Investigating diffractive processes in the ALICE experiment at the LHC

XII Latin American Symposium on High Energy Physics

26th-30th November 2018
Lima, Perú

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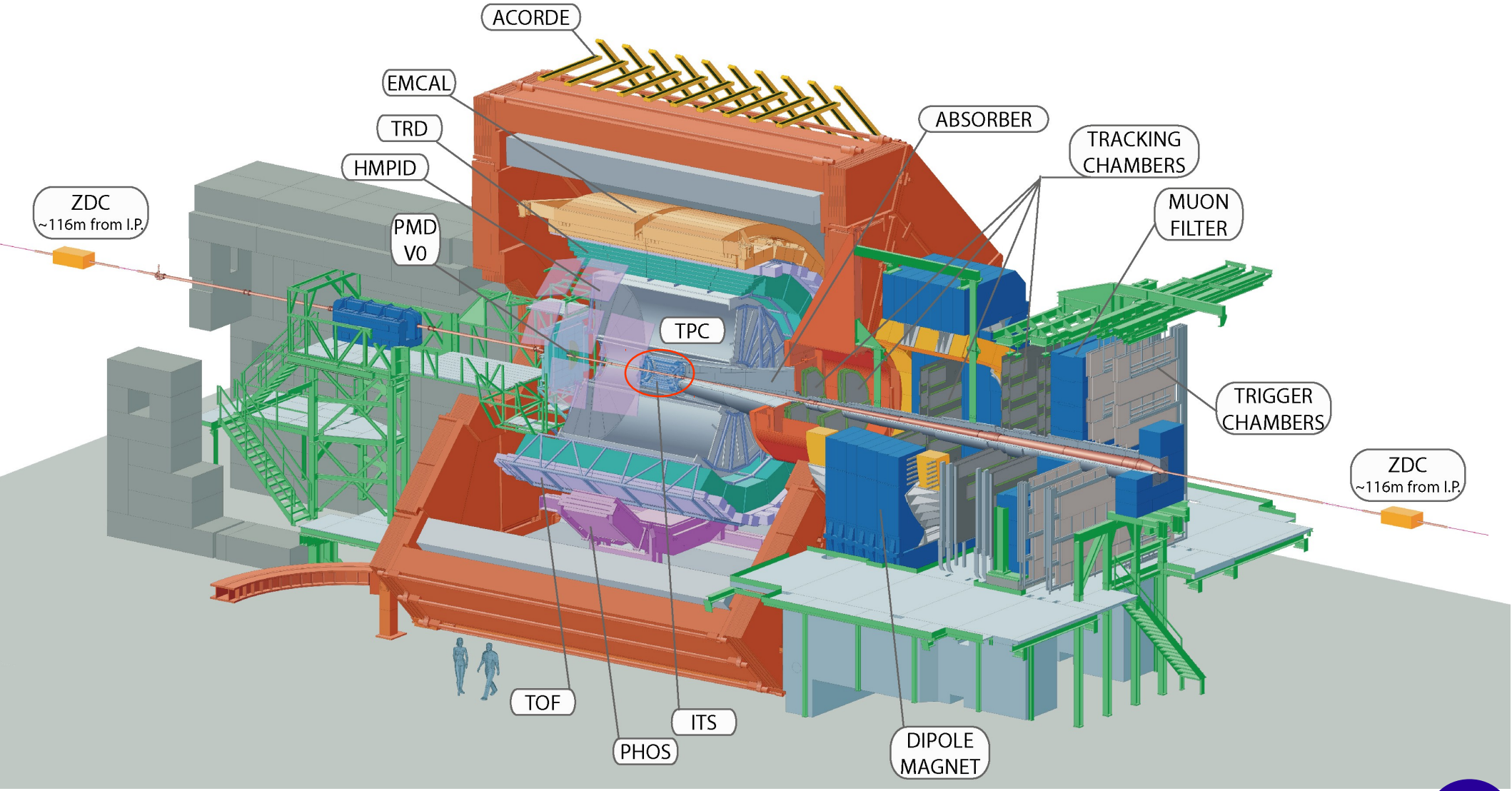
on behalf of the ALICE Collaboration
Pontificia Universidad Católica del Perú

ALICE detectors



Diffraction in Run I

$$\sigma_{total} = \sigma_{elastic} + \sigma_{Non\text{-}Diff} + \sigma_{SD} + \sigma_{DD} + \sigma_{CD}$$

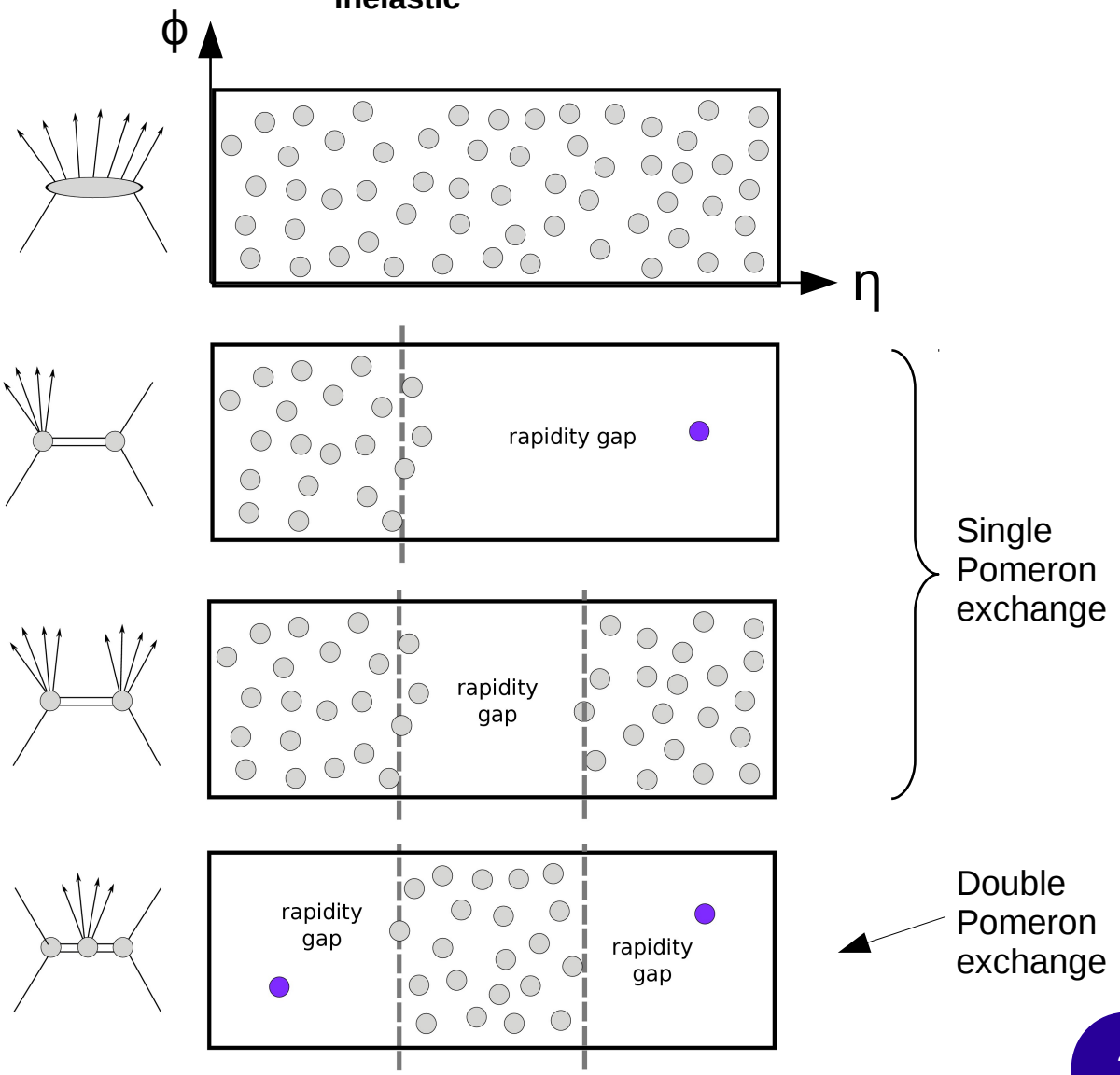
$$\sigma_{Inelastic}$$

Non diffractive event (ND). No gap

Single diffractive event (SD)

Double diffractive event (DD)

Central diffractive event (CD)

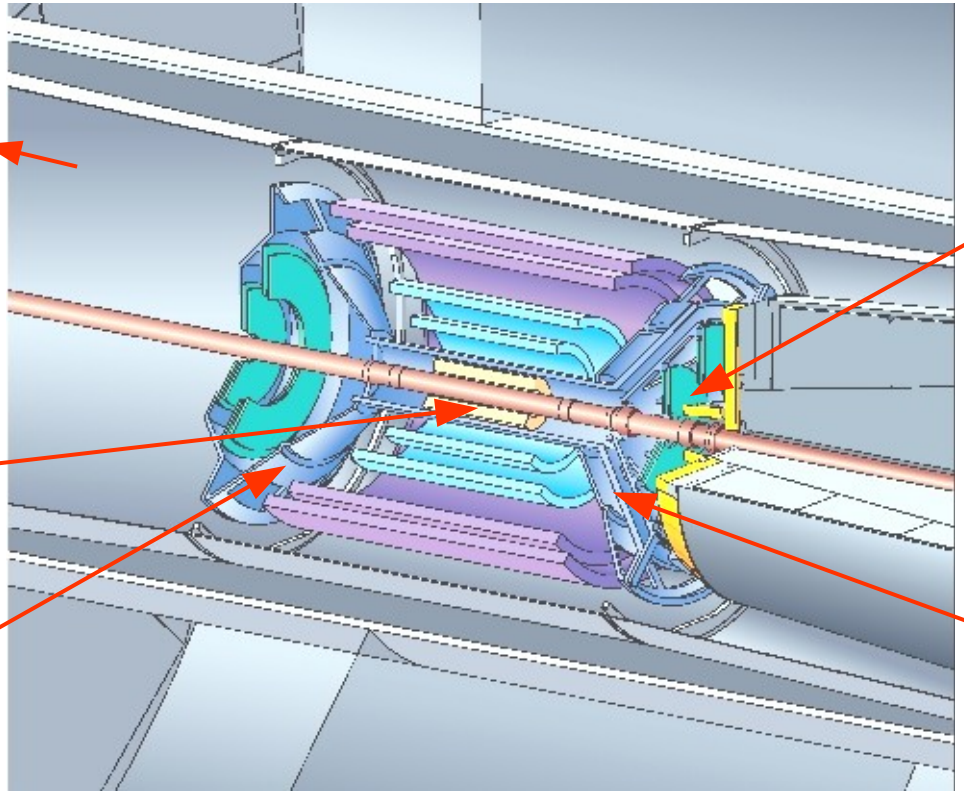


Diffraction in Run I

VZERO-A
scintillator tiles divided in 4 rings (δη=0.5) and 8 sectors in azimuth (δϕ=45°)

SPD
Silicon Pixel Detector (2 layers)

FMD-A
(silicon strip detectors)



VZERO-C
scintillator tiles divided in 4 rings (δη=0.5) and 8 sectors in azimuth (δϕ=45°)

FMD-C
(silicon strip detectors)

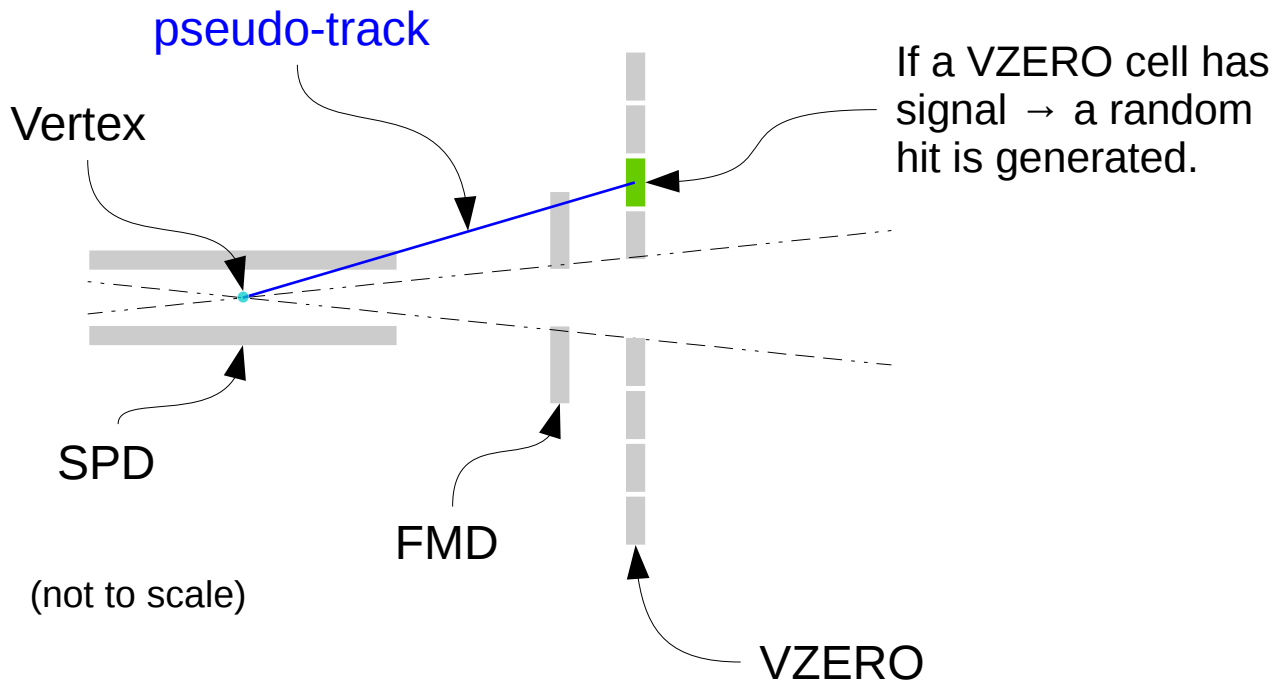
Diffraction in Run I

track → pseudo-track

Association of the reconstructed vertex with a hit in SPD, FMD or VZERO.

