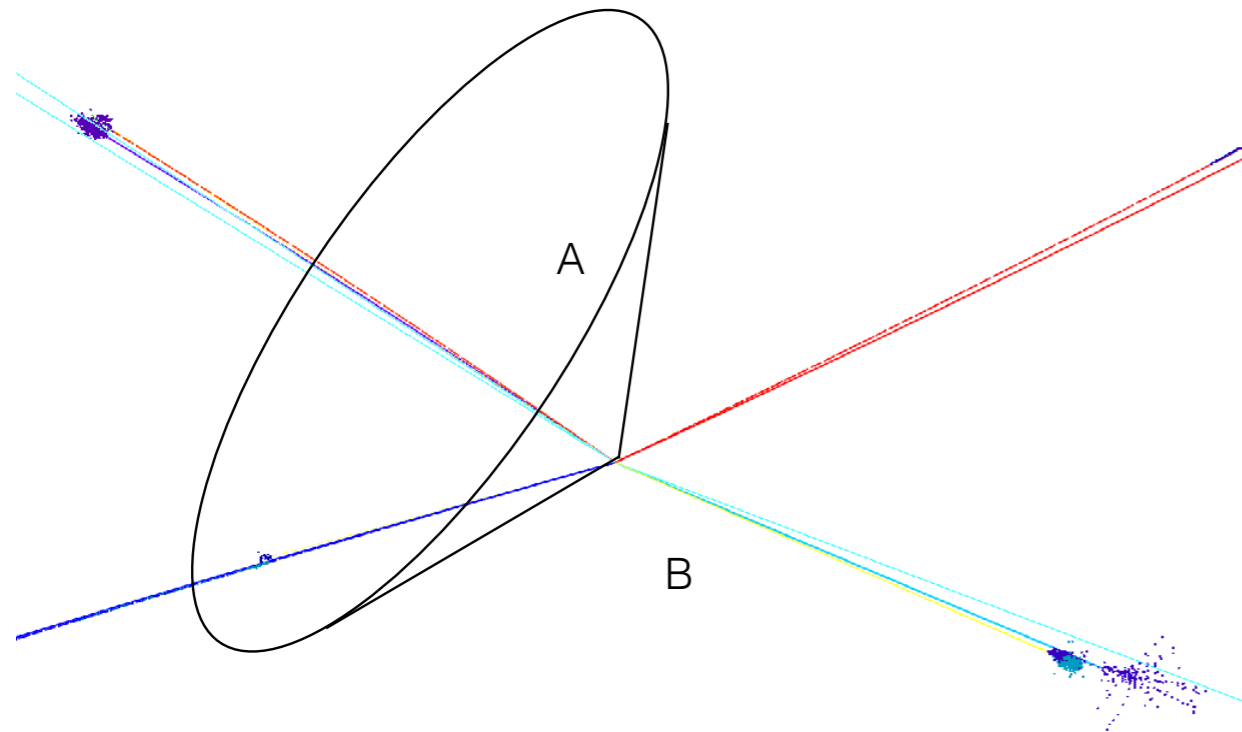


# Higgs $\rightarrow$ $\tau\tau$ Channel Signal Strength in CEPC

CEPC\_V1(250GeV) vs CEPC\_V4(240GeV)

- $H \rightarrow \tau\tau$  has been analyzed @ CEPC\_V1(IIH/qqH)
- Idea: Multiplicity + Impact Parameter + (Event info)
- Result:  $\delta(\sigma \times \text{Br}) / (\sigma \times \text{Br}) \sim 0.81\%$
- Signal full simulation @ CEPC\_V4 + Bkg @ CEPC\_V1

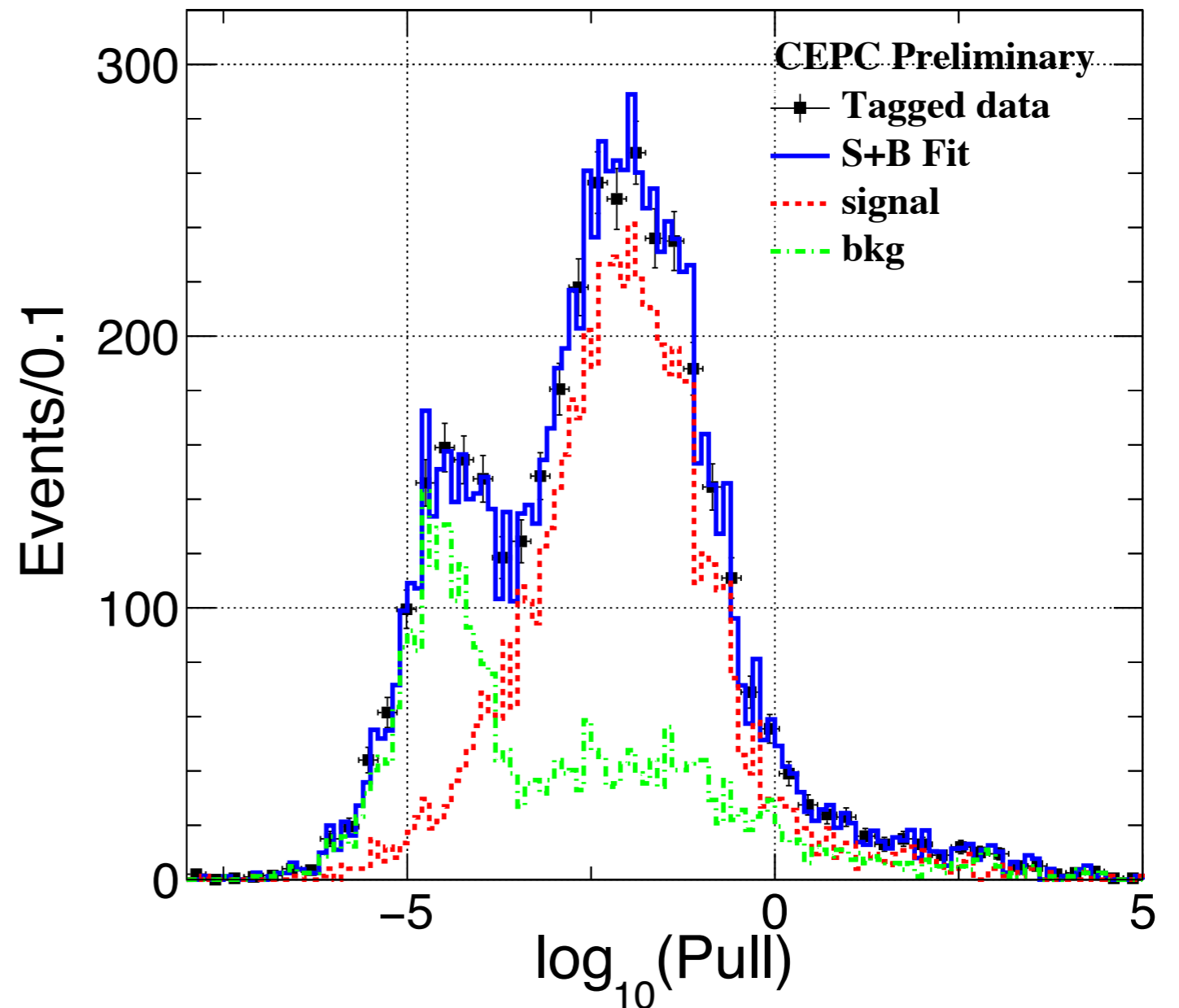
# Tau Finder (lH)



