

**E570**

**Shift and Width**

2007 Aug. 20     Hideyuki Tatsuno

# Systematic Error of Shift

## Two types

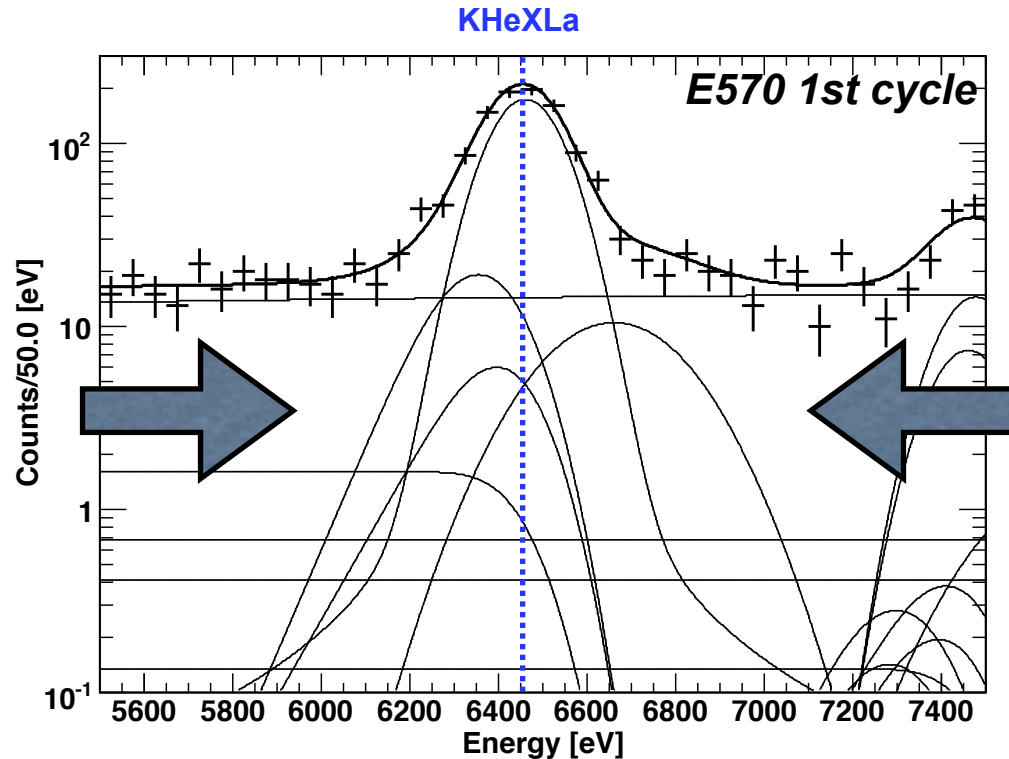
“Attractive side”

“Repulsive side”

- +LE-Tail ( $1\sigma$ )
- +Compton (5%)
- +Shelf ( $1\sigma$ )
- Pileup (10%)

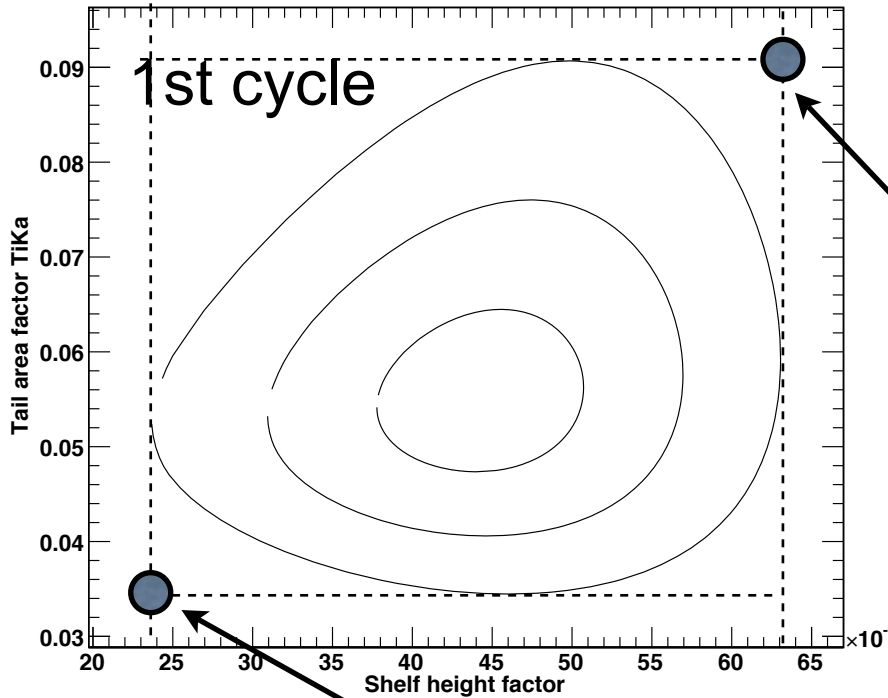
- LE-Tail ( $1\sigma$ )
- Compton (5%)
- Shelf ( $1\sigma$ )
- +Pileup (10%)

**Pull !**



**Push !**

fit contour (1,2 and 3  $\sigma$ )

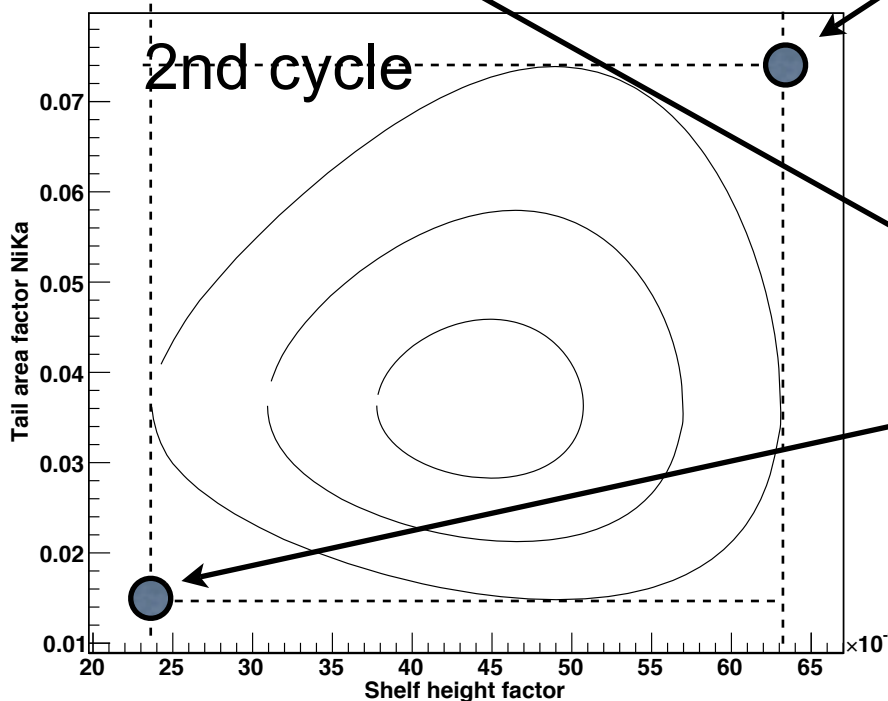


Tail ratio vs shelf height  
(to estimate systematics)

attractive side

Shelf  $+1\sigma$  & tail  $-1\sigma$

fit contour (1,2 and 3  $\sigma$ )



repulsive side

Shelf  $-1\sigma$  & tail  $-1\sigma$

# Systematic Error of Width

## Two types

### “Resolution +”

$$\sigma_+ = \sqrt{N_+^2 + F_+ w E}$$

### “Resolution -”

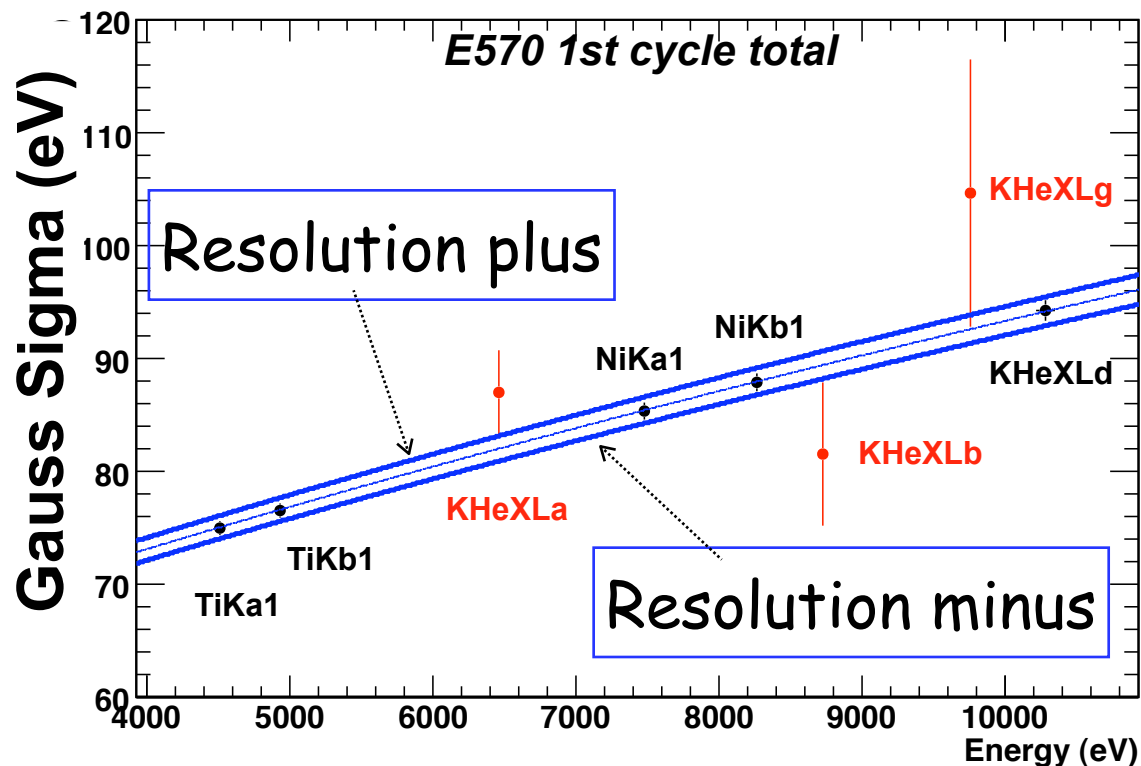
$$\sigma_- = \sqrt{N_-^2 + F_- w E}$$

$$N_+ = N + \sigma_N$$

$$F_+ = F + \sigma_F$$

$$N_- = N - \sigma_N$$

$$F_- = F - \sigma_F$$



# E570 cycle I total

	“Resolution-”						“Resolution+”		
<i>Systematic error</i>	attractive side	center	repulsive side	attractive side	center	repulsive side	attractive side	center	repulsive side
$L\alpha$	+1.509	6461.159 +- 3.998	-1.521	+1.491	6461.132 +- 3.999	-1.504	+1.473	6461.103 +- 4.001	-1.486
$L\beta$	+1.287	8723.516 +- 7.241	-1.302	+1.269	8723.240 +- 7.252	-1.283	+1.251	8722.967 +- 7.263	-1.265
$L\gamma$	+1.574	9760.052 +-12.134	-1.593	+1.549	9759.806 +-12.13	-1.568	+1.526	9759.563 +-12.132	-1.543
<i>Shift</i>	+1.468	-1.783 +- 3.363	-1.482	+1.450	-1.882 +- 3.365	-1.463	+1.431	-1.983 +- 3.367	-1.445
<i>Width</i>	+0.262	7.078 +- 8.832	-0.178	+0.237	4.167 +- 8.886	-0.157	+0.218	1.257 +-15.798	-0.133

