Constraining the CKM matrix with $B \to K\pi\pi$

Reina Camacho (HELEN fellow, LPNHE)
Jérôme Charles (CPT Marseille)
Alejandro Pérez, José Ocariz (LPNHE BaBar)

Motivation

- Exploit the experimental information available in Dalitz analysis for charmless 3 body B decays $K\pi\pi$.
- $B\rightarrow K^*\pi$ and $B\rightarrow\rho K$ modes have the same isopin relations as $B\rightarrow K\pi$, but more observables are accesible from DP analyses.
- Our plan is to:
  - Test hadronic parameters asumming CKM from global fit.
  - Test CKM constraints using some hadronic hypothesis.
  - Using CKMFitter code

Time-dependent Dalitz Plot Analyses

Amplitude parameterization using Isobar Model:

Dalitz Plot Isobar Model

$$A(DP) = \sum a_j F_j(DP)$$
$$\overline{A}(DP) = \sum \overline{a}_j \overline{F}_j(DP)$$

Shapes of intermediate states over DP

Time-dependent DP PDF

mixing and decay CPV

DCPV

$$f(\Delta t, DP, q_{tag}) \propto \left(|A|^2 + |\bar{A}^2|\right) \frac{e^{-|\Delta t|/\tau}}{t\tau} \left(1 + q_{tag} \frac{2Im[\bar{A}A^* e^{-i2\beta}]}{|A|^2 + |\bar{A}^2|} sin(\Delta m_d \Delta t) - q_{tag} \frac{|A|^2 - |\bar{A}^2|}{|A|^2 + |\bar{A}^2|} cos(\Delta m_d \Delta t)\right)$$

CP violation varies over DP

Complex amplitudes a_j and $\overline{a}_j$ determine DP interference pattern.
Module and phases can be directly fitted on data.

Time-dependent Dalitz Plot Analyses

Parametrizing signal PDF using Isobar Model:

Dalitz Plot Isobar Model

$$A(DP) = \sum a_j F_j(DP)$$
$$\bar{A}(DP) = \sum \bar{a}_j \bar{F}_j(DP)$$

Shapes of intermediate states over DP

Time-dependent DP PDF — mixing and decay CPV — DCPV

$$f(\Delta t, DP, q_{tag}) \propto \left(|A|^2 + |\bar{A}|^2\right) \frac{e^{-|\Delta t|/\tau}}{4\tau} \left(1 + q_{tag} \frac{2Im[\bar{A}A^* e^{-i2\beta}]}{|A|^2+|\bar{A}|^2} sin(\Delta m_d \Delta t) - q_{tag} \frac{|A|^2-|\bar{A}|^2}{|A|^2+|\bar{A}|^2} cos(\Delta m_d \Delta t)\right)$$

CP violation varies over DP

Complex amplitudes a_j and $\bar{a}_j$ determine DP interference pattern.

Module and phases can be directly fitted on data.

Time-dependent CPV parameters:

$$C_j = \frac{|a_j|^2 - |\bar{a}_j|^2}{|a_j|^2 + |\bar{a}_j|^2} \quad S_j = \frac{2\,\mathrm{Im}[a_j \bar{a}_j^*]}{|a_j|^2 + |\bar{a}_j|^2}$$

Interference helps disentangling strong and weak phases and thus raises the degeneracy on the phases.

Time-dependent Dalitz Plot Analyses

Time-dependent DP PDF

Term sensitive to phase differences between A and A

$$f(\Delta t, DP, q_{tag}) \propto \left(|A|^2 + |\bar{A}^2|\right) \frac{e^{-|\Delta t|/\tau}}{t\tau} \left(1 + q_{tag} \frac{2Im[\bar{A}A^* e^{-i2\beta}]}{|A|^2+|\bar{A}^2|} sin(\Delta m_d \Delta t) - q_{tag} \frac{|A|^2-|\bar{A}^2|}{|A|^2+|\bar{A}^2|} cos(\Delta m_d \Delta t)\right)$$

Mixing angle is written explicitly

Time-dependent Dalitz Plot Analyses

Time-dependent DP PDF

Term sensitive to phase diferences between A and A

$$f(\Delta t, DP, q_{tag}) \propto (|A|^2 + |\bar{A}^2|)\frac{e^{-|\Delta t|/\tau}}{4\tau}\left(1 + q_{tag}\frac{2Im[\bar{A}A^* e^{-i2\beta}]}{|A|^2+|\bar{A}^2|}sin(\Delta m_d \Delta t) - q_{tag}\frac{|A|^2-|\bar{A}^2|}{|A|^2+|\bar{A}^2|}cos(\Delta m_d \Delta t)\right)$$

Time-Integrated (TI) DP PDF

Term sensitive only to direct CP asymmetries

$$f(DP, q_{tag}) \propto (|A|^2 + |\bar{A}^2|)\left(a - q_{tag}\frac{|A|^2 - |\bar{A}^2|}{|A|^2 + |\bar{A}^2|}b\right)$$

All the information about phase differences between A and A is lost

Time-dependent Dalitz Plot Analyses

Time-dependent DP PDF

Term sensitive to phase diferences between A and A

$$f(\Delta t, DP, q_{tag}) \propto (|A|^2 + |\bar{A}^2|)\frac{e^{-|\Delta t|/\tau}}{4\tau}\left(1 + q_{tag}\frac{2Im[\bar{A}A^{*}e^{-i2\beta}]}{|A|^2+|\bar{A}^2|}sin(\Delta m_d \Delta t) - q_{tag}\frac{|A|^2-|\bar{A}^2|}{|A|^2+|\bar{A}^2|}cos(\Delta m_d \Delta t)\right)$$

Time-Integrated (TI) DP PDF

Term sensitive only to direct CP asymmetries

$$f(DP, q_{tag}) \propto (|A|^2 + |\bar{A}^2|)\left(a - q_{tag}\frac{|A|^2 - |\bar{A}^2|}{|A|^2 + |\bar{A}^2|}b\right)$$

Time-Integrated (TI) and tag-Integrated (tI) DP PDF

No sensitivity to direct CP violation at all

$$f(DP) \propto (|A|^2 + |\bar{A}^2|)$$

Isospin relations $K^*\pi$

Without loss of generality the complete $B\to K^*\pi$ system can be parametrized by eight amplitudes and the CKM couplings.

$$A(B^0\to K^{*+}\pi^-) = V_{us}V^*_{ub}T^{+-} + V_{ts}V^*_{tb}P^{+-}$$
$$A(B^+\to K^{*0}\pi^+) = V_{us}V^*_{ub}T^{0+} + V_{ts}V^*_{tb}P^{0+}$$
$$A(B^+\to K^{*+}\pi^0) = V_{us}V^*_{ub}T^{+0} + V_{ts}V^*_{tb}P^{+0}$$
$$A(B^0\to K^{*0}\pi^0) = V_{us}V^*_{ub}T^{00} + V_{ts}V^*_{tb}P^{00}$$

It is implicitly understood that those amplitudes receive various contributions of distinct topologies.

Isospin relations $K^*\pi$

If we assume isospin symmetry, then we can write these amplitudes as:

$$A(B^0 \to K^{*+}\pi^-) = V_{us}V^*_{ub}T^{+-} + V_{ts}V^*_{tb}P^{+-}$$

$$A(B^+ \to K^{*0}\pi^+) = V_{us}V^*_{ub}N^{0+} + V_{ts}V^*_{tb}(-P^{+-}+P^{C}_{EW})$$

$$\sqrt{2}A(B^+ \to K^{*+}\pi^0) = V_{us}V^*_{ub}(T^{+-}+T_C^{00}-N^{0+}) + V_{ts}V^*_{tb}(P^{+-}-P^{C}_{EW}+P_{EW})$$

$$\sqrt{2}A(B^0 \to K^{*0}\pi^0) = V_{us}V^*_{ub}T_C^{00} + V_{ts}V^*_{tb}(-P^{+-}+P_{EW})$$

In this parameterization, we use three penguin P^{+-}, P_{EW}, P^C_{EW} and three tree amplitudes T^{+-} , $N^{0+} = T^{0+}$ and T_C^{00} . The notation N^{0+} refers to the fact that the tree contribution to the $K^{*0}\pi^+$ mode has an annihilation topology. Since $K^{*0}\pi^0$ is color-suppressed, its tree amplitude is denoted T_C^{00}

No other hypothesis than isospin is used

Isospin relations:

$$A^{0+} + \sqrt{2}A^{+0} = \sqrt{2}A^{00} + A^{+-}$$

$$\bar{A}^{0+} + \sqrt{2}\bar{A}^{+0} = \sqrt{2}\bar{A}^{00} + \bar{A}^{+-}$$

Isospin $K^*\pi$: measurement of γ (CPS/GPSZ)

Taking the $B^0\to K^{*+}\pi^-$ and $B^0\to K^{*0}\pi^0$ subsystems

Neglecting P_{EW}, the amplitude combinations:

$$3A_{3/2} = A(B^0\to K^{*+}\pi^-) + \sqrt{2}.A(B^0\to K^{*0}\pi^0) = V_{us}V^*_{ub}(T^{+-}+T^{00})$$

$$3\overline{A}_{3/2} = \overline{A}(\overline{B^0}\to K^{*-}\pi^+) + \sqrt{2}.\overline{A}(\overline{B^0}\to \overline{K^{*0}}\pi^0) = V^*_{us}V_{ub}(T^{+-}+T^{00})$$

which gives: $R_{3/2} = (3A_{3/2})/(3\overline{A}_{3/2}) = e^{-2i\gamma}$

CPS PRD74:051301
GPSZ PRD75:014002

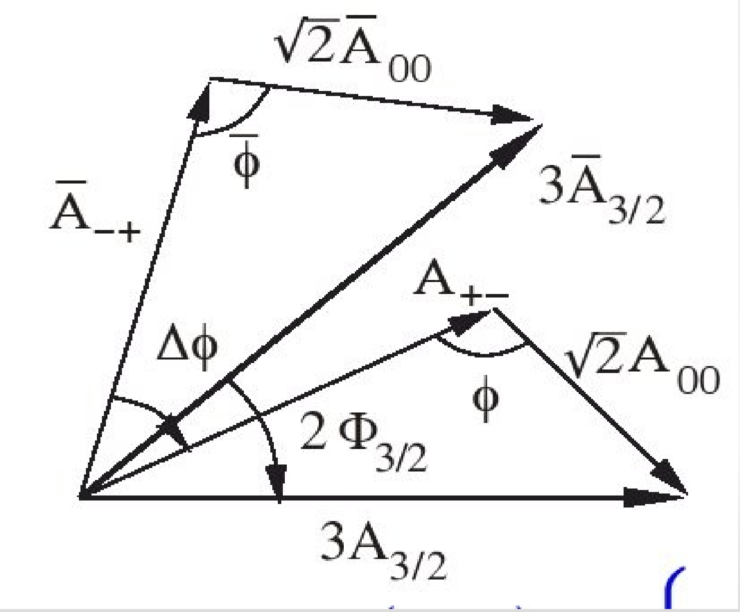
CPS/GPSZ: Direct access to γ

From experiment:

Measurable from $K^+\pi^-\pi^0$ and $K^0_S\pi^+\pi^-$

- $|A(B^0\to K^{*+}\pi^-)|$ and $|A(B^0\to K^{*0}\pi^0)|$
- $|\overline{A}(\overline{B^0}\to \overline{K^{*}}\pi^+)|$ and $|\overline{A}(\overline{B^0}\to \overline{K^{*0}}\pi^0)|$

Through BRs and A_{CP}



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CPS PRD74:051301
GPSZ PRD75:014002

CPS/GPSZ: Direct access to γ

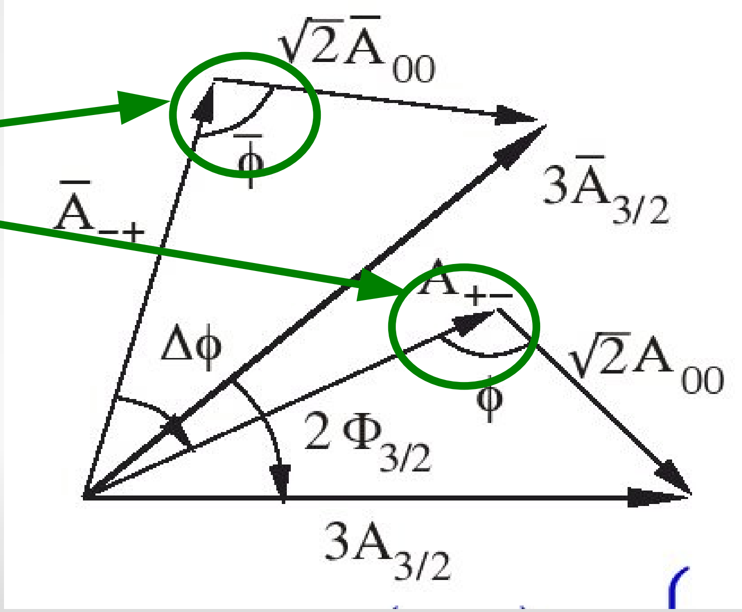
From experiment:

Measurable from $K^+\pi^-\pi^0$

$$\phi = \arg(A(B^0 \to K^{*+}\pi^-)A^*(B^0 \to K^{*0}\pi^0))$$

$$\overline{\phi} = \arg(\overline{A}(\overline{B^0} \to K^{*-}\pi^+)\overline{A}^*(\overline{B^0} \to \overline{K^{*0}}\pi^0))$$

Through interference in the same DP B^0(B^0-bar) plane



Isospin $K^*\pi$: measurement of γ (CPS/GPSZ)

Taking the $B^0 \to K^{*+}\pi^-$ and $B^0 \to K^{*0}\pi^0$ subsystems

Neglecting P_{EW}, the amplitude combinations:

$$3A_{3/2} = A(B^0 \to K^{*+}\pi^-) + \sqrt{2}.A(B^0 \to K^{*0}\pi^0) = V_{us}V^*_{ub}(T^{+-}+T^{00})$$

$$3\overline{A}_{3/2} = \overline{A}(\overline{B^0} \to K^{*-}\pi^+) + \sqrt{2}.\overline{A}(\overline{B^0} \to \overline{K^{*0}}\pi^0) = V^*_{us}V_{ub}(T^{+-}+T^{00})$$

which gives: $R_{3/2} = (3A_{3/2})/(3\overline{A}_{3/2}) = e^{-2i\gamma}$

CPS PRD74:051301
GPSZ PRD75:014002

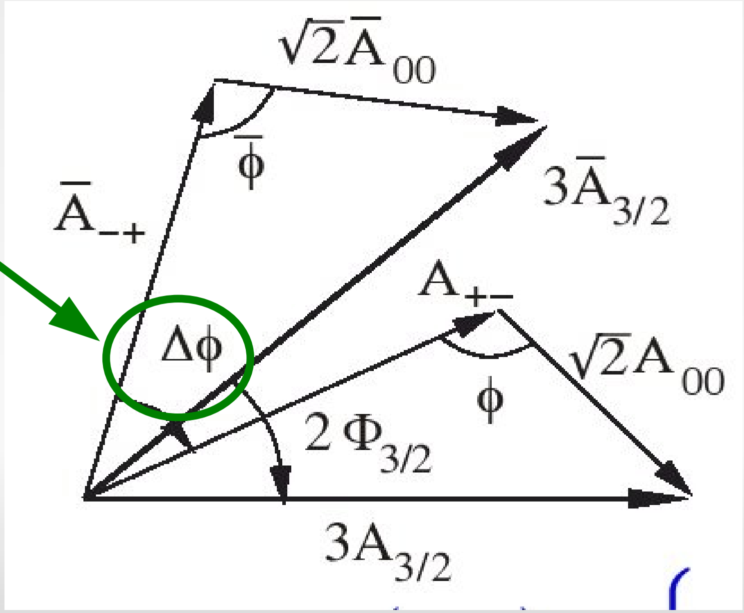
CPS/GPSZ: Direct access to γ

From experiment:

Measurable from a TI DP analysis of $K^0_S\pi^+\pi^-$

$$\Delta\phi = \arg(\overline{A}(\overline{B^0} \to K^{*-}\pi^+)A^*(B^0 \to K^{*+}\pi^-))$$

Through interference with other resonances contributing to the same Dalitz plot



CPS/GPSZ use $\Delta\phi(A(B^0 \to K^{*-}\pi^+)A^*(B^0 \to K^{*+}\pi^-))$ obtained from a TI DP analysis of $B \to K_s\pi\pi$

$$\Delta\phi = \arg((q/p)A(B^0 \to K^{*-}\pi^+)A^*(B^0 \to K^{*+}\pi^-))$$

In our study we will also follow a "Nir-Quinn" like strategy (as in Julie Malcles' PhD thesis)

Nir and Quinn PRL 67, 541 (1991)

Experimental results for $K^*\pi$ system

$K^*\pi$ Isospin relations: 11 QCD and 2 CKM = 13 parameters

$$A(B^0\to K^{*+}\pi^-) = V_{us}V^*_{ub}T^{+-} + V_{ts}V^*_{tb}P^{+-}$$

$$A(B^+\to K^{*0}\pi^+) = V_{us}V^*_{ub}N^{0+} + V_{ts}V^*_{tb}(-P^{+-}+P^C_{EW})$$

$$\sqrt{2}A(B^+\to K^{*+}\pi^0) = V_{us}V^*_{ub}(T^{+-}+T^{00}-N^{0+}) + V_{ts}V^*_{tb}(P^{+-}-P^C_{EW}+P_{EW})$$

$$\sqrt{2}A(B^0\to K^{*0}\pi^0) = V_{us}V^*_{ub}T^{00} + V_{ts}V^*_{tb}(-P^{+-}+P_{EW})$$

Observables:

- 4 BFs and 4 A_{CP} from DP and Q2B analyses.
- 5 phase differences:
  - $* \Delta\phi = \arg((q/p)\overline{A}(\overline{B^0}\to K^{*-}\pi^+)A^*(B^0\to K^{*+}\pi^-))$ from $B^0\to K^0_S\pi^+\pi^-$
  - $* \Delta\phi = \arg(A(B^0\to K^{*0}\pi^0)A^*(B^0\to K^{*+}\pi^-))$ and
  - $\overline{\Delta\phi} = \arg(\overline{A}(\overline{B^0}\to \overline{K^{*0}}\pi^0)\overline{A}^*(\overline{B^0}\to K^{*-}\pi^+))$ from $B^0\to K^+\pi^-\pi^0$
  - $* \Delta\phi = \arg(A(B^+\to K^{*0}\pi^+)A^*(B^+\to K^{*+}\pi^0))$ and
  - $\overline{\Delta\phi} = \arg(\overline{A}(B^-\to \overline{K^{*0}}\pi^-)A^*(B^-\to K^{*-}\pi^0))$ from $B^+\to K^0\pi^+\pi^0$

A total of 13 observables

Constrained system...but...

Experimental results for K*π system

$K^*\pi$ Isospin relations: **11 QCD and 2 CKM = 13 parameters**

$$A(B^0\to K^{*+}\pi^-) = V_{us}V^*_{ub}T^{+-} + V_{ts}V^*_{tb}P^{+-}$$

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$$\sqrt{2}A(B^+\to K^{*+}\pi^0) = V_{us}V^*_{ub}(T^{+-}+T^{00}-N^{0+}) + V_{ts}V^*_{tb}(P^{+-}-P^C_{EW}+P_{EW})$$

Due to Reparametrization Invariance (RpI) hadronic hypothesis have to be made to put a constrain on CKM parameters from the K*π experimental inputs

* $\Delta\phi = \arg((q/p)\overline{A}(\overline{B}^0\to K^{*-}\pi^+)A^*(B^0\to K^{*+}\pi^-))$ from $B^0\to K^0_S\pi^+\pi^-$
* $\Delta\phi = \arg(A(B^0\to K^{*0}\pi^0)A^*(B^0\to K^{*+}\pi^-))$ and
  $\overline{\Delta\phi} = \arg(\overline{A}(\overline{B}^0\to \overline{K}^{*0}\pi^0)\overline{A}^*(\overline{B}^0\to K^{*-}\pi^+))$ from $B^0\to K^+\pi^-\pi^0$
* $\Delta\phi = \arg(A(B^+\to K^{*0}\pi^+)A^*(B^+\to K^{*+}\pi^0))$ and
  $\overline{\Delta\phi} = \arg(A(B^-\to \overline{K}^{*0}\pi^-)A^*(B^-\to K^{*-}\pi^0))$ from $B^+\to K^0\pi^+\pi^0$

A total of 13 observables

Reparametrization Invariance (RpI)

Due to RpI we can not fit simultaneously CKM and hadronic parameters. Without any hadronic assumption one cannot extract a correlation in the (η,ρ) plane

A general parametrization of the decay amplitudes in term of weak $\{\phi_1,\phi_2\}$ and strong phases $\{\delta_1,\delta_2\}$ is:

$$
\begin{aligned}
A &= M_1\, e^{+i\phi_1}\; e^{i\delta_1} + M_2\, e^{+i\phi_2}\; e^{i\delta_2} \;, \\
\bar{A} &= M_1\, e^{-i\phi_1}\; e^{i\delta_1} + M_2\, e^{-i\phi_2}\; e^{i\delta_2} \;, \qquad (1)
\end{aligned}
$$

If now we consider a new set of weak phases $\{\varphi_1,\varphi_2\}$

$$
\begin{aligned}
A &= \mathcal{M}_1\, e^{+i\varphi_1}\; e^{i\Delta_1} + \mathcal{M}_2\, e^{+i\varphi_2}\; e^{i\Delta_2} \;, \\
\bar{A} &= \mathcal{M}_1\, e^{-i\varphi_1}\; e^{i\Delta_1} + \mathcal{M}_2\, e^{-i\varphi_2}\; e^{i\Delta_2} \;, \qquad (5)
\end{aligned}
$$

London D., Sinha N and Sinha R. PRD 60 074020 (1999)

Botella, F.and Silva PRD 71 094008 (2005)

Reparametrization Invariance (RpI)

This change in the basis set of weak phases should not have physical implications, because of RpI

Consider two basic sets of weak phases $\{\phi_1, \phi_2\}$ and $\{\phi_1, \varphi_2\}$ with $\phi_2 \neq \varphi_2$; if an algorithm allows us to write ϕ_2 as a function of physical observables then, owing to the functional similarity of equation (1) and (5), we would extract φ_2 with exactly the same function, leading to $\phi_2 = \varphi_2$, in contradiction with the assumptions; then, a priori, the weak phases in the parametrization of the decay amplitudes have no physical meaning, or cannot be extracted without hadronic input.

At least one hadronic hyphotesis is needed to break RI

London D., Sinha N and Sinha R. PRD 60 074020 (1999)

Botella, F.and Silva PRD 71 094008 (2005)

Experimental results for K*π system

Table 2. Isospin $K^*\pi$: experimental results

Channel	$\mathcal{B}_j(10^{-6})$	A^j_{CP}	Analysis [Mevents]
$B^0 \to K^{*+}\pi^-$	$12.6^{+2.7}_{-1.6} \pm 0.9$	$-0.19^{+0.20}_{-0.18} \pm 0.04$	$DP\ B^0 \to K^+\pi^0\pi^-$ ($BABAR$ 231.8 ± 2.6)
	$11.0 \pm 1.5 \pm 0.5 \pm 0.4$	$-0.11 \pm 0.14 \pm 0.05$	$Q2B\ B^0 \to K^0_S\pi^+\pi^-$ ($BABAR$ 231.8 ± 2.5)
		$-0.30 \pm 0.11 \pm 0.03$	$DPTD\ B^0 \to K^+\pi^-\pi^0$ ($BABAR$ 454.0 ± 2.5)
	$8.4 \pm 1.1^{+1.0}_{-0.9}$		$DPTI\ B^0 \to K^0\pi^+\pi^-$ ($BELLE$ 388.0)
	$14.8^{+4.6+1.5+2.4}_{-4.4-1.0-0.9}$		$Q2B\ B^0 \to K^+\pi^0\pi^-$ ($BELLE$ 85.0)
$B^0 \to K^{*0}\pi^0$	$3.6 \pm 0.7 \pm 0.4$	$-0.09^{+0.21}_{-0.24} \pm 0.09$	$DP\ B^0 \to K^+\pi^-\pi^0$ ($BABAR$ 231.8 ± 2.6)
		$-0.15 \pm 0.12 \pm 0.02$	$DP\ B^0 \to K^+\pi^-\pi^0$ ($BABAR$ 454.0)
	$0.4^{+1.9}_{-1.7} \pm 0.1$		$Q2B\ B^0 \to K^+\pi^-\pi^0$ ($BELLE$ 85.0)
$B^+ \to K^{*0}\pi^+$	$10.8 \pm 0.6^{+1.1}_{-1.3}$	$0.032 \pm 0.052^{+0.16}_{-0.13}$	$DP\ B^+ \to K^+\pi^-\pi^+$ ($BABAR$ 383.2 ± 4.2)
	$9.7 \pm 0.6^{+0.8}_{-0.9}$	$-0.149 \pm 0.064 \pm 0.02^{0.008}_{0.008}$	$DPTI\ B^+ \to K^+\pi^-\pi^+$ ($BELLE$ 386.0)
		$-0.032 \pm 0.059^{0.044}_{0.033}$	$I. Adachi et al. BELLE-CONF-0827(2008)$
$B^+ \to K^{*+}\pi^0$	$6.9 \pm 2.0 \pm 1.3$	$0.04 \pm 0.29 \pm 0.05$	$Q2B\ B^+ \to K^+\pi^-\pi^0$ ($BABAR$ 232.0)

