



THE *Belle II* EXPERIMENT

DANIEL ČERVENKOV ON BEHALF OF BELLE II COLLABORATION

SEPTEMBER 26, 2018 | NEW TRENDS IN HIGH-ENERGY PHYSICS, MONTENEGRO

CHARLES UNIVERSITY



Past

- Belle and BaBar
- 1999 – 2010
- e^+e^- , asymmetric
- Collectively accumulated 1.5 ab^{-1}

Present

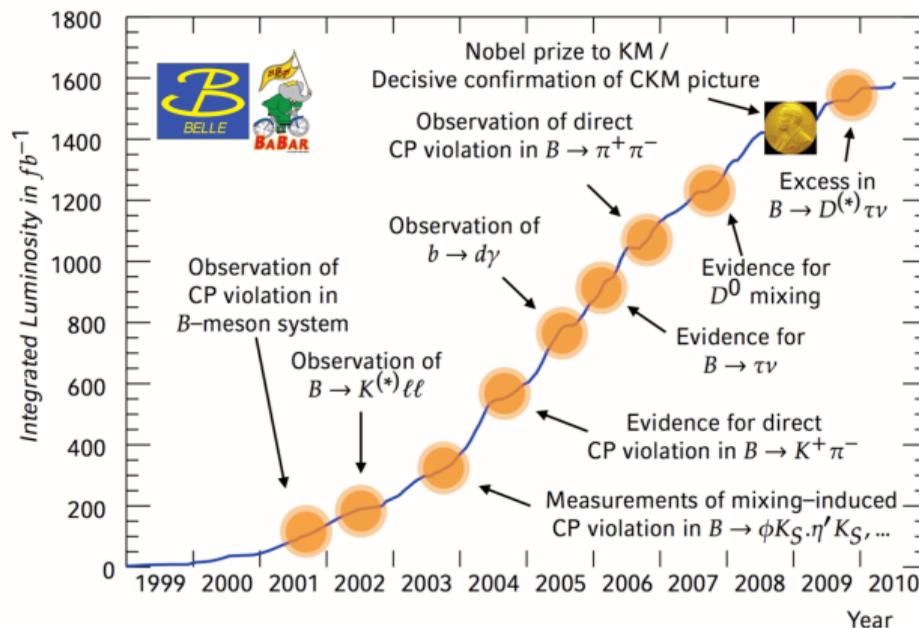
- LHCb
- 2008 – today
- pp , symmetric
- $\sim 8 \text{ fb}^{-1}$ (not directly comparable)

