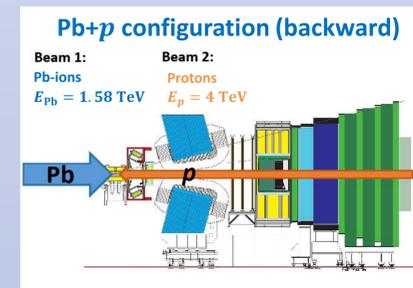
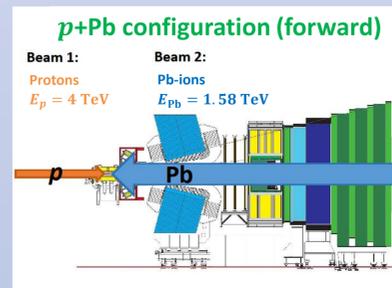


- LHCb is fully instrumented in the forward region
  - Provide full measurement capabilities at forward rapidity
  - Complementary measurements to other LHC experiments
- LHCb collected **proton-lead** collisions at a nucleon-nucleon center-of-mass energy of  $\sqrt{s_{NN}} = 5$  TeV



**rapidity coverage:  $1.5 < y < 4.5$**  **rapidity coverage:  $-5.5 < y < -2.5$**   
 Data used  $\mathcal{L} = 0.46 \text{ nb}^{-1}$  **Data used  $\mathcal{L} = 0.30 \text{ nb}^{-1}$**

## Event selection and definition of event-activity

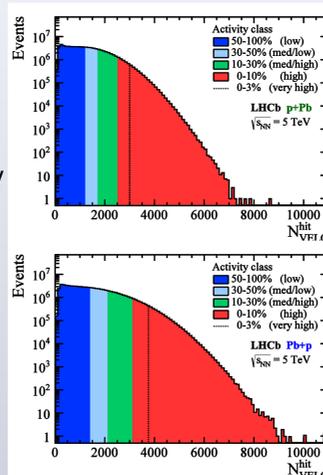
### Event selection

- =1 primary vertex (PV) per event
- PV must be in a luminous region, defined as  $3\sigma$ -range around the core interaction point

### Definition of event-activity

- Use VELO-hit multiplicity to measure the event activity  
-> VELO surrounds the interaction point  
-> most comprehensive measure of event activity  
-> proportional to number of charged particles
- Hit-multiplicities in **Pb+p** greater than in **p+Pb**
- Relative activity classes**  
-> from low (50-100%) to very high (0-3%) event activity.
- Common absolute activity classes for Pb+p and p+Pb**  
-> 5 bins from 2200-3500 VELO hits

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## Two-particle correlations

- The correlation function is defined as **per-trigger particle associated yield**,

$$\frac{1}{N_{trig}} \frac{d^2 N_{pair}}{d\Delta\eta d\Delta\phi} = \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)} \times B(0, 0)$$

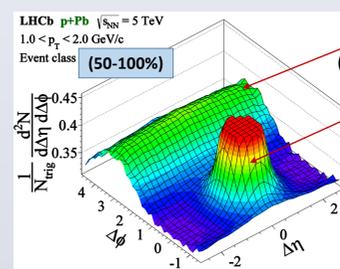
$$\text{Signal } S(\Delta\eta, \Delta\phi) = \frac{1}{N_{trig}} \frac{d^2 N_{same}}{d\Delta\eta d\Delta\phi}$$

$$\text{Background } B(\Delta\eta, \Delta\phi) = \frac{1}{N_{trig}} \frac{d^2 N_{mix}}{d\Delta\eta d\Delta\phi}$$

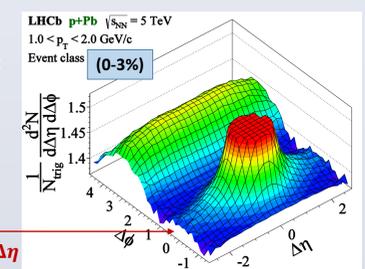
Particle pairs for all combinations  $N_{same}$  of two particles within the **same event**.  
Calculate  $\Delta\eta$  and  $\Delta\phi$  for each pair.

Mix particles of event with particles of five similar\*, but **different events** ->  $N_{mix}$  particle pairs.

