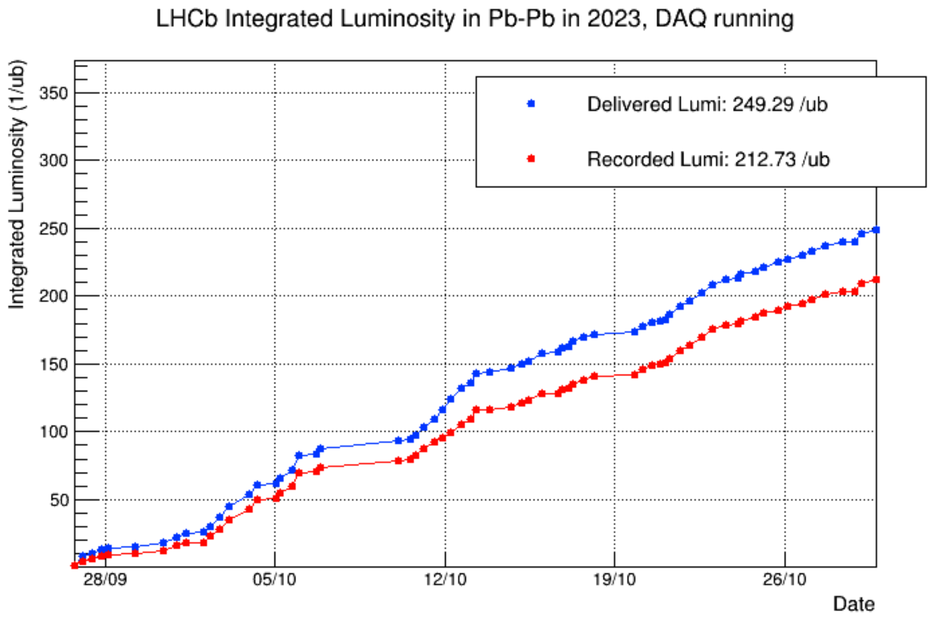
LHCB STATUS REPORT

- DETECTOR STATUS REPORT
- ION OPERATION REPORT
- PHYSICS REPORT

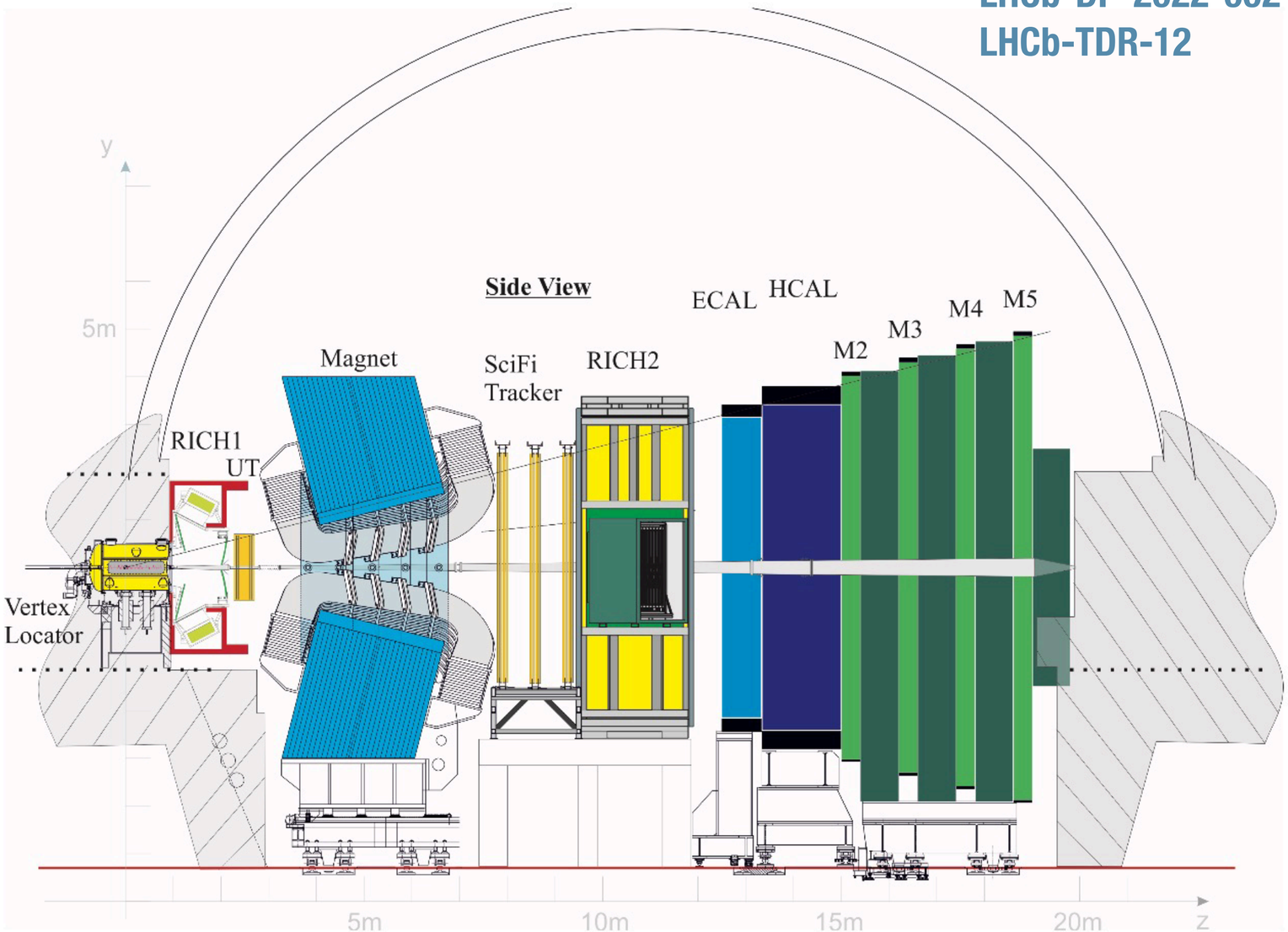
Benjamin Audurier for the LHCb collaboration - 156th LHCC Meeting - Nov. 29th 2023

DETECTOR STATUS REPORT

LHCb condition during the ion run

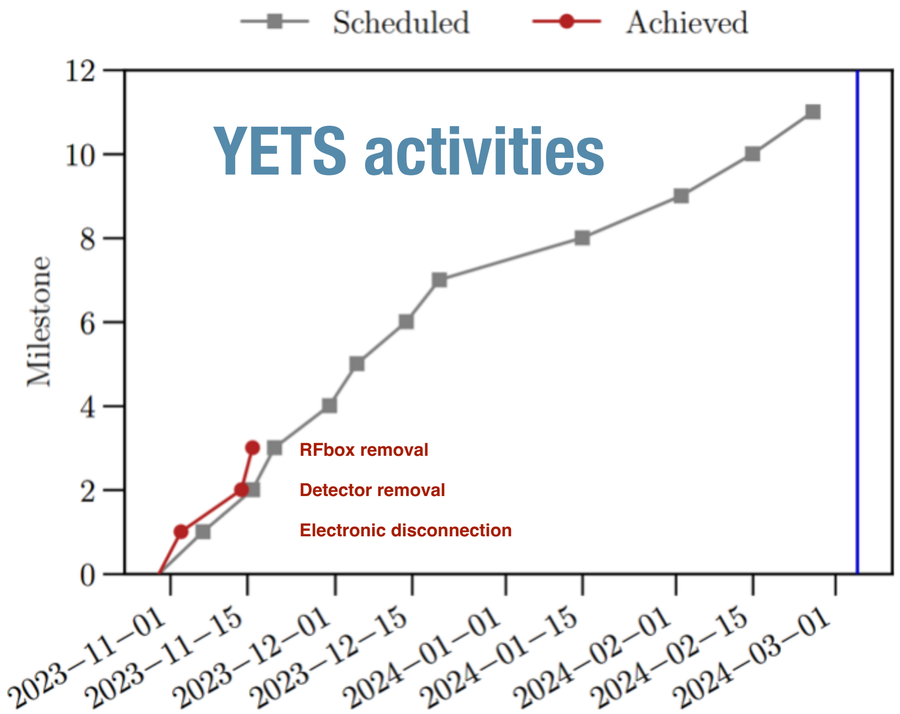


LHCb-DP-2022-002
LHCb-TDR-12

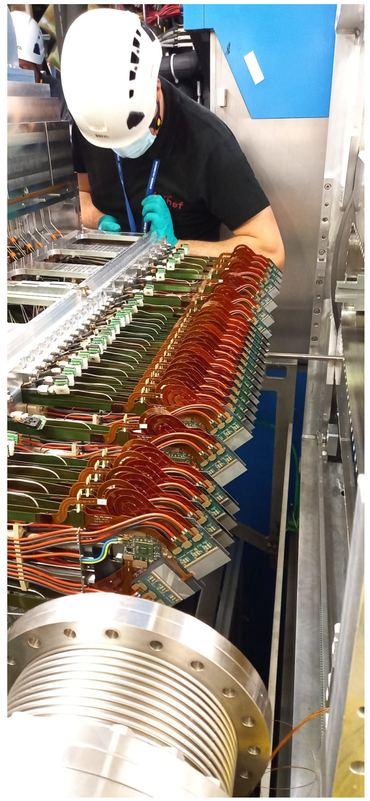


- **Specific status:**
  - Vertex Locator (VELO) with 49 mm gap.
  - Commissioning ongoing for the Upstream Tracker.
  - Gas (Ar) injected with SMOG continuously.
- **Other sub-detectors were running in their nominal state.**

VErtex LOcator (VELO)



removal of the detector

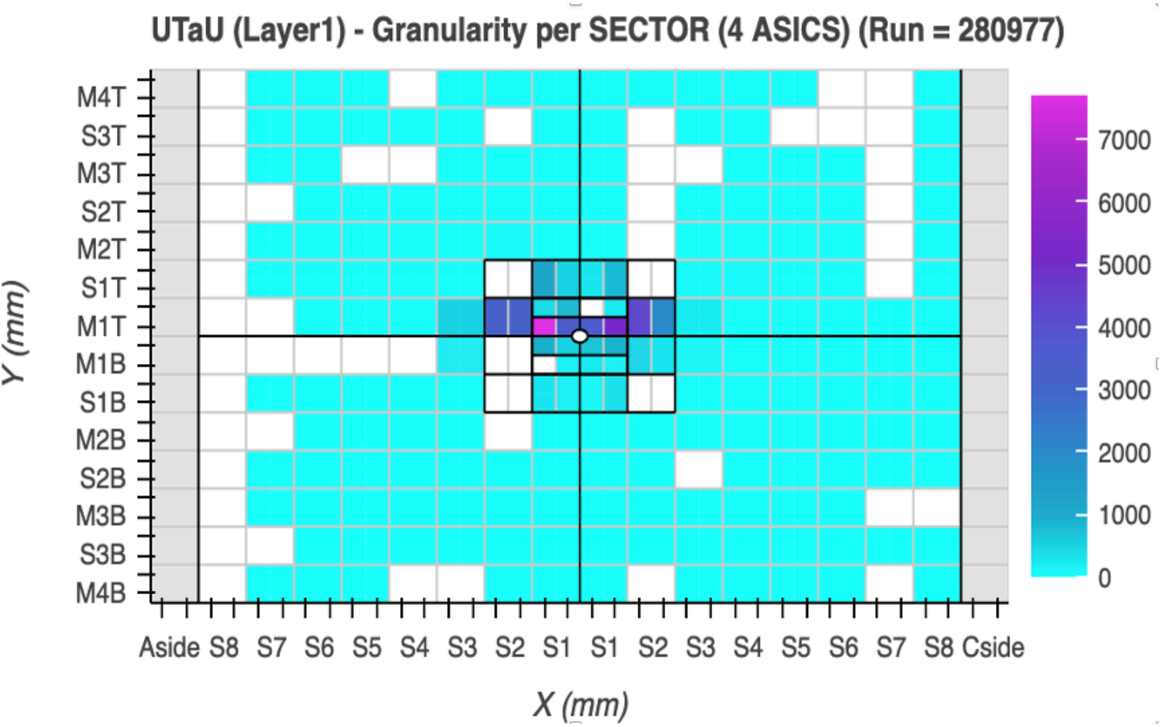


removal of the RF box

Replacement of the RF

- **2023 operation:**
  - **>99.6% of the links active.**
  - DAQ inefficiencies down to 0.14% at the end of the run.
  - **Dedicated firmware** to handle large events present in PbPb.
- **Ongoing work during YETS:**
  - Replacement of the boxes deformed in the vacuum incident in January.
    - ~16-17 weeks work program.

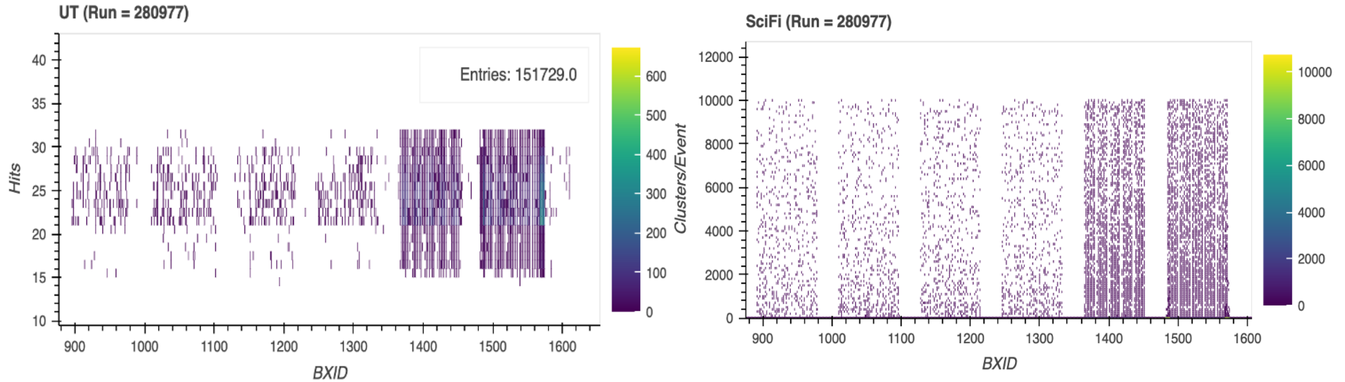
Upstream Tracker (UT)



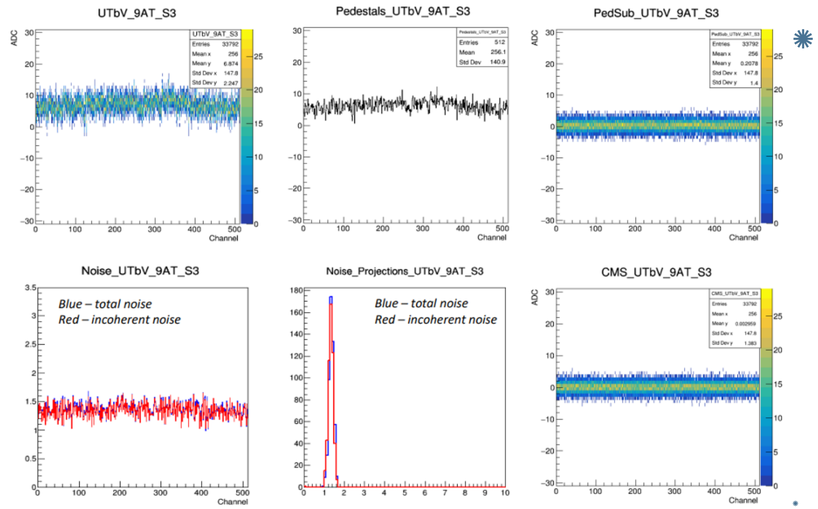
First data collected in the Global LHCb data-taking during the Ions run

- Commissioning delayed by link issues → **partially solved.**
- **Ongoing work during YETS:**
  - Install new Beam pipe collar and new approach mechanism for detector boxes.
  - Find the optimum working point of the detector.
  - Exercise the system in ZS as a first step towards efficient data taking.
  - Continue work on firmware and data processing algorithms.

