The Future. . . ?!

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OUTLINE

1. Are kaons still intersting?
2. The near future
3. The far future

What did we learn from kaons

1. Flavor
2. $\not{P}$
3. $\Delta S = \Delta Q$
4. Dominance of $\Delta I = 1/2$

   still embarassing

5. Mixing ($\sin\theta_C$)
6. Quarks
7. $\not{C}\not{P}$

Other $\not{C}\not{P}$ Kaon Physics

1. $K_S \to \pi^0\pi^0\pi^0$, BR$\sim 2\times 10^{-9}$	NA48/1, KLOE 200?
2. Odd pion slopes from K^+ - K^-	NA48/2, KLOE 200?
3. $K \to \pi^+\pi^-\gamma$	NA48/2, KLOE 200?
4. $\Gamma(++-) \Leftrightarrow \Gamma(--+)$ etc.	KLOE 200?
5. $K_L \to \pi^0 e^+ e^-$, "SD"!	NA48/1, KLOE 200?
6. $K_L \to \pi^0 \nu\bar{\nu}$, BR$\sim 3\times 10^{-11}$	KLOE-DAΦNE– NO

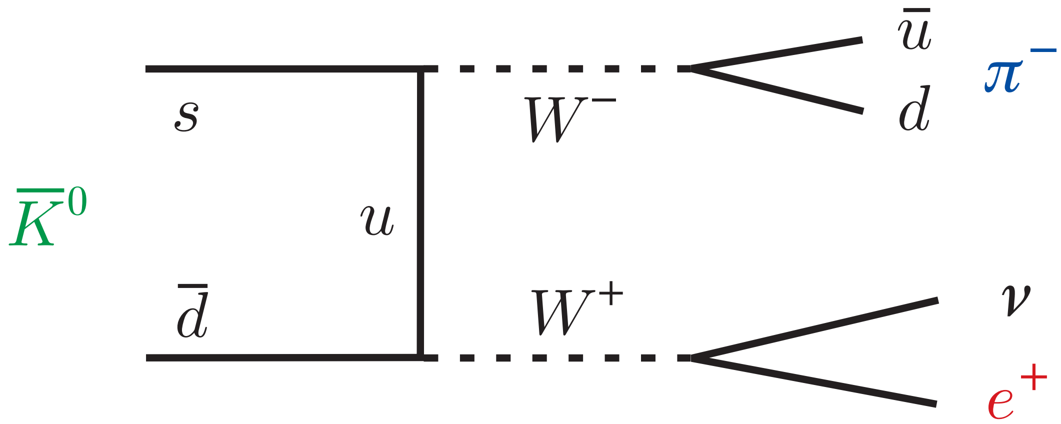
Important Things

1. Measure V_{ij}
2. Verify unitarity
3. Find $K_S \rightarrow \pi^0 \pi^0 \pi^0$
4. Study $K_S \rightarrow \pi \ell \nu$
5. Verify $\Delta S = \Delta Q$
6. Keep an eye on TCP
7. Hopefully peek beyond the SM

$\Delta S = \Delta Q$

There is no $\Delta S = -\Delta Q$ in the SM: $s \to W^- u$, $\bar{s} \to W^+ \bar{u}$

Fake $\Delta S = -\Delta Q$



$$x = \frac{A(\bar{K} \to \ell^+ \pi^- \nu)}{A(\bar{K} \to \ell^- \pi^+ \bar{\nu})} \sim G m^2 \sim 10^{-6}$$

Exp: $x < 10^{-2}$ @90% CL

NOT $x = \dfrac{A(\Delta S = -\Delta Q)}{A(\Delta S = \Delta Q)}$

1. $K_S \to \pi^0 \pi^0 \pi^0$

From K_S impurity:

BR=1.89×10^{-9}, uncertainty $\sim$1.3%, a must!!

2. $K^\pm \to 3\pi$

Let $\Gamma(K^+ \to \pi^+\pi^+\pi^-) \equiv \Gamma^+_{++-}$

then $\Gamma^+_{++-} - \Gamma^-_{--+} \neq 0 \Rightarrow \not{C}\not{P}$, etc.

