In2p3

PARTICLE PHYSICS JOINT LAB JAPAN - FRANCE

Flavour Physics and Theoretical Challenges for Precision

Report of B_05 (2013-2017) & New Proposal of FLAV_02 (2017-)

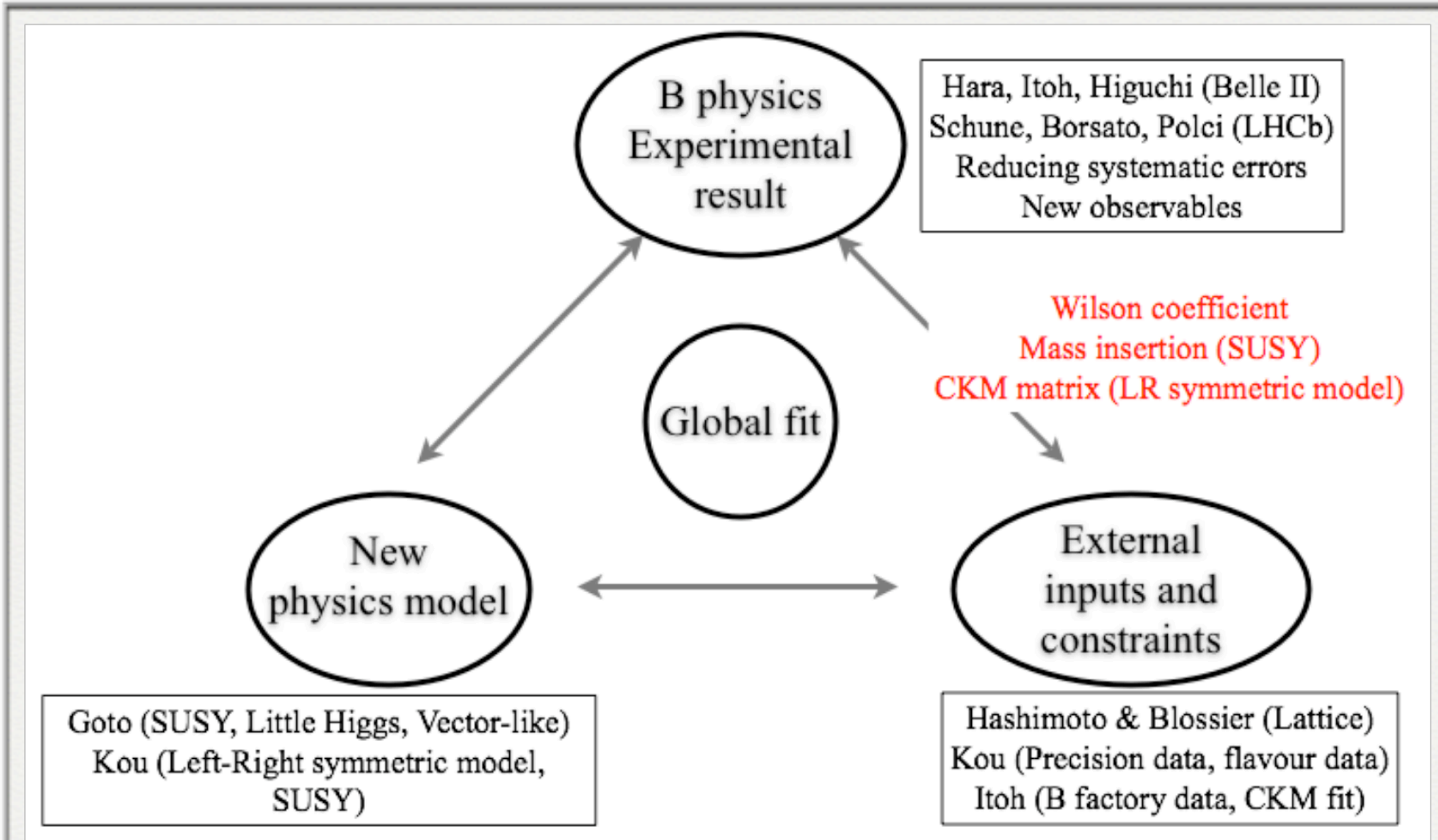
E. KOU (LAL/IN2P3) & T. Kaneko (KEK)

TYL-FKPPL joint meeting: IPH Strasbourg
10-12th June 2017

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Final Report B_05 for 2013-2017

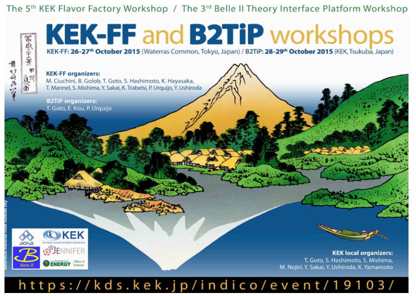
M.-H. Schune & K. Hara



✓Since 2015, our activity has been integrated in a more global framework of Belle II collaboration (B2TiP): the members of TYL played he central role of B2TiP.

B2TiP

B2TiP is the official Belle II physics working group. During 2014-2017, we held 4 workshops. Current members will continue until 2019.



- *02/14* *Approval of B2TiP*
- *06/14* Kickoff meeting
- *10/14* *WS-KEK KEKFF*
- *02/15* *NP-WG KIT workshop*
- ~04/15 WS (nonKEK) Krakow
- *~10/15* *WS-KEK KEKFF (Tokyo)*
- *11/15* *NP-WG PNNL workshop*
- *03/15* *NP-WG LAL workshop*
- *~05/16* *WS (nonKEK) Pittsburgh*
- *~11/16* *B2TiP Report Camp @ MIAPP (Munich)*
- *early 17* *Editorial meeting*

REPORT PLANNING

Phase 1(2014)

- Identifying the 'Golden channels'

Phase II (2015)

- Detailed studies (theory uncertainties, experimental simulations)
- New ideas???

