Belle II

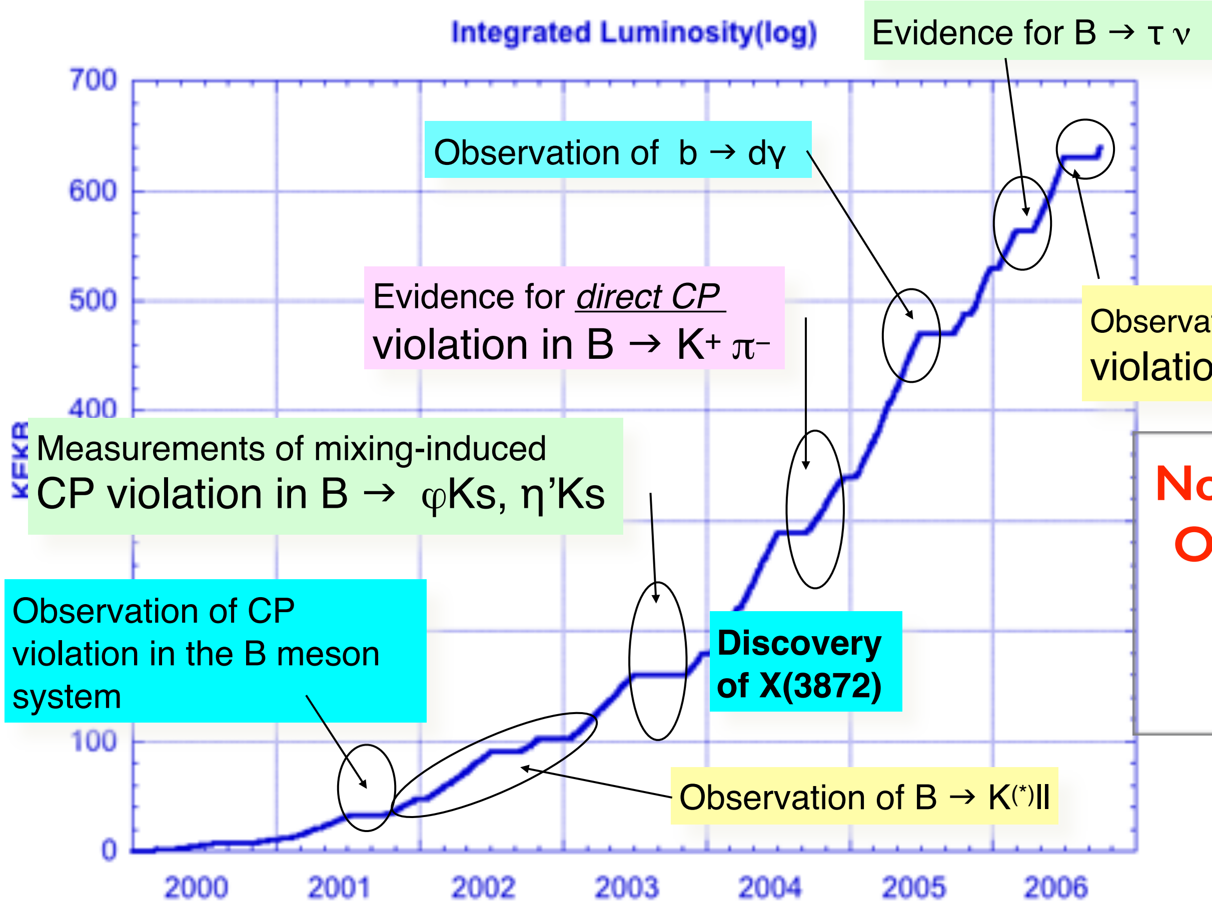
Emi Kou
(LAL-IN2P3)

Journée prospectives du LLR 2019
@ Toulouse 18 September 2019

The Belle II experiment

B factories, Babar/Belle

B factories: e+e- circular with energy at Υ(4S)(→BBbar)



Nobel Prize to Kobayashi-Maskawa (2009)
Origin of CP violation in Standard Model

KEK (Japan) = Belle/KEKB
SLAC (US) = Babar/PEP-II

BABAR
Collaboration Home Page

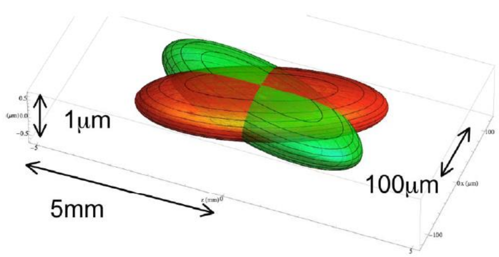
BELLE

SuperKEKB

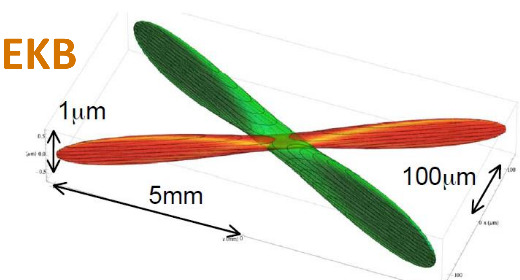
Nano-beam technology to reach to 40 times more luminosity

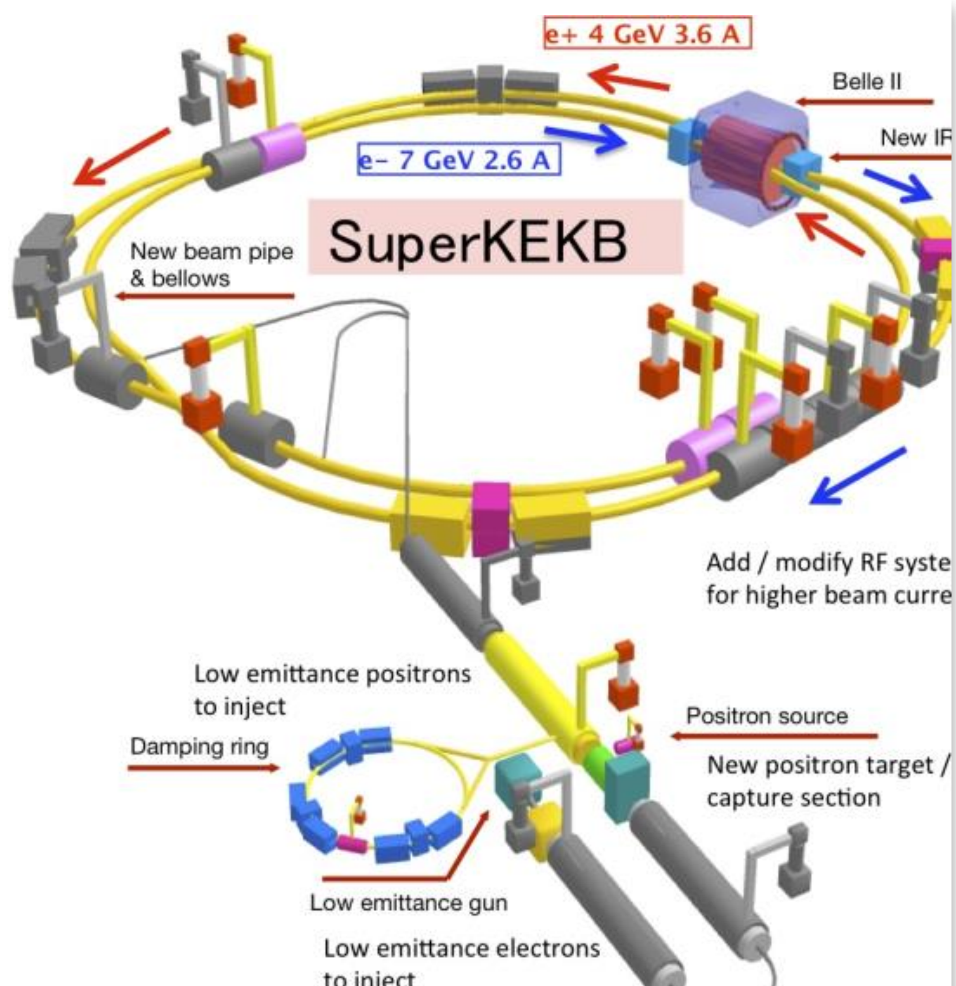
- **40x increase in luminosity**
- "Nano-beam" interaction point
- Increase in current

