High Promise of Beauty

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Nagoya Univ.

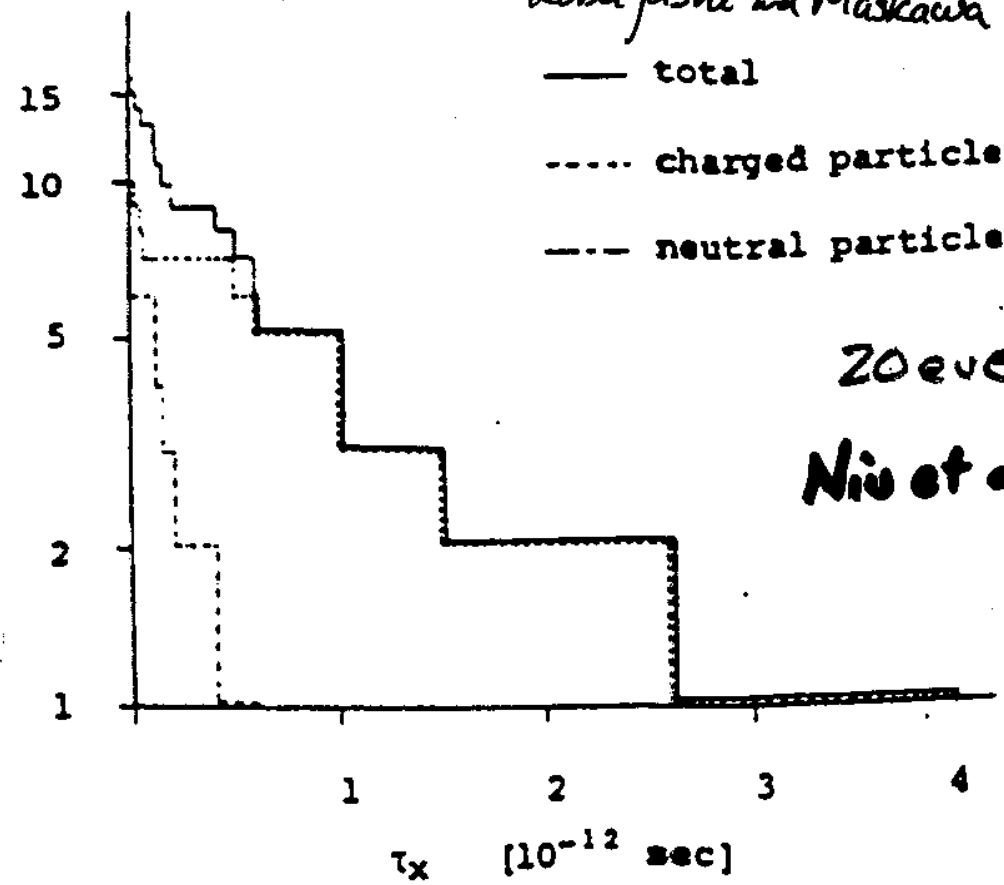
HQ98 workshop
Fermilab

Outline

1. The necessity of Beauty
2. Gold mine
3. Technical difficulties

If you have 4 why not 6!

Kobayashi and Maskawa 1973



20 events

Niu et al 1975

$\tau_I = (1 \sim 2) \times 10^{-12}$ sec

$\tau_0 = (3 \sim 4) \times 10^{-13}$ sec

Hoshino et.al 14th Int. Cosmic Ray Conf (Munich) 7, 2442 (1975)

G. Goldhaber et.al. PRL 37, 255 (1976)

Gell-Mann 1964 in Phys, 1 63
also in Eightfold way P. 198 + 199

In other words, we construct a mathematical theory of the strongly interacting particles, which may or may not have anything to do with reality, find suitable algebraic relations that hold in the model, postulate their validity, and then throw away the model. We may compare this process to a method sometimes employed in French cuisine: a piece of pheasant meat is cooked between two slices of veal, which are then discarded.[10)]

Their non-appearance could certainly be consistent with the bootstrap idea, and also possibly with a theory containing a fundamental triplet which is hidden, i.e., has effectively infinite mass.

2. Gold mine

(A) B-$\bar{B}$ mixing

Ellis Gaillard Nanopoulos, Rudaz
NP B133, 285 (1977)

$$\frac{\Delta M}{\Gamma} \cong \frac{m_t^2}{700\ \text{GeV}^2}$$

$f_B \sim 500$ MeV

(B) $\frac{\text{Im } m}{\Delta m} \gtrsim \tan 2\delta$

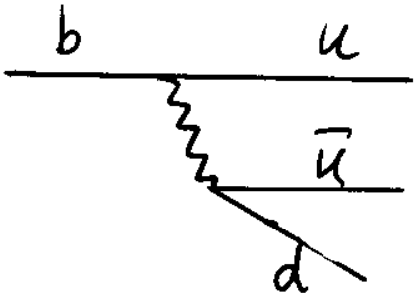
$\epsilon_B \gg \epsilon_K$?

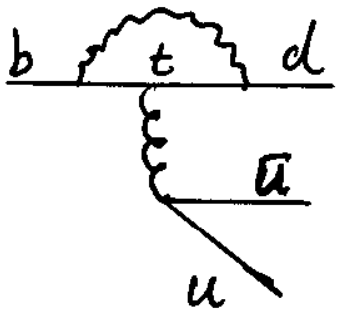
Problem: Find rephasing invariant observable!

