



ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA



BOLOGNA – LHCb – Internship opportunities

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Bologna's group

Senior

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Pedigree

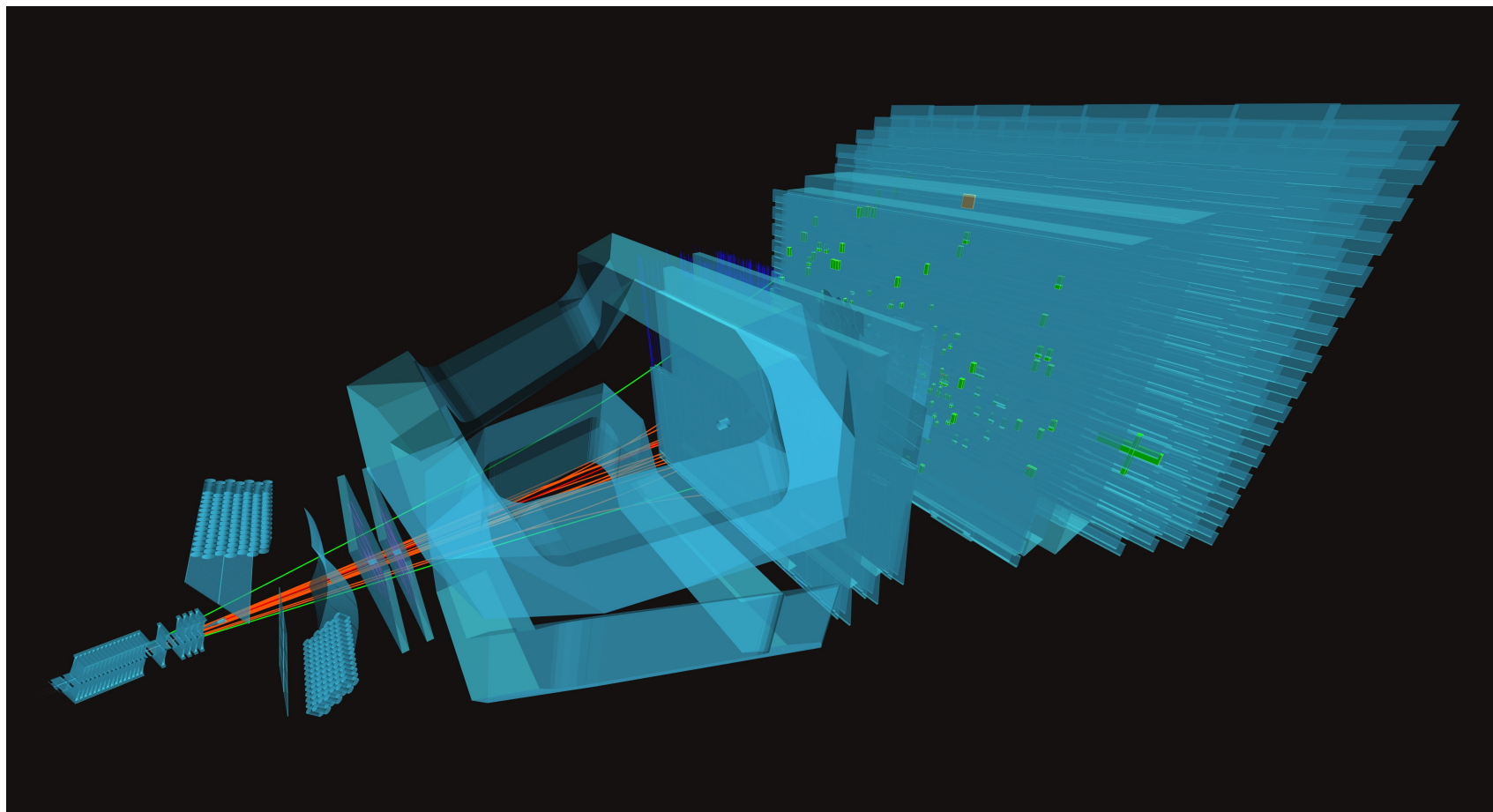
Search for CP violation → Discovery
CP violation in D and B mesons;

Decades of experience in data
analysis → more than 20 papers as
primary authors.

