TAU DECAYS WITH KAON(S)

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DEPARTMENT OF ENGINEERING PHYSICS

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A letter to Prof. LI Jin on March 20, 1992

Dear Professor Li Jin,

I was delighted to get some news from the τ mass experiment you are conducting. Let me congratulate you for having succeeded to perform such a beautiful measurement in a short time. Remembering many early discussions I had with Profs. Fang Shouxian and Zheng Zhipeng about this opportunity and the exciting meeting we had last September on this topic, I really think this measurement is a very important milestone for Chinese High Energy Physics and is a major contribution to our field.

You seem to be very prudent about quoting the result, which is understandable in such a careful measurement. I would appreciate very much to get your result as soon as it can be made public (the rumor is that you are 7 MeV below DELCO mass...).

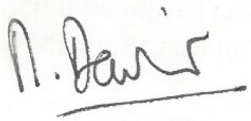
We have also made significant progress in ALEPH : using the microvertex detector, we have a new value for the lifetime with an error reduced by a factor of 3 (even smaller than the previous world average error). New branching ratio values will be given this summer with errors reduced by a factor of 2. So I think the situation on τ decays and lepton universality should be quite clarified soon.

Please send me a copy of your preprint when it is available.

If yourself or someone else from your group happens to be in Europe, I would gladly invite him to give a seminar at LAL-Orsay on the τ mass measurement. It would have to be after April 21. If there is any possibility, please contact me soon (I am away to Japan from April 2 to 20).

Give my friendly wishes and congratulations to Profs. Fang Shouxian and Zheng Zhipeng.

Best regards,



M. DAVIER
LAL Director

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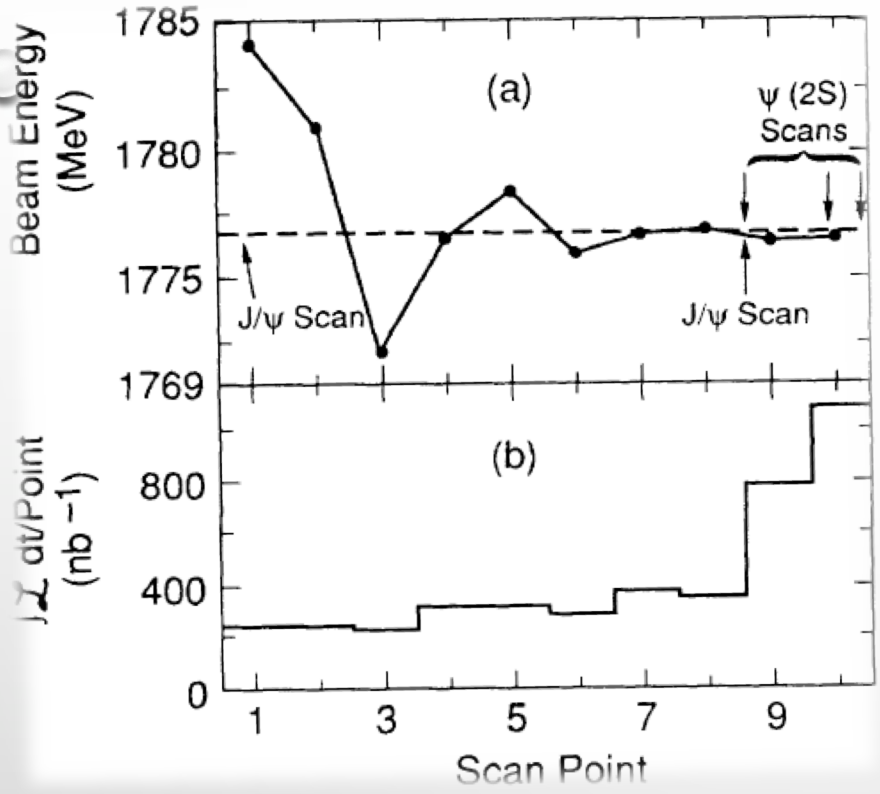
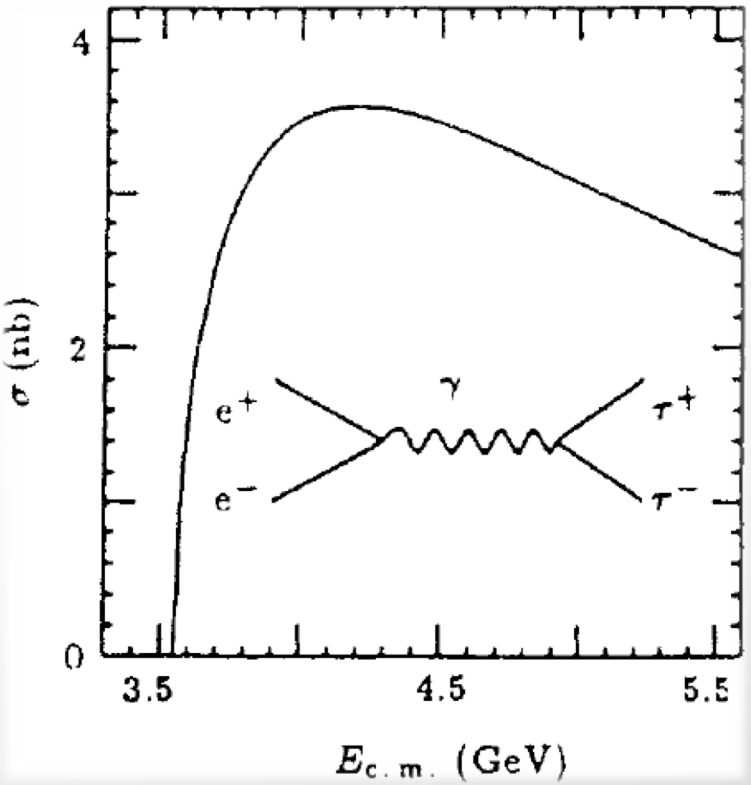
BES 1992 measurement $m_\tau = 1769.9\ ^{+0.4}_{-0.5} \pm 0.2$ MeV





Right after the tau mass measurement, BEPC changed the center-mass-energy to 4.03 GeV, where the cross-section is close to maximum.

PDG 1992

ν_τ $J = \frac{1}{2}$

Mass $m <$ 35 MeV, CL = 95%

Mean life/mass, τ/m_{ν_τ}

Magnetic moment $\mu < 4 \times 10^{-6}\ \mu_B$, CL = 90%

BES 1992 measurement

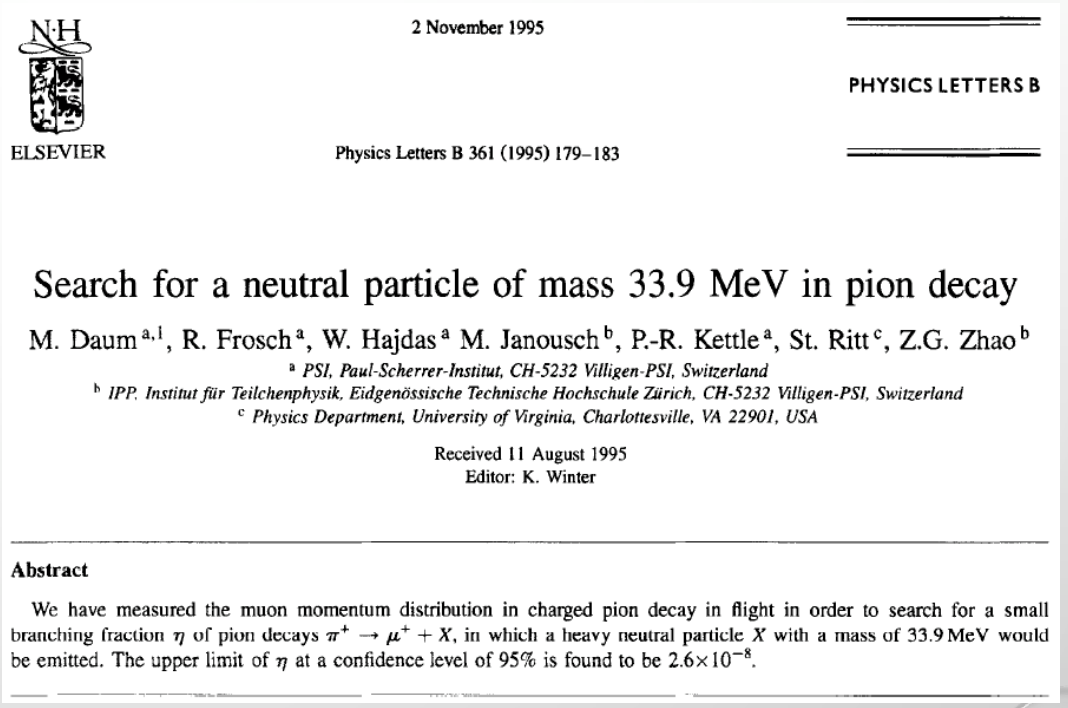
$$m_\tau = 1769.9\ ^{+0.4}_{-0.5} \pm 0.2\ \text{MeV}$$

