



# **Belle II Physics Analysis and Software/Hardware Collaboration**

## **B2Collab**

Andrzej BOZEK (IFJ-PAN) and Emi KOU (IJCLab) @ IFJ PAN, 24th October 2024



# Belle II Experiment

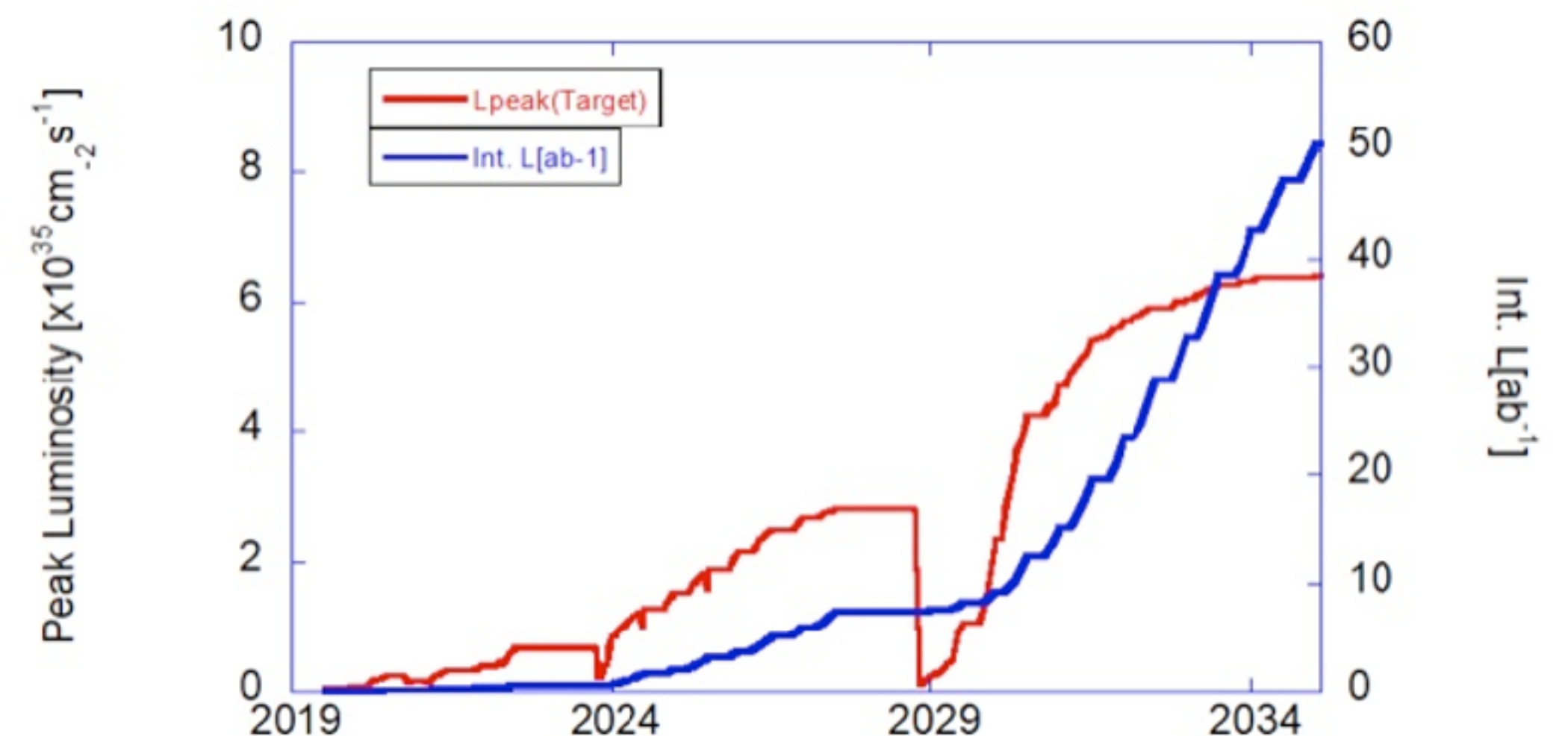


## Scientific objectives

- 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

★ New member

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

