Fisica del *Tau* e del *Charm* a BaBar

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(on behalf of **BaBar** Collaboration)

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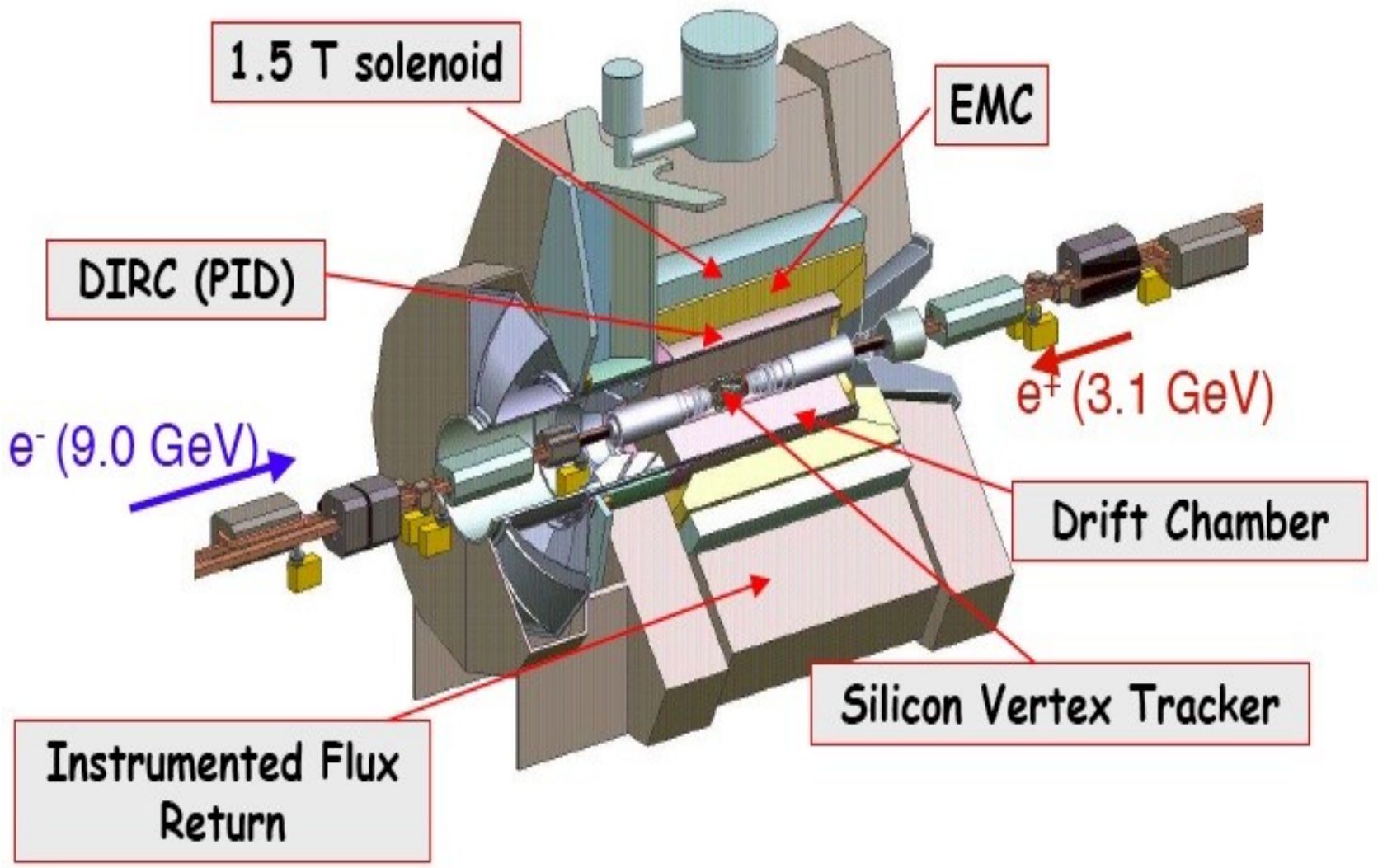
Outlines

- **Tau physics**:
  - Hadronic tau decays
  - Lepton Flavour and Baryonic Number Violation
- **Charm physics**:
  - Mesons: decays, amplitudes, form factor
  - New charmonium(-like) states
  - Heavy quark models test and new baryonic states
  - Mixing D^0 not discussed (see talk by G. Piredda)
- **Conclusions**

Notes: Most results in this talk are **PRELIMINARY** if not otherwise specified

BaBar detector at Slac



Same cross-sections for $\tau\tau$, $c\bar{c}$ and $b\bar{b}$: ~1nb

Tau had decays: motivation

- Strong interactions effects and estimate fundamental parameter of the Standard Model, like α_s, $|V_{us}|$ using the available knowledge of m_s.
- A combined $|V_{us}|/m_s$ fit is also possible

