LHCb Run 3 status

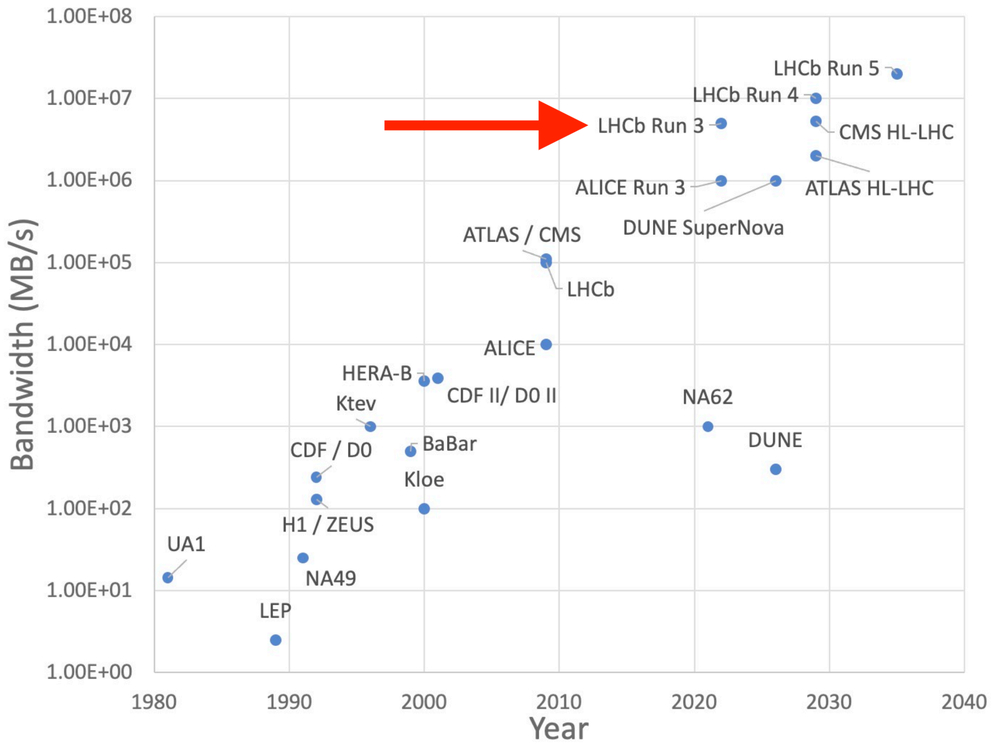
And happy new year!

Michel De Cian, LHCb UK meeting, January 7 2025

LHCb in Run 3

(Almost) all new

- Goal for LHCb in Run 3 was to run at a 5x higher luminosity than in Run 1+2
- This was to be achieved by a triggerless readout at 40MHz, using a pure software trigger.
- These goals required significant changes to the subdetectors and the data processing infrastructure.



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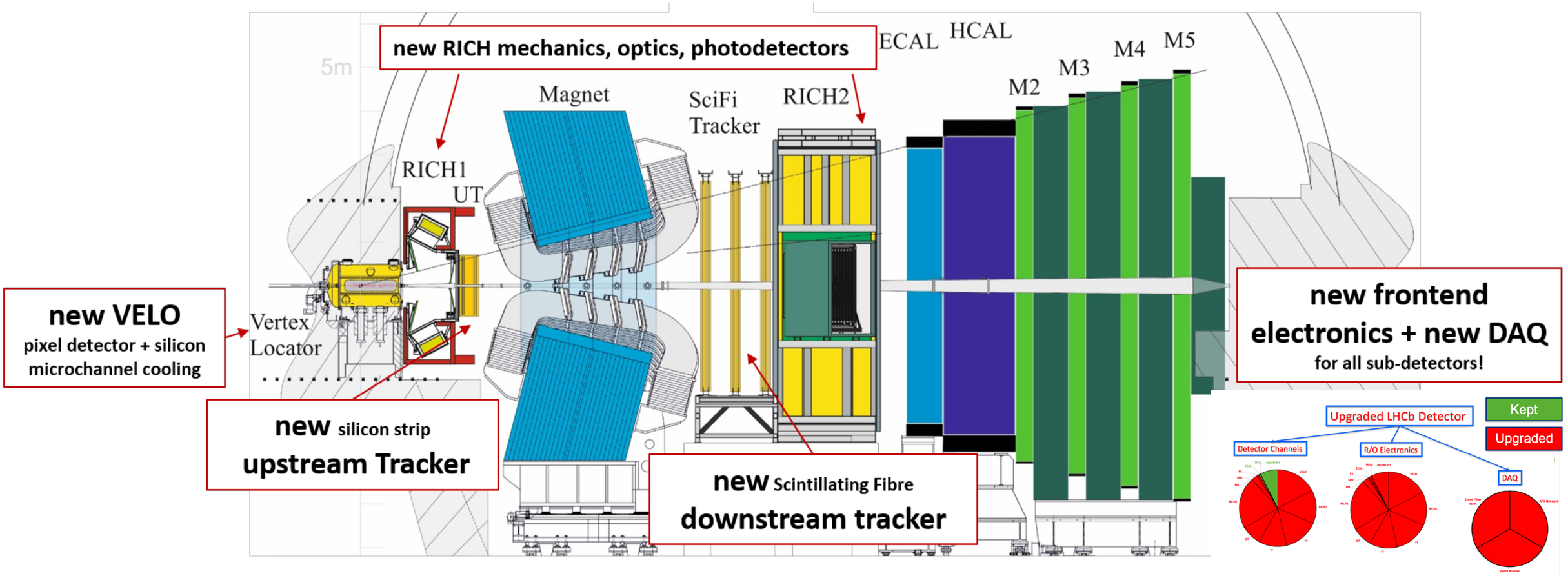


2022 + 2023

A bit of a rough start to Run 3

- Most of 2022 dedicated to (hardware) commissioning,
  -> only small data set (probably) useful for a publication.

