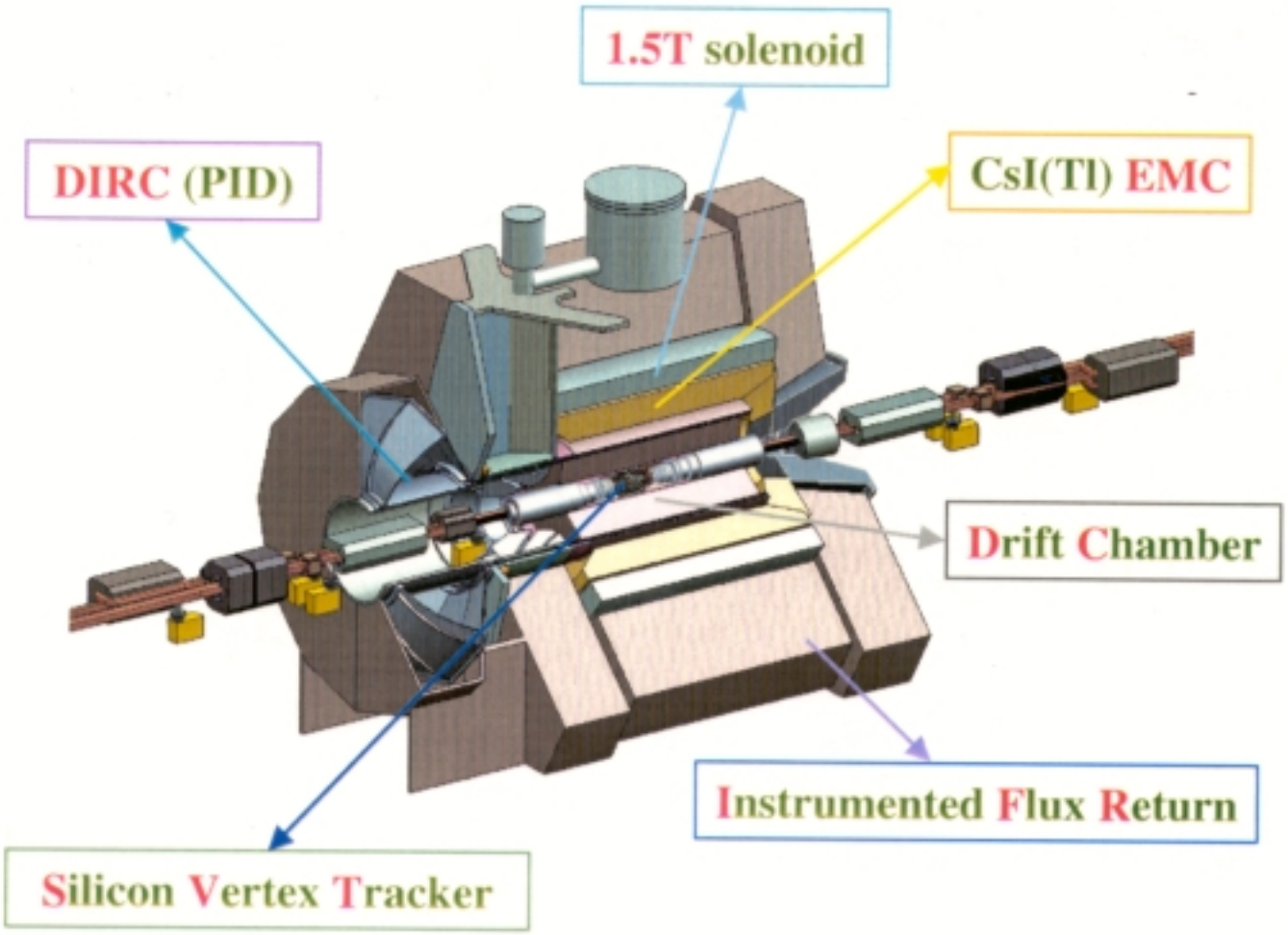


CP

Results from

BaBar

CP

Results from

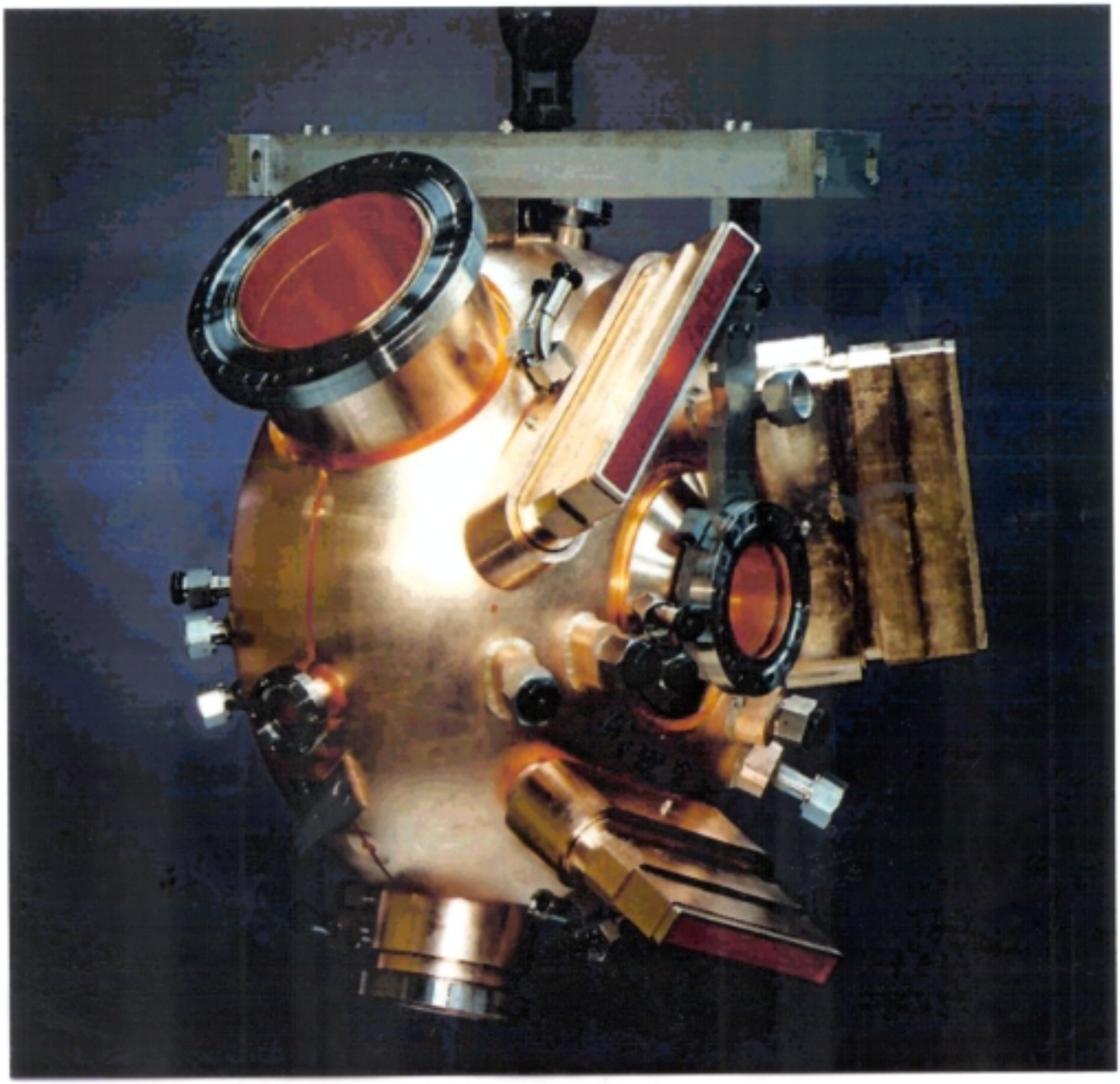
BaBar

$\beta \alpha \gamma$

CP direct

SLAC

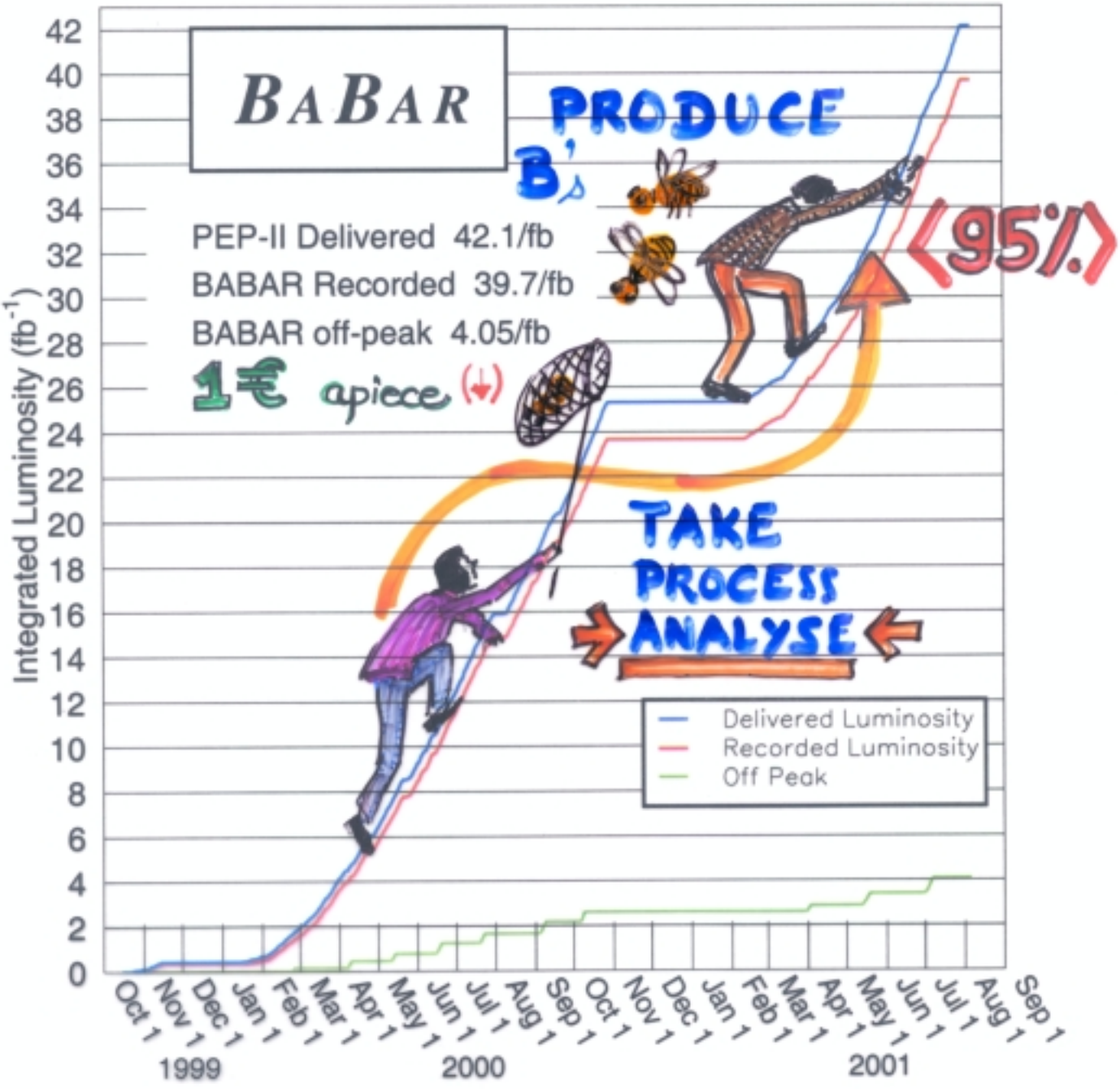
PeP-II

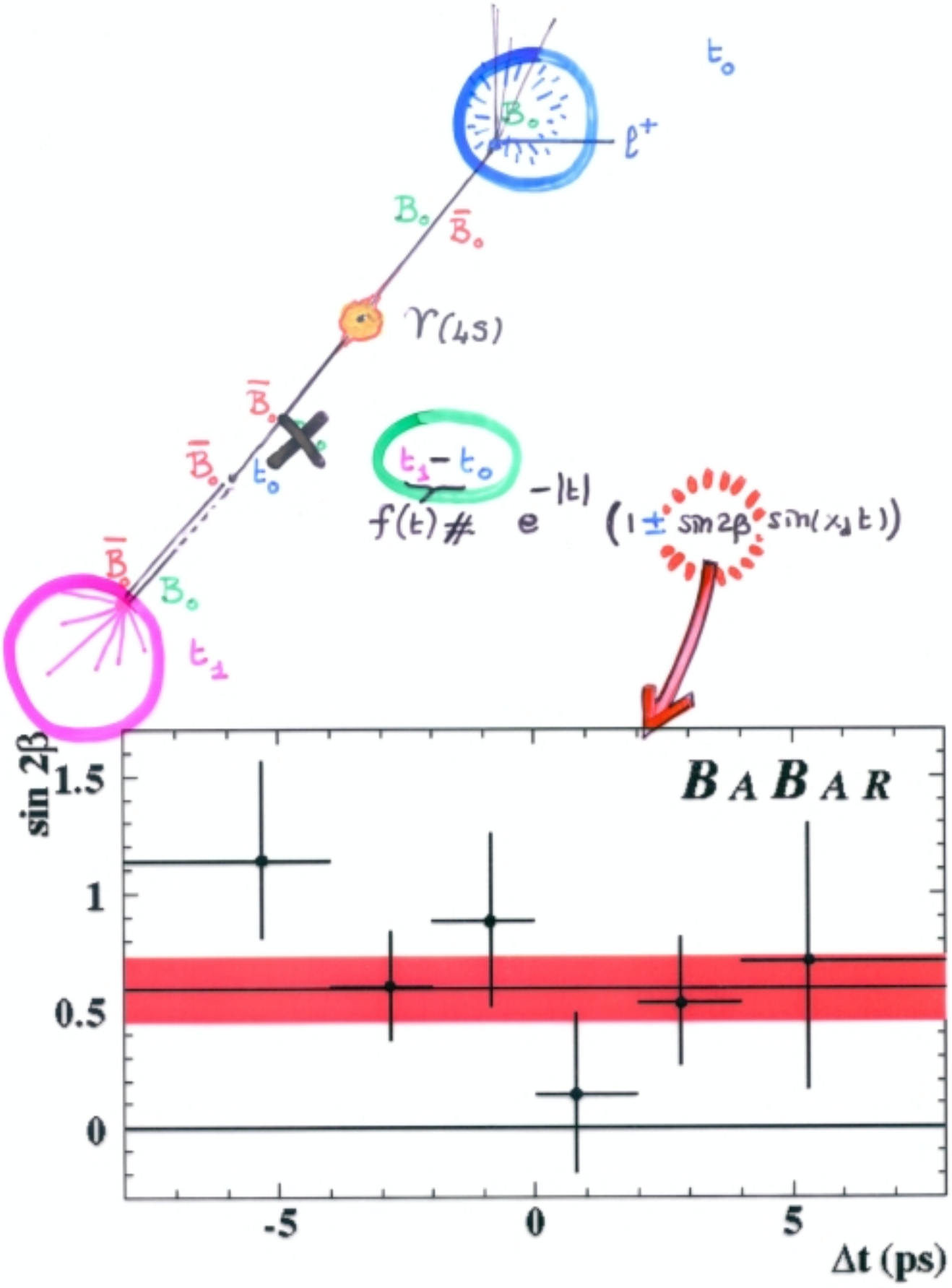


CAV_13 PEP-II RF Cavity 8-19-97

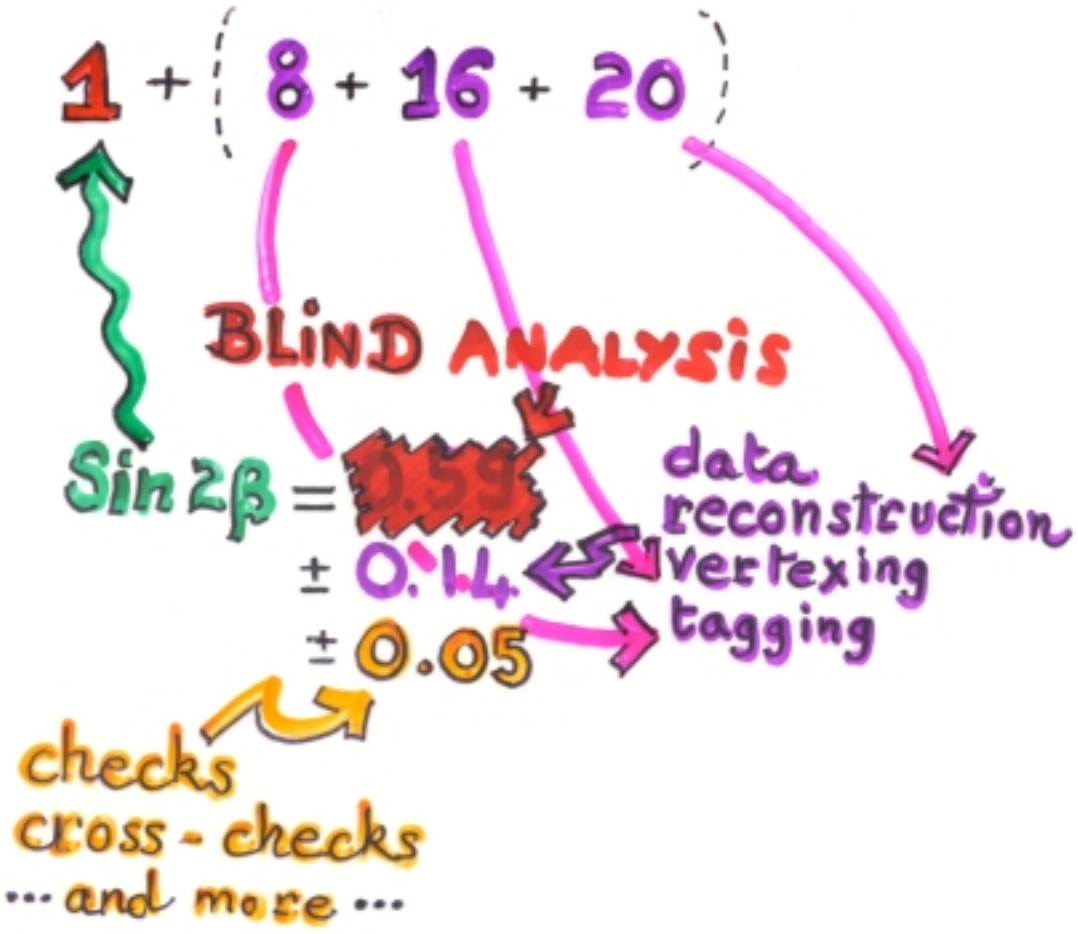
Honey Talk

2001/08/07 03.40




t_0
B^0
ℓ^+
B^0
$\bar{B}^0$
$\Upsilon(4S)$
$\bar{B}^0$
$\bar{B}^0$
t_0
$t_1 - t_0$
$f(t) \propto e^{-|t|}(1 \pm \sin 2\beta \sin(x_d t))$
$\bar{B}^0$
B^0
t_1
sin 2β
1.5
1
0.5
0
-5
0
5
Δt (ps)
BABAR

Global Likelihood fit



$J/\psi K^0_S$

$CP = -1$

$$f_\pm(t) = e^{-|t|}\left(1 \pm \sin 2\beta \sin(x_d t)\right)$$

tagging ↓

mistag rate

$$f_\pm(t) = (1-w) f_\pm + w f_\mp \quad (B^0 \text{ tag} \rightarrow f_\pm)$$

$$= e^{-|t|} \pm (1-2w) \sin 2\beta\, e^{-|t|} \sin(x_d t)$$

vertexing ↓ (convolution)

$\Delta z \rightarrow t$

$\sigma_{\Delta z} \ll$ mm

$$f_\pm(t) = E(t) \pm \sin 2\beta\, S(t)$$

background ↓

$$f_\pm(t) = E(t) \pm \sin 2\beta\, S(t)$$

$$f_{\pm}(t) = E(t)\left(1 \pm \sin 2\beta\, \chi(t)\right)$$

$$\chi(t) = \pm\frac{S}{E} = \text{金}$$

Kin Gold

variable

?!?

