

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

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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$ $M_{ll} > 60\text{GeV}$	0.48
$Z \rightarrow e^+e^-$ $\sigma \sim 1500 \text{ pb}$	Pythia5144 140,000 evts	1 e: Pt>10GeV, $ \eta < 2.7$ $M_{ll} > 60\text{GeV}$	0.86
$H \rightarrow \gamma\gamma$ $\sigma \sim 0.06 \text{ pb}$	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$ $M_{ll} > 60\text{GeV}$	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

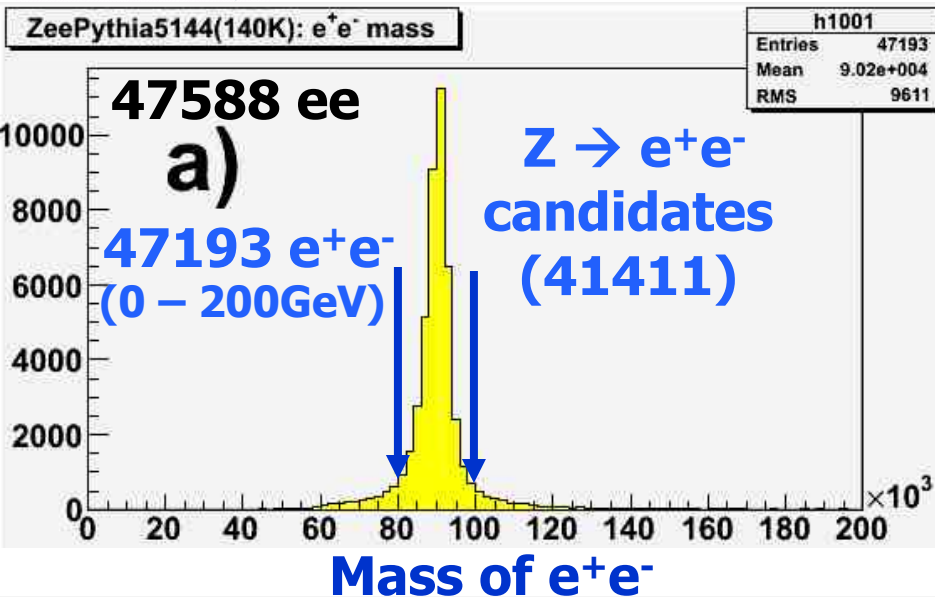
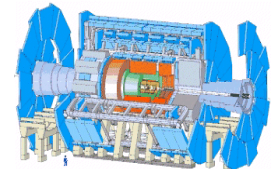
This talk: **e fake rates from 140K $Z \rightarrow e^+e^-$ ($\sim 100\text{pb}^{-1}$)**

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 $e\gamma$	1.0540	1.0210	0.0014	0.0324	0.8793
3,627 $e\tau$	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 $e\mu$	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

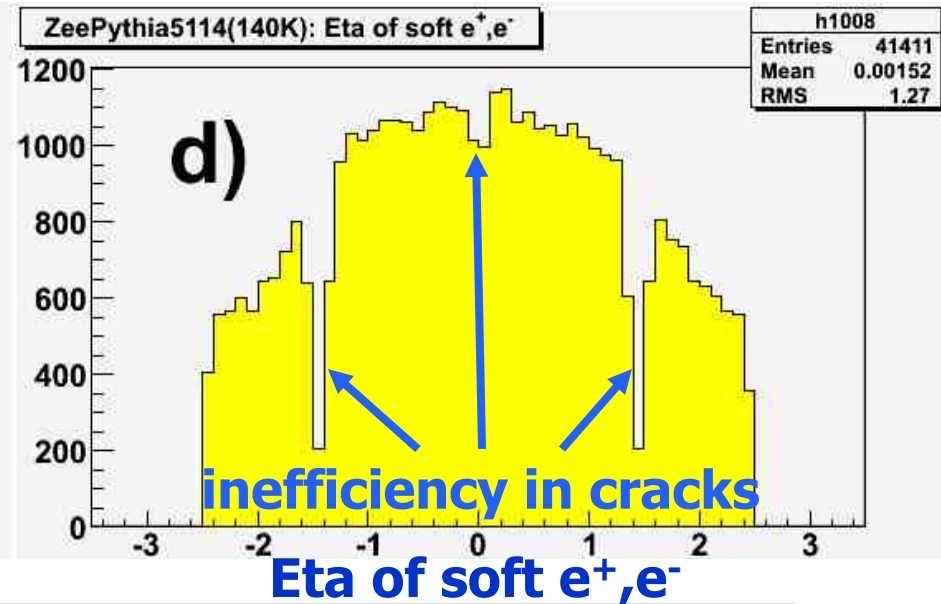
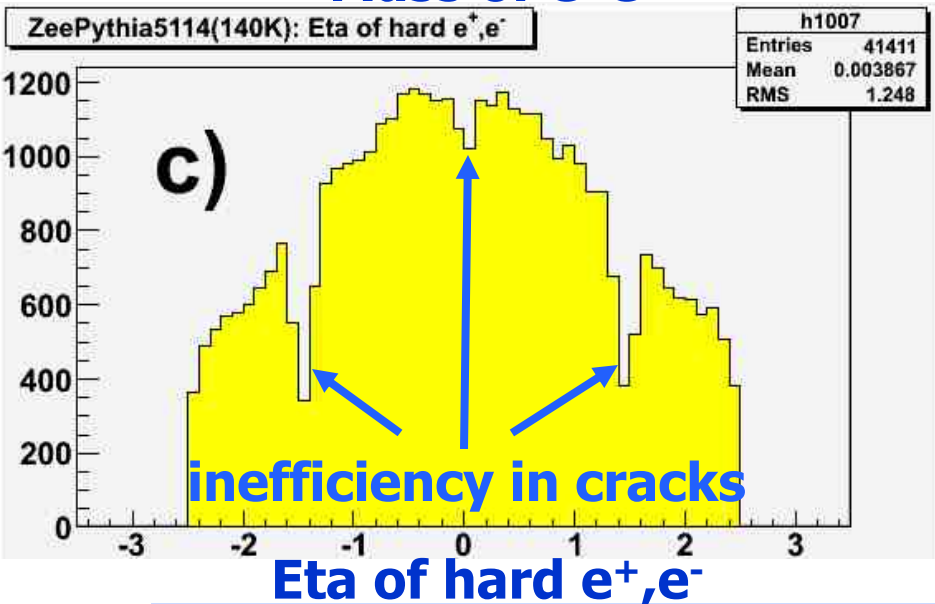
140K $Z \rightarrow e^+e^-$ events as e^+e^-



Sample/Selection:

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

41411 $Z \rightarrow e^+e^-$ candidates
($\sim 25.4\%$ pass full cuts)

