Flavor physics and theoretical challenges for precision

Takashi Kaneko and Emi Kou

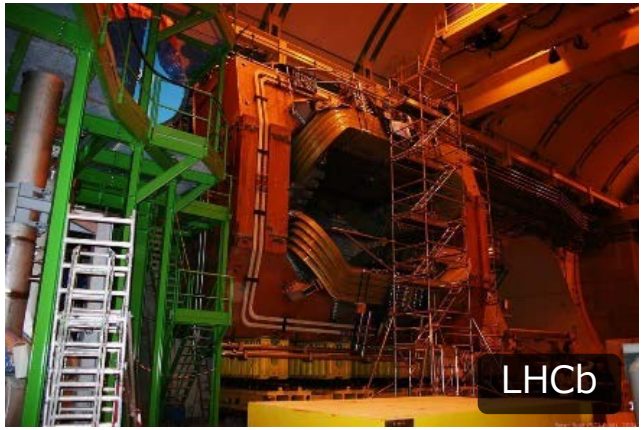
for FLAV-03

Joint Workshop of FKPPL & TYL/FJPPL

May 9 2019, Seogwipo KAL Hotel, Jeju Island

Flavor Physics

establishment of the SM / key information on BSM



Flavor Physics

establishment of the SM / key information on BSM

"B physics anomalies"

$$R\left(D^{(*)}\right)=\frac{\Gamma\left(B\to D^{(*)}\tau\nu\right)}{\Gamma\left(B\to D^{(*)}\{e,\mu\}\nu\right)},\ B\to K^{(*)}\ell\ell,\ \cdots$$

SuperKEKB / Belle II

x10-100 sensitivities

⇒ (dis)prove, find "new"

Flavor Physics

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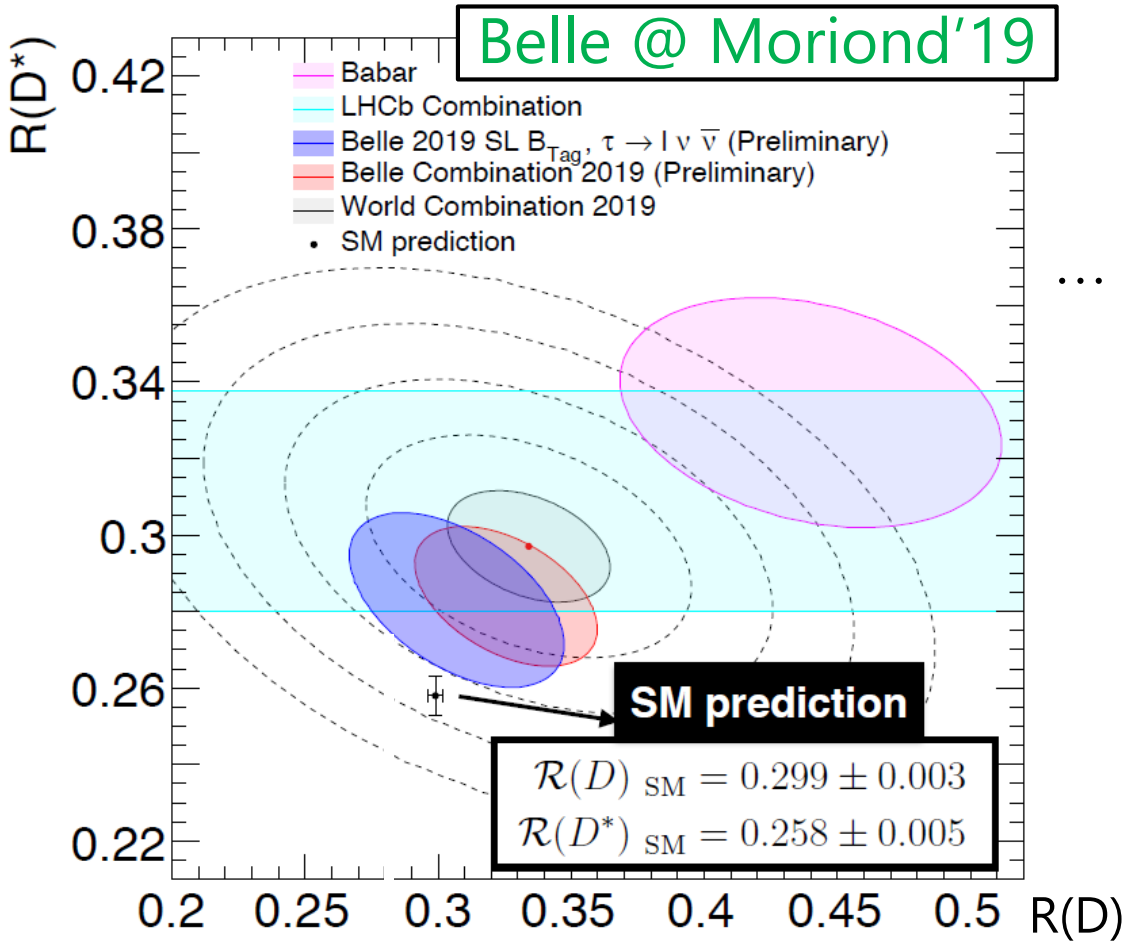

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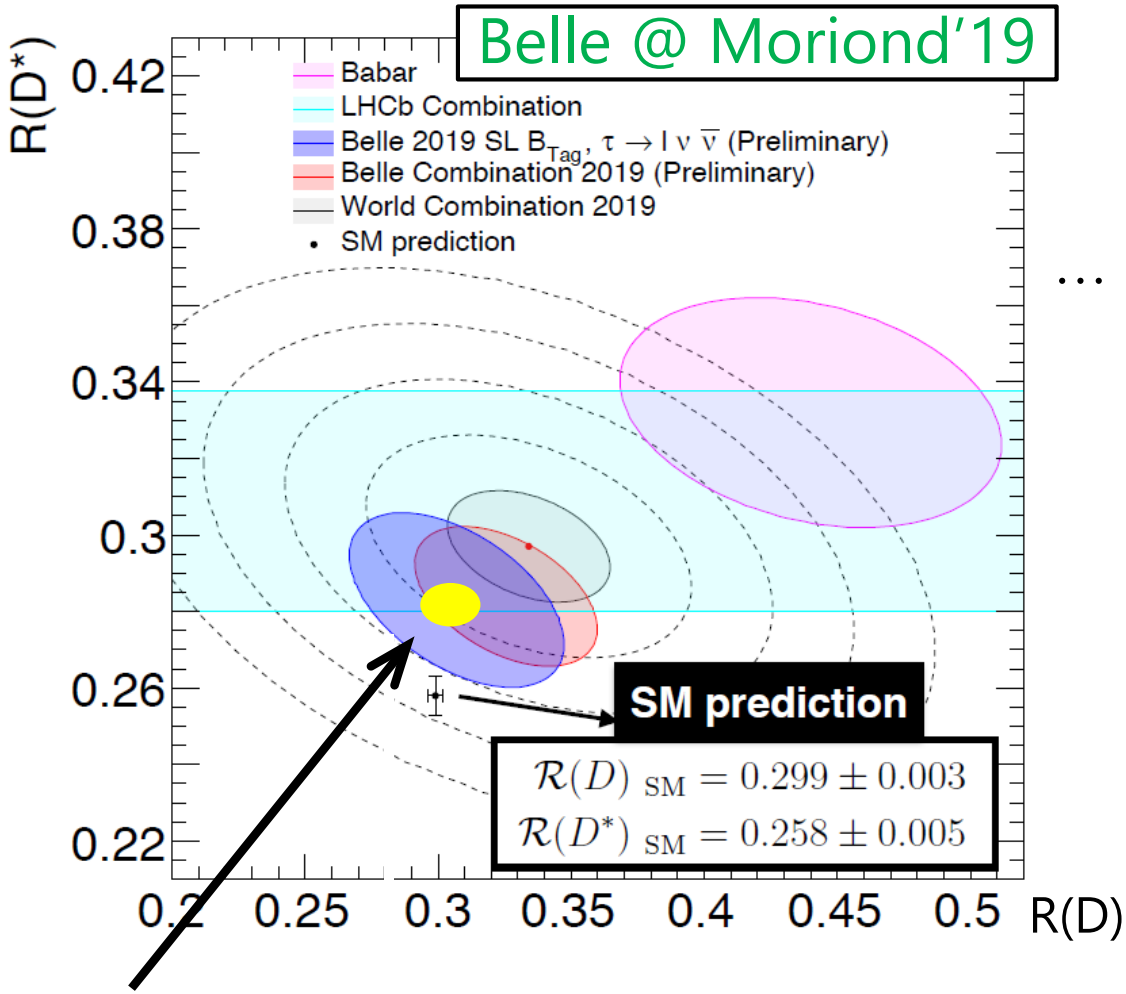

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Belle II sensitivity in "Belle II Physics Book" '18

