Use Tag & Probe method to measure electron efficiency

Group 9

iSTEP-2016

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Motivation

- electron detection
  - in many physics processes at LHC,electron is an important signature
  - electron can be detected accurately in tracker and calorimeter
- electron efficiency
  - probability that a electron is detected by the detector and used to predict total electrons based on observed electrons
  - bias sources: trigger inefficiency, misidentified hadrons(jet), photon conversions, non-isolated electrons from heavy-flavors decays.
  - efficiency factor: $C = \epsilon_{event} \cdot \alpha_{reco} \cdot \epsilon_{ID} \cdot \epsilon_{trig} \cdot \epsilon_{isol}$

Method:Tag and Probe

- the dilepton decays of some particles are the best choices for lepton efficiency measurement like Z boson, $J/\psi, \Upsilon$ ...
- choose one lepton passed selection call Tag, the other one is Probe without any selection.
- the total Probe lepton Number: N_{probe_total}, the number of probe pass selection: $N_{probe+pass}$

leg1	leg2	comments
pass	pass	selected
pass	fail	selected
fail	pass	selected
fail	fail	Not selected

- corresponding efficiency:

$$\epsilon = \frac{N_{probe+pass}}{N_{probe\_total}}$$

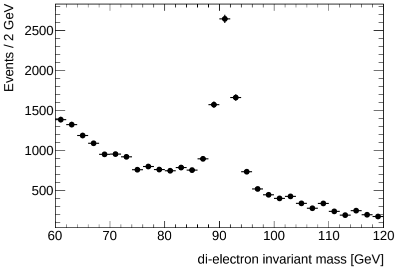
Strategy

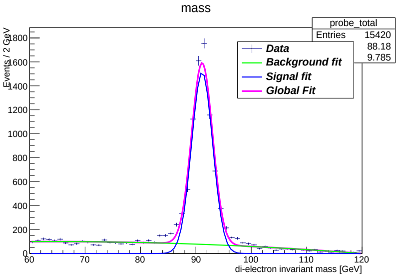
- sample used: mixed Zee(Signal)+Dijet(Background) samples
- background substraction:
  - $N_{leptons} = 2$, Opposite Charge.
  - the criteria for ID used in Tag and Probe.

    probability of jet misidentified as electron pretty low.
  - exclude background by fitting.
- improve statistics
  - select tag electron randomly, every event used twice

Fitting Strategy

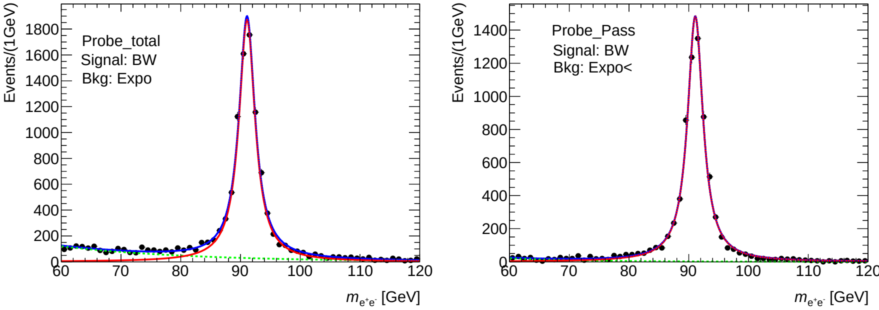
- the shape: a Gaussian-like peak and a expo-like background.
- fit Model: Signal: Breit-Wigner/Gaussian
  Bkg: Expo./2nd Polynomial.
- Bkg fit: set two separate range [60, 70] GeV and [110, 120] GeV to make bkg template





