Diffractive physics in ALICE

- ALICE experiment
- ALICE performance
- Diffractive gap trigger
- First analysis on double pomeron events
- Long term observable – the Odderon
- Conclusions, outlook

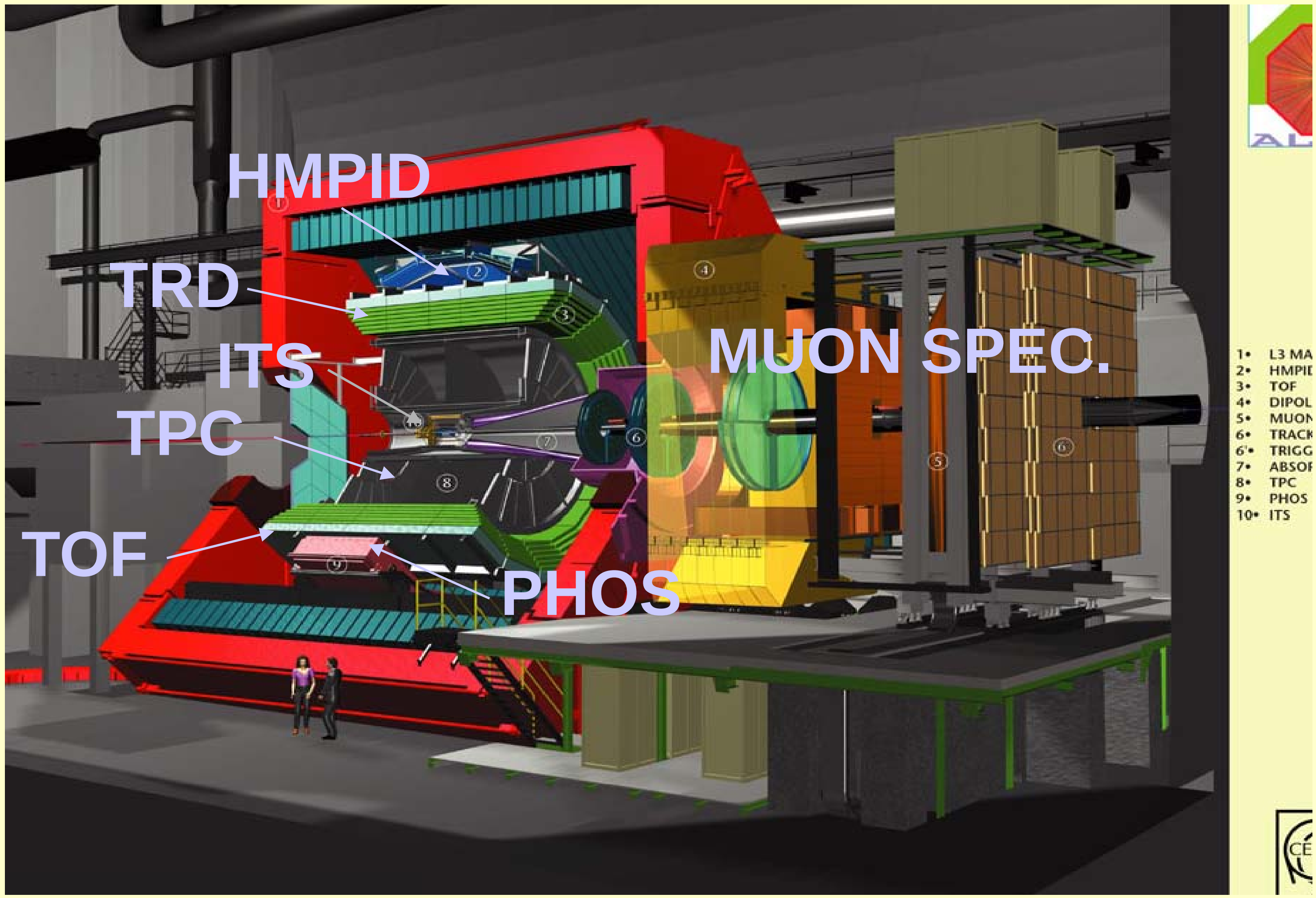
The ALICE experiment

Acceptance central barrel

-0.9 < η < 0.9

Acceptance muon spectr.

2.5 < η < 4.

