7/23 Meeting

Christina

Three Global Methods

1. Monte Carlo (what we are currently using)
2. Differential Evolution
3. Basinhopping (a markov chain Monte Carlo method)

Monte Carlo

Advantage: takes little time (although it becomes significant when the data set becomes huge)

Disadvantage: not robust to noise

Differential Evolution

The algorithm randomly selects n points (population) from the 6D space (with user-defined range), then recombines the points and updates the points' new positions until there is only one point with the lowest chi^2 value left (or that the number of iteration exceeds the limit)

Advantage: very robust to noise; large rate of convergence when the population size is large

Disadvantage: Takes a significantly longer time (>30 seconds per event)

Basinhopping

Given a starting point (initial condition), the algorithm calculates the local minimum of chi^2 value using a user-defined local method, then applies a random perturbation to the coordinates. The new position is accepted /rejected based on the Metropolis criteria. The point with the lowest chi^2 value is updated as the newest global minimum

Advantage: less time than Differential Evolution but gives comparable results

Disadvantage: not robust to noise

Event 504

Data with noise

Monte-Carlo: 90.04

Conjugate Gradient: 101.06

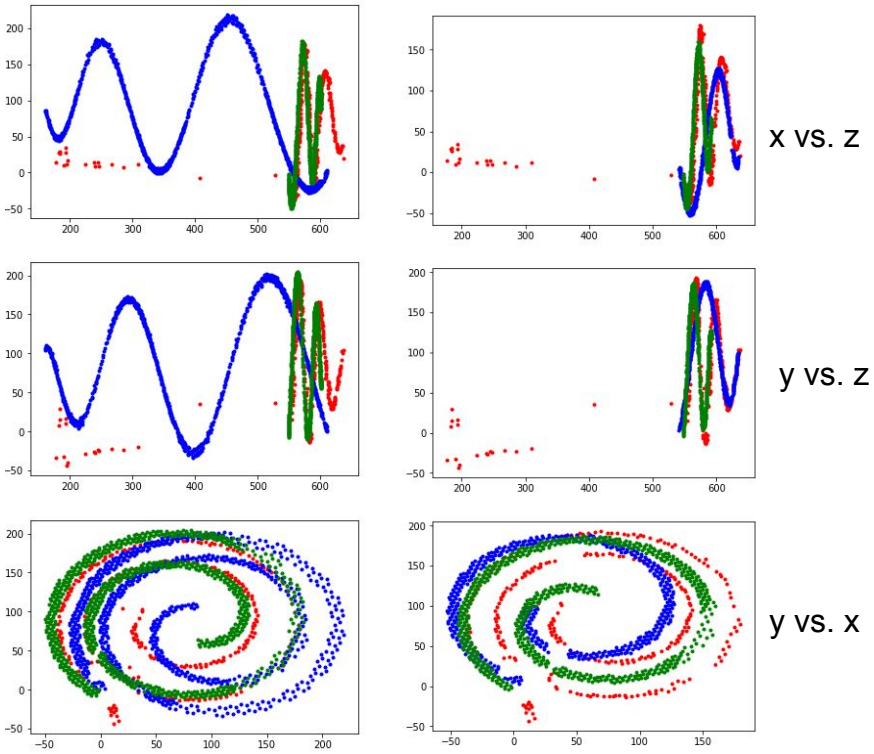
Differential Evolution: 68.06

Data with reduced noise

Monte-Carlo: 45.0

Conjugate Gradient: 93.57

Differential Evolution: 57.61



Red: real data (with noise)
Blue: fittings of data with noise
Green: fitting of data without noise

