Higgs Recoil Mass & Cross Section

General Meeting vol.5

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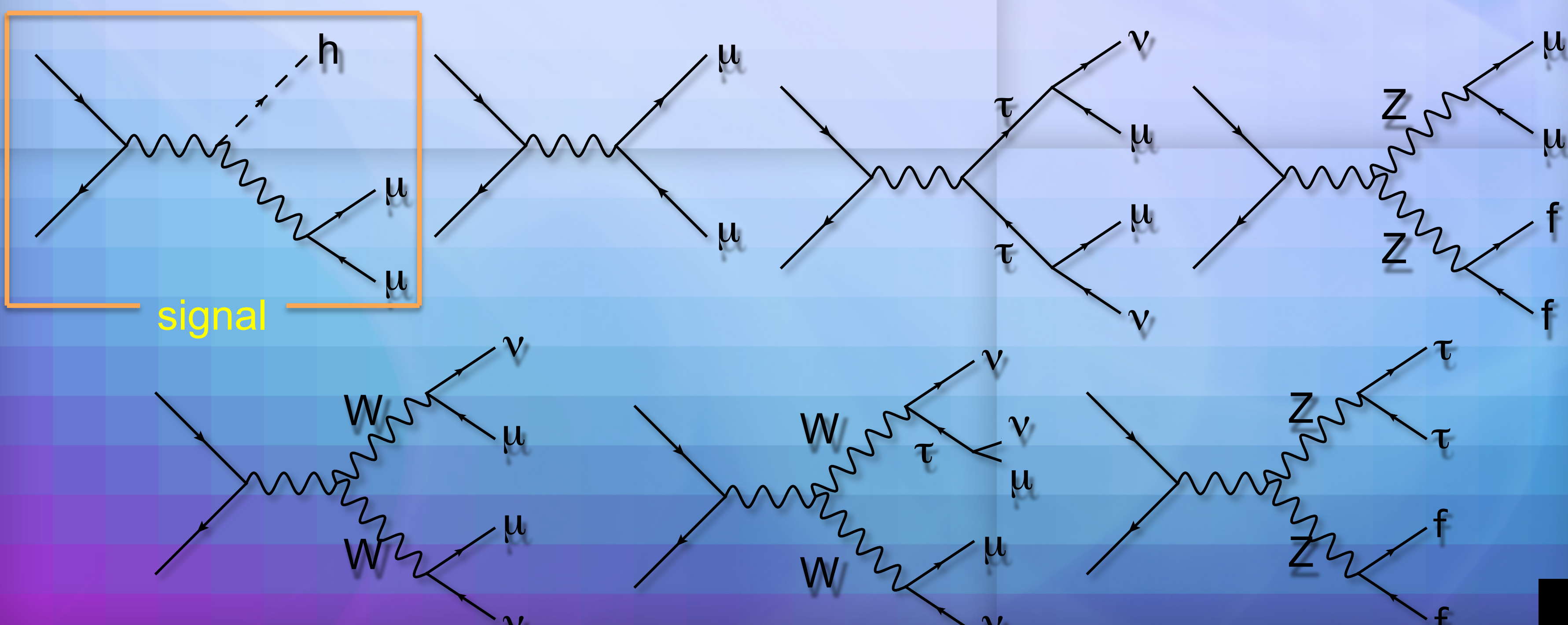
Motivation

- My target is precise measurement of Higgs mass and cross section using DBD samples(m_H=125[GeV]).
- I use only ee -> Zh -> llh ($l=\mu$, e) of E_{CM}=250[GeV] signal event.