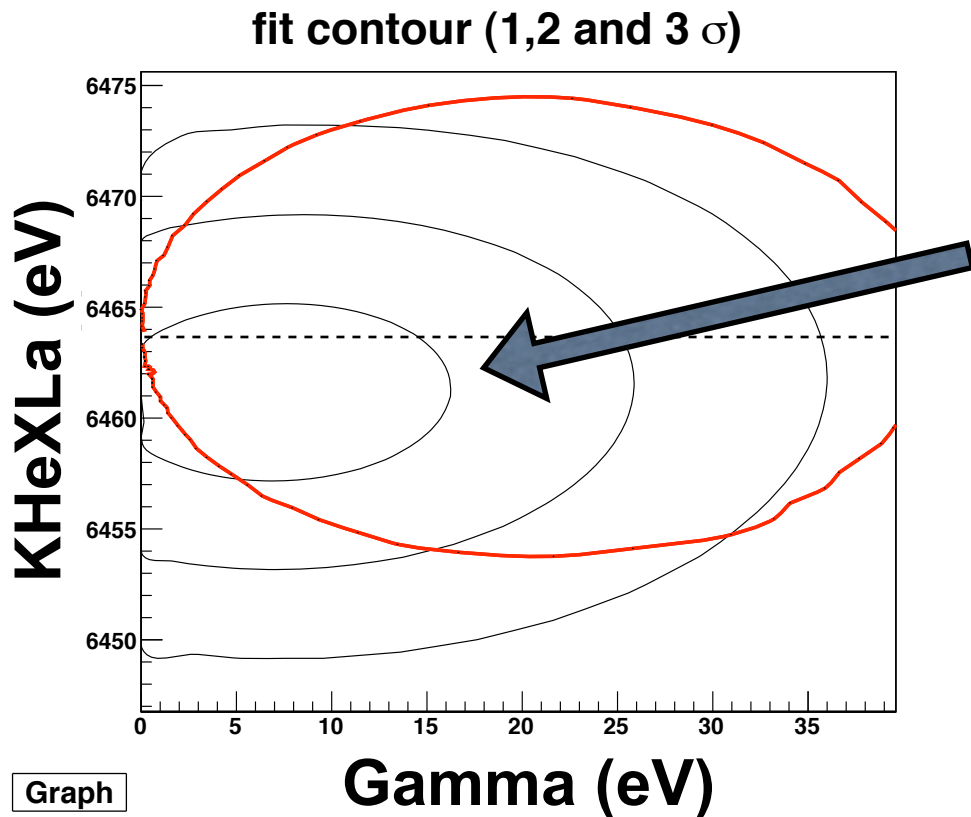
weighted average  
 $L\alpha$ - $L\gamma$

**Shift =  $-1.9 \pm 3.4(\text{Stat.}) +1.5 -1.5(\text{Syst.})$  eV** *from Koike's calc.*  
(without calibration and EM-calc. errors)

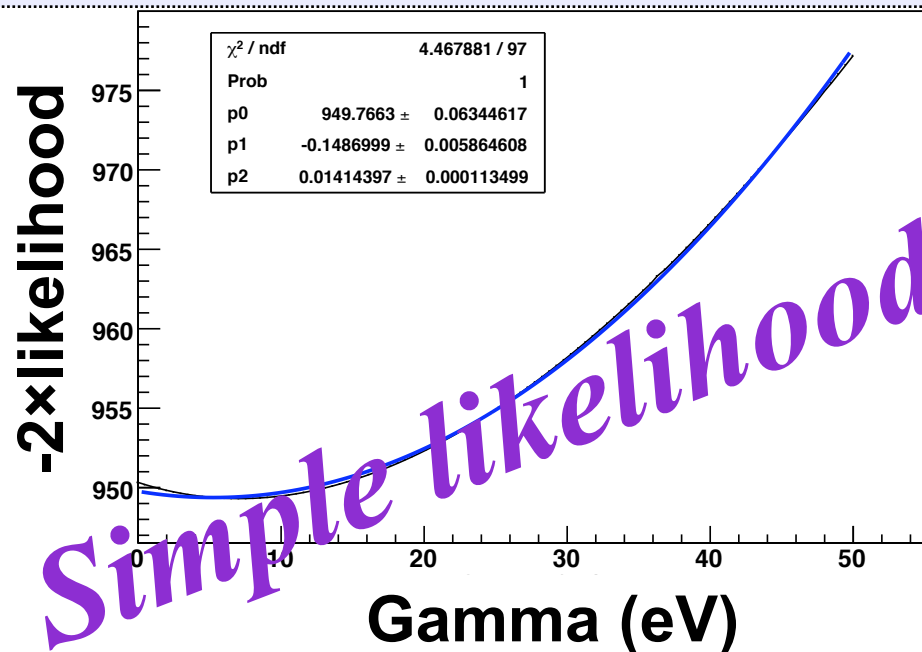
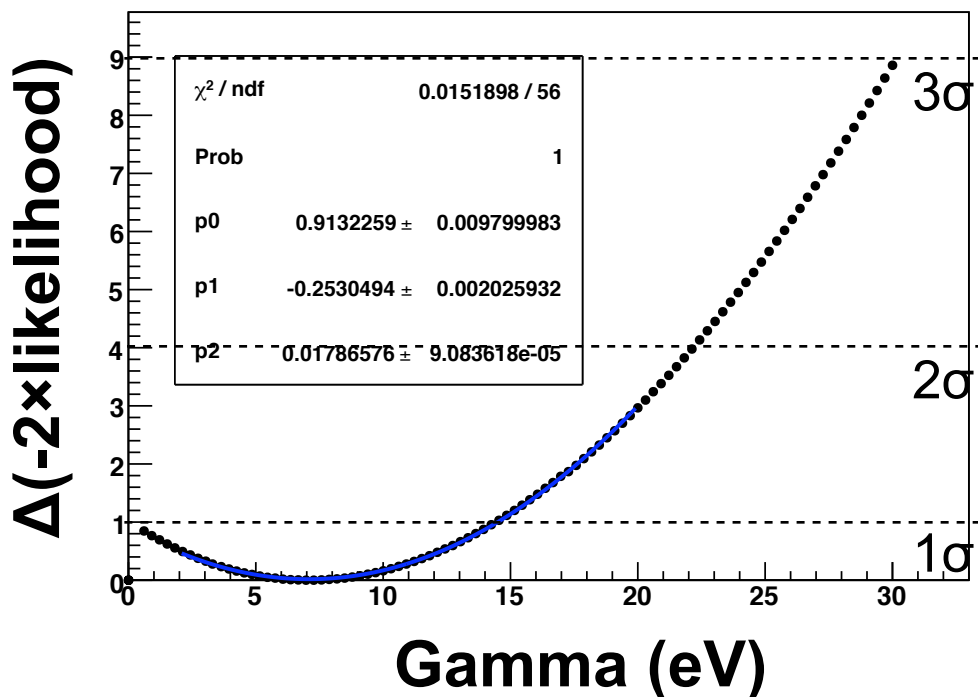
# Cycle I “Resolution minus”

*MINOs error is OK*

Gamma [eV] 7.07883e+00  
 negative: at limit, positive 9.16374e+00



These plots do not correspond to the contour one perfectly, because the likelihood is calculated with fixing the other parameters.



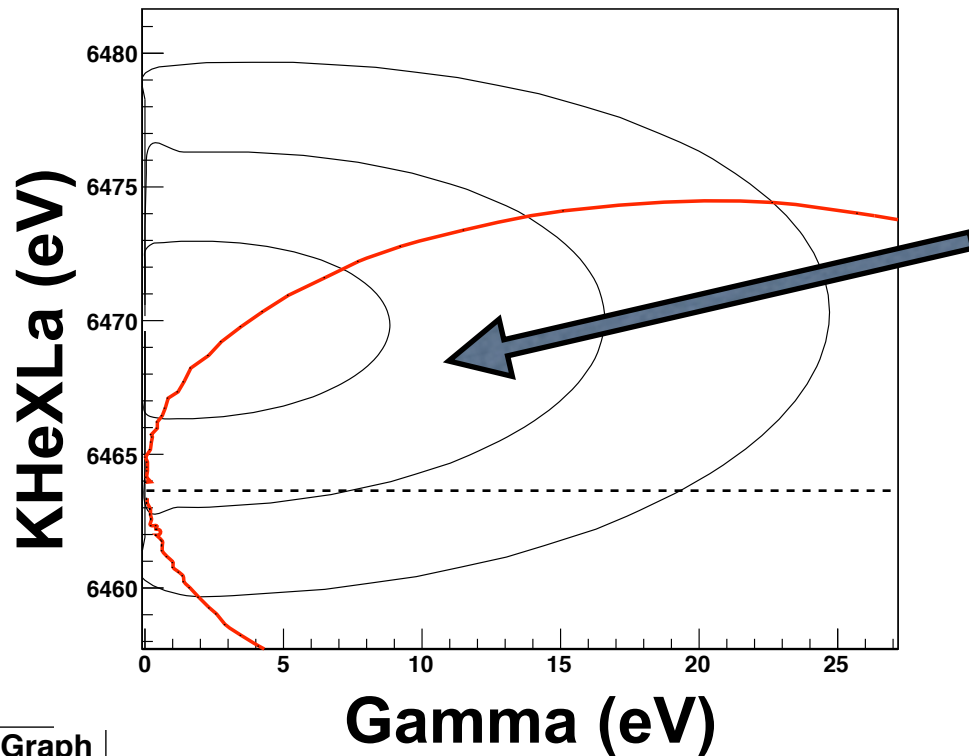
# E570 cycle 2 total

	“Resolution-”						“Resolution+”		
<i>Systematic error</i>	attractive side	center	repulsive side	attractive side	center	repulsive side	attractive side	center	repulsive side
$L\alpha$	1.056	6469.645 +- 3.318	-1.066	+1.050	6469.574 +- 3.325	-1.061	+1.048	6469.539 +- 3.348	-1.058
$L\beta$	1.036	8723.781 +- 6.218	-1.045	+1.027	8723.547 +- 6.238	-1.035	+1.024	8723.317 +- 6.276	-1.032
$L\gamma$	0.989	9761.684 +-10.348	-0.992	+0.973	9761.638 +-10.359	-0.978	+0.963	9761.625 +-10.391	-0.968
<i>Shift</i>	1.048	4.476 +- 2.817	-1.057	+1.042	4.374 +- 2.823	-1.051	+1.039	4.294 +- 2.842	-1.048
<i>Width</i>	-0.041	1.416 +- 9.063	0.102	+0.000	0.000 +-23.301	-0.000	+0.000	0.000 +- 7.446	-0.000

*weighted average  
L $\alpha$ -L $\gamma$*

**Shift = +4.4  $\pm$  2.8(Stat.) +1.1 -1.1(Syst.) eV** *from Koike's calc.*  
(without calibration and EM-calc. errors)

fit contour (1,2 and 3  $\sigma$ )

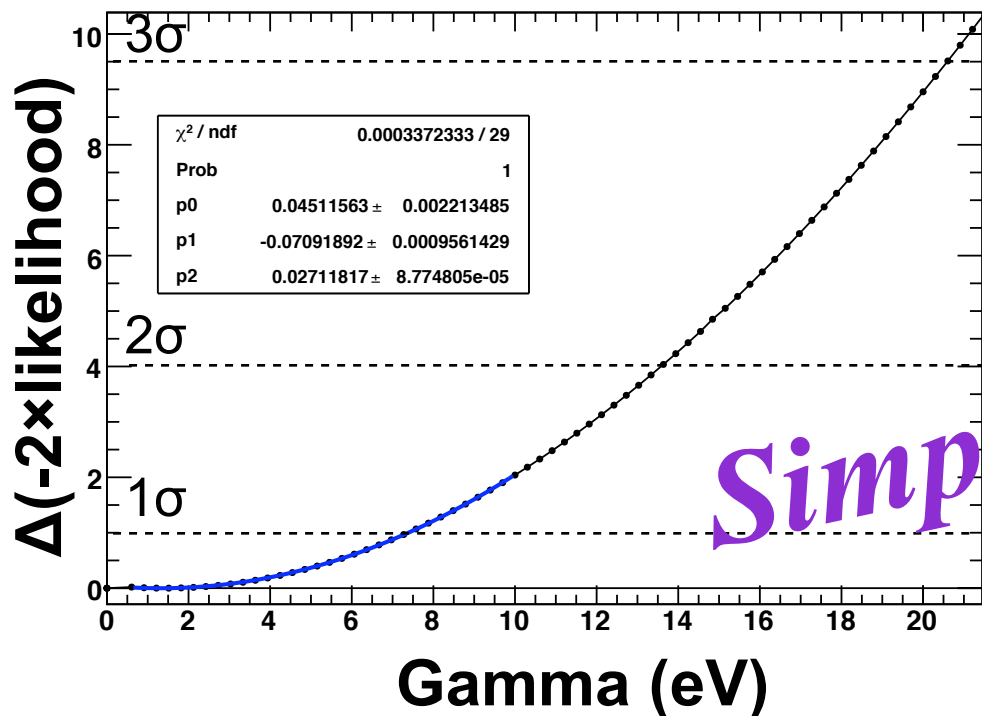


Cycle2 “Resolution minus”

*MINOs error is OK*

Gamma [eV] 1.41812e+00  
 negative: at limit, positive: 7.42292e+00

Graph



This plot does not correspond to the contour one perfectly, because the likelihood is calculated with fixing the other parameters.

