E570

Normalization

2007 Aug. 20 Hideyuki Tatsuno

From Suzuki-san's report
equation (34)

Observed number of X-ray
(Summed up SDDs)

$$\phi^{-}(E) = \frac{C^{-}(E)}{\int_V d^3\vec{r} \cdot V(\vec{r}) \cdot \epsilon^{-}(E,\vec{r})'}. \quad (34)$$

DAQ live time rate
was already canceled.

Dead time (average)

These dead times are non-extendable type

Signal gate	signal rate = R_{sig} (/sec)	signal gate width = τ_{sig} (sec)
Reset VETO	R_{rst}	τ_{rst}
Crosstalk VETO	R_{ctl}	τ_{ctl}
Overflow VETO	R_{ovf}	τ_{ovf}

$$\text{Percent dead time} = \frac{\sum_{SDD}\{(R_{sig} \times \tau_{sig}) + (R_{rst} \times \tau_{rst}) + (R_{ctl} \times \tau_{ctl}) + (R_{ovf} \times \tau_{ovf})\}}{N_{SDD}}$$

$$\sim (\overline{R_{sig}} \times \overline{\tau_{sig}}) + (\overline{R_{rst}} \times \overline{\tau_{rst}}) + (\overline{R_{ctl}} \times \overline{\tau_{ctl}}) + (\overline{R_{ovf}} \times \overline{\tau_{ovf}})$$

Need to take into account averaging errors (variance)

Gate widths

τ_{sig} ~ ADC gate 7μs

Cycle1	SDD2	SDD4	SDD5	Average※1
Reset	400 μs	510 μs	400 μs	437±64 μs
Upper	620 ns	610 ns	610 ns	613±6 ns
Crosstalk	-	14.8 μs※2	-	-

※1 simple average and standard deviation

※2 until SDD3 was tuned off (run 156)

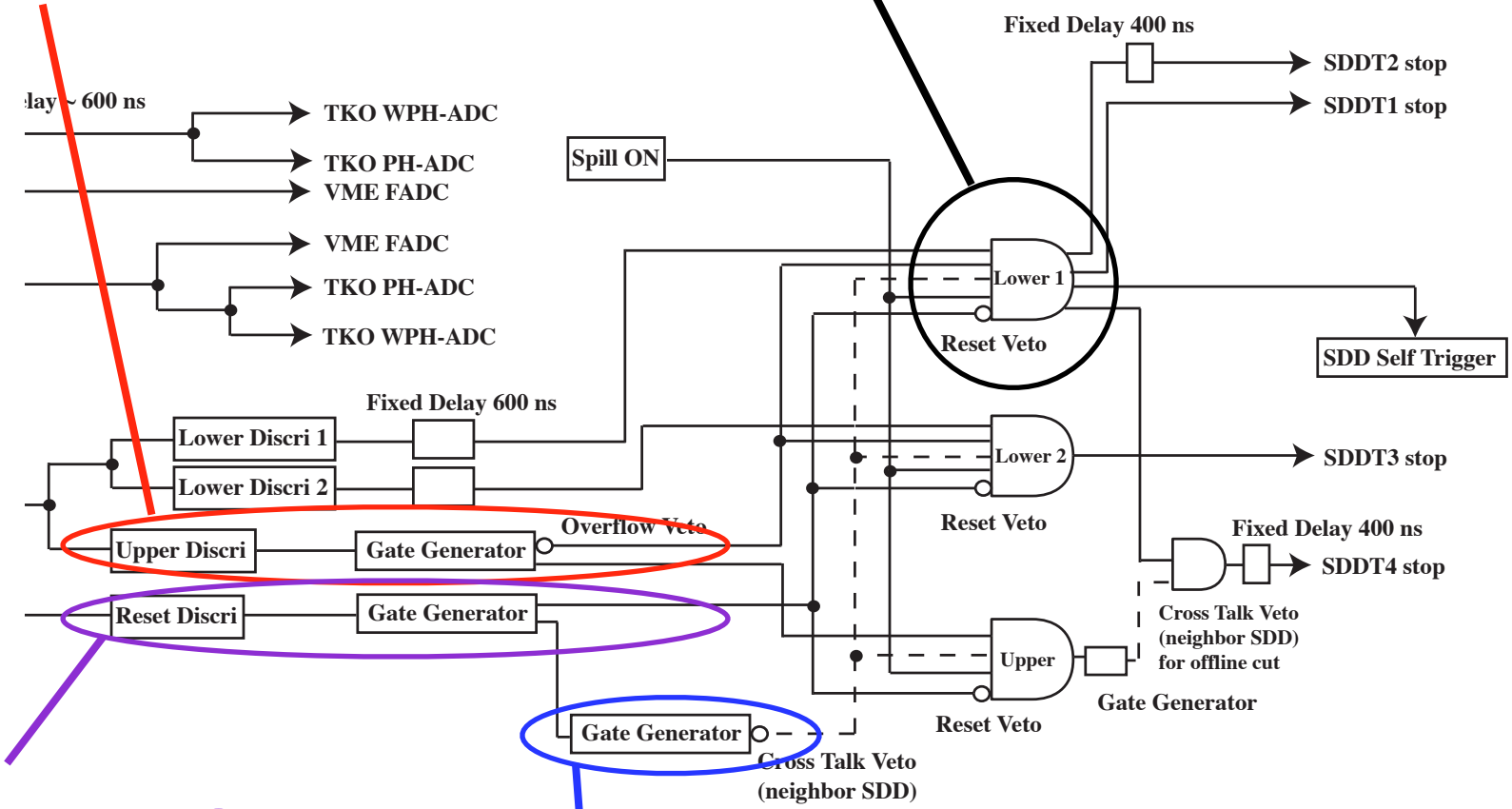
Cycle2	SDD1	SDD2	SDD3	SDD4	SDD5	SDD7	SDD8	Average※1
Reset (μs)	600	400	400	500	400	600	300	450±107
Upper (ns)	500	880	820	805	840	2080	2080	1146±652
Crosstalk (μs)	13.0	10.0	15.0	13.8	13.6※2	15.0	15.0	13.6±1.8

※1 simple average and standard deviation

※2 until SDD6 was tuned off (run 457)