KEKB



SuperKEKB



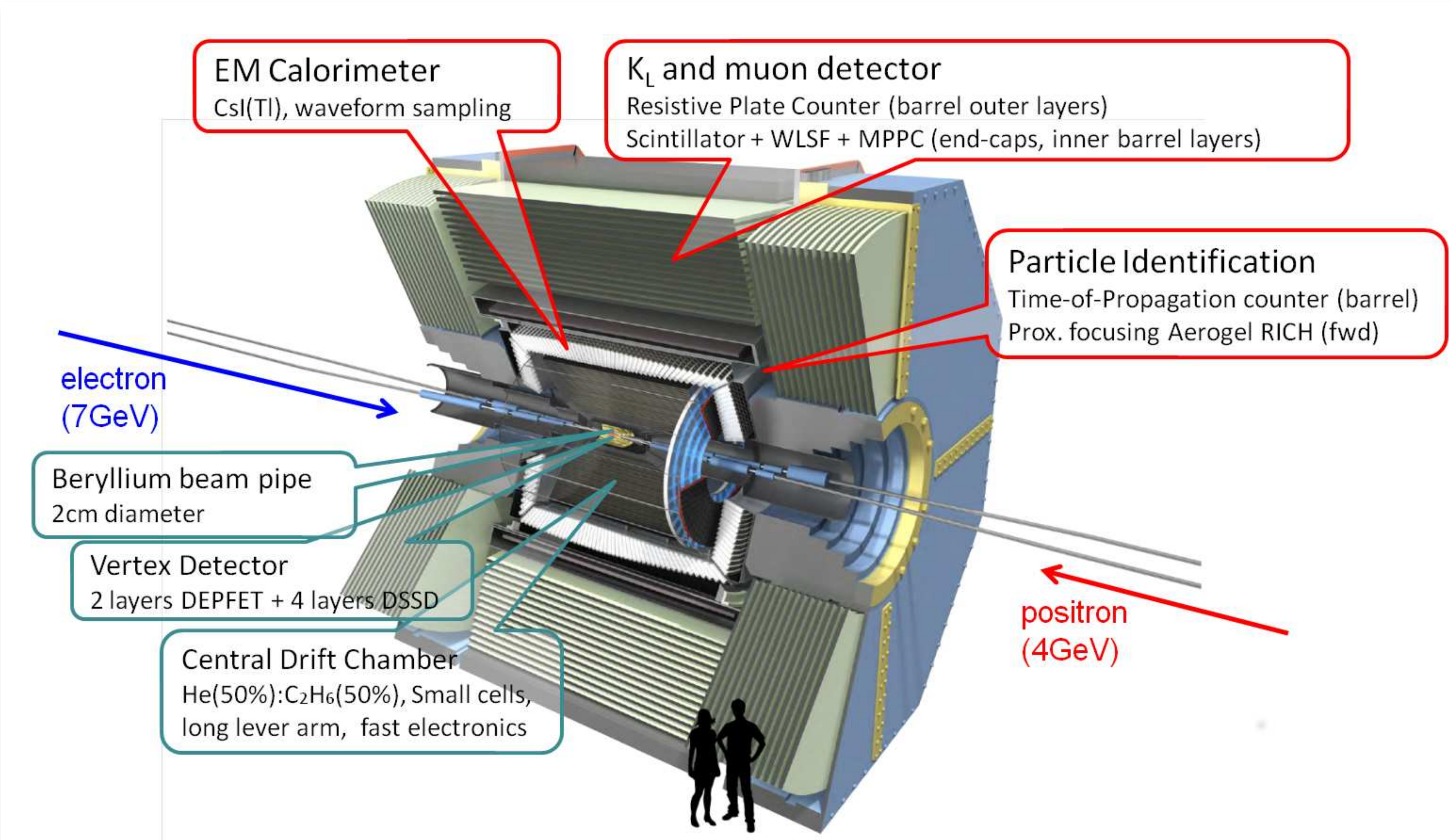


- **First turns achieved Feb 2016!**

Slide from Belle II talk at ICHEP 2016

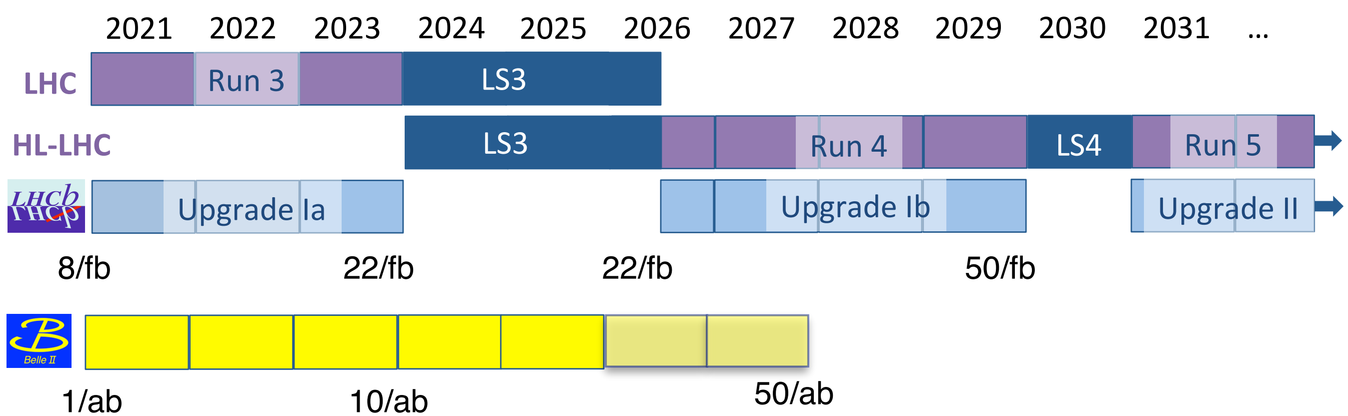
Upgraded Belle II detector

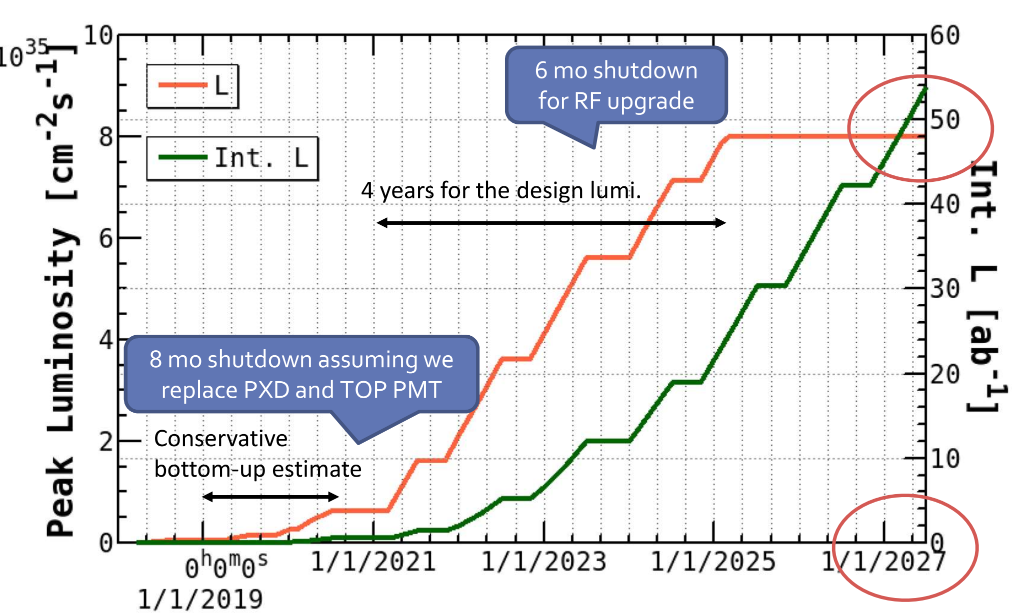
Better particle identification, higher coverage...

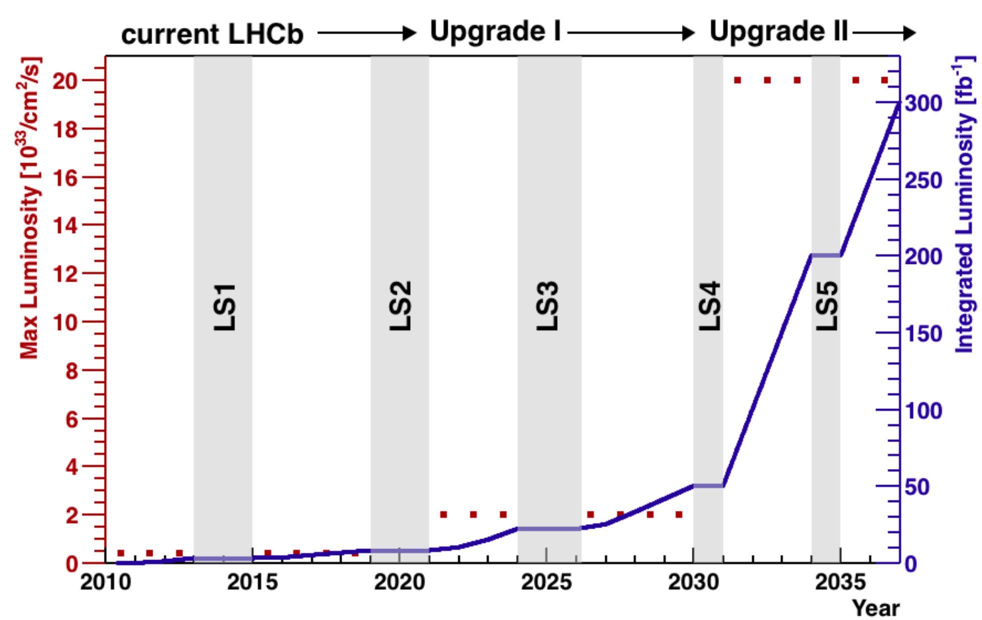


Timeline of Flavour Physics

Competition/Complementarity between Belle II vs LHCb

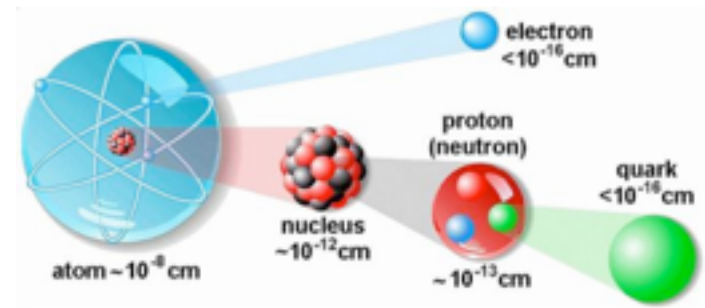




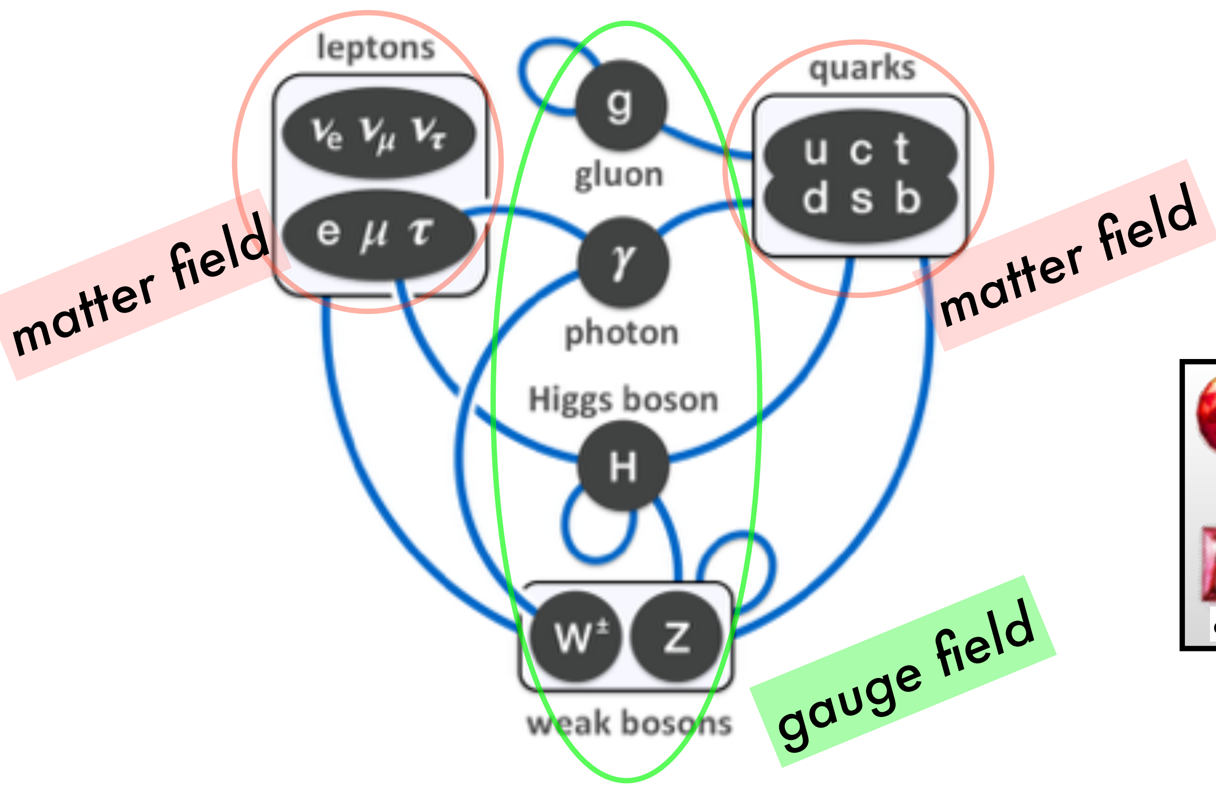


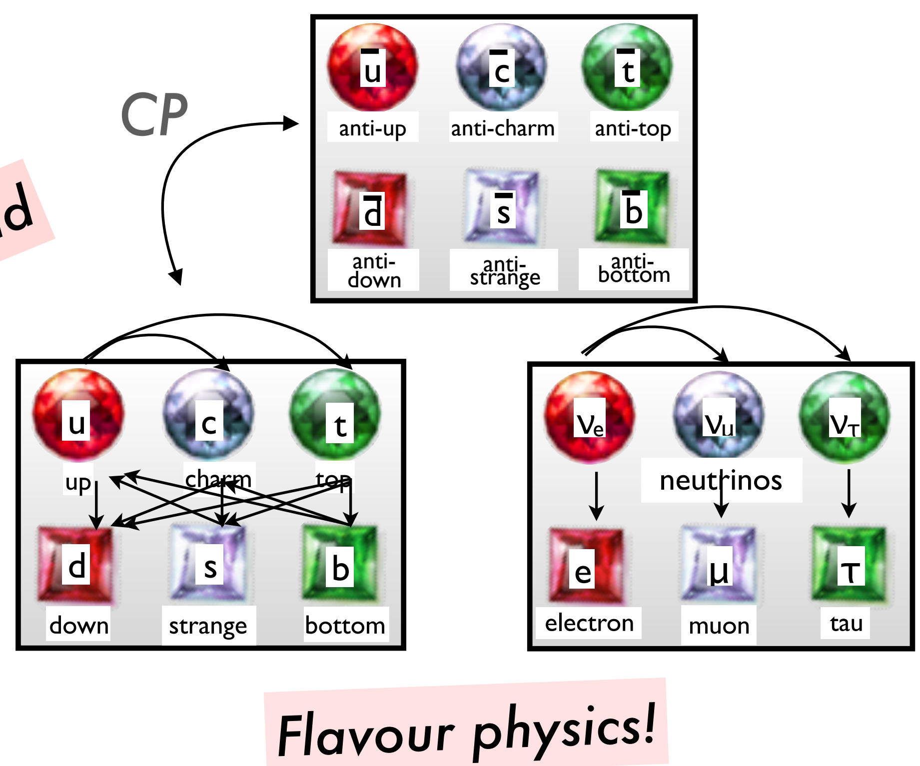
Searching new physics in flavour physics

Flavour physics



- Investigating the fundamental interaction through transitions among different **quarks and leptons**
- **The CP violation** is one of the most interesting phenomena in flavour physics





Flavour Physics within SM

In SM, the difference between mass and interaction basis explains, the GIM mechanism, the CP Violation! Very concise!

$$\mathcal{L}_Y = \sum_{ij} Y^u_{ij} \overline{Q_{iL}} \begin{pmatrix} \phi^0 \\ \phi^- \end{pmatrix} u_{jR} + \sum_{ij} Y^d_{ij} \overline{Q_{iL}} \begin{pmatrix} -\phi^{-\dagger} \\ \phi^{0\dagger} \end{pmatrix} d_{jR} + h.c.$$

Yukawa coupling

Glashow, Illiopolous, Maiani '70

$$(U^u_{L,R})^\dagger U^u_{L,R} \equiv \mathbf{1}, \quad (U^d_{L,R})^\dagger U^d_{L,R} \equiv \mathbf{1}$$

Flavour changing neutral current suppression

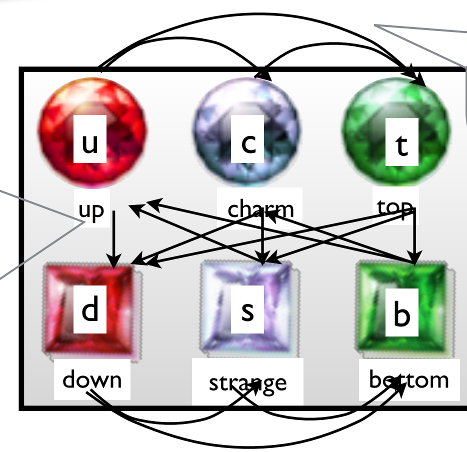
Cabibbo '63
Kobayashi, Maskawa '73

$$(U^u_L)^\dagger U^d_L \equiv V_{\mathrm{CKM}}$$

Charged current: CKM matrix
Origin of CP Violation
(complex phase)!

