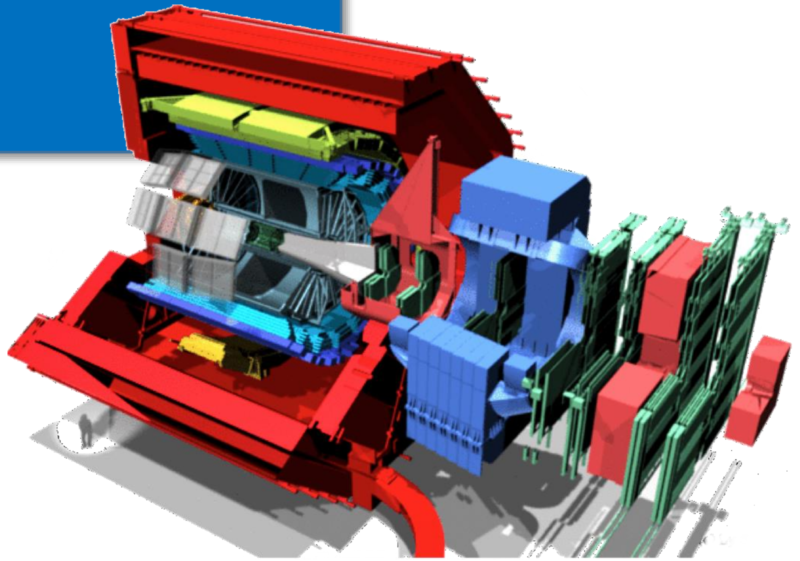
AD, the ALICE at LHC Diffractive Detector

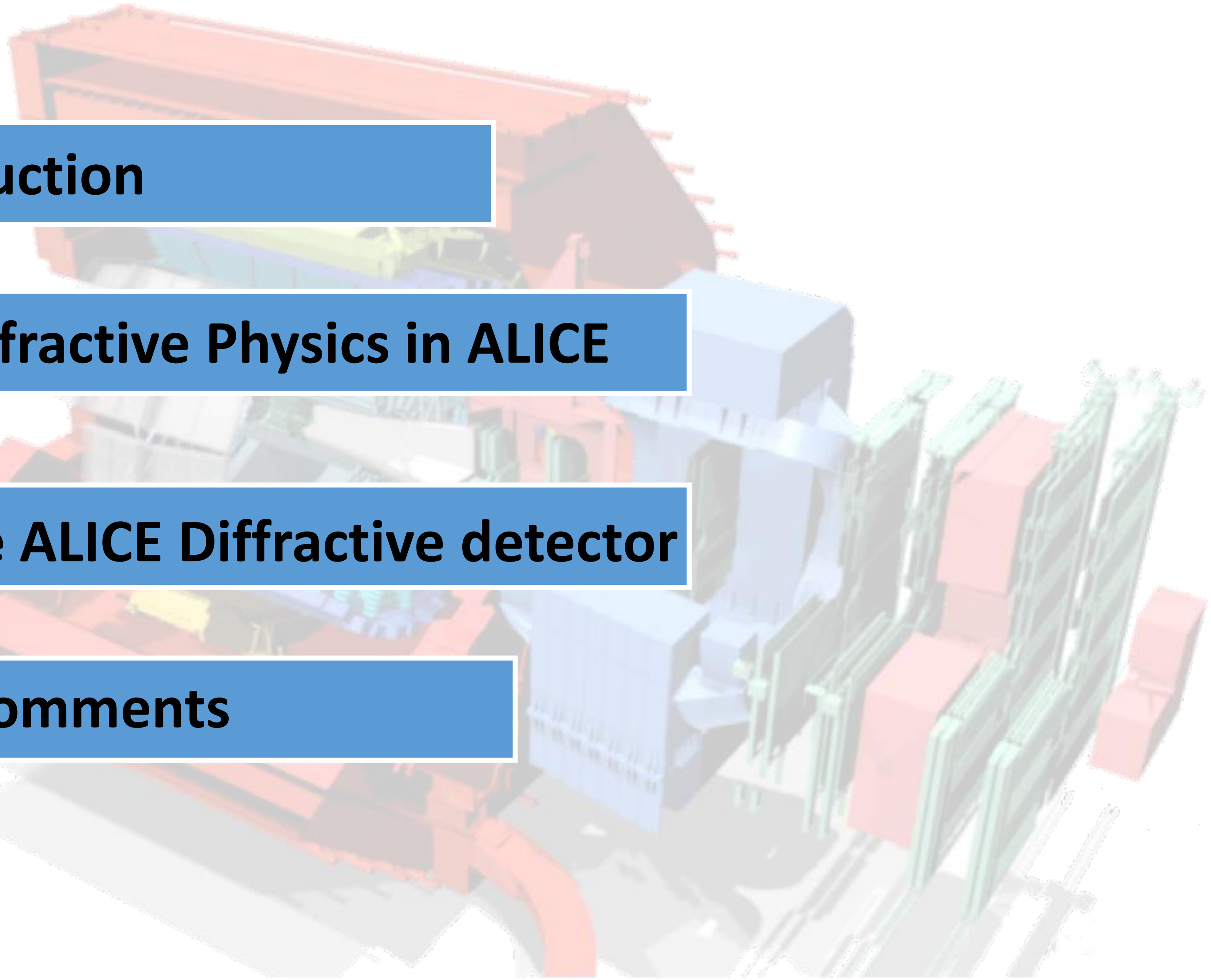


Abraham Villatoro Tello
On behalf of the ALICE Collaboration
Autonomous University of Puebla
(México)

7 September 2016

Diffraction 2016
International Workshop on Diffraction in High-Energy Physics.
Santa Tecla di Acireale (Italy)

Plan of this talk



- Introduction
- Diffractive Physics in ALICE
- The ALICE Diffractive detector
- Final comments

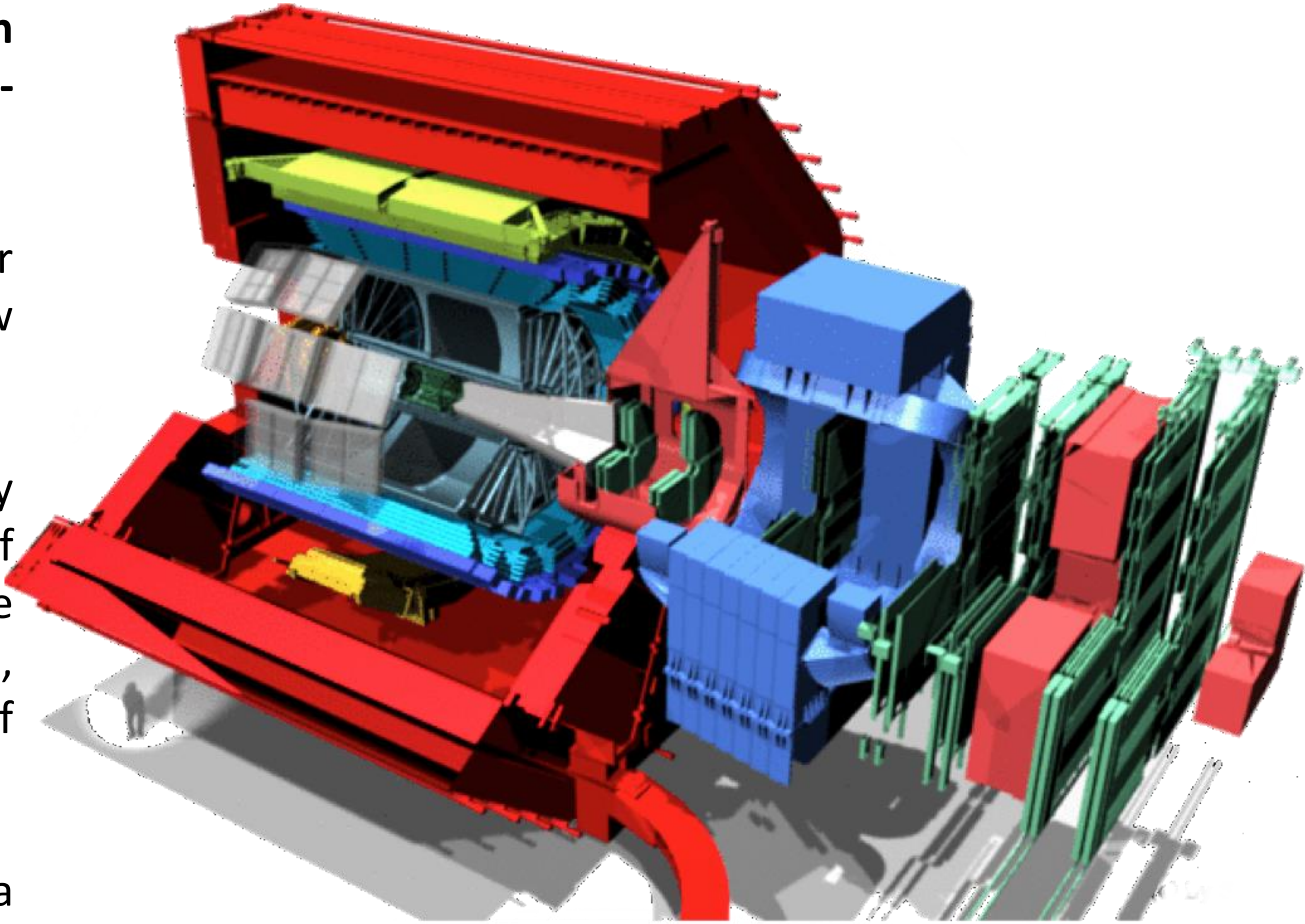
Introduction

- The **ALICE Collaboration has built** a dedicated **heavy-ion** detector to exploit the unique physics potential of **nucleus-nucleus interactions at LHC energies**.

- Our **aim** is to study the physics of strongly interacting matter at extreme energy densities, where the formation of a new phase of matter, the quark-gluon plasma, is expected.

- The existence of such a phase and its properties are key issues in QCD for the understanding of confinement and of chiral-symmetry restoration. For this purpose, we are carrying out a comprehensive study of the hadrons, electrons, muons and photons produced in the collision of heavy nuclei.