SDD signal

Upper VETO



Reset VETO

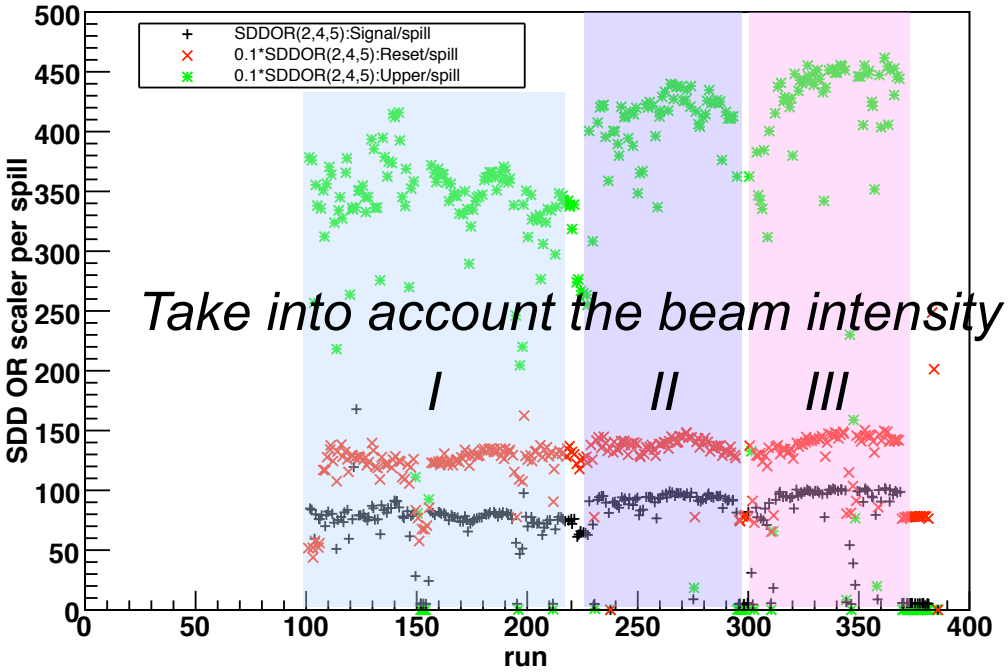
Crosstalk VETO
(neighbor SDD)

$$\overline{R_{rst}} \sim \overline{R_{ctl}}$$

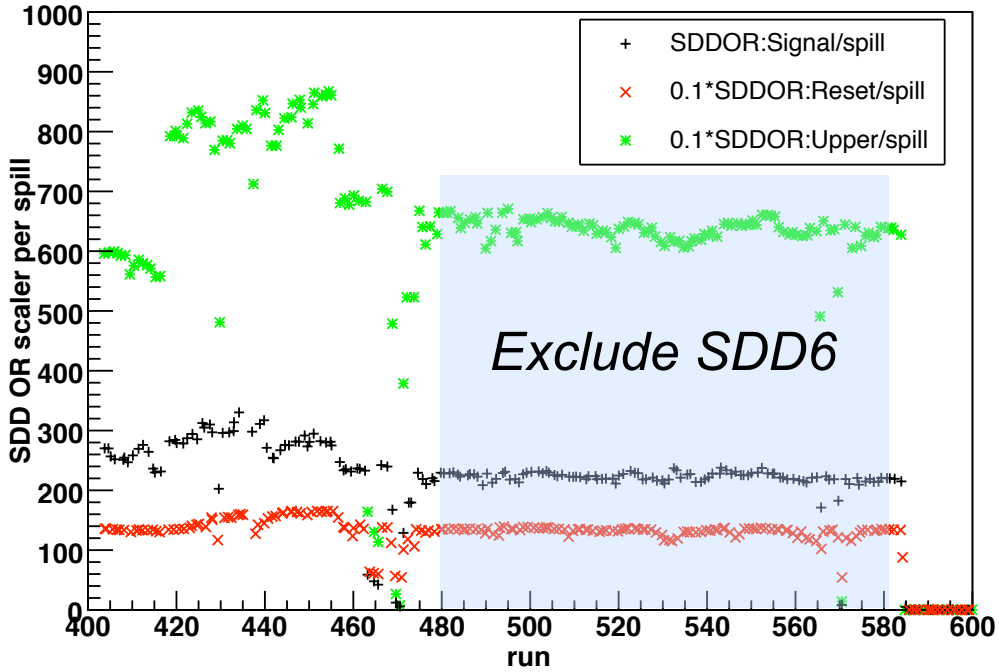
Note : Cycle1: SDD3 preamp wes turned off before run 156
Cycle2: SDD6 preamp wes turned off before run 457

Averaged rate calculations

cycle 1



cycle 2



using only production runs

Cycle 1	I (/spill/SDD)	II (/spill/SDD)	III (/spill/SDD)	Average
Signal	25.6±2.6	30.7±1.8	31.5±2.6	29.3±3.2
Reset	423±26	458±18	467±23	449±23
Upper	1140±120	1360±90	1420±120	1310±150

An error was estimated by a standard deviation of the samples in a run region

Average error is the standard deviation of the three numbers (not depends on their errors)

1st cycle averaged rate calculation

(SDD3 was excluded already)

