WG2 – B/D/K decays

List of tasks (reminder...)

Hadronic uncertainties

Benchmark Models & Tools

Outline of Yellow Book Chapter

G. Buchalla, T. Komatsubara, F. Muheim, L. Silvestrini

List of Tasks (from 1st meeting)

- **Study complementarity between collider and flavour physics**
  - SUSY benchmark (e.g. SPS1a) in collider physics
  - Add flavour violation ($\rightarrow$ squark decays)
  - Compute effective Hamiltonian (OPE)
  - Evaluate flavour observables, check consistency with data
- **Beyond SUSY**
  - NP model independent studies, MFV

➔ Common session WG1 & WG2

- **Hadronic Uncertainties**

➔ dedicated session at next meeting

- **Experimental Studies**
  - Sensitivities – LHC, (super-)B & tau/charm factories, fixed target
  - Triggers, Backgrounds,

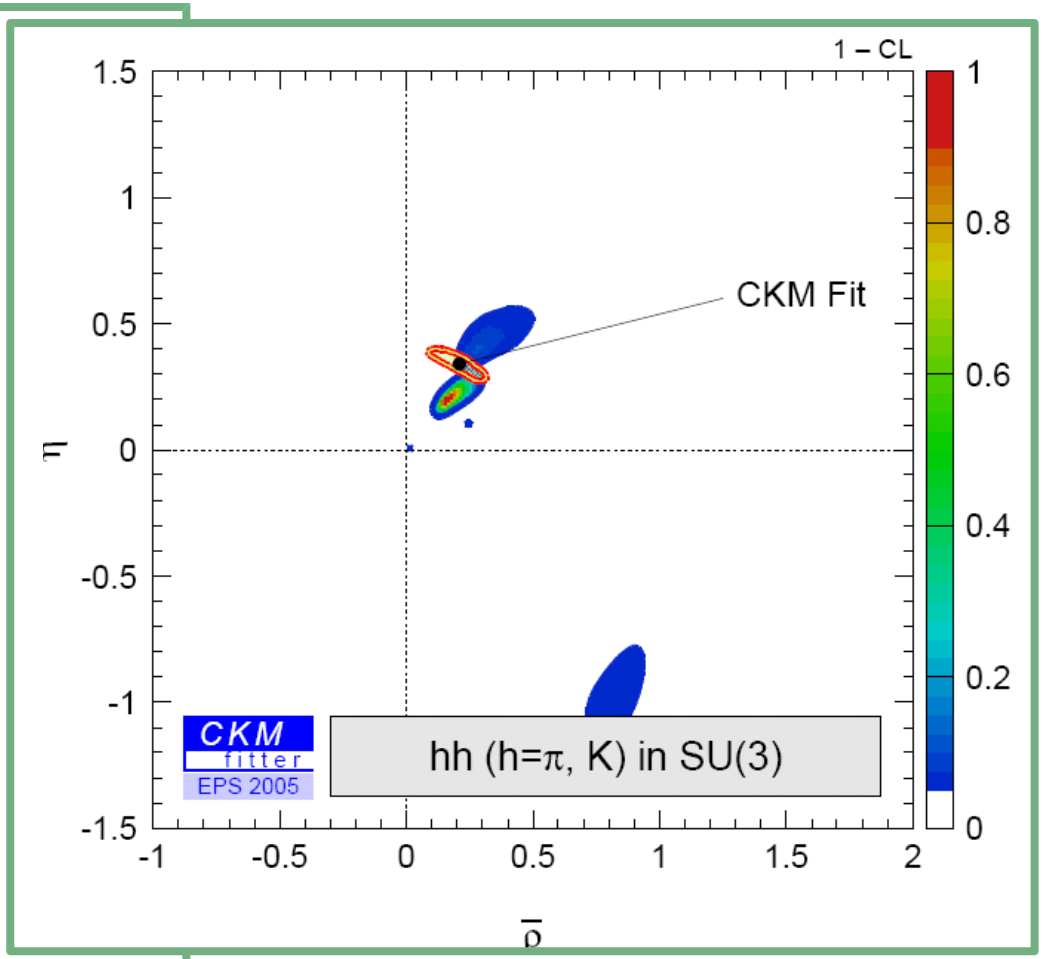
Hadronic Uncertainties

- CKM analysis
  - Malcles: SU(3) limit
  - Ciuchini: $B \to K\pi\pi$ Dalitz
- Charmless two-body
  - Feldmann: overview
  - Jaeger: NLO spectator effects
- Non-perturbative methods
