

GammaLib - Action #1303

Improve fitting convergence behavior for shell models

07/28/2014 08:54 PM - Knödlseeder Jürgen

Status:	Closed	Start date:	07/28/2014
Priority:	Normal	Due date:	
Assigned To:	Knödlseeder Jürgen	% Done:	100%
Category:		Estimated time:	0.00 hour
Target version:	00-09-00		
Description			
The shell model fit requires a large number of iterations, indicating problem with convergence which are likely related to numerical noise in the computation of the spatial parameter gradients (see #1299). The convergence behavior of the model should be improved.			
Related issues:			
Related to GammaLib - Bug # 1299: Fitting problems with radial disk model		Closed	07/25/2014

History

#1 - 10/29/2014 04:06 PM - Knödlseeder Jürgen

- Status changed from New to In Progress

- Assigned To set to Knödlseeder Jürgen

I studied the impact of the transition points in the integration scheme on the result. It turned out that the transition point related to the shell radius has not been set correctly (the shell radius was retrieved in degrees which the method expected a value in radians).

Originally, there was a single active transition point at $\text{transition_point} = \text{delta_max} - \text{zeta}$. This gave:

```
>Iteration 0: -logL=35267.348, Lambda=1.0e-03
Parameter "Width" drives optimization step (step=0.160656)
Parameter "Width" hits minimum: 0.01 < 0.01 (1)
Iteration 1: -logL=35267.348, Lambda=1.0e-03, delta=-46.510, max(|grad|)=16173.840440 [Width:3] (stalled)
Parameter "Width" does not drive optimization step anymore.
Parameter "Width" hits minimum: -0.419089 < 0.01 (2)
Iteration 2: -logL=35267.348, Lambda=1.0e-02, delta=-766.211, max(|grad|)=4695.710231 [Width:3] (stalled)
Parameter "Width" drives optimization step (step=0.29825)
Parameter "Width" hits minimum: 0.01 < 0.01 (3)
Iteration 3: -logL=35267.348, Lambda=1.0e-01, delta=-46.387, max(|grad|)=16942.638241 [Width:3] (stalled)
Parameter "Width" does not drive optimization step anymore.
Iteration 4: -logL=35267.348, Lambda=1.0e+00, delta=-29.779, max(|grad|)=4648.801580 [Width:3] (stalled)
>Iteration 5: -logL=35266.887, Lambda=1.0e+01, delta=0.461, max(|grad|)=1018.887844 [Width:3]
>Iteration 6: -logL=35260.439, Lambda=1.0e+00, delta=6.448, max(|grad|)=428.821260 [Radius:2]
>Iteration 7: -logL=35258.384, Lambda=1.0e-01, delta=2.055, max(|grad|)=349.658308 [Radius:2]
Iteration 8: -logL=35258.384, Lambda=1.0e-02, delta=-4.818, max(|grad|)=130.663905 [Radius:2] (stalled)
Iteration 9: -logL=35258.384, Lambda=1.0e-01, delta=-8.284, max(|grad|)=445.029473 [Width:3] (stalled)
Iteration 10: -logL=35258.384, Lambda=1.0e+00, delta=-0.831, max(|grad|)=189.062455 [Radius:2] (stalled)
>Iteration 11: -logL=35258.159, Lambda=1.0e+01, delta=0.225, max(|grad|)=213.675143 [Radius:2]
Iteration 12: -logL=35258.159, Lambda=1.0e+00, delta=-1.797, max(|grad|)=2028.395494 [Width:3] (stalled)
>Iteration 13: -logL=35258.089, Lambda=1.0e+01, delta=0.069, max(|grad|)=137.837075 [Radius:2]
Iteration 14: -logL=35258.089, Lambda=1.0e+00, delta=-0.125, max(|grad|)=514.946557 [Width:3] (stalled)
>Iteration 15: -logL=35258.057, Lambda=1.0e+01, delta=0.032, max(|grad|)=86.939405 [Radius:2]
>Iteration 16: -logL=35257.961, Lambda=1.0e+00, delta=0.096, max(|grad|)=78.540429 [Radius:2]
Iteration 17: -logL=35257.961, Lambda=1.0e-01, delta=-1.318, max(|grad|)=243.413734 [Width:3] (stalled)
Iteration 18: -logL=35257.961, Lambda=1.0e+00, delta=-0.075, max(|grad|)=197.304107 [Width:3] (stalled)
>Iteration 19: -logL=35257.950, Lambda=1.0e+01, delta=0.011, max(|grad|)=32.384030 [Radius:2]
Iteration 20: -logL=35257.950, Lambda=1.0e+00, delta=-0.015, max(|grad|)=125.138318 [Width:3] (stalled)
