# EM Certification Results

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**For the EM-ID group**

# Outline

- **EM_CERT Package**
- **EM-ID Certification Results**
- **Conclusion**

# EM_CERT package (I)

- A framework package for EM certification purposes
- Coherent treatment of EM certification Results
- Monitor the EM Reconstruction Software
- Monitor the data quality

# EM_CERT package (II)

- **Run on DST or TMB files and provide the following results:**
- **Data-MC Comparison**
- **Electron Identification Efficiency**
- **Track Matching Efficiency**
- **Track Matching Efficiency vs Chi2 Probability Cut**
- **Fake Probability of Track Matching**
- **Trigger Turn-On Curve**
- **Energy Resolution**
- **MC Re-Smearing**
- **Efficiency and Fake Rate for Shower Shape Cut**
- **Efficiency and Fake Rate for Electron Likelihood**
- **Efficiency and Fake Rate for CPS-CAL Matching**

# EM_CERT Package (III)

- **Instruction:**
- **Addpkg em_cert v00-01-15**
- **Submit jobs to CAB using d0tools**
- **Use macros to analyze the output root tuples**
- **Detail Information: /work/toll-clued0/junjie/emcertnote.ps (D0Note 4171)**
- **Certification Results (Version 4.0):**
- **http://www-d0.fnal.gov/phys_id/emid/d0_private/certification/welcome.html**

# Data and MC Samples

- **Data:**
- **di-em and em+jets samples selected by Marco (Processed with p13.05 and p13.06) (April 2002 - Early May 2003, no fixes for calorimeter problems)**
- **Definition names: wzskim_diem and wzskim_emjet**
- **MC:**
- **Certification Files generated by MC Farms (Processed with p13.08)**
- **Definition name: z_ee_m60_130_mcp14_tmb**
- **EM Software:**
- **em_util v00-02-82, emcandidate v00-01-07, em_evt v00-15-36, emreco v00-12-29, hmreco v00-06-14, empartfit v00-03-12 (July 7, 2003)**

# EM Certification Results

## EM-ID Selection

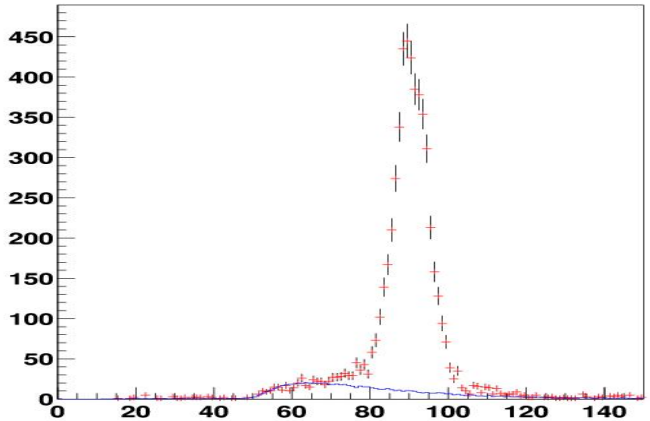
- **Standard EM-ID Cuts:**
- **abs(id)=10, 11**
- **pT>25 GeV**
- **EMFrac > 0.9, Isolation <0.15, Hmatrix8<20**
- **In fiducial region**

# EM Certification Results

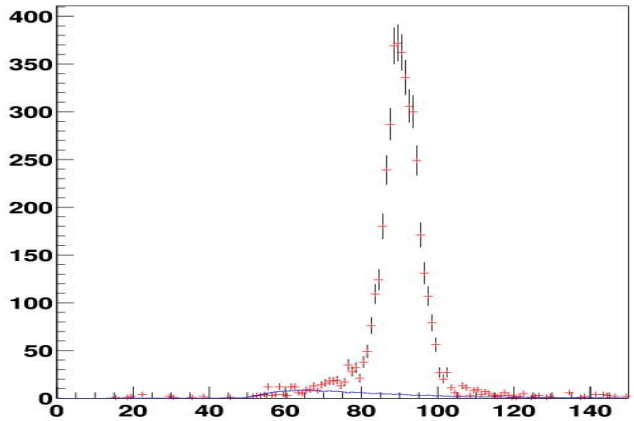
## Electron Identification Efficiency (I)

- **Tag/Probe Method:** tag electron is required to pass EMID cuts and has a matched track and probe electron is required to pass abs(id)=10, 11, pT>25
- Subtract QCD background and count number of Z events inside mass window [80, 100] GeV
- Do the same for events where probe electron also passes the EMID cuts
- EMID Efficiency:
- CC: (85.00 +- 1.96)% (Data)
  (96.54 +- 1.98)% (MC)
- EC: (91.75 +- 4.33)% (Data)
  (96.54 +- 3.74)% (MC)

