IXPE-tools

Release 0.0.1

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CONTENTS

A very useful toolbox for your IXPE data analysis. This package is designed to handle IXPE polarization data and spectroscopy. We provide tools to easily utilize Xspec and provide a package to display the results.

Installation

Navigation

Download the whole repository to your local directory using `git clone` or `git fetch`.

For example, In you local path execute:

```
git clone https://github.com/tuoyl/IXPE-tools.git
```

And you will get the folder `IXPE-tools`, in the folder you will see a file named `setup.py`. We will install the whole package based on this script.

The most elegant thing to do before installing is to create a new conda environment to avoid conflicts with your existing python environment.

```
conda create -n ixpe-env python=3
```

after downloading the dependancies, execute

```
conda activate ixpe-env
```

to enter the ixpe-env environment of conda, you will see (`ixpe-env`) before the shell prompt.

Now you are all set to install the repository. In the directory where the setup.py located, execute:

```
python3 -m pip install -e .
```

if you want to uninstall the package for generating the product.

```
python3 -m pip uninstall ixpetools
```

CONTENTS

1.1 Spectral Analysis using Xspec

```
[1]: from xspec import *
     from ixpetools.xspeclib.io import loadpha
     import matplotlib.pyplot as plt
     from astropy.io import fits
     import matplotlib as mpl
     import numpy as np
     import os
     %matplotlib inline
```

```
2022-06-24 10:43:40 -    INFO - [__init__.py: 16 -   <module>()] - sucessfully import␣
→pyXspec
```

```
***Warning: You do not have an up-to-date version of Xspec.init
      in your ~/.xspec directory.  It is recommended that you move
      your old Xspec.init aside and start up XSPEC again.  This will
      place a new version Xspec.init in your directory, which you may
      then modify using your old settings.
```

1.1.1 Load Spectra

```
[2]: os.chdir("../ixpetools/test/event_l2_xspec")
     specs = loadpha(['ixpe01001299_det1_evt2_v01_picorr_wcscorr_barycorr_pwn_pha1.fits',
                      'ixpe01001299_det1_evt2_v01_picorr_wcscorr_barycorr_pwn_pha1q.fits',
                      'ixpe01001299_det1_evt2_v01_picorr_wcscorr_barycorr_pwn_pha1u.fits'])
```

```
['ixpe01001299_det1_evt2_v01_picorr_wcscorr_barycorr_pwn_pha1.fits', 'ixpe01001299_det1_
→evt2_v01_picorr_wcscorr_barycorr_pwn_pha1q.fits', 'ixpe01001299_det1_evt2_v01_picorr_
→wcscorr_barycorr_pwn_pha1u.fits']
1 spectrum  in use

Spectral Data File: ixpe01001299_det1_evt2_v01_picorr_wcscorr_barycorr_pwn_pha1.fits ␣
→Spectrum 1
Net count rate (cts/s) for Spectrum:1  1.532e-01 +/- 4.222e-04
 Assigned to Data Group 1 and Plot Group 1
  Noticed Channels:  1-375
  Telescope: IXPE Instrument: GPD  Channel Type: PI
  Exposure Time: 8.592e+05 sec
```

```
 Filtering Keys:
    Stokes: 0
 Using fit statistic: chi
 Using Response (RMF) File            ixpe_d1_20170101_01.rmf for Source 1
 Using Auxiliary Response (ARF) File  ixpe_d1_20170101_01.arf



2 spectra  in use

Spectral Data File: ixpe01001299_det1_evt2_v01_picorr_wcscorr_barycorr_pwn_pha1q.fits ␣
↪Spectrum 2
Net count rate (cts/s) for Spectrum:2  -1.782e-03 +/- 5.958e-04
 Assigned to Data Group 2 and Plot Group 2
  Noticed Channels:  1-375
  Telescope: IXPE Instrument: GPD  Channel Type: PI
  Exposure Time: 8.592e+05 sec
  Filtering Keys:
    Stokes: 1
 Using fit statistic: chi
 Using Response (RMF) File            ixpe_d1_20170101_01.rmf for Source 1
 Using Auxiliary Response (ARF) File  ixpe_d1_20170101_01.mrf



3 spectra  in use

Spectral Data File: ixpe01001299_det1_evt2_v01_picorr_wcscorr_barycorr_pwn_pha1u.fits ␣
↪Spectrum 3
Net count rate (cts/s) for Spectrum:3  -1.116e-02 +/- 5.975e-04
 Assigned to Data Group 3 and Plot Group 3
  Noticed Channels:  1-375
  Telescope: IXPE Instrument: GPD  Channel Type: PI
  Exposure Time: 8.592e+05 sec
  Filtering Keys:
    Stokes: 2
 Using fit statistic: chi
 Using Response (RMF) File            ixpe_d1_20170101_01.rmf for Source 1
 Using Auxiliary Response (ARF) File  ixpe_d1_20170101_01.mrf
```

Three PHA file are loaded, An `XspecSpec` object are created. Note that the background and response file are stored in the header of PHAs.

