Diffuse emission imaging with SPIROS

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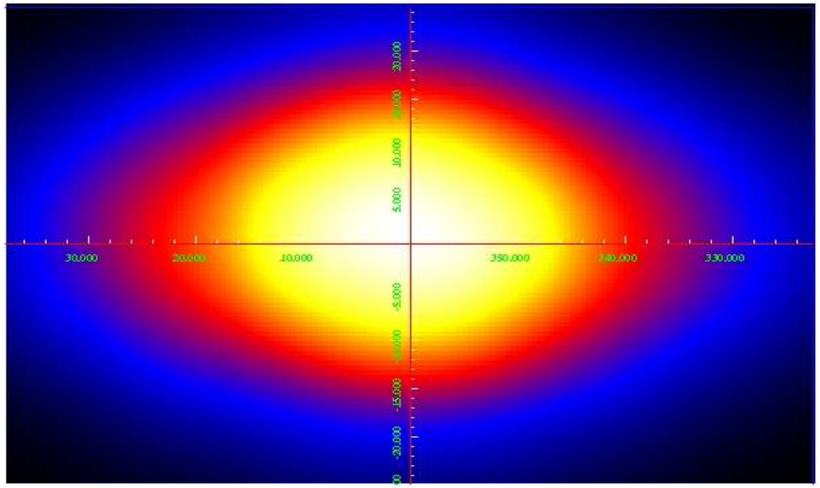
Diffuse emission imaging topics

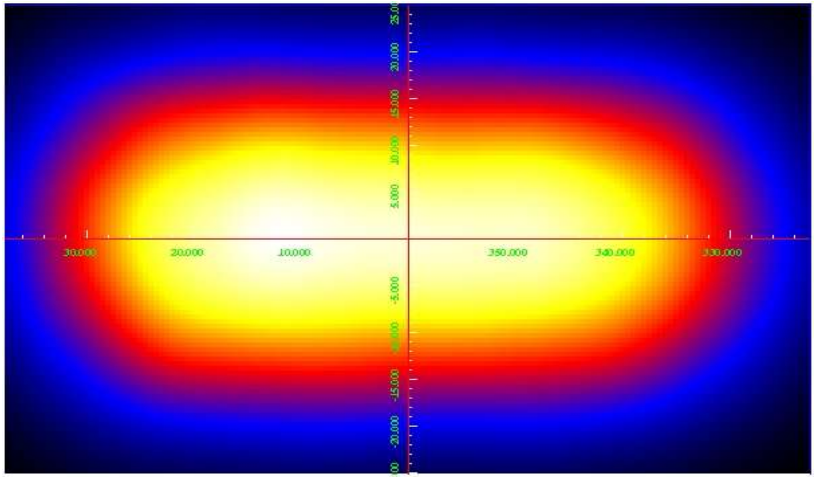
- Using SPIROS-9.0 for point/diffuse source imaging
- Selection of diffuse models via a source catalogue
- Varying diffuse source location and dimensions
- Searching for additional point sources
- Effects of background modelling
- Effects of detectors 2 and 17 failing
- Examples using GCDE observations of 511 keV line

GCDE observation data

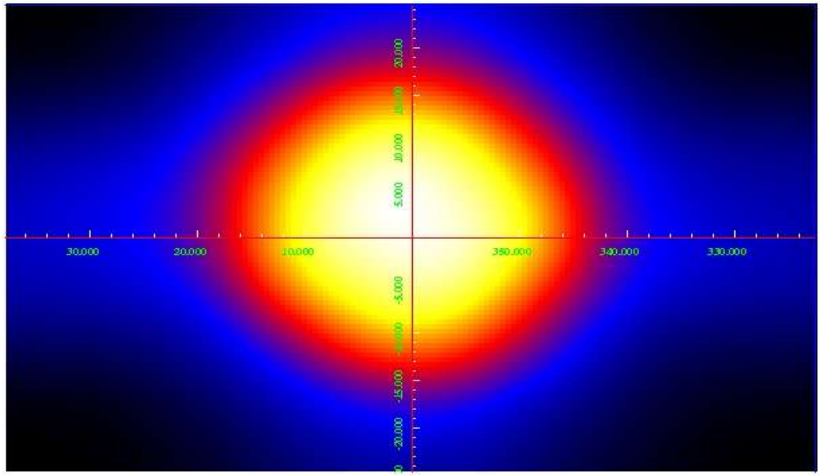
4080 exposures in a 509-513 keV bin
with GEDSAT+NO background tracer



GCDE-subset-1:
Orbit/exposure range: 46 / 96 - 123 / 105
2104 exposures covering 816 hours
All detectors functioning



GCDE-subset-2:
Orbit/exposure range: 163 / 54 - 243 / 114
1976 exposures covering 859 hours
1073 exposures without detector 2
903 exposures without detector 17



Mean count modulation background model

Assuming detector background $\mathbf{B(d,p)}$ can be modelled as a multiplicative function of the type $\mu_\mathbf{d}\mathbf{B_p}$ the coded mask count response to sources $\alpha_\mathbf{n}$ can be written as

$$\mathbf{C_{d,p}} = \mu_\mathbf{d}\,\mathbf{B_p} + \sum_\mathbf{n} \mathbf{M_{d,p,n}}\,\alpha_\mathbf{n} \quad (1)$$

The mean value over all detectors for each pointing is then

$$\overline{\mathbf{C}}_\mathbf{p} = \overline{\mu}\,\mathbf{B_p} + \sum_\mathbf{n} \overline{\mathbf{M}}_\mathbf{n,p}\,\alpha_\mathbf{n} \quad (2)$$

