D Meson Production at Hera

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3. 10. 2000

Outline:

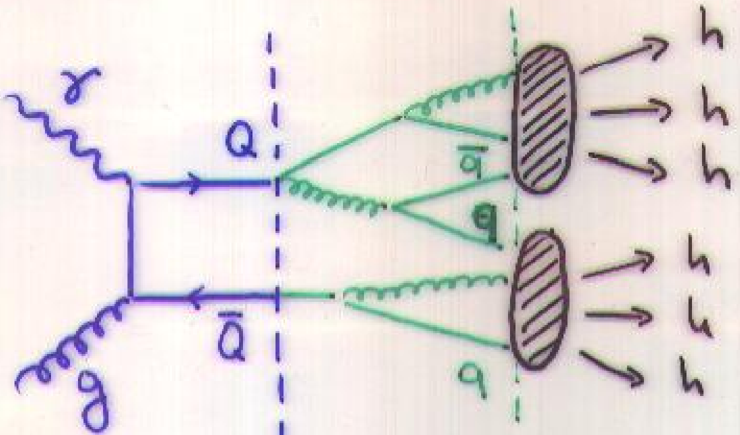
- Motivation = Fragmentation
  - Basic Idea of Analysis
- Decay Length Distribution
  - Argumentation of the Analysis
- Results obtained up to now
  - Summary

Motivation

* "hard" processes allow tests of theory, e.g. pQCD
* pQCD predicts behavior of PARTONS in final state
* but detectors measures only HADRONS ⚠

⇒ SOLUTION = FACTORISATION

e.g. BGF



pQCD: fixed order calculation

short distances, free partons

e.g. parton showers (pQCD "inspired")

clean up: phenomenological FRAGMENTATION models

soft, long distance (confinement)

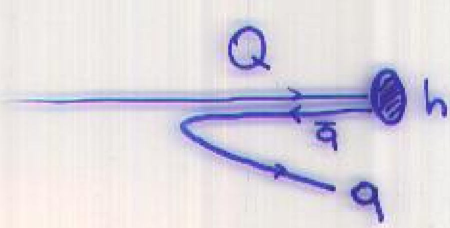
e.g. Peterson, Lund String Fragmentation

UNDERSTANDING NEEDED TO BE ABLE...

... TO STUDY pQCD ⚠

INGREDIANCES OF FRAGMENTATION

- Peterson model for heavy quarks

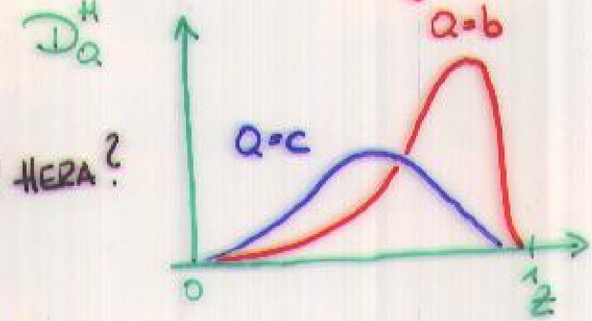


$$D_Q^H(z) = \frac{N_H}{z}\left[1 - \frac{1}{z} - \frac{\varepsilon}{1-z}\right]^{-2}$$

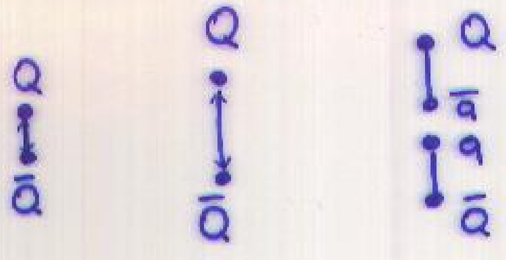
- $D_Q^H(z)dz$: Probability to find hadron H within $[z, z+dz]$
- $z = \frac{E_H}{E_Q}$, $0 \le z \le 1$ energy fraction taken by H
- N_H : Normalisation
- ε : parameter describing "hardness" of fragmentation

$$\varepsilon \approx \frac{m_q^2}{m_Q^2}$$

$\varepsilon(D)$ measured @ LEP, same ε @ HERA?



- Lund String Model:



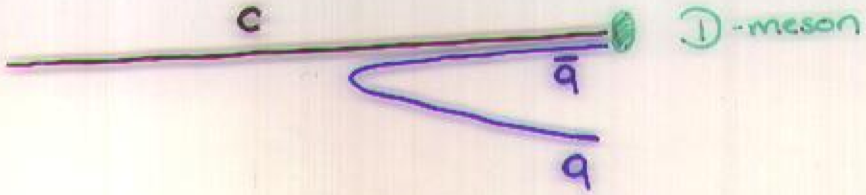
plug-ins:

× flavour mixing u : d : s = 1 : 1 : 0,3 $\left(\sim \exp\left[-\frac{\pi m_Q^2}{\kappa}\right]\right)$

× spin mixing: PS : VM = 1 : 3 (~ # states)

× κ : mass density of strings $\left(\sim \frac{1\,\mathrm{GeV}}{\mathrm{fm}}\right)$

BASIC ANALYSIS IDEA



$D^0 = (c\bar{u})$ $J^P = 0^-$

$D^+ = (c\bar{d})$ $J^P = 0^-$

$D_s^+ = (c\bar{s})$ $J^P = 0^-$

$D^{*+} = (c\bar{d})$ $J^P = 1^-$

$\Rightarrow D^0 : D^+ : D_s^+ \approx u : d : s$

$D^+ : D^{*+} \approx PS : VM$

$p_t(D) \Rightarrow$ hardness ε

× selected channels:

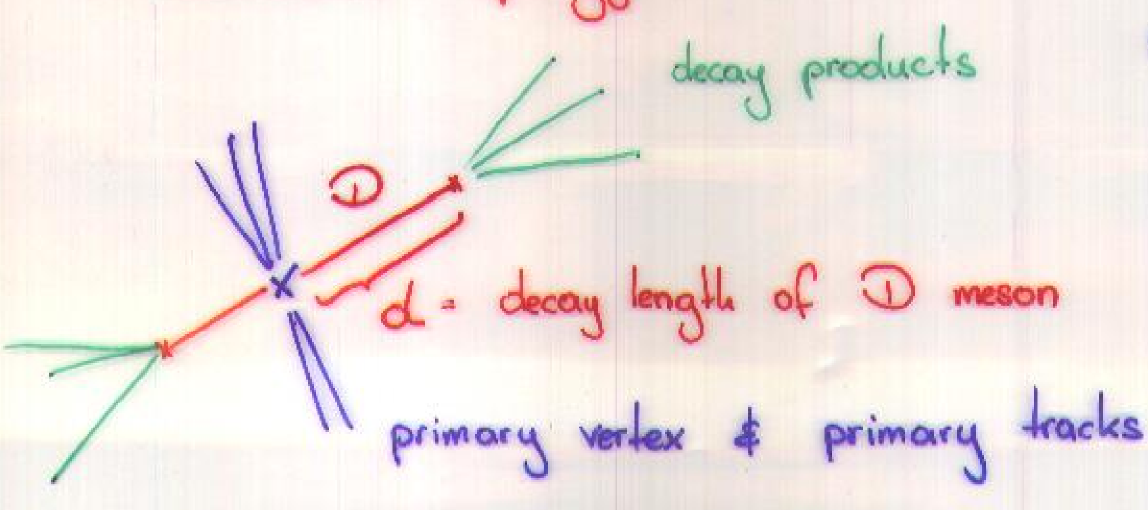
$D^0 \to K\pi$

$D^+, D_s \to \phi\pi$, $\phi \to KK$

$D^{*+} \to D^0 \pi_s$, $D^0 \to K\pi$

× use finit life time of D mesons to reject uds background → NO LIFE TIME ∇

⇒ reconstruct topology:



Decay Length

$c\tau(D^0) = 124\ \mu m$

$c\tau(D_s^+) = 140\ \mu m$

$c\tau(D^+) = 315\ \mu m$

$$\#D(t^*) \sim \exp\left(-\frac{ct^*}{c\tau}\right)$$

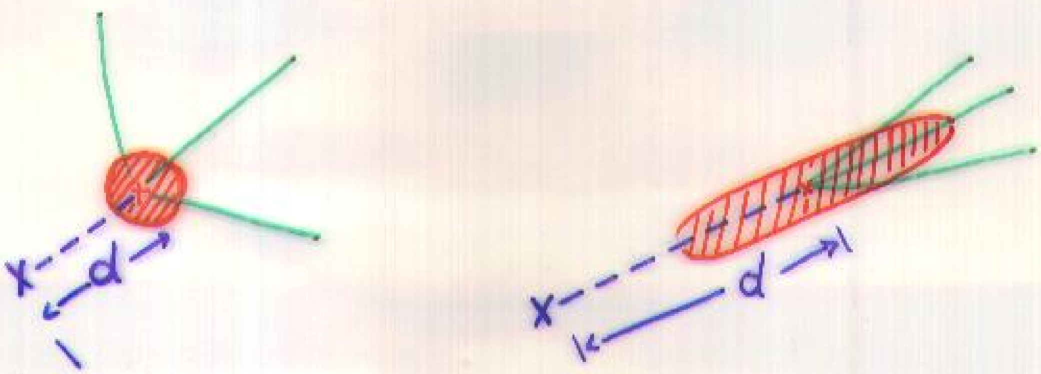
$$d := d_{r\varphi} = \frac{p_t(D) \cdot t^*}{m(D)}$$

@ HERA: $\#D(p_t) \sim \exp\left(-\frac{p_t}{p_t^0}\right)$

$$\#D \sim \exp\left(-\frac{ct^*}{c\tau}\right) \cdot \exp\left(-\frac{p_t}{p_t^0}\right)$$

peaks @ 0 ⚠

But: @ lower $p_t(D)$ decay length d well measurable



Line of Argumentation

× use (HERA's) "gold plated"* channel

$D^* \longrightarrow D^0 \pi_s$ $\quad$ $(\# D^* \sim \mathcal{O}(10'000))$

$\quad\quad\quad \hookrightarrow K\pi$

to proof the principle of the method.

(* very precise measurement of $\Delta m = m(K\pi\pi_s) - m(K\pi)$)

× cut on the significance of decay length $\frac{d}{\sigma_d}$

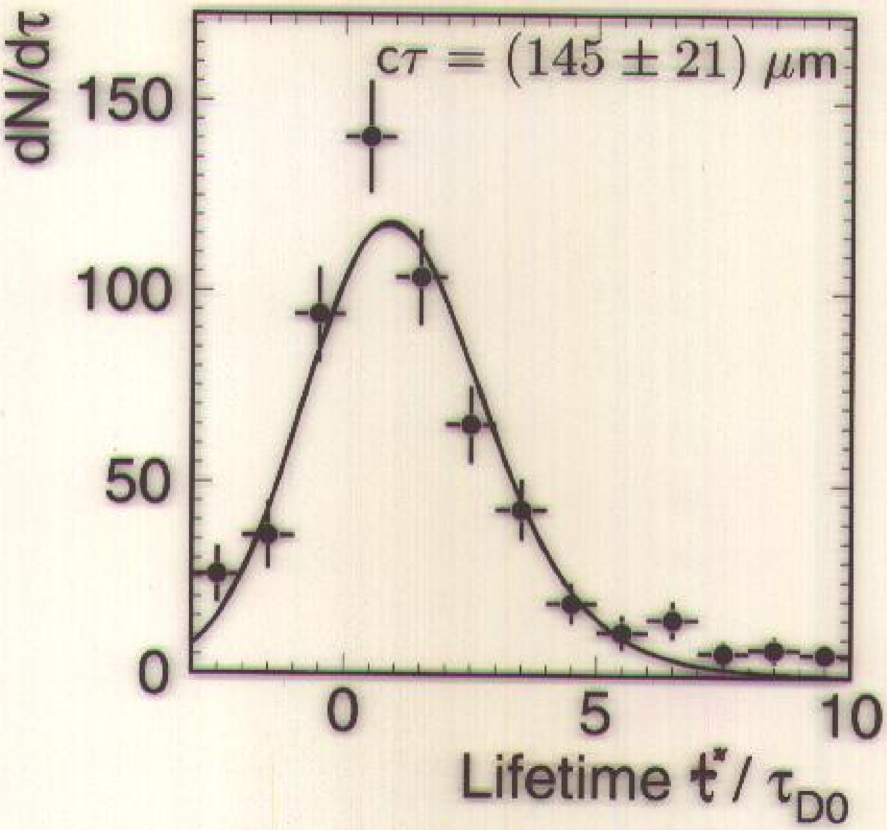
to suppress background most efficiently.

× apply same method to determine cross sections of D^0, D^+, D_s. $[\# D \sim \mathcal{O}(100)]$

× determine ratios $\frac{\sigma(ep \to D^0 X)}{\sigma(ep \to D^+ X}$, ...

as a function of p_t, η, ...