Phase III (2016)

- Finalizing the analysis/text
- Editing

Krakow workshop (~100 participants)

B2TiP working group

Find details on the B2TiP website

https://belle2.cc.kek.jp/~twiki/bin/view/Public/B2TIP

WG1	G. De Nardo, A. Zupanic, M. Tanaka, F. Tackmann, A. Kronfeld
WG2	A. Ishikawa, J. Yamaoka, U. Haisch, T. Feldmann
WG3	T. Higuchi, L. Li Gioi, J. Zupan, S. Mishima
WG4	J. Libby, Y. Grossman, M. Blanke
WG5	P. Goldenzweig, M. Beneke, C.-W. Chiang, S. Sharpe
WG6	G. Casarosa, A. Schwartz, A. Kagan, A. Petrov
WG7	Ch.Hanhart, R.Mizuk, R.Mussa, C.Shen, Y.Kiyo, A.Polosa, S.Prelovsek
WG8	K. Hayasaka, T. Feber, E. Passemar, J. Hisano
WG9	R.Itoh, F.Bernlochner, Y.Sato, U.Nierste, L.Silvestrini, J.Kamenik, S. Simula

I: Leptonic/Semi-leptonic II: Radiative/Electroweak III: phi1(beta)/phi2(alpha) IV: phi3 (gamma)
V: Charmless/hadronic B decays VI: Charm VII: Quarkonium(like) VIII: Tau & low multiplicity IX: New Physics

B2TiP working group

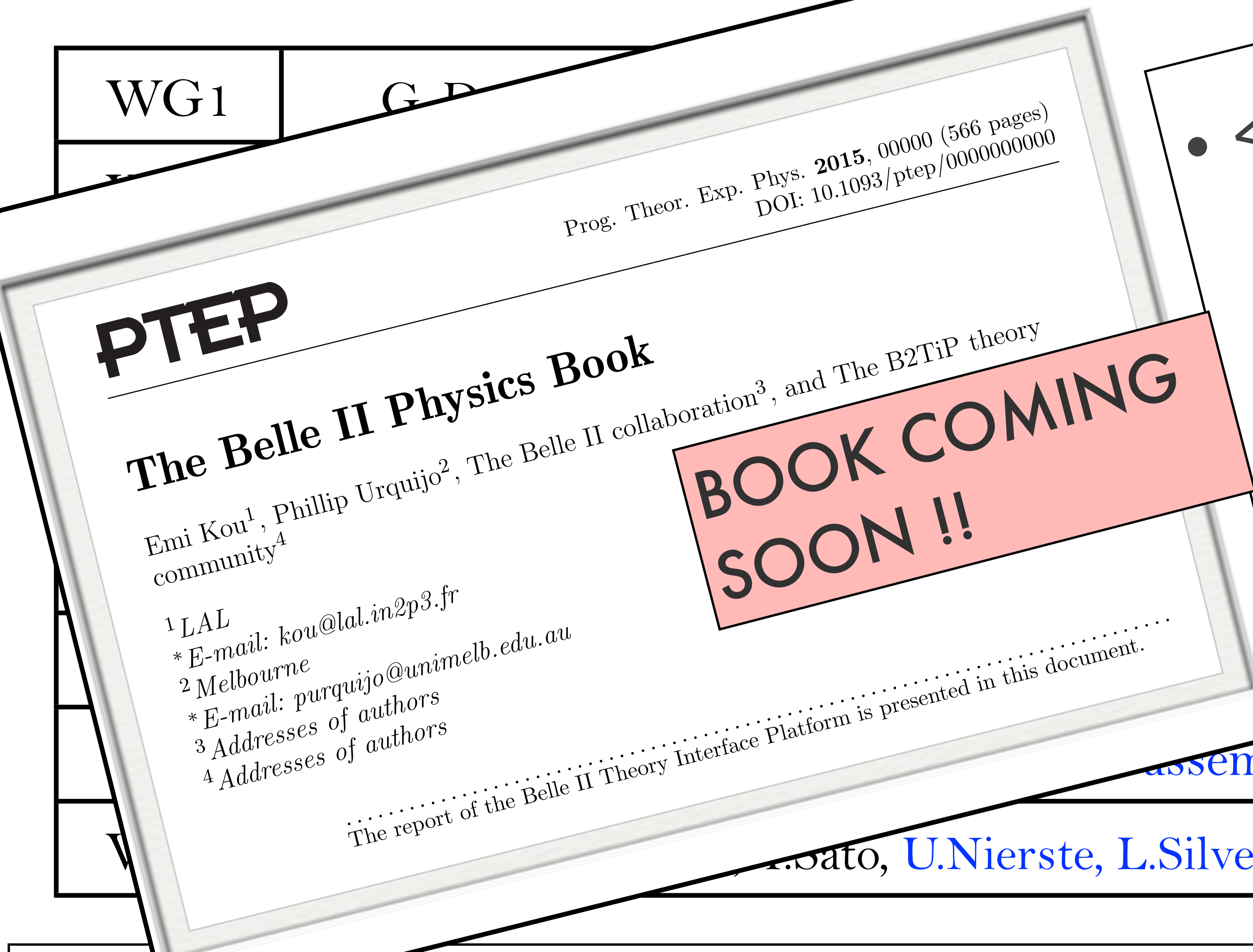
Fir...

