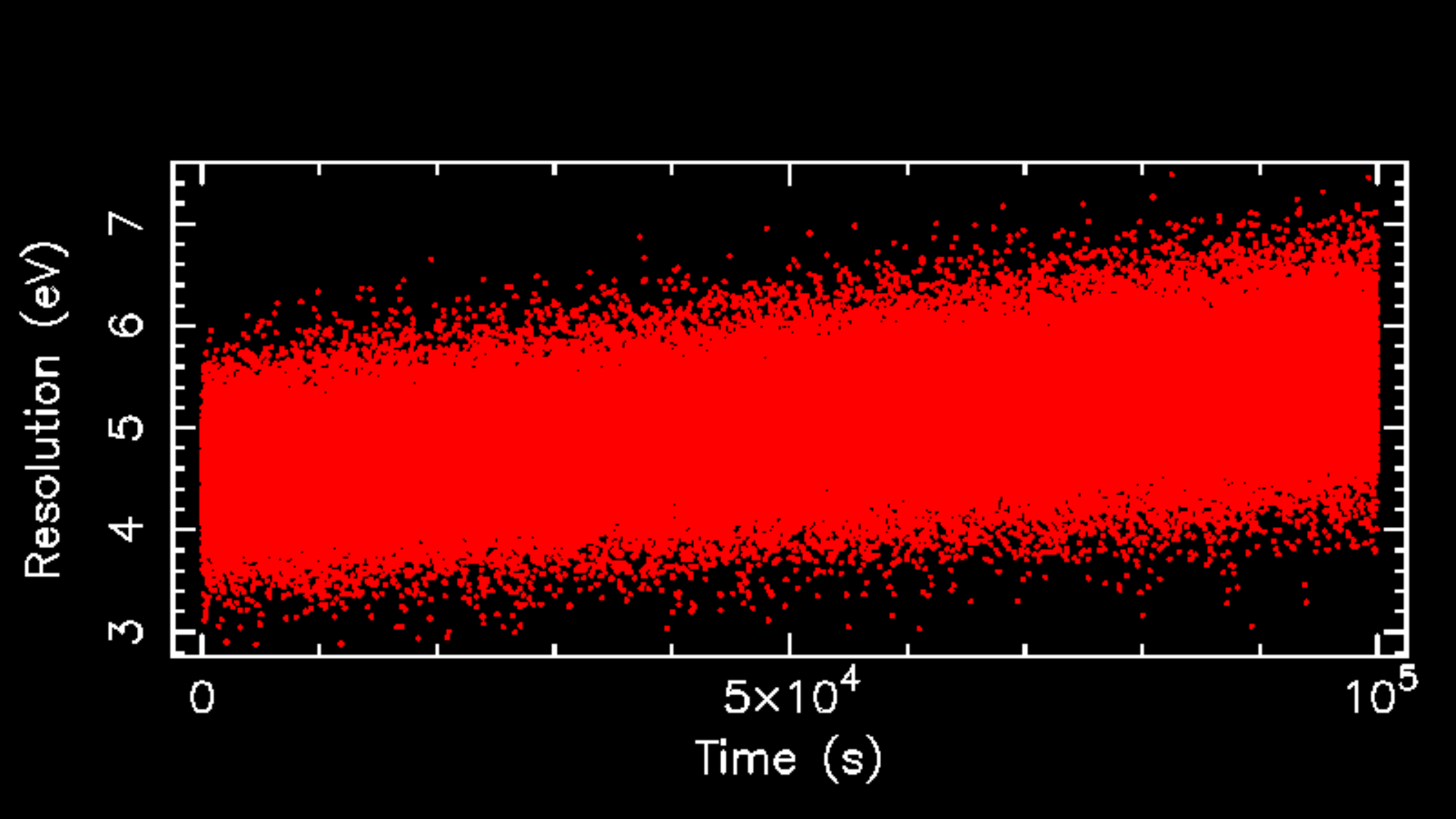

Entries = 100000
Mean = 8.00E01
RMS = 3.01E-01
Entries per bin
0
1000
2000
78
79
80
81
82
Temperature (K)

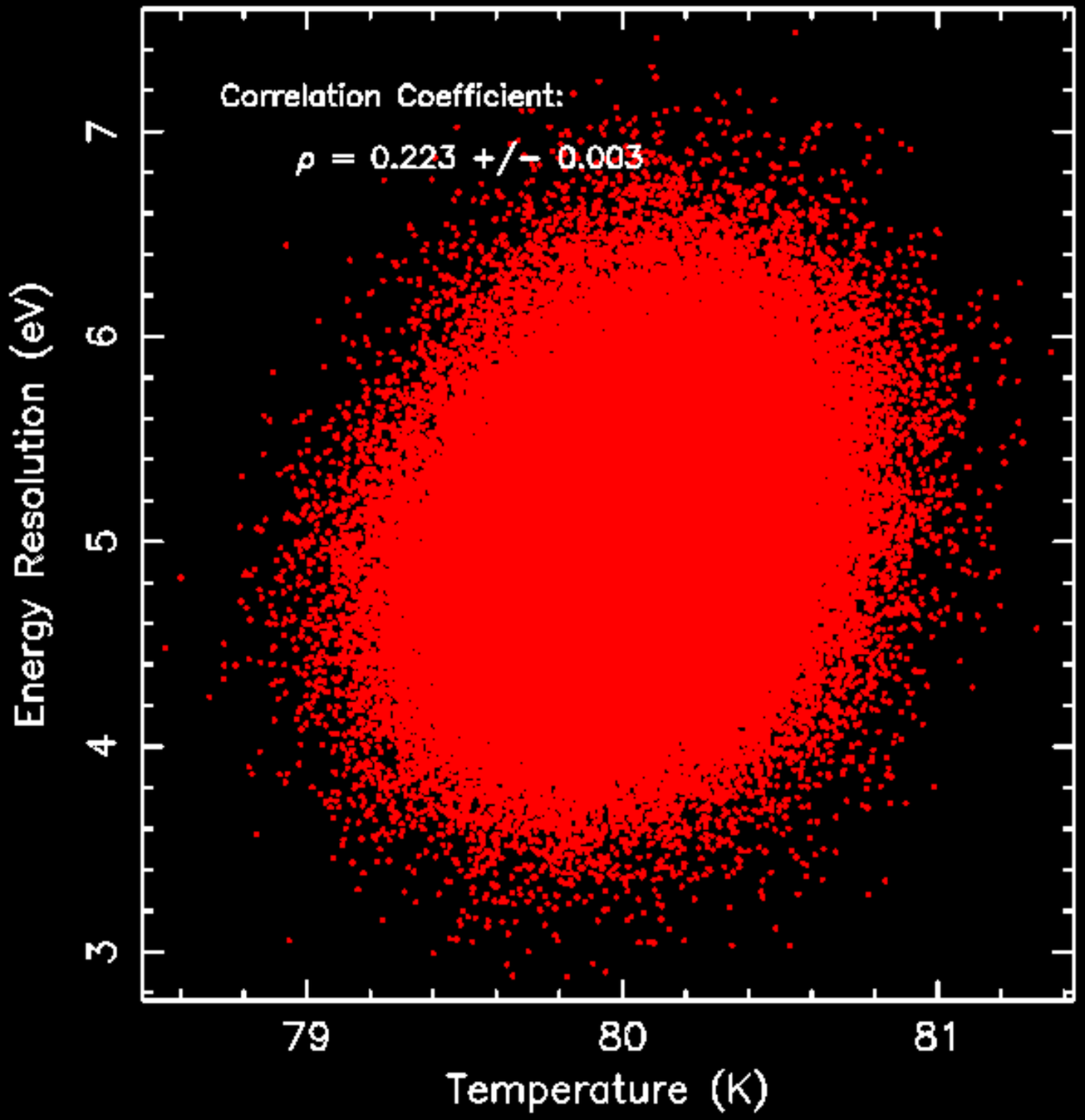

Entries = 100000
Mean = 8.00E01
RMS = 3.34E-01
Entries per bin
0
1000
2000
78
79
80
81
82
Temperature (K)

