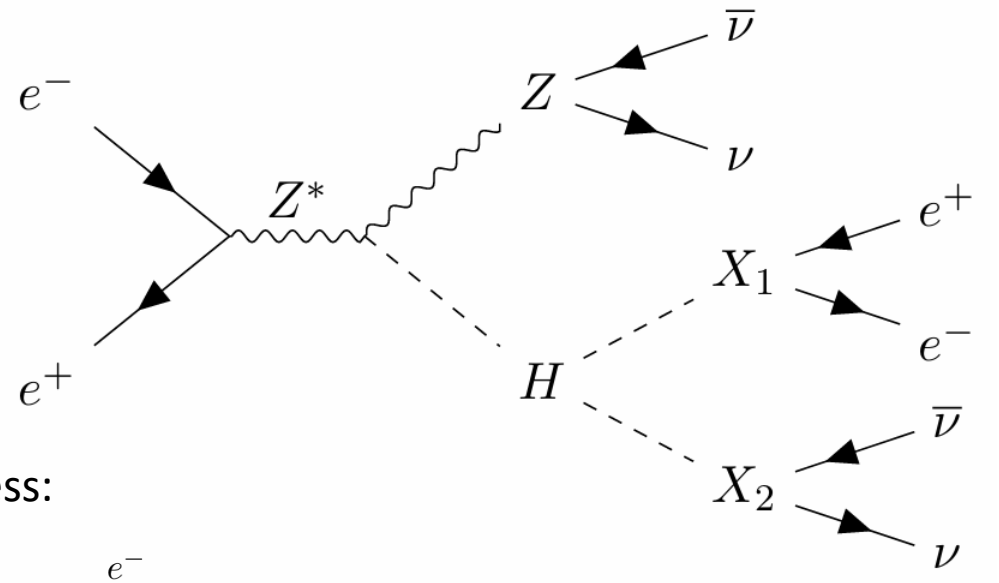
CEPC LLP Study

Xiang Chen, Ziyang Sun, Liang Li

Shanghai Jiao Tong University

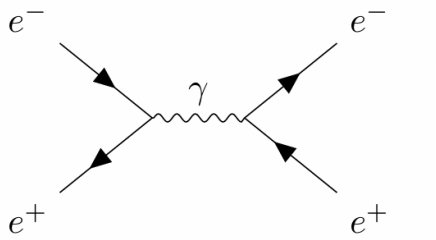
2-electron channel full simulation analysis

Signal:

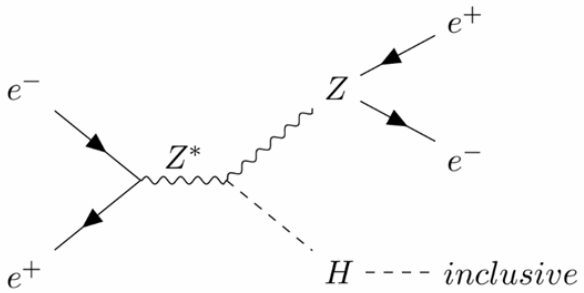


Signal events: 100,000, $M_{X1,2}$: 1,10, 50GeV
Bhabha process events: 98,000
vvHX events: 1,000,000
eeHX events: 1,000,000
eeZ events: 500,000
evW events: 500,000

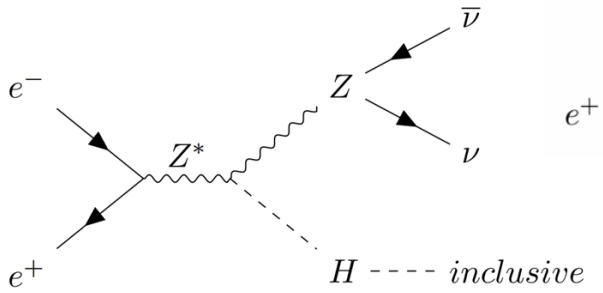
Bhabha process:



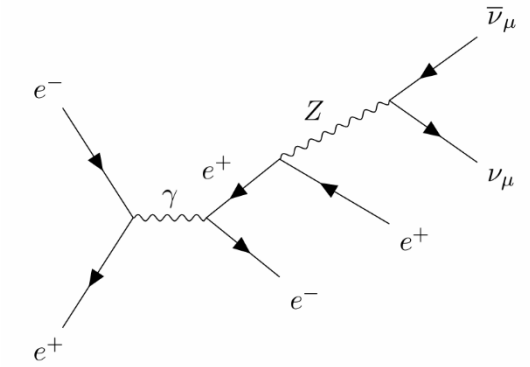
eeHX:



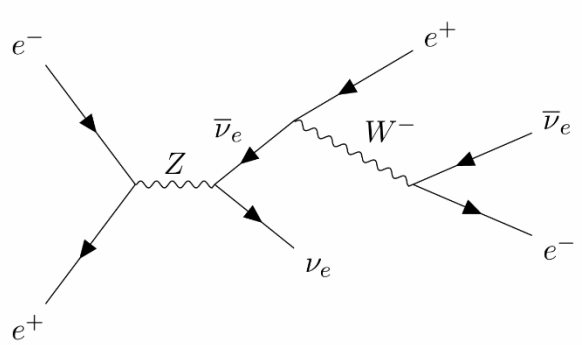
vvHX:



eeZ process:
Final state: ee $\nu_{\mu,\tau}\nu_{\mu,\tau}$



evW process:
Final state: ee$\nu_e\nu_e$



Cut Flow Summary

Total events
nPFO<20: Jet veto
Lepton pair: exactly two opposite sign lepton Using FinalPID
ΔR: Two leptons back-to-back
ΔT > 0.1 ns(0.05ns): LLP decay signal has large time difference
Recoil mass(GeV): Z veto
Invariant mass(GeV): LLP signal mass selection

The time difference:

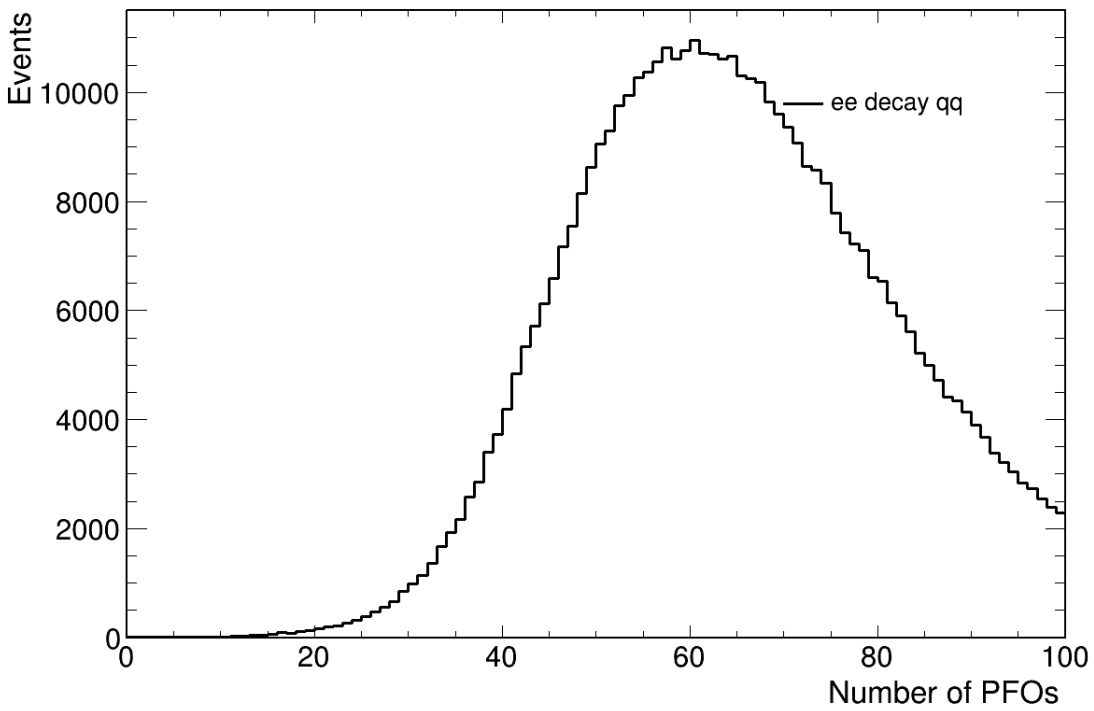
$$\Delta T = t_{hit,i} - r_{hit,i}/c$$

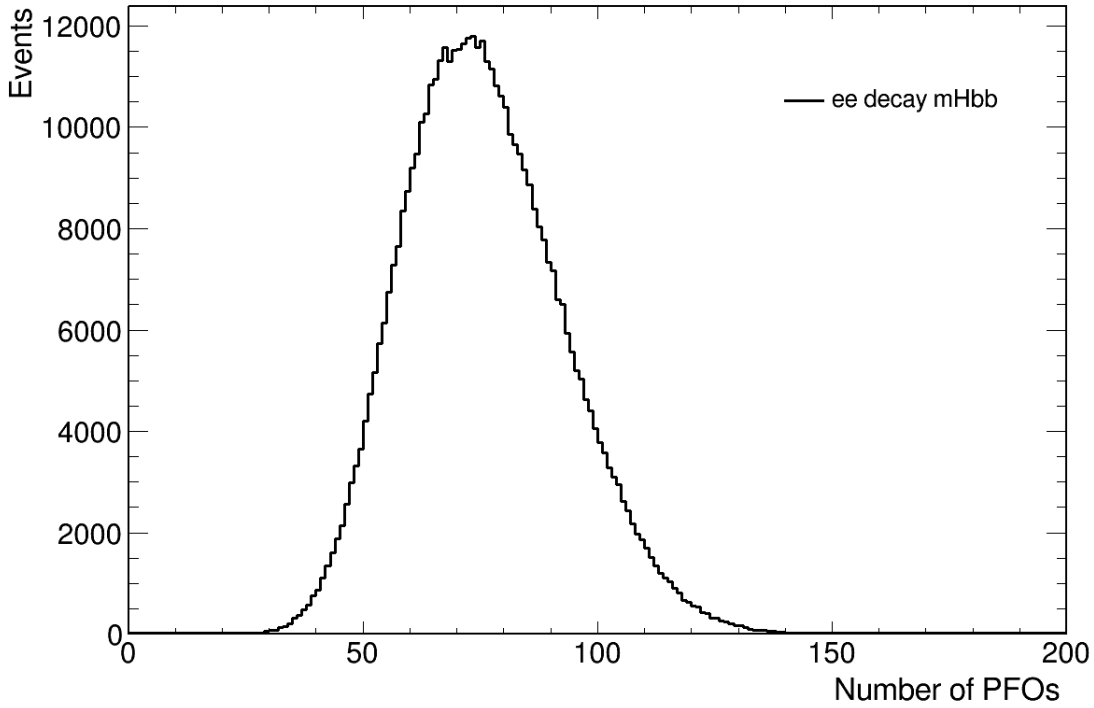
$t_{hit,i}$: the hitting time of the ith component in the jet cluster measured by the muon spectrometer;

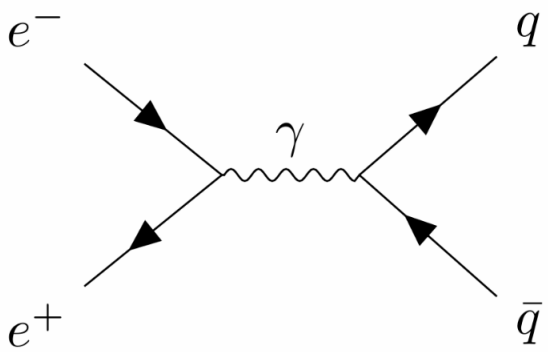
$r_{hit,i}$: the ith Euclidean distance to IP;

c : light speed in vacuum.