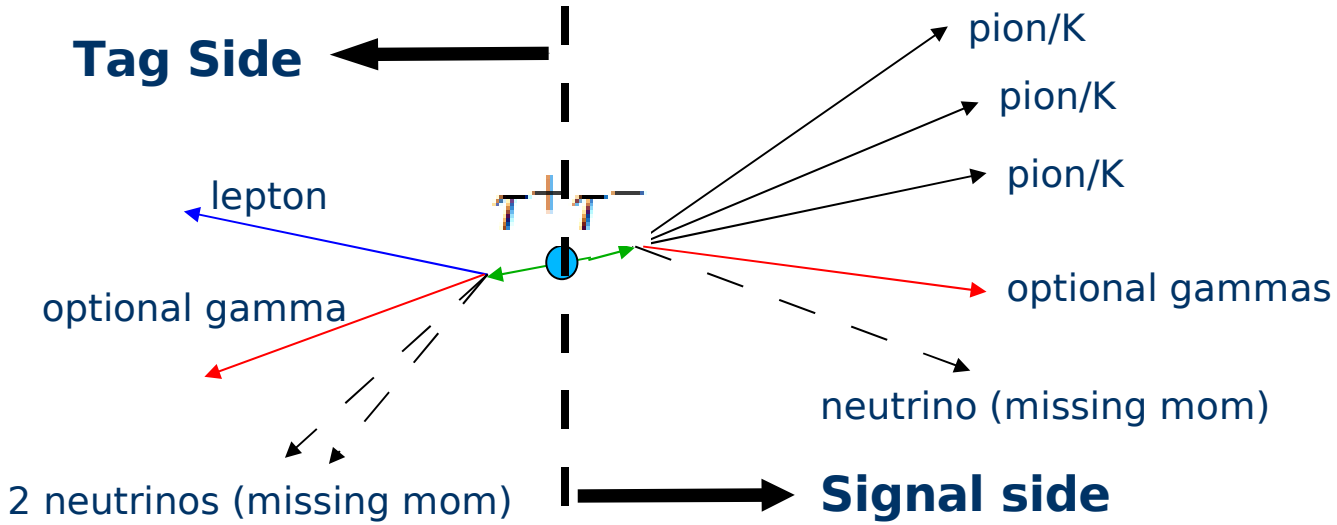
τ^- Decay	Sample (fb^{-1})
$\pi^-\pi^-\pi^+\nu_\tau$ $K^-\pi^-\pi^+\nu_\tau$ $K^-\pi^-K^+\nu_\tau$ $K^-K^-K^+\nu_\tau$ $\phi\pi^-\nu_\tau$ $\phi K^-\nu_\tau$	344
$K^-\pi^0\nu_\tau$	230
$\pi^-\pi^-\pi^+\pi^0\nu_\tau$ $\omega\pi^-\nu_\tau$	210
$\pi^-\pi^-\pi^+\eta\nu_\tau$ $f_1(1285)(\to \pi^+\pi^-\eta)\pi^-\nu_\tau$ $f_1(1285)\pi^-\nu_\tau$ $\eta'(958)\pi^-\nu_\tau$	234

References:

- Maltman, Phys. Lett. B 639 (2006)
- Gamiz et al, Phys. Rev. Lett. 94 (2005) 011803, hep-ph/0408044
- Gamiz et al, J. High Energy Phys. 01 (2003) 060, hep-ph/0212230

Tau had decays: general aspects

- Two hemispheres in CM frame using thrust, looking for 1-3 (or 1-1) topology with net charge 0
- Reduce **bkg** using: thrust, transverse Missing Momentum, veto on π^0, K_S, photon conversion and net neutral energy



- Remaining **bkg** are 3-prong wrong decays with more π^0 and K^0, kaon/pion misidentification
- Main **systematics** are from cross-feed between channels (2-4%), π^0 and η efficiency (3.0, 5.0%), luminosity*cross-section (2.3%) (Forthcoming improvement)

Tau had decays: summary

- Some uncertainties are not so high but already systematic dominated, more work ongoing on this

