Lepton Flavor Universality tests with inclusive $B \to X_s l^+ l^-$ decays at Belle II

GP-PU Progress Status Presentation

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Lepton Flavor Universality (LFU) : e, μ, τ are identical, except for masses

LFU tests in B meson decay

$$R_{K^{(*)}} \equiv \frac{\mathrm{Br}\left(B \to K^{(*)} \mu^+ \mu^-\right)}{\mathrm{Br}\left(B \to K^{(*)} e^+ e^-\right)}$$

Standard Model expectation : $R_K \simeq R_{K^*} \simeq 1.00$

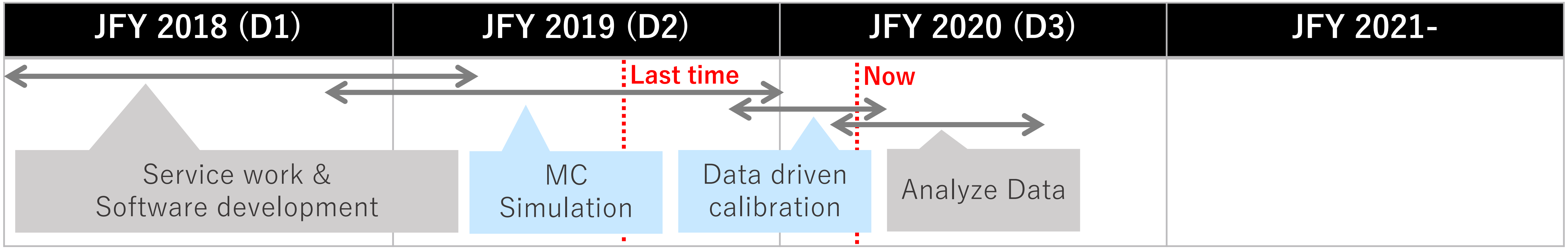
Latest results in LHCb :

$R_K = 0.846^{+0.060}_{-0.054}(\mathrm{stat.})^{+0.016}_{-0.014}(\mathrm{syst.}),$

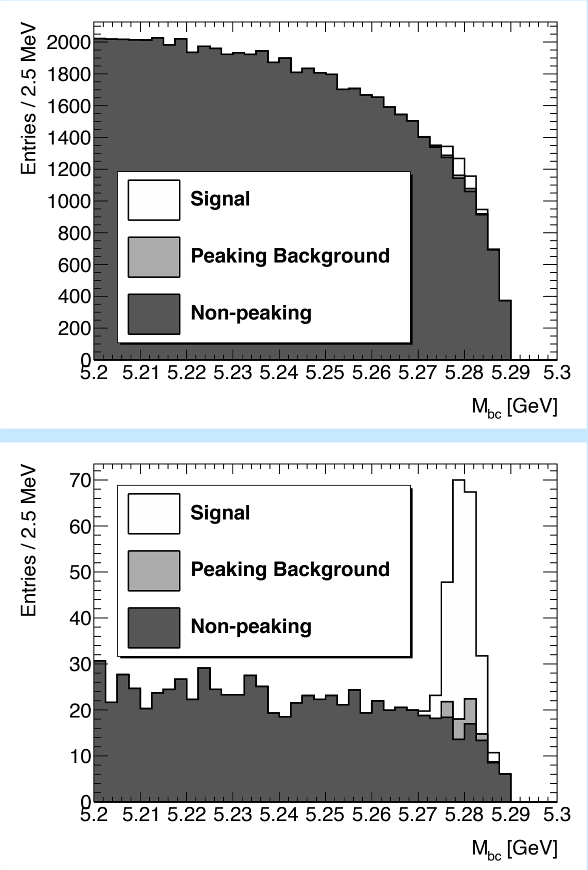
$R_{K^*} = 0.69^{+0.11}_{-0.07}(\mathrm{stat.}) \pm 0.05(\mathrm{syst.})$

e : More or
μ : Less ???