*Simple likelihood*



# Shift

*1st cycle*    **Shift =  $-1.9 \pm 3.4(\text{Stat.}) +1.5 -1.5(\text{Syst.})$  eV**

*2nd cycle*    **Shift =  $+4.4 \pm 2.8(\text{Stat.}) +1.1 -1.1(\text{Syst.})$  eV**

*Total*        **Shift =  $+1.9 \pm 2.2(\text{Stat.}) \pm ?(\text{Syst.})$  eV**

## Width upper limit (@Resolution minus)

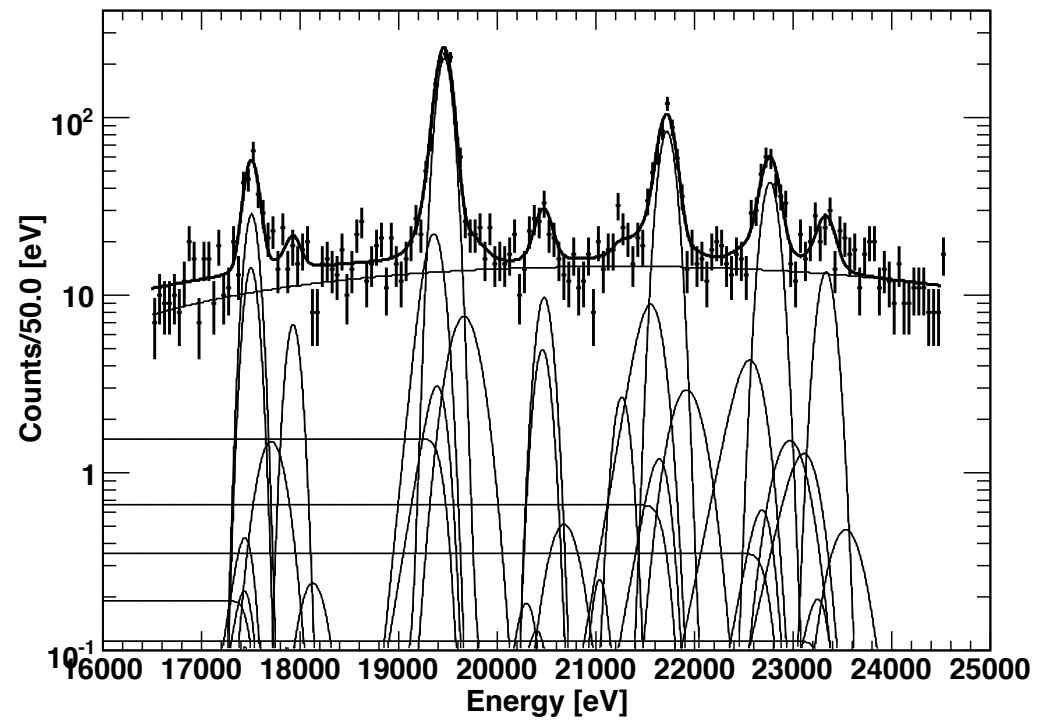
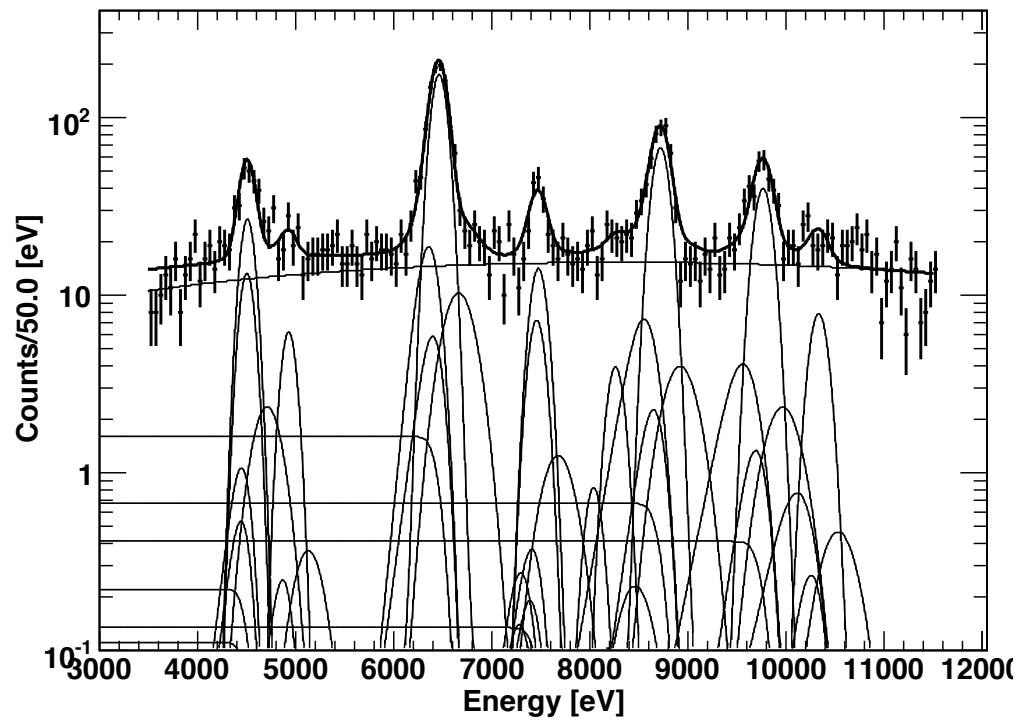
*1st cycle*    **Width =  $7.1 + 8.8$  eV (within Syst.)**

*2nd cycle*    **Width =  $1.4 + 9.0$  eV (within Syst.)**

*Total*        **Width = ???**

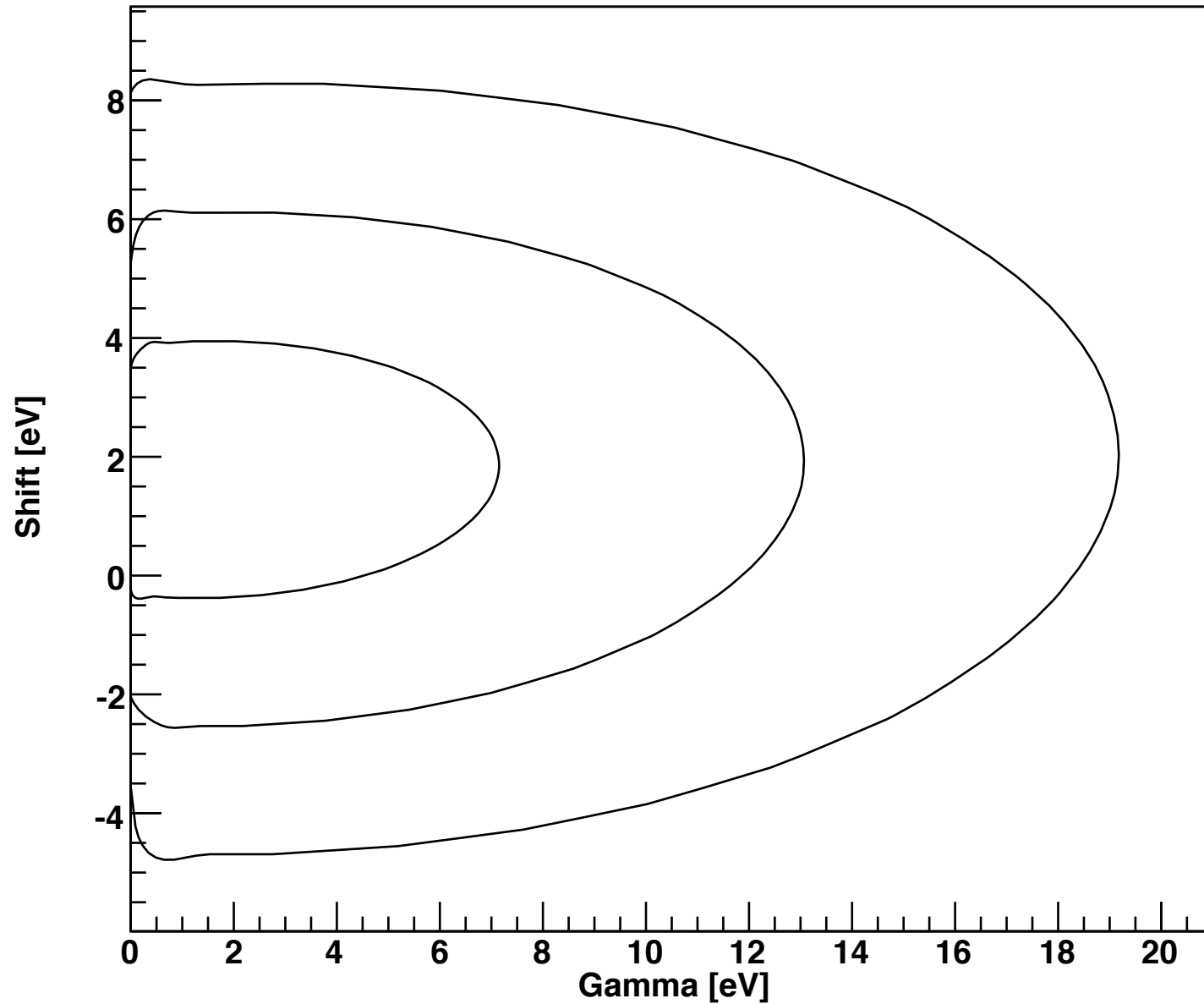
**How to combine these data ?**

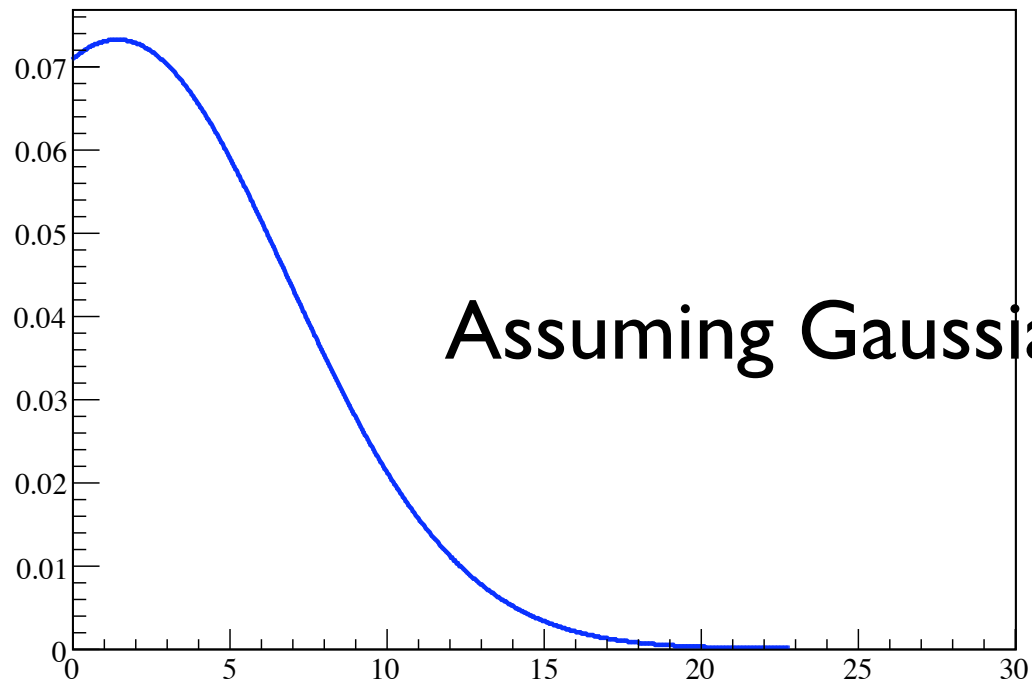
# Unified fit (1st and 2nd cycles)



Unified fit (stat. errors only)