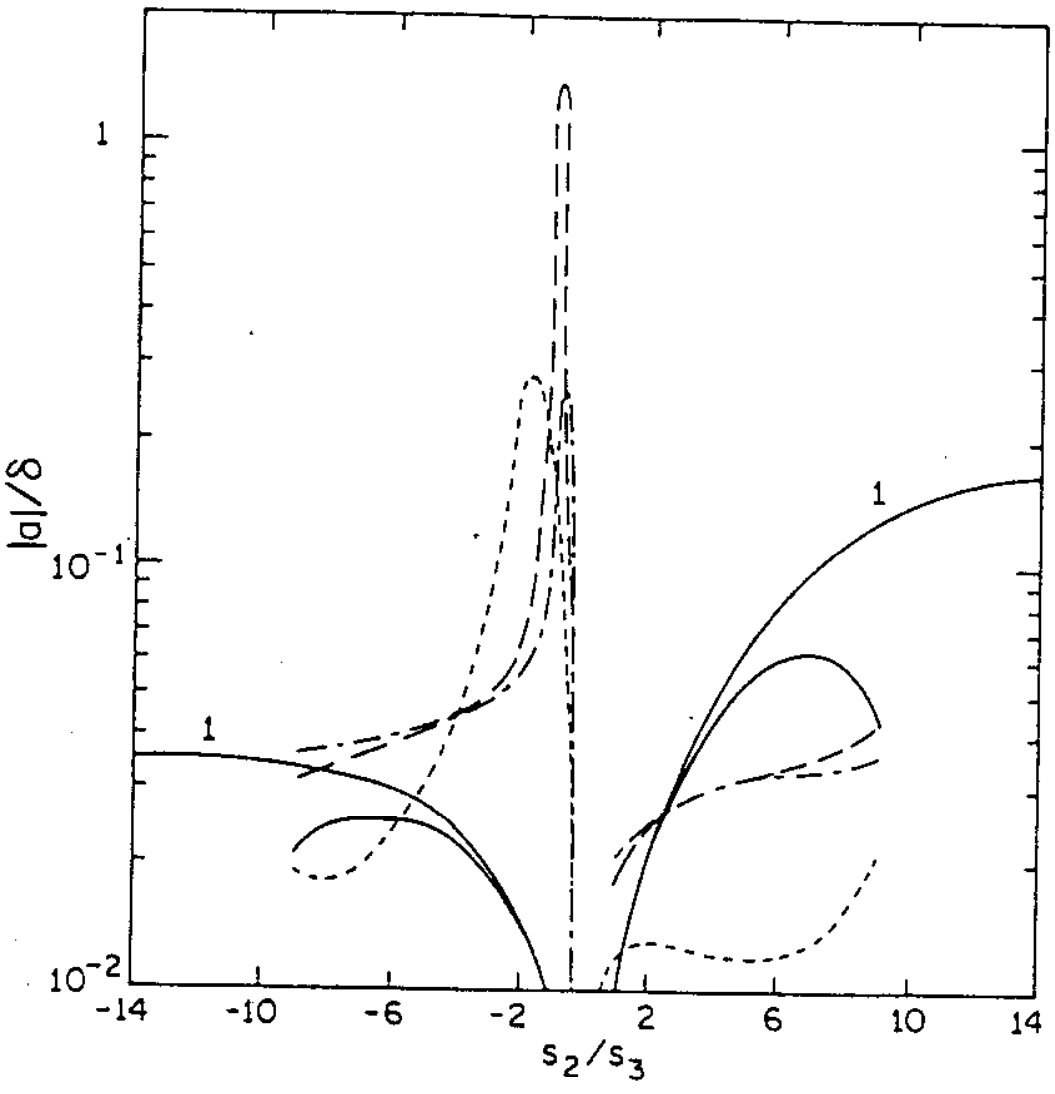
1. 1st result

Bander Silverman + Soni
PRL 43 1979

$$a = \frac{\Gamma(b \to f q\bar{q}) - \Gamma(\bar{b} \to \bar{f} q\bar{q})}{\Gamma(b \to f q\bar{q}) + \Gamma(\bar{b} \to \bar{f} q\bar{q})}$$



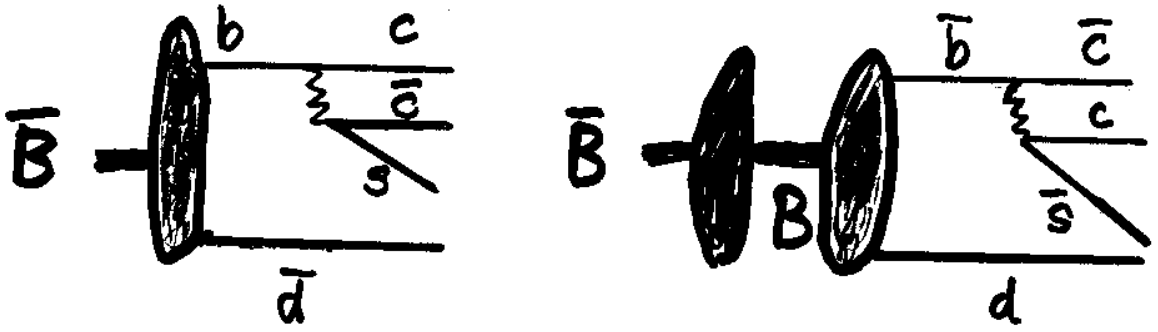




Bander Silverman & Sons

2. ~~CP~~ in $B \to$ hadrons

Carter + Sanda
PRL 45, 959 (1980)
PR 23 (1981)



~~CP~~ in major decay mode!
Only if these diagrams interfere!

