Status of
Tau branching fractions global fit

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Introduction

Status

- since 2016, the PDG tau branching fractions global fit is a version of the HFLAV tau fit
- 3 differences between the post-2016-PDG fit and the HFLAV fit
  - PDG fit is unitarity constrained because PDG BF fit are so, HFLAV is not
  - HFLAV uses alternate set of ALEPH hadronic tau BFs measurements, PDG does not
    - see next slide for details
  - HFLAV uses an ALEPH estimate for $\mathcal{B}(\tau \to a_1(\to \pi\gamma)\nu)$, PDG does not
    - ALEPH estimate is not in the PDG listings, because it is not a measurement

PDG SCHAEL 05C measurements

$\mathcal{B}(\tau^- \to e^- \bar{\nu}_e \nu_\tau^-)$
$\mathcal{B}(\tau^- \to \mu^- \bar{\nu}_\mu \nu_\tau^-)$
$\mathcal{B}(\tau^- \to \pi^- \nu_\tau)$
$\mathcal{B}(\tau^- \to \pi^- \pi^0 \nu_\tau)$
$\mathcal{B}(\tau^- \to \pi^- 2\pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to \pi^- 3\pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to h^- 4\pi^0 \nu_\tau\ (\text{ex.}K^0, \eta))$
$\mathcal{B}(\tau^- \to \pi^- \pi^- \pi^+ \nu_\tau\ (\text{ex.}K^0, \omega))$
$\mathcal{B}(\tau^- \to \pi^- \pi^- \pi^+ \pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to h^- h^- h^+ 2\pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to h^- h^- h^+ 3\pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to 3h^- 2h^+ \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to 3h^- 2h^+ \pi^0 \nu_\tau\ (\text{ex.}K^0))$

HFLAV SCHAEL 05C alternate set

$\mathcal{B}(\tau^- \to e^- \bar{\nu}_e \nu_\tau^-)$
$\mathcal{B}(\tau^- \to \mu^- \bar{\nu}_\mu \nu_\tau^-)$
$\mathcal{B}(\tau^- \to h^- \nu_\tau)$
$\mathcal{B}(\tau^- \to h^- \pi^0 \nu_\tau)$
$\mathcal{B}(\tau^- \to h^- 2\pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to h^- 3\pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to h^- 4\pi^0 \nu_\tau\ (\text{ex.}K^0, \eta))$
$\mathcal{B}(\tau^- \to h^- h^- h^+ \nu_\tau\ (\text{ex.}K^0, \omega))$
$\mathcal{B}(\tau^- \to h^- h^- h^+ \pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to h^- h^- h^+ 2\pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to h^- h^- h^+ 3\pi^0 \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to 3h^- 2h^+ \nu_\tau\ (\text{ex.}K^0))$
$\mathcal{B}(\tau^- \to 3h^- 2h^+ \pi^0 \nu_\tau\ (\text{ex.}K^0))$

Plans

- add alternate set of ALEPH hadronic tau BFs measurements into PDG
- no plan to change current PDG treatment of $\mathcal{B}(\tau \to a_1(\to \pi\gamma)\nu)$
  - continue to use constraint based on $\mathcal{B}(a_1 \to \pi\gamma)$ (present in the PDG listings)
  - ad-hoc corrrection to the fit result to account for the uncertainty of $\mathcal{B}(a_1 \to \pi\gamma)$

This presentation

- why HFLAV uses the alternate set of SCHAEL 05C measurements
- how HFLAV reconstructs the alternate set of SCHAEL 05C measurements
- what is holding off the addition of the alternate ALEPH measurements into the PDG?