$$\langle \text{金}^2 \rangle$$

$$\langle \text{金} \rangle = \int E\left(1 + \sin 2\beta \frac{S}{E}\right)\left(+\frac{S}{E}\right)^2 + E\left(1 - \sin 2\beta \frac{S}{E}\right)\left(-\frac{S}{E}\right)^2 = \sin 2\beta \; 2\int \frac{S^2}{E}$$

$$\langle \text{金}^2 \rangle = 2\int \frac{S^2}{E}$$

$$f_{\pm}(t) = E(t)\left(1 \pm \sin 2\beta\, x(t)\right)$$

$$x(t) = \pm\frac{S}{E} = \text{金}$$

Kin Gold

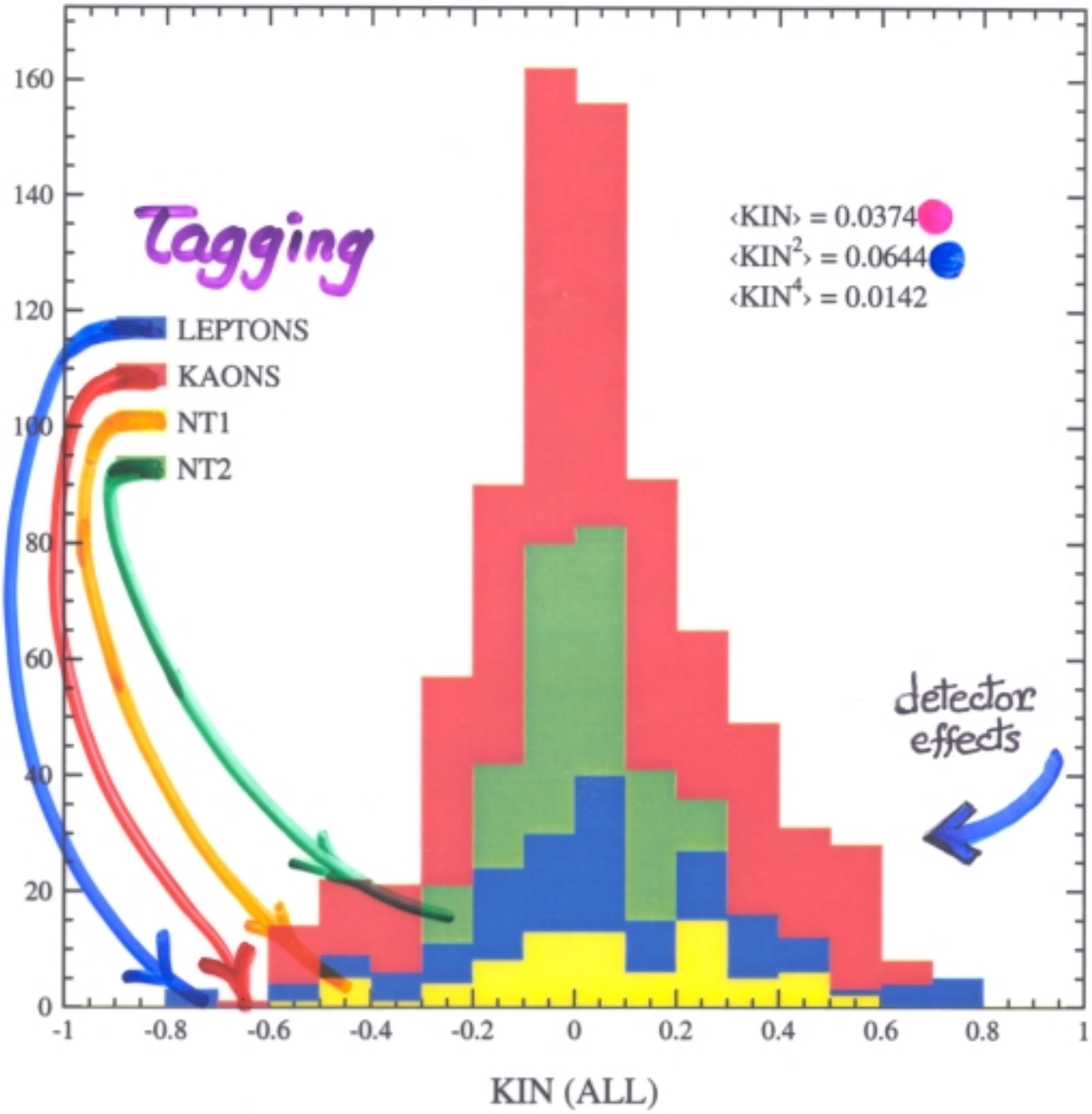
variable

?!?

$$\sin 2\beta = \frac{\langle x \rangle}{\langle x^2 \rangle} \pm \frac{1}{\sqrt{N\langle x^2 \rangle}}$$

- Graphical display: ~~GP~~ = Kin asymmetry
- all types at once: Events; Tag; experiment ...
- almost no information loss

