Belle II Physics Prospects & Complementarity

Youngjoon Kwon
Yonsei Univ.

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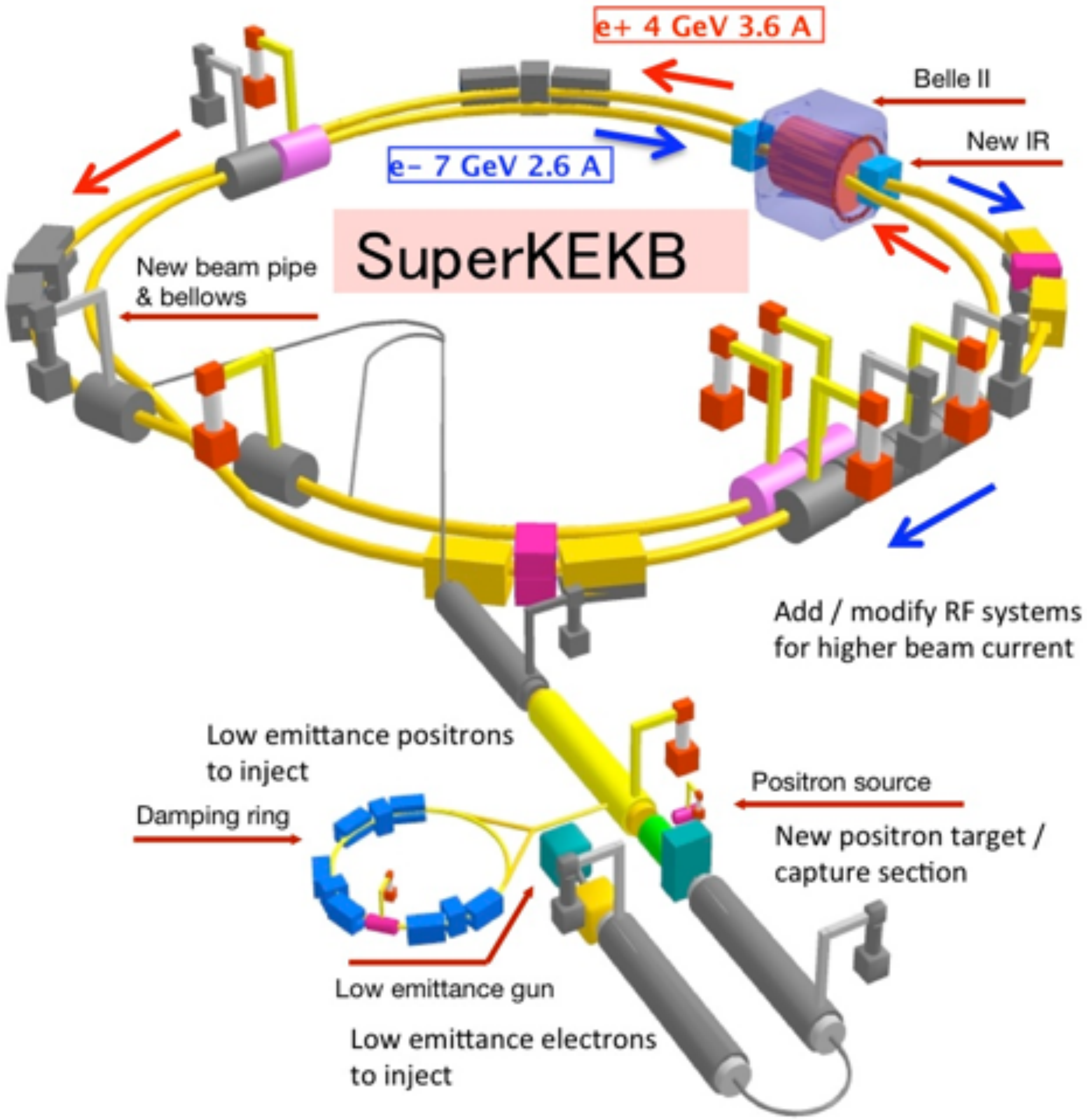
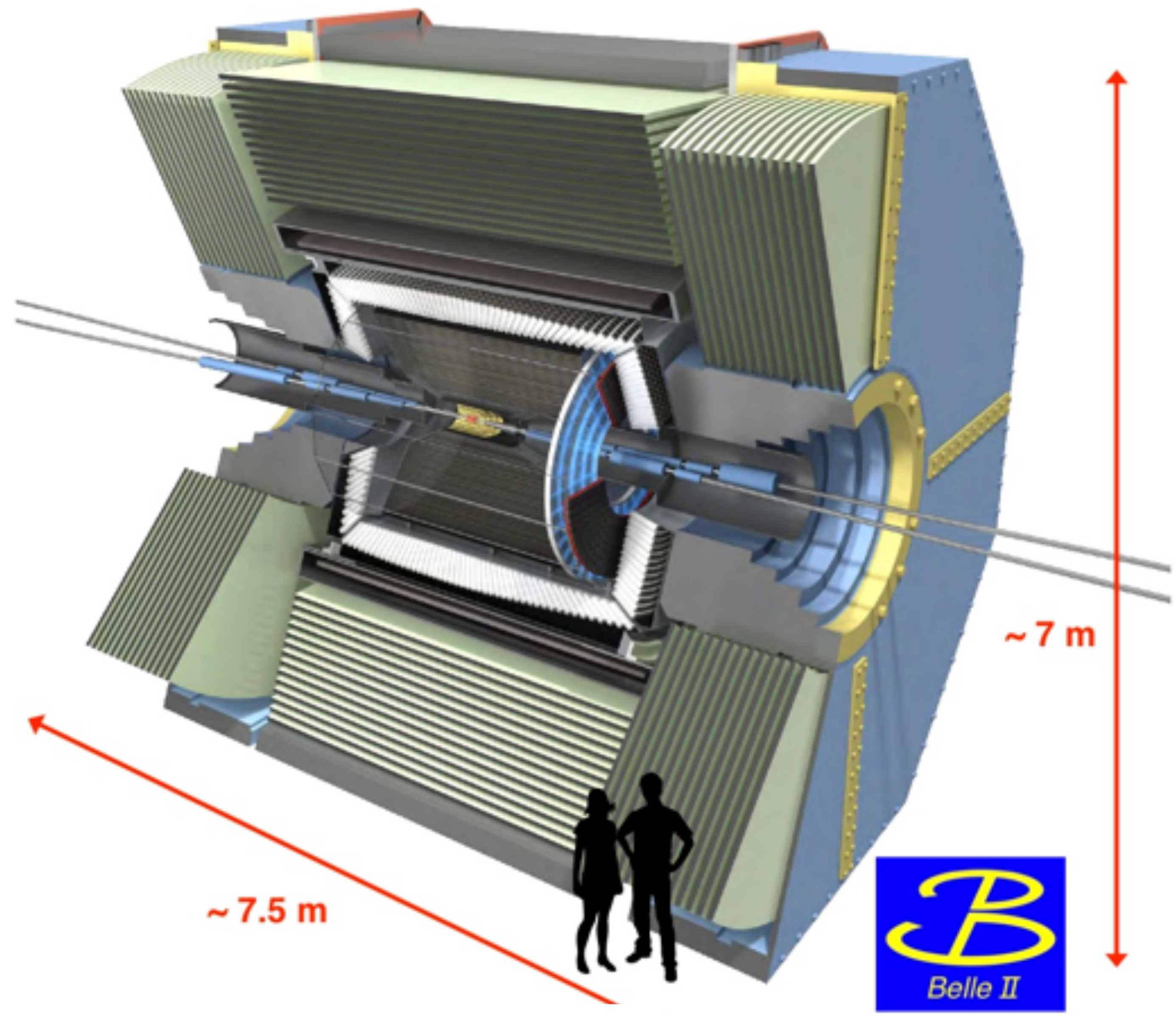
Outline

- Introduction -- the Intensity Frontier
- Strengths (unique features) of Belle II
- The driving questions for Belle II
- Conclusion

SuperKEKB & Belle II





$$\mathcal{L}_{\text{peak}} = 8 \times 10^{35} \text{cm}^{-2}\text{s}^{-1}$$

$$e^{-} \xrightarrow{\text{7 GeV}} (\star) \xleftarrow{\text{4 GeV}} e^{+}$$

$$\int^{\text{goal}} \mathcal{L}\, dt = 50 \text{ ab}^{-1}$$

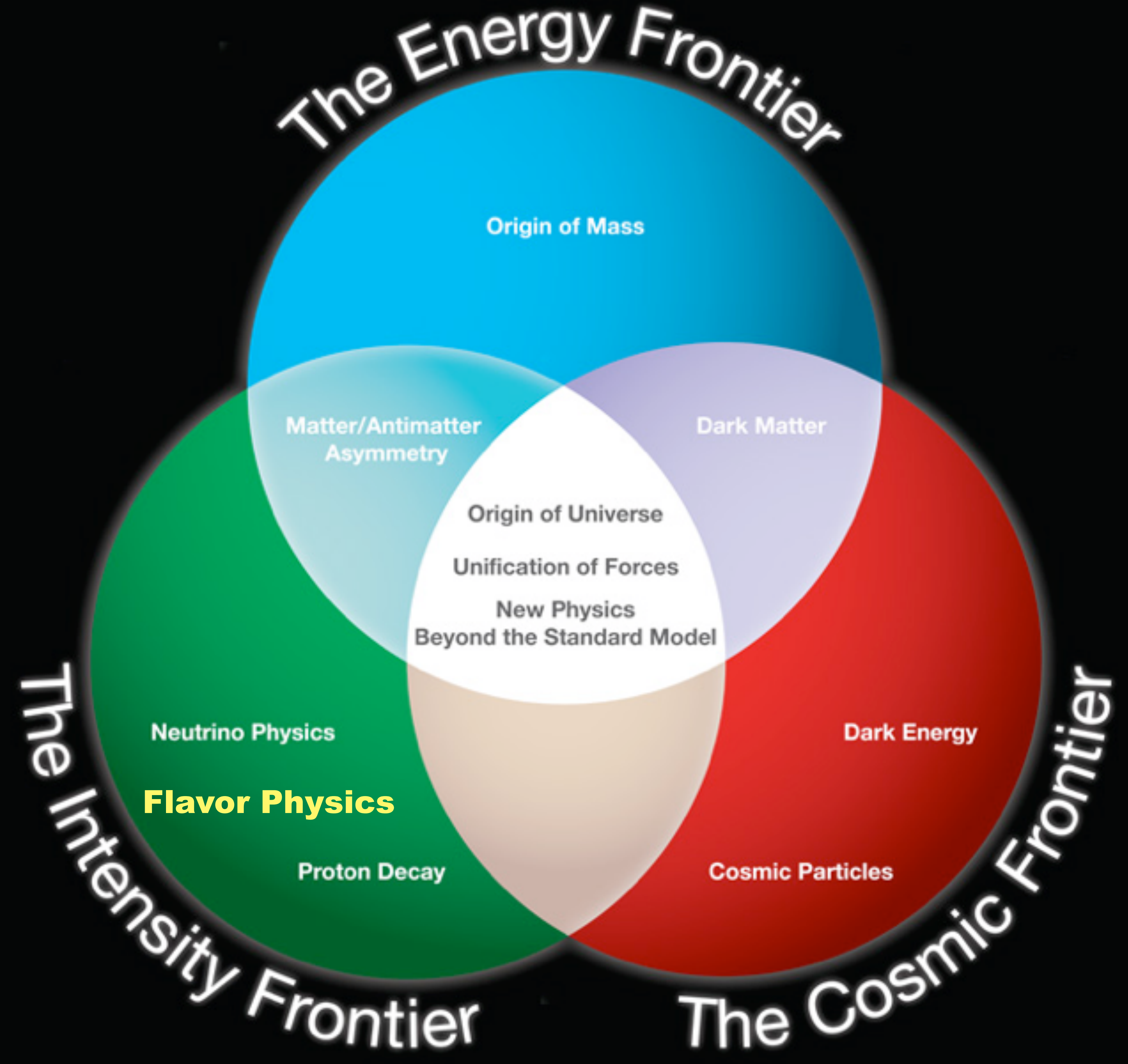
Expected data sample

Channel	Belle	BaBar	Belle II (per year)*
$B\bar{B}$	7.7×10^8	4.8×10^8	1.1×10^{10}
$B_s^{(*)}\bar{B}_s^{(*)}$	7.0×10^6	–	6.0×10^8
$\Upsilon(1S)$	1.0×10^8		1.8×10^{11}
$\Upsilon(2S)$	1.7×10^8	0.9×10^7	7.0×10^{10}
$\Upsilon(3S)$	1.0×10^7	1.0×10^8	3.7×10^{10}
$\Upsilon(5S)$	3.6×10^7	–	3.0×10^9
$\tau\tau$	1.0×10^9	0.6×10^9	1.0×10^{10}

Note: $\sigma_{b\bar{b}} \simeq \sigma_{c\bar{c}} \simeq \sigma_{\tau^+\tau^-}$

* assuming 100% running at each energy

The three frontiers



Past highlights from Intensity Frontier

a flavor physics hat trick!

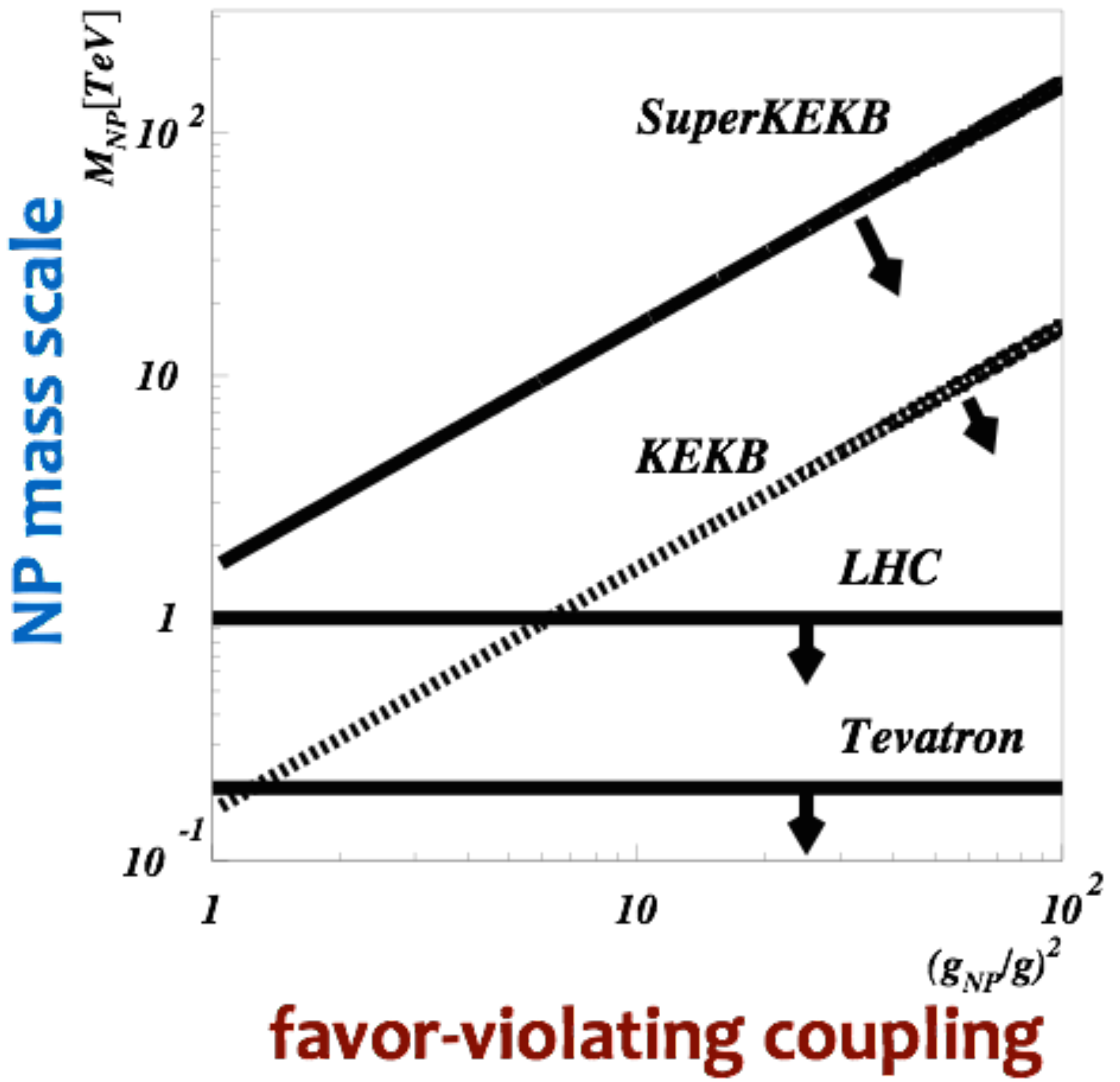
- suppression of $K_L^0 \to \mu^+\mu^-$ decays
  $\Rightarrow$ existence of charm quark by GIM mechanism
- $K^0\bar{K}^0$ oscillations, $B^0\bar{B}^0$ oscillations
  $\Rightarrow$ charm and top quark masses
- CPV in K^0 systems
  $\Rightarrow$ 3rd generation of quarks & KM mechanism

> "A special search at Dubna was carried out by E. Okonov and his group. They did not find a single $K_L \to \pi^+ \pi^-$ event among 600 decays into charged particles [12] (Anikira et al., JETP 1962). At that stage the search was terminated by the administration of the Lab. The group was unlucky."
>
> -Lev Okun, "The Vacuum as Seen from Moscow"

a lesson from history...

(1964) $\mathcal{B} = 2 \times 10^{-3}$

Energy vs. Intensity Frontier



- Intensity Frontier is **complementary** to the Energy Frontier
- If LHC finds NP
  - * precision flavor input is essential to further clarify those discoveries
- Even if no new NP is found
  - * high-statistics flavor sector measurements (on b, c, and τ) can provide beyond-TeV-scale probe for NP

The Intensity Frontier

- Explorers of the Intensity Frontier
  1) hadron machines, e.g. LHCb
  2) next generation flavor factories, e.g. Belle II @ SuperKEKB, or BESIII @ BEPC

- **LHCb**
  - ultra-high-statistics sample of B and B_s in all-charged modes

- **Belle II**
  - unique for final states with neutrinos or multiple photons (i.e. π^0)
  - also a good place to study charm, $\tau^+\tau^-$, $\Upsilon(nS)$
  - ***hermeticity*** is a great plus, too!