Promising first steps in coarse time alignment



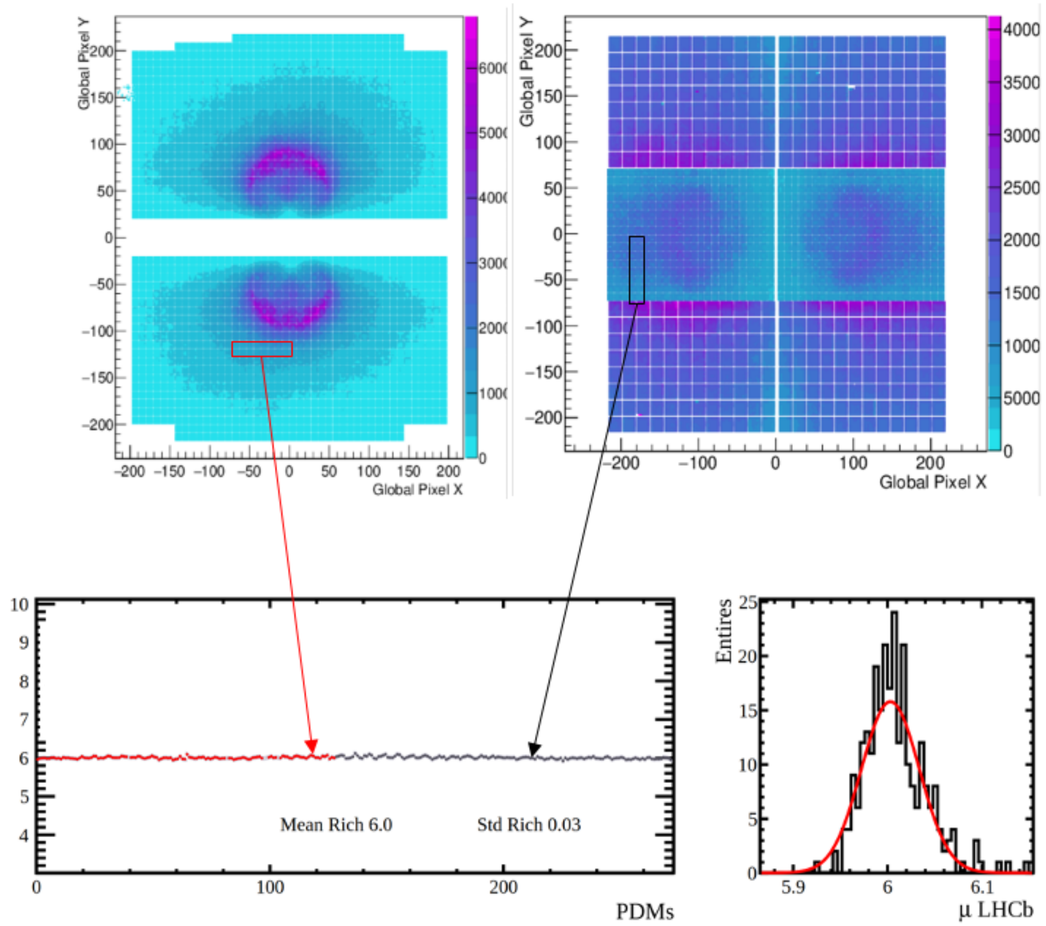
Pedestal and noise calibration



- Preliminary results:
  - uniform incoherent noise in the detector
  - observed the variation of pedestals across the layer
  - noise check after pedestal subtraction
  - agreement with the early performance studies

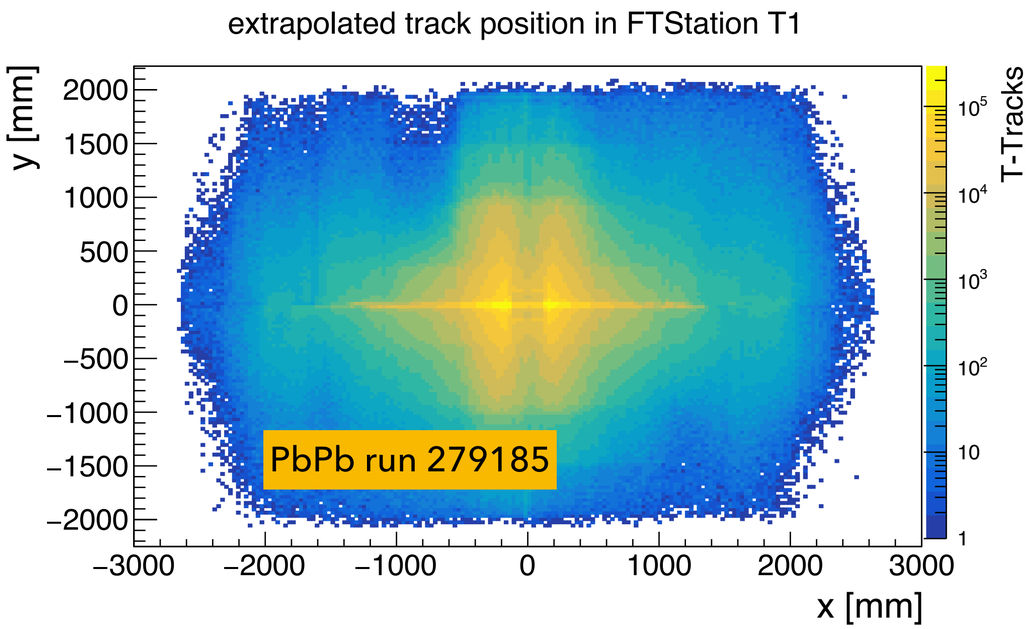
RICH

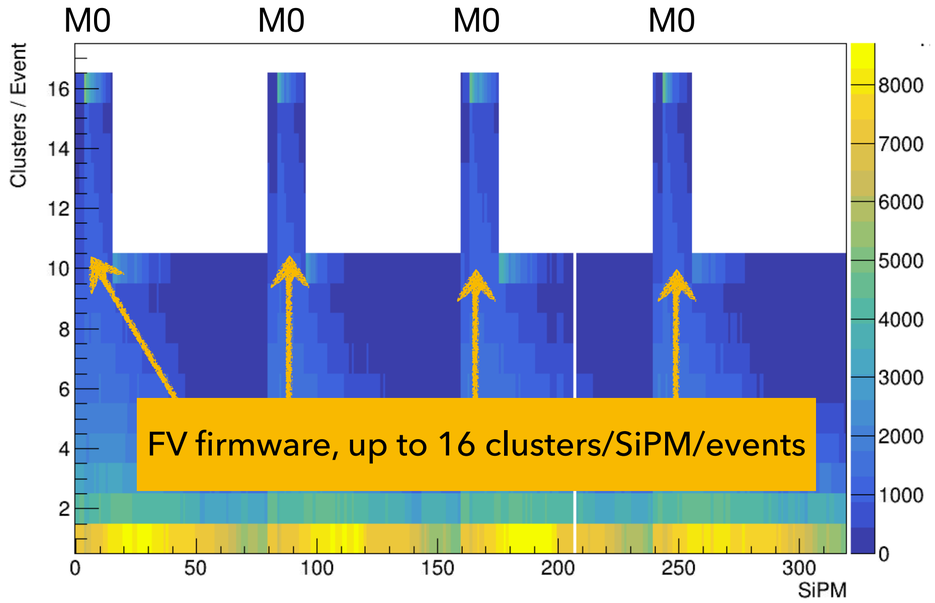
- **Activity report:**
  - Effort dedicated to the calibration and fine tuning of the operational points of the RICH detectors:
    - MaPMTs HV tuning to equalize the gain of over 200k channels.
    - In depth study of the background.
    - In depth study of the Hadron ID.
    - RICHes prepared and tuned to extract the best possible performance from the PbPb Run.
  - Dedicated studies on pp Run to tune the estimate of the luminosity provided by the RICH system.
    - different counters under study.
  - Luminosity calibrated from Hits and estimated from VdM for each Photon Detector Module (PDM).
    - excellent consistency!



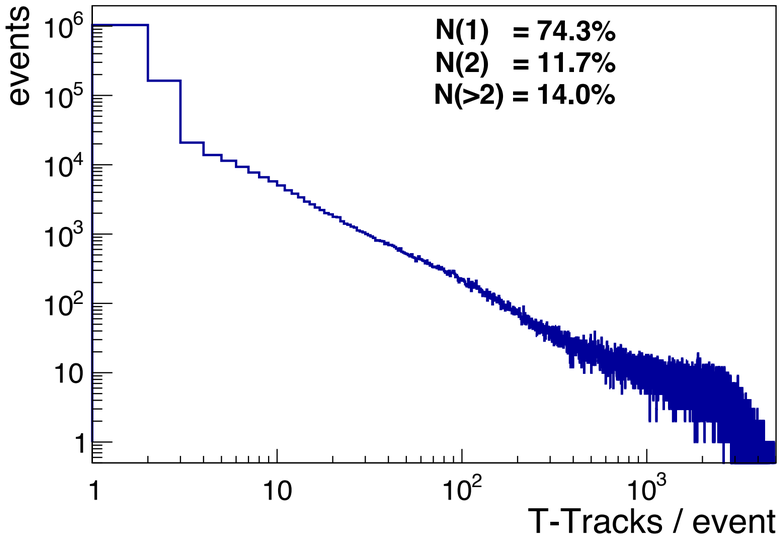
RICH Hadron Identification approaching design performance at nominal luminosity.

SciFi

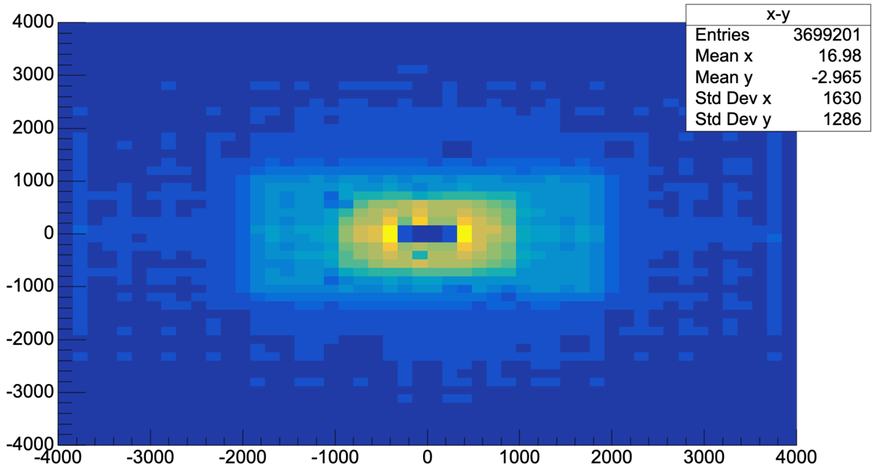




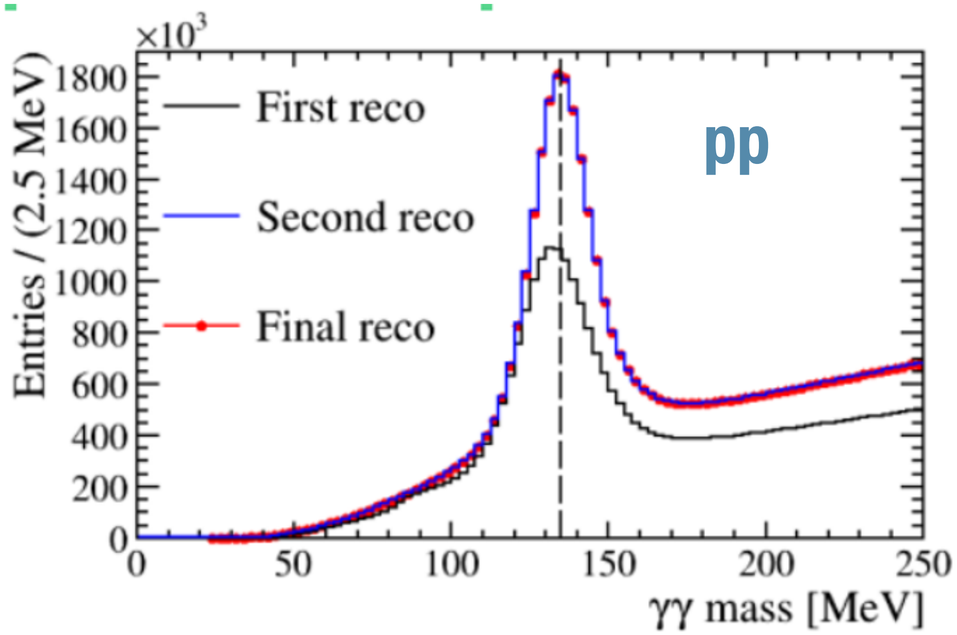
- **Activity reports:**
  - **Stable data-taking**
    - Mitigation measures against GBTx instabilities done.
  - **New flavor of firmware** (Fixed Variable - FV) deployed for high occupancy regions (M0 modules) allowing to record more clusters per SiPM per event thus reducing saturation effects.
- **Ongoing work during YETS:**
  - Problematic Front-Ends and optical fibers (1% detector channels) will be investigated and eventually replaced.
  - The detector is kept warm and the SiPMs are annealed.