  - Zwicky: Light-cone QCDSR
  - Duerr: Lattice QCD
- QED corrections
  - Baracchini: $B \to PP$
  - Was: Photos
- $K^+ \to \pi^+ \nu\nu$
  - Haisch

With full system of inputs for EPS 2005

With all available inputs:

- Elimination of some of the mirror solutions
- The interesting zone does not change a lot
- Very constraining!
- Good agreement with the SM (p-value > 30%)
- Main contributions to χ^2:
  - BR($K_s\pi^0$), S($K_s\pi^0$)
  - BR($K^+\pi^-$)
- Better fit obtained with non-standard WPs



A new bound on the CKM Matrix

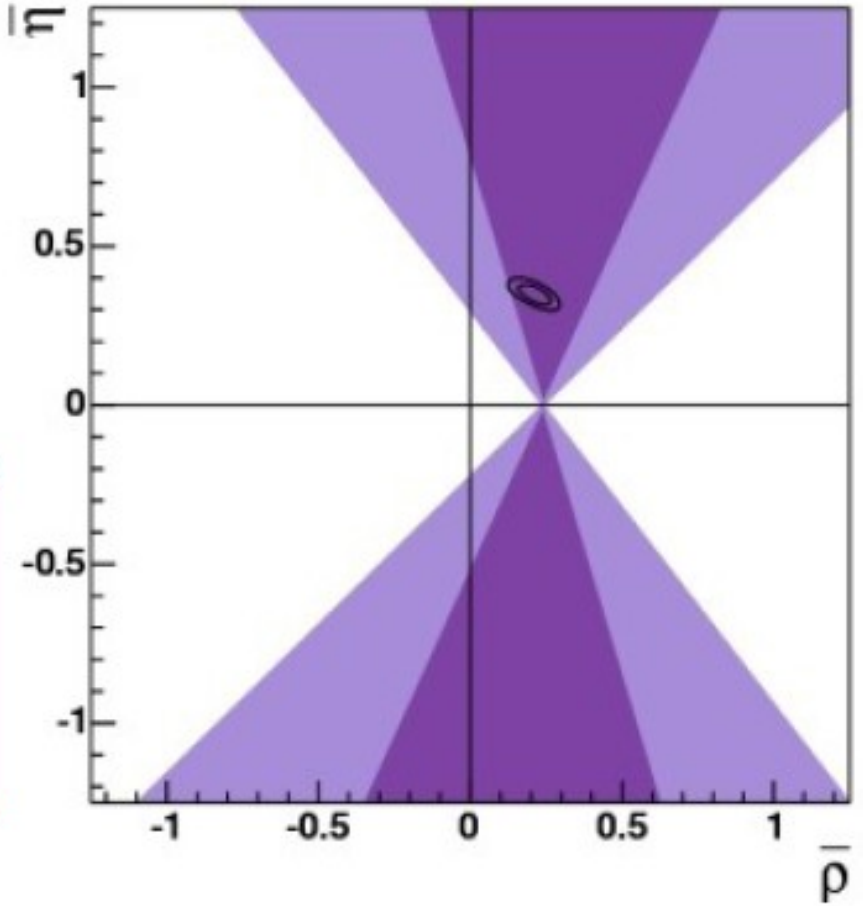
from $K^+\pi^-\pi^0$ Dalitz plot

$$A^0 = A(K^{*+}\pi^-) + \sqrt{2}\,A(K^{*0}\pi^0) = -V^*_{ub}V_{us}(E_1 + E_2)$$

$$R^0 = \frac{\bar{A}^0}{A^0} = \frac{V_{ub}V^*_{us}}{V^*_{ub}V_{us}} = e^{-2i\gamma + i\,Arg(1+k_{EW})}$$

$$\bar{\eta} = -\tan\left(\frac{1}{2}\,Arg\,R^0\right)(\bar{\rho} - \bar{\rho}_0)$$

$$\bar{\rho}_0 = -\frac{3(C_9 + C_{10})}{2(C_1 + C_2) + 3(C_9 + C_{10})}\,\frac{(1-\lambda^2/2)^2}{\lambda^2}$$