Belle II vs. LHCb

Observable	SM prediction	
$\lvert V_{us}\rvert$ $[K \to \pi\ell\nu]$	input	
$\lvert V_{cb}\rvert$ $[B \to X_c\ell\nu]$	input	Belle II
$\lvert V_{ub}\rvert$ $[B \to \pi\ell\nu]$	input	Belle II
γ $[B \to DK]$	input	LHCb/Belle II
$S_{B_d \to \psi K}$	$\sin(2\beta)$	Belle II/LHCb
$S_{B_s \to \psi\phi}$	0.036	LHCb
$S_{B_d \to \phi K}$	$\sin(2\beta)$	Belle II/LHCb
$S_{B_s \to \phi\phi}$	0.036	LHCb
$S_{B_d \to K^*\gamma}$	few $\times$ 0.01	Belle II
$S_{B_s \to \phi\gamma}$	few $\times$ 0.01	LHCb
$A^d_{\rm SL}$	-5×10^{-4}	Belle II/LHCb
$A^s_{\rm SL}$	2×10^{-5}	LHCb
$A_{CP}(b \to s\gamma)$	< 0.01	Belle II
$\mathcal{B}(B \to \tau\nu)$	1×10^{-4}	Belle II
$\mathcal{B}(B \to \mu\nu)$	4×10^{-7}	Belle II
$\mathcal{B}(B_s \to \mu^+\mu^-)$	3×10^{-9}	LHCb
$\mathcal{B}(B_d \to \mu^+\mu^-)$	1×10^{-10}	LHCb
$A_{\rm FB}(B \to K^*\mu^+\mu^-)_{q_0^2}$	0	LHCb
$B \to K\nu\bar{\nu}$	4×10^{-6}	Belle II
$\lvert q/p\rvert_{D-\rm mixing}$	1	Belle II
ϕ_D	0	Belle II
$\mathcal{B}(K^+ \to \pi^+\nu\bar{\nu})$	8.5×10^{-11}	
$\mathcal{B}(K_L \to \pi^0\nu\bar{\nu})$	2.6×10^{-11}	
$R^{(e/\mu)}(K \to \pi\ell\nu)$	2.477×10^{-5}	
$\mathcal{B}(t \to c\,Z,\gamma)$	$\mathcal{O}\left(10^{-13}\right)$	

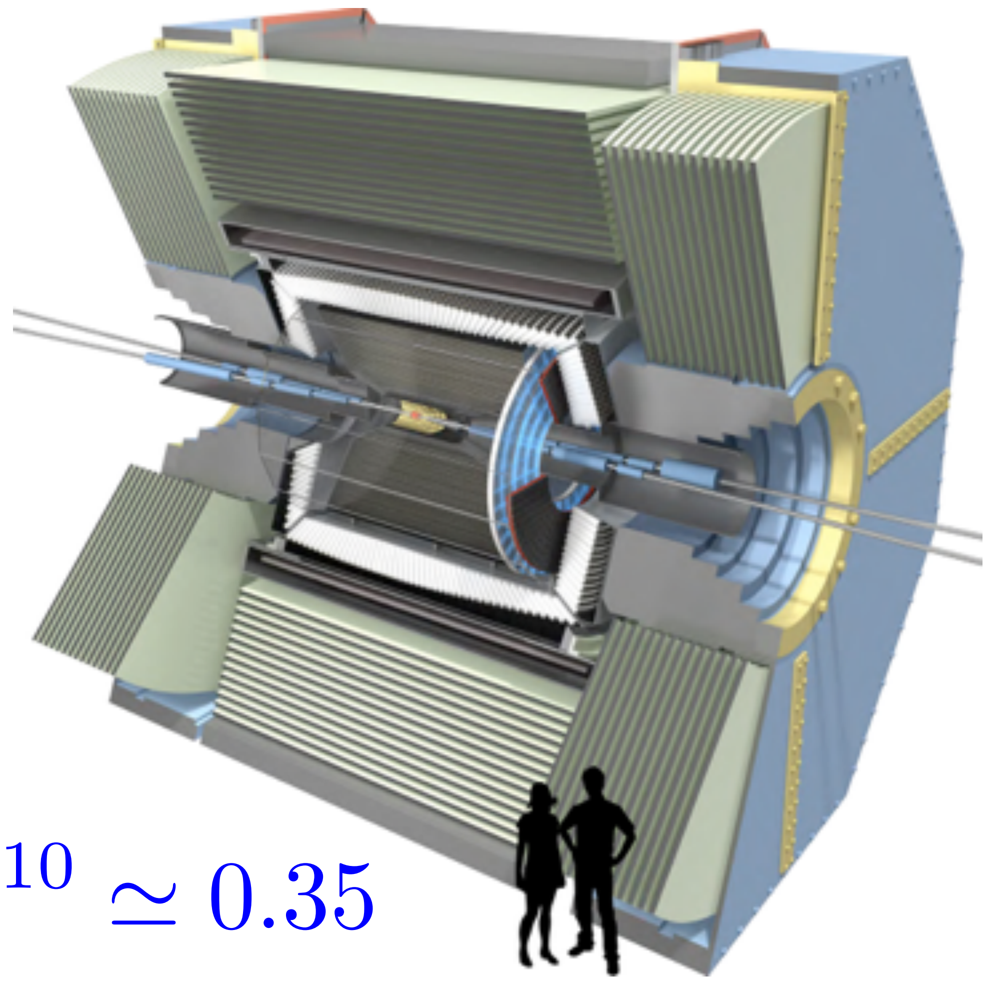
complementarity
(or competition!)
at a glance

adapted from

1. **Flavor Physics Constraints for Physics Beyond the Standard Model**
Gino Isidori (Frascati & TUM-IAS, Munich), Yosef Nir, Gilad Perez (Weizmann Inst.). Feb 2010. 33 pp.
Published in **Ann.Rev.Nucl.Part.Sci. 60 (2010) 355**

Strengths of Belle II

- **Full reconstruction of B**
  - * modes w/ multiple ν's
  - * inclusive measurements
- **Hermeticity**
  - * minimal trigger for, e.g. Dalitz analysis
  - * precision τ measurements
- **Neutral particles** π^0, K_S^0, K_L^0
  - * and for η, η', ρ^+, etc.
- *other notable features*
  - * good PID for both $\mu^\pm$ and $e^\pm$
  - * high flavor-tagging efficiency
    - (×15 better than LHC)



$0.9^{10} \simeq 0.35$

Belle II covering ≳90% of 4π, and ⟨N(track)⟩ ~ 10 per event

Production of B in Belle(II)

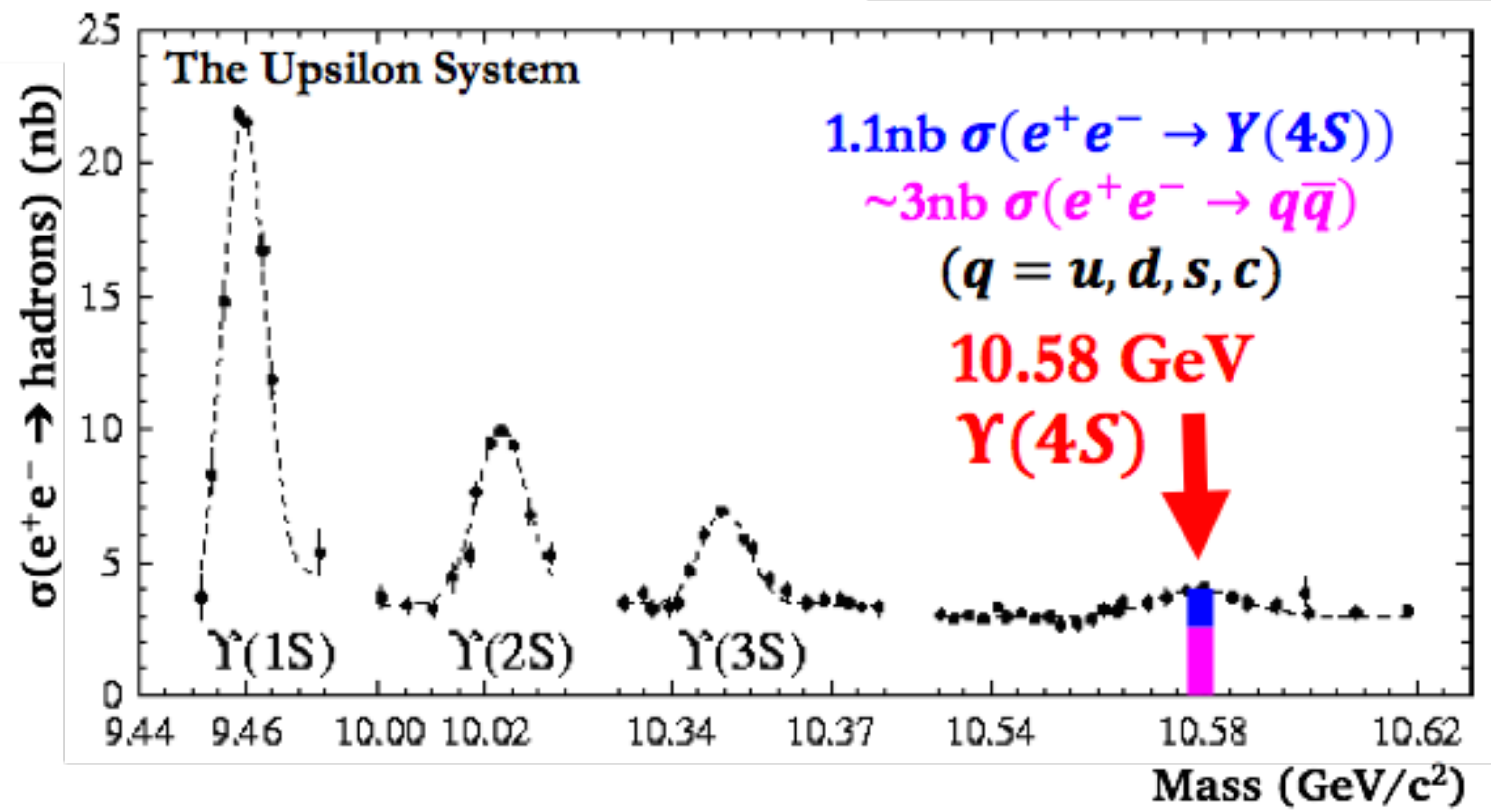
- making B's at hadron colliders (e.g. LHCb)
  - huge number of B mesons are produced, but
  - no info. on p^{μ}_{B}, unless you actually reconstruct the B meson

    $\Rightarrow$ will be of little use for modes with invisible particle(s)
- making B's at $e^{+}e^{-}$ colliders with $\sqrt{s} = m(\Upsilon(4S))$
  - a moderate number of B mesons are produced
  - $E_B = \sqrt{s}/2 \ \sim 5.29$ GeV ; $|\vec{p}_B| \sim 0.35$ GeV/c
  - but.. direction of $\vec{p}_B$?

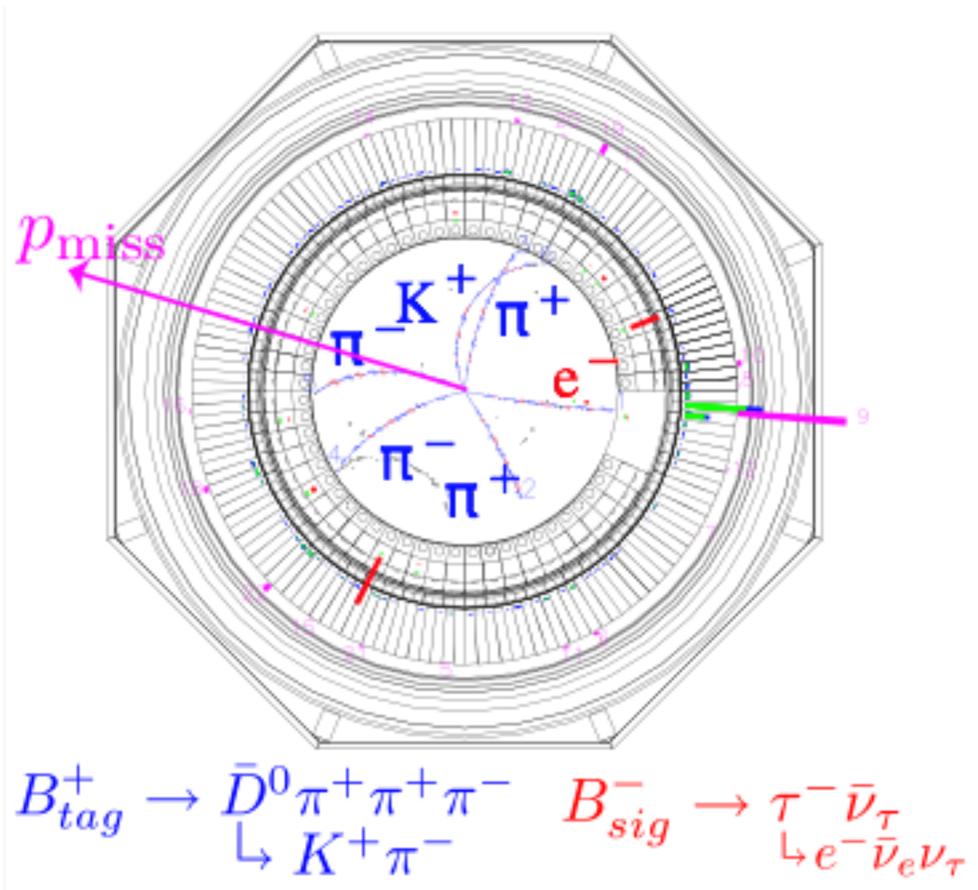
- $\mathcal{B}(\Upsilon(4S) \to B\bar{B}) > 96\%$

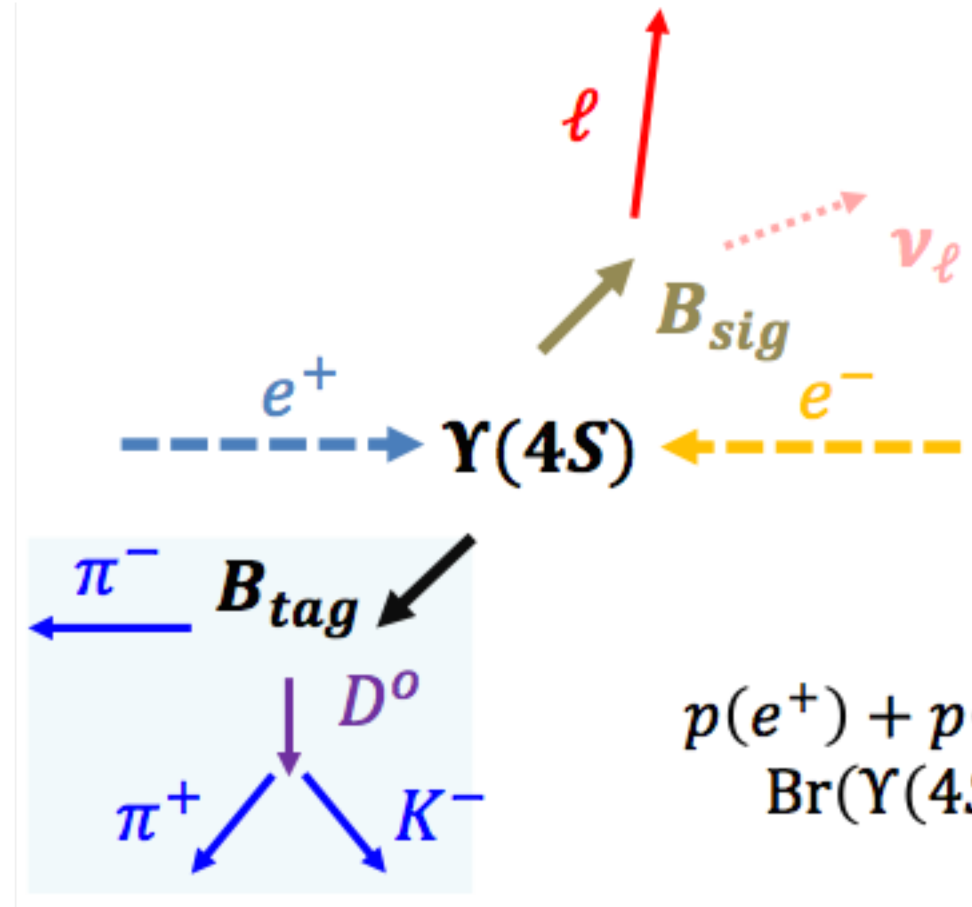
  $\Rightarrow$ nothing but $B\bar{B}$ in the final state

  $\therefore$ if we know $(E, \vec{p})$ of one B, the other B is also constrained



Full reconstruction of B

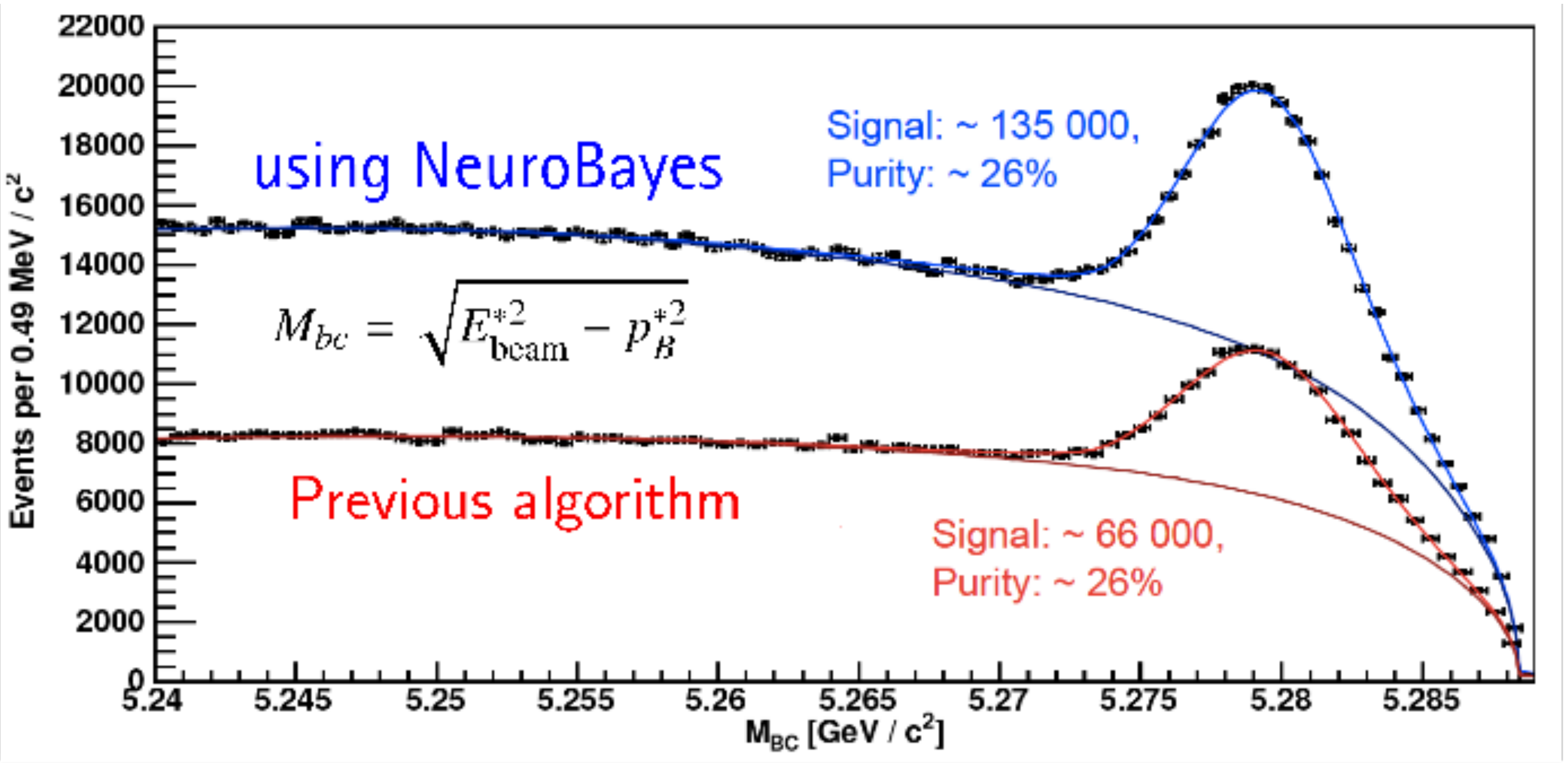




$$p(e^+) + p(e^-) = p(B) + p(\bar{B})$$
$$\mathrm{Br}(\Upsilon(4S) \to B\bar{B}) > 96\%$$

