



Belle II Physics Analysis and Software/Hardware Collaboration

B2Collab

Andrzej BOZEK (IFJ-PAN) and Emi KOU (IJCLab) @ IJCLab, 17th November 2025



Belle II Experiment



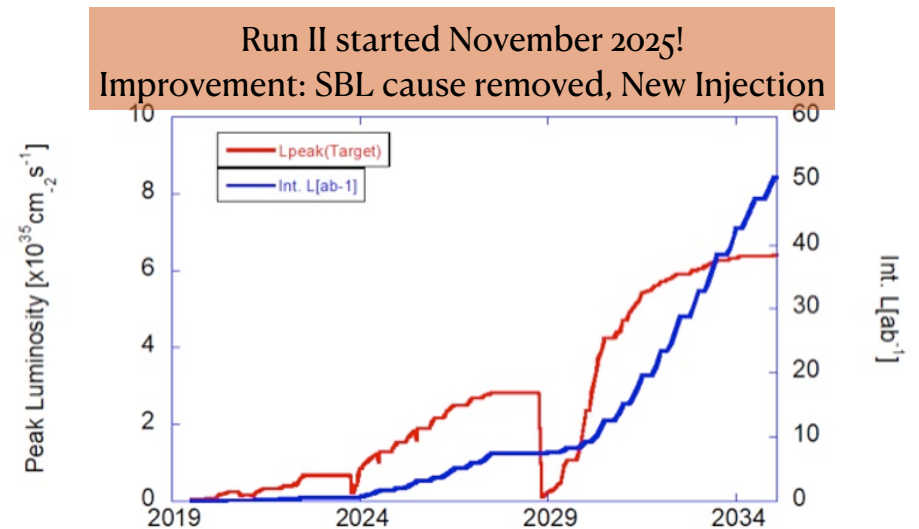
Scientific objectives

- 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
Postdoc
PhD student
Engineers

★ New member

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

Devender Kumar ★

Future Project

Soft(Hard)ware development : detector upgrade

Data analysis : hadronic τ decay for muon g-2

→ Project 3

A. Bozek & E. Kou

A. Martens ★

Z. Zhang

F. Callet

K. Demory

B. Qian ★

Engineers

Z. Was ★

J. John ★

A. Tapadar ★

R. Mizuk

J. Wiechczynski

Oliwia Krasowska

A. Chaabi ★

Project 1

Data analysis :

LFV new physics $B \rightarrow \tau h l$

Project 2

Data analysis :

