

Wei-Ming Yao (LBNL)

PDG advisory meeting, Oct 27, 2018
Lawrence Berkeley National Laboratory

Outline:

- **What's new in RPP 2018**
- **Issues and Challenges**
- **HFLAV Activities**
- **Prospects for 2020 Edition**

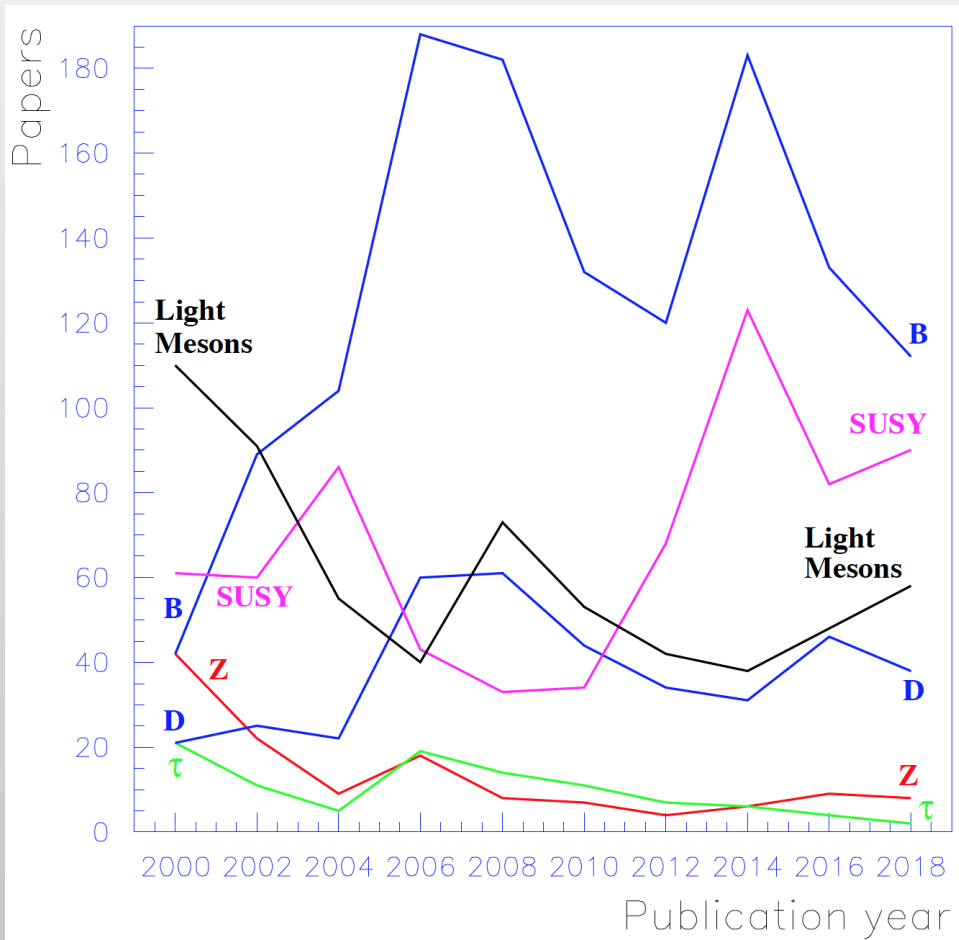
B team:

- **Overseers: Alex Cerri(Sussex, GB) and Wei-Ming Yao(LBNL)**
- **Encoders: P. Eerola(Helsinki), M. Kreps(Warwick), Y. Kwon(Yonsei)**
- **HFLAV: Alan Schwartz(Cincinnati, out-going), Abner Soffer(Tel Aviv, in-coming), Ulrik Egede(Imperial College London)**