Measurement of $c\tau(D^0)$ via $D^* \to D^0 \pi_s$



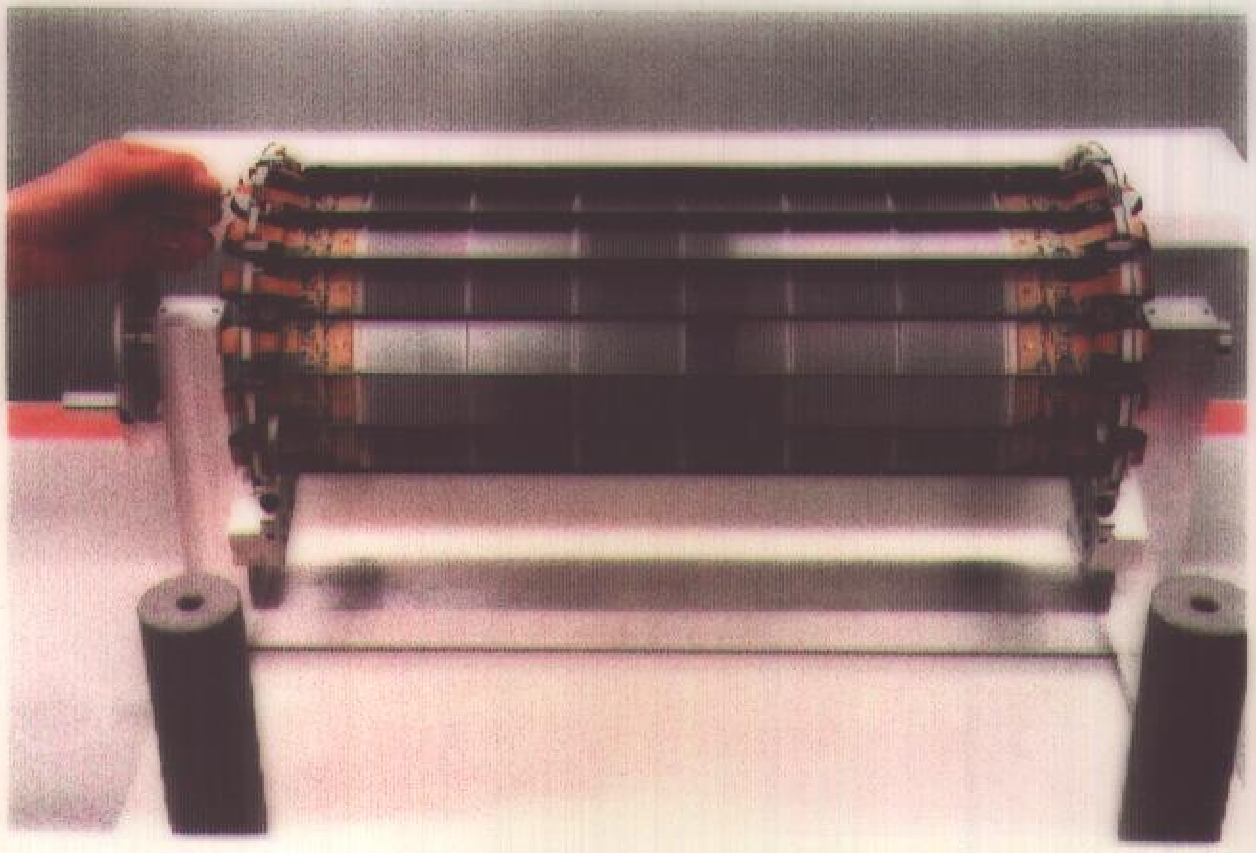
done by Stefan Hengstmann using the CST.

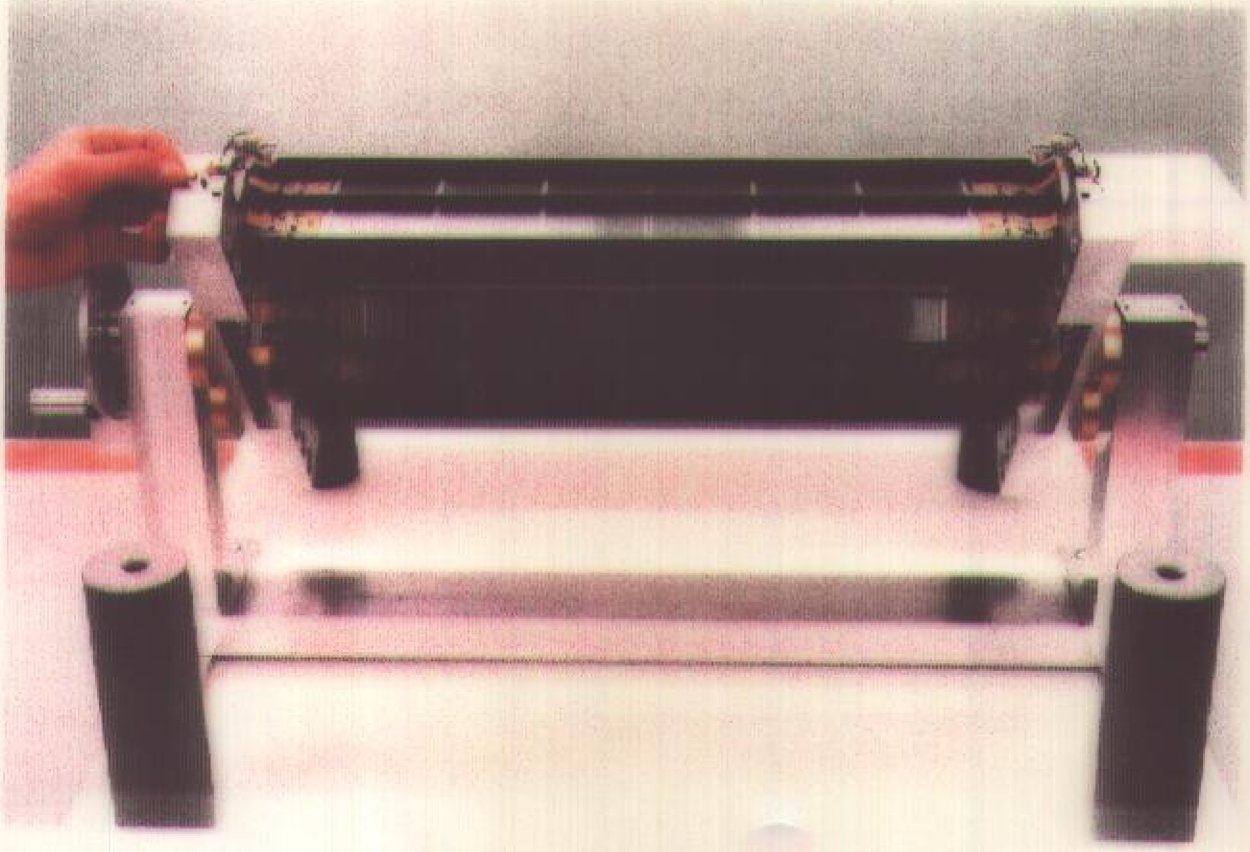
PDG $c\tau(D^0) = 124$ μm

Fit: exponential folded with gaussian.

rem.:

$$d = \frac{p_t(D^0)\, t^*}{m(D^0)}$$





CHALLANGES AT HERA / H1

× intrinsic resolutions: CJC: $\sigma_\infty(d) \sim 400\,\mu m$
CST: $\sigma_\infty(d) \sim 60\,\mu m$

× But multiple scattering (mainly in beam pipe)

$$\Rightarrow \quad \sigma^2(d) = \sigma_\infty^2(d) + \left(\frac{\sigma_{MS}}{p_t}\right)^2$$

⇒ MS dominates resolution @ low p_t (where most D mesons are produced)
⇒ crucial to understand $\frac{d}{\sigma_d}$ distribution.