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

Z. Zhang  
F. Callet  
F. Mawas  
K. Demory ★  
Engineers

A. Bozek & E. Kou

R. Mizuk  
J. Wiechczynski  
★ Oliwia Krasowska

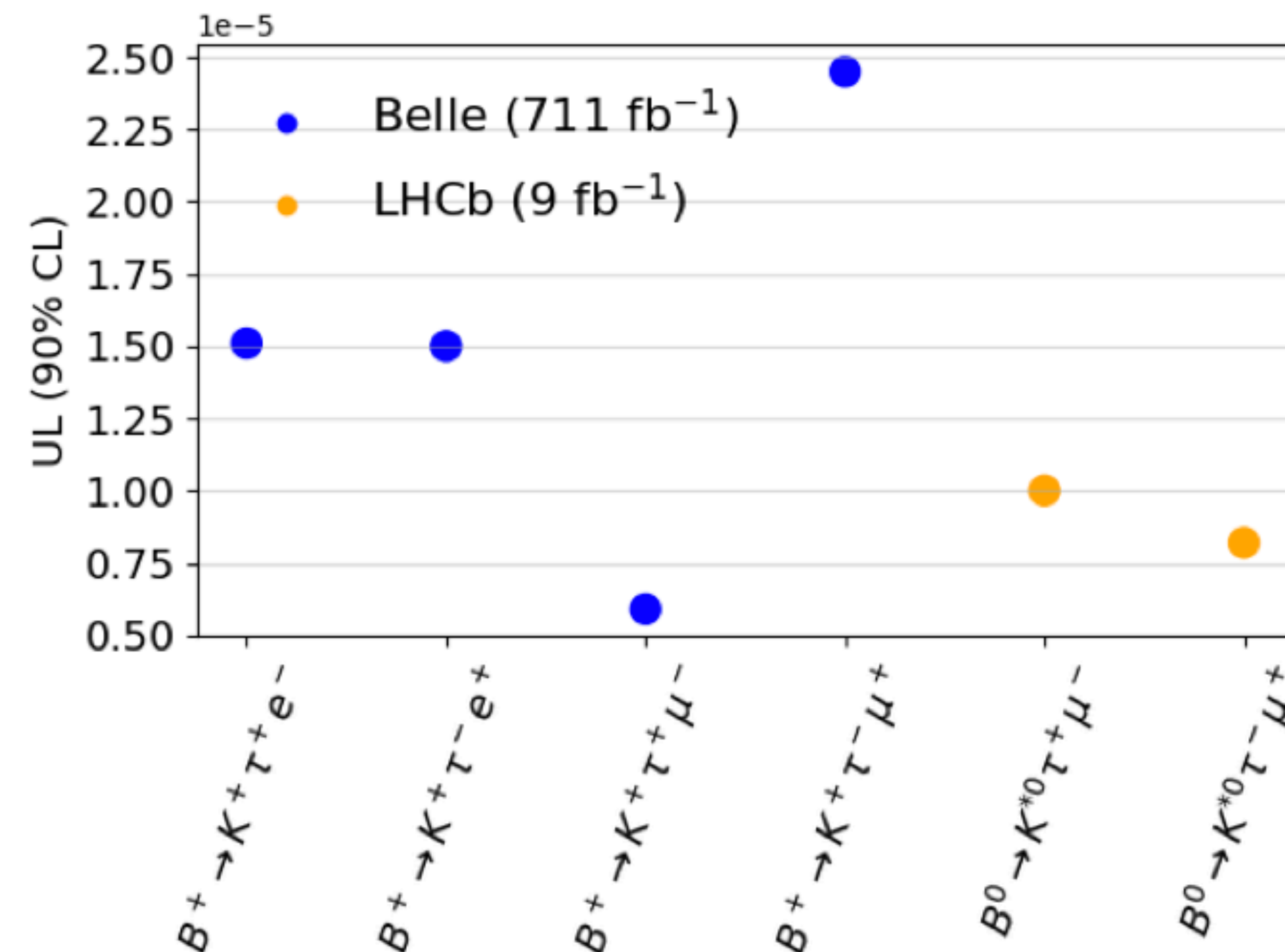
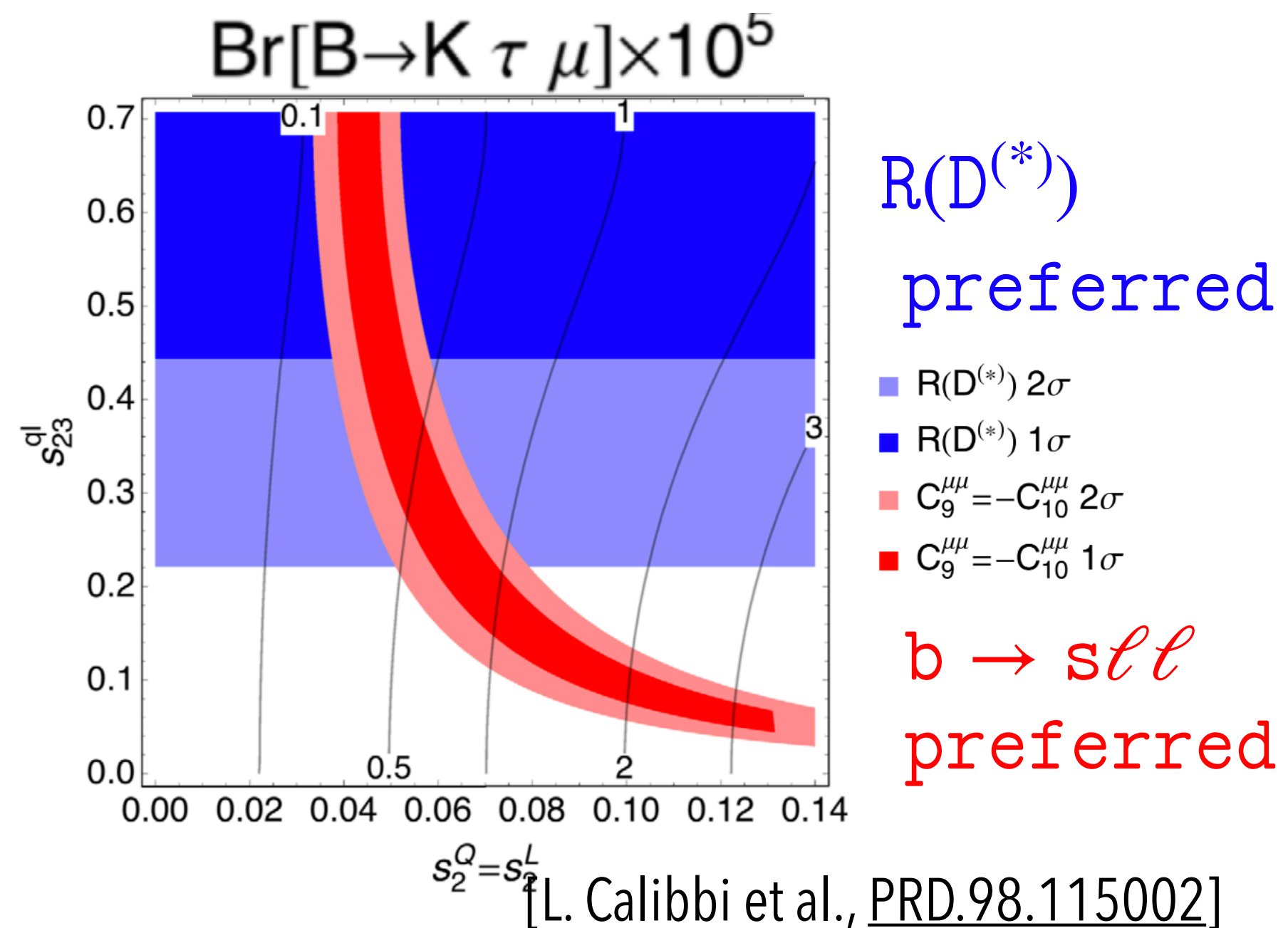
**Project 1**  
Data analysis :  
LFV new physics  $B \rightarrow \tau h l$

