Some Updates on $h \to \mu^+\mu^-$ Benchmark

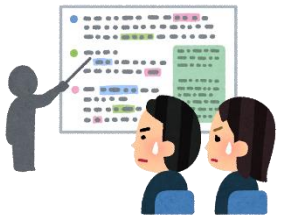
Shin-ichi Kawada (DESY)

2018/November/21

ILD Analysis/Software Meeting

General Status

- DBD-paper: no activities, working on v01 -> v02
- Vietnam proceedings (deadline: Nov./30): uploaded at practice page
- LCWS2018 proceedings: just prepared template
- benchmark analysis: full analysis chain is now working
- IDR note: in parallel with benchmark analysis
- IDR itself: nothing
- HC2018 talk: preparing for 10+5 min. talk, rehearsal on Nov./22, 13:00



Disclaimer

- I just got some numbers in IDR analysis, not yet think deeply. Your comments are welcome.

Benchmark Analysis: Overview

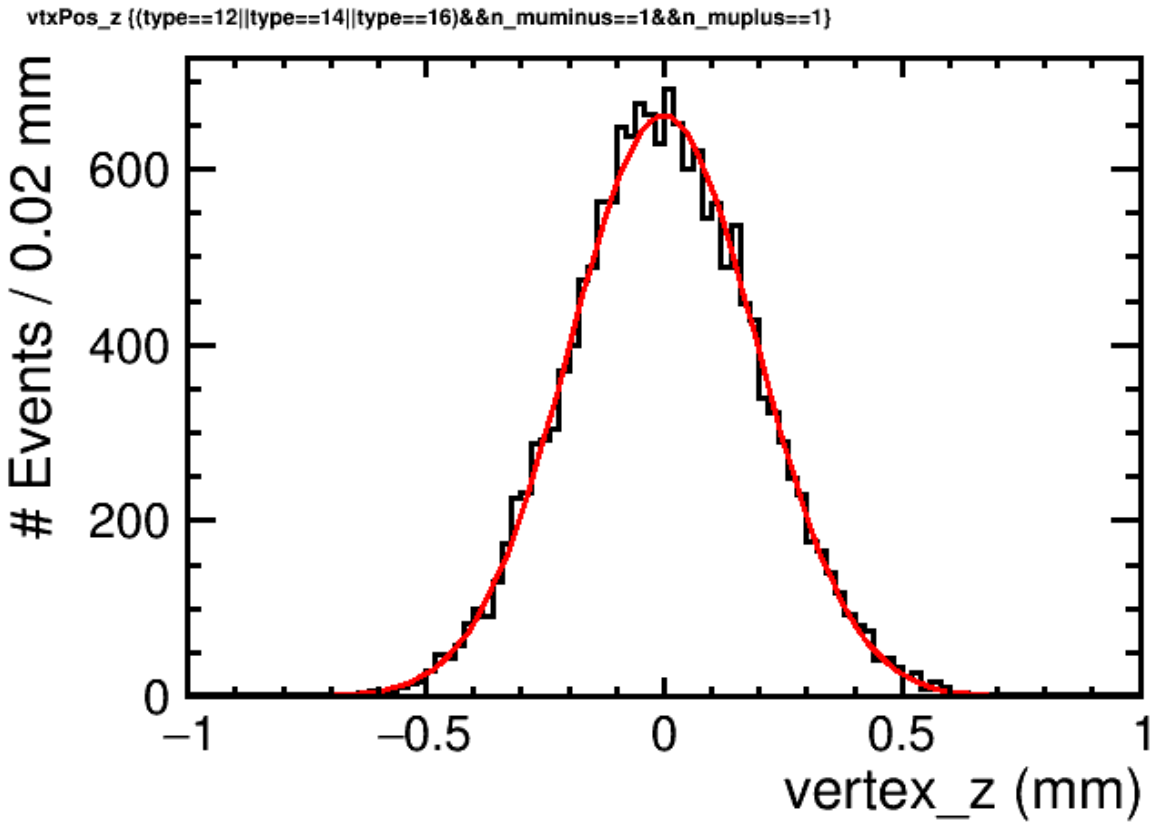
- IDR samples with v02-00-01, further analysis with v02-00-02
- Use IsolatedLeptonTagging and VertexInfo
- Cut-based analysis (preselection)
- TMVA (BDTG)
- Toy MC

- Everything now technically works with ROOT6.08
  - many thanks to Daniel/Junping/Remi/Yan/Jakob
  - github work: finished uploading, no documentation yet

