Electron Identification
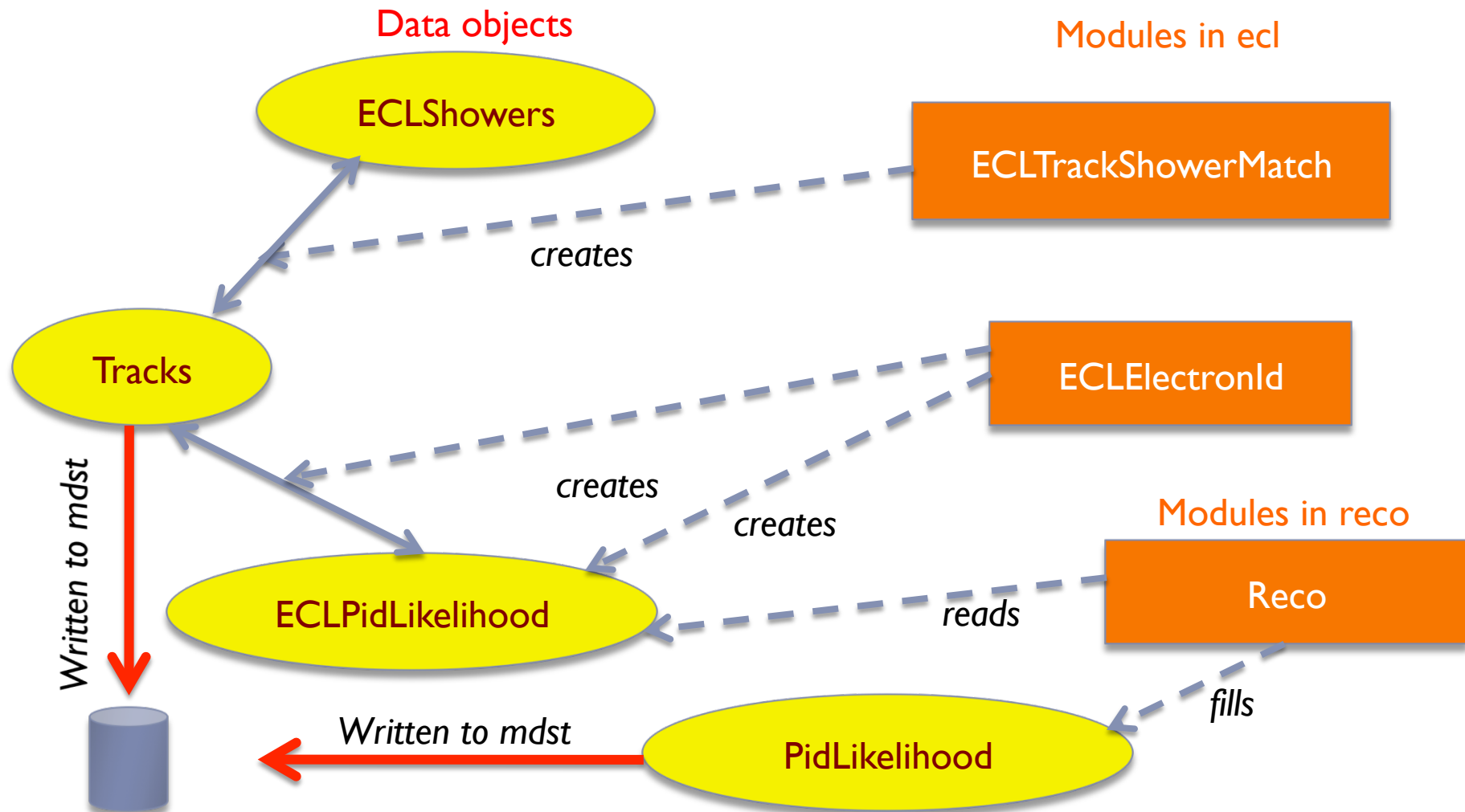
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Software framework

- In Belle II analysis model analysts expected to use just mdst

  - Only lightweight high level data objects stored ("Particles", for example)

  - Particle identification info saved in a single object `PidLikelihood`

  - To each charged Particle corresponds one object.

  - The object keeps the log-likelihoods from all the sub-detectors

  - The interface provides access to likelihood for each particle hypothesis (e, μ, π, k, p), plus some utility functions

- Sub-system responsibility to provide a response function for each particle hypothesis (a likelihood value)

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Electron identification software (ecl)

