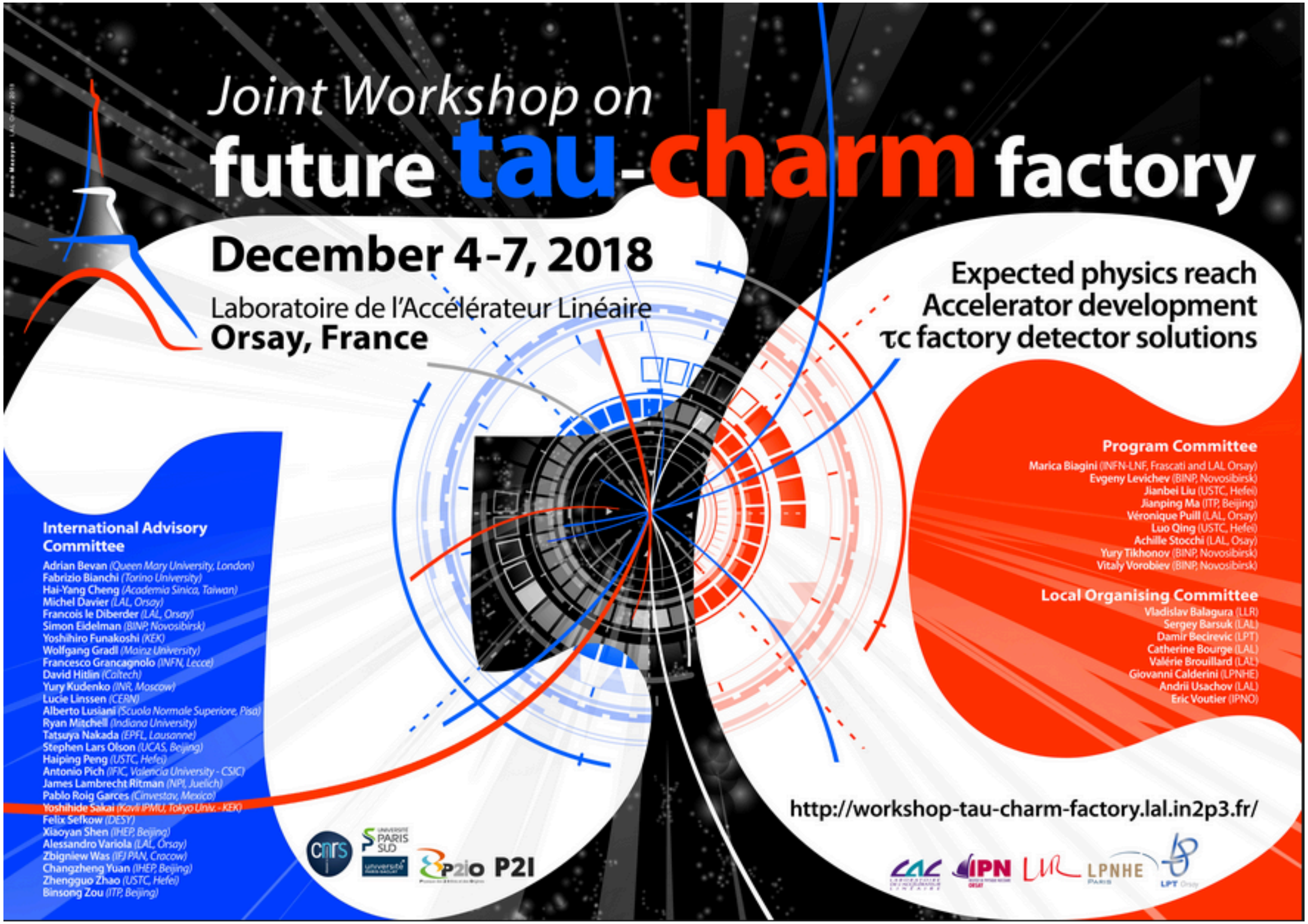
Round table


Joint Workshop on
future tau-charm factory
December 4-7, 2018
Laboratoire de l'Accélérateur Linéaire
Orsay, France
Expected physics reach
Accelerator development
τc factory detector solutions
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http://workshop-tau-charm-factory.lal.in2p3.fr/

