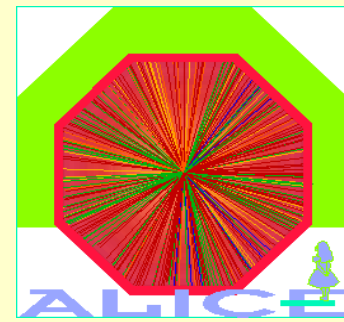
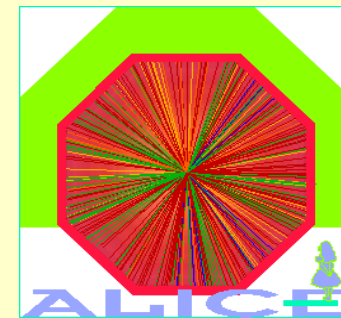


Central Meson Production in ALICE



- ALICE detector
- Selection of central diffractive single/double gap events
- Central Meson production in pp-collisions at $\sqrt{s} = 7$ TeV
- Analysis of $f_0(980)$ and $f_2(1270)$ production
- Central Meson production in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.74$ TeV
- Analysis of $\rho(770)$
- Conclusions, outlook

The ALICE experiment

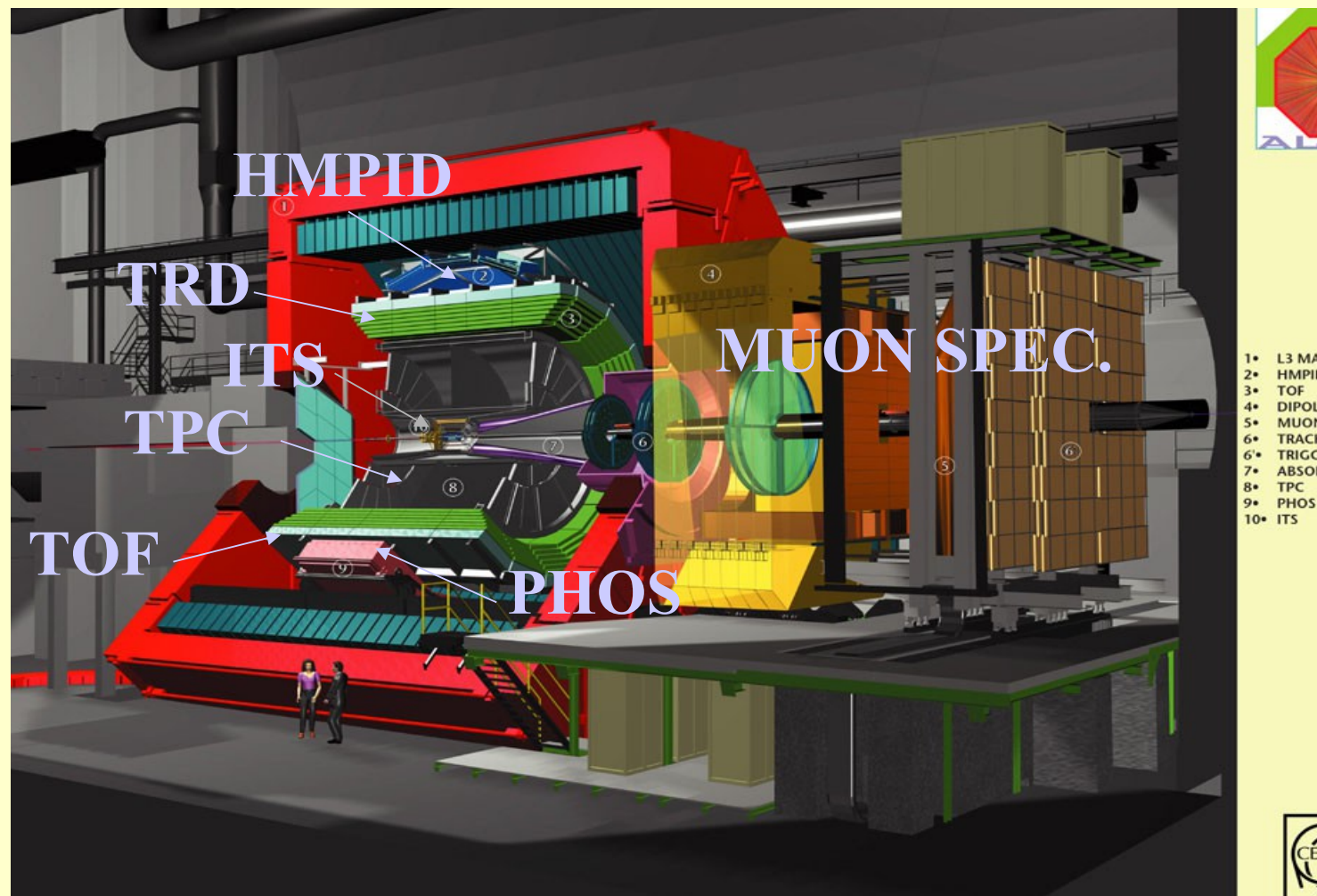