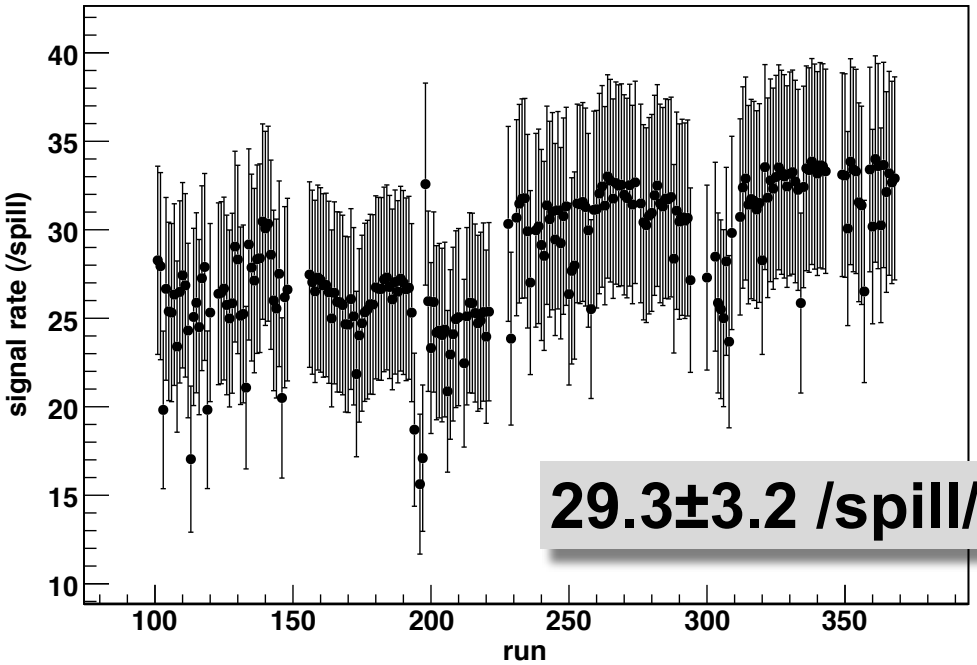
region I : run 100-222

region II : run 226-297

region III : run 300-370

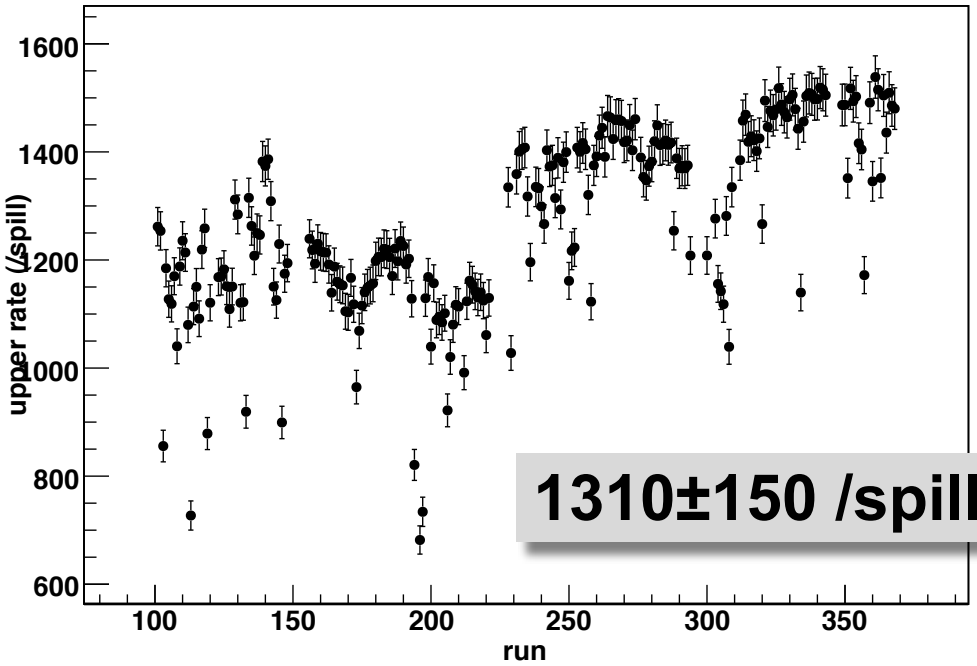
(errors show the std. deviation)