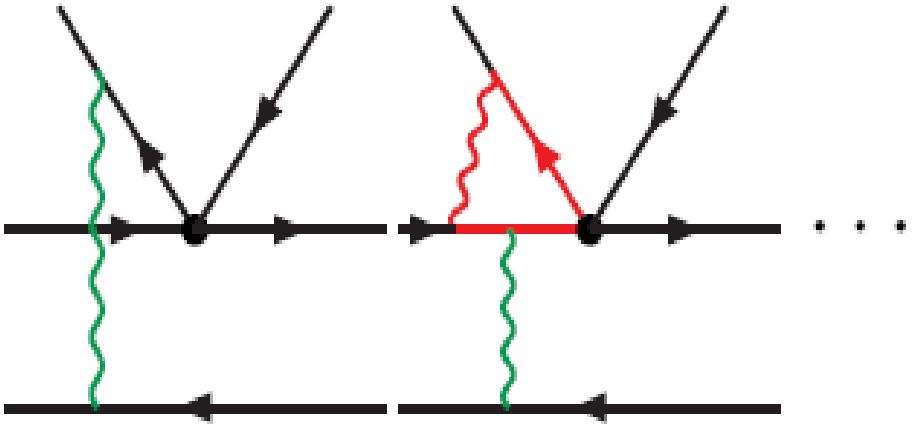
summary.tmp

T. Feldmann

- hadronic uncertainties as input to QCD factorization
- non-factorizable hadronic uncertainties at $\mathcal{O}(1/m_b)$
- symmetry constraints
- non-perturbative effects estimated via LCSRs
  (in QCD or in SCET)
- phenomenological situation not completely satisfactory
  - depends on particular channel/observable
  - may partly be improved by NNLO effects in QCDF

    [→ talk by S. Jäger]
  - more experimental feedback may help, too!

S. Jaeger



- no large complex phases
- some enhancement of color-suppressed tree possible

For BRs, use fit values for $f_+(0), \lambda_B, a_2^\pi$ (parameter set "G" $\approx$ S4)

$$10^6\,\mathrm{Br}(B^- \to \pi^-\pi^0) = 5.5^{+0.3}_{-0.3}(\mathrm{CKM})^{+0.5}_{-0.4}(\mathrm{hadr.})^{+0.9}_{-0.8}(\mathrm{pow.}) \qquad [\mathrm{Exp}: 5.5 \pm 0.6]$$

$$10^6\,\mathrm{Br}(\bar{B}^0 \to \pi^+\pi^-) = 5.0^{+0.8}_{-0.9}(\mathrm{CKM})^{+0.3}_{-0.5}(\mathrm{hadr.})^{+1.0}_{-0.5}(\mathrm{pow.}) \qquad [\mathrm{Exp}: 5.0 \pm 0.4]$$

$$10^6\,\mathrm{Br}(\bar{B}^0 \to \pi^0\pi^0) = 0.73^{+0.27}_{-0.24}(\mathrm{CKM})^{+0.52}_{-0.21}(\mathrm{hadr.})^{+0.35}_{-0.25}(\mathrm{pow.}) \qquad [\mathrm{Exp}: 1.45 \pm 0.29]$$

A1 The $F^{B_{(d,s)}\to P,V}(q^2)$ can be calculated for $0 < q^2 <\sim 14\mathrm{GeV}^2$ from LCSR

Lattice provides $F^{B_{d,s}\to P}$ so far for $q^2 > 16\mathrm{GeV}^2$ complementarity!

A2 LCSR only source for vector formfactors. Other methods would be nice.
Ingenious lattice people will hopefully come up with something

A3 Two-pole param. fits the LCSR-well and survives consistency tests.

