Is it possible to test Quantum correlations @ JHF?

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Introduction

CPLEAR

Other systems ?

KEK, Dec. 11, 2001

Quantum Entanglement

Fundamental importance

(EPR, Bell's Inequalities, GHZ equality, BKS contextuality)

Implications to Quantum computing & information theory

A little bit of History:

Einstein, Podolsky and Rosen Phys.Rev. 47 (1935) 777.

Physical reality and completeness of quantum mechanics

Schrödinger Proc. Camb. Phil. Soc. 31 (1935) 555.

Extension of EPR

Bohm Quantum theory (1951)

Dichotomic observables

Bell Physics 1, (1965) 195.

Inequalities based on local realism

Bell, Kochen and Specker *1960s*

Contextuality theorem

Clauser, Horne, Shimony and Holt *PRL 23 (1969) 880.*

Ratio measurements to test the EPR

Greenberger, Horne and Zeilinger

Bell's theorem Quantum Theory And Conceptions of the Universe (1989)

Three spin 1/2 particles and compatible observables.

R. P. Feynmann *Int. J. Theor. Phys. 21, 467 (1982).*

Simulation of quantum mechanial objects

David Deutsch *Proc. R. Soc. London A 400, 97 (1985)*

Universal quantum computer

Peter Shor *Foundations of Computer Science (1994)*

Quantum algorithm for efficient factorization

Lov Grover *ACM symposium 1996*

A fast quantum mechanical algorithm for database search.

Cory, Fahmy and Havel *Proc. Natl. Acad. Sci (1997)*

Prototype quantum computer .....?

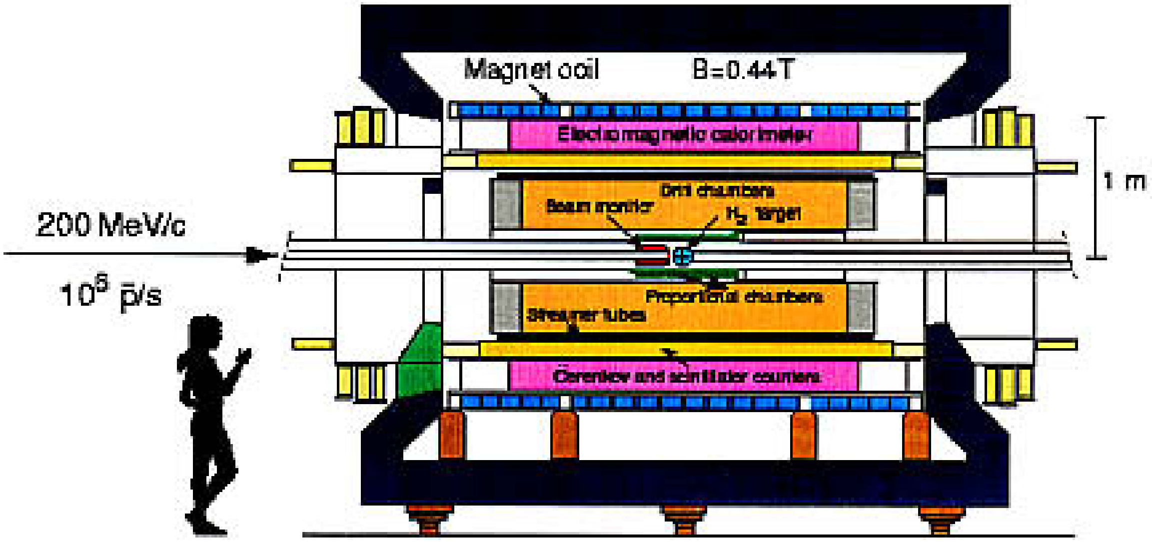
STRANGENESS OSCILLATIONS $K_0 \bar{K}_0$

