

Internal INTEGRAL Workshop

held at ESTEC in Noordwijk, January 17-21, 2005

Saclay SPI data analysis program

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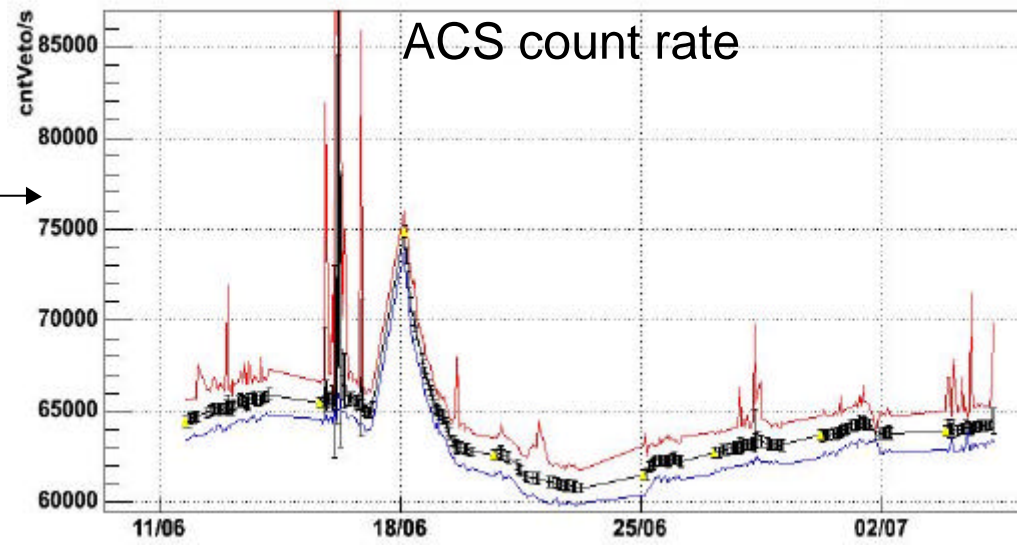
Search for ^{26}Al in Galactic Plane
Status of ^{26}Al search in Vela Region
(Vela “R_Sci” report)

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Vela observations: 2.2 Ms
 June 2003 (Rev 81 - 88)
 solar flare in Rev 82 →
 Nov 2003 (Rev 137 - 141)
 solar XRF in Rev 139
 loss of Ge 2 in Rev 140
 Useful observation time < 1 Ms



Data selection : Rev 40 - 139 (public data + ISWT data)

“Light Bucket” (sum counts of all detectors, 1 keV binned, per SCW)

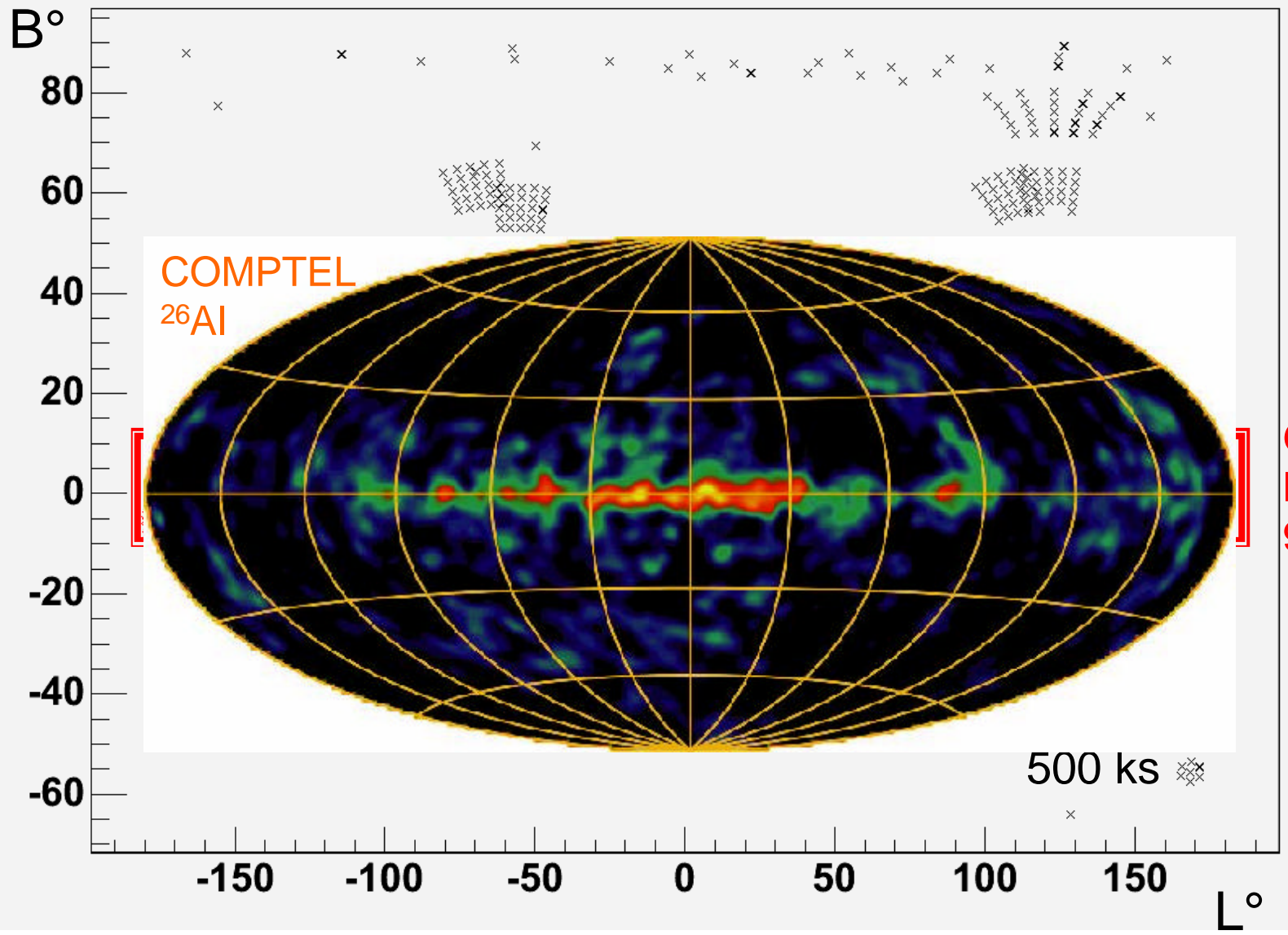
#SCW:	8719	All data	
	6613	Good quality	(Data, ScHK & IREM complete)
	6430	Temperature T0	84 - 86 K
	6017	PSAC activity	700 - 1000 counts/s (remove end of rev)
	5785	IREM protons 11-30 MeV	< 0.14 counts/s (remove solar flare)
	5606	PSAC activity	750 - 1000 counts/s (=)

1326	OffPlane	outside $-10^\circ < B < 10^\circ$	500 k
4280	GalPlane	inside $-10^\circ < B < 10^\circ$	9000 M
274	Vela	GalPlane & $-101^\circ < l < -89^\circ$	900

