GammaLib - Bug #1561

Elliptical Gauss model shows fit convergence problems

10/30/2015 12:36 AM - Knödlseder Jürgen

Status:	In Progress	**Start date:**	10/30/2015
Priority:	Normal	**Due date:**	
Assigned To:	Knödlseder Jürgen	**% Done:**	50%
Category:		**Estimated time:**	0.00 hour
Target version:			

Description

I found convergence problems with the elliptical Gauss model that explain why the fit is so slow. The following model leads to the problems:

```
<?xml version="1.0" standalone="no"?>
<source_library title="source library">
  <source name="Crab" type="ExtendedSource">
    <spectrum type="PowerLaw">
      <parameter name="Prefactor" scale="1e-16" value="5.7"  min="1e-07" max="1000.0" free="1"/>
      <parameter name="Index"     scale="-1"    value="2.48" min="0.0"   max="+5.0"   free="1"/>
      <parameter name="Scale"     scale="1e6"   value="0.3"  min="0.01"  max="1000.0" free="0"/>
    </spectrum>
    <spatialModel type="EllipticalGauss">
      <parameter name="RA"          scale="1.0" value="83.6331" min="-360"  max="360" free="1"/>
      <parameter name="DEC"         scale="1.0" value="22.0145" min="-90"   max="90"  free="1"/>
      <parameter name="PA"          scale="1.0" value="45.0"    min="-360"  max="360" free="1"/>
      <parameter name="MinorRadius" scale="1.0" value="0.2"     min="0.001" max="10"  free="1"/>
      <parameter name="MajorRadius" scale="1.0" value="0.4"     min="0.001" max="10"  free="1"/>
    </spatialModel>
  </source>
  <source name="Background" type="CTAIrfBackground" instrument="CTA">
    <spectrum type="PowerLaw">
      <parameter name="Prefactor" scale="1.0" value="1.0" min="1e-3" max="1e3"    free="1"/>
      <parameter name="Index"     scale="1.0" value="0.0" min="-5.0" max="+5.0"   free="1"/>
      <parameter name="Scale"     scale="1e6" value="1.0" min="0.01" max="1000.0" free="0"/>
    </spectrum>
  </source>
</source_library>
```

The problems can be seen in the result of the pull distribution fit:

```
2015-08-21T14:00:34: +==================================+
2015-08-21T14:00:34: | Maximum likelihood optimisation |
2015-08-21T14:00:34: +==================================+
2015-08-21T14:02:12:  >Iteration   0: -logL=108962.288, Lambda=1.0e-03
2015-08-21T14:03:40:   Iteration   1: -logL=108962.288, Lambda=1.0e-03, delta=-62.781, max(|grad|)=-1422.695134 [RA:0] (stalled)
2015-08-21T14:05:14:   Iteration   2: -logL=108962.288, Lambda=1.0e-02, delta=-61.650, max(|grad|)=-1409.424285 [RA:0] (stalled)
2015-08-21T14:06:54:   Iteration   3: -logL=108962.288, Lambda=1.0e-01, delta=-52.524, max(|grad|)=-1309.322322 [RA:0] (stalled)
2015-08-21T14:08:31:   Iteration   4: -logL=108962.288, Lambda=1.0e+00, delta=-19.640, max(|grad|)=-833.365056 [RA:0] (stalled)
2015-08-21T14:10:11:   Iteration   5: -logL=108963.142, Lambda=1.0e+01, delta=-0.854, max(|grad|)=-901.230893 [RA:0] (stalled)
2015-08-21T14:11:56:  >Iteration   6: -logL=108962.669, Lambda=1.0e+02, delta=0.473, max(|grad|)=-471.078708 [RA:0]
2015-08-21T14:13:41:   Iteration   7: -logL=108962.790, Lambda=1.0e+01, delta=-0.120, max(|grad|)=1241.129876 [RA:0] (stalled)
2015-08-21T14:15:15:  >Iteration   8: -logL=108961.539, Lambda=1.0e+02, delta=1.250, max(|grad|)=1090.299204 [RA:0]