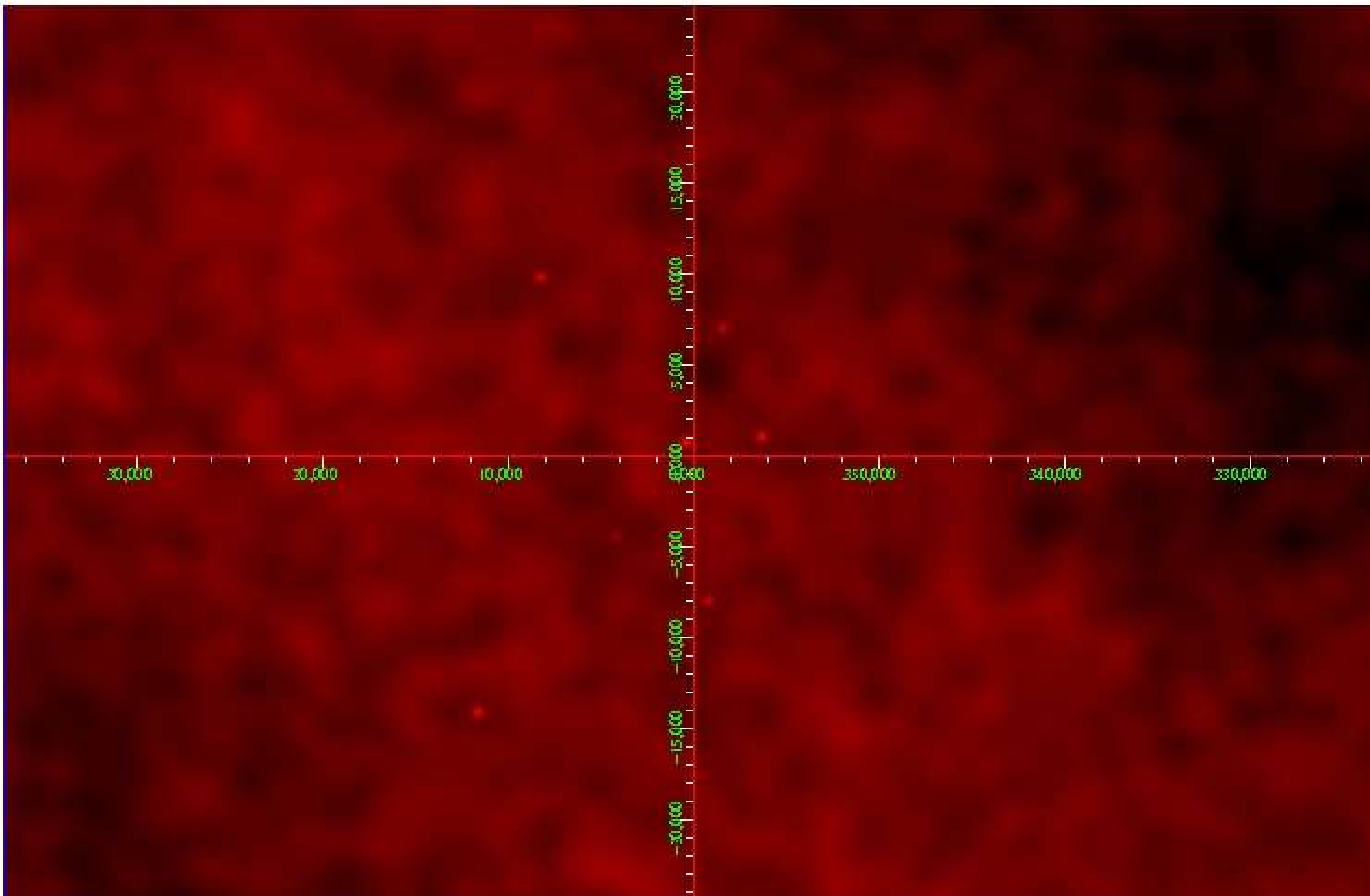
Multiplying by $\beta_\mathbf{d} = \mu_\mathbf{d}/\overline{\mu}$ the background can subtraced from (1) to give

$$\mathbf{C_{d,p}} - \beta_\mathbf{d}\,\overline{\mathbf{C}}_\mathbf{p} = \sum_\mathbf{n} \left[\mathbf{M_{d,p,n}} - \beta_\mathbf{d}\,\overline{\mathbf{M}}_\mathbf{n,p}\right]\alpha_\mathbf{n} \quad (3)$$

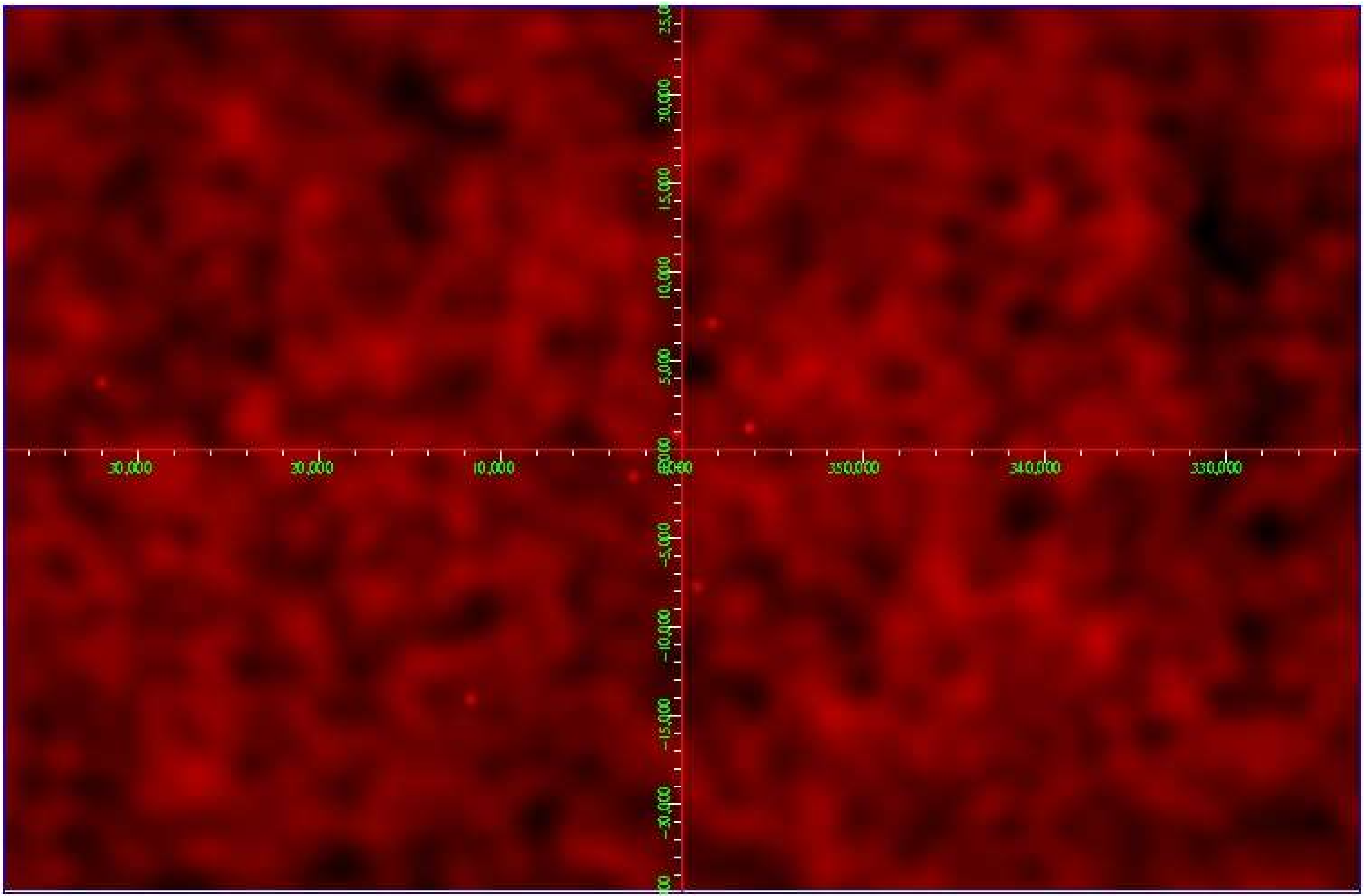
or the **MEAN COUNT MODULATION** background model equation

$$\mathbf{c_{d,p}}(\beta_\mathbf{d}) = \sum_\mathbf{n} \mathbf{m_{d,p,n}}(\beta_\mathbf{d})\,\alpha_\mathbf{n} \quad (4)$$