Averaged signal rate per spill



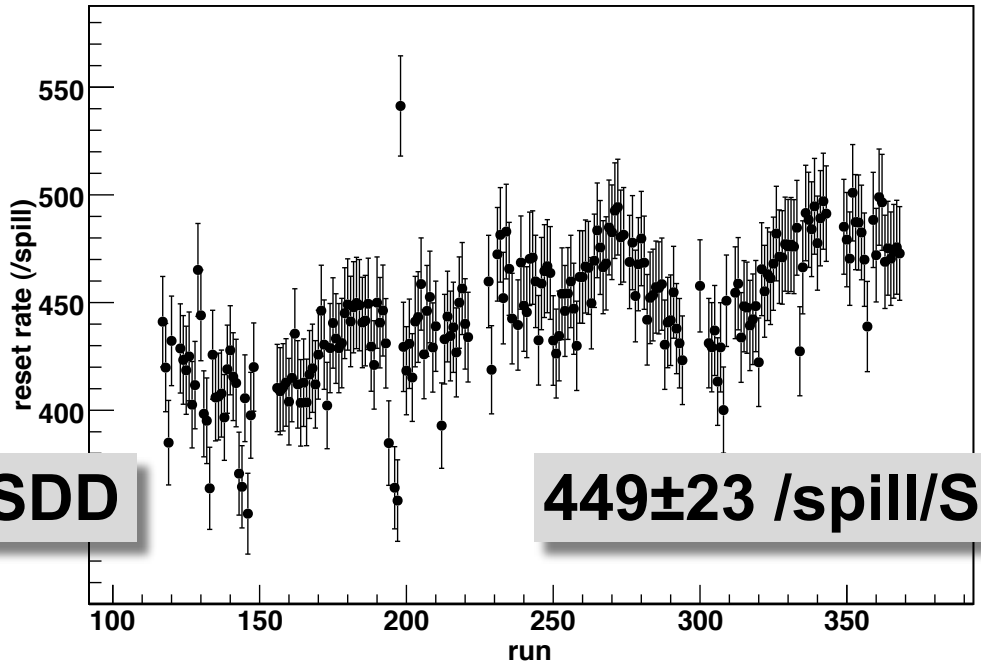
29.3±3.2 /spill/SDD

Averaged upper rate per spill



1310±150 /spill/SDD

Averaged reset rate per spill

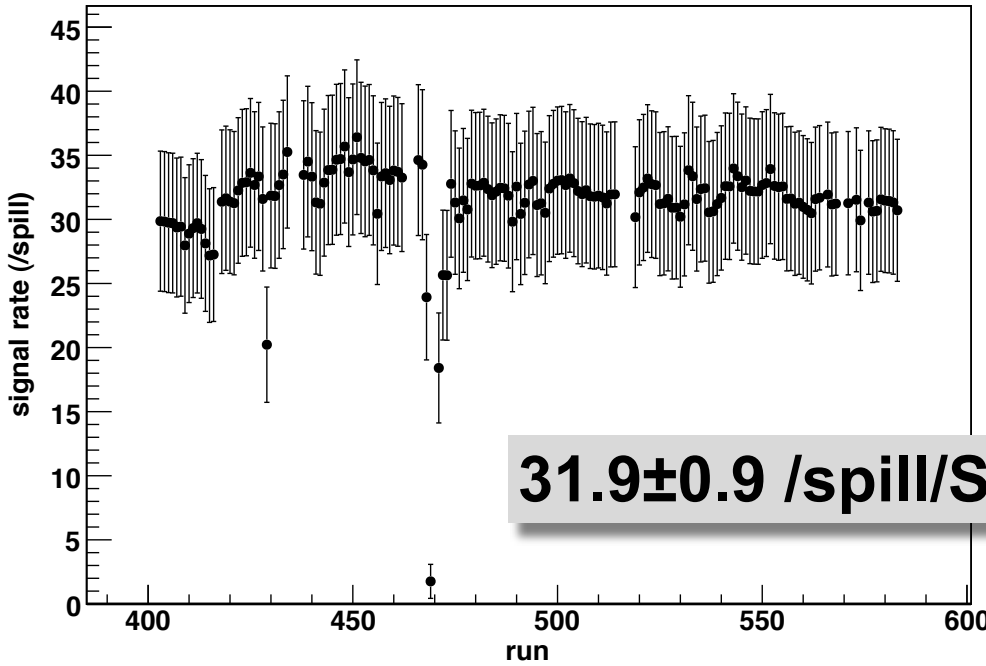


449±23 /spill/SDD

2nd cycle averaged rate calculation

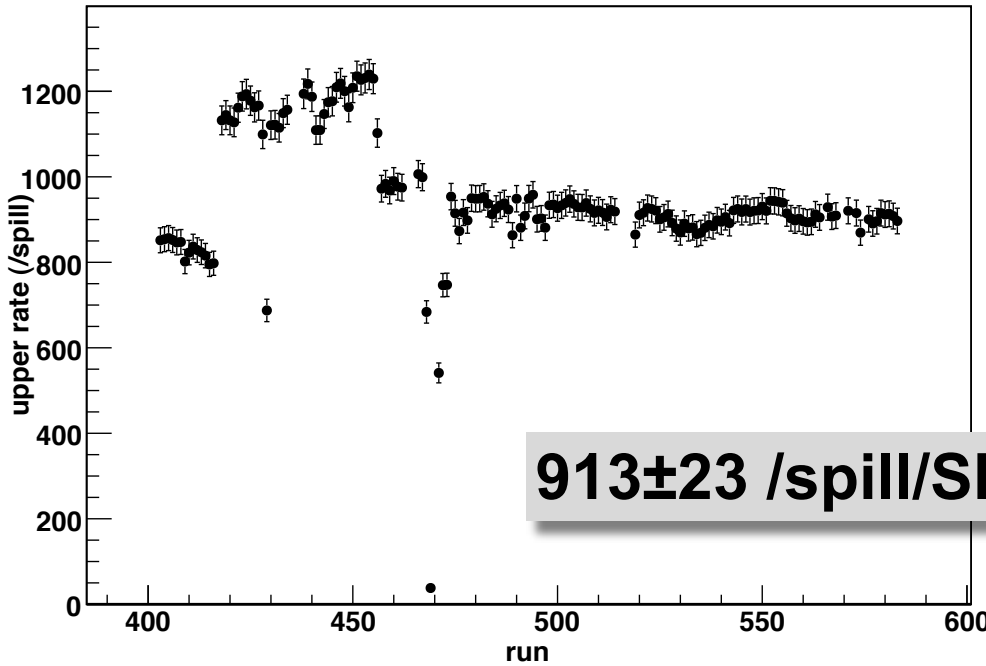
run 480-580

Averaged signal rate per spill



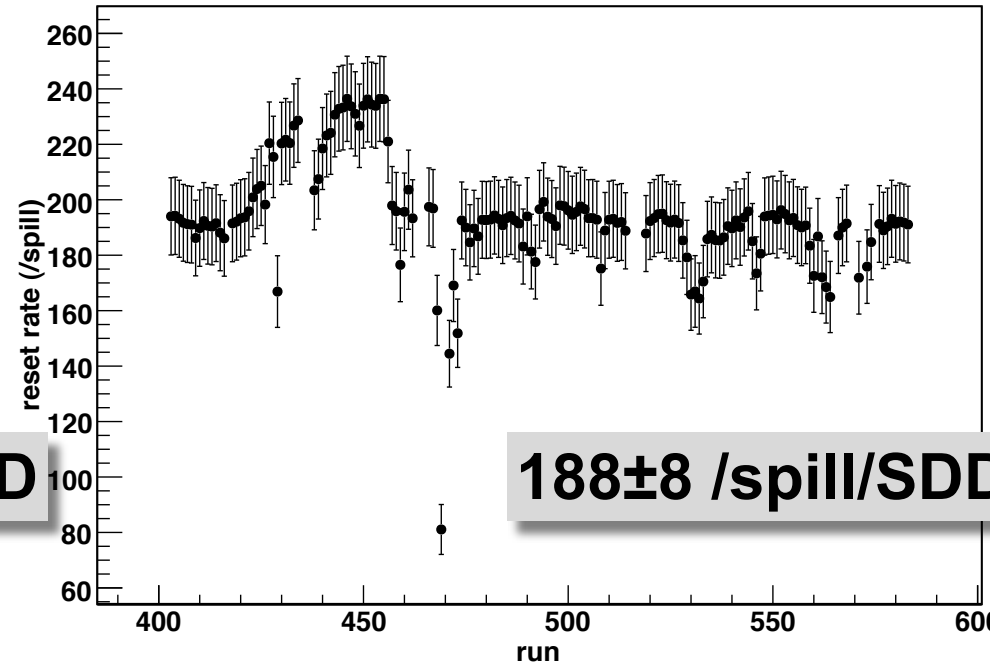
31.9±0.9 /spill/SDD

Averaged upper rate per spill



913±23 /spill/SDD

Averaged reset rate per spill



188±8 /spill/SDD

Percent dead time $\sim (\overline{R_{sig}} \times \overline{\tau_{sig}}) + (\overline{R_{rst}} \times \overline{\tau_{rst}}) + (\overline{R_{ctl}} \times \overline{\tau_{ctl}}) + (\overline{R_{ovf}} \times \overline{\tau_{ovf}})$

Cycle 1

Percent dead time ~ {29.3±3.2 (/spill) × 7.0 (μs) / 2.0 (sec/spill)} +
{449±23 (/spill) × 437±64 (μs) / 2.0 (sec/spill)} +
{ neglect ..} +
{1310±150 (/spill) × 613±6 (ns) / 2.0 (sec/spill)}

= {0.00010(1)} + {0.09811±0.01522} + {neglect} + {0.00040(4)}

= 9.9±1.5 %

Cycle 2

Percent dead time ~ {31.9±0.9 (/spill) × 7.0 (μs) / 2.0 (sec/spill)} +
{188±8 (/spill) × 450±107 (μs) / 2.0 (sec/spill)} +
{188±8 (/spill) × 13.6±1.8 (μs) / 2.0 (sec/spill)} +
{913±23 (/spill) × 1146±652 (ns) / 2.0 (sec/spill)}

= {0.00011(3)} + {0.04230±0.01022} + {0.00128(17)} + {0.00052(30)}

= 4.4±1.1 %

From Suzuki-san's report
equation (34)

Observed number of X-ray
(Summed up SDDs)

$$\phi^{-}(E) = \frac{C^{-}(E)}{\int_V d^3\vec{r} \cdot V(\vec{r}) \cdot \epsilon^{-}(E,\vec{r})'}. \quad (34)$$

DAQ live time rate
was already canceled.

