CEPC Tau Analysis

CEPC Workshop 2019

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CEPC

Content

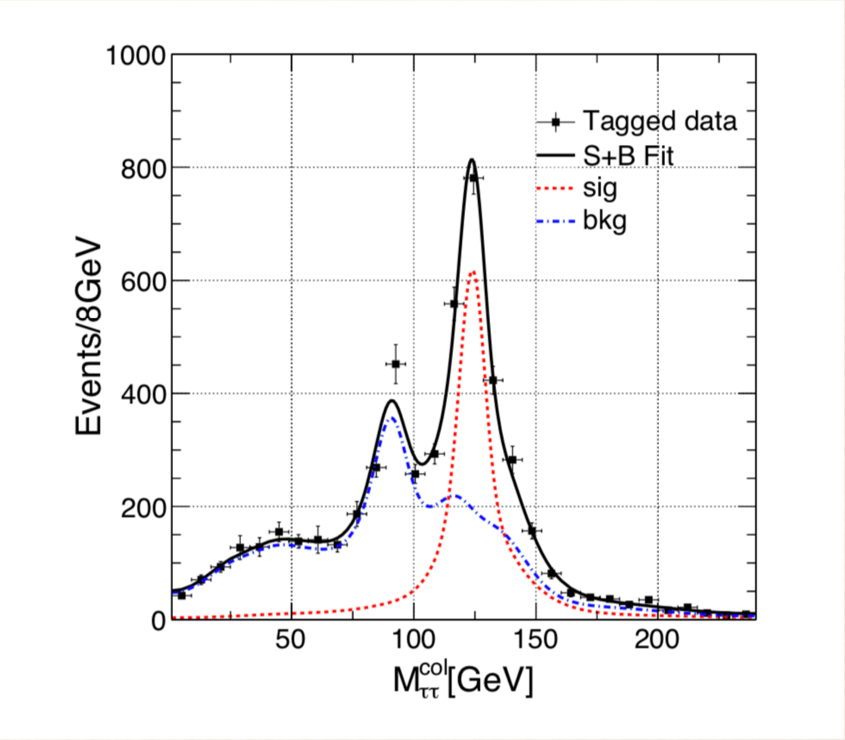
- The CEPC $H \rightarrow \tau\tau$ signal strength analysis
  - Dedicate package
  - Combined accuracy
- CEPC τ decay mode analysis
  - Possible biases
  - Current status

Motivation

- Tau is the heaviest SM lepton - large coupling to Higgs boson Br($H \rightarrow \tau\tau$): 6.27%
- Rich relevant physics
- Performance rely on particle separation
    - Testbed for PFA/Objectives for detector optimization

Signal Strength Analysis (without jets)

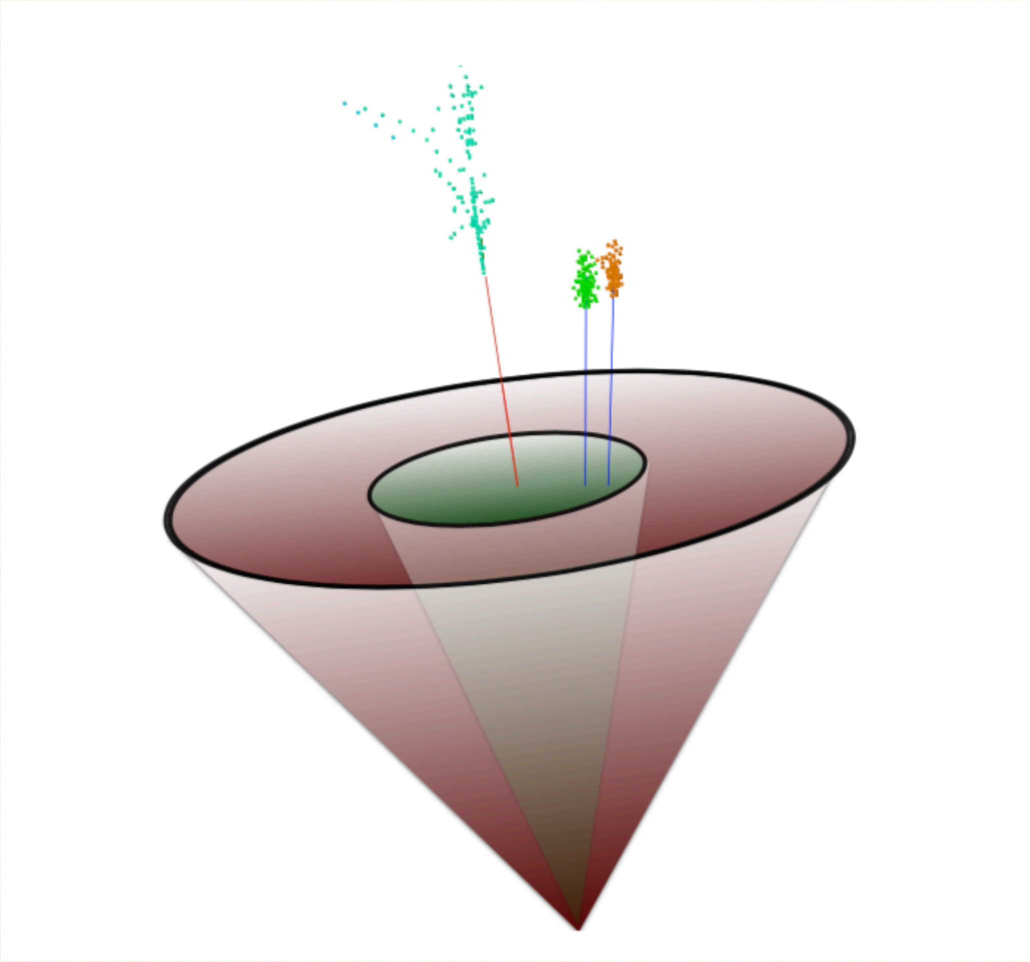
- Veto the two isolate lepton
- Divide the whole space into 2 part
- Use the multiplicity and impact parameter for ττ event selection.
- Fit the collinear mass for signal and background statistics