2015-08-21T14:17:00:  >Iteration   9: -logL=108961.068, Lambda=1.0e+01, delta=0.471, max(|grad|)=-540.297475 [RA:0]
2015-08-21T14:18:36:   Iteration  10: -logL=108961.883, Lambda=1.0e+00, delta=-0.815, max(|grad|)=202.976034 [DEC:1] (stalled)
2015-08-21T14:20:15:  >Iteration  11: -logL=108961.391, Lambda=1.0e+01, delta=0.492, max(|grad|)=188.715977 [RA:0]
2015-08-21T14:21:58:  >Iteration  12: -logL=108958.816, Lambda=1.0e+00, delta=2.575, max(|grad|)=426.349305 [DEC:1]
2015-08-21T14:23:41:   Iteration  13: -logL=108958.816, Lambda=1.0e-01, delta=-0.711, max(|grad|)=224.674851 [RA:0] (stalled)
2015-08-21T14:25:24:  >Iteration  14: -logL=108957.509, Lambda=1.0e+00, delta=1.307, max(|grad|)=-617.376738 [DEC:1]
2015-08-21T14:27:05:   Iteration  15: -logL=108957.509, Lambda=1.0e-01, delta=-11.635, max(|grad|)=565.058180 [DEC:1] (stalled)
```

```
2015-08-21T14:28:45:   Iteration  16: -logL=108957.509, Lambda=1.0e+00, delta=-3.688, max(|grad|)=205.103811 [DEC:1] (stalled)
2015-08-21T14:30:32:  >Iteration  17: -logL=108956.518, Lambda=1.0e+01, delta=0.991, max(|grad|)=307.205446 [DEC:1]
2015-08-21T14:32:08:   Iteration  18: -logL=108956.518, Lambda=1.0e+00, delta=-0.556, max(|grad|)=803.938079 [DEC:1] (stalled)
2015-08-21T14:33:56:  >Iteration  19: -logL=108956.507, Lambda=1.0e+01, delta=0.010, max(|grad|)=-289.729848 [DEC:1]
2015-08-21T14:35:31:   Iteration  20: -logL=108956.507, Lambda=1.0e+00, delta=-3.233, max(|grad|)=129.124075 [DEC:1] (stalled)
2015-08-21T14:37:14:   Iteration  21: -logL=108956.507, Lambda=1.0e+01, delta=-0.013, max(|grad|)=380.779002 [DEC:1] (stalled)
2015-08-21T14:38:57:  >Iteration  22: -logL=108956.447, Lambda=1.0e+02, delta=0.060, max(|grad|)=-220.031413 [DEC:1]
2015-08-21T14:40:38:   Iteration  23: -logL=108956.447, Lambda=1.0e+01, delta=-0.005, max(|grad|)=319.798781 [DEC:1] (stalled)
2015-08-21T14:42:17:  >Iteration  24: -logL=108956.409, Lambda=1.0e+02, delta=0.038, max(|grad|)=-162.676580 [DEC:1]
2015-08-21T14:43:56:  >Iteration  25: -logL=108956.403, Lambda=1.0e+01, delta=0.006, max(|grad|)=261.122944 [DEC:1]
2015-08-21T14:45:31:   Iteration  26: -logL=108956.403, Lambda=1.0e+00, delta=-1.164, max(|grad|)=795.467853 [DEC:1] (stalled)
2015-08-21T14:47:05:   Iteration  27: -logL=108956.403, Lambda=1.0e+01, delta=-0.032, max(|grad|)=-302.539921 [DEC:1] (stalled)
2015-08-21T14:48:49:  >Iteration  28: -logL=108956.368, Lambda=1.0e+02, delta=0.035, max(|grad|)=202.644334 [DEC:1]
2015-08-21T14:50:27:   Iteration  29: -logL=108956.368, Lambda=1.0e+01, delta=-0.008, max(|grad|)=-229.737232 [DEC:1] (stalled)
2015-08-21T14:52:12:  >Iteration  30: -logL=108956.347, Lambda=1.0e+02, delta=0.021, max(|grad|)=157.438869 [DEC:1]
2015-08-21T14:53:56:  >Iteration  31: -logL=108956.340, Lambda=1.0e+01, delta=0.007, max(|grad|)=-169.521882 [DEC:1]
2015-08-21T14:55:35:   Iteration  32: -logL=108956.340, Lambda=1.0e+00, delta=-2.594, max(|grad|)=444.524648 [DEC:1] (stalled)
2015-08-21T14:57:10:   Iteration  33: -logL=108956.340, Lambda=1.0e+01, delta=-0.029, max(|grad|)=306.672572 [DEC:1] (stalled)
2015-08-21T14:58:49:  >Iteration  34: -logL=108956.316, Lambda=1.0e+02, delta=0.024, max(|grad|)=-117.537404 [DEC:1]
2015-08-21T15:00:29:   Iteration  35: -logL=108956.316, Lambda=1.0e+01, delta=-0.005, max(|grad|)=236.848867 [DEC:1] (stalled)