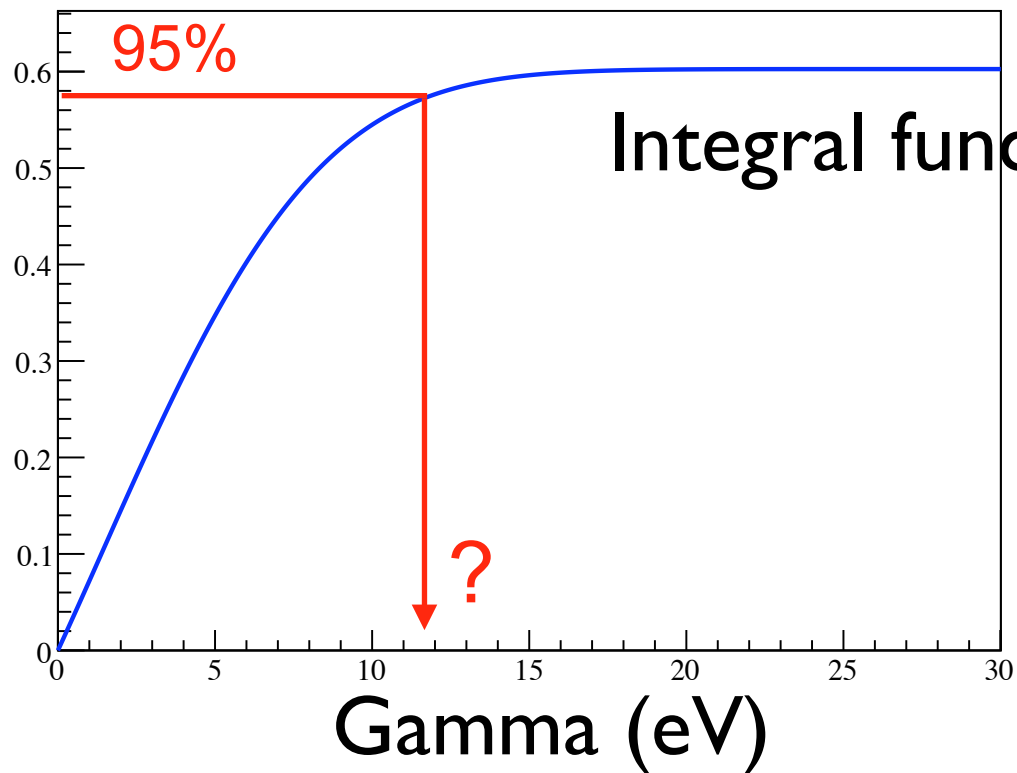
**fit contour (1,2 and 3  $\sigma$ )**





95% confidence level of  
Gamma

Assuming Gaussian PDF

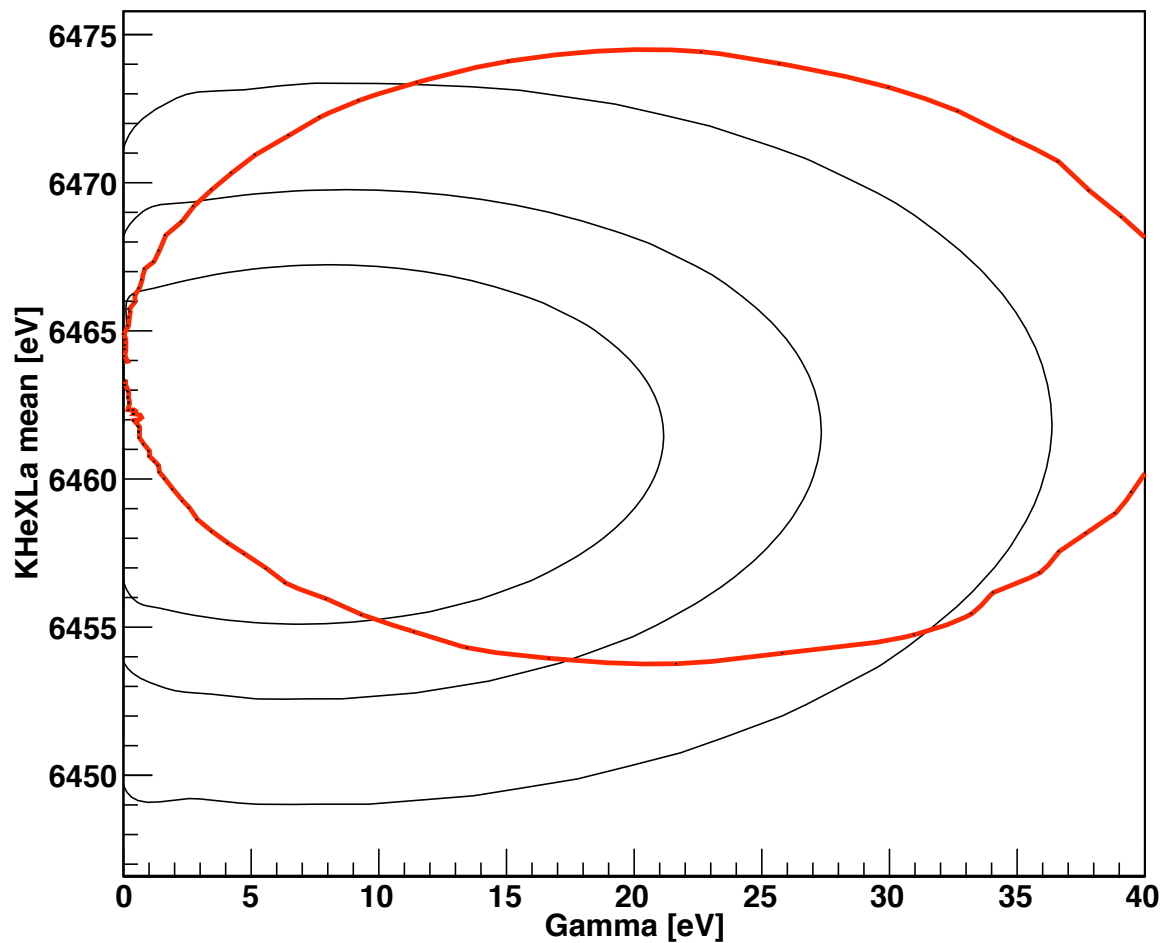


Integral function

Unified fit (stat. errors only)

Confidence Level	number of free parameters					
	1	2	3	4	5	6
68.3%	1.00	2.30	3.53	4.72	5.89	7.04
90%	2.71	4.61	6.25	7.78	9.24	10.6
95.4%	4.00	6.17	8.02	9.70	11.3	12.8
99%	6.63	9.21	11.3	13.3	15.1	16.8
99.73%	9.00	11.8	14.2	16.3	18.2	20.1
99.99%	15.1	18.4	21.1	23.5	25.7	27.8

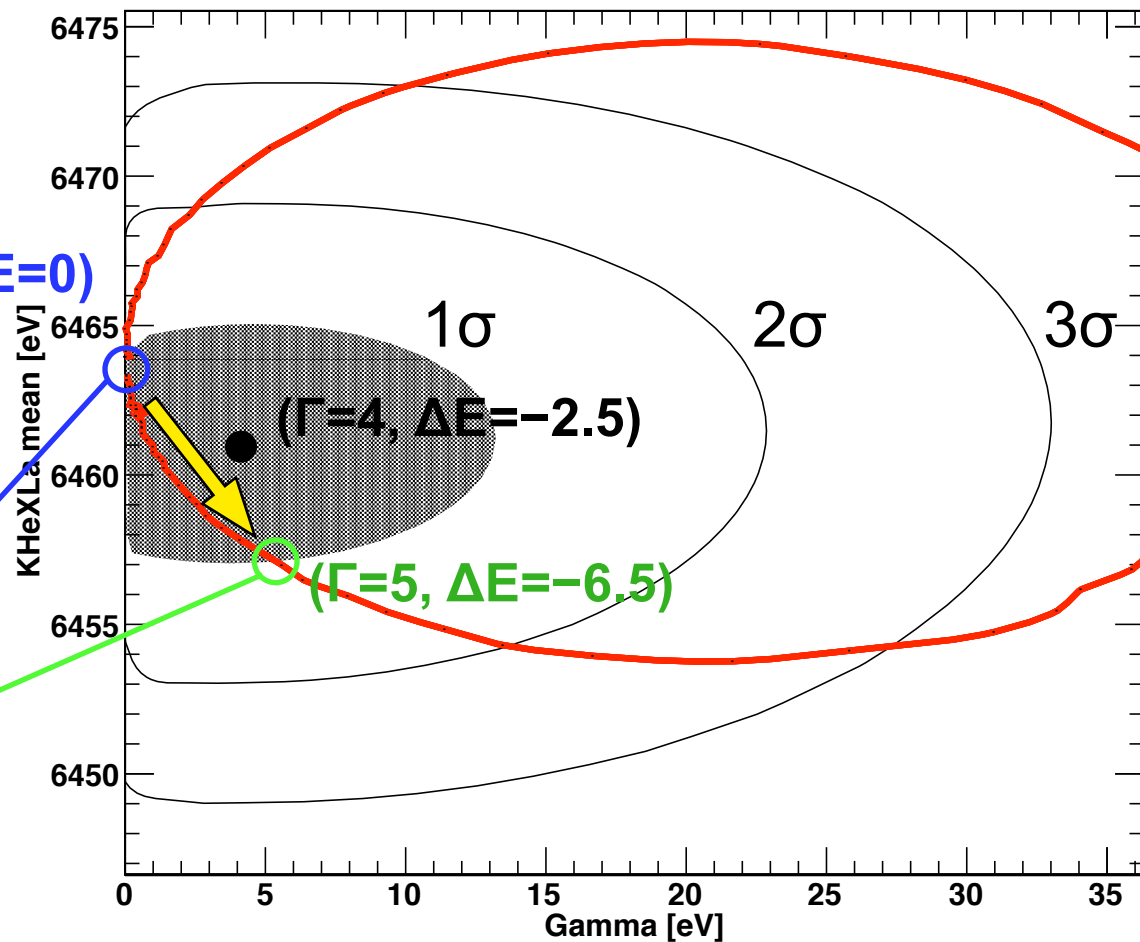
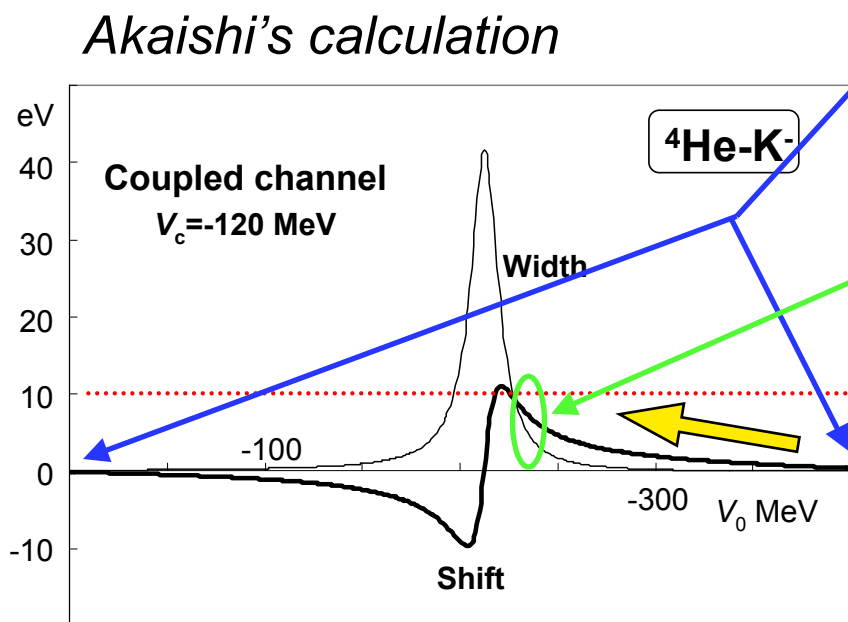
### Confidence level (68.3%, 90%, 99%)



# Comparison with Akaishi's calculation

(1st cycle)

# KHeXL $\alpha$ energy vs Gamma fit contour (1,2 and 3 $\sigma$ )

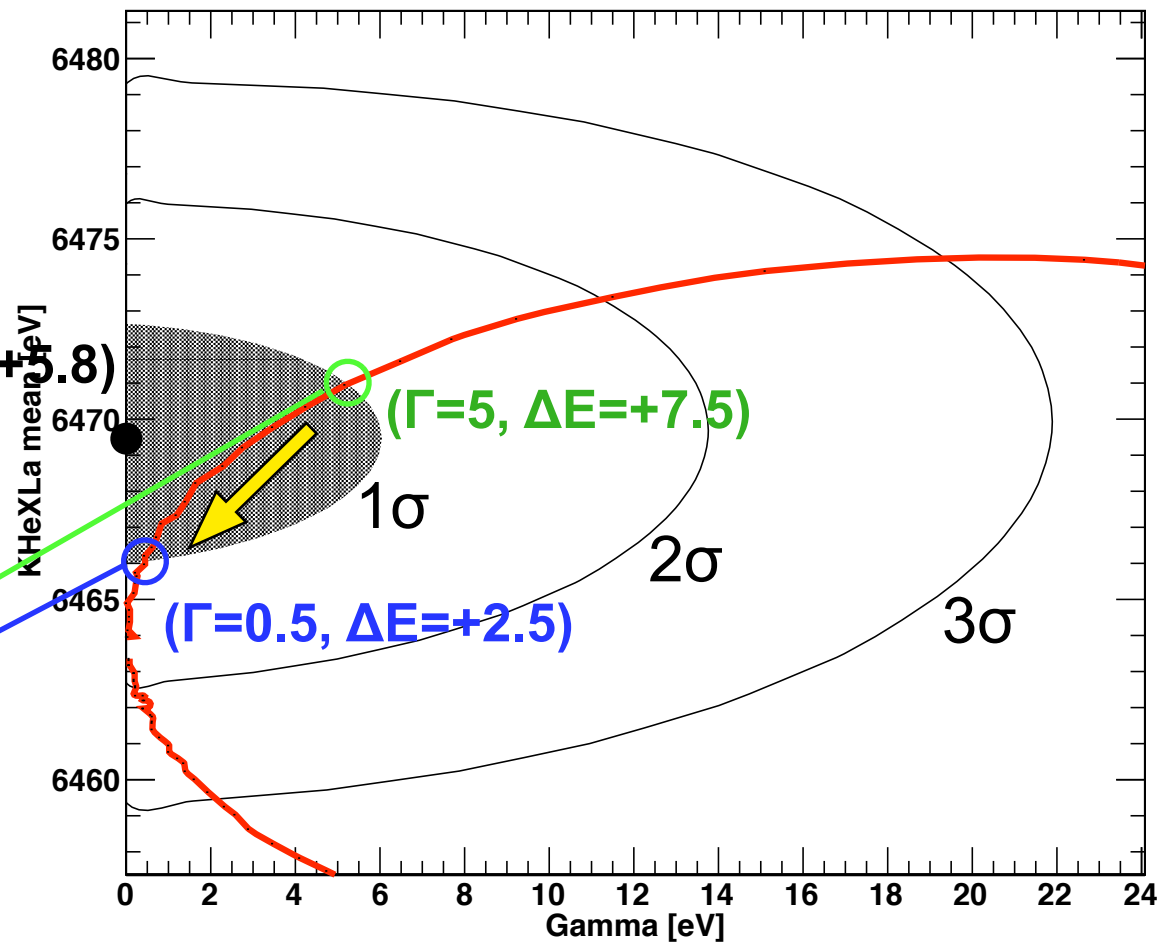
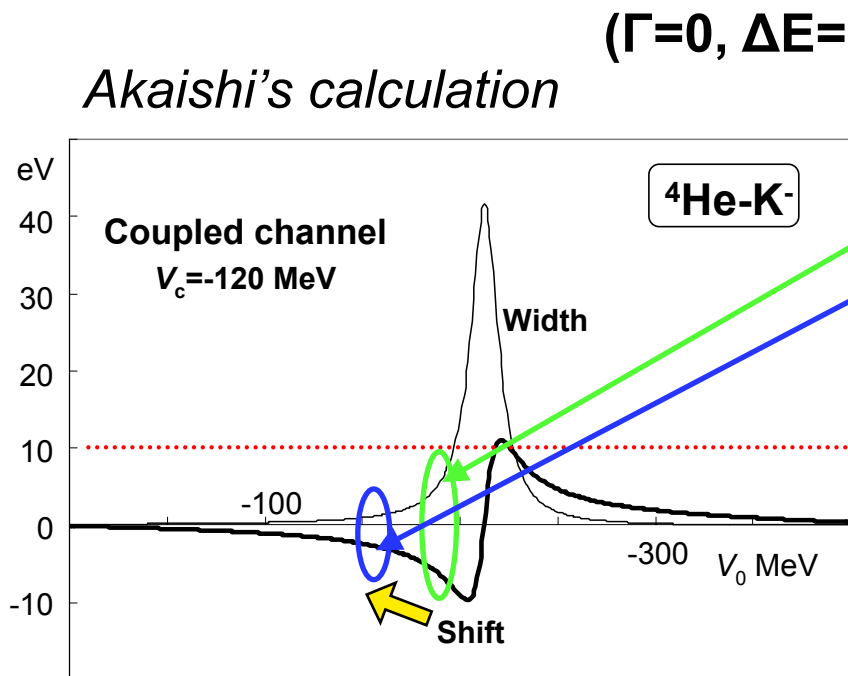