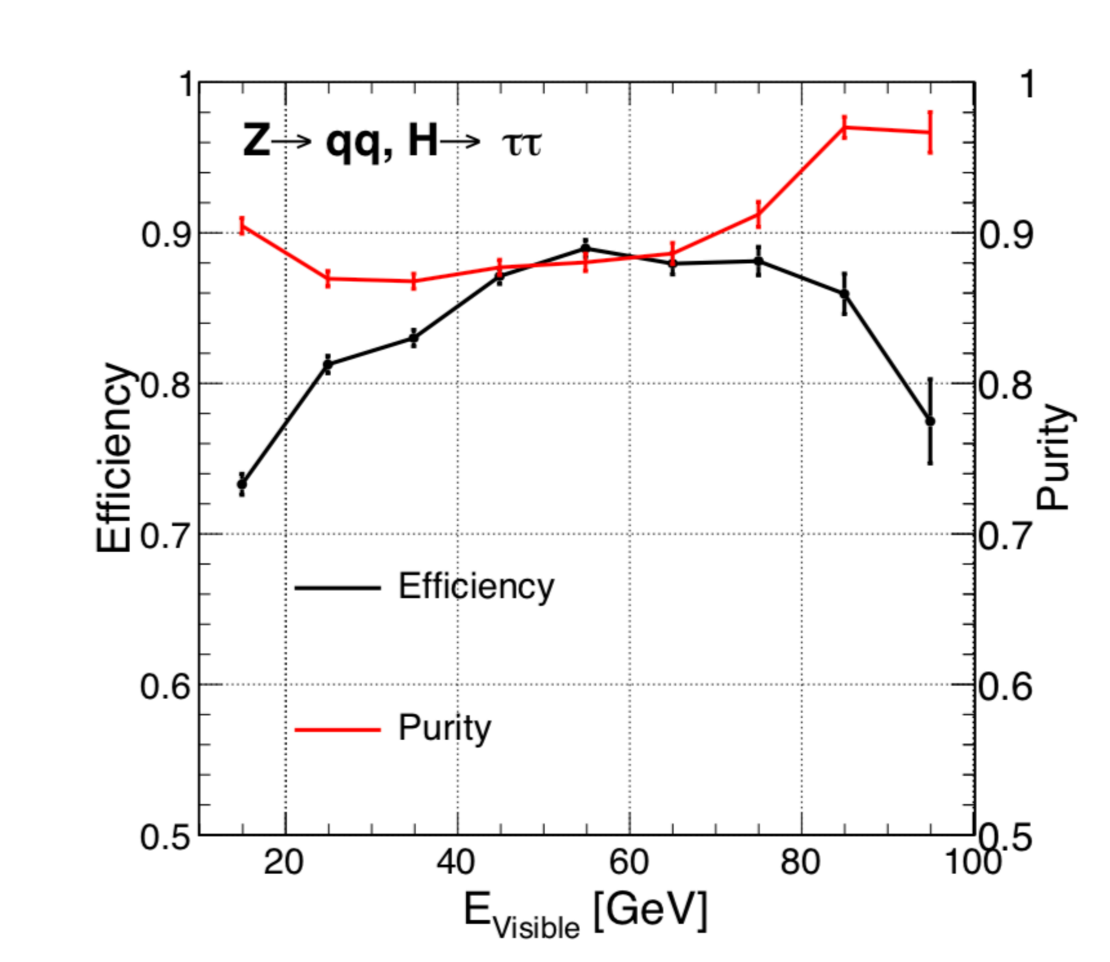


	$\mu\mu H\tau\tau$	$2f$	SW	SZ	WW	ZZ	mixed	ZH	total Bkg	$\sqrt{S+B}/S(\%)$
total generated	2388	801152078	19517399	9072946	50826211	6389424	21839941	1102582	909900581	1263.17
$N_{\mu^+} > 1, N_{\mu^-} > 1$	2341	22894549	37923	720547	1335231	831861	1251657	567636	27639404	233.56
$115GeV < M_{recoil} < 160GeV$	2186	864849	154	155502	396485	112837	164225	3114	1697166	61.75
$60GeV < M_{invariant} < 105GeV$	2118	662042	0	31145	111376	56642	99874	987	962066	48.08
$E_{Le} < 65GeV$	2101	658199	0	17760	111340	56516	99822	957	944594	48.02
$N_{Trk}(A/B) < 6$ & $N_{Ph}(A/B) < 7$	1977	78	0	996	2576	8019	29	105	11803	6.16
BDT>0.78	1891	0	0	264	231	3682	9	39	4225	4.26
$M_{\tau\tau}^{col} > 0$	1853	0	0	259	88	3099	9	35	3490	4.07
$\tau\tau$ collinear mass fit result										2.75

Signal Strength Analysis (with jets)

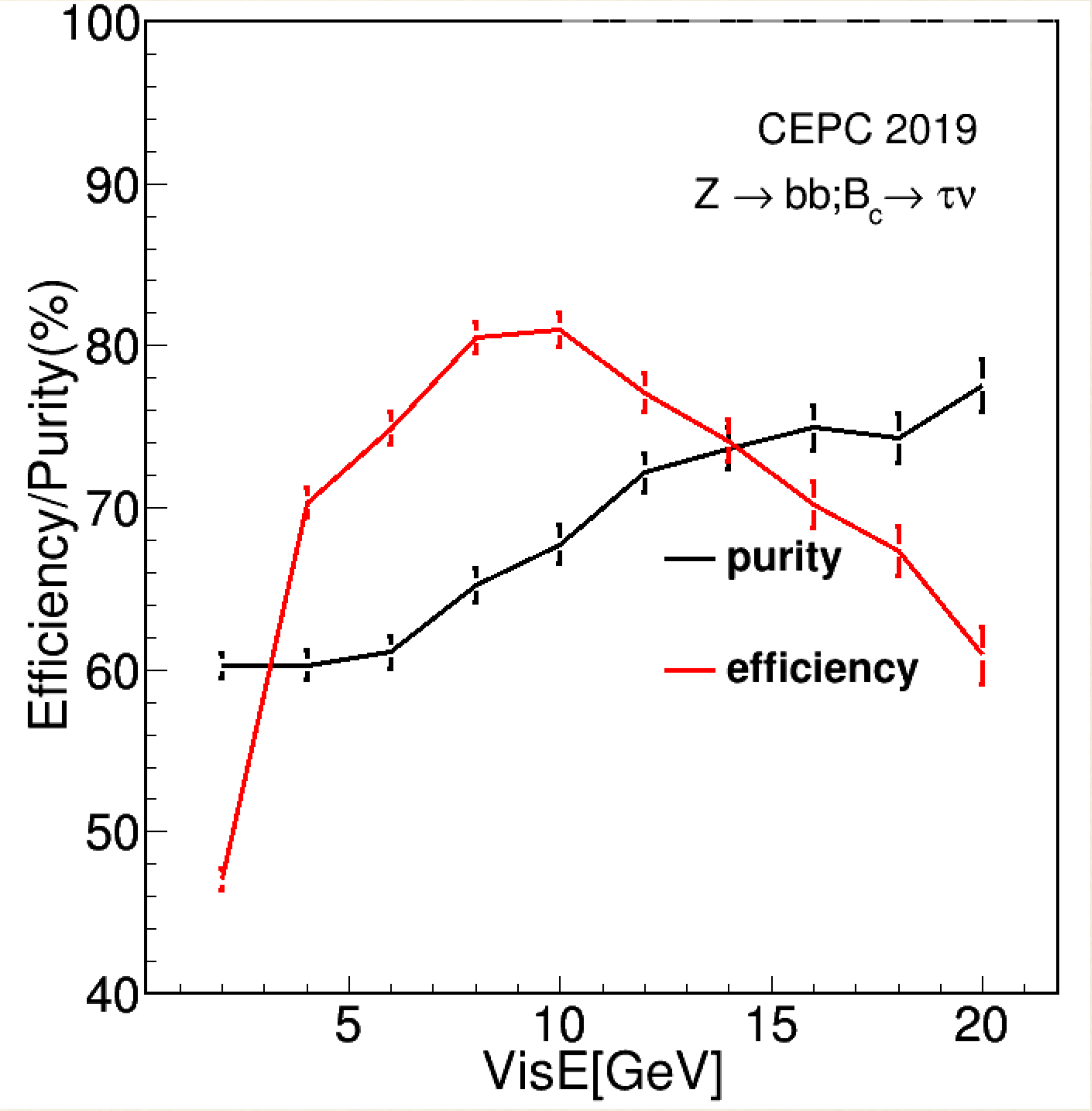
- TAURUS: A dedicate τ reconstruction package based on double cone algorithm
- Leading τ pair as the Higgs products