- Exploit the reaction process $e^+e^- \to \Upsilon(4S) \to B_{\rm tag}\bar{B}_{\rm sig}$
  - * full reconstruction of $B_{\rm tag}$ decay chain, and
  - * constrain the $(E, \vec{p})$, charge, flavor, etc. of $B_{\rm sig}$

Full recon. of *B*, *ever improved!*

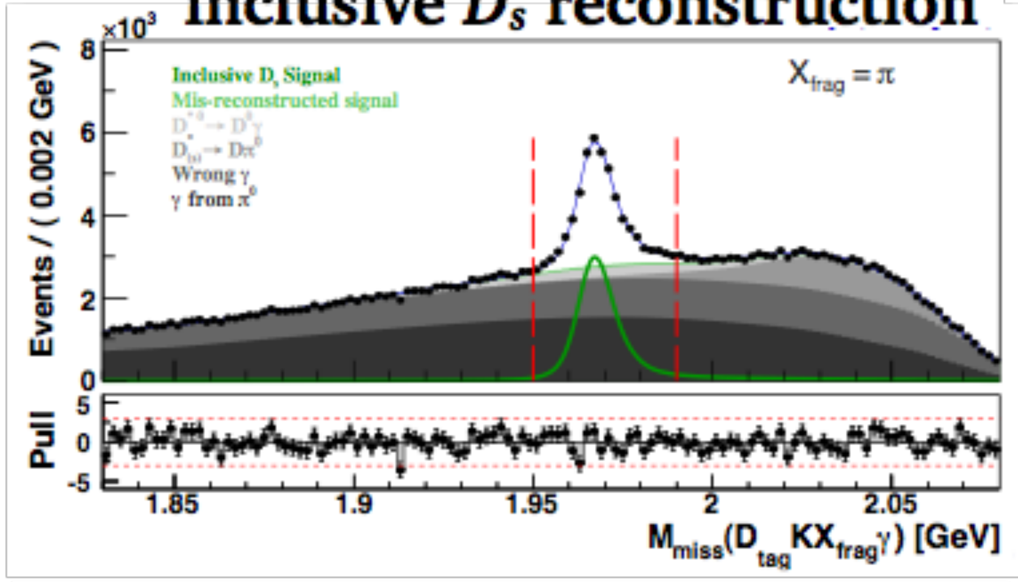


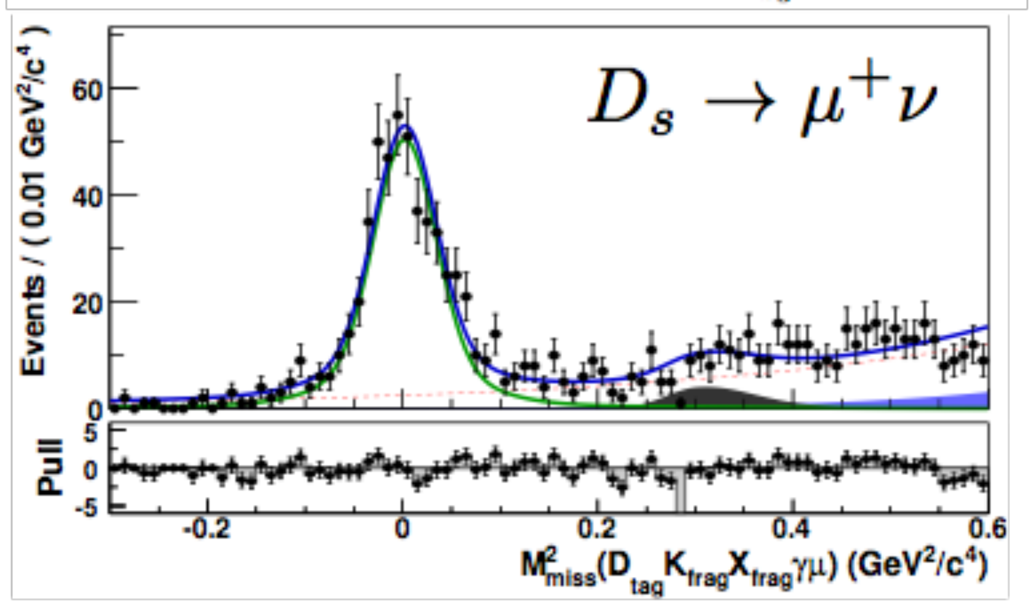
- **"NeuroBayes"** M. Feindt et al., NIM A 654, 432 (2011)
  - ∗ a novel method of *B* full recon. with neural network
  - ∗ the NN output is interpreted as Bayesian probability of truth
- of great use for $B \to \tau^+\nu,\ \ell^+\nu,\ \nu\bar{\nu},\ X\ell^+\nu,\ X_{s,d}\gamma$, etc.

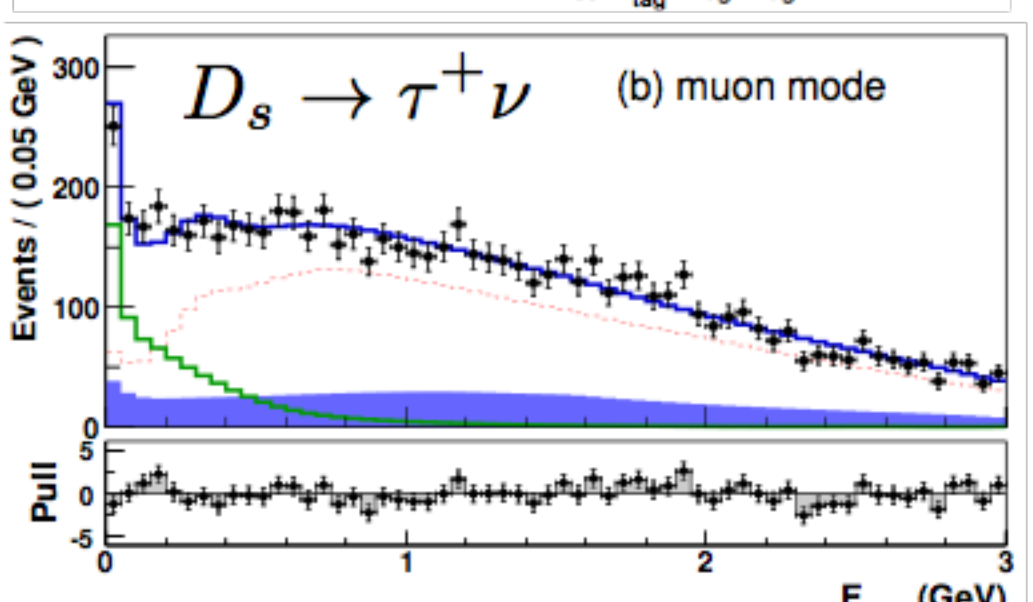
Full-recon. for charm

JHEP 09 (2013) 139

inclusive D_s reconstruction







- Recoil method in $c\bar{c}$ events: $e^+e^- \to c\bar{c} \to \overline{D}_{\rm tag}\, K\, X_{\rm frag}\, D_s^{*+}$ $(D_s)\gamma$
- Inlcusive D_s for normalization

  $\Rightarrow$ use missing mass: $M_{\rm miss}(\overline{D}_{\rm tag}\, K\, X_{\rm frag}\, \gamma)$

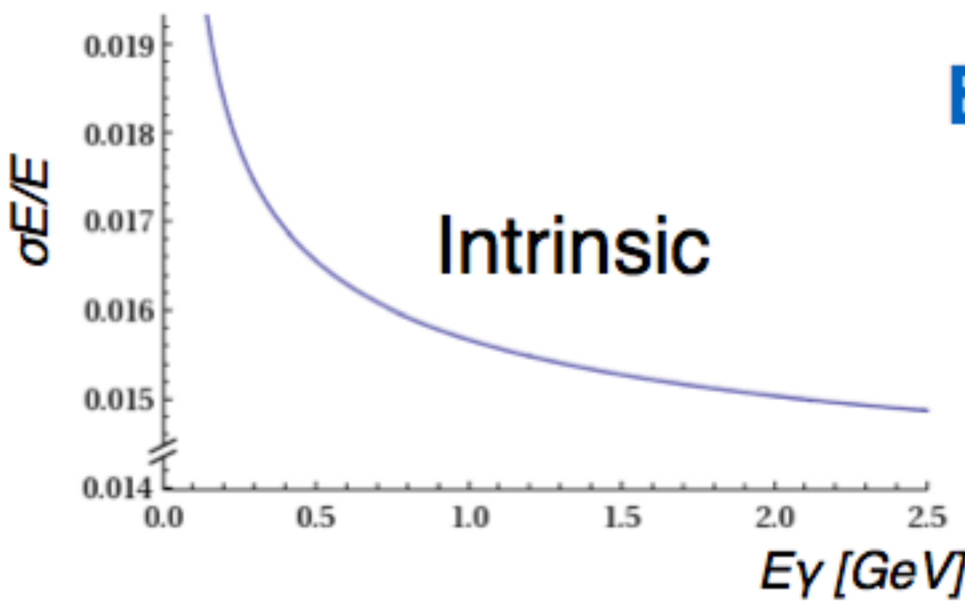
	Statistical	Systematic reducible	Systematic irreducible	Total
$\mathcal{B}(D_s \to \mu\nu)$				
913 fb^{-1}	5.3	0.0	3.8	6.5
5 ab^{-1}	2.3	1.6	0.0-0.9	2.9
50 ab^{-1}	0.7	0.5	0.0-0.9	0.9-1.3
$\mathcal{B}(D_s \to \tau\nu)$				
913 fb^{-1}	3.7%	4.4%	3.5%	6.8%
5 ab^{-1}	1.6%	1.9%-2.3%	3.5%-2.2%	3.5%-4.3%
50 ab^{-1}	0.5%	0.6%-0.7%	3.5%-2.2%	2.3%-3.6%

- more modes to explore with this method
  - * $D^0 \to \nu\bar{\nu}$: sensitive to new scalar particles (DM, etc.)
  - * $D^0 \to \gamma\gamma$: expect to reach $\mathcal{O}(10^{-7})$ sensitivity
    $\Rightarrow$ measure of the long distance contributions to the $\mu^+\mu^-$ mode

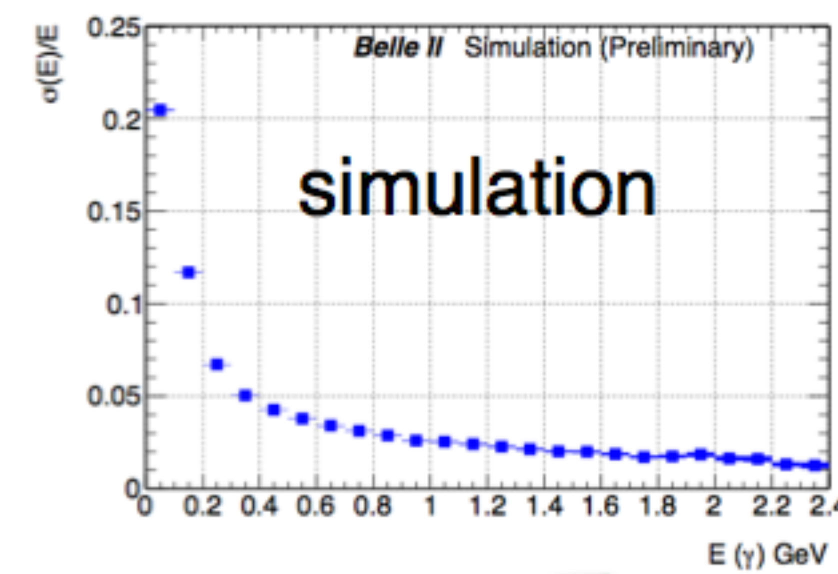
Neutral particles @ Belle II

- Much fewer background photons than in hadron collider
- Higher performance calorimeter
- Much less material in front (esp. good for electrons)

Belle



+ Material effects (& not optimised for waveform sampling)

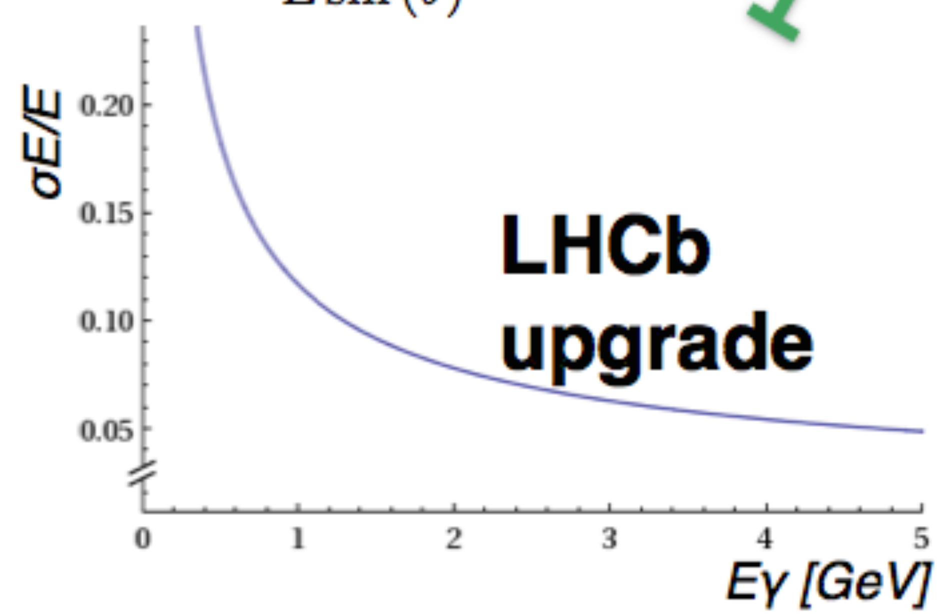


LHCb

$$\frac{\sigma(E)}{E} = \frac{10\%}{\sqrt{E(\text{GeV})}} \oplus 1.5\% \oplus \frac{0.0025 \times \text{RMS}}{E\sin(\theta)}(\text{Pile}-\text{up}) \oplus \frac{0.01}{E\sin(\theta)}(\text{Noise})$$

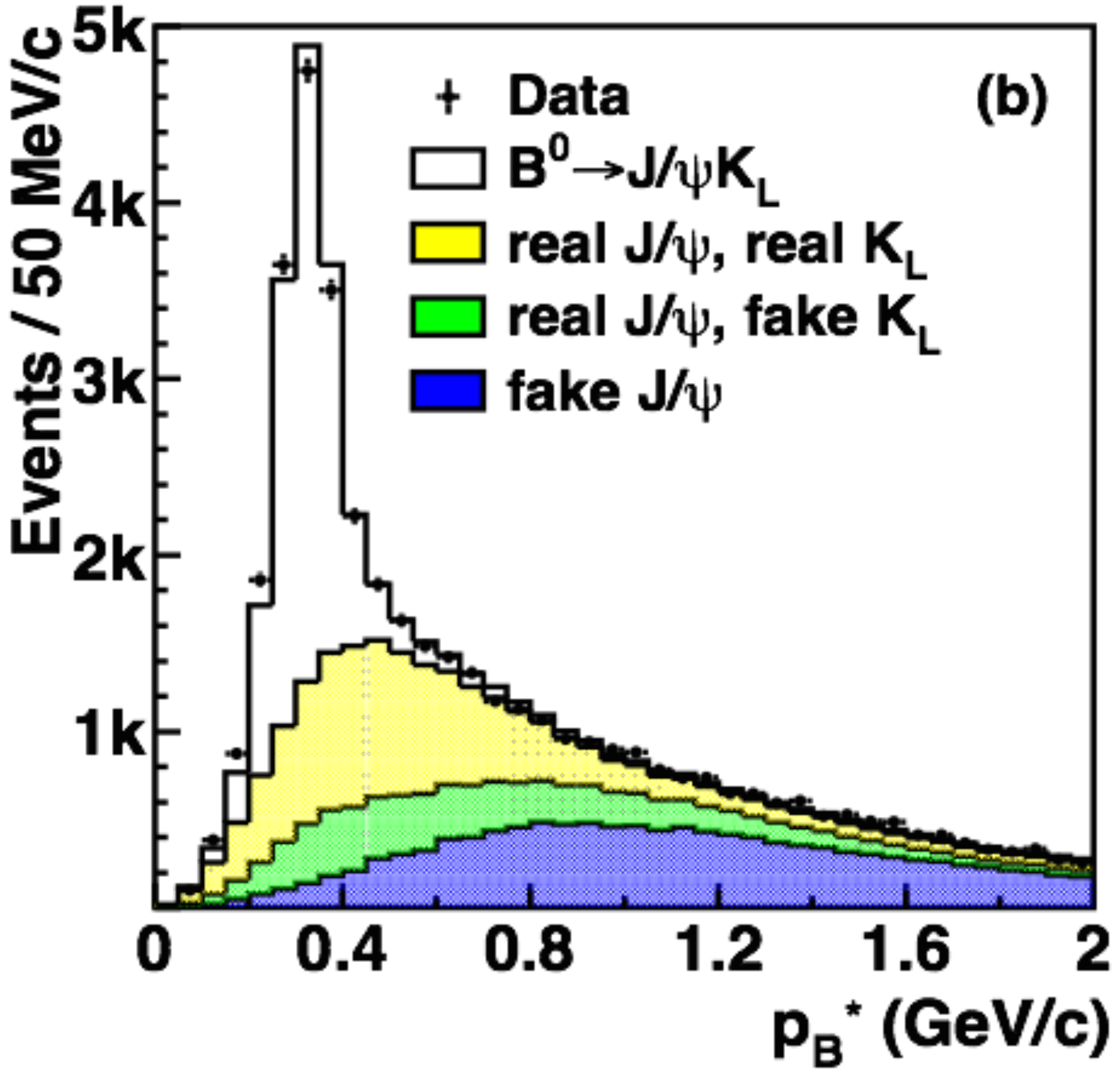
Noise+Pileup

$\mathcal{L}(cm^{-2}.s^{-1})$	2×10^{32}		10^{33}	
Resolution	Total	Pile-up	Total	Pile-up
$B \to D^*(D\gamma)K$	7.4%	4.7%	14.3%	13.1%
$B \to \phi\gamma$	2.3%	0.5%	2.7%	1.5%



Neutral particles @ Belle II

Strengths of Belle II



$B \to J/\psi K_L^0$ signal from full Belle sample

Even K_L is not a problem at all, for Belle II
➔ provide a test of consistency with K_S and K_L modes

impossible mission @ LHC

better S/B in Belle II is expected, due to
(1) using scintillators in the end caps and inner barrel layers ➔ higher efficiency and reduced neutron background
(2) using a prompt timing cut in RPCs and scintillators ➔ reduced neutron background.