BES data showed an evidence for $\rho^-(1700)$ in J/ψ decay, therefore

$$\tau^- \to \rho^-(1700)\nu_\tau$$

$$\rho^-(1700) \to K\bar{K}^*(892) + cc$$

$$m_{\nu_\tau} < m_\tau - m_{\rho^-(1700)}$$



N·H

ELSEVIER

2 November 1995

PHYSICS LETTERS B

Physics Letters B 361 (1995) 179–183

Search for a neutral particle of mass 33.9 MeV in pion decay

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[b] IPP, Institut für Teilchenphysik, Eidgenössische Technische Hochschule Zürich, CH-5232 Villigen-PSI, Switzerland

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Received 11 August 1995

Editor: K. Winter

Abstract

We have measured the muon momentum distribution in charged pion decay in flight in order to search for a small branching fraction η of pion decays $\pi^+ \to \mu^+ + X$, in which a heavy neutral particle X with a mass of 33.9 MeV would be emitted. The upper limit of η at a confidence level of 95% is found to be 2.6×10^{-8}.

BES should have a sensitivity for neutrino mass around ~10 MeV level.

分类号　　密级

U D C

学位论文

τ 含三个带电膺标介子衰变与 τ 中微子质量测量的实验研究

陈 少 敏

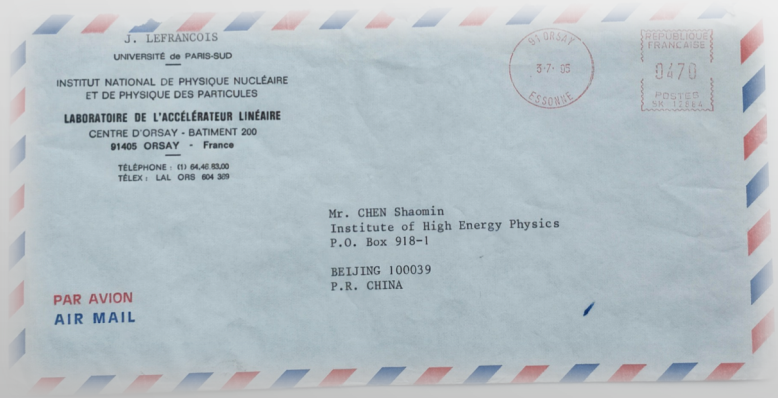
指导教师:郑志鹏　研究员（中科院高能物理研究所）
严武光　研究员（中科院高能物理研究所）
漆纳丁　博　士（中科院高能物理研究所）

申请学位:博士　　专业:高能实验物理
论文提交日期:　　论文答辩日期:
学位授与单位和日期:

答辩委员会主席

评阅人

一九九四年四月三十日



INSTITUT NATIONAL DE PHYSIQUE NUCLÉAIRE ET DE PHYSIQUE DES PARTICULES

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TÉL : (1) 44 96 40 00 • TÉLÉCOPIE : (1) 44 96 50 04

Le Directeur,
EP-FY

Paris, le 10 juillet 1995

Monsieur S. CHEN
Institute of High Energy Physics
P.O. Box 918-1
Beijing 100039
P.R. China

Monsieur,

Je suis heureux de vous faire savoir que l'Institut National de Physique Nucléaire et de Physique des Particules est en mesure de vous proposer un contrat de visiteur étranger d'une durée d'**un an à partir du 1er octobre 1995,** avec un salaire mensuel net d'environ , pour effectuer un séjour au Laboratoire de l'Accélérateur Linéaire à Orsay.

Au moment de votre arrivée, une proposition de contrat sera adressée à votre attention à J. LEFRANCOIS, Directeur du Laboratoire de l'Accélérateur Linéaire à Orsay.

J'attire votre attention sur le fait que la délivrance d'une autorisation de séjour et de travail lors de votre arrivée en France est subordonnée à la possession d'un visa de séjour. Ce visa vous sera remis par le Consulat de France qui vous convoquera quand aura abouti la procédure d'introduction que mes services vont engager pour vous.

Je vous prie d'agréer, Monsieur, l'expression de mes sentiments distingués.

Claude DETRAZ

Copie à : J. LEFRANCOIS, Directeur du L.A.L. Orsay

CNRS CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

PDG 1995 Tau Branching Review

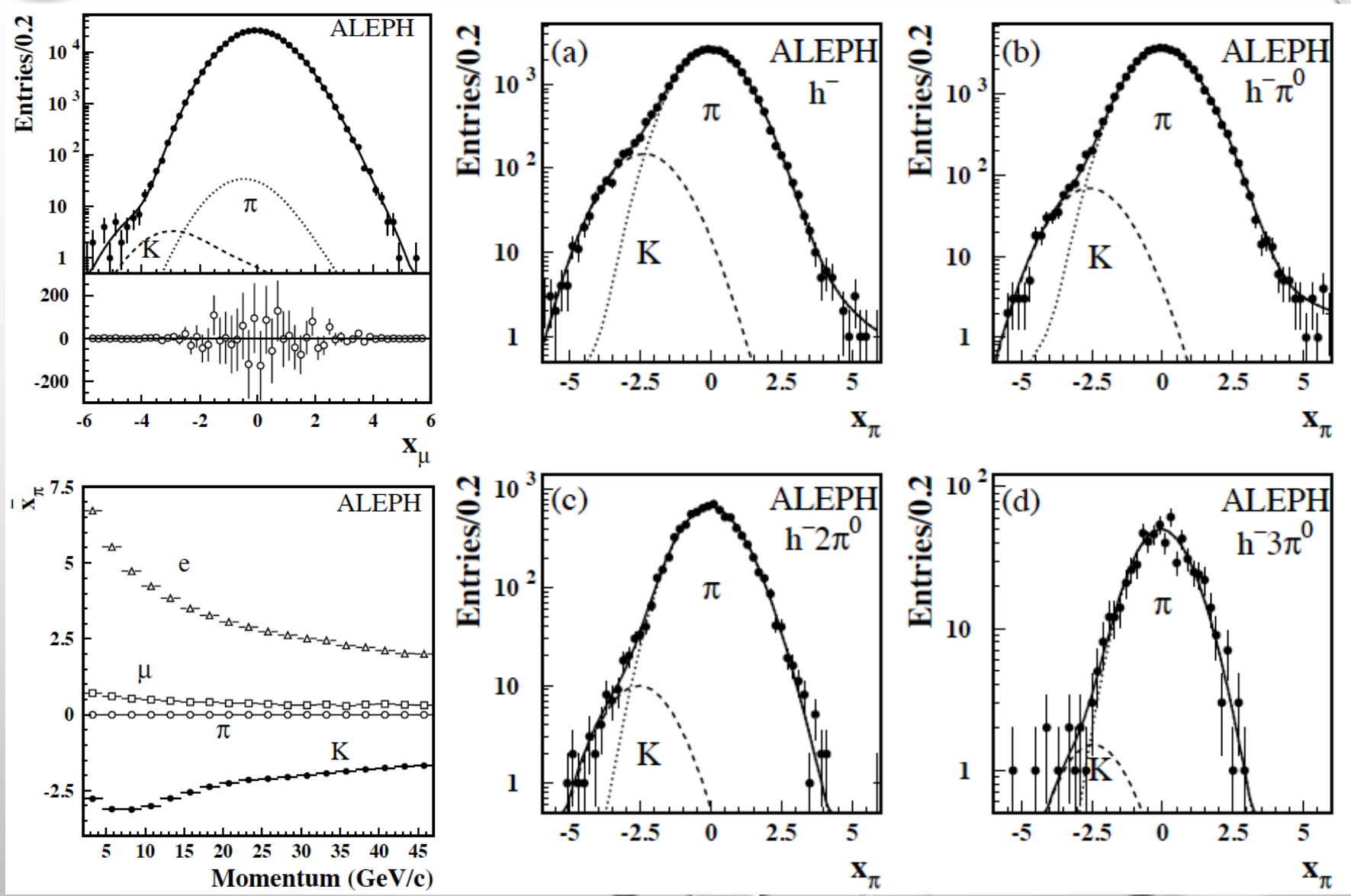
Kaons present several of special problems at the 0.5% level, whether they come directly from τ^- decay or from the decay of an intermediate K^*. This comes about for several reasons:

(a) Most experiments lack charged particle identification, and hence our basis modes of the form "m charged hadrons + $(\geq)n\pi^0$'s" must include directly produced kaons but exclude those from $K^*(892)$ decay.