Cronin, Fitch, Christenson,Turlay '64

Vckm: Cabibbo-Kobayashi-Maskawa matrix



FCNC suppressed

What has been confirmed?

Observed Quark masses

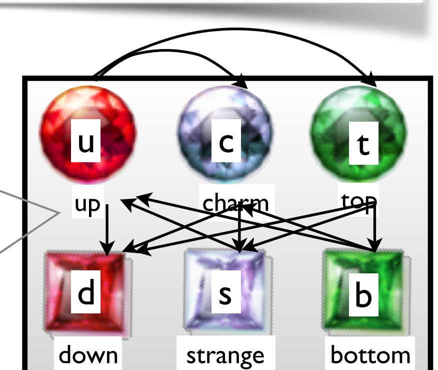
	1st generation	2nd generation	3rd generation
up type charge 2/3	up 2.2±0.5MeV	charm 1.27±0.03GeV	top 173.21±0.87GeV
down type charge -1/3	down 4.7±0.5MeV	strange 96±6MeV	bottom 4.18±0.04GeV
charged lepton charge -1	electron 0.511MeV	μ 105.7MeV	τ 1.78GeV
neutrinos charge 0	ν_e <2.0eV	ν_μ <0.17eV	ν_τ <18.2eV

Observed Quark mixing V_{CKM}

	down	strange	bottom
up	Vub 0.97417±0.00021	Vus 0.2248±0.0006	Vub 0.00409±0.0003
charm	Vcd 0.220±0.005	Vcs 0.995±0.016	Vcb 0.0405±0.0015
top	Vtd	Vts	Vtb 1.009 ± 0.031

- ✓ SM does not say anything about the Yukawa coupling so the masses and the couplings are not predictable.
- ✓ **V_{CKM} has to be a 3x3 unitary matrix which includes only one complex phase.**
- ✓ N.B. LHC and LCs can tell us the linearity of the masse and the Higgs coupling.

Vckm: Cabibbo-Kobayashi-Maskawa matrix

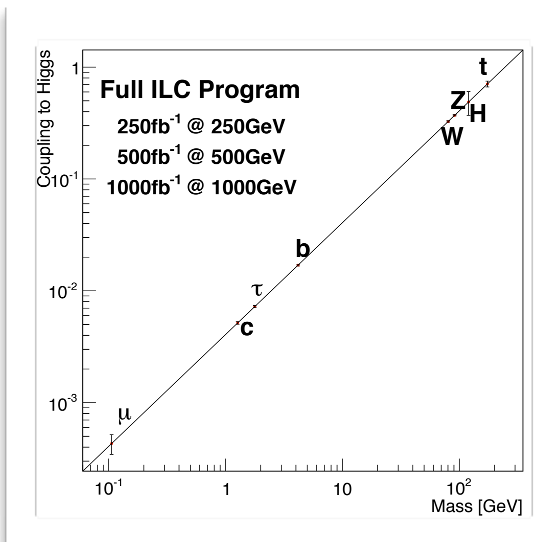


What has been confirmed?

Observed Quark masses

	1st generation	2nd generation	3rd generation
up type cha	up	charm	top
dov char			
ch l ch			
ne ch			

1.009 ± 0.031

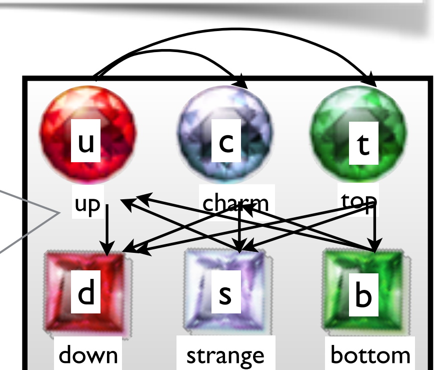


DBD 2012

Do fermion masses come entirely from the Yukawa coupling?

- ✓ SM does not say anything about the Yukawa coupling so the masses and the couplings are not predictable.
- ✓ **V_{CKM} has to be a 3x3 unitary matrix which includes only one complex phase.**
- ✓ N.B. LHC and LCs can tell us the linearity of the masse and the Higgs coupling.

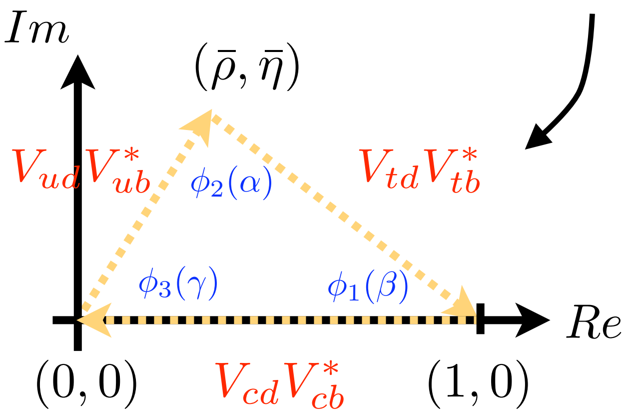
Vckm: Cabibbo-Kobayashi-Maskawa matrix



The Unitarity triangle: test of Unitarity?

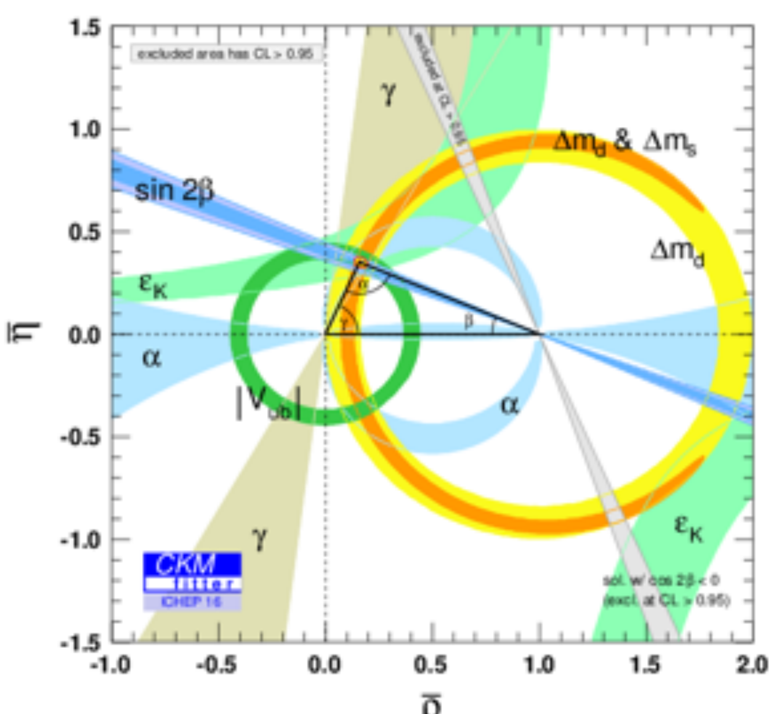
$$\underbrace{V_{ud}V_{ub}^*}_{A\lambda^3(\rho+i\eta)} + \underbrace{V_{cd}V_{cb}^*}_{-A\lambda^3} + \underbrace{V_{td}V_{tb}^*}_{A\lambda^3(1-\rho-i\eta)} = 0$$

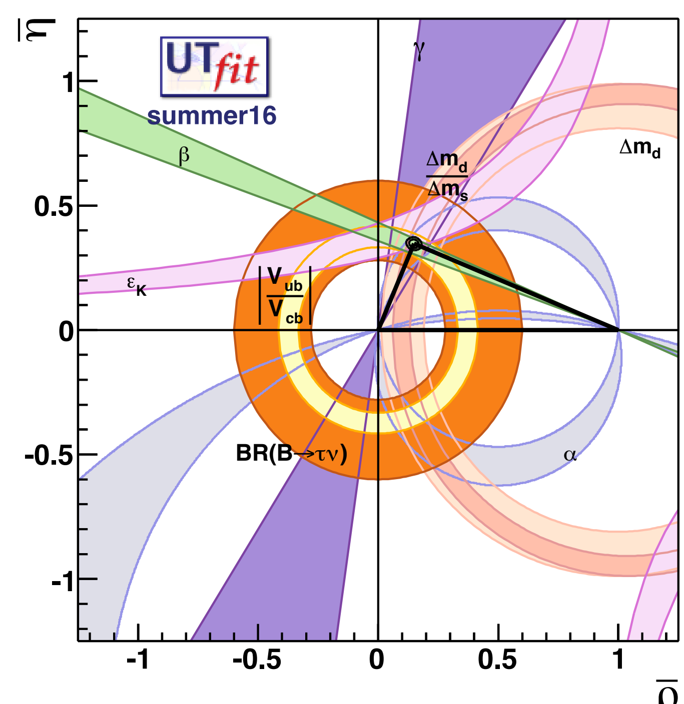
divide by Aλ³



$$arg\left(\frac{V_{tb}^*V_{td}}{V_{cb}^*V_{cs}}\right) \equiv -\phi_1$$
$$arg\left(\frac{V_{tb}^*V_{td}}{V_{ub}^*V_{ud}}\right) \equiv -\phi_2$$
$$arg\left(\frac{V_{cb}^*V_{cs}}{V_{ub}^*V_{ud}}\right) \equiv -\phi_3$$

- **Successful explanation** of flavour physics up to now! Hundreds of observables (including dozens of CPV) are explained by this single matrix.





Flavour Physics beyond SM

The indirect search of new physics through quantum effect: very powerful tool to search for new physics signal!

- This very simple picture does not exist in most of the extensions of SM: suppression of the FCNC is NOT automatic and also CP violation parameters can appear.
  N.B.: SM also has an "unwanted" CP parameter (strong CP problem).

SUSY: Quark and Squark mass matrices can not be diagonalized at the same time ---> FCNC and CP violation

Mutli-Higgs model, Left-Right symmetric model: Many Higgs appearing in this model ---> tree level FCNC and CP violation

Warped extra-dimension with flavour in bulk: Natural FCNC suppression though, K-K mixing might be too large due to the chiral enhancement

Flavour Physics beyond SM

The indirect search of new physics through quantum effect: very powerful tool to search for new physics signal!

- This very simple picture does not exist in most of the extensions of SM: suppression of the FCNC is NOT automatic and also CP violation parameters can appear.
  N.B.: SM also has an "unwanted" CP parameter (strong CP problem).

SUSY: Quark and Squark mass matrices can not be diagonalized at the same time ---> FCNC and CP violation

Mutli-Higgs model,
Left
sy

Warped extra-
with

New particle introduces new source of flavour/CP violations. Then, if new physics exist, we should observe those phenomena at some point!

The strategies…

Strategy for discovery via precision

Discovery by the intensity frontier experiments.

WE WANT 5-7σ DEVIATION !!

Reducing uncertainties = probing higher energies

$$\Delta_{NP} = \text{Deviation from SM}$$
$$= (\text{exp.} - \text{SM}) \pm \sqrt{(\sigma_{exp})^2 + (\sigma_{SM})^2}$$
$$= c/(M_{NP})^n$$

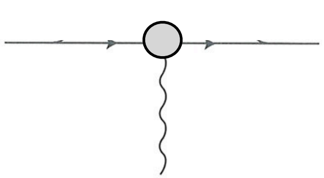
new physics coupling c, new physics scale M_{NP}

E.x. muon g-2

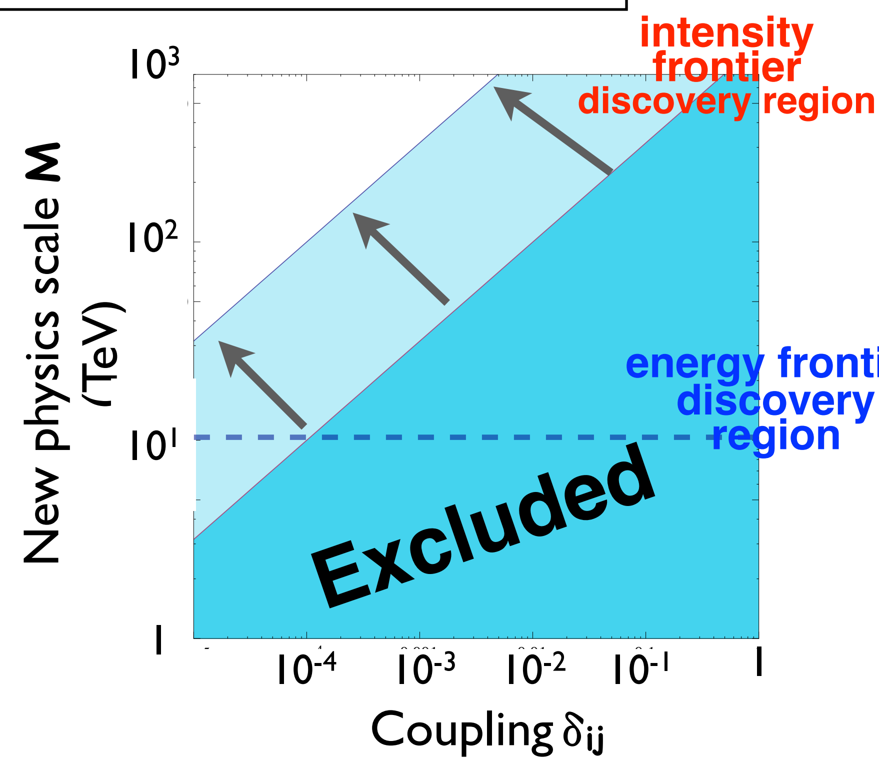
3.6σ effect!