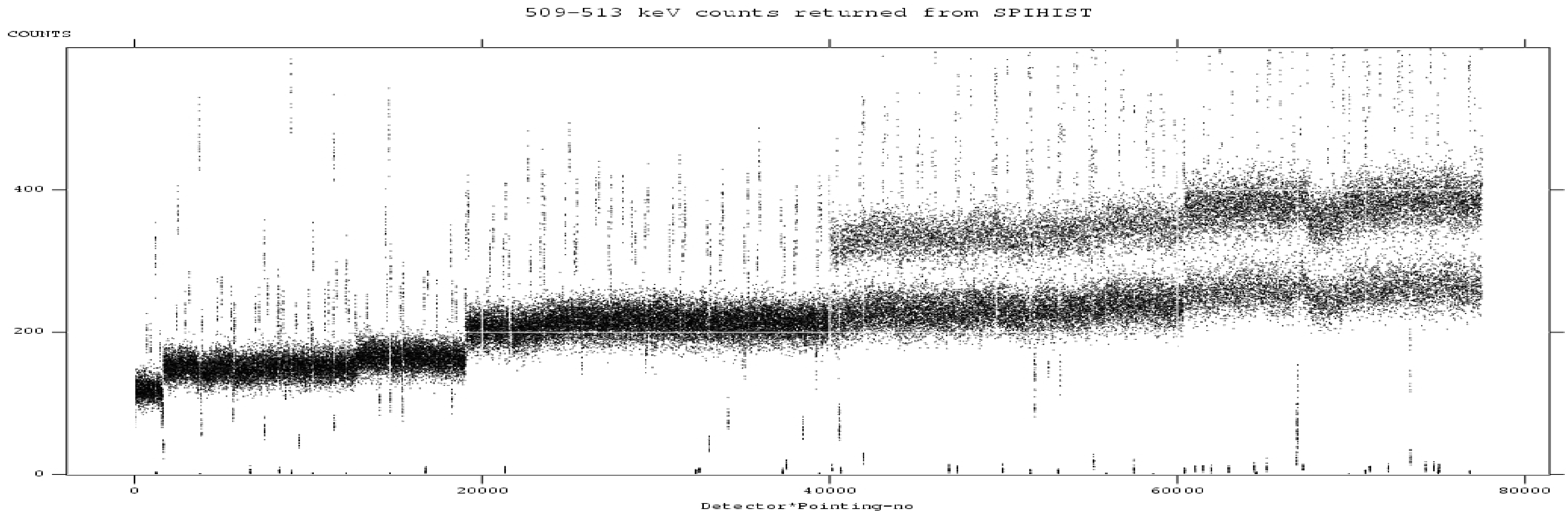
Point source location imaging with GEDSAT+NO background