DP = Dalitz analysis

$Q2B$ = Quasi two body analysis

TD = Time dependent analysis

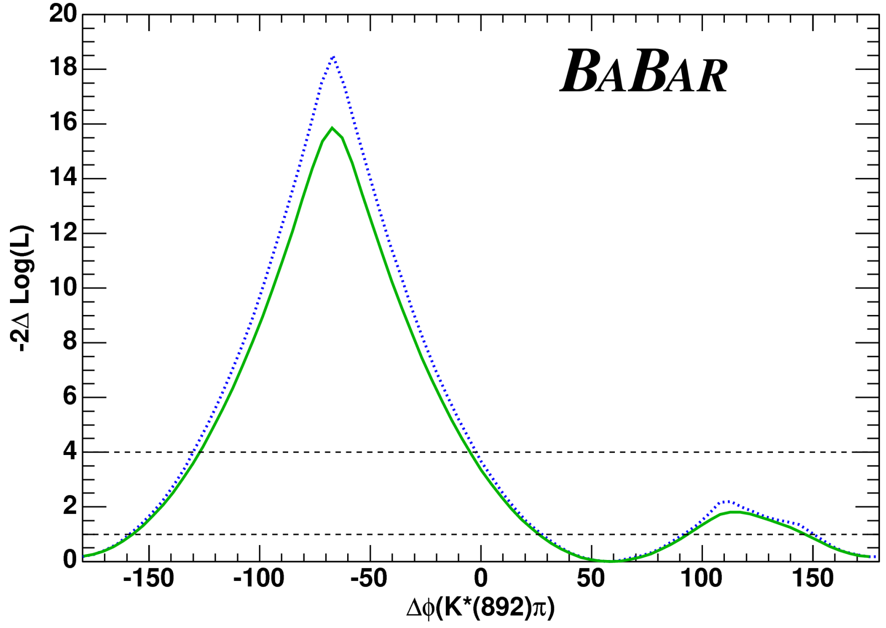
TI = Time integrated analysis

Experimental results for $K^*\pi$ system

$\Delta\phi = \arg((q/p)A(B^0 \to K^{*-}\pi^+)A^*(B^0 \to K^{*+}\pi^-))$

- $|A_{ij}| \leftrightarrow$ BRs well measured
- $\Delta\varphi$ obtained from Dalitz $B^0 \to K^0_S\pi^+\pi^-$:

$B^0 \to K^0_S\pi^+\pi^-$, see Alejandro's talk



$|A_{ij}| \leftrightarrow$ BRs well measured

- φ and $\overline{\varphi}$ obtained from Dalitz $B^0 \to K^+\pi^-\pi^0$:

The best solution is separated by 3.9 units of NLL from the next best solution

$B^0 \to K^+\pi^-\pi^0$ arXiv:0807.4567

$\Delta\phi = \arg(A(B^0 \to K^{*0}\pi^0)A^*(B^+ \to K^{*+}\pi^-))$
$= (-5.2 \;^{+/-}\; 24.6)^\circ$ (stat. + syst.)

$\Delta\phi = \arg(A(B^0 \to K^{*0}\pi^0)A^*(B^+ \to K^{*-}\pi^+))$
$= (-21.2 \;^{+/-}\; 29.2)^\circ$ (stat. + syst.)

$\Delta\phi = \arg(A(B^+ \to K^{*0}\pi^+)A^*(B^+ \to K^{*+}\pi^0))$ and

$\Delta\phi = \arg(A(B^- \to K^{*0}\pi^-)A^*(B^- \to K^{*-}\pi^0))$ from $B^+ \to K^0\pi^+\pi^0$

Ongoing Analysis.

Isospin $K^*\pi$: exploring hadronic parameters

Using $K^*\pi$ experimental inputs in a two step approach:

- Using Fit standard results on CKM parameters we make scans on the hadronic parameters.
- Using some theoretical hypothesis, a scan on the $\rho-\eta$ plane.

$$P_{EW} = P^{C}_{EW} = 0$$

SU(3) limit for the color-allowed electroweak penguin amplitude, which we call "IPLL":

$$P_{EW} = R^{+}(T^{+-}+T^{00})$$

with $R^{+} = (1.35 \pm 0.25) \times 10^{-2}$

Errors suggested by Jerome Charles (also use a 100% error)

Always, the A and λ parameters are fixed.

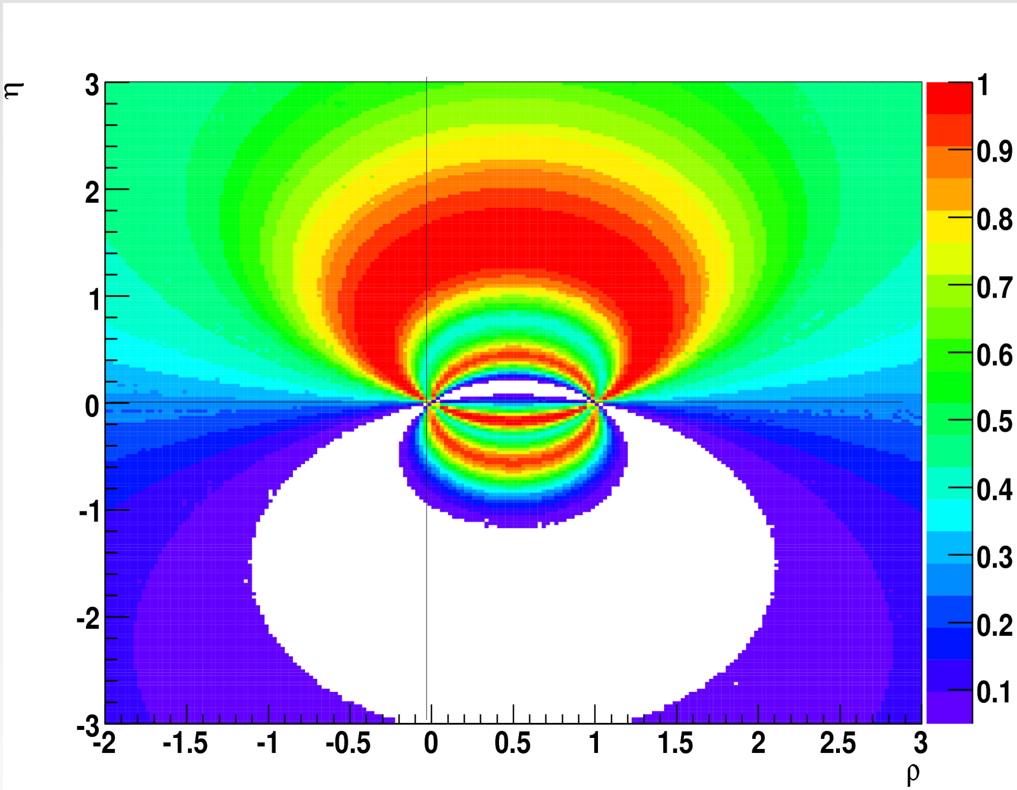
Same hypothesis will be tested for $K\rho$ system

Constrain in ρ-η plane using $K^*\pi$ neutral modes

Isospin $K^*\pi$ exploring hadronic parameters: Results of measurement of α

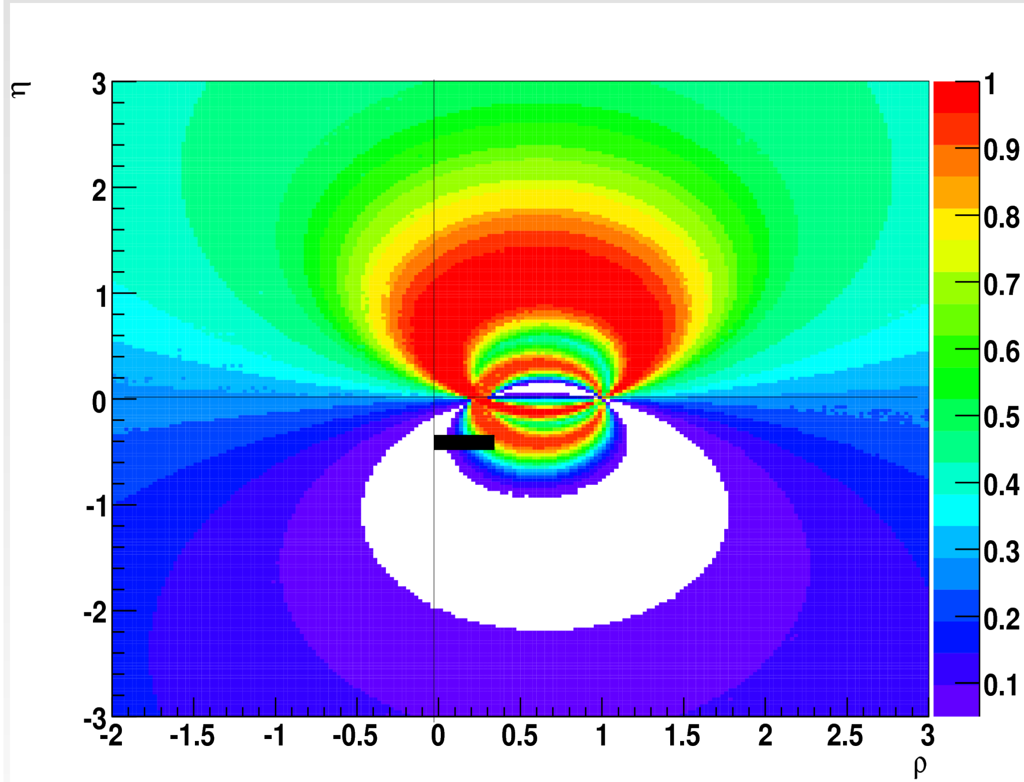
Taking the $B^0 \to K^{*+}\pi^-$ and $B^0 \to K^{*0}\pi^0$ subsystems

$\rho-\eta$ scan $P_{EW} = 0$



"Nir Quinn"

