Search for CP violation in 4-body Cabibbo Suppressed D^0 decays.

Antimo Palano

INFN and University of Bari.

SuperB VI , Valencia, January 10, 2008

□ For references see:

W. Bensalem and D. London: T-Odd Triple-Product Correlations in Hadronic b Decays, hep-ph/0005018, 2000.

S. Bianco, F. L. Fabbri, D. Benson, I. Bigi: A Cicerone for the Physics of Charm, hep-ex/0309021, Journal-ref: Riv.Nuovo Cim. 26N7 (2003) 1-200.

I. Bigi: I Know She Invented Fire, But What Has She Done Recently?" – On The Future Of Charm Physics, hep-ph/0608073

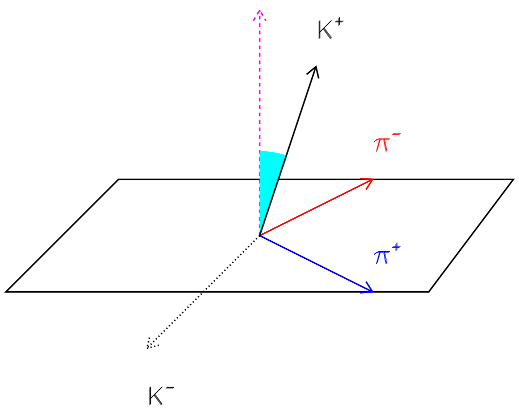
Search for T-odd correlations.

□ Consider the Cabibbo Suppressed D^0 decay:

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

□ T-odd correlations can be formed using the momenta of the particles:

$$C_T = p_{K^+} \cdot (p_{\pi^+} \times p_{\pi^-})$$



□ Under time reversal T, we have $C_T \to -C_T$.

□ $C_T \neq 0$ does not necessarily established T violation.

□ Consider also:

$$\overline{D^0} \to K^+ K^- \pi^+ \pi^-$$

where we can compute:

$$\overline{C_T} = p_{K^-} \cdot (p_{\pi^-} \times p_{\pi^+})$$

□ Finding:

$$C_T \neq -\overline{C_T}$$

establishes CP violation.

T-odd correlations.

- Separate the data sample into D^0 and $\bar{D}^0$.
- Then separate for $C_T > 0$ and $C_T < 0$.
- We build T-odd asymmetries using decay rates for a given decay:

$$A_T = \frac{\Gamma(C_T > 0) - \Gamma(C_T < 0)}{\Gamma(C_T > 0) + \Gamma(C_T < 0)}$$

$$\overline{A_T} = \frac{\Gamma(\overline{C_T} > 0) - \Gamma(\overline{C_T} < 0)}{\Gamma(\overline{C_T} > 0) + \Gamma(\overline{C_T} < 0)}$$

- The T-violation asymmetry is:

$$A_{Tviol} = \frac{1}{2}(A_T - \overline{A_T})$$

- $A_{Tviol} \neq 0$ implies CP violation.

Test made by FOCUS.

- Use of 351 events.

$$A_{Tviol} = 0.075 \pm 0.064$$

Presented by D.Pedrini at the round table of the Int. Conf. on Frontier Science Frascati (Italy), October 2002

A different approach (I. Bigi).

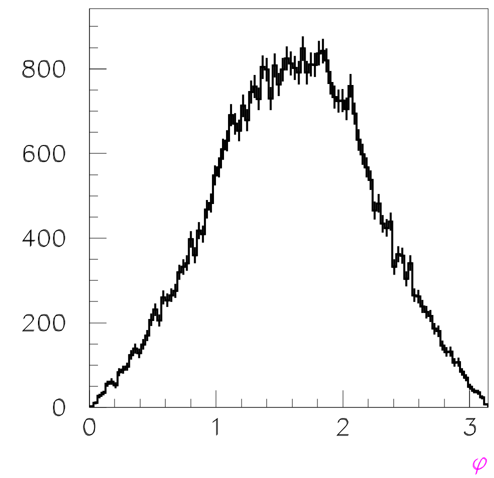
□ Compute the angle ϕ between the K^+K^- and $\pi^+\pi^-$ decay planes for $D^0 \to K^+K^-\pi^+\pi^-$. Then one has:

$$\frac{d\Gamma}{d\phi}(D^0 \to K^+K^-\pi^+\pi^-) = \Gamma_1 cos^2\phi + \Gamma_2 sin^2\phi + \Gamma_3 cos\phi sin\phi$$

$$\frac{d\Gamma}{d\phi}(\overline{D^0} \to K^+K^-\pi^+\pi^-) = \bar{\Gamma}_1 cos^2\phi + \bar{\Gamma}_2 sin^2\phi + \bar{\Gamma}_3 cos\phi sin\phi$$

$$\Gamma_3 \neq \bar{\Gamma}_3 \to CP \quad violation$$

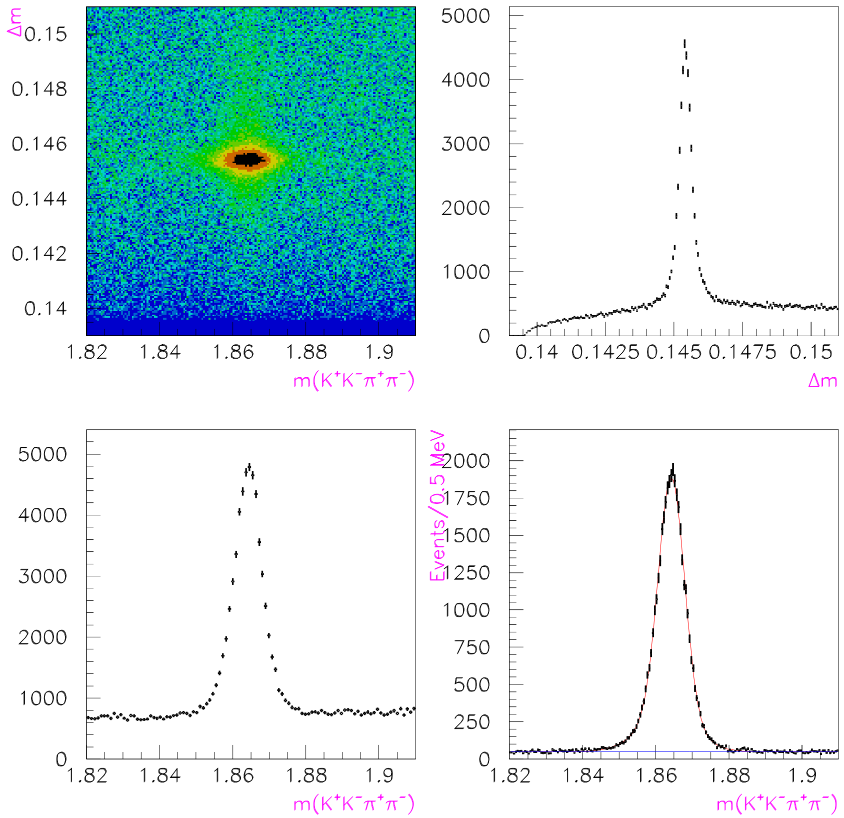
□ Distribution of ϕ using BaBar data.



□ Not necessarily the above expression gives a good fit.

Some yields estimate using BaBar data.

- Use $\approx 380\ fb^{-1}$.
- Identify D^0 or $\bar{D}^0$ using $D^{*+} \to D^0\pi^+$.
- Study of $D^0 \to K^+K^-\pi^+\pi^-$.
- Scatter diagram Δm vs. $m(K^+K^-\pi^+\pi^-)$ and projections.