...2TIP

WG1	G. D...
	..., S.Prelovsek
	...ssemar, J. Hisano
W...	..., I.Sato, U.Nierste, L.Silvestrini, J.Kamenik, S. Simula

I: ...nic/Semi-leptonic II: Radiative/Electroweak III: phi1(beta)/phi2(alpha) IV: phi3 (gamma)

V: Charmless ...



PTEP

Prog. Theor. Exp. Phys. **2015**, 00000 (566 pages)
DOI: 10.1093/ptep/0000000000

The Belle II Physics Book

Emi Kou[1], Phillip Urquijo[2], The Belle II collaboration[3], and The B2TiP theory community[4]

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[3] *Addresses of authors*
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The report of the Belle II Theory Interface Platform is presented in this document.

BOOK COMING SOON !!

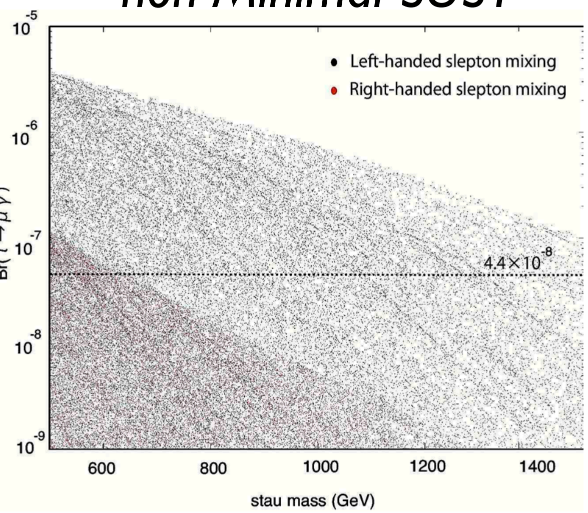
- <600 pages covering
  - ✓ B, D, tau physics
  - ✓ quarkonium, XYZ exotics
  - ✓ low-multiplicity physics (g-2, Dark matter, Higgs)

We are grateful for the supports by TYL, DOI, EU-Jennifer

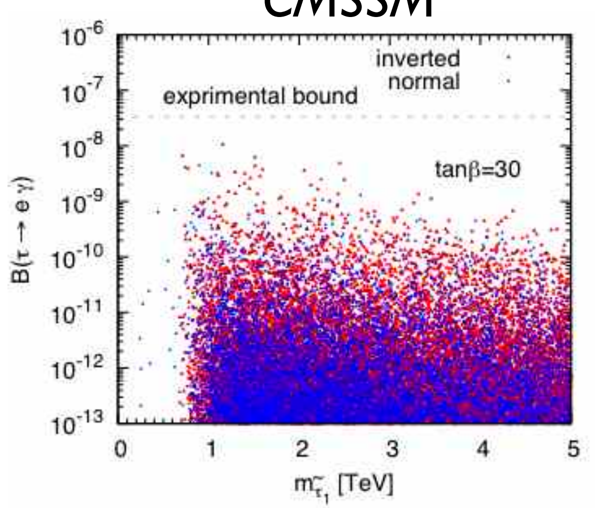
TYL members contributions to B2TiP

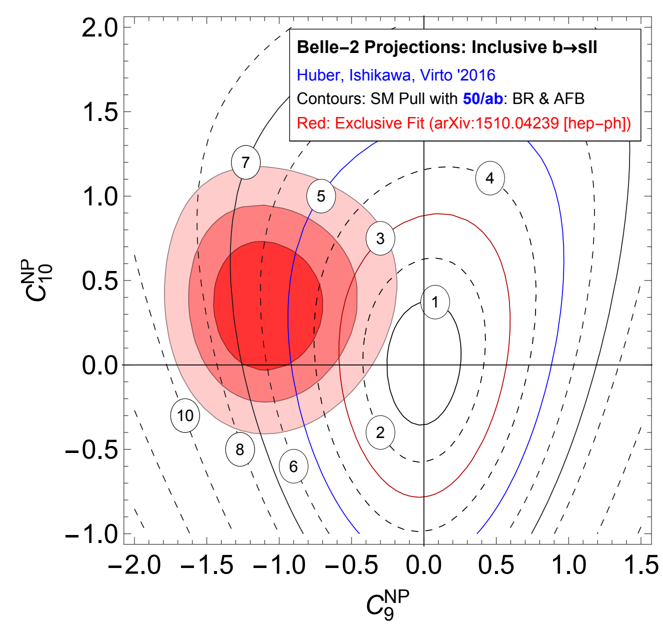
- *WG2: Radiative and Electroweak penguin B decays : A. Ishikawa (convener), M.-H. Schune, E. Kou, F. Le Diberder*
- *WG3: Time dependent CP asymmetry : S. Mishima (convener)*
- *WG4: phi_3 measurement : K. Trabelsi (reviewer)*
- *WG8: Tau physics: K. Hayasaka (convener), B. Moussallam, J. Hisano, E. Kou*
- *WG9: New Physics : R. Itoh (convener), Y. Sato (convener), S. Mishima, E. Kou, M. Nojiri*