1.1.2 Set models

```
[3]: specs.set_model("TBabs*powerlaw*polconst")
     AllModels(1).polconst.psi = -50

     # Use 2--8 keV data
     specs.set_energy(energy_low=2, energy_high=8, ngroups='all')
```

```
2022-06-24 10:43:42 -    INFO - [io.py:148 - set_energy()] - Xspec cmd: ignore **-2.0 8.
→0-**
```

```
========================================================================
Model TBabs<1>*powerlaw<2>*polconst<3> Source No.: 1   Active/On
Model Model Component  Parameter  Unit     Value
 par  comp
                              Data group: 1
   1    1   TBabs       nH          10^22   1.00000      +/-  0.0
   2    2   powerlaw    PhoIndex            1.00000      +/-  0.0
   3    2   powerlaw    norm                1.00000      +/-  0.0
   4    3   polconst    A                   1.00000      +/-  0.0
   5    3   polconst    psi         deg     45.0000      +/-  0.0
                              Data group: 2
   6    1   TBabs       nH          10^22   1.00000      = p1
   7    2   powerlaw    PhoIndex            1.00000      = p2
   8    2   powerlaw    norm                1.00000      = p3
   9    3   polconst    A                   1.00000      = p4
  10    3   polconst    psi         deg     45.0000      = p5
                              Data group: 3
  11    1   TBabs       nH          10^22   1.00000      = p1
  12    2   powerlaw    PhoIndex            1.00000      = p2
  13    2   powerlaw    norm                1.00000      = p3
  14    3   polconst    A                   1.00000      = p4
  15    3   polconst    psi         deg     45.0000      = p5
_____


Fit statistic  : Chi-Squared            2.537813e+09     using 375 bins.

***Warning: Chi-square may not be valid due to bins with zero variance
            in spectrum number: 1
                Chi-Squared              356.30     using 375 bins.

***Warning: Chi-square may not be valid due to bins with zero variance
            in spectrum number: 2
                Chi-Squared            1.389245e+08     using 375 bins.

***Warning: Chi-square may not be valid due to bins with zero variance
            in spectrum number: 3
Total fit statistic                     2.676738e+09     with 1120 d.o.f.

Test statistic : Chi-Squared            2.676738e+09     using 1125 bins.

***Warning: Chi-square may not be valid due to bins with zero variance
```

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```
            in spectrum number(s): 1 2 3

 Null hypothesis probability of 0.000000e+00 with 1120 degrees of freedom
 Current data and model not fit yet.


Fit statistic  : Chi-Squared                 2.537813e+09     using 375 bins.


***Warning: Chi-square may not be valid due to bins with zero variance
            in spectrum number: 1
                Chi-Squared                 1.021435e+07     using 375 bins.


***Warning: Chi-square may not be valid due to bins with zero variance
            in spectrum number: 2
                Chi-Squared                 1.337030e+08     using 375 bins.


***Warning: Chi-square may not be valid due to bins with zero variance
            in spectrum number: 3
Total fit statistic                         2.681731e+09     with 1120 d.o.f.


Test statistic : Chi-Squared                 2.681731e+09     using 1125 bins.


***Warning: Chi-square may not be valid due to bins with zero variance
            in spectrum number(s): 1 2 3

 Null hypothesis probability of 0.000000e+00 with 1120 degrees of freedom
 Current data and model not fit yet.
    50 channels (1-50) ignored in spectrum #      1
```

```
tbvabs Version 2.3
Cosmic absorption with grains and H2, modified from
Wilms, Allen, & McCray, 2000, ApJ 542, 914-924
Questions: Joern Wilms
joern.wilms@sternwarte.uni-erlangen.de
joern.wilms@fau.de

http://pulsar.sternwarte.uni-erlangen.de/wilms/research/tbabs/

PLEASE NOTICE:
To get the model described by the above paper
you will also have to set the abundances:
   abund wilm

Note that this routine ignores the current cross section setting
as it always HAS to use the Verner cross sections as a baseline.
```

```
    176 channels (200-375) ignored in spectrum #      1


Fit statistic  : Chi-Squared                 2.238297e+09     using 149 bins.
                Chi-Squared                 1.021435e+07     using 375 bins.


***Warning: Chi-square may not be valid due to bins with zero variance
            in spectrum number: 2
                Chi-Squared                 1.337030e+08     using 375 bins.
```

```
***Warning: Chi-square may not be valid due to bins with zero variance
           in spectrum number: 3
Total fit statistic                    2.382215e+09     with 894 d.o.f.

Test statistic : Chi-Squared           2.382215e+09     using 899 bins.

***Warning: Chi-square may not be valid due to bins with zero variance
           in spectrum number(s): 2 3

 Null hypothesis probability of 0.000000e+00 with 894 degrees of freedom
 Current data and model not fit yet.

    50 channels (1-50) ignored in spectrum #     2
   176 channels (200-375) ignored in spectrum #     2

Fit statistic  : Chi-Squared           2.238297e+09     using 149 bins.
                 Chi-Squared           3.963908e+06     using 149 bins.
                 Chi-Squared           1.337030e+08     using 375 bins.

***Warning: Chi-square may not be valid due to bins with zero variance
           in spectrum number: 3
Total fit statistic                    2.375964e+09     with 668 d.o.f.

Test statistic : Chi-Squared           2.375964e+09     using 673 bins.

***Warning: Chi-square may not be valid due to bins with zero variance
           in spectrum number(s): 3

 Null hypothesis probability of 0.000000e+00 with 668 degrees of freedom
 Current data and model not fit yet.

    50 channels (1-50) ignored in spectrum #     3
   176 channels (200-375) ignored in spectrum #     3

Fit statistic  : Chi-Squared           2.238297e+09     using 149 bins.
                 Chi-Squared           3.963908e+06     using 149 bins.
                 Chi-Squared           1.284872e+08     using 149 bins.
Total fit statistic                    2.370748e+09     with 442 d.o.f.

Test statistic : Chi-Squared           2.370748e+09     using 447 bins.
 Null hypothesis probability of 0.000000e+00 with 442 degrees of freedom
 Current data and model not fit yet.
```

1.1.3 Fit and Plot spectra

```
[4]: specs.fit(stat='chi2') # set statistical method to chisquare
     data = specs.plot(show=True, retrieve_data=True)
```

```
Default fit statistic is set to: Chi-Squared
   This will apply to all current and newly loaded spectra.

Fit statistic  : Chi-Squared              2.238297e+09      using 149 bins.
                 Chi-Squared              3.963908e+06      using 149 bins.
                 Chi-Squared              1.284872e+08      using 149 bins.
Total fit statistic                       2.370748e+09      with 442 d.o.f.