$$\sin 2\beta = \frac{\bullet}{\bullet} \pm \frac{1}{\sqrt{803\ \bullet}}$$



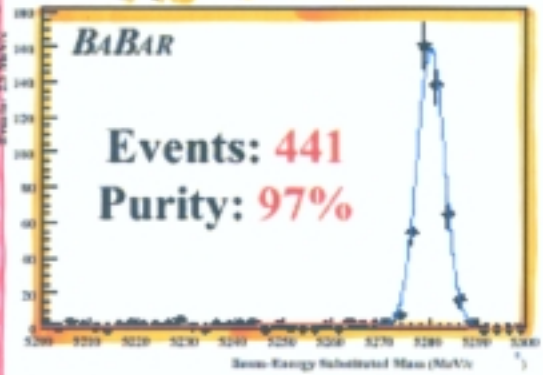
••• assume hard work done

CP

32 10^6 $B\bar{B}$

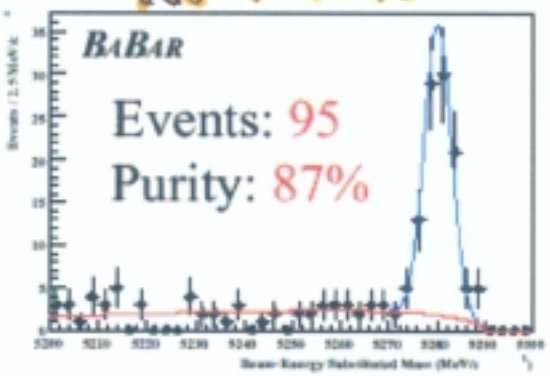
CP = -1 events

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

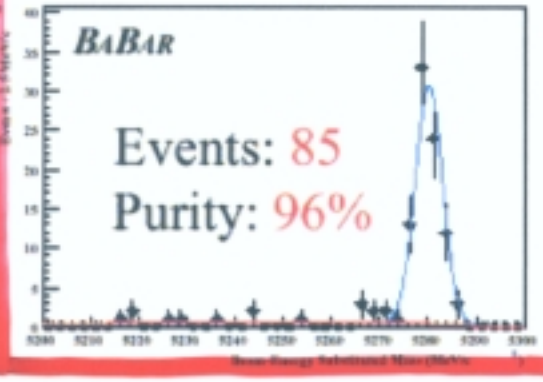


J/ψ K^0_S

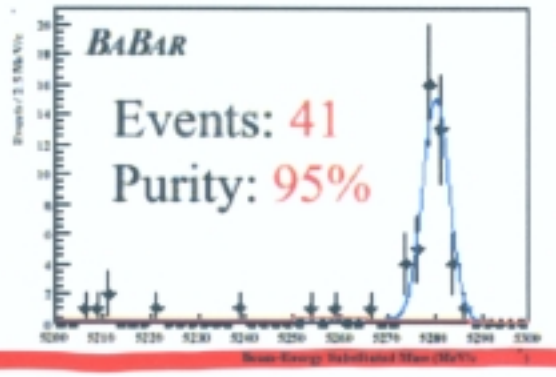
$K^0_S \to \pi^0\pi^0$



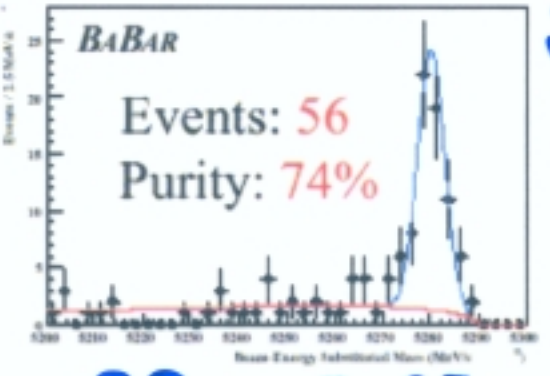
$\psi(2S)$ K^0_S



χ_{c1} K^0_S

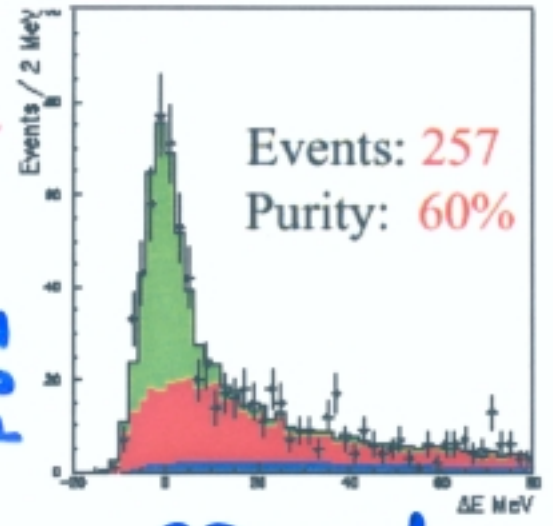


J/ψ K^*



CP ≃ 0.65

J/ψ K^0_L

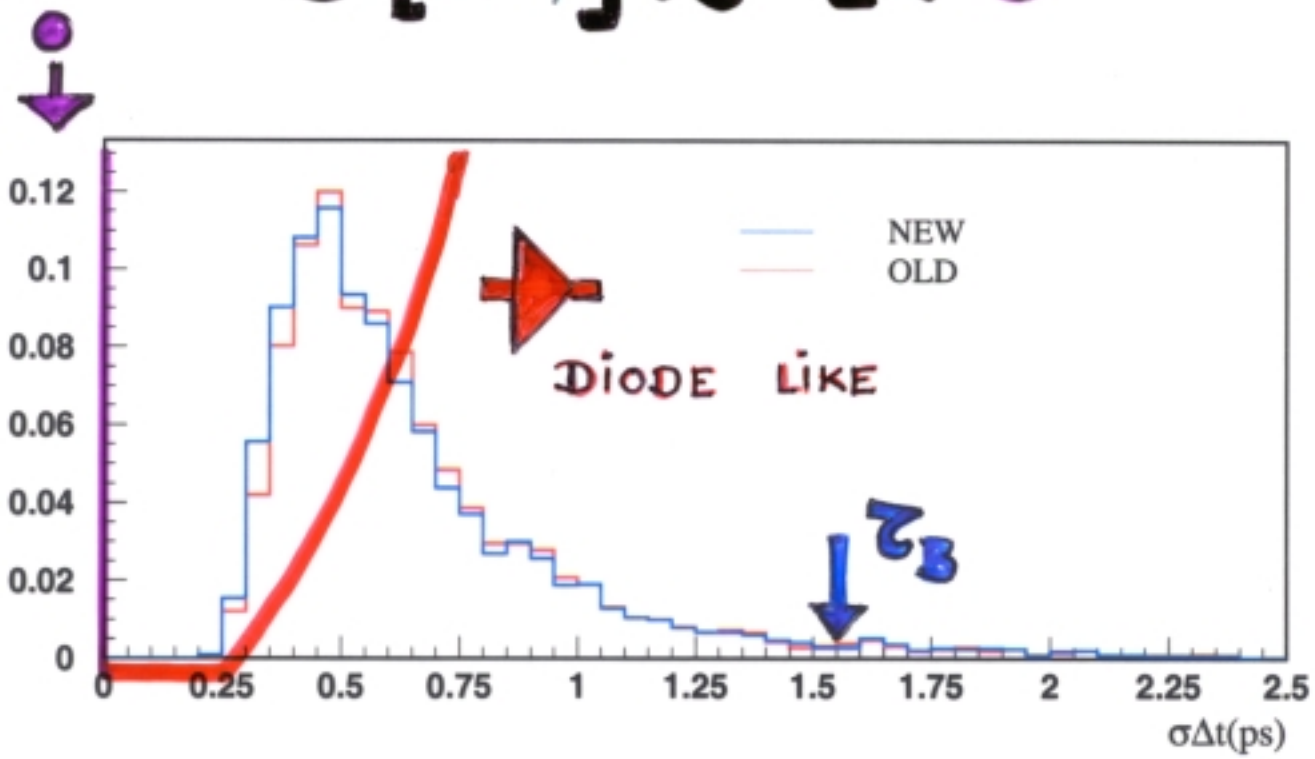


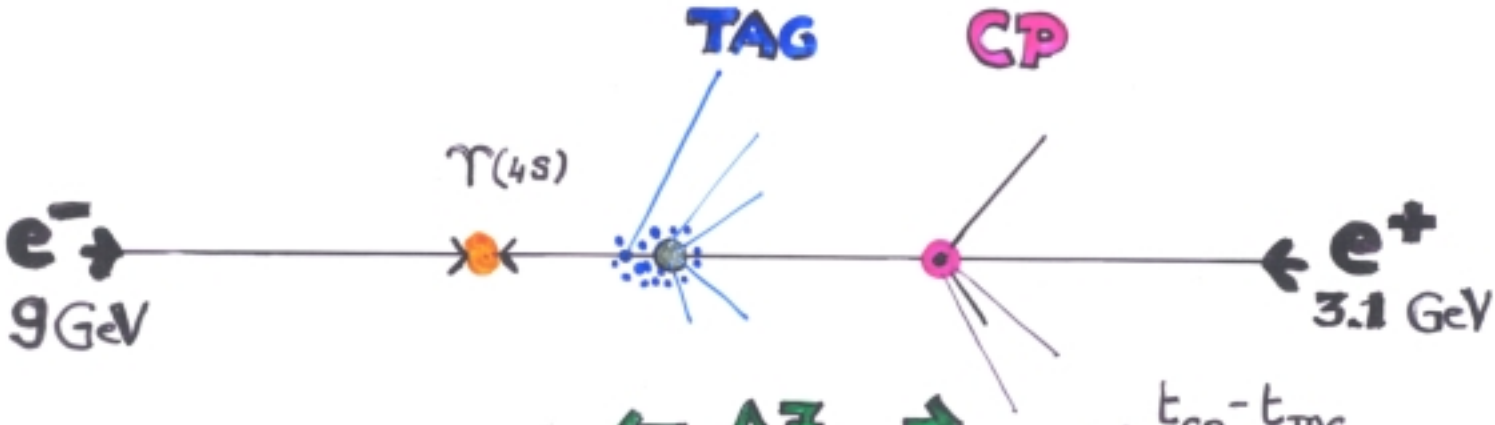
CP = +1

High Purity

Before Tagging

$\sigma[\sin 2\beta] \sim 1 +$ ●





$\approx \beta\gamma c\tau\, t$

Boost ≈ .56

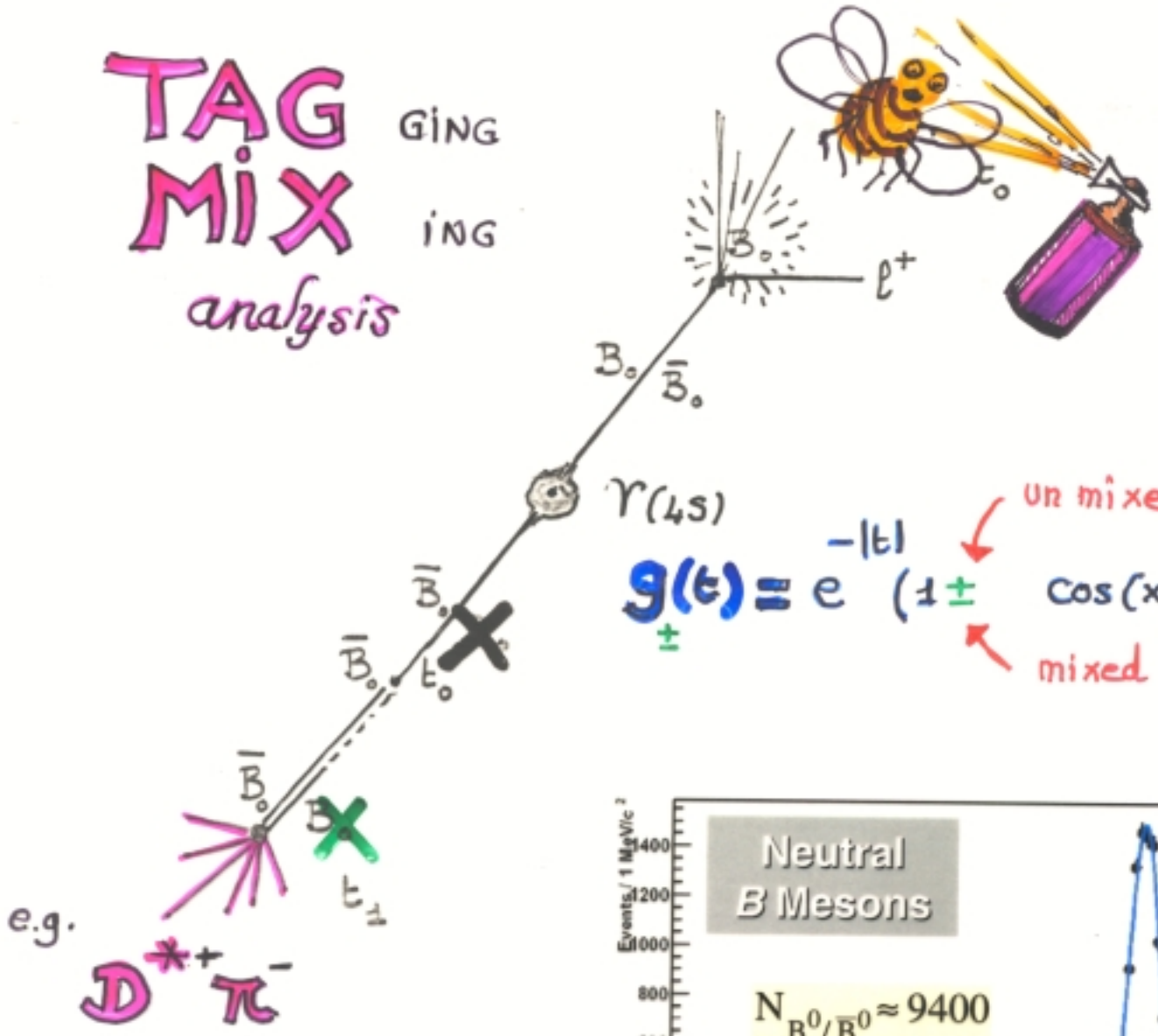
TAGGING

$$(1-2w)\sin 2\beta$$

$$\sigma[\sin 2\beta] \sim \frac{1}{\sqrt{\underbrace{\varepsilon_{tag}(1-2w)^2}_{Q}}}$$

additive Quality factor

TAG GING MIX ING analysis



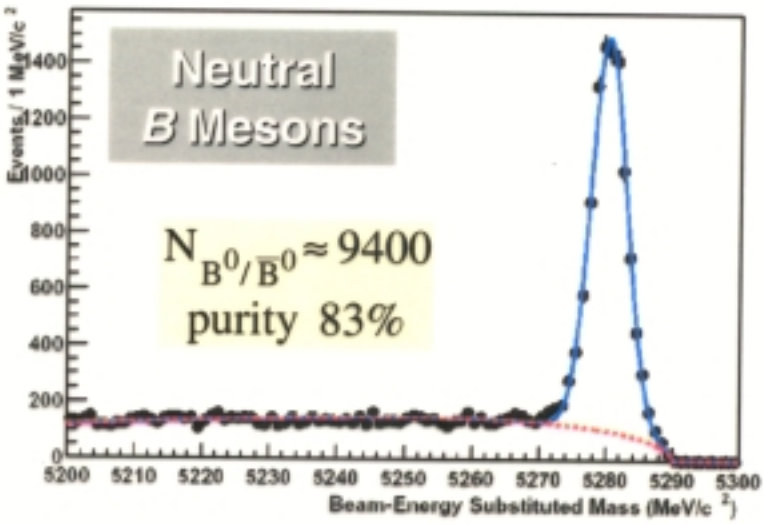
$$g^{\pm}(t) = e^{-|t|}(1 \pm \cos(x_d t))$$