3. Odd pion slope

$A = (g_+ - g_-)/(g_+ + g_-) \neq 0 \Rightarrow \not{C}\not{P}$

It has been said that finding a different answer would be proof that QM is no good (JE).

$K_S \rightarrow \pi\ell\nu$

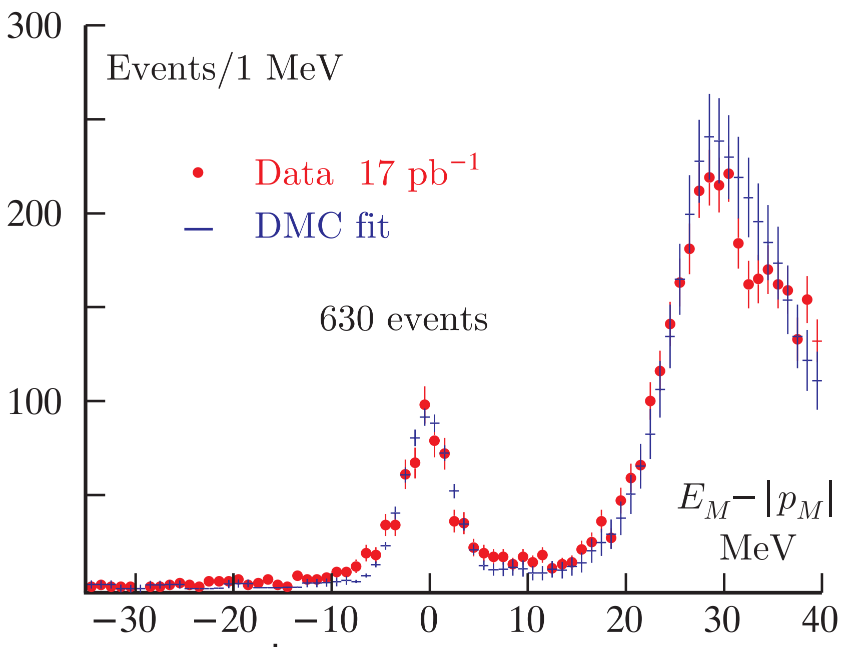
Learn about

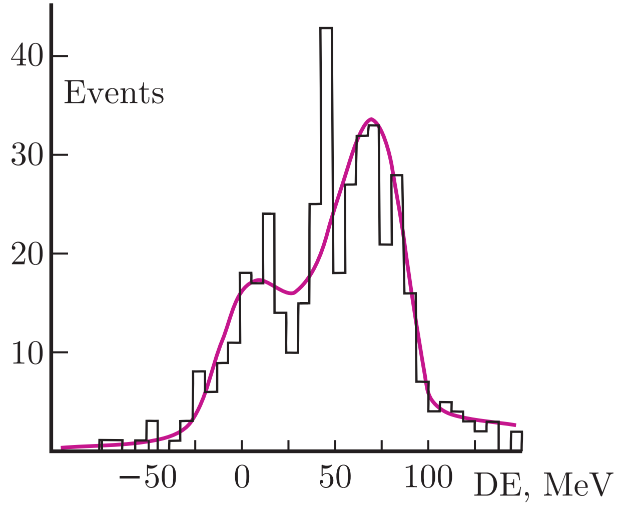
1. $\Delta S = \Delta Q$
2. TCP

by measuring

3. $\Gamma(K_S \rightarrow \pi\ell\nu)$
4. $\mathcal{A}_\ell^S$

KLOE 2000, 17 pb^{-1}





CMD-2 1998

ALSO

The first truly inclusive measurment of $\Gamma(K_S \to \pi^+\pi^-)/\ldots\pi^0\pi^0$

The first quantitative measurements of scalar's (and ps) properties.

KLOE 2001-2, 200+300 pb^{-1}

Absolute BR

$\mathcal{O}(10^{-3})$ accuracies on $K_S \to \pi^+\pi^-, \pi^0\pi^0$, $K_{L3}, K^{\pm}{}_{\pi2,..\ell3}$, all$+\gamma$

Radiation spectra

$\Delta S/\Delta Q$, $\mathcal{A}_S^{\ell}$

High precision in $\phi \to \gamma + ??$

$\sigma(e^+e^- \to \pi^+\pi^-\gamma + \mathrm{n}\gamma)$

The program remains valid up to about 2000 pb^{-1}. In particular one can measure $K_L \to \pi^+\pi^-, \pi^0\pi^0$ which are poorly known..

