$D^0\overline{D}^0$ Mixing

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- Previous Measurements
- HERA-B Measurement
  - cross section
  - trigger
  - neutrino momentum
  - vertex resolution
  - HB accuracy
  - future work

Previous Measurements

Search for mixing in channel $D^{\star+} \to D^0\pi^+$

- E691 studied $D^0 \to \overline{D}^0 \to K^+\pi^-$, or $K^+\pi^-\pi^+\pi^-$ problems with DCS
- E791 uses semileptonic decays of D^0

$$D^0 \to K^- l^+ \nu$$

$$D^0 \to \bar{D}^0 \to K^+ l^- \bar{\nu}$$

- identification using Q

$$Q = M(K^- l^+ \nu \pi^+) - M(K^- l^+ \nu) - M(\pi^+) = 5.8 MeV$$

RS

- $D^{\star +} \rightarrow D^0 \pi^+ \rightarrow K^- l^+ \nu \pi^+$
  g(Q), exp($-\Gamma$ t), g(D^0 mass)
- D^0 + random π^+
  exp($-\Gamma$ t), g($Kl\nu$ mass)
- random $K^- l^+ \pi^+$

WS

- $D^{\star +} \rightarrow D^0 \pi^+ \rightarrow \overline{D}^0 \pi^+ \rightarrow K^+ l^- \bar{\nu} \pi^-$
  g(Q), t$^2\cdot$ exp($-\Gamma$ t), g($Kl\nu$ mass)
- $\overline{D}^0$ + random π^+
  exp($-\Gamma$ t), g($Kl\nu$ mass)
- random $K^+ l^- \pi^+$

[10] For a more detailed discussion of the M_{min} distribution, see, for example, K. Kodama *et al.*, Phys. Lett. **B336**, 605 (1994).

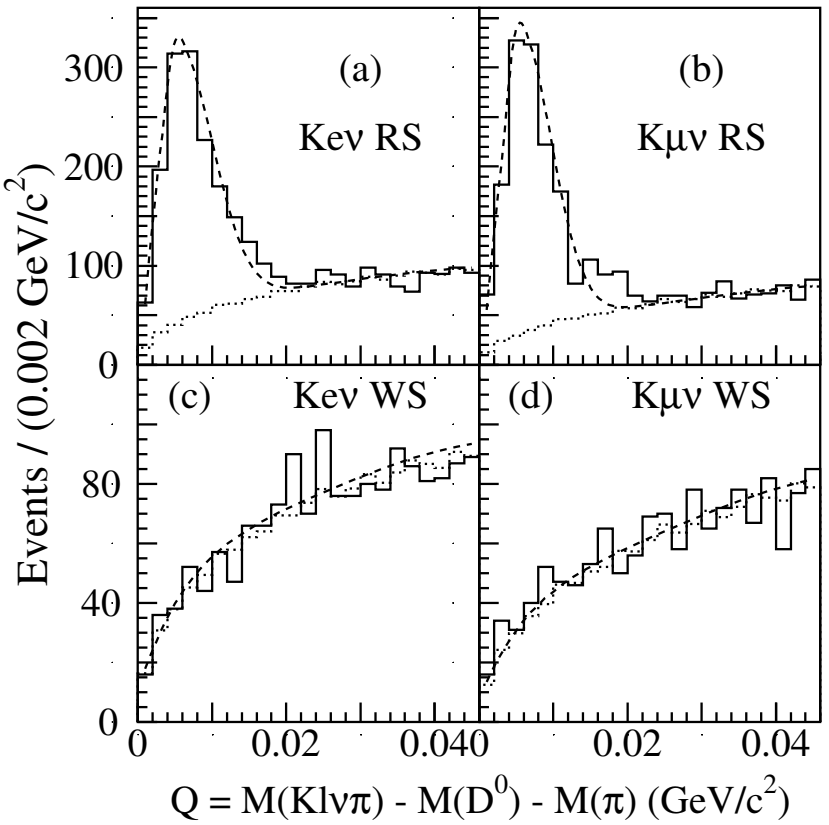


Figure 1: The Q-value distributions for (a) $Ke\nu$ RS, (b) $K\mu\nu$ RS, (c) $Ke\nu$ WS, and (d) $K\mu\nu$ WS candidates. The solid line histograms show the data Q-value distributions, the dashed lines are the projections of the fit in Q-value, and the dotted lines show the Q-value distribution obtained from combining a D^0 from one event and π from another, normalized to the number of events with $Q > 0.025$ GeV/c^2 in the respective histograms.