Flavor Physics

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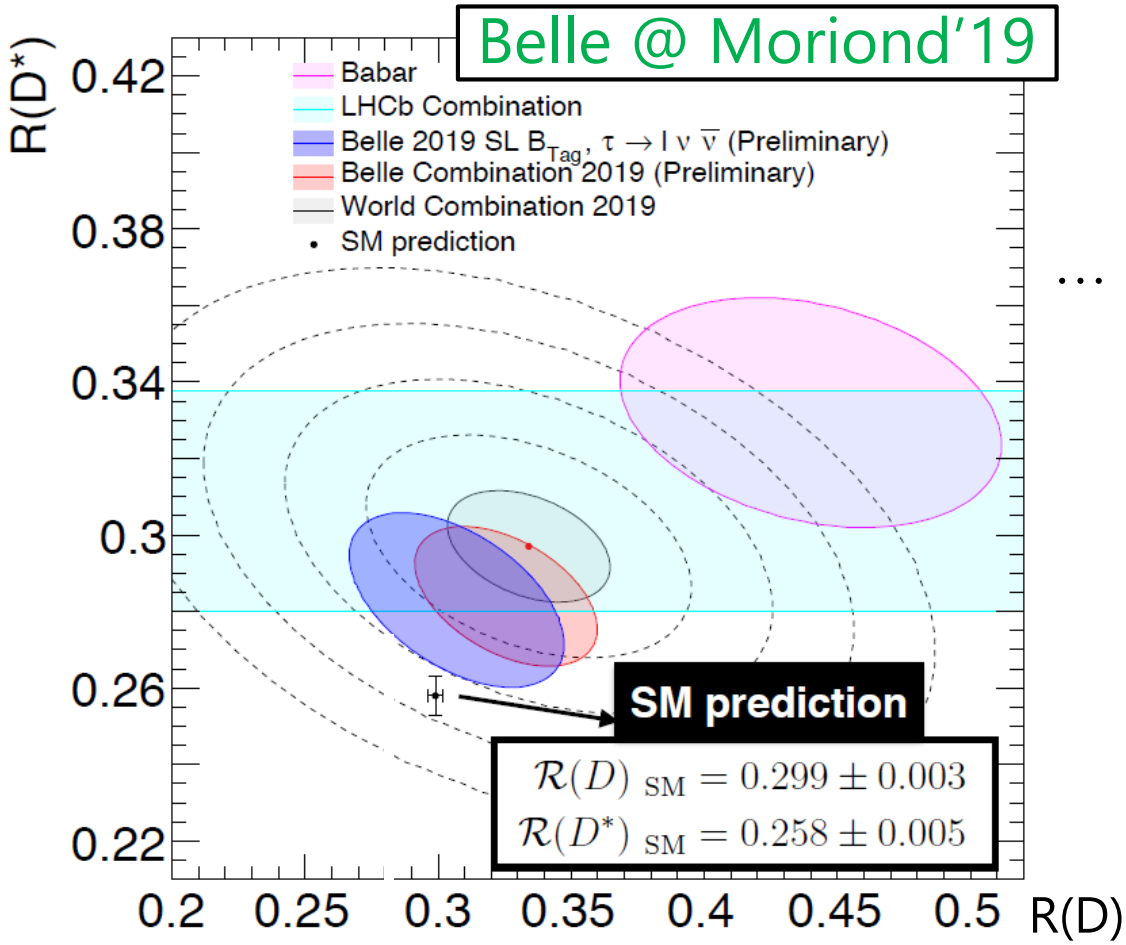

...

rapid progress & great hope for discovery

Project goal

shift of focus in the era of Belle II and LHCb

e.g. rare decays: ~~observations~~ $\Rightarrow$ quantitative analyses

$\Rightarrow$ strong impact on data analysis

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latest progress on phenomenology and lattice QCD

$\Rightarrow$ improved / new description of decay amplitudes

in Belle II / LHCb analyses

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latest progress on phenomenology and lattice QCD

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in Belle II / LHCb analyses

bring close collaborations

b/w flavor physics communities in France and Japan

b/w theorists and experimentalists

Members

	France	Japan
Theory	E. Kou (LAL)* B. Moussallam (IPNO)	T. Kaneko (KEK)* S. Hashimoto (KEK)
Exp't	F. Le Diberder (LAL) K. Trabesi (LAL) S. Watanuki (LAL) B. Knysh (LAL) M.-H. Schune (LAL)	K. Hara (KEK) K. Hayasaka (Niigata) A. Ishikawa (KEK) M. Kakuno (TMU) M. Nakao (KEK) S. Nishida (KEK)

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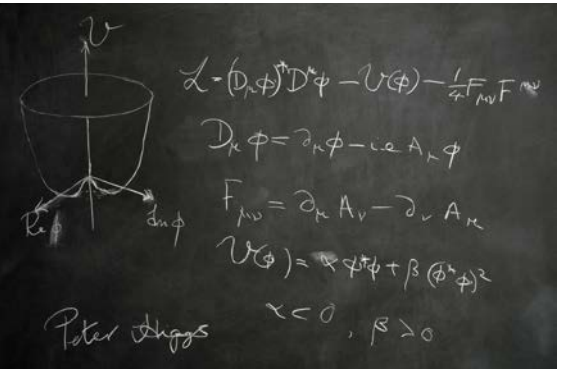

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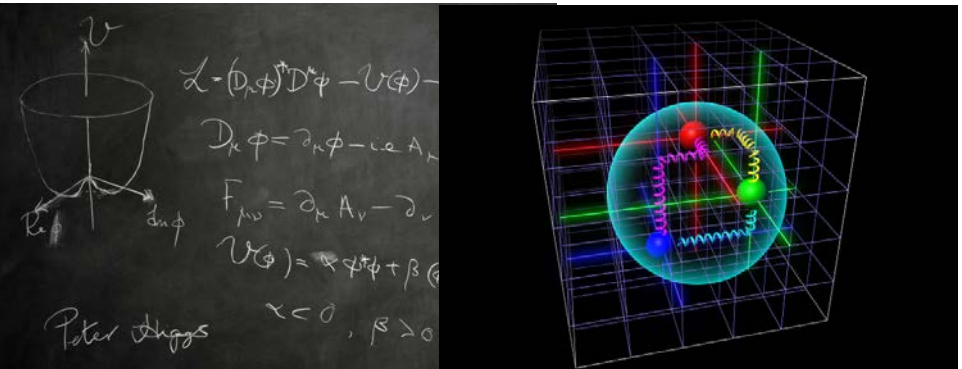

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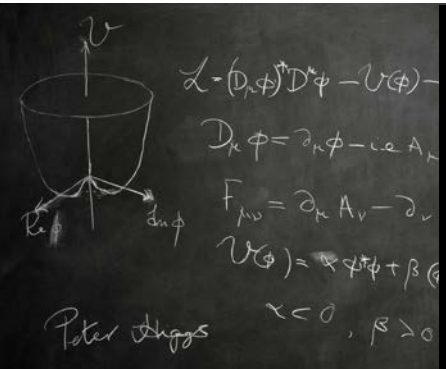

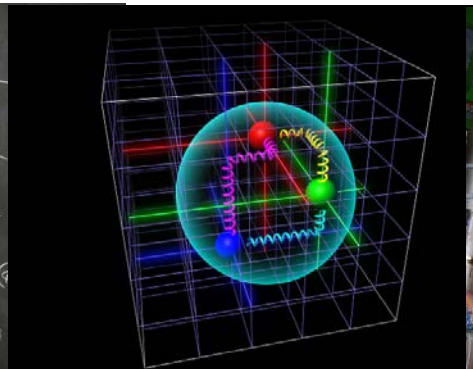


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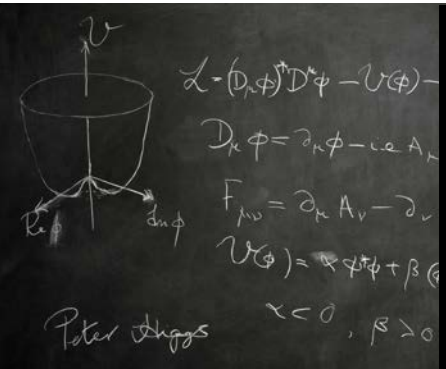
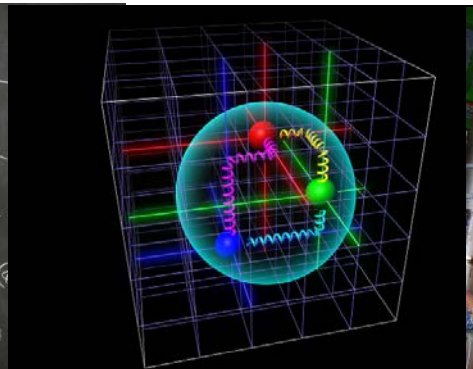

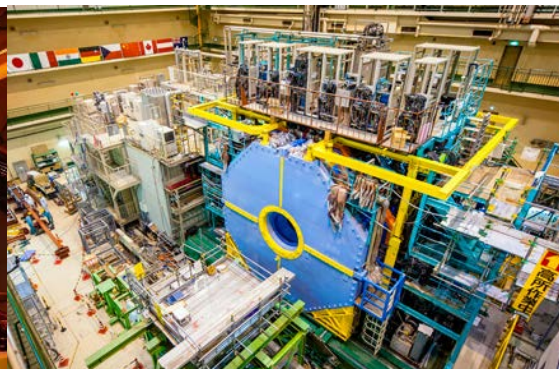

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new member: staff / PD / student

Activities in 2018-2019

identify / prepare possible collaborations

regular video meetings (every 2-3 months)

short-term visits

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- A. Ishikawa : asymmetries in $B \to K^* \gamma$
- F. Le Diberder : model-independent analysis of $B \to K \pi \pi \gamma$
- E. Kou : formulation & event generator for $B \to K \pi \pi \gamma$
- B. Knysh : event generator for $B \to K \pi \pi \gamma$
- K. Hayasaka : status of $\tau \to K \pi \pi \nu$ @ Belle

cf. last year: Φ_3 from $B \to DK$, $B \to D^{(*)} \ell \nu$

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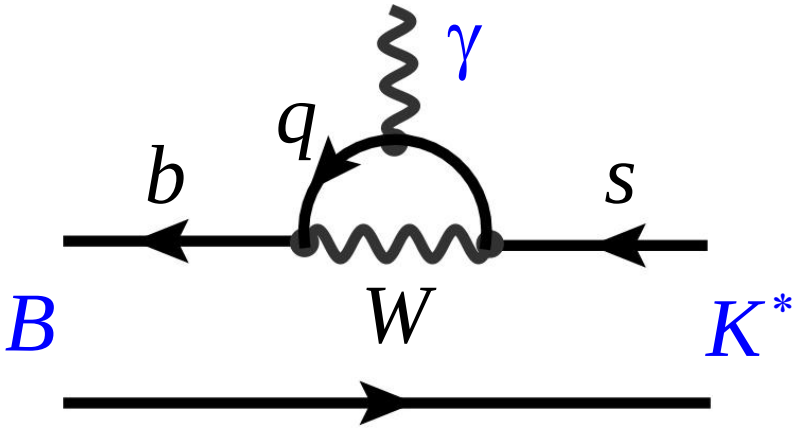
short-term visits