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

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

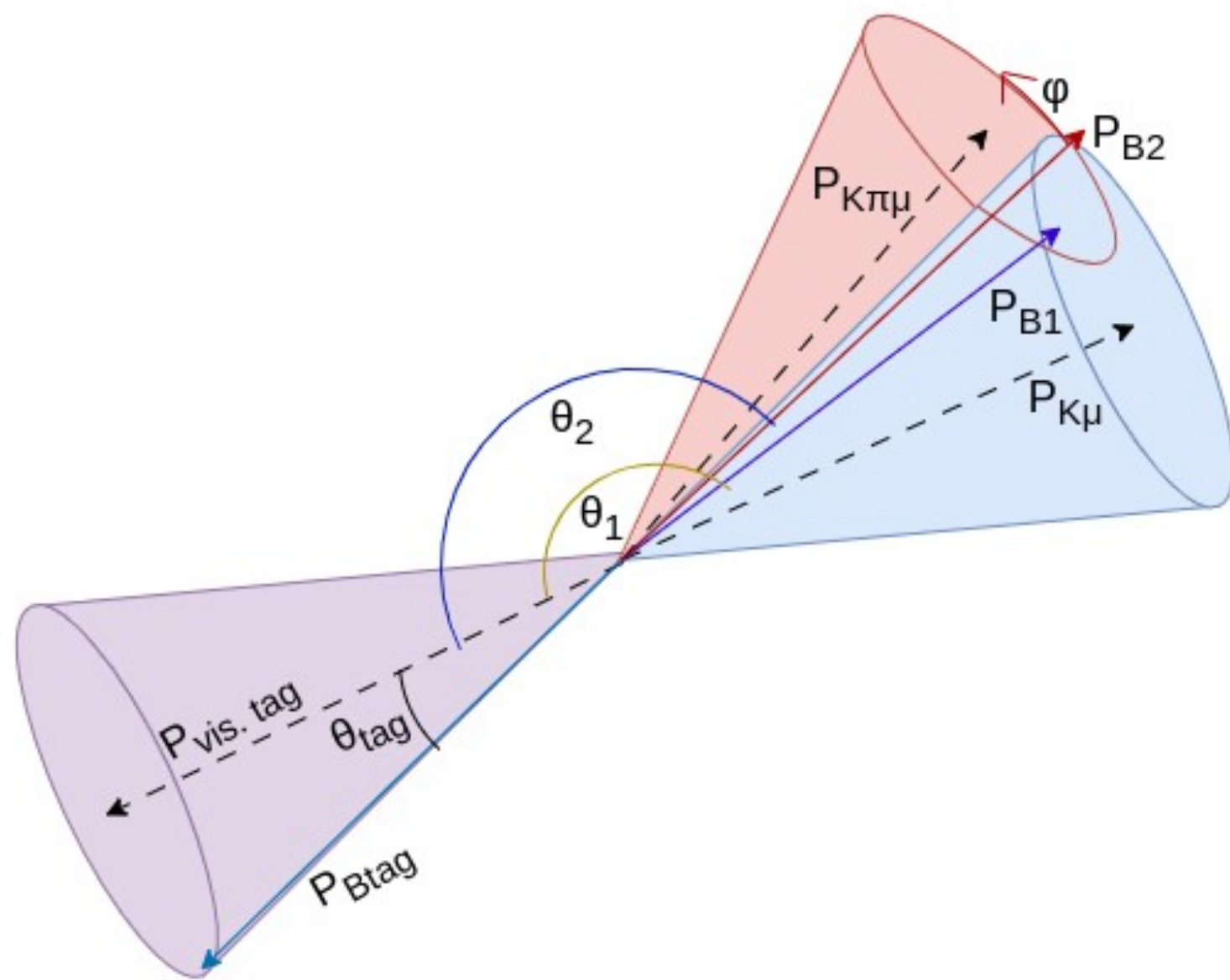
$h=K, K^* \dots l=e \text{ or } \mu$

- 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

Belle II, being e+e- machine has an advantage of using “tagging” methods to identify the neutrino on the signal side!



We have the two sum of cosine angles, from which we pick the best one by using the following condition

