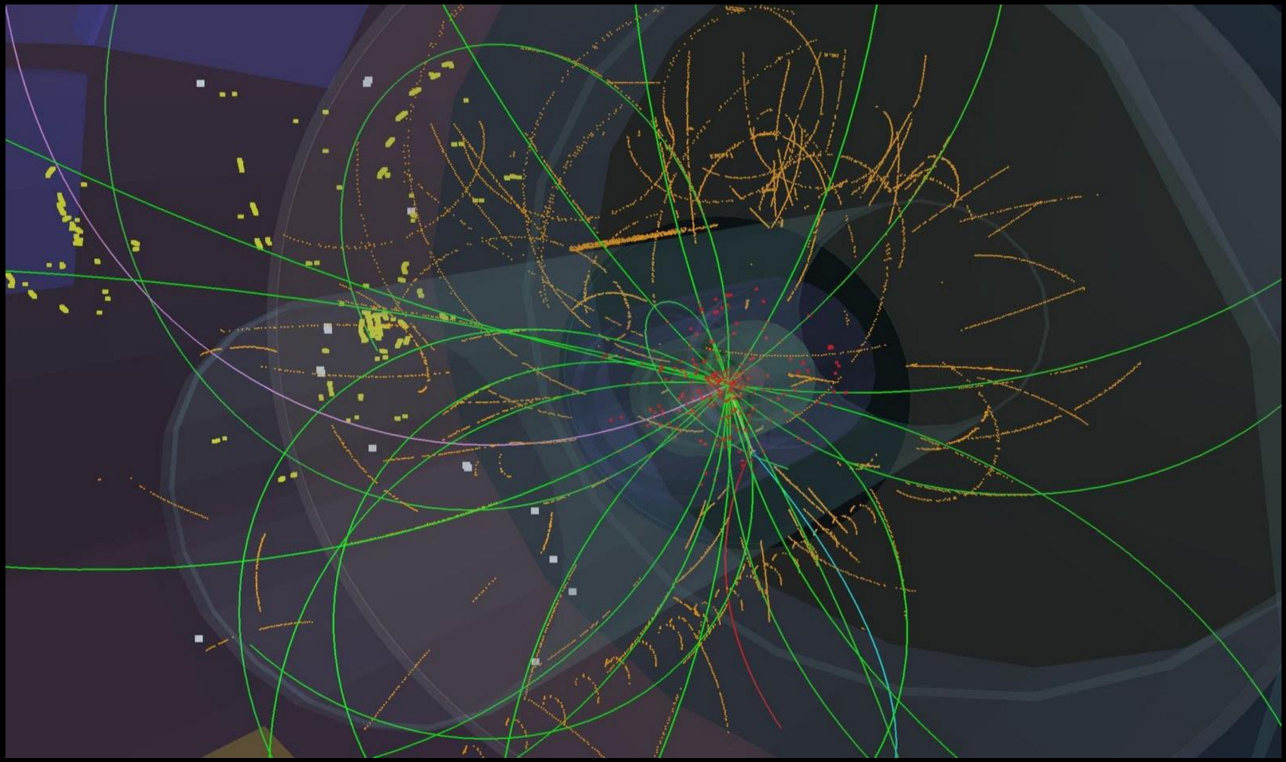
Diffraction in ALICE at the LHC



Introduction

Summary of measurements on Diffractive Physics

Central Diffractive studies

Studies on Ultra Peripheral Collisions

Possible improvements of ALICE for diffractive physics

Plans for the future

Wilhelm and Elsen Heraeus Summerschool
Diffractive and electromagnetic processes at high energies
Heidelberg, sept. 2-6, 2013

Gerardo Herrera Corral - CINVESTAV - México
(on behalf of ALICE Collab.)

Introduction

$$Pb = 82p + 126n$$

2.76 TeV/nucleon

fully stripped
Pb ions

$$Pb^{82+}$$

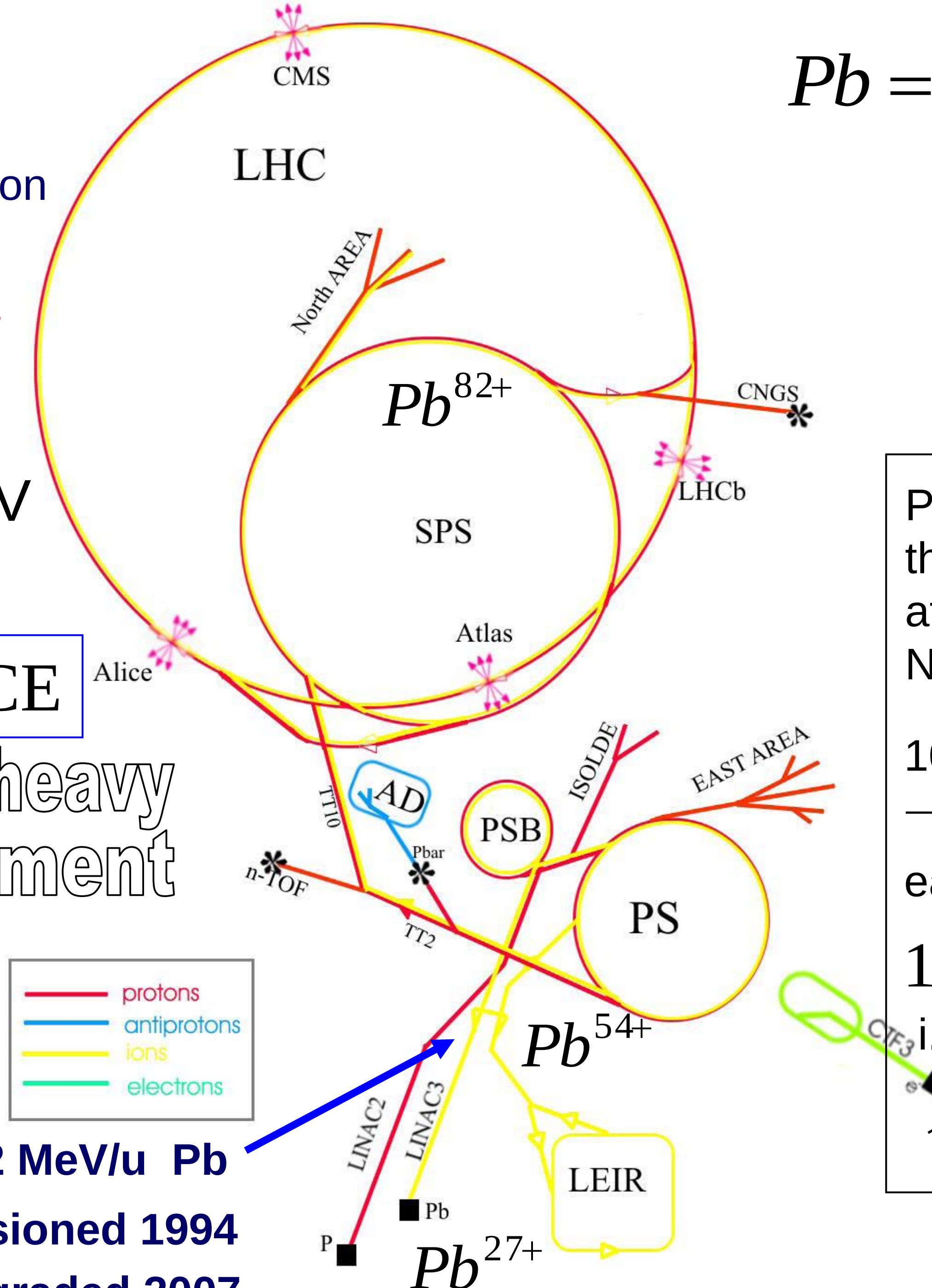
LARGE amounts of energy involved

$$\sqrt{s} = 1154 \text{ TeV}$$

Pb – Pb collisions

ALICE

dedicated heavy ion experiment



Previous project in the field RHIC at Brookhaven National Laboratory

100 GeV/nucleon
→ Gold nucleus

each nucleus

100×197 GeV

i.e. 19.7 TeV

$$\sqrt{s} = 39.4 \text{ TeV}$$

4.2 MeV/u Pb

commissioned 1994

upgraded 2007

High Energy Heavy Ion Collisions is an emerging field of research

LARGE amount of energy involved

RHIC at Brookhaven National Laboratory

100 GeV/nucleon $\rightarrow$ Gold nucleus

each nucleus 100×197 GeV i.e. 19.7 TeV

$$\sqrt{s_{NN}} = 39.4 \quad \text{TeV}$$

LHC at CERN

$\sqrt{s} = 1154$ TeV Lead – Lead collisions

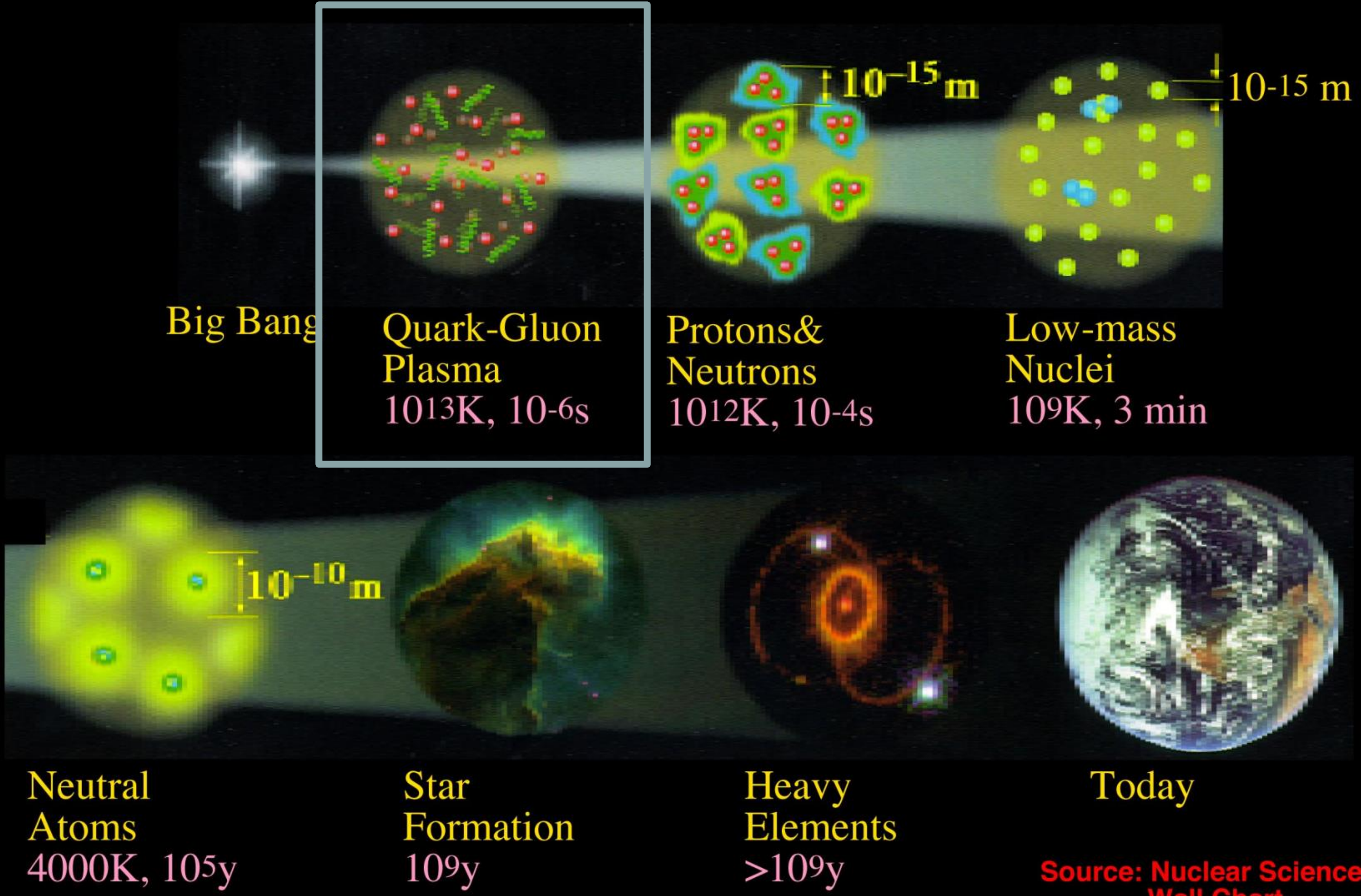
A large amount of energy is deposited in a small region of space in a very short time

In this region the density of energy is very large … this may favor the appearance of new forms of matter

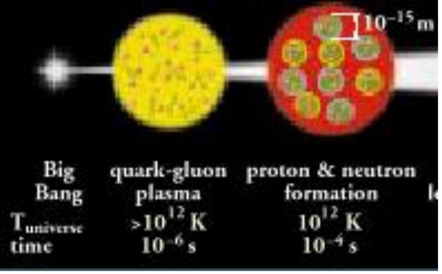
matter in extreme conditions

The search for new forms of matter under extreme conditions of high energy densities is an important objective of high energy heavy ion collisions

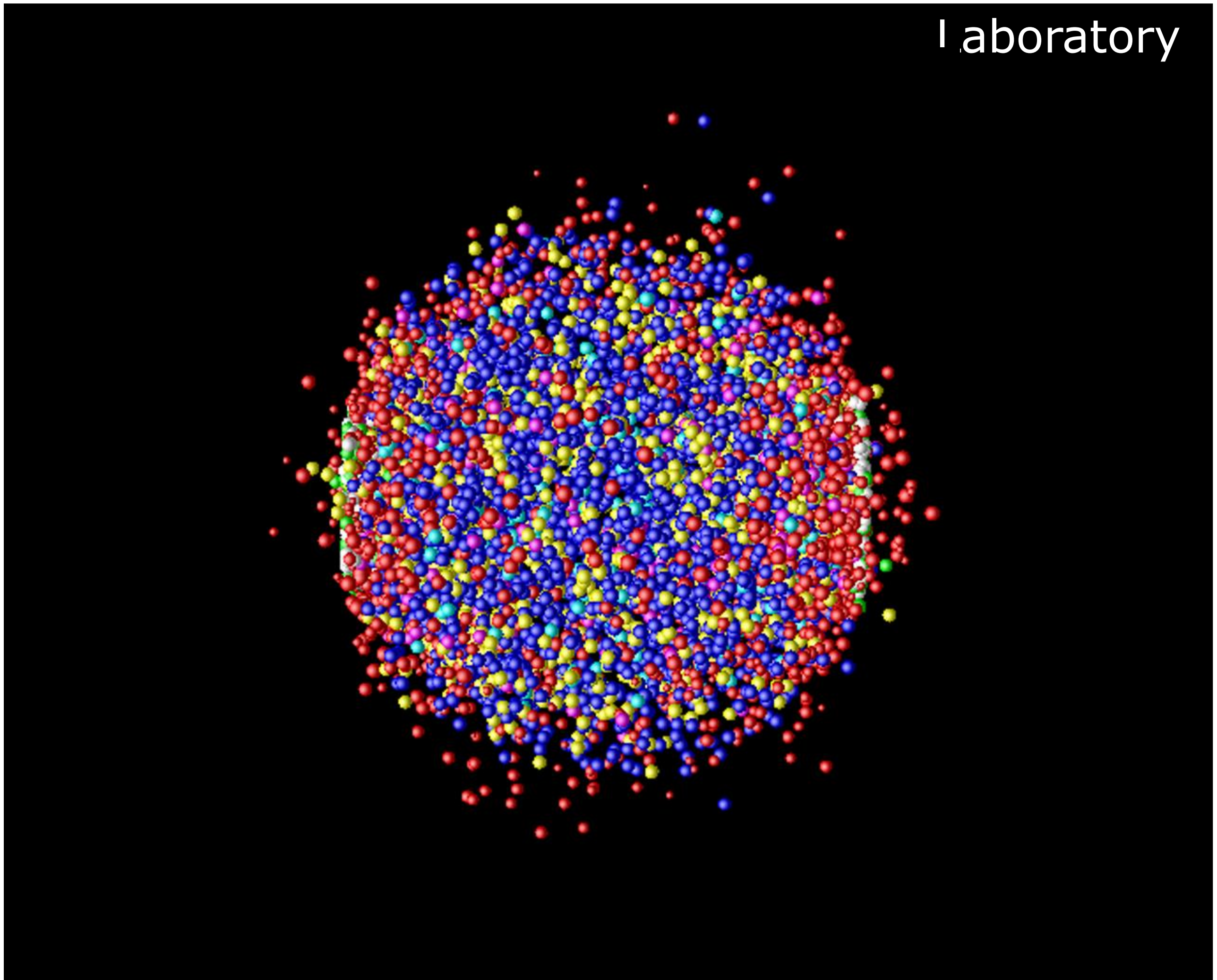
History of the Universe



Source: Nuclear Science Wall Chart



The mini Big Bang



v/c = 0,99999993

Lorentz Contraction : 7 fm → 0,003 fm

1. Accelerated ions collide head on

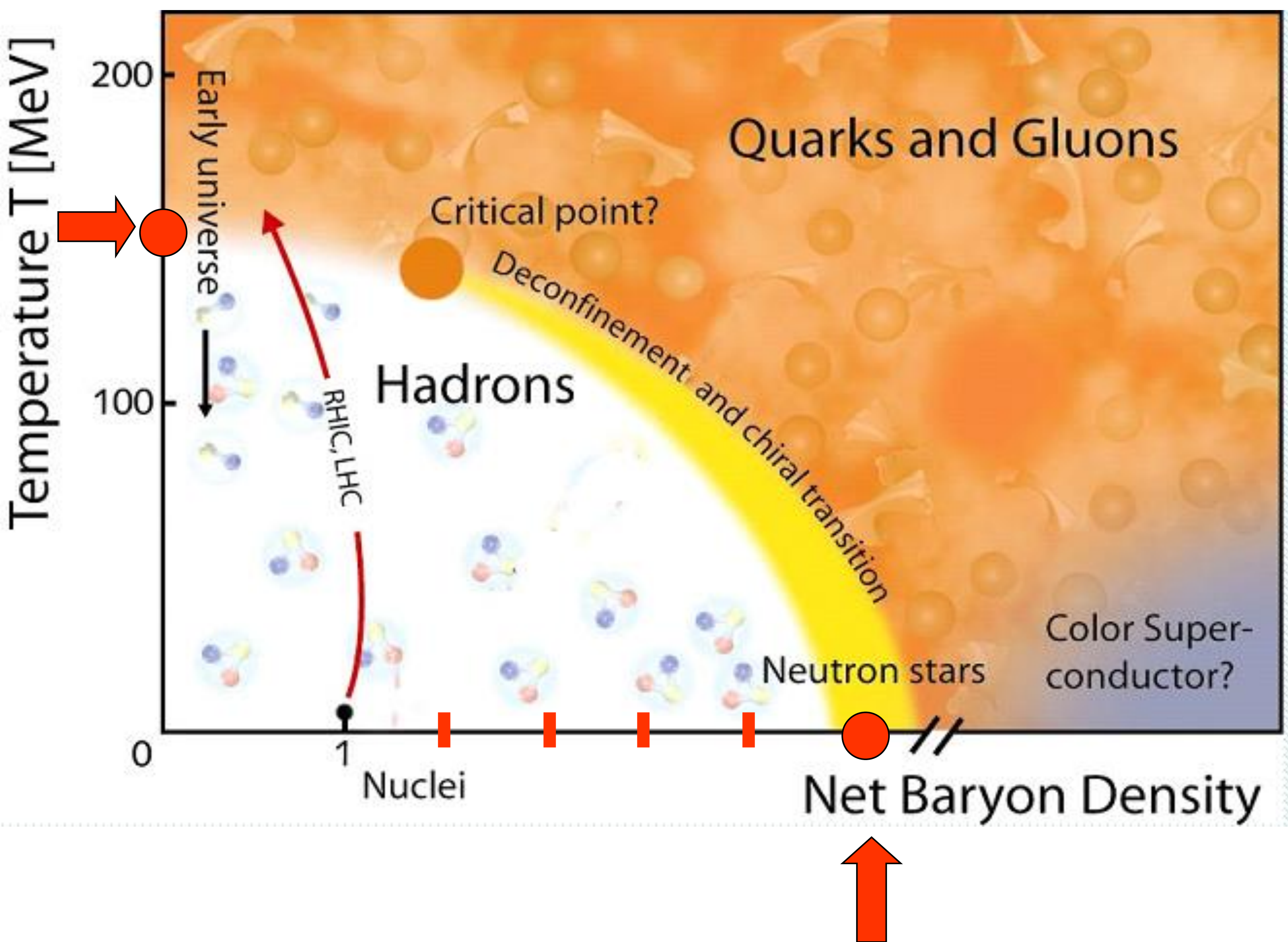
2. The energy of collision is materialized into quarks and gluons

3. Quarks and gluons interact via the strong interaction: matter equilibrates

4. The system expands and cools down

5. Quarks and gluons condensate into hadrons

Phase Diagram of QCD Matter



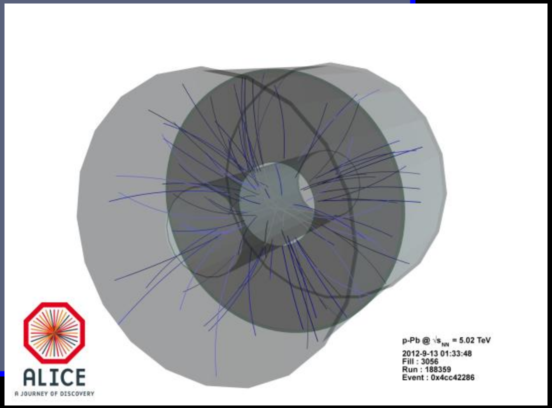
LHC heavy ion runs

- **Two heavy-ion runs at the LHC so far:**
  - 2010 – commissioning and first data taking
  - 2011 – above nominal instant luminosity

- **p–Pb next year – 2013**
  - plan for ~ 30 nb^{-1}

  pilot run September 12th successful !!!