Driving questions for Belle II

(1) **Are there any new CPV phases?**

(2) **Any right-handed currents from NP?**

(3) **Quark FCNC beyond the SM? New operators with quarks enhanced by NP?**

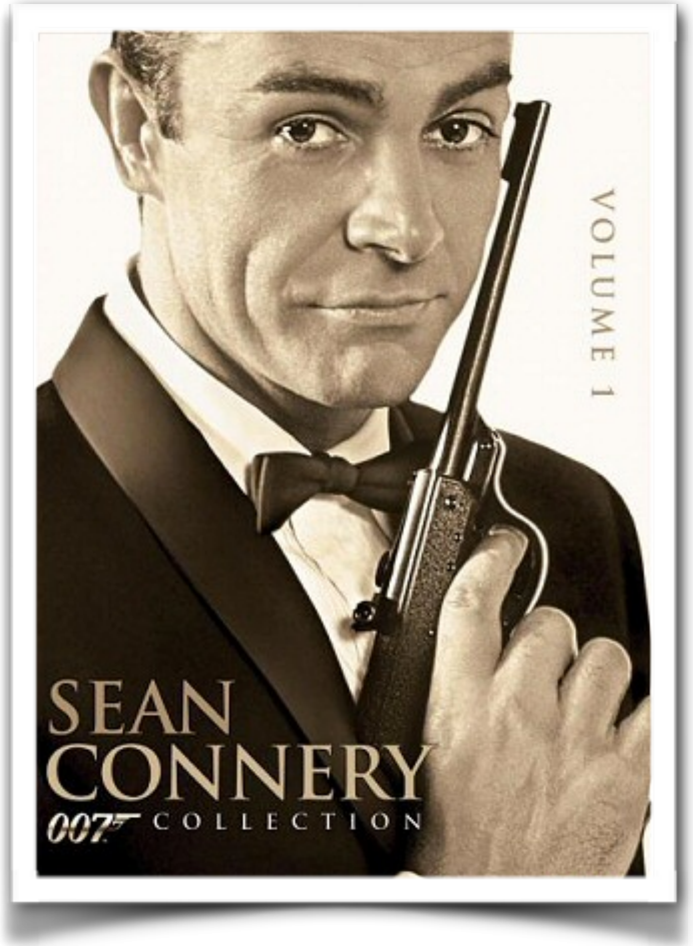
(4) **Sources of LFV from NP?**

(5) **Any more higgs? (e.g. H^+)**

(6) **Understanding exotic QCD states?**

(7) **Hidden dark sector?**

… just listing 007 such questions …*

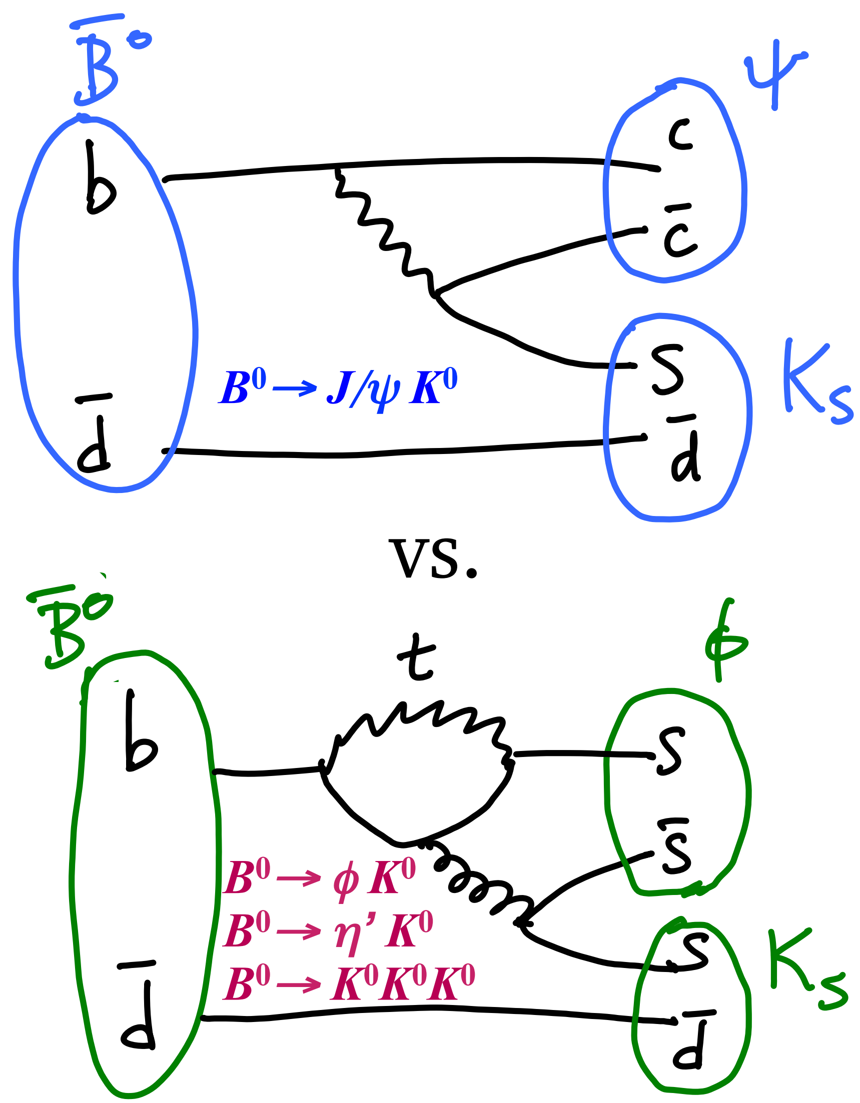


* parodying the first talk of this conference

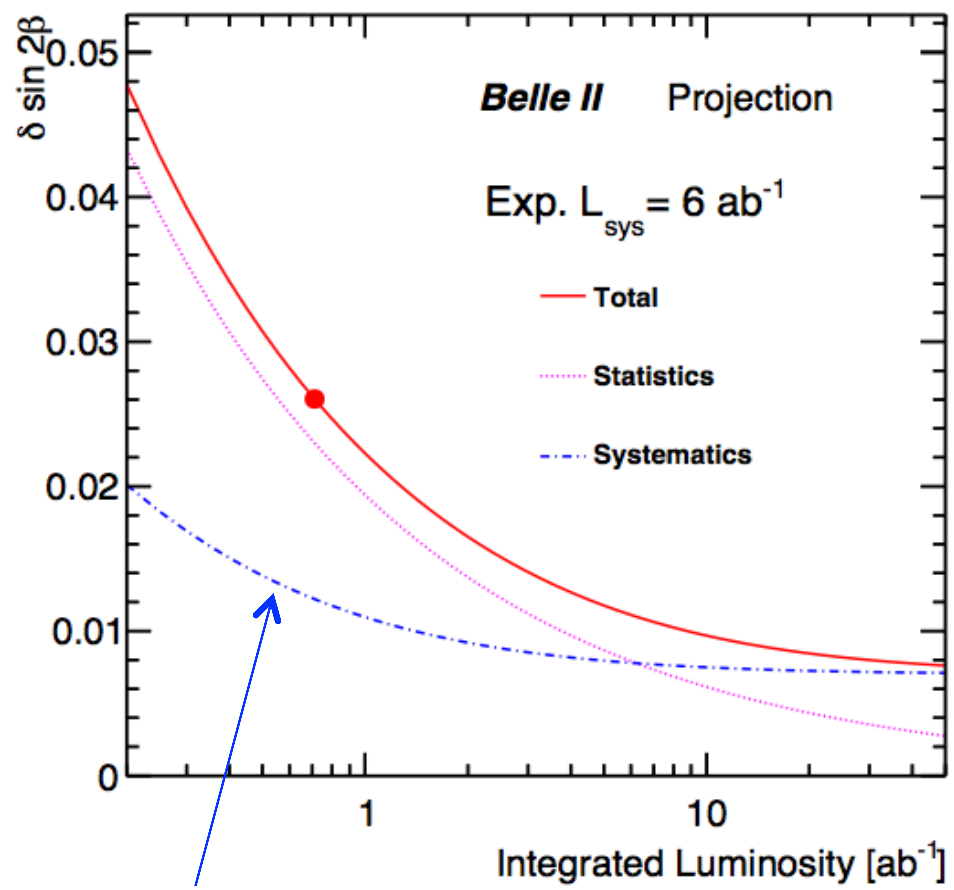
Driving questions for Belle II (1)

- **Are there any new CPV phases?**

Check $\Delta S \equiv \sin 2\phi_{1,\mathrm{eff}}(b \to s\bar{s}s) - \sin 2\phi_1(b \to c\bar{c}s)$

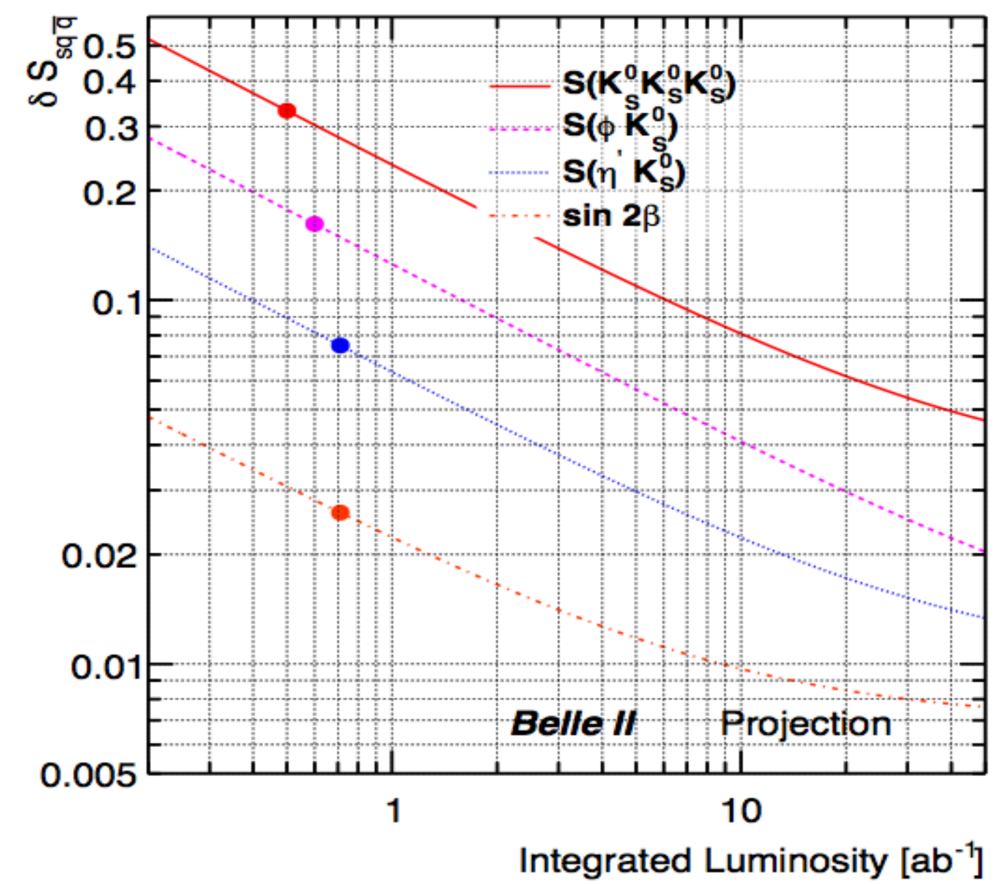


$\delta \sin 2\phi_1$



dominated by vertex resolution, which will improve: 61→ ~18 μm

$\delta S_{sq\bar{q}}$

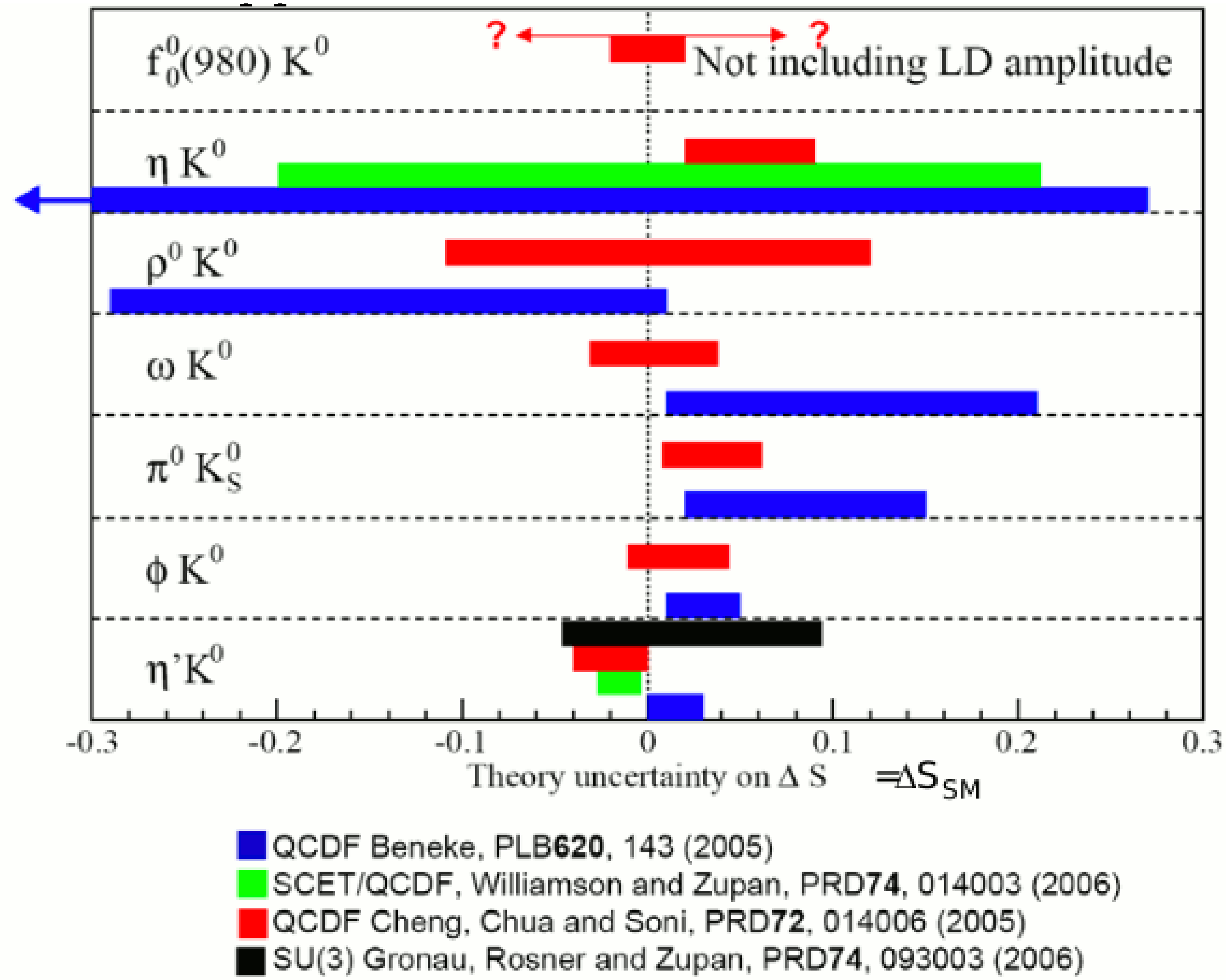


Prospect $\delta(S_{b\to s}) \sim 0.012$ @ $50ab^{-1}$

Driving questions for Belle II (1)

- **Are there any new CPV phases?**

  Check $\Delta S \equiv \sin 2\phi_{1,\mathrm{eff}}(b \to s\bar{s}s) - \sin 2\phi_1(b \to c\bar{c}s)$



$\delta(S_{b\to s}) \sim 0.012$ @ $50\ \mathrm{ab}^{-1}$

➔ good enough to test theory models

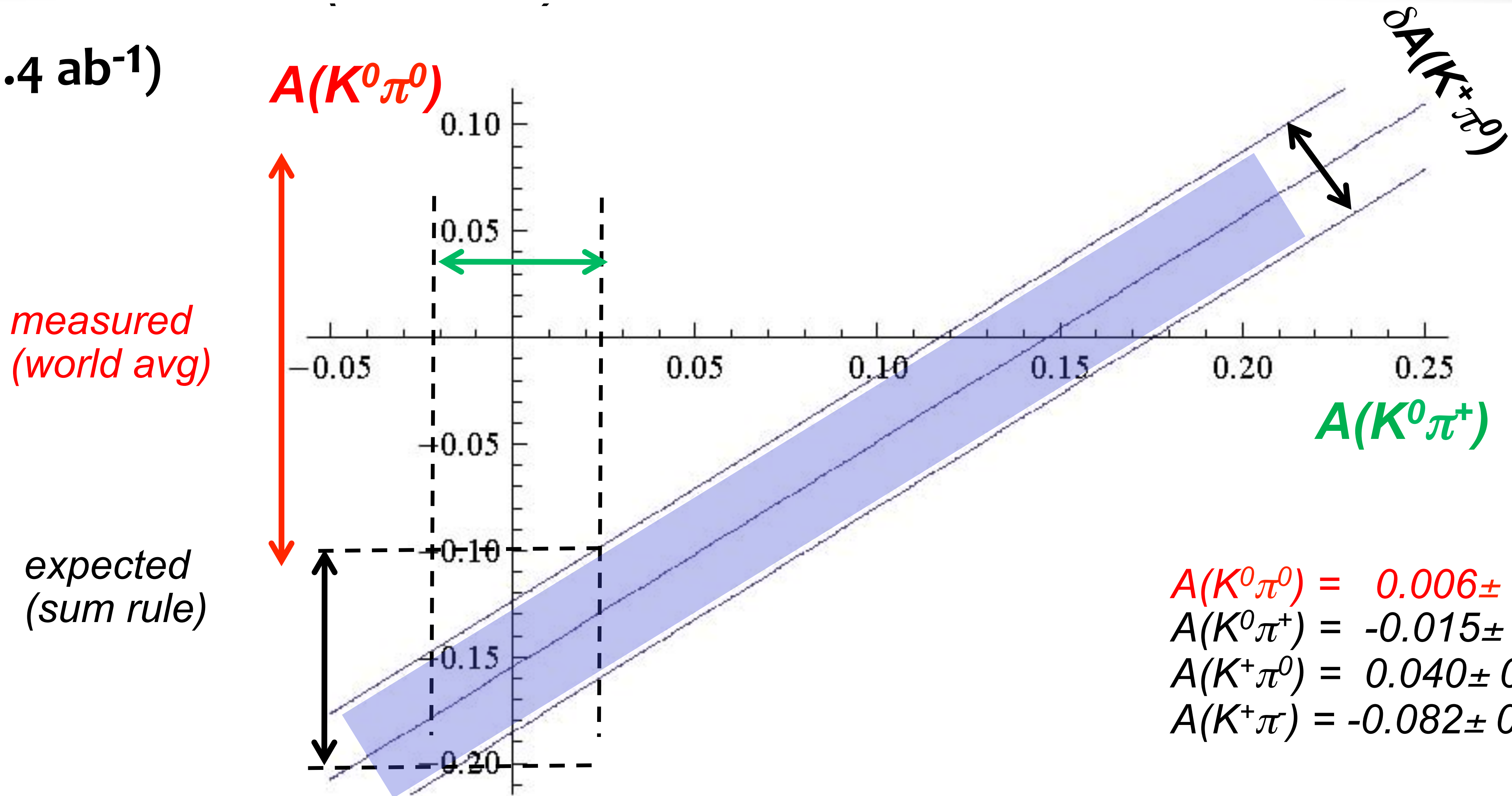
Driving questions for Belle II (1′)

- **Direct CP asymmetry in $B \to K\pi$**
  - currently, > 5σ deviation from naive SM expectation
  - the 'sum rule' can be put on a stringent test with Belle II, with crucial inputs from neutral mode

