

BELLE STATUS-Report

CP-Verletzung $B^0 \bar{B}^0$

Messung $\sin 2\Phi_1$

$B \rightarrow J/\psi K$

Messung $\sin 2\Phi_2$

$B \rightarrow \pi^+ \pi^-$



WIENER BEITRÄGE

Messung von V_{ub}

Vergleich $B \rightarrow \rho l \nu \Leftrightarrow D \rightarrow \rho l \nu$

bzw. $B \rightarrow \pi l \nu \Leftrightarrow D \rightarrow \pi l \nu$

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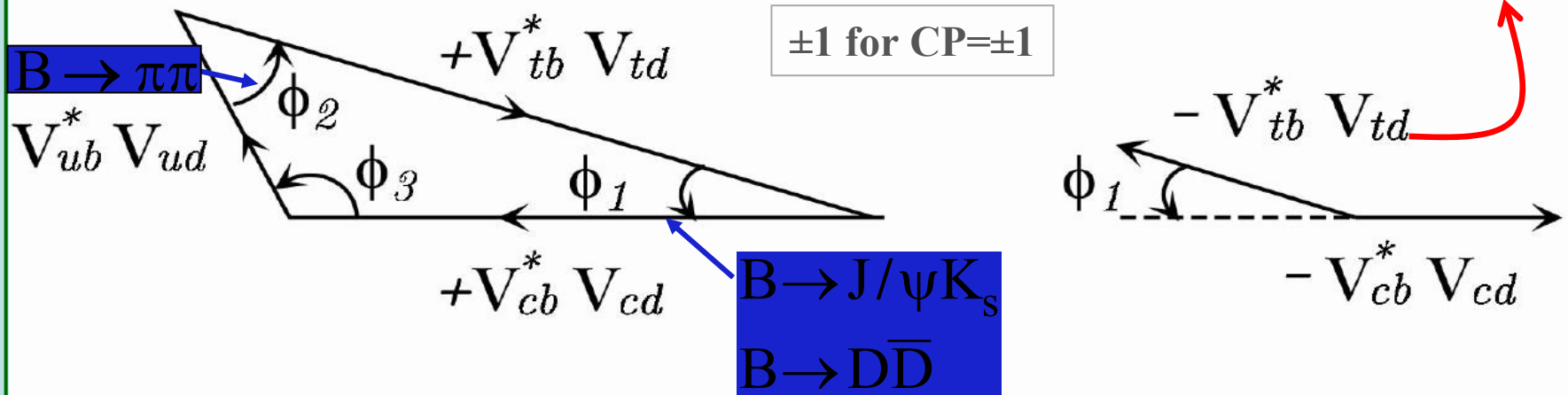


SM-theory for mixing-induced CP-violation

$$A(\Delta t) \equiv \frac{\Gamma(\overline{B}_d^0 \rightarrow f_{CP}) - \Gamma(B_d^0 \rightarrow f_{CP})}{\Gamma(\overline{B}_d^0 \rightarrow f_{CP}) + \Gamma(B_d^0 \rightarrow f_{CP})} = -\xi_f \sin 2\phi_1 \sin \Delta m_d \Delta t,$$

Δt $\equiv t_{CP} - t_{tag}$
 f_{CP} : CP eigenstate
 $\Gamma(\overline{B}_d^0 (B_d^0) \rightarrow f_{CP})$: decay rate for a $\overline{B}_d^0 (B_d^0)$ to f_{CP} at Δt
 ξ_f : CP-eigenvalue of f_{CP}

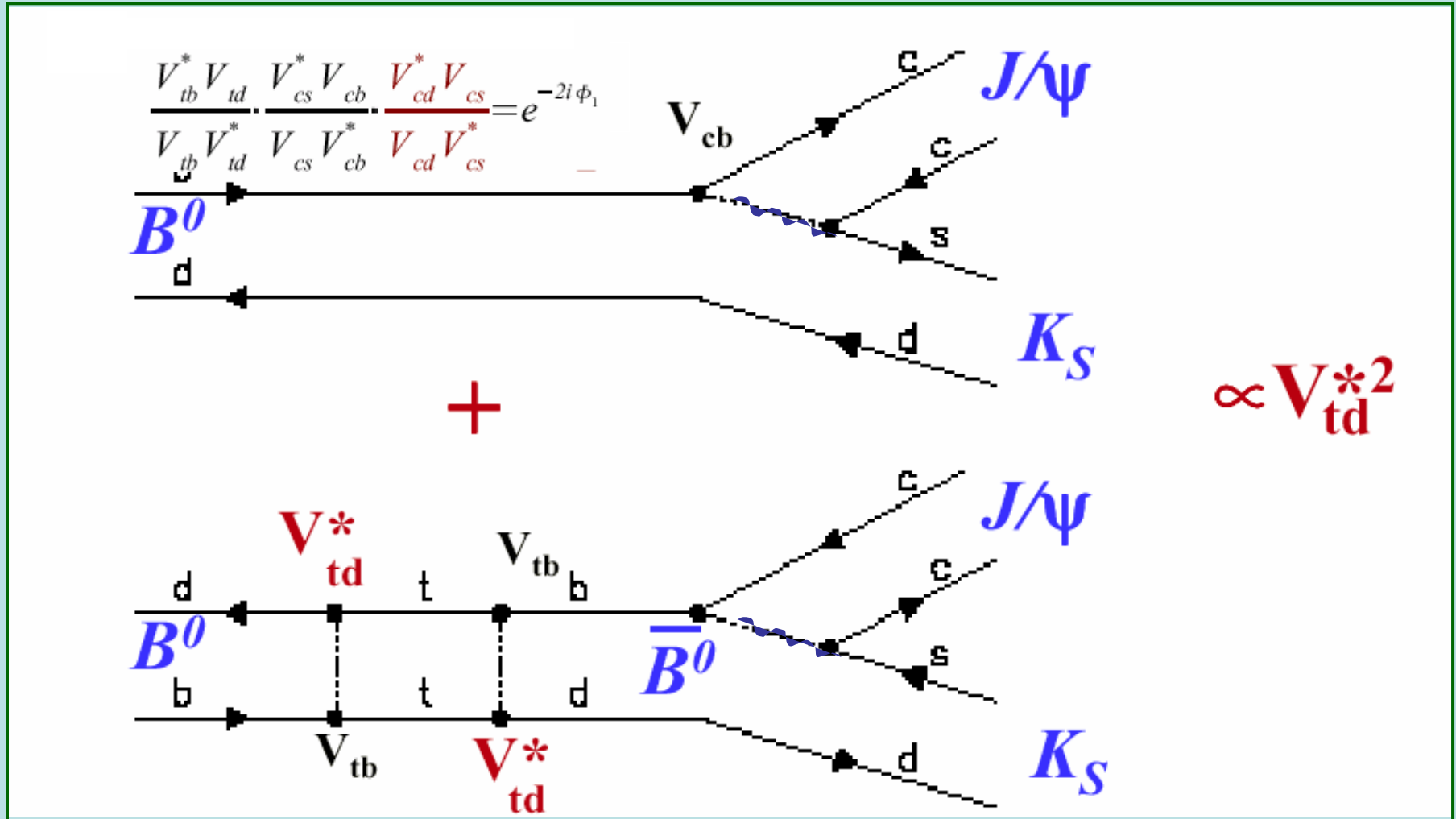
$$\phi_1 \equiv \pi - \arg \left(\frac{-V_{tb}^* V_{td}}{-V_{cb}^* V_{cd}} \right) = \beta$$



Kobayashi-Maskawa-Ansatz in the Standard Model



$\sin 2\phi_1 : B \rightarrow f_{CP} + B \leftrightarrow \bar{B} \rightarrow f_{CP}$ Interferenz