non-Minimal SUSY



CMSSM

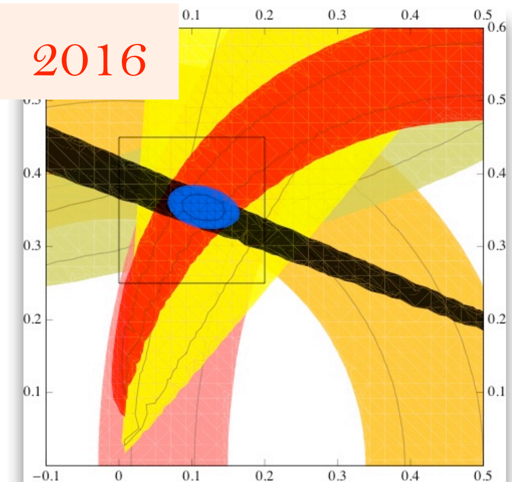




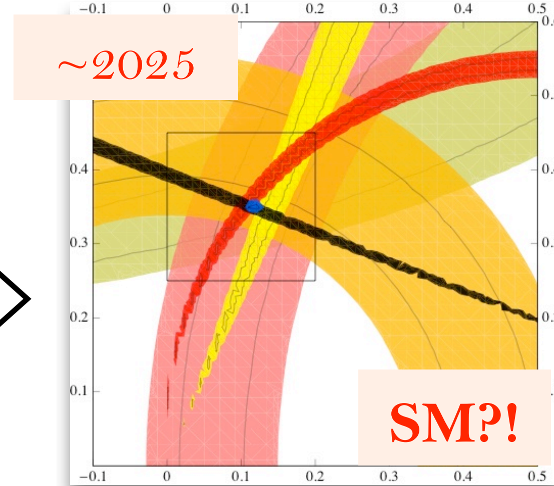
WG8 : LFV τ -> μγ sensitivity to SUSY-GUT

*WG2 : LHCb anomaly in B->K*μμ vs Belle II*

Future prospect of the UT triangle



50ab-1
Belle II

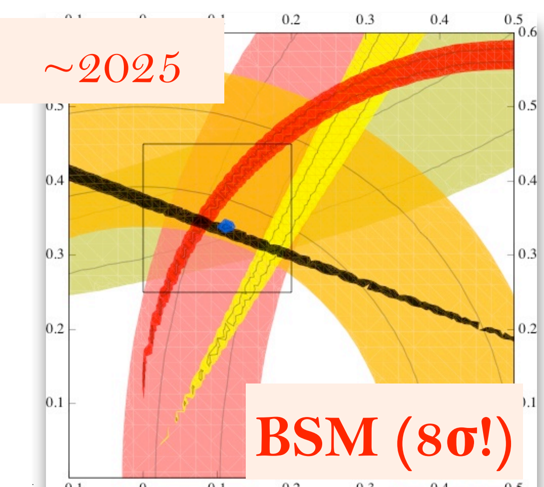


E.K.& F. Le Diberder
for B2TiP working group
Results are preliminary

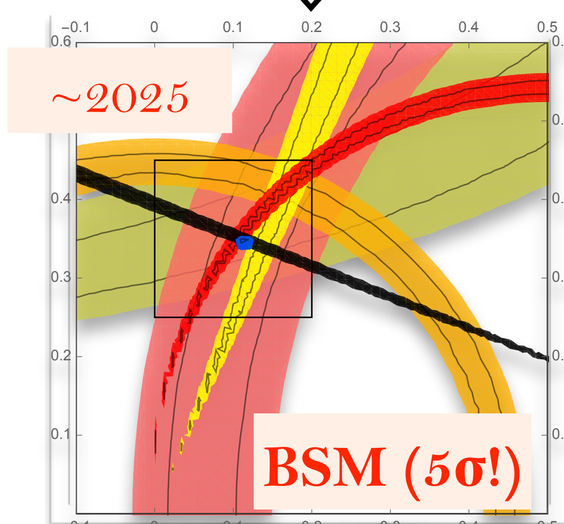
50ab-1
Belle II

OR

50ab-1
Belle II



If all the central values
a little go lower...

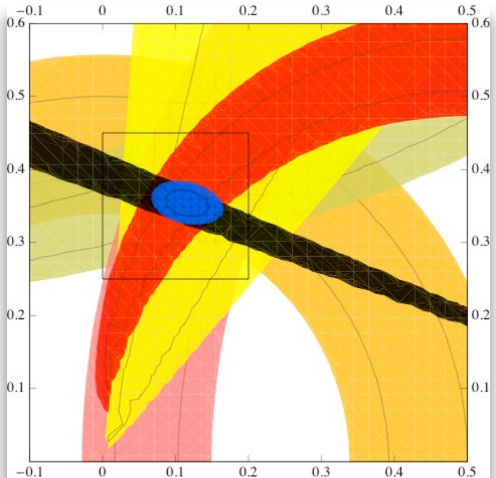


Sum of the angles are 180 degree
but the side doesn't meet!

Lattice inputs are very important
for the sides measurements

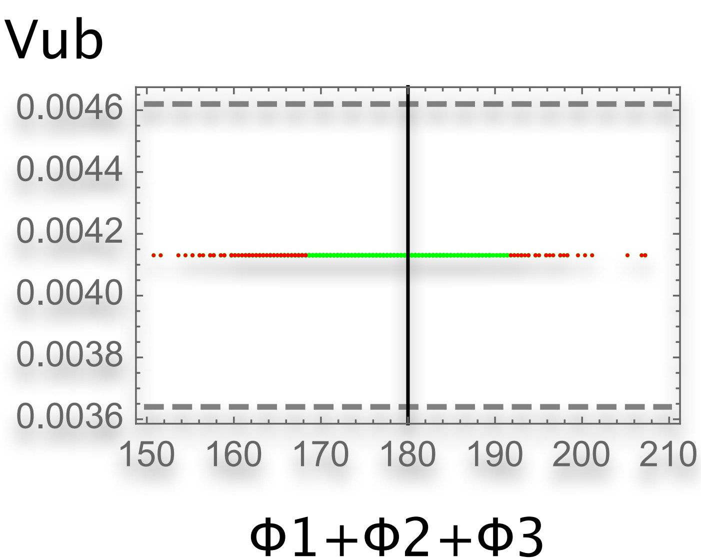
$\mathcal{L}$ [ab^{-1}]	$\sigma_{\mathcal{B}}$ (stat$\pm$sys)	$\sigma_{LQCD}^{\text{forecast}}$	$\sigma_{V_{ub}}$
1	3.6 ± 4.4 1.3 ± 3.6	current	6.2, 6.2 3.6, 3.6
5	1.6 ± 2.7 0.6 ± 2.2	in 5 yrs	3.2, 3.0 2.1, 1.9
10	1.2 ± 2.4 0.4 ± 1.9	in 5 yrs	2.7, 2.6 1.9, 1.7
50	0.5 ± 2.1 0.2 ± 1.7	in 10 yrs	1.7, 1.4 1.3, 1.0

