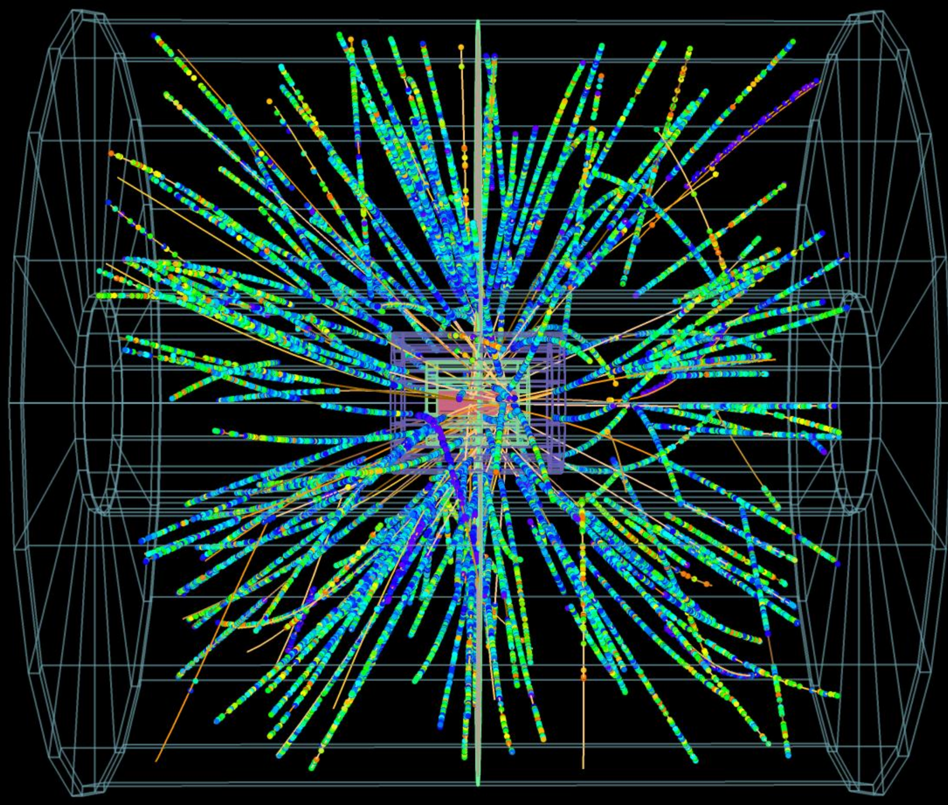
ALICE: diffraction studies, status and plans



p-Pb 2013

Introduction

Summary of measurements on Diffractive Physics

Central Diffractive studies

Plans to improve performance of ALICE in diffractive physics

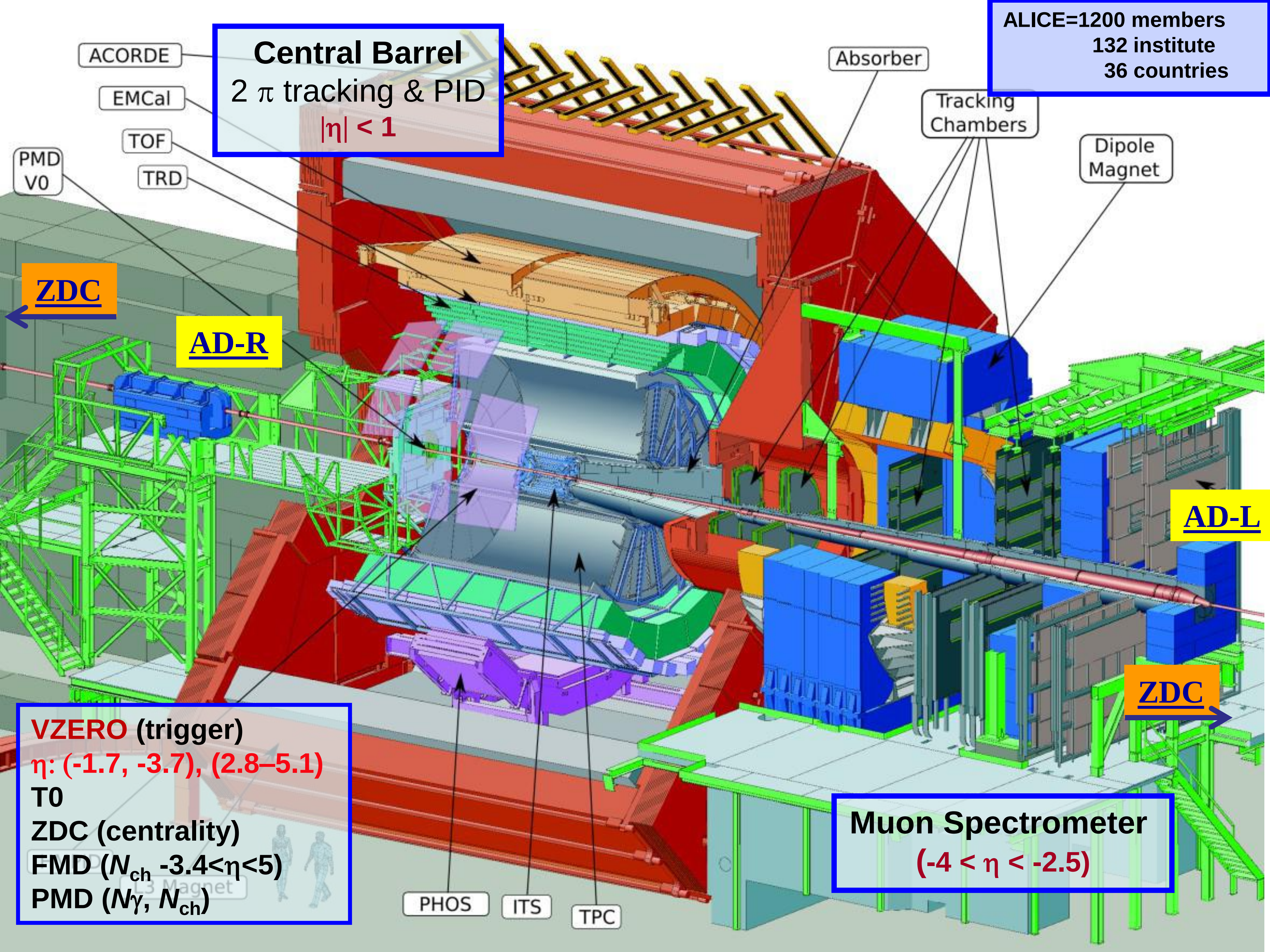
Plans for Diffractive studies in p-Pb

Conclusion

LISHEP 2013, Rio de Janeiro , Brasil, March 17-24, 2013

Gerardo Herrera Corral

Introduction

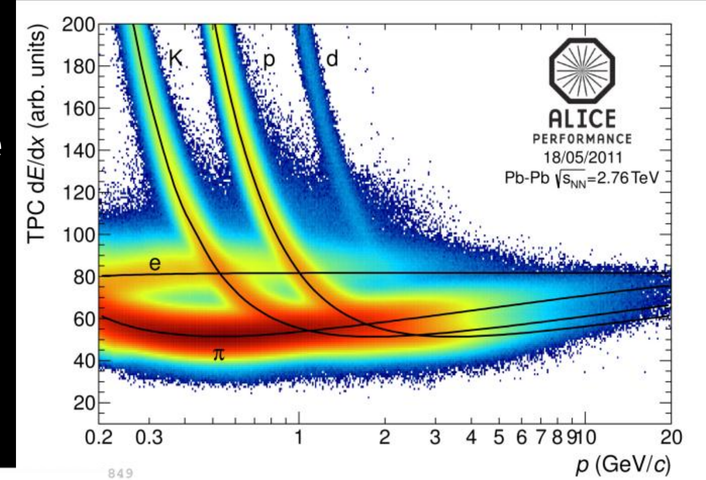


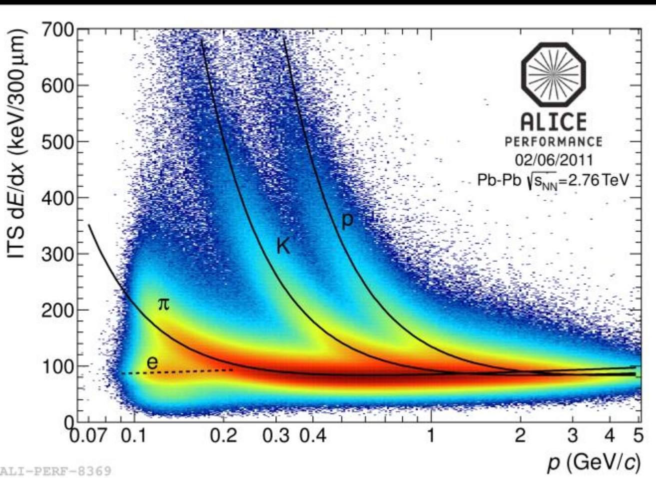
ALICE=1200 members
132 institute
36 countries
Central Barrel
2 π tracking & PID
|η| < 1
ACORDE
EMCal
TOF
TRD
PMD
V0
Absorber
Tracking Chambers
Dipole Magnet
ZDC
AD-R
AD-L
ZDC
VZERO (trigger)
η: (-1.7, -3.7), (2.8–5.1)
T0
ZDC (centrality)
FMD (N_{ch} -3.4<η<5)
PMD ($N\gamma$, N_{ch})
PHOS
ITS
TPC
Muon Spectrometer
(-4 < η < -2.5)

all known techniques for particle identification:

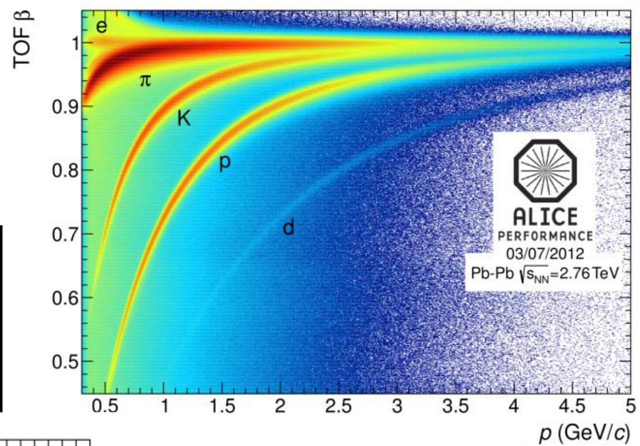
inclusive and exclusive particle production in centrally produced systems, in various channels …

in progress





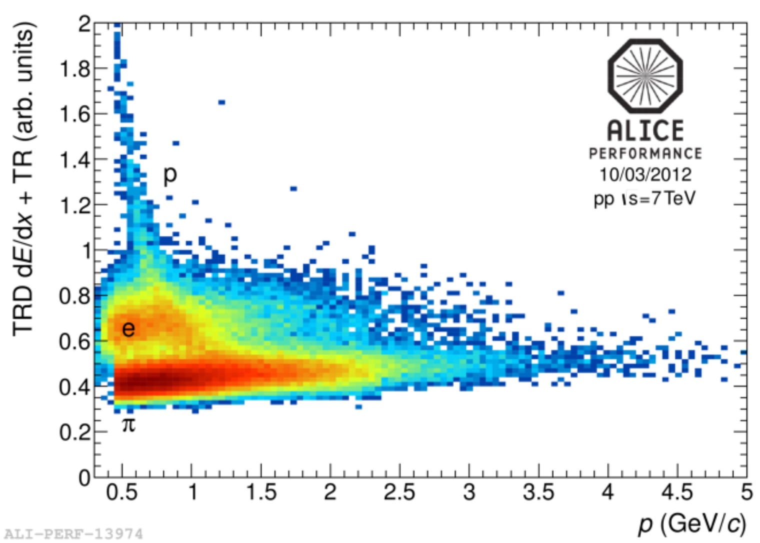
ITS



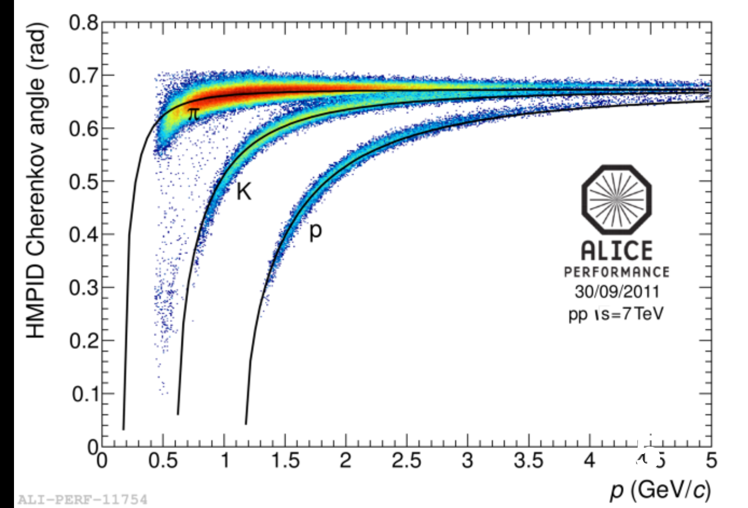
TPC

TOF

HMPID



TRD



LHC heavy ion runs

- **Two heavy-ion runs at the LHC so far:**
  - 2010 – commissioning and first data taking
  - 2011 – above nominal instant luminosity
- **p–Pb & Pb–p - 2013**
  - Goal ~ 30 nb^{-1}

  pilot run September 13th 2012 → **4 papers submitted**
- **Long Shutdown in 2013-2014**

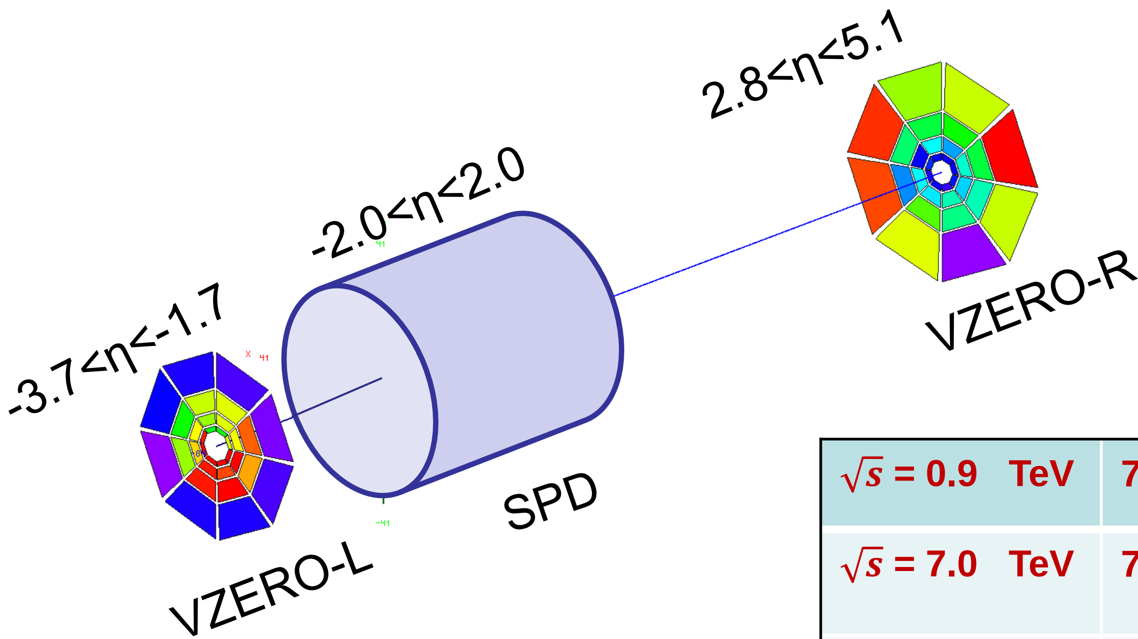
year	system	Energy $\sqrt{s_{NN}}$ (TeV)	integrated luminosity
2010	**Pb – Pb**	**2.76**	**~ 10 μb^{-1}**
2011	**Pb – Pb**	**2.76**	**~ 0.1 nb^{-1}**
2013	**p – Pb**	**5.02**	**~ 30 nb^{-1}**