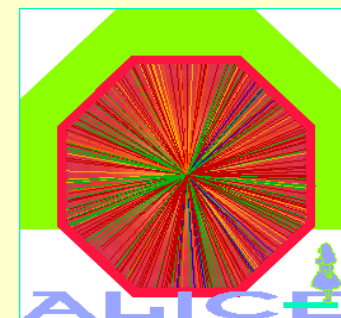
*Acceptance
central barrel*

$$-0.9 < \eta < 0.9$$

*Acceptance
muon spectr.*

$$-2.5 < \eta < -4.$$





ALICE pseudorapidity acceptance

→ *additional forward detectors*
(no particle identification)

$$1 < \eta < 5 \text{ and } -4 < \eta < -1$$

→ *definition of gaps η_+ , η_-*

p-p luminosity $L = 5 \times 10^{30} \text{cm}^{-2} \text{s}^{-1}$:

→ reduced prob. overlapping events

diffractive L0 trigger (hardware):

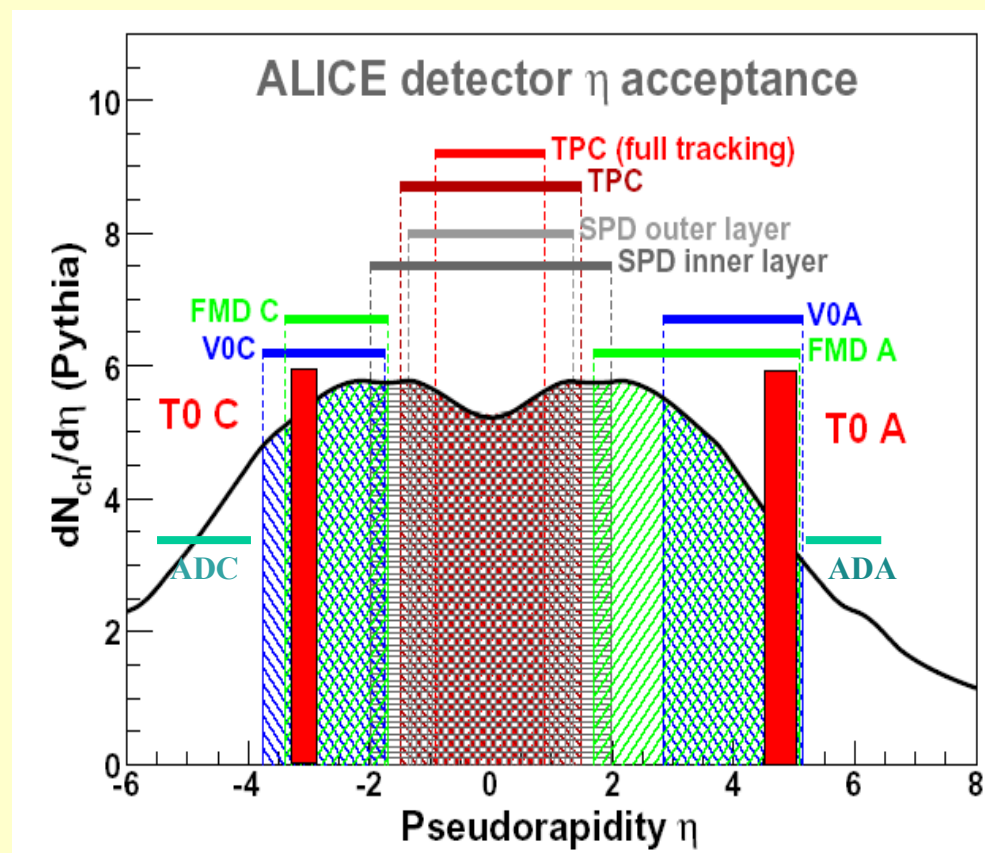
Pixel or TOF mult (central barrel)

