ILC Asian Physics and Software meeting

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Tempalet Fit implementation

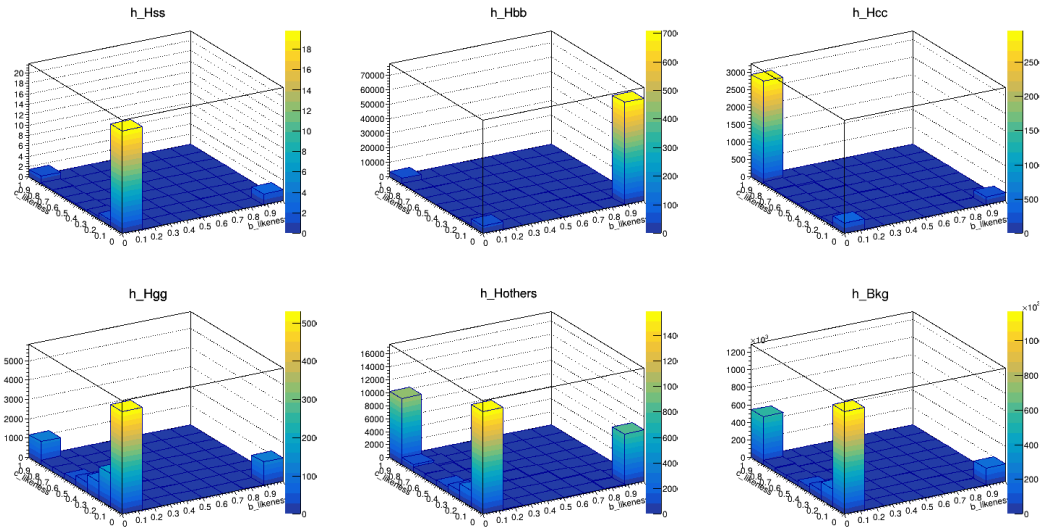
implemented Tempalet fit method following previous study(ono-sans-paper)
(as a benchmark against previous method & comparison with only DNN multiclass classification)

- Dataset: same as that used for DNN only method.
  - Preselected with ParT score > 0.1
  - jet pairing using flavortag+mass
- processed through DNN (but without flavortag variables, >> Hqq/4fSMbg/2fSMbg 3class)
- currently used eLpR dataset only, since the purpose is comparison
- Simultaneous extraciton of measurement pehrecisions for H→bb/cc/gg/ss.

- "X-likeness" is used for fitting
  - (b, c, bc_i -likeness are used in ono-sans-paper)
  - its definition:

$$X = \frac{x_1 x_2}{x_1 x_2 + (1-x_1)(1-x_2)} \quad \text{w/ } x_i = b_i, c_i, g_i, s_i$$

  - $x_{1/2}$ denotes the 2 jets assigned to the Higgs candidates.
- created templates(→)



Tempalet Fit implementation

Template Creation

- 3-class DNN categorization (Hqq / 4f SM bg / 2f SM bg) $\rightarrow$ Reject events below given Hqq score threshold.
- Construct N-dimensional histograms ($N = 2 - 4$) using b, c, g, s-likeness (g-likeness directly uses `gtag`; others use x+xbar).
- Normalized such that $X_b + X_c + X_g + X_s = 1$; 3D templates built with X_b, X_c, X_s.
  - Non-physical region ($X_b + X_c + X_s > 1$) excluded.
- Uniform binning of 8^N (pseudo-count of 10^{-5} added to empty bins).

Toy MC & Sensitivity Evaluation

- Generate pseudo-data by applying Poisson fluctuations to template bins; 1M pseudo-experiments performed.
- Extended log-likelihood fit on scale factors r_s using binned PDF:

$$f = \sum_s r_s N^s_{ijk} + N^{\text{bkg}}_{ijk}$$

  (assumed the # bkg processes are well known)
- Precision calculated as RMS/Mean from fit results.

result

best result (w/ bcgs-likeness)

- precut: Hqq score > 0.9
  - Lower cuts leave excessive background(SMbkg); higher cuts lose too much signal.
- performance comparison with previous results(JPS spring + two reference leterature)

acc[%]	result (jps26s)	current result	ono-sans-paper	FCC report (link)
Hbb	0.73	0.8	1.5	0.32
Hcc	18.8	22.4	10.2	3.52
Hgg	10.5	9.5	13.1	3.07
Hss	3333	3799	-	410

- Yields results similar to DNN-only classification; $H \to cc$ precision remains relatively poor.
- Additional ParT score cuts were tested, but showed no significant improvement.