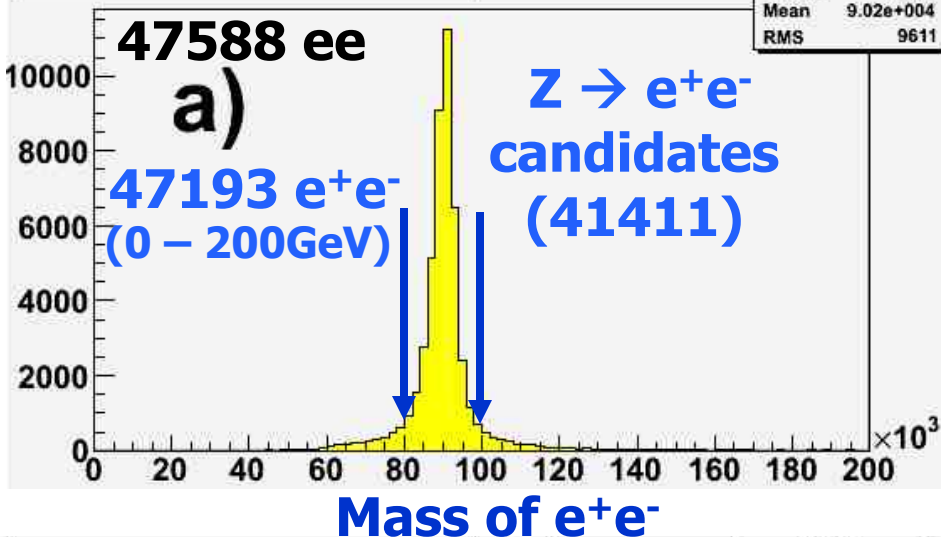


140K $Z \rightarrow e^+e^-$ events as $e^\pm e^\pm$



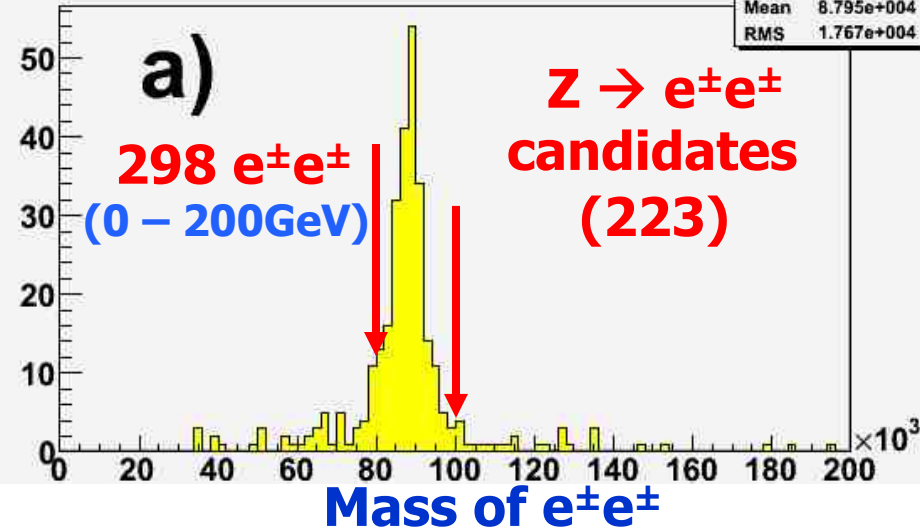
ZeePythia5144(140K): e^+e^- mass

h1001	
Entries	47193
Mean	9.02e+004
RMS	9611



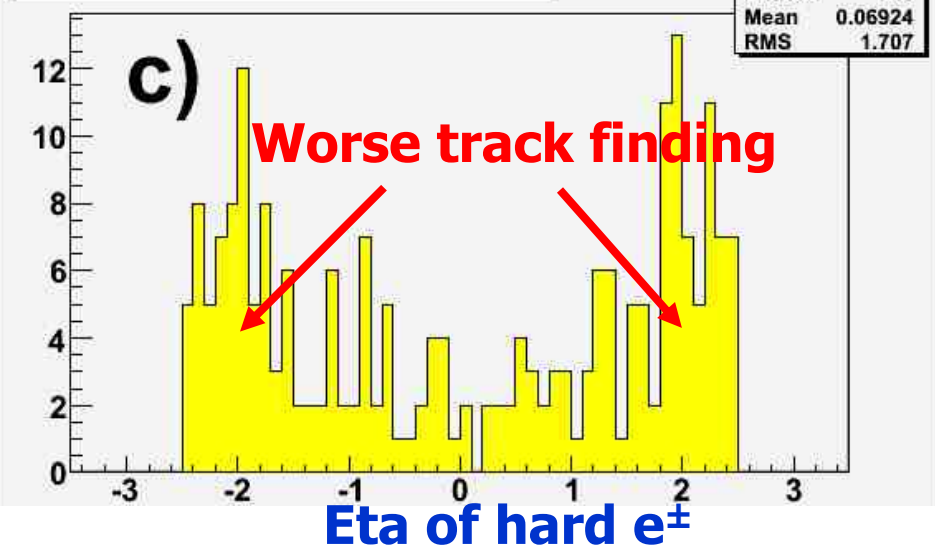
ZeePythia5114(140K): $e^\pm e^\pm$ mass

h1001	
Entries	298
Mean	8.795e+004
RMS	1.767e+004



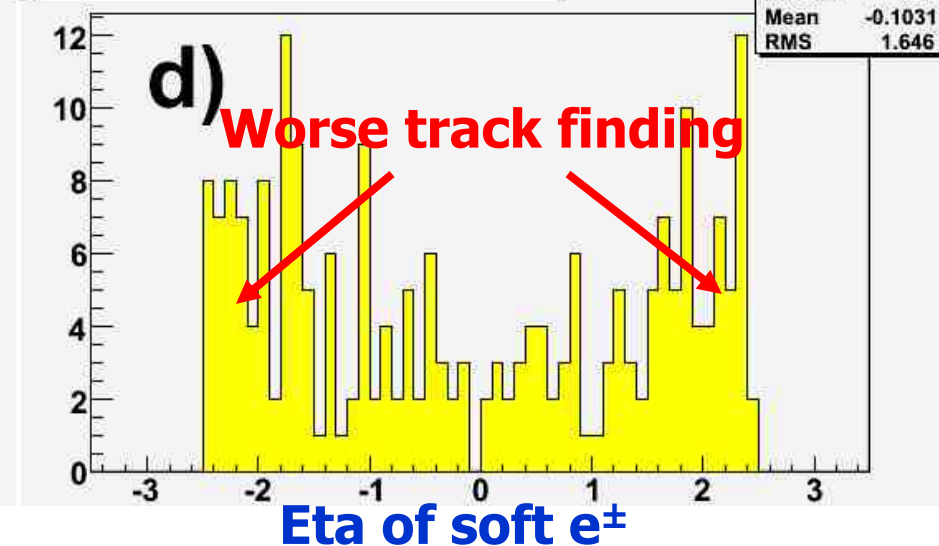
ZeePythia5114(140K): Eta of hard e^+, e^-

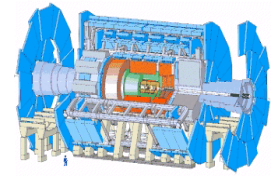
h1007	
Entries	223
Mean	0.06924
RMS	1.707



ZeePythia5114(140K): Eta of soft e^+, e^-

h1008	
Entries	223
Mean	-0.1031
RMS	1.646





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



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

Total of 47,193 e^+e^- pairs among which

41,411 pairs are between 80 and 100 GeV

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

Measure e charge confusion rate from real data

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

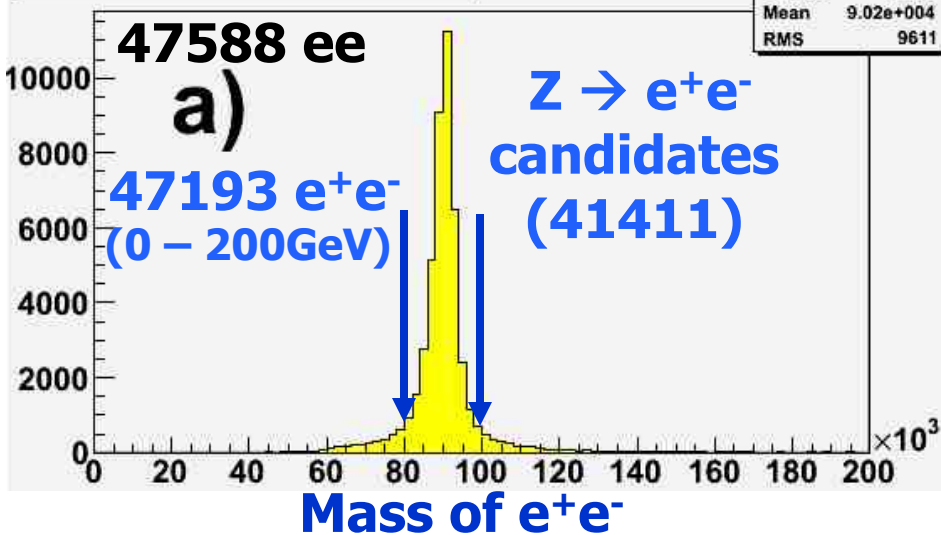
- **Impact NP searches with $l^\pm l^\pm$: Exotic/SUSY/..**

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



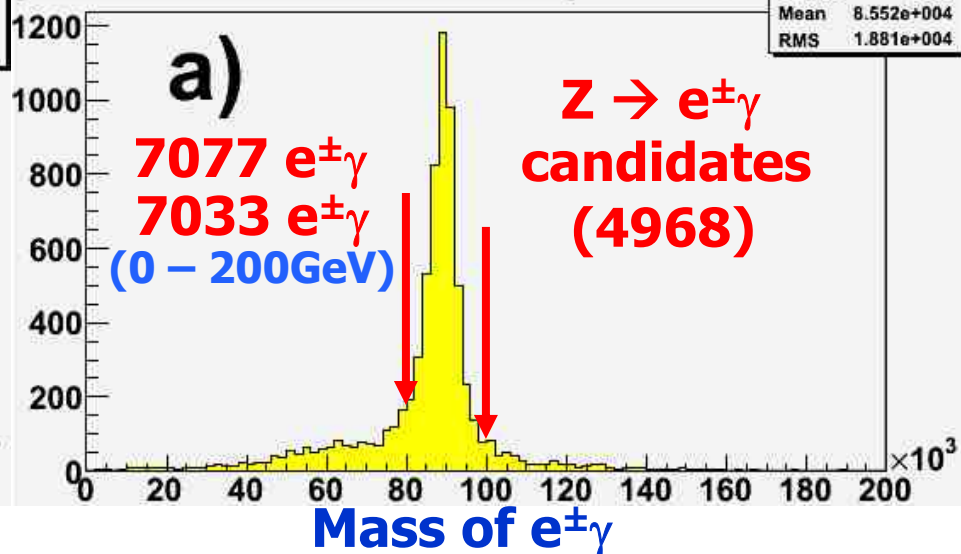
ZeePythia5144(140K): e^+e^- mass

h1001	
Entries	47193
Mean	9.02e+004
RMS	9611



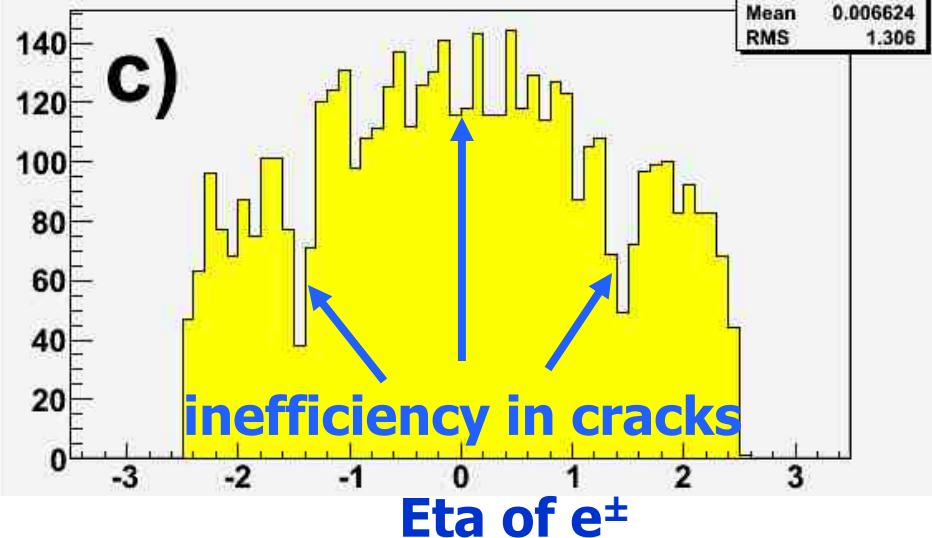
ZeePythia5114(140K): $e^\pm\gamma$ mass

h1001	
Entries	7033
Mean	8.552e+004
RMS	1.881e+004



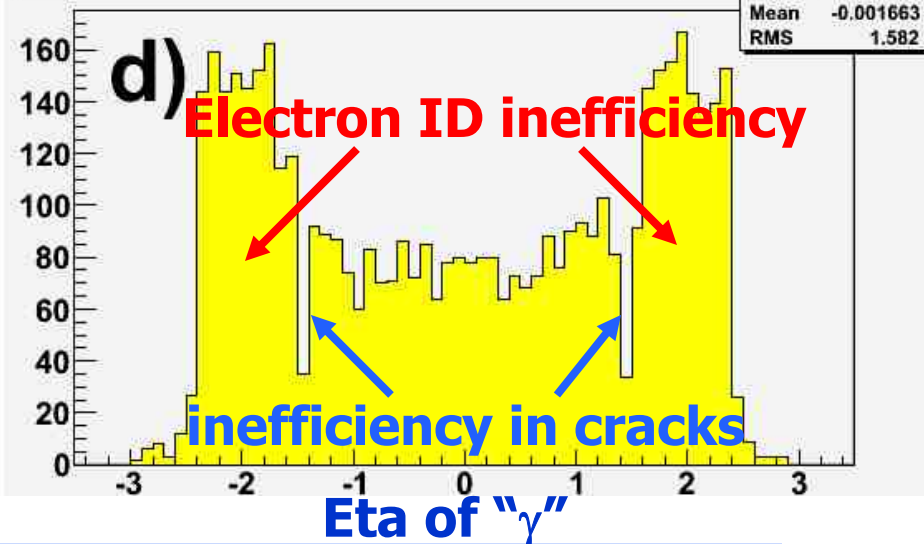
ZeePythia5114(140K): Eta of e^\pm in $Z \rightarrow e^\pm\gamma$

h1007	
Entries	4968
Mean	0.006624
RMS	1.306



ZeePythia5114(140K): Eta of Gamma in $Z \rightarrow e^\pm\gamma$

h1008	
Entries	4968
Mean	-0.001663
RMS	1.582





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



- **140K $Z \rightarrow e^+e^-$ events ($\sim 100\text{pb}^{-1}$ 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.**

