CEPC Tau Analysis

2019/07/02 CEPC Physics Workshop

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Content

- The CEPC H→ττ 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 → ττ): 6.27%

- Rich relevant physics

- Performance rely on particle separation

  - Testbed for PFA/Objectives for detector optimization
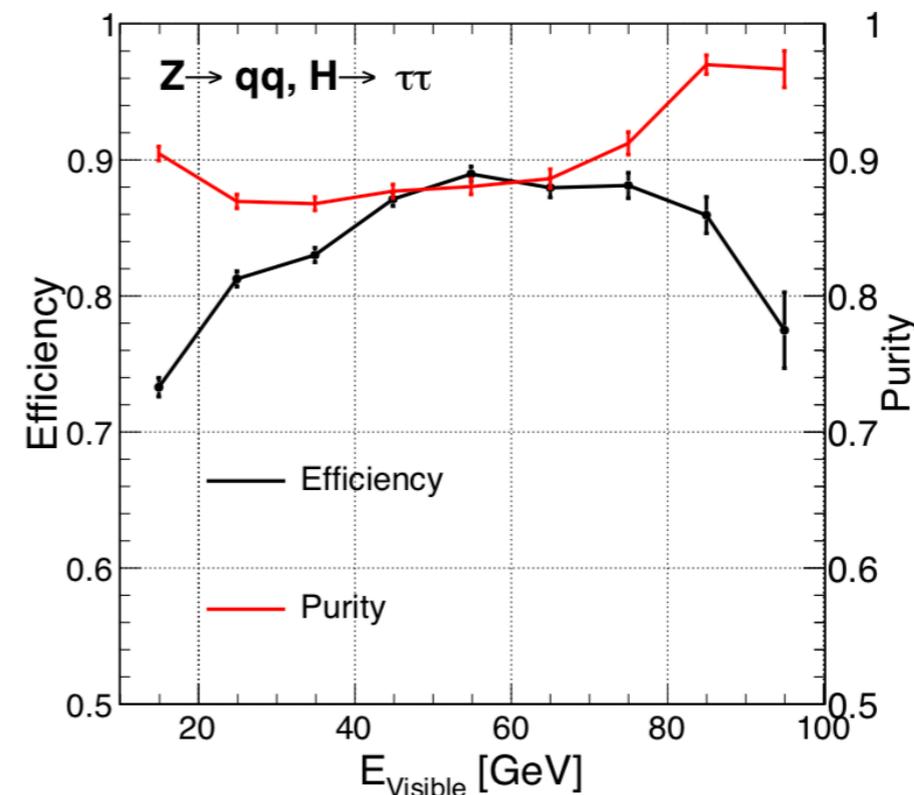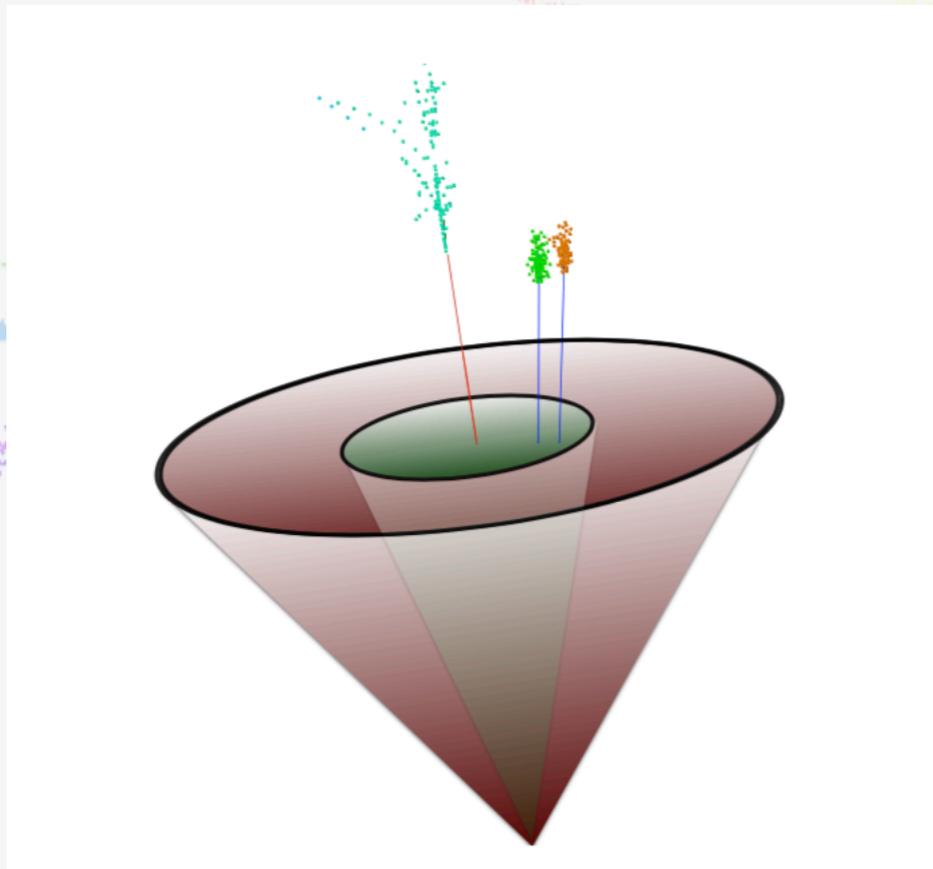
Signal Strength Analysis (without jets)