Data objects

Modules in ecl

ECLShowers

ECLTrackShowerMatch

creates

Tracks

ECLElectronId

creates

creates

Modules in reco

Written to mdst

ECLPidLikelihood

reads

Reco

fills

Written to mdst

PidLikelihood

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Dataset and software used

- Used release-00-04-01 and a data sample from the recent (finished a week ago) MC-3.5 production
  - 2M $\tau\tau$ + 2M B^+B^- + 2M B^0B^0 events
  - Calibrated the E/p distribution for e, μ and π from $\tau\tau$ pairs
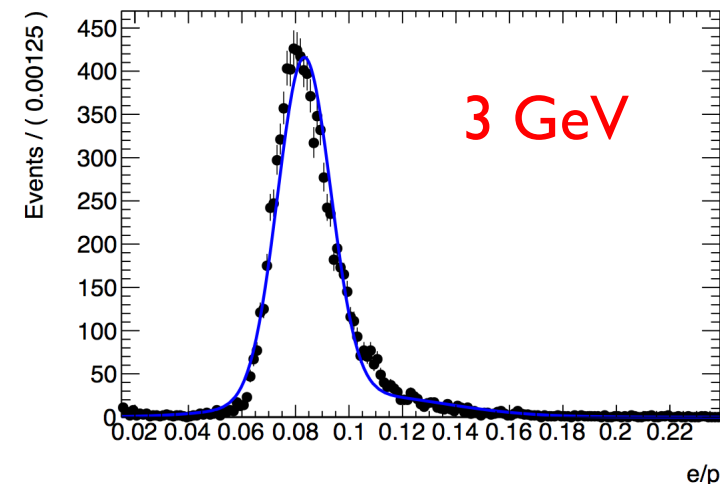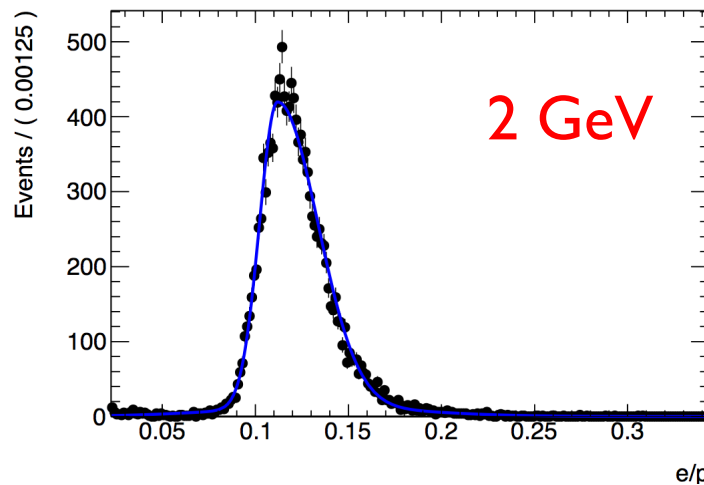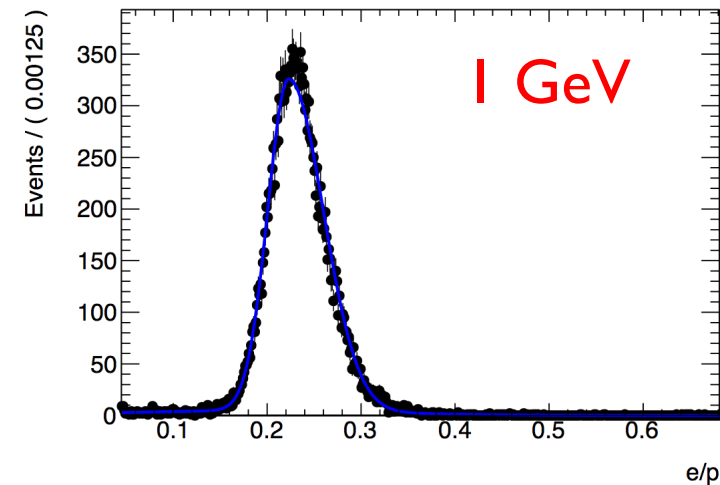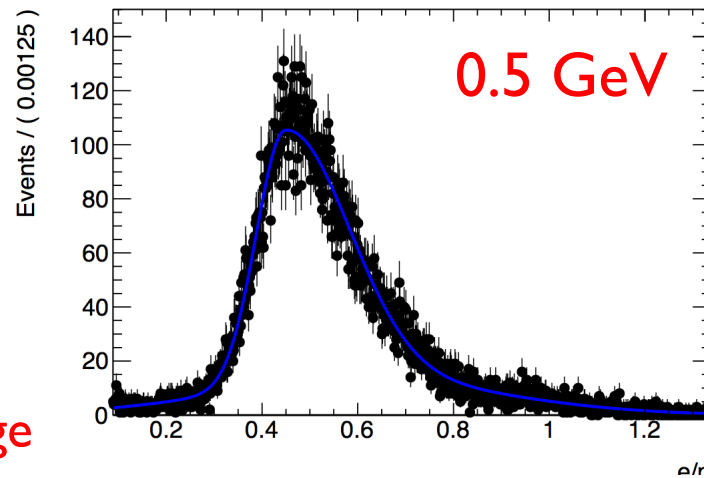 - Defined a test selection and measured performances on BB pairs

Momentum in LAB frame

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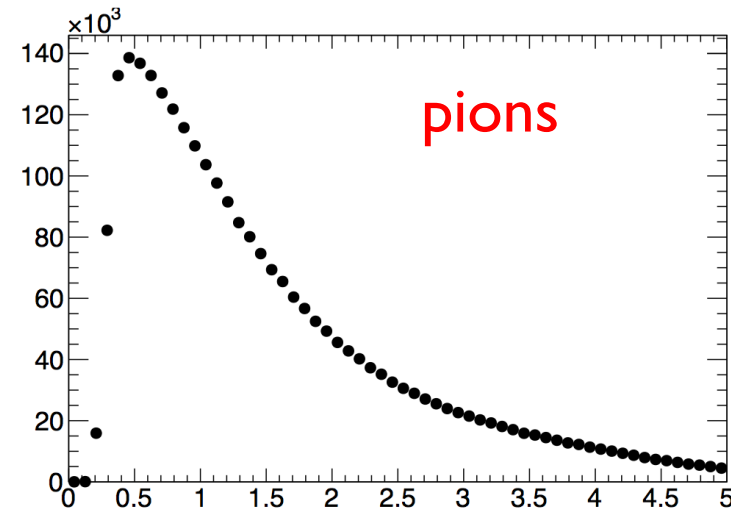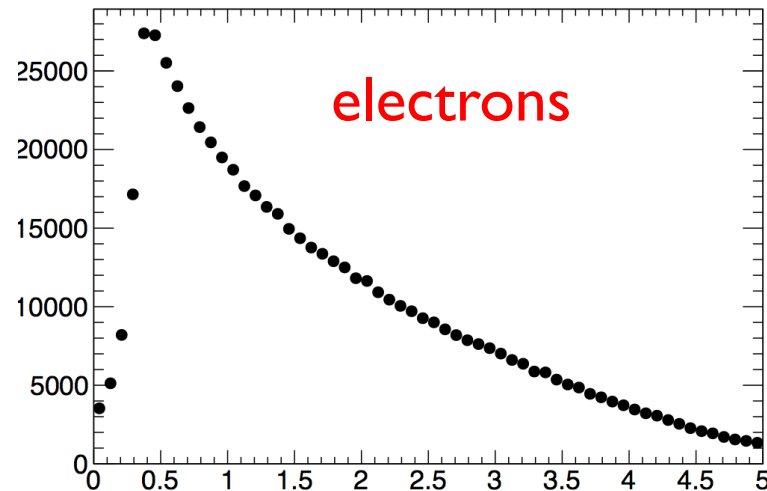
Electron E/p distributions