Future prospect of the CKM UT?

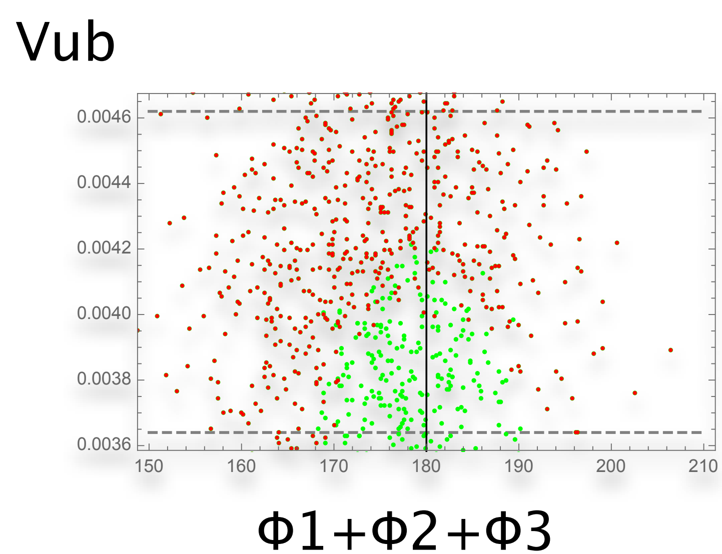


- To understand this “8σ” effect better, we have run a Monte Carlo simulation.
- We randomly sample the central values (1000 trials) assuming Gaussian measurements and compute the significance.
- What is the chance to observe a deviation < **5σ significance** in CKM Unitarity Triangle ??

25% chance without Vub



69% chance with Vub



Red points are chi2 indicating deviation from unitarity > **5σ significance**

New project FLAV_02

*responsible

JP

Theory

KEK (Theory group):
T. Kaneko*
S. Hashimoto
S. Mishima

Belle II

KEK:
K. Hara
K.Trabelsi
Universities:
K. Hayasaka (Niigata)
A. Ishikawa (Tohoku)

FR

Theory

LAL/IN2P3:
E.Kou*
(T. Moskalets)
IPNO/IN2P3:
B. Moussallam

Belle II & LHCb

LAL/IN2P3:
F. Le Diberder
M.-H. Schune

Common physics topics

i) the photon polarization measurement of b->sγ processes (with final state, K*, K_1 etc, including γ->e+e-)

ii) the hadronic tau decays, in particular, to observe the CP violation in τ->K$\pi\nu$ channel

iii) the CKM Φ_3/γ determination via channels such as B->D (->K$\pi\pi$)K etc.

These 3 observables are among the Golden Channels of Belle II/LHCb and many efforts are ongoing both theoretically and experimentally.

New project FLAV_02

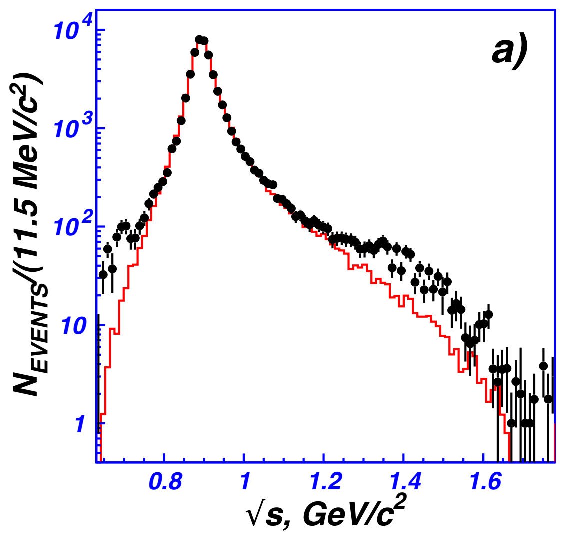
- The goal of the project :
  Investigating a possible improvement in the decay amplitudes description (signal/background) for Belle II and LHCb observables.
  Based on the latest progresses on the lattice QCD and the hadron physics.
- Possible outcome:
  Application of the new amplitude description to the BelleII/LHCb analysis.
  Publishing a phenomenology paper on the new amplitude description.
- Regular video meeting (journal club style)
  Experimentalists : raising questions of the analysis
  Theorists : explaining the basics of the subject and the latest progress in the field
- Visiting Japan/France
  Long term (7-10 days?) visit for collaboration
  Short term visit : B2TiP meeting, Theory group seminars, TYL-FJPPL workshops