- **Alice is also studying p-p, p-Pb collisions** both as a comparison with lead-lead collisions and in the kinematic region where **ALICE is competitive with other LHC experiments.**



http://alice-collaboration.web.cern.ch/

mail: Abraham.Villatoro.tello@cern.ch

Introduction

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MORE DETAILS IN EUGENIO SCAPPARONE SLIDES

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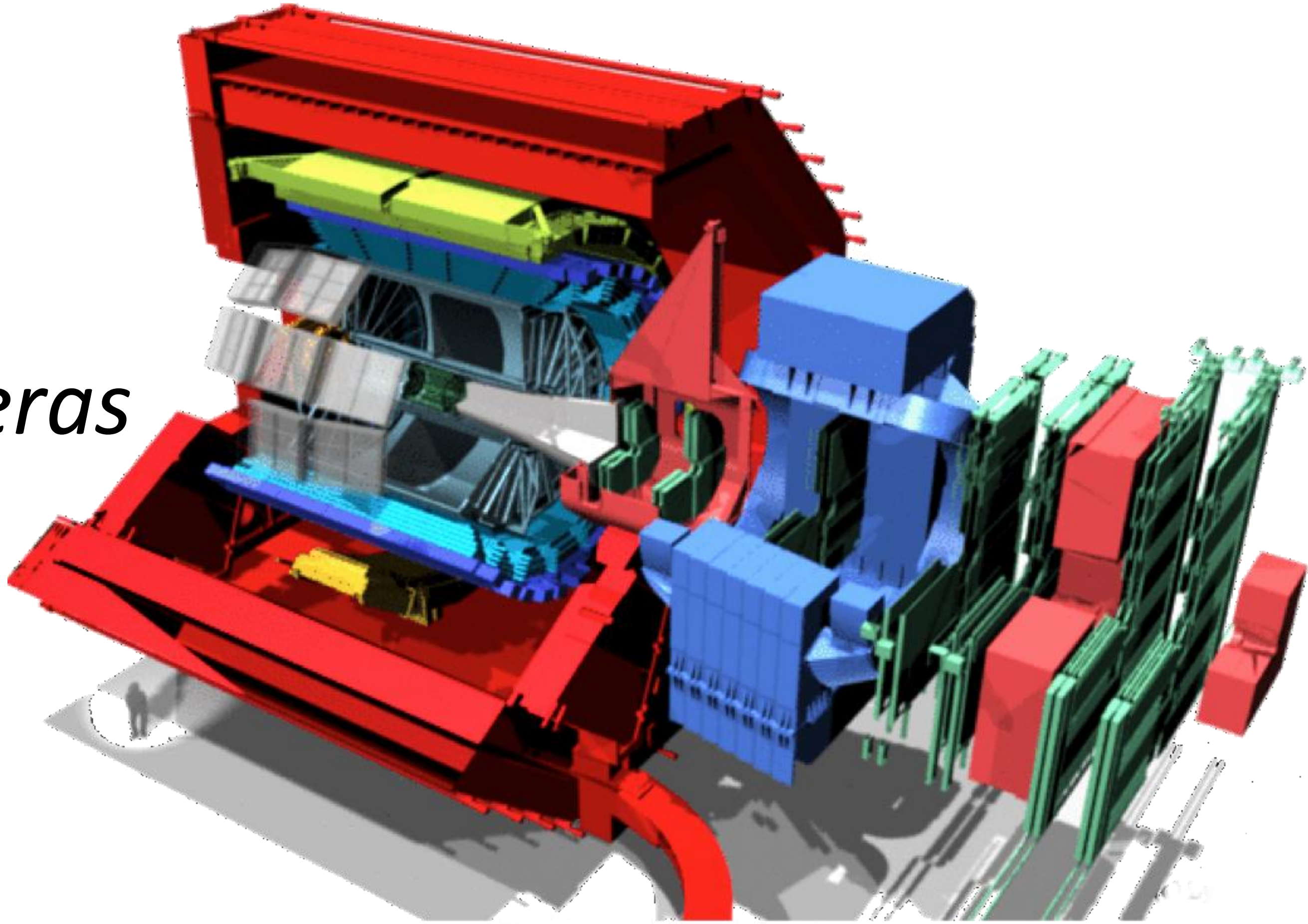
Introduction

- Global features of collisions
- Ultra-peripheral collisions
  - *See talks of G. Contreras and J. Adam*
- Cosmic-ray Physics
- **DIFFRACTIVE PHYSICS**



Introduction

- In a diffractive reaction, no colour is exchanged between the particles colliding at high energies.

- Diffraction is elastic (or quasi elastic) scattering caused by the absorption of components of the wave function of the incoming particles

- p-p -> p-p, p-p -> pX (single proton dissociation, Single Diffractive), p-p -> XY (both protons dissociate, Double Diffractive), or Central Diffractive, p-p->p+X+p

- A diffractive process is characterized by a rapidity gap. Experimentally, there is no defined way to distinguish rapidity gaps caused by Pomeron exchange from those caused by other colour-neutral exchanges, so the separation is model dependent.

Introduction

- In a diffraction reaction, no color is exchanged between the particles colliding at high energies.

- Usually the total pp cross section is decomposed as:

$$\sigma_{Tot} = \sigma_{elastic} + \sigma_{Non-Diffractive} + \sigma_{SD} + \sigma_{DD} + \sigma_{CD}$$

p-p;
both
protons dissociate, Double Diffractive), or Central Diffractive, p-p->p+X+p

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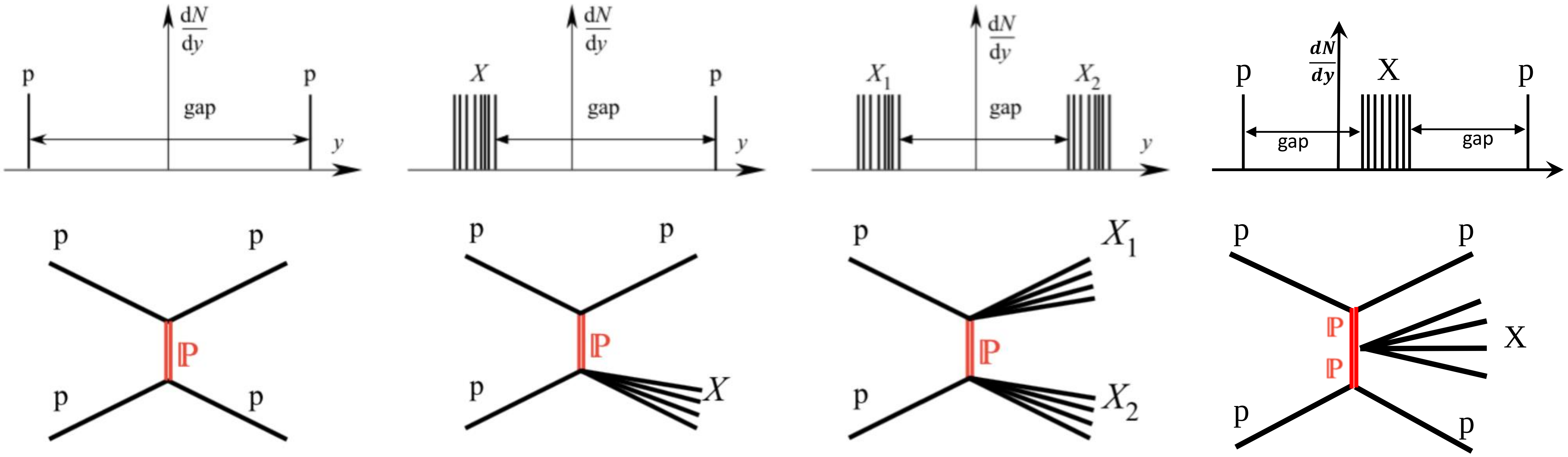
Diffractive Physics in ALICE - RUN1

Measuring SD and DD with ALICE

Strategy: Measure gap distribution over **8 units in η** using the central barrel and forward detectors.

Elastic | **Single Diffractive** | **Double Diffractive** | **Central Exclusive Production**

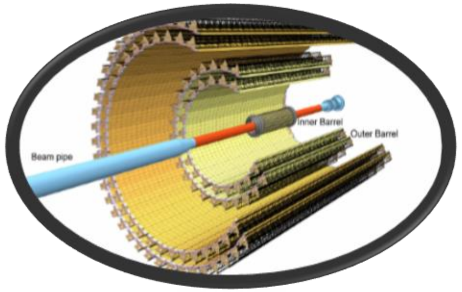


The **ALICE** experiment – Diffractive Physics in **RUN 1**

V0

V0A $2.8 < \eta < 5.1$

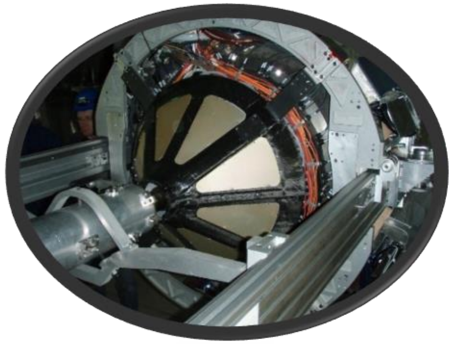
V0C $-3.7 < \eta < -1.7$



ITS (SPD)