Summary of measurements on Diffractive Physics

Measurements of Diffractive and Inelastic Cross Section

Event samples

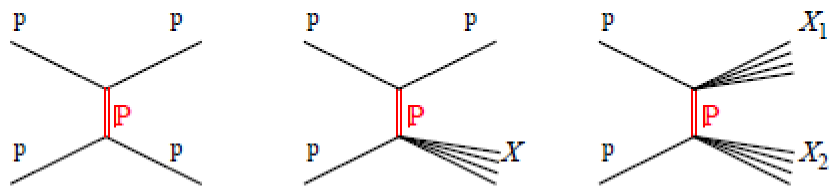
- Data at three energies : $\sqrt{s}$ = 0.9 2.76 7 TeV
- Low luminosity, low pile-up:
  average number of collisions per bunch crossing = 0.1
- Trigger used: Minimum Bias – OR i.e.
  at least one hit in SPD or VZERO
- VZERO signal should be in time with particles produced in the collisions



DATA

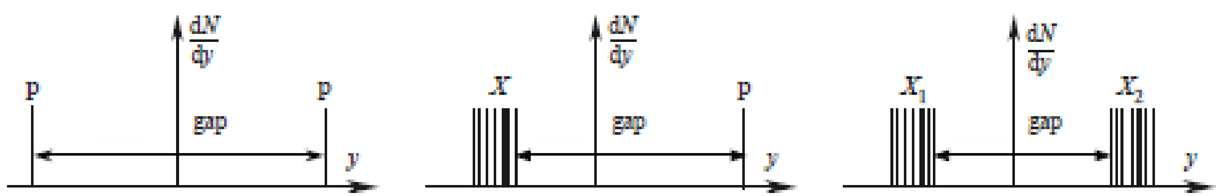
$\sqrt{s}$ = 0.9 TeV	7 $\times 10^6$ events
$\sqrt{s}$ = 7.0 TeV	75 $\times 10^6$ events
$\sqrt{s}$ = 2.76 TeV	23 $\times 10^6$ events

- Filled and empty bunch buckets used to measure beam induced background, accidentals due to electronics noise and cosmic showers



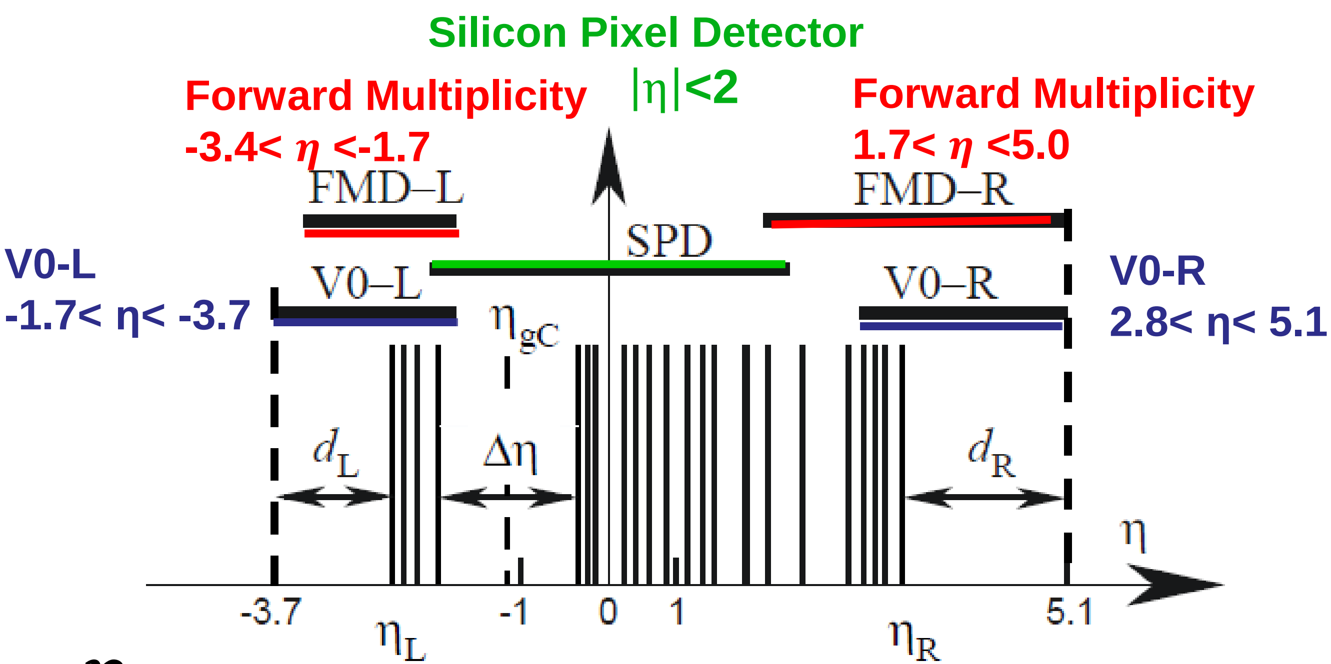
theory

elastic - single - double - diffractive proton-proton scattering



experiment

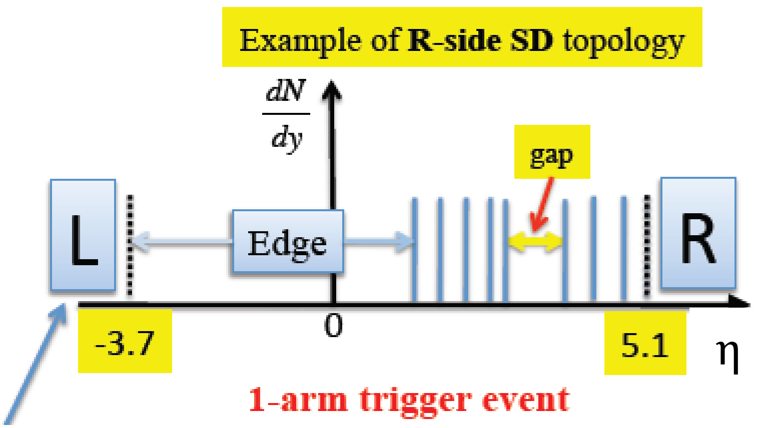
ALICE

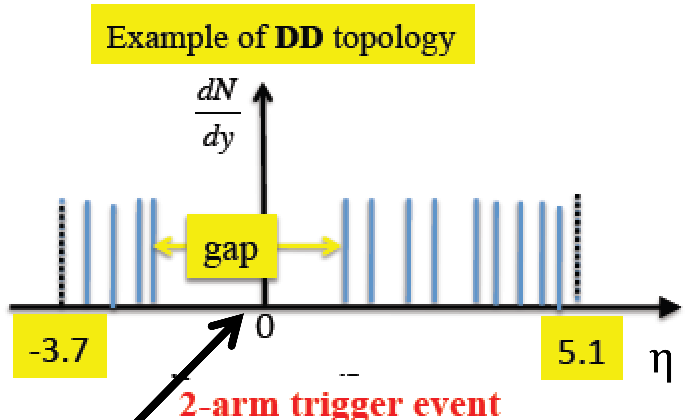


$$\eta_c = \frac{1}{2}(\eta_L + \eta_R)$$

η_L **lowest-** η_R **highest - pseudorapidity**

offline event clasification: "1 arm-L" "1 arm-R" "2 arm"





muon spectrometer

$$\eta_c = \frac{1}{2}(\eta_L + \eta_R)$$

$\eta_C < 0$	1-arm-L
$\eta_C > 0$	1-arm-R

if largest	$\Delta\eta > d_L$ and d_R	2-arm
if both	$-1 \leq \eta_L$ and $\eta_R \leq 1$	2-arm

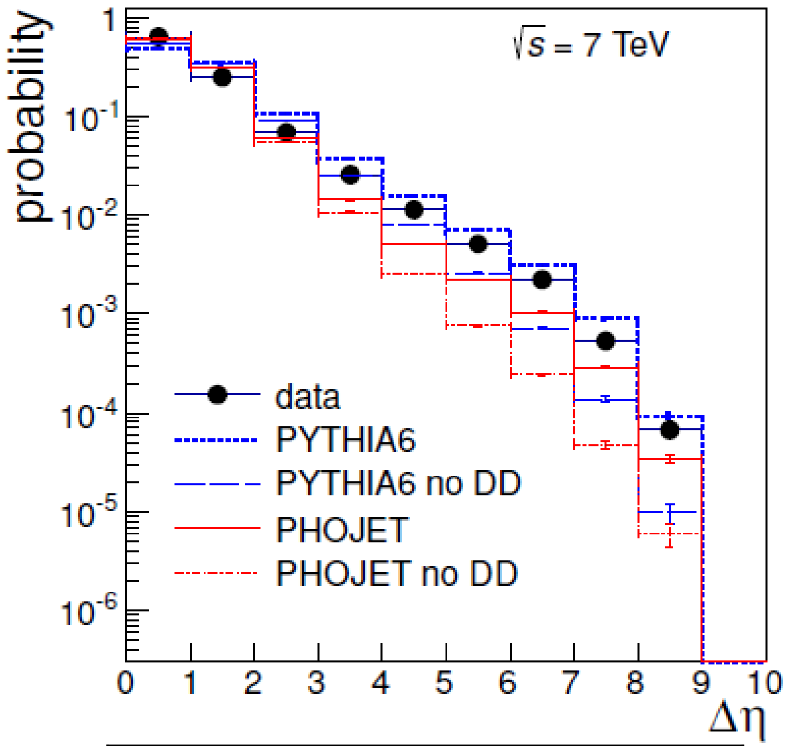
If	$\eta_R < 1$	1-arm-L
If	$\eta_L > -1$	1-arm-R

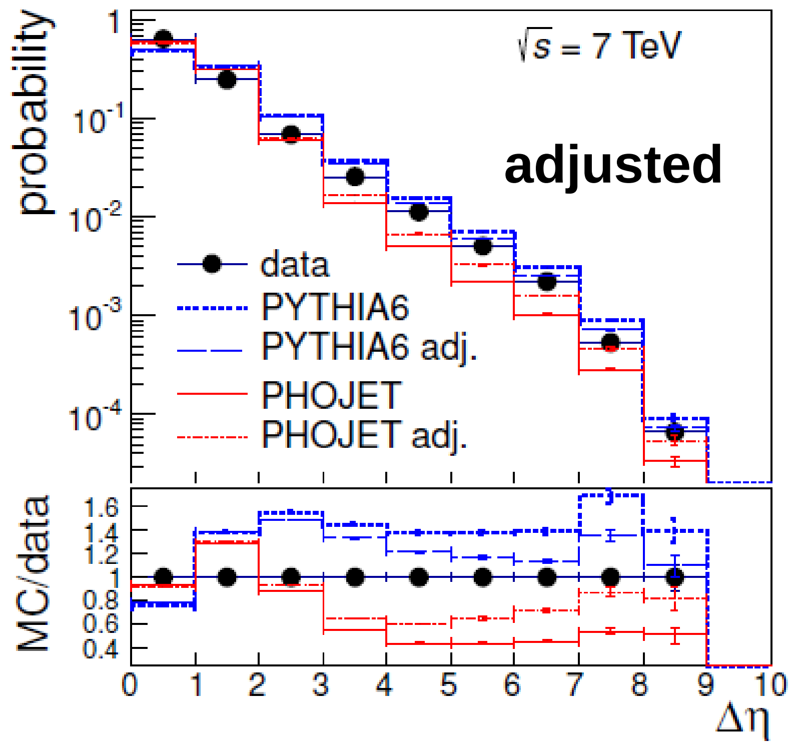
arXiv:1208.4968 [hep-ex]

2-arm events

largest $\Delta\eta$

tuning PYTHIA and PHOJET double diffraction to experimental width distribution of two arm events





$\sqrt{s}$ TeV	PYTHIA	PHOJET
0.9	0.12	0.06
7.0	0.13	0.05

$\sqrt{s}$ TeV	PHYTIA tuned	PHOJET tuned
0.9	0.10	0.11
7.0	0.09	0.07

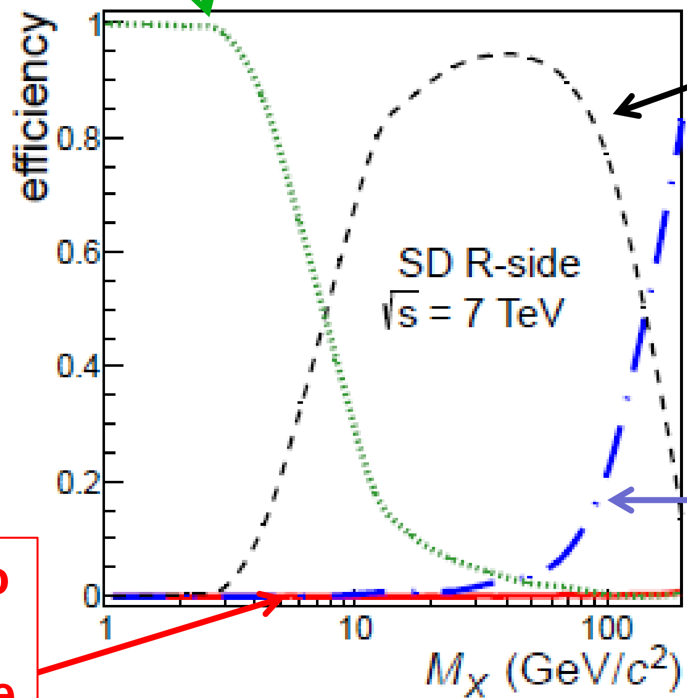
- **Once DD is chosen the ratios 1-arm-L and 1-arm-R to 2-arm can be used to compute SD fractions.**

- **efficiency/in-efficiency versus diffractive mass for SD :**

probability of not detecting

efficiency for a SD to be classified as 1-armL(R)

PYTHIA 6



efficiency to be classified as 2-arm

efficiency to be taken as the opposite

efficiencies used: mean between PYTHIA and PHOJET

efficiency of SD & NSD to be classified as 1-arm L(R), 2-arm

at high energy the ratio remains constant

$\sqrt{s}$ (TeV)	ratio definition	ratio	side	$\sigma_{SD}/\sigma_{INEL}$ per side	$\sigma_{SD}/\sigma_{INEL}$ total
0.9	1-arm-L/2-arm	0.0576 ± 0.0002	L-side	0.10 ± 0.02	0.21 ± 0.03
	1-arm-R/2-arm	0.0906 ± 0.0003	R-side	0.11 ± 0.02	
2.76	1-arm-L/2-arm	0.0543 ± 0.0004	L-side	0.09 ± 0.03	$0.20^{+0.07}_{-0.08}$
	1-arm-R/2-arm	0.0791 ± 0.0004	R-side	$0.11^{+0.04}_{-0.05}$	
7	1-arm-L/2-arm	0.0458 ± 0.0001	L-side	$0.10^{+0.02}_{-0.04}$	$0.20^{+0.04}_{-0.07}$
	1-arm-R/2-arm	0.0680 ± 0.0001	R-side	$0.10^{+0.02}_{-0.03}$	

consistent with UA5 $p\,\bar{p}$

results symmetric despite different acceptance from ALICE

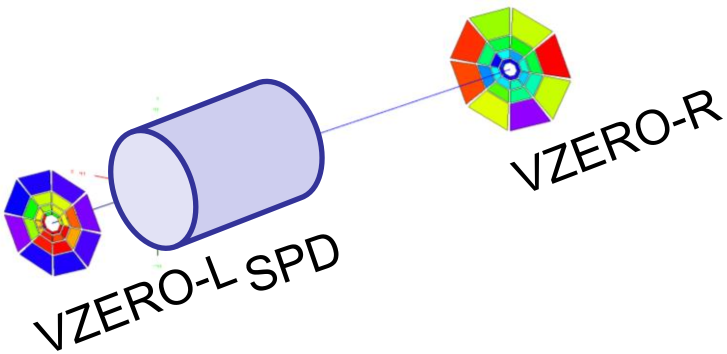
corrected for acceptance, efficiency, beam background, electronic noise and collision pileup