2. ~~CP~~ in $B \to$ hadrons

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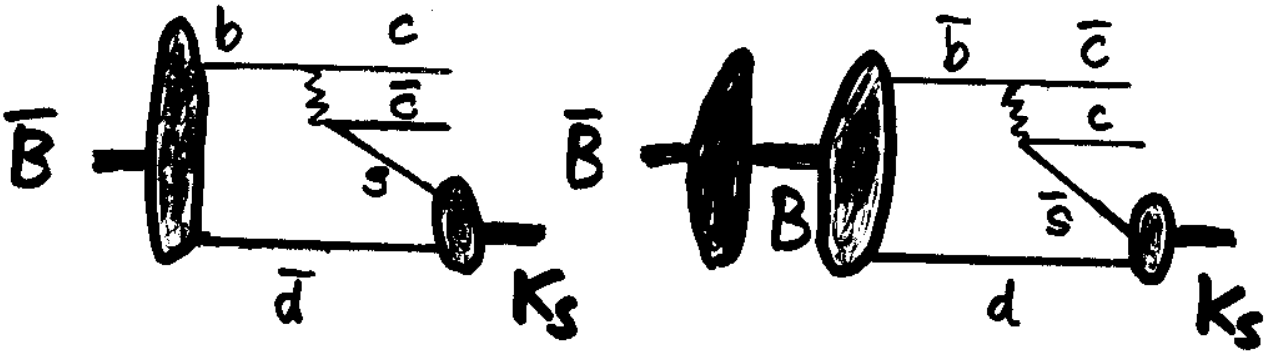


~~CP~~ in major decay mode!
Only if these diagrams interfere!
Idea came to me on a hot saturday afternoon when I was supervising a math exam.

No supp. $B \to c\bar{c} K_S$ asymmetry in a major decay mode!

Difficulties

$B \to K_S c\bar{c}$ inclusive

CP asymmetry may cancel.

Bigi + AlS NP 193 85 (81)

$B_d \to \psi K_S + \pi$'s

$$CP\,|\psi K_S\, n\pi^0\rangle = -(-1)^n\,|\psi K_S\, n\pi^0\rangle$$

$$\mathrm{Im}\left(\frac{q}{p}\rho\right) = -\mathrm{Im}\left(\frac{V_{tb}V_{td}^*}{V_{tb}^*V_{td}}\;\frac{V_{cb}V_{cs}^*}{V_{cb}^*V_{cs}}\right)$$

Time integrated asym = 0 for $(B\bar{B})_{C=-1}$

How do we get Swave $B\bar{B}$ state?

$$\underset{C=-1}{\Upsilon(4S)} \to B\bar{B}^* \to \underbrace{B\bar{B}}_{C=+1}\,\gamma_{C=+1}$$

8. Technical Difficulties – numerous

1. $Br(B \to \psi K_S) \sim 10^{-4}$
   $Br(B \to \ell \nu X) \sim 10^{-1}$
   $Br(\psi \to e^+e^-) \sim 10^{-1}$
   ] 10^{-6}

   Need 10^8 $B^0\bar{B}^0$ to have 100 ψK_S tagged

$\mathcal{L} = 10^{34}\ cm^{-2}\ sec^{-1}$ CESR $10^{31} \sim 10^{32}\ cm^{-2} sec^{-1}$

2. Long awaited decay mode

$\Upsilon(4S) \to B\bar{B}^* \to B\bar{B}\gamma$ Did not happen!
$C=-1$ $C=+1$ $C=-1$

CUSP (83)
CLEO

$$\Downarrow$$

$$Asym = Im\left(\frac{q}{p}\rho\right) \sin \Delta m (t_1 - t_2)$$

Time integrated asym. vanishes

3. $\tau_B \approx 1$ ps $\Rightarrow$ B track $\sim 20\mu m$.

Impossible to measure!

Discovery of B-$\bar{B}$ mixing

ARGUS (87)

Exp. Detectors + Exp Areas for SSC Berkeley (8

Bottom and Top physics Foley et.al
measuring time dep. taken seriously.