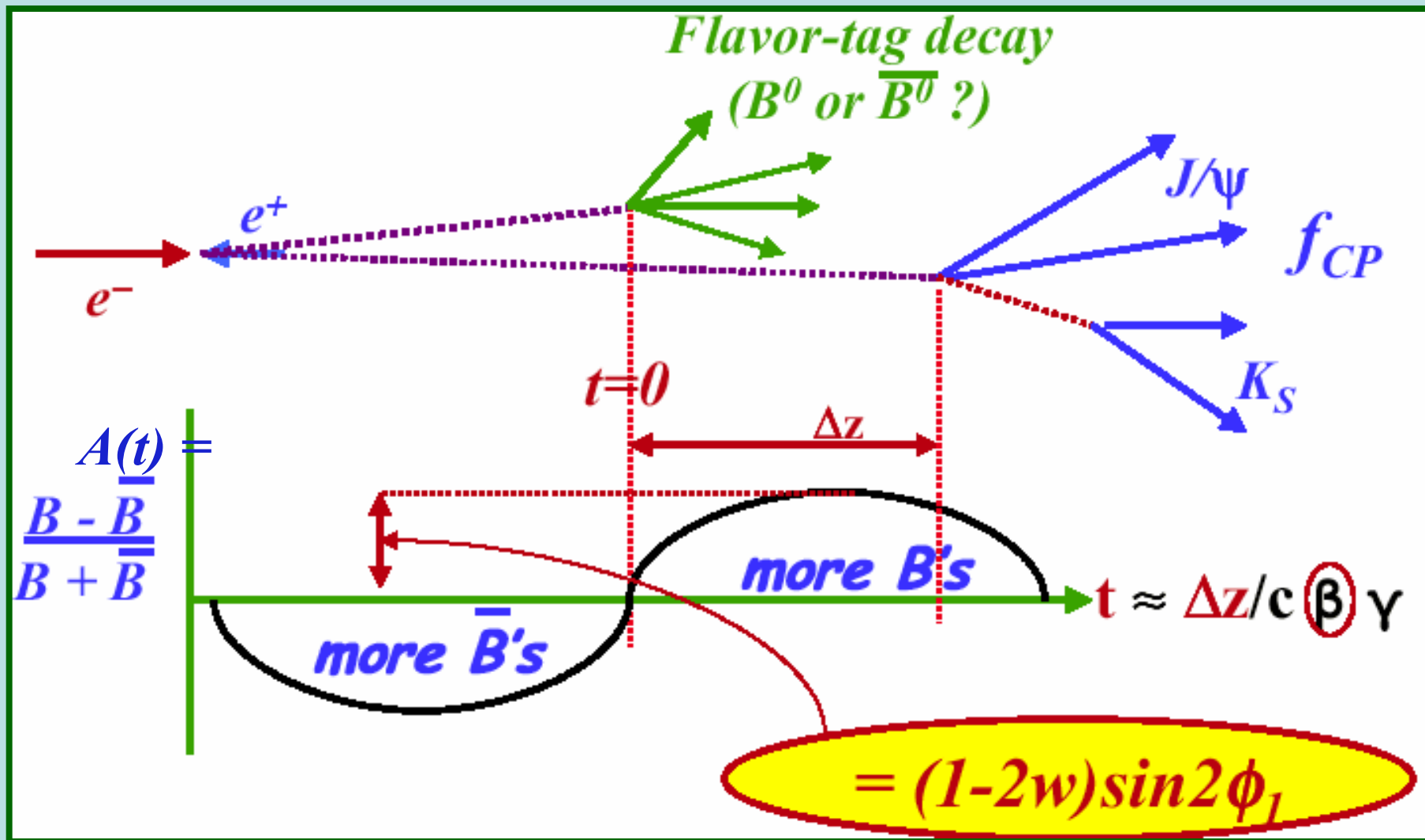


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Was wird wirklich gemessen?



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Ergebnis: $\sin 2\phi_1$

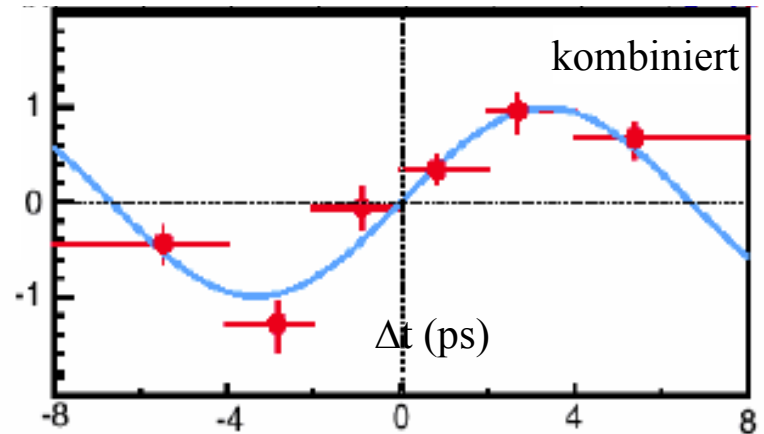
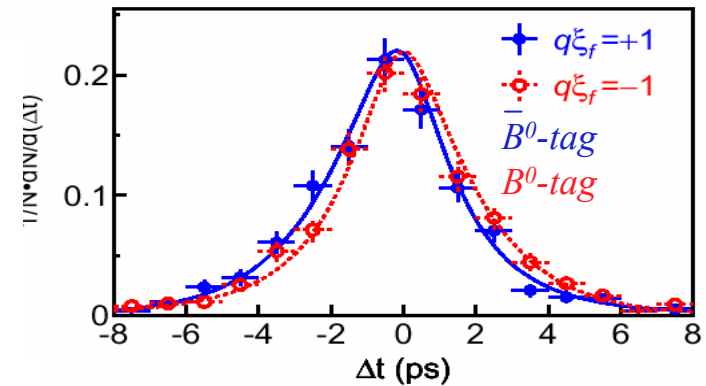
CP im B-Zerfall stark verletzt

>6 σ !!

$$\sin 2\phi_1 = 0.82 \pm 0.12(\text{stat}) \pm 0.05(\text{syst})$$

$\sin 2\phi_1$ nahe am
„erwarteten“ Wert
lt. Standard Modell

$$0.82 \pm 0.12 \pm 0.05$$



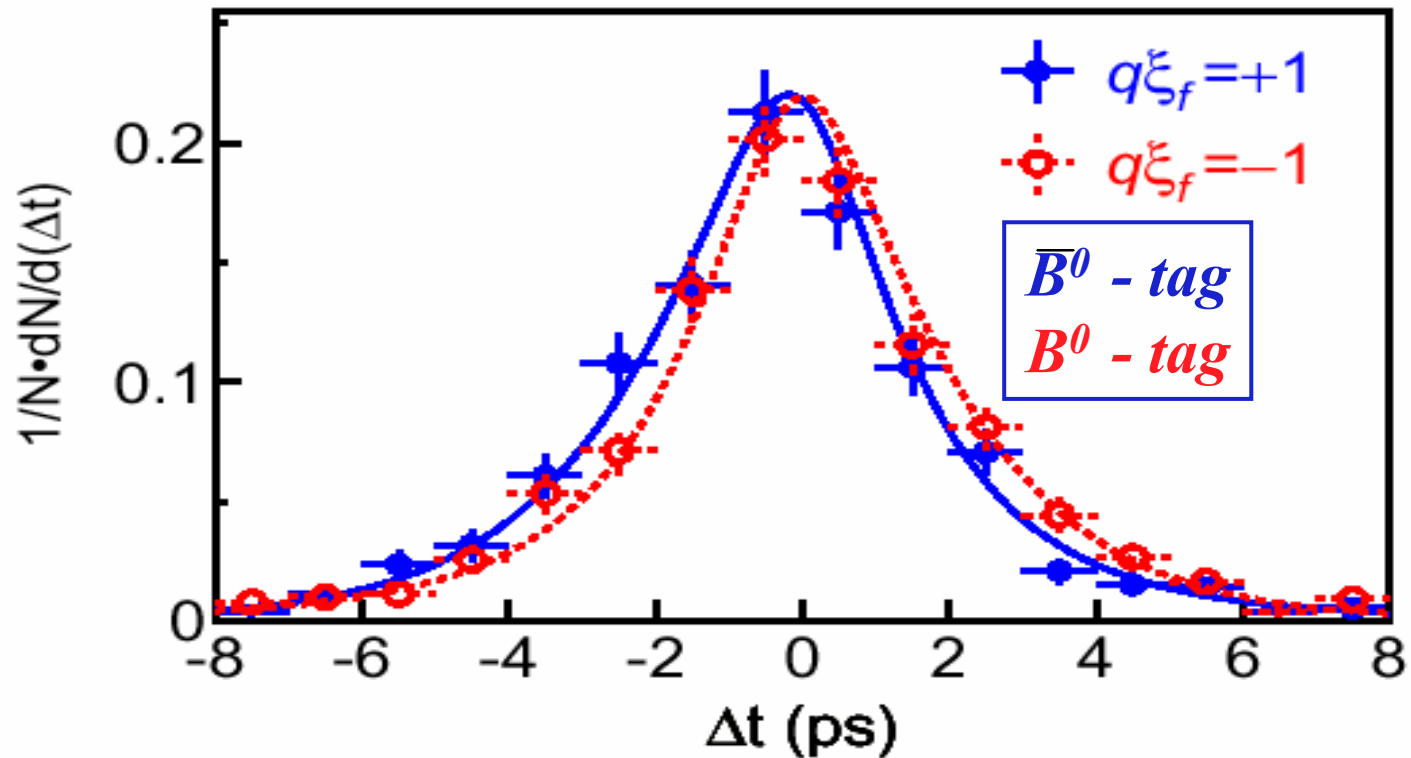
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Neues Ergebnis: BELLE

