Particle Identification at ZEUS for Semi-Leptonic Decays of Charm

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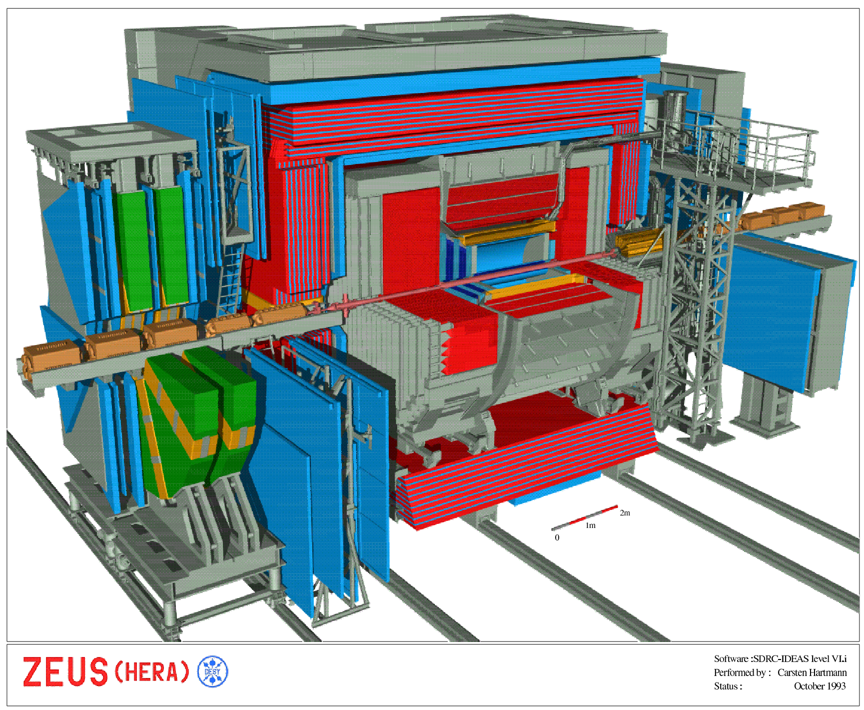
Mark Bell, Oxford University

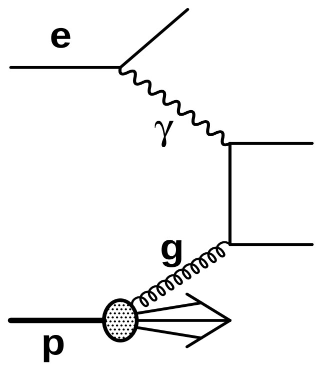
HERA & ZEUS

- HERA collides 920 GeV p with 27.6 GeV $e^{\pm}$, centre of mass energy 318 GeV.
- ZEUS one of two multi-purpose colliding experiments, main components are central tracking detector (CTD) and calorimeter (CAL).
- Upgraded detector includes new silicon micro vertex detector (MVD).
- Nearly 200 pb^{-1} data collected from HERA-II, hopefully 500 pb^{-1} more to come!



Charm Production in DIS

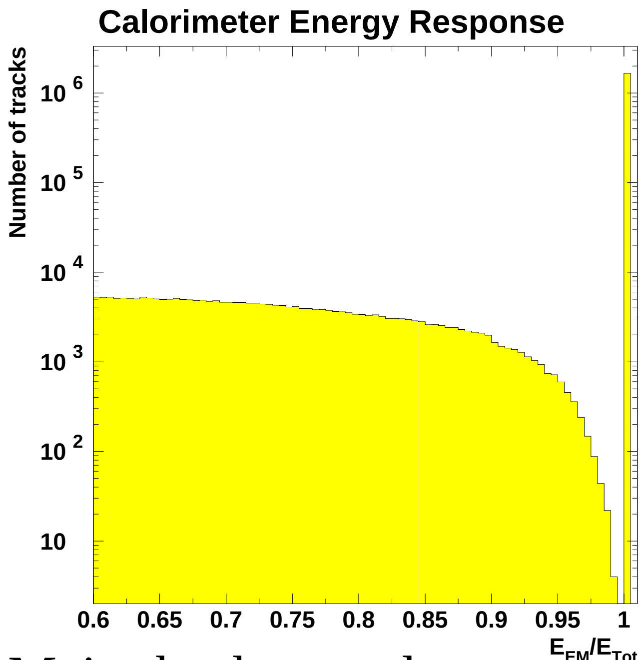
- Charm production in DIS is a testing ground for QCD.
- $m_{charm} \gg \Lambda_{QCD} \Rightarrow$ perturbative calculations can be performed.
- Dominant contribution is Boson Gluon Fusion ($\gamma g \rightarrow q\bar{q}$), sensitive to gluon distribution of proton.