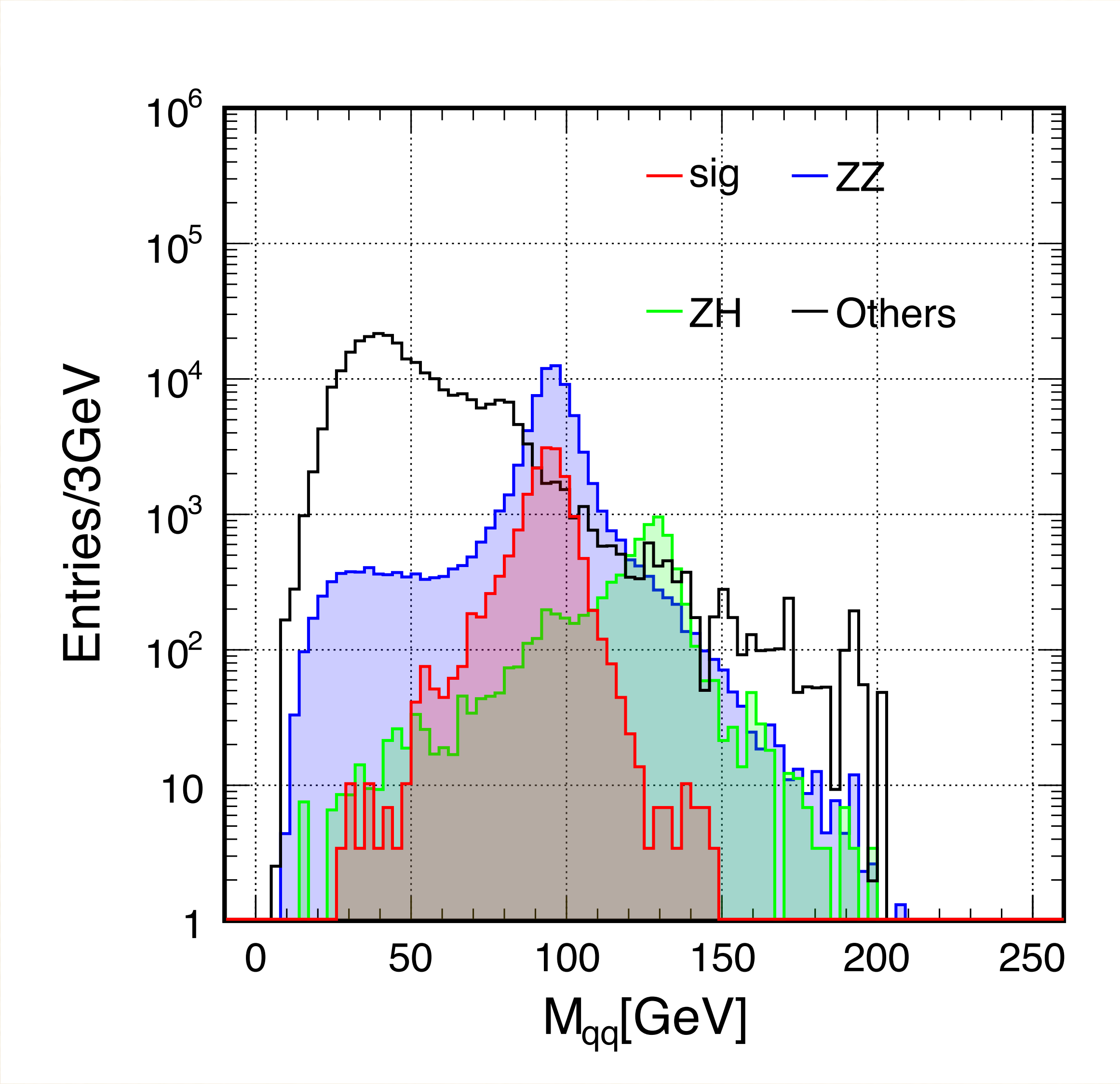
Tau in jets

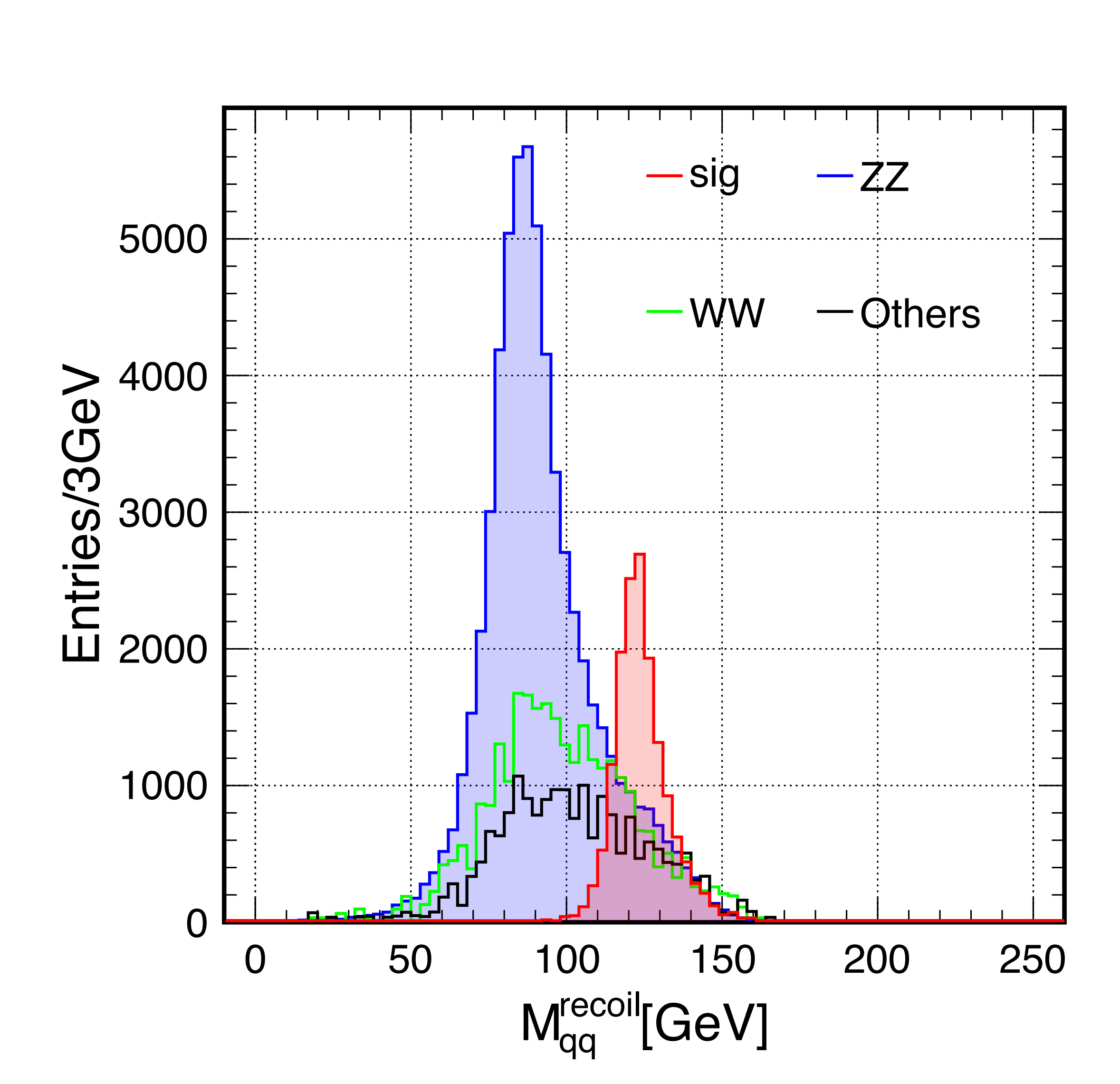
- Sample:
  - Bc→τν
  - Re-optimized with maximized eff*pur



Signal Strength Analysis (with jets)

- Event selection: qq system information





Signal Strength Analysis (with jets)

