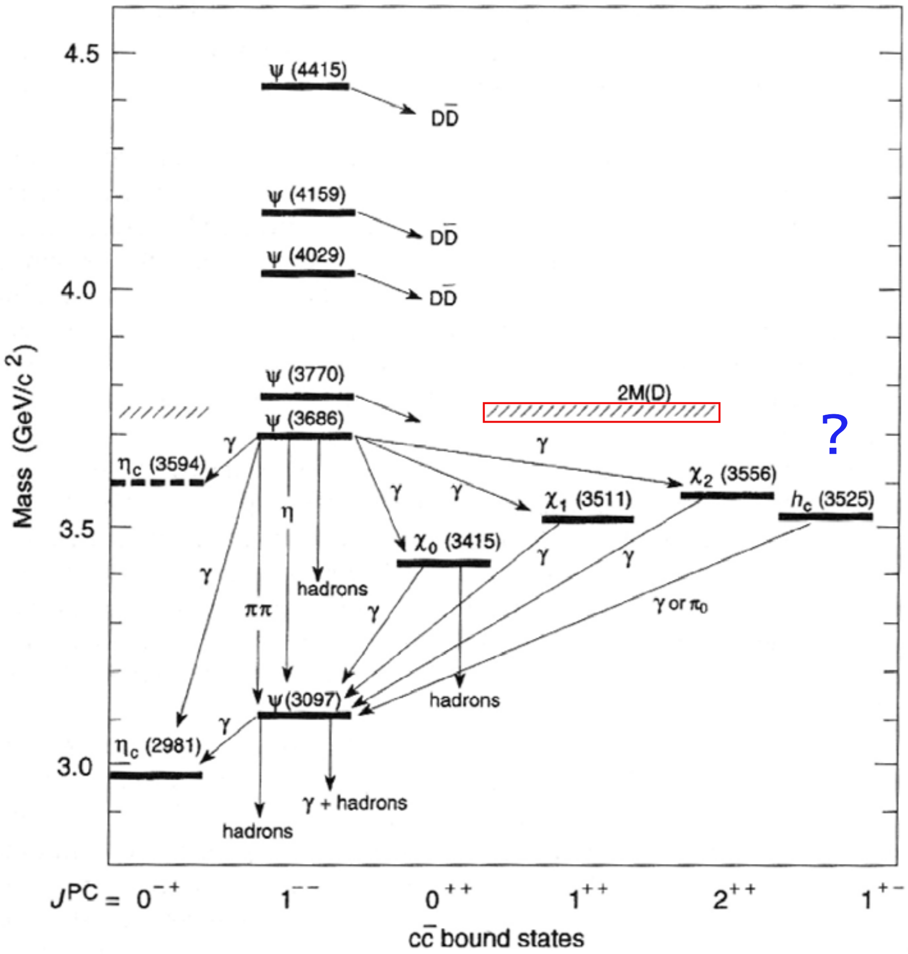
Novo z Belle

B. Golob, FMF, IJS

- Nova resonanca
- CP asimetrija
  - v $B \rightarrow \phi K_s$
  - v $B \rightarrow D^0 K^{\pm}$
- Delo MR-jev
  - meritev $|V_{ub}|$
  - mešanje D^0–$\overline{D^0}$

Nova resonanca



$B^+ \to K^+ \pi^+ \pi^- J/\psi$

$J/\psi \to l^+ l^-$

$$\Delta E = E_B^{cms} - E_{beam}^{cms}$$

$$M_{bc} = \sqrt{(E_{beam}^{cms})^2 - (p_B^{cms})^2}$$

$$\Delta M = M(\pi^+\pi^-\ell^+\ell^-) - M(\ell^+\ell^-)$$

$\psi(1D) \to \pi^+\pi^- J/\psi$

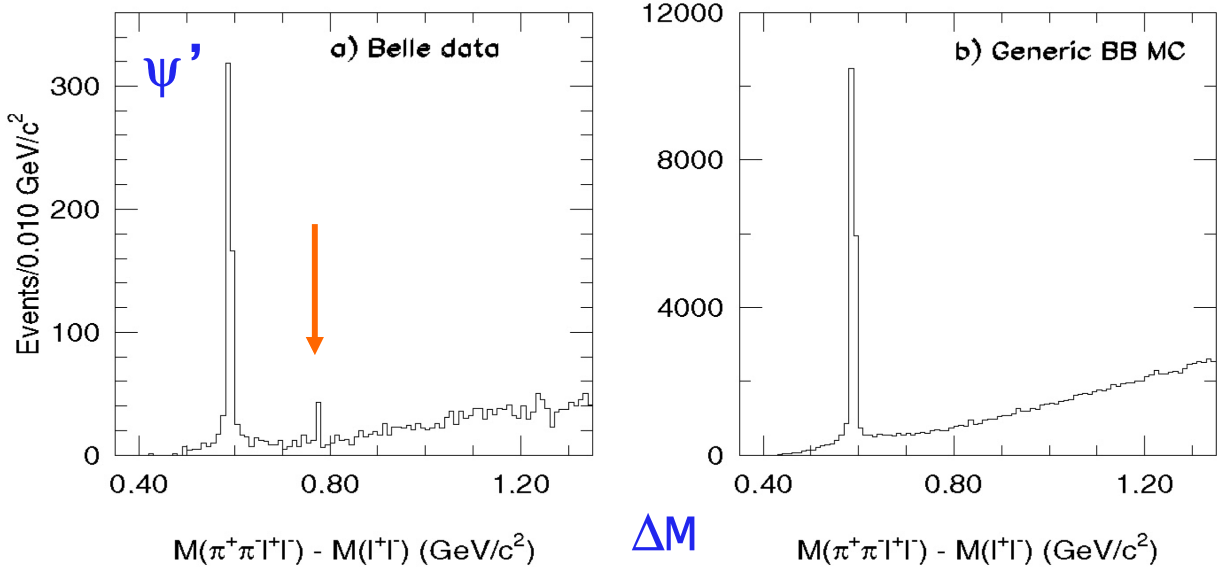
S

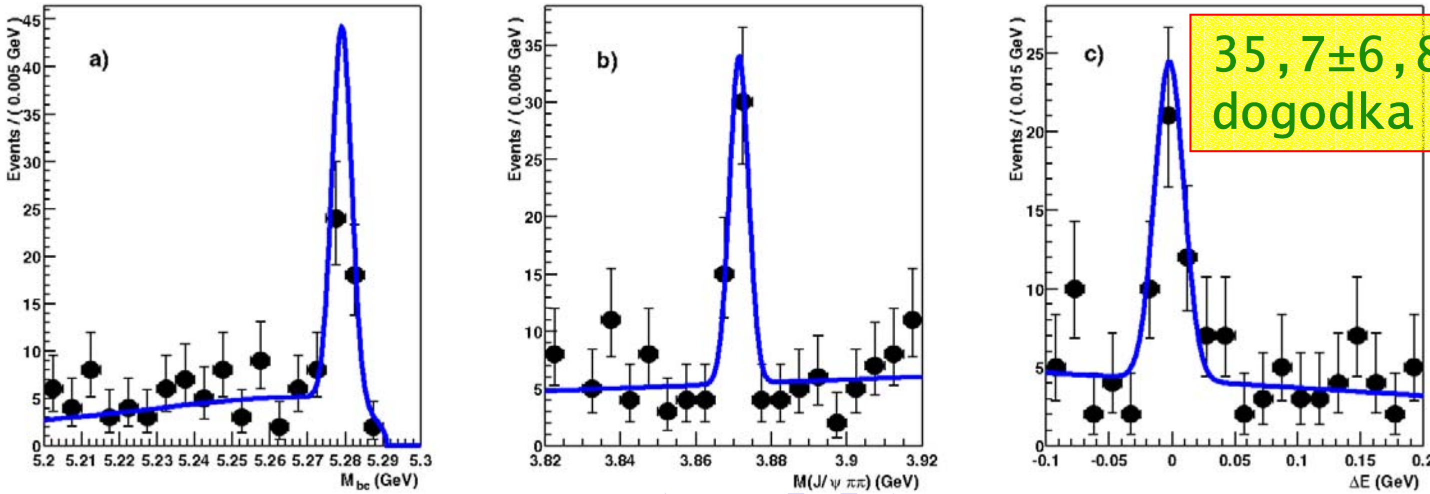
P

D ?