$-2.0 < \eta < 2.0$

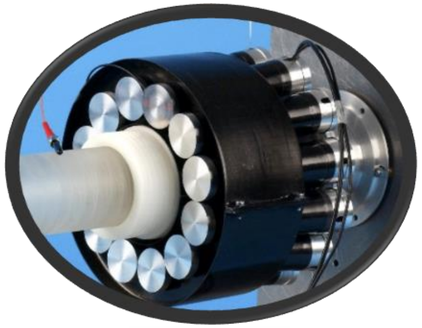
$-1.4 < \eta < 1.4$



FMD

$1.7 < \eta < 5.0$

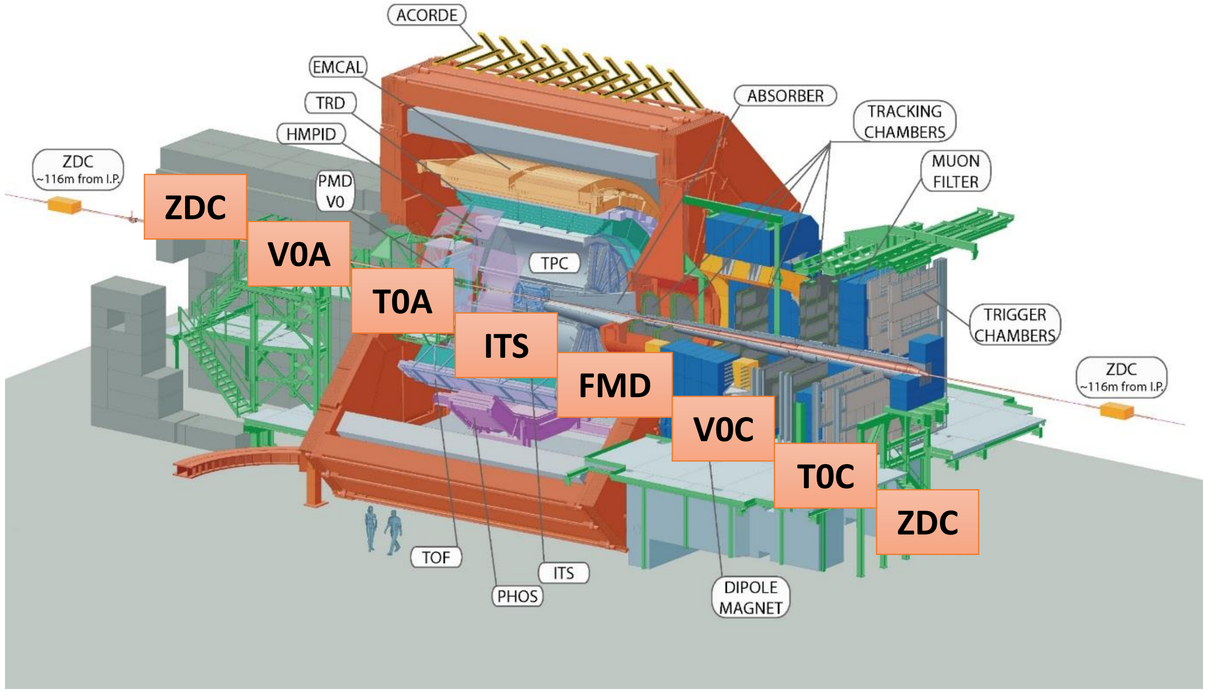
$-3.4 < \eta < -1.7$

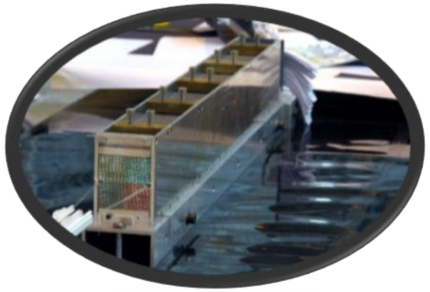


T0

T0A $4.6 < \eta < 4.9$

T0C $-3.0 < \eta < -3.3$





ZDC

ZNA & ZNC

$|\eta| > 8.8$

Diffractive Physics in ALICE - RUN1

Measurement of inelastic, single- and double-diffraction cross sections in proton–proton collisions at the LHC with ALICE

The ALICE Collaboration, B. Abelev, J. Adam, D. Adamová, A. M. A… …a, A. G. Agocs, A. Agostinelli, S. Aguilar Salazar, Z. Ahammed, A. Ahmad … …in … show 973 more

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Experimental Physi… …aboration, Abelev, B., Adam, …

First On… …al. Eur. Phys. J. C (2013) 73: 2456.

…56-0 doi:10.1140/epjc/s10052-013-2456-0

59 Citations 2.4k Views

ALICE DIFFRACTIVE PAPER WITH RUN 1 DATA

*Eur. Phys. J. C (2013 73:2456)

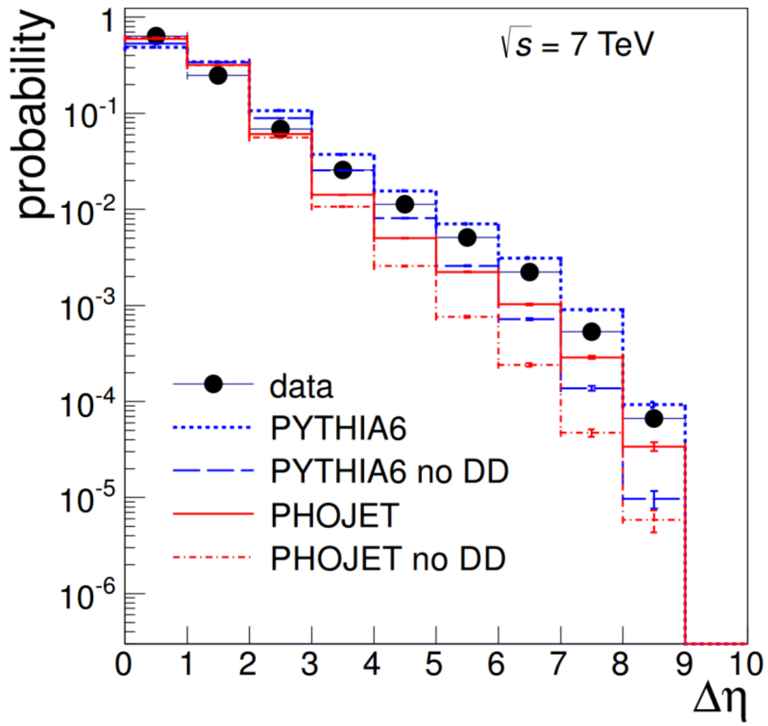
Diffractive Physics in ALICE - RUN1

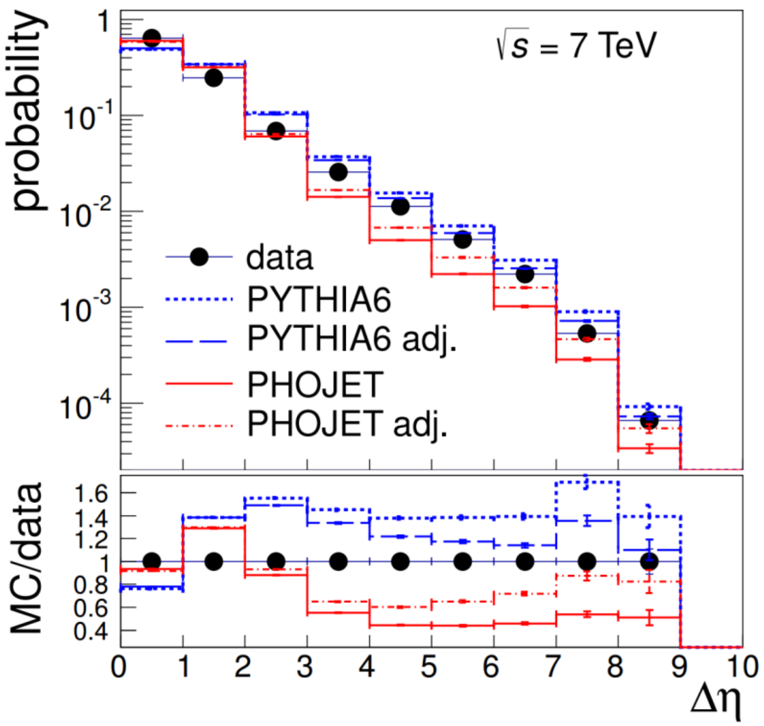
- As in ATLAS and CMS, ALICE gets sensitivity to diffractive processes.

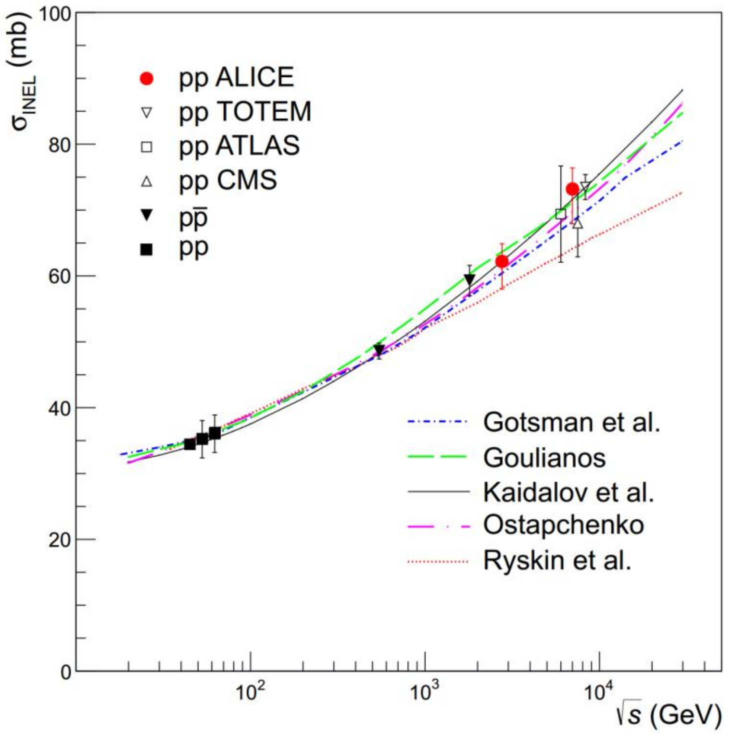
ALICE	$-3.7 < \eta < -1.7$, $\|\eta\| < 2$, $1.7 < \eta < 5.1$	$M_x > 10$ GeV
ATLAS	$\|\eta\| < 3.8$, $5.6 < \|\eta\| < 5.9$	$M_x > 7$ GeV
CMS	$\|\eta\| < 2.5$, $3.0 < \|\eta\| < 5.2$, $-6.6 < \eta < -5.2$	$M_x > 16$ GeV
TOTEM	$3.1 < \|\eta\| < 4.7$, $5.3 < \|\eta\| < 6.5$	$M_x > 3.4$ GeV

*Eur. Phys. J. C (2013 73:2456)
*Nat. Commun. 2, 463(2011)
*Physics Letters B 722 (2013) 5–27
*Phys. Rev. Lett. 111, 262001

- The result of ALICE is consistent with the measurement by ATLAS, CMS and TOTEM.