Gronau, PLB 627, 82 (2005); Atwood & Soni, PRD 58, 036005 (1998):

$$\mathcal{A}_{CP}(K^+\pi^-) + \mathcal{A}_{CP}(K^0\pi^+)\frac{\mathcal{B}(K^0\pi^+)}{\mathcal{B}(K^+\pi^-)}\frac{\tau_0}{\tau_+} = \mathcal{A}_{CP}(K^+\pi^0)\frac{2\mathcal{B}(K^+\pi^0)}{\mathcal{B}(K^+\pi^-)}\frac{\tau_0}{\tau_+} + \mathcal{A}_{CP}(K^0\pi^0)\frac{2\mathcal{B}(K^0\pi^0)}{\mathcal{B}(K^+\pi^-)}$$

B factories now (~1.4 ab^{-1})



$A(K^0\pi^0) = 0.006 \pm 0.06$
$A(K^0\pi^+) = -0.015 \pm 0.019$
$A(K^+\pi^0) = 0.040 \pm 0.021$
$A(K^+\pi^-) = -0.082 \pm 0.006$

Driving questions for Belle II (1′)

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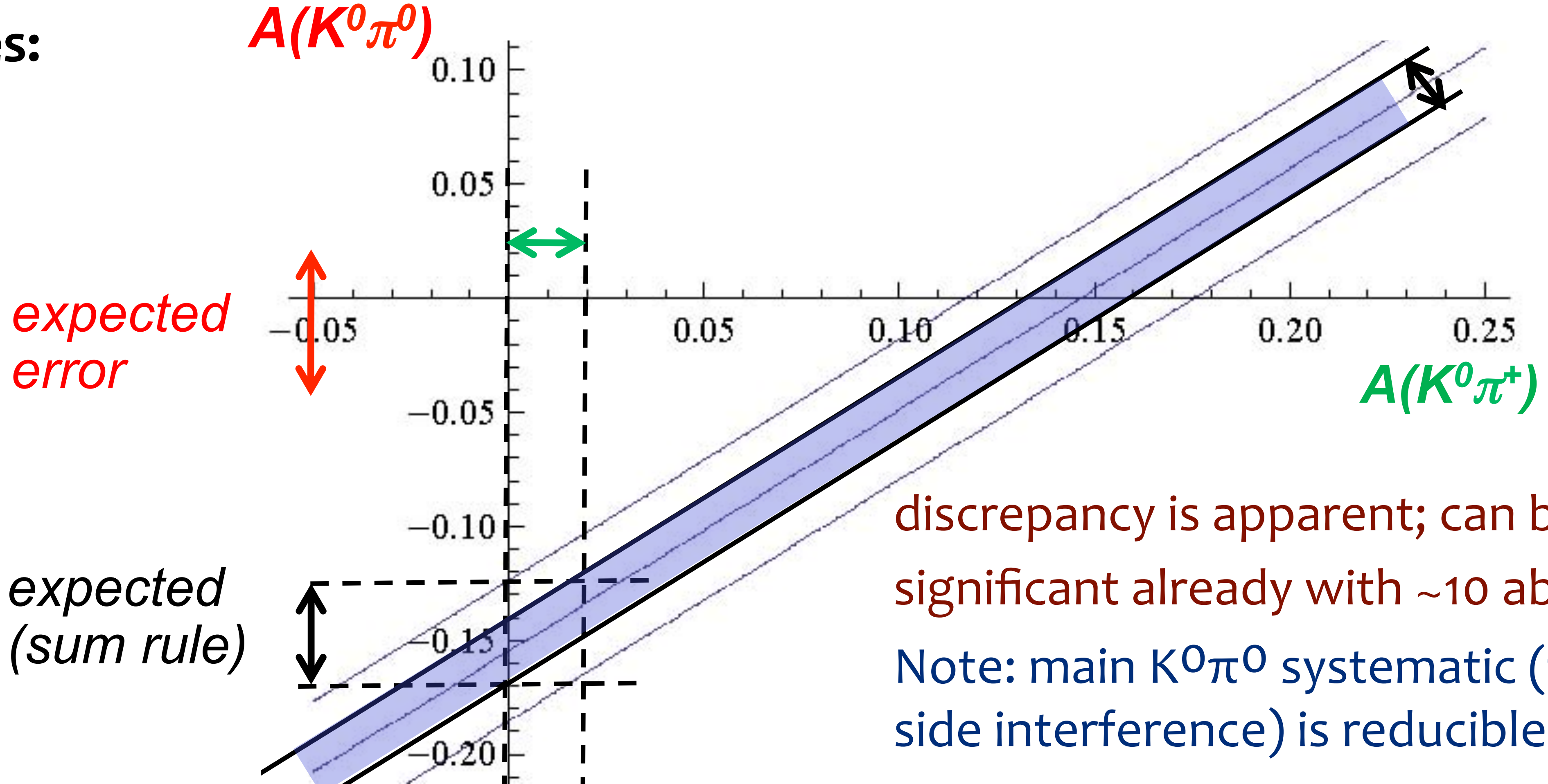
B factory at 50 ab^{-1}, with today's central values:

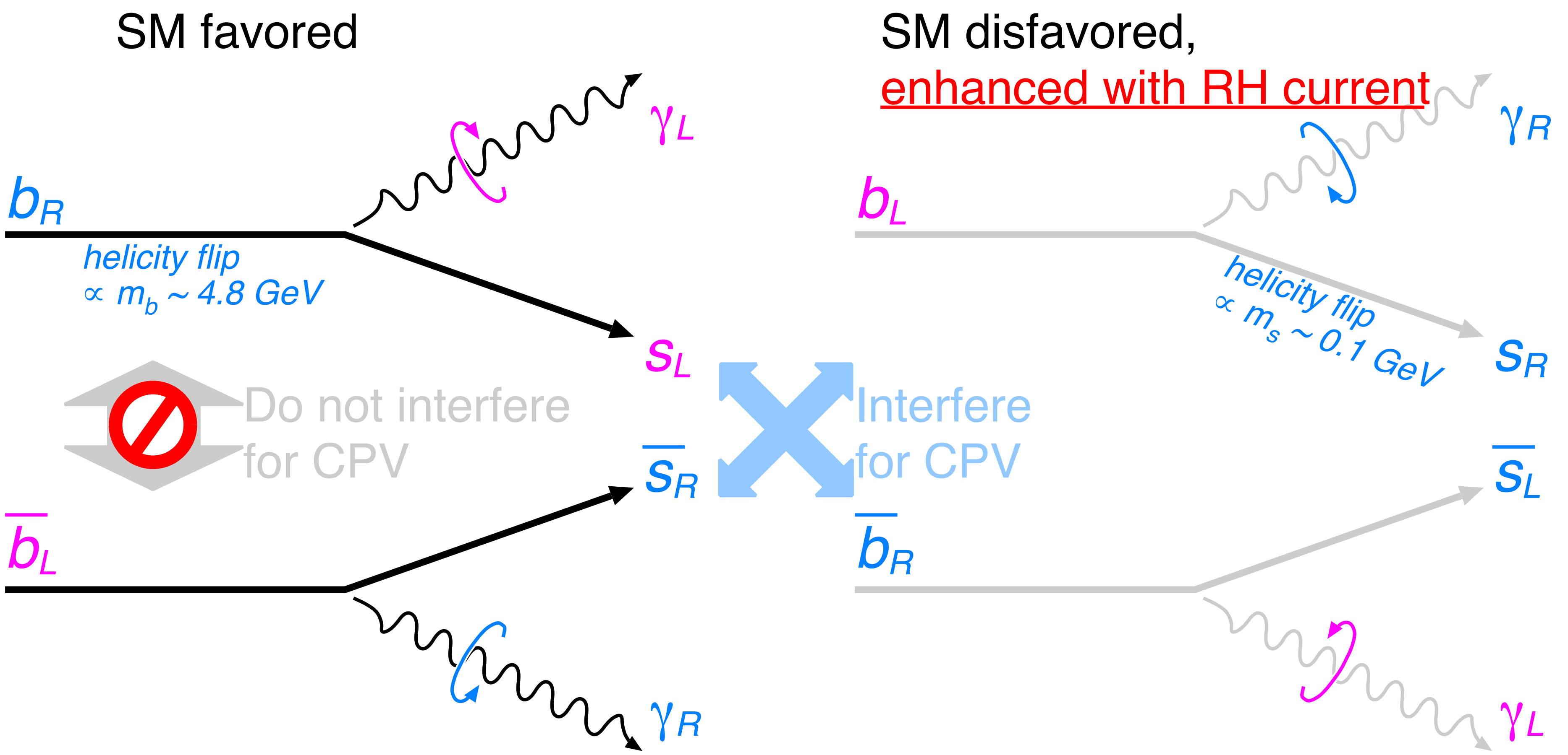


discrepancy is apparent; can be significant already with ~10 ab^{-1}

Note: main $K^0\pi^0$ systematic (tag-side interference) is reducible

Driving questions for Belle II (2)

- **Any right-handed currents from NP?**



can be probed by t-dep. CP asymmetry with $B^0 \to K^0_S \pi^0 \gamma$

In SM, one naively expects:

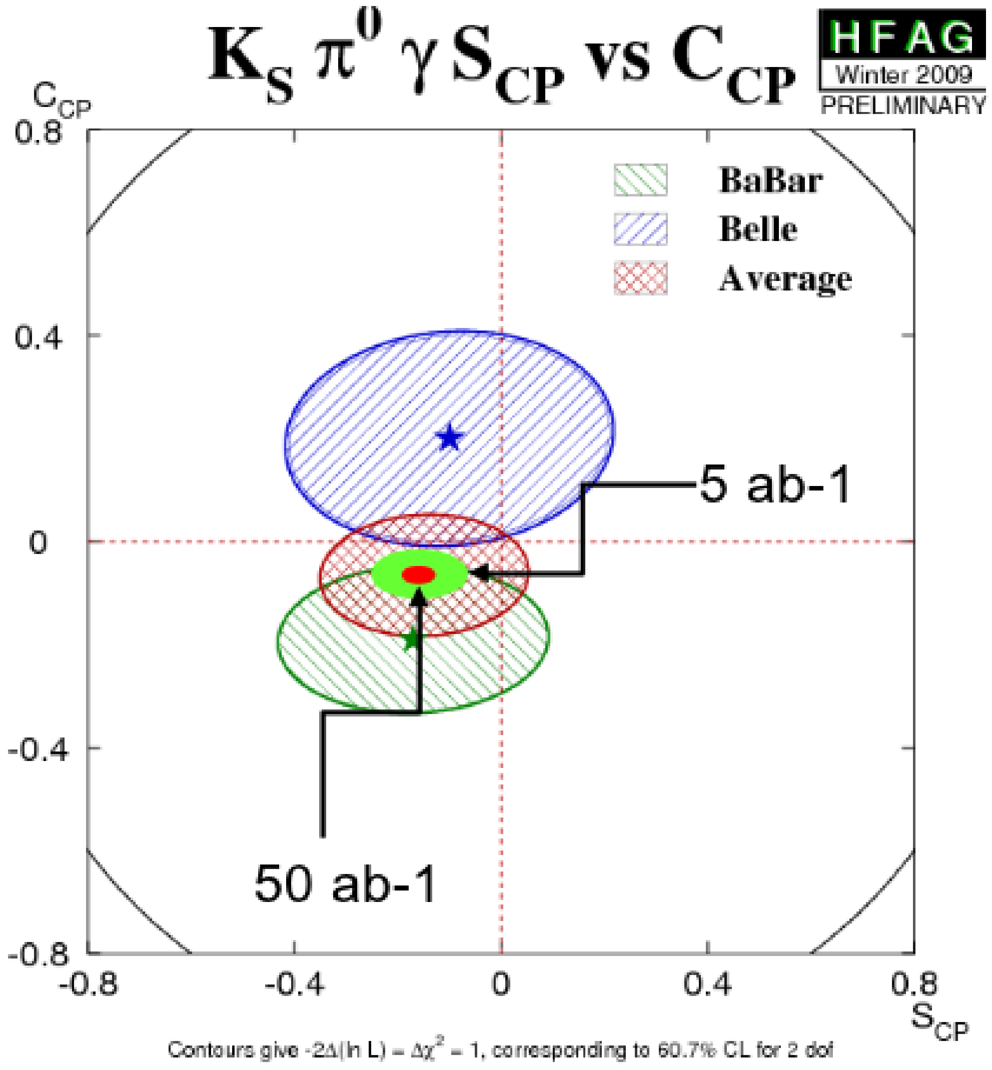
$$S_{K^0_S\pi^0\gamma} = -2\frac{m_s}{m_b}\sin 2\phi_1 \sim -0.03$$

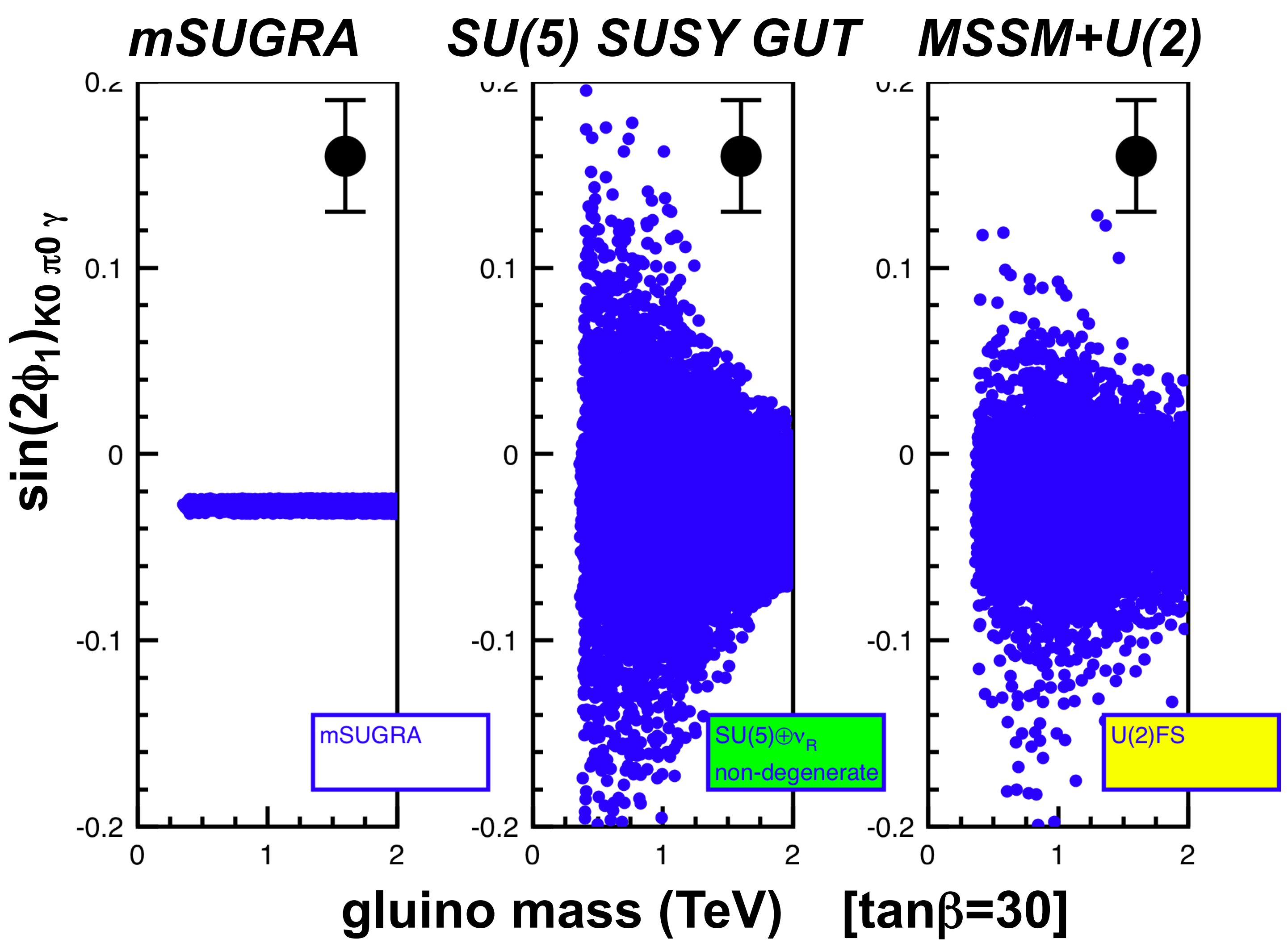
In a L-R symmetric model,

$$S_{K^0_S\pi^0\gamma} \sim 0.5$$

Driving questions for Belle II (2)

- **Any right-handed currents from NP?**





$$S = -0.16 \pm 0.22, \quad C = -0.04 \pm 0.14$$

mostly statistics limited

$$\sigma(S_{K^*\gamma}) \sim 0.09 \text{ @ } 5\ \mathrm{ab}^{-1}$$
$$\sim 0.03 \text{ @ } 50\ \mathrm{ab}^{-1}$$

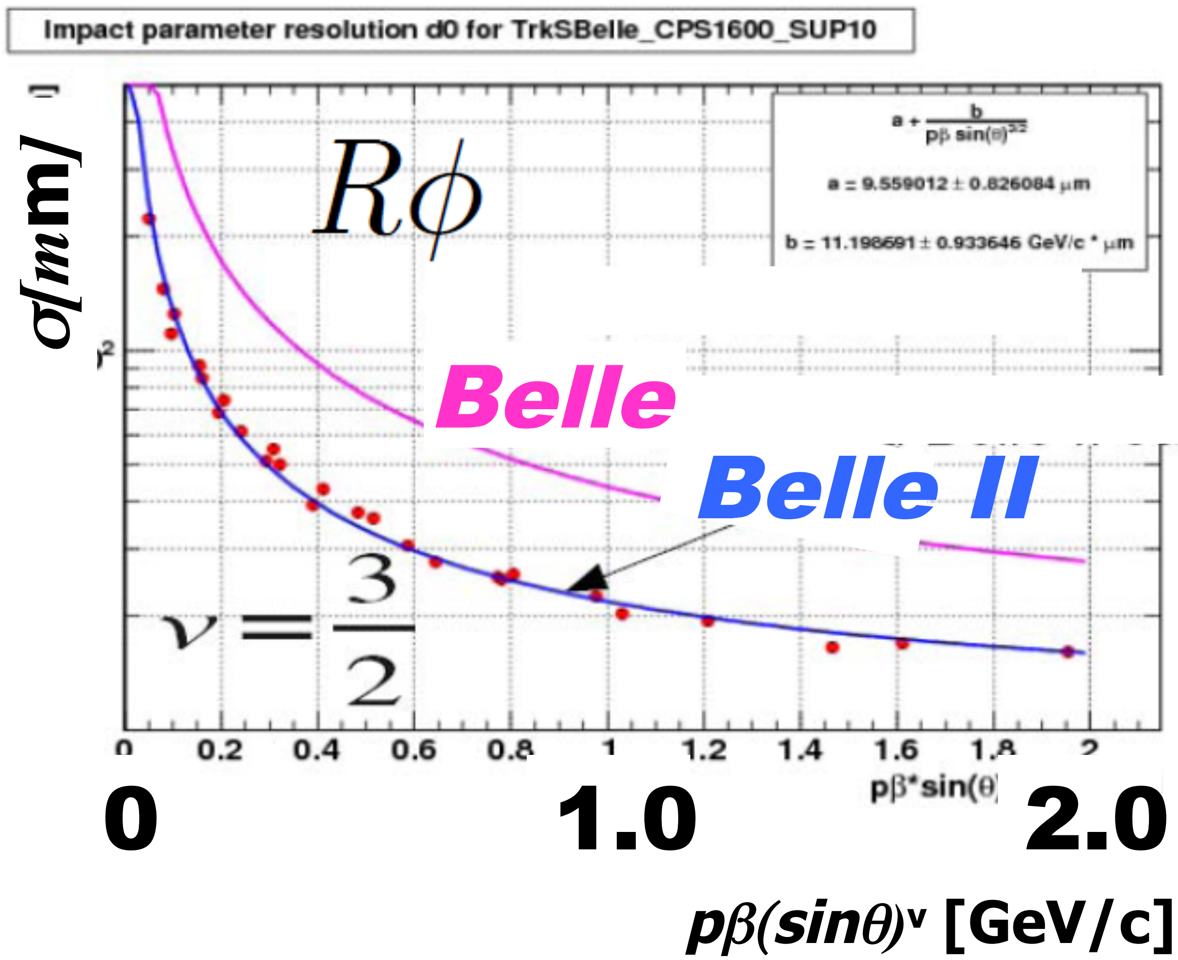
value of S can discriminate among SUSY-breaking mechanisms