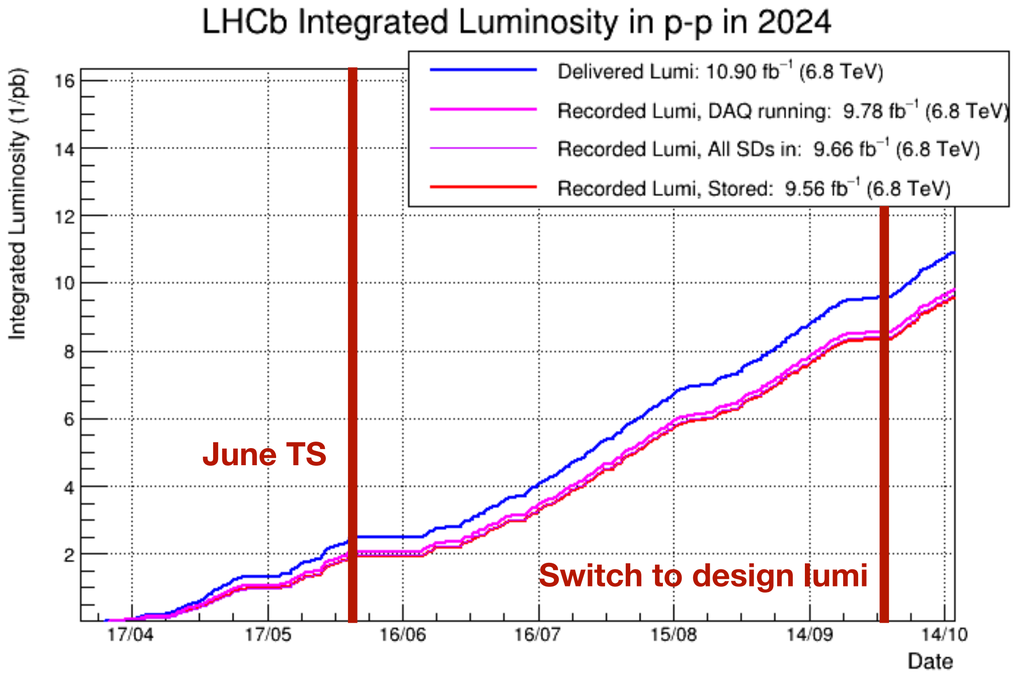
- 2023 was unfortunate: Vacuum incident did not allow Vertex Locator to be closed, significantly reducing the IP resolution. Also this data set is limited in size, and without the UT detector.

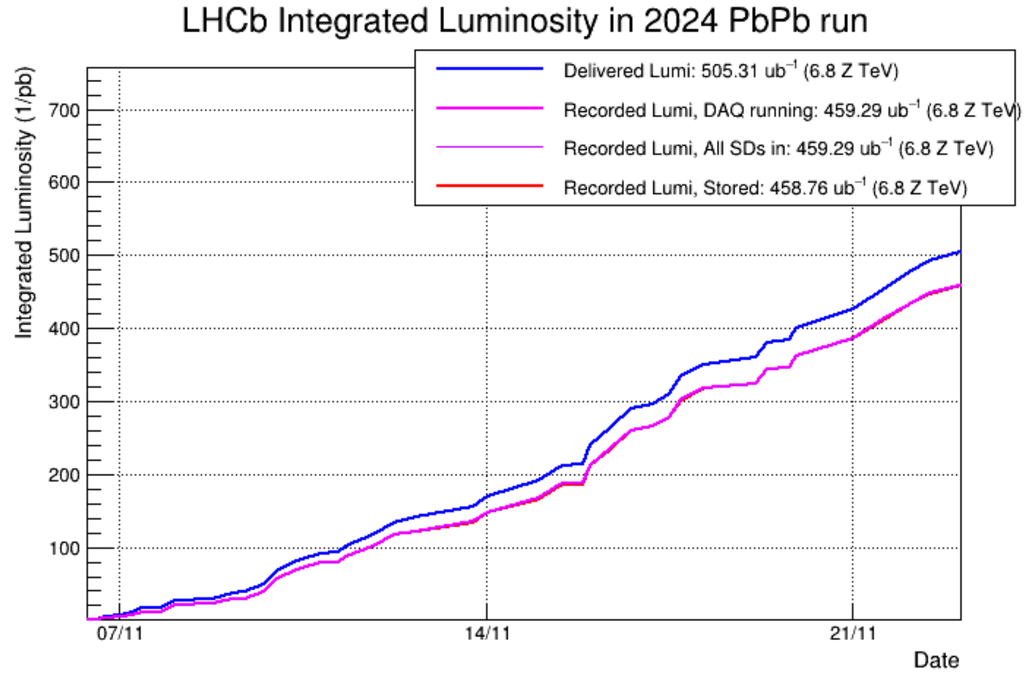
- 2024 however was to be much more successful.

Luminosity in 2024

Shiny happy events

- Collected 9.5 fb^{-1} in 2024 (more than all of Run 1+2). About 7fb^{-1} with the UT detector included (i.e. nominal LHCb configuration)
- Early data taking period with less stable conditions and not UT, last data pp taking with design conditions ($\mu = 5.3$).
- Large PbPb and PbAr/PbNe samples.