- 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
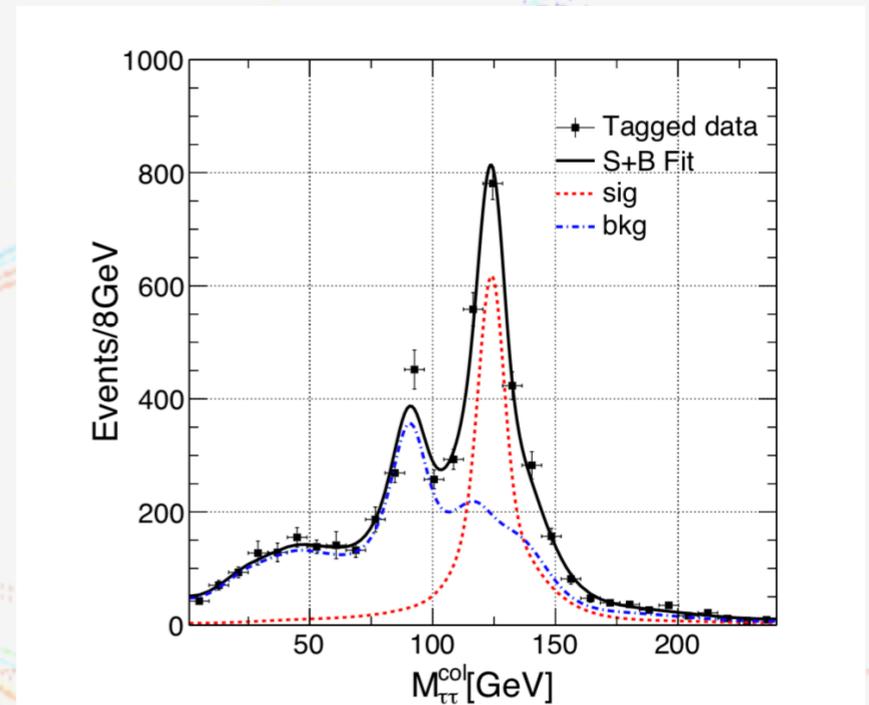
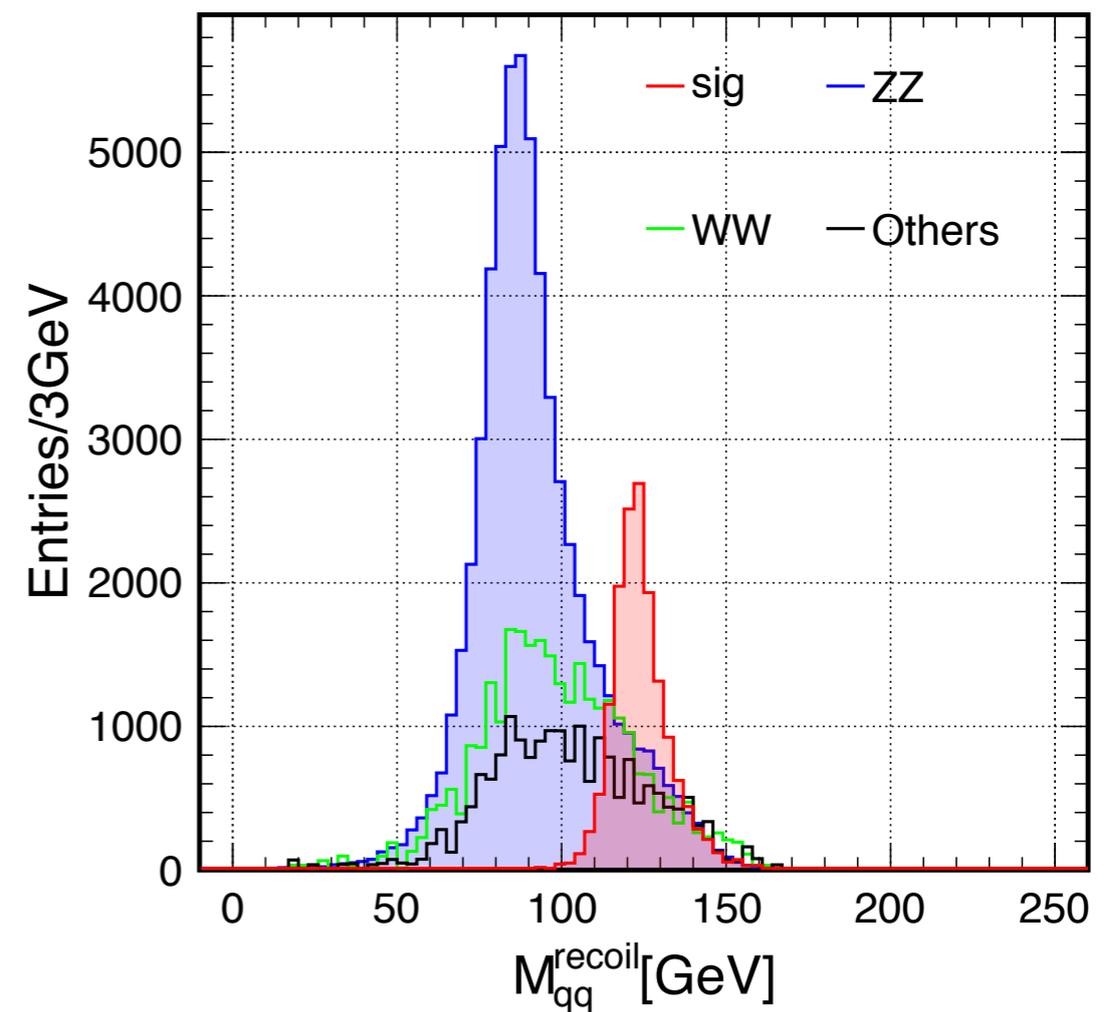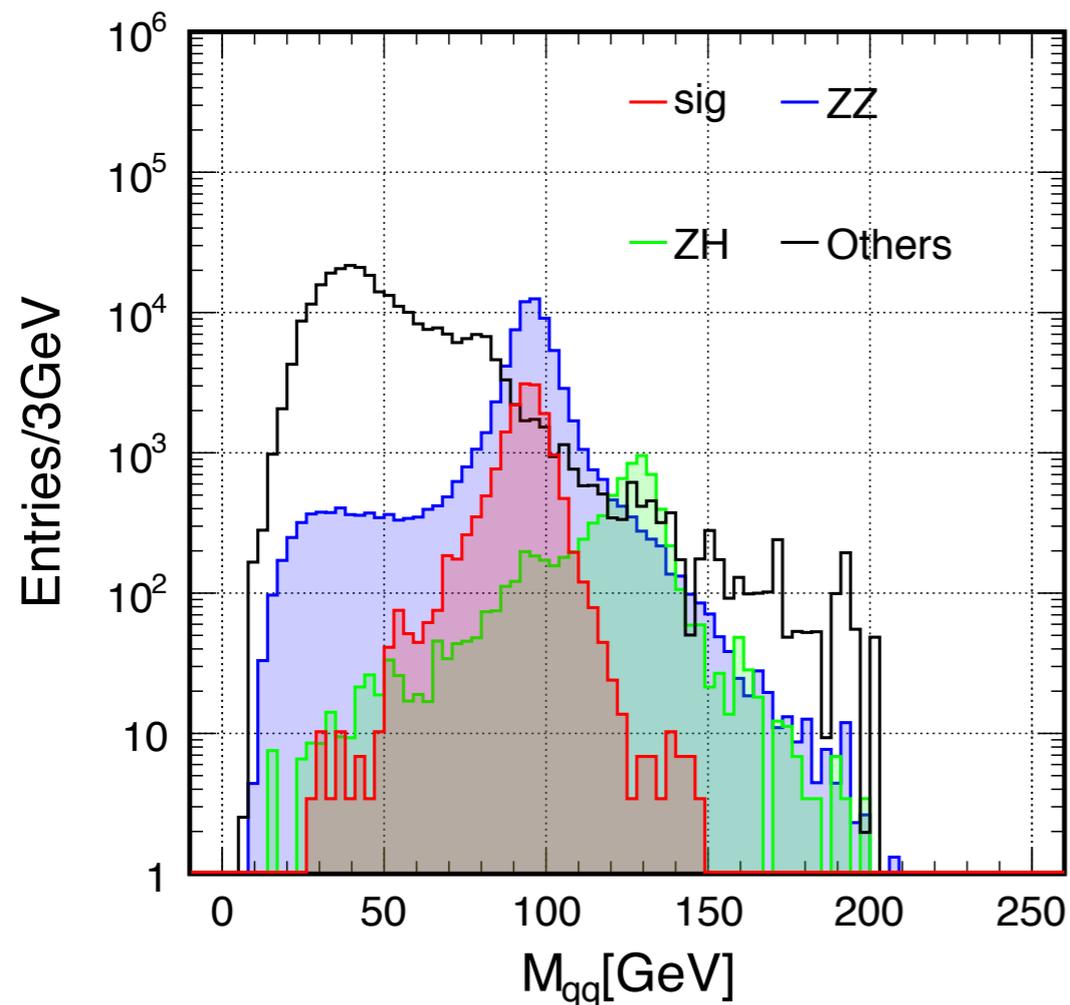|	$\mu\mu H\tau\tau$	2f	SW	SZ	WW	ZZ	mixed	ZH	total Bkg	$\sqrt{S+B}/S(\%)$
total generated	2388	801152078	19517399	9072946	50826211	6389424	21839941	1102582	909900581	1263.17
$N_{\mu+} > 1, N_{\mu-} > 1$	2341	22894549	37923	720547	1335231	831861	1251657	567636	27639404	233.56
$115GeV < M_{recoil} < 160GeV$	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
ττ 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