All Events



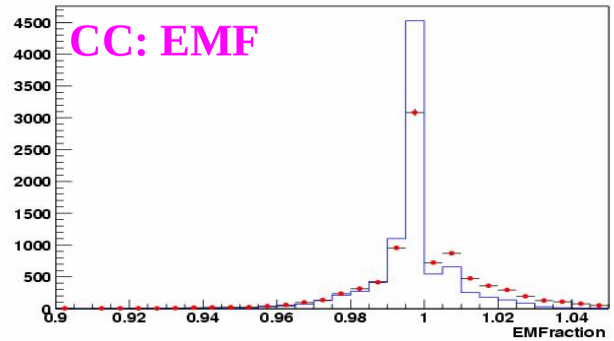

Probe electron passes EMID cuts

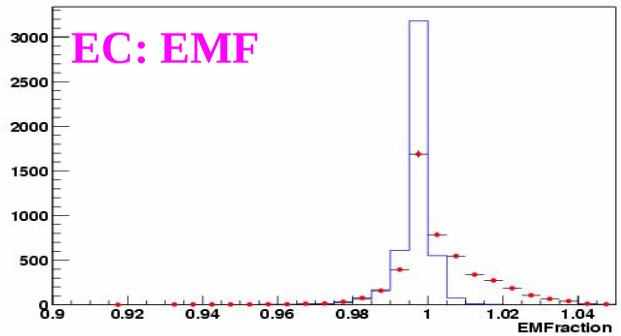


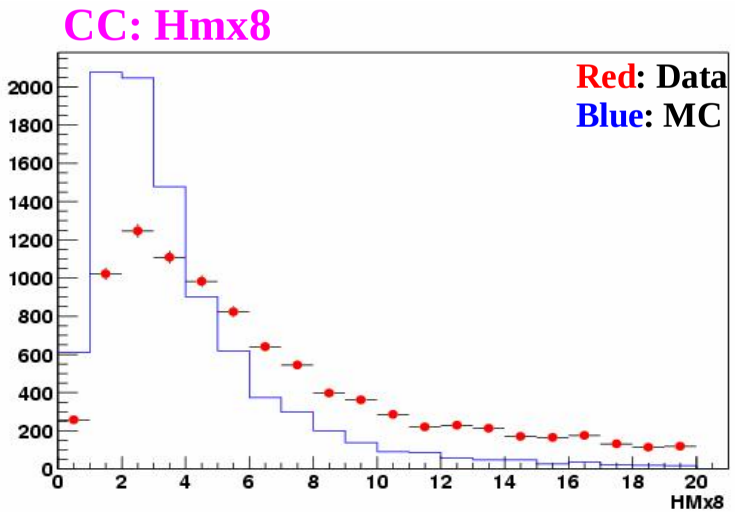
# EM Certification Results

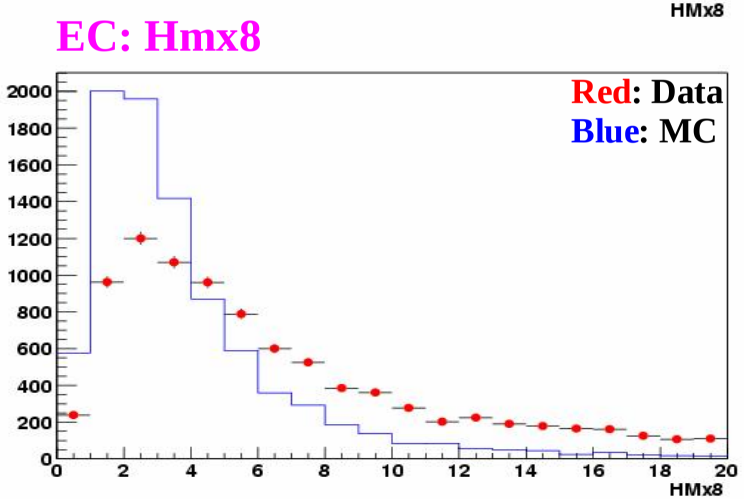
## Electron Identification Efficiency (II)

- **EM-ID efficiency quite low**
- **Hmatrix tuned from MC, while Data and MC do not agree**



# EM Certification Results

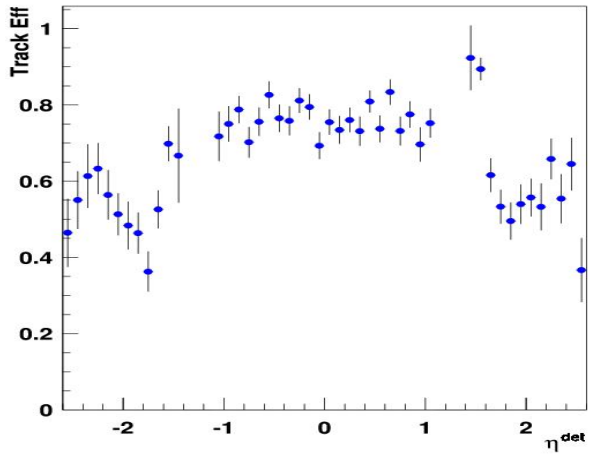
## Track Matching Efficiency (I)

- $\chi^2 = \left(\frac{\Delta z}{\sigma(z)}\right)^2 + \left(\frac{\Delta \phi}{\sigma(\phi)}\right)^2 + \left(\frac{E_T/p_T - 1}{\sigma(E_T/p_T)}\right)^2$ **With Et/Pt**
- $\chi^2 = \left(\frac{\Delta z}{\sigma(z)}\right)^2 + \left(\frac{\Delta \phi}{\sigma(\phi)}\right)^2$ **No Et/Pt, Spatial-Only**
- $\Delta z$ , $\Delta \phi$ **are the difference between the track position and the EM cluster positon at the third floor of the calorimeter,** $\sigma$ **values are the root-mean-squares of the experimental measurements of each quality**
- **An electron is considered to have a matched track if** $P(\chi 2) > 10^{-2}$
- **CC: with Et/Pt**
- **EC: no Et/Pt**

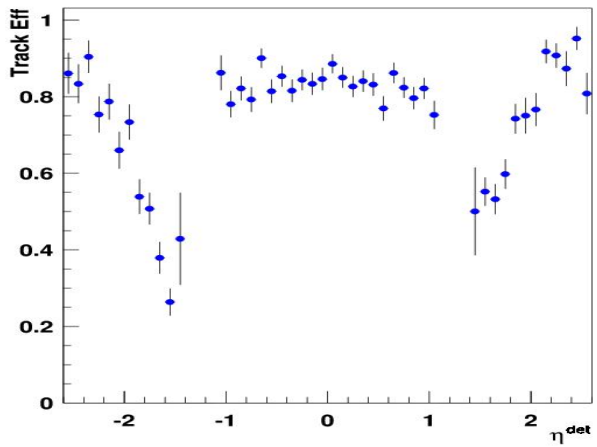
# EM Certification Results
## Track Matching Efficiency (II)

- **Tag/Probe Method**
- **Track Efficiency (CC):**
- **(76.91 +- 2.67)% (Data)**
  **(82.51 +- 1.96)% (MC)** **With Et/Pt**
- **(90.72 +- 2.84)% (Data)**
  **(84.27 +-1.99)% (MC)** **No Et/Pt**
- **Track Efficiency (EC):**
- **(55.81 +- 4.18)% (Data)**
  **(71.64 +- 3.09)% (MC)** **No Et/Pt**

**DATA**




**MC**

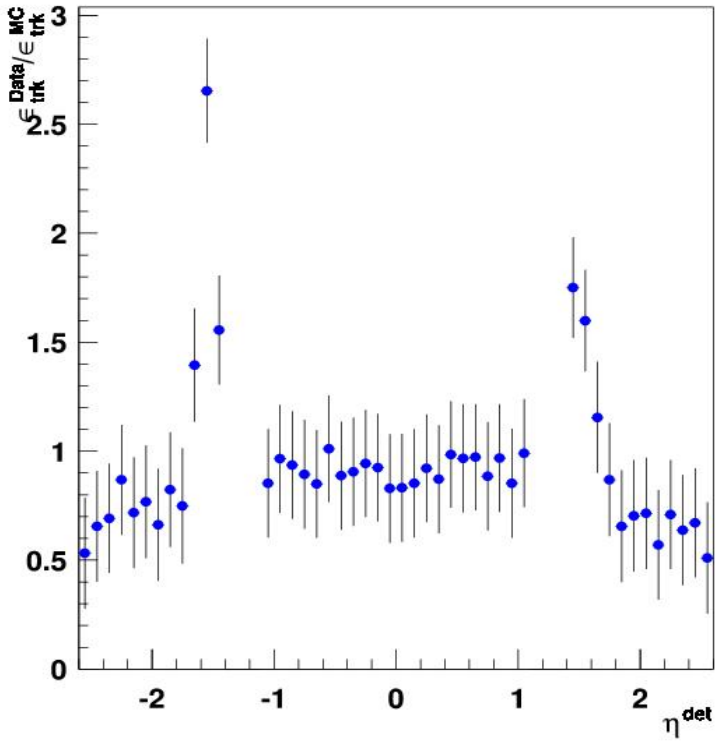


# EM Certification Results

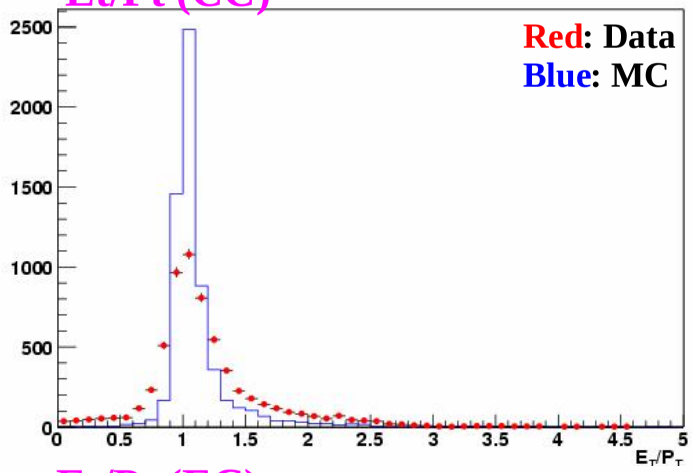
## Track Matching Efficiency (III)