- T. Kaneko : practical collaboration on $B \to D^{(*)} \ell \nu$
- E. Kou : held "Physics Week" workshop

$b \to s\gamma$

asymmetries in $B \to K^*\gamma$ and $X_s\gamma$



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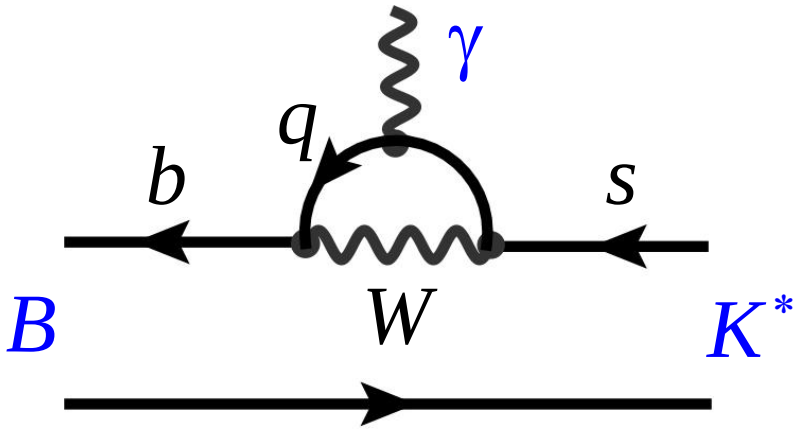

- isospin Δ_{0+}

$$\Delta_{0+} = \frac{\Gamma(B^0 \to K^{*0}\gamma) - \Gamma(B^+ \to K^{*+}\gamma)}{\Gamma(B^0 \to K^{*0}\gamma) + \Gamma(B^+ \to K^{*+}\gamma)}$$

- A_{CP} ($B \Leftrightarrow B^{bar}$)
- ΔA_{CP} b/w $B^0 \Leftrightarrow B^+$
- $\Gamma(B \to K^*\gamma)/\Gamma(Bs \to \varphi\gamma)$

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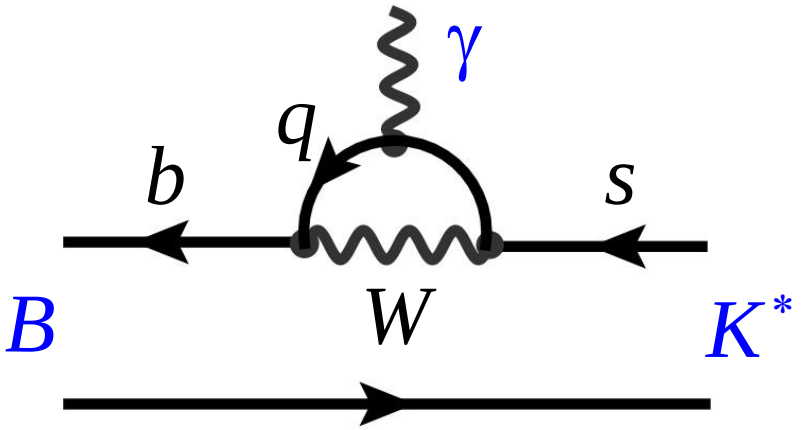

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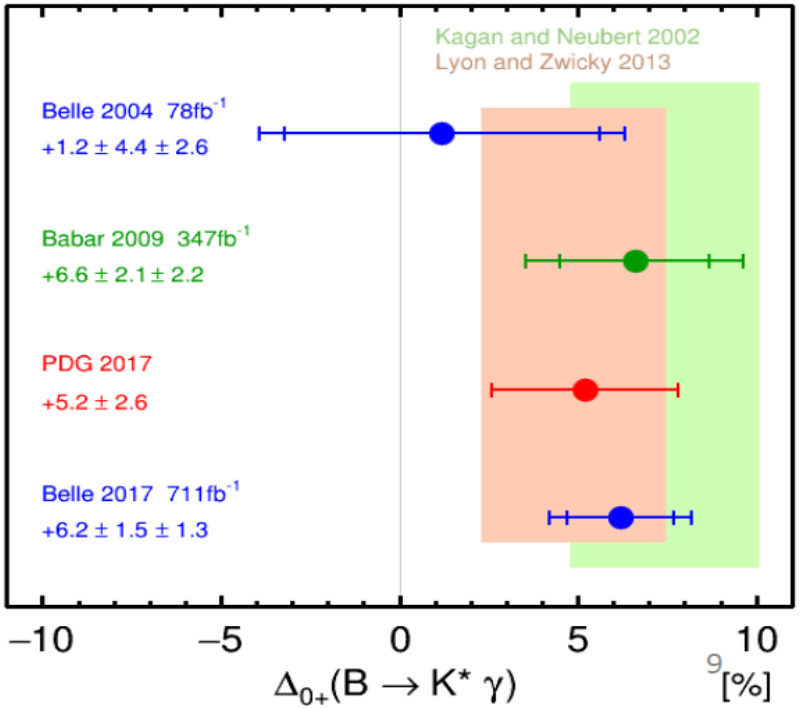
- 1st evidence Δ_{0+} (Belle'17)



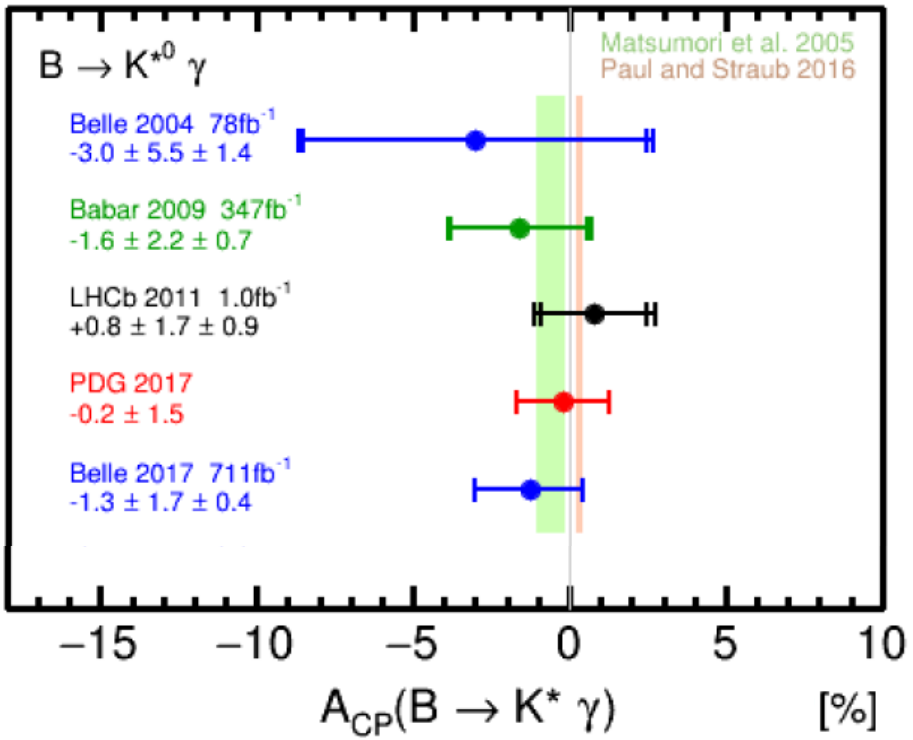
$b \to s\gamma$

asymmetries in $B \to K^*\gamma$ and $X_s\gamma$

- others consistent w/ 0
- good Belle II prospects

  A_{CP}, ΔA_{CP} ~ O(10^{-3})

  $\Rightarrow$ new CP $\Rightarrow$ #baryon



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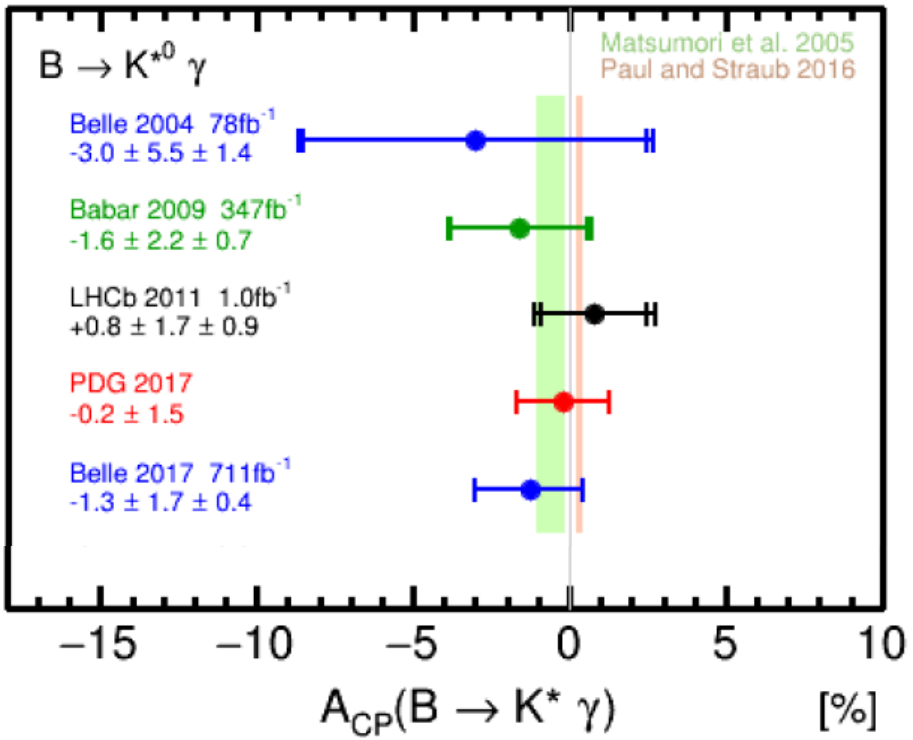
convener of Belle II analysis