τ^- Decay	$\mathcal{B}.\mathcal{F}.$	$\frac{\sigma_{Stat}}{\sigma_{Syst}}$ Ratio
$\pi^-\pi^-\pi^+\nu_\tau$	$(9.11 \pm 0.01 \pm 0.25) \times 10^{-2}$	0.04
$K^-\pi^-\pi^+\nu_\tau$	$(2.88 \pm 0.02 \pm 0.11) \times 10^{-3}$	0.18
$K^-\pi^-K^+\nu_\tau$	$(1.373 \pm 0.011 \pm 0.037) \times 10^{-3}$	0.3
(inclusive)->$K^-K^-K^+\nu_\tau$	$(1.59 \pm 0.14 \pm 0.09) \times 10^{-5}$	1.56
NEW $\phi\pi^-\nu_\tau$	$(3.49 \pm 0.55 \pm 0.32) \times 10^{-5}$	1.72
$\phi K^-\nu_\tau$	$(3.48 \pm 0.20 \pm 0.26) \times 10^{-5}$	0.77
$K^-\pi^0\nu_\tau$	$(4.39 \pm 0.03 \pm 0.21) \times 10^{-3}$	0.14
$\pi^-\pi^-\pi^+\pi^0\nu_\tau$	$(4.39 \pm 0.01 \pm 0.21) \times 10^{-2}$	0.05
$\omega\pi^-\nu_\tau$	$(1.97 \pm 0.01 \pm 0.10) \times 10^{-2}$	0.10
$\pi^-\pi^-\pi^+\eta\nu_\tau$	$(1.84 \pm 0.09 \pm 0.13) \times 10^{-4}$	0.7
$f_1(1285)(\to \pi^+\pi^-\eta)\pi^-\nu_\tau$	$(1.33 \pm 0.11 \pm 0.07) \times 10^{-4}$	1.6
$f_1(1285)\pi^-\nu_\tau$	$(3.83 \pm 0.32 \pm 1.20) \times 10^{-4}$	0.27

mostly from f_1, $\mathcal{B}.\mathcal{R}.(f_1(1285) \to \pi^-\pi^+\eta) = 0.35 \pm 0.11$

LFV decays: motivation & aspects

- Neutrino mixing permits tau LFV decays at very low rates
- But New Physics models allow for LFV rates that are within experimental reach (SUSY+Seesaw, Heavy Dirac neutrinos, Two Higgs doublet, R-parity violating SUSY, Flavour changing *Z*' with non-universal couplings)
- With baryonic tau decays, test of *B*-*L* number violation

τ^- **Decay**	**Sample** (fb^{-1})	
$l^-\pi^0$ $l^-\eta$ $l^-\eta'$	339	➔ PRL 98, 061803 (2007)
$\overline{\Lambda^0}h^-$ $(B-L$ conserving$)$ $\Lambda^0 h^-$ $(B-L$ violating$)$	237	➔ hep-ex/0607040

- **Topology** similar to hadronic decays, no neutrino on signal side
- **Systematics**: variation of signal box by photon energy scale and resolution (2-4%), Λ reco (5%) and tracking (4%).

Tau LFV decays: summary

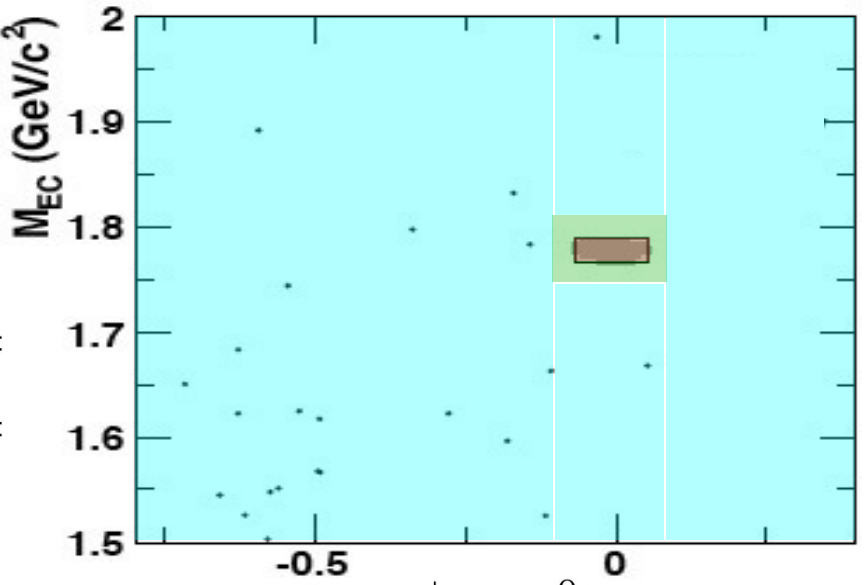
$$\tau^- \to l^-(\pi^0, \eta, \eta')$$

$$\tau^- \to h^- \overline{\Lambda^0}, h^- \Lambda^0$$

$$\mathcal{B}.\mathcal{R}.(\Lambda \to p\pi^-) = 0.639 \pm 0.005$$

τ^- Decay	$\mathcal{U}.\mathcal{L}.(10^{-7})$ @ 90% C.L.
$e^-\pi^0$	1.3
$\mu^-\pi^0$	1.1
$e^-\eta$	1.6
$\mu^-\eta$	1.5
$e^-\eta'$	2.4
$\mu^-\eta'$	1.4
$\overline{\Lambda^0}\pi^-$	0.59
$\Lambda^0\pi^-$	0.58
$\overline{\Lambda^0}K^-$	0.72
$\Lambda^0 K^-$	1.5

NEW



$\tau^- \to \mu^-\eta(\to \pi^+\pi^-\pi^0)$

sideband | blinding | signal

- Blinded analyses, 2D unbinned ML fit to estimate bkg from sidebands
- **Bkg for** $\tau^- \to l^-(\pi^0, \eta, \eta')$**:**