Event 765

Data with noise

Monte-Carlo: 100.05

Conjugate Gradient: 106.98

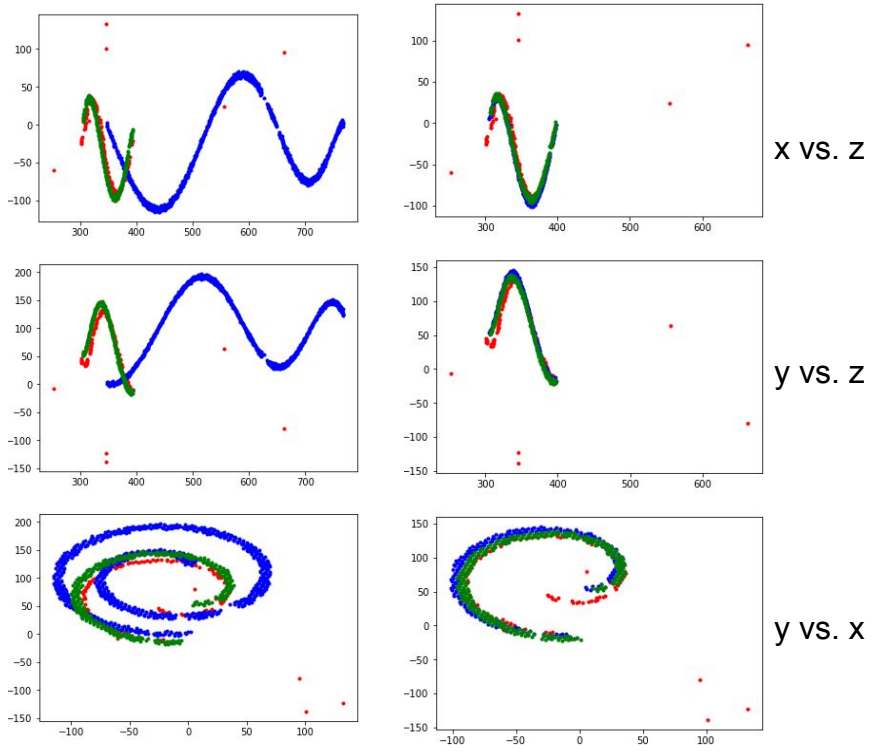
Differential Evolution: 35.45

Data with reduced noise

Monte-Carlo: 33.53

Conjugate Gradient: 65.87

Differential Evolution: 34.27



Red: real data (with noise)
Blue: fittings of data with noise
Green: fitting of data without noise

Monte Carlo

```
average time: 0.48798972368240356 seconds
average chi2 value (with noise): 61.584411066315134
average chi2 value (without noise): 31.393359085475915
```

Differential Evolution

```
average time: 33.156591317483354 seconds
average chi2 value (with noise): 42.02732836605447
average chi2 value (without noise): 42.00646858265847
```