$\Re(\epsilon'/\epsilon)$requires at least 20,000 pb^{-1} to be significant today

Moving up to 100 or more fb^{-1} opens really new fields. Like measuring $\delta = \epsilon_S - \epsilon_L$ to maybe $\ll 10^{-4}$. This by the way means reaching $\Delta M_K/M_K >/< M_K/M_{\text{Planck}}$

It might finally become feasible to measure slope and rate asymmetries in τ, τ', measure well $K_S \to \pi^0\pi^0\pi^0 \ldots$, another number which is quite well known in the SM.

1

2

Conclusions

DAΦNE is beginning to show promise.

KLOE has begun its program.

Major DAΦNE upgrades in 2002.

$$TCP \text{ and } \Delta S = \Delta Q$$

$$K \to \pi \ell \nu$$

$$\Gamma(K_S \to \pi \ell \nu) = \Gamma(K_L \to \pi \ell \nu)$$

Leptonic Asymmetry

$$\mathcal{A}_\ell^S = \mathcal{A}_\ell^L$$

It is not possible to disentangle both within the K_S-K_L system.

It is necessary to combine with K^0 (or $\overline{K^0}$) states tagged by SI.

TCP can be violated in mass-matrix and/or decay amplitudes: 5 complex parameters for $K \to \pi \ell \nu$.

$$2\delta = \epsilon_S - \epsilon_L$$

$$a = A(TCP\text{-even},\ \Delta S = \Delta Q)$$

$$b = A(TCP\text{-odd},\ \Delta S = \Delta Q)$$

$$c = A(TCP\text{-even},\ \Delta S = -\Delta Q)$$

$$d = A(TCP\text{-odd},\ \Delta S = -\Delta Q)$$

Need *eg*, $e^+e^-\to\phi\to K^+K^-$. One K tags the other. Charge exchange in any material gives K^0(or $\overline{K^0}$).

If $c = d = 0$, then

$$\mathcal{A}_\ell^S - \mathcal{A}_\ell^L = 4\Re\delta$$

A limit from the above improves the determination of $\left(M(K^0) - M(\overline{K^0})\right)/M$