Calorimeters



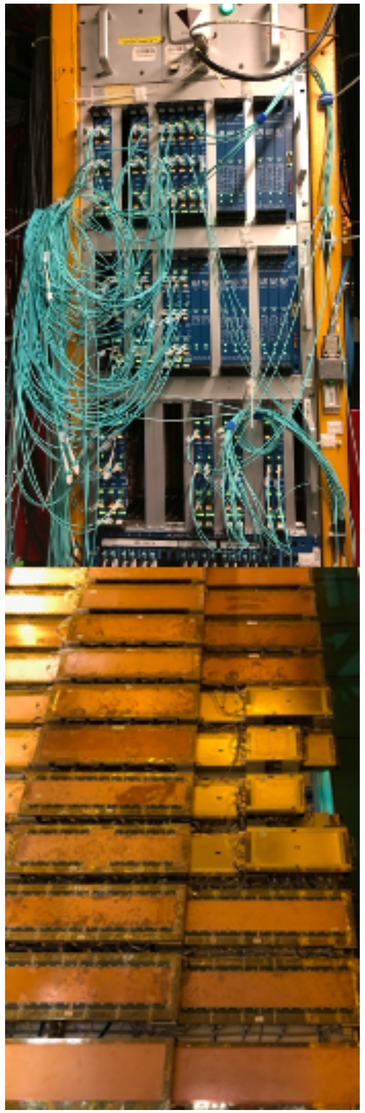
Monitoring PbPb (Run 281042)



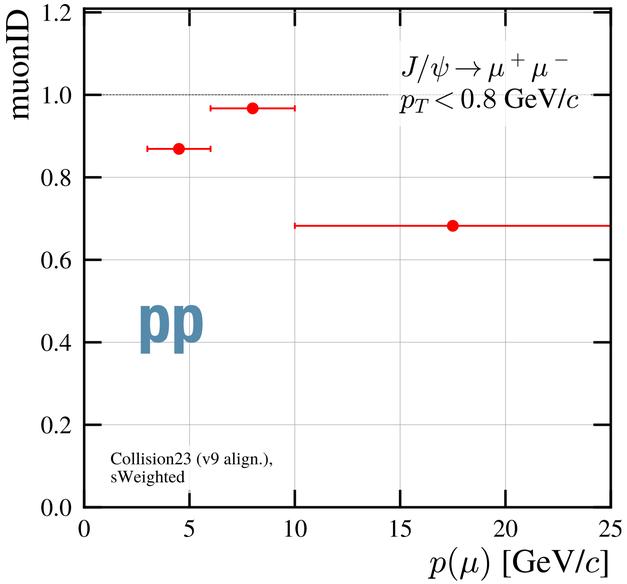
π⁰ reconstruction after an iterative procedure

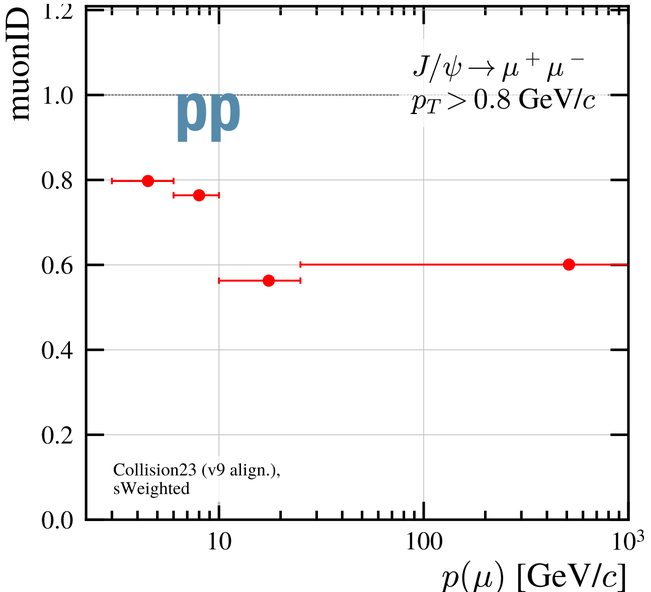
- **Activity report:**
  - **Improvement of the Ecal monitoring.**
  - **The DAQ is running smoothly.**
    - Occasional problems this year with a group of TELL40 solved on the flight with no dead-time.
  - **The calorimeter software has been thoroughly improved.**
    - Minor bugs have been fixed recently, work on-going to improve the reconstruction (cluster), pid, etc…
    - Commissioning of new simulations (DD4HEP) is ongoing.
- **Ongoing work during YETS:**
  - Very few channels are dead (PMT, CW base or FE channel broken) and should be cured
  - Mechanical issue (HCAL Cs Source calibration system) is being fixed.

MUON

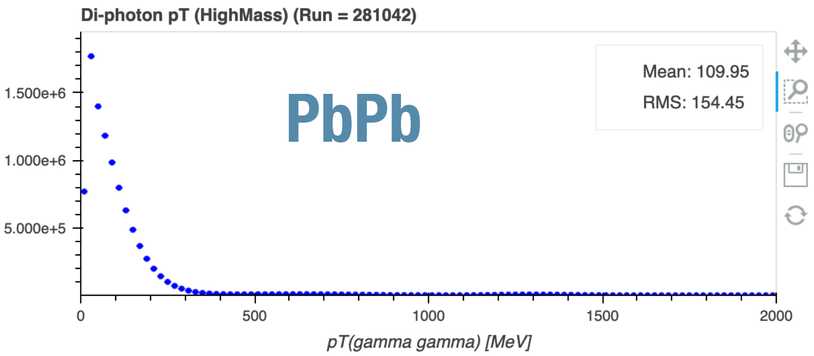


- **Activity report:**
  - Many mitigations decreased the rate of **de-synchronization of data links** to~2/h (during Ion run)
  - DD4HEP description **almost completed**
    - Final consistency tests are ongoing
  - **Brand new online monitoring** fully commissioned
    - Started to work on MWPC efficiency monitoring
  - First systematic study of ID and misID performance from pp.
- MuonID performance below the usual 98.5% per muon track
  - Current ~96% hit efficiency (residual detector time mis-alignment) explains the 60-80% MuonID efficiency.
  - Time mis-alignment understood.
    - Clear plans on how to optimize it at beginning of 2024 data taking.
- **Ongoing work during YETS:**
  - replacement of a few MWPCs and FEB (ongoing)
  - final refurbishment and test of Muon nacelles

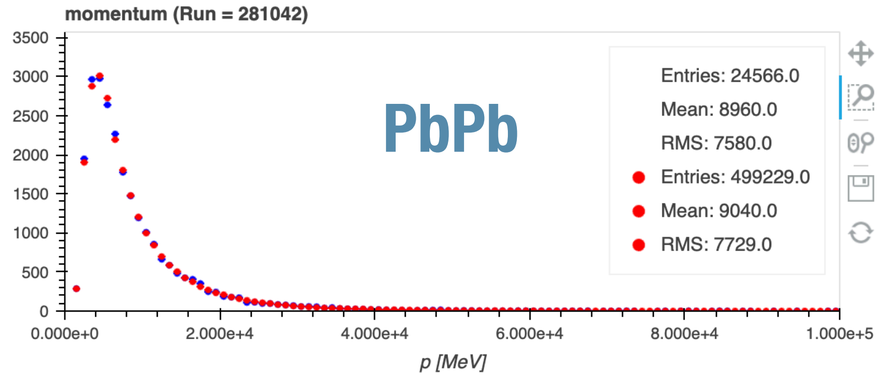




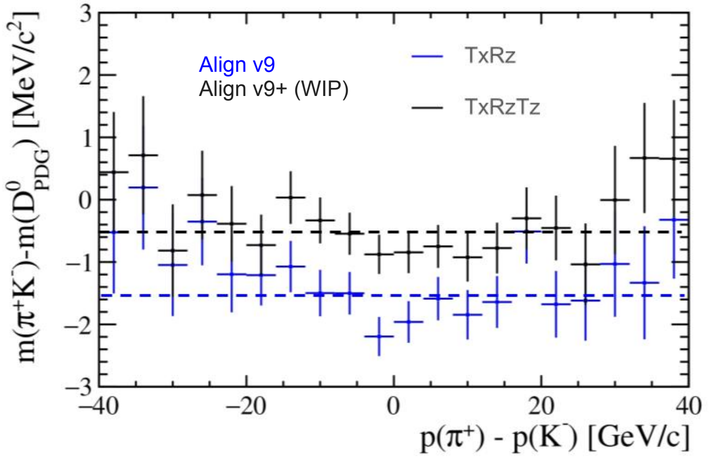
Real Time Analysis (RTA)



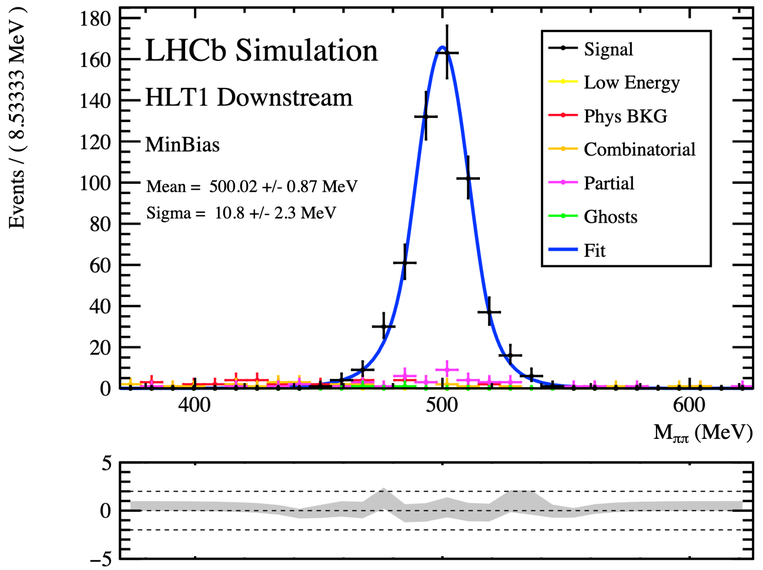
HLT1 di-photon line



LongTrack



- **Activity report:**
  - Huge amount of work to adapt monitoring to ion operations.
  - Detailed studies of the alignment for pp data ongoing.
- **Preparations for 2024:**
  - Downstream tracking is working in HLT1 on simulation, waiting for data commissioning.
  - Update of the bandwidth division for nominal pile-up conditions ongoing.

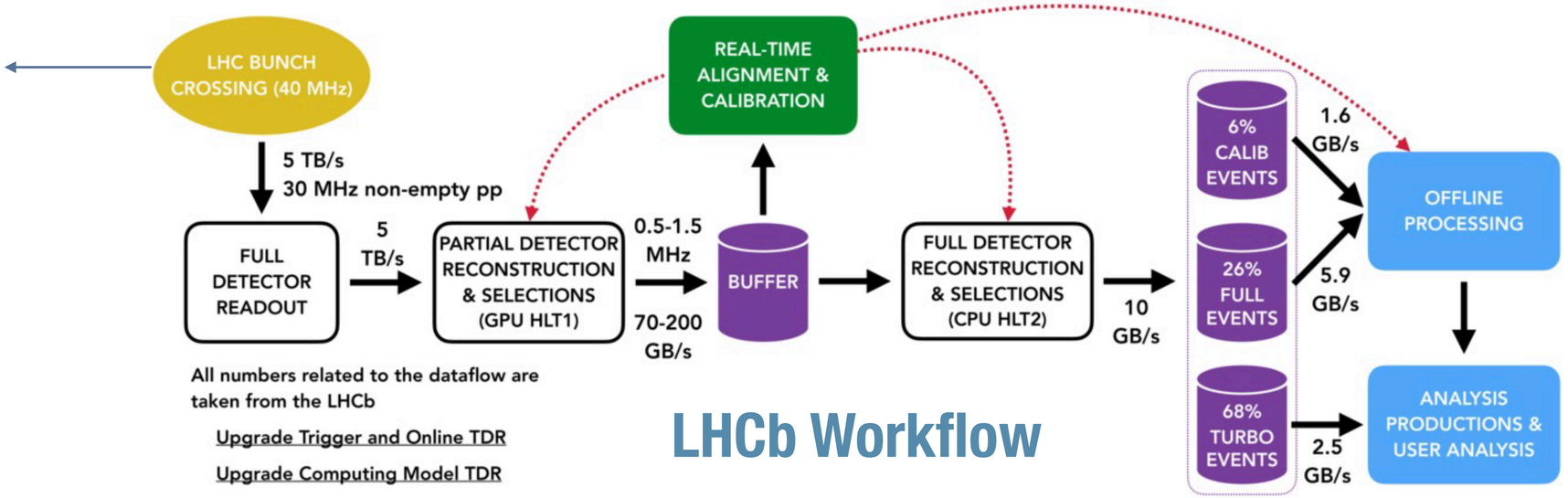


Offline computing

- The NCBJ (Swierk, PL) and IHEP (Beijing, CN) Tier2 sites are making progress to become Tier1 sites for LHCb
  - requirements in terms of network, storage (most notably: tape), services, service level agreement
- NCBJ: network OK, computing hardware and configuration ready
  - Tape software has been upgraded in September, data challenge has been performed successfully
- IHEP: computing HW and SW OK, network ~OK
  - 100Gps available in shared mode, functional tests OK, data challenge imminent
- Two new Tier1 sites will help LHCb to alleviate the anticipated pressure on storage, most notably tape, for Run 3 data taking and beyond

ION OPERATION REPORT

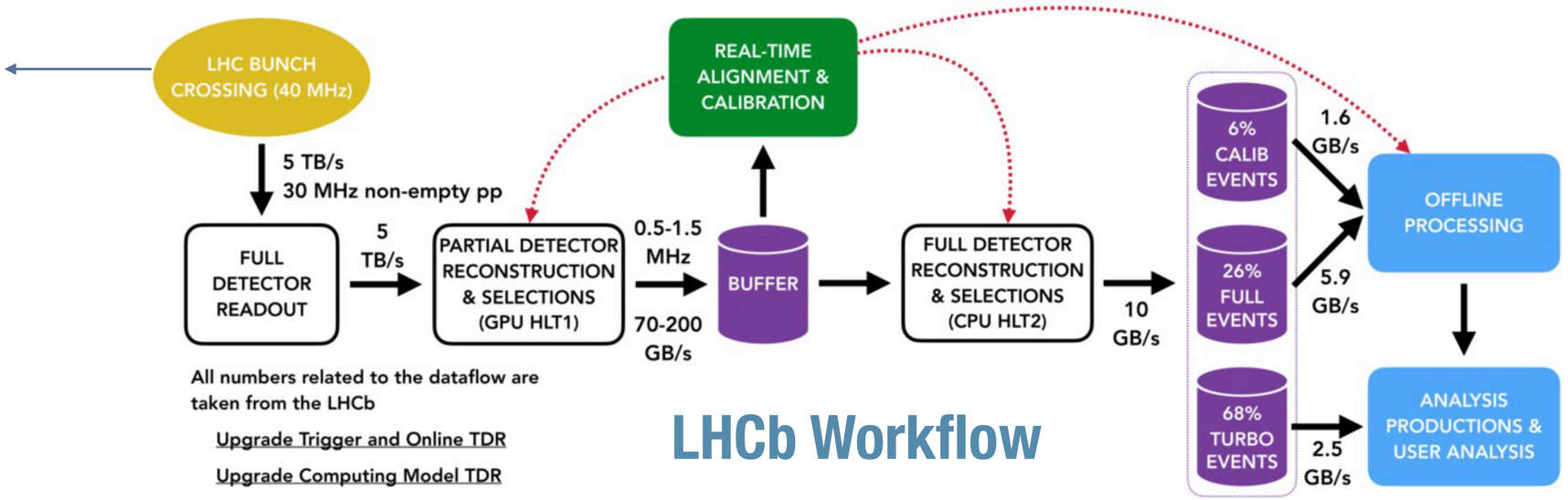
LHCb strategy for ion conditions



LHCb strategy for ion conditions

Ion data conditions

- Low hadronic interaction rate.
- Higher occupancy.
- SMOG injected all the time.