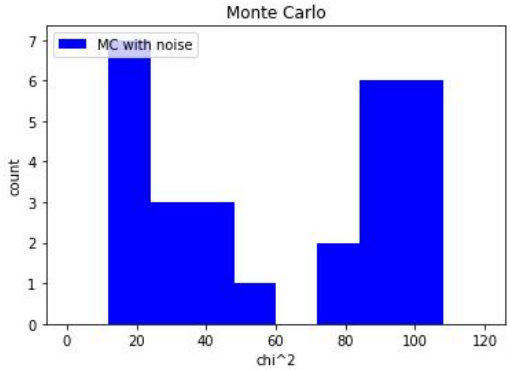
Basinhopping
niter = 10

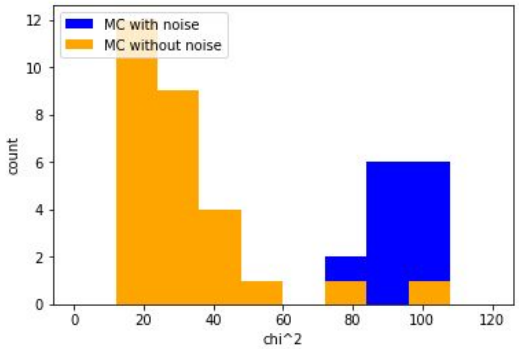
```
average time for Nelder-Mead: 7.100889333656856 seconds
chi2 value (with noise) for Nelder-Mead: 56.602099562368004
chi2 value (without noise) for Nelder-Mead: 36.739391372534904
average time for Powell: 15.809054085186549 seconds
chi2 value (with noise) for Powell: 72.39768213081769
chi2 value (without noise) for Powell: 48.439384824847956
average time for CG: 5.473999002150127 seconds
chi2 value (with noise) for CG: 85.06981919655972
chi2 value (without noise) for CG: 68.7291566328876
average time for BFGS: 6.69640759059361 seconds
chi2 value (with noise) for BFGS: 71.78550302526396
chi2 value (without noise) for BFGS: 57.42162601972965
average time for L-BFGS-B: 5.841121426650456 seconds
chi2 value (with noise) for L-BFGS-B: 81.43751391791639
chi2 value (without noise) for L-BFGS-B: 66.45097907673568
average time for TNC: 6.563905213560377 seconds
chi2 value (with noise) for TNC: 74.96609741576006
chi2 value (without noise) for TNC: 58.198438073015446
average time for COBYLA: 1.666680829865592 seconds
chi2 value (with noise) for COBYLA: 78.49874464606329
chi2 value (without noise) for COBYLA: 66.19309393961564
average time for SLSQP: 2.873416449342455 seconds
chi2 value (with noise) for SLSQP: 62.756947144902846
chi2 value (without noise) for SLSQP: 37.88723205549305
```

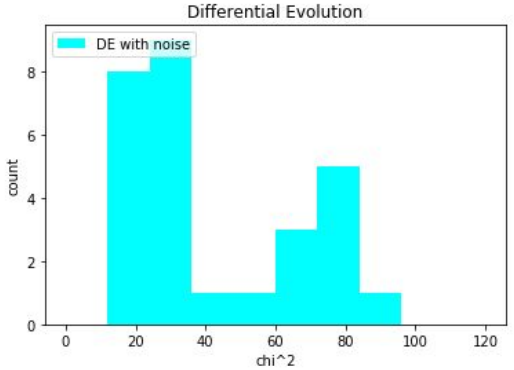
Basinhopping
niter = 25

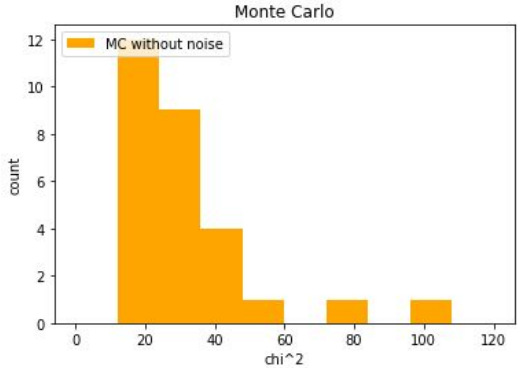
```
average time for Nelder-Mead: 20.268136343785695 seconds
chi2 value (with noise) for Nelder-Mead: 49.02851080971168
chi2 value (without noise) for Nelder-Mead: 30.06558285392754
average time for Powell: 36.70845403841564 seconds
chi2 value (with noise) for Powell: 59.04416700450565
chi2 value (without noise) for Powell: 47.49919979627662
average time for BFGS: 16.16957257475172 seconds
chi2 value (with noise) for BFGS: 68.93500843710063
chi2 value (without noise) for BFGS: 46.31901726906612
average time for SLSQP: 6.993133834430149 seconds
chi2 value (with noise) for SLSQP: 63.31442266173478
chi2 value (without noise) for SLSQP: 33.89991591501348
```