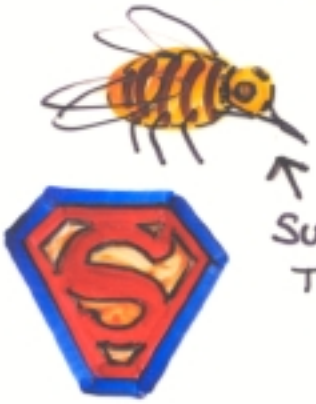
un mixed

mixed

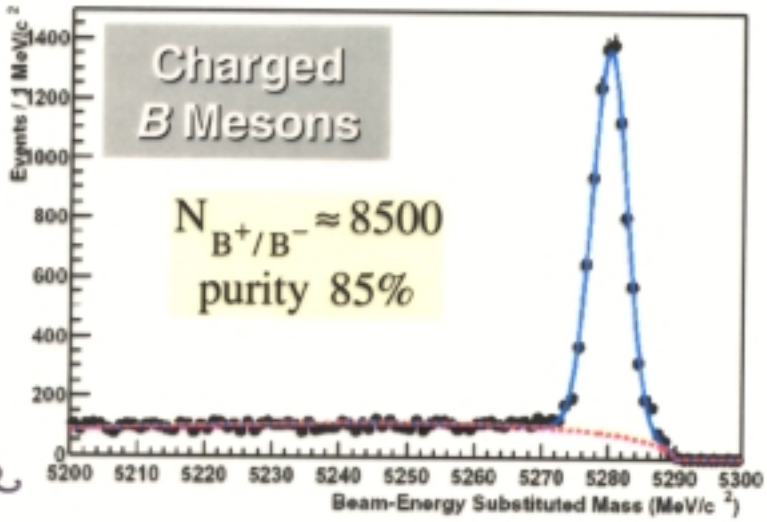
e.g. $D^{*+}\pi^-$

fully$^{(*)}$ reconstructed



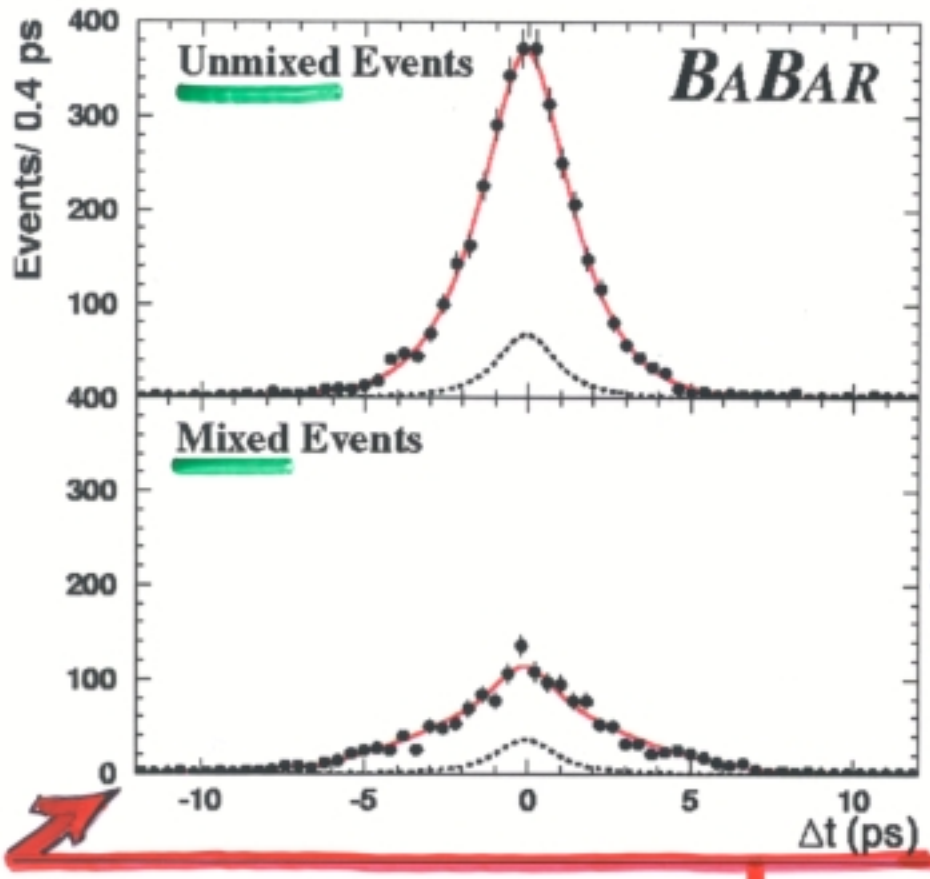


Super Tag



(*) $D^{(*)}\ell\nu$ as a cross-check

$e^{-|t|}$

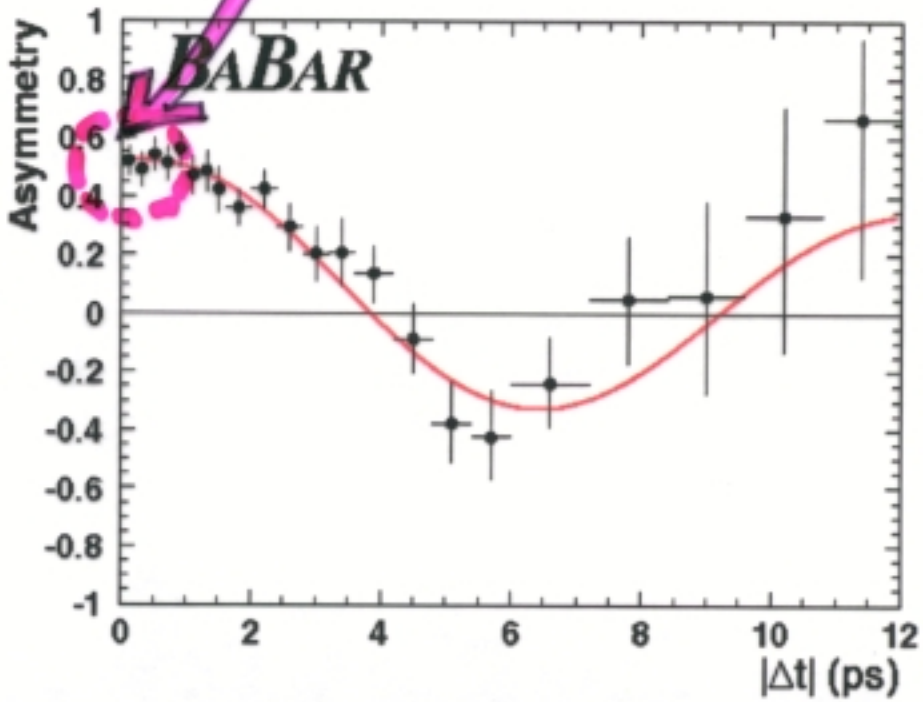


$\times\ 1 + (1-2w)\cos(x_d t)$

$\times\ 1 - (1-2w)\cos(x_d t)$

1-2W

- ℓ, K, N_{t1}, N_{t2}
- $B^0, \bar{B}^0$



Cross-checked with OneBin analysis

Category	ε (%)	w (%)	Q (%)
Lepton	10.9 ± 0.3	8.9 ± 1.3	7.4 ± 0.5
Kaon	35.8 ± 0.5	17.6 ± 1.0	15.0 ± 0.9
NT1	7.8 ± 0.3	22.0 ± 2.1	2.5 ± 0.4
NT2	13.8 ± 0.3	35.1 ± 1.9	1.2 ± 0.3
All	68.4 ± 0.7		26.1 ± 1.2