- llH channel:
  - Pre-selection
  - $\tau$  finding
    - Multiplicity
    - Rejection: jets
  - Impact parameter
    - Vertex information
    - Rejection:  $H \rightarrow WW$

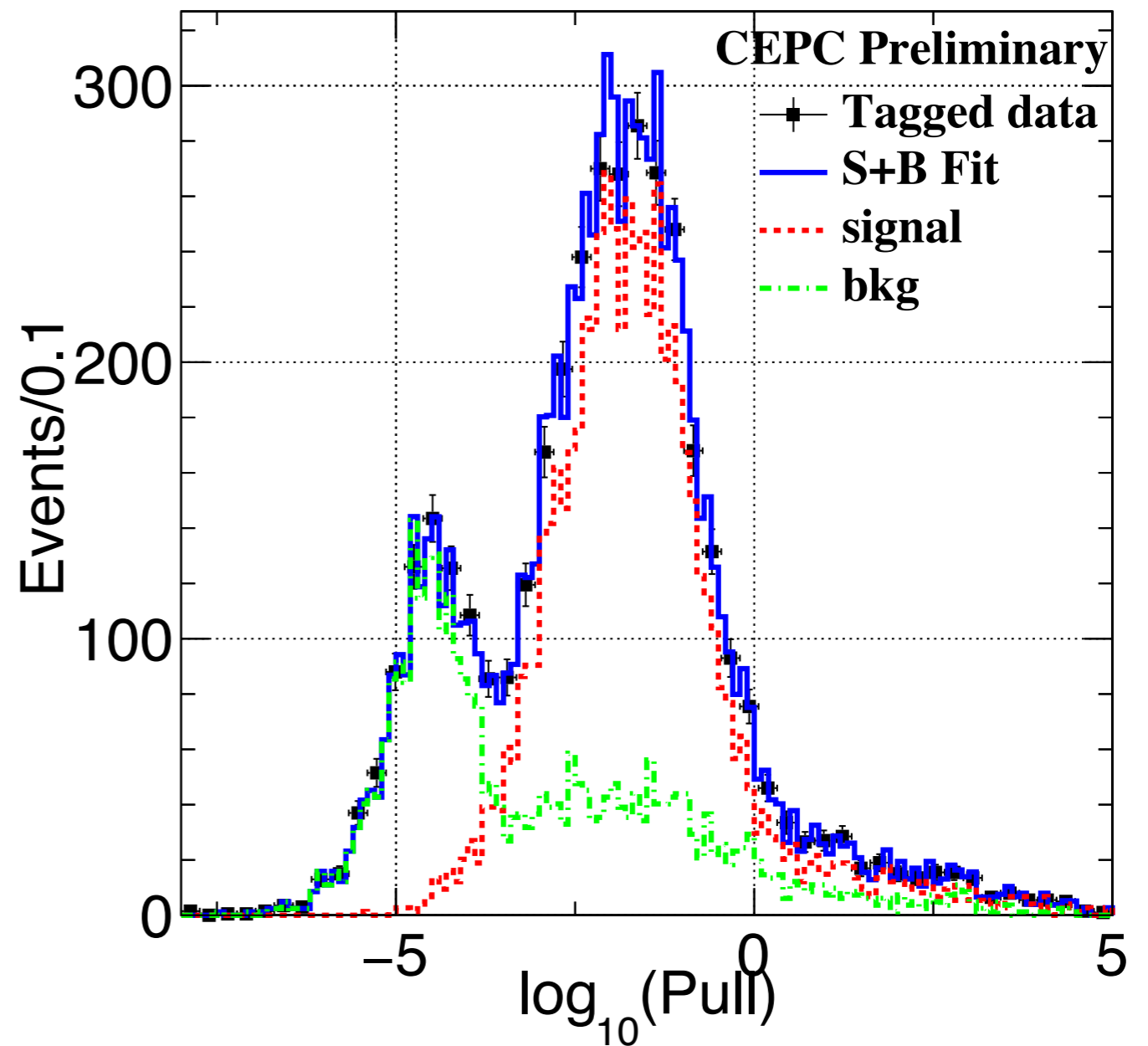
# Tau Finder (IH)

- Cut efficiency: 93.15%
- Impact parameter: starting points for tracks decayed from  $\tau$  > others
- Fit result: signal  $\sim 2137 \pm 48$
- $\mu\mu H$  Accuracy: **2.26%**
- $nnH$ : 4.29% (Huge background)