In 10% of cases there is no reconstructed vertex → A **random vertex is generated** from measured vertex distribution

VZERO
scintillator tiles divided in 4 rings (δη=0.5) and 8 sectors in azimuth (δϕ=45°)



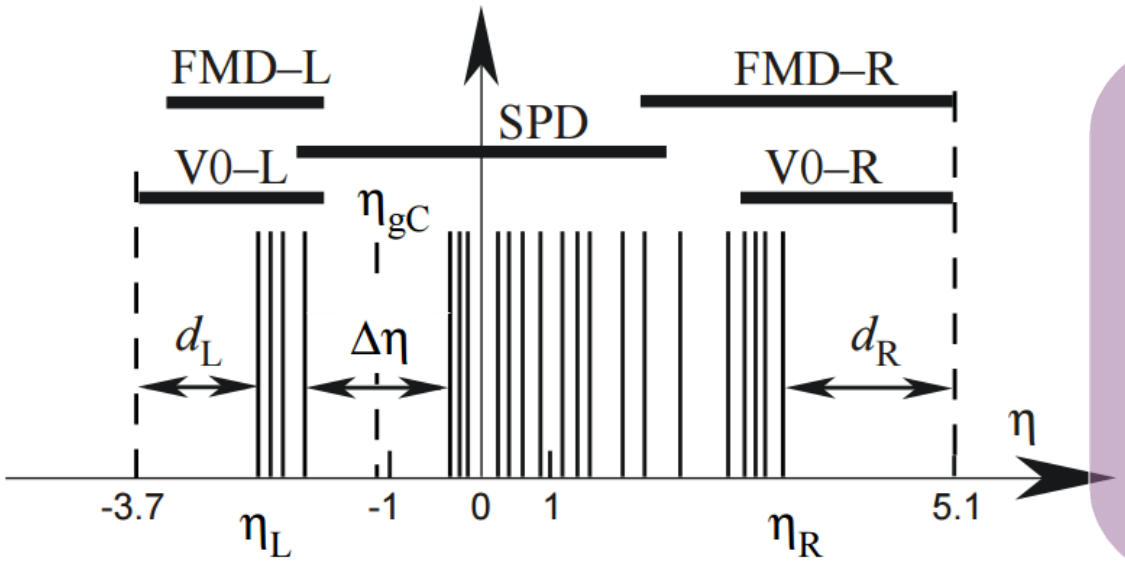
Diffraction in Run I

track ⟶ pseudo-track

Association of the reconstructed vertex with a hit in SPD, FMD or VZERO.

In 10% of cases there is no reconstructed vertex → A **random vertex is generated** from measured vertex distribution

VZERO
scintillator tiles divided in 4 rings ($\delta\eta=0.5$) and 8 sectors in azimuth ($\delta\phi=45°$)



"One-track" event → If all pseudo-tracks in event are confined to η_R-η_L < 0.5 and $\delta\phi=45°$ **(small fraction of events, resolution imposed by VZERO)**

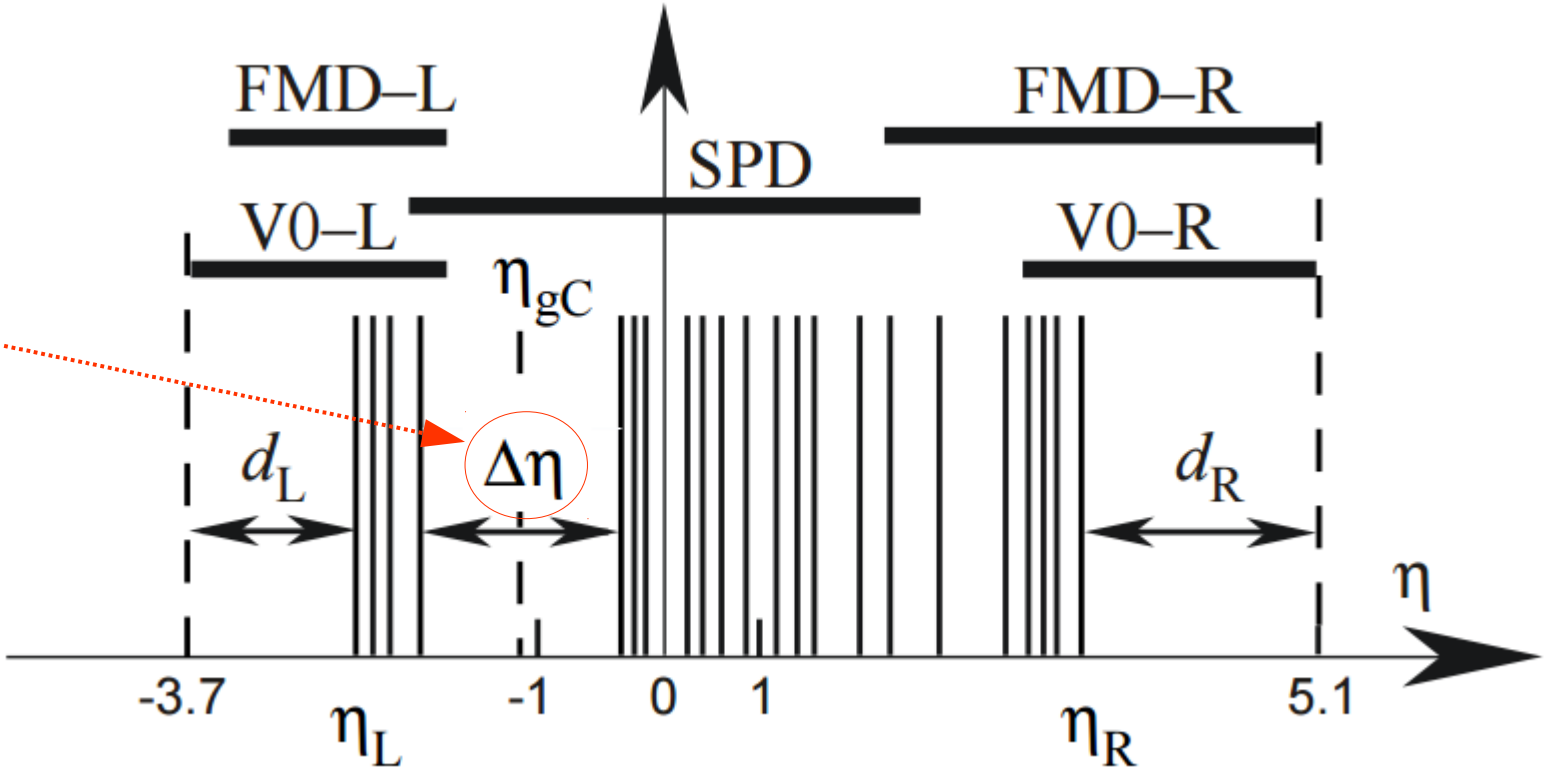
"Multi-track" event → All other events

Diffraction in Run I

There are 3 event categories:

1-arm-L → **SD-L** (left or $\eta<0$)
1-arm-R → **SD-R** (right or $\eta>0$)
2-arm → **ND** and **DD** events

DD: 2-Arm and $\Delta\eta>3$



Diffraction in Run I: Classification procedure

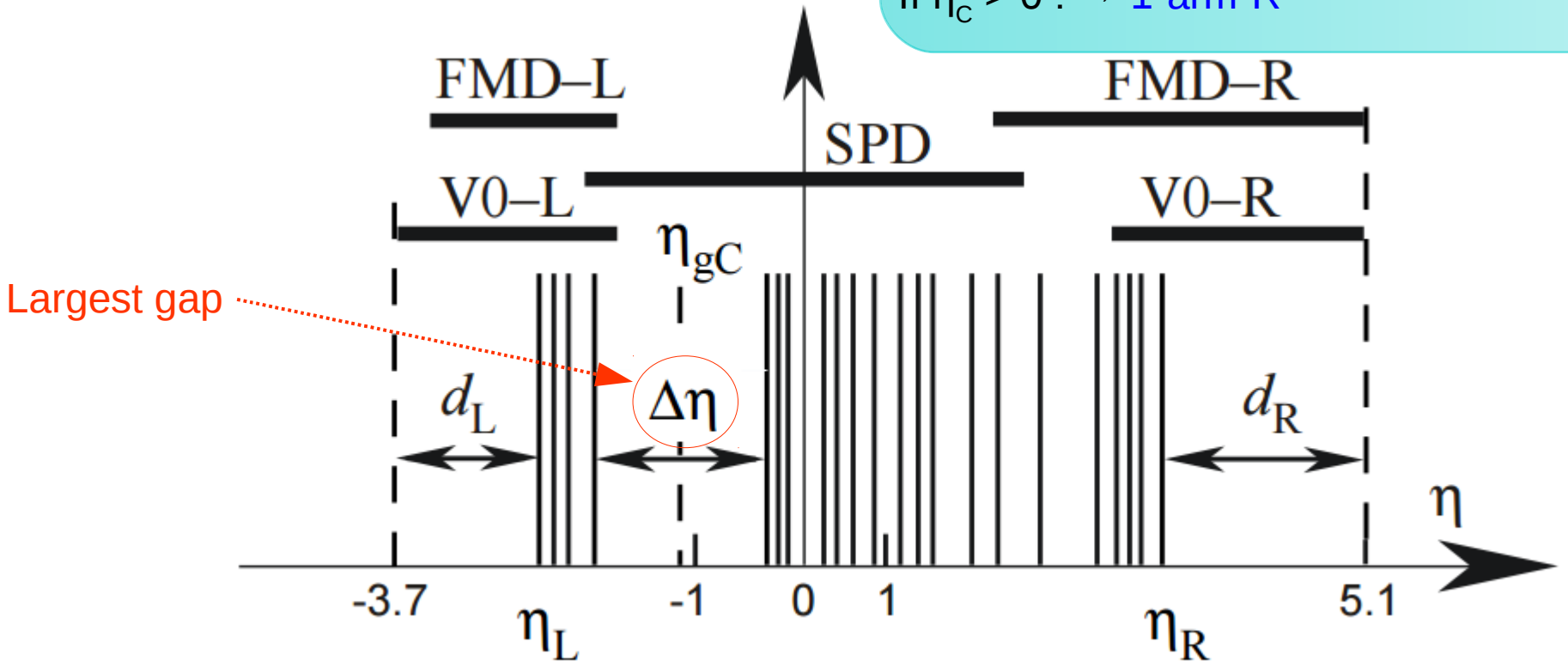
There are 3 event categories:
1-arm-L for **SD-L** (left or $\eta<0$)
1-arm-R for **SD-R** (right or $\eta>0$)
2-arm for ND and DD events

DD: 2-Arm and $\Delta\eta>3$

One-track event:
all events satisfying the condition $(\eta_R-\eta_L) < 0.5$ and having all pseudo-tracks within 45° in ϕ.
(small fraction of events, resolution set by VZERO)

For them we use:

$\eta_C = 1/2(\eta_L + \eta_R)$
If $\eta_C < 0$: → 1-arm-L
If $\eta_C > 0$: → 1-arm-R



Diffraction in Run I: Classification procedure

There are 3 event categories:

1-arm-L for **SD-L** (left or $\eta<0$)
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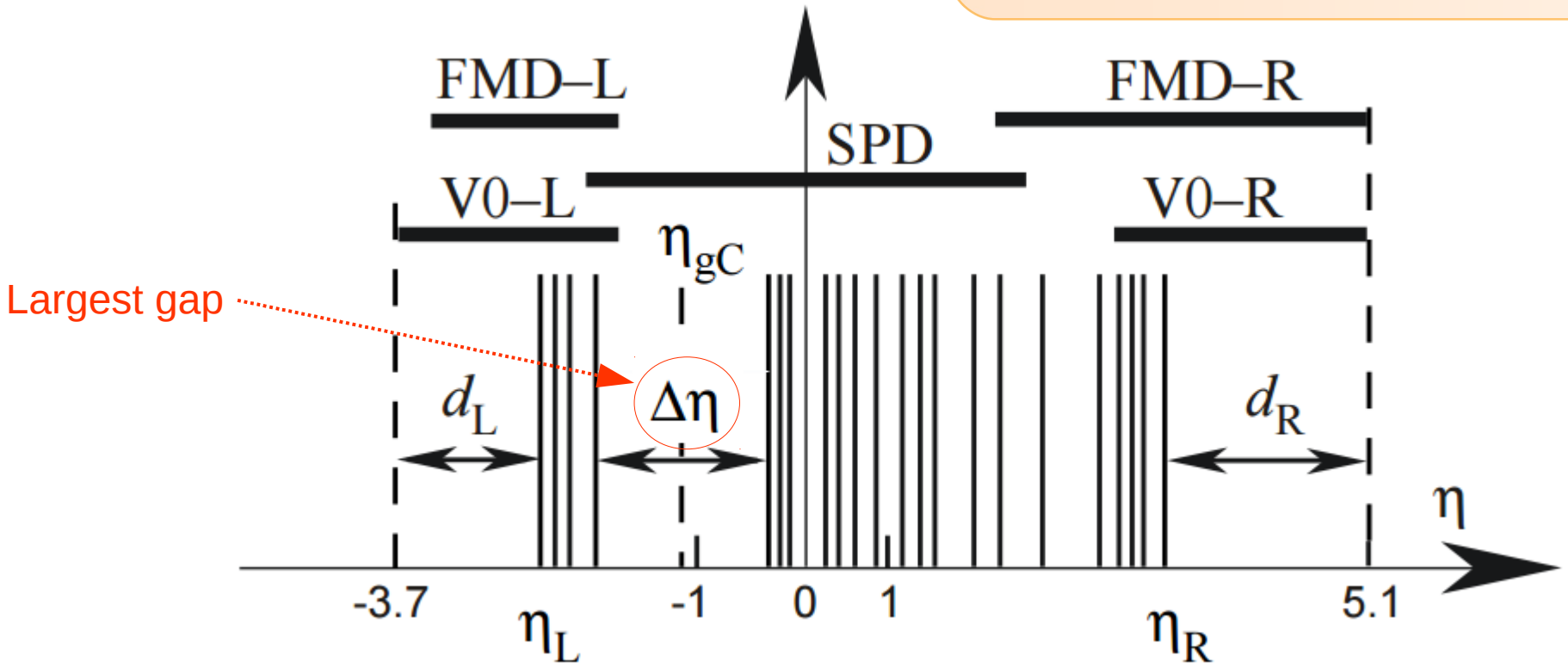
2-arm for ND and DD events

