

Pentaquark search with the H1 experiment

Jörg Gayler, DESY, H1 collaboration

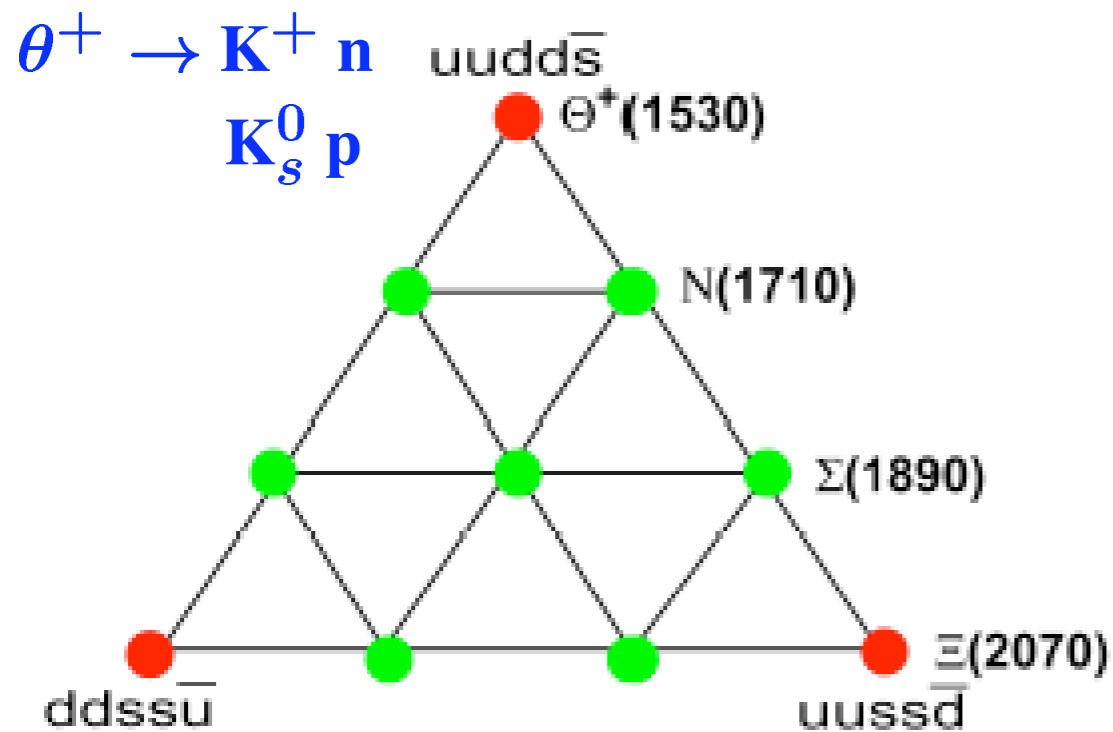
▲ Evidence for anticharmed baryon in H1 Phys. Lett. B588 (2004) 17 ▲

Search motivated

by signals for $uudd\bar{s}$ states



look for $uudd\bar{c}$ candidates

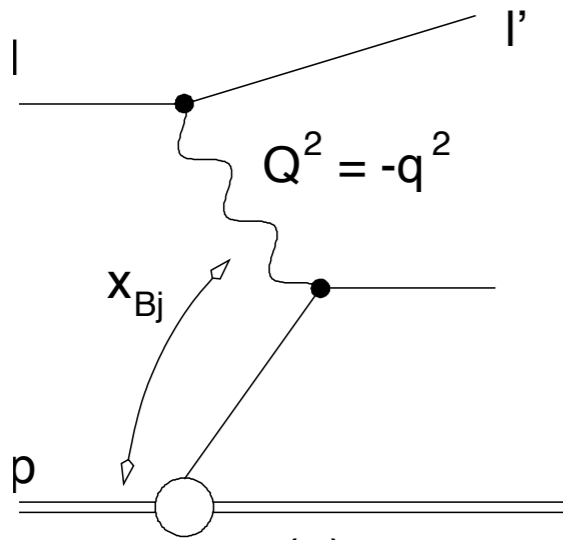


use reaction $\theta_c^0 \rightarrow D^* p$

D^* gives clean charm signature

use dE/dx for proton

ep kinematics at HERA



ep energies $E_e = 27.6 \text{ GeV}$ $E_p = 820, 920 \text{ GeV}$

c.m. energy $\sqrt{s} = 300 - 319 \text{ GeV}$

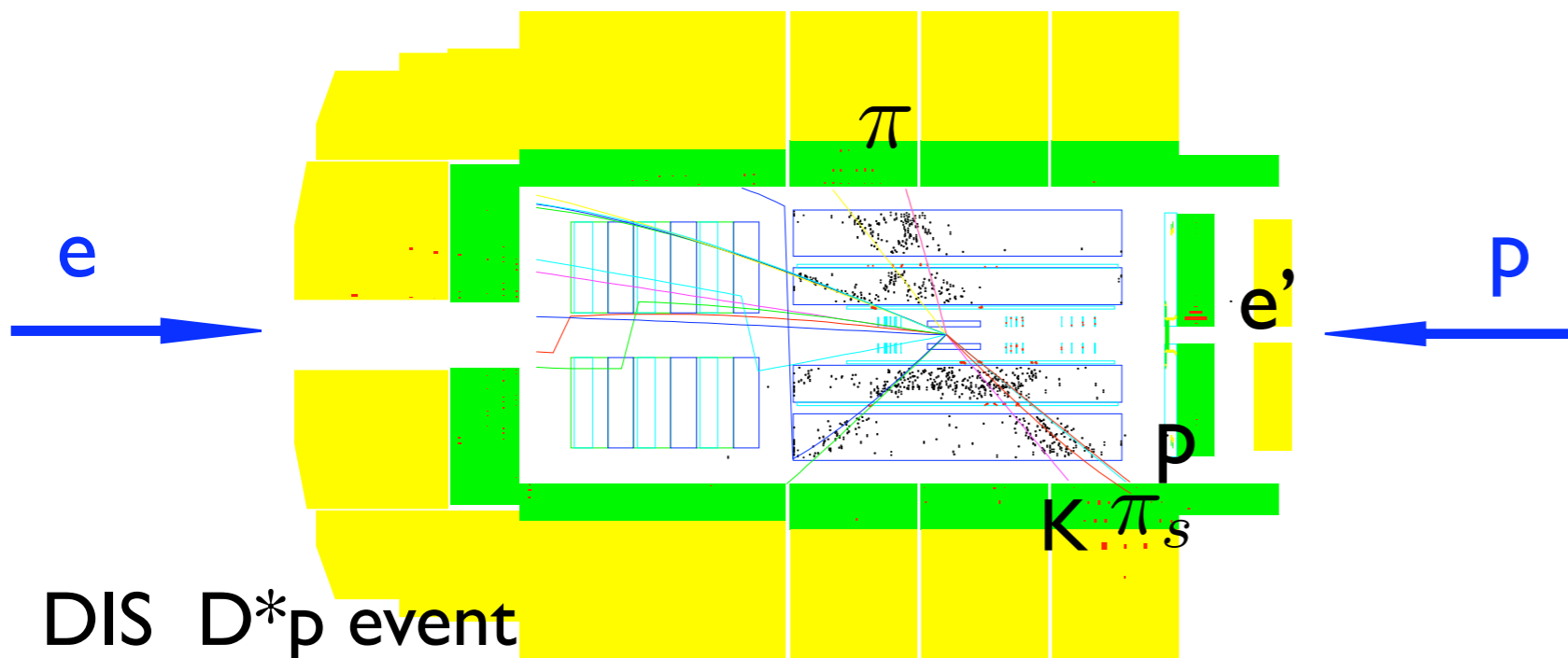
photon virtuality Q^2

photoproduction : $Q^2 \approx 0$, **DIS** : $Q^2 > 1 \text{ GeV}^2$

inelasticity $y = Q^2 / (x_{Bj} s)$

production elasticity $z(D^*) = (E - p_z)_{D^*} / 2yE_e$

pseudorapidity $\eta = -\ln \tan(\theta/2)$

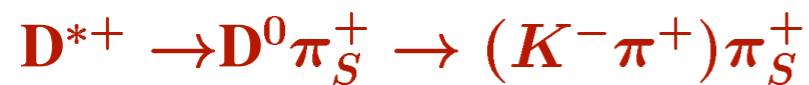


measure hadrons
in central detector
away from
proton remnant

Search for a charmed PQ decaying to $D^*p + c.c.$

$D^{*-}p$: minimal quark content $\bar{c}duud$

D^* experimentally well suited
due to golden channel :