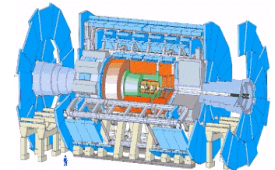
Measure e to γ fake rate from real LHC data

e to γ fake rate/e ID efficiency $\sim 6.0\%$

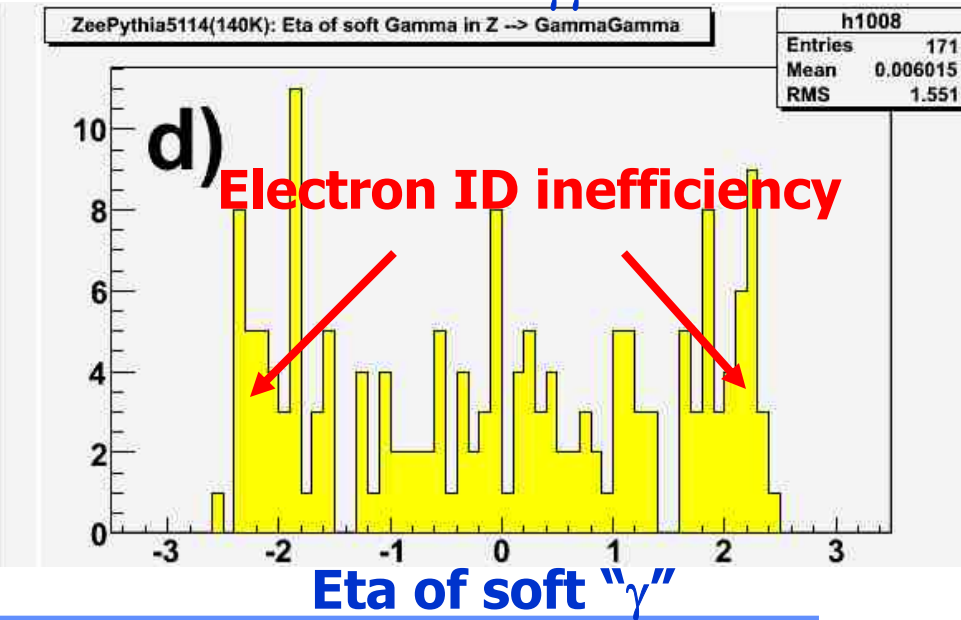
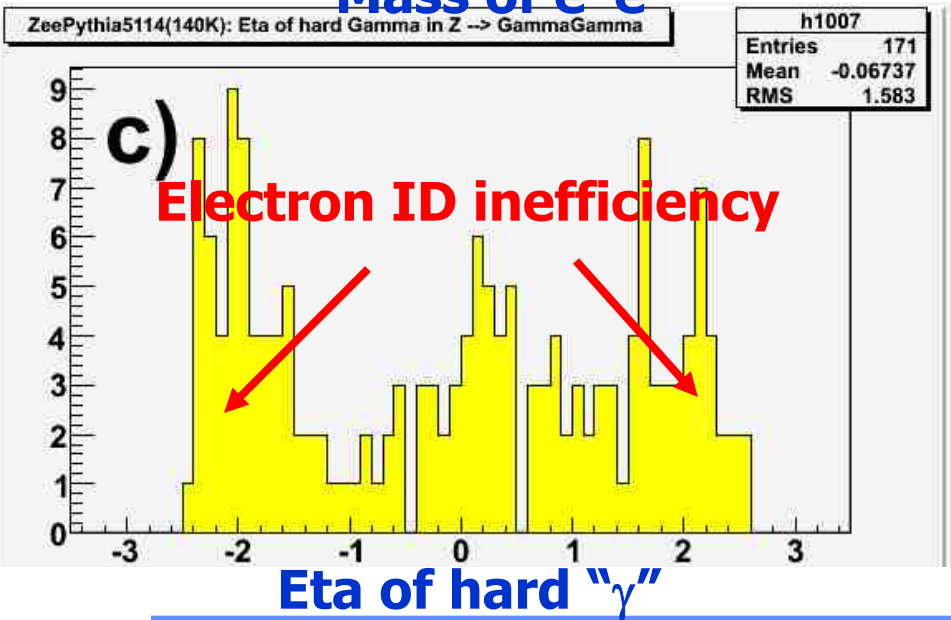
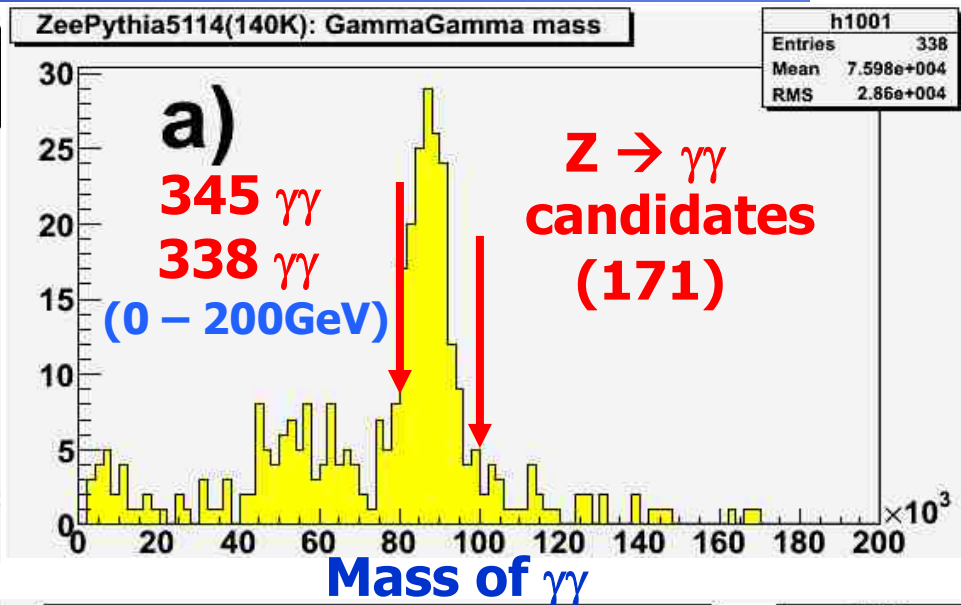
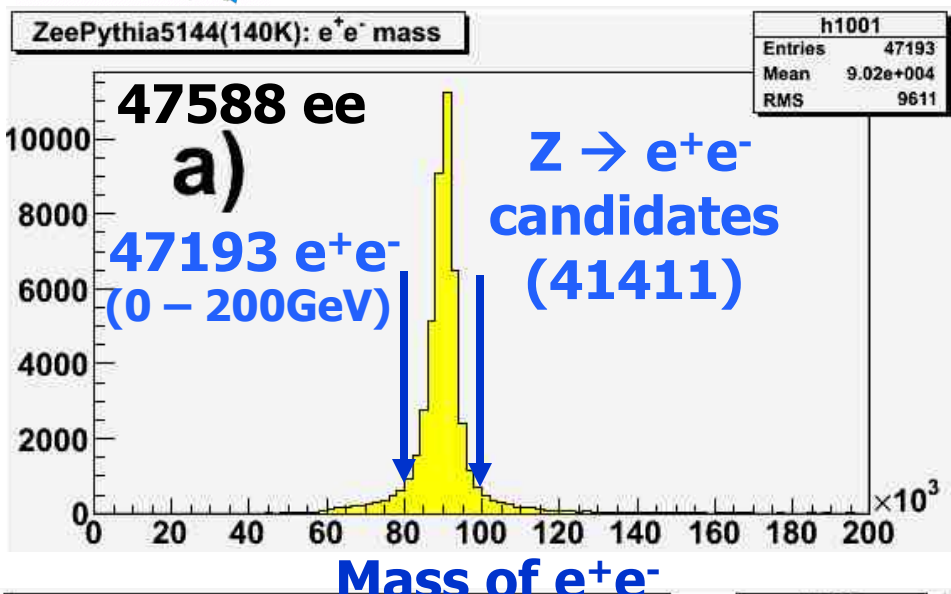
(ATLAS Technical Design Report: 0.2%)

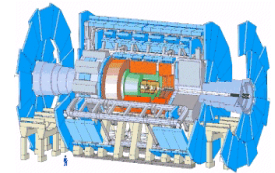
Fake γ from e: Serious BKG in NP search with γ :

e.g. $H \rightarrow \gamma\gamma$ (most important Higgs channel)



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





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



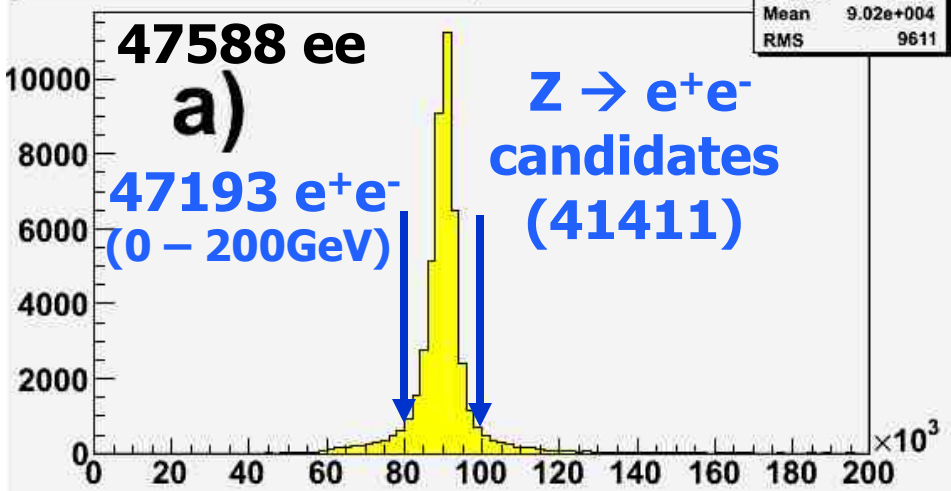
- **140K $Z \rightarrow e^+e^-$ events ($\sim 100 \text{pb}^{-1}$ ATLAS data):**
Total 338 $\gamma\gamma$ pairs with 171 bw 80 and 100GeV
(comparing with 41,411 e^+e^- pairs):
- Small/clean $\gamma\gamma$ reflection peak at Z mass
- $Z \rightarrow \gamma\gamma$ (" σ " ~ 6 pb) \gg expected $H \rightarrow \gamma\gamma$ signal
- Yield/location/width of $Z \rightarrow \gamma\gamma$ and Data/MC differences: **systematics uncertainties in $H \rightarrow \gamma\gamma$**
Excellent calibration mode for $H \rightarrow \gamma\gamma$
e to γ fake rate/e ID efficiency $\sim 6.4\%$
(consistent with 6.0% $e^\pm\gamma$ reflection results)

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



ZeePythia5144(140K): e^+e^- mass

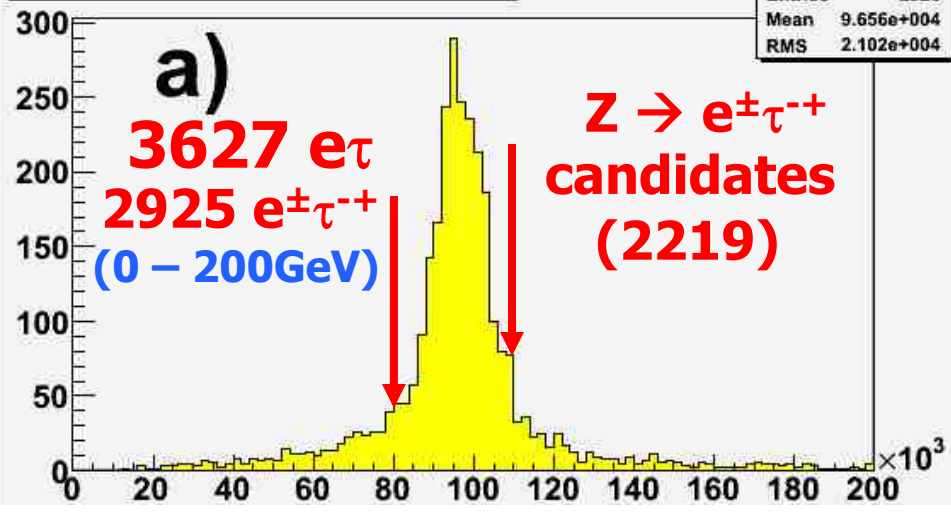
h1001
Entries 47193
Mean 9.02e+004
RMS 9611