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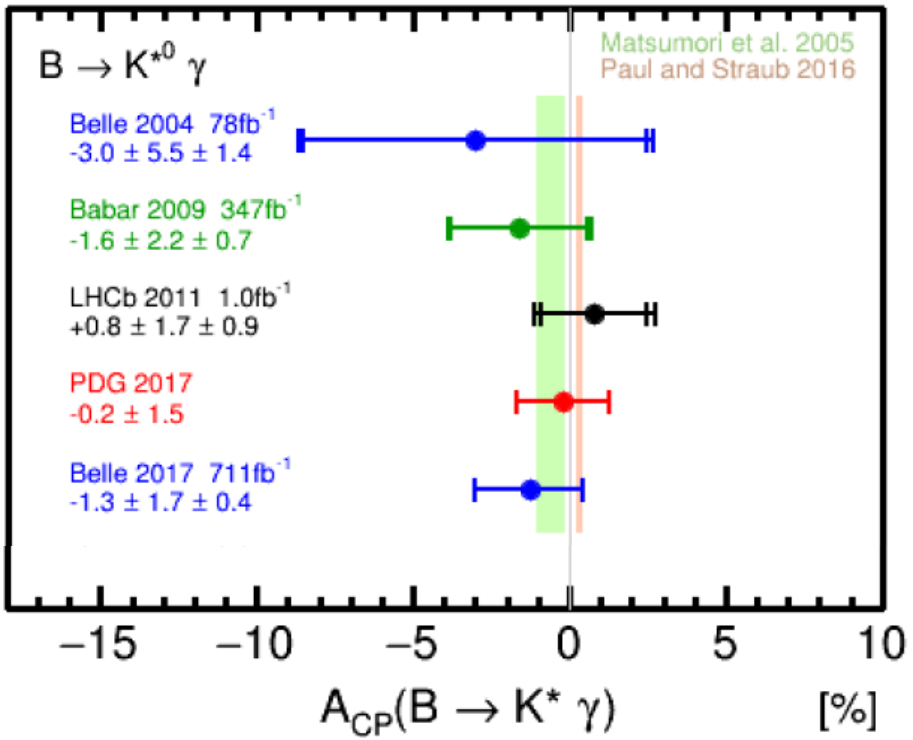


discussions (also this year)

A_{CP} = +0.003(1) Paul-Straub '16

-0.006(5) Keum et al. '04

up loop contribution?

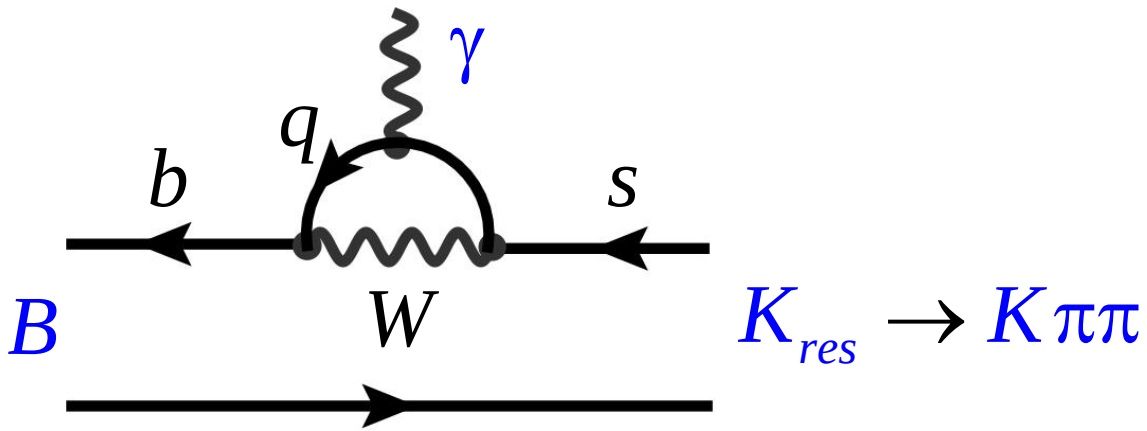
QCD factorization?

$b \to s\gamma$

photon polarization in $B \to K\pi\pi\gamma$

- BSM w/ RH current

$$b_R \to s_L \gamma_L \Leftrightarrow b_L \to s_R \gamma_R$$



- not precise yet
- large data samples

  $\Rightarrow$ Belle II & LHCb

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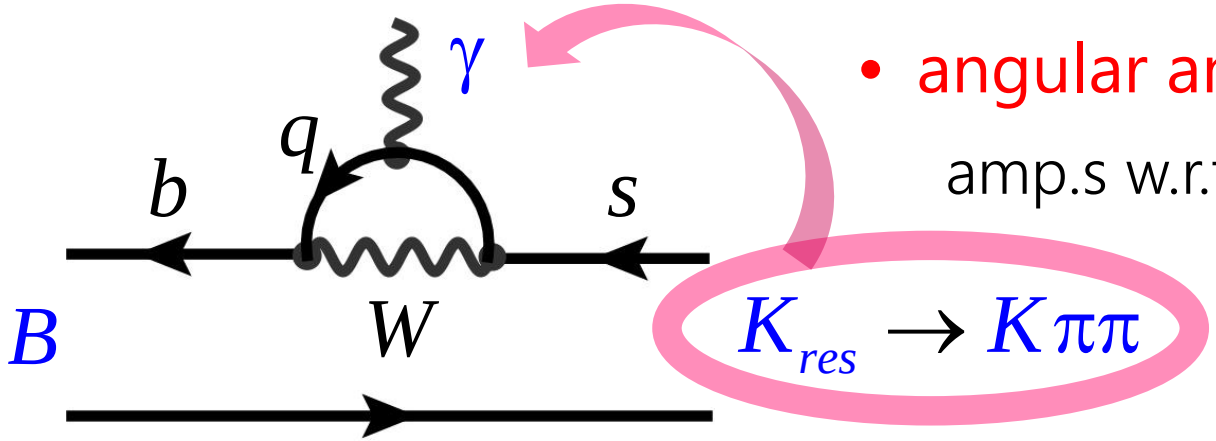

- angular analysis of $K_{\rm res} \to K\pi\pi$

  amp.s w.r.t. 3 $M_{\rm inv}$'s + 2 $\theta_{\rm decay}$'s

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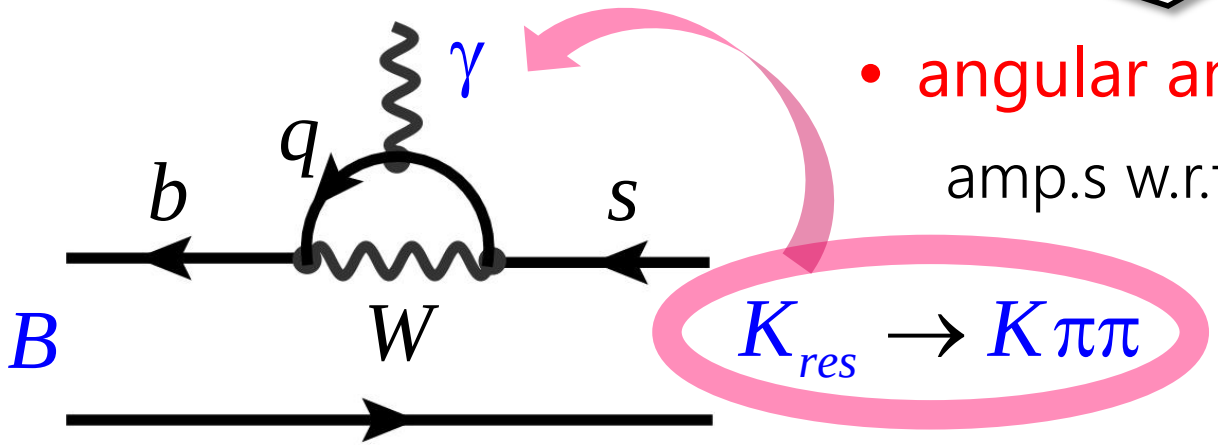
Kou et al. '11
QM approach for K_1 ($J^P = 1^+$)



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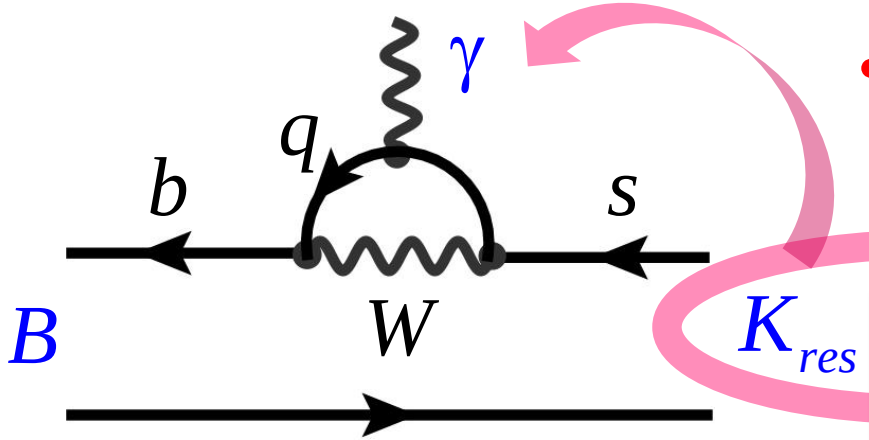

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QM approach for K_1 ($J^P = 1^+$)

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  amp.s w.r.t. 3 M_{inv}'s + 2 θ_{decay}'s