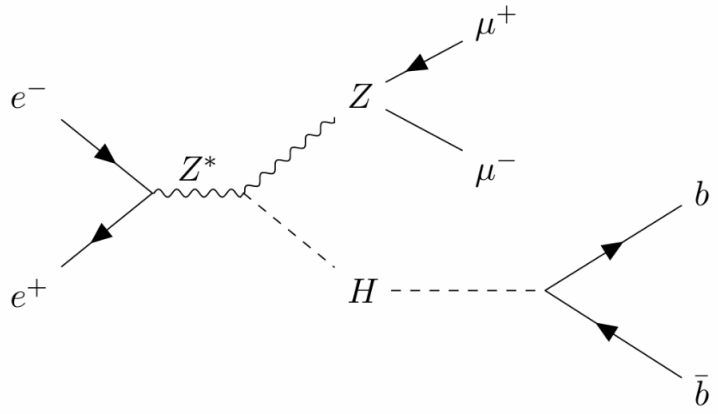
Jet Veto





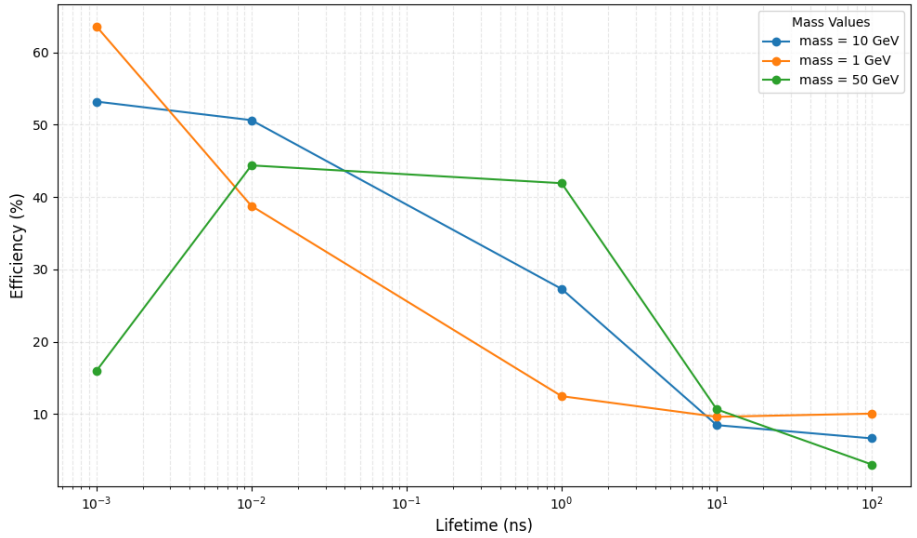


Jet Veto:
nPFO<20



Preliminary Result

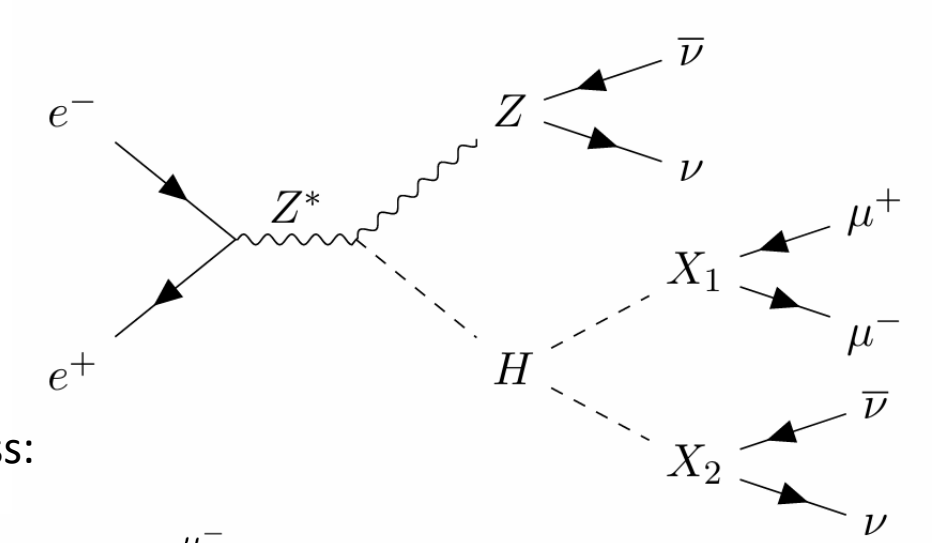
The cutflow for 2-electron channel is shown in below