Nova resonanca

prilagajanje s 3D nebinirano funkcijo maks. zanesljivosti





35,7±6,8 dogodka

M_{bc} $M(\pi^+\pi^- l^+l^-)$ ΔE

signifikanca 10,3 σ

$M_X = M_X^{meas} - M_{\psi'}^{meas} + M_{\psi'}^{PDG}$

$M_X = 3872{,}0 \pm 0{,}6 \pm 0{,}5$ MeV
$\sigma = 2{,}5 \pm 0{,}5$ MeV (resol.)

Nova resonanca

potencialni modeli
srednja masa $1D_J$ 60 MeV nižja

napoved $\Gamma(^3D_2 \rightarrow \gamma\chi_{c1}) > 5 \times \Gamma(^3D_2 \rightarrow \pi^+ \pi^- J/\psi)$

izmerjeno $\Gamma(^3D_2 \rightarrow \gamma\chi_{c1}) / \Gamma(^3D_2 \rightarrow \pi^+ \pi^- J/\psi) < 0.89$ @ 95% CL

$\hookrightarrow \gamma\ J/\Psi$

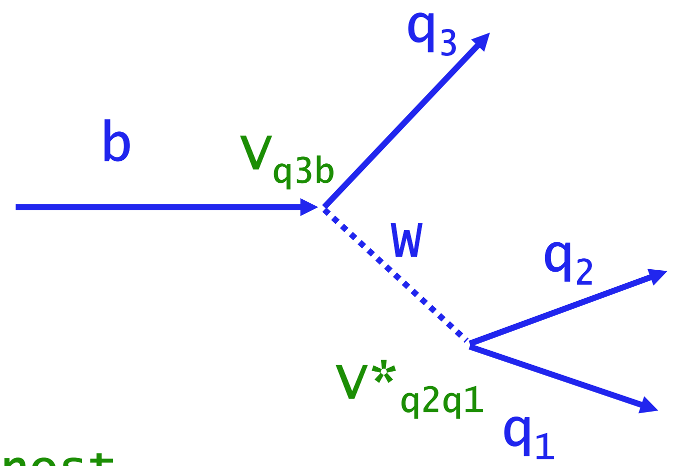
~~CP~~ v B → ϕK_s

$$\mathcal{M}(q\bar{q}q') = V_{cb}V^*_{cq'}T_{c\bar{c}q'}\delta_{qc} + V_{ub}V^*_{uq'}T_{u\bar{u}q'}\delta_{qu} + $$

drevo

$$+ V_{ub}V^*_{uq'}P^u_{q'} + V_{cb}V^*_{cq'}P^c_{q'} + V_{tb}V^*_{tq'}P^t_{q'}$$

pingvin



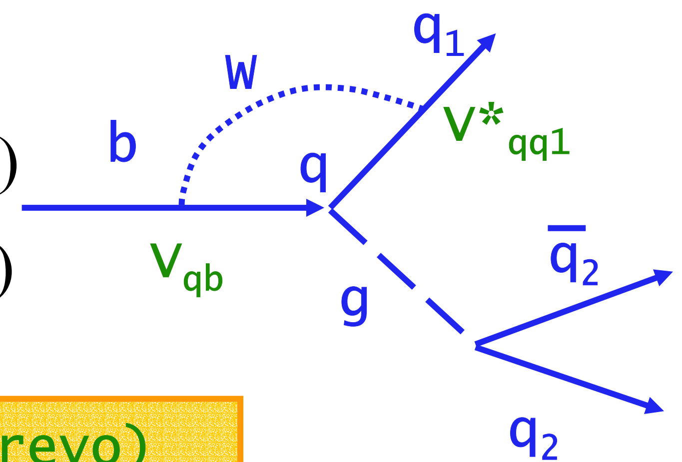
$$\mathcal{M}(q\bar{q}s) = V_{cb}V^*_{cs}(T_{c\bar{c}s}\delta_{qc} + P^c_s - P^t_s) +$$

$$+ V_{ub}V^*_{us}(T_{u\bar{u}s}\delta_{qu} + P^u_s - P^t_s)$$

unitarnost

$$\mathcal{M}(c\bar{c}s) = V_{cb}V^*_{cs}(T_{c\bar{c}s} + P^c_s - P^t_s) + V_{ub}V^*_{us}(P^u_s - P^t_s)$$

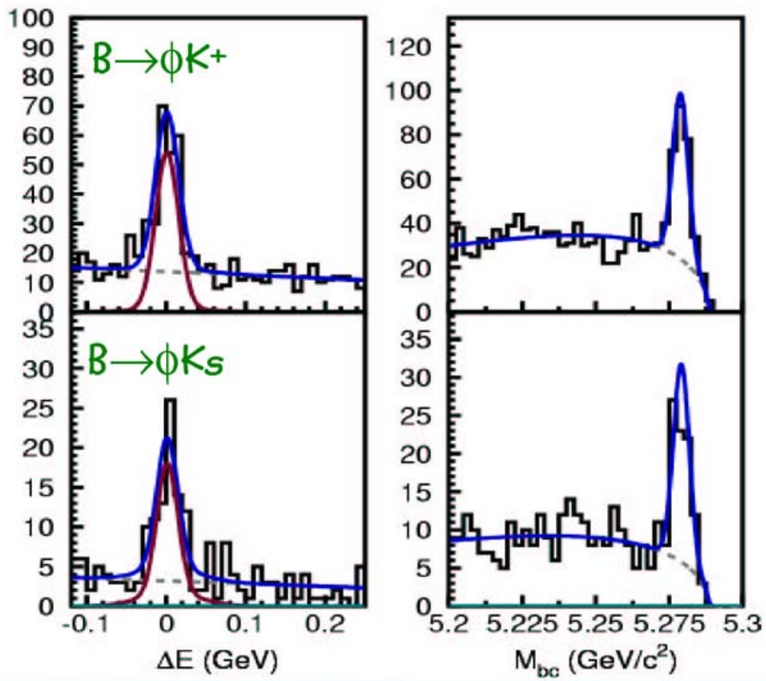
$$\mathcal{M}(s\bar{s}s) = V_{cb}V^*_{cs}(P^c_s - P^t_s) + V_{ub}V^*_{us}(P^u_s - P^t_s)$$



Enaka šibka faza za B → $J/\psi K_s$ (drevo)
in B → ϕK_s (pingvin)

CP asimetrija v B → ϕK_s

70±9

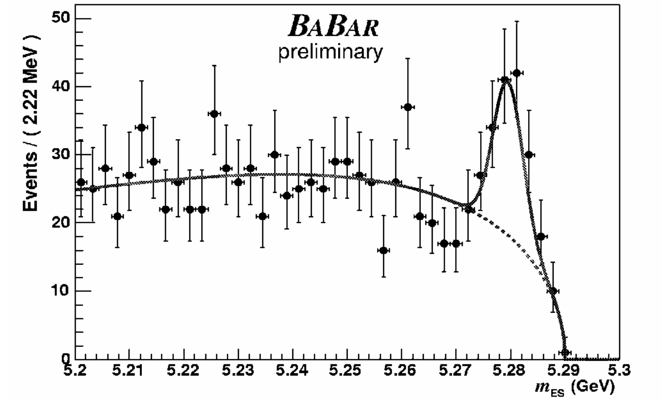


— Yield —

$N[\phi K^+] = 205.^{+18.}_{-17.}$

$N[\phi K_s] = 67.9^{+9.8}_{-9.1}$

(In signal box)