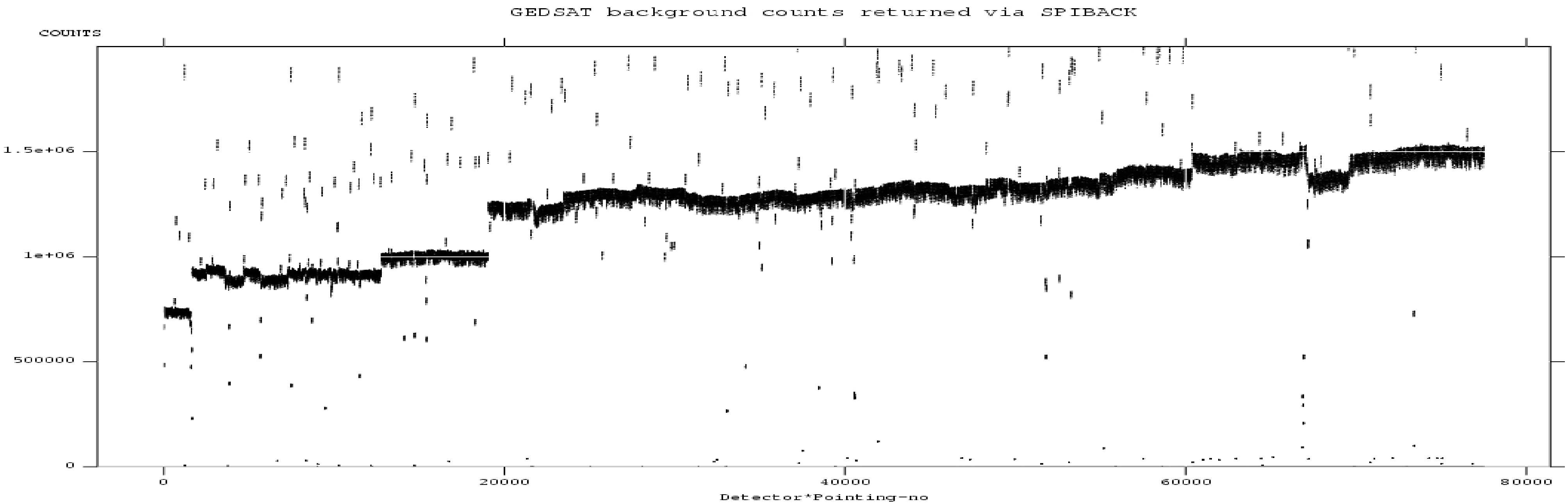


Point source location imaging with MCM background model

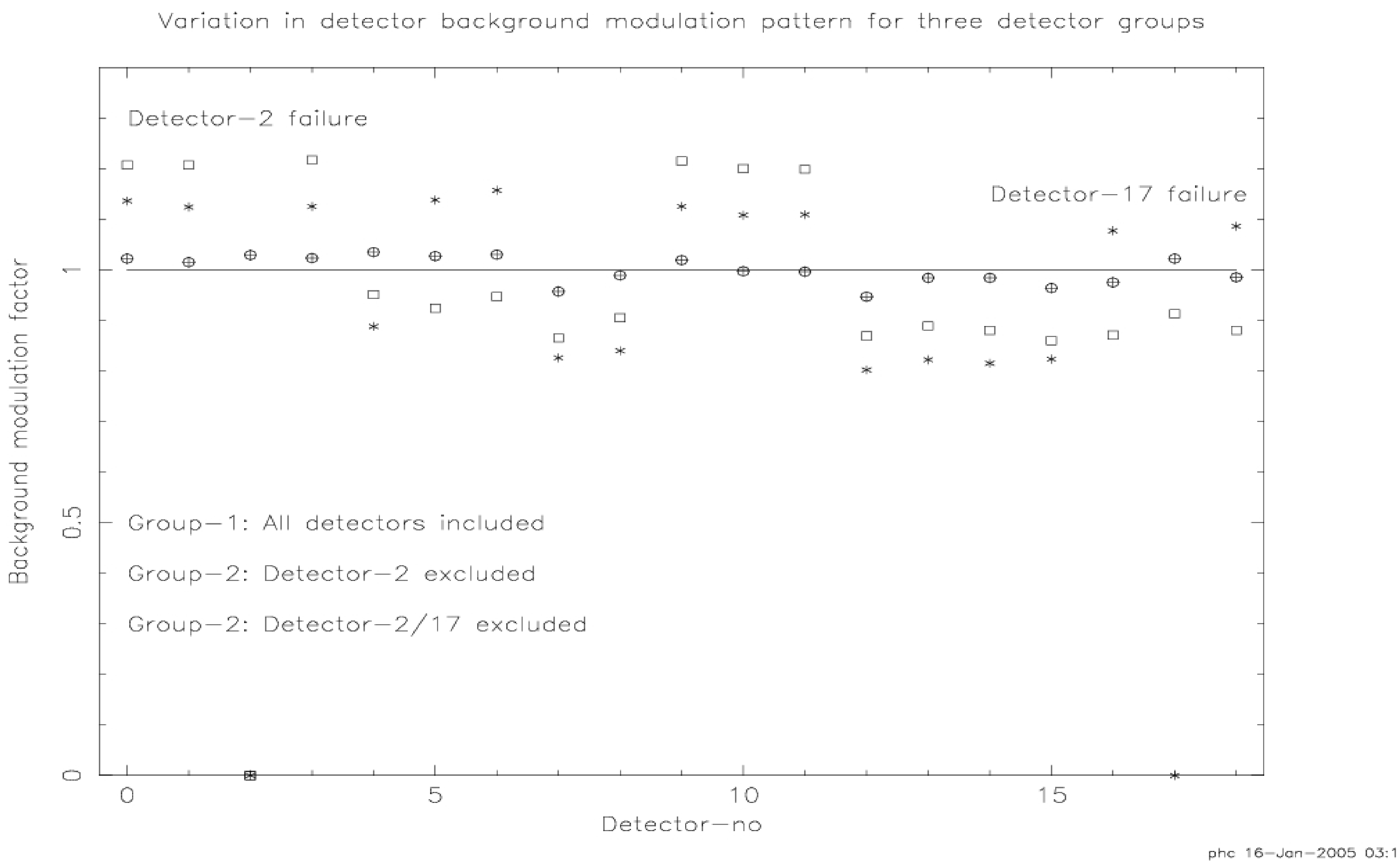


509-513 keV count data and GEDSAT+NO background tracer





Effect of detector failure on the background modulation pattern



Selecting a SPIROS diffuse model via a source catalogue

SPA_MODL

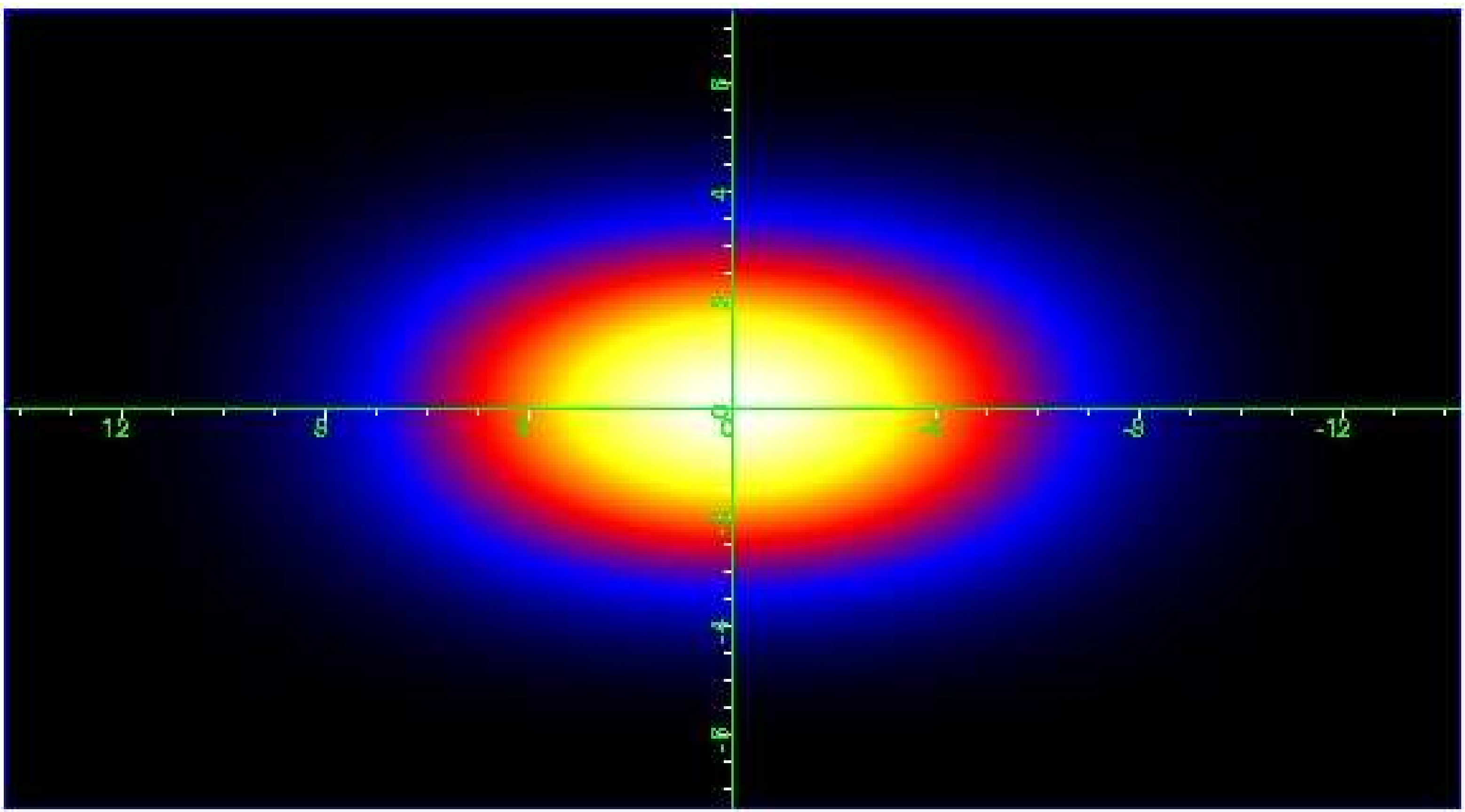
CUBIC-RADIAL-FLOC-FWID
CUBIC-ELLIPSE-VLOC-VWID
CUBIC-ELLIPSE-FLOC-VMAG

SPA_PARS

(1) X-fwhm
(2) Y-fwhm

SPA_NPAR

No of additional “rings”