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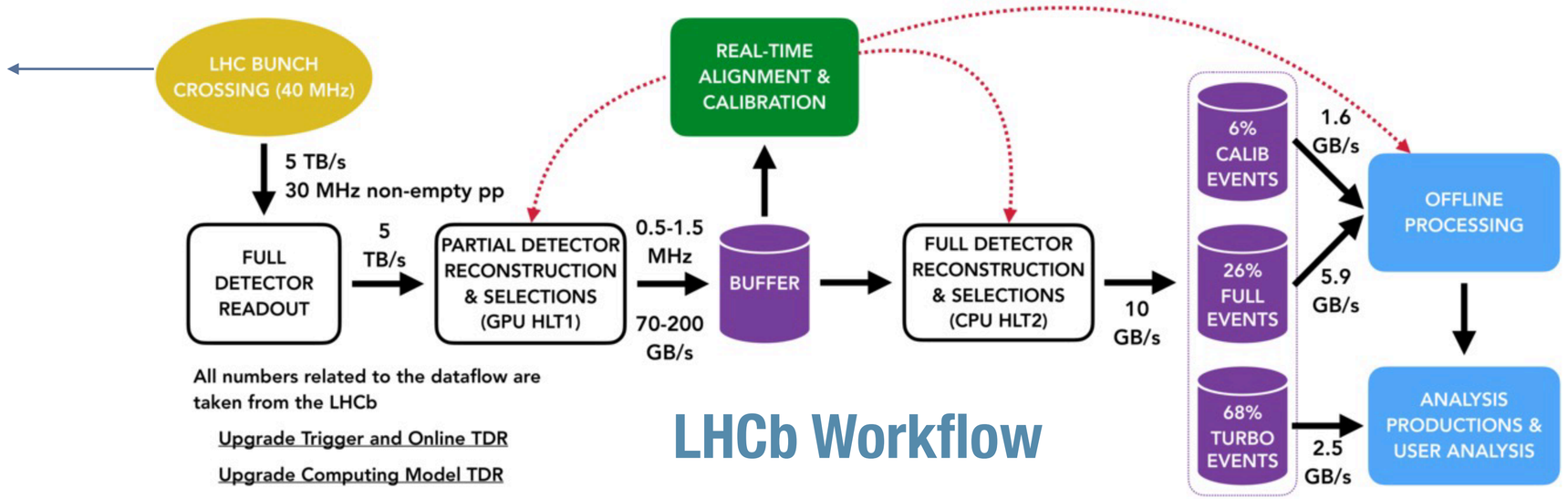
Minimal strategy

- Data are « tagged » with HLT1 trigger lines.
- High occupancy events are vetoed (Global Event Cut -GEC).
- HLT2 and Offline processing are « passthrough ».



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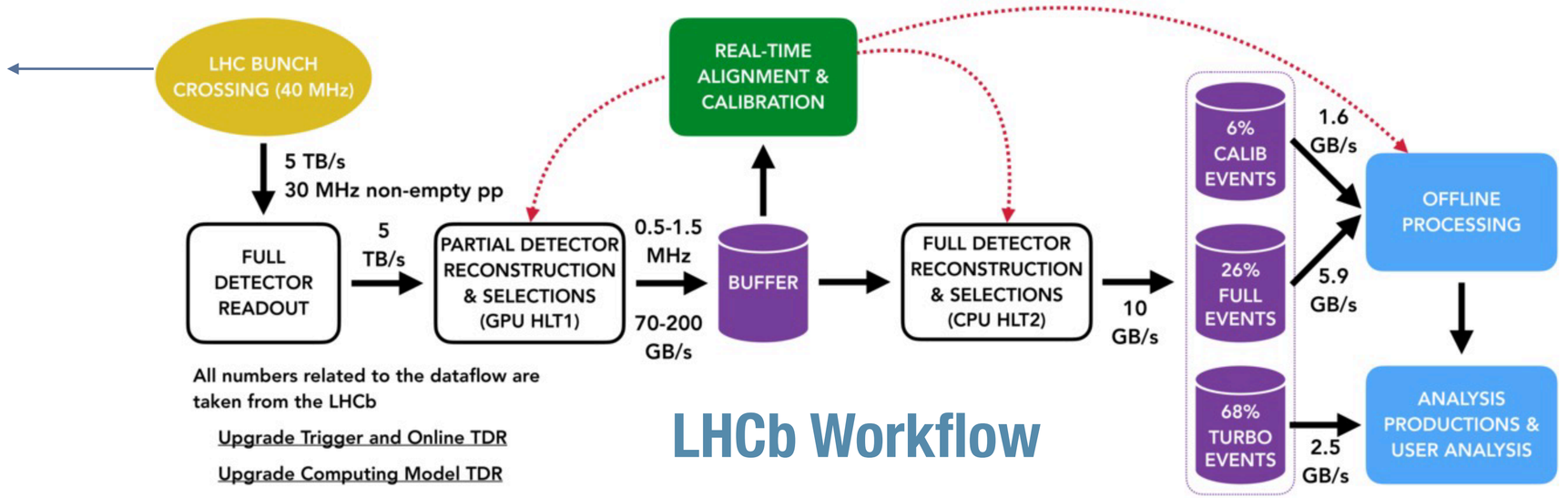


LHCb Workflow

HLT1 lines in a nutshell

Physics lines (GEC)

- Selection based on
  - Calorimeter energy.
  - Primary vertex position.

Calibration/Alignment lines (GEC)

- VELO, RICH, Muon calibration.
- Technical line
- SMOG monitoring.

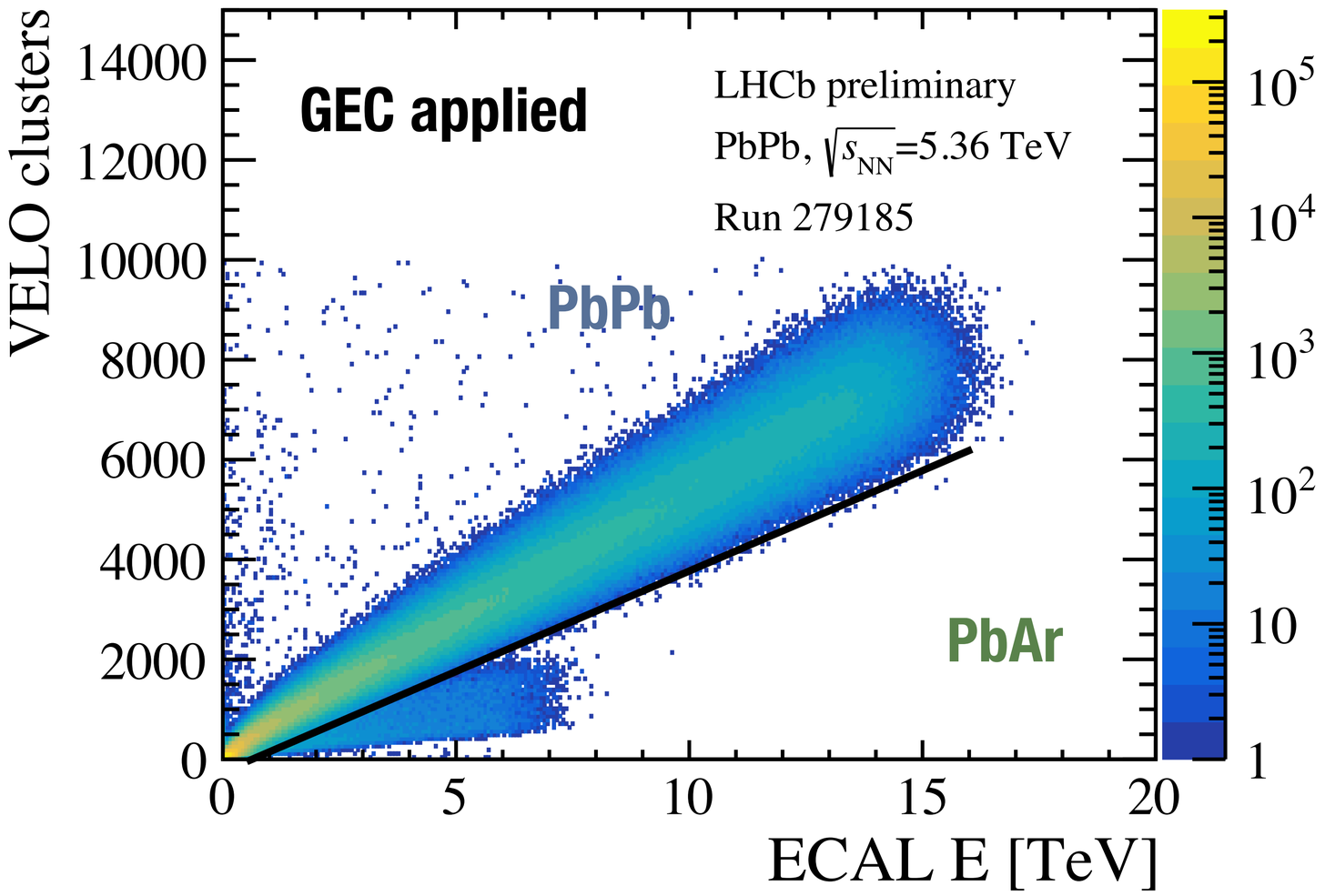
Monitoring lines

- Invariant mass histograms.
- Track and PV distributions.
- …

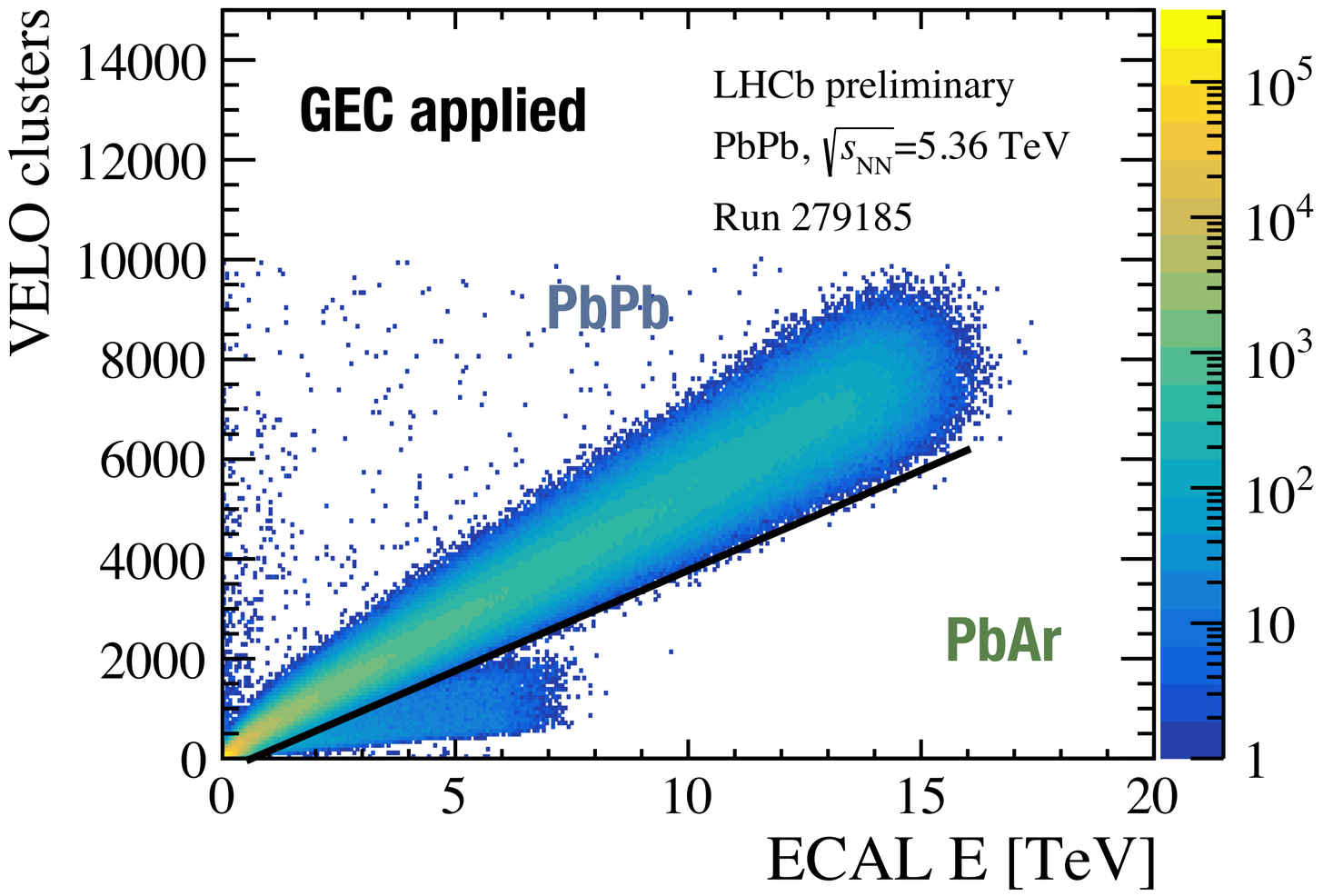
Luminosity lines

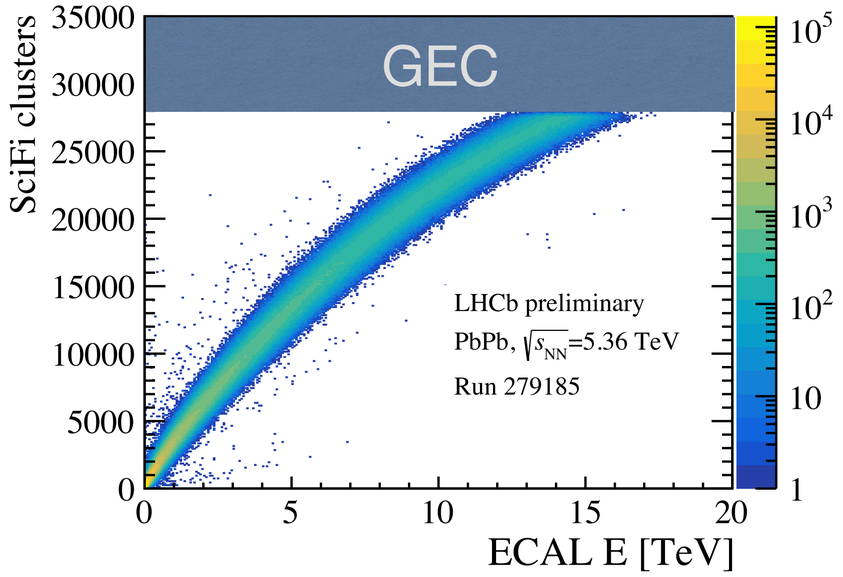
- All luminosity counters.
- Will be used for centrality studies.