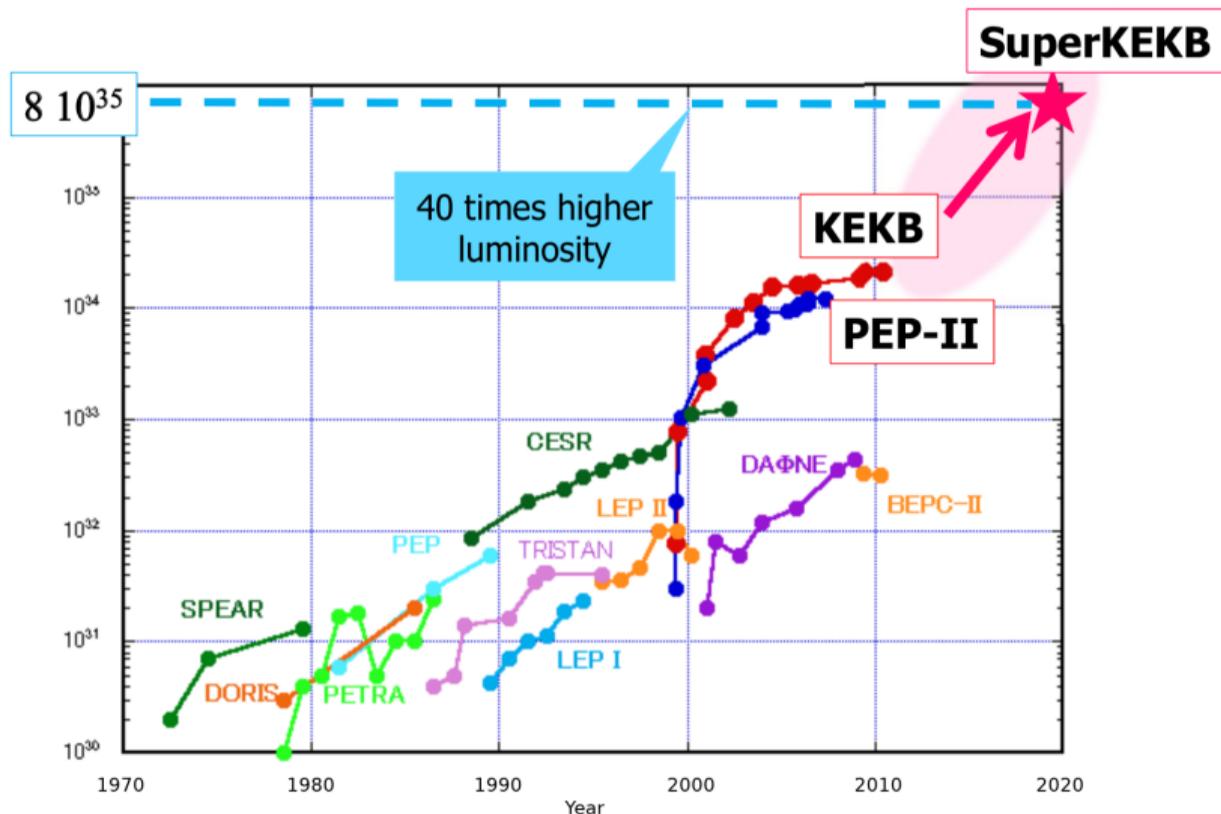
(Very near) Future

- Belle II
- 2018 –
- e^+e^- , asymmetric
- Plans to accumulate 50 ab^{-1} by 2026

- Low background (compared to hadronic machines)
 - Just above $\Upsilon(4S)$ threshold
 - Low multiplicity ($\sim 15 - 20$ vs hundreds in pp)
- Knowledge of collision 4-momentum — can reconstruct decays with missing energy
 - e^+e^- annihilation \Rightarrow initial 4-momentum is known
 - Hermeticity
- Good reconstruction efficiency of neutral particles

- Confirmation of CKM mechanism
- CPV in B decays
- D^0 mixing
- Discoveries of exotic particles
 - $X(3872)$
 - $Y(4340)$
 - $Z(4430)$
 - ...
- Limits on New Physics scenarios

