PID Fake Rates using Reflections of Z Decays and their Impacts on Physics

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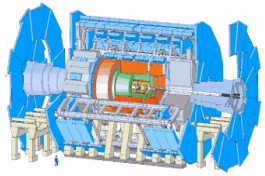
June 27, 2007 at SLAC Forum

- Motivation
- Results with 11.0.5 & EventView
- Results with 12.0.6 & HighPtView
  - Improve e charge confusion rate
  - Summary & Future Work



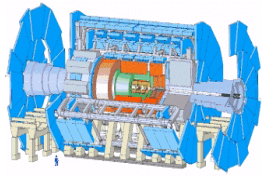
Motivation

- **PID efficiencies/Fake rates: ALL essential for EVERY ATLAS physics analysis (signal & bkg). ALL correlated, to be studied ALTOGETHER**

  Need to be measured from real ATLAS data

Reflections of Z decays (e.g. $Z \rightarrow e^+e^-$)

- **$e\gamma$, $\gamma\gamma$ mass peaks at 90GeV from real data: calibration, performance study, fake rate, etc**
- **Powerful way to measure fake rates from real ATLAS data under realistic environments**
- **Applies to other combinations/processes**



ALL depend on Software/cuts

EventView (EV) default selection

EtCUT: 20GeV for hadronic τ, 15GeV for others

Electron: IsEM, no TRT, Isolation (15GeV)

Photon: IsEM

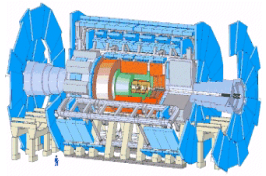
Muon: Relative Isolation, Chi2Ndof (20)

TauJet: Likelihood, HadronEnergyFraction

ParticleJet: Cone Size: DeltaR = 0.5

Overlap Removal: DeltaRCut = 0.1

MECHANISM to evaluate & achieve best PID performance using incoming real ATLAS data

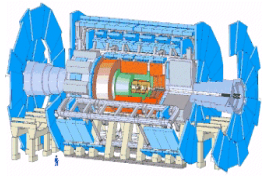


CSC11 AOD with release 11.0.5

Process	CSC/Events	Generator Level Cuts	Filter ε
$Z \rightarrow e^+e^-$	Jimmy5112 15,000 evts	2 e: Pt>10GeV, $\|\eta\|<2.7$ M_ll > 60GeV	0.48
$Z \rightarrow e^+e^-$ $\sigma \sim 1500$ pb	Pythia5144 140,000 evts	1 e: Pt>10GeV, $\|\eta\|<2.7$ M_ll > 60GeV	0.86
$H \rightarrow \gamma\gamma$ $\sigma \sim 0.06$ pb	H120Pythia5310 38,000 evts	2 γ: Pt>20GeV, $\|\eta\|<2.7$	0.76
$Z \rightarrow \mu^+\mu^-$	Herwig5141 89,950 evts	1 μ: Pt>5GeV, $\|\eta\|<2.8$ M_ll > 60GeV	0.88
$H \rightarrow \tau^+\tau^-$ $\rightarrow$ hh	Pythia5332 35,000 evts	2 hadronic τ: Pt>12GeV, $\|\eta\|<2.7$ $\|\Delta\Phi\|<2.9$ (VBF only)	0.24
$H \rightarrow \tau^+\tau^-$ $\rightarrow$ lh	Pythia5331 18,000 evts	1 lepton: Pt>5GeV, $\|\eta\|<2.7$ (gg + VBF)	0.46

Talks at SM, e/γ, Higgs, Exotics, Jet/EtMiss since 9/2006

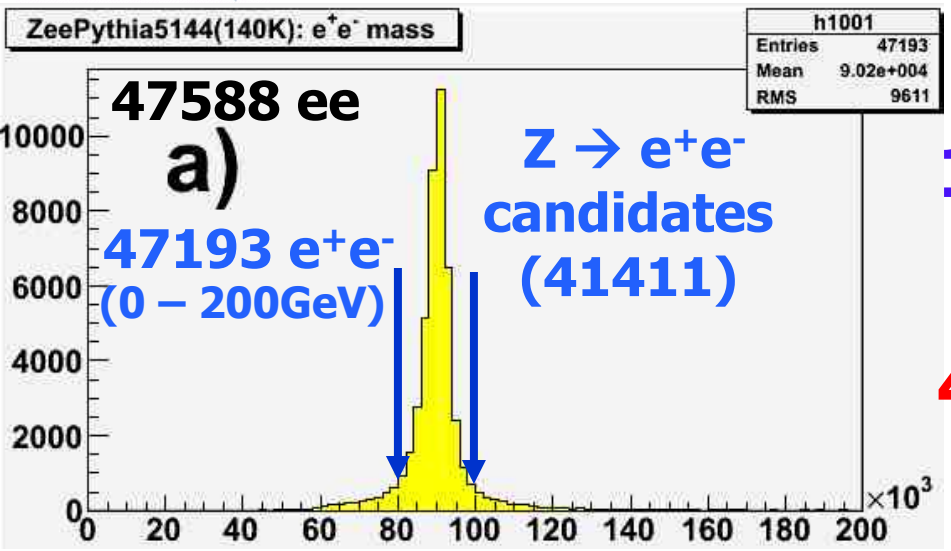
This talk: e fake rates from 140K $Z \rightarrow e^+e^-$ (~100pb^{-1})



Global view of $Z \rightarrow e^+e^-$ evts

	Av. e	Av. γ	Av. μ	Av. τ	Av. Jet
140,000 evt	1.1440	0.0866	0.0030	0.0415	1.4420
47,588 ee	2.0010	0.0080	0.0025	0.0112	0.7997
7,077 eγ	1.0540	1.0210	0.0014	0.0324	0.8793
3,627 eτ	1.1470	0.0631	0.0022	1.0180	0.9611
524 $\gamma\tau$	0.4447	1.0340	0.0000	1.0100	1.0920
345 $\gamma\gamma$	0.2174	2.0170	0.0000	0.0261	0.9043
303 eμ	1.3890	0.0330	1.0070	0.0264	1.5410
81 $\tau\tau$	0.4198	0.0617	0.0000	2.0000	1.0990
22 $\gamma\mu$	0.4545	1.0000	1.0000	0.0000	1.7730
14 $\tau\mu$	0.7143	0.0000	1.0000	1.0000	1.2860
1 $\mu\mu$	2.0000	0.0000	2.0000	0.0000	1.0000

140K Z→e⁺e⁻ events as e⁺e⁻



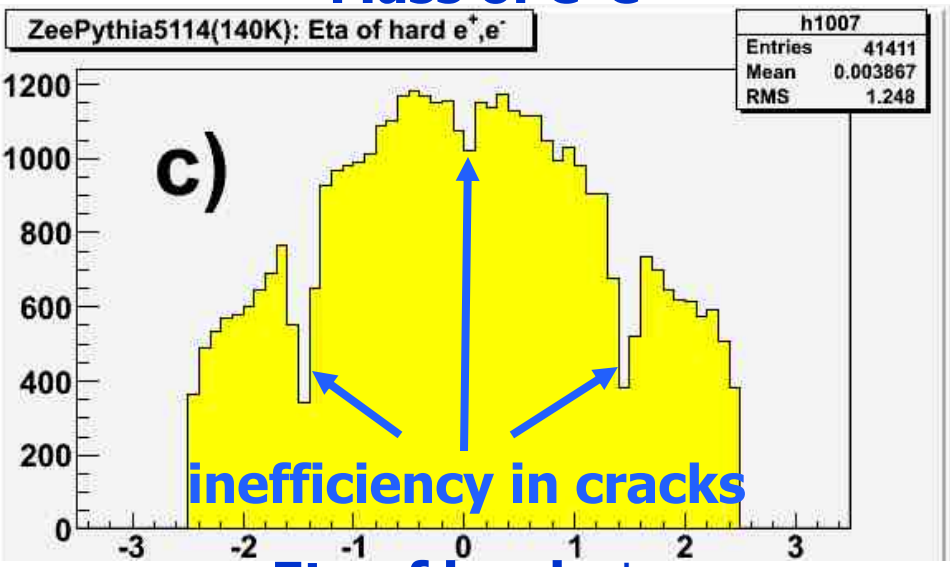
Sample/Selection:

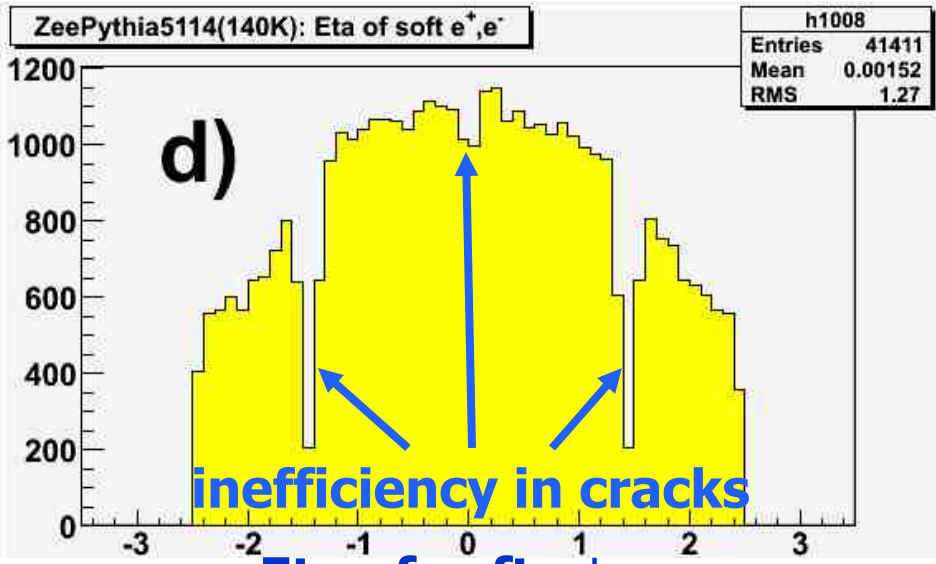
140K Z→e⁺e⁻ MC events

(~100pb⁻¹)

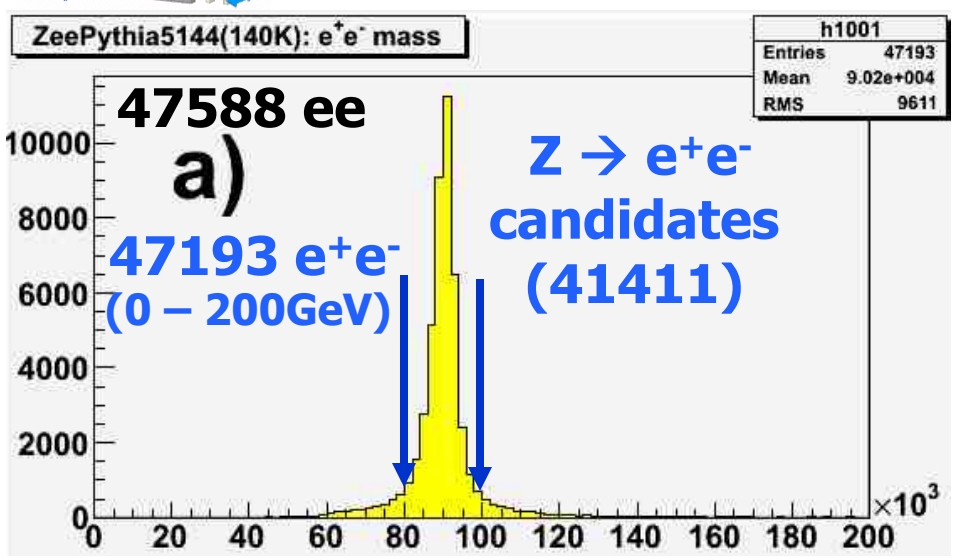
41411 Z→e⁺e⁻ candidates

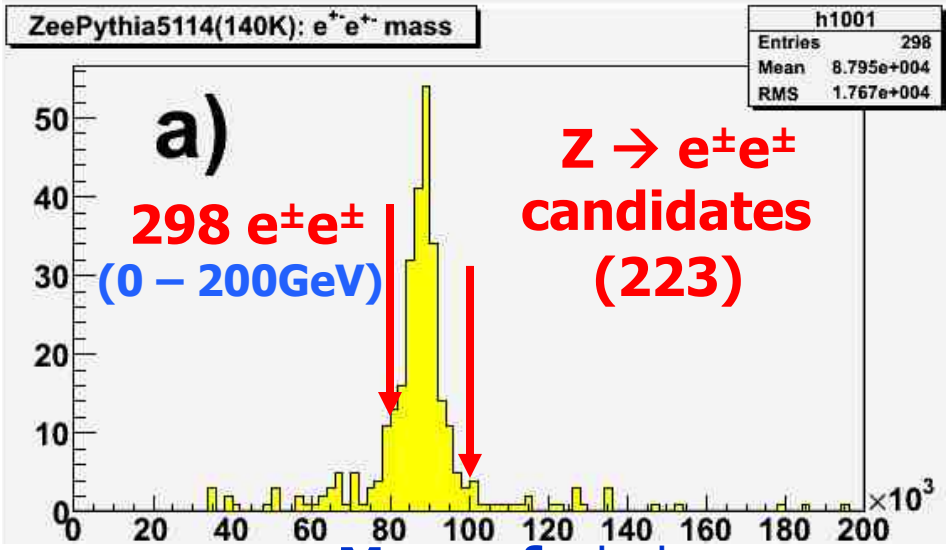
(~25.4% pass full cuts)