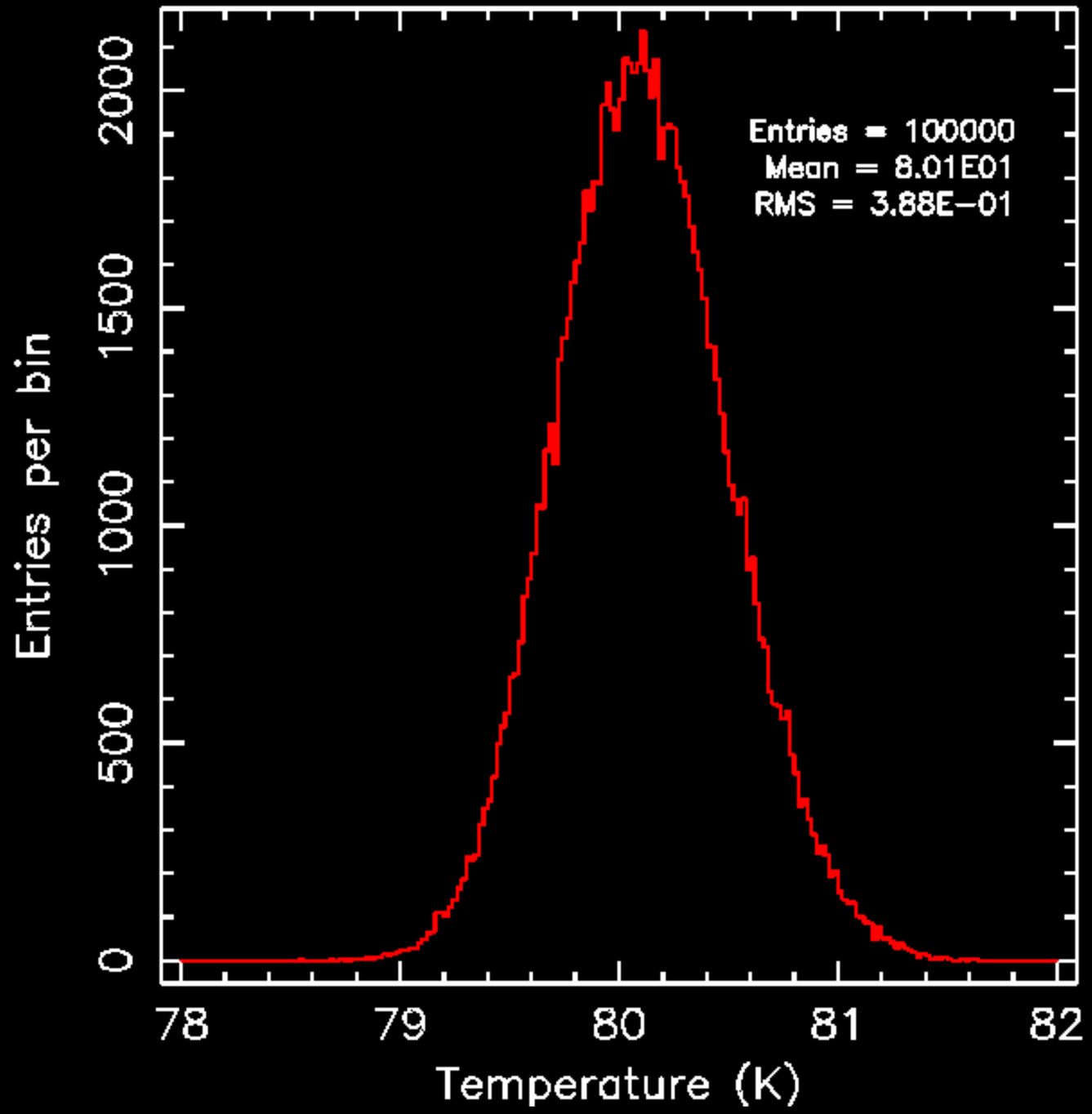

Temperature (K)
79
80
81
0
5×10^4
10^5
Time (s)

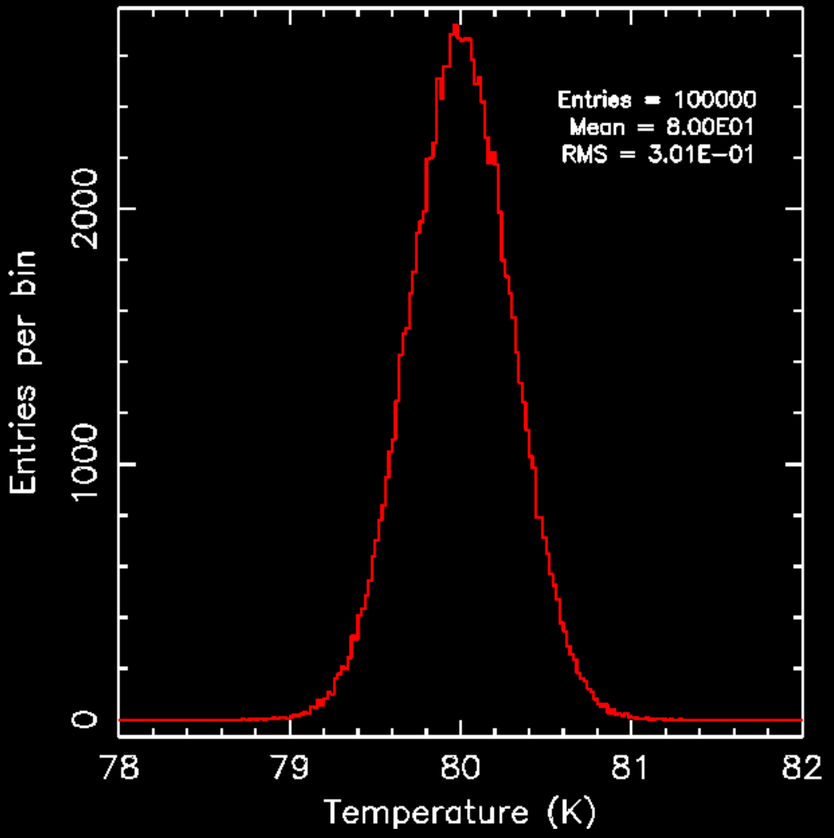

Resolution (eV)
3
4
5
6
7
0
5×10^4
10^5
Time (s)

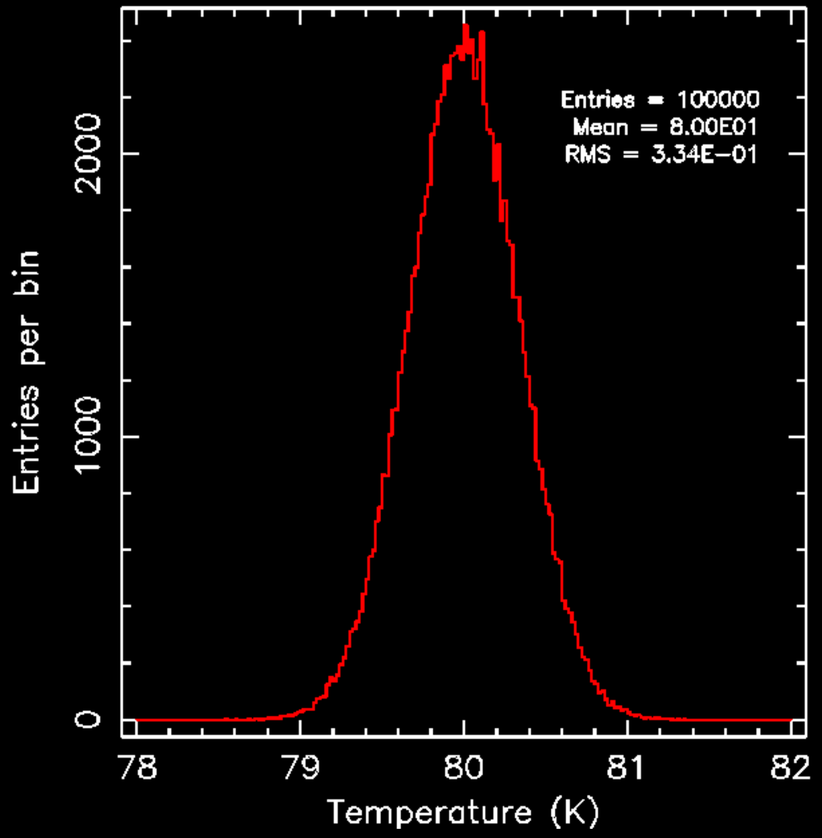

Correlation Coefficient:
ρ = 0.008 +/- 0.003
Energy Resolution (eV)
7
6
5
4
3
79
80
81
Temperature (K)