Hadron physics $B \rightarrow D_s X$

The 2nd IFJ PAN-IJCLab Heavy Flavour Workshop 2025

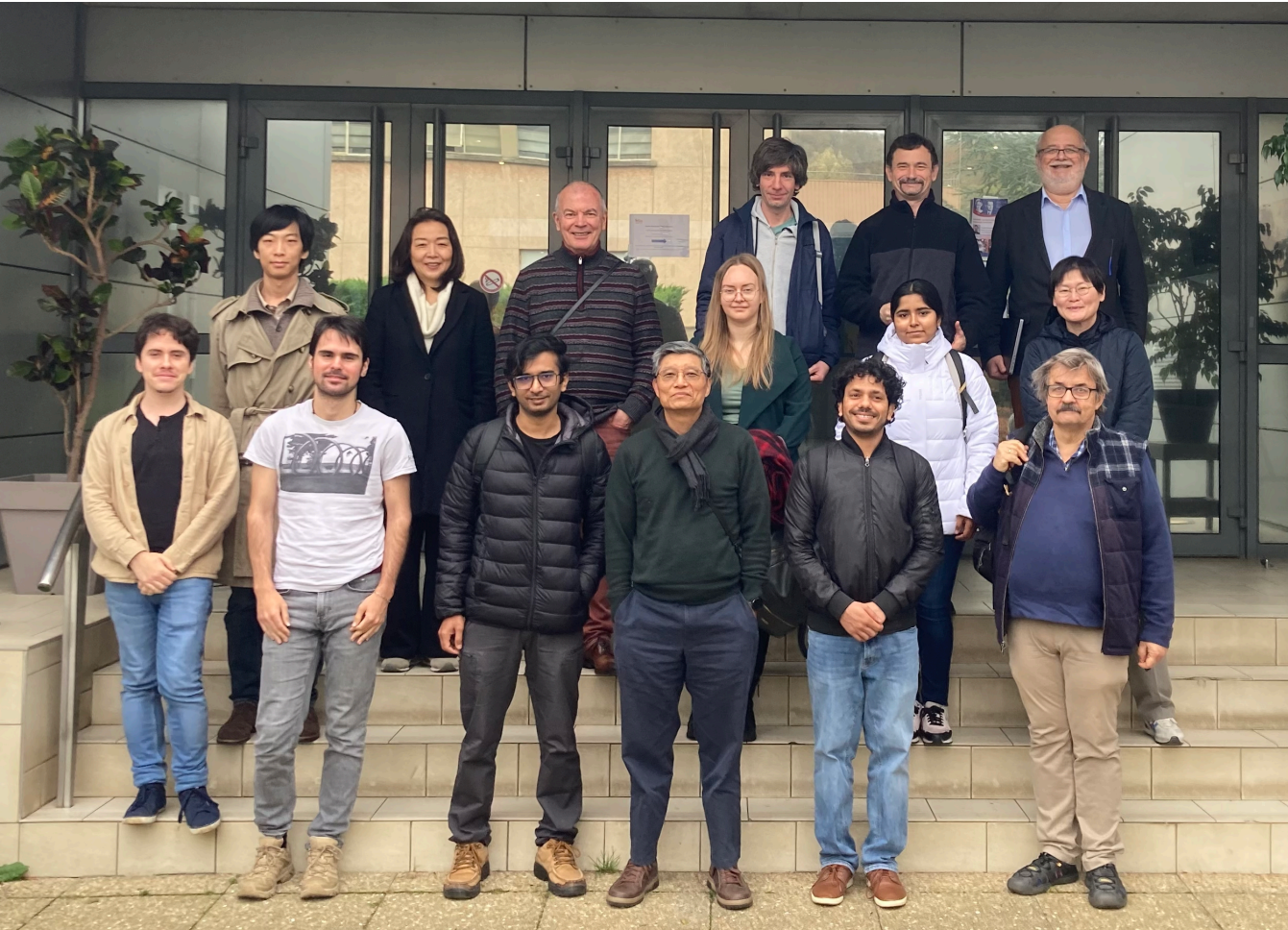
<https://indico.ijclab.in2p3.fr/event/12202/>



- 2 day meeting
- 1 day for hands on session
- 1 day of presentation
- 18 people onsite & 4 people online

- Very intensive discussion
- Close collaboration started!
- Great atmosphere!