2015-08-21T15:02:12:  >Iteration  36: -logL=108956.302, Lambda=1.0e+02, delta=0.014, max(|grad|)=96.053356 [RA:0]
2015-08-21T15:03:53:  >Iteration  37: -logL=108956.293, Lambda=1.0e+01, delta=0.009, max(|grad|)=181.094062 [DEC:1]
2015-08-21T15:05:40:   Iteration  38: -logL=108956.293, Lambda=1.0e+00, delta=-2.074, max(|grad|)=147.701889 [DEC:1] (stalled)
2015-08-21T15:07:15:   Iteration  39: -logL=108956.293, Lambda=1.0e+01, delta=-0.029, max(|grad|)=-251.997590 [DEC:1] (stalled)
2015-08-21T15:08:54:  >Iteration  40: -logL=108956.277, Lambda=1.0e+02, delta=0.016, max(|grad|)=135.134822 [DEC:1]
2015-08-21T15:10:36:   Iteration  41: -logL=108956.277, Lambda=1.0e+01, delta=-0.004, max(|grad|)=-177.703403 [DEC:1] (stalled)
2015-08-21T15:12:14:  >Iteration  42: -logL=108956.267, Lambda=1.0e+02, delta=0.010, max(|grad|)=102.118817 [DEC:1]
2015-08-21T15:13:54:  >Iteration  43: -logL=108956.259, Lambda=1.0e+01, delta=0.009, max(|grad|)=-122.391464 [DEC:1]
2015-08-21T15:15:33:   Iteration  44: -logL=108956.259, Lambda=1.0e+00, delta=-2.033, max(|grad|)=659.108683 [DEC:1] (stalled)
2015-08-21T15:17:17:   Iteration  45: -logL=108956.259, Lambda=1.0e+01, delta=-0.029, max(|grad|)=275.529340 [DEC:1] (stalled)
2015-08-21T15:18:56:  >Iteration  46: -logL=108956.245, Lambda=1.0e+02, delta=0.013, max(|grad|)=87.118714 [RA:0]
2015-08-21T15:20:36:   Iteration  47: -logL=108956.245, Lambda=1.0e+01, delta=-0.004, max(|grad|)=200.456491 [DEC:1] (stalled)
2015-08-21T15:22:17:  >Iteration  48: -logL=108956.238, Lambda=1.0e+02, delta=0.008, max(|grad|)=75.336813 [RA:0]
2015-08-21T15:23:53:  >Iteration  49: -logL=108956.229, Lambda=1.0e+01, delta=0.008, max(|grad|)=145.054215 [DEC:1]
2015-08-21T15:25:37:   Iteration  50: -logL=108956.229, Lambda=1.0e+00, delta=-2.077, max(|grad|)=-254.272515 [DEC:1] (stalled)
2015-08-21T15:27:25:   Iteration  51: -logL=108956.229, Lambda=1.0e+01, delta=-0.029, max(|grad|)=-237.827189 [DEC:1] (stalled)
2015-08-21T15:29:05:  >Iteration  52: -logL=108956.219, Lambda=1.0e+02, delta=0.010, max(|grad|)=104.127190 [DEC:1]
2015-08-21T15:30:43:   Iteration  53: -logL=108956.219, Lambda=1.0e+01, delta=-0.004, max(|grad|)=-158.281731 [DEC:1] (stalled)
2015-08-21T15:32:23:  >Iteration  54: -logL=108956.213, Lambda=1.0e+02, delta=0.006, max(|grad|)=76.317731 [DEC:1]
2015-08-21T15:34:03:  >Iteration  55: -logL=108956.206, Lambda=1.0e+01, delta=0.007, max(|grad|)=-102.711962 [DEC:1]
2015-08-21T15:35:47:   Iteration  56: -logL=108956.206, Lambda=1.0e+00, delta=-1.761, max(|grad|)=753.001479 [DEC:1] (stalled)
2015-08-21T15:37:19:   Iteration  57: -logL=108956.206, Lambda=1.0e+01, delta=-0.032, max(|grad|)=269.654185 [DEC:1] (stalled)
2015-08-21T15:38:59:  >Iteration  58: -logL=108956.196, Lambda=1.0e+02, delta=0.010, max(|grad|)=73.088665 [RA:0]
2015-08-21T15:40:34:   Iteration  59: -logL=108956.196, Lambda=1.0e+01, delta=-0.005, max(|grad|)=185.786016 [DEC:1] (stalled)
2015-08-21T15:42:15:  >Iteration  60: -logL=108956.191, Lambda=1.0e+02, delta=0.005, max(|grad|)=62.420519 [RA:0]
2015-08-21T15:43:57:  >Iteration  61: -logL=108956.185, Lambda=1.0e+01, delta=0.006, max(|grad|)=127.568193 [DEC:1]
2015-08-21T15:45:43:   Iteration  62: -logL=108956.185, Lambda=1.0e+00, delta=-2.007, max(|grad|)=-436.839358 [DEC:1] (stalled)