Mass of e^+e^-

ZeePythia5114(140K): $e^+\tau^+$ mass

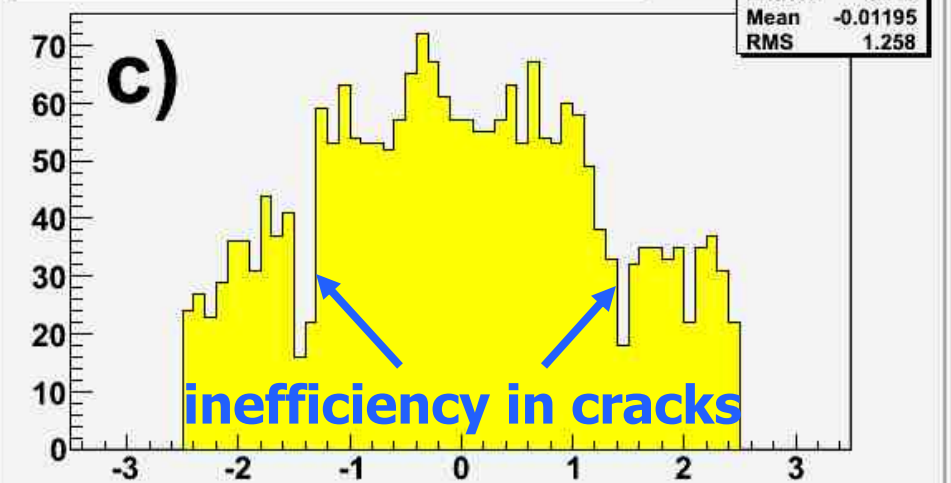
h1001
Entries 2925
Mean 9.656e+004
RMS 2.102e+004



Mass of $e^\pm\tau^\mp$

ZeePythia5114(140K): Eta of e^\pm in $Z \rightarrow e^+\tau^+$

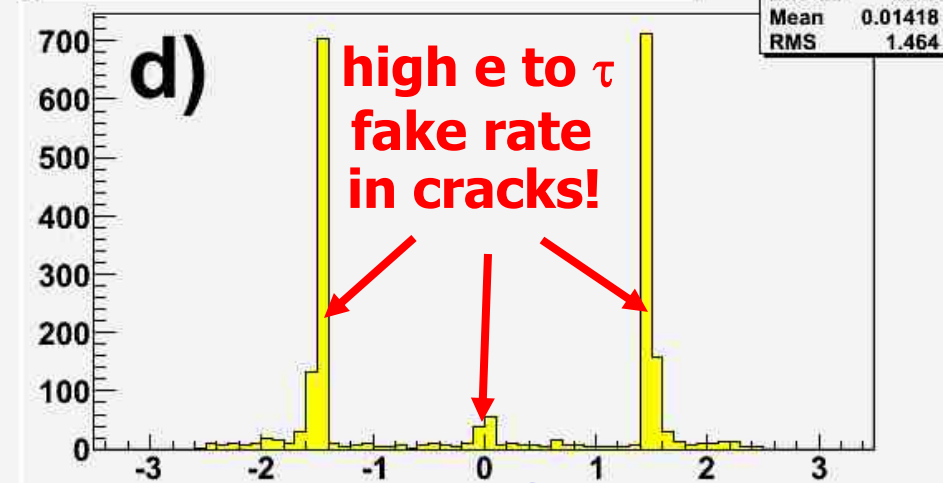
h1007
Entries 2219
Mean -0.01195
RMS 1.258



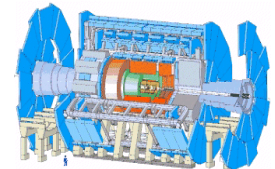
Eta of e^\pm

ZeePythia5114(140K): Eta of τ^\pm in $Z \rightarrow e^+\tau^+$

h1008
Entries 2219
Mean 0.01418
RMS 1.464



Eta of τ^\mp



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

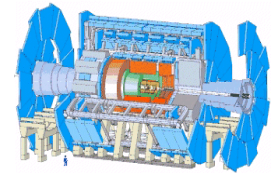


- Large $e^\pm\tau^{\mp+}$ reflection peak $\sim 95\text{GeV}$: 2925 $e^\pm\tau^{\mp+}$ pairs with 2,219 bw 80 and 110GeV (comparing 41,411 e^+e^- pairs)

Measure e to τ fake rate from real ATLAS data

- e to τ fake rate/e ID efficiency: $\sim 2.7\%$
- e to τ fake happens mostly in the cracks!
- Software improvements essential!

- Impact NP searches with τ : Higgs/SUSY/...



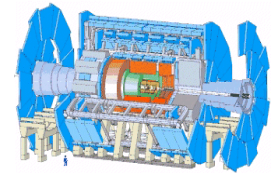
Results with 11.0.5



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

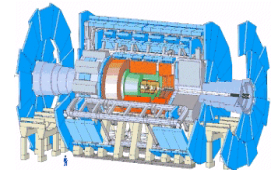
- **trig1_misal1...12.0.6.6...AANT1** (1mm fixed)
- **Tau ID: TauRec, Muon ID: MuID**

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

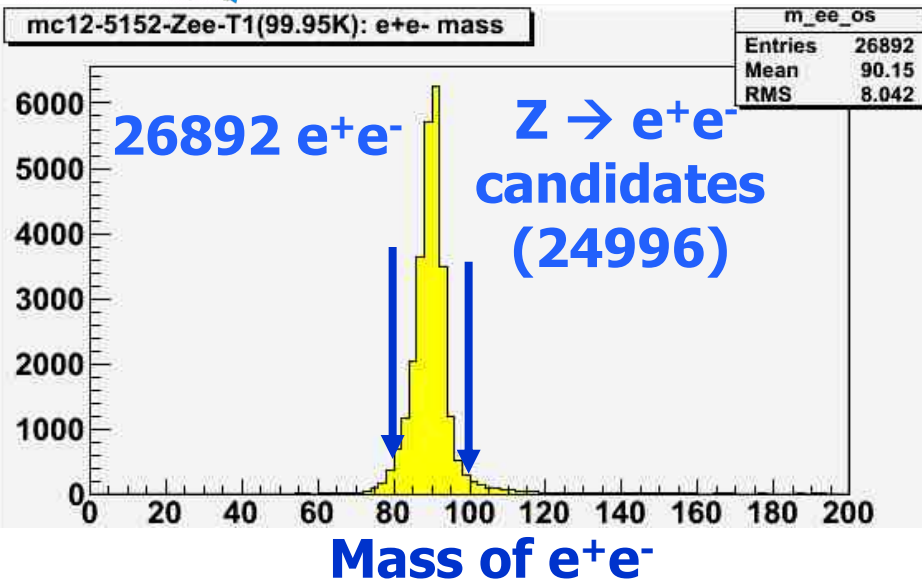
(Ready soon)

(Ready soon)

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



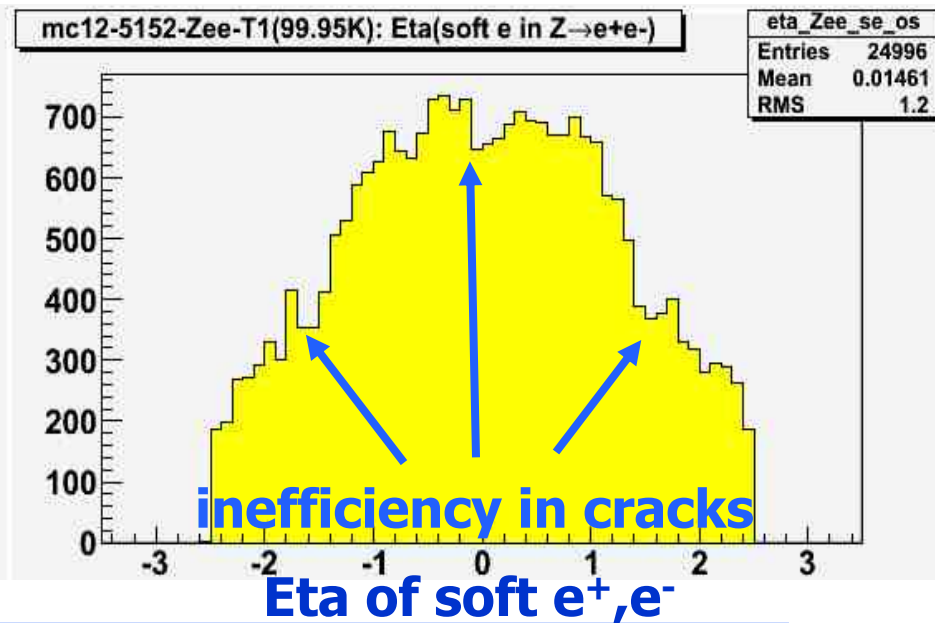
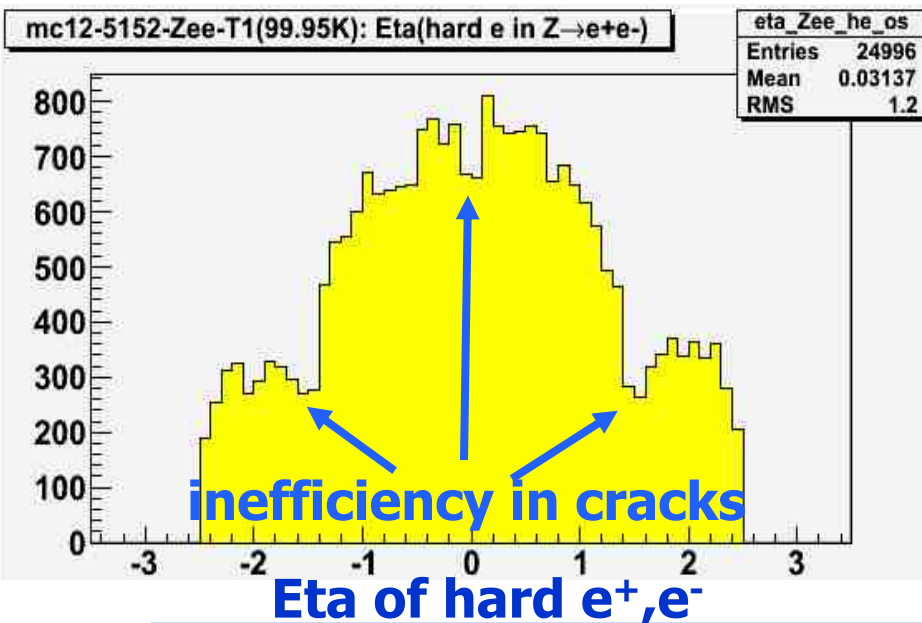
100K $Z \rightarrow e^+e^-$ events as e^+e^-

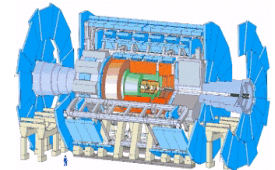


Sample/Selection:

$\sim 100\text{K } Z \rightarrow e^+e^-$ (5152)
 ($\sim 70\text{pb}^{-1}$)

24996 $Z \rightarrow e^+e^-$ candidates
 ($\sim 19.3\%$ pass full cuts)