Le Diberder

- a model indep. approach

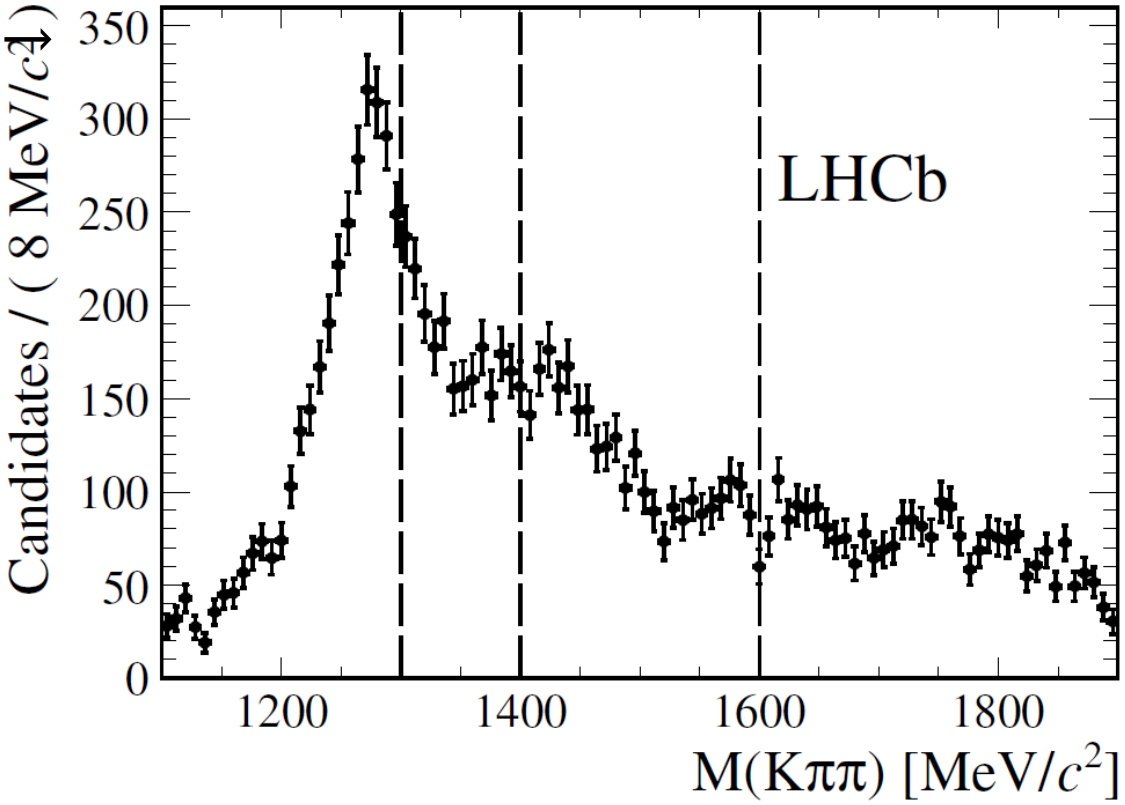
  $J^P = 1^+, 1^-$
- lower bound on polarization

  Schwartz inequalities for amp

$b \to s\gamma$

better understanding of kaonic resonances

LHCb '14 $M(K\pi\pi)$ → UD asymmetry



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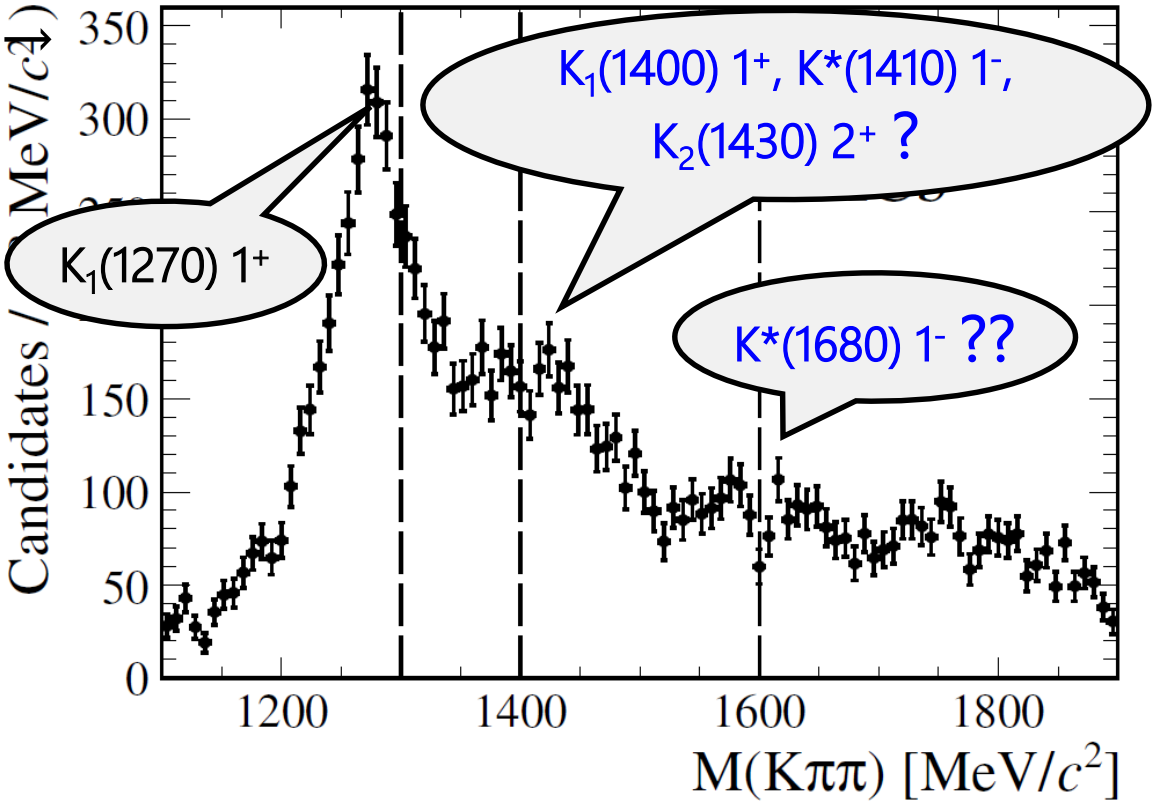

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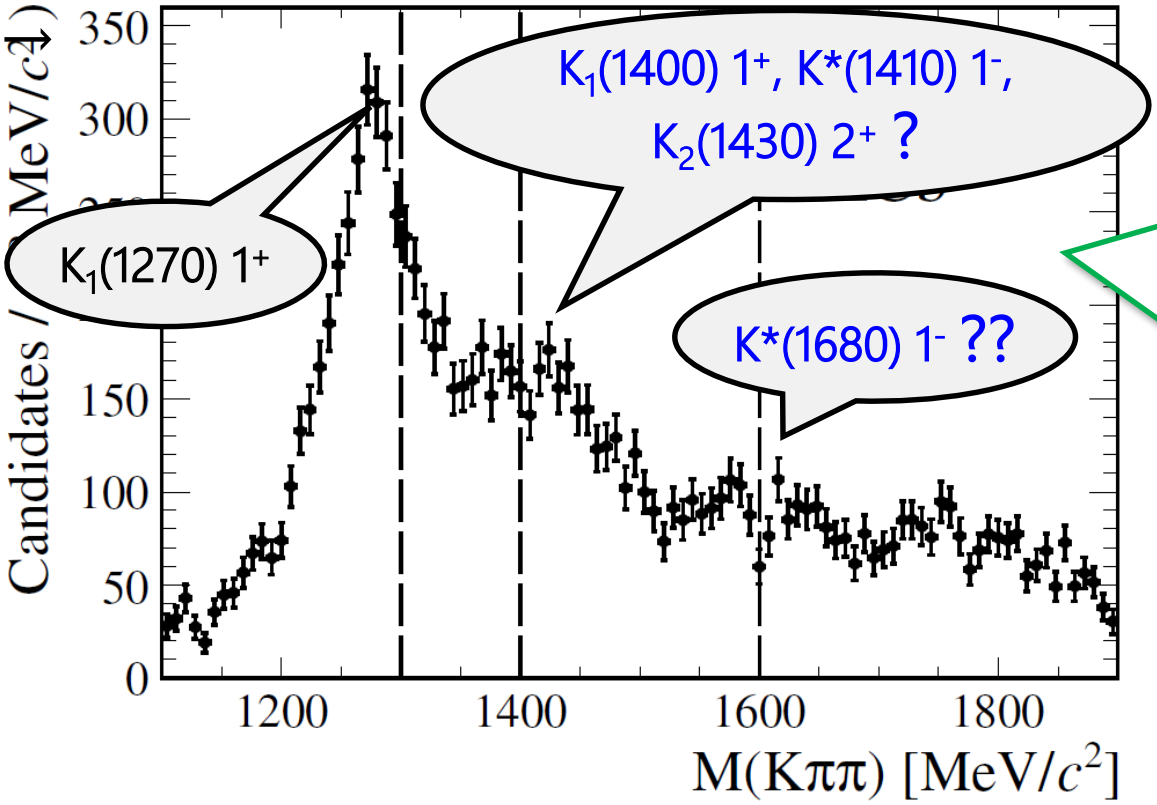

Kou & Knysh
event generator
for $J^P = 1^+, 1^-, 2^+$
(mathematica, c++)

