GammaLib - Bug #2458

Extended model fits better than diffuse map

04/23/2018 05:21 PM - Knödlseder Jürgen

Status:	Closed	**Start date:**	04/23/2018
Priority:	Normal	**Due date:**	
Assigned To:	Knödlseder Jürgen	**% Done:**	100%
Category:		**Estimated time:**	0.00 hour
Target version:	1.6.0		

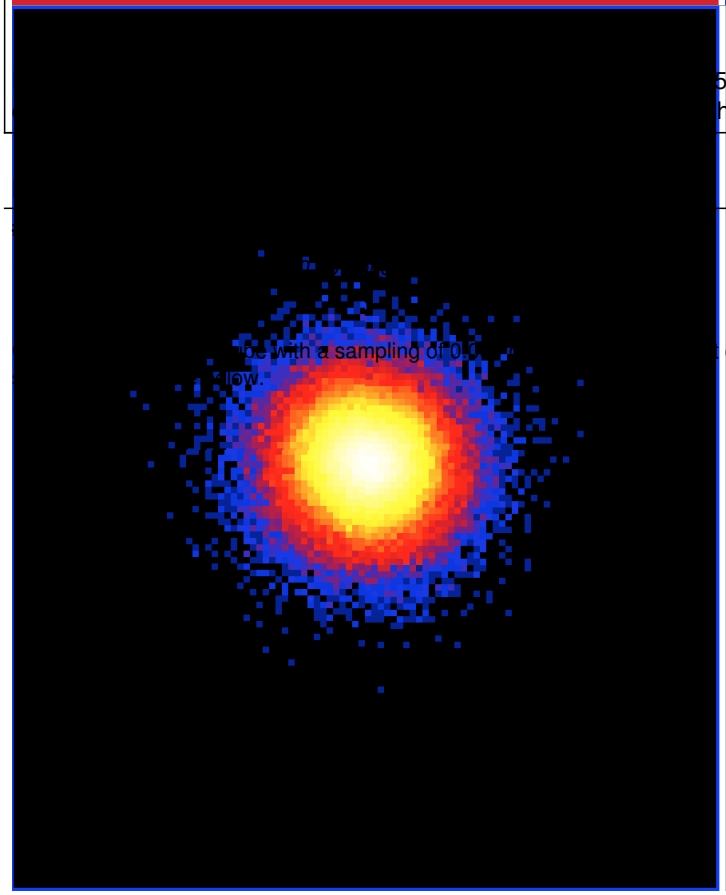
Description

Michele Fiori reported a problem where simulating events from a diffuse map and fitting the simulated events using different spatial models led to a strange behavior, where a extended source model fitted the data better than the original diffuse map from which the data were simulated.

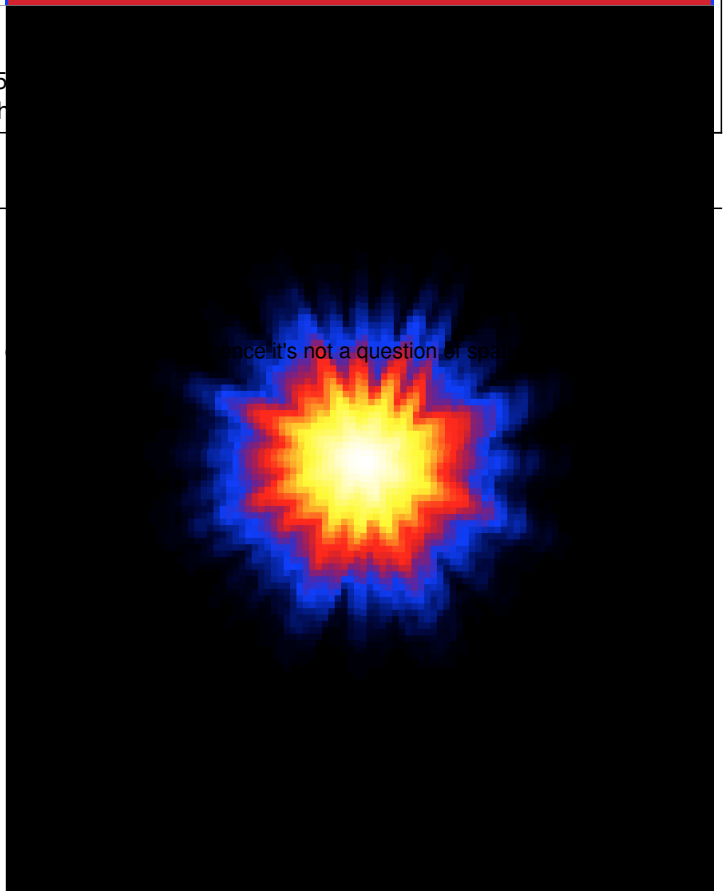
He sent a few residuals maps where some strange structures were present. I could reproduce the structures in the residual maps by simulating only source events (no background) for a simulation duration of 1 800 000 seconds. Below some residual maps for CAR and TAN projection with a spatial binning of 0.01 deg.