Need $n \times 10^{10}$ K's, thousands of pb^{-1}

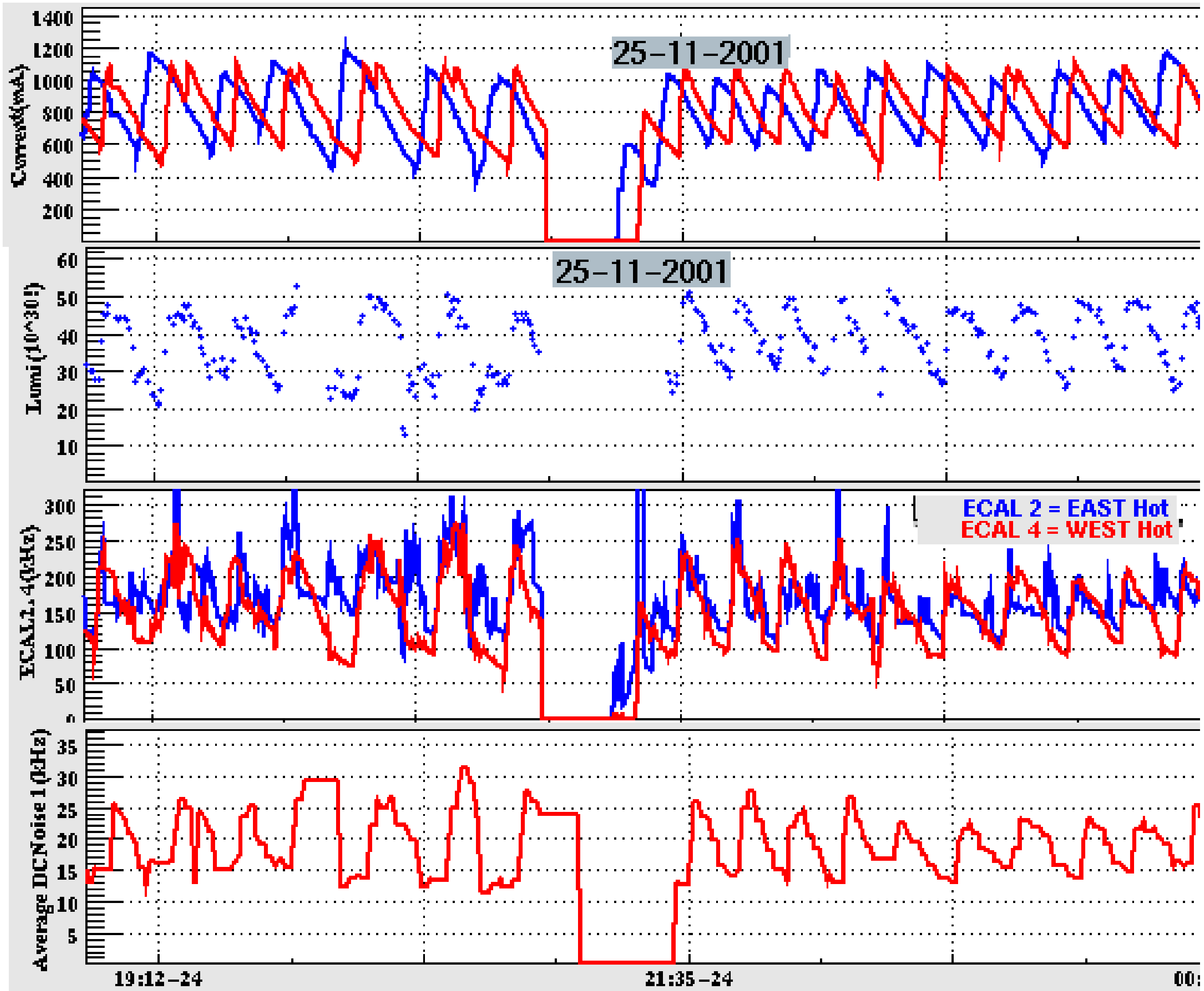
DAΦNE 2001

I ma

$\mathcal{L}$, μb^{-1} s^{-1}

Bckgnd kHz

DC Hits, kHz



DAΦNE 2002

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$\mathcal{L}$, μb^{-1} s^{-1}