▸ Crystall ball + Gaussian
_{eop}

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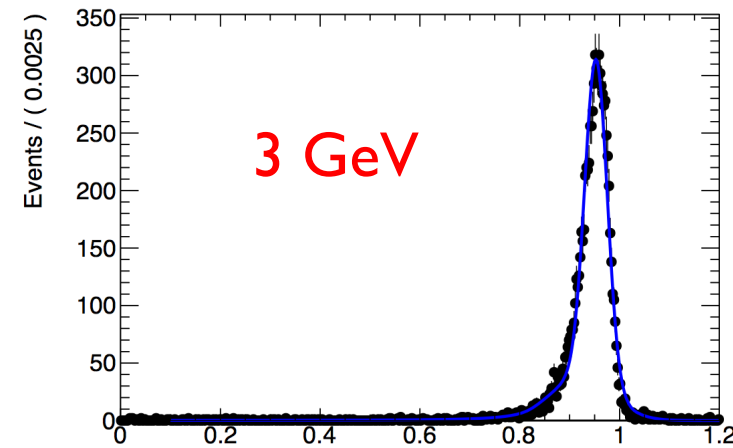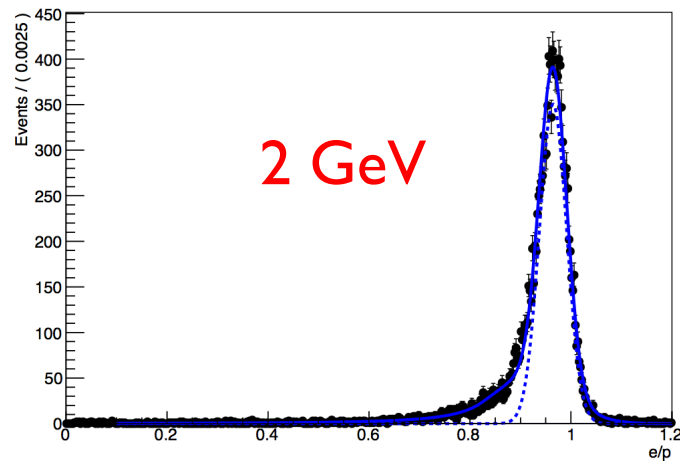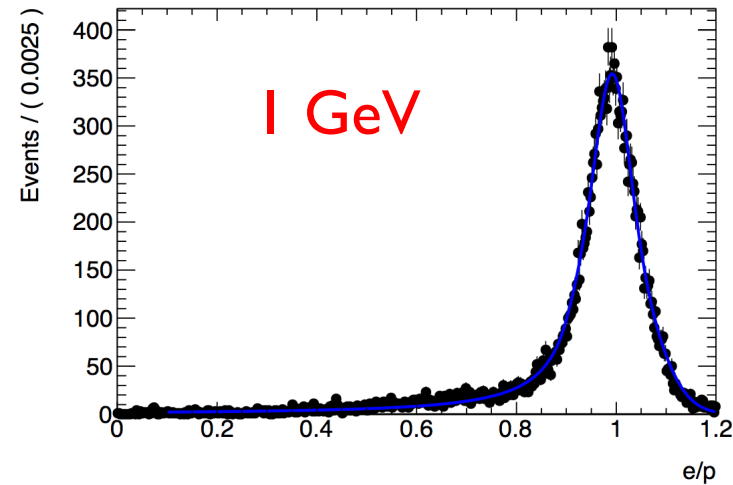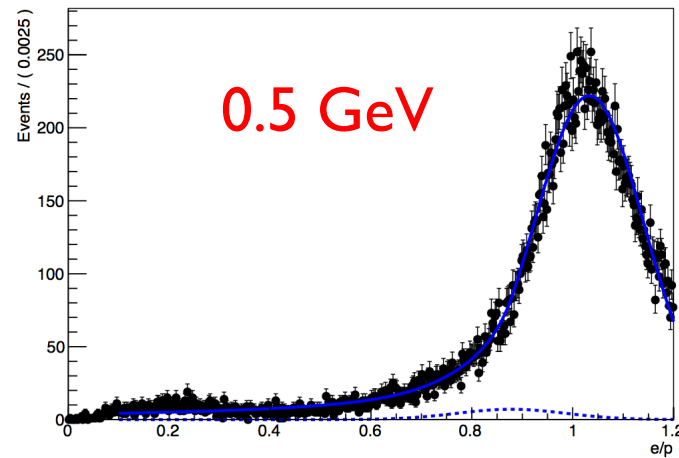
Muons pdf

▸ Bifurcated gaussian + gaussian

Note the change in E/p axis

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Pions pdf

▸ Bimodal distribution: MIP-component + wide gaussian

Feature to be understood
Cluster reco problem?