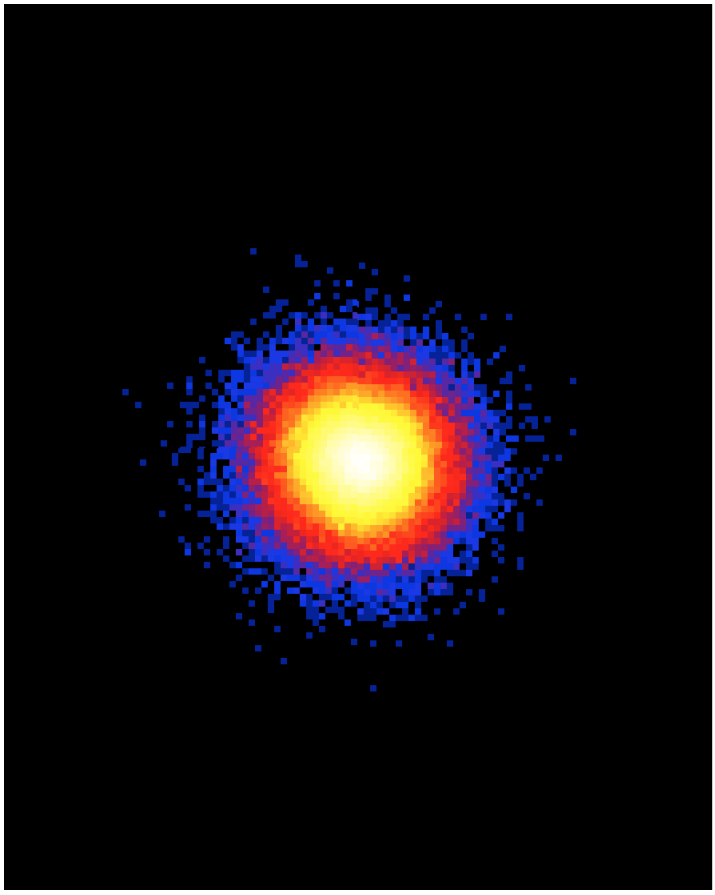
Below the corresponding counts map (left) and model map (right). The structure is only present in the model map while it is absent in the counts map. The problem seems to come from the modeling.