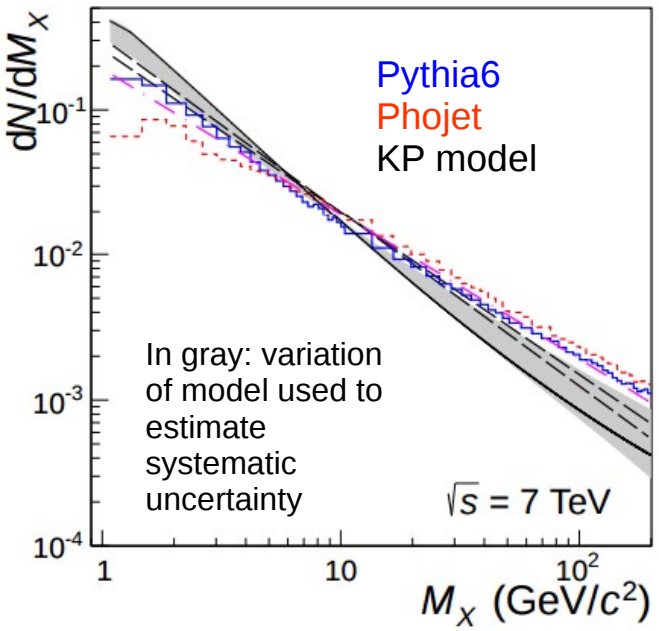
DD: 2-Arm and $\Delta\eta>3$

Multi-track event:

If $\Delta\eta$ is larger than d_R and d_L → 2-arm
If **$-1<\eta<1$** for all pseudo-tracks → 2-arm
else,
If **$\eta_R<1$** → 1-arm-L
If **$\eta_L>-1$** → 1-arm-R
Any remaining events → 2-arm



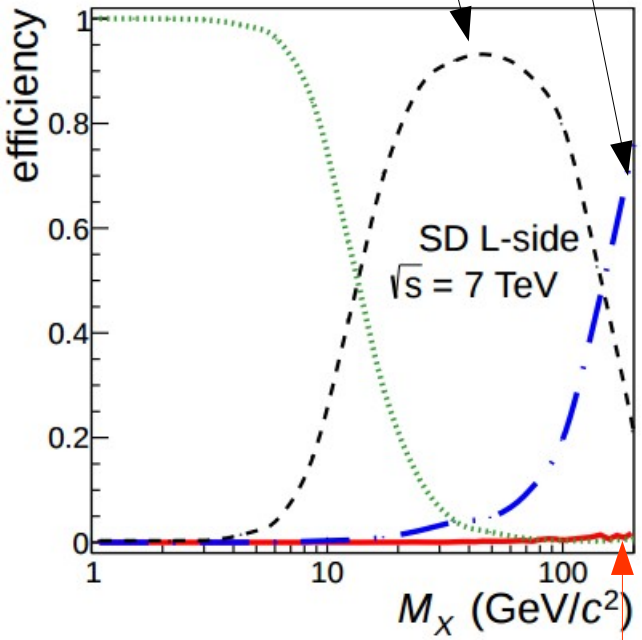
Diffraction in Run I: Arm Efficiency



Diffractive-mass distributions, normalized to unity, for the SD process in pp collisions (7 TeV)

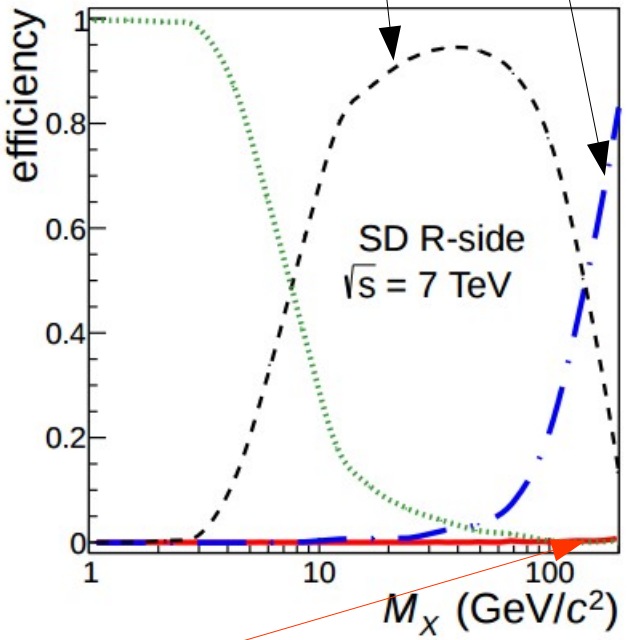
2-arm efficiency

1-arm-L efficiency



2-arm efficiency

1-arm-R efficiency



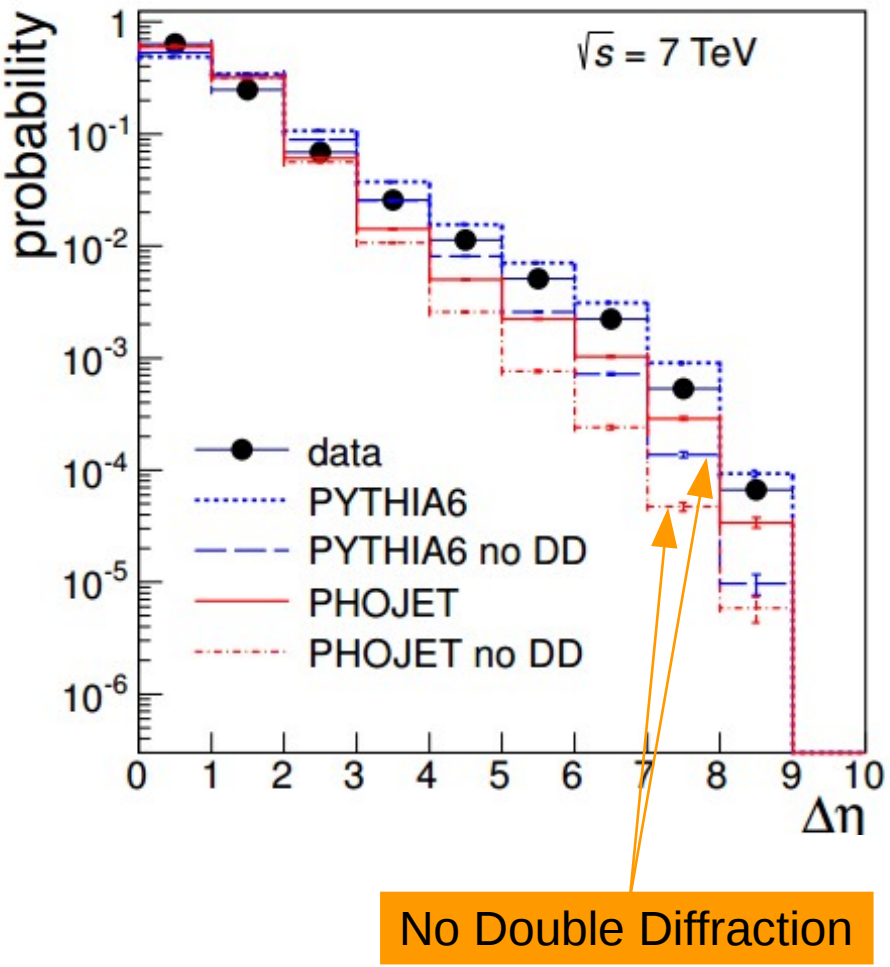
Opposite side efficiency

ALICE: Eur.Phys.J. C73 (2013) no.6, 2456

Diffraction in Run I: MC adjustment

ALICE: Eur.Phys.J. C73 (2013) no.6, 2456

Largest gap distribution:
Comparison between data and MC with and **without** double-diffraction



Diffraction in Run I: MC adjustment

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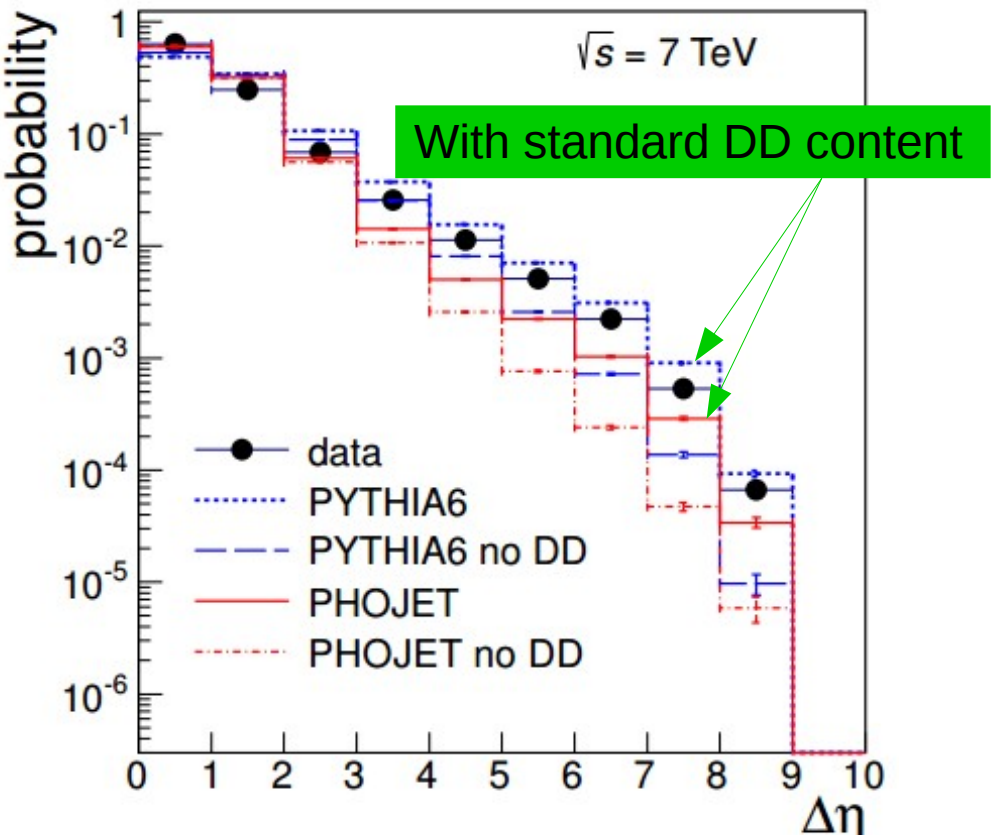
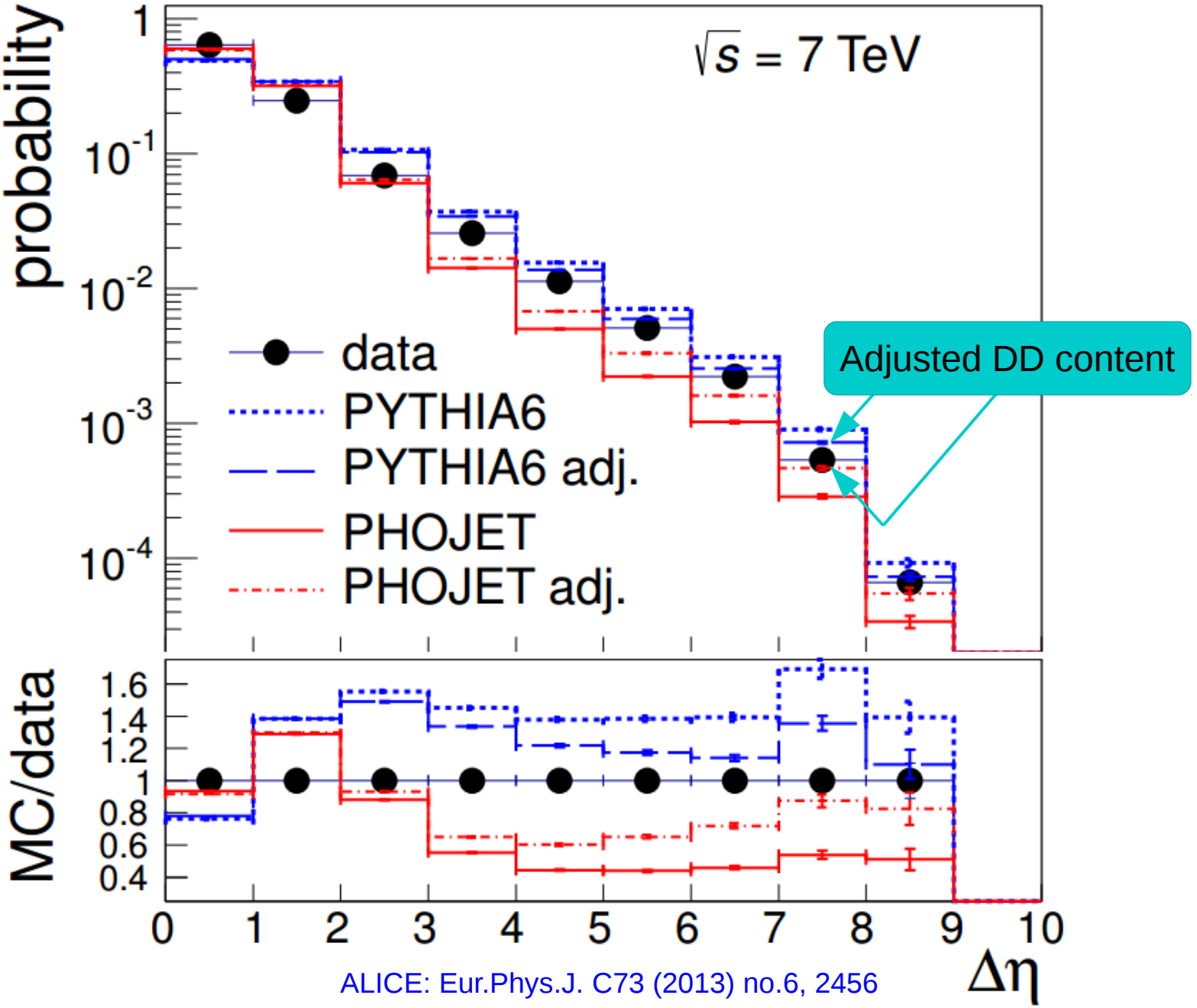
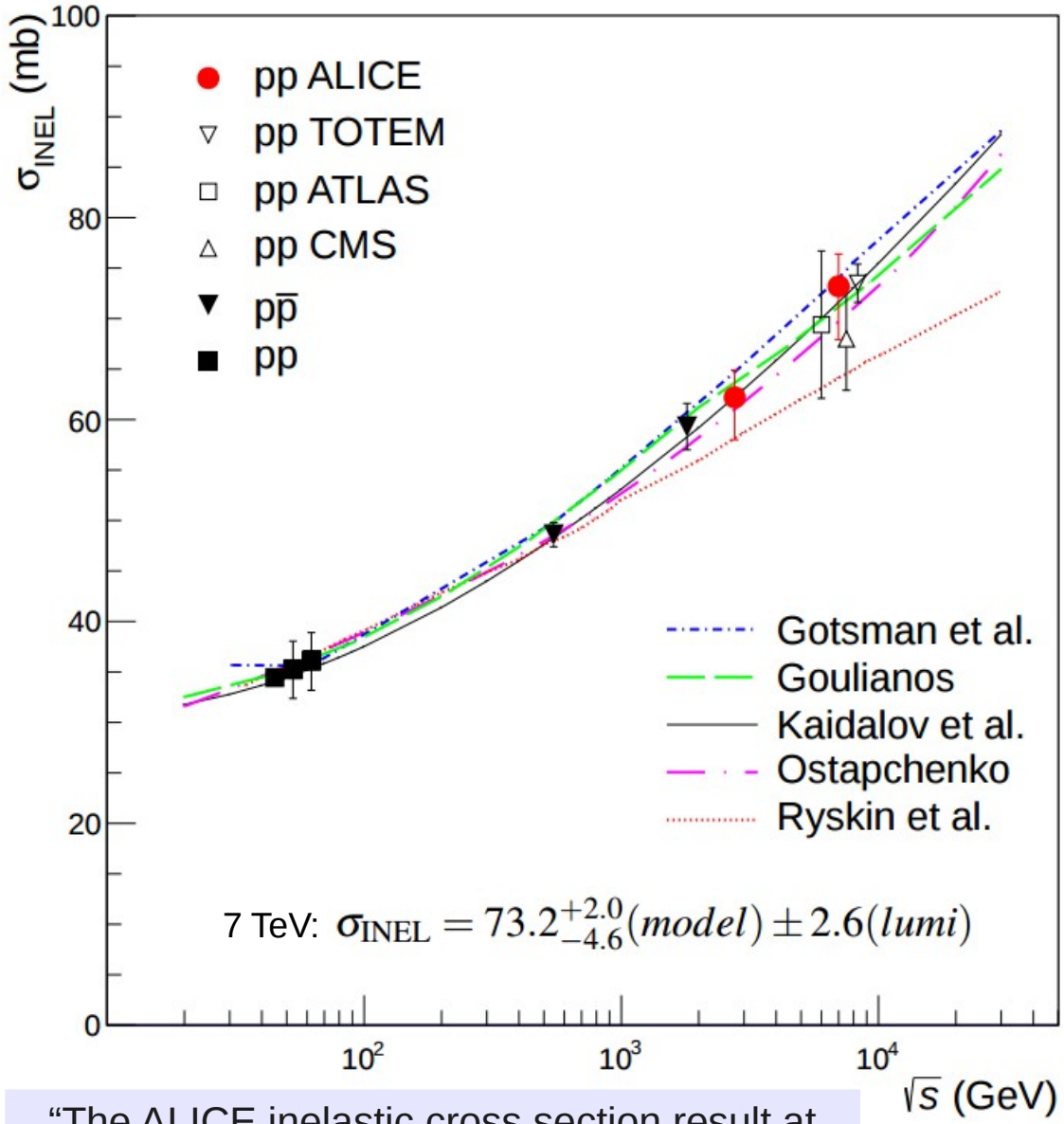


