



Belle II Physics Analysis and Software/Hardware Collaboration

B2Collab

Andrzej BOZEK (IFJ-PAN) and Emi KOU (IJCLab) @ IJCLab, 7th December



Belle II Experiment

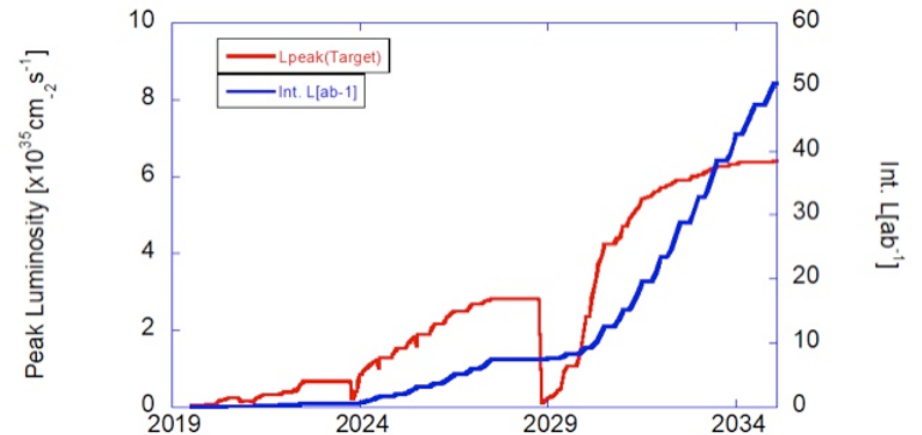


Scientific objectives

- Searching for a signal beyond the Standard Model with B meson, D meson, tau lepton decays.
- A large community of Hadron physics (quarkonium, exotics XYZ states)

Technical objectives

- SuperKEKB: highest luminosity
- KEK (80km from Tokyo) Japan
- 1188 members from 27 countries





B2collab



Timeline

Permanent researcher
PhD student
Engineers

Future Project
Soft(Hard)ware development : detector upgrade
Data analysis : hadronic τ decay for muon $g-2$

Z. Zhang
F. Callet
Engineers

F. Le Diberder
K. Adamczyk
M. Kaleta
J. Ur Rehman

A. Bozek & E. Kou

R. Mizuk
J. Wiechczynski
New student(s)

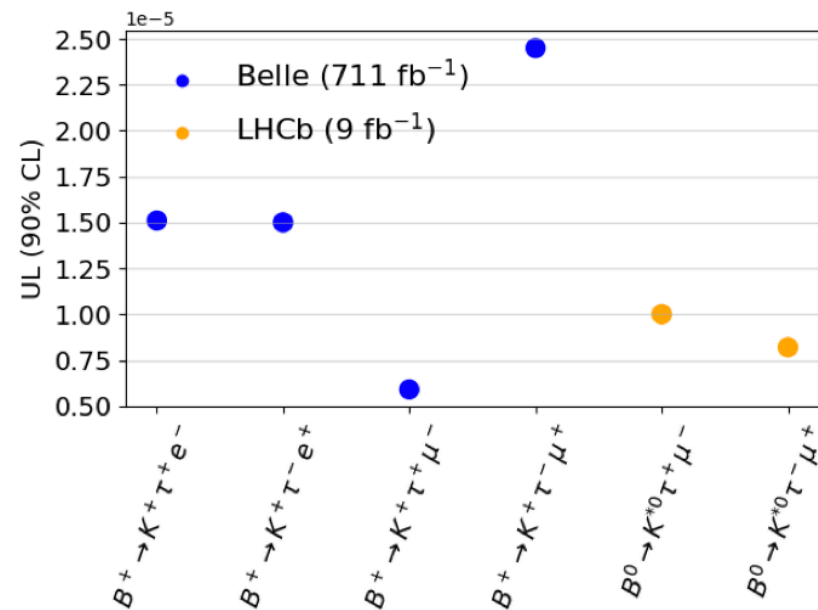
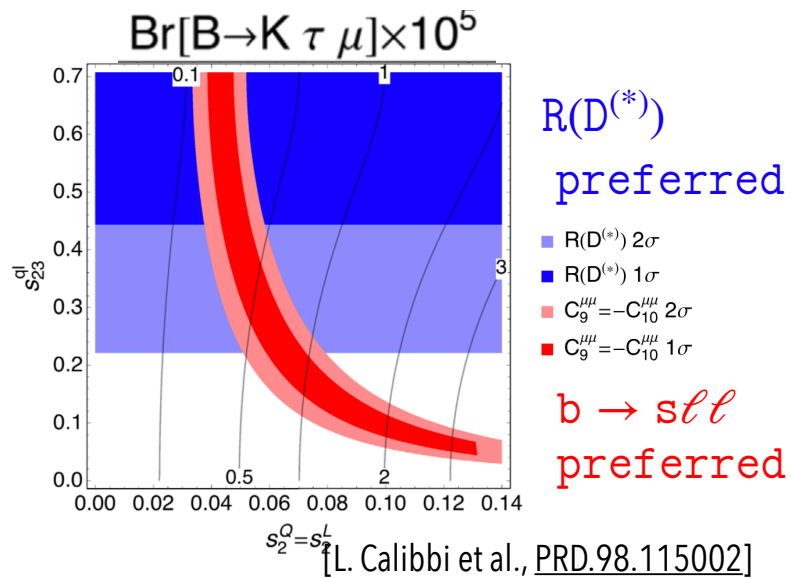
Project 1
Data analysis :
LFV new physics $B \rightarrow \tau h l$