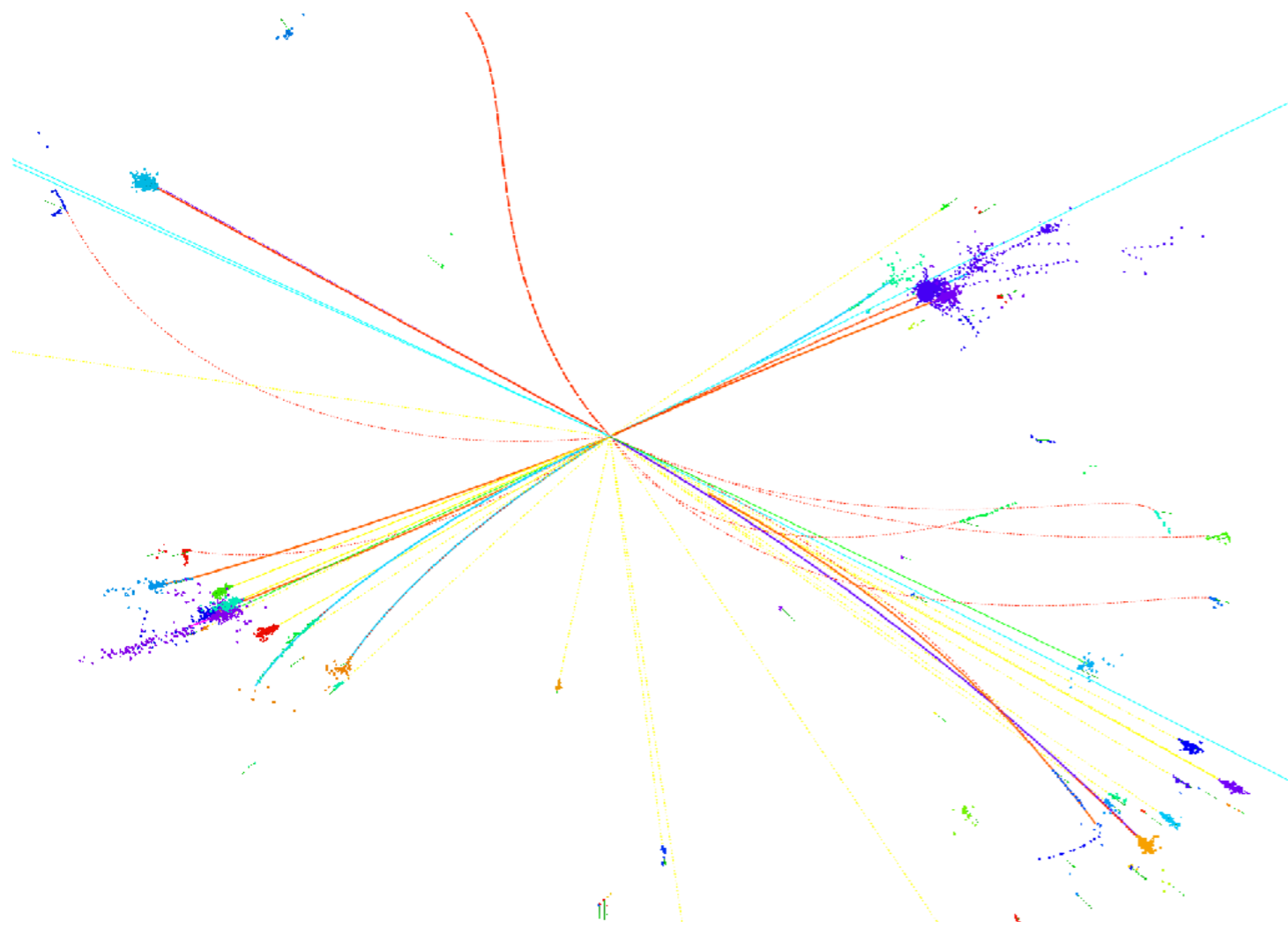


# Tau Finder (IH) - CEPC\_V4(240GeV)

- Cut efficiency: 95.81%
- Fit result: signal  $\sim 2152 \pm 44$
- $\mu\mu H$  Accuracy: **2.06%**



# Tau Finder (qqH)

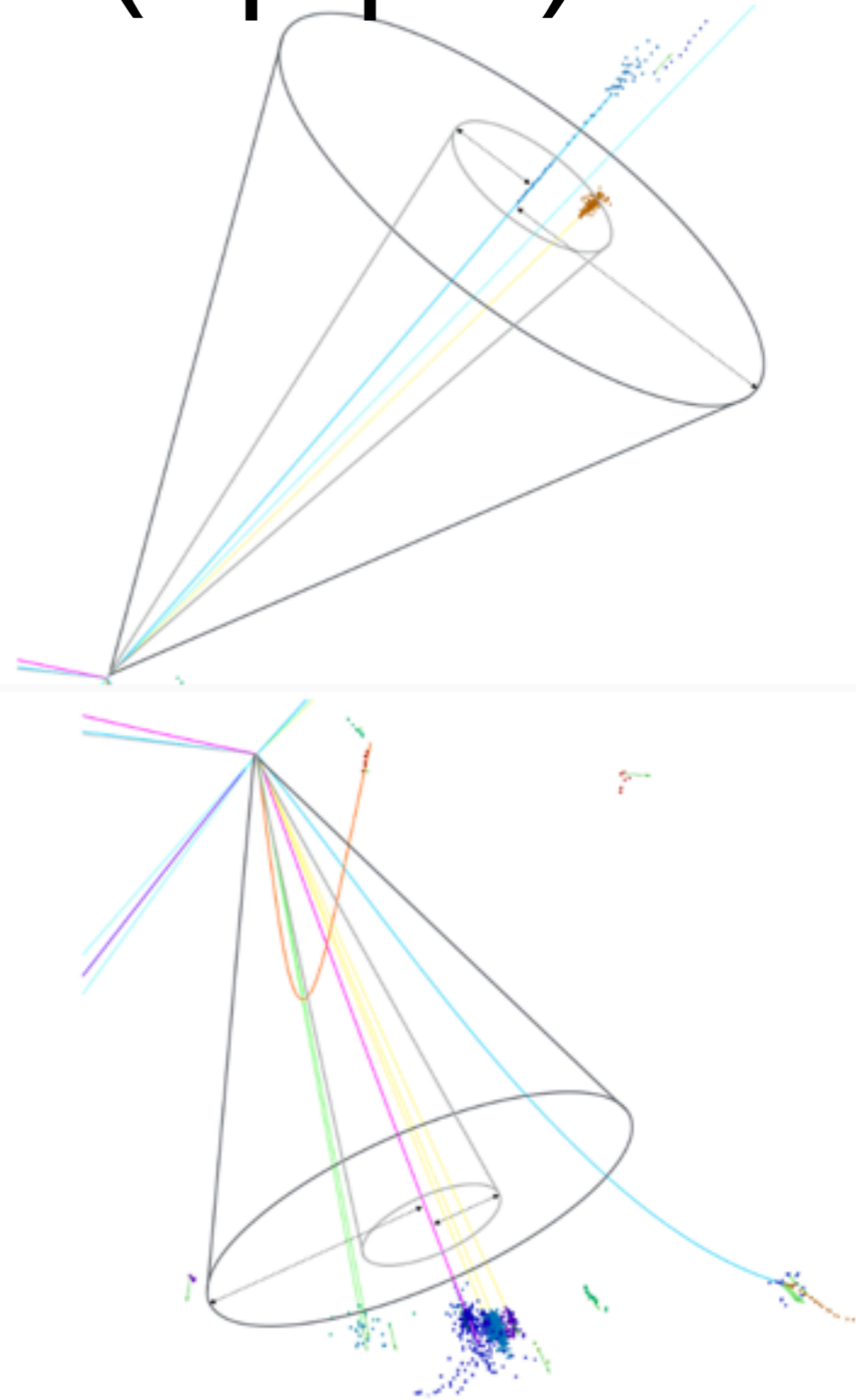


qqH channel:

- Pre-selection
- $\tau$  finding
  - Multiplicity and isolation
  - Rejection: jets
- Event finding
  - $\tau\tau$  information
  - qq information
- Impact parameter

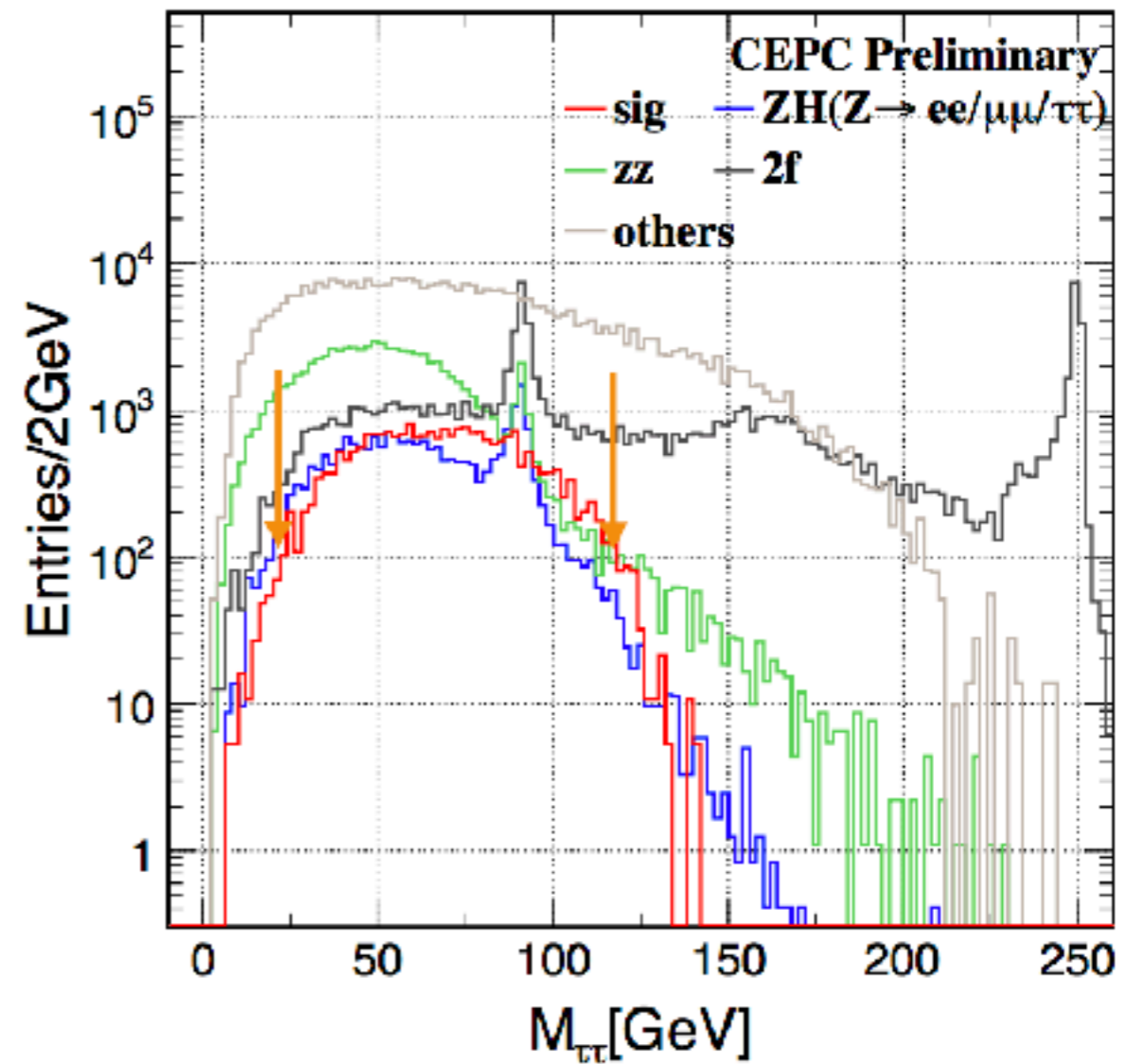
# Tau Finder (qqH)

- Tracks energy ( $> 1.5\text{GeV}$ )
  - $N_{\text{tracks}} < 7$ ,  $N_{\text{photons}} < 10$  in  $\text{cone}_s(0.15)$
  - Isolated: energy ratio of  $\text{cone}_s$  to  $\text{cone}_l(0.45) > 0.92$
  - visible mass ( $< 2.0\text{GeV}$ )
  - existing opposite charged  $\tau$ s
  - optimized to efficiency  $\times$  purity (58%)
- efficiency:  
 $N(\tau^+\tau^-)/N(\text{qqH}\tau\tau)$
- purity:  
 $1 - N(\tau^+\tau^-)/N(\text{qqHinclusive})$