$a_\mu^{exp.} = 116592091(54)(33) \times 10^{-11}$.

$a_\mu^{the.} = 116591803(1)(42)(26) \times 10^{-11}$



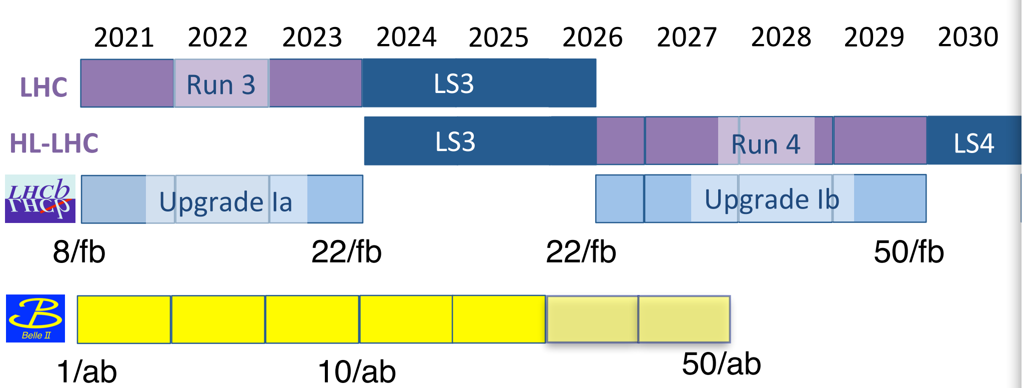
$$\frac{e}{M}\overline{\psi}\sigma_{\mu\nu}\psi F^{\mu\nu}$$



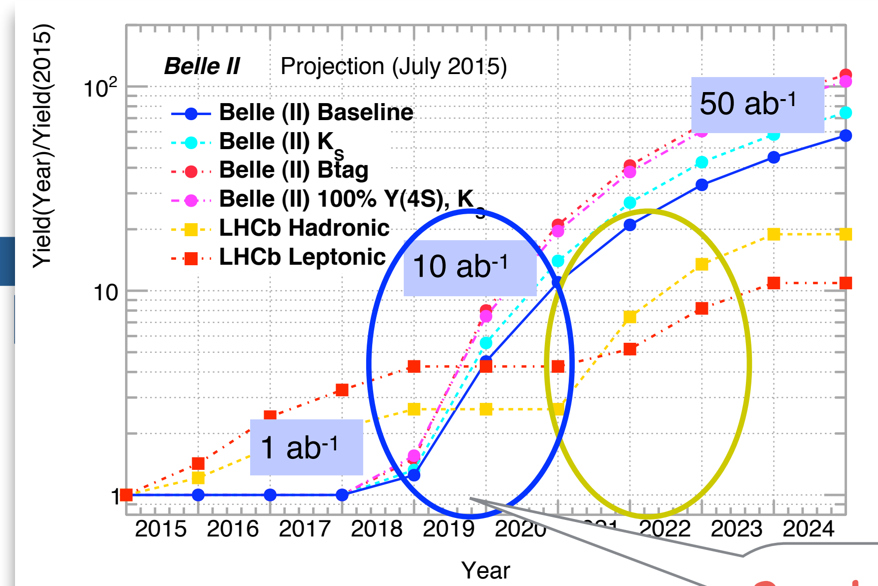
Strategy I: reducing experimental uncertainties

$$\Delta_{NP} = (\text{exp.} - \text{SM}) \pm \sqrt{(\sigma_{exp})^2 + (\sigma_{SM})^2}$$

Future increase of the luminosity in Heavy Flavour physics



BELLE2-NOTE-PH-2015-004



Breakthrough possible!

- Belle II increases the luminosity (50 times by 2027)
- Hadronic channels become available after LHCb upgrade (starting 2021)
- Reducible systematic errors can also be reduced as statistics increases

Strategy I: reducing experimental uncertainties

- Many statistical uncertainties become at a few per-cent level: increasing number of systematic uncertainties (of order of a few per-mill !) are to be taken into account.

Observable	LHCb 2018	Upgrade (50 fb^{-1})
$2\beta_s(B_s^0 \to J/\psi\phi)$	0.025	0.008
$2\beta_s(B_s^0 \to J/\psi f_0(980))$	0.045	0.014
a_{sl}^s	0.6×10^{-3}	0.2×10^{-3}
$2\beta_s^{\rm eff}(B_s^0 \to \phi\phi)$	0.17	0.03
$2\beta_s^{\rm eff}(B_s^0 \to K^{*0}\overline{K}^{*0})$	0.13	0.02
$2\beta^{\rm eff}(B^0 \to \phi K_S^0)$	0.30	0.05
$2\beta_s^{\rm eff}(B_s^0 \to \phi\gamma)$	0.09	0.02
$\tau^{\rm eff}(B_s^0 \to \phi\gamma)/\tau_{B_s^0}$	5 %	1 %
$S_3(B^0 \to K^{*0}\mu^+\mu^-; 1 < q^2 < 6\,{\rm GeV}^2/c^4)$	0.025	0.008
$s_0 A_{\rm FB}(B^0 \to K^{*0}\mu^+\mu^-)$	6 %	2 %
$A_{\rm I}(K\mu^+\mu^-; 1 < q^2 < 6\,{\rm GeV}^2/c^4)$	0.08	0.025
$\mathcal{B}(B^+ \to \pi^+\mu^+\mu^-)/\mathcal{B}(B^+ \to K^+\mu^+\mu^-)$	8 %	2.5 %
$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	0.5×10^{-9}	0.15×10^{-9}
$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	~100 %	~35 %
$\gamma(B \to D^{(*)}K^{(*)})$	4°	0.9°
$\gamma(B_s^0 \to D_s K)$	11°	2.0°
$\beta(B^0 \to J/\psi K_S^0)$	0.6°	0.2°
A_Γ	0.40×10^{-3}	0.07×10^{-3}
ΔA_{CP}	0.65×10^{-3}	0.12×10^{-3}

LHCb upgrade LOI: CERN-LHCC-2011-001
see alo PoS(FPCP2016) 041

e.g. systematic uncertainty for φs measurement with Bs->J/psi KK

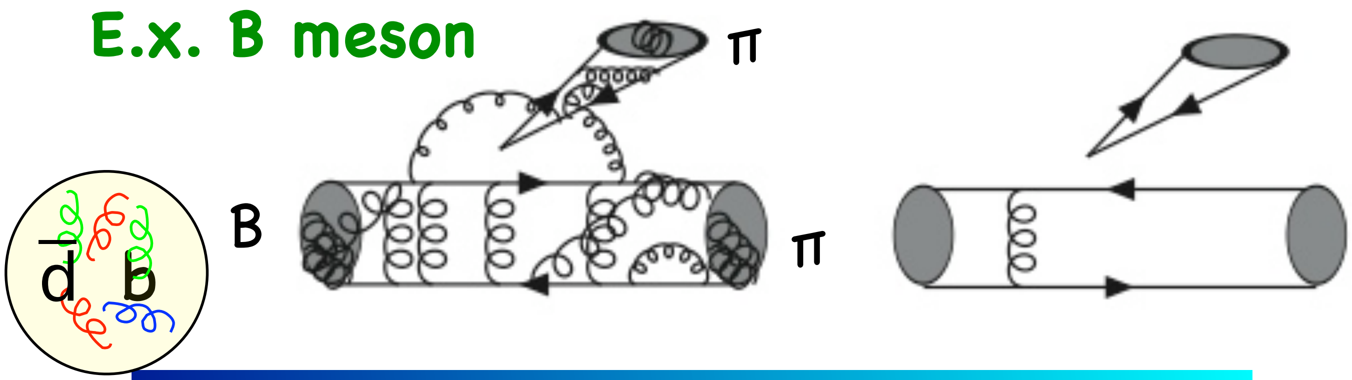
Source	$\lvert A_0\rvert^2$	$\lvert A_\perp\rvert^2$	ϕ_s [rad]	$\lvert\lambda\rvert$	$\delta_\perp - \delta_0$ [rad]	$\delta_\parallel - \delta_0$ [rad]	$\Gamma_s - \Gamma_d$ [ps^{-1}]	$\Delta\Gamma_s$ [ps^{-1}]	Δm_s [ps^{-1}]
Mass width parametrisation	0.0006	0.0005	-	-	0.05	0.009	-	0.0002	0.001
Mass factorisation	0.0002	0.0004	0.004	0.0037	0.01	0.004	0.0007	0.0022	0.016
Multiple candidates	0.0006	0.0001	0.0011	0.0011	0.01	0.002	0.0003	0.0001	0.001
Fit bias	0.0001	0.0006	0.001	-	0.02	0.033	-	0.0003	0.001
$C_{\rm SP}$ factors	-	0.0001	0.001	0.0010	0.01	0.005	-	0.0001	0.002
Quadratic OS tagging	-	-	-	-	-	-	-	-	-
Time res.: statistical	-	-	-	-	-	-	-	-	-
Time res.: prompt	-	-	-	-	-	0.001	-	-	0.001
Time res.: mean offset	-	-	0.0032	0.0010	0.08	0.001	0.0002	0.0003	0.005
Time res.: Wrong PV	-	-	-	-	-	0.001	-	-	0.001
Ang. acc.: statistical	0.0003	0.0004	0.0011	0.0018	-	0.004	-	-	0.001
Ang. acc.: correction	0.0020	0.0011	0.0022	0.0043	0.01	0.008	0.0001	0.0002	0.001
Ang. acc.: low-quality tracks	0.0002	0.0001	0.0005	0.0014	-	0.002	0.0002	0.0001	-
Ang. acc.: t & σ_t dependence	0.0008	0.0012	0.0012	0.0007	0.03	0.006	0.0002	0.0010	0.003
Dec.-time eff.: statistical	0.0002	0.0003	-	-	-	-	0.0012	0.0008	-
Dec.-time eff.: $\Delta\Gamma_s = 0$ sim.	0.0001	0.0002	-	-	-	-	0.0003	0.0005	-
Dec.-time eff.: knot pos.	-	-	-	-	-	-	-	-	-
Dec.-time eff.: p.d.f. weighting	-	-	-	-	-	-	0.0001	0.0001	-
Dec.-time eff.: kin. weighting	-	-	-	-	-	-	0.0002	-	-
Length scale	-	-	-	-	-	-	-	-	0.004
Quadratic sum of syst.	0.0024	0.0019	0.0061	0.0064	0.10	0.037	0.0015	0.0026	0.018

Strategy II: reducing theoretical uncertainties

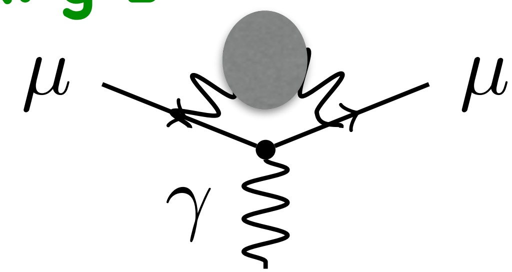
$$\Delta_{NP} = (\text{exp.} - \text{SM}) \pm \sqrt{(\sigma_{exp})^2 + (\sigma_{SM})^2}$$

- Theoretical development in QCD higher order corrections, Lattice QCD etc allow to reduce the theoretical uncertainties.
- Improved measurements of "theoretical control channels" are very important to reduce the theoretical errors.

E.x. B meson



E.x. g-2



Lattice QCD, QCD sum rules, Large Nc QCD, HQET, Perturbative QCD etc...

OR

Data driven

Strategy II: reducing theoretical uncertainties

arXiv:1808.10567 (PTEP 2019)
Belle II Physics Book

e.g. Vub measurement from exclusive B->πlν decay
(agreement inclusive/exclusive crucial!)