0.5 GeV

1 GeV

2 GeV

3 GeV

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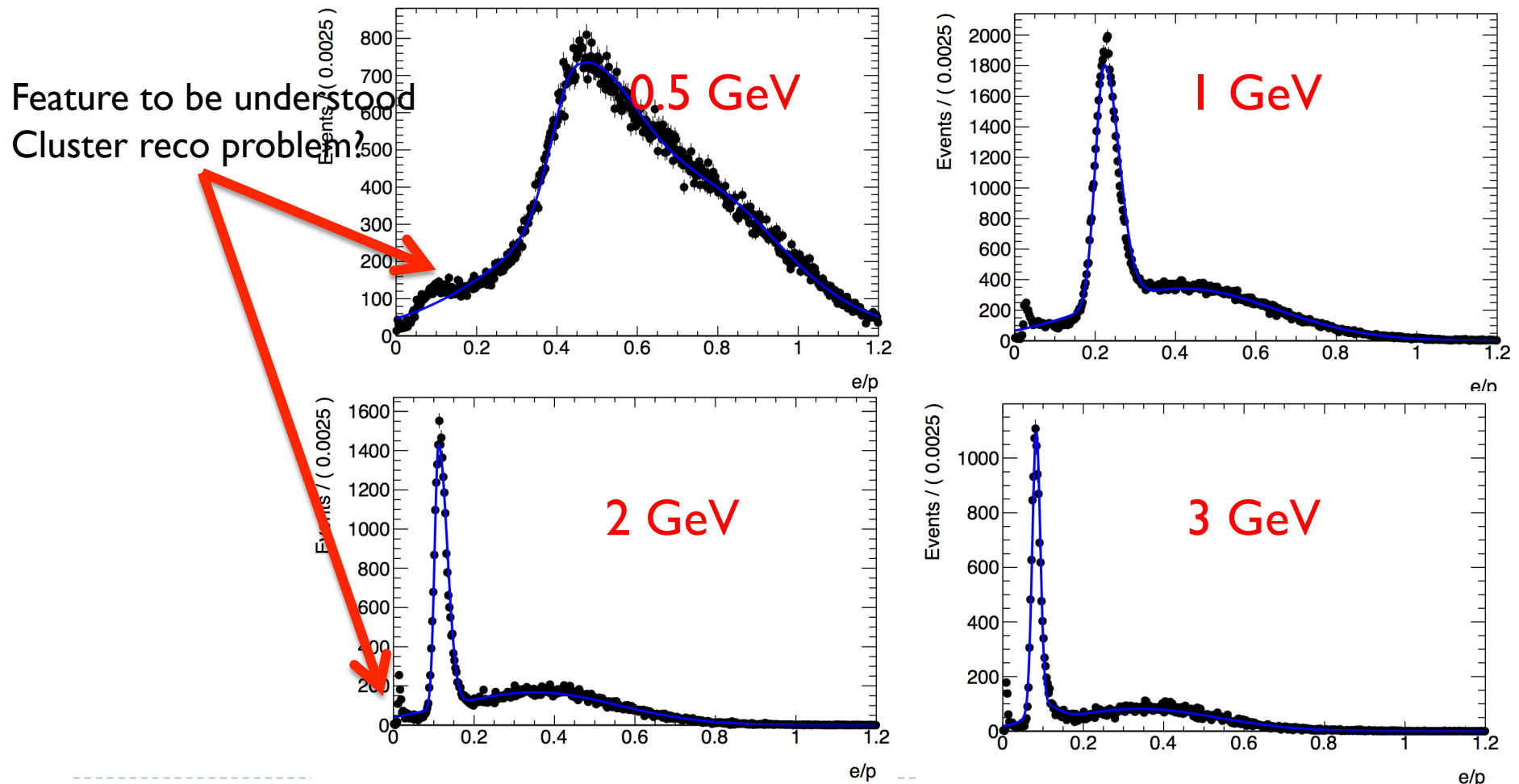
Test of performances

▸ There are several ways to combine probabilities to build a test of hypothesis

▸ To check performances have a look at a likelihood ratio and set a possible selection by eye