2015-08-21T15:47:33:   Iteration  63: -logL=108956.185, Lambda=1.0e+01, delta=-0.034, max(|grad|)=-245.600053 [DEC:1] (stalled)
2015-08-21T15:49:12:  >Iteration  64: -logL=108956.176, Lambda=1.0e+02, delta=0.008, max(|grad|)=87.470588 [DEC:1]
2015-08-21T15:50:47:   Iteration  65: -logL=108956.176, Lambda=1.0e+01, delta=-0.006, max(|grad|)=-154.658341 [DEC:1] (stalled)
2015-08-21T15:52:20:  >Iteration  66: -logL=108956.172, Lambda=1.0e+02, delta=0.004, max(|grad|)=61.711204 [DEC:1]
2015-08-21T15:52:20:
2015-08-21T15:52:20:  +==================+
2015-08-21T15:52:20:  | Curvature matrix |
2015-08-21T15:52:20:  +==================+
2015-08-21T15:52:20:  === GMatrixSparse ===
2015-08-21T15:52:20:   Number of rows ............: 13
2015-08-21T15:52:20:   Number of columns .........: 13
2015-08-21T15:52:20:   Number of nonzero elements : 81
2015-08-21T15:52:20:   Number of allocated cells .: 593
2015-08-21T15:52:20:   Memory block size .........: 512
2015-08-21T15:52:20:   Sparse matrix fill ........: 0.47929
2015-08-21T15:52:20:   Pending element ...........: 0
2015-08-21T15:52:20:   Fill stack size ...........: 0 (none)
2015-08-21T15:52:20:   15839.7, -9820.18, -1.24854, -260.507, 837.681, -0.910593, 19.4204, 0, 0, -10.6466, 26.5364, 0, 0
2015-08-21T15:52:20:   -9820.18, 17709.6, 2.26539, 129.736, 31.9295, -20.1912, -72.4292, 0, 0, -31.9753, 92.9646, 0, 0
2015-08-21T15:52:20:   -1.24854, 2.26539, 0.494084, -0.161682, -1.55698, 0.013647, -0.0163916, 0, 0, -0.065022, 0.0423105, 0, 0
```

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2015-08-21T15:52:20:   -260.507, 129.736, -0.161682, 10731, 1352.88, -244.975, 121.064, 0, 0, 831.063, -879.816, 0, 0
2015-08-21T15:52:20:   837.681, 31.9295, -1.55698, 1352.88, 37436.6, -376.737, 6.83239, 0, 0, 1906.19, -2193.39, 0, 0
2015-08-21T15:52:20:   -0.910593, -20.1912, 0.013647, -244.975, -376.737, 56.3002, -118.254, 0, 0, 175.477, -270.351, 0, 0
2015-08-21T15:52:20:   19.4204, -72.4292, -0.0163916, 121.064, 6.83239, -118.254, 2784.35, 0, 0, 323.287, -1026.12, 0, 0
2015-08-21T15:52:20:   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
2015-08-21T15:52:20:   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
2015-08-21T15:52:20:   -10.6466, -31.9753, -0.065022, 831.063, 1906.19, 175.477, 323.287, 0, 0, 12175.4, -19490.1, 0, 0
2015-08-21T15:52:20:   26.5364, 92.9646, 0.0423105, -879.816, -2193.39, -270.351, -1026.12, 0, 0, -19490.1, 37417.1, 0, 0
2015-08-21T15:52:20:   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
2015-08-21T15:52:20:   0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
2015-08-21T15:54:00:
2015-08-21T15:54:00: +=========================================+
2015-08-21T15:54:00: | Maximum likelihood optimization results |
2015-08-21T15:54:00: +=========================================+
2015-08-21T15:54:00: === GOptimizerLM ===
2015-08-21T15:54:00:  Optimized function value ..: 108956.172
2015-08-21T15:54:00:  Absolute precision .....: 0.005
2015-08-21T15:54:00:  Acceptable value decrease .: 2
2015-08-21T15:54:00:  Optimization status .......: converged
2015-08-21T15:54:00:  Number of parameters ......: 13
2015-08-21T15:54:00:  Number of free parameters .: 9
2015-08-21T15:54:00:  Number of iterations ......: 66
2015-08-21T15:54:00:  Lambda ....................: 10
2015-08-21T15:54:00:  Maximum log likelihood ....: -108956.172