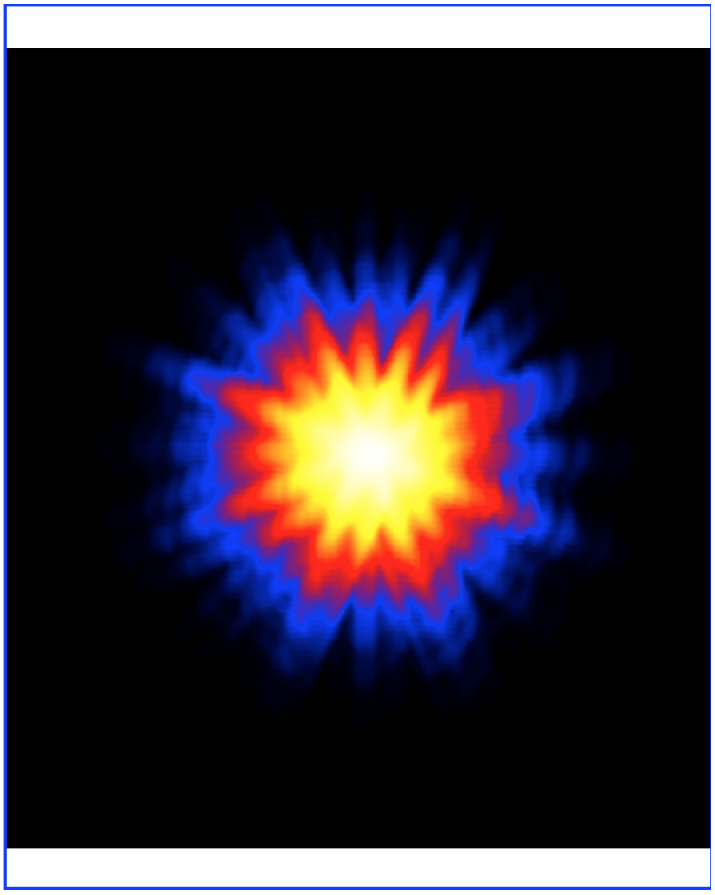
CAR



TAN







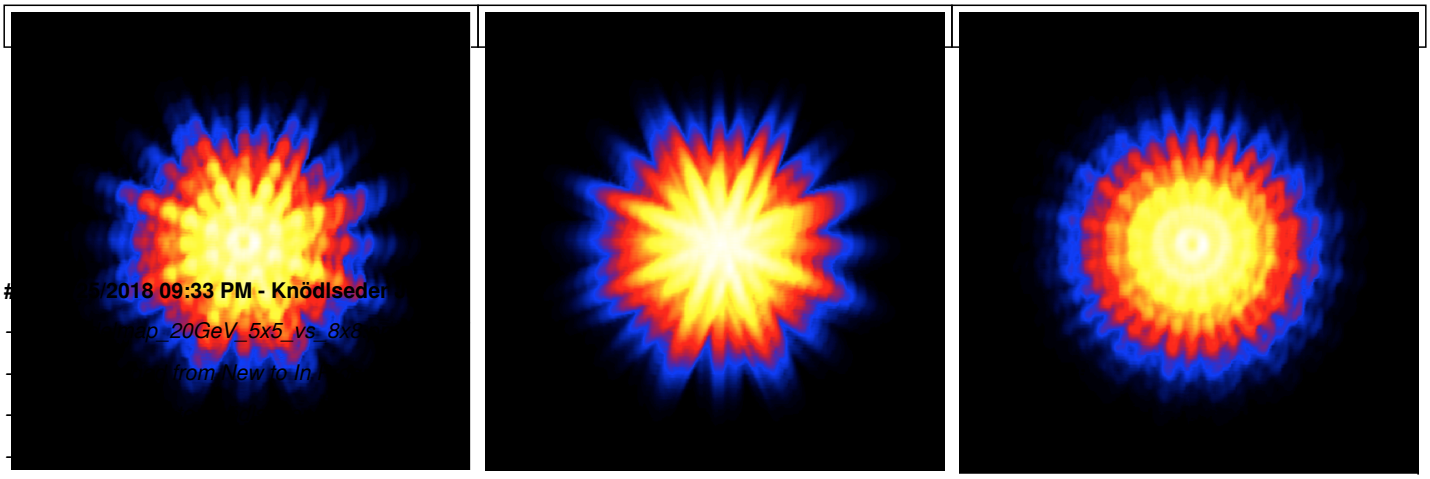
#2 - 04/24/2018 08:59 AM - Knödlseder Jürgen

- File modslice_1800000_tan_0.001_rho5_phi5.png added

- File modslice_1800000_tan_0.001_rho6_phi5.png added

- File modslice_1800000_tan_0.001_rho5_phi6.png added

The problem comes from the discret integration steps in GCTAResponseIrf::irf_diffuse, with the number of Romberg iterations in rho and phi fixed to 5, which corresponds to 16 integration steps in radius and azimuth. Below the resulting model map in the 100-140 GeV bin for rho=phi=5 (left, default), rho=6, phi=5 (centre) and rho=5, phi=6. Increasing the number of steps in the radial direction smoothes the result radially, but still leads to a star-like structure. Increasing the number of steps in the azimuthal direction doubles the number of azimuthal steps and hence reduces the star-like appearance of the model.



#3 - 05/2018 09:33 PM - Knödlseder

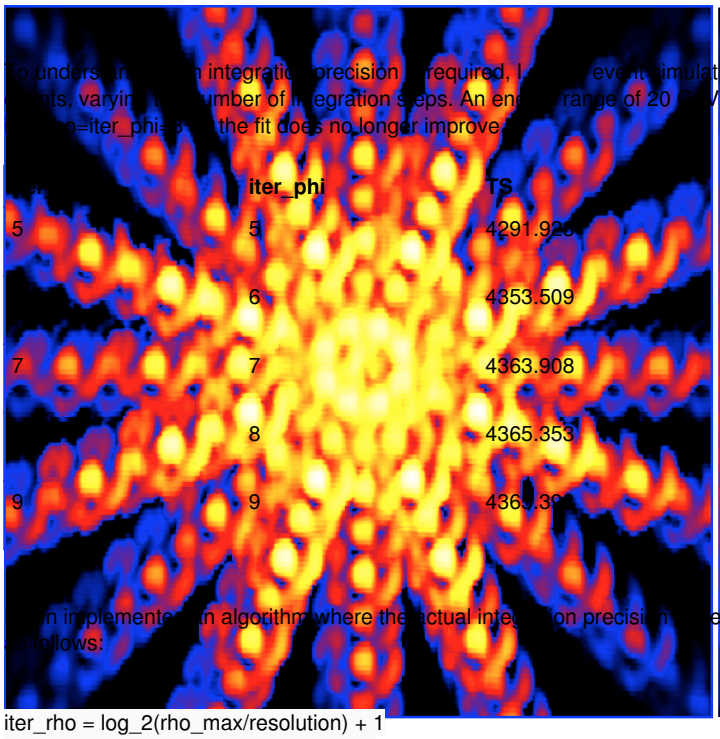
- File ...p_20GeV_5x5_vs_8x8.png added

- ... from New to In...