Radial B-spline model of 511 keV emission with GEDSAT+NO background

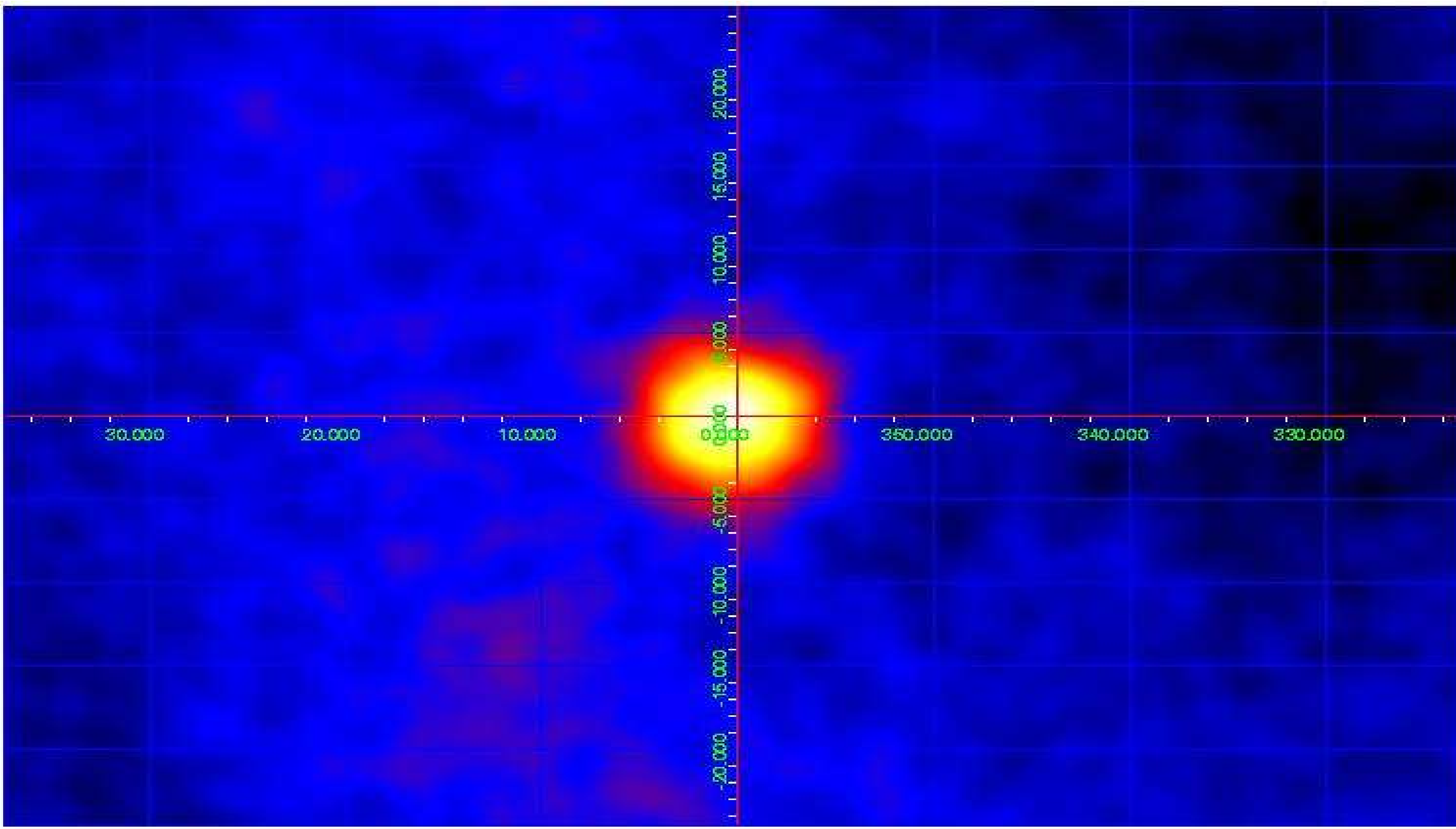
2104 exposures covering 816 hours in a 4 keV bin