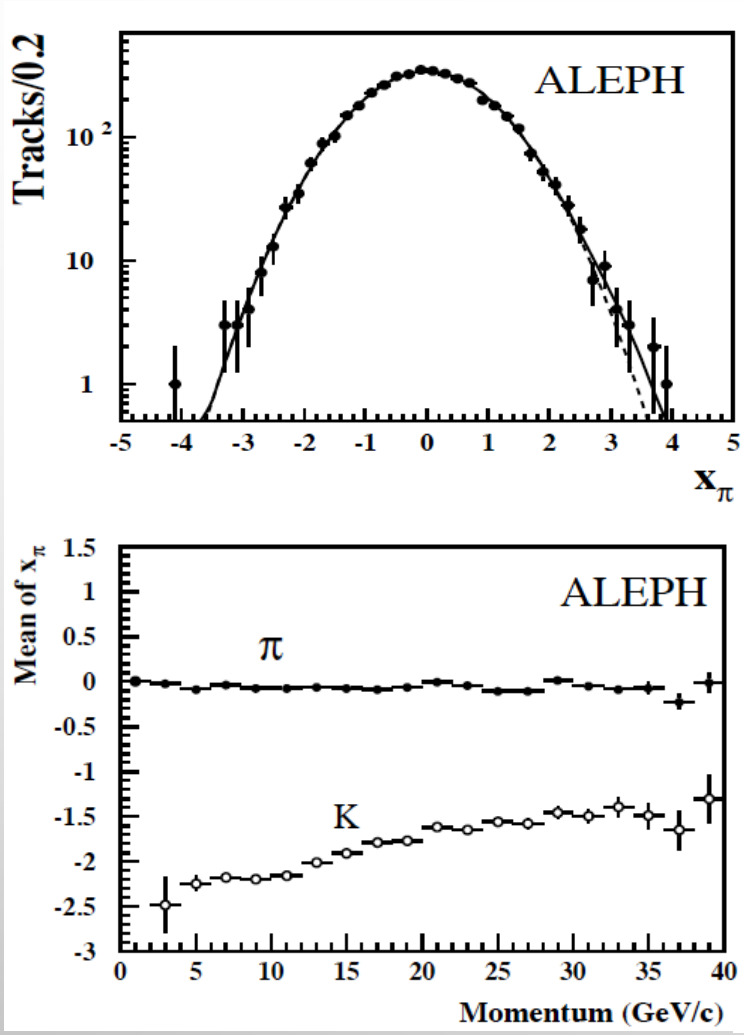
(b) K_L's are usually undetected.

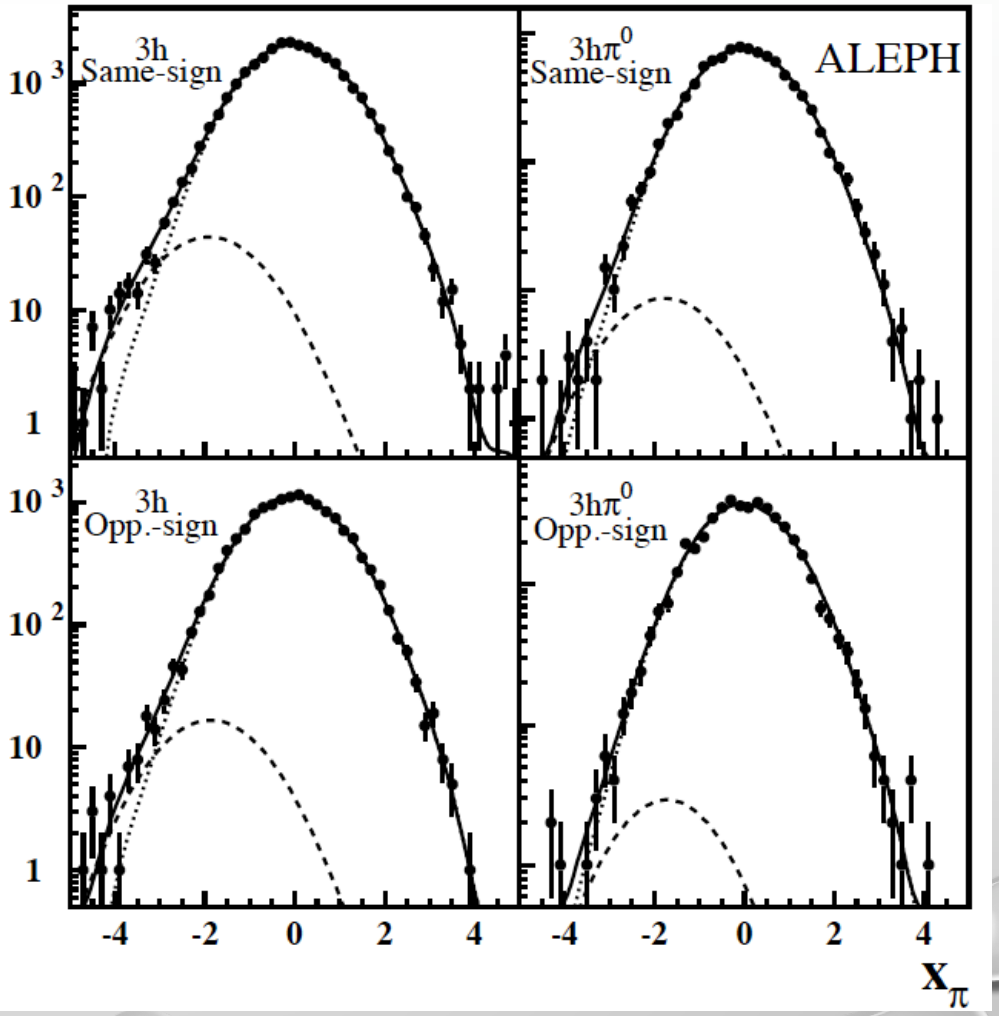
(c) $K_S \to \pi^+\pi^-$ causes confusion even for the topological branching ratios, since it is only recently that they can be sorted out with practical efficiency. Even so, branching ratios to final states containing K_S's (exclusive of those with an intermediate $K^*(892)$) are poorly known. For the moment, events containing such decays are counted with the 3-prong modes.

dE/dx calibration and PID (1)