- **Data-MC correction**

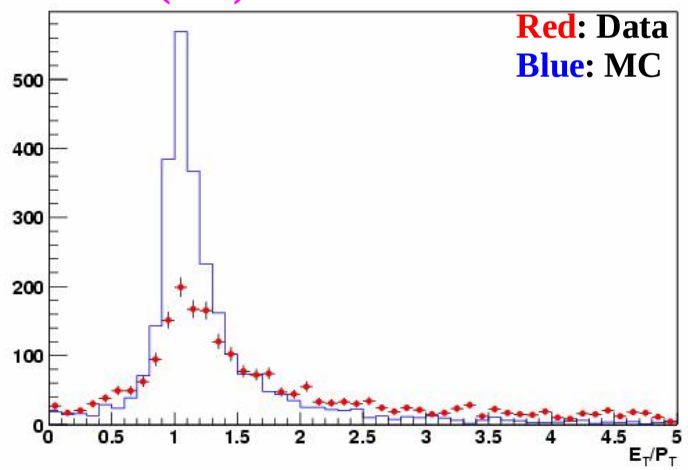
Trk Eff (Data)/Trk Eff(MC)




Et/Pt (CC)



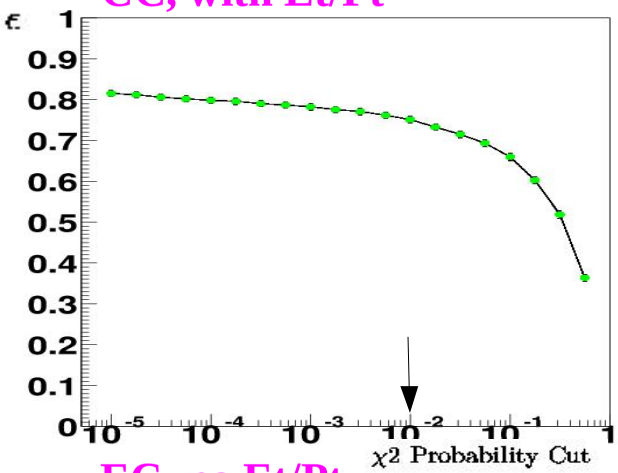

Et/Pt (EC)



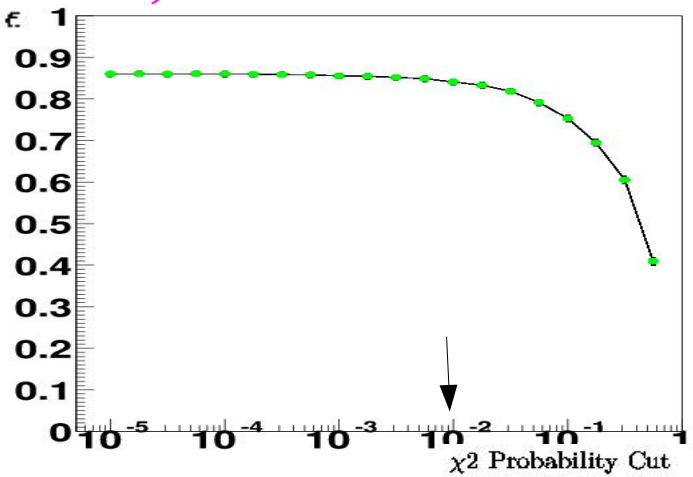
# EM Certification Results

## Track Efficiency vs Chi2

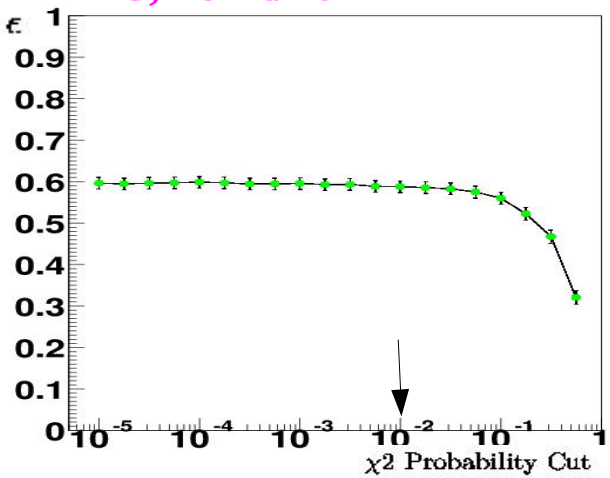
CC, with Et/Pt




CC, no Et/Pt




EC, no Et/Pt




- **Start from di-em sample**
- **Change chi2 probability cut, and count N0, N1 and N2**
- **Calculate track efficiency**

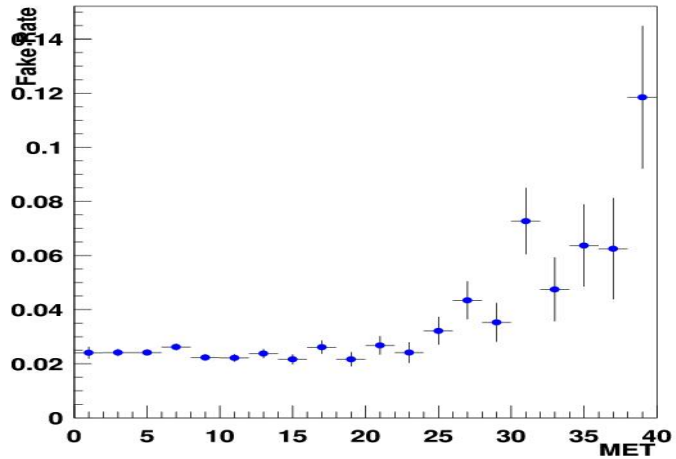
$$\epsilon_{trk} = \frac{N_1+2N_2}{2(N_0+N_1+N_2)}$$

# EM Certification Results

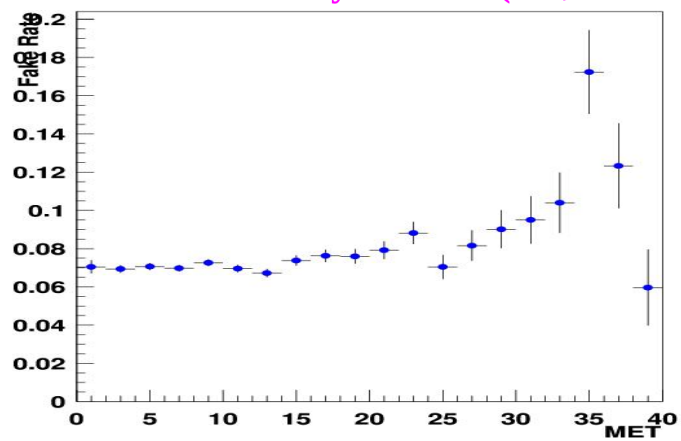
## Fake Probability of Track Matching (I)