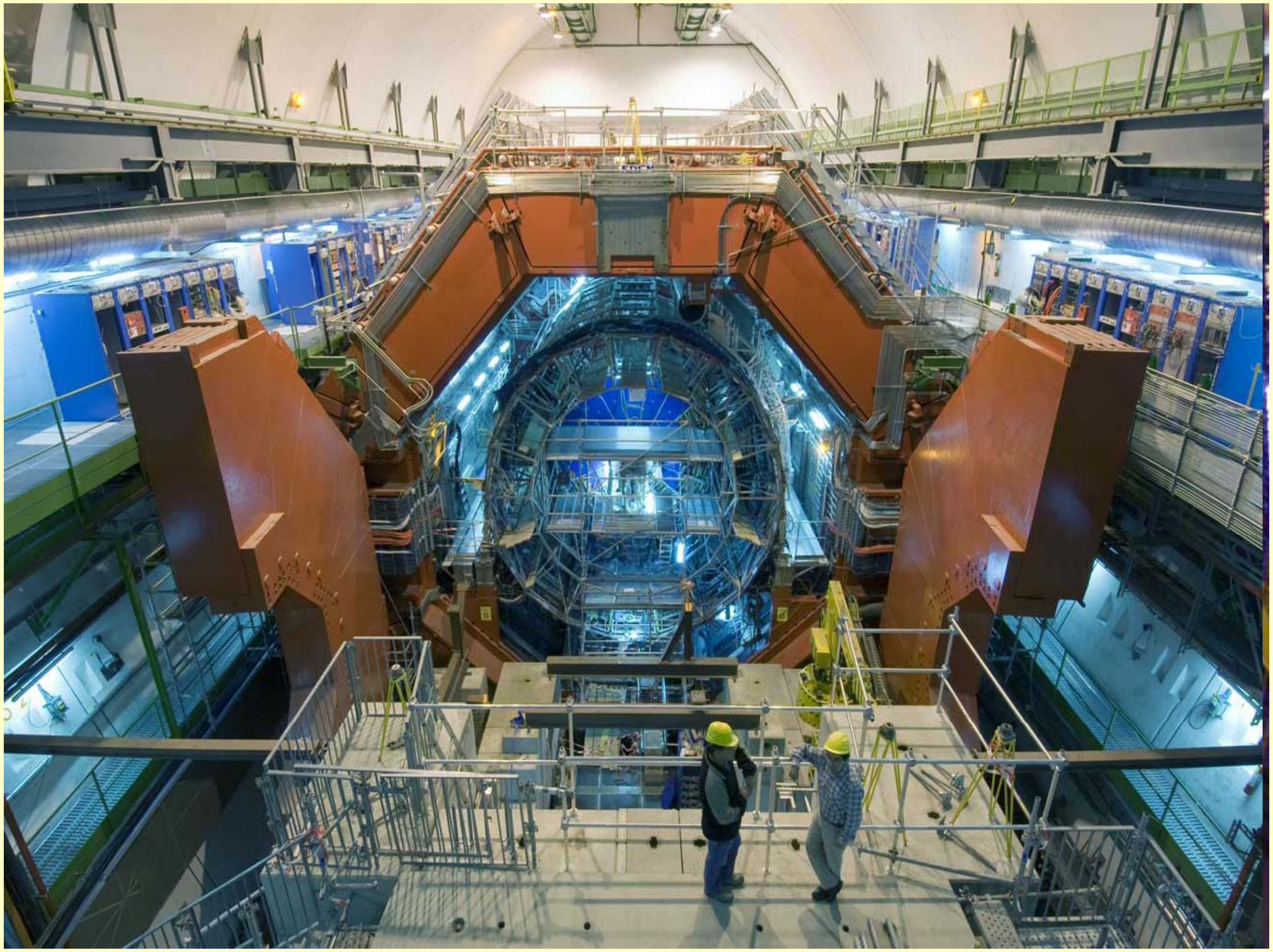


The ALICE magnet

LHC: IP2
(LEP L3)

B = 0.2 - 0.5
T

2001
6



Central barrel detector systems

- Inner Tracking Systems (ITS)
  - Two layers of silicon pixel
  - Two layers of silicon drift
  - Two layers of silicon strip