(tested configuration summary)

acc.[%]	b-c likeness	b-c-s	b-c-g-s	Hqq score > 0.7	score > 0.9	score > 0.95
Hbb	0.8	0.8	0.8	0.7	0.8	0.8
Hcc	26.6	26.6	24.9	23.5	22.4	22.3
Hgg	21.7	20.5	10.5	9.9	9.5	9.5
Hss	9893	8123	7912	6509	3709	6153

introduce variable binning & DNN score axis

- Extended to 4D fit by adding the DNN score axis
- Implemented variable binning to suppress the explosion of total bin count:
  - (0.0 - 0.2 - 0.5 - 0.9 - 0.95 - 1.0) for $X_{\mathrm{b/c/s}}$ axis
  - (0.0 - 0.1 - 0.5 - 0.9 - 0.95 - 1.0) for DNN score axis
- scanned ParT score preselection threshold
- >> best result obtained at cut threshold = 0.3:
  - (see the right table)
  - Hcc precision improved by $\sim 2\%$, whereas Hss severely

next

- search for best variable binning config.
- chk MC truth for bkg events contaminating the bin with the most Hcc events
- add other cuts or other fit axis??

ParT cut: 0.1

```
[H->ss] True:       37.0 | Fit Mean:       37.1 | RMS:     1510.0 | Precision: 4075.7 %
[H->bb] True:   105354.2 | Fit Mean:   105354.8 | RMS:      729.5 | Precision:    0.7 %
[H->cc] True:     5282.4 | Fit Mean:     5282.3 | RMS:     1054.0 | Precision:   20.0 %
[H->gg] True:    15233.3 | Fit Mean:    15232.4 | RMS:     1364.4 | Precision:    9.0 %
```

ParT cut: 0.2

```
[H->ss] True:       36.6 | Fit Mean:       36.9 | RMS:     1489.5 | Precision: 4070.2 %
[H->bb] True:   102352.7 | Fit Mean:   102352.5 | RMS:      709.6 | Precision:    0.7 %
[H->cc] True:     5194.1 | Fit Mean:     5193.8 | RMS:     1034.1 | Precision:   19.9 %
[H->gg] True:    15012.9 | Fit Mean:    15014.0 | RMS:     1346.3 | Precision:    9.0 %
```

ParT cut: 0.3

```
[H->ss] True:       36.1 | Fit Mean:       33.7 | RMS:     1466.4 | Precision: 4063.5 %
[H->bb] True:    99344.2 | Fit Mean:    99343.7 | RMS:      692.8 | Precision:    0.7 %
[H->cc] True:     5101.0 | Fit Mean:     5100.7 | RMS:     1016.7 | Precision:   19.9 %
[H->gg] True:    14740.9 | Fit Mean:    14742.8 | RMS:     1326.6 | Precision:    9.0 %
```

ParT cut: 0.35

```
[H->ss] True:       35.8 | Fit Mean:       36.8 | RMS:     1454.5 | Precision: 4061.3 %
[H->bb] True:    97723.7 | Fit Mean:    97723.1 | RMS:      685.5 | Precision:    0.7 %
[H->cc] True:     5046.2 | Fit Mean:     5046.1 | RMS:     1009.1 | Precision:   20.0 %
[H->gg] True:    14583.0 | Fit Mean:    14582.3 | RMS:     1317.0 | Precision:    9.0 %
```

ParT cut: 0.4

```
[H->ss] True:       35.5 | Fit Mean:       36.0 | RMS:     1445.0 | Precision: 4068.5 %
[H->bb] True:    96101.0 | Fit Mean:    96100.3 | RMS:      676.6 | Precision:    0.7 %
[H->cc] True:     4993.3 | Fit Mean:     4992.2 | RMS:     1001.4 | Precision:   20.1 %
[H->gg] True:    14401.0 | Fit Mean:    14402.0 | RMS:     1304.6 | Precision:    9.1 %
```