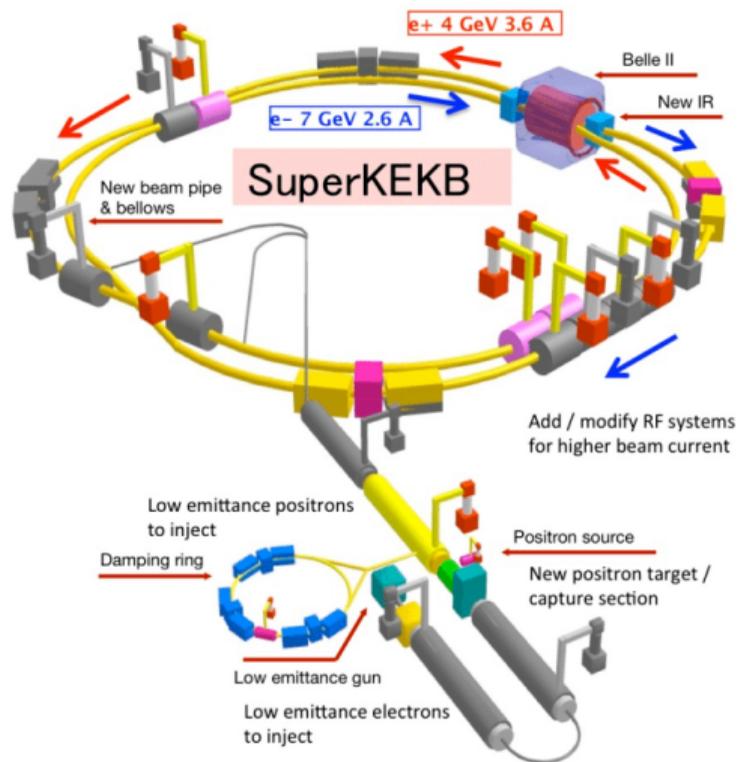




Increased luminosity
+
Improved detector

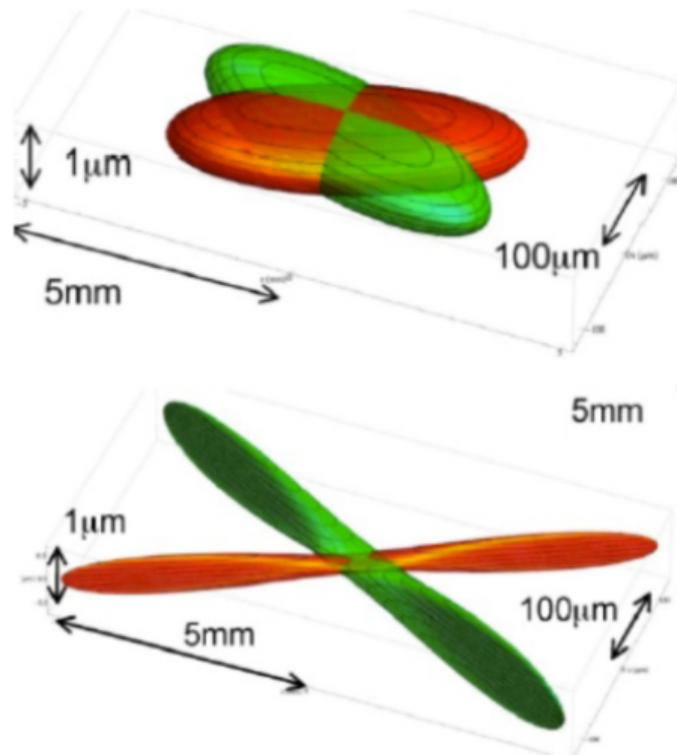


A chance to study highly suppressed (B)SM processes, or other processes with high accuracy



$$\mathcal{L} = \frac{\gamma_{\pm}}{2er_e} \left(1 + \frac{\sigma_y^*}{\sigma_x^*} \right) \frac{I_{\pm} \xi_{y\pm}}{\beta_{y\pm}^*} \frac{R_L}{R_{\xi_y}}$$

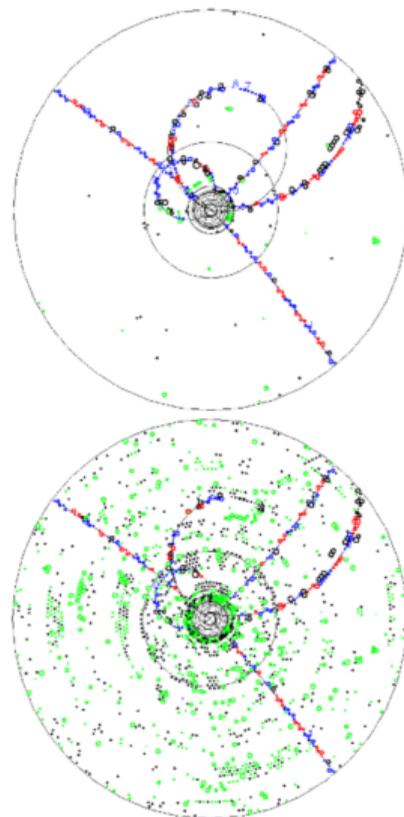
Parameter	KEKB	SuperKEKB
$I_{+/-}$ [A]	1.6/1.2	3.6/2.6
$\beta_{y+/-}^*$ [mm]	5.9/5.9	0.27/0.30
\mathcal{L} [cm ⁻² s ⁻¹]	2.1×10^{34}	8×10^{35}