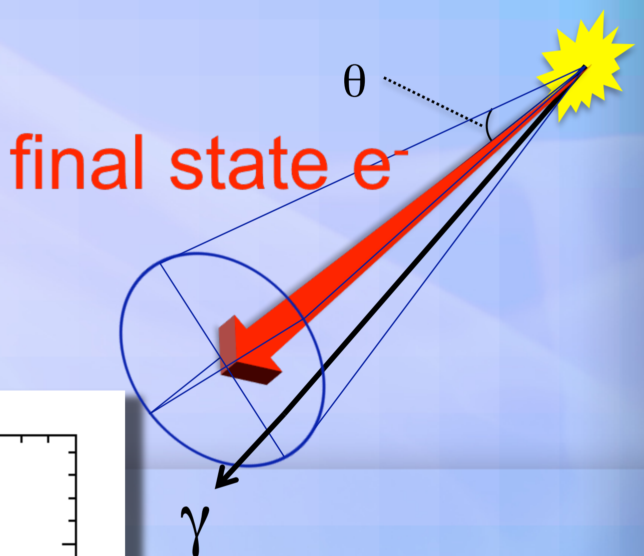


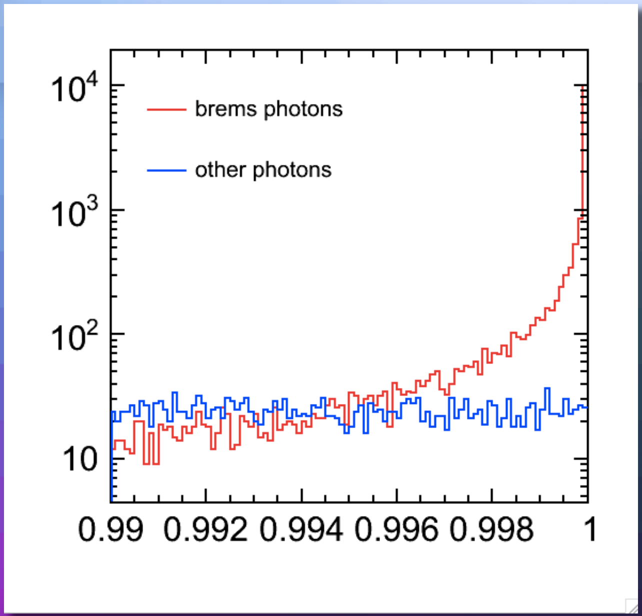
Lepton Selection

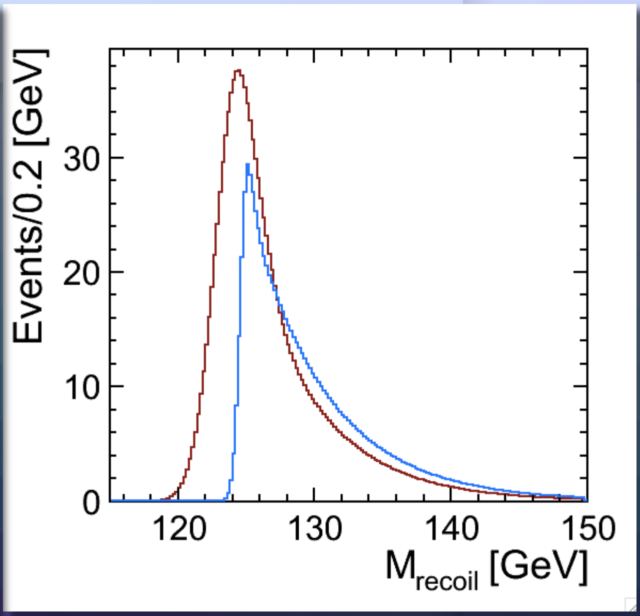
- Muon (and electron) selection
  - Momentum p > 15 [GeV]
  - Small (Large) energy deposite in caloriemeters
    - $E_{ecal} / E_{total} < 0.5$ (> 0.6)
    - $E_{total} / p_{track} < 0.3$ (> 0.9)
- Good track selection
  - Track with small error (different selections between polar angle of tracks, barrel or end cap)
    $dp / p^2 < 2.5 \times 10^{-5} \oplus 8 \times 10^{-4} / p$ (for $\cos\theta < 0.78$)
    $dp / p^2 < 5 \times 10^{-4}$ (for $\cos\theta > 0.78$)
- Impact parameter (only for muon)
  - To suppress muons from tau decays which tend to have large impact parameters.
    $D_0 / dD_0 < 5$

Bremsstrahlung Recovery

- Only for eeX channel cross section measurements, the photon's 4 momentum around final state electron (cosθ > 0.999) is added to the electron.
- This process contributes the distribution of recoil mass significantly.
- For mass analysis, it is effective not to perform the recovery.