$\rho-\eta$ scan IPLL



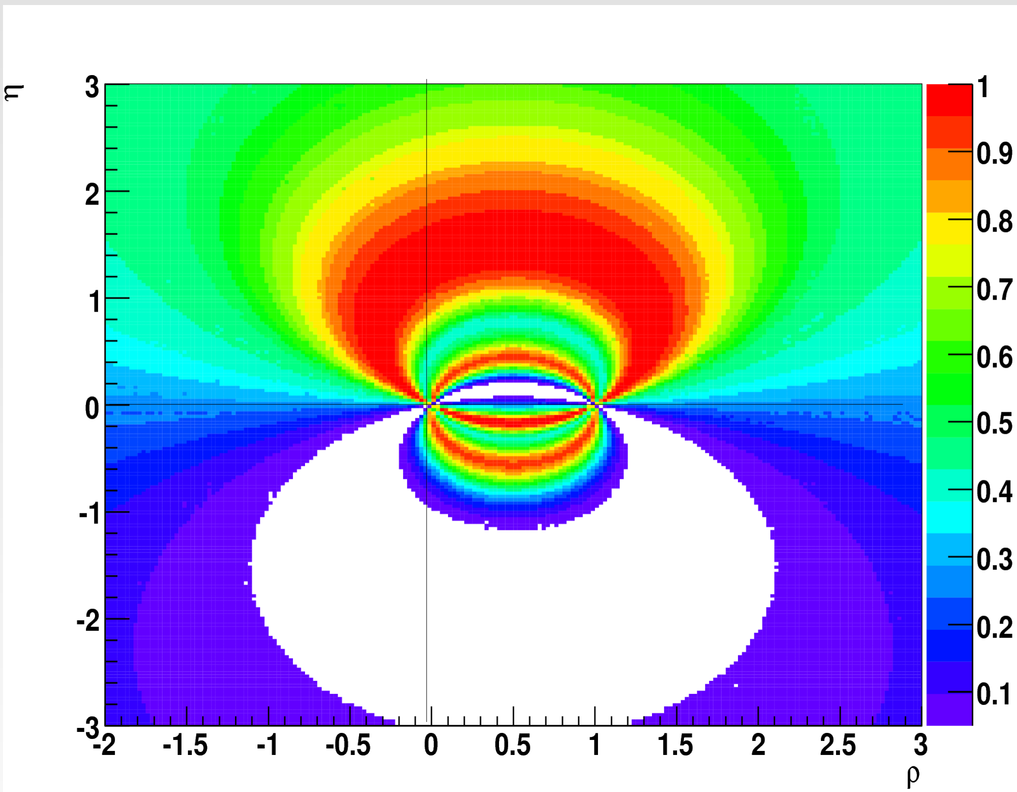
The shift is due to Pew≠0

CL>5%

Isospin $K^*\pi$ exploring hadronic parameters: Results of measurement of α

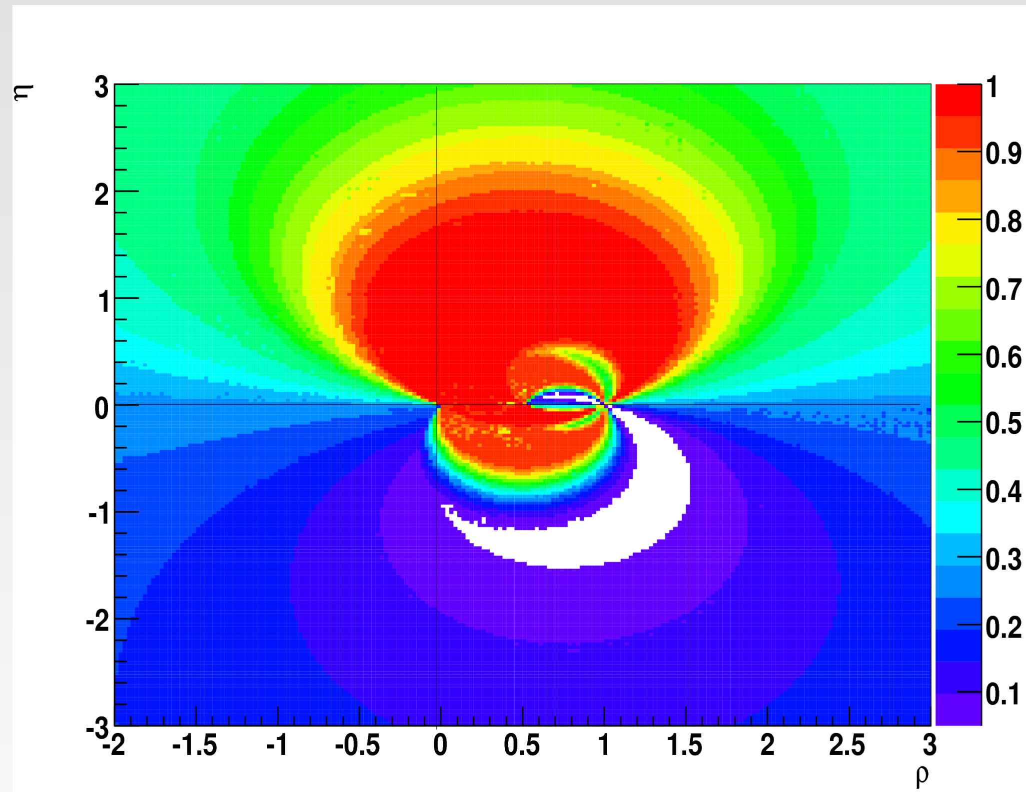
Taking the $B^0 \to K^{*+}\pi^-$ and $B^0 \to K^{*0}\pi^0$ subsystems

$\rho-\eta$ scan $P_{EW} = 0$



"Nir Quinn"

$\rho-\eta$ scan IPLL 100% of error



A more complicated constrain

CL>5%

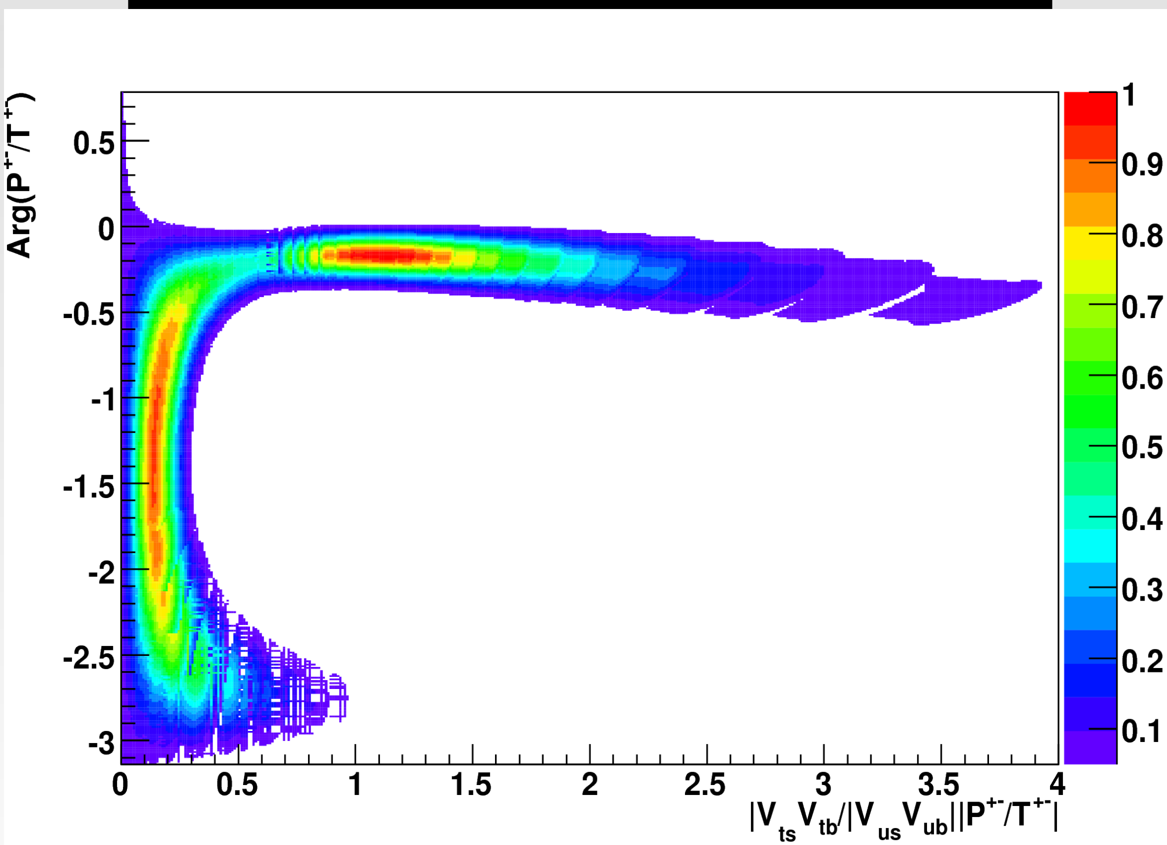
Exploring hadronic parameters using the complete $K^*\pi$ system