Talk by S. Fajfer

NP explaining both B anomalies

$$R_{D^{(*)}}^{exp} > R_{D^{(*)}}^{SM}$$

$$\mathcal{L}_{NP} = \frac{1}{(\Lambda^D)^2} 2\,\bar{c}_L \gamma_\mu b_L \bar{\tau} \gamma^\mu \nu_L$$

$$\Lambda^D \simeq 3\,\mathrm{TeV}$$

$$R_{K^{(*)}}^{exp} < R_{K^{(*)}}^{SM}$$

$$\mathcal{L}_{NP} = \frac{1}{(\Lambda^K)^2} \bar{s}_L \gamma_\mu b_L \bar{\mu}_L \gamma^\mu \mu_L$$

$$\Lambda^K \simeq 30\,\mathrm{TeV}$$

$$\Lambda^D \simeq \Lambda^K \equiv \Lambda$$

NP in FCNC $B \to K^{(*)}\mu^+\mu^-$ has to be suppressed

$$\frac{1}{(\Lambda^K)^2} = \frac{C_K}{\Lambda^2} \qquad C_K \simeq 0.01$$

suppression factor

Charged current charm meson decays and New Physics

$$\mathcal{L}_{SM} = \frac{4G_F}{\sqrt{2}} V_{cs} \bar{s}_L \gamma^\mu c_L \, \bar{\nu}_l \gamma_\mu l$$

$$\mathcal{L}_{NP} = \frac{2}{\Lambda_c^2} \bar{s}_L \gamma^\mu c_L \, \bar{\nu}_l \gamma_\mu l$$

PDG 2018

$$f_{D^+} = 211.9(1.1)\ \text{MeV}$$

$$f_{D_s} = 249.0(1.2)\ \text{MeV}$$

$$\frac{f_{D_s}}{f_{D^+}} = 1.173(3)\,.$$

$$|V_{cs}| = 0.997 \pm 0.017$$

Electro-magnetic correction 1-3%

1 % error in

$$\Gamma(D_s^+ \to l^+ \nu_l)$$

$$\Lambda_c \sim 2.5\ \text{TeV}$$

Message:
Even if there is NP at 3 TeV scale the effect on charm leptonic decay can be ~ 1%!

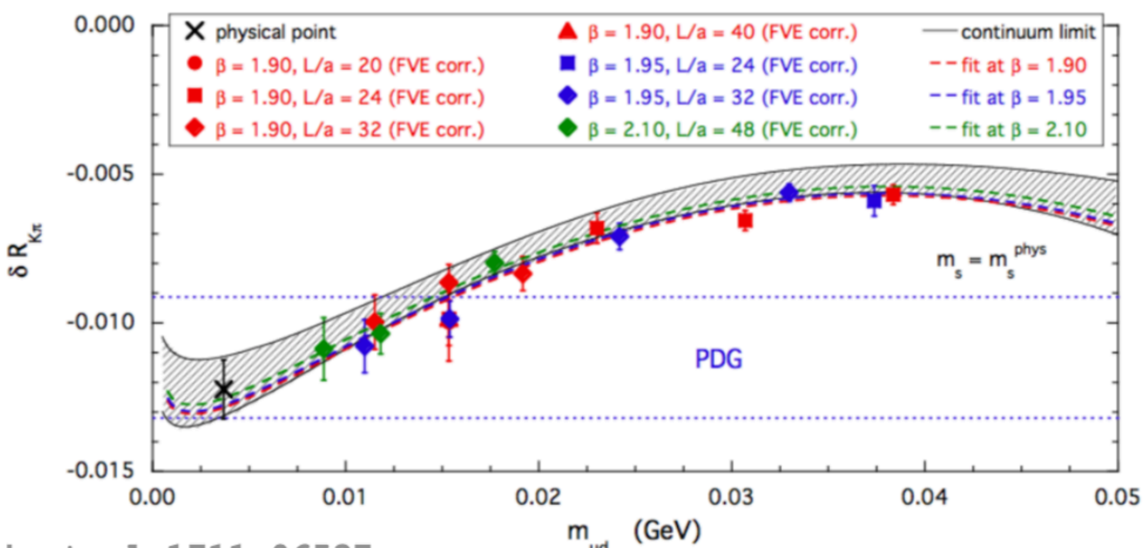
Need more advertising in LQCD

QED corrections to leptonic decays

- Need $P \to \ell\nu + \ell\nu\gamma$ for KLN
- Real photon emission in pert.th up to a (tiny) ΔE_γ in P-rest frame
- IR divergences universal and cancel between virtual photon contribution (NP) and real photon emission (pert) - L acts as intermediate IR regulator Inclusive   Carrasco et al 1502.00257

$$\begin{aligned}\Gamma(P_{\ell 2}) &= \Gamma_0 + \Gamma_1^{pt}(\Delta E_\gamma) \\ &= \lim_{L\to\infty}\left[\Gamma_0(L) - \Gamma_0^{pt}(L)\right] + \lim_{\mu_\gamma\to 0}\left[\Gamma_0^{pt}(\mu_\gamma) + \Gamma_1^{pt}(\Delta E_\gamma, \mu_\gamma)\right]\end{aligned}$$