$$\sin 2\phi_1 = 0.82 \pm 0.12(\text{stat}) \pm 0.05(\text{syst})$$



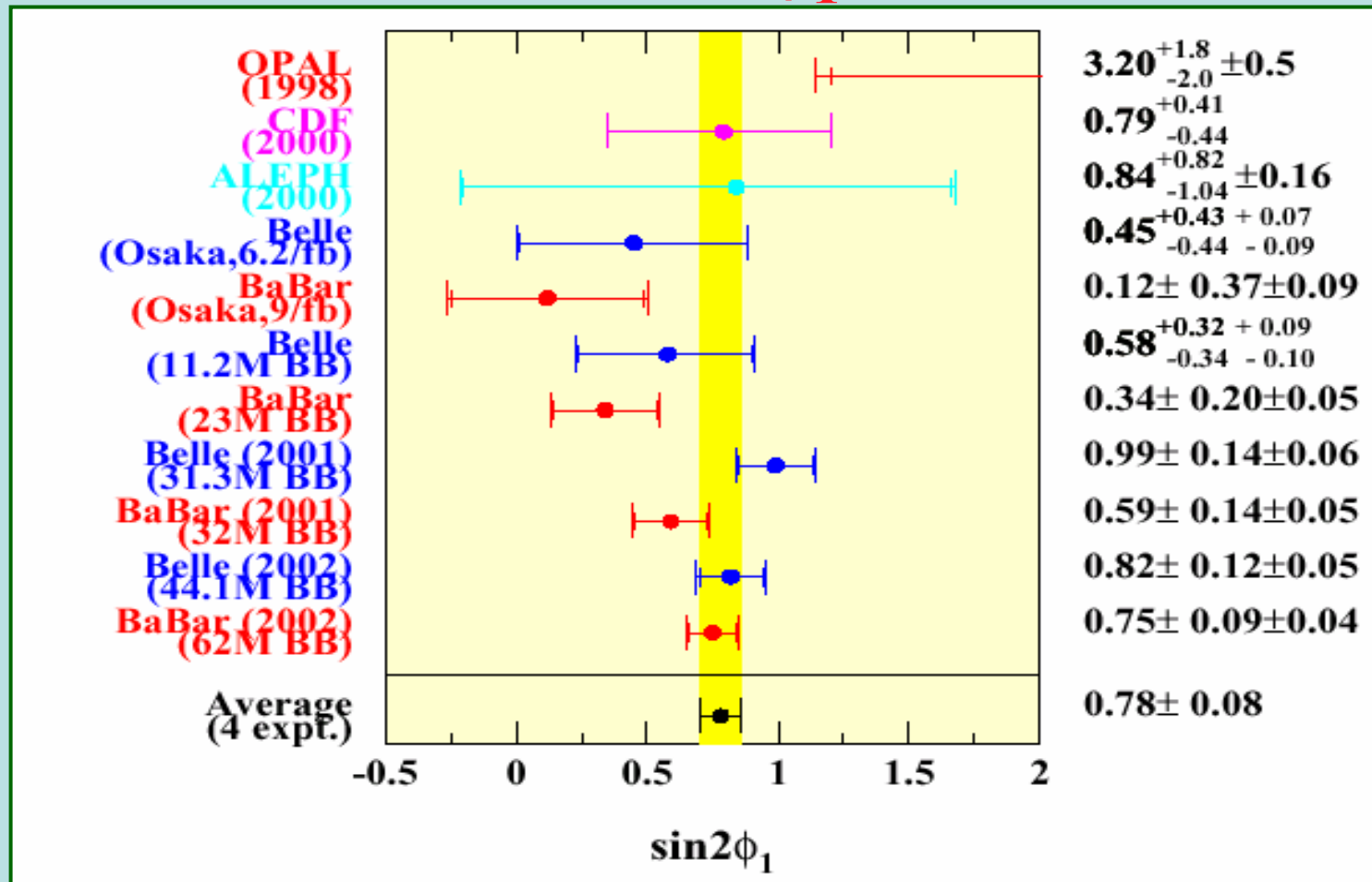
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Vergleich mit anderen Experimenten

$\sin 2\phi_1$

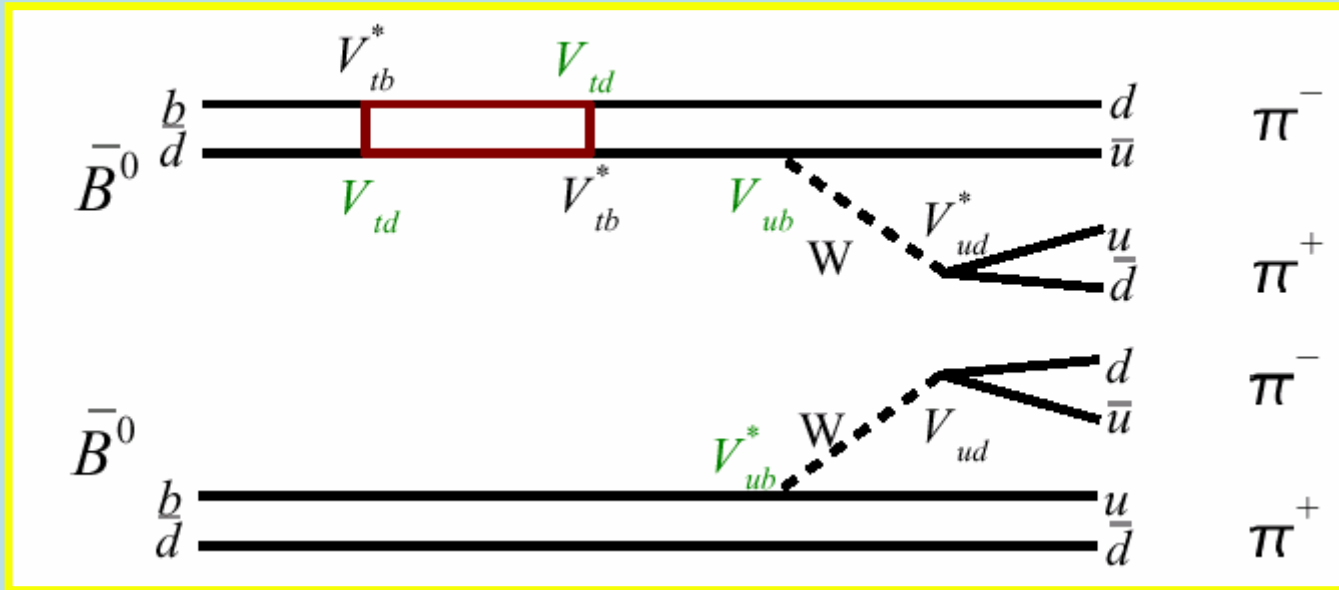


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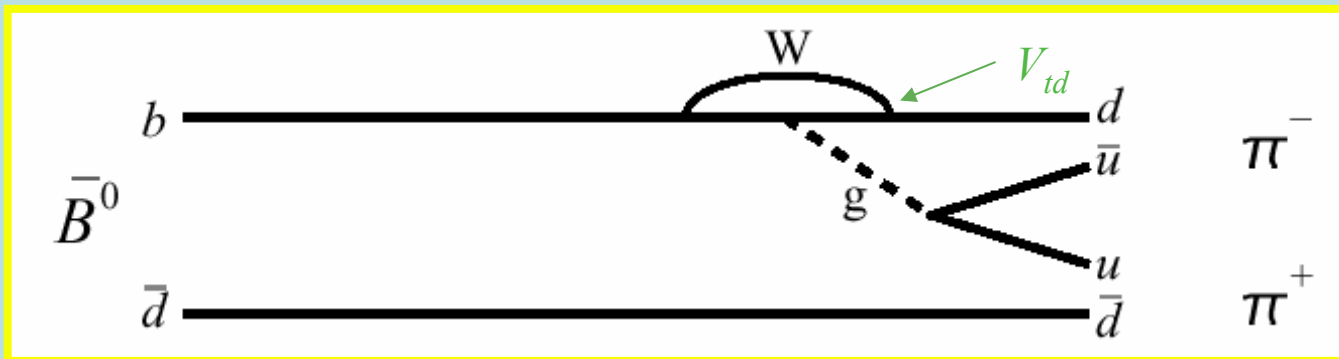
$\sin 2\phi_2 : B \rightarrow f_{CP} + B \leftrightarrow \bar{B} \rightarrow f_{CP}$ Interferenz



$$\frac{V_{tb}^* V_{td}}{V_{tb} V_{td}^*} \cdot \frac{V_{ud}^* V_{ub}}{V_{ud} V_{ub}^*} = e^{-2i\phi_2}$$