DD events defined as NSD with large gap

$\sqrt{s}$ (TeV)	$\sigma_{DD}/\sigma_{INEL}$
0.9	0.11 ± 0.03
2.76	0.12 ± 0.05
7	$0.12^{+0.05}_{-0.04}$

with $\Delta\eta > 3$

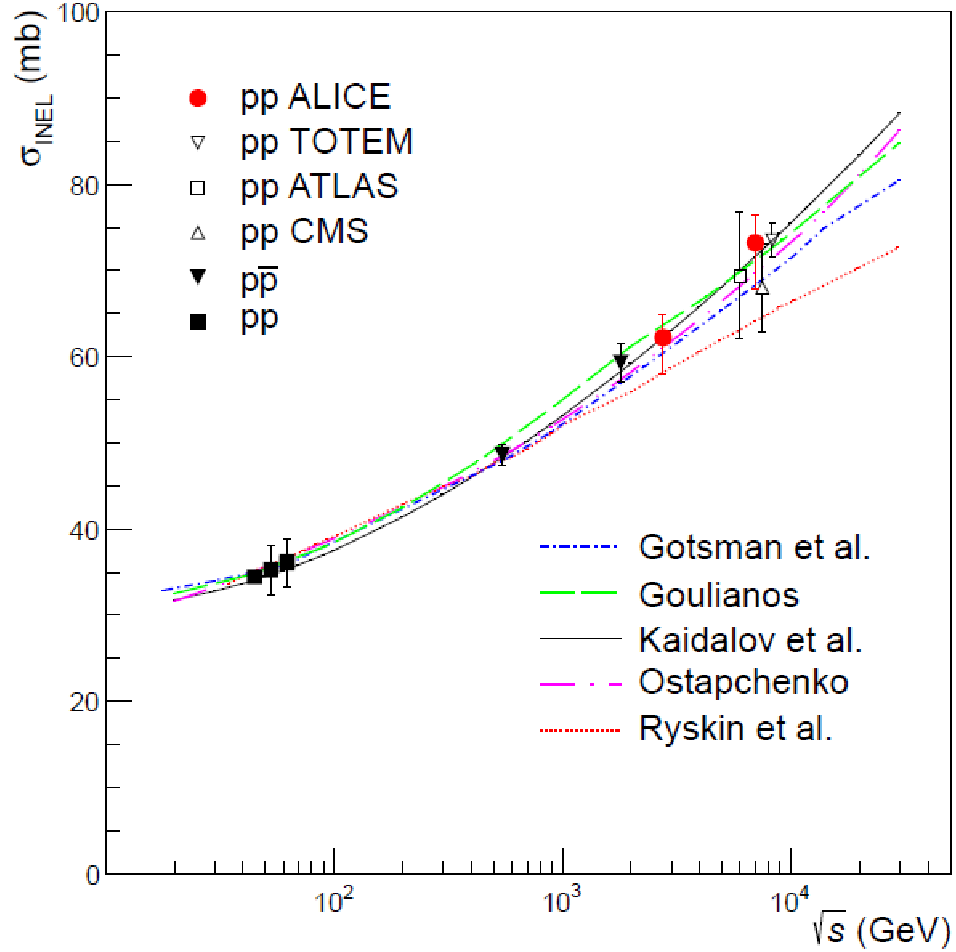
Measurement of Inelastic Cross Section



MB-and : coincidence of VZERO-L and –R in a van der Meer scan

$$\frac{dN(MBand)}{dt} = A \times \sigma_{inel} \times L$$

acc. and eff. determined with adjusted simulation



Experiment	σ_{INEL} (mb)
ALICE	$73.2^{+2.0}_{-4.6}(model) \pm 2.6(lumi)$
ATLAS [19]	$69.4 \pm 6.9(model) \pm 2.4(exp)$
CMS [20]	$68.0 \pm 4.0(model) \pm 2.0(syst) \pm 2.4(lumi)$
TOTEM [21]	$73.5^{+1.8}_{-1.3}(syst) \pm 0.6(stat)$

Measurements of Diffractive Cross Section

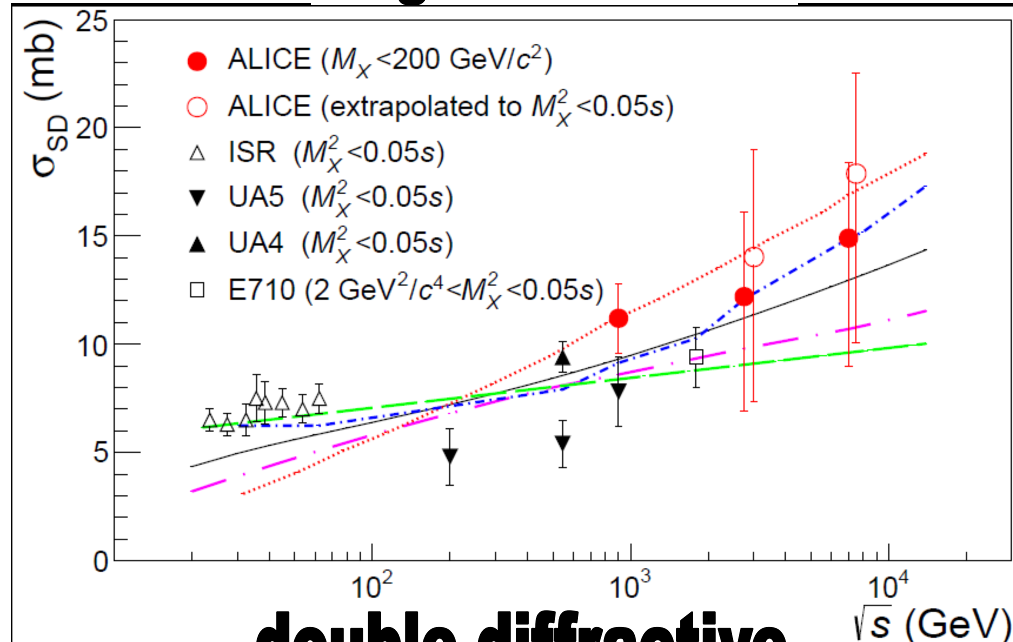
with inelastic cross section and relative rates we obtain SD and DD cross sections

for $\sqrt{s} = 0.9\ TeV$ we do not have vdM scan and σ_{inel} from UA5 was used

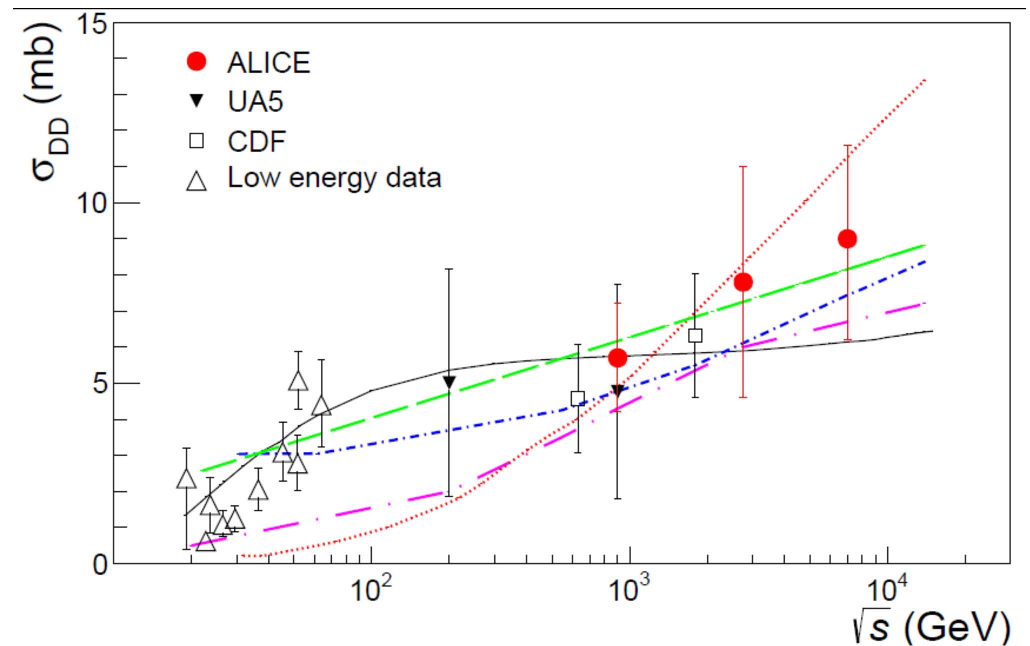
$$\sigma_{INEL} = 52.5^{+2}_{-3.3}\ mb$$

Gotsman et al.
Goulianos
Kaidalov et al.
Ostapchenko
Ryskin et al.

single diffractive



double diffractive



Central Diffractive Physics

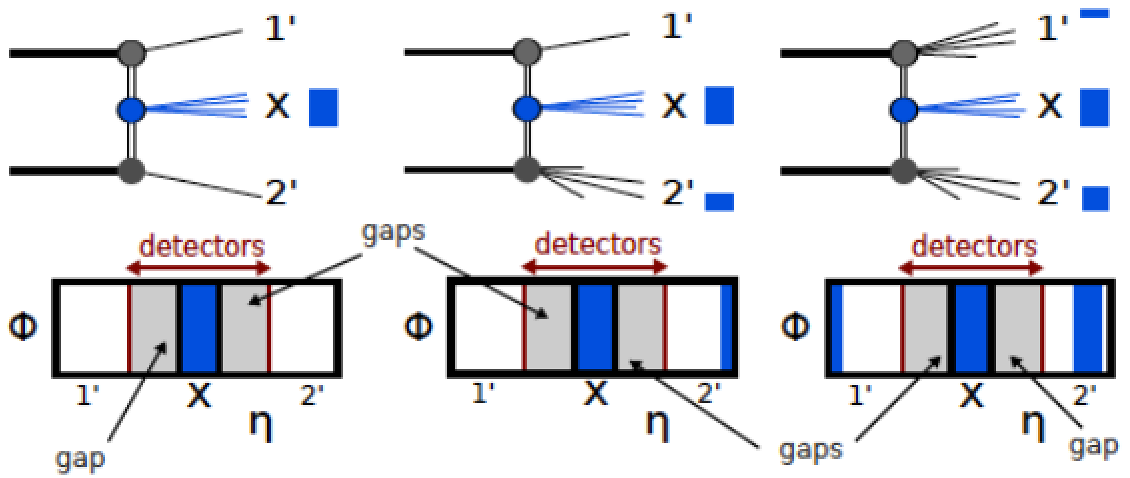
Central diffraction in proton proton collisions at $\sqrt{s}$ = 7 TeV