Distribution of pointings in Galactic coordinates

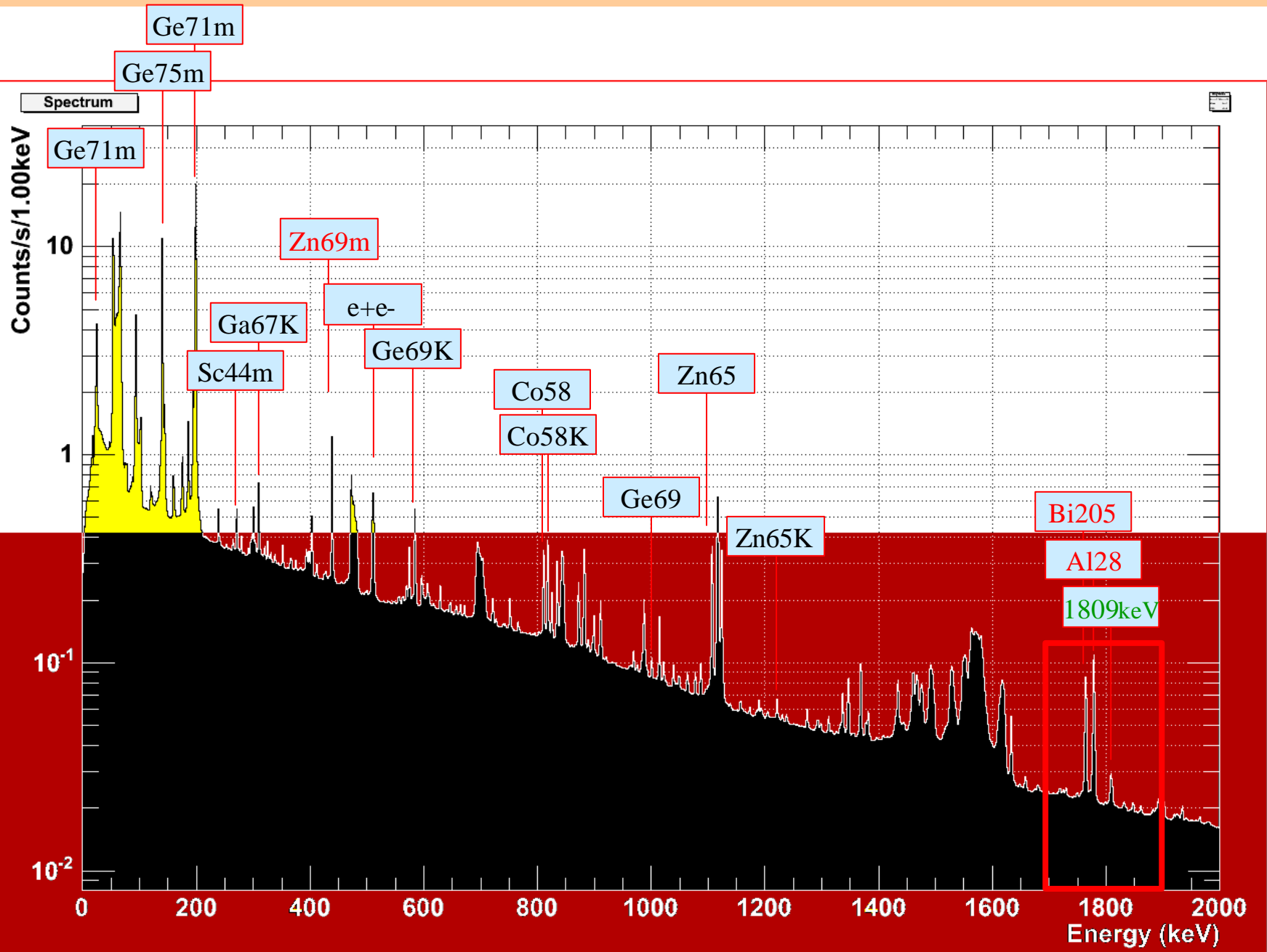
number of SCW: 5606

good time: 9500 ks



GalPlan
B=-10°
9000 ks

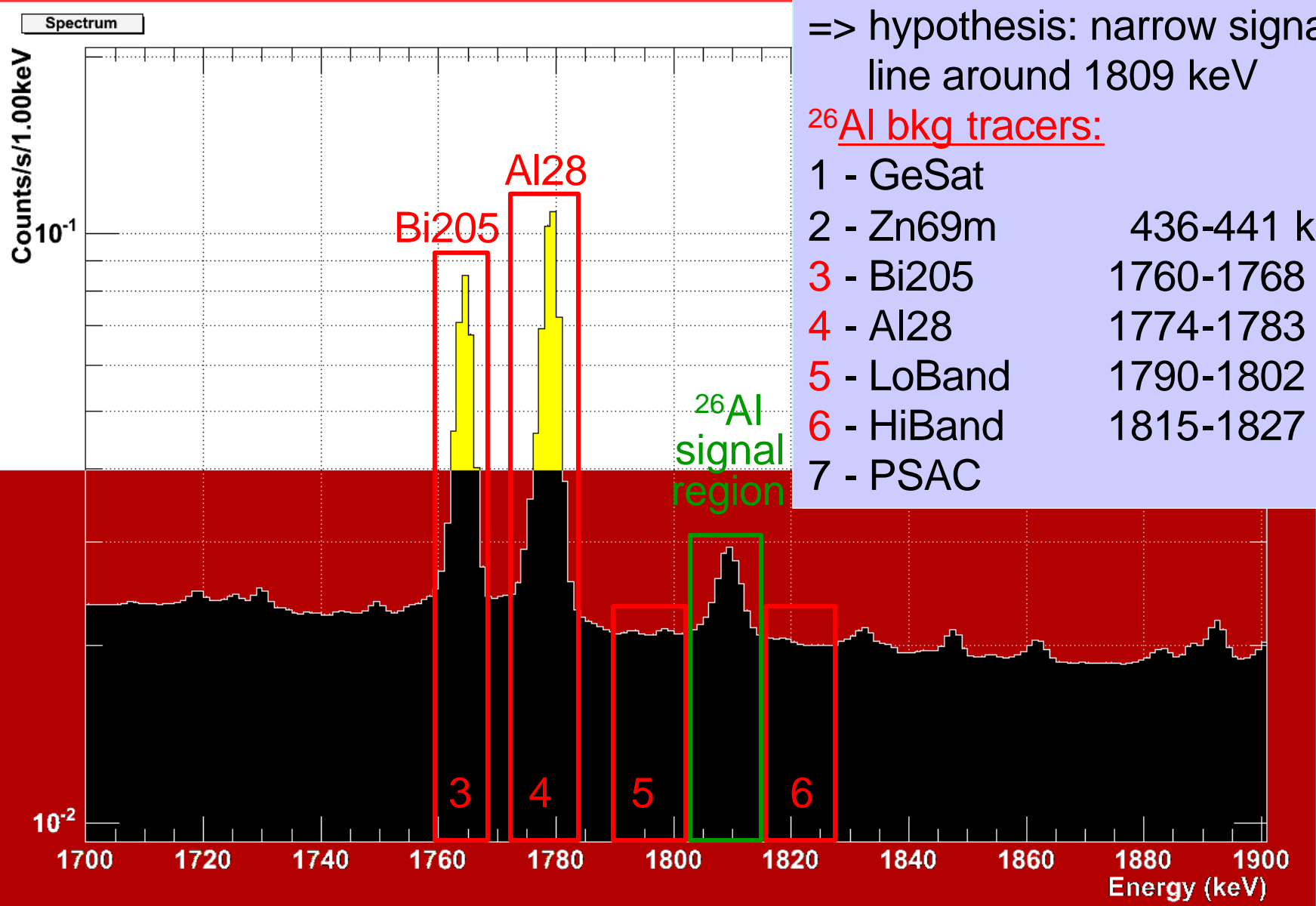
Or + background spectrum



^{26}Al sig region: 1803-1815 keV
 => hypothesis: narrow signal line around 1809 keV

^{26}Al bkg tracers:

- 1 - GeSat
- 2 - Zn69m 436-441 keV
- 3 - Bi205 1760-1768
- 4 - Al28 1774-1783
- 5 - LoBand 1790-1802
- 6 - HiBand 1815-1827
- 7 - PSAC