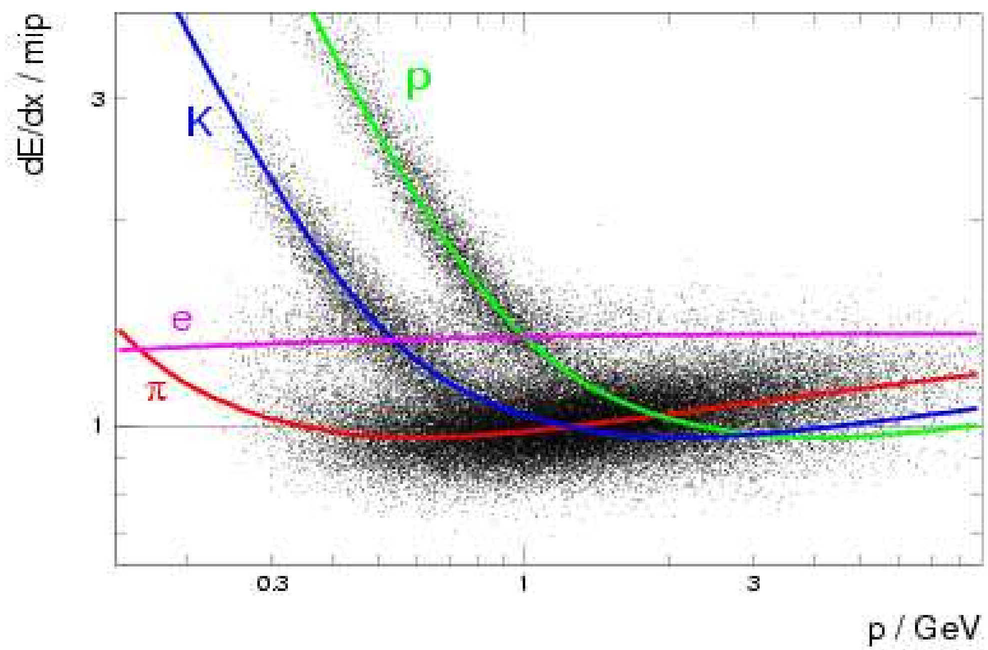


- Charm tagged through detection of charmed hadrons.
  - Exclusive: $BR(c \rightarrow D^{*} \rightarrow D^{0} \rightarrow K\pi\pi) = 0.66\%$
  - Inclusive: $BR(c \rightarrow e) = 10.3\%$

Semi-Leptonic Decays of Charmed Hadrons

- Inclusive measurement of $c \to e\nu_e X$.
- Identify electrons through combination of energy deposit in calorimeter and dE/dx measurement in gaseous Central Tracking Detector (CTD).