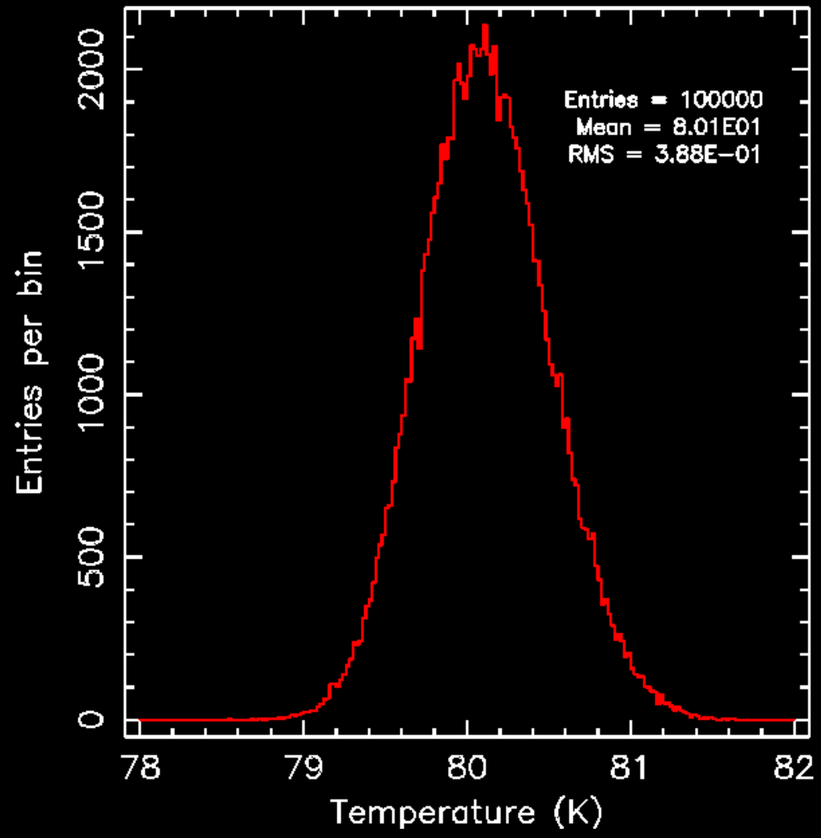

Resolution (eV)
3
4
5
6
7
0
5×10^4
10^5
Time (s)

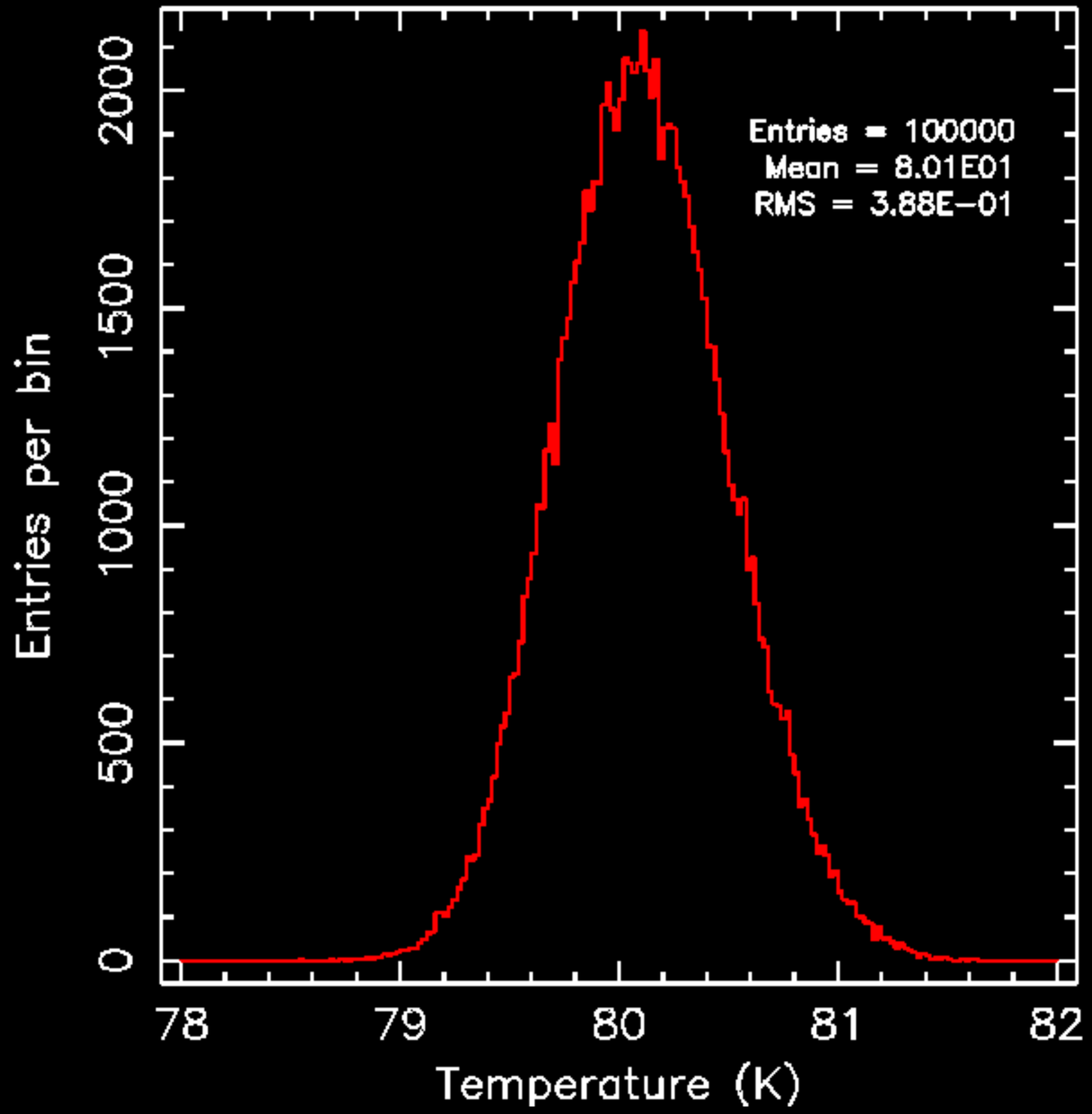

Correlation Coefficient:
ρ = 0.223 +/- 0.003
Energy Resolution (eV)
3
4
5
6
7
79
80
81
Temperature (K)