Covariance Matrix

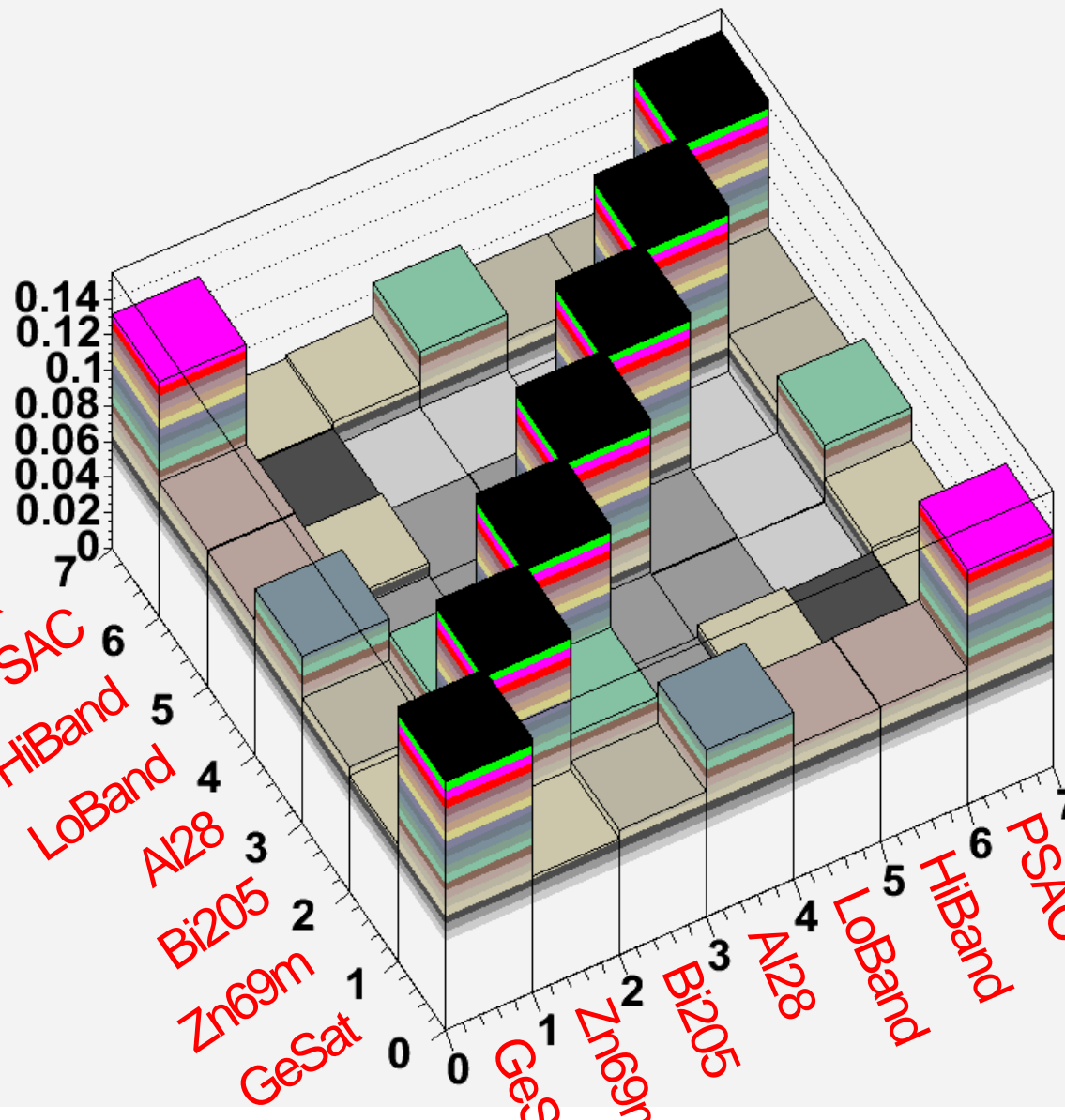
All data (Off+GalPlane)

Use Bkg Tracers:

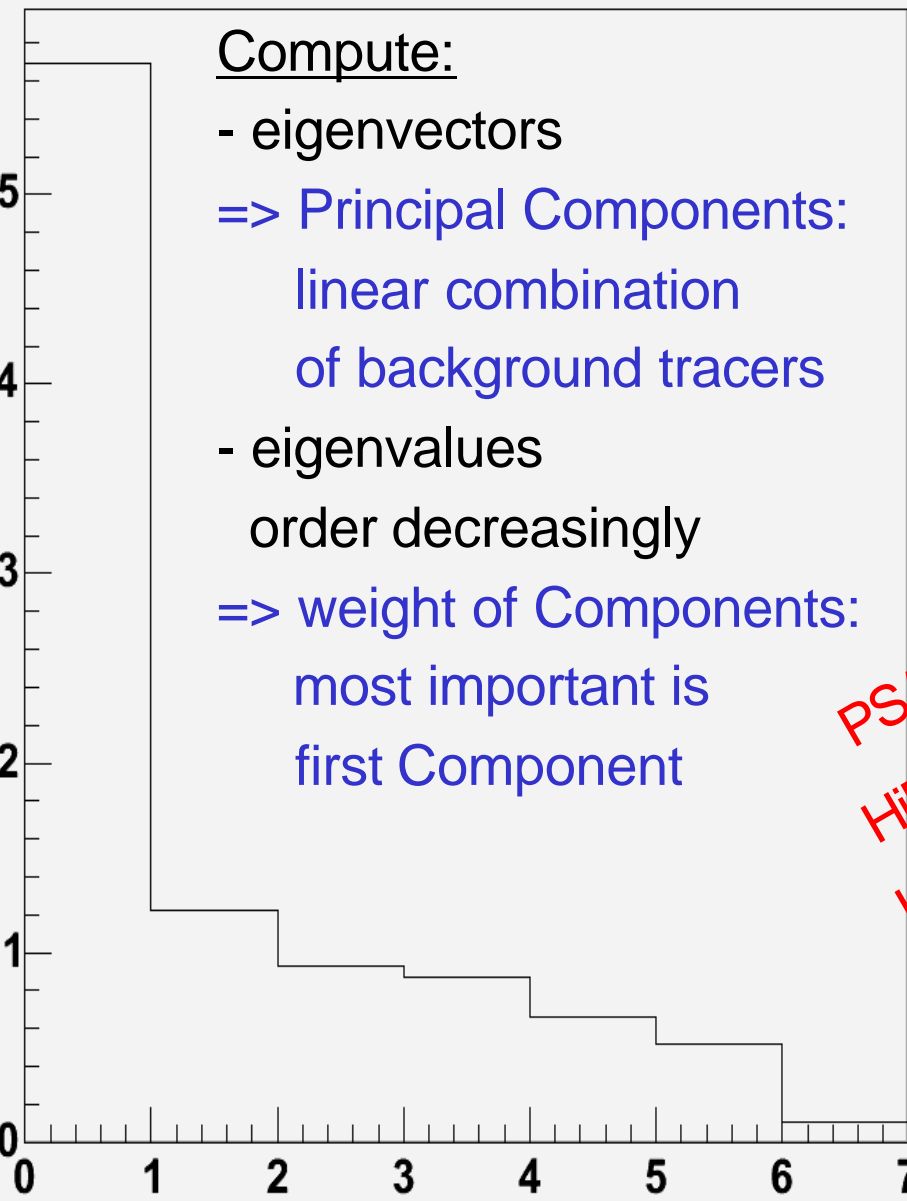
- normalize
- center

Between Tracers:

- covariance matrix
- diagonalize (SVD)