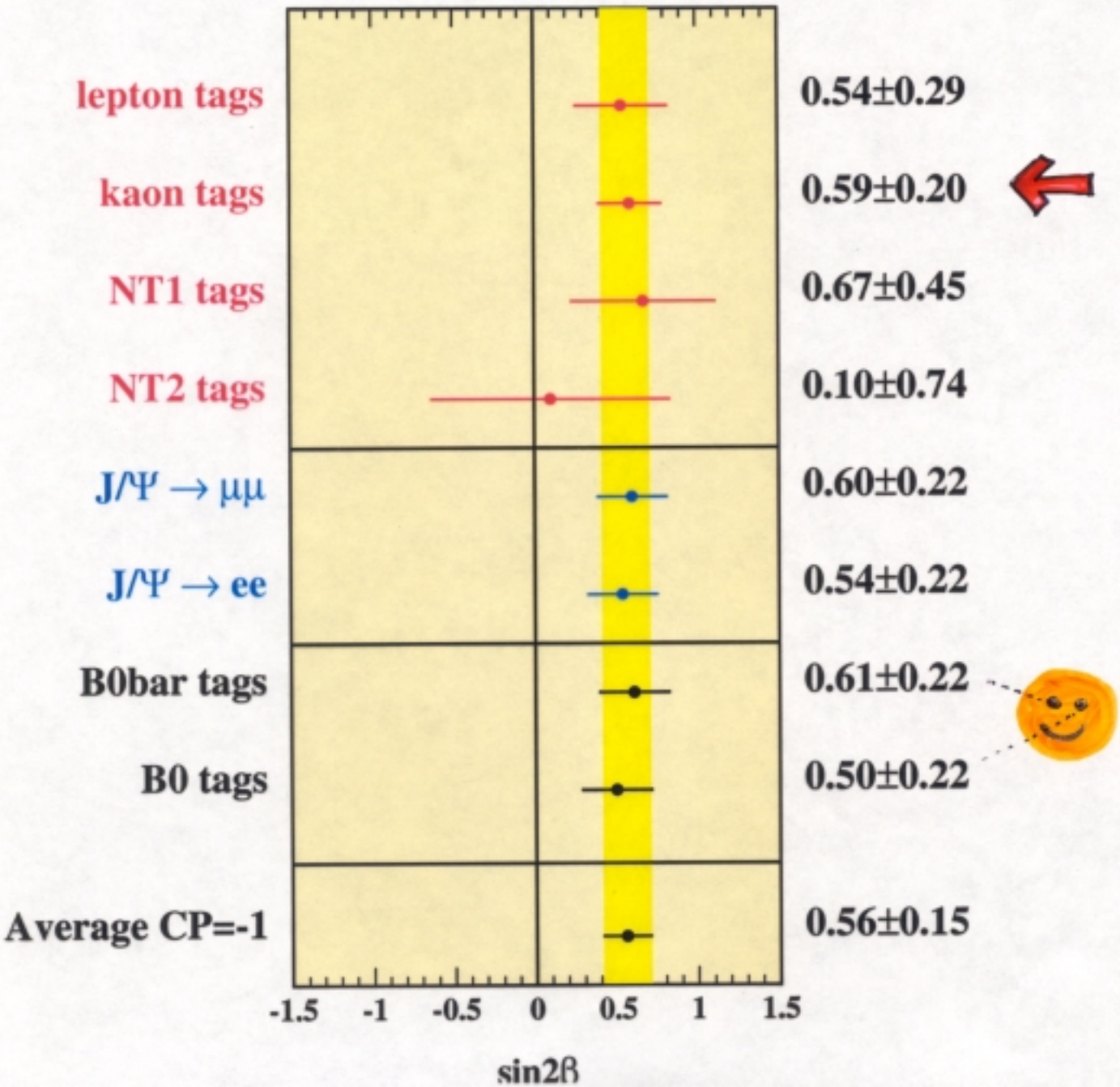
TAGGING

Global fit output

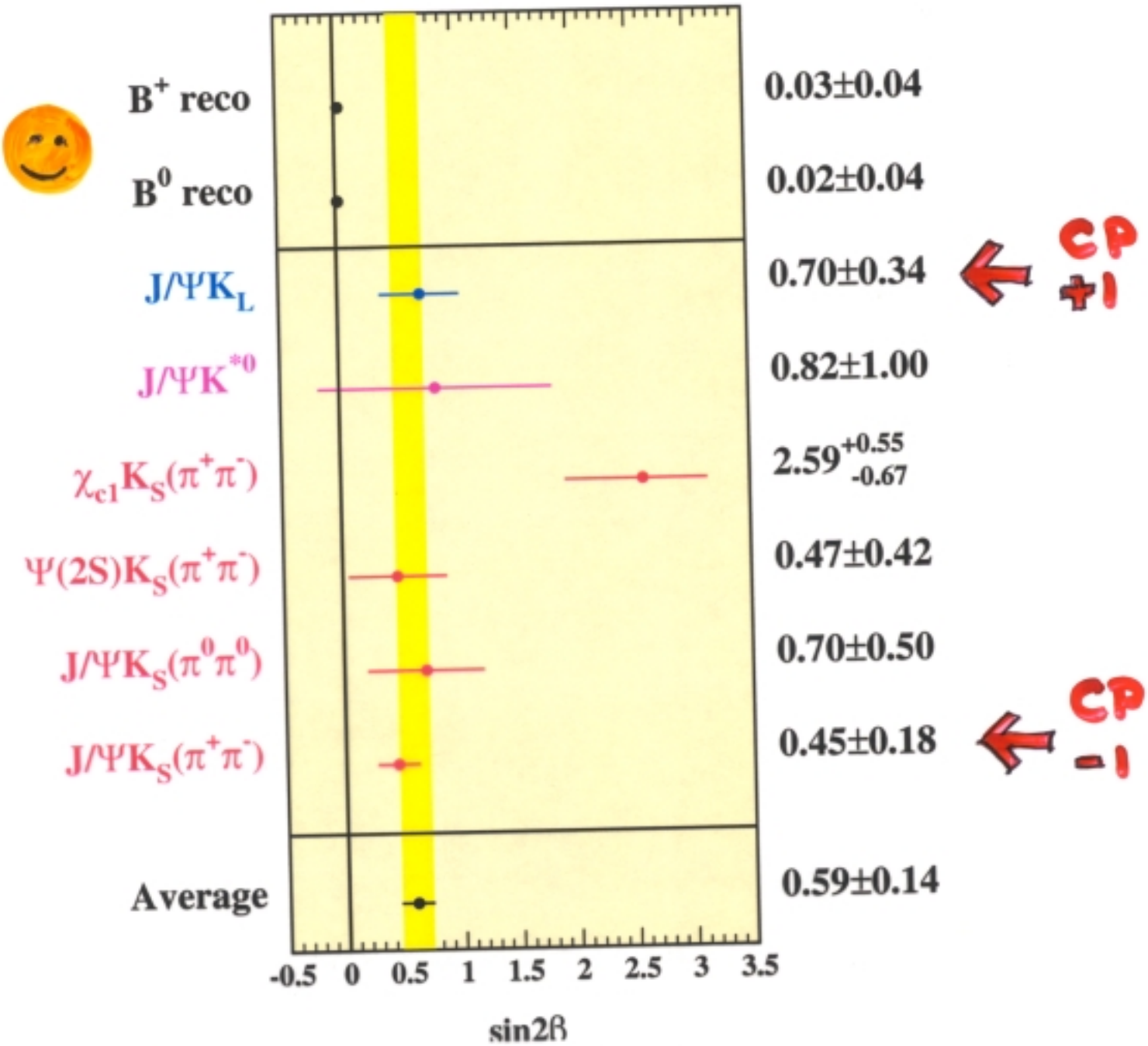
vertexing

Parameter	Run 1	Run 2
σ_{Core} $(/\sigma_{\Delta t})$	1.2 ± 0.1	1.1 ± 0.1
σ_{Tail} $(/\sigma_{\Delta t})$	3	3
σ_{Outlier} (ps)	8	8
f_{Tail}	0.08 ± 0.06	0.04 ± 0.04
f_{Outlier}	0.006 ± 0.003	0 ± 0.01
$\delta_{\text{Core, Lepton}}$ $(/\sigma_{\Delta t})$	0.07 ± 0.12	0.05 ± 0.16
$\delta_{\text{Core, Kaon}}$ $(/\sigma_{\Delta t})$	-0.26 ± 0.08	-0.19 ± 0.10
$\delta_{\text{Core, NT1}}$ $(/\sigma_{\Delta t})$	-0.21 ± 0.15	-0.33 ± 0.21
$\delta_{\text{Core, NT2}}$ $(/\sigma_{\Delta t})$	-0.31 ± 0.11	-0.18 ± 0.15
δ_{Tail} $(/\sigma_{\Delta t})$	-1.6 ± 1.4	-3.2 ± 2.7
δ_{Outlier} (ps)	0	0

Sub-Samples

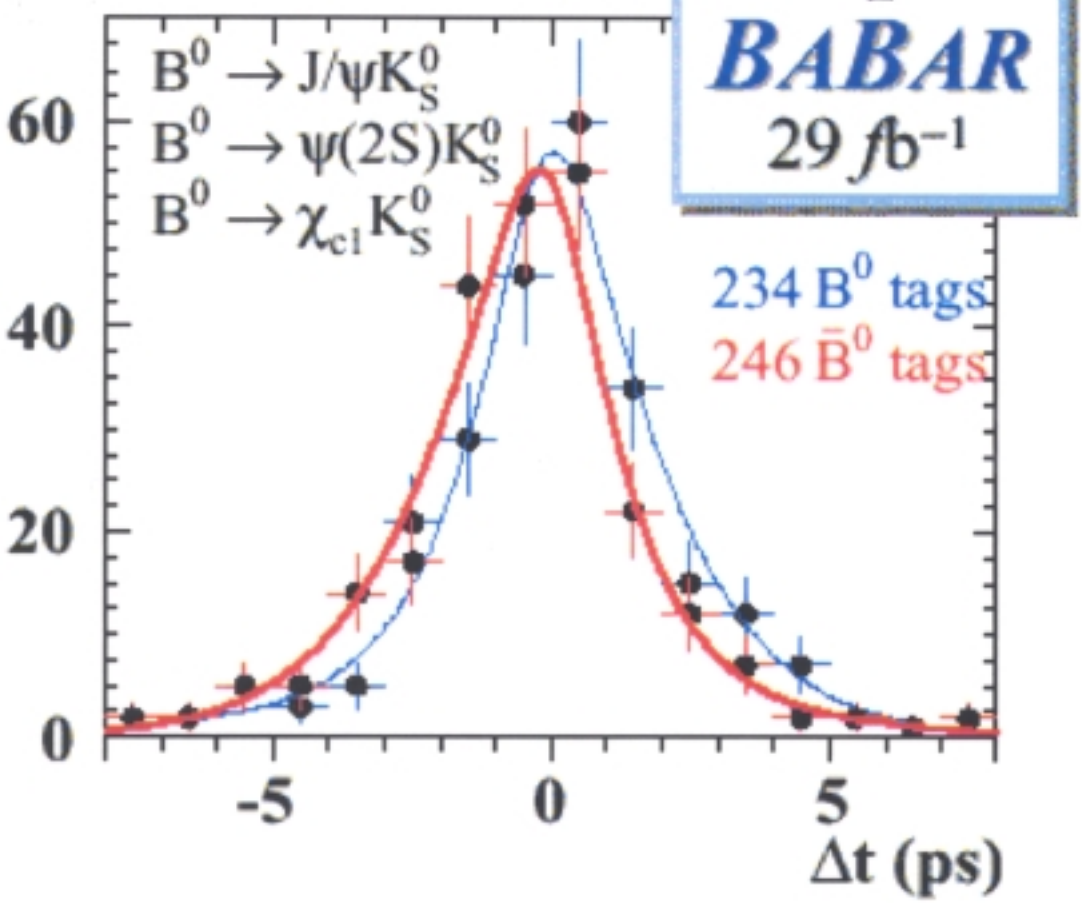

lepton tags
kaon tags
NT1 tags
NT2 tags
J/Ψ → μμ
J/Ψ → ee
B0bar tags
B0 tags
Average CP=-1
0.54±0.29
0.59±0.20
0.67±0.45
0.10±0.74
0.60±0.22
0.54±0.22
0.61±0.22
0.50±0.22
0.56±0.15
-1.5
-1
-0.5
0
0.5
1
1.5
sin2β

Sub - Samples (cont'd)



~~CP~~ from time distribution

$e^{-|t|}(1 \pm \sin 2\beta \sin(x_d t))$ ⊗



$\sin 2\beta = 0.59 \pm 0.14 \pm 0.05$

PRL 87 August 27th

τ_{B^0} τ_{B^+} PRL approved

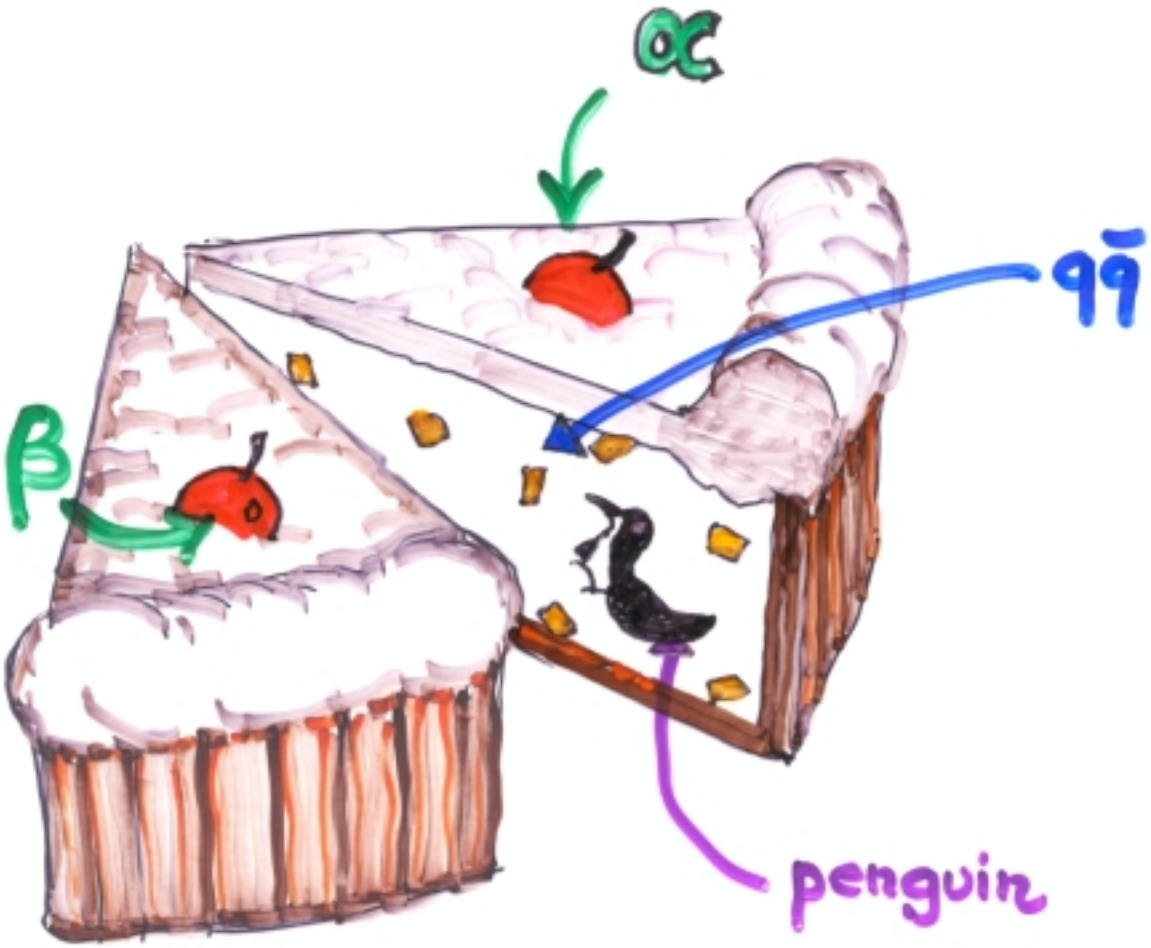
(OK PDG)