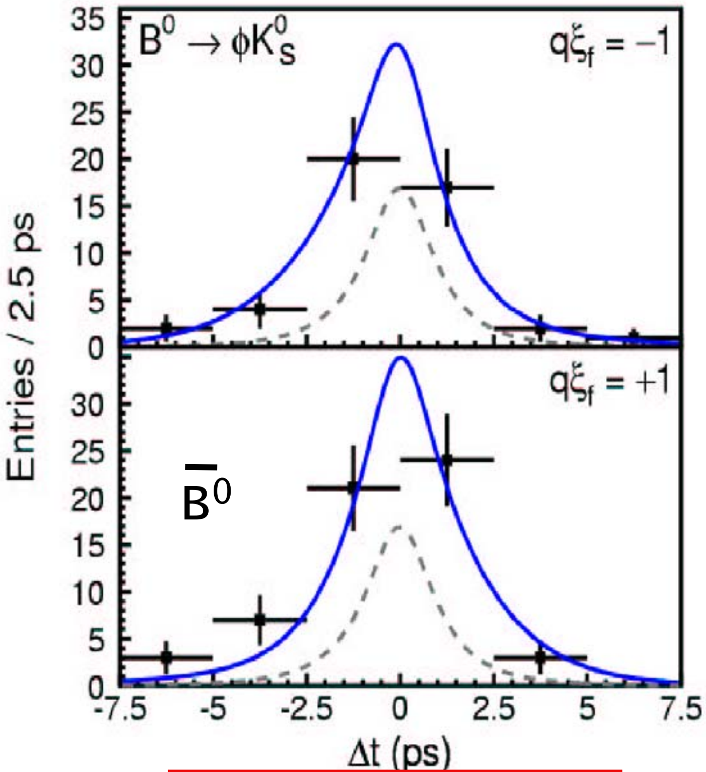


A

S = sin2ϕ_1

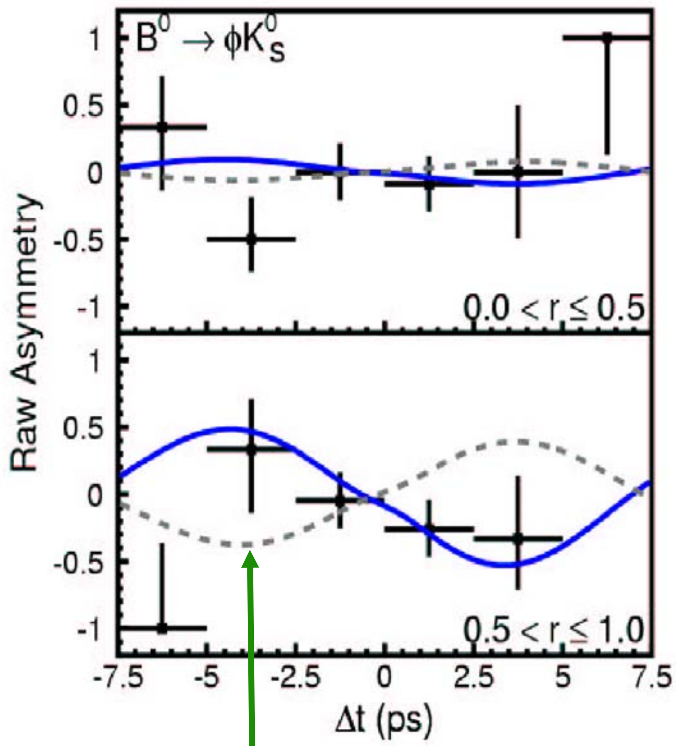
$$a_{f_{CP}} = \frac{P(\overline{B}^0 \to f_{CP},t) - P(B^0 \to f_{CP},t)}{P(\overline{B}^0 \to f_{CP},t) + P(B^0 \to f_{CP},t)} = \frac{|\lambda_{f_{CP}}|^2 - 1}{1 + |\lambda_{f_{CP}}|^2} \cos(\Delta m t) + \frac{2\,\mathrm{Im}(\lambda_{f_{CP}})}{1 + |\lambda_{f_{CP}}|^2} \sin(\Delta m t)$$

CP asimetrija v B → ϕK_s



$S = -0.96 \pm 0.50$

$A = -0.15 \pm 0.29$



slabše označevanje

boljše označevanje

$S = 0.736 \pm 0.049$

odmik 3.5 σ

sistematika (S):

KKK_s, f_0K_s	+0.001
	-0.084
bias	+0.064

preverjanje $B \to \phi K^{\pm}$

$S = -0.09 \pm 0.26$

$A = 0.18 \pm 0.20$

CP asimetrija v $B \to \phi K_s$

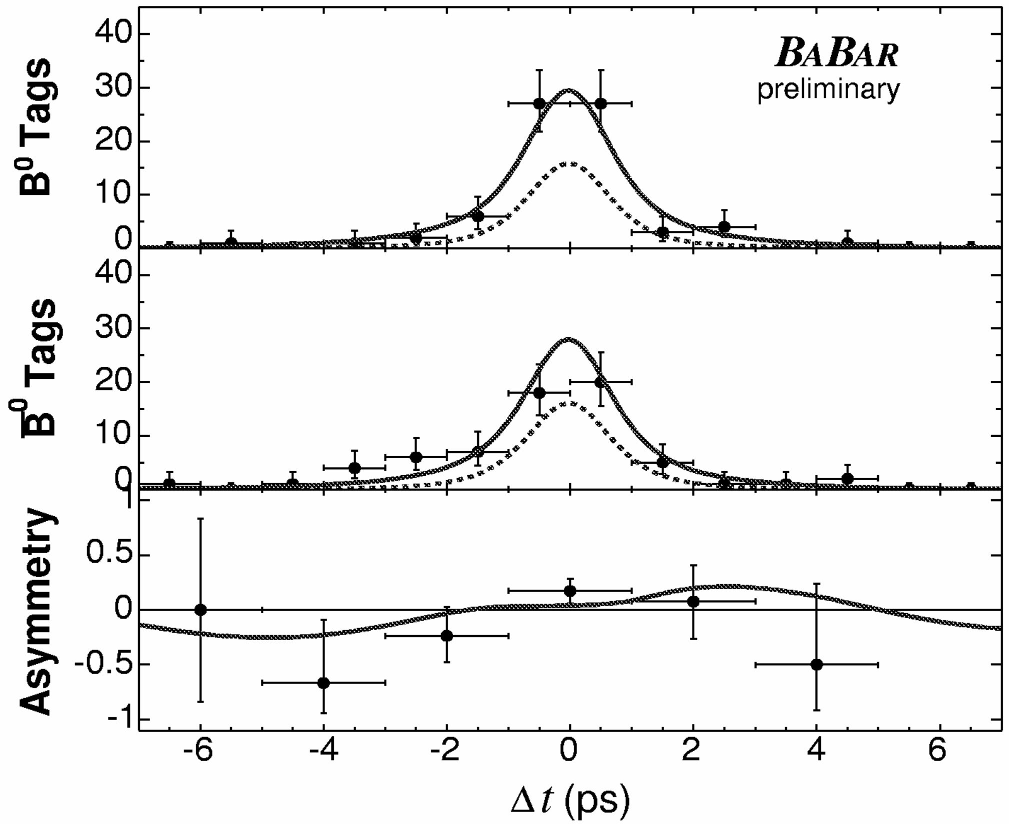
BaBar 2003:

$\sin 2\phi_1 (\phi K_S) =$
$+0.45 \pm 0.43 \pm 0.07$

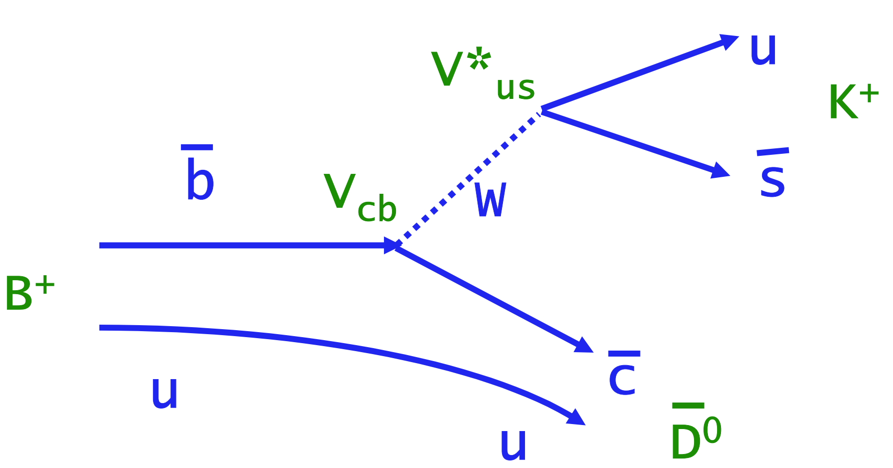
?