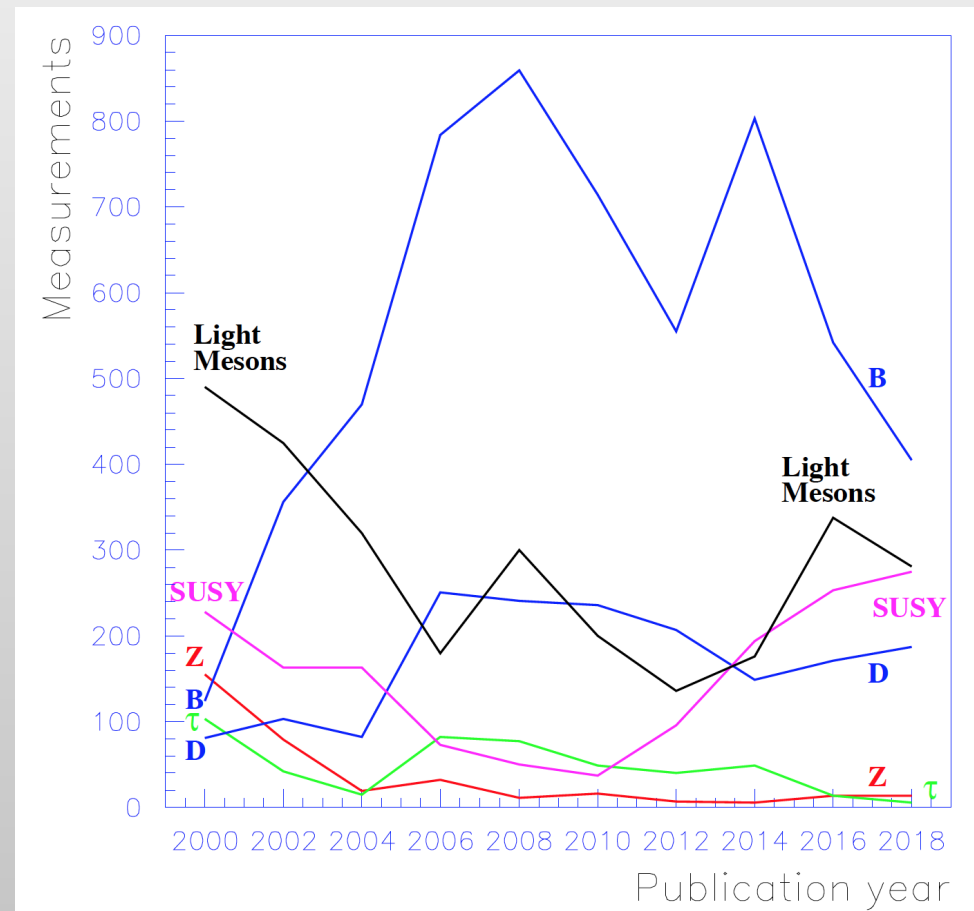
- B physics continues to be one of the most active fields in RPP.
- We added in RPP 2018:
 - 112 papers and 405 measurements.
 - Including some hints of possible deviation from SM predictions related to lepton flavor non-universality.
- Update excellent mini reviews:
 - B production and decays (Eerola, Kreps, and Kwon)
 - $B\bar{B}$ mixing (Schneider)
 - V_{cb}/V_{ub} determinations (Kowalewski and Mannel)
 - B Polarization (Gritsan)

- LHCb are going strong, and Belle II is on the way!

- Papers vs Year:

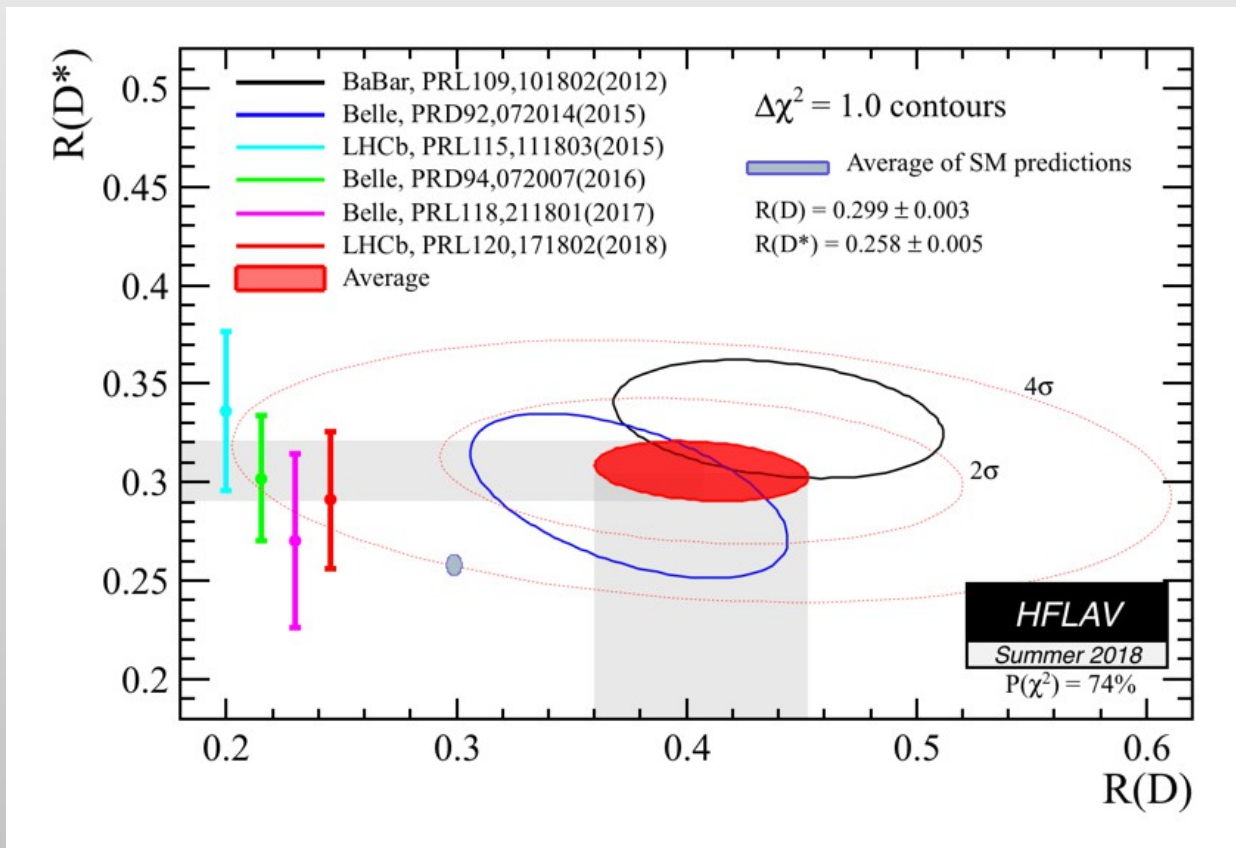
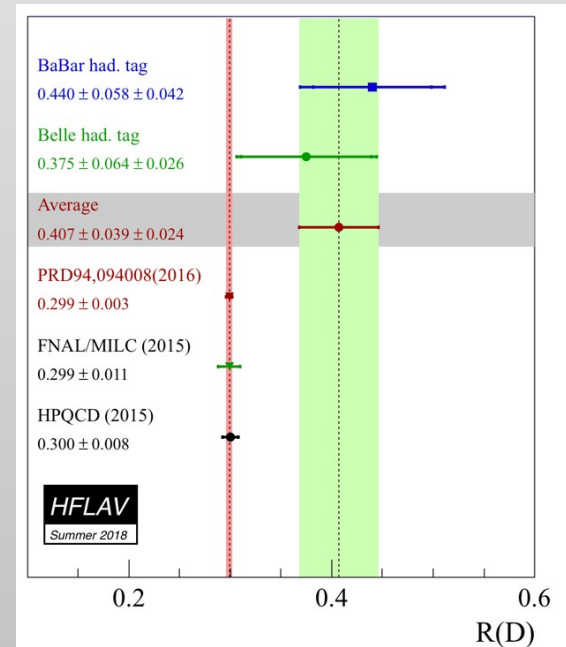
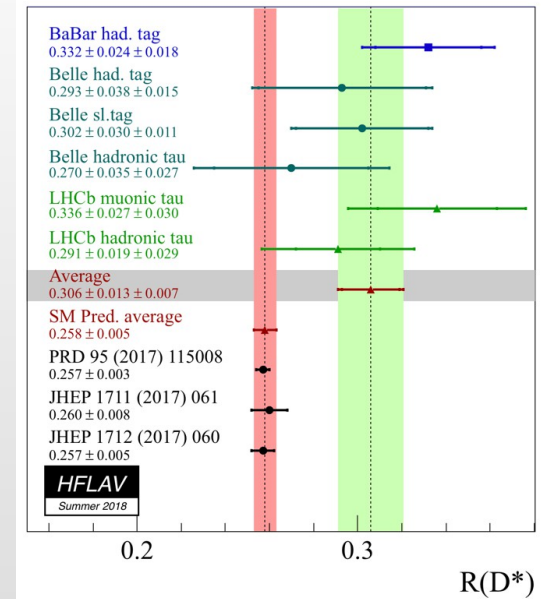


- Measurements vs Year:



Lepton flavor non-universality ?