Ever increasing τ_B

MAC, MARK II LEP

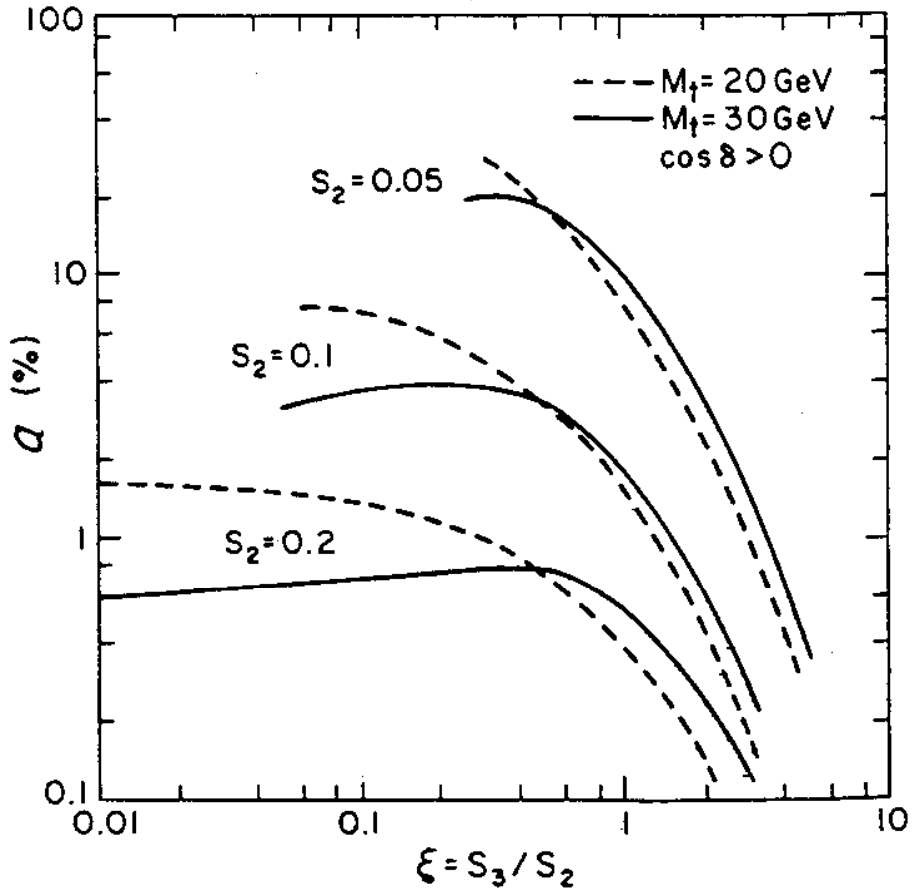
$\Rightarrow$ $V_{cb} \rightarrow A\lambda^2$ Asym $\uparrow$

Measuring $\sin \Delta m (t_1 - t_2)$ becomes easier

Advances in vertex detectors

~~CP~~ asym. $\xi = \left|\frac{S_3}{S_2}\right| = \left|\frac{V_{ub}}{\lambda V_{cb}}\right| = \sqrt{\rho^2+\eta^2}$