- Start from em+jets sample
- Require exactly one EM cluster passes EMID cuts
- Require exactly one jet passes jet quality cuts
- Electron and jet are back-to-back
- Require MET<15 GeV to get rid of W+jets background
- See how often those fake electrons are found to have a matching track

Fake Probability vs MET (CC, with Et/Pt)



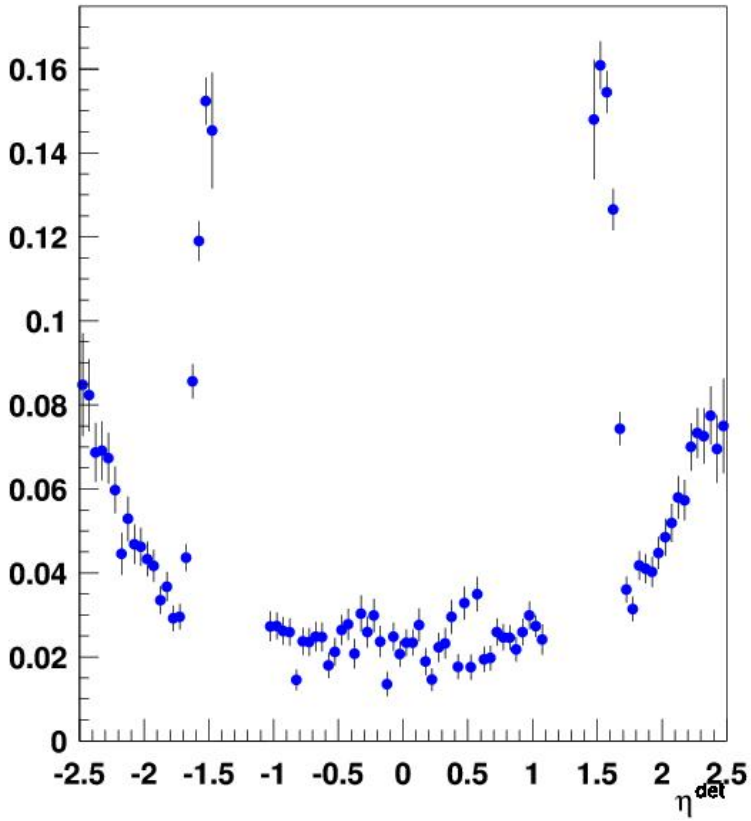

Fake Probability vs MET (EC, no Et/Pt)



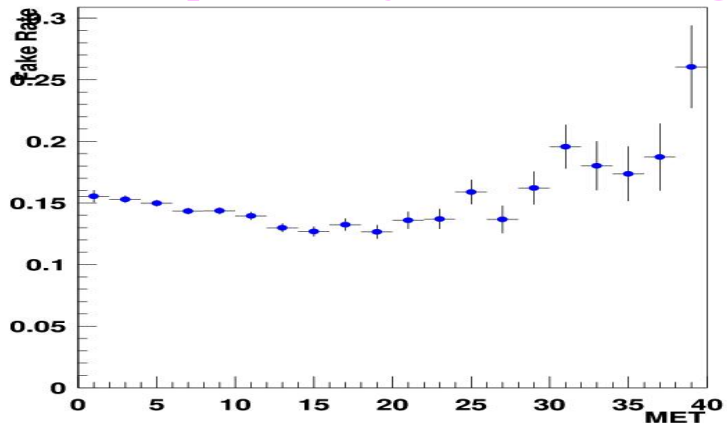
# EM Certification Results

## Fake Probability of Track Matching (II)

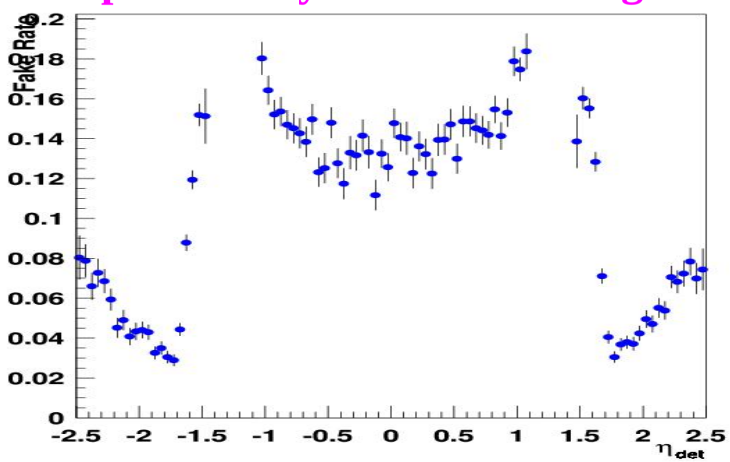
Fake Probability vs detector eta (With Et/Pt)




CC, Spatial-Only Track Matching




Spatial-Only Track Matching

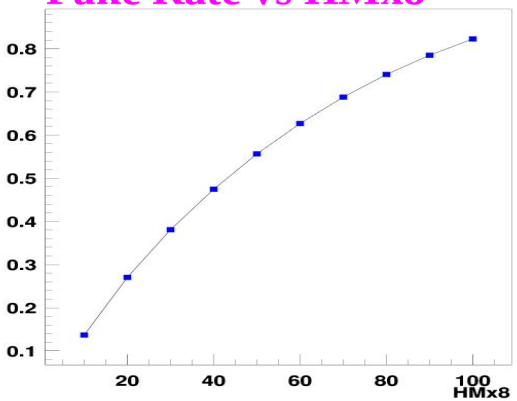


# EM Certification Results

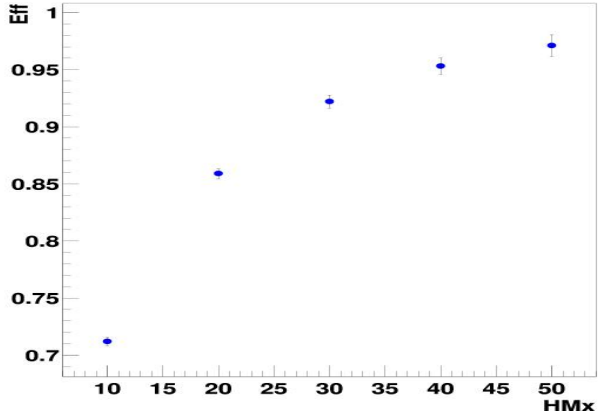
## Efficiency and Fake Rate for HMx

- **Efficiency (diem, Tag/Probe Method)**
- **Probe electron passes standarad EMID cuts except Hmx8**
- **Fake Rate (em+jets)**
- **Fake electron passes standard EMID cuts except Hmx8**