# TauTau Invariant Mass

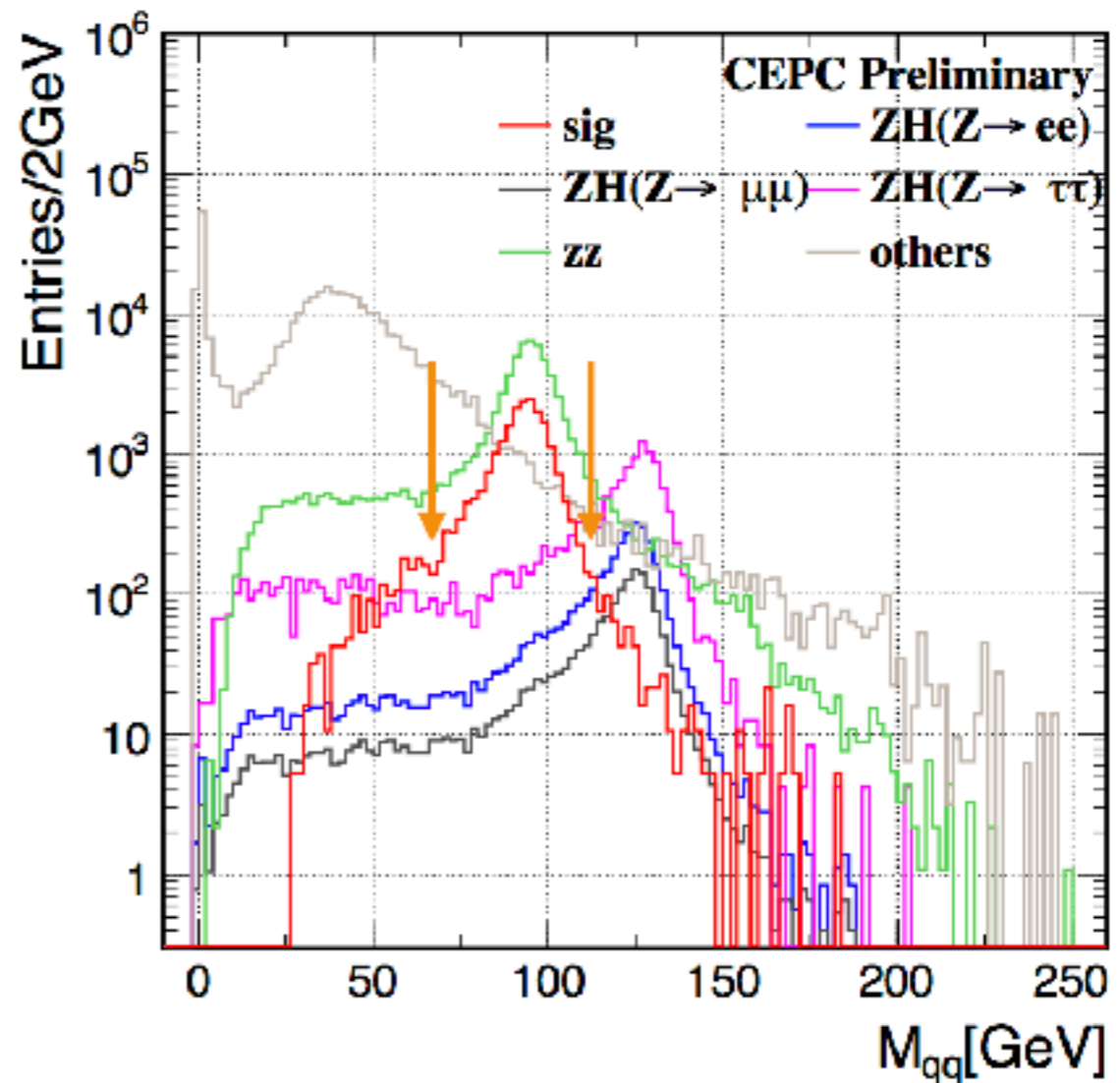
- (20GeV, 120GeV)
- Main background reduced:
  - 2f
  - fake tau candidate
- Main background remaining:
  - ZH
  - ZZ
  - WW





# qq Invariant Mass

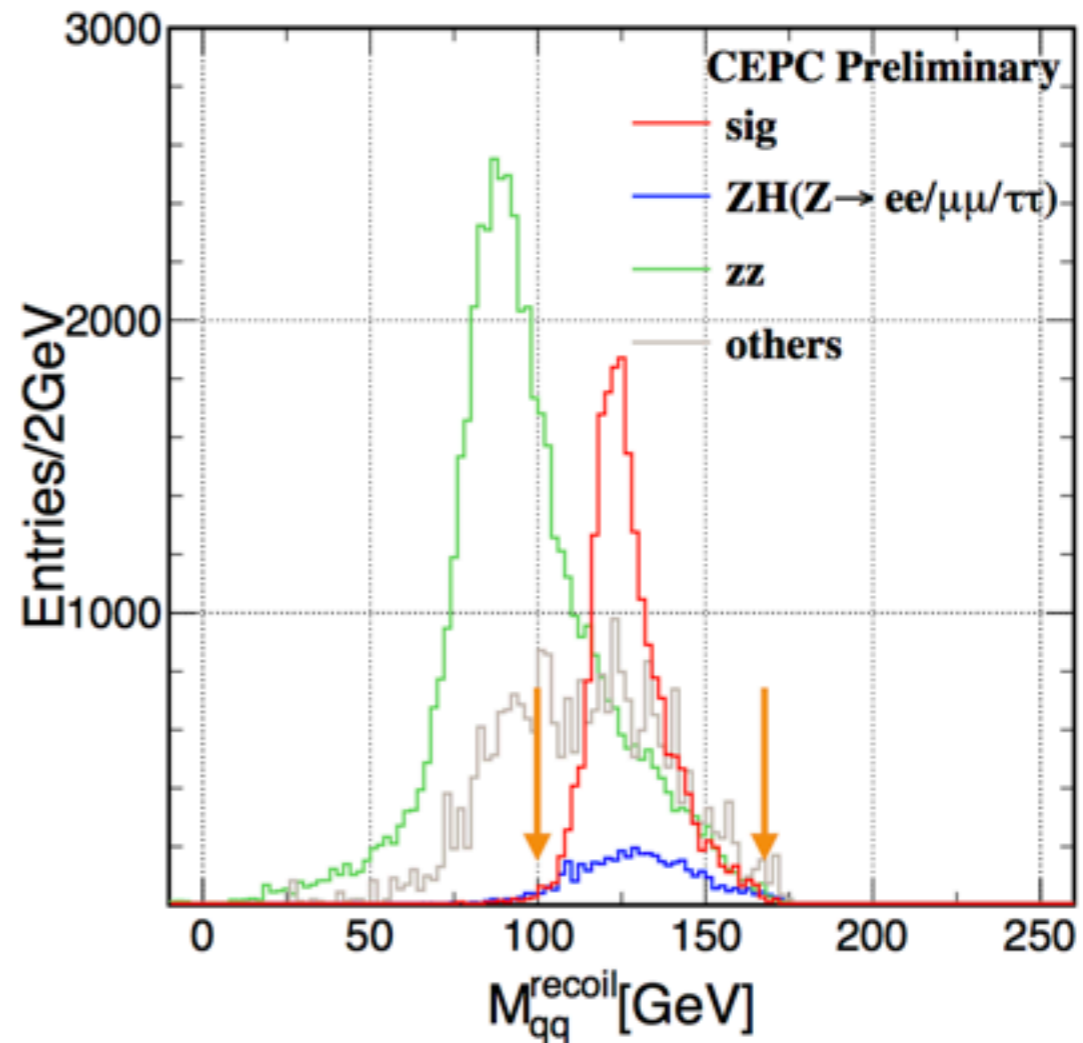
- Peak @  $M_Z$
- Main background reduced:
  - ZH with Z to tau
  - WW semi-leptonic
- Main background remaining:
  - ZZ



