

GammaLib - Bug #1150

Spectral model log parabola not compatible between Fermi science tools and gammalib/ctools

02/21/2014 04:54 PM - Schulz Anneli

Status:	Closed	Start date:	02/21/2014
Priority:	Normal	Due date:	
Assigned To:		% Done:	100%
Category:		Estimated time:	0.00 hour
Target version:			

Description

Performing further cross checks between the fermi science tools and ctools the following problem came up:

If one takes the xmlfile from the science tools and tries to analyse it with gammalib/ctools the following happens:

input example:

```
<spectrum normPar="norm" type="LogParabola">
  <parameter error="0.0403546564" free="1" max="100000" min="1e-05" name="norm" scale="6.664498894e-12"
value="0.330797703"/>
  <parameter error="0.1932913856" free="1" max="5" min="-0" name="alpha" scale="1" value="2.762437733"/>
  <parameter error="0.9494770106" free="1" max="10" min="-10" name="beta" scale="0.1" value="3.304939119"/>
  <parameter free="0" max="300" min="0.02" name="Eb" scale="1000" value="1.444281016"/>
</spectrum>
```

this means if the source is fitted also the Pivotenergy is free, which leads to the huge errors on the fitted parameters (I think due to problem of correlated parameters) an example shown here:

```
<spectrum type="LogParabola">
  <parameter name="Prefactor" value="0.001" error="0.0510866" scale="1e-09" min="0.001" max="1000" free="1" />
  <parameter name="Index" value="-3.71444e-05" error="878492" scale="1" min="-10" max="10" free="1" />
  <parameter name="Curvature" value="-0.319421" error="0.108217" scale="1" min="-10" max="10" free="1" />
  <parameter name="Scale" value="511.743" error="7.03715e+08" scale="1" min="20" max="10000" free="1" />
</spectrum>
```

But also fixing the Pivotenergy does not solve the problem at the moment since the definitions of the parameters in the fermi science tools and gammalib/ctools are not completely compatible. This leads to a fit result like this:

```
<spectrum type="LogParabola">
  <parameter name="Prefactor" value="1.13197" error="0.0615543" scale="6.6645e-12" min="1e-05" max="100000" free="1" />
  <parameter name="Index" value="-4.18061" error="0.0833878" scale="1" min="-5" max="5" free="1" />
  <parameter name="Curvature" value="-10" error="0" scale="0.1" min="-10" max="10" free="1" />
  <parameter name="Scale" value="1.44428" scale="1000" min="0.02" max="300" free="0" />
</spectrum>
```

History

#1 - 02/21/2014 05:00 PM - Schulz Anneli

- Description updated

#2 - 02/21/2014 05:00 PM - Schulz Anneli

- Description updated

#3 - 02/21/2014 10:13 PM - Knödseder Jürgen

Are the parameters defined identically? I see that for Fermi

```
norm = 0.330797703  
alpha = 2.762437733  
beta = 3.304939119
```

and for GammaLib

```
Prefactor = 1.13197  
Index = -4.18061  
Curvature = -10
```

In particular, the curvature runs against the minimum, so I'm wondering whether the formulae in ScienceTools and GammaLib are at the end the same?

#4 - 02/22/2014 05:41 PM - Mayer Michael

in the Fermi Science Tools, the parameters are defined differently compared to gammalib. In order to be consistent within gammalib, we decided to define Index and Curvature with a different sign than alpha and beta ([wikipage](#)). Maybe there got something mixed up when reading the signs. However, since the scale of the Curvature is 0.1 in the example file, the boundaries of [-10;10] might be too narrow.

#5 - 03/04/2014 08:55 PM - Schulz Anneli

Hi,

so I spent some more time on it and found out that it's not the log parabola which causes the issue but the super exponential cutoff power law. The number of predicted events goes of by factors $1e6$ or $1e7$...

I went back to only diffuse and one source and checked the values:

```
2014-03-04T19:04:55: === GOptimizerLM ===  
2014-03-04T19:04:55: Optimized function value ...: -386110.673  
2014-03-04T19:04:55: Absolute precision .....: 1e-06  
2014-03-04T19:04:55: Optimization status .....: converged  
2014-03-04T19:04:55: Number of parameters .....: 14  
2014-03-04T19:04:55: Number of free parameters ..: 5  
2014-03-04T19:04:55: Number of iterations .....: 41  
2014-03-04T19:04:55: Lambda .....: 0.0001  
2014-03-04T19:04:55: Maximum log likelihood ....: 386110.673  
2014-03-04T19:04:55: Observed events (Nobs) ...: 1057409.000  
2014-03-04T19:04:55: Predicted events (Npred) ...: 1057409.000 (Nobs - Npred = -7.26331e-05)
```