  $\tau^- \to e\nu_\tau\overline{\nu}_\tau\gamma, \rho\nu_\tau$
- **Bkg for** $\tau^- \to h^-\overline{\Lambda^0}, h^-\Lambda^0$**:**

continuum, K_S and γ conversion

Charm mesons: motivation & aspects

- Amplitude analyis from Dalitz plot of 3-body decays
- Extraction of form factors from semi-leptonic decays
- Precise measurement of 2-body B.F. used in D and B physics for other analyses

Analysis	Sample(fb^{-1})
$\mathcal{A}(D^0 \to K^- K^+ \pi^0)$	385
$D^0 \to K^- e^+ \nu_e$	75
$D^0 \to K^- \pi^+$	210

- **Recostruction:** event is not always fully reconstructed, clean sample using a kinematic fit of decay tree
- Constraint on $\Delta m = M_{D^*} - M_D$, $D^* \to D\pi_s$, soft pion
- Some analyses take D's from well-known B sample
- **Systematics**: particle identification and tracking (~1%), models and fitting procedures

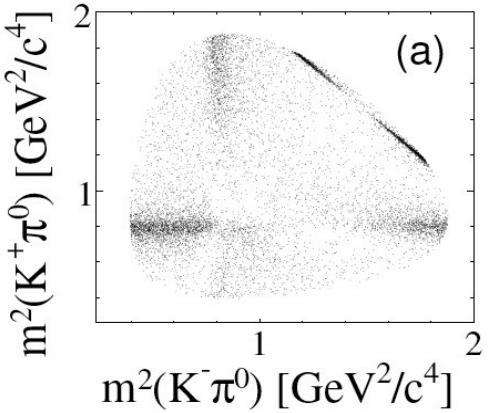
Charm mesons: amplitude

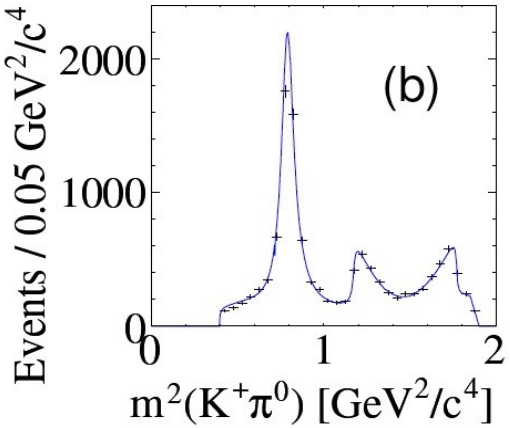
$$D^0 \to K^- K^+ \pi^0$$

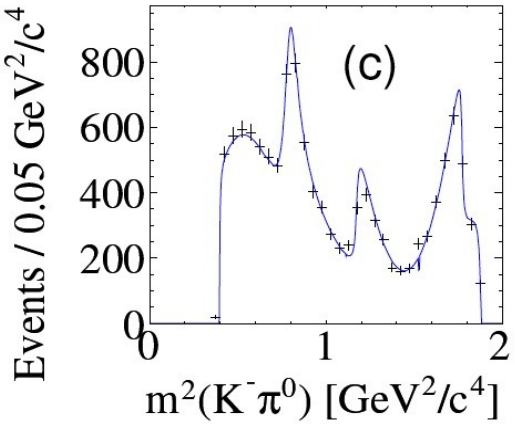
- Isobar model

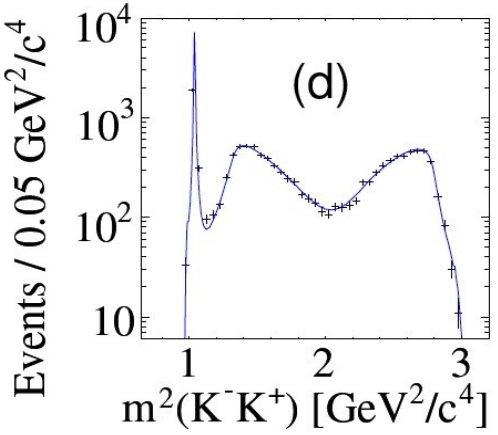
$$D^0 \to res(\to AB)C$$

- Different models for intermediate states
- Excellent agreement with no need for higher resonance than K(1430)
- Strong phase and amplitudes ratio