V0A: gap η_+ : $3 < \eta < 5 \rightarrow \Delta\eta \sim 0.5$

V0C: gap η_- : $-2 < \eta < -4 \rightarrow \Delta\eta \sim 0.5$

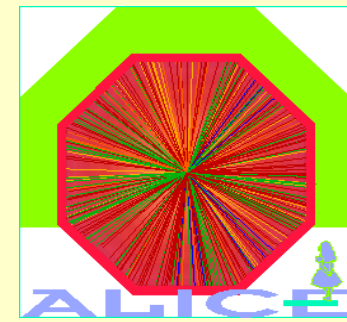
high level trigger (software):

gap η_+ : $0.9 < \eta < 5.1$ } V0-FMD-
gap η_- : $-3.7 < \eta < -0.9$ } SPD-TPC



→ *improved including ADA, ADD*

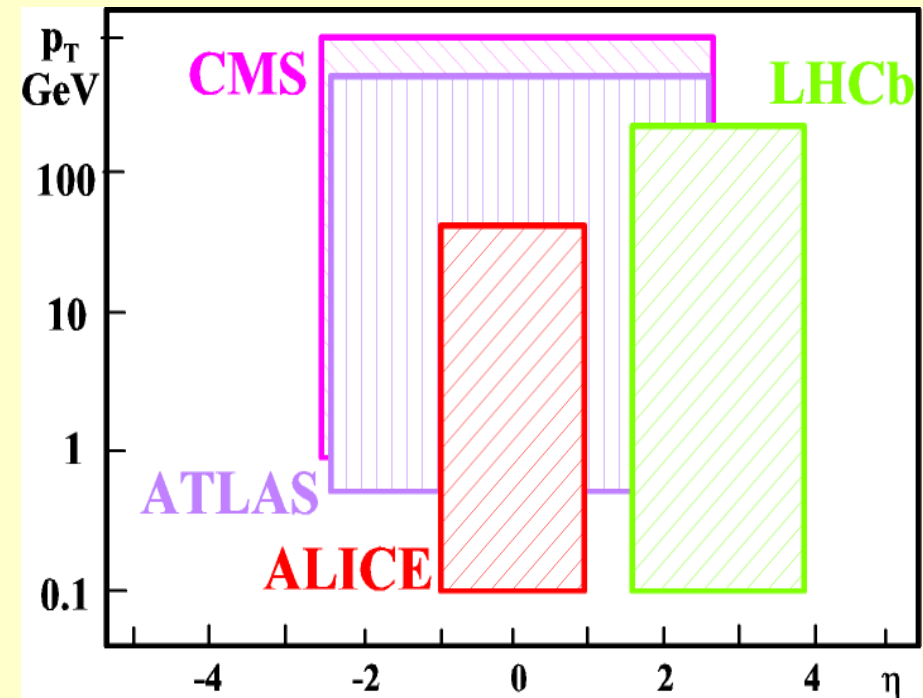
ALICE central barrel comparison to other LHC detectors



low magnetic field

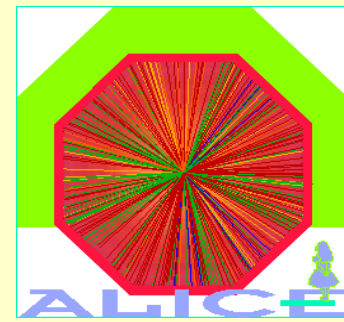
	Magn. field (T)	P_T cutoff GeV/c	Material x/x_0 (%)
ALICE	0.2-0.5	0.1-0.25	7
ATLAS	2.0	0.5 (0.08)	20
CMS	4.0	0.75 (0.2)	30
LHCb	4Tm	0.1	3.2

η - p_T acceptance



→ low p_T trigger ?