$S_2 \approx V_{cb} \sim A\lambda^2 = A(.05)$



Asymmetric Collider

Oddone  came to him during conv. with Bigi, AIS

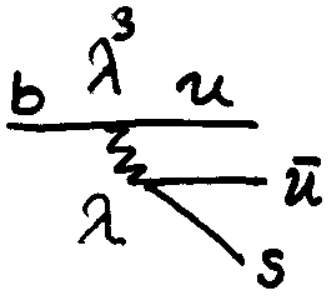
Richter & Oddone

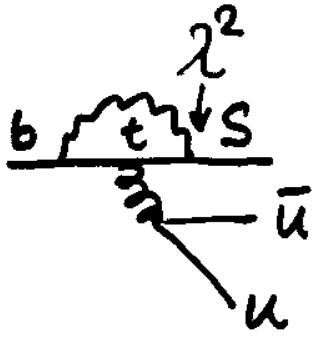
B factory Proporsals

1. SIN
2. KEK AR
3. KEKB BELLE
4. PEP BaBar

Expectations at T(4S) B factories

$B \to K\pi$

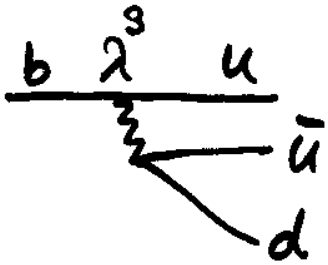


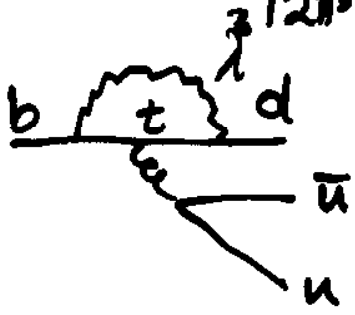


$T(K\pi) \sim \lambda^4$

$P(K\pi) \sim \lambda^2 \frac{\alpha_s}{12\pi^3} \ln \frac{m_t}{m_c}$

$B \to \pi\pi$





$T(\pi\pi) \sim \lambda^3$

$P(\pi\pi) \sim \lambda^3 \frac{\alpha_s}{12\pi^3} \ln \frac{m_t}{m_c}$

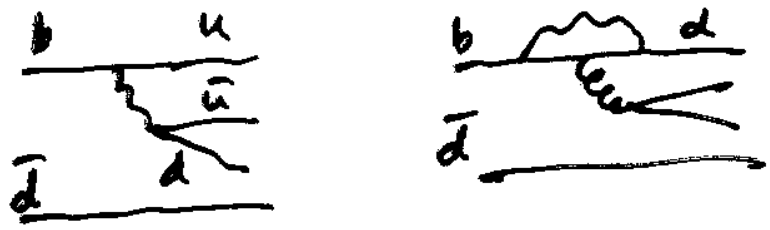
CLEO

$Br(B \to K\pi) > Br(B \to \pi\pi)$

$\frac{T(K\pi)}{T(\pi\pi)} \sim \lambda$ so if $P \ll T$,

$\frac{Br(K\pi)}{Br(\pi\pi)} \sim \lambda^2$

Penguins are important



$$A(B\to f) = e^{i\xi_1} e^{i\delta_1} |A_1| + e^{i\xi_2} e^{i\delta_2} |A_2|$$

$$\Delta\xi = \xi_2 - \xi_1 \qquad \Delta\delta = \delta_2 - \delta_1$$

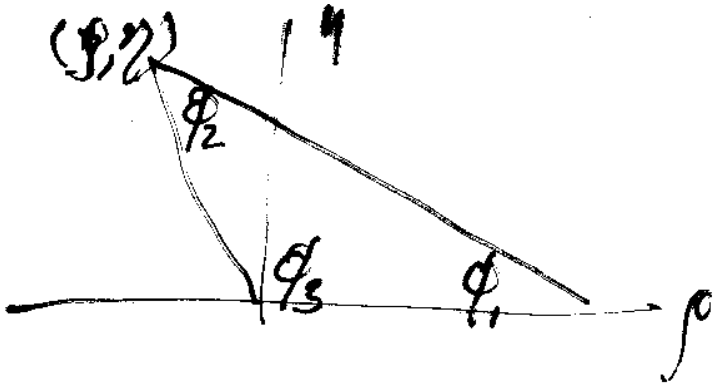
$$\bar{\rho} = \frac{A(\bar{B}\to f)}{A(B\to f)} \sim e^{-2\xi_1}\left(1 - 2i\left|\frac{A_2}{A_1}\right| e^{i\Delta\xi}\sin\Delta\xi\right)$$

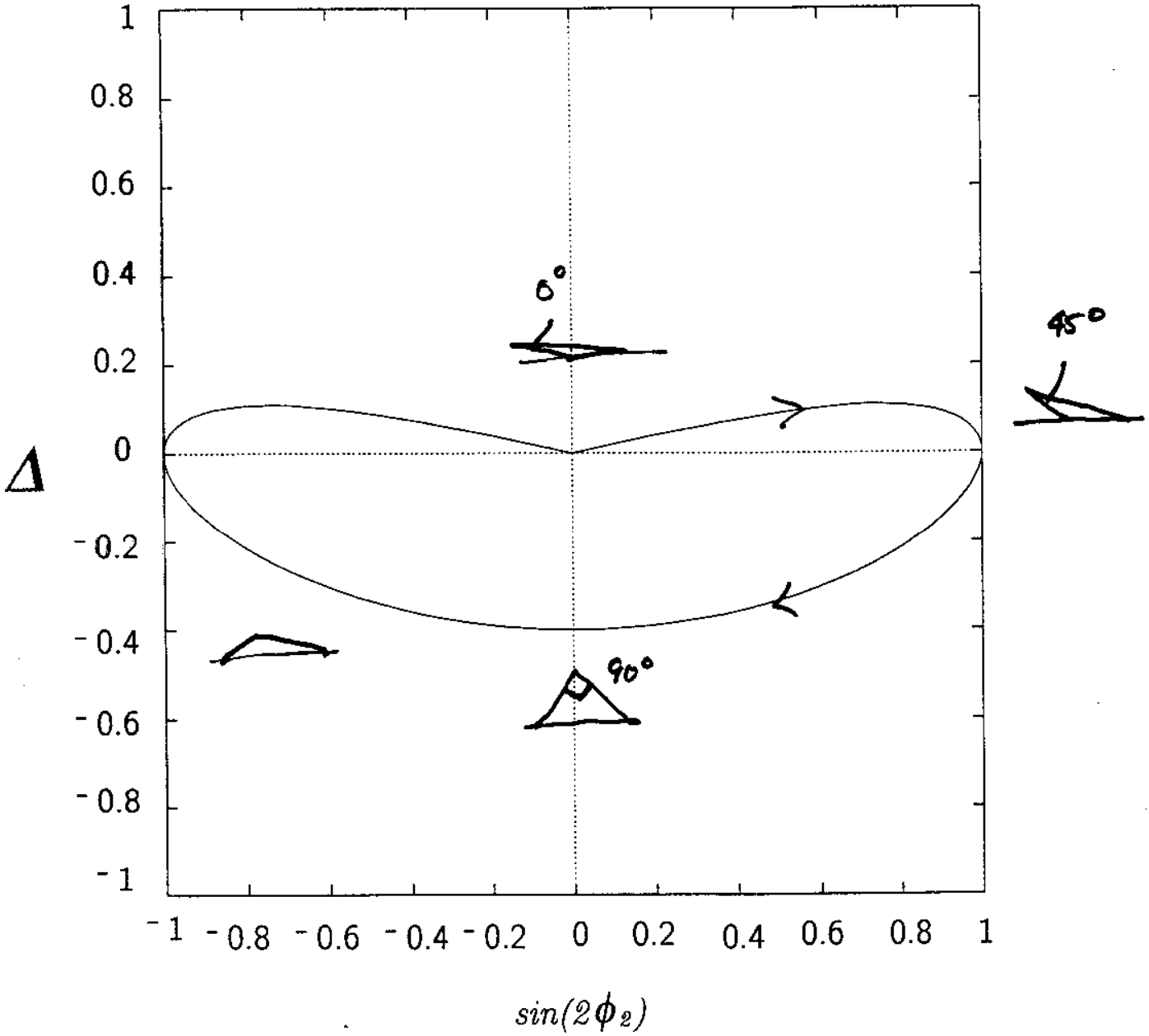
$$\left|\frac{A_2}{A_1}\right| \ll 1$$

$$A_{sym} = \mathrm{Im}\left(\frac{q}{p}\bar{\rho}(f)\right) \sim \sin 2(\phi_m - \xi_1)$$

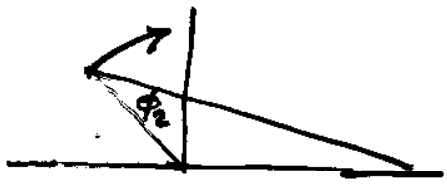
$$-2\left|\frac{A_2}{A_1}\right| \sin\Delta\xi \cos\left(2\phi_m - 2\xi_1 + \Delta\delta\right)$$