2015-08-21T15:54:00:  Observed events  (Nobs) ...: 16083.000
2015-08-21T15:54:00:  Predicted events (Npred) ..: 16069.565 (Nobs - Npred = 13.4354)
2015-08-21T15:54:00: === GModels ===
2015-08-21T15:54:00:  Number of models ..........: 2
2015-08-21T15:54:00:  Number of parameters ......: 13
2015-08-21T15:54:00: === GModelSky ===
2015-08-21T15:54:00:  Name ......................: Crab
2015-08-21T15:54:00:  Instruments ................: all
2015-08-21T15:54:00:  Instrument scale factors ..: unity
2015-08-21T15:54:00:  Observation identifiers ...: all
2015-08-21T15:54:00:  Model type ................: ExtendedSource
2015-08-21T15:54:00:  Model components ..........: "EllipticalGauss" * "PowerLaw" * "Constant"
2015-08-21T15:54:00:  Number of parameters ......: 9
2015-08-21T15:54:00:  Number of spatial par's ...: 5
2015-08-21T15:54:00:   RA .......................: 83.6417 +/- 0.00982085 [-360,360] deg (free,scale=1)
2015-08-21T15:54:00:   DEC ......................: 22.0147 +/- 0.00928538 [-90,90] deg (free,scale=1)
2015-08-21T15:54:00:   PA .......................: 46.0707 +/- 1.42317 [-360,360] deg (free,scale=1)
2015-08-21T15:54:00:   MajorRadius ..............: 0.400028 +/- 0.010374 [0.001,10] deg (free,scale=1)
2015-08-21T15:54:00:   MinorRadius ..............: 0.206587 +/- 0.00546521 [0.001,10] deg (free,scale=1)
2015-08-21T15:54:00:  Number of spectral par's ..: 3
2015-08-21T15:54:00:   Prefactor ................: 5.6221e-16 +/- 1.6123e-17 [1e-23,1e-13] ph/cm2/s/MeV (free,scale=1e-16,gradient)
2015-08-21T15:54:00:   Index ....................: -2.51816 +/- 0.0203739 [-0,-5]  (free,scale=-1,gradient)
2015-08-21T15:54:00:   PivotEnergy ..............: 300000 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
2015-08-21T15:54:00:  Number of temporal par's ..: 1
2015-08-21T15:54:00:   Normalization ............: 1 (relative value) (fixed,scale=1,gradient)
2015-08-21T15:54:00: === GCTAModelIrfBackground ===
2015-08-21T15:54:00:  Name ......................: Background model
2015-08-21T15:54:00:  Instruments ................: CTA
2015-08-21T15:54:00:  Instrument scale factors ..: unity
2015-08-21T15:54:00:  Observation identifiers ...: all
2015-08-21T15:54:00:  Model type ................: "PowerLaw" * "Constant"
2015-08-21T15:54:00:  Number of parameters ......: 4
2015-08-21T15:54:00:  Number of spectral par's ..: 3
2015-08-21T15:54:00:   Prefactor ................: 1.00587 +/- 0.0227185 [0.001,1000] ph/cm2/s/MeV (free,scale=1,gradient)
2015-08-21T15:54:00:   Index ....................: 0.00228971 +/- 0.012819 [-5,5]  (free,scale=1,gradient)
2015-08-21T15:54:00:   PivotEnergy ..............: 1e+06 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
2015-08-21T15:54:00:  Number of temporal par's ..: 1
2015-08-21T15:54:00:   Normalization ............: 1 (relative value) (fixed,scale=1,gradient)
```

History

#1 - 10/30/2015 12:39 AM - Knödlseder Jürgen

- Status changed from New to In Progress

I could reproduce the problem with a simple ctobssim run followed by ctlike.

#2 - 10/30/2015 09:42 AM - Knödlseder Jürgen

- % Done changed from 0 to 10

I verified that the elliptical Gaussian model is correctly normalized. Note that the normalization only is accurate in the small angle approximation.