from LH fit

$N_{RS} = 1237 \pm 45$ $\quad$ $N_{mix} = 4.4 \pm 11$ $\quad$ e sample

$N_{RS} = 1267 \pm 44$ $\quad$ $N_{mix} = 1.8 \pm 12$ $\quad$ μ sample

$r = (0.11 \pm 0.30)\%$ $\quad$ $r < 0.50\%$ at 90% CL

$$\frac{\sigma_r}{r} \approx \frac{\sigma(N_{WS})}{N_{WS}} \Longrightarrow \sigma_r \approx \frac{\sigma(N_{WS})}{N_{RS}}$$

HERA–B Measurement

Cross Section

How many $D^{\star+}$ events can we expect?

- $$N_{trig} = \epsilon_{trig} \frac{\sigma(D^{\star+}) + \sigma(D^{\star-})}{\sigma_{inel}} \cdot \nu \cdot T$$
- reaction $p\ nucleon$ at 800 GeV
  $\sigma_{inc}(D^{\star+}) + \sigma_{inc}(D^{\star-}) = 19.5 \pm 3.2 \mu b/nucleon$
  (average of E653, E747, E789)
- measurements at 200 GeV with π^- beam (NA32)

$$\frac{\sigma(D^{\star+})}{\sigma(D^0)} = \frac{1}{f}, \qquad f \approx 6$$

Trigger

- J/Ψ trigger requires e^+e^- or $\mu^+\mu^-$
- non J/Ψ dilepton trigger in the Proposal
  - two leptons of arbitrary charge and flavour
  - $P_t > 1$ GeV for each lepton
  - non zero impact parameters of the leptons
- THIS TRIGGER IS NOT STUDIED UP TO KNOW
- 33 of 19800 MC events (thanks to T. Oest) triggered
- after Br correction

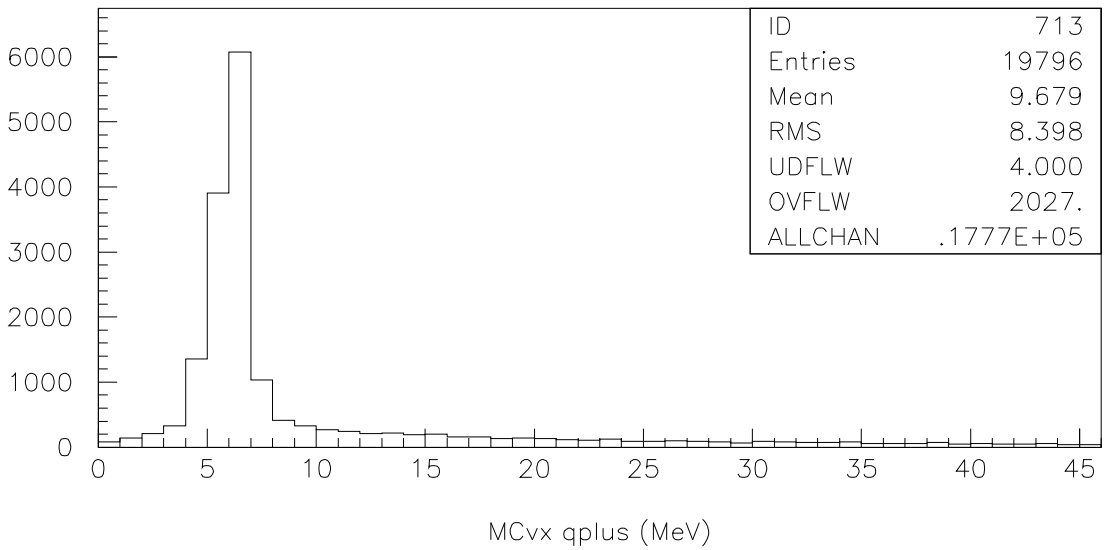
$$\epsilon_{trig}(D^{\star+} \to D^0\pi^+) = (5.3 \pm 1.5) \cdot 10^{-5}$$