ALICE acceptance



- ALICE acceptance matched to diffractive central production:

central

C-side barrel *A-side*

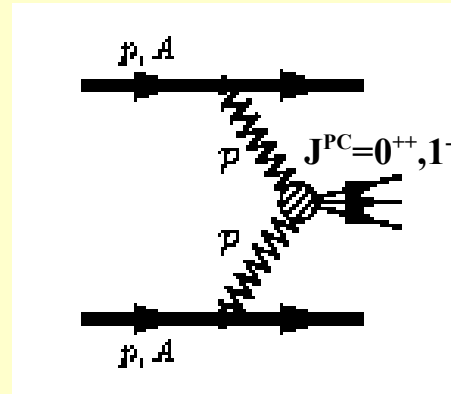
$\Delta\eta \sim 3$ $\Delta\eta \sim 2$ $\Delta\eta \sim 4$

gap	had	gap
-----	-----	-----

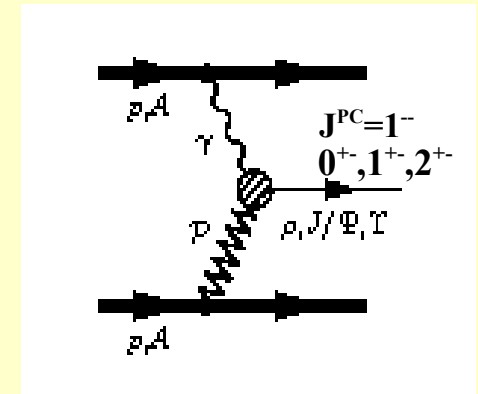
Activity table

yes	yes	no	gap A
no	yes	no	double gap
no	yes	yes	gap C
yes	yes	yes	no gap

double pomeron



γ -pomeron



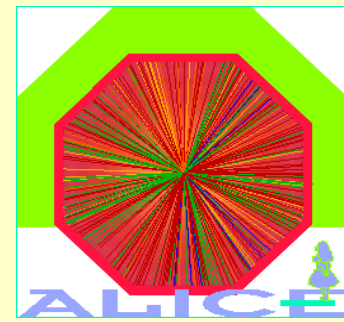
Data taking:

pp @ $L = 5 \times 10^{30} \text{ cm}^{-2}\text{s}$ $\left(\rightarrow \frac{d\sigma}{dy} \Big|_{y=0} \sim nb \right)$

pPb @ $L = 10^{29} \text{ cm}^{-2}\text{s}^{-1}$

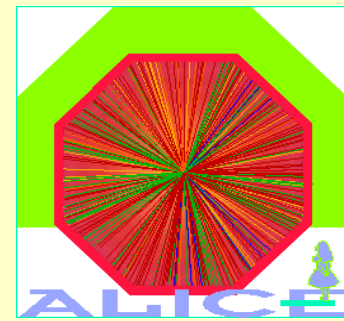
PbPb @ $L = 10^{27} \text{ cm}^{-2}\text{s}^{-1}$