Background Rejection (μμX)

mmh	signal		mmnn		mmff		tlnn		tlff		others	
No Cut	2574		149636		160432		596518		83418		~10M	
Selection	2271	88.21%	12467	8.33%	7864	4.90%	3010	0.50%	28	0.03%	14649	0.14%
p_{Tdl}	2160	83.89%	10653	7.12%	6799	4.24%	2706	0.45%	27	0.03%	8907	0.09%
M_{dl}	2050	79.65%	6458	4.32%	5901	3.68%	1404	0.24%	19	0.02%	7518	0.07%
acop	1916	74.43%	6078	4.06%	5370	3.35%	1290	0.22%	11	0.01%	6637	0.06%
dp_{Tbal}	1871	72.70%	5949	3.98%	4965	3.09%	1267	0.21%	11	0.01%	927	0.01%
$cosq_{missing}$	1859	72.22%	5949	3.98%	4705	2.93%	1267	0.21%	11	0.01%	682	0.01%
M_{recoil}	1856	72.10%	3987	2.66%	2643	1.65%	882	0.15%	11	0.01%	453	0.00%
Likelihood	1564	60.77%	2401	1.60%	1734	1.08%	333	0.06%	0	0%	350	0.00%

Background Rejection (eeX)

eeh	signal		eenn		eeff		tlnn		tlff		others	
No Cut	2701		145891		184568		596518		60970		~10M	
Selection	1924	71.23%	12771	8.75%	8076	4.38%	11996	2.01%	273	0.45%	75814	0.74%
p_{Tdl}	1874	69.39%	11470	7.86%	7175	3.89%	11213	1.88%	196	0.32%	51342	0.50%
M_{dl}	1729	64.01%	6649	4.56%	5243	2.84%	6142	1.03%	122	0.20%	31762	0.31%
acop	1614	59.75%	6339	4.35%	4790	2.60%	5516	0.92%	83	0.14%	25227	0.25%
dp_{Tbal}	1552	57.46%	6038	4.14%	4094	2.22%	5300	0.89%	73	0.12%	7195	0.07%
$cosq_{missing}$	1543	57.13%	6034	4.14%	3848	2.09%	5300	0.89%	72	0.12%	6489	0.06%
M_{recoil}	1523	56.39%	4242	2.91%	2294	1.24%	3997	0.67%	57	0.09%	4419	0.04%
Likelihood	1026	37.97%	1428	0.98%	840	0.46%	966	0.16%	2	0.00%	974	0.01%

Signal eff. each h decay mode(μμX)

Cut	bb	eff.	WW	eff.	gg	eff.	ττ	eff.	cc	eff.
No Cut	1513		550		220		169		71	
selection	1334	88.1%	486	88.3%	193	87.5%	151	89.5%	63	88.2%
P_{Tdl}	1265	83.6%	460	83.6%	184	83.7%	142	84.0%	59	83.4%
M_{dl}	1200	79.3%	436	79.2%	176	79.8%	135	80.0%	55	77.1%
acop	1122	74.1%	408	74.1%	165	74.9%	127	75.1%	52	72.9%
dP_{Tbal}	1106	73.1%	400	72.7%	161	73.2%	119	70.5%	50	70.2%
$cosq_{miss}$	1099	72.6%	396	72.0%	160	72.9%	118	70.0%	50	70.2%
M_{recoil}	1096	72.4%	395	71.9%	160	72.8%	118	69.9%	50	70.2%
f_L	904	59.7%	323	58.8%	133	60.6%	98	58.1%	42	59.3%
Cut	**ZZ**	**eff.**	**gg**	**eff.**	**Zg**	**eff.**	**ss**	**eff.**	**mm**	**eff.**
No Cut	69		5		3		2		1	
selection	61	87.9%	5	95.5%	3	99.6%	1	87.8%	0	66.7%
P_{Tdl}	58	83.7%	5	91.3%	3	99.6%	1	75.5%	0	66.7%
M_{dl}	54	78.1%	5	87.0%	3	91.7%	1	75.5%	0	66.7%
acop	51	73.5%	5	86.8%	3	91.7%	1	62.6%	0	33.3%
dP_{Tbal}	50	72.5%	0	3.8%	2	83.9%	1	62.6%	0	33.3%
$cosq_{miss}$	50	71.9%	0	3.8%	2	69.0%	1	50.4%	0	33.3%
M_{recoil}	49	71.3%	0	3.8%	2	69.0%	1	50.4%	0	33.3%
f_L	40	58.1%	0	3.8%	2	59.4%	1	48.9%	0	33.3%

Signal eff. each h decay mode(eeX)