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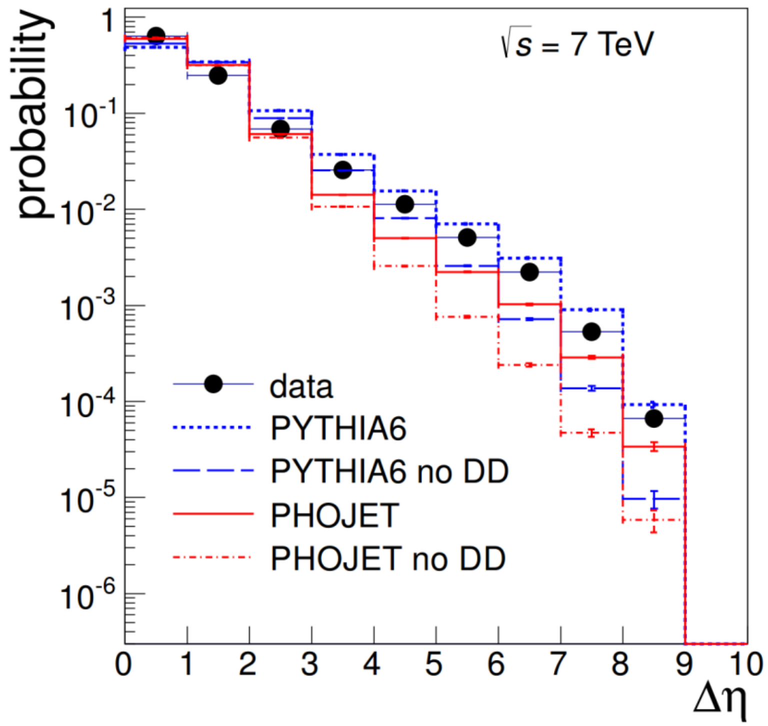
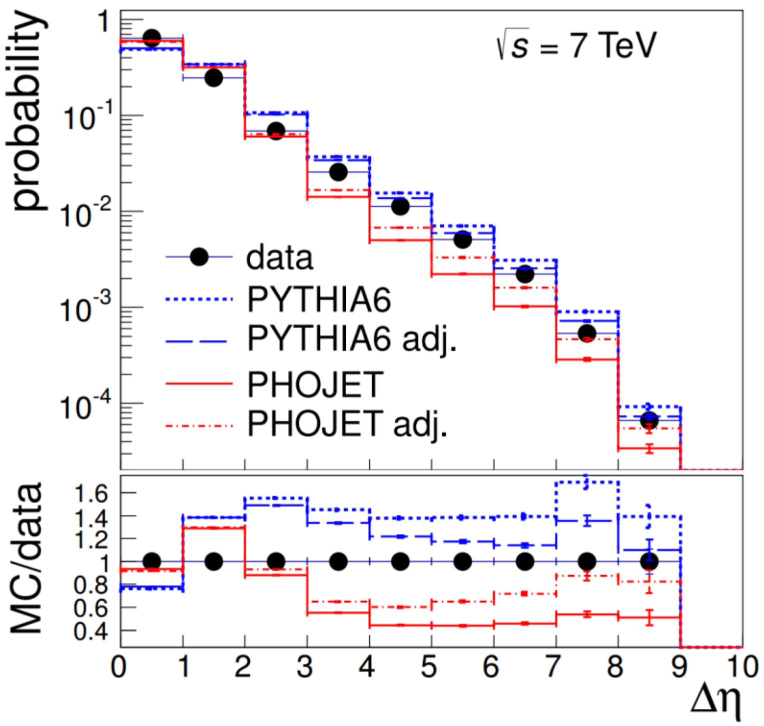
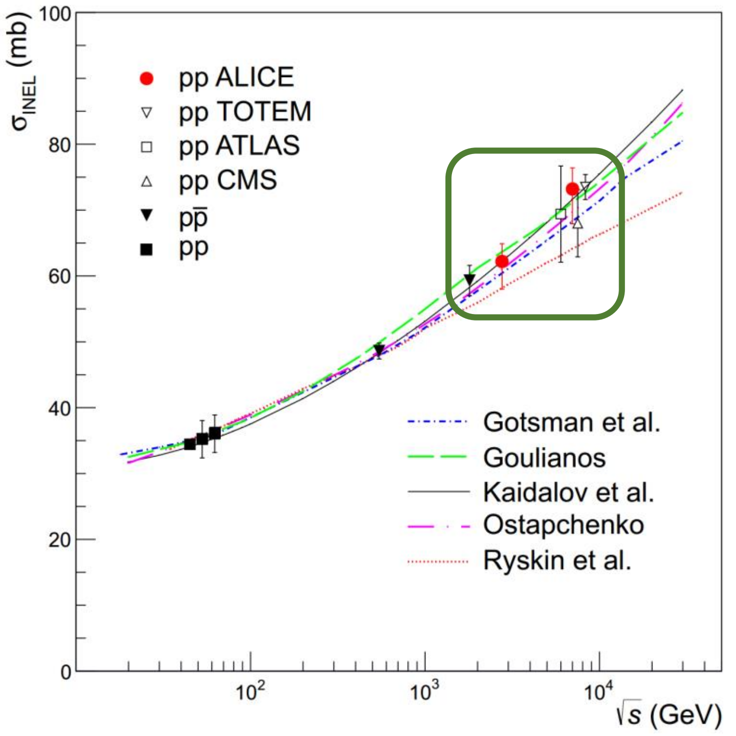
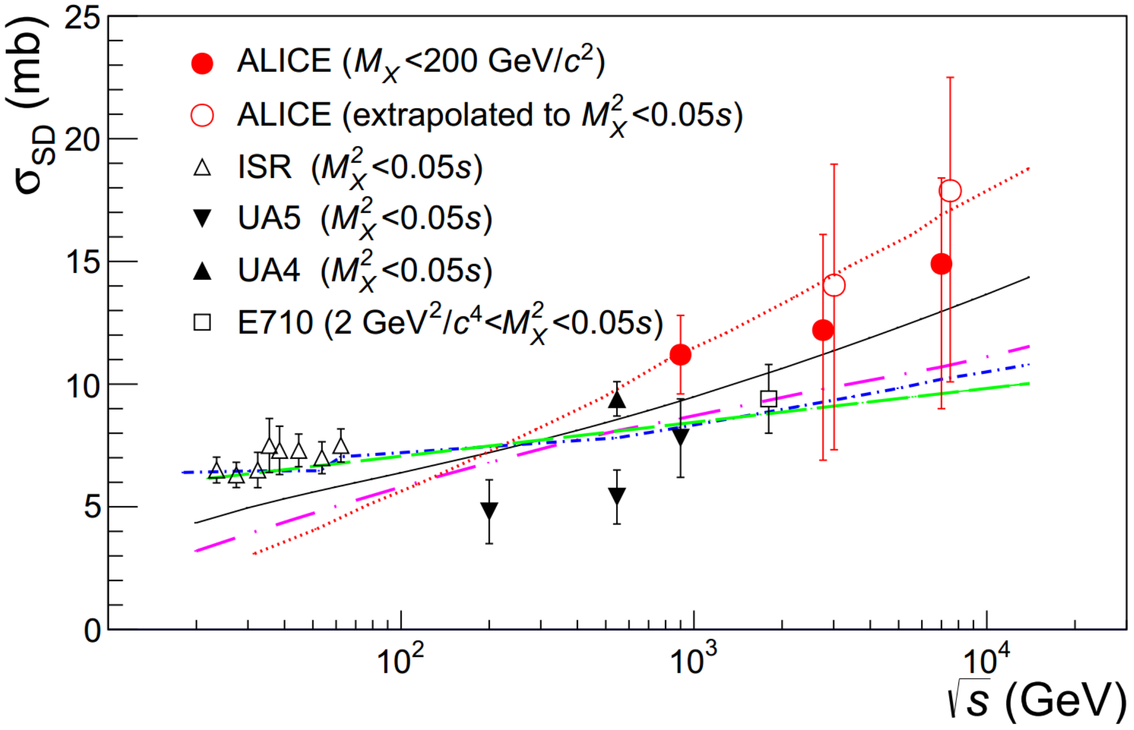


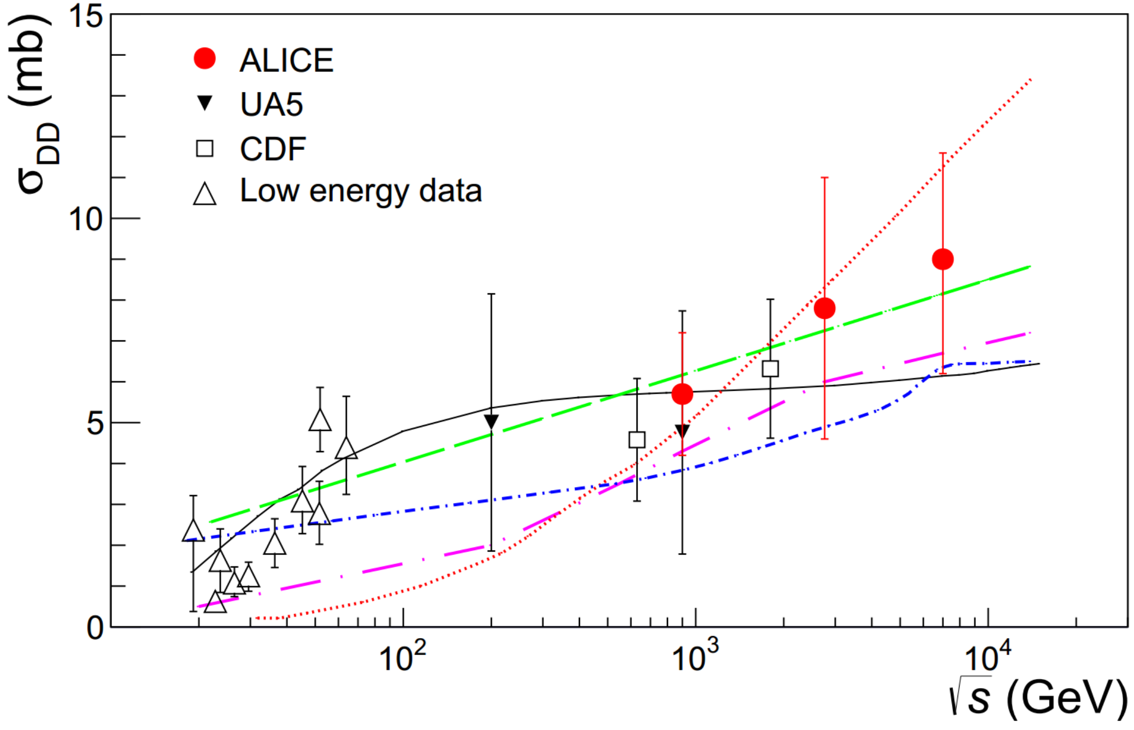




Diffractive Physics in ALICE - RUN1

- Within large uncertainties ALICE measurements are in agreement with the measurements from UA5, UA4 and CDF.