Isospin $K^*\pi$: exploring hadronic parameters

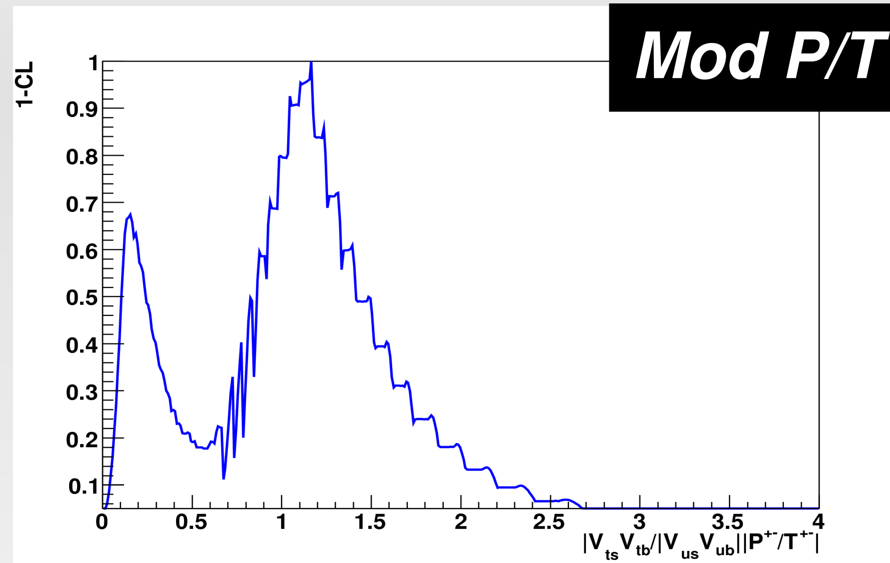
Taking the whole $B\to K^*\pi$ system

CL>5%

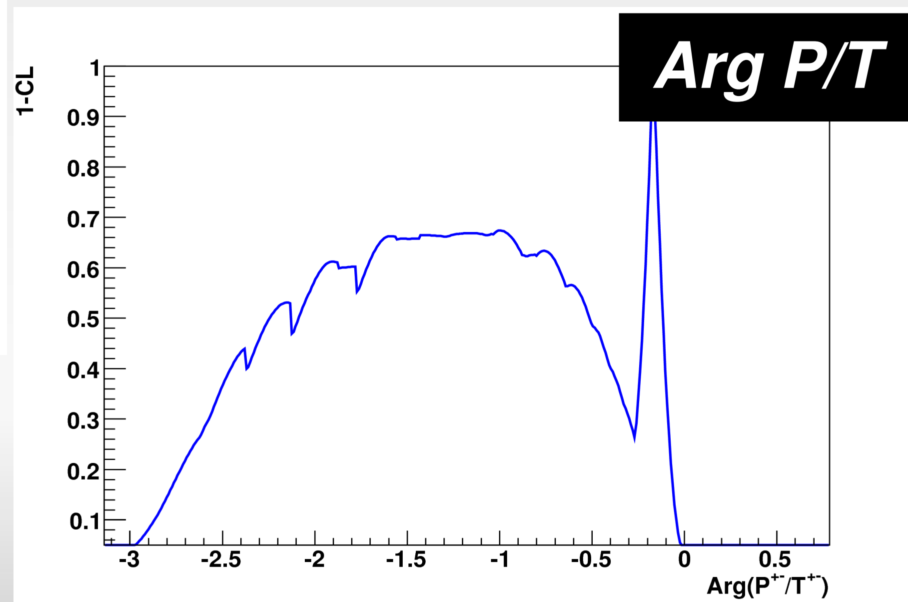
Mod Arg P/T scan



Mod P/T



Arg P/T

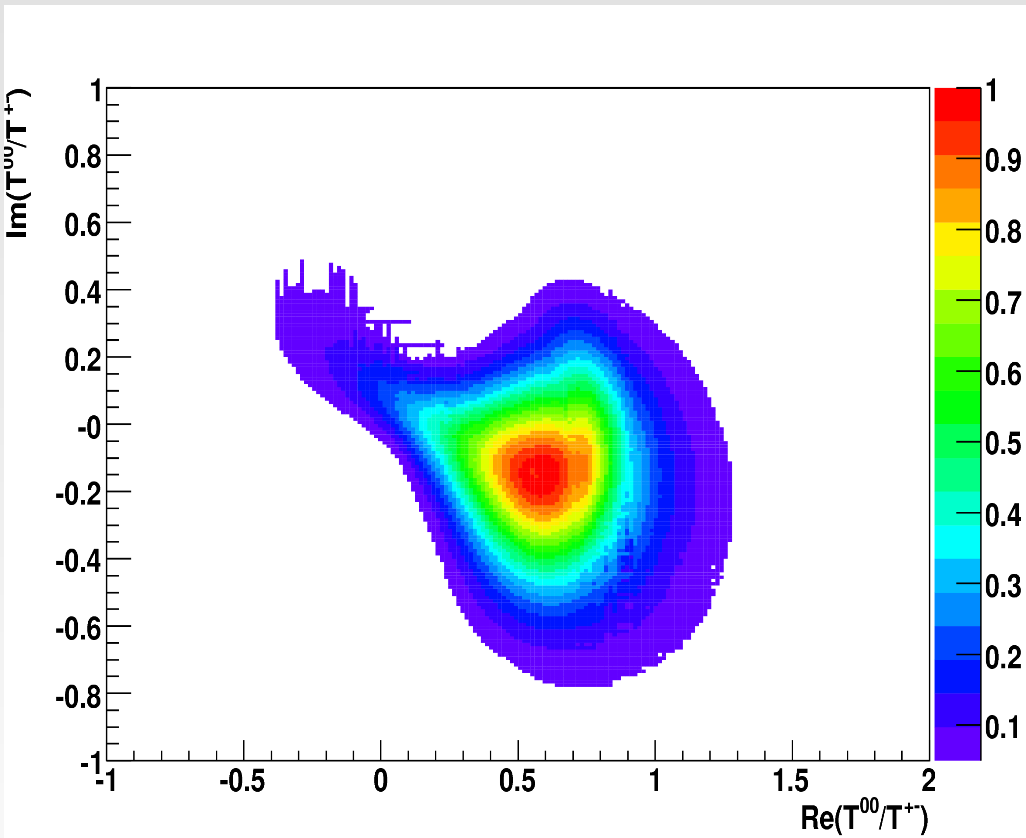
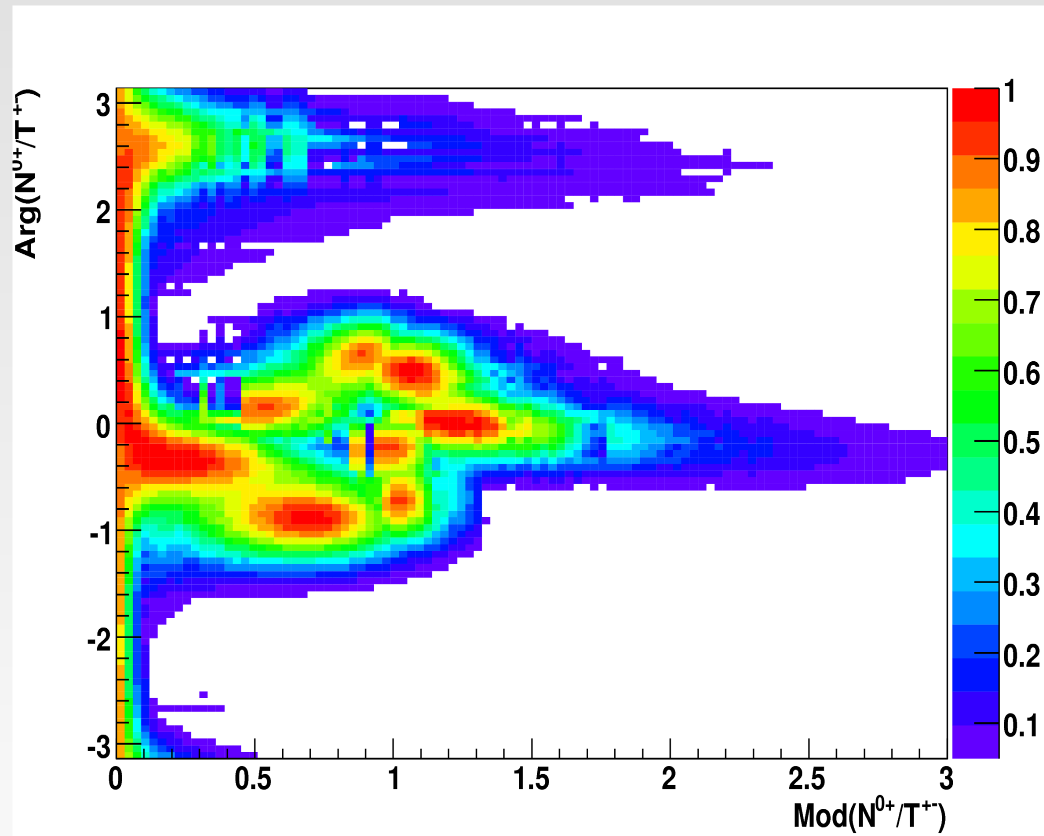


2 solutions |P/T|~1 and |P/T|~0.2
Bound in |P/T| < 2.5
Negative solutions preffered

Isospin $K^*\pi$: exploring hadronic parameters

Taking the whole $B \to K^*\pi$ system

CL>5%

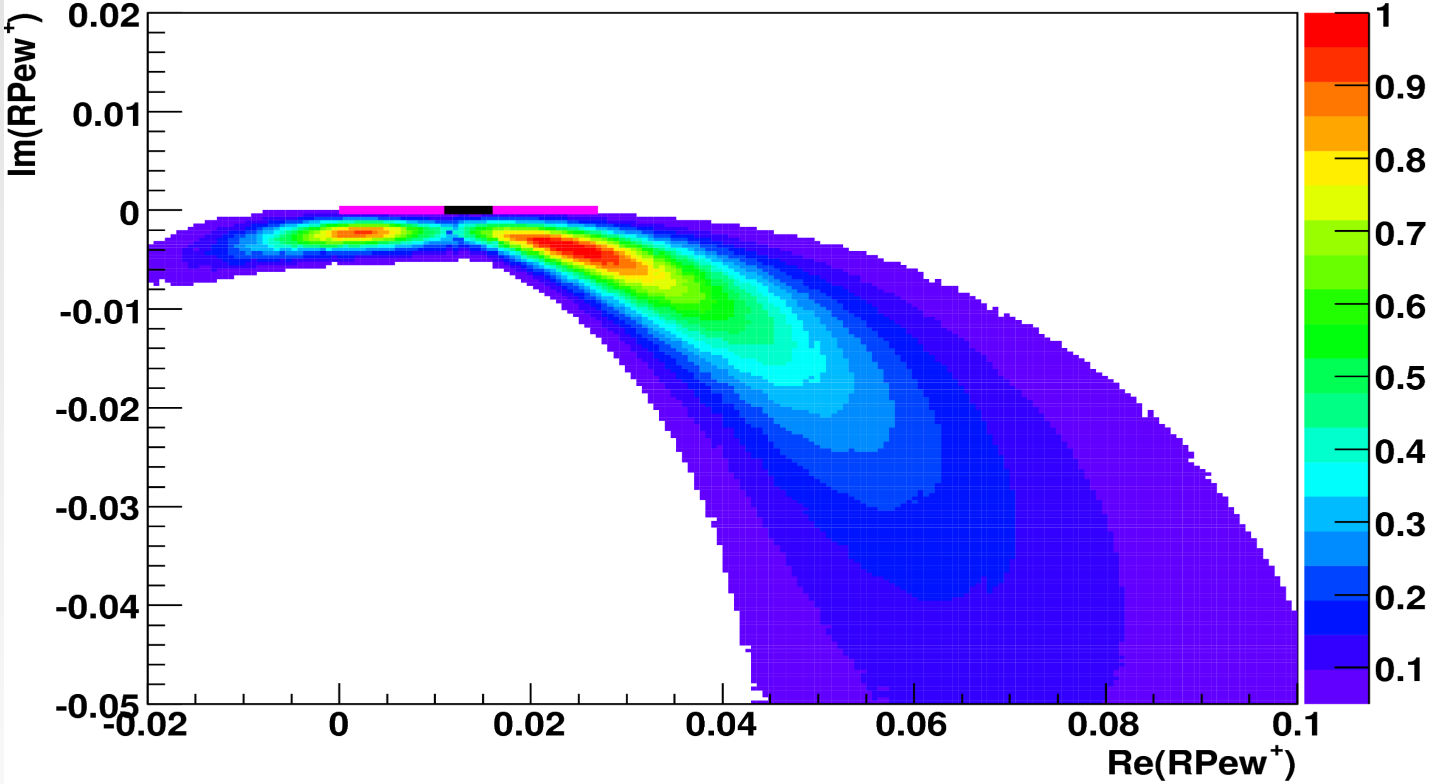
ReIm T^{00}/T scan	***Mod Arg N^{0+}/T scan***
	
The solution prefer IV quadrant because $C(K^{*0}\pi^0)$ is at ~1σ	**Bound in $\|N^{0+}/T\| < 2.5$**

Isospin $K^*\pi$: exploring hadronic parameters

Taking the whole $B \to K^*\pi$ system

CL>5%

ReIm R+ scan



IPLL aproximation

IPLL aproximation 100% of error

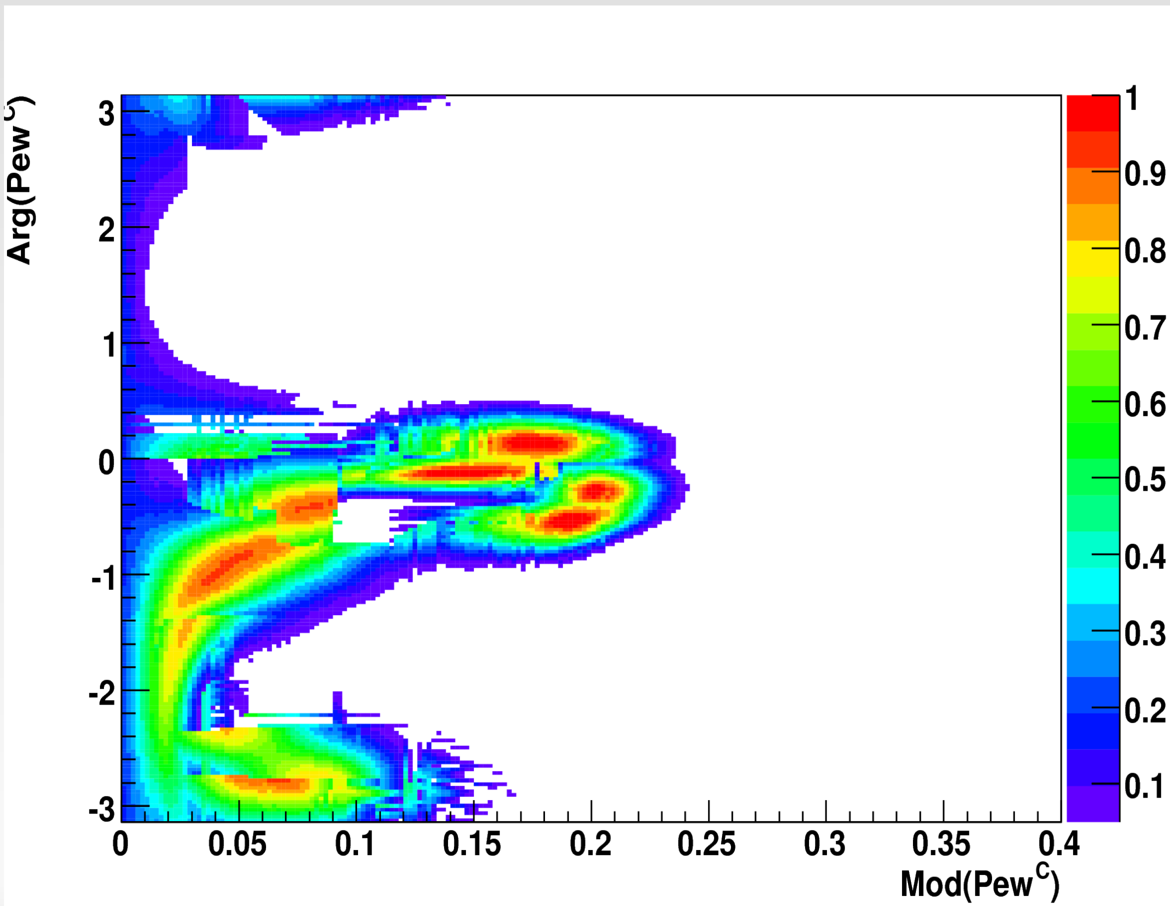
There are two solutions due to the two minimum of the phase difference $\Delta\phi = arg((q/p)A(B^0 \to K^{*-}\pi^+)A^*(B^0 \to K^{*+}\pi^-))$. Imaginary component different from 0.