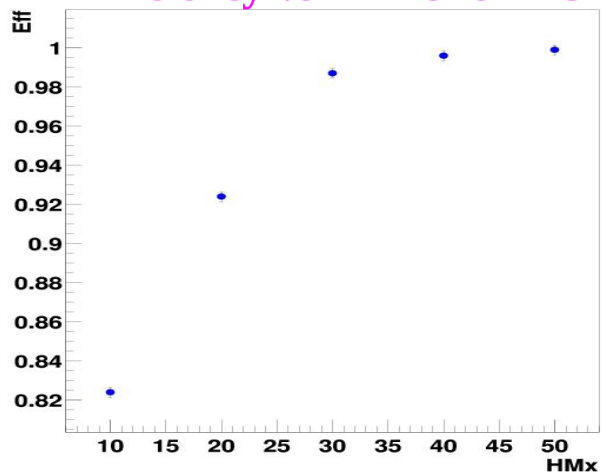
**Fake Rate vs HMx8**




**Efficiency vs Hmx8 for CC**




**Efficiency vs Hmx8 for EC**



# EM Certification Results

## Trigger Turn-On Curve (I)

- **Tag/Probe Method (diem sample)**
- **Highest pT electron is used as the tag electron: a matched track and passes EM_HI_SH or EM_HI_2EM5_SH trigger (pass trigger pT requirement and have matched trigger objects at all trigger levels)**
- **The matching requirements:**

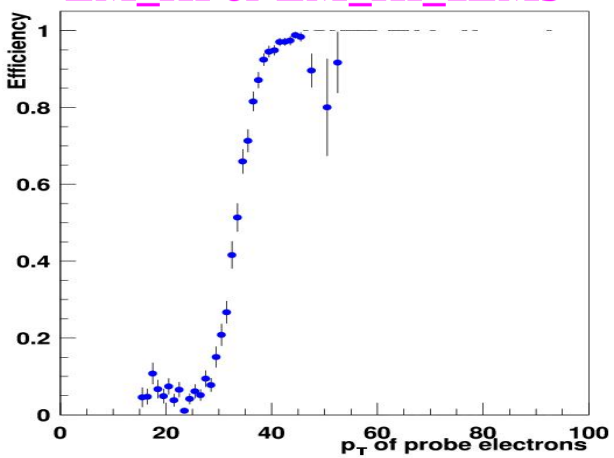
L1: $\delta\phi < 0.4$, L2: $\delta R < 0.4$, L3: $\delta R < 0.4$

- **Check whether the probe electron also passes one specific trigger**

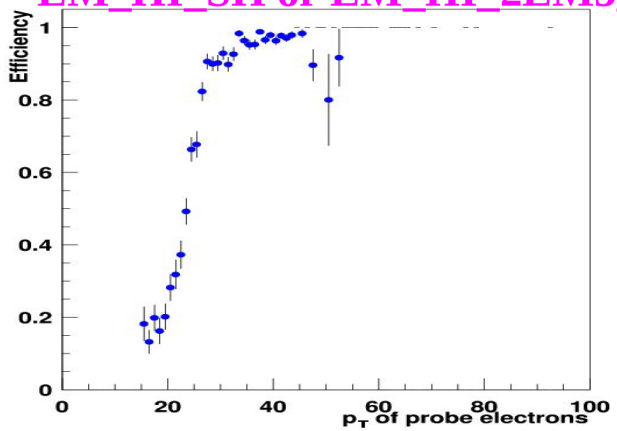
# EM Certification Results

## Trigger Turn-On Curve (II)

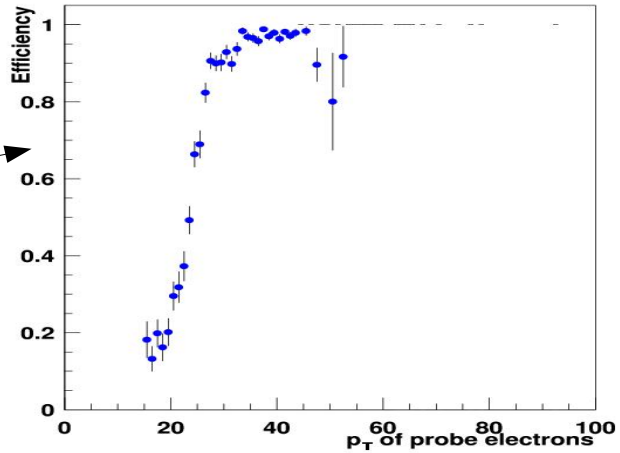
EM_HI or EM_HI_2EM5




EM_HI_SH or EM_HI_2EM5_SH




EM_HI or EM_2EM5_HI
or EM_HII_SH or EM_HI_2EM5_SH



# EM Certification Results

## Energy Resolution

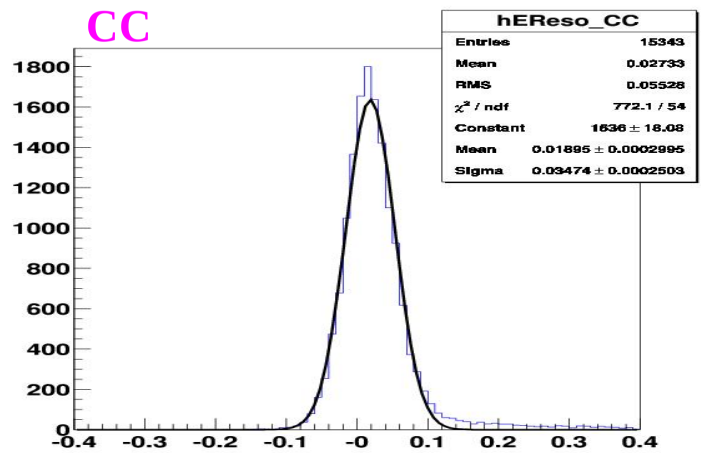
- Start from MC zee sample
- Require generator-level electrons have abs(id)=11 and pT>10 GeV
- Found the matched reconstructed EM cluster and also pT>10 GeV

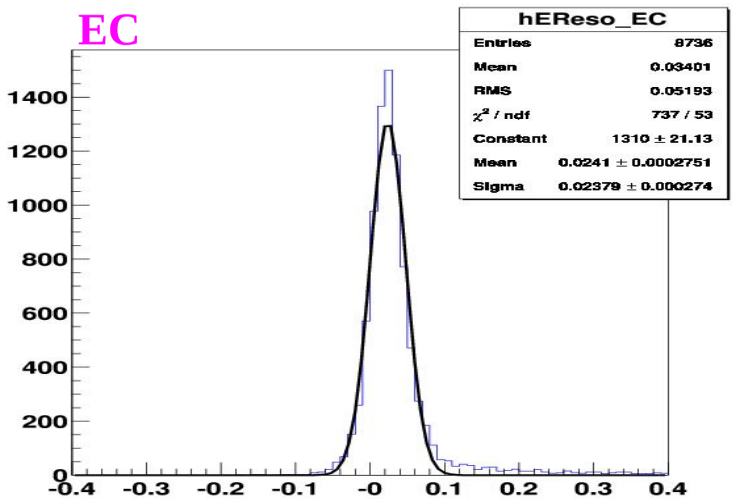
$$\delta R = \sqrt{\delta\eta^2 + \delta\phi^2} < 0.1$$