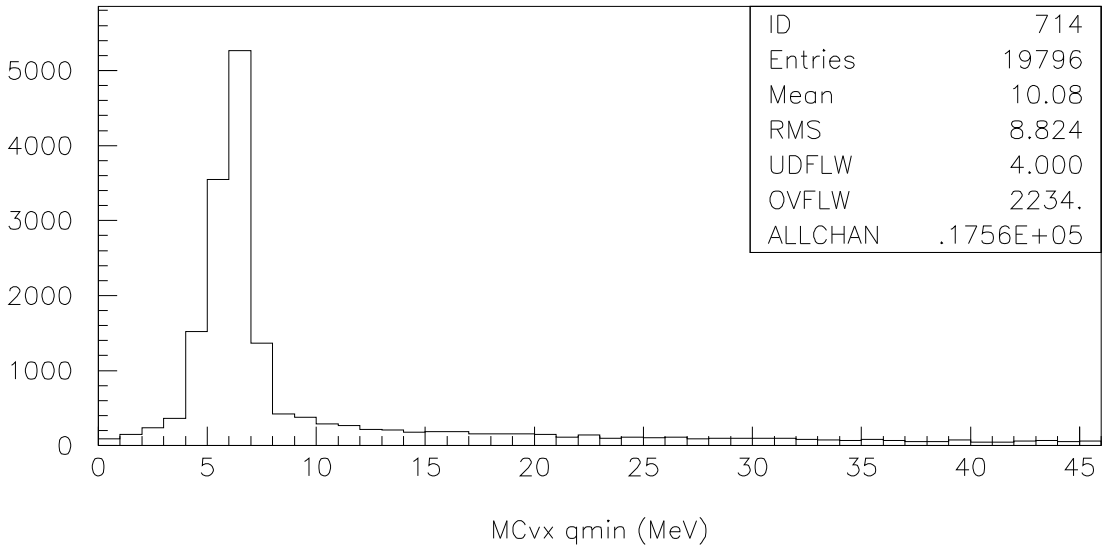
- $\nu = 40$ MHz, T=10^7 s, $\sigma_{inel} = 13$mb
  $\Longrightarrow N_{trig} = 3 \cdot 10^7/f$

Neutrino Momentum

$$Q = M(K^- l^+ \nu \pi^+) - M(K^- l^+ \nu) - M(pi^+) = 5.8 MeV$$

- ν momentum is deduced using conditions
  - $M(Kl\nu) = M(D^0)$
  - D^0 momentum parallel with vector connecting primary and secondary vertices
- square equation obtained