Central Meson production in pp-collisions at $\sqrt{s} = 7$ TeV

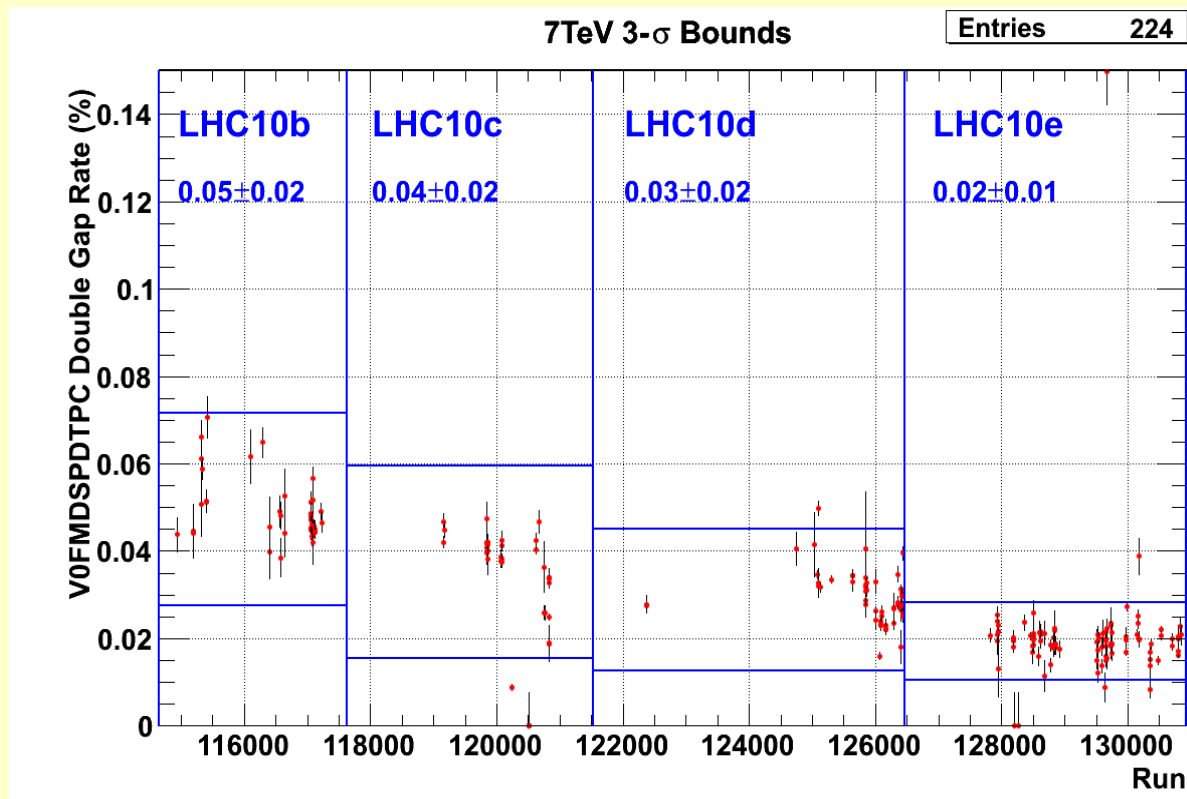


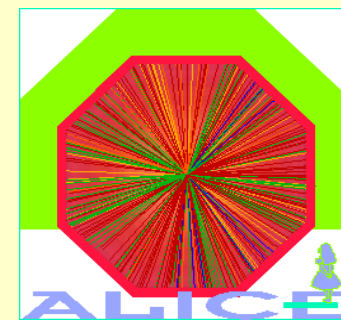
- Data taken in 2010-2011 with minimum bias trigger
- Offline analysis event type: no gap/gap A/gap C/double gap
- Compare single/double gap events to no gap events
- Analysis of multiplicity-distribution
- Analysis of $f_0(980)$ and $f_2(1270)$ production