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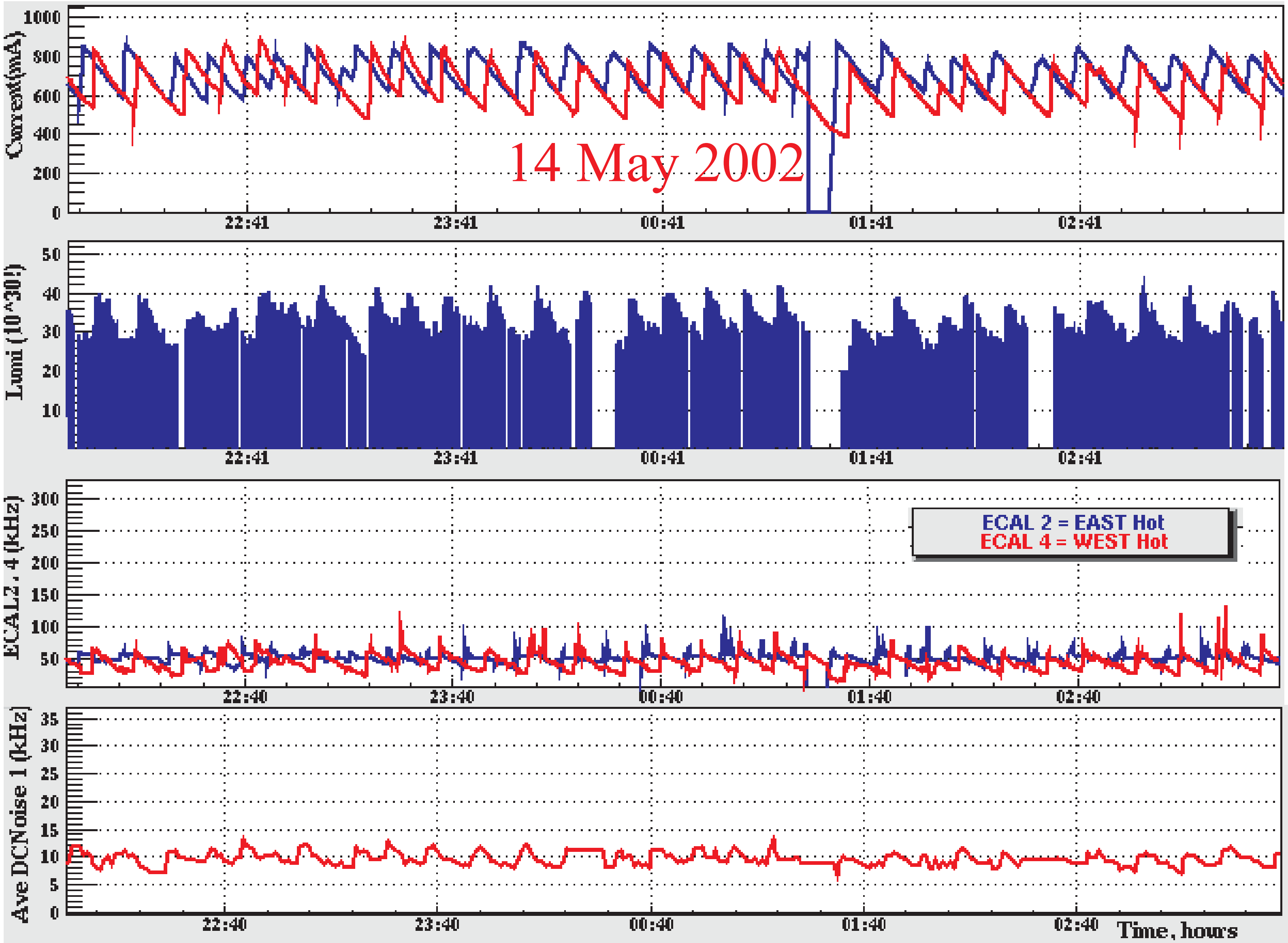


ϕ–decays

Mode	BR, %
K^+K^-	49.2
$K^0\overline{K}^0$	33.8
$\pi^+\pi^-\pi^0$	15.5
$\eta\gamma$	1.3
$\pi^0\gamma$	0.1
other	$<$0.1

$$\gamma\beta c\tau_L = 3.4 \text{ m}$$

Drives detector size

$$\gamma\beta c\tau_S = 5.6 \text{ mm}$$

Drives IP surroundings

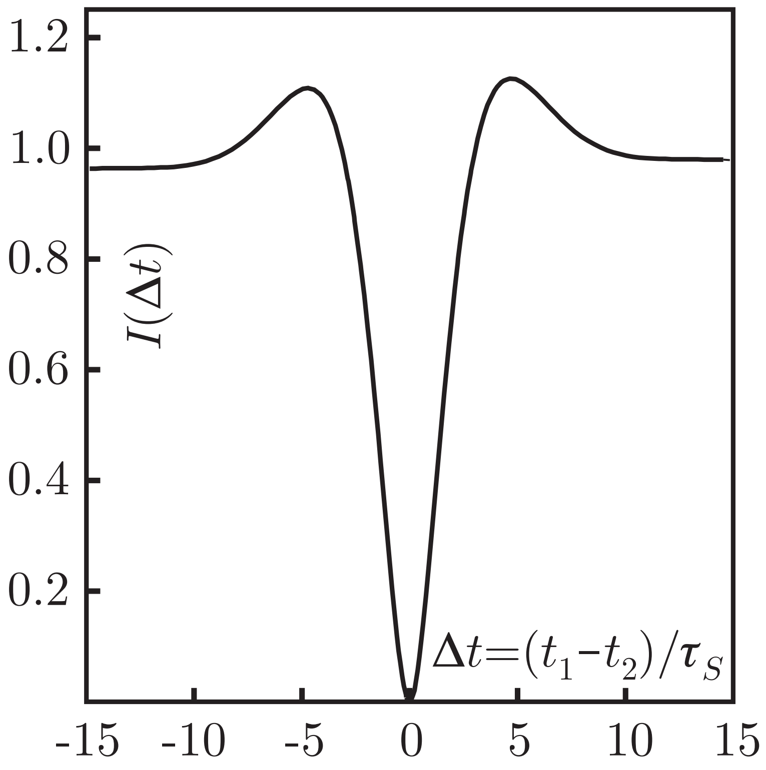
$$I(f_1,f_2,t_1,t_2) = |\langle\, f_1|\, K_S\,\rangle|^2 |\langle\, f_2|\, K_S\,\rangle|^2 e^{-\Gamma_S\, t/2} \times$$
$$[|\eta_1|^2 e^{\Gamma_S \Delta t/2} + |\eta_2|^2 e^{-\Gamma_S \Delta t/2} - 2|\eta_1||\eta_2| \cos(\Delta m\, t + \phi_1 - \phi_2)]$$