$$\Delta \cos \theta = \min |\cos \theta_{1,2} + \cos \theta_{\text{tag}}|$$

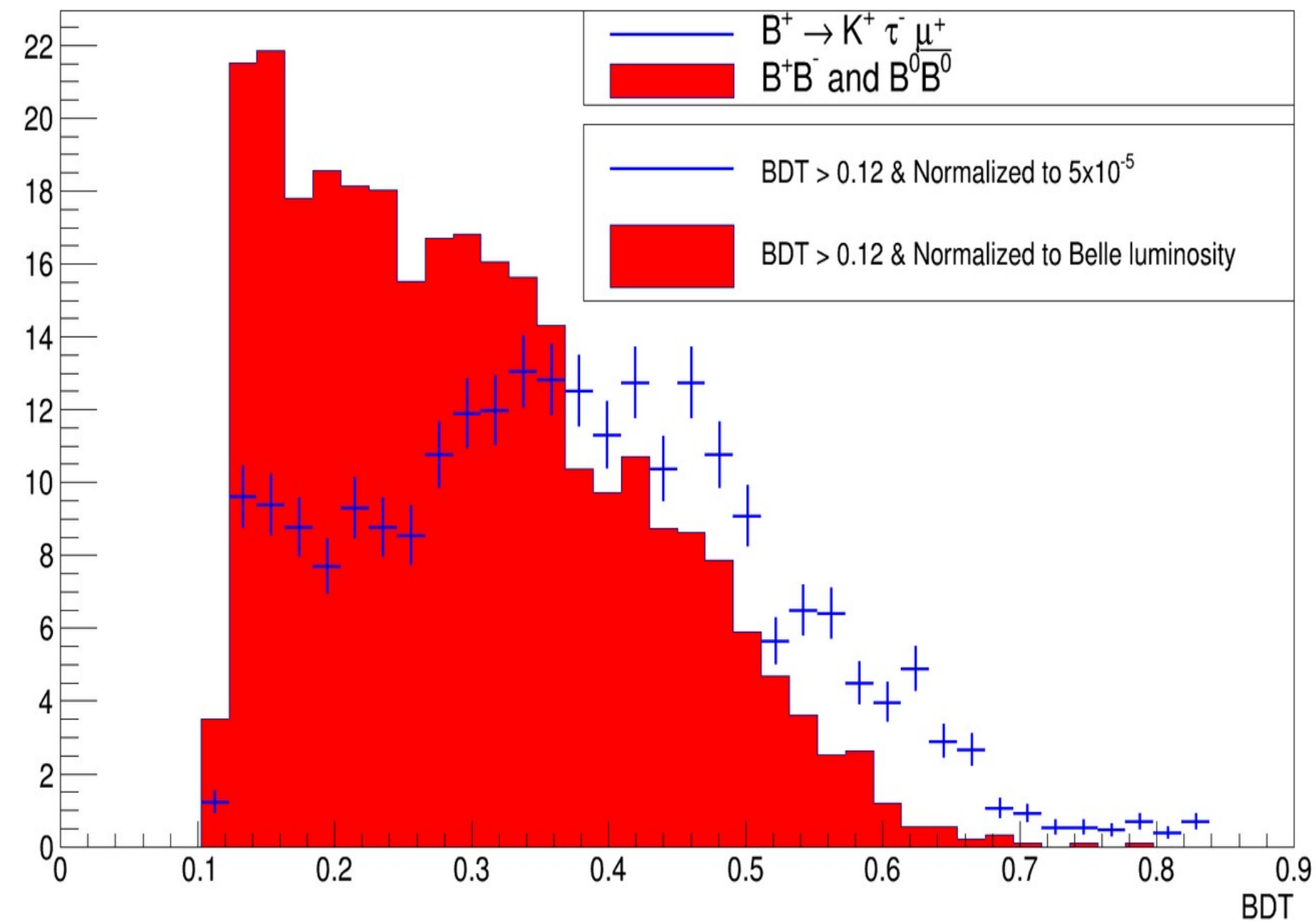
## Expertise

- [IFJ PAN](#) : Working on specific tagging channel (e.g. semi-leptonic decay). Many progresses have been made last year, using tau hadronic decay. Now competitive to the tau leptonic decay studies!
- [IJCLab](#) : A discriminant variable has been investigated for semi-leptonic tagging

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

# Project 1: Challenge with missing energy

J. Ur Rehman



$$N_{\text{sig}} = 246$$

$$N_{\text{bg}} = 293$$

## Status

- Using BDT, Signal to Background ratio improved significantly.
- Test of BDT with control samples looks quite good.