× beam spot size ($150 \times 30\,\mu m^2$) & position

× outliers suppression: wrongly linked CST hits
lead to "precise" tracks pointing to nowhere
⇒ fake big decay lengths ⚠

× decay length depending link efficiency

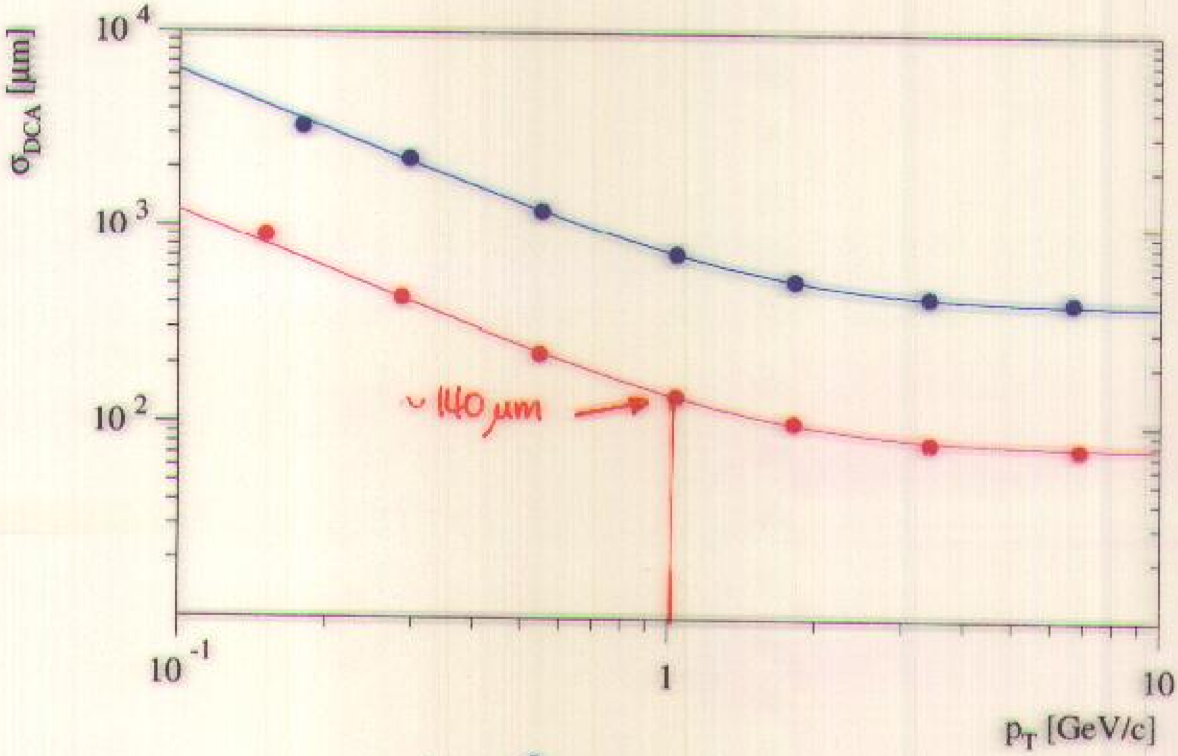
⇒ A LOT OF TECHNICAL WORK TO BE DONE !

Impact Parameter Resolution 1997

measure d'_{ca} resolution of CJC and CST tracks versus p_t

$\Rightarrow$ unfold multiple scattering: $\sigma_{ms} = \frac{const}{p_t}$

$\Rightarrow \sigma^2_{d'_{ca}} = \sigma^2_{d'_{ca}}(p_t) = \sigma^2_{d'_{ca}}(\infty) + \left(\frac{const}{p_t}\right)^2$