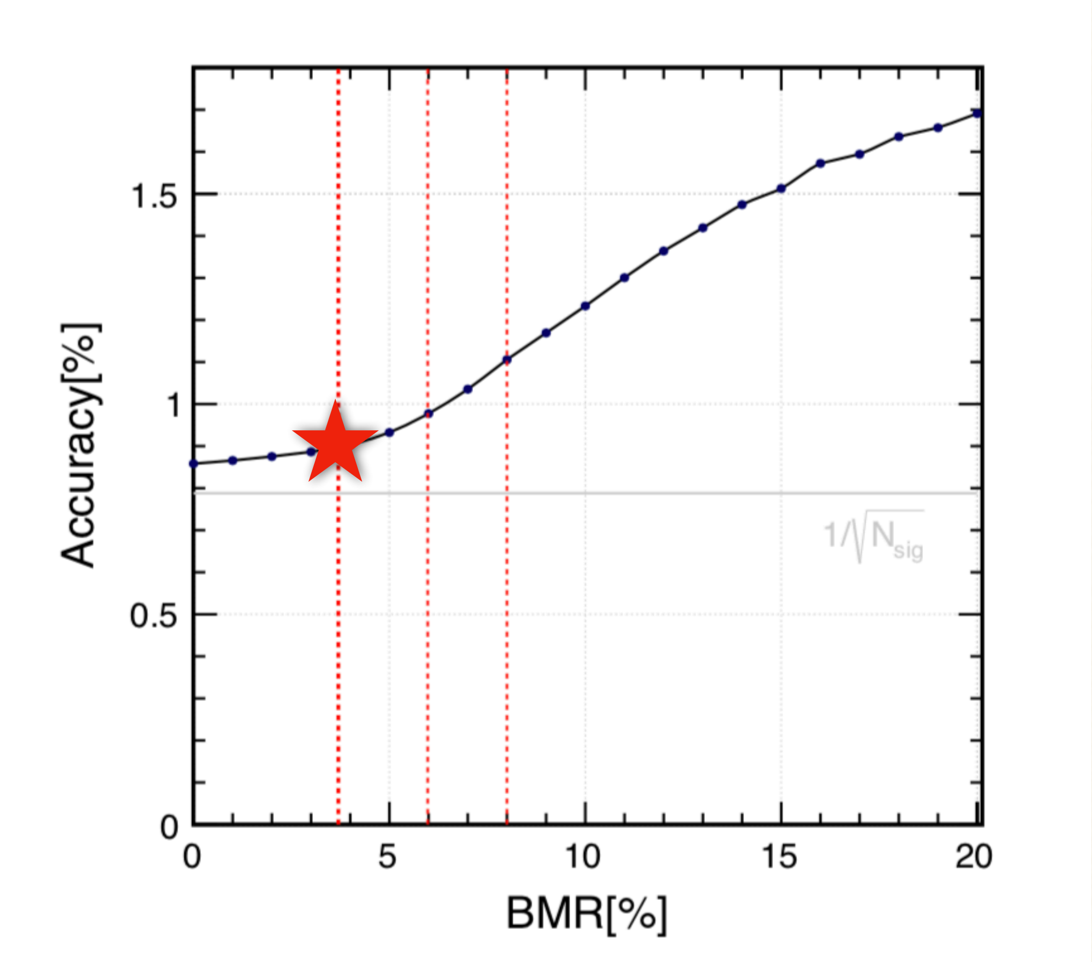
- Event selection: qq system information

	$qqH\tau\tau$	$2f$	SW	SZ	WW	ZZ	mixed	ZH	total Bkg	$\sqrt{S+B}/S$ (%)
Total Statistic	48266	801152078	19517399	9072946	50826211	6389424	21839941	374357	909679268	62.43
NCh>10	47347	272992986	13765307	1969972	47052263	5756249	18020636	331843	359889260	40.07
$110GeV < E_{tot} < 235GeV$	46183	173589861	13159096	942644	31297172	3239464	5154115	264535	227646887	32.67
$E_{Le} < 45GeV, E_{L\mu} < 65GeV$	44093	169589868	3413790	707027	22428227	2911836	4985026	237240	204273014	32.41
$N_{\tau^+} > 0, N_{\tau^-} > 0$	24214	401147	212183	13999	1129502	171380	193055	16821	2138087	6.55
$90GeV < M_{\tau\tau}^{col} < 160GeV$	17176	9717	21483	1689	135538	62721	7722	5305	244175	2.97
$70GeV < M_{qq} < 110GeV$	16257	1596	4119	1012	26823	52307	1818	717	88392	1.98
$M_{qq}^{rec}(GeV) > 100GeV$	16211	0	1463	637	11071	13814	1265	647	28897	1.31
2-D impact parameter fit result										0.93

Results &
BMR Dependency

- Combined Accuracy: 0.8%
- BMR: boson mass resolution, Separate W/Z/H in hadronic decays
- 3.8% for the current Detector+PFA
- qqH signal strength accuracy degrades by 20% if the boson mass resolution degrades from 3.8% to 8%.

	$\delta(\sigma \times BR)/(\sigma \times BR)$
$\mu\mu H$	2.8%
eeH	5.1%
$\nu\nu H$	7.9%
qqH	0.9%
combined	0.8%