- **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}**

The program of ALICE

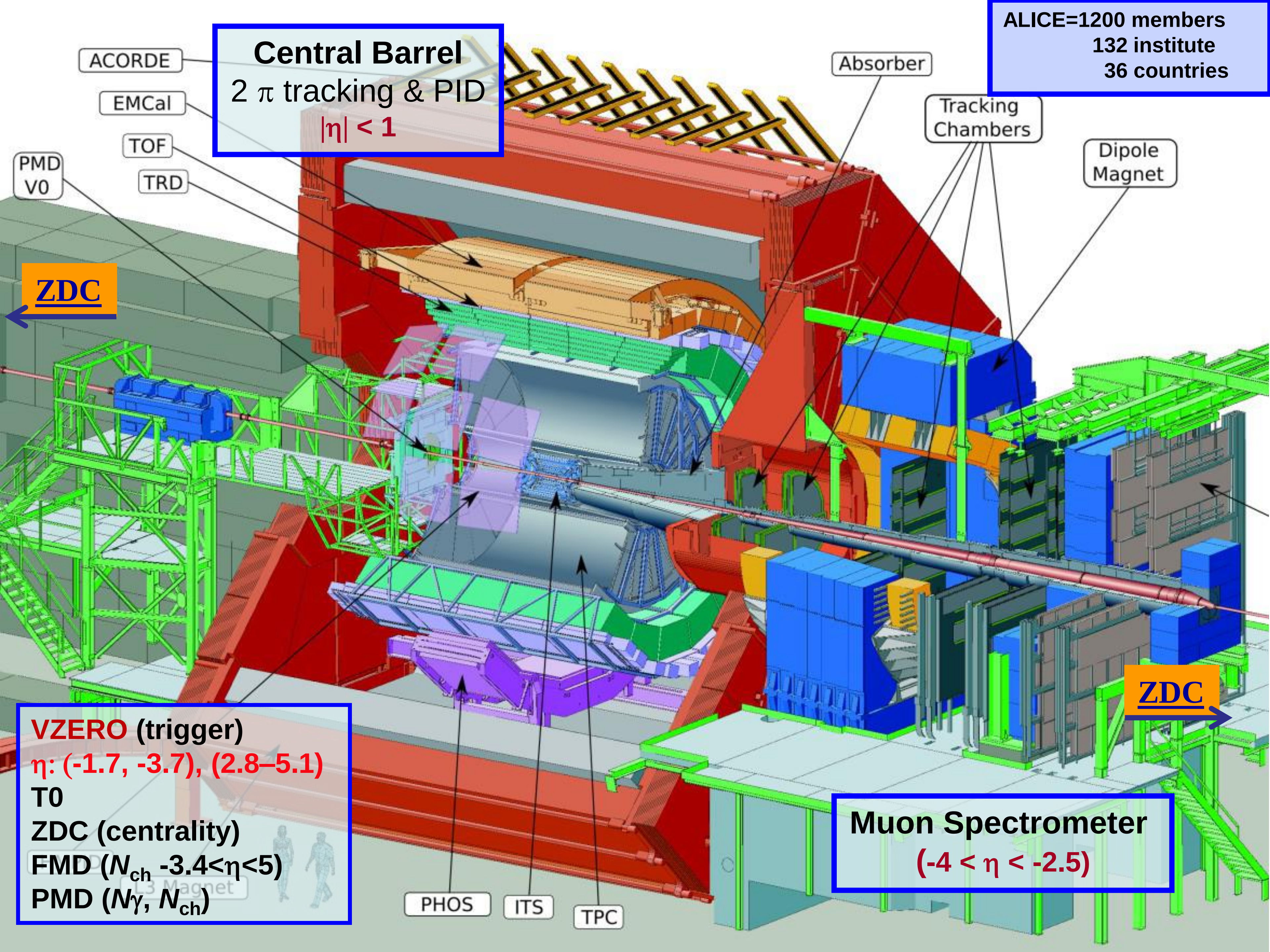
ALICE heavy-ion program approved for ~ 1 nb^{-1}:

- **2013–14 Long Shutdown 1 - completion of TRD and calorimeters**
- **2015 Pb–Pb at $\sqrt{s_{NN}}$ = 5.1 TeV**
- **2016–17 Pb–Pb at $\sqrt{s_{NN}}$ = 5.5 TeV**

- **2018 Long Shutdown 2**
- **2019 probably Ar–Ar high-luminosity run**
- **2020 p–Pb comparison run at full energy**
- **2021 Pb–Pb run to complete initial ALICE program**
- **2022 Long Shutdown 3**

This will improve statistical significance of our main results (~ x 3)

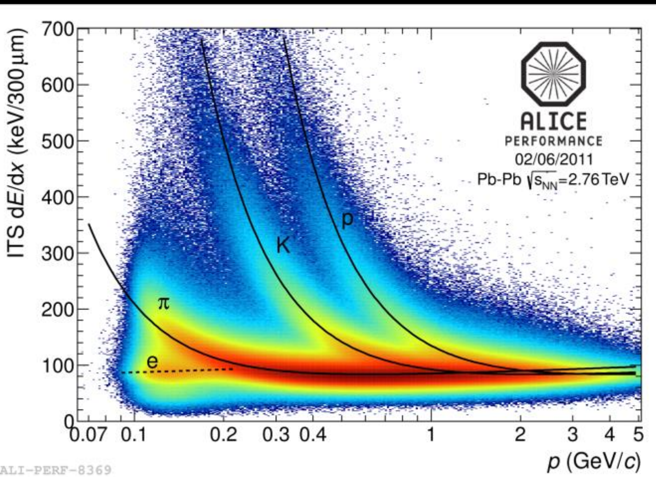
The physics reach will be extended both by the new energy and by the completion of TRD and Calorimeters


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
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)

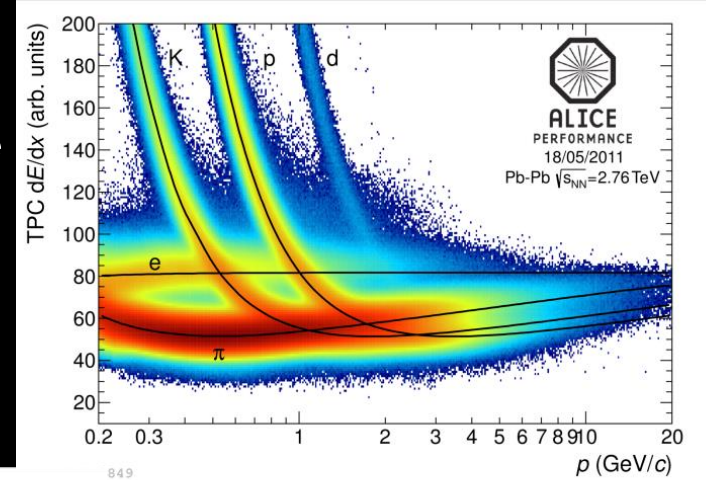
all known techniques for particle identification:

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

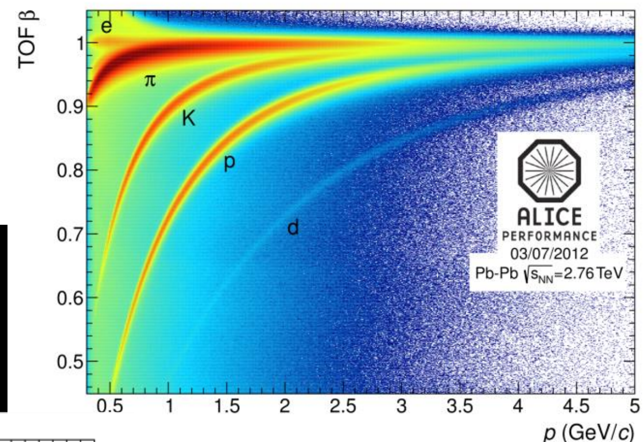
in progress



ITS

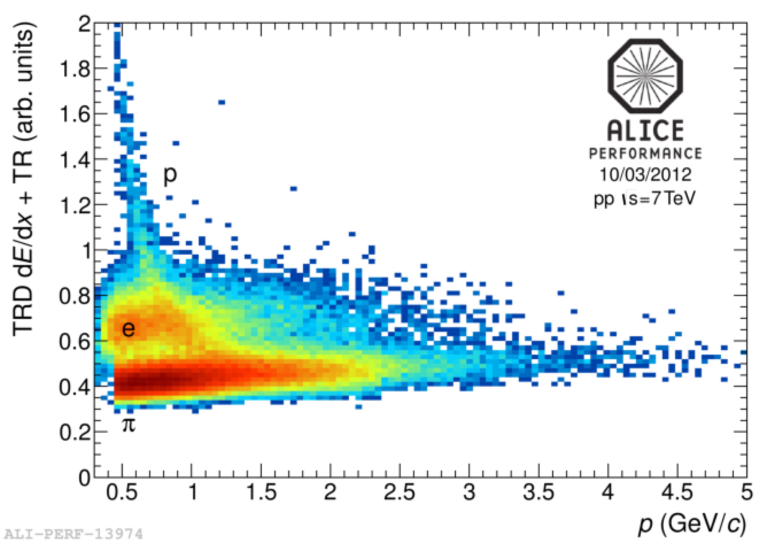


TPC

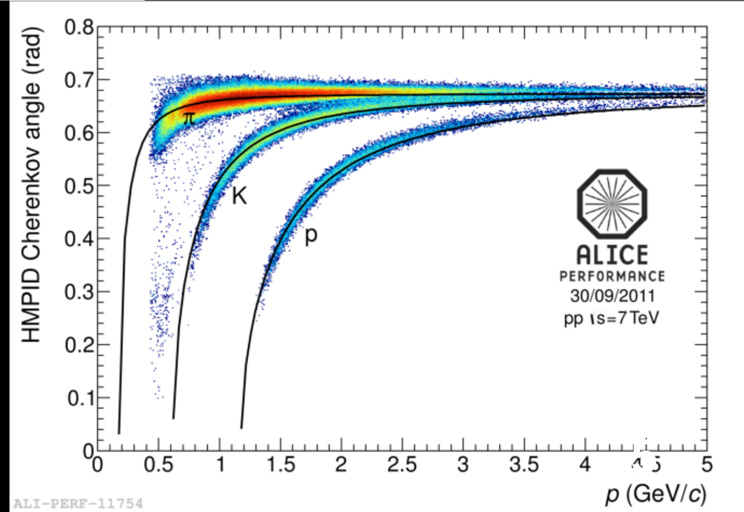


TOF

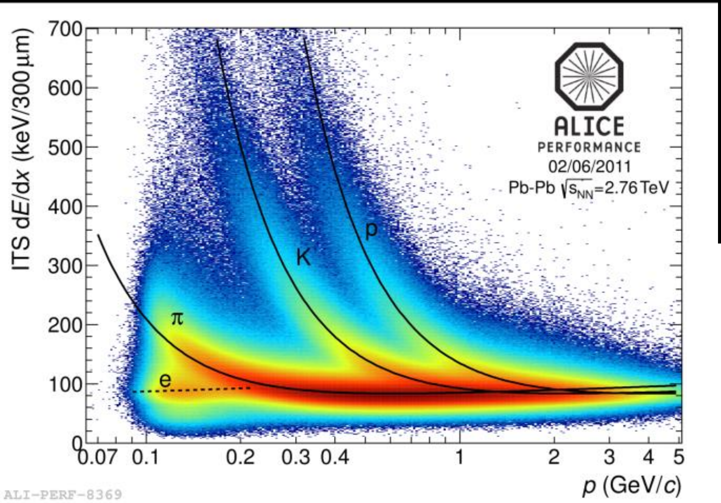
HMPID

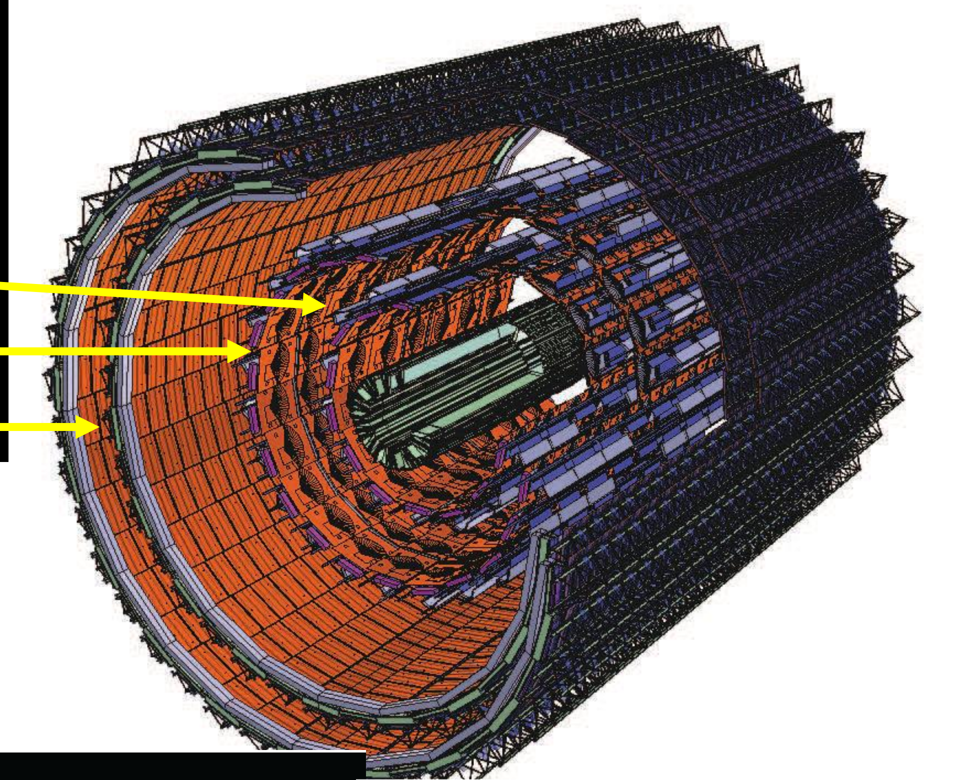


TRD



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

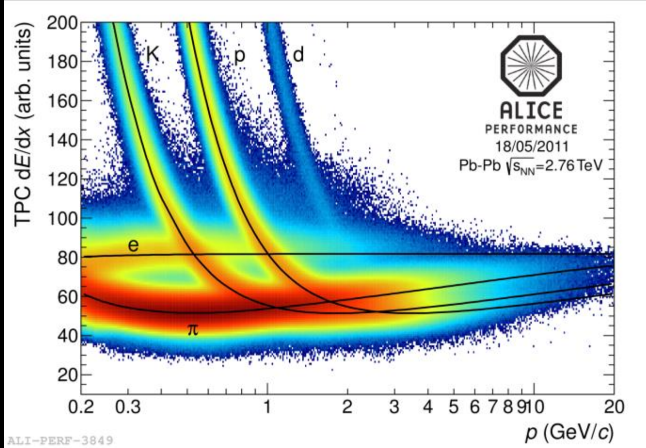
low material budget

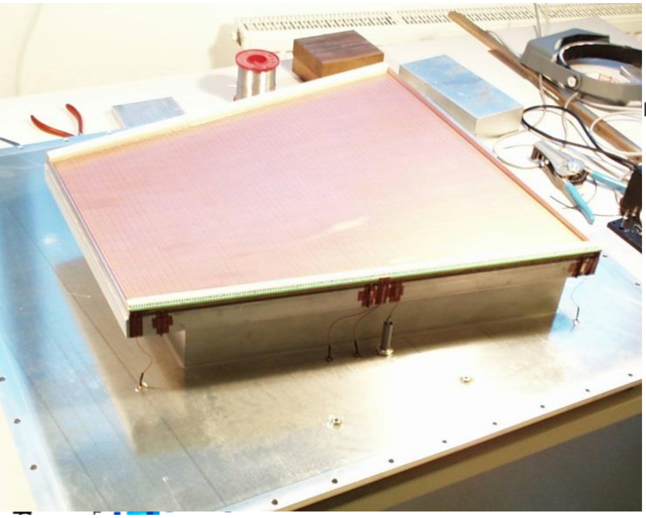
all known techniques for particle identification:

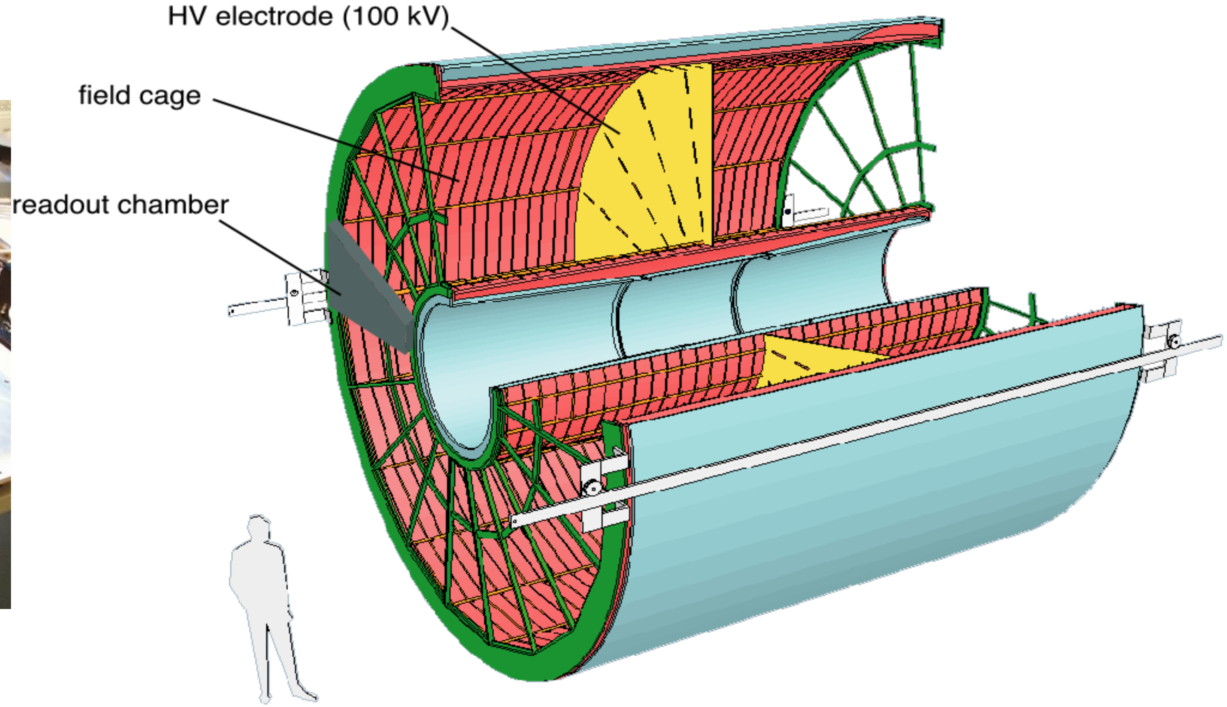
for tracking and PID via dE/dx

$-0.9 < \eta < 0.9$

drift gas
90% Ne - 10%CO_2





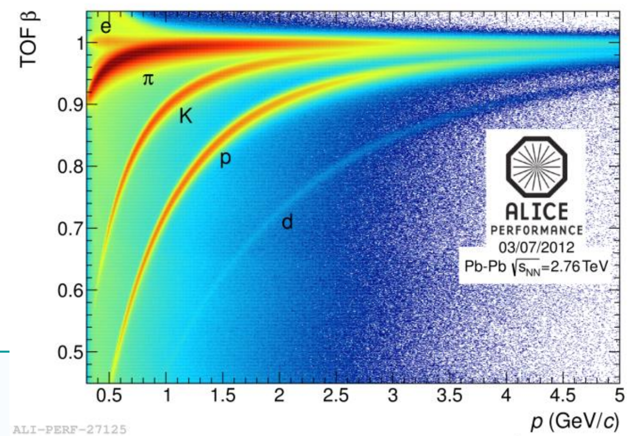


Time Projection Chamber
largest ever: 88 m^3, 570 k channels

all known techniques for particle identification:

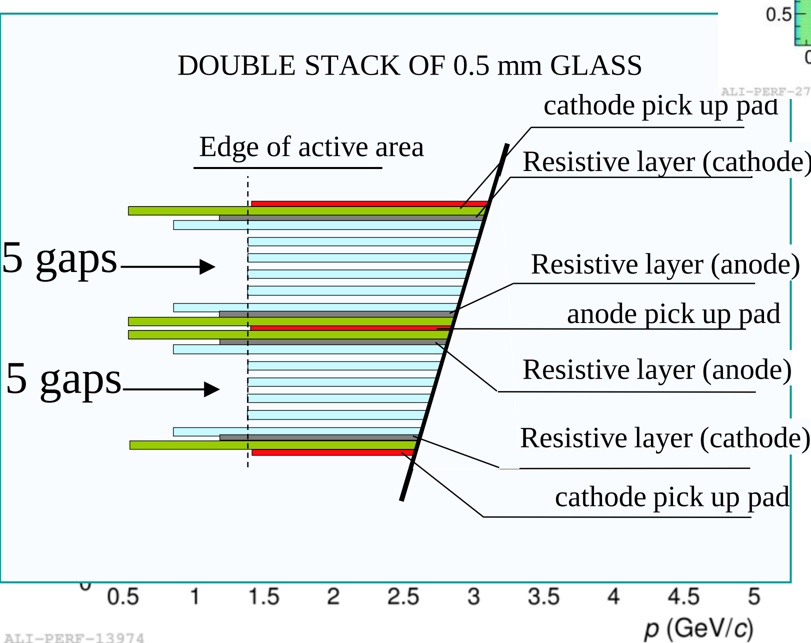
Multigap Resistive Plate Chambers

Time Of Flight



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:

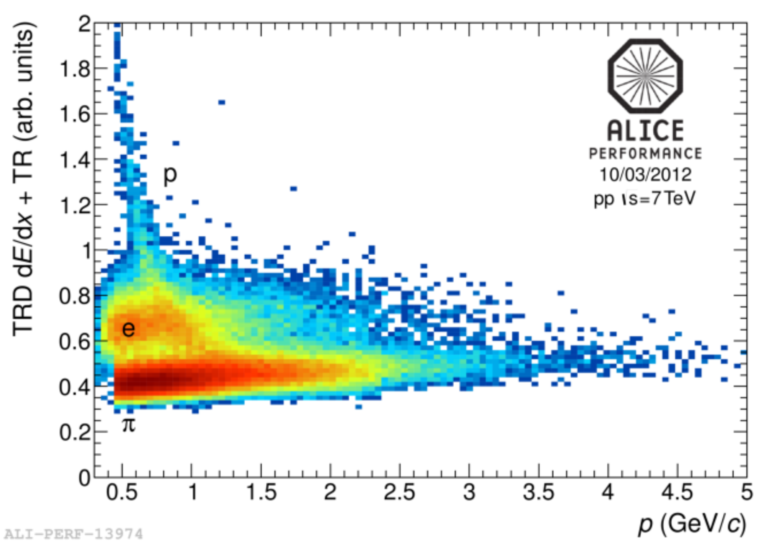
$-0.9 < \eta < 0.9$

Transition Radiation Detector

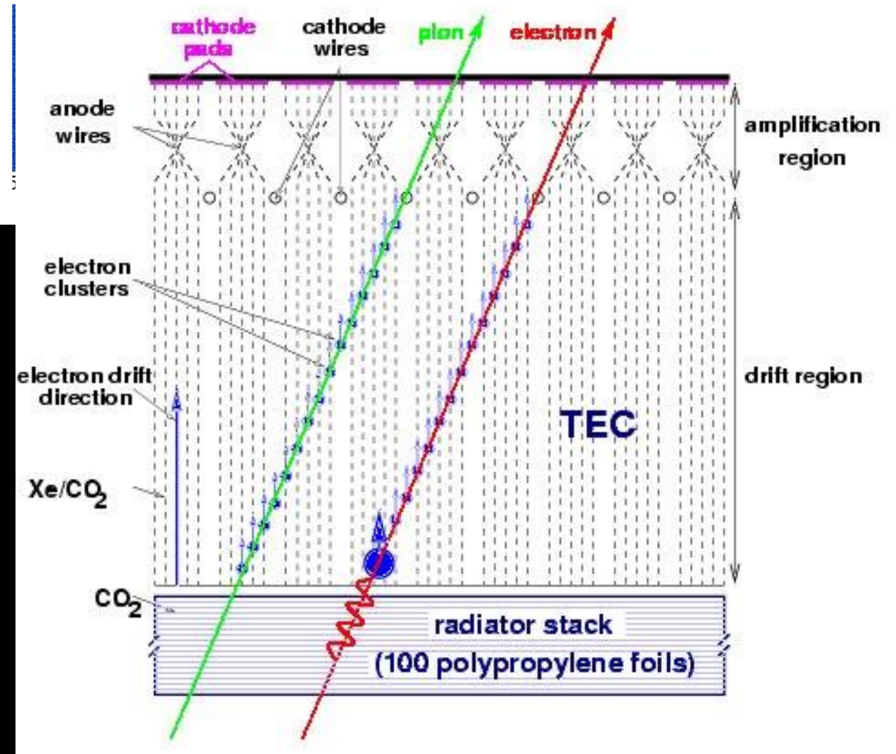
for e PID, p>1 GeV/c for e and high p_t trigger, p>3 GeV/c

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

fiber radiator to induce TR (γ > 2000)



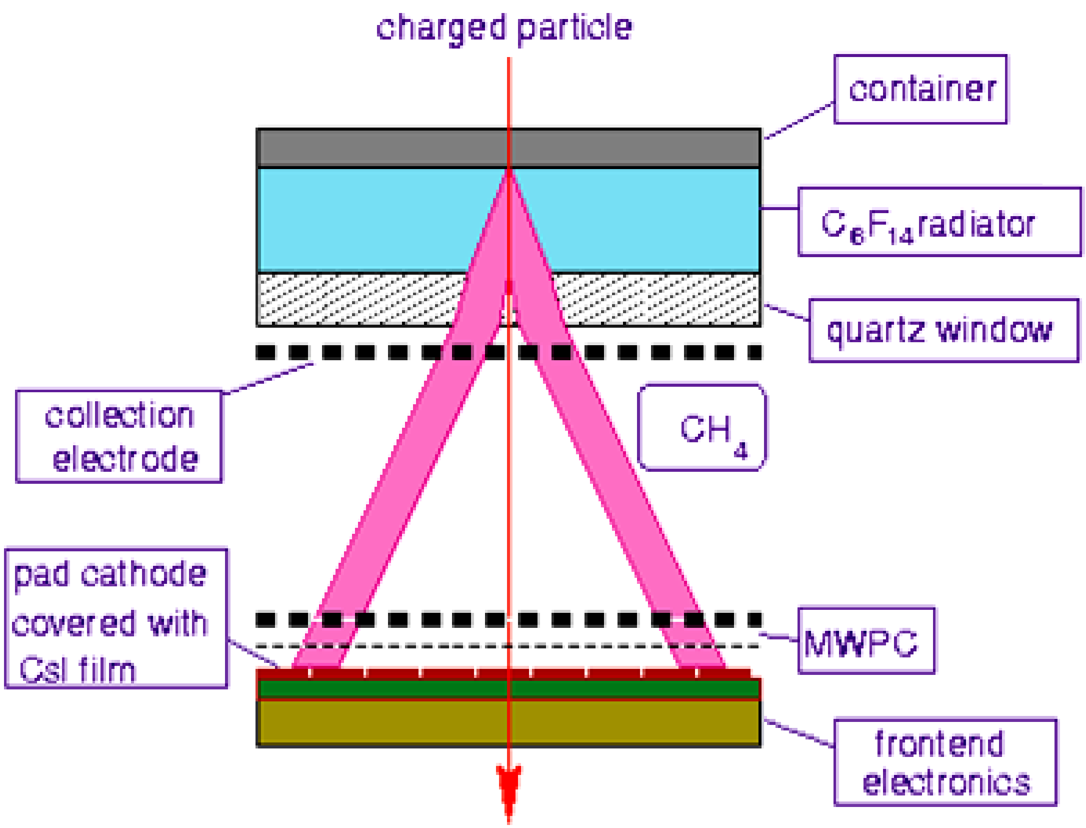
TRD

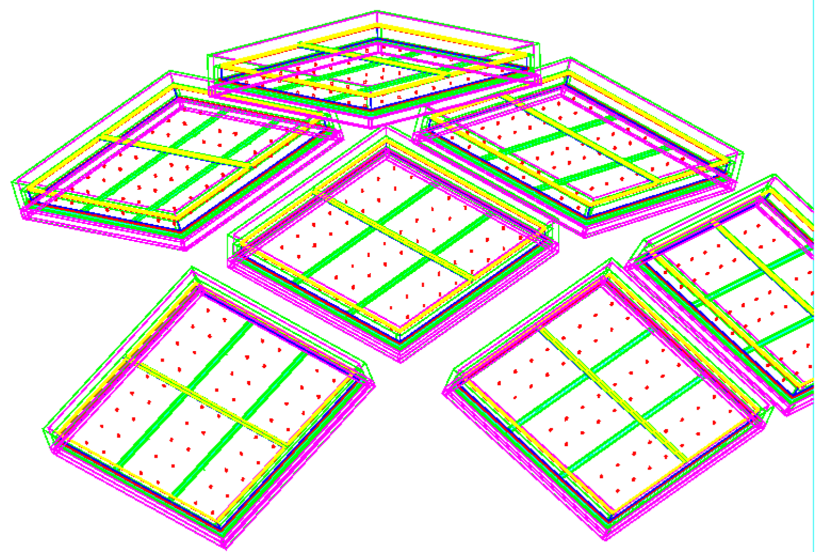


all known techniques for particle identification:

7 modules, each ~1.5 x 1.5 m^2

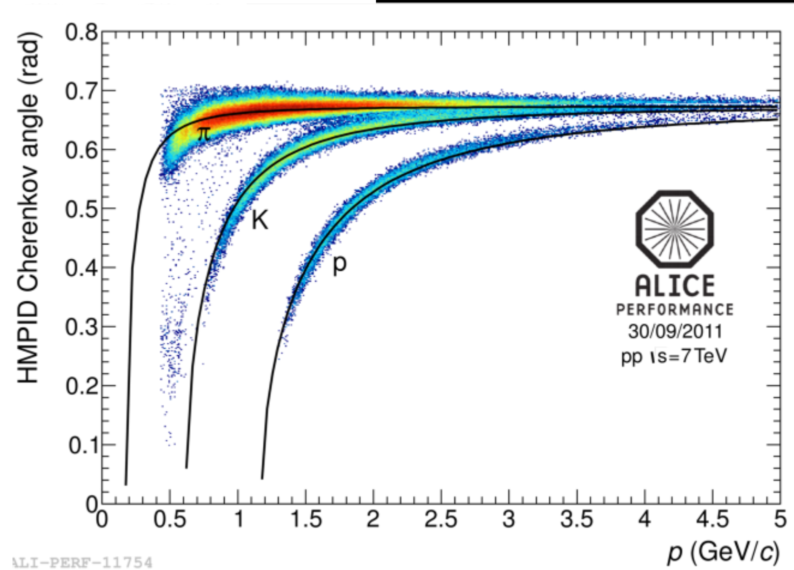
High Momentum Particle Identification

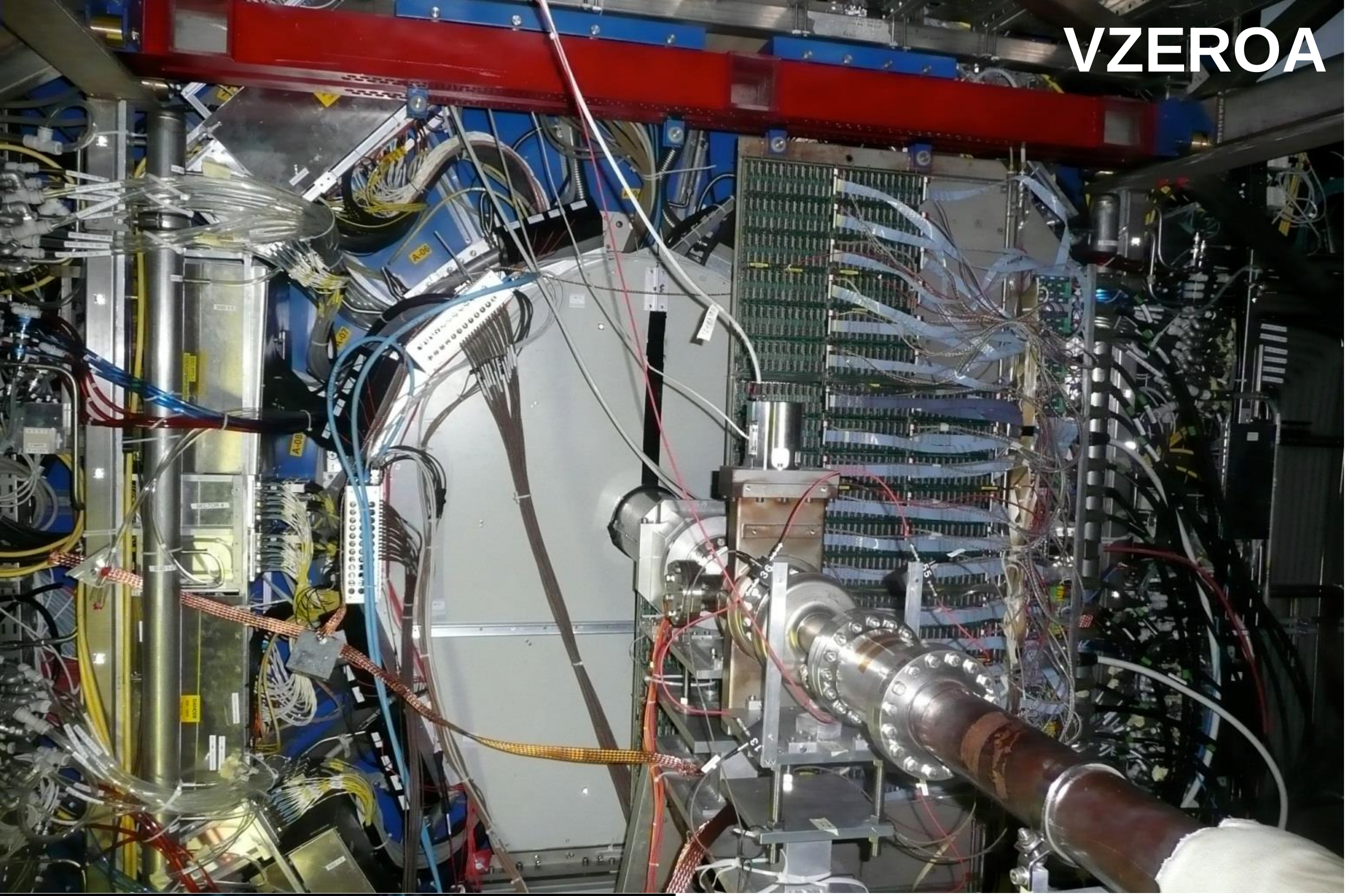




RICH

HMPID



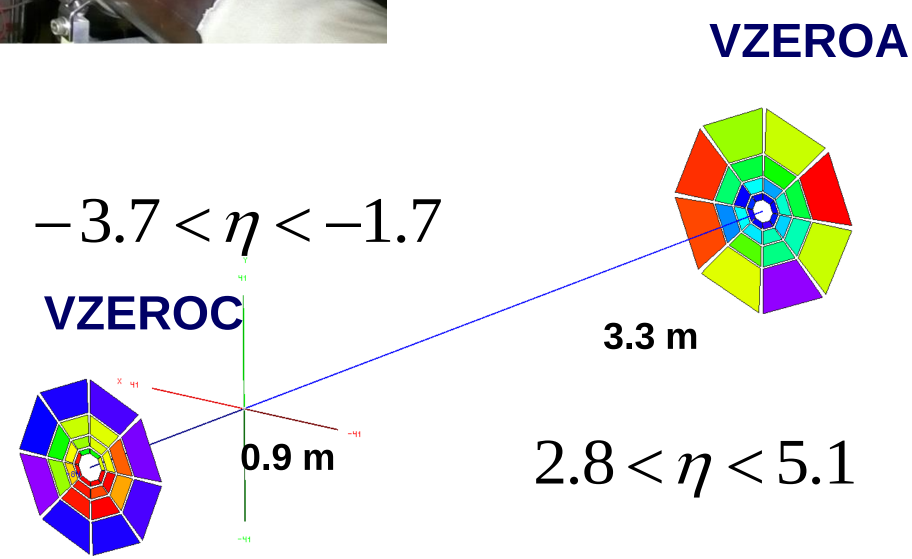


Trigger

Centrality measurement

Beam Gas suppresion

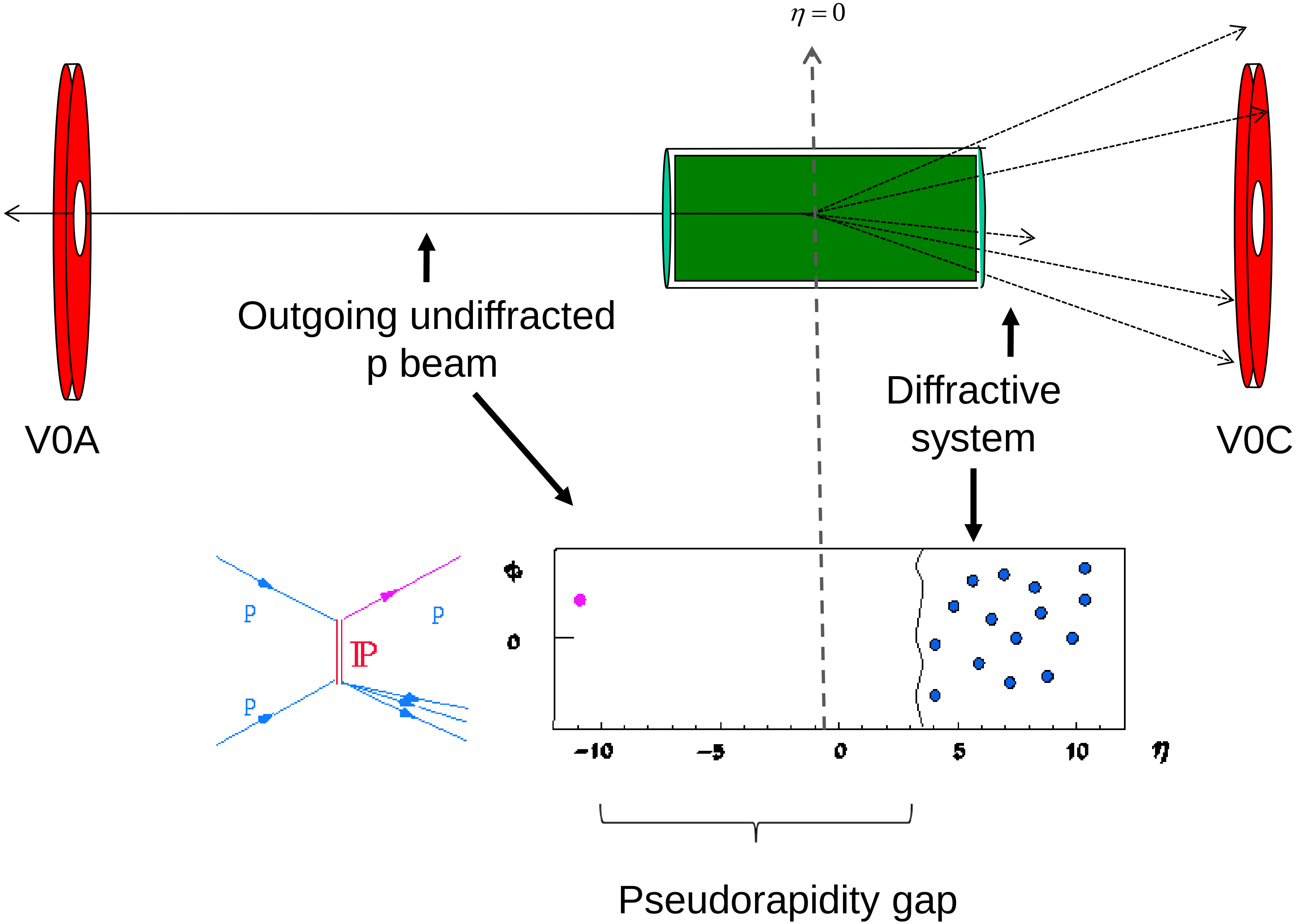
Event plane determination



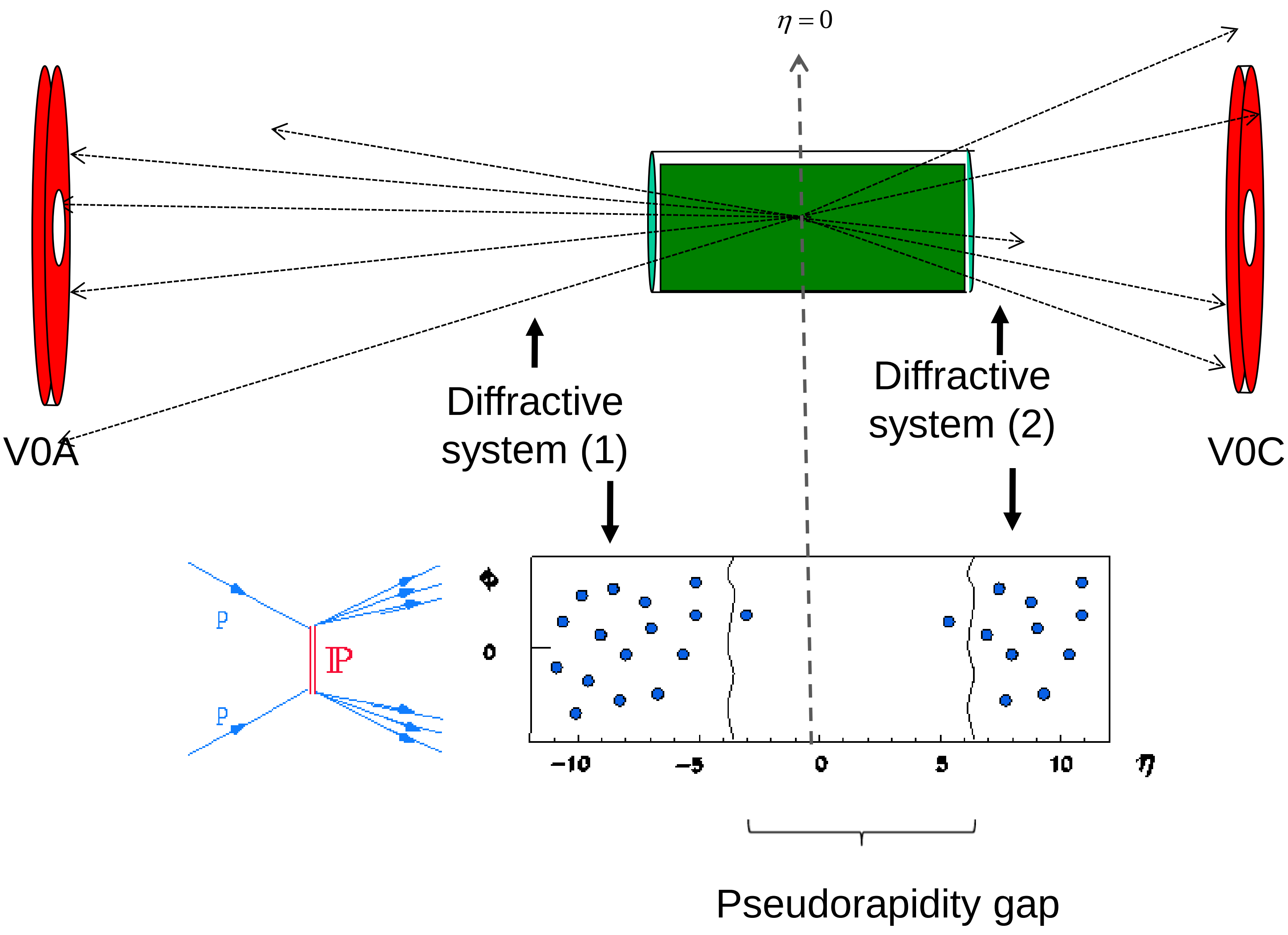
$$-3.7 < \eta < -1.7$$

$$2.8 < \eta < 5.1$$

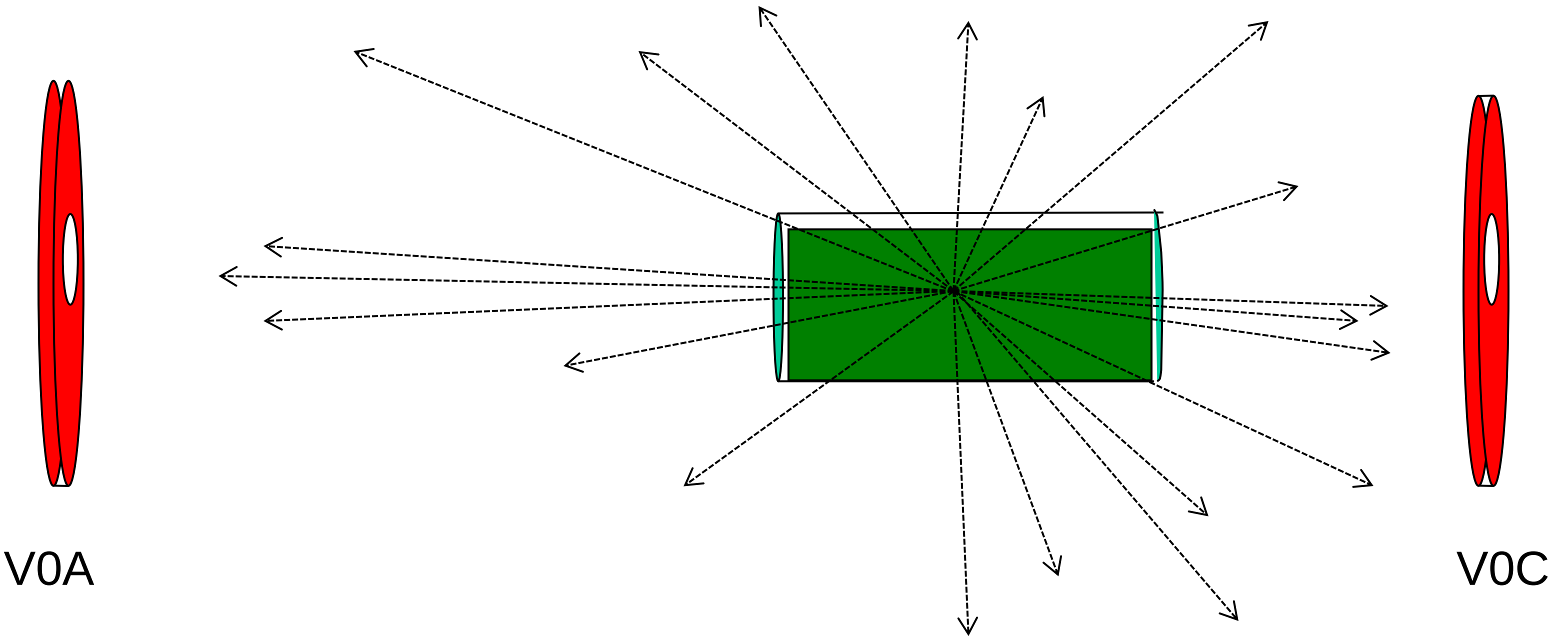
Single Diffraction (SD)