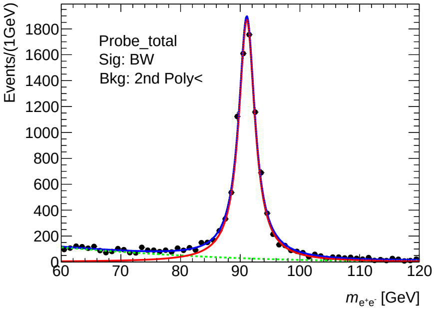
Fitting Results(1)

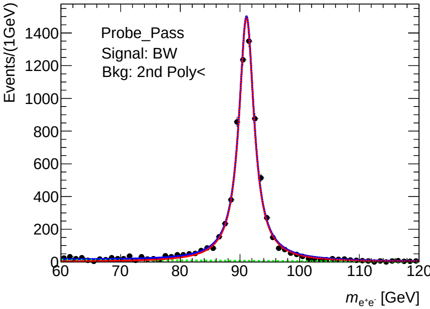
- Signal: Breit-Wigner Bkg: Expo.
- probe total(left): χ^2/ndof = 2.65 probe pass(right): χ^2/ndof = 2.67
- after bkg substraction: left: 9265.55; right: 7065.71
- eff = 0.763 ± 0.004(stat.)



Fitting Results(2)

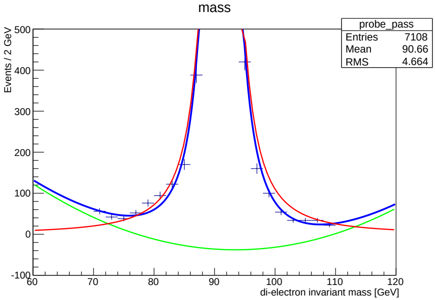
- Signal: Breit-Wigner Bkg: 2nd Poly.
- probe total(left): $\chi^2/\text{ndof} = 2.53$ probe pass(right): $\chi^2/\text{ndof} = 2.96$
- after bkg substraction: left: 9300.67; right: 6915.88
- eff $= 0.744 \pm 0.005$(stat.)

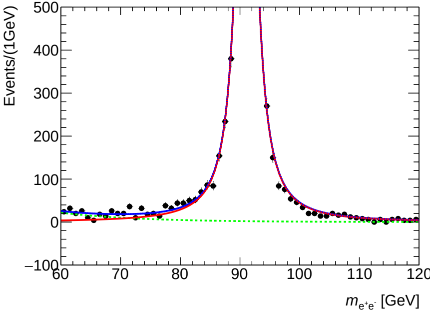




Fitting Results(3)

- BW+quaridiac model(left), BW+exponential model(right)





the BW+quaridiac model may have problems in fitting the peak region.

choose the BW+exponential model as the main model.

Uncertainty(1)

- Statistics Uncertainties

  Every experiment is a Bernoulli distribution,the probability of the n times experiments:$P(X) = C_n^x p^x (1-p)^{n-x}, q = 1-p$

  Expectation:$\bar{x} = np$ Variance:$v(x) = npq$

  Efficiency:

$$\epsilon = \frac{N_{probe+pass}}{N_{probe\_total}}$$

  Statistics Uncertainties:

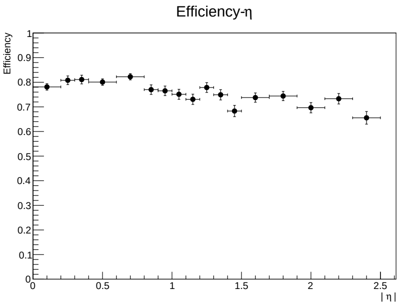
$$\sigma_\epsilon = \sqrt{N_{prob\_total}\epsilon(1-\epsilon)}/N_{probe\_total} = \sqrt{\epsilon(1-\epsilon)/N_{probe\_total}}$$

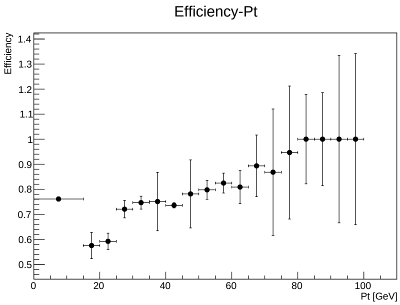
Uncertainty(2)

- Systematic Uncertainties
  - internal systematic in model: from the errors of parameters
  - model vs model: alternative model: signal(B-W function)+background(quadratic model)
  - The size of signal window
  - Other possible observed bias$\cdots$
- for Integral Region: eff $= 0.763 \pm 0.004$(stat.) $\pm$ 0.022(syst.)

eff-eta & eff-pt

calculate the efficiency in different eta and pt bins.