First analysis min bias data



3 σ cut on single gap, double gap fraction on a run basis

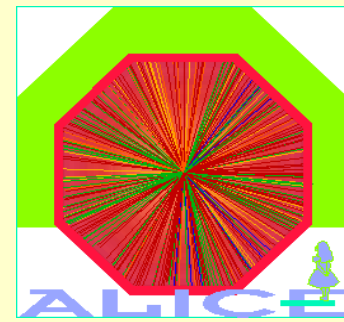




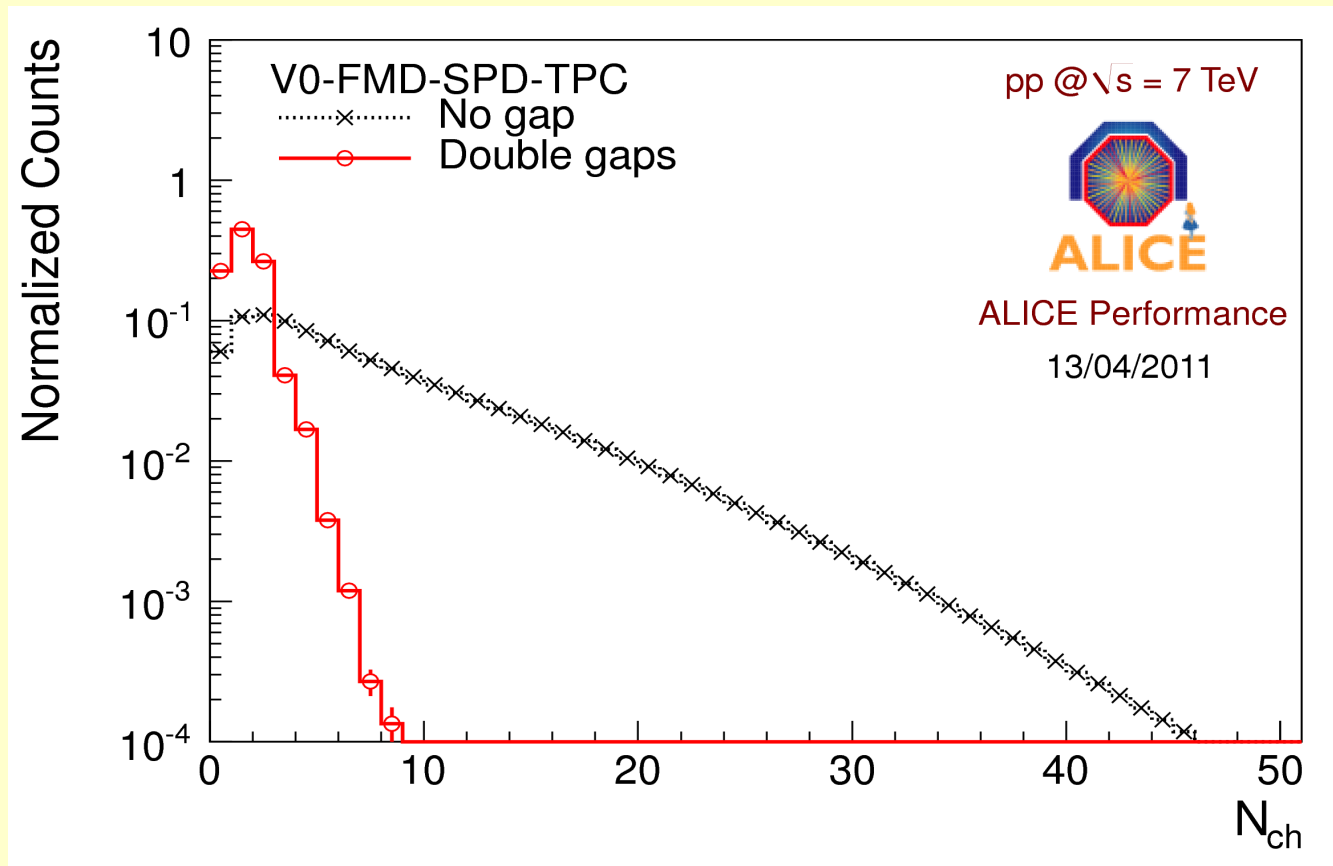
Data sample pp collisions at 7 TeV

• Physics selection	3.5×10^8
• Primary vertex	2.9×10^8
• 2-track events total	3.2×10^7
– no gap	3.1×10^7
– double gap V0 (L0 trigger)	1.6×10^5
– double gap V0-FMD-SPD-TPC	2.2×10^4