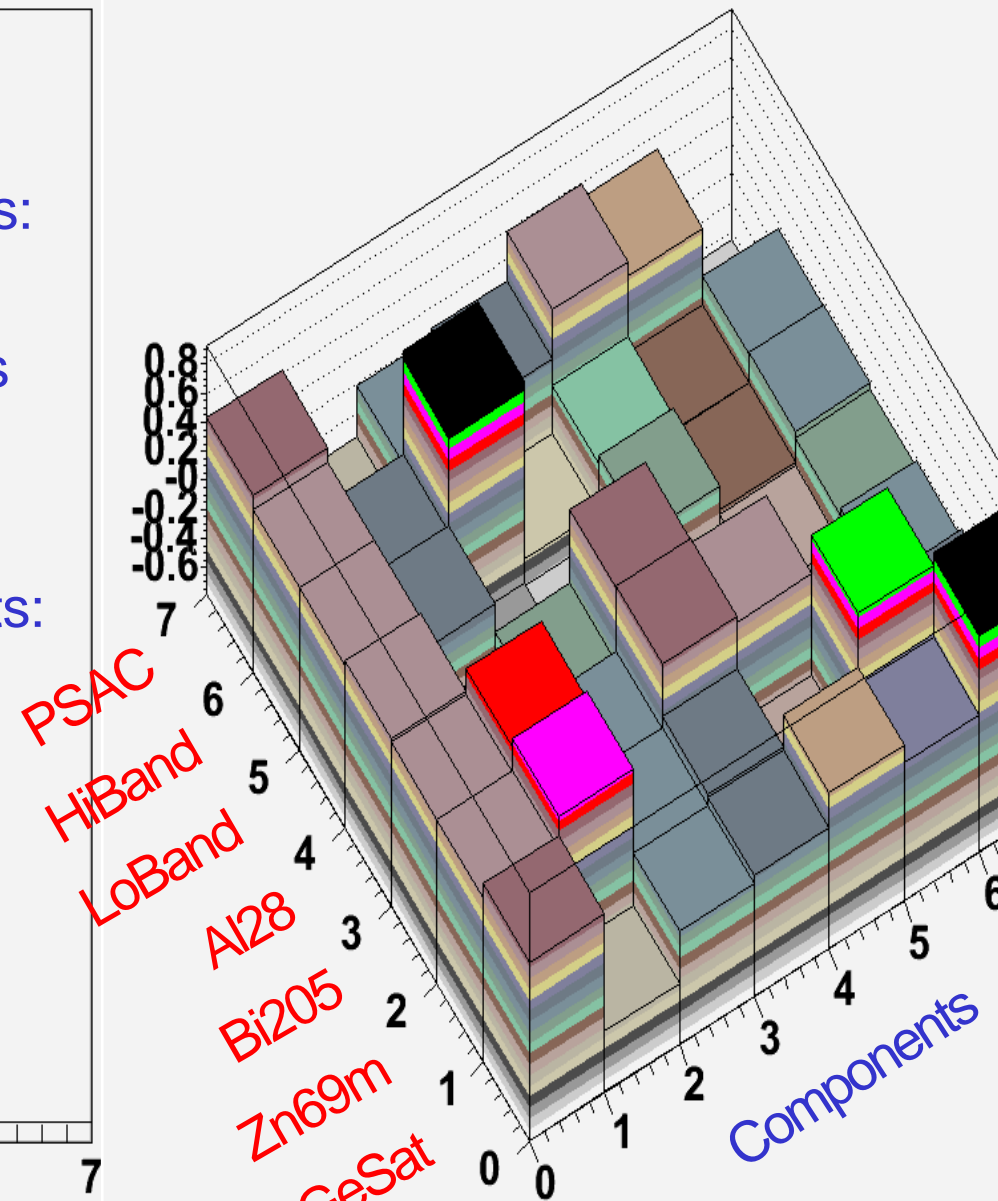
Eigen Values

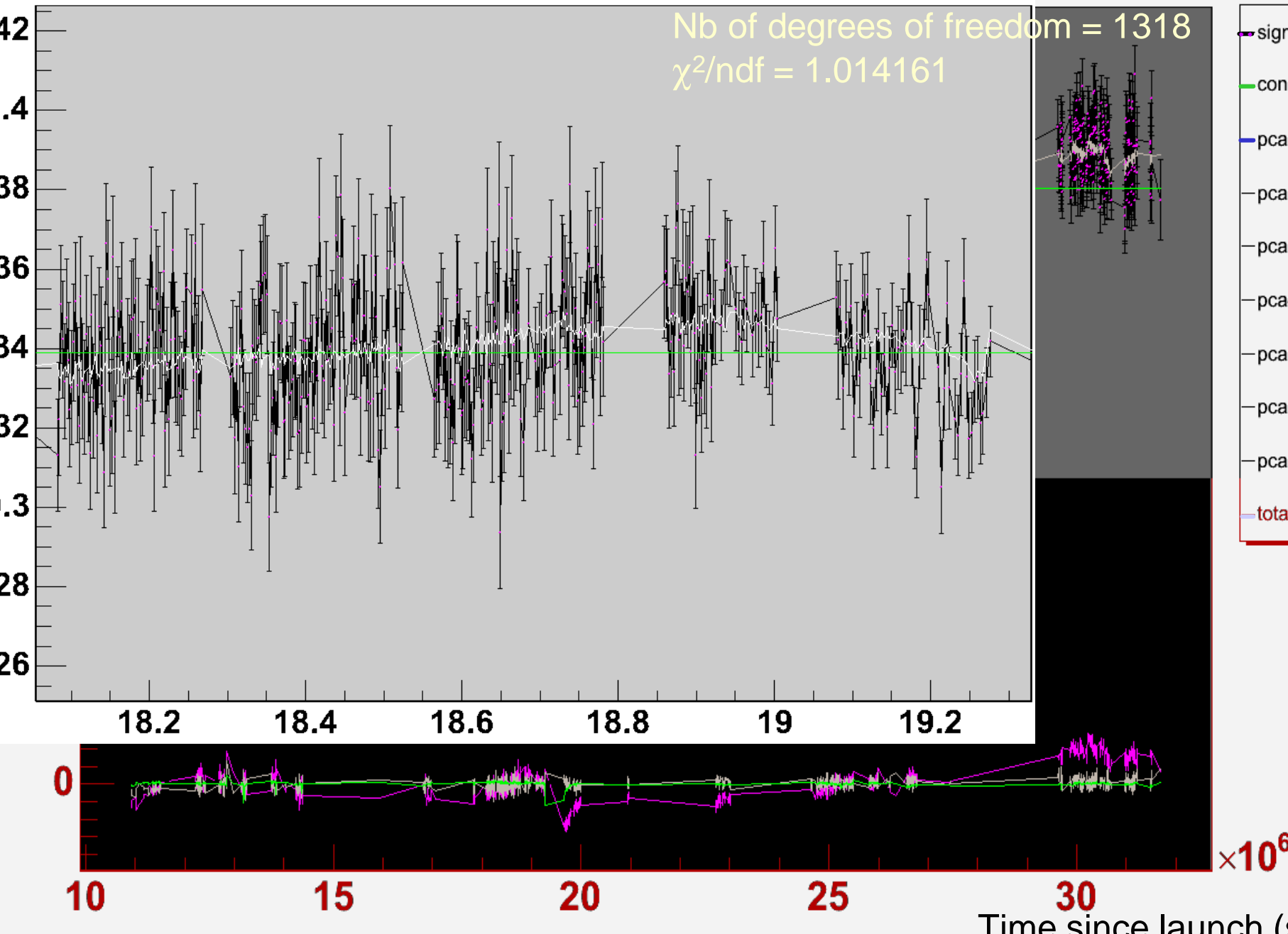


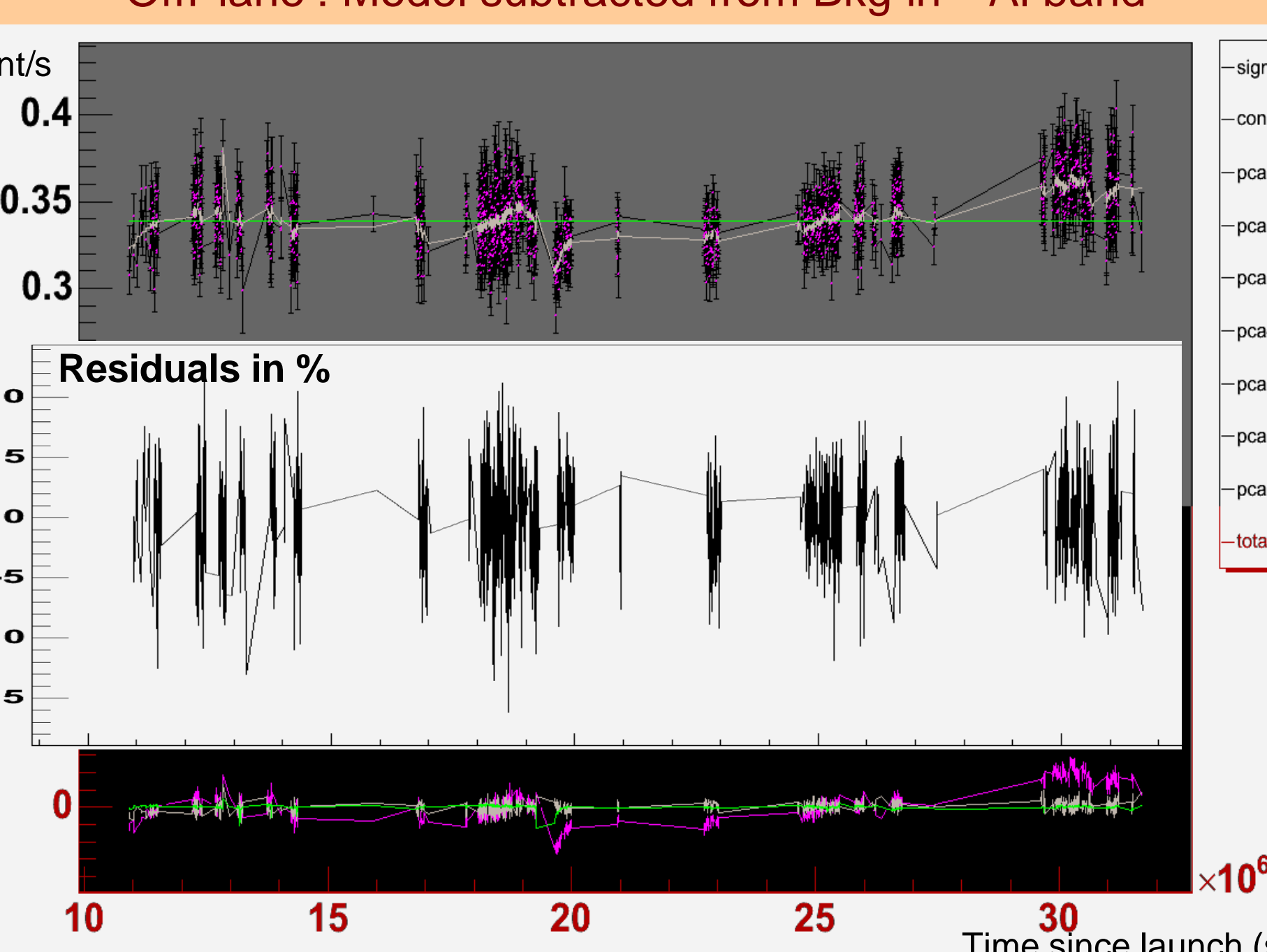
Compute:

- eigenvectors
=> Principal Components:
linear combination
of background tracers
- eigenvalues
order decreasingly
=> weight of Components:
most important is
first Component

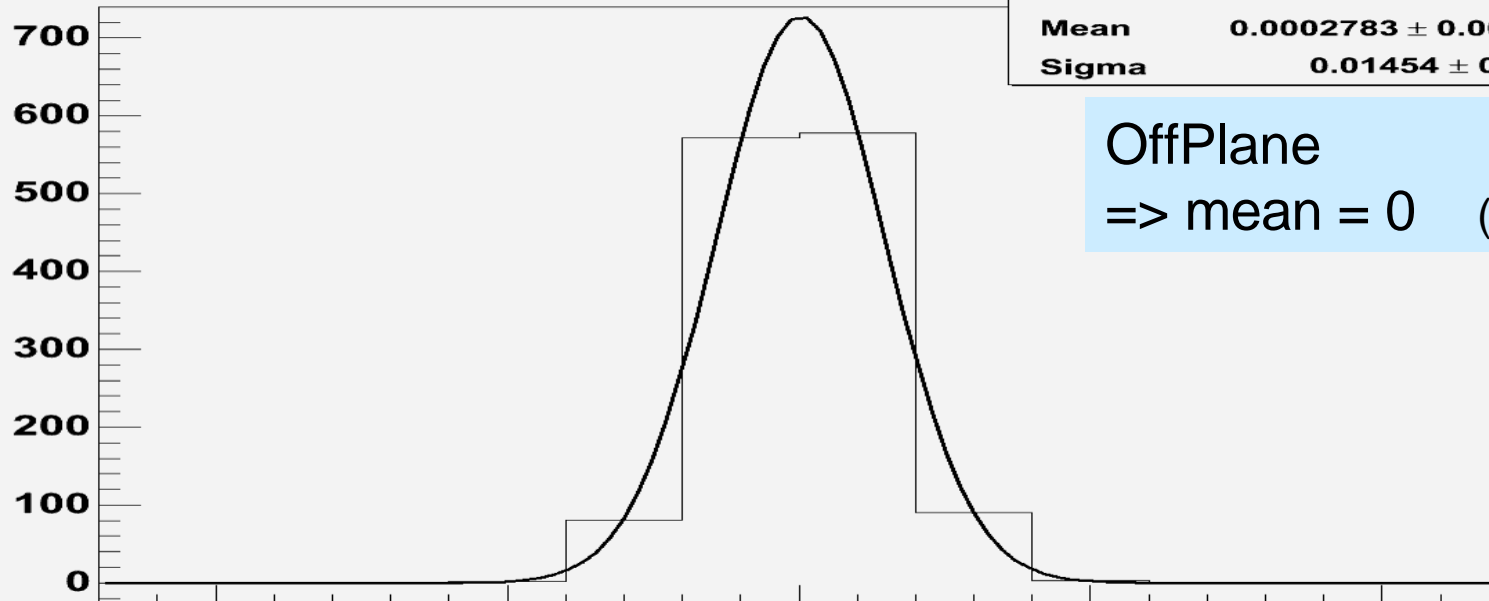
Eigen Vectors







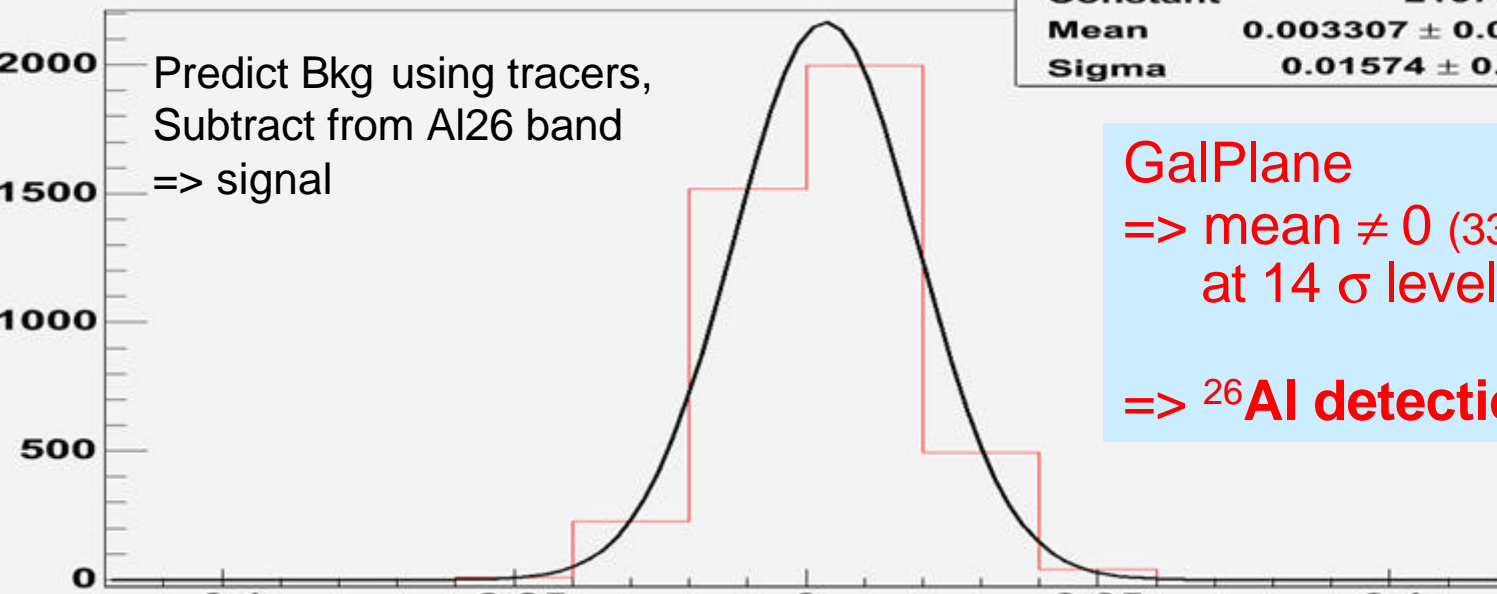
Histogram of residuals



χ^2 / ndf	0.4165 / 3
Constant	727.5 ± 24.8
Mean	0.0002783 ± 0.0003995
Sigma	0.01454 ± 0.00029

OffPlane
 $\Rightarrow \text{mean} = 0$ ($2.7 \pm 4.0 \times 10^{-4} \text{ cm}$)