- A visit of PhD student (~3 months) is discussed.



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

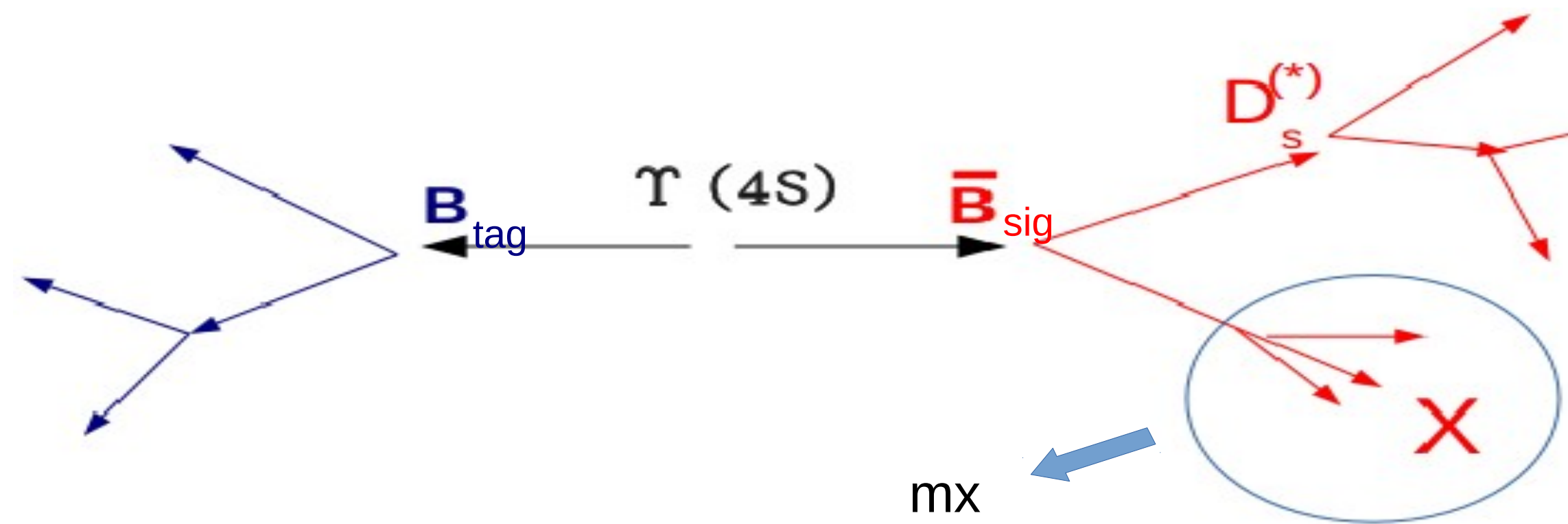
X= anything

- 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  $D_s$  states
- This process can be major background of new physics search modes
- For  $B_s$ , it provides the  $B_s$  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*

- [IFJ 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

Oliwia Krasowska

# Project 2 : Challenge of the inclusive measurement

## *Plan*

R. Mizuk

J. Wiechczynski

Oliwia Krasowska

- Detailed MC studies are ongoing both in IFJ PAN ( $B_d$  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!
- A New PhD student (IFJ PAN) started in October 2024