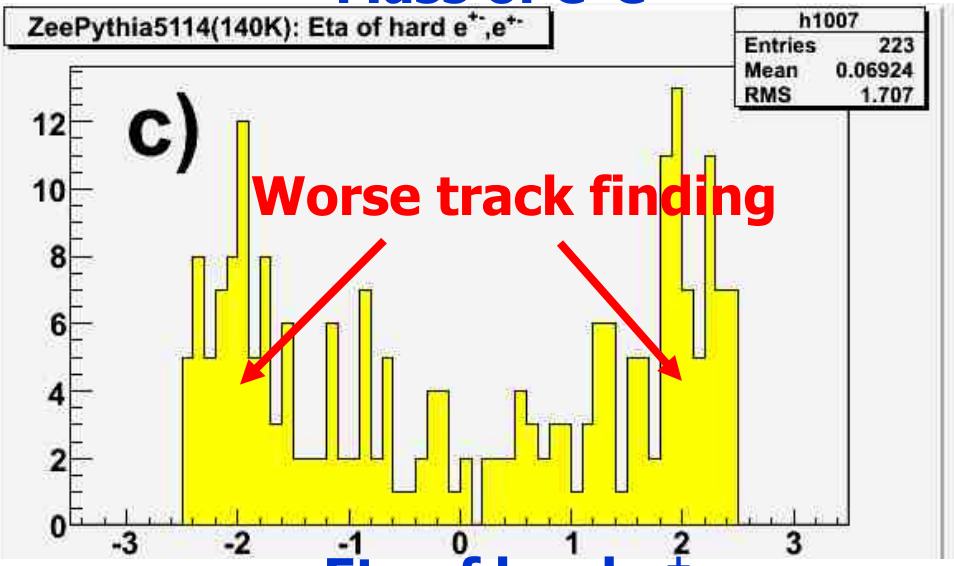


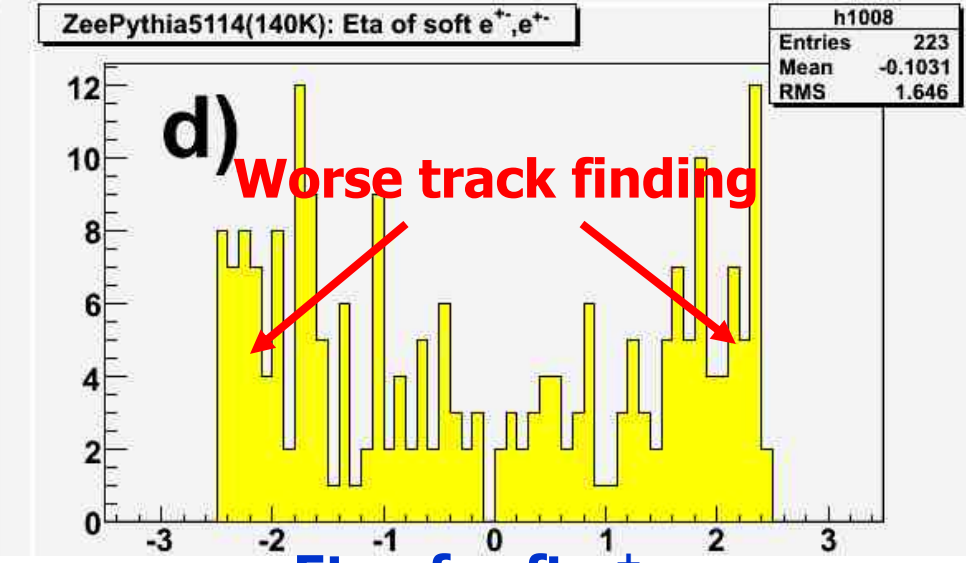


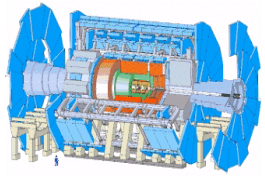
140K $Z \rightarrow e^+e^-$ events as $e^{\pm}e^{\pm}$











140K $Z \rightarrow e^+e^-$ events (100 pb^{-1})

- **140K $Z \rightarrow e^+e^-$ events (~100pb^{-1} ATLAS data)**
  Total of 47,193 e^+e^- pairs among which 41,411 pairs are between 80 and 100GeV

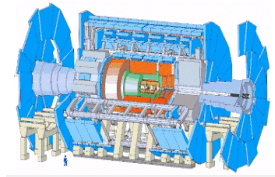
- **Small/Clean $e^{\pm}e^{\pm}$ peak at 90GeV. Total of 223 (out of 298) between 80 and 100GeV.**

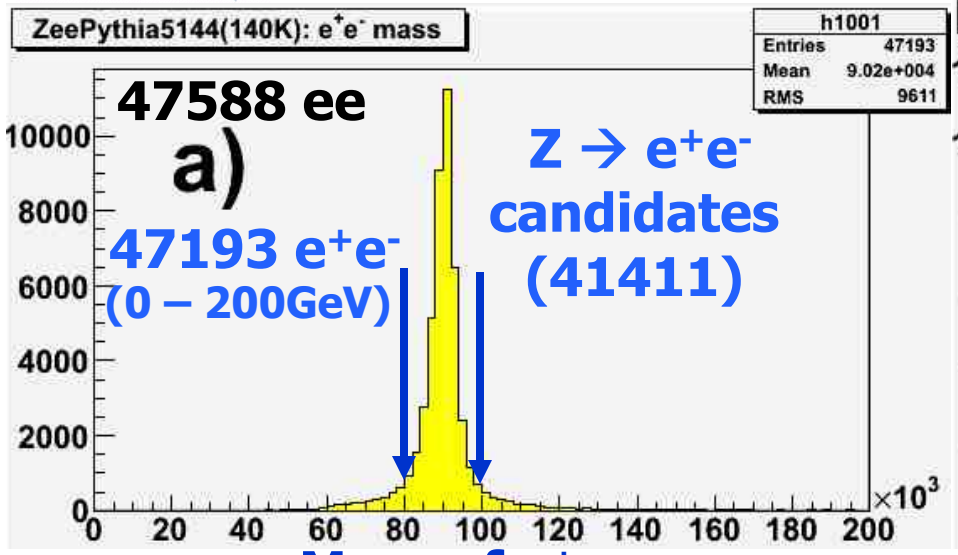
Measure e charge confusion rate from real data

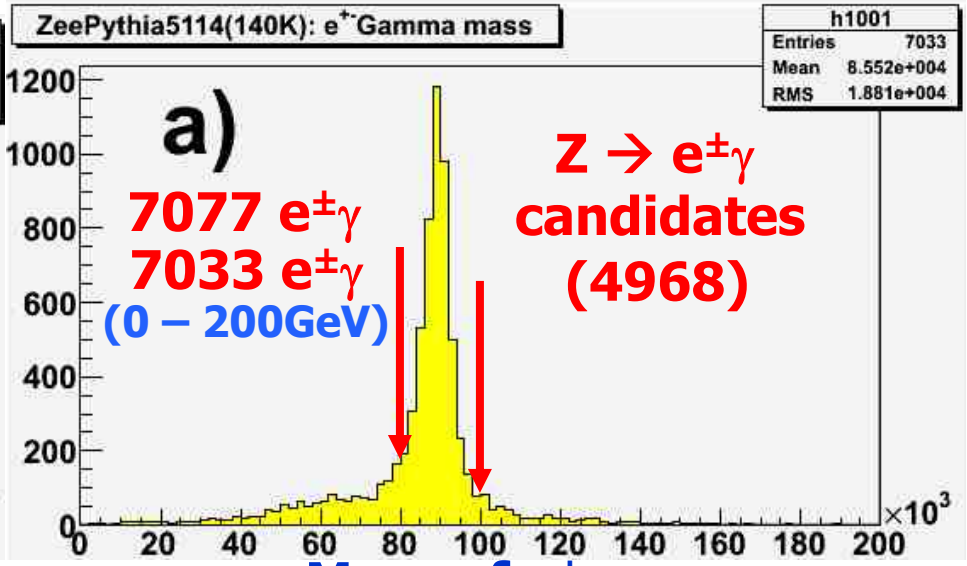
- **Electron charge confusion rate: ~ 0.3%**
  (ATLAS Technical Design Report:< 0.1%)

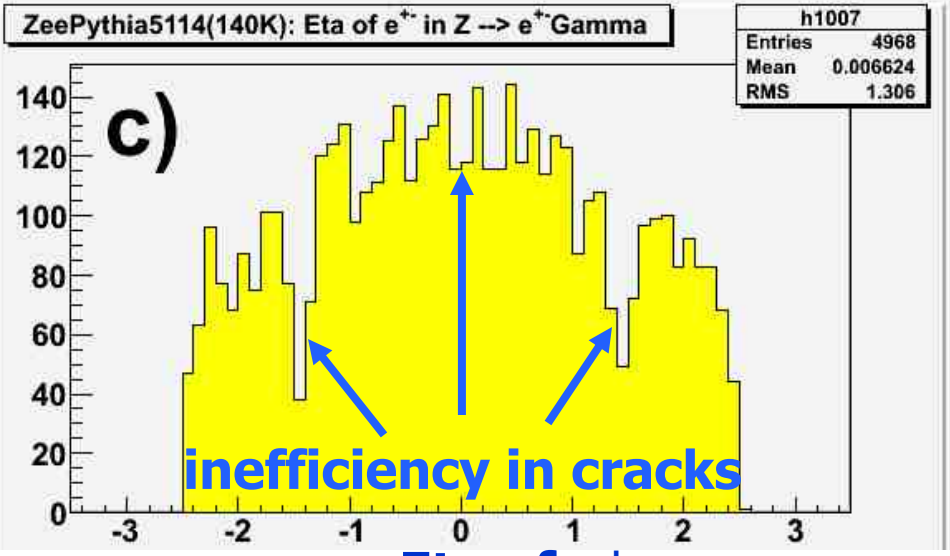
- **Impact NP searches with $l^{\pm}l^{\pm}$: Exotic/SUSY/..**

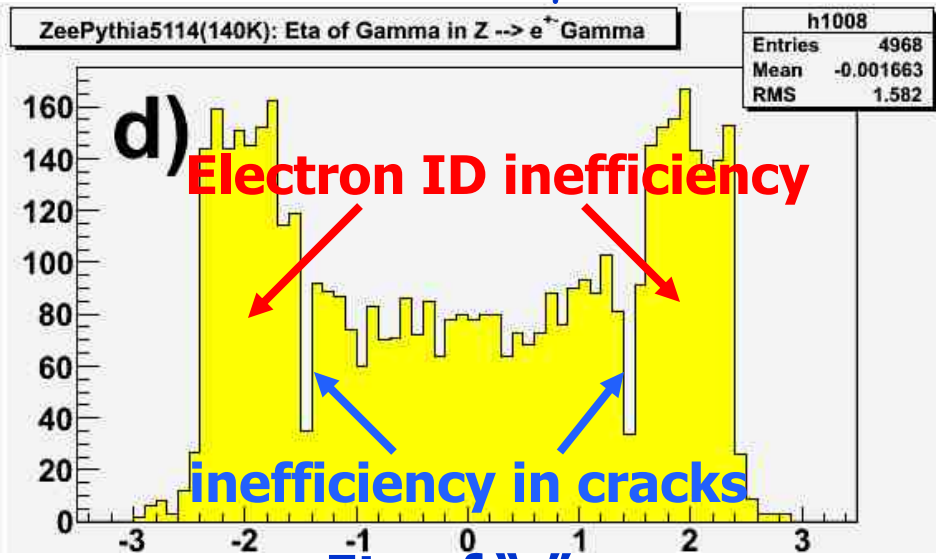
140K $Z \rightarrow e^+e^-$ events as $e^{\pm}\gamma$