$$p_t(D^*) > 1.5 \text{ GeV}$$

$$p_t(K) + p_t(\pi) > 2 \text{ GeV}$$

$$-1.5 < |\eta(D^*)| < 1$$

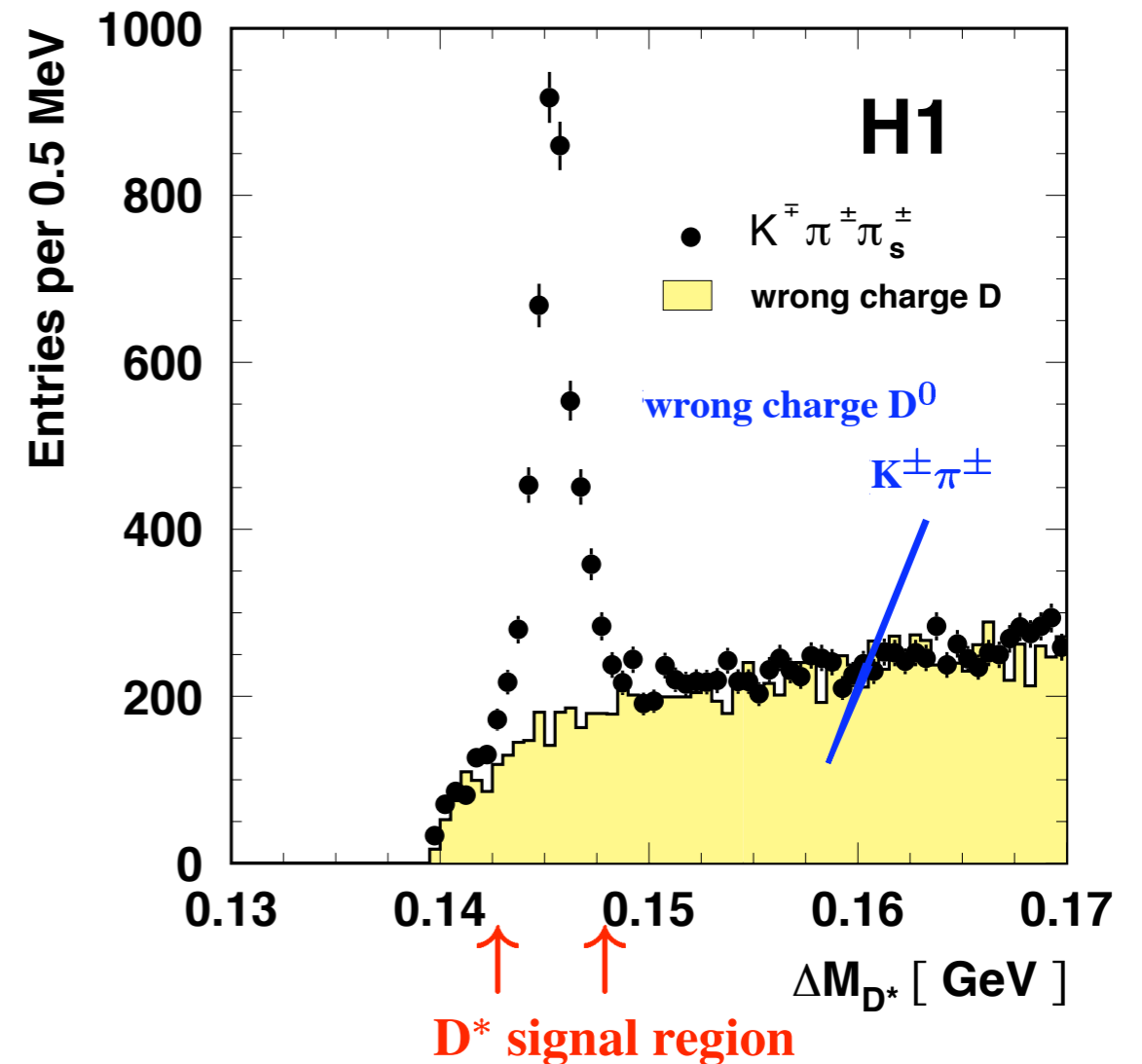
$$\text{elasticity } z(D^*) > 0.2$$

select in signal region $\sim 3500 D^*$ in DIS

good signal/background ratio

75 pb^{-1} DIS : $1 < Q^2 < 100 \text{ GeV}^2$

$0.05 < y < 0.7$



$$\Delta M_{D^*}^* = m(K \pi \pi_S) - m(K \pi)$$

proton identification

use dE/dx in drift chamber

precision of parameterisation

$\sim 3 - 5\%$

mip resolution $\sim 8\%$

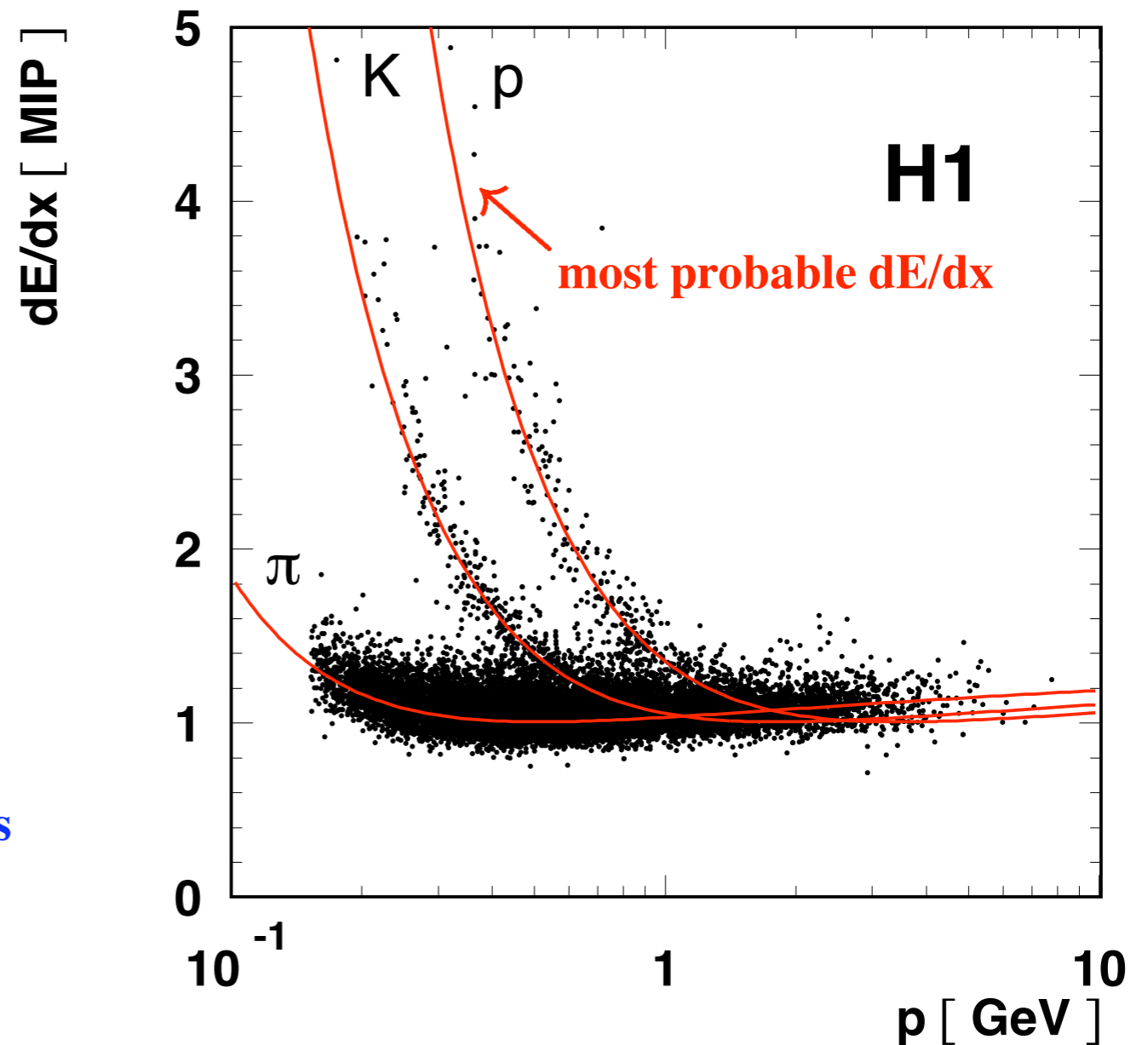
use normalised likelihoods

$$L(\pi) + L(K) + L(p) = 1$$

some back ground suppression by the cuts

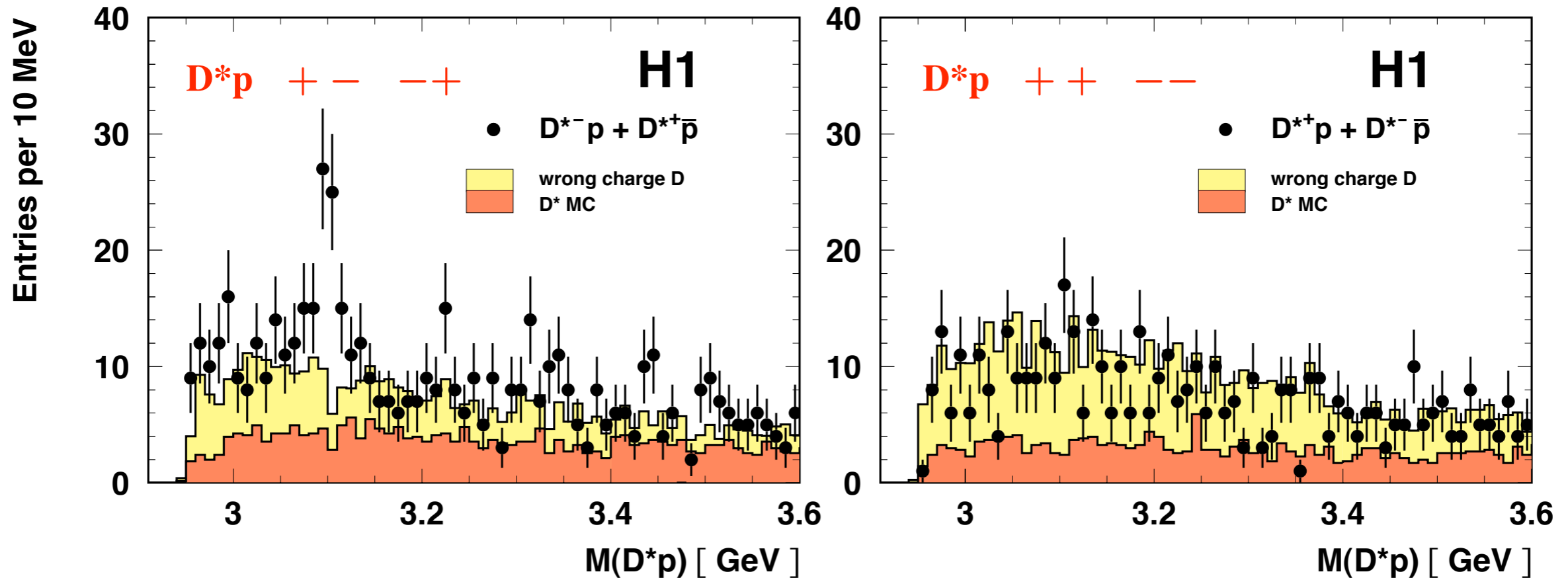
$$p(p) < 2 \text{ GeV} : L(p) > 0.3$$

$$p(p) > 2 \text{ GeV} : L(p) > 0.1$$



Signal at ~ 3.1 GeV in opposite sign D^*p mass distribution

$$M(D^*p) = m(K\pi\pi_s p) - m(K\pi\pi_s) + m(D^*)_{\text{PDG}}$$

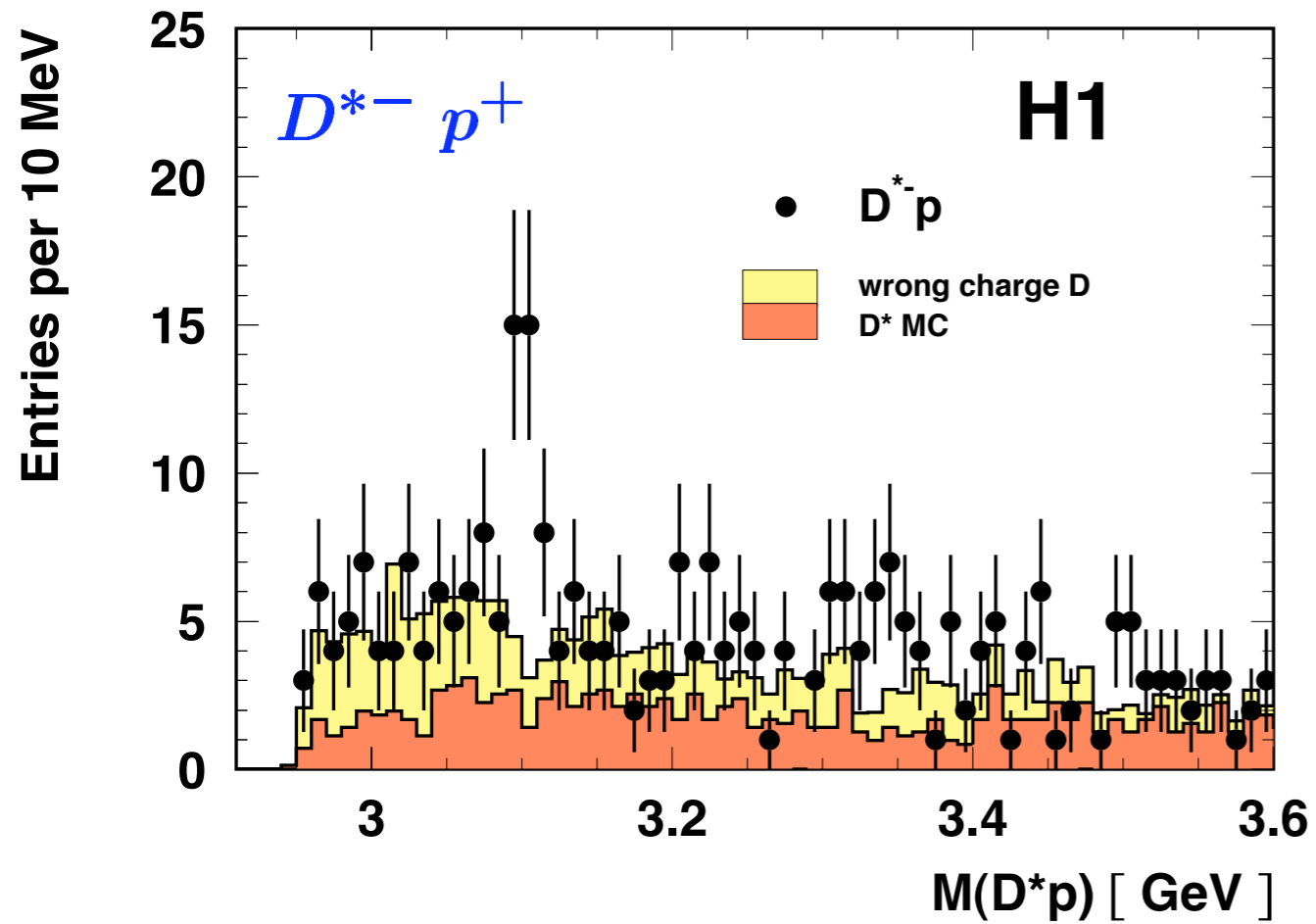


- reasonable background description by sum of
 - “wrong charge D^0 ” ($K^\pm\pi^\pm$)
 - + D^* combined with random p (MC)
- no significant signal in same charge combination