- $R(D) = B(B \rightarrow D\tau\nu)/B(B \rightarrow Dlv)$ and $R(D^*) = B(B \rightarrow D^*\tau\nu)/B(B \rightarrow D^*lv)$ data seem in disagreement with theory at 2σ and 3σ level.
- **Measurements statistical limited, need more data.**



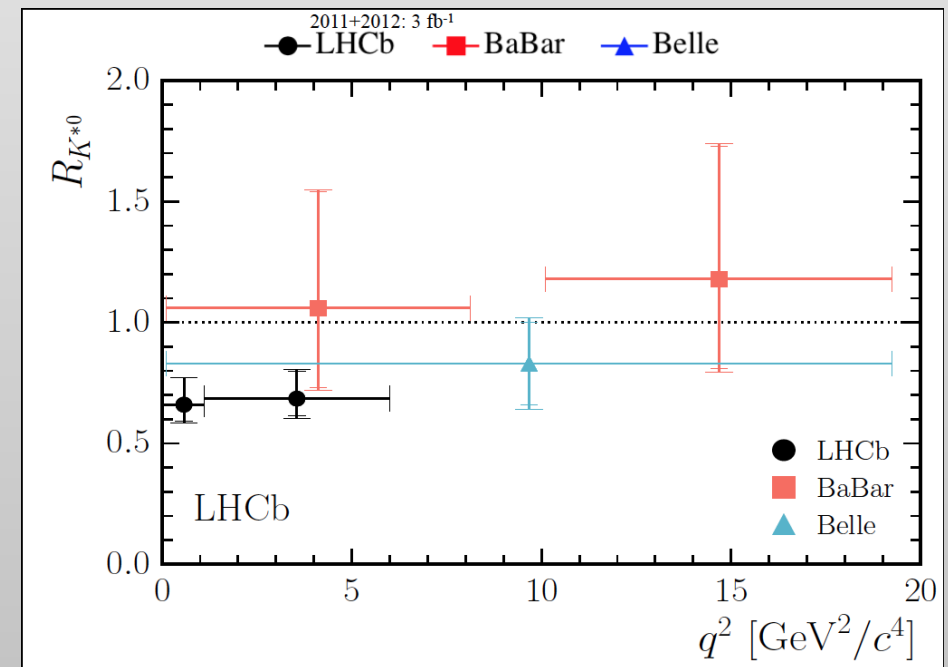
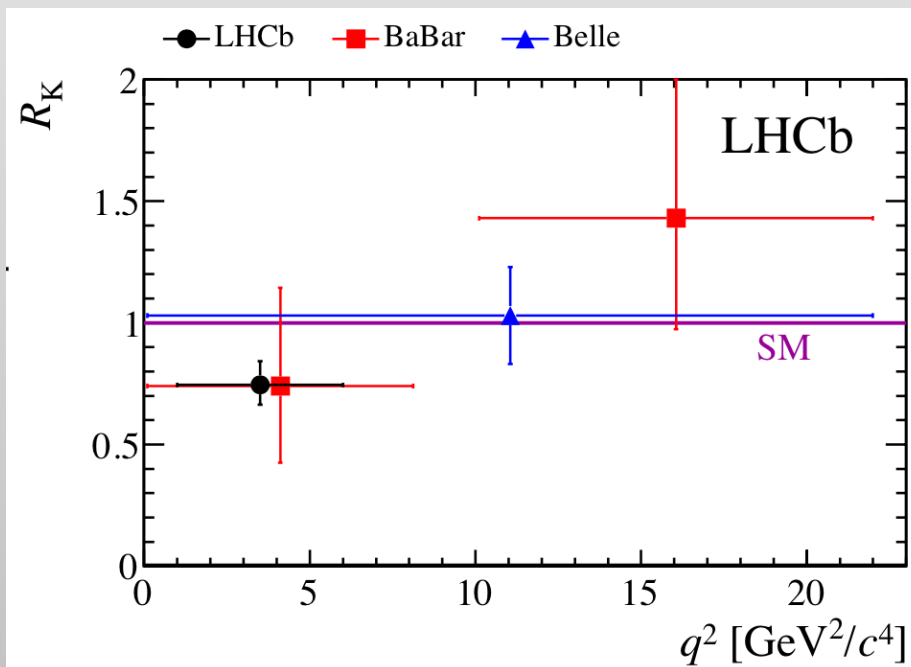
- $R_K = B(B \rightarrow K \mu \mu) / B(B \rightarrow K e e)$ and $R_{K^*0} = B(B \rightarrow K^*0 \mu \mu) / B(B \rightarrow K^*0 e e)$ data seem in disagreement with SM at 2σ and 3σ level.

$$-R_K = 0.745^{+0.090}_{-0.074} \pm 0.036 \text{ [LHCb, PRL 113(2014) 151601.]}$$