Selected performances

VELO

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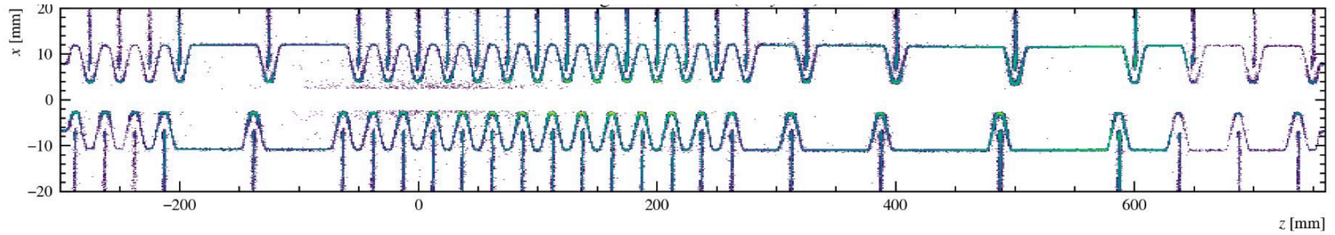
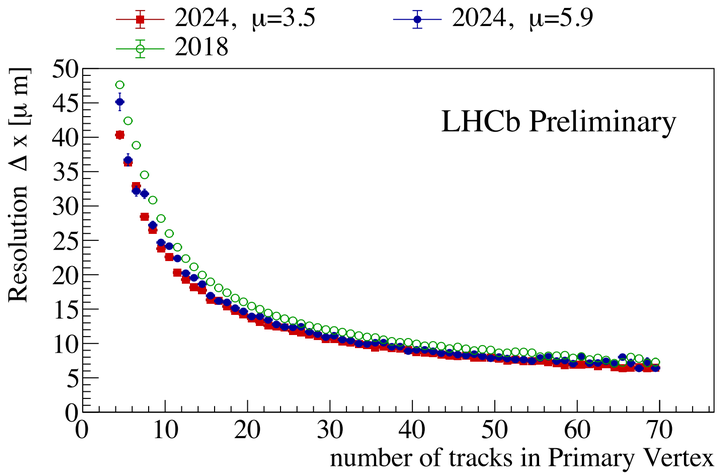
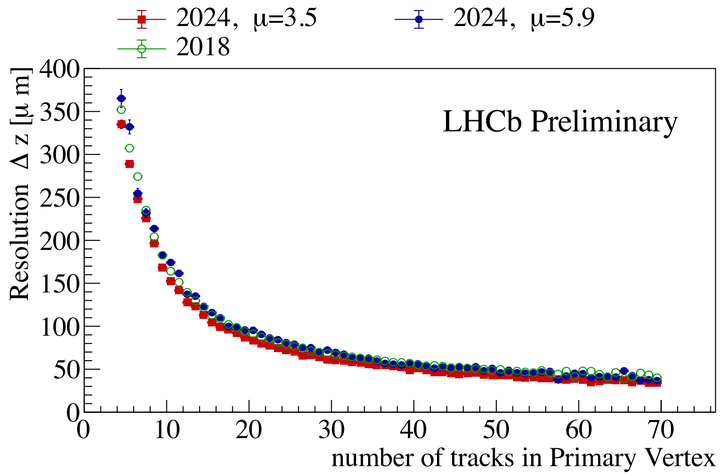
- 2024 was first year with Velo fully closed at nominal luminosity.
- Successful recovery of the 2023 vacuum incident, hit efficiency > 98%, very high track reconstruction efficiency.
- Performance numbers close or better than the Run 1+2 equivalents.

Selfie of the new RF-box and VELO modules with reconstructed hadronic interaction vertices







RICH

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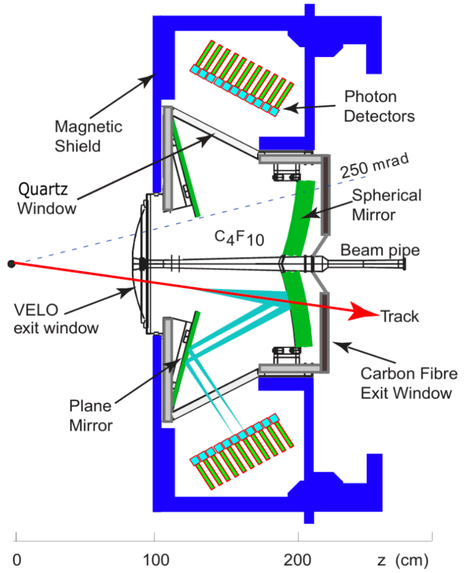
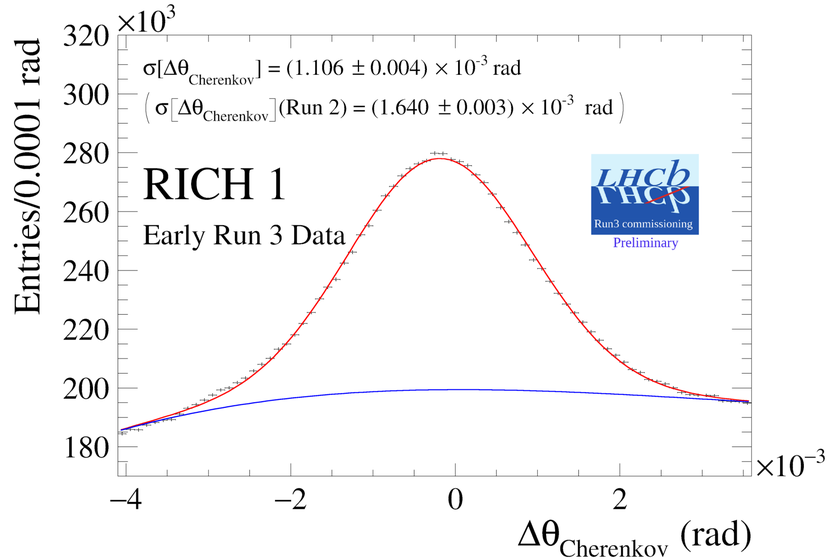
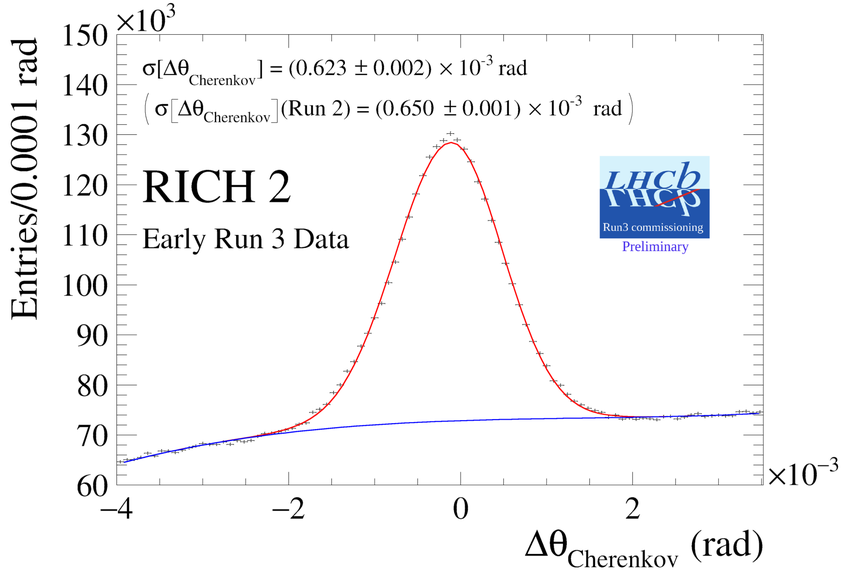
- Redesigned optics (RICH 1), new mechanical support, new electronics to deal with 40 MHz, and new photodetectors.
- Improved Cherenkov angle resolution compared to Run 1+2.
- Very efficient data taking in 2024.
- More (exciting) results in Innes' talk.







