Searches for New Physics at the Belle II Experiment

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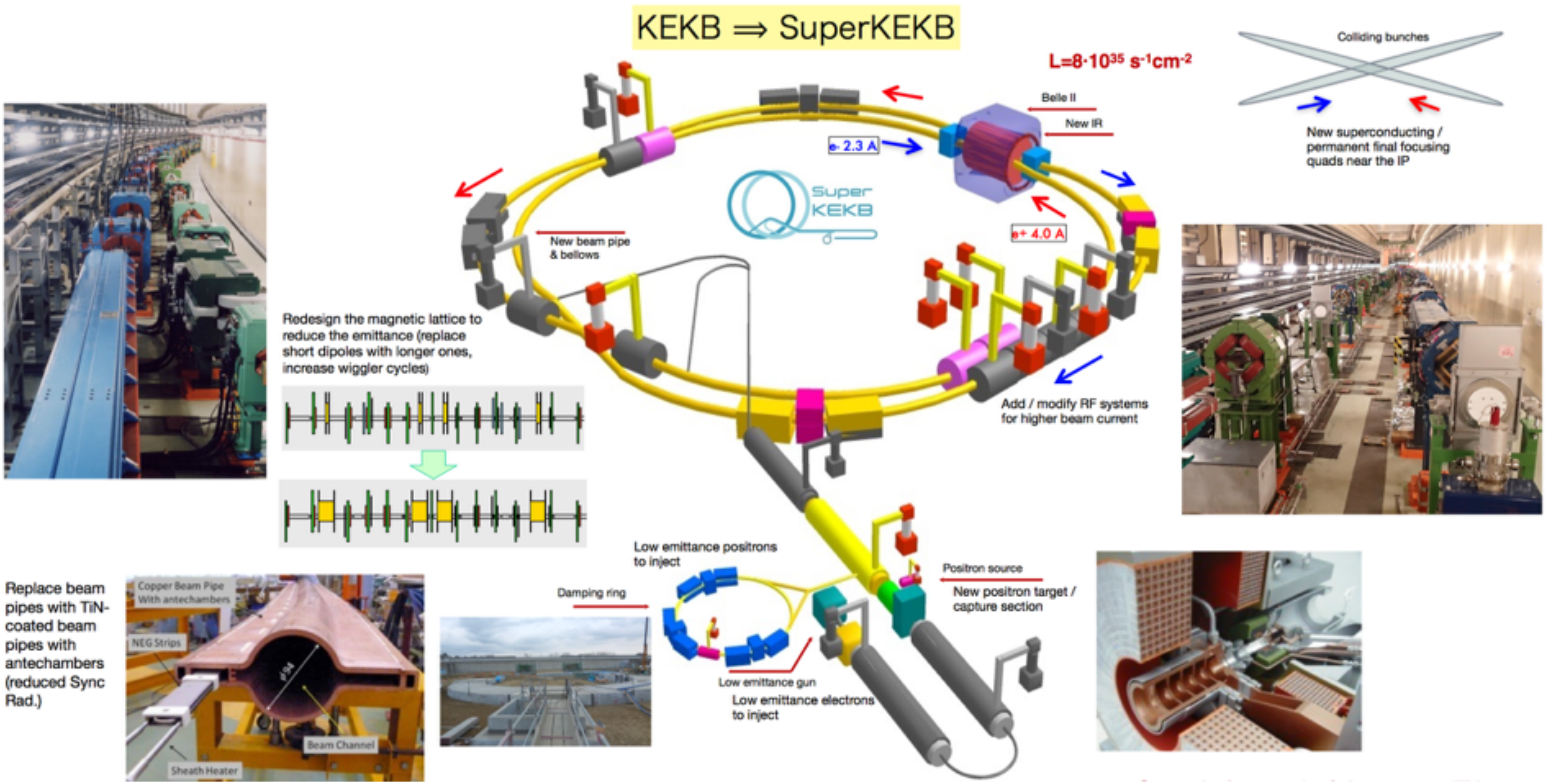
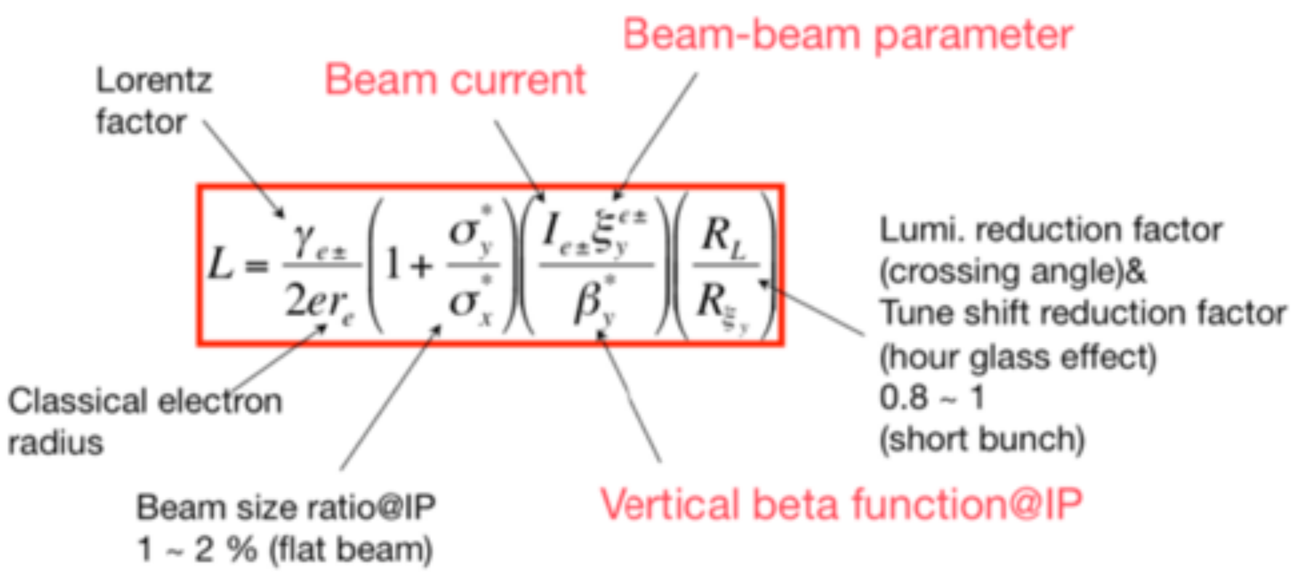
Super-KEKB

A e^+e^- collider runs at Υ(4S) resonance to produce B meson pairs.

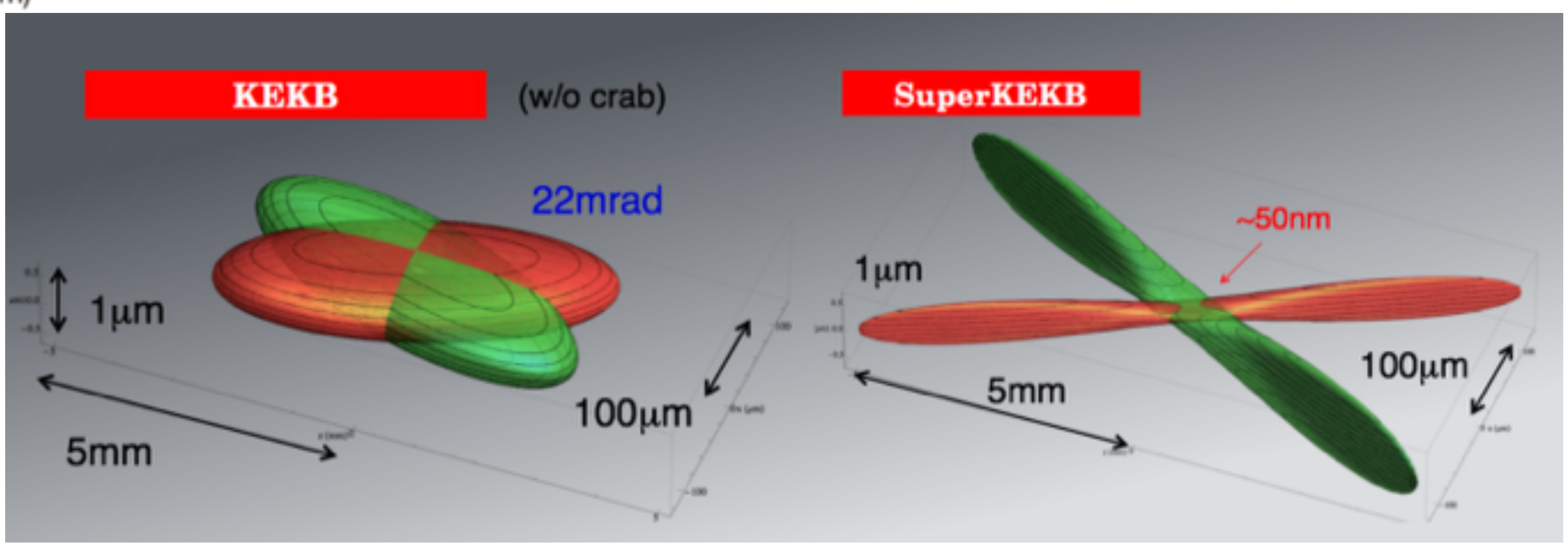


Belle/KEKB: ~$1ab^{-1}$, BaBar/PEP-II: ~$0.5ab^{-1}$, Belle II/SuperKEKB: ~$50ab^{-1}$