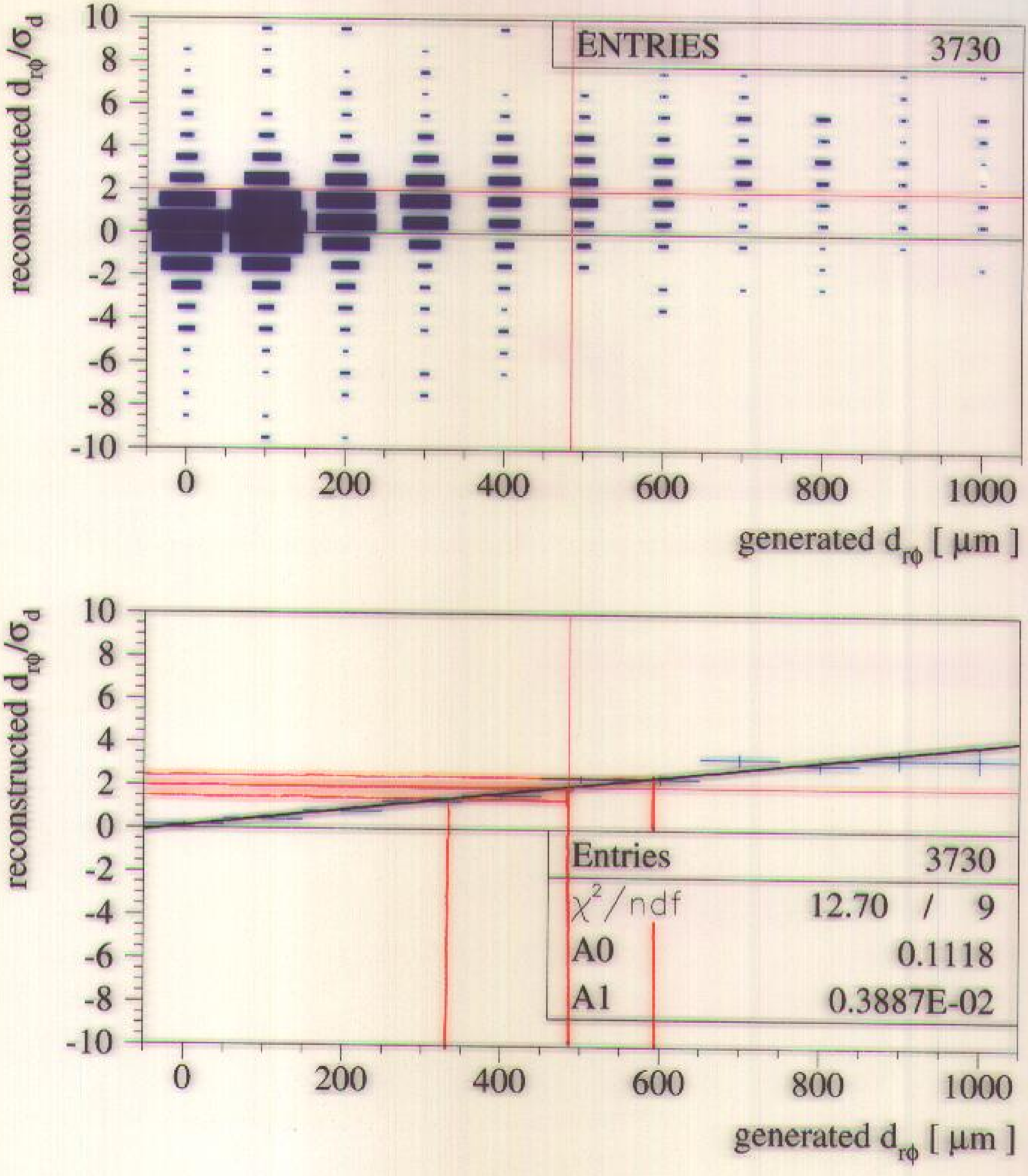


CJC: $\sigma^2_{d'_{ca}} = 400^2 + \left(\frac{630}{p_t}\right)^2 \ \mu m^2$

CST: $\sigma^2_{d'_{ca}} = 76^2 + \left(\frac{121}{p_t}\right)^2 \ \mu m^2$ (beam spot not unfolded)

1997 ep data, d'_{ca} to CST run vertex, CJC: l_{track} >55 cm,
CST: $|z_{vertex}| < 20$ cm, horizontal tracks

MC 97: $D_s^{\pm} \rightarrow \Phi\pi \rightarrow KK\pi$



Example $D^+ / D_s^+ \to \phi\,\pi$
$\hookrightarrow KK$

PDG:

D^+

$m = 1869.3 \pm 0.5$ MeV

D_s^+

$m = 1968.5 \pm 0.6$ MeV

$\Delta m = 99.2$ MeV

$J^P = 0^-$ PS $J^P = 0^-$

$c\tau = 315 \pm 5\ \mu m$

$c\tau = 149 \pm 5\ \mu m$

$c\tau(D^+) : c\tau(D_s^+) = 2 : 1$

$BR(c \to D^+) = 0.23^+$

$BR(c \to D_s^+) = 0.10^+$

$BR(D^+ \to \phi\pi,\ \phi \to KK) = 3 \cdot 10^{-3}$

$BR(D_s^+ \to \phi\pi,\ \phi \to KK) = 1.8 \cdot 10^{-2}$

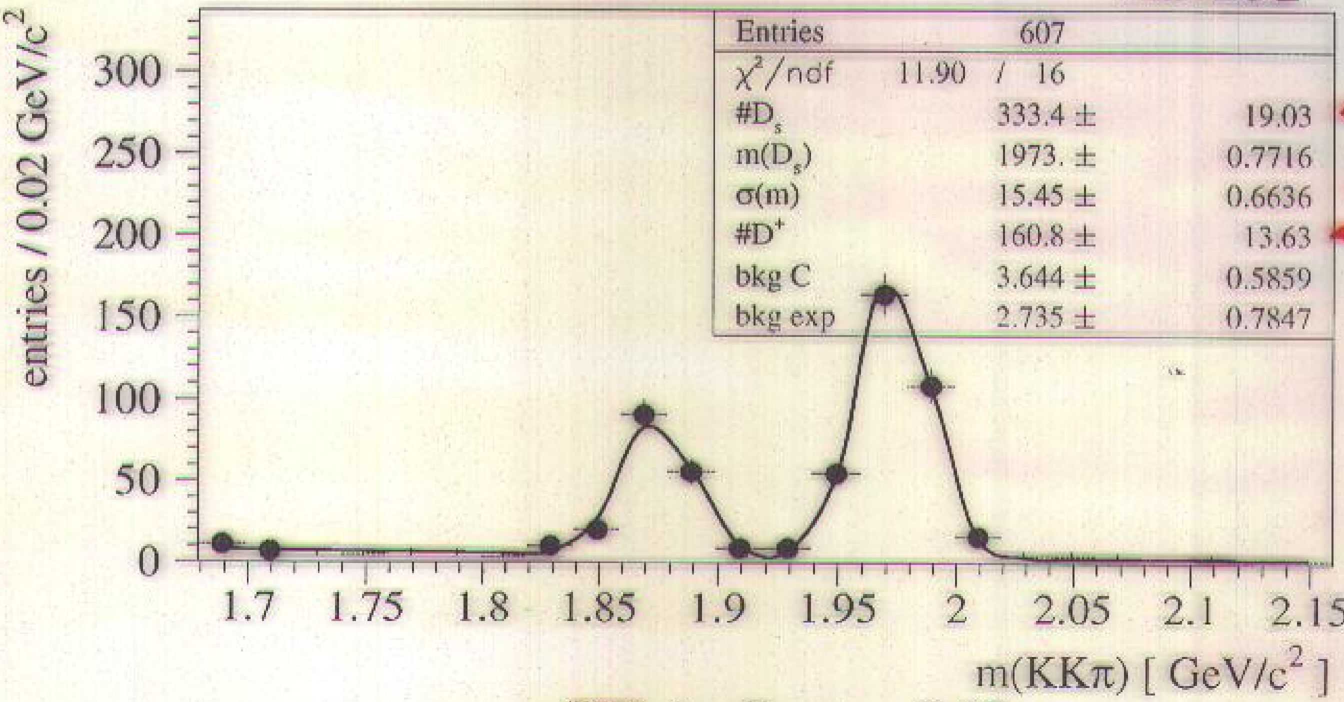
$\#D^+ : \#D_s^+ = 1 : 2{,}6$

+ hep-ex/9912064

MC 97: $D_s/D^{\pm} \to \Phi\pi \to KK\pi$

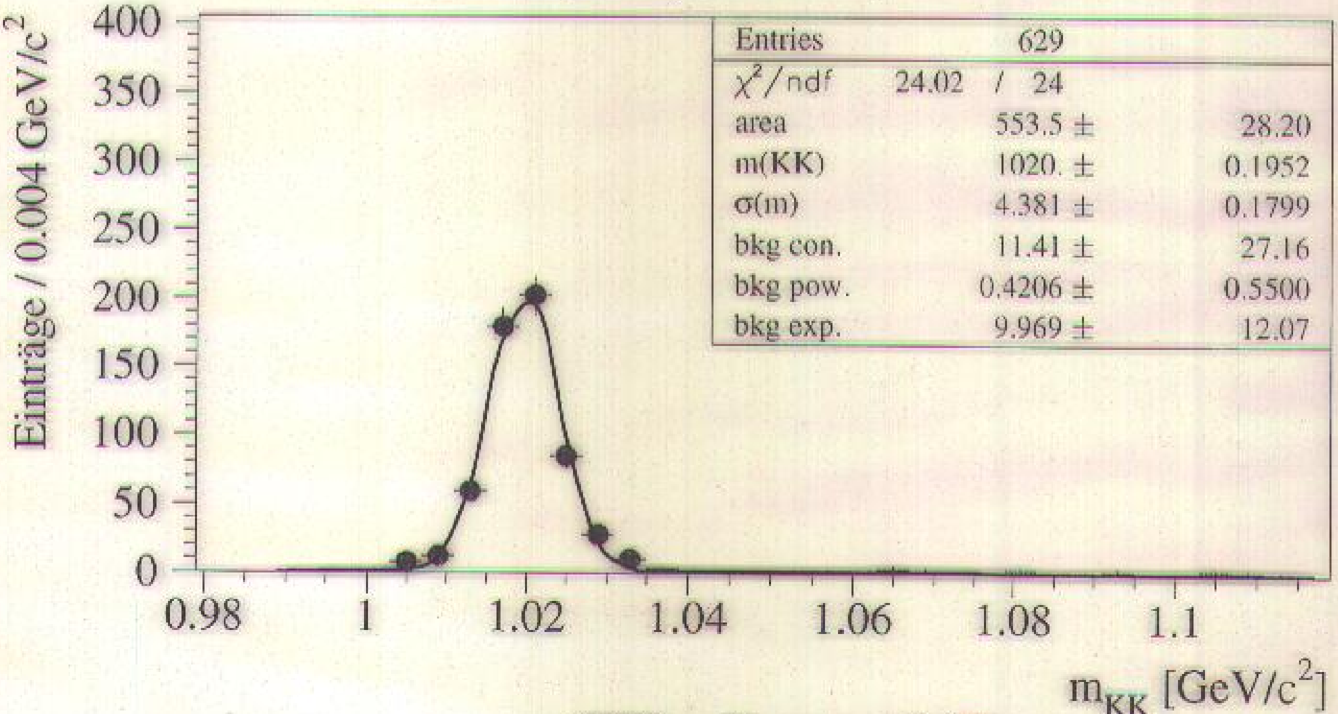
($\mathcal{L}$ = 194 pb^{-1})

AROMA 2.2



2 : 1

m(KKπ), all cuts, all 97



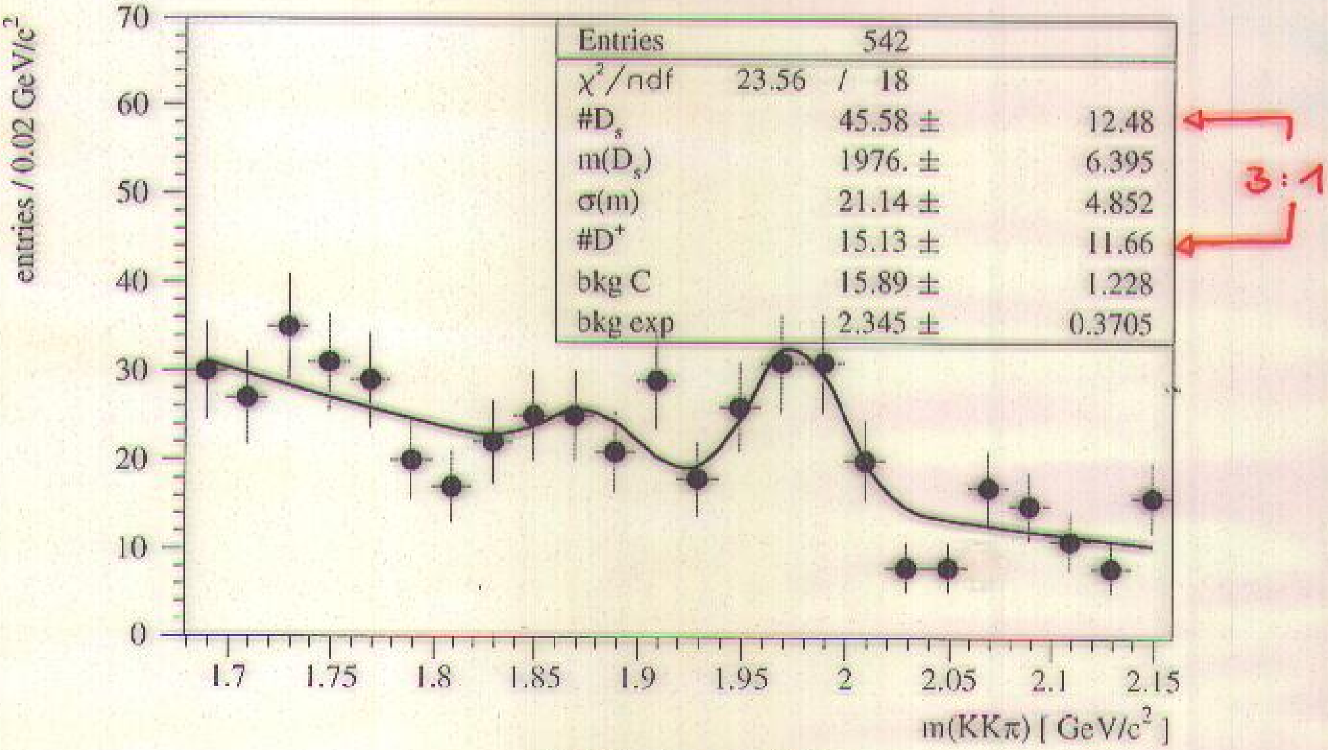
m(KK), all cuts, all 97

<u>fit</u> $\sigma_{D_s} = \sigma_{D^+}$ Bkg = $C \cdot e^{-E(m - \bar{m}_{D_s})}$