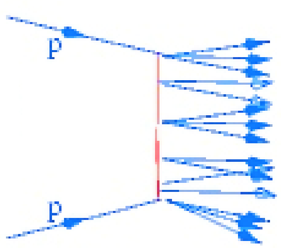


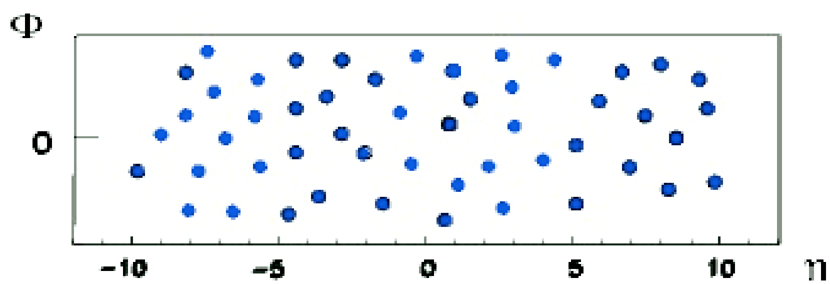
Double Diffraction (DD)



Non Diffractive (ND)



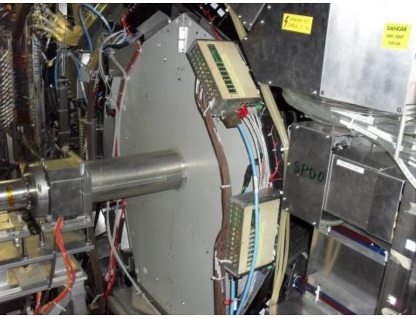




No pseudorapidity gap

Instrumentation for diffractive physics in ALICE - today

VZEROA

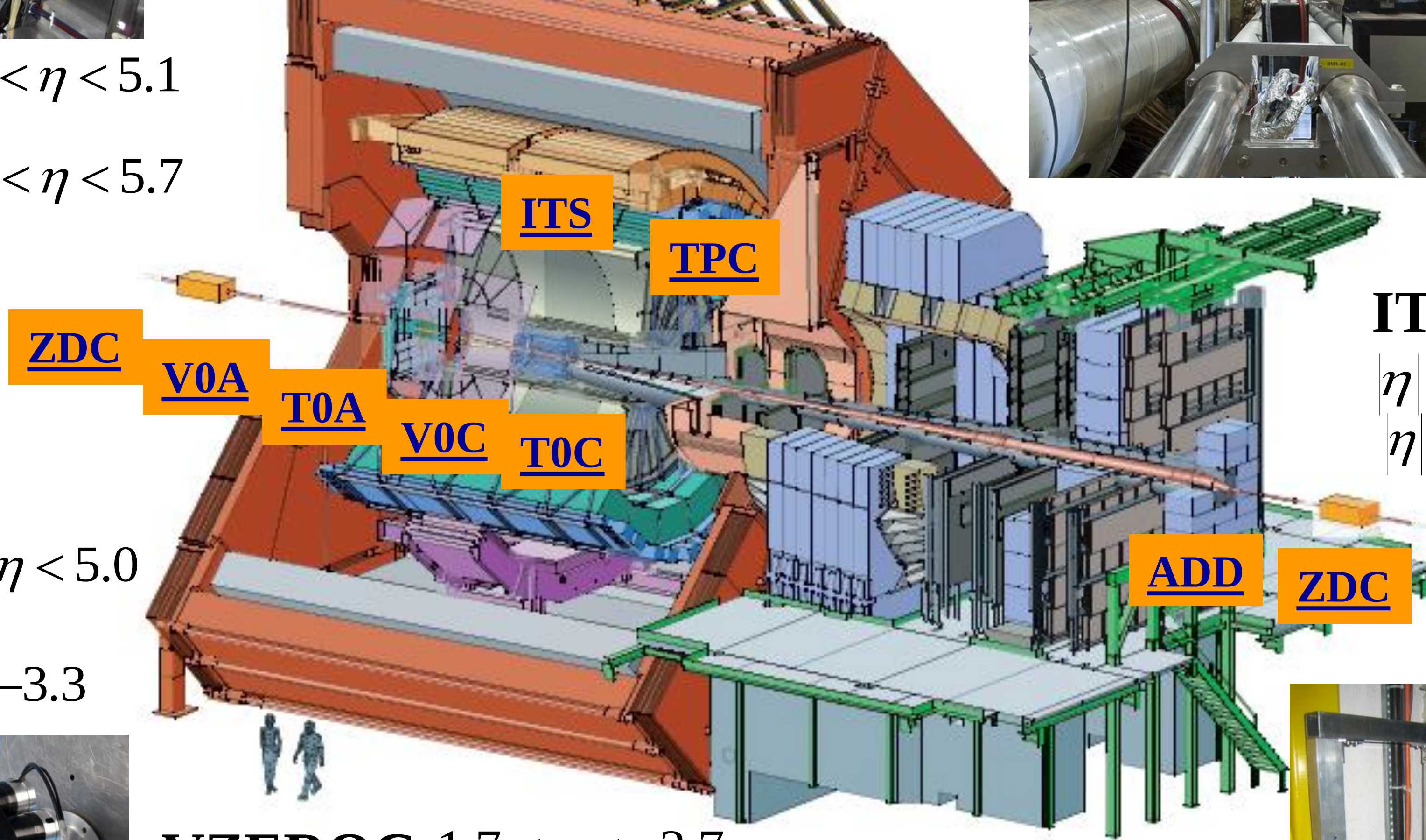


$2.8 < \eta < 5.1$

ZN $|\eta| > 8.7$ **ZP** $|\eta| > 8.4$

TPC $|\eta| < 0.9$

ZEM $4.8 < \eta < 5.7$



ITS

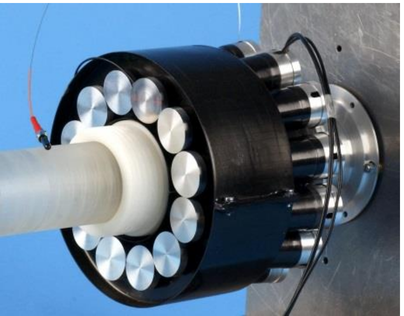
$|\eta| < 1.4$

$|\eta| < 2.0$

T0A $4.5 < \eta < 5.0$

T0C

$-2.9 < \eta < -3.3$



VZEROC $-1.7 < \eta < -3.7$

FMD $1.7 < \eta < 5.0 \quad -3.4 < \eta < -1.7$

ADD $-4.9 < \eta < -6.0$

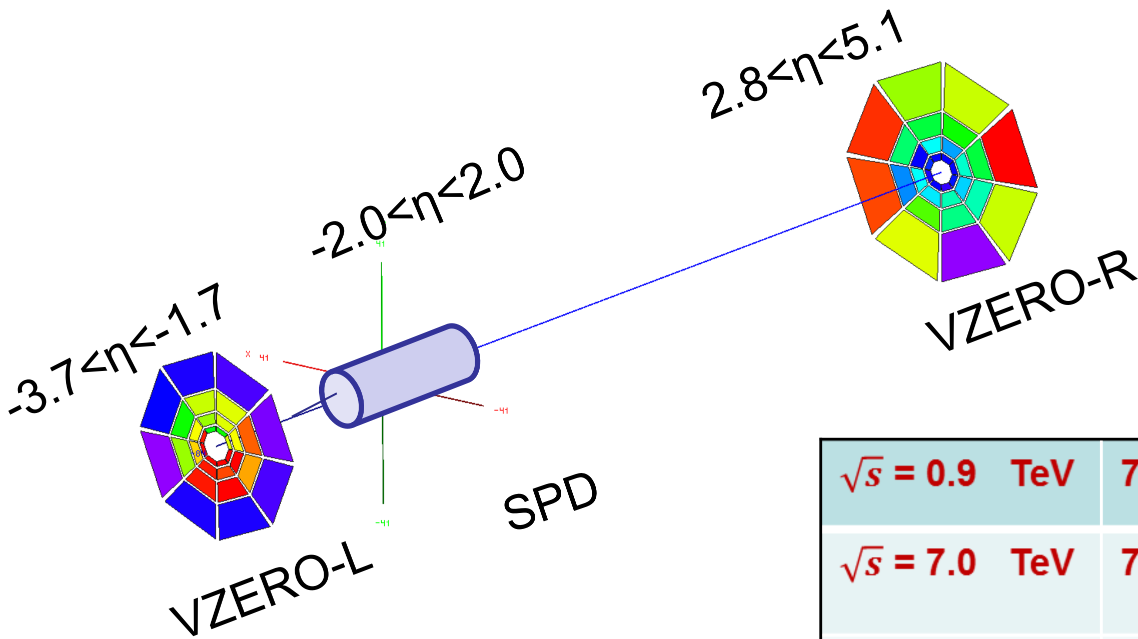
Summary of measurements on Diffractive Physics

Measurements of Diffractive and Inelastic Cross Section

Eur. Phys.J. C73 (2013) 2456

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

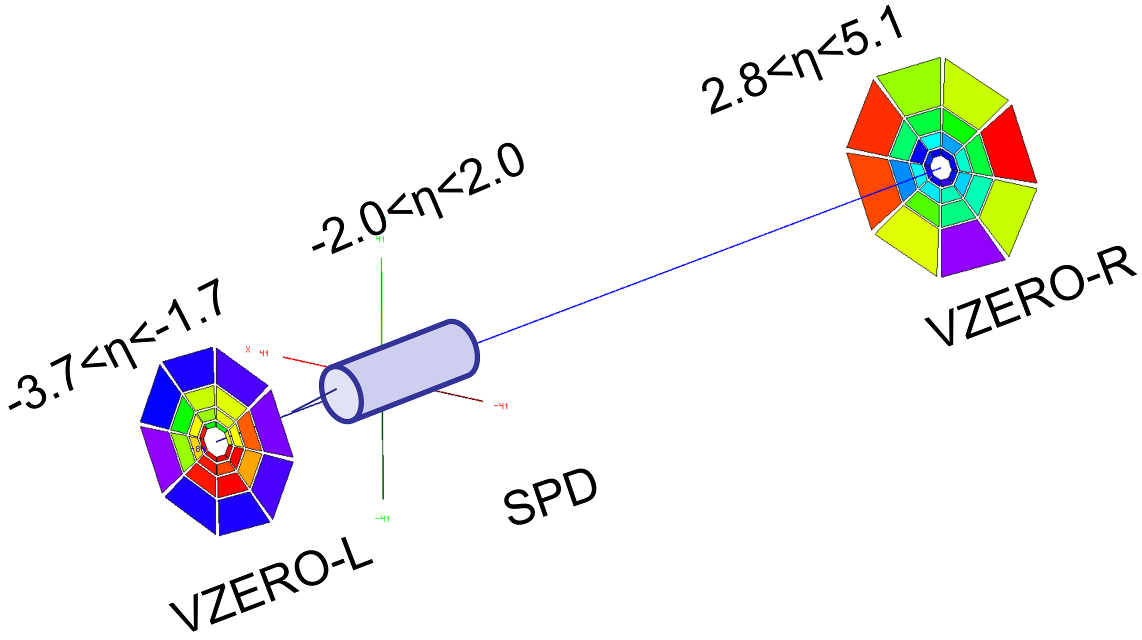


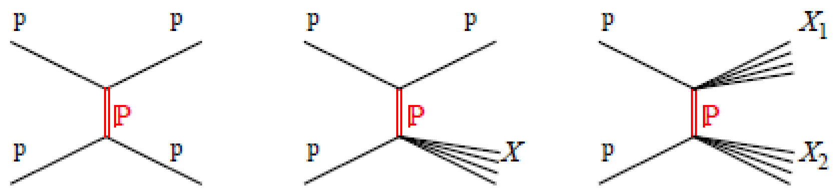
DATA

$\sqrt{s}$ = 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

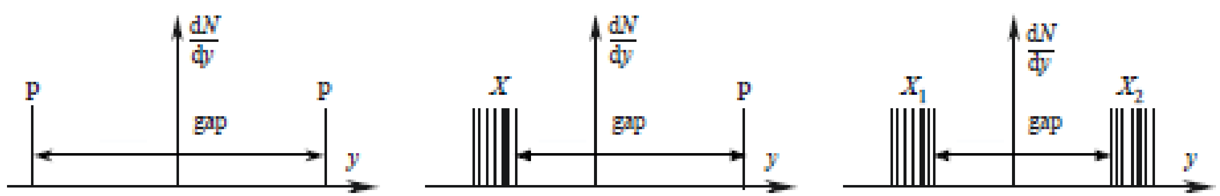
Minimum Bias Trigger - OR





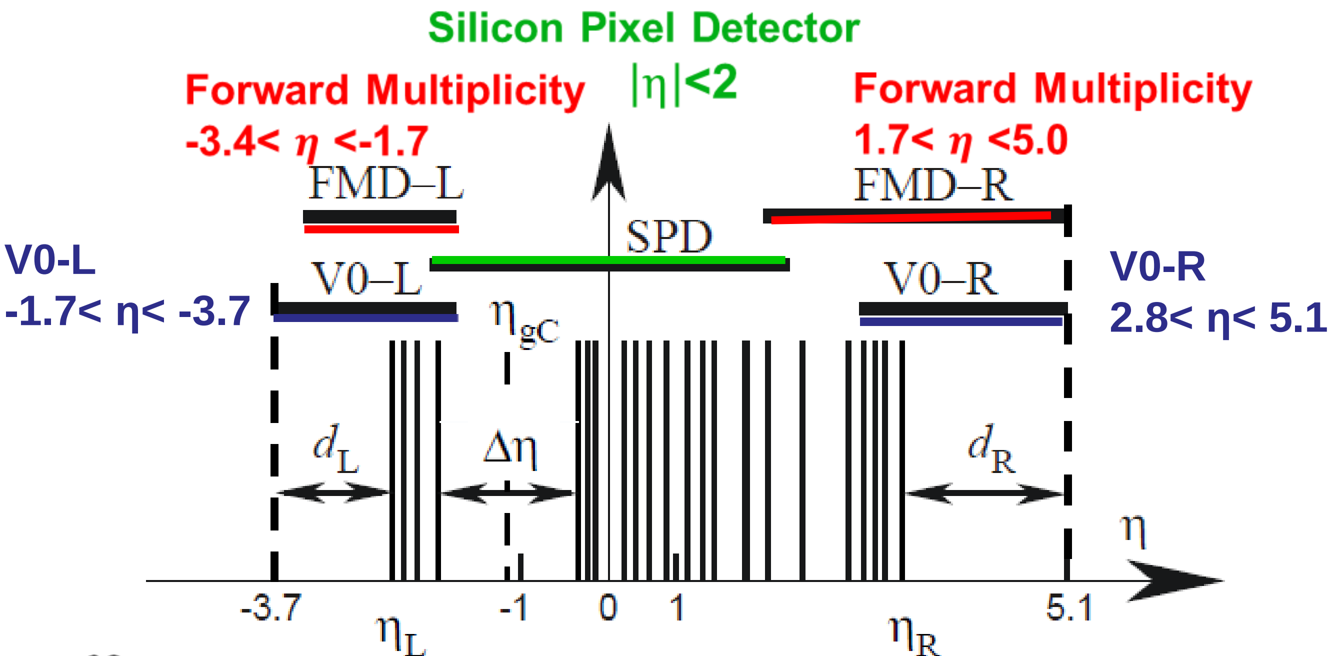
theory

elastic - single - double - diffractive proton-proton scattering



experiment

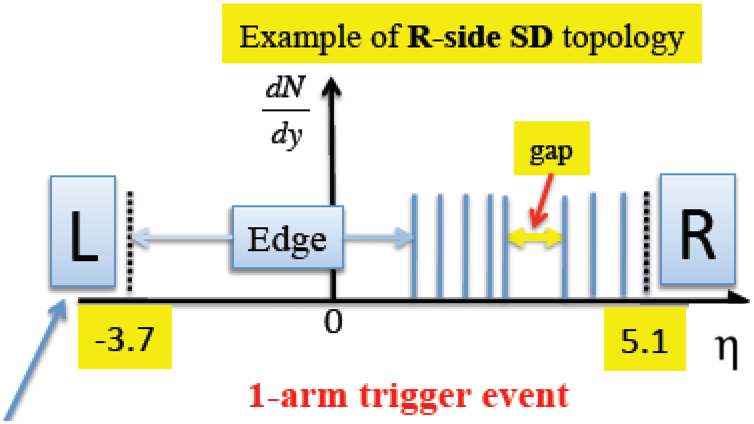
ALICE

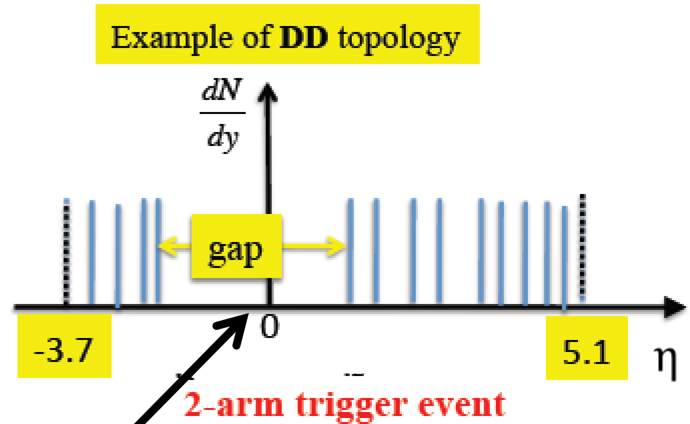


$$\eta_c = \frac{1}{2}(\eta_L + \eta_R)$$

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

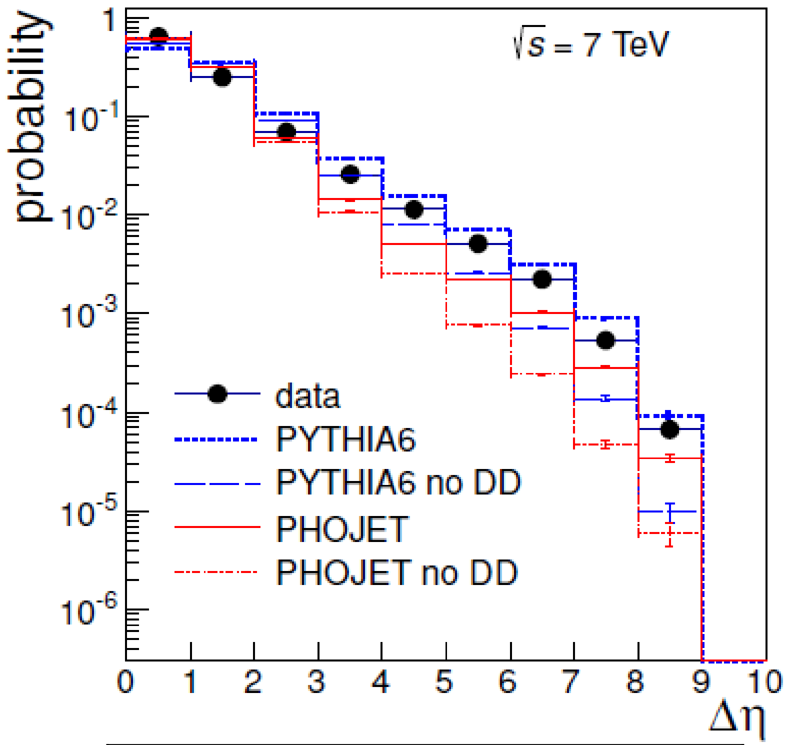
If	$\eta_R < 1$	1-arm-L
If	$\eta_L > -1$	1-arm-R