How to achieve 40x luminosity

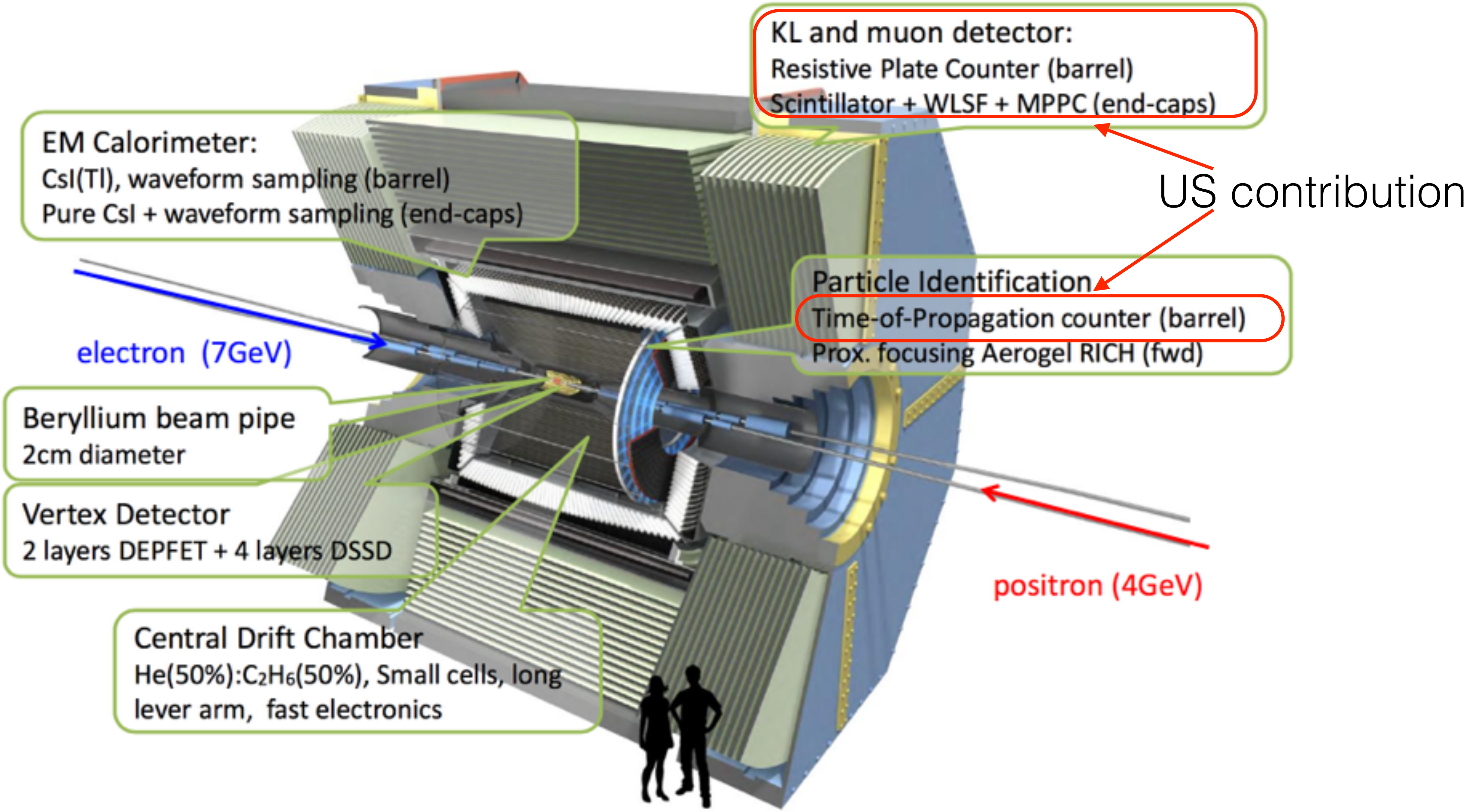


- Nano beam:
  - Small current increase (2-3x)
  - Smaller β_y^* (20x) via superconducting focus magnets

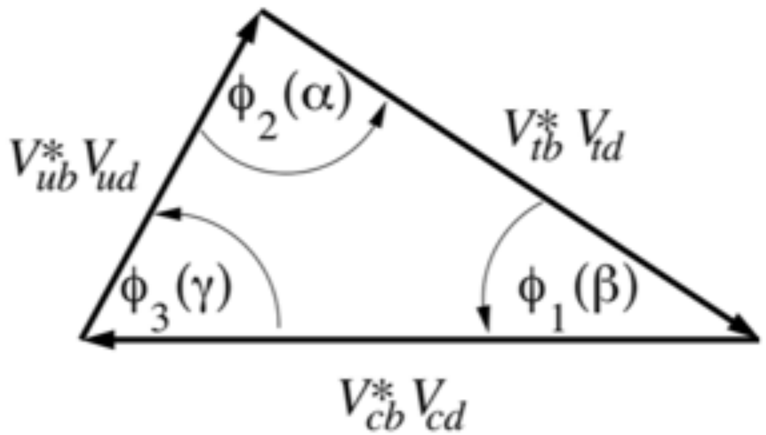


	E (GeV) LER/HER	β^*_y (mm) LER/HER	β^*_x (cm) LER/HER	φ (mrad)	I (A) LER/HER	L ($cm^{-2}s^{-1}$)
KEKB	3.5/8.0	5.9/5.9	120/120	11	1.6/1.2	2.1 x 10^{34}
SuperKEKB	4.0/7.0	0.27/0.30	3.2/2.5	41.5	3.6/2.6	80 x 10^{34}

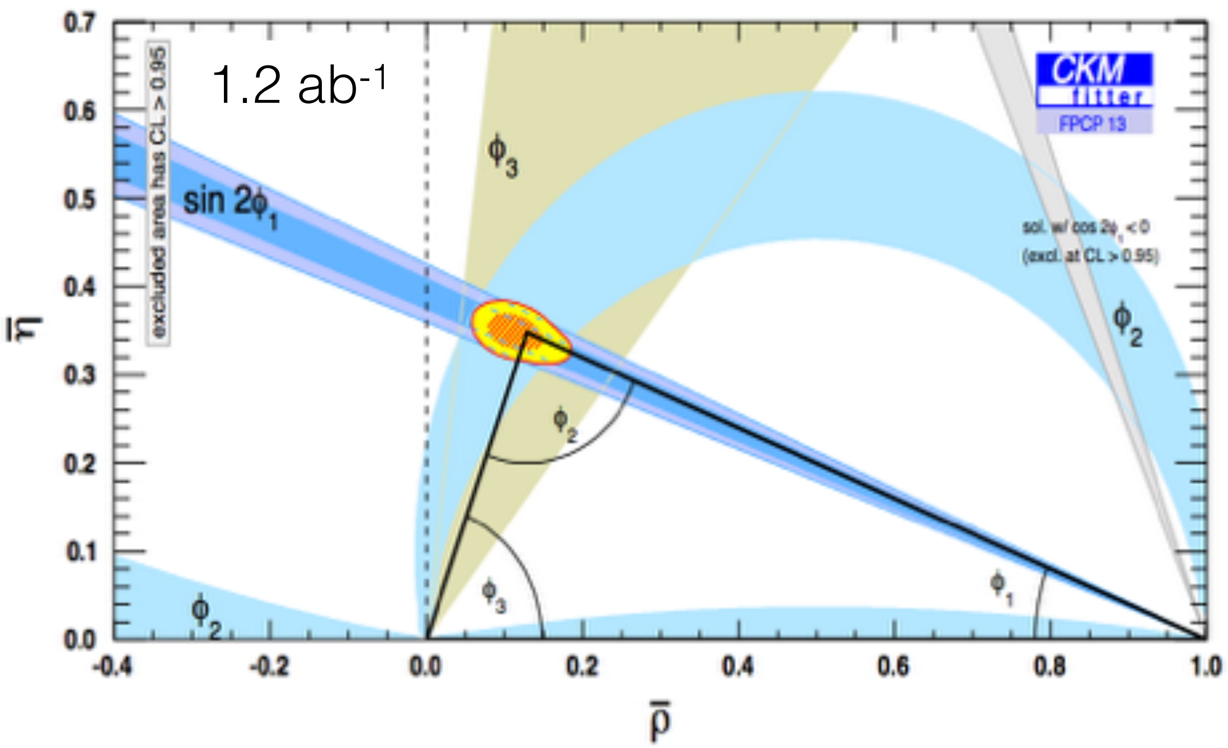
Belle II Detector

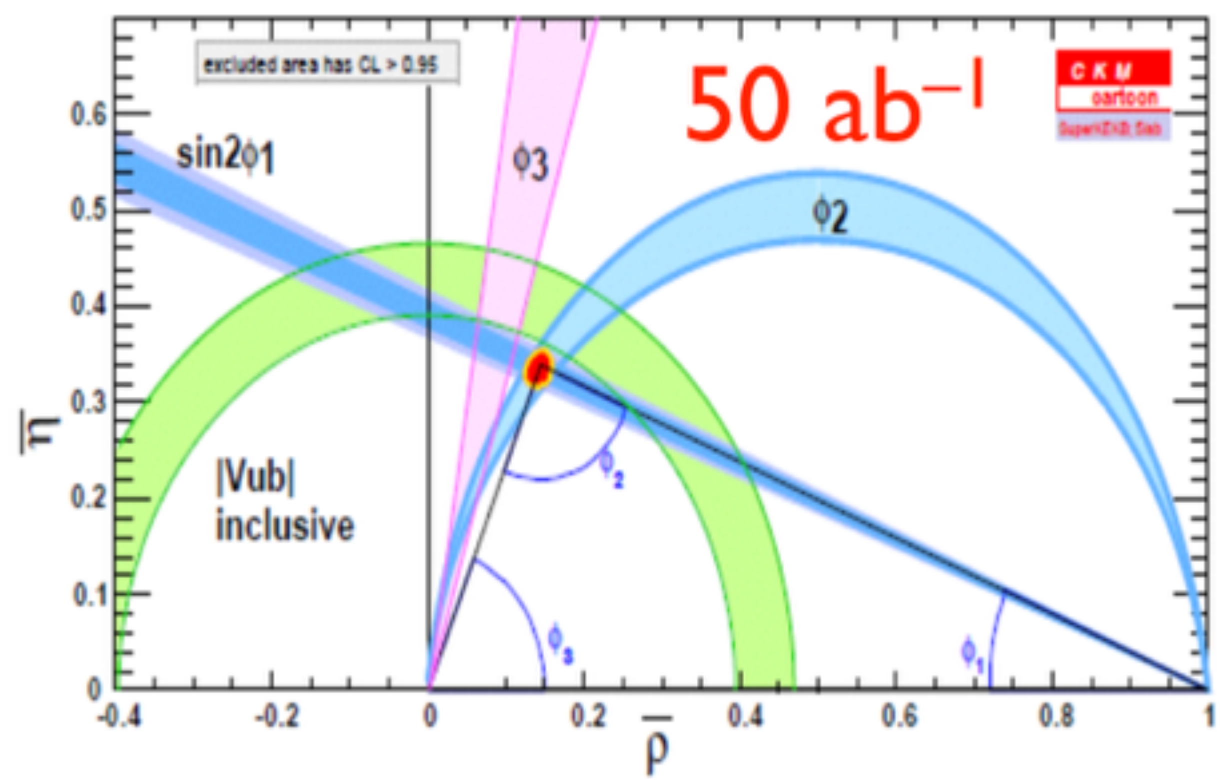


Constraining the CKM UT

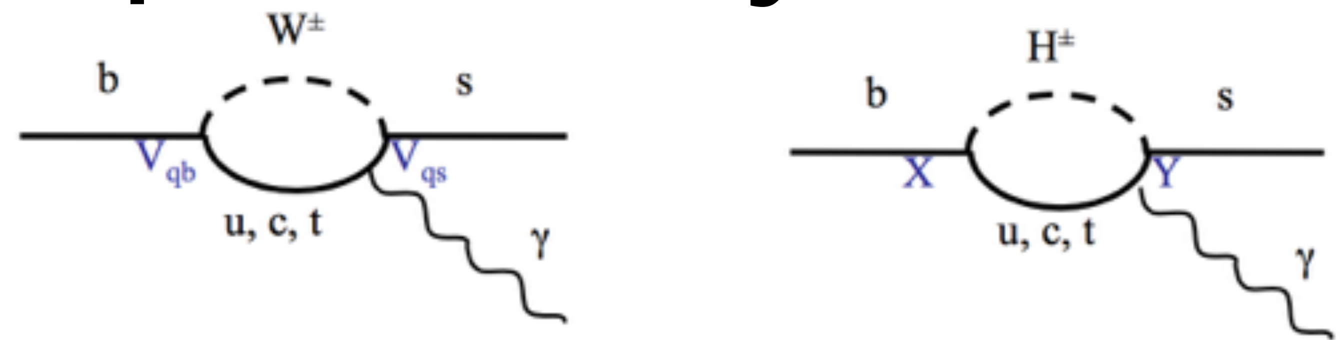


With much higher luminosity, the uncertainties on the CKM UT triangle could be substantially reduced.

