Electron identification and e+e- analysis

Overview

- G4 simulation in the BaBar-like software
  - physics list
  - validation

- Electron identification with the EMC (december 2006)
  - e/p and shower shape
  - neural network
  - results for a test sample (march 2007)
  - status and possible improvements

- e+e- analysis
  - reconstruction efficiency
  - $\pi^+\pi^-$ background study

B. Kopf, Ruhr-Universität Bochum

G4 simulation

- BaBar-like software with G4.7.1

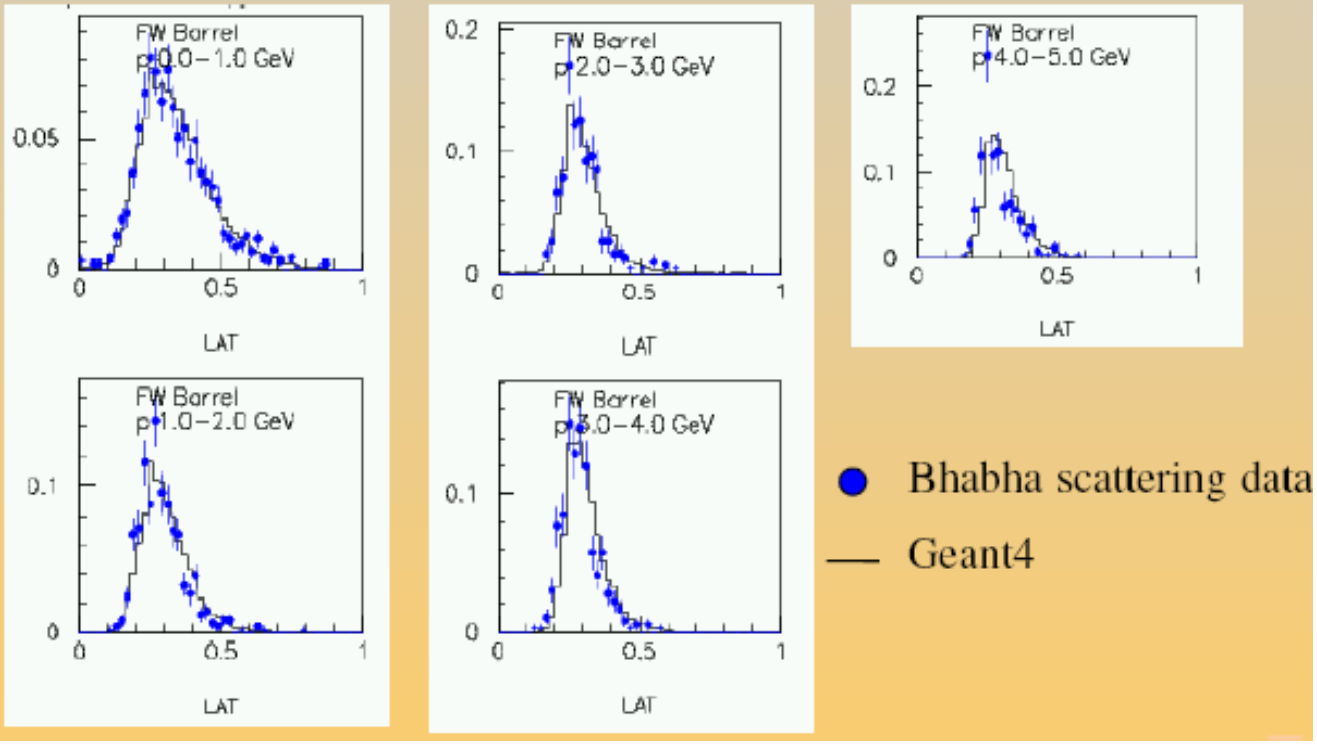
- All detectors of the present favoured design implemented
  - apart from Cherenkov detectors in forward direction