▸ Use the B+B- and B0B0 sample measure the performances

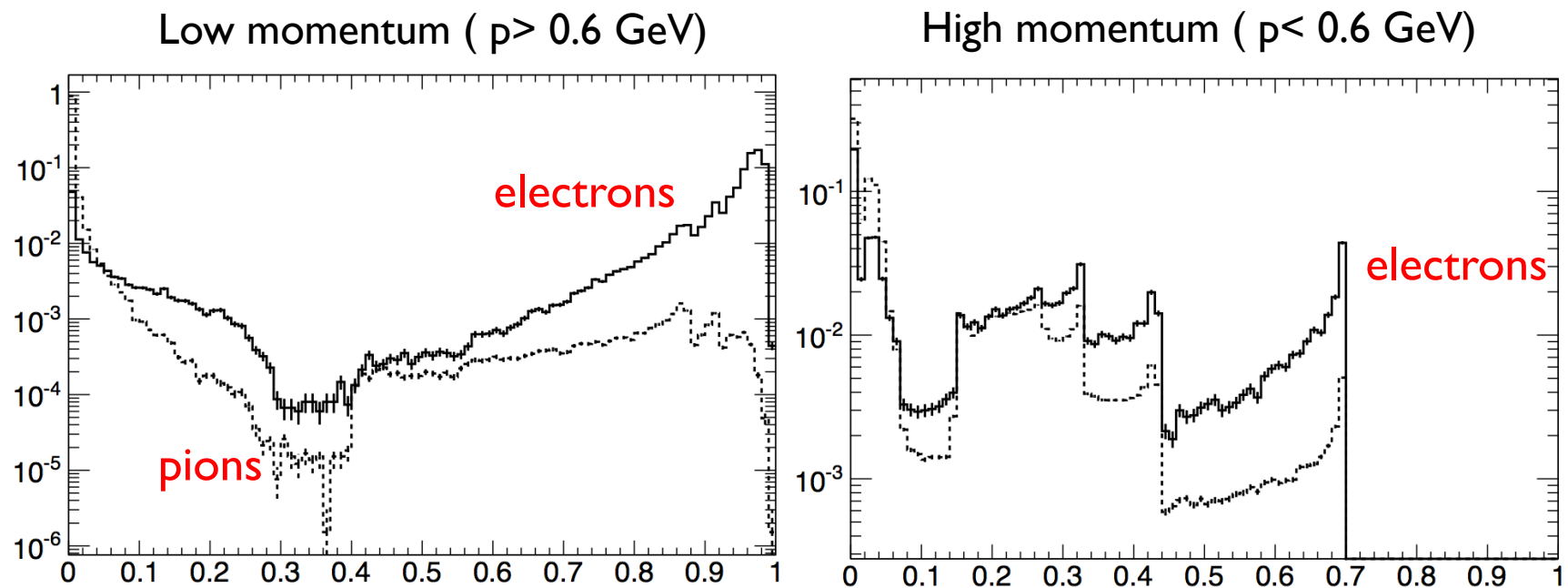$$R = \frac{\mathcal{L}(E/p\,|e)}{\mathcal{L}(E/p\,|e) + \mathcal{L}(E/p\,|\mu) + \mathcal{L}(E/p\,|\pi)}$$
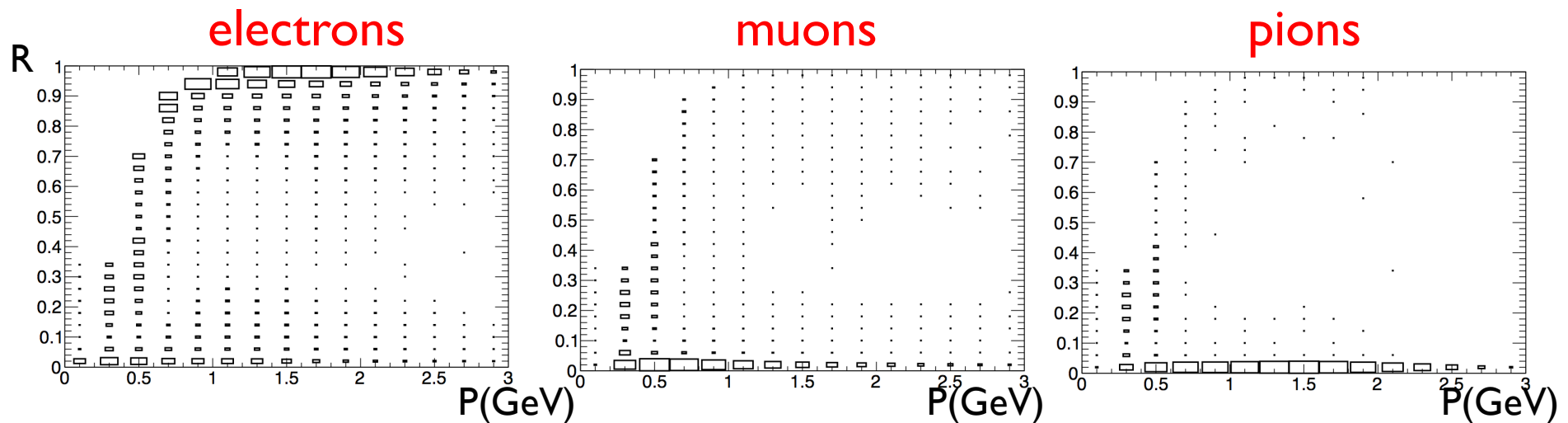
Two regions ECL:

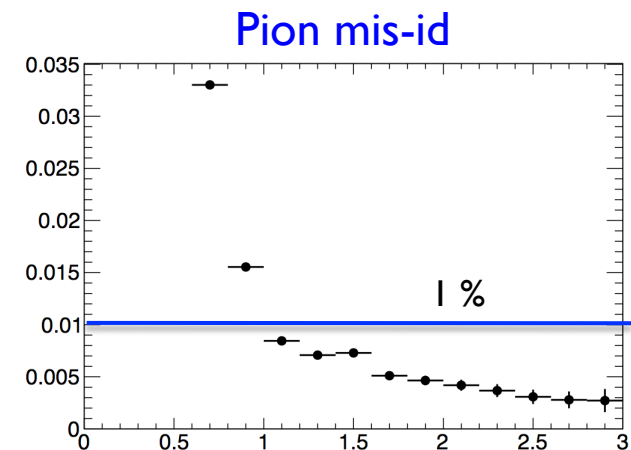p>600 MeV good e/μ/π separation, otherwise the distributions become too similar