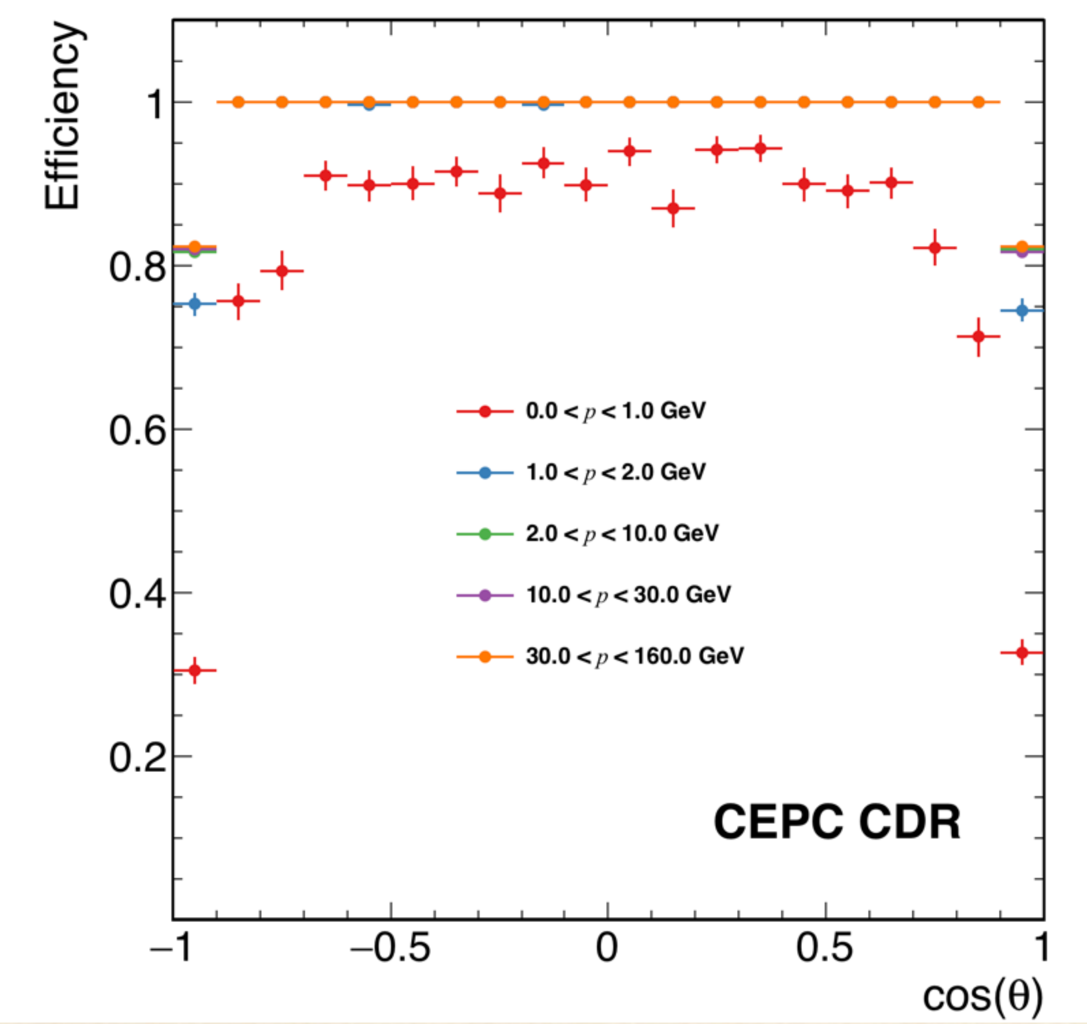


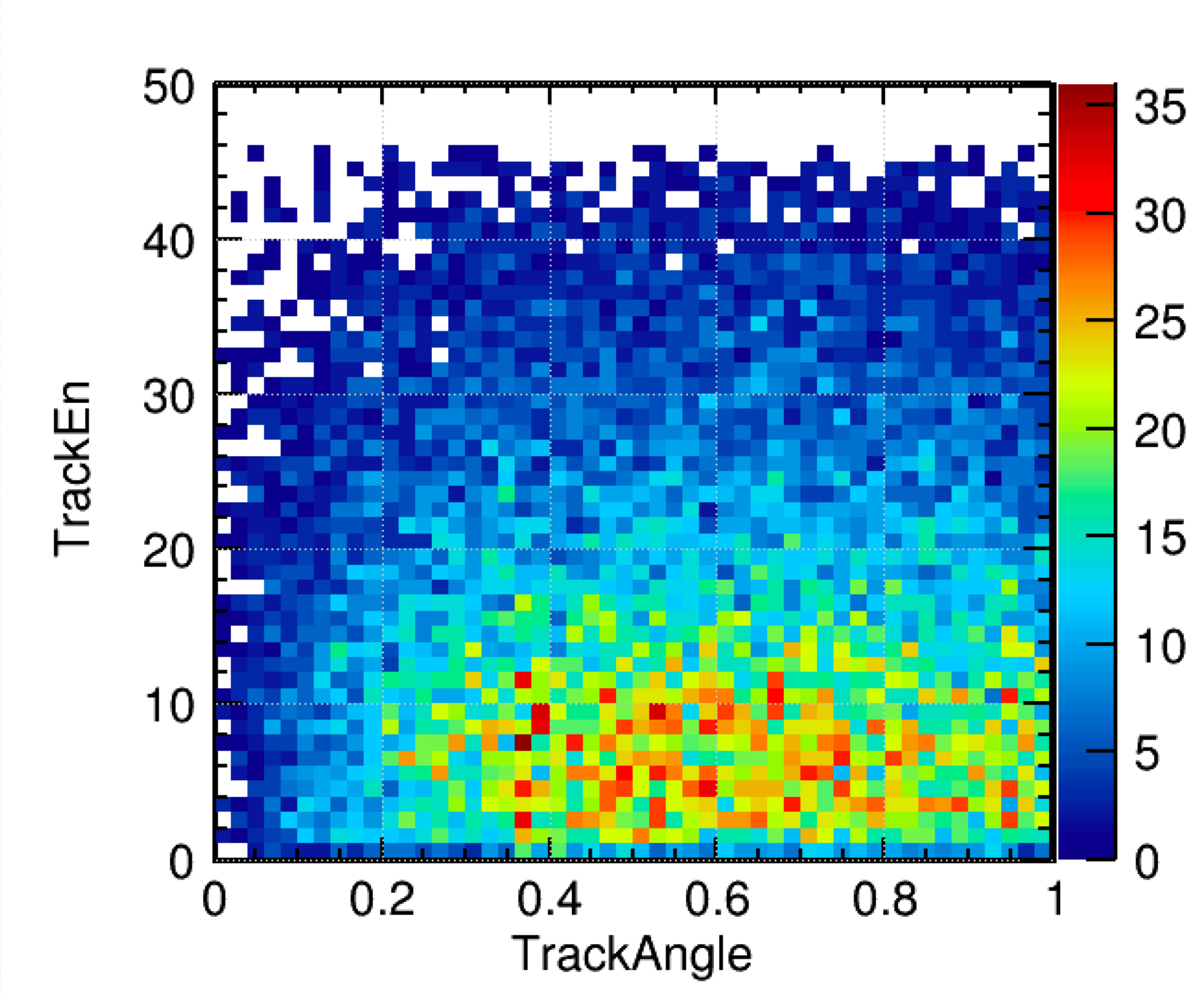
Next

- Taurus in other ZH channels
  - $\tau\tau H$ accuracy: 14% (low statistics)
- Tau in jets
- Measurement of polarization, CPV
  - Decay modes identification
    - event selection, non-τ background
    - photon detection efficiency, bremsstrahlung and radiative photons
    - charged particle identification, tracking of charged particles, converted photons, photon identification, fake photons, $\pi 0$ reconstruction

Tracking of Charged Particles

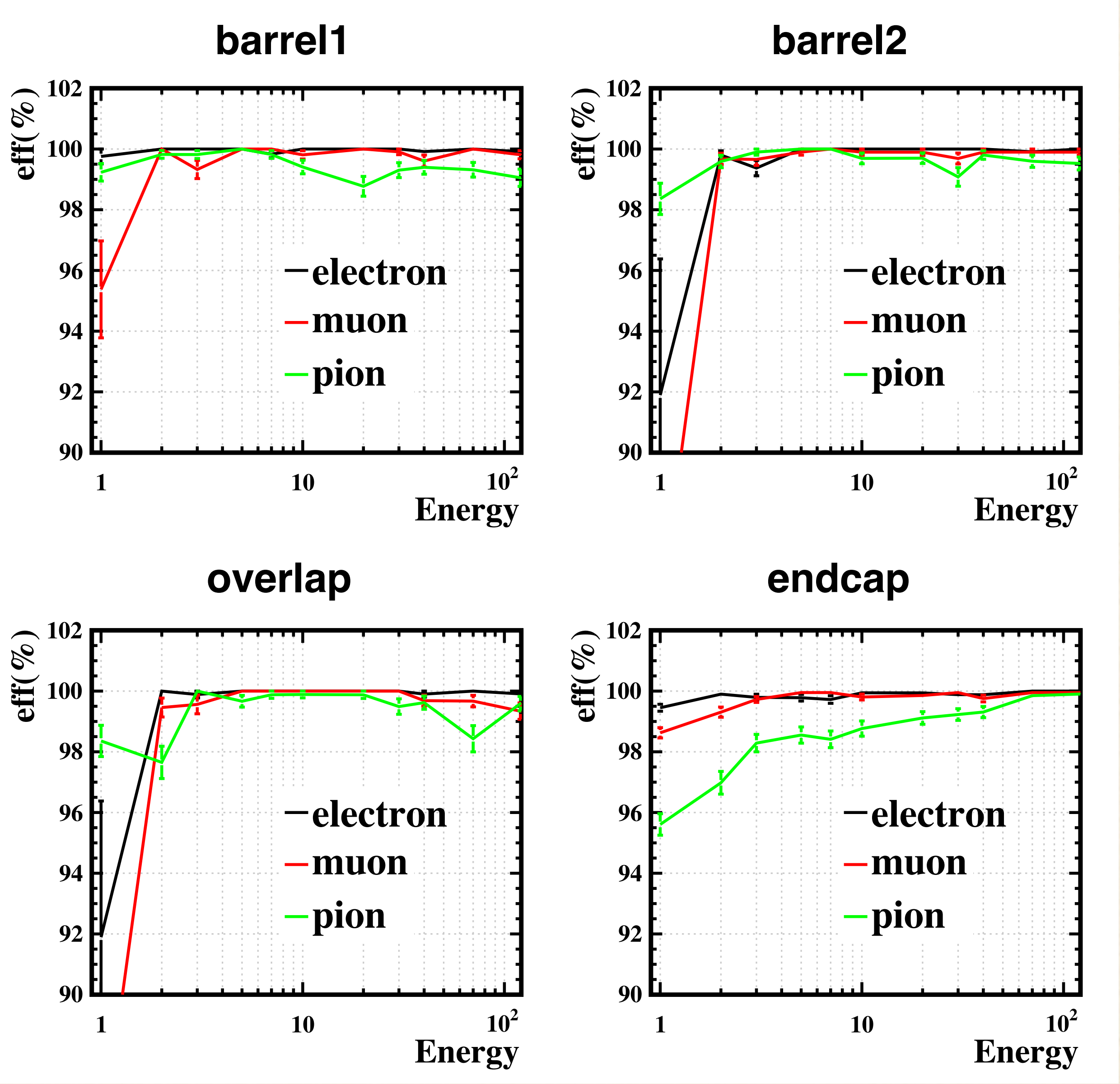
- Tracking efficiency in CDR
- Energy vs Angle of tracks decayed from Z pole to τ events
- Generally 97% for Z pole to τ events