I did a special run with a model where the major and minor axis are identical, and hence the position angle is fit. This went well:

```
2015-10-30T08:40:04: +==================================+
2015-10-30T08:40:04: | Maximum likelihood optimisation |
2015-10-30T08:40:04: +==================================+
2015-10-30T08:40:22:  >Iteration   0: -logL=107816.489, Lambda=1.0e-03
2015-10-30T08:40:45:  >Iteration   1: -logL=107811.316, Lambda=1.0e-03, delta=5.173, max(|grad|)=-39.237446 [MajorRadius:3]
2015-10-30T08:41:08:  >Iteration   2: -logL=107811.263, Lambda=1.0e-04, delta=0.053, max(|grad|)=3.248685 [RA:0]
2015-10-30T08:41:31:  >Iteration   3: -logL=107811.263, Lambda=1.0e-05, delta=0.000, max(|grad|)=-0.348673 [MajorRadius:3]
...
2015-10-30T08:41:54: +=========================================+
2015-10-30T08:41:54: | Maximum likelihood optimization results |
2015-10-30T08:41:54: +=========================================+
2015-10-30T08:41:54: === GOptimizerLM ===
2015-10-30T08:41:54:  Optimized function value ..: 107811.263
2015-10-30T08:41:54:  Absolute precision ........: 0.005
2015-10-30T08:41:54:  Acceptable value decrease .: 2
2015-10-30T08:41:54:  Optimization status .......: converged
2015-10-30T08:41:54:  Number of parameters ......: 13
2015-10-30T08:41:54:  Number of free parameters .: 8
2015-10-30T08:41:54:  Number of iterations ......: 3
2015-10-30T08:41:54:  Lambda ....................: 1e-06
2015-10-30T08:41:54:  Maximum log likelihood ....: -107811.263
2015-10-30T08:41:54:  Observed events  (Nobs) ...: 16051.000
2015-10-30T08:41:54:  Predicted events (Npred) ..: 16050.999 (Nobs - Npred = 0.000532591)
2015-10-30T08:41:54: === GModels ===
2015-10-30T08:41:54:  Number of models ..........: 2
2015-10-30T08:41:54:  Number of parameters ......: 13
2015-10-30T08:41:54: === GModelSky ===
2015-10-30T08:41:54:  Name ......................: Crab
2015-10-30T08:41:54:  Instruments ................: all
2015-10-30T08:41:54:  Instrument scale factors ..: unity
2015-10-30T08:41:54:  Observation identifiers ...: all
2015-10-30T08:41:54:  Model type ................: ExtendedSource
2015-10-30T08:41:54:  Model components ..........: "EllipticalGauss" * "PowerLaw" * "Constant"
2015-10-30T08:41:54:  Number of parameters ......: 9
2015-10-30T08:41:54:  Number of spatial par's ...: 5
2015-10-30T08:41:54:   RA .......................: 83.6201 +/- 0.00540797 [-360,360] deg (free,scale=1)
2015-10-30T08:41:54:   DEC ......................: 22.0229 +/- 0.00495831 [-90,90] deg (free,scale=1)
2015-10-30T08:41:54:   PA .......................: 45 [-360,360] deg (fixed,scale=1)
2015-10-30T08:41:54:   MajorRadius ..............: 0.198383 +/- 0.00435272 [0.001,10] deg (free,scale=1)
2015-10-30T08:41:54:   MinorRadius ..............: 0.197431 +/- 0.00433051 [0.001,10] deg (free,scale=1)
2015-10-30T08:41:54:  Number of spectral par's ..: 3
2015-10-30T08:41:54:   Prefactor ................: 5.65536e-16 +/- 1.34654e-17 [1e-23,1e-13] ph/cm2/s/MeV (free,scale=1e-16,gradient)
2015-10-30T08:41:54:   Index ....................: -2.47701 +/- 0.0183248 [-0,-5]  (free,scale=-1,gradient)
2015-10-30T08:41:54:   PivotEnergy ..............: 300000 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
2015-10-30T08:41:54:  Number of temporal par's ..: 1
2015-10-30T08:41:54:   Normalization ............: 1 (relative value) (fixed,scale=1,gradient)
2015-10-30T08:41:54: === GCTAModelIrfBackground ===
2015-10-30T08:41:54:  Name ......................: Background
2015-10-30T08:41:54:  Instruments ................: CTA
2015-10-30T08:41:54:  Instrument scale factors ..: unity
2015-10-30T08:41:54:  Observation identifiers ...: all
2015-10-30T08:41:54:  Model type ................: "PowerLaw" * "Constant"
2015-10-30T08:41:54:  Number of parameters ......: 4
2015-10-30T08:41:54:  Number of spectral par's ..: 3
2015-10-30T08:41:54:   Prefactor ................: 1.00555 +/- 0.0222552 [0.001,1000] ph/cm2/s/MeV (free,scale=1,gradient)
2015-10-30T08:41:54:   Index ....................: 0.00812948 +/- 0.012662 [-5,5]  (free,scale=1,gradient)
```

```
2015-10-30T08:41:54:   PivotEnergy .............: 1e+06 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
2015-10-30T08:41:54:  Number of temporal par's ..: 1
2015-10-30T08:41:54:   Normalization ............: 1 (relative value) (fixed,scale=1,gradient)
```

#3 - 10/30/2015 09:56 AM - Knödlseder Jürgen

Fixing the position angle but having different sizes made the problem re-appear. The semiminor axis was 0.2, semimajor axis was 0.4.