ALEPH SCHAEL 05C, p.241, mainly reports measurements of exclusive modes (e.g., $\tau \to \pi\ n\pi^0 \nu$)

Table 14
Combined results for the exclusive branching ratios (B) for modes without kaons

Mode	B $\pm\sigma_{\text{stat}} \pm \sigma_{\text{syst}}$	[%]
e	$17.837 \pm 0.072 \pm 0.036$	
μ	$17.319 \pm 0.070 \pm 0.032$	
π^-	$10.828 \pm 0.070 \pm 0.078$	
$\pi^-\pi^0$	$25.471 \pm 0.097 \pm 0.085$	
$\pi^- 2\pi^0$	$9.239 \pm 0.086 \pm 0.090$	
$\pi^- 3\pi^0$	$0.977 \pm 0.069 \pm 0.058$	
$\pi^- 4\pi^0$	$0.112 \pm 0.037 \pm 0.035$	
$\pi^-\pi^-\pi^+$	$9.041 \pm 0.060 \pm 0.076$	
$\pi^-\pi^-\pi^+\pi^0$	$4.590 \pm 0.057 \pm 0.064$	
$\pi^-\pi^-\pi^+ 2\pi^0$	$0.392 \pm 0.030 \pm 0.035$	
$\pi^-\pi^-\pi^+ 3\pi^0$	$0.013 \pm 0.000 \pm 0.010$	Estimate
$3\pi^- 2\pi^+$	$0.072 \pm 0.009 \pm 0.012$	
$3\pi^- 2\pi^+ \pi^0$	$0.014 \pm 0.007 \pm 0.006$	
$\pi^-\pi^0\eta$	$0.180 \pm 0.040 \pm 0.020$	ALEPH [13]
$\pi^- 2\pi^0\eta$	$0.015 \pm 0.004 \pm 0.003$	CLEO [27]
$\pi^-\pi^-\pi^+\eta$	$0.024 \pm 0.003 \pm 0.004$	CLEO [27]
$a_1^-(\to \pi^-\gamma)$	$0.040 \pm 0.000 \pm 0.020$	Estimate
$\pi^-\omega(\to \pi^0\gamma, \pi^+\pi^-)$	$0.253 \pm 0.005 \pm 0.017$	ALEPH [13]
$\pi^-\pi^0\omega(\to \pi^0\gamma, \pi^+\pi^-)$	$0.048 \pm 0.006 \pm 0.007$	ALEPH [13] + CLEO [26]
$\pi^- 2\pi^0\omega(\to \pi^0\gamma, \pi^+\pi^-)$	$0.002 \pm 0.001 \pm 0.001$	CLEO [27]
$\pi^-\pi^-\pi^+\omega(\to \pi^0\gamma, \pi^+\pi^-)$	$0.001 \pm 0.001 \pm 0.001$	CLEO [27]

The contributions from channels with η and ω are given separately, the latter only for the electromagnetic ω decays. All results are from this analysis, unless explicitly stated. The “estimates” are discussed in the text.

ALEPH SCHAEL 05C, p.242, correlations only reported for inclusive modes (e.g., $\tau \to h\, n\pi^0 \nu$)

statistical correlation

Table 15
Correlation matrix of the statistical errors on the branching fractions

	μ	h	$h\pi^0$	$h2\pi^0$	$h3\pi^0$	$h4\pi^0$	$3h$	$3h\pi^0$	$3h2\pi^0$	$3h3\pi^0$	$5h$	$5h\pi^0$
e	−0.21	−0.15	−0.25	−0.09	−0.01	0.00	−0.15	−0.10	0.03	−0.06	0.00	0.01
μ	1.00	−0.13	−0.21	−0.07	−0.06	0.00	−0.09	−0.07	0.00	−0.02	0.00	−0.04
h		1.00	−0.31	−0.02	0.01	−0.06	−0.12	−0.06	−0.02	0.01	−0.01	0.02
$h\pi^0$			1.00	−0.40	0.05	0.00	−0.11	−0.06	−0.02	0.00	−0.04	−0.04
$h2\pi^0$				1.00	−0.51	0.26	−0.09	0.01	−0.07	0.06	−0.01	0.03
$h3\pi^0$					1.00	−0.75	0.01	−0.03	0.05	−0.02	−0.01	0.01
$h4\pi^0$						1.00	−0.02	−0.02	−0.03	0.01	0.02	−0.03
$3h$							1.00	−0.33	0.08	−0.05	−0.04	0.00
$3h\pi^0$								1.00	−0.45	0.19	−0.02	−0.02
$3h2\pi^0$									1.00	−0.65	0.03	0.02
$3h3\pi^0$										1.00	−0.01	−0.04
$5h$											1.00	−0.24
$5h\pi^0$												1.00