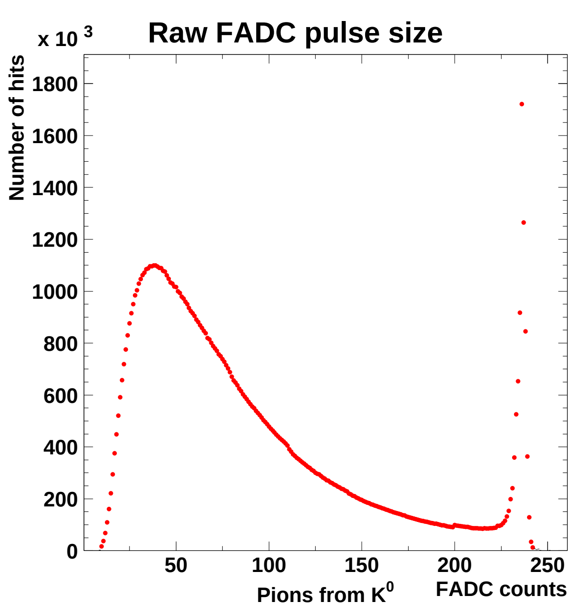


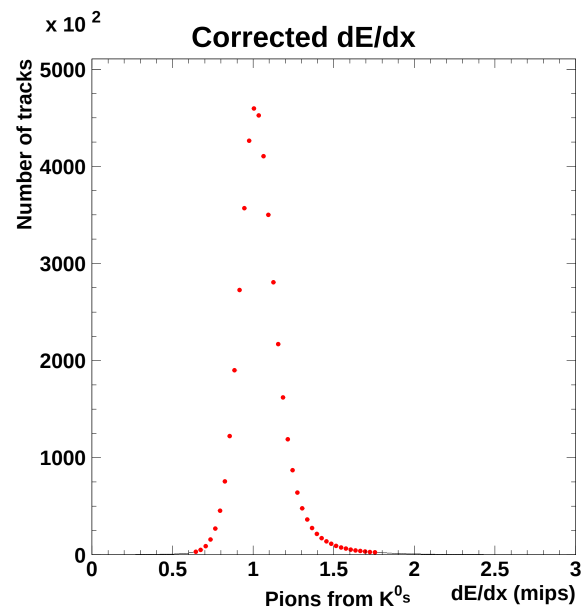


- Major backgrounds:
  - Photon conversions ($\gamma \to e^+e^-$).
  - Dalitz decays of neutral pions ($\pi^0 \to \gamma e^+e^-$).
  - Hadrons which fake electrons.
  - Semi-leptonic decays of beauty.

CTD dE/dx

- CTD is a gas filled wire drift chamber, 83% Ar, 12% CO_2, 5% C_2H_6.
- Contains 4608 sense wires arranged in 9 superlayers, 8 layers of wires per superlayer.
- Energy loss of charged particles in CTD gas proportional to charge signal detected on sense wires.

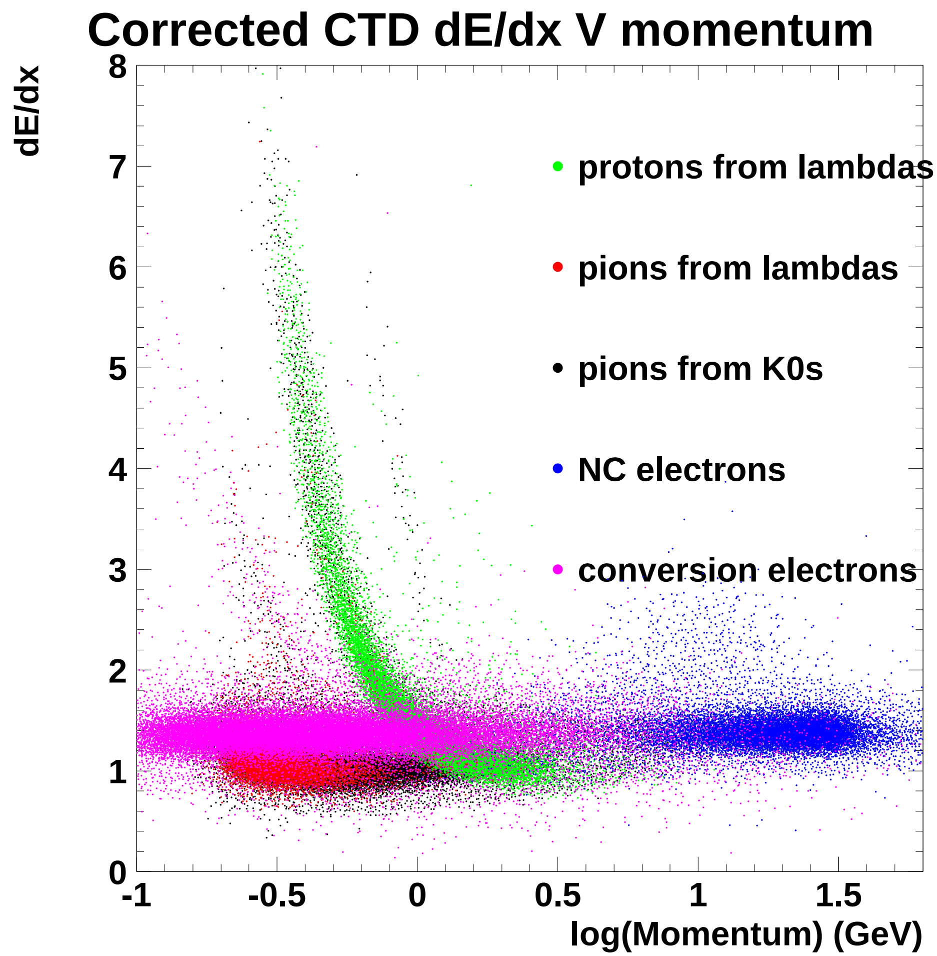




- Truncated mean of pulse heights on a particle's track taken to calculate dE/dx.
- Corrections made for a number of factors including path length, wire gains, drift distance, environmental conditions.