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%
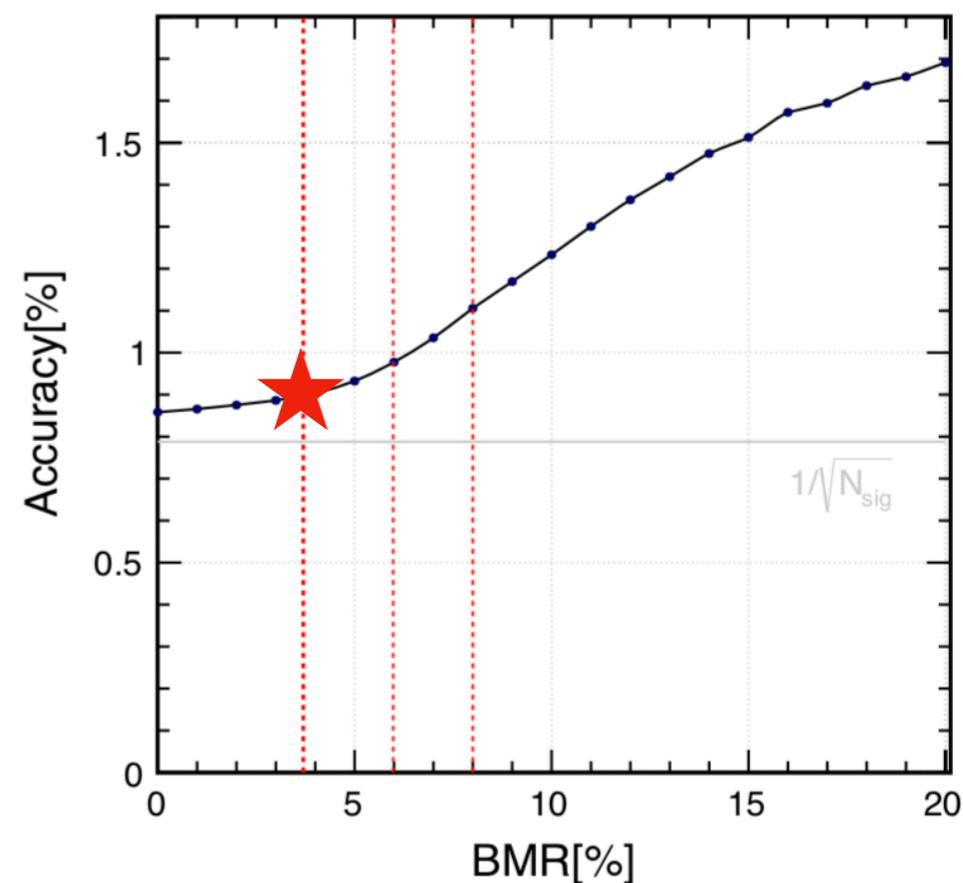
Next

- Taurus in other ZH channels

- 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, π0 reconstruction
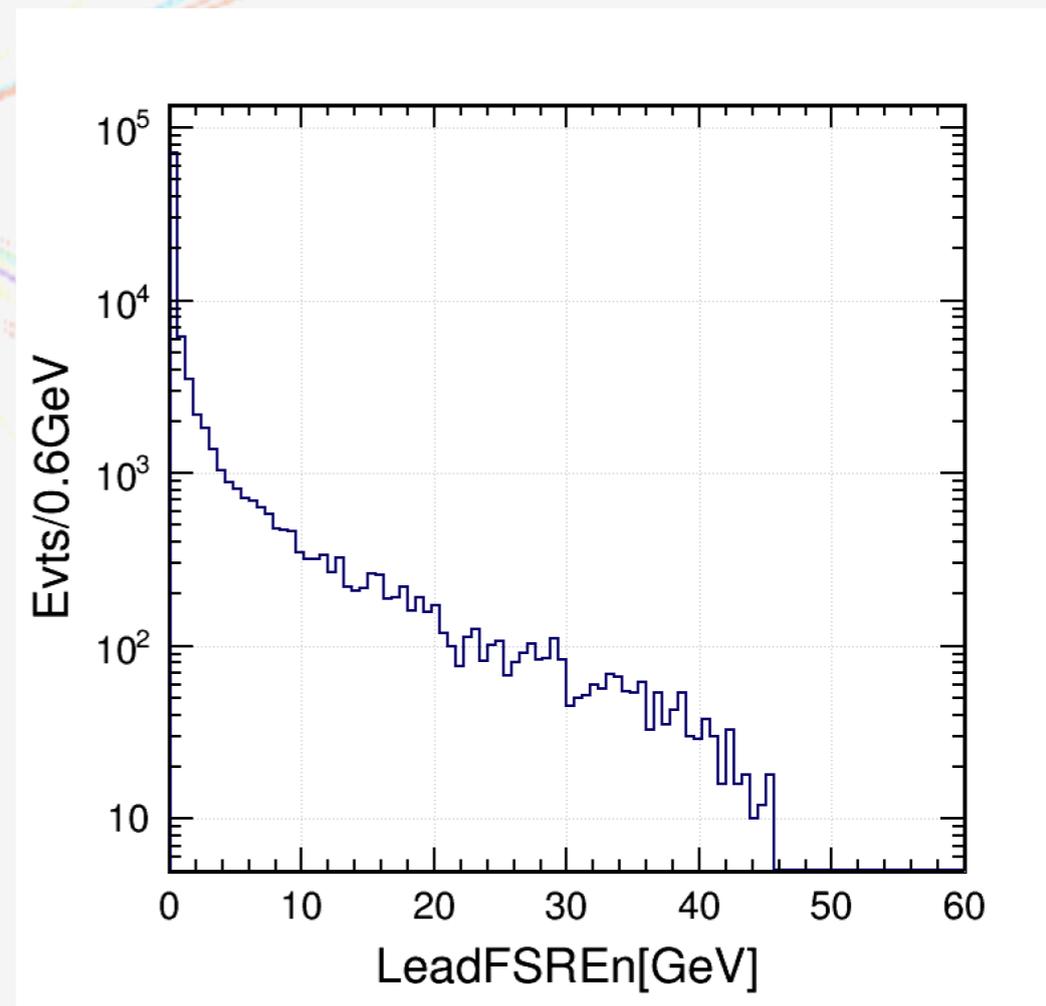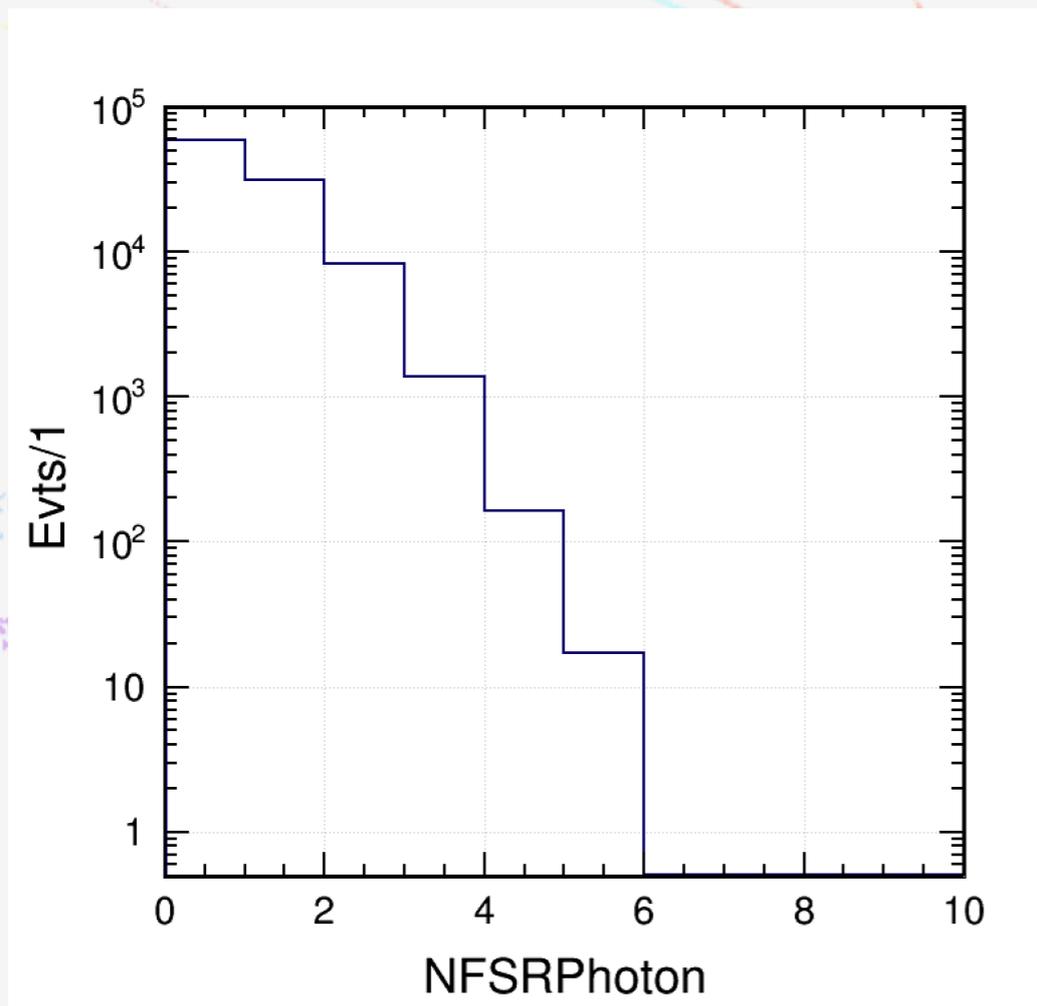
Detector & Physics Dependency