Project 2
Data analysis :
Hadron physics $B \rightarrow D_s X$

Project 1: New physics search in $B \rightarrow \tau h l$

$h=K, K^* \dots l=e \text{ or } \mu$

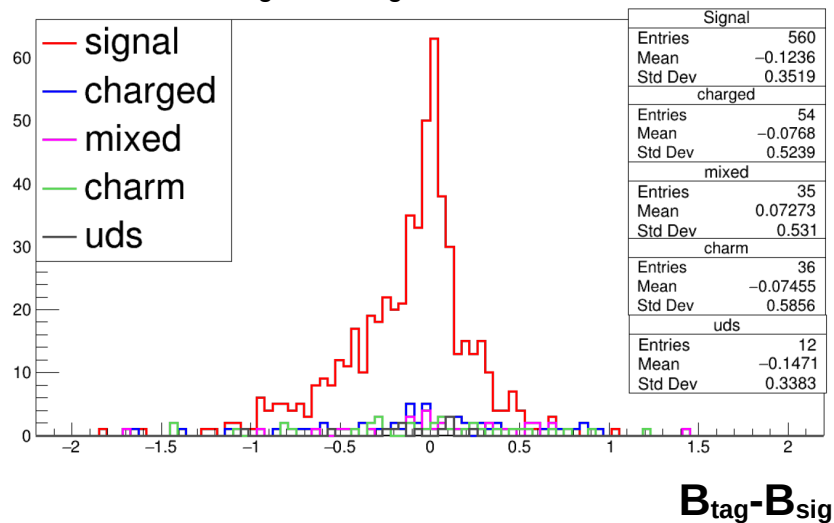
- The so-called B anomaly indicates that a new physics signal may appear in $B \rightarrow \tau h l$ mode with branching ratio at order of 10^{-6}
- LHCb and Belle II are challenging this target!
- The difficulty is the missing energy coming from the tau lepton in the signal



Project 1: Challenge with missing energy

$h=K, K^* \dots l=e \text{ or } \mu$

Difference of the between signal and tag side reconstructed momenta directions



Plan

- Detailed MC study is ongoing in IFJ PAN
- Further improvement on background reduction will be discussed within this collaboration!
- For this goal, a visit of PhD student (~3 months) will be most important!

F. Le Diberder
K. Adamczyk
M. Kaleta
J. Ur Rehman



B2collab



Timeline

Permanent researcher
PhD student
Engineers

Future Project
Soft(Hard)ware development : detector upgrade
Data analysis : hadronic τ decay for muon $g-2$

Z. Zhang
F. Callet
Engineers

F. Le Diberder
K. Adamczyk
M. Kaleta
J. Ur Rehman

A. Bozek & E. Kou

R. Mizuk
J. Wiechczynski
New student(s)

Project 1
Data analysis :
LFV new physics $B \rightarrow \tau h l$

Project 2
Data analysis :
Hadron physics $B \rightarrow D_s X$

Project 2: Hadron physics with $B_{d/s} \rightarrow Ds^{(*)} X$

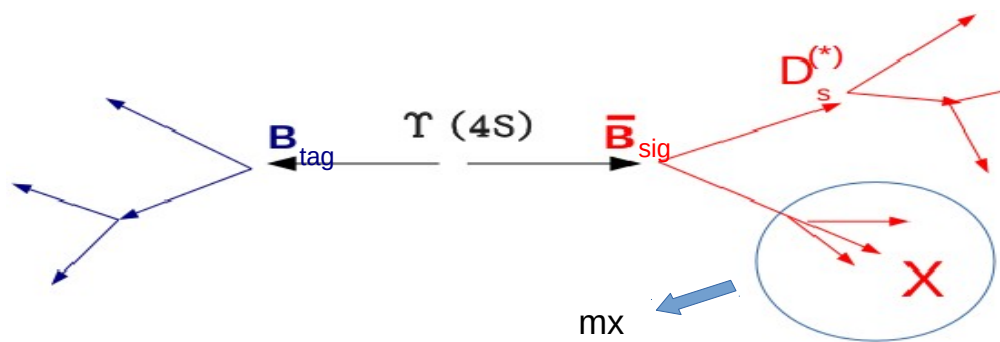
X= anything

- It has never been measured at a high precision (theoretical prediction is extremely high): sum of exclusive is far from this prediction
- We can obtain valuable information of excited Ds states
- This process can be major background of new physics search modes
- For Bs, it provides the Bs production rate, which is the normalisation of any branching ratio measurement (not only at Belle II but also at LHCb)