Histogram of residuals



Predict Bkg using tracers,
 Subtract from Al26 band
 \Rightarrow signal

χ^2 / ndf	5.244 / 3
Constant	2167 ± 41.5
Mean	0.003307 ± 0.000241
Sigma	0.01574 ± 0.00018

GalPlane
 $\Rightarrow \text{mean} \neq 0$ ($33.1 \pm 2.4 \times 10^{-4} \text{ cm}$)
 at 14σ level (stat error on mean)
 \Rightarrow **^{26}Al detection in GalPlane**

Galactic Residuals: 7 tracers, 7 us

PCA, 7 tracers, 7 us

nt/s

0.06
0.04
0.02
0
0.02
0.04

mean_xB

30

20

10

0

-10

-20

-30

-40

-150

-100

-50

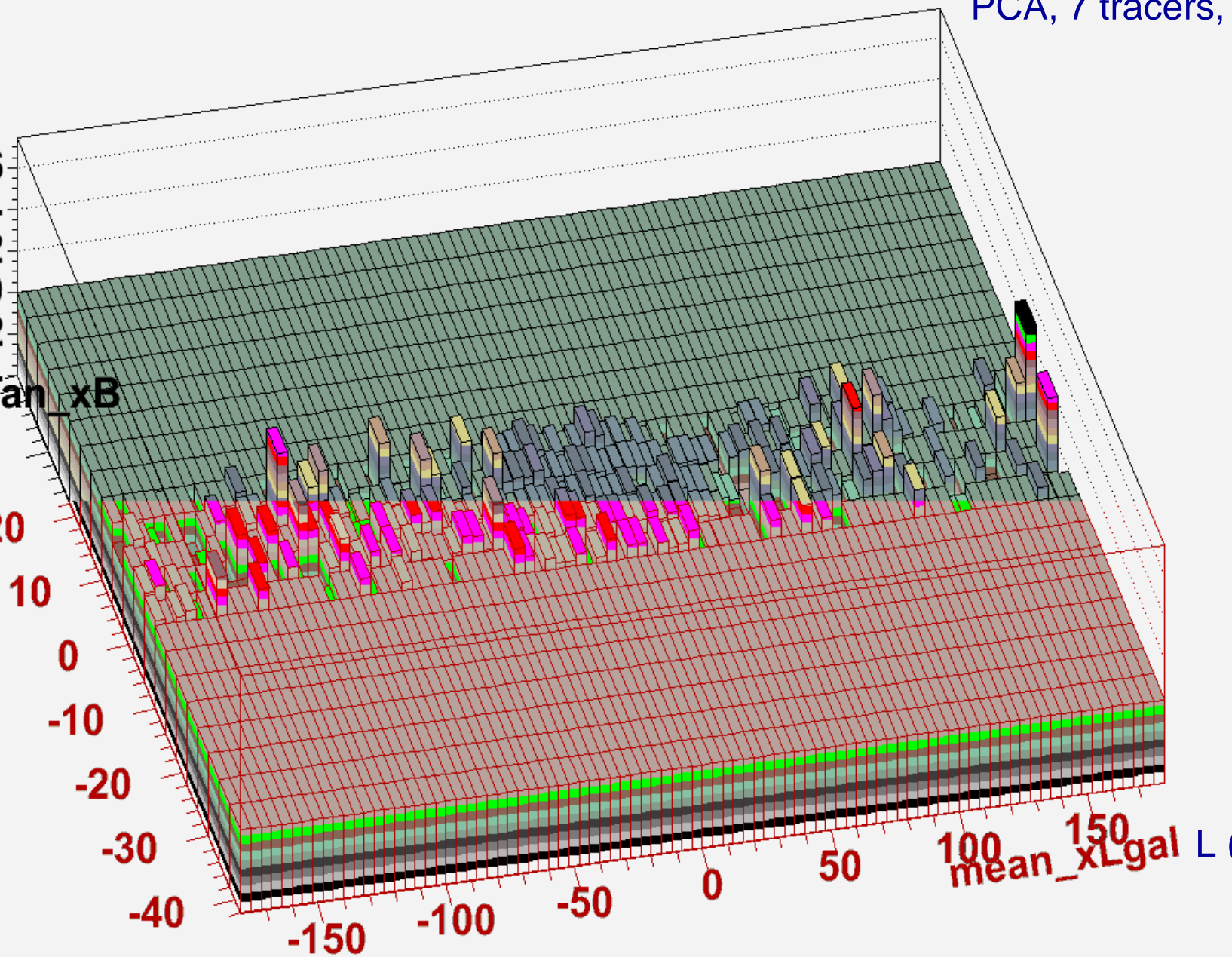
0

50

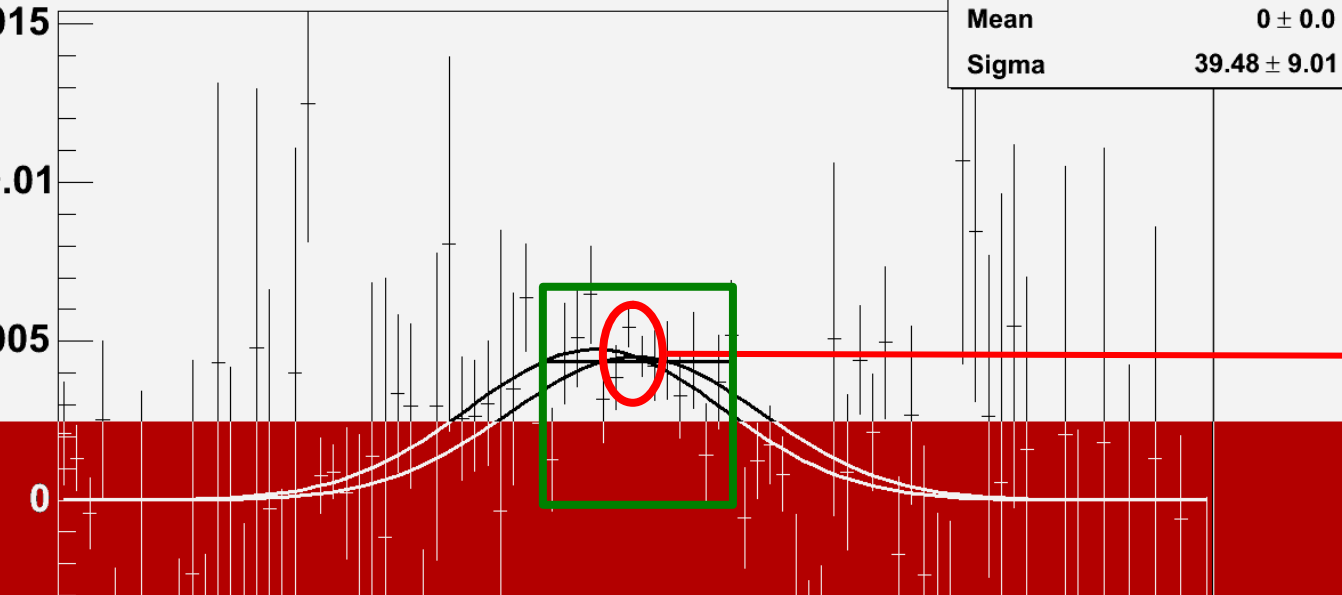
100

150

mean_xLgal L (°)