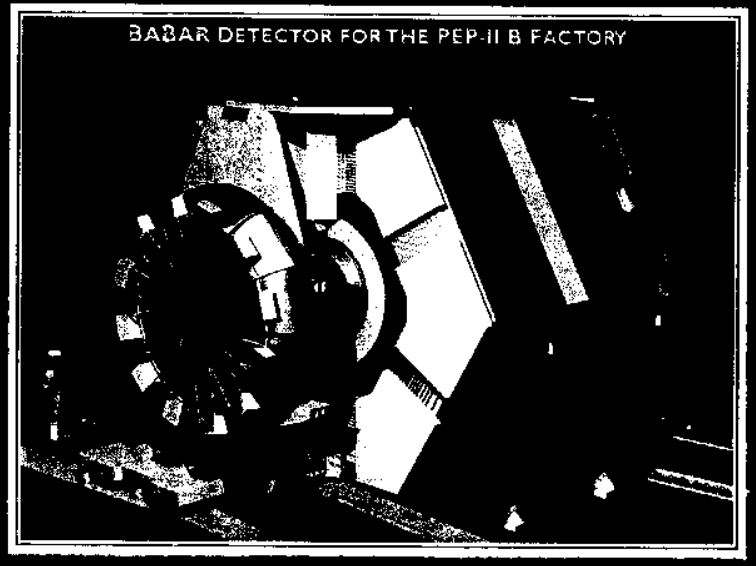
$$\Delta$$

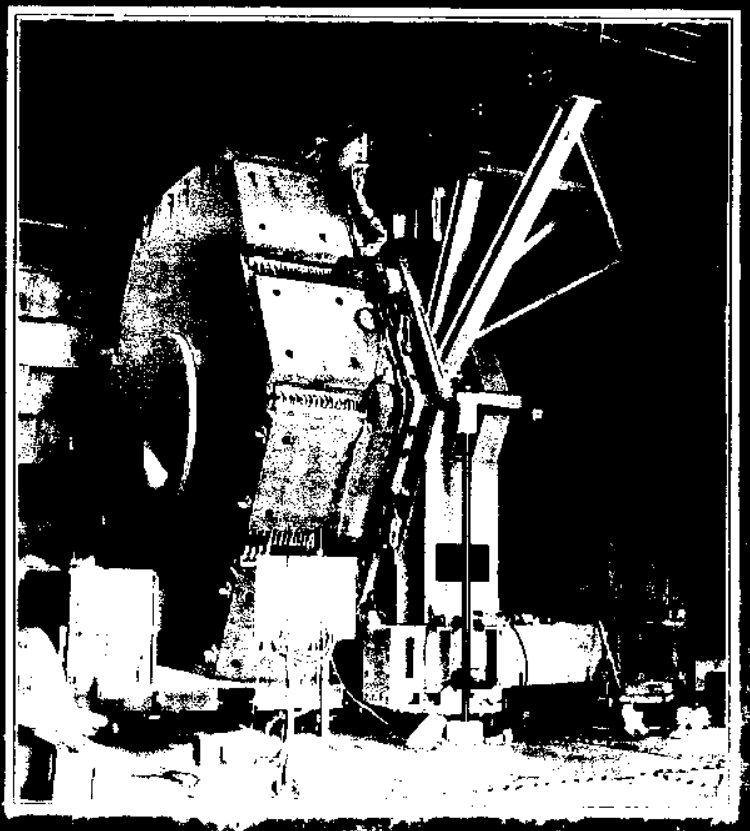


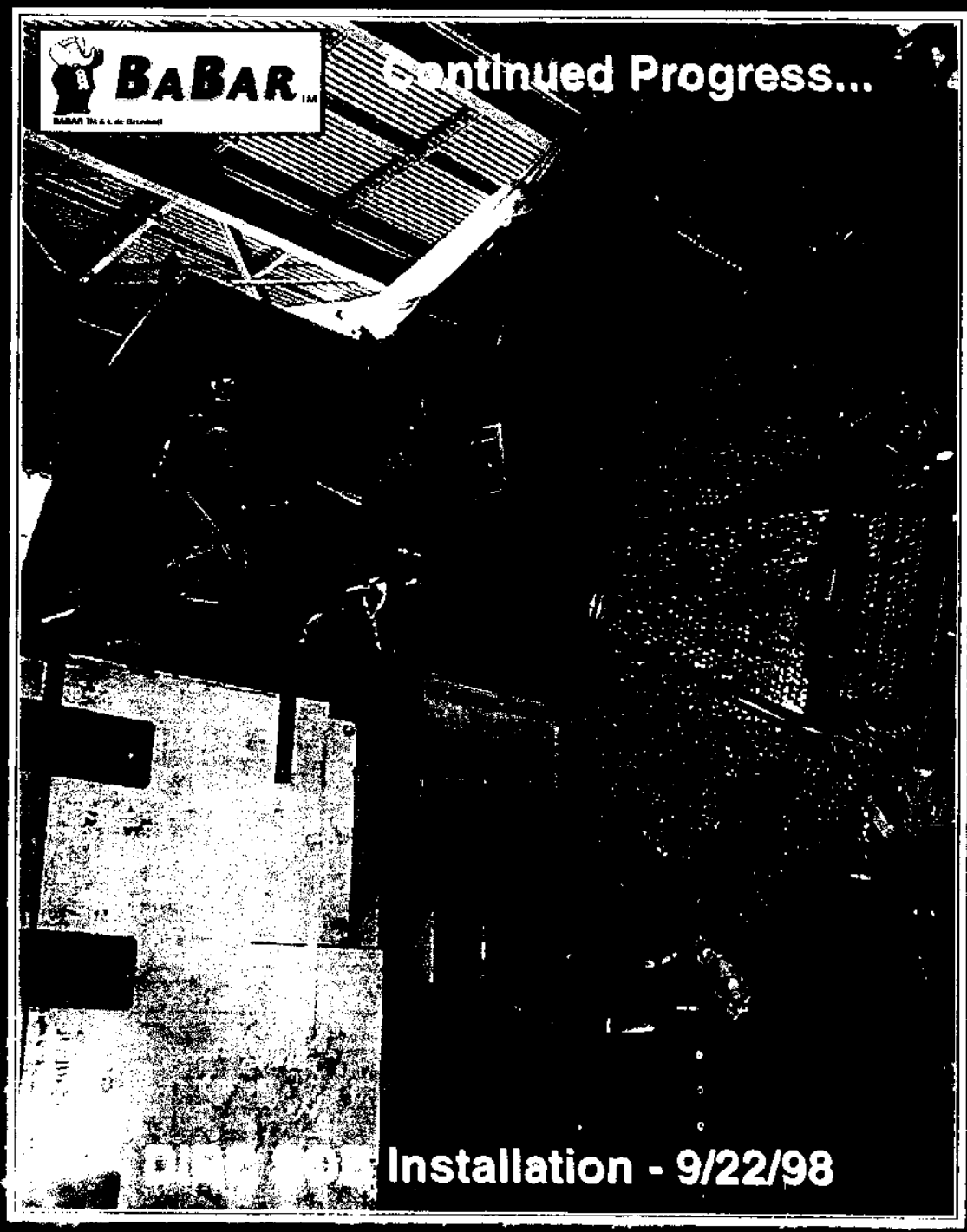