Double Gap topology as a filter for Central Diffraction

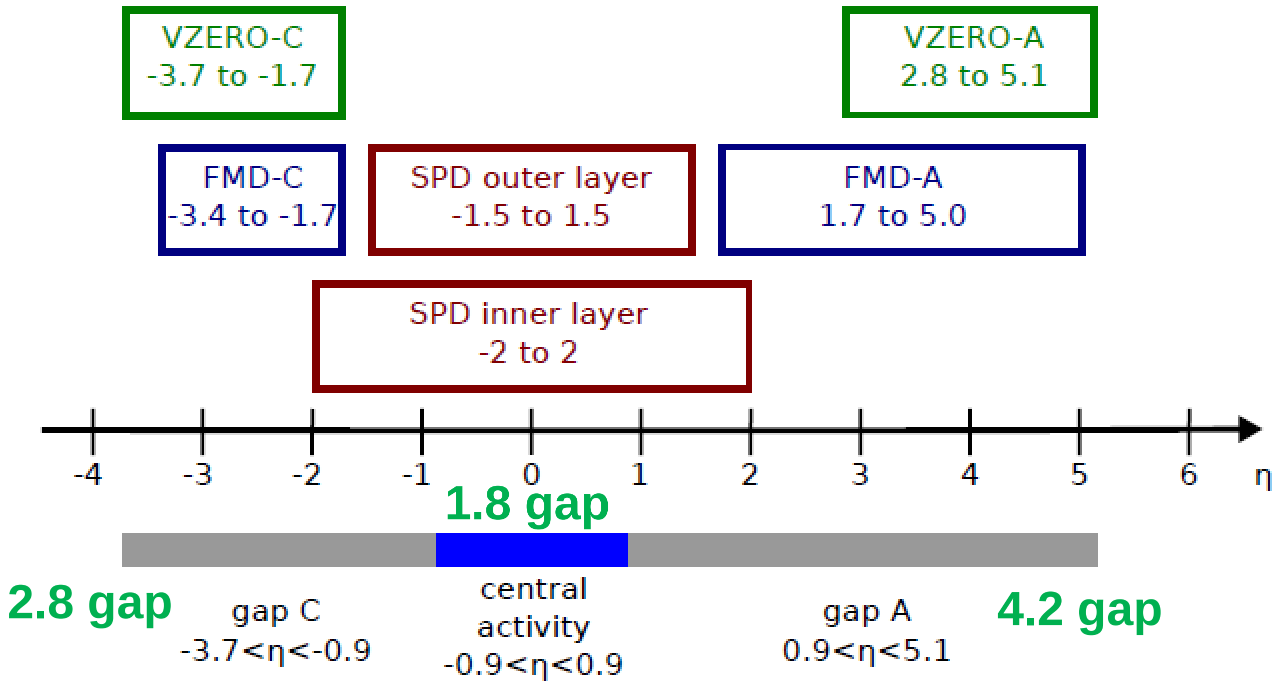
Central Diffraction

CD with single Diffractive dissociation

CD with double Diffractive dissociation



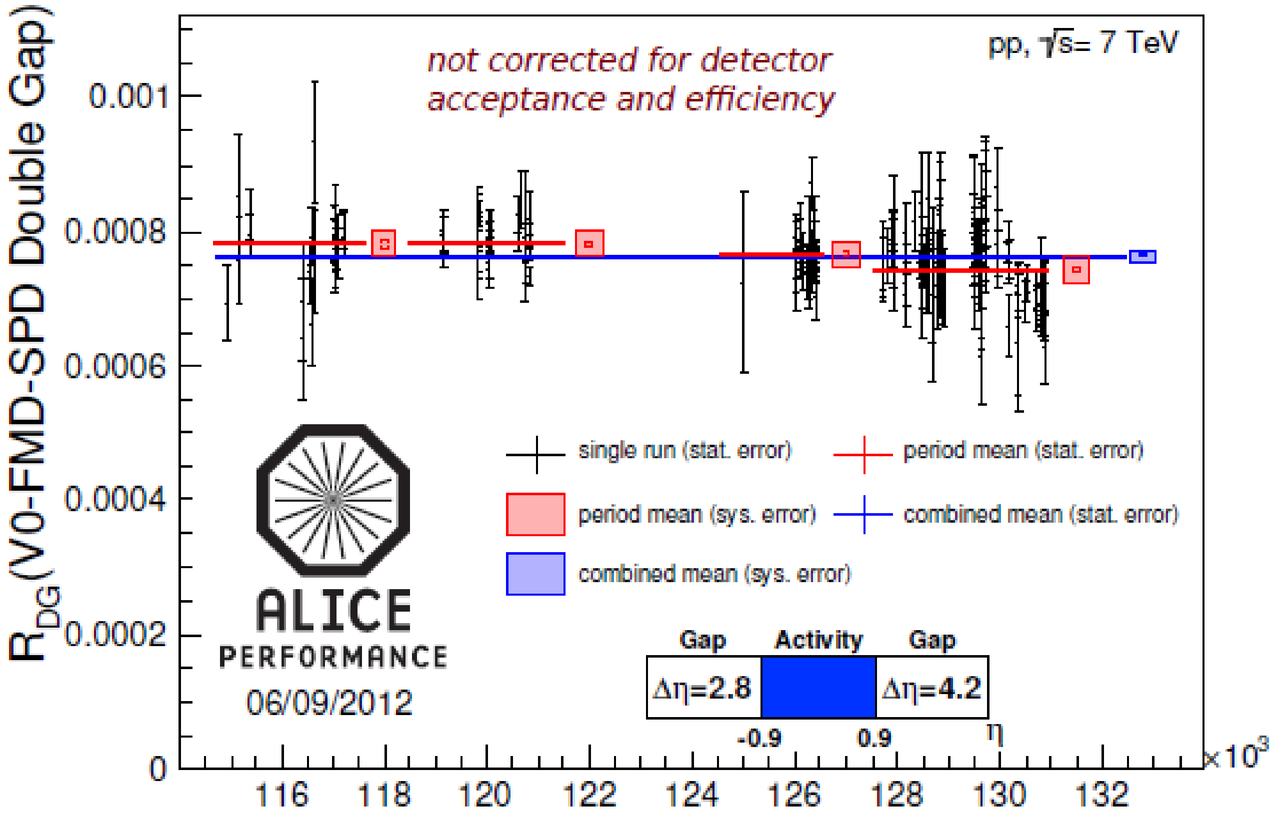
Double Gap topology



$$N_{DG} = \frac{\text{Number of Double Gap events}}{\text{Number of VZERO-L –R coincidence}}$$

Potential measure of the amount of Central Diffractive events in Minimum Bias data

Double Gap fraction in proton proton $\sqrt{s} = 7\ TeV$



systematic error estimated from the spread of the period means, doesn't include detector effects

$$\frac{N_{DG}}{N_{\mathrm{MBand}}} = (7.63 \pm 0.02(stat.) \pm 0.95(syst.)) \cdot 10^{-4}$$

- **fraction uniform over several data taking periods**

Next:

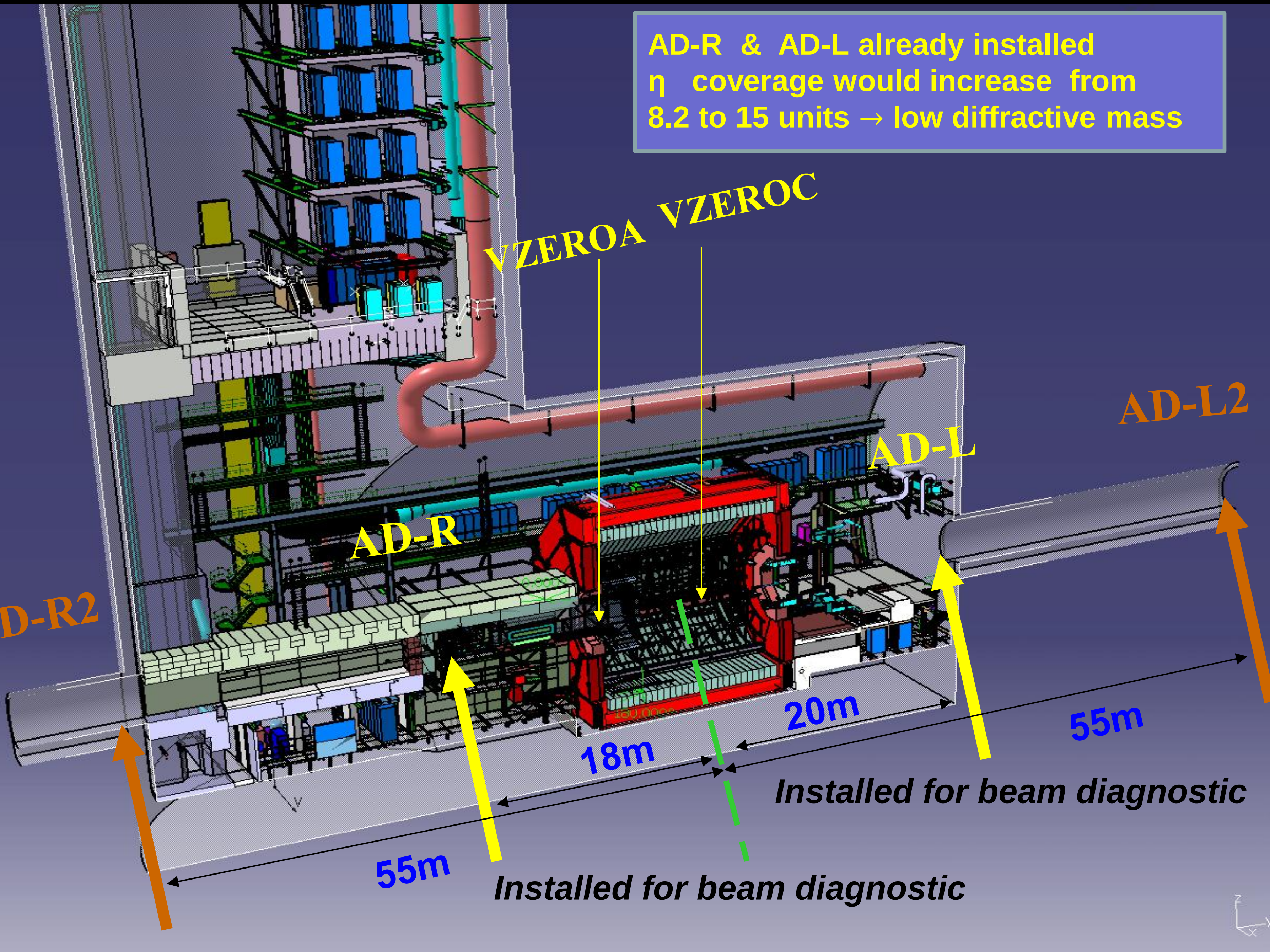
turn it into a cross section

we are exploring the invariant mass distribution

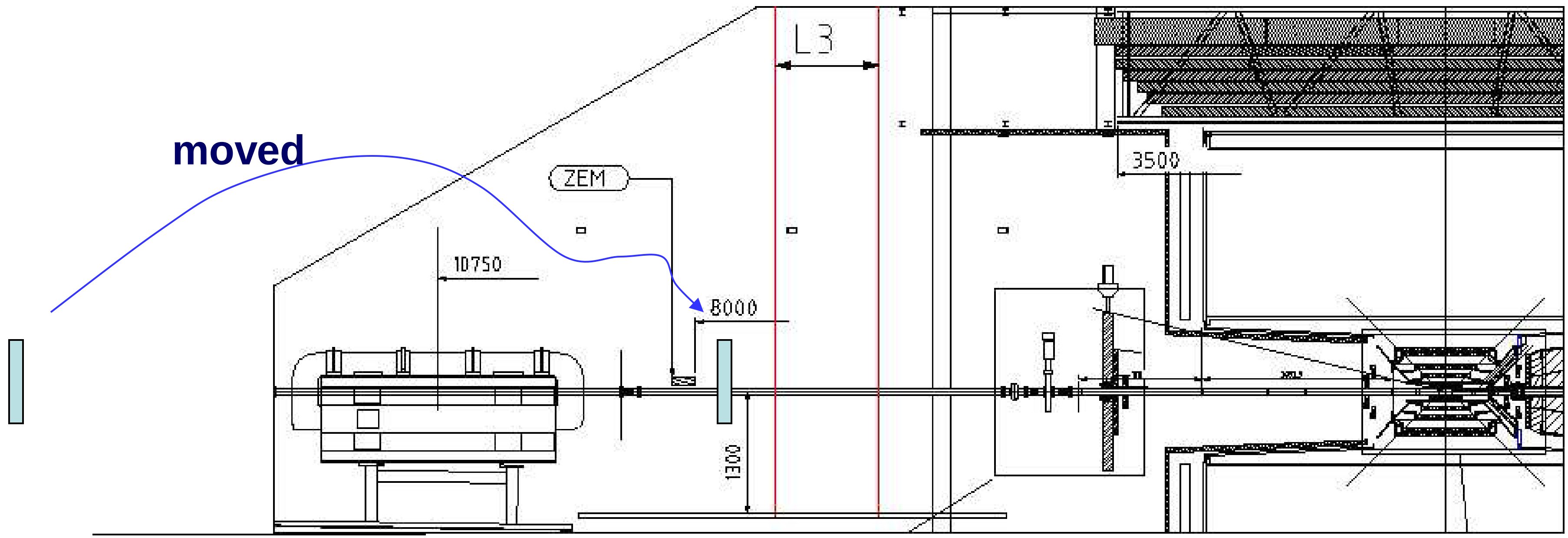
plans to improve ALICE performance on photon induced and diffractive physics

stations of scintillation detectors - Proposed -

AD-R & AD-L already installed
η coverage would increase from
8.2 to 15 units → low diffractive mass



AD-R installed and operating as beam loss monitor

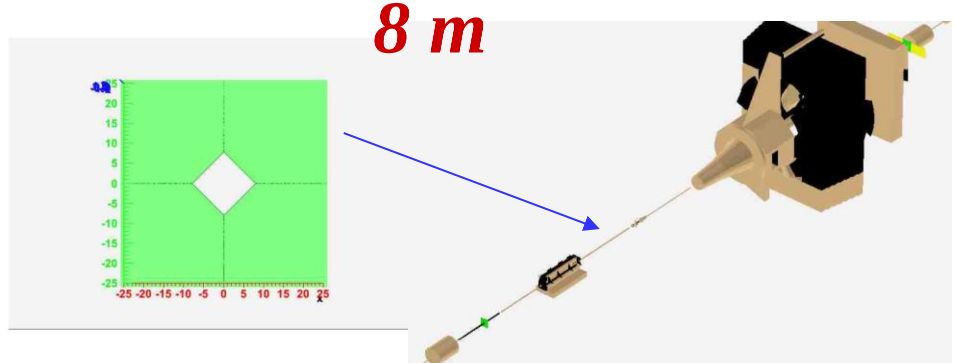


17 m

IP

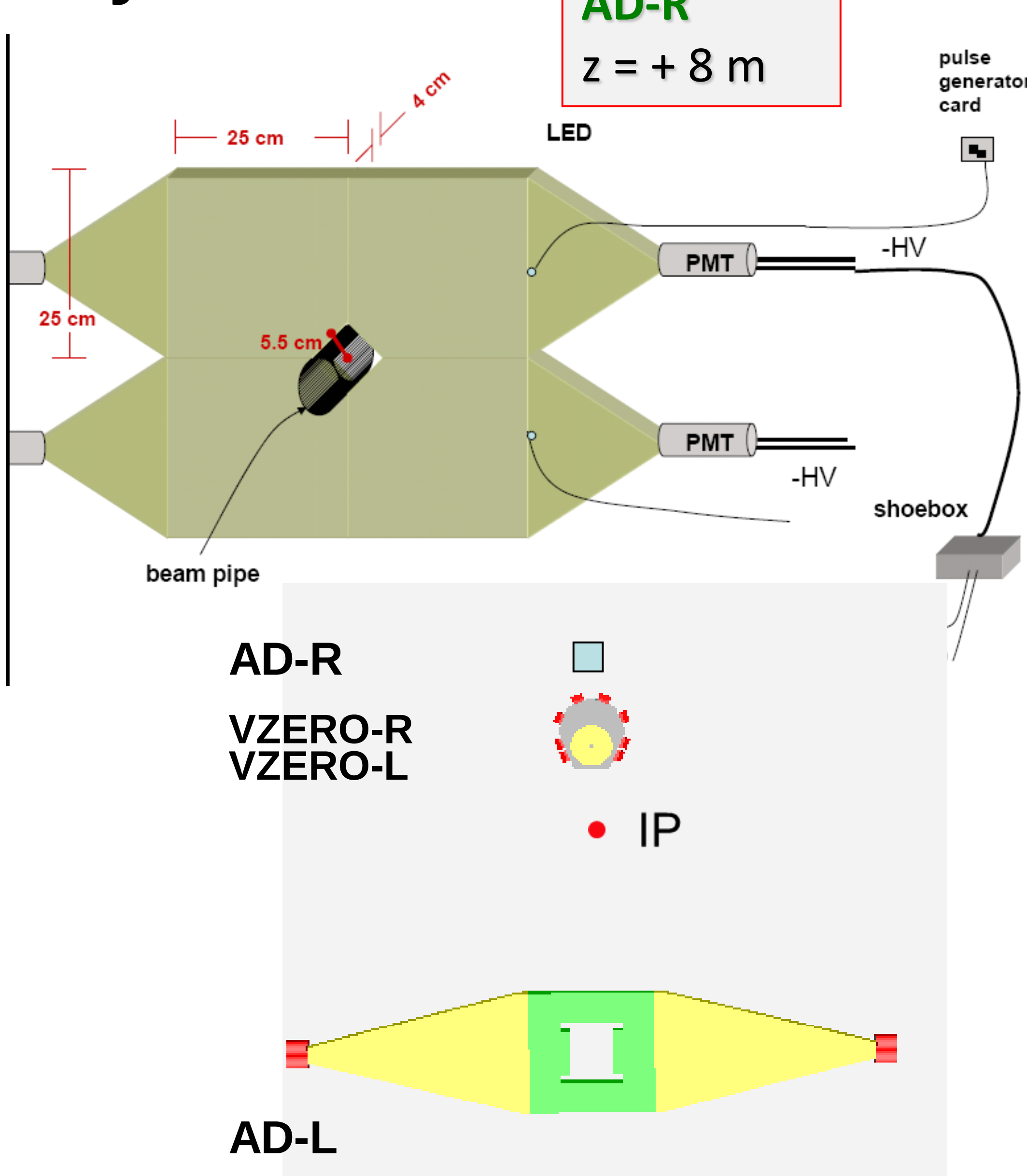
8 m

AD-R



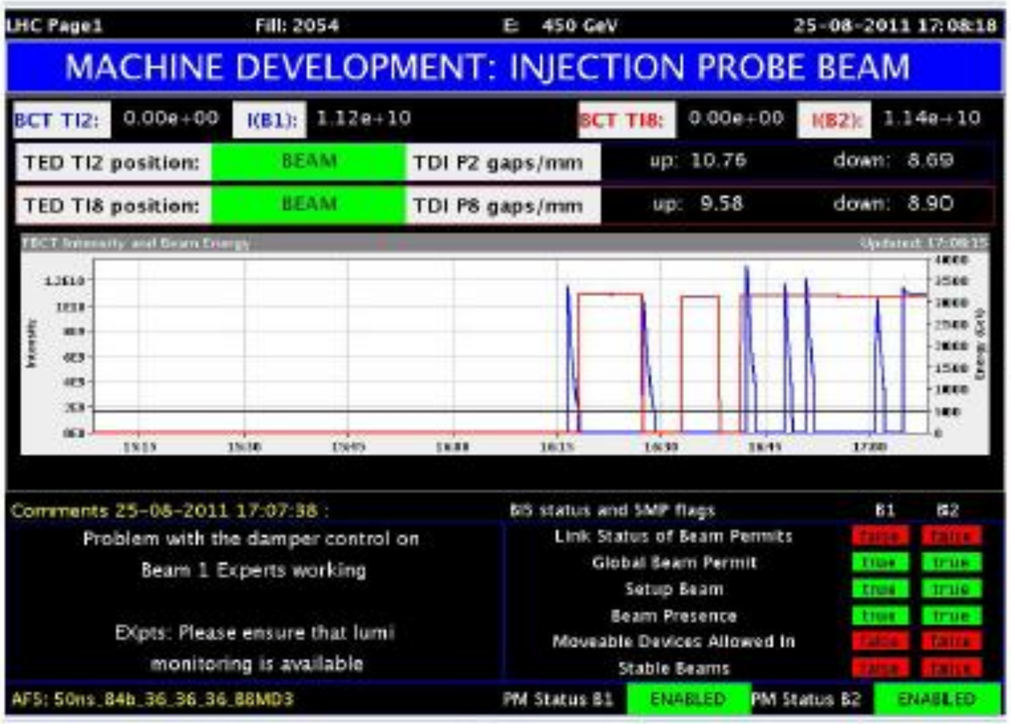
Diffractive Physics- Beam Loss Scintillator layout