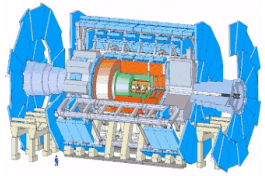












Reflection of $Z \rightarrow e^+e^-$ as $e^{\pm}\gamma$

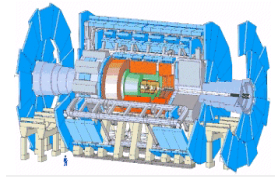
- 140K $Z \rightarrow e^+e^-$ events (~100pb^{-1} ATLAS data):
  7,033 $e^{\pm}\gamma$ pairs with 4,968 bw 80 and 100GeV
  (comparing with 41,411 e^+e^- pairs)

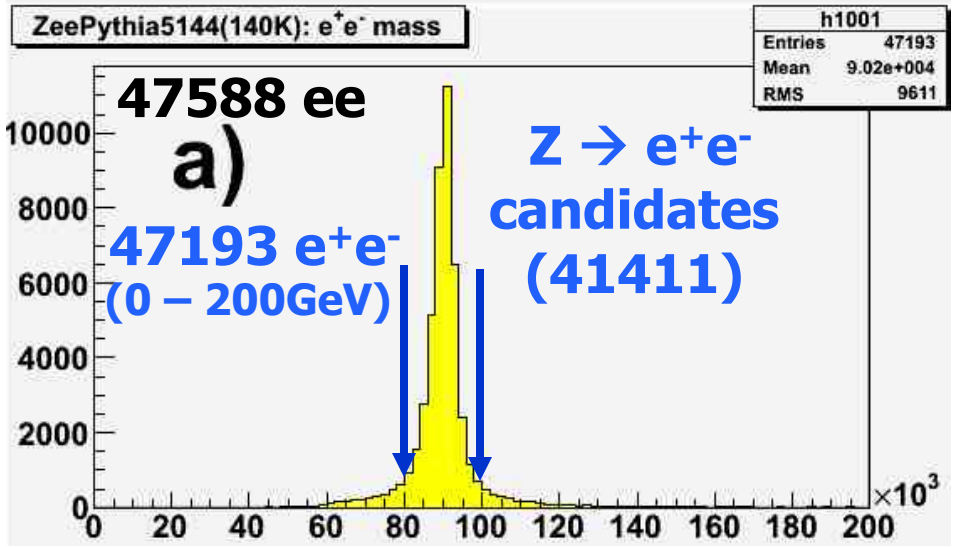
- Clean $e\gamma$ reflection peak at Z mass.
  Measure e to γ fake rate from real LHC data

e to γ fake rate/e ID efficiency ~ 6.0%
(ATLAS Technical Design Report: 0.2%)

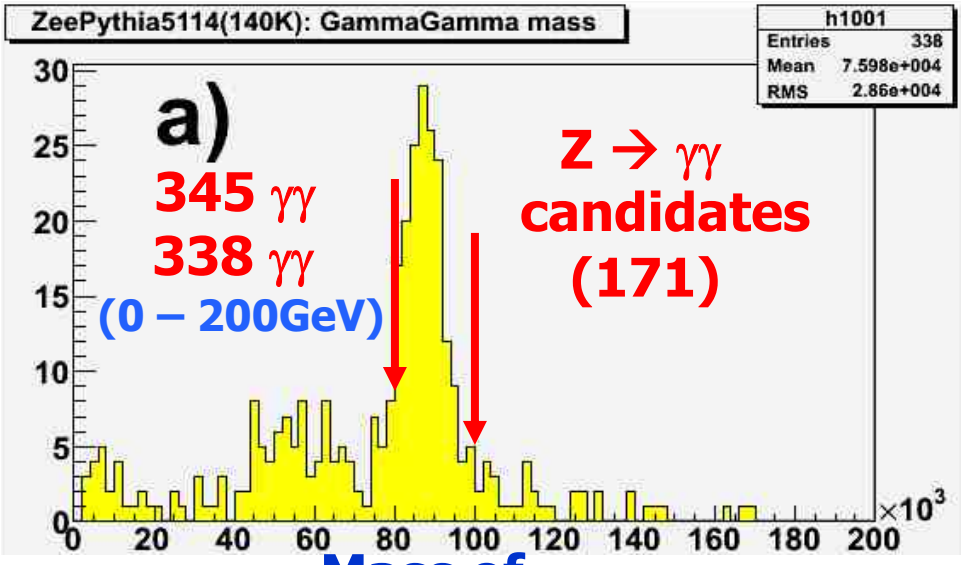
Fake γ from e: Serious BKG in NP search with γ:
e.g. $H \rightarrow \gamma\gamma$ (most important Higgs channel)

140K $Z \rightarrow e^+e^-$ events as $\gamma\gamma$

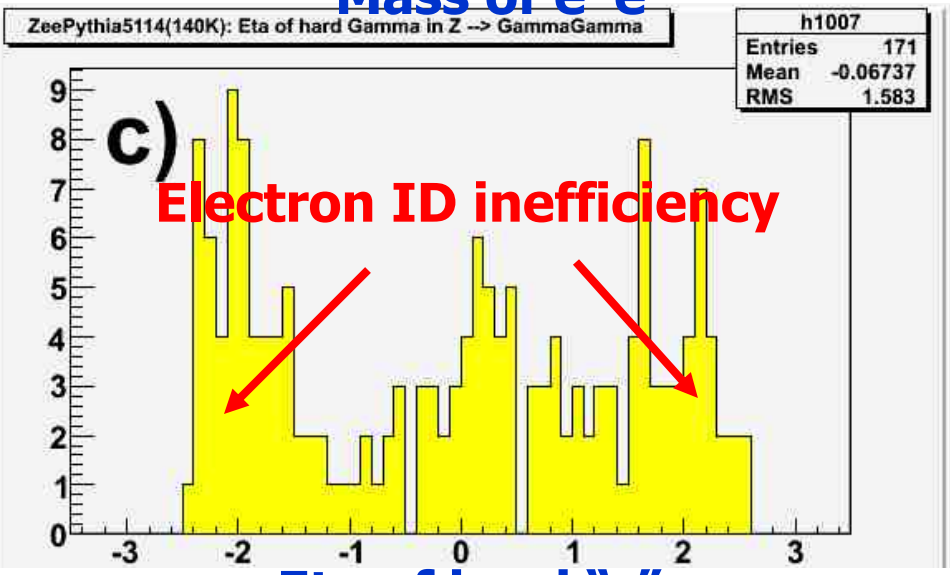




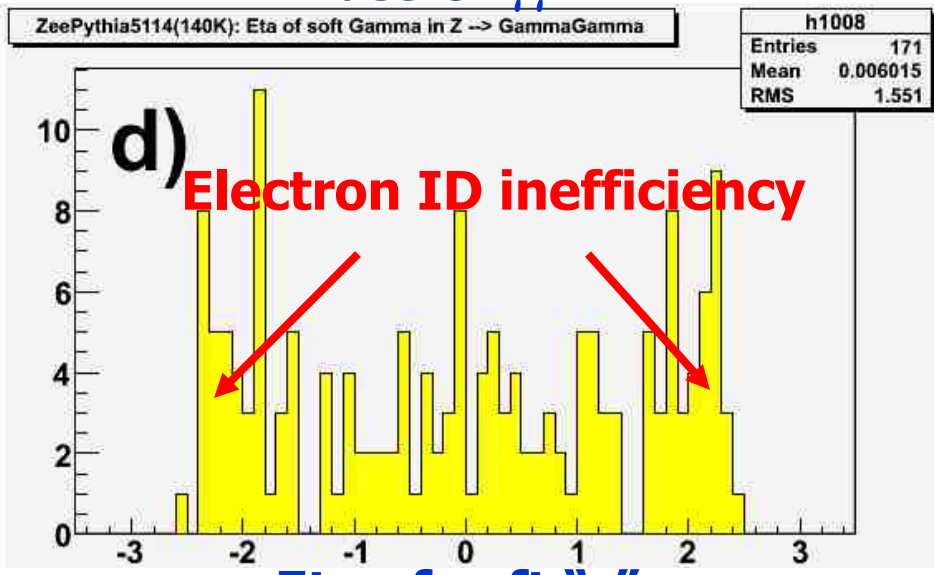
Mass of e^+e^-



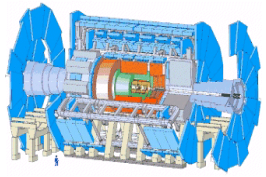
Mass of $\gamma\gamma$



Eta of hard "γ"



Eta of soft "γ"



Reflection of $Z \rightarrow e^+e^-$ as $\gamma\gamma$

- **140K $Z \rightarrow e^+e^-$ events (~100pb^{-1} ATLAS data):**

  Total 338 $\gamma\gamma$ pairs with 171 bw 80 and 100GeV

  (comparing with 41,411 e^+e^- pairs):

- **Small/clean $\gamma\gamma$ reflection peak at Z mass**

- **Z → $\gamma\gamma$ ("σ"~6 pb) >> expected H → $\gamma\gamma$ signal**

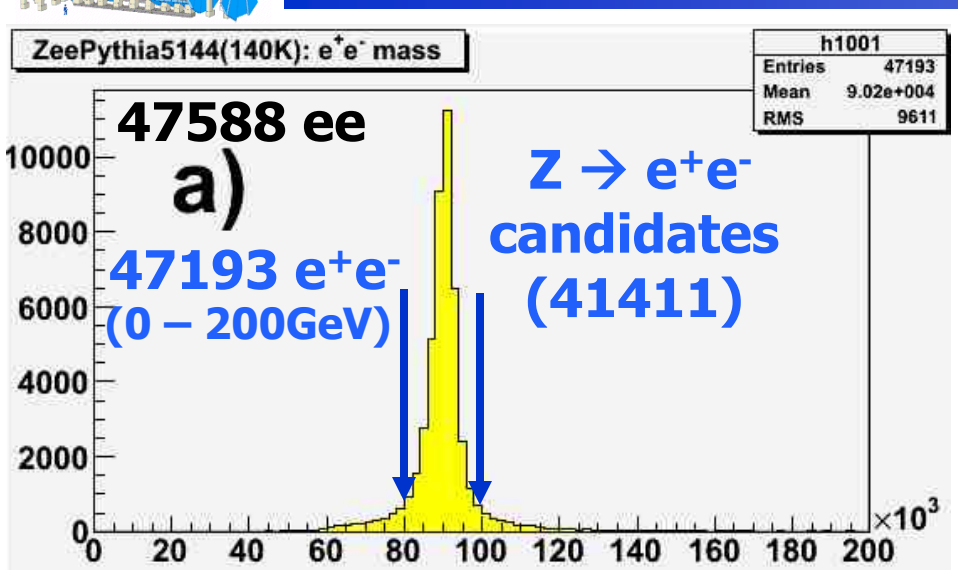
- **Yield/location/width of Z → $\gamma\gamma$ and Data/MC differences: systematics uncertainties in H→$\gamma\gamma$**

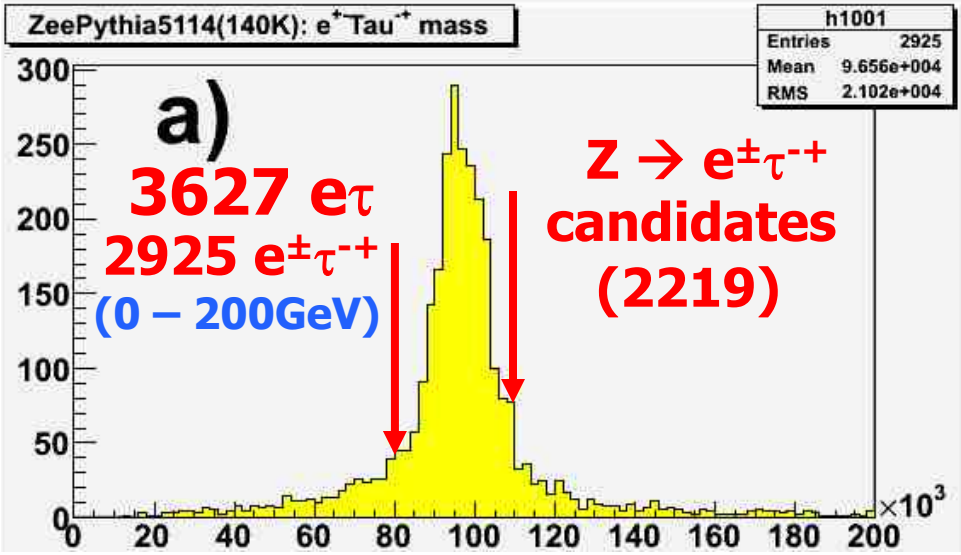
Excellent calibration mode for H→$\gamma\gamma$