- Physics list
  - took over the list used by BaBar
  - em processes for e-: G4MultipleScattering, G4eIonisation, G4eBremsstrahlung (G4 standard)
  - em processes for e+: G4MultipleScattering, G4eIonisation, G4eBremsstrahlung, G4eplusAnnihilation (G4 standard)
  - em process for $\pi-$ and $\pi+$: G4MultipleScattering, G4hIonisation
  - hadronic interactions for $\pi-$ and $\pi+$:
    - hadr. elast. interactions for all hadrons: G4HadronElasticProcess with G4LElastic model
    - hadr. inelast. interactions unique to each hadron: G4PionPlusInelasticProcess and G4PionMinusInelasticProcess with Bertini model

G4 simulation

Dennis Wright (SLAC): G4 Tutorial, 8-10 March 2004

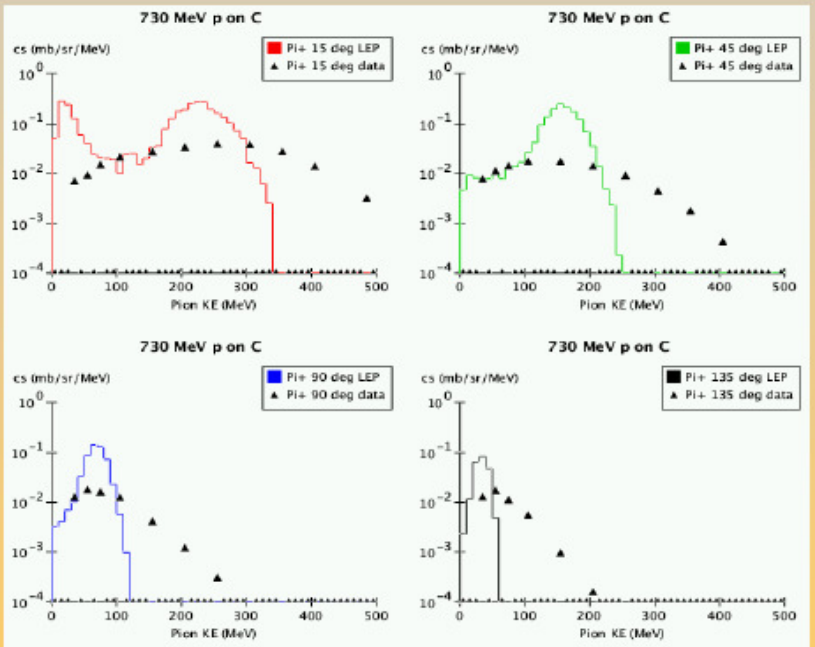
BaBar EM Calorimeter (EM shower shapes)



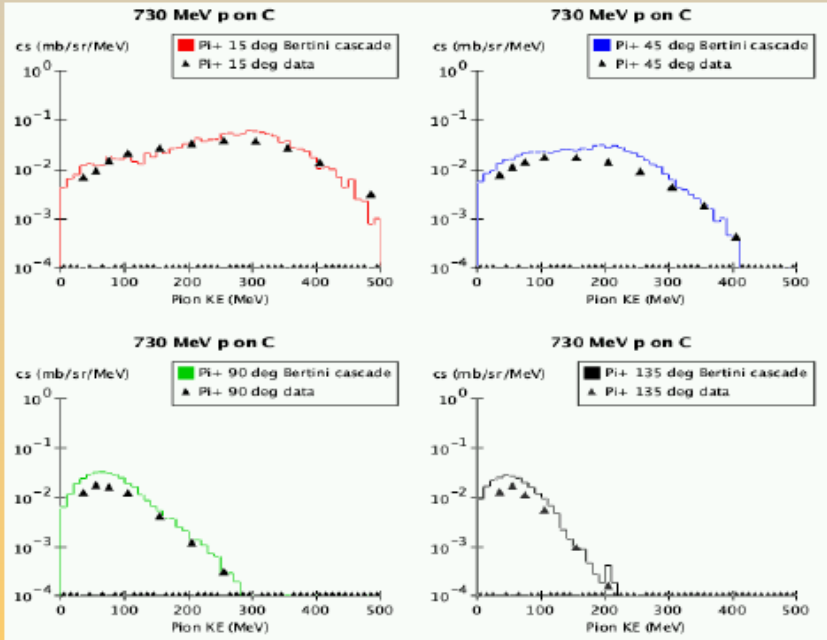
G4 simulation

Dennis Wright (SLAC): G4 Tutorial, 8-10 March 2004

π Production from 730 MeV p (LEP Model)