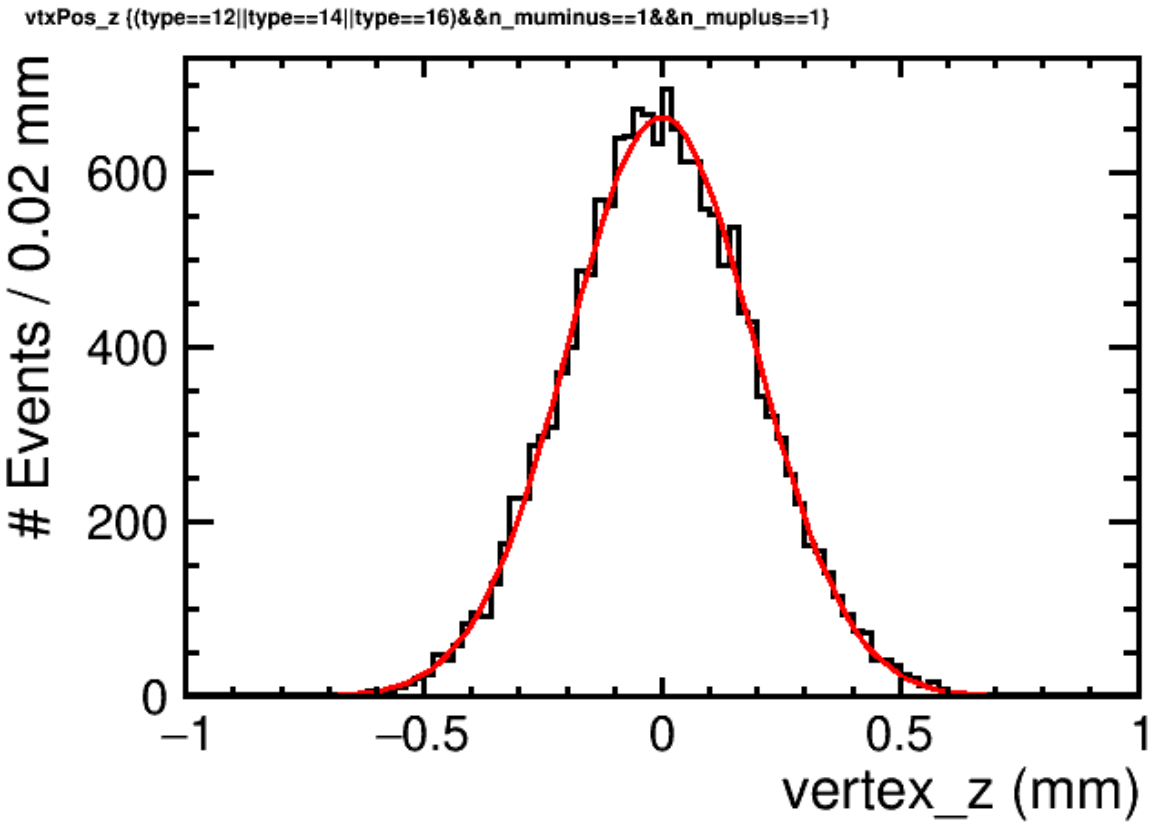
Benchmark Analysis

- Start to use VertexInfo functionality written by Daniel
  - code is available on github
  - estimate primary vertex position using 2 tracks and fitting
- IsolatedLeptonTagging -> VertexInfo
  - $E_{CAL}/p < 0.5$, $p > 10$ GeV, $|d0sig| < 10^{10}$, $|z0sig| < 10^{10}$, $E_{yoke} > 0.5$ GeV, MVA cut > 0.7
  - 2 muon tracks are subjected to VertexInfo
  - with or without beam spot constraint

Without/With Constraint (x, y, z) = (10e-3, 10e-6, 0.3) [mm]