R&D → expertise in LHCb operation,
data acquisition system, real-time
data analysis, photomultipliers,
micro-channel-plates, picosecond
time measurements

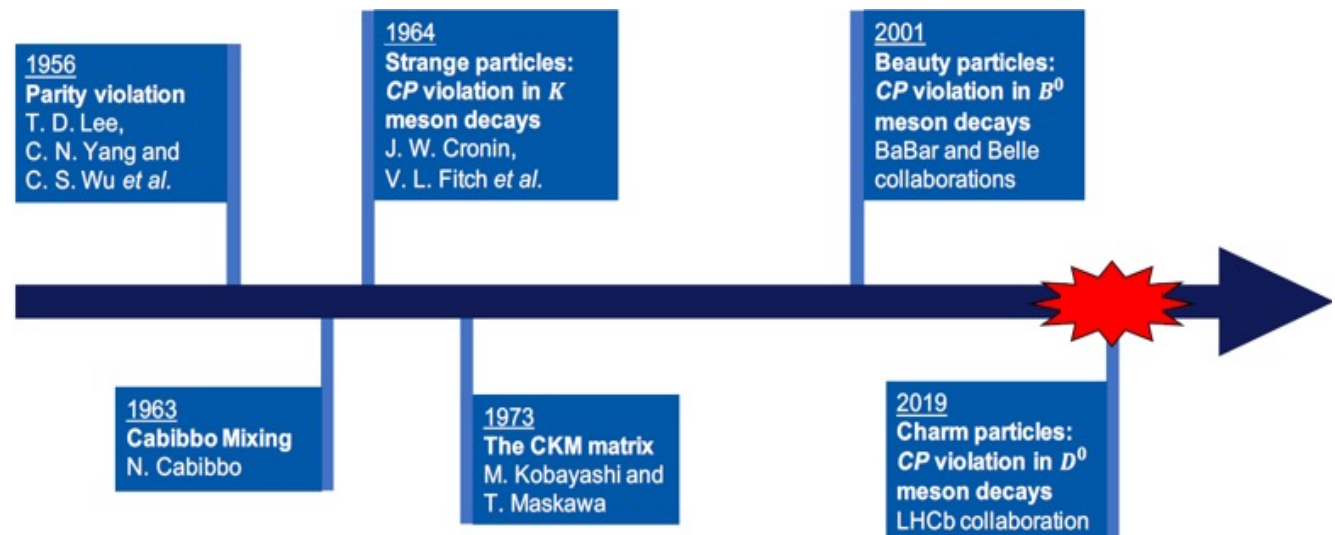


The LHCb experimet

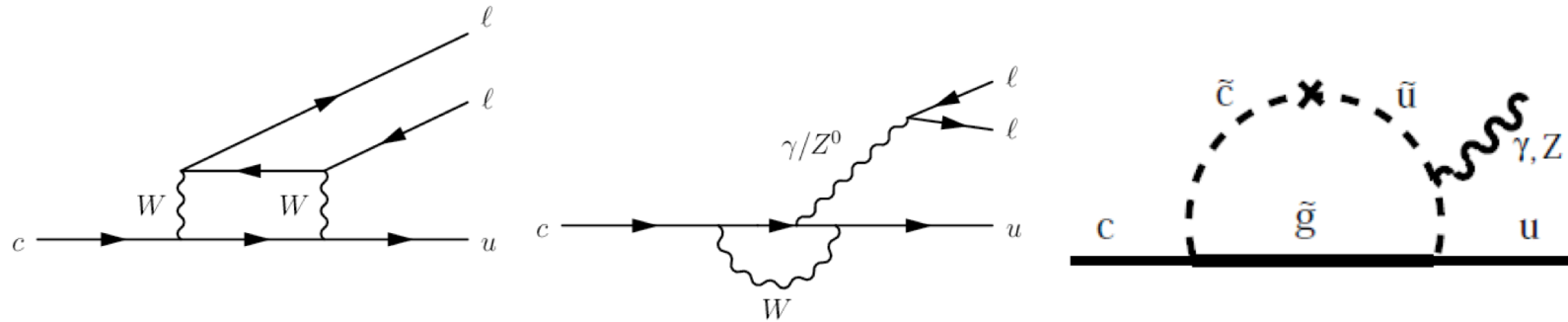


Search for CP violation in charm decays

- Charm physics is a powerful tool for the indirect search for New Physics
- CP violation in charm decays was **recently discovered**
- It opens up a new field of research: the study of CP-violating effects in the sector of **up-type quarks** and searches for **new physics** effects
- CP violation in SM highly suppressed \rightarrow relatively large observation of CP violation can reveal new physics



Rare charm decays



- Flavour changing neutral current decays \rightarrow probe for New Physics