π Production from 730 MeV p (Bertini Model)



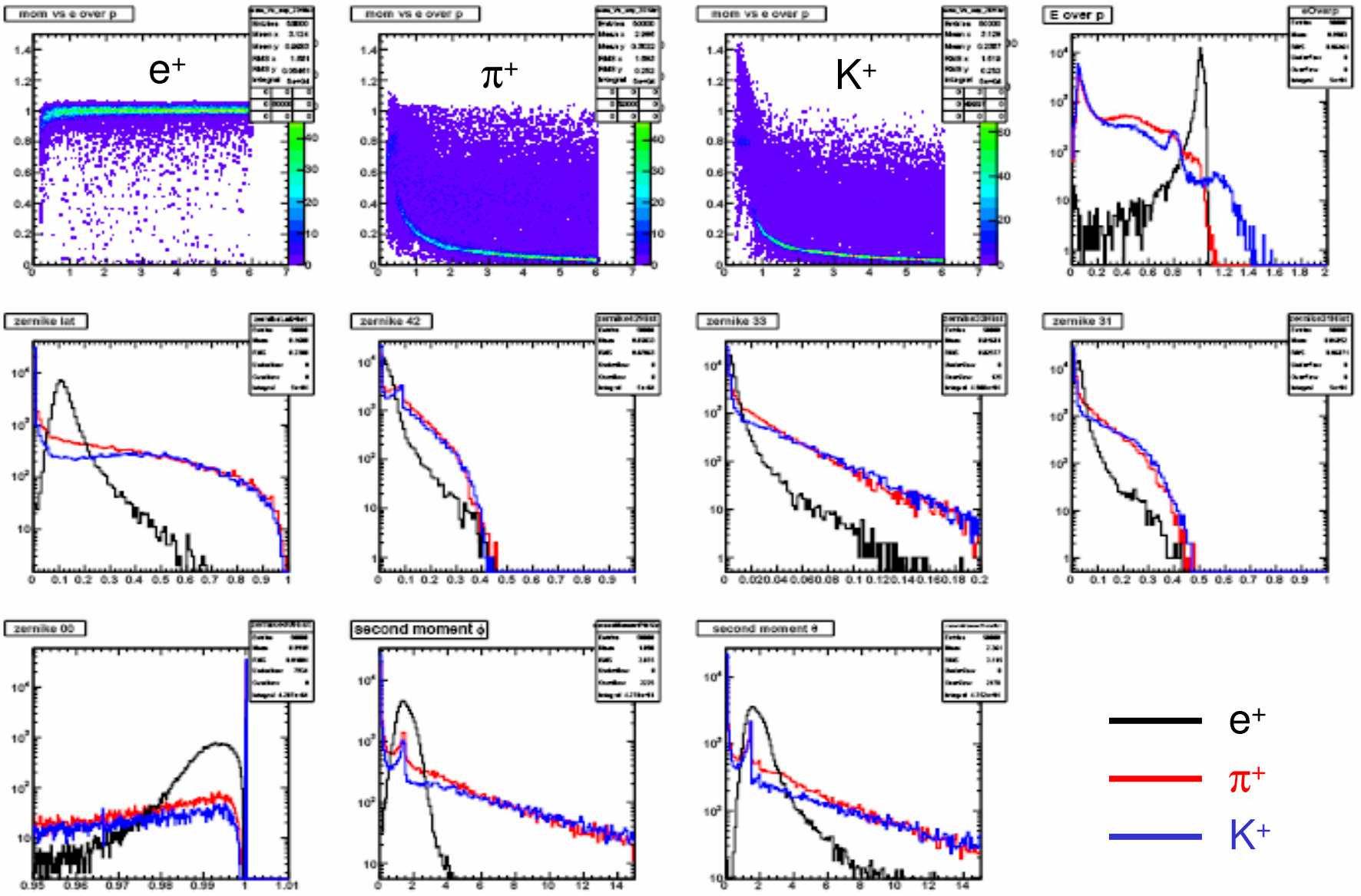
e identification with EMC

- Full simulation chain
  - G4 simulation with the complete detector, digitization, full reconstruction for the EMC
  - single particles between 0.2 … 6.0 GeV/c and cos(Θ) = -0.7 … 0.7
    - appr. 100k e^+ , π^+ , K^+ each