l5, Gaussian fit
width = 0.196 mm



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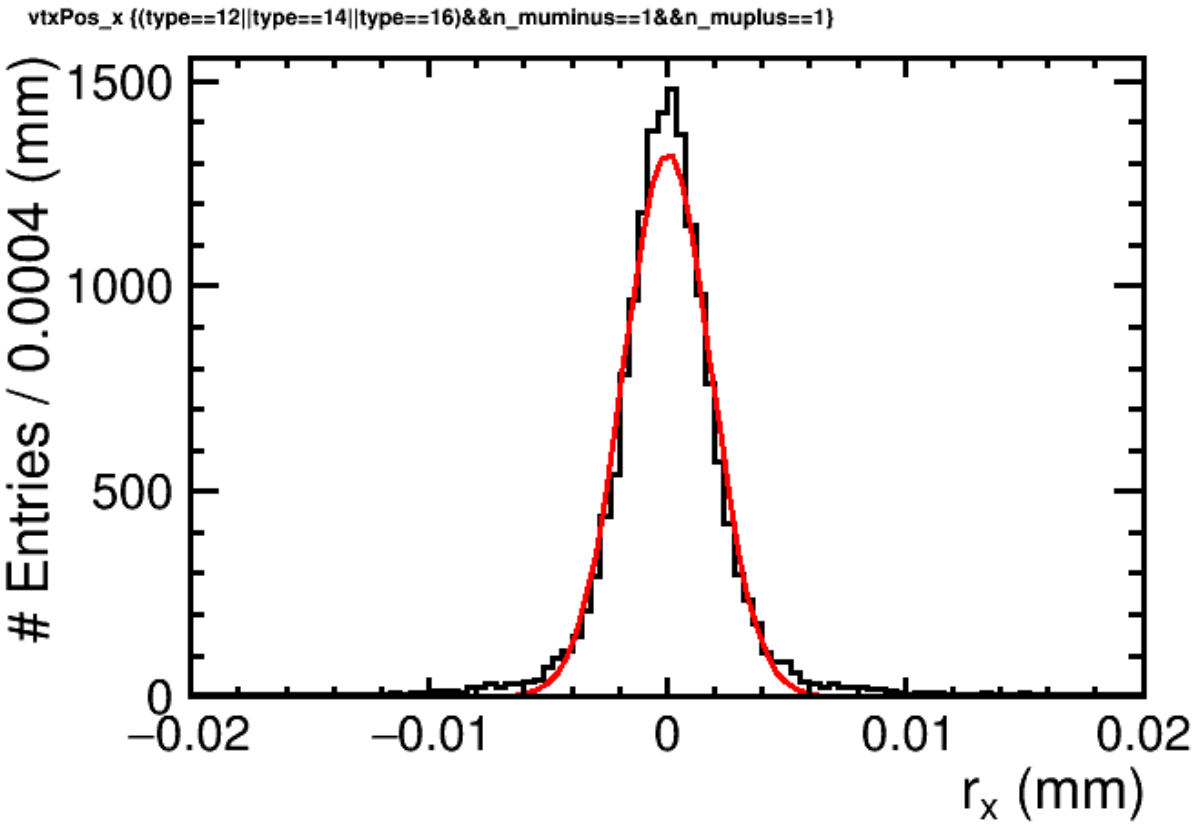
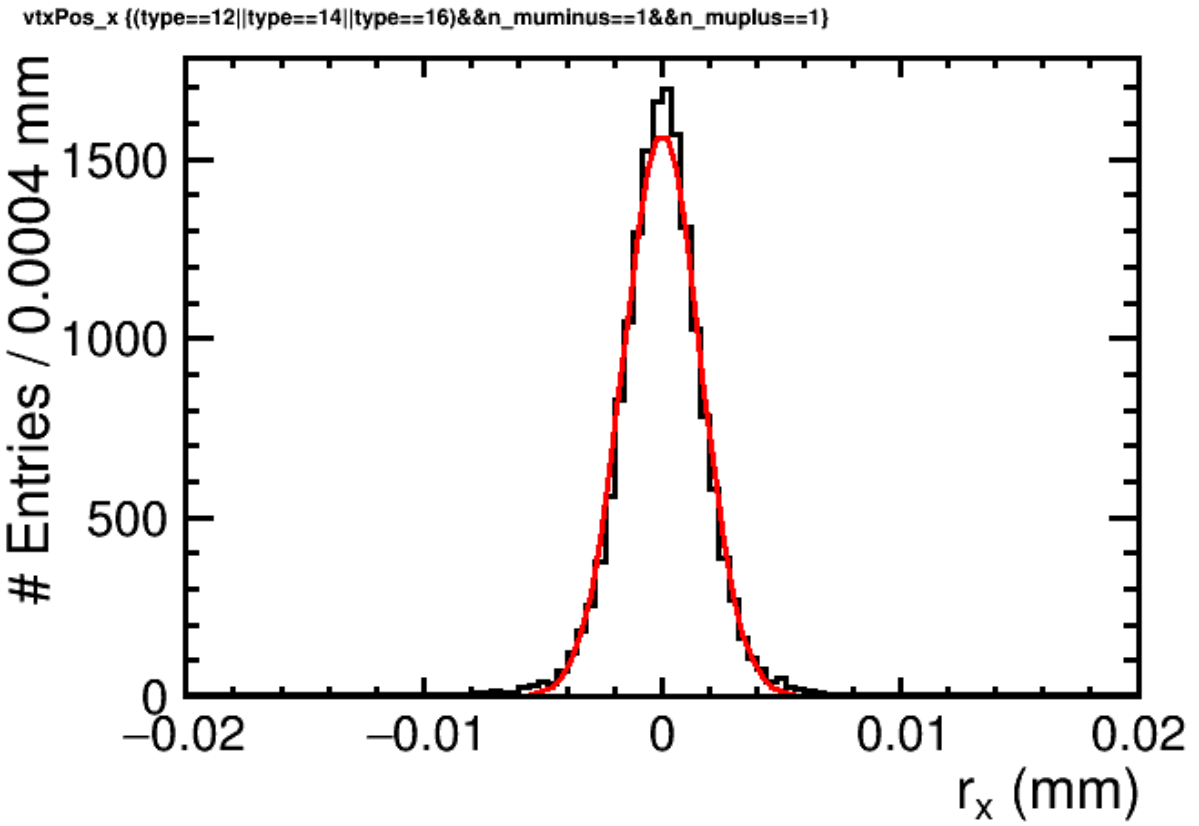