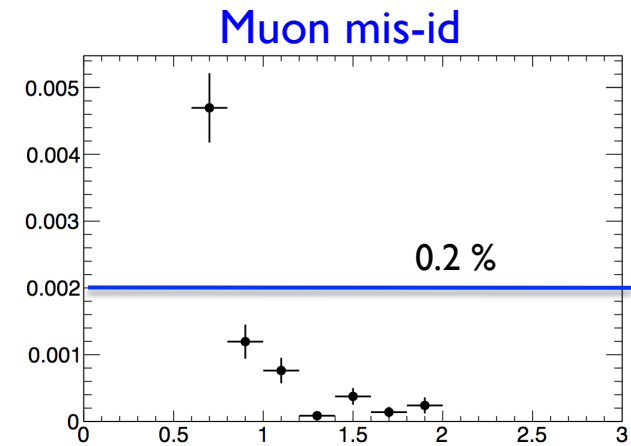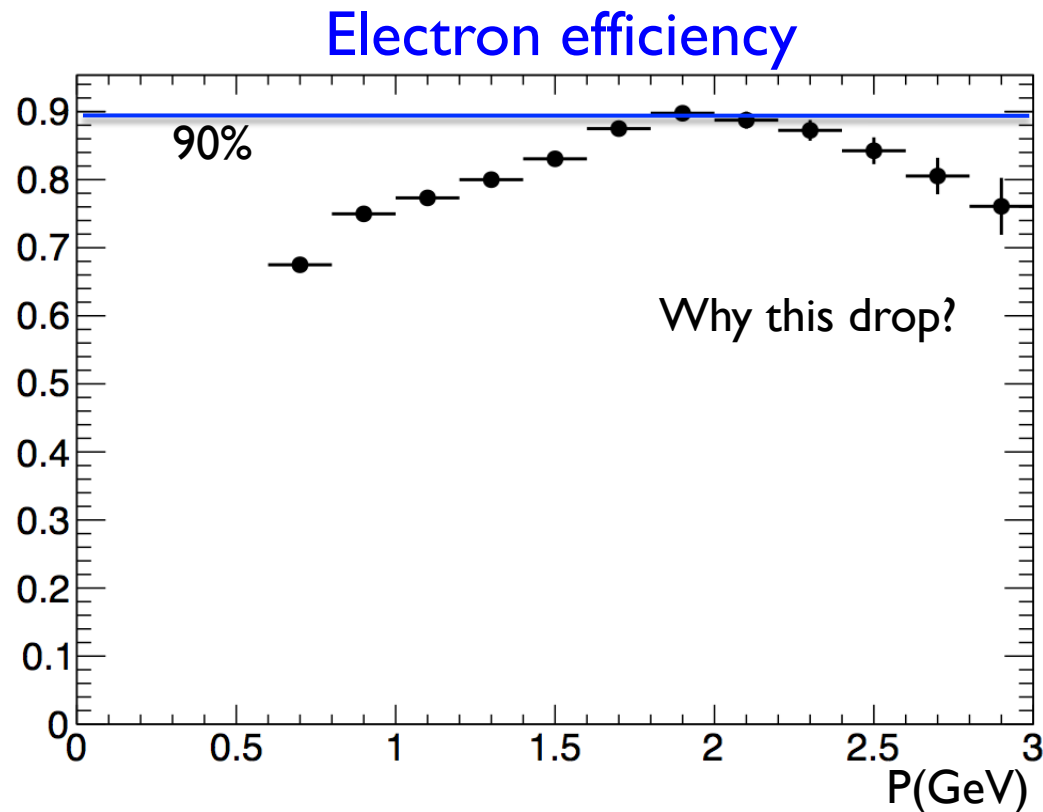Guglielmo De Nardo - Electron Identification

Likelihood fraction distribution for high and low momentum

Low momentum (p> 0.6 GeV)

High momentum (p< 0.6 GeV)

electrons

pions

electrons

Guglielmo De Nardo - Electron Identification

Performances for a test selection (R>0.7)

▸ Selection chosen by eye just for illustrative purposes

Electron efficiency

Muon mis-id

Pion mis-id

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Intrinsic efficiency and mis-ids