- Very low SM rates ($\text{BF}(c \rightarrow u\ell\ell) \sim 10^{-8}$) for loop processes provide a unique window to observe NP (TeV Scale) in rare charm processes
- New Physics can introduce new particles into loop or new tree-level neutral current phenomena

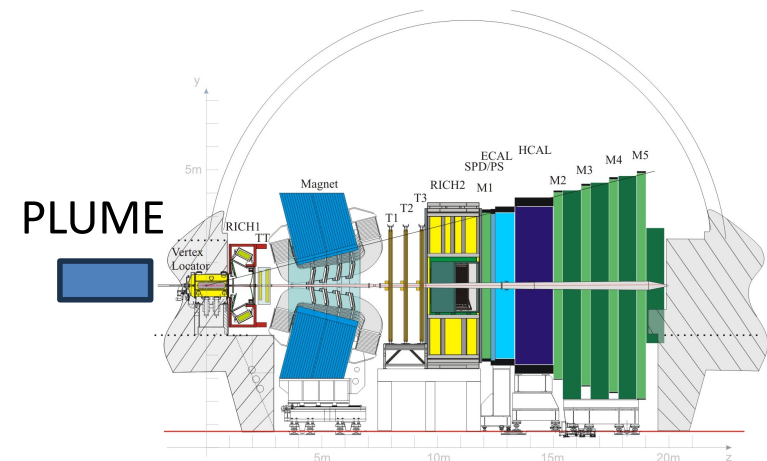
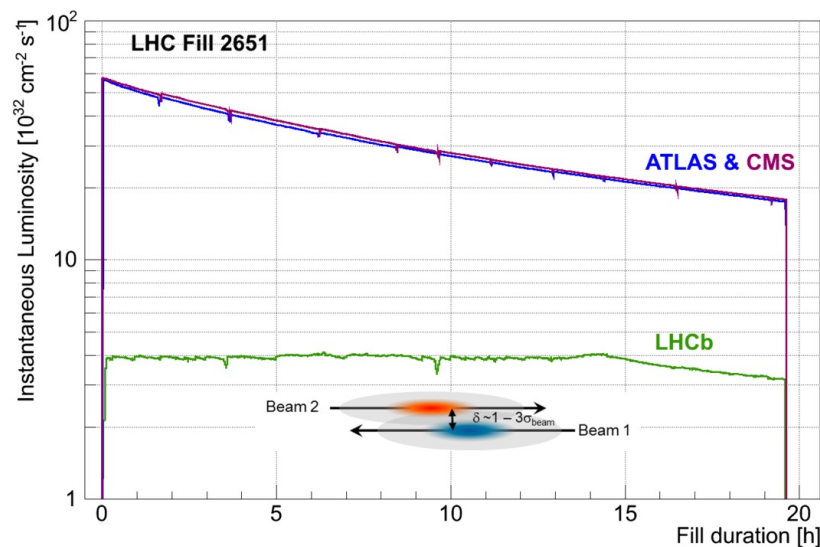
Search for CP violation in beauty decays

- Unitarity triangle → UT covered by FP course
 - Different B decays give access to angle and side of UT
- Tree-level and Penguin level interference → covered by FP course
 - Interference between diagrams may enhance CP violation, and discrepancy with SM may reveal New Physics
- Time-integrated and time-dependent analysis covered by FP course →
 - Give access to different parameters describing CP violation in the SM