Δm_d preliminary

Summer Conferences

A piece of cake

... but the cake is larger

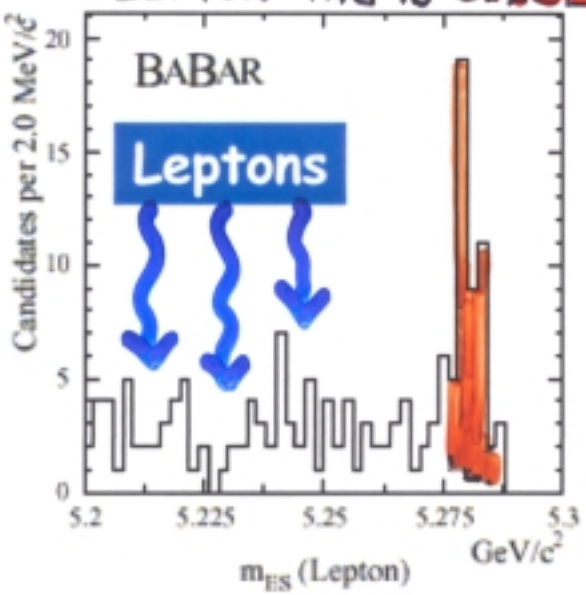


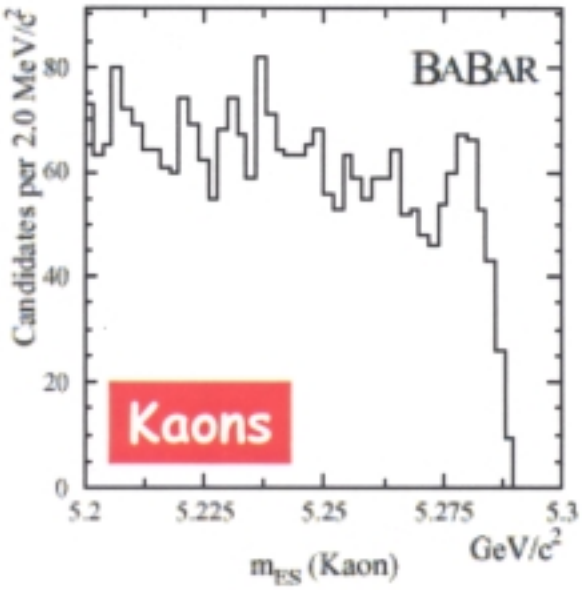
direct CP

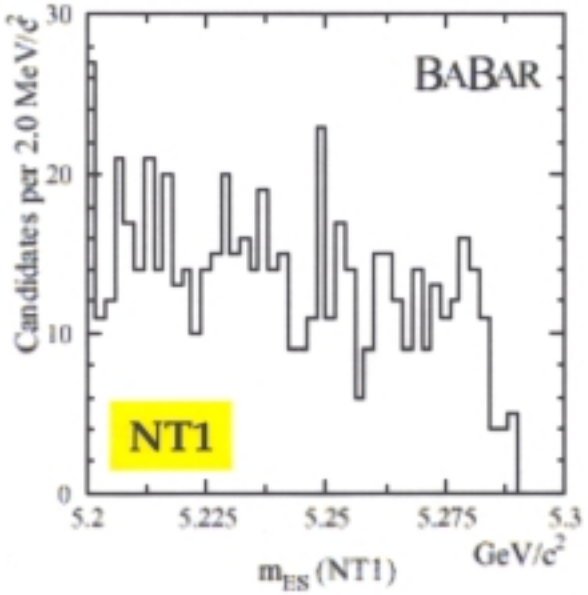
$$e^{-|t|}\left(1 \pm S \sin(x_d t) \mp C \cos(x_d t)\right)$$

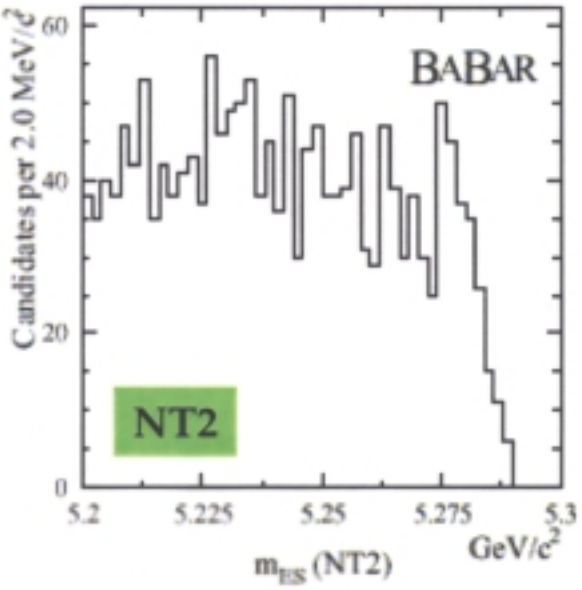
Background level akin To LEP-1 Higgs search

LEPTON TAG is NICE









direct CP

$$\sim e^{-|t|}\left(1 \pm S \sin(x_{dt}) \mp C \cos(x_{dt})\right)$$

Global fit $30.4\,fb^{-1}$

- TAG + noTAG
- $\pi^+\pi^-$ K^+K^- $K^+\pi^-$ π^+K^-
- 6 discriminating variables

$\Rightarrow$ 65^{+12}_{-11} $\pi^+\pi^-$ $\quad 217 \pm 18$ $K^\pm\pi^\mp$ $\quad 4.3^{+6.3}_{-4.3}$ K^+K^-

$$S_{\pi\pi} = 0.03 \pm .55 \pm .11$$

$$C_{\pi\pi} = -0.25 \pm .46 \pm .14$$

$$A_{K\pi} = -0.07 \pm .08 \pm .02$$

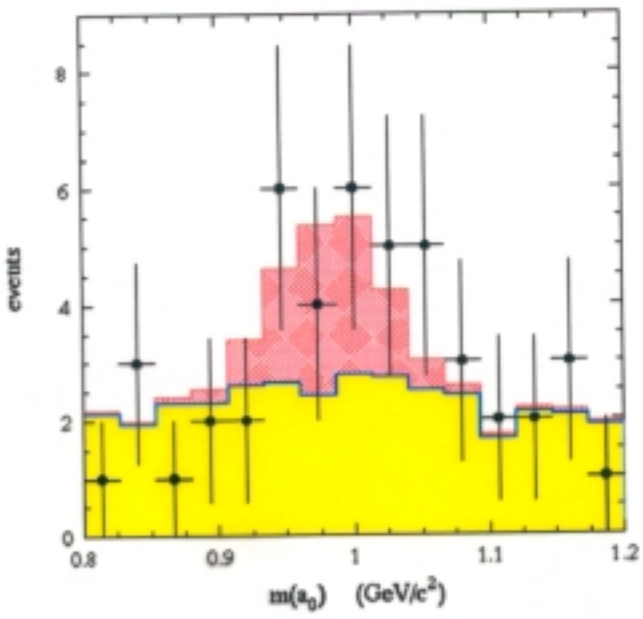
+ cross checks

- Direct CP
- other channels

eg: $\pi^+\pi^-\pi^0$

α , γ , CP ...

$a_0^+\pi^-$



What did we learn ... so far?

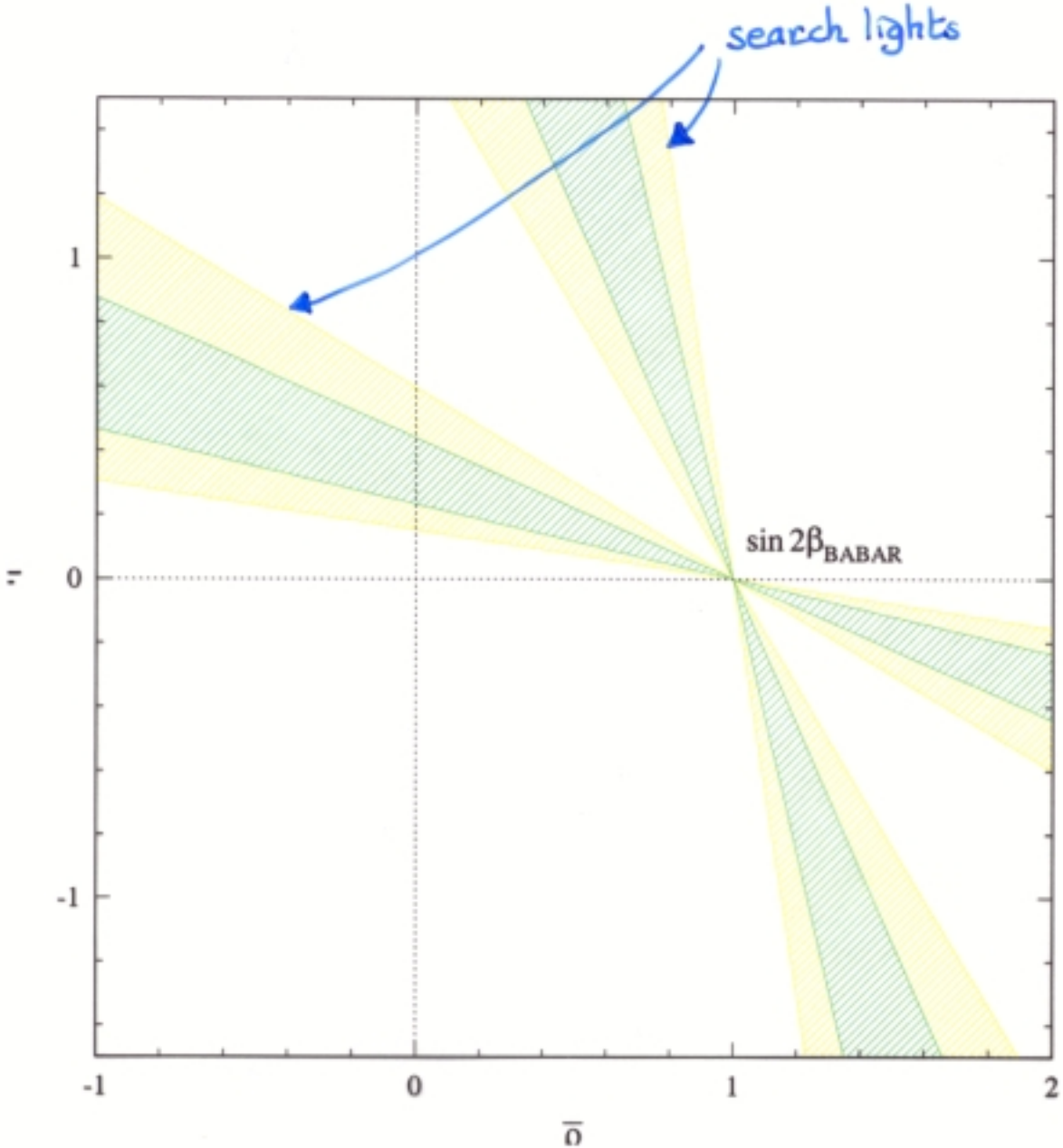
CP violation established in B system©

⇒ Standard Model©?