Summary & Outlook

- Summary

  Be familiar with the ROOT software & Tag and Probe Method;

  Study the electron efficiency of Zee.

- Outlook

  more available statistic;

  more accurate fit function;

  separate MC sample for Zee and Dijet;

  more variables...

Contribution list

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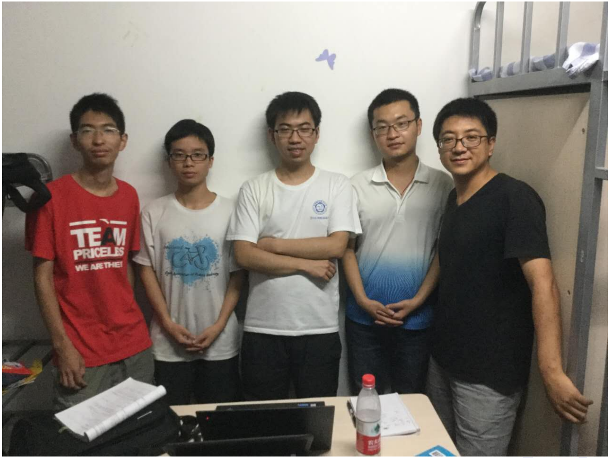


References

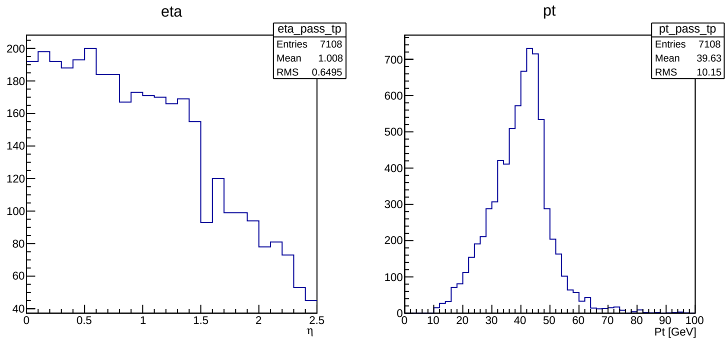
- ATLAS Collaboration,Electron performance measurements with the ATLAS detector using the 2010 LHC proton-proton collision data,arXiv:1110.3174.
- ATLAS Collaboration,Electron reconstruction and identification efficiency measurements with the ATLAS detector using the 2011 LHC proton-proton collision data,arXiv:1404.2240v3.
- ATLAS Collaboration, Reconstruction and identification of electrons in ATLAS,SMU-HEP-08-21.pdf.
- CMS Collaboration, Performance of electron reconstruction and selection with the CMS detector in proton-proton collisions at 8 TeV, arXiv:1502.02701.

Acknowledgements

- Thanks for the guidance and help from Prof. Ning Zhou and Prof. Huaqiao Zhang;
- Best wishes for all the professors and classmates of iSTEP;
- Thanks for your attention!