photon detection efficiency

- Detector acceptance

  - Sample: photons from zpole→ττ decayed π0

  - Angle distribution: <0.98

  - Energy distribution: >0.2GeV

  - efficiency of photon pair: 90%
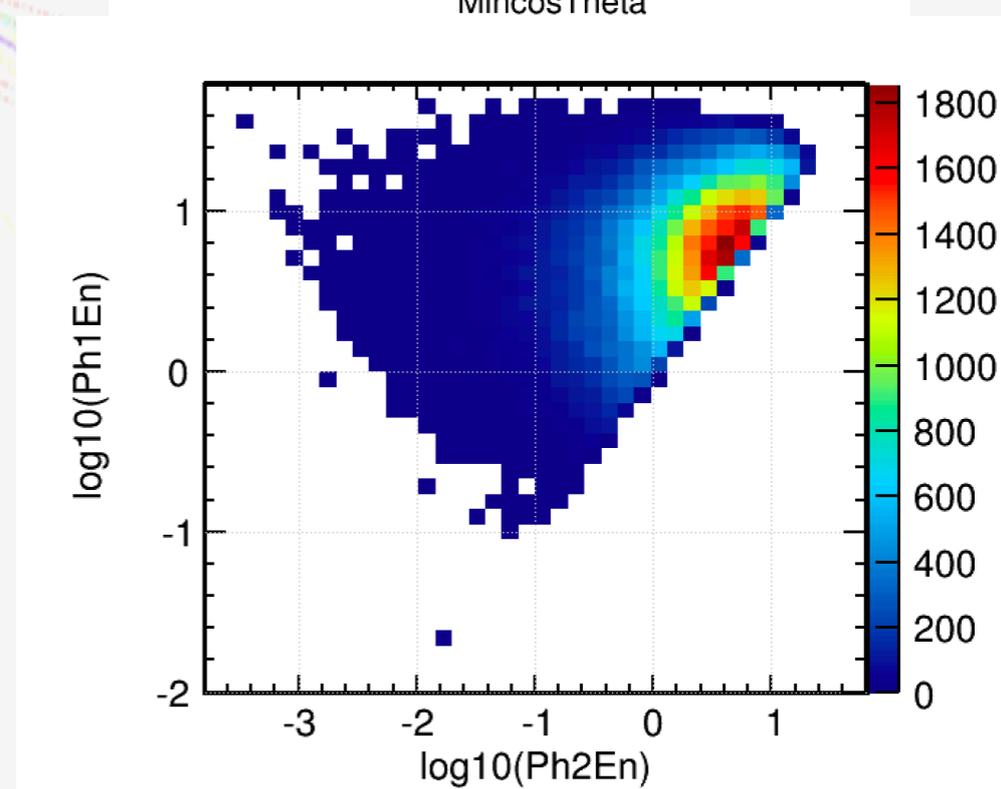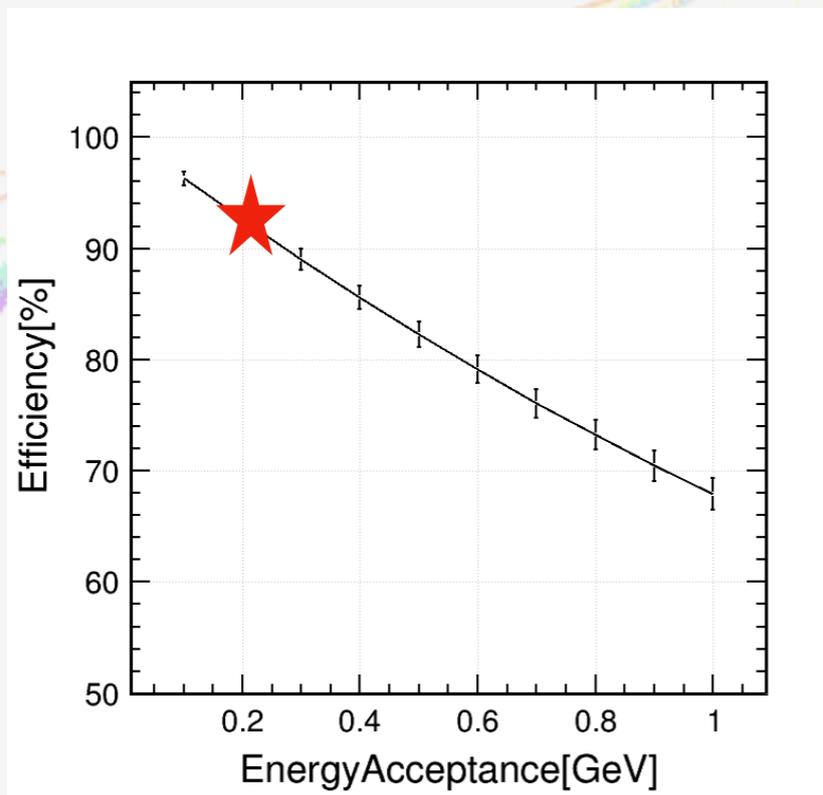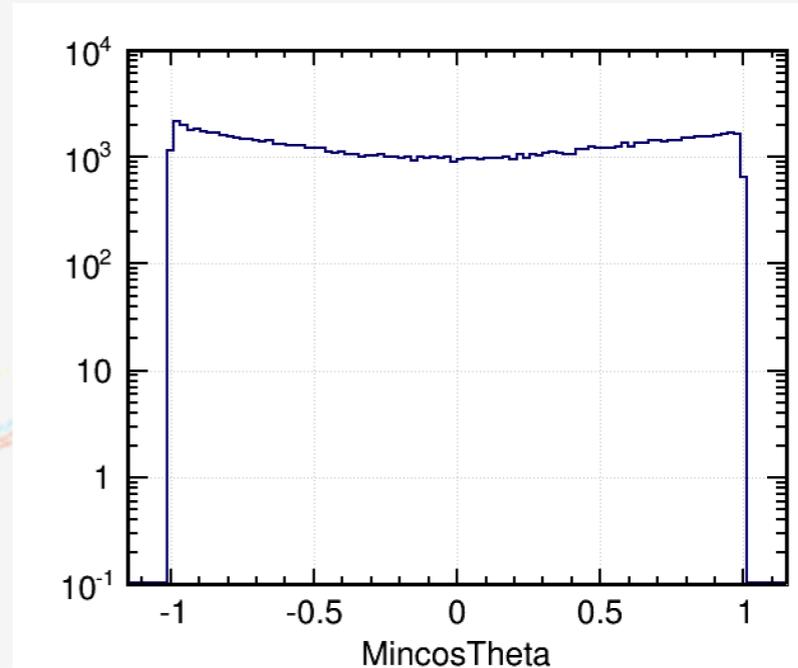
Radiative Photons