projection of residual signal versus longitude

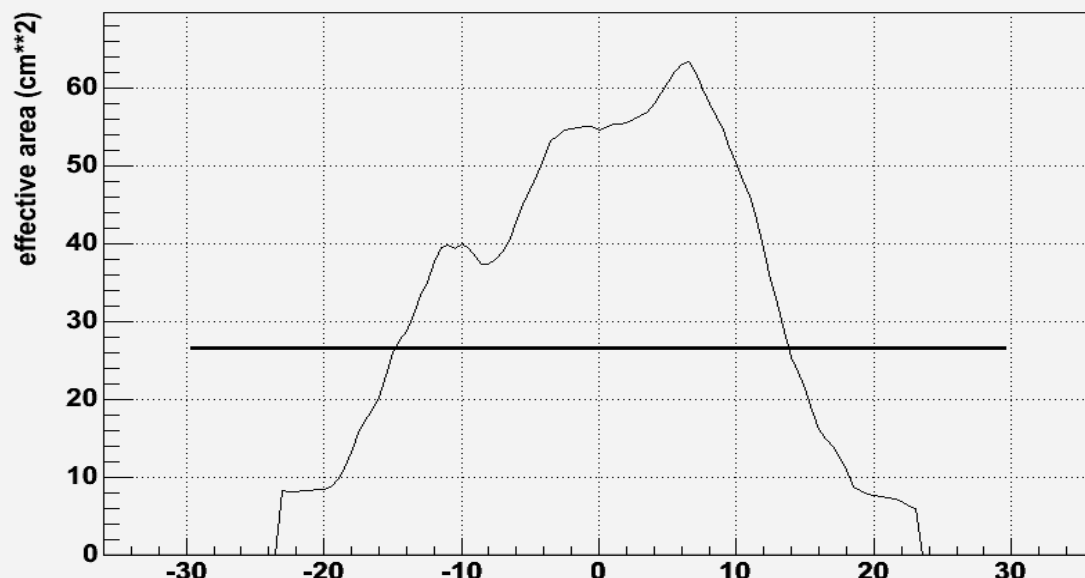


PCA, 7 tracers, 7 us

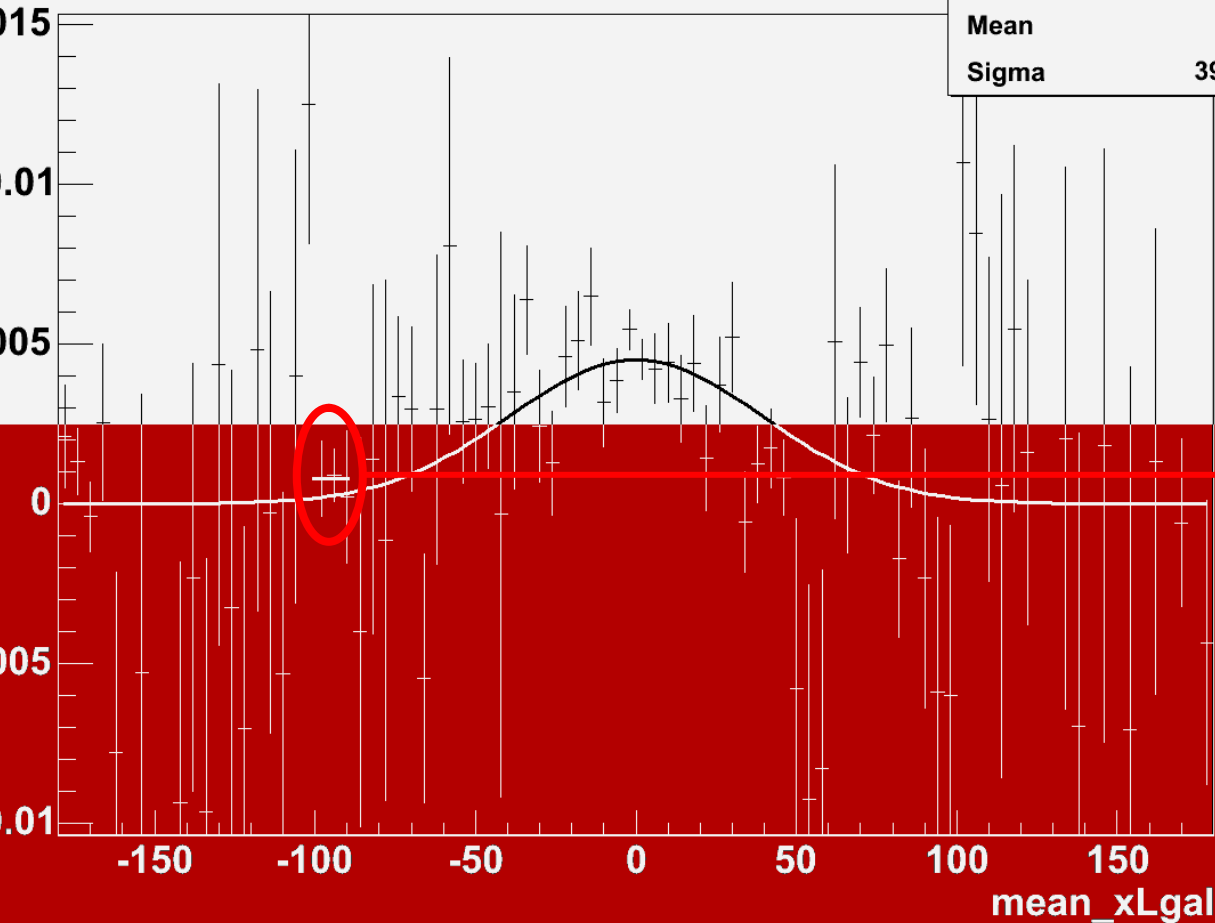
fit Gaussian
with Mean=0 fixedAt $L=0^\circ$, ^{26}Al Rate
 $45.0 \pm 3.6 \times 10^{-4} \text{ cm}^{-2} \text{ s}^{-1}$
(12 σ , stat error onSPI response
at 1809 keV

- for a point source
 $A_{\text{eff}} = 55 \text{ cm}^2$
- for a diffuse source
integrated over
 -30° to 30° :
 $A_{\text{eff}} = 26 \text{ cm}^2$

SE+ME response at 1809 keV


 ^{26}Al Flux in $L=-30^\circ$ to 30°
(assume: uniform in region
around Galactic center
 $1.73 \pm 0.14 \times 10^{-4} \text{ ph/cm}^2 \text{ s}^{-1}$)

projection of residual signal versus longitude



7 tracers

Vela : fit Constant
 $L = -101^\circ$ to -89°

Vela ^{26}Al Rate:
 $8.0 \pm 6.4 \times 10^{-4}$ cnt/s
(1.2 σ , stat error on
NO DETECTION