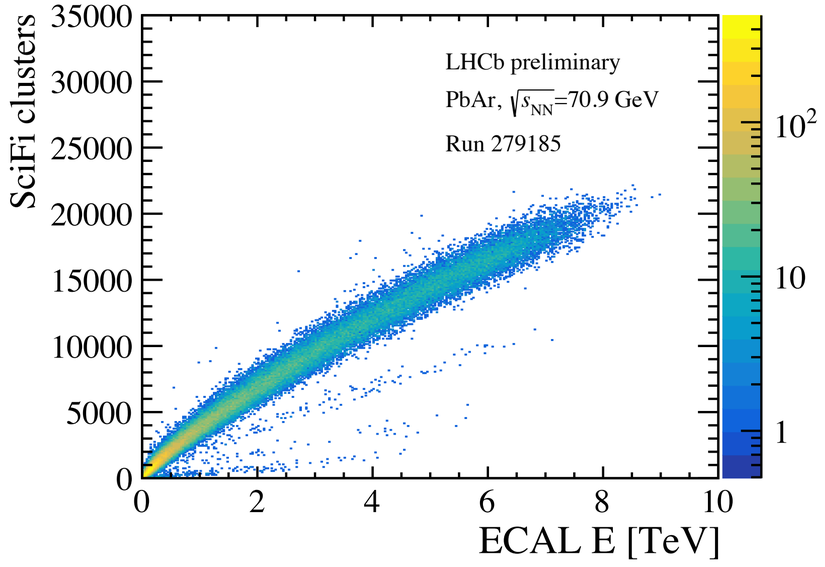
Preliminary results from HLT2



Preliminary results from HLT2







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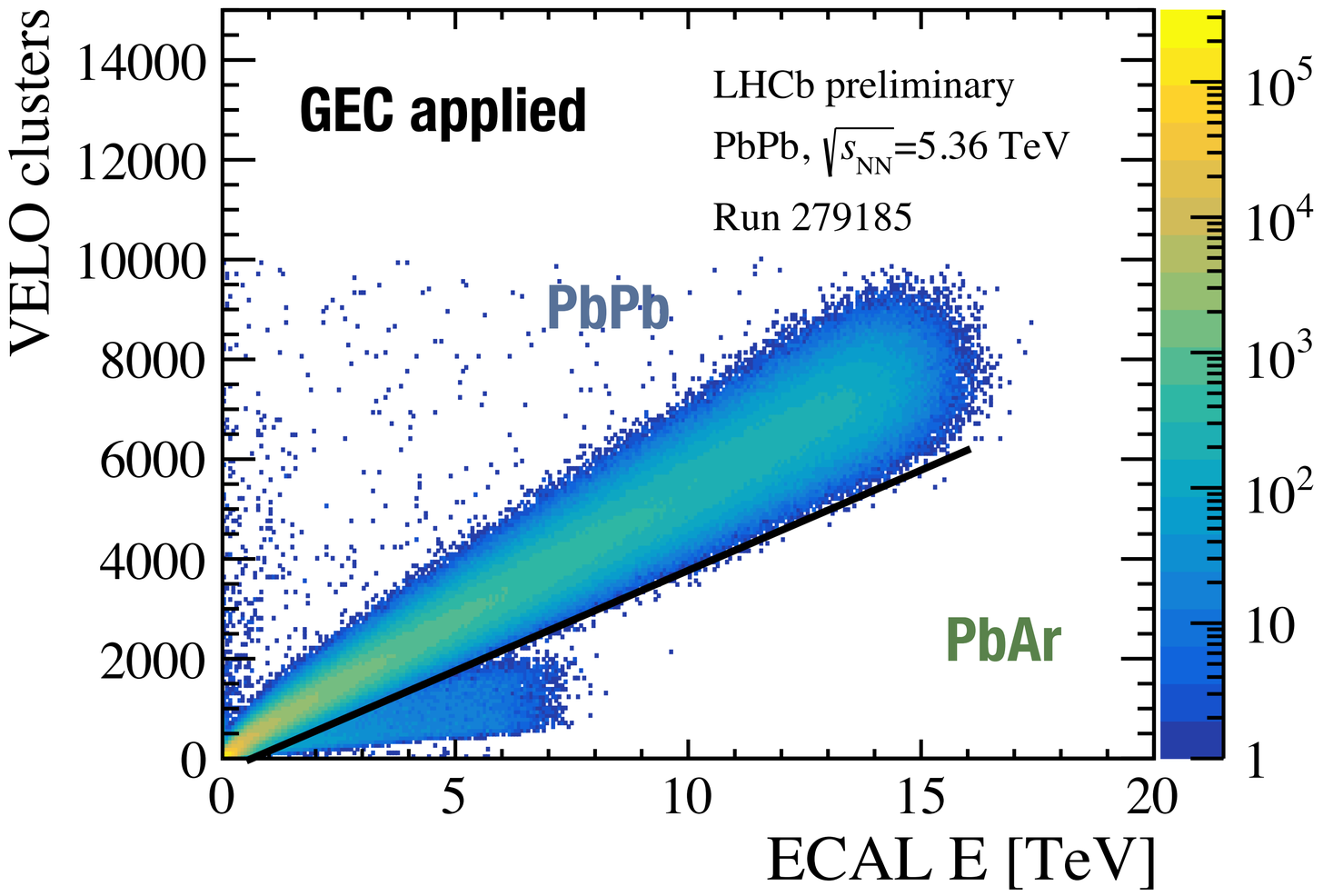

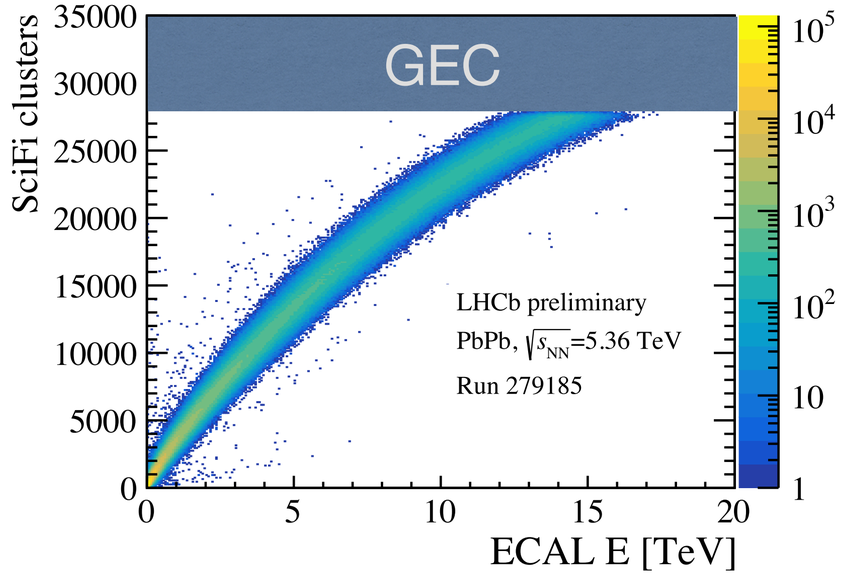

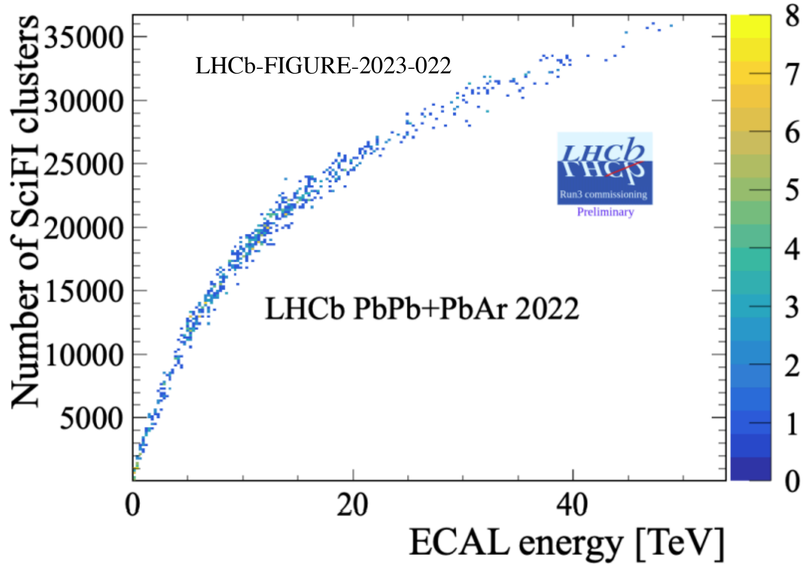

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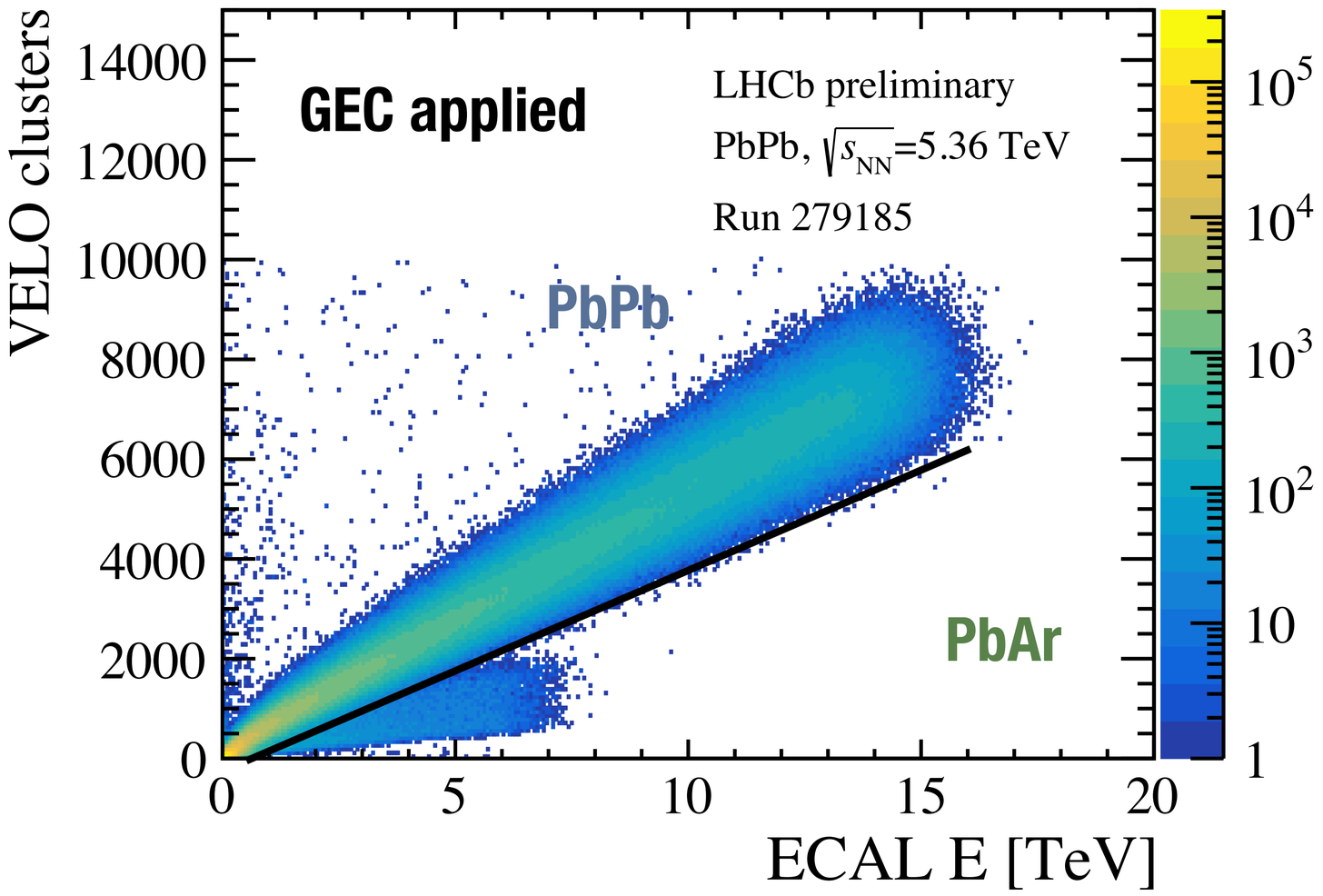
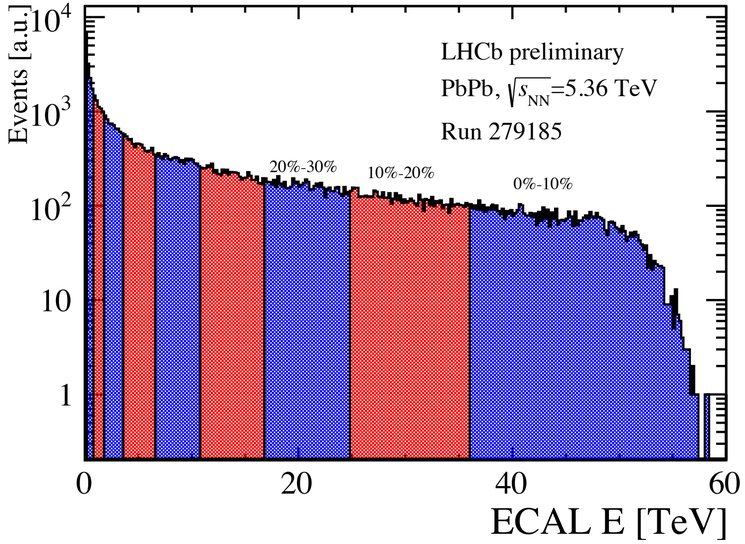
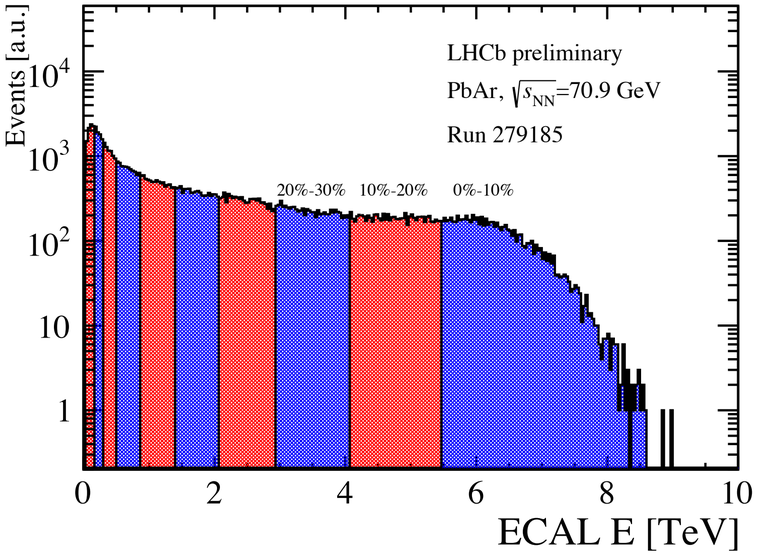
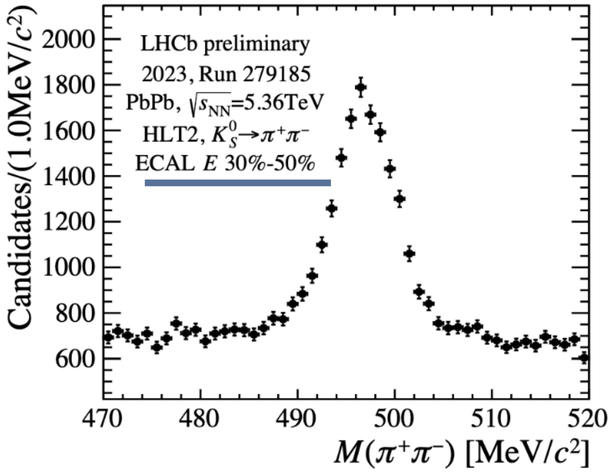