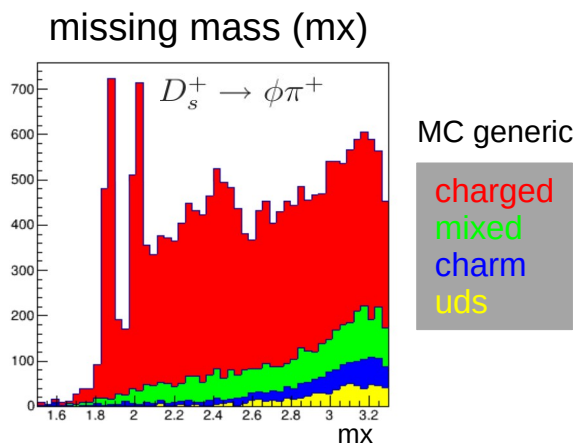
Project 2: Challenge of the inclusive measurement

X= anything

Expertise



- [IEJ PAN](#): Hadronic tag method for $B_d \rightarrow D_s^{(*)} X$ mode
- [IJCLab](#): Hadronic tag method for $B_s \rightarrow D_s^{(*)} X$ mode with Upsilon(5S) data
- [IJCLab](#): The new tagging algorithm (Full Event Reconstruction) has been applied



R. Mizuk
J. Wiechczynski
New student(s)

Project 2: Challenge of the inclusive measurement

X= anything

Plan

R. Mizuk
J. Wiechczynski
New student(s)

- Detailed MC studies are ongoing both in IFJ PAN (B_d decay) and IJCLab (B_s decay): there are many common problems that can be worked out in collaboration
- For this goal, visits of researchers (~1-2 weeks) will be very useful!
- There is already a good candidate for PhD at IFJ PAN (possibility of joint-PhD?)



B2collab



Timeline

Permanent researcher
PhD student
Engineers

Future Project
Soft(Hard)ware development : detector upgrade
Data analysis : hadronic τ decay for muon $g-2$

Z. Zhang
F. Callet
Engineers

F. Le Diberder
K. Adamczyk
M. Kaleta
J. Ur Rehman

A. Bozek & E. Kou

R. Mizuk
J. Wiechczynski
New student(s)

Project 1
Data analysis :
LFV new physics $B \rightarrow \tau h l$

Project 2
Data analysis :
Hadron physics $B \rightarrow D_s X$

Future projects 1: Belle II detector upgrade

Expertise

- **IJCLab** & **IFJ PAN** collaboration : Data Acquisition system (DAQ) upgrade with PCIe40 card developed by IN2P3!
- **IJCLab** : Commissioning of DAQ
- **IJCLab** : Installing the new clock system, White Rabbit, developed by CERN

Future collaboration

- DAQ upgrade II (PCIe400?)
- DAQ system for the new vertex detector?

Development and Performance of the Belle II DAQ Upgrade

Q.-D. Zhou,^{a,*} M. Bessner,^b D. Biswas,^c D. Charlet,^d T. S. Lau,^d D. Levit,^e O. Hartbrich,^b T. Higuchi,^f R. Itoh,^g E. Jules,^g P. Kapusta,^g T. Kunigo,^e Y.-T. Lai,^f M. Nakao,^e K. Nishimura,^b S. Park,^g E. Plaige,^a H. Purwar,^g P. Robbe,^{a,h} R. Sugiura,^e S.Y. Suzuki,^e M. Taurigna,^g G. Varner^b and S. Yamada^e

^aInstitute of Advanced Research and Kobayashi-Maskawa Institute, Nagoya Univ., Nagoya 464-8601, Japan.

^bDept. of Phys. & Astr., Univ. of Hawaii at Manoa, Honolulu, HI, 96822, USA.

^cUniversity of Louisville, Louisville, Kentucky, 40292, USA.

^dThe Laboratoire de Physique des Deux Infinis Irene Joliot-Curie (IJCLab), Orsay F-91898, France.

^eHigh Energy Accelerator Research Organization (KEK), Ibaraki 305-0801, Japan.