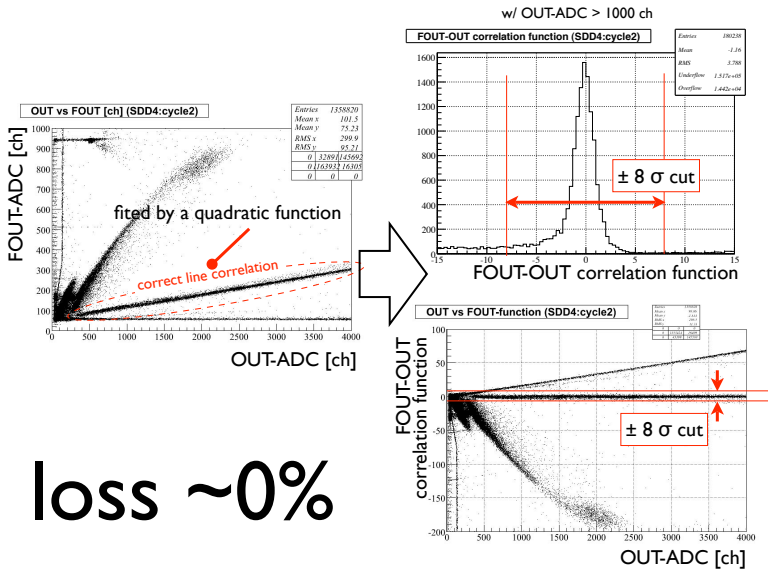
Selection (average)

FOUT-OUT correlation cut : loss ~ 0%

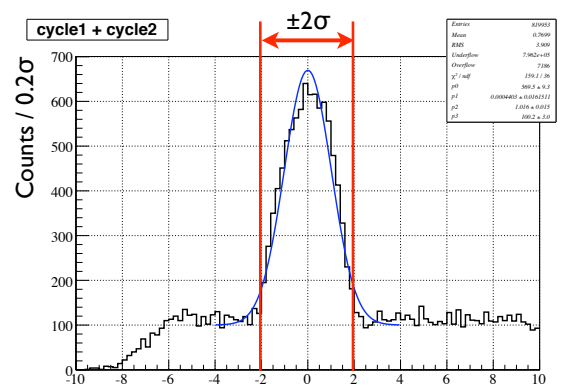
Kaon timing cut : loss ~ 4.6%

Stopped kaon selection : common for the denominator and the numerator

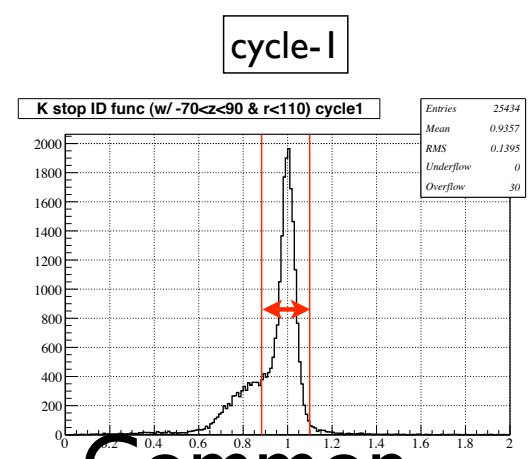
※ Also fiducial volume cuts are common, not need to consider them