  Tracking, secondary vertices of hyperons, D and B mesons, particle identification by dE/dx
- Time Projection Chamber (TPC)
  - Tracking, particle identification by dE/dx
- Transition Radiation Detector (TRD, *not complete for first runs*)
  - Tracking, electron-pion separation
- Time-of-Flight array (TOF)
  - Particle identification

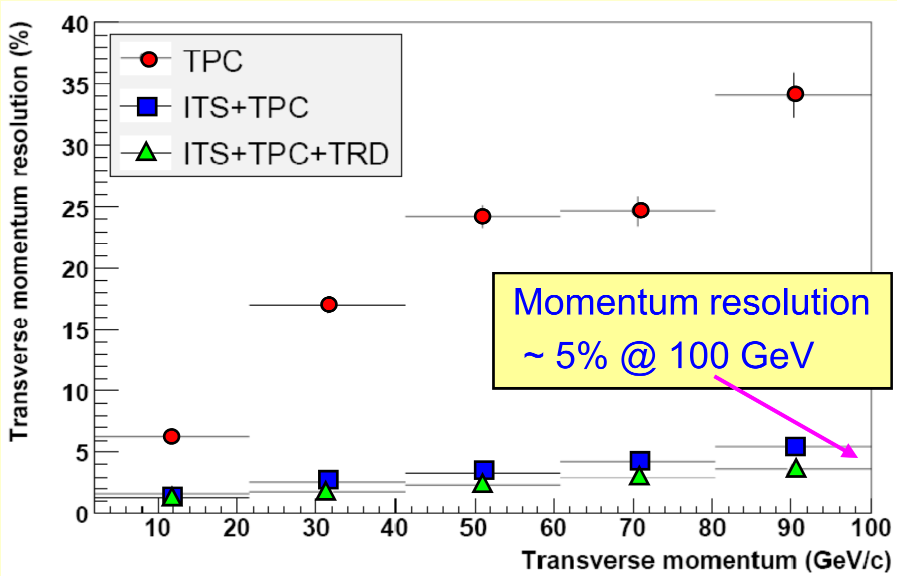
ALICE central barrel tracking performance