- Energy Resolution

$$\frac{\sigma_E}{E} = \frac{E_{reco} - E_{gen}}{E_{gen}}$$

- (3.47 +- 0.03)% for CC
- (2.38 +- 0.03)% for EC

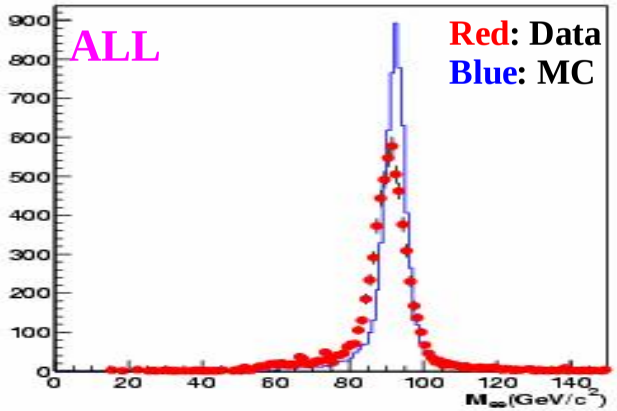


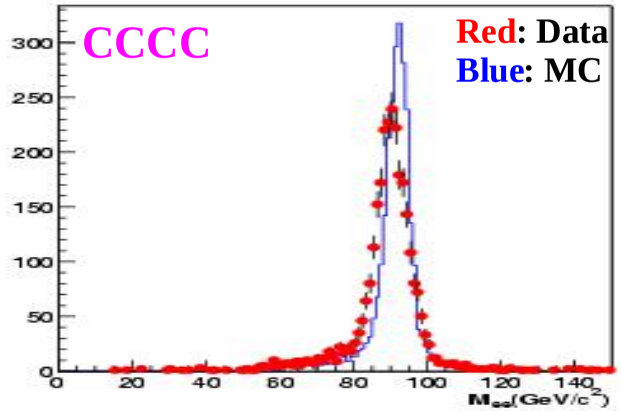



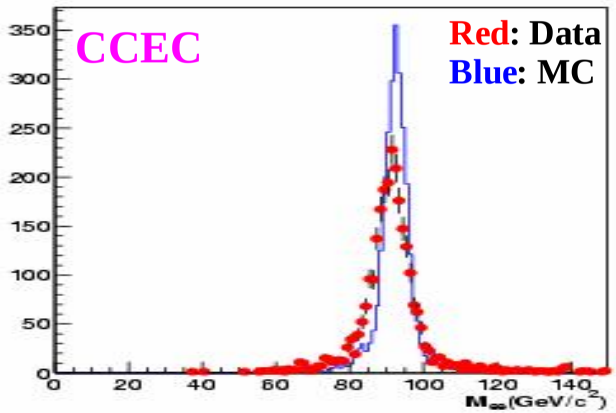
# EM Certification Results

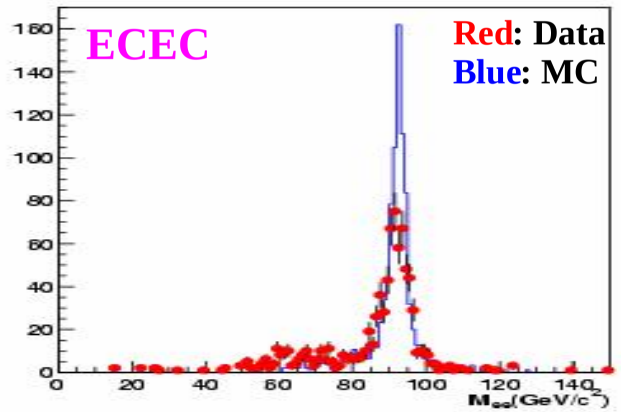
## MC Re-Smearing (I)

### Data-MC Comparison before Smearing



# EM Certification Results

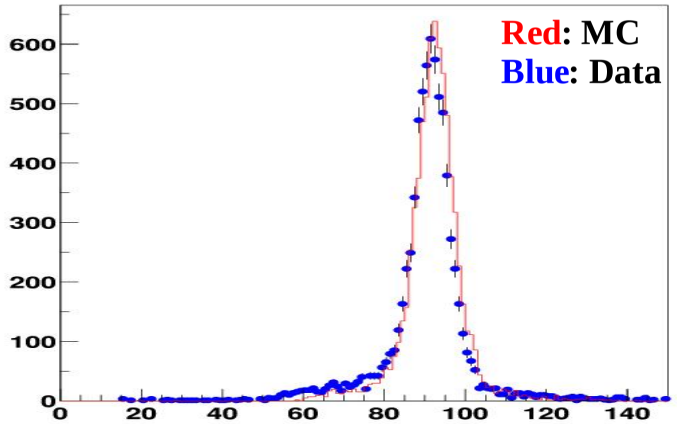
## MC Re-Smearing (II)

- **Re-Smearing Formula**

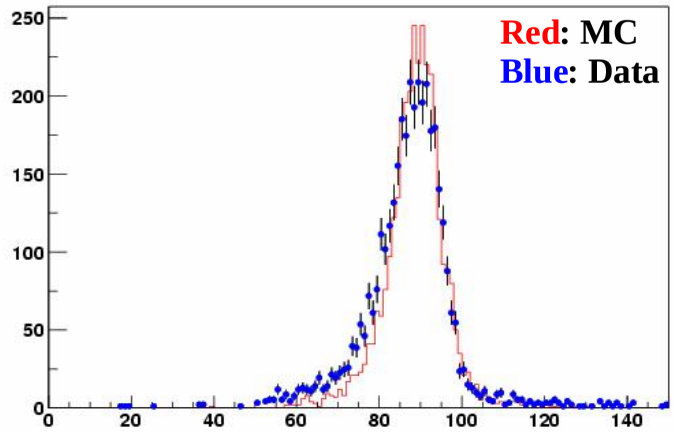
$$E' = \alpha E^{MC} + \beta$$
$$E^{re-smear} = E' + x \times \sigma \times E'$$

- $\alpha = 1.0, \beta = 0.0, \sigma = 0.047$ **Fiducial region (CC, EC)**
- $\alpha = 0.95, \beta = 0.0, \sigma = 0.05$ **Non-fiducial region**