Eur. Phys. J. C (2013 73:2456)

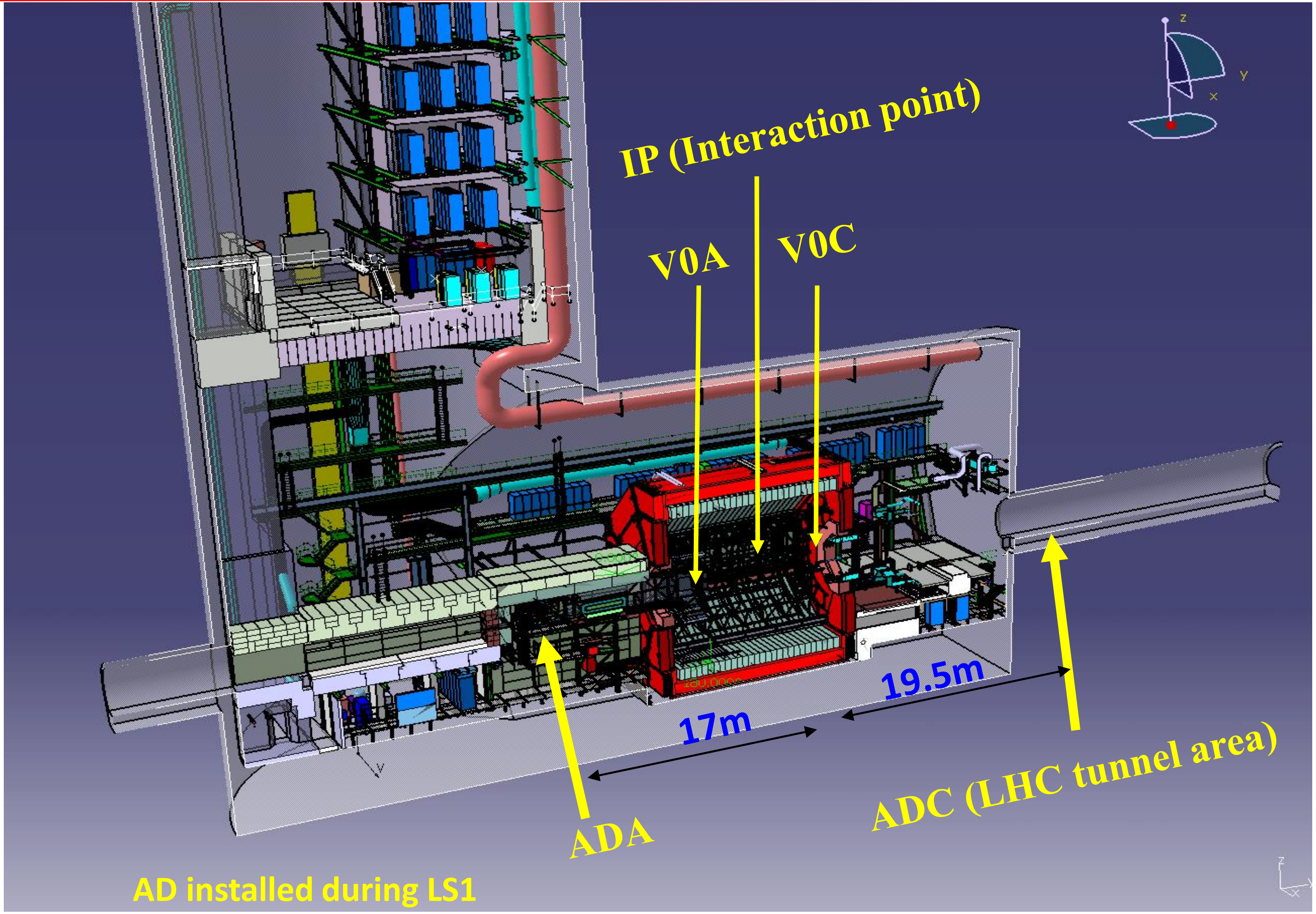
The ALICE Diffractive detector

- As a complement to the heavy-Ion physics program, ALICE started during Run 1 of LHC an extensive program dedicated to the study of proton-proton diffractive processes.

- In order to optimize its trigger efficiencies and purities in selecting diffractive events, the ALICE collaboration installed a very forward detector during LS1 of LHC.

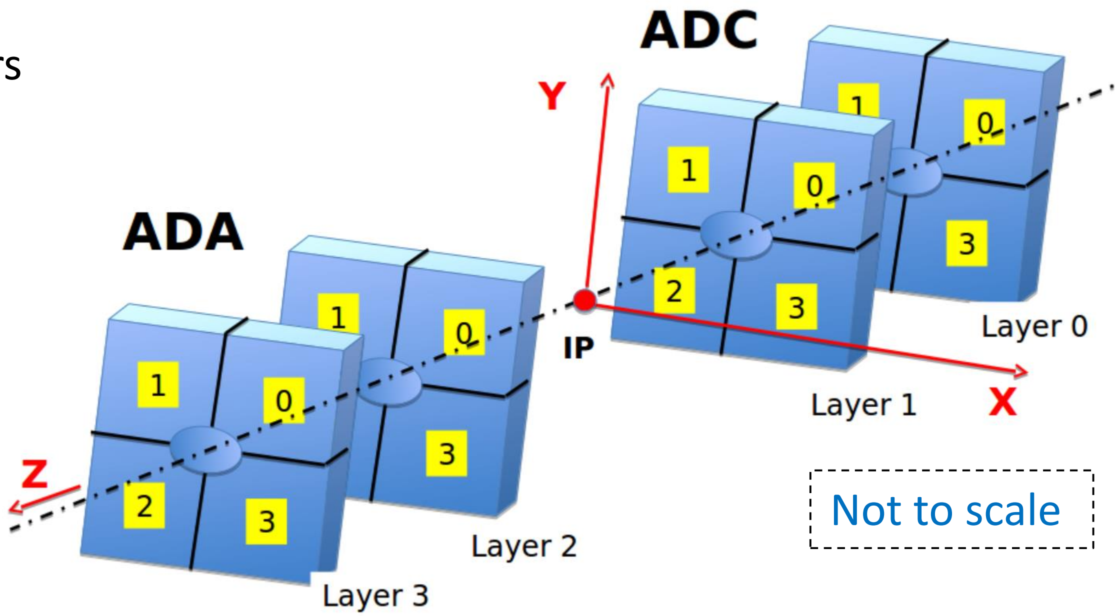
- With the inclusion of the ALICE Diffractive Detector (AD), ALICE has increased its sensitivity towards smaller diffractive masses.

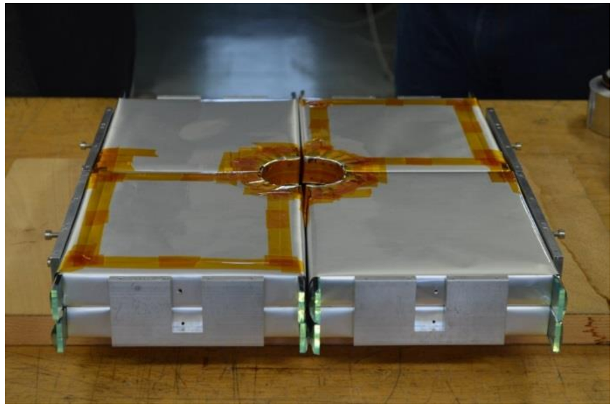
The ALICE Diffractive detector

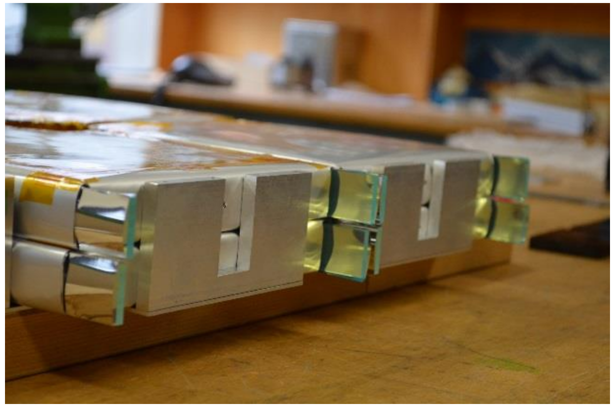


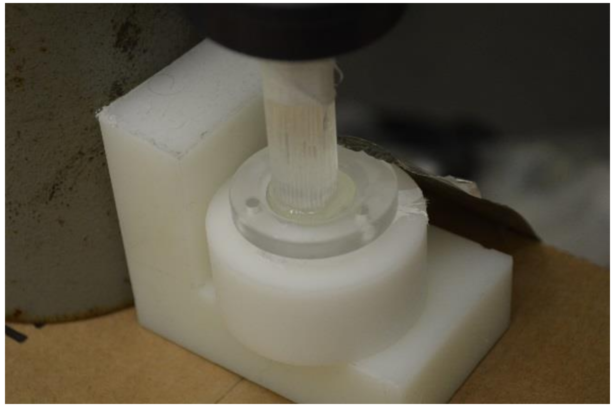
The ALICE Diffractive detector

- AD is formed by two main stations, each station consists of 2 layers with 4 plastic scintillator pads each (8 pads per side).
- Each scintillator measures roughly 18cm x 21cm.
- Each scintillator plastic is coupled to a PMT through a wave length shifting bar and an array of clear optic fibers.
- For trigger generation, a coincidence between adjacent pads is required.