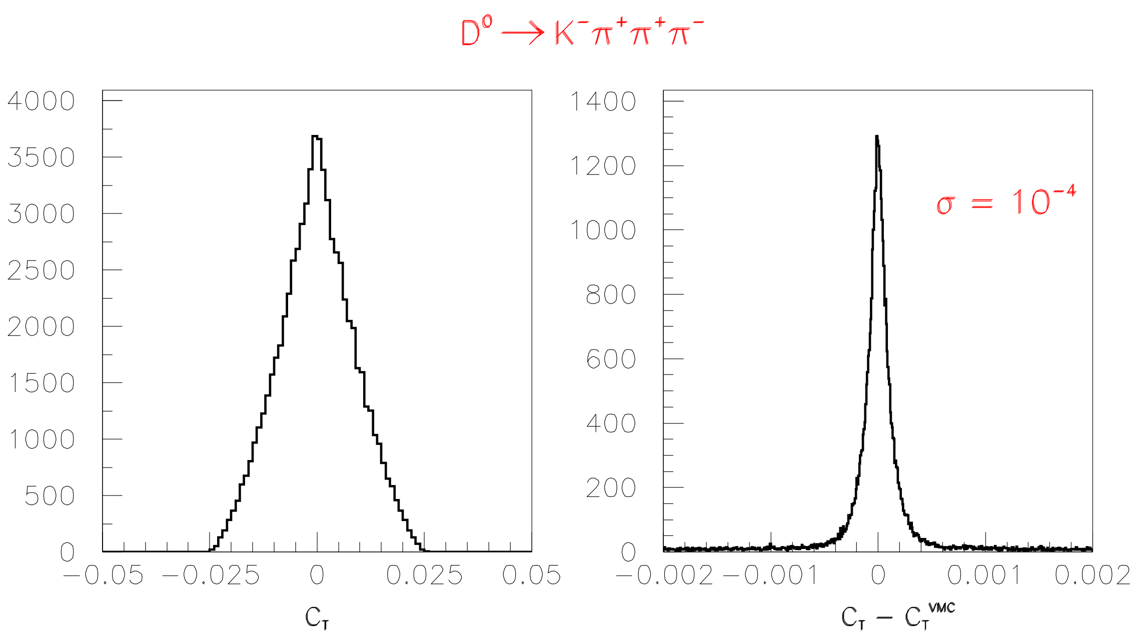


- 36 000 events within 2σ in Δm.

C_T distribution for the control sample $D^0 \to K^- \pi^+ \pi^+ \pi^-$.

□ C_T distribution for $K^- \pi^+ \pi^+ \pi^-$ and resolution.

□ The resolution has been obtained as the difference between the Monte Carlo generated and reconstructed C_T value.



Study of $D^0 \to K^+K^-\pi^+\pi^-$.

□ Channel dominated by 3-body and 2-body intermediate resonances.

□ Presence of both $D^0 \to \phi\rho^0$ and $D^0 \to K^{*0}\overline{K^{*0}}$ decays.

□ With 380 fb^{-1} the error on A_{Tviol} is 5.3 $\times 10^{-3}$.

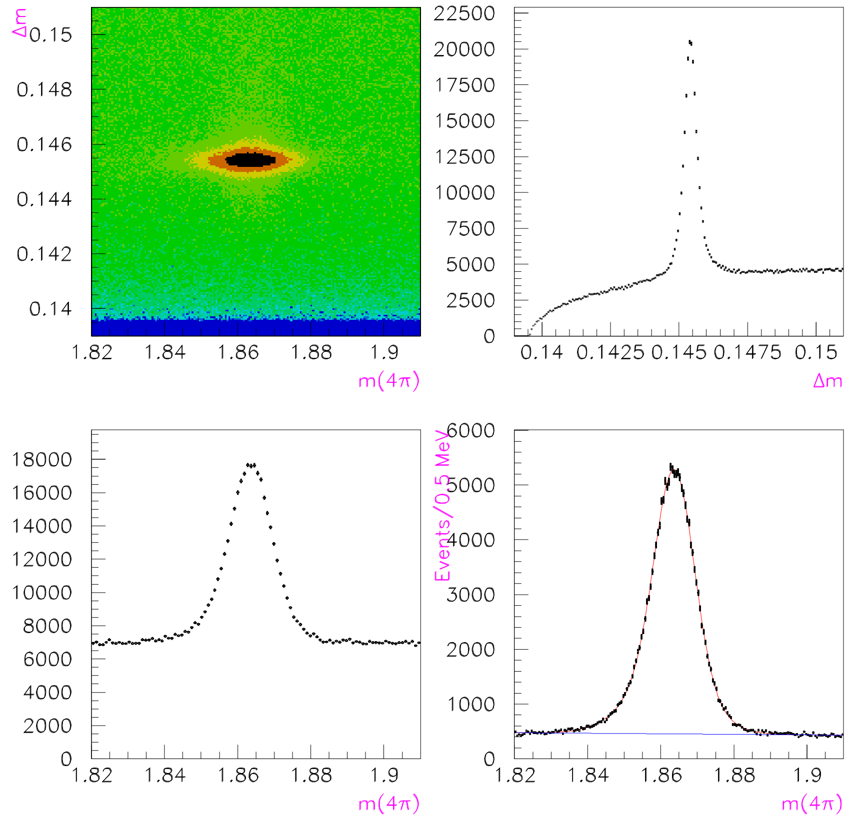
□ Estimate for 10 ab^{-1}.