Real-time analysis

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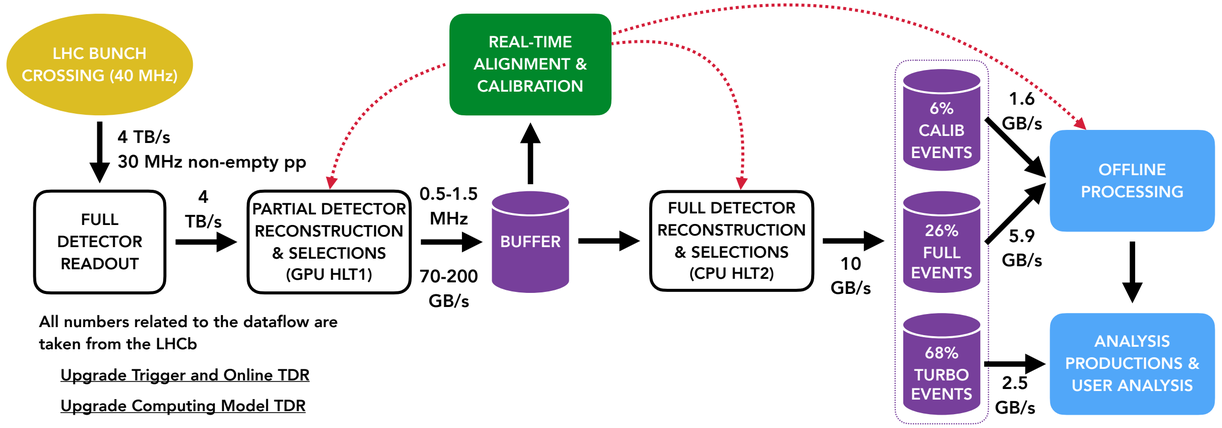
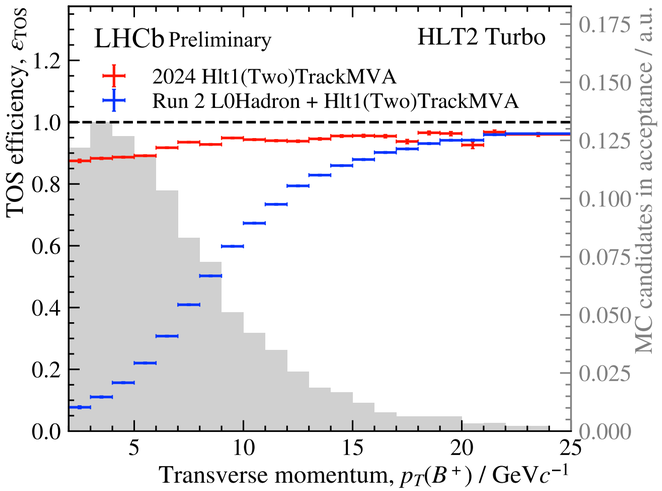
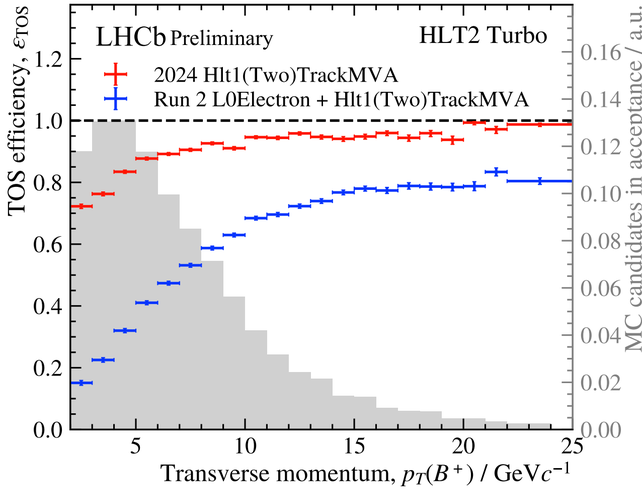
- Two-staged pure software trigger on GPUs and CPUs.
- Final reconstruction + calibration performed online.
- Significant work in 2024 to achieve nominal performance at $\mu = 5.3$ (Run2: $\mu = 1.1$)
- Much improved trigger efficiency compared to Run 1+2.