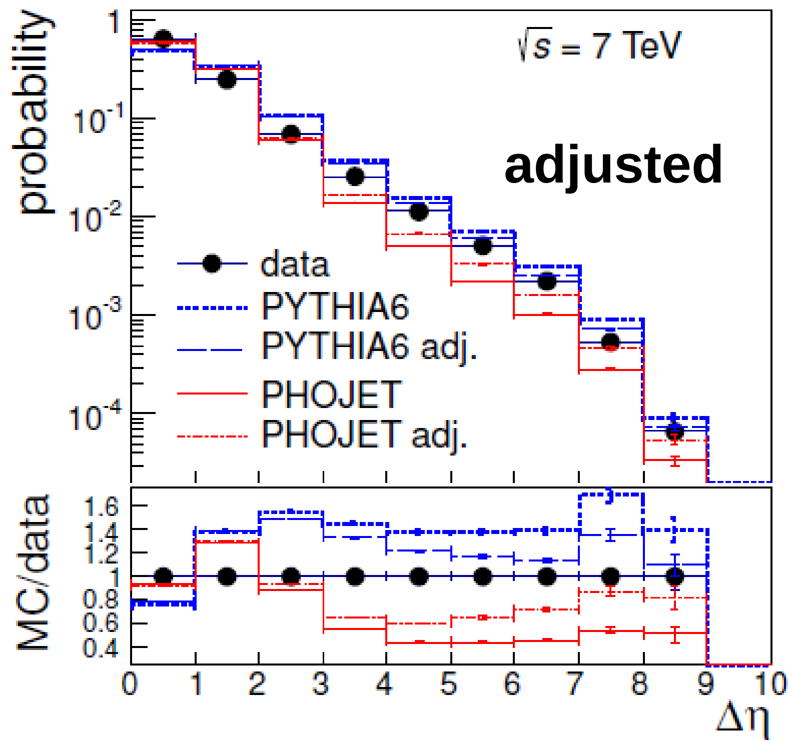
2-arm events

largest $\Delta\eta$

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

arXiv:1208.4968 [hep-ex]





$\sqrt{s}$ 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

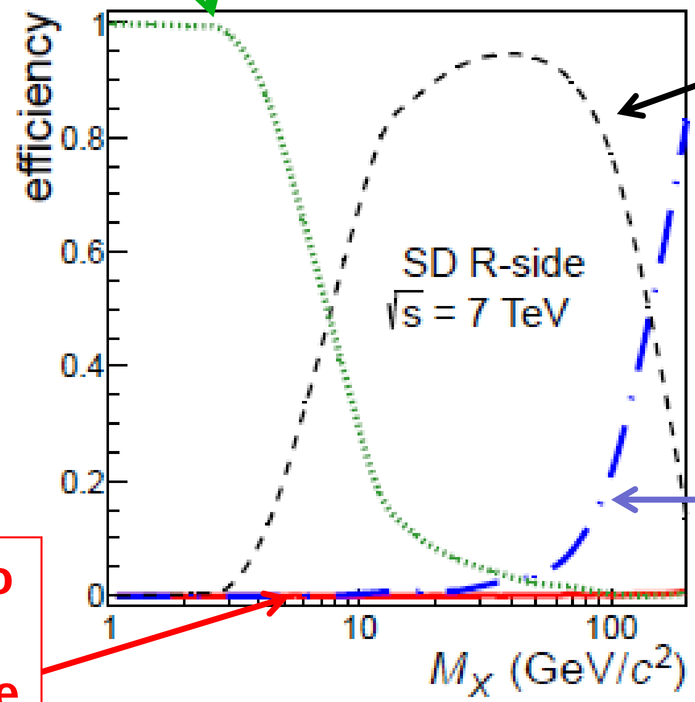
- **Once DD is chosen the ratios 1-arm-L and 1-arm-R to 2-arm can be used to compute SD fractions.**

- 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 $p\,\overline{p}$

results symmetric despite different acceptance from ALICE

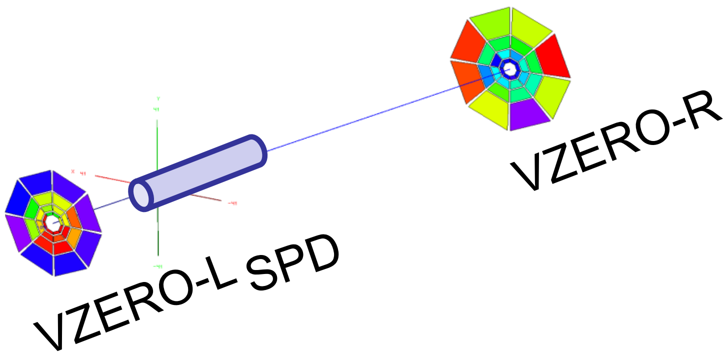
corrected for acceptance, efficiency, beam background, electronic noise and collision pileup

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 $\Delta\eta > 3$

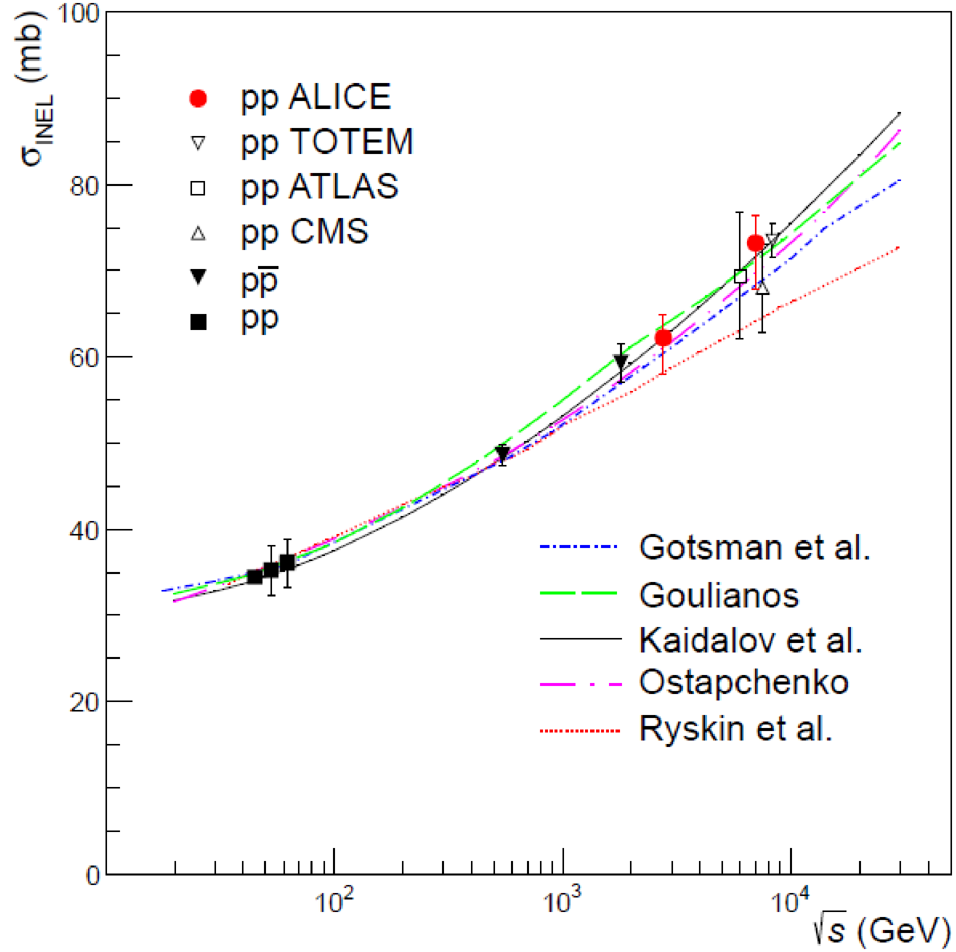
Measurement of Inelastic Cross Section



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]	$73.5^{+1.8}_{-1.3}(syst) \pm 0.6(stat)$

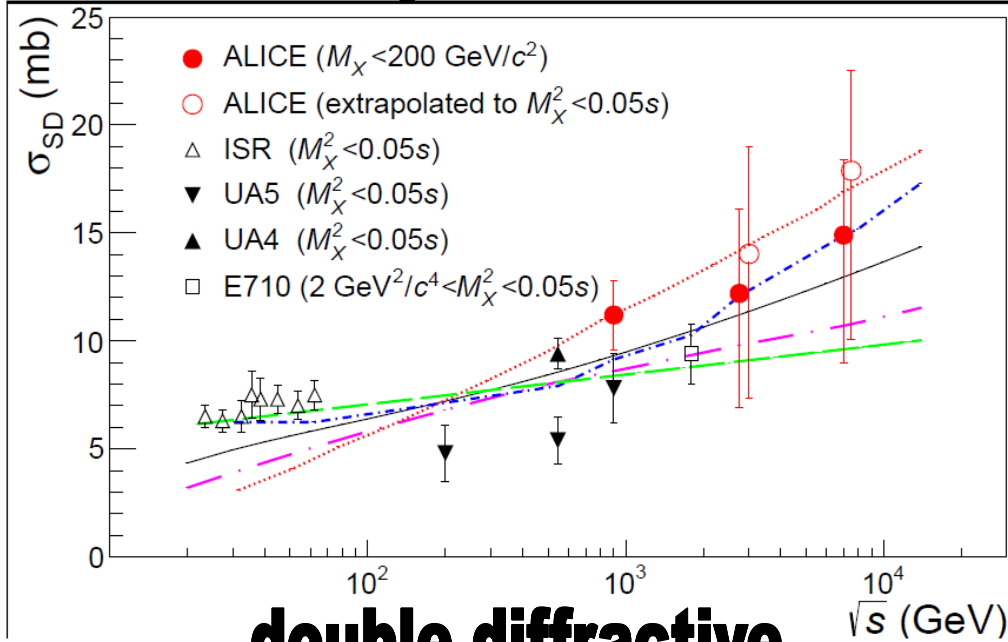
Measurements of Diffractive Cross Section

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

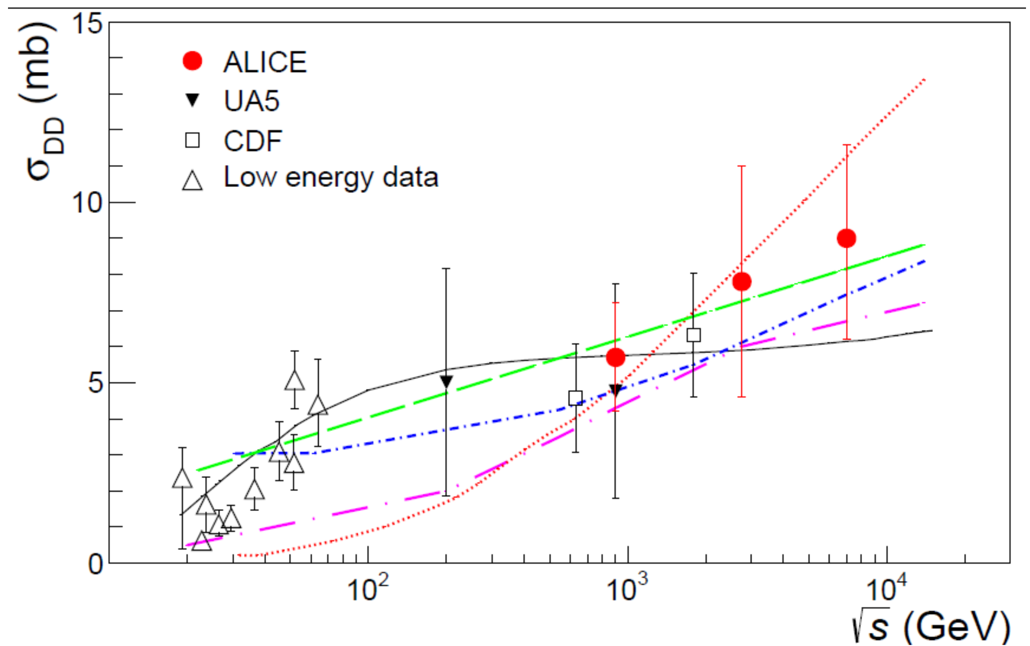
for $\sqrt{s} = 0.9\,TeV$ we do not have vdM scan and σ_{inel} from UA5 was used

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

single diffractive



double diffractive



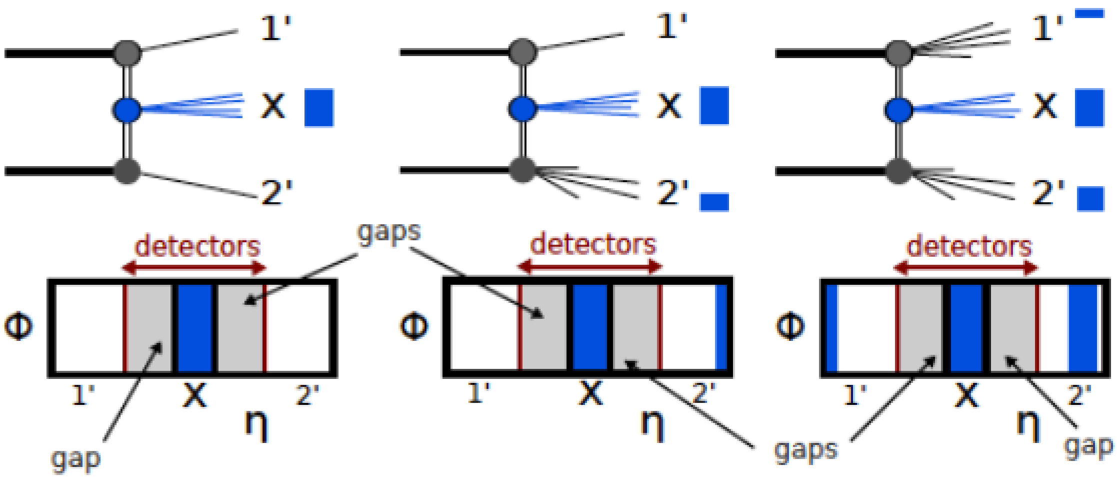
Gotsman et al.
Goulianos
Kaidalov et al.
Ostapchenko
Ryskin et al.

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**



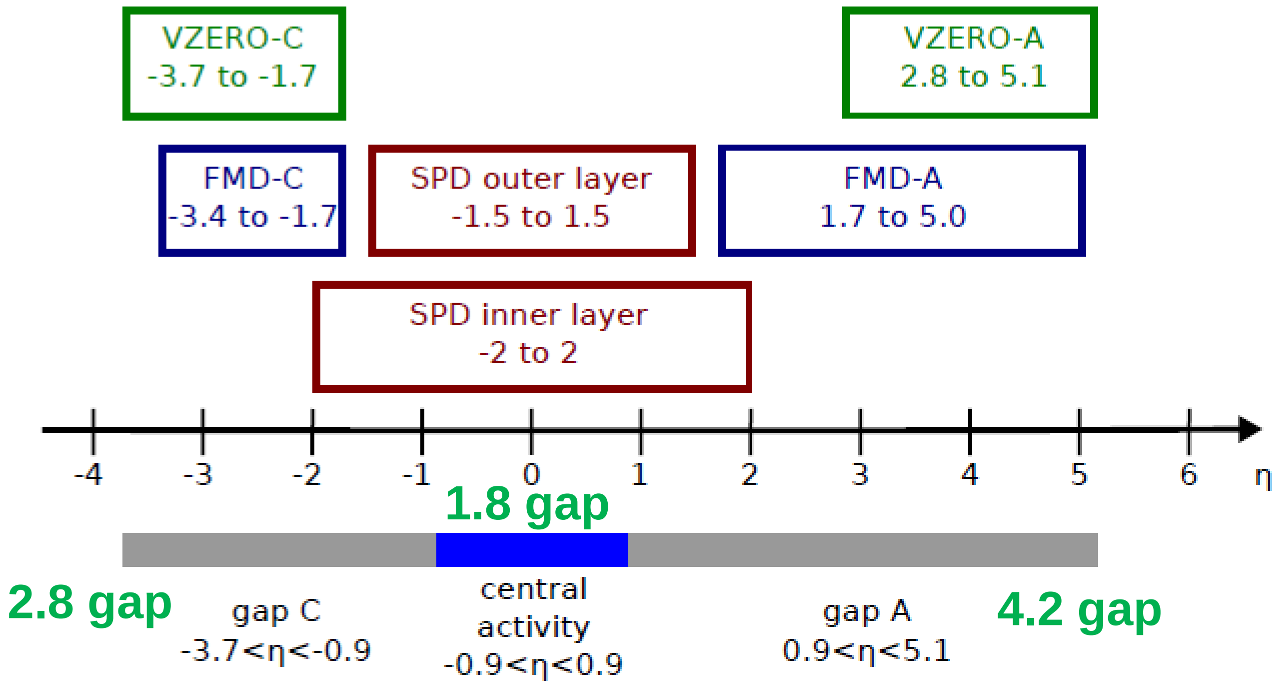
Low mass central diffractive final states decaying into a small number of particles

production of meson states: glueballs, hybrids,

A search for structure in the mass spectra of exclusive decays such as $\pi^+ \pi^-$

$K^+ K^-$ $2\pi^+ 2\pi^-$ $K^+ K^- \pi^+ \pi^-$ etc.

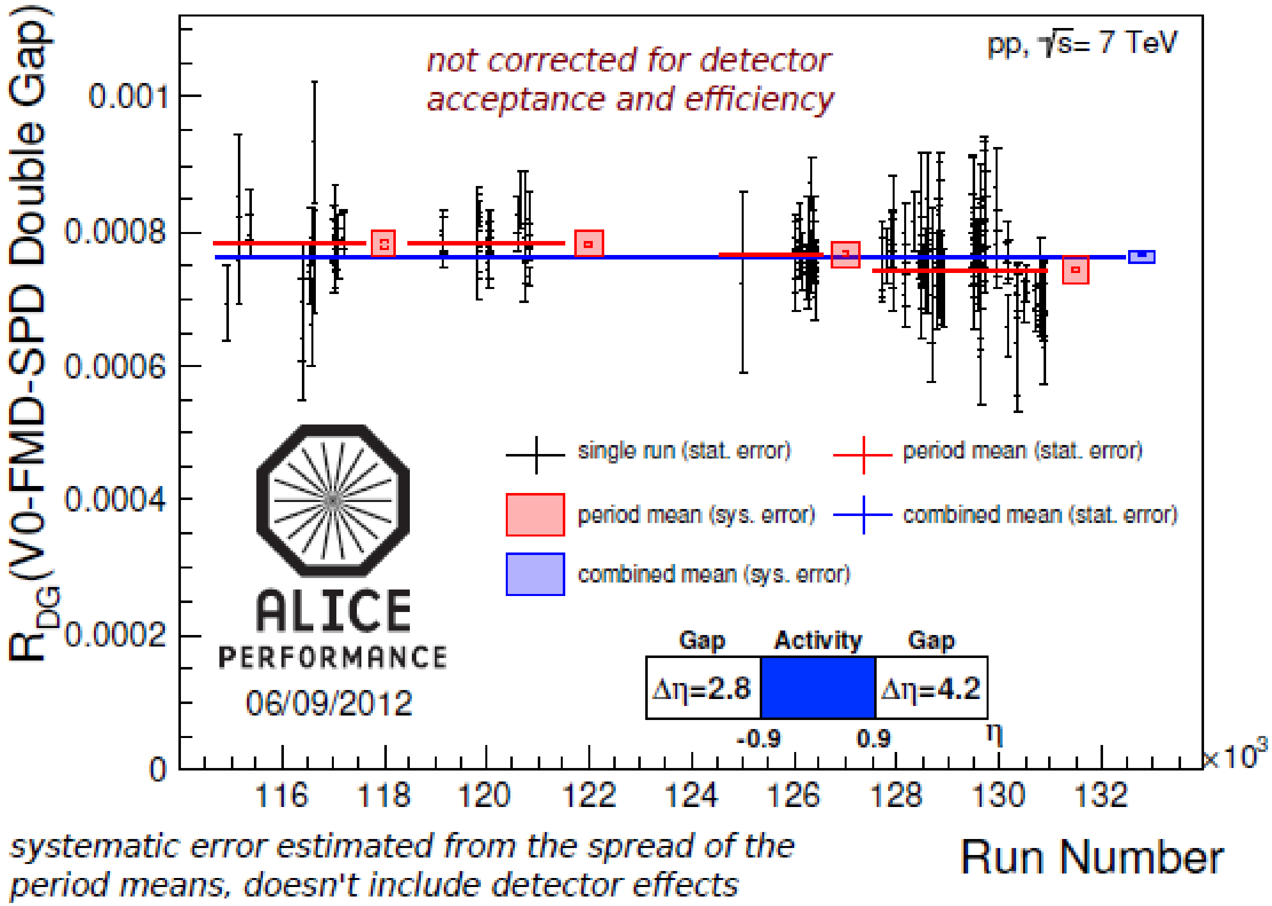
Double Gap topology



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

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

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



- fraction uniform over several data taking periods

Next:

turn it into a cross section

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

we are exploring the invariant mass distribution

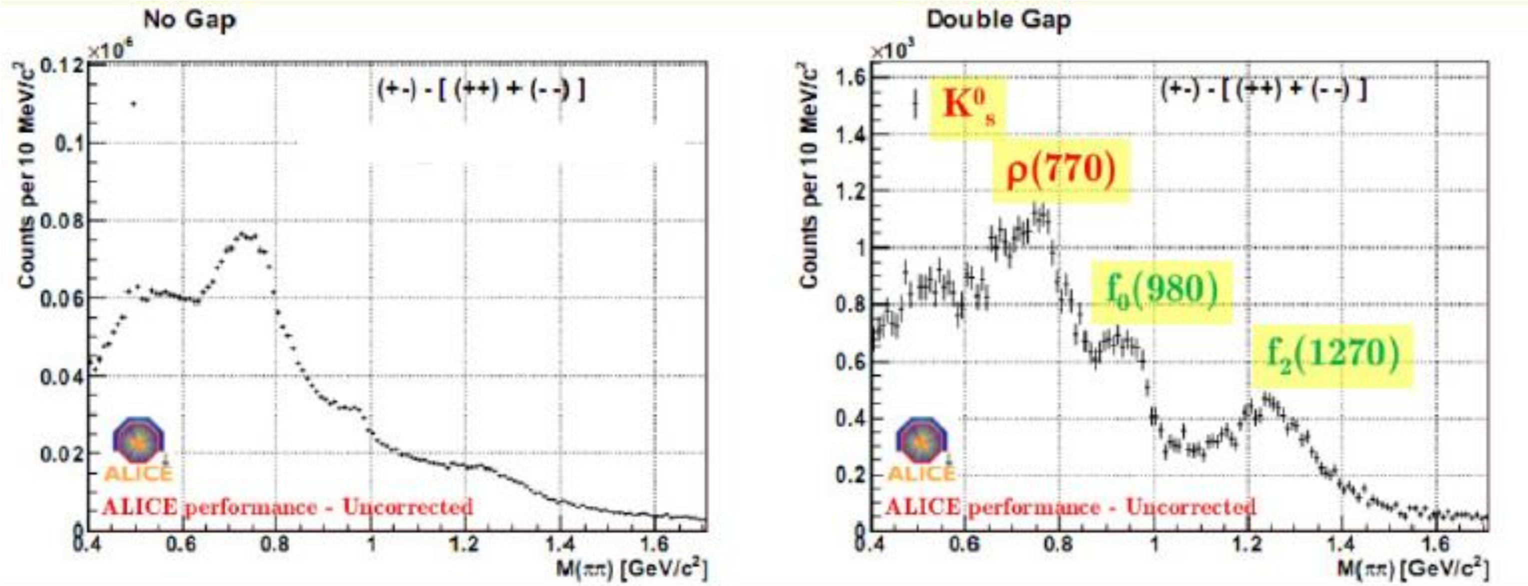
2011 data

361 M events with the Minimum Bias Trigger

32.3 M events with primary vertex and exactly 2 tracks in the TPC+ITS

29.2 M events with no gaps

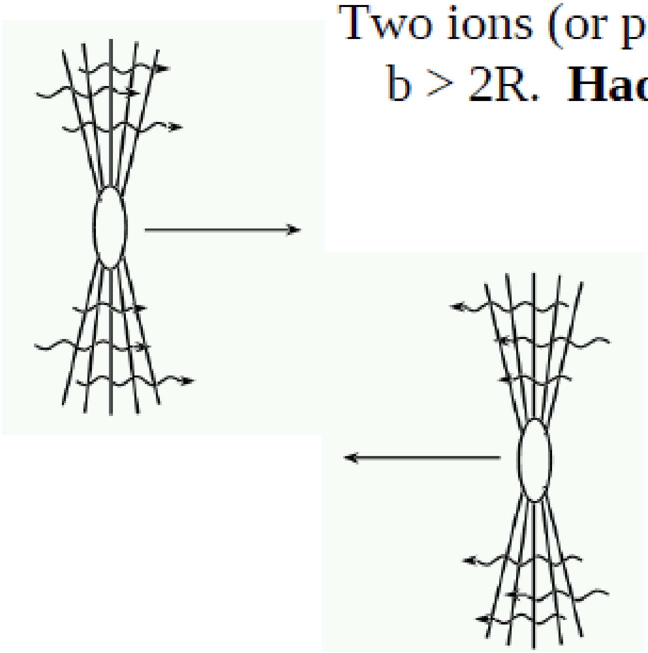
Exclusive resonance production in proton proton at 7 TeV cms



M_{inv} for two track events with-out gaps.

M_{inv} for two track events with gaps on both sides

Studies in Ultra Peripheral Colisions



Two ions (or protons) pass by each other with impact parameters b > 2R. **Hadronic interactions are strongly suppressed**

Number of photons scales like Z^2 for a single source ⇒ exclusive particle production in heavy-ion collisions dominated by electromagnetic interactions.

The virtuality of the photons → 1/R ~ 30 MeV/*c*

Coherent production:

Photon couples coherently to all nucleons

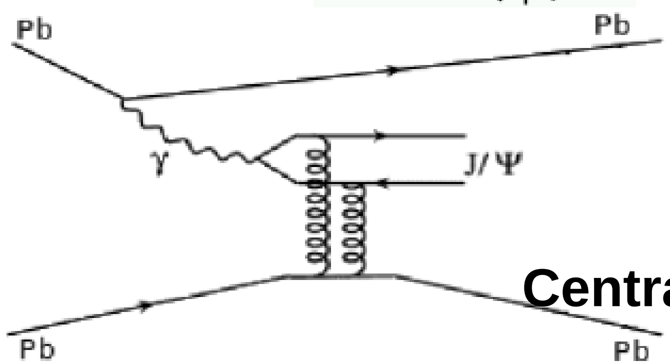
$\langle p_T \rangle \sim 60$ MeV/*c*; target nucleus normally does not break up

Incoherent production

Photon couples to a single nucleon

Quasi-elastic scattering off a single nucleon

$\langle p_T \rangle \sim 500$ MeV/*c*



Central rapidity

A big jump in energy ...

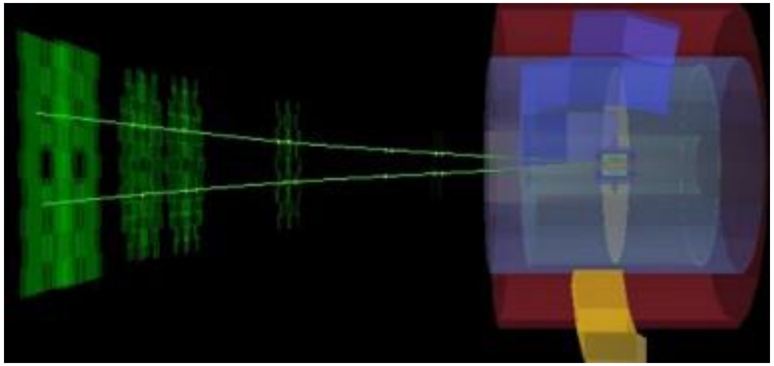
RHIC: $W_{\gamma N,max} \sim 34$ GeV

HERA: $W_{\gamma N,max} \sim 300$ GeV

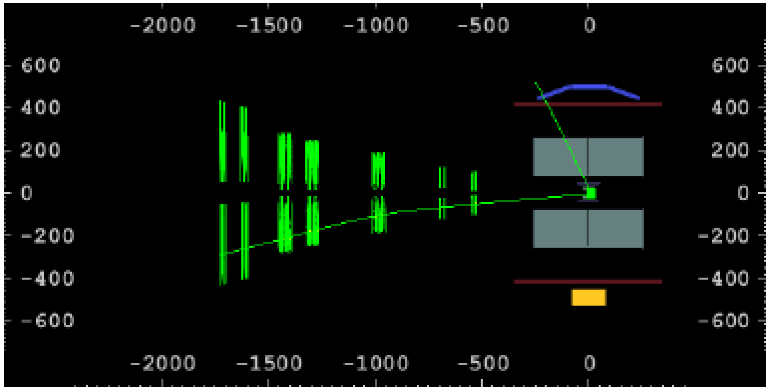
LHC: $W_{\gamma N,max}$ reaches up to 950 GeV !

γ + p → J/ψ + p

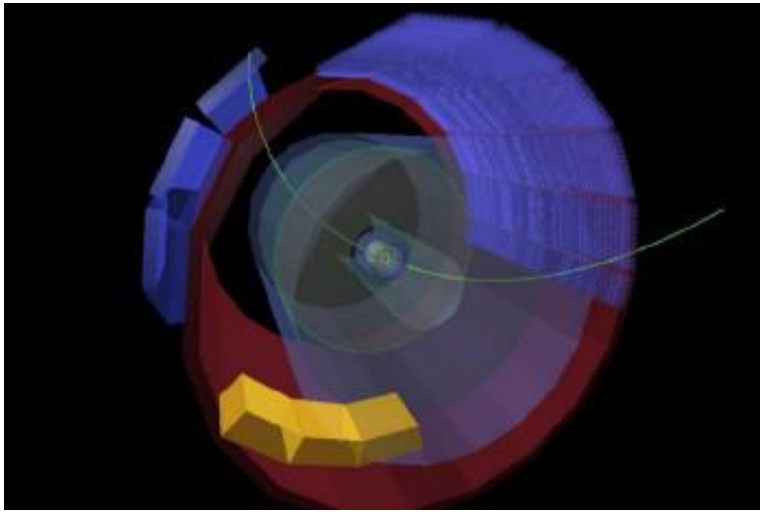
modelled in pQCD: exchange of two gluons with no net-colour transfer



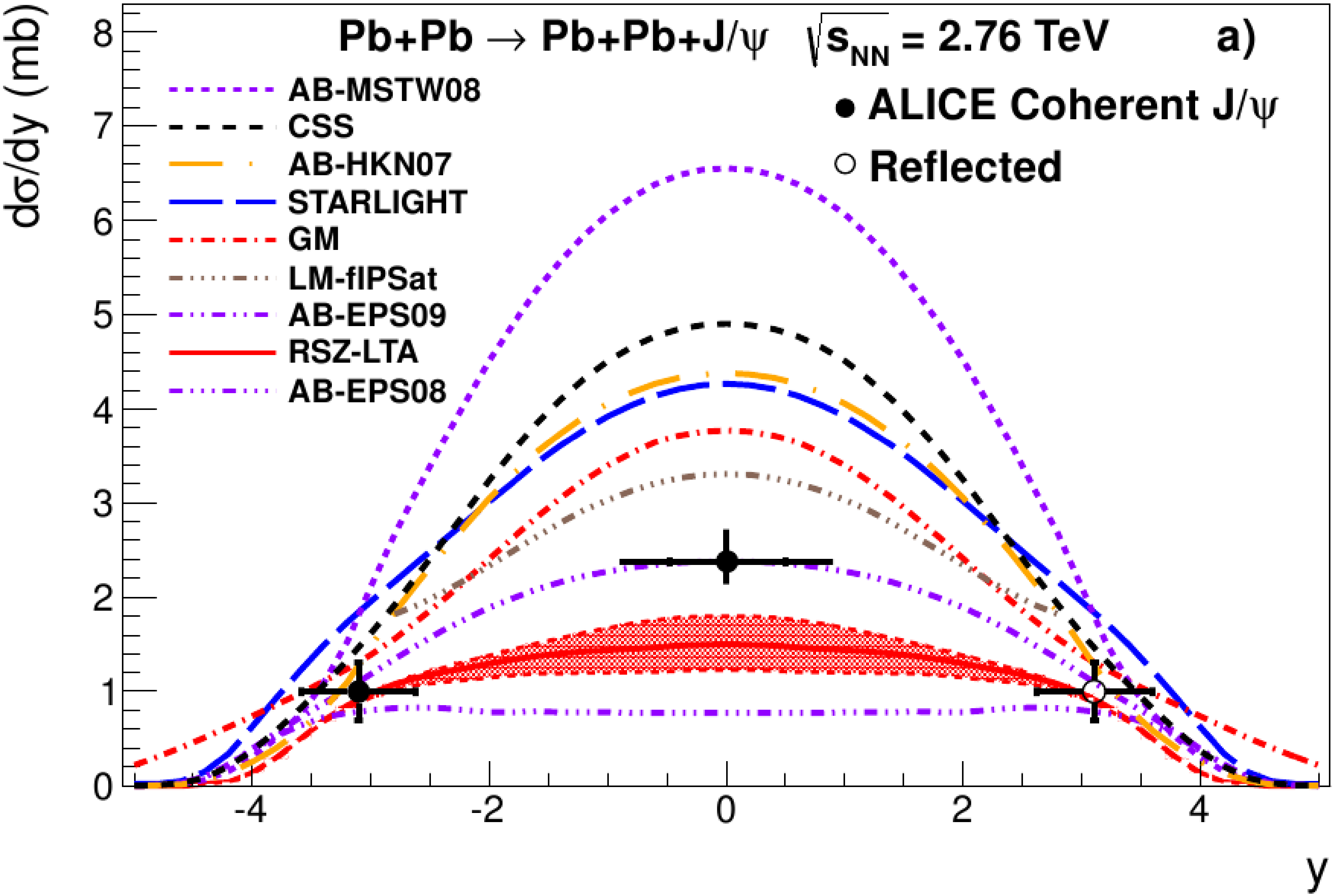
two muons in the muon arm



one muon in the muon arm one in the barrel



two muons in the barrel

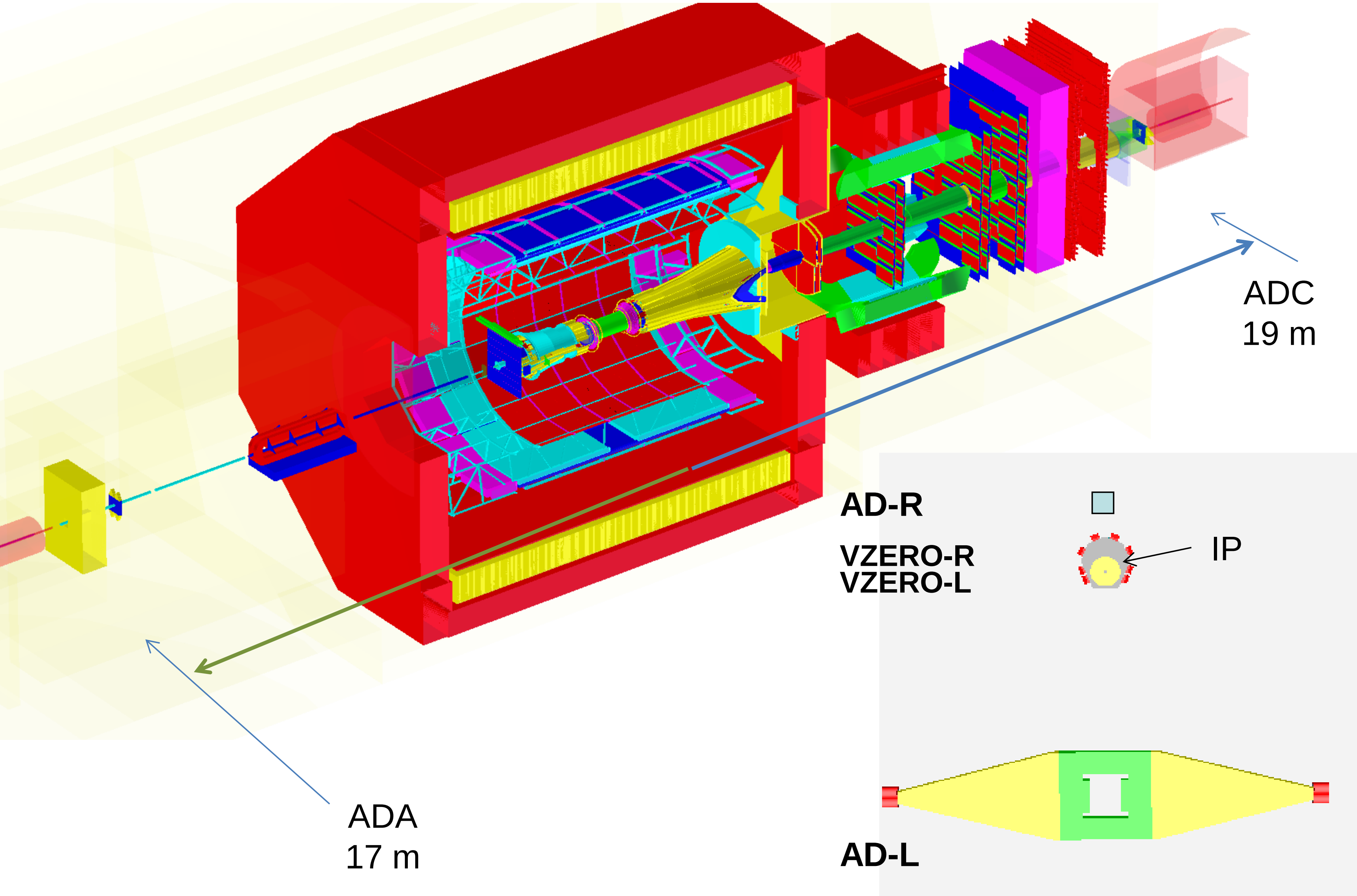


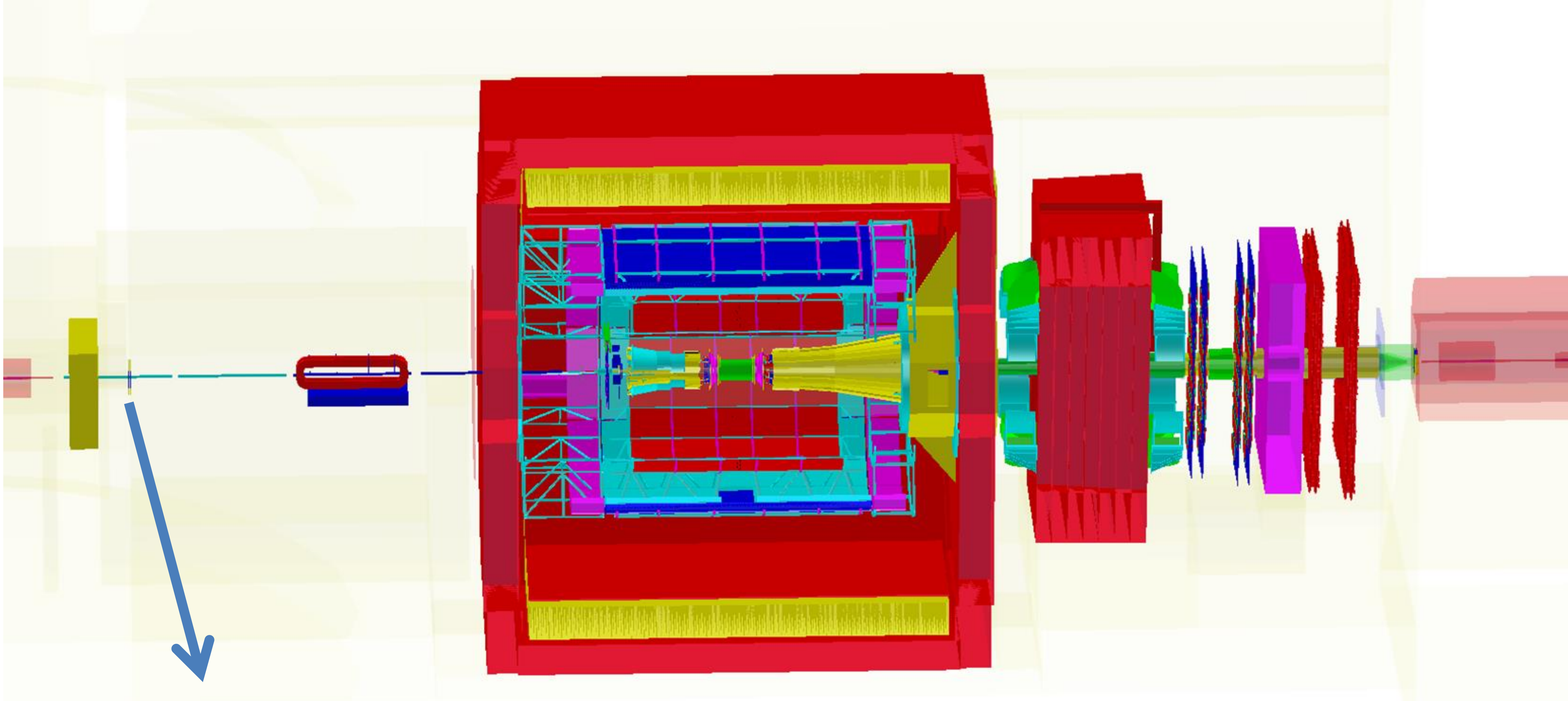
In agreement with models that include moderate gluon shadowing:

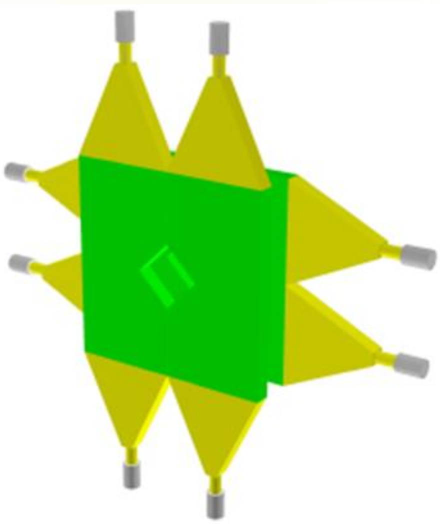
AB EPS09 parametrization

possible improvements to ALICE performance on photon induced and diffractive physics