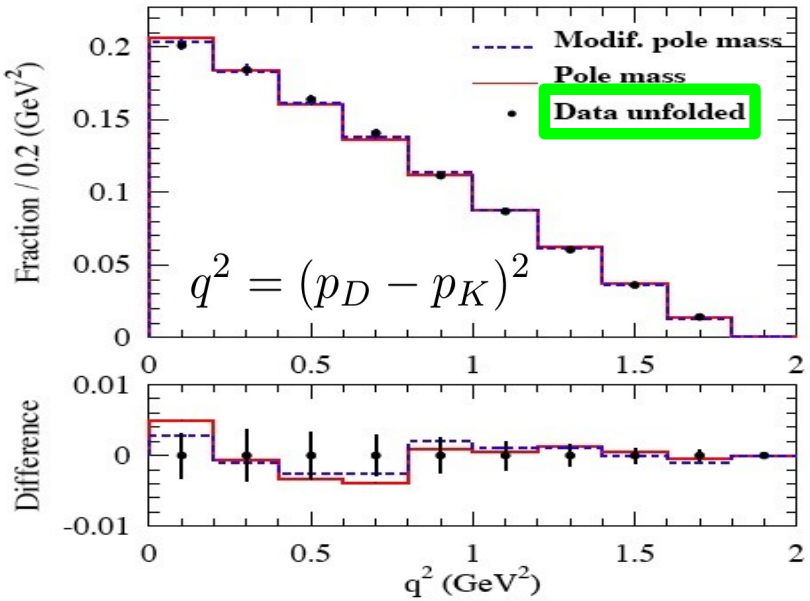


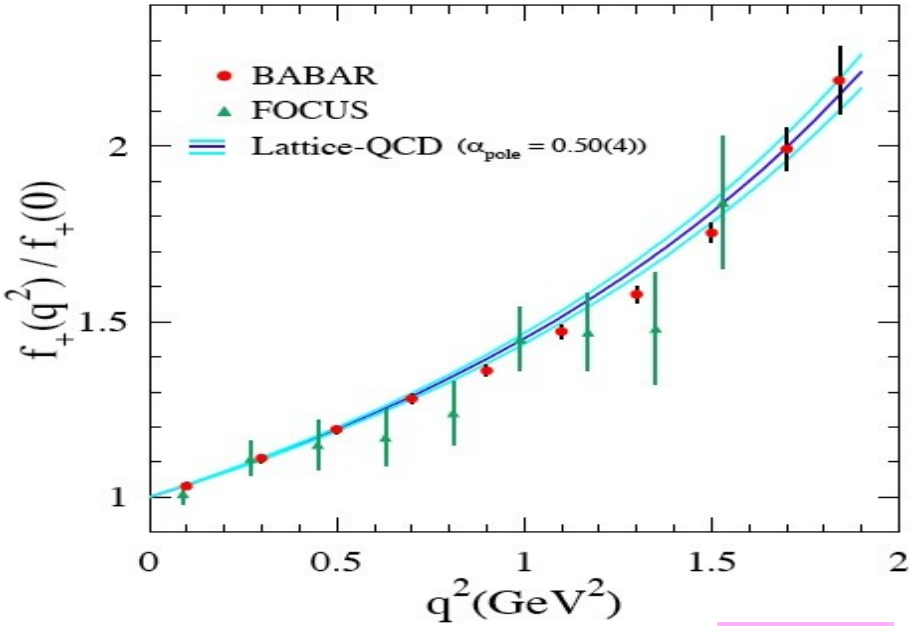
$$D^0 \to K^*(892)^+ K^- \qquad \delta_D = -35.5^o \pm 1.9^o \pm 2.2^o$$

$$\overline{D}^0 \to K^*(892)^+ K^- \qquad r_D = 0.599 \pm 0.013 \pm 0.014$$

$D^0 \to K^- e^+ \nu_e$ Form factor

- 2 form factor, one suppressed for e mass, other one, $f_+(q^2)$, can be parametrized with different model (Taylor exp, poles, simple or mod)
- D mom and nu energy constrained by the rest of events, $\Delta m = M_{D^*} - M_D$





$\mathcal{B}.\mathcal{R}.(D^0 \to K^- e^+ \nu_e(\gamma)) = (3.522 \pm 0.027 \pm 0.045 \pm 0.045)\%$

syst from D->Kπ old B.F.

$f_+(0) = 0.727 \pm 0.007 \pm 0.005 \pm 0.007$

model independent

- **D->Kπ** Measured from B partial semileptonic reconstruction

$$\mathcal{B}.\mathcal{R}.(D^0 \to K^- \pi^+) = (4.007 \pm 0.037 \pm 0.070)\%$$

- Same precision like the average of all the previous meas.