▸ ## Requiring an cluster in the ECL

Electron efficiency

Muon mis-id

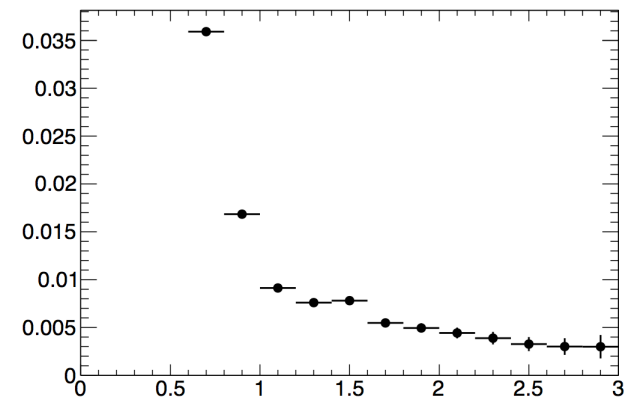**Pion mis-id**

Drop in the efficiency less evident
→to be investigated cluster reconstruction and track/cluster association
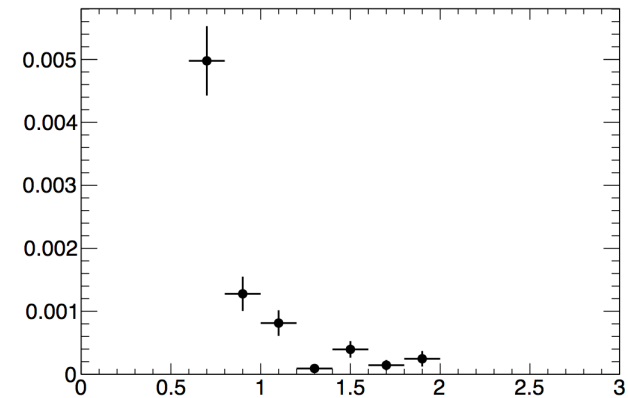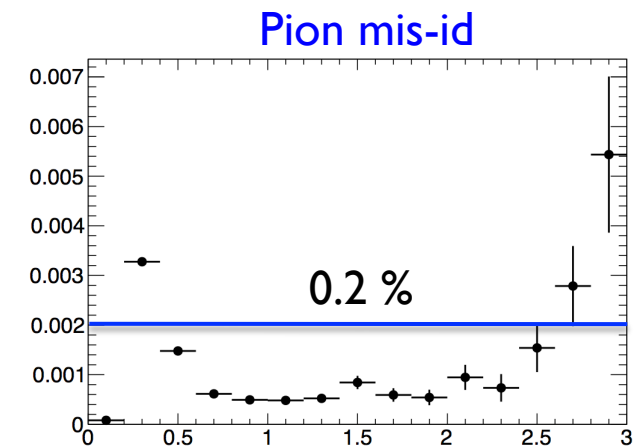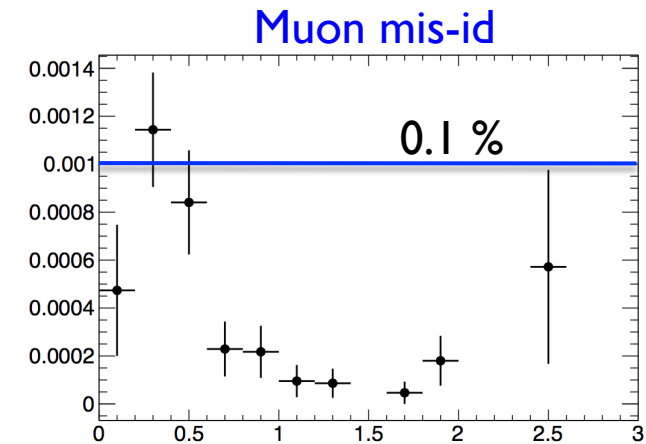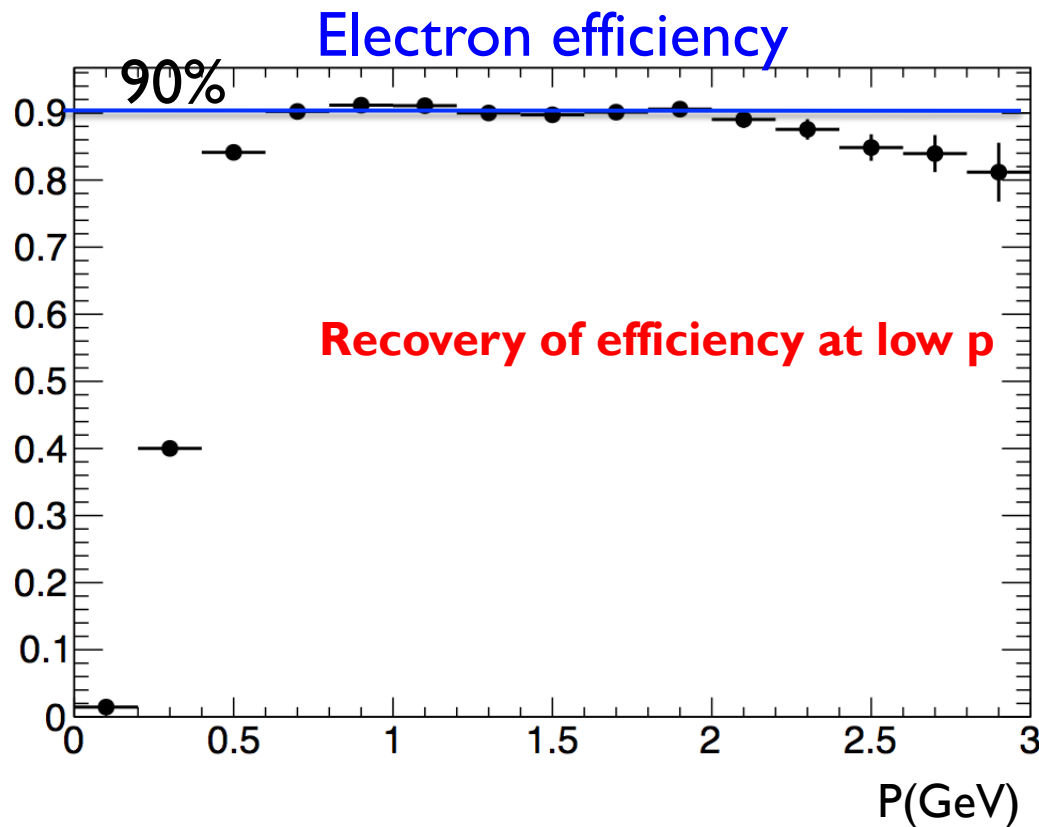
Augmenting the likelihood

- ▶ **Adding more variables to the likelihood should improve the efficiency and further reduce mis-identification rates**

  - ▶ dE/dx from tracking devices (useful at low p)

  - ▶ Shower shape variables for e/π discrimination

    - ▶ BaBar like LAT (lateral shape) already implemented in ECLCluster (ecl object in the mdst)

    - ▶ Other variables identified for mdst, but to be implemented

  - ▶ dE/dx already available in PidLikelihood: let's see the effect using:

$$\mathcal{L}(E/p\,|\mathrm{h}) = \mathcal{L}_{ECL}(E/p\,|\mathrm{h}) \times \mathcal{L}_{SVD}(dE/dx\,|\mathrm{h}) \times \mathcal{L}_{DCH}(dE/dx\,|\mathrm{h})$$

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Performance test (R>0.95)

▸ Without requiring an associated cluster to the track

Electron efficiency

90%

Recovery of efficiency at low p

P(GeV)