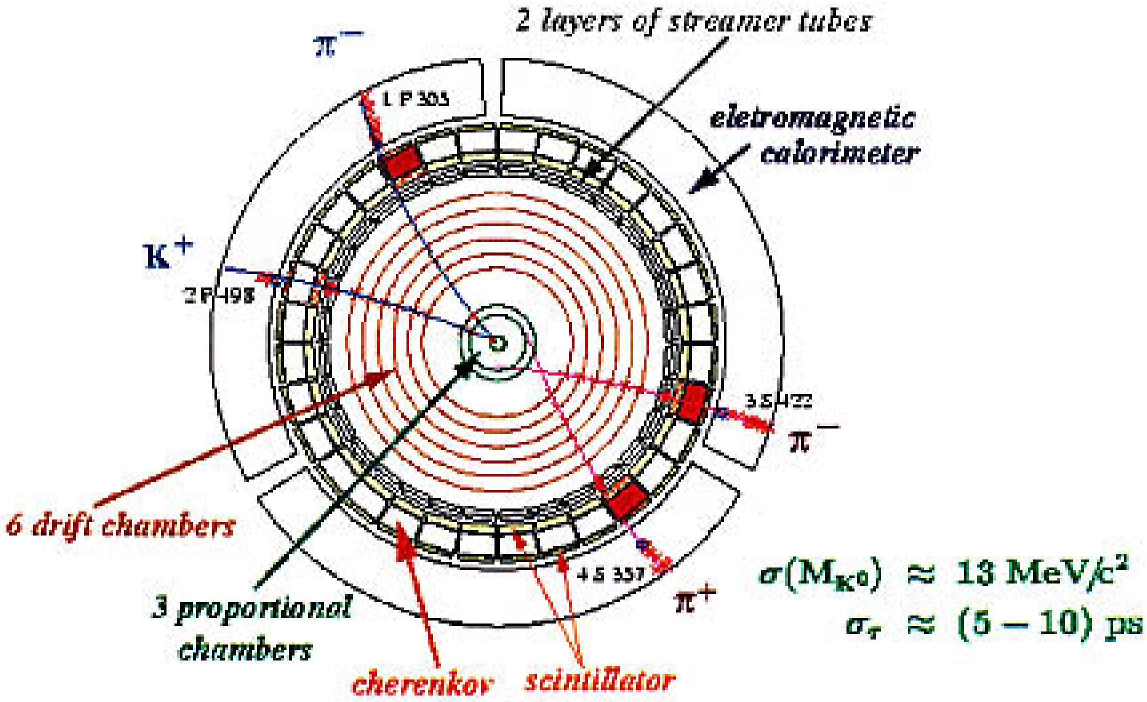
Produce $K_0 \bar{K}_0$ $(J^{PC} = 1^{--})$ @ $t=0$

$$I_{like}(t_a, t_b) \propto \Big\{ e^{-\gamma_S |t_a - t_b|} + e^{-\gamma_L |t_a - t_b|}$$
$$- 2 e^{-\gamma |t_a - t_b|} \cos\left[\Delta m (t_a - t_b)\right] \Big\}$$

$$I_{unlike}(t_a, t_b) \propto \Big\{ e^{-\gamma_S |t_a - t_b|} + e^{-\gamma_L |t_a - t_b|}$$
$$+ 2 e^{-\gamma |t_a - t_b|} \cos\left[\Delta m (t_a - t_b)\right] \Big\}$$