- Electron can be identified via
  - E/p (E: energy deposit of the cluster; p: reconstructed momentum of the track)
  - shower shape of the cluster

- Studies based on
  - complete EMC reconstruction
    - reconstructed energy deposit of the cluster
    - reconstructed shower shape of the cluster (Zernike momenta)
    - events with exactly one cluster and no multi-bump cluster
      (no split offs, no e^+ which produces one or more photons via bremsstrahlung, …)
  - tracking not taken into account
    - no matching of the charged track with the cluster
    - MC truth momentum

e identification with EMC



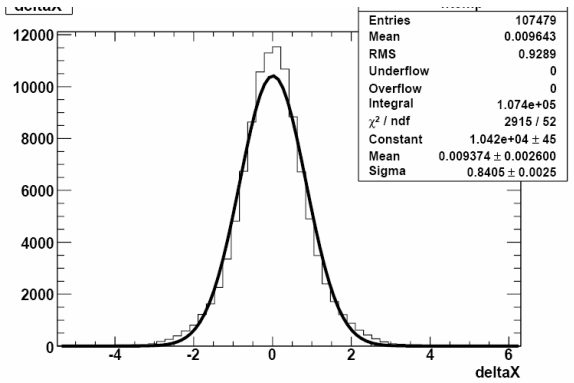
e identification with EMC

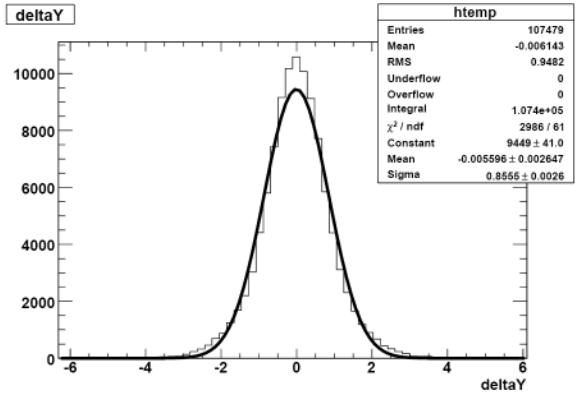
- Suitable properties for electron ID
  - e/p, p, Zernike momenta of the cluster
- Problem
  - how to find the optimal cut parameters in the multi-dimensional space
  - possible solution: usage of neural networks
- BaBar like software
  - 8 different (supervised and non supervised) neural networks available
  - first training of a multi layer perceptron (MLP) already done
    - training files: ~90k for e^+ , π^+, K^+ each
    - 9 input parameters: e/p, p, Zernike00, 31, 33, 42 and Zernike lateral, 2. momentum Φ, 2. momentum Θ
    - net response = 1 for „good“ tracks (electrons)
    - net response = -1 for „bad“ tracks (π,K)