Offline / DPA

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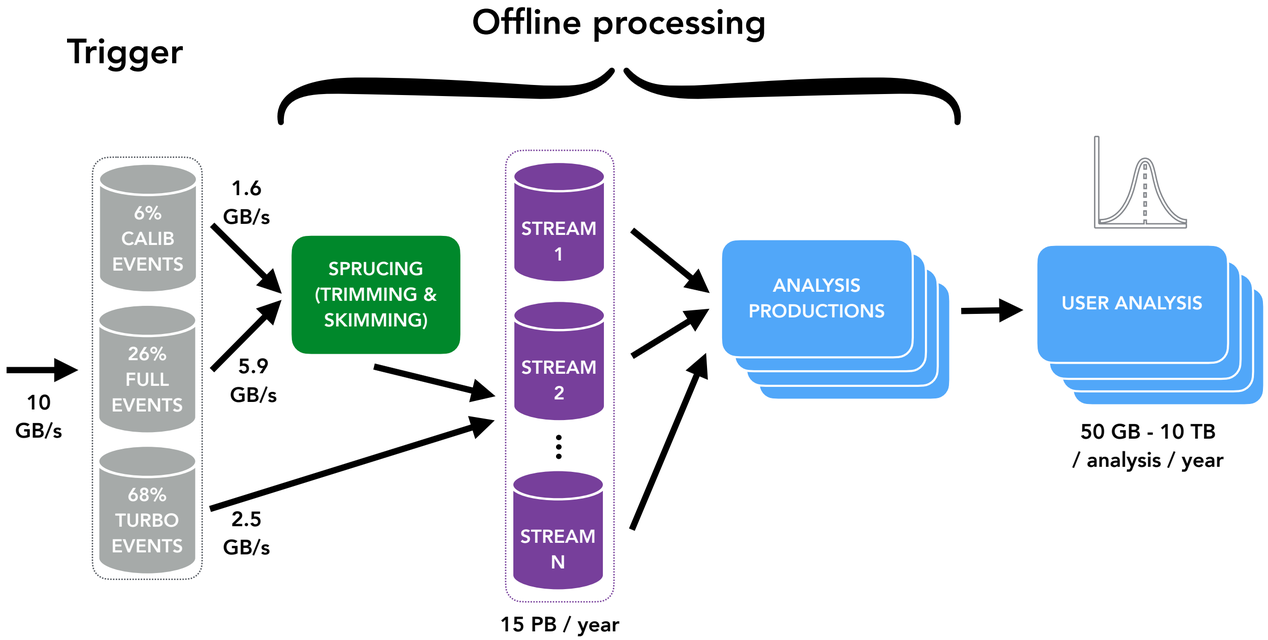
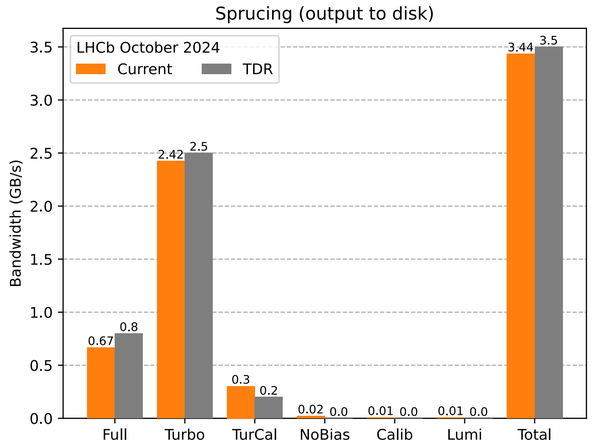
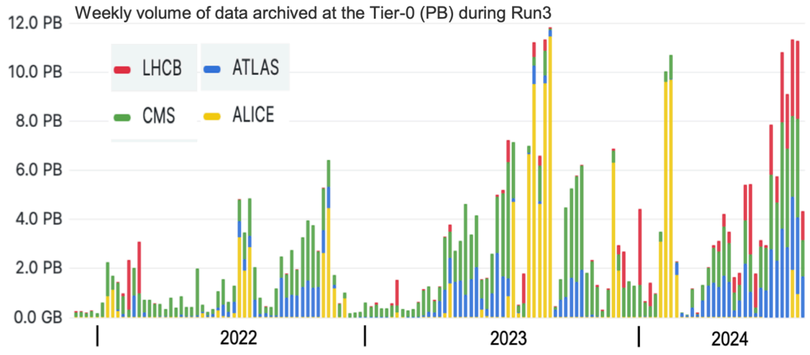
- Part of the events undergo a further offline selection called „Sprucing“.
- Keeping the output bandwidth under control crucial to optimize the usage of disk (and tape).
- Analysis production proved to be extremely value for a smooth user access to data.