Lcen: 0.54º ± 0.35 Bcen: -0.29º ± 0.41

Fwhm: 8.31º ± 1.0

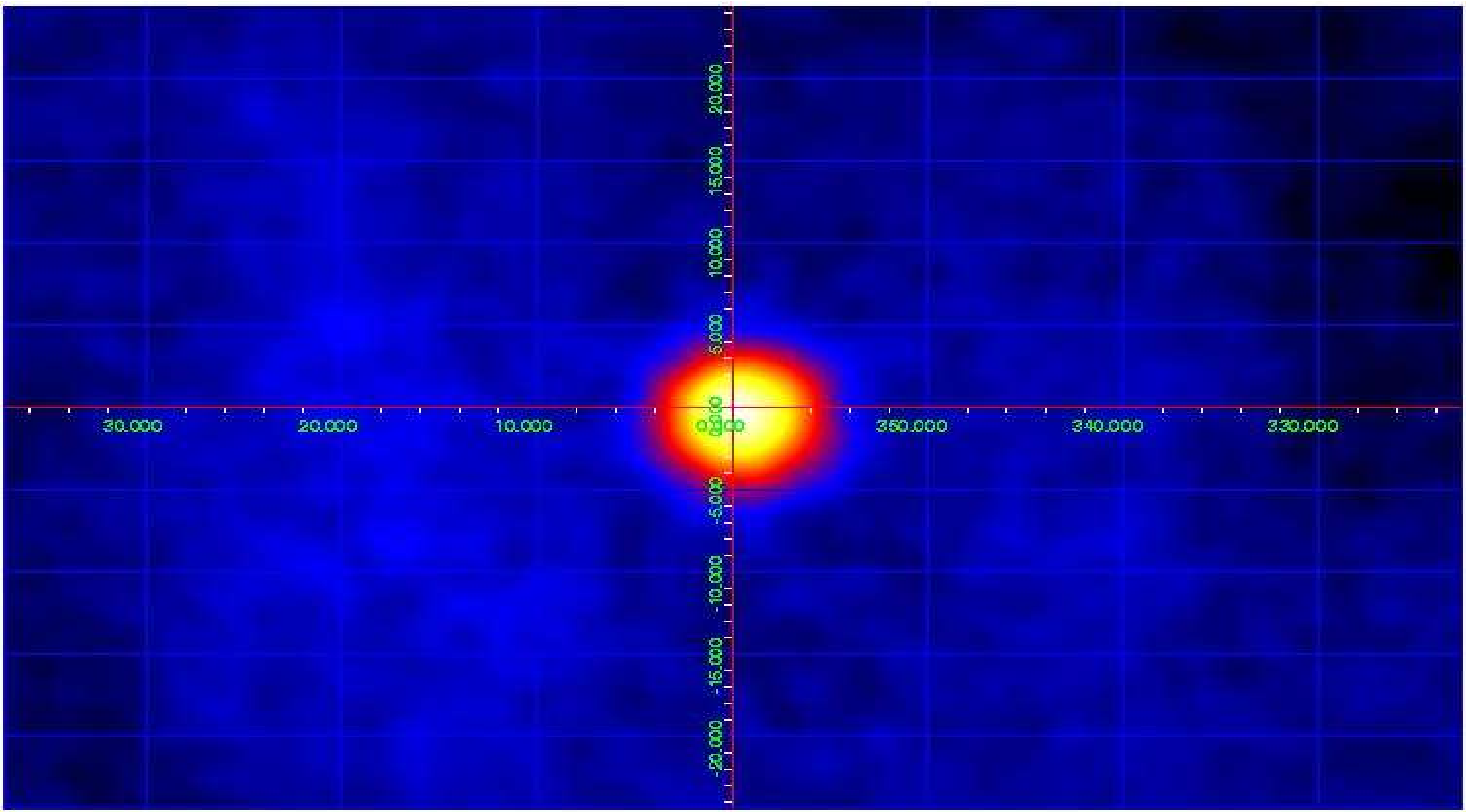
Flux: 7.97x10-3 ph/cm2/sec Sigma: 22.5

Residue cloud assymmetric with 1 or 2 significant hotspots



Radial B-spline model of 511 keV emission with GEDSAT+NO background

4080 exposures covering 1675 hours in 4 keV bin
Centrepoint, width, flux TBR
Asymmetry of residue cloud reduced along with hotspots



Radial B-spline model of 511keV emission with MCM background

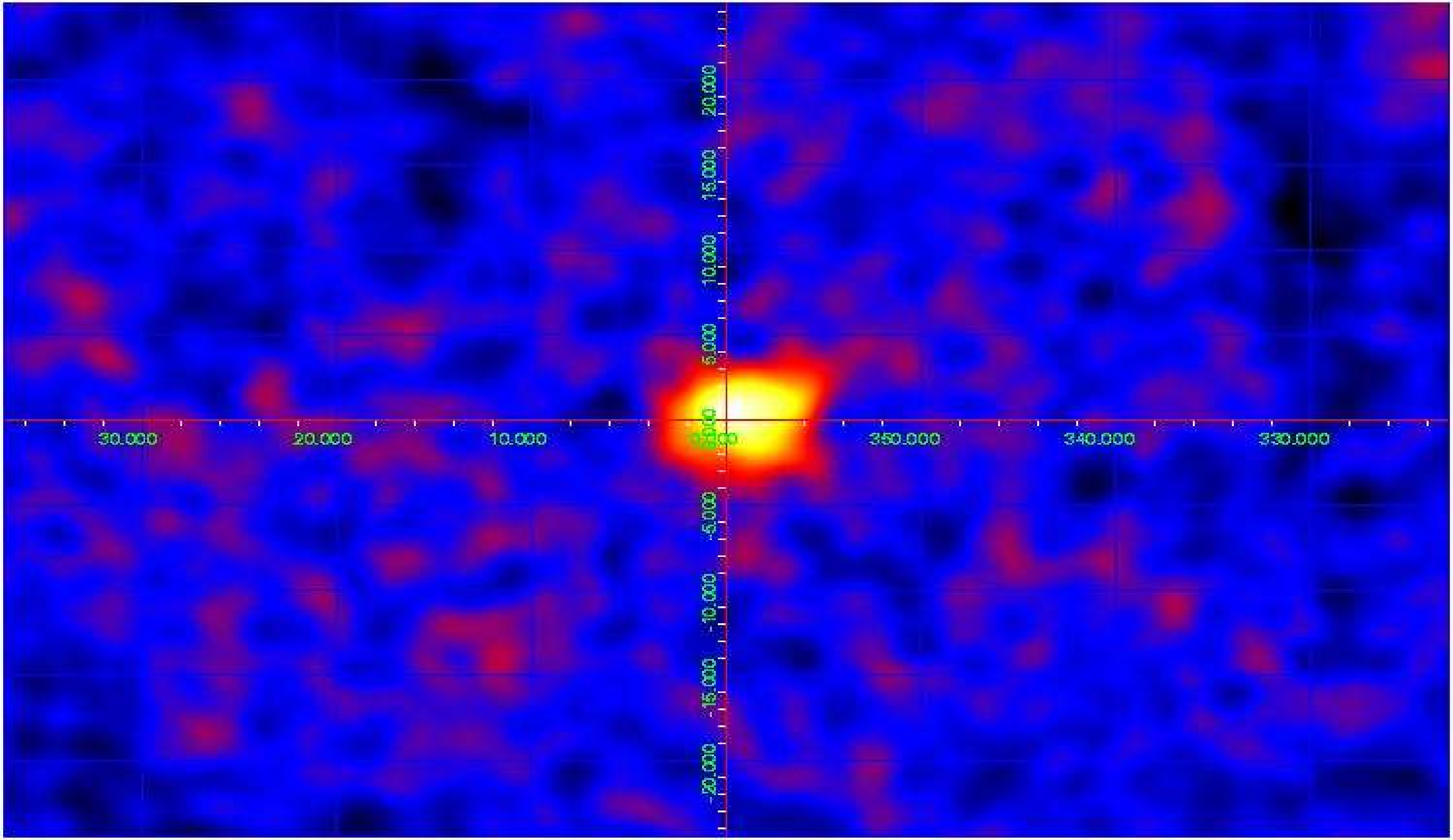
2014 exposures covering 816 hours in a 4 keV bin