A4 good numerical agreement with Lattice-QCD (comp. upon extrapol.)

B1 After confusion considerable progress on leading Kaon DA – Gegenbauer moment a_1

B2 Progress on Kaon DA immediate impact on $B \to K^*\gamma$ vs. $B \to \rho\gamma$

$$\xi = \frac{T_1^{B\to K^*}(0)}{T_1^{B\to\rho}(0)} = 1.16 \pm 0.1_{\mathrm{param}} \pm 0.005_{a_1^{\parallel}} \pm 0.035_{a_1^{\perp}} = 1.16 \pm 0.1 \pm 0.04_{a_1}$$

R. Zwicky

S. Duerr

Summary

With a phenomenological lattice paper, please check:

- does the "effective mass/matrix-element" look convincing ?
- has the continuum limit been taken ?
- are backgrounds quenched/dynamical ?
- are (some) pions in the "chiral" regime, say $200\,\mathrm{MeV} < M_\pi < 300...500\,\mathrm{MeV}$?
- is the "chiral" extrapolation done after $a \to 0$, or with a dedicated finite-a ansatz ?
- are finite-volume effects under control ?
- for experts: improvement/renormalization/matching non-perturbatively ?
- for experts: need worry about action/algorithm issues ?

Please don't:

- throw away high-precision (!) lattice data, just because they are quenched (except for observables which are known to get corrupted by $N_f = 0$) !
- select "small cut-off effect" lattices by a cut on the lattice spacing (say $a < 0.1\,\mathrm{fm}$) !

E. Baracchini, M. Ciuchini, G. Isidori, M. Pierini, L. Silvestrini in preparation

Phenomenological application

Kπ charged modes

no correction on $K^0\pi^0$

	BaBar		Belle		Average	
Channel	$BR \times 10^6$	$G(E^{max})$	$BR \times 10^6$	$G(E^{max})$	$QEDCor.$	$HFAG$
$K^+\pi^-$	19.2 ± 0.8	0.950 ± 0.005	18.5 ± 1.2	0.967 ± 0.005	20.2 ± 0.7	18.9 ± 0.7
$K^+\pi^0$	12.0 ± 0.9	0.976 ± 0.005	12.0 ± 1.7	0.982 ± 0.005	12.2 ± 0.8	12.1 ± 0.8
$K^0\pi^+$	26.0 ± 1.6	0.955 ± 0.005	22.0 ± 2.2	0.967 ± 0.005	25.2 ± 1.4	24.1 ± 1.3

Taking the average on BR, one must take into account the e.m. correction factor $G(E^{max})$, cut on photon spectrum E^{max} dependent (equal to the imposed lower cut on ΔE)

preliminary

$$R = \left[\frac{BR(B_d^0 \to \pi^- K^+) + BR(\overline{B_d}^0 \to \pi^+ K^-)}{BR(B^+ \to \pi^+ K^0) + BR(B^- \to \pi^- \overline{K^0})}\right]\frac{\tau_{B^+}}{\tau_{B_d^0}}$$

$$R_c = 2\left[\frac{BR(B^+ \to \pi^0 K^+) + BR(B^- \to \pi^0 K^-)}{BR(B^+ \to \pi^+ K^0) + BR(B^- \to \pi^- \overline{K^0})}\right]$$

$$R_n = \frac{1}{2}\left[\frac{BR(B_d^0 \to \pi^- K^+) + BR(\overline{B_d}^0 \to \pi^+ K^-)}{BR(B_d^0 \to \pi^0 K^0) + BR(\overline{B_d}^0 \to \pi^0 \overline{K^0})}\right]$$

Parameter	HFAG	QED corr
R	0.86 ± 0.06	0.87 ± 0.06
R_c	1.01 ± 0.09	0.97 ± 0.08
R_n	0.83 ± 0.08	0.89 ± 0.08

News on PHOTOS Monte Carlo: issue of systematic errors .