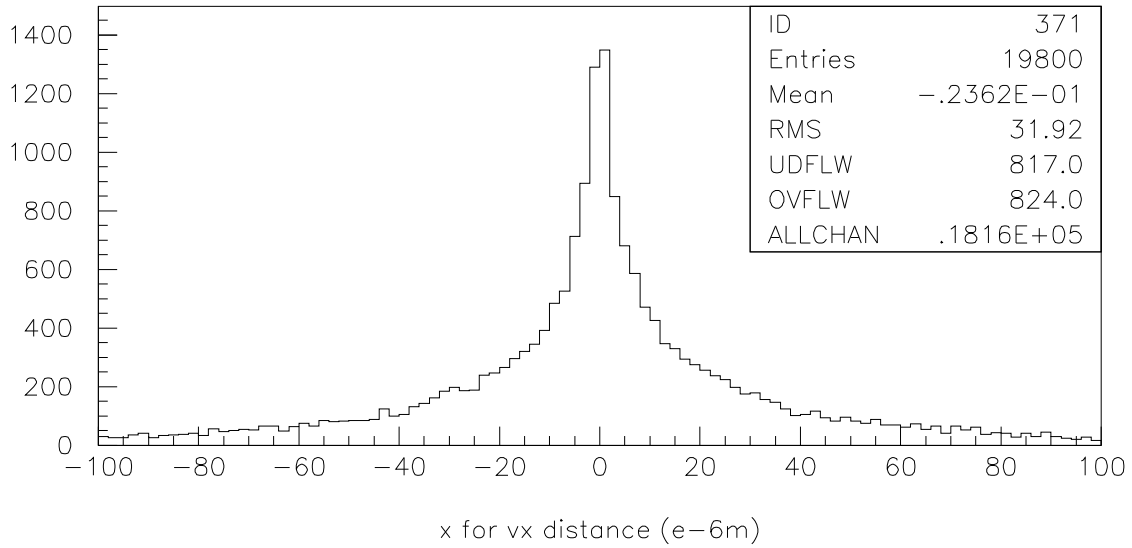


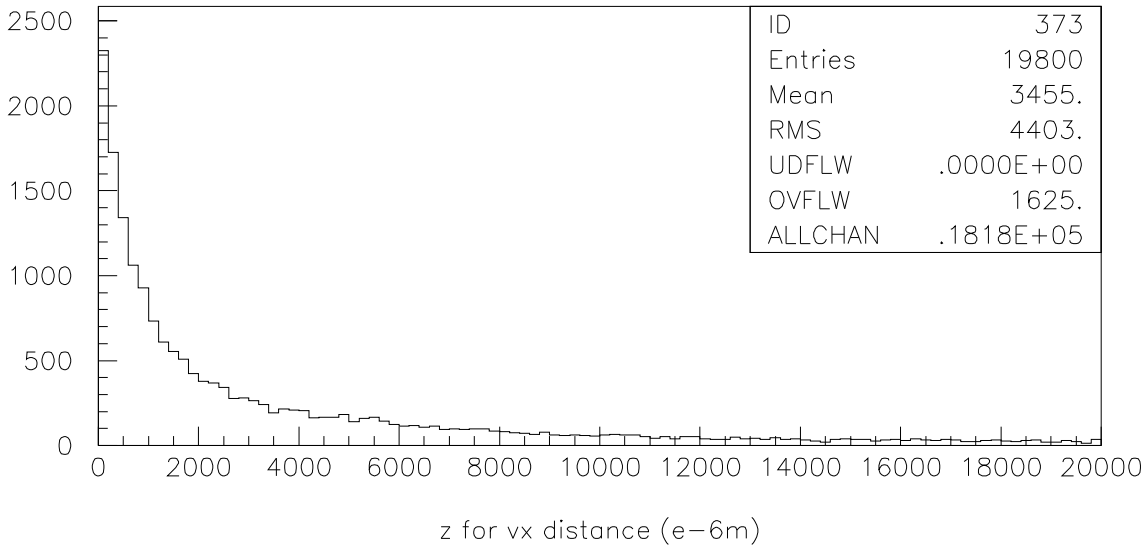


Two solutions for Q

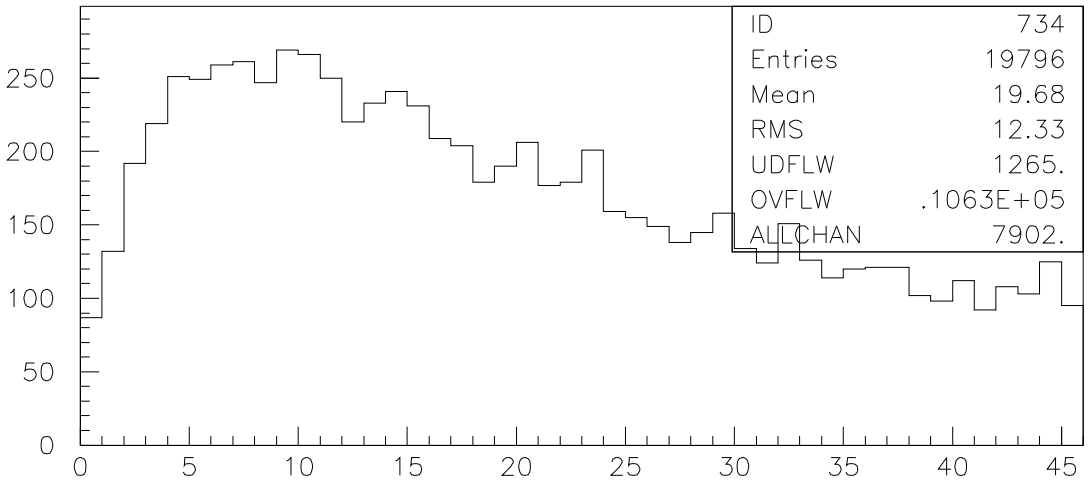
Vertex Resolution

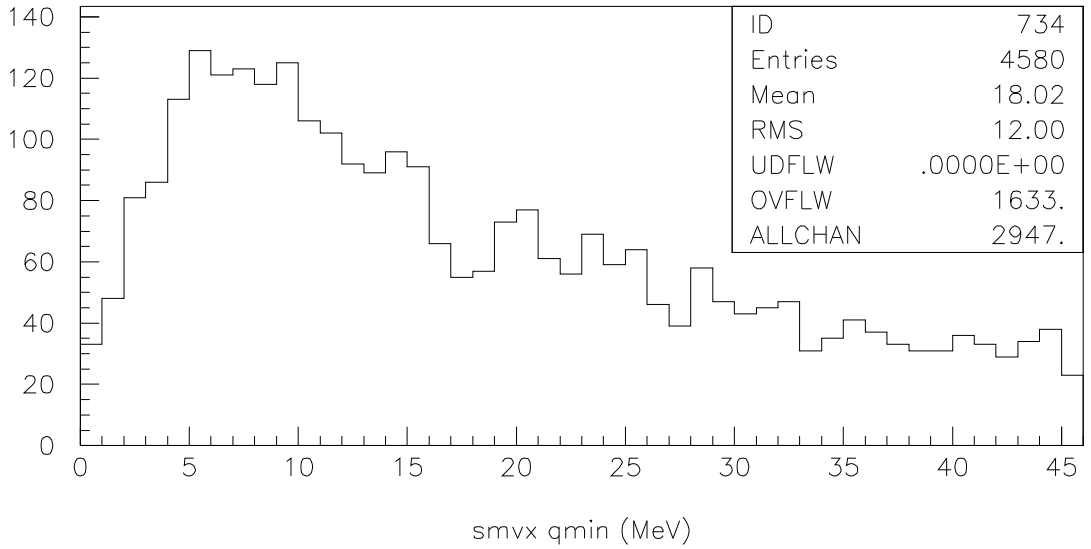
- vertex resolution is crucial
- determined for B vertex (Proposal)
- I used for secondary vertex
  - $\sigma_{x,y} = 25\mu$m
  - $\sigma_z = 500\mu$m,
- and for primary vertex
  - $\sigma_{x,z} = \frac{2r}{\sqrt{12}} = \frac{50\mu m}{\sqrt{12}}$
  - σ_y=25 μm