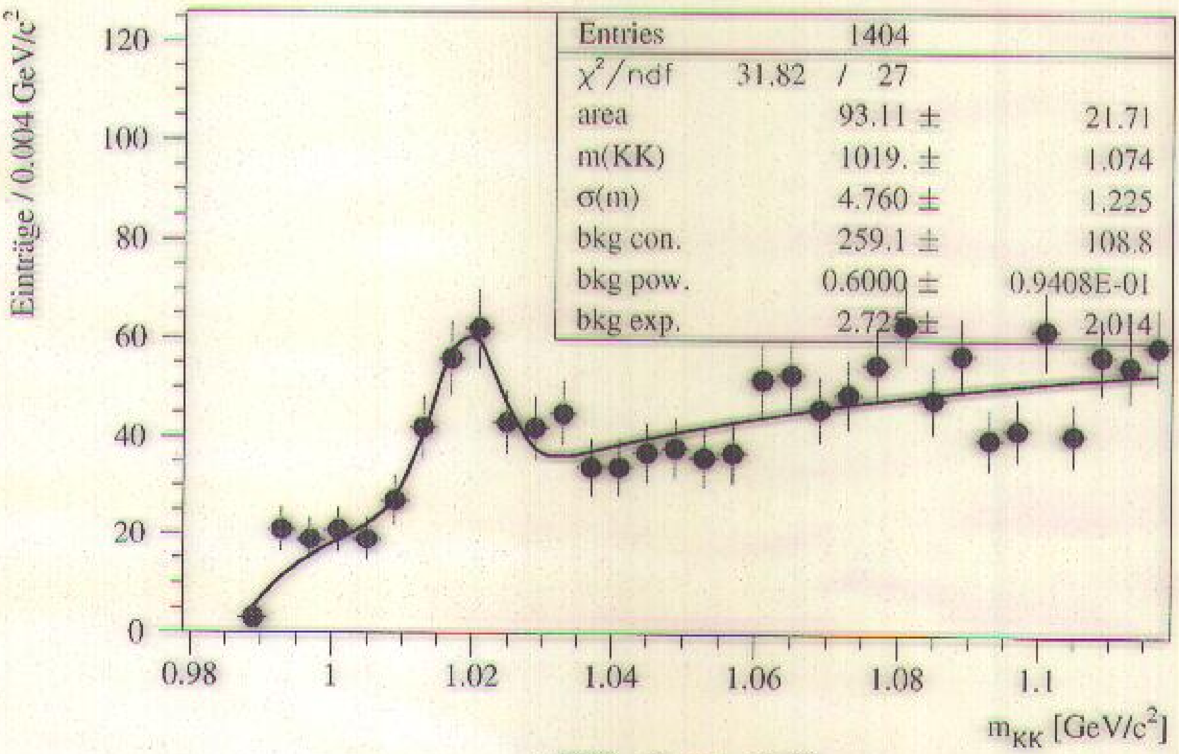
$\bar{m}_{D_s} - \bar{m}_{D^+}$ = 99.2 MeV