Cut	bb	eff.	WW	eff.	gg	eff.	ττ	eff.	cc	eff.
No Cut	1577		602		225		167		72	
selection	1118	70.9%	431	71.6%	162	72.0%	117	70.1%	48	67.0%
P_{Tdl}	1091	69.2%	419	69.6%	158	70.0%	115	68.9%	47	65.4%
M_{dl}	1010	64.1%	386	64.2%	147	65.0%	106	63.3%	44	61.1%
acop	939	59.6%	361	59.9%	137	60.9%	100	59.8%	41	57.1%
dP_{Tbal}	913	57.9%	346	57.4%	131	58.3%	92	55.1%	39	54.1%
$cosq_{miss}$	907	57.5%	344	57.1%	130	57.9%	92	54.8%	39	53.7%
M_{recoil}	898	57.0%	339	56.3%	128	57.0%	91	54.3%	38	52.8%
f_L	607	38.5%	226	37.5%	88	38.9%	60	36.0%	26	35.8%

Cut	ZZ	eff.	gg	eff.	Zg	eff.	ss	eff.	mm	eff.
No Cut	72		8		5		1		0	
selection	51	70.8%	6	75.9%	4	76.8%	1	79.4%	0	95.5%
P_{Tdl}	50	69.6%	6	75.9%	4	76.8%	1	79.4%	0	95.5%
M_{dl}	45	63.0%	6	73.1%	4	76.8%	1	79.4%	0	95.5%
acop	42	58.6%	5	61.8%	3	66.5%	1	60.3%	0	95.5%
dP_{Tbal}	41	56.3%	0	3.2%	3	53.3%	1	60.3%	0	95.5%
$cosq_{miss}$	41	56.3%	0	3.2%	3	53.3%	1	60.3%	0	95.5%
M_{recoil}	40	55.1%	0	3.2%	3	53.3%	1	58.7%	0	95.5%
f_L	25	34.9%	0	0.2%	3	52.2%	1	58.7%	0	95.5%

Fitting Method

- Fitting function
  - signal -> Gaussian Peak with Exponential Tail (GPET)

$$\begin{cases} Ne^{-\frac{1}{2}\left(\frac{x-\bar{x}}{\sigma}\right)^2} & \left(\frac{x-\bar{x}}{\sigma} < k\right) \\ N\left\{be^{-\frac{1}{2}\left(\frac{x-\bar{x}}{\sigma}\right)^2} + (1-b)e^{-k\frac{x-\bar{x}}{\sigma}}e^{\frac{b^2}{2}}\right\} & \left(\frac{x-\bar{x}}{\sigma} \geq k\right) \end{cases}$$

  - BG -> 3^{rd} order polynomial

* GPET has 5 parameters

- ✧ **height : N**
- ✧ mean : $\bar{x}$
- ✧ width : s
- ✧ boundary : k
- ✧ junction : b

- Toy-MC study
  - The sum of signal and BG distributions are fitted with the functions above.
  - Make the toy-MC events according to the fitted functions.
  - Fit the distribution again with the same function by floating height and mean of GPET.

Result of Statistical Error

Cross section	mmh	eeh	Combined
MI	3.6%	5.2%	3.0%
semi-MI	3.0%	4.6%	2.5%

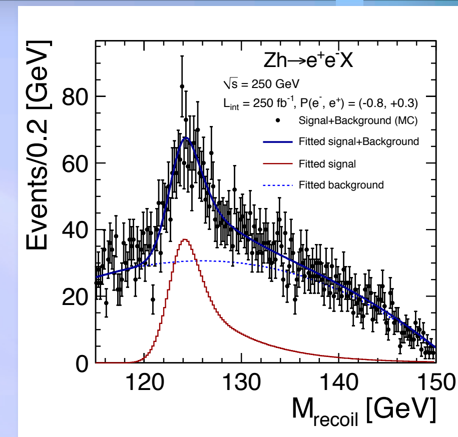
Mass	mmh	eeh	Combined
MI	37MeV	122MeV	35MeV
MD	33MeV	92MeV	31MeV

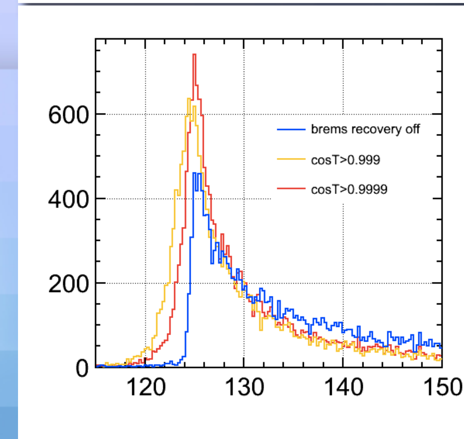
… However, there are still some problems.