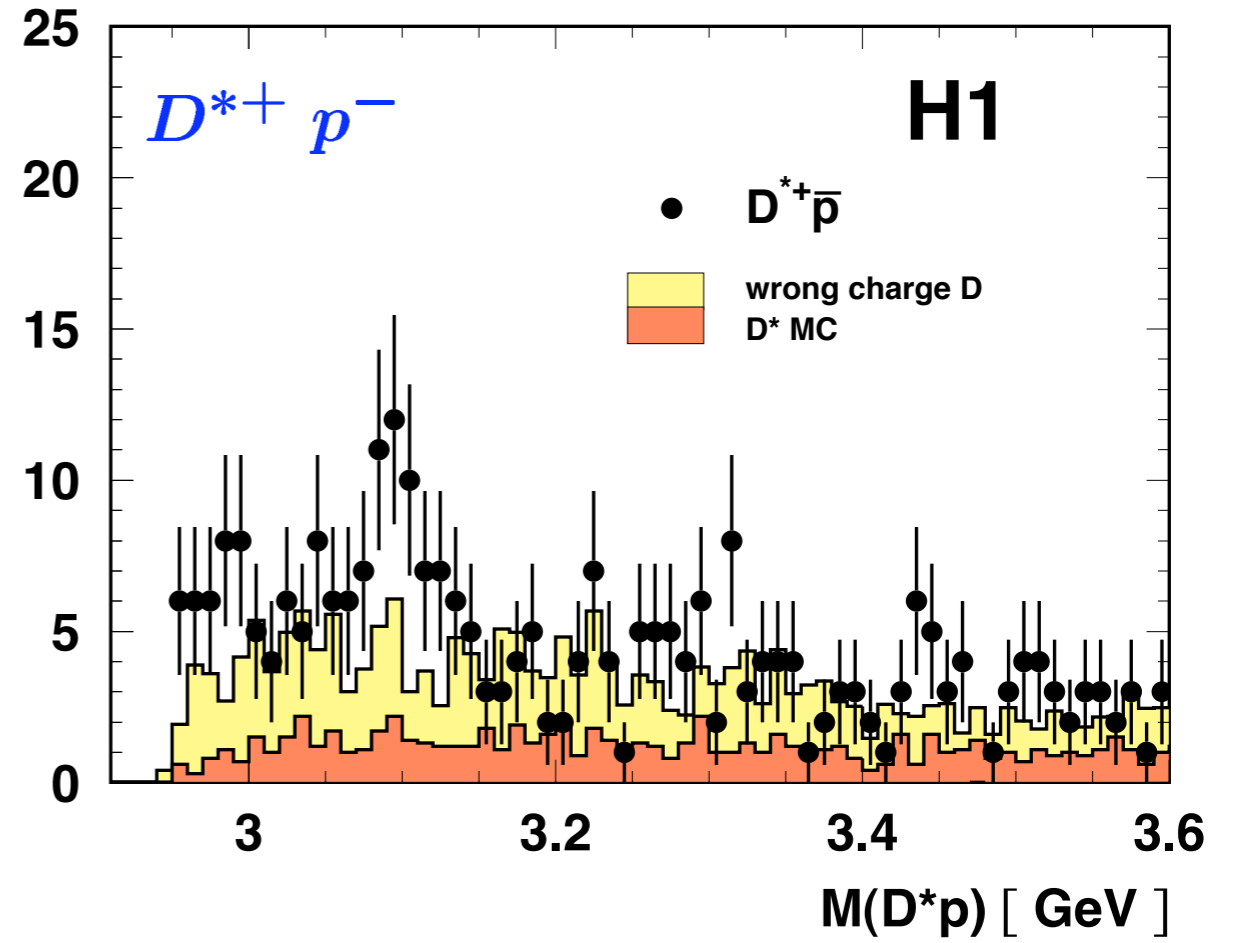
$M(D^{*-} p)$ and $M(D^{*+} \bar{p})$

$$M(D^{*-} p) = 3102 \pm 3 \text{ MeV}$$

$$M(D^{*+} \bar{p}) = 3096 \pm 6 \text{ MeV}$$



signal 25.8 ± 7.1 events



23.4 ± 8.6 events

signal of similar strength observed in both charge combinations

independent sample of photoproduction

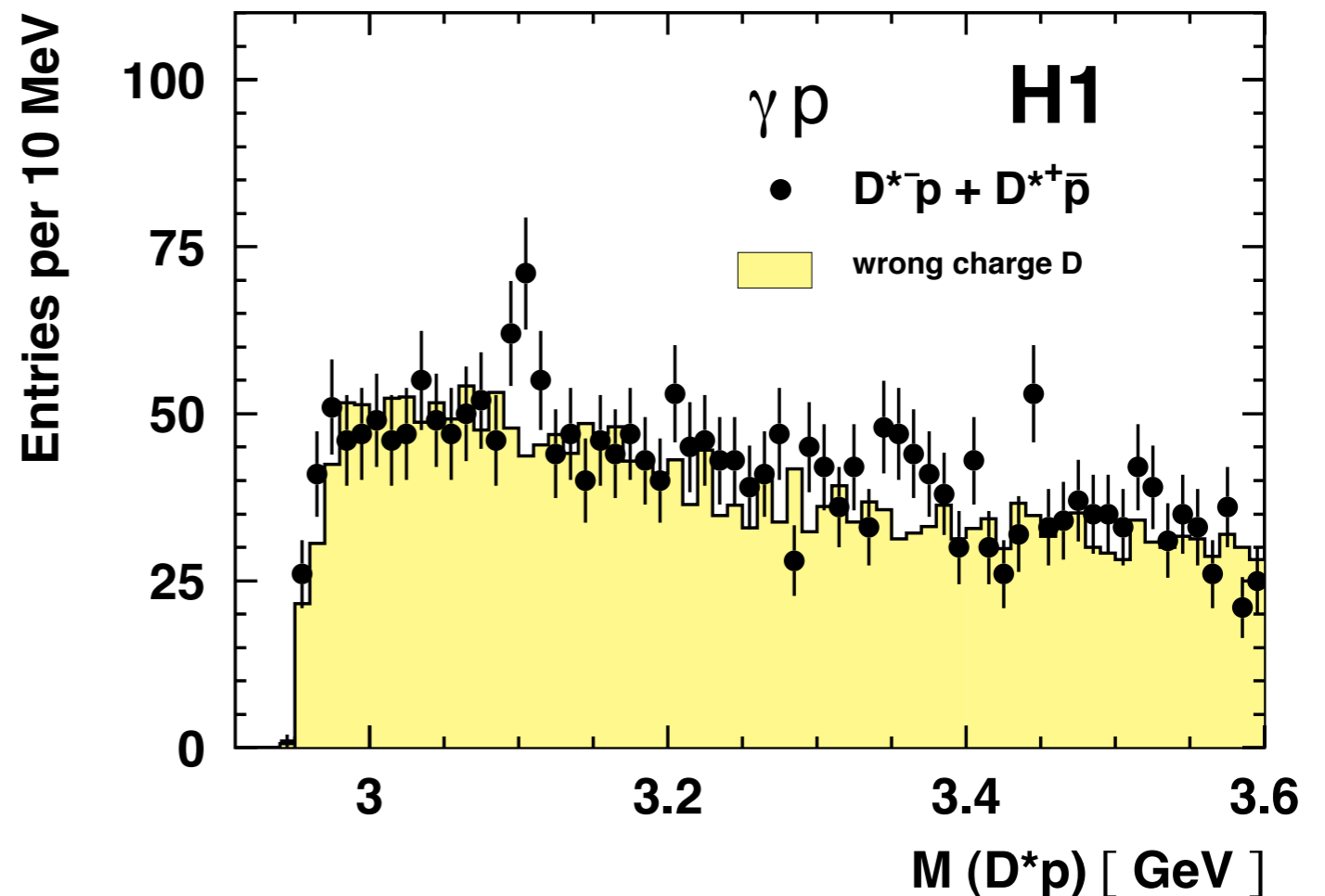
more combinatorial background

→ tighter cuts

$p_t(D^*) > 2 \text{ GeV}$

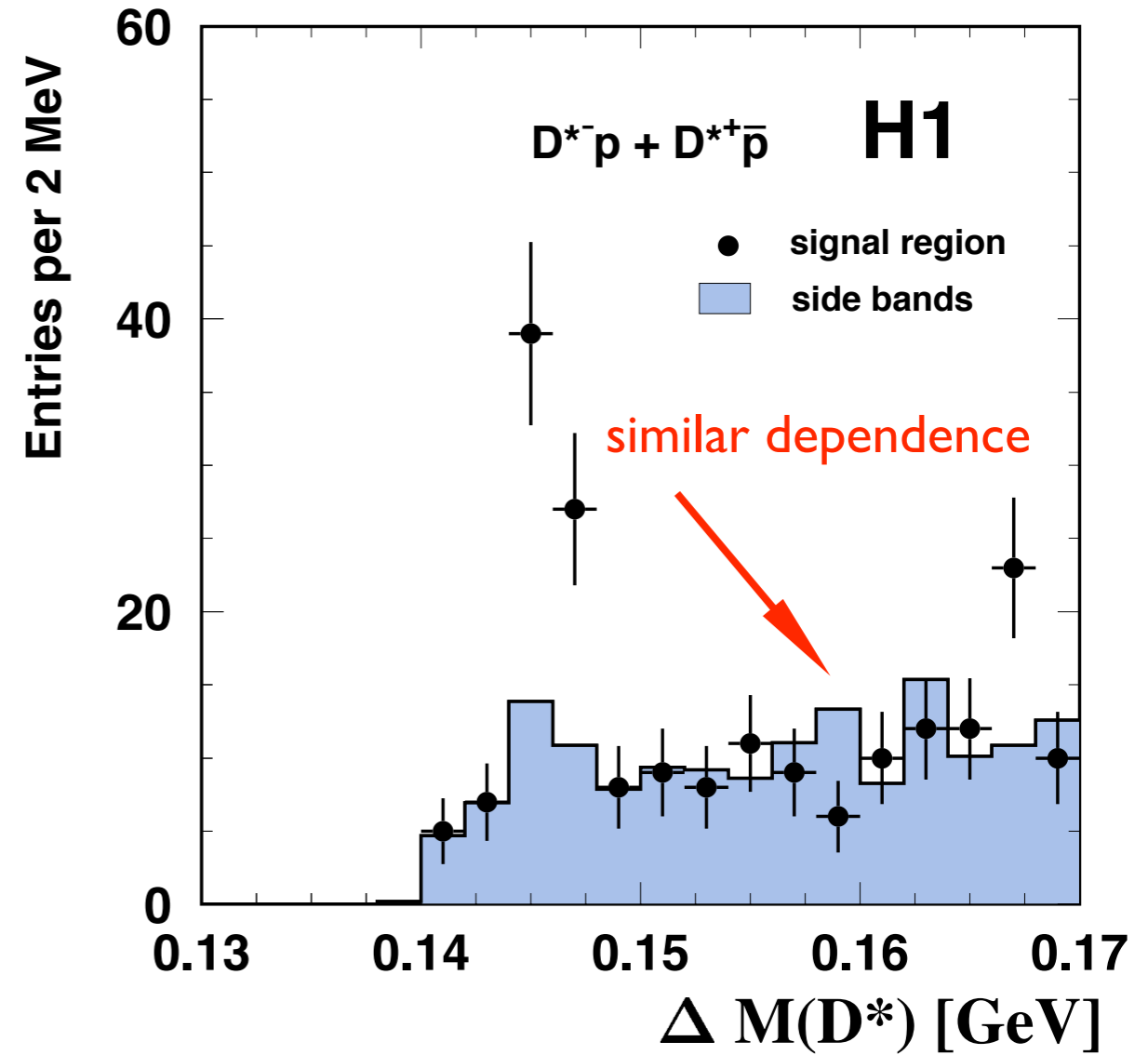
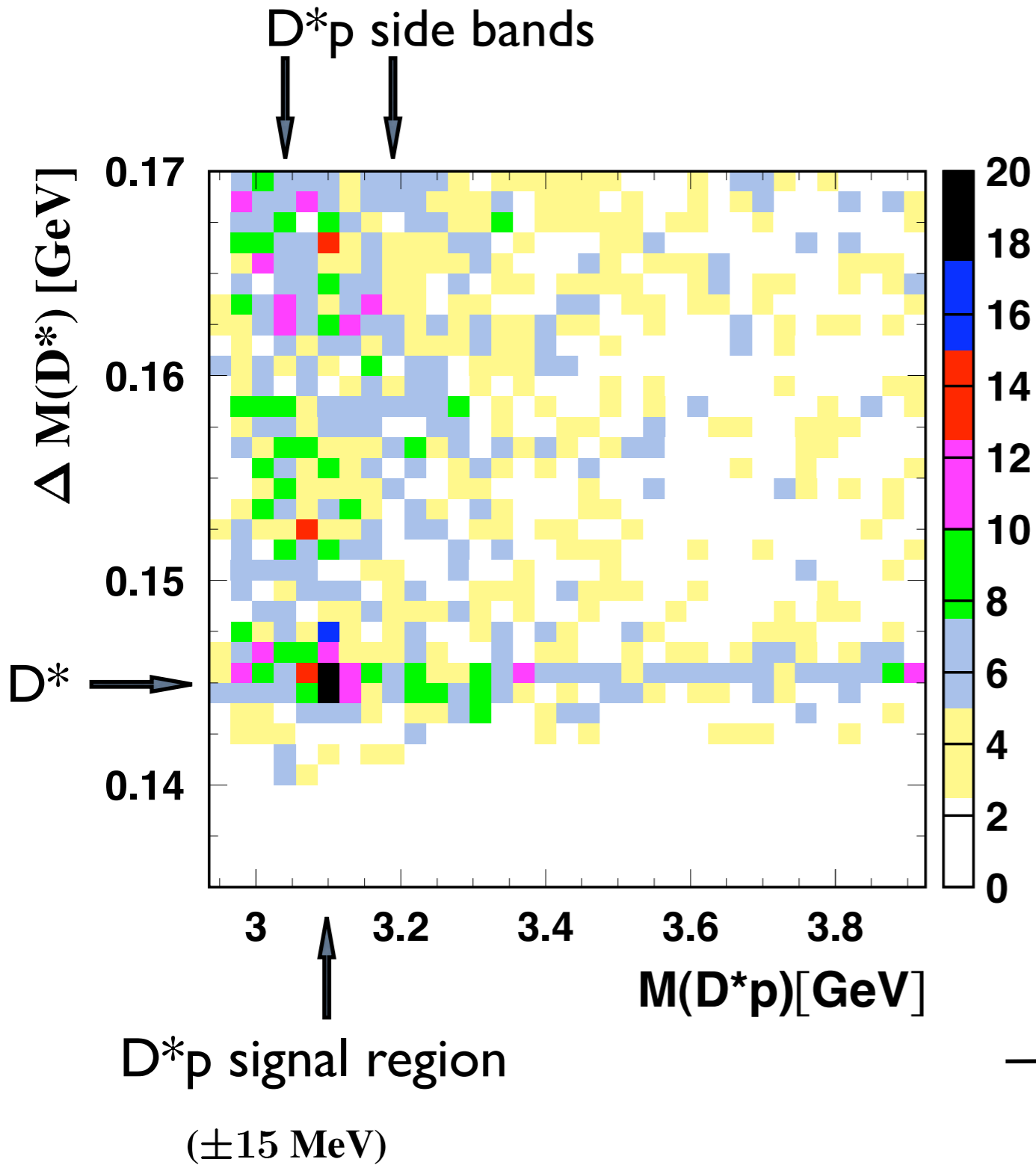
p likelihood $L(p) > 0.25$

exclude $1.6 < p(p) < 2.0 \text{ GeV}$
(weakest dE/dx separation)



less significant signal also in photoproduction ($M(D^*p) = 3.103 \pm 0.004 \text{ GeV}$)
base further analysis on DIS

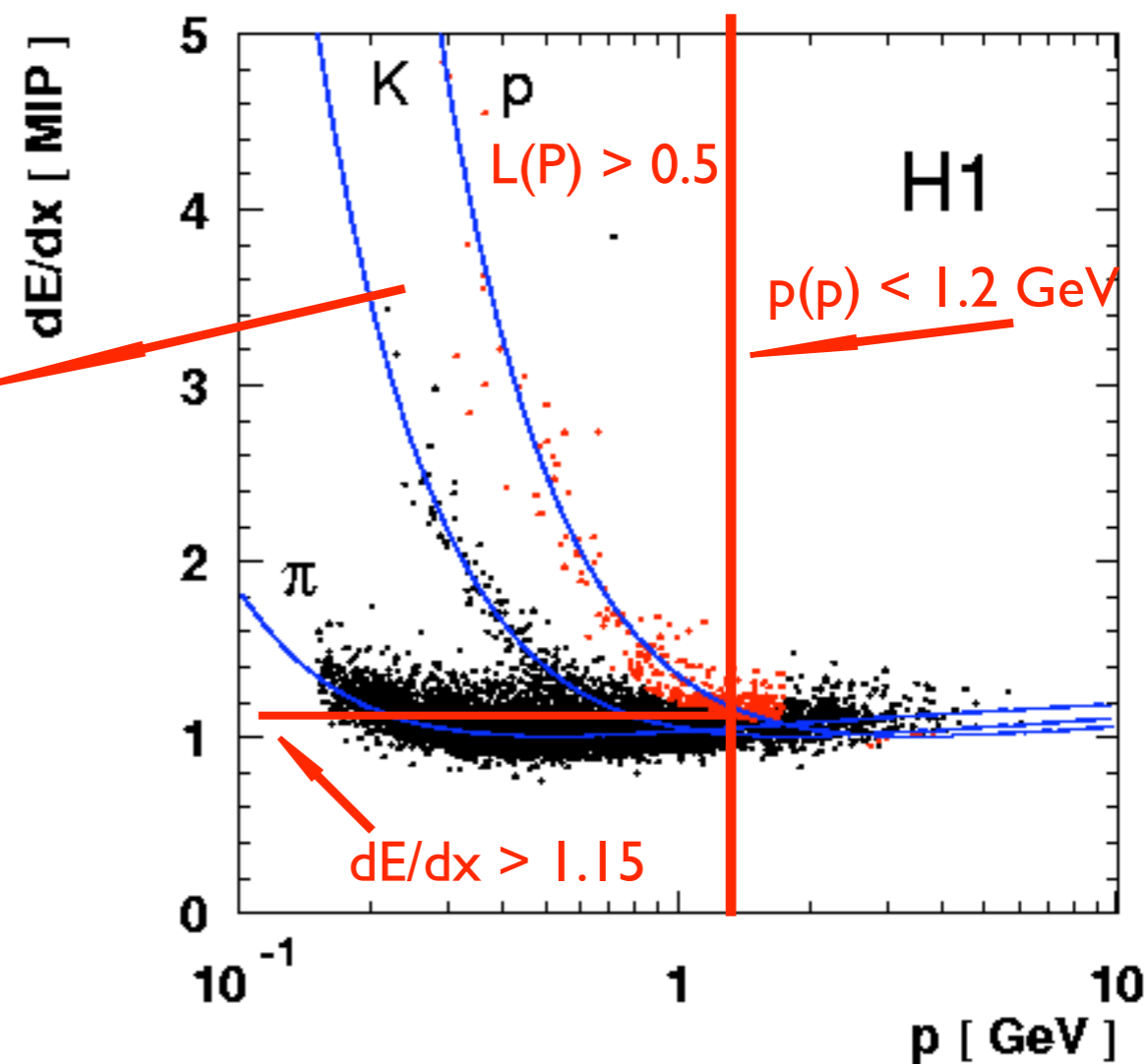
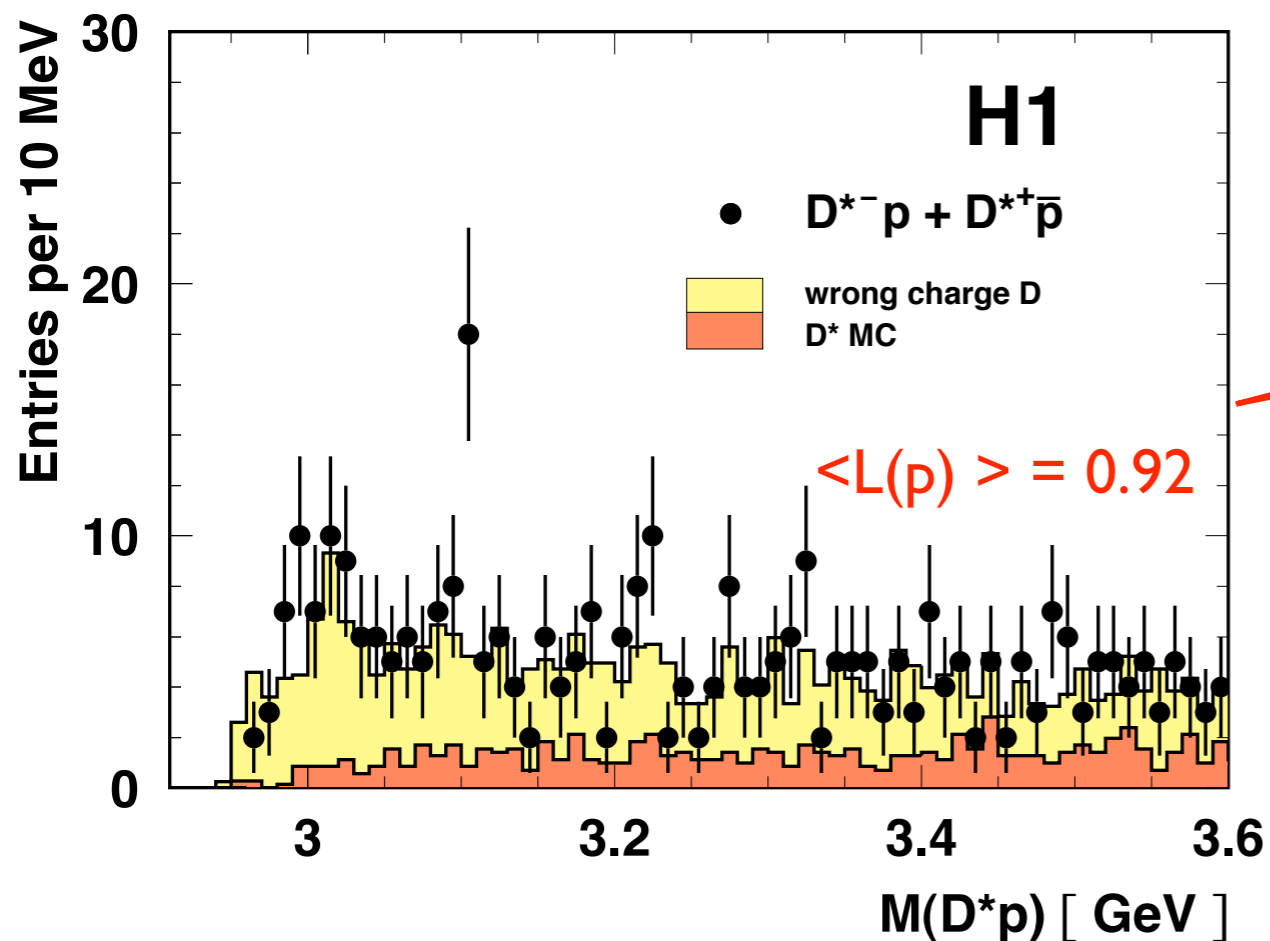
signal related to charm ?