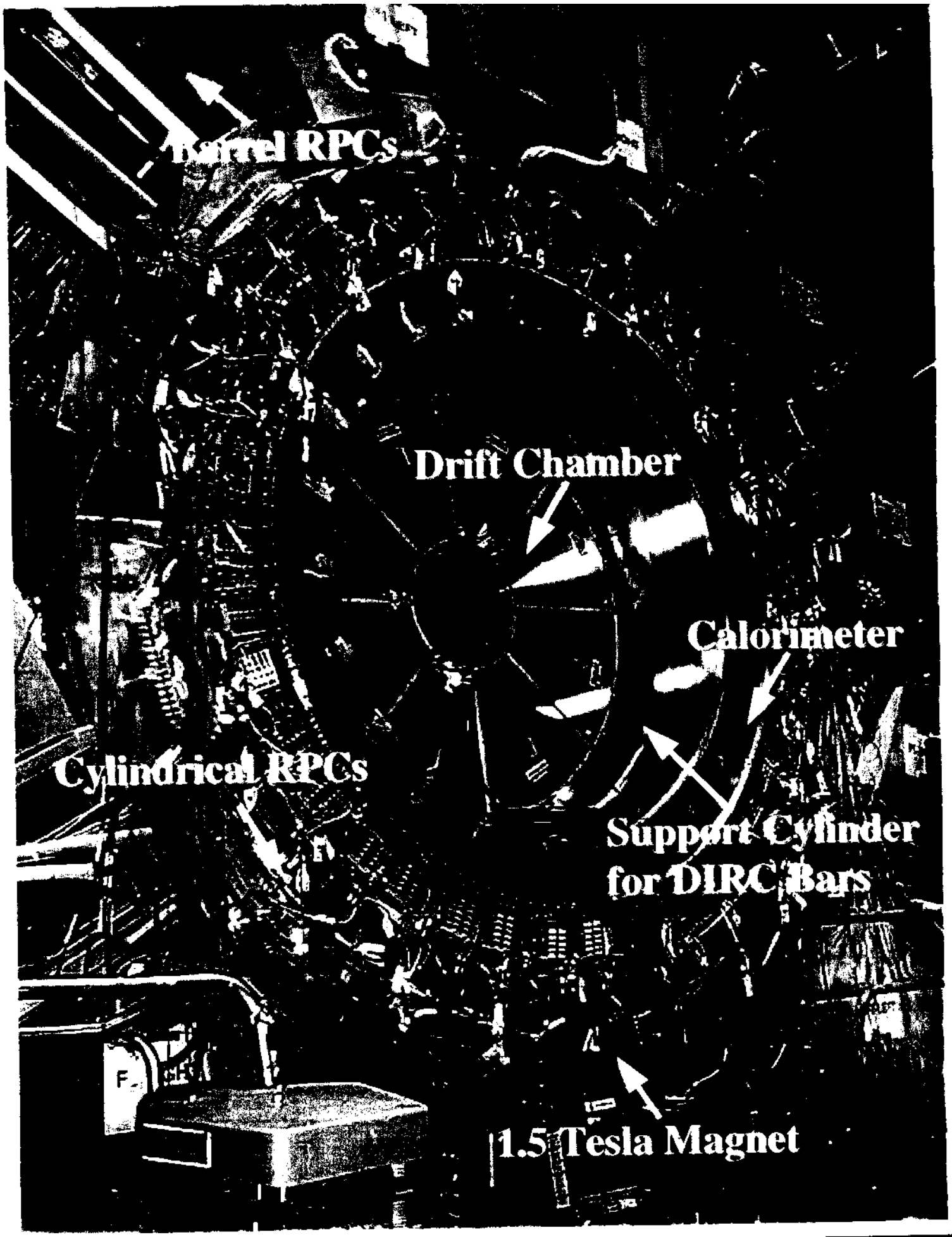
$\left|\frac{A_2}{A_1}\right| \sim \lambda \qquad \sin\Delta\delta = 1$