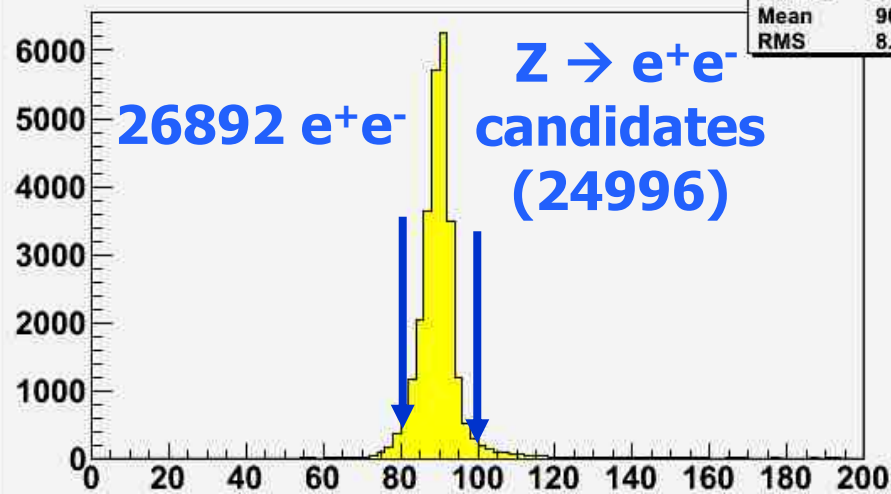


100K $Z \rightarrow e^+e^-$ events as $e^\pm e^\pm$



mc12-5152-Zee-T1(99.95K): e+e- mass

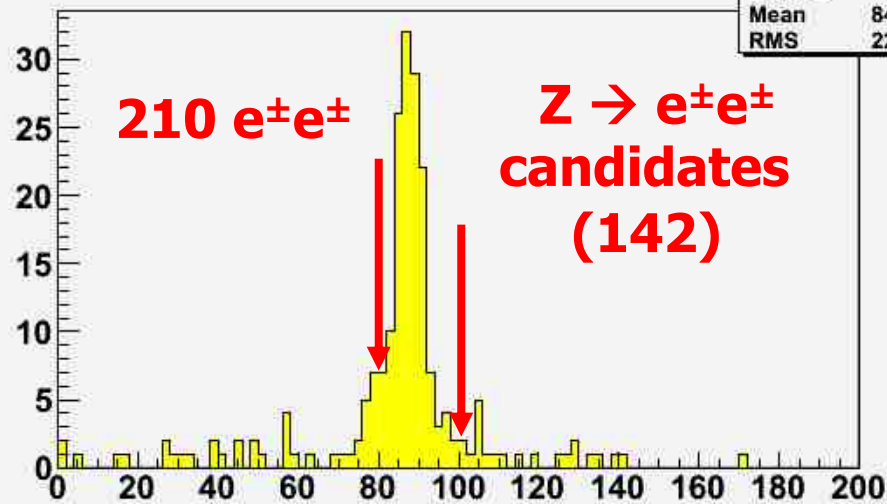
m_ee_os	
Entries	26892
Mean	90.15
RMS	8.042



Mass of e^+e^-

mc12-5152-Zee-T1(99.95K): e+-e+- mass

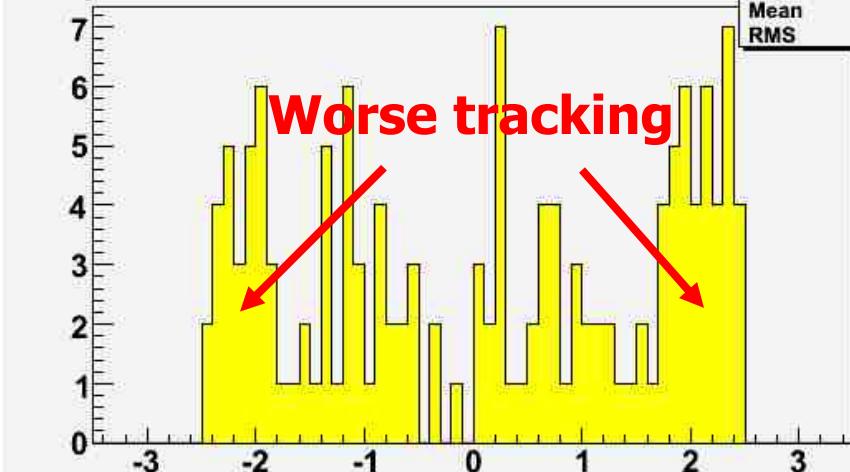
m_ee_ss	
Entries	210
Mean	84.43
RMS	22.06



Mass of $e^\pm e^\pm$

mc12-5152-Zee-T1(99.95K): Eta(hard e in $Z \rightarrow e^+e^-$)

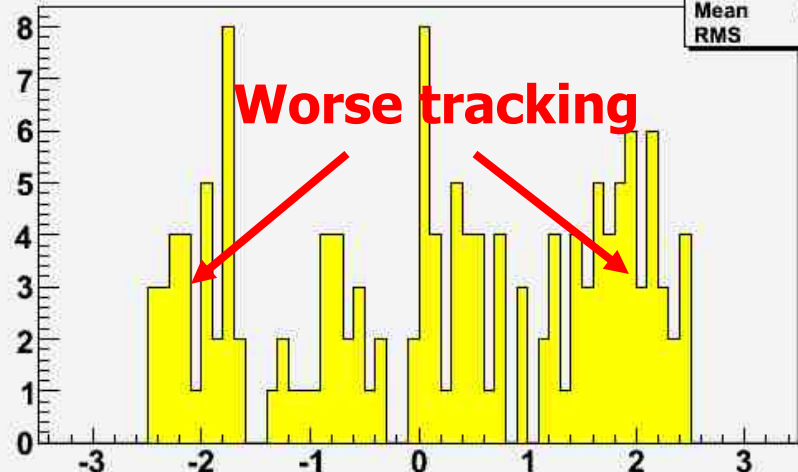
eta_Zee_he_ss	
Entries	142
Mean	0.118
RMS	1.625



Eta of hard e^\pm

mc12-5152-Zee-T1(99.95K): Eta(soft e in $Z \rightarrow e^+e^-$)

eta_Zee_se_ss	
Entries	142
Mean	0.1837
RMS	1.536



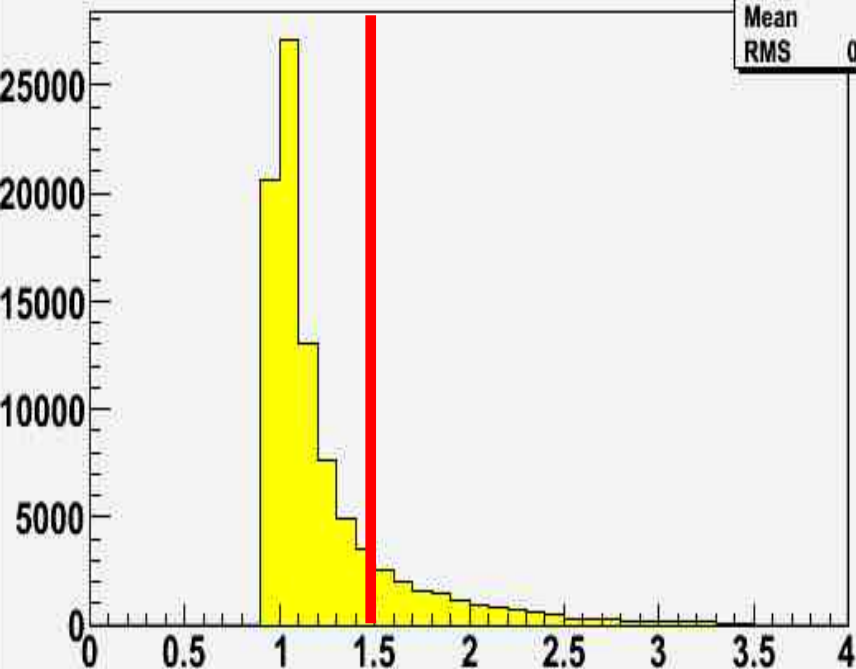
Eta of soft e^\pm

e (right/wrong Q by truth)



mc12-5152-Zee-T1(99.95K): EoverP(recmatc e)

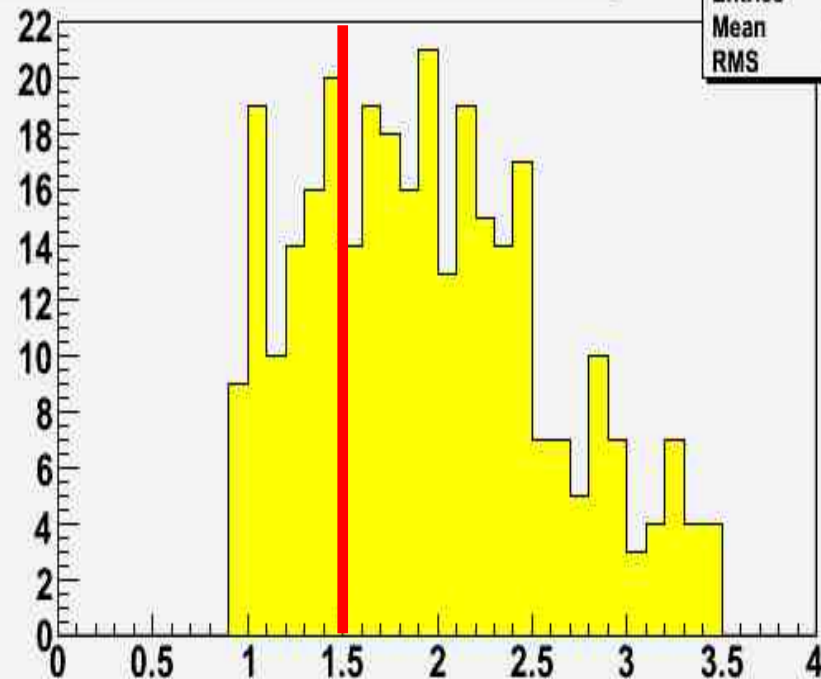
e_mc_EoverP	
Entries	91322
Mean	1.241
RMS	0.3954



E/P (MC matched, correct Q)

mc12-5152-Zee-T1(99.95K): EoverP(recmatw e)

e_mw_EoverP	
Entries	312
Mean	1.957
RMS	0.631



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

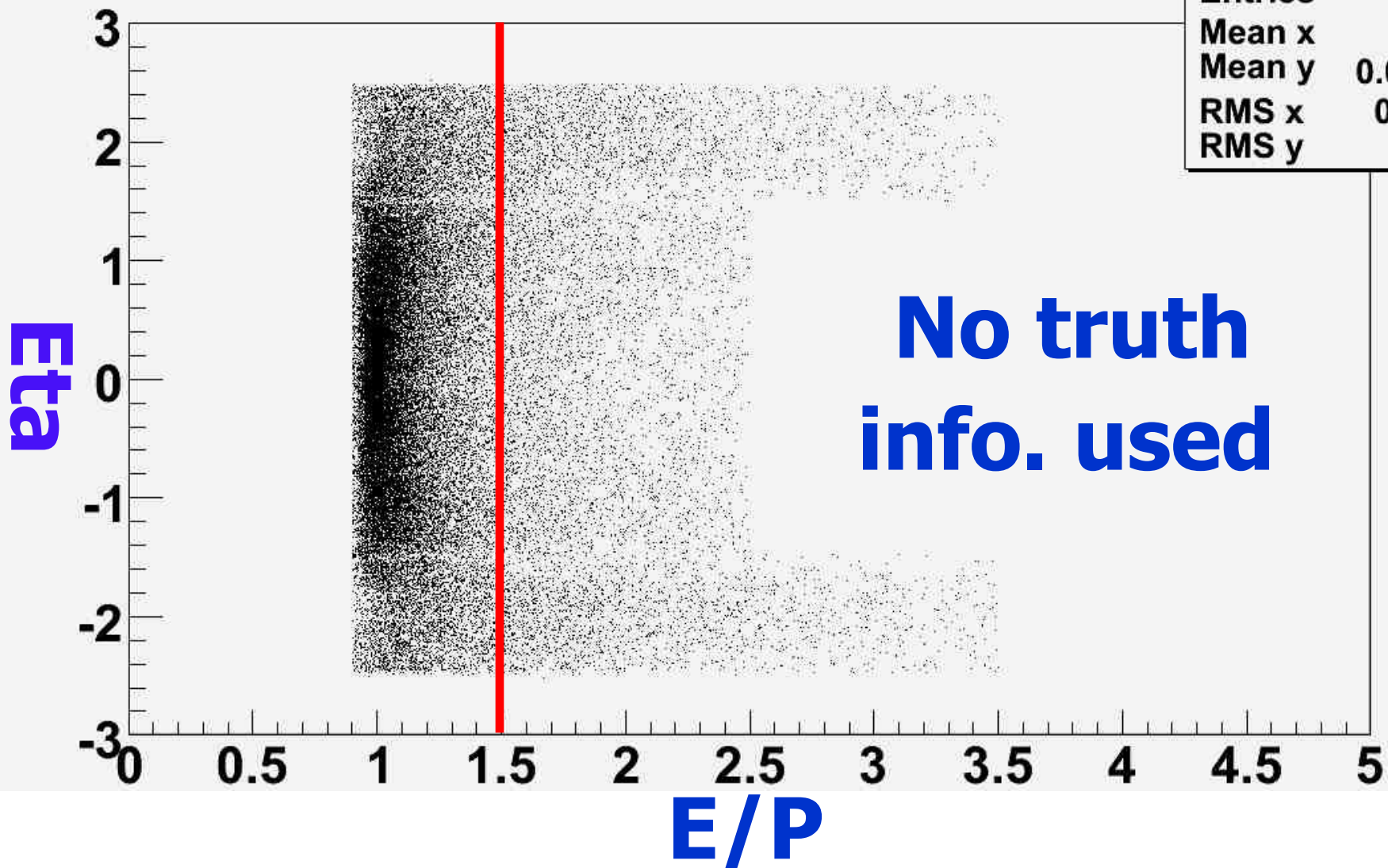
- **Charge confused electron has large E/P**
- **Consistent with Bremsstrahlung+conversion**
(thanks to Daniel Froidevaux, Markus Elsing)