large D^* content in peak

select sample with tighter proton id

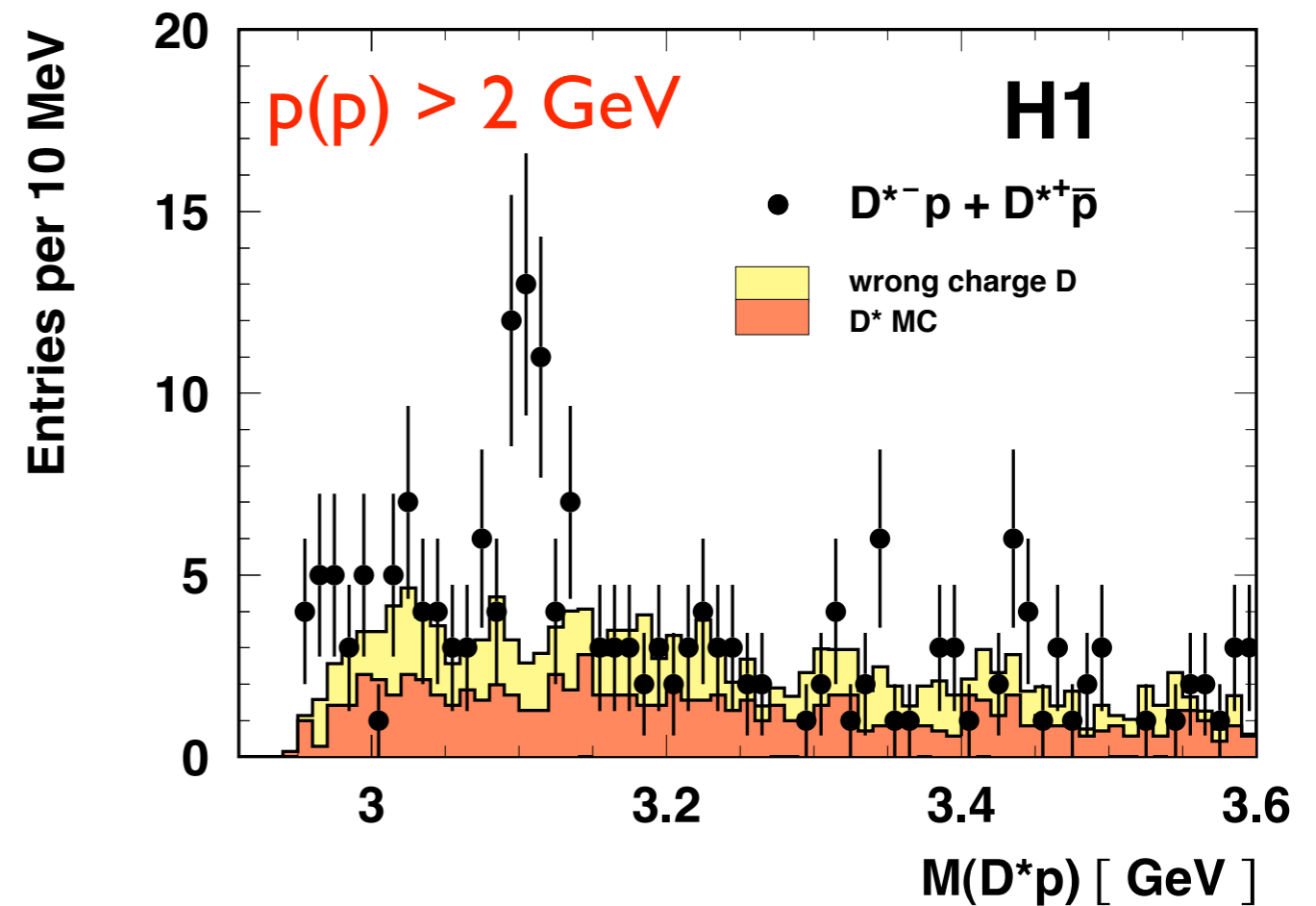
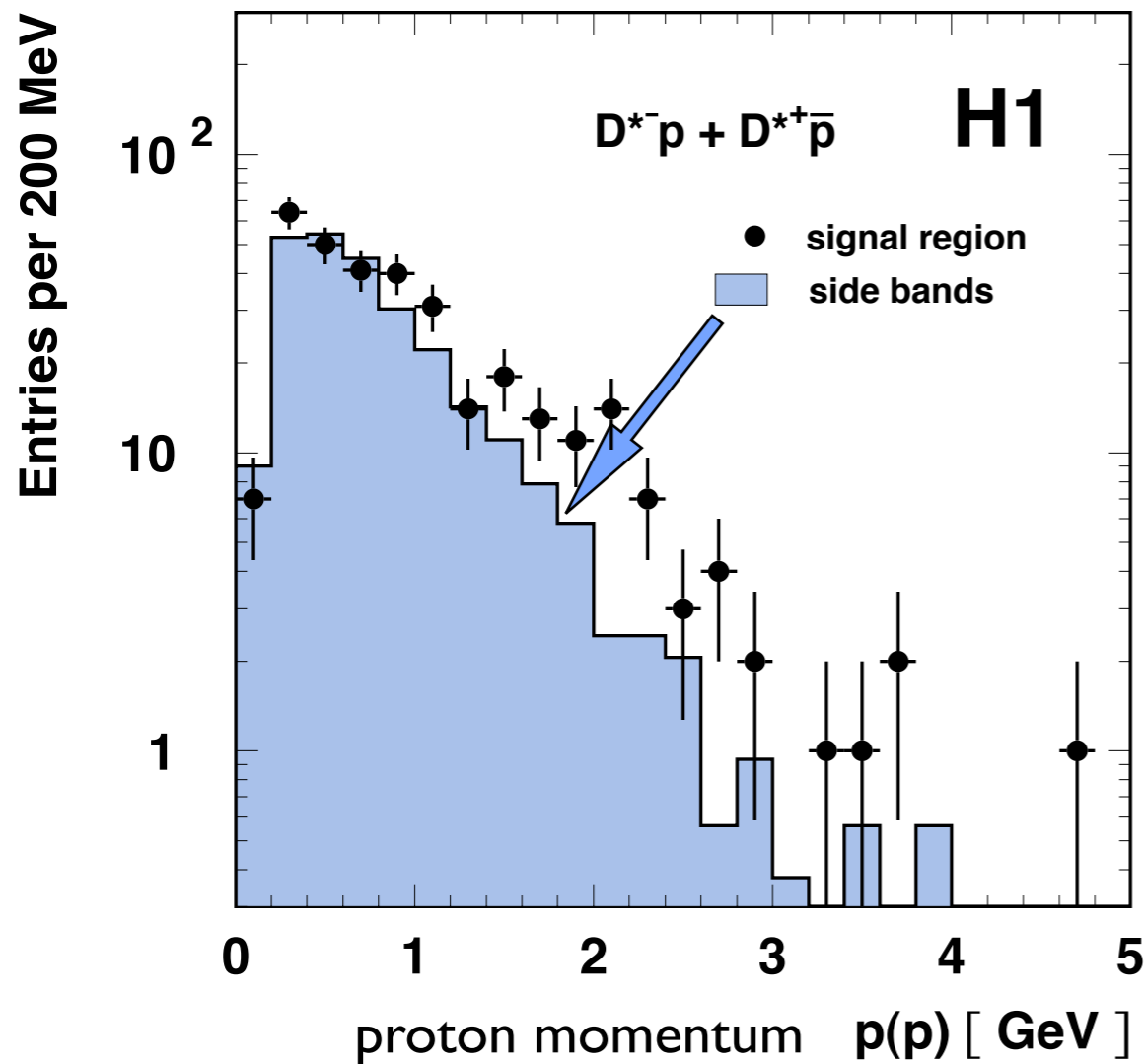
$$M(D^*p) = 3.104 \pm 0.003 \text{ GeV}$$



signal observed also in p enriched sample

Signal at high p momenta

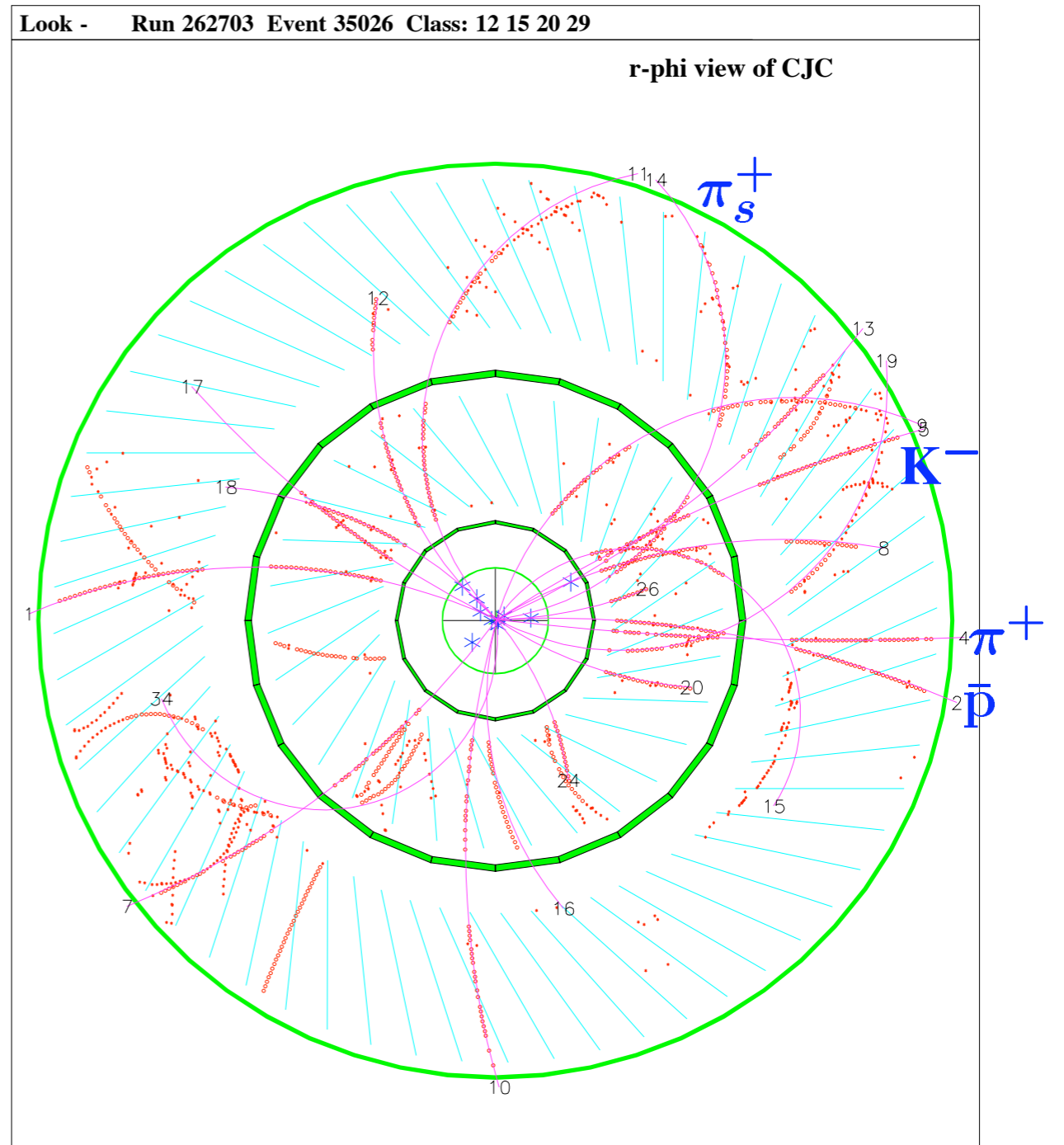
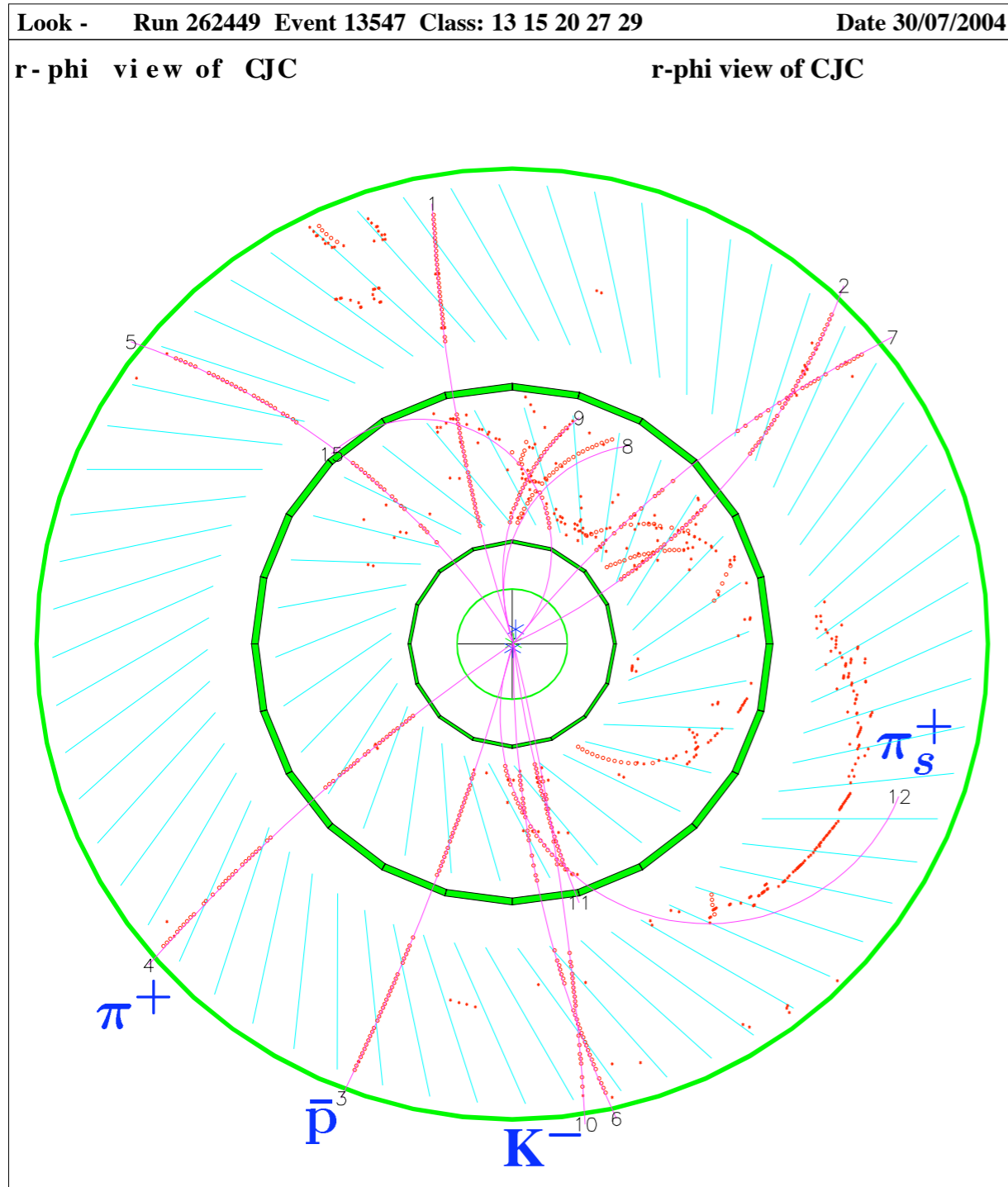
no dE/dx cut