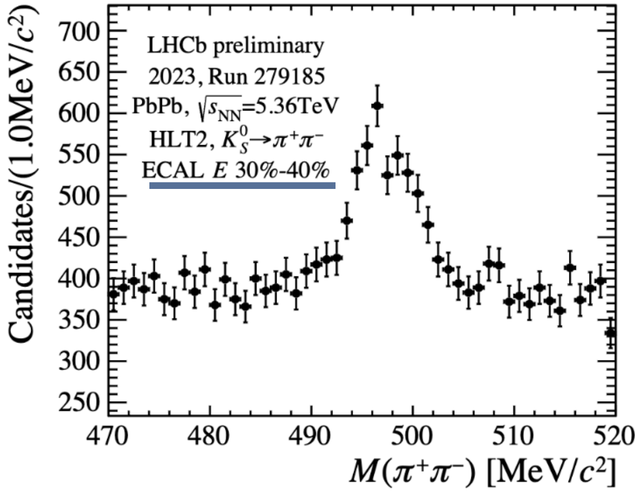


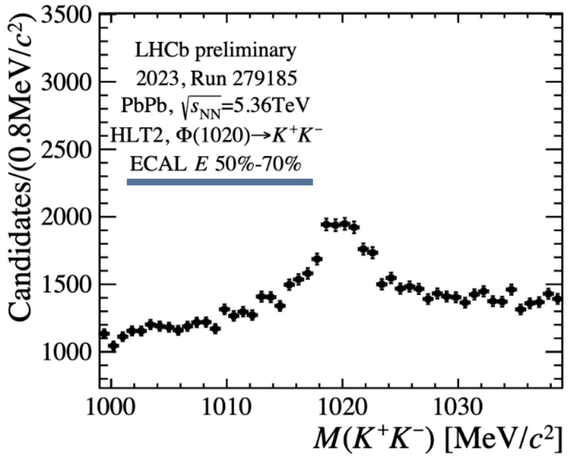


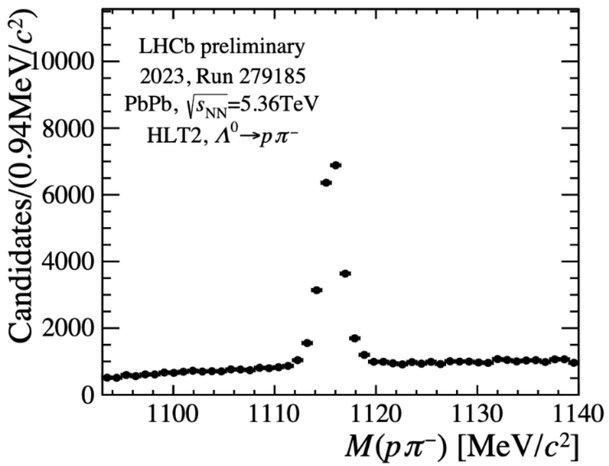
PbPb data reconstructed up to 30% centrality.

Preliminary results from HLT2

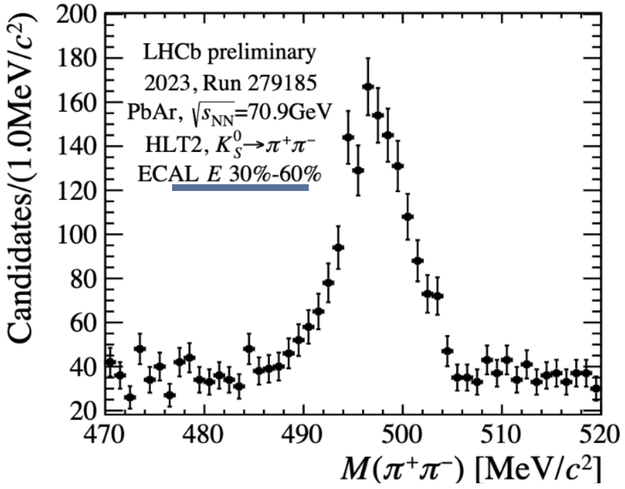


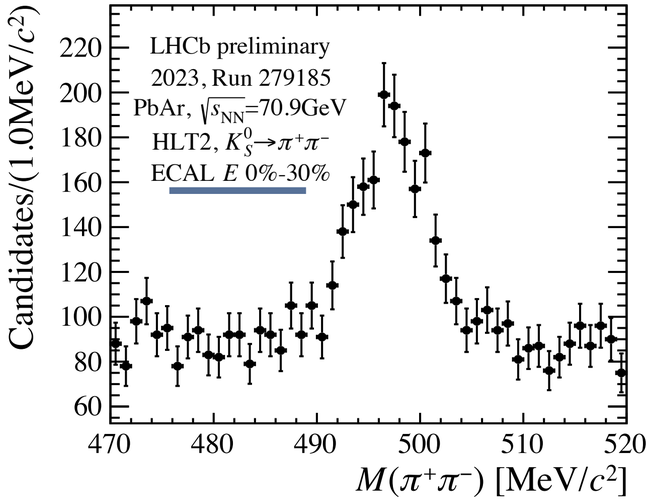


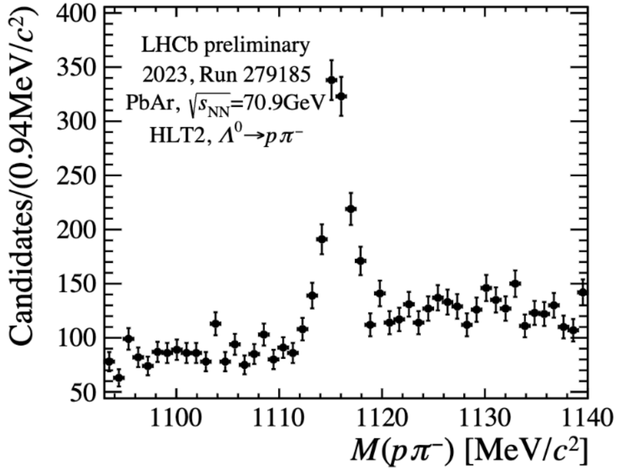




First PbPb data reconstructed down to 30% centrality by LHCb







PLOTS MADE WITH 40MIN OF DATA.

First PbAr data reconstructed down to full centrality by LHCb

PHYSICS REPORT

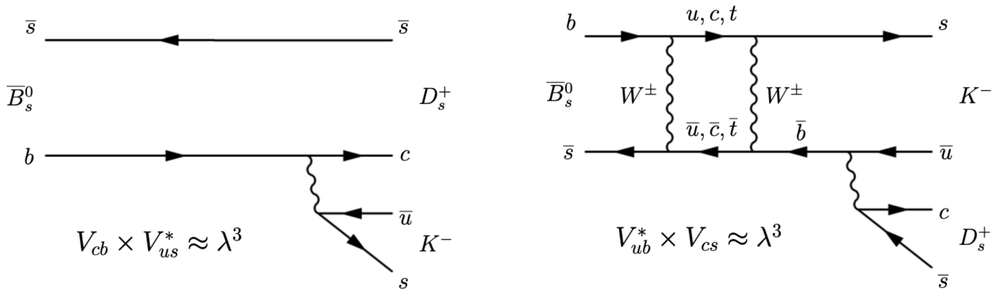
Since the last LHCC - September to November

Paper	Title
	Submitted since the September 2023 LHCC
PAPER-2023-009	Measurement of the CKM angle γ in the $B^0 \to D^0 K^{*0}$ channel using $D^0 \to K^0_S h^+ h^-$ decays
PAPER-2023-012	γ from $B \to D^* K$ BPGGSZ - MI
PAPER-2023-013	CP violation in $B \to \psi K_S$ decays
PAPER-2023-017	Observation of $\Xi_b \to \Xi_c D_s$
PAPER-2023-019	Search for CPV in $D^0 \to K_S K\pi$ Energy Test
PAPER-2023-020	D^* polarisation measurement in $B^0 \to D^* \tau\nu$
PAPER-2023-021	Observation of strangeness enhancement with charm mesons in high-mult. pPb collisions at 8.16 TeV
PAPER-2023-022	Measurement of double charmonium production cross-sections in pp collisions at $\sqrt{s} = 13$ TeV
PAPER-2023-023	Measurement of J/ψ-$\psi(2S)$ production cross-section in pp collisions at $\sqrt{s} = 13$ TeV
PAPER-2023-025	A measurement of $\Delta\Gamma_s$
PAPER-2023-027	Λ_b Production in high multiplicity
PAPER-2023-028	Fraction of χ_c decays in prompt J/ψ measured in pPb and Pbp collisions 8.16 TeV
PAPER-2023-029	Measurement of gamma in $B \to D^* h$, $D \to K_S hh$ using partial reconstruction method
PAPER-2023-030	Studies of η and η' production in pp and pPb collisions
PAPER-2023-031	Long range charged hadron correlations in PbPb at 5 TeV
DP-2023-001	Charge-dependent curvature-bias corrections using a pseudomass method
DP-2023-002	Helium identification
DP-2023-003	Momentum scale calibration of the LHCb spectrometer
CONF-2023-003	Measurement of CP violation in $B^0 \to DK^*$ decays
CONF-2023-004	Measurement of CP asymmetry in $B_s \to D_s K$ decays
	Preliminary results since the September 2023 LHCC
PAPER-2023-032/033	Amplitude analysis of the $B \to K^* \mu^+ \mu^-$ decay
PAPER-2023-034	Measurement of the relative BF of $\Lambda_b^0 \to \Lambda_c^+ D^{(*)0} K^-$ and $\Lambda_b^0 \to \Lambda_c^+ D_s^{*-}$ decays
PAPER-2023-035	Multiplicity Dependence of $\sigma_{\psi(2S)}/\sigma_{J/\psi}$ in pp collision at $\sqrt{s} = 13$ TeV
PAPER-2023-036	Amplitude analysis of the the $\Lambda_b \to pK\gamma$ decay
PAPER-2023-037	Search for $B_c^+ \to \pi\mu\mu$
PAPER-2023-039	Study of the $B_c \to \chi_c \pi$ decays

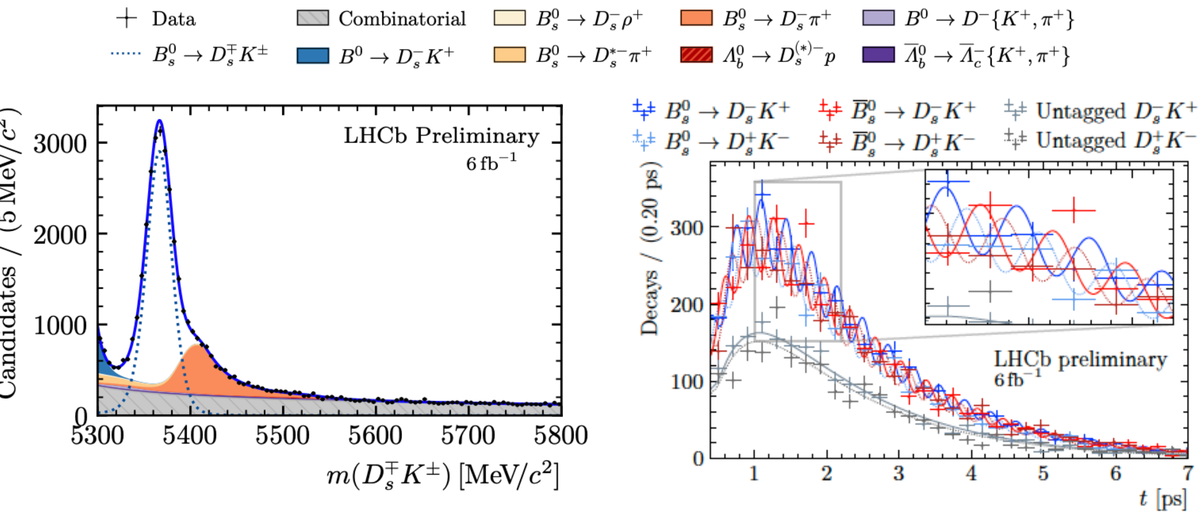
LHCb has submitted 700 papers to arXiv, of which 677 are published

$B_s^0 \to D_s^{\mp} K^{\pm}$ analysis in pp@13TeV

LHCb-CONF-2023-004



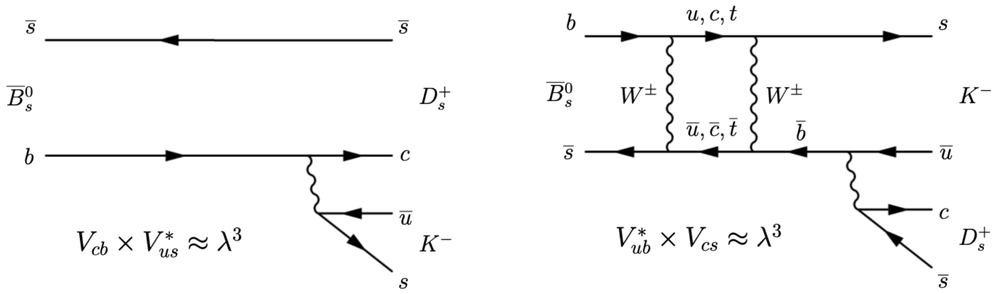
- Time-dependent analysis.



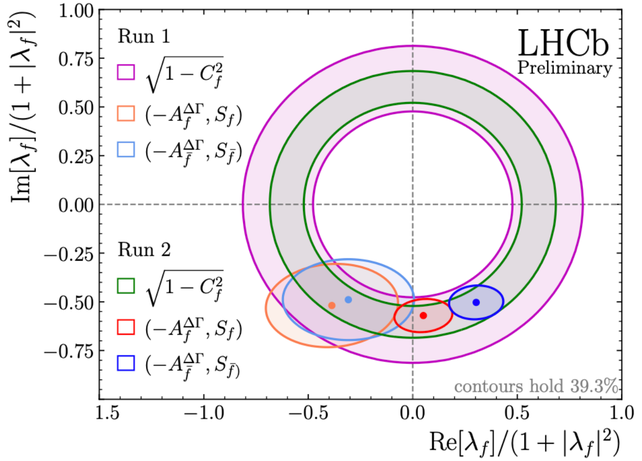
- Analysis updated with Run 2 data.