	Statistical	Systematic (reducible, irreducible)	Total Exp	Theory	Total
$\lvert V_{ub}\rvert$ exclusive (had. tagged)					
711 fb^{-1}	3.0	(2.3, 1.0)	3.8	7.0	8.0
5 ab^{-1}	1.1	(0.9, 1.0)	1.8	1.7	3.2
50 ab^{-1}	0.4	(0.3, 1.0)	1.2	0.9	1.7
$\lvert V_{ub}\rvert$ exclusive (untagged)					
605 fb^{-1}	1.4	(2.1, 0.8)	2.7	7.0	7.5
5 ab^{-1}	1.0	(0.8, 0.8)	1.2	1.7	2.1
50 ab^{-1}	0.3	(0.3, 0.8)	0.9	0.9	1.3

Lattice forecast

	$\mathcal{L}$ [ab^{-1}]	$\sigma_{\mathcal{B}}$ (stat, sys)	$\sigma_{\mathrm{QCD}}^{\mathrm{forecast}}$	$\sigma_{V_{ub}}$(EM)	$\sigma_{V_{ub}}$(no EM)
1	T	3.6, 4.4	current	6.2	-
	UT	1.3, 3.6		3.6	3.6
5	T	1.6, 2.7	in 5 yrs	3.2	3.0
	UT	0.6, 2.2		2.1	1.9
10	T	1.2, 2.4	in 5 yrs	2.7	2.6
	UT	0.4, 1.9		1.9	1.7
50	T	0.5, 2.1	in 10 yrs	1.7	1.4
	UT	0.2, 1.7		1.3	1.0

e.g. sin 2Φ_1 from b->sss penguin modes

Theory predictions depend on models. Different theoretical methods must be applied to cross check.

Mode	QCDF [662]	QCDF (scan) [662]	$SU(3)$
$\pi^0 K_S^0$	$0.07^{+0.05}_{-0.04}$	$[0.02, 0.15]$	$[-0.11, 0.12]$ [664]
$\rho^0 K_S^0$	$-0.08^{+0.08}_{-0.12}$	$[-0.29, 0.02]$	
$\eta' K_S^0$	$0.01^{+0.01}_{-0.01}$	$[0.00, 0.03]$	$(0 \pm 0.36) \times 2\cos(\phi_1)\sin\gamma$ [665]
ηK_S^0	$0.10^{+0.11}_{-0.07}$	$[-1.67, 0.27]$	
ϕK_S^0	$0.02^{+0.01}_{-0.01}$	$[0.01, 0.05]$	$(0 \pm 0.25) \times 2\cos(\phi_1)\sin\gamma$ [665]
ωK_S^0	$0.13^{+0.08}_{-0.08}$	$[0.01, 0.21]$	

Strategy III: explore new observables !

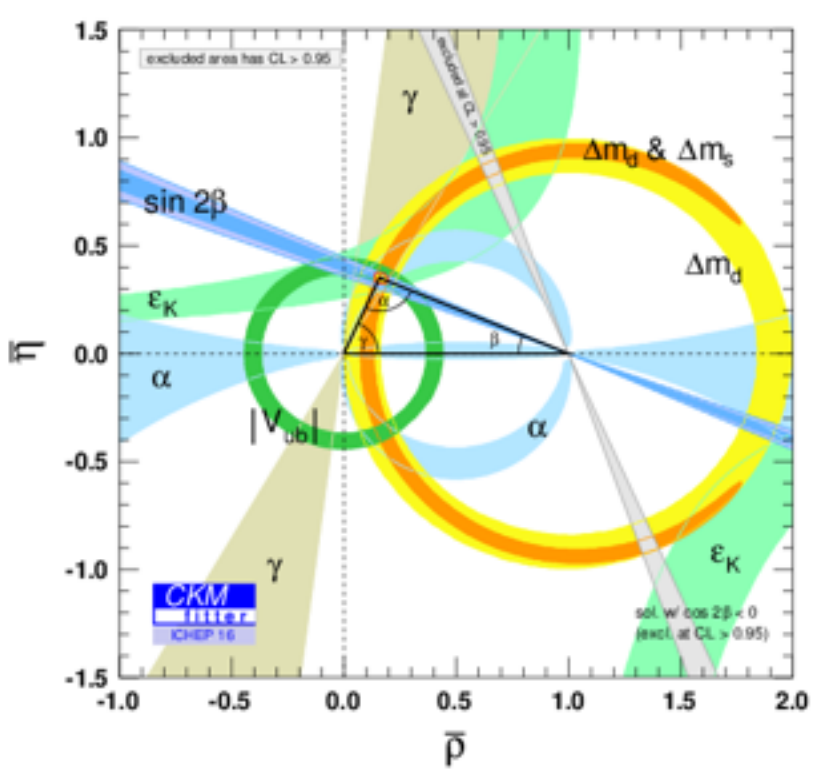
arXiv:1808.10567 (PTEP 2019)
Belle II Physics Book

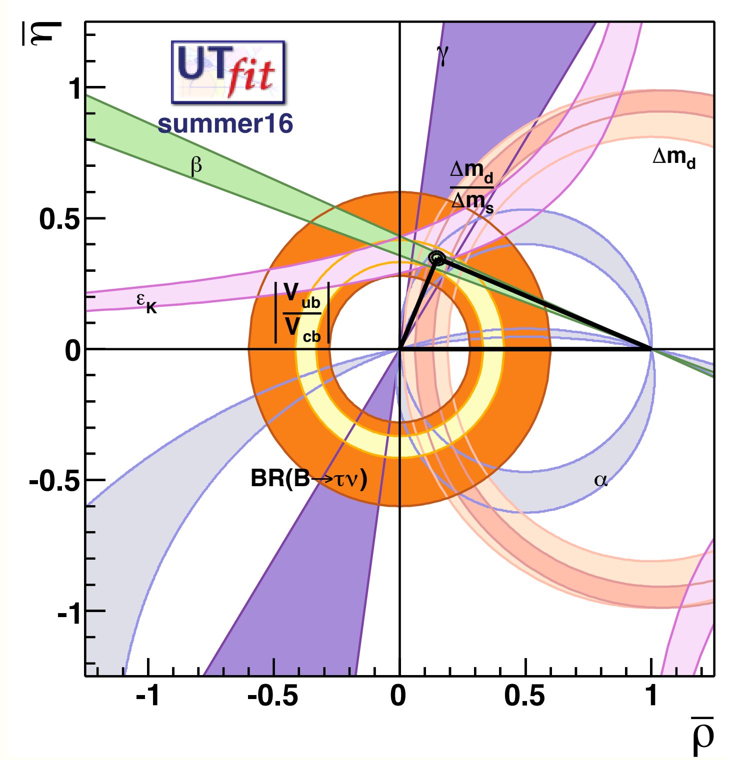
- High statistics data or detector upgrade allow us to explore new observables, (**w/wo theoretical motivation**), which have never been studied before!
  - ★ Null test
    - Unexpected CPV, LFV (e.g. $\tau \to \mu\gamma$), LFUV, Dark Photon, Axion etc…
  - ★ (Ultra)-rare decays
    - B->$\gamma\gamma$, K(*)$\nu\nu$ (start seeing them in a few yeas at Belle II!), baryon decays (more and more available at LHCb) etc…
  - ★ Angular/Dalitz distribution
    - Polarisation, CPV etc…
  - ★ New hadronic resonances
    - More XYZ, more Pentaquarks!

What is the odds for discovery: example of CKM unitarity triangle

The Unitarity triangle: test of Unitarity?

Can we expect a discovery of New Physics
with the Unitarity Triangle ?!

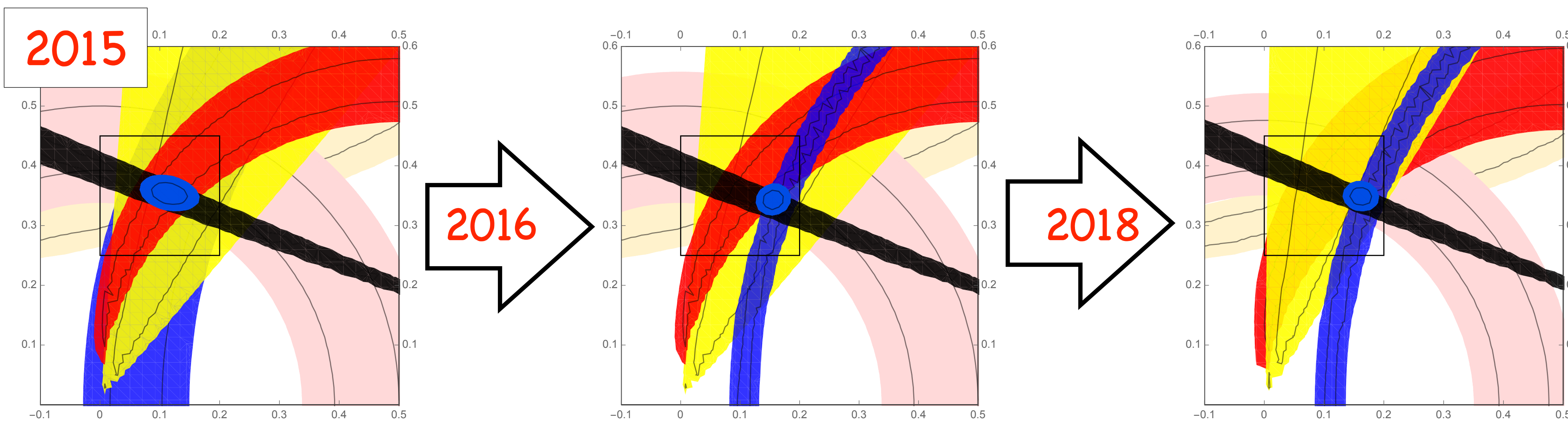




Future of the Unitarity Triangle

What do we expect to see in the future???

E.K. for B2TiP working group



Consistent with SM

New lattice result on ΔMs/ΔMd hadronic parameter: Consistent with SM

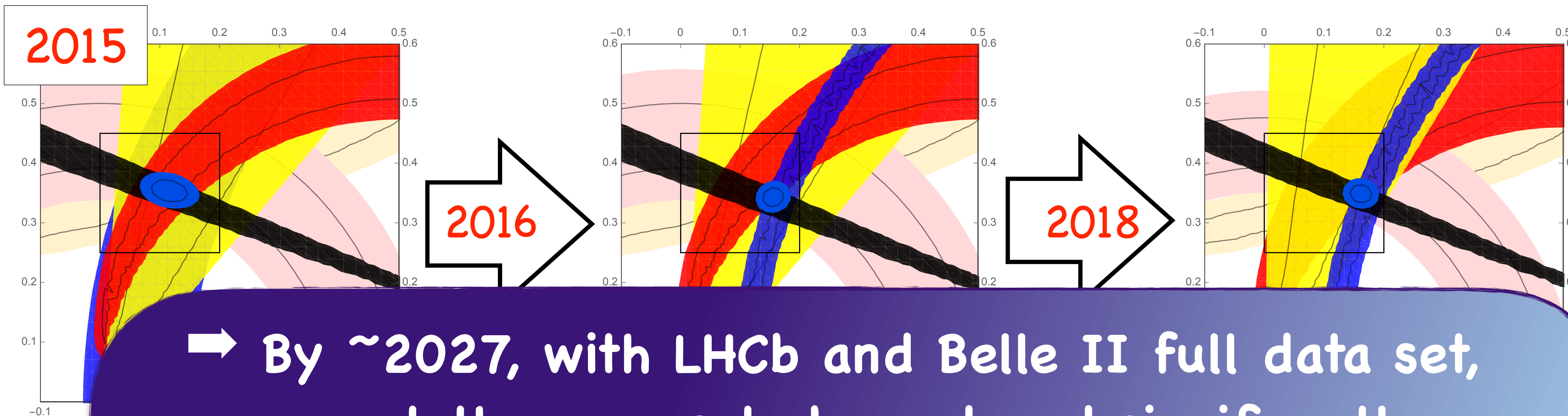
Latest average of the γ measurement of LHCb: Consistent with SM

Fermilab-MILK arXiv: 1602.03560
confirmed by RBC arXiv:1812.0879

Future of the Unitarity Triangle

What do we expect to see in the future???

E.K. for B2TiP working group



Con

➡ By ~2027, with LHCb and Belle II full data set, we expect the errors to be reduced significantly.