*On the red line : Akaishi's calculation*

# Comparison with Akaishi's calculation

(2nd cycle)

# KHeXL $\alpha$ energy vs Gamma fit contour (1,2 and 3 $\sigma$ )



*On the red line : Akaishi's calculation*

Backups



FCN=948.714 FROM MINOS STATUS=SUCCESSFUL 3560 CALLS 3979 TOTAL  
 EDM=1.3398e-08 STRATEGY= 1 ERROR MATRIX ACCURATE

# Cycle I

EXT NO.	PARAMETER NAME	VALUE	PARABOLIC ERROR	MINOS ERRORS	
				NEGATIVE	POSITIVE
1	BGa	1.83386e+00	4.31151e+00	-4.35531e+00	4.42025e+00
2	BGb	3.13038e-03	1.26914e-03	-1.29768e-03	1.28729e-03
3	BGc	-1.85856e-07	8.29820e-08	-8.42163e-08	8.47713e-08
4	Noise [eV]	5.56199e+01	fixed		
5	Fano	1.47044e-01	fixed		
6	TiKa1 area	4.97546e+03	5.09709e+02	-5.00737e+02	5.19110e+02
7	NiKa1 area	3.03057e+03	4.59704e+02	-4.51249e+02	4.70267e+02
8	Ti Kb/Ka1 ratio	2.37658e-01	fixed		
9	Ni Kb/Ka1 ratio	2.86110e-01	fixed		
10	KHeXLa area	3.59596e+04	1.46062e+03	-1.44624e+03	1.47847e+03
11	LaLb ratio	4.21148e-01	2.98992e-02	-2.91911e-02	3.06955e-02
12	LaLg ratio	2.55866e-01	2.43245e-02	-2.37292e-02	2.49808e-02
13	LaLd ratio	5.37226e-02	1.66113e-02	-1.61575e-02	1.71170e-02
14	Gamma [eV]	4.16664e+00	8.88629e+00	at limit	9.18028e+00
15	KHeXLa mean [eV]	6.46113e+03	3.99823e+00	-3.99645e+00	4.00241e+00
16	KHeXLa mean [eV]	8.72324e+03	7.24757e+00	-7.25818e+00	7.24502e+00
17	KHeXLg mean [eV]	9.75981e+03	1.21213e+01	-1.21436e+01	1.21220e+01
18	KHeXLd mean [eV]	1.02838e+04	6.14245e+01	-5.50878e+01	7.75254e+01
19	TiKa1 mean [eV]	4.51089e+03	fixed		
20	NiKa1 mean [eV]	7.47825e+03	fixed		
21	TiKb1 mean [eV]	4.93180e+03	fixed		
22	NiKb1 mean [eV]	8.26470e+03	fixed		
23	Pile area factor	1.16783e-01	fixed		
24	Pile shift [eV]	2.00000e+02	fixed		
25	Pile sigma factor	2.00000e+00	fixed		
26	Tail TiKa area factor	5.51491e-02	fixed		
27	Tail NiKa area factor	3.63280e-02	fixed		
28	Tail slope Ka	1.26956e+00	fixed		
29	Tail Kb/Ka area factor	1.00000e+00	fixed		
30	Tail La area factor	4.59426e-02	fixed		
31	Tail Lb area factor	4.59426e-02	fixed		
32	Tail Lg area factor	4.59426e-02	fixed		
33	Tail Ld area factor	4.59426e-02	fixed		
34	Tail slope L	1.26956e+00	fixed		
35	Shelf height factor	4.42415e-05	fixed		

# Cycle I

36	Comp TiKa1 shift	3.76289e+01	fixed
37	Comp TiKa1 sigma	1.01712e+00	fixed
38	Comp TiKa1 area	4.06609e-03	fixed
39	Comp TiKa1 slope	6.06911e-01	fixed
40	Comp TiKa2 shift	3.39473e+01	fixed
41	Comp TiKa2 sigma	9.02316e-01	fixed
42	Comp TiKa2 area	4.23928e-03	fixed
43	Comp TiKa2 slope	7.72300e-01	fixed
44	Comp TiKb1 shift	2.95193e+01	fixed
45	Comp TiKb1 sigma	8.71439e-01	fixed
46	Comp TiKb1 area	6.67607e-03	fixed
47	Comp TiKb1 slope	1.09449e+00	fixed
48	Comp NiKa1 shift	1.21237e+02	fixed
49	Comp NiKa1 sigma	1.15272e+00	fixed
50	Comp NiKa1 area	2.68013e-02	fixed
51	Comp NiKa1 slope	8.07486e-01	fixed
52	Comp NiKa2 shift	1.20076e+02	fixed
53	Comp NiKa2 sigma	1.16287e+00	fixed
54	Comp NiKa2 area	2.65636e-02	fixed
55	Comp NiKa2 slope	7.65928e-01	fixed
56	Comp NiKb1 shift	1.53099e+02	fixed
57	Comp NiKb1 sigma	1.15663e+00	fixed
58	Comp NiKb1 area	3.16241e-02	fixed
59	Comp NiKb1 slope	8.22839e-01	fixed
60	Comp La shift	4.95963e+01	fixed
61	Comp La sigma	1.07244e+00	fixed
62	Comp La area	1.40976e-01	fixed
63	Comp La slope	8.87743e-01	fixed
64	Comp Lb shift	8.19417e+01	fixed
65	Comp Lb sigma	1.20844e+00	fixed
66	Comp Lb area	1.79960e-01	fixed
67	Comp Lb slope	1.26568e+00	fixed
68	Comp Lg shift	1.04870e+02	fixed
69	Comp Lg sigma	1.34014e+00	fixed
70	Comp Lg area	1.90469e-01	fixed
71	Comp Lg slope	1.28216e+00	fixed
72	Comp Ld shift	1.09365e+02	fixed
73	Comp Ld sigma	1.38889e+00	fixed
74	Comp Ld area	1.93709e-01	fixed
75	Comp Ld slope	1.41048e+00	fixed
76	CuKa/NiKa1 ratio	5.92272e-02	fixed
77	CuKa mean [eV]	8.04107e+03	fixed
78	Voigt r	4.00000e+00	fixed

# Cycle I

```
# ---- Fit info -----
# FitOption : REL0
# Chisqr/NDF = 177.848/146 = 1.218

# ---- Tail ratio ----
# TiKa1 0.0551491 +- 0.00858469
# NiKa1 0.036328 +- 0.00877294
# KHeXLa 0.0459426 +- 0.00613577
# KHeXLb 0.0459426 +- 0.00613577
# KHeXLg 0.0459426 +- 0.00613577
# KHeXLd 0.0459426 +- 0.00613577

# ---- X-rays -----
# KHeXLa : 6461.132 +- 3.999, Ref = 6463.500, Shift = -2.368 +- 3.999(Stat.) +- 0.190(Ref.)
# KHeXLb : 8723.240 +- 7.252, Ref = 8721.700, Shift = 1.540 +- 7.252(Stat.) +- 0.240(Ref.)
# KHeXLg : 9759.806 +-12.133, Ref = 9766.800, Shift = -6.994 +-12.133(Stat.) +- 0.270(Ref.)
# KHeXLd : 10283.752 +-66.307, Ref = 10334.400, Shift = -50.648 +-66.307(Stat.) +- 0.290(Ref.)

# ---- Shift -----
# Shift(weighted average La-Lb) = -1.457 +- 3.502 (Only Stat.)
# Shift(weighted average La-Lg) = -1.882 +- 3.365 (Only Stat.)
# Shift(weighted average La-Ld) = -2.008 +- 3.360 (Only Stat.)

# ---- Width -----
# Gamma = 4.167 +- 8.886

#### Systematic Errors ####
# ---- Attractive side ----- # ---- Repulsive side -----
# -- X-ray -- # -- X-ray --
# KHeXLa : -1.491 # KHeXLa : 1.504
# KHeXLb : -1.269 # KHeXLb : 1.283
# KHeXLg : -1.549 # KHeXLg : 1.568
# KHeXLd : 1.608 # KHeXLd : -1.711
# -- Shift -- # -- Shift --
# w2shift : -1.441 # w2shift : 1.454
# w3shift : -1.450 # w3shift : 1.463
# w4shift : -1.437 # w4shift : 1.451
# -- Gamma -- # -- Gamma --
# Gamma : -0.237 # Gamma : 0.157
```

FCN=946.961 FROM MINOS STATUS=SUCCESSFUL 4209 CALLS 4653 TOTAL

EDM=1.32282e-08 STRATEGY= 1 ERROR MATRIX ACCURATE

# Cycle2

EXT NO.	PARAMETER NAME	VALUE	PARABOLIC ERROR	MINOS NEGATIVE	MINOS POSITIVE
1	BGa	-5.96858e+00	3.69377e+00	-3.72196e+00	3.82570e+00
2	BGb	4.95611e-03	1.07815e-03	-1.12438e-03	1.09147e-03
3	BGc	-3.01149e-07	7.09995e-08	-7.19101e-08	7.39450e-08
4	Noise [eV]	5.44311e+01	fixed		
5	Fano	1.29595e-01	fixed		
6	TiKa1 area	5.11656e+03	4.97436e+02	-4.87996e+02	5.07255e+02
7	NiKa1 area	1.95347e+03	4.20816e+02	-4.11291e+02	4.31803e+02
8	Ti Kb/Ka1 ratio	2.43399e-01	fixed		
9	Ni Kb/Ka1 ratio	2.84612e-01	fixed		
10	KHeXLa area	4.20393e+04	1.43642e+03	-1.42304e+03	1.50333e+03
11	LaLb ratio	4.21389e-01	2.75423e-02	-2.69035e-02	2.82453e-02
12	LaLg ratio	2.25046e-01	2.06331e-02	-2.01251e-02	2.11806e-02
13	LaLd ratio	7.24488e-02	1.49178e-02	-1.45066e-02	1.53640e-02
14	Gamma [eV]	7.91917e-09	2.33015e+01	at limit	6.39698e+00
WARNING - - ABOVE PARAMETER IS AT LIMIT.					
15	KHeXLa mean [eV]	6.46957e+03	3.32440e+00	-3.32324e+00	3.32602e+00
16	KHeXLb mean [eV]	8.72355e+03	6.23665e+00	-6.23306e+00	6.24371e+00
17	KHeXLg mean [eV]	9.76164e+03	1.03510e+01	-1.03551e+01	1.03623e+01
18	KHeXLd mean [eV]	1.03427e+04	3.74055e+01	-3.59928e+01	3.92805e+01
19	TiKa1 mean [eV]	4.51089e+03	fixed		
20	NiKa1 mean [eV]	7.47825e+03	fixed		
21	TiKb1 mean [eV]	4.93180e+03	fixed		
22	NiKb1 mean [eV]	8.26470e+03	fixed		
23	Pile area factor	6.98549e-02	fixed		
24	Pile shift [eV]	2.00000e+02	fixed		
25	Pile sigma factor	2.00000e+00	fixed		
26	Tail TiKa area factor	2.31401e-02	fixed		
27	Tail NiKa area factor	2.04589e-02	fixed		
28	Tail slope Ka	1.65477e+00	fixed		
29	Tail Kb/Ka area factor	1.00000e+00	fixed		
30	Tail La area factor	2.18590e-02	fixed		
31	Tail Lb area factor	2.18590e-02	fixed		
32	Tail Lg area factor	2.18590e-02	fixed		
33	Tail Ld area factor	2.18590e-02	fixed		
34	Tail slope L	1.65477e+00	fixed		
35	Shelf height factor	3.66460e-05	fixed		