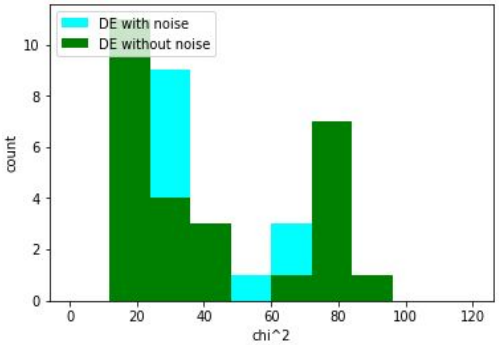
Histograms

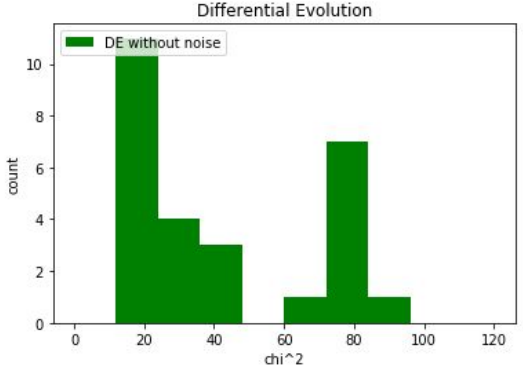

Monte Carlo
MC with noise
count
chi^2

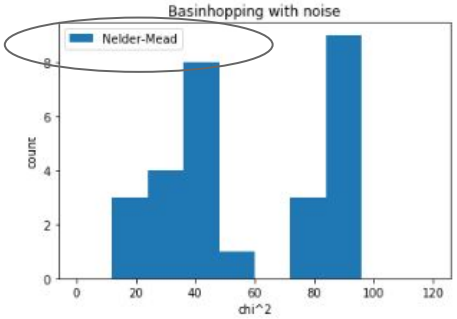

MC with noise
MC without noise
count
chi^2

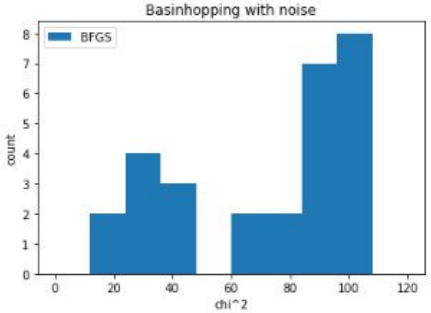

Differential Evolution
DE with noise
count
chi^2

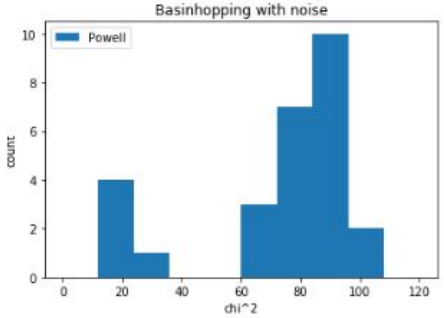

Monte Carlo
MC without noise
count
chi^2

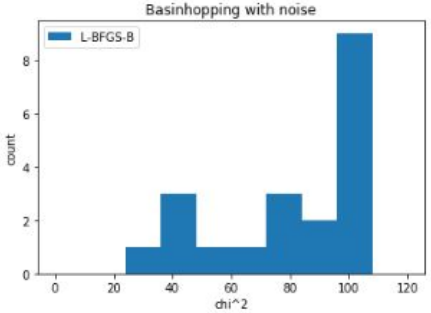

DE with noise
DE without noise
count
chi^2

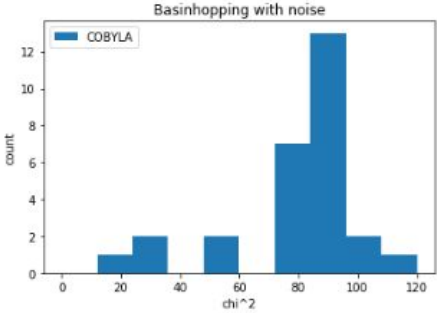

Differential Evolution
DE without noise
count
chi^2

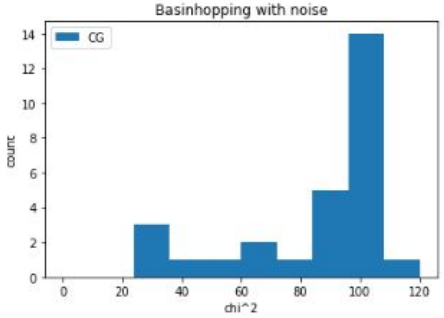

Basinhopping with noise
Nelder-Mead
count
chi^2

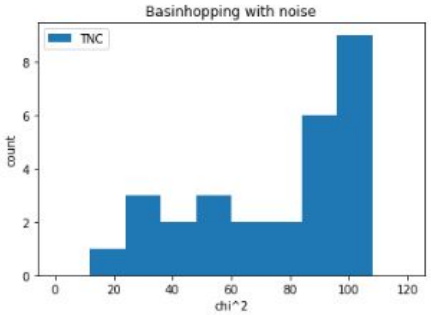

Basinhopping with noise
BFGS