(*) II-HFW



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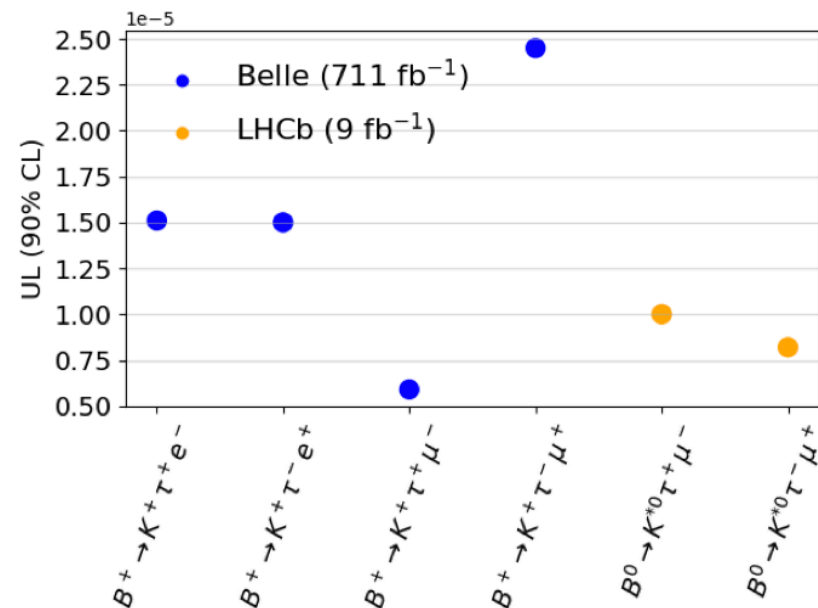
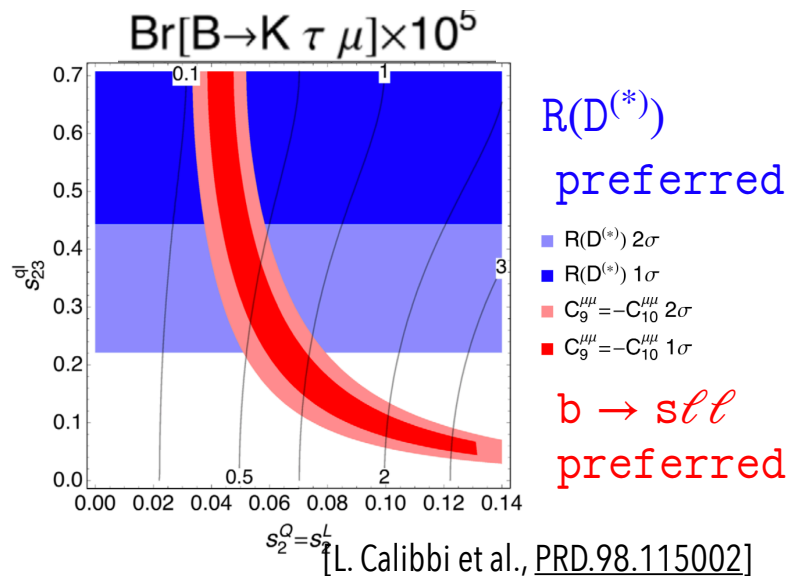
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e!

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

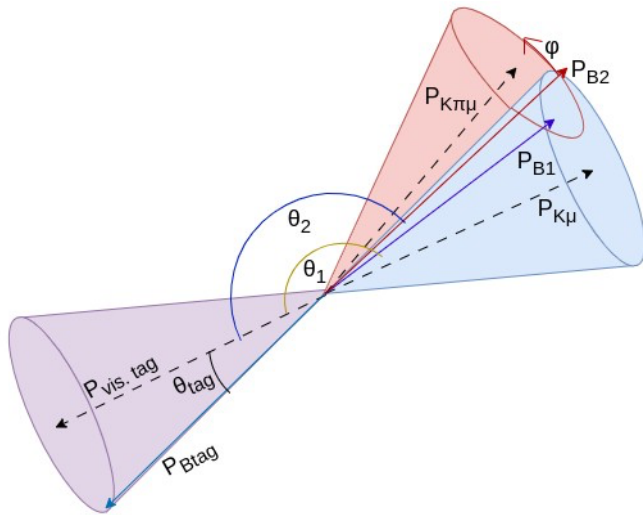
$h=K, K^* \dots l=e \text{ or } \mu$

- 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

- Junaid Rehman visited IJCLab for one month in May-June 2025
- M. Kaleta and Devender Kumar gave a talk at 2025 workshop