- Robust, redundant tracking

  from < 100 MeV/c to > 100 GeV/c

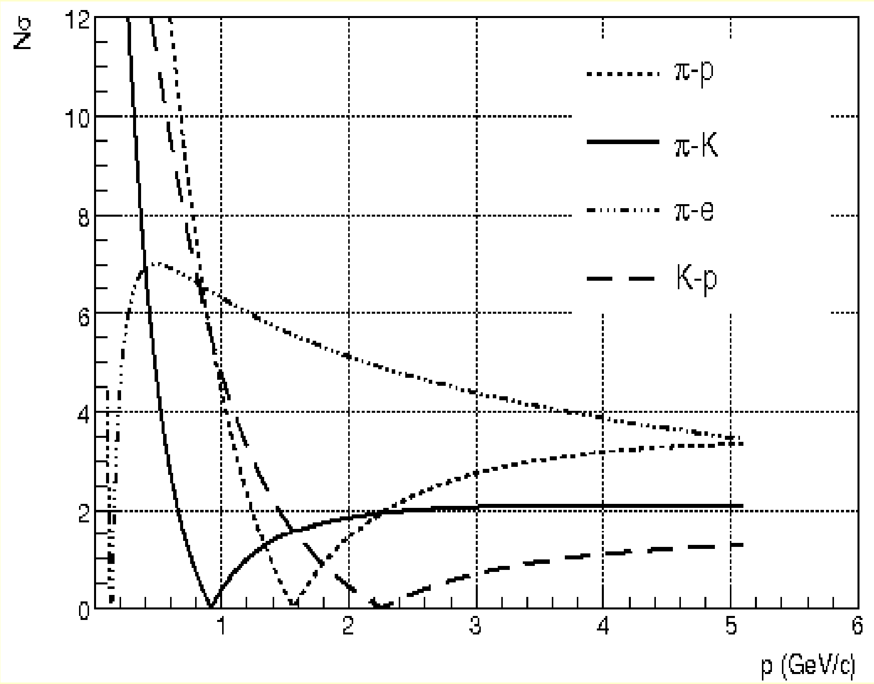
- Very little dependence on

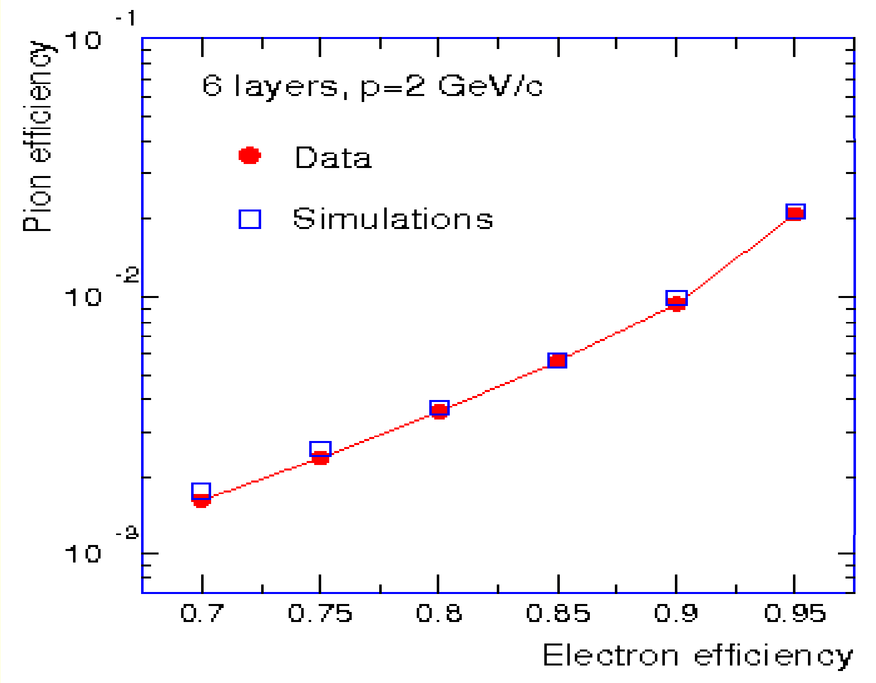
  dN/dy up to dN/dy ≈ 8000



- $\delta p/p < 5\%$ at 100 GeV with careful control of systematics

ALICE central barrel particle identification





Particle identification by dE/dx in central barrel as function of momentum

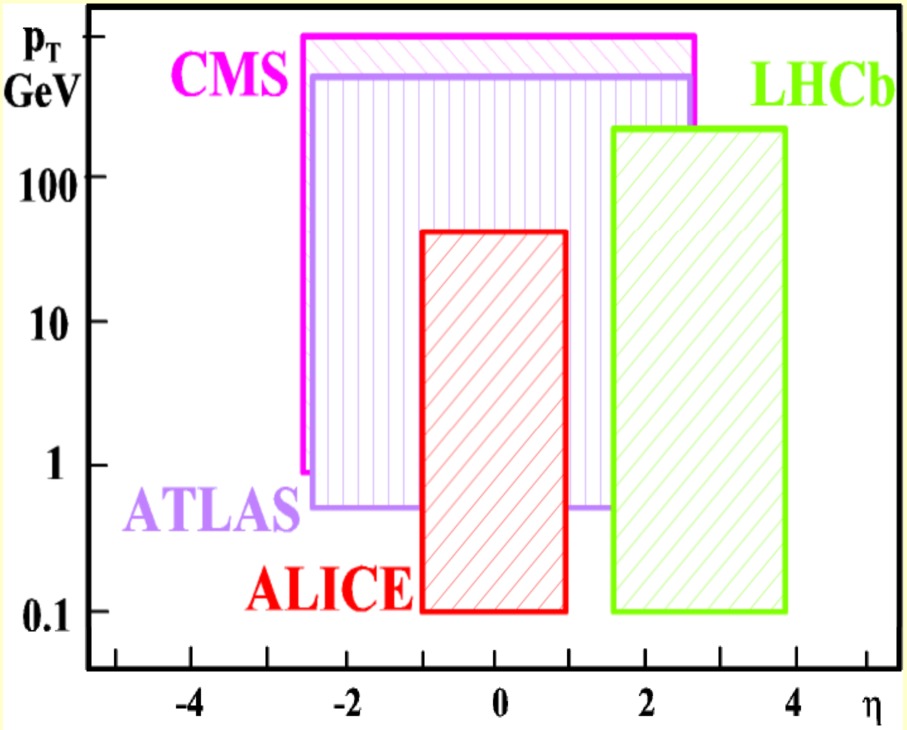
Electron-pion separation in TRD as function of momentum