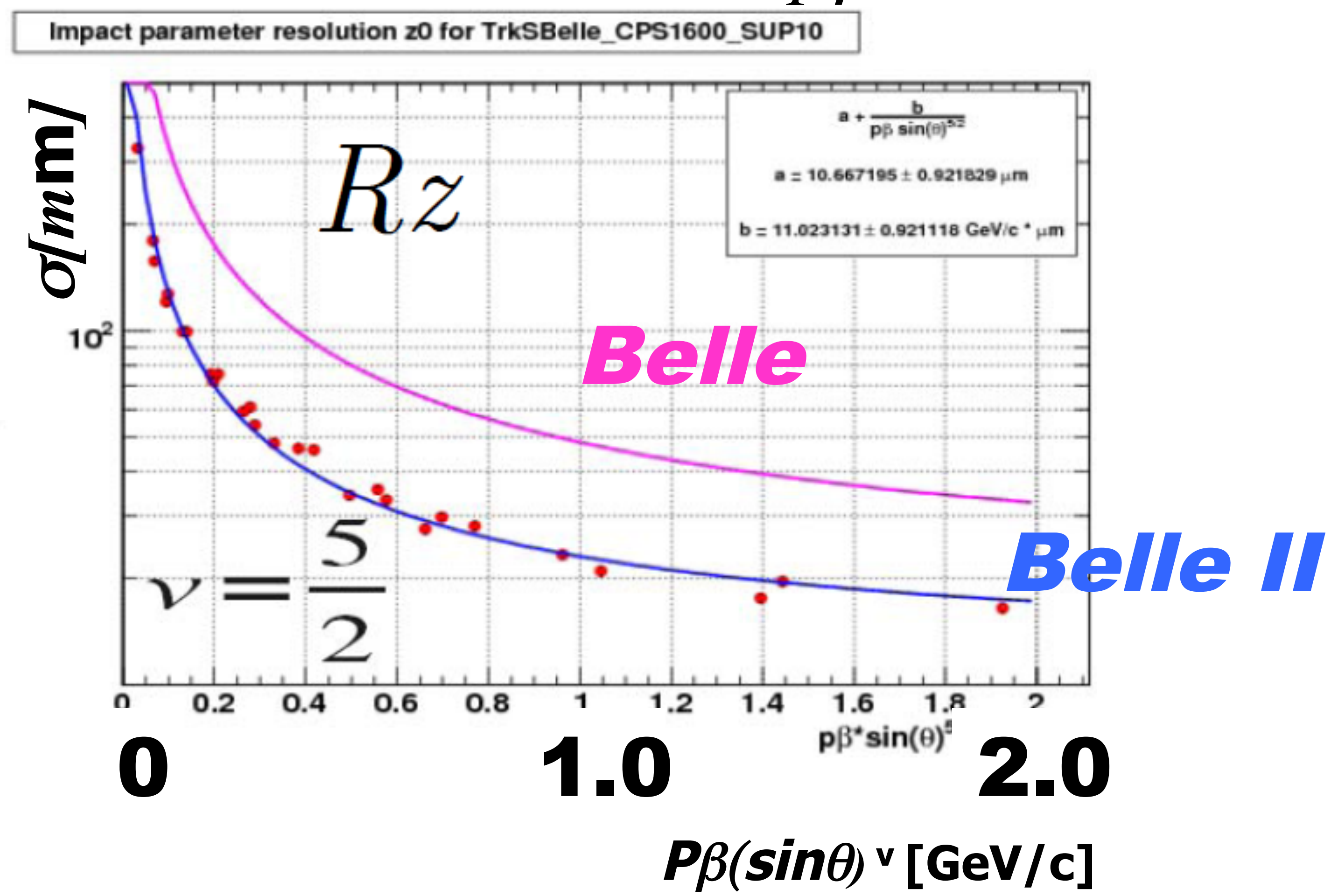
G. Buchalla et al., EPJC 57, 309 (2008)

What Belle II does to improve $S_{K_S \pi^0 \gamma}$

Significant improvement in IP resolution:

$$\sigma = a + \frac{b}{p\beta \sin^{\nu}\theta}$$





Will improve analyses such as $B \to K_S \pi^0 \gamma$ (decay vertex determined by K_S and IP)

$C_{CP}(K_S\ \pi^0\gamma) = -0.07 \pm 0.12$

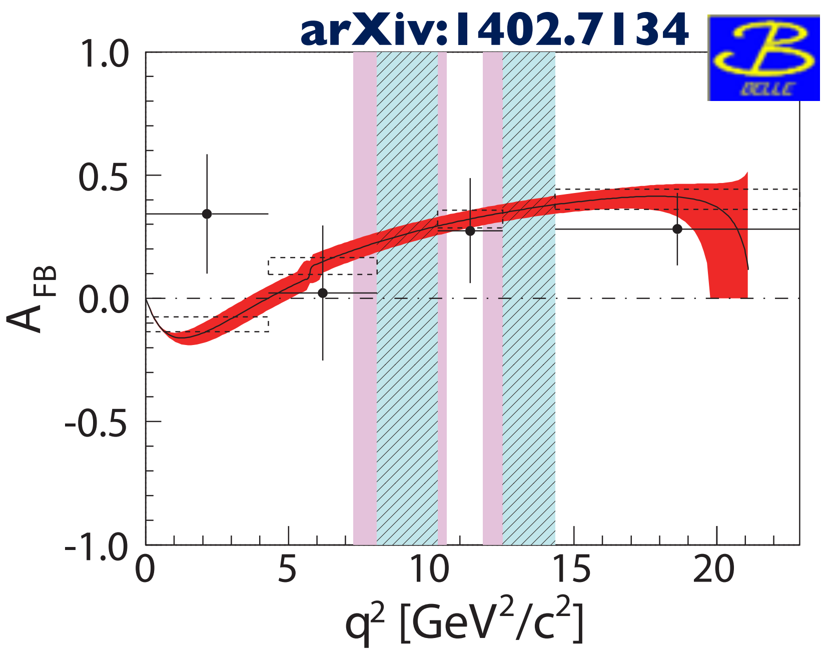
$S_{CP}(K_S\ \pi^0\gamma) = -0.15 \pm 0.20 \to\ 0.10\ (5\ fb^{-1})$

$\to\ 0.04\ (50\ fb^{-1})$

Driving questions for Belle II (3)

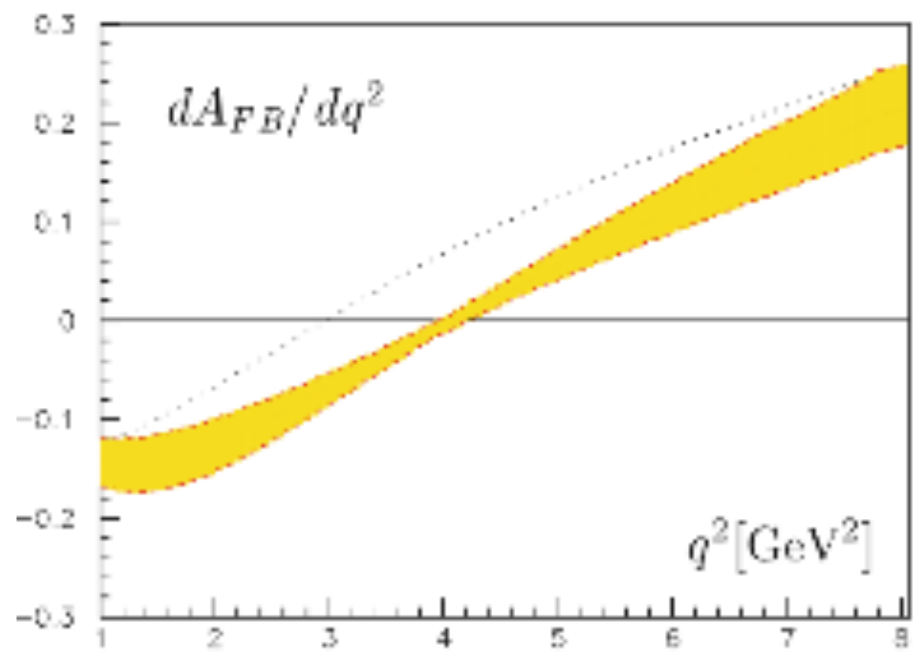
- **Quark FCNC beyond the SM? New operators with quarks enhanced by NP?**

$B \to X_s \ell^+ \ell^-$ inclusive



$K^*\ell^+\ell^-$

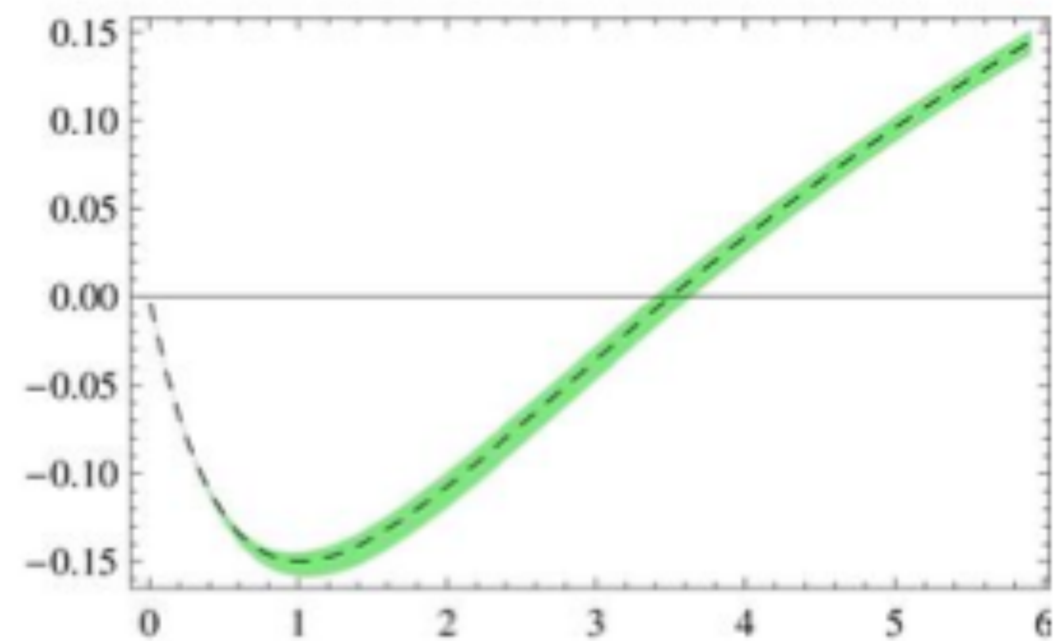
[Ali et al.,EPJ,C47(2006) 625]



$$q_0^2 = \left(4.07^{+0.16}_{-0.13}\right)\ \mathrm{GeV}^2$$

$X_s\ell^+\ell^-$

[Huber et al., NPB 802 (2008) 40]



$$(q_0^2)_{\mu\mu} = (3.50 \pm 0.12)\ \mathrm{GeV}^2$$
$$(q_0^2)_{ee} = (3.38 \pm 0.11)\ \mathrm{GeV}^2$$

$$R_{K^{(*)}} = \frac{\Gamma(B \to K^{(*)}\mu^+\mu^-)}{\Gamma(B \to K^{(*)}e^+e^-)}$$

"×5 less signal (for e+e- mode) mainly due to low trigger and recon eff"

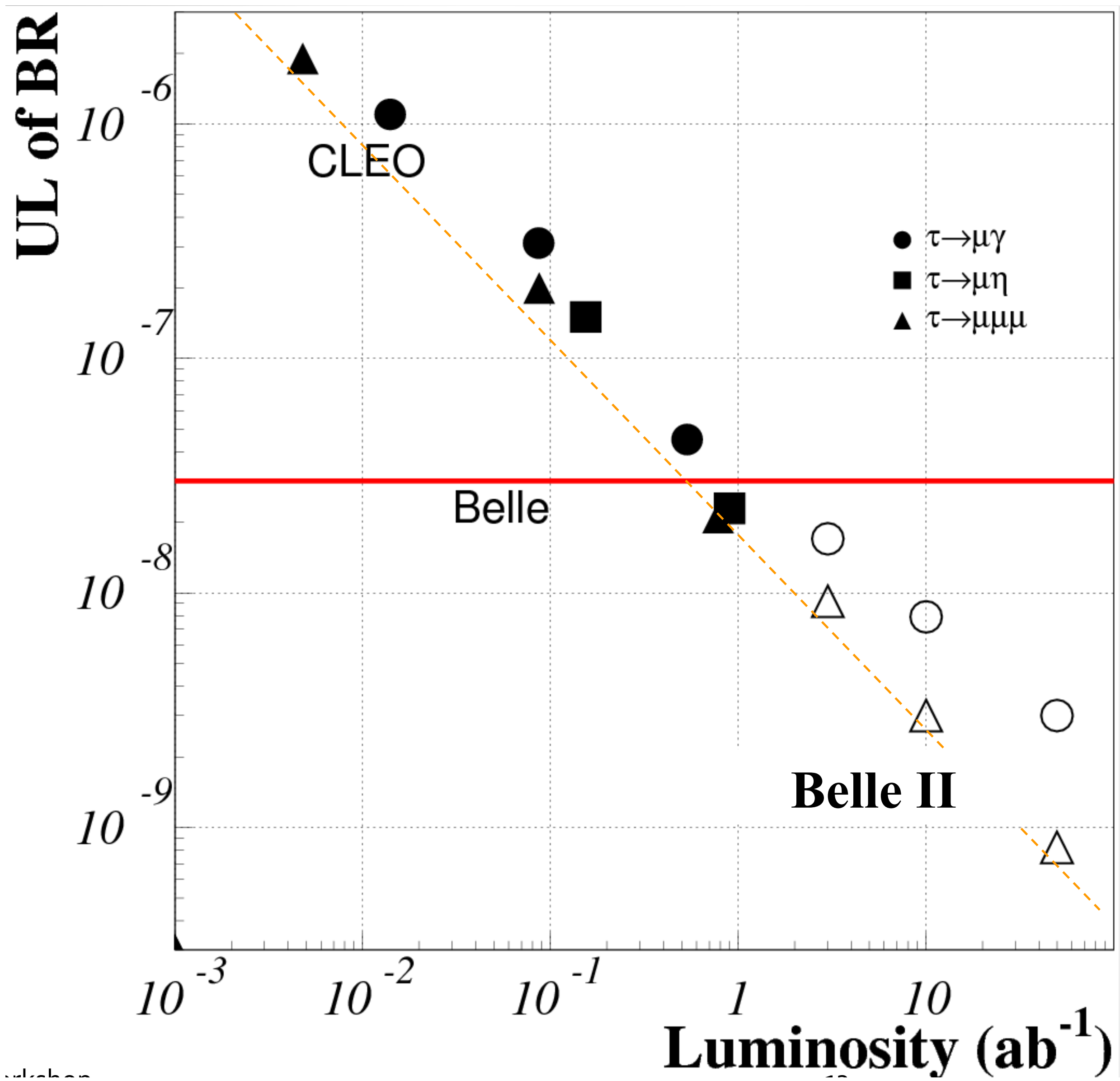
from M. D. Cian @ LHCP 2014

- * With 'inclusive', theory band is narrower ➔ unique for Belle II
- * Belle II can be competitive for R_K, R_{K^*} with excellent electron ID

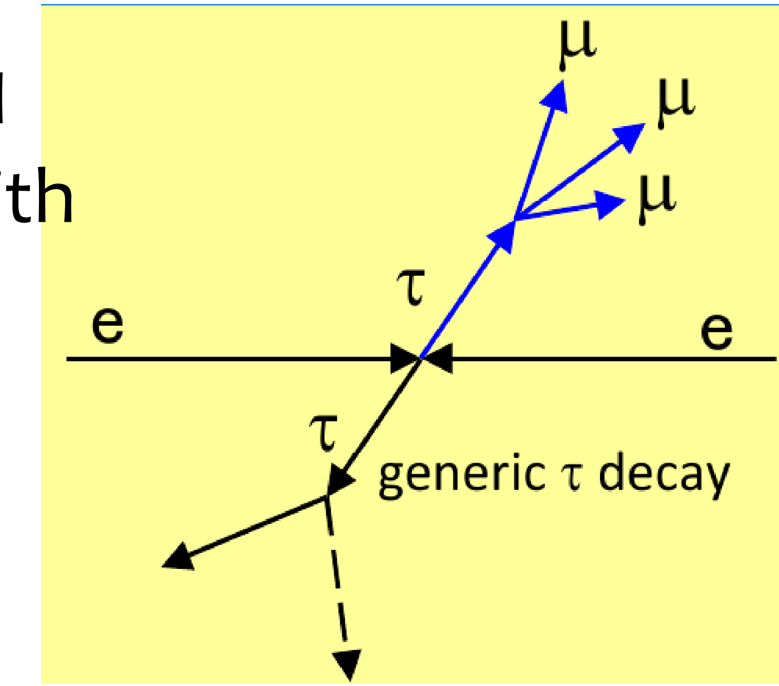
Driving questions for Belle II (4)

- **Sources of LFV from NP?**

e.g. search for τ LFV decays



* **hermeticity** of Belle II
* efficient τ-tagging, with minimal trigger bias



$$\tau^+ \to \mu^+ \mu^- \mu^+$$

- very clean, essentially background-free up to 50/ab
- search sensitivity $\sim \int \mathscr{L}\, dt$, linearly

	reference	τ→μγ	τ→μμμ
SM + heavy Maj ν_R	PRD 66(2002)034008	10^{-9}	10^{-10}
Non-universal Z'	PLB 547(2002)252	10^{-9}	10^{-8}
SUSY SO(10)	PRD 68(2003)033012	10^{-8}	10^{-10}
mSUGRA+seesaw	PRD 66(2002)115013	10^{-7}	10^{-9}
SUSY Higgs	PLB 566(2003)217	10^{-10}	10^{-7}

from A. Schwartz @ FPCP 2014

Driving questions for Belle II (5)

- **Any more higgs? (e.g. H^+)**

- $\mathcal{L}_{\rm peak} = 8 \times 10^{35} {\rm cm}^{-2}{\rm s}^{-1},\ \mathcal{L}_{\rm int} = 50{\rm ab}^{-1}$