Z. Was

Institute of Nuclear Physics, Krakow *and* CERN-PH, Geneva

talk include contributions from:

P. Golonka CERN IT/CO-BE , Geneva, Institute of Nuclear Physics, Krakow

G. Nanava JINR, Dubna, Russia, Institute of Nuclear Physics, Krakow

E. Barberio Melbourne University, Australia

and:

Other members of BELLE and NA48 Collab.

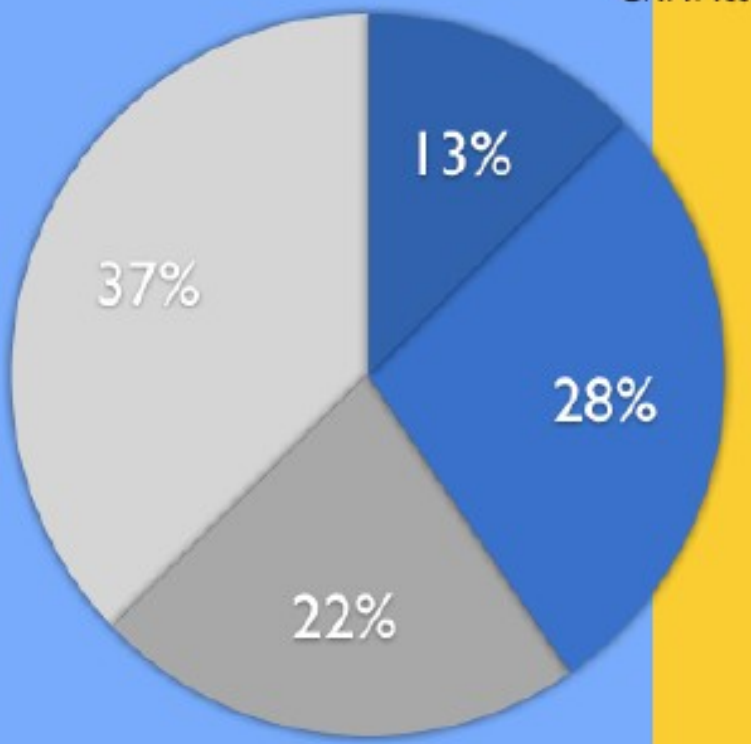
Web pages: http://wasm.home.cern.ch/wasm/goodies.html

http://piters.home.cern.ch/piters/MC/PHOTOS-MCTESTER/

SM Prediction of $K^+ \to \pi^+ \nu\bar{\nu}$

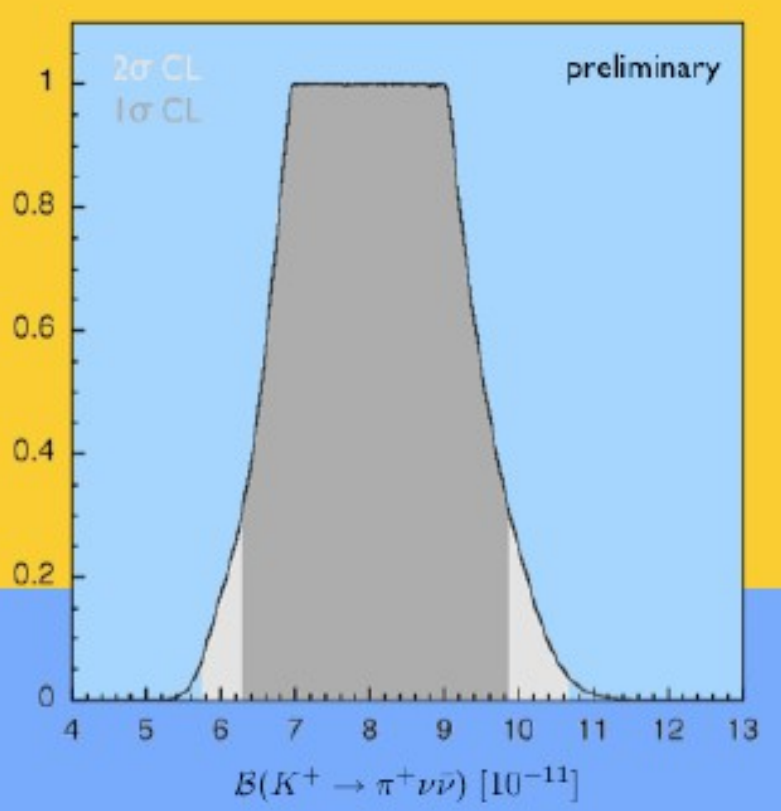
$$\mathcal{B}(K^+ \to \pi^+ \nu\bar{\nu}) = (8.0 \pm 0.2 \pm 0.5 \pm 0.4 \pm 0.7) \times 10^{-11}$$