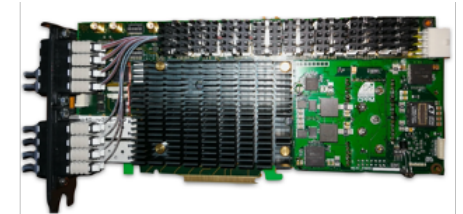
^fThe Kavli Institute for the Physics and Mathematics of the Universe (IPMU), University of Tokyo, Chiba, 277-8583, Japan

^gThe Henryk Niewodniczanski Institute of Nuclear Physics (IFJ), Polish Academy of Sciences (PAN), Krakow, 31-342, Poland.

^hThe Univ. Paris-Saclay, CNRS/IN2P3, Orsay F-91898, France.

ⁱTokyo University, Tokyo, 113-0033, Japan.

PCIe40 card



Future projects 2 : τ decay for muon $g-2$

Z. Zhang
F. Callet

- Muon $g-2$ has been one of the most significant deviations (4.2σ) from the SM observed in particle physics today
- However, there is some controversy reported recently on the SM predictions...

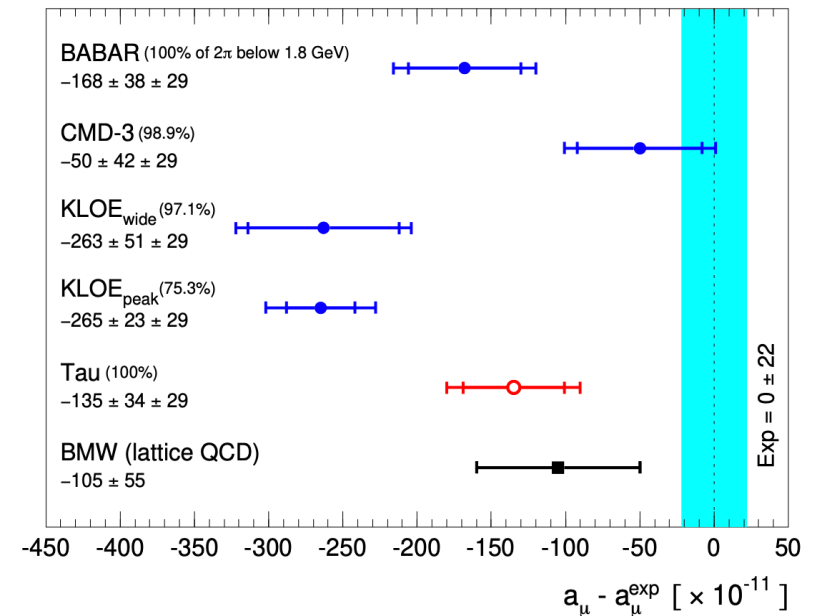
Expertise

- **IJCLab** : We will continue to solve this issue! Our first step is to re-visit the τ decay!
- For this aim, we start from the $\pi 0$ reconstruction efficiency study (one PhD started in 2023!)

Future collaboration

- Belle II data analysis of hadronic τ decays
- Phenomenological study for extracting SM prediction of muon $g-2$

M. Davier et al arXiv: 2312.02053



Future projects 1&2

Plan for 2023

- We will organise a **workshop at IFJ PAN**, inviting interested people to discuss possible collaborations.
- Once we identify the projects, we will investigate the feasibility
- We will prepare for **grant applications** (IJCLab-IFJ PAN collaboration, European grant etc...) to materialise the project!

Summary

2023

- Project 1 : Student visit to IJCLab
- Project 2 : Researcher visit to IJCLab
- Future collaboration : Workshop at IFJ PAN

Next year+

- Project 1 : Student visit to IJCLab
- Project 2 : Student visit to IFJ PAN
- New collaboration : Student/
Researcher visit to IJCLab/IFJ PAN

For Project 2, we are also considering joint-PhD : currently PhD grants are separately requested in both labs.

Backup



B2collab Team



First name / Family name	Function (Researcher, Engineer etc)	Role in the pre-project	% of participation
<u>Andrzej Bozek</u>	Researcher	Coordinator	30
<u>Jarek Wiechczynski</u>	Researcher	Project 2	30
<u>Karol Adamczyk</u>	Researcher	Project 1	30
<u>Mateusz Kaleta</u>	2 nd Year PhD	Project 1	30
<u>Junaid Ur Rehman</u>	1 st Year PhD	Project 1	30
New student from October 2024	PhD student	Project 2	30

First name / Family name	Function (Researcher, Engineer etc)	Role in the pre-project	% of participation
<u>Emi Kou</u>	Researcher	Coordinator	30
<u>Francois Le Diberder</u>	Professor	Project 1	30
<u>Roman Mizuk</u>	Researcher	Project 2	30
<u>Zhiqing Zhang</u>	Researcher	Future project	30
<u>Flavien Callet</u>	1 st Year PhD	Future project	30