systematic correlation

Table 16
Correlation matrix of the systematic errors on the branching fractions

	μ	h	$h\pi^0$	$h2\pi^0$	$h3\pi^0$	$h4\pi^0$	$3h$	$3h\pi^0$	$3h2\pi^0$	$3h3\pi^0$	$5h$	$5h\pi^0$
e	−0.17	−0.01	0.02	0.01	0.03	−0.08	−0.17	−0.22	−0.05	0.02	0.00	0.00
μ	1.00	0.05	0.09	−0.03	0.02	−0.13	−0.11	−0.24	−0.06	0.01	0.03	−0.04
h		1.00	0.36	−0.29	−0.32	−0.42	0.34	−0.40	−0.40	−0.07	0.16	−0.09
$h\pi^0$			1.00	−0.35	−0.02	−0.33	0.01	−0.54	−0.26	0.02	0.11	−0.06
$h2\pi^0$				1.00	−0.01	0.13	−0.24	0.07	0.13	0.06	−0.13	0.03
$h3\pi^0$					1.00	−0.13	−0.29	−0.02	0.15	0.09	−0.06	0.04
$h4\pi^0$						1.00	−0.14	0.34	0.27	0.00	−0.12	−0.05
$3h$							1.00	−0.03	−0.16	−0.11	0.17	−0.06
$3h\pi^0$								1.00	0.04	−0.03	−0.07	−0.01
$3h2\pi^0$									1.00	−0.14	−0.09	0.07
$3h3\pi^0$										1.00	−0.02	0.02
$5h$											1.00	−0.26
$5h\pi^0$												1.00

from C. Patrignani et al. (Particle Data Group), Chin. Phys. C, 40, 100001 (2016) and 2017 update

- PDG uses inclusive-modes total correlation for exclusive & semi-exclusive BFs

[1] Correlation matrix for SCHAEL 05C branching fractions, in percent:

(1) $\Gamma(\tau^- \to e^- \overline{\nu}_e \nu_\tau)/\Gamma_{\text{total}}$
(2) $\Gamma(\tau^- \to \mu^- \overline{\nu}_\mu \nu_\tau)/\Gamma_{\text{total}}$
(3) $\Gamma(\tau^- \to \pi^- \nu_\tau)/\Gamma_{\text{total}}$
(4) $\Gamma(\tau^- \to \pi^- \pi^0 \nu_\tau)/\Gamma_{\text{total}}$
(5) $\Gamma(\tau^- \to \pi^- 2\pi^0 \nu_\tau (\text{ex.} K^0))/\Gamma_{\text{total}}$
(6) $\Gamma(\tau^- \to \pi^- 3\pi^0 \nu_\tau (\text{ex.} K^0))/\Gamma_{\text{total}}$
(7) $\Gamma(\tau^- \to h^- 4\pi^0 \nu_\tau (\text{ex.} K^0,\eta))/\Gamma_{\text{total}}$
(8) $\Gamma(\tau^- \to \pi^- \pi^+ \pi^- \nu_\tau (\text{ex.} K^0,\omega))/\Gamma_{\text{total}}$
(9) $\Gamma(\tau^- \to \pi^- \pi^+ \pi^- \pi^0 \nu_\tau (\text{ex.} K^0))/\Gamma_{\text{total}}$
(10) $\Gamma(\tau^- \to h^- h^- h^+ 2\pi^0 \nu_\tau (\text{ex.} K^0))/\Gamma_{\text{total}}$
(11) $\Gamma(\tau^- \to h^- h^- h^+ 3\pi^0 \nu_\tau)/\Gamma_{\text{total}}$
(12) $\Gamma(\tau^- \to 3h^- 2h^+ \nu_\tau (\text{ex.} K^0))/\Gamma_{\text{total}}$
(13) $\Gamma(\tau^- \to 3h^- 2h^+ \pi^0 \nu_\tau (\text{ex.} K^0))/\Gamma_{\text{total}}$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(2)	-20											
(3)	-9	-6										
(4)	-16	-12	2									
(5)	-5	-5	-17	-37								
(6)	0	-4	-15	2	-27							
(7)	-2	-4	-24	-15	20	-47						
(8)	-14	-9	15	-5	-17	-14	-8					
(9)	-13	-12	-25	-30	4	-2	16	-15				
(10)	0	-2	-23	-14	4	10	13	-6	-17			
(11)	1	0	-5	1	4	6	0	-9	-2	-11		
(12)	0	1	9	4	-8	-4	-6	9	-5	-4	-2	
(13)	1	-4	-3	-5	3	2	-4	-3	-1	4	1	-24