$\frac{d_{r\varphi}}{\sigma_d} > 2.$ $P > 1\%$

DIS 97: $D_s^{\pm} \rightarrow \Phi\pi \rightarrow KK\pi$



m(KKπ), all cuts, all 97



m(KK), all cuts, all 97

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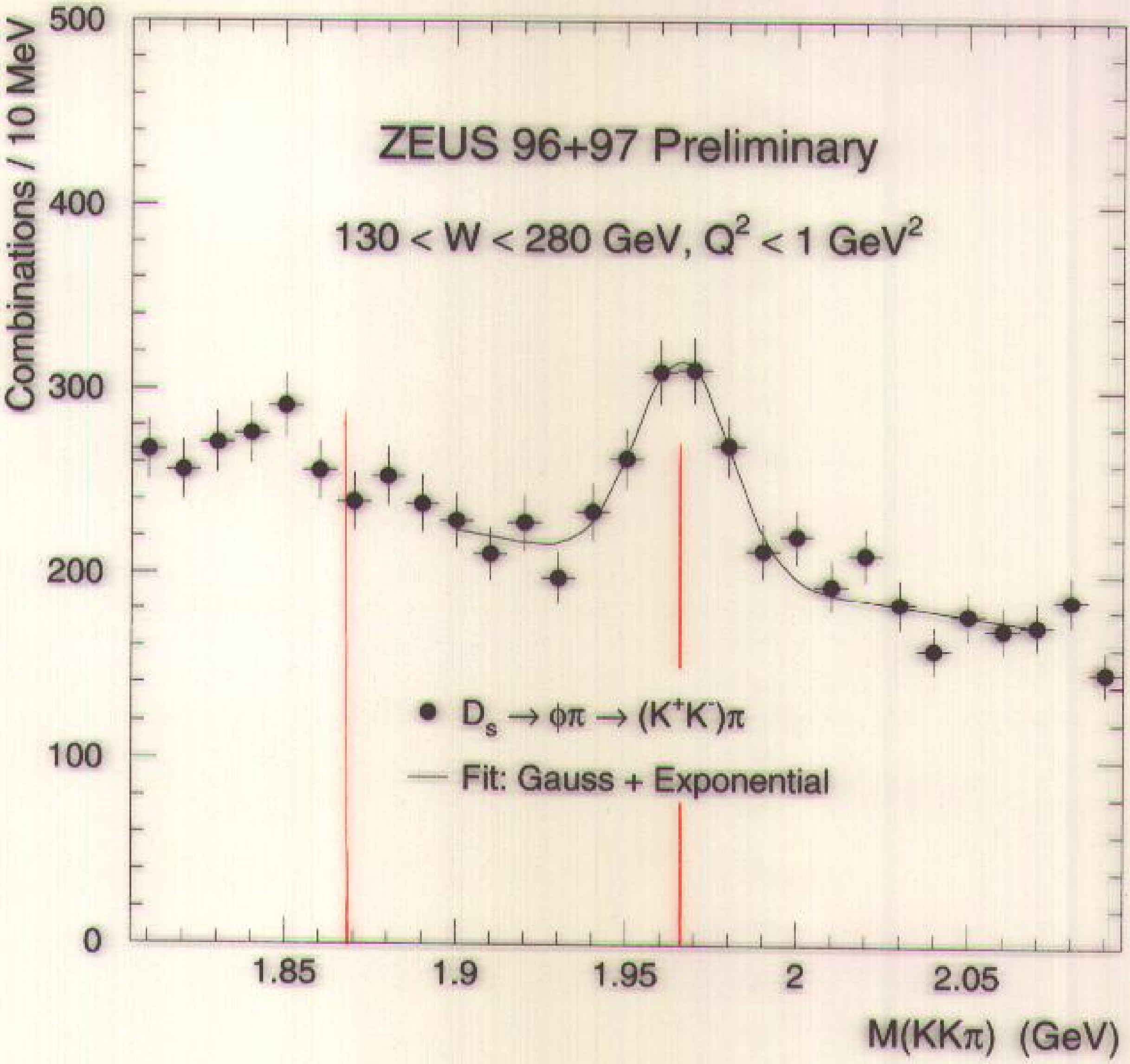
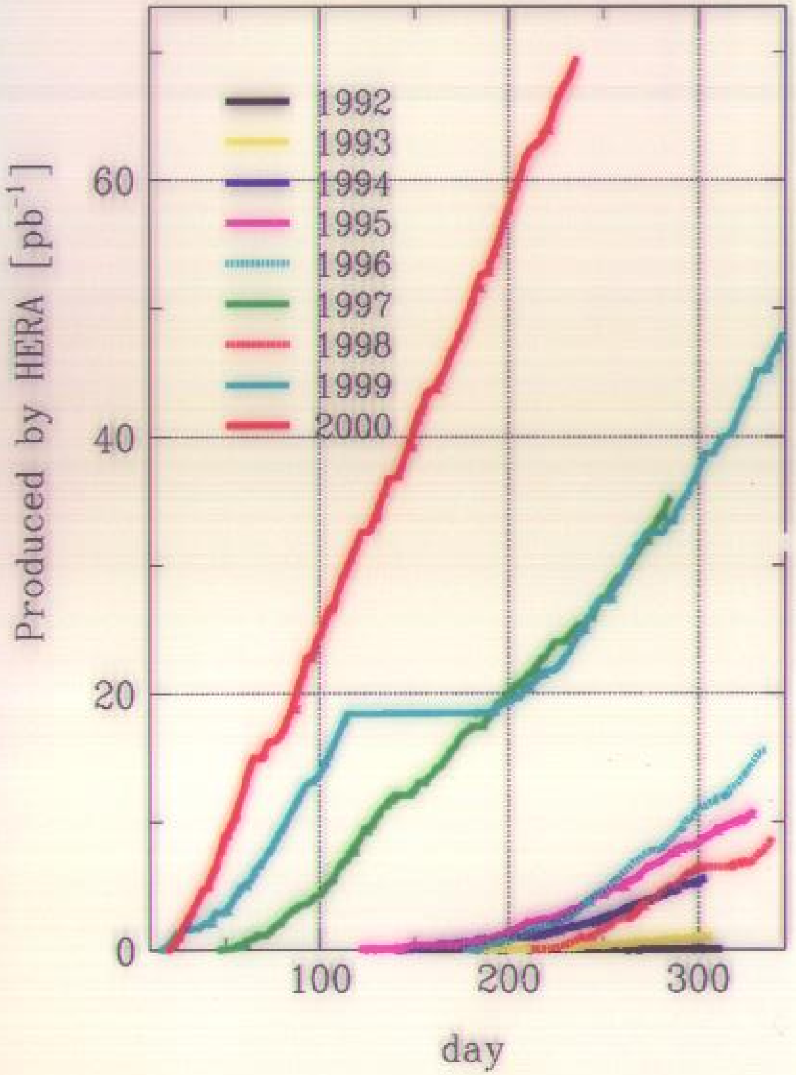
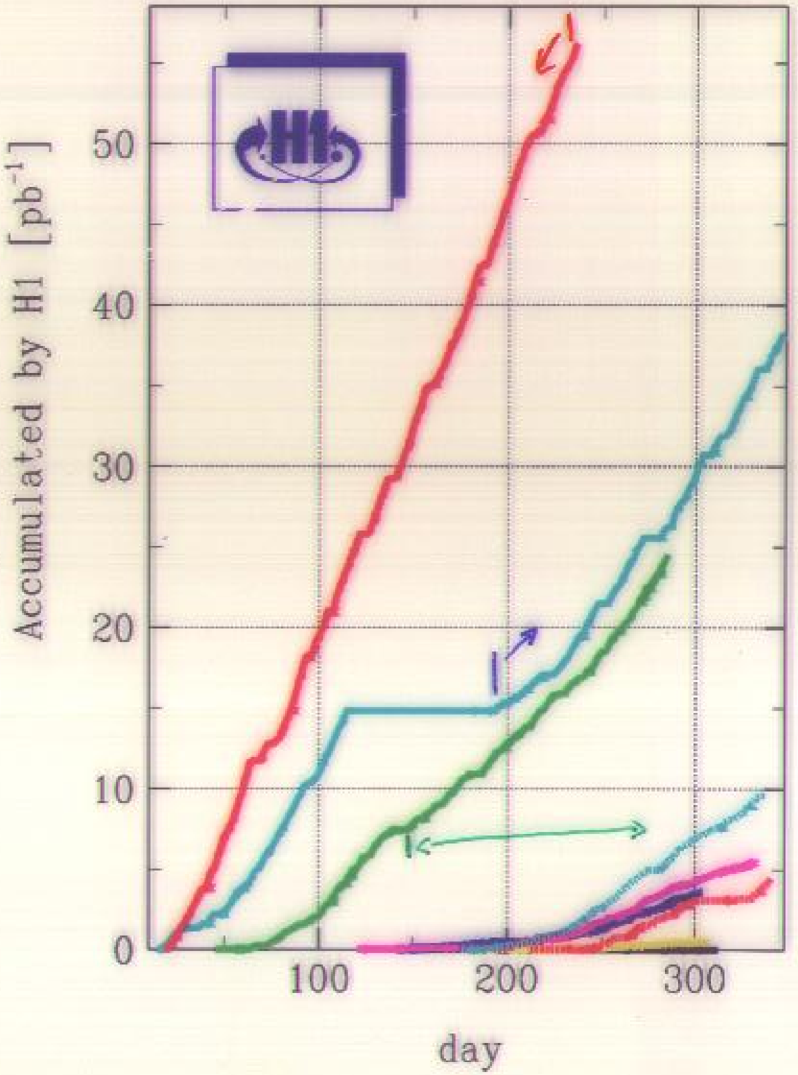


Figure 2: *Mass distribution of the D_s candidates for events inside the ϕ mass region ($1.0115 < M(K^+K^-) < 1.0275$ GeV). The solid curve is an unbinned fit to a Gaussian-shaped resonance plus an exponential background.*

INTEGRATED LUMINOSITY (24.08.00)





SUMMARY:

- Test independence of fragmentation by comparing LEP & HERA results
- Introduce vertex tagging for charm analysis at H1 / HERA
- most techincal problems understood and solved
- first results look promising, so I'm of good cheer to benefit from the lot of luminosity collected in 1999/2000 for the channels with small BR.