AD detectors: Beam Diagnostic and Diffractive Physics

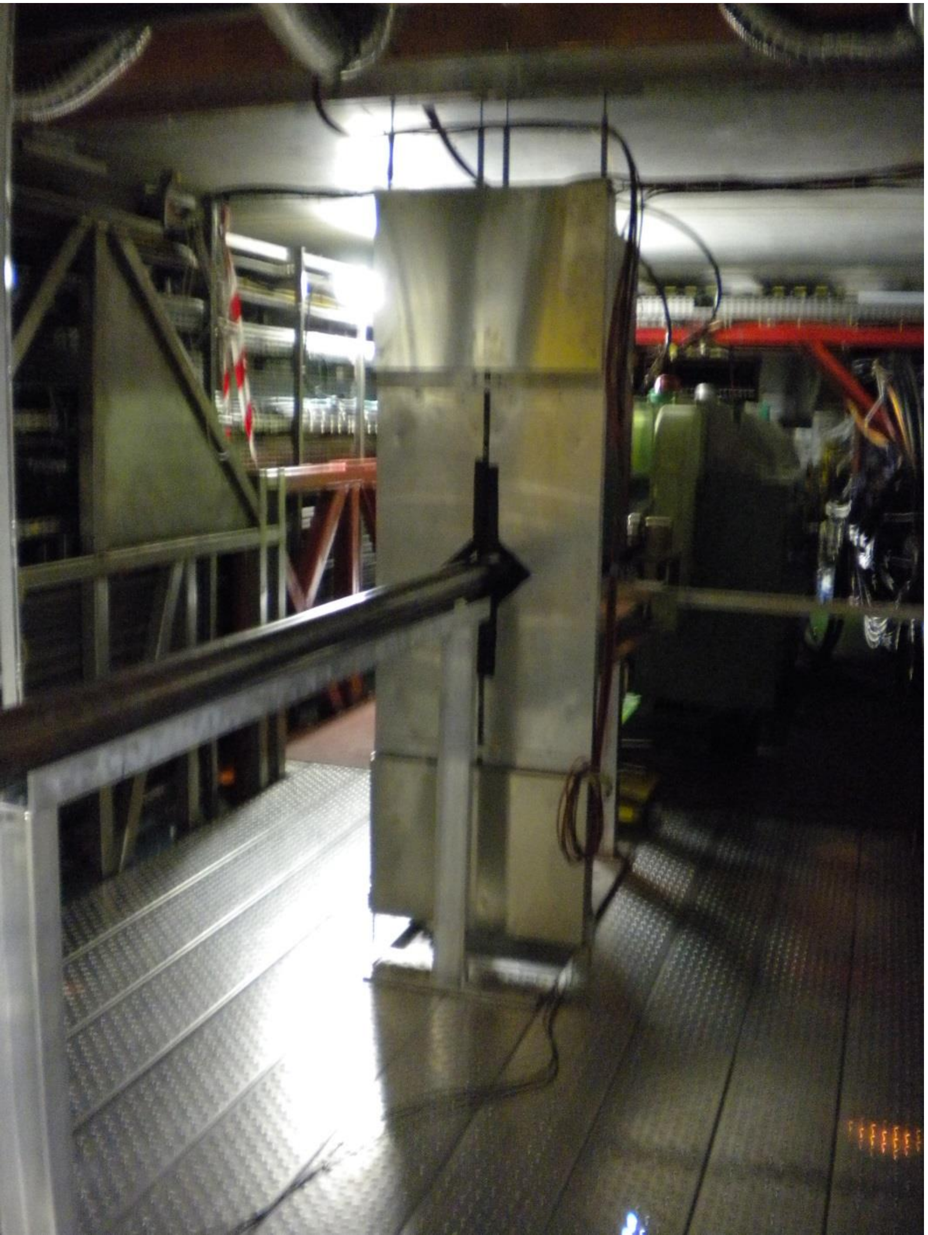


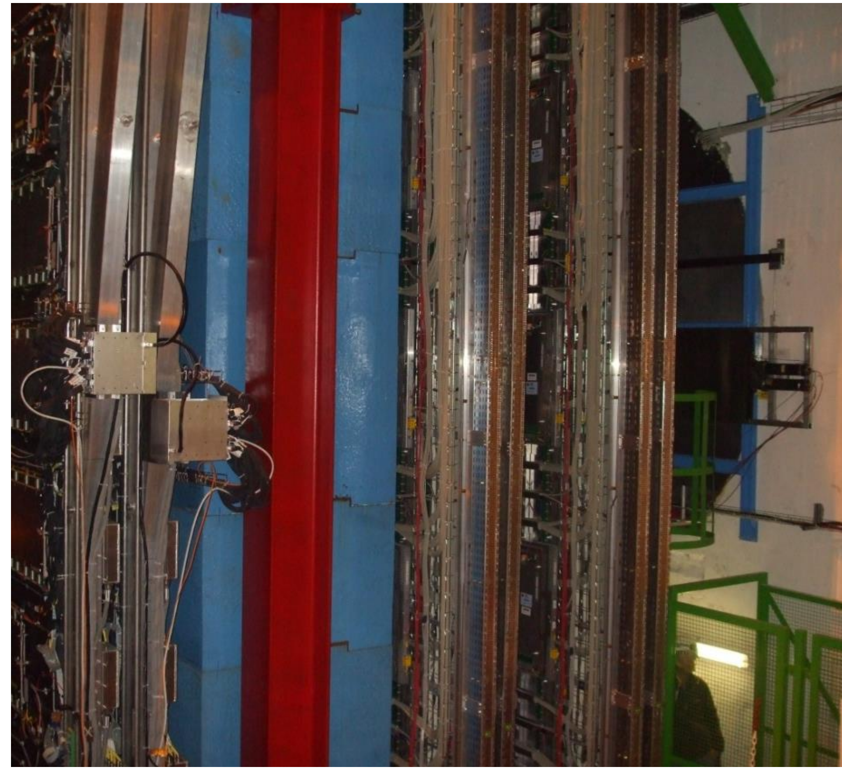




- Two arrays of 4 scintillators 25x25x4 cm surrounding the beam pipe both sides of the interaction point. Hamamatsu fine mesh PMT
- Conceived for diffractive physics
- Readout board: Beam Phase Intensity Monitor
- Bunch by bunch rates, collision and background.

AD Aside AD Cside





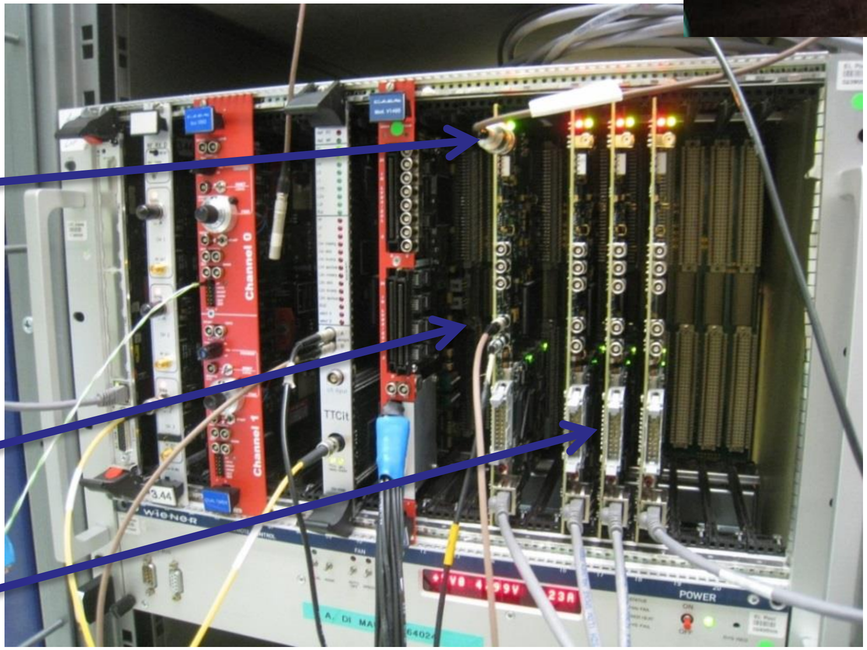
The readout system in Control Room

- BLS boards connected to AD
- The boards need clock/orbit signals to work

AD0 channel

clock/orbit signals

BLS boards



Beam Losses

- Losses during injection: ALICE under the fire of showers
- Losses during circulating beams: beam Halo, fast losses due to scraping, losses due to beam movements, increasing background, beam-beam effects, etc...

Luminosity

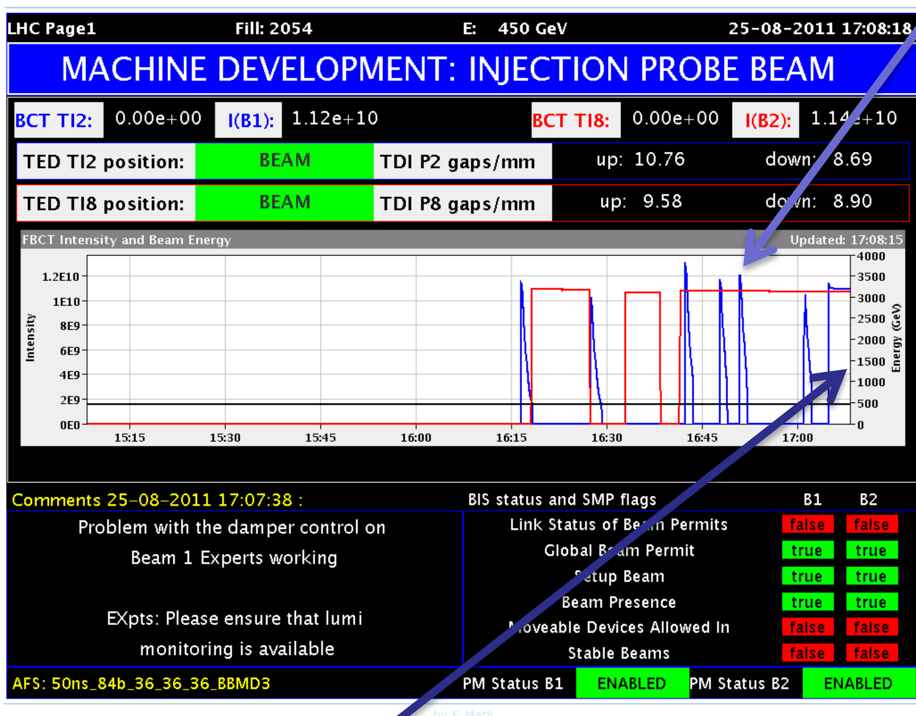
- Independent luminosity measurement: cross-check with official ALICE luminosities measurement (from trigger rate)

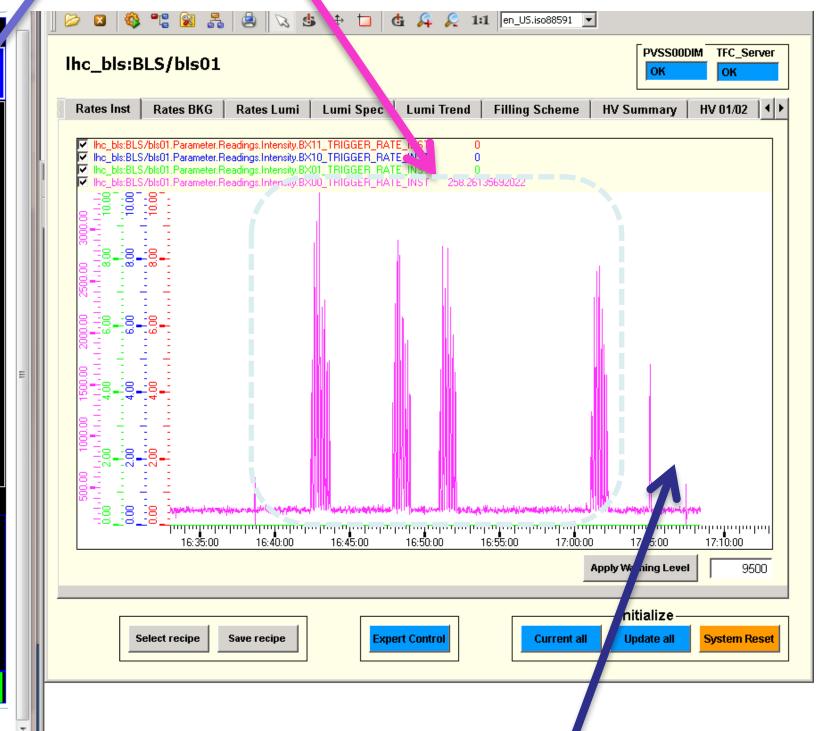
May be provide Lumi to ALICE when not available (detector not running or not ready during collisions). Bunch by bunch luminosity.

Physics

Forward Physics

During the injection of Beam1 in Fill 2054, four big losses were observed and AD signal reproduced them very well.





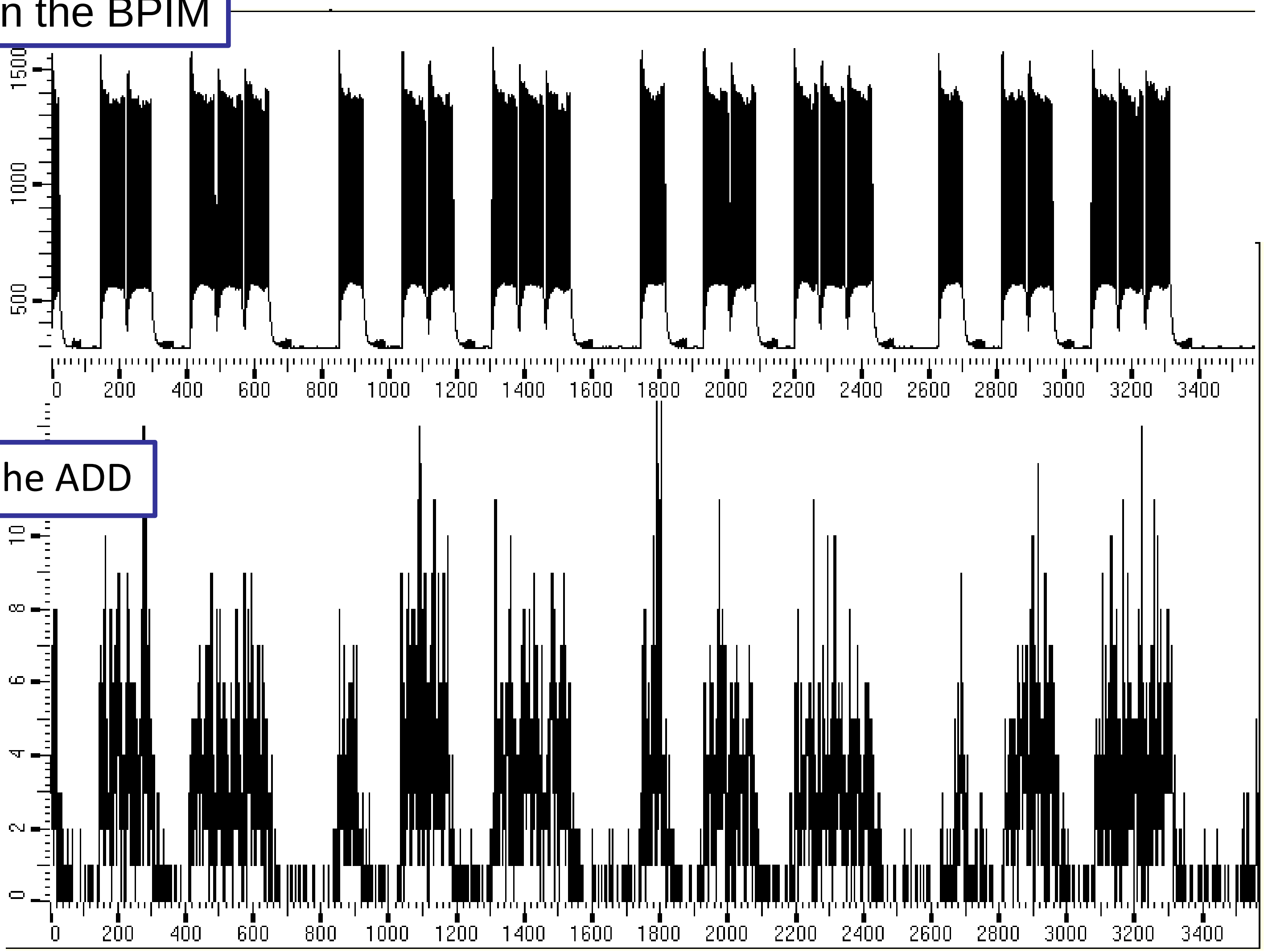
When the LHC problem was solved and the beam injected correctly , ADA didn't see significant losses anymore

performance on April 12 2012

Bunches seen in the BPIM

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

Losses seen in the ADD

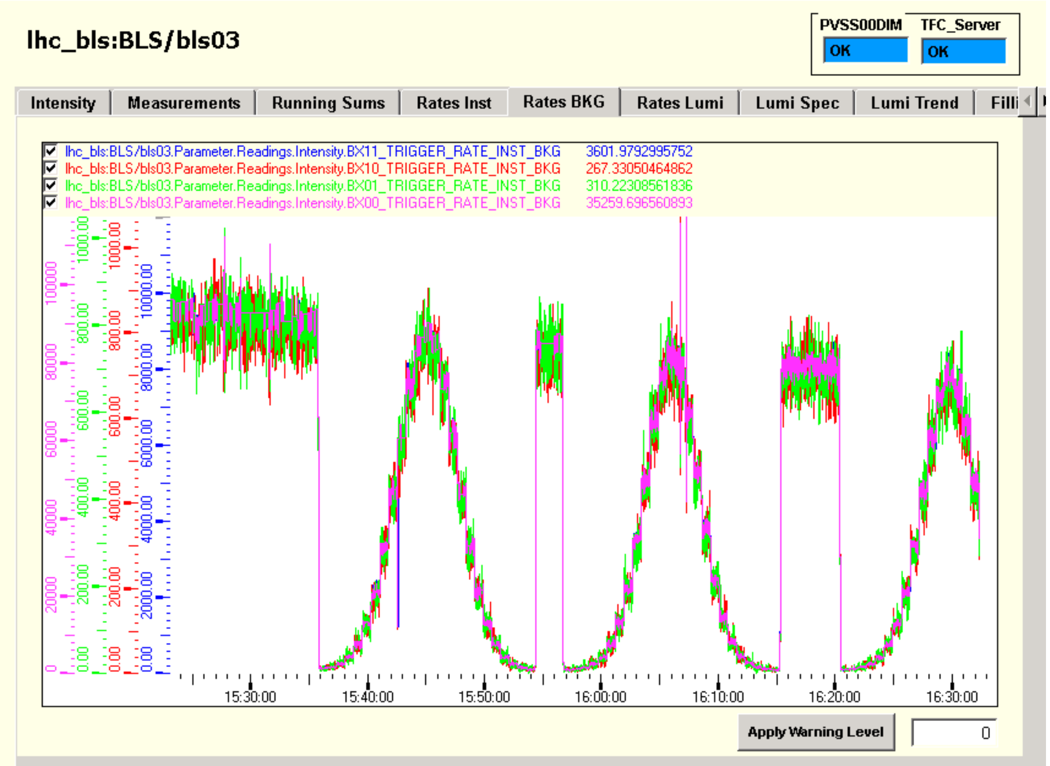


Time →

- VDM scan on December 1, 2011
- The 4 curves are the bunch-by-bunch rates, integrated on the same class of bunches

- BX11 (blue) are the colliding bunches
- BX01 and BX10 (red/green) are the non colliding bunches (coming from A side-beam1, C-side beam2)
- BX00 (pink) are the empty bunches

(note that the 4 scales are different)



ALICE – Diffractive R

AD-R

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

Present:

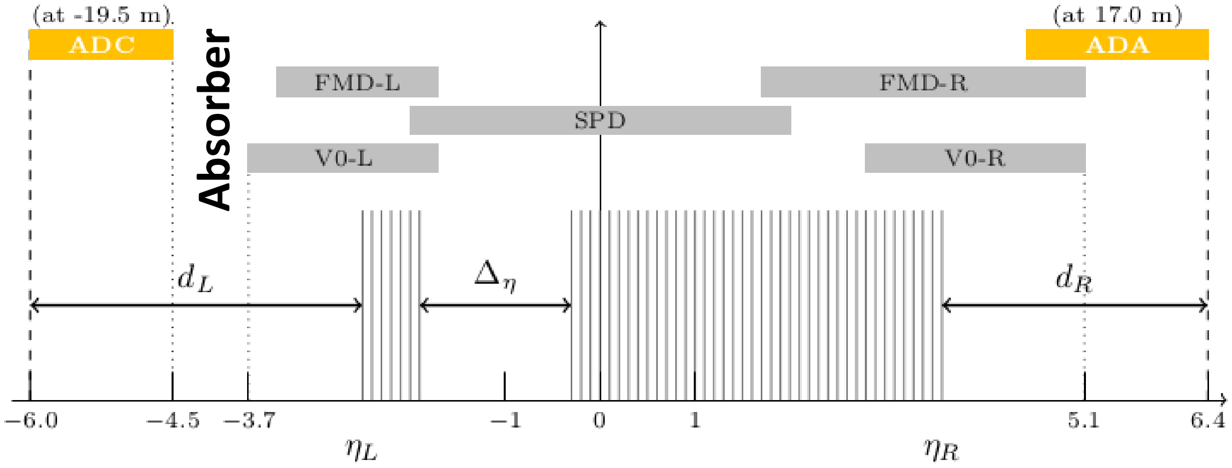
- **beam monitor with asynchronous read-out of charge deposited in the detectors → working**

Future:

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

Run 2: Diffraction (SD and DD)

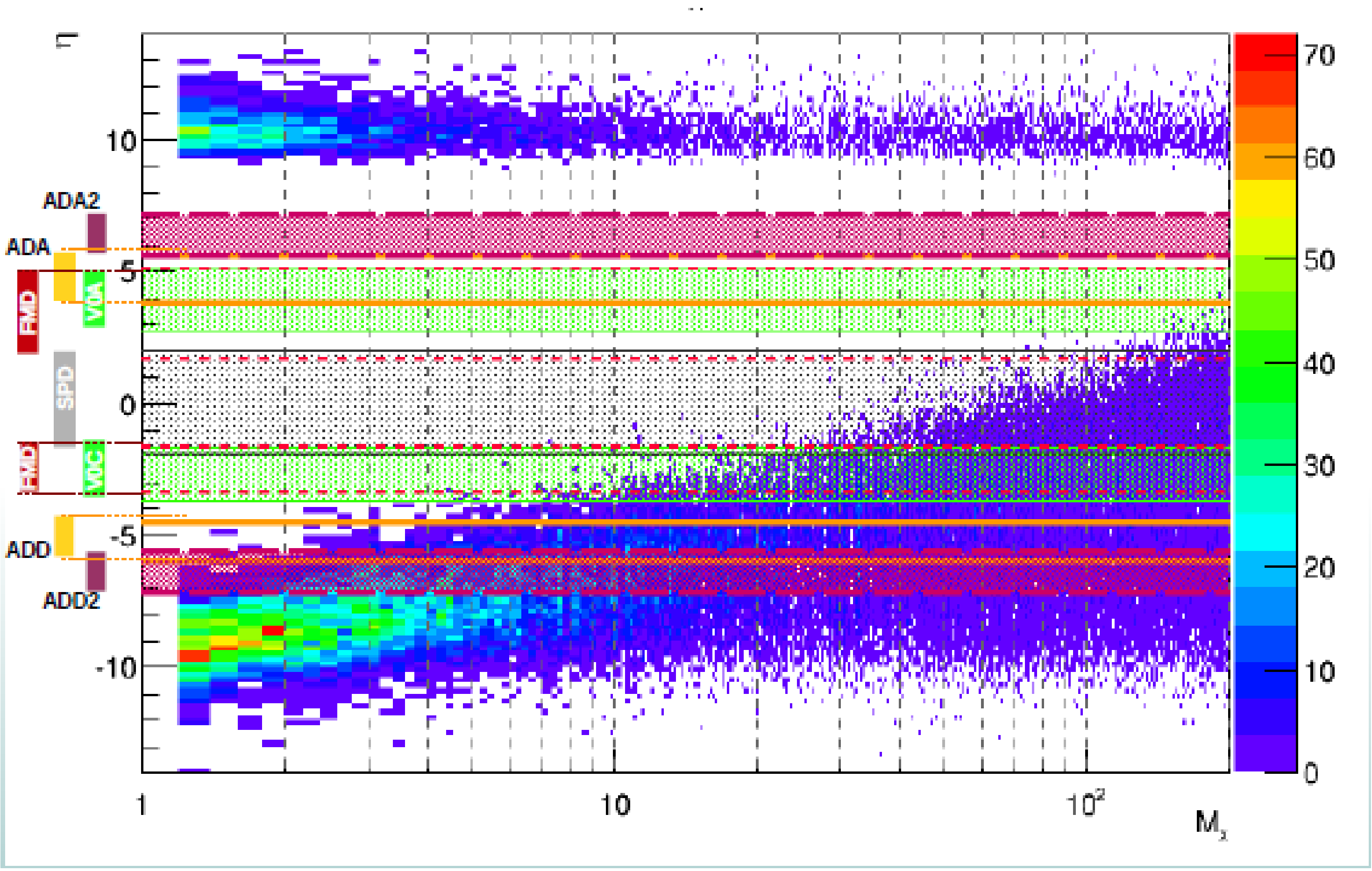
ADA and ADC counters will increase the **pseudorapidity coverage from 8.8 to 13.2**