CKMFitter, Buras, Gorbahn, Nierste & UH '06



scales $r_{K^+}, \delta P_c$

$m_c(m_c)$ $M_t, \alpha_s(M_z)$, CKM



U. Haisch

Discussion...

- Exclusive hadronic B decays:
  - need to disentangle CKM, NP, hadronic effects
  - theory guidance (factorization): need to identify/quantify power corrections
  - accurate experimental data on multitude of channels useful
  - flavour symmetry approach

NP Flavour Benchmark Models

- Useful to assess NP potential of future experiments
- Provide a "restricted" parameter space, easier to explore
- Allow to connect different sectors (hadrons/leptons, high-pt/flavour, ...)
- Work available/in progress on SUSY-GUTs, light stop (Raklev's talk), 4^{th} generation (Hou's talk + last workshop)

Benchmark models (cont'd)

- More work on SUSY benchmarks needed: high-pt benchmarks should be extended to include flavour & CPV (SLHA2?)
- Non-SUSY benchmarks to be explored (pioneering investigations in MFVLHWTP suggested in Schmaltz's talk)
- But don't take benchmarks too seriously...

Discussion on Tools

- Strong request of flavour physics tools from
  - Flavour physics experiments (M. Hazumi's talk)
  - WG1 (Polesello's talk at WG1/2 joint session)
- Interface with high-pt and/or spectrum computations to be defined according to SLHA2 (Heinemeyer's talk)
- Common hadronic/low-energy input parameters to be specified

- SUSY:
  - considered $\Delta S=1,2$, $\Delta B=2$, b->s,d γ, B-> $K^*\gamma$,b->s l^+l^-, $B_{s,d}$ -> $\mu^+\mu^-$, b->s$\nu\nu$, B->$\tau\nu$. (B->PP postponed...)
    - Identified volunteers for all of the above in both MFV and non-MFV MSSM
- Non-SUSY: Extra-dim, Little Higgs, ...
  - possibly available, only one group... please sign up!

- Model independent
  - Provide model-independent intermediate steps in SUSY programs:
    - Calculation of Wilson coefficients at the EW scale: NP-model dependent
    - Amplitude calculation from Wilson coefficients: NP-model independent, sensitive to hadronic parameters

Study Groups (as of today)

- Radiative Penguin Decays
  - $b \to s\gamma$, $b \to d\gamma$ inclusive and exclusive
  - LHCb, BaBar – Bechtle, Sciolla, Playfer, Belle – Hazumi, Iijima
  - Theory - Feldmann, Misiak, Gambino, Ball, Zwicky
- Electroweak Penguin Decays
  - $b \to sll$ inclusive and exclusive
  - LHCb – Koppenburg, ATLAS – Smizanska, Reznicek
  - BaBar – Berryhill, Playfer, Eigen, Belle – Iijima
  - Theory – Feldmann, Safir, (Greub, Hiller), Colangelo,Mannel, Khodjamirian, Ball, Zwicky
- Neutrino modes:
  - $b \to s\nu\nu$, $B \to \tau+\nu$, $D\tau+\nu$
  - BaBar - Robertson, Belle – Iijima
  - Theory – (Okada), Foster, Paradisi
- Very rare decays:
  - $B_{s,d} \to \mu+\mu-$, $\mu\mu\pi$, $\mu\mu\gamma$, $(\tau+\tau-)$
  - ATLAS – Smizanska, Nikitine,Sivoklokov, Eigen, Buanes, CMS – Speer, Langenegger, Starodumov, CDF- Herndon, D0 – Ay, LHCb, BaBar – Robertson, BELLE - Hazumi
  - Theory – (Nierste, Dedes), Foster, Paradisi