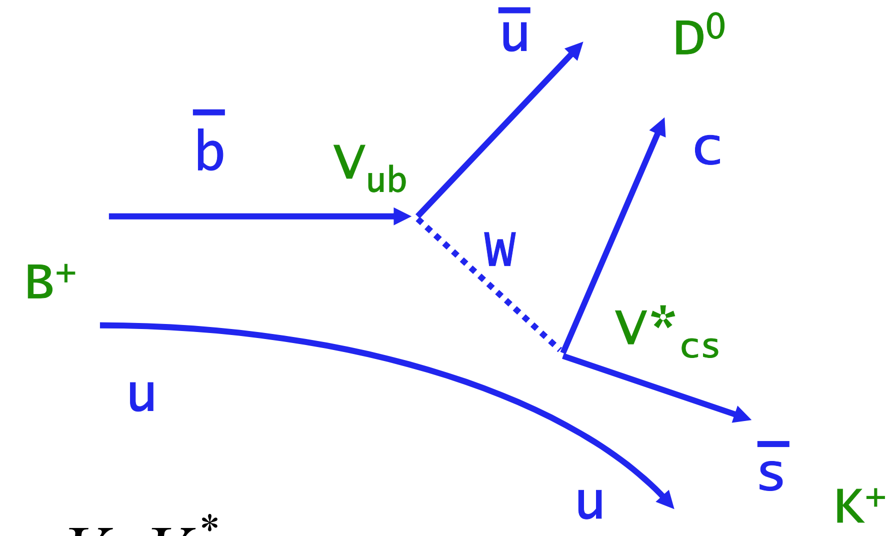
Povprečje:
$\sin 2\phi_1 = -0.15 \pm 0.33$

odmik 2.7 σ od $c\bar{c}s$



CP asimetrija v B → D^0K





$$\mathcal{M}_1 \propto V_{cb} V_{us}^{*}$$

$$\mathcal{M}_2 \propto V_{ub} V_{cs}^{*}$$

$D^0 \to K_s \pi\pi$

$$\mathcal{M}_+ = f(m_+^2, m_-^2) + a e^{i\phi_3 + i\delta} f(m_-^2, m_+^2)$$

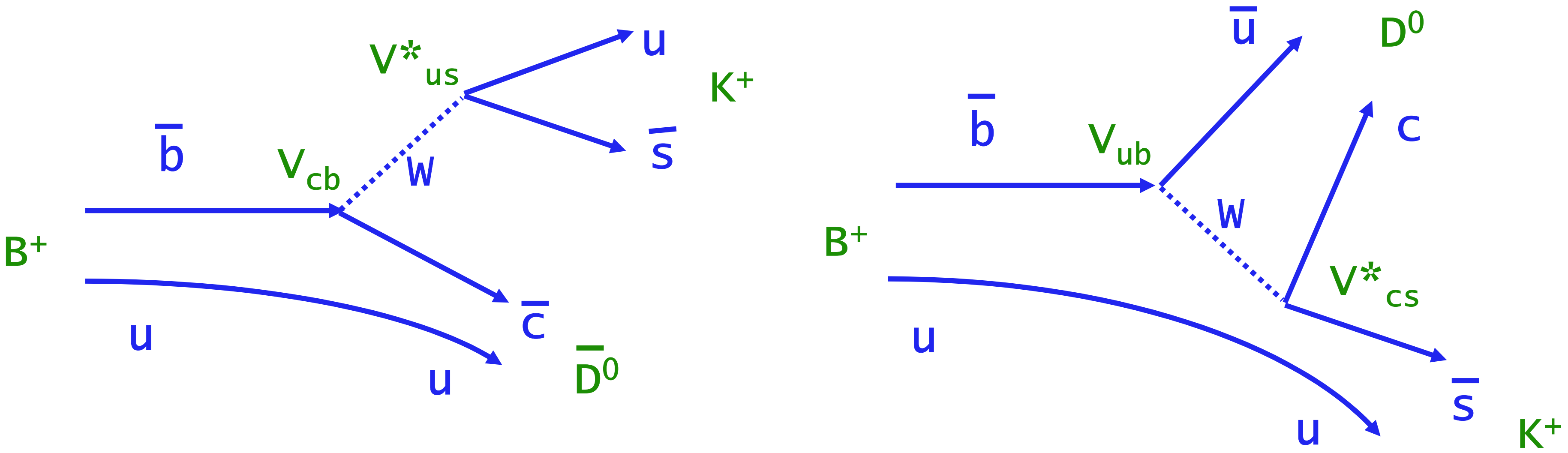
$$\mathcal{M}_- = f(m_-^2, m_+^2) + a e^{-i\phi_3 + i\delta} f(m_+^2, m_-^2)$$

a~0.25

$$m_+^2 = m^2(K_s \pi^+)$$

$$m_-^2 = m^2(K_s \pi^-)$$

CP asimetrija v B → D^0K



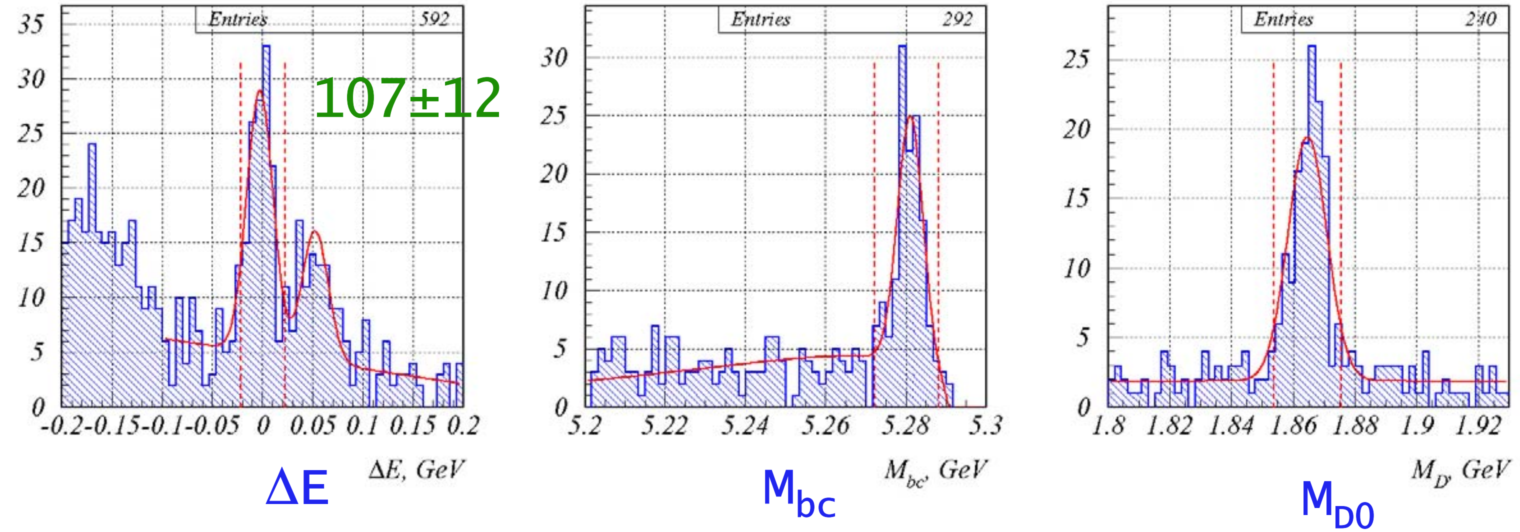
originalna ideja Gronau, London, Wyler:
izmeriti

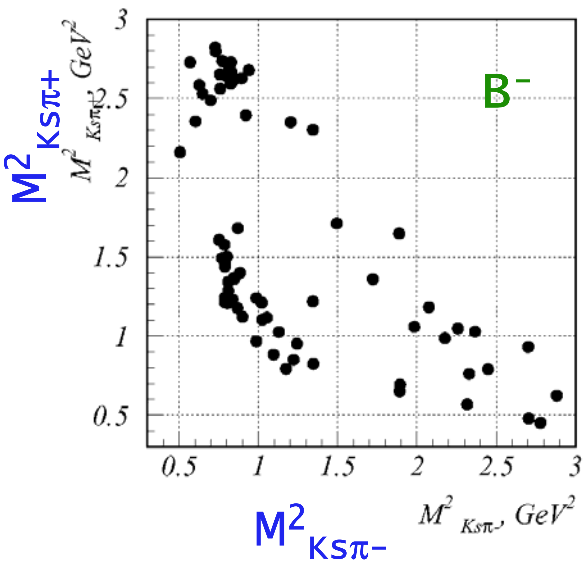
$Br(B^- \to K^- D^0)$
$Br(B^- \to K^- \bar{D}^0)$ } → a