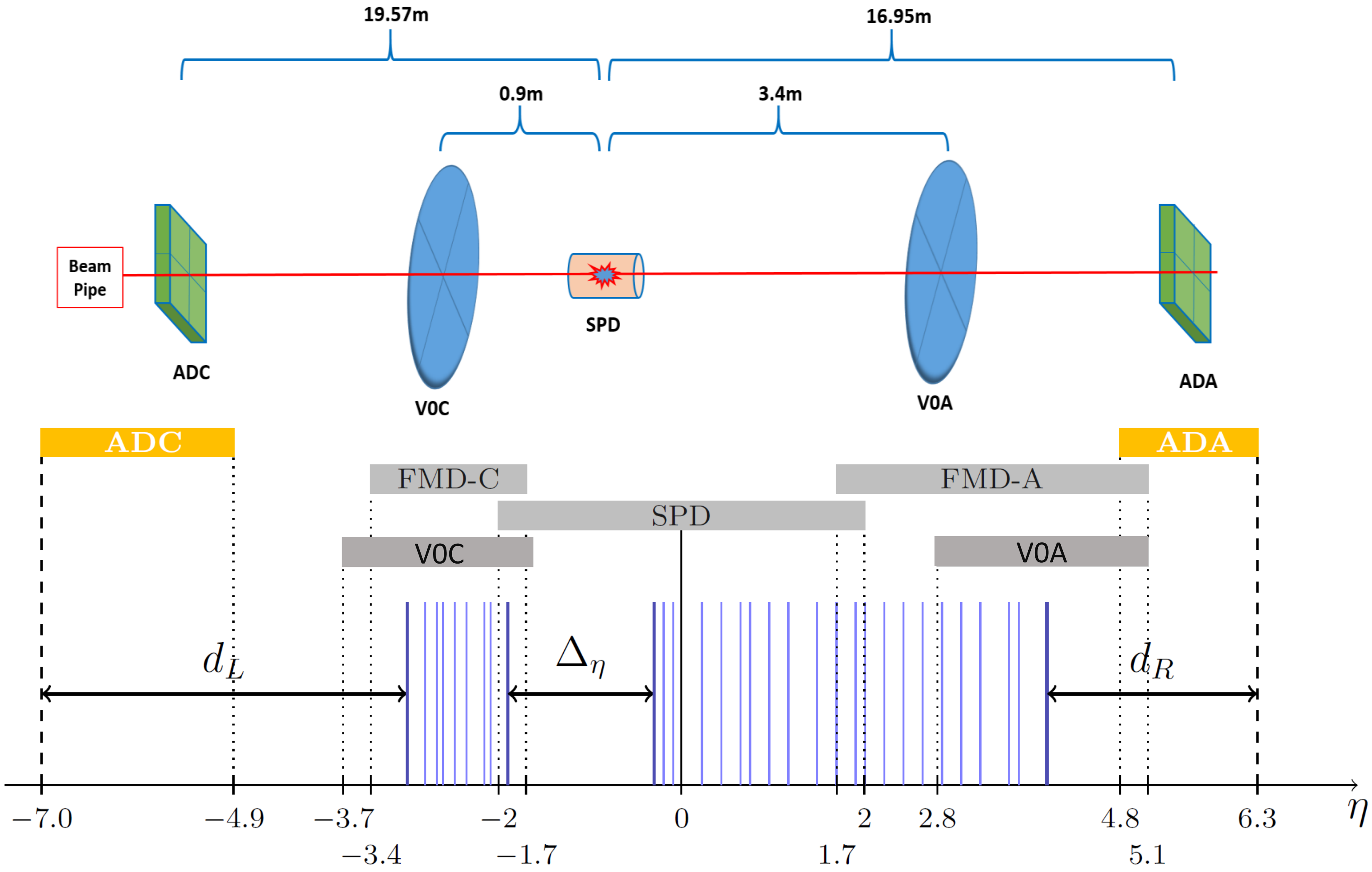


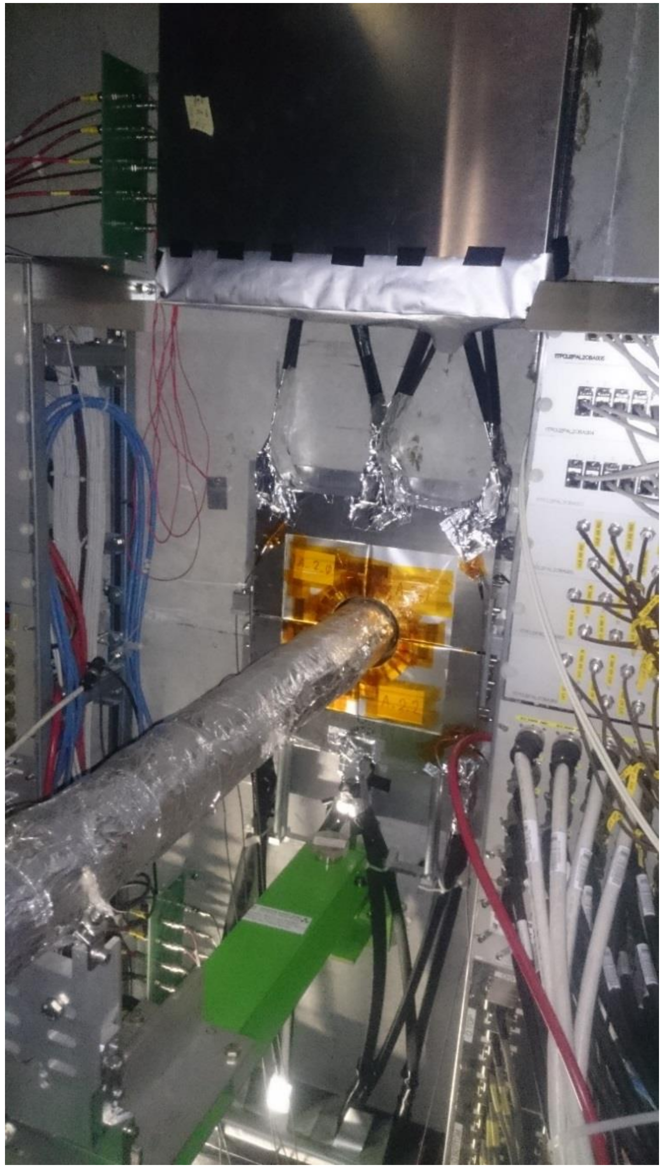






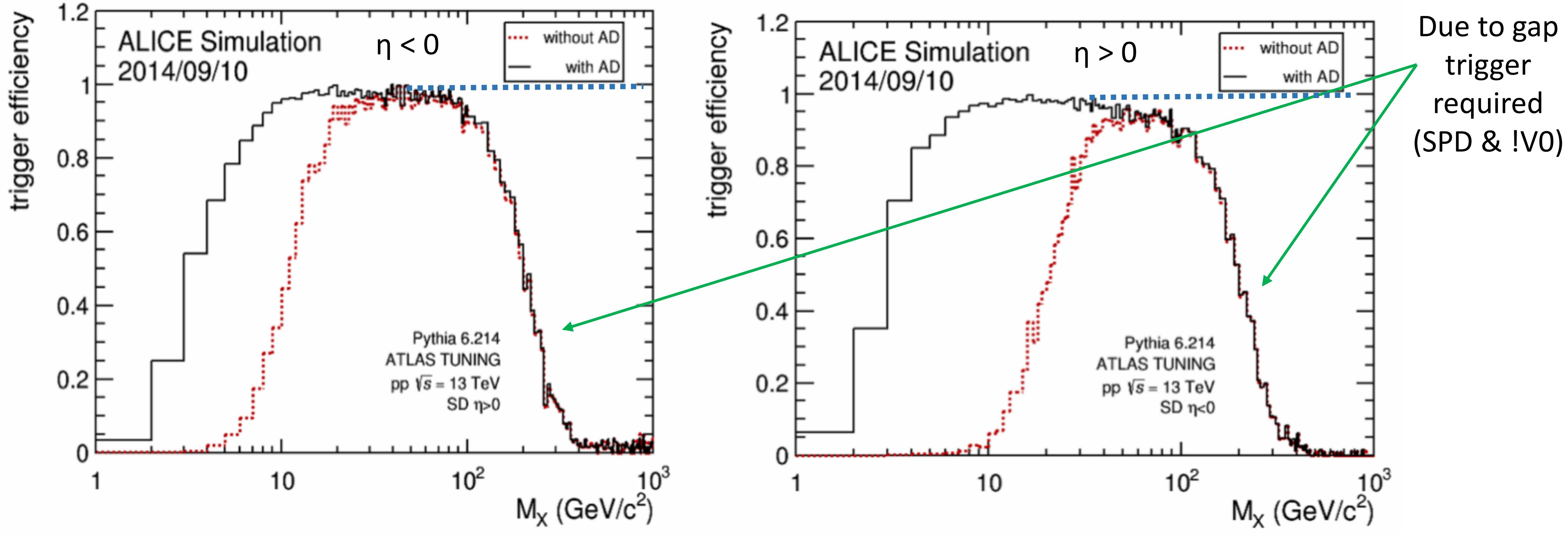
The ALICE Diffractive detector





➢ Increase in pseudorapidity coverage. Before ~8.8 units in η, now, ~12.1.