C side

A side

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



Triggers for Diffractive Physics

The triggers for Single Diffractive

Single Diffractive Left

$$
\begin{aligned}
SD\text{-}L_0 &= \quad \sim V0A \;\wedge\; \sim SPD \;\wedge\; V0C \\
SD\text{-}L_1 &= \quad \sim (ADA \vee V0A) \;\wedge\; \sim SPD \;\wedge\; (V0C \vee ADD) \\
SD\text{-}L_2 &= \quad \sim (ADA2 \vee ADA \vee V0A) \;\wedge\; \sim SPD \;\wedge\; (ADD2 \vee ADD \vee V0C)
\end{aligned}
$$

Single Diffractive Right

$$
\begin{aligned}
SD\text{-}R_0 &= \quad V0A \;\wedge\; \sim SPD \;\wedge\; \sim V0C \\
SD\text{-}R_1 &= \quad (ADA \vee V0A) \;\wedge\; \sim SPD \;\wedge\; \sim (V0C \vee ADD) \\
SD\text{-}R_2 &= \quad (ADA2 \vee ADA \vee V0A) \;\wedge\; \sim SPD \;\wedge\; \sim (ADD2 \vee ADD \vee V0C)
\end{aligned} \tag{2.2}
$$

The triggers for double diffraction (DD_i) are:

Double Diffractive

$$
\begin{aligned}
DD_0 &= \quad V0A \;\wedge\; \sim SPD \;\wedge\; V0C \\
DD_1 &= \quad (ADA \vee V0A) \;\wedge\; \sim SPD \;\wedge\; (V0C \vee ADD) \\
DD_2 &= \quad (ADA2 \vee ADA \vee V0A) \;\wedge\; \sim SPD \;\wedge\; (ADD2 \vee ADD \vee V0C)
\end{aligned} \tag{2.3}
$$

and for central diffraction (CD).

Central Diffraction

$$
\begin{aligned}
CD_0 &= \quad \sim V0A \;\wedge\; SPD \;\wedge\; \sim V0C \\
CD_1 &= \quad \sim (ADA \vee V0A) \;\wedge\; SPD \;\wedge\; \sim (V0C \vee ADD) \\
CD_2 &= \quad \sim (ADA2 \vee ADA \vee V0A) \;\wedge\; SPD \;\wedge\; \sim (ADD2 \vee ADD \vee V0C)
\end{aligned}
$$

VZERO, SPD & FMD
VZERO, SPD & FMD+2 stations
VZERO, SPD & FMD+4 stations

PHOJET 7 TeV

trigger	Efficiency Pure–events (%)	Efficiency Minimum–Bias (%)	Purity (%)
$SD\text{-}L_0$	13.14	1.26	71.44
$SD\text{-}L_1$	27.66	2.25	84.33
$SD\text{-}L_2$	31.15	2.45	87.48
$SD\text{-}R_0$	19.68	1.98	68.45
$SD\text{-}R_1$	30.92	2.55	83.17
$SD\text{-}R_2$	33.47	2.66	86.57
DD_0	4.69	0.45	51.57
DD_1	13.60	0.99	68.37
DD_2	16.35	1.14	71.37
CD_0	3.28	0.11	55.55
CD_1	3.11	0.06	97.29
CD_2	3.10	0.06	98.73

PYTHIA 6 7 TeV

trigger	Efficiency Pure–events(%)	Efficiency Minimum–Bias (%)	Purity (%)
$SD\text{-}L_0$	11.30	1.80	59.95
$SD\text{-}L_1$	26.38	3.23	78.18
$SD\text{-}L_2$	31.54	3.56	84.84
$SD\text{-}R_0$	16.73	2.96	54.08
$SD\text{-}R_1$	29.05	3.76	74.01
$SD\text{-}R_2$	32.93	3.85	81.84
DD_0	5.31	1.00	64.96
DD_1	16.80	2.63	78.43
DD_2	21.93	3.28	82.15

PYTHIA 6 7 TeV

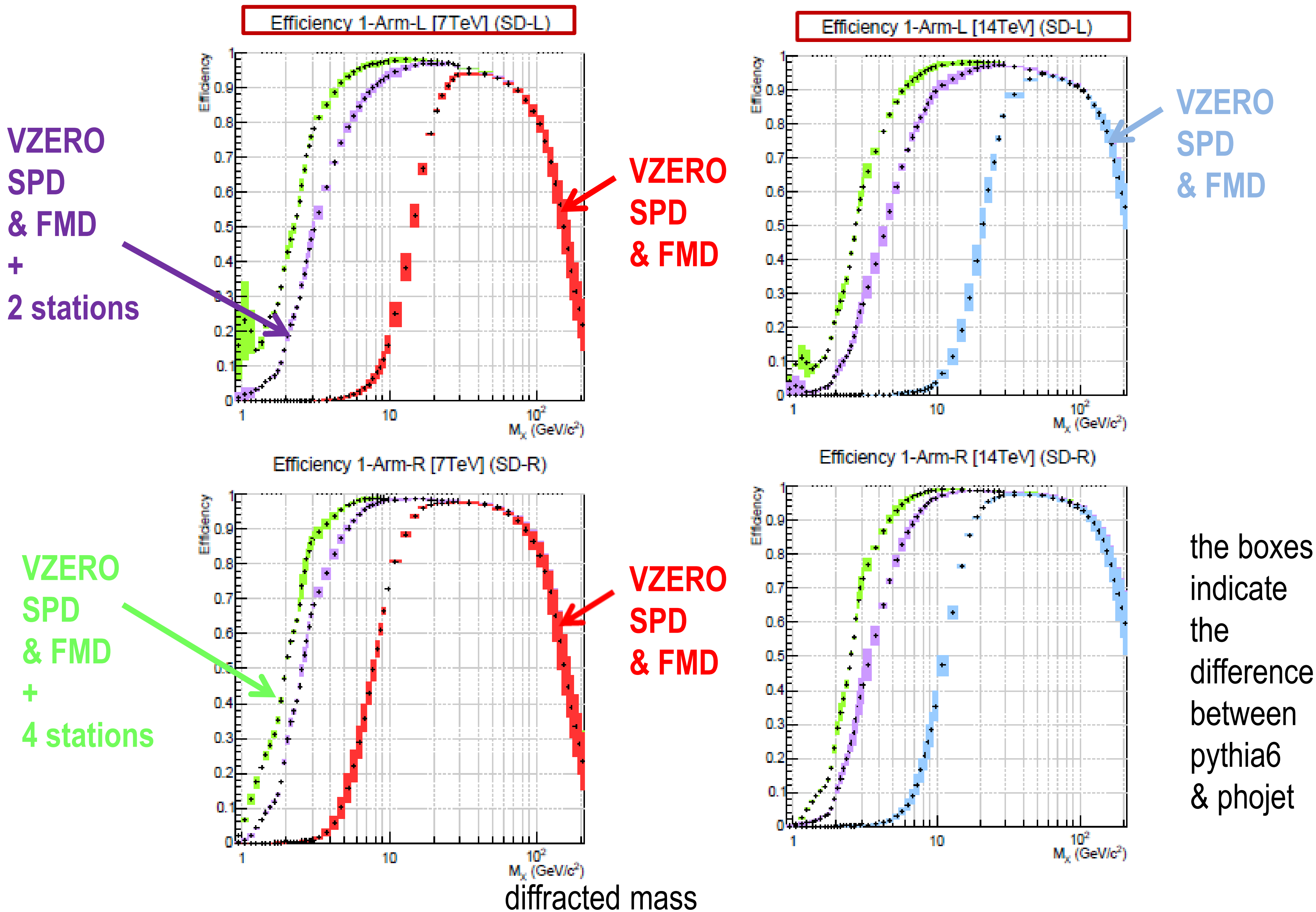
trigger	Efficiency Pure–events(%)	Efficiency Minimum–Bias(%)	Purity (%)
1–Arm–L_0	23.61	3.87	58.36
1–Arm–L_1	38.60	4.77	77.42
1–Arm–L_2	41.25	4.71	83.84
1–Arm–R_0	30.23	5.79	49.93
1–Arm–R_1	40.96	5.49	71.37
1–Arm–R_2	42.79	5.17	79.14

VZERO, SPD & FMD
VZERO, SPD & FMD+2 stations
VZERO, SPD & FMD+4 stations

PHOJET 7 TeV

trigger	Efficiency Pure–events(%)	Efficiency Minimum–Bias(%)	Purity(%)
1–Arm–L_0	27.01	2.87	64.67
1–Arm–L_1	41.38	3.67	77.37
1–Arm–L_2	44.85	3.82	80.59
1–Arm–R_0	35.10	3.97	60.73
1–Arm–R_1	46.00	4.19	75.49
1–Arm–R_2	48.53	4.21	79.17

As defined in the recent paper: arXiv:1208.4968 accepted in Eur. Phys. J. C

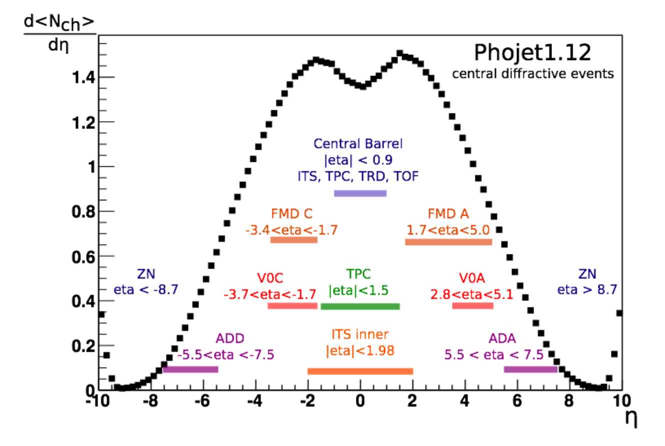

Efficiency 1-Arm-L [7TeV] (SD-L)
Efficiency 1-Arm-L [14TeV] (SD-L)
Efficiency 1-Arm-R [7TeV] (SD-R)
Efficiency 1-Arm-R [14TeV] (SD-R)
Efficiency
M_X (GeV/c^2)
VZERO
SPD
& FMD
+
2 stations
VZERO
SPD
& FMD
VZERO
SPD
& FMD
VZERO
SPD
& FMD
+
4 stations
VZERO
SPD
& FMD
diffracted mass
the boxes indicate the difference between pythia6 & phojet

Plans for the future

Future running of ALICE

Run 2   2015 – 2017:

- 2015   proton–proton at $\sqrt{s_{pp}}$ = 13 TeV
  starting at $\sqrt{s_{pp}}$ = 12 TeV -- 25 ns bunch spacing
- Possibility of low luminosity and low beam intensity
  Minimum Bias Trigger - OR
- Lab energy increases →
- Better pseudorapidity coverage →
- UPC cross section increase with energy



Run 3   2019 – 2021:

- proton–proton at $\sqrt{s_{pp}}$ = 14 TeV
- Upgraded ALICE detector (Calorimetry, faster read-out, new beam pipe, different Internal Tracking System etc.)
- New Trigger Detectors

ALICE upgrade

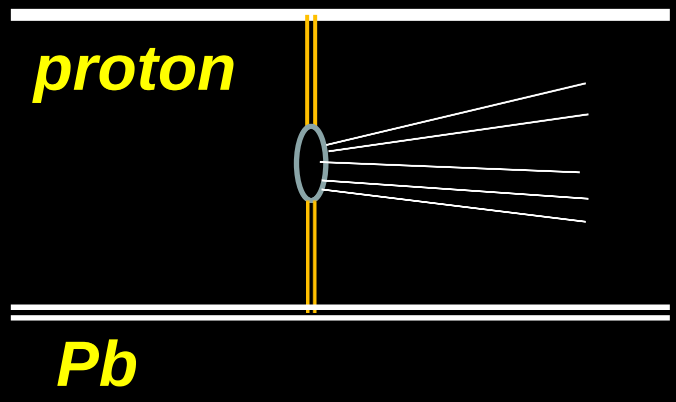
- luminosity upgrade – 50 kHz for Pb–Pb collisions and 2 MHz in pp
- improved vertex measurement and tracking at low p_T
- preserve particle-identification capability
- high-luminosity operation without dead-time
- new, smaller radius beam pipe
- new inner tracker (ITS) (performance and rate upgrade)
- high-rate upgrade for the readout of the TPC, TRD, TOF, CALs, DAQ-HLT, Muon-Arm and Trigger detectors
- Muon Forward Tracker (MFT)
- Forward Calorimeter (FoCal)

- 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
- ALICE upgrade Letter Of Intent submitted to LHCC

encore

Diffractive physics in proton - Pb

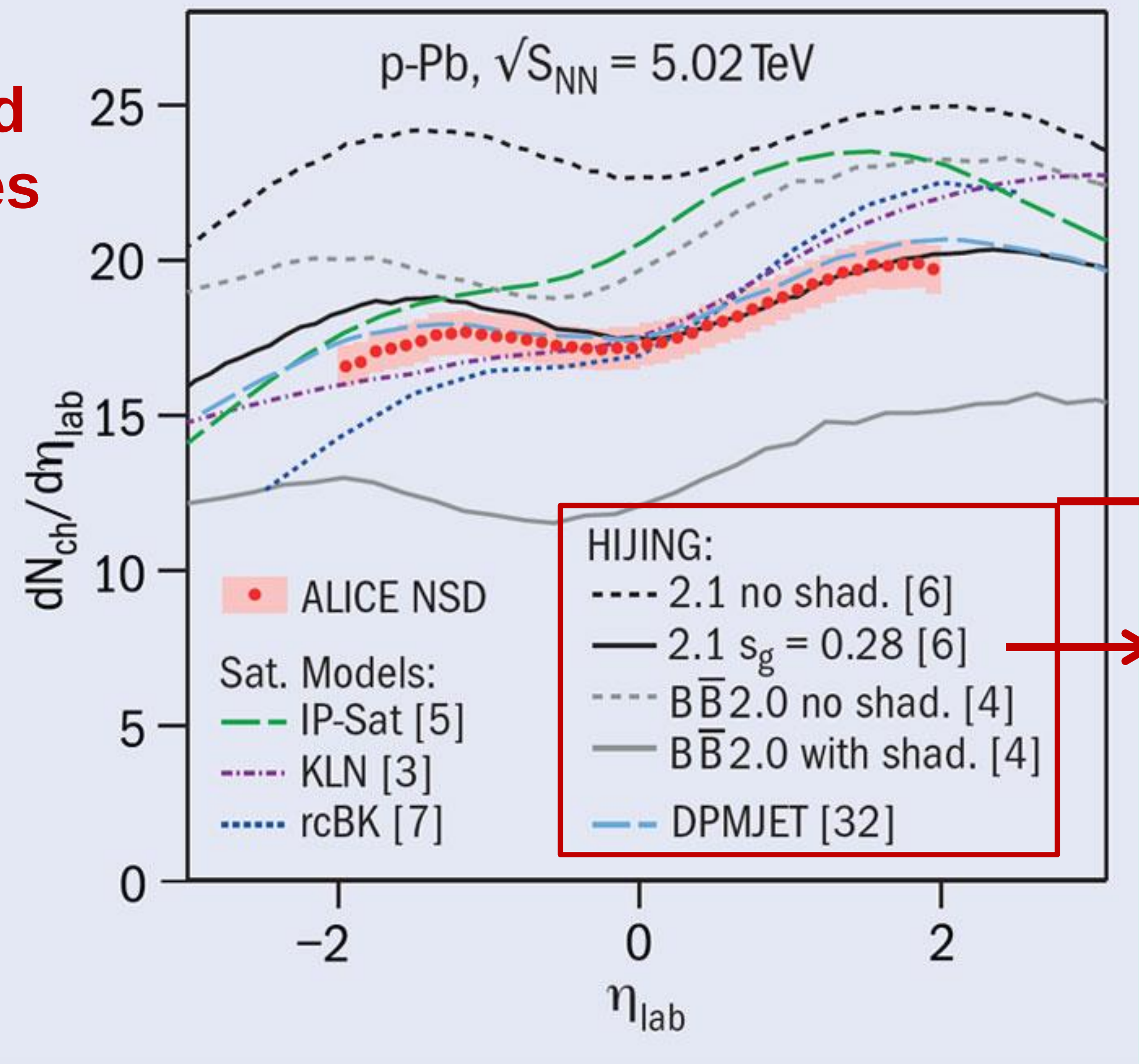
- diffractive physics in p A is almost completely unknown
- One could analyze central diffraction processes searching several final states :
- Compare *pp* and *pA*



Pseudo-rapidity density of charged particles

proton - Pb, 2 million events collected in september 2012

ALICE Collab. arXiv:1210.3615

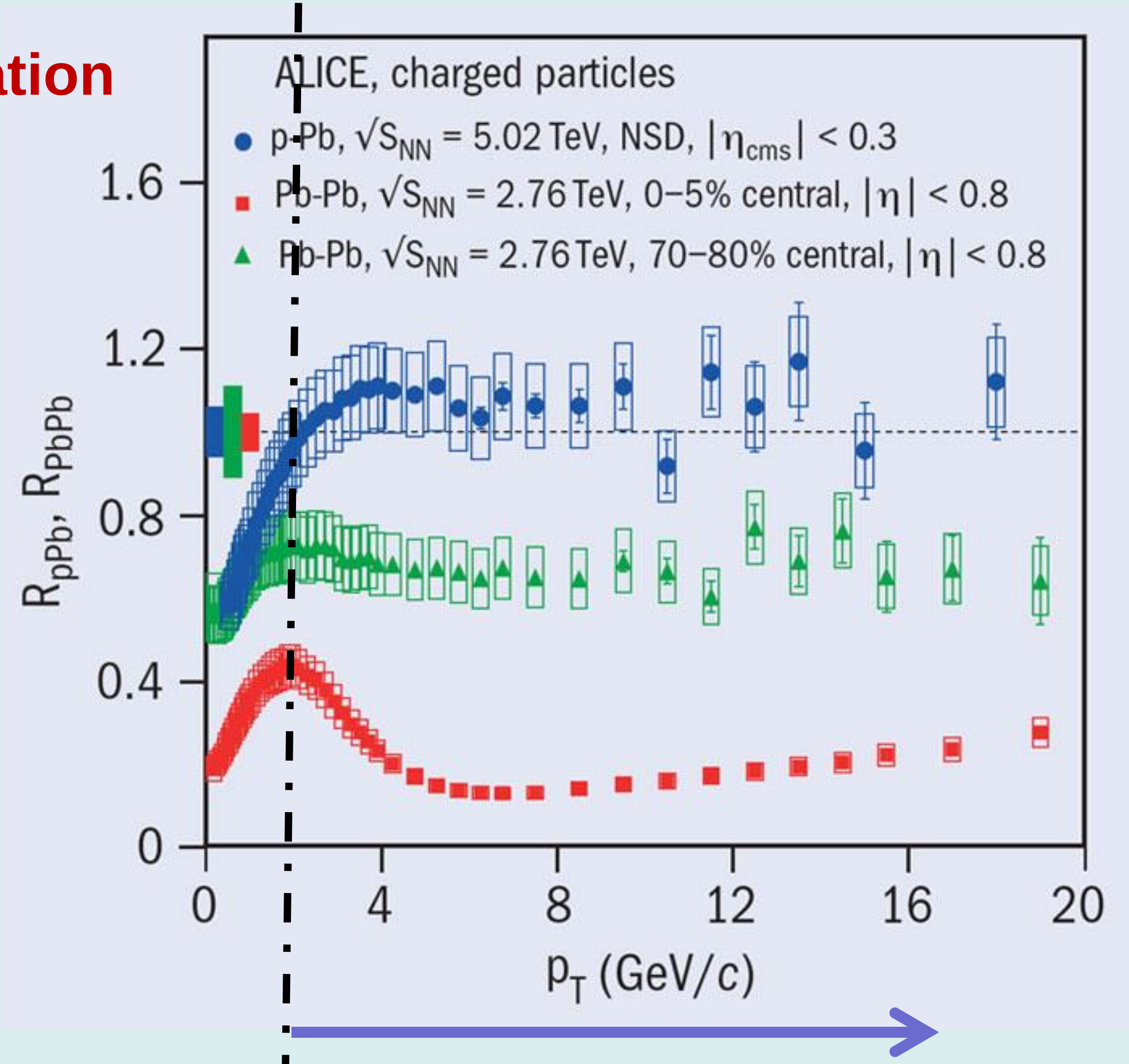


nuclear modification

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