ALICE central barrel comparison to other LHC detectors

low magnetic field

	Magn. field (T)	P_T cutoff GeV/c	Material x/x0 (%)
ALICE	0.2-0.5	0.1-0.25	7
ATLAS	2.0	0.5 (0.08)	20
CMS	4.0	0.75 (0.2)	30
LHCb	4Tm	0.1	3.2

η–pt acceptance



→ *low p_T trigger ?*

ALICE forward calorimeter

- neutron calorimeter on each side
  - Placed at 116 m from interaction region
  - Measures neutral energy at 0^o (neutrons, π^0)
- Diffractive events:
  - pp → ppX : no energy in zero degree calorimeter
  - pp → pN*X : energy in one calorimeter
  - pp → N*N*X : energy in both calorimeters

(no Roman pots for proton tagging)

ALICE diffractive gap trigger

→ *additional forward detectors for event classification (no particle identification)*

$1 < \eta < 5, \; -4 < \eta < -1$

→ *definition of gaps* η_+ , η_-

Luminosity L = 5x10^{30}cm^{-2}s^{-1} → one interaction/ 80 bunches

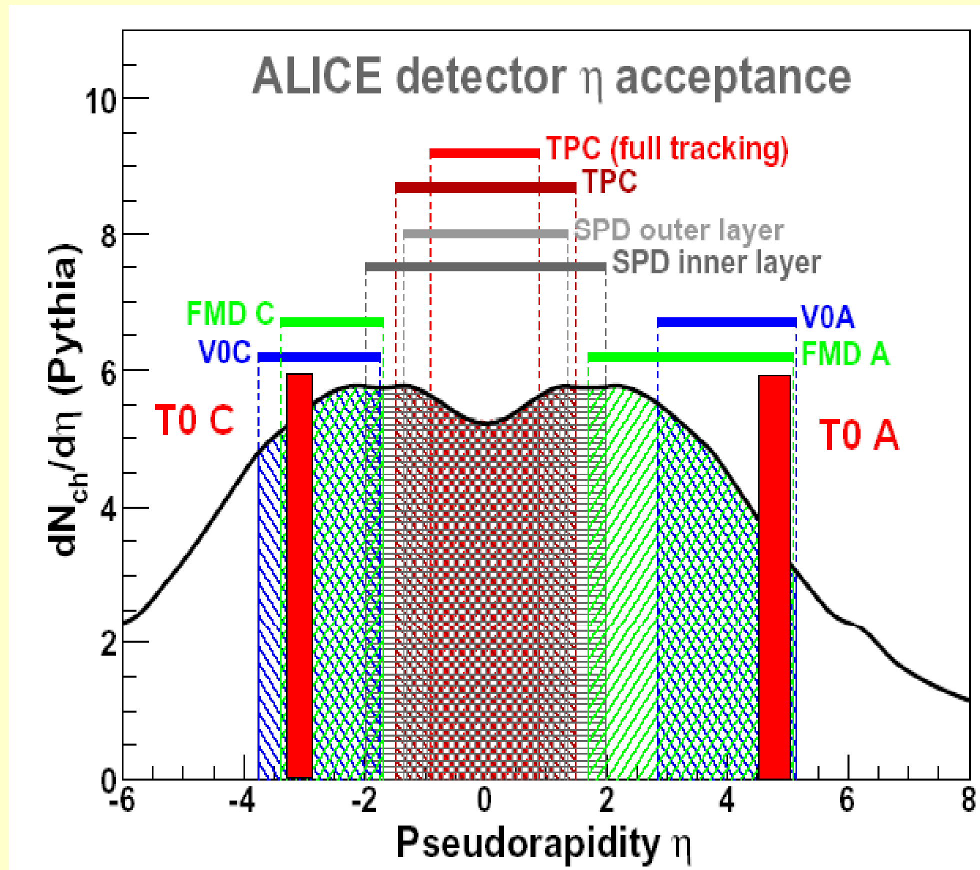
diffractive L0 trigger (hardware):

pixel ITS: multiplicity signal

(→ p$_T$ threshold ~ 100 MeV/c)