Iteration 21: -logL=35257.950, Lambda=1.0e+01, delta=-0.001, max(|grad|)=16.279204 [Radius:2] (stalled)
Iteration 22: -logL=35257.950, Lambda=1.0e+02, delta=-0.000, max(|grad|)=29.952981 [Radius:2] (stalled)
Iteration 23: -logL=35257.950, Lambda=1.0e+03, delta=-0.000, max(|grad|)=32.154405 [Radius:2] (stalled)
Iteration 24: -logL=35257.950, Lambda=1.0e+04, delta=-0.000, max(|grad|)=32.361191 [Radius:2] (stalled)
Iteration 25: -logL=35257.950, Lambda=1.0e+05, delta=-0.000, max(|grad|)=32.381748 [Radius:2] (stalled)
Iteration 26: -logL=35257.950, Lambda=1.0e+06, delta=-0.000, max(|grad|)=32.381526 [Radius:2] (stalled)
Iteration 27: -logL=35257.950, Lambda=1.0e+07, delta=-0.000, max(|grad|)=32.381506 [Radius:2] (stalled)
Iteration 28: -logL=35257.950, Lambda=1.0e+08, delta=-0.000, max(|grad|)=32.381501 [Radius:2] (stalled)
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Iteration 29: -logL=35257.950, Lambda=1.0e+09, delta=-0.000, max(|grad|)=32.381504 [Radius:2] (stalled)
=== GOptimizerLM ===
Optimized function value ...: 35257.950
Absolute precision .....: 0.005
Optimization status .....: stalled
Number of parameters .....: 13
Number of free parameters ..: 9
Number of iterations .....: 29
Lambda .....: 1e+10
Number of models .....: 2
Number of parameters .....: 13
=== GModelSky ===
Name .....: Gaussian Crab
Instruments .....: all
Instrument scale factors ...: unity
Observation identifiers ...: all
Model type .....: ExtendedSource
Model components .....: "ShellFunction" * "PowerLaw" * "Constant"
Number of parameters .....: 8
Number of spatial par's ...: 4
RA .....: 83.6324 +/- 0.00551318 [-360,360] deg (free,scale=1)
DEC .....: 22.0203 +/- 0.004991 [-90,90] deg (free,scale=1)
Radius .....: 0.280905 +/- 0.00712947 [0.01,10] deg (free,scale=1)
Width .....: 0.125087 +/- 0.00971526 [0.01,10] deg (free,scale=1)
Number of spectral par's ...: 3
Prefactor .....: 5.84407e-16 +/- 2.19786e-17 [1e-23,1e-13] ph/cm2/s/MeV (free,scale=1e-16,gradient)
Index .....: -2.44876 +/- 0.026312 [-0,-5] (free,scale=-1,gradient)
PivotEnergy .....: 300000 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
Number of temporal par's ...: 1
Constant .....: 1 (relative value) (fixed,scale=1,gradient)
=== GCTAModelRadialAcceptance ===
Name .....: Background
Instruments .....: CTA
Instrument scale factors ...: unity
Observation identifiers ...: all
Model type .....: "Gaussian" * "PowerLaw" * "Constant"
Number of parameters .....: 5
Number of radial par's .....: 1
Sigma .....: 3.03552 +/- 0.0398728 [0.01,10] deg2 (free,scale=1,gradient)
Number of spectral par's ...: 3
Prefactor .....: 6.00756e-05 +/- 1.79609e-06 [0,0.001] ph/cm2/s/MeV (free,scale=1e-06,gradient)
Index .....: -1.85691 +/- 0.0166786 [-0,-5] (free,scale=-1,gradient)
PivotEnergy .....: 1e+06 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
Number of temporal par's ...: 1
Constant .....: 1 (relative value) (fixed,scale=1,gradient)
Elapsed time .....: 115.498 sec

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Adding a transition point at transition_point = src_max - delta_max that takes care of the case that the Psf is fully contained in the model gave:

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>Iteration 0: -logL=35266.697, Lambda=1.0e-03
Parameter "Width" drives optimization step (step=0.220368)
Parameter "Width" hits minimum: 0.01 < 0.01 (1)
Iteration 1: -logL=35266.697, Lambda=1.0e-03, delta=-37.338, max(|grad|)=18086.039507 [Width:3] (stalled)
Parameter "Width" does not drive optimization step anymore.
Parameter "Width" hits minimum: -0.283135 < 0.01 (2)
Iteration 2: -logL=35266.697, Lambda=1.0e-02, delta=-598.127, max(|grad|)=8004.340348 [Width:3] (stalled)