**Both Fiducial Electrons**




**At Least One non-fiducial Electron**

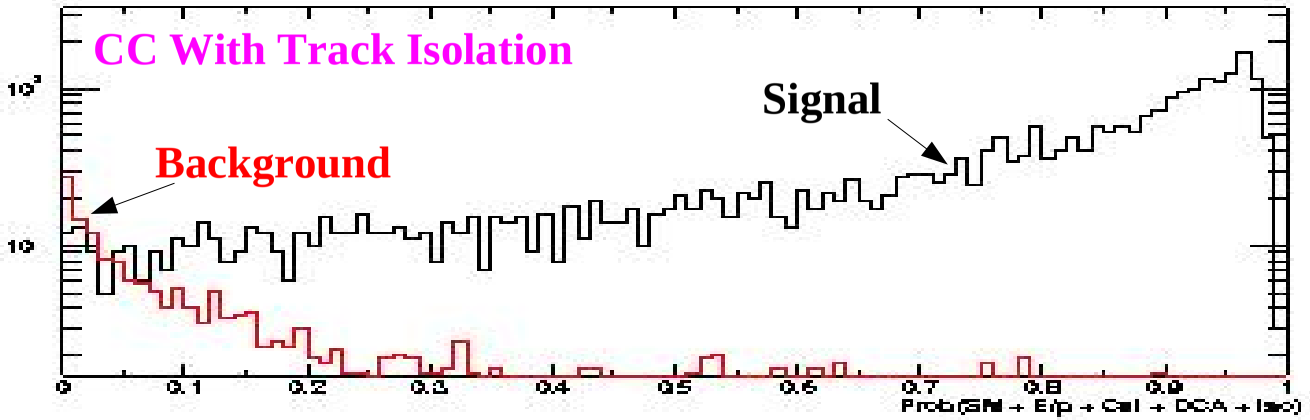


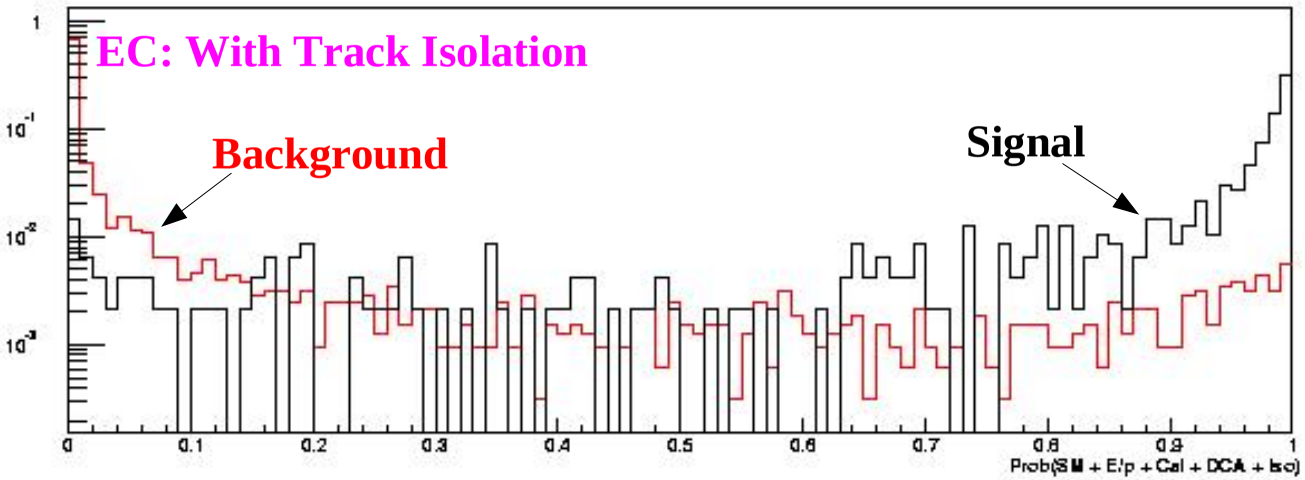
# EM Certification Results
## Electron Likelihood (I)

- Daniel Whiteson and Lukas Phaf (Code implemented in em_cert)
- From distribution of good and poor electrons, form
- $P(\bar{x}|sig), P(\bar{x}|bkg)$ X is a vector of measurements
- Assume uncorrelated $P_{sig}(\bar{x}) = P(x_1|sig)P(x_2|sig)\cdots$
- Form discriminant D $D(\bar{x}) = \frac{P_{sig}(\bar{x})}{P_{sig}(\bar{x}) + P_{bkg}(\bar{x})}$
- Six (Five) Quantities
- $\chi^2 = \left(\frac{\Delta z}{\sigma(z)}\right)^2 + \left(\frac{\Delta \phi}{\sigma(\phi)}\right)^2$
- Et/Pt
- Hmatrix
- DCA
- EMFraction
- Track Isolation (Distance in R to the track second closest to the EM cluster)

# EM Certification Results

## Electron Likelihood (II)

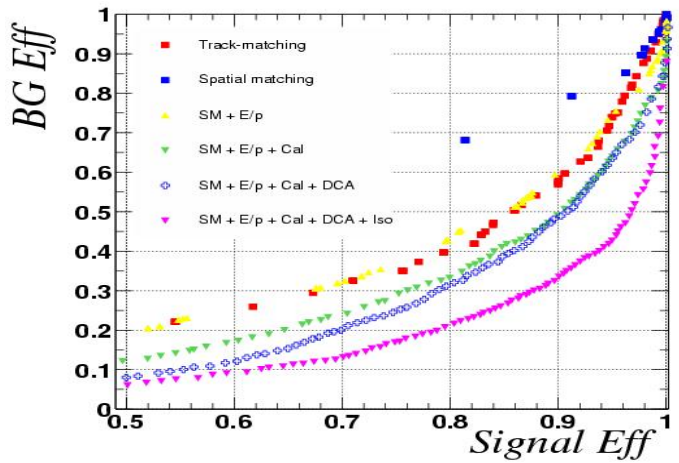


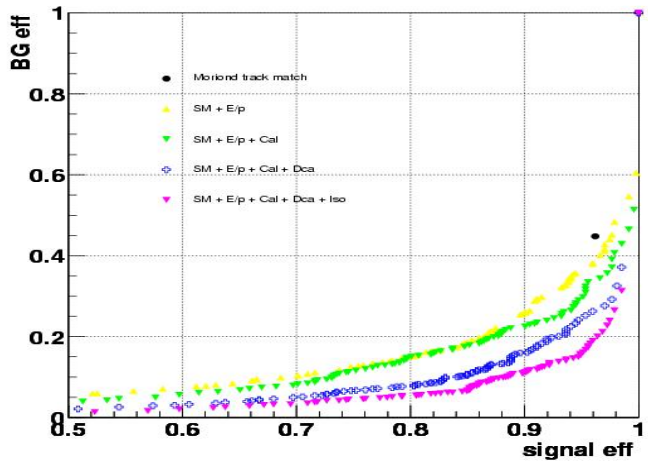



# EM Certification Results

## Electron Likelihood (III)

- **Signal Efficiency: (diem)**
- **2 EM clusters with pT>25, Hmx<20, EMF>0.9, Iso<0.15**
- **80 < Mass < 100**
- **The EM object be associated with a track candidate**
- **Background Efficiency: (em+jets)**
- **Require exactly one EM cluster passes EMID cuts**
- **Require exactly one jet passes jet quality cuts**
- **Electron and jet are back-to-back**
- **Require MET<15 GeV to get rid of W+jets background**