New charm states: motivation & aspects

- Classification of new meson states, like X(3872) et al., as charmonium states or other (diquark-antidiquark, DD molecule)
- Test of models for the heavy quark jet fragmentation with spectrum of charmed baryons
- Classification of new excited baryonic states

Analysis	Sample(fb^{-1})
$B^+ \to X(3872)(\to J/\psi\gamma)K^+$ $B^+ \to (\chi_{c1}, \chi_{c2}, Y(3940), Z(3930))K^+$	260
$e^+e^- \to \gamma_{ISR}(J/\psi\gamma\gamma, J/\psi\pi^+\pi^-)$	230
$e^+e^- \to \gamma_{ISR}\psi(2S)(\to J/\psi\pi^+\pi^-)\pi^+\pi^-$	298
$e^+e^- \to \gamma_{ISR}D\overline{D}$	289
$e^+e^- \to \Lambda_c^+(\to pK^-\pi^+)X$	90
$\Xi_c(2980), \Xi_c(3077) \to \Lambda_c^+K^-\pi^+$	315
$e^+e^- \to (\Xi_c'^+, \Xi_c'^0)X$	232
$e^+e^- \to \Omega_c^*(\to \Omega_c^0\gamma)X$	232
$\Omega_c^0 \to \Omega^-(\pi^+, \pi^+\pi^0, \pi^+\pi^-\pi^+)$	230

- **Tecnique:** Initial State Radiation or well-known B sample, J/psi reconstructed in 2 e,μ
- Partial reconstruction with a kinematic fit from final products.
- **Systematics**: tracking, model, fitting procedure, other B.F. (shown separately if relevant)

Charmonium(-like) states

hep-ex/0607050 hep-ex/0610057 hep-ex/0607083 hep-ex/0608004

$$\mathcal{B}.\mathcal{R}.(B^+ \to X(3872)K^+) \cdot \mathcal{B}.\mathcal{R}.(X(3872) \to J/\psi\gamma) = (3.3 \pm 1.0 \pm 0.3) \times 10^{-6}$$

- 3.4 sigma, X(3872) has C=-1

$$\mathcal{B}.\mathcal{R}.(B^+ \to \chi_{c1}K^+) = (4.9 \pm 0.3 \pm 0.4) \times 10^{-4}$$

- No obs for other chi, X or Y res

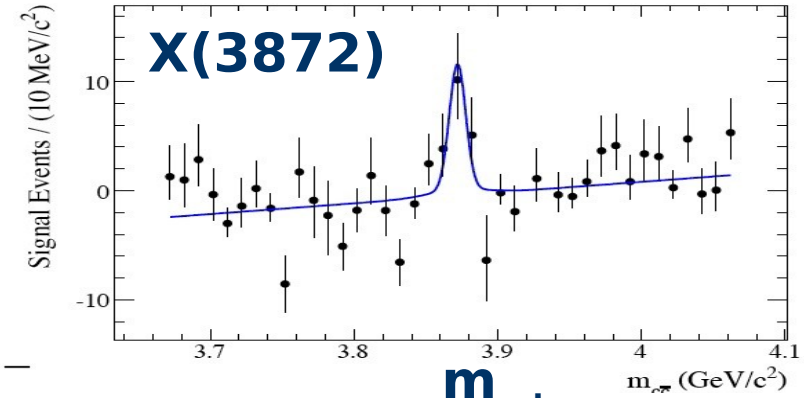
- A broad structure observed in

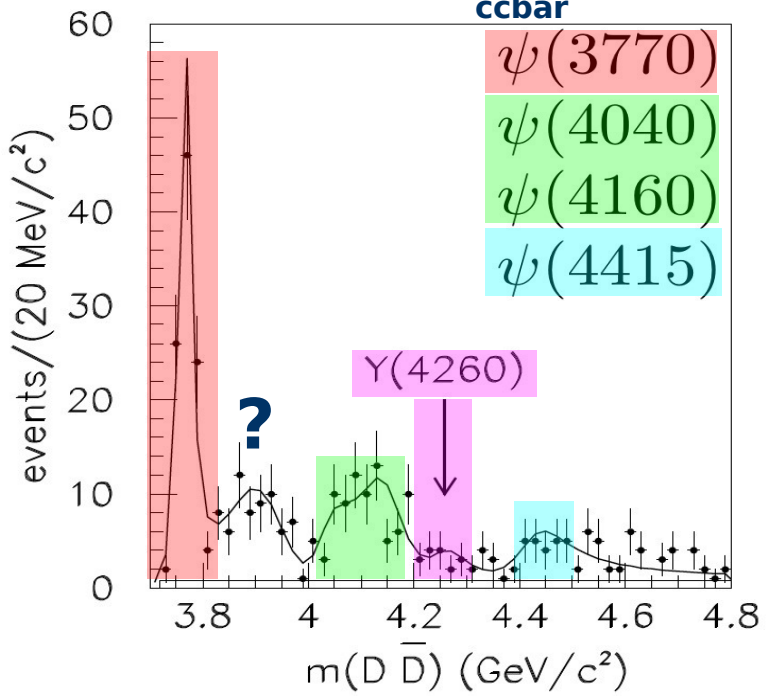
$$e^+e^- \to \gamma_{ISR}\psi(2S)(\to J/\psi\pi^+\pi^-)\pi^+\pi^-$$

but is not compatible with Y(4260)

$$R = \frac{\mathcal{B}(Y(4260) \to X)}{\mathcal{B}(Y(4260 \to J/\psi\pi^+\pi^-))}$$