- spectrum in signal region harder than in D^*p sidebands
- $p(p) > 2$ GeV: signal also without dE/dx cut

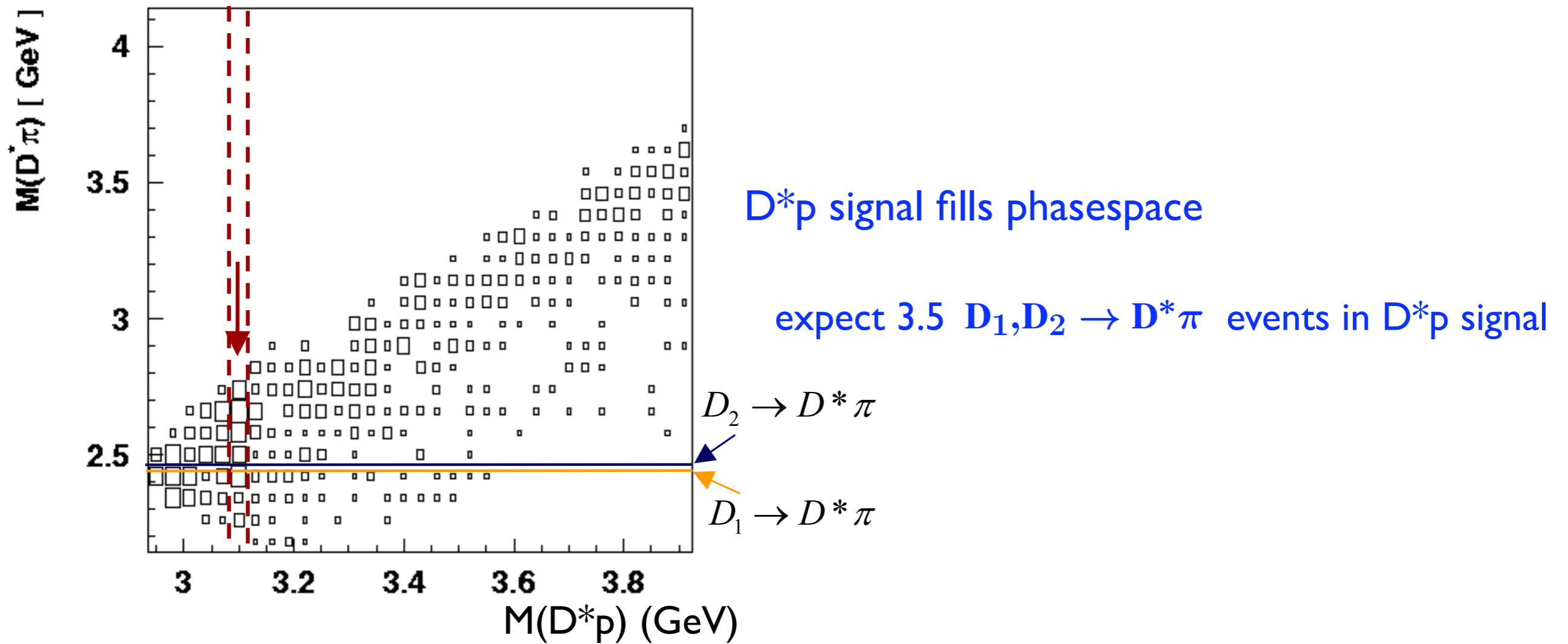
candidate events

events in D^*p peak were scanned, no problems found



D^*p peak, result of reflections ?

e.g. $D_1(2420), D_2(2460) \rightarrow D^*\pi$

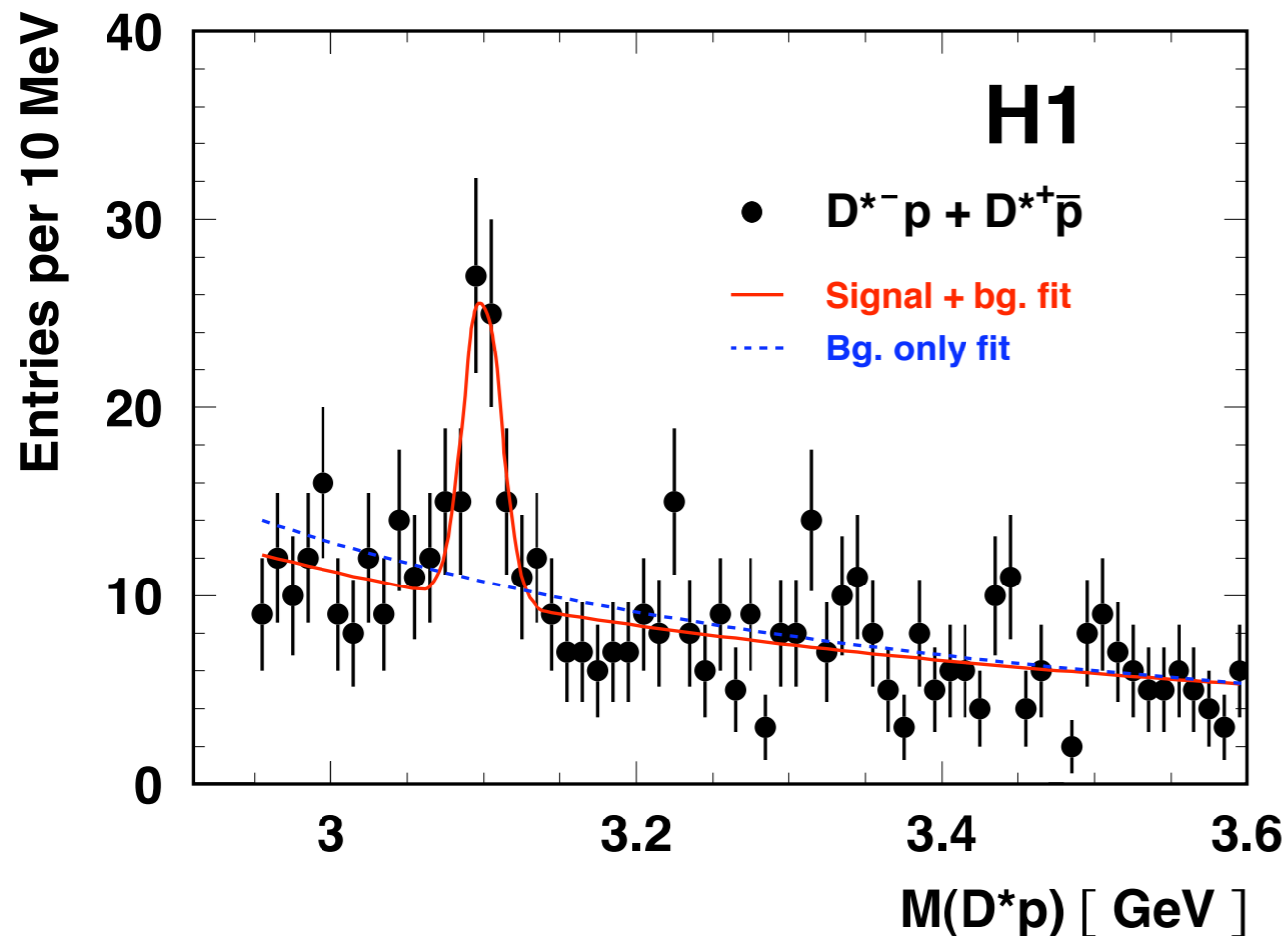


Extensive studies of wrong mass assignments gave no indication of significant reflections

Significance estimate (DIS selection)

Signal + background fit

Gaussian + power law background $\propto [M(D^*p) - M(D^*)]^\beta$



Mass $3099 \pm 3(\text{stat}) \pm 5(\text{syst})\text{MeV}$

Width $12 \pm 3 \text{ MeV}$

(consistent with exp. resolution)

within 2σ :

$N_B = 45.0 \pm 2.8$

$N_S = 50.6 \pm 11.2$ ($\sim 1\%$ of D^* yield)

($1.46 \pm 0.32 \%$, uncorrected in acceptance)

Full distribution in background fit (broken line)

within 2σ : $N_B = 51.7 \pm 2.7$

Poisson probability (4×10^{-8}) for background ($N_B = 51.7$) to fluctuate to ≥ 95 events corresponds to 5.4σ (Gauss)

Conclusions

- Narrow resonance observed in DIS for $D^{*-}p$ and $D^{*+}\bar{p}$
- Mass 3099 ± 3 (stat) ± 5 (syst) MeV
- Gaussian width 12 ± 3 MeV (consistent with exp. resolution)
- significance 5.4σ
- minimal quark content $uudd\bar{c}$, candidate for charmed PQ
- not yet confirmed

Backups

Other experiments searching for charmed PQs ?

positive evidence

HI

ep

(Phys. Lett. B588 (2004) 17)

negative unpublished reports

FOCUS γN

ALEPH e^+e^-

CDF $p\bar{p}$

ZEUS *ep*

} different reactions/kinematics

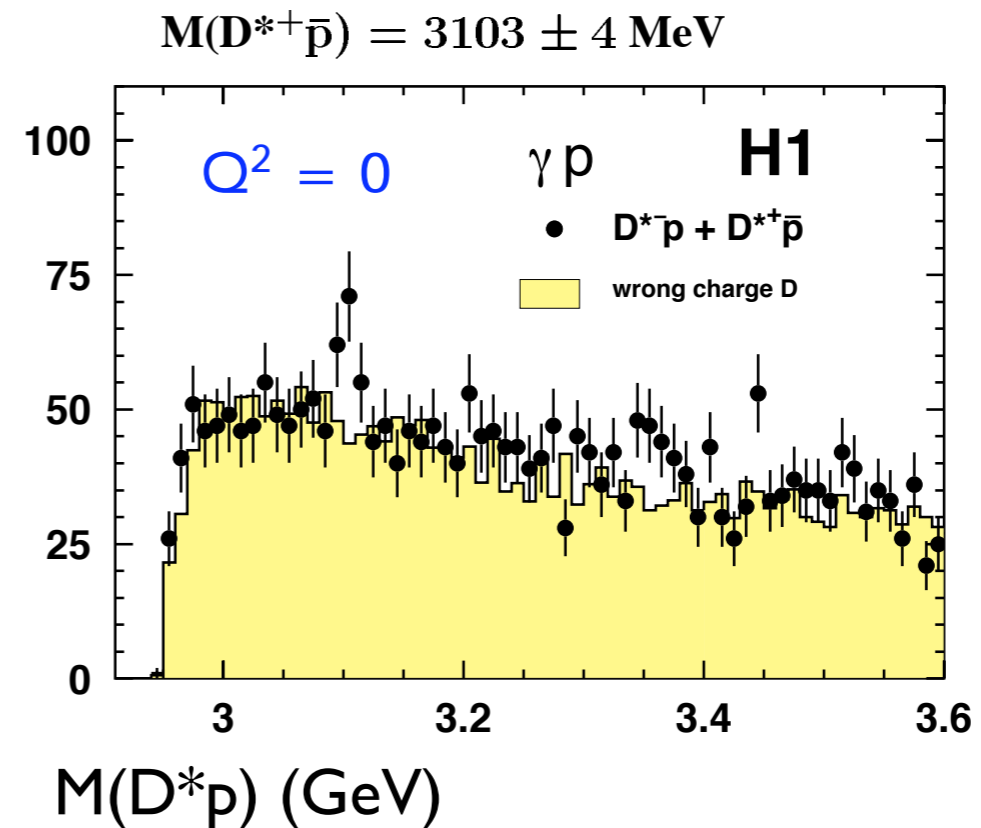
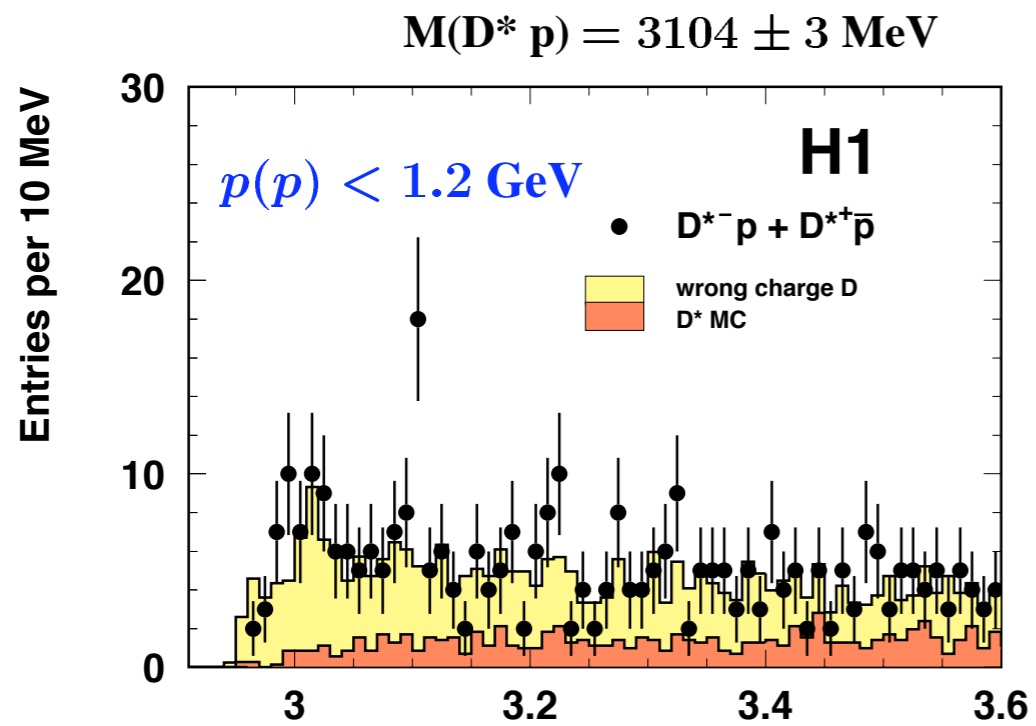
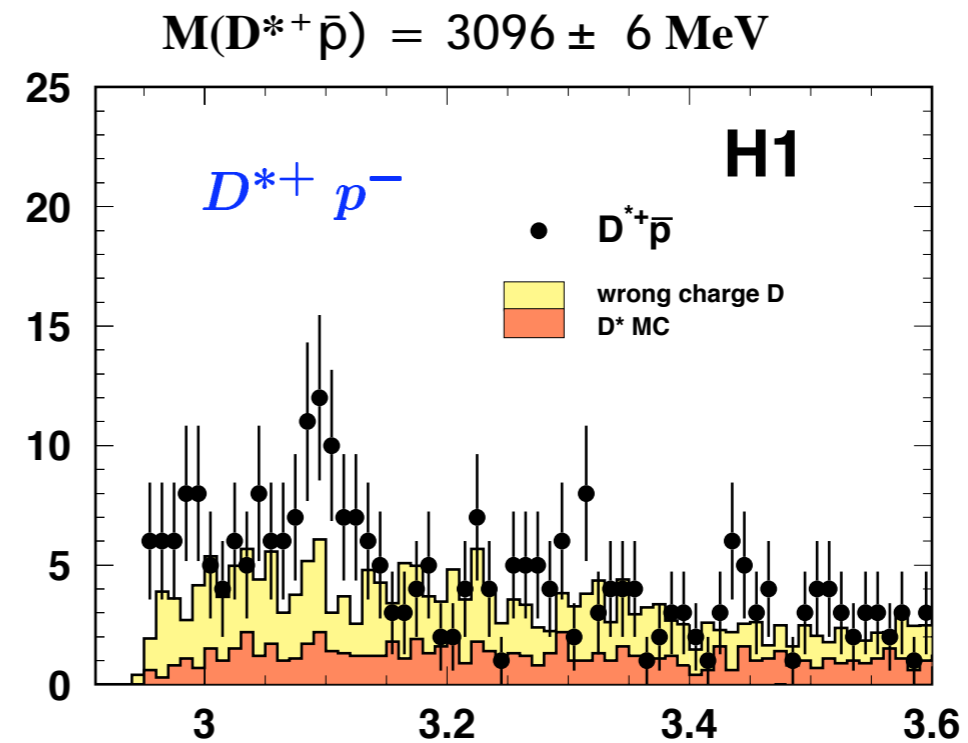
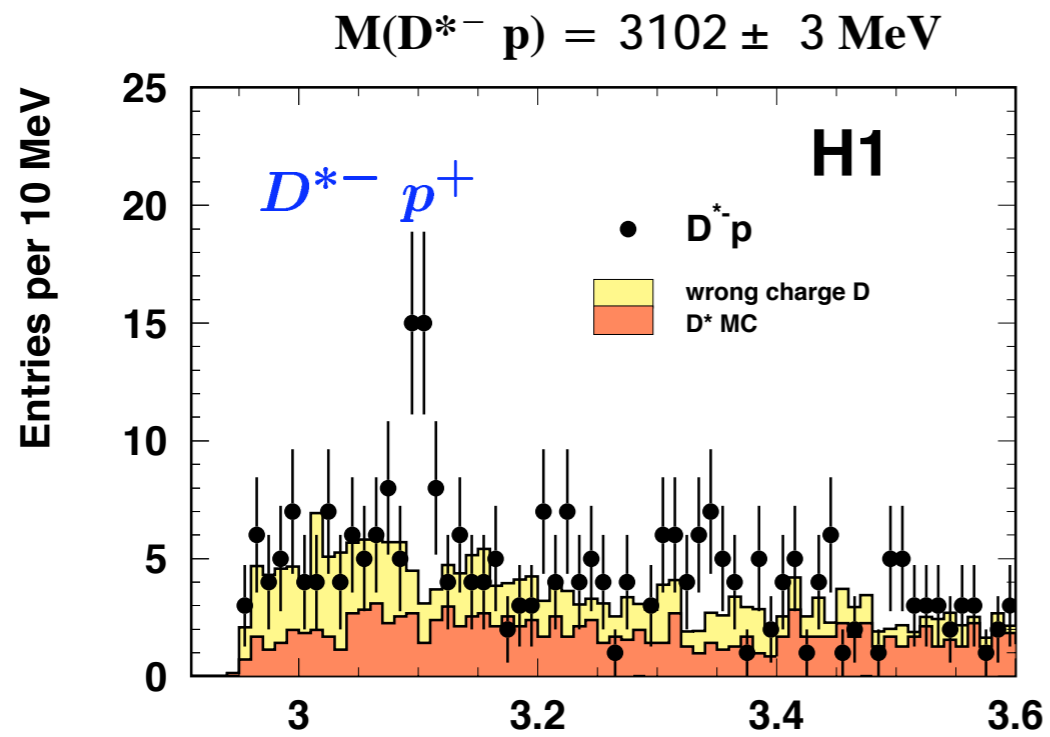
to be published