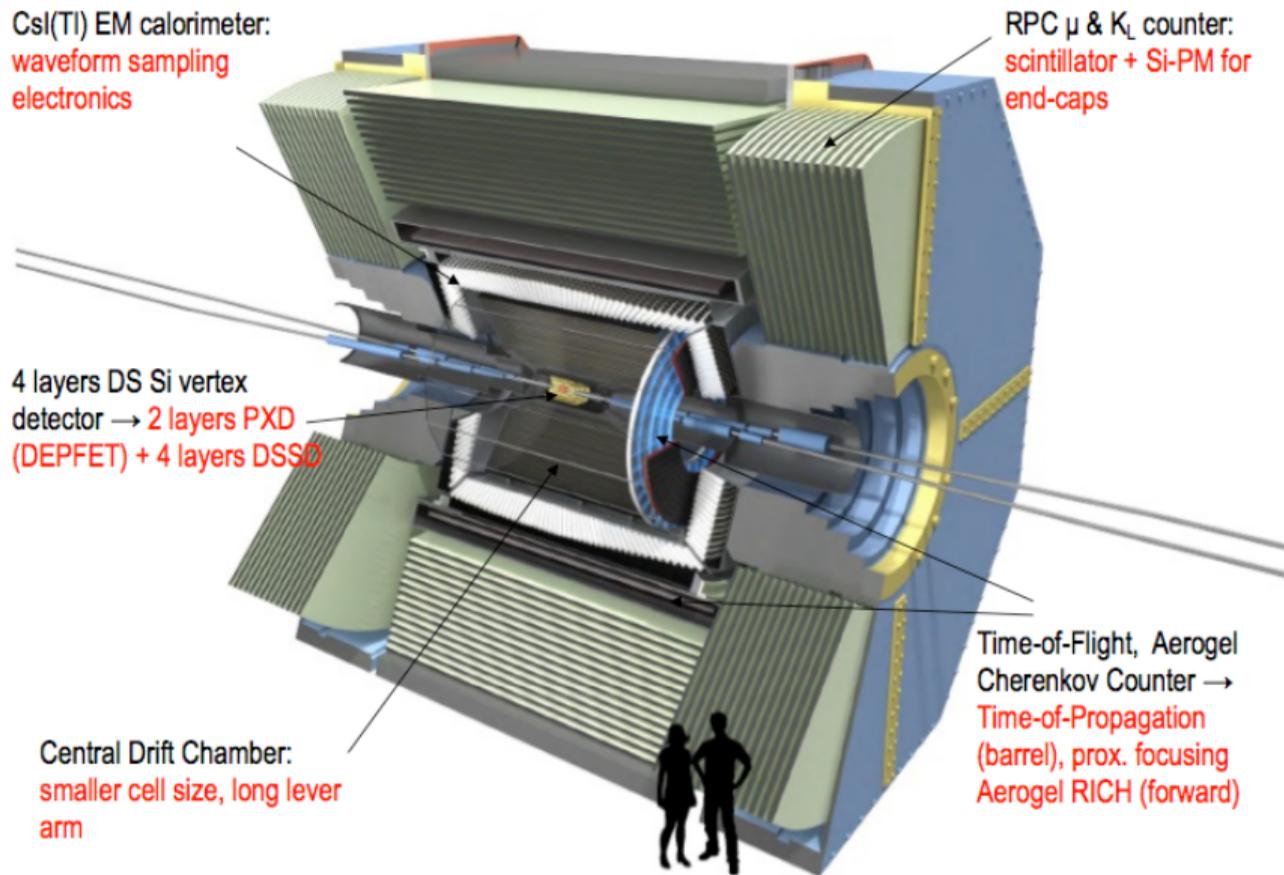


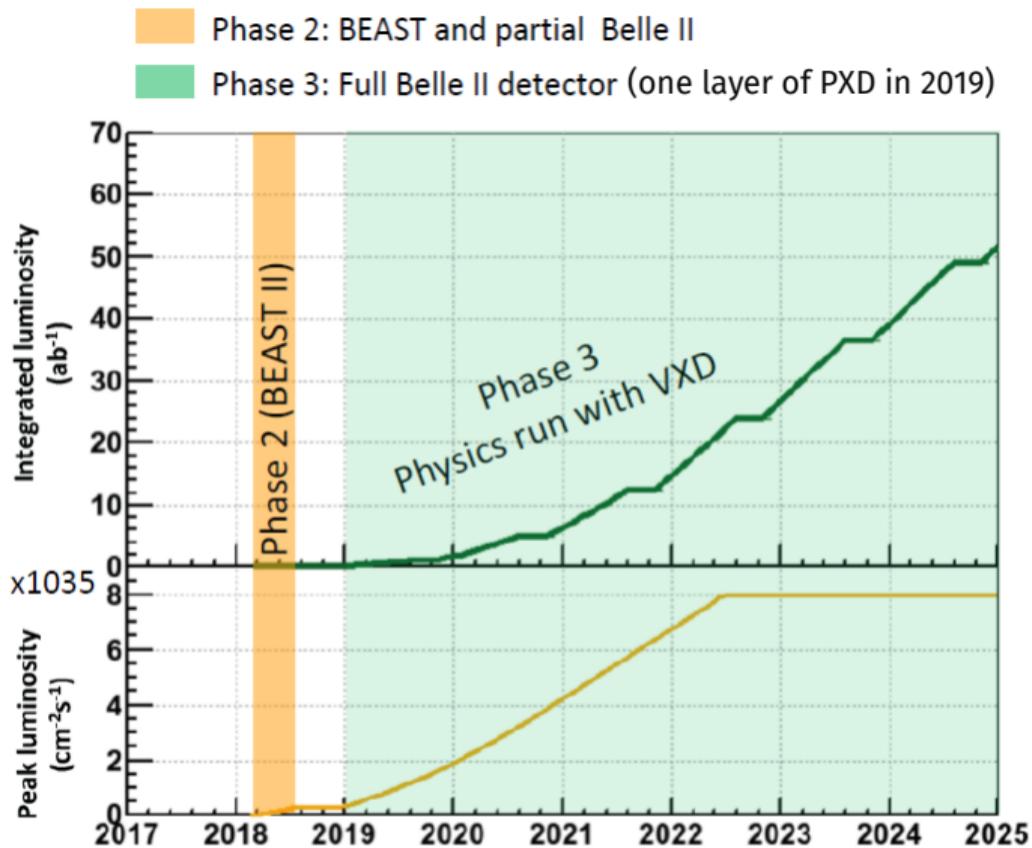
Beams at interaction point:

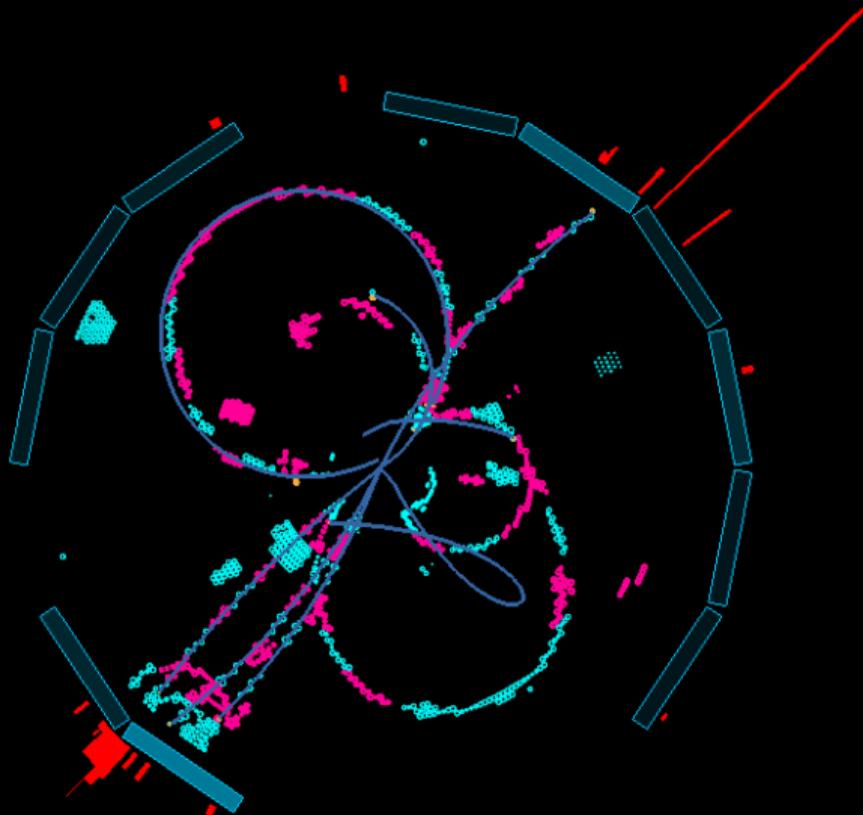
- $\sigma_y^* = 42 \text{ nm}$
- $\sigma_x^* = 6 \mu\text{m}$

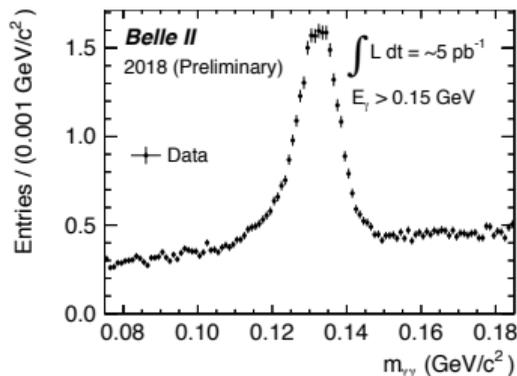
- 40× higher luminosity
 - 20× higher background (shielding and collimator optimization)
 - Higher rate DAQ, trigger
 - Volume of data
 - Pile-up (faster SVD, CDC, ECL)
 - Radiation damage