# Cycle2

36	Comp TiKa1 shift	3.55243e+01	fixed	60	Comp La shift	4.99760e+01	fixed
37	Comp TiKa1 sigma	9.68995e-01	fixed	61	Comp La sigma	1.09200e+00	fixed
38	Comp TiKa1 area	4.08567e-03	fixed	62	Comp La area	1.39261e-01	fixed
39	Comp TiKa1 slope	6.92819e-01	fixed	63	Comp La slope	9.16263e-01	fixed
40	Comp TiKa2 shift	2.69409e+01	fixed	64	Comp Lb shift	8.17678e+01	fixed
41	Comp TiKa2 sigma	9.41592e-01	fixed	65	Comp Lb sigma	1.22835e+00	fixed
42	Comp TiKa2 area	4.28535e-03	fixed	66	Comp Lb area	1.79957e-01	fixed
43	Comp TiKa2 slope	8.18358e-01	fixed	67	Comp Lb slope	1.27435e+00	fixed
44	Comp TiKb1 shift	5.59391e+01	fixed	68	Comp Lg shift	1.07475e+02	fixed
45	Comp TiKb1 sigma	1.01373e+00	fixed	69	Comp Lg sigma	1.36932e+00	fixed
46	Comp TiKb1 area	6.76844e-03	fixed	70	Comp Lg area	1.89807e-01	fixed
47	Comp TiKb1 slope	5.91786e-01	fixed	71	Comp Lg slope	1.30237e+00	fixed
48	Comp NiKa1 shift	1.20543e+02	fixed	72	Comp Ld shift	1.15847e+02	fixed
49	Comp NiKa1 sigma	1.15581e+00	fixed	73	Comp Ld sigma	1.44506e+00	fixed
50	Comp NiKa1 area	2.66478e-02	fixed	74	Comp Ld area	1.92379e-01	fixed
51	Comp NiKa1 slope	8.41702e-01	fixed	75	Comp Ld slope	1.35922e+00	fixed
52	Comp NiKa2 shift	1.11697e+02	fixed	76	CuKa/NiKa1 ratio	2.63618e-02	fixed
53	Comp NiKa2 sigma	1.11794e+00	fixed	77	CuKa mean [eV]	8.04107e+03	fixed
54	Comp NiKa2 area	2.66751e-02	fixed	78	Voigt r	4.00000e+00	fixed
55	Comp NiKa2 slope	9.42068e-01	fixed				
56	Comp NiKb1 shift	1.64345e+02	fixed				
57	Comp NiKb1 sigma	1.30804e+00	fixed				
58	Comp NiKb1 area	3.13493e-02	fixed				
59	Comp NiKb1 slope	6.24173e-01	fixed				

# Cycle2

```
# ---- Fit info -----  
# FitOption : REL0  
# Chisqr/NDF = 181.880/146 = 1.246
```

```
# ---- Tail ratio ----  
# TiKa1 0.0231401 +- 0.00544478  
# NiKa1 0.0204589 +- 0.00569207  
# KHeXLa 0.021859 +- 0.00393456  
# KHeXlb 0.021859 +- 0.00393456  
# KHeXLg 0.021859 +- 0.00393456  
# KHeXLd 0.021859 +- 0.00393456
```

```
# ---- X-rays -----  
# KHeXLa : 6469.574 +- 3.325, Ref = 6463.500, Shift = 6.074 +- 3.325(Stat.) +- 0.190(Ref.)  
# KHeXlb : 8723.547 +- 6.238, Ref = 8721.700, Shift = 1.847 +- 6.238(Stat.) +- 0.240(Ref.)  
# KHeXLg : 9761.638 +-10.359, Ref = 9766.800, Shift = -5.162 +-10.359(Stat.) +- 0.270(Ref.)  
# KHeXLd : 10342.663 +-37.637, Ref = 10334.400, Shift = 8.263 +-37.637(Stat.) +- 0.290(Ref.)
```

```
# ---- Shift -----  
# Shift(weighted average La-Lb) = 5.139 +- 2.934 (Only Stat.)  
# Shift(weighted average La-Lg) = 4.374 +- 2.823 (Only Stat.)  
# Shift(weighted average La-Ld) = 4.396 +- 2.815 (Only Stat.)
```

```
# ---- Width -----  
# Gamma = 0.000 +-23.301
```

## #### Systematic Errors ####

```
# ---- Attractive side ----- # ---- Repulsive side -----  
# -- X-ray -- # -- X-ray --  
# KHeXLa : -1.050 # KHeXLa : 1.061  
# KHeXlb : -1.027 # KHeXlb : 1.035  
# KHeXLg : -0.973 # KHeXLg : 0.978  
# KHeXLd : -0.589 # KHeXLd : 0.572  
# -- Shift -- # -- Shift --  
# w2shift : -1.045 # w2shift : 1.055  
# w3shift : -1.042 # w3shift : 1.051  
# w4shift : -1.039 # w4shift : 1.048  
# -- Gamma -- # -- Gamma --  
# Gamma : -0.000 # Gamma : 0.000
```

“Resolution minus”

$$\sigma_- = \sqrt{N_-^2 + F_- w E}$$

$$N_- = N - \sigma_N$$

$$F_- = F - \sigma_F$$

FCN=949.311 FROM MINOS STATUS=SUCCESSFUL 3474 CALLS 3881 TOTAL  
 EDM=6.09021e-08 STRATEGY= 1 ERROR MATRIX ACCURATE

# Cycle I

EXT NO.	PARAMETER NAME	VALUE	PARABOLIC ERROR	MINOS ERRORS	
				NEGATIVE	POSITIVE
1	BGa	2.01471e+00	4.03105e+00	-4.35303e+00	4.41826e+00
2	BGb	3.07811e-03	1.18275e-03	-1.29666e-03	1.28618e-03
3	BGc	-1.82646e-07	7.73852e-08	-8.41378e-08	8.46992e-08
4	Noise [eV]	5.48538e+01	fixed		
5	Fano	1.43068e-01	fixed		
6	TiKa1 area	4.94485e+03	5.07411e+02	-4.98913e+02	5.17321e+02
7	NiKa1 area	3.02740e+03	4.54554e+02	-4.49397e+02	4.68393e+02
8	Ti Kb/Ka1 ratio	2.37658e-01	fixed		
9	Ni Kb/Ka1 ratio	2.86110e-01	fixed		
10	KHeXLa area	3.60393e+04	1.45598e+03	-1.44695e+03	1.47942e+03
11	LaLb ratio	4.21092e-01	2.98501e-02	-2.91763e-02	3.06803e-02
12	LaLg ratio	2.55818e-01	2.43064e-02	-2.37262e-02	2.49799e-02
13	LaLd ratio	5.36512e-02	1.66027e-02	-1.61485e-02	1.71115e-02
14	Gamma [eV]	7.07783e+00	8.83168e+00	at limit	9.16478e+00
15	KHeXLa mean [eV]	6.46116e+03	3.99688e+00	-3.99514e+00	4.00147e+00
16	KHeXLa mean [eV]	8.72352e+03	7.23624e+00	-7.24798e+00	7.23360e+00
17	KHeXLg mean [eV]	9.76005e+03	1.21208e+01	-1.21466e+01	1.21209e+01
18	KHeXLd mean [eV]	1.02835e+04	6.17855e+01	-5.50052e+01	7.95129e+01
19	TiKa1 mean [eV]	4.51089e+03	fixed		
20	NiKa1 mean [eV]	7.47825e+03	fixed		
21	TiKb1 mean [eV]	4.93180e+03	fixed		
22	NiKb1 mean [eV]	8.26470e+03	fixed		
23	Pile area factor	1.16783e-01	fixed		
24	Pile shift [eV]	2.00000e+02	fixed		
25	Pile sigma factor	2.00000e+00	fixed		
26	Tail TiKa area factor	5.51491e-02	fixed		
27	Tail NiKa area factor	3.63280e-02	fixed		
28	Tail slope Ka	1.26956e+00	fixed		
29	Tail Kb/Ka area factor	1.00000e+00	fixed		
30	Tail La area factor	4.59426e-02	fixed		
31	Tail Lb area factor	4.59426e-02	fixed		
32	Tail Lg area factor	4.59426e-02	fixed		
33	Tail Ld area factor	4.59426e-02	fixed		
34	Tail slope L	1.26956e+00	fixed		
35	Shelf height factor	4.42415e-05	fixed		

## resolution minus



# Fixed parameters

# Cycle I

## resolution minus

36	Comp TiKa1 shift	3.76289e+01	fixed	60	Comp La shift	4.95963e+01	fixed
37	Comp TiKa1 sigma	1.01712e+00	fixed	61	Comp La sigma	1.07244e+00	fixed
38	Comp TiKa1 area	4.06609e-03	fixed	62	Comp La area	1.40976e-01	fixed
39	Comp TiKa1 slope	6.06911e-01	fixed	63	Comp La slope	8.87743e-01	fixed
40	Comp TiKa2 shift	3.39473e+01	fixed	64	Comp Lb shift	8.19417e+01	fixed
41	Comp TiKa2 sigma	9.02316e-01	fixed	65	Comp Lb sigma	1.20844e+00	fixed
42	Comp TiKa2 area	4.23928e-03	fixed	66	Comp Lb area	1.79960e-01	fixed
43	Comp TiKa2 slope	7.72300e-01	fixed	67	Comp Lb slope	1.26568e+00	fixed
44	Comp TiKb1 shift	2.95193e+01	fixed	68	Comp Lg shift	1.04870e+02	fixed
45	Comp TiKb1 sigma	8.71439e-01	fixed	69	Comp Lg sigma	1.34014e+00	fixed
46	Comp TiKb1 area	6.67607e-03	fixed	70	Comp Lg area	1.90469e-01	fixed
47	Comp TiKb1 slope	1.09449e+00	fixed	71	Comp Lg slope	1.28216e+00	fixed
48	Comp NiKa1 shift	1.21237e+02	fixed	72	Comp Ld shift	1.09365e+02	fixed
49	Comp NiKa1 sigma	1.15272e+00	fixed	73	Comp Ld sigma	1.38889e+00	fixed
50	Comp NiKa1 area	2.68013e-02	fixed	74	Comp Ld area	1.93709e-01	fixed
51	Comp NiKa1 slope	8.07486e-01	fixed	75	Comp Ld slope	1.41048e+00	fixed
52	Comp NiKa2 shift	1.20076e+02	fixed	76	CuKa/NiKa1 ratio	5.92272e-02	fixed
53	Comp NiKa2 sigma	1.16287e+00	fixed	77	CuKa mean [eV]	8.04107e+03	fixed
54	Comp NiKa2 area	2.65636e-02	fixed	78	Voigt r	4.00000e+00	fixed
55	Comp NiKa2 slope	7.65928e-01	fixed				
56	Comp NiKb1 shift	1.53099e+02	fixed				
57	Comp NiKb1 sigma	1.15663e+00	fixed				
58	Comp NiKb1 area	3.16241e-02	fixed				
59	Comp NiKb1 slope	8.22839e-01	fixed				

# Fit summary

# Cycle I

## resolution minus

```
# ---- Fit info -----  
# FitOption : REL0  
# Chisqr/NDF = 178.443/146 = 1.222
```

```
# ---- Tail ratio ----  
# TiKa1 0.0551491 +- 0.00858469  
# NiKa1 0.036328 +- 0.00877294  
# KHeXLa 0.0459426 +- 0.00613577  
# KHeXLb 0.0459426 +- 0.00613577  
# KHeXLg 0.0459426 +- 0.00613577  
# KHeXLd 0.0459426 +- 0.00613577
```

```
# ---- X-rays -----  
# KHeXLa : 6461.159 +- 3.998, Ref = 6463.500, Shift = -2.341 +- 3.998(Stat.) +- 0.190(Ref.)  
# KHeXLb : 8723.516 +- 7.241, Ref = 8721.700, Shift = 1.816 +- 7.241(Stat.) +- 0.240(Ref.)  
# KHeXLg : 9760.052 +-12.134, Ref = 9766.800, Shift = -6.748 +-12.134(Stat.) +- 0.270(Ref.)  
# KHeXLd : 10283.487 +-67.259, Ref = 10334.400, Shift = -50.913 +-67.259(Stat.) +- 0.290(Ref.)
```

```
# ---- Shift -----  
# Shift(weighted average La-Lb) = -1.370 +- 3.500 (Only Stat.)  
# Shift(weighted average La-Lg) = -1.783 +- 3.363 (Only Stat.)  
# Shift(weighted average La-Ld) = -1.906 +- 3.359 (Only Stat.)
```

```
# ---- Width -----  
# Gamma = 7.078 +- 8.832
```