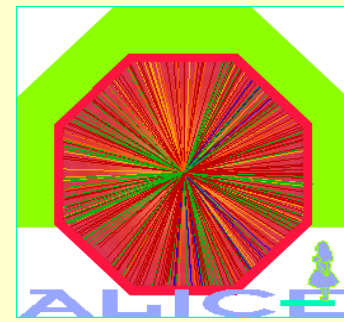
Multiplicity distribution



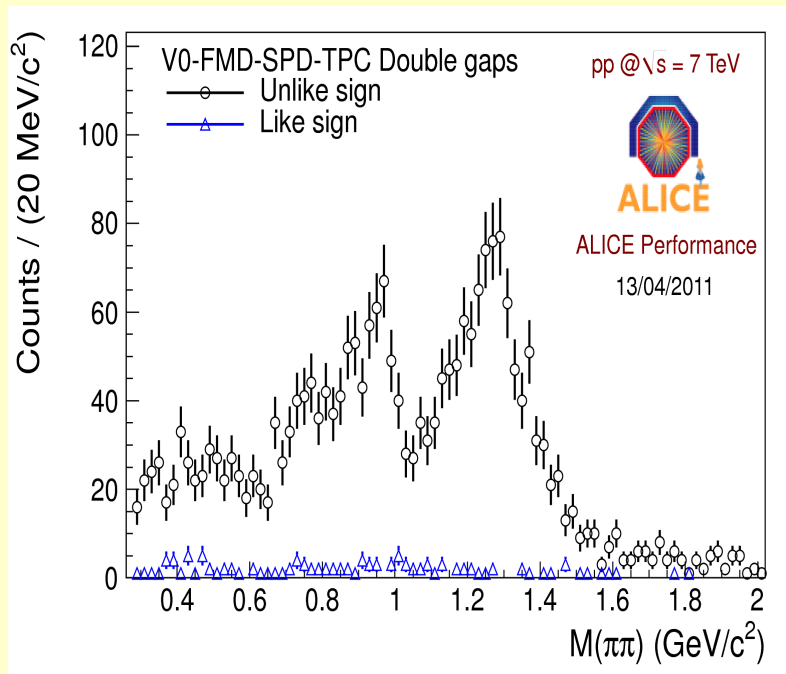
- Multiplicity distribution of gap and no gap events (good tracks)



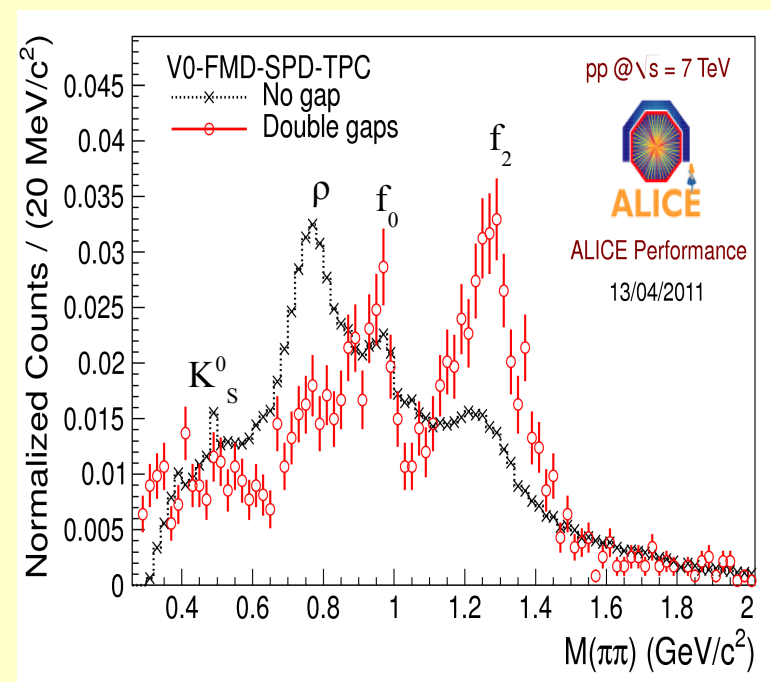
Invariant mass distribution



- Invariant mass distribution of pion pairs



distribution for double gap events
unlike and like-sign pairs

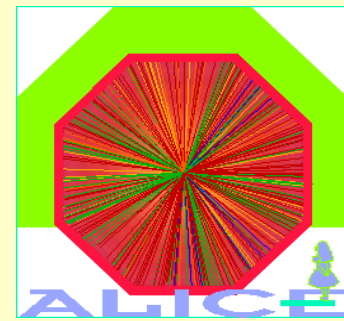


like-sign corrected distribution for
double and no-gap events

→ enhanced f_0, f_2 production in double gap events

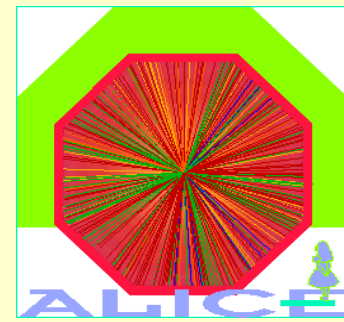
Diffraction data taking in PbPb-collisions