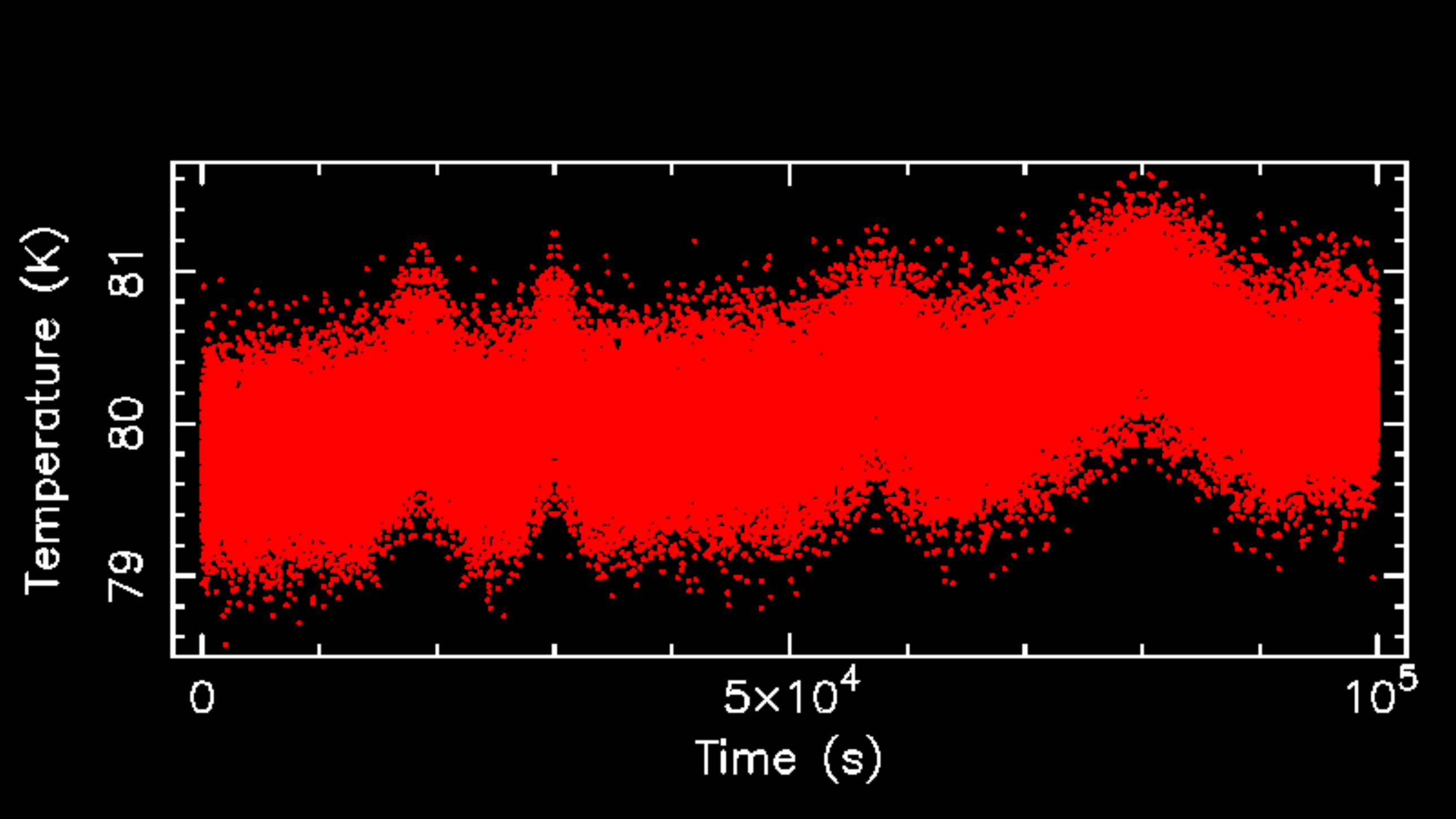

Entries = 100000
Mean = 8.01E01
RMS = 3.88E-01
Entries per bin
0
500
1000
1500
2000
78
79
80
81
82
Temperature (K)


Entries = 100000
Mean = 8.00E01
RMS = 3.01E-01
Entries per bin
0
1000
2000
78
79
80
81
82
Temperature (K)

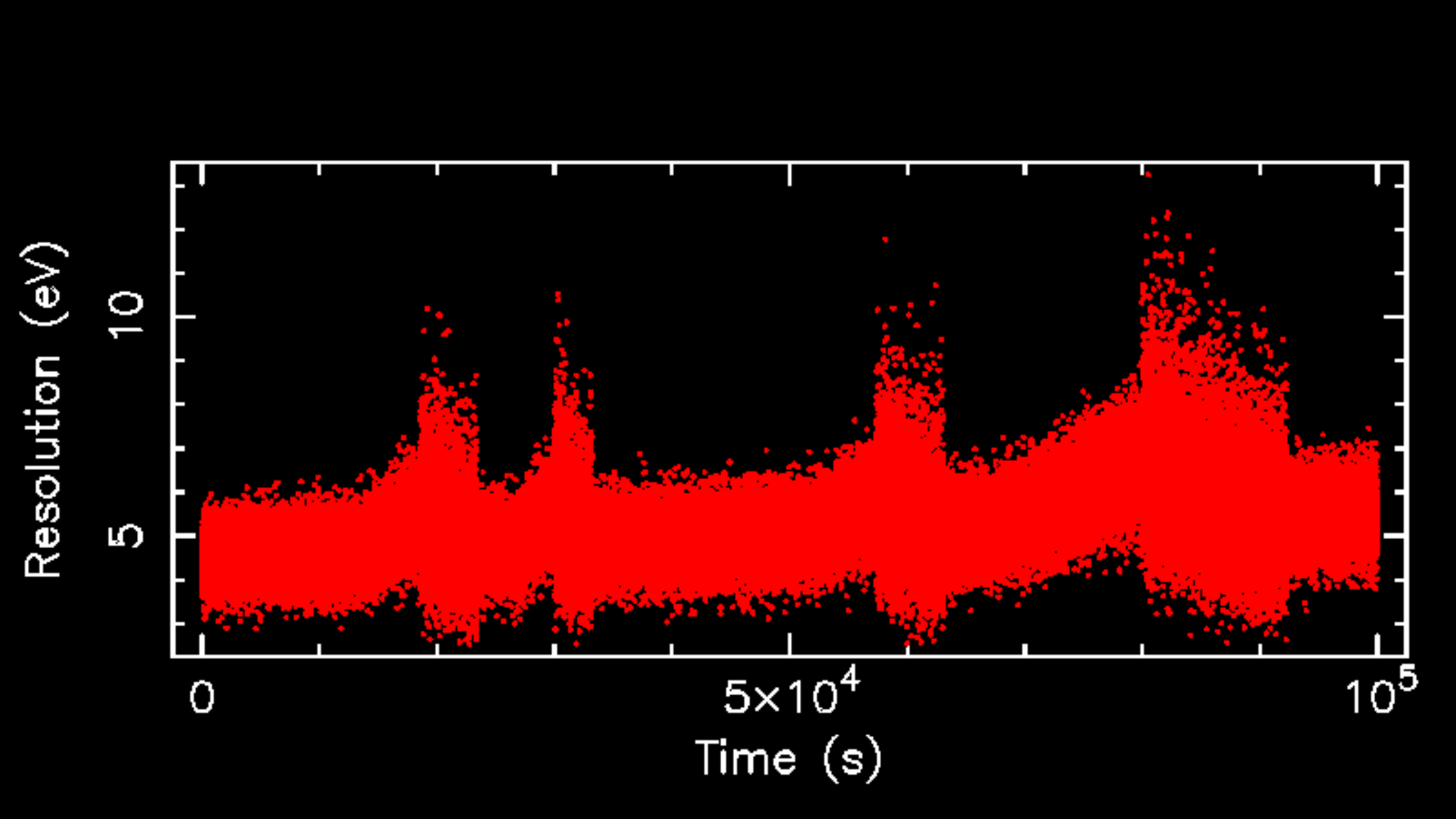

Entries = 100000
Mean = 8.00E01
RMS = 3.34E-01
Entries per bin
0
1000
2000
78
79
80
81
82
Temperature (K)

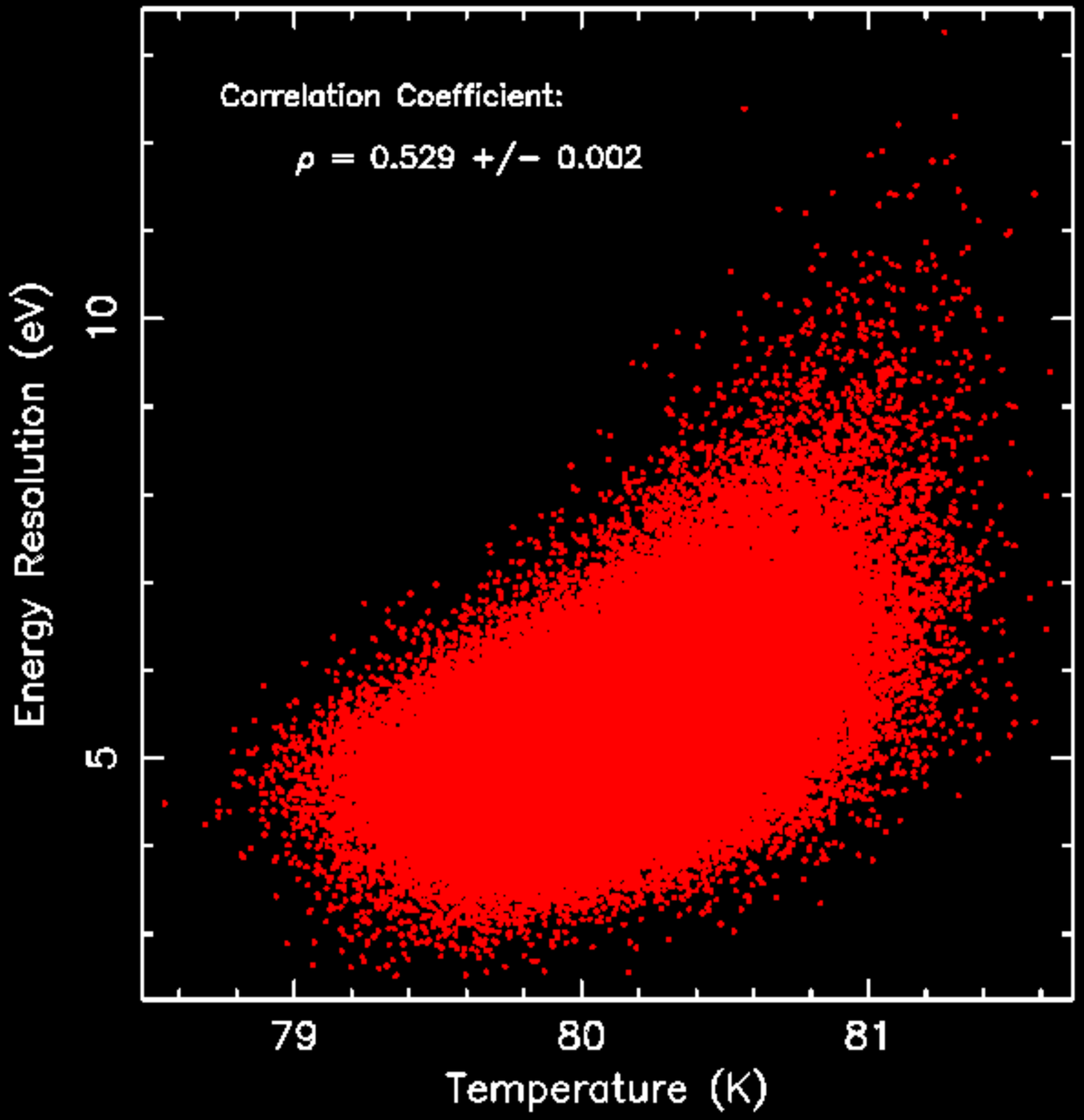

Entries = 100000
Mean = 8.01E01
RMS = 3.88E-01
Entries per bin
0
500
1000
1500
2000
78
79
80
81
82
Temperature (K)