### #### Systematic Errors ####

# ---- Attractive side -----	# ---- Repulsive side -----
# -- X-ray --	# -- X-ray --
# KHeXLa : -1.509	# KHeXLa : 1.521
# KHeXLb : -1.287	# KHeXLb : 1.302
# KHeXLg : -1.574	# KHeXLg : 1.593
# KHeXLd : 1.588	# KHeXLd : -1.698
# -- Shift --	# -- Shift --
# w2shift : -1.460	# w2shift : 1.472
# w3shift : -1.468	# w3shift : 1.482
# w4shift : -1.456	# w4shift : 1.469
# -- Gamma --	# -- Gamma --
# Gamma : -0.262	# Gamma : 0.178

FCN=947.235 FROM MINOS STATUS=SUCCESSFUL 3972 CALLS 4384 TOTAL  
 EDM=1.60145e-07 STRATEGY= 1 ERROR MATRIX ACCURATE

# Cycle2

EXT NO.	PARAMETER NAME	VALUE	PARABOLIC ERROR	MINOS ERRORS	
				NEGATIVE	POSITIVE
1	BGa	-5.97142e+00	3.61872e+00	-3.87048e+00	3.95377e+00
2	BGb	4.96349e-03	1.07278e-03	-1.17170e-03	1.14794e-03
3	BGc	-3.01734e-07	7.06403e-08	-7.56026e-08	7.70295e-08
4	Noise [eV]	5.37633e+01	fixed		
5	Fano	1.26290e-01	fixed		
6	TiKa1 area	5.09182e+03	4.96043e+02	-4.86786e+02	5.06120e+02
7	NiKa1 area	1.94067e+03	4.21577e+02	-4.14985e+02	4.35548e+02
8	Ti Kb/Ka1 ratio	2.43399e-01	fixed		
9	Ni Kb/Ka1 ratio	2.84612e-01	fixed		
10	KHeXLa area	4.20490e+04	1.55920e+03	-1.51517e+03	1.58191e+03
11	LaLb ratio	4.21011e-01	2.75762e-02	-2.69719e-02	2.82991e-02
12	LaLg ratio	2.24671e-01	2.07030e-02	-2.02112e-02	2.12582e-02
13	LaLd ratio	7.21350e-02	1.50033e-02	-1.45850e-02	1.54563e-02
14	Gamma [eV]	1.41644e+00	9.06302e+00	at limit	7.42421e+00
15	KHeXLa mean [eV]	6.46964e+03	3.31718e+00	-3.31361e+00	3.32286e+00
16	KHeXLa mean [eV]	8.72378e+03	6.21535e+00	-6.21313e+00	6.22232e+00
17	KHeXLg mean [eV]	9.76168e+03	1.03395e+01	-1.03424e+01	1.03530e+01
18	KHeXLd mean [eV]	1.03423e+04	3.75330e+01	-3.60444e+01	3.94792e+01
19	TiKa1 mean [eV]	4.51089e+03	fixed		
20	NiKa1 mean [eV]	7.47825e+03	fixed		
21	TiKb1 mean [eV]	4.93180e+03	fixed		
22	NiKb1 mean [eV]	8.26470e+03	fixed		
23	Pile area factor	6.98549e-02	fixed		
24	Pile shift [eV]	2.00000e+02	fixed		
25	Pile sigma factor	2.00000e+00	fixed		
26	Tail TiKa area factor	2.31401e-02	fixed		
27	Tail NiKa area factor	2.04589e-02	fixed		
28	Tail slope Ka	1.65477e+00	fixed		
29	Tail Kb/Ka area factor	1.00000e+00	fixed		
30	Tail La area factor	2.18590e-02	fixed		
31	Tail Lb area factor	2.18590e-02	fixed		
32	Tail Lg area factor	2.18590e-02	fixed		
33	Tail Ld area factor	2.18590e-02	fixed		
34	Tail slope L	1.65477e+00	fixed		
35	Shelf height factor	3.66460e-05	fixed		

## resolution minus

# resolution minus

# Cycle2

36	Comp TiKa1 shift	3.55243e+01	fixed	60	Comp La shift	4.99760e+01	fixed
37	Comp TiKa1 sigma	9.68995e-01	fixed	61	Comp La sigma	1.09200e+00	fixed
38	Comp TiKa1 area	4.08567e-03	fixed	62	Comp La area	1.39261e-01	fixed
39	Comp TiKa1 slope	6.92819e-01	fixed	63	Comp La slope	9.16263e-01	fixed
40	Comp TiKa2 shift	2.69409e+01	fixed	64	Comp Lb shift	8.17678e+01	fixed
41	Comp TiKa2 sigma	9.41592e-01	fixed	65	Comp Lb sigma	1.22835e+00	fixed
42	Comp TiKa2 area	4.28535e-03	fixed	66	Comp Lb area	1.79957e-01	fixed
43	Comp TiKa2 slope	8.18358e-01	fixed	67	Comp Lb slope	1.27435e+00	fixed
44	Comp TiKb1 shift	5.59391e+01	fixed	68	Comp Lg shift	1.07475e+02	fixed
45	Comp TiKb1 sigma	1.01373e+00	fixed	69	Comp Lg sigma	1.36932e+00	fixed
46	Comp TiKb1 area	6.76844e-03	fixed	70	Comp Lg area	1.89807e-01	fixed
47	Comp TiKb1 slope	5.91786e-01	fixed	71	Comp Lg slope	1.30237e+00	fixed
48	Comp NiKa1 shift	1.20543e+02	fixed	72	Comp Ld shift	1.15847e+02	fixed
49	Comp NiKa1 sigma	1.15581e+00	fixed	73	Comp Ld sigma	1.44506e+00	fixed
50	Comp NiKa1 area	2.66478e-02	fixed	74	Comp Ld area	1.92379e-01	fixed
51	Comp NiKa1 slope	8.41702e-01	fixed	75	Comp Ld slope	1.35922e+00	fixed
52	Comp NiKa2 shift	1.11697e+02	fixed	76	CuKa/NiKa1 ratio	2.63618e-02	fixed
53	Comp NiKa2 sigma	1.11794e+00	fixed	77	CuKa mean [eV]	8.04107e+03	fixed
54	Comp NiKa2 area	2.66751e-02	fixed	78	Voigt r	4.00000e+00	fixed
55	Comp NiKa2 slope	9.42068e-01	fixed				
56	Comp NiKb1 shift	1.64345e+02	fixed				
57	Comp NiKb1 sigma	1.30804e+00	fixed				
58	Comp NiKb1 area	3.13493e-02	fixed				
59	Comp NiKb1 slope	6.24173e-01	fixed				

```
# ---- Fit info -----
# FitOption : REL0
# Chisqr/NDF = 182.044/146 = 1.247
```

# Fit summary

# Cycle2

```
# ---- Tail ratio ----
# TiKa1 0.0231401 +- 0.00544478
# NiKa1 0.0204589 +- 0.00569207
# KHeXLa 0.021859 +- 0.00393456
# KHeXlb 0.021859 +- 0.00393456
# KHeXLg 0.021859 +- 0.00393456
# KHeXLd 0.021859 +- 0.00393456
```

## resolution minus

```
# ---- X-rays -----
# KHeXLa : 6469.645 +- 3.318, Ref = 6463.500, Shift = 6.145 +- 3.318(Stat.) +- 0.190(Ref.)
# KHeXlb : 8723.781 +- 6.218, Ref = 8721.700, Shift = 2.081 +- 6.218(Stat.) +- 0.240(Ref.)
# KHeXLg : 9761.684 +-10.348, Ref = 9766.800, Shift = -5.116 +-10.348(Stat.) +- 0.270(Ref.)
# KHeXLd : 10342.264 +-37.762, Ref = 10334.400, Shift = 7.864 +-37.762(Stat.) +- 0.290(Ref.)
```

```
# ---- Shift -----
# Shift(weighted average La-Lb) = 5.244 +- 2.927 (Only Stat.)
# Shift(weighted average La-Lg) = 4.476 +- 2.817 (Only Stat.)
# Shift(weighted average La-Ld) = 4.495 +- 2.809 (Only Stat.)
```

```
# ---- Width -----
# Gamma = 1.416 +- 9.063
```

### #### Systematic Errors ####

# ---- Attractive side -----	# ---- Repulsive side -----
# -- X-ray --	# -- X-ray --
# KHeXLa : -1.056	# KHeXLa : 1.066
# KHeXlb : -1.036	# KHeXlb : 1.045
# KHeXLg : -0.989	# KHeXLg : 0.992
# KHeXLd : -0.600	# KHeXLd : 0.554
# -- Shift --	# -- Shift --
# w2shift : -1.051	# w2shift : 1.061
# w3shift : -1.048	# w3shift : 1.057
# w4shift : -1.046	# w4shift : 1.055
# -- Gamma --	# -- Gamma --
# Gamma : 0.041	# Gamma : -0.102

“Resolution plus”

$$\sigma_+ = \sqrt{N_+^2 + F_+ w E}$$

$$N_+ = N + \sigma_N$$

$$F_+ = F + \sigma_F$$

FCN=948.185 FROM MINOS STATUS=SUCCESSFUL 4189 CALLS 4598 TOTAL  
 EDM=2.90691e-07 STRATEGY= 1 ERROR MATRIX ACCURATE

EXT NO.	PARAMETER NAME	VALUE	PARABOLIC ERROR	MINOS ERRORS	
				NEGATIVE	POSITIVE
1	BGa	1.65296e+00	4.32526e+00	-4.30907e+00	4.42220e+00
2	BGb	3.18295e-03	1.27377e-03	-1.29868e-03	1.26123e-03
3	BGc	-1.89093e-07	8.32862e-08	-8.24890e-08	8.48410e-08
4	Noise [eV]	5.63860e+01	fixed		
5	Fano	1.51020e-01	fixed		
6	TiKa1 area	5.00535e+03	5.11508e+02	-5.02549e+02	5.20855e+02
7	NiKa1 area	3.03344e+03	4.61706e+02	-4.52949e+02	4.72081e+02
8	Ti Kb/Ka1 ratio	2.37658e-01	fixed		
9	Ni Kb/Ka1 ratio	2.86110e-01	fixed		
10	KHeXLa area	3.58790e+04	1.46044e+03	-1.38320e+03	1.47765e+03
11	LaLb ratio	4.21201e-01	2.99169e-02	-2.92063e-02	3.07107e-02
12	LaLg ratio	2.55913e-01	2.43284e-02	-2.37306e-02	2.49838e-02
13	LaLd ratio	5.37920e-02	1.66186e-02	-1.61659e-02	1.71226e-02
14	Gamma [eV]	1.25702e+00	1.57982e+01	at limit	9.19858e+00
15	KHeXLa mean [eV]	6.46110e+03	3.99955e+00	-3.99786e+00	4.00363e+00
16	KHeXLa mean [eV]	8.72297e+03	7.25896e+00	-7.26968e+00	7.25630e+00
17	KHeXLg mean [eV]	9.75956e+03	1.21209e+01	-1.21405e+01	1.21244e+01
18	KHeXLd mean [eV]	1.02840e+04	6.10544e+01	-5.51414e+01	7.57593e+01
19	TiKa1 mean [eV]	4.51089e+03	fixed		
20	NiKa1 mean [eV]	7.47825e+03	fixed		
21	TiKb1 mean [eV]	4.93180e+03	fixed		
22	NiKb1 mean [eV]	8.26470e+03	fixed		
23	Pile area factor	1.16783e-01	fixed		
24	Pile shift [eV]	2.00000e+02	fixed		
25	Pile sigma factor	2.00000e+00	fixed		
26	Tail TiKa area factor	5.51491e-02	fixed		
27	Tail NiKa area factor	3.63280e-02	fixed		
28	Tail slope Ka	1.26956e+00	fixed		
29	Tail Kb/Ka area factor	1.00000e+00	fixed		
30	Tail La area factor	4.59426e-02	fixed		
31	Tail Lb area factor	4.59426e-02	fixed		
32	Tail Lg area factor	4.59426e-02	fixed		
33	Tail Ld area factor	4.59426e-02	fixed		
34	Tail slope L	1.26956e+00	fixed		
35	Shelf height factor	4.42415e-05	fixed		