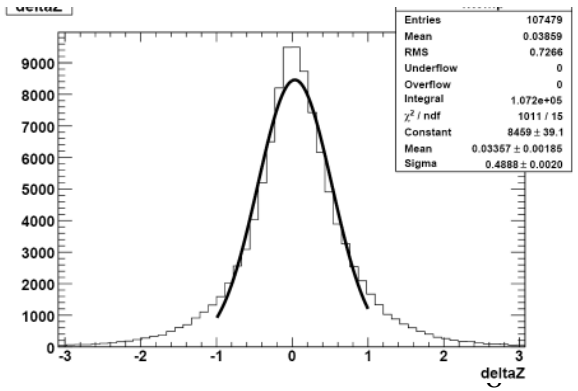
e identification with EMC

Test sample

- Test files (March 2007)
  - single particles between 0.2 … 6.0 GeV/c and cos(Θ) = -0.966 … 0.966
    - 10k e^+ , π^+, K^+, μ^+, p each
- Reconstructed and Kalman fitted STT tracks used
  - Θ coverage: ~15^0-170^0
  - pion @ 0.5 GeV/c : $\sigma(p_T)/p_T$ ~ 1.3%, σ(d0)~560 μm, σ(z0)~5260 μm
  - combined fit with MVD without and with material site also possible but not yet used
    - pion @ 0.5 GeV/c (without material): $\sigma(p_T)/p_T$ ~ 0.66%, σ(d0)~41μm, σ(z0)~42μm
    - pion @ 0.5 GeV/c (with material) : $\sigma(p_T)/p_T$ ~ 0.42%, σ(d0)~35μm, σ(z0)~37μm
- Track matching with EMC
  - association of the reconstructed track with the corresponding bump