Mass	ee	4f_szeorsw_l	4f_sze_l0nunu	vvHX	eeHX
LLP 1 GeV	0.02%	1.3%	1.1%	0.06%	0.06%
LLP 10 GeV	0.06%	3%	2%	0.07%	0.15%
LLP 50 GeV	0.08%	4.12%	3.26%	0.13%	0.22%

2-muon channel full simulation analysis

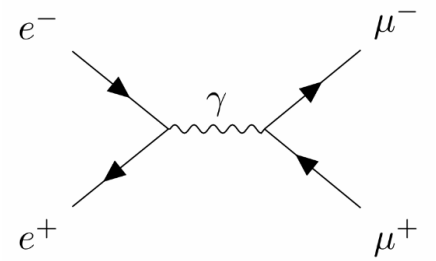
Signal:



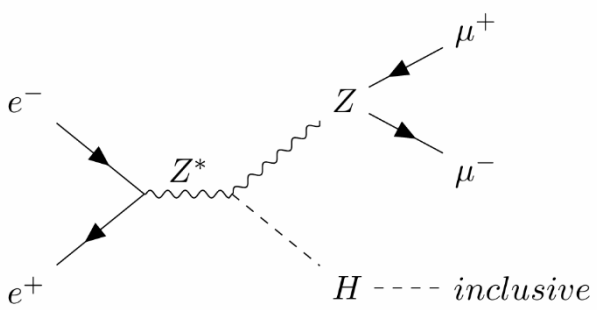
Signal events: 100,000, MX1,2: 1,10,50 GeV

μμ process events: 98,000
vvHX events: 1,000,000
μμHX events: 1,000,000
ee->ZZ->μμ events : 1,250,000
ee->Z->μμ events : 500,000

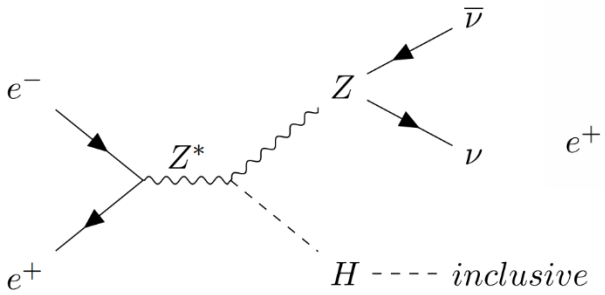
μμ process:



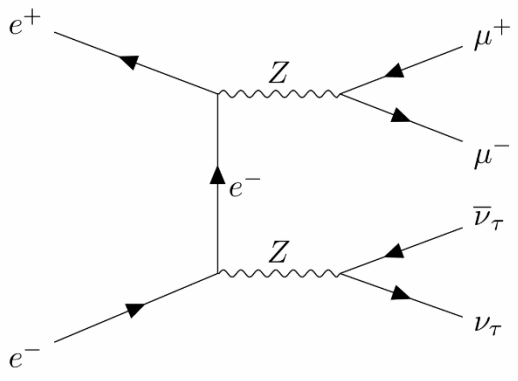
μμHX



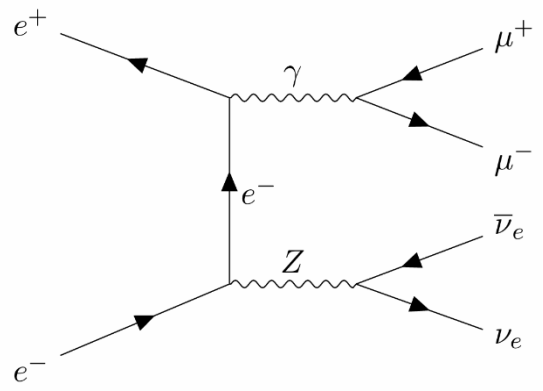
vvHX:



ee->ZZ->μμ process:
Final state: $\nu_\tau\nu_\tau\mu\mu$

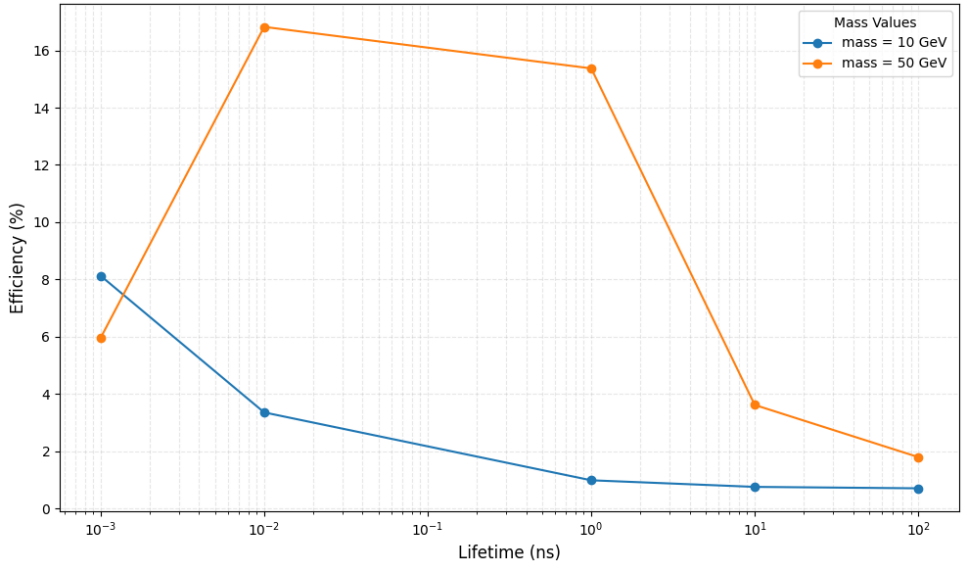


ee->Z->μμ process:
Final state: $\nu_e\nu_e\mu\mu$



Preliminary Result

The cutflow for 2-mu channel is shown in below, lower than electron result, because many muon are predicted as pion



Mass	e2e2	4f_sznu	4f_szz	4f_szzorww	vvHX	mmHX
LLP 10 GeV	0.26%	10.35%	4.72%	0.66%	0.01%	0.01%
LLP 50 GeV	1.08%	4.54%	1.86%	1.27%	0.03%	0.03%

Summary & To-do

- Using XGBoost for PID: good result for background, also good for of axis
- Will update for the muon result today
- Off axis is ready with chengguang's code and it may suppress all the SM background coming from collision point

BACKUP

Preliminary Result

The cutflow for 2-electron channel is shown in below, LLP mass I 1 GeV

Selections	0.01ns	1ns	100ns	e2e2	ee->Z->ee	ee->ZZ->ee	vvHX	eeHX
Total Events	199023	199023	61165	90280	199900	199400	2090	2225
nPFO < 20 (jet veto)	99%	99%	99%	64%	99%	99%	8%	6%
Lepton: e+e-	74%	38%	9%	33%	77%	85%	0.59%	3%

Background events

/cefs/higgs/zhangkl/Production/25036/4fermions

bkd						
2e	E240_e1e1	E240_4f_eeZ	E240_4f_evW	E240_vvHX	E240_eeHX	
events	392	2000	2000	4000	4000	
2mu	E240_e2e2	E240_4f_ee->ZZ->mumu	E240_4f_ee->Z->mumu	E240_vvHX	E240_mmHX	E240_4f_zzorww_l0mumu
events	392	5000	2000	4000	4000	2000
4e	E240_eeHX	E240_vvHX	E240_4f_4e			
events	4000	4000	2000			
4mu	E240_mmHX	E240_vvHX	E240_4f_4mu			
events	4000	4000	2000			