- Wide width of eeX recoil mass distribution.
- Especially for eeX channel, GPET may be not optimal function to fit.

About wide width of eeX study

- The recoil distribution of eeX channel has wider width than previous study because of too many bremsstrahlung recovery. (maybe)
- Plan for this problem.
  - Is it relevant to recovery photons partially to obtain sharper distribution?
  - Should I recovery only energy (momentum) of electron and scale momentum (energy) to make invariant mass m_e=0.511[MeV]?
  - Did I recovery photon splitted from electron in calorimeter?

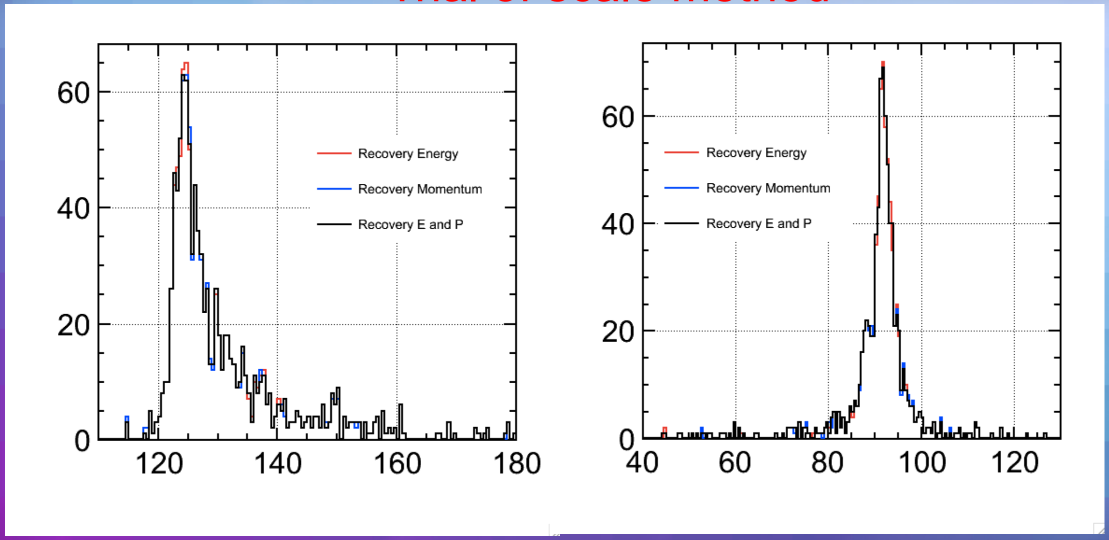




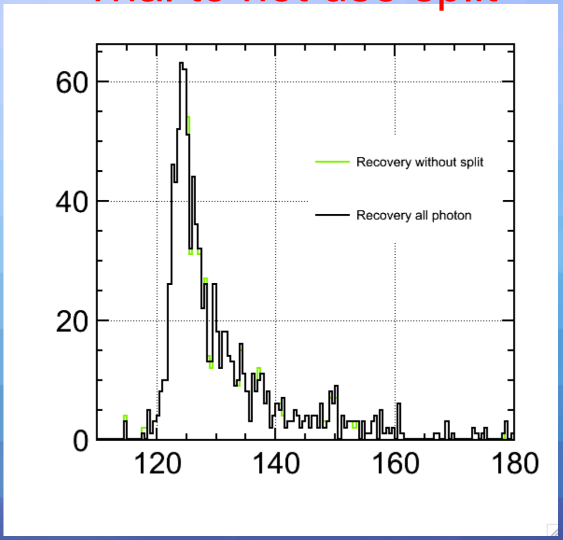
Result of trial

- Using each scale method (recovery E and scale **P**, or reverse), the deviation from black distribution seems to be small.
- Splitted photon may be very rare (0.7%) so that reconstruction to not recovery such photons seems to be also almost same as black one.