+ Interferenz

$$P_{\pi^+\pi^-}(\Delta t) = \frac{e^{-|\Delta t|/\tau_B}}{4\tau_B} (1 + q(1 - 2w_i)(S \sin(\Delta m_d \Delta t) + A \cos(\Delta m_d \Delta t)))$$



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Direkte CP-Verletzungsasymmetrie

Asymmetry in B decay rates

$$a_{dir} \equiv \frac{\Gamma(\bar{B} \rightarrow \bar{f}) - \Gamma(B \rightarrow f)}{\Gamma(\bar{B} \rightarrow \bar{f}) + \Gamma(B \rightarrow f)}$$
$$= \frac{2r \sin \phi \sin \delta}{1 + r^2 + 2r \cos \phi \cos \delta}$$

$r = |P| / |T|$, $\phi = \text{weak phase diff.}$,

$\delta = \text{strong phase diff.}$

Direct CP asymmetry (a_{dir}) can be significant if penguin (P) and tree(T) amplitudes are comparable.



“Schwache Phase” in CKM-Matrix

- CKM Matrix is Unitary, Elements can be complex.
- One phase cannot be rotated away. Usually put in corner terms

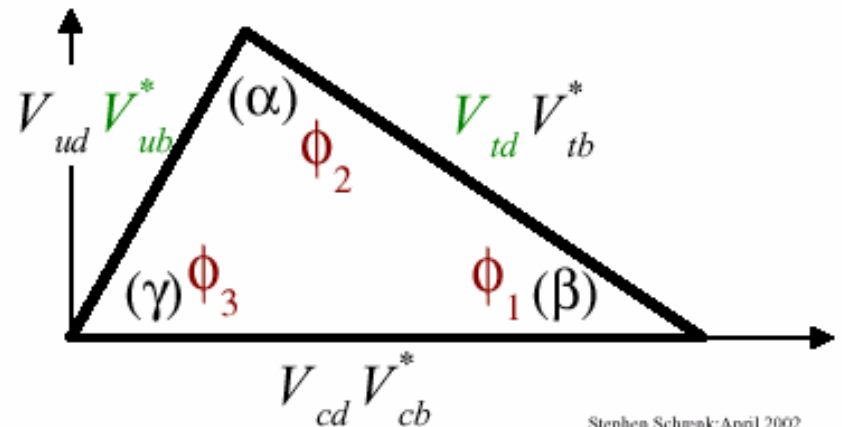
$$V \equiv \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \approx \begin{pmatrix} 1 - \lambda^2/2 & \lambda & A\lambda^3(\rho - i\eta) \\ -\lambda & 1 - \lambda^2/2 & A\lambda^2 \\ A\lambda^3(1 - \rho - i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

Wolfenstein Parameterization

- Unitarity and columns 1 & 3:

$$V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$

CP Violation is proportional to the area of the triangle.

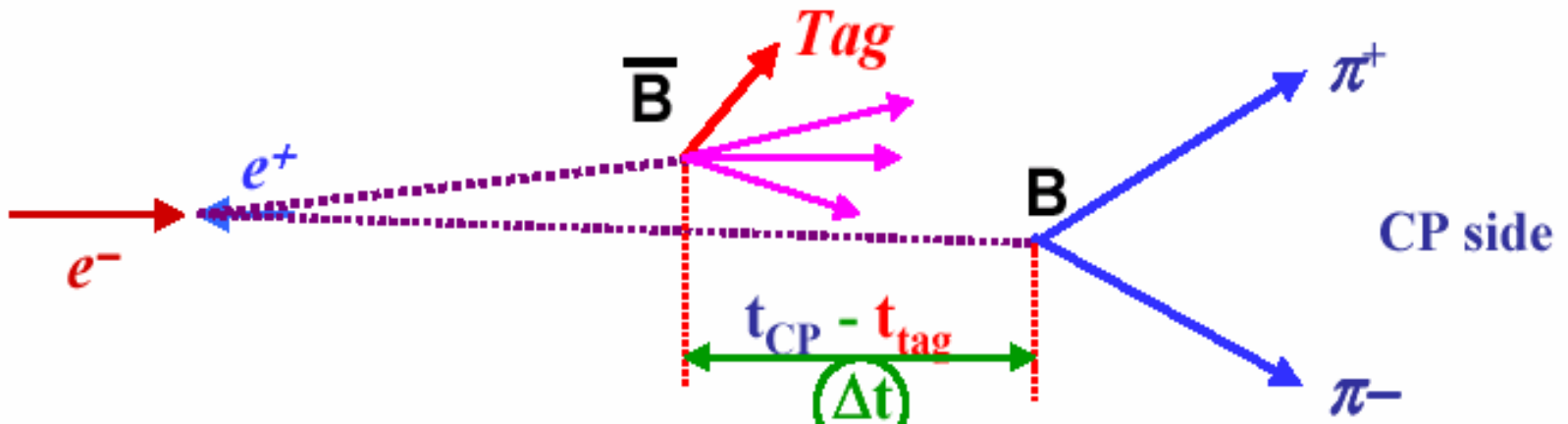


Stephen Schrenk: April 2002

Direkte CP-Verletzung und $\sin 2\phi_2$

$$Rq (B \rightarrow \pi^+ \pi^-; \Delta t) = \frac{e^{-|\Delta t|/\tau_B}}{4\tau_B} [1 + q \cdot \{ C_{\pi\pi} \cos(\Delta m \Delta t) + S_{\pi\pi} \sin(\Delta m \Delta t) \}]$$

$q = +1$ (B^0 tagging), -1 (\bar{B}^0 tagging)



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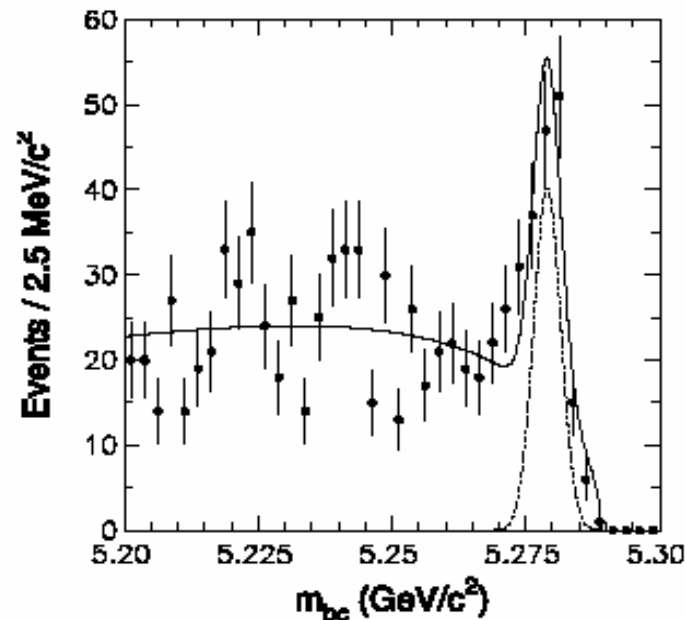


$\sin 2\phi_2$ beam-constrained-mass

Signal of $B \rightarrow \pi^+ \pi^-$

- M_{bc} (beam-constrained mass)

41.8 fb^{-1}
 $44.1 \times 10^6 \text{ BB pairs}$



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$\sin 2\phi_2$: Direkte und indirekte CP-Verletzung