Theme of 2017

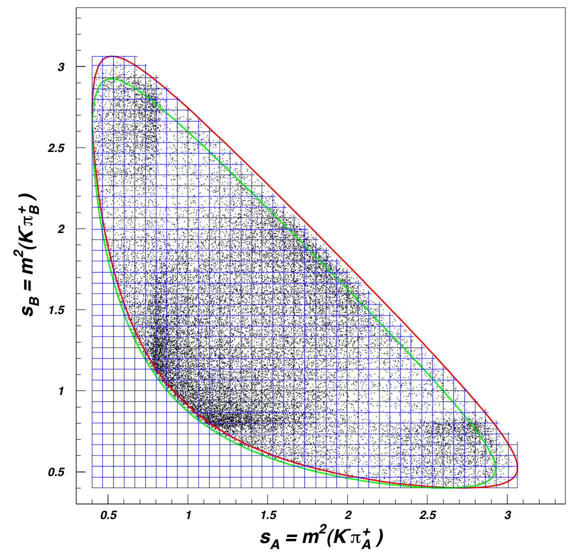
- ✴ This first year, we will focus on the overlap of the K* resonance and the so-called K-π s-wave contribution.
- ✴ This contribution has been recognized in many measurements, while how to treat this "state" depends on modeling (no common agreement on the modeling).
- ✴ The modeling dependence affects especially to the strong phase, which is the crucial information needed e.g. for determining the CP violating parameters.

Appearance of K-π s-wave

arXiv:0706/2231:
Belle τ->Kπν



hep-ex/0507099
E791 D+->K-π+π+



BW vs LASS models

$$F_S = \varkappa \frac{s}{M^2_{K_0^*(800)}} BW_{K_0^*(800)}(s) + \gamma \frac{s}{M^2_{K_0^*(1430)}} BW_{K_0^*(1430)}(s).$$

$$F_S = \lambda A_{\mathrm{LASS}}(s),\ \ A_{\mathrm{LASS}} = \frac{\sqrt{s}}{P}(\sin\delta_B e^{i\delta_B} + e^{2i\delta_B} BW_{K_0^*(1430)}(s)),$$

Model dependence results in different strong phase. For the CP asymmetry measurement, the phase from the vector-scalar form factor is crucial.

S-wave parameterization in MIPWA

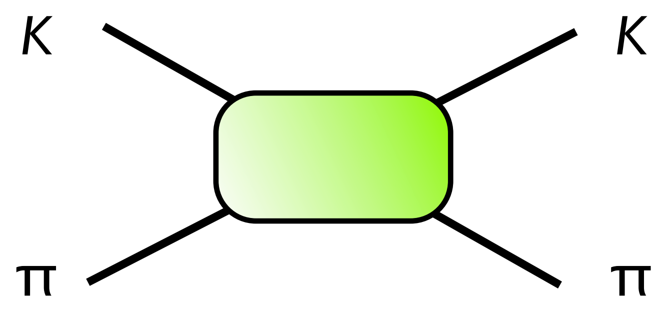
$$C_0(s_k) = c_k e^{i\gamma_k}$$

D decays are very important for γ/Φ3 measurement, where the model dependent becomes crucial !!!

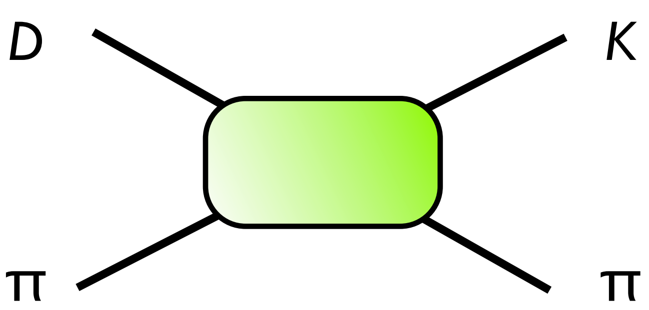
Discussions on-going...

arXiv:0607133:

κ (Kpi S-wave) is not a usual resonance..
A strict definition is "pole in the $K\pi \to \pi K$ amplitude on the second Riemann sheet"......



Can we use this "definition" and apply for τ, D, B decays?
In fact, one can apply the S-matrix method for τ decay as long as it comes from the vector and scalar couplings.



arXiv:1509.03188

For the D decay, we have to compute $D\pi K\pi$ scattering.

Advantage: the number of parameters, strictly respecting the unitarity of the scattering.
What is the impact on the γ/Φ_3 measurement?

arXiv:1307.0736

Relevant work in lattice QCD on $K\pi$ p-wave study.

Conclusions

- ✳ We are very excited to start a new collaboration with a smaller groups of people.
- ✳ This year, we will work on the K-pi s wave problem in the Belle II and LHCb analysis.
- ✳ We have already started monthly Skype meeting.
- ✳ We plan a face-to-face meeting this year.
- ✳ We plan to keep contributing to the new series of the B2TiP workshops.