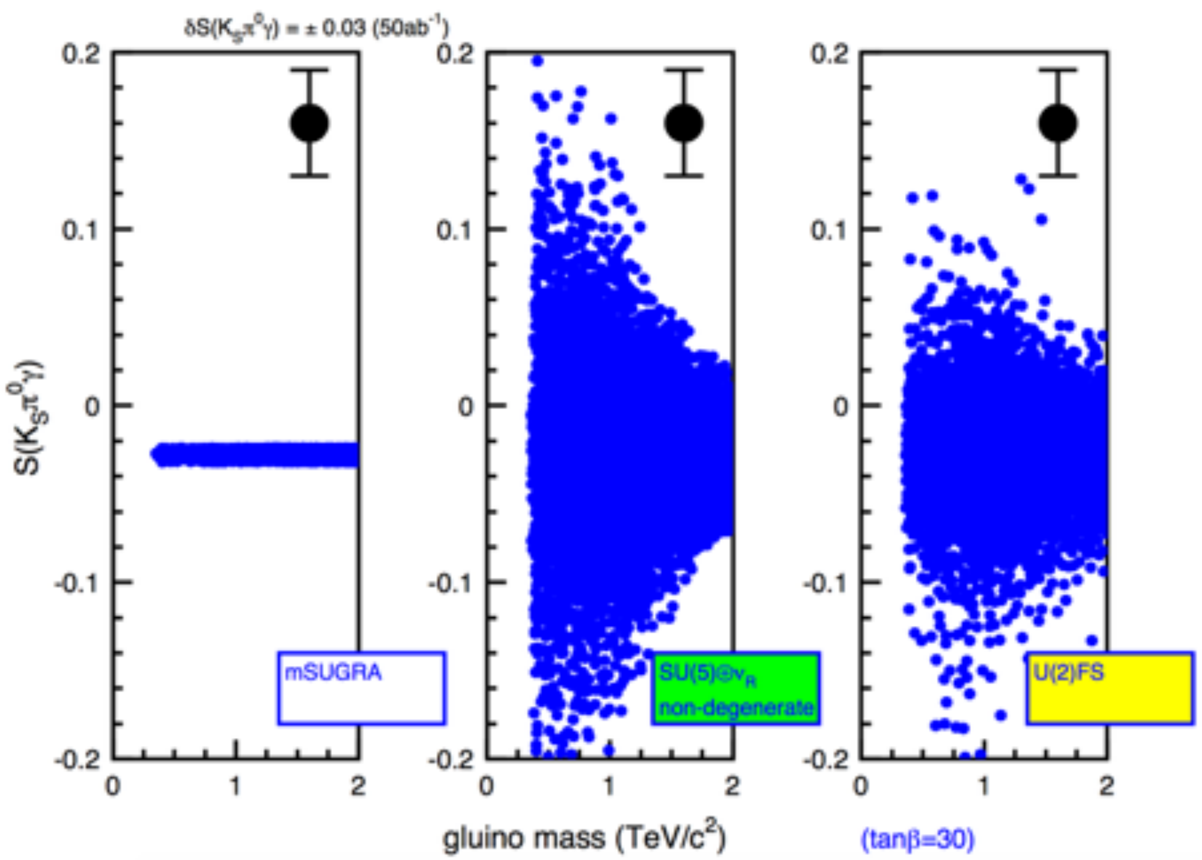


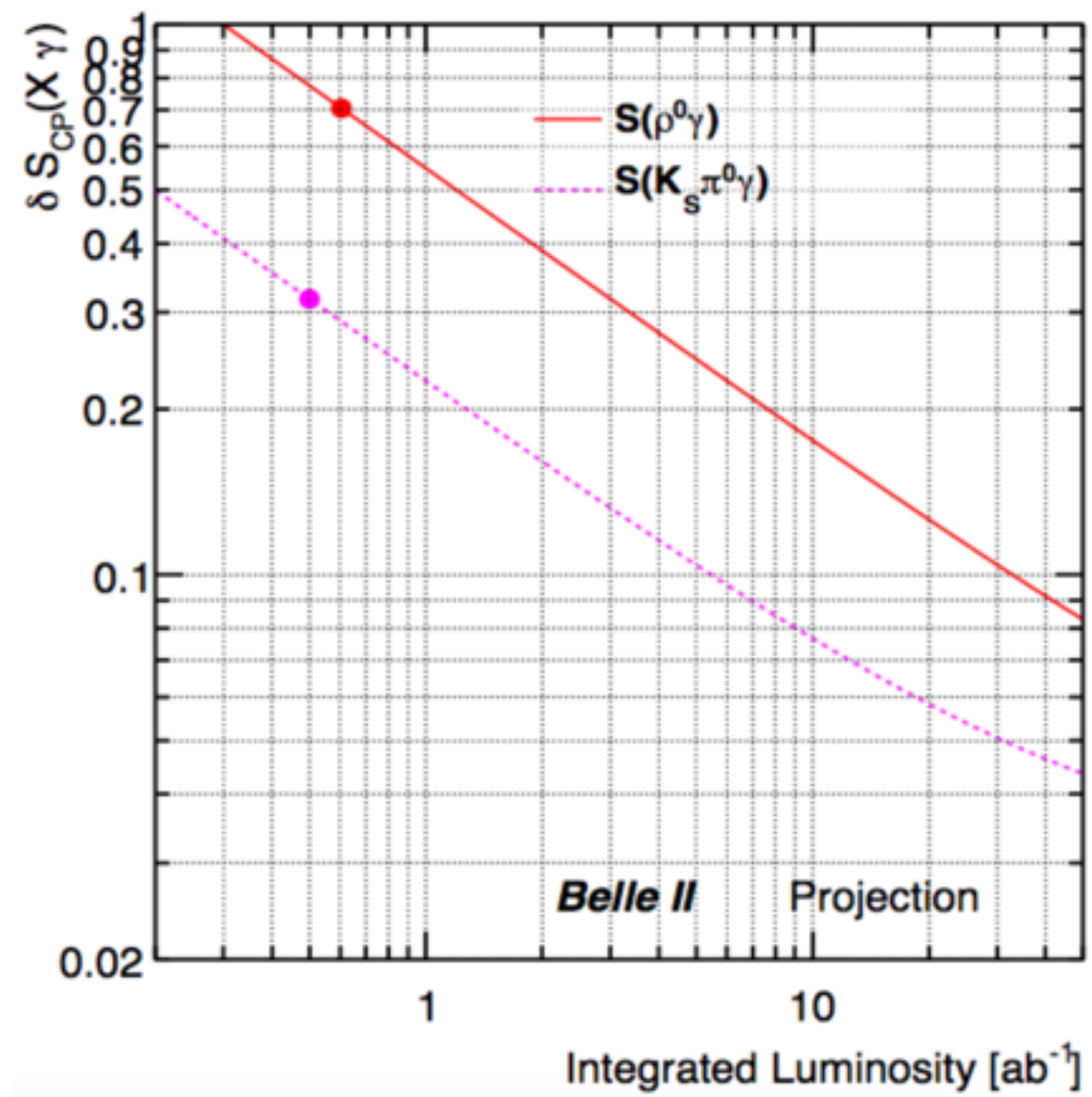


b → sγ decays



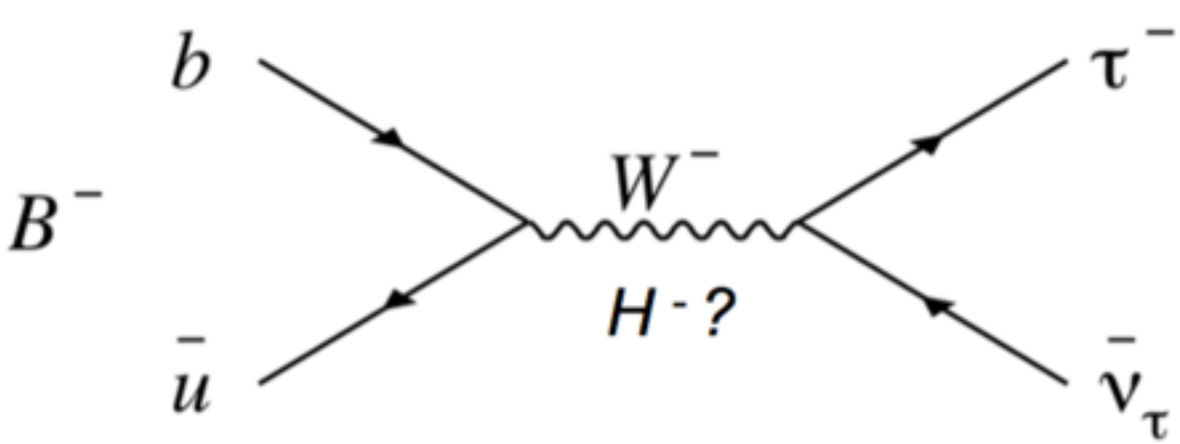
- Suppressed in SM, sensitive to NP.
- For $B^0 \to K_S \pi^0 \gamma$, the CP asymmetry is estimated as $S \approx -0.04$