l5, Gaussian fit
x-position, without



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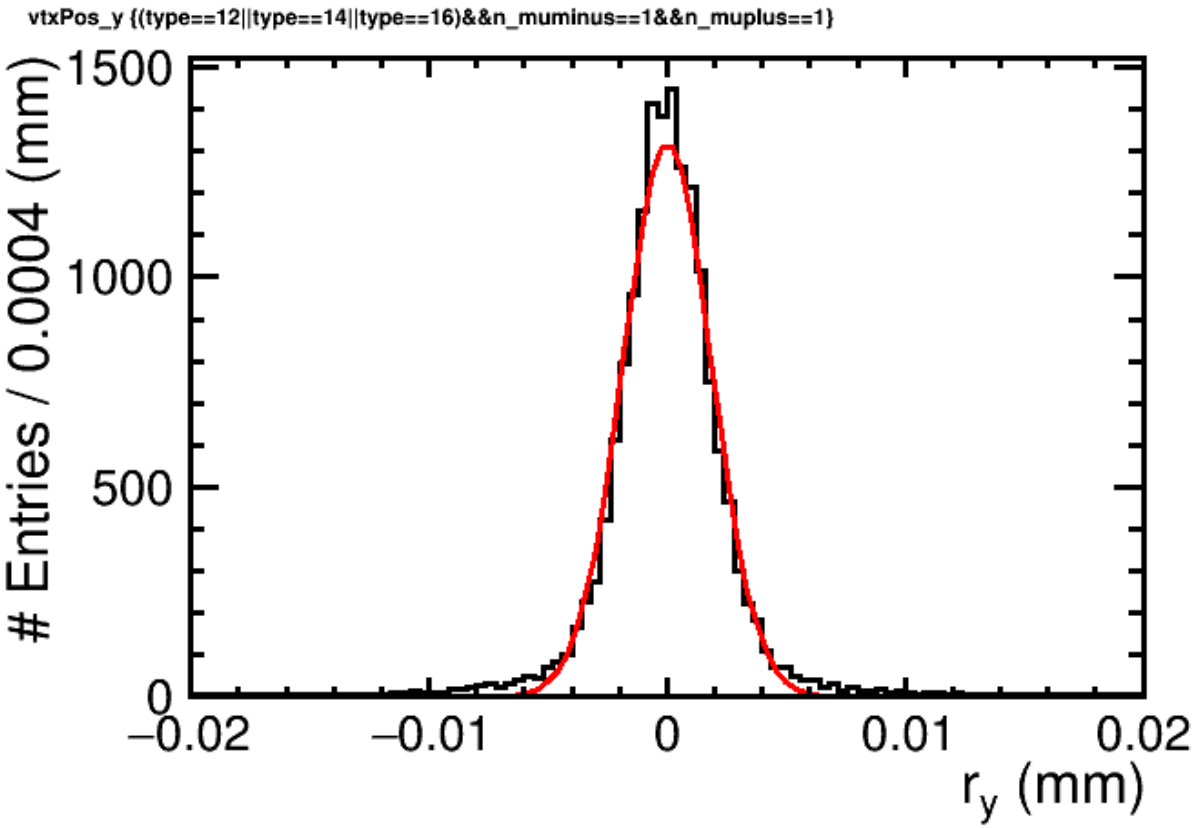
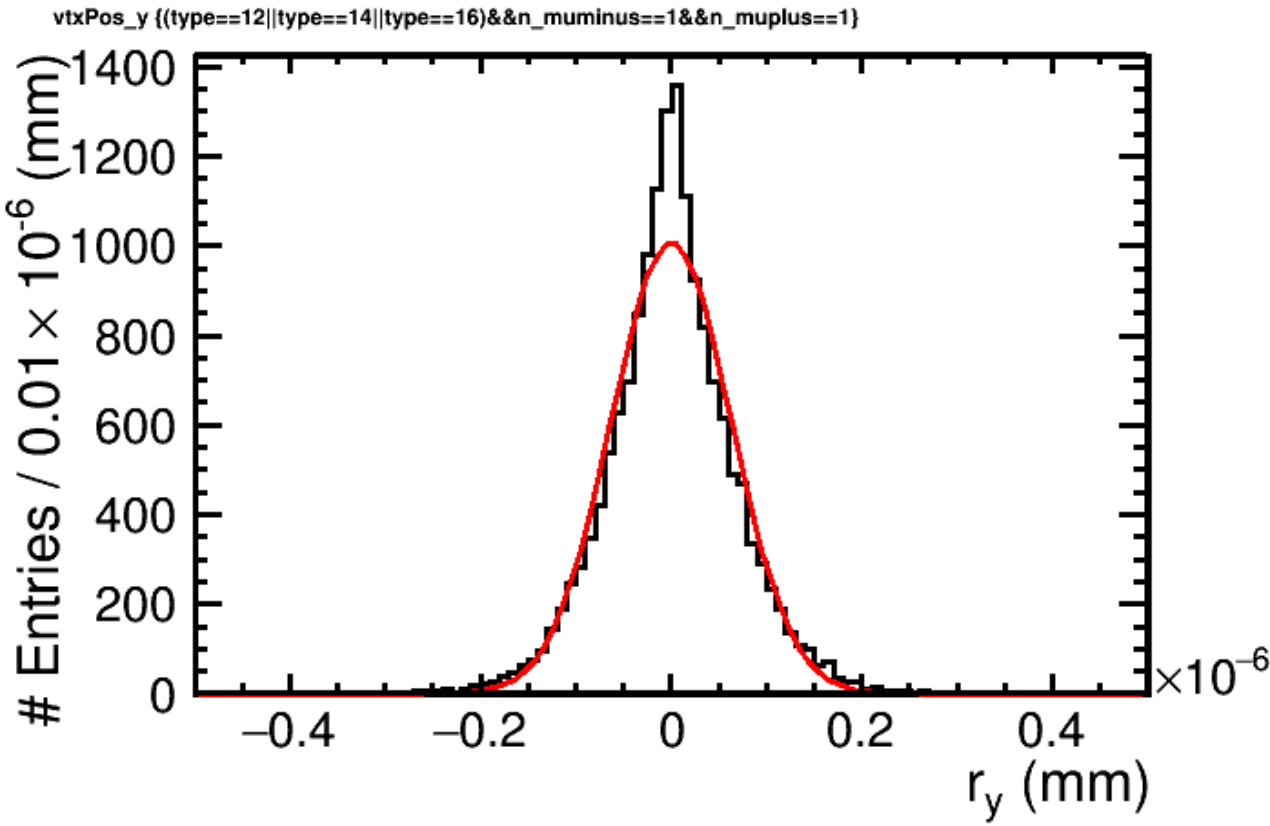


l5, Gaussian fit
y-position, without



l5, Gaussian fit
y-position, with

Cut-based Analysis

- Needed some work for ROOT5 -> ROOT6

Table 1: List of processes used in this analysis.

type	process name
Higgs	`ffh_mumu`
	`higgs_ffh`
2f	`2f_Z_bhabhag`
	`2f_Z_leptonic`
4f	`4f_singleW_leptonic`
	`4f_singleW_semileptonic`
	`4f_singleZee_leptonic`
	`4f_singleZee_semileptonic`
	`4f_singleZnunu_leptonic`
	`4f_singleZnunu_semileptonic`
	`4f_singleZsingleWMix_leptonic`
	`4f_WW_leptonic`
	`4f_WW_semileptonic`
	`4f_ZZ_leptonic`
	`4f_ZZ_semileptonic`
	`4f_ZZWWMix_leptonic`
$\gamma\gamma \to 4f$	`aa_4f`

Table 5: List of selection cuts. Definition of variables are written in the text.