ALEPH tau BFs correlations in the PDG

- correlations published for SCHAEL 05C inclusive modes are used for the exclusive modes
- SCHAEL 05C documents that exclusive pion BFs are computed subtracting kaon, η and ω tau BFs from inclusive hadron BFs, therefore there are correlations between the exclusive BFs and kaon, η and ω tau BFs
  - however, these correlations are not included in the PDG
- ALEPH instructed how to insert into PDG the measurements in SCHAEL 05C
- ALEPH priority: measuring exclusive modes, more directly testing tau decay models
- HFLAV priority: improve precision of global fit of tau BFs
- HFLAV addressed above issues by reconstructing the inclusive ALEPH SCHAEL 05C measurements and by using these measurements instead of the exclusive ones

Determining inclusive BFs measured in SCHAEL 05C is non-trivial

ALEPH SCHAEL 05C, p.221, inclusive modes are measured, but only sample-specific numbers are published

Table 8
Branching ratios (%) from 1991–1993 and 1994–1995 data sets; the first error is statistical and the second is systematic

Topology	91–93	94–95
e	$17.859 \pm 0.112 \pm 0.058$	$17.799 \pm 0.093 \pm 0.045$
μ	$17.356 \pm 0.107 \pm 0.055$	$17.273 \pm 0.087 \pm 0.039$
h	$12.238 \pm 0.105 \pm 0.104$	$12.058 \pm 0.088 \pm 0.083$
$h\pi^0$	$26.132 \pm 0.150 \pm 0.104$	$26.325 \pm 0.123 \pm 0.090$
$h2\pi^0$	$99.680 \pm 0.139 \pm 0.124$	$9.663 \pm 0.107 \pm 0.105$
$h3\pi^0$	$1.128 \pm 0.110 \pm 0.086$	$1.229 \pm 0.089 \pm 0.068$
$h4\pi^0$	$0.227 \pm 0.056 \pm 0.047$	$0.163 \pm 0.050 \pm 0.040$
$3h$	$9.931 \pm 0.097 \pm 0.072$	$9.769 \pm 0.080 \pm 0.059$
$3h\pi^0$	$4.777 \pm 0.093 \pm 0.074$	$4.965 \pm 0.077 \pm 0.066$
$3h2\pi^0$	$0.517 \pm 0.063 \pm 0.050$	$0.551 \pm 0.050 \pm 0.038$
$3h3\pi^0$	$0.016 \pm 0.029 \pm 0.020$	$-0.021 \pm 0.023 \pm 0.019$
$5h$	$0.098 \pm 0.014 \pm 0.006$	$0.098 \pm 0.011 \pm 0.004$
$5h\pi^0$	$0.022 \pm 0.010 \pm 0.009$	$0.028 \pm 0.008 \pm 0.007$
Class 14	$0.017 \pm 0.043 \pm 0.042$	$0.099 \pm 0.035 \pm 0.037$