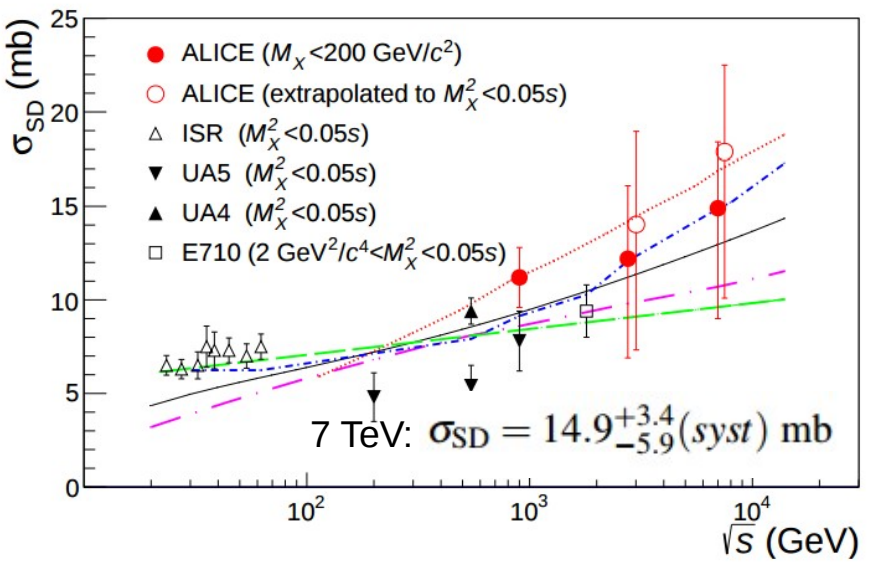
Diffraction in Run I: MC adjustment

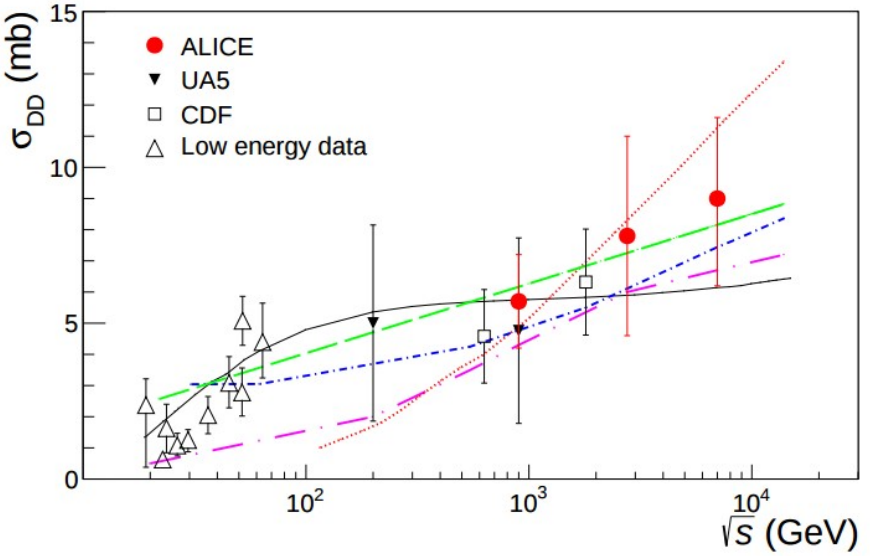


ALICE: Eur.Phys.J. C73 (2013) no.6, 2456

Diffraction in Run I: Results





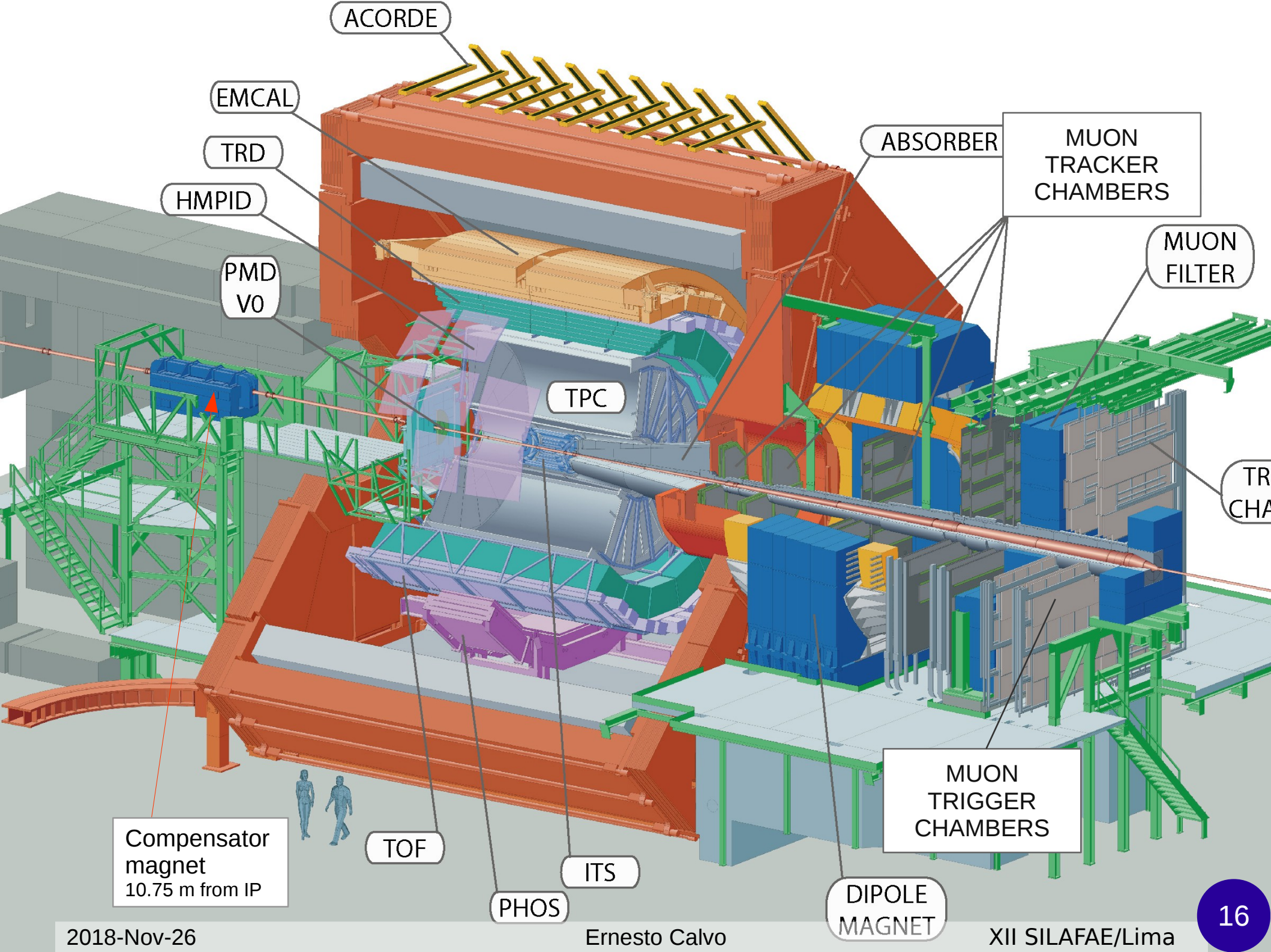


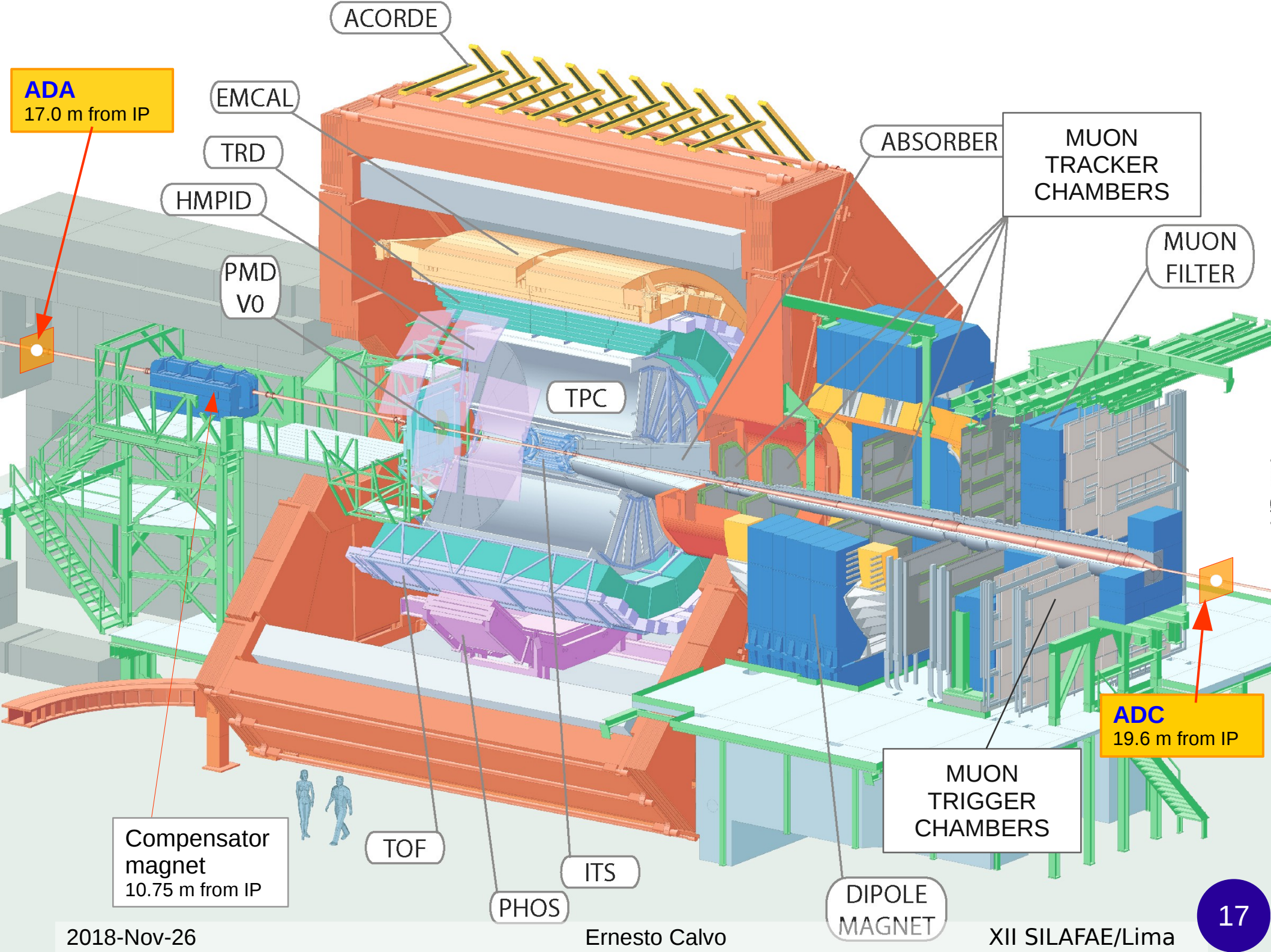
"The ALICE inelastic cross section result at √s = 7 TeV is consistent with those from ATLAS, CMS, and TOTEM"