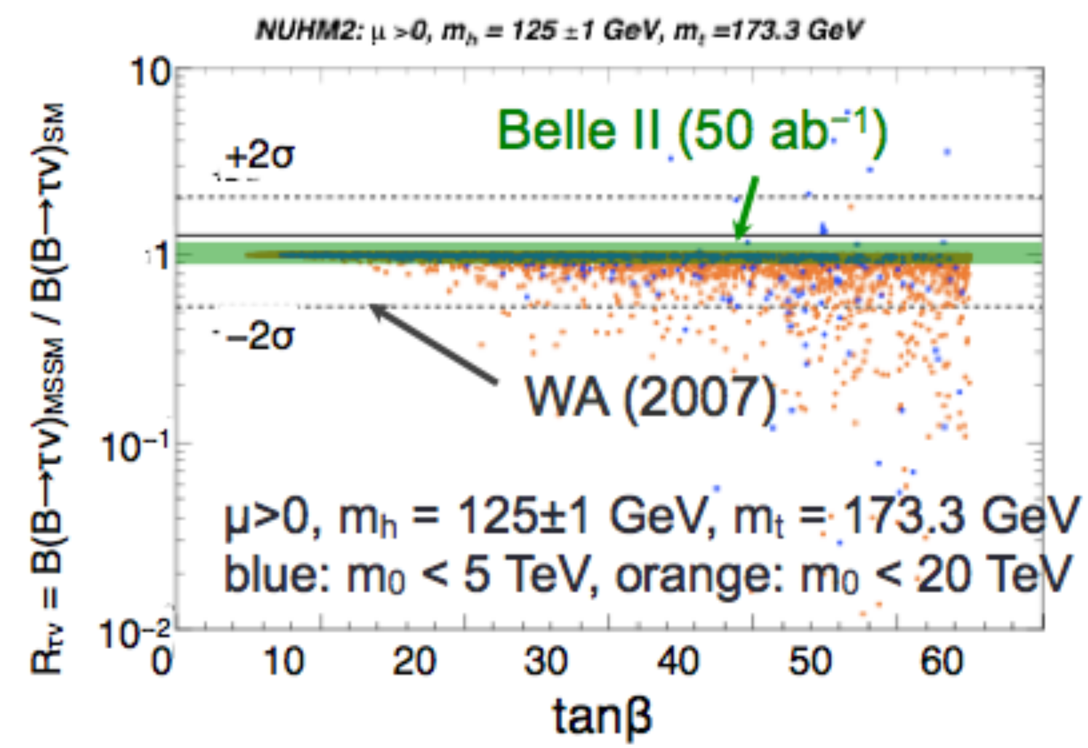
- $B^+ \to \tau^+\nu_\tau$
  - * $\Delta\mathcal{B} \sim$ a few %
  - * need better precision for $f_B|V_{ub}|$

- $B^+ \to \mu^+\nu_\mu$, $B^+ \to e^+\nu_e$
  - * 5σ observation expected for $B^+ \to \mu^+\nu_\mu$ (SM) at ~ 10 ab^{-1}
  - * $\mathcal{O}(10^{-8})$ sensitivity at 50 ab^{-1}
  - * interesting to compare with $B^+ \to \tau^+\nu_\tau$

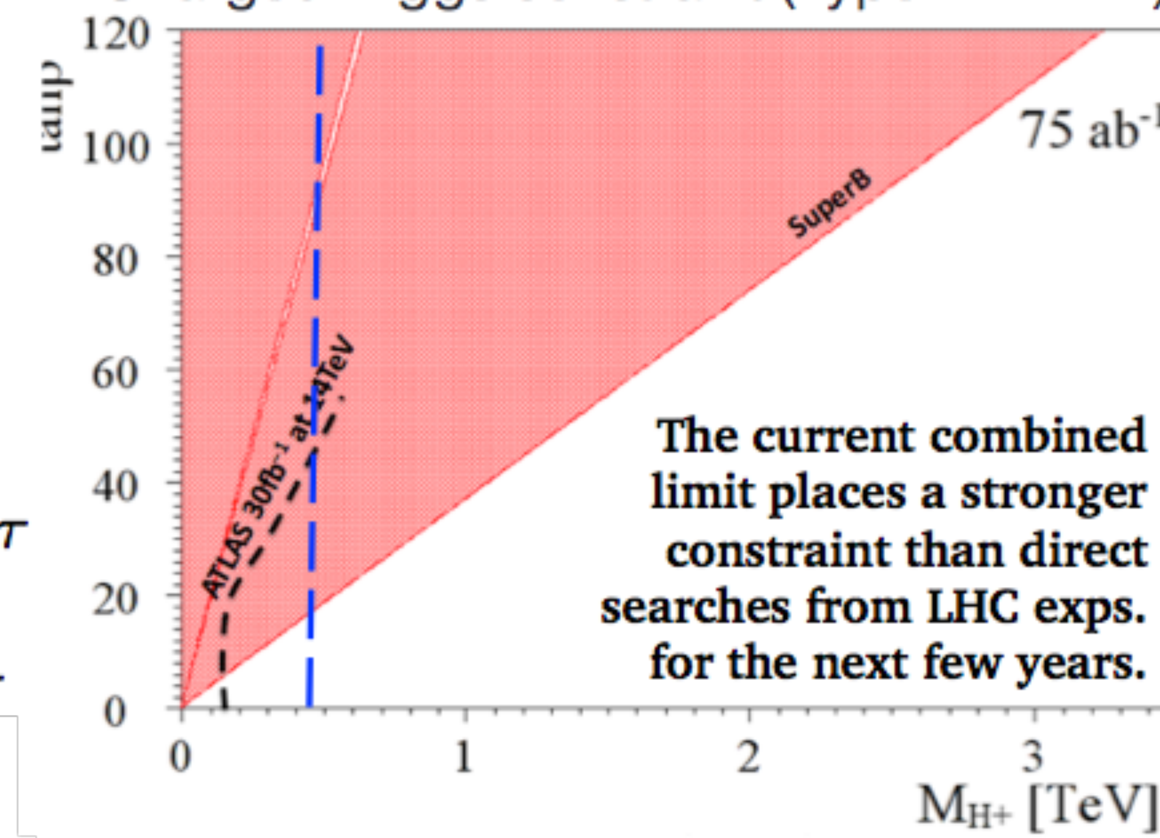
- and don't forget we also have $B \to D^{(*)}\tau^+\nu_\tau$

2-parameter nonuniversal Higgs model

H. Baer, V. Barger, and A. Mustafayev, PRD85, 075010

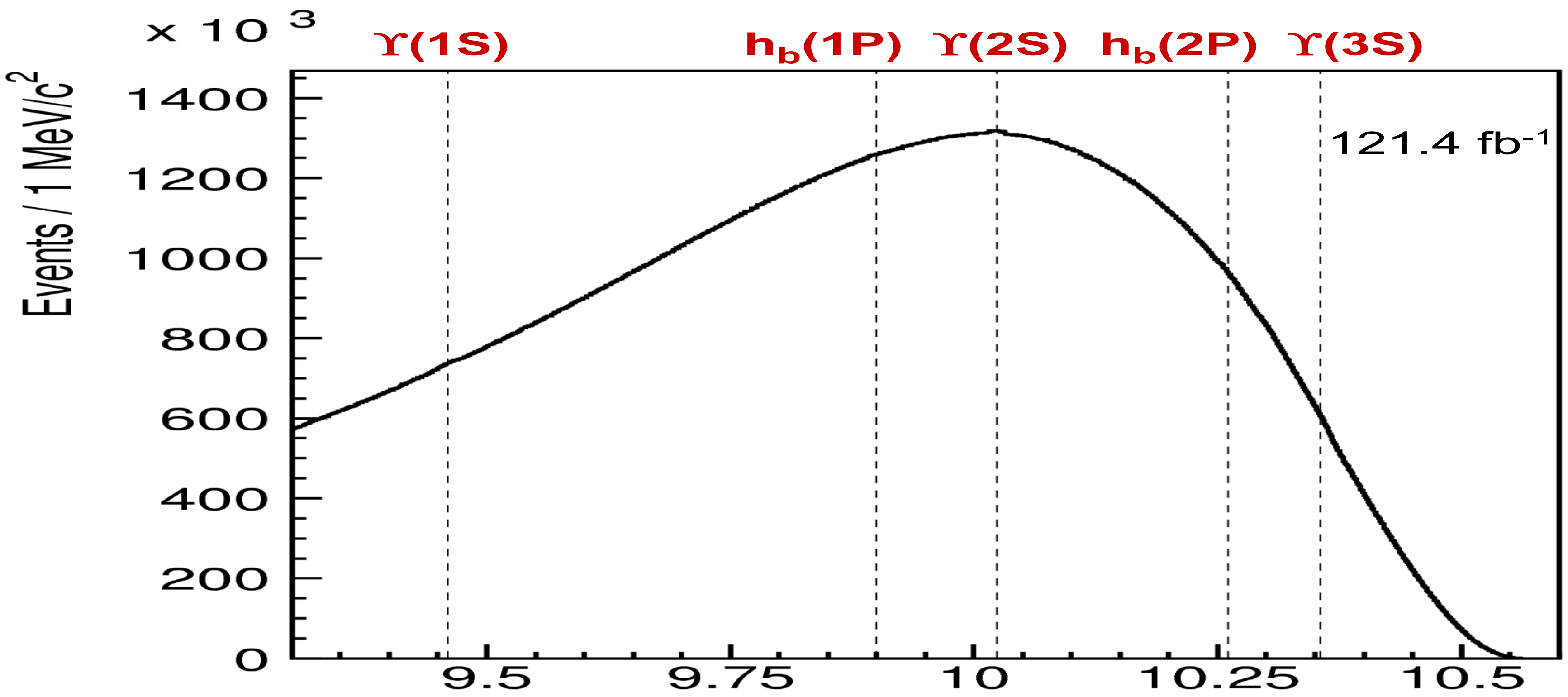


Charged Higgs constraint (Type-II 2HDM)

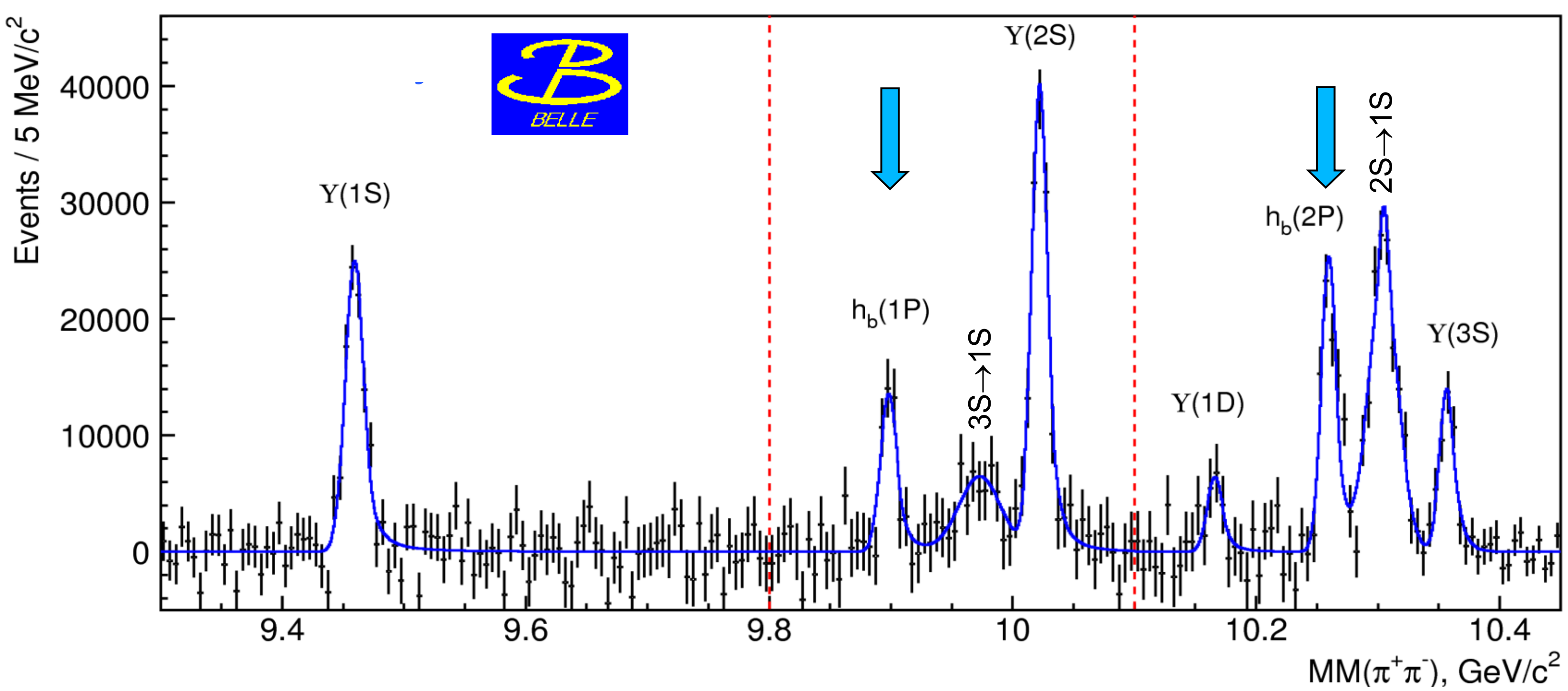


Driving questions for Belle II (6)

- **Understanding exotic QCD states?**



PRL 108, 032001 (2012)

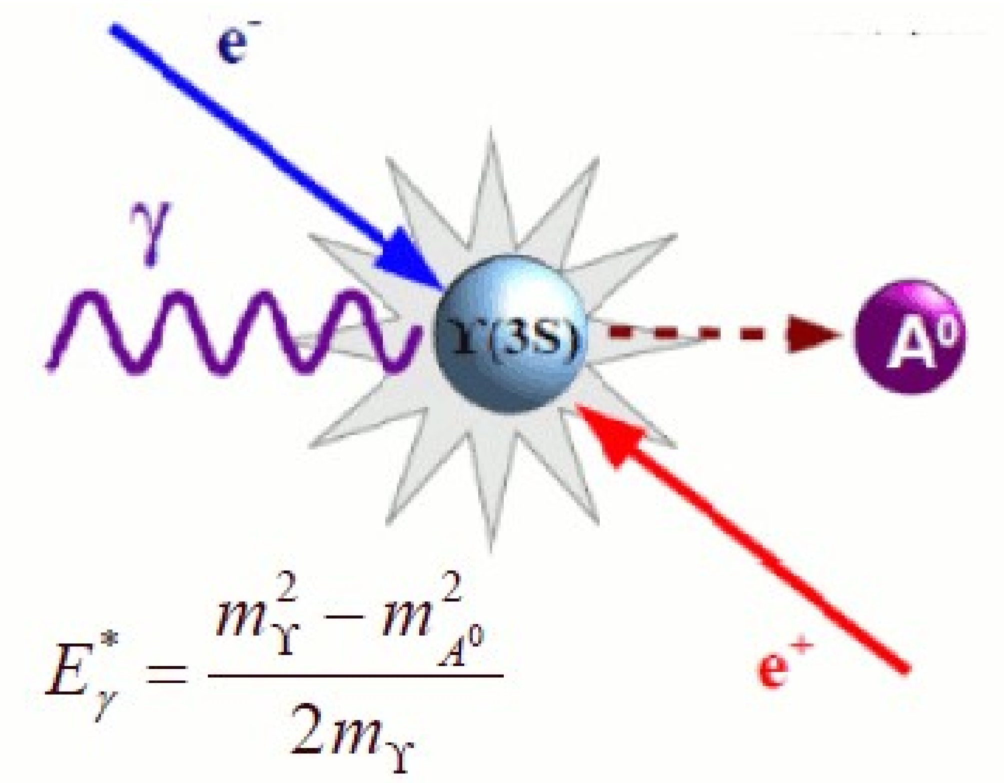


- **hermeticity** of Belle II gives a great potential to discover and understand exotic QCD states

- look for signals in the missing (recoil) mass against $\pi^+\pi^-$
  $\Upsilon(5S) \to (\cdots)\pi^+\pi^-$
- lead to discoveries of $h_b(1P)$ and $h_b(2P)$
- and, consequent discoveries of exotic Z_b^+ states in $h_b(1,2P)\pi^+$

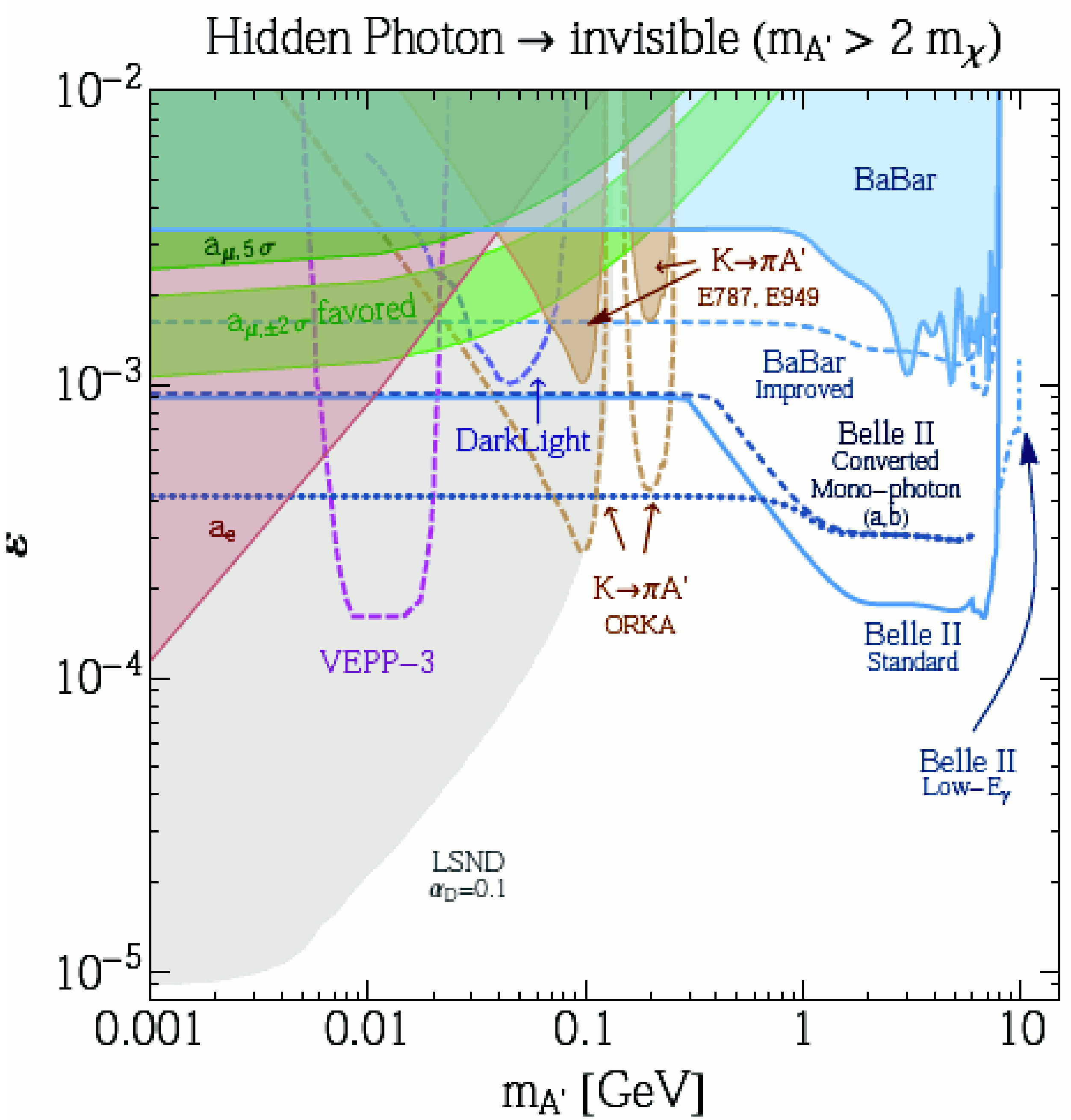
Driving questions for Belle II (7)