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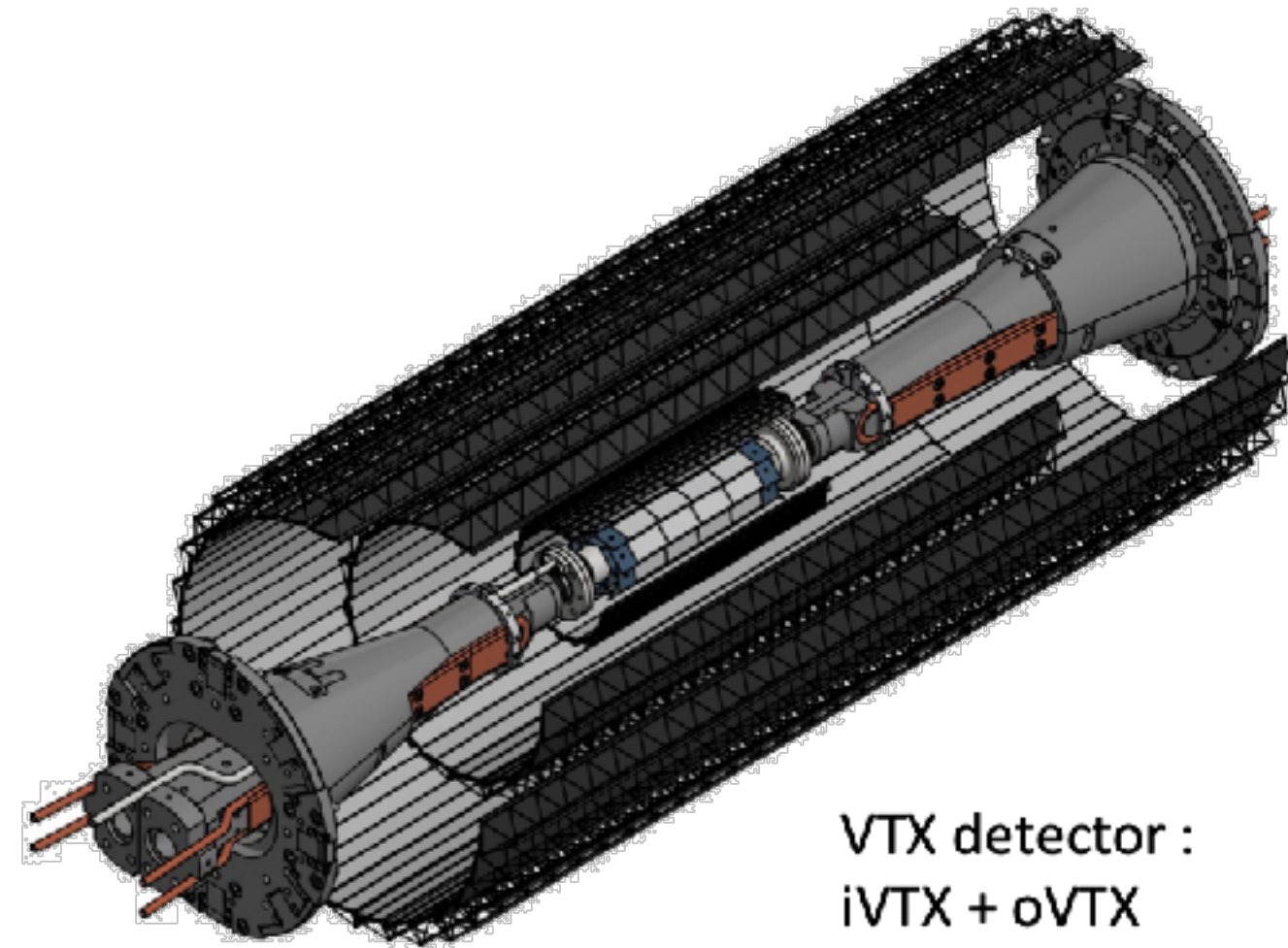