#	variable	cut
0	nothing	no cut
1	# $\mu^{\pm}$	$= 1$
2	$\chi^2/\mathrm{Ndf}(\mu^{\pm})$	$0.5 - 1.5$
3	$\lvert r_z \rvert$	< 0.5 mm
4	$\lvert r_x \rvert$	< 0.01 mm
5	$\lvert r_y \rvert$	$< 0.5 \times 10^{-6}$ mm
6	$\sigma(M_{\mu^+\mu^-})$	< 1 GeV
7	$M_{\mu^+\mu^-}$	$100 - 130$ GeV
8	$\cos\theta_{\mu^+\mu^-}$	< 0.55
9	N_{P_t}	$= 0$
10	E_{vis}	$125 - 300$ GeV
11	missing P_t	> 5 GeV
12	$\lvert \cos\theta_{\mathrm{miss}} \rvert$	< 0.99

Cut Table

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Table 6: Cut table of nnh500-L-l5.

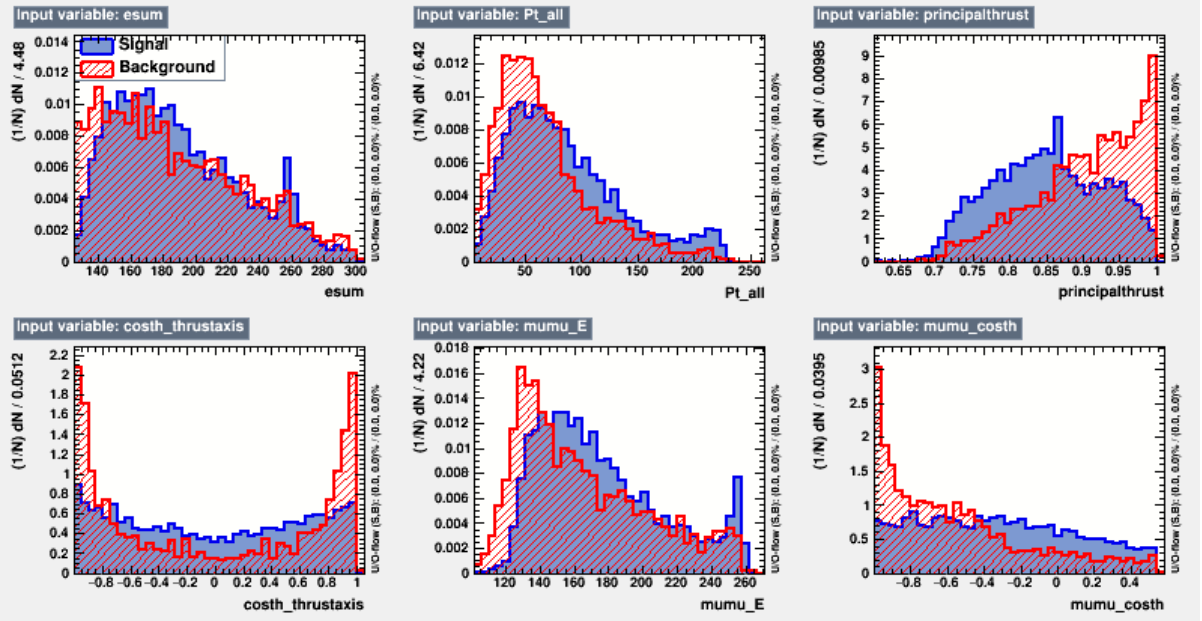
#	$\nu\bar{\nu}h$ $h \to \mu^+\mu^-$	$q\bar{q}h/\ell^+\ell^-h$ $h \to \mu^+\mu^-$	$f\bar{f}h$ other	2f	4f	$\gamma\gamma \to$ 4f
0	57.54	31.12	4.122×10^5	1.084×10^7	3.808×10^7	3.329×10^5
1	54.67	28.17	6719.11	1.889×10^6	1.213×10^6	1.777×10^4
2	53.66	27.78	6623.89	1.731×10^6	1.057×10^6	1.507×10^4
3	53.11	27.45	6539.38	1.711×10^6	1.044×10^6	1.496×10^4
4	53.04	27.40	6304.93	1.691×10^6	1.014×10^6	1.455×10^4
5	53.04	27.40	6282.49	1.690×10^6	1.012×10^6	1.453×10^4
6	52.29	26.85	6195.86	1.234×10^6	9.471×10^5	1.406×10^4
7	50.88	26.13	164.25	4.090×10^4	3.209×10^4	380.49
8	50.87	26.09	123.39	2.602×10^4	3.066×10^4	379.94
9	50.70	0.17	3.66	2.551×10^4	1.834×10^4	204.94
10	50.08	0.03	2.56	1.293×10^4	1.263×10^4	169.81
11	49.90	0.02	2.56	1249.39	1.204×10^4	153.87
12	48.87	0.01	2.56	397.50	1.089×10^4	144.03