#4 - 10/30/2015 10:11 AM - Knödlseder Jürgen

I was able to remove the convergence problems by limiting the theta_max to 2 times the semimajor axis value. This truncates the Gaussian quite a bit, but seriously helps the convergence. Limiting to 3 times did still produce a bunch of stalls.

So this is a kind of dirty fix as it does not guarantee that it will always work, and it may bias the fitted values somewhat. I'll check now the pull distributions for that.

```
2015-10-30T09:08:03: +==================================+
2015-10-30T09:08:03: | Maximum likelihood optimisation |
2015-10-30T09:08:03: +==================================+
2015-10-30T09:08:28:  >Iteration   0: -logL=108594.263, Lambda=1.0e-03
2015-10-30T09:08:54:  >Iteration   1: -logL=108573.932, Lambda=1.0e-03, delta=20.330, max(|grad|)=-593.564853 [MinorRadius:4]
2015-10-30T09:09:19:  >Iteration   2: -logL=108569.495, Lambda=1.0e-04, delta=4.437, max(|grad|)=-209.463817 [MinorRadius:4]
2015-10-30T09:09:44:  >Iteration   3: -logL=108568.824, Lambda=1.0e-05, delta=0.671, max(|grad|)=-56.621377 [MinorRadius:4]
2015-10-30T09:10:09:  >Iteration   4: -logL=108568.769, Lambda=1.0e-06, delta=0.055, max(|grad|)=-9.553020 [MinorRadius:4]
2015-10-30T09:10:35:  >Iteration   5: -logL=108568.766, Lambda=1.0e-07, delta=0.003, max(|grad|)=-2.084455 [MajorRadius:3]
...
2015-10-30T09:11:00: +=========================================+
2015-10-30T09:11:00: | Maximum likelihood optimization results |
2015-10-30T09:11:00: +=========================================+
2015-10-30T09:11:00: === GOptimizerLM ===
2015-10-30T09:11:00:  Optimized function value ..: 108568.766
2015-10-30T09:11:00:  Absolute precision ........: 0.005
2015-10-30T09:11:00:  Acceptable value decrease .: 2
2015-10-30T09:11:00:  Optimization status .......: converged
2015-10-30T09:11:00:  Number of parameters ......: 13
2015-10-30T09:11:00:  Number of free parameters .: 9
2015-10-30T09:11:00:  Number of iterations ......: 5
2015-10-30T09:11:00:  Lambda ....................: 1e-08
2015-10-30T09:11:00:  Maximum log likelihood ....: -108568.766
2015-10-30T09:11:00:  Observed events  (Nobs) ...: 15997.000
2015-10-30T09:11:00:  Predicted events (Npred) ..: 15996.994 (Nobs - Npred = 0.00569292)
2015-10-30T09:11:00: === GModels ===
2015-10-30T09:11:00:  Number of models ..........: 2
2015-10-30T09:11:00:  Number of parameters ......: 13
2015-10-30T09:11:00: === GModelSky ===
2015-10-30T09:11:00:  Name ......................: Crab
2015-10-30T09:11:00:  Instruments ...............: all
2015-10-30T09:11:00:  Instrument scale factors ..: unity
2015-10-30T09:11:00:  Observation identifiers ...: all
2015-10-30T09:11:00:  Model type ................: ExtendedSource
2015-10-30T09:11:00:  Model components ..........: "EllipticalGauss" * "PowerLaw" * "Constant"
2015-10-30T09:11:00:  Number of parameters ......: 9
2015-10-30T09:11:00:  Number of spatial par's ...: 5
2015-10-30T09:11:00:   RA .......................: 83.6225 +/- 0.00786815 [-360,360] deg (free,scale=1)
2015-10-30T09:11:00:   DEC ......................: 22.0224 +/- 0.0076174 [-90,90] deg (free,scale=1)
2015-10-30T09:11:00:   PA .......................: 46.9073 +/- 1.57835 [-360,360] deg (free,scale=1)
2015-10-30T09:11:00:   MajorRadius ..............: 0.421999 +/- 0.00760163 [0.001,10] deg (free,scale=1)
2015-10-30T09:11:00:   MinorRadius ..............: 0.218288 +/- 0.00384325 [0.001,10] deg (free,scale=1)