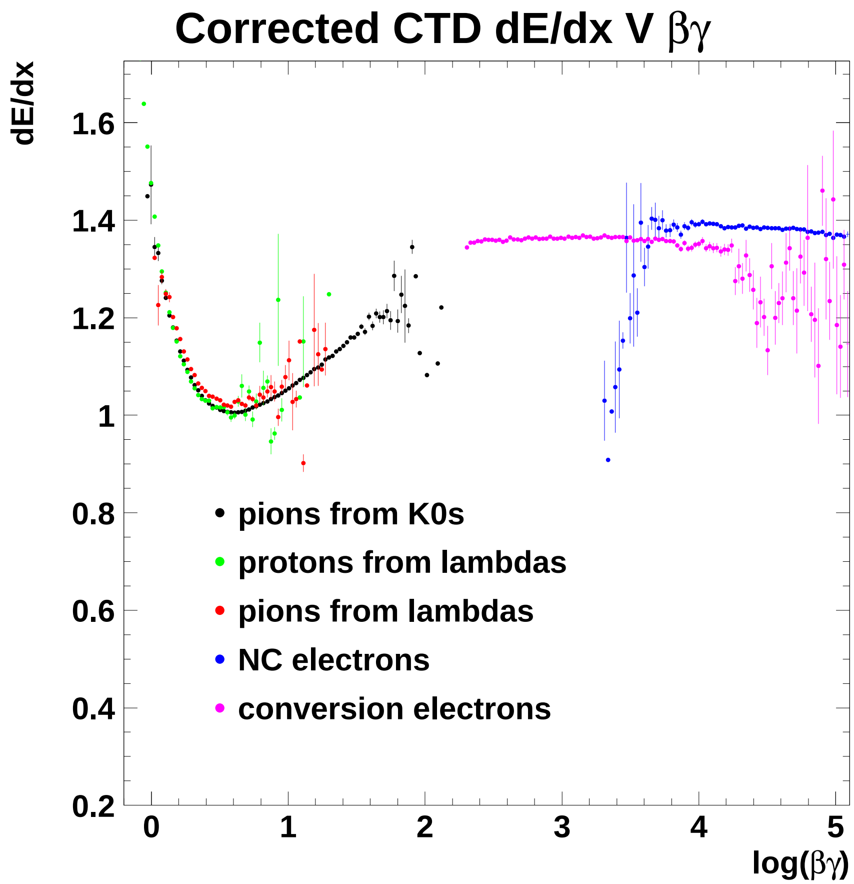
dE/dx Parametrisation

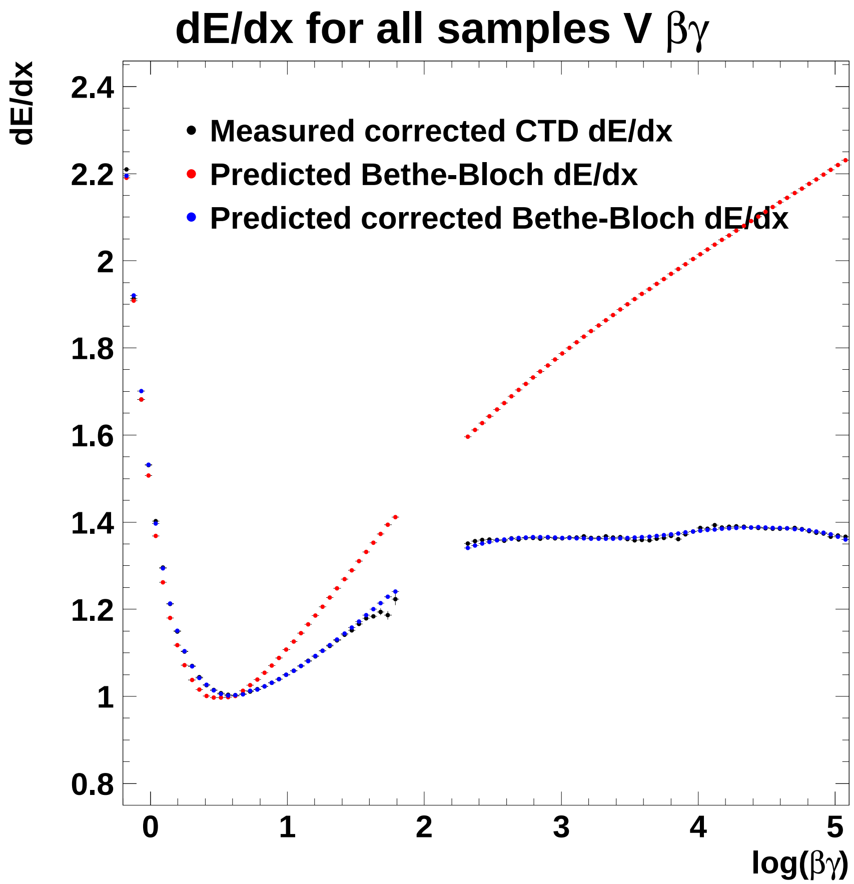
- dE/dx parametrisation:
  - test function for likelihood method
  - simulation of dE/dx in MC
- Large known particle samples collected:
  - $K_s^0 \rightarrow \pi^+\pi^-$
  - $\Lambda^0 \rightarrow p\pi$
  - NC DIS $e^\pm$
  - $\gamma \rightarrow e^+e^-$
- Only tracks passing through all 9 superlayers of CTD used to get best dE/dx measurement.