count
chi^2

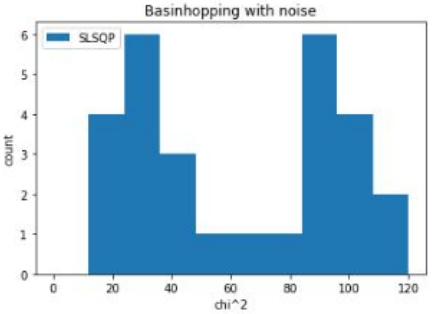

Basinhopping with noise
Powell
count
chi^2

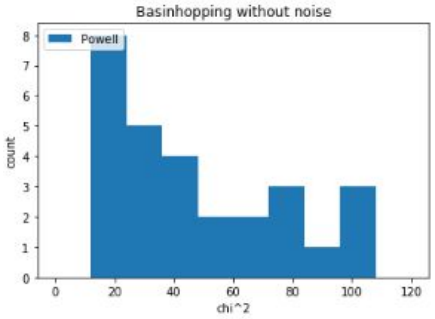

Basinhopping with noise
L-BFGS-B
count
chi^2

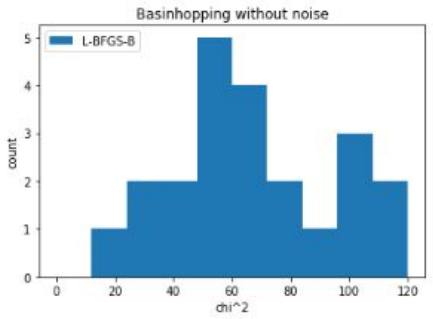

Basinhopping with noise
COBYLA
count
chi^2

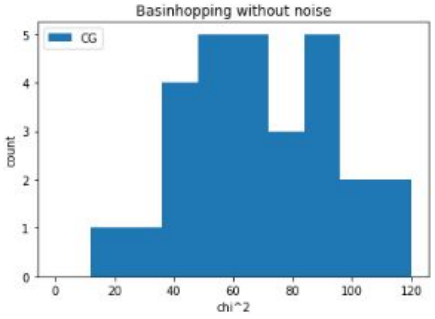

Basinhopping with noise
CG
count
chi^2

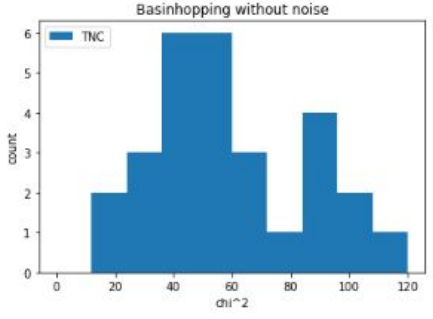

Basinhopping with noise
TNC
count
chi^2

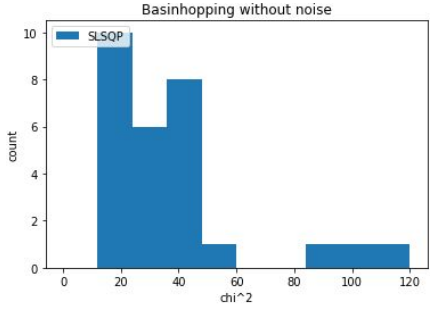

Basinhopping with noise
SLSQP
count
chi^2

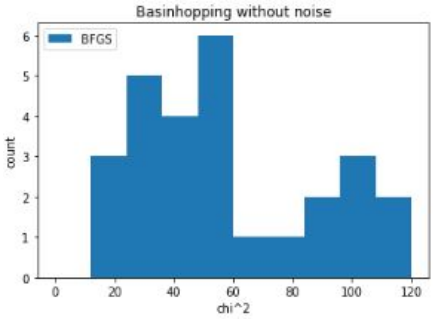

Basinhopping without noise
Powell
count
chi^2

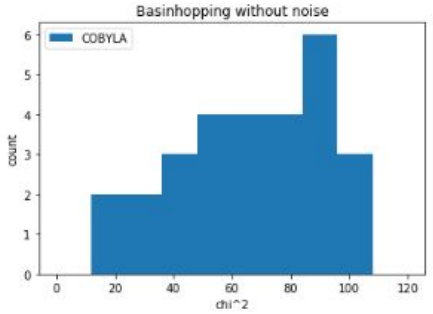

Basinhopping without noise
L-BFGS-B
count
chi^2

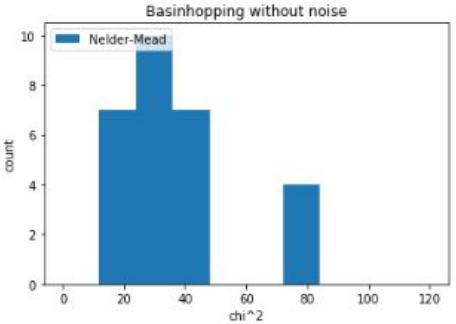