2015-10-30T09:11:00:  Number of spectral par's ..: 3
2015-10-30T09:11:00:   Prefactor ................: 6.13256e-16 +/- 1.6225e-17 [1e-23,1e-13] ph/cm2/s/MeV (free,scale=1e-16,gradient)
2015-10-30T09:11:00:   Index ....................: -2.48327 +/- 0.0194069 [-0,-5]  (free,scale=-1,gradient)
2015-10-30T09:11:00:   PivotEnergy ..............: 300000 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
2015-10-30T09:11:00:  Number of temporal par's ..: 1
2015-10-30T09:11:00:   Normalization ............: 1 (relative value) (fixed,scale=1,gradient)
2015-10-30T09:11:00: === GCTAModelIrfBackground ===
2015-10-30T09:11:00:  Name ......................: Background
```

```
2015-10-30T09:11:00:  Instruments ...............: CTA
2015-10-30T09:11:00:  Instrument scale factors ..: unity
2015-10-30T09:11:00:  Observation identifiers ...: all
2015-10-30T09:11:00:  Model type ................: "PowerLaw" * "Constant"
2015-10-30T09:11:00:  Number of parameters ......: 4
2015-10-30T09:11:00:  Number of spectral par's ..: 3
2015-10-30T09:11:00:   Prefactor ................: 1.04264 +/- 0.0227002 [0.001,1000] ph/cm2/s/MeV (free,scale=1,gradient)
2015-10-30T09:11:00:   Index ....................: 0.0229344 +/- 0.0125059 [-5,5]  (free,scale=1,gradient)
2015-10-30T09:11:00:   PivotEnergy ..............: 1e+06 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
2015-10-30T09:11:00:  Number of temporal par's ..: 1
2015-10-30T09:11:00:   Normalization ............: 1 (relative value) (fixed,scale=1,gradient)
```

#5 - 10/30/2015 10:20 AM - Knödlseder Jürgen

Limiting to 2.5 times the semimajor axis seams also okay. Let's take that.

#6 - 10/30/2015 02:28 PM - Knödlseder Jürgen

- % Done changed from 10 to 80

It looks like the problem came from using inconsistently small angle and full trigonometric computations. As I don't know how to do everything for full trigonometry I switched to small angle approximation and things behave much better. I selected a Gaussian cutoff of 3 sigma, as 2 sigma seems to overestimate the ellipse size.

Pull distributions will follow.

#7 - 10/30/2015 02:54 PM - Knödlseder Jürgen

- % Done changed from 80 to 40

There are still problems with stalls.

I switch back to a cut-off value of 2.5 sigma, which seems to behave better, but there are still stalls.

I suspect that this comes from the IRF integration method which assumes spherical coordinates instead of a small angle approximation, however I cannot confirm this at this stage. I should try to use spherical coordinates consistently, but this needs more time. Unless there is a bias, it does not need to be fixed for release 1.0.

#8 - 10/30/2015 03:27 PM - Knödlseder Jürgen

Although the stalls do not disappear in all cases, I tested small and large ellipses and things look overall ok for 2.5.

#9 - 10/30/2015 10:42 PM - Knödlseder Jürgen

- Priority changed from Immediate to Normal

- % Done changed from 40 to 50

But 2.5 looks biased in the size of the ellipse (which is too large), I therefore switched back to 3.0.

#10 - 10/06/2016 05:03 PM - Knödlseder Jürgen

- Target version set to 1.2.0

#11 - 03/03/2017 10:14 AM - Knödlseder Jürgen

- Target version changed from 1.2.0 to 1.3.0

#12 - 06/06/2017 11:08 PM - Knödlseder Jürgen

- Target version changed from 1.3.0 to 1.4.0

#13 - 07/31/2017 11:07 PM - Knödlseder Jürgen

- Target version deleted (1.4.0)