gap η_+: $3 < \eta < 5 \rightarrow \Delta\eta \sim 0.5$

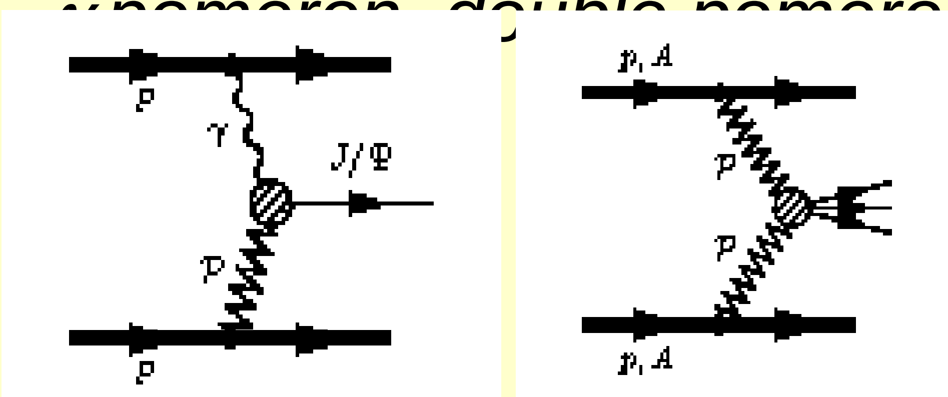
gap η_-: $-2 < \eta < -4 \rightarrow \Delta\eta \sim 0.5$



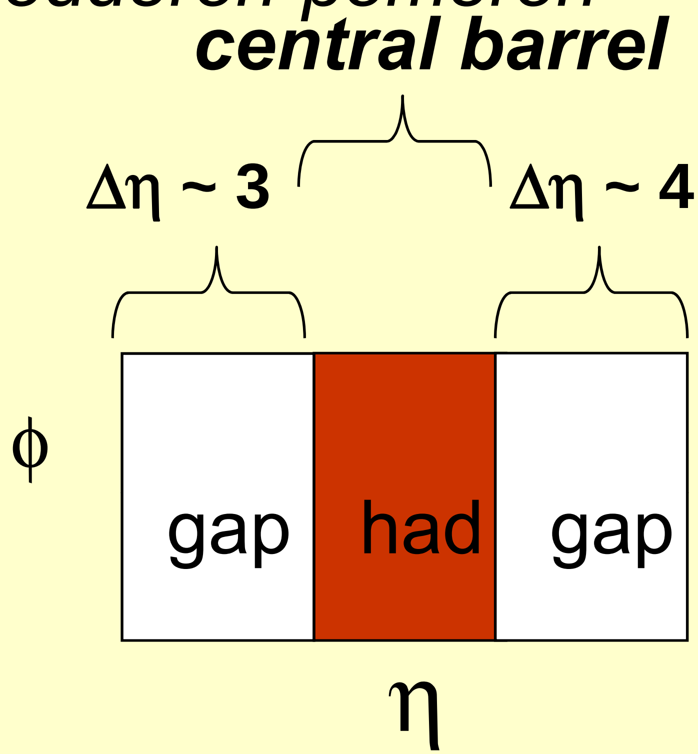
ALICE diffractive physics

- ALICE acceptance matched to diffractive central production:

  γ-pomeron, double pomeron, odderon-pomeron



Data taking:
pp @ L = $5x10^{30}$ $cm^{-2}s^{-1}$
pPb @ L = 10^{29} $cm^{-2}s^{-1}$
PbPb @ L = 10^{27} $cm^{-2}s^{-1}$



First analysis on double pomeron events

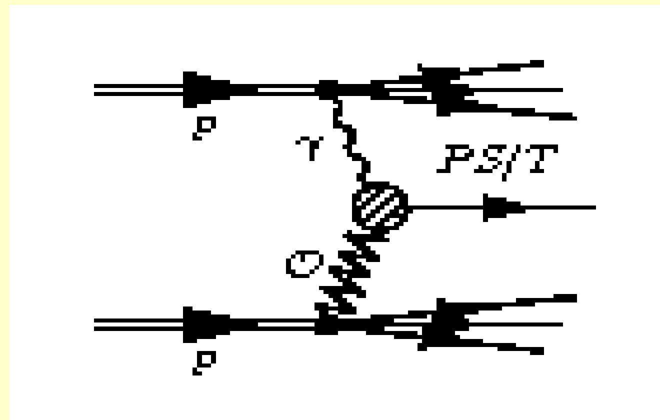
- First data expected later this year:
  - Compare multiplicity distributions of double pomeron events and min. bias inelastic events
  - Compare events of same central barrel multiplicity
    - **P_T distribution**
    - **Invariant mass distribution**
    - **K^+/π^+, K^-/π^- ratio**