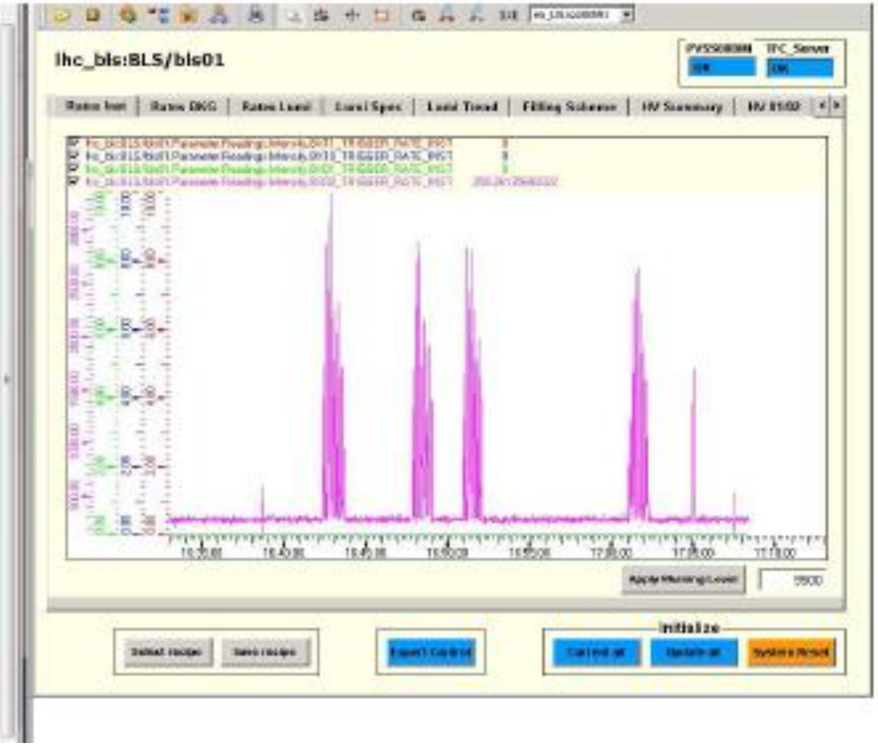
- Two arrays of 4 scintillators 25x25x4 cm surrounding the beam pipe both sides of the interaction point, mounted on EMI9814B PMTs (gain $3x10^7$)
- Conceived for diffractive physics
- Readout board: Beam Phase Intensity Monitor
- Bunch by bunch rates, collision and background.



- **The only Beam radiation monitoring system capable of detecting minimum ionizing particles**

- **Measures relative rates of background particles and collision products entering ALICE**





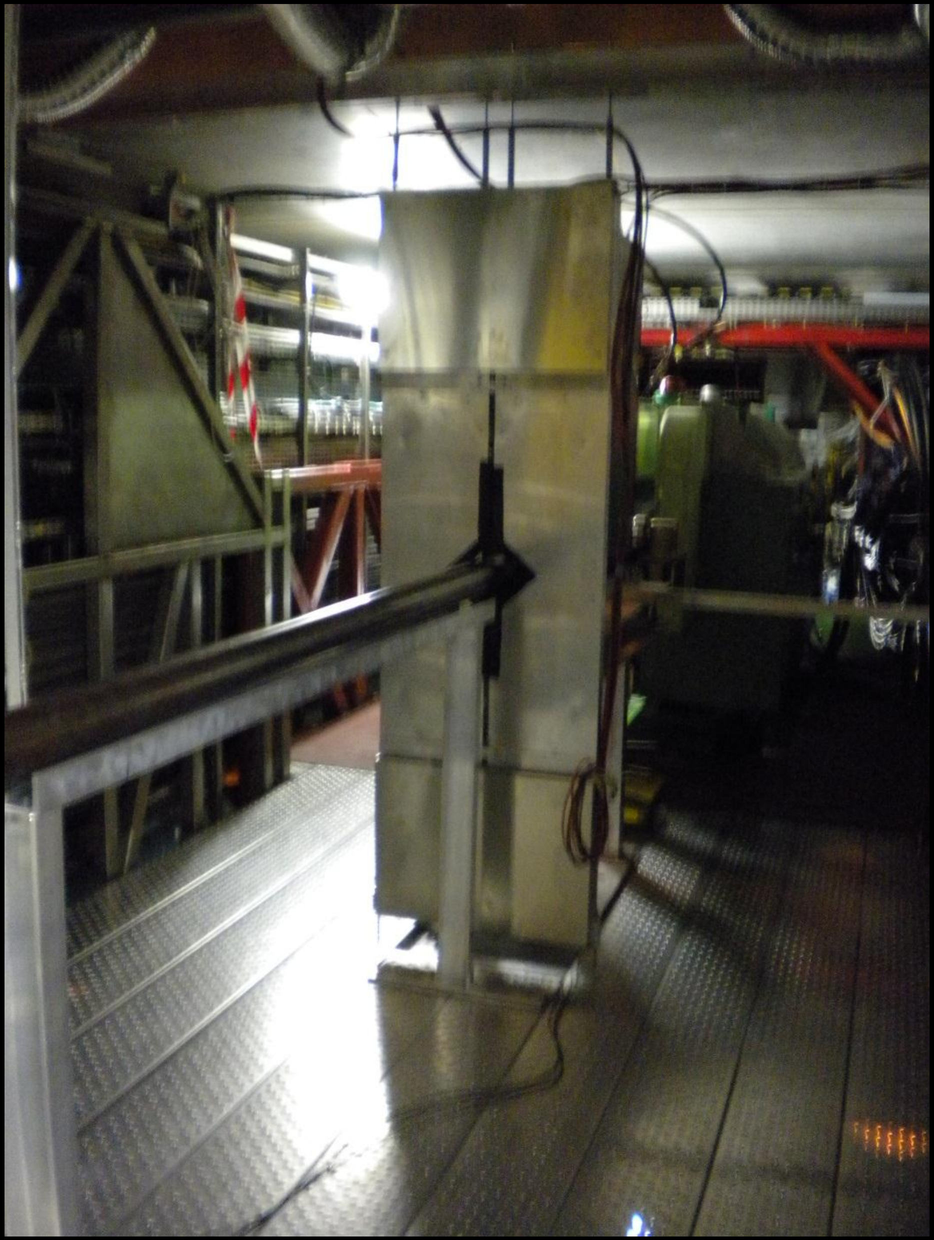
AD-R

Present:

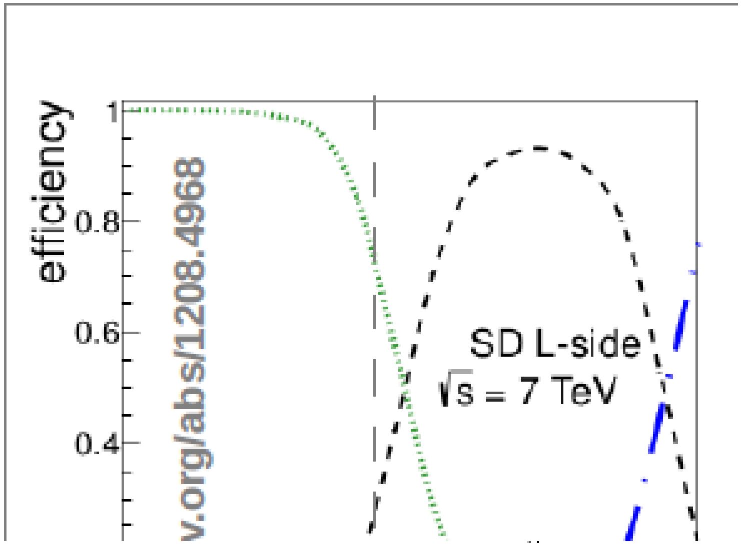
- **beam monitor with asynchronous read-out of charge deposited in the detectors → working**

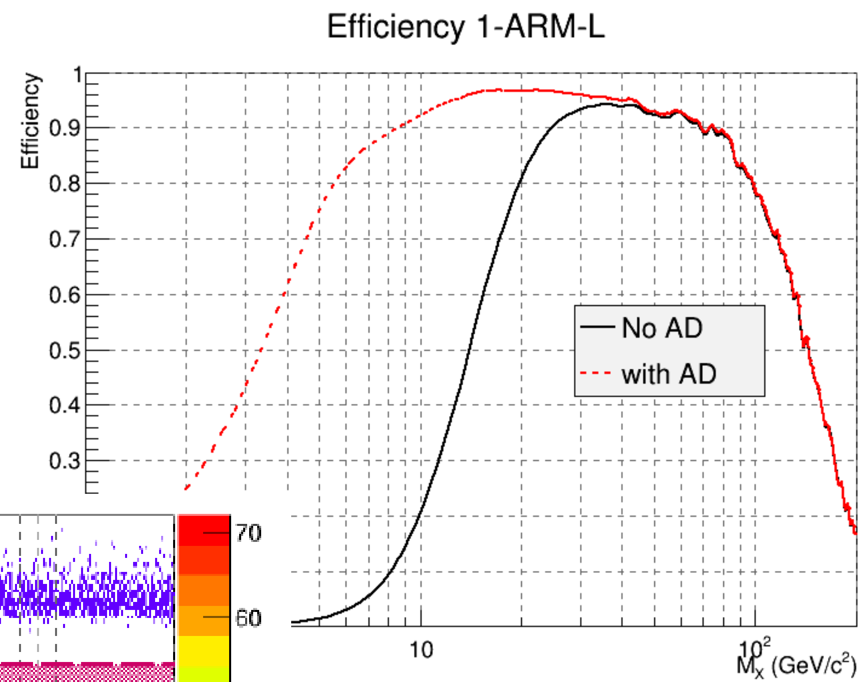
Future:

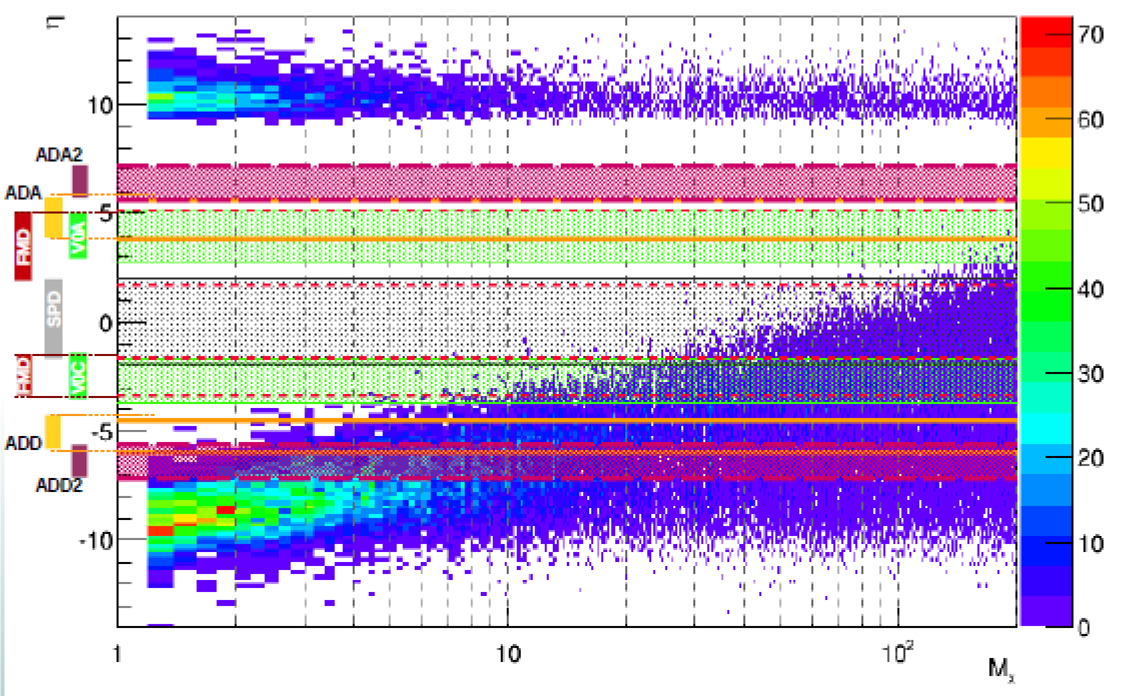
- **interesting diffractive physics using the particle identification of ALICE … could be offline trigger**

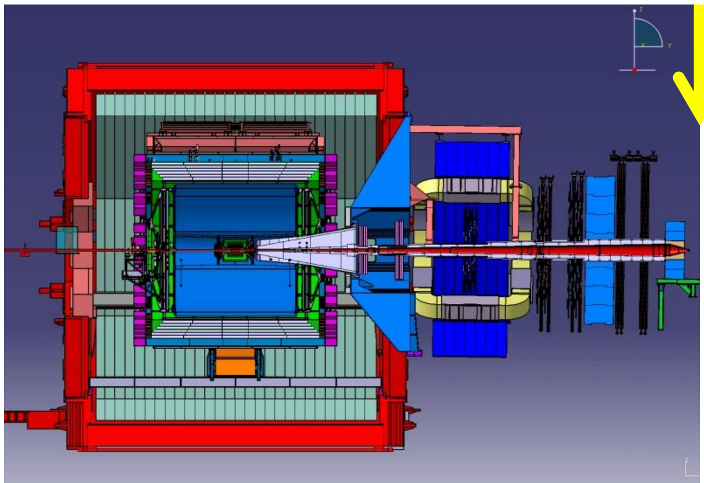


Integration of AD-L and AD-R in ALICE would enhance considerably the efficiency at low diffractive mass.