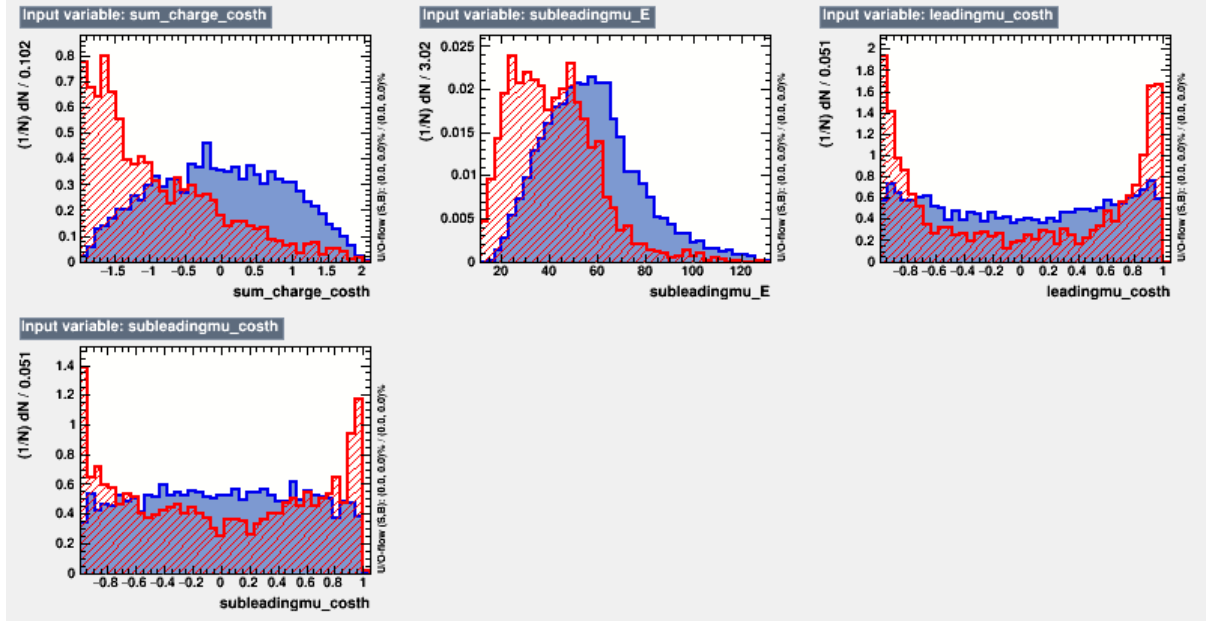
Table 8: Cut table of nnh500-L-s5.

#	$\nu\bar{\nu}h$ $h \to \mu^+\mu^-$	$q\bar{q}h/\ell^+\ell^-h$ $h \to \mu^+\mu^-$	$f\bar{f}h$ other	2f	4f	$\gamma\gamma \to$ 4f
0	57.54	31.12	4.122×10^5	1.084×10^7	3.808×10^7	3.348×10^5
1	54.54	28.01	6699.71	1.894×10^6	1.215×10^6	1.769×10^4
2	53.46	27.58	6587.68	1.731×10^6	1.056×10^6	1.505×10^4
3	52.89	27.29	6508.94	1.711×10^6	1.043×10^6	1.492×10^4
4	52.79	27.27	6283.48	1.689×10^6	1.013×10^6	1.452×10^4
5	52.78	27.27	6256.57	1.683×10^6	1.011×10^6	1.450×10^4
6	52.20	26.82	6192.16	1.315×10^6	9.590×10^5	1.412×10^4
7	50.76	26.13	159.94	4.427×10^4	3.244×10^4	385.11
8	50.74	26.09	117.49	2.764×10^4	3.099×10^4	384.57
9	50.54	0.19	2.97	2.697×10^4	1.830×10^4	212.93
10	49.95	0.03	1.29	1.416×10^4	1.274×10^4	173.06
11	49.79	0.01	1.29	1275.97	1.218×10^4	158.94
12	48.77	0.01	1.29	279.91	1.103×10^4	146.86