Backup

arXiv:1606.04731
LHCb B->Kπμμ

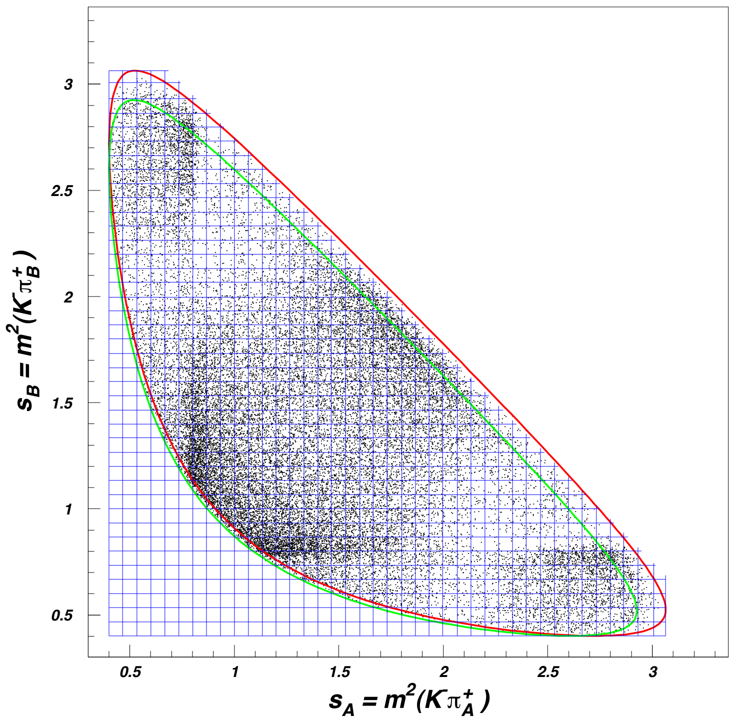
If the goal is only to eliminate the S-wave component, the angular analysis is enough. But if the goal is to use the S-wave and/or S-wave/P-wave intereference, the result depends on the model.

The remaining I_j and I_j coefficients can be written in terms of the decay amplitudes given in Ref. [27]. Defining $\vec{\Omega}' \equiv (\cos\theta_K,\, \cos\theta_\ell,\, \phi')$, the resulting differential decay rate has the form

$$\begin{aligned}
\frac{\mathrm{d}^5(\Gamma+\overline{\Gamma})}{\mathrm{d}m_{K\pi}\mathrm{d}q^2\,\mathrm{d}\vec{\Omega}'} = {} & \frac{1}{4\pi} G_{\mathrm{S}}\left|f_{\mathrm{LASS}}(m_{K\pi})\right|^2(1-\cos 2\theta_\ell)\,+ \\
& \frac{3}{4\pi} G_{\mathrm{P}}^{0}\left|f_{\mathrm{BW}}(m_{K\pi})\right|^2\cos^2\theta_K(1-\cos 2\theta_\ell)\,+ \\
& \frac{\sqrt{3}}{2\pi}\mathrm{Re}\left[\left(G_{\mathrm{SP}}^{\mathrm{Re}}+iG_{\mathrm{SP}}^{\mathrm{Im}}\right)f_{\mathrm{LASS}}(m_{K\pi})f^{*}_{\mathrm{BW}}(m_{K\pi})\right]\cos\theta_K(1-\cos 2\theta_\ell)\,+ \\
& \frac{9}{16\pi} G_{\mathrm{P}}^{\perp\|}\left|f_{\mathrm{BW}}(m_{K\pi})\right|^2\sin^2\theta_K\left(1+\frac{1}{3}\cos 2\theta_\ell\right)+ \\
& \frac{3}{8\pi} S_3(G_{\mathrm{P}}^{0}+G_{\mathrm{P}}^{\perp\|})\left|f_{\mathrm{BW}}(m_{K\pi})\right|^2\sin^2\theta_K\sin^2\theta_\ell\cos 2\phi'\,+ \\
& \frac{3}{2\pi} A_{\mathrm{FB}}(G_{\mathrm{P}}^{0}+G_{\mathrm{P}}^{\perp\|})\left|f_{\mathrm{BW}}(m_{K\pi})\right|^2\sin^2\theta_K\cos\theta_\ell\,+ \\
& \frac{3}{4\pi} S_9(G_{\mathrm{P}}^{0}+G_{\mathrm{P}}^{\perp\|})\left|f_{\mathrm{BW}}(m_{K\pi})\right|^2\sin^2\theta_K\sin^2\theta_\ell\sin 2\phi',
\end{aligned} \tag{3}$$

where $f_{\mathrm{BW}}(m_{K\pi})$ denotes the $m_{K\pi}$ dependence of the resonant P-wave component, which is modelled using a relativistic Breit–Wigner function. The S-wave component is modelled using the LASS parameterisation [29], $f_{\mathrm{LASS}}(m_{K\pi})$. The exact definitions of the P- and S-wave line shapes are given in Appendix A. The real-valued coefficients G_{S}, $G_{\mathrm{SP}}^{\mathrm{Re}}$, $G_{\mathrm{SP}}^{\mathrm{Im}}$, G_{P}^{0} and $G_{\mathrm{P}}^{\perp\|}$ are bilinear combinations of the q^2-dependent parts of the K^{*0} ($\overline{K}^{*0}$) helicity

hep-ex/0507099
E791 D+->K-π+π+



The first application of the so-called "Model Independent Partial Wave Analysis".

$$C_1(s) = [\mathcal{W}_{K^*(892)}(s) + B_{K_1^*(1410)}\mathcal{W}_{K_1^*(1410)}(s) + B_{K_1^*(1680)}\mathcal{W}_{K_1^*(1680)}(s)] \times \mathcal{F}_R^L(p, r_R),$$

$$C_2(s) = \left[B_{K_2^*(1430)}\mathcal{W}_{K_2^*(1430)}(s)\right] \times \mathcal{F}_R^L(p, r_R).$$

$$\mathcal{F}_D^0 = e^{-(rq)^2/12} \quad \text{scalar}$$

$$\mathcal{F}_D^1 = \left[1 + (rq)^2\right]^{-\frac{1}{2}} \quad \text{vector}$$

$$\mathcal{F}_D^2 = \left[9 + 3(rq)^2 + (rq)^4\right]^{-\frac{1}{2}} \quad \text{tensor}$$