Signature Odderon cross section

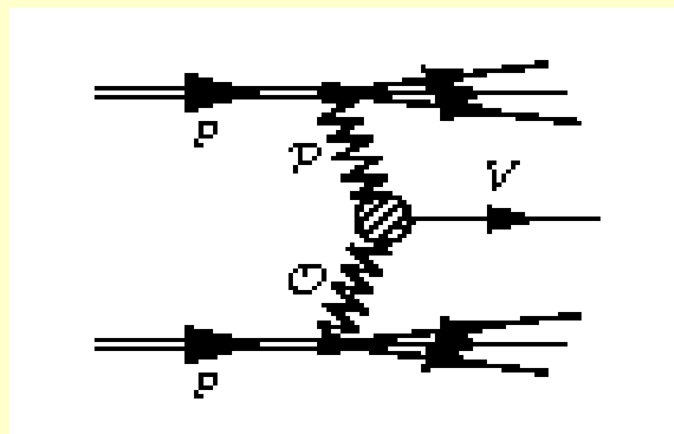
Look at processes with rapidity gaps

Examples:

diffractive pseudo scalar and tensor meson production: C = +1 states



diffractive vector meson production: C = -1 states



→ measure cross sections

The hunt for the Odderon

- Production cross sections in pp at LHC energies
  - diffractive production: $\pi^0, \eta, \eta_c (J^{PC}=0^{-+})$, $f0(0^{++})$, $a2(2^{++})$

    → contributions from Photon-Photon, Photon-Odderon, Odderon-Odderon −−
  - Look for diffractive J/Ψ production: $J^{PC} = 1^{--}$

    → Photon-Pomeron, Odderon-Pomeron contributions

→ such an experimental effort is a continuation of physics programs carried out at LEP ($\gamma\gamma$) and HERA (γ-Odderon)

Diffractive J/Ψ production in pp at LHC

- First estimates by Schäfer, Mankiewicz, Nachtmann 1991
- pQCD estimate by Bzdak, Motyka, Szymanowski, Cudell
  - Photon: t-integrated $\left.\frac{d\sigma}{dy}\right|_{y=0}$ ~ 10 nb (2.4 - 27 nb)
  - Odderon: t-integrated $\left.\frac{d\sigma}{dy}\right|_{y=0}$ ~ 1 nb (0.3 - 4 nb)

At L = 5×10^{30} $cm^{-2}s^{-1}$:

→ ***0.15 J/Ψ in ALICE central barrel in 1 s, 150k in 10^6 s***

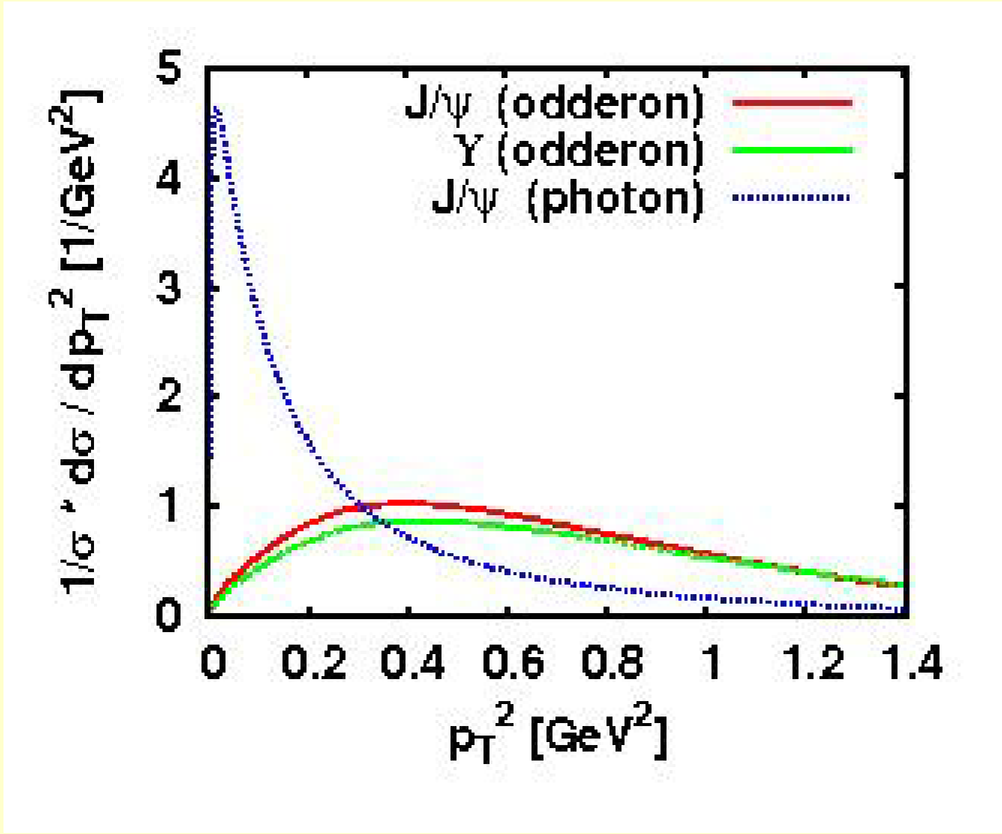
→ ***6000 (Photon), 600 (Odderon) e^+e^- decays of J/Ψ***