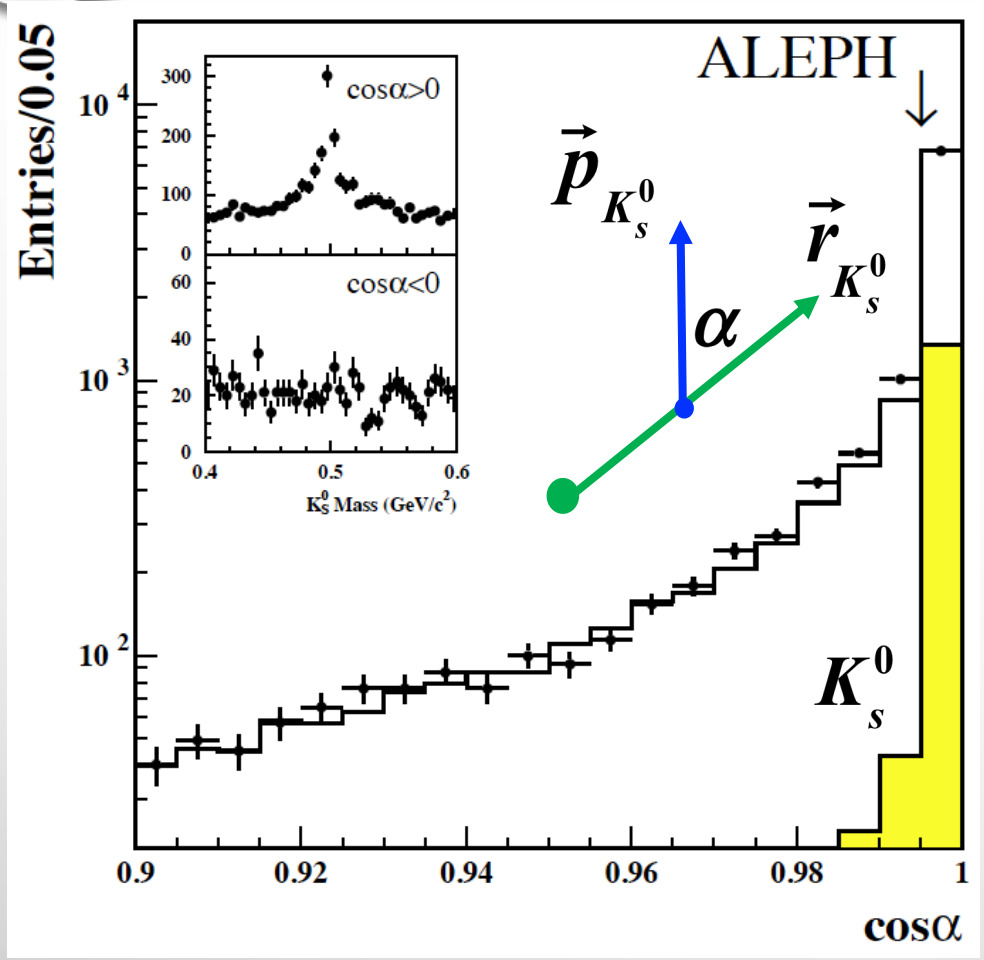


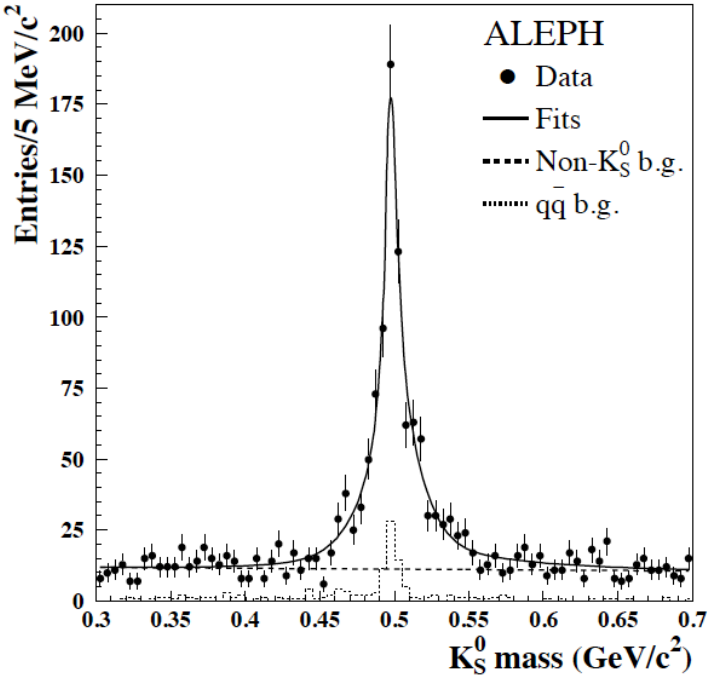
dE/dx calibration and PID (2)

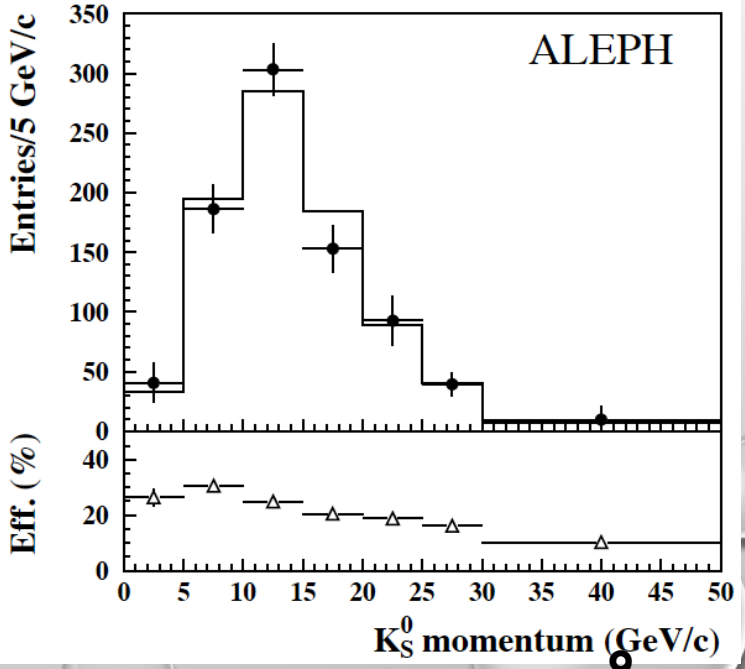




$K_s^0 \longrightarrow \pi^+\pi^-$ tagging

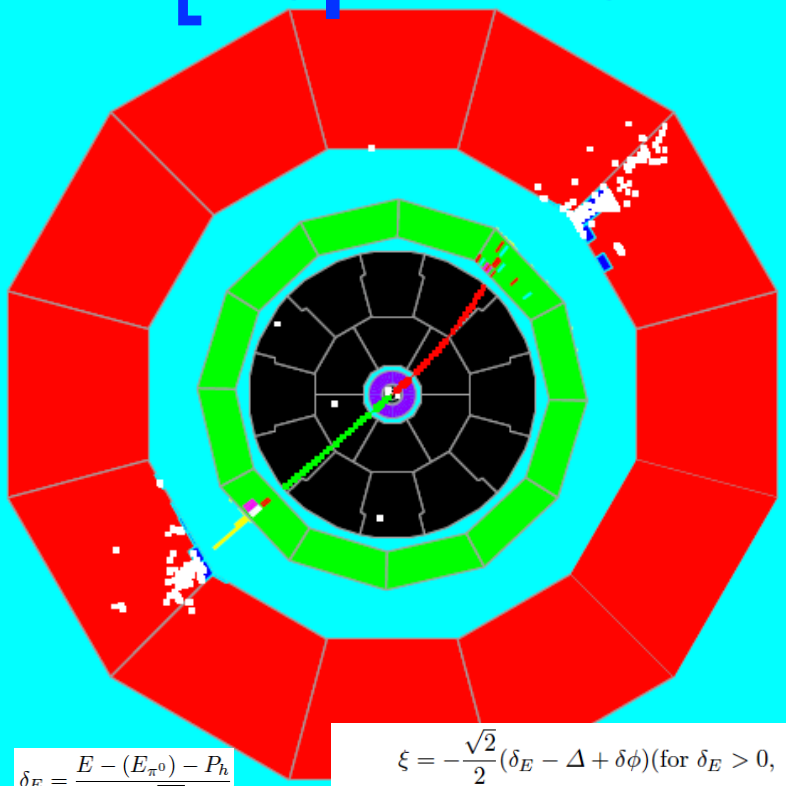






It may decay far from the interaction point and its mass resolution is strongly correlated with momentum.

K_L separation



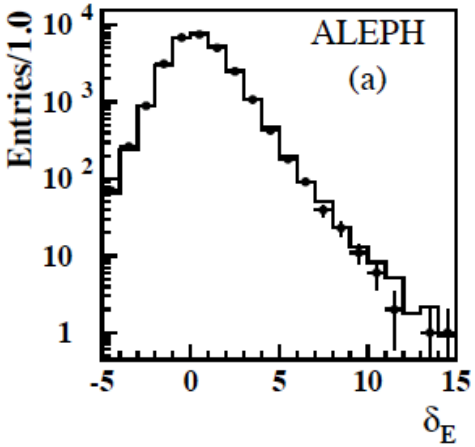
$$\delta_E = \frac{E - (E_{\pi^0}) - P_h}{C\sqrt{P_h}}$$

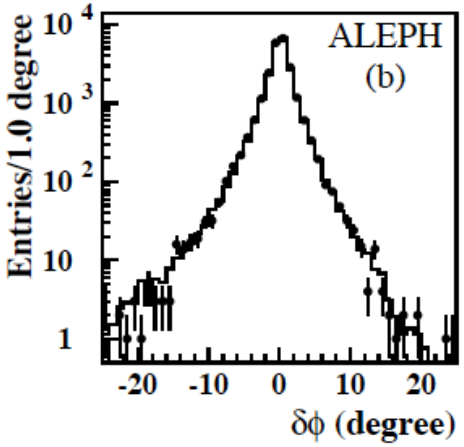
$$\delta\phi = \pm|\phi_{barycentre} - \phi_{track\ impact}|$$