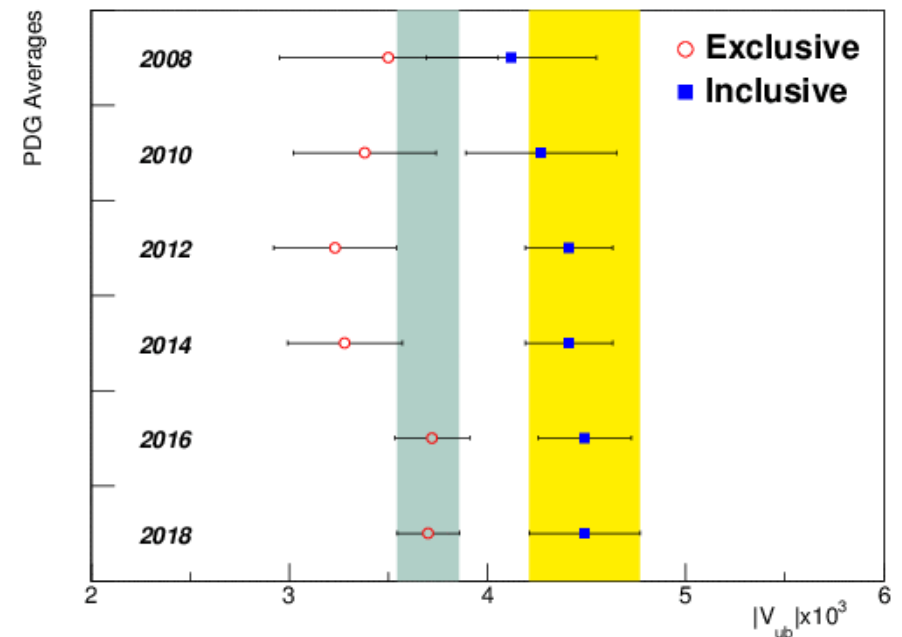
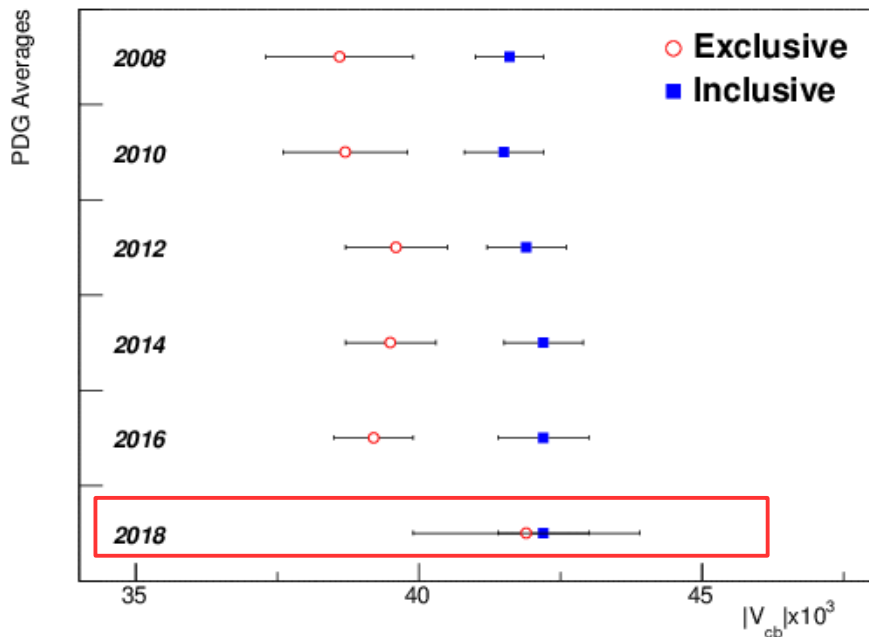
$$-R_{K^*0} = 0.66^{+0.11}_{-0.07} \pm 0.03 \text{ for } 0.045 < q^2 < 1.1 \text{ GeV}^2/c^4 \text{ [LHCb, JHEP 1708(2017) 055]}$$

$$-R_{K^*0} = 0.69^{+0.11}_{-0.07} \pm 0.05 \text{ for } 1.1 < q^2 < 6.0 \text{ GeV}^2/c^4$$

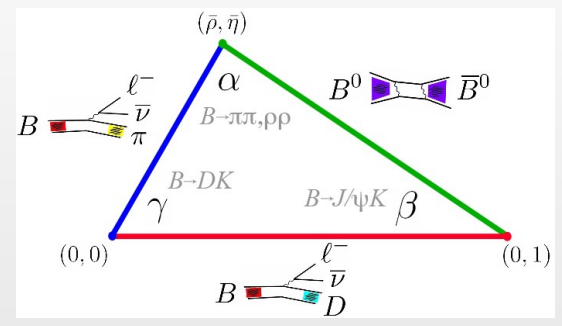
- **Measurements are statistical limited and need more data.**