→ identify Photon and Odderon contribution by analysing p_T distribution (Odderon harder p_T spectrum)

Odderon in diffractive J/Ψ production

- Photon and Odderon contribution have different t-dependence

→ different p_T – distribution of J/Ψ



L.Motyka, L.Szymanowski

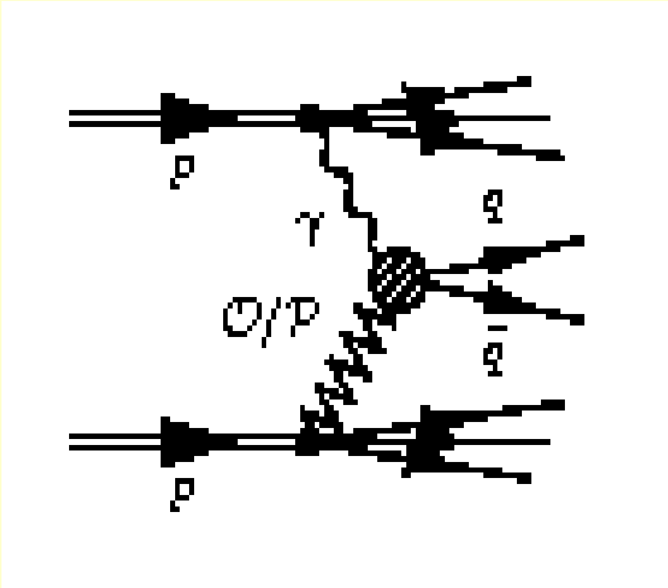
Signature Odderon interference

- Cross sections contain squared Odderon amplitudes

→ ***Odderon-Pomeron interference !***

$$d\sigma \sim |A\gamma(A_P + A_O)|^2 \, d^N q$$

$$\sim |A_P|^2 + 2\mathrm{Re}(A_P A_O^*) + |A_O|^2$$



→ ***look at final states which can be produced by Odderon or Pomeron exchange***

→ ***find signatures for interference of C-odd and C-even amplitude***

Interference signal

- Interference effects (relative contribution C = +1)
  - Photon-pomeron amplitude: C= 1
  - Photon-odderon amplitude: C= +1
  - Asymmetries in $\pi^+\pi$ and K^+K pairs (C = + 1) in continuum

→ charge asymmetry relative to polar angle of π^+ in dipion rest frame

Brodsky, Rathsman, Merino 1999: asymmetry fractional energy open charm in diffractive photoproduction ~ 15 %

Hägler, Pire, Szymanowski, Teryaev 2002: forward-backward charge asymmetry in pion production ~10 %, 1 GeV/c² < $m_{\pi+\pi-}$ < 1.3 GeV/c²

Conclusions, outlook

- ALICE has opportunity for diffractive/photon physics
- Diffractive trigger defined by two rapidity gaps
- Neutron tagging at zero degree
- Phenomenology of Pomeron/Odderon
- Photon-Photon physics