Test statistic : Chi-Squared              2.370748e+09      using 447 bins.
 Null hypothesis probability of 0.000000e+00 with 442 degrees of freedom
 Current data and model not fit yet.
                              Parameters
Chi-Squared    |beta|/N   Lvl        1:nH      2:PhoIndex         3:norm            4:A      ␣
↪    5:psi
7177.06        1482.15     -3     0.406015       1.19081       0.00498799        0.492256    ␣
↪ -49.8945
3160.88        553264      -4     0.124239       1.52711       0.00753722        0.406779    ␣
↪ -49.8288
613.62         307486      -5     0.0607673      1.60416       0.00943680        0.421312    ␣
↪ -49.9515
487.285        70317.6     -6     0.0274957      1.59759       0.00953779        0.418682    ␣
↪ -49.9531
467.995        32908       -7     0.00366012     1.59806       0.00954395        0.418760    ␣
↪ -49.9547
466.176        24627.7     -8     0.00146543     1.59820       0.00954678        0.418734    ␣
↪ -49.9571
465.471        23653.1     -9     0.000403999    1.59821       0.00954696        0.418732    ␣
↪ -49.9573
465.294        23274.9     -10    0.000142958    1.59822       0.00954705        0.418731    ␣
↪ -49.9574
465.209        23178.5     -11    1.29677e-05    1.59822       0.00954707        0.418730    ␣
↪ -49.9575
465.203        23132.3     -12    4.85983e-06    1.59822       0.00954708        0.418730    ␣
↪ -49.9575
============================================================
 Variances and Principal Axes
                 1         2         3         4         5
 1.2032E-09|  -0.0021   -0.0101    0.9999    0.0002   -0.0000
 1.4487E-04|   0.3817   -0.9216   -0.0085    0.0694    0.0000
 3.2822E-04|   0.0264   -0.0642   -0.0004   -0.9976    0.0000
 8.5436E-03|   0.9239    0.3825    0.0058   -0.0001   -0.0000
 1.5113E+00|   0.0000    0.0000    0.0000    0.0000    1.0000
------------------------------------------------------------


============================================================
  Covariance Matrix
      1          2          3          4          5
   7.314e-03   2.968e-03   4.532e-05   -5.976e-06   4.353e-05
```

```
    2.968e-03    1.375e-03    2.011e-05    1.127e-05    2.217e-05
    4.532e-05    2.011e-05    2.994e-07    4.800e-08    3.152e-07
   -5.976e-06    1.127e-05    4.800e-08    3.273e-04    1.339e-05
    4.353e-05    2.217e-05    3.152e-07    1.339e-05    1.511e+00
   ------------------------------------------------------------


   ========================================================================
   Model TBabs<1>*powerlaw<2>*polconst<3> Source No.: 1   Active/On
   Model Model Component  Parameter  Unit      Value
    par  comp
                             Data group: 1
      1    1   TBabs       nH         10^22     4.85983E-06  +/-  8.55240E-02
      2    2   powerlaw    PhoIndex             1.59822      +/-  3.70768E-02
      3    2   powerlaw    norm                 9.54708E-03  +/-  5.47163E-04
      4    3   polconst    A                    0.418730     +/-  1.80925E-02
      5    3   polconst    psi        deg       -49.9575     +/-  1.22935
                             Data group: 2
      6    1   TBabs       nH         10^22     4.85983E-06  = p1
      7    2   powerlaw    PhoIndex             1.59822      = p2
      8    2   powerlaw    norm                 9.54708E-03  = p3
      9    3   polconst    A                    0.418730     = p4
     10    3   polconst    psi        deg       -49.9575     = p5
                             Data group: 3
     11    1   TBabs       nH         10^22     4.85983E-06  = p1
     12    2   powerlaw    PhoIndex             1.59822      = p2
     13    2   powerlaw    norm                 9.54708E-03  = p3
     14    3   polconst    A                    0.418730     = p4
     15    3   polconst    psi        deg       -49.9575     = p5
   _____


   Fit statistic  : Chi-Squared              189.88     using 149 bins.
                    Chi-Squared              150.77     using 149 bins.
                    Chi-Squared              124.55     using 149 bins.
   Total fit statistic                       465.20     with 442 d.o.f.

   Test statistic : Chi-Squared              465.20     using 447 bins.
    Null hypothesis probability of 2.15e-01 with 442 degrees of freedom
```
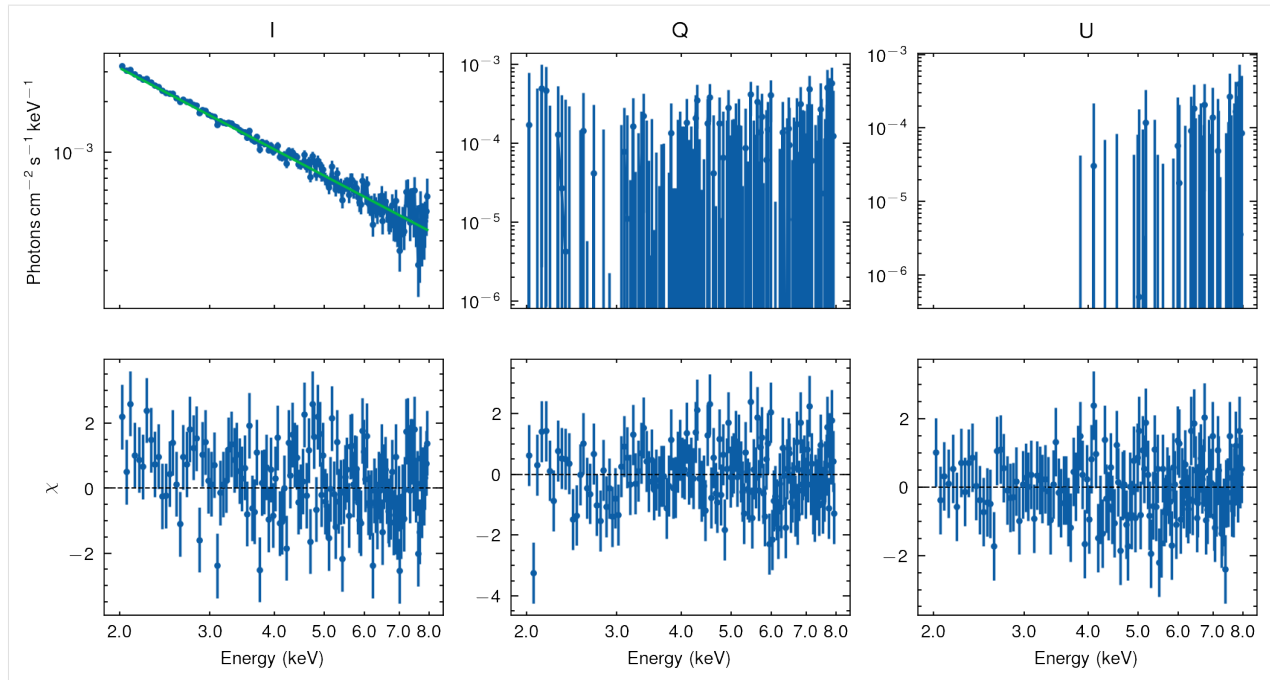
The parameter `show=True` in method `XspecSpec.plot()` present the Xspec plots in XWindow. You can also retrieve the data and make our own plots in Python. The retrieved `data` are structured data object optimized for `plot_stokes_spectra` method.