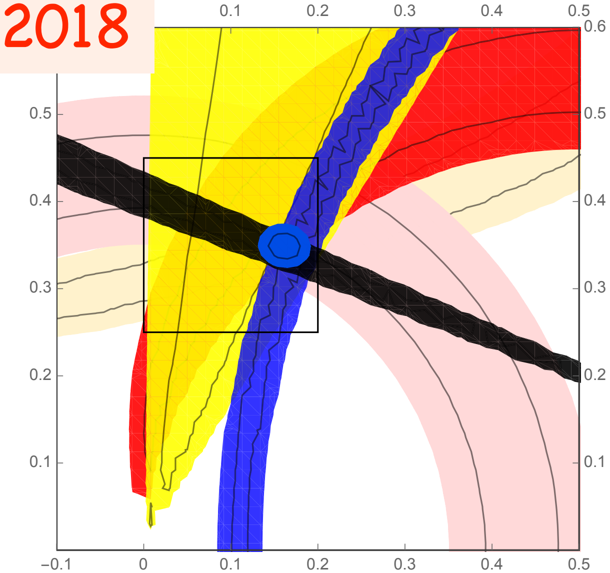
➡ Let's see what could happen when the error will go down to

$$\delta\phi_1\ (\delta\beta)=0.4^\circ,\ \delta\phi_2\ (\delta\alpha)=1^\circ,\ \delta\phi_3\ (\delta\gamma)=1.5^\circ,$$

$$\delta V_{ub}^{today}/\delta V_{ub}=1/2$$

Future of the Unitarity Triangle

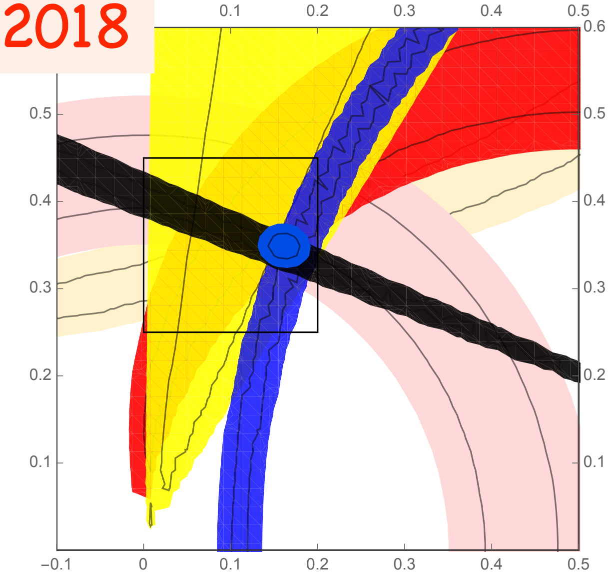
2018



Consistent with SM

Future of the Unitarity Triangle

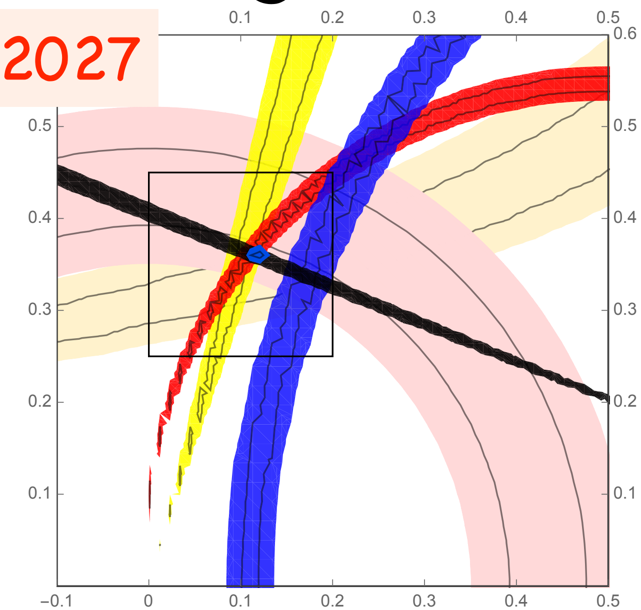
2018



Consistent with SM

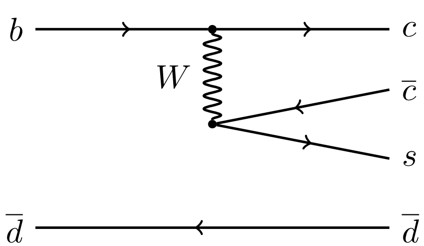
If the central value remains exactly the same (though unlikely)...

~2027



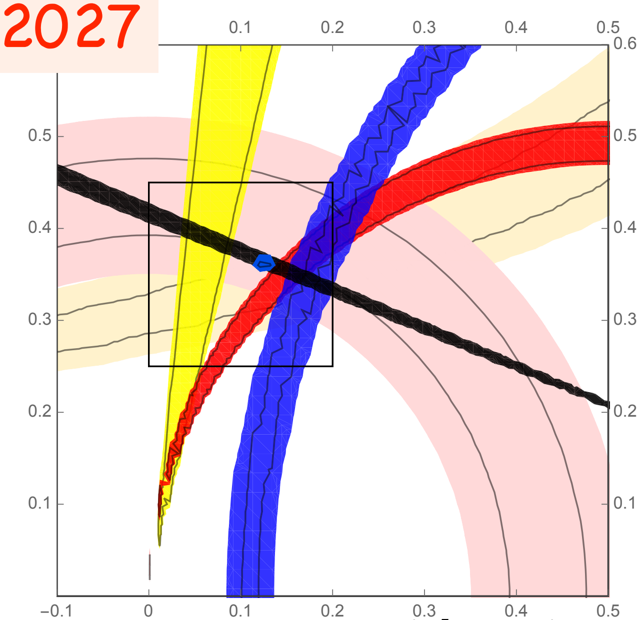
3.5σ effect (=SM???)

tree



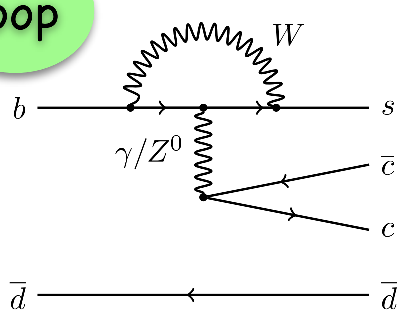
If 3 angles measurements move a little higher (within 1σ)...

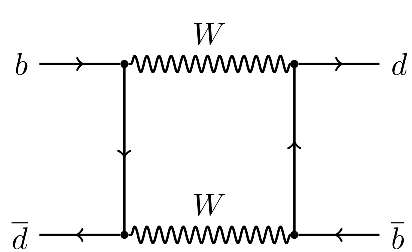
~2027



7σ effect (≠SM)!

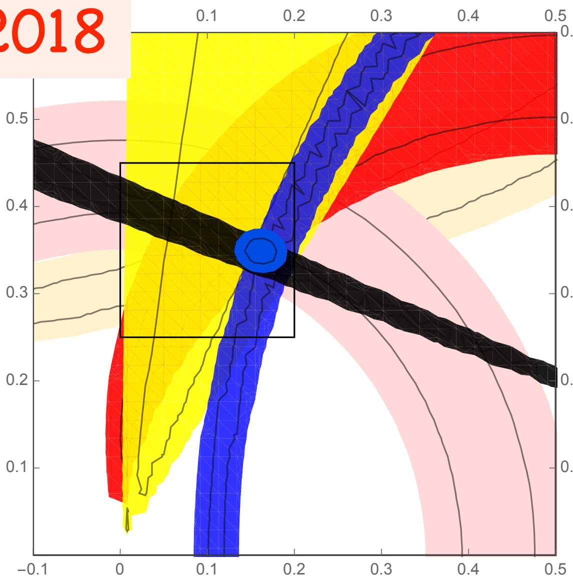
loop





Future of the Unitarity Triangle

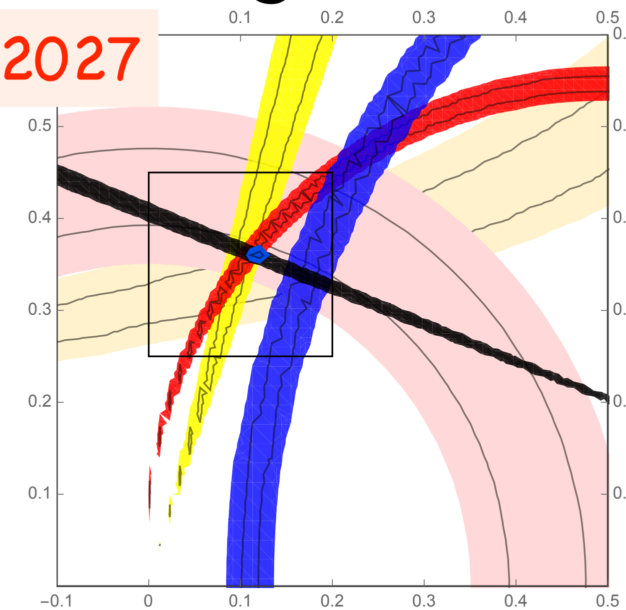
2018



Consistent with SM

If the central value remains exactly the same (though unlikely)...

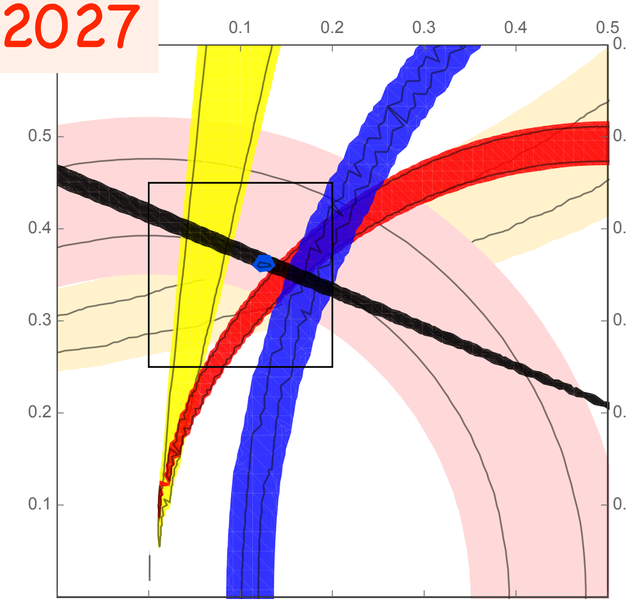
~2027



3.5σ effect (=SM???)

If 3 angles
...easurements
...a little
...within
...σ)...

~2027

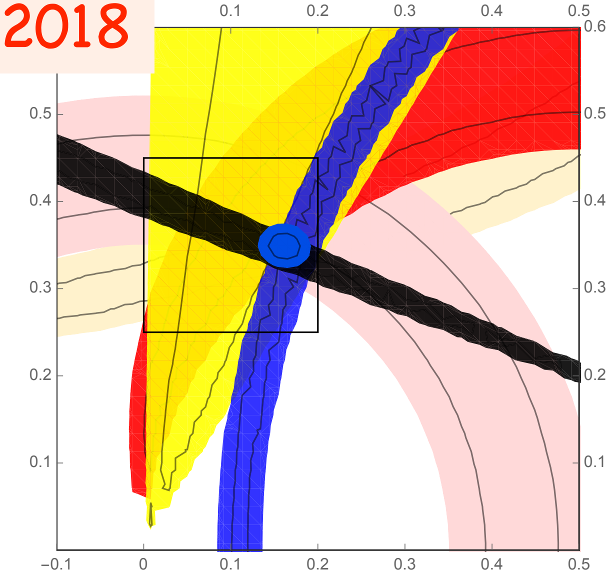


7σ effect (≠SM)!

Is this 7σ an "odd case" ???

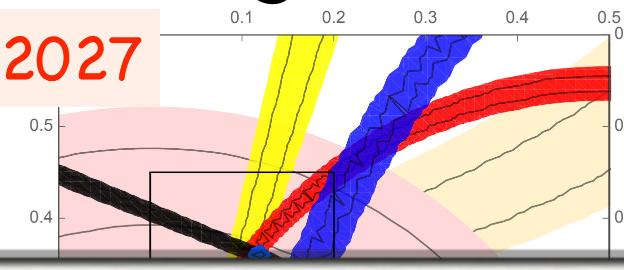
Future of the Unitarity Triangle

2018



Consistent with SM

~2027



If the central

- To understand this "7σ" effect better, we have run a Monte Carlo simulation.
- We randomly sample the central values (1000 trials) assuming Gaussian measurements and compute the significance.
- The result shows that **the chance to observe deviation more than 7σ significance is currently 20% !**

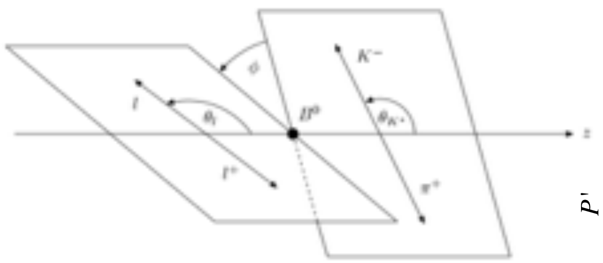
E.K. & F. Le Diberder for B2TiP working group

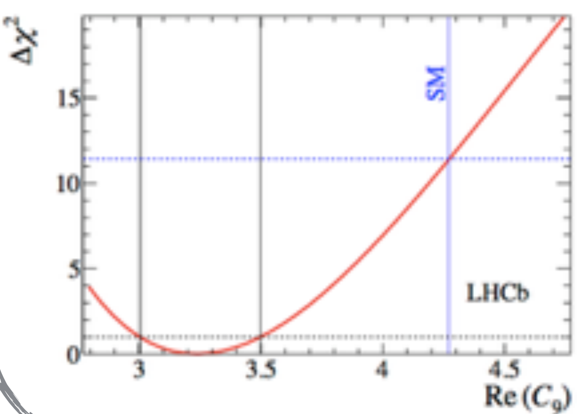
Is this 7σ
an "odd case" ?

Near future of flavour physics…

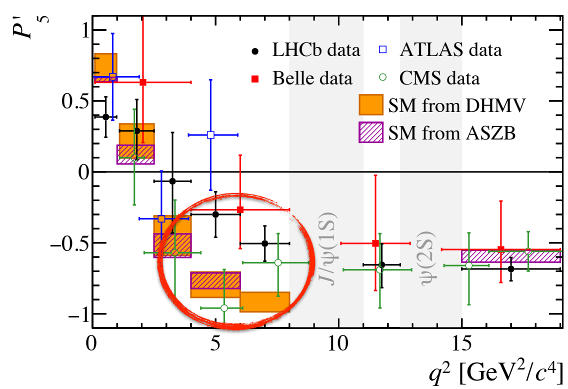
LHCb/Babar anomalies and theory?