Isospin K*π: exploring hadronic parameters

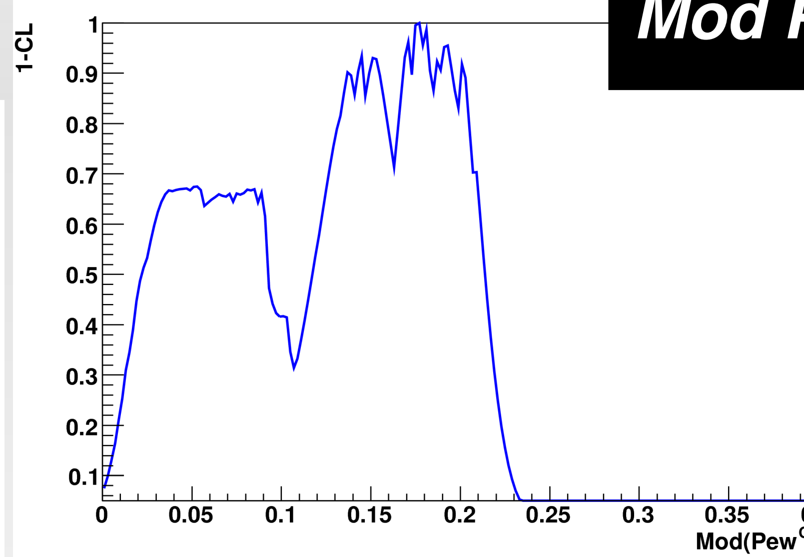
Taking the whole $B \to K^* \pi$ system

CL>5%

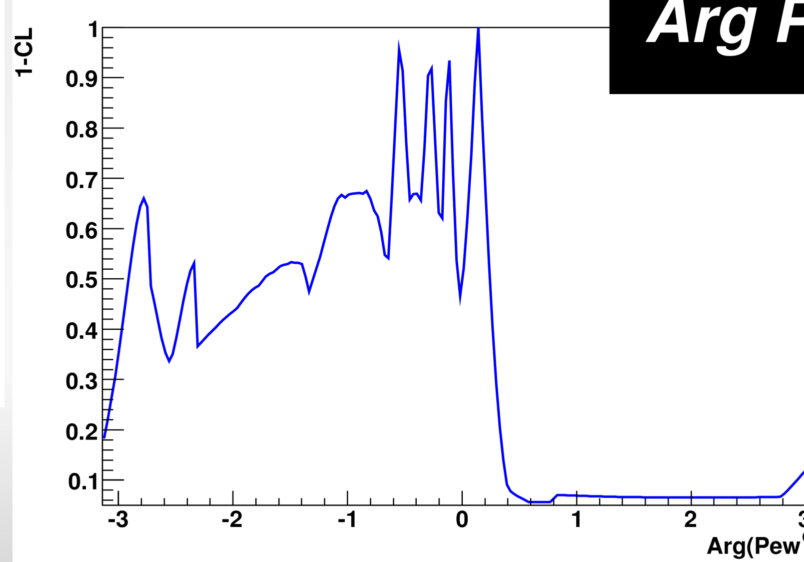
Mod Arg P^c_{ew} scan



Mod P^c_{ew}



Arg P^c_{ew}



There is a bound in $|P^c_{ew}| < 0.25$

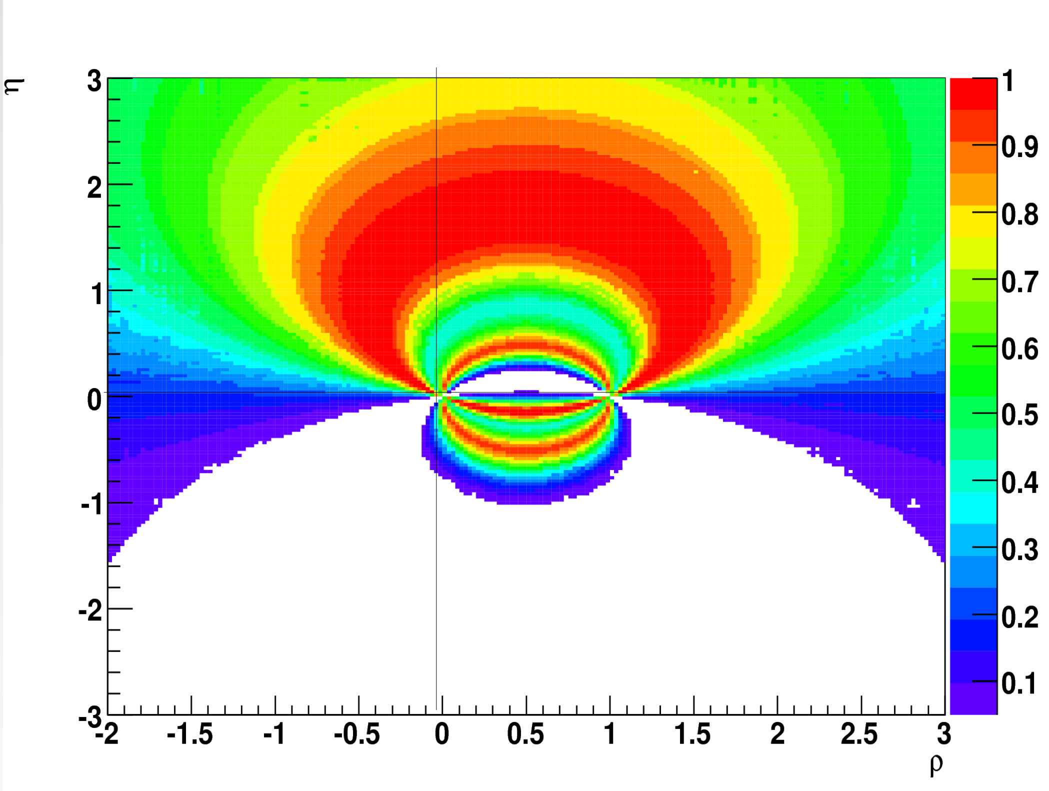
Bal

Constrain in ρ-η plane using the complete $K^*\pi$ system

Isospin $K^*\pi$ exploring hadronic parameters: Results of measurement of α

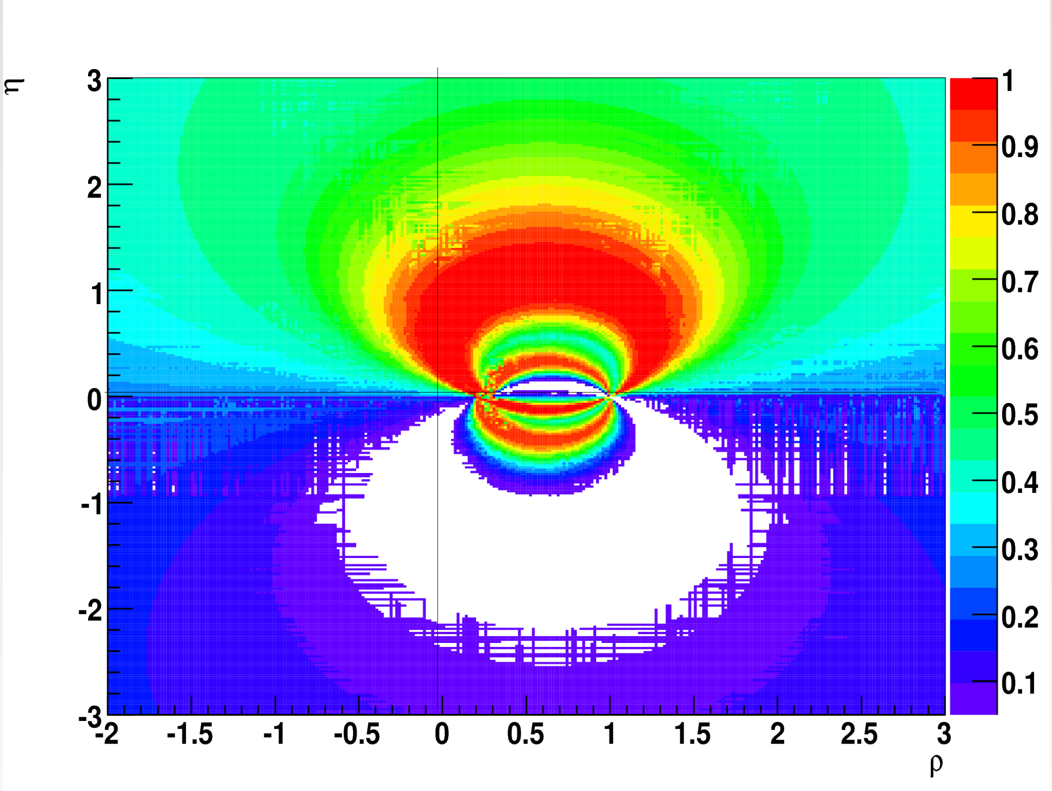
Taking the whole $B \to K^*\pi$ system

$\rho-\eta$ scan $P_{EW} = P^c_{EW} = 0$



Constrain in (ρ,η) plane

$\rho-\eta$ scan IPLL



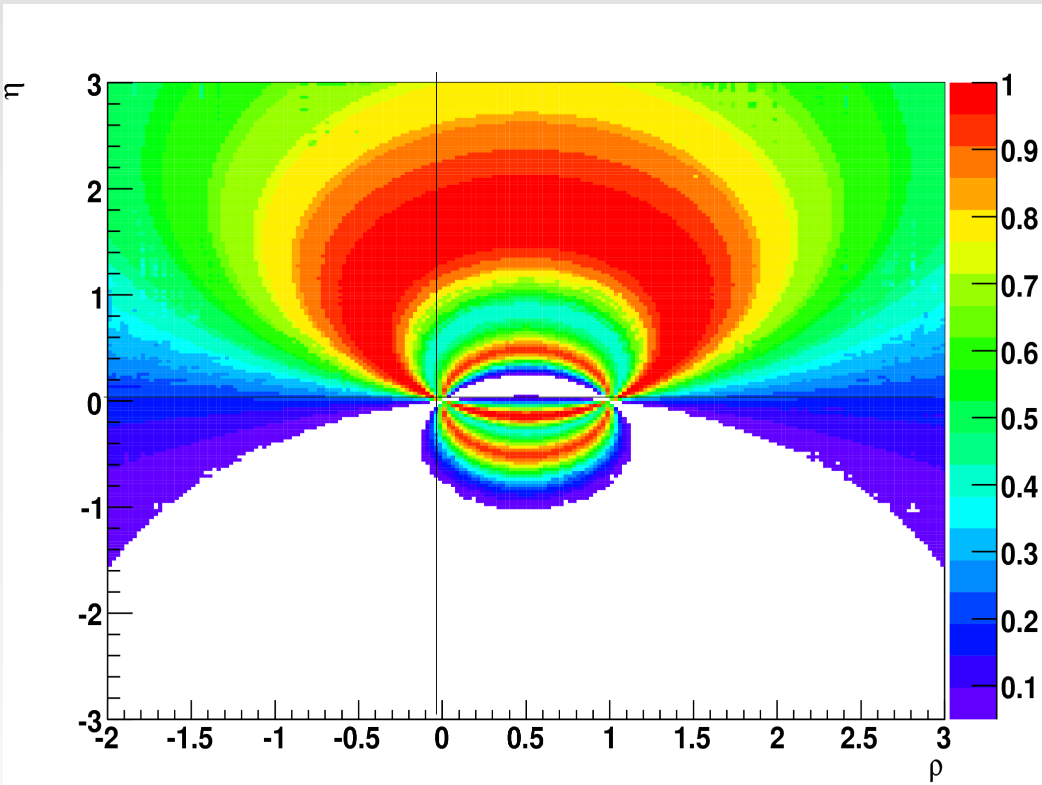
A more complicated constrain

CL>5%

Isospin $K^{*}\pi$ exploring hadronic parameters: Results of measurement of α

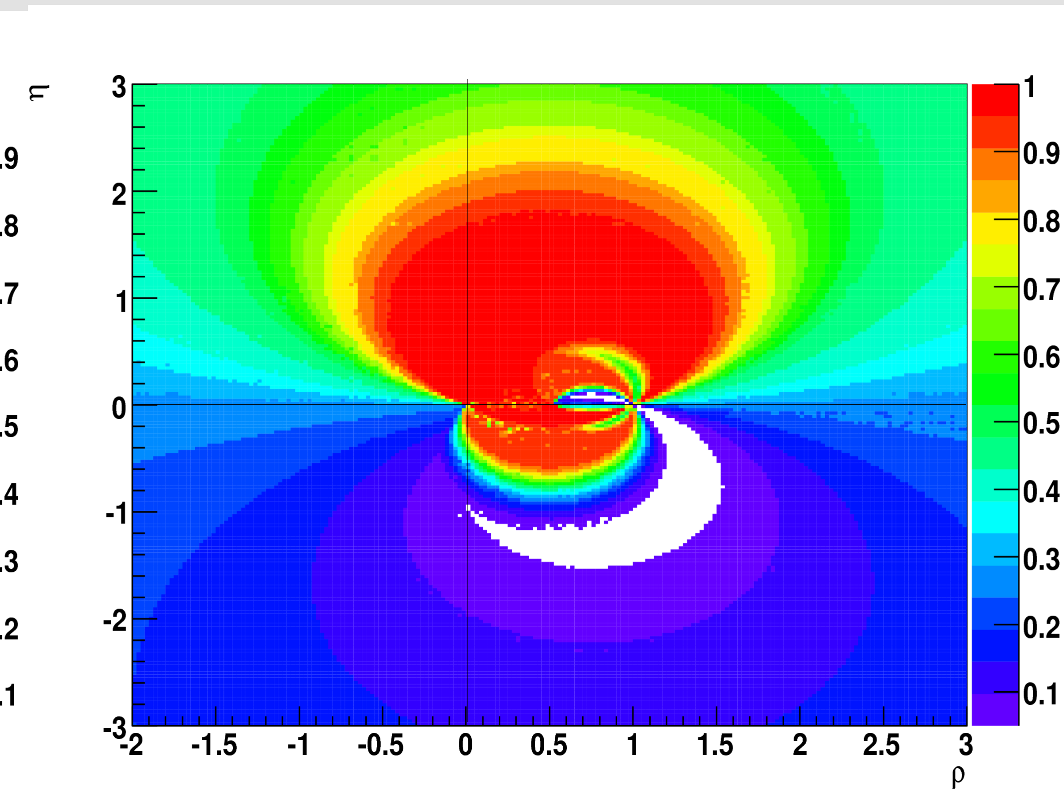
Taking the whole $B \rightarrow K^{*}\pi$ system