□ We expect $\approx 10^6$ events.

□ The data set is then divided into 4 class of events. Using 250 $\times 10^3$ events for each category, the error on A_{Tviol} is 1×10^{-3}.

Study of $D^0 \to 2\pi^+ 2\pi^-$.

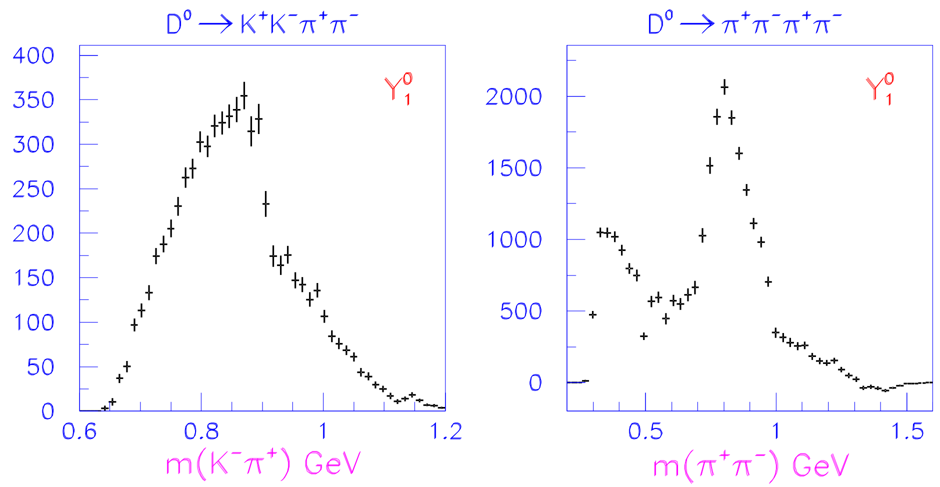
- Scatter diagram Δm vs. $m(2\pi^+2\pi^-)$ and projections.



- 148,500 events within 2σ in Δm.

Y_L^0 Moments.

- Small asymmetries could be evidenced by differences in Y_L^0 moments.
- Example of Y_1^0 moments for $D^0 \to K^+K^-\pi^+\pi^-$ and $D^0 \to 2\pi^+2\pi^-$.



- CP asymmetries can be computed on Y_L^0 moments separated for D^0 and $\bar{D}^0$.

A more complete approach.

☐ Full amplitude analysis.

☐ $D^0 \to \phi\rho^0$ in P-wave is described by a term of the type:

$$(\mathbf{t}_\phi \times \mathbf{p}_\rho) \cdot \mathbf{t}_\rho$$

where the $\mathbf{t}$ are obtained from differences between D^0 center of mass 3-momenta.

☐ Similarly for $D^0 \to K^* \bar{K}^*$.

☐ A Full amplitude analysis is able to extract the amplitudes but in addition is able to measure relative phases.

Conclusions.

□ 4-body Cabibbo suppressed charm decays provide many variables where it is possible to test for CP violation.

□ At a Super B-factory the sensitivity on CP violation can go below 10^{-3}.