```
[5]: specs.plot_stokes_spectra(data)
     plt.show()
```

```
2022-06-24 10:43:42 - WARNING - [io.py:246 - plot_stokes_spectra()] - The style of plot␣
→requires the LaTeX package pre-installed. see https://pypi.org/project/SciencePlots/␣
→for details.
```
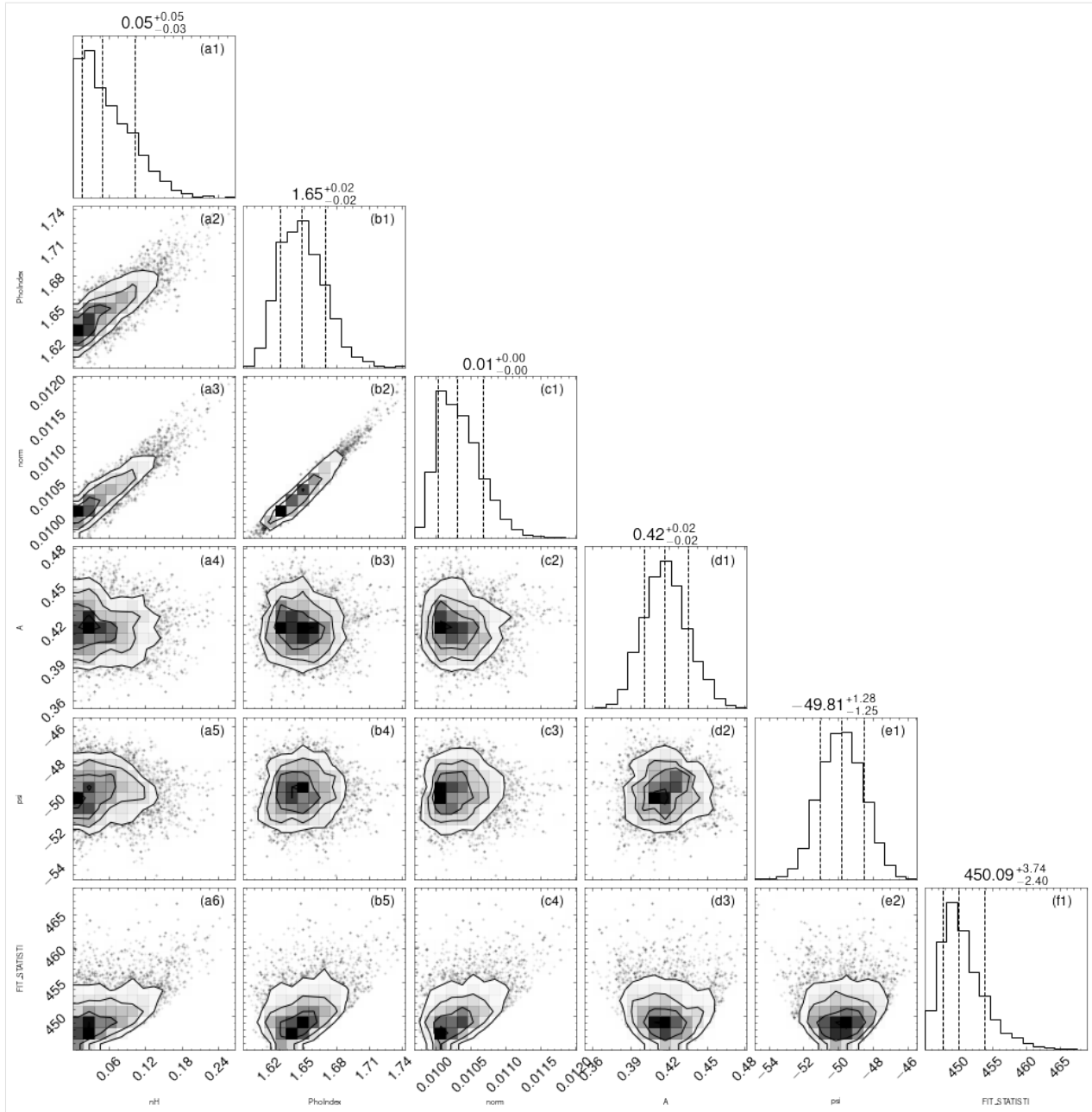
MCMC analysis

We implemented MCMC tool in Xspec for spectral fitting and error estimation.

```
[6]: from ixpetools.utils.plot_chain import plot_corner
     specs.mcmc('chain.fits',
                length=5000, burn=1000, nwalker=4)
     plot_corner('chain.fits')
     plt.show()
```

```
    All chains are now removed.
  New chain chain.fits is now loaded.