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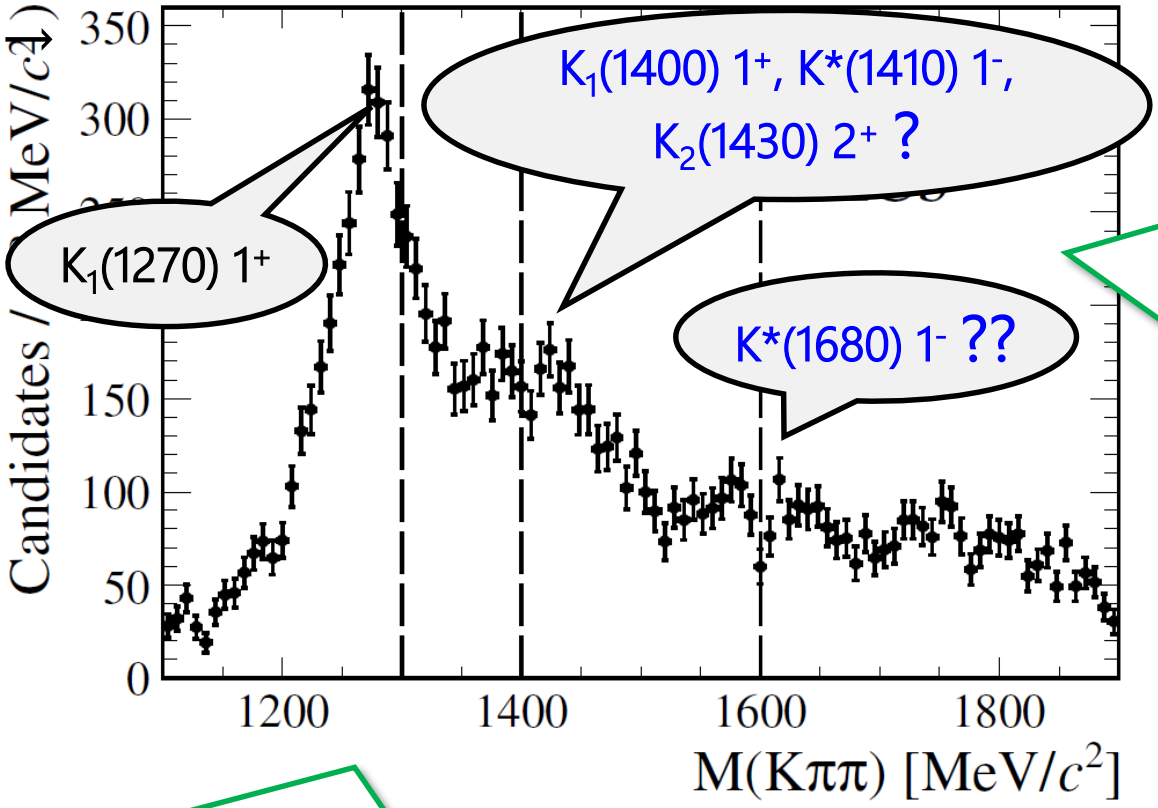

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Trabelsi working on Belle data

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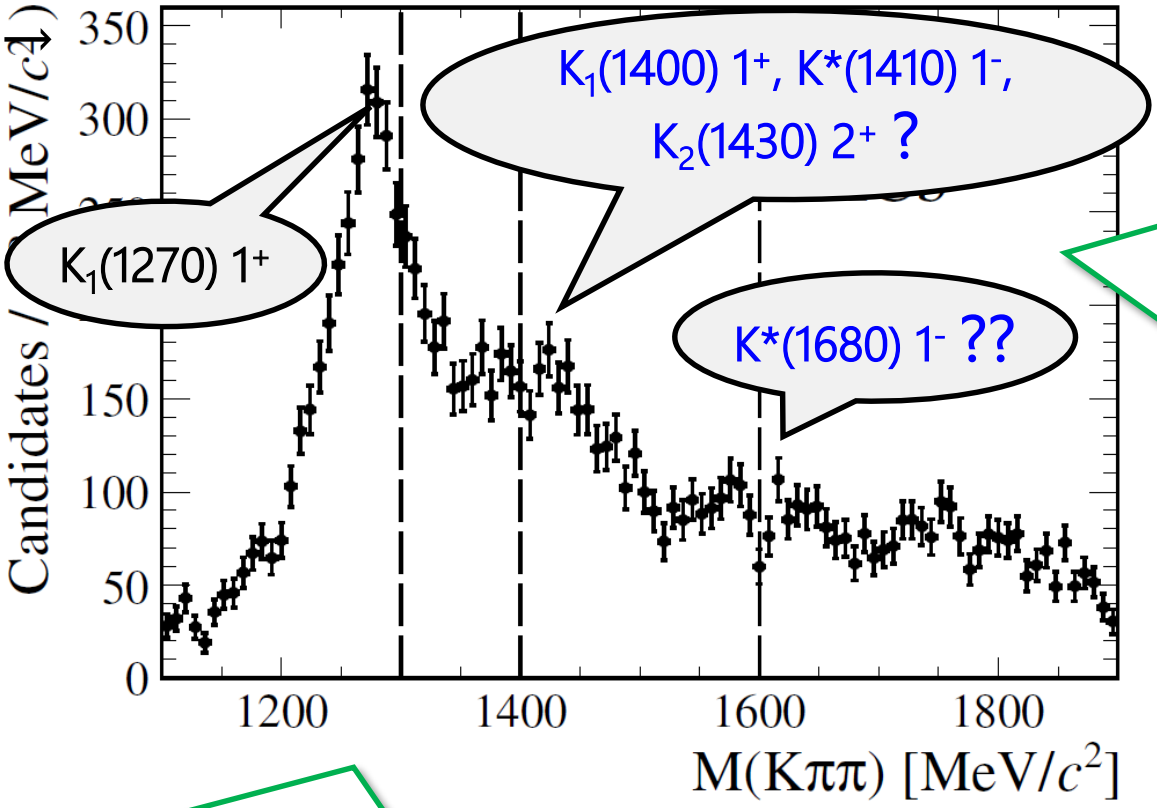

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Trabelsi working on Belle data

2018 – 2019
- method/code to Belle data
- rediscovery @ Belle II

τ decays

$\tau \to K\pi\pi\nu$ and kaonic resonances

- CPV in lepton decays
- much less accurate / not very consistent w/ other modes

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e.g. $K^{*\pm}$ mass, width [MeV]	PDG'18	
891.8(3) ± i 51(1)	$D \to K_S K\pi$, …	taking bad model?
895.5(8) ± i 46(1)	τ decays	only spectrum anly.

just low statistics?

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Belle II large data sample + amplitude analysis may help!

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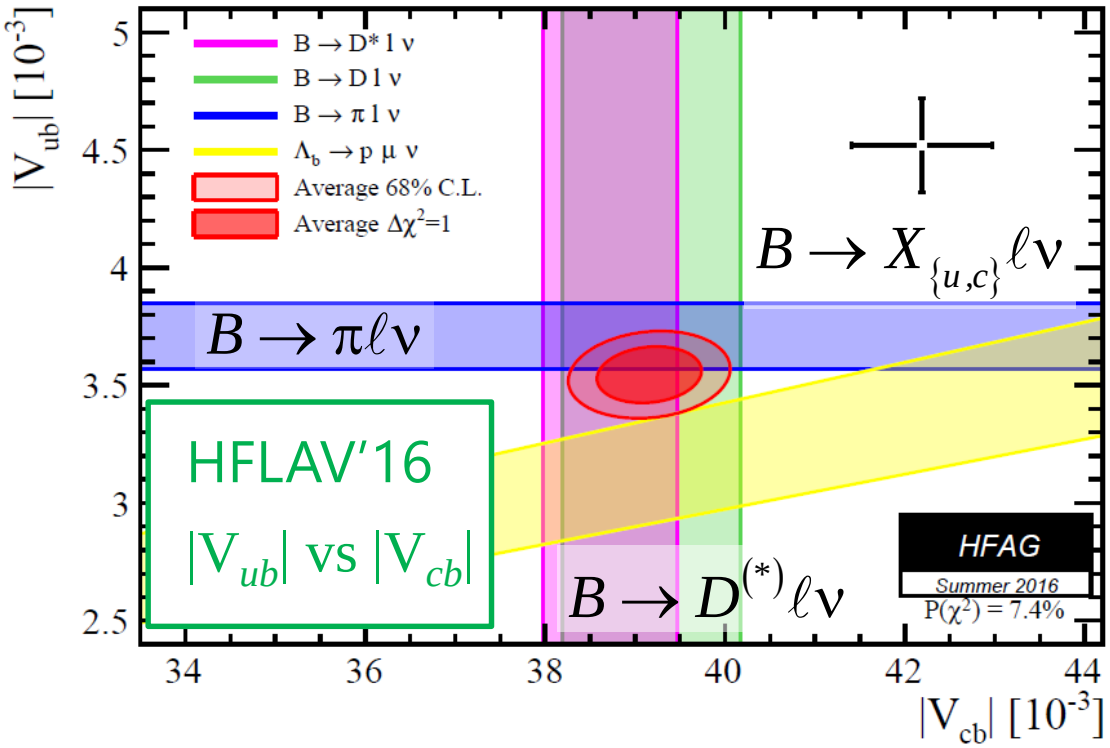
good interplay w/ B→Kππγ

code (Kou, Knysh), method (Kou, Le Diberder), hadronic param.s (Trabelsi)

$B \to D^{(*)} \ell \nu$

long standing tension in $|V_{ub}|$ and $|V_{cb}|$



$\Delta|V_{Ub}| > \Delta\Gamma^{1/2}$

$\Leftrightarrow$ precision NP search

$B \to D^{(*)} \ell \nu$

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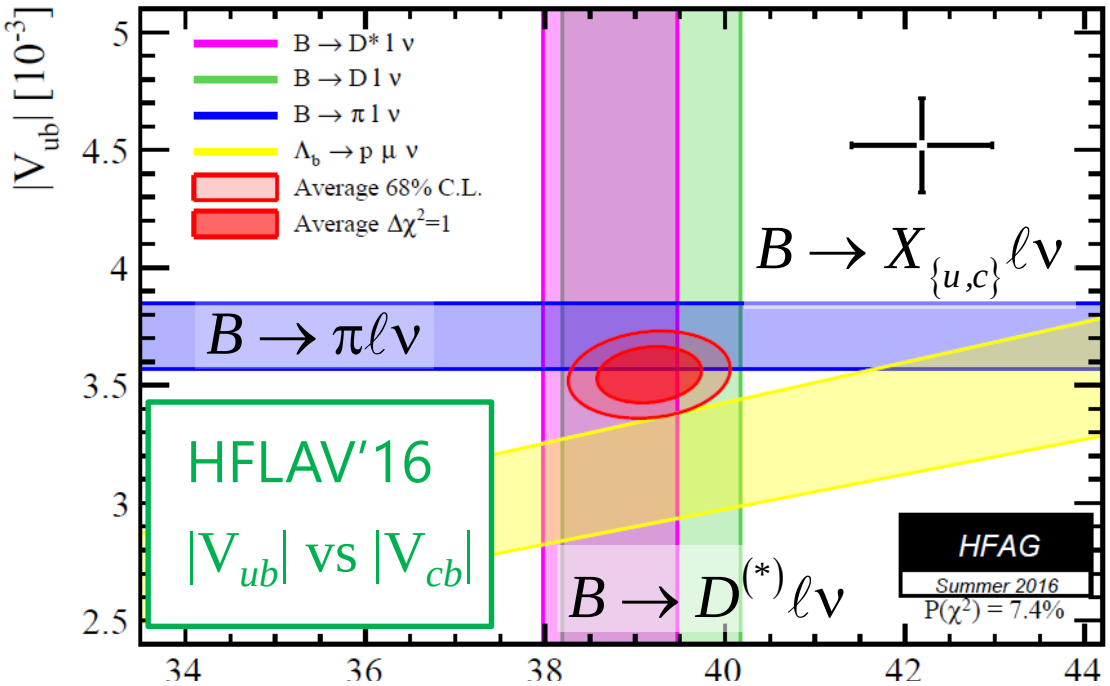