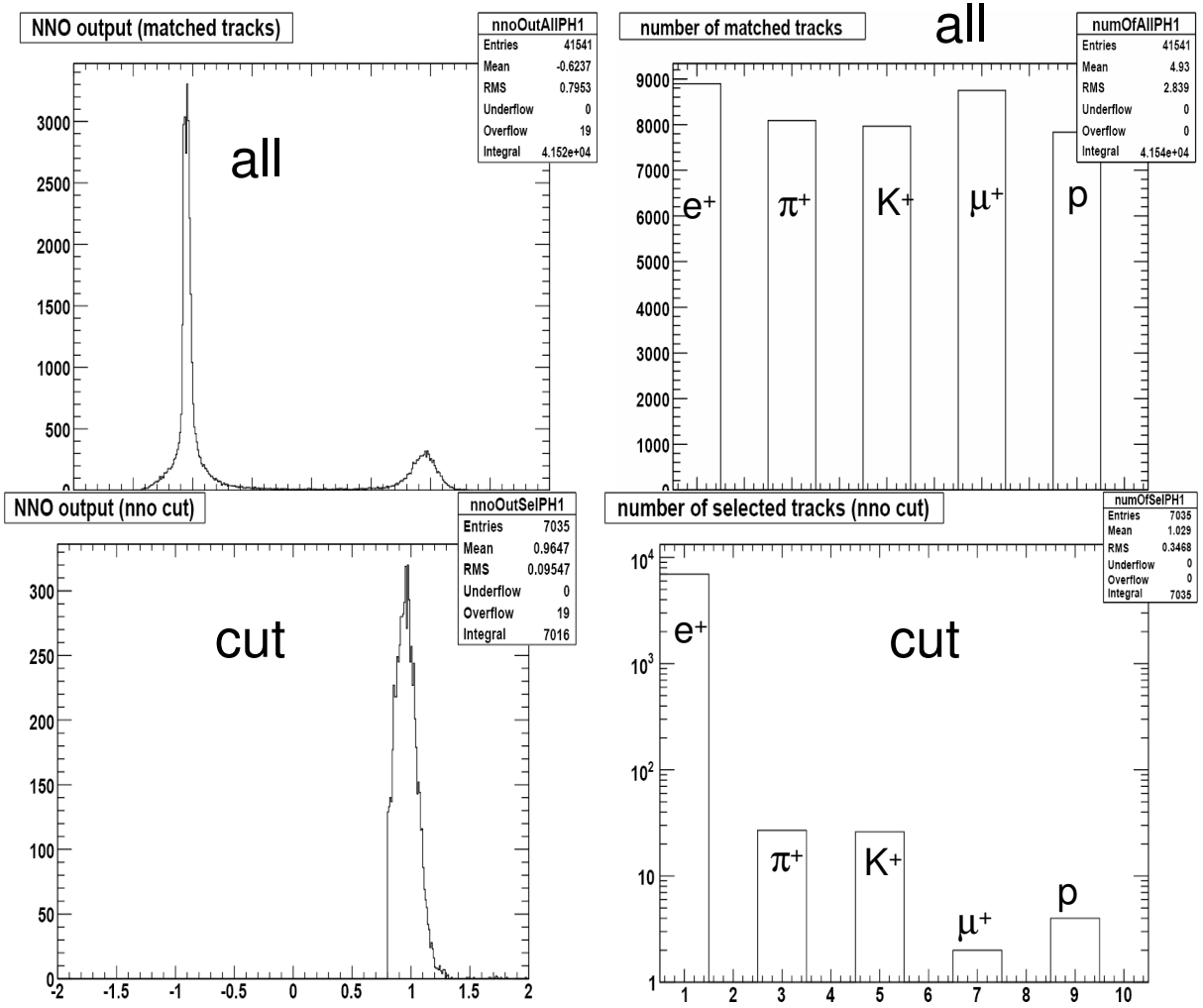






e identification with EMC

Test sample



cut: net output > 0.8

	all	EMC match	identif. as e+
# e^+	10k	8895	69,8%
# π^+	10k	8092	0,27%
# K+	10k	7966	0,26%
#μ+	10k	8753	$2*10^{-4}$
#p	10k	7835	$4*10^{-4}$

e identification with EMC

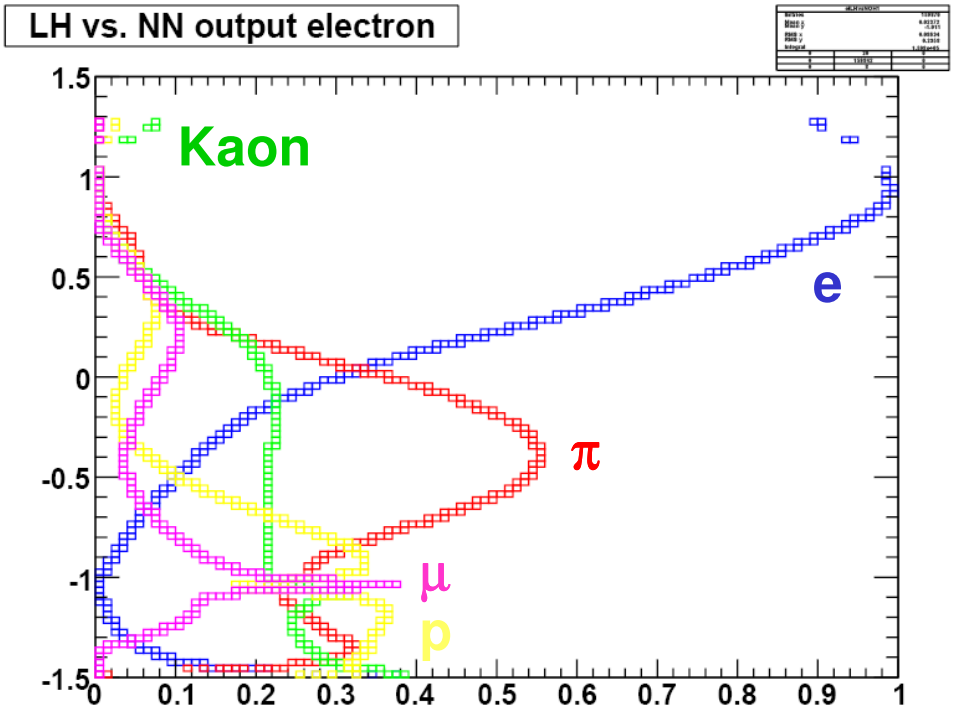
Status and possible improvements

- Electron ID via e/p and shower shape seems to work
- Background in the order of 10^{-3} for equal fluxes
- Improvements possible
  - complete tracking and track matching should be included for the training files
  - additional/other properties as input for NN
  - how many hidden nodes for the MLP?
  - test with other neural networks
  - combination with other detectors (e.g. dE/dx, tof, cherenkov)

e+e- analysis

- 4 different BtaElectronCandLists based on NN (part of reconstruction)