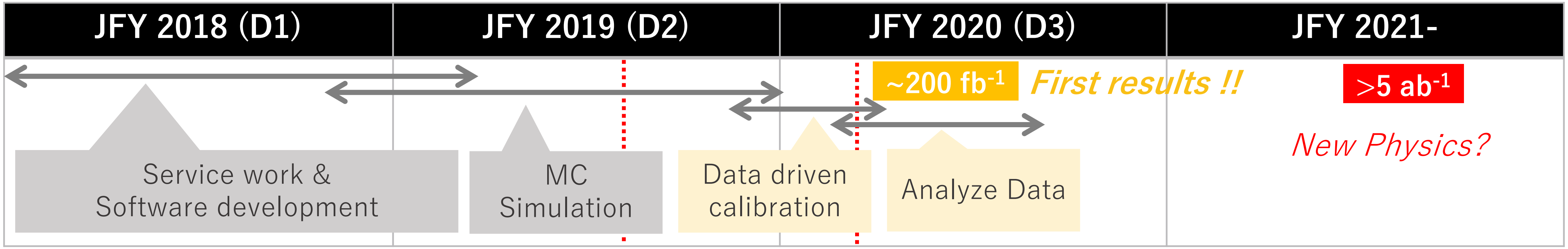
? \ Observables	$R_{?} \equiv \frac{\mathrm{Br}\left(B \to ?\, \mu^+ \mu^-\right)}{\mathrm{Br}\left(B \to ?\, e^+ e^-\right)}$ *Test LFU*	$\mathrm{Br}\left(B \to ?\, \mu^+ \mu^-\right)$ & $\mathrm{Br}\left(B \to ?\, e^+ e^-\right)$ *Determine a model*
K , K^*	Theoretical uncertainty : ~1% → High accuracy test	Theoretical uncertainty : 20-50% → Not accurate enough
X_s : K ($K\pi$) ($K\pi\pi$) …	Theoretical uncertainty : ~1% → High accuracy test	Theoretical uncertainty : ~10% → **High accuracy test**



- Established the analysis method with MC simulation.
  - Reconstruction of $B \to X_s l^+ l^-$ from 40 final states.
    - $X_s \to K n\pi\ (0 \leq n \leq 4), 3K.\ \ l = e, \mu$
  - Background suppression with a machine learning technics.
    - Employed Boosted Decision Tree (BDT)
    - 54.3% of signal are kept, while 99.4% of backgrounds are rejected. (Comparison between right two figures)
  - Estimation of sources of peaking background.
    - Signal yield is obtained by fitting $M_{bc} (= \sqrt{E_{beam}^2 - p_B^2})$. Need to estimate peaking backgrounds.



M_{bc} distributions. before(top)/after(bottom) BDT



- **☐** Estimate and correct differences between data and MC.
  - Correct reconstruction efficiency differences.
    - Use $B \to X_s J/\psi(\to l^+l^-)$ as control samples.
  - Estimate the shape and yield of peaking background in M_{bc}.
    - (e.g.) $B^+ \to K^+\pi^+\pi^-$ mis-identified as $B^+ \to K^+\pi^+\pi^-$. Kinematics is very similar with signal, so they can have a peak on the M_{bc} distribution.

- **☐** Analyze real data and measure $Br(B \to X_s l^+l^-)$ and R_{X_s}.
  - Fitter of M_{bc} is going to be prepared. The shapes of the M_{bc} distribution are determined from control data.
  - **The first measurements in Belle II. The first measurement of R_{X_s} in the world !!**

GPPU activities

Points:

- GSP : 20, GASP : 1, GEP : 14.

Research trips : 57 days in total

- ☐ 8th January – 2nd February, 2019. DESY (Hamburg, Germany)
    - Lepton ID systematics study with DESY colleagues as a service job.
- ☐ 15th May – 15th June, 2019, DESY (Hamburg, Germany)
    - Software development for the reconstruction of $B \to X_s l^+ l^-$

(plan, ~40 days?)

- ☐ 13th May - (still ongoing, ~30 days?), Indiana University (USA) Remotely.
    - Discuss with theorists about the effects of the bremsstrahlung on results.
- ☐ 28th July – 5th Auguste (9 days) ICHEP (virtual)