X	$\mathcal{U}.\mathcal{L}.(R)$
$J/\psi\eta$	1.4
$J/\psi\pi^0$	0.6
$\chi_{c1}\gamma \to J/\psi\gamma\gamma$	3.6
$\chi_{c2}\gamma \to J/\psi\gamma\gamma$	2.6
$J/\psi\gamma\gamma$	1.2
$D\overline{D}$	7.6





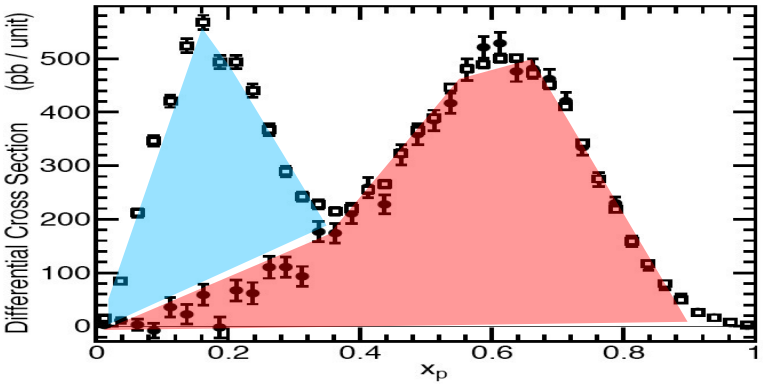
$e^+e^- \to \Lambda_c^+ X$

Baryonic spectrum

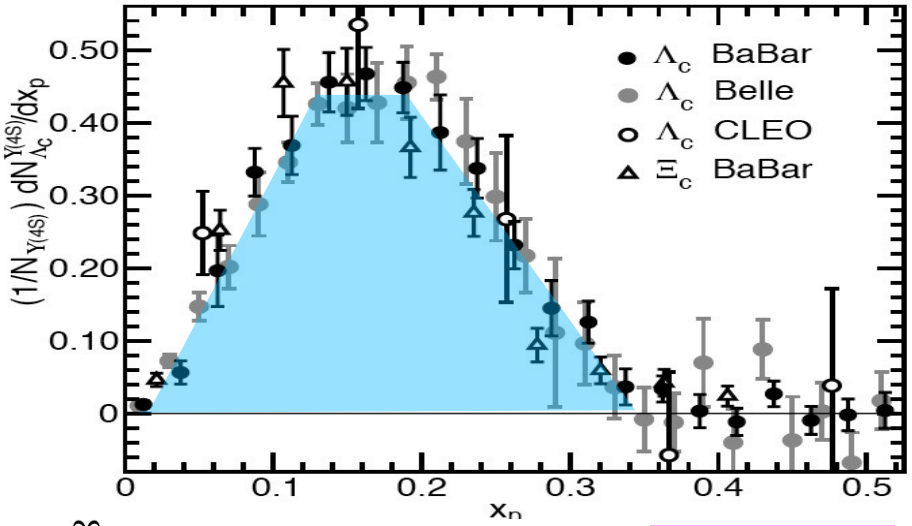
hep-ex/0609004

- Separate components using on-res and off-res sample
- Test of various models:
  - $c\bar{c}$: good agreement using Lund and Bowler description
  - B decays: not so good agreement, need more studies