$\rho-\eta$ scan $P_{EW} = P^{c}_{EW} = 0$



Constrain in (ρ, η) plane

$\rho-\eta$ scan IPLL



A more complicated constrain

CL>5%

Isospin relations for the Kρ system

Same relations of are valid for the Kρ system:

$$A(B^0\to K^+\rho^-) = V_{us}V^*_{ub}T^{+-} + V_{ts}V^*_{tb}P^{+-}$$

$$A(B^+\to K^0\rho^+) = V_{us}V^*_{ub}N^{0+} + V_{ts}V^*_{tb}(-P^{+-}+P^C_{EW})$$

$$A(B^+\to K^+\rho^0) = V_{us}V^*_{ub}(T^{+-}+T^{00}-N^{0+}) + V_{ts}V^*_{tb}(P^{+-}-P^C_{EW}+P_{EW})$$

$$\sqrt{2}A(B^0\to K^0\rho^0) = V_{us}V^*_{ub}T^{00} + V_{ts}V^*_{tb}(-P^{+-}+P_{EW})$$

No other hypothesis than isospin is used

Observables:

- 4 BFs and 4 A_{CP} from DP and Q2B analyses.
- 1 phase difference:

  * $2\beta_{eff} = \arg((q/p)\bar{A}(\overline{B^0}\to K^0\rho^0)A^*(B^0\to K^0\rho^0))$ from $B^0\to K^0_S\pi^+\pi^-$

Only 9 observables. Less than in K*π

Isospin Kρ: experimental results

Table 2. Isospin ρK : experimental results

Channel	$B_J(10^{-6})$	A^J_{CP}	Analysis [Mevents]
$B^0 \to K^+\rho^-$	$8.0^{+0.8}_{-1.3} \pm 0.6$	$0.11^{+0.14}_{-0.18} \pm 0.07$	$DP\ B^0 \to K^+\pi^0\pi^-$ ($BABAR$ 231.8 ± 2.6)
		$0.14 \pm 0.06 \pm 0.01$	$DP\ B^0 \to K^+\pi^0\pi^-$ ($BABAR$ 454.0)
	$15.1^{+3.4+2.4}_{-3.3-2.6}$	$-0.22^{+0.22+0.06}_{-0.23-0.02}$	$DP\ B^0 \to K^+\pi^0\pi^-$ ($BELLE$ 78 fb^{-1})
$B^+ \to K^0\rho^+$	$8.0^{+1.4}_{-1.3} \pm 0.6$	$-0.12 \pm 0.17 \pm 0.02$	$Q2B$ ($BABAR$ 231.8 ± 2.6)
$B^+ \to K^+\rho^0$	$3.56 \pm 0.45 \pm^{+0.57}_{-0.46}$	$0.44 \pm 0.10^{+0.06}_{-0.14}$	$DP\ B^+ \to K^+\pi^-\pi^+$ ($BABAR$ 383.2 ± 4.2)
	$3.89 \pm 0.47^{+0.43}_{-0.41}$	$0.30 \pm 0.11^{+0.11}_{-0-05}$	$DP\ B^+ \to K^+\pi^-\pi^+$ ($BELLE$ 386.0)
		$0.405 \pm 0.101^{+0.036}_{-0.077}$	$I.Adachi et al. BELLE-CONF-0827(2008)$
$B^0 \to K^0\rho^0$	$4.9 \pm 0.8 \pm 0.9$		$Q2B$ ($BABAR$ 227.0)
		$0.02 \pm 0.27 \pm 0.08 \pm 0.06$	$DP\ B^0 \to K^0\pi^-\pi^+$ ($BABAR$ 383.0)
	$6.1 \pm 1.0^{+1.1}_{-1.3}$		$DP\ B^0 \to K^0\pi^-\pi^+$ ($BELLE$ 388.0)
		$-0.03^{+0.24}_{-0.23} \pm 0.11 \pm 0.11$	CKM 2008 $BELLE$

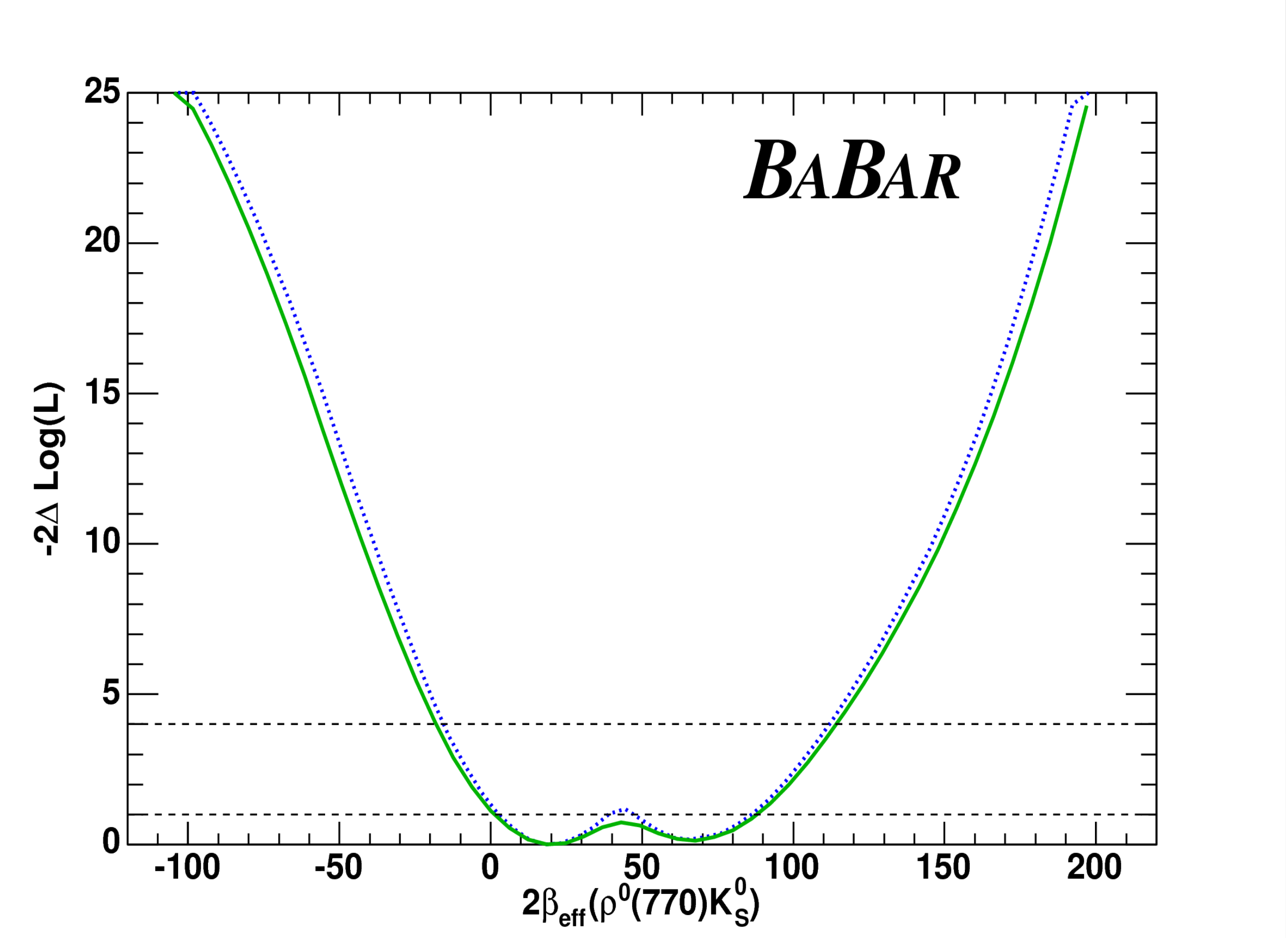
DP = Dalitz analysis

Q2B = Quasi two body analysis

$2\beta_{eff}$ from time-dependent DP analysis: $K^0_S\pi^+\pi^-$

- $|A_{ij}| \leftrightarrow$ BRs well measured
- $\Delta\varphi$ obtained from Dalitz $B^0 \to K^0_S\pi^+\pi^-$

$2\beta_{eff}(\rho^0(770)K^0)$



Exploring hadronic parameters using ρK whole system

$K\rho$ Isospin relations: 11 QCD and 2 CKM = 13 parameters and just 9 observables

In this case we don't have enough information to obtain contrains. Additional hadronic hypothesis would be needed. It is a pity because there is a direct CP violation in the mode $K^{+}\rho^{0}$

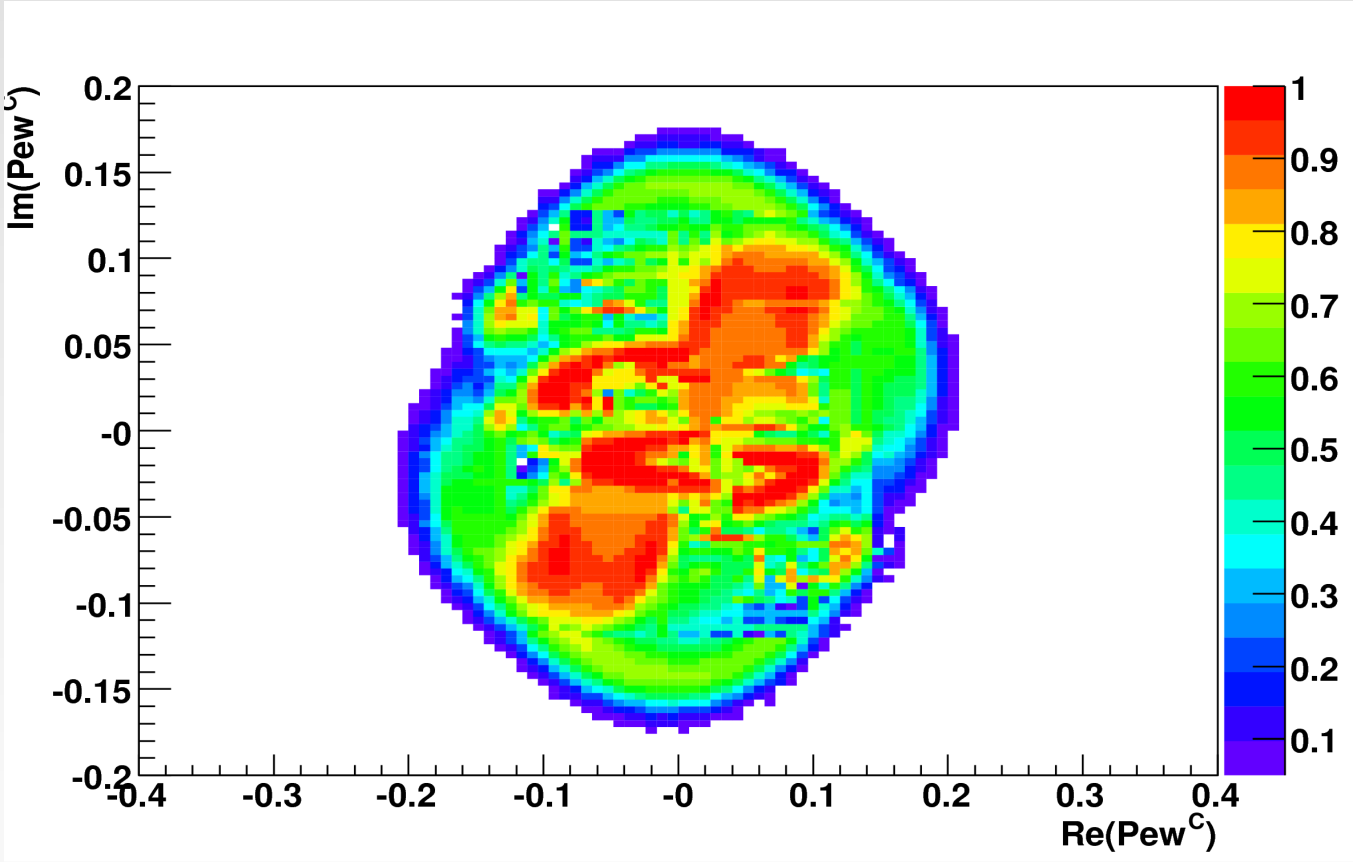
Most of the constrains observed in hadronic parameters were soft in Modules but strong in Arguments due to CPV in mode $K^{+}\rho^{0}$