Parameter "Width" drives optimization step (step=0.377765)
Parameter "Width" hits minimum: 0.01 < 0.01 (3)
Iteration 3: -logL=35266.697, Lambda=1.0e-01, delta=-36.883, max(|grad|)=19091.473377 [Width:3] (stalled)
Parameter "Width" does not drive optimization step anymore.
Iteration 4: -logL=35266.697, Lambda=1.0e+00, delta=-4.235, max(|grad|)=1228.332795 [Width:3] (stalled)
>Iteration 5: -logL=35265.425, Lambda=1.0e+01, delta=1.272, max(|grad|)=-778.103446 [Width:3]
>Iteration 6: -logL=35260.036, Lambda=1.0e+00, delta=5.389, max(|grad|)=404.556811 [Radius:2]
>Iteration 7: -logL=35259.115, Lambda=1.0e-01, delta=0.922, max(|grad|)=215.402269 [Width:3]
Iteration 8: -logL=35259.115, Lambda=1.0e-02, delta=-1.206, max(|grad|)=-708.637607 [Width:3] (stalled)
Iteration 9: -logL=35259.115, Lambda=1.0e-01, delta=-4.082, max(|grad|)=-658.710119 [Width:3] (stalled)
>Iteration 10: -logL=35259.102, Lambda=1.0e+00, delta=0.012, max(|grad|)=-163.582591 [Width:3]
Iteration 11: -logL=35259.102, Lambda=1.0e-01, delta=-3.654, max(|grad|)=-283.420540 [Width:3] (stalled)
>Iteration 12: -logL=35258.933, Lambda=1.0e+00, delta=0.169, max(|grad|)=110.089966 [Width:3]
Iteration 13: -logL=35258.933, Lambda=1.0e-01, delta=-1.349, max(|grad|)=274.215424 [Width:3] (stalled)
>Iteration 14: -logL=35258.895, Lambda=1.0e+00, delta=0.038, max(|grad|)=-74.399458 [Width:3]
Iteration 15: -logL=35258.895, Lambda=1.0e-01, delta=-8.898, max(|grad|)=-662.409464 [Width:3] (stalled)

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Iteration 16: -logL=35258.895, Lambda=1.0e+00, delta=-0.004, max(|grad|)=36.818054 [Width:3] (stalled)
>Iteration 17: -logL=35258.876, Lambda=1.0e+01, delta=0.019, max(|grad|)=-58.062935 [Width:3]
Iteration 18: -logL=35258.876, Lambda=1.0e+00, delta=-0.008, max(|grad|)=45.512503 [Width:3] (stalled)
>Iteration 19: -logL=35258.868, Lambda=1.0e+01, delta=0.008, max(|grad|)=-46.287111 [Width:3]
Iteration 20: -logL=35258.868, Lambda=1.0e+00, delta=-0.005, max(|grad|)=47.328912 [Width:3] (stalled)
>Iteration 21: -logL=35258.859, Lambda=1.0e+01, delta=0.009, max(|grad|)=-42.130132 [Width:3]
Iteration 22: -logL=35258.859, Lambda=1.0e+00, delta=-0.020, max(|grad|)=52.015101 [Width:3] (stalled)
>Iteration 23: -logL=35258.854, Lambda=1.0e+01, delta=0.005, max(|grad|)=-22.348328 [Width:3]
Iteration 24: -logL=35258.854, Lambda=1.0e+00, delta=-0.004, max(|grad|)=53.393351 [Width:3] (stalled)
>Iteration 25: -logL=35258.852, Lambda=1.0e+01, delta=0.002, max(|grad|)=8.995648 [Radius:2]
=== GOptimizerLM ===
Optimized function value ...: 35258.852
Absolute precision .....: 0.005
Optimization status .....: converged
Number of parameters .....: 13
Number of free parameters ..: 9
Number of iterations .....: 25
Lambda .....: 1
=== GModels ===
Number of models .....: 2
Number of parameters .....: 13
=== GModelSky ===
Name .....: Gaussian Crab
Instruments .....: all
Instrument scale factors ...: unity
Observation identifiers ...: all
Model type .....: ExtendedSource
Model components .....: "ShellFunction" * "PowerLaw" * "Constant"
Number of parameters .....: 8
Number of spatial par's ...: 4
RA .....: 83.632 +/- 0.00570752 [-360,360] deg (free,scale=1)
DEC .....: 22.0193 +/- 0.00513503 [-90,90] deg (free,scale=1)
Radius .....: 0.274423 +/- 0.0100412 [0.01,10] deg (free,scale=1)
Width .....: 0.133876 +/- 0.0136274 [0.01,10] deg (free,scale=1)
Number of spectral par's ...: 3
Prefactor .....: 5.86297e-16 +/- 2.20807e-17 [1e-23,1e-13] ph/cm2/s/MeV (free,scale=1e-16,gradient)
Index .....: -2.44825 +/- 0.0262896 [-0,-5] (free,scale=-1,gradient)
PivotEnergy .....: 300000 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