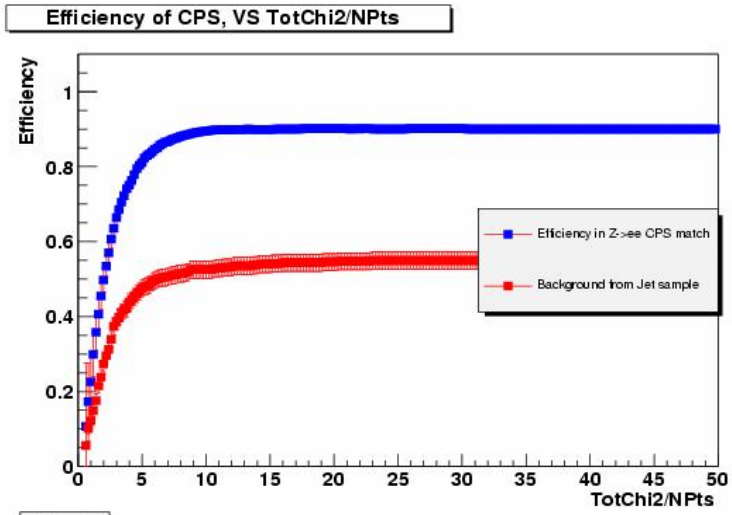


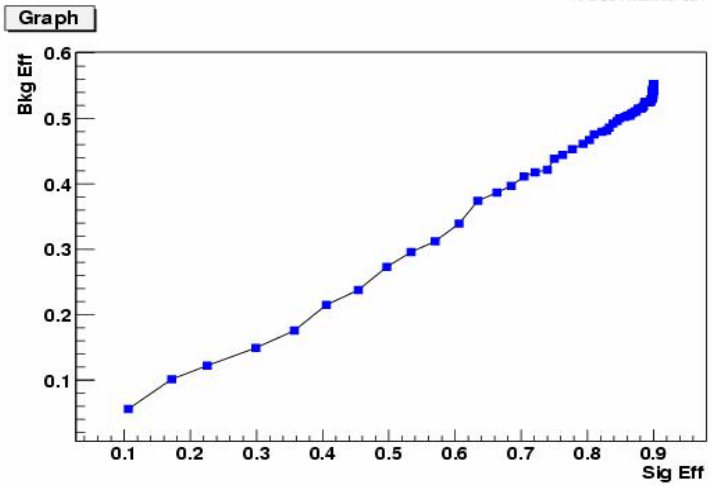



# EM Certification Results

## CPS-CAL Matching

- Andrew Askew (Code implemented in em_cert)
- Signal Efficiency: (diem)
- Subtract background and count number of Z candidates
- Do the same for the subsets where both EM clusters are matched to CPS clusters (make matching cut on the total chi2 of the two fits)
- Background Efficiency: (em+jets)
- See how often for a given chi2 cut we match a CPS cluter to a fake electron

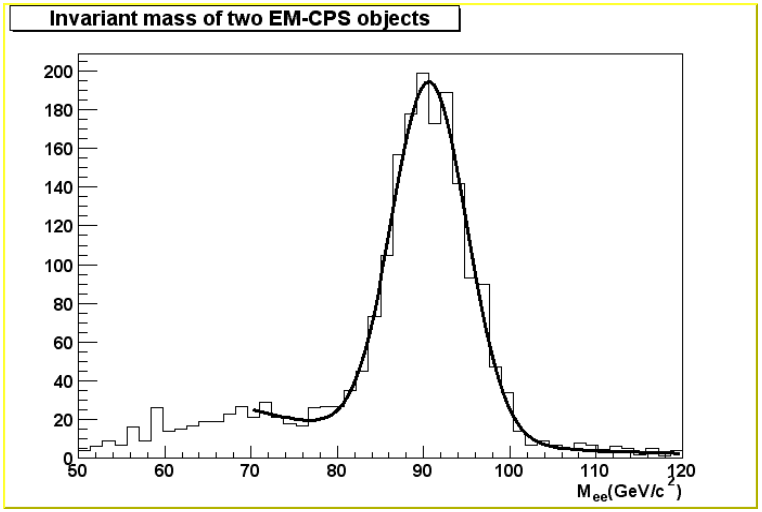


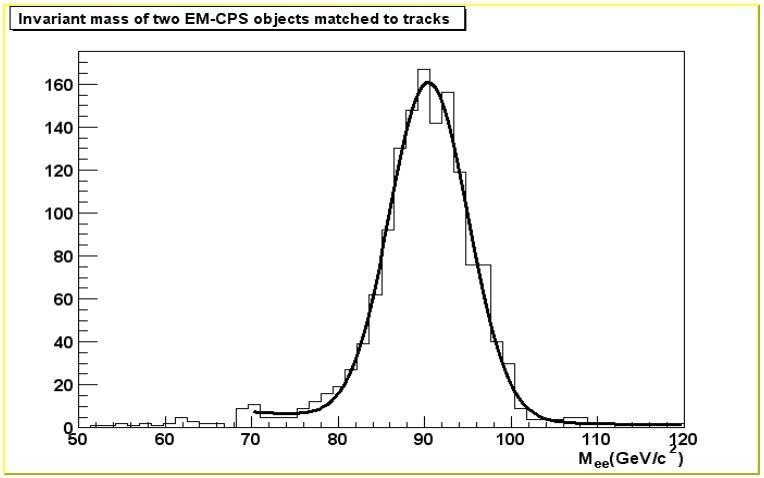



# EM Certification Results

## CPS-TRK Matching (I)

- Yurii Maravin
- Pick z->ee candidates from Marco's diEM skim samples
- Reconstructed with p14.03
- Propogate the track to the CPS using D0GTrackPropagator
- Calculate the distance between the track and the CPS cluster
- CPS-TRK Matching: deltaR<0.03

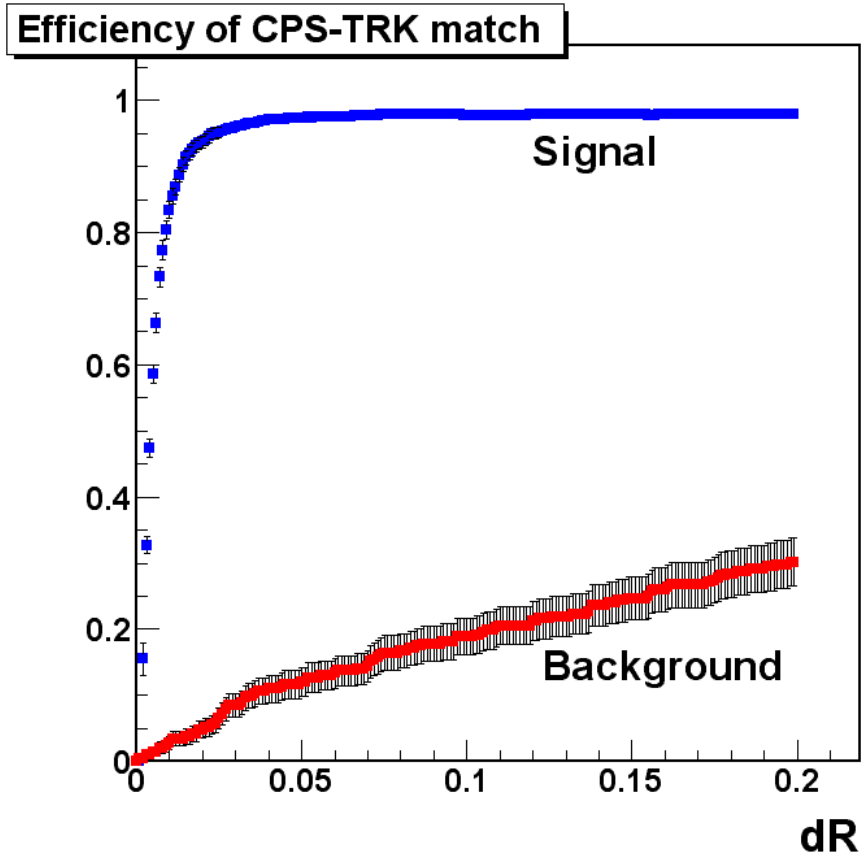


# EM Certification Results

## CPS-TRK Matching (II)

- **Signal Efficiency: (diem)**
- **Require one CPS cluster matched with each EM object, subtract background and count number of Z candidates**
- **Do the same for the subsets where both EM clusters have CPS-TRK matching**
- **Background Efficiency: (em+jets)**
- **See how often for a given deltaR cut we have a CPS-TRK matching for the fake electron**



# Conclusion

- **Add CPS-TRK matching code into em_cert**
- **em_cert package still under development, all comments are welcome**