dE/dx Parametrisation

- dE/dx only depends on βγ, independent of particle type.
- Spectrum fitted with Bethe-Bloch function corrected to fit data.

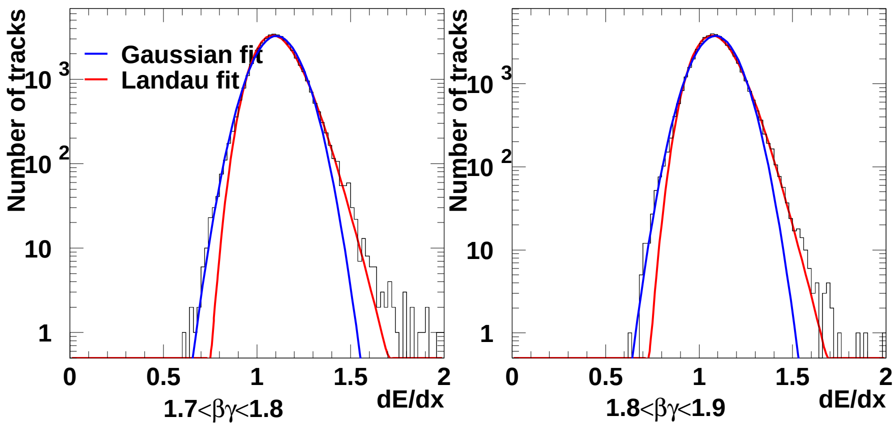




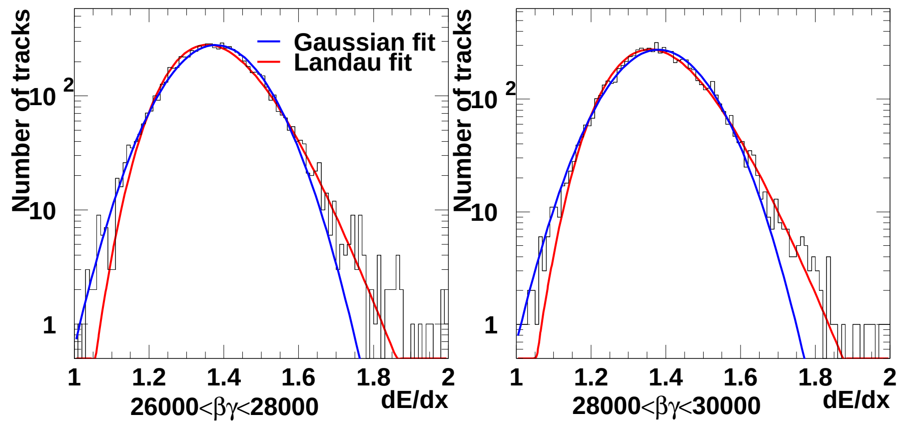
dE/dx Parametrisation

- Shape of dE/dx spectrum needs to be fitted to properly describe data.
- Fits performed on spectrum in bins of βγ for all the different particle samples.
- Different functions tried:
  - Gaussian: $f(x) = Ae^{-\frac{1}{2}\left(\frac{x-B}{C}\right)^2}$
  - Landau: $f(x) = Ae^{-\frac{1}{2}\left(\frac{x-B}{C}+e^{-\left(\frac{x-D}{E}\right)}\right)}$