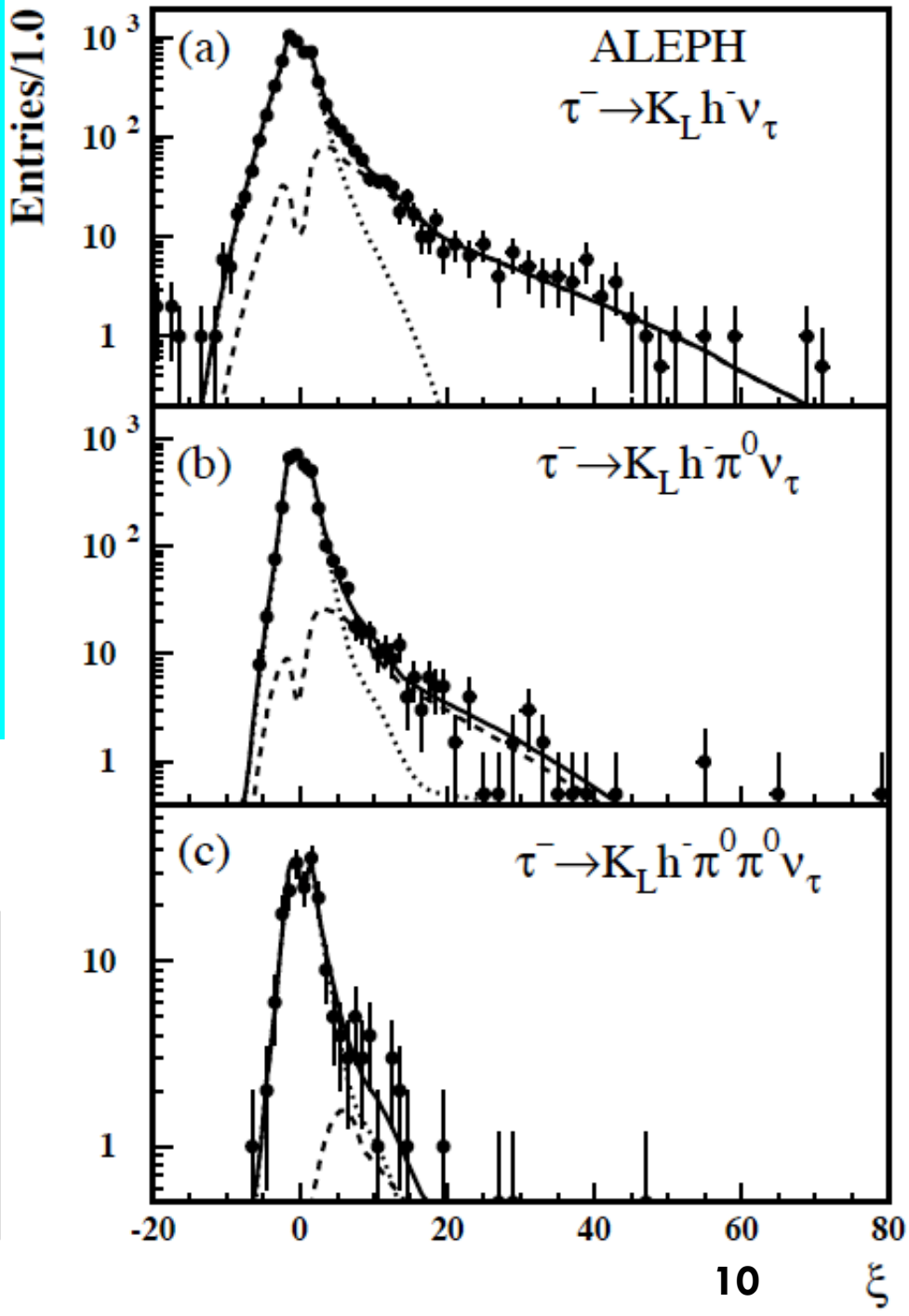
$$\xi = -\frac{\sqrt{2}}{2}(\delta_E - \Delta + \delta\phi)(\text{for } \delta_E > 0,\ \delta\phi > 0),$$

and

$$\xi = \frac{\sqrt{2}}{2}(\delta_E - \Delta - \delta\phi)(\text{for } \delta_E > 0,\ \delta\phi \leq 0),$$







Mode	New B $(\times 10^{-3})$	Old B $(\times 10^{-3})$
$K^- X \nu_\tau$	$15.20 \pm 0.40 \pm 0.40$	–
$K^- \nu_\tau$	$6.96 \pm 0.25 \pm 0.14$	$6.4 \pm 0.5 \pm 0.5$ (94) $7.2 \pm 0.4 \pm 0.4$ (96)
$K^- \pi^0 \nu_\tau$	$4.44 \pm 0.26 \pm 0.23$	$5.3 \pm 0.5 \pm 0.7$ (94) $5.2 \pm 0.4 \pm 0.5$ (96)
$K^- \pi^0 \pi^0 \nu_\tau$	$0.56 \pm 0.20 \pm 0.15$	$0.4 \pm 0.3 \pm 0.2$ (94) $0.8 \pm 0.2 \pm 0.2$ (96)
$K^- 3\pi^0 \nu_\tau$ (ex. η)	$0.37 \pm 0.21 \pm 0.11$	–
$K^- K^0 \nu_\tau$	$1.62 \pm 0.21 \pm 0.11$	$2.9 \pm 1.2 \pm 0.3$ (94) $2.6 \pm 0.9 \pm 0.2$ (96)
$K^- K^0 \pi^0 \nu_\tau$	$1.43 \pm 0.25 \pm 0.20$	$0.5 \pm 0.5 \pm 0.1$ (94) $1.0 \pm 0.5 \pm 0.3$ (96)
$K^- K^0 \pi^0 \pi^0 \nu_\tau$	< 0.18 (95% C.L.)	–
$\overline{K}^0 \pi^- \nu_\tau$	$9.28 \pm 0.45 \pm 0.31$	$8.8 \pm 1.4 \pm 0.9$ (94) $7.9 \pm 1.0 \pm 0.9$ (96)
$\overline{K}^0 \pi^- \pi^0 \nu_\tau$	$3.47 \pm 0.53 \pm 0.36$	$3.3 \pm 1.4 \pm 0.7$ (94) $3.2 \pm 1.1 \pm 0.5$ (96)
$\overline{K}^0 \pi^- \pi^0 \pi^0 \nu_\tau$	< 0.66 (95% C.L.)	–