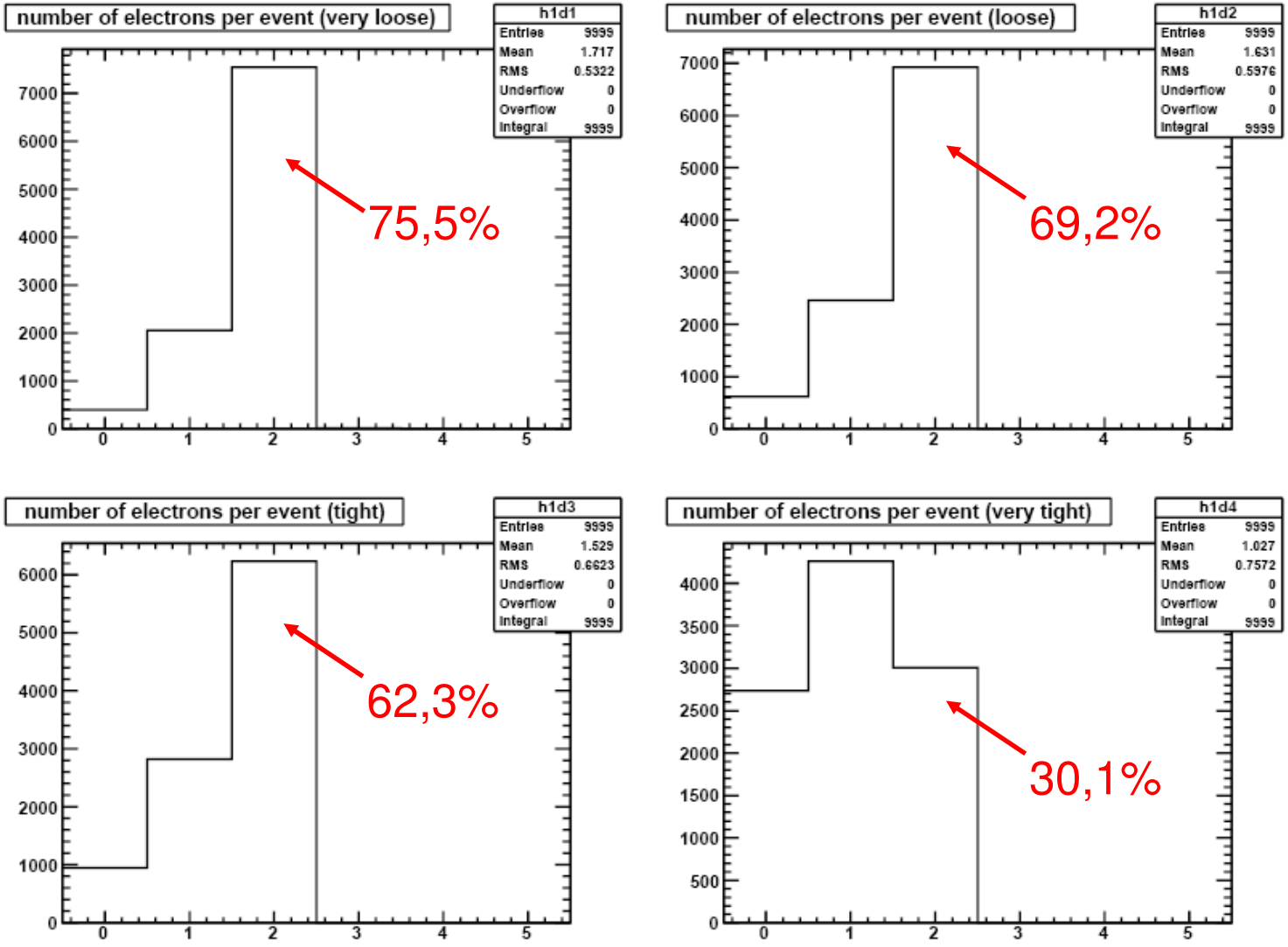
  - veryLoose: LH for electronId > 5%
  - loose: > 75%
  - tight: > 90%
  - veryTight > 98%



- 10k e+e- events @ η_C (phasespace)
- 910k $\pi^+\pi^-$ background events @ η_C (phasespace)