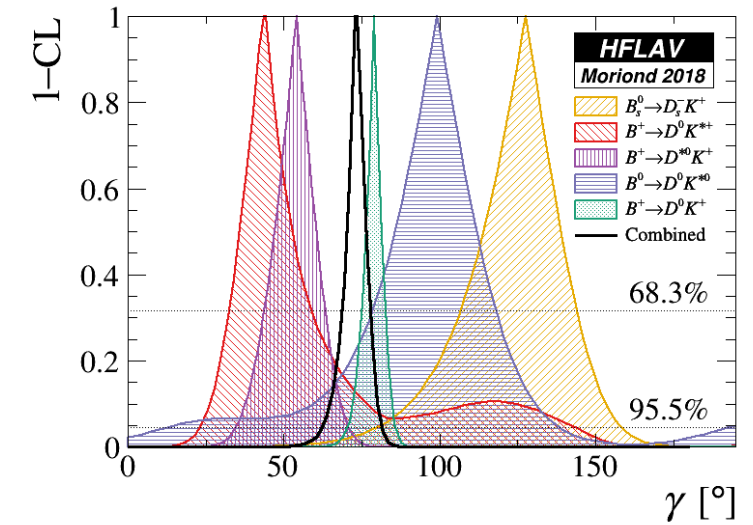
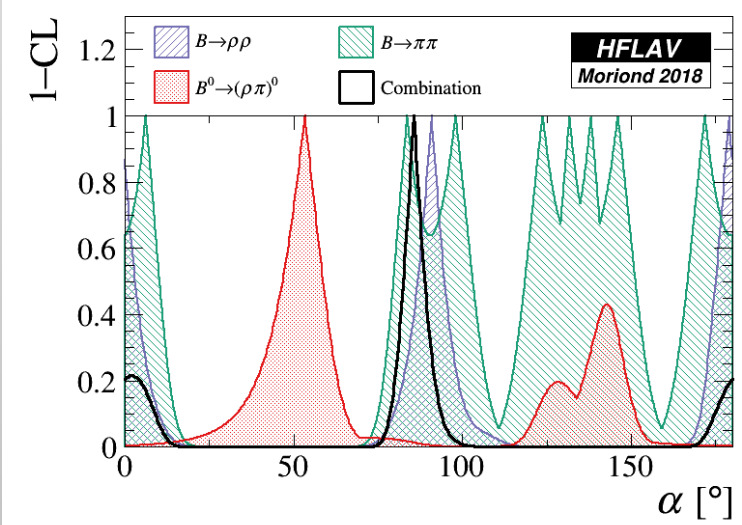
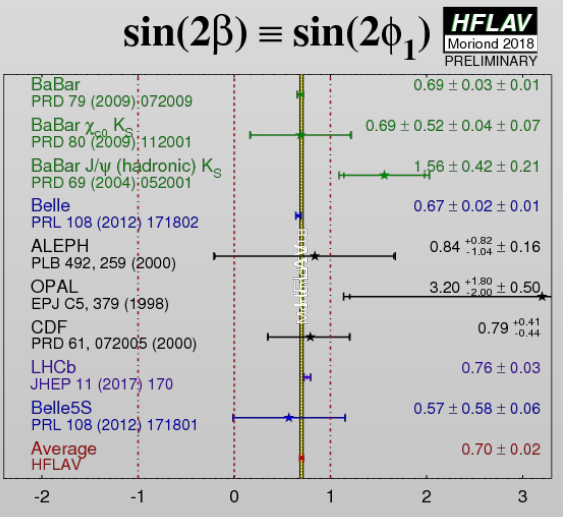
- Reviewing issues in inclusive and exclusive $|V_{ub}|$ and $|V_{cb}|$.
- Recent Belle's $B \rightarrow D^* l \nu$ exclusive $|V_{cb}|$ agrees with inclusive value with more general BGL form-factor parametrization instead of standard CLN.
- $|V_{ub}|$ still differs at 2.5σ , which are sensitive to higher order corrections.
- Phil Urquijo (Melbourne) will replace Bob Kowalewski for next edition.