Bozek
F. Le Diberder
K. Adamczyk
M. Kaleta
J. Ur Rehman
Devender Kumar



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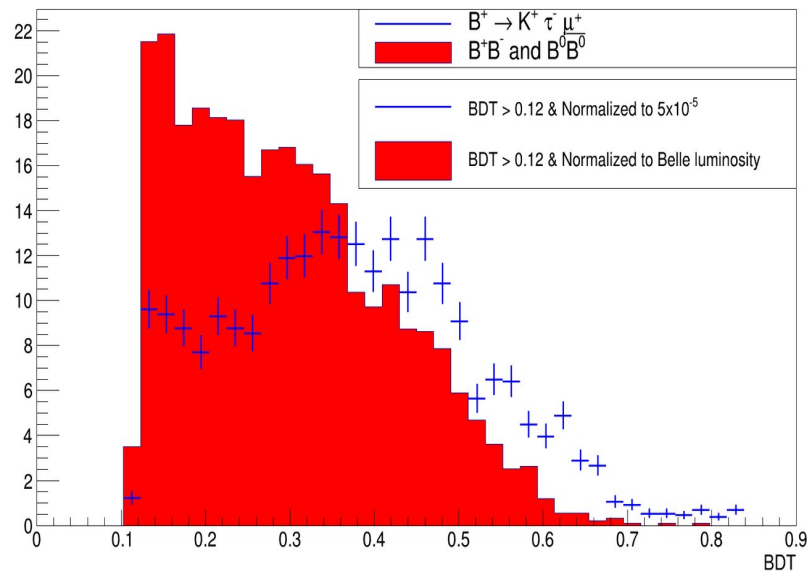
Project 2

Data analysis :

Hadron physics $B \rightarrow D_s X$

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.

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

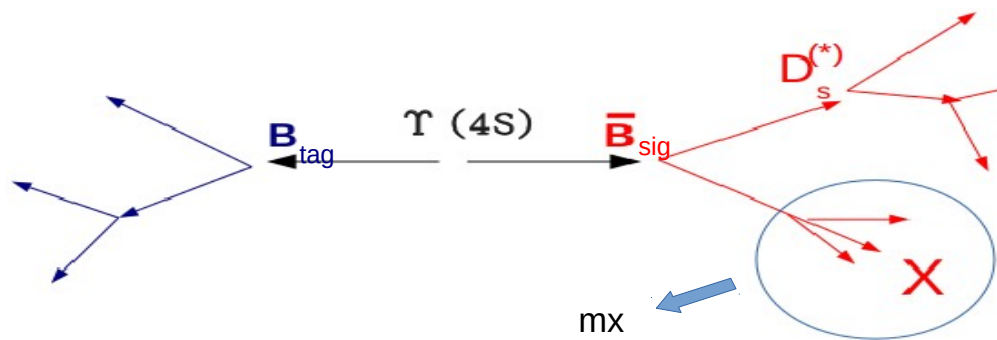
X= anything

- 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



R. Mizuk
J. Wiechczynski
Oliwia Krasowska
A. Chaabi

- [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

- O. Krasowska gave talk at 2025 workshop
- Plan for long term visit of O. Krasowska in 2026

Project 2: Challenge of the inclusive measurement

Main outcome of the hands-on session discussion

R. Mizuk
J. Wiechczynski
Oliwia Krasowska
A. Chaabi

- Better understanding of the custom FEI structure
- B_{tag} invariant mass could be utilized (instead of ΔE) to extract B_{tag} signal
- Attention for an efficiency trap!

$$\epsilon_{B_{\text{tag}} D_s} \neq \epsilon_{B_{\text{tag}}} \times \epsilon_{D_s}$$
- Idea of B_{tag} efficiency correction by (Data – MC) yield comparison for each B_{tag} mode (next slide)
- Importance of the sensitivity evaluation for this analysis

- Intensive discussions at hands-on session organised at IJCLab workshop 2025!
- Close collaboration started!

Project 3: Hadronic τ decay and CP violation

Z. Zhang
F. Callet
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J. John
A. Tapadar

- Most of τ study at Belle II focus on the LFV new physics search but with the current low statistics, we are hitting the limit.
- Hadronic τ decay is “over”-produced at Belle/Belle II but the study is going very slowly. IJCLab Belle II group is putting special emphasis on this project (ERC advanced grant submitted 2025).
- One of the obstacle is the MC generator. Many iterations to improve the theoretical models inside are essential.