ALICE: Eur.Phys.J. C73 (2013) no.6, 2456

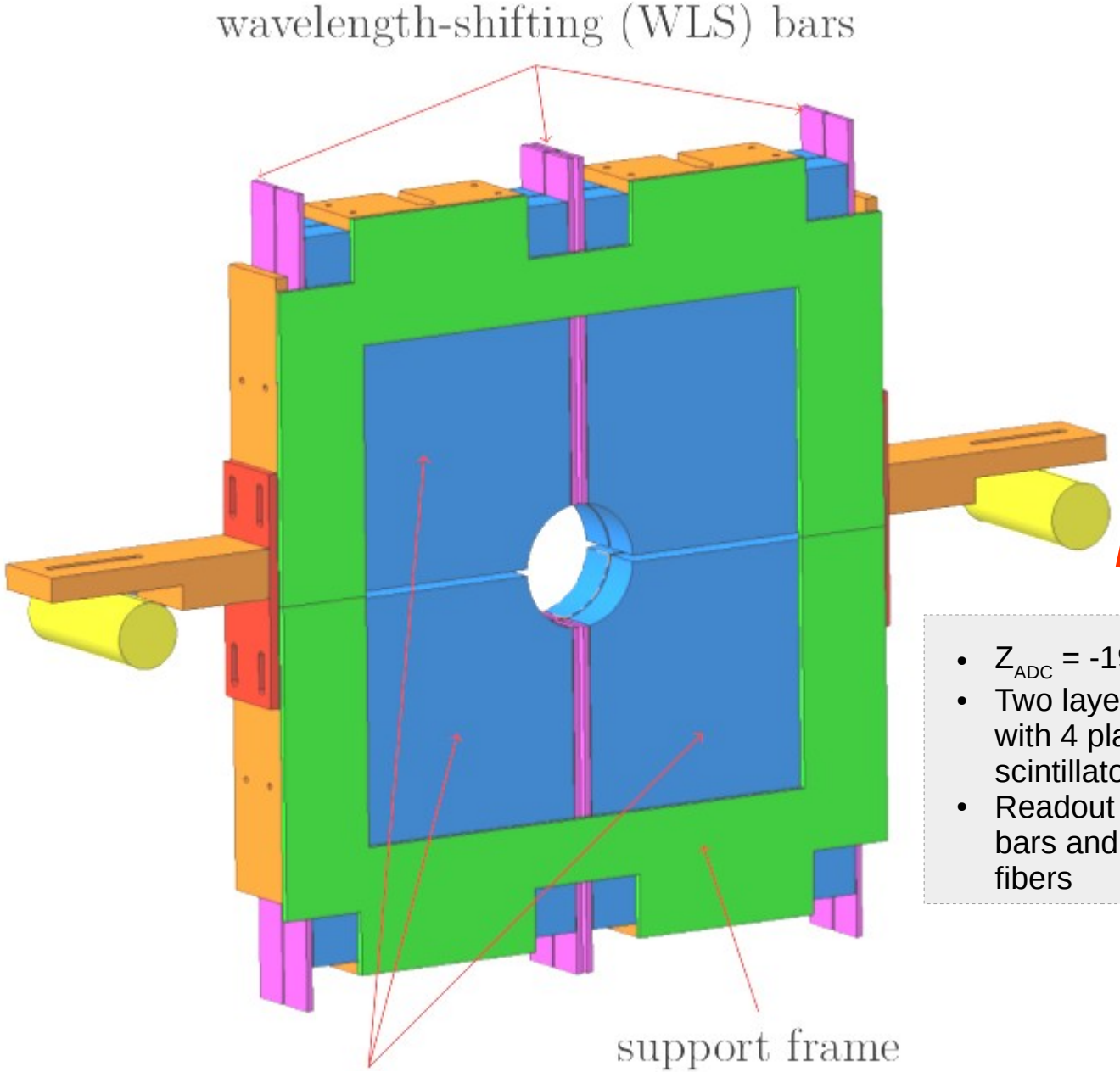
Diffraction in Run II

- At the end of Run I the **ALICE Diffractive** detector (**AD**) was installed and commissioned, with the aim of increasing the pseudorapidity coverage and the sensitivity of ALICE to low mass diffractive systems.
- Two stations, ADA and ADC, located at z=-19.6 and z=17.0 meters respectively from the interaction point (IP).


ACORDE
EMCAL
TRD
HMPID
PMD
V0
TPC
ABSORBER
MUON
TRACKER
CHAMBERS
MUON
FILTER
TR
CHA
MUON
TRIGGER
CHAMBERS
Compensator
magnet
10.75 m from IP
TOF
ITS
PHOS
DIPOLE
MAGNET

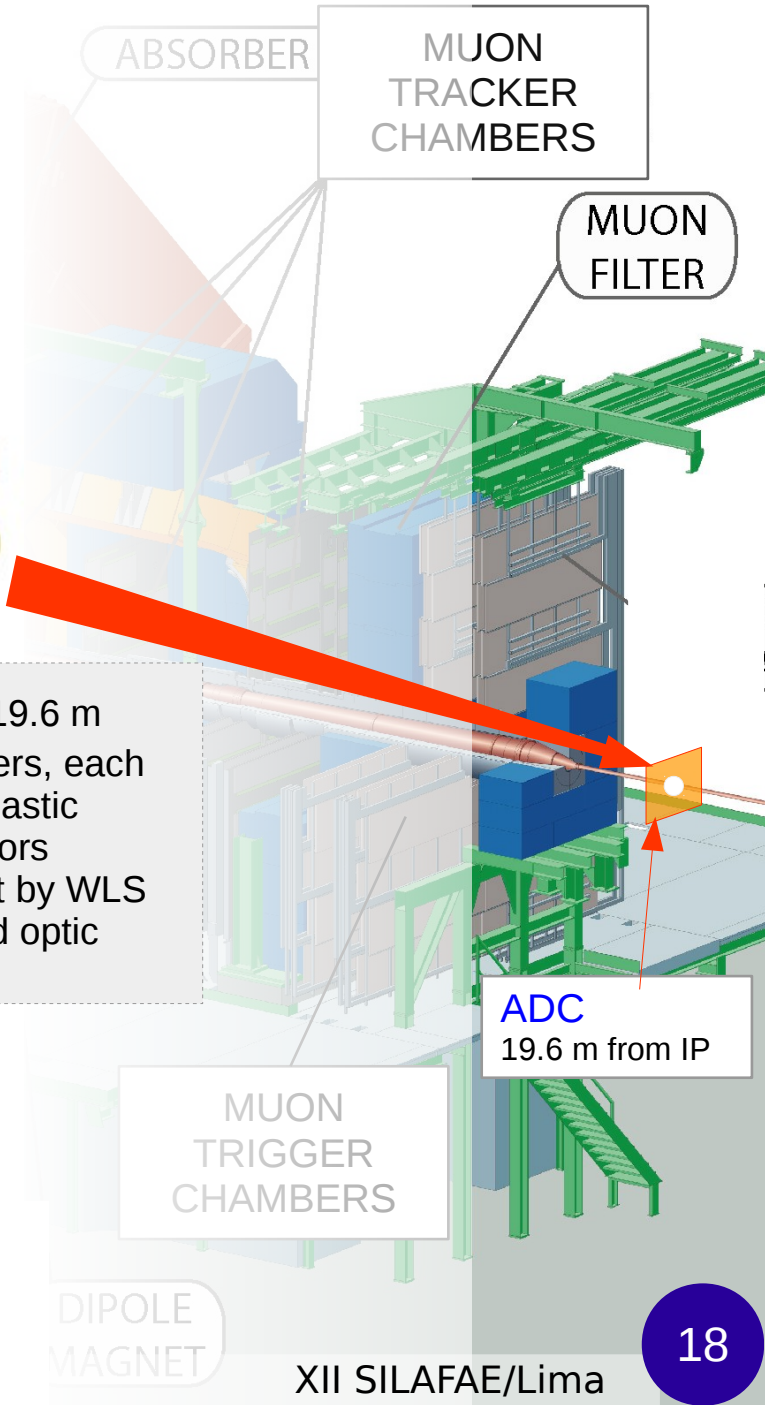

ACORDE
ADA
17.0 m from IP
EMCAL
TRD
HMPID
PMD
V0
ABSORBER
MUON
TRACKER
CHAMBERS
MUON
FILTER
TPC
ADC
19.6 m from IP
MUON
TRIGGER
CHAMBERS
Compensator
magnet
10.75 m from IP
TOF
ITS
PHOS
DIPOLE
MAGNET

ADC Detector

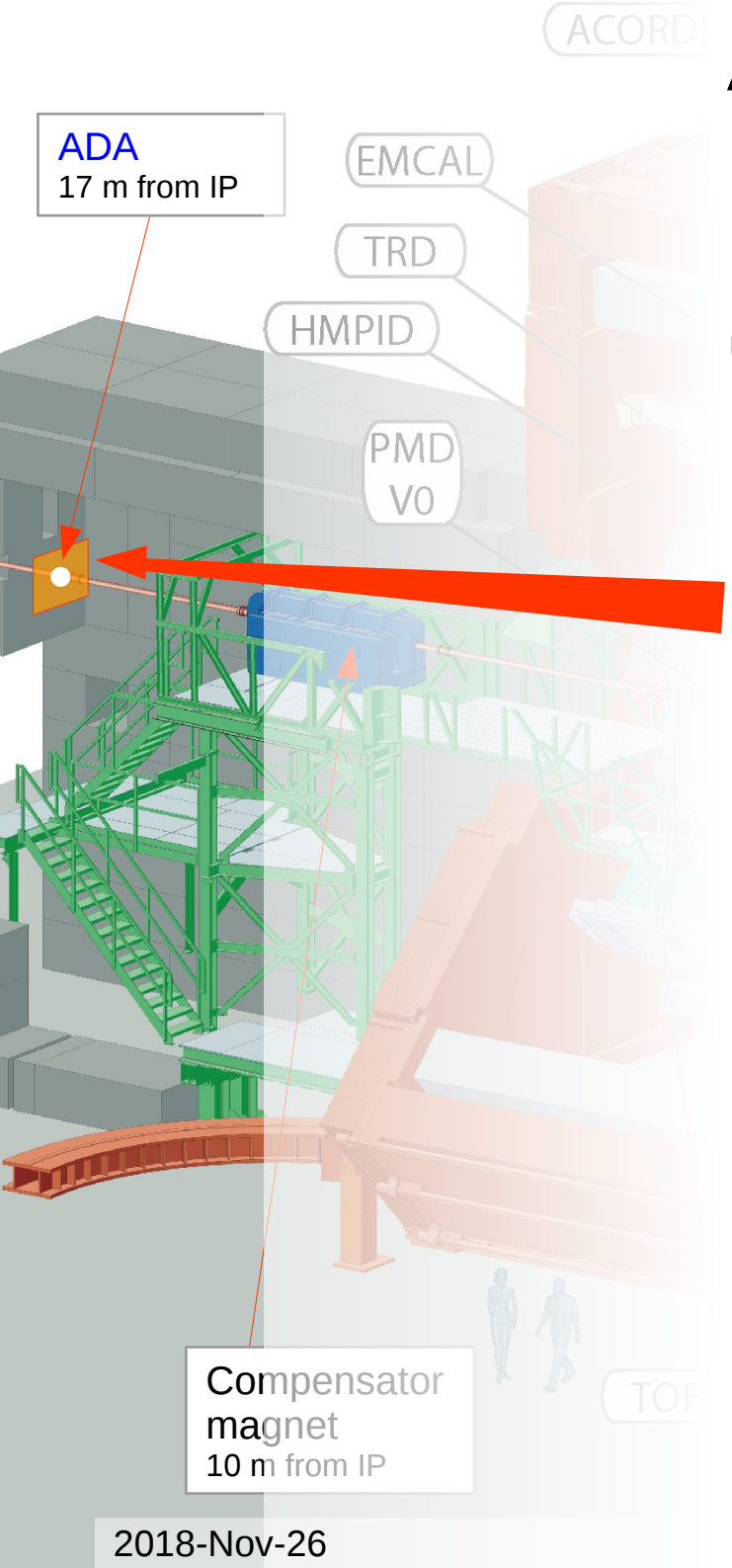


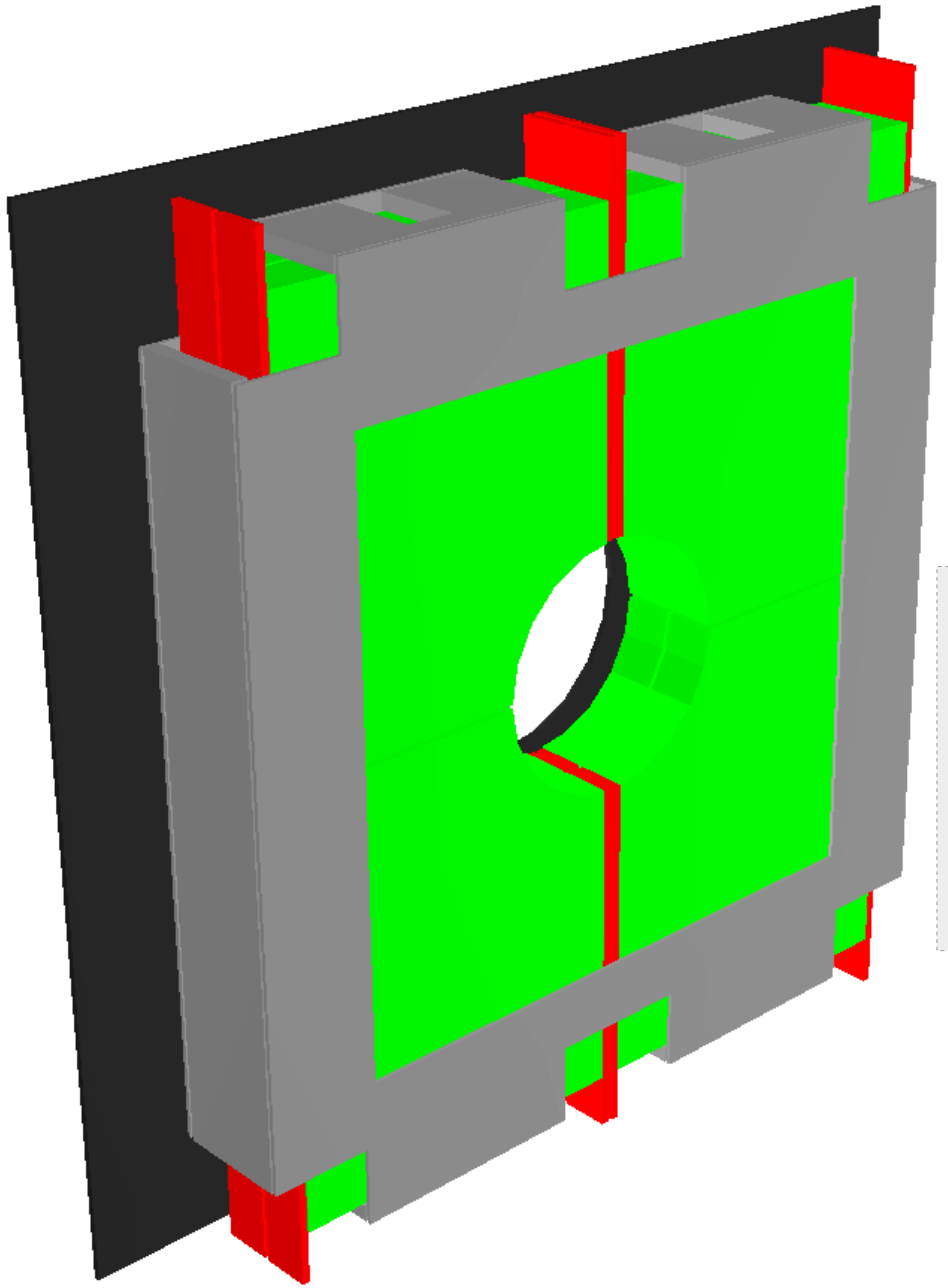
Scintillator pads

- Z_{ADC} = -19.6 m
- Two layers, each with 4 plastic scintillators
- Readout by WLS bars and optic fibers