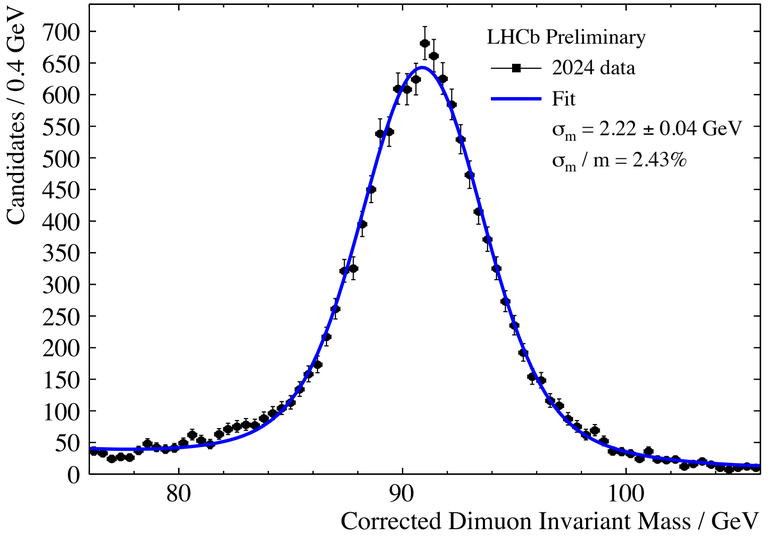


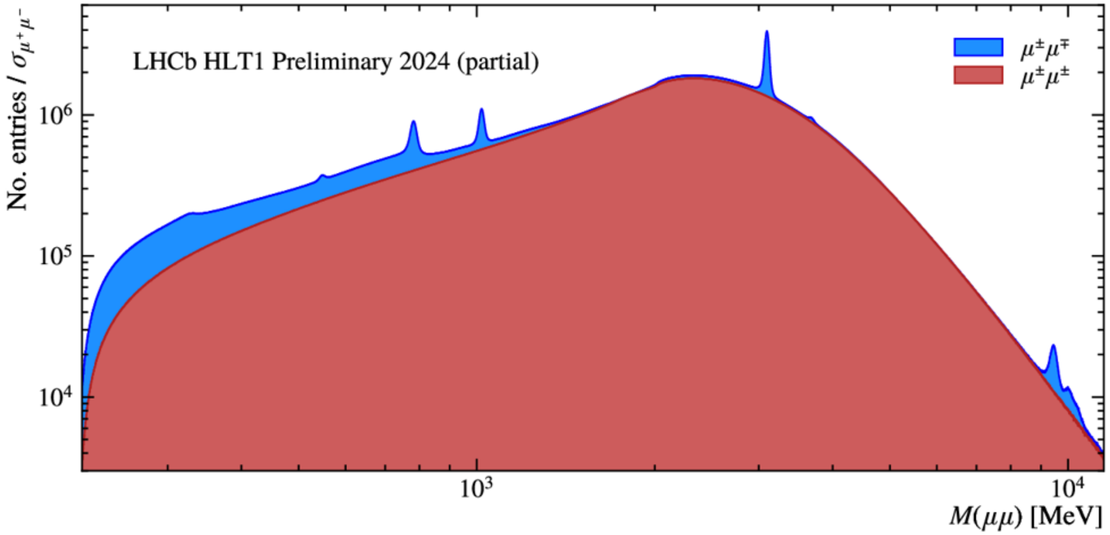


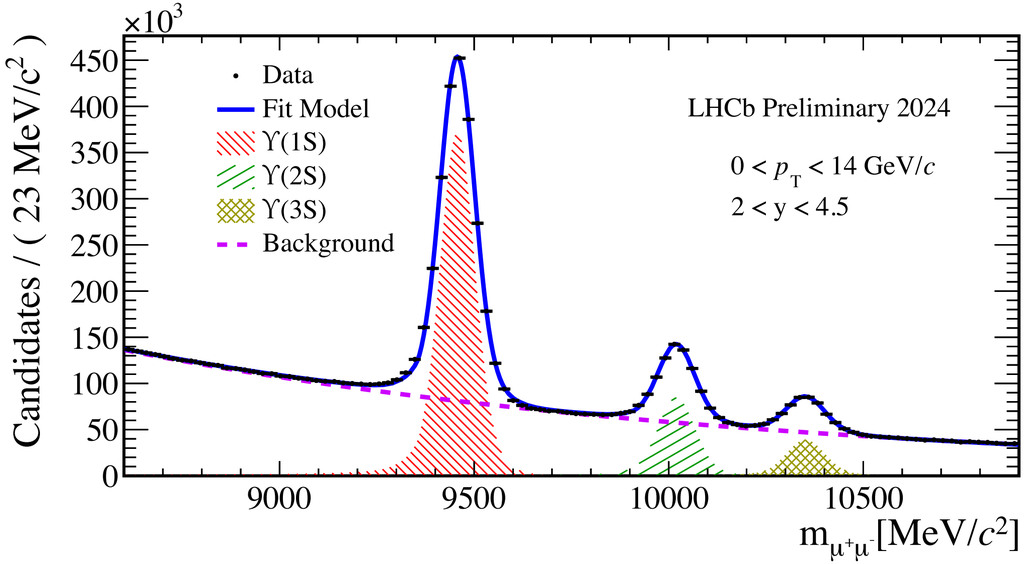


Performances

With dimuons!