Decay	K^0 detected	S	B (10^{-3})	$B(K_L^0 + K_S^0)$ (10^{-3})
$\tau^- \to K^- \nu_\tau$	–		6.96 ± 0.29	–
$\tau^- \to K^- \pi^0 \nu_\tau$	–		4.44 ± 0.35	–
$\tau^- \to \overline{K^0} \pi^- \nu_\tau$	K_L^0		9.28 ± 0.56	9.17 ± 0.52
$\tau^- \to \overline{K^0} \pi^- \nu_\tau$	K_S^0		8.55 ± 1.34	
$\tau^- \to \overline{K^0} \pi^- \pi^0 \nu_\tau$	K_L^0		3.47 ± 0.65	3.27 ± 0.51
$\tau^- \to \overline{K^0} \pi^- \pi^0 \nu_\tau$	K_S^0		2.94 ± 0.82	
$\tau^- \to K^- \pi^+ \pi^- \nu_\tau$	–	-1	2.14 ± 0.47	–
$\tau^- \to K^- \pi^0 \pi^0 \nu_\tau$	–		0.56 ± 0.25	–
$\tau^- \to \overline{K^0} \pi^- \pi^0 \pi^0 \nu_\tau$	K_L^0		< 0.66 (95% C.L.)	0.26 ± 0.24
$\tau^- \to \overline{K^0} \pi^- \pi^0 \pi^0 \nu_\tau$	K_S^0		0.58 ± 0.36	
$\tau^- \to K^- \pi^0 \pi^0 \pi^0 \nu_\tau$	–		0.37 ± 0.24 (excl. η)	–
$\tau^- \to K^- \pi^+ \pi^- \pi^0 \nu_\tau$	–		0.54 ± 0.43 (excl. η)	–
$\tau^- \to K^- \eta \nu_\tau$	–		$0.29^{+0.15}_{-0.14}$	–
$\tau^- \to K^- K^+ K^- \nu_\tau$	–		< 0.19 (95% C.L.)	–
$\tau^- \to K^- K^0 \nu_\tau$	K_L^0		1.62 ± 0.24	1.61 ± 0.21
$\tau^- \to K^- K^0 \nu_\tau$	K_S^0		1.58 ± 0.45	
$\tau^- \to K^- K^0 \pi^0 \nu_\tau$	K_L^0		1.43 ± 0.32	1.45 ± 0.30
$\tau^- \to K^- K^0 \pi^0 \nu_\tau$	K_S^0		1.52 ± 0.79	
$\tau^- \to K^- K^0 \pi^0 \pi^0 \nu_\tau$	K_L^0		< 0.18 (95% C.L.)	< 0.16 (95% C.L.)
$\tau^- \to K^- K^0 \pi^0 \pi^0 \nu_\tau$	K_S^0	0	< 0.39 (95% C.L.)	
$\tau^- \to K_S^0 K_L^0 \pi^- \nu_\tau$	–		1.01 ± 0.26	1.53 ± 0.35
$\tau^- \to K_S^0 K_S^0 \pi^- \nu_\tau$	–		0.26 ± 0.12	
$\tau^- \to K_S^0 K_L^0 \pi^- \pi^0 \nu_\tau$	–		0.31 ± 0.12	0.31 ± 0.23
$\tau^- \to K_S^0 K_S^0 \pi^- \pi^0 \nu_\tau$	–		< 0.20 (95% C.L.)	
$\tau^- \to K^- K^+ \pi^- \nu_\tau$	–		1.63 ± 0.27	–
$\tau^- \to K^- K^+ \pi^- \pi^0 \nu_\tau$	–		0.75 ± 0.33	–
$\tau^- \to K^0 h^- h^+ h^- \nu_\tau$	K_S^0	mixed	0.23 ± 0.20	0.23 ± 0.20

PDG2016

$\Gamma(K^-\nu_\tau)/\Gamma_{\text{total}}$ Γ_{10}/Γ

VALUE (%)	EVTS	DOCUMENT ID		TECN	COMMENT
0.696±0.010 OUR FIT					
0.685±0.023 OUR AVERAGE					
0.658±0.027±0.029		[1] ABBIENDI	01J	OPAL	1990–1995 LEP runs
0.696±0.025±0.014	2032	BARATE	99K	ALEP	1991–1995 LEP runs
0.85 ±0.18	27	ABREU	94K	DLPH	LEP 1992 Z data
0.66 ±0.07 ±0.09	99	BATTLE	94	CLEO	$E^{ee}_{\text{cm}} \approx$ 10.6 GeV

$\Gamma(K^-\pi^0\nu_\tau)/\Gamma_{\text{total}}$ Γ_{16}/Γ

VALUE (%)	EVTS	DOCUMENT ID		TECN	COMMENT
0.433±0.015 OUR FIT					
0.426±0.016 OUR AVERAGE					
0.416±0.003±0.018	78k	AUBERT	07AP	BABR	230 fb^{-1} E^{ee}_{cm}= 10.6 GeV
0.471±0.059±0.023	360	ABBIENDI	04J	OPAL	1991-1995 LEP runs
0.444±0.026±0.024	923	BARATE	99K	ALEP	1991-1995 LEP runs
0.51 ±0.10 ±0.07	37	BATTLE	94	CLEO	$E^{ee}_{\text{cm}} \approx$ 10.6 GeV

$\Gamma(\pi^-\overline{K}^0\nu_\tau)/\Gamma_{\text{total}}$ Γ_{36}/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
8.40±0.14 OUR FIT					
8.39±0.22 OUR AVERAGE		Error includes scale factor of 1.5. See the ideogram below.			
8.32±0.02±0.16	158k	[1] RYU	14	BELL	669 fb^{-1} E^{ee}_{cm}=10.6 GeV
9.33±0.68±0.49	377	ABBIENDI	00C	OPAL	1991–1995 LEP runs
9.28±0.45±0.34	937	[2] BARATE	99K	ALEP	1991–1995 LEP runs
9.5 ±1.5 ±0.6		[3] ACCIARRI	95F	L3	1991–1993 LEP runs

Physics behind tau branching ratios

QCD and Resonance Physics: Applications
Mikhail A. Shifman, A.I. Vainshtein, Valentin I. Zakharov (Moscow, ITEP). 1978. 71 pp.
Published in **Nucl.Phys. B147 (1979) 448-518**
ITEP-94-1978, ITEP-81-1978
DOI: 10.1016/0550-3213(79)90023-3

References | BibTeX | LaTeX(US) | LaTeX(EU) | Harvmac | EndNote

Detailed record - Cited by 2778 records 1000+

QCD and Resonance Physics. Theoretical Foundations
Mikhail A. Shifman, A.I. Vainshtein, Valentin I. Zakharov (Moscow, ITEP). 1978. 63 pp.
Published in **Nucl.Phys. B147 (1979) 385-447**
ITEP-73-1978, ITEP-80-1978
DOI: 10.1016/0550-3213(79)90022-1

References | BibTeX | LaTeX(US) | LaTeX(EU) | Harvmac | EndNote

Detailed record - Cited by 5014 records 1000+

QCD analysis of the tau hadronic width
E. Braaten (Northwestern U.), Stephan Narison (Montpellier U.), A. Pich (CERN). Sep 1991. 32 pp.
Published in **Nucl.Phys. B373 (1992) 581-612**
CERN-TH-6070-91, NUHEP-TH-91-8, PM-91-8
DOI: 10.1016/0550-3213(92)90267-F

References | BibTeX | LaTeX(US) | LaTeX(EU) | Harvmac | EndNote
CERN Document Server; KEK scanned document

Detailed record - Cited by 646 records 500+

Semi-leptonic tau decays

$$R_\tau^{\text{had}} = \frac{\Gamma(\tau^- \to \text{hadron(s)}^- \nu_\tau)}{\Gamma(\tau^- \to e^- \bar{\nu}_e \nu_\tau)}$$

$$= R_{\tau,\text{V}}^{S=0} + R_{\tau,\text{A}}^{S=0} + R_{\tau,\text{V}}^{S=-1} + R_{\tau,\text{A}}^{S=-1}$$

Parton model prediction

$$R_\tau^{\text{had}} = N_C \left(|V_{ud}|^2 + |V_{us}|^2 \right) \approx 3$$

$$R_{\tau,\text{V}}^{S=0} = R_{\tau,\text{A}}^{S=0} \quad \text{and} \quad R_{\tau,\text{V}}^{S=-1} = R_{\tau,\text{A}}^{S=-1}$$

Perturbative QCD prediction

$$R_{\tau,(S)} =$$

$$3 |V_{\text{CKM}}|^2 S_{EW} \left[1 + \delta^{(0)} + \delta^{(2-mass)} + \sum_{D=4,6,\cdots} \delta^{(D)} + \delta'_{EW} \right]$$