If the parameters are fixed to the 2FGL values (e.g. here for

```
2FGL J2017.3+0603  
Number of spectral par's ...: 5
```

2014-03-04T19:12:10: Prefactor: 4.31505e-12 [1e-13,1e-09] ph/cm2/s/MeV (fixed,scale=1e-11,gradient)
2014-03-04T19:12:10: Index1: -1.04592 [-0,-5] (fixed,scale=-1,gradient)
2014-03-04T19:12:10: Cutoff: 3743.96 [100,1e+06] MeV (fixed,scale=10000,gradient)
2014-03-04T19:12:10: PivotEnergy: 1525.24 [896.688,1525.24] MeV (fixed,scale=1,gradient)
2014-03-04T19:12:10: Index2: 1 [0,5] (fixed,scale=1,gradient)

I get the following result:

2014-03-04T19:12:10: === GOptimizerLM ===
2014-03-04T19:12:10: Optimized function value ...: 1448179.296
2014-03-04T19:12:10: Absolute precision: 1e-06
2014-03-04T19:12:10: Optimization status: converged
2014-03-04T19:12:10: Number of parameters: 22
2014-03-04T19:12:10: Number of free parameters ..: 5
2014-03-04T19:12:10: Number of iterations: 41
2014-03-04T19:12:10: Lambda: 1000
2014-03-04T19:12:10: Maximum log likelihood: -1448179.296
2014-03-04T19:12:10: Observed events (Nobs): 1057409.000
2014-03-04T19:12:10: Predicted events (Npred) ...: 3042652.294 (Nobs - Npred = -1.98524e+06)

if I free the prefactor for the source it is fit to the minimum (1e-13).

So there is something wrong when reading in xmlfiles containing plsUPEREXPCUTOFF from fermi.

#6 - 03/10/2014 10:04 AM - Schulz Anneli

Since the problem does not seem to be related to the log parabola, I put more results on comparisons in the wiki:

https://cta-redmine.irap.omp.eu/projects/gammalib/wiki/Validation_of_Pass_7REP

#7 - 03/12/2014 03:51 PM - Knödseder Jürgen

I was doing a check by fitting the Crab using a log-parabola spectrum. The analysis was done for one week of Crab data, using 20 bins in energy between 200 MeV and 20 GeV.

Using the ScienceTools I get

Crab:
norm: 2.32745 +/- 1.27195
alpha: 1.66168 +/- 0.182328
beta: 0.194544 +/- 0.0528259

Eb: 299.806 +/- 97.7888
TS value: 1435.31
Flux: 1.03049e-06 +/- 5.70869e-08 photons/cm^2/s

Extragal_diffuse:
Normalization: 1.49686 +/- 0.354927
Flux: 0.000104134 +/- 2.46826e-05 photons/cm^2/s

Galactic_diffuse:
Value: 1.10188 +/- 0.0397298
Flux: 0.000328965 +/- 1.18608e-05 photons/cm^2/s

WARNING: Fit may be bad in range [3169.79, 3990.52] (MeV)

Total number of observed counts: 4832
Total number of model events: 4831.5

-log(Likelihood): 25972.37267

Elapsed CPU time: 45.78

and using the ctlike I get

2014-03-11T17:40:18: Maximum log likelihood: -25973.120
2014-03-11T17:40:18: Observed events (Nobs): 4832.000
2014-03-11T17:40:18: Predicted events (Npred) ..: 4832.000 (Nobs - Npred = 4.23437e-05)
2014-03-11T17:40:18: Prefactor: 2.31551e-09 +/- 0.00184344 [1e-16,1e-06] ph/cm2/s/MeV (free,scale=1e-09,gradient)
2014-03-11T17:40:18: Index: -1.66673 +/- 181170 [-5,5] (free,scale=1,gradient)
2014-03-11T17:40:18: Curvature: -0.189644 +/- 0.0559916 [-10,10] (free,scale=1,gradient)
2014-03-11T17:40:18: PivotEnergy: 299.557 +/- 1.43086e+08 [10,1e+06] MeV (free,scale=1,gradient)

This looks pretty consistent, at least when the values are concerned (note that alpha is -Index and beta is -Curvature). The errors are not corrected due to correlation of parameters, which is not handled correctly so far (known problem).

So is there still a bug related to the log-parabola spectrum or can this be closed?

#8 - 03/12/2014 03:52 PM - Knödseder Jürgen

- *Status changed from New to In Progress*

#9 - 03/12/2014 04:59 PM - Schulz Anneli

You are right. As written above, the problem is not about the log parabola, but something else. So this issue can be closed, further discussion on the science tools validation will be in the wiki. Sorry that I blamed a wrong part of the code, it just came up there.

#10 - 06/16/2014 11:32 AM - Knödseder Jürgen

- *Status changed from In Progress to Closed*

- *% Done changed from 0 to 100*