B->K*μ+μ-: Re(C9) (~3-4σ)

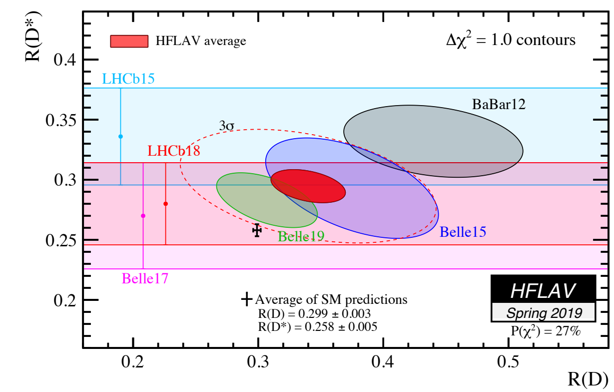




P5′

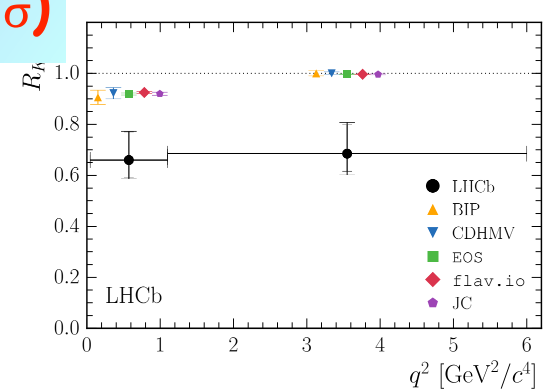


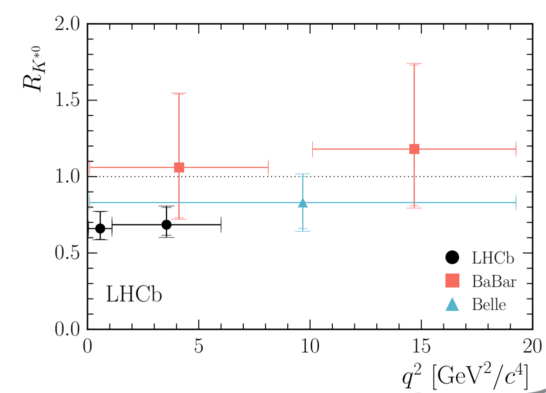
B->D*τν/B->D*τν: R(D*) (~3σ)



B->K*e+e-/K*μ+μ-: R(K*) (~2σ)

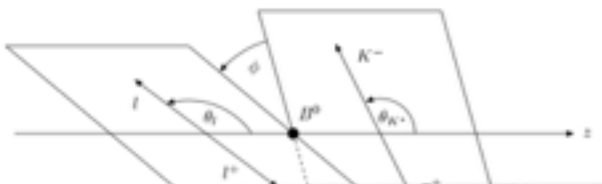
	low-q^2	central-q^2
$R_{K^{*0}}$	$0.66\ ^{+\ 0.11}_{-\ 0.07} \pm 0.03$	$0.69\ ^{+\ 0.11}_{-\ 0.07} \pm 0.05$
95.4% CL	[0.52, 0.89]	[0.53, 0.94]
99.7% CL	[0.45, 1.04]	[0.46, 1.10]





LHCb/Babar anomalies and theory?

B->K*μ+μ-: Re(C9) (~3-4σ)



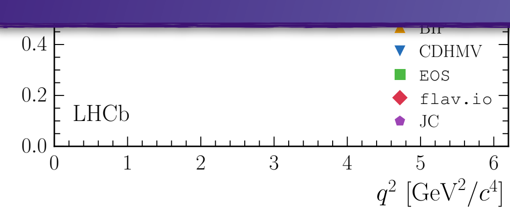
P5′

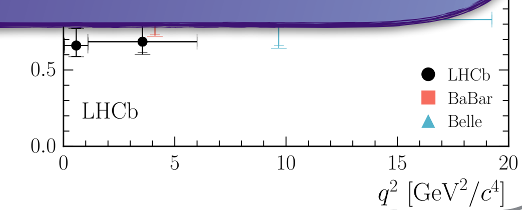
B->D*τν/B->D*τν: R(D*) (~3σ)

- Very convincing signals.
- SM uncertainties in B->K*μ+μ- to be further scrutinised.
- Many model independent studies (e.g. global fit of the effective couplings) are ongoing.
- The appearance of the anomaly implies a very "flavour/Dirac structure specific" new physics.

B-

95.4% CL	[0.52, 0.89]	[0.53, 0.94]
99.7% CL	[0.45, 1.04]	[0.46, 1.10]

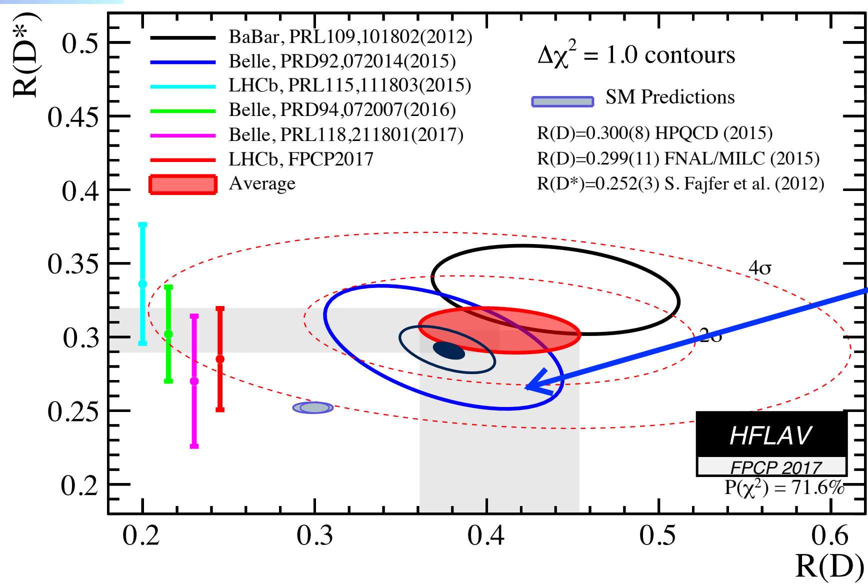




What Belle II could tell us?

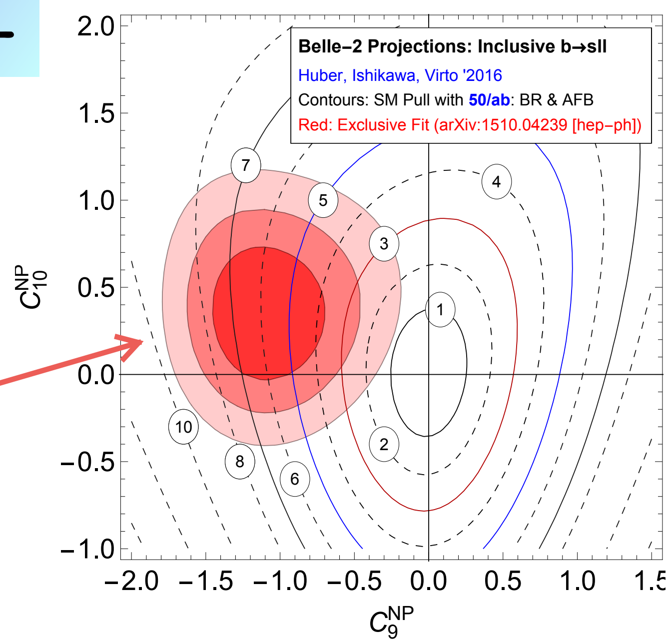
R(D^(*))

arXiv:1808.10567 (PTEP 2019)
Belle II Physics Book



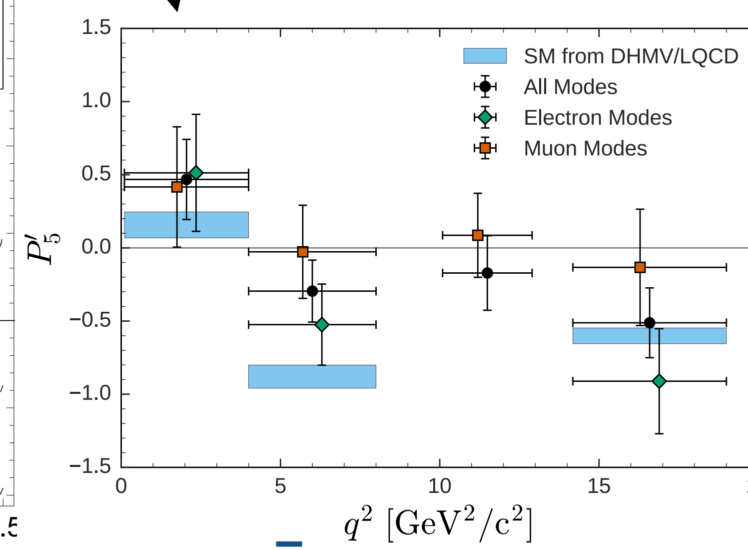
Belle II prospect
(with the current Belle '15 central value)
14(6)σ deviation with 50(10)ab^{-1} of data!

b->sμ+μ-/e+e-



Belle II confirmation
via inclusive channel.

High sensitivity both to
μ+μ-/e+e- channels



Conclusions

- The coming years are very exciting for flavour physics: the startup of Belle II and the upgrades of LHCb will improve the sensitivity to new physics drastically.
- Even for the processes, which were claimed in the previous generation experiment as "consistent to SM", may show some deviations. Many breakthrough towards "going beyond the SM" is possible!
- The LHCb anomalies are very intriguing. It was unexpected but many interpretations have been made. A confirmation by Belle II experiment can be done in a few years time (at ~10 ab^{-1}).
- Theoretically, what we are looking for seems to be "Flavour/Dirac structure specific", which may need be postulated to further construct new physics models.

Backup

Many contributions from theorists!!

Belle II physics book

arXiv:1808.10567 (PTEP 2019)
B2TiP theory community + Belle II collaboration
(edited by E.K. & Ph. Urquijo)

- **B physics** : CKM UT measurement, rare decays, CP violation, QCD-based computation
- **D physics** : CP violation, rare decays, multi-body decays

Belle II(/LHCb) precision vs theory uncertainties

» UT angle measurements (very clean): Belle II+LHCb will reduce the errors significantly $\delta\phi_1(\delta\beta)=0.2^\circ$, $\delta\phi_2(\delta\alpha)=1^\circ$, $\delta\phi_3(\delta\gamma)=1.5^\circ$, ⇨ theory can achieve about the same precision.

» Rare decays, hadronic B decays... ⇨ more difficult but data driven, more measurements could give us a guide.

Many contributions from theorists!!

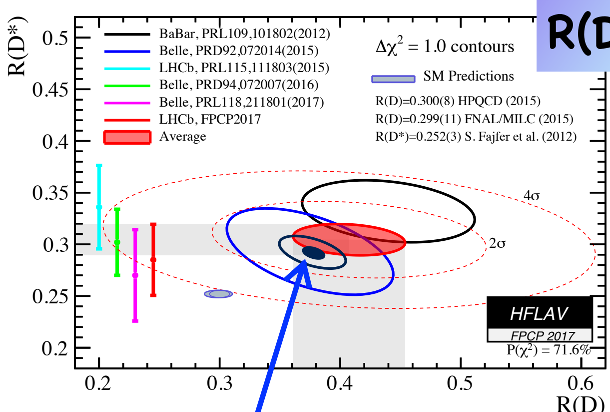
Belle II physics book

arXiv:1808.10567 (PTEP 2019)
B2TiP theory community + Belle II collaboration
(edited by E.K. & Ph. Urquijo)

- **B physics** : CKM UT measurement, rare decays, CP violation, QCD-based computation
- **D physics** : CP violation, rare decays, multi-body decays

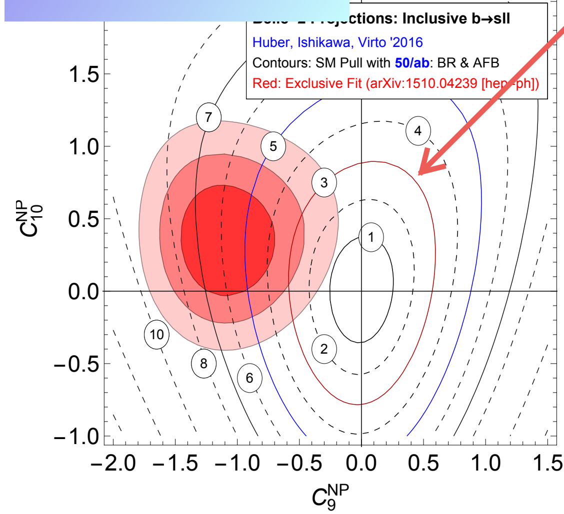
Will Belle II tell us something about LHCb anomalies?