QCD application at Tau decays

Non-strange tau decay

$$R^{S=0}_{\tau,\mathrm{V}}, \quad R^{S=0}_{\tau,\mathrm{A}}$$

$$\alpha_s(M_\tau)$$

Leptonic tau decays

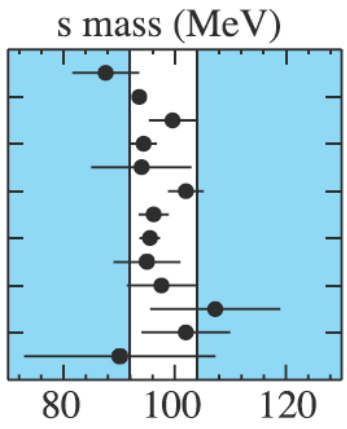
Strange tau decay

$$R^{S=-1}_{\tau,\mathrm{V}}, \quad R^{S=-1}_{\tau,\mathrm{A}}$$

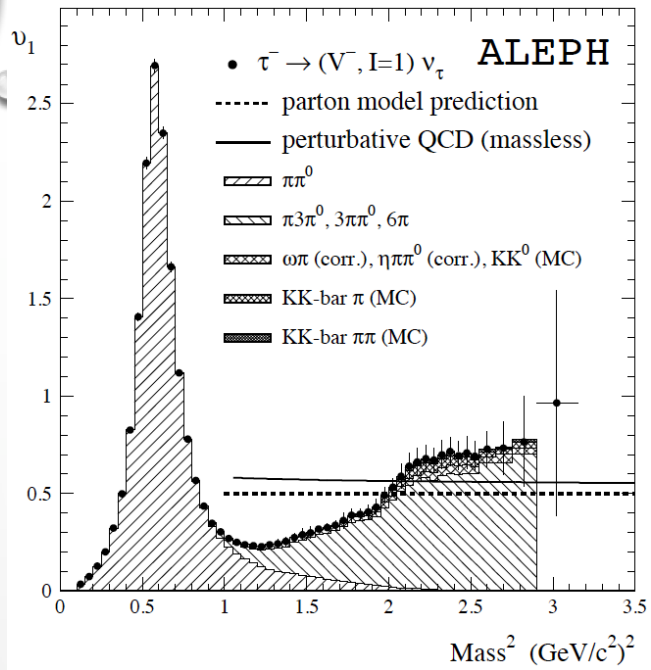
$$m_s(M_\tau)$$

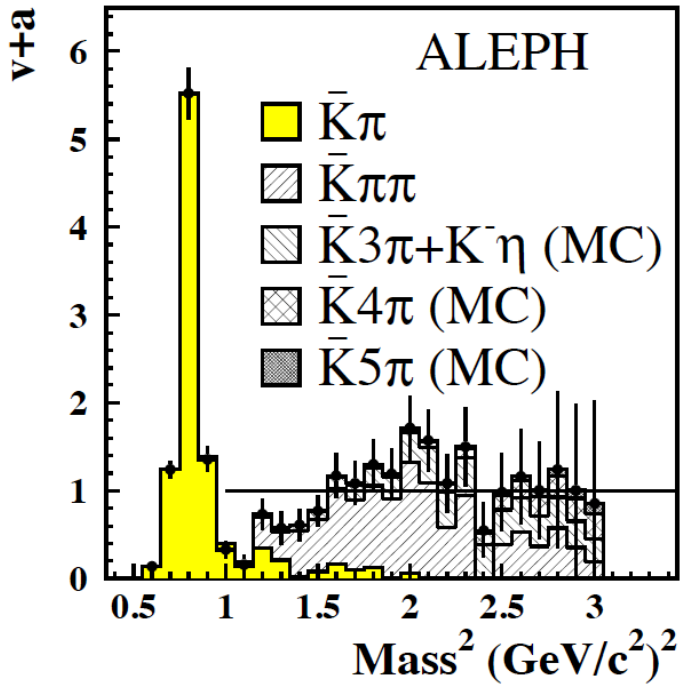
$$V_{us}$$

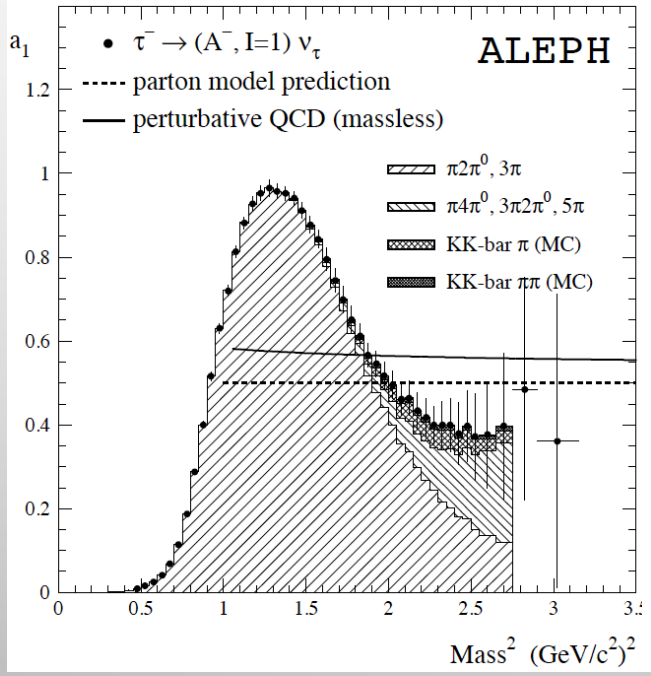
PDG2016

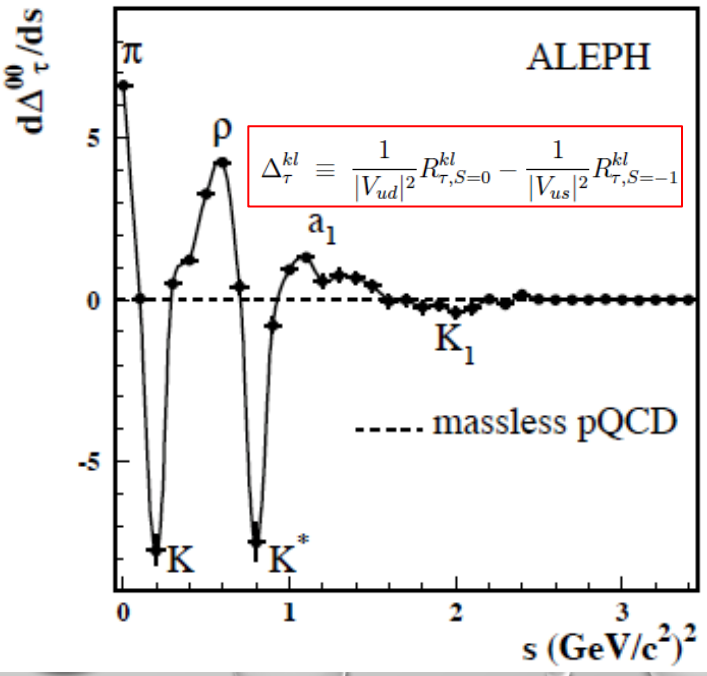


$$R^{kl}_{\tau,(S)} \equiv \int_0^{M_\tau^2} ds \left(1 - \frac{s}{M_\tau^2}\right)^k \left(\frac{s}{M_\tau^2}\right)^l \frac{dR_{\tau,(S)}}{ds}$$


v_1
ALEPH
• $\tau^- \to (V^-, I=1)\ \nu_\tau$
parton model prediction
perturbative QCD (massless)
$\pi\pi^0$
$\pi 3\pi^0, 3\pi\pi^0, 6\pi$
$\omega\pi$ (corr.), $\eta\pi\pi^0$ (corr.), KK^0 (MC)
KK-bar π (MC)
KK-bar $\pi\pi$ (MC)
Mass^2 (GeV/c^2)^2


v+a
ALEPH
$\bar{K}\pi$
$\bar{K}\pi\pi$
$\bar{K}3\pi+K^-\eta$ (MC)
$\bar{K}4\pi$ (MC)
$\bar{K}5\pi$ (MC)
Mass^2 (GeV/c^2)^2


a_1
• $\tau^- \to (A^-, I=1)\ \nu_\tau$
ALEPH
parton model prediction
perturbative QCD (massless)
$\pi 2\pi^0, 3\pi$
$\pi 4\pi^0, 3\pi 2\pi^0, 5\pi$
KK-bar π (MC)
KK-bar $\pi\pi$ (MC)
Mass^2 (GeV/c^2)^2


$d\Delta^{00}_\tau/ds$
ALEPH
π
ρ
a_1
K_1
K
K^*
$\Delta_\tau^{kl} \equiv \frac{1}{|V_{ud}|^2} R^{kl}_{\tau,S=0} - \frac{1}{|V_{us}|^2} R^{kl}_{\tau,S=-1}$
massless pQCD
s (GeV/c^2)^2

1. **|Vus| determination from inclusive strange tau decay and lattice HVP**
   Peter Boyle (Edinburgh U.), Renwick James Hudspith (York U., Canada), Taku Izubuchi (Brookhaven Natl. Lab. & RIKEN BNL), Andreas Jüttner (Southampton U.), Christoph Lehner (Brookhaven Natl. Lab.), Randy Lewis (York U., Canada), Kim Maltman (York U., Canada & Adelaide U., Sch. Chem. Phys.), Hiroshi Ohki (RIKEN BNL & Nara Women's U.), Antonin Portelli, Matthew Spraggs (Edinburgh U.). 2018. 8 pp.
   Published in **EPJ Web Conf. 175 (2018) 13011**
   DOI: 10.1051/epjconf/201817513011
   Conference: C17-06-18.1 Proceedings
   References | BibTeX | LaTeX(US) | LaTeX(EU) | Harvmac | EndNote
   ADS Abstract Service
   Detailed record