$$x_p \equiv p_H^*/p_{max}^*(CMS)$$



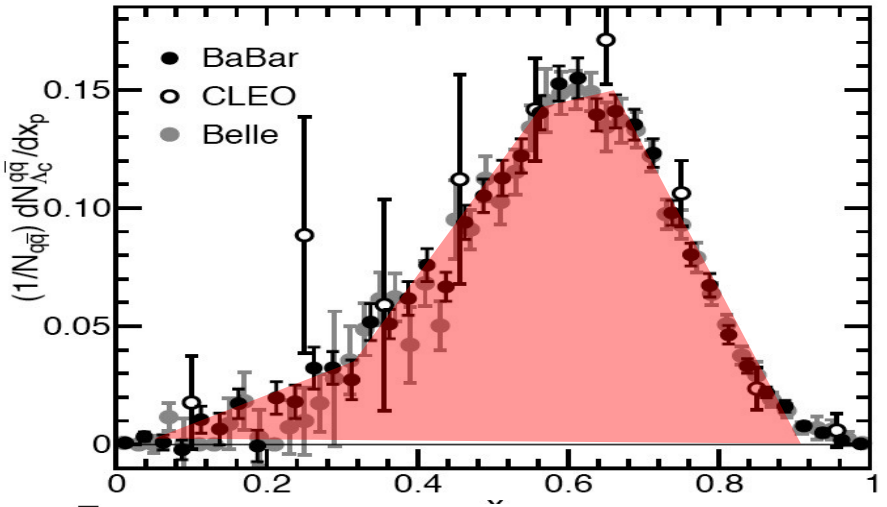
From B decays



$$N_{\Lambda c}^{\Upsilon} = 0.045 \pm 0.003(exp) \pm 0.012(BF)$$

$$\mathcal{B}.\mathcal{R}.(\Lambda_c^+ \to pK^-\pi^+) = (5.0 \pm 1.3)\%$$

From $c\bar{c}$ events



$$N_{\Lambda c}^{q\bar{q}} = 0.057 \pm 0.002(exp) \pm 0.015(BF)$$

N=# of Λ_c per hadronic events

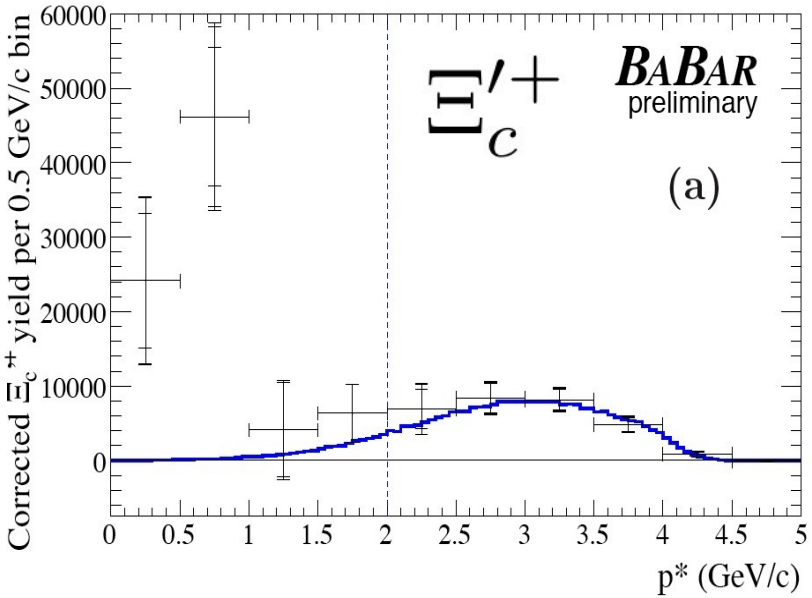
Other Charm baryons results

hep-ex/0607042
hep-ex/0607086

$$\Xi_c'^+ \to \Xi_c^+\gamma, \Xi_c'^0 \to \Xi_0^+\gamma$$

- Agreement of $c\bar{c}$ production with Bowler model
- First observation in B decays
- Excited states observation:

$\Xi_c(2980)^+(7.0\sigma), \Xi_c(3077)^+(8.6\sigma)$

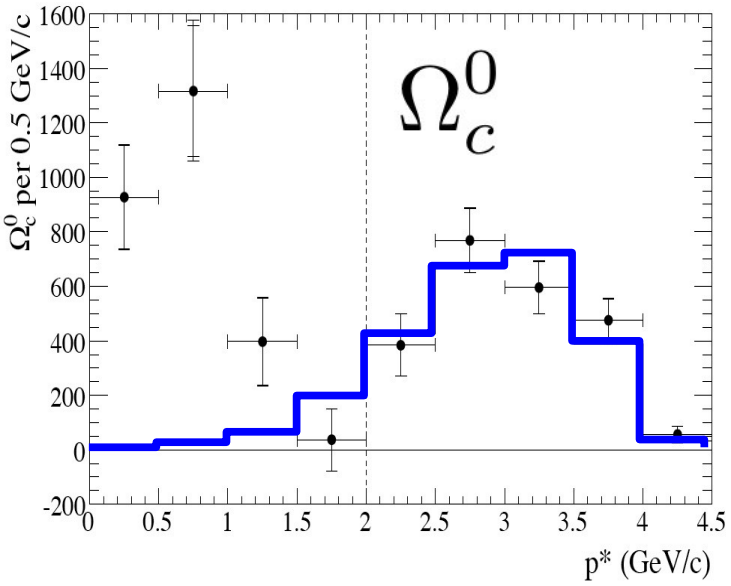


hep-ex/0703030

$$\Omega_c^0 \to \Omega^-\pi^+$$

- Agreement of $c\bar{c}$ production with Bowler model
- Production in B decays lower than Λ_c^+, Ξ_c^0
- Excited states observation:

$\Omega_c^* \to \Omega_c^0\gamma(5.2\sigma)$



Conclusions

- Many tau decays (hadronic and LFV): 2 new measurements and 2 new upper limits, precision improvement on others
- A lot of results from charmed particle sudies: B.F., classification of new states, but also form factors measurements and fragmentation model tests
- B-factory high luminosity has been fundamental for all these measurements, LFV searches in particular
- BaBar data-taking goes on until 2008, but we could do a big jump having 10 times or more statistics (SuperB factory)

For more details, see:

- Tau: talks by **Banerjee, Lafferty,Nugent, Sobie** at TAU06, http://tau06.sns.it/program
- Charm: talks by **Grenier, Zhang** at MoriondQCD07, http://moriond.in2p3.fr/QCD/2007/MorQCD07Prog.html

The end...