$Br(B^- \to K^- D_+^0)$ ali $Br(B^- \to K^- D_-^0)$ → interferenca med zgornjimi diagrami →
ter nabojno konjugirane razpade;

iz B^- dobimo a $\cos(\phi_3-\delta)$
iz B^+ dobimo a $\cos(\phi_3+\delta)$

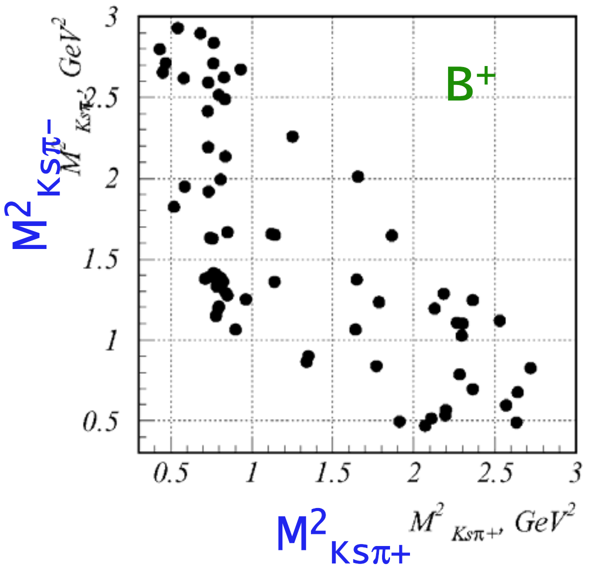
CP asimetrija v $B \to D^0K$



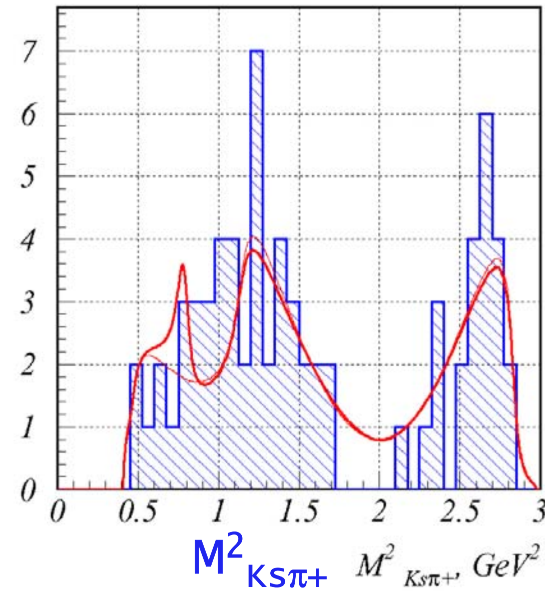


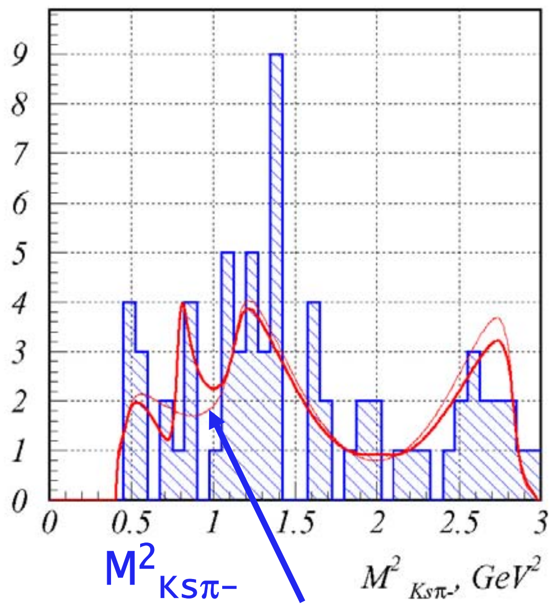
Prilagajanje
$f(m_+,m_-)+$
$ae^{i\theta}f(m_-,m_+)$

z modelom za
$D^0 \to K_s\pi\pi$ Dalitz;
a,δ,ϕ_3 prosti;



CP asimetrija v B → D^0K

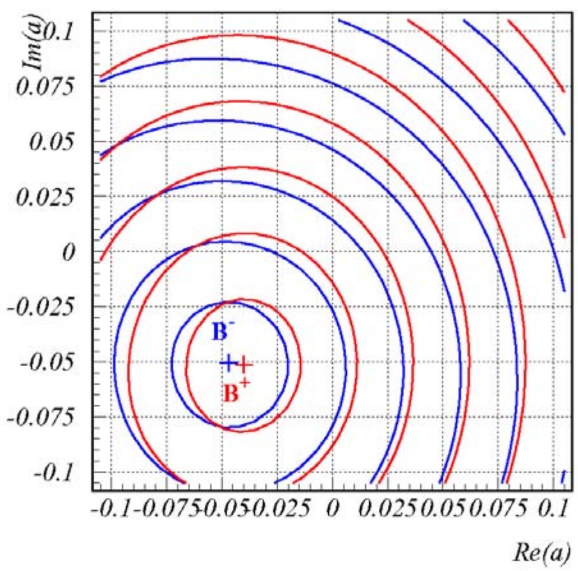




a=0

$a=0.33\pm0.10$
$\delta=165^o\ ^{+17^o}_{-19^o}$
$\phi_3=92^o\ ^{+19^o}_{-17^o}$

sistematika $\pm10^o$ ϕ_3
(model D^0)



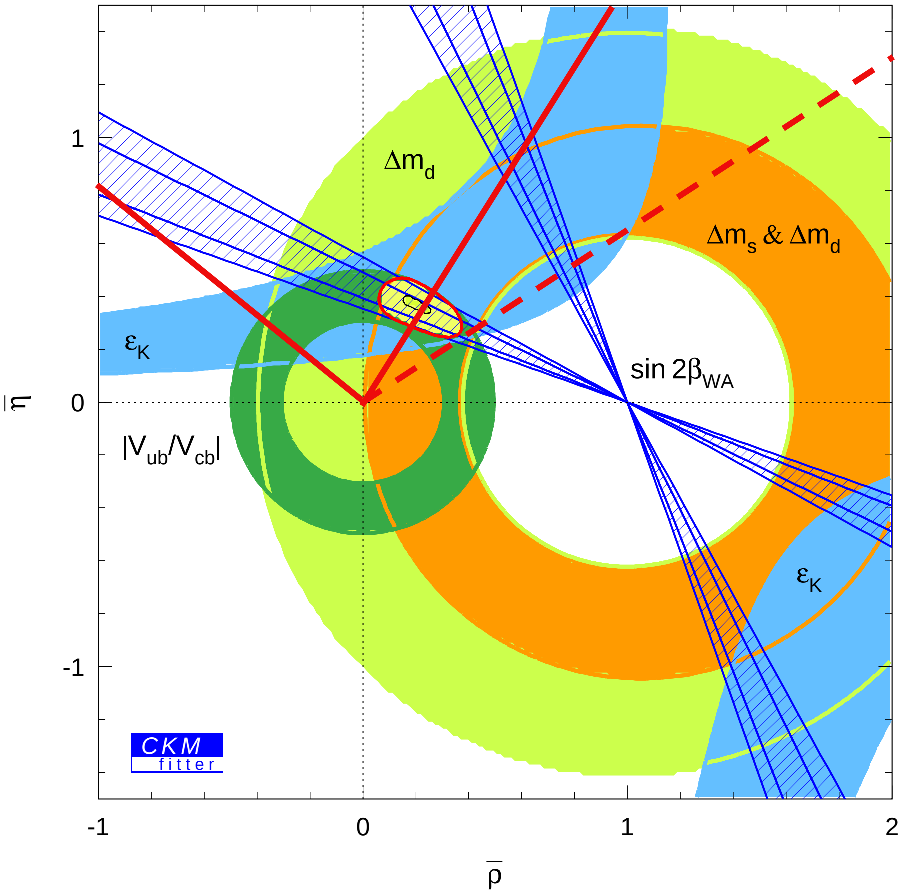
preverjanje B → $D^0\pi$

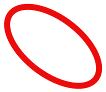
bias v a
$\pm12^o$ ϕ_3

$61^o < \phi_3 < 142^o$

@ 90% C.L.