2. **Novel $|V_{us}|$ Determination Using Inclusive Strange τ τ Decay and Lattice HVPs**
   RBC and UKQCD Collaborations (Peter Boyle (Edinburgh U.) *et al.*). Mar 19, 2018. 9 pp.
   e-Print: **arXiv:1803.07228** **[hep-lat]** | **PDF**
   References | BibTeX | LaTeX(US) | LaTeX(EU) | Harvmac | EndNote
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3. **Determination of |Vus| from the tau lepton branching fractions**
   Alberto Lusiani (INFN, Pisa & Pisa, Scuola Normale Superiore). Nov 17, 2014. 5 pp.
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   e-Print: **arXiv:1411.4526** **[hep-ex]** | **PDF**
   References | BibTeX | LaTeX(US) | LaTeX(EU) | Harvmac | EndNote
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4. **Determination of |Vus| from tau Decays**
   Ian M. Nugent (RWTH Aachen U.). Jan 2013.
   Conference: C12-09-28
   e-Print: **arXiv:1301.0637** **[hep-ex]** | **PDF**
   References | BibTeX | LaTeX(US) | LaTeX(EU) | Harvmac | EndNote
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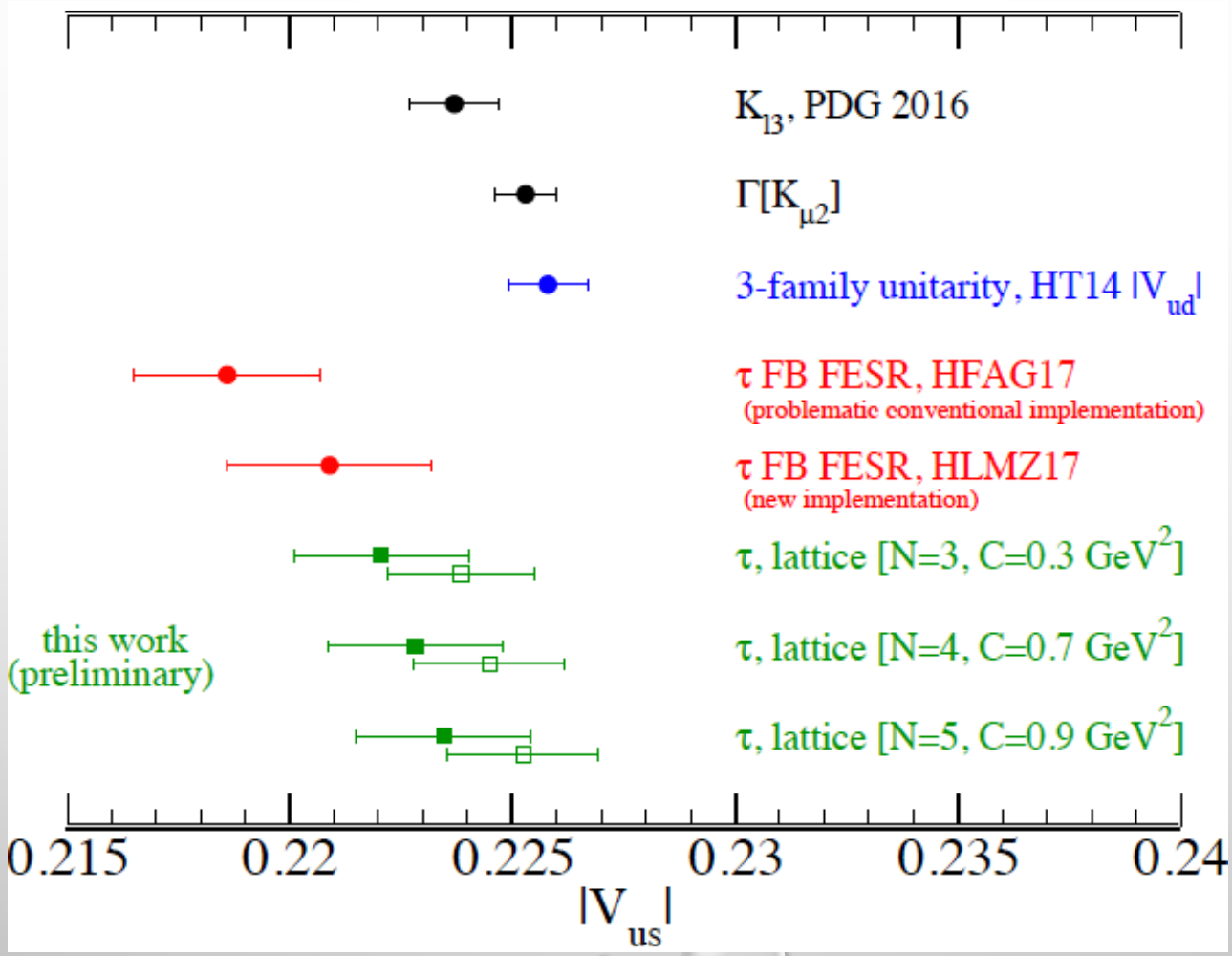
   Detailed record - Cited by 3 records

arXiv:1803.07228
RBC & UKQCD Collaboration



1. **Study of tau decays involving kaons, spectral functions and determination of the strange quark mass**
ALEPH Collaboration (R. Barate (Annecy, LAPP) *et al.*). Feb 1999. 38 pp.
Published in **Eur.Phys.J. C11 (1999) 599-618**
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2. **One prong tau decays with kaons**
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DOI: 10.1007/BF01245798
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4. **K0(S) production in tau decays**
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Detailed record - Cited by 37 records

Michel: ”Shaomin，do you know how many pages of papers you have published? ”

ALEPH Tau Papers

1. **Tau lepton physics at LEP**
   ALEPH and DELPHI and OPAL Collaborations (Zhiging Zhang (Orsay, LAL) for the collaboration). Feb 2006. 3 pp.
   Published in **PoS HEP2005 (2006) 290**
   LAL-05-184
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   Presented at Conference: C05-07-21 Proceedings
   e-Print: hep-ex/0602044 | **PDF**

Tau group contributed ~10% ALEPH papers!

62. **Measurement of tau branching ratios from ALEPH**
   ALEPH Collaboration (Z.Q. Zhang (Orsay, LAL & Orsay) for the collaboration). Sep 1990. 10 pp.
   Prepared for Conference: C90-09-24.1, p.151-160 Proceedings

Citations summary — ALEPH Papers

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648 papers found, 386 of them citeable (published or arXiv)

Citation summary results	Citeable papers	Published only
Total number of papers analyzed:	386	296
Total number of citations:	30,920	27,340
Average citations per paper:	80.1	92.4
Breakdown of papers by citations:		
Renowned papers (500+)	4	4
Famous papers (250-499)	15	11
Very well-known papers (100-249)	56	47
Well-known papers (50-99)	92	88
Known papers (10-49)	142	136
Less known papers (1-9)	44	8
Unknown papers (0)	33	2
h_{HEP} index [?]	89	83

Citations summary — ALEPH Tau Papers

Generated on 2018-06-14

62 papers found, 43 of them citeable (published or arXiv)

Citation summary results	Citeable papers	Published only
Total number of papers analyzed:	43	37
Total number of citations:	3,097	3,067
Average citations per paper:	72.0	82.9
Breakdown of papers by citations:		
Renowned papers (500+)	0	0
Famous papers (250-499)	3	3
Very well-known papers (100-249)	5	5
Well-known papers (50-99)	11	11
Known papers (10-49)	18	17
Less known papers (1-9)	6	1
Unknown papers (0)	0	0
h_{HEP} index [?]	29	29

FRANCE 1998

FIFA WORLD CUP
RUSSIA 2018

Pot 1	Pot 2	Pot 3	Pot 4
Russia (65) *(hosts)*	Spain (8)	Denmark (19)	Serbia (38)
Germany (1)	Peru (10)	Iceland (21)	Nigeria (41)
Brazil (2)	Switzerland (11)	Costa Rica (22)	Australia (43)
Portugal (3)	England (12)	Sweden (25)	Japan (44)
Argentina (4)	Colombia (13)	Tunisia (28)	Morocco (48)
Belgium (5)	Mexico (16)	Egypt (30)	Panama (49)
Poland (6)	Uruguay (17)	Senegal (32)	South Korea (62)
France (7)	Croatia (18)	Iran (34)	Saudi Arabia (63)

THANK YOU FOR YOUR ATTENTION!