The ALICE Diffractive detector

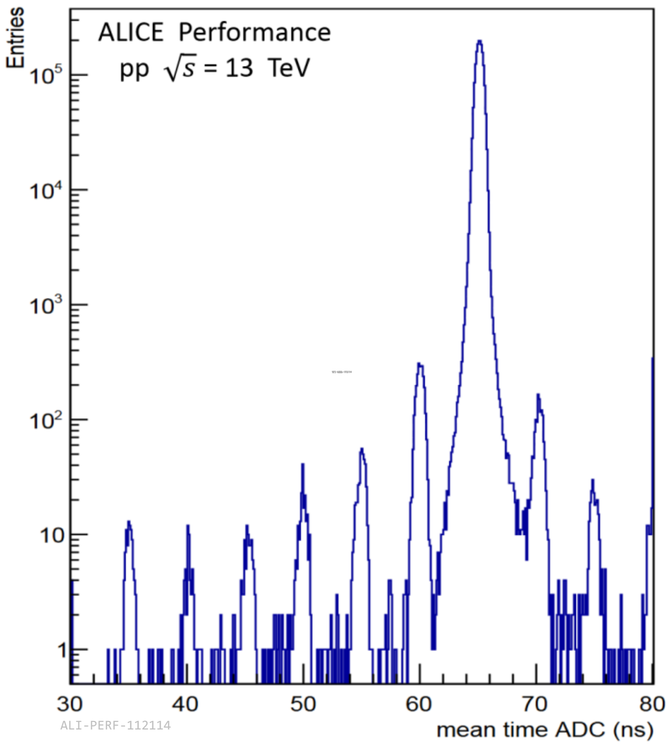


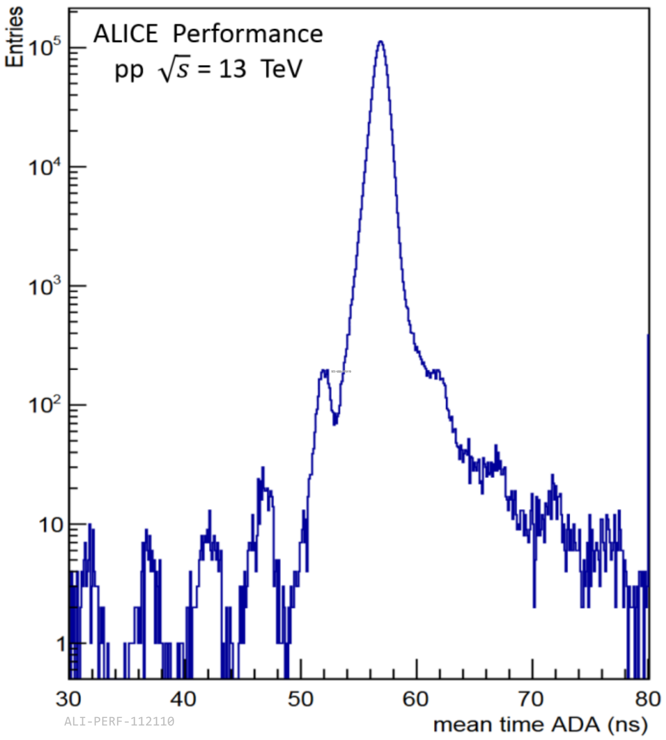
*CERN-PH-LPCC-2015-001 SLAC-PUB-16364 DESY 15-167

- The AD detector increases the sensitivity to diffractive masses close to threshold ($m_p + m_{pion}$) $M_x > 10$ GeV -> $M_x > 4$ GeV (50%), and also partially compensates for the loss of trigger efficiency for Minimum Bias events.

The ALICE Diffractive detector – Performance

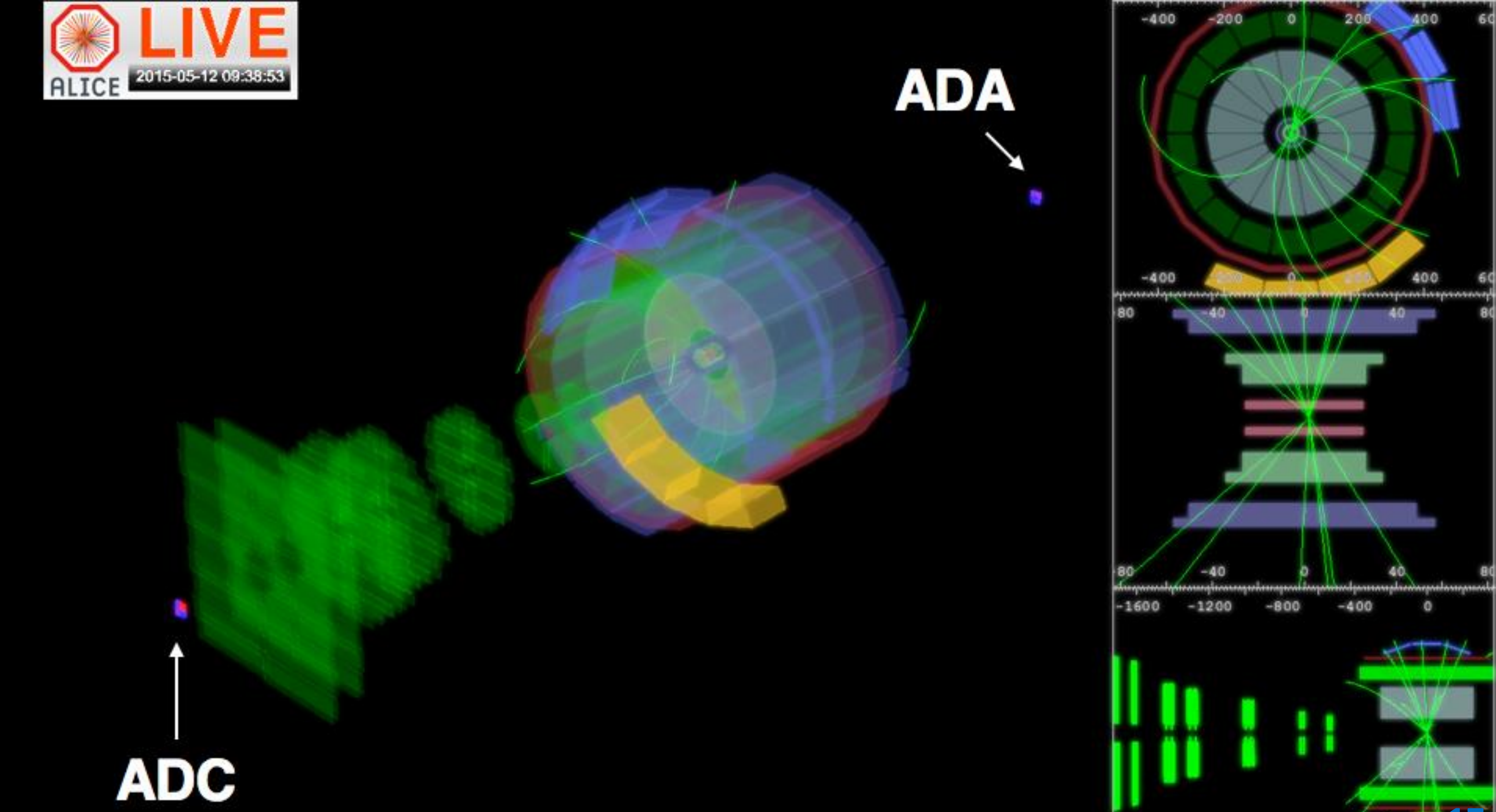
- AD group has conducted two Beam-Tests, in order to measure the performance of the full detector.
- The efficiency along the scintillator is uniform, as well as the charge measured when the beam hits in different parts of the scintillator.





- One can identify the hits in different parts of the detector (scintillator, PMTs, fibers) with the time measurements. Time resolution for A-side (C-side) is ~440ps (~300ps).
- Thanks to AD time resolution, 5 ns spaced satellite bunches are clearly seen.

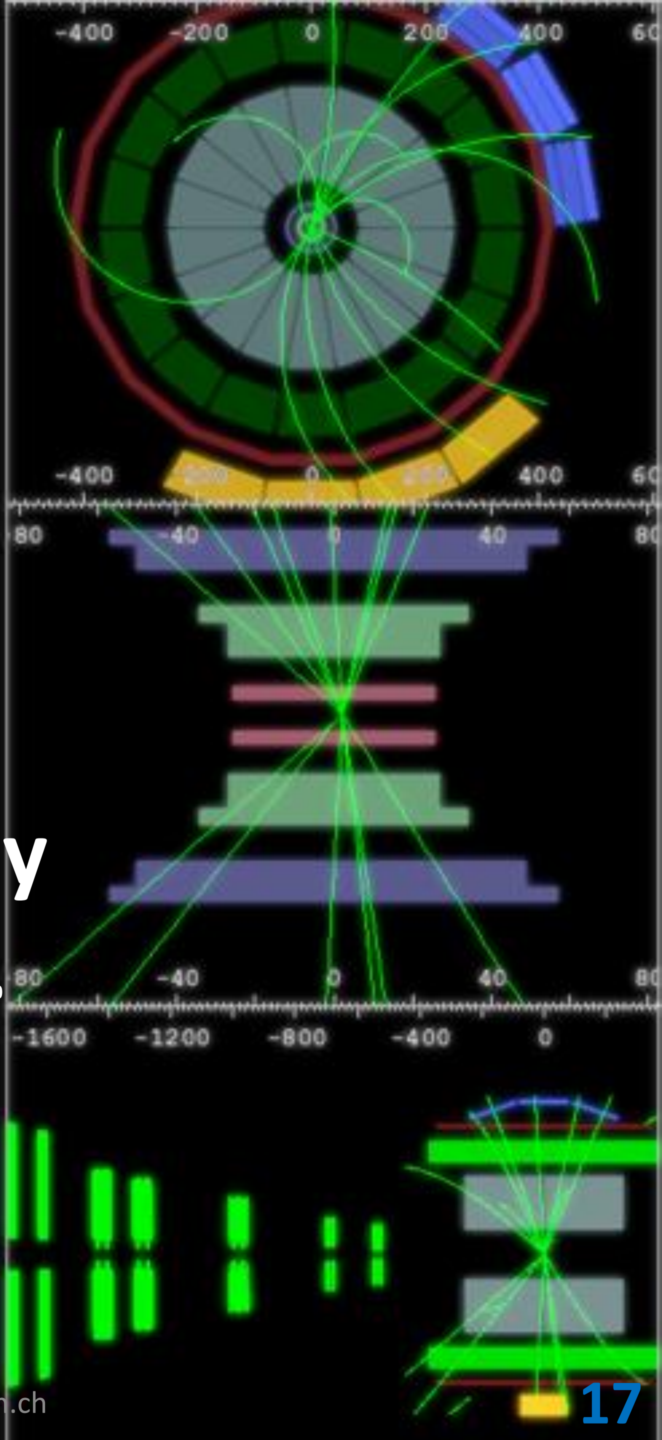
*General Characteristics of the AD Detector