ADA Detector

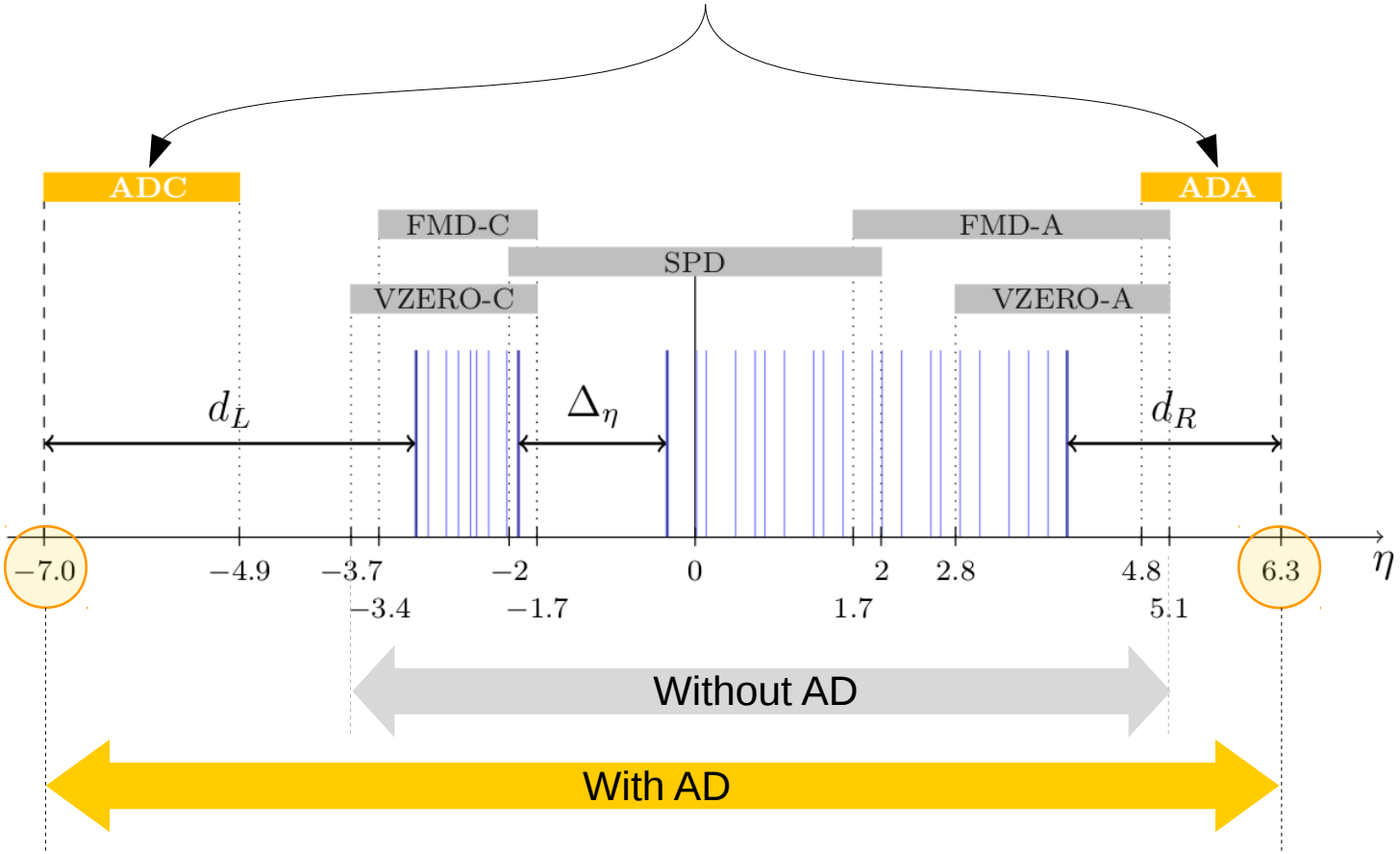




- Z_{ADA} = +17.0 m
- Two layers, each with 4 plastic scintillators
- Readout by WLS bars and optic fibers

AD Performance

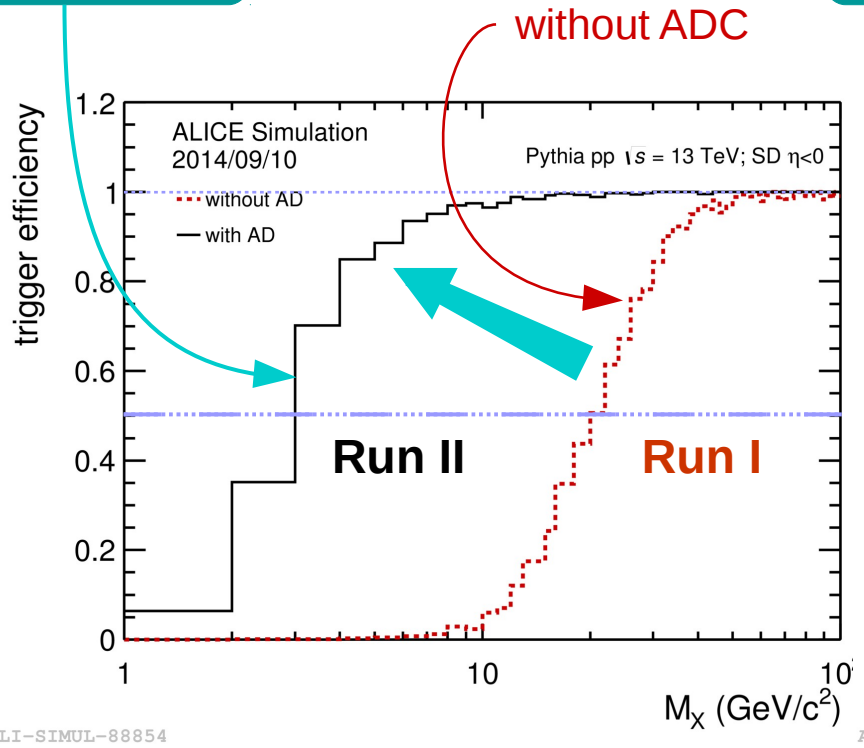
ADA and ADC extend the pseudorapidity coverage of ALICE.



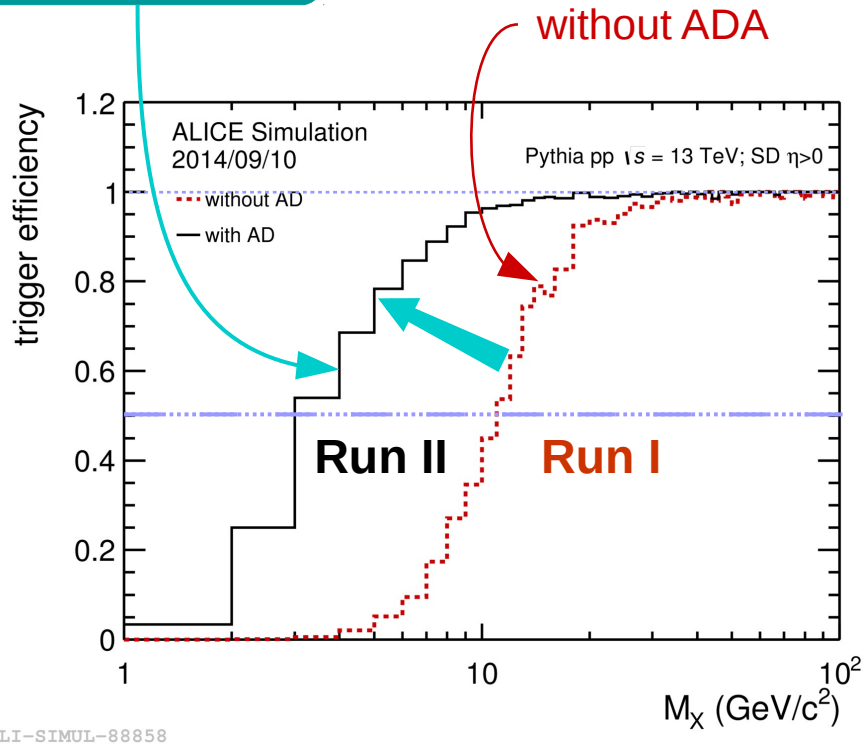
AD Performance

AD improves trigger efficiency for diffractive events at low diffracted masses.