HI and ZEUS

same reaction / similar phase space

→ good prospects for clarification

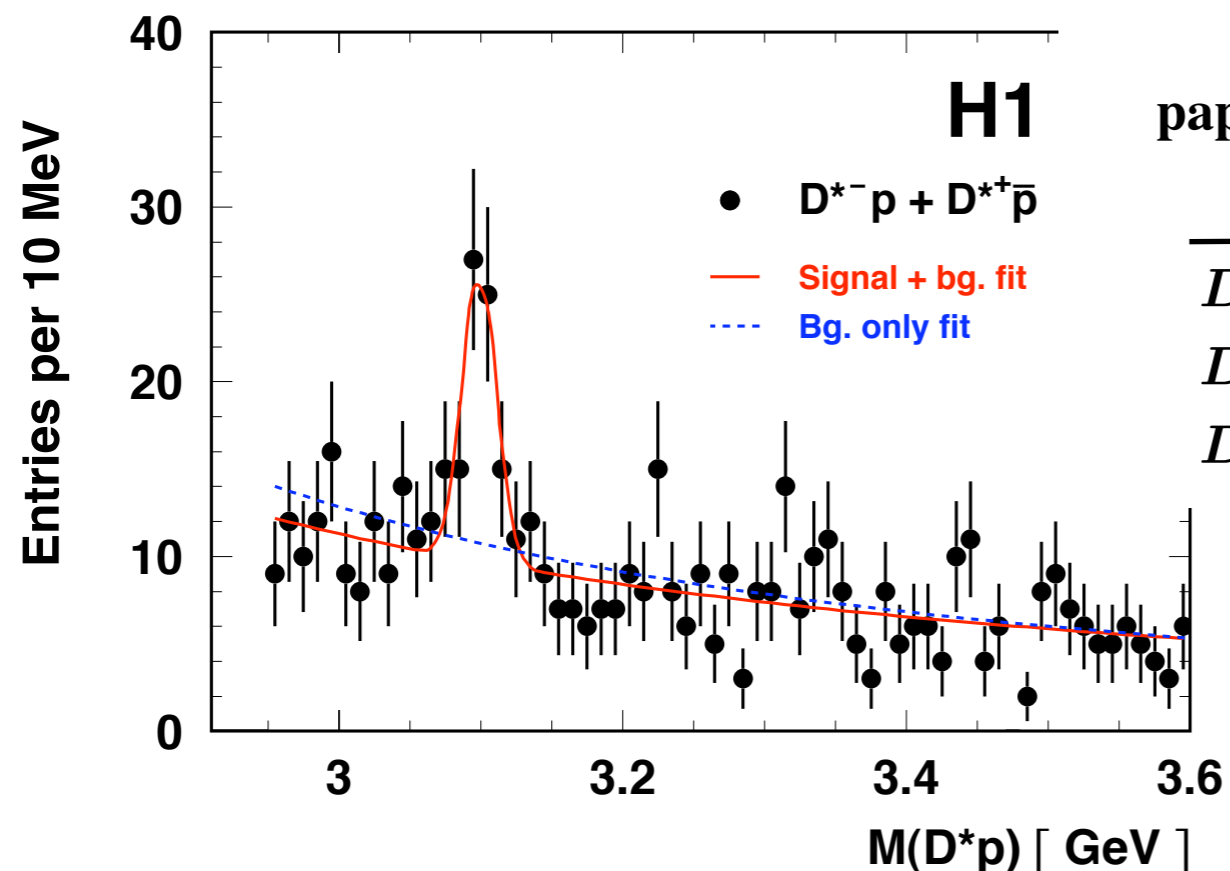
Signal for different selections



Signal fits

fit Gaussian + power law background $\propto [M(D^*p) - M(D^*)]^\beta$

(broken line : fit background to full distribution)



paper:

	$M(D^*p)$	σ/MeV	NS
$D^{*+} \bar{p} + D^{*-} p$	3099 ± 3	12 ± 3	50.6 ± 11.2
$D^{*-} p$	3102 ± 3	9 ± 3	25.8 ± 7.1
$D^{*+} \bar{p}$	3096 ± 6	13 ± 6	23.4 ± 8.6

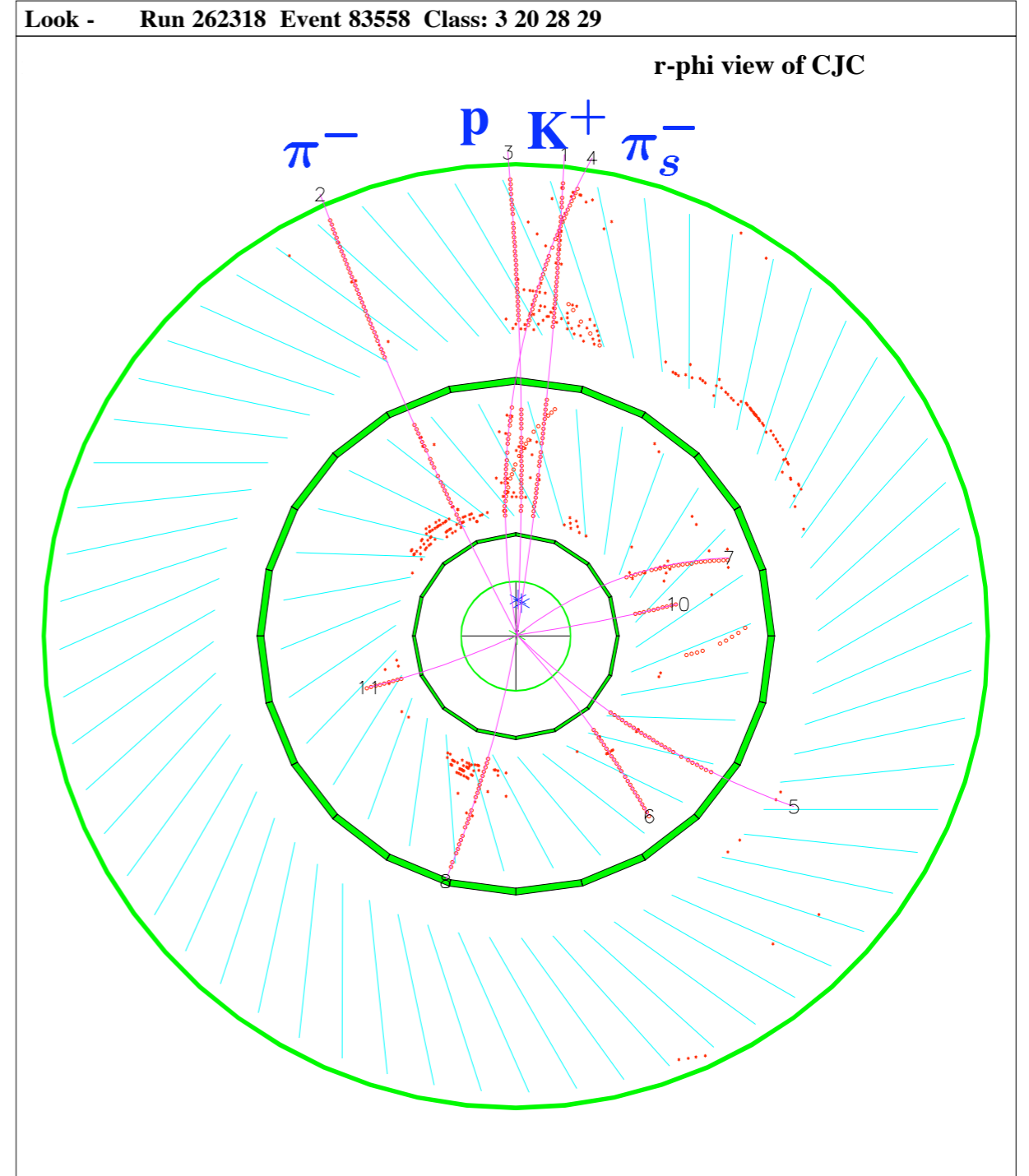
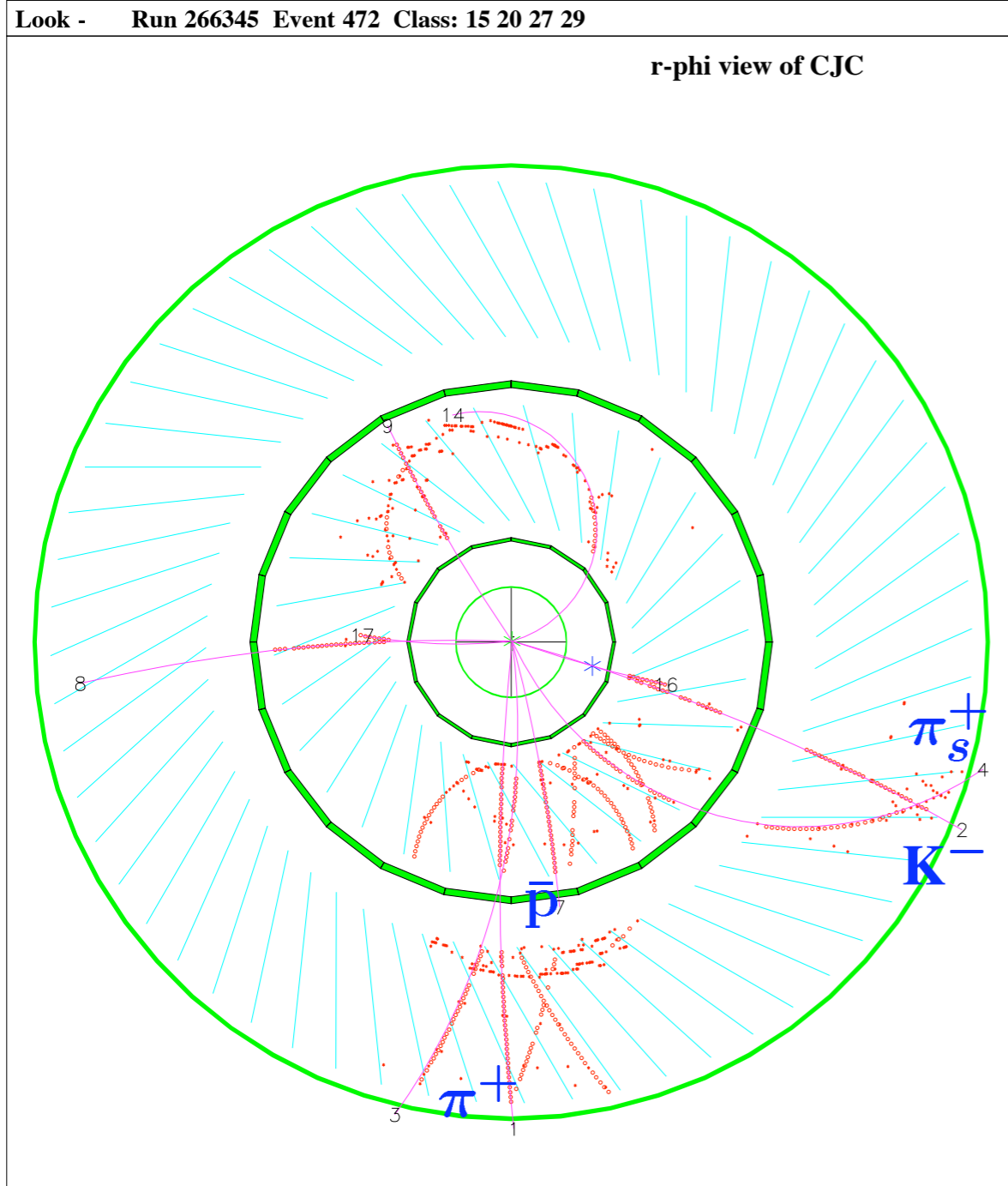
width of other peaks