Buchalla et al., EPJC 57, 309 (2008); arXiv:0801.1833

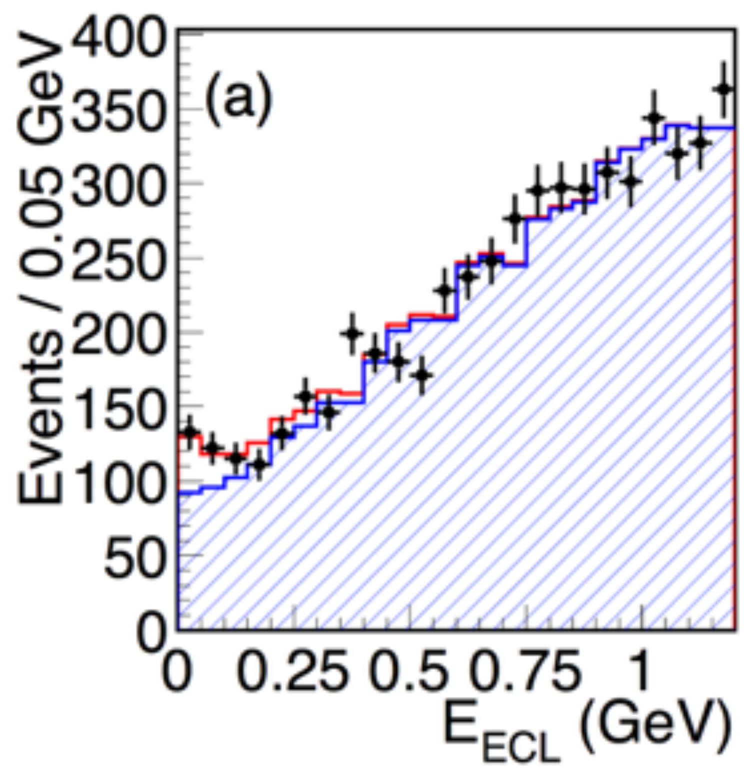
Charged Higgs: $B^+ \to \tau^+ \nu$

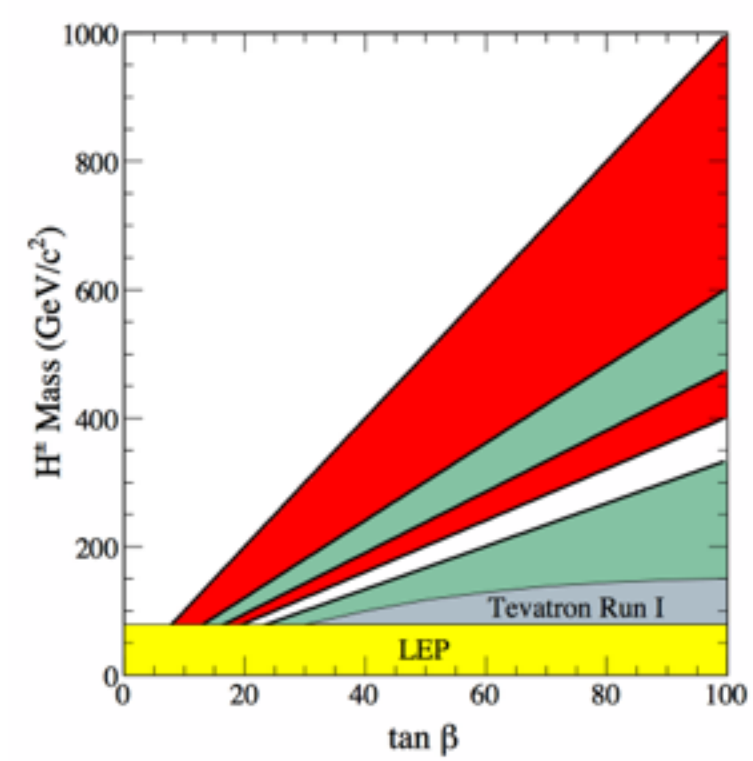


Helicity suppressed. NP could interfere charged Higgs and change the BR.

$$\Gamma(B^+ \to \tau^+\nu_\tau) = \Gamma^{\rm SM}(B^+ \to \tau^+\nu_\tau)[1-(m_B^2/m_H^2)\tan^2\beta]^2$$

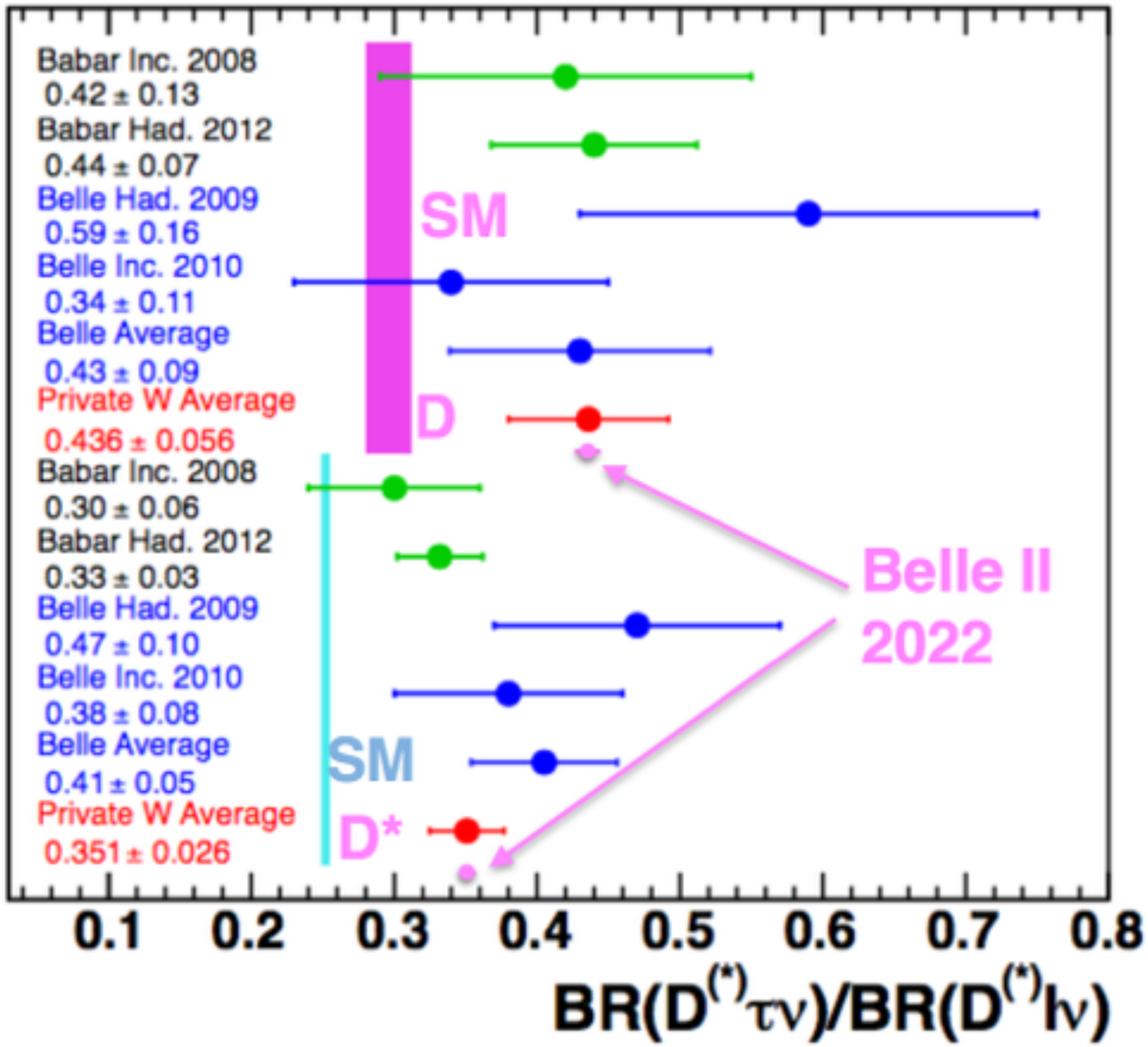
- Hadronic or semi-leptonic tags
- Signal: fitting ECL distribution. Peak near zero indicates $\tau \to l\nu\nu$, $\pi\nu$ decays.



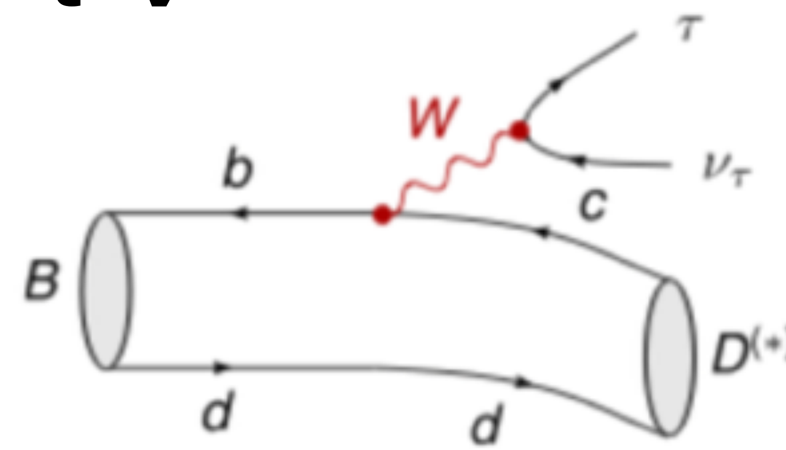


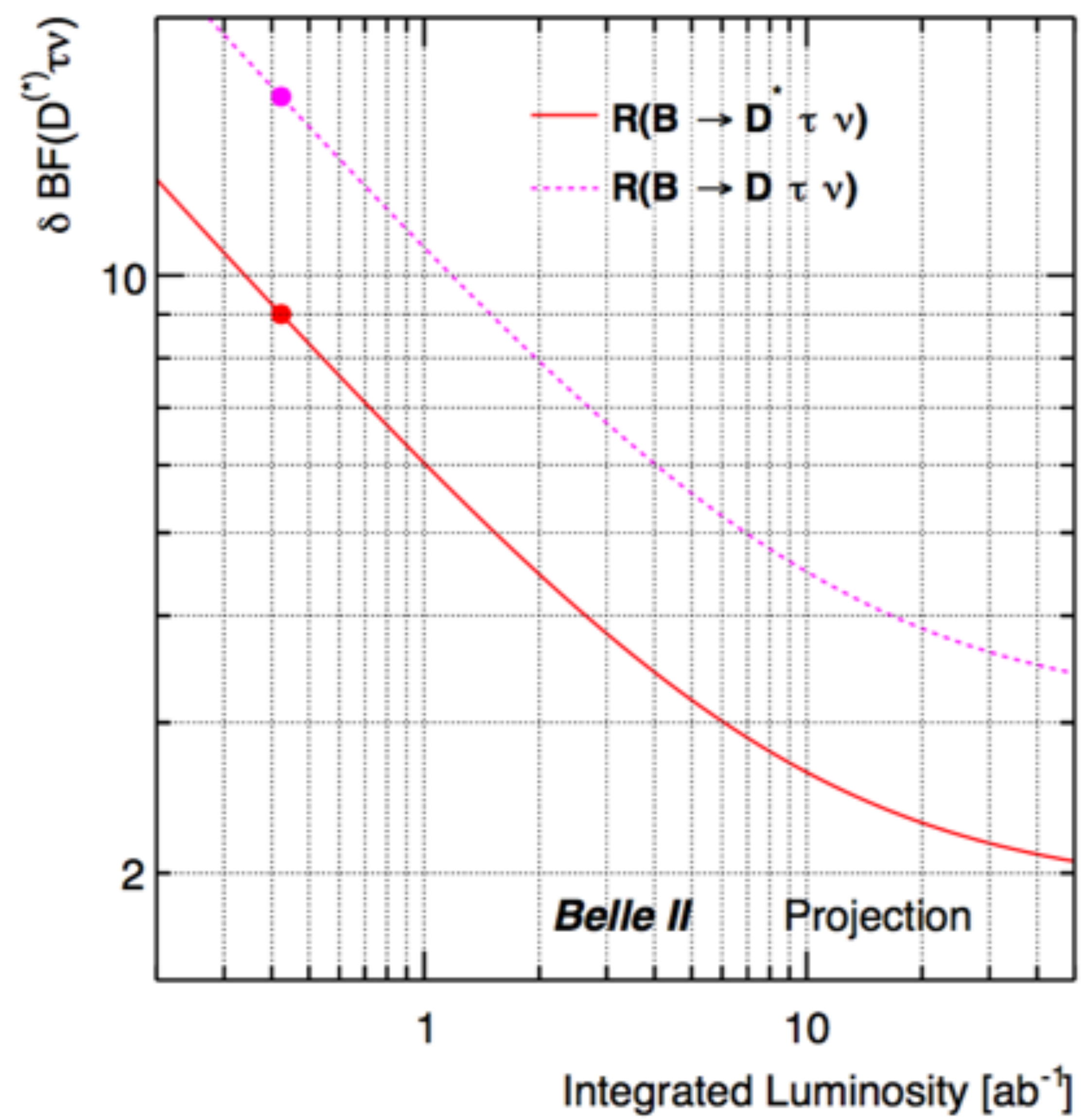
Belle, I. Adachi et al., (2008), 0809.3834