CP asimetrija v B → D^0K



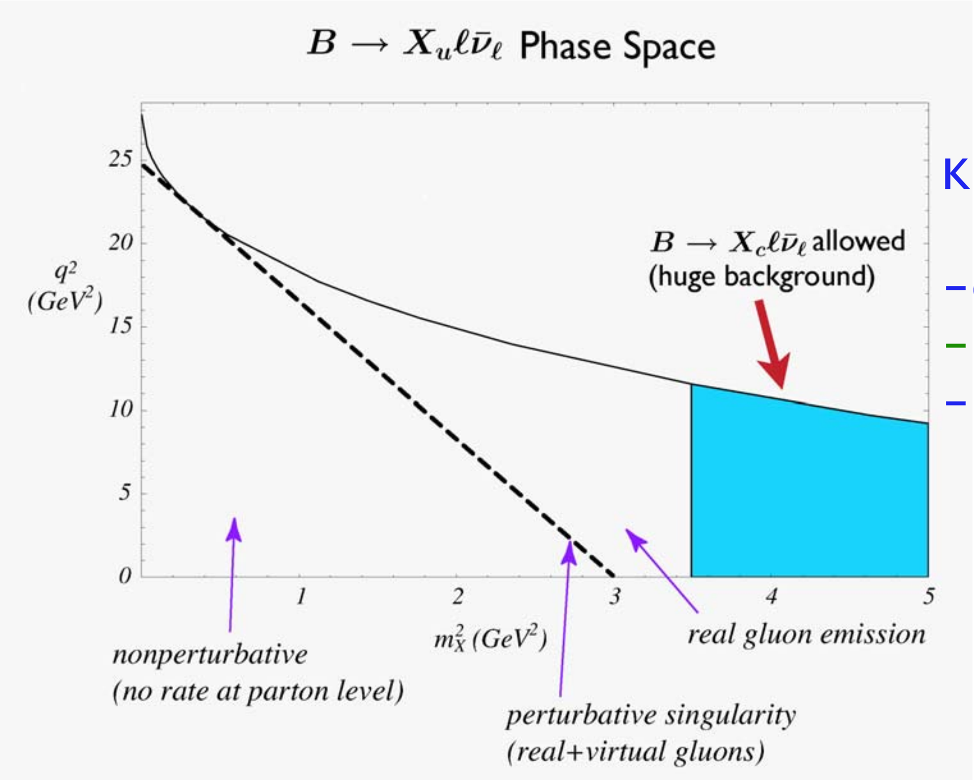


90% C.L. contour

Meritev V_{ub} (I.B.)

Semileptonski $b \to u\, l\, \nu$

zadovoljiva statistika in teoretske napovedi



Kin. kol. za separacijo $b \to u l \nu$:

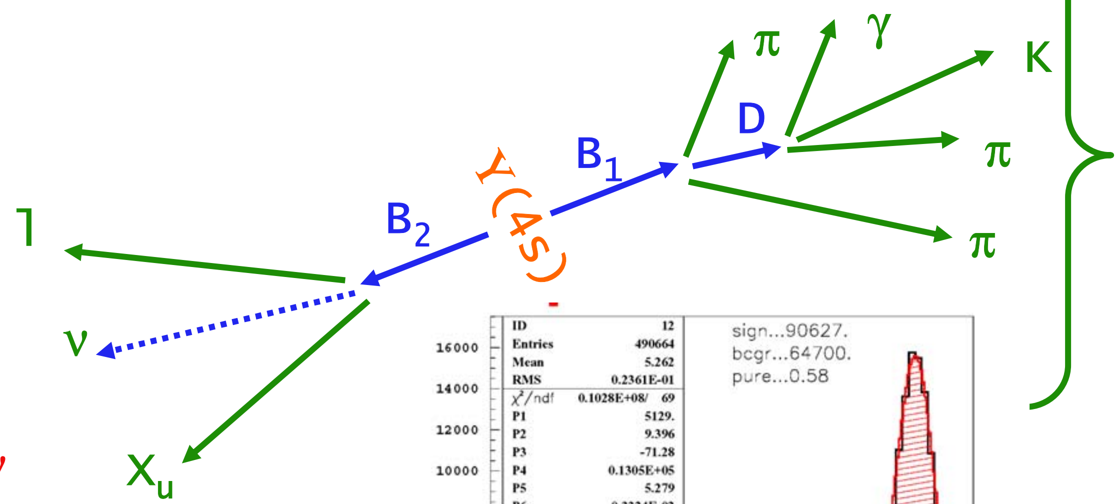
- -energija leptona E_l;
- -hadronska inv. masa M_X;
- -leptonska inv. masa q^2;

Meritev V_{ub} (I.B.)

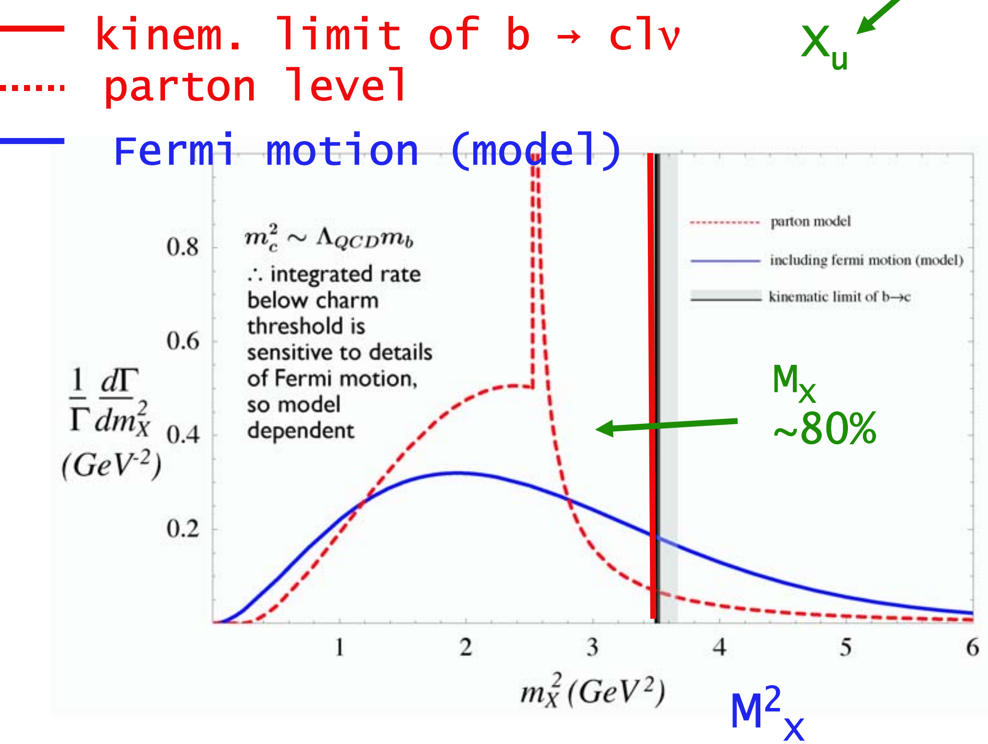
CMS:

$M_{bc}=\sqrt{(E_{beam}^2-p_B^2)}$

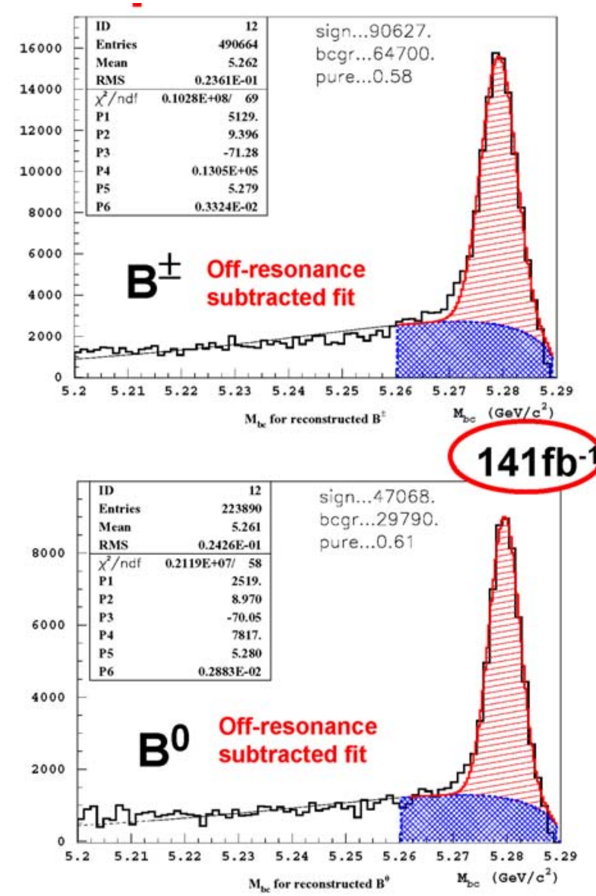
$\Delta E=E_B-E_{beam}$



popolno rekonstruiran (M_{bc})