TMVA (BDTG) Analysis

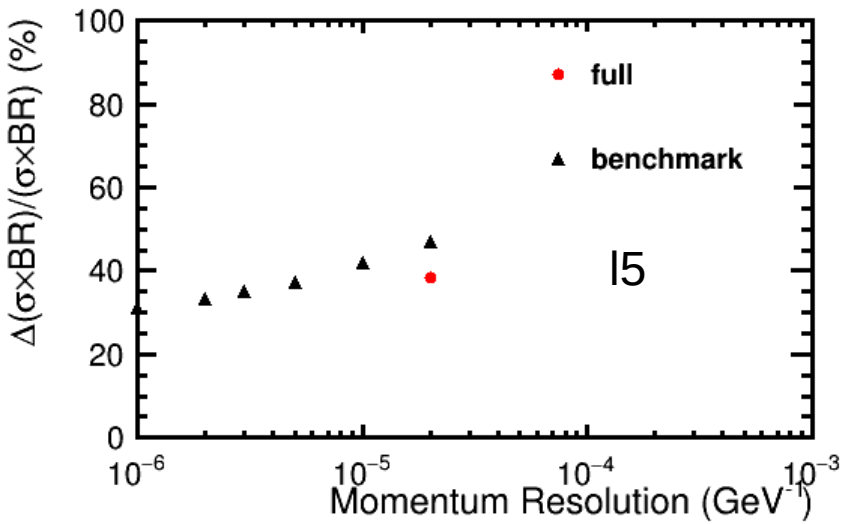
- Needed some work for ROOT5 -> ROOT6
- Input variables are the same as of DBD (these plots are l5-option ones)

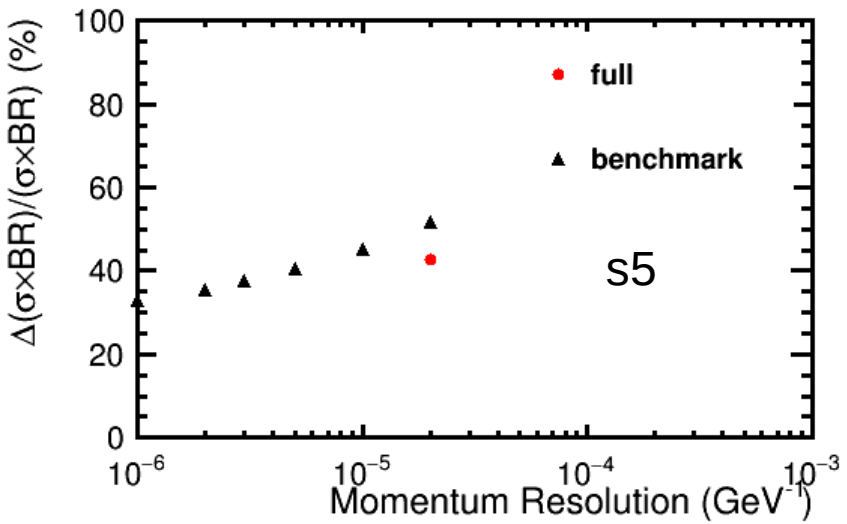




Toy MC

- Same technique applied as of DBD: using CBG and pol1
- full + benchmark: CBG fitting in bad resolution cases didn't work, and nnh500-R cases gave negative precision (too small events?)
- Obtained results for nnh500-L:
  - l5: 38.2%
  - s5: 42.8%
  - DBD: 37.9%





Final Statistics

- BDTG cut point is different due to optimization
  - >0.45 for l5, > 0.65 for s5

Table 6: Cut table of nnh500-L-l5.

#	$\nu\bar{\nu}h$ $h \to \mu^+\mu^-$	$q\bar{q}h/\ell^+\ell^-h$ $h \to \mu^+\mu^-$	$f\bar{f}h$ other	2f	4f	$\gamma\gamma \to$ 4f
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11	49.90	0.02	2.56	1249.39	1.204×10^4	153.87
12	48.87	0.01	2.56	397.50	1.089×10^4	144.03
B	30.21	0	0.04	29.12	904.89 (854.74)	26.00 (25.41)

Table 8: Cut table of nnh500-L-s5.

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12	48.77	0.01	1.29	279.91	1.103×10^4	146.86
B	31.45	0	0	0	1157.12 (1037.44)	38.96 (37.49)

Summary

- Everything is technically working.
- Writing an IDR note is in good shape.
- Thinking time: l5(38.2%) v.s. s5(42.8%). What is the origin of this difference?

- Need to work on HC2018