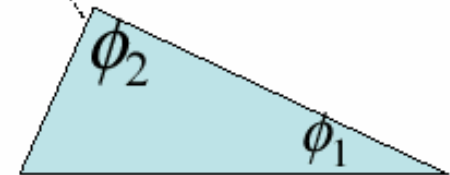
$$S_{\pi\pi} \text{ and } C_{\pi\pi}$$

$$S_{\pi\pi} = \frac{2 \operatorname{Im} \lambda}{|\lambda|^2 + 1} = \sqrt{1 - C_{\pi\pi}^2} \sin 2(\phi_2 + \theta)$$

$\theta\left(\left|\frac{P}{T}\right|, \delta_P\right)$
 phase from Penguin contribution

$$C_{\pi\pi} = \frac{|\lambda|^2 - 1}{|\lambda|^2 + 1} = \frac{|\bar{A}_{+-}|^2 - |A_{+-}|^2}{|\bar{A}_{+-}|^2 + |A_{+-}|^2}$$

**DCPV
asymmetry**



*CKM matrix
Unitarity triangle*

$$\lambda \equiv e^{-2\phi_1} \frac{\bar{A}_{+-}}{A_{+-}} = e^{-2\phi_1} \frac{A(\bar{B}^0 \rightarrow \pi^+\pi^-)}{A(B^0 \rightarrow \pi^+\pi^-)}$$

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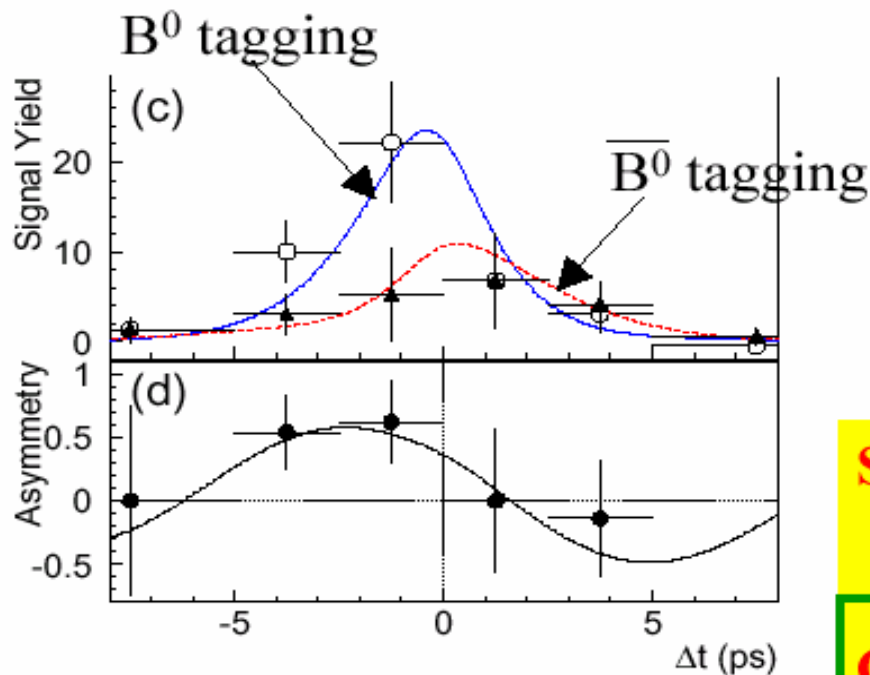
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BELLE Ergebnis

CP fit results : $S_{\pi\pi}$ and $C_{\pi\pi}$

Only $\pi^+\pi^-$ extracted
(by subtracting $q\bar{q}+K\pi$)



99.6% C.L.
For $C_{\pi\pi} > 0$ (2.9σ)

$$S_{\pi\pi} = -1.21 \begin{matrix} +0.38 & +0.16 \\ -0.27 & -0.13 \end{matrix}$$

(stat.) (syst.)

$$C_{\pi\pi} = +0.94 \begin{matrix} +0.25 \\ -0.31 \end{matrix} \pm 0.09$$

Direct CPV asym.

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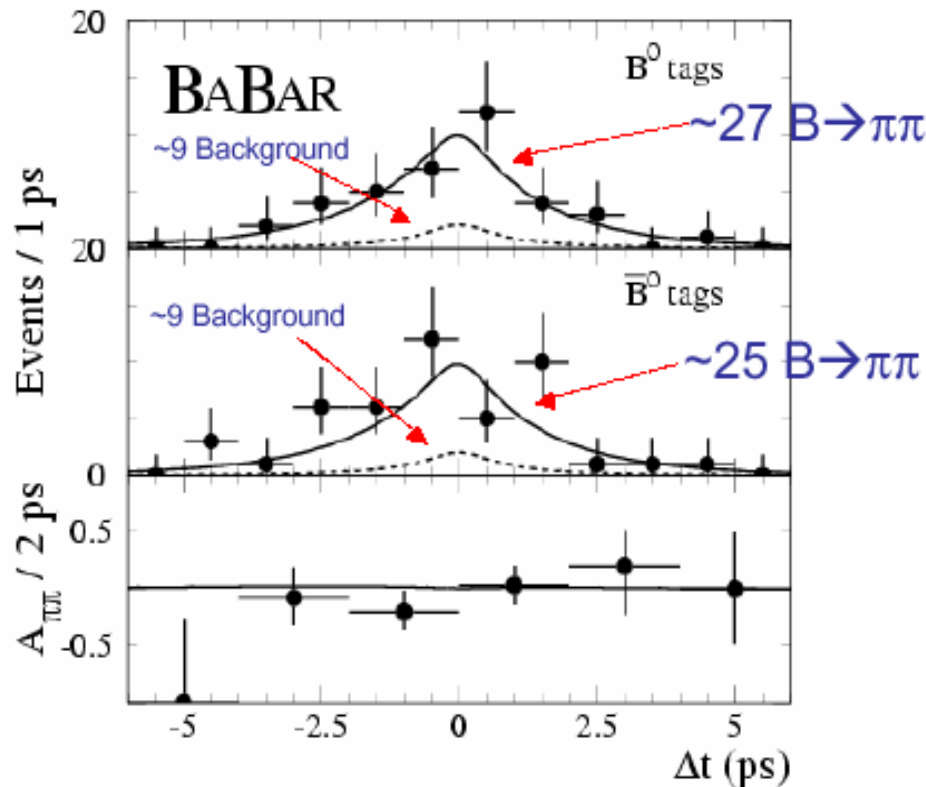


BaBar Ergebnis

$$S_{\pi\pi} = -0.01 \pm 0.37 \pm 0.07 \quad [-0.66, +0.62]$$

$$C_{\pi\pi} = -0.02 \pm 0.29 \pm 0.07 \quad [-0.54, +0.48]$$

90% CL



Select $B \rightarrow \pi\pi$
sample and plot
the asymmetry
between
mixed/unmixed
events.

BaBar

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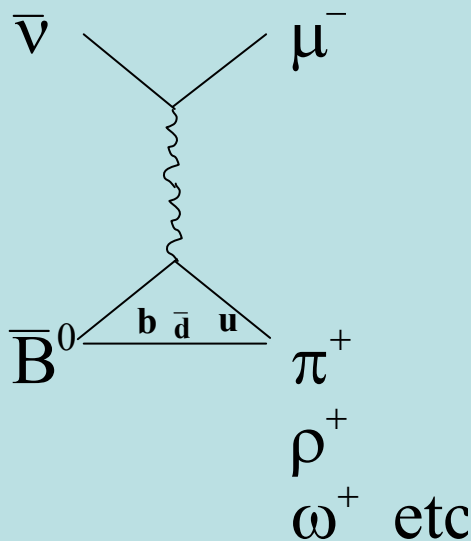
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Messung von V_{ub}