- zpole→ττ

- FSR rate (MCTruth Distribution)
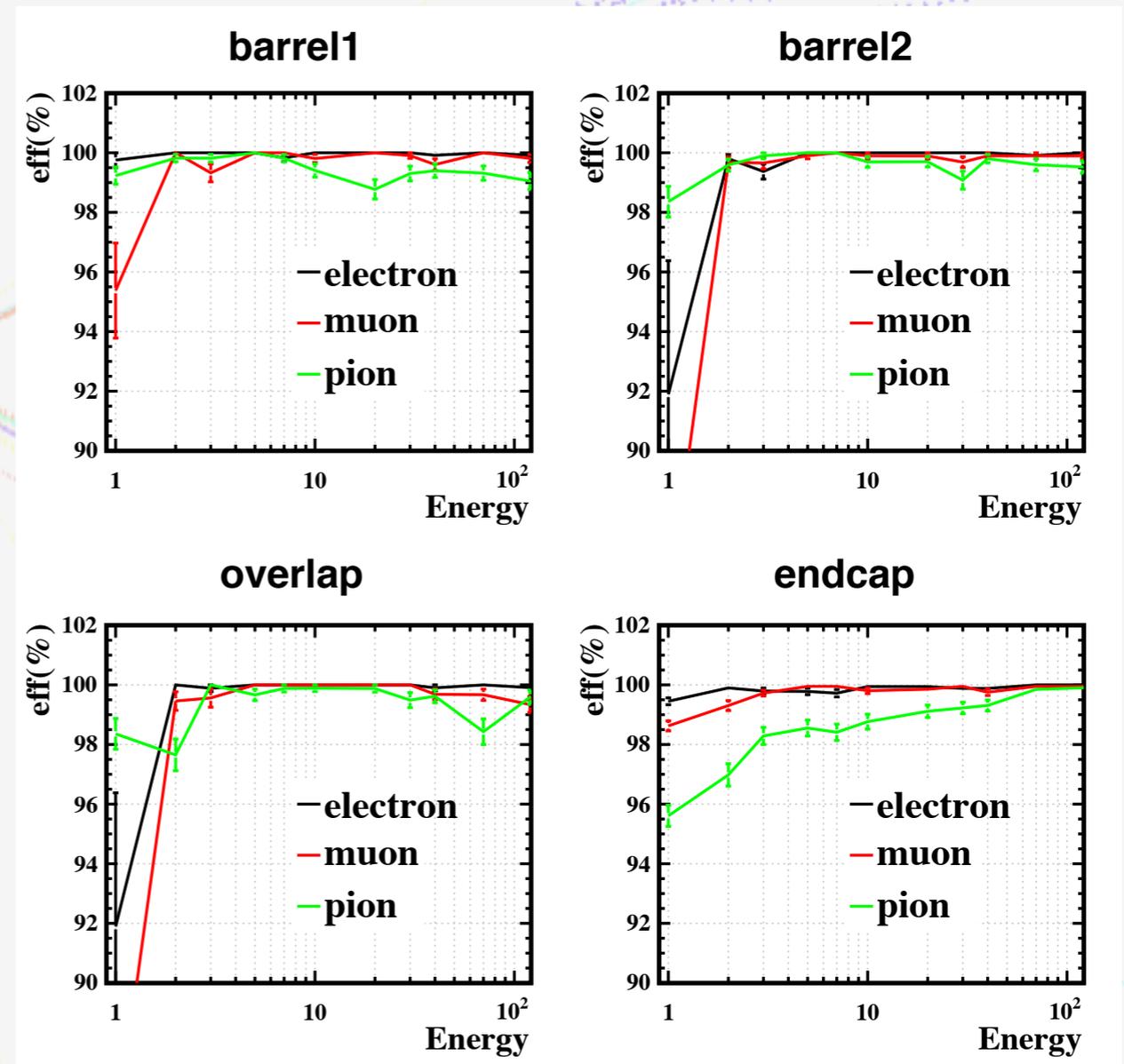
- En>0.2GeV rate: 15.6%