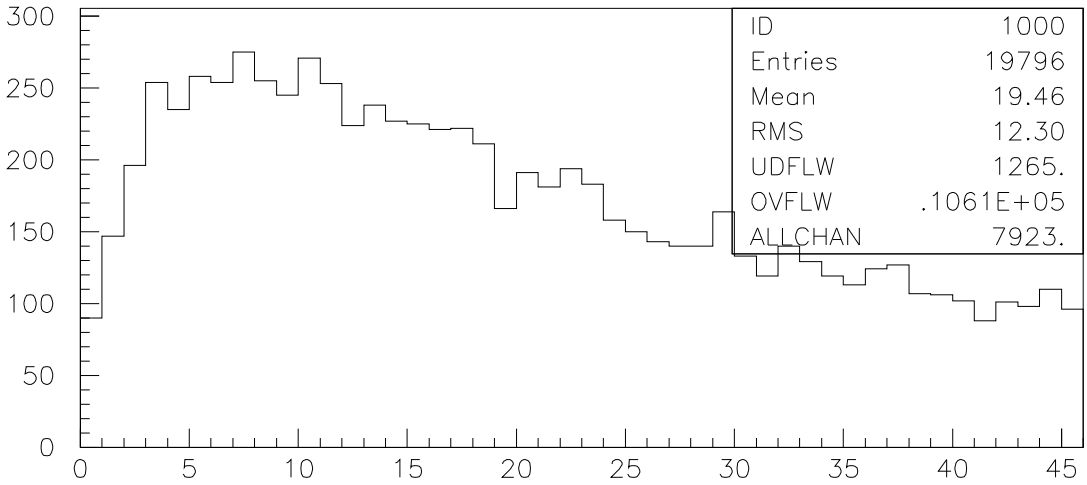
Distribution of x and z component of vertex distance vector