- ALEPH SCHAEL 05C does not report ALEPH measurements for fully inclusive modes (inclusive means including $h = \pi, K$, $K_S^0 \to \pi^+\pi^-, 2\pi^0$, intermediate resonances η, ω)
- inclusive modes reported for 1991-1993 and 1994-1995 samples separately, but
  - systematic correlations of uncertainties for the two samples are not reported
  - reported values are unrealistic, they appear to be just analysis intermediate numbers

e.g., for $\mathcal{B}(\tau \to h\nu)$	averaging above values (%)	$12.130 \pm 0.067 \pm 0.065$
	from fig.42 in same paper (%)	$11.524 \pm 0.070 \pm 0.078$

Determining inclusive BFs measured in SCHAEL 05C is non-trivial

ALEPH SCHAEL 05C, p.240, corrections from inclusive to exclusive modes are reported

Table 12
Corrections for the exclusive non-strange branching ratios

QE class	E class	Correction to BR (%)
e	e	-0.000 ± 0.000
μ	μ	
h	π^-	-1.341 ± 0.040
$h\pi^0$	$\pi^-\pi^0$	-0.756 ± 0.038
$h2\pi^0$	$\pi^-2\pi^0$	-0.408 ± 0.030
$h3\pi^0$	$\pi^-3\pi^0$	-0.236 ± 0.032
$h4\pi^0$	$\pi^-4\pi^0$	-0.085 ± 0.016
$3h$	$\pi^-\pi^-\pi^+$	-0.770 ± 0.057
$3h\pi^0$	$\pi^-\pi^-\pi^+\pi^0$	-1.994 ± 0.100
$3h2\pi^0$	$\pi^-\pi^-\pi^+2\pi^0$	-0.480 ± 0.071
$3h3\pi^0$	$\pi^-\pi^-\pi^+3\pi^0$	-0.032 ± 0.006
$5h$	$3\pi^-2\pi^+$	-0.026 ± 0.004
$5h\pi^0$	$3\pi^-2\pi^+\pi^0$	-0.012 ± 0.002

'QE' and 'E' denote the quasi-exclusive (with kaons, ω and η included) and exclusive modes, respectively. Treating the ω and η contributions separately is made necessary because of their large radiative (i.e. with photons not originating from π^0's) modes.

- undoing reported corrections on published exclusive BFs leads to unrealistic inclusive BFs (resulting inclusive BFs are similar to Table 8 values: there is internal consistency)

How did HFLAV obtain in 2011 the inclusive BFs for SCHAEL 05C?

ALEPH SCHAEL 05C, p.244, fig. 42 reports $\mathcal{B}(\tau \to h\nu)$, to compare it with previous measurements

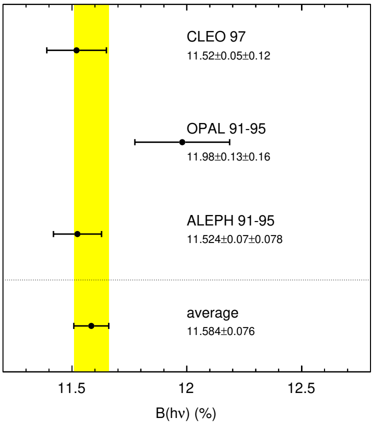

Fig. 42. Comparison of ALEPH measurement with published precise results from other experiments for $\boxed{\tau \to h\nu \text{ (sum of } \pi\nu \text{ and } K\nu\text{)}}$. References for other experiments are CLEO [31], OPAL [36].

HFLAV ALEPH SCHAEL 05C (semi) inclusive BFs

	descr	value	stat	syst
Gamma5	G(e- nubar(e) nu(tau))	0.17837	0.00072	0.00036
Gamma3	G(mu- nubar(mu) nu(tau))	0.17319	0.00070	0.00032
Gamma8	G(h- nu(tau))	0.11524	0.00070	0.00078
Gamma13	G(h- pi0 nu(tau))	0.25924	0.00097	0.00085
Gamma19	G(h- 2pi0 nu(tau) (ex. K0))	0.09295	0.00084	0.00088
Gamma26	G(h- 3pi0 nu(tau))	0.01082	0.00071	0.00059
Gamma30	G(h- 4pi0 nu(tau) (ex. K0, eta))	0.00112	0.00037	0.00035
Gamma58	G(h- h- h+ nu(tau) (ex. K0, omega))	0.09469	0.00062	0.00073
Gamma66	G(h- h- h+ pi0 nu(tau) (ex. K0))	0.04734	0.00059	0.00049
Gamma76	G(h- h- h+ 2pi0 nu(tau) (ex. K0))	0.00435	0.00030	0.00035
Gamma103	G(3h- 2h+ nu(tau) (ex. K0))	0.00072	0.00009	0.00012
Gamma104	G(3h- 2h+ pi0 nu(tau) (ex. K0))	0.00021	0.00007	0.00009
Gamma805	G(a1-(pi- gamma) nu(tau))	0.00040	0.00020	0.00000