CP in SM

© Belle & BaBar © Kobayashi & Masukawa

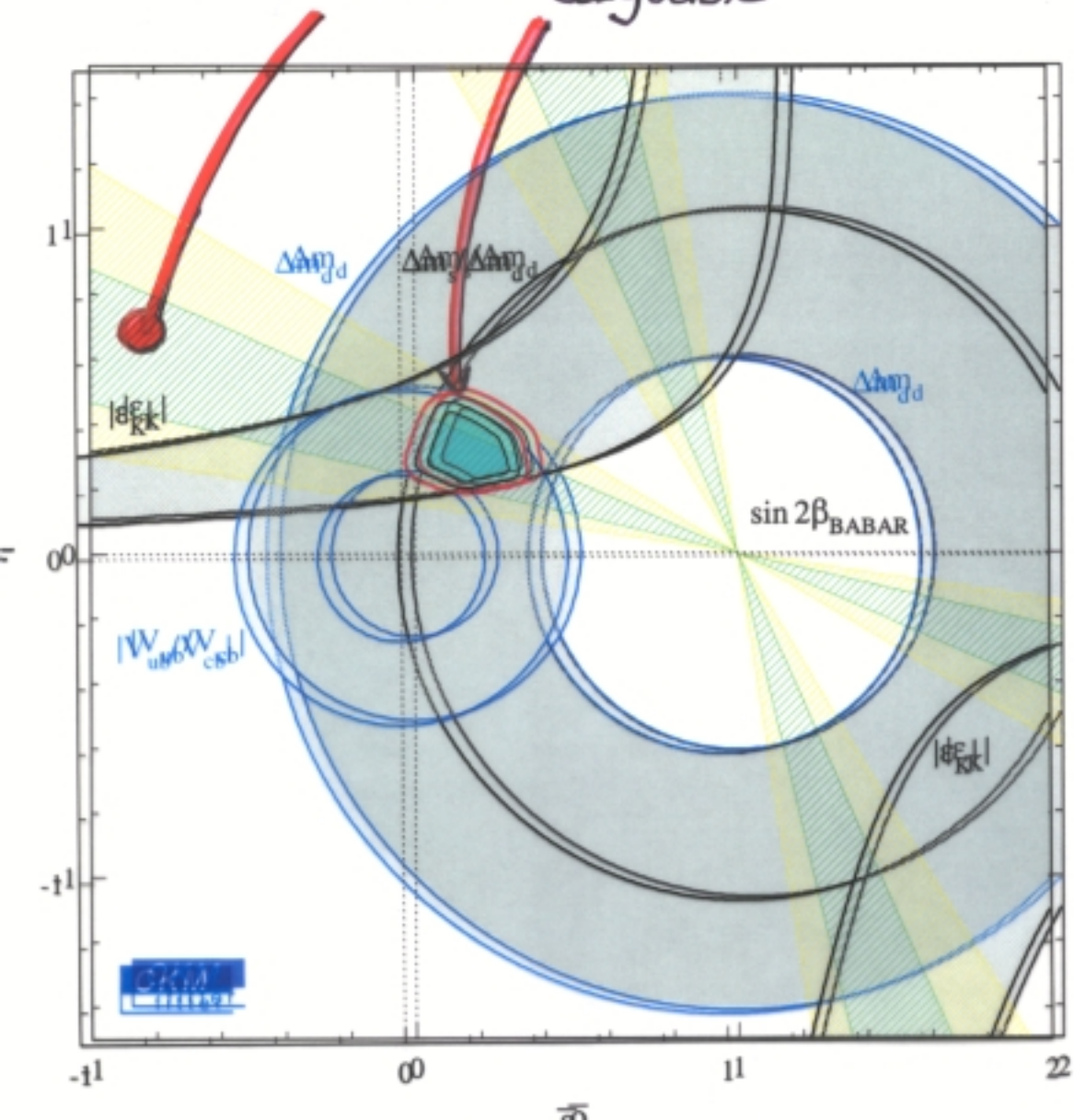
Sin 2β in ρ-η plane



The Standard Model tests in CKM sector just started

Well defined experimental uncertainties

arguable

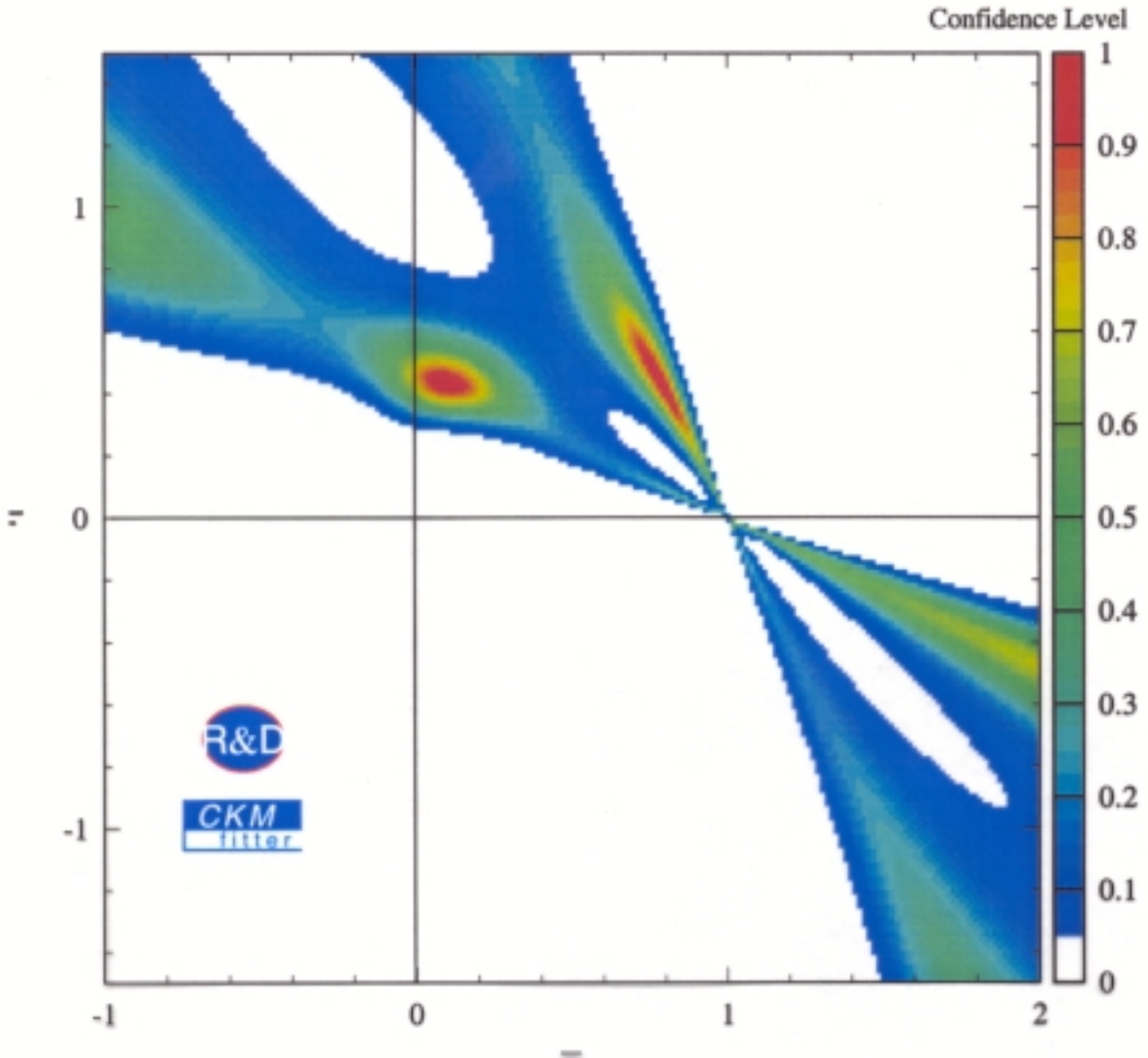


So far

So good

...

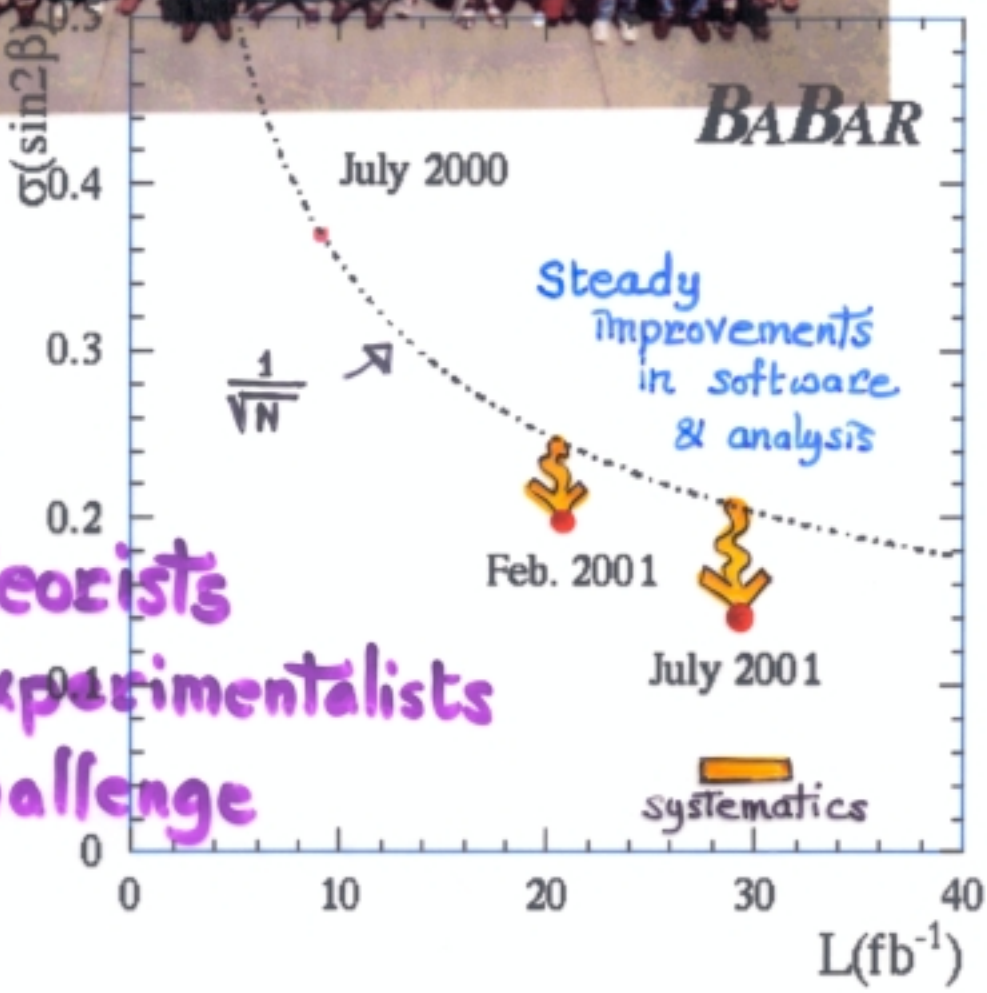
Höcker et al.
Eur. Phys. J.
C 21/2 (2001) 225


Confidence Level
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
0
-1
-1
0
1
2
R&D
CKM
fitter

CONCLUSION : NEXT ?

← You are Welcome

Free



β α γ

CP direct

σ Sin2β

Theorists Experimentalists Challenge