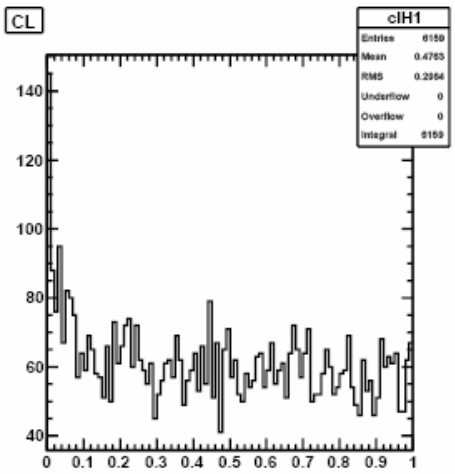
e+e- analysis

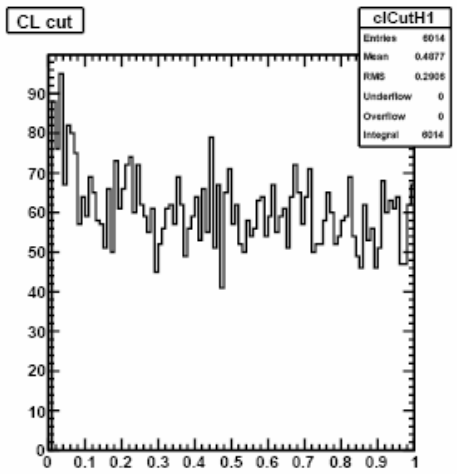
- 10k e+e- events @ η_C (phasespace)

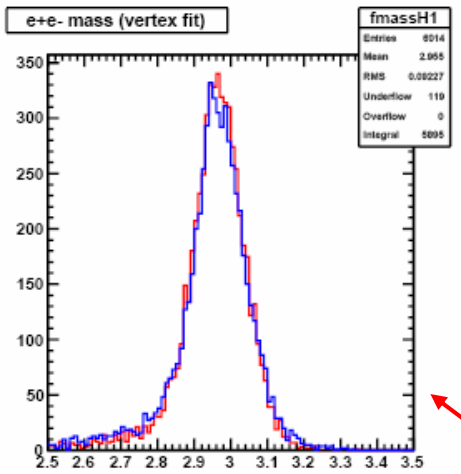


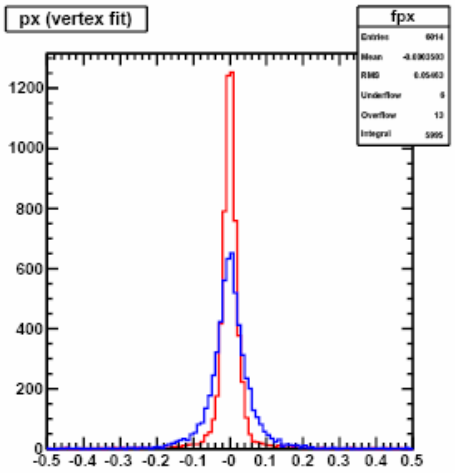
e+e- analysis

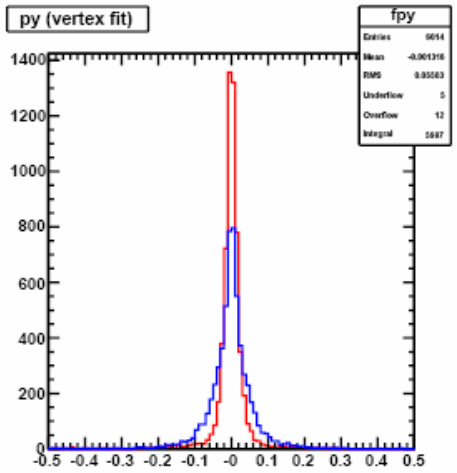
- vertex and kinematic fitting works

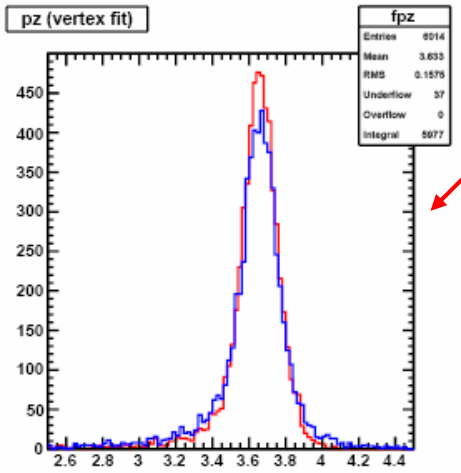












vertex fit only based on STT reco tracks

e+e- analysis: π+π– background

- 910k π+π– events @ η_C (phasespace)