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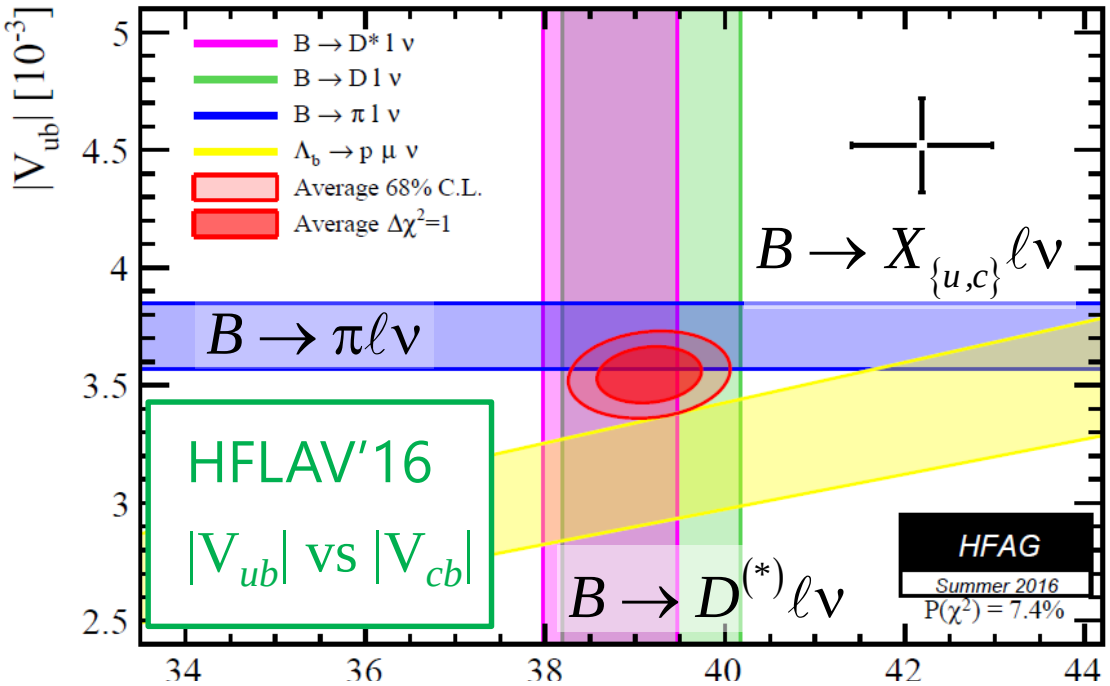
$|V_{cb}|$: B→D* FFs @ nonzero recoils

$B \to D^{(*)} \ell \nu$

long standing tension in $|V_{ub}|$ and $|V_{cb}|$



$\Delta|V_{Ub}| > \Delta\Gamma^{1/2}$

$\Leftrightarrow$ precision NP search

$|V_{cb}|$: B→D* FFs @ nonzero recoils

Kaneko

(B)SM FFs from lattice QCD

h_{A1}, h_{A2}, h_{A3}, h_V, h_P, h_{T1}, h_{T2}, h_{T3}

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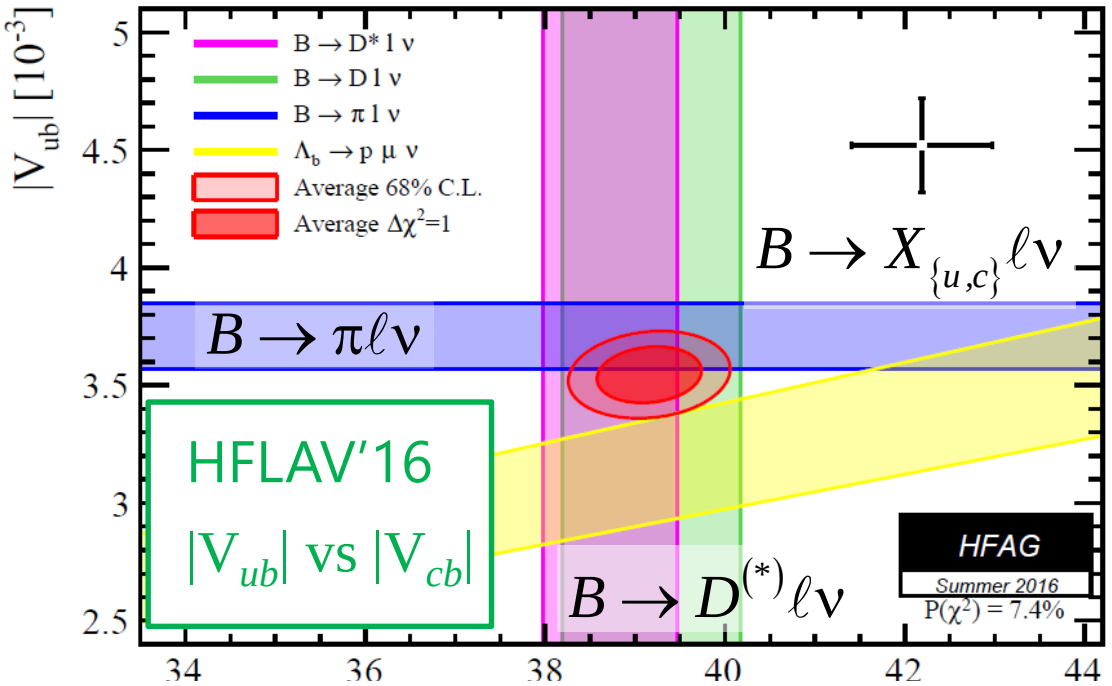

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w/ many parameters

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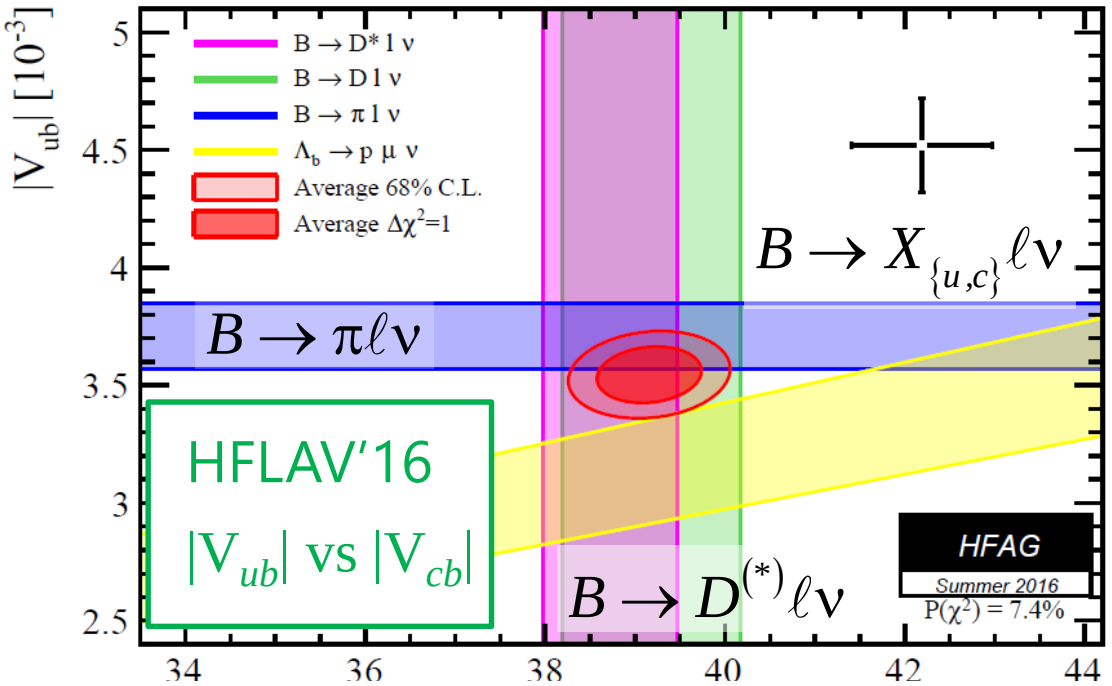

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2018 – 2019
collaborative analysis
- reliable $|V_{cb}|$
- constraints on NP