Reconstruction Dependency

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
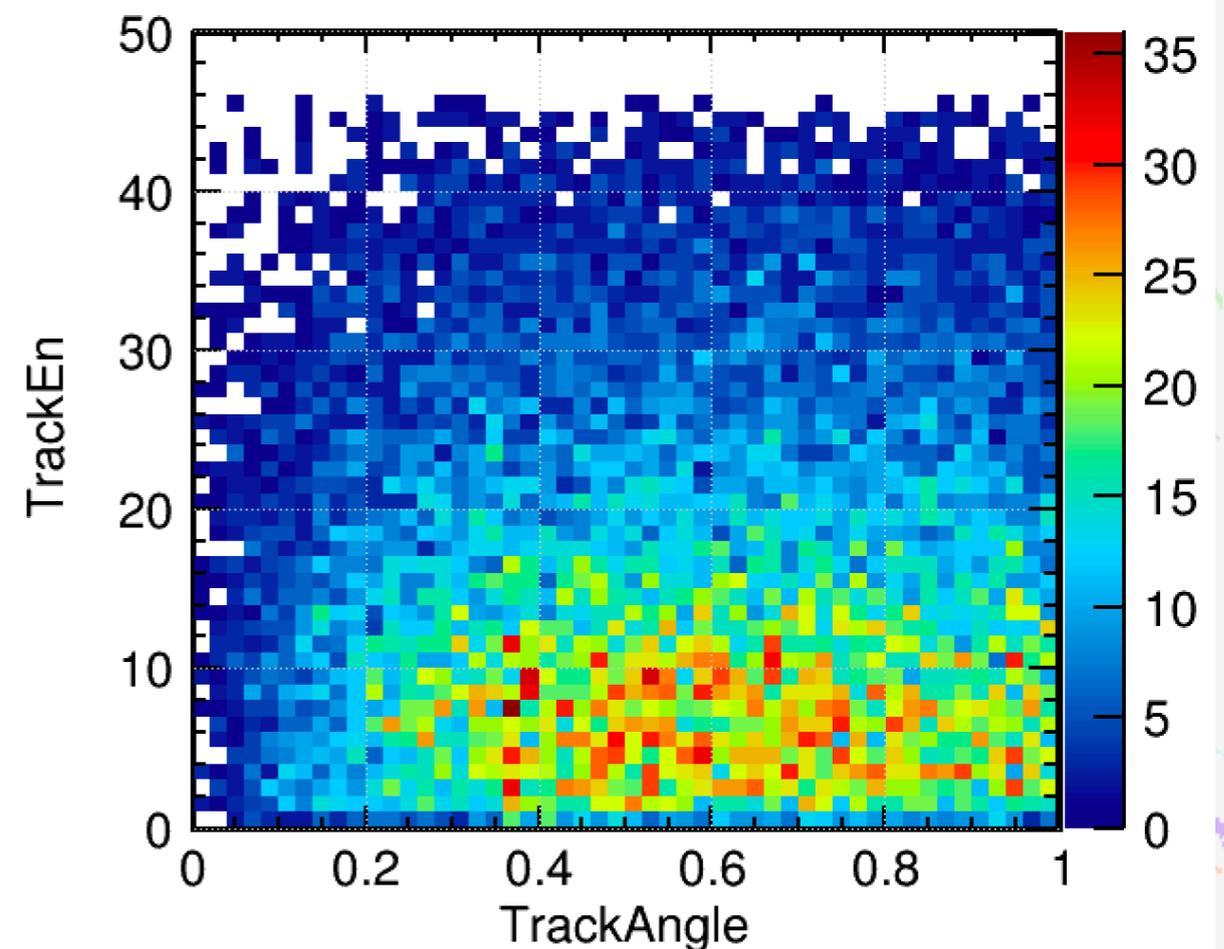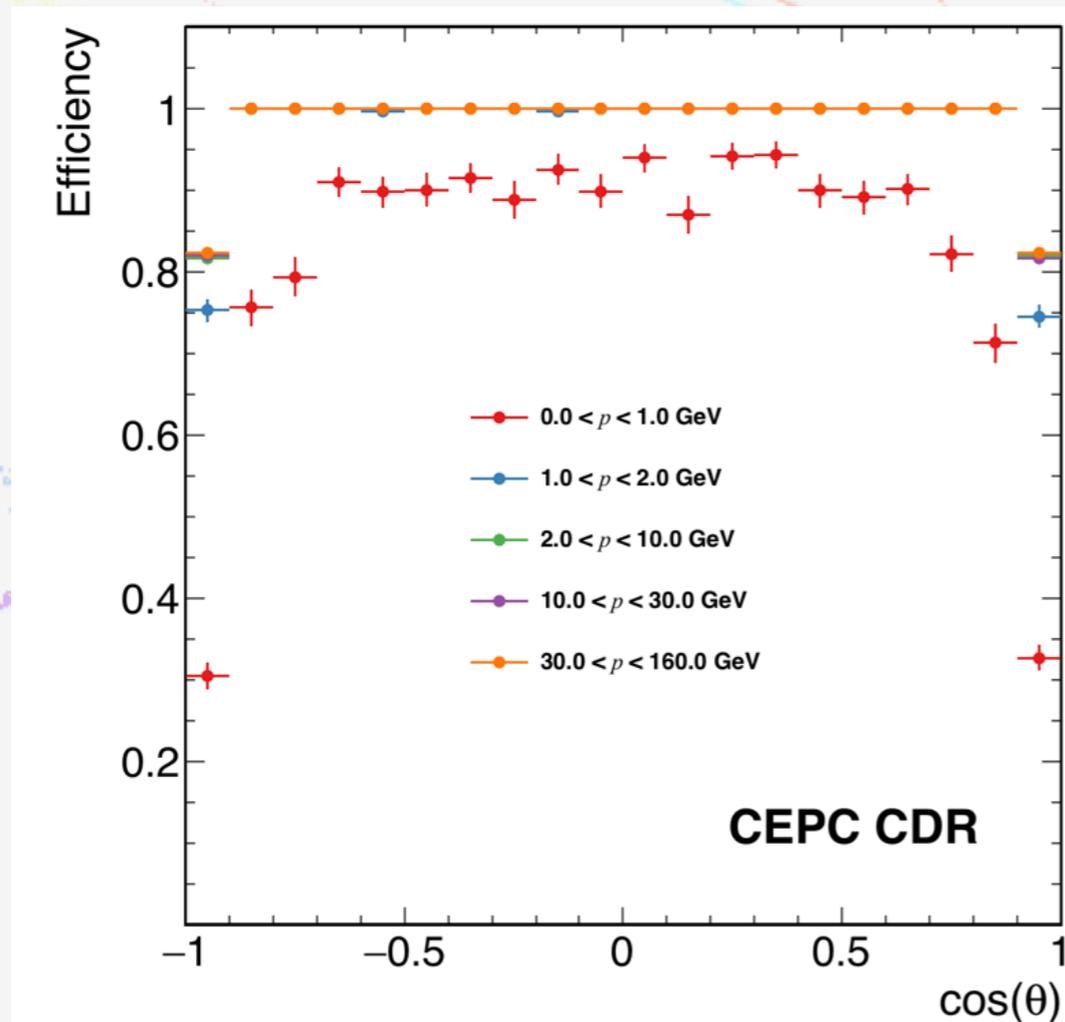
Particle Identification

- 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)