3 σ (stat) upper limit
< 19×10^{-4} cnt/s

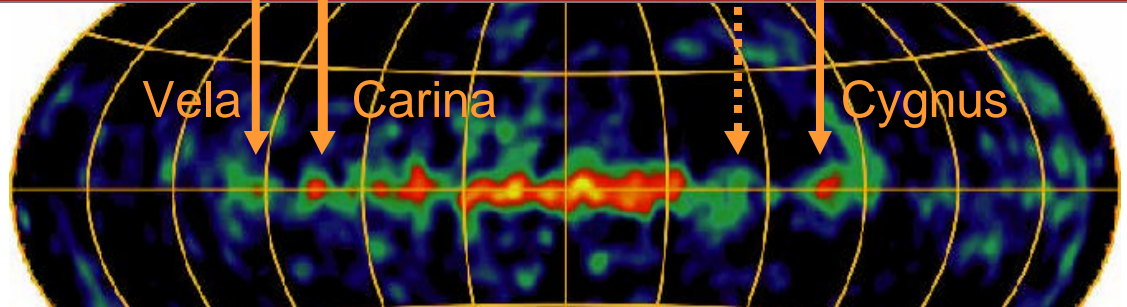
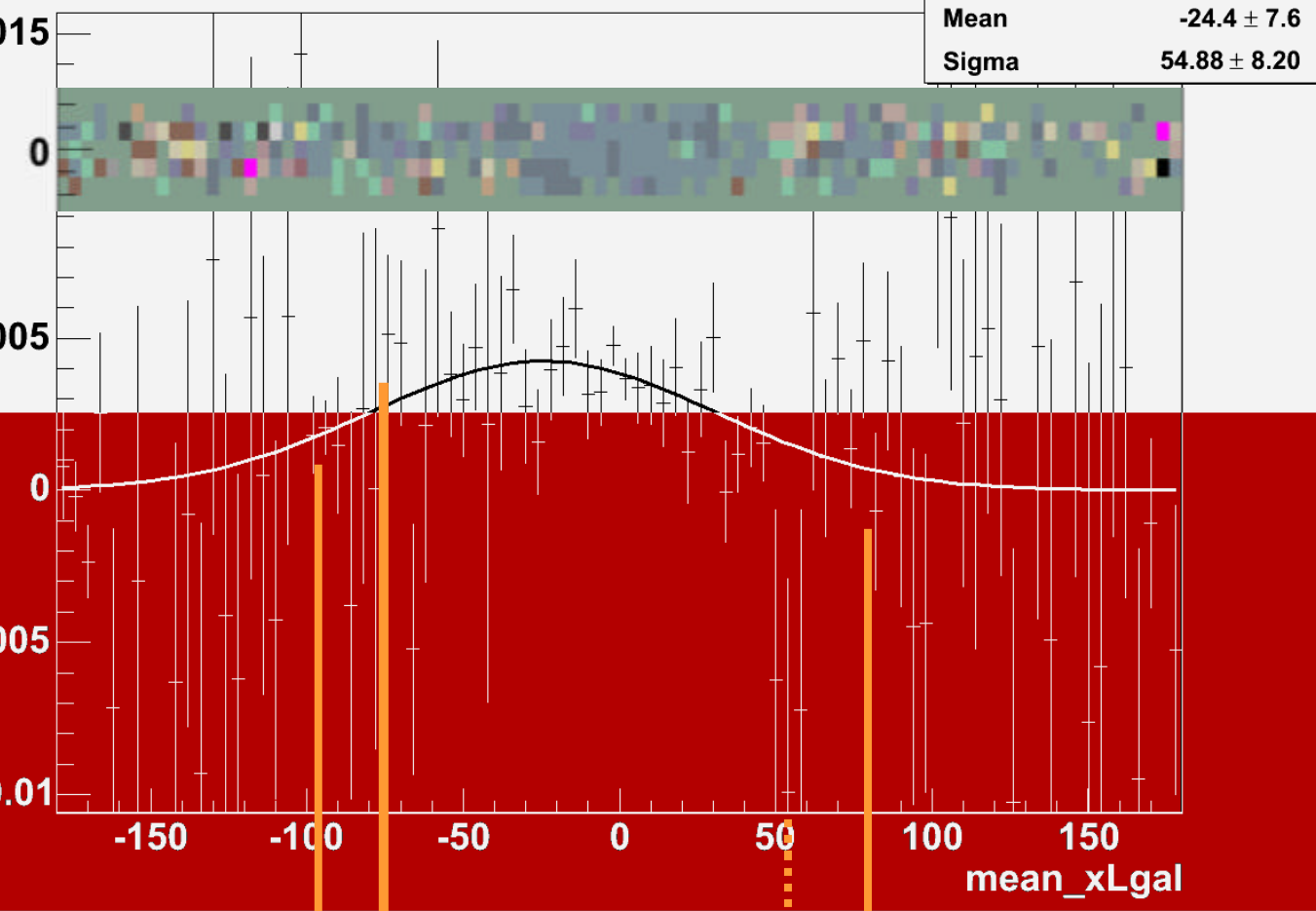
point source hypothesis
 $A_{\text{eff}} = 55 \text{ cm}^2$

Vela ^{26}Al Flux, 3 σ (stat) upper limit
< 0.34×10^{-4} ph/cm 2

Towards a mapping of ^{26}Al in the Galaxy!

projection of residual signal versus longitude

χ^2 / ndf	91 / 85
Constant	0.004249 ± 0.000425
Mean	-24.4 ± 7.6
Sigma	54.88 ± 8.20



46 tracers (before: 7)

=> our best Bkg fit,

$\chi^2=1.003$ (1.01)

$\sigma_R=0.0143$ c/s (0.01)

^{26}Al Flux [10^{-4} ph/cm

(stat errors only):

- $L=-30$ to 30°

1.43 ± 0.14 (1.73 ± 0.14)

10.2σ (12.3σ)

COMPTEL: 2.80 ± 0.10

- Vela

0.35 ± 0.13 (0.14 ± 0.05)

2.8σ (1.2σ)

COMPTEL: 0.36 ± 0.05

Systematic errors

tracers, PCA used=	1	2	3	4	5	6	7	Er
Bkg Chi2/NDF	1.0746	1.0670	1.0676	1.0666	1.0671	1.0232	1.0142	
Big NDF	1324	1323	1322	1321	1320	1319	1318	
CR 10^{-4} ph/cm ² /s	1.72	1.88	1.88	1.87	1.88	1.61	1.73	0.0
la 10^{-4} ph/cm ² /s	-0.14	0.01	0.01	0.03	0.05	0.08	0.14	0.0

tracers, PCA used=	1	3	9	22	31	40	46	Er
Bkg Chi2/NDF		1.0233	1.0195	1.0073	1.0082	1.0045	1.0032	
Big NDF		1322	1316	1303	1294	1285	1279	
CR 10^{-4} ph/cm ² /s		1.53	1.45	1.44	1.32	1.46	1.43	0.0
la 10^{-4} ph/cm ² /s		0.02	0.00	0.03	0.08	0.34	0.35	0.0

I mean value					
	Value	Stat	Syst	Stat+Syst	N sigma
CR 10^{-4} ph/cm ² /s	1.63	0.13	0.21	0.24	6.75
la 10^{-4} ph/cm ² /s	0.08	0.12	0.21	0.24	0.33
la 10^{-4} ph/cm ² /s 3 sigma		0.35	0.62	0.71	

COMPTTEL	
Value	Stat+Syst
2.80	0.0
0.36	0.0

PI narrow line sensitivity at 1809 keV
 for : 1 Ms observation, 3 s (stat only)
 2.5×10^{-4} ph/cm²/s ←

Vela : 0.9 Ms observation,
 σ (stat): expected = 0.26×10^{-4} ph/cm²/s
 measured = 0.36×10^{-4} ph/cm²/s

> **COMPTEL Flux**: 0.36×10^{-4} ph/cm²/s
 with 0.9 Ms, could not expect detection

AO-3 Open Time proposal accepted (2 Ms Vela observation)

We should detect ²⁶Al in Vela (hopefully no solar flare pollutes the data again...)

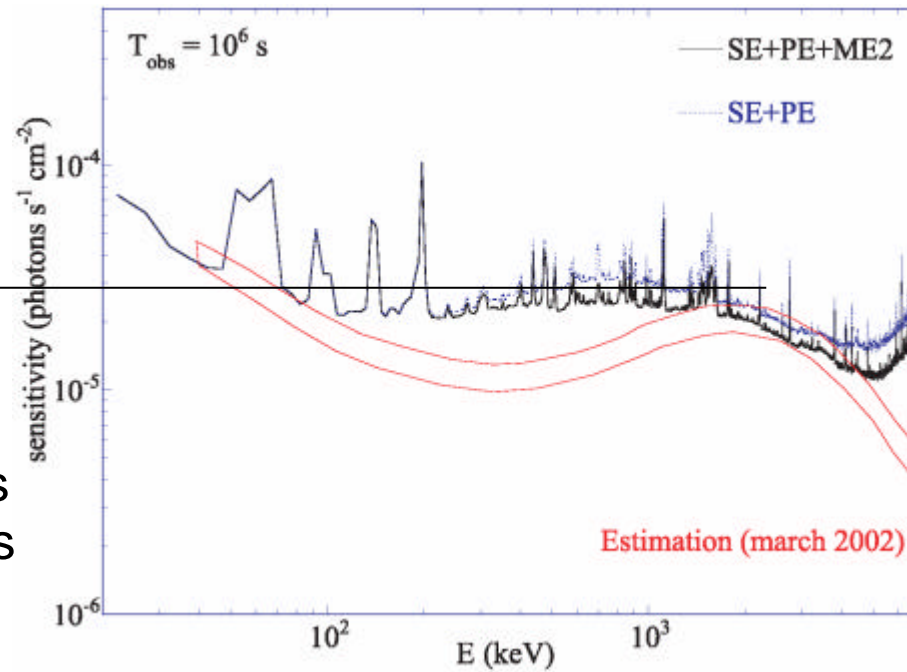
GCR : 9 Ms observation,
 σ (stat): expected = 0.08×10^{-4} ph/cm²/s
 measured = 0.39×10^{-4} ph/cm²/s

> Stat error estimate : factor 5 too pessimistic ??

Due to limited OffPlane observations (only 0.5 Ms useable)

Urgently needed: more off-plane data
 for SPI line analyses (core prog & open time)

but not scheduled in sufficient amount...



Thank you !