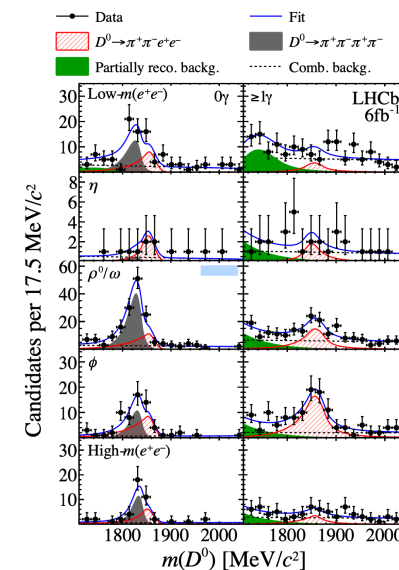
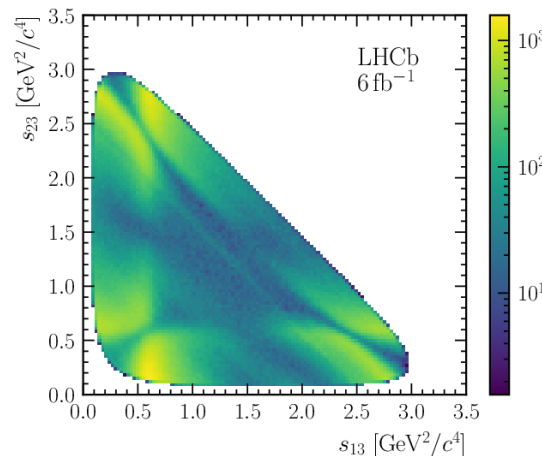
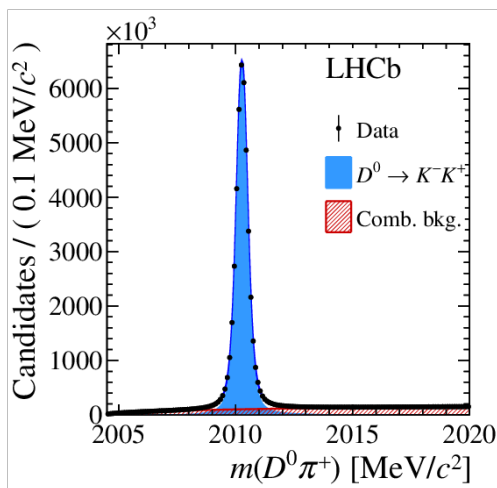
The PLUME detector

- Bologna has the responsibility to provide the luminosity measurement in the LHCb interaction point
- PLUME is a luminometer made of 44 photomultipliers, each of them measures independently the luminosity
- A value every 3 seconds is provided to LHC