S-wave parameterization in MIPWA

$$C_0(s_k) = c_k e^{i\gamma_k}$$

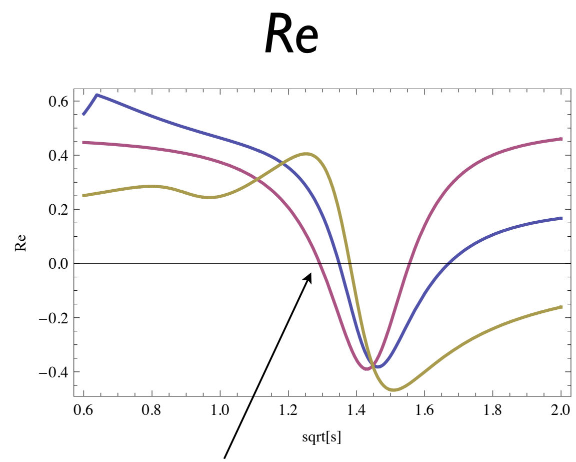
$$\mathcal{W}_R(s) = \frac{1}{m_R^2 - s - i m_R \Gamma(r_R, s)},$$

$$\Gamma(r_R, s) = \Gamma_R \left(\frac{m_R}{\sqrt{s}}\right)\left(\frac{p}{p_R}\right)^{2L+1}\left[\frac{\mathcal{F}_R^L(p, r_R)}{\mathcal{F}_R^L(p_R, r_R)}\right]^2$$

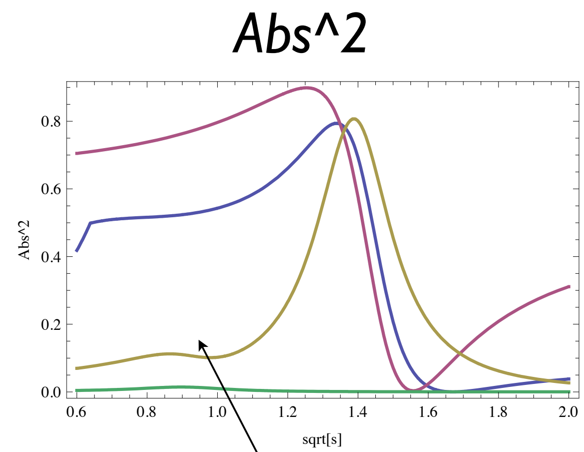
D decays are very important for γ/Φ3 measurement, where the model dependent becomes crucial !!!

Many more examples can be found by the talk by A. Palano at IWHSS17 conference.

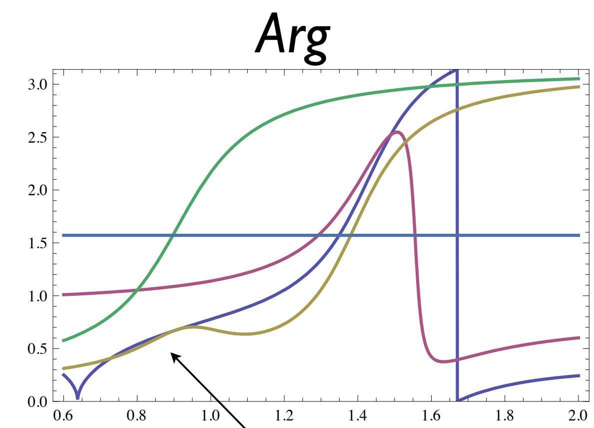
Demonstration of the model dependence



Shift of zero position (pole) due to the background



What is lacking for kappa +K*0(1430) with respect to LASS must be the u-channel, t-channel effects



The kappa+K*0(1430) model can explain rather well the LASS phase. The lower phase at kappa region is due to the interference to K*0(1430)

- LASS (by Babar)
- K*0(1430) + BG with delta=Pi/4
- kappa + K*0(1430) by Schechter
- kappa only by Schechter

K*0(1430) + BG

$$\frac{e^{2i\delta} m_* \Gamma_*}{m_*^2 - s - i m_* \Gamma_*} + e^{i\delta}\sin\delta,$$

kappa by Schechter

$$\frac{m_\kappa G_\kappa}{m_\kappa^2 - s - i m_\kappa G'_\kappa},$$

$$G_\kappa = \frac{3\gamma_{\kappa K\pi}^2 q(m_\kappa^2)}{64\pi m_\kappa^2}\left(m_\kappa^2 - m_K^2 - m_\pi^2\right)^2$$

Fitted Parameter	$\gamma_{\sigma K\bar{K}} = \gamma_{\sigma\pi\pi}$
m_κ	897 ± 2.1 MeV
G'_κ	322 ± 6.0 MeV
$\gamma_{\kappa K\pi}$	5.0 ± 0.07 GeV $^{-1}$
m_*	1385 ± 3.3 MeV
G'_*	266 ± 9.5 MeV
γ_*	4.3 ± 2.1 GeV $^{-1}$
χ^2	4.0

LASS by Babar

$$\mathrm{R_{LASS}}(m) = \frac{m}{|\mathbf{q}|\cot\delta_B - i|\mathbf{q}|} + e^{2i\delta_B}\frac{m_0\Gamma_0\frac{m_0}{|\mathbf{q}|_0}}{(m_0^2 - m^2) - i m_0\Gamma_0\frac{|\mathbf{q}|}{m}\frac{m_0}{|\mathbf{q}|_0}}\Bigg|_{m=m_{K\pi}}$$

$$\cot\delta_B = \frac{1}{a|\mathbf{q}|} + \frac{1}{2}r|\mathbf{q}|.$$

$m_0 = 1425 \pm 50$
$\Gamma_0 = 270 \pm 80$
$a = 2.07 \pm 0.10\ (\mathrm{GeV}/c)^{-1}$
$r = 3.32 \pm 0.34\ (\mathrm{GeV}/c)^{-1}$