

RF and precision timing

Matthew Rudolph

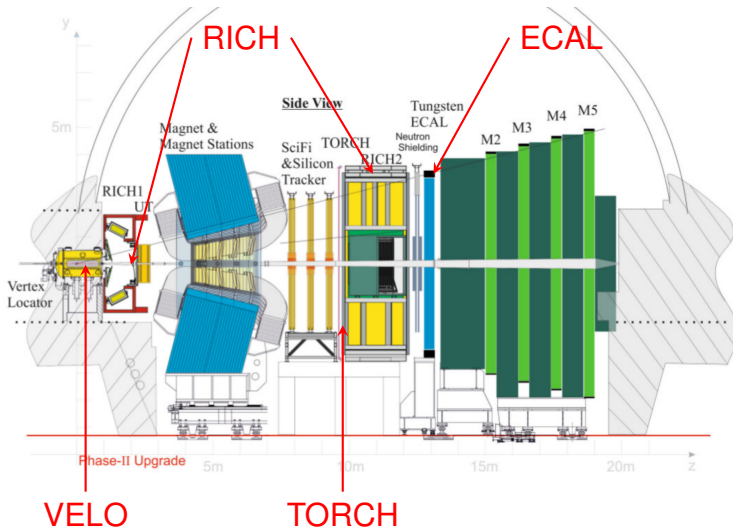
Syracuse University

July 21, 2022

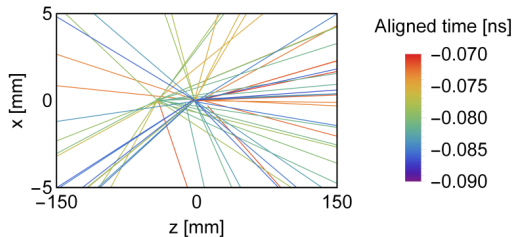
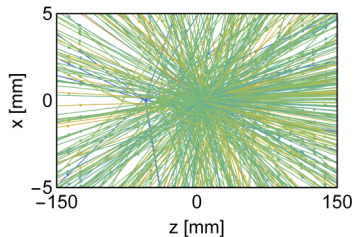
The benefits of timing

- Time resolution < 100 ps (ideally $\lesssim 20$ ps) benefits high intensity experiments for precision measurements
- Many proposals integrate timing across **multiple** subdetectors
- Precision timing **reduces combinatorics**
 - Reduce background from mismatches
 - Faster computation to improve triggering
- Allows use of time-of-flight for PID
- In interests of time**: will focus on LHCb Upgrade II as an **example** combining many uses
- Also NA62 successor, Belle 2 upgrade, *et al*

Where timing fits in



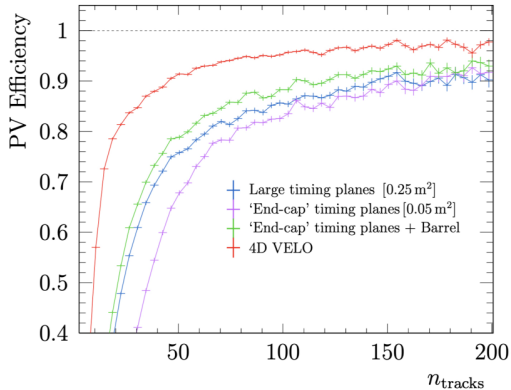
VELO



- 20 ps timing per track greatly improves vertexing
- Timestamp needed to **start the clock** for rest of detector

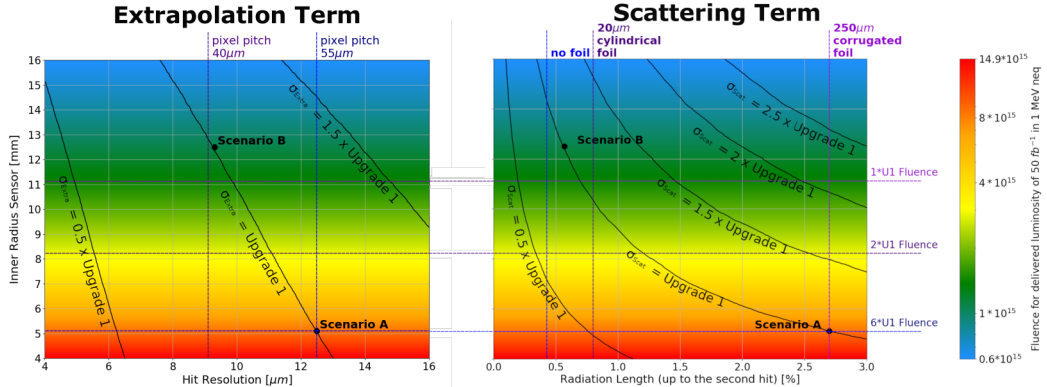
4D tracking

- full 4D much better than timing layers
- Challenging in high radiation environment