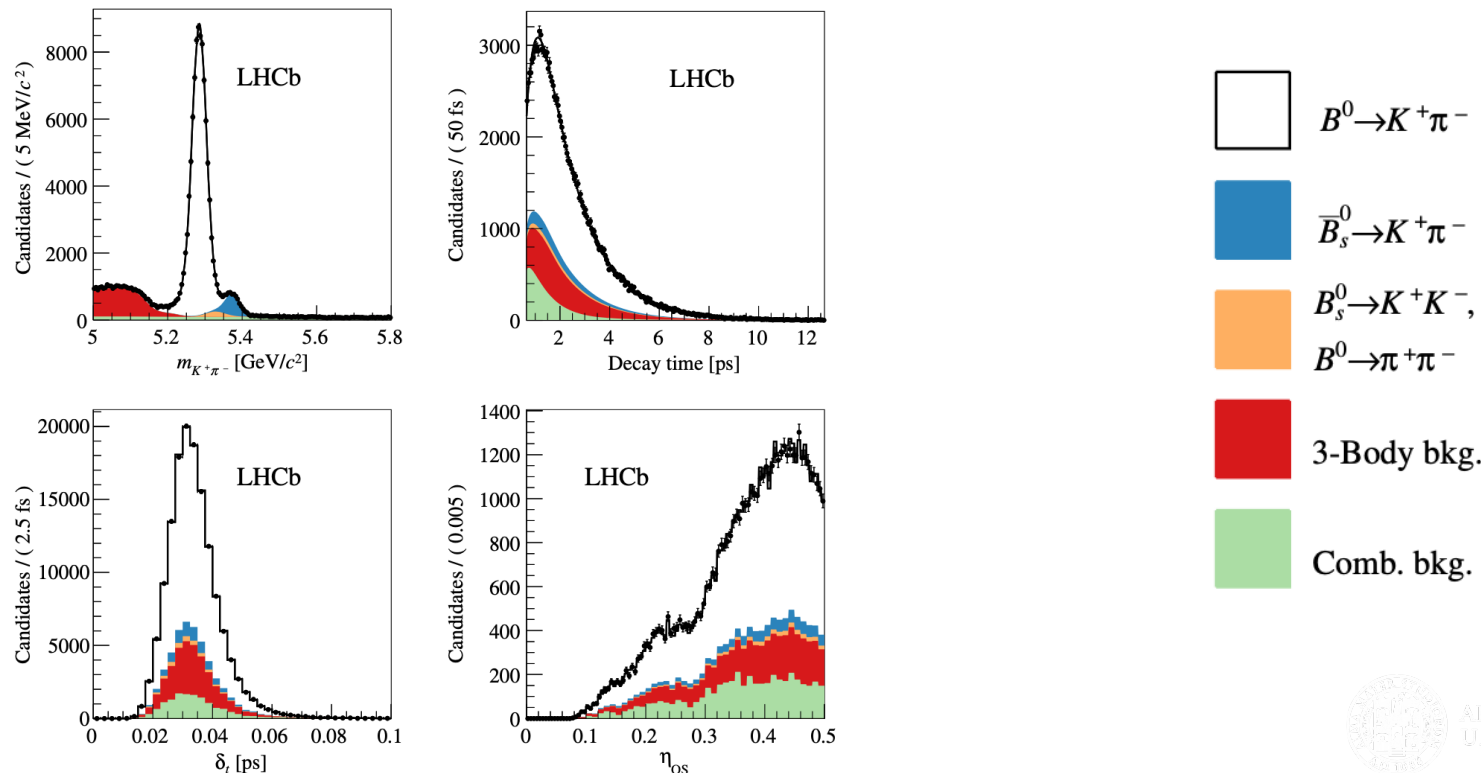
Internship with charm decays

- Recently, we started looking at the RUN 3 data (data acquired in 2024). The signal yields in charm correspond to about 2 times the data acquired in 2016-2018 → a huge amount of charm decays
- The LHCb group is involved in the analysis of the following decays
 - Search for CP violation with $D^0 \rightarrow K^- K^+$ and $D^0 \rightarrow \pi^- \pi^+$
 - Search for CP violation with $D^0 \rightarrow K^- K^+ \pi^0 \rightarrow$ Dalitz analysis
 - Rare decays $D^0 \rightarrow K^- K^+ e^- e^+$ and $D^0 \rightarrow \pi^- \pi^+ e^- e^+$



Internship with beauty decays

- Recently, we started looking at the RUN 3 data (data acquired in 2024). The LHCb group is involved in the analysis of the following decays
 - Search for CP violation with $B_s^0 \rightarrow h^- h^+$ with $h = \pi$ or K
 - Time-integrated and time-depedent analysis
 - Working with baryons is also possible



Internship with PLUME

- For the LHCb RUN-4 2029, we would like to update PLUME to measure with a precision of a few pico-seconds the time of arrival of the proton-proton beams
- This is important for future upgrades where the measurement of time is fundamental for disentangling tracks coming from different primary vertex
- This topics requires MC simulation to simulate LHCb RUN-4
- For a picosecond time resolution measurement it will be fundamental to identify the proper photomultipliers (LAB work possible)
- Data acquisition system needs to be developed → possible of working with firwmare development