R(D(*))



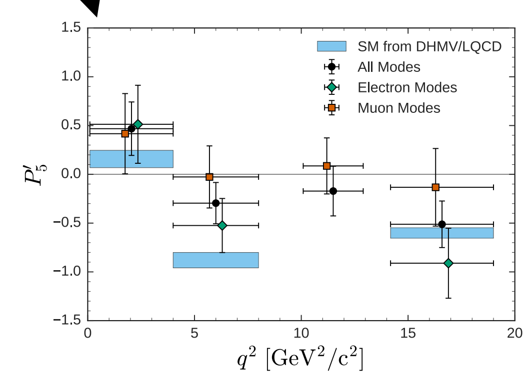
Belle II prospect
(with the current Belle central value)
14(6)σ deviation with 50(10)ab^{-1} of data!

b->sμ+μ-/e+e-



Belle II confirmation via inclusive channel.

A high sensitivity to e+e- channel



» Also observation of B->γγ, K(*)$\nu\bar{\nu}$ in a few years!

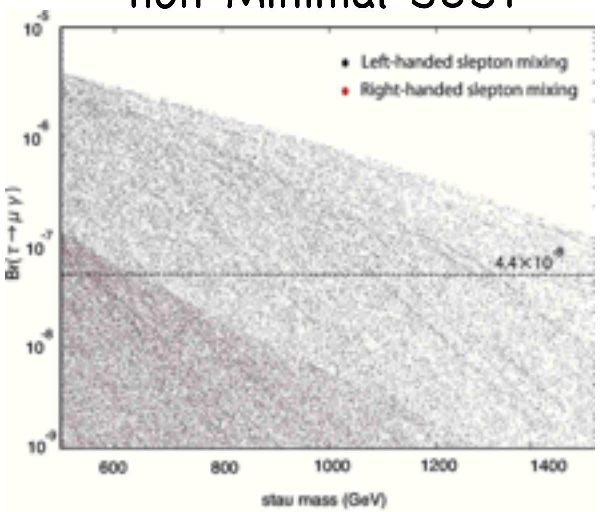
Many contributions from theorists!!

Belle II physics book

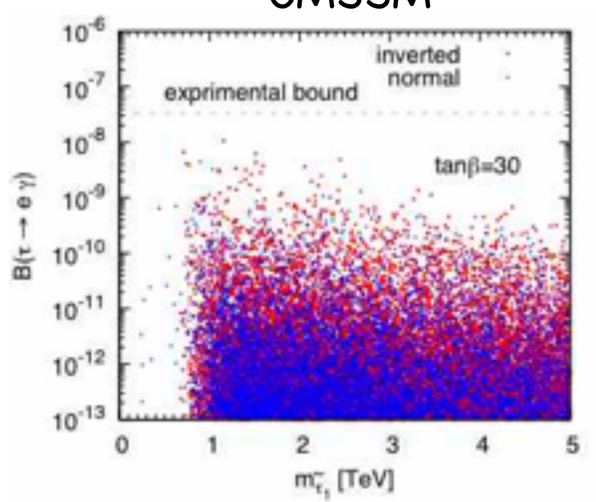
arXiv:1808.10567 (PTEP 2019)
B2TiP theory community + Belle II collaboration
(edited by E.K. & Ph. Urquijo)

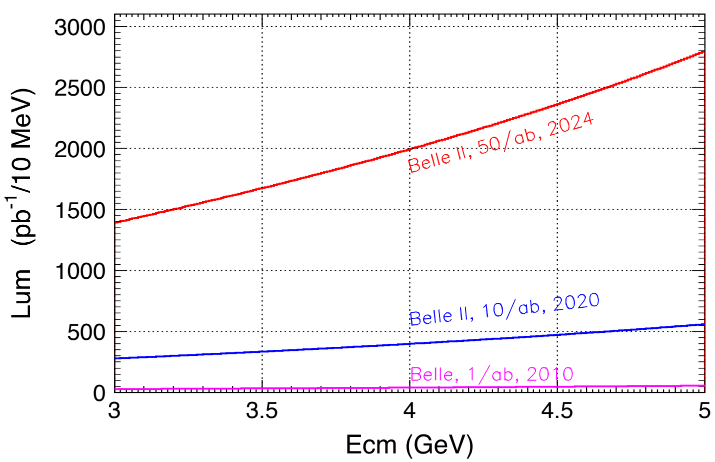
- **tau physics** : LFV, CP violation, a "wish list"...
- **g-2 related measurement** : hadronic cross section, two photon processes
- **quarkonium and exotics** : missing quarkonium (below threshold), pros and cons of the exotic interpretations

non-Minimal SUSY



CMSSM





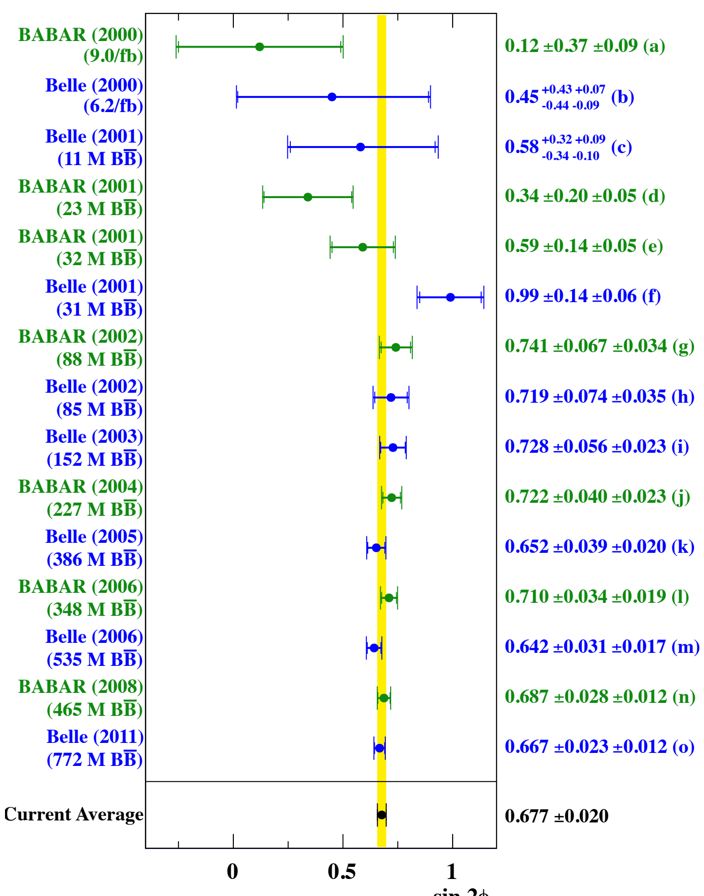
LFV τ-> μγ sensitivity to SUSY-GUT

ISR luminosity at Belle II

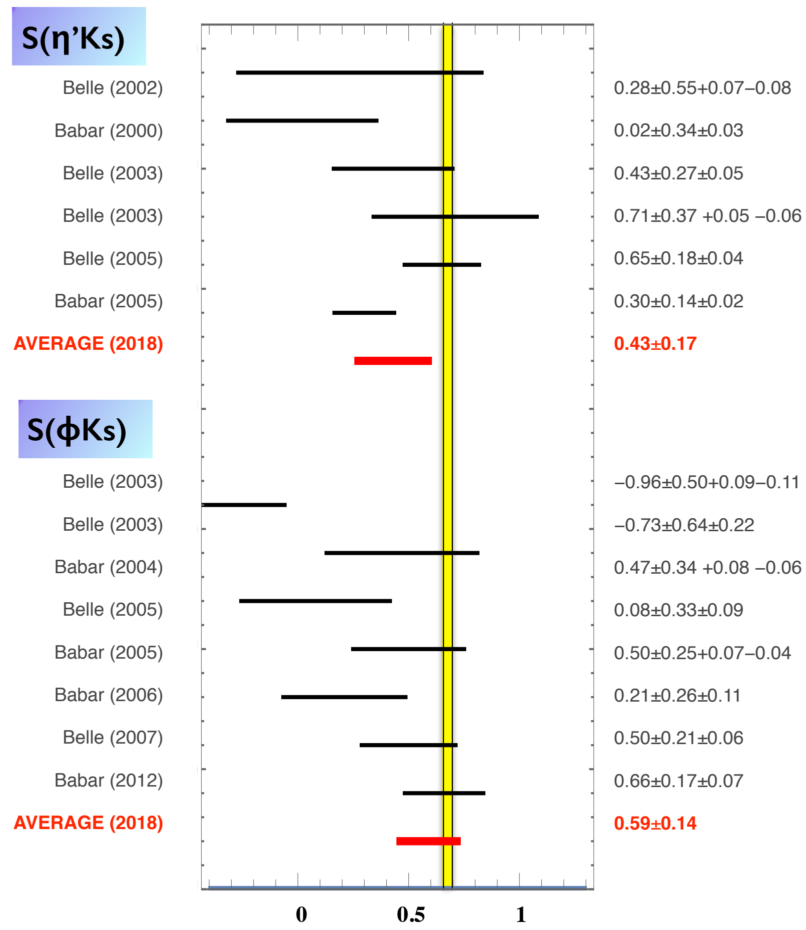
Yet, we(I) want more CPV…

- Those observables which are "consistent to SM" as of today are potential discovery channels!

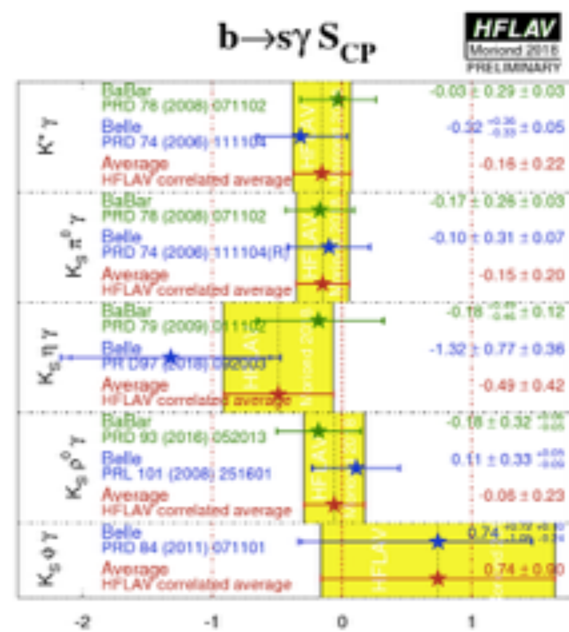
$\sin 2\phi_1$ from b->ccs (tree) decay



$\sin 2\phi_1$ from b->sss (penguin) decay



$\sin 2\phi_1$ from b->sγ (penguin) decay



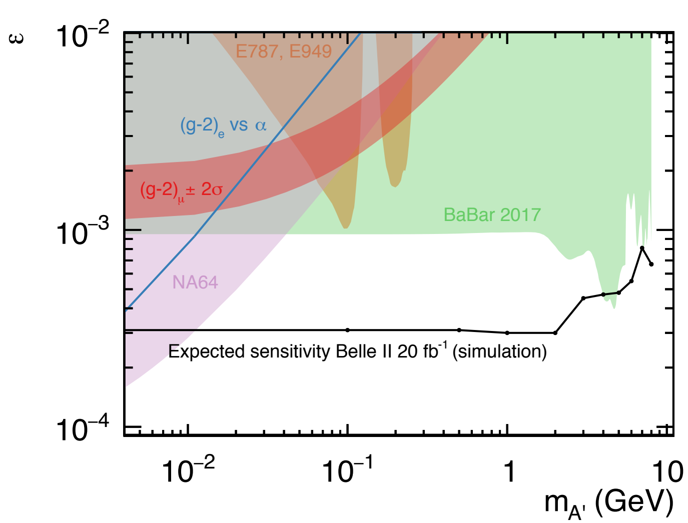
Many contributions from theorists!!

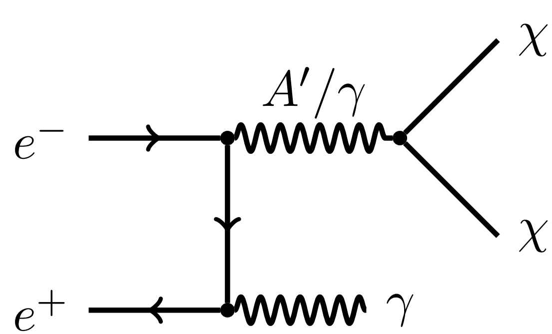
Belle II physics book

arXiv:1808.10567 (PTEP 2019)
B2TiP theory community + Belle II collaboration
(edited by E.K. & Ph. Urquijo)

- **Dark matter and Higgs** : dark photon search in phase II (2018), light Higgs search from quarkonium decays
- **Theory**: lattice "forecast", flavour benchmark models (and their "DNA test"), global fit packages

Dark Photon search at Belle II





Lattice forecast for Vub

$\mathcal{L}$ [ab^{-1}]	$\sigma_{\mathcal{B}}$ (stat±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

upper/down number: wo/w EM correction