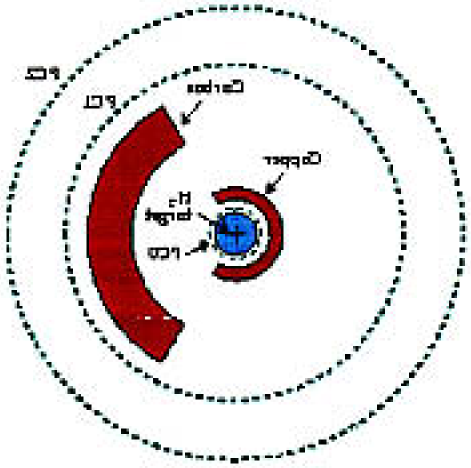
The CPLEAR Detector





Reference: Nucl. Instrum. Methods Phys. Res., A : 379 (1996) 76-100,

Strangeness Tagging



$K^0 + N \rightarrow K^+ + X$

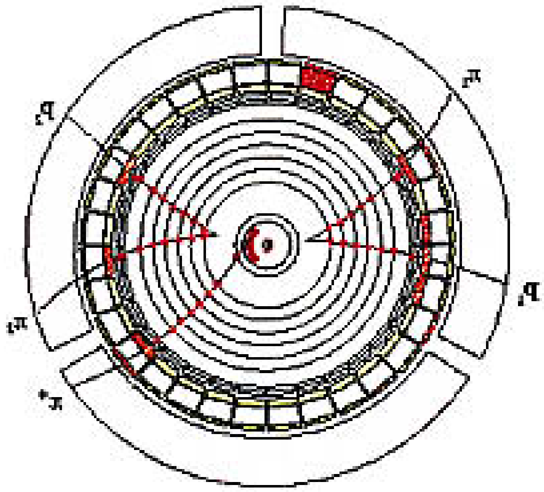
$\overline{K}^0 + N \rightarrow K^- + X$

$\overline{K}^0 + N \rightarrow \Lambda + X$

Position of the absorber allows to measure two constellations:

C(0) $t_1 \approx t_2$

C(5) $|t_1 - t_2| \approx 1.2\tau_S$



$\Lambda\Lambda(\overline{K}^0\overline{K}^0)$ event:
with $|t_1 - t_2| \approx 1.2\tau_S$

EPR Paradox

A. Einstein, B. Podolsky and N. Rosen, Phys. Rev. 47 (1935) 777.

$$p\bar{p} \rightarrow |K^0{}_{\vec{p}}\rangle|\overline{K}^0{}_{-\vec{p}}\rangle \mp |K^0{}_{-\vec{p}}\rangle|\overline{K}^0{}_{\vec{p}}\rangle$$

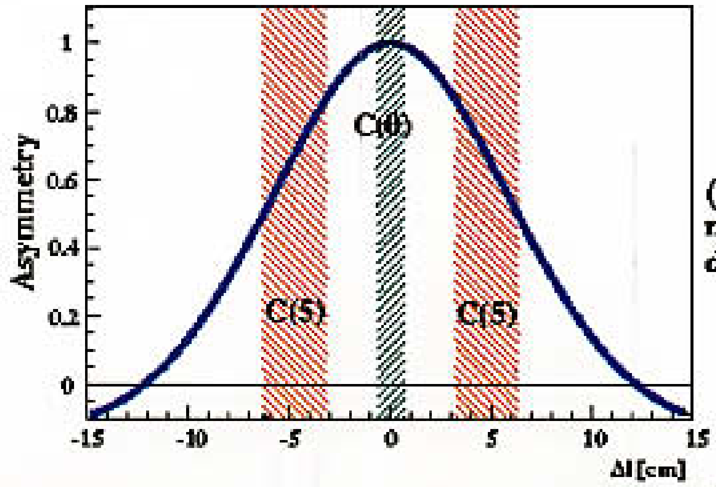
$$'-' \equiv J^{PC} = 1^{--} \qquad '+' \equiv J^{PC} = 0^{++},\ 2^{++}$$

$$\frac{(0^{++},2^{++})}{1^{--}} = 7.4\%$$ Phys.Lett. B403 (1997) 383.

Strangeness correlation for $J^{PC} = 1^{--}$:

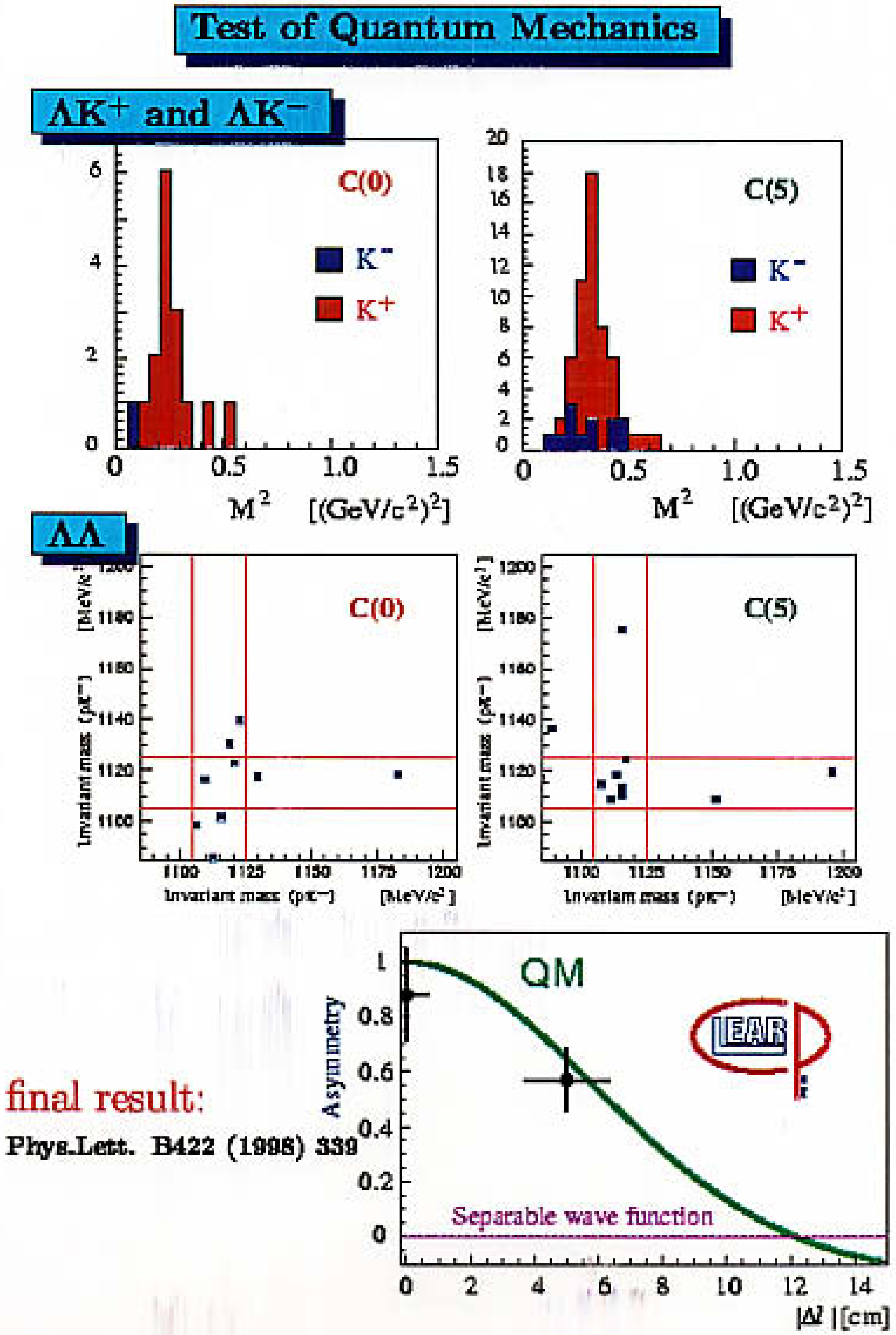
like $\equiv K^0K^0$ or $\overline{K}^0\overline{K}^0$ at times t_1 and t_2
unlike $\equiv \overline{K}^0K^0$ or $K^0\overline{K}^0$ at times t_1 and t_2

$$A = \frac{\text{unlike} - \text{like}}{\text{unlike} + \text{like}} = \frac{2\cos\{\Delta m(t_2 - t_1)\}}{e^{-\Delta\Gamma(t_2-t_1)/2} + e^{\Delta\Gamma(t_2-t_1)/2}}$$



(two body decay → momentum is constant, distance = time)

without long distance correlations: $A = 0$



Reference: Phys. Lett., B : 442 (1998) 339,

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Other Systems?

- B- mesons

- J/ψ
  - $\to \Lambda\bar{\Lambda}$ (.13%)
  - $\to \Xi\bar{\Xi}$ (~.18%)