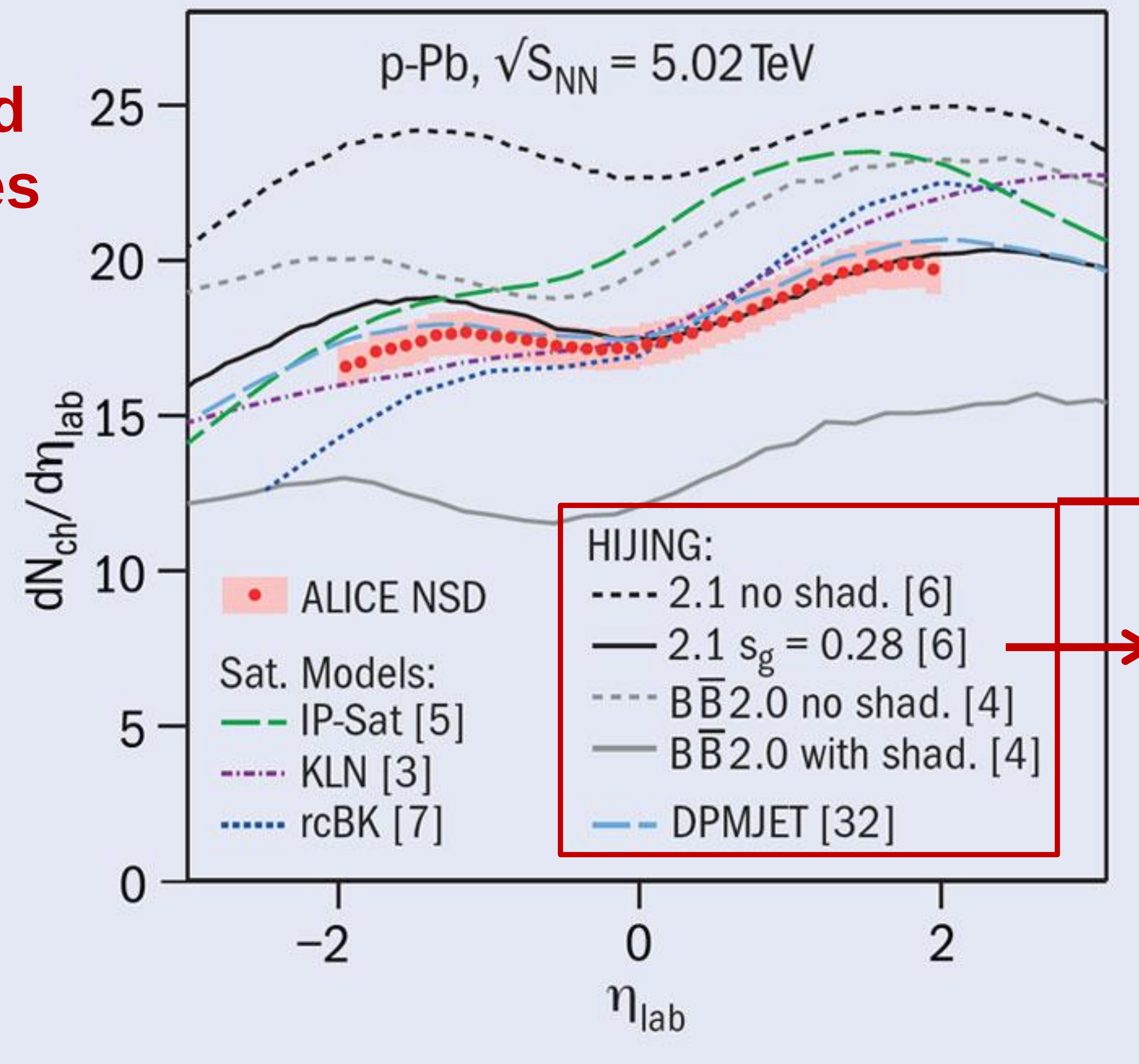


Plans for Diffractive Physics studies in p-Pb

Pseudo-rapidity density of charged particles

proton - Pb,   2 million events collected in september 2012

ALICE Collab. arXiv:1210.3615

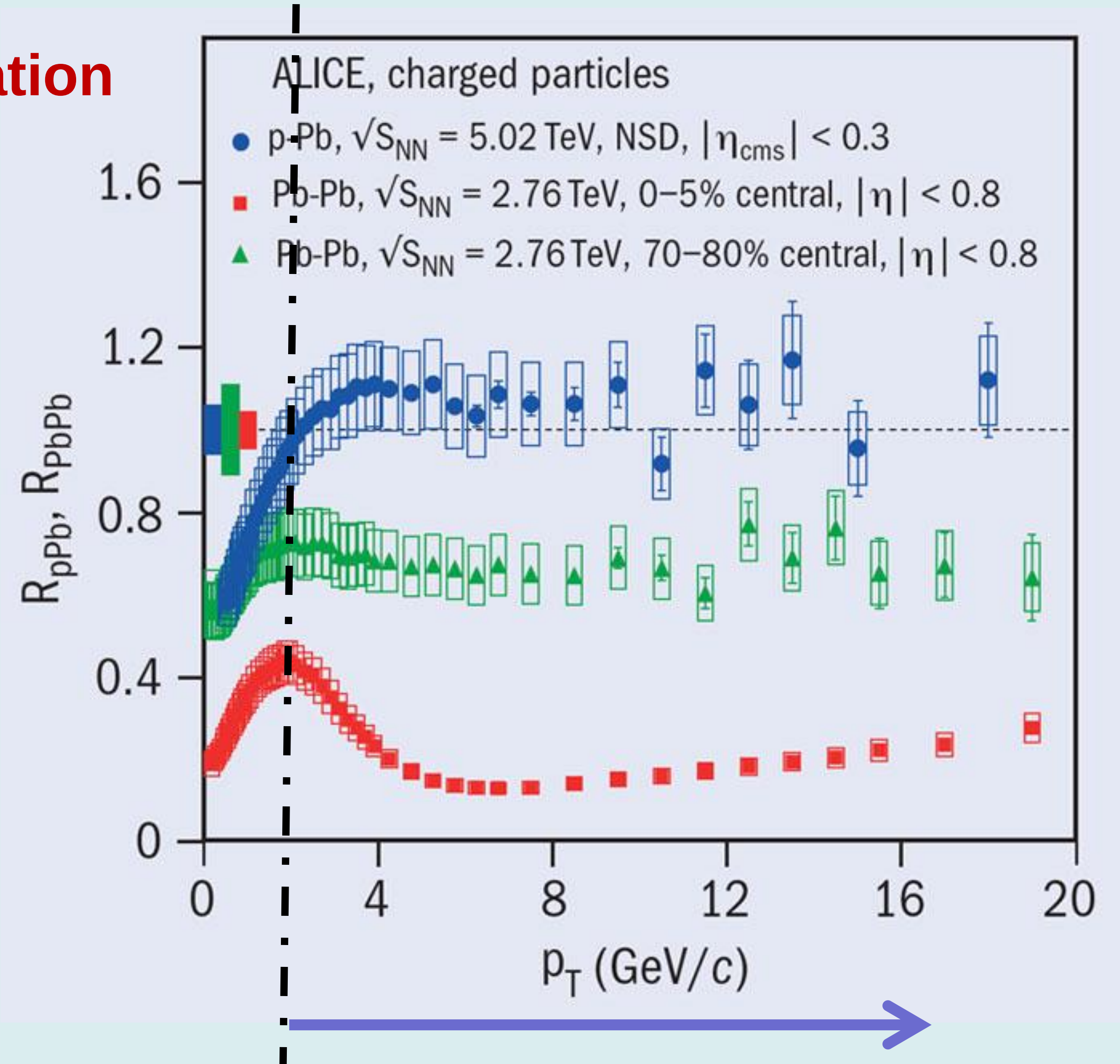


nuclear modification

shadowing parameter tuned to data at lower energy

ALICE Collab. arXiv:1210.4520

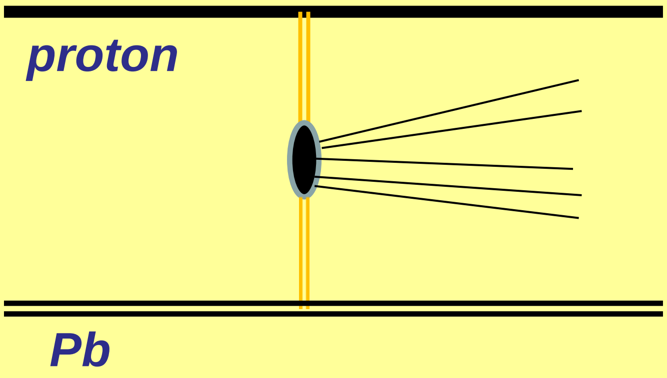
Nuclear Modification Factor



the suppresion observed in PbPb is not the result of cold nuclear matter

Diffractive physics in proton - Pb

- diffractive physics in p A is almost completely unknown
- One could analyze central diffraction processes searching several final states : ρ^0 J/ψ f_0 f_2 ….
- Compare *pp* and *pA*
- Trigger implemented, goal: 20000 good events in pion channels



- Preliminar results may be ready for summer

Conclusions

- A rich program on Pb–Pb, proton-Pb and proton proton in the years to come

- Low p_T , photon induced and diffractive physics have started to produce results and will continue to do so

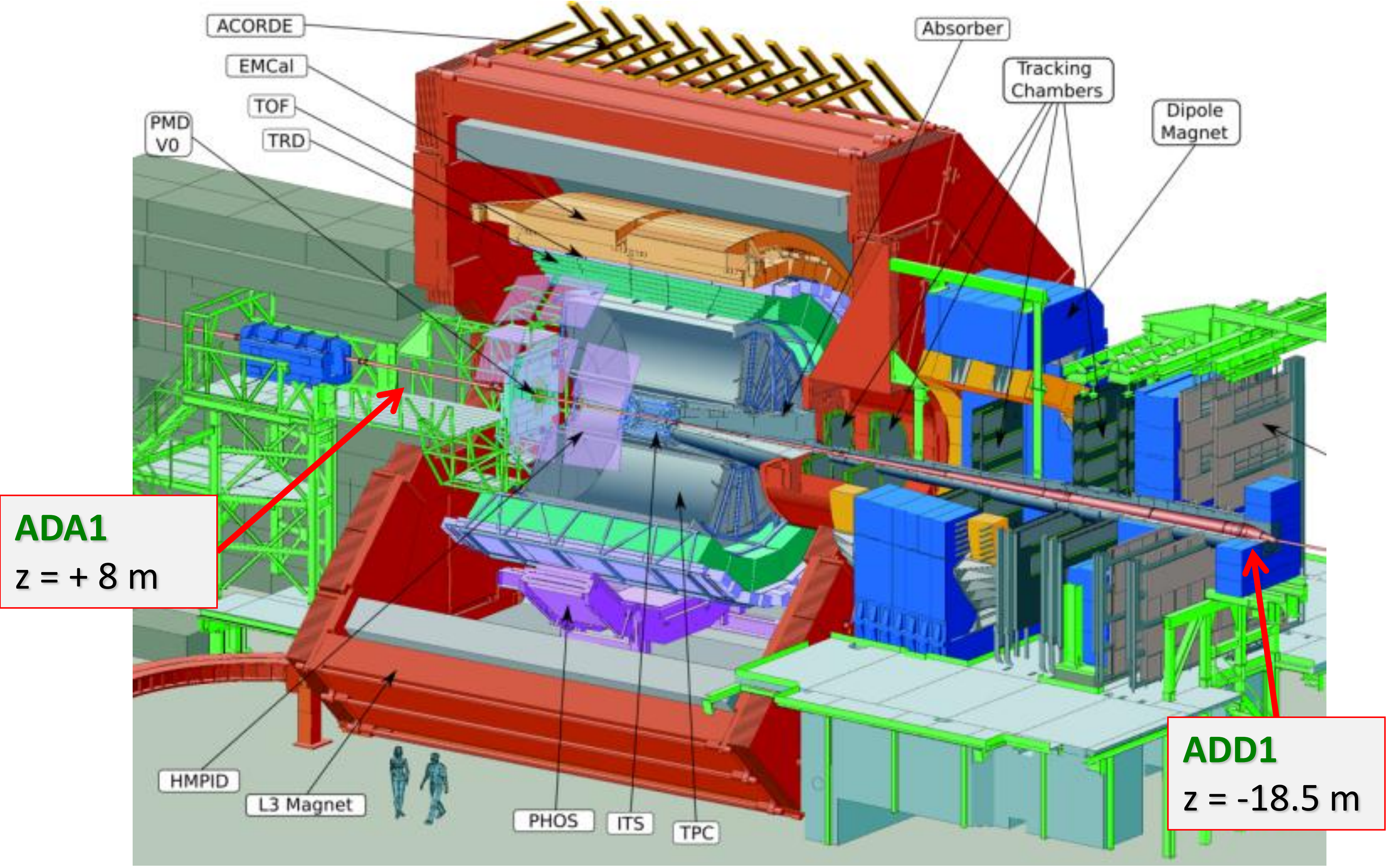
- In the long shutdown, the efficiency for Diffractive proton-proton could be enhanced by integrating to ALICE DAQ the information from new detectors, → AD forward detectors

Thursday

- Overview of recent ALICE results on bulk and soft observation by Yiota Foka
- Meson production with ALICE by Riccardo Russo
- Flow of phi meson in Pb Pb collision at 2.76 TeV with ALICE by Ajay Dash