Note

- above BF modes are not fully inclusive (in some cases, K_S^0 or ω are excluded)
  - paper plots serve to compare with former results, not to publish fully inclusive BFs
- they should be fully inclusive, because reported correlations are for fully inclusive modes

Small inconsistencies in HVLAV inclusive BFs reconstruction

$\mathcal{B}(\tau \to h\nu)$ in SCHAEL 05C fig.42 is inconsistent

$\mathcal{B}(\tau \to \pi\nu)$ ALEPH SCHAEL 05C (%)	$10.828 \pm 0.070 \pm 0.078$
$\mathcal{B}(\tau \to K\nu)$ ALEPH BARATE 99K (%)	$0.696 \pm 0.025 \pm 0.014$
$\mathcal{B}(\tau \to h\nu)$ combining (*) above two measurements (%)	$11.524 \pm 0.070 \pm 0.073$
$\mathcal{B}(\tau \to h\nu)$ HFLAV (SCHAEL 05C fig.42) (%)	$11.524 \pm 0.070 \pm 0.078$

(*) combination assuming $\mathcal{B}(\tau \to \pi\nu)$ was computed subtracting $\mathcal{B}(\tau \to K\nu)$ from $\mathcal{B}(\tau \to h\nu)$, with the total error of $\mathcal{B}(\tau \to K\nu)$ added in quadrature to the systematic error. This procedure appears to be the one generally followed in SCHAEL 05C.

Using $\mathcal{B}(\tau \to h\nu)$ in SCHAEL 05C fig.42 makes $\mathcal{B}(\tau \to \pi\nu)$ less precise in HFLAV

- PDG $\mathcal{B}(\tau \to \pi\nu) = 10.828 \pm 0.070 \pm 0.078$
  - using SCHAEL 05C exclusive modes, directly
- HFLAV $\mathcal{B}(\tau \to \pi\nu) = 10.828 \pm 0.070 \pm 0.083$
  - subtracting $\mathcal{B}(\tau \to K\nu)$ from $\mathcal{B}(\tau \to h\nu)$ (they are uncorrelated)
- note that the ALEPH measurement is the most precise for this mode
- however, in this case we could be fully consistent just combining published numbers from sources cited by SCHAEL 05C and according to SCHAEL 05C prescriptions

Small inconsistencies in HVLAV inclusive BFs reconstruction

- inconsistencies similar to $\mathcal{B}(\tau \to \pi\nu)$ exist also for the other modes
- these inconsistencies are small and were obfuscated by computing and listing total uncertainties for the inclusive modes, instead of computing and listing separately statistical and systematic uncertainties
- why did I realize all the above just recently?
  because only recently I could work on the plan to add to the PDG listings the reconstructed fully inclusive measurements for the modes studied in SCHAEL 05C and I wanted to do that with the best possible accuracy
- since PDG data must be as stable and reliable as possible, I want to:
  - complete my study of SCHAEL 05C inclusive BFs reconstruction
  - carefully discuss and agree with relevant parties before making changes to the PDG