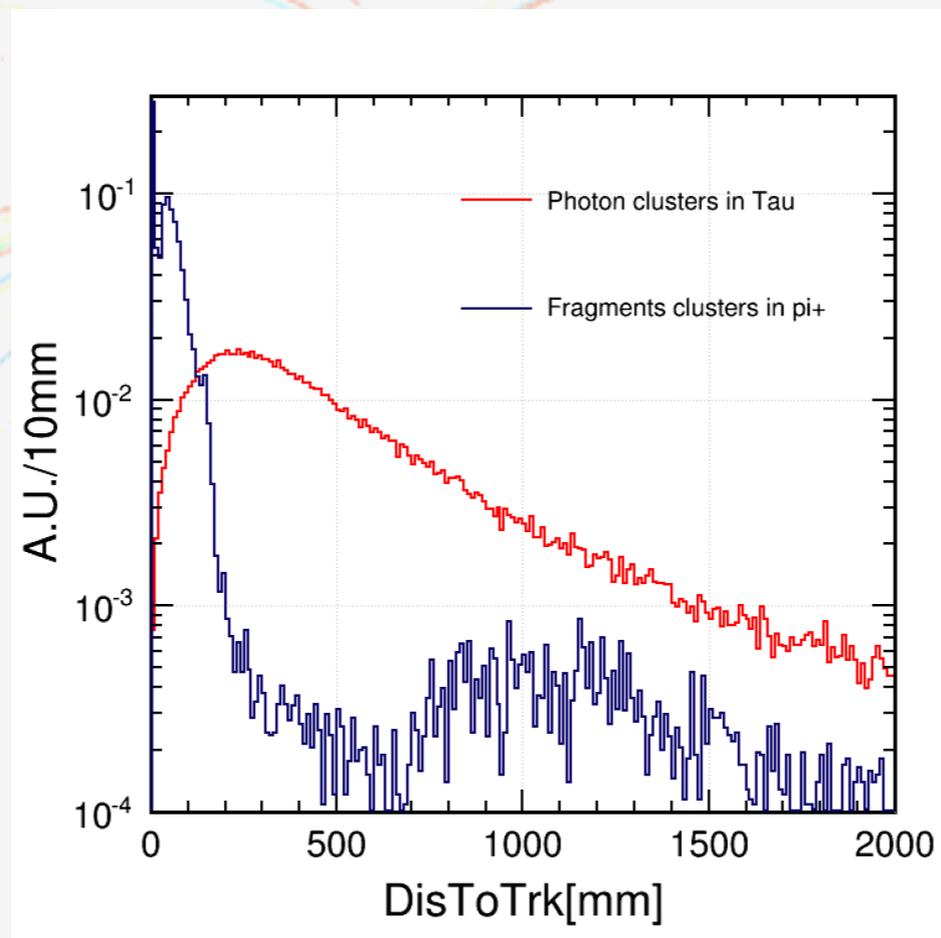- Distance to the closest charged track
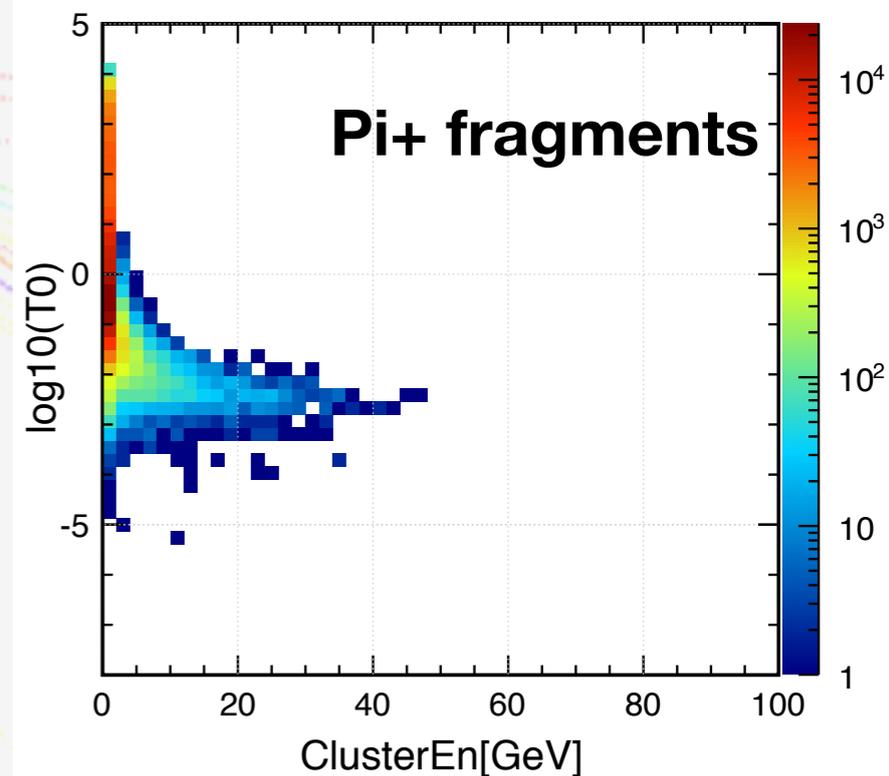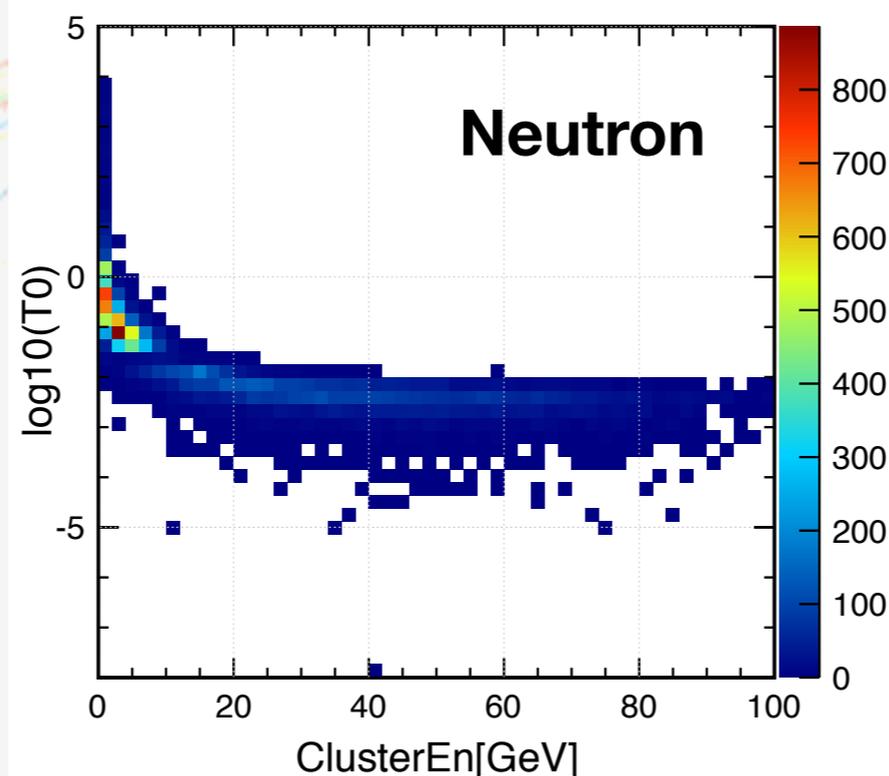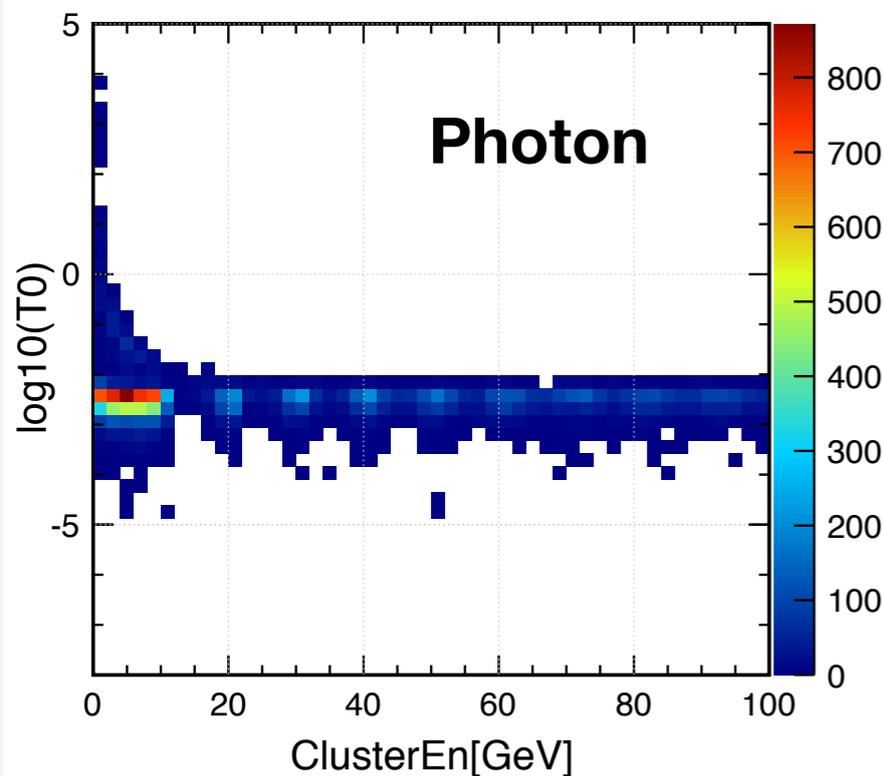
Fake Photons