$$I(f_1,\ f_2;\ \Delta t) = \frac{1}{2\Gamma} |\langle f_1|\, K_S\,\rangle\langle f_2|\, K_S\,\rangle|^2 \times [|\eta_1|^2 e^{-\Gamma_L \Delta t} +$$
$$|\eta_2|^2 e^{-\Gamma_S \Delta t} - 2|\eta_1||\eta_2| e^{-\Gamma \Delta t/2} \cos(\Delta m \Delta t + \phi_1 - \phi_2)]$$

Measure ΔM, Γ, η_i – including phases.

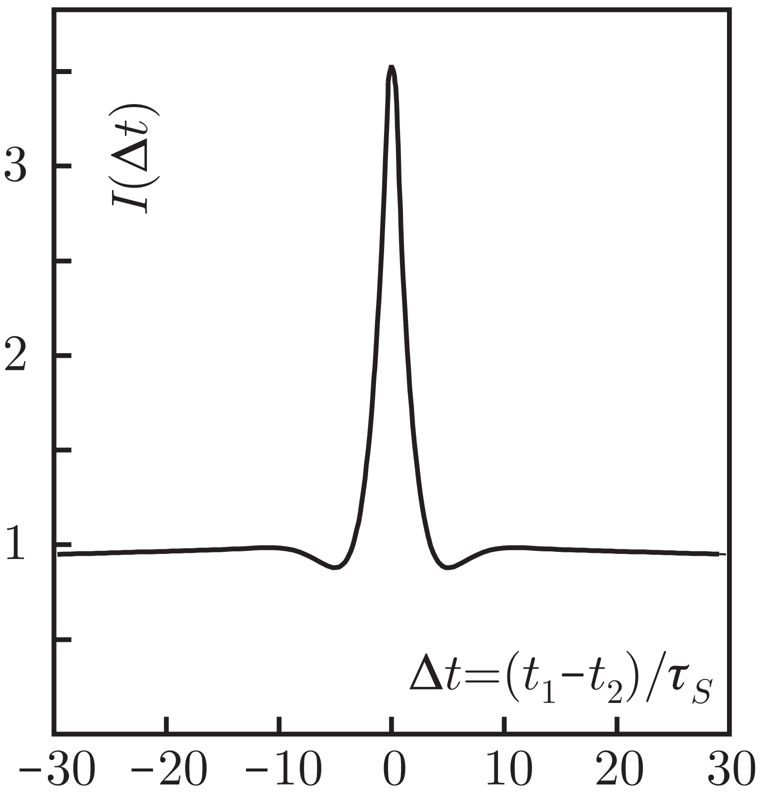
$$\eta_i = \frac{A(K_L \to i)}{A(K_S \to i)},\quad \arg(\eta) = \phi$$

Interference examples



$f_{1,2}{=}\pi^+\pi^-,\ \pi^0\pi^0$

$\Re(\epsilon'/\epsilon)$, $\Im(\epsilon'/\epsilon)$



$f_{1,2} = \ell^-, \ell^+$

$\Re$ and $\Im$ of $A_{\ell\pm}$