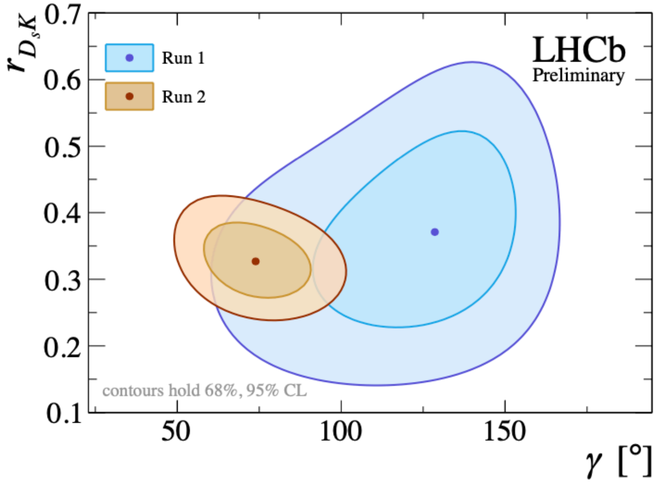
$B_s^0 \to D_s^{\mp} K^{\pm}$ analysis in pp@13TeV

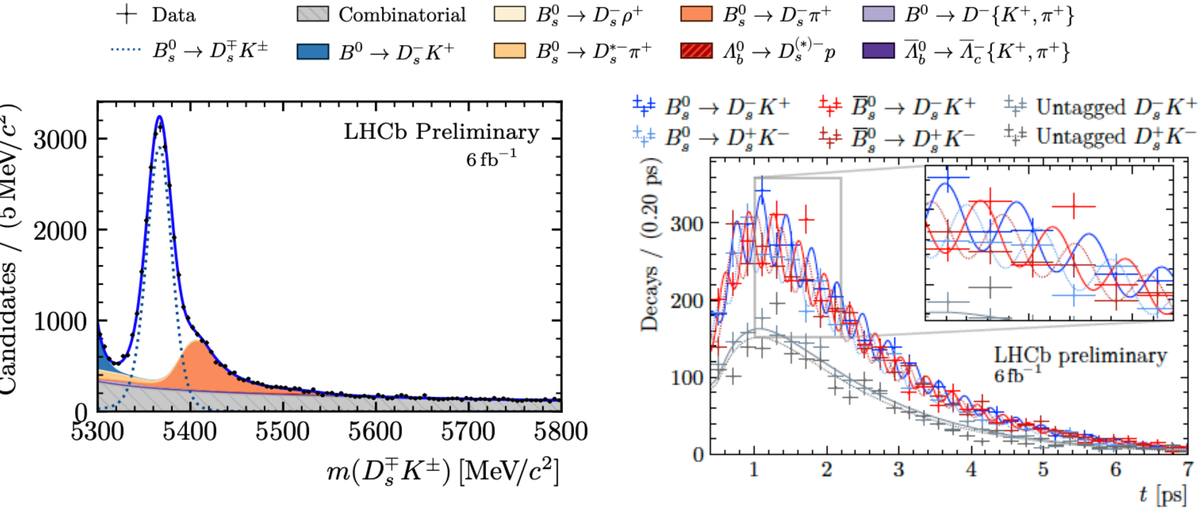
LHCb-CONF-2023-004

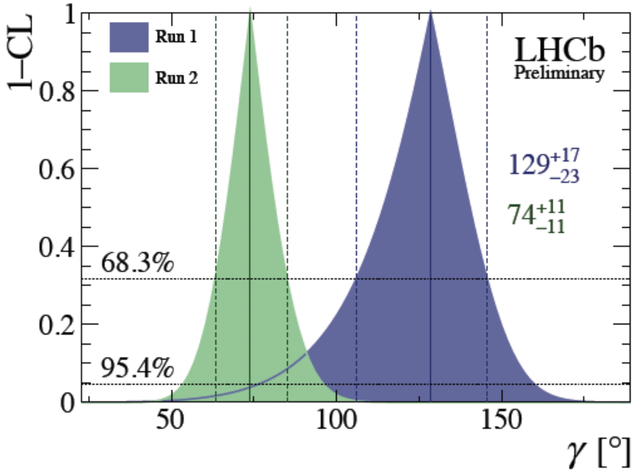


- Time-dependent analysis.









$$
\begin{aligned}
C_f &= 0.791 \pm 0.061 \pm 0.015\,, \\
A_f^{\Delta\Gamma} &= -0.051 \pm 0.134 \pm 0.037\,, \\
A_{\bar{f}}^{\Delta\Gamma} &= -0.303 \pm 0.125 \pm 0.037\,, \\
S_f &= -0.571 \pm 0.084 \pm 0.017\,, \\
S_{\bar{f}} &= -0.503 \pm 0.084 \pm 0.022
\end{aligned}
$$

$$
\begin{aligned}
\gamma &= (74 \pm 11)^\circ\,, \\
\delta &= (346.9 \pm 6.6)^\circ\,, \\
r_{D_sK} &= 0.327 \pm 0.038\,,
\end{aligned}
$$

- Analysis updated with Run 2 data.

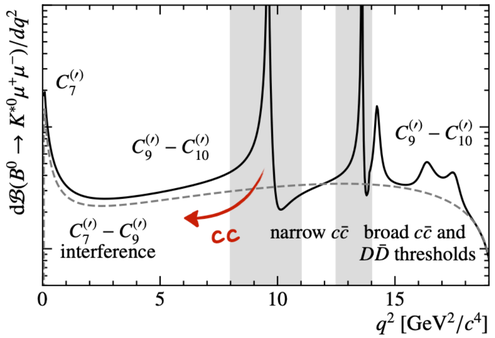
$B^0 \to K^{*0}\mu^+\mu^-$ amplitude analysis

LHCb-PAPER-2023-032/033

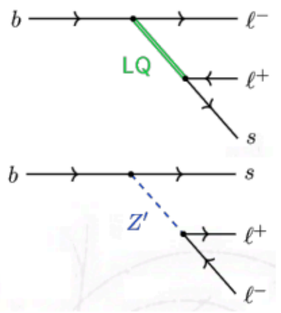
LHC SEMINAR

$$\mathcal{A}_\lambda^{L,R} = \mathcal{N}\left\{\left[(\mathcal{C}_9 \pm \mathcal{C}_9') \mp (\mathcal{C}_{10} \pm \mathcal{C}_{10}')\right]\mathcal{F}_\lambda(q^2,k^2) + \frac{2m_b M_B}{q^2}\left[(\mathcal{C}_7 \pm \mathcal{C}_7')\mathcal{F}_\lambda^T(q^2,k^2) - 16\pi^2\frac{M_B}{m_b}\mathcal{H}_\lambda(q^2,k^2)\right]\right\}$$

- Wilson coefficient
- Form factor
- Non-local hadronic matrix elements ("charm loop")
  - ➡ Novelty: different encoding of H as an expanded polynomial)



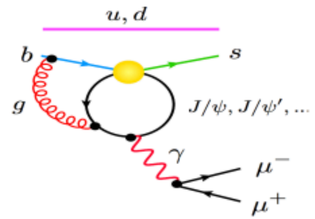
New Physics



can affect both C_9 and C_{10}

or

"charm loop"

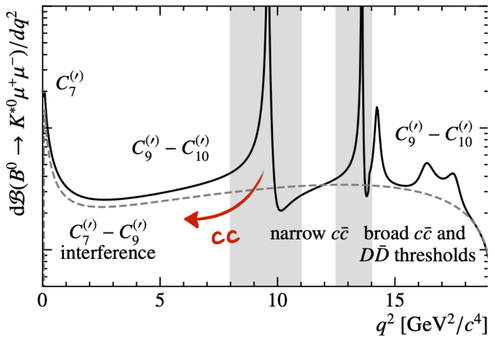


pollutes only C_9 (vector structure)

$B^0 \to K^{*0}\mu^+\mu^-$ amplitude analysis

$$\mathcal{A}_\lambda^{L,R} = \mathcal{N}\left\{\left[(\mathcal{C}_9 \pm \mathcal{C}_9') \mp (\mathcal{C}_{10} \pm \mathcal{C}_{10}')\right]\mathcal{F}_\lambda(q^2,k^2) + \frac{2m_b M_B}{q^2}\left[(\mathcal{C}_7 \pm \mathcal{C}_7')\mathcal{F}_\lambda^T(q^2,k^2) - 16\pi^2\frac{M_B}{m_b}\mathcal{H}_\lambda(q^2,k^2)\right]\right\}$$

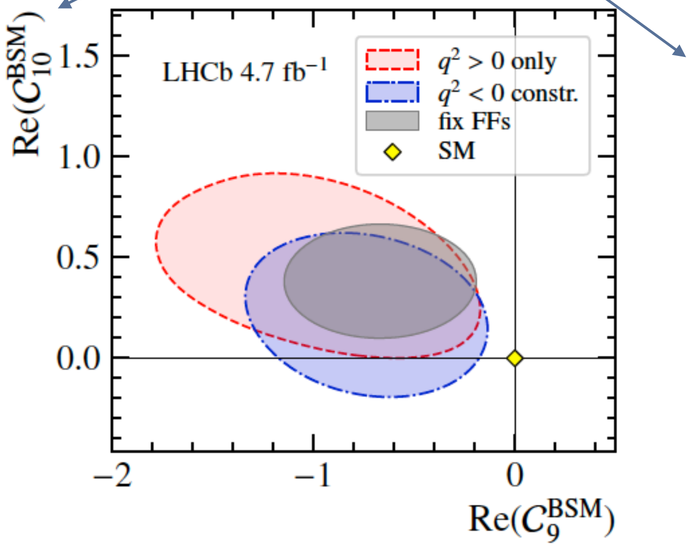
- Wilson coefficient
- Form factor
- Non-local hadronic matrix elements ("charm loop")
  - ➡ Novelty: different encoding of H as an expanded polynomial)

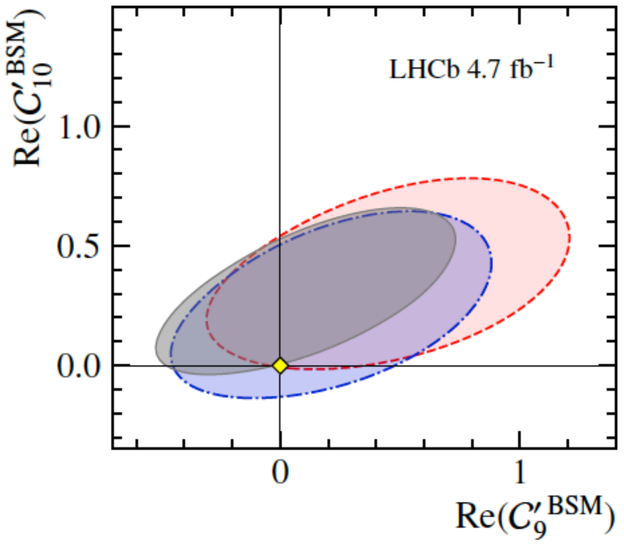


LHCb-PAPER-2023-032/033

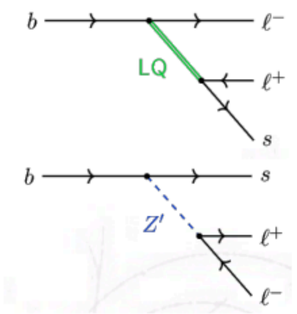
LHC SEMINAR

Axial-vector coupling





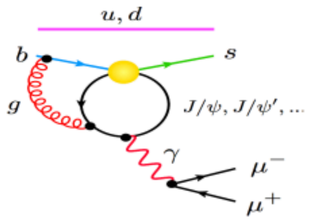
New Physics



can affect both C_9 and C_{10}

or

"charm loop"

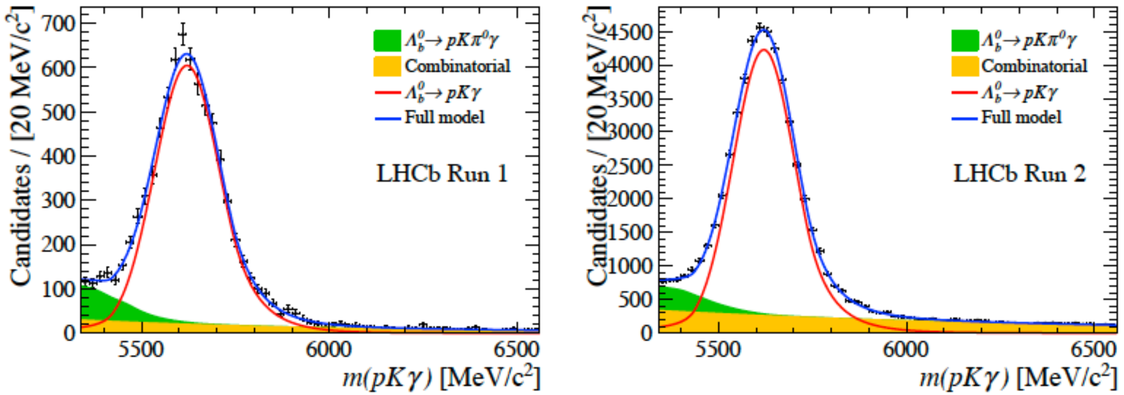


pollutes only C_9 (vector structure)

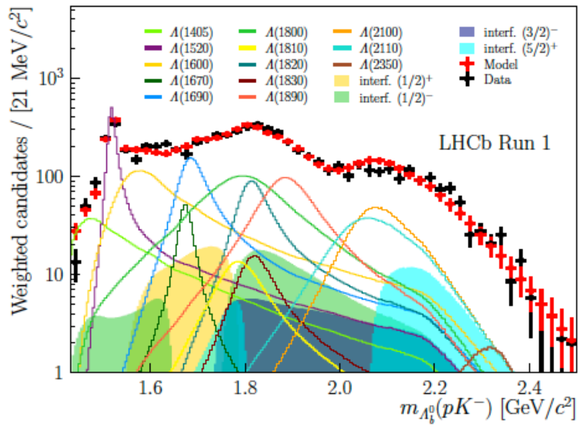
- **First unbinned analysis** using 2011 to 2016 data.
- **First direct measurement of these Wilson coefficients.**
- **Tension with SM up to 2σ** with this fit models.