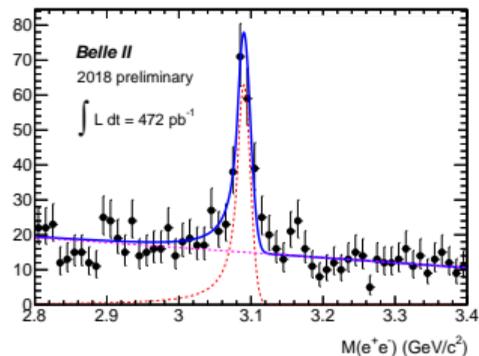




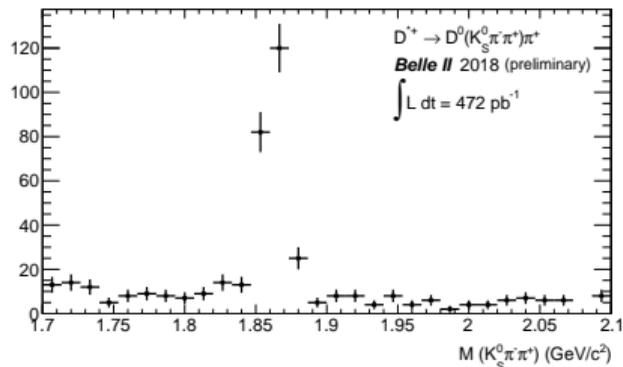




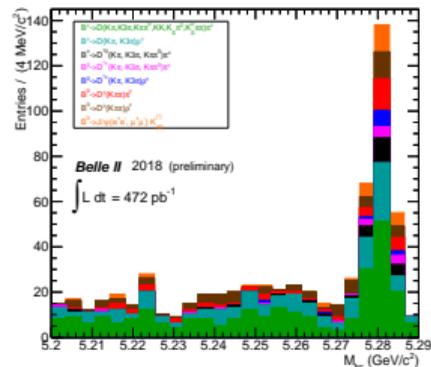
Invariant mass of π^0 candidates



Invariant mass of J/ψ candidates

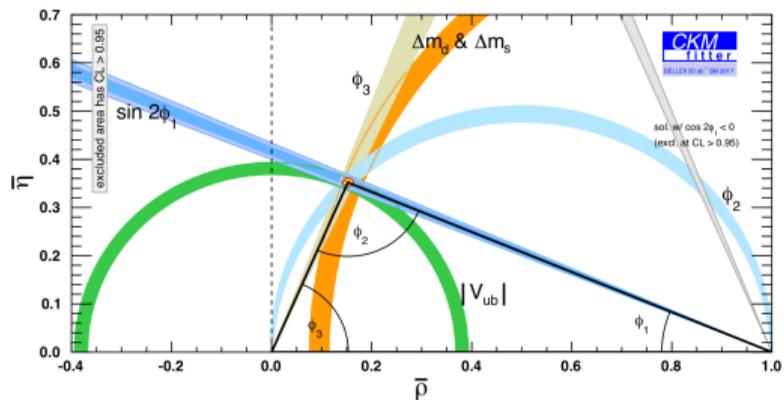
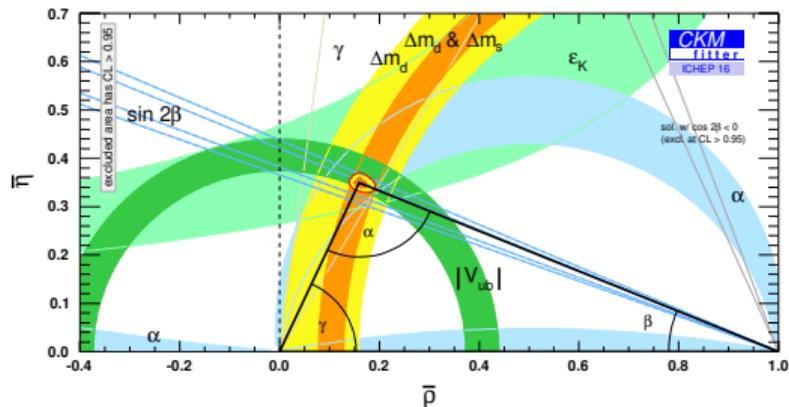