- Computed $\Gamma(P \to \ell\nu[\gamma]) = \Gamma_P^{tree} \times (1 + \delta R_P)$



D. Giusti et al 1711.06537

τ Anomalous Magnetic Moment

Talk by A. Pich

Difficult to measure! $a_\tau^{\rm exp} = (-0.018 \pm 0.017)$ **DELPHI**

$-0.007 < a_\tau^{\rm New\,Phys} < 0.005$ **González-Springer, Santamaria, Vidal '00** **(LEP/SLD data)**

Eidelman, Passera

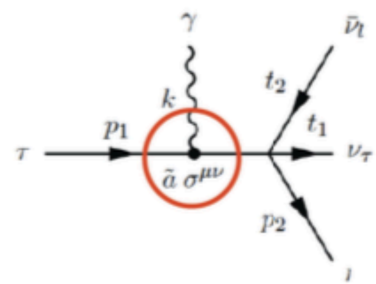
$$
\begin{aligned}
10^8 \cdot a_\tau^{\rm th} = & \; 117\,324 \pm 2 && \text{QED} \\
& + 47.4 \pm 0.5 && \text{EW} \\
& + 337.5 \pm 3.7 && \text{hvp} \\
& + 7.6 \pm 0.2 && \text{hvp NLO} \\
& + 5 \pm 3 && \text{light-by-light} \\
& = \mathbf{117\,721 \pm 5} &&
\end{aligned}
$$

Enhanced sensitivity to new physics: $(m_\tau/m_\mu)^2 = 283$

	Electron	Muon	Tau
a^{EW}/a^{HAD}	1/56	1/45	1/7
$a^{EW}/\delta a^{HAD}$	1.6	3	10

Essentially unknown

May be accessible at BFs through radiative leptonic decays (Fael et al)

