CEPC HZZ Project Update
Comparison with White Paper & Yuqian's Thesis

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Comparison with Yuqian's thesis (1)

➢ Analysis comparison (cut-based)

- ➢ **Integrated luminosity: 5000 fb^{-1} (Yuqian's thesis)**
  5600 fb^{-1} (Our analysis)

- ➢ **Cut flow comparison (μμHνvjj)**

Yuqian's

选择条件 \ 事例类型	signal	ZH	leptonic	hadronic	znu_sl	ze_sl	ww_sl	zz_sl
Object Selection (1 pair of μ) 物理对象挑选	246	10527	131752	12235	2	7	68085	69190
M(miss) > M(dijet) 丢失质量>2 喷注不变质量	122	543	65381	1491	2	0	7701	1782
M(dimuon) 缪子对不变质量（80，100）GeV	111	494	19457	36	0	0	360	704
M(dimuon recoil) 缪子对反冲质量（120，160）	111	489	14621	27	0	0	307	576
N(pfo) Particle flow object 数量	102	72	37	27	0	0	305	535
P_T(visible) 事例总横动量 > 10Gev	100	70	14	11	0	0	295	77
$Angle_{min}$(μ-jet) 最小缪子-喷注夹角 > 0.3	93	66	12	0	0	0	13	67
M(miss) & M(dijet) 丢失质量&喷注不变质量	88	12	1	0	0	0	1	11

Comparison with Yuqian's thesis (2)

➢ Analysis comparison (cut-based)

➢ Cut flow comparison (μμHνvjj) continue

Cut	Signal	ZH Background	2f Background	4f Background	$\frac{S}{\sqrt{S+B}}$
Expected	1000.88±31.64	1140511±1067	801811977±28316	107203890±10353	
Pre − selection	616.68±24.83	30494 ±174	480828±693	515448±717	
Signal or not	211.44±14.54	30282 ±174	480828±693	515448±717	
$M_{missing} > M_{dijet}$	107.97±10.39	1608 ±40	115062±339	28809 ±169	0.283
$N(pfo)$	104.16±10.21	908 ±30	33480 ±182	14159 ±118	0.4722
M_{dimuon}	92.43 ±9.61	296 ±17	24151 ±155	1625 ±40	0.5714
M_{dijet}	87.58 ±9.36	280 ±16	851 ±29	819 ±28	1.9395
$M_{missing}$	71.98 ±8.48	124 ±11	97 ±9	101 ±10	3.6196
$*cos\ \theta$	71.98 ±8.48	124 ±11	97 ±9	101 ±10	3.6196
$cos\theta_{visible}$	68.7 ±8.29	118 ±10	22 ±4	39 ±6	4.349
$Angle_{\mu j}$	62.43 ±7.9	95 ±9	14 ±3	20 ±4	4.4919
M^{rec}_{dimuon}	61.2 ±7.82	79 ±8	14 ±3	8 ±2	4.7795
M^{rec}_{dijet}	59.24 ±7.7	69 ±8	0 ±0	4 ±2	5.1374
$*M_{visible}$	59.24 ±7.7	69 ±8	0 ±0	4 ±2	5.1374
$*P_{visible}$	59.24 ±7.7	69 ±8	0 ±0	4 ±2	5.1374
$*P_{T_{visible}}$	59.24 ±7.7	69 ±8	0 ±0	4 ±2	5.1374
$*E_{leading\ jet}$	59.24 ±7.7	69 ±8	0 ±0	4 ±2	5.1374
$*P_{T_{leading\ jet}}$	59.24 ±7.7	69 ±8	0 ±0	4 ±2	5.1374
$*E_{sub-leading\ jet}$	59.24 ±7.7	69 ±8	0 ±0	4 ±2	5.1374
$*P_{T_{sub-leading\ jet}}$	59.24 ±7.7	69 ±8	0 ±0	4 ±2	5.1374
not qqHZZ	59.24 ±7.7	69 ±8	0 ±0	4 ±2	5.1374
not ννHZZ	52.85 ±7.27	33 ±5	0 ±0	4 ±2	5.5581±0.5833

Ours

Comparison with Yuqian's thesis (3)

➢ Results comparison (cut-based)