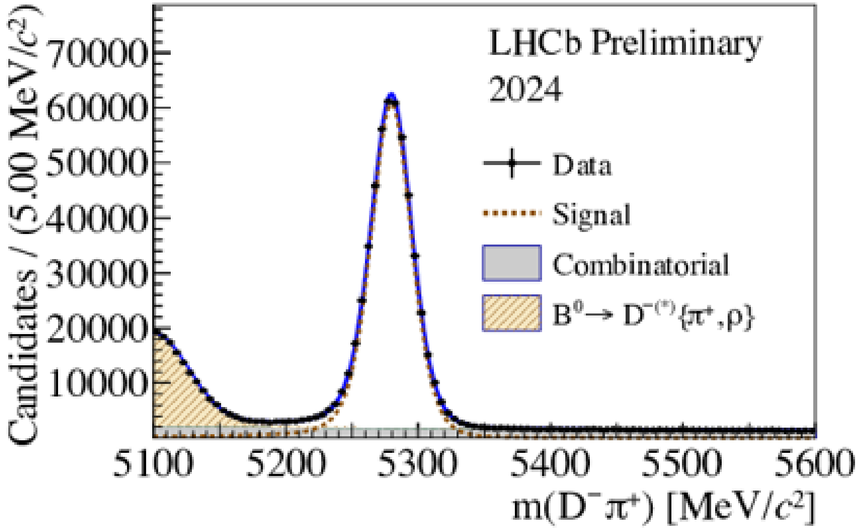


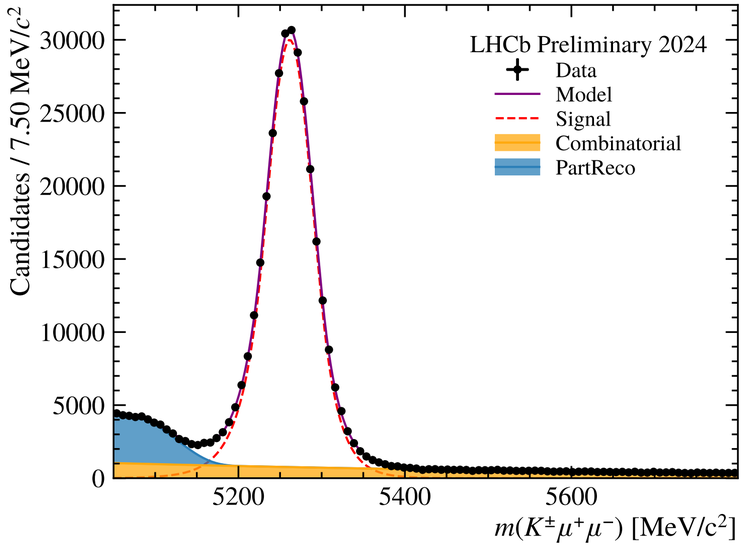


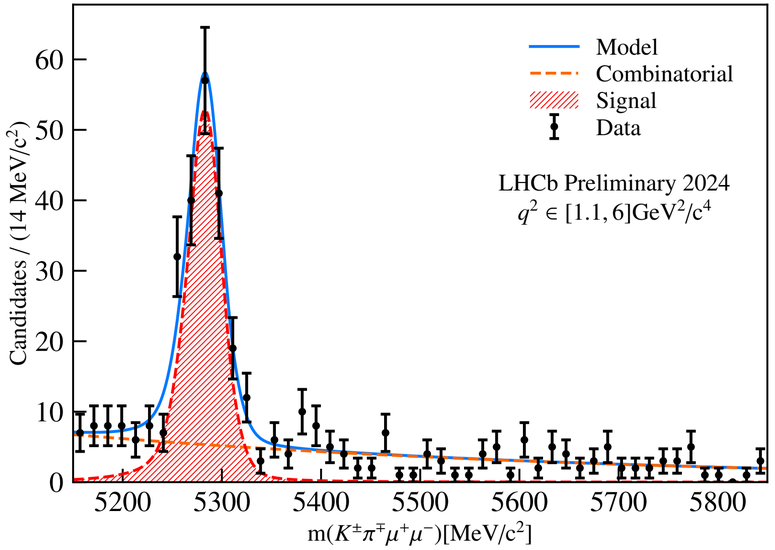


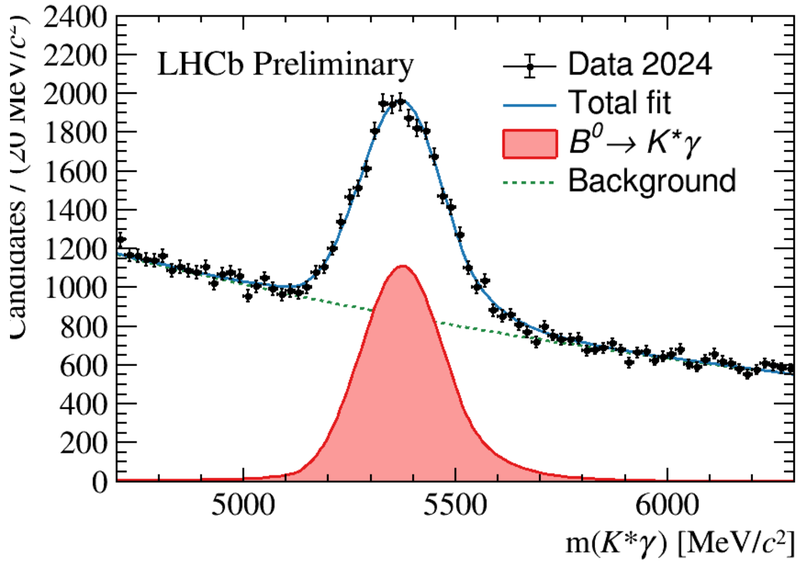
Performances

With other things!