- CKM angles ($\varphi_1, \varphi_2, \varphi_3$ or α, β, γ) determined:
 - $B \rightarrow J/\psi K_s$ for φ_1/β : averages are straightforward.
 - $B \rightarrow \pi\pi, \rho\rho$ for φ_2/α : involves some subtle aspects.
 - $B \rightarrow D^{(*)}K^{(*)}$ for φ_3/γ : involves many theory inputs and nuisance parameters.
 - Measurements are fragmented into different part of B^0, B^+, B_s listings.



- Consolidating into CKM elements (S052) with a short mini-review:
 - Providing technique details on how PDG averages obtained, similar to Vxb, Mixing.



- There will be much more data in the coming years:
 - LHCb will accumulate up to 30 fb^{-1} by 2023.
 - Belle II will accumulate up to 50 ab^{-1} , a factor of 50 increase.
- This is exciting and presents significant challenges to the PDG
 - Both LHC & Belle II will reach unprecedented level of precision.
 - Many results will be limited by systematics and their combinations requiring special care.
 - There will be many more searches for constraining BSM physics.
- We will continue to work closely with the HF community for a concise and accurate compilation/evaluation of data.



Heavy Flavor Averaging Group

HFLAV

Alan Schwartz
 PDG Collaboration/Advisory Meeting
 Lawrence Berkeley Laboratory
 October 26, 2018

Goal: provide up-to-date world averages for measurements of B and D mesons, and τ lepton related quantities. Results can be freely quoted by conference speakers, theorists, etc.

Policy: We use the latest conference results in averages; however, if a result is not submitted for publication within ~ 2 years of presentation (or if there are no plans to publish a result), we withdraw it from world averages. For world averages, we do not inflate errors.

Web pages: Extensive plots, tables, listing of results, updated typically 2-3 times/year, e.g., after Moriond/La Thuile, after ICHEP/LP, after FPCP/CKM. <https://hflav.web.cern.ch/>

Preprint/publication: Every ~ 18 months, all results are compiled into a preprint and posted to the arXiv. Most recent version was published, which we plan to continue going forward.
 Most recent version:

Y. Amhis et al., "Averages of b -hadron, c -hadron, and t -lepton properties as of summer 2016,"
 Eur. Phys. Jour. C 77 (2017) 895, arXiv:1612.07233

Members: are chosen by their respective collaborations. HFLAV does not choose its own members. HFLAV invites experiments producing results to propose members.

Two co-leaders: originally selected by Belle and BaBar, now selected by Belle II and LHCb.

2018:		Alan Schwartz → <i>Abi Soffer</i>
2017:		Tim Gershon → <i>Ulrike Egede</i>
2011-2017:		Alan Schwartz, Tim Gershon
2007-2010:		Alan Schwartz, Gianluca Cavoto
2005-2007:		Soeren Prell, Simon Eidelman
2002-2005:		David Kirkby, Yoshihide Sakai

Organized into 7 subgroups with 1-2 conveners each:

- *B lifetimes and mixing* *Olivier Schneider*
- *Semileptonic B decays* *Christoph Schwanda, Marcello Rotondo*
- *Unitarity triangle* *Tim Gershon*
- *Rare B decays* *Eli Ben-Haim*
- *b to c decays* *Thomas Kuhr*
- *Charm physics* *Alan Schwartz, Marco Gersabeck*
- *Tau physics* *Alberto Lusiani*

All members are expected to contribute to preparation of averages and documentation. No “forced retirement” as long as a member remains active, but an experiment can change its members.

Averaging procedures vary among subgroups, but the following is typical:

- *gather inputs, representatives of each experiment check inputs to make sure relevant results are included and there are no typos, etc.*
- *discussion of any issues, e.g., treatment of correlations due to common systematic uncertainties, treatment of nuisance parameters, significant disagreements between measurements, new results superseding previous results, theoretical inputs, etc.*
- *averaging procedure agreed upon and performed, results and new plots posted to webpage. All plots contain HFLAV logo and “timestamp.”*
- *procedure described on webpage and in biennial preprint.*
- ***for PDG averages: all preliminary results come out (!)***

HFAG provides numerous averages to the PDG (contact: Weiming Yao)
The provided averages currently include:

A. Lifetimes and Oscillations:

- b lifetimes
- B mixing parameters
- b production fractions
- $\Delta\Gamma_s, \phi_s$

B. UT Triangle:

- $\sin 2\beta, |\lambda| (B^0 \rightarrow c\bar{c} K^0)$
- $\sin 2\alpha (B^0 \rightarrow \pi\pi/\pi\rho/\rho\rho)$
- $\gamma, r_B, \delta_B (B \rightarrow DK)$

C. Charm:

- mixing parameters x, y
- strong phases $\delta_{K\pi}, \delta_{K\pi\pi}$
- CPV parameters $|q/p|, \phi$