Invariant mass of J/ψ candidates



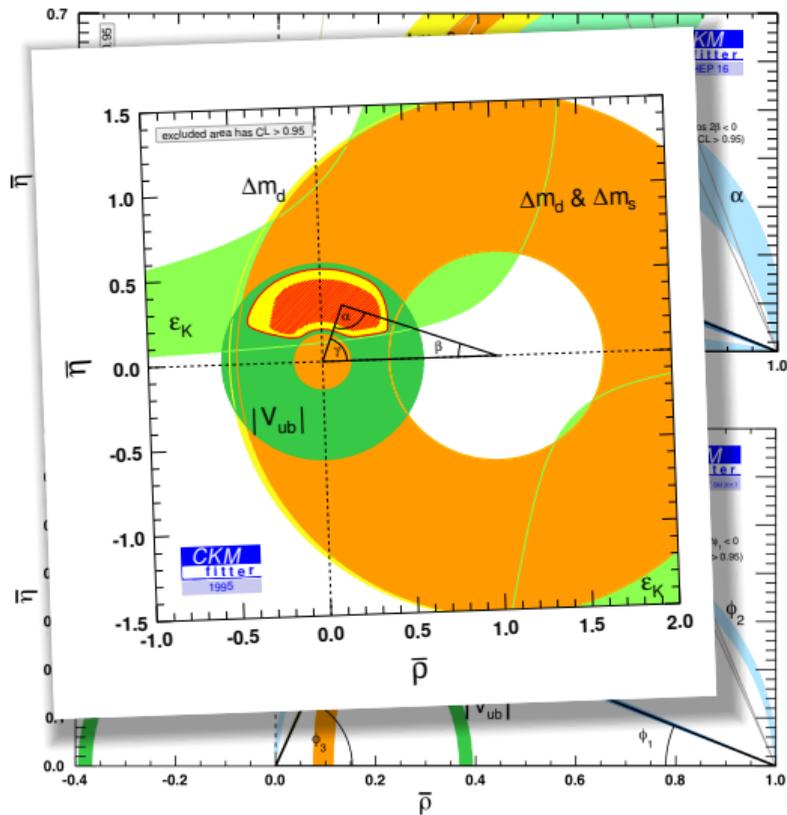
“Invariant mass” of B candidates

- Precise measurements of the CKM unitarity triangle
- Search for Lepton Flavor Violating (LFV) decays
- Dark sector searches
- Flavor Changing Neutral Current (FCNC) studies
- Hadronic spectroscopy