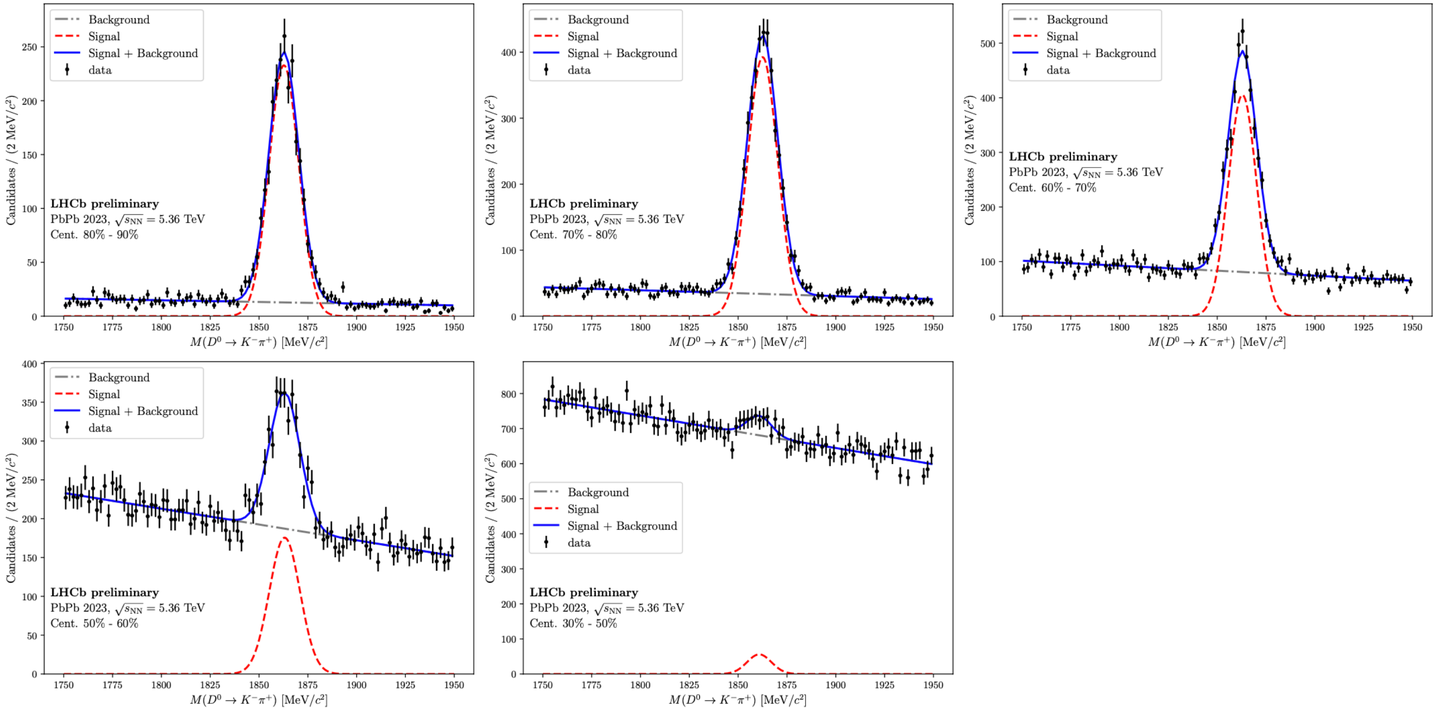


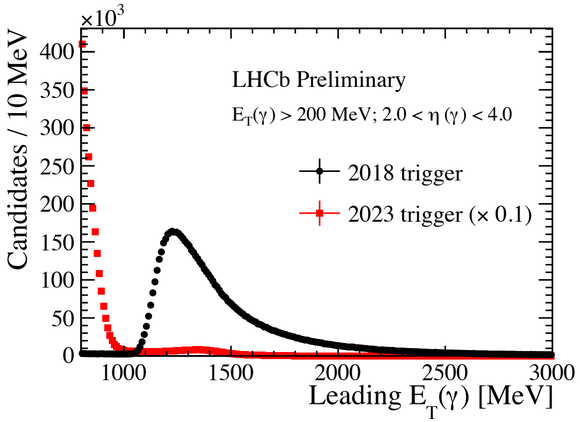


Performances

Heavy Ion

- Goal for Run 3 is to reach 30% centrality in PbPb collisions
- Very busy events required special configuration for hardware and software.
- Low-pt triggers for Ultra-peripheral collisions, e.g. for studying light-by-light scattering or axion searches.





Comments on performances

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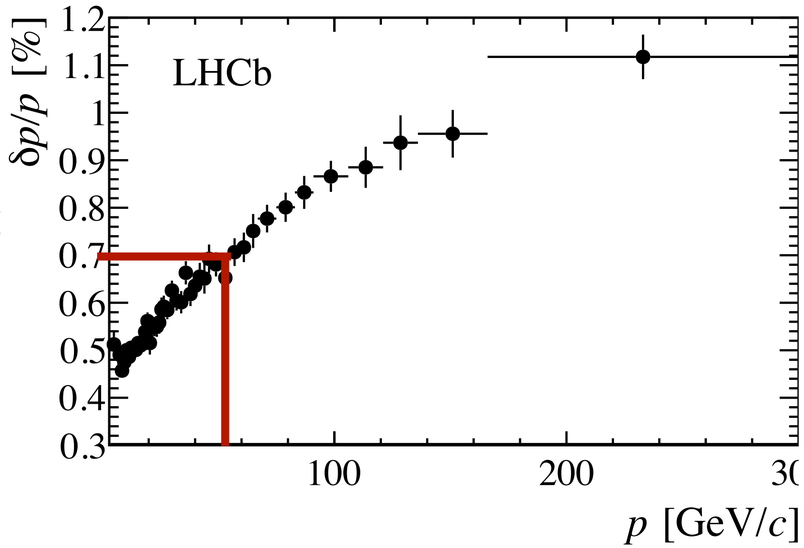
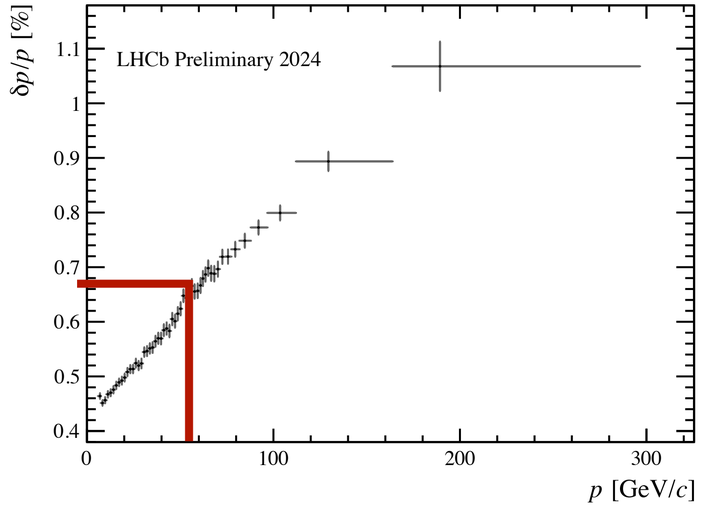
- In many areas LHCb equalled the performance of Run 1+2 or is within 10% (while having 5 x more events to process)
- Main goal of 2025 is to achieve the maximum performance of the detector(s) & trigger & reconstruction.
- Selected new features will be added, but focus clearly on stability





Run 3 physics analysis results

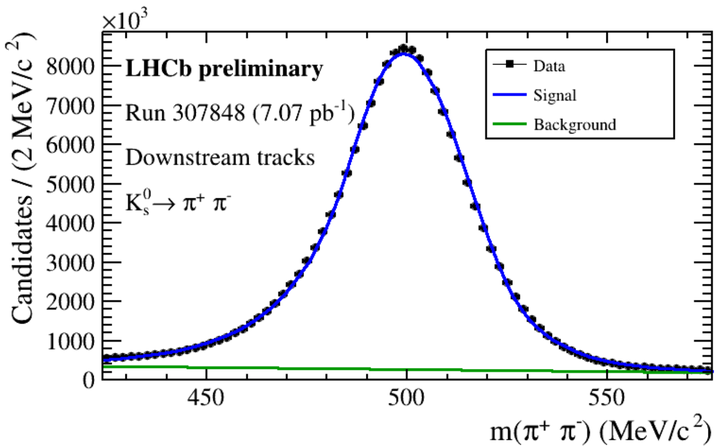
~~Run 3 physics analysis results~~

Advantages of Run 3 LHCb for physics analysis results

Advantages of Run 3 LHCb

May the real results arrive soon

- Higher yield / lumi for purely hadronic / electron final states, while maintaining the yield / lumi of Run 2 for all other final states.
- At least equal performance for detector-related quantities for precision measurements.
- Better sensitivity for long-lived particles
- Unique physics case for fixed-target and heavy-ion collisions (and UPCs)



Conclusions

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- After a bit of a rough start, LHCb reached its nominal data taking mode in 2024.
- Performance numbers suggest that design goals will (mostly) be achieved.
- Flood of data will turn into physics analysis results in 2025+