Number of temporal par's ...: 1
Constant .....: 1 (relative value) (fixed,scale=1,gradient)
=== GCTAModelRadialAcceptance ===
Name .....: Background
Instruments .....: CTA
Instrument scale factors ...: unity
Observation identifiers ...: all
Model type .....: "Gaussian" * "PowerLaw" * "Constant"
Number of parameters .....: 5
Number of radial par's ....: 1
Sigma .....: 3.03743 +/- 0.0399576 [0.01,10] deg2 (free,scale=1,gradient)
Number of spectral par's ...: 3
Prefactor .....: 5.9936e-05 +/- 1.79318e-06 [0,0.001] ph/cm2/s/MeV (free,scale=1e-06,gradient)
Index .....: -1.85782 +/- 0.0166832 [-0,-5] (free,scale=-1,gradient)
PivotEnergy .....: 1e+06 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
Number of temporal par's ...: 1
Constant .....: 1 (relative value) (fixed,scale=1,gradient)
Elapsed time .....: 122.346 sec

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After correcting the transition point related to the shell radius I got the following:

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>Iteration 0: -logL=35265.099, Lambda=1.0e-03
>Iteration 1: -logL=35261.796, Lambda=1.0e-03, delta=3.303, max(|grad|)=45.073735 [RA:0]
>Iteration 2: -logL=35261.742, Lambda=1.0e-04, delta=0.054, max(|grad|)=-12.689001 [RA:0]
>Iteration 3: -logL=35261.739, Lambda=1.0e-05, delta=0.003, max(|grad|)=3.982421 [RA:0]
=== GOptimizerLM ===
Optimized function value ...: 35261.739
Absolute precision .....: 0.005
Optimization status .....: converged
Number of parameters .....: 13
Number of free parameters ..: 9
Number of iterations .....: 3
Lambda .....: 1e-06
=== GModels ===

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Number of models .....: 2
Number of parameters .....: 13
=== GModelSky ===
Name .....: Gaussian Crab
Instruments .....: all
Instrument scale factors ...: unity
Observation identifiers ...: all
Model type .....: ExtendedSource
Model components .....: "ShellFunction" * "PowerLaw" * "Constant"
Number of parameters .....: 8
Number of spatial par's ...: 4
RA .....: 83.6326 +/- 0.00538575 [-360,360] deg (free,scale=1)
DEC .....: 22.0195 +/- 0.00484489 [-90,90] deg (free,scale=1)
Radius .....: 0.285584 +/- 0.0125695 [0.01,10] deg (free,scale=1)
Width .....: 0.116752 +/- 0.0182694 [0.05,10] deg (free,scale=1)
Number of spectral par's ...: 3
Prefactor .....: 5.81654e-16 +/- 2.19191e-17 [1e-23,1e-13] ph/cm2/s/MeV (free,scale=1e-16,gradient)
Index .....: -2.44849 +/- 0.0263003 [-0,-5] (free,scale=-1,gradient)
PivotEnergy .....: 300000 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
Number of temporal par's ...: 1
Constant .....: 1 (relative value) (fixed,scale=1,gradient)
=== GCTAModelRadialAcceptance ===
Name .....: Background
Instruments .....: CTA
Instrument scale factors ...: unity
Observation identifiers ...: all
Model type .....: "Gaussian" * "PowerLaw" * "Constant"
Number of parameters .....: 5
Number of radial par's .....: 1
Sigma .....: 3.03832 +/- 0.0399827 [0.01,10] deg2 (free,scale=1,gradient)
Number of spectral par's ...: 3
Prefactor .....: 5.98494e-05 +/- 1.78956e-06 [0,0.001] ph/cm2/s/MeV (free,scale=1e-06,gradient)
Index .....: -1.85884 +/- 0.0166747 [-0,-5] (free,scale=-1,gradient)
PivotEnergy .....: 1e+06 [10000,1e+09] MeV (fixed,scale=1e+06,gradient)
Number of temporal par's ...: 1
Constant .....: 1 (relative value) (fixed,scale=1,gradient)
Elapsed time .....: 40.805 sec

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This is perfect! So it was just a bug in the transition point computation.

#2 - 10/29/2014 04:14 PM - Knödseder Jürgen

- *Status changed from In Progress to Closed*
- *Target version set to 00-09-00*
- *% Done changed from 0 to 100*
- *Remaining (hours) set to 0.0*