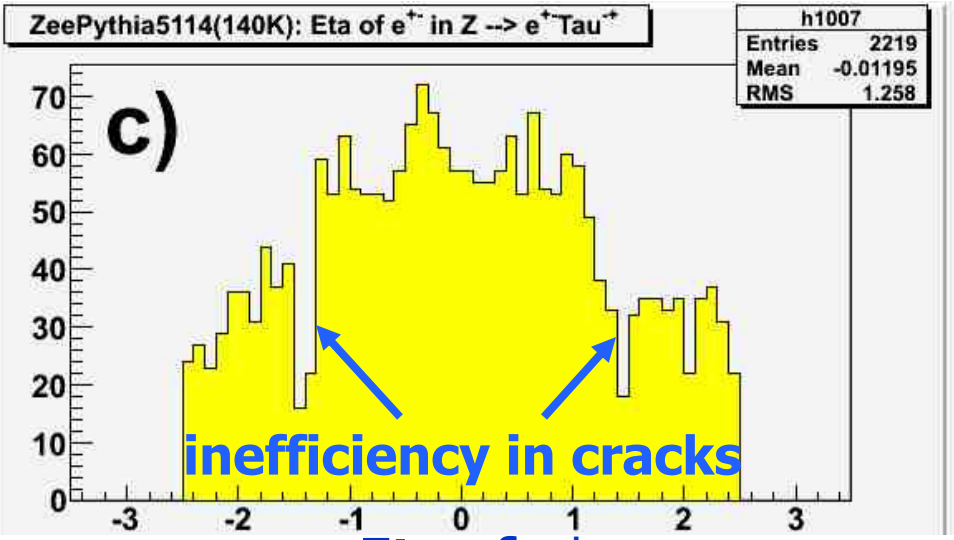
e to γ fake rate/e ID efficiency ~ 6.4%

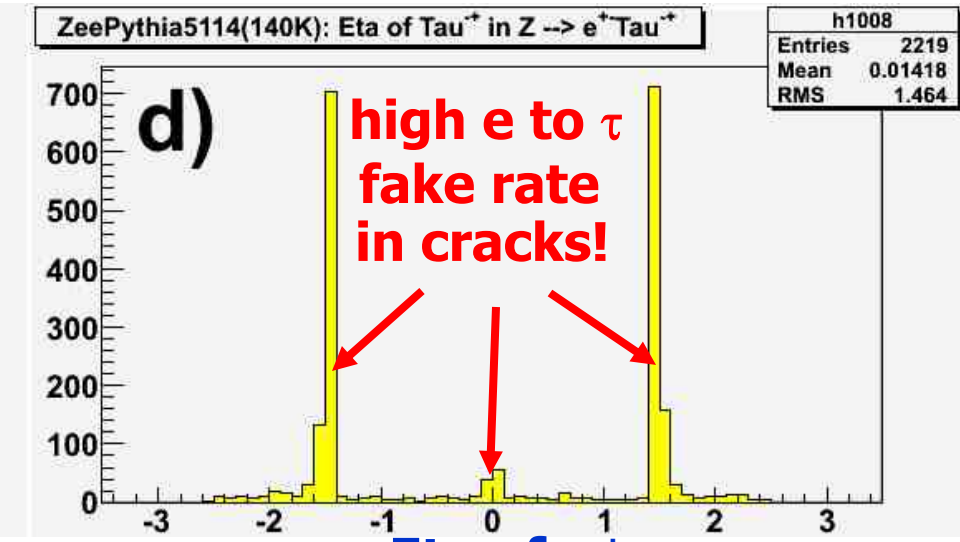
(consistent with 6.0% $e^{\pm}\gamma$ reflection results)

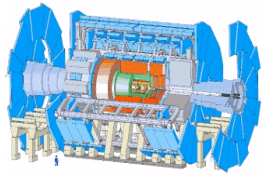
140K $Z \rightarrow e^+e^-$ events as $e^{\pm}\tau^{-+}$









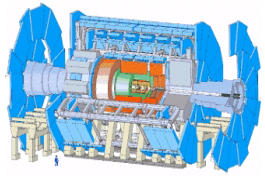


Reflection of $Z \rightarrow e^+e^-$ as $e^{\pm}\tau^{-+}$

- Large $e^{\pm}\tau^{-+}$ reflection peak ~95GeV: 2925 $e^{\pm}\tau^{-+}$ pairs with 2,219 bw 80 and 110GeV (comparing 41,411 e^+e^- pairs)

Measure e to τ fake rate from real ATLAS data

- e to τ fake rate/e ID efficiency: ~ 2.7%
- e to τ fake happens mostly in the cracks!
- Software improvements essential!
- **Impact NP searches with τ: Higgs/SUSY/…**



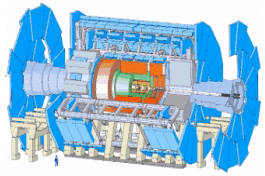
Results with 11.0.5

- e charge confusion ~ 0.3% (Exotic/SUSY/..)
- e to γ fake rate/e ID ε ~ 6% (Higgs/Exotic/..)
  (much higher than ATLAS TDR)
- e to τ fake rate/e ID ε ~ 3% (Higgs/SUSY/..)
- e to Particle Jet fake rate/e ID ε ~ 37%

- Relevant to ALL subsystems/SW/PHYSICS

My talks at the ATLAS Standard Model, e/γ, Higgs, Exotics, Jet/Etmiss/Tau Working Groups since September, 2006

ATL-COM-PHYS-2007-022



12.0.6 & HighPtView

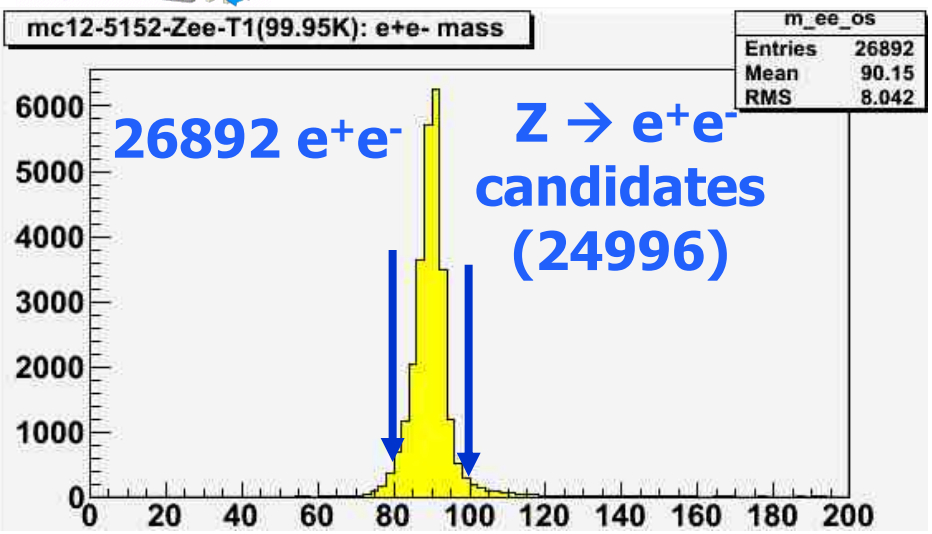
Fabien Tarrade's 12.0.6 HPTV Ntuples

- trig1_misal1...12.0.6.6...AANT1 (1mm fixed)
- Tau ID: TauRec, Muon ID: MuID

Process	Sample	# of events	
$Z \rightarrow e^+e^-$	5152	99.95K	
$Z \rightarrow e^+e^-$	5144	476.30K	(Ready soon)
$Z \rightarrow \mu^+\mu^-$	5151	99.15K	
$Z \rightarrow \tau^+\tau^-$	5146	54.60K	
Dijiet (JF17) BKG	5802	1107.8K	(Ready soon)

Thanks F. Tarrade, S. Ye, H. Ma, K. Cranmer

100K Z→e⁺e⁻ events as e⁺e⁻



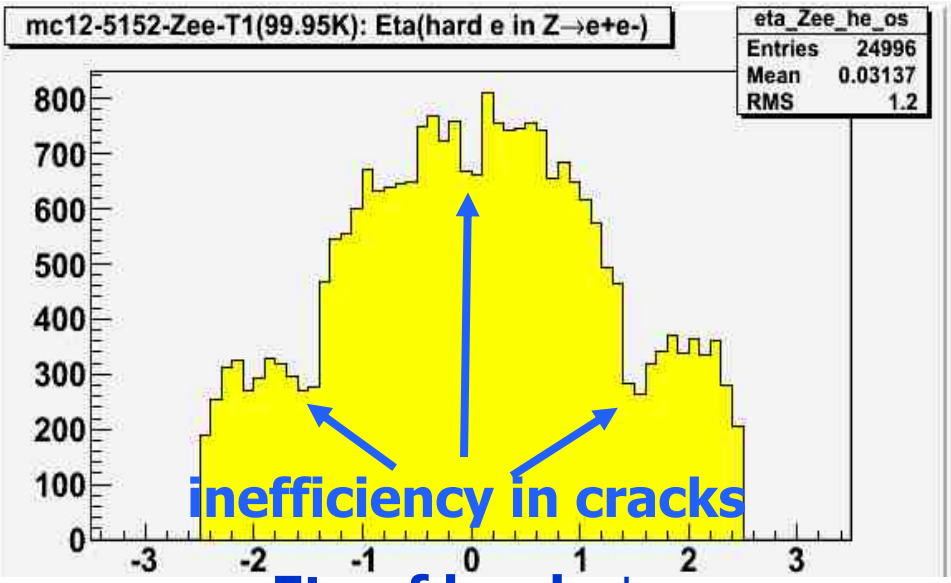
Sample/Selection:

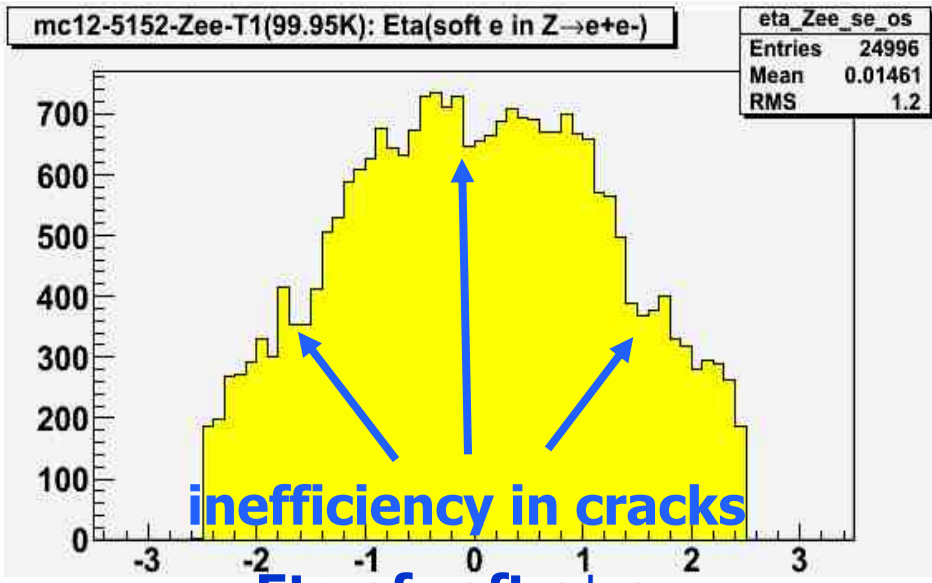
~100K Z→e⁺e⁻ (5152)

(~70pb⁻¹)