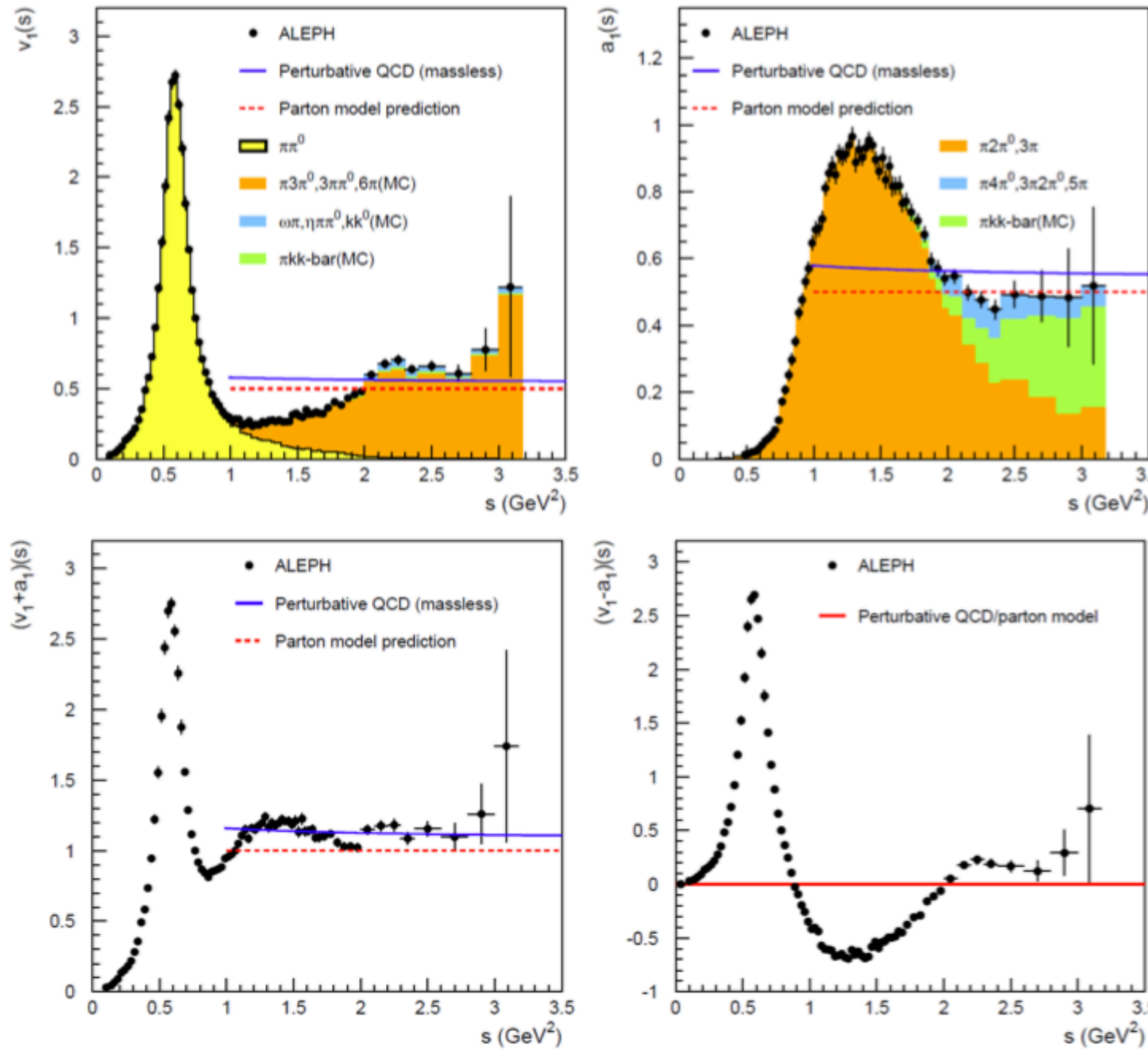


SPECTRAL FUNCTIONS

Davier et al, 1312.1501

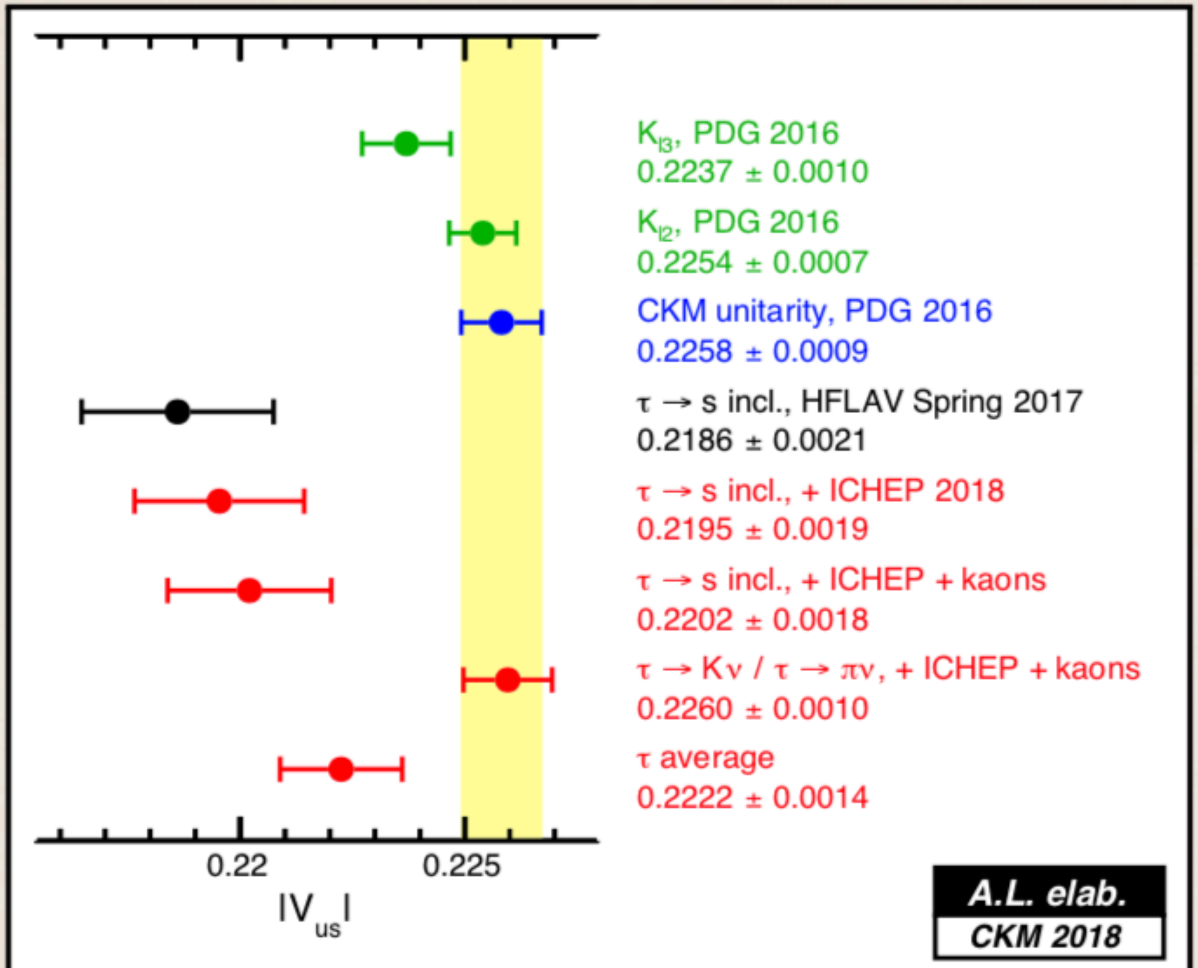
$$v_1(s) = 2\pi \, \mathrm{Im}\, \Pi^{(0+1)}_{ud,V}(s)$$