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

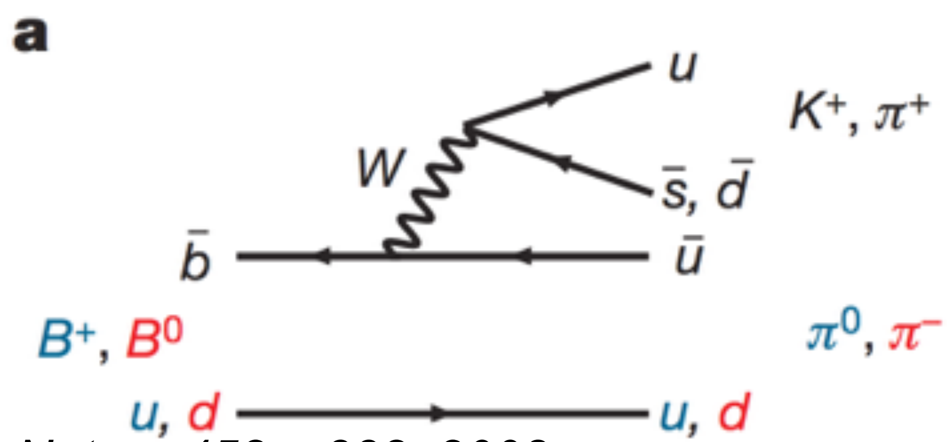


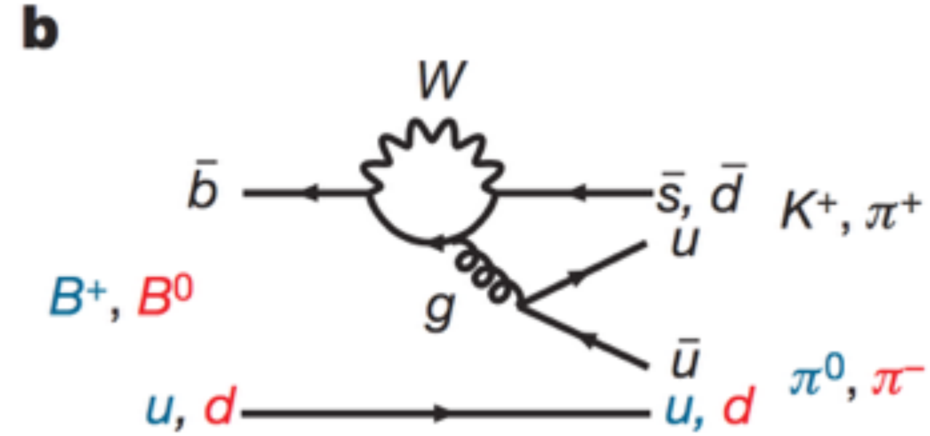
World average is ~5σ from the SM. Belle II should resolve this discrepancy.



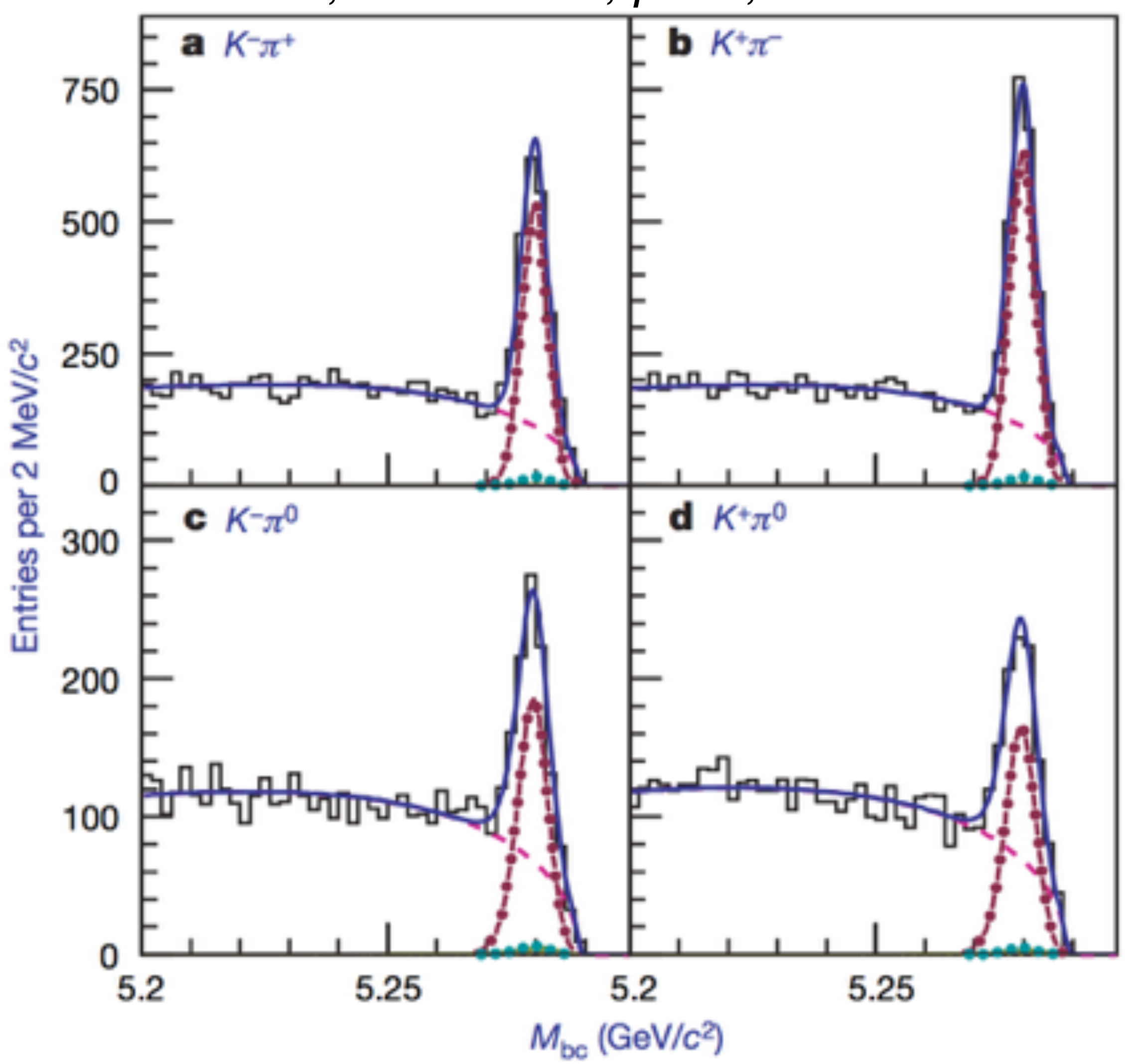


Direct CPV: B → Kπ





Belle, Nature 452, p332, 2008



- A_{CP} should be the same for $K\pi^-$ and $K\pi^0$.
- Belle measurement showed they are different:

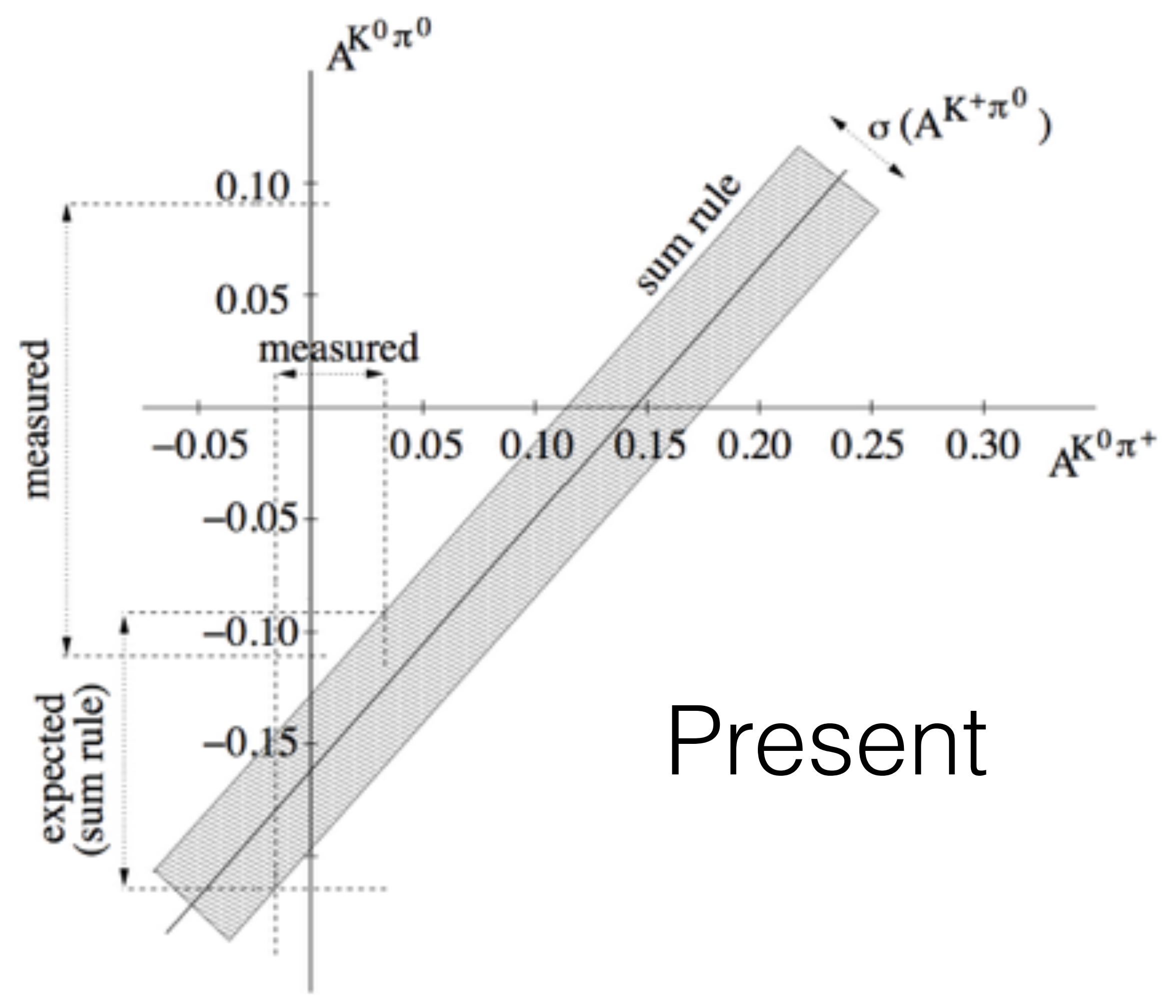
$A_{CP}(K^+\pi^0) - A_{CP}(K^+\pi^-) = 0.164 \pm 0.035 \pm 0.013$

