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3 **Long-range correlations in high-multiplicity proton–proton collisions at**  
4  **$\sqrt{s} = 13$  TeV**

5 **Abstract**  
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## 1 Introduction

Collective effect is one of key probes to explore evolution of the hot and dense matter as consequence of heavy ion collisions at high energy. The enhancement in the production of two-particle correlations at small relative azimuthal angle( $\Delta\phi$ ) that extends over a long-range of relative pseudorapidity( $\Delta\eta$ ) is often referred to as the “ridge”, which is one observable of the collective effect. In recent years, many results of unexpected observation of ridge in small systems, like proton-proton collisions and proton-nucleus collisions, has been reported, showing similar features to those in heavy ion collisions, where the volume and lifetime of the medium produced are expected to be too small to form Quark Gluon Plasma(QGP) thought to play an important and dominant role in formation of the ridge in heavy ion collisions. There are many theoretical trials to interpret the ridge considering hydrodynamics, saturation or other mechanisms, not demonstrating measured data fully, because the sources of the ridge is not understood quantitatively. The understanding of possible origins of the ridge in small systems may provide a hint to distinguish the mechanism of formation of ridges in large systems and small systems.

## 2 Experimental setup

## 3 Data sample and analysis

## 4 Results

## 5 Conclusions