loss ~0%



loss ~4.6%

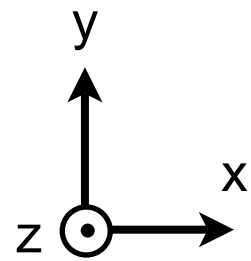


Common

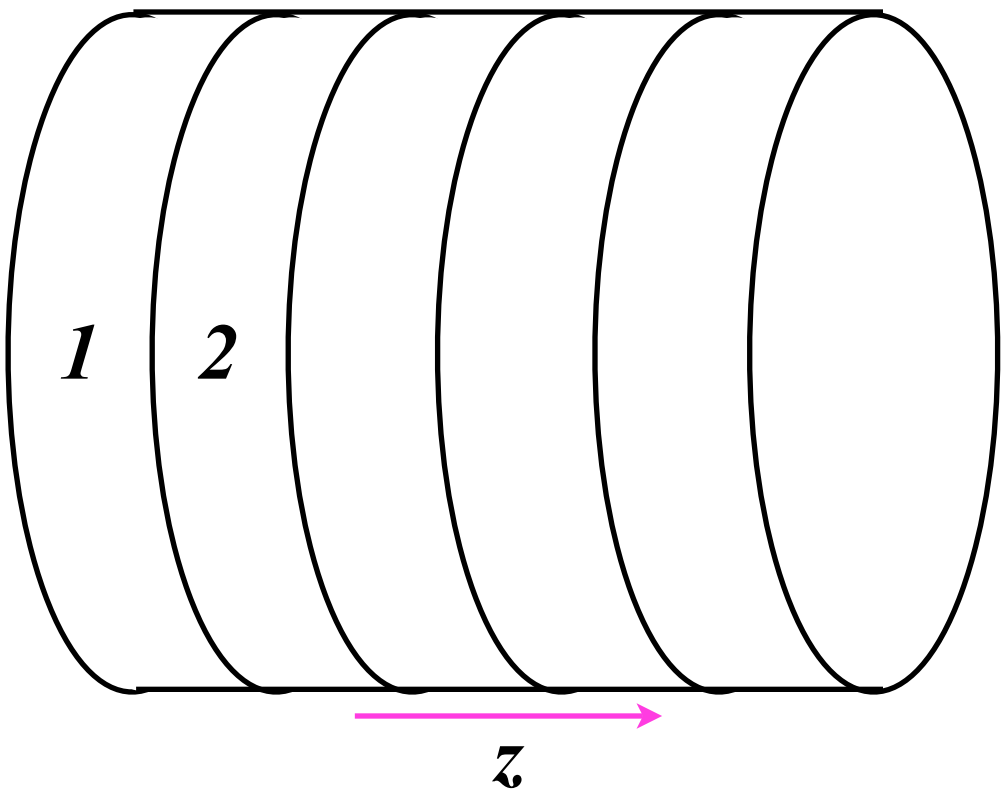
Simulation to normalize

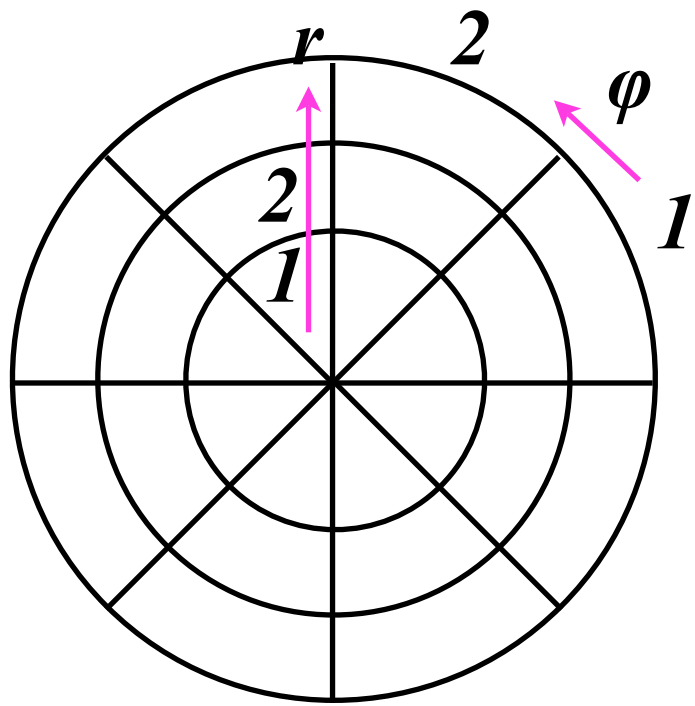
$$\phi^-(E) = \frac{C^-(E)}{\int_V d^3\vec{r}\, V(\vec{r}) \cdot \epsilon^-(E,\vec{r})'} \qquad (34)$$

Position dependence



Since the statistics is limited, we need to divide the target volume just like as following





$$\sum_{z_i,\phi_i,r_i} V(z_i,\phi_i,r_i) \cdot \epsilon(E,z_i,\phi_i,r_i)$$

To calculate $\sum_{z_i,\phi_i,r_i} V(z_i,\phi_i,r_i)\cdot\epsilon(E,z_i,\phi_i,r_i)$

data simulation

$$\epsilon(E,z_i,\phi_i,r_i)=\frac{C_{sim}(E,z_i,\phi_i,r_i)}{G_{sim}(E,z_i,\phi_i,r_i)}$$

Counts

Generated number

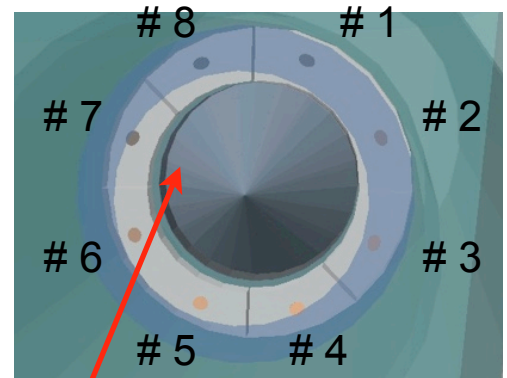
for example

cycle 2 KHeX Lα
Divide (z,φ,r) = (5,8,5)

Using tight target region
-60 mm < z < 80 mm
r < 90 mm

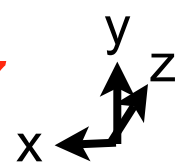
SDD id	z	φ	r	data V(z,φ,r)	ε(z,φ,r)	Error of ε
1	3	1	2	6.6415e+04	1.6616e-04	7.7647e-06
2	3	1	2	6.6415e+04	1.5092e-04	7.4001e-06
3	3	1	2	6.6415e+04	1.5056e-04	7.3912e-06
4	3	1	2	6.6415e+04	1.4621e-04	7.2835e-06
5	3	1	2	6.6415e+04	1.6688e-04	7.7817e-06
6	3	1	2	6.6415e+04	2.1042e-04	8.7381e-06
7	3	1	2	6.6415e+04	2.2820e-04	9.0998e-06
8	3	1	2	6.6415e+04	1.9554e-04	8.4235e-06

GEANT4 simulation



φ=1
→ near SDD 7

Consistent geometry



Cycle 1

-60 mm < z < 80 mm
r < 90 mm

```
# ---- Fit info ------
# FitOption : REL0
# Chisqr/NDF = 200.395/146 =  1.373

# ---- 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


# ---- X-rays -------
# TiKa1  :  4510.890 +- 0.000, Ref =  4510.890, Shift =   0.000 +- 0.000(Stat.)
# TiKb1  :  4931.800 +- 0.000, Ref =  4931.800, Shift =   0.000 +- 0.000(Stat.)
# NiKa1  :  7478.250 +- 0.000, Ref =  7478.250, Shift =   0.000 +- 0.000(Stat.)
# NiKb1  :  8264.700 +- 0.000, Ref =  8264.700, Shift =   0.000 +- 0.000(Stat.)
# KHeXLa :  6458.701 +- 4.142, Ref =  6463.500, Shift =  -4.799 +- 4.142(Stat.)
# KHeXLb :  8721.404 +- 7.449, Ref =  8721.700, Shift =  -0.296 +- 7.449(Stat.)
# KHeXLg :  9755.667 +-11.523, Ref =  9766.800, Shift =  -11.133 +-11.523(Stat.)


# ---- Shift -------
# Shift(weighted average La-Lg) = -4.400 +- 3.453  (Only Stat.)

# ---- Width -------
# Gamma =  0.518 +-36.947
# (MINOS)  Gamma [eV] = 5.18482e-01 + 9.11282e+00

# ---- Counts -------
# Area La = 814.950 +- 25.577
# Area Lb = 350.756 +- 22.180
# Area Lg = 228.145 +- 17.422
# Area Ld = 65.818 +- 11.349
```

```
#### Systematic Errors ####
# ---- Attractive side -------
# -- X-ray --
# KHeXLa :  1.518
# KHeXLb :  1.291
# KHeXLg :  1.527

# -- Shift --
# w3shift :  1.474
# -- Gamma --
# Gamma :  0.255
# -- Counts --
# Area La : -1.154
# Area Lb :  0.130
# Area Lg : -0.379
# Area Ld :  0.382


# ---- Repulsive side -------
# -- X-ray --
# KHeXLa : -1.529
# KHeXLb : -1.308
# KHeXLg : -1.536

# -- Shift --
# w3shift : -1.486
# -- Gamma --
# Gamma : -0.168
# -- Counts --
# Area La :  0.921
# Area Lb : -0.227
# Area Lg :  0.314
# Area Ld : -0.386
```