Chain chain.fits now has length 10000
    All loaded chains have the same length.
```

Show Contour

```
[11]:  # If plot contour using steppar, the Fit.steppar in PyXspec must have executed.
       mpl.rcParams['figure.dpi'] = 350
       mpl.rcParams['figure.figsize'] = (8,4)
       specs.plot_contour(steppar=True,A_parID=4, psi_parID=5,
                          A_steps=10, psi_steps=10,
                          show_chi2map=False)
```

```
2022-06-24 10:44:47 - WARNING - [io.py:355 - plot_contour()] - The style of plot␣
→requires the LaTeX package pre-installed. see https://pypi.org/project/SciencePlots/␣
→for details.
Errors calculated from chains
 Parameter   Credible Interval (68.27%)
      4     0.400373     0.435487    (-0.0182412,0.0168727)
      5      -51.071     -48.5279    (-1.10751,1.43563)


     Chi-Squared    Delta                  A          psi
                 Chi-Squared               4            5


***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        490.35       45.53    0     0.33083    0    -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        482.81       37.987   1     0.34839    0    -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         477.2       32.379   2     0.36594    0    -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        473.52       28.703   3     0.3835     0    -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        471.78       26.954   4     0.40106    0    -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        471.95       27.129   5     0.41861    0    -56.321
```

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```
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        474.04       29.222    6     0.43617    0     -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        478.05       33.229    7     0.45373    0     -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        483.96       39.143    8     0.47129    0     -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        491.78       46.958    9     0.48884    0     -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        501.49       56.668    10    0.5064     0     -56.321
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        489.73       44.904    10    0.5064     1     -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        480.42       35.597    9     0.48884    1     -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
```

```
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
          473.01        28.186     8      0.47129     1      -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
          467.5         22.678     7      0.45373     1      -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
          463.9         19.077     6      0.43617     1      -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
          462.21        17.39      5      0.41861     1      -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
          462.44        17.622     4      0.40106     1      -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
          464.6         19.778     3      0.3835      1      -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
          468.68        23.861     2      0.36594     1      -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
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         474.7        29.878    1     0.34839    1      -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         482.65       37.83     0     0.33083    1      -55.05
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         476.65       31.824    0     0.33083    2      -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         468.38       23.554    1     0.34839    2      -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         462.04       17.219    2     0.36594    2      -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         457.64       12.817    3     0.3835     2      -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         455.17       10.343    4     0.40106    2      -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         454.62       9.7939    5     0.41861    2      -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
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 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        455.99       11.164     6     0.43617     2     -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        459.27       14.448     7     0.45373     2     -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        464.46        19.64     8     0.47129     2     -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        471.56       26.735     9     0.48884     2     -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        480.55       35.726    10      0.5064     2     -53.778
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        473.98       29.155    10      0.5064     3     -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        465.21        20.39     9     0.48884     3     -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
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caused by the fit being insensitive to the parameter.
       458.34     13.522    8     0.47129    3    -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       453.38     8.5561    7     0.45373    3    -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       450.32     5.4992    6     0.43617    3    -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       449.18     4.3567    5     0.41861    3    -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       449.96     5.1338    4     0.40106    3    -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       452.66     7.8352    3     0.3835     3    -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       457.29     12.465    2     0.36594    3    -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       463.85     19.028    1     0.34839    3    -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
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 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        472.35       27.527    0     0.33083    3     -52.507
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        469.77       24.947    0     0.33083    4     -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        461.13       16.311    1     0.34839    4     -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        454.43       9.6103    2     0.36594    4     -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        449.66       4.8427    3     0.3835     4     -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        446.83       2.004     4     0.40106    4     -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        445.91       1.0898    5     0.41861    4     -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
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Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         446.92      2.0952     6     0.43617     4      -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         449.84      5.0152     7     0.45373     4      -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         454.67      9.8441     8     0.47129     4      -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         461.4      16.576     9     0.48884     4      -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         470.03      25.205     10    0.5064      4      -51.235
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         468.7       23.883     10    0.5064      5      -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         460.12      15.301     9     0.48884     5      -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         453.44      8.6151     8     0.47129     5      -49.963
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***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        448.65      3.8326     7     0.45373     5     -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        445.78      0.95902    6     0.43617     5     -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        444.82  1.3736e-09     5     0.41861     5     -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        445.78      0.96067    4     0.40106     5     -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        448.67      3.8458     3     0.3835      5     -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        453.48      8.6597     2     0.36594     5     -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        460.23      15.406     1     0.34839     5     -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
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***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         468.91       24.089     0     0.33083    5    -49.963
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         469.78       24.956     0     0.33083    6    -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         461.14       16.318     1     0.34839    6    -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         454.44       9.6159     2     0.36594    6    -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         449.67       4.8467     3     0.3835     6    -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         446.83       2.0061     4     0.40106    6    -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         445.91       1.0899     5     0.41861    6    -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
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       446.92      2.0932    6     0.43617   6     -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       449.83      5.0109    7     0.45373   6     -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       454.66      9.8374    8     0.47129   6     -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       461.39      16.567    9     0.48884   6     -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       470.01      25.193    10    0.5064    6     -48.692
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       473.95      29.132    10    0.5064    7     -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       465.19      20.372    9     0.48884   7     -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       458.33      13.509    8     0.47129   7     -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
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 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         453.37        8.548      7      0.45373      7      -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         450.32        5.4956     6      0.43617      7      -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         449.18        4.3573     5      0.41861      7      -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         449.96        5.1384     4      0.40106      7      -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         452.67        7.8435     3      0.3835       7      -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         457.3         12.477     2      0.36594      7      -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         463.86        19.043     1      0.34839      7      -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
```

```
caused by the fit being insensitive to the parameter.
        472.37      27.545     0     0.33083     7      -47.42
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        476.67      31.852     0     0.33083     8      -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         468.4      23.577     1     0.34839     8      -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        462.06      17.237     2     0.36594     8      -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        457.65       12.83     3      0.3835     8      -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        455.17      10.351     4     0.40106     8      -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        454.62       9.796     5     0.41861     8      -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        455.98       11.16     6     0.43617     8      -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
```