Yuqian's

- ➢ Didn't perform the fitting
- ➢ Use the formula $\sqrt{S+B}/S$

	N(signal) 信号事例数	Signal Efficiency 信号效率	Statistical 统计误差 Uncertainty
$e^+e^-\nu\nu jj$	65±8	50.1%	15.1%
$\mu^+\mu^-\nu\nu jj$	88±9	67.3%	12.0%
$\nu\nu e^+e^- jj$	43±7	27.6%	18.6%
$\nu\nu \mu^+\mu^- jj$	90±9	57.4%	11.4%
$\nu\nu jj \mu^+\mu^-$	77±8	49.7%	12.9%

Other channels: >20%

Combined: 5.96%

Ours

- ➢ Precision gotten form the fitting

Category	$\frac{\Delta(\sigma\cdot BR)}{(\sigma\cdot BR)}$ [%] cut-based	BDT
$\mu\mu H\nu\nu qq^{cut/mva}$	15.5	13.6
$\mu\mu Hqq\nu\nu^{cut/mva}$	48.0	42.1
$\nu\nu H\mu\mu qq^{cut/mva}$	11.9	12.5
$\nu\nu Hqq\mu\mu^{cut/mva}$	23.5	20.5
$qqH\nu\nu\mu\mu^{cut/mva}$	45.3	37.0
$qqH\mu\mu\nu\nu^{cut/mva}$	52.4	44.4
Combined	8.34	7.89

Comparison with Yuqian's thesis (4)

➢ Preliminary conclusions – Cut flow part

- ➢ **For the cut flow comparison, Yuqian got bettern S/B ratio (i.e., more signals at the same background level)**
- ➢ **Yuqian's number ZH events is significantly less than ours since the pre-selection**

➢ Preliminary conclusions – Precision part

- ➢ **Yuqian got the precision by calculation instead of by fitting the m_H distrbutions**
- ➢ **Yuqian got slightly better precisions for each & combined channels (but with more channel like ee)**

Comparison with CEPC White Paper (1)

➢ Analysis comparison (cut-based)

- **Integrated luminosity: 5600 fb^{-1} (white paper)**
  5600 fb^{-1} (Our analysis)

- **Cut flow comparison**
  - **In the white paper, only two channels are analyzed: μμHνvjj νvHlljj**

μμHνvjj : dimuon mass (80, 100), dimuon recoil mass (120, 160),
dimuon pt (> 10), dijet mass (10, 38)

νvHlljj : visible energy (< 180), missing mass (58, 138),
mass & pt cuts on lepton/jet pairs

Comparison with CEPC White Paper (2)

➢ Results comparison (cut-based)

White paper

➢ **Precision gotten from the fitting (seems the same as Kaili's package)**

ZH final state		Precision
$Z \to \mu^+\mu^-$	$H \to ZZ^* \to \nu\bar{\nu}q\bar{q}$	7.2%
$Z \to \nu\bar{\nu}$	$H \to ZZ^* \to \ell^+\ell^- q\bar{q}$	7.9%
Combination		4.9%

Ours

➢ **Precision gotten form the fitting**

Category	$\frac{\Delta(\sigma \cdot BR)}{(\sigma \cdot BR)}$ [%]	
	cut-based	BDT
$\mu\mu\mathrm{H}\nu\nu qq^{\mathrm{cut/mva}}$	15.5	13.6
$\mu\mu\mathrm{H}qq\nu\nu^{\mathrm{cut/mva}}$	48.0	42.1
$\nu\nu\mathrm{H}\mu\mu qq^{\mathrm{cut/mva}}$	11.9	12.5
$\nu\nu\mathrm{H}qq\mu\mu^{\mathrm{cut/mva}}$	23.5	20.5
$qq\mathrm{H}\nu\nu\mu\mu^{\mathrm{cut/mva}}$	45.3	37.0
$qq\mathrm{H}\mu\mu\nu\nu^{\mathrm{cut/mva}}$	52.4	44.4
Combined	8.34	7.89

Comparison with CEPC White Paper (3)

➢ Preliminary conclusions – Cut flow part

- ➢ **For the cut flow comparison, the analysis in the white paper use less cuts**
- ➢ **Not clear about how the cut flow like**

➢ Preliminary conclusions – Precision part

- ➢ **Both the white paper and our analysis use m_H fitting to get the precisions**
- ➢ **The precisions in the white paper for the two channels are much better than ours**
- ➢ **The combined precision is also much better in the white paper νvHlljj**