Lcen: -0.89º ± 0.45 Bcen: 0.02º ± 0.44

Fwhm: 6.14º ± 1.55

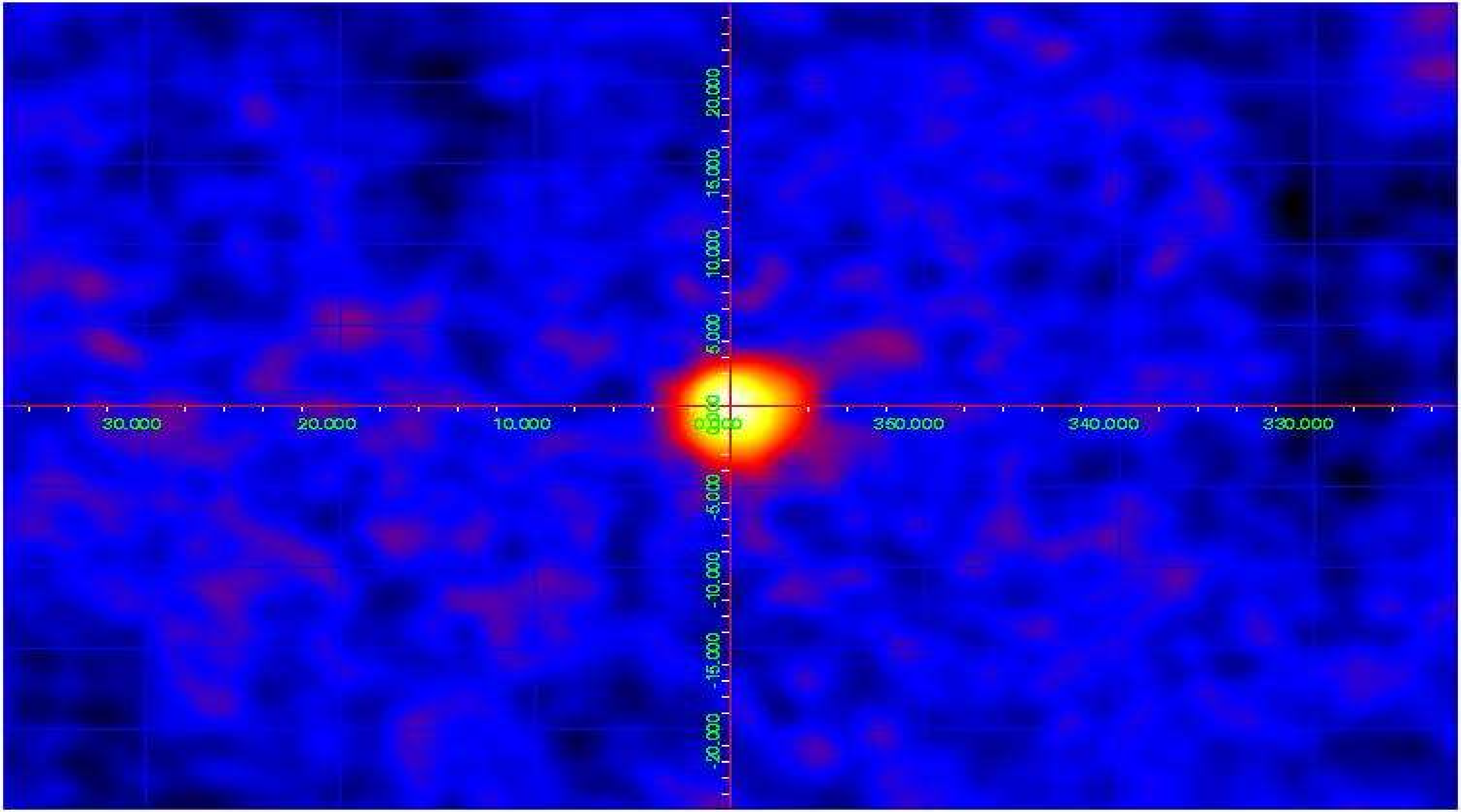
Flux: 6.3x10-4 ph/cm2/sec Sigma = 10.4

Residue cloud uniform with many significant hotspots



Radial B-spline model of 511keV emission with MCM background

4080 exposures covering 1675 hours in 4 keV bin
Location, width flux TBR
Residue cloud still uniform but with reduction in significant hotspots



Elliptical B-spline model of 511 keV emission with GEDSAT+NO background

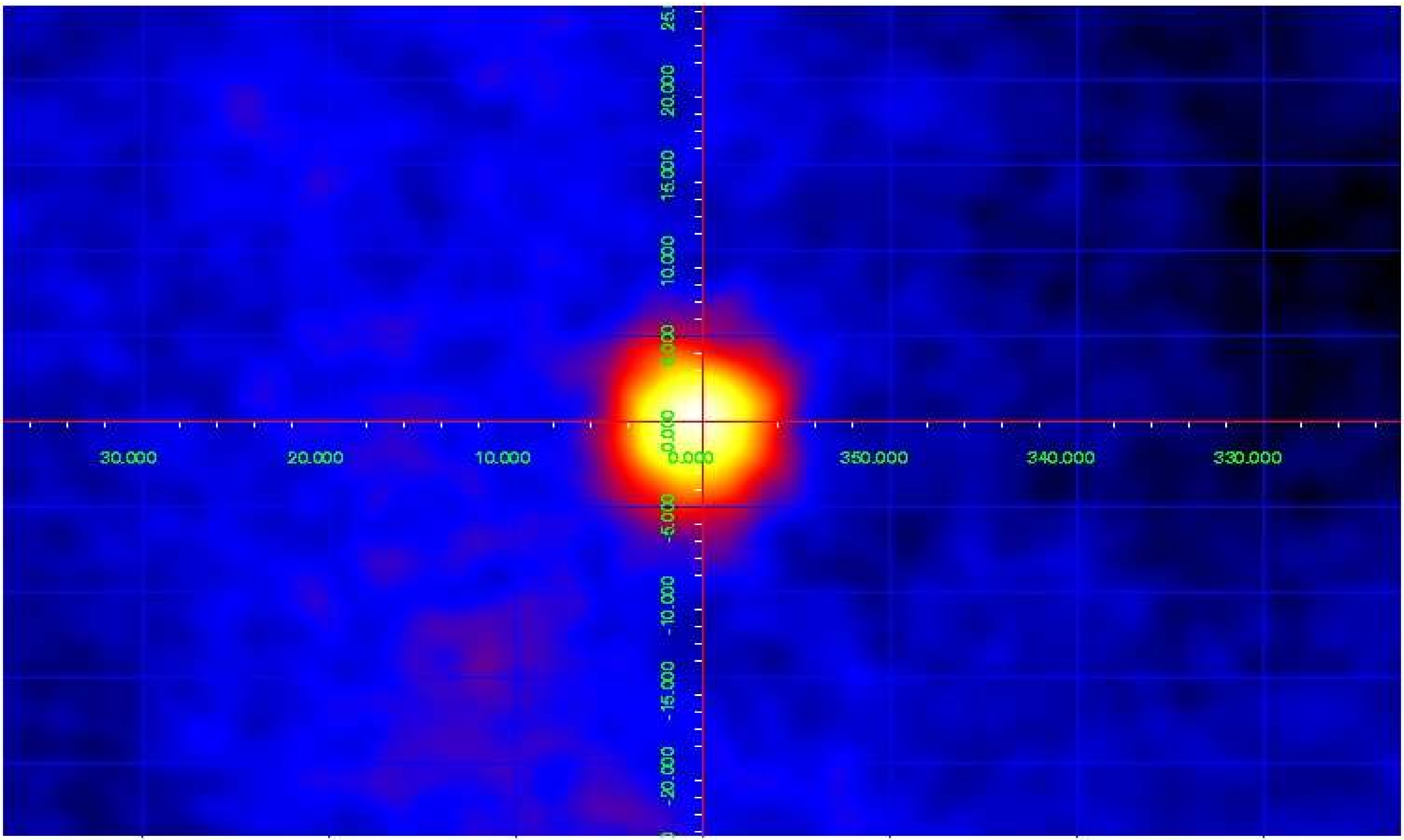
2104 exposures covering 816 hours in 4 keV bin