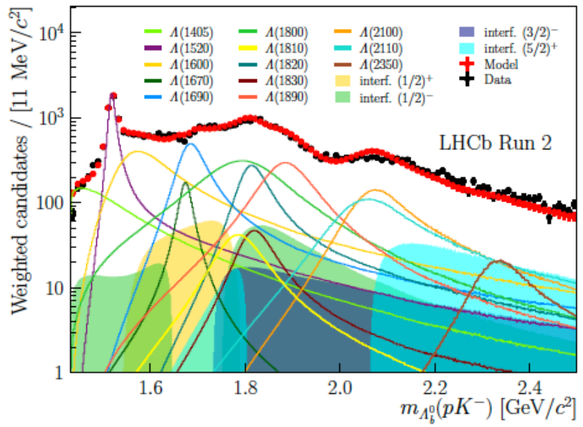
$\Lambda_b^0 \to pK\gamma$ amplitude analysis

Invariant mass fit



sWeigth



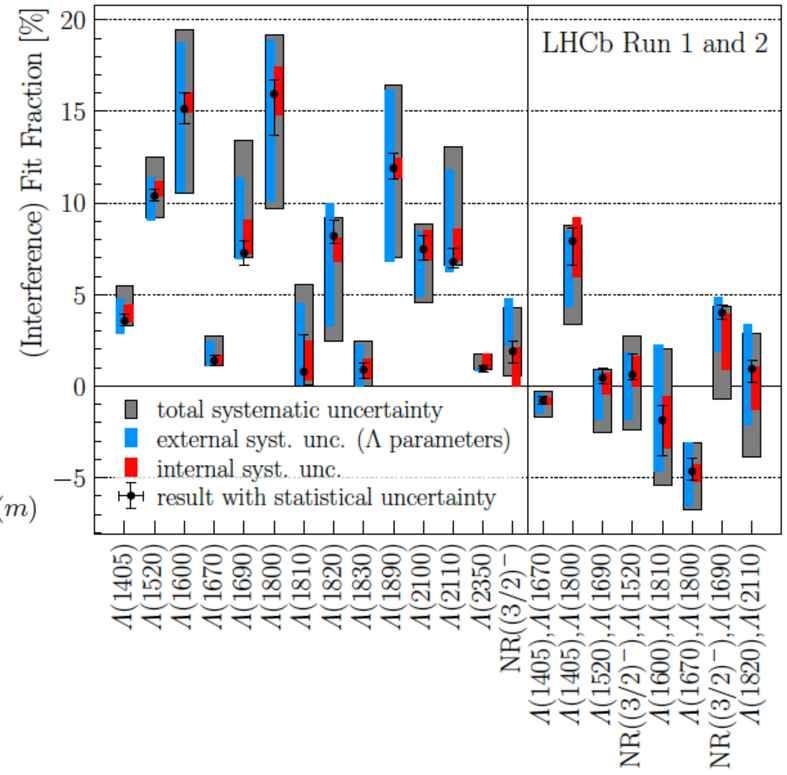


Amplitude fit

$$\mathrm{FF}(n) = \frac{\int_{\mathcal{D}} \left(\frac{\mathrm{d}\Gamma(n)}{\mathrm{d}\mathcal{D}}\right) \mathrm{d}\mathcal{D}}{\int_{\mathcal{D}} \left(\frac{\mathrm{d}\Gamma}{\mathrm{d}\mathcal{D}}\right) \mathrm{d}\mathcal{D}}$$

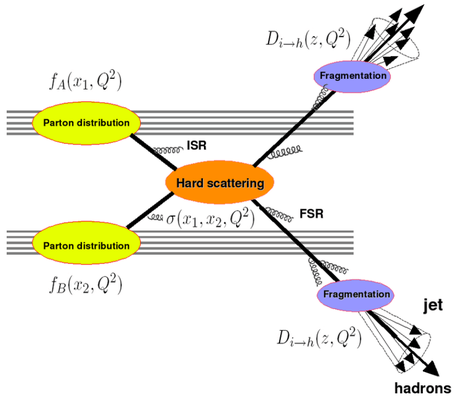
$$\mathrm{IFF}(n,m) = \frac{\int_{\mathcal{D}} \left(\frac{\mathrm{d}\Gamma(n,m)}{\mathrm{d}\mathcal{D}}\right) \mathrm{d}\mathcal{D}}{\int_{\mathcal{D}} \left(\frac{\mathrm{d}\Gamma}{\mathrm{d}\mathcal{D}}\right) \mathrm{d}\mathcal{D}} - \mathrm{FF}(n) - \mathrm{FF}(m)$$

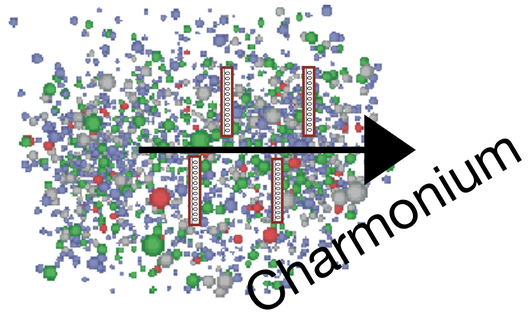
LHCb-PAPER-2023-036



- Systematic uncertainties dominated by external inputs.
  - Width, mass of the intermediate Λ states.
- Most precise pK spectrum analysis !

$\psi(2s)/J/\psi$ production versus multiplicity in pp@13TeV collisions



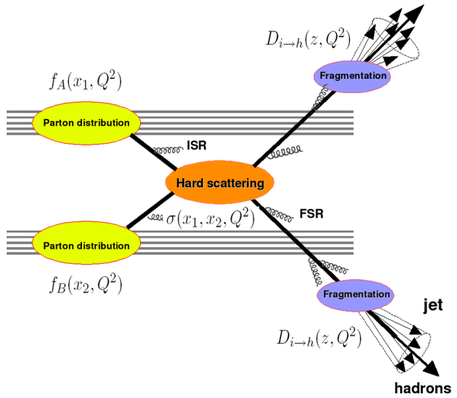


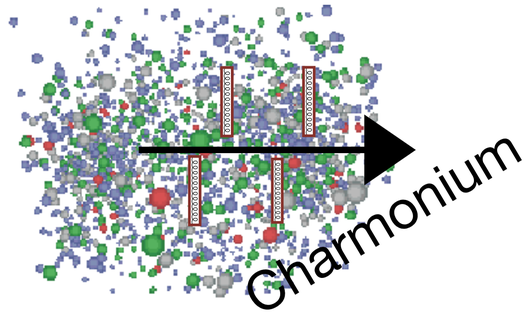
LHCb-PAPER-2023-035

- Jet fragmentation vs comovers interactions.

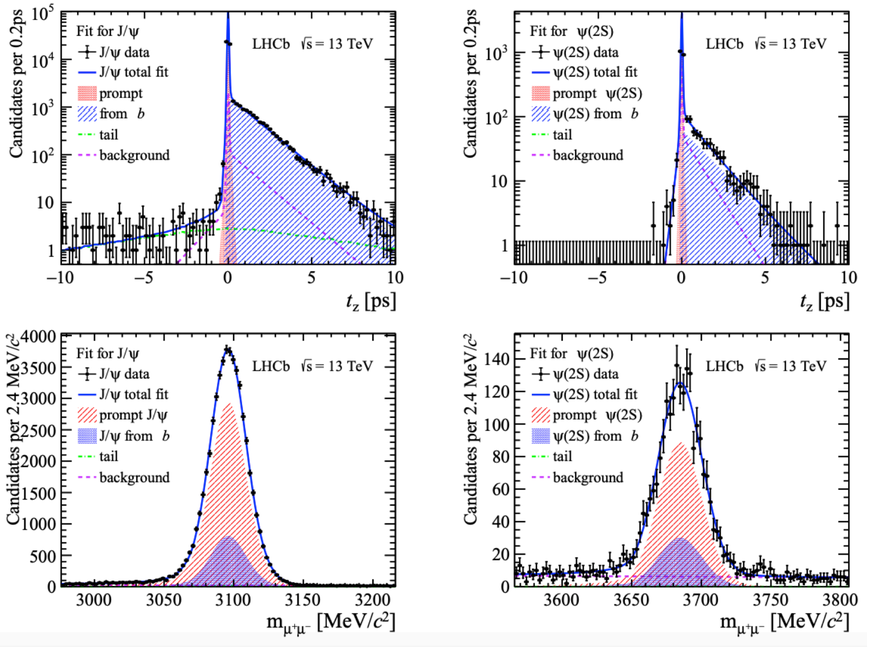
$\psi(2s)/J/\psi$ production versus multiplicity in pp@13TeV collisions

LHCb-PAPER-2023-035



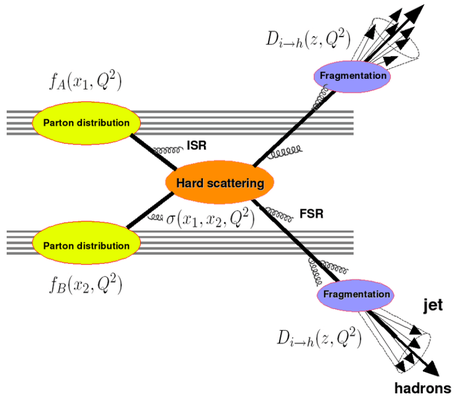


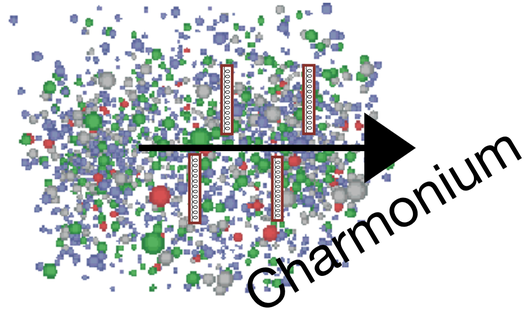
- Jet fragmentation vs comovers interactions.



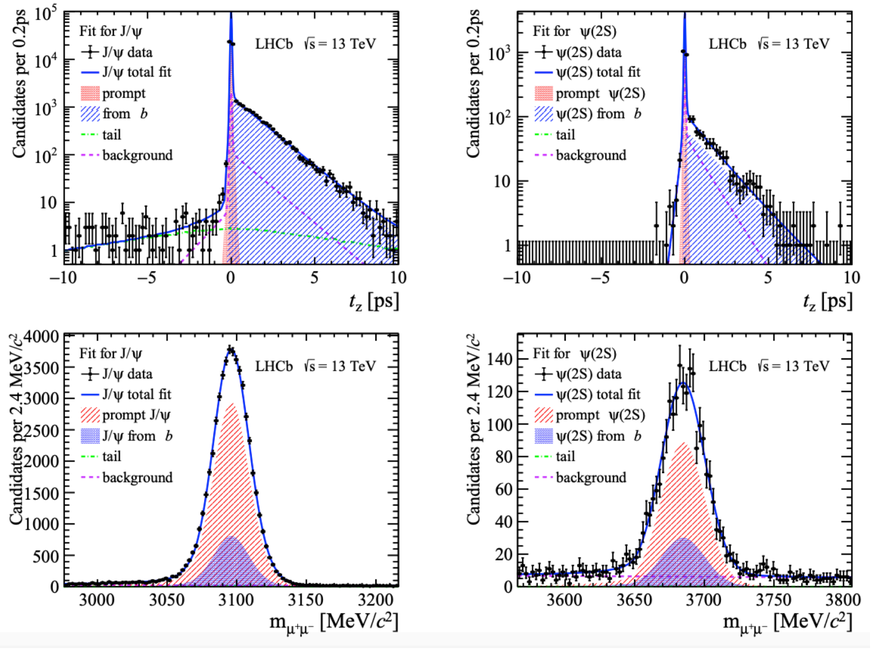
- 2D-fits simultaneous fit

$\psi(2s)/J/\psi$ production versus multiplicity in pp@13TeV collisions

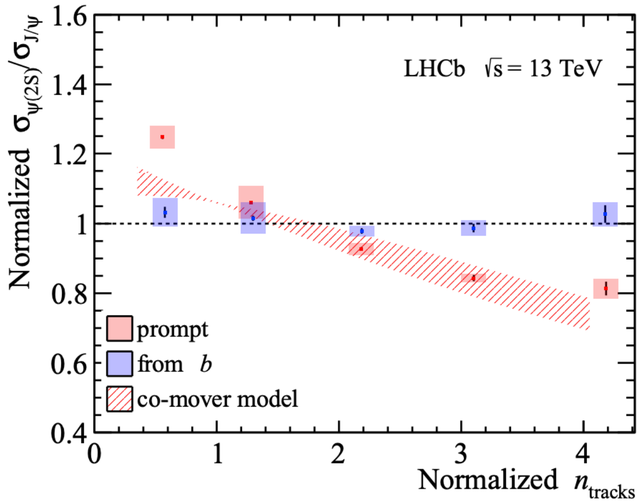




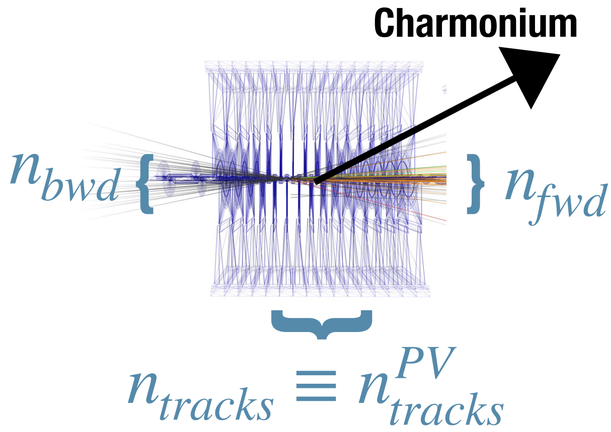
- Jet fragmentation vs comovers interactions

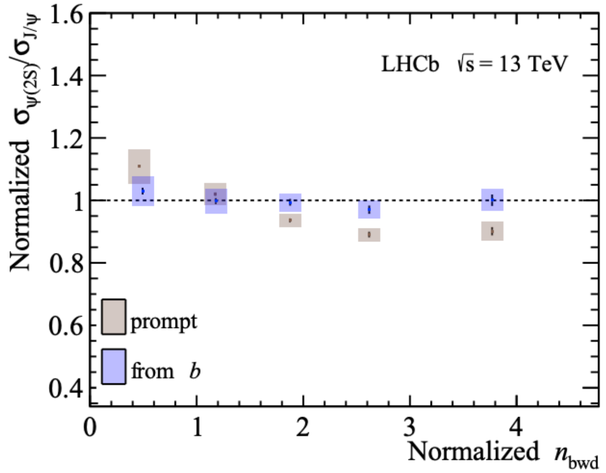


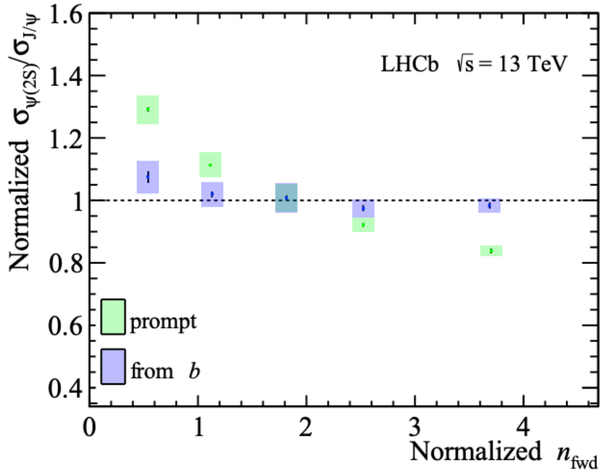
- 2D-fits simultaneous fit



LHCb-PAPER-2023-035







Decreasing trend versus multiplicity observed for prompt contributions.

Conclusions and prospects

- **Stable operation during ion run:**
  - **First data collected with all LHCb including also UT.**
- **Promising ion data:**
  - Events recorded down to targeted centrality.
  - **Three datasets in one:**
    - Hadronic PbPb data down to semi-central collisions.
    - Full centrality coverage for Pb-SMOG.
    - Clean minimum bias Ultra-Peripheral Collisions data.
  - Reconstruction ongoing.
- **Run 2 data still being analyzed:**
  - 18 new papers submitted for publications since the last LHCC.
- Next steps: moving to very busy YETS operations and be ready for next year.