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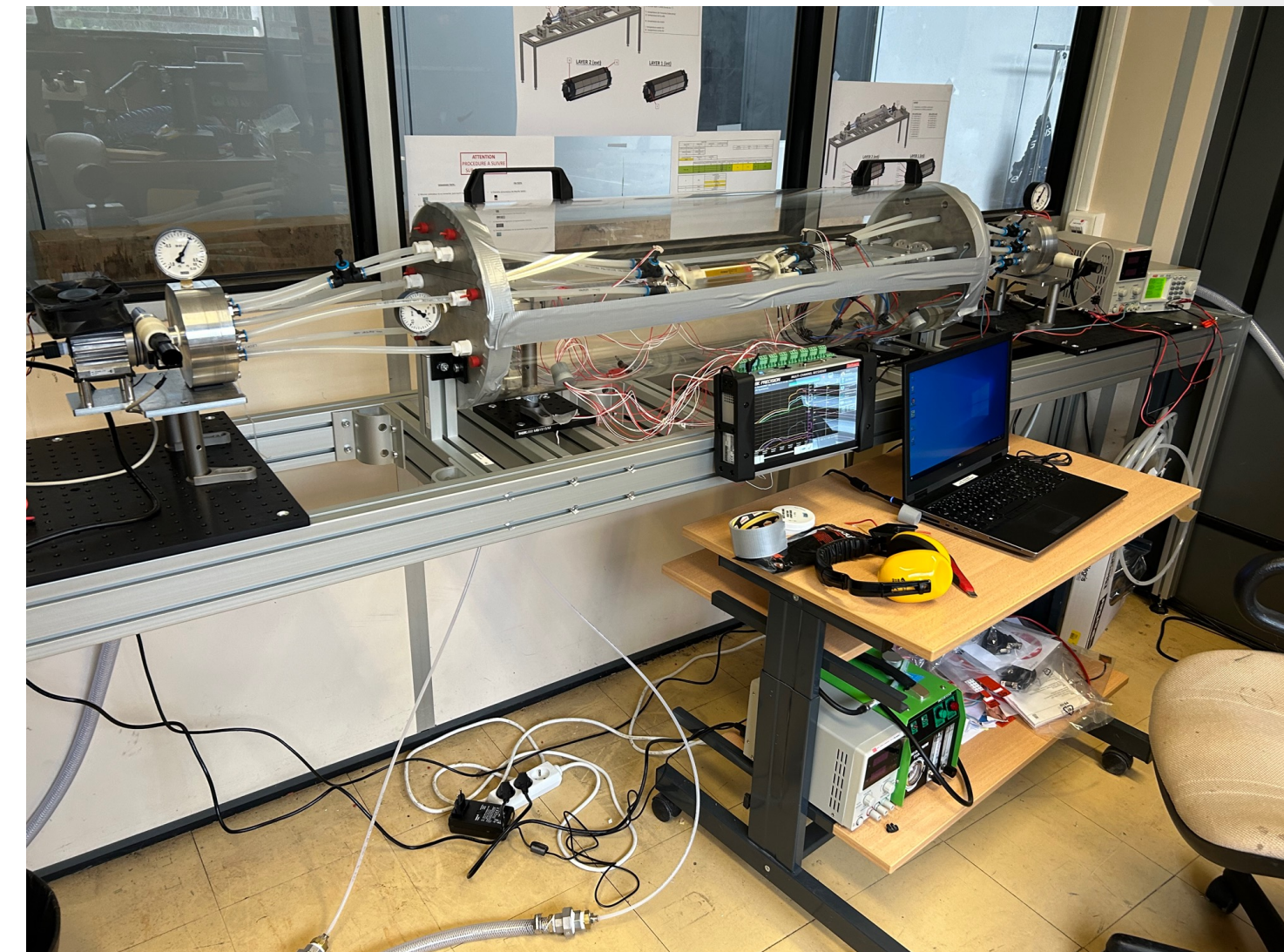
# Future projects 1: Belle II detector upgrade