Improvement with ADC



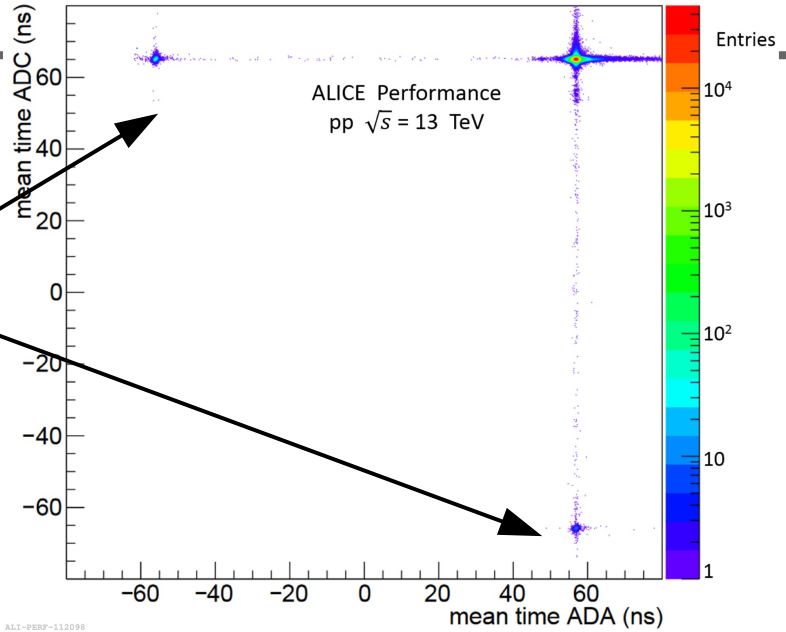
Improvement with ADA



Run I :	MB_{OR} = V0C + SPD + V0A
Run II:	MB_{OR} = **ADC** + V0C + SPD + V0A + **ADA**

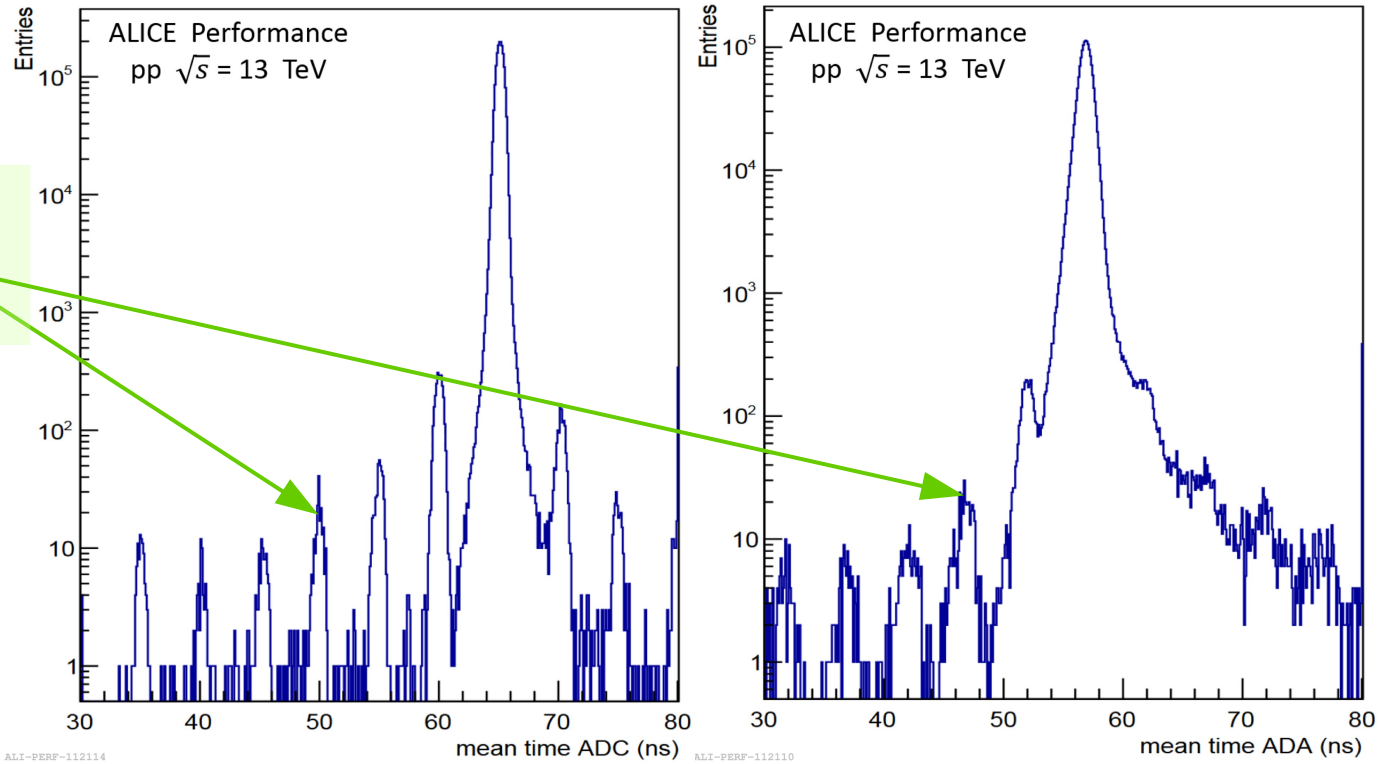
AD Performance

Excellent Beam-Gas separation



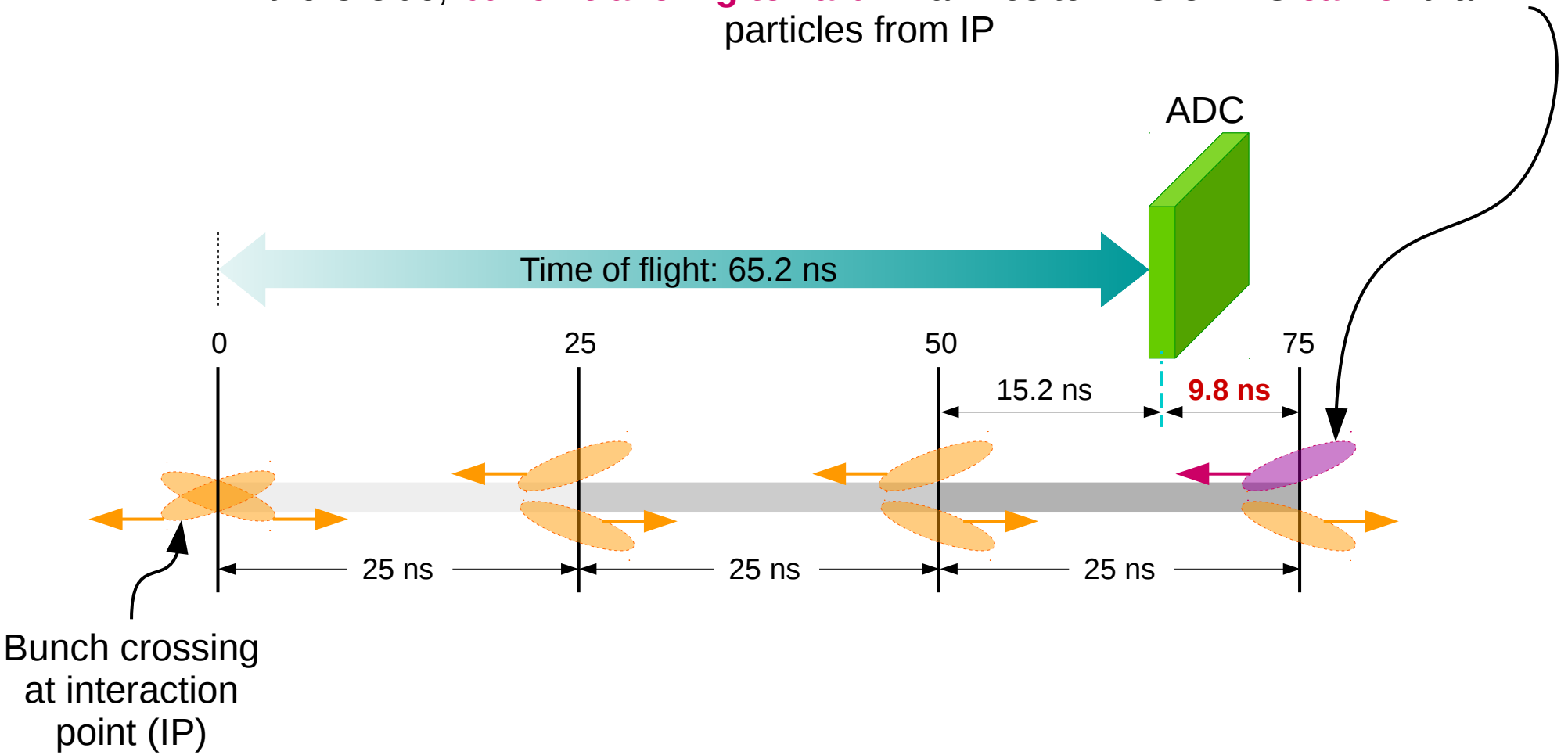
General characteristics of the AD detector

Highly sensitive:
Satellites are clearly visible



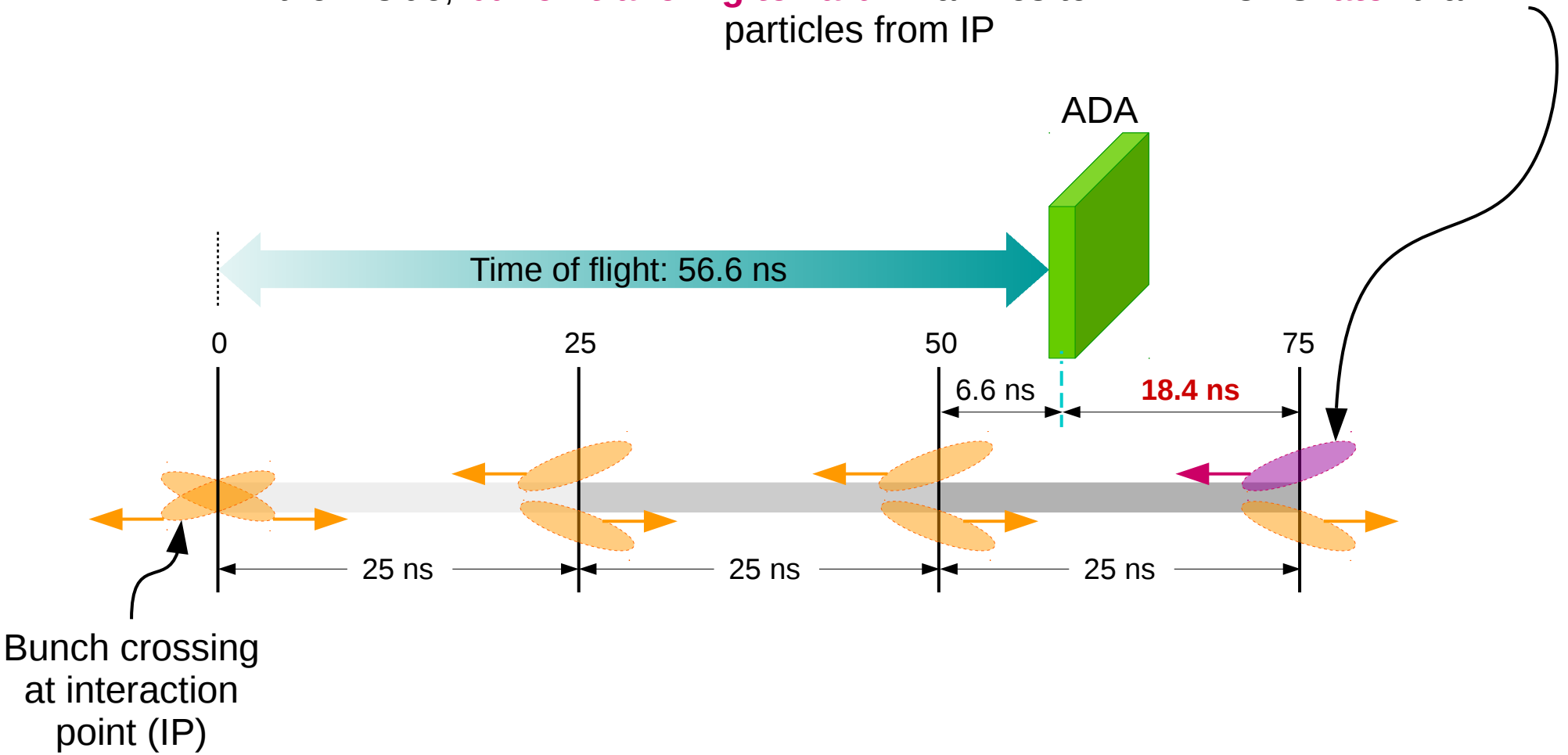
Excellent Beam-Gas rejection

In the C-side, **bunch traveling toward IP** arrives to ADC **5.4 ns earlier** than particles from IP



Excellent Beam-Gas rejection

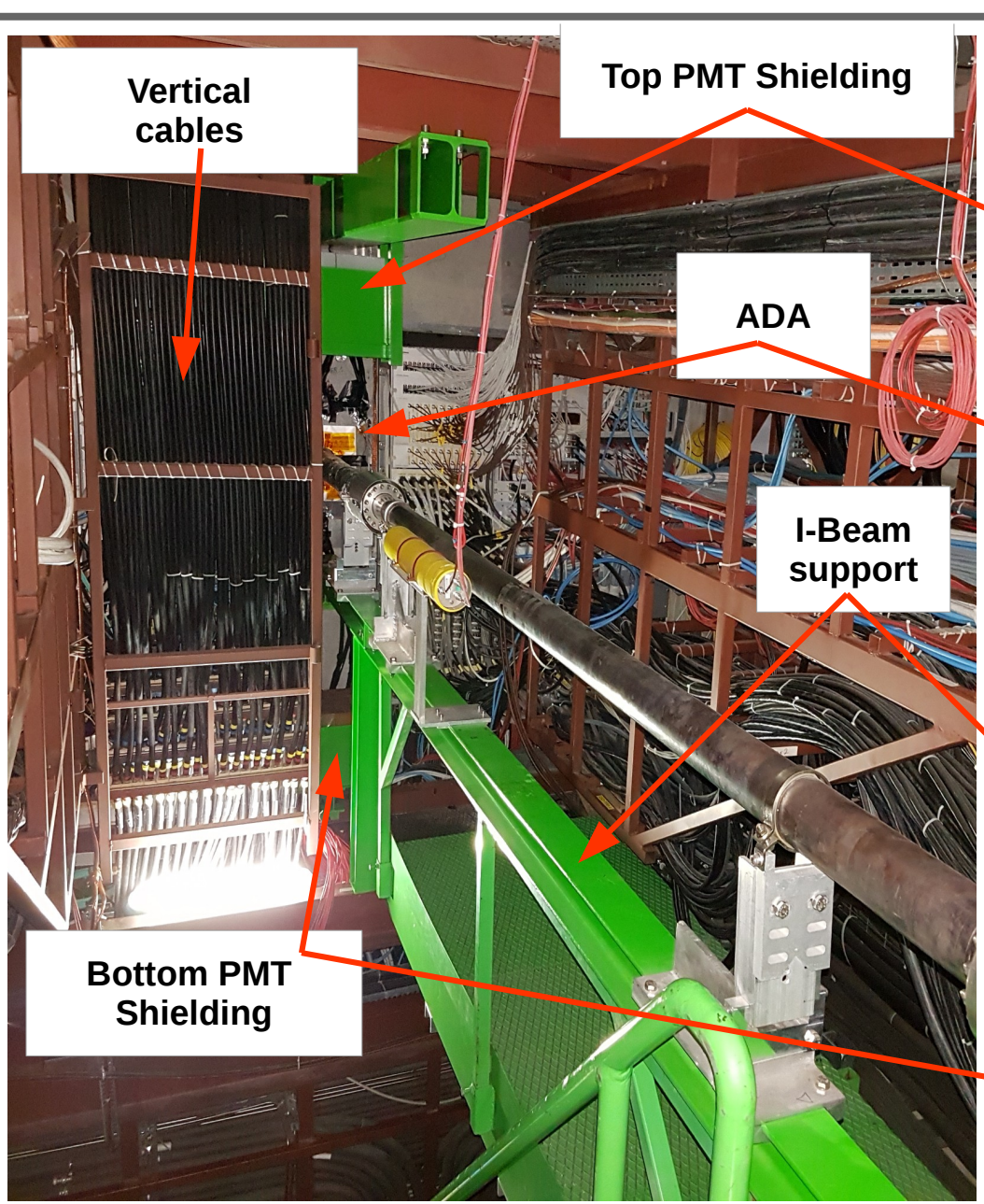
In the A-side, **bunch traveling toward IP** arrives to ADA **11.8 ns later** than particles from IP

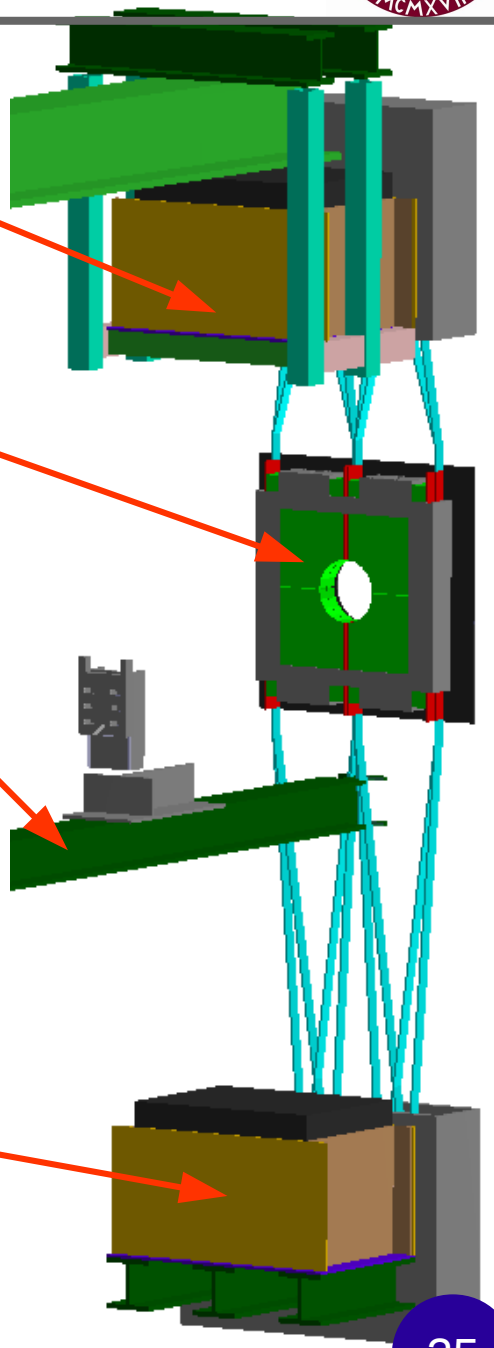


Improvements to AD

Left: Iron Shielding was added in front of the PMT boxes to protect the PMTs from direct particles hits, improving AD signal.