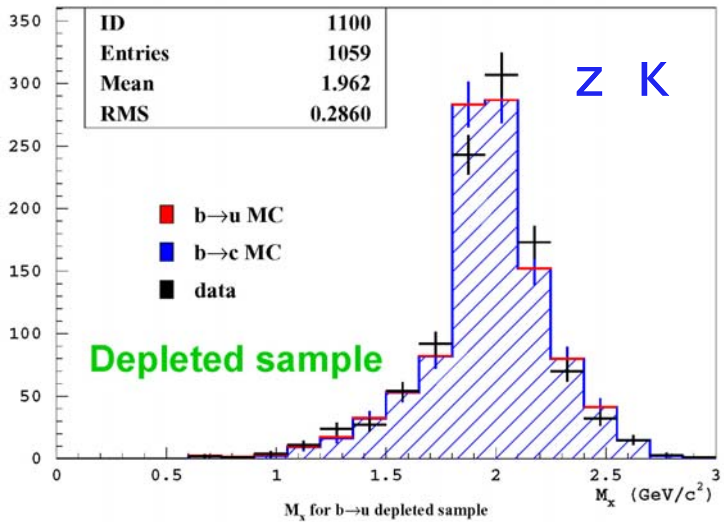


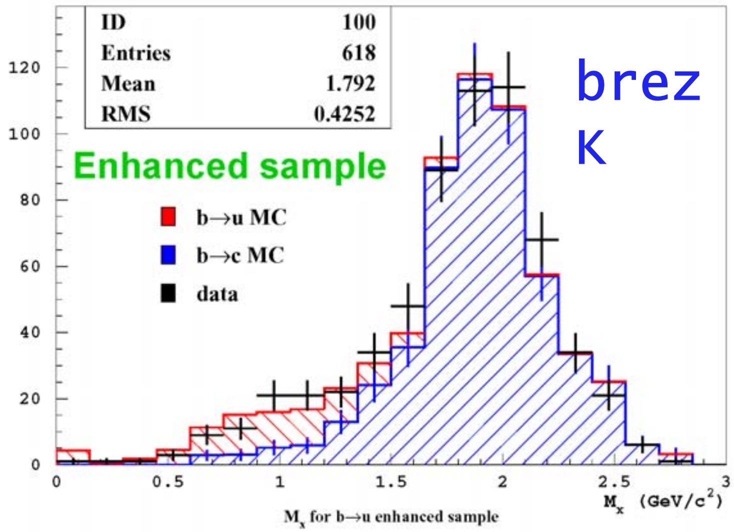
M^2_X



M_{bc}

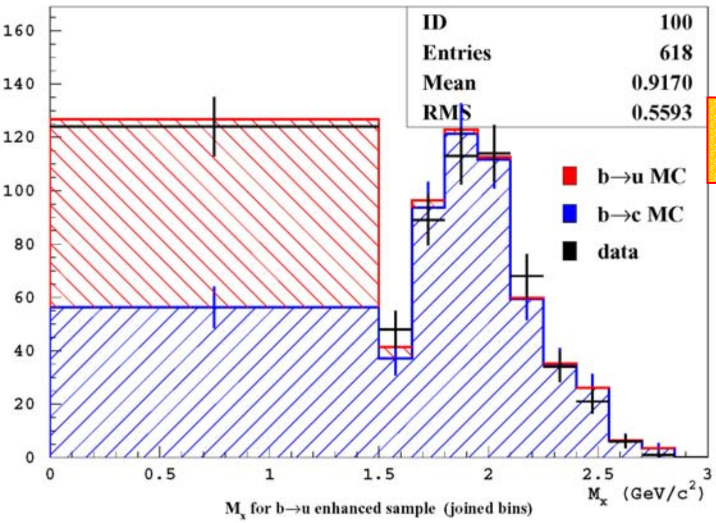
Meritev V_{ub} (I.B.)





izbira:
- p_l^*
- q^2
- ...

M_X



$Br(b \to u\, l\, \nu) = 1.65\times10^{-3}\ (1 \pm 0.16)$

- normalizacija
- modelska sistematika

(BaBar:

$Br(B\to X_u l\nu) = (2.14\pm0.29\pm0.25\pm0.37)\times10^{-3})$

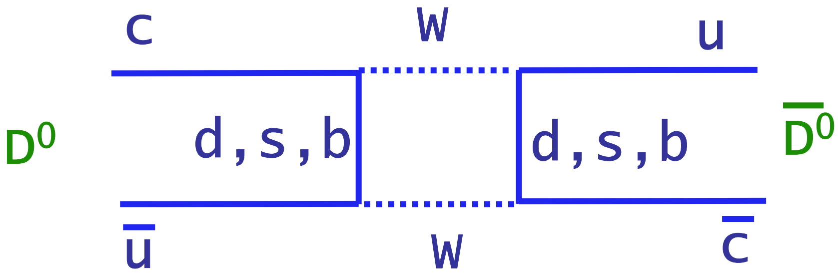
stat. syst. sh.f.

In Mx<1.5: Excess of events: 68

b→c events : 56

Meritev mešanja D^0-$\overline{D}^0$ (U.B.)

kinematična f. zanke;
če $m_i=m_j$ →
zaradi unitarnosti amplit. 0;
prispevek b ($V_{cb}^*V_{ub}$) zanemarljiv;
$m_d \sim m_s$ → verjetnost majhna



$$\langle \overline{D}^0 | H_{wk} | D^0 \rangle \propto \sum_{i,j=d,s,b} V_{ci}^* V_{ui} V_{cj} V_{uj}^* S(m_i^2, m_j^2)$$

$$r_{mix}(t) = \Gamma(D^0 \to \overline{D}^0) = \frac{1}{2}\left|\frac{q}{p}\right|^2 e^{-\Gamma t}\left[ch\left(\frac{\Delta\Gamma t}{2}\right) - \cos(\Delta M t)\right] \approx$$

$$\approx \frac{1}{4} e^{-\Gamma t}\left|\frac{q}{p}\right|^2 (x^2+y^2)(\Gamma^2 t^2) \qquad x \equiv \frac{\Delta M}{\Gamma}, y \equiv \frac{\Delta\Gamma}{2\Gamma} << 1$$

Meritev mešanja D^0-$\overline{D}^0$ (U.B.)

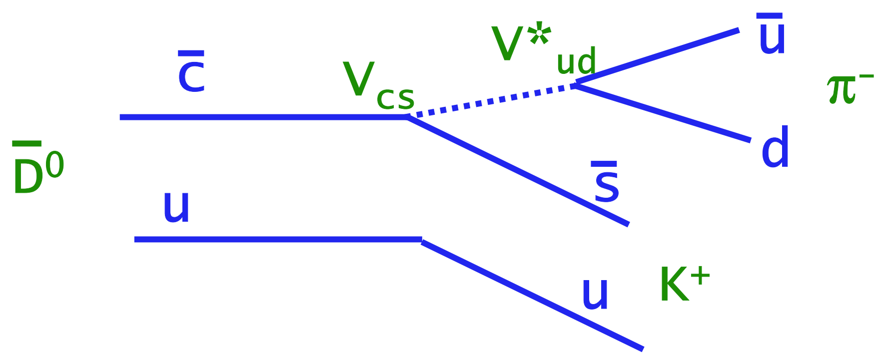
"wrong sign searches"

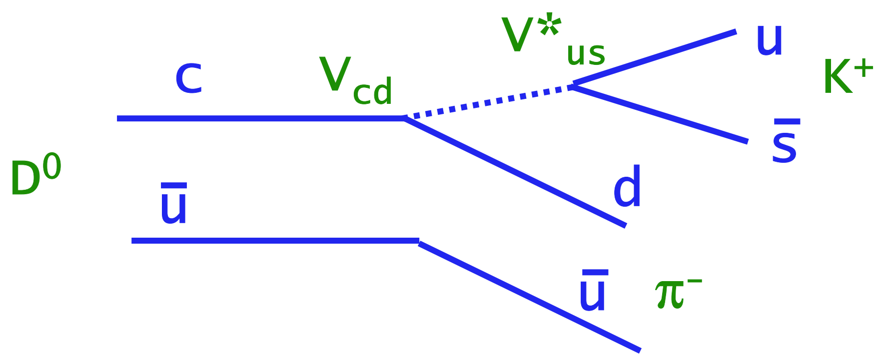
$D^0 \to \overline{D}^0 \to \overline{f}$

naboj K^+, l^-: D^0 ali $\overline{D}^0$ pri razpadu

$D^{*+} \to D^0\pi^+$: D^0 ali $\overline{D}^0$ ob nastanku

$\overline{f} = K^+\pi^-,\ K^+l^-\overline{\nu}$





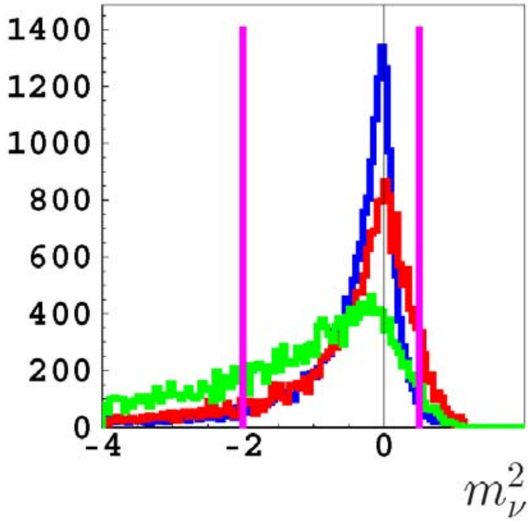
Meritev mešanja D^0–$\overline{D}^0$ (U.B.)