$M_Z$ : signal, ZZ  
 $M_H$ : ZH conjugation

# qq Recoil Mass

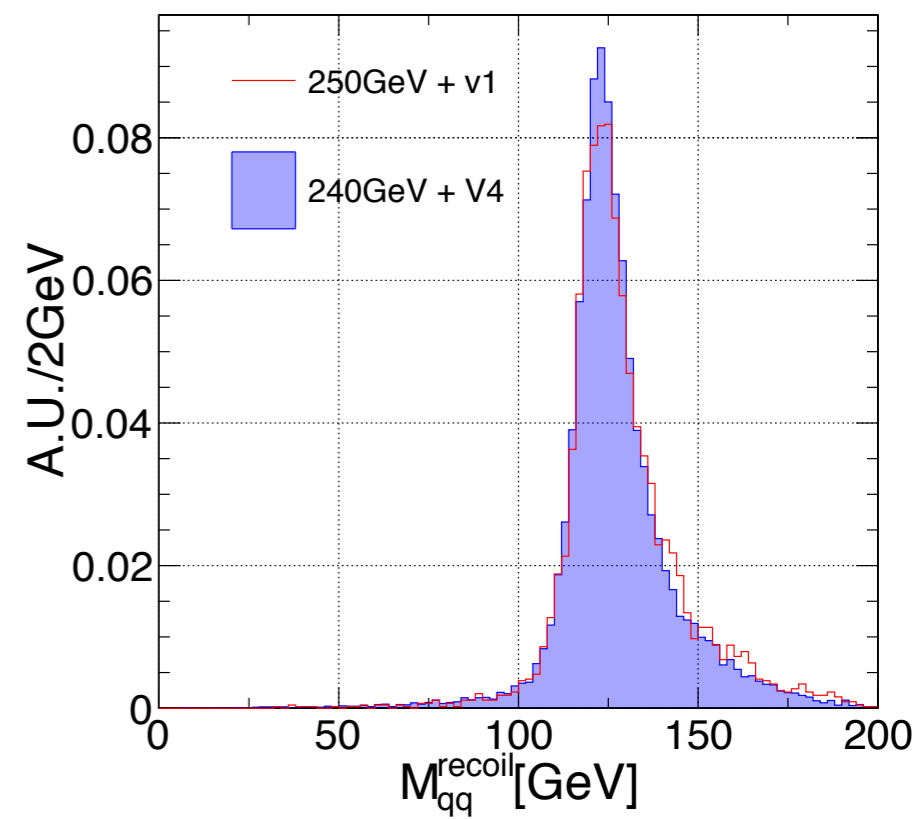
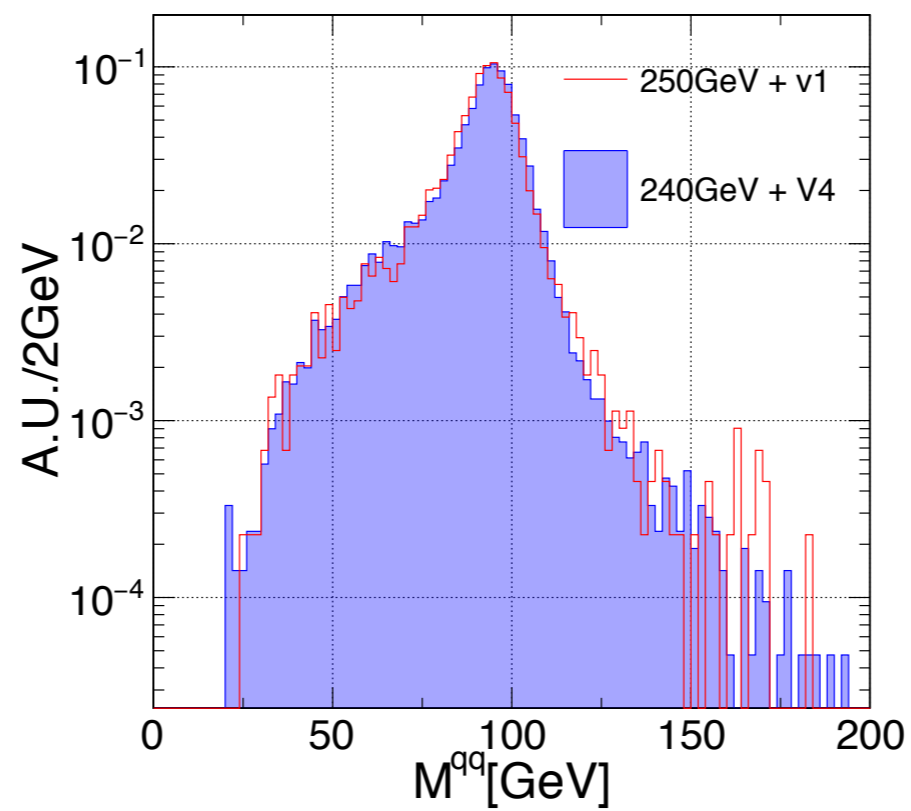
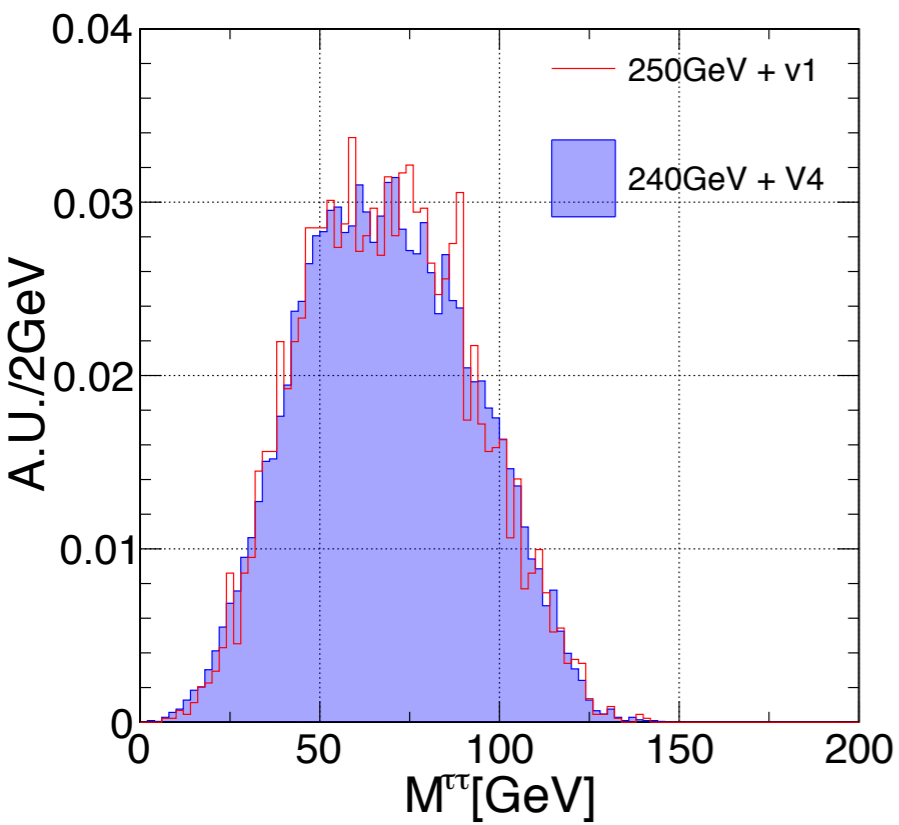
- Peak @  $M_H$
- Main background reduced:
  - $ZZ \rightarrow qq\tau\tau$
- Main background remaining:
  - irreducible backgrounds