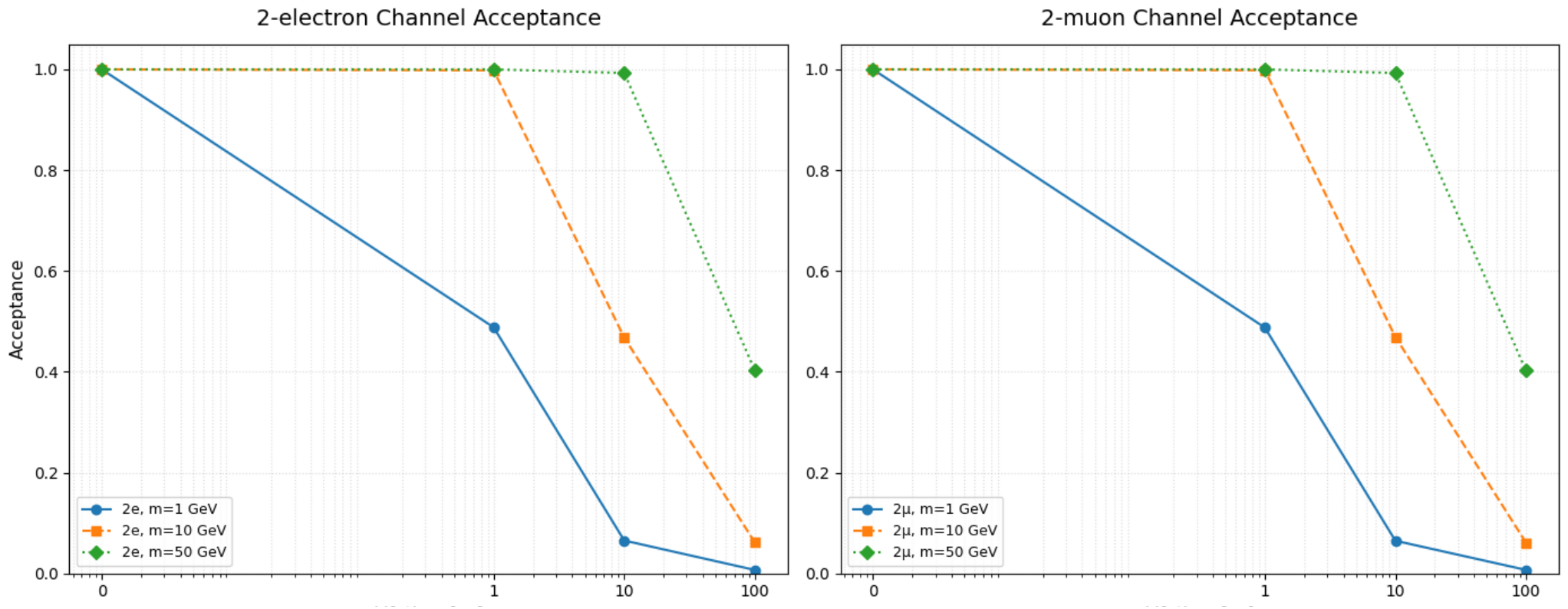
Events = files number * 250(evtmax)

LLP Selection Events

2e	0.001ns	1ns	10ns	100ns
1GeV	100000	48828	6531	686
10GeV	100000	99807	46773	6156
50GeV	100000	100000	99290	40286
2mu	**0.001ns**	**1ns**	**10ns**	**100ns**
1GeV	99997	48777	6486	697
10GeV	100000	99826	46895	6106
50GeV	100000	100000	99287	40213
4e	**0.001ns**	**1ns**	**10ns**	**100ns**
1GeV	100000	48843	6483	703
10GeV	100000	99829	46854	6148
50GeV	100000	100000	99269	40268
4mu	**0.001ns**	**1ns**	**10ns**	**100ns**
1GeV	99997	48750	6482	691
10GeV	100000	99829	46854	6148
50GeV	100000	100000	99269	40268

Signal efficiency = Acceptance × Detection efficiency

Acceptance = LLP events / total events;
Detection efficiency = Selection events / Reconstructed Events



The 6000mm vertex cut reduces acceptance for both long-lived LLPs (large decay lengths) and light-mass LLPs (high momentum)