Entries = 100000
Mean = 8.01E01
RMS = 3.88E-01
Entries per bin
0
500
1000
1500
2000
78
79
80
81
82
Temperature (K)


Temperature (K)
79
80
81
0
5×10^4
10^5
Time (s)

delta(res) = Math.exp(0.4*delta(T))

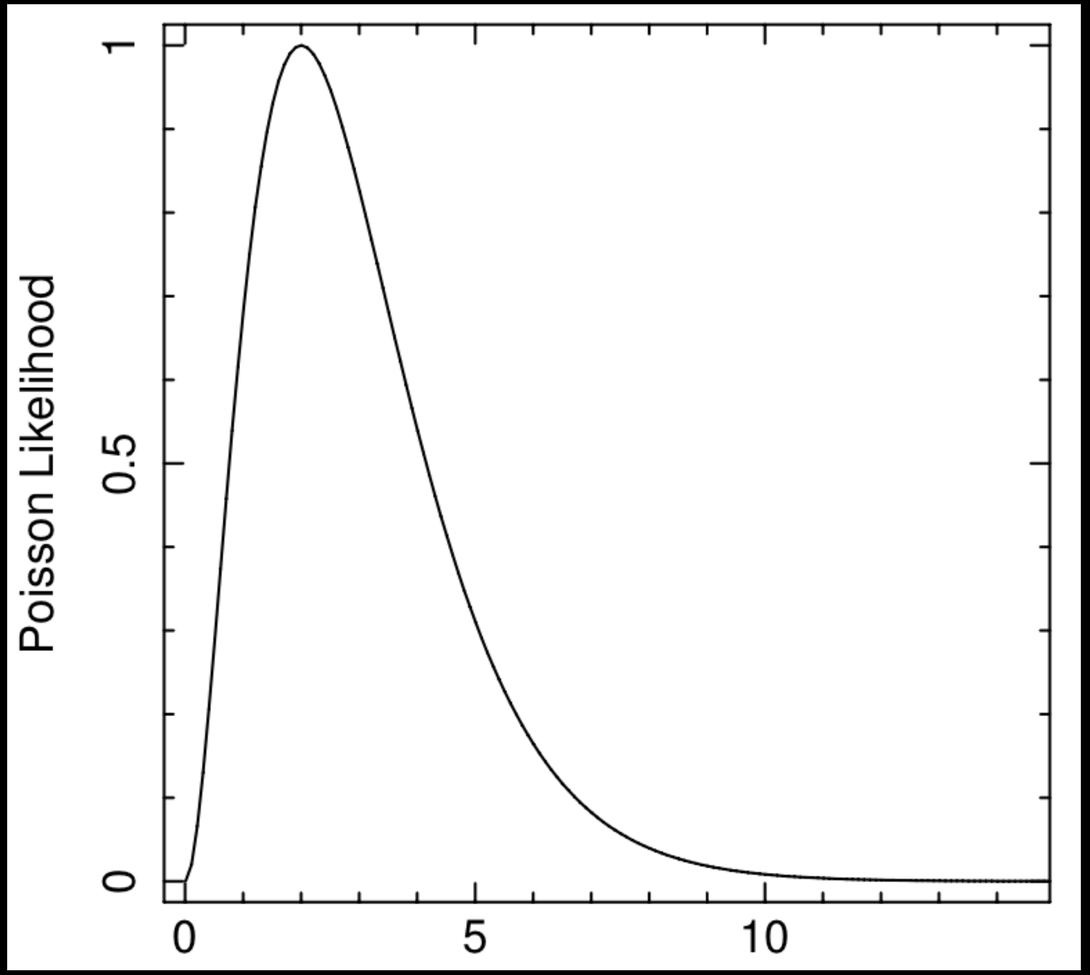

Resolution (eV)
5
10
0
5×10^4
10^5
Time (s)


Correlation Coefficient:
ρ = 0.529 +/− 0.002
Energy Resolution (eV)
5
10
79
80
81
Temperature (K)

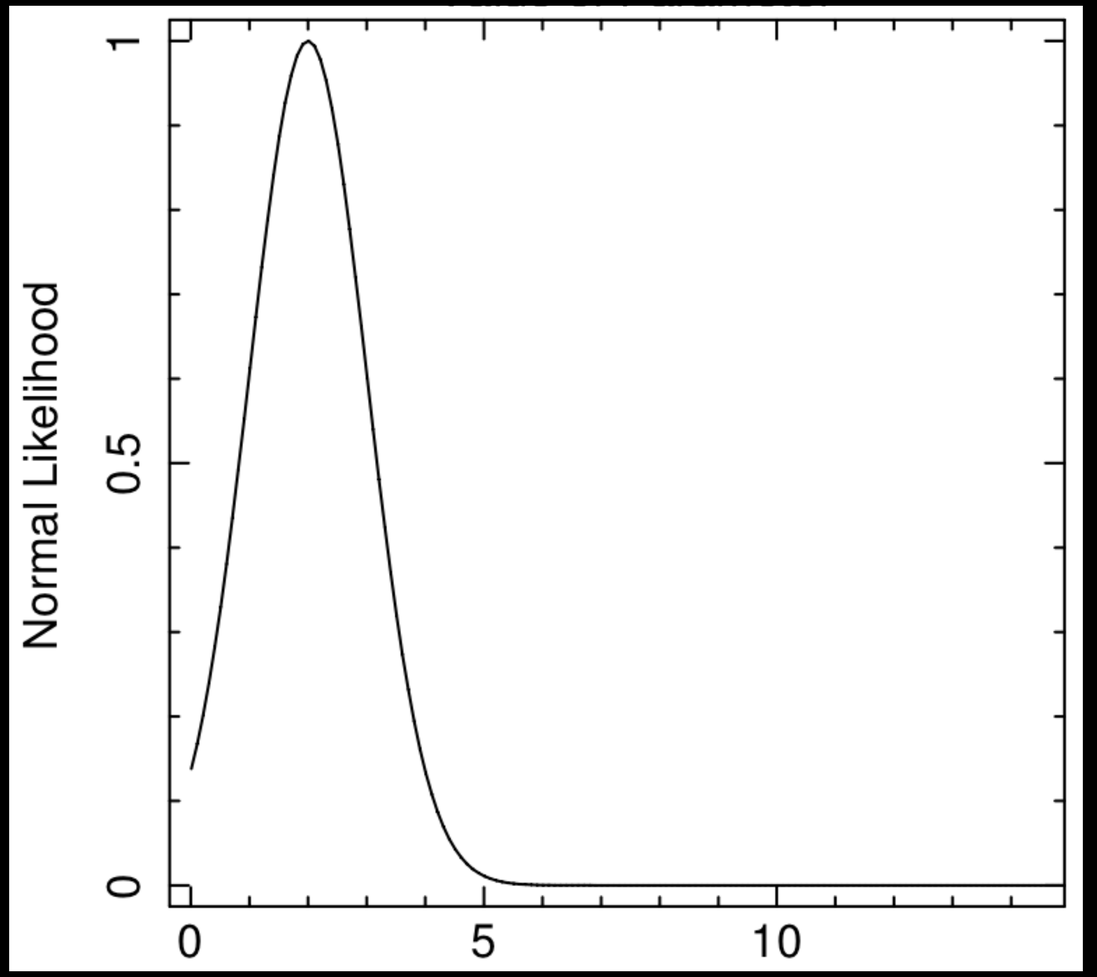
Is Machine Learning about recognizing cats and dogs?