- **Hidden dark sector?**
  - low-mass Higgs in Υ(nS) decays (NMSSM models w/ light CP-odd Higgs)
  - U(1) gauge boson in the dark sector ("dark forces")



$$E_\gamma^* = \frac{m_\Upsilon^2 - m_{A^0}^2}{2m_\Upsilon}$$

$$e^+e^- \to \Upsilon(nS) \to \gamma A^0$$



- Trigger can be an outstanding concern:
  - * 1 photon + missing-E
  - * low mass $\pi^+\pi^-$
  - * 1 photon + 2 tracks + missing-E

Key Observables (Belle II)

Observable	SM theory	Current measurement (early 2013)	Belle II * ($50\,\mathrm{ab}^{-1}$)
$S(B \to \phi K^0)$	0.68	0.56 ± 0.17	± 0.018
$S(B \to \eta' K^0)$	0.68	0.59 ± 0.07	± 0.011
α from $B \to \pi\pi,\ \rho\rho$		$\pm 5.4^\circ$	$\pm 1^\circ$
γ from $B \to DK$		$\pm 11^\circ$	$\pm 1.5^\circ$
$S(B \to K_S \pi^0 \gamma)$	< 0.05	-0.15 ± 0.20	± 0.035
$S(B \to \rho\gamma)$	< 0.05	-0.83 ± 0.65	± 0.07
$A_{\mathrm{CP}}(B \to X_{s+d}\,\gamma)$	< 0.005	0.06 ± 0.06	± 0.005
A^d_{SL}	-5×10^{-4}	-0.0049 ± 0.0038	± 0.001
$\mathcal{B}(B \to \tau\nu)$	1.1×10^{-4}	$(1.64 \pm 0.34) \times 10^{-4}$	$\pm 3\%$
$\mathcal{B}(B \to \mu\nu)$	4.7×10^{-7}	$< 1.0 \times 10^{-6}$	$\gg 5\sigma$
$\mathcal{B}(B \to X_s\gamma)$	3.15×10^{-4}	$(3.55 \pm 0.26) \times 10^{-4}$	$\pm 6\%$
$\mathcal{B}(B \to K^{(*)}\nu\overline{\nu})$	3.6×10^{-6}	$< 1.3 \times 10^{-5}$	$\pm 30\%$
$\mathcal{B}(B \to X_s \ell^+\ell^-)$ $(1 < q^2 < 6\,\mathrm{GeV}^2)$	1.6×10^{-6}	$(4.5 \pm 1.0) \times 10^{-6}$	$\pm 0.10 \times 10^{-6}$
$A_{\mathrm{FB}}(B^0 \to K^{*0}\ell^+\ell^-)$ zero crossing	7%	18%	5%
$\lvert V_{ub}\rvert$ from $B \to \pi\ell^+\nu$ $(q^2 > 16\,\mathrm{GeV}^2)$	9% $\to$ 2%	11%	2.1%

adapted from **arXiv:1311.1076** COMMUNITY PLANNING STUDY: SNOWMASS 2013
with modifications(*) for Belle II projections, reported at BPAC 2014

Key Observables (LHCb)

Observable	Current SM theory uncertainty	Precision as of 2013	LHCb (6.5 fb^{-1})	LHCb Upgrade (50 fb^{-1})
$2\beta_s(B_s \to J/\psi\phi)$	~ 0.003	0.09	0.025	0.008
$\gamma(B \to D^{(*)}K^{(*)})$	$< 1^\circ$	8°	4°	0.9°
$\gamma(B_s \to D_s K)$	$< 1^\circ$	—	$\sim 11^\circ$	2°
$\beta(B^0 \to J/\psi K_S^0)$	small	0.8°	0.6°	0.2°
$2\beta_s^{\rm eff}(B_s \to \phi\phi)$	0.02	1.6	0.17	0.03
$2\beta_s^{\rm eff}(B_s \to K^{*0}\bar{K}^{*0})$	< 0.02	—	0.13	0.02
$2\beta_s^{\rm eff}(B_s \to \phi\gamma)$	0.2%	—	0.09	0.02
$2\beta^{\rm eff}(B^0 \to \phi K_S^0)$	0.02	0.17	0.30	0.05
$A_{\rm SL}^s$	0.03×10^{-3}	6×10^{-3}	1×10^{-3}	0.25×10^{-3}
$\mathcal{B}(B_s \to \mu^+\mu^-)$	8%	36%	15%	5%
$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s \to \mu^+\mu^-)$	5%	—	~100%	~35%
$A_{\rm FB}(B^0 \to K^{*0}\mu^+\mu^-)$ zero crossing	7%	18%	6%	2%

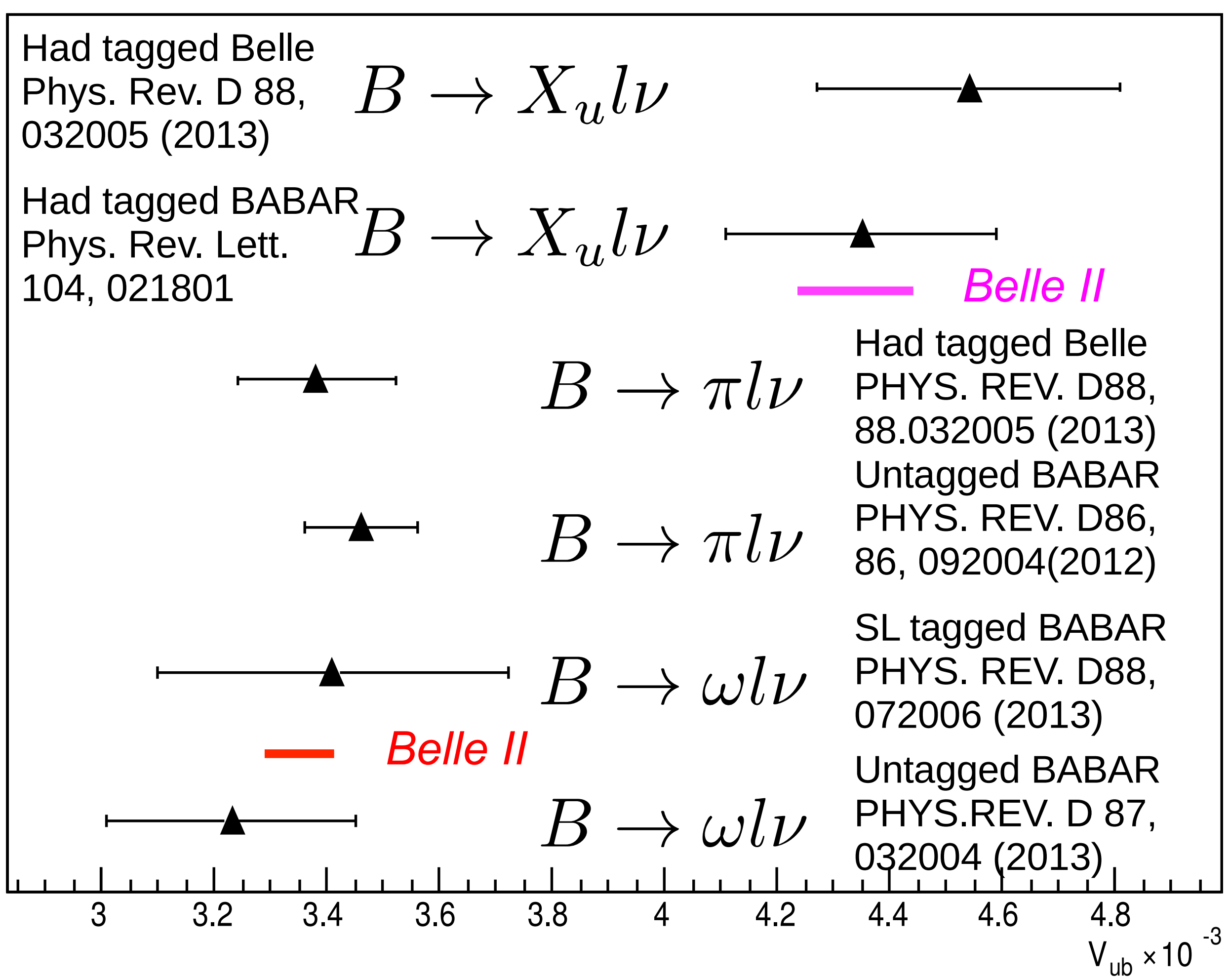
from **arXiv:1311.1076** Community Planning Study: Snowmass 2013

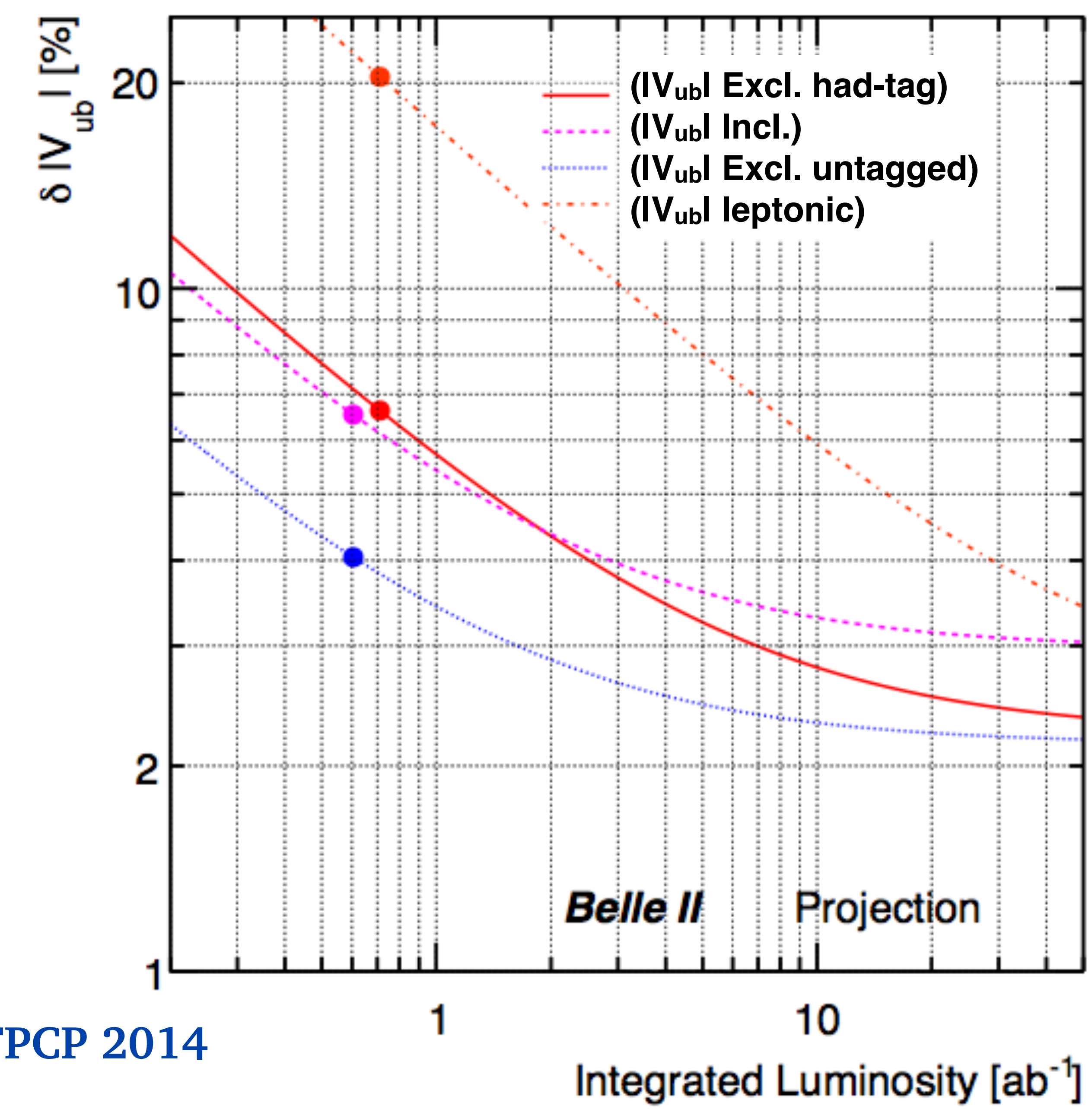
Comparing the two tables, it is clear that Belle II can cover most "driving questions" with the unique key observables which are complementary with others.

not discussed, but no less important

- Semileptonic B decays (inclusive & exclusive) for $|V_{ub}|$, $|V_{cb}|$
  * ∃ lingering concerns on "exclusive vs. inclusive" puzzle
- CPV and mixing for charm

Alexander Ermakov (FPCP14):





from A.J. Schwartz @ FPCP 2014

not discussed, but no less important

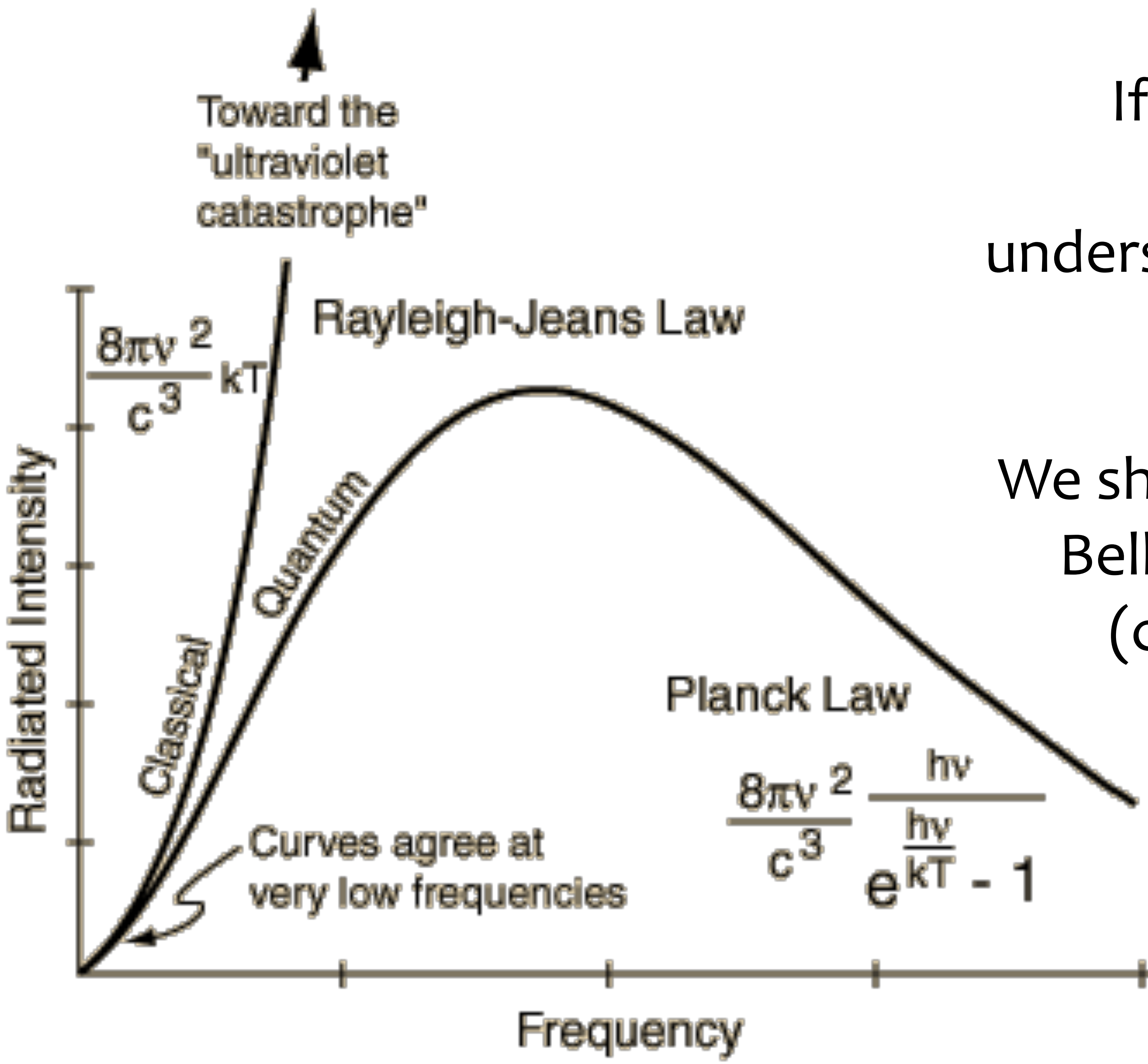
- Semileptonic B decays (inclusive & exclusive) for $|V_{ub}|$, $|V_{cb}|$
  - * ∃ lingering concerns on "exclusive vs. inclusive" puzzle
- CPV and mixing for charm

mode	$\mathcal{L}$ (fb^{-1})	A_{CP} (%)	Belle II at 50 ab^{-1}
$D^0 \to K^+K^-$	976	$-0.32 \pm 0.21 \pm 0.09$	± 0.03
$D^0 \to \pi^+\pi^-$	976	$+0.55 \pm 0.36 \pm 0.09$	± 0.05
$D^0 \to \pi^0\pi^0$	976	$\sim \pm 0.60$	± 0.08
$D^0 \to K_s^0\pi^0$	791	$-0.28 \pm 0.19 \pm 0.10$	± 0.03
$D^0 \to K_s^0\eta$	791	$+0.54 \pm 0.51 \pm 0.16$	± 0.07
$D^0 \to K_s^0\eta'$	791	$+0.98 \pm 0.67 \pm 0.14$	± 0.09
$D^0 \to \pi^+\pi^-\pi^0$	532	$+0.43 \pm 1.30$	± 0.13
$D^0 \to K^+\pi^-\pi^0$	281	-0.60 ± 5.30	± 0.40
$D^0 \to K^+\pi^-\pi^+\pi^-$	281	-1.80 ± 4.40	± 0.33
$D^+ \to \phi\pi^+$	955	$+0.51 \pm 0.28 \pm 0.05$	± 0.04
$D^+ \to \eta\pi^+$	791	$+1.74 \pm 1.13 \pm 0.19$	± 0.14
$D^+ \to \eta'\pi^+$	791	$-0.12 \pm 1.12 \pm 0.17$	± 0.14
$D^+ \to K_s^0\pi^+$	977	$-0.36 \pm 0.09 \pm 0.07$	± 0.03
$D^+ \to K_s^0K^+$	977	$-0.25 \pm 0.28 \pm 0.14$	± 0.05
$D_s^+ \to K_s^0\pi^+$	673	$+5.45 \pm 2.50 \pm 0.33$	± 0.29
$D_s^+ \to K_s^0K^+$	673	$+0.12 \pm 0.36 \pm 0.22$	± 0.05

modes with π^0's *(easier @ e^+e^-)*

table by M. Staric @ KEK FFW 2014

Epilogue



If only the low-frequency part of the spectrum had been measured, understanding of quantum physics might have come much later.

We should search for every window, and Belle II provides views to many unique (complementary) windows for BSM!