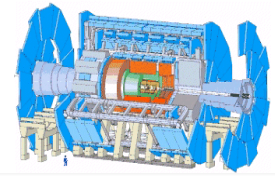
24996 Z→e⁺e⁻ candidates

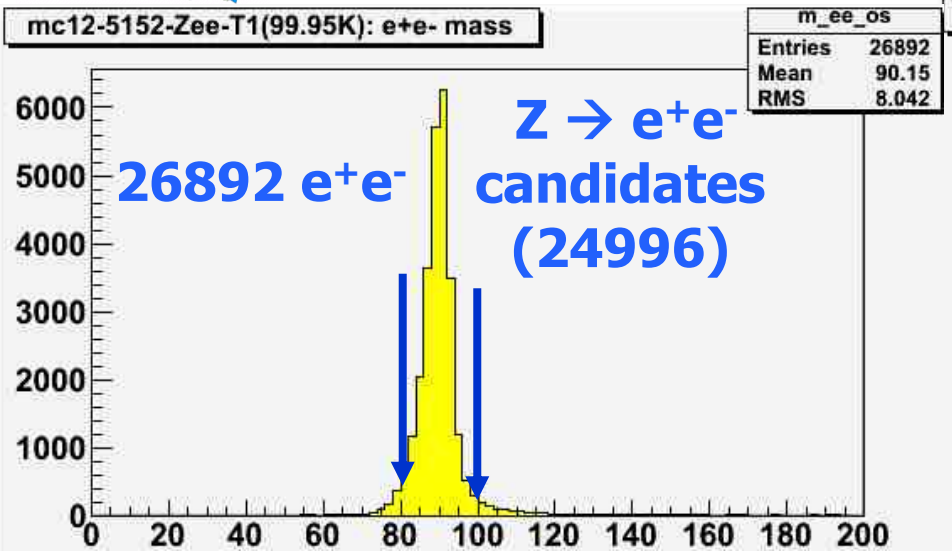
(~19.3% pass full cuts)



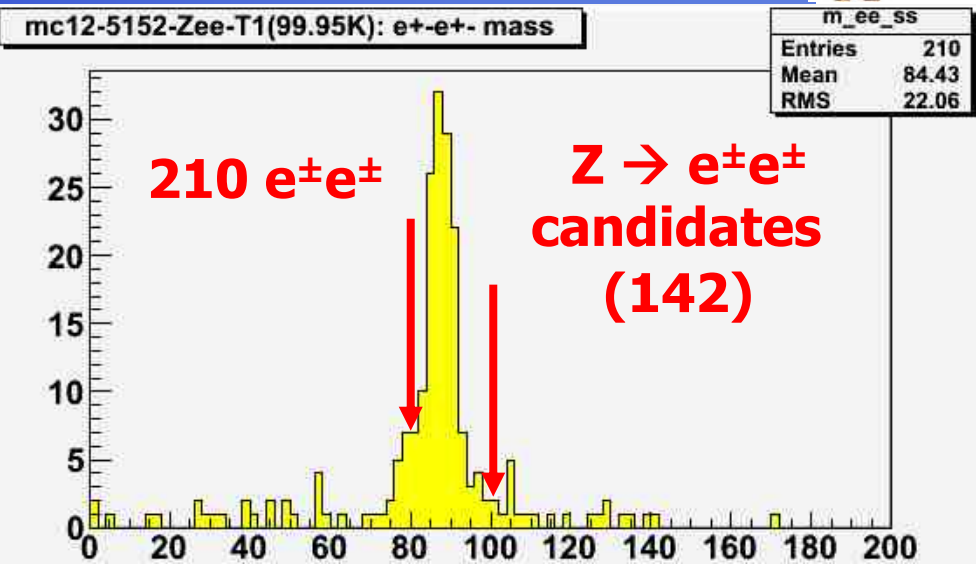


100K $Z \rightarrow e^+e^-$ events as $e^{\pm}e^{\pm}$

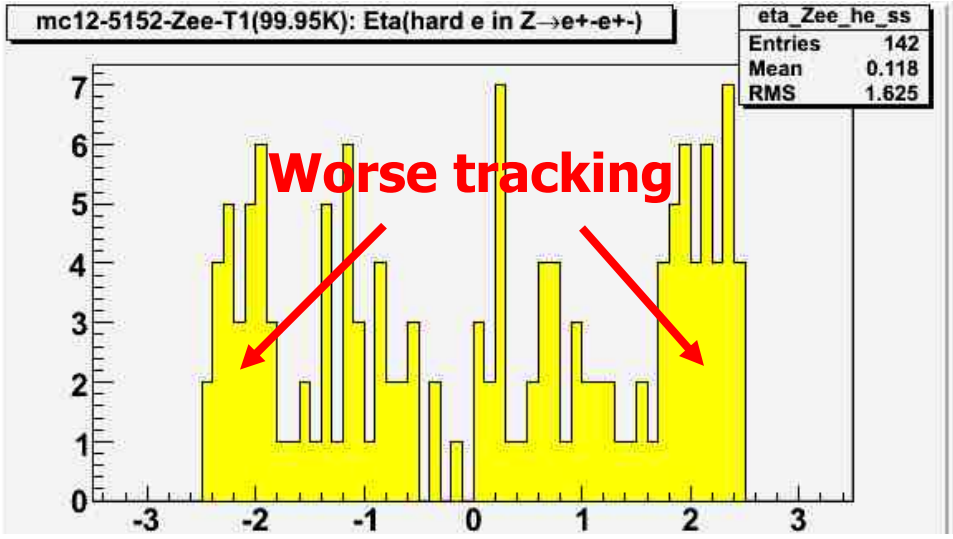




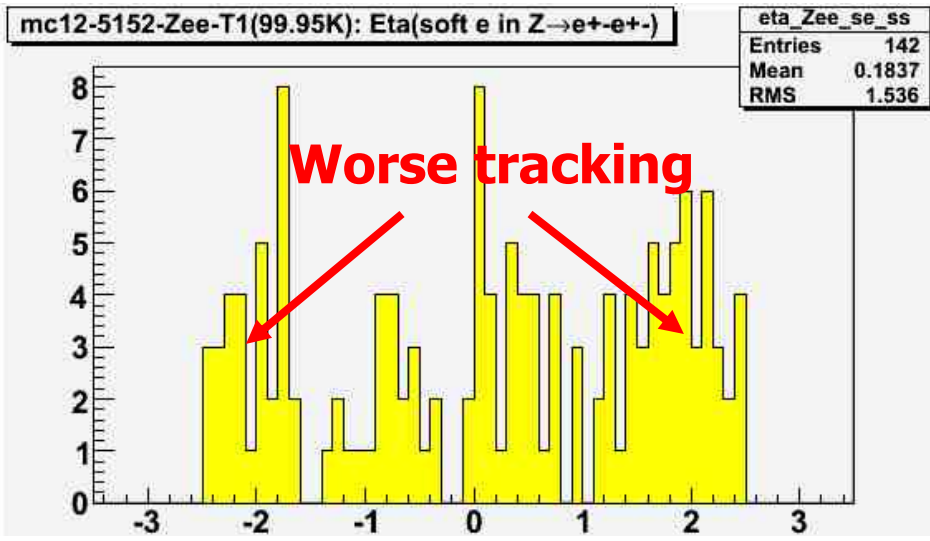
Mass of e^+e^-



Mass of $e^{\pm}e^{\pm}$

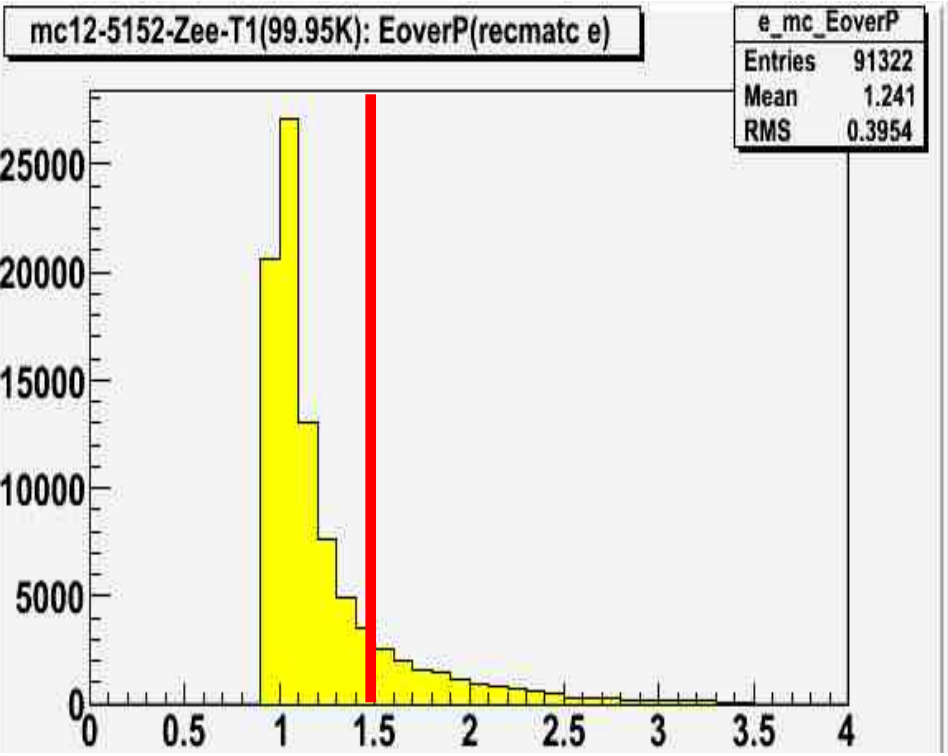


Eta of hard $e^{\pm}$

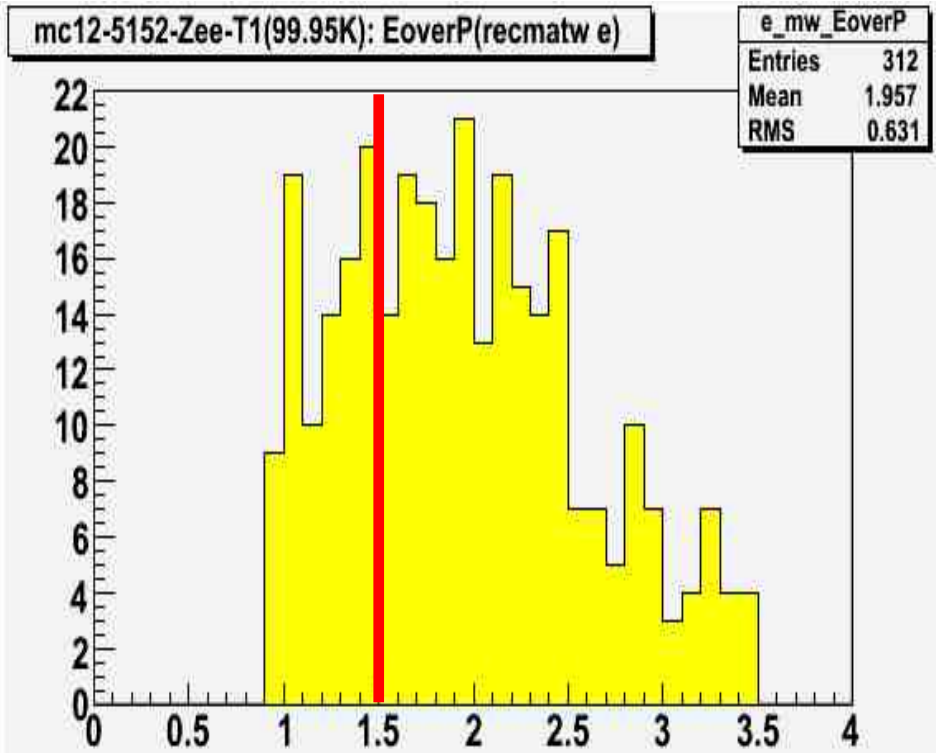


Eta of soft $e^{\pm}$

e (right/wrong Q by truth)