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 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       459.26      14.437    7     0.45373    8     -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       464.44      19.622    8     0.47129    8     -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       471.53       26.71    9     0.48884    8     -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       480.52      35.693   10      0.5064    8     -46.149
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       489.68      44.863   10      0.5064    9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       480.39      35.566    9     0.48884    9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
       472.99      28.165    8     0.47129    9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
```

```
Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        467.49       22.666    7    0.45373    9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        463.9        19.074    6    0.43617    9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        462.22       17.395    5    0.41861    9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        462.46       17.634    4    0.40106    9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        464.62       19.797    3    0.3835     9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        468.71       23.887    2    0.36594    9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        474.73       29.91     1    0.34839    9     -44.877
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        482.69       37.867    0    0.33083    9     -44.877
```

```
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         490.4       45.579    0     0.33083   10    -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         482.85      38.029    1     0.34839   10    -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         477.24      32.414    2     0.36594   10    -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         473.55      28.73     3     0.3835    10    -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         471.79      26.973    4     0.40106   10    -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         471.96      27.138    5     0.41861   10    -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
         474.04      29.222    6     0.43617   10    -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
```
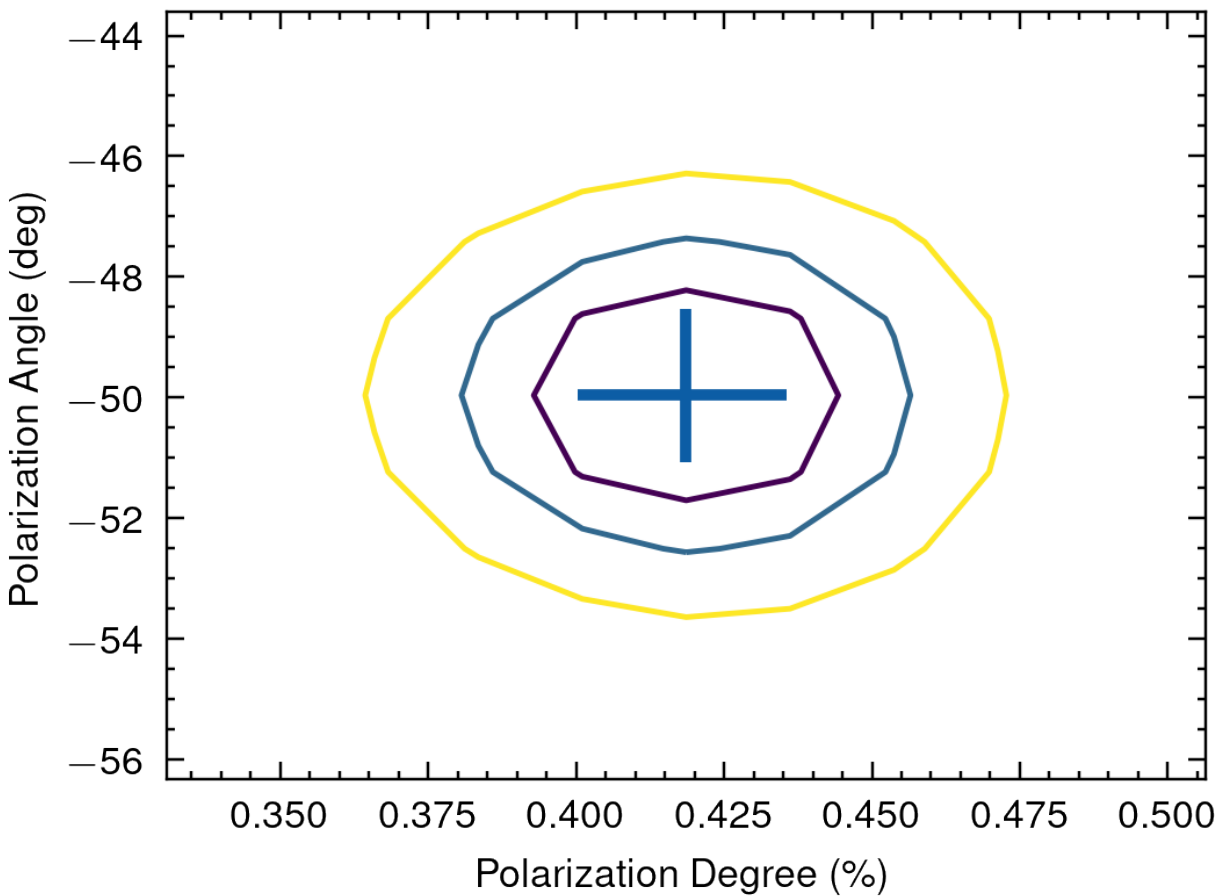
```
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        478.04       33.218    7      0.45373    10     -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        483.94       39.121    8      0.47129    10     -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        491.75       46.924    9      0.48884    10     -43.606
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
***Warning: Zero alpha-matrix diagonal element for parameter 1
 Parameter 1 is pegged at 1.822e-17 due to zero or negative pivot element, likely
 caused by the fit being insensitive to the parameter.
        501.44       56.622   10       0.5064    10     -43.606
```
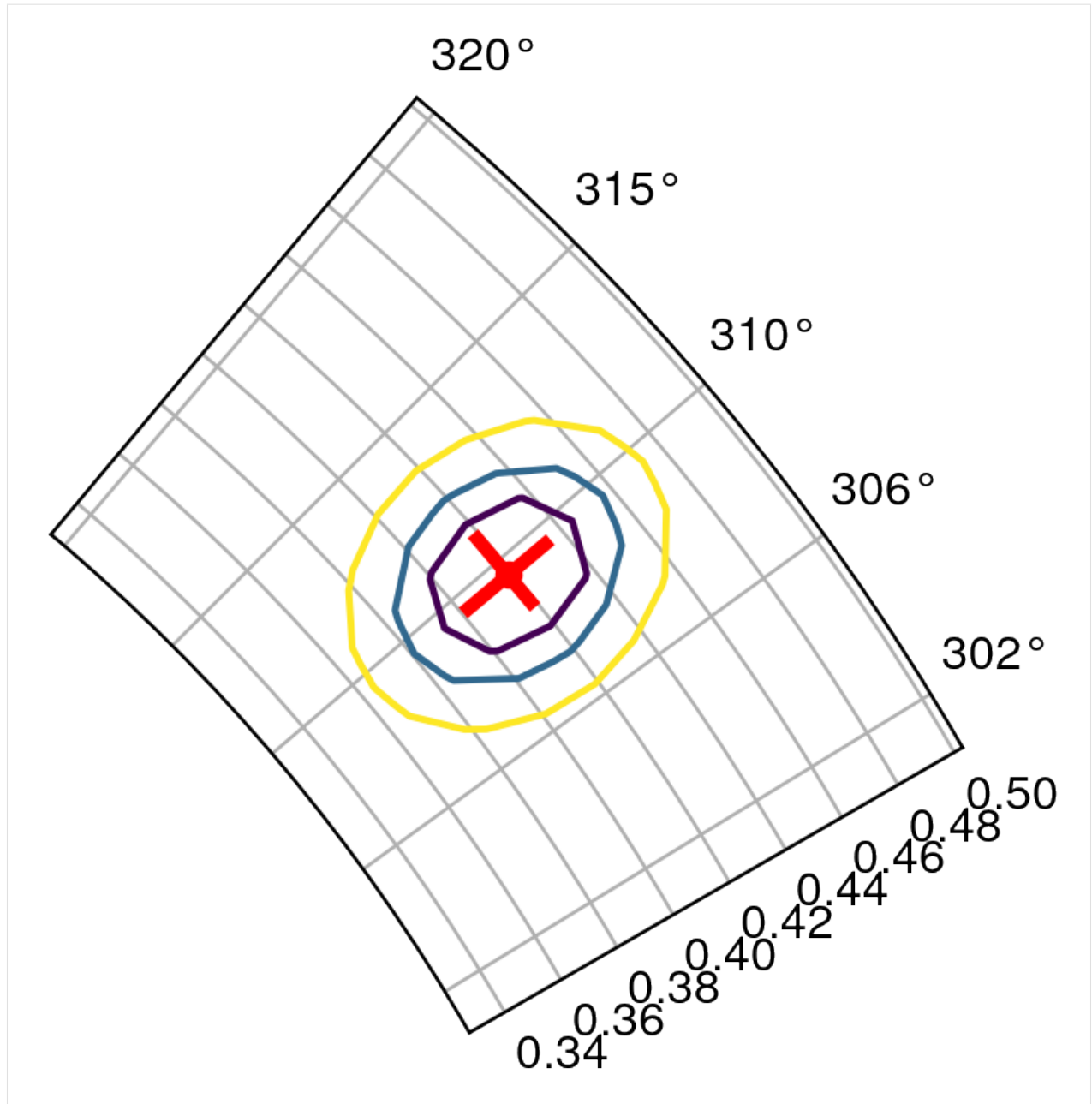
```
[10]: ## Show plot in 'polar' projection
      import matplotlib as mpl
      mpl.rcParams['figure.dpi'] = 350
      mpl.rcParams['figure.figsize'] = (8,6)
      specs.plot_contour(steppar=False,A_parID=4, psi_parID=5,
                         projection='polar',
                         show_chi2map=False)
```