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



mc12-5152-Zee-T1(99.95K): e($Z \rightarrow e^+e^-$) EoverP vs Eta

eeo_EtaEoP	
Entries	49992
Mean x	1.225
Mean y	0.02299
RMS x	0.3739
RMS y	1.2

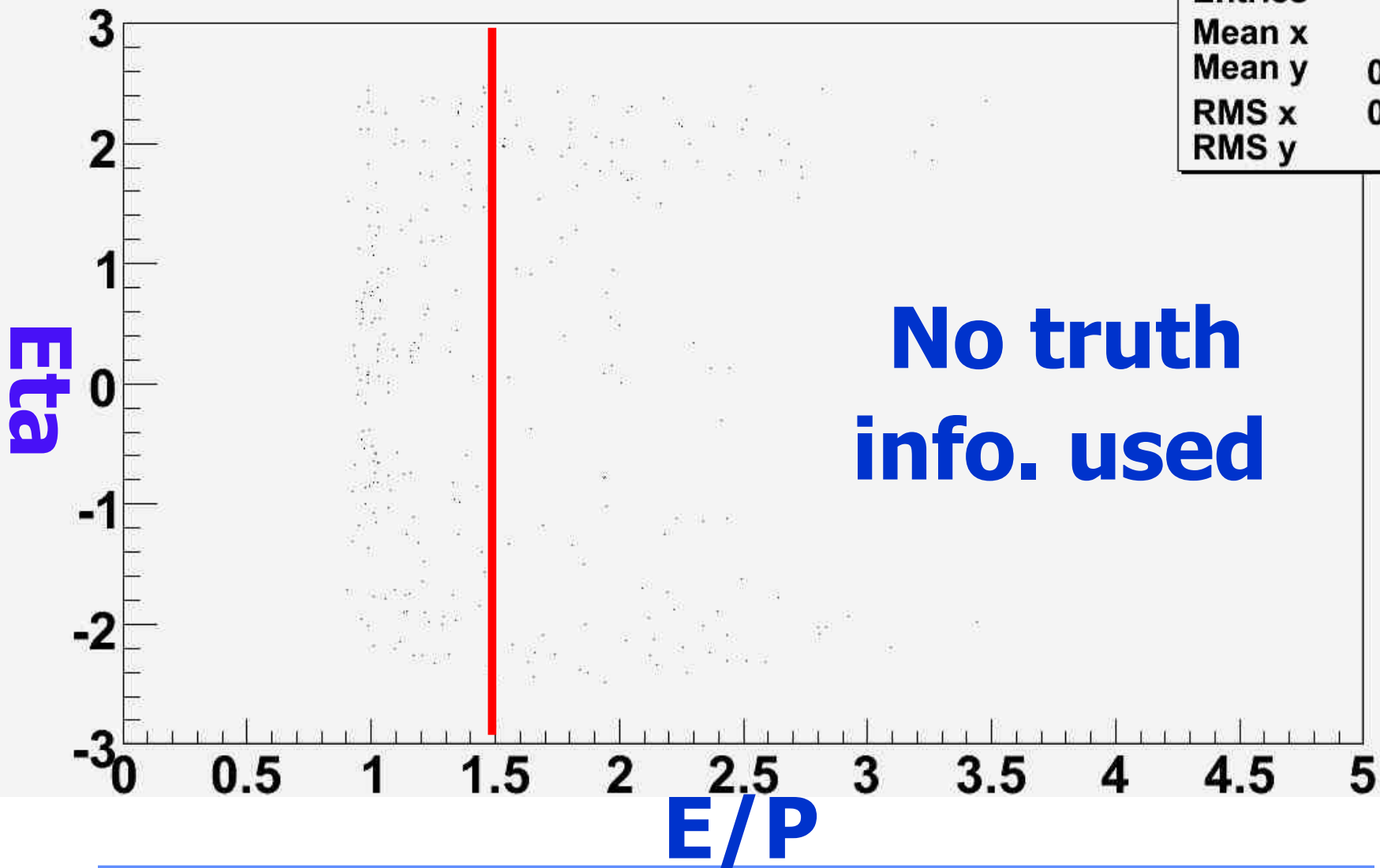


electrons in $Z \rightarrow e^\pm e^\pm$ reflection

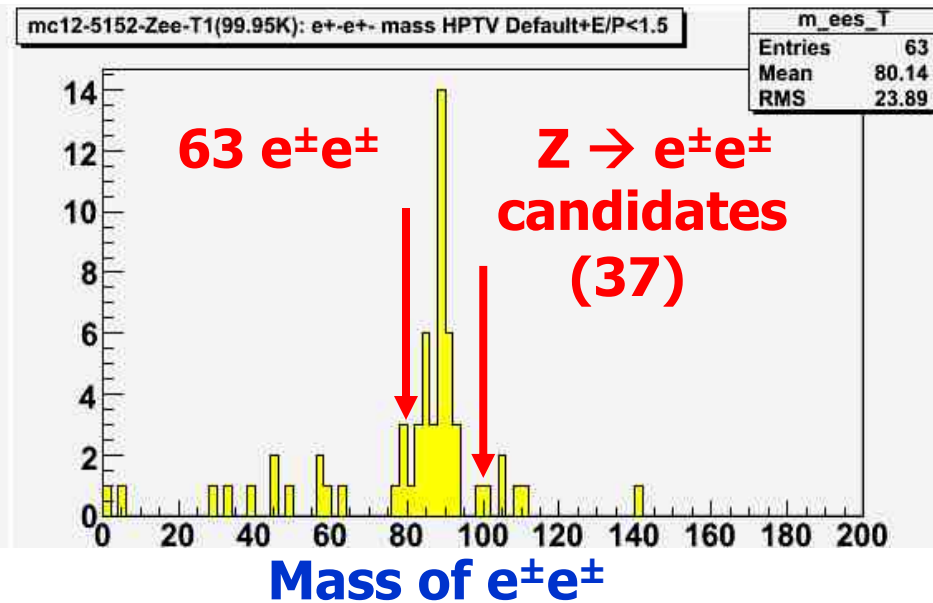
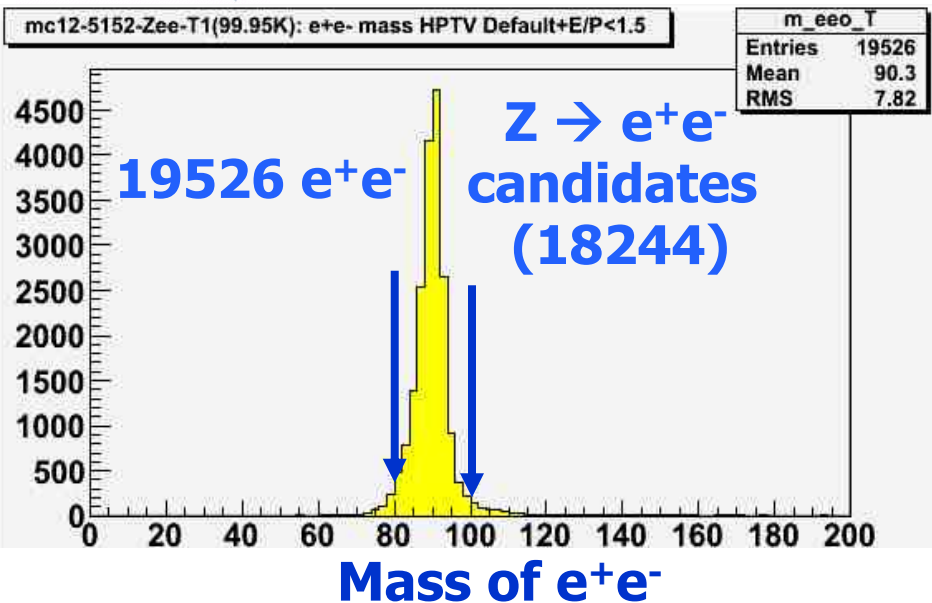


mc12-5152-Zee-T1(99.95K): e($Z \rightarrow e^+e^-$) Eoverp vs Eta

ees_EtaEoP	
Entries	284
Mean x	1.549
Mean y	0.1508
RMS x	0.5899
RMS y	1.582



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

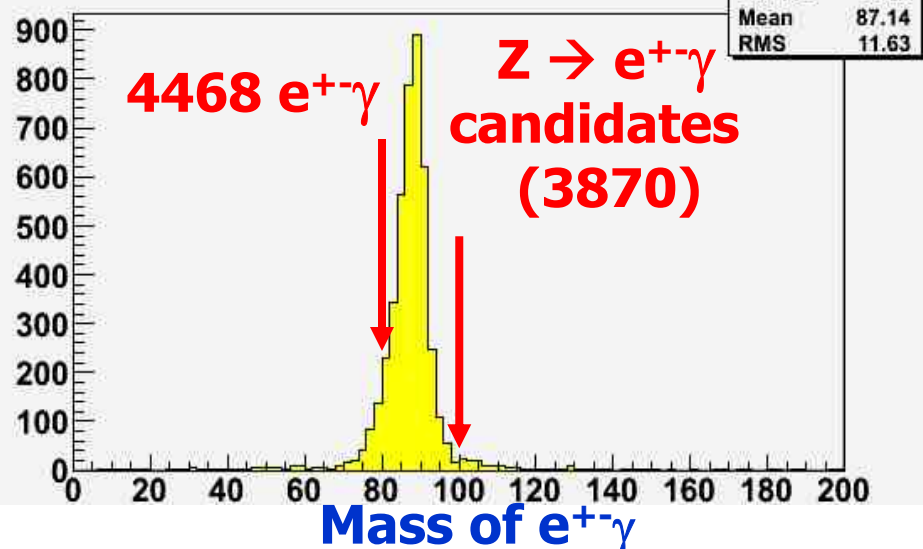
e charge confusion: from 0.28% to 0.10%

Loss in electron ID efficiency: $\sim 15\%$

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



mc12-5152-Zee-T1(99.95K): e+-Gamma mass



12.0.6 wth HPTV:

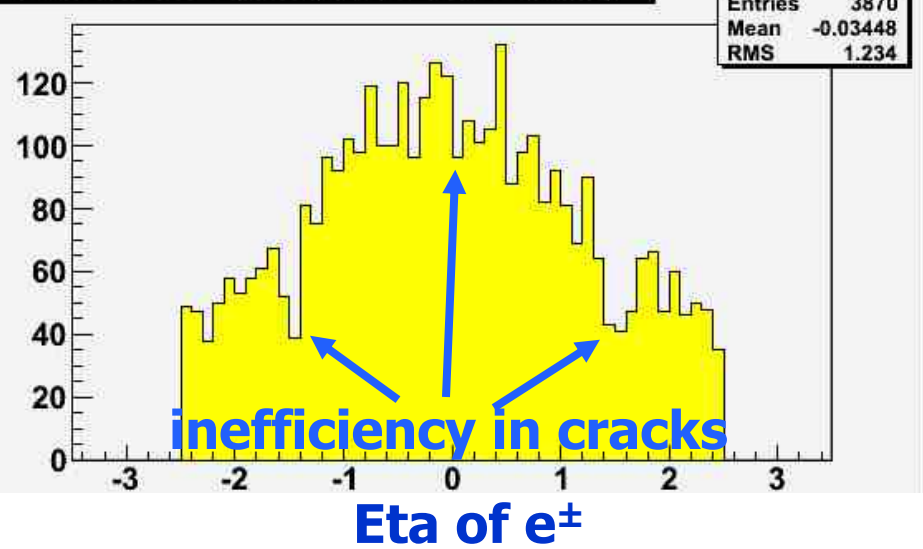
24996 $Z \rightarrow e^+e^-$ candidates

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

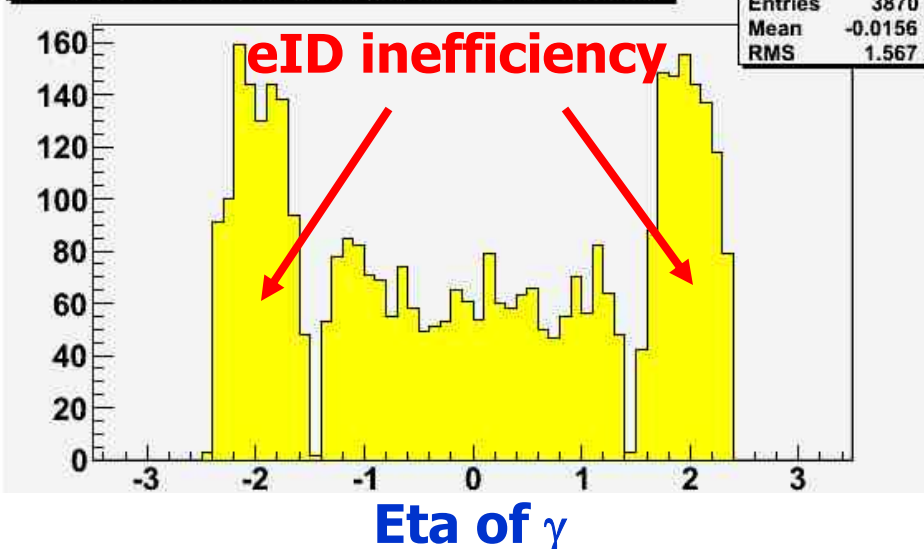
e to γ /e ID $\epsilon \sim 7.7\%$

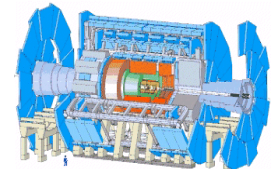
(11.0.5 & EV: $\sim 6\%$)

mc12-5152-Zee-T1(99.95K): Eta(e in Z to e+-Gamma)

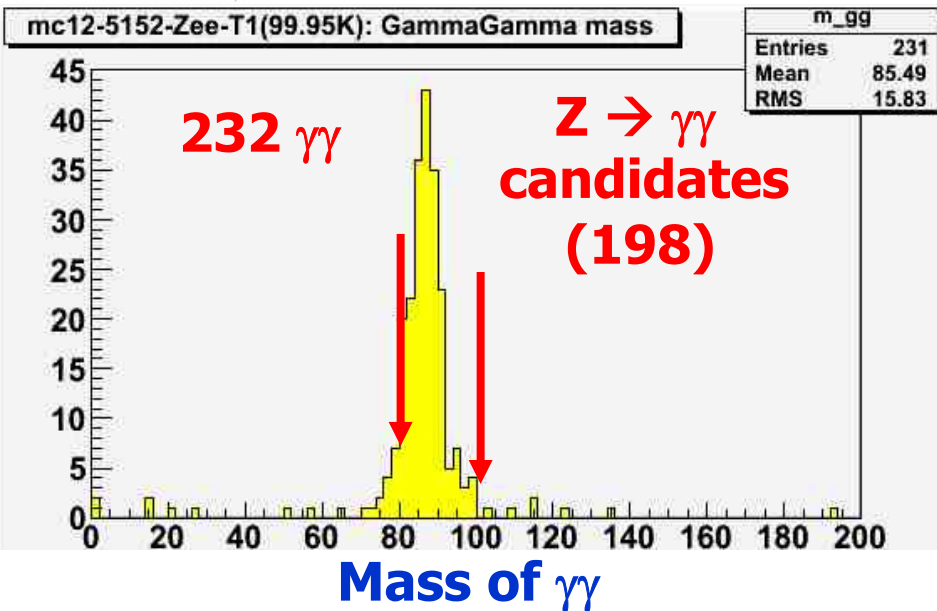


mc12-5152-Zee-T1(99.95K): Eta(Gamma in Z to e+-Gamma)





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



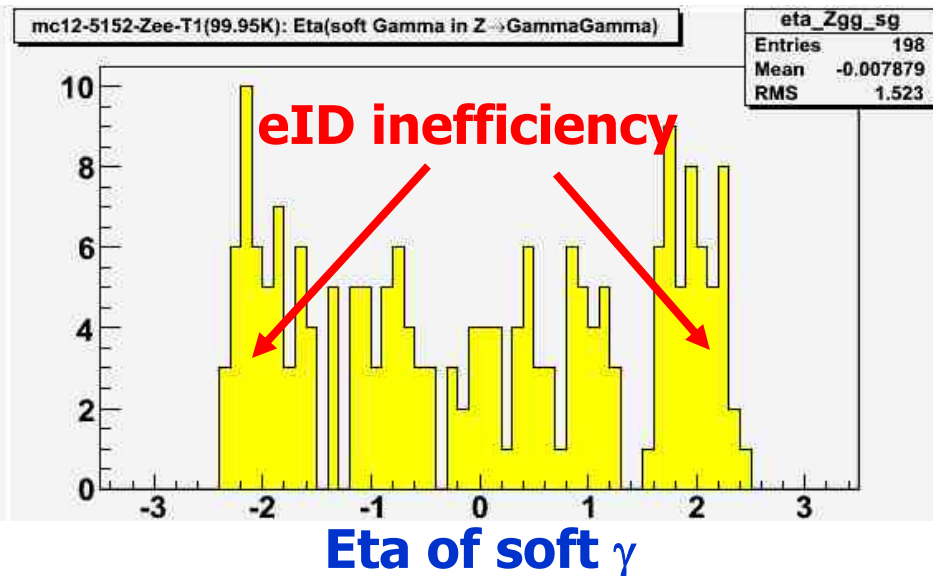
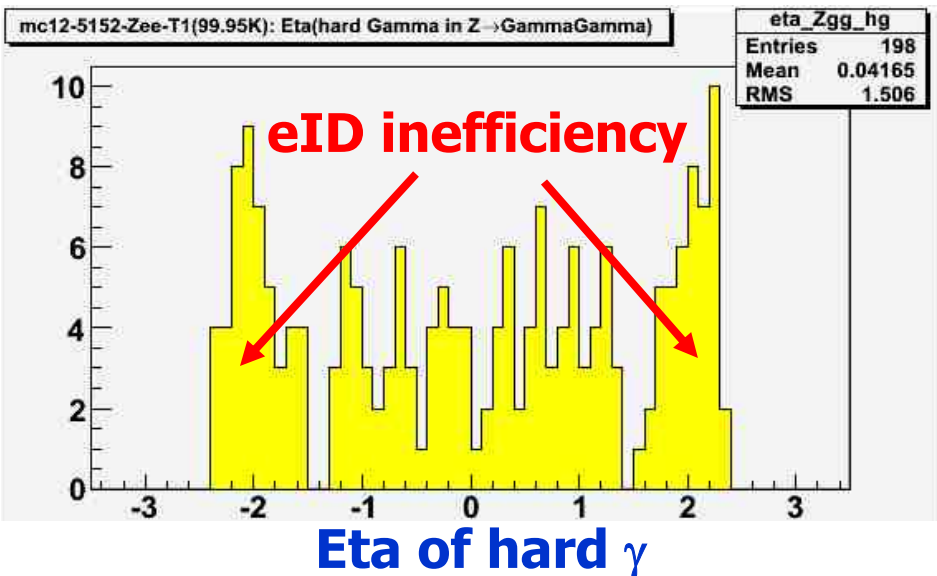
12.0.6 wth HPTV:

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

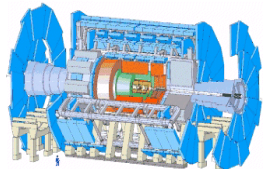
198 $Z \rightarrow \gamma\gamma$ candidates

e to γ /e ID $\varepsilon \sim 8.9\%$

(11.0.5 & EV: $\sim 6\%$)



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



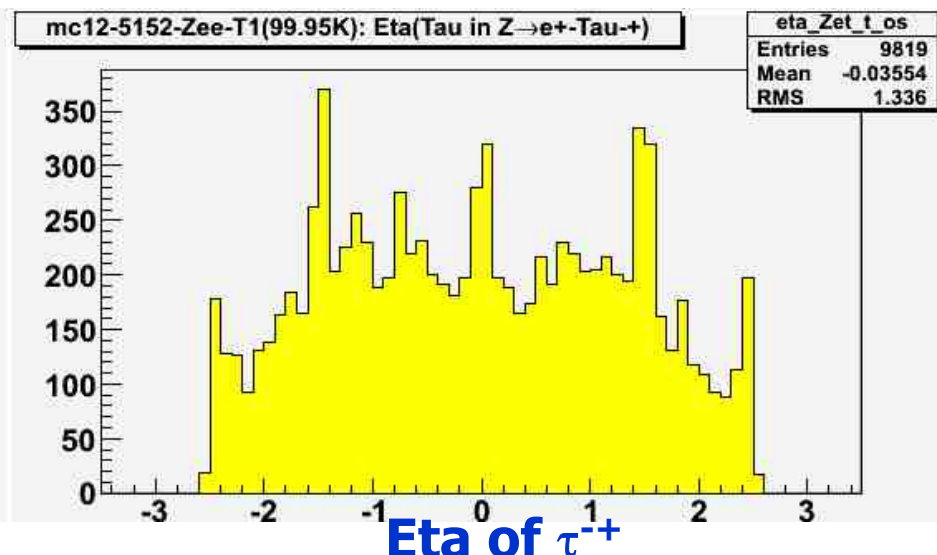
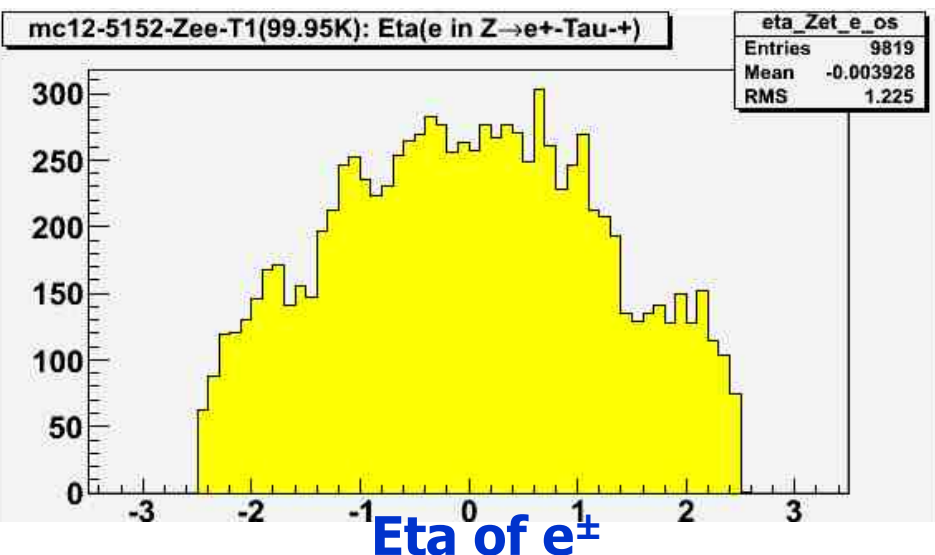
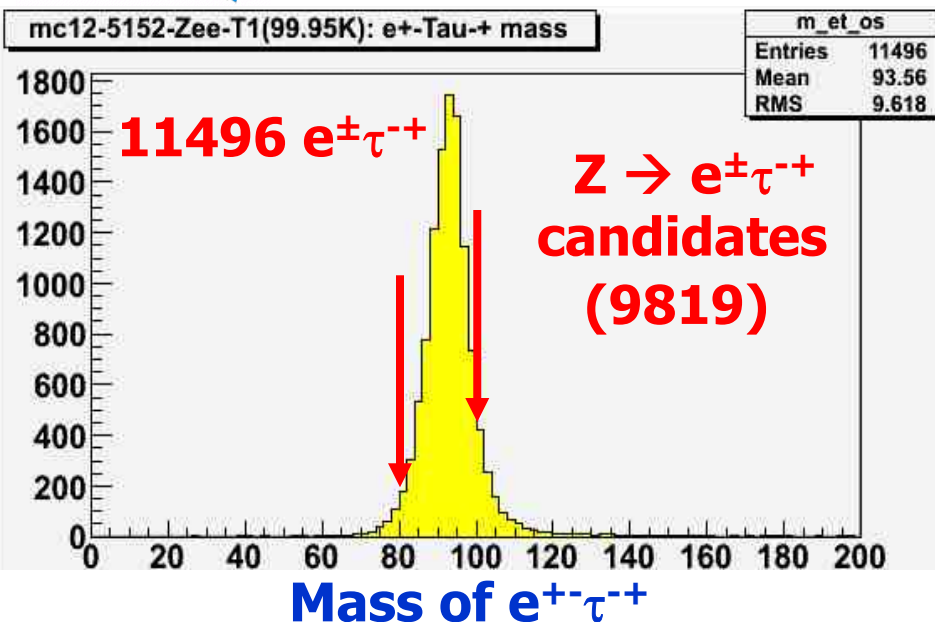
12.0.6 wth HPTV:

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

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

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

(11.0.5 & EV: $\sim 3\%$)

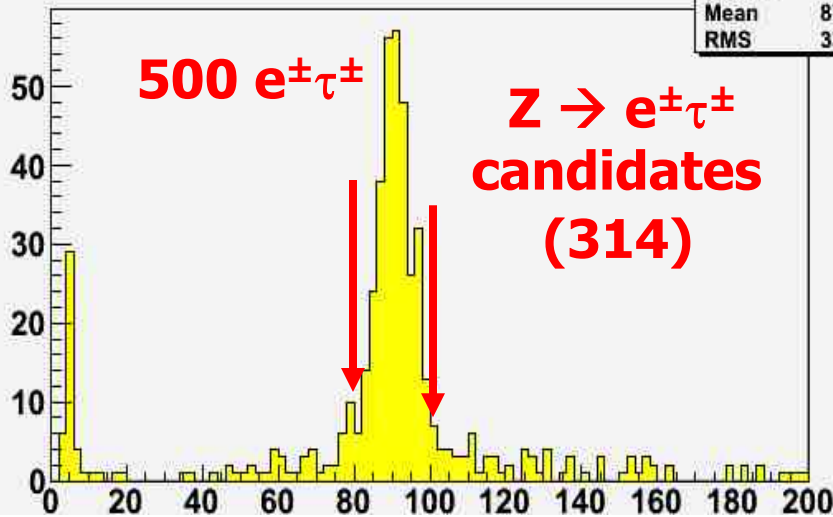


100K $Z \rightarrow e^+e^-$ events as $e^\pm\tau^\pm$



mc12-5152-Zee-T1(99.95K): e+-Tau+- mass

m_et_ss	
Entries	500
Mean	87.33
RMS	33.75



Mass of $e^+\tau^+$

12.0.6 wth HPTV:

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

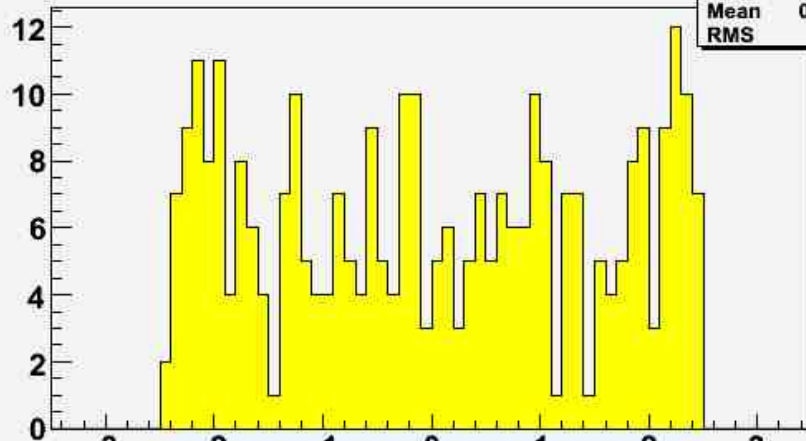
314 $Z \rightarrow e^\pm\tau^\pm$ candidates

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

(11.0.5 & EV: negligible)

mc12-5152-Zee-T1(99.95K): Eta(e in Z->e+-Tau+-)

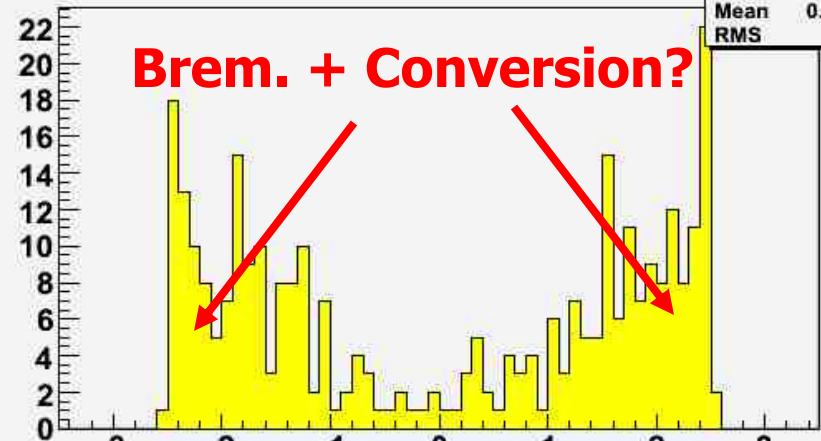
eta_Zet_e_ss	
Entries	314
Mean	0.02388
RMS	1.513



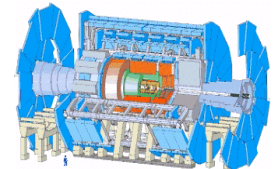
Eta of e^\pm

mc12-5152-Zee-T1(99.95K): Eta(Tau in Z->e+-Tau+-)

eta_Zet_t_ss	
Entries	314
Mean	0.04317
RMS	1.811



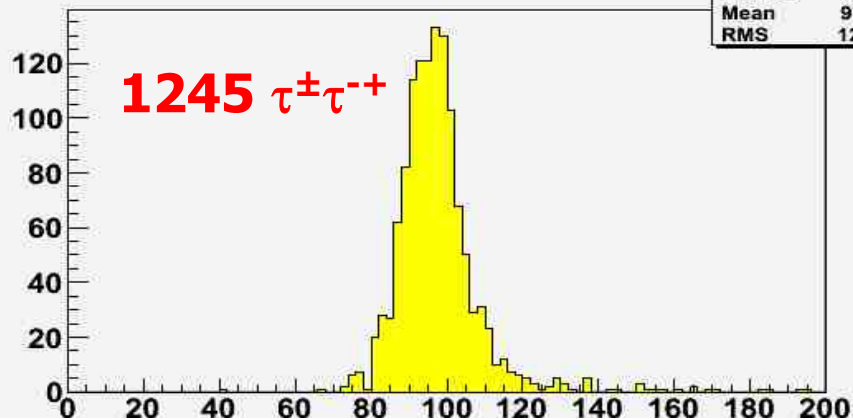
Eta of τ^\pm



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

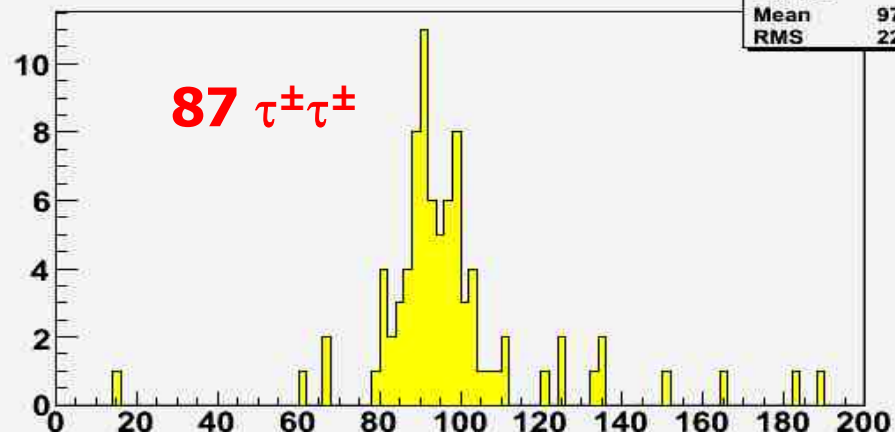


mc12-5152-Zee-T1(99.95K): t+t- mass



m_tt_os	
Entries	1245
Mean	97.71
RMS	12.08

mc12-5152-Zee-T1(99.95K): t+-t+- mass



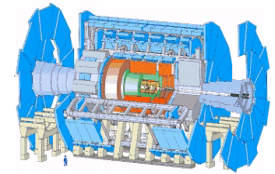
m_tt_ss	
Entries	87
Mean	97.95
RMS	22.88

Mass of $\tau^+\tau^-$

Mass of $\tau^\pm\tau^\pm$

(consistent with previous reflection results)

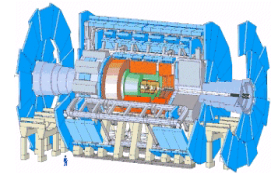
Charge Confusion/PID Fake Rate	11.0.5 EV	12.0.6 HPTV
Electron charge confusion rate	~0.3%	~0.3%
e to γ fake rate/e ID efficiency	~6%	~8%
e^\pm to τ^\pm fake rate/e ID efficiency	~3%	~20%
e^\pm to $\tau^+\tau^-$ fake rate/e ID efficiency	negligible	~0.6%



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 **\sim factor of 3** with **$\sim 15\%$** 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 $\rightarrow \gamma\gamma$ 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