Expertise

- [IEJ PAN](#): House of TAUOLA generator development
- [IEJ PAN](#): Two postdocs are hired in 2025 for further develop TAUOLA!!!
- [IEJ PAN](#): Long experience in tau physics phenomenology
- [IJCLab](#): Two PhD ongoing on hadronic tau decay analysis at Belle II,, 2π channel for muon g-2 and 3π channel for CP violation
- [IJCLab](#): Interest in polarised beam (which is useful for tau physics)

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Goals :

- Install fortran tauola and make it run (wednesday)
- Reproduce $K\pi\pi$ and $\pi\pi\pi$ plots presented at Tau workshop 2025
- Run tauola through KKMC using basf2.
- Test with $\pi\pi\pi$ plot.
- Identify key points for future analysis : Flags to disactivate ISR/FSR, change form factors

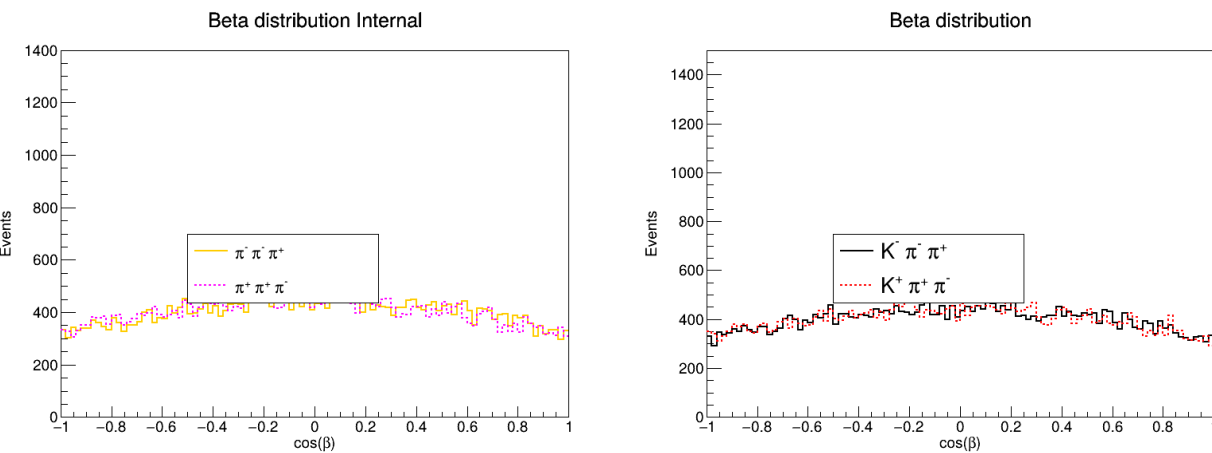
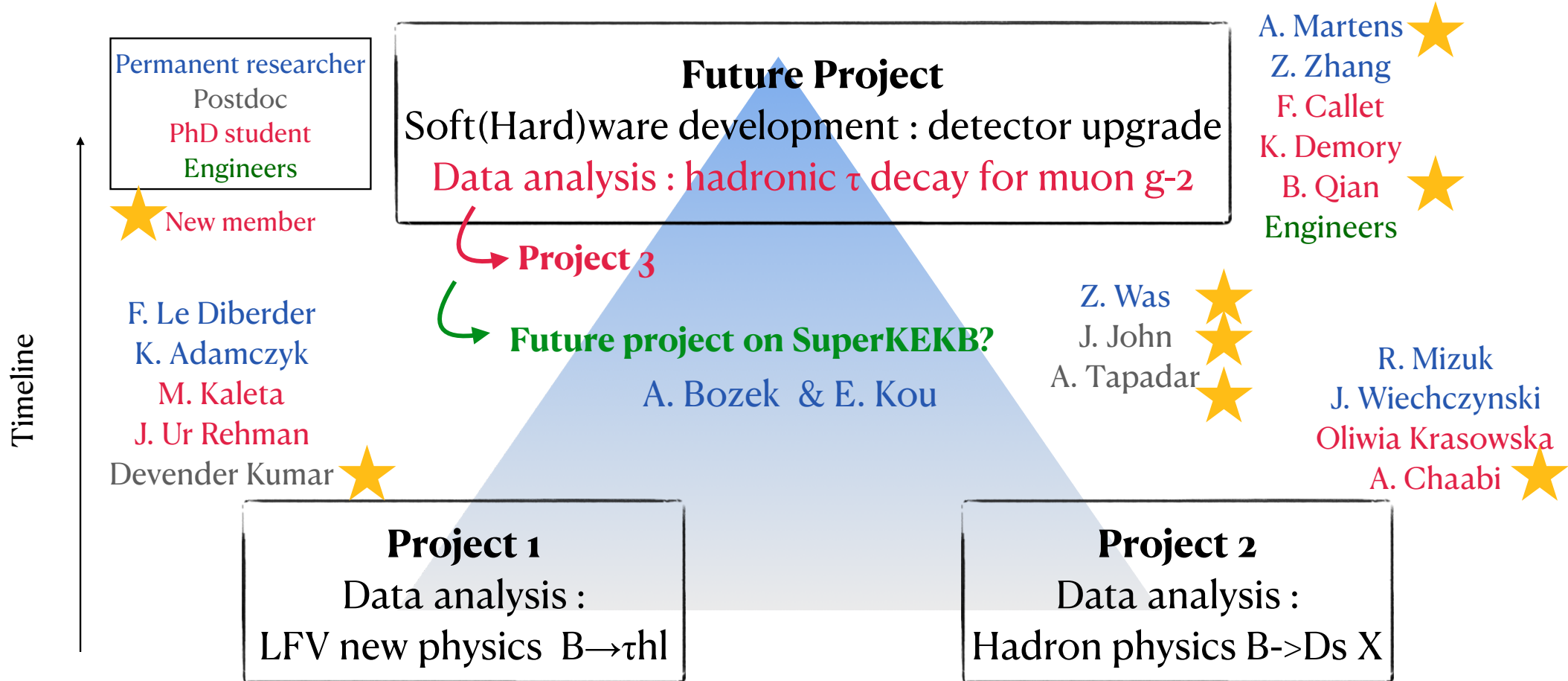