Basinhopping without noise
CG
count
chi^2

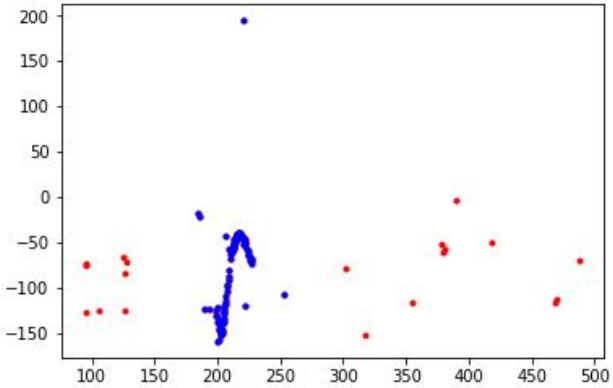

Basinhopping without noise
TNC
count
chi^2

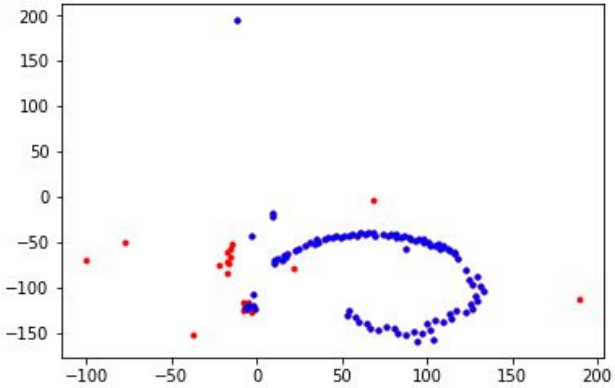

Basinhopping without noise
SLSQP
count
chi^2


Basinhopping without noise
BFGS
count
chi^2


Basinhopping without noise
COBYLA
count
chi^2

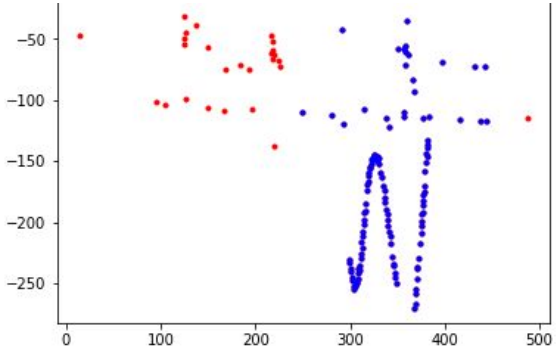

Basinhopping without noise
Nelder-Mead
count
chi^2

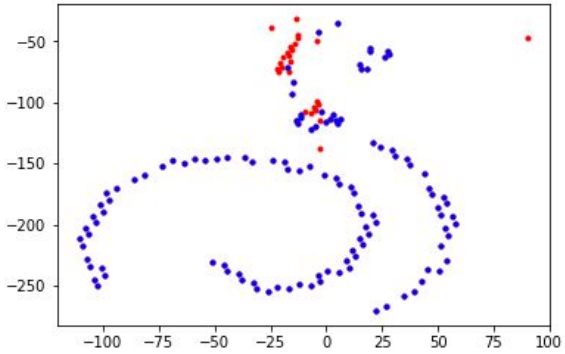




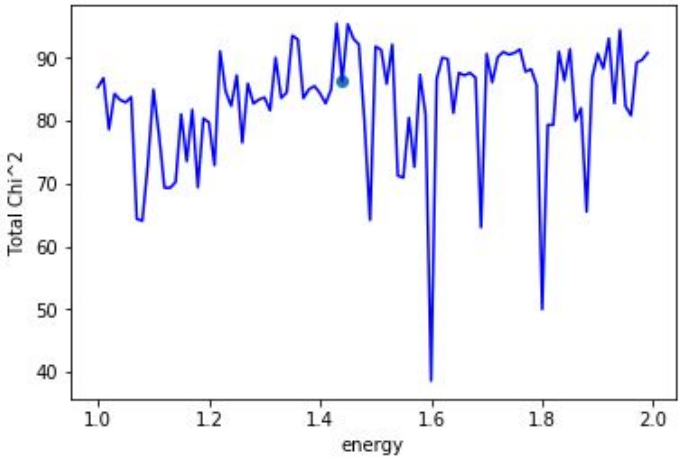
blue: after cleaning
red: before cleaning

```
Monte Carlo event 22 with noise: 3.3545570373535156 seconds
position chi2: 69.87104346161969 energy chi2: 5.03323325941875 vertex chi^2: 0.0014947120336555385 total chi2: 74.9057714
330721