```
2022-06-24 10:44:27 - WARNING - [io.py:355 - plot_contour()] - The style of plot␣
→requires the LaTeX package pre-installed. see https://pypi.org/project/SciencePlots/␣
→for details.
Errors calculated from chains
 Parameter   Credible Interval (68.27%)
     4     0.400373     0.435487     (-0.0182412,0.0168727)
     5     -51.071     -48.5279     (-1.10751,1.43563)
```

1.2 IXPE-tools API

Here follows the API documentation for the IXPE Tools.

1.2.1 Xspec Anaysis

A module that wraps the Xspec tool, you need to pre-install HEASOFT Xspec and initialize the HEADAS environment.

@author: Youli

class ixpetools.xspeclib.io.**XspecSpec**(*spec_files=[]*, *background_files=[]*, *response_files=[]*)
> A spectrum class prepared for Xspec analysis

> **fit**(*stat='chi2'*)
>> perform the fitting procedure, the parameter stat set the statistics to fit, default is 'pgstat' optional: {pgstat | chi2 | cstat} return the covariance of the fitting results

>> **Parameters stat** : str

>>> The statistic method to execute the fitting, optional methods are {'pgstat', 'chi2', 'cstat'}

> **flux**(*ngroups*, *energy_low*, *energy_high*, *cal_error=True*)
>> Calculate the (total) Model flux of specific group of data return the flux of specific compoent of model

>> **Parameters ngroups** : int

>>> the number of the data group

>>> **energy_low** : float

>>> the lower energy limits to calculate the flux

>>> **energy_high** : float

>>> the upper limits of the energy range to calculate the flux

>>> **cal_error** : bool (True for default)

>>> whether to calculate the error of the flux (errsims option in Xspec)

>> **Returns flux** : tuple

>>> The standard Xspec tuple of the results of flux. the tutple contains 6 value (val errLow errHigh(in ergs/cm2) val errLow errHigh(in photons)). Error values are .0 if flux was not run with errsims option.

> **static fromxcm**(*xcmname*)
>> Load the Xspec data and models from xcm file.

>> **Parameters xcmname** : str

>>> The filename of the xcm file

> **mcmc**(*chainfile*, *length=5000*, *burn=1000*, *nwalker=4*)
>> Perform MCMC to fit the spectrum and return the chain data. Call the function defined in *ixpetools.utils.plot_chain.plot_corner()*

>> **Parameters chainfile** : str

>>> The FITS file to save the Chain data

>>> **length** : int

>>> the total length of chain to run

> **burn** : int
>
> > The length to burn the chain
>
> **nwalker** : int
>
> > The number of walkers

`plot`(*show=False*, *savefig=None*, *retrieve_data=False*)

> plot the results in a simple and explicit manner. The plot is conducted by Xspec.
>
> > **Parameters show** : boolean
> >
> > > whether to show the plot in XWindow (default is False)
> >
> > **savefig: None or str**
> >
> > > Whether to save figure as output, give the name of output figure to savefig
> >
> > **retrieve_data: boolean**
> >
> > > whether to export the data of the point, the output will be a dictionary object e.g.:
> > > {'group1': {'x': [...], 'y': [...], 'xerr': [...], 'yerr': [...]}, 'group2': {'x': [...], 'y': [...], 'xerr': [...], 'yerr': [...]}, ... 'model1': array-like, 'model2': array-like, ... }

`plot_contour`(*steppar=True*, *A_parID=4*, *psi_parID=5*, *A_steps=100*, *psi_steps=100*, *A_range=None*, *psi_range=None*, *projection=None*, *show_chi2map=True*, *use_latex=True*, ***kwargs*)

> Perform the *Fit.steppar* in Xspec and plot the contour levels
>
> > **Parameters steppar** : boolean
> >
> > > whether to perform the steppar for parameters, otherwise only plot the contour based on the *Fit.steppar* of Xspec that executed before.
> >
> > **A_parID** : int
> >
> > > The parameter ID of parameter A in Xspec (start by 1).
> >
> > **psi_parID** : int
> >
> > > The parameter ID of parameter psi in Xspec (start by 1).
> >
> > **A_steps** : int
> >
> > > The steps for polarization degree. only works when steppar=True.
> >
> > **psi_steps** : int
> >
> > > The steps for polarization angle. Only works when steppar=True.
> >
> > **A_range** : float
> >
> > > The range to execute steppar. range is $[A-A\_range, A+A\_range]$, default is determined by the 1sigma error of parameter A, that $A\_range = 5 * \sigma_A$
> >
> > **psi_range** : float
> >
> > > The range to execute steppar. range is $[\psi-\psi\_range, \psi+\psi\_range]$, default is determined by the 1sigma error of parameter psi, that $\psi\_range = 5 * \sigma_\psi$
> >
> > **projection** : str
> >
> > > Projection to show the plots, {None, 'polar'}
> >
> > **show_chi2map** : boolean
> >
> > > whether to plot chisquare hot map. (default is True)
> >
> > **use_latex** : boolean

Whether the plt style use LaTeX to compline. This requires the LaTeX package pre-installed. see https://pypi.org/project/SciencePlots/ for details.

plot_stokes_spectra(*PlotData_ojb*, *use_latex=True*, *dpi=250*, *figsize=(8, 4)*, ***kwargs*)
  Plot the I, Q, U fitting results and the corresponding residuals in six panels. The data are retrived from function *plot()* (set retrieve_data=True). It's a structed data object containing data and models, see the docstring for details.

  Parameters **PlotData_ojb** : object

  retrived from function *plot()* (set retrieve_data=True)

  use_latex : boolean

  Whether the plt style use LaTeX to compline. This requires the LaTeX package pre-installed. see https://pypi.org/project/SciencePlots/ for details.

  **kwarg :

  The arguments for matplotlib.pyplot

set_energy(*energy_low*, *energy_high*, *ngroups='all'*)
  setup the energy range (ignore command in Xspec) for specific Group data

  Parameters **energy_low** : float

  the lower energy limits of energy range

  energy_high : float

  the upper limits of the energy range

  ngroups : string or int

  group number should start with 1, not zero! if it is a int: specify the number of the data group to setup energy range if it's string and it's "all", setup all spectra in the same energy range

set_model(*model_name*)
  setup model name for Xspec fitting

  Parameters **model_name** : str

  The Xspec supported model names in string format. e.g. "TBabs*powerlaw".

ixpetools.xspeclib.io.**get_spectrum_extension**(*hdulist*)
  find the extension number of Spectrum in PHA FITS file

ixpetools.xspeclib.io.**get_spectrum_type**(*hdulist*)
  get the type of spectrum return {'TYPE:I', 'TYPE:II'}

ixpetools.xspeclib.io.**loadpha**(*loadfile*)
  load the spec file return the Spectrum class the input format could be 1. PHA file name 2. Python list of PHA files 3. xcm file

1.2.2 Utilities

Several useful utilities used throughout various modules

Logger tool

Global logger setup Must be used by the whole application

The default format can be restored at any time with LoggerSetup.set_default_format() The log level can be set at any time with LoggerSetup.set_debug/info/warning/error_level The level is set at INFO by default

imported from pipeline-bricks Created on 4 December 2019

@author: michel

class `ixpetools.utils.logger.`**`LoggerSetup`**
>   manage the logger setup
>
>   **static** **`get_logger`**`()`
>>   Format and return the system logger :return : system logger :rtype: logger
>
>   **static** **`restore_default_level`**`()`
>>   restore the message level with the last value set by a setter INFO by default
>
>   **static** **`set_debug_level`**`()`
>>   Switch to debug level
>
>   **static** **`set_default_format`**`()`
>>   set the default message format
>
>   **static** **`set_error_level`**`()`
>>   Switch to error level
>
>   **static** **`set_info_level`**`()`
>>   Switch to info level
>
>   **static** **`set_warning_level`**`()`
>>   Switch to warning level

Plot MCMC Chain

`ixpetools.utils.plot_chain.`**`plot_corner`**`(`*filename*, *burn=0*`)`
>   use corner to plot parameters
>
>>   **Parameters** **filename** : str
>>
>>>   The Xspec chain file generated by Xspec MCMC program

PYTHON MODULE INDEX

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