Plans

- refine HFLAV reconstruction of SCHAEL 05C inclusive measurements
  - obtain as much as possible fully inclusive measurements
  - rely on published numbers rather than numbers on plots in SCHAEL 05C
- discuss the results with Michel Davier (author of SCHAEL 05C), HFLAV-Tau, PDG
- insert agreed numbers in PDG
  - I have discussed the matter with the last ALEPH spokesperson, Roberto Tenchini, according to the ALEPH regulations, as former ALEPH member, I have the ability to publish the reconstructed results as ALEPH elaborations of ALEPH results and to insert them in the PDG as ALEPH numbers. That will probably require a refereed publication.
- remove from PDG listings the present correlation matrix for SCHAEL 05C exclusive BFs
- add the proper correlation matrix for reconstructed SCHAEL 05C inclusive BFs
- add PDG notes mentioning that exclusive SCHAEL 05C modes are derived from the inclusive ones, which are the ones to be used in global fits, including the documented correlations
- update PDG and HFLAV BF global fits to use the same inputs

Backup Slides

ALEPH SCHAEL 05C, p.239, "From reconstructed classes to exclusive modes"

So far branching fractions have been determined in 13 classes corresponding to major τ decay modes. However, as shown in Table 3, these classes still contain the contributions from final states involving kaons. The latter are coming from Cabibbo-suppressed τ decays or modes with a $K\overline{K}$ pair, both characterized by small branching ratios compared to the non-strange modes without kaons.

Complete analyses of τ decays involving neutral or charged kaons have been performed by ALEPH on the full LEP 1 data [6–8]. They are summarized in Ref. [9] where measurements with K_S^0 or K_L^0 are combined. The ALEPH analyses have provided measurements of branching ratios of modes with kaons containing up to 4 hadrons in the final states. Thus they are fully adequate to cover the needs of the present analysis of the non-strange modes.

The τ decays involving η or ω mesons also require special attention in this analysis because of their electromagnetic decay modes. Indeed the final state classification relies in part on the π^0 multiplicity, thereby assuming that all photons—except those specifically identified as bremsstrahlung or radiative—originate from π^0 decays. Therefore the non-π^0 photons from η and ω decays are treated as π^0 candidates in the analysis and the systematic bias introduced by this effect must be evaluated. The corrections are based on specific measurements by ALEPH of τ decay modes containing those mesons [13]. Thus the final results correspond to exclusive branching ratios obtained from the values measured in the topological classification, corrected by the removed contributions from K, η and ω modes measured separately, taking into account through the Monte Carlo their specific selection and reconstruction efficiencies to enter the classification. This delicate bookkeeping takes into account all the major decay modes of the considered mesons [25], including the isospin-violating $\omega \to \pi^+\pi^-$ decay mode. The main decay modes considered are $\pi\omega$, $\pi\pi^0\omega$ and $\pi\pi^0\eta$ with branching fractions of $(2.26 \pm 0.18) \times 10^{-2}$, $(4.3 \pm 0.5) \times 10^{-3}$, and $(1.80 \pm 0.45) \times 10^{-3}$ [13], respectively. The first two values are derived from the branching ratios for the $3\pi\pi^0$ and $3\pi 2\pi^0$ modes obtained in this analysis and the measured ω fractions of0.431 $\pm$ 0.033 from ALEPH [13] and the average value, 0.78 $\pm$ 0.06, from ALEPH [13] and CLEO [26], respectively.

Some much smaller contributions with η and ω have been identified and measured by CLEO [27] with the decay modes $\tau \to \nu_\tau \eta \pi^-\pi^+\pi^-$ $((2.4 \pm 0.5) \times 10^{-4})$, $\tau \to \nu_\tau \eta \pi^- 2\pi^0$ $((1.5 \pm 0.5) \times 10^{-4})$, $\tau \to \nu_\tau \omega \pi^-\pi^+\pi^-$ $((1.2 \pm 0.2) \times 10^{-4})$, and $\tau \to \nu_\tau \omega \pi^- 2\pi^0$ $((1.5 \pm 0.5) \times 10^{-4})$. Even though the corrections from these channels are very small they have been included for the sake of completeness. Finally, another very small correction has been applied to take into account the a_1 radiative decay into $\pi\gamma$ with a branching fraction of $(2.1 \pm 0.8) \times 10^{-3}$ obtained from Ref. [28].