Muon mis-id

0.1 %

Pion mis-id
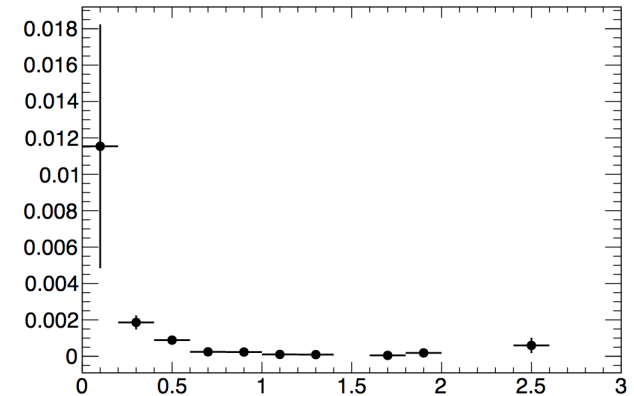
0.2 %

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Likelihood based selection efficiency (excluding reco ineff. and acceptace)

▸ Requiring a cluster in the ECL

Electron efficiency

Muon mis-id

Pion mis-id

Guglielmo De Nardo - Electron Identification
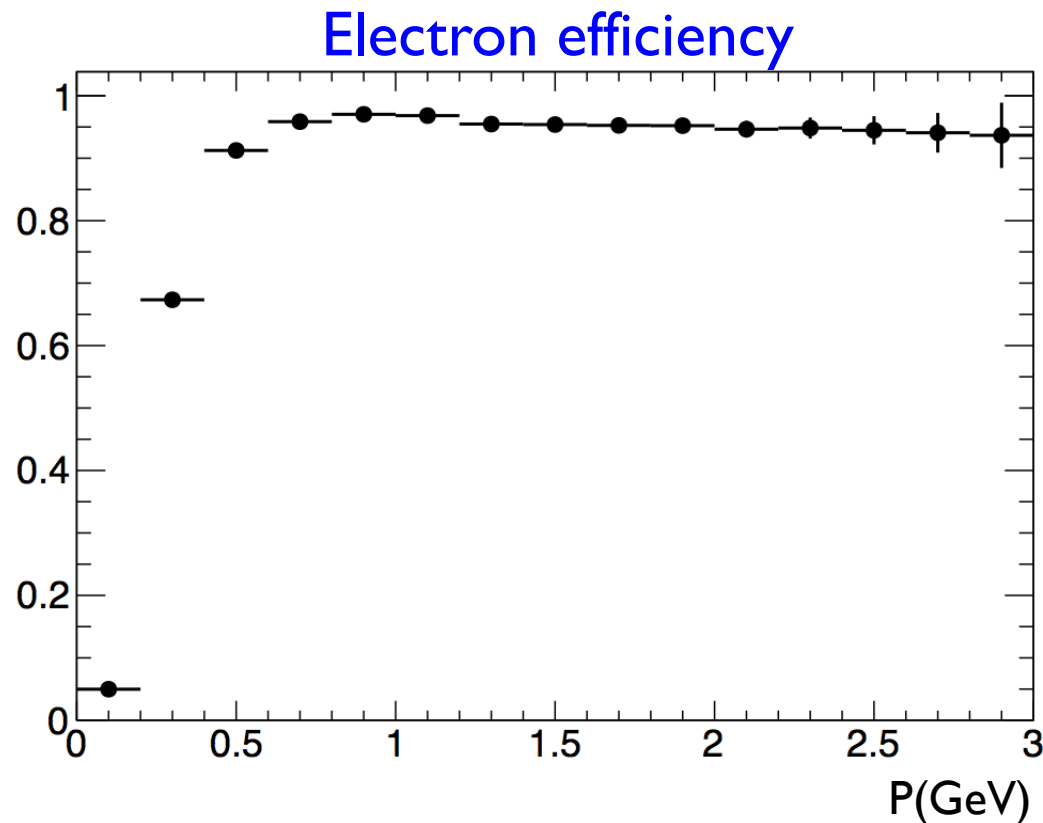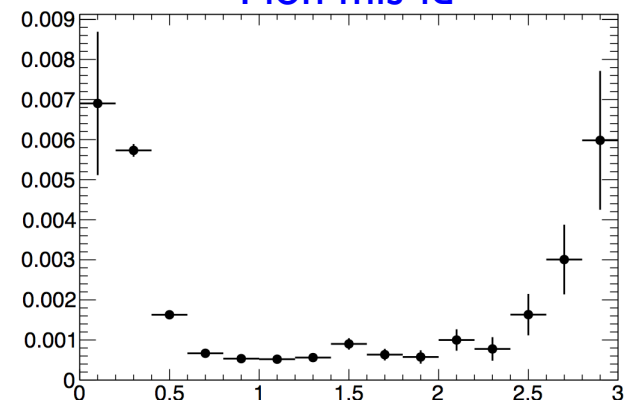
Conclusions

- **Current Status**
  - Ecl E/p P.d.f. calibrated with V00-04-01 and MC-3.5 production
  - Evaluated an electron identification selection with dE/dx and E/p
    - Electron id efficiency $\varepsilon > 90\%$ at plateau
    - Pion mis-id at 0.1 % level, negligible muon mis-id

- **Next steps**
  - Commit the new p.d.f. for ecl likelihoods for future usage
    - Also provide an analysis module to update the likelihoods (to use them also for already produced MC 3.5 mdst)
  - Review cluster reconstruction and Track/cluster matching
  - Study additional ecl variables related to shower lateral development
    - Sinergy with neutral particle identification (γ, $\pi0$, K_L)

- **People willing to join very welcome!**