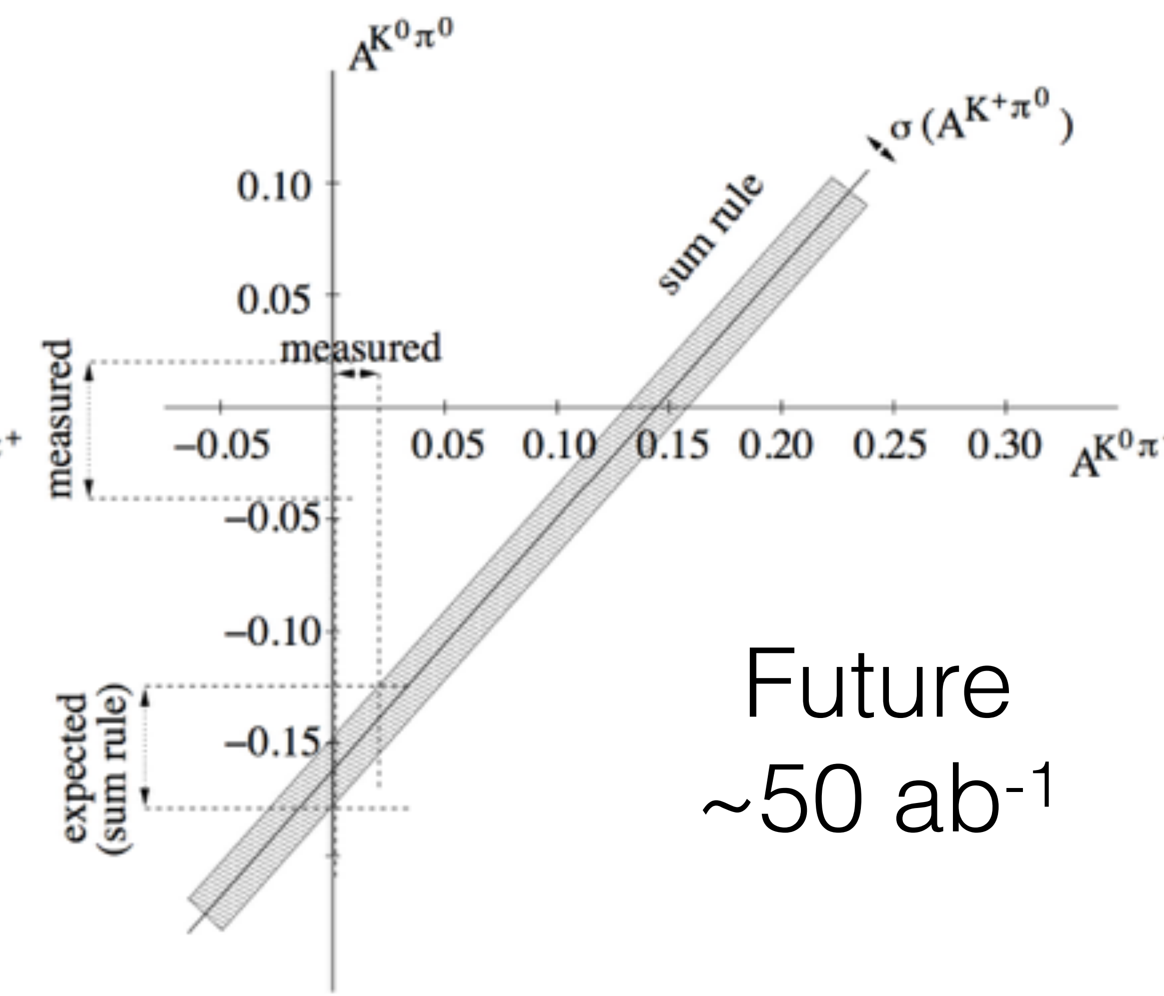
Direct CPV: B → Kπ

By using the sum rule:

$$A_{CP}^{K^+\pi^-} + A_{CP}^{K^0\pi^+}\frac{\mathcal{B}(B^+\to K^0\pi^+)\tau_{B^0}}{\mathcal{B}(B^0\to K^+\pi^-)\tau_{B^+}} = A_{CP}^{K^+\pi^0}\frac{2\ \mathcal{B}(B^+\to K^+\pi^0)\tau_{B^0}}{\mathcal{B}(B^0\to K^+\pi^-)\tau_{B^+}} + A_{CP}^{K^0\pi^0}\frac{2\ \mathcal{B}(B^0\to K^0\pi^0)}{\mathcal{B}(B^0\to K^+\pi^-)}\ ,$$