at $\sqrt{s}_{NN} = 2.74 \text{ TeV}$



- Heavy-ion collisions Pb-Pb at the LHC nov-dec 2010
- ALICE collected data on 12 M minimum bias collisions
- dedicated diffractive triggers running:
 - OM2 – TOF only trigger: (number of hits in TOF ≥ 2)
 - CCUP2 – TOF+SPD+V0 trigger: (TOF hits ≥ 2) AND (SPD hits ≥ 2) AND (V0A, V0C)
 - CMUP1 – Muon arm + V0 trigger: (at least one muon candidate) AND (V0A)
- OM2 running in early low luminosity runs, CMUP1 and CCUP2 in later parts, CCUP2 downscaled by factor 5-30

Electromagnetic/diffractive interactions in heavy ion collisions at high energies



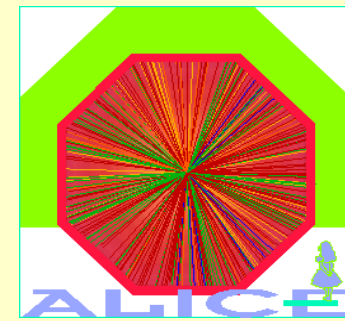
- Electromagnetic interactions in heavy ion reactions:
 - Photoabsorption with breakup of nucleus or excitation of dipole giant resonance followed by neutron emission → beam particle is lost
 - Photon-photon: Electromagnetic production of pseudoscalars π^0, η, η' and pairs of bosons ($\pi^+\pi^-, K^+K^-$) and fermions ($e^+e^-, \mu^+\mu^-, \tau^+\tau^-$)
 - Photon-hadron: diffractive photoproduction of vector mesons

Baur et al, *Coherent gamma-gamma and gamma-A interactions in very peripheral collisions at relativistic ion colliders*, Phys. Rep. **364**, 359 (2002)

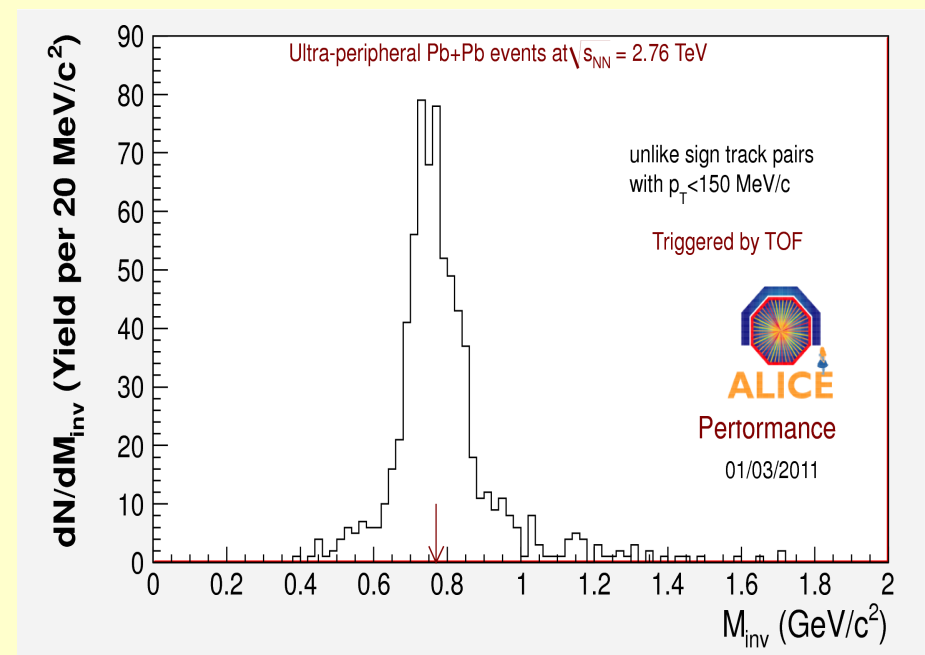