LIVE
ALICE
2015-05-12 09:38:53
ADA
ADC
-400
-200
0
200
400
80
-40
0
40
-1600
-1200
-800
-400
0

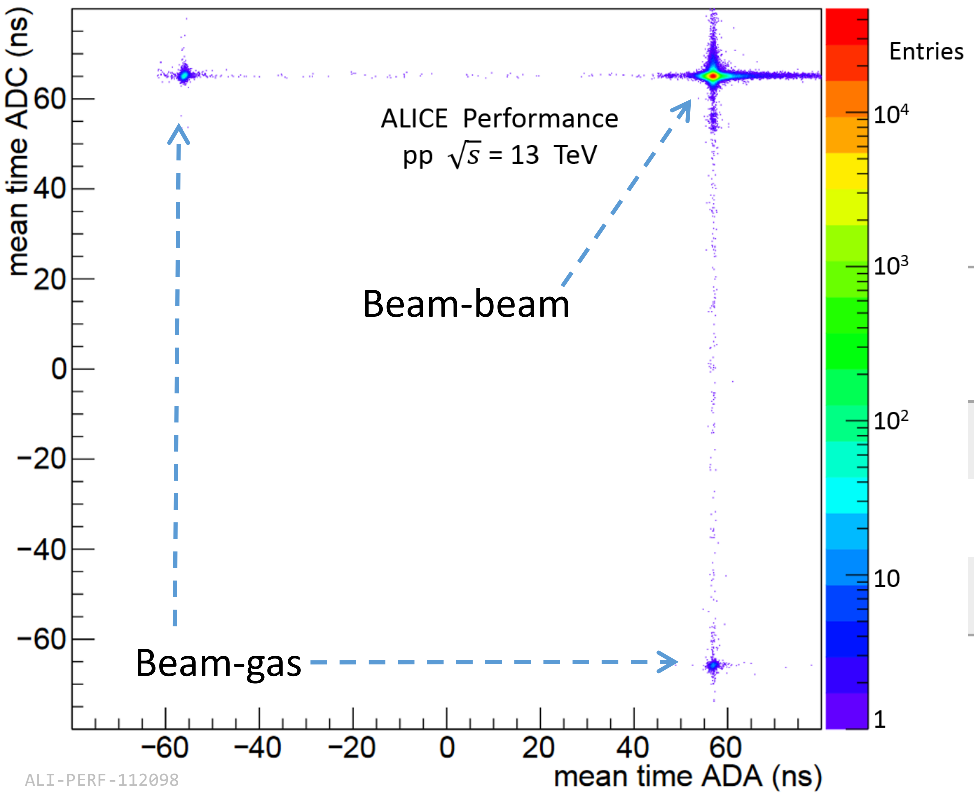
AD provides a level zero trigger signal which is crucial for diffractive cross section measurements.

It extends the pseudo rapidity gap trigger.

Additionally, AD provides an extended centrality trigger in both Pb-Pb and p-Pb collision studies.



The ALICE Diffractive detector – Data



The situation now

ALICE	-7.0 < η < -4.9, -3.7 < η < -1.7, |η| < 2, 1.7 < η < 6.3	M_x > 4 GeV (50%)
ATLAS	|η| < 3.8, 5.6 < |η| < 5.9	M_x > 7 GeV
CMS	|η| < 2.5, 3.0 < |η| < 5.2, -6.6 < η < -5.2	M_x > 16 GeV
TOTEM	3.1 < |η| < 4.7, 5.3 < |η| < 6.5	M_x > 3.4 GeV

- The mean time for ADA t_A (ADC t_C) is 56.9ns (65.1ns) with respect to the collision time. For single bunches in LHC, AD beam-gas background arrives $-t_A$ ($-t_C$). Resulting in an excellent rejection of beam background.

*General Characteristics of the AD Detector

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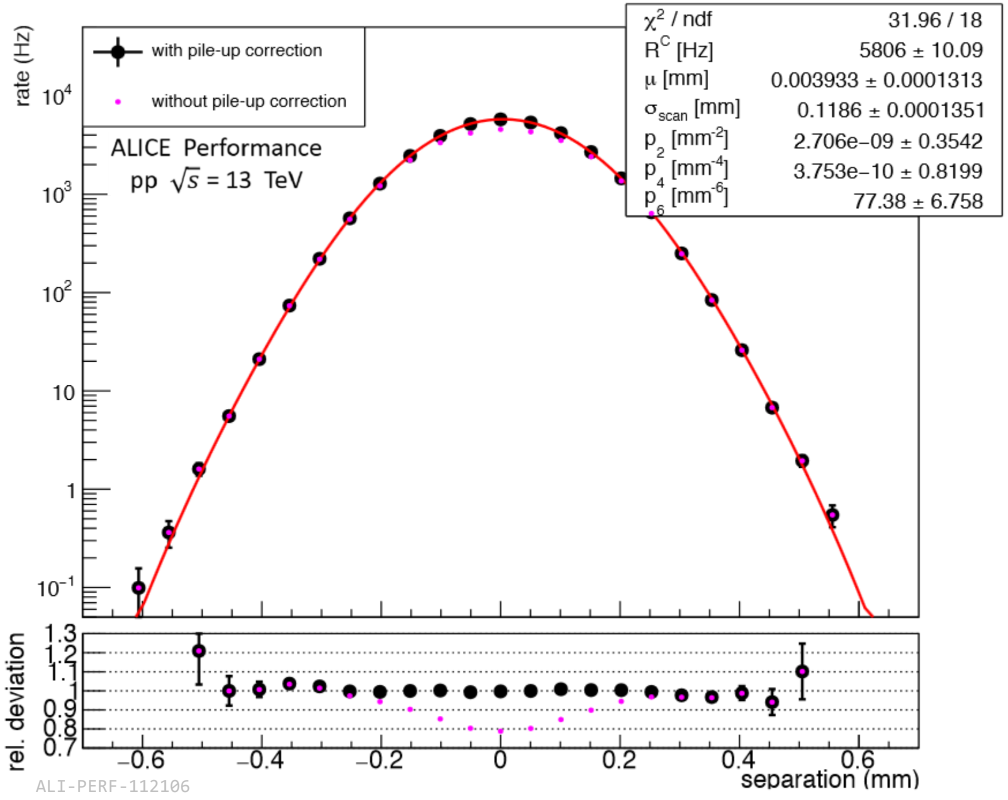
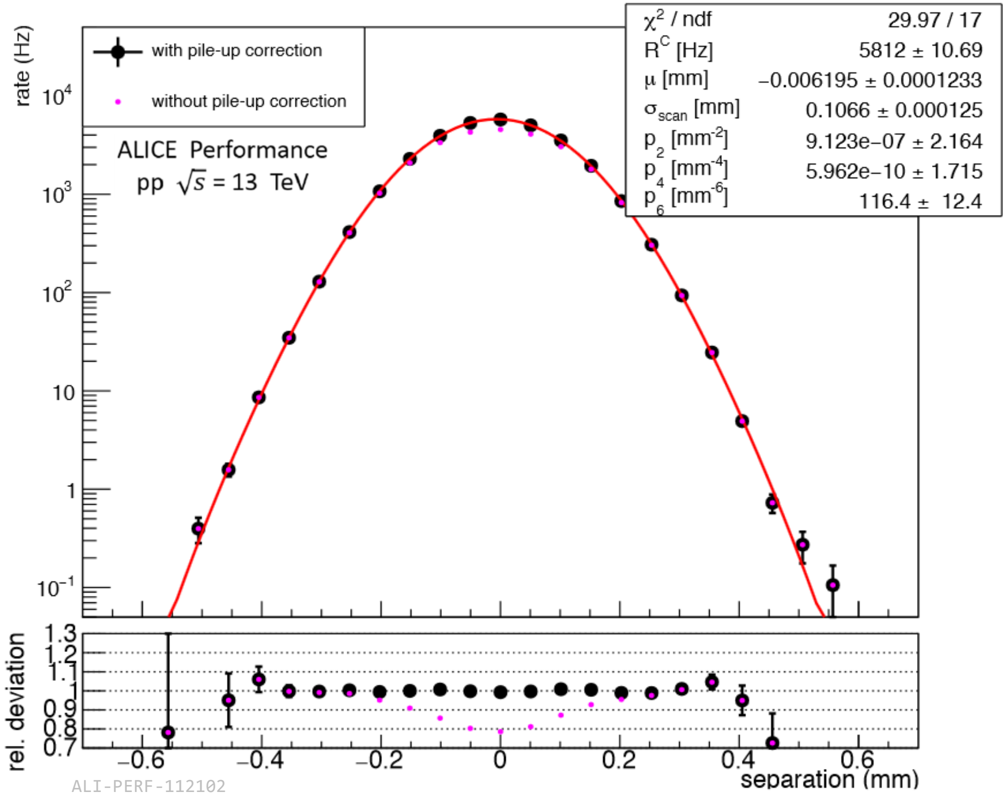
The ALICE Diffractive detector – van der Meer scan

- ➢ Trigger rate of AD_{AND} (coincidence between ADA and ADC triggers) in a single Bunch Crossing w.r.t. beam separation
- ➢ Background level is negligible





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Conclusions

- ALICE has measured inelastic, single and double diffractive cross sections at $\sqrt{s} = 7$ TeV using data collected in run 1.

- The ALICE Diffractive detector AD substantially increases the acceptance for diffractive physics. The range in pseudo-rapidity is extended from 8.8 to 12.1 units in η, which translates into an increased sensitivity for lower diffractive masses.

- AD performs very well (time resolution, beam background rejection, vdM) both in p-p and Pb-Pb.

- During Run-2, ALICE has collected a large sample of inclusive diffractive events and gap-gap triggers.

- **Ongoing** detailed studies on Central Production and Diffractive cross sections, **expect news soon.**