M. Gronau, Phys. Lett. B627, 82 (2005), hep-ph/0508047, 10.1016/j.physletb.2005.09.014

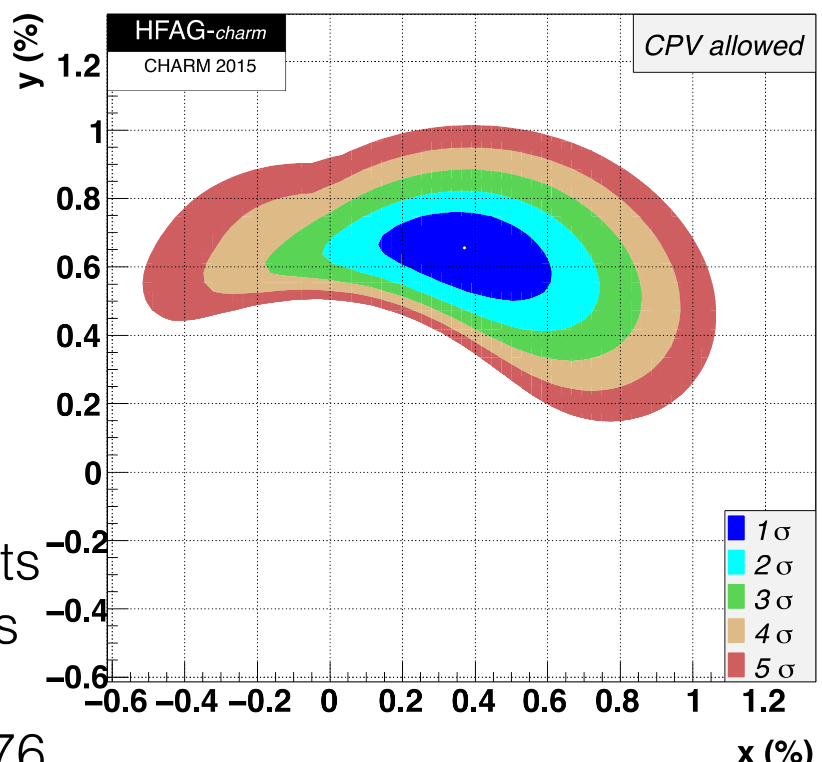


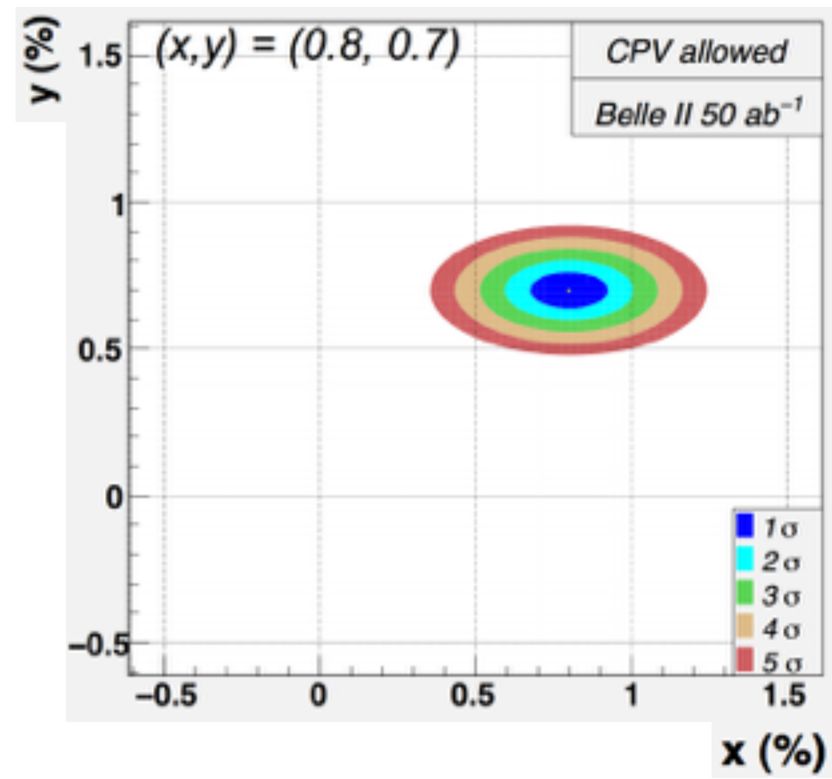


CPV in $D^0 - \overline{D^0}$ Mixing

Now

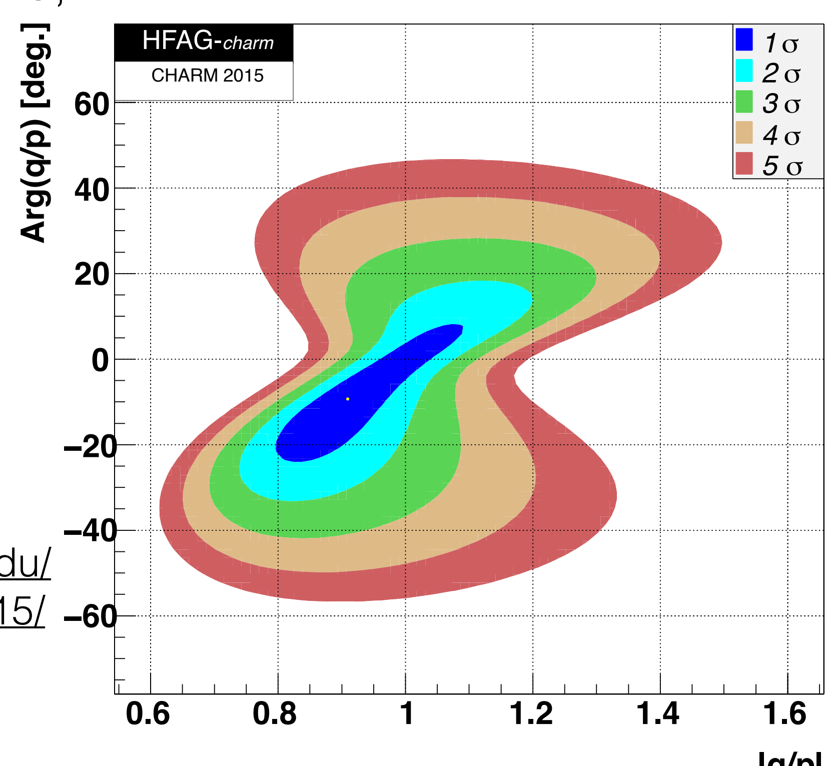
50 ab^{-1}

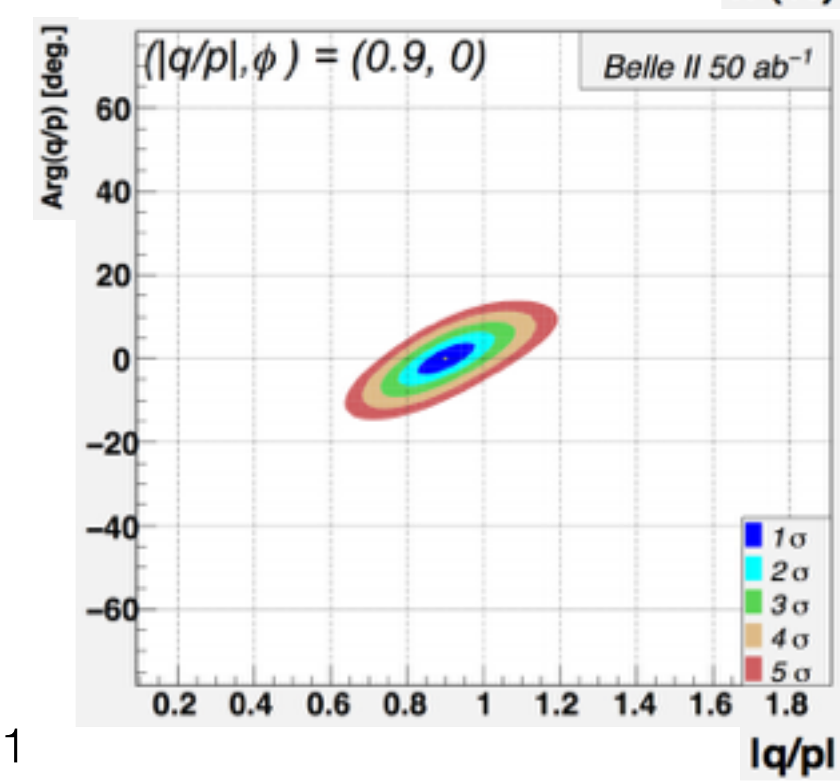




Current measurements give many constraints on NP models (see Golowich et al., PRD76, 095009 (2007))

More precise results with higher luminosity

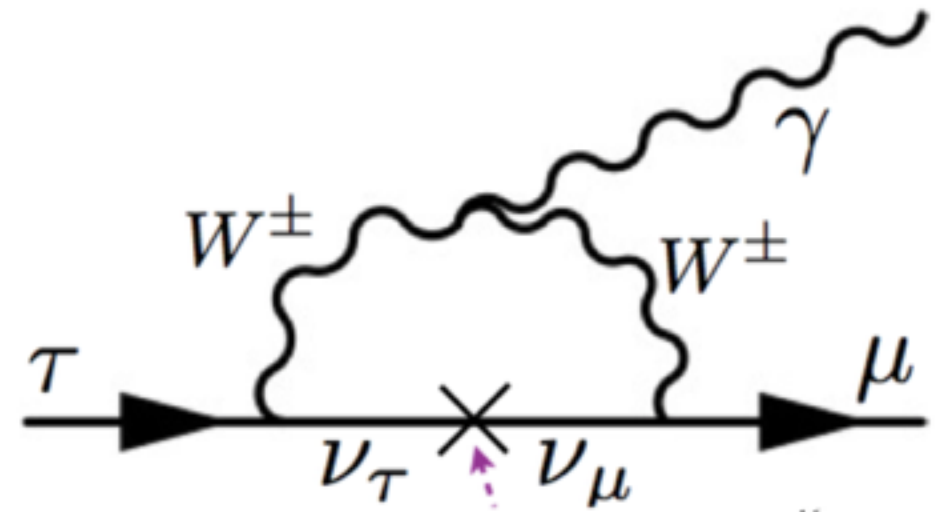




http://www.slac.stanford.edu/xorg/hfag/charm/CHARM15/results_mix_cpv.html

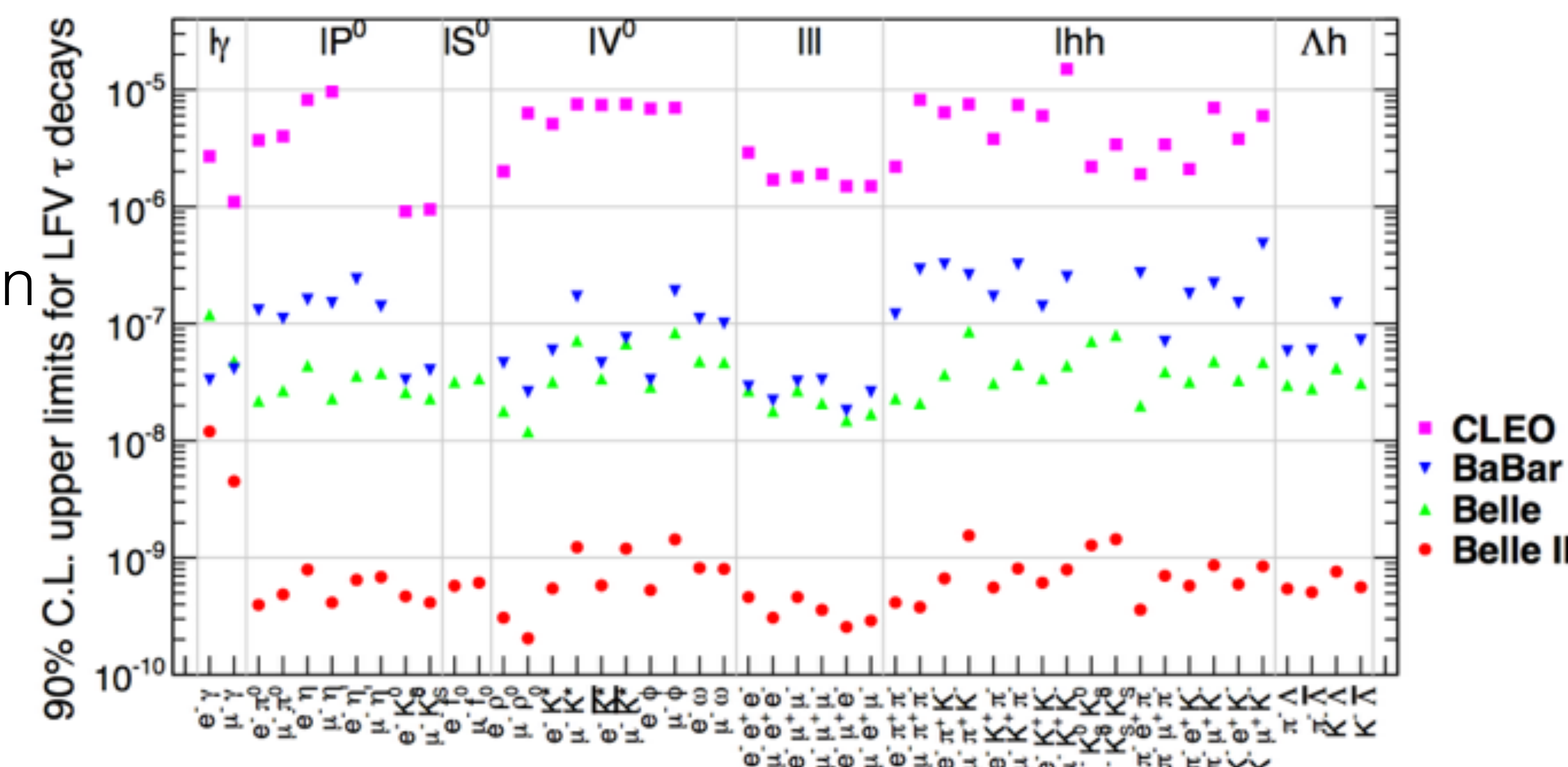
τ Lepton Flavour Violation

SM prediction:
BR(LFV) ~ 10^{-25}



Possible NP in LFV:

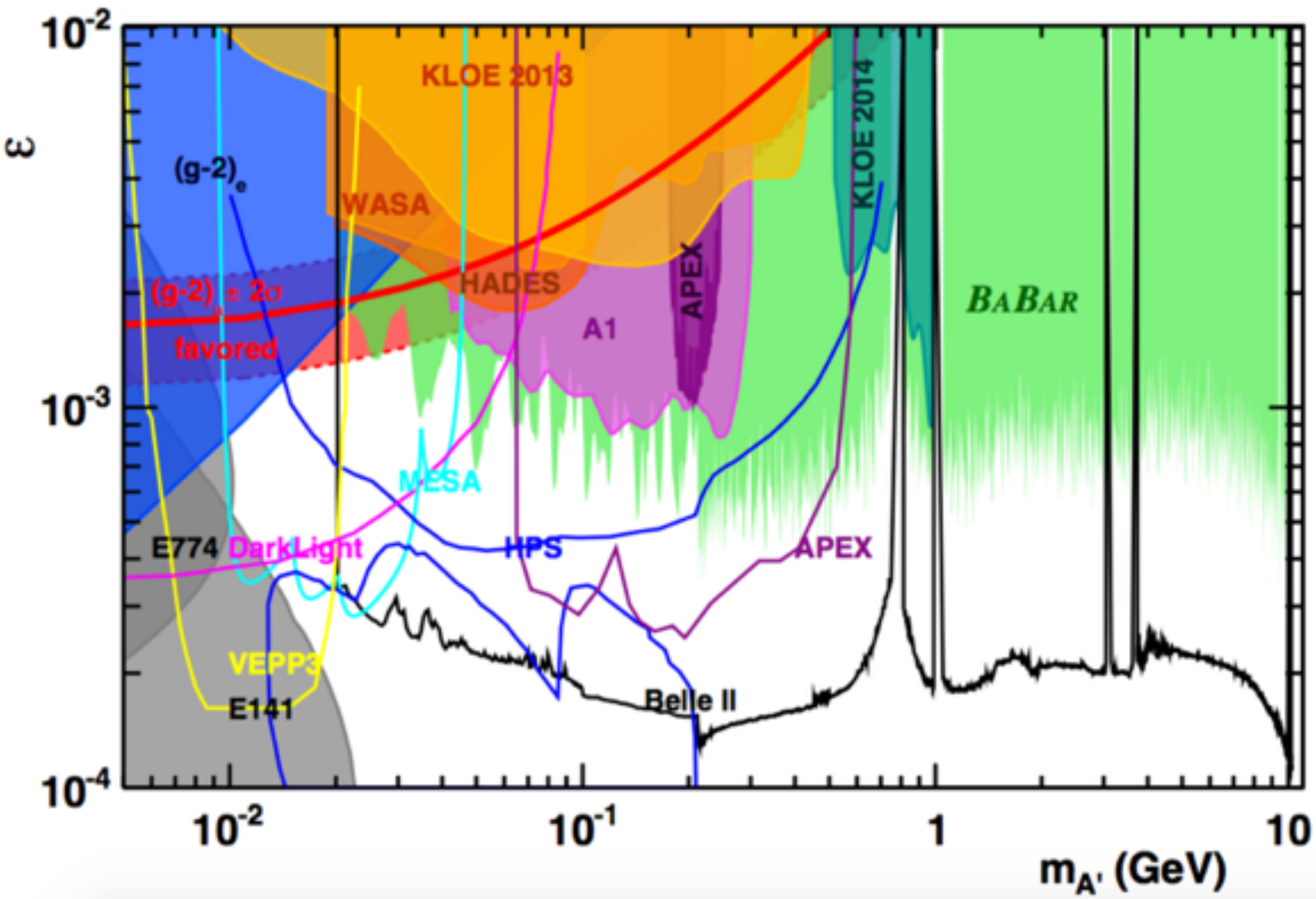
- slepton mixing
- H^{++} Zee-Babu models
- Neutral Higgs boson
- Majorana neutrinos
- Seesaw mechanisms



Belle II Flavour Prospects (B2TiP 2014)

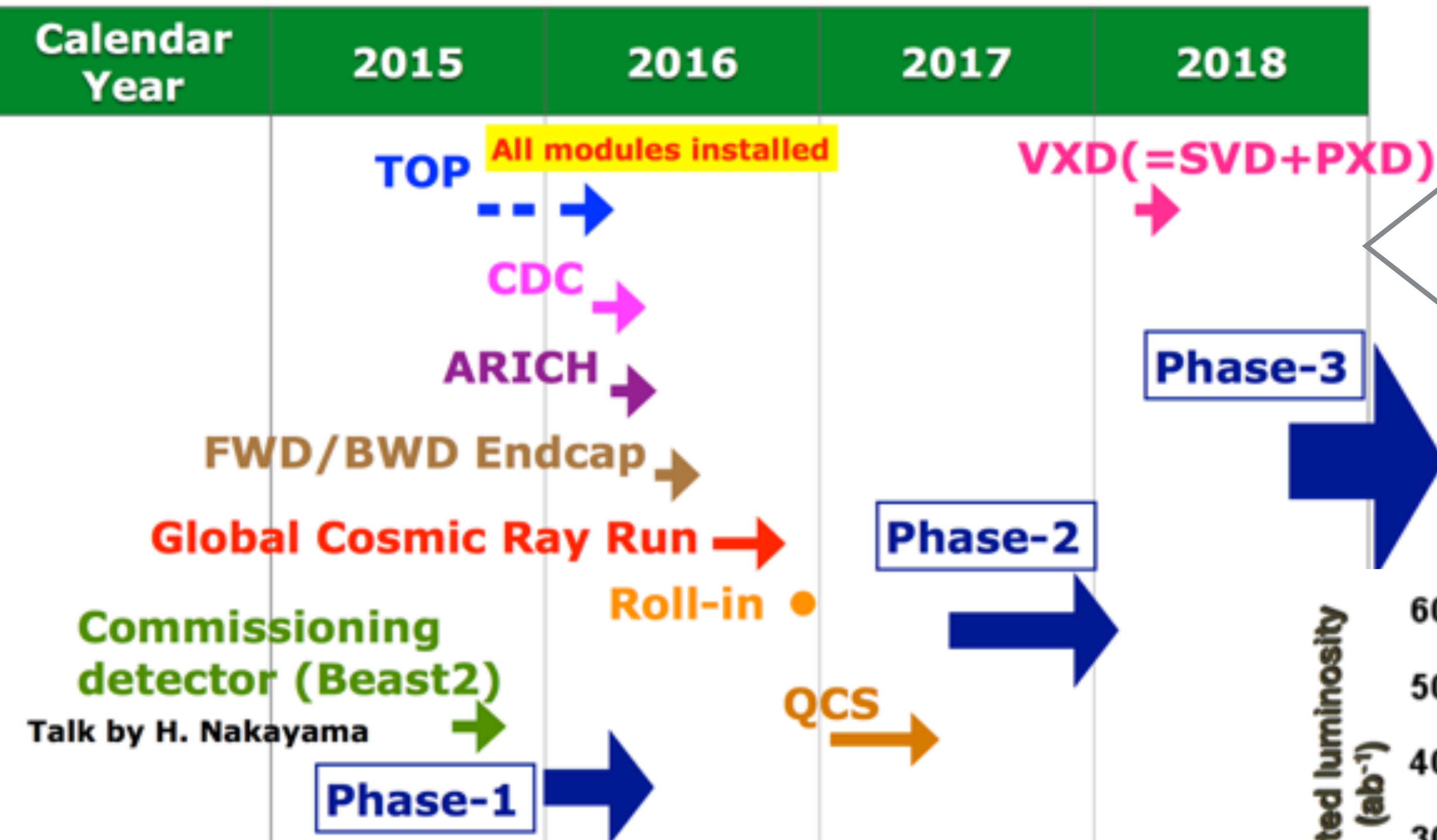
Dark Sector

- Dark matter suggests dark sector.
- Dark photon: A', to be in MeV ~ GeV mass.
- Probing method:
  - Leptonicaly decaying dark photons through mixing.
  - Sub-GeV dark matter in invisible decays.



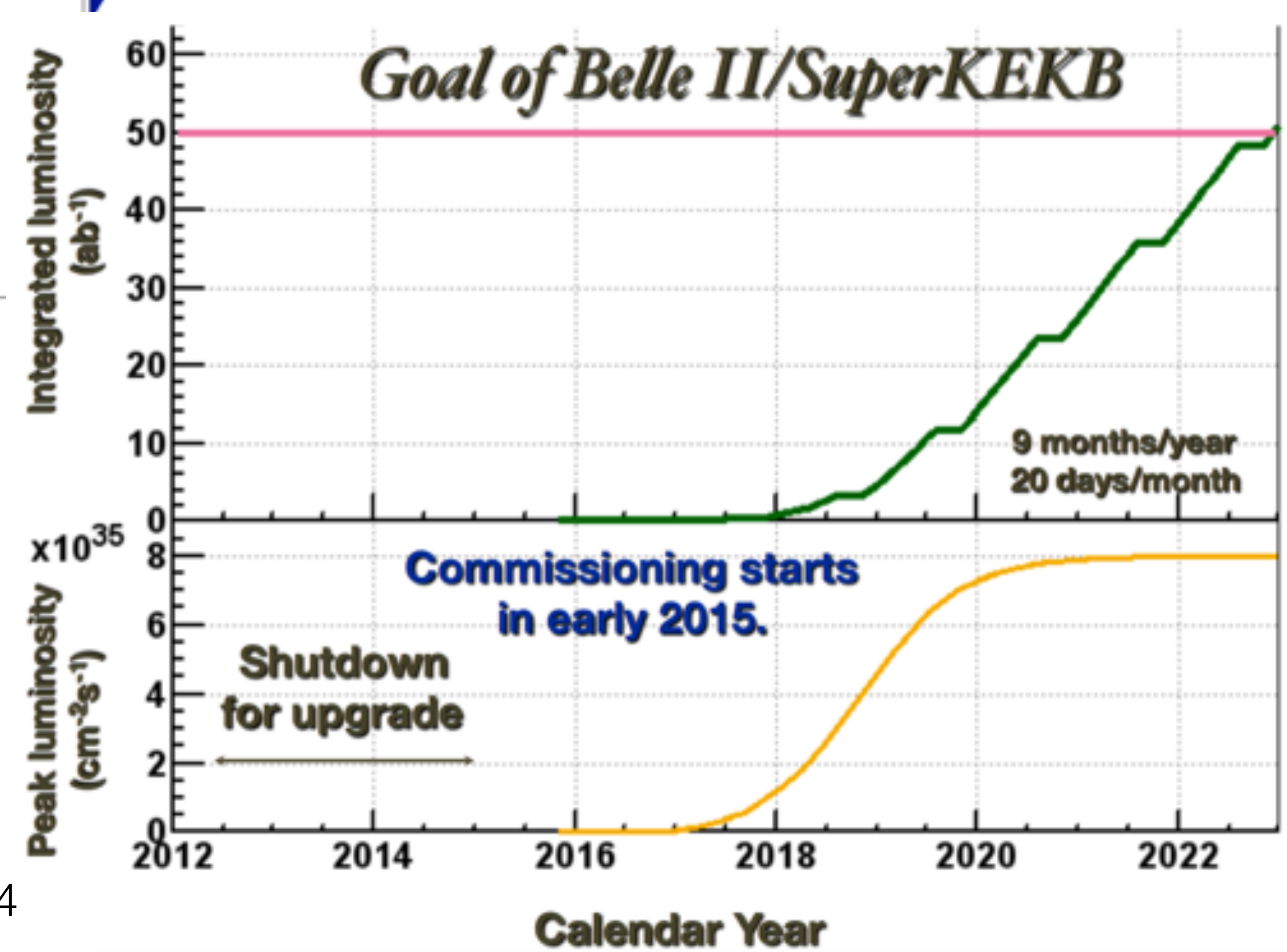
Current and projected limits, radiative production of dark photon, decay to SM particles (C. Hearty, B2TIP 2014)

Schedule



Installation and commissioning plan

Luminosity schedule



Summary

- Upgrade of Super-KEKB and Belle II is on going.
- Physics opportunities on Belle II:
  - Constraining on CKM UT
  - Probing charged Higgs
  - New sources of CPV
  - Lepton Flavour Violation
  - Dark sectors
- Belle II will start operation in 2016.