Machine Learning
is maths and
Stats

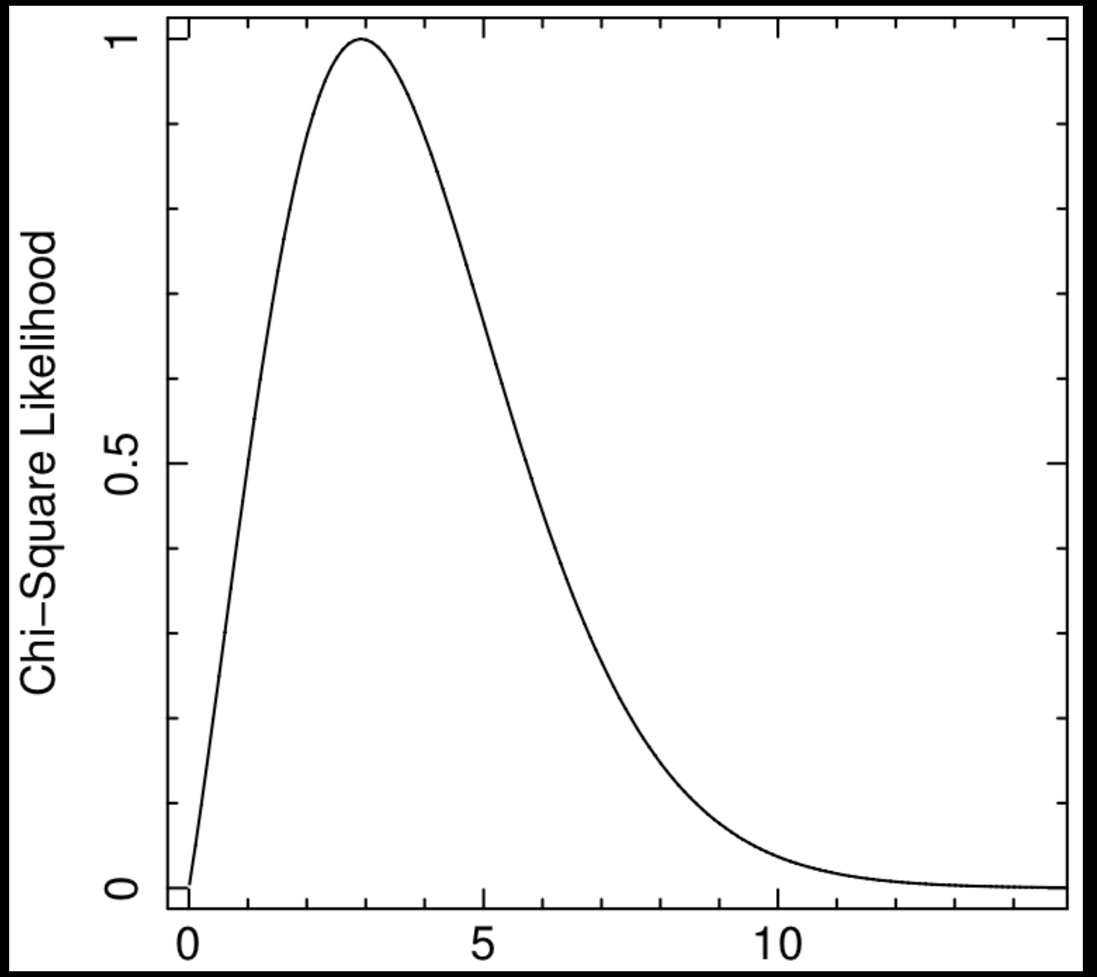
$$L(\boldsymbol{\nu}|\boldsymbol{n}) = \prod_i \frac{{\nu_i}^{n_i} e^{-\nu_i}}{n_i!}$$



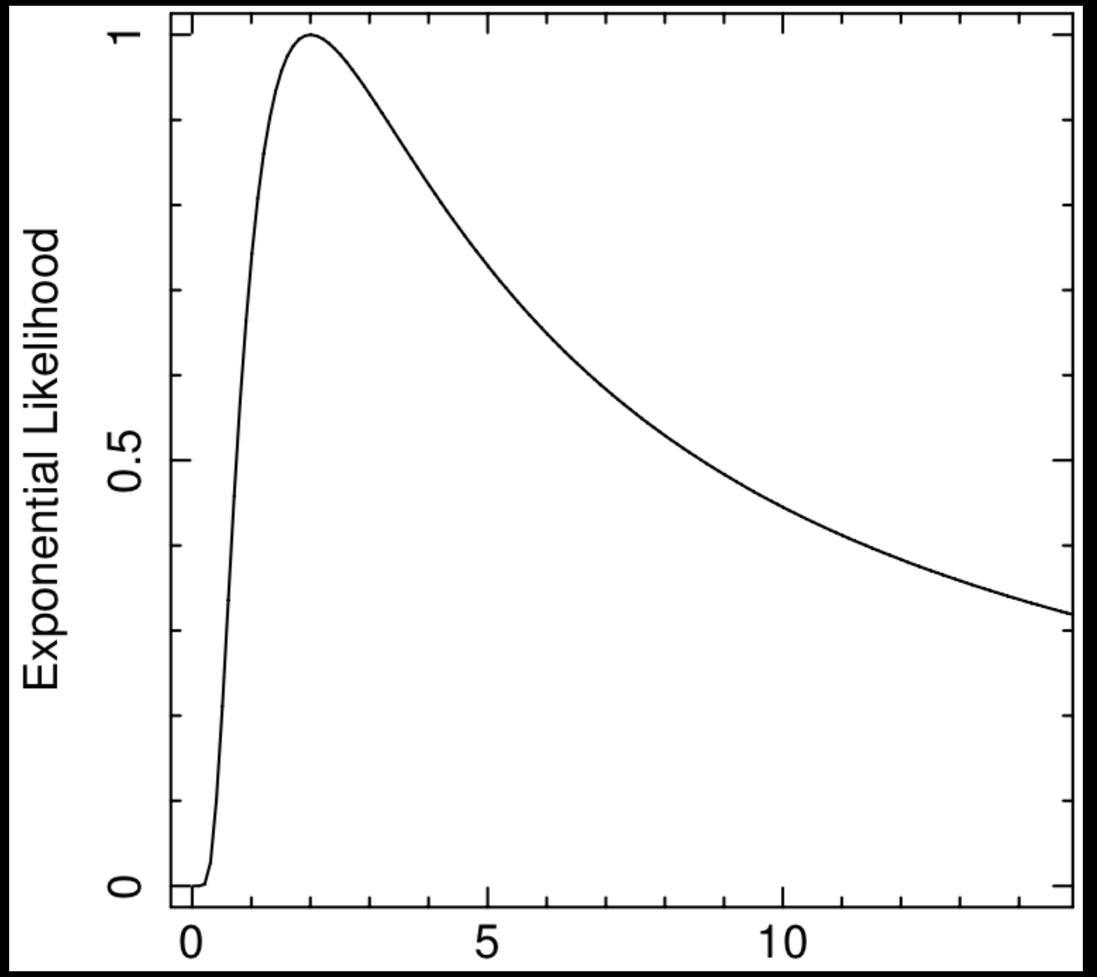
$$L(\boldsymbol{\mu}, \boldsymbol{\sigma} | \boldsymbol{x}) = \prod_i \frac{1}{\sqrt{2\pi\sigma_i^2}} e^{-(x_i - \mu_i)^2 / 2\sigma_i^2}$$