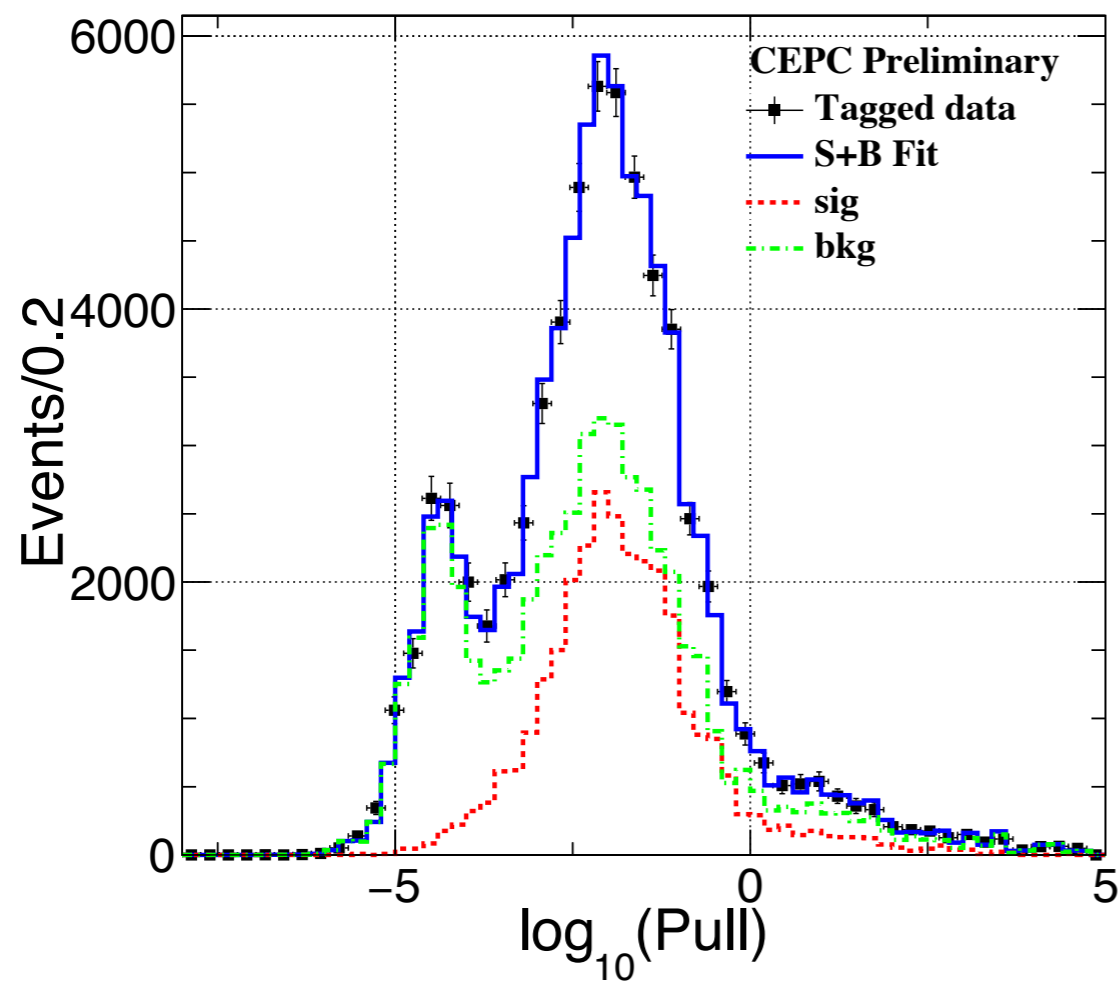
$M_Z$ : ZZ

$M_H$ : signal

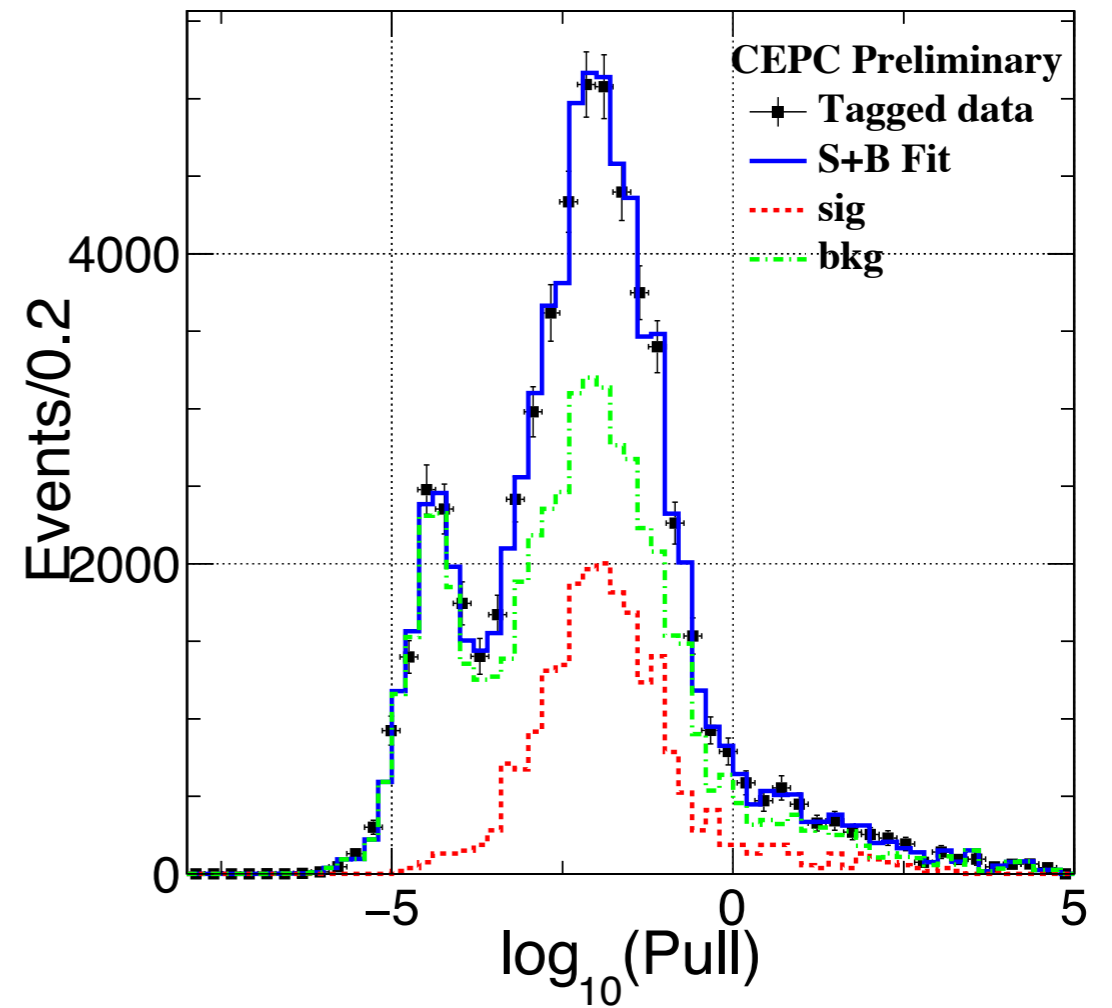
# Parameters Comparison



# Impact Parameter Fit



CEPC\_V1 250GeV



CEPC\_V4 240GeV

# Cut Chain & signal strength

Sample	CEPC_V1 + 250GeV		CEPC_V4 + 240GeV	
	sig	qqH bkg	sig	qqH bkg
a pair of tau	54.66%	4.20%	54.16%	4.34%
M(tautau)	53.79%	3.60%	53.10%	3.67%
M(qq)	50.80%	1.21%	48.38%	1.26%
RecoilM(qq)	50.29%	1.17%	47.80%	1.19%
qqH accuracy	0.93%		0.97%	
convolute accuracy	0.81%		0.85%	

# Summary

- Full simulation for signal @ CEPC\_V4 (240GeV), no obvious difference for  $H \rightarrow \tau\tau$  analysis
- Parameters for cut chain not fully optimized

Back up

- Similar procedure as  $\mu\mu H$ , without vetoing charged track
- Signal efficiency after pre-selection: 60.8% (not optimized)
- Signal efficiency after  $\tau$  finder: 57.02%
- Huge irreducible background: tough to fit...
- Accuracy: 4.29%

	$\nu\nu H\tau\tau$	$\nu\nu H$ inclusive bkg	ZZ	WW	singleW	single Z	2f
total generated	15497	231670	5711445	44180832	17361538	7809747	418595861
after preselection	9434	214830	1239457	7463105	3327803	956694	12826280
$N_{Trk}(A/B) < 6$ & $N_{Ph}(A/B) < 7$	9260	8858	24760	1354852	17389	676185	1535029
BDT $> 0.78$	8836	6587	15450	89729	1355	10739	11243
efficiency	57.02%	2.84%	0.27%	0.20%	<0.01%	0.14%	<0.01%



# Combine & extrapolation

Combined result for CEPC ( $5 \text{ ab}^{-1}$ )

	$\delta (\sigma \times \text{BR}) / (\sigma \times \text{BR})$