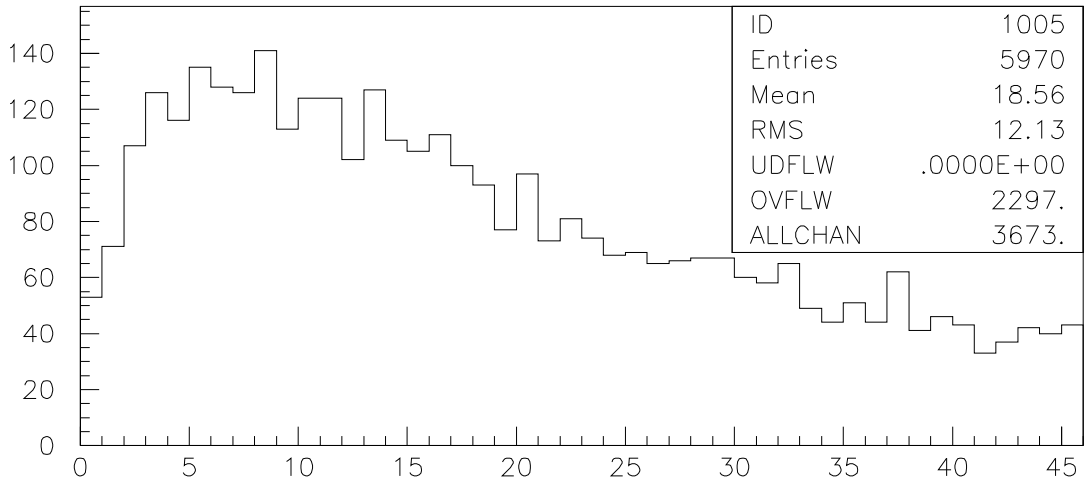




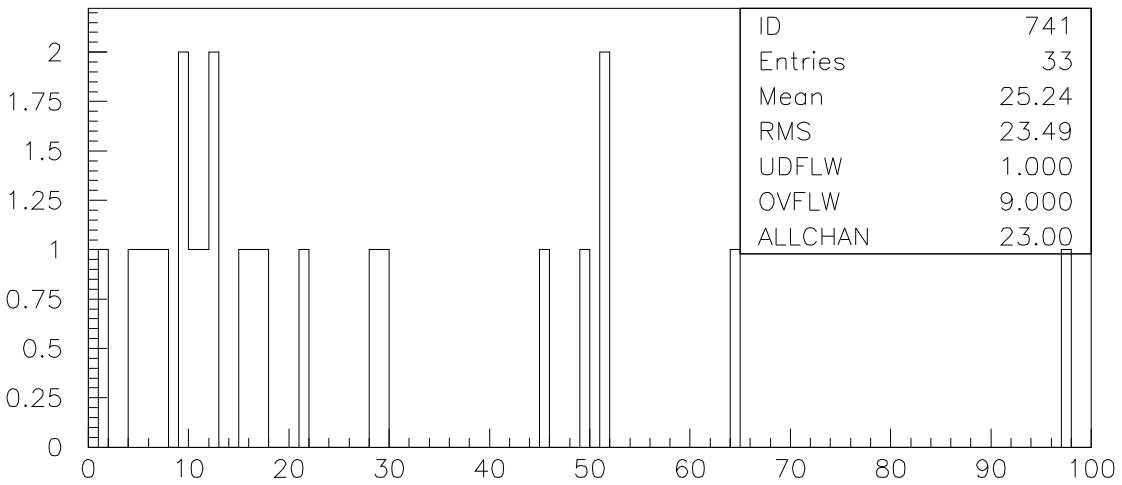
$Q+$ for all events, and for events with D positive

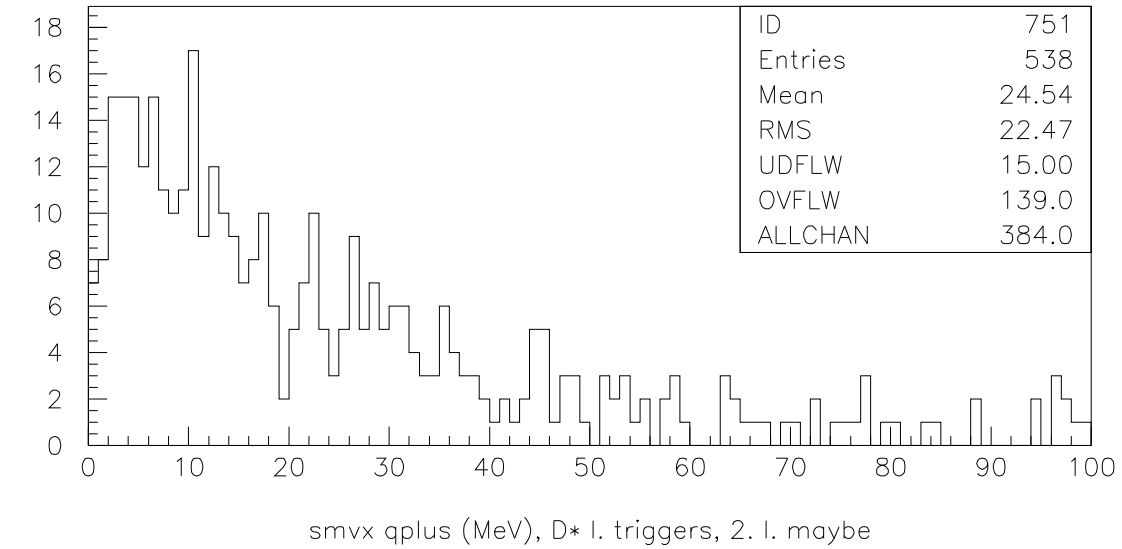
- Discriminant of the square eq. becomes negative in 78% of events
  - $Q < 20$ MeV in 23 % of events all events
  - $Q < 20$ MeV in 9 % of events D positive