dE/dx for pions from K^0_s



dE/dx for NC DIS electrons

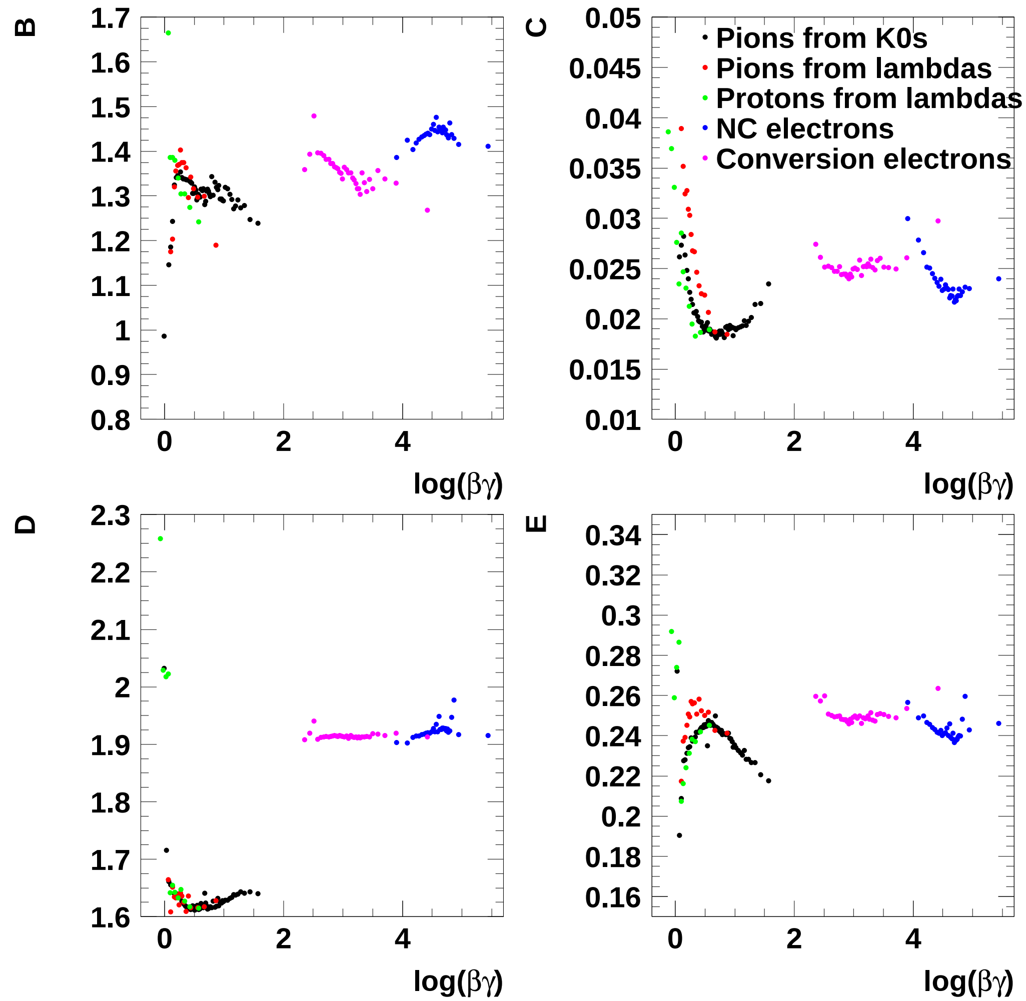


- Landau function slightly better at describing tails of distribution.

dE/dx Simulation

- Landau fit parameters can be plotted and fit as a function of $\beta\gamma$.
- Accurate parametrisation and simulation of value and shape of dE/dx can be made.

$$f(x) = Ae^{-\frac{1}{2}\left(\frac{x-B}{C}+e^{-\left(\frac{x-D}{E}\right)}\right)}$$



Summary

- Charm production plentiful at HERA.
- Semi-leptonic decays to electrons provide a large branching ratio.
  - Comparing to $D^* \rightarrow D^0 \rightarrow K\pi\pi$, making large assumptions about effiencies and acceptances, expect of the order of 50,000 $e^{\pm}$ for 200 pb^{-1}.
- Measurement, parametrisation and simulation of dE/dx crucial to electron identification.
- MVD offers possibility of second independent measurement of dE/dx.