Monte Carlo event 22 without noise: 0.004172086715698242 seconds
position chi2: 12.335112557278215 energy chi2: 9.976280991366055 vertex chi^2: 2.356934868932885 total chi2: 24.668328417
577154
```

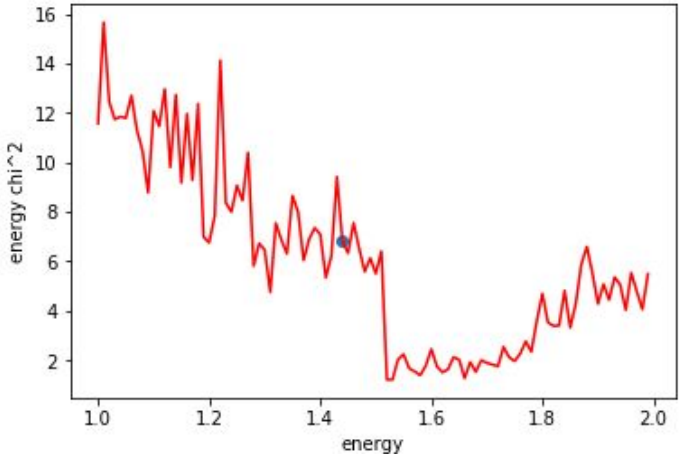




Monte Carlo event 4 with noise: 1.2983119487762451 seconds
position chi2: 92.90023920547613 energy chi2: 6.472256835315422 vertex chi^2: 0.004010717299439259 total chi2: 99.3765067
5809098
Monte Carlo event 4 without noise: 0.00415492057800293 seconds
position chi2: 20.784715524144897 energy chi2: 10.00076390117045 vertex chi^2: 1.7830718470284022 total chi2: 32.56855127
234375




```
Text(0,0.5,'energy chi^2')
```



The energy chi^2 only counts towards a small part of the total chi^2 value.