Lcen: 0.53º ± 0.35 Bcen: -0.33º ± 0.46

FWHX: 7.93º ± 1.0 FWHY: 9.03º ± 1.0

Flux: 8.0x10-4 ph/cm2/sec Sigma: 22.5

Residue cloud asymmetric with 1 or 2 significant hotspots



Elliptical B-spline model of 511 keV emission with MCM background

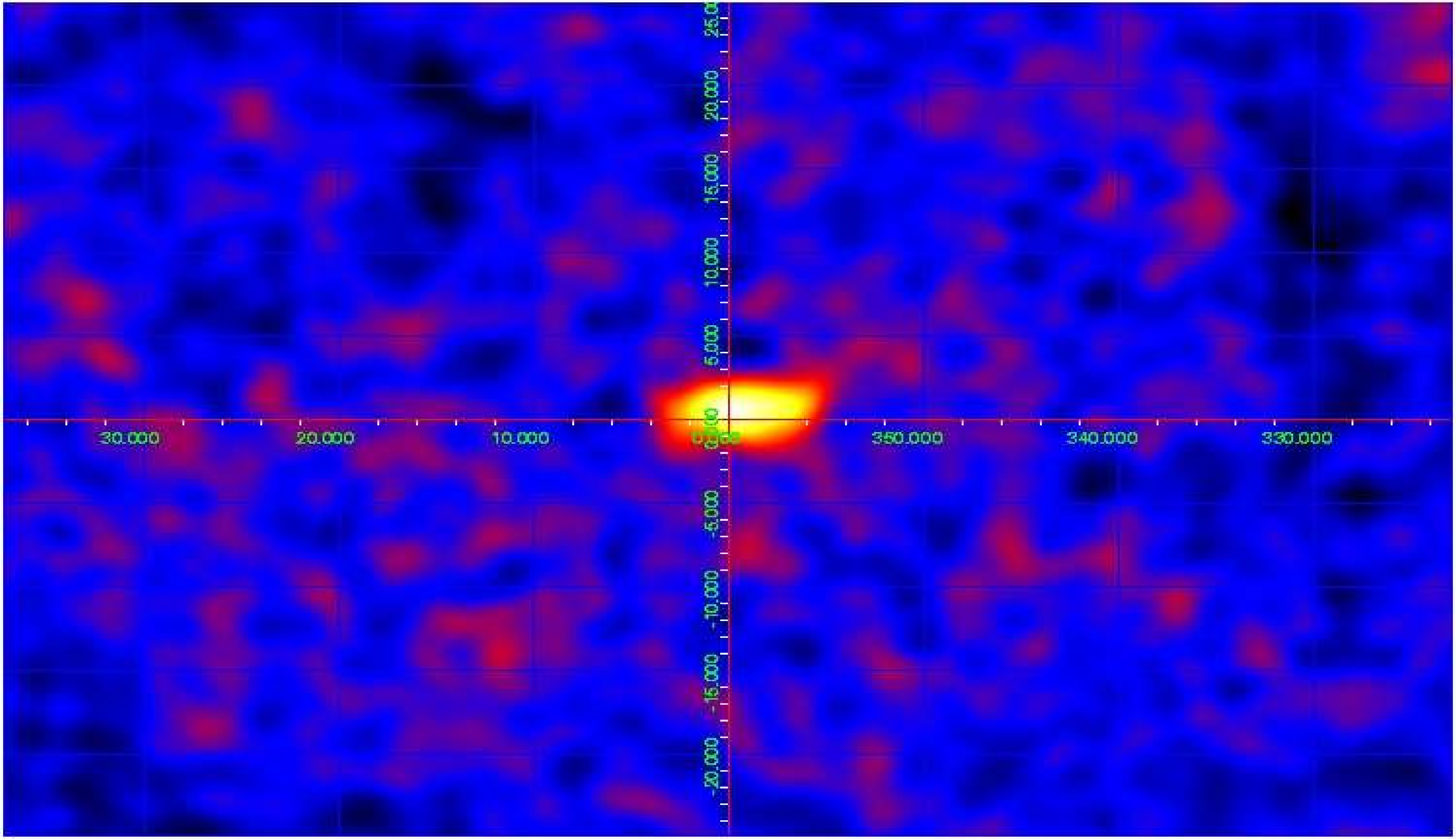
2104 exposures covering 816 hours in a 4 keV bin

Lcen: -0.80º ± 0.44 Bcen: 0.37º ± 0.34

FWHX: 6.50º ± 0.87 FWHY: 3.52º ± 1.54

Flux: 5.9x10-4 ph/cm2/sec Sigma: 10.5

Residue cloud uniform with multiple significant hotspots



Comparison of point source and diffuse emission models

GEDSAT+NO Source-name	Source L(deg)	location B (deg)	Separated Source flux (ph/cm2/sec)	Sigma	Combined Source flux (ph/cm2/sec)	Sigma	χ^2-values
SOURCE-1	0.432	0.680	0.2229E-03	7.3	0.1641E-03	4.1	40058 1.02 2.81
SOURCE-2	-3.648	0.963	0.1734E-03	6.0	0.1361E-03	4.1	
SOURCE-3	-0.791	-8.066	0.1409E-03	4.5	0.1152E-03	3.5	
SOURCE-4	-1.559	6.912	0.1245E-03	4.0	0.0974E-03	3.0	
SOURCE-5	11.617	-14.187	0.2015E-03	5.8	0.1983E-03	5.8	
SOURCE-6	4.178	-4.508	0.0576E-03	1.9	0.1842E-03	0.5	
SOURCE-7	8.272	9.702	0.1441E-03	4.9	0.1281E-03	4.3	
Radial spline	0.536	-0.292	0.7971E-03	22.5	0.2184E-03	2.3	40131 1.02 3.02

MCM-backgr Source-name	Source L(deg)	location B (deg)	Separated Source flux (ph/cm2/sec)	Sigma	Combined Source flux (ph/cm2/sec)	Sigma	χ^2-values
SOURCE-1	0.365	0.751	0.1748E-03	5.2	0.1439E-03	3.4	37293 1.0 0.46
SOURCE-2	-3.659	1.056	0.1604E-03	4.9	0.1358E-03	3.5	
SOURCE-3	-0.790	-7.887	0.1196E-03	3.4	0.1091E-03	3.0	
SOURCE-4	-1.635	6.950	0.1270E-03	3.6	0.1141E-03	3.1	
SOURCE-5	11.694	-14.227	0.1522E-03	3.5	0.1521E-03	3.5	
SOURCE-6	2.713	-1.664	0.1187E-03	3.6	0.1013E-03	2.8	
SOURCE-7	32.023	3.624	0.1461E-03	3.2	0.1471E-03	3.2	
Radial spline	-0.892	0.454	0.6302E-03	10.4	0.1298E-03	1.2	37345 1.0 0.60

Conclusions

- SPIROS-9.0 now allows the selection of diffuse emission ring models
- It can also combine this with the search for additional point sources
- Problems with general background modelling (MCM vs GEDSAT)
- Problems with effects of detector failure on background models
- For line emission models more GCDE data needed