$$a_1(s) = 2\pi \, \mathrm{Im}\, \Pi^{(0+1)}_{ud,A}(s)$$



Better data needed

$|V_{us}|$ from tau using HFLAV, BABAR ICHEP 2018, kaon predictions



- $\tau \to s$ inclusive vs. CKM unitarity discrepancy: $-2.7\,\sigma$
- most complete unbiased usage of exp. data for $|V_{us}|$ with $\tau \to s$ inclusive

Plenty of stringent limits

Reaction	Present limit	C.L.	Experiment	Year
$\pi^0 \to \mu e$	$< 3.6 \times 10^{-10}$	90%	KTeV	2008
$K_L^0 \to \mu e$	$< 4.7 \times 10^{-12}$	90%	BNL E871	1998
$K_L^0 \to \pi^0 \mu^+ e^-$	$< 7.6 \times 10^{-11}$	90%	KTeV	2008
$K^+ \to \pi^+ \mu^+ e^-$	$< 1.3 \times 10^{-11}$	90%	BNL E865	2005
$J/\psi \to \mu e$	$< 1.5 \times 10^{-7}$	90%	BESIII	2013
$J/\psi \to \tau e$	$< 8.3 \times 10^{-6}$	90%	BESII	2004
$J/\psi \to \tau \mu$	$< 2.0 \times 10^{-6}$	90%	BESII	2004
$B^0 \to \mu e$	$< 1.0 \times 10^{-9}$	90%	LHCb	2017
$B^0 \to \tau e$	$< 2.8 \times 10^{-5}$	90%	BaBar	2008
$B^0 \to \tau \mu$	$< 2.2 \times 10^{-5}$	90%	BaBar	2008
$B \to K \mu e$ ‡	$< 3.8 \times 10^{-8}$	90%	BaBar	2006
$B^0 \to K^{*0} \mu e$	$< 1.8 \times 10^{-7}$	90%	Belle	2018
$B^+ \to K^+ \tau \mu$	$< 4.8 \times 10^{-5}$	90%	BaBar	2012
$B^+ \to K^+ \tau e$	$< 3.0 \times 10^{-5}$	90%	BaBar	2012
$B_s^0 \to \mu e$	$< 5.4 \times 10^{-9}$	90%	LHCb	2017
$\Upsilon(1s) \to \tau \mu$	$< 6.0 \times 10^{-6}$	95%	CLEO	2008

Evgeni Levitchev

Qs for round tables from accelerator:

1. What are REASONABLE luminosity requirements at the different energies? Of course, the higher the better, but it may be expensive for accelerator design.

2. What is REASONABLE polarization level and lifetime at the different energies? Which areas are more interesting for experiments with longitudinal polarization?

3. Luminosity vs. polarization. Higher lumi or higher polar?

4. Maximum beam energy: 3 GeV, 3.5 GeV, 4 GeV… when to stop?

5. What is the Priority (time table) in physics program? Energies, luminosity, polarization… Taking into account that it is difficult to reach the full luminosity from the very beginning.

6. MDI – design of the detector allowing to insert the accelerator equipment inside in a simple, robust, reliable, effective way.

7. Preparation of a proposal to submit in the new European particle physics strategy.