Particle Identification

- LICH: lepton identification package
- Tracks in τ are isolated
- Performance comparable to single particle
- >97% for En>2GeV



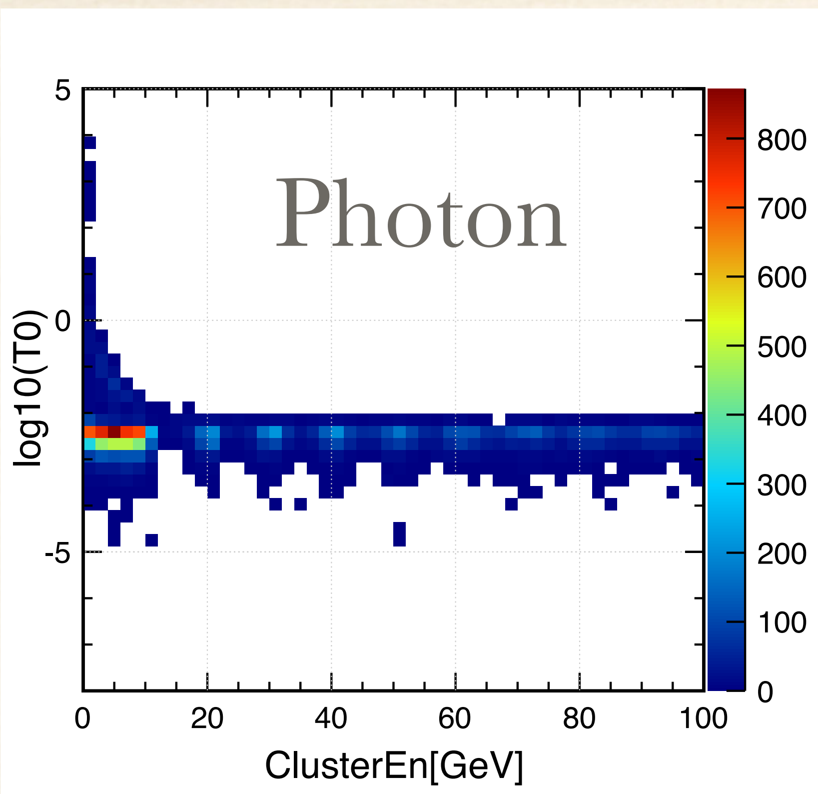
Photon Identification

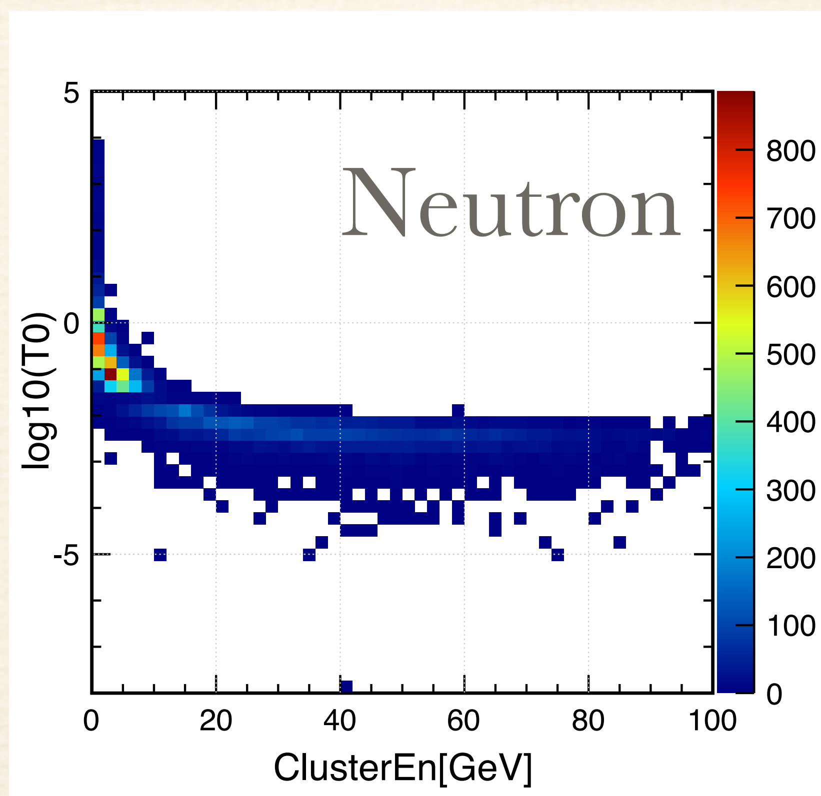
- efficiency vs mis-id rate
- No neutron mis-id
- Probability for tracks to have no fragments:
  - e:90.26%
  - μ:88.66%
  - π: 65.11%

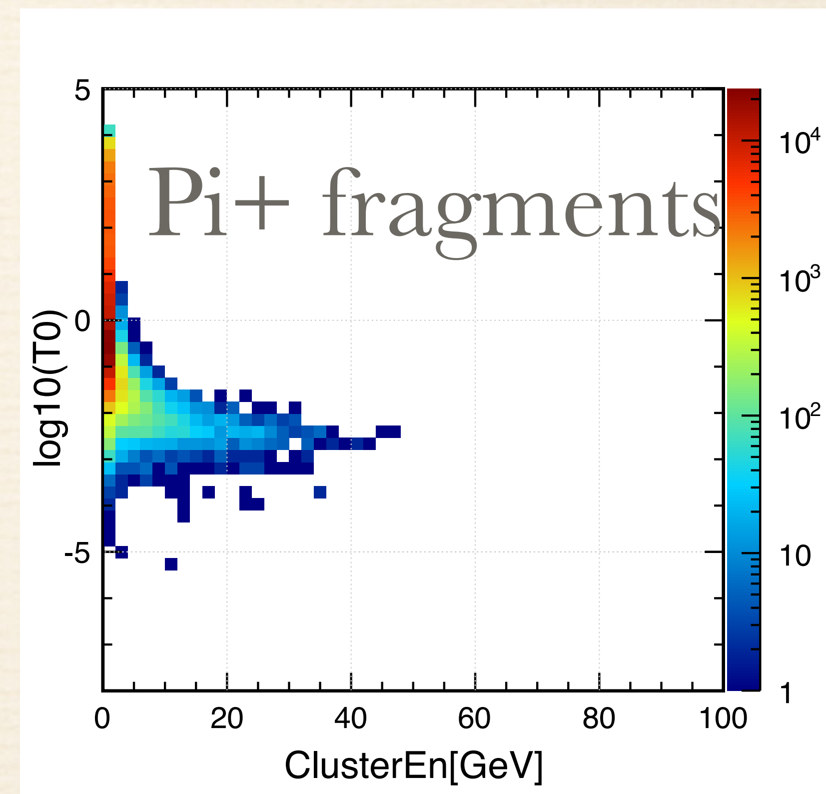
	<1GeV	1-5GeV	>5GeV
Photon	99.37	99.34	99.85
EM Fragments	39.53	45.08	33.44
Hadron Fragments	0	0.04	3.71
Neutron	0	0.02	4.7