$D^{*+} \to D^0\pi^+$
$\quad\quad \hookrightarrow K^- l^+ \nu$

osnovna kin. količina
za ločevanje signala:
$\Delta m = m(K^- l^+ \nu \pi^+) - m(K^- l^+ \nu)$

rekonstrukcija nevtrina:

$$^4P_\nu = (E_{cms}, 0) - {}^4P_{K\ell\pi} - {}^4P_{rest}$$
$$({}^4P_{K\ell\pi} + {}^4P_\nu)^2 = m^2_{D*}$$
$$^4P_\nu^2 = 0$$

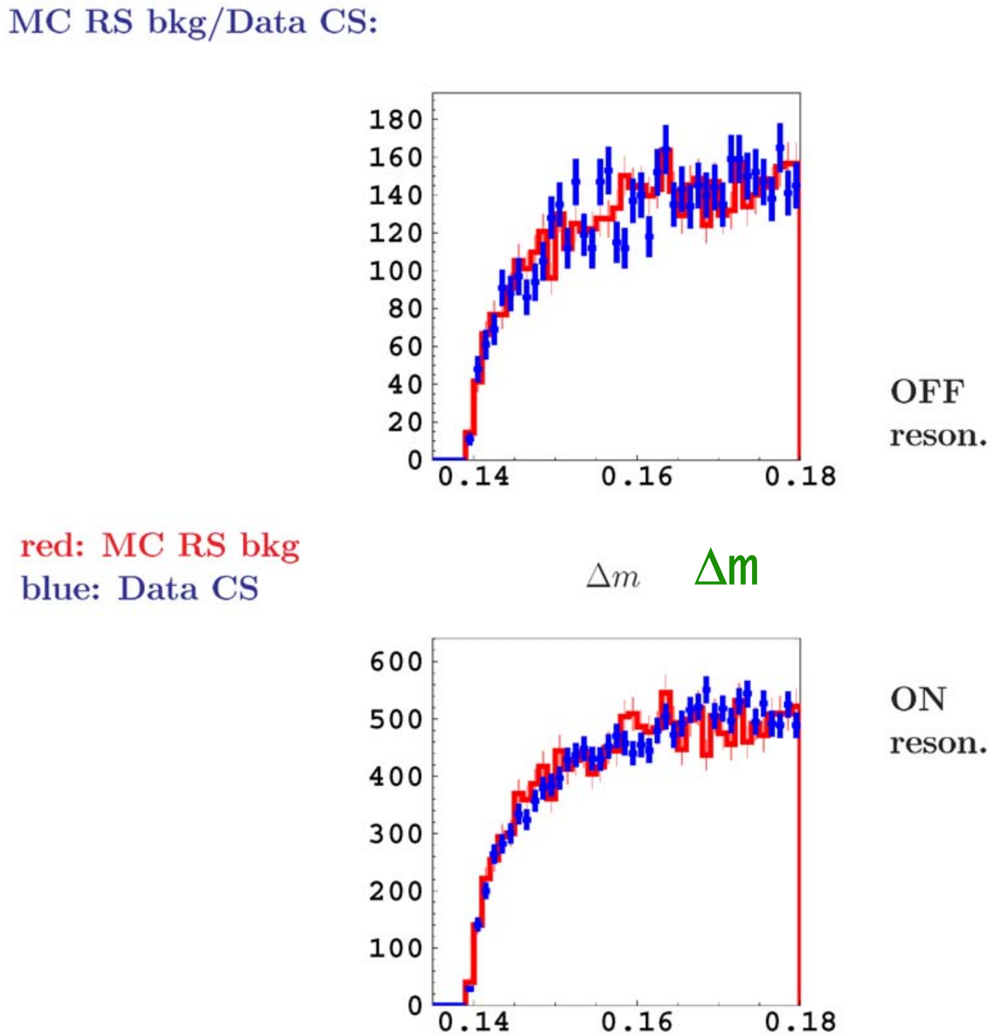


red: cc & uds bkg
blue: sig
green: bb bkg

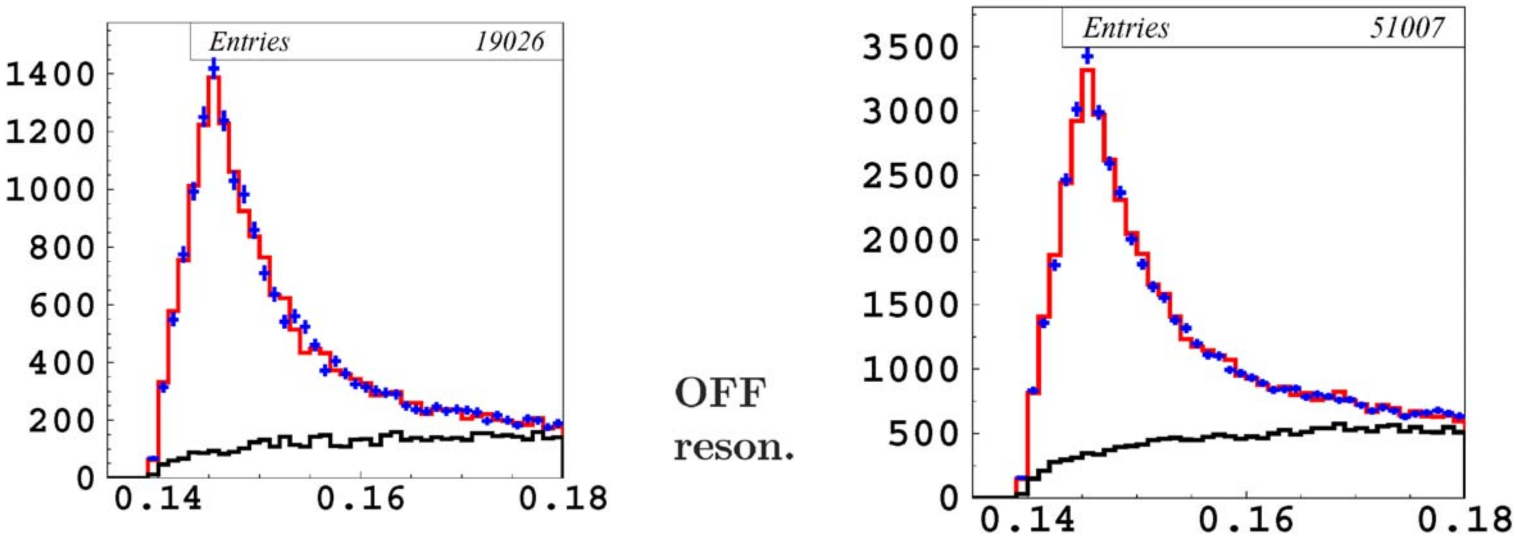
Meritev mešanja D^0-$\bar{D}^0$ (U.B.)

parameter mešanja iz N(pravilen naboj)/N(napačen naboj)

Nabojna kombinacija	π	K	e
Pravilna signal brez mešanja	+	-	+
Kombinatorna ozadje	+ +	+ -	+ -
Napačna signal z mešanjem	+	+	-



Meritev mešanja D^0–$\overline{D}^0$ (U.B.)



Δm Signal brez mešanja Δm

časovna porazdelitev (daljši raz. časi)
optimizacija selekcije
prilagajanje
sistematika