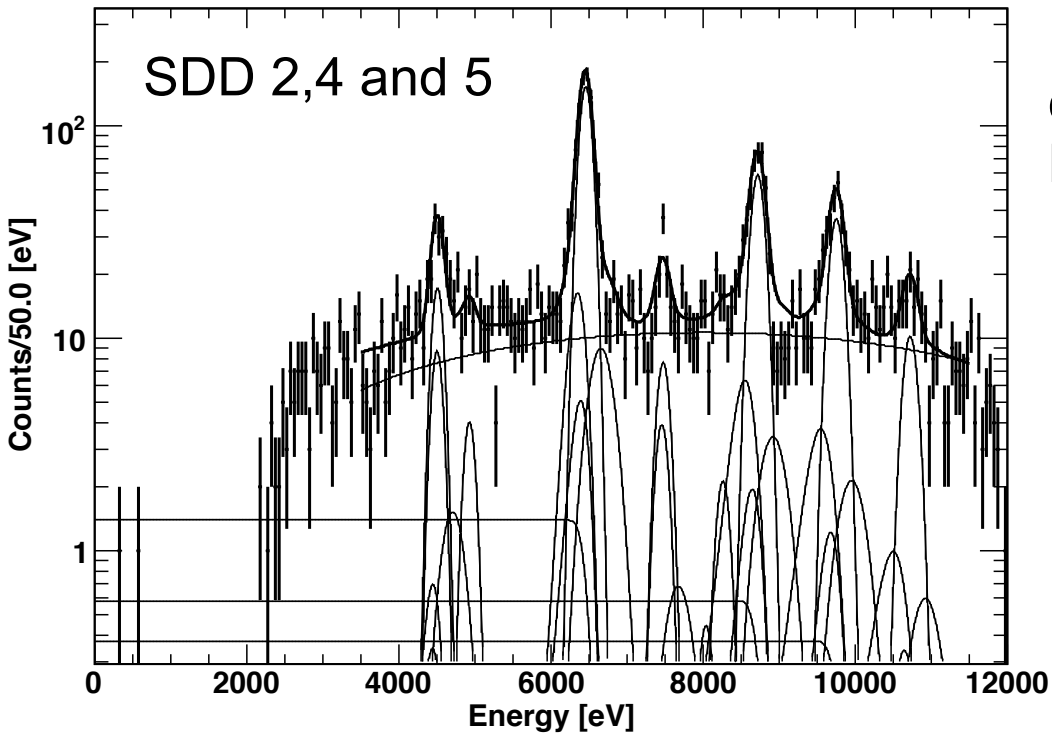
Cycle I

-60 mm < z < 80 mm
r < 90 mm

$$Area = A_{peak} \times (1 + R_{pile} + R_{tail} + R_{comp})$$

$C(E)$

```
# ---- Counts -------
# Area La = 814.950 +- 25.577
# Area Lb = 350.756 +- 22.180
# Area Lg = 228.145 +- 17.422
# Area Ld = 65.818 +- 11.349
```



cycle1 KHeX Lα
Divide (z,φ,r) = (5,8,5)

SDD id	$\sum_{z_i,\phi_i,r_i} V(z_i,\phi_i,r_i)\cdot\epsilon(E,z_i,\phi_i,r_i)$	error
1	5.06508e+03	1.69126e+01
2	5.11669e+03	1.70485e+01
3	5.10818e+03	1.70645e+01
4	5.13195e+03	1.71255e+01
5	5.09656e+03	1.70321e+01
6	5.06337e+03	1.69203e+01
7	5.02048e+03	1.68174e+01
8	5.05506e+03	1.68629e+01

$$\phi(E) = \frac{C(E)\cdot\overline{\epsilon_{dead}}}{\sum_{z,\varphi,r} V(z,\varphi,r)\cdot\epsilon(E,z,\varphi,r)}$$

$$\overline{\epsilon_{dead}} = \frac{1}{1-(0.099\pm0.015)} \times \frac{1}{1-0.046}$$

dead time selection loss

Cycle1
Divide (z,φ,r) = (5,8,5)

KHeX Lα

1	5.06508e+03	1.69126e+01
2	5.11669e+03	1.70485e+01
3	5.10818e+03	1.70645e+01
4	5.13195e+03	1.71255e+01
5	5.09656e+03	1.70321e+01
6	5.06337e+03	1.69203e+01
7	5.02048e+03	1.68174e+01
8	5.05506e+03	1.68629e+01

sum: 1.534524e+04 +- 2.956395e+01
Br: 6.178517e-02 +- 1.678343e-03

6.2±0.2 %

KHeX Lβ

1	6.34414e+03	1.89514e+01
2	6.38082e+03	1.90678e+01
3	6.41656e+03	1.91579e+01
4	6.42029e+03	1.91749e+01
5	6.42975e+03	1.91432e+01
6	6.37042e+03	1.90215e+01
7	6.35253e+03	1.89555e+01
8	6.33794e+03	1.89106e+01

sum: 1.923091e+04 +- 3.313185e+01
Br: 2.121935e-02 +- 1.112190e-03

2.1±0.1 %

KHeX Lγ

1	6.29923e+03	1.88881e+01
2	6.31040e+03	1.89688e+01
3	6.32809e+03	1.90341e+01
4	6.35416e+03	1.90705e+01
5	6.30977e+03	1.89706e+01
6	6.25556e+03	1.88517e+01
7	6.25962e+03	1.88218e+01
8	6.27944e+03	1.88324e+01

sum: 1.897437e+04 +- 3.291484e+01
Br: 1.398848e-02 +- 1.093572e-03

1.4±0.1 %

Cycle 2

-60 mm < z < 80 mm
r < 90 mm

```
# ---- Fit info ------
# FitOption : REL0
# Chisqr/NDF = 179.803/146 =  1.232

# ---- 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


# ---- X-rays -------
# TiKa1  :  4510.890 +- 0.000, Ref =  4510.890, Shift =   0.000 +- 0.000(Stat.)
# TiKb1  :  4931.800 +- 0.000, Ref =  4931.800, Shift =   0.000 +- 0.000(Stat.)
# NiKa1  :  7478.250 +- 0.000, Ref =  7478.250, Shift =   0.000 +- 0.000(Stat.)
# NiKb1  :  8264.700 +- 0.000, Ref =  8264.700, Shift =   0.000 +- 0.000(Stat.)
# KHeXLa :  6470.789 +- 3.520, Ref =  6463.500, Shift =   7.289 +- 3.520(Stat.)
# KHeXLb :  8723.794 +- 6.439, Ref =  8721.700, Shift =   2.094 +- 6.439(Stat.)
# KHeXLg :  9753.123 +- 9.632, Ref =  9766.800, Shift =  -13.677 +- 9.632(Stat.)

# ---- Shift -------
# Shift(weighted average La-Lg) =  4.251 +- 2.941  (Only Stat.)

# ---- Width -------
# Gamma =  0.000 +- 3.495
# (MINOS)  Gamma [eV] = 3.17468e-10 + 2.99875e+00


# ---- Counts -------
# Area La = 888.803 +- 26.363
# Area Lb = 401.365 +- 24.455
# Area Lg = 229.114 +- 17.551
# Area Ld = 45.068 +- 10.466
```

```
#### Systematic Errors ####
# ---- Attractive side -------
# -- X-ray --
# KHeXLa :  1.027
# KHeXLb :  1.092
# KHeXLg :  0.949

# -- Shift --
# w3shift :  1.036
# -- Gamma --
# Gamma : -0.000
# -- Counts --
# Area La : -1.365
# Area Lb : -0.093
# Area Lg :  0.174
# Area Ld :  0.393


# ---- Repulsive side -------
# -- X-ray --
# KHeXLa : -1.039
# KHeXLb : -1.100
# KHeXLg : -0.954

# -- Shift --
# w2shift : -1.054
# w3shift : -1.046
# w4shift : -1.059
# -- Gamma --
# Gamma :  0.000
# -- Counts --
# Area La :  1.011
# Area Lb : -0.062
# Area Lg : -0.269
# Area Ld : -0.412
```