Fake Photons

- Fluctuations of a shower can generate "fake photons" which are artefacts of the clustering algorithm or true photons produced by secondary interactions in the ECAL.
- Time (Truth)
- Distance to the closest charged track

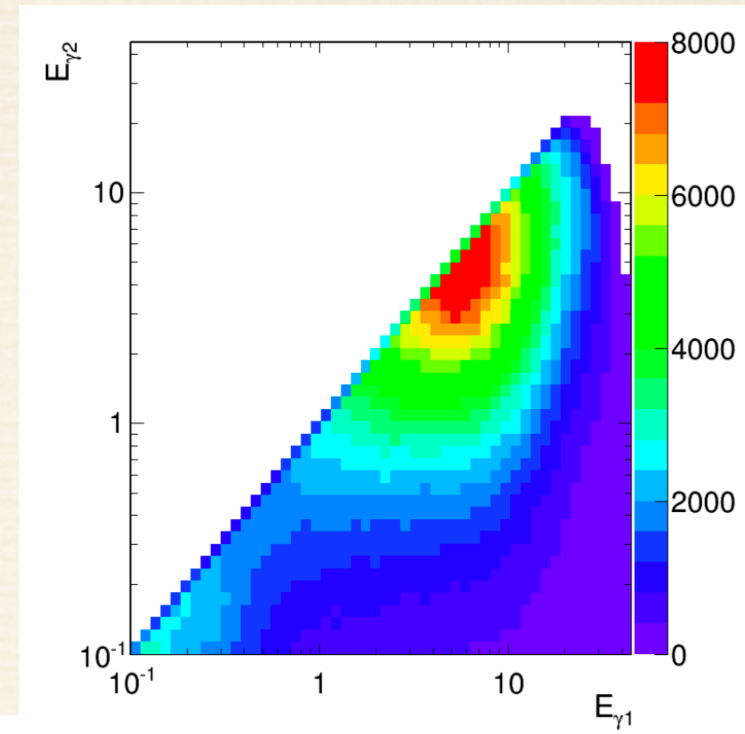


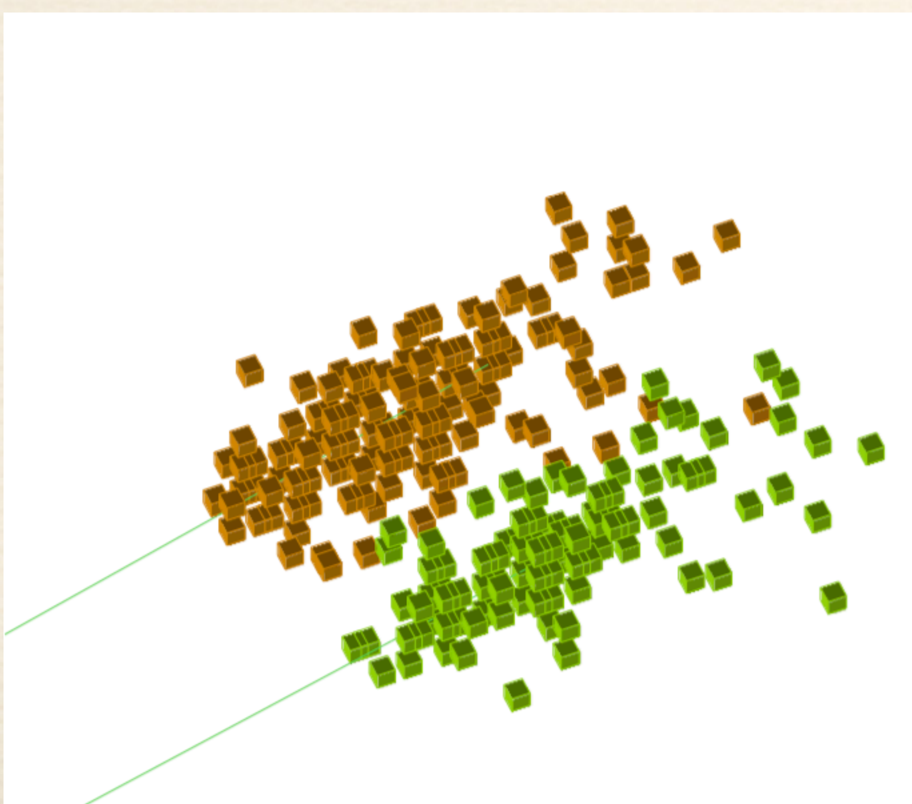


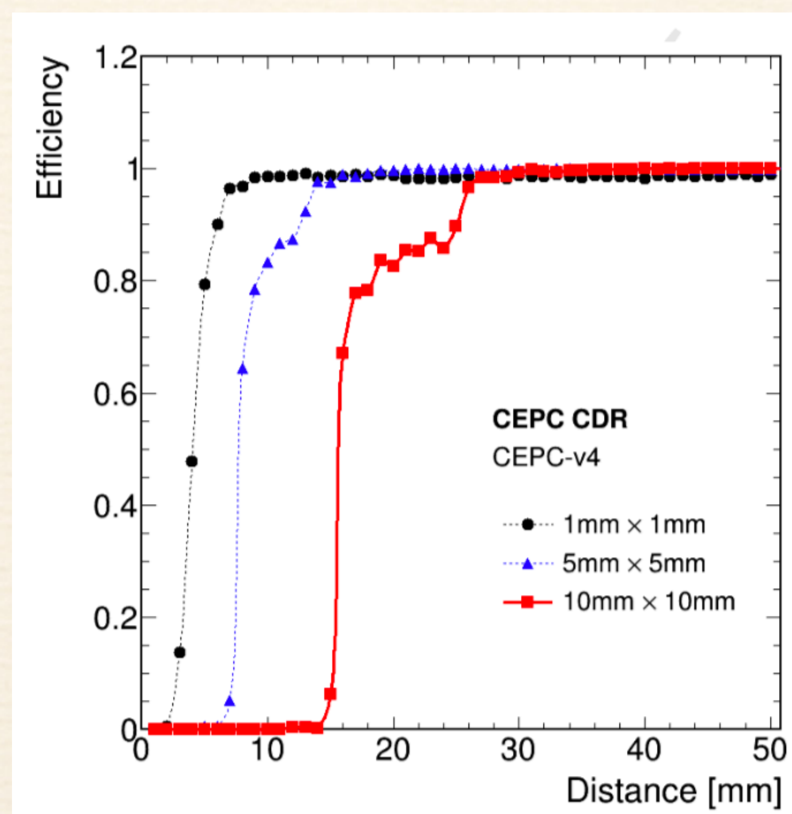


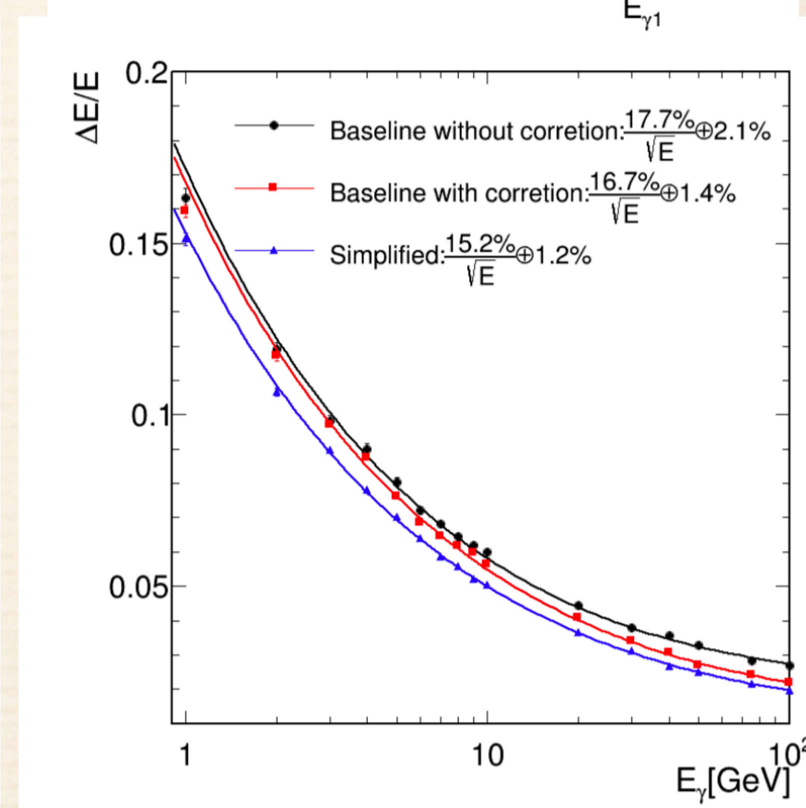
π0 reconstruction

- No dedicate π0 reconstruction yet — Efficiency of well separating photon pair
- photon distance (>15mm)
  - photons well separated ~ 90%
- photon energy resolution
- Pairing: can take care of not detected photons, FSR, ISR…



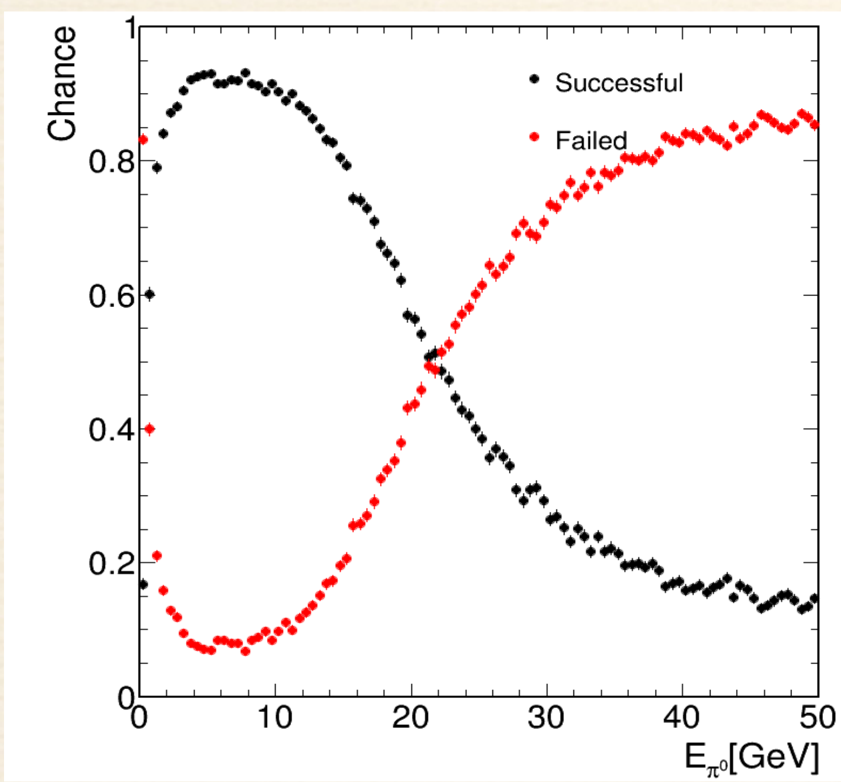


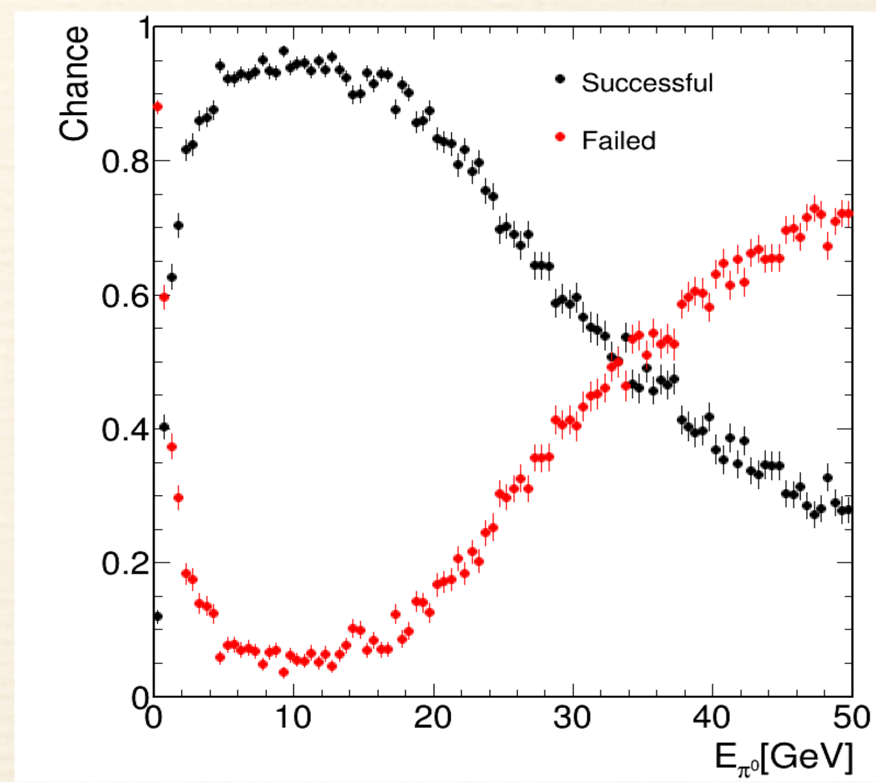




π0 reconstruction

The chance of the successfully reconstructed π^0 is defined as the probability of successfully reconstructed two photons at least and with the leading invariant mass between (0.135-5σ, 0.135+5σ) MeV.





by Yuqiao Shen

Estimate Efficiency

- Detector&Physics dependency not included