$p < 1.2 \text{ GeV}$ (paper fig. 4) $4.1 \pm 1.3 \text{ MeV}$

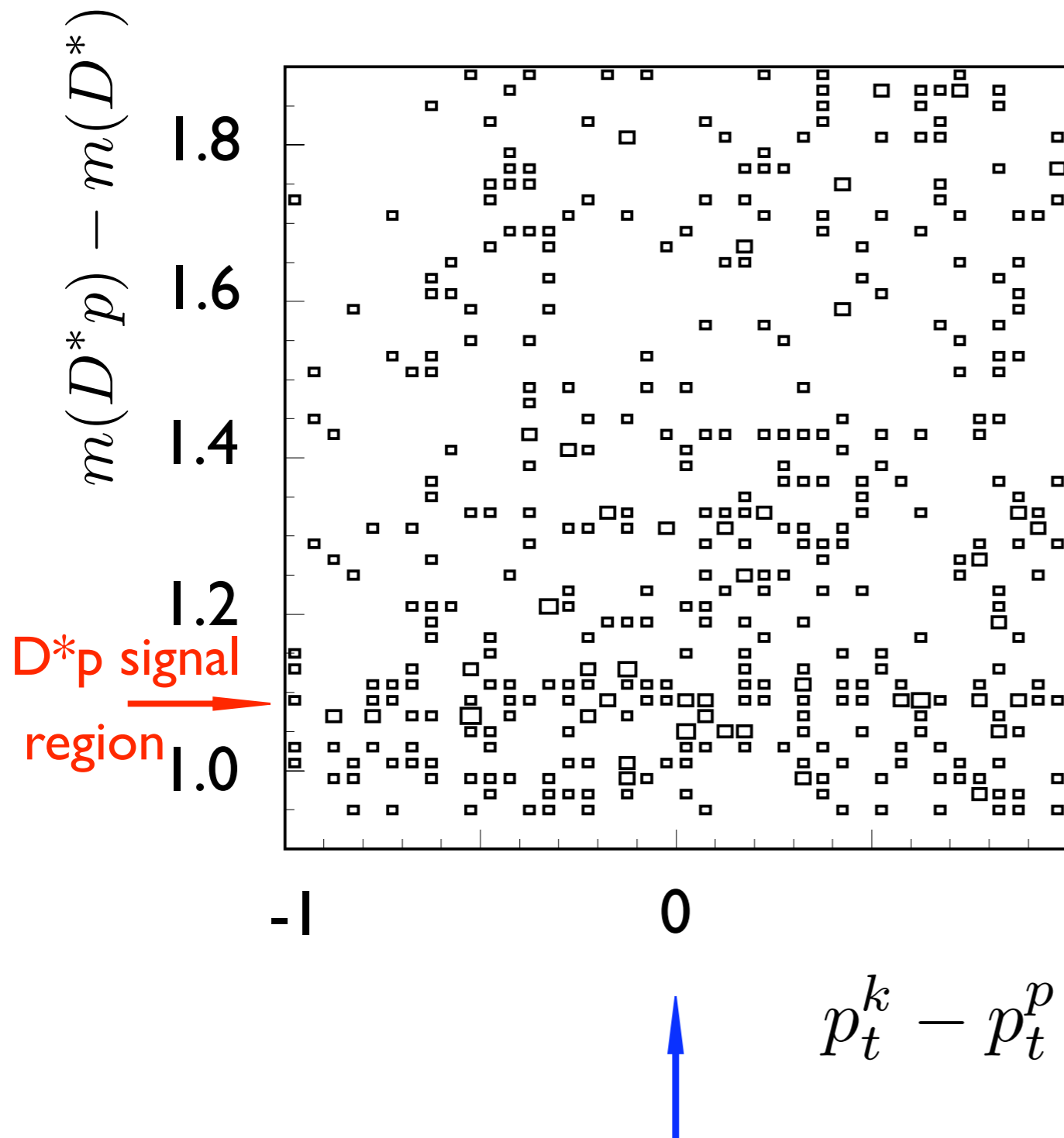
$p > 2 \text{ GeV}$ (paper fig. 5b) $12.2 \pm 3.6 \text{ MeV}$

$Q^2 = 0$ (paper fig. 6) $7 \pm 3 \text{ MeV}$

candidate events



checks against multiple use of tracks



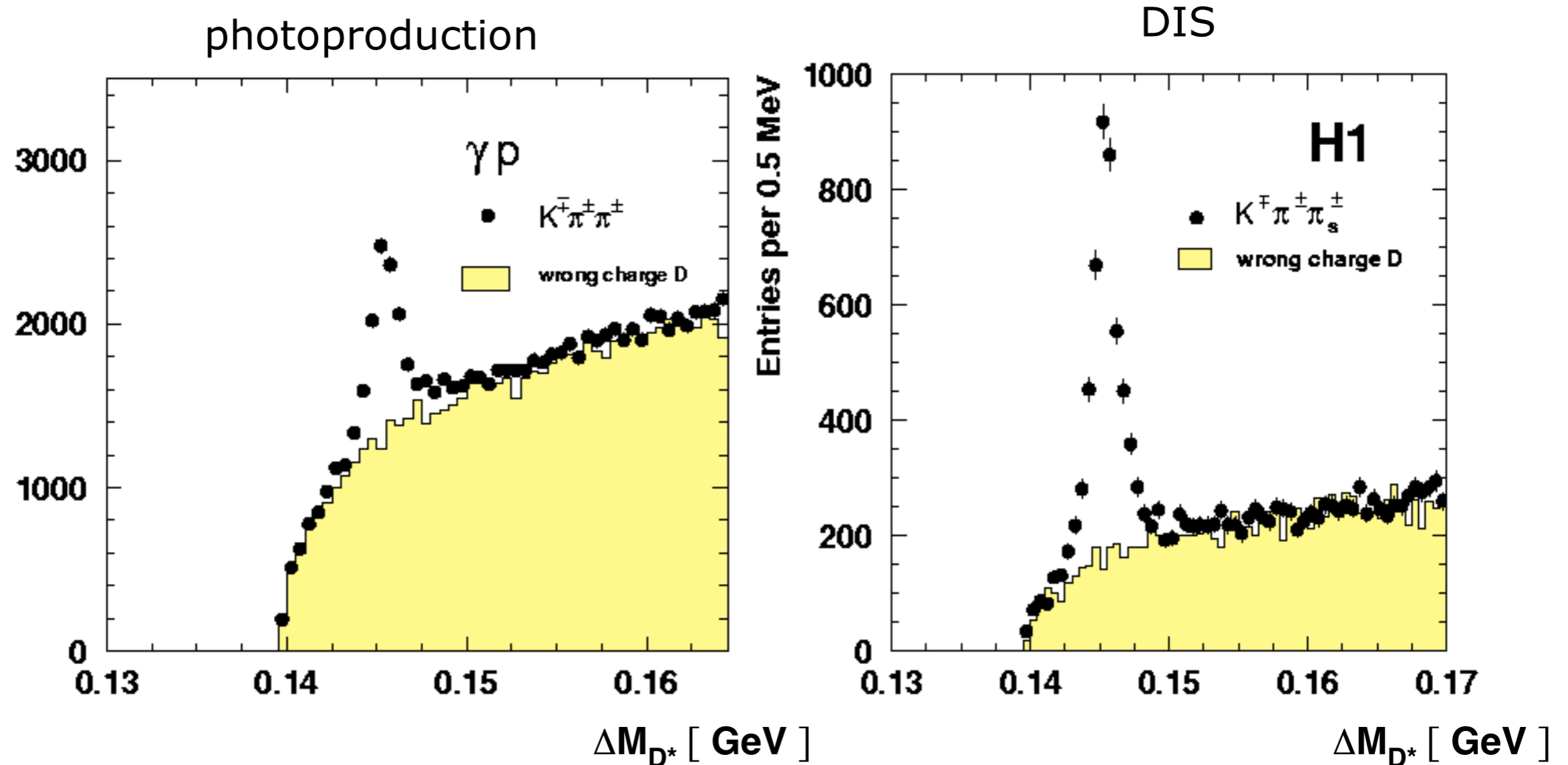
D* ρ mass peak generated by multiple use of ρ and K candidates ?

→ no peak at $\Delta p_t = 0$

further :

- the peak events were scanned
no anomalies found
- all entries in ± 24 MeV of peak
from different events (1 exception
with 2 K candidates of same event)