Right: AD Simulation correspondingly updated.

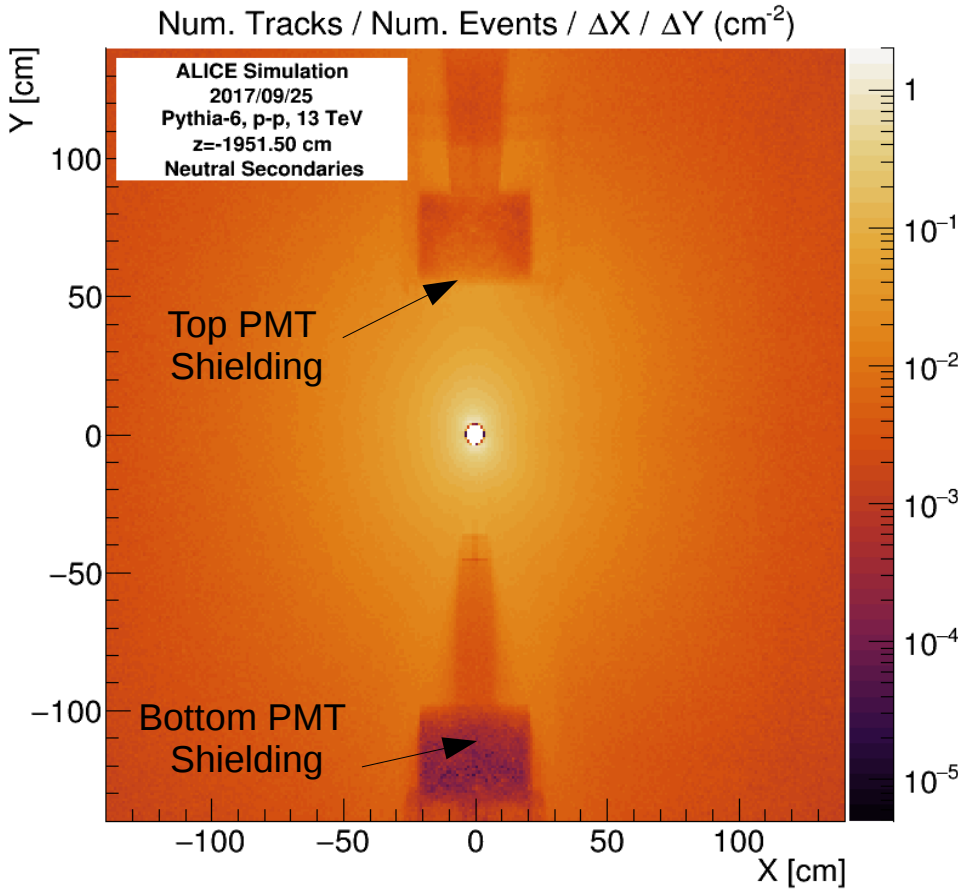


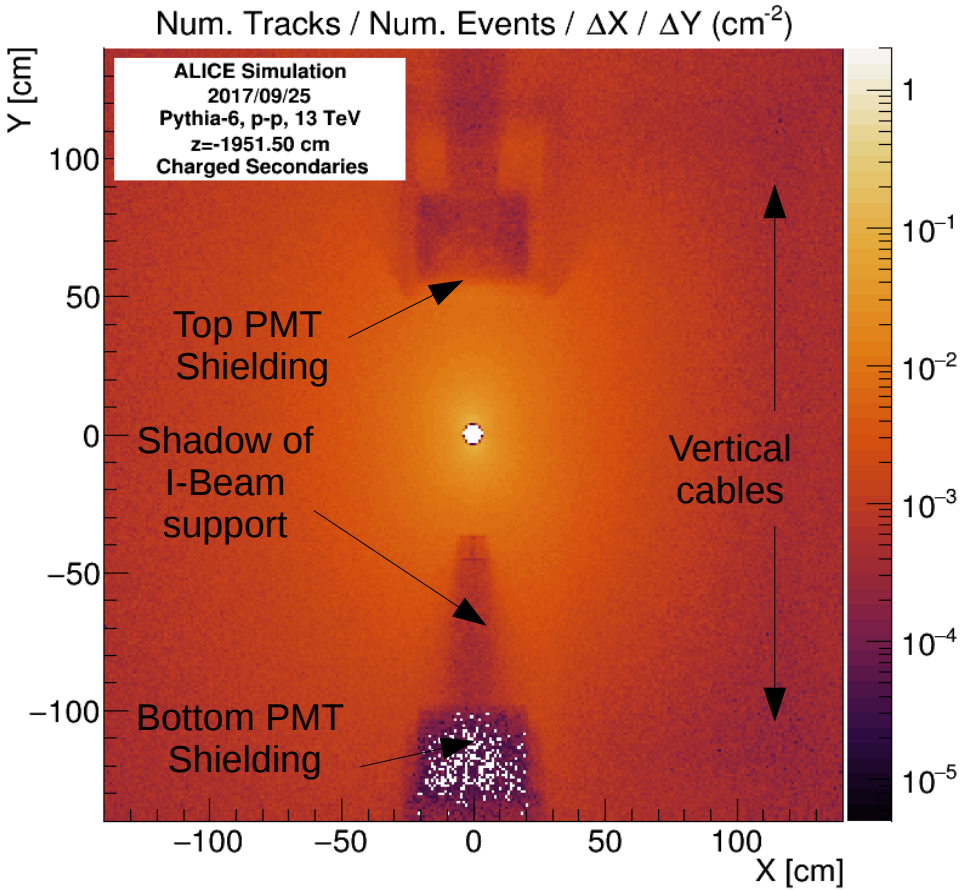


Particle flux at A-Side (Z=1685 cm)

You are looking towards the interaction point!

New Geometry (2017)





Simulation: Neutral (left) and charged (right) secondaries arriving to ADA plane. It can be seen how the new shielding protects the PMT boxes.

Conclusions

- ALICE has measured inelastic, single and double diffractive cross sections in pp collisions at 7 TeV at the LHC (run I).
- The ALICE Diffractive detector (AD) increases the pseudorapidity coverage from 8.8 to 12.1 units in η.
- This translates into a higher sensitivity to lower mass diffractive systems.
- AD has a great performance (good time resolution, beam-gas rejection) and is participating in run II data taking, collecting a large sample of inclusive diffractive events and double-gap triggers.
- Analysis and simulation work is ongoing. Expect news soon.

Thanks!

Back-up

Diffraction in Run I

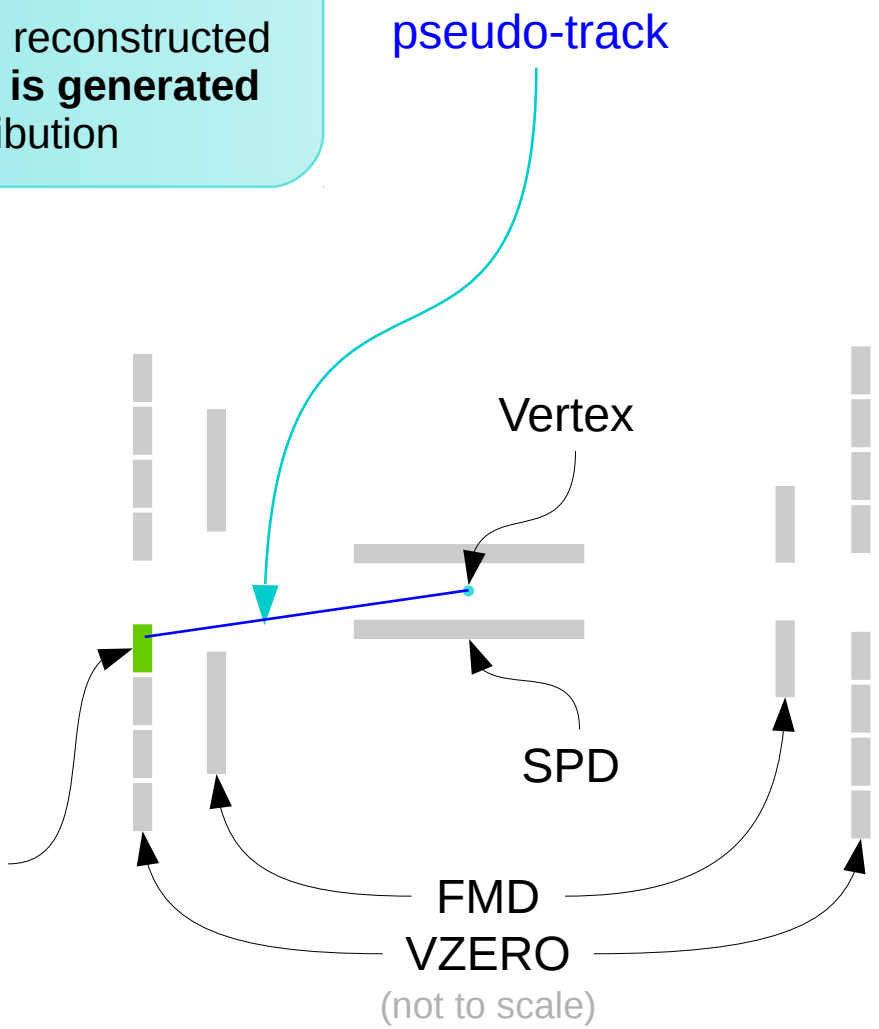
track → pseudo-track

Association of the reconstructed vertex with a hit in SPD, FMD or VZERO.

In 10% of cases there is no reconstructed vertex → A **random vertex is generated** from measured vertex distribution

VZERO
scintillator tiles divided in 4 rings ($\delta\eta=0.5$) and 8 sectors in azimuth ($\delta\phi=45°$)

If a VZERO cell has signal → a random hit is generated.



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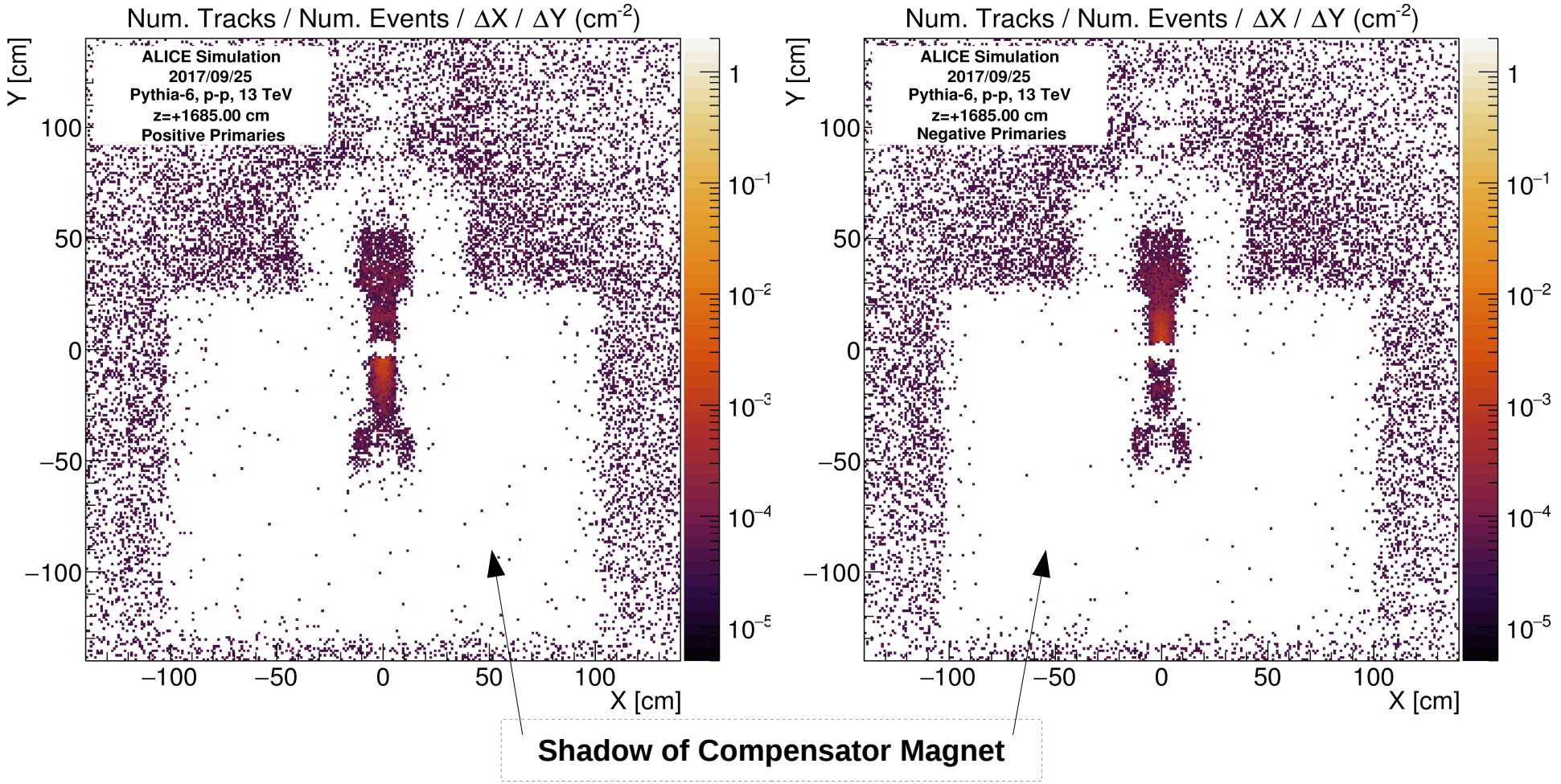

Simulation: Positive (left) and Negative (right) primaries arriving to ADA plane. The shadow of the compensator magnet located between ADA and the interaction point is clearly visible.

The ALICE experiment.
View of the “A-Side”