back up

Detector location

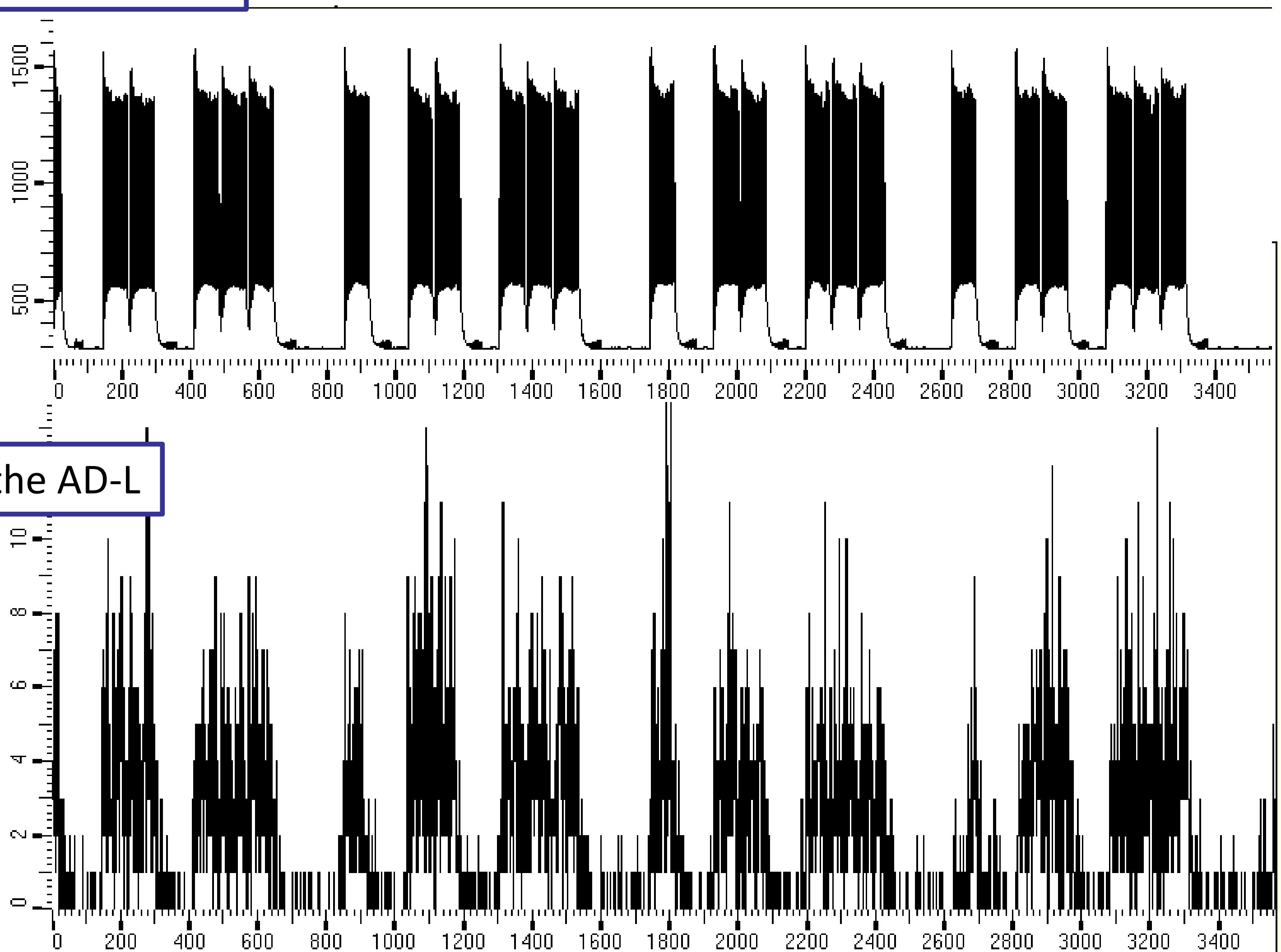


performance on April 12 2012

Bunches seen in the BPIM

Beam **P**hase and **I**ntensity **M**onitor

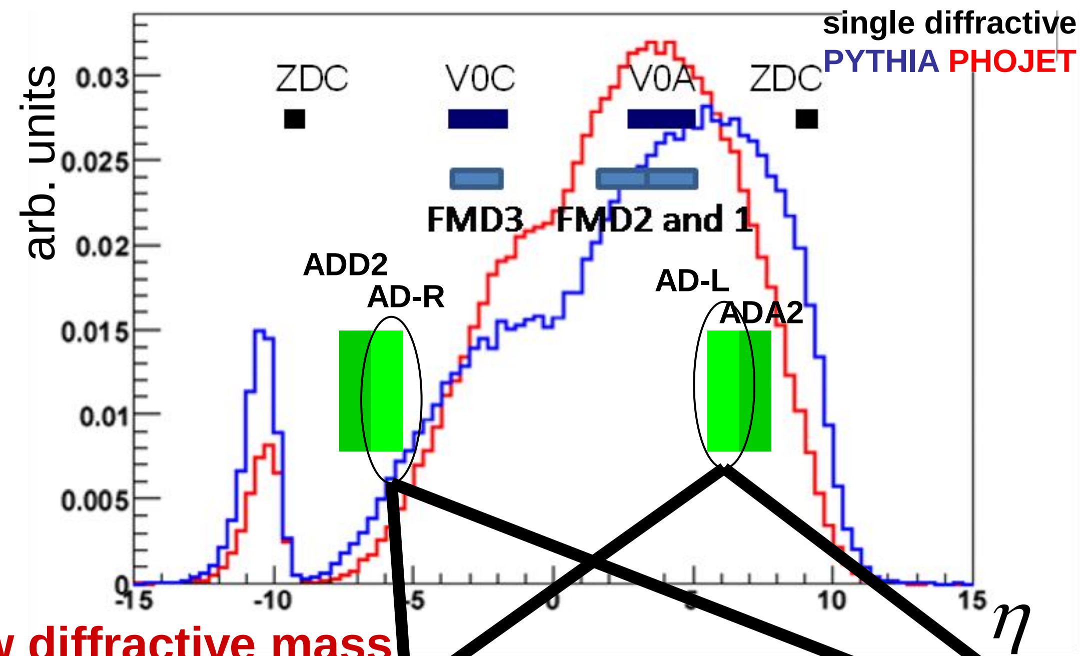
Losses seen in the AD-L



Time →

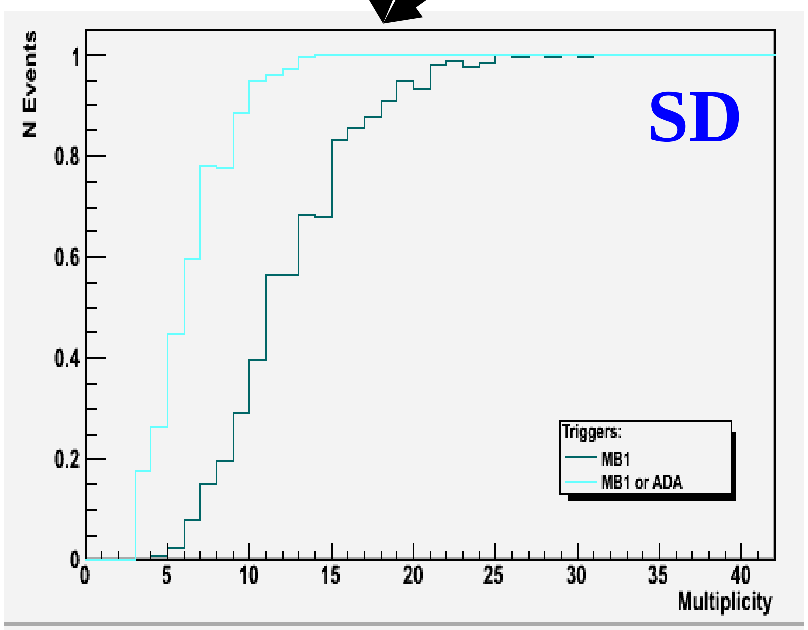
offline triggger

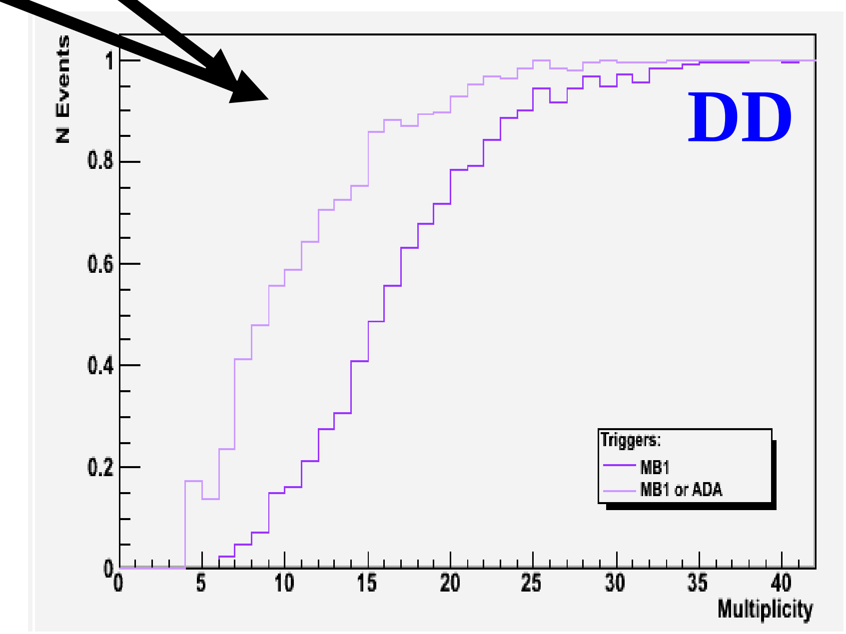
Gap tagger in a sensitive region of pseudorapidity to separate SD and DD events.



PHOJET PYTHIA

PHOJET	Default fractions	PYTHIA
0.134	SD	0.187
0.063	DD	0.127





ALICE upgrade

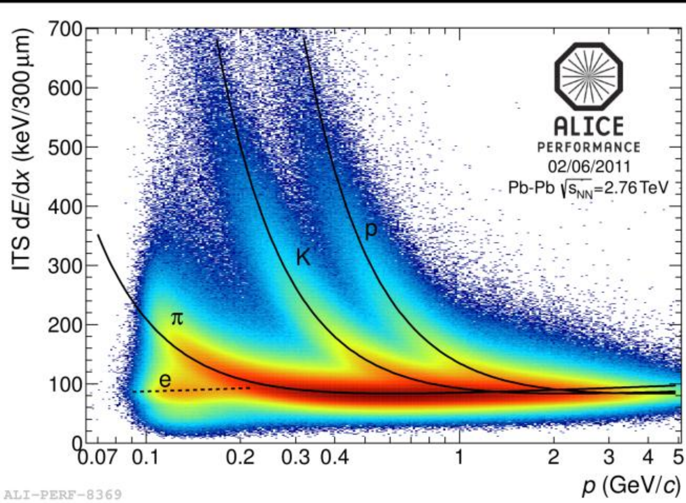
- luminosity upgrade – 50 kHz target minimum-bias rate for Pb–Pb
- run ALICE at this high rate

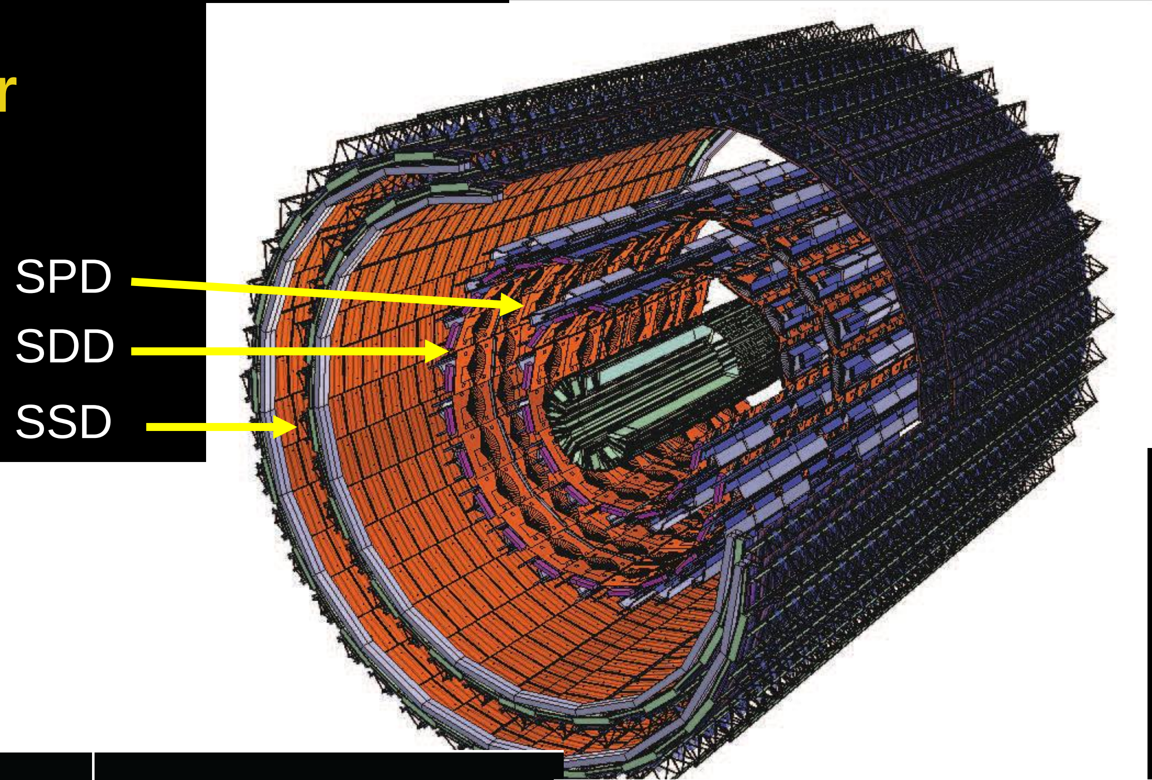
- improved vertex measurement and tracking at low p_T
- preserve particle-identification capability
- high-luminosity operation without dead-time

- new, smaller radius beam pipe
- new inner tracker (ITS) (performance and rate upgrade)
- high-rate upgrade for the readout of the TPC, TRD, TOF, CALs, DAQ-HLT, Muon-Arm and Trigger detectors

- target for installation and commissioning LS2 (2018)
- collect more than 10 nb^{-1} of integrated luminosity
  - implies running with heavy ions for a few years after LS3
- physics program – factor > 100 increase in statistics
  - (today maximum readout ALICE ~ 500 Hz)
- for triggered probes increase in statistics by factor > 10

all known techniques for particle identification:





Layer	Det. Type	Radius (cm)	Length (cm)	Resolution (μm)	
				rφ	z
1	pixel	3.9	28.2	12	100
2	pixel	7.6	28.2	12	100
3	drift	15.0	44.4	35	25
4	drift	23.9	59.4	35	25
5	strip	38.0	86.2	20	830
6	strip	43.0	97.8	20	830

Inner Tracking System

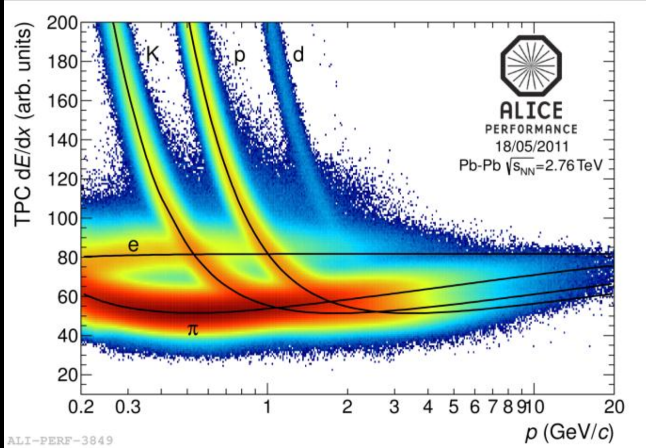
3 silicon technologies

low momentum acceptance

high granularity

low material budget

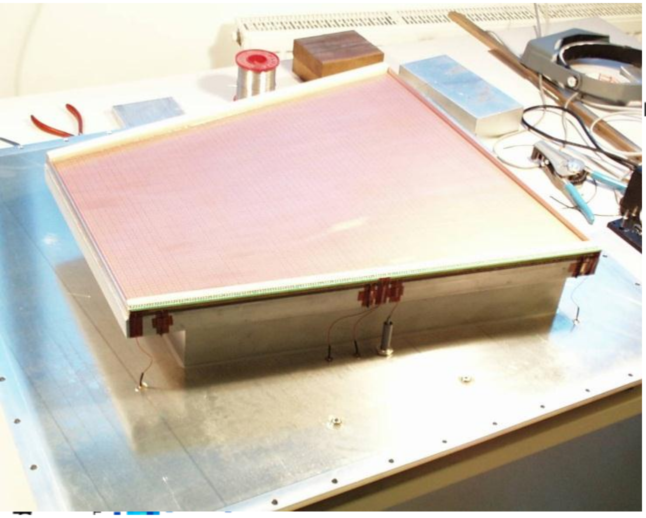
all known techniques for particle identification:

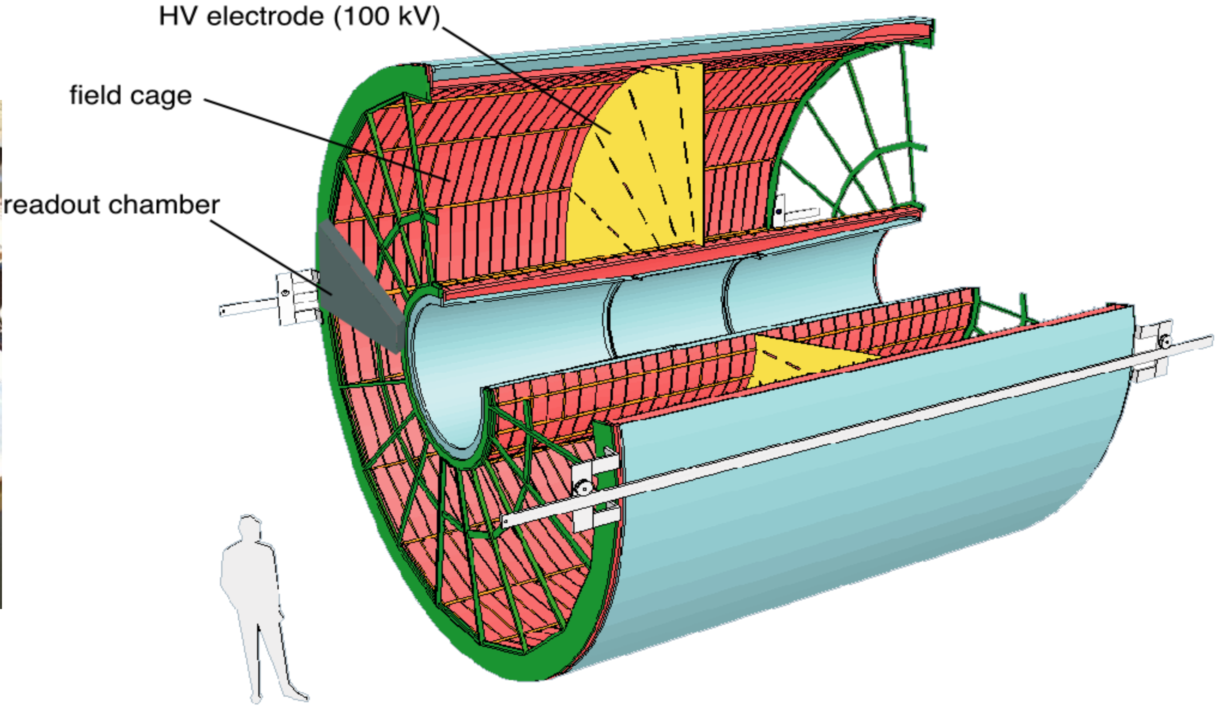


drift gas
90% Ne - 10%CO_2

for tracking and PID via dE/dx

$-0.9 < \eta < 0.9$





Time Projection Chamber
largest ever: 88 m^3, 570 k channels

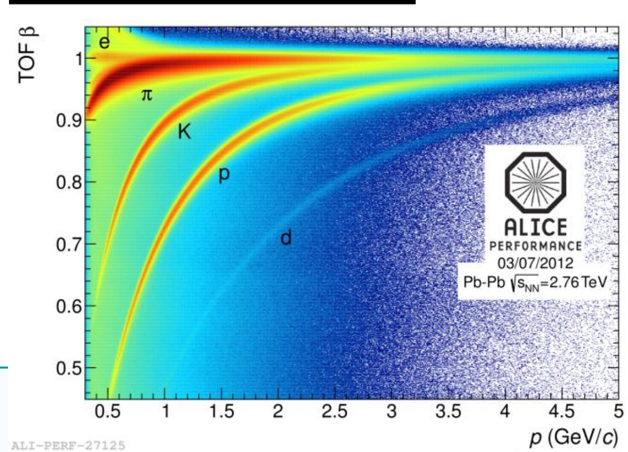
all known techniques for particle identification:

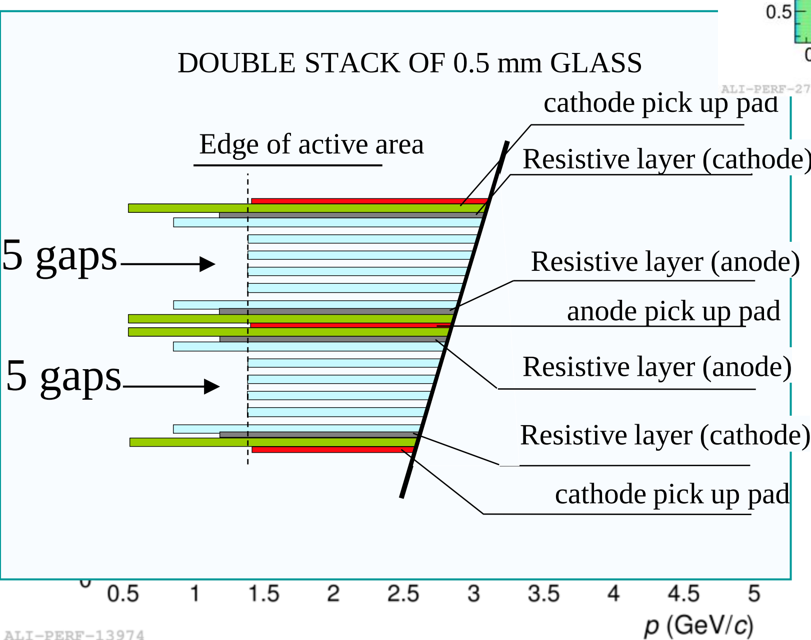
Time Of Flight

Multigap Resistive Plate Chambers

for π, K, p PID
π, K for p <2 GeV/c
p for p <4 GeV/c

- 0.9 < η < 0.9
full ϕ





all known techniques for particle identification:

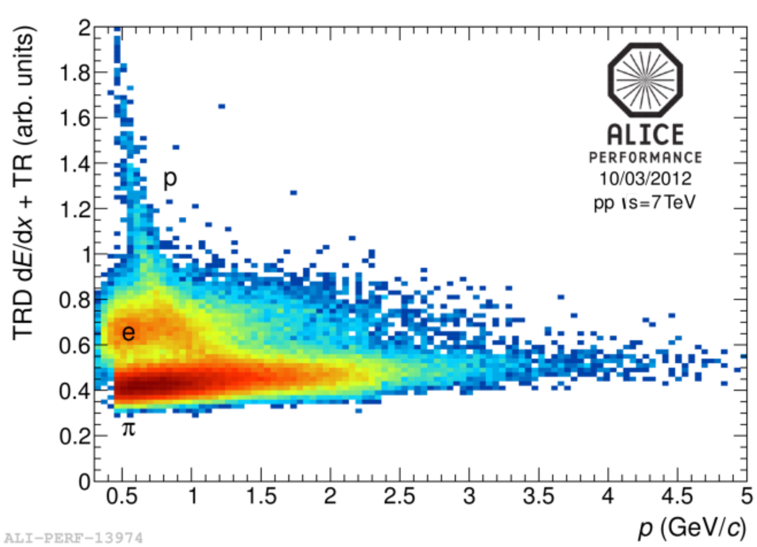
$-0.9 < \eta < 0.9$

Transition Radiation Detector

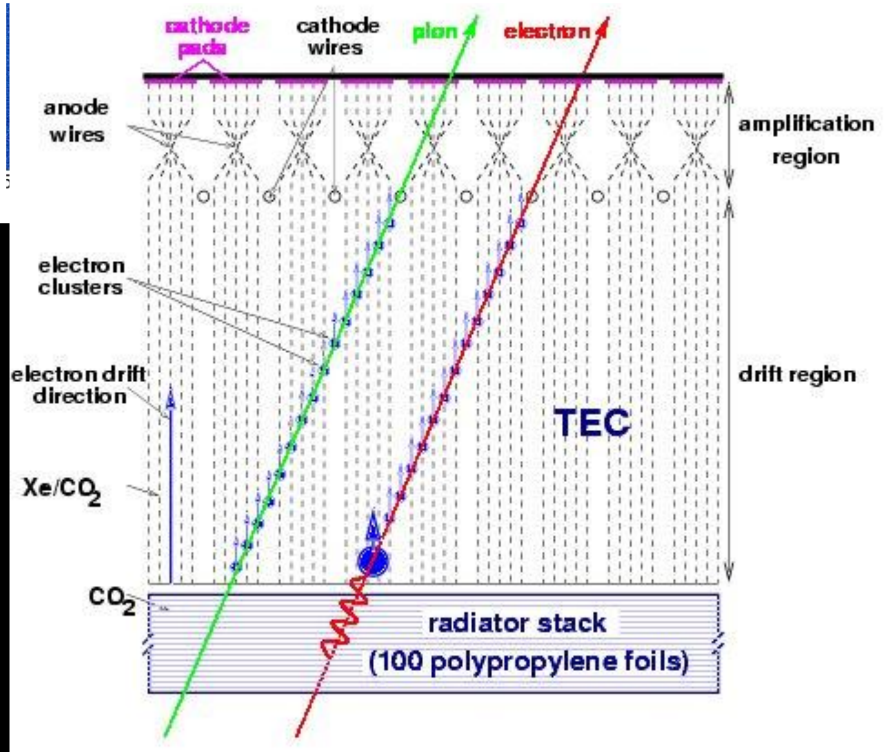
for e PID, *p*>1 GeV/c for e and high p_t trigger, *p*>3 GeV/c

Large (800 m^2), high granularity (> 1M ch.)

fiber radiator to induce TR (γ > 2000)



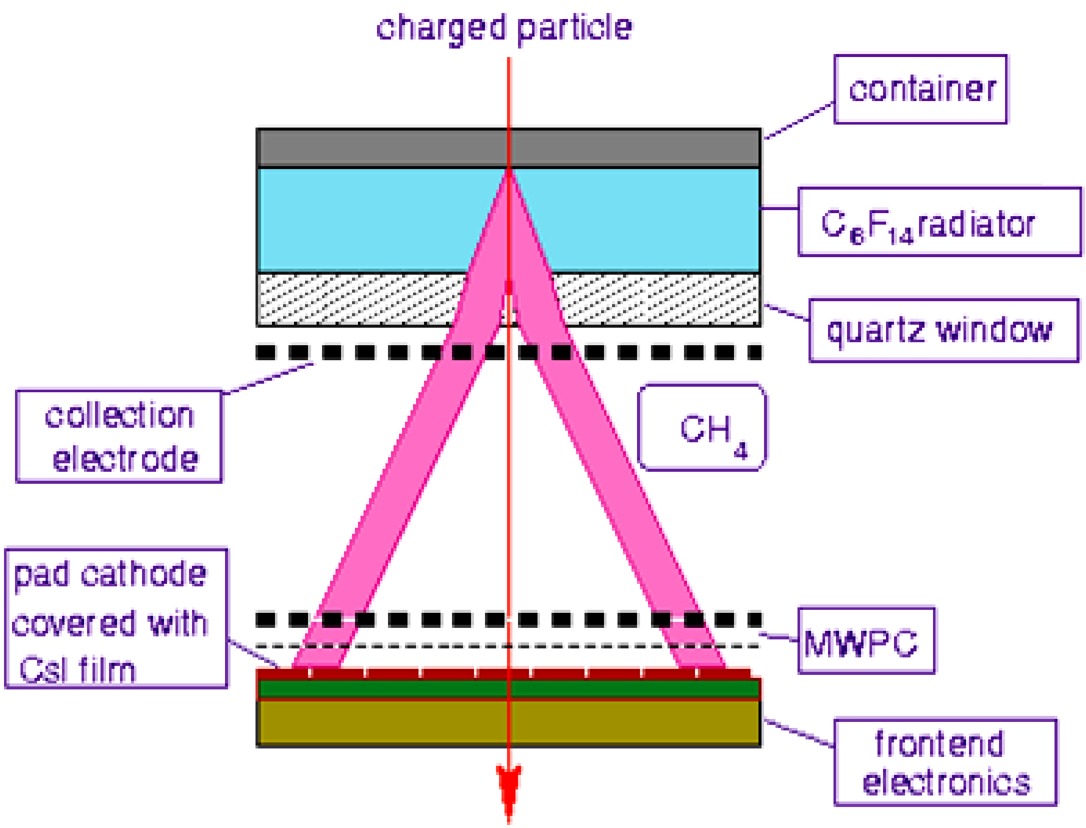
TRD

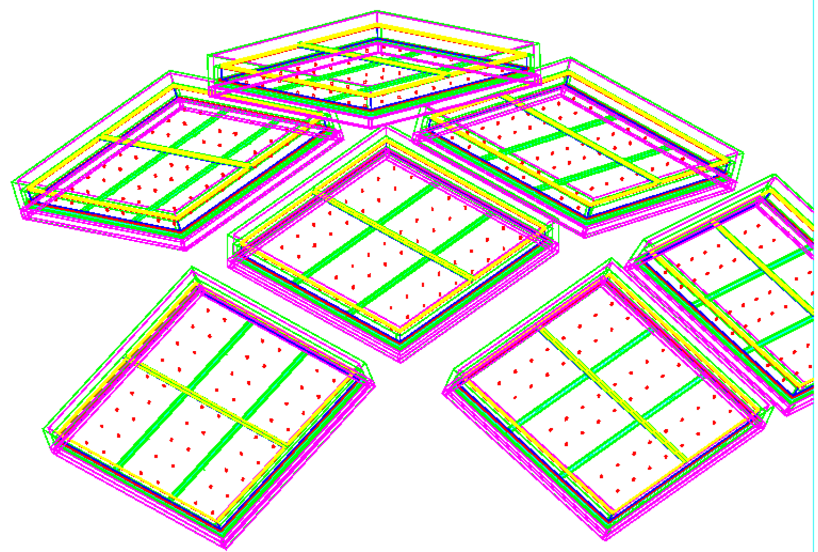


all known techniques for particle identification:

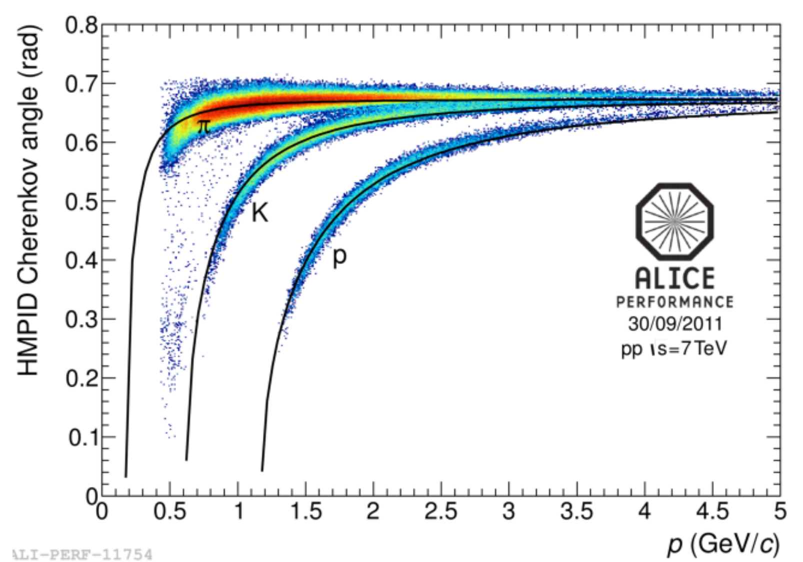
7 modules, each ~1.5 x 1.5 m^2

High Momentum Particle Identification





RICH **HMPID**



Process Efficiency	SD (%) XC	XA	DD (%)	LP (%)
MB1	**69.3**	**75.5**	**87.5**	**99.9**
MB1.or.ADA1	**69.9**	**88.8**	**94.5**	**100.0**
MB3	**35.1**	**39.8**	**43.1**	**97.8**
MB3.and.ADA1	**13.7**	**36.9**	**35.1**	**95.5**

MB1 = VOC or SPD or VOA

MC studies

No ADA or ADD: GF0 && (!V0A) && (!V0C)

#	ND	SD	DD	CD
	276	531	125	2207
%	ND	SD	DD	CD
	8.8%	16.9%	4.0%	70.3%

ADA and ADD: GF0 && (!V0A) && (!V0C) && (!ADA) && (!ADD)

#	ND	SD	DD	CD
	49	62	4	2123
%	ND	SD	DD	CD
	2.2%	2.8%	0.2%	94.9%

pp 7 TeV PHOJET   assuming 100% efficiency