Selektion des Signals gegen Untergrund

$Y(4s) \Rightarrow B\bar{B}$



$$m_{bc} = \sqrt{(\mathbf{E}_{CM}/2)^2 - (\vec{p}_\pi + \vec{p}_l + \vec{p}_\nu)^2} > 5.26 \text{ GeV}$$

$$\Delta E = |\mathbf{E}_\pi + \mathbf{E}_l + \mathbf{E}_\nu - \mathbf{E}_{CM}/2| < 0.3 \text{ GeV}$$

reject continuum

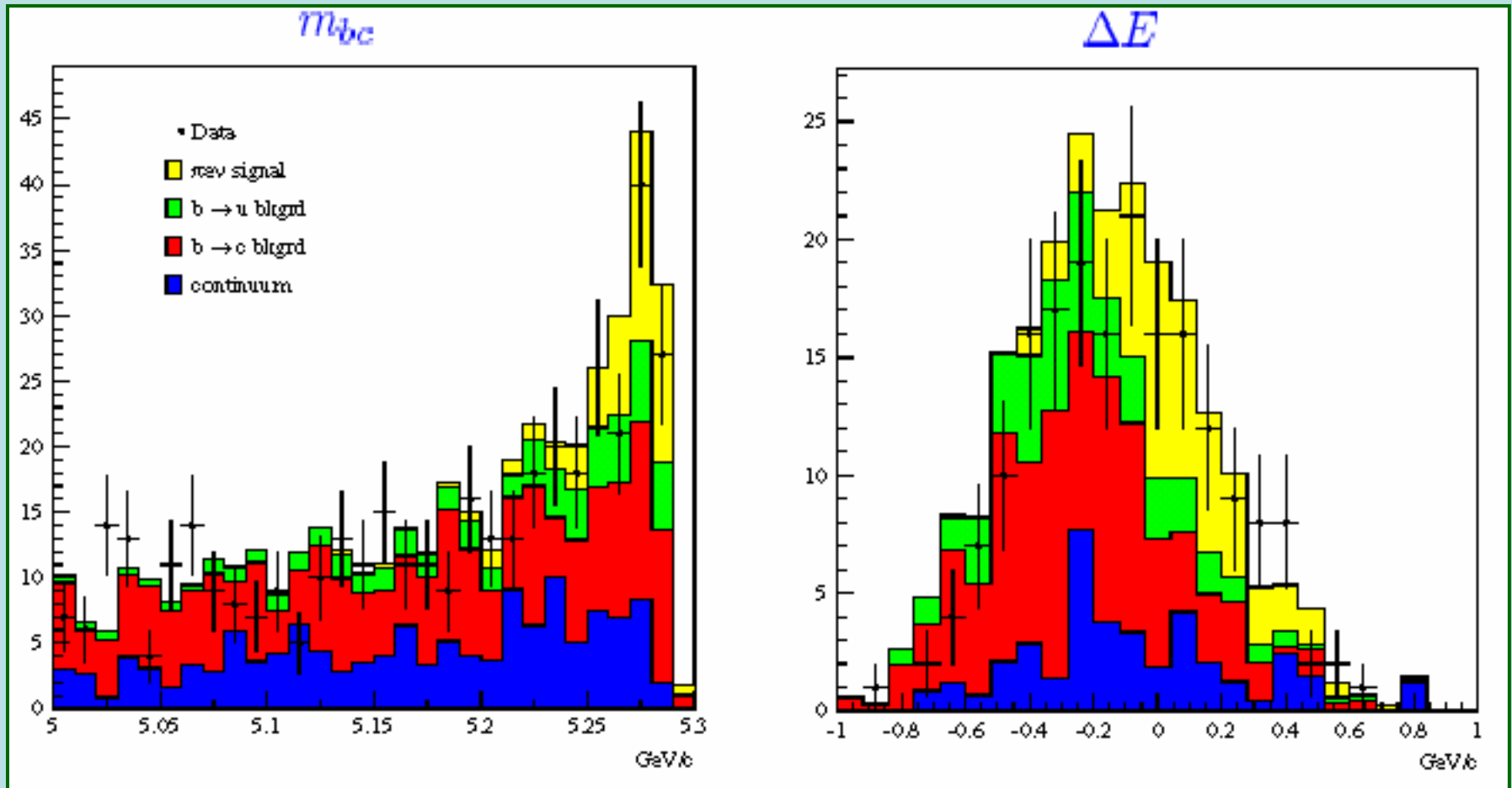
$$|\mathbf{E}_{\text{miss}}^2 - \vec{p}_{\text{miss}}^2| < 2 \text{ GeV}^2$$

4 Diskriminanten Variablen:

$$\vec{p}_\pi, \vec{p}_l, \text{Vertex prob}(l, \pi), \cos \Theta_{B, \pi l}$$

Wiener Beitrag

Bestimmung von V_{ub} : $B^0 \rightarrow \pi^- e^+ \nu$



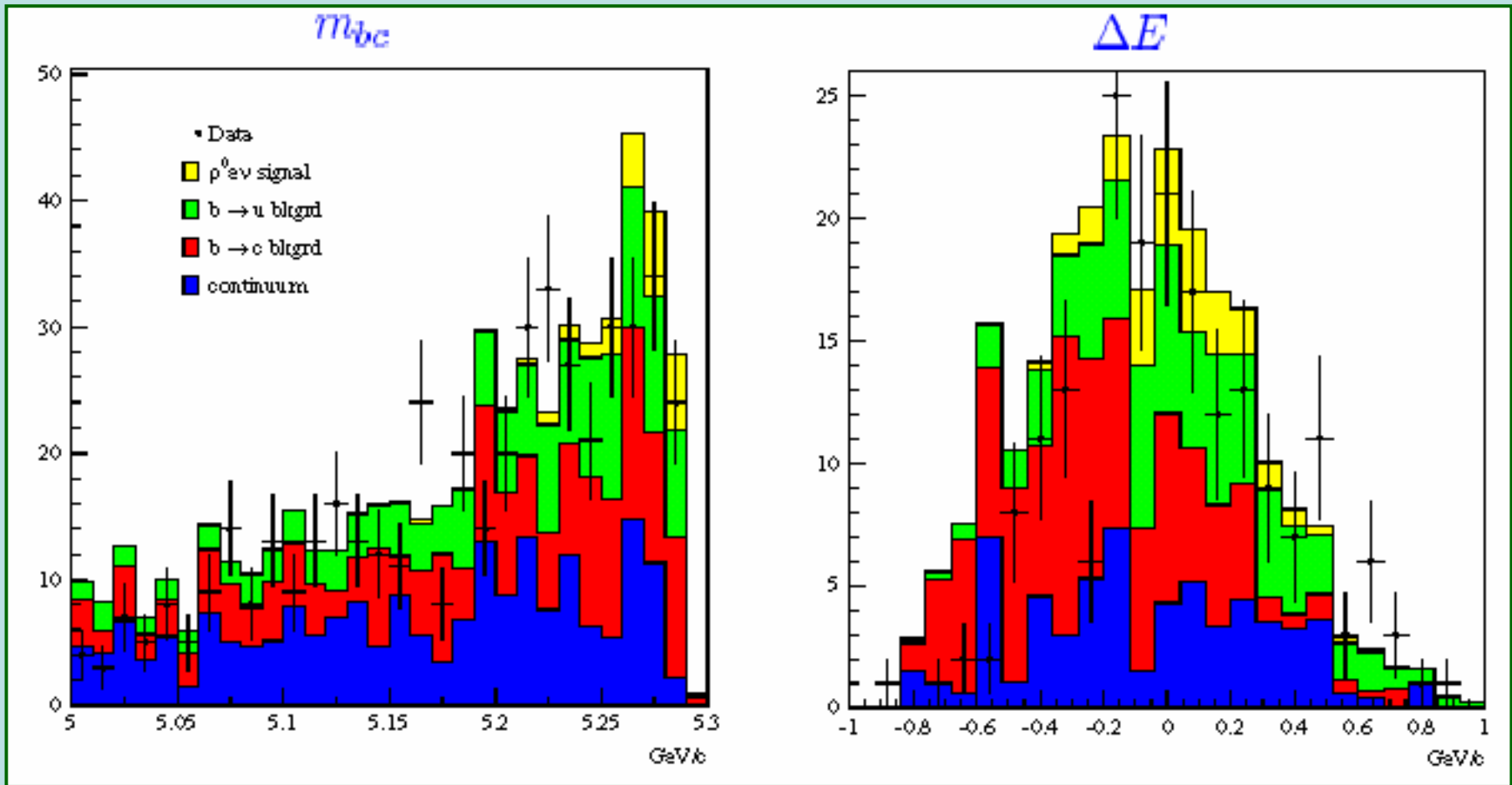
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Wiener Beitrag