- % Done changed from 0 to 50

The problem arises in fact for sky maps that have a spatial resolution that is smaller than the CTA PSF. Due to the energy dependence this happens actually for many sky maps.

The left image below illustrated the problem. It shows a high-resolution model map for iter_rho=iter_phi=5 generate at 20 GeV, i.e. at an energy where the PSF is worst. At each point that was sampled, the image shows a little replica of the input sky map (a whirly structure around a spot). Increasing the number of iteration steps produces the image on the right. There is still some structure due to the discrete integration steps, but overall the model is now rather smooth.



To unders... integrati... precision is required, I ... event simulation and fitted the sky map using an unbinned analysis to the simulated ... ts, varyi... number of integration steps. An ene... range of 20 G... - 100 TeV was used. The results are summarized in the table below. For ... =iter_phi=... the fit does no longer improve.

...	iter_phi	TS	Prefactor	Index	CPU time
5	5	4291.92...	9.596e-18 +/- 3.612e-19	2.217 +/- 0.022	10.500 seconds
	6	4353.509	9.705e-18 +/- 3.645e-19	2.242 +/- 0.022	22.366 seconds
7	7	4363.908	9.722e-18 +/- 3.649e-19	2.247 +/- 0.022	70.653 seconds
	8	4365.353	9.723e-18 +/- 3.650e-19	2.247 +/- 0.022	235.604 seconds
9	9	4365.39...	9.723e-18 +/- 3.650e-19	2.247 +/- 0.022	928.304 seconds

... implemente... an algorithm where the actual integ... on precisi... ends on the spatial resolution of the map, computing iter_rho and iter_phi ... follows:

iter_rho = log_2(rho_max/resolution) + 1
iter_phi = log_2(2*pi*rho/resolution) + 1

and constraining the number of iterations to the interval [5,8].

I then validated the algorithm using the simulation of Michele. The table below shows the results. For reference, the fit with the old scheme is shown in the first row. The next three rows show the results of the new scheme with a maximum number of iterations set to 7, 8 and 9, respectively. Also here, the TS value and fit parameters converge for a value of 8, hence we retain this value for the code. Note that with the new scheme, the TS value for the radio map are now larger than the values for the point source, radial disk and Gaussian disk models.

Model	Scheme	TS	Prefactor	Index	Radius	CPU time
Radio map	5x5	14100.852	8.138e-19 +/- 1.195e-20	2.277 +/- 0.011		7.291 s
Radio map	max 7x7	14365.360	8.336e-19 +/- 1.212e-20	2.283 +/- 0.011		71.8693 s
Radio map	max 8x8	14363.749	8.337e-19 +/- 1.212e-20	2.283 +/- 0.011		129.999 s
Radio map	max 9x9	14363.853	8.337e-19 +/- 1.212e-20	2.283 +/- 0.011		158.459 s
Point source	-	13145.970	7.483e-19 +/- 1.150e-20	2.295 +/- 0.012		2.989 s
Radial disk	-	14307.270	8.272e-19 +/- 1.230e-20	2.285 +/- 0.011	0.047 +/- 0.001	32.247 s
Radial Gaussian	-	14322.504	8.298e-19 +/- 1.241e-20	2.283 +/- 0.011	0.0243 +/- 0.0007	89.717 s

#4 - 04/26/2018 10:24 AM - Knödlseder Jürgen

- Status changed from In Progress to Feedback

- % Done changed from 50 to 100

Merged code into devel.

#5 - 04/26/2018 12:29 PM - Knödlseder Jürgen

- Status changed from Feedback to Closed

Files

resmap_1800000_car-tan_0.01.png	72.3 KB	04/23/2018	Knödlseder Jürgen
cnt_vs_mod_map_1800000_tan_0.01.png	64.6 KB	04/23/2018	Knödlseder Jürgen
modmap_1800000_tan_0.001.png	178 KB	04/23/2018	Knödlseder Jürgen
modslice_1800000_tan_0.001_rho5_phi5.png	234 KB	04/24/2018	Knödlseder Jürgen
modslice_1800000_tan_0.001_rho6_phi5.png	234 KB	04/24/2018	Knödlseder Jürgen
modslice_1800000_tan_0.001_rho5_phi6.png	228 KB	04/24/2018	Knödlseder Jürgen
modelmap_20GeV_5x5_vs_8x8.png	1.01 MB	04/25/2018	Knödlseder Jürgen