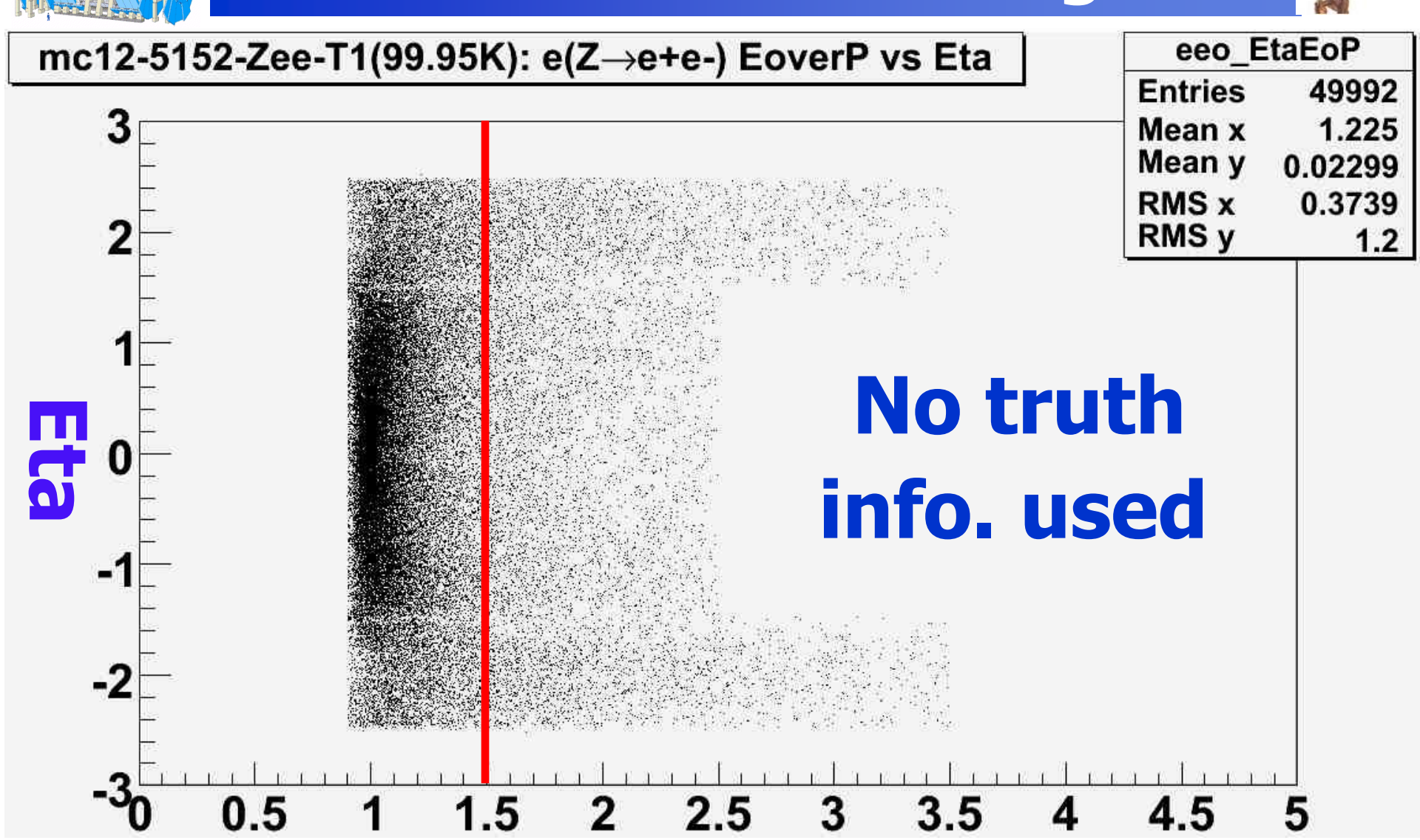
E/P (MC matched, correct Q)

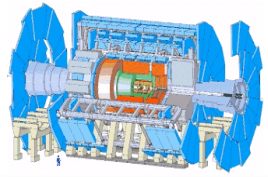


E/P (MC matched, **WRONG** Q)

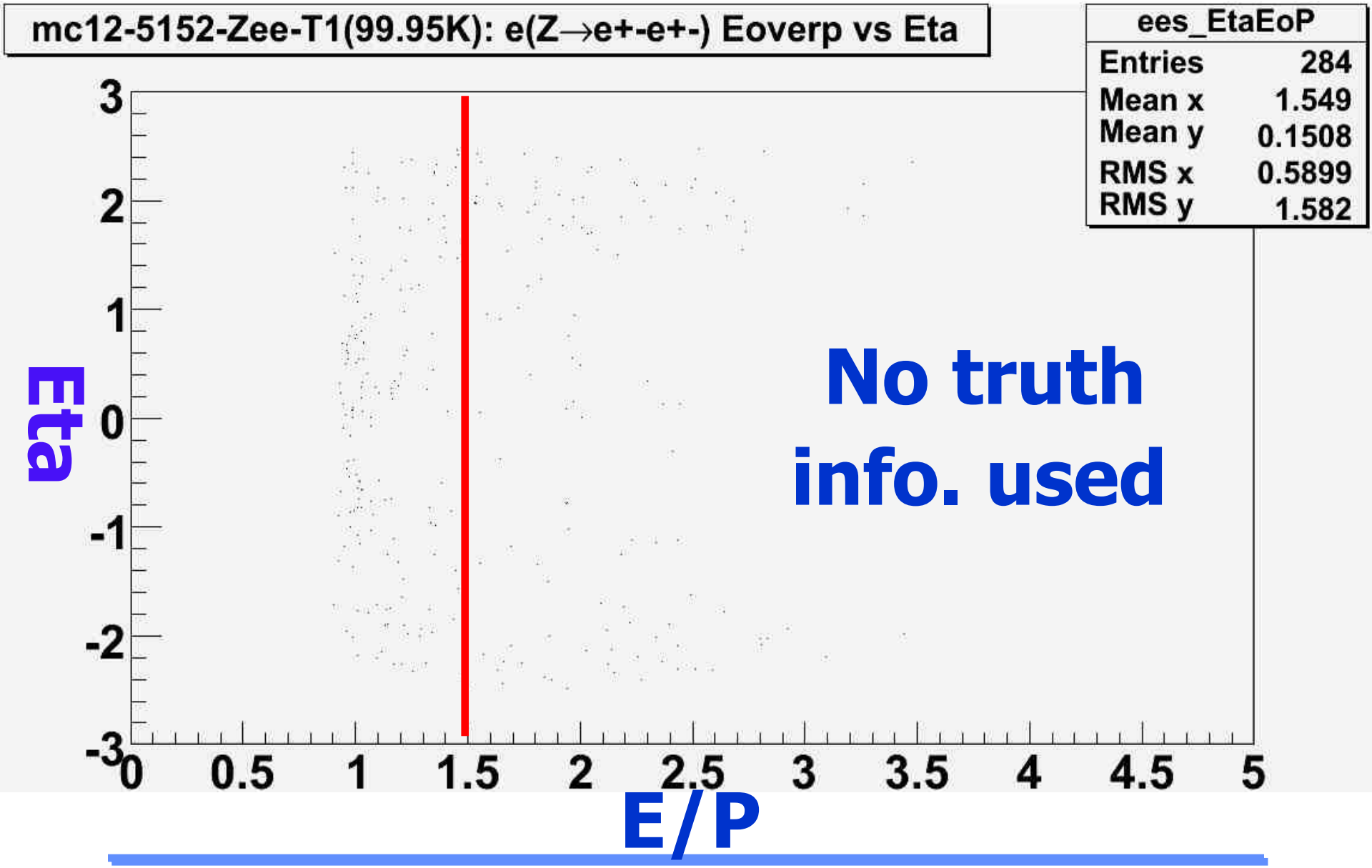
- **Charge confused electron has large E/P**
- **Consistent with Bremsstrahlung+conversion (thanks to Daniel Froidevaux, Markus Elsing)**

electrons in $Z \rightarrow e^+e^-$ signal

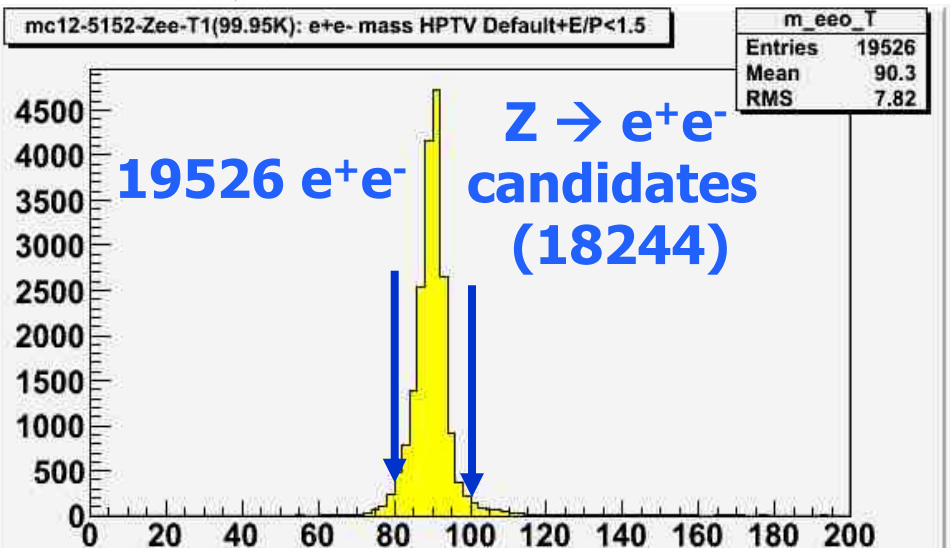


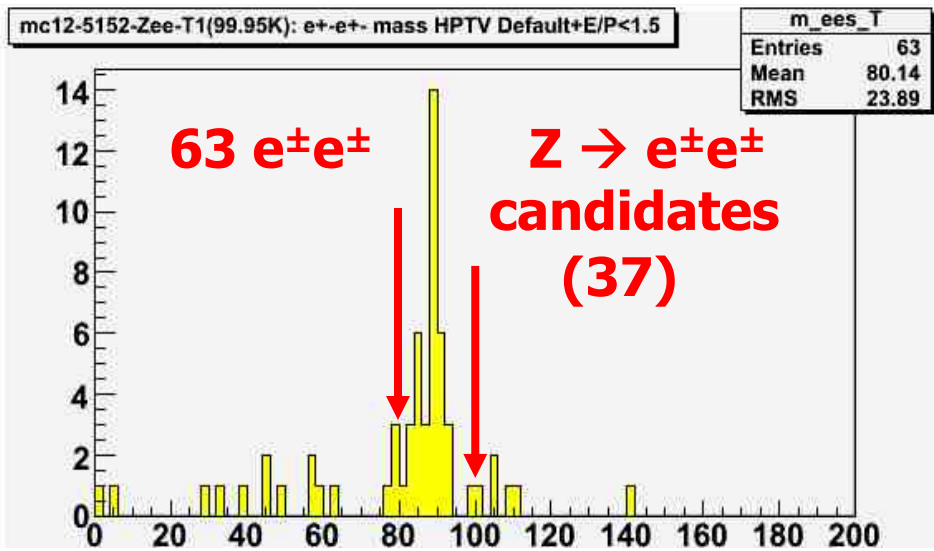


electrons in Z→$e^{\pm}e^{\pm}$ reflection



After E/P<1.5 requirement



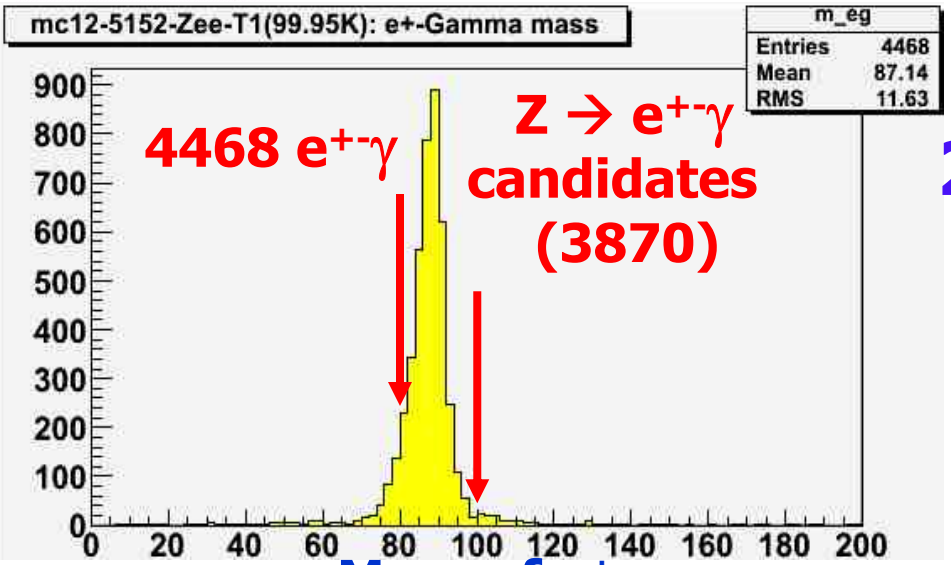


Signal Yield	HPTV default	After both e: E/P<1.5
$Z \rightarrow e^+e^-$	24996	18244
$Z \rightarrow e^{+-}e^{+-}$	142	37

e charge confusion: from 0.28% to 0.10%

Loss in electron ID efficiency: ~15%

100K $Z \rightarrow e^+e^-$ events as $e^{\pm}\gamma$



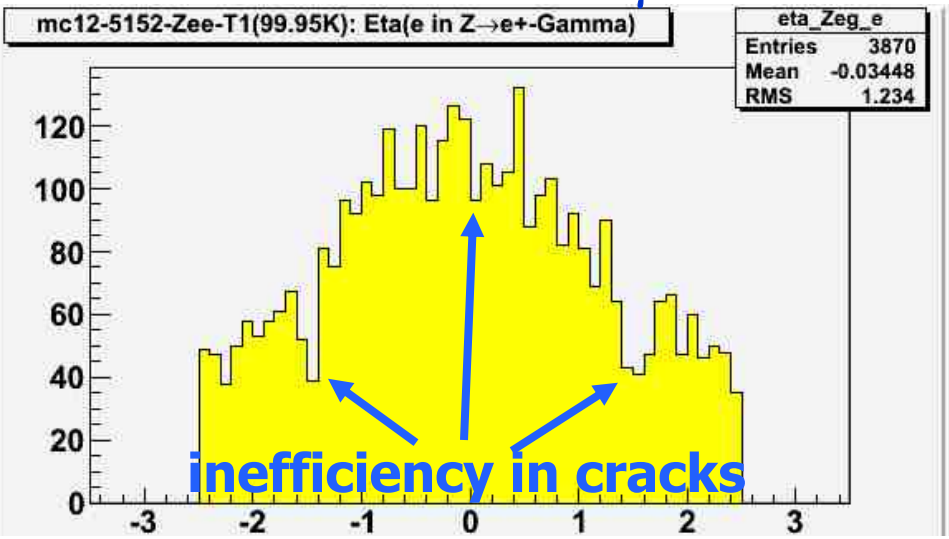
12.0.6 wth HPTV:

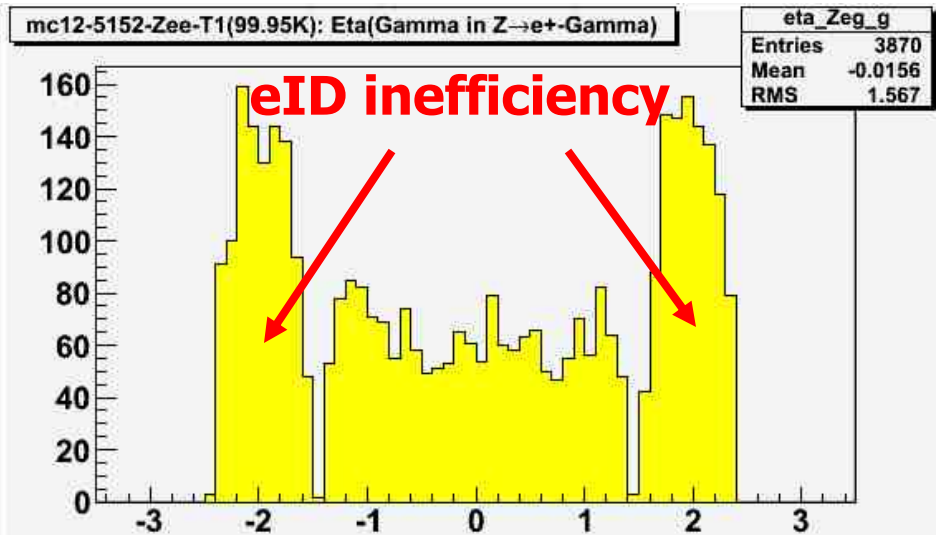
24996 $Z \rightarrow e^+e^-$ candidates

3870 $Z \rightarrow e^{\pm}\gamma$ candidates

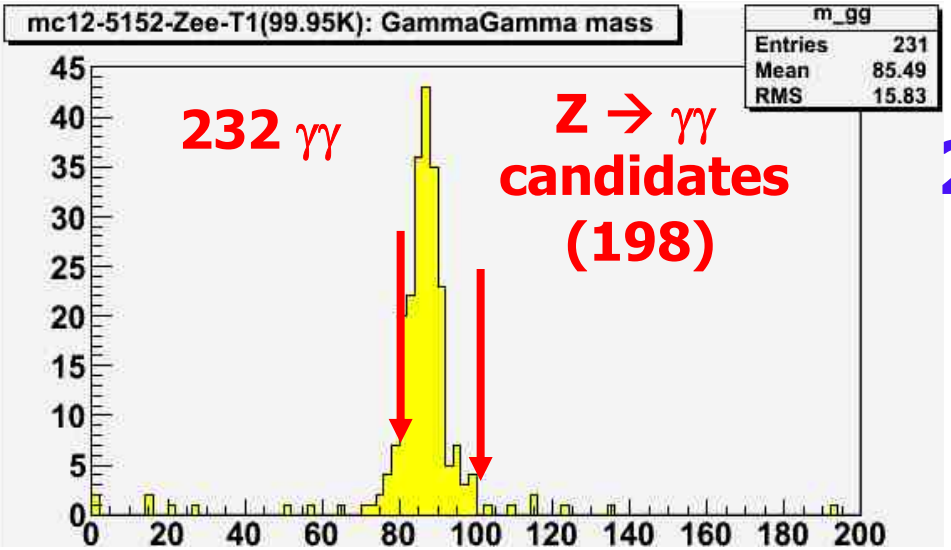
e to γ/e ID ε ~ 7.7%

(11.0.5 & EV: ~6%)





100K $Z \rightarrow e^+e^-$ events as $\gamma\gamma$



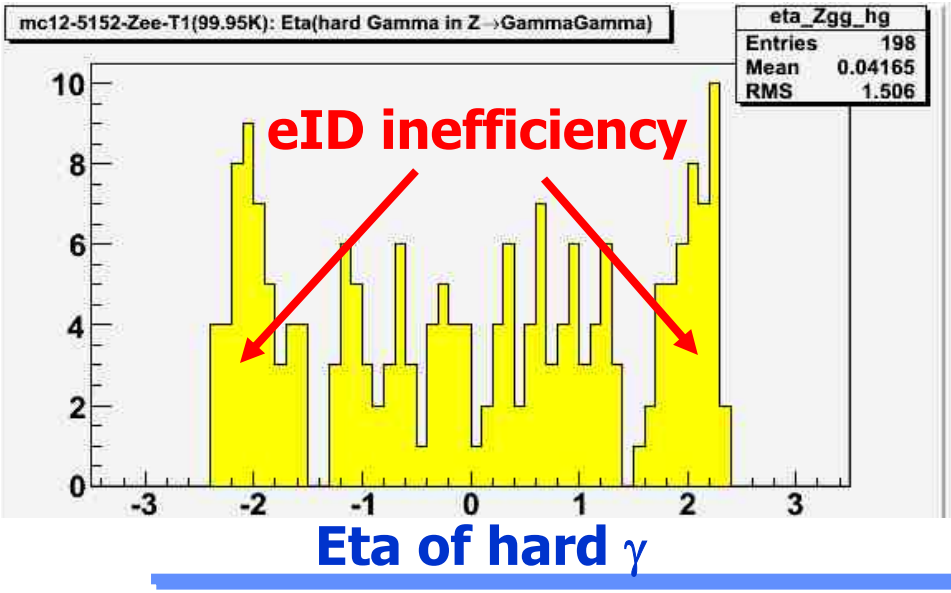
12.0.6 wth HPTV:

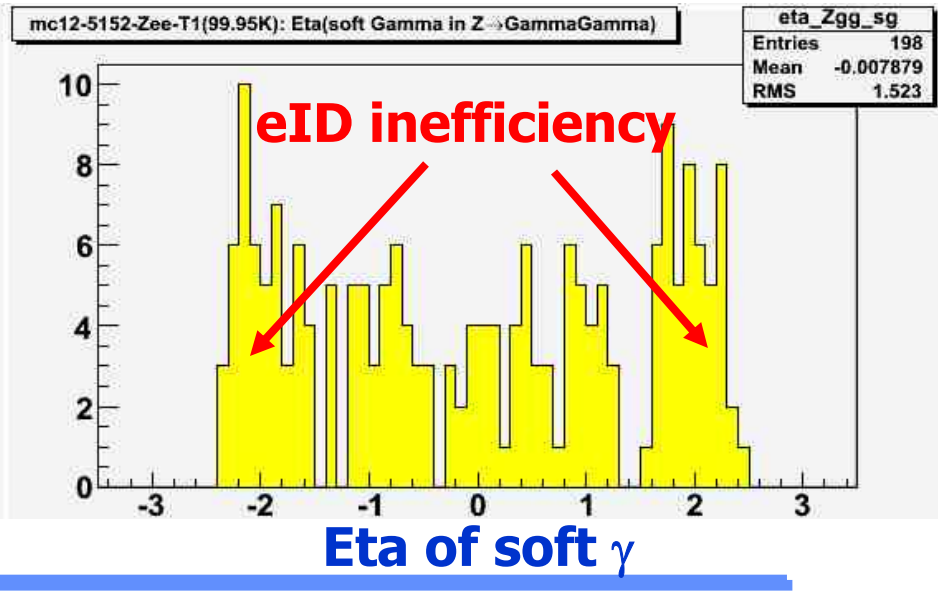
24996 $Z \rightarrow e^+e^-$ candidates

198 $Z \rightarrow \gamma\gamma$ candidates

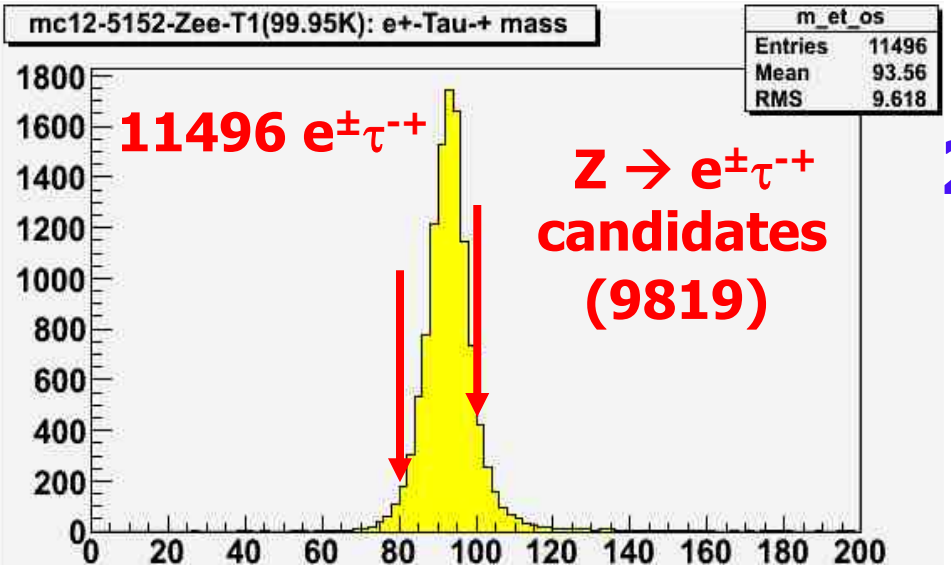
e to γ/e ID $\varepsilon \sim 8.9\%$

(11.0.5 & EV: ~6%)





100K $Z \rightarrow e^+e^-$ events as $e^{\pm}\tau^{-+}$



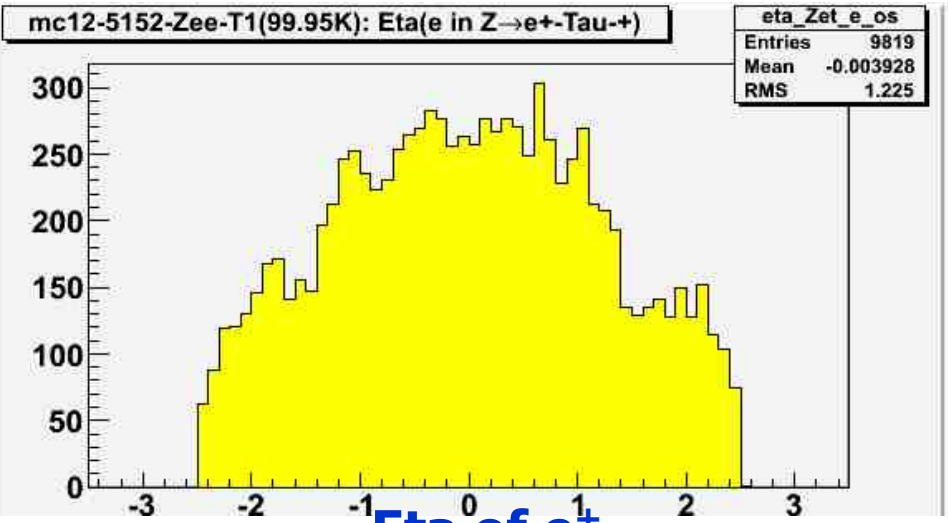
12.0.6 wth HPTV:

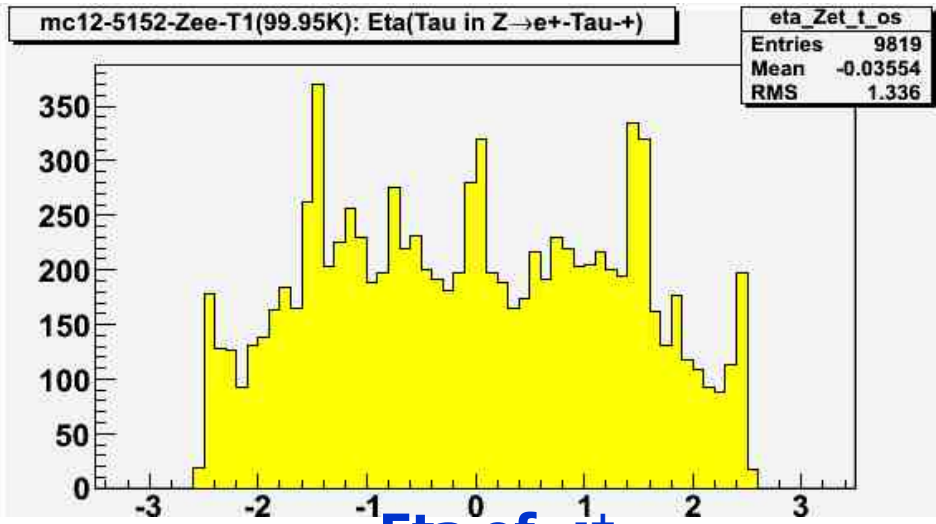
24996 $Z \rightarrow e^+e^-$ candidates

9819 $Z \rightarrow e^{\pm}\tau^{-+}$ candidates

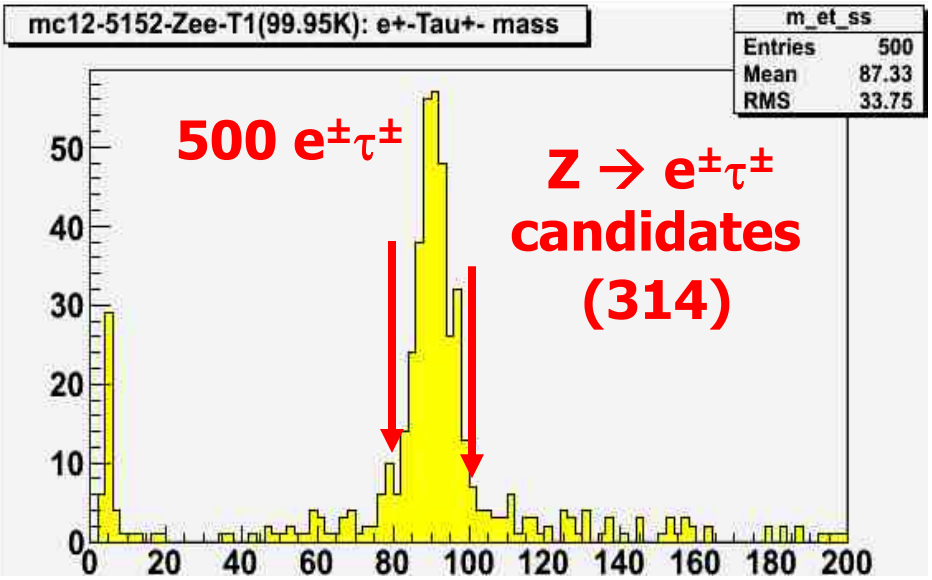
e to τ/e ID $\varepsilon \sim 19.6\%$!

(11.0.5 & EV: ~3%)





100K $Z \rightarrow e^+e^-$ events as $e^{\pm}\tau^{\pm}$



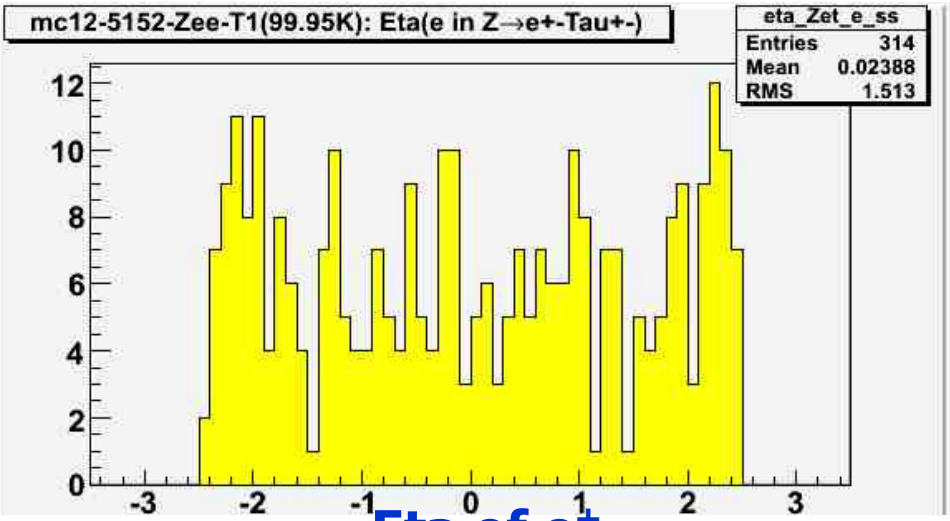
12.0.6 wth HPTV:

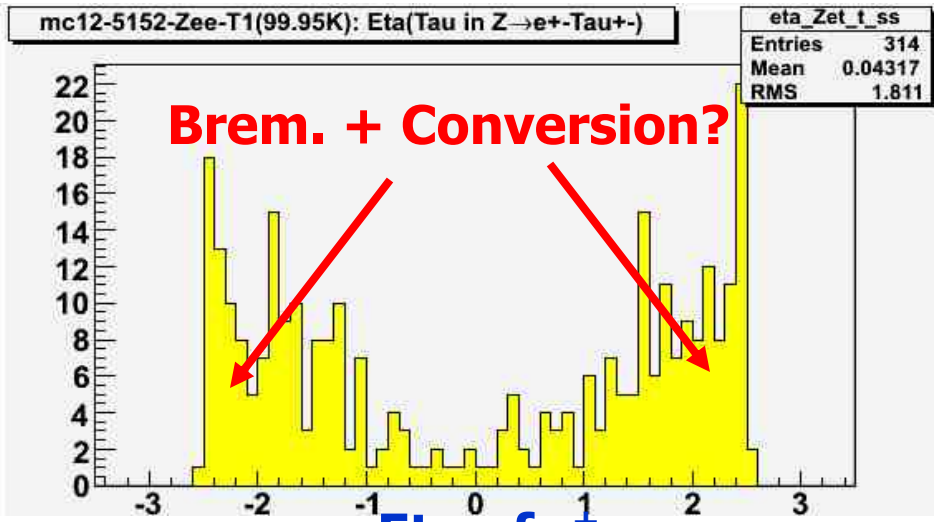
24996 $Z \rightarrow e^+e^-$ candidates

314 $Z \rightarrow e^{\pm}\tau^{\pm}$ candidates

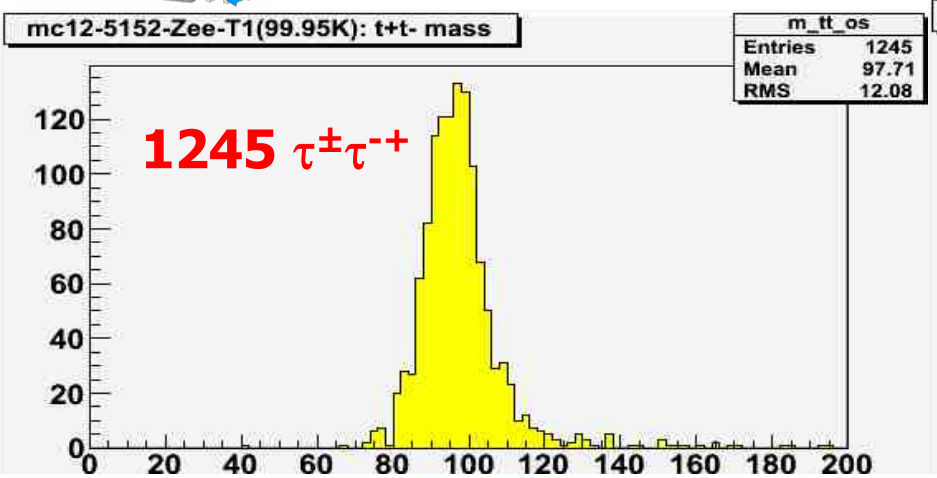
$e^{\pm}$ to τ^{-+}/e ID $\varepsilon \sim 0.6\%$

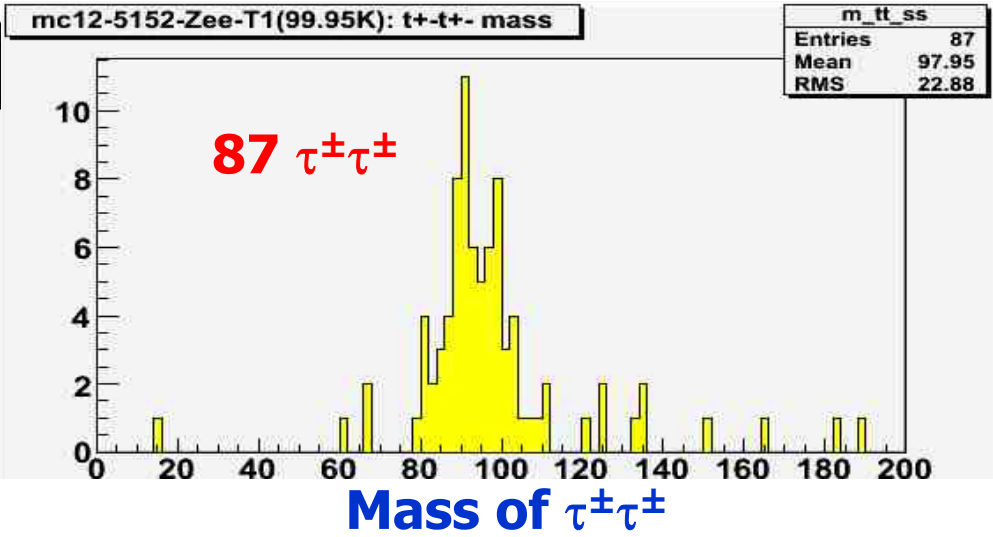
(11.0.5 & EV: negligible)





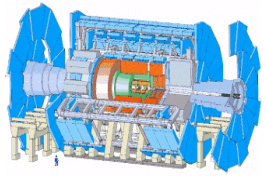
100K $Z \rightarrow e^+e^-$ as $\tau^+\tau^-$, $\tau^\pm\tau^\pm$





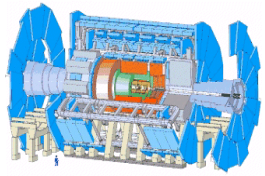
(consistent with previous reflection results)

Charge Confusion/PID Fake Rate	11.0.5 EV	12.0.6 HPTV
Electron charge confusion rate	~0.3%	~0.3%
e to γ fake rate/e ID efficiency	~6%	~8%
$e^\pm$ to $\tau^\pm$ fake rate/e ID efficiency	~3%	~20%
$e^\pm$ to τ^{-+} fake rate/e ID efficiency	negligible	~0.6%



Background study started

Sample	5152Zee	5146Ztt	5151Zmm	5802 JF17
# Events	99.95K	54.6K	99.15K	1107.9K
e^+e^-	26892	1257	0	Started
$e^{+-}e^{+-}$	210	32	0	Started
$e^{+-}\gamma$	4468	308	0	Started
$\gamma\gamma$	231	18	1	Started
$e^{+-}\tau^{-+}$	11496	386	0	Started
$e^{+-}\tau^{+-}$	500	66	0	Started
$\tau^+\tau^-$	1245	41	0	Started
$\tau^{+-}\tau^{+-}$	87	13	1	Started
$\mu^+\mu^-$	2	2810	47971	Started
$\mu^{+-}\mu^{+-}$	1	46	75	Started



Summary/Future Work

PID fake rates with 12.0.6 & HPTV

- e charge confusion rate can be reduced by ~ factor of 3 with ~15% loss in e efficiency
- slightly higher e to γ but much higher e to τ fake rates in 12.0.6 HPTV than 11.0.5 EV (advice/suggestions from experts needed)
- Talk at H → $\gamma\gamma$ CSC note meeting last Friday
- Detailed Background/Trigger study started. Lot more work/results expected soon

Thank F. Tarrade, S. Ye, H. Ma, K. Cranmer