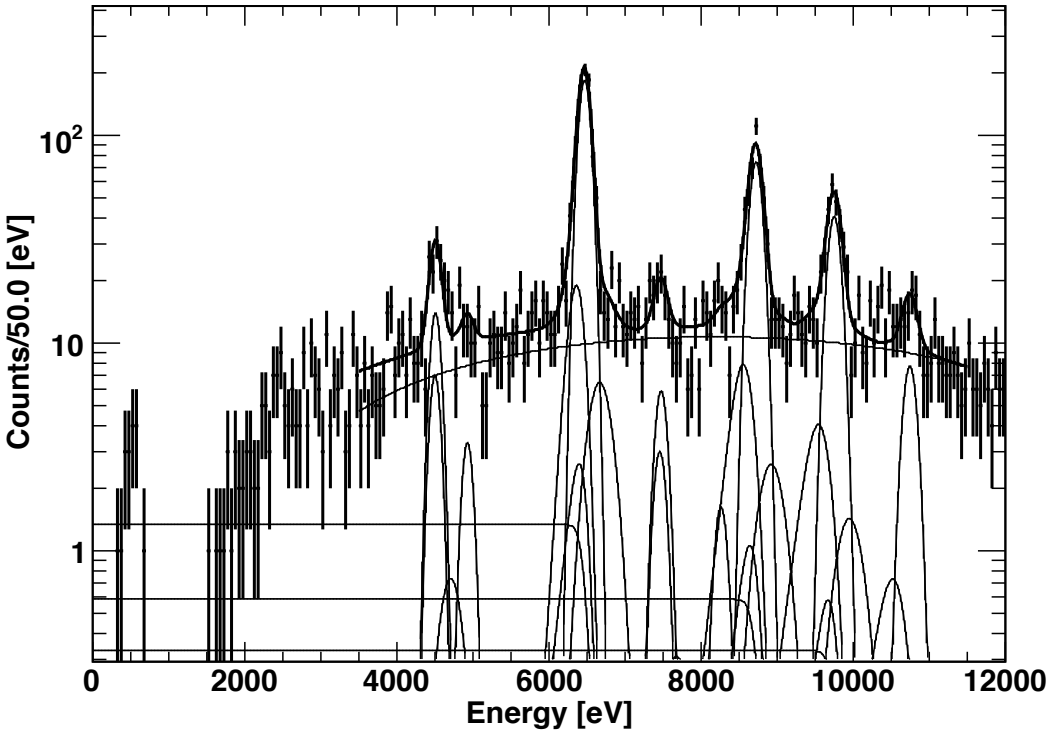
Cycle 2

-60 mm < z < 80 mm
r < 90 mm

$$Area = A_{peak} \times (1 + R_{pile} + R_{tail} + R_{comp})$$

$C(E)$

```
# ---- Counts -------
# Area La = 888.803 +- 26.363
# Area Lb = 401.365 +- 24.455
# Area Lg = 229.114 +- 17.551
# Area Ld = 45.068 +- 10.466
```



cycle2 KHeX Lα
Divide (z,φ,r) = (5,8,5)

$$\sum_{z_i,\phi_i,r_i} V(z_i,\phi_i,r_i) \cdot \epsilon(E,z_i,\phi_i,r_i)$$

SDD id		error
1	2.24418e+03	7.55117e+00
2	2.26318e+03	7.59531e+00
3	2.29167e+03	7.66413e+00
4	2.26230e+03	7.63386e+00
5	2.28928e+03	7.67432e+00
6	2.25965e+03	7.60661e+00
7	2.25389e+03	7.57255e+00
8	2.24701e+03	7.55030e+00

$$\phi(E) = \frac{C(E) \cdot \overline{\epsilon_{dead}}}{\sum_{z,\varphi,r} V(z,\varphi,r) \cdot \epsilon(E,z,\varphi,r)}$$

$$\overline{\epsilon_{dead}} = \frac{1}{1-(0.044 \pm 0.011)} \times \frac{1}{1-0.046}$$

dead time　　selection loss

Cycle2
Divide (z,φ,r) = (5,8,5)

KHeX Lα

1	2.24418e+03	7.55117e+00
2	2.26318e+03	7.59531e+00
3	2.29167e+03	7.66413e+00
4	2.26230e+03	7.63386e+00
5	2.28928e+03	7.67432e+00
6	2.25965e+03	7.60661e+00
7	2.25389e+03	7.57255e+00
8	2.24701e+03	7.55030e+00

sum: 1.585152e+04 +- 2.012385e+01
Br: 6.147922e-02 +- 1.407245e-03

6.1±0.1 %

KHeX Lβ

1	2.81227e+03	8.46577e+00
2	2.82324e+03	8.50145e+00
3	2.85224e+03	8.56822e+00
4	2.85416e+03	8.58554e+00
5	2.84039e+03	8.55666e+00
6	2.84479e+03	8.54874e+00
7	2.81886e+03	8.49042e+00
8	2.81348e+03	8.46516e+00

sum: 1.981463e+04 +- 2.253955e+01
Br: 2.220993e-02 +- 1.004579e-03

2.2±0.1 %

KHeX Lγ

1	2.79258e+03	8.44022e+00
2	2.79310e+03	8.45849e+00
3	2.81383e+03	8.51163e+00
4	2.81996e+03	8.53213e+00
5	2.83471e+03	8.54664e+00
6	2.81107e+03	8.49935e+00
7	2.79644e+03	8.46035e+00
8	2.78511e+03	8.42099e+00

sum: 1.963574e+04 +- 2.244020e+01
Br: 1.279376e-02 +- 9.911521e-04

1.3±0.1 %

Consistent with 1st cycle one