# Cycle I

## resolution plus

# resolution plus

# Cycle I

36	Comp TiKa1 shift	3.76289e+01	fixed	60	Comp La shift	4.95963e+01	fixed
37	Comp TiKa1 sigma	1.01712e+00	fixed	61	Comp La sigma	1.07244e+00	fixed
38	Comp TiKa1 area	4.06609e-03	fixed	62	Comp La area	1.40976e-01	fixed
39	Comp TiKa1 slope	6.06911e-01	fixed	63	Comp La slope	8.87743e-01	fixed
40	Comp TiKa2 shift	3.39473e+01	fixed	64	Comp Lb shift	8.19417e+01	fixed
41	Comp TiKa2 sigma	9.02316e-01	fixed	65	Comp Lb sigma	1.20844e+00	fixed
42	Comp TiKa2 area	4.23928e-03	fixed	66	Comp Lb area	1.79960e-01	fixed
43	Comp TiKa2 slope	7.72300e-01	fixed	67	Comp Lb slope	1.26568e+00	fixed
44	Comp TiKb1 shift	2.95193e+01	fixed	68	Comp Lg shift	1.04870e+02	fixed
45	Comp TiKb1 sigma	8.71439e-01	fixed	69	Comp Lg sigma	1.34014e+00	fixed
46	Comp TiKb1 area	6.67607e-03	fixed	70	Comp Lg area	1.90469e-01	fixed
47	Comp TiKb1 slope	1.09449e+00	fixed	71	Comp Lg slope	1.28216e+00	fixed
48	Comp NiKa1 shift	1.21237e+02	fixed	72	Comp Ld shift	1.09365e+02	fixed
49	Comp NiKa1 sigma	1.15272e+00	fixed	73	Comp Ld sigma	1.38889e+00	fixed
50	Comp NiKa1 area	2.68013e-02	fixed	74	Comp Ld area	1.93709e-01	fixed
51	Comp NiKa1 slope	8.07486e-01	fixed	75	Comp Ld slope	1.41048e+00	fixed
52	Comp NiKa2 shift	1.20076e+02	fixed	76	CuKa/NiKa1 ratio	5.92272e-02	fixed
53	Comp NiKa2 sigma	1.16287e+00	fixed	77	CuKa mean [eV]	8.04107e+03	fixed
54	Comp NiKa2 area	2.65636e-02	fixed	78	Voigt r	4.00000e+00	fixed
55	Comp NiKa2 slope	7.65928e-01	fixed				
56	Comp NiKb1 shift	1.53099e+02	fixed				
57	Comp NiKb1 sigma	1.15663e+00	fixed				
58	Comp NiKb1 area	3.16241e-02	fixed				
59	Comp NiKb1 slope	8.22839e-01	fixed				



# resolution plus

# Cycle I

# ---- Fit info -----

# FitOption : REL0

# Chisqr/NDF = 177.336/146 = 1.215

# ---- Tail ratio ----

# TiKa1 0.0551491 +- 0.00858469

# NiKa1 0.036328 +- 0.00877294

# KHeXLa 0.0459426 +- 0.00613577

# KHeXLb 0.0459426 +- 0.00613577

# KHeXLg 0.0459426 +- 0.00613577

# KHeXLd 0.0459426 +- 0.00613577

# ---- X-rays -----

# KHeXLa : 6461.103 +- 4.001, Ref = 6463.500, Shift = -2.397 +- 4.001(Stat.) +- 0.190(Ref.)

# KHeXLb : 8722.967 +- 7.263, Ref = 8721.700, Shift = 1.267 +- 7.263(Stat.) +- 0.240(Ref.)

# KHeXLg : 9759.563 +-12.132, Ref = 9766.800, Shift = -7.237 +-12.132(Stat.) +- 0.270(Ref.)

# KHeXLd : 10283.951 +-65.450, Ref = 10334.400, Shift = -50.449 +-65.450(Stat.) +- 0.290(Ref.)

# ---- Shift -----

# Shift(weighted average La-Lb) = -1.544 +- 3.504 (Only Stat.)

# Shift(weighted average La-Lg) = -1.983 +- 3.367 (Only Stat.)

# Shift(weighted average La-Ld) = -2.111 +- 3.362 (Only Stat.)

# ---- Width -----

# Gamma = 1.257 +-15.798

#### Systematic Errors ####

# ---- Attractive side -----

# -- X-ray --

# KHeXLa : -1.473

# KHeXLb : -1.251

# KHeXLg : -1.526

# KHeXLd : 1.621

# -- Shift --

# w2shift : -1.423

# w3shift : -1.431

# w4shift : -1.419

# -- Gamma --

# Gamma : -0.218

# ---- Repulsive side -----

# -- X-ray --

# KHeXLa : 1.486

# KHeXLb : 1.265

# KHeXLg : 1.543

# KHeXLd : -1.717

# -- Shift --

# w2shift : 1.436

# w3shift : 1.445

# w4shift : 1.432

# -- Gamma --

# Gamma : 0.133

FCN=946.966 FROM MINOS STATUS=SUCCESSFUL 3195 CALLS 3601 TOTAL

EDM=1.82518e-08 STRATEGY= 1 ERROR MATRIX ACCURATE

EXT NO.	PARAMETER NAME	VALUE	PARABOLIC ERROR	MINOS NEGATIVE	MINOS POSITIVE
1	BGa	-5.74940e+00	3.49459e+00	-3.72312e+00	3.78917e+00
2	BGb	4.87280e-03	1.01731e-03	-1.10227e-03	1.09169e-03
3	BGc	-2.95603e-07	6.70289e-08	-7.19132e-08	7.25137e-08
4	Noise [eV]	5.50989e+01	fixed		
5	Fano	1.32900e-01	fixed		
6	TiKa1 area	5.14477e+03	4.98770e+02	-4.89693e+02	5.08915e+02
7	NiKa1 area	1.97932e+03	4.20914e+02	-4.13445e+02	4.33931e+02
8	Ti Kb/Ka1 ratio	2.43399e-01	fixed		
9	Ni Kb/Ka1 ratio	2.84612e-01	fixed		
10	KHeXLa area	4.21480e+04	1.43724e+03	-1.42467e+03	1.45236e+03
11	LaLb ratio	4.22125e-01	2.75161e-02	-2.68954e-02	2.82343e-02
12	LaLg ratio	2.25786e-01	2.06383e-02	-2.01361e-02	2.11892e-02
13	LaLd ratio	7.31079e-02	1.49593e-02	-1.45499e-02	1.54047e-02
14	Gamma [eV]	9.71445e-13	7.44615e+00	at limit	4.67713e+00

WARNING - - ABOVE PARAMETER IS AT LIMIT.

15	KHeXLa mean [eV]	6.46954e+03	3.34821e+00	-3.34704e+00	3.34991e+00
16	KHeXLb mean [eV]	8.72332e+03	6.27464e+00	-6.27057e+00	6.28225e+00
17	KHeXLg mean [eV]	9.76162e+03	1.03825e+01	-1.03867e+01	1.03948e+01
18	KHeXLd mean [eV]	1.03436e+04	3.73755e+01	-3.60596e+01	3.91386e+01
19	TiKa1 mean [eV]	4.51089e+03	fixed		
20	NiKa1 mean [eV]	7.47825e+03	fixed		
21	TiKb1 mean [eV]	4.93180e+03	fixed		
22	NiKb1 mean [eV]	8.26470e+03	fixed		
23	Pile area factor	6.98549e-02	fixed		
24	Pile shift [eV]	2.00000e+02	fixed		
25	Pile sigma factor	2.00000e+00	fixed		
26	Tail TiKa area factor	2.31401e-02	fixed		
27	Tail NiKa area factor	2.04589e-02	fixed		
28	Tail slope Ka	1.65477e+00	fixed		
29	Tail Kb/Ka area factor	1.00000e+00	fixed		
30	Tail La area factor	2.18590e-02	fixed		
31	Tail Lb area factor	2.18590e-02	fixed		
32	Tail Lg area factor	2.18590e-02	fixed		
33	Tail Ld area factor	2.18590e-02	fixed		
34	Tail slope L	1.65477e+00	fixed		
35	Shelf height factor	3.66460e-05	fixed		

# Cycle2

## resolution plus

# resolution plus

# Cycle2

36	Comp TiKa1 shift	3.55243e+01	fixed	60	Comp La shift	4.99760e+01	fixed
37	Comp TiKa1 sigma	9.68995e-01	fixed	61	Comp La sigma	1.09200e+00	fixed
38	Comp TiKa1 area	4.08567e-03	fixed	62	Comp La area	1.39261e-01	fixed
39	Comp TiKa1 slope	6.92819e-01	fixed	63	Comp La slope	9.16263e-01	fixed
40	Comp TiKa2 shift	2.69409e+01	fixed	64	Comp Lb shift	8.17678e+01	fixed
41	Comp TiKa2 sigma	9.41592e-01	fixed	65	Comp Lb sigma	1.22835e+00	fixed
42	Comp TiKa2 area	4.28535e-03	fixed	66	Comp Lb area	1.79957e-01	fixed
43	Comp TiKa2 slope	8.18358e-01	fixed	67	Comp Lb slope	1.27435e+00	fixed
44	Comp TiKb1 shift	5.59391e+01	fixed	68	Comp Lg shift	1.07475e+02	fixed
45	Comp TiKb1 sigma	1.01373e+00	fixed	69	Comp Lg sigma	1.36932e+00	fixed
46	Comp TiKb1 area	6.76844e-03	fixed	70	Comp Lg area	1.89807e-01	fixed
47	Comp TiKb1 slope	5.91786e-01	fixed	71	Comp Lg slope	1.30237e+00	fixed
48	Comp NiKa1 shift	1.20543e+02	fixed	72	Comp Ld shift	1.15847e+02	fixed
49	Comp NiKa1 sigma	1.15581e+00	fixed	73	Comp Ld sigma	1.44506e+00	fixed
50	Comp NiKa1 area	2.66478e-02	fixed	74	Comp Ld area	1.92379e-01	fixed
51	Comp NiKa1 slope	8.41702e-01	fixed	75	Comp Ld slope	1.35922e+00	fixed
52	Comp NiKa2 shift	1.11697e+02	fixed	76	CuKa/NiKa1 ratio	2.63618e-02	fixed
53	Comp NiKa2 sigma	1.11794e+00	fixed	77	CuKa mean [eV]	8.04107e+03	fixed
54	Comp NiKa2 area	2.66751e-02	fixed	78	Voigt r	4.00000e+00	fixed
55	Comp NiKa2 slope	9.42068e-01	fixed				
56	Comp NiKb1 shift	1.64345e+02	fixed				
57	Comp NiKb1 sigma	1.30804e+00	fixed				
58	Comp NiKb1 area	3.13493e-02	fixed				
59	Comp NiKb1 slope	6.24173e-01	fixed				

## resolution plus

```
# ---- Fit info -----
# FitOption : REL0
# Chisqr/NDF = 181.974/146 = 1.246
```

```
# ---- Tail ratio ----
# TiKa1 0.0231401 +- 0.00544478
# NiKa1 0.0204589 +- 0.00569207
# KHeXLa 0.021859 +- 0.00393456
# KHeXLb 0.021859 +- 0.00393456
# KHeXLg 0.021859 +- 0.00393456
# KHeXLd 0.021859 +- 0.00393456
```

```
# ---- X-rays -----
# KHeXLa : 6469.539 +- 3.348, Ref = 6463.500, Shift = 6.039 +- 3.348(Stat.) +- 0.190(Ref.)
# KHeXLb : 8723.317 +- 6.276, Ref = 8721.700, Shift = 1.617 +- 6.276(Stat.) +- 0.240(Ref.)
# KHeXLg : 9761.625 +-10.391, Ref = 9766.800, Shift = -5.175 +-10.391(Stat.) +- 0.270(Ref.)
# KHeXLd : 10343.601 +-37.599, Ref = 10334.400, Shift = 9.201 +-37.599(Stat.) +- 0.290(Ref.)
```

```
# ---- Shift -----
# Shift(weighted average La-Lb) = 5.059 +- 2.954 (Only Stat.)
# Shift(weighted average La-Lg) = 4.294 +- 2.842 (Only Stat.)
# Shift(weighted average La-Ld) = 4.322 +- 2.834 (Only Stat.)
```

```
# ---- Width -----
# Gamma = 0.000 +- 7.446
```

## #### Systematic Errors ####

# ---- Attractive side -----	# ---- Repulsive side -----
# -- X-ray --	# -- X-ray --
# KHeXLa : -1.048	# KHeXLa : 1.058
# KHeXLb : -1.024	# KHeXLb : 1.032
# KHeXLg : -0.963	# KHeXLg : 0.968
# KHeXLd : -0.580	# KHeXLd : 0.561
# -- Shift --	# -- Shift --
# w2shift : -1.043	# w2shift : 1.052
# w3shift : -1.039	# w3shift : 1.048
# w4shift : -1.036	# w4shift : 1.045
# -- Gamma --	# -- Gamma --
# Gamma : -0.000	# Gamma : -0.000