- Results in the p+Pb configuration:**  $p_T$  range: 1.0 - 2.0 GeV/c



**Away-side ridge**  
(momentum conservation)  
**Jet peak**  
(particles from same hard process)

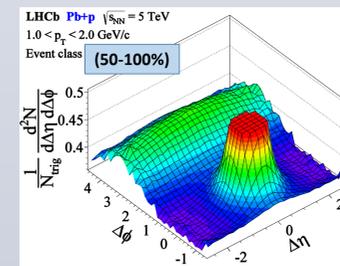


**Near-side ridge elongated over large  $\Delta\eta$**

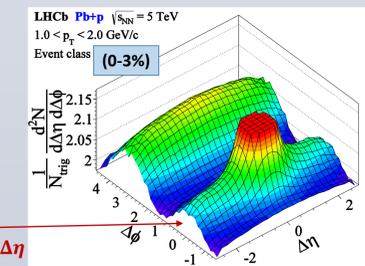
**At low event-activity (50-100%):**  
 $\Delta\phi = \pi$  : Away-side ridge present  
 $\Delta\phi = 0$  : No sign of a near-side ridge

**Towards high event-activity (0-3%):**  
 $\Delta\phi = 0$  : Near-side ridge is evolving!  
→ The ridge is clearly visible

- Results in the Pb+p configuration:**  $p_T$  range: 1.0 - 2.0 GeV/c



**Near-side ridge elongated over large  $\Delta\eta$**

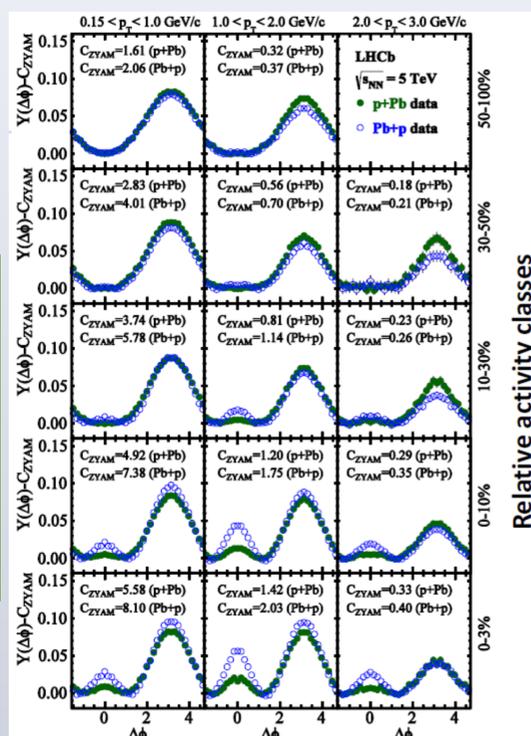


## Long-range correlation yield as a function of $\Delta\phi$

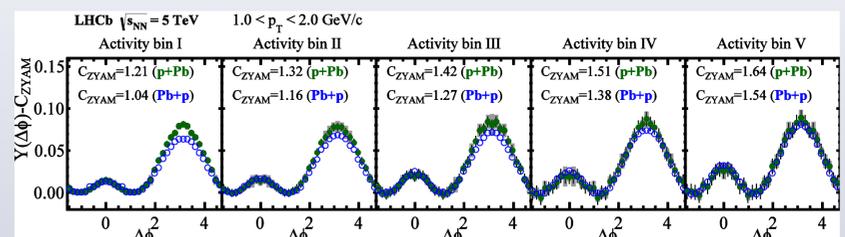
$$Y(\Delta\phi) \equiv \frac{1}{N_{trig}} \frac{dN_{pair}}{d\Delta\phi} = \frac{1}{\Delta\eta_b - \Delta\eta_a} \int_{\Delta\eta_a}^{\Delta\eta_b} \frac{1}{N_{trig}} \frac{d^2 N_{pair}}{d\Delta\eta d\Delta\phi} d\Delta\eta$$

- Average the 2D-yield in the range of  $2.0 < \Delta\eta < 2.9$ , to exclude short-range correlations (jet peak)
- Subtract the zero-yield-at-minimum

- The correlation yield increases with event activity
- The away-side ridge decreases towards higher  $p_T$
- On the near side, the second ridge emerges with a maximum in the range  $1 < p_T < 2$  GeV/c
- Near side is more pronounced in **Pb+p** than in **p+Pb**



- Compare both hemispheres (Pb or p direction) in **common absolute activity ranges**.
- Five identical activity ranges for the **p+Pb** and **Pb+p** configurations, accounting for the same particle production in  $2.0 < \eta < 4.9$ .



- Strength of **near-side ridges** in both hemispheres are **compatible with each other!**
- Different probed rapidity ranges in both beam configurations show no sizable effect.