D. Semileptonic decays:

- $|V_{cb}| \times F(1)$ for $B^0 \rightarrow D^{*-} l^+ \nu$ with ρ^2 and correlation
- $|V_{cb}| \times F(1)$ for $B^0 \rightarrow D^- l^+ \nu$ with ρ^2 and correlation
- Exclusive $B(B^0 \rightarrow D^- l^+ \nu)$
- Exclusive $B(B^0 \rightarrow D^{*-} l^+ \nu)$
- Exclusive $B(B^+ \rightarrow D^0 l^+ \nu)$
- Exclusive $B(B^+ \rightarrow D^{*0} l^+ \nu)$
- Exclusive $B(B^+ \rightarrow D^- \pi^+ l^+ \nu)$
- Exclusive $B(B^+ \rightarrow D^{*-} \pi^+ l^+ \nu)$
- Exclusive $B(B^0 \rightarrow D^0 \pi^+ l^+ \nu)$
- Exclusive $B(B^0 \rightarrow D^{*0} \pi^+ l^+ \nu)$
- Inclusive $B(B^0/B^+ \rightarrow l^+ \nu X)$
- V_{ub} for inclusive and exclusive b to u $l^+ \nu$ decays
- Exclusive $B(B^0 \rightarrow \pi^- l^+ \nu)$
- Exclusive $B(B^0 \rightarrow \rho^- l^+ \nu)$

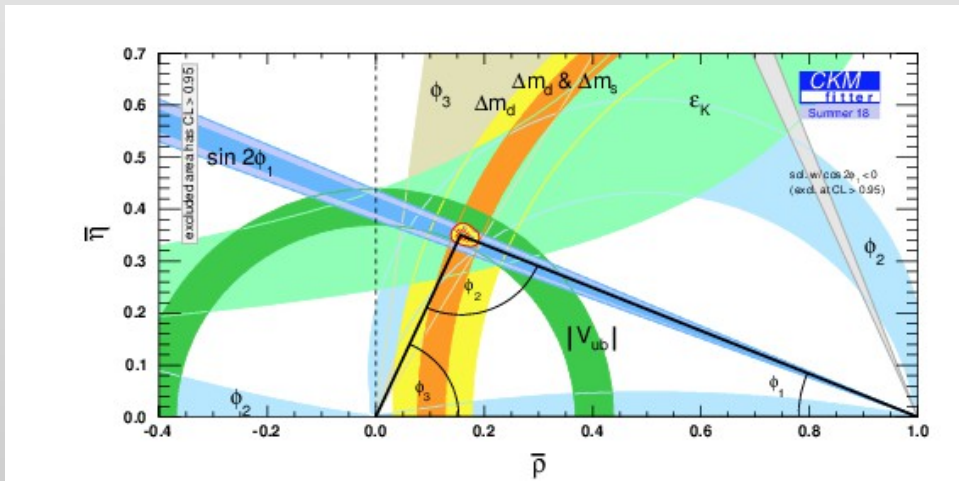
E. τ branching fractions:

- see previous report by A. Lusiani

For these results,
 all preliminary
 (unpublished)
 results are
 removed

- Occasional results still coming from BaBar, consistent stream of results from Belle, many new results from LHCb, some new results from BESIII/ATLAS/CMS
- Interaction with (and input to) the PDG is very positive, this seems a good service to the HEP community
- To remain relevant and at the forefront, HFLAV has evolved:
 - New management: Belle, BaBar → Belle II, LHCb
 - New leadership: Tim Gershon, Alan Schwartz → Ulrik Egede, Abi Soffer
 - New members: added ATLAS and CMS representatives
 - New web pages: all pages moved from SLAC → CERN (our new host)
 - Biennial preprint now published: European Physics Journal C
 - Much interaction with theoretical community: e.g., form factors, lattice input for extracting $|V_{ub}|$, $|V_{cb}|$, $|V_{cs}|$
- **HFLAV will remain active in providing averages to the PDG**
 - A request: the $b \rightarrow c$ decays and Rare decays subgroups calculate dozens of world averages for branching fractions, CP asymmetries, etc. To find errors they compare their results with PDG averages. It would be helpful if there were an electronic way (an API) to retrieve PDG averages.

- Continue to work with HFLAV working groups to provide the world best parameters for B-listings.
- Planning and updating for data driven mini-reviews for B-listing.
- All data are consistent with SM, but some BSM hints may confirm or show up soon!



With Belle II 50 ab⁻¹