Figure: β distribution for CLEO model. Left : $\tau \rightarrow \pi\pi\pi$. Right : $\tau \rightarrow K\pi\pi$.

- Practical hands-on session organised at IJCLab workshop 2025!
- Close collaboration started!



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Future projects 3: SuperKEKB

Expertise

- [IJCLab](#) : Lumi Belle II
- [IFJ PAN](#) : High energy bremsstrahlung phenomenology

- PHC Polonium project submitted
- Interesting training opportunity for PhD students from IJCLab and IFJ PAN!

Special seminar organised during workshop by Krzysztof!

11:00

Long range quantum electrodynamical effects in high energy bremsstrahlung

<https://indico.ijclab.in2p3.fr/event/12075/>

Auditorium P. Lehmann Building 200

Speaker: Dr Krzysztof Piotrkowski (AGH University of Krakow)

P. Bambade
K. Piotrkowski
(AGH university, Krakow)
E. Kou
R. Mizuk
J. Wiehczynski
Oliwia Krasowska
A. Chaabi

Summary

2025

- One month visit of J. Ur Rehman funded by IFJ PAN
- 2nd workshop held 13-14th November 2025 IJCLab
 - ✓ 3 people funded by IFJ PAN
 - ✓ 3 people funded by IJCLab

2026

- Long term (>1 month) visit of Oliwia Krasowska
- 3rd workshop in IFJ PAN (autumn 2026)