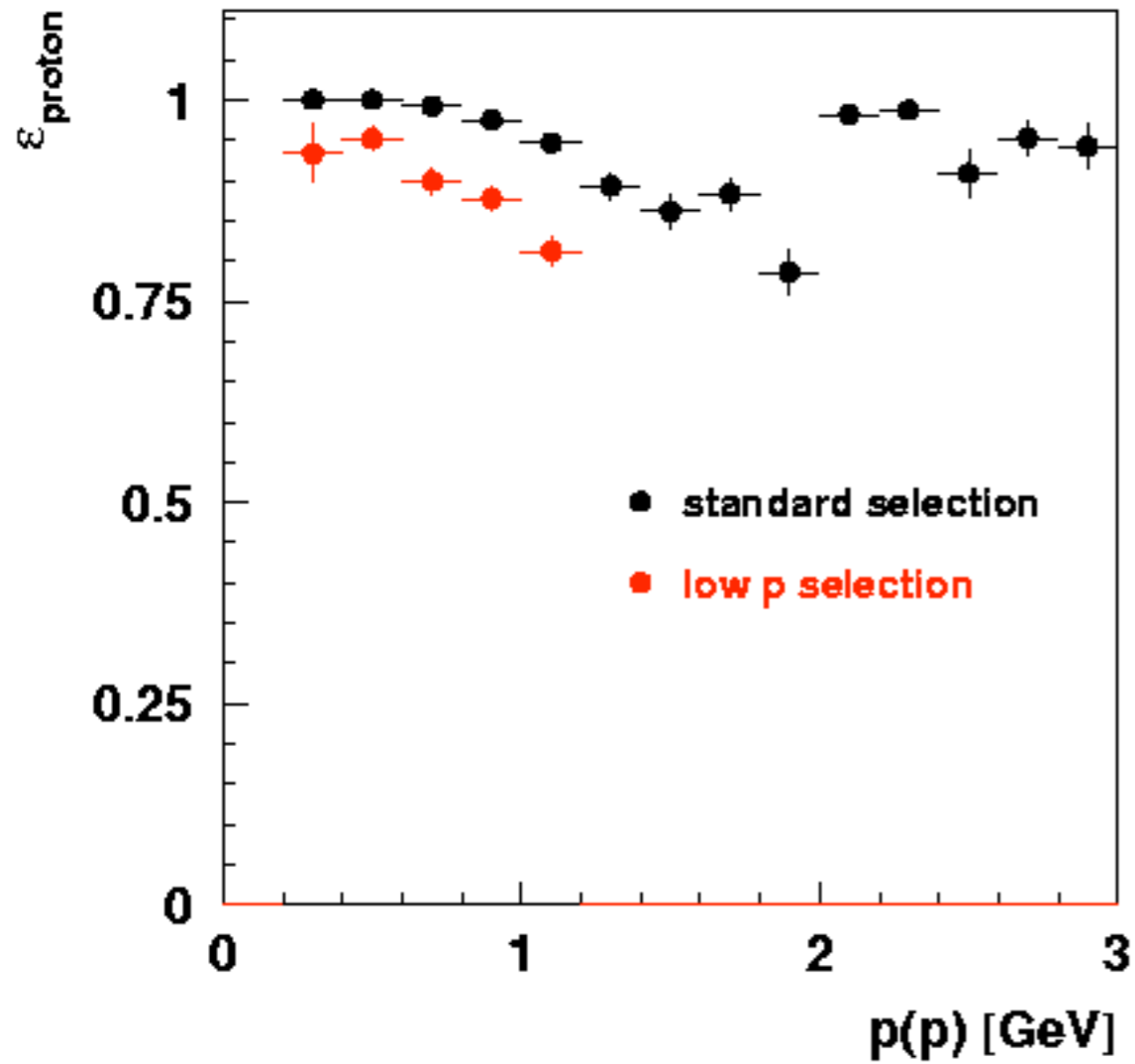
D* signal in photoproduction and DIS



- DIS selection cleaner
- consider photoproduction as supporting evidence

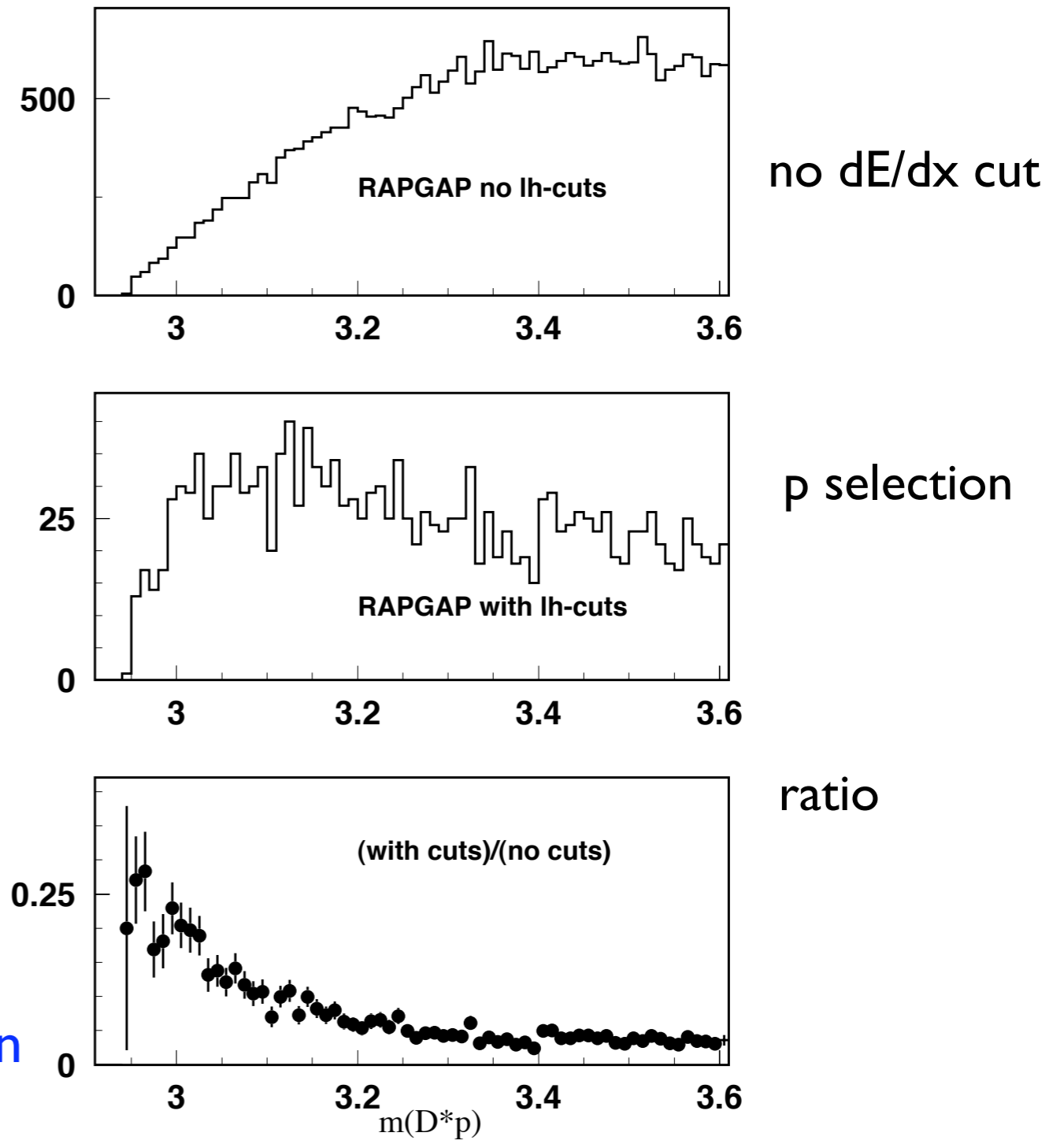
dE/dx selection

proton efficiency



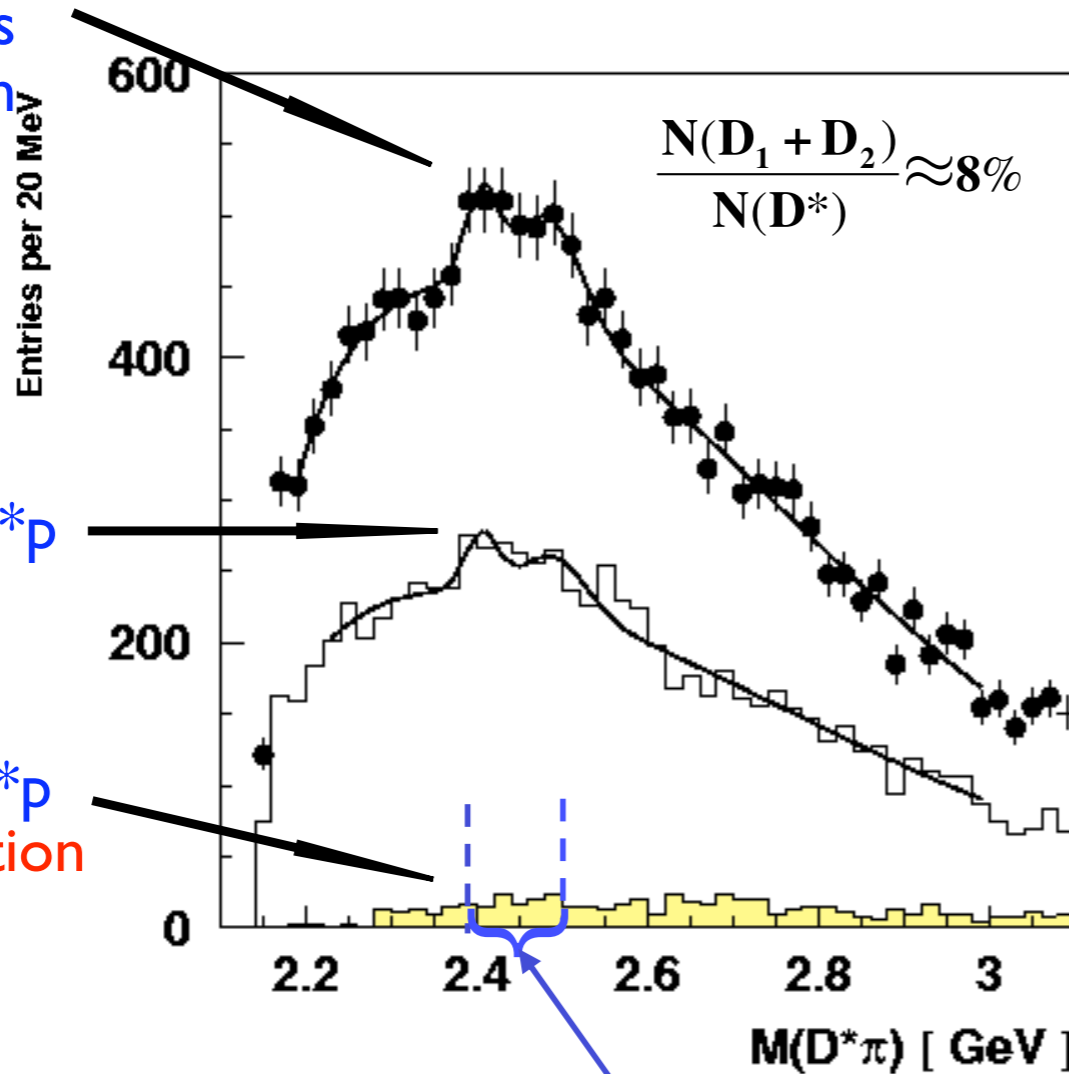
smooth in signal region

pion suppression by p selection (MC)



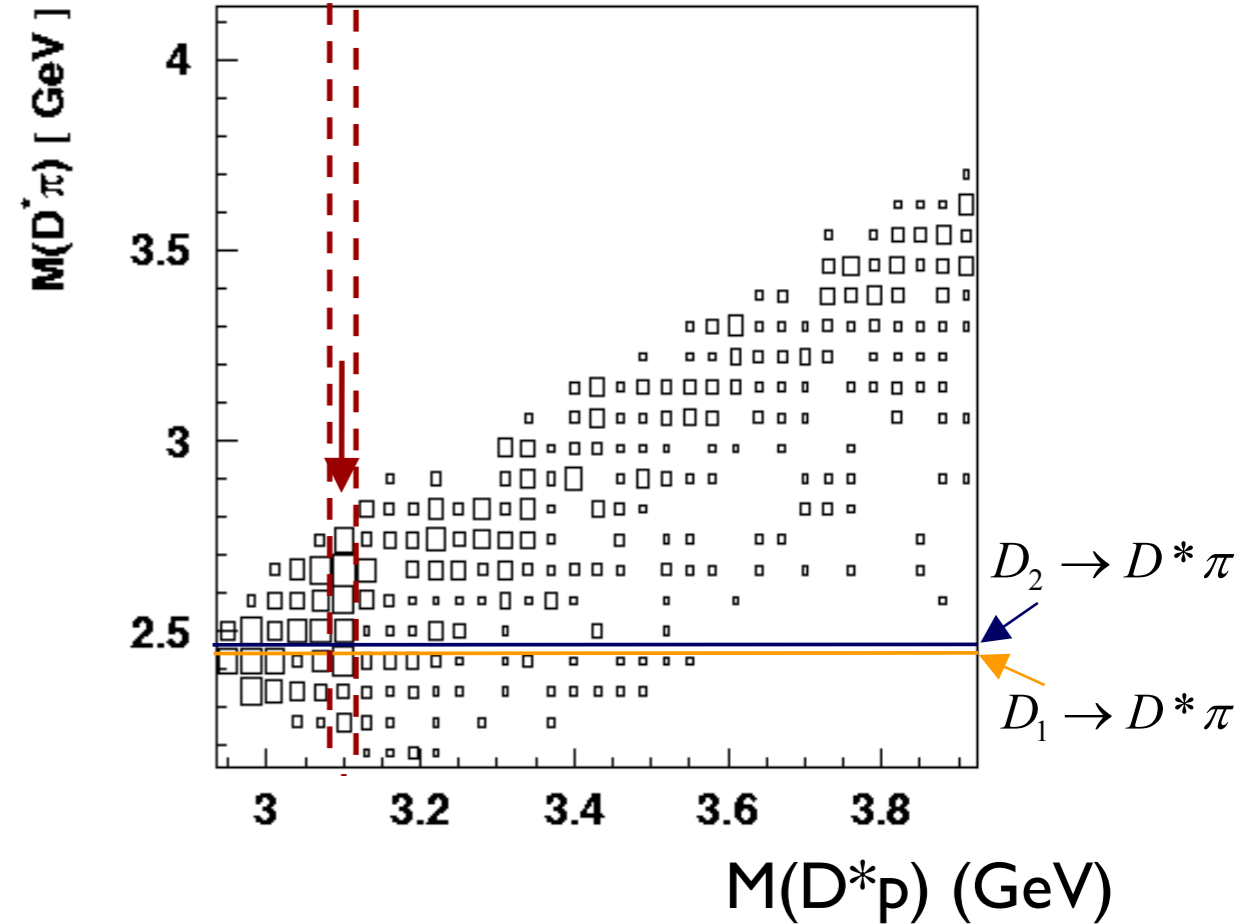
Reflections from $D_1(2420), D_2(2460) \rightarrow D^* \pi$?

loose D^* cuts
 π selection



D^* cuts of D^*p
 π selection

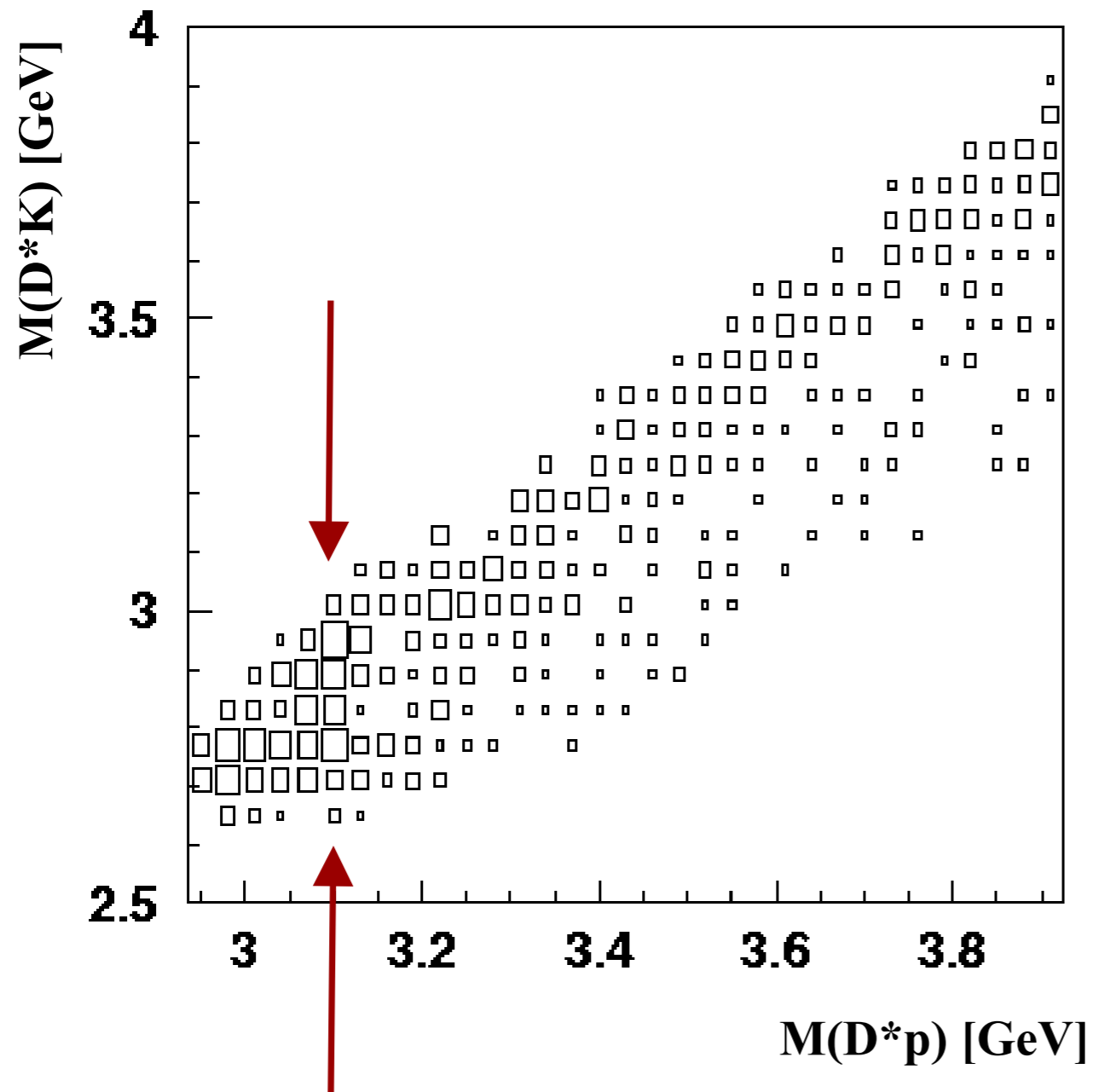
D^* cuts of D^*p
proton selection



D_1, D_2 window

expect 3.5 $D_1, D_2 \rightarrow D^* \pi$ events in D^*p signal

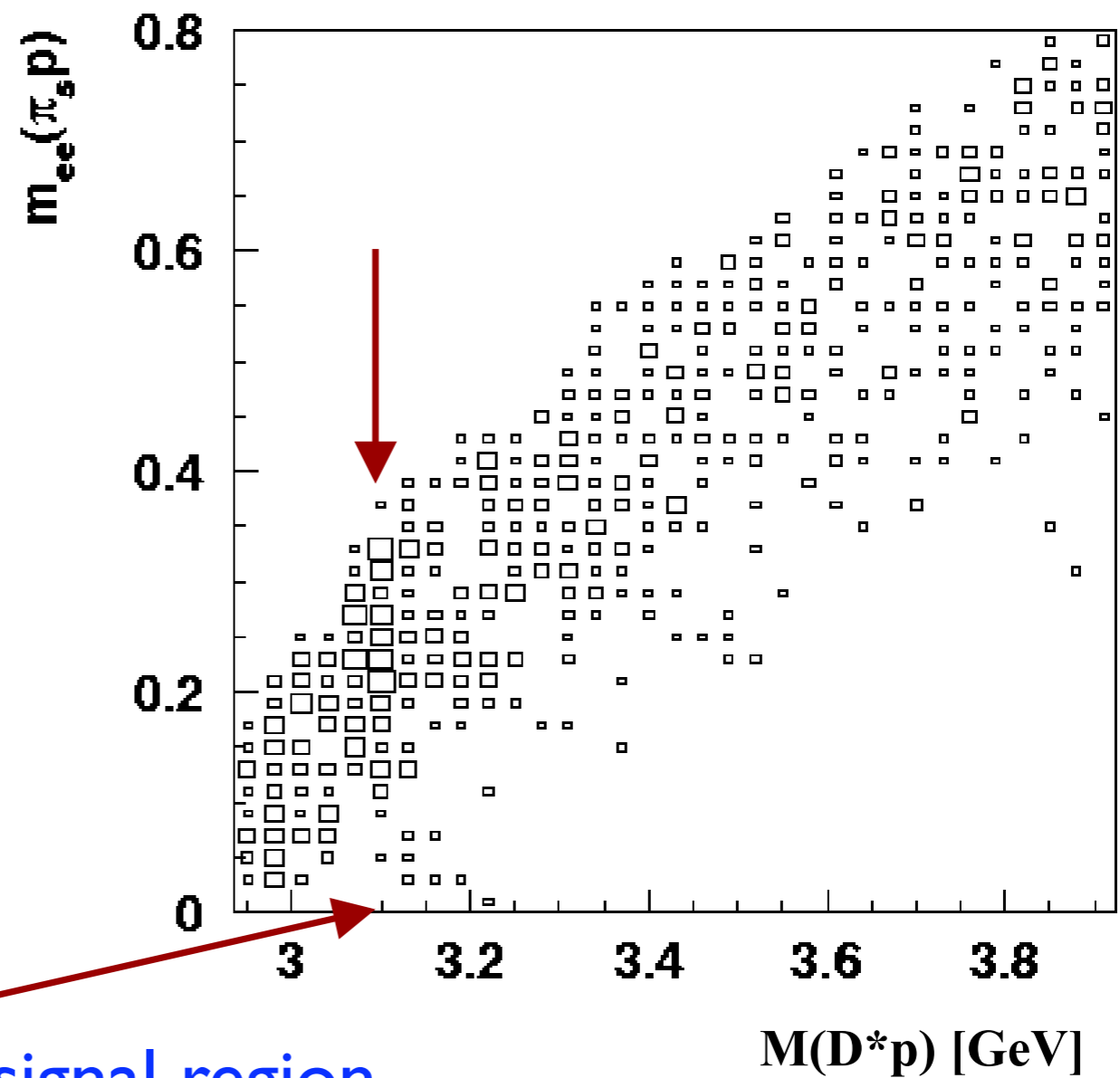
D*K ?



D* K band visible

D*p signal fills phase space

are π_{slow} and proton ee conversions from $D^{*0} \rightarrow D^0\gamma$?



no small masses m_{ee} in signal region