Isospin ρK: exploring hadronic parameters

Taking the whole $B \to \rho K$ system

Re Im P^c_{ew} scan

Assuming also IPLL



There is a bound in $|P^c_{ew}| < 0.25$

CL>5%

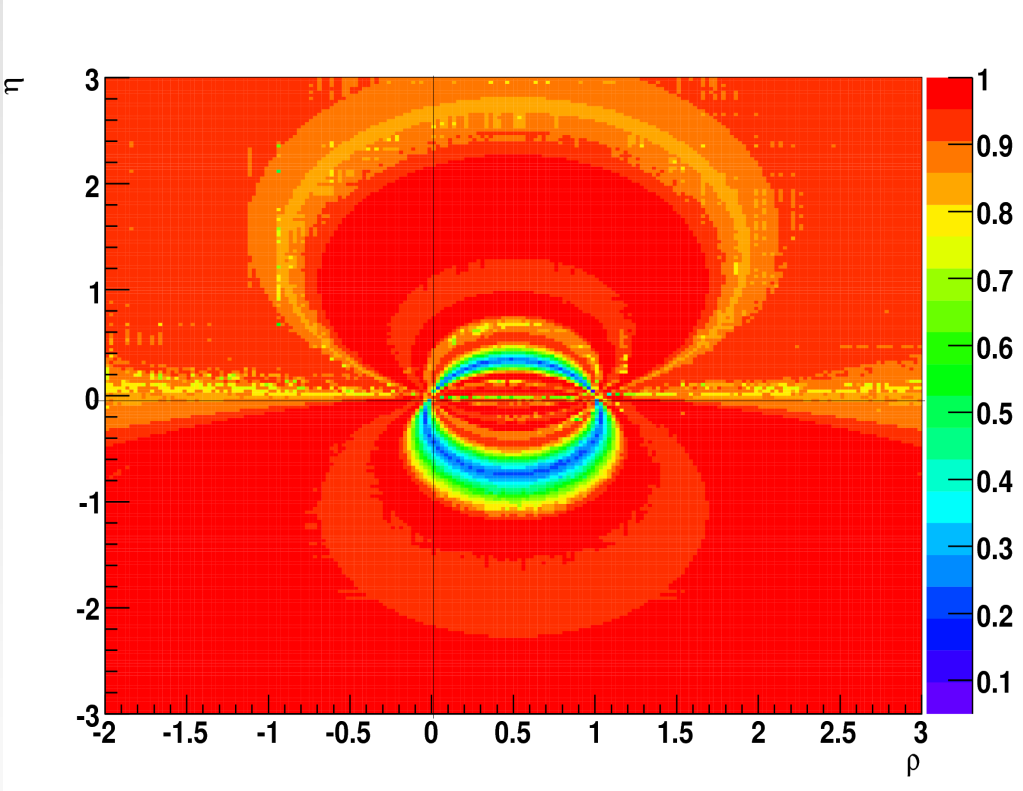
Constrain in ρ-η plane using ρK whole system

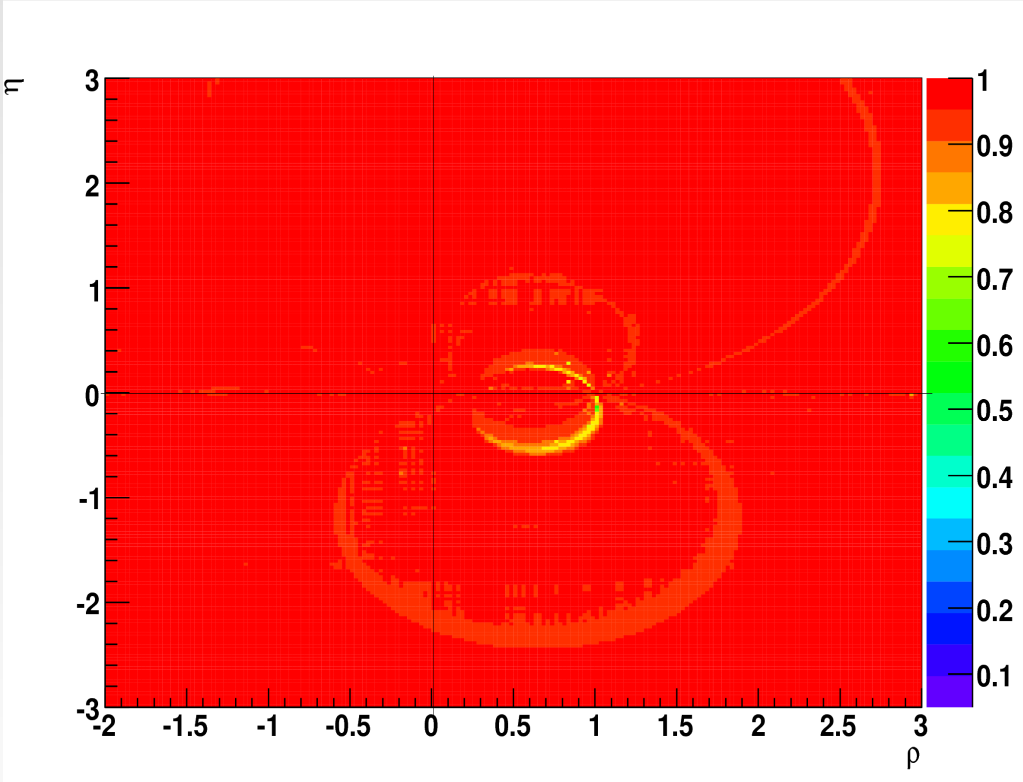
Isospin ρK: exploring hadronic parameters

Taking the whole $B \to \rho K$ system

$\rho-\eta$ scan $P_{EW} = 0$

$\rho-\eta$ scan IPLL 100%





Constrain in (ρ,η) plane

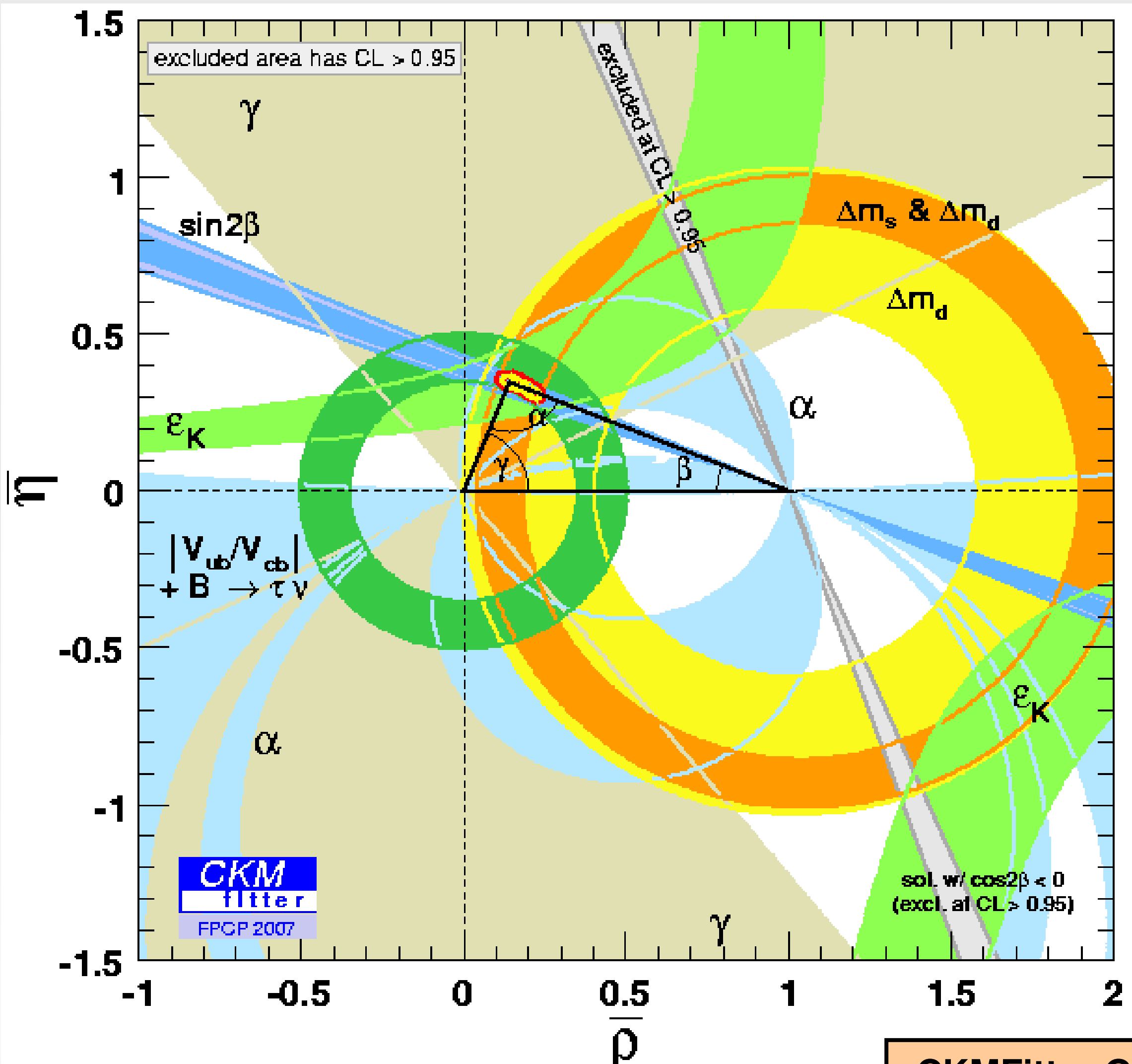
Only 9 available observables, so it isn't possible to obtain a constrain only with one hadronic hyphotesis

Conclusions and Perspectives

- $K^*\pi$ has more observables than ρK
- Safer constrains on CKM parameters
- Interesting bounds on hadronics parameters with current data
- We plan to test other hadronic hypotheses (i.e. SU3 relations)
- We plan to make a prospective study...Ongoing
- The goal is to produce a CKMFitter note

Backup

CKM Matrix: Current knowledge



All measurement compatible between each other

(Compatible with SM)

Compare "pure tree" measurements with "pure loop" measurements

CKMFitter Group (J. Charles et al.) Eur. Phys. J. C41, 1-131 (2005)

Reparameterization Invariance

General $K^*\pi$ amplitudes (1):

$$A^{+-} = CKM_1 T^{+-} + CKM_2 P^{+-}$$
$$A^{0+} = CKM_1 T^{0+} + CKM_2 P^{0+}$$
$$A^{+0} = CKM_1 T^{+0} + CKM_2 P^{+0}$$
$$A^{00} = CKM_1 T^{00} + CKM_2 P^{00}$$

CP ⇔

General $K^*\pi$ amplitudes (2):

$$\bar{A}^{+-} = CKM^*_1 T^{+-} + CKM^*_2 P^{+-}$$
$$\bar{A}^{0+} = CKM^*_1 T^{0+} + CKM^*_2 P^{0+}$$
$$\bar{A}^{+0} = CKM^*_1 T^{+0} + CKM^*_2 P^{+0}$$
$$\bar{A}^{00} = CKM^*_1 T^{00} + CKM^*_2 P^{00}$$

Isospin relations:

$$A^{0+} + \sqrt{2}A^{+0} = \sqrt{2}A^{00} + A^{+-}$$
$$\bar{A}^{0+} + \sqrt{2}\bar{A}^{+0} = \sqrt{2}\bar{A}^{00} + \bar{A}^{+-}$$

For a given value of the A^{ij}/A^{ij} and a given value of CKM_k the ecuations (1) and (2) can always be inverted for the T^{ij} and P^{ij} in such a way to satisfy the Isospin relations.