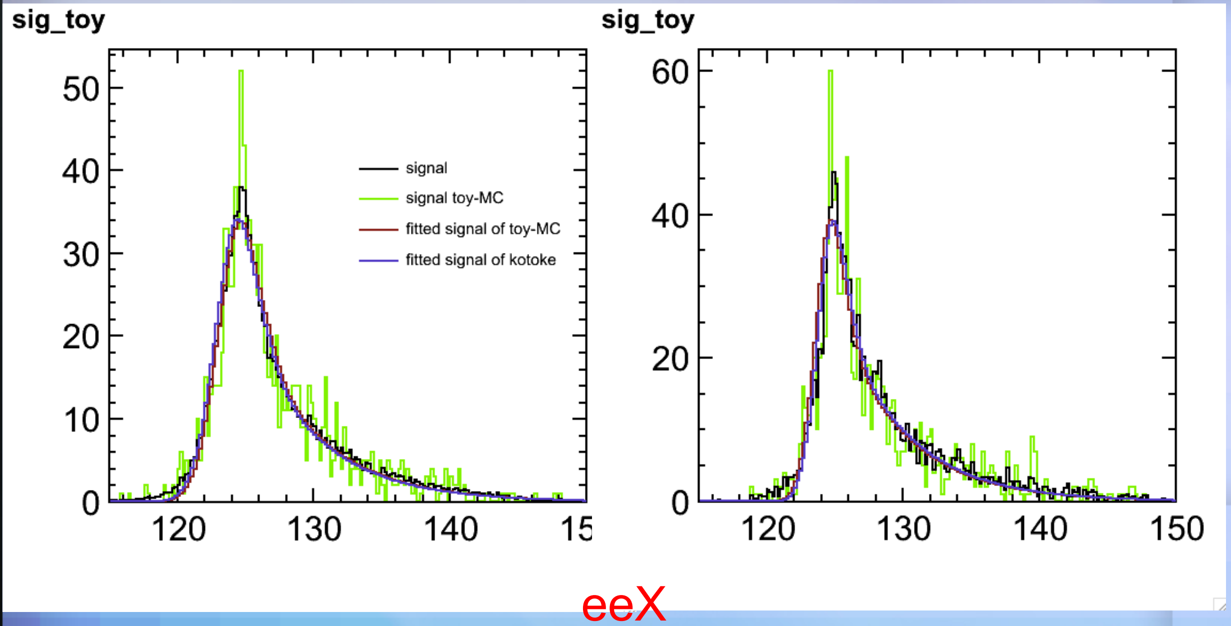
Trial of scale method

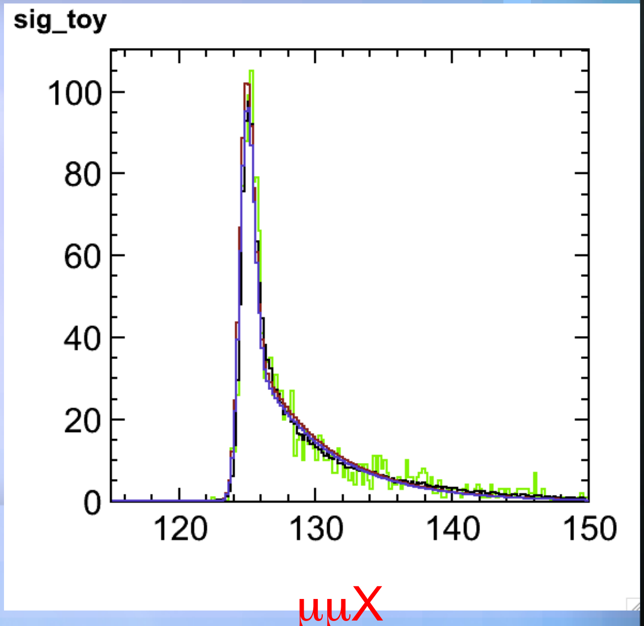


Trial to not use split



About fitting method





- Especially for eeX channel, GPET may be not optimal to fit recoil mass distribution (?).
- Should I try Kernel Estimation which is fitting method used in previous study?

Summary and Next Plan

- While statistical errors are obtained, there are some problems to investigate.
  - It is necessary to find cause of wide width of eeX channel.
    (Is there no cause? Partial recovery is optimal?)
  - Fitting method may be able to be optimized. (Kernel Estimation)