$\mu\mu\text{H}$	2.26%
eeH(extrapolated)	2.72%
$\nu\nu\text{H}$	4.29%
qqH	0.93%
combined	0.81%

Extrapolation to ILC250 ( $2 \text{ ab}^{-1}$ ):

Type	(-80%,30%)	(80%,-30%)	non-pol
Total Higgs	604224	396196	424000
$\mu\mu\text{H}$	2.98	3.63	3.57
$\nu\nu\text{H}$	5.48	4.34	6.78
qqH	1.26	1.36	1.47
combined	1.13	1.22	1.33

	$\mu\mu H\tau\tau$	$\mu\mu H$ inclusive bkg	$ZZ$	$WW$	single $W$	single $Z$	$2f$
total generated	2292	33557	5711445	44180832	15361538	7809747	418595861
after preselection	2246	32894	122674	223691	0	86568	1075886
$N_{Trk}(A/B) < 6$ & $N_{Ph}(A/B) < 7$	2219	1039	2559	352	0	9397	25583
BDT > 0.78	2135	885	484	24	0	157	161
efficiency	93.15%	2.63%	<0.01%	<0.01%	<0.01%	<0.01%	<0.01%

	$qqH\tau\tau$	$qqH$ inclusive bkg	$ZH$ inclusive bkg	$ZZ$	$WW$	single $W$	single $Z$	$2f$
total generated (scaled to $5 \text{ ab}^{-1}$ )	45597	678158	357249	5711445	44180832	17361538	7809747	418595861
1st preselection	45465	677854	310245	5039286	42425195	1267564	1398362	148401031
2nd preselection	45145	174650	226059	293306	12452091	125735	117306	547402
$N_{\tau^+} > 0, N_{\tau^-} > 0$	24674	7342	33721	93955	723989	33887	54386	103642
$20 \text{ GeV} < M_{\tau^+\tau^-}$ < $120 \text{ GeV}$	24284	6290	32344	88245	597480	24927	36039	56615
$70 \text{ GeV} < M_{qq}$ < $110 \text{ GeV}$	22937	2103	4887	65625	21718	738	1893	556
$100 \text{ GeV} < M_{qq}^{Rec}$ < $170 \text{ GeV}$	22703	2045	4524	23789	13154	315	306	193
efficiency	49.97%	0.31%	1.26%	0.41%	0.04%	<0.01%	<0.01%	< 0.01%