## Expertise

- **IJCLab** : Installing the new clock system, White Rabbit, developed by CERN, for the purpose of SuperKEKB beam-abort (developpement of PEARL), using IDROGEN board
- **IJCLab** : Cooling of iVTX (inner most pixel detector). Upgrade plan: TDR 2027, installation 2032.



VTX detector :  
iVTX + oVTX



*iVTX air cooling test bench at IJCLab*

# Future projects 2 : $\tau$ decay for muon g-2

Z. Zhang  
F. Callet  
K. Demory

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

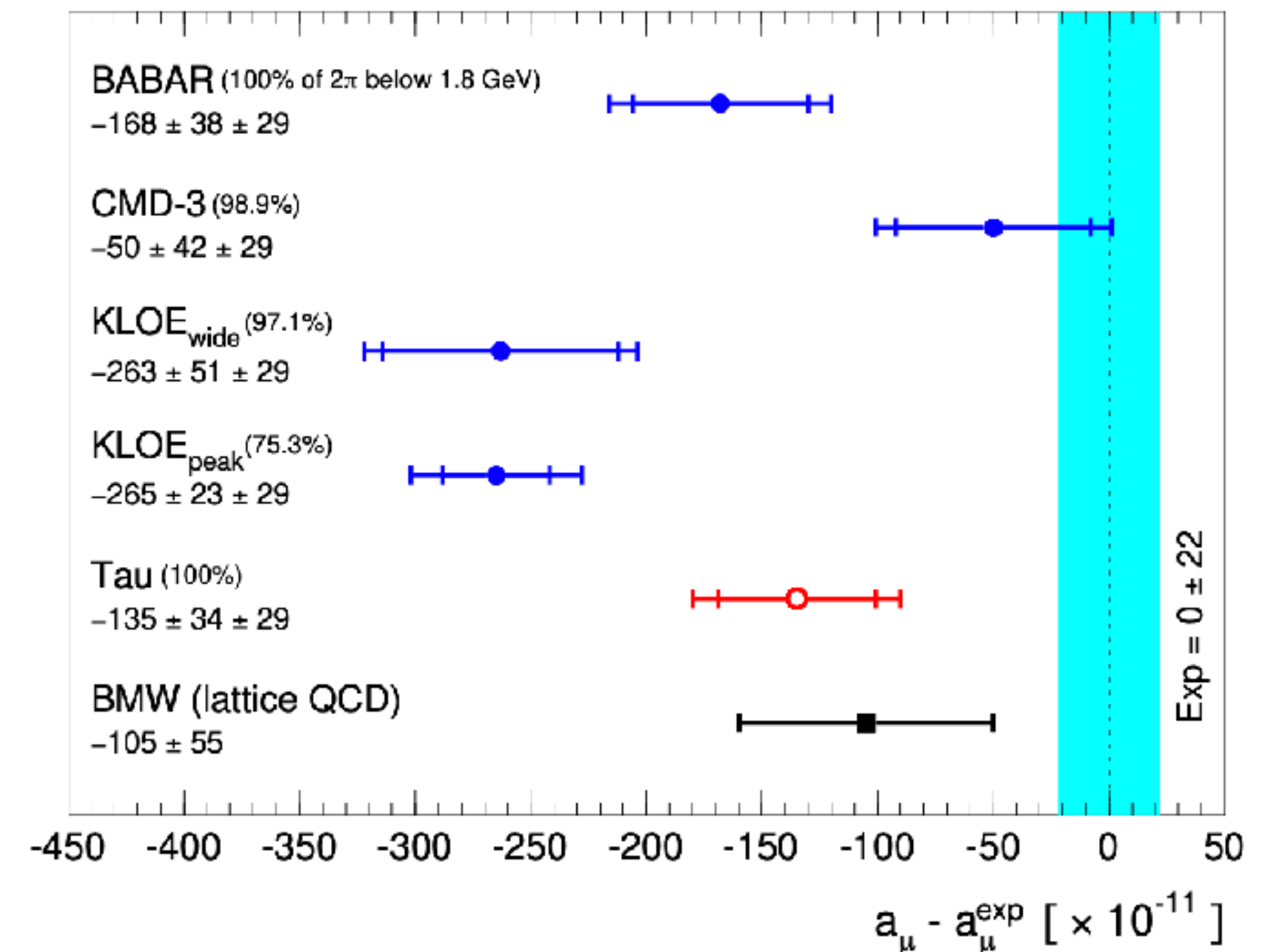
## Expertise

- [IJCLab](#) : We will continue to solve this issue!  
Two PhD ongoing, one for tau decay and one for ISR process

## Future collaboration

- Event Generator is crucial for this work and Krakow is the centre of MC generator developments (e.g. TAUOLA, KKMC, PHOKHARA)!

*M. Davier et al arXiv: 2312.02053*





# IFJ PAN-IJCLab Heavy Flavour Workshop 2024

<https://indico.ifj.edu.pl/event/1302>


- 1.5 day meeting presenting status of both groups
- Several special guest theorists from Krakow on generator developments


Joint IJCLAB -IFJ PAN Heavy Flavor meeting


12–13 Nov 2024  
IFJ  
Europe/Warsaw timezone



- Overview
- Timetable
- Registration
- Participant List

 **Starts** 12 Nov 2024, 08:00  
**Ends** 13 Nov 2024, 13:00  
Europe/Warsaw

 IFJ

 **Registration**  
Registration for this event is currently open.

 15 [Register now >](#)

- This will be the official kick-off meeting for our collaboration!
- 22 people registered so far, including 8 Belle II members from IJCLab, 4 theorists from Krakow region

# Summary

2024

- A. Bozek visited IJCLab to start the collaboration
- Official kick-off meeting will be held 12-13th November 2024 at IJF PAN

Next year+

- Long term (>1 month) Student/Reseracher visits between IFJ PAN & IJCLab
- Participating to the Physics Meeting (bi-weekly, organised by R. Mizuk)
- Second workshop in IJCLab (~autumn 2025)
- Joint PhD for project 2?

*We will soon apply for “France excellence SSHN program” for student exchange for Project 1*

**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 Wiehczynski</u>	Researcher	Project 2	30
<u>Karol Adamczyk</u>	Researcher	Project 1	30
<u>Mateusz Kaleta</u>	2 <sup>nd</sup> Year PhD	Project 1	30
<u>Junaid Ur Rehman</u>	1 <sup>st</sup> 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 <sup>st</sup> Year PhD	Future project	30

↓  
**Oliwia Krasowska**