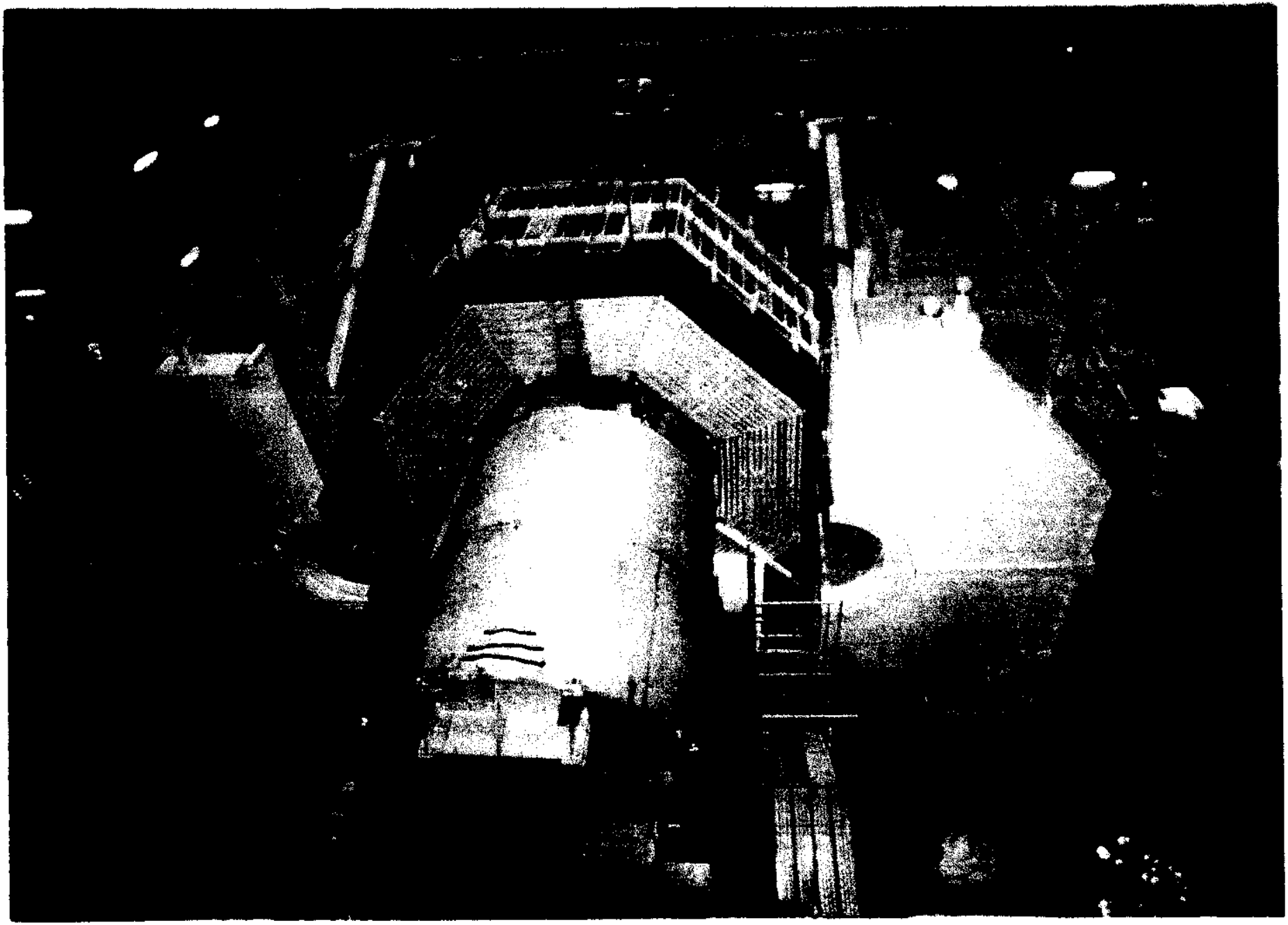



BABAR DETECTOR FOR THE PEP-II B FACTORY

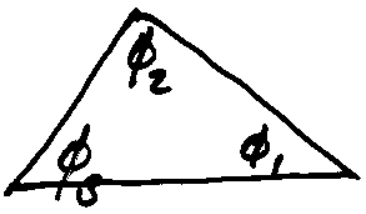



BABAR
Continued Progress...
Installation - 9/22/98


Barrel RPCs
Drift Chamber
Calorimeter
Cylindrical RPCs
Support Cylinder
for DIRC Bars
1.5 Tesla Magnet



KEKB	Beam will come on in Dec. 98
BELLE	Detector closes in Nov. 98
Exp. starts	April 99.
PEP II	some sign of collision
BaBar	Detector closes in Nov. 98 ?
Exp. starts	April 99.



$\sin 2\phi_1$ measured by late 1999 ??

Summary

1. Close collaboration between experimentalists and theorists

2. 10 % measurement of ϕ_1, ϕ_2, ϕ_3(?)
   Best senario

3. High sensitivity B experiment is a must!

K physics — K^0 discovered Oct. 1946
52 years old

B physics — 20 years old

It will go on at least for another 30 years!

Second generation precision exp. must be done!