  - no FSR/ISR events
  - Photons energy > 0.2GeV events

	1-prong(l)	1-prong(h)	1prong + 2photon	1prong + 4photon	3prong	3prong + 2photon
Reco Dependency Estimate	95%	94%	63%	42%	90%	59%

Current Migration Matrix

	No Trk	1-prong(l)	1-prong(h)	1prong + 1photon	1prong + 2photon	1prong + 3photon	1prong + 4photon	1prong + 5photon	3prong	3prong+ 2photon	other
1-prong(l)	3.58	88.42	3.17	2.58	0.04	0	0	0	0.35	0	Ntrk>1
1-prong(h)	5.90	5.76	78.17	4.49	0.82	0.20	0.06	0	1.16	0	Ntrk>1
1prong + 2photon	2.47	1.31	0.88	29.01	58.34	3.27	0.21	0.01	0.03	1.59	Ntrk>1
1prong + 4photon	1.93	1.23	0.17	1.78	9.75	31.07	45.01	3.24	0	0.19	Ntrk>1
3prong	1.34	1.93	0.34	0.15	0.05	0	0	0	88.44	0.24	Ntrk=2
3prong + 2photon	1.12	1.68	0.14	0.10	0.33	0.10	0.02	0.01	1.08	63.94	Nph=1

Summary

- $H \to \tau\tau$ signal strength accuracy 0.8%
- Dependance on BMR studied
- τ decay mode study on going
  - Reconstruction tools
    - photon reconstruction, fragments absorption, $\pi 0$ reconstruction
  - Polarization, CPV, …

Thank you!