- Look for discrepancies in tree-level and loop decays





- Look for discrepancies in tree-level and loop decays

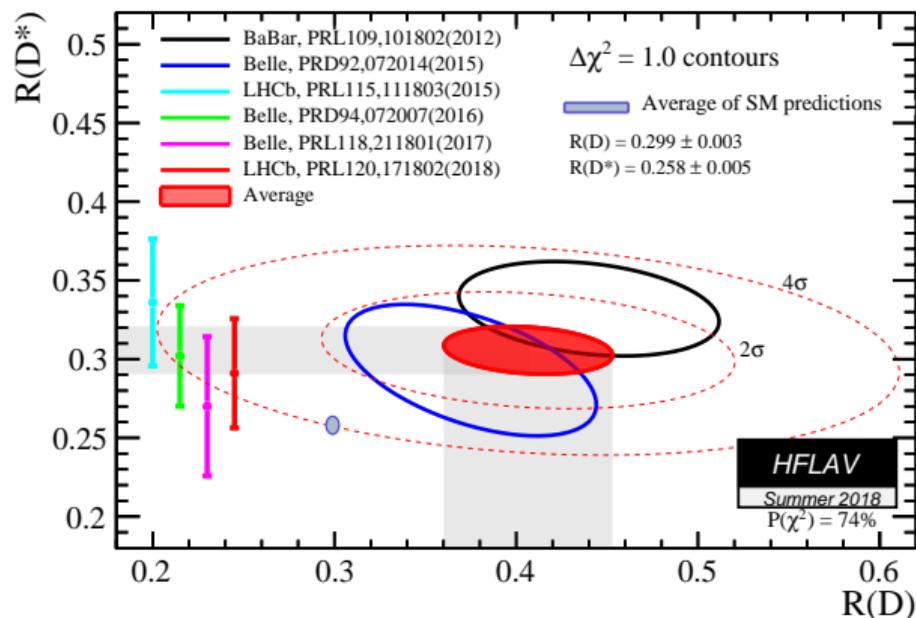


Energy
frontier



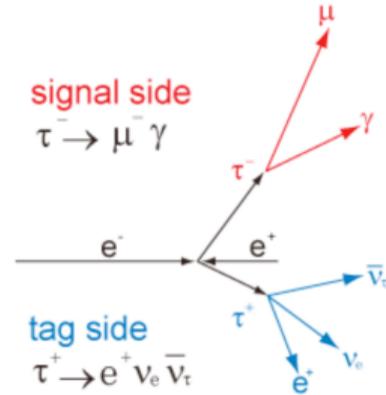
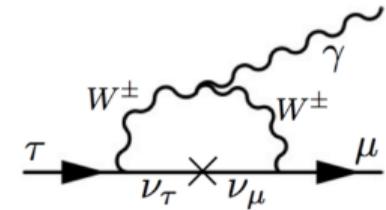
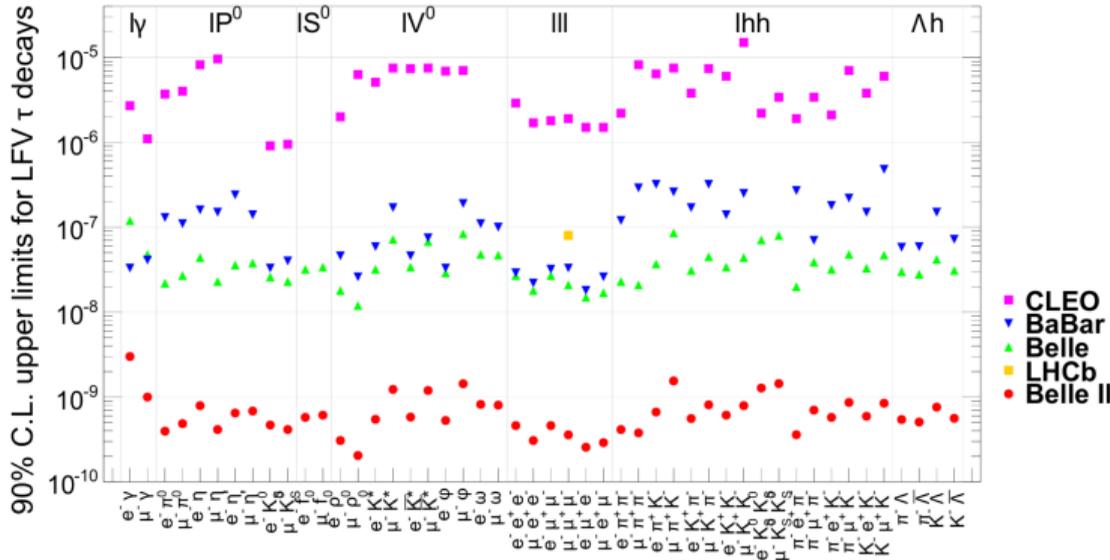
Intensity
frontier

$$R(D^*) = \frac{\mathcal{B}(B \rightarrow D^* \tau \nu)}{\mathcal{B}(B \rightarrow D^* l \nu)} \stackrel{\text{SM}}{=} 0.258 \pm 0.005, \quad (l = e, \mu)$$

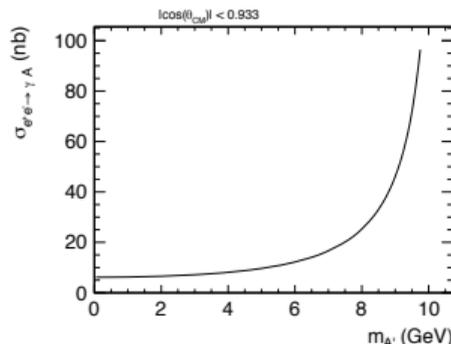
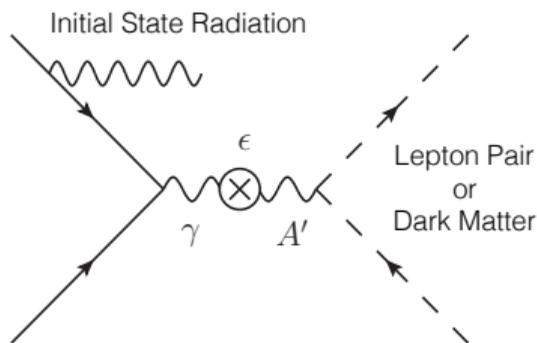
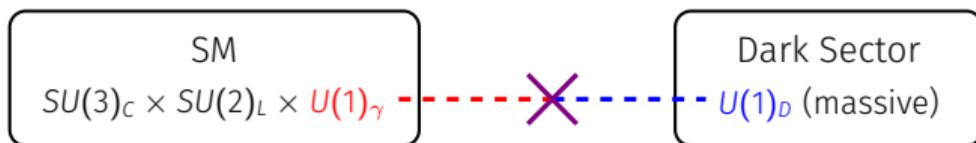


- (One of) the largest discrepancies between SM and measurement
- 4.1σ disagreement

- Neutrino oscillations \Rightarrow neutral LfV beyond SM
- Some NP models also predict charged LfV of various degrees ($\mathcal{B} \in [10^{-7}, 10^{-40}]$) \Rightarrow powerful probe of NP
- B-factory exclusive, LHCb not competitive



- *Vector portal* (minimal scheme): massive dark photon A' mixes with SM photon γ with coupling ϵ



- Belle II has a *single photon* trigger \Rightarrow can look for decay into dark matter

- Belle II offers high sensitivity to possible New Physics at the intensity frontier, largely complementary to LHCb
- Improved detector offers good neutral particle reconstruction, precise decay vertex determination, possibility to study decays with missing energy
- Physics program includes: CKM, CPV, LFV, dark sector, FCNC and many others
- Physics runs to start in February 2019

THANK YOU!