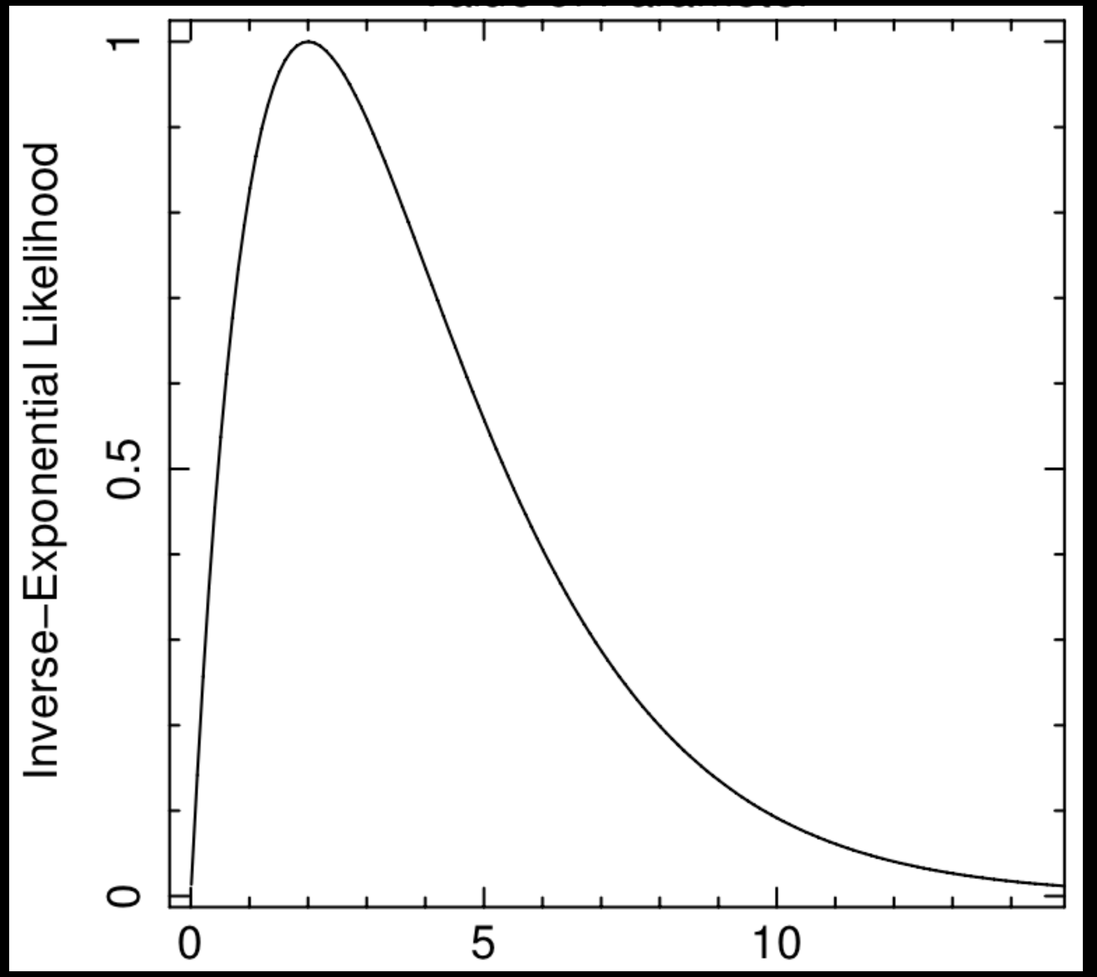
$$L(\boldsymbol{k}|\boldsymbol{x}) = \prod_i \frac{1}{2^{k_i/2}\Gamma(k_i/2)} x_i^{k_i/2-1} e^{-x_i/2}$$