Study Groups (as of today)

- UT angles (tree-dominated)

  β or ϕ_1: $B_d \to \psi K_S$, …

  α or ϕ_2: $B_d \to \rho\pi, \pi\pi, \rho\rho$

  Belle – Hazumi, Babar- Bevan, Gritsan, Malcles, Pierini, Eigen
  LHCb - Deschamps

  γ or ϕ_3: $B_{d,u} \to DK$ – Dalitz

  - $B_s \to D_sK$, $B_d \to \pi\pi/B_s \to KK$
  - Belle – Hazumi, Gershon, Babar – Bona, Cavoto
  - LHCb – Lazzeroni, Patel, CDF – Punzi
  - Theory: Vysotski, Fleischer, (Franco)
- B_s-$B_s$bar mixing
  - Mass difference Δm_s, weak phase ϕ_s, lifetime difference $\Delta\Gamma/\Gamma$
  - $B_s \to D_s\pi$, $B_s \to J/\psi\phi$
  - CDF – Kroll, Bedeschi, Oldeman, D0 – Ay, LHCb – Fernandez, CMS –Speer, Starodumov
  - Theory – (Lubicz, Lenz, Nierste)
- b$\to$s and b$\to$d hadronic transitions
  - $B_d \to \phi K_S$, $\eta' K_S$, $B_s \to \phi\phi$,… $B_d \to \pi\pi/B_s \to KK$, $B_d \to \rho\pi, \pi\pi, \rho\rho, \pi K$
  - Babar – Gritsan, Dujimic, Pierini, Belle – Hazumi,Gershon, LHCb
  - Theory – Ciuchini, (Beneke), Fleischer, Safir, Jaeger

Study Groups (as of today)

- Kaon decays
  - $K \rightarrow \pi\nu\nu$, $K_L \rightarrow \pi^0 ll$
  - NA48/III - Ruggiero, JPARC – Komatsubara
  - Theory – (Haisch, Cirigliano) Buras, (Isidori), Smith, Trine

- Charm decays
  - D^0-D^0bar mixing,
  - D rare decays
  - CLEO-3 – Stone, Briere, BaBar – Cavoto, CDF – Campanelli, LHCb –
  - Theory – (Bigi), Fajfer

Workshop Report

- Timeline:
  - 2nd meeting (WGs): CERN Feb 6-8 2006
    Discuss outline of report
  - 3rd meeting (WGs): CERN, May 15-17 2006
    Presentations from study groups and of other activities
  - 4th meeting (WGs): CERN,sometime in September 2006
    first draft of the report available
  - Finalise report and deliver conclusions at the
    final Plenary meeting: CERN, sometime in Dec 2006 / Jan 2007

- Guidelines
  - None given
  - Today: discuss first attempt for outline by convenors
  - Estimated length: for workshop proceedings 100 to 300 pages
  - For WG2 - 50 to 100 pages

Outline of Report

- Introduction
- High pt vs quark and lepton flavour physics
  - Scope of different working groups

Common Sections

- New Physics Scenarios
  - Overview
  - SUSY (MFV, non-MFV, Specific)
  - Non-SUSY
  - Model independent analyses
  - Methods and tools
- Hadronic Uncertainties
- New Physics in Benchmark Channels
  - Prospects for existing facilities, LHC, Super-B factories, Fixed Target
  - Radiative Penguin Decays
  - Electroweak Penguin Decays
  - Very rare Decays
  - ...
- Assessments
  - New Physics Patterns/correlations (between channels)
  - Connections to high pT (WG1) and lepton (WG3) flavour physics
  - Discrimination between NP scenarios
- Conclusions

WG2 Sections

Items for next workshop

- Status reports on results from study groups on benchmark modes
- Status reports for tools:
  - input definition
  - user interface and joint discussion with WG1
- Progress on benchmark models
- Interplay with WG1/3

In the meanwhile…

- WG mailing list being set up
- Results of present workshop will appear soon on WG2 web page
- Contact persons for subgroups to be appointed soon
- Start working!