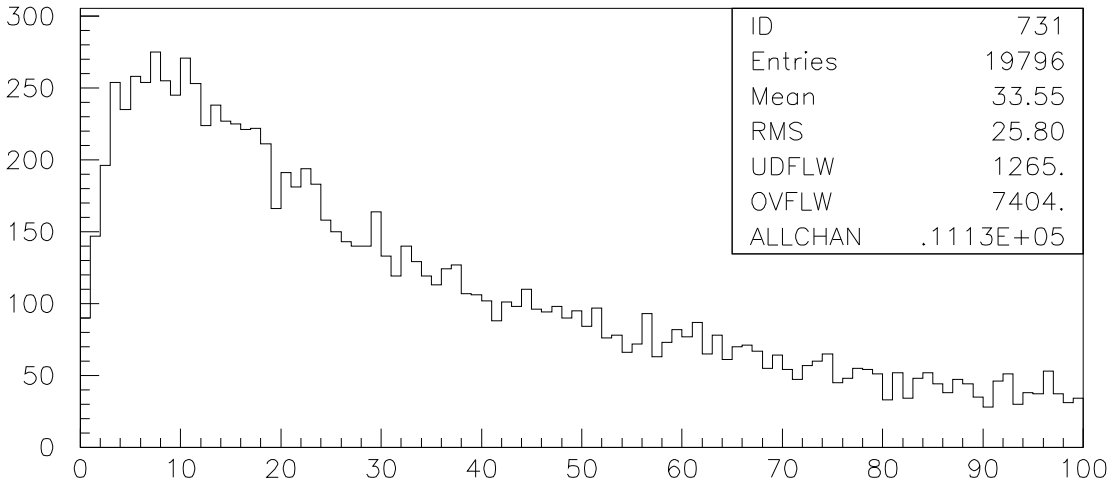


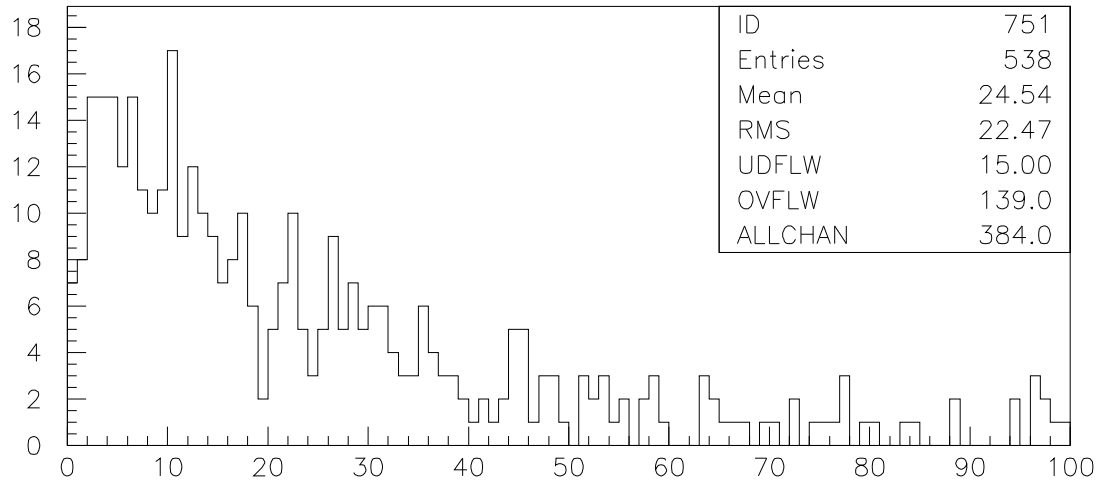
Influence of the decay length





Q for triggered events, and high P_t leptons





Q for all and high P_t leptons

HERA–B Accuracy

How many events can we use for mixing analysys?

$$N = Br(D^{\star +} \to D^0 \pi^+) \cdot \epsilon_Q \cdot \epsilon_{rec} \cdot N_{trig} \approx 10^5$$

- E791 has 2500 events
- if our data would be of the same quality as their,

$$\frac{(\sigma_r)_{HB}}{(\sigma_r)_{E791}} = \sqrt{\frac{2500}{10^5}} \approx 1/6$$

- $(\sigma_r)_{HB}$=0.05

  But,

  - Q distribution of E791 is more narrow $\to$ more resolving power
  - E791 does not have problems with random $Kl\pi$ combinations

Future Work

What has to be done?

- LH fit on MC data
- VX resolution has to be determined
- trigger has to be studied