$$L(\boldsymbol{\tau}) = \prod_i \frac{1}{\tau_i} e^{-x_i/\tau_i}$$



$$L(\boldsymbol{t}) = \prod_i \frac{t_i}{x_i{}^2} e^{-t_i / x_i}$$

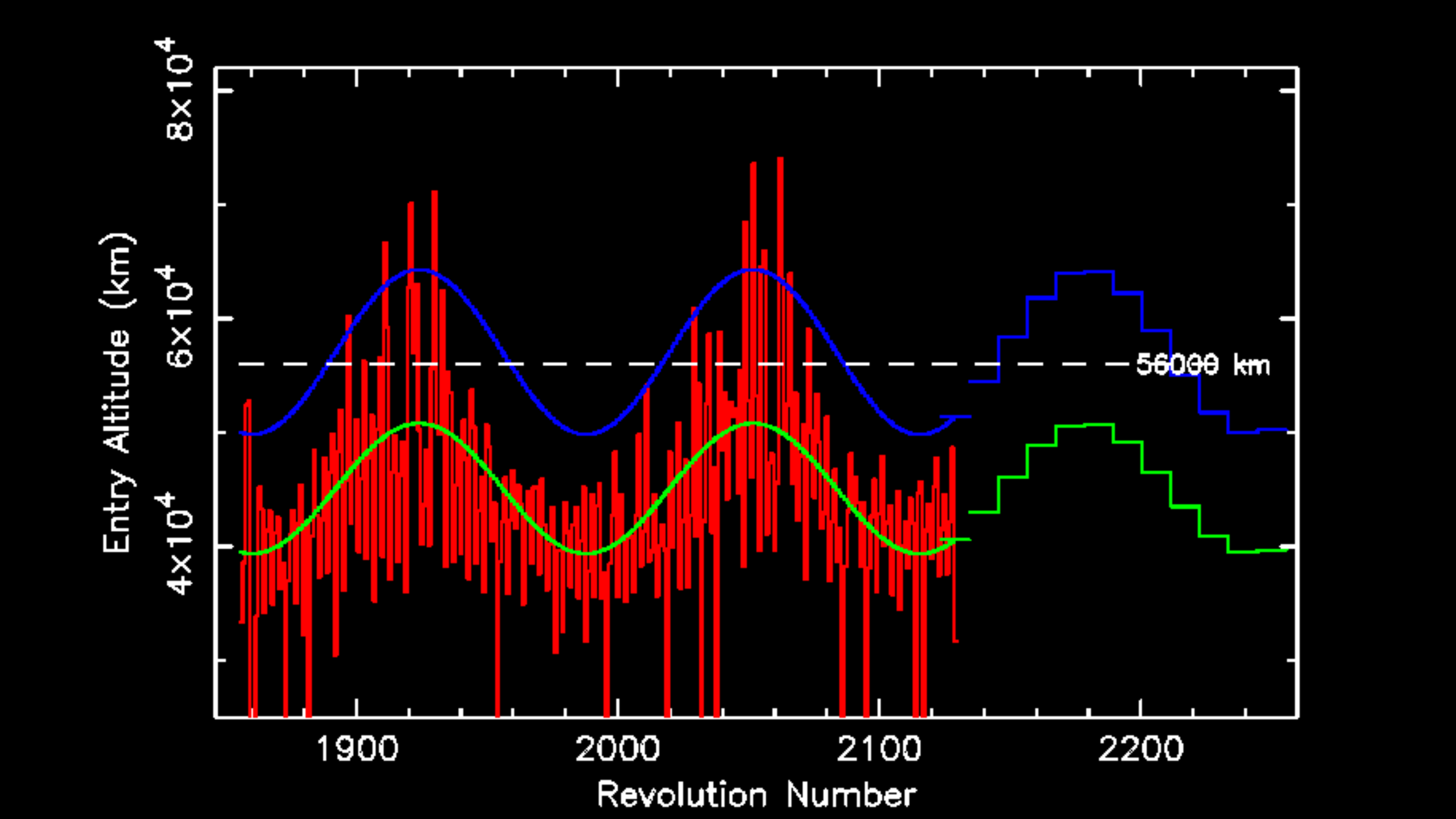


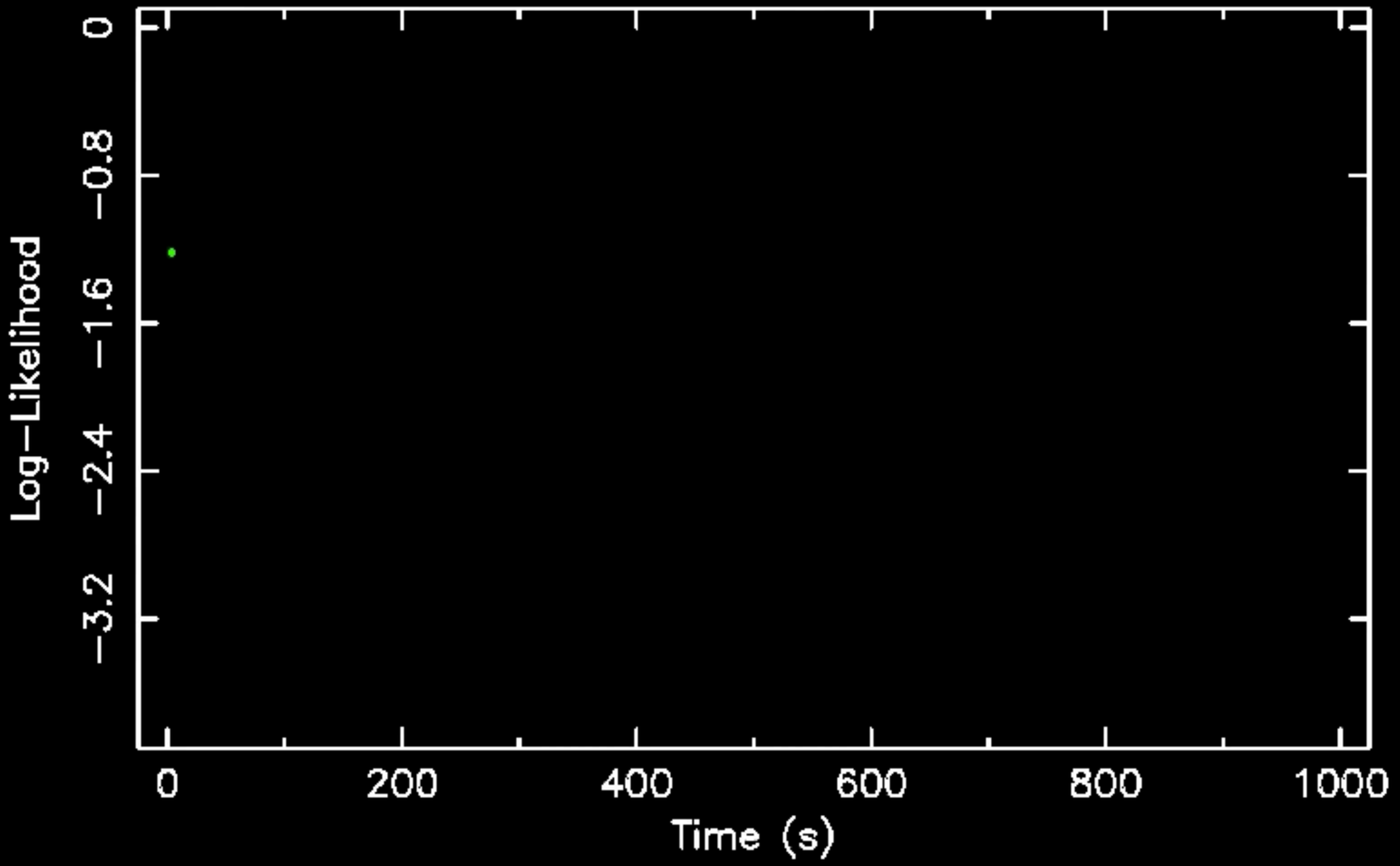
Machine Learning
is actually
Statistical Learning

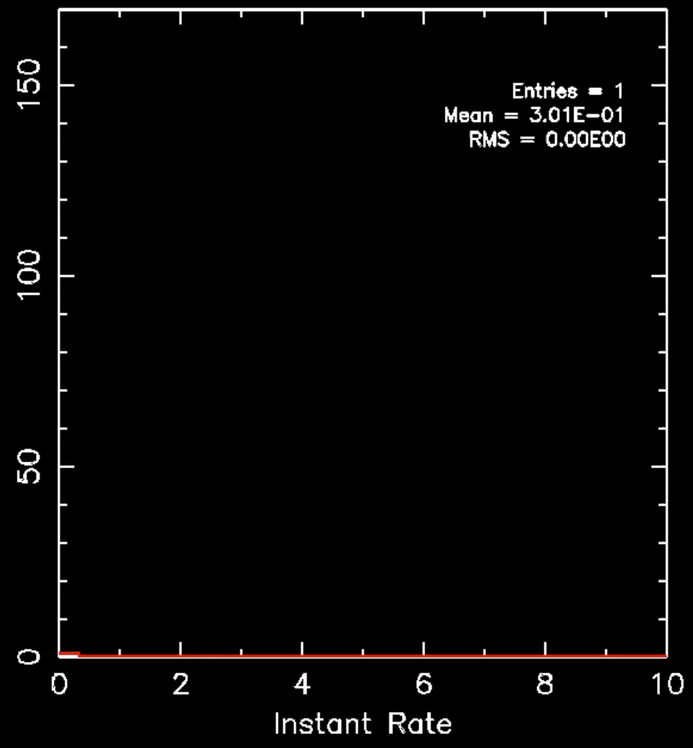
Statistical Learning
relies on
Inference

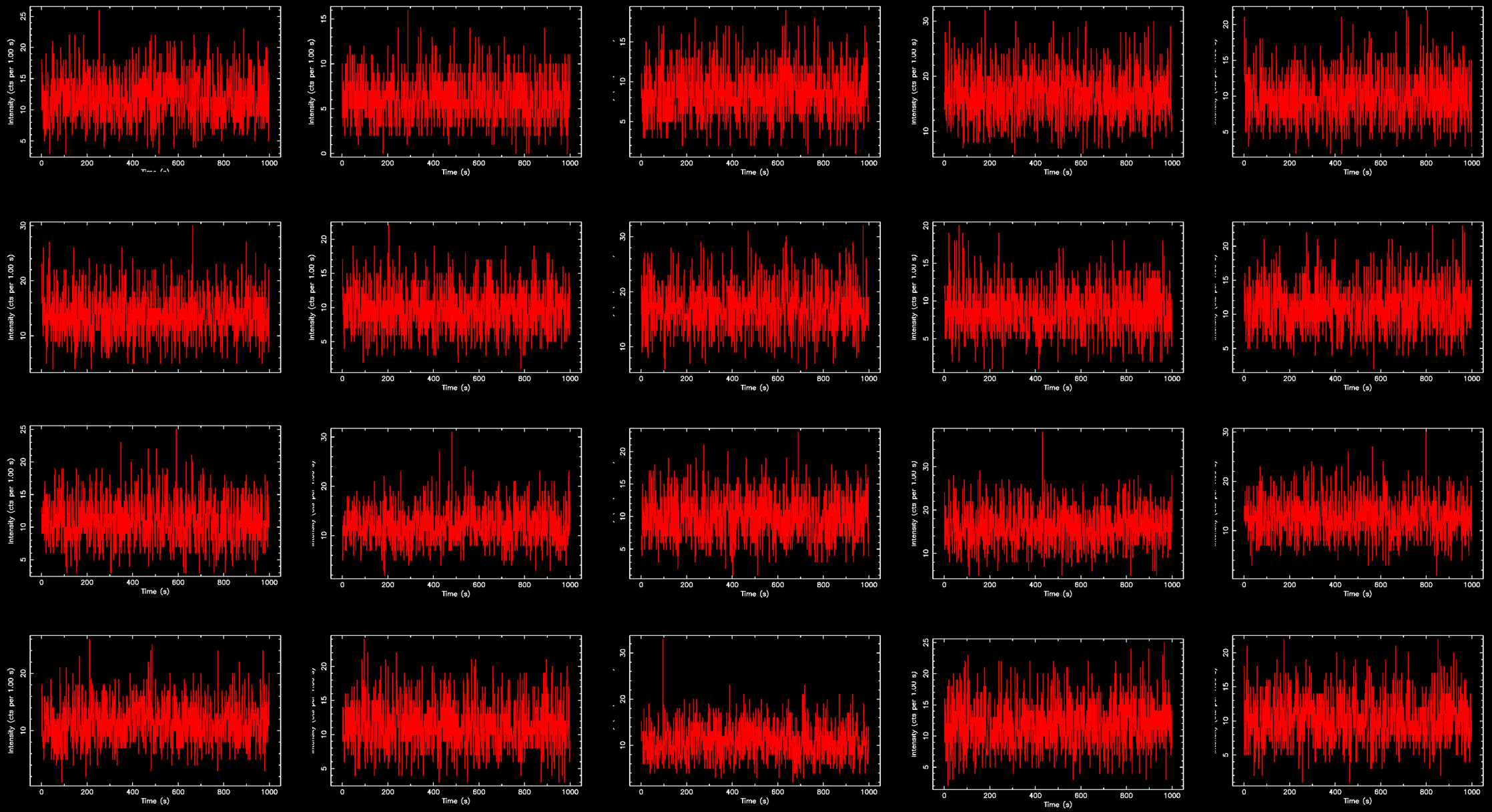
Inference
really means
Bayesian Analysis

Best guess = Prior x Likelihood


Entry Altitude (km)
8x10^4
6x10^4
4x10^4
56000 km
1900
2000
2100
2200
Revolution Number


Log-Likelihood
0
−0.8
−1.6
−2.4
−3.2
0
200
400
600
800
1000
Time (s)


Entries = 1
Mean = 3.01E−01
RMS = 0.00E00
150
100
50
0
0
2
4
6
8
10
Instant Rate


Intensity (cts per 1.00 s)
Time (s)

Takeaways

- Machine Learning is about maths, statistics, and inference.
- There is a lot more to do besides clustering and classification.
- There are literally millions of parameters that need to be monitored.
- We can do a lot better than simple alarms on out-of-range values.
- The potential for Statistical Machine Learning in SciOps is massive.