Bestimmung von V_{ub} : $B^+ \rightarrow \rho^0 e^+ \nu$



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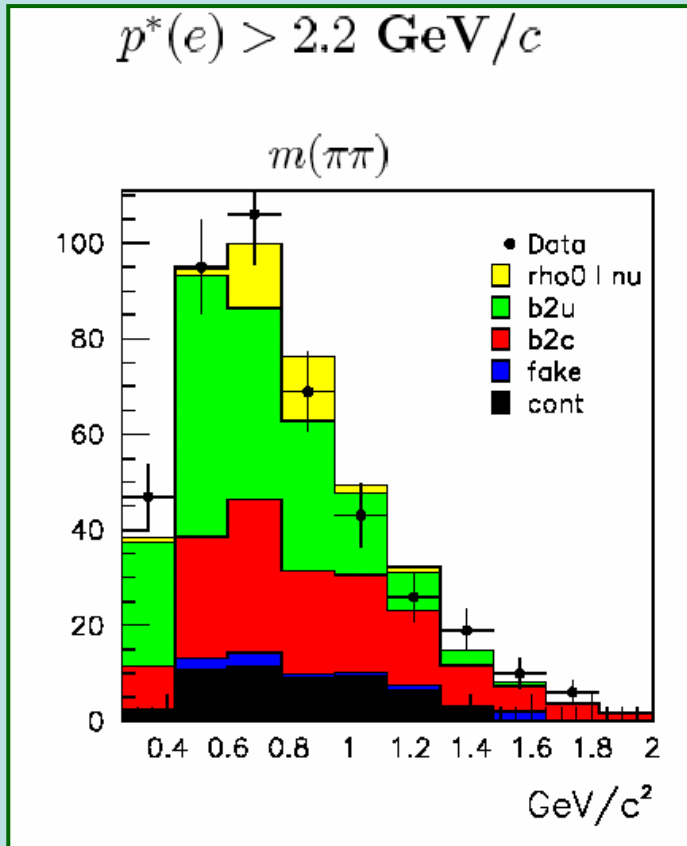
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Wiener Beitrag

$$\text{Br}(B^+ \rightarrow \rho^0 e^+ \nu)$$

Very preliminary!!



	$p^*(e) > 2 \text{ GeV}/c$	$p^*(e) > 2.2 \text{ GeV}/c$
$N(\rho^0 l \nu)$	55 ± 23	32 ± 17
efficiency	$265/25,017 = 1.1\%$	$229/25,017 = 0.9\%$
$B(B^+ \rightarrow \rho^0 l^+ \nu)$	$(1.7 \pm 0.7) \cdot 10^{-4}$	$(1.1 \pm 0.6) \cdot 10^{-4}$

- To be compared with
 - $\Gamma(B^0 \rightarrow \rho^- l^+ \nu) = 2\Gamma(B^+ \rightarrow \rho^0 l^+ \nu)$ and
 - $B(B^0 \rightarrow \rho^- l^+ \nu) = (2.57 \pm 0.6) \cdot 10^{-4}$ (CLEO 98)



Messung von V_{ub} bei CLEO 2001

$$|V_{ub}| = (3.25 \pm 0.14^{+0.21}_{-0.29} \pm 0.55) \times 10^{-3}$$

statistisch
systematisch
Theorie!!

**Reduktion des theoretischen Fehlers möglich durch
gleichzeitige Messung:**

$$\frac{d\Gamma(B \rightarrow \pi \ell \nu)/dq^2}{d\Gamma(D \rightarrow \pi \ell \nu)/dq^2} \bigg|_{E_\pi^*}, \frac{f_{B \rightarrow \pi \ell \nu}}{f_{D \rightarrow \pi \ell \nu}} \bigg|_{E_\pi^*} = \sqrt{\frac{m_B}{m_D}} \left(1 + \left(\frac{1}{m_B} - \frac{1}{m_D}\right) \mathbf{Korr}\right)$$



Messung beider Wirkungsquerschnitte bei BELLE

$$\sigma(e^+e^- \rightarrow c\bar{c}) \geq \sigma(e^+e^- \rightarrow Y(4s))$$

Kontinuum

Resonanz

$$D^0 \rightarrow \pi^- e^+ \nu_e$$

**aus $D^{(*)}D^{(*)}$ -Zerfall im Kontinuum
erfolgt jetartige Struktur, daher
schwieriger als B-Zerfall**

$$\text{Br}(D^0 \rightarrow \pi^- e^+ \nu_e) = 3.7 \times 10^{-3}$$

$$\text{Br}(B^0 \rightarrow \pi^- e^+ \nu_e) = 1.8 \times 10^{-4}$$



Ereignis Sample: Daten (30Mio B \bar{B}) und MONTE CARLO: Signal und Untergrund

	# HadronB		# HadronB
on_resonance-e000007	24,609,751	continuum-e000007	1,856,326
on_resonance-e000009	18,359,826		
on_resonance-e000011	34,573,801	continuum-e000011	5,405,636
on_resonance-e000013	44,537,849	continuum-e000013	2,149,159
mixed-e000007	9,910,058	charm-e000007	12,080,635
mixed-e000009	9,920,183	charm-e000009	12,113,482
mixed-e000011	9,918,458	charm-e000011	12,116,007
mixed-e000013	9,896,633	charm-e000013	12,086,165
charged-e000007	9,924,404	uds-e000007	16,787,000
charged-e000009	9,933,593	uds-e000009	16,843,182
charged-e000011	9,933,161	uds-e000011	16,839,522
charged-e000013	9,906,565	uds-e000013	16,775,474
signal-e000011	776,909		

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BELLE Cluster in Wien

Server

mit 6 Knotenrechnern

Doppelprozessoren

Dual Athlon MP 1800+

mit 3 bzw. 1 GB Ram

Betriebssystem

Red Hat Linux 7.2

Speichermedien

10 Festplatten zu 73.4 GB Ultra 160 SCSI,
RAID-System Level 5 und 0 ergeben 500 GB

Streamer-Bandstation HP DDS4

mit 20 GB-Bändern

DVD Writer HP dvd 100i RW+ mit 5 GB

Komplette **BELLE-Software** wie in KEK

dzt. installierte **Libraries**: b20010523_0725 b20011005_2131

Rechenleistung für $q\bar{q}$ -MC: 3-4 Ereignisse /Sekunde



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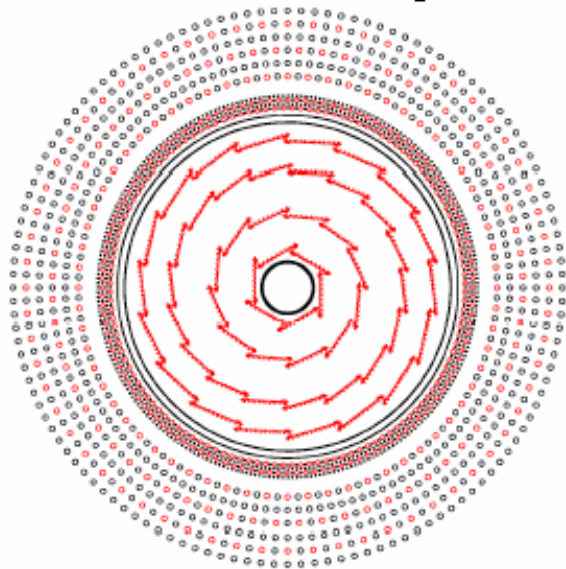
Status von SVD 2.0

New Inner Tracking:

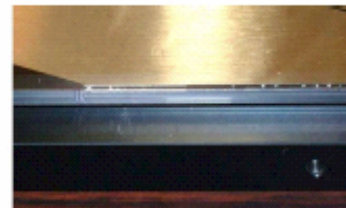
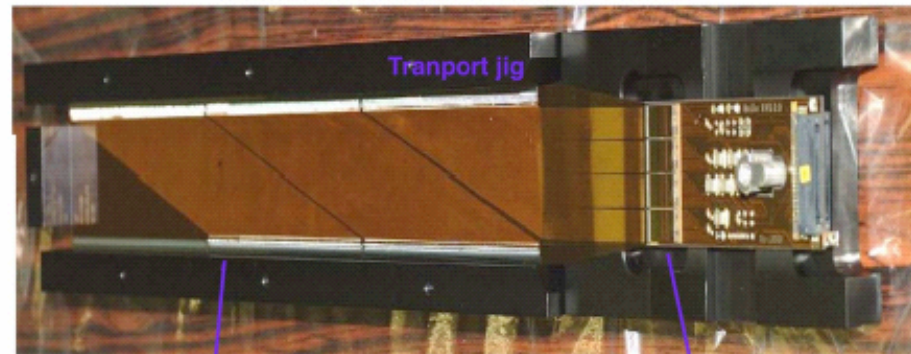
- Four Layer SVD
- Half-size Drift Cells

r_{IP_pipe} 2.0 cm \Rightarrow 1.5 cm

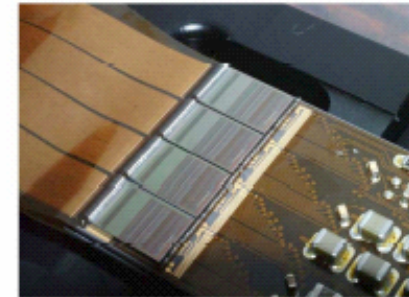
Installation in August



Half ladder z-side view



Z-pad closeup



Hybrid/VA1TA

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SVD 2.0 Dock mit MAMBO



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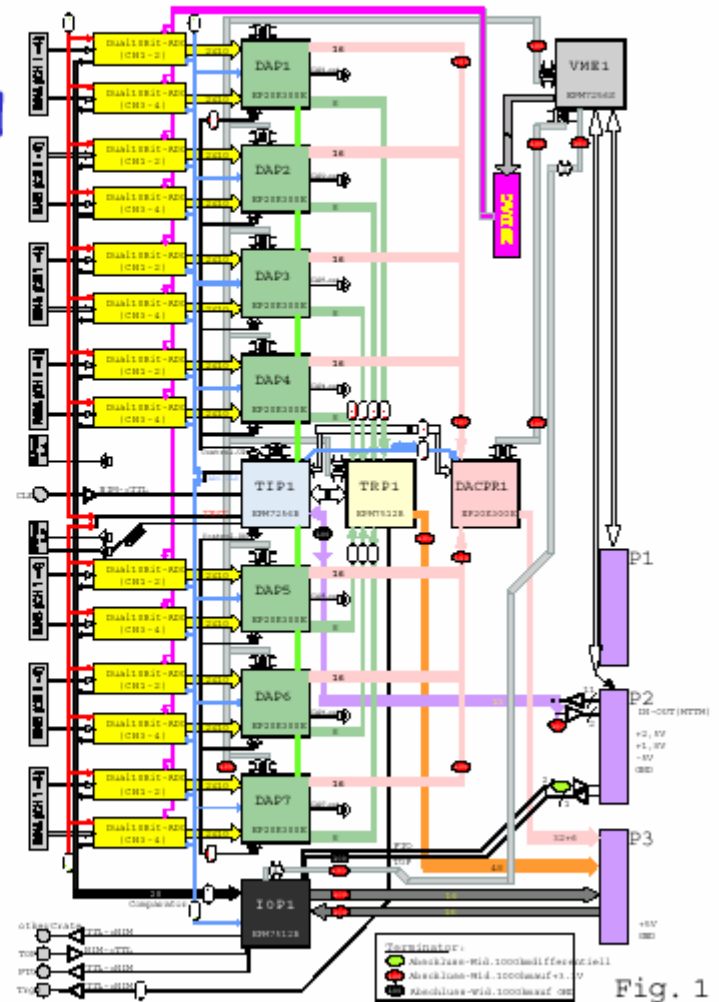
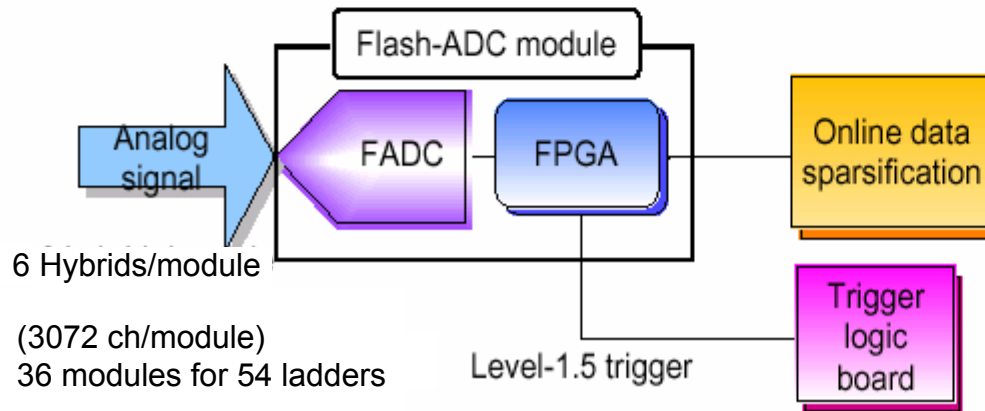


FADC system for SVD2

New FADC system

- 28 FADC (40MHz, 10 bit) on a board
- search L-0 triggers (VA1TA, TOF)
- generate L-1.5 trigger signal
- two events data can be stored
- prototype finished

Backend electronics schematic diagram

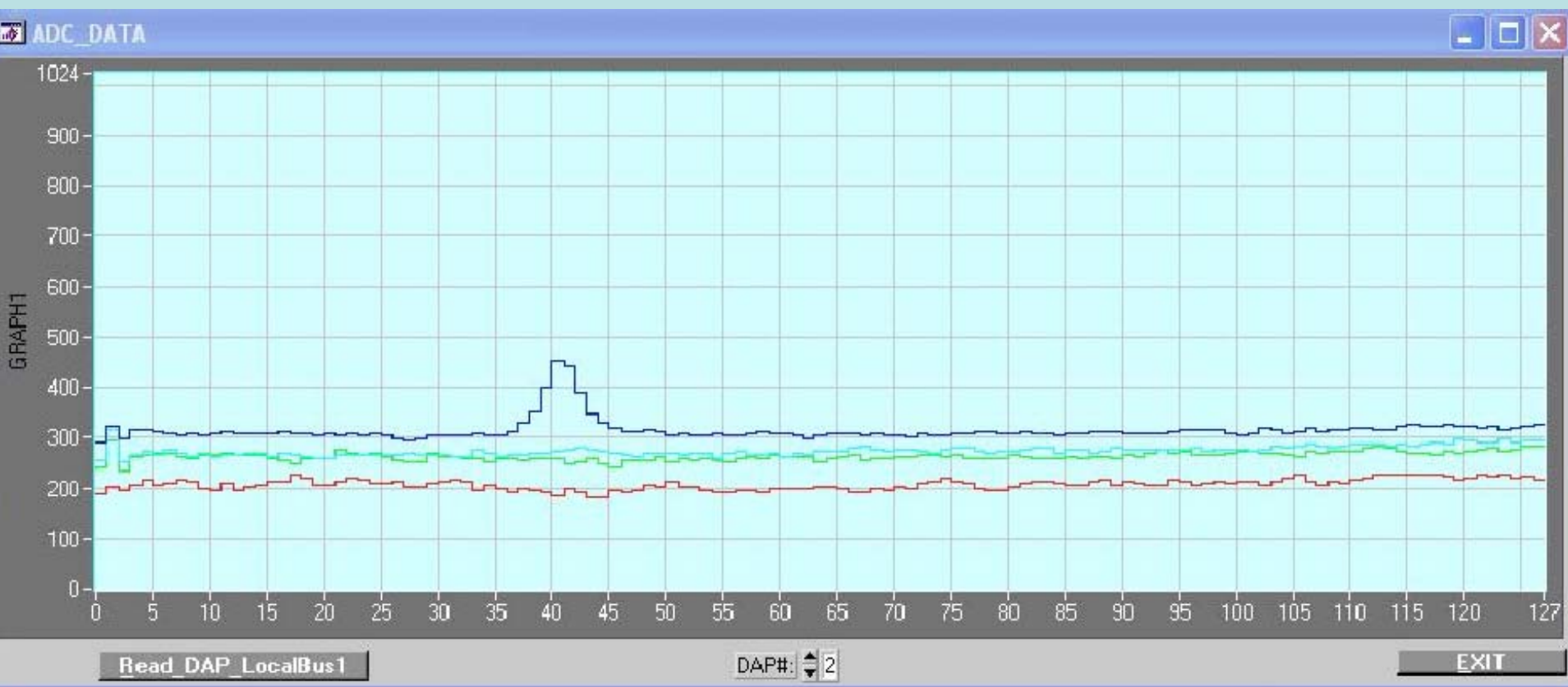


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SVD 2.0 FADC: erstes Signal mit Laser



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