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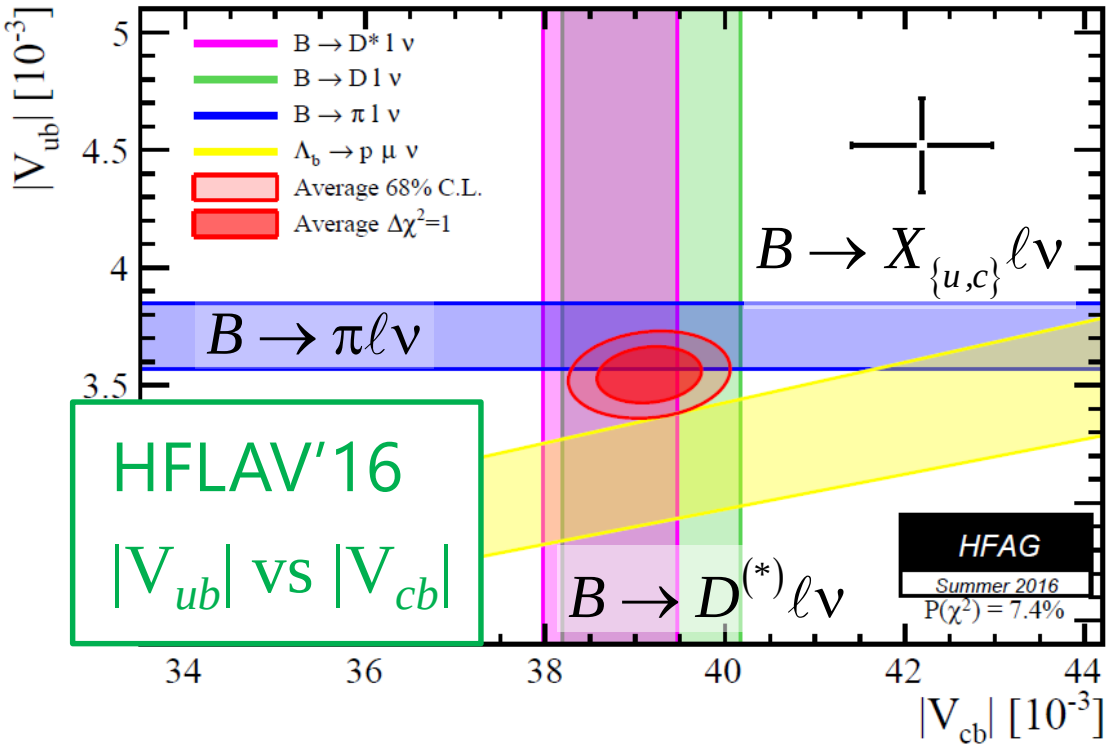

HFLAV'16

$|V_{ub}|$ vs $|V_{cb}|$

|Vub| : ??? (b→c BG???)

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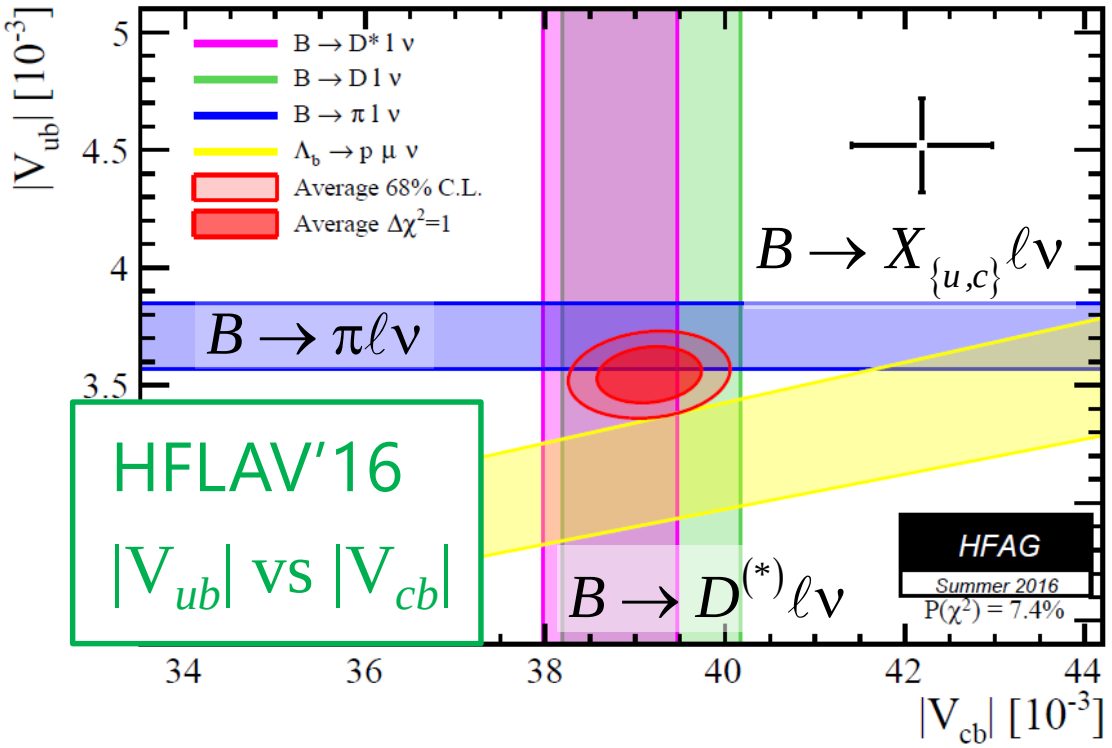

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inclusive decays

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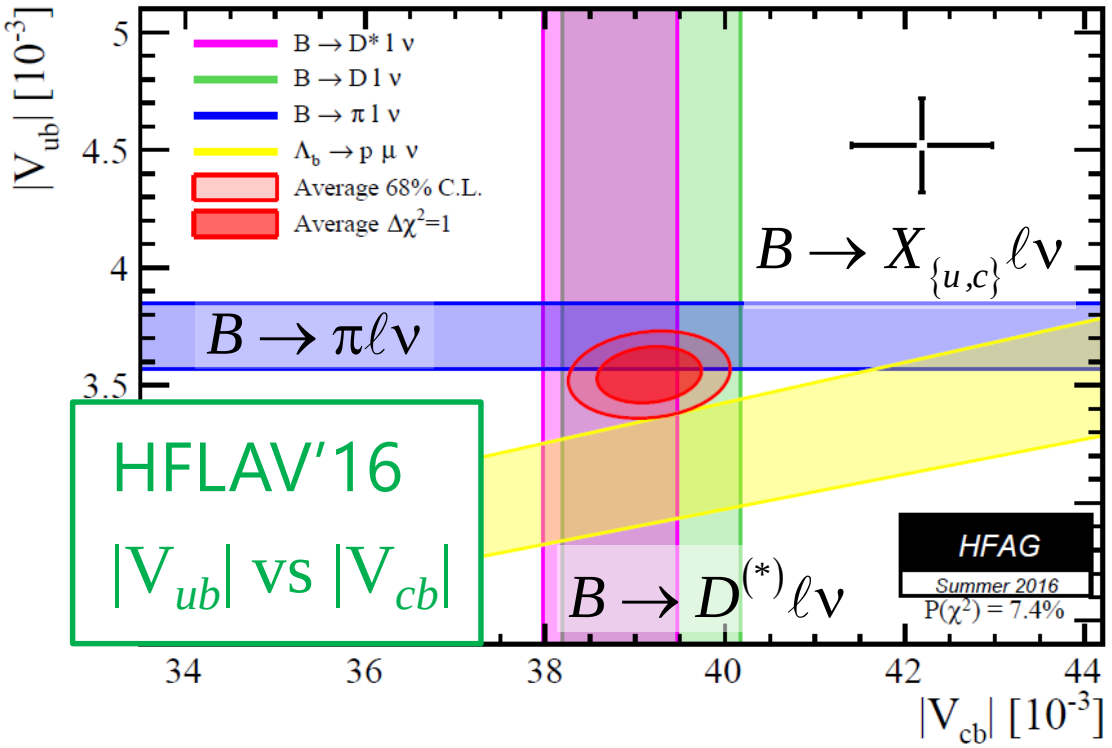

HFLAV'16
$|V_{ub}|$ vs $|V_{cb}|$

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on the lattice

- lattice QCD
- heavy quark expansion
- vs $B \to \pi \ell \nu$

$\Rightarrow$ hint on $|V_{ub}|$ tension (?)

B2TiP

Belle II Theory interface Platform

https://confluence.desy.de/display/BI/B2TiP+WebHome

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  ≲700 pages, impact of Belle II ⇒ NP search

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  $\lesssim$700 pages, impact of Belle II $\Rightarrow$ NP search

- project members made major contributions

  Kou (Organizer & Editor), Hashimoto (Advisory Committee),
  Hayasaka, Ishikawa (WG Coordinator), Kaneko (Lattice Board)

- close connection b/w theorists and experimentalists

  $\Rightarrow$ demands to keep this contact b/w th. and exp.

“Physics Week” Workshop

- organizers: A. Gaz, E. Kou, P. Urquijo + K. Trabelsi (2019-)
- LO @ KEK : S. Hashimoto
- 1st meeting in Oct. 22-26

  lectures on “Physics Book”

  tutorials on physics analysis
- 81 participants

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Local organizers : Hashimoto, Kaneko, Nakao, Nishida

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keep on activities to increase the contact

Plan for 2019-2020

discussions (video meeting + visit)

- $B \to K^* \gamma$: theoretical understanding of QCD effects
- $B \to K \pi \pi \gamma$: method & code to Belle (II) data
- $\tau \to K \pi \pi \nu$: interplay w/ $B \to K \pi \pi \gamma$: code / hadronic param.s
- new topic : lepton flavor violating $B \to K^{(*)} \tau \mu$, $K^{(*)} \tau e$

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workshops (visit)

- "Physics Week" workshop 2019 ...

Budget

2018-2019

- E. Kou : held “Physics Week” Workshop, Oct 21-26
- T. Kaneko : collaboration on $B \to D^{(*)} \ell \nu$, Mar 6-8

  (K. Trabelsi moved from KEK to LAL)

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2019-2020

- France to Japan : 2 travels + 10 day stay, 4,000€

  for workshop (Kou, Trabelsi, Physics Week)
- Japan to France : 3 travels + 15 day stay, 750 k ¥

  for collaboration (Kaneko, $B \to D^{(*)} \ell \nu$)

  intensive discussions (Ishikawa, Kakuno, $b \to s\gamma$)

Summary: FLAV-03

- recent progress on phenomenology and lattice QCD
  $\Rightarrow$ improvements in Belle II and LHCb analyses
- good mixture among Pheno / Lattice / Belle II / LHCb & France / Japan
- practical collaboration on $B \to D^{(*)} \ell \nu$
- discussing collaborations on $b \to s\gamma$, τ decays, ...
- increase the contact b/w th. and exp. : "Physics Week"