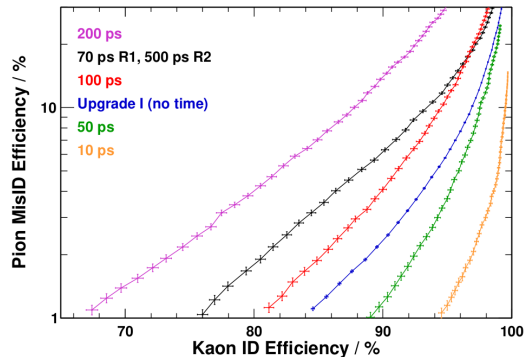
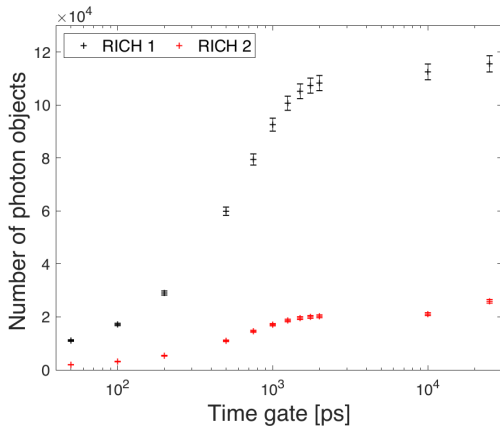
VELO requirements

- Strict requirements along many axes



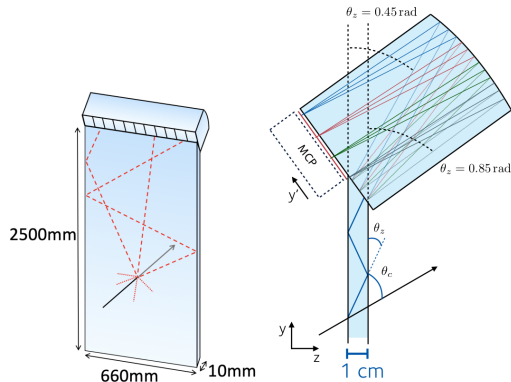
RICH

RICH photodetectors also need $\lesssim 100$ ps per photon timestamp for matching



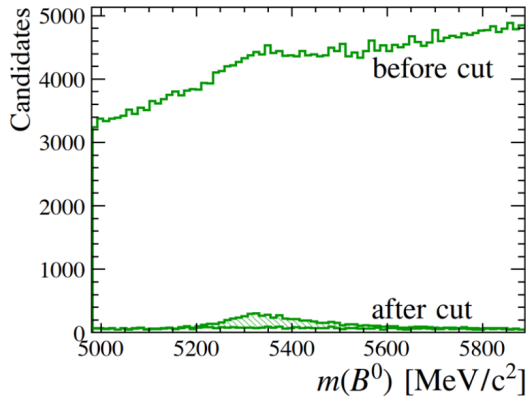
TORCH

- New TORCH for TOF PID, mainly at low momentum (need 15 ps at 10 GeV)
- Requires single photons at 70 ps



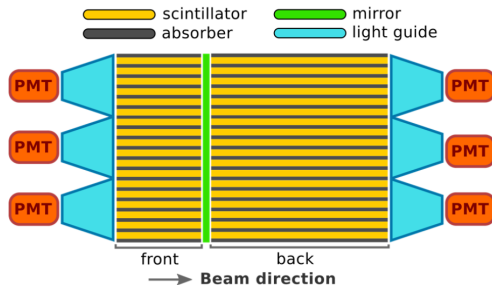
ECAL

- Timing rescues signal: e.g. $B^0 \rightarrow \pi^+ \pi^- \pi^0$
- Timing resolution assumed $< 30\text{ps}$ across most of energy range



ECAL

- Challenges for intrinsic response and readout
 - Need performance with in-time and out-of-time pile-up
- Further study needed to identify best strategy
 - Timing from crystal only?
 - Timing plane(s)?
 - SiW option with timing also



Conclusions

- Require precise timing resolution across a **variety** of subdetectors with different purposes
- 4D tracking** a big gain in dense, high rate environments
- Matching** in time reduces background **and** computational complexity
 - For tracking, PID, calorimetry
- Enables use of time-of-flight

Backup

NA62

- Kaon decay experiments have similar challenges
- Running NA62 at 3 GHz requires ~ 25 ps timing throughout the detector