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- Time

- Distance to the closest charged track

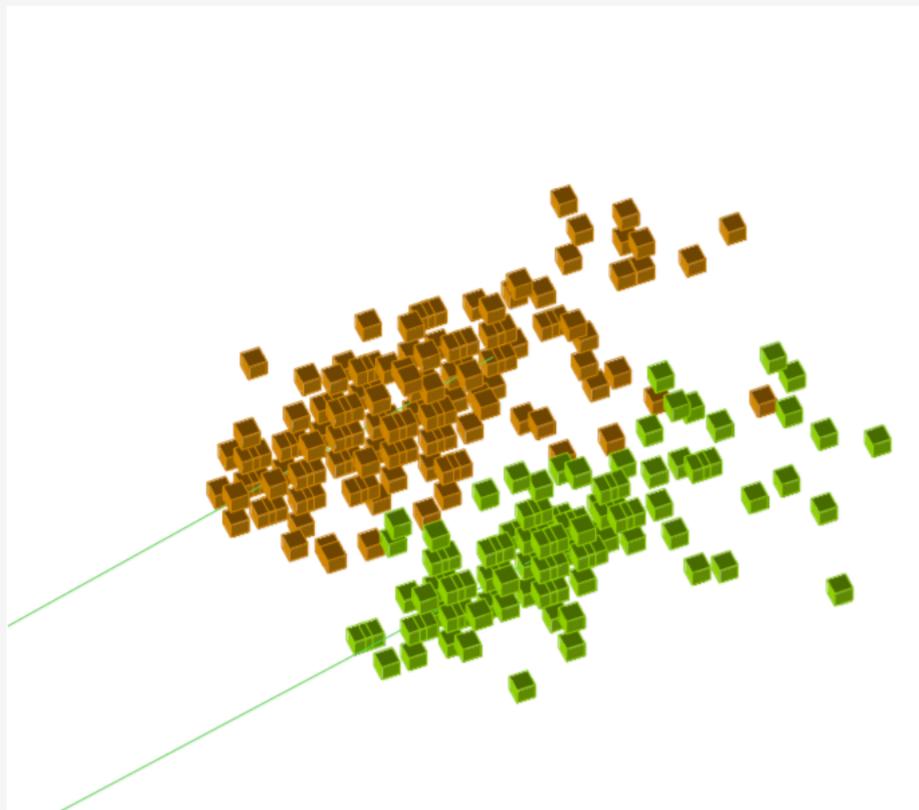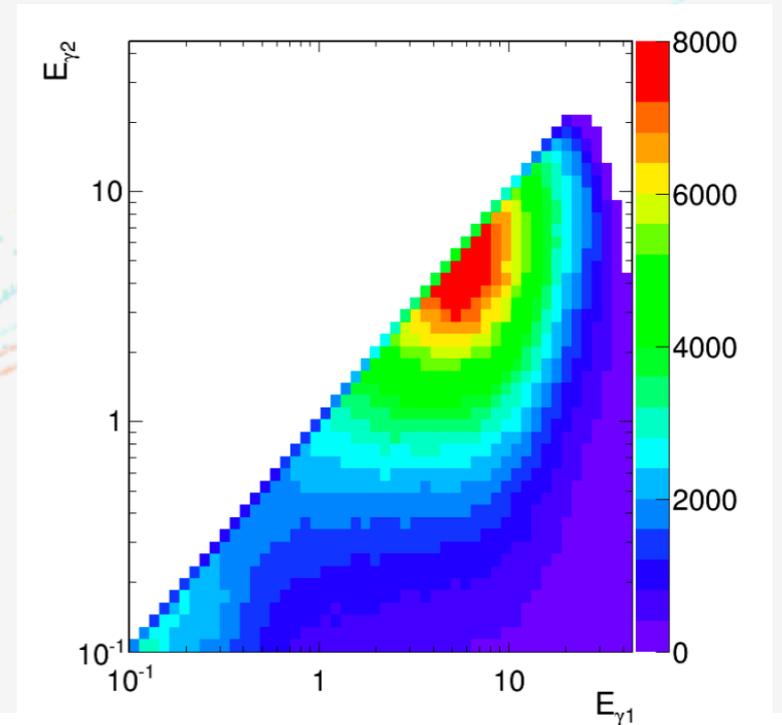# π0 reconstruction

- 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…
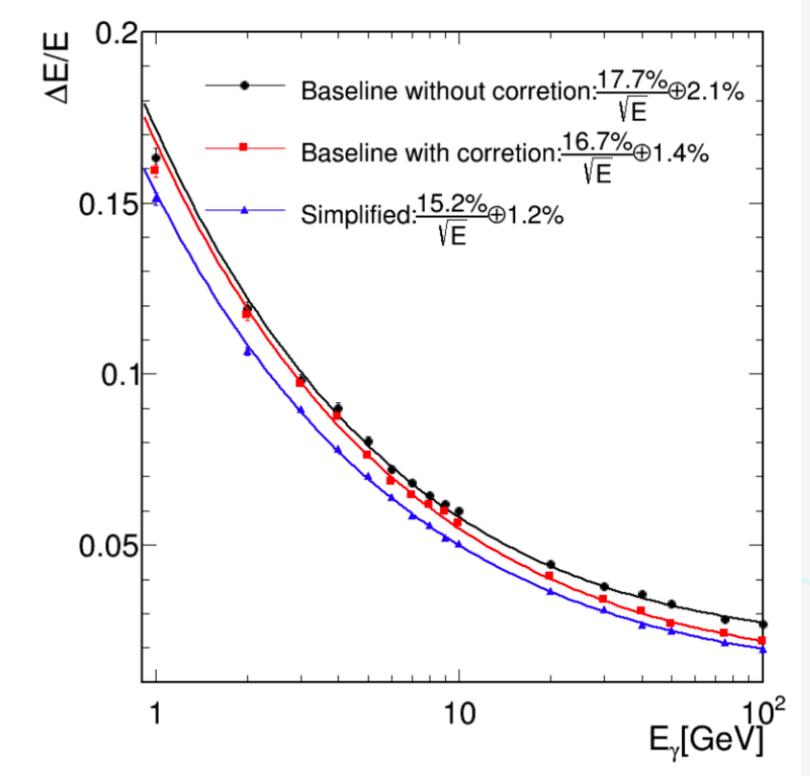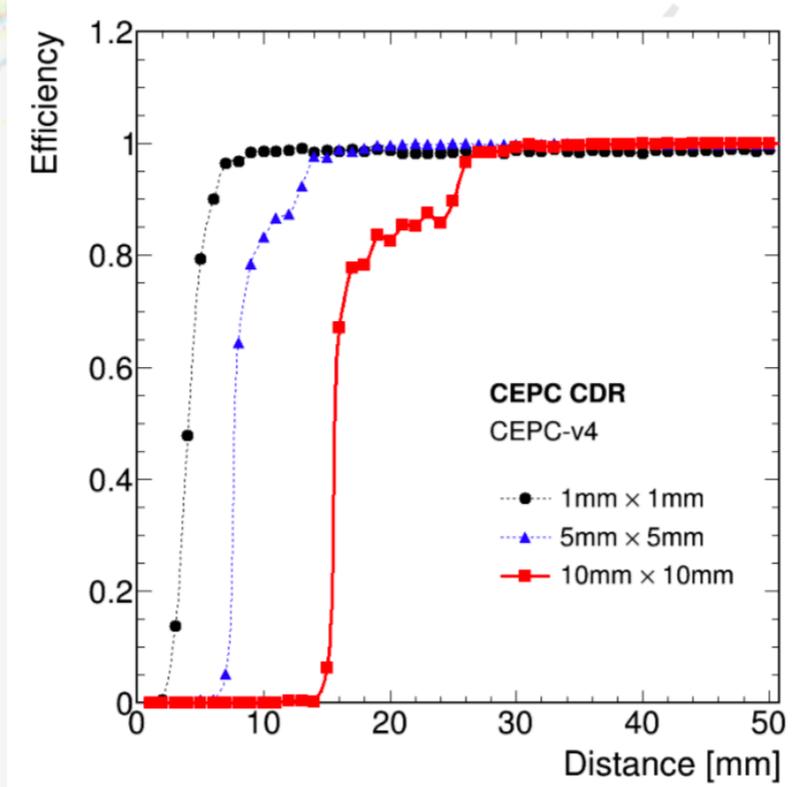
Estimate Efficiency

- 1 prong without photon: Eff_trk * (1-Prob_frag*MisPh)

  - Tracking efficiency, Probability of having fragments, MisID rate of fragments to photon …

- 1 prong with two photon: Eff_trk * (Eff_ph2 * (1-Prob_frag*MisPh)2 +Eff_ph*(1-Eff_ph)*(1-Prob_frag*MisPh))

- …

- ISR/FSR, photon conversion not included

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→ττ signal strength accuracy 0.8%

- Dependance on BMR studied

- τ decay mode study on going

  - Reconstruction tools

    - photon reconstruction, fragments absorption, π0 reconstruction

  - Polarization, CPV, ...

Thank you!