Backup(1)

the pt and eta distributions for $probe_pass$ electron



Backup(2)

eta Efficiency : statistical error : systematic error

Nbin:	1	range:	0	—	0.2	eff:	0.781065	err:	0.0131335	serr:	0.021606
Nbin:	2	range:	0.2	—	0.3	eff:	0.80808	err:	0.0176053	serr:	0.0285407
Nbin:	3	range:	0.3	—	0.4	eff:	0.811005	err:	0.0176868	serr:	0.0283485
Nbin:	4	range:	0.4	—	0.6	eff:	0.800729	err:	0.013079	serr:	0.0265342
Nbin:	5	range:	0.6	—	0.8	eff:	0.822268	err:	0.0126991	serr:	0.0235423
Nbin:	6	range:	0.8	—	0.9	eff:	0.769998	err:	0.0194462	serr:	0.032396
Nbin:	7	range:	0.9	—	1	eff:	0.765147	err:	0.0194461	serr:	0.0242351
Nbin:	8	range:	1	—	1.1	eff:	0.751179	err:	0.0203361	serr:	0.0272443
Nbin:	9	range:	1.1	—	1.2	eff:	0.730704	err:	0.0208984	serr:	0.0322832
Nbin:	10	range:	1.2	—	1.3	eff:	0.778582	err:	0.0199412	serr:	0.0354229
Nbin:	11	range:	1.3	—	1.4	eff:	0.749146	err:	0.0209612	serr:	0.0349767
Nbin:	12	range:	1.4	—	1.5	eff:	0.683085	err:	0.0230703	serr:	0.0338697
Nbin:	13	range:	1.5	—	1.7	eff:	0.737726	err:	0.0188363	serr:	0.0319835
Nbin:	14	range:	1.7	—	1.9	eff:	0.744096	err:	0.0188303	serr:	0.0309326
Nbin:	15	range:	1.9	—	2.1	eff:	0.696597	err:	0.0208794	serr:	0.0294867
Nbin:	16	range:	2.1	—	2.3	eff:	0.73305	err:	0.0212604	serr:	0.0273563
Nbin:	17	range:	2.3	—	2.5	eff:	0.655548	err:	0.0257066	serr:	0.104211

Backup(3)

PT Efficiency : statistical error : systematic error

Nbin: 1	range: 0 — 15	eff: 0.759576	err: 0.0174502	serr: 0.0284194
Nbin: 2	range: 15 — 20	eff: 0.793843	err: 0.015912	serr: 0.0219019
Nbin: 3	range: 20 — 25	eff: 0.808261	err: 0.0159702	serr: 0.026741
Nbin: 4	range: 25 — 30	eff: 0.782414	err: 0.0167504	serr: 0.0256149
Nbin: 5	range: 30 — 35	eff: 0.843759	err: 0.0155366	serr: 0.0399394
Nbin: 6	range: 35 — 40	eff: 0.814429	err: 0.0159163	serr: 0.0303071
Nbin: 7	range: 40 — 45	eff: 0.75523	err: 0.0175729	serr: 0.0259772
Nbin: 8	range: 45 — 50	eff: 0.797548	err: 0.0169506	serr: 0.025292
Nbin: 9	range: 50 — 55	eff: 0.754308	err: 0.0178253	serr: 0.0241767
Nbin: 10	range: 55 — 60	eff: 0.750114	err: 0.0189108	serr: 0.0320689
Nbin: 11	range: 60 — 65	eff: 0.754763	err: 0.0185574	serr: 0.0287558
Nbin: 12	range: 65 — 70	eff: 0.718455	err: 0.0196301	serr: 0.031854
Nbin: 13	range: 70 — 75	eff: 0.781691	err: 0.0228375	serr: 0.0407119
Nbin: 14	range: 75 — 80	eff: 0.663948	err: 0.0249841	serr: 0.0381147
Nbin: 15	range: 80 — 85	eff: 0.759617	err: 0.0239329	serr: 0.0357574
Nbin: 16	range: 85 — 90	eff: 0.694938	err: 0.025467	serr: 0.0307754
Nbin: 17	range: 90 — 95	eff: 0.691467	err: 0.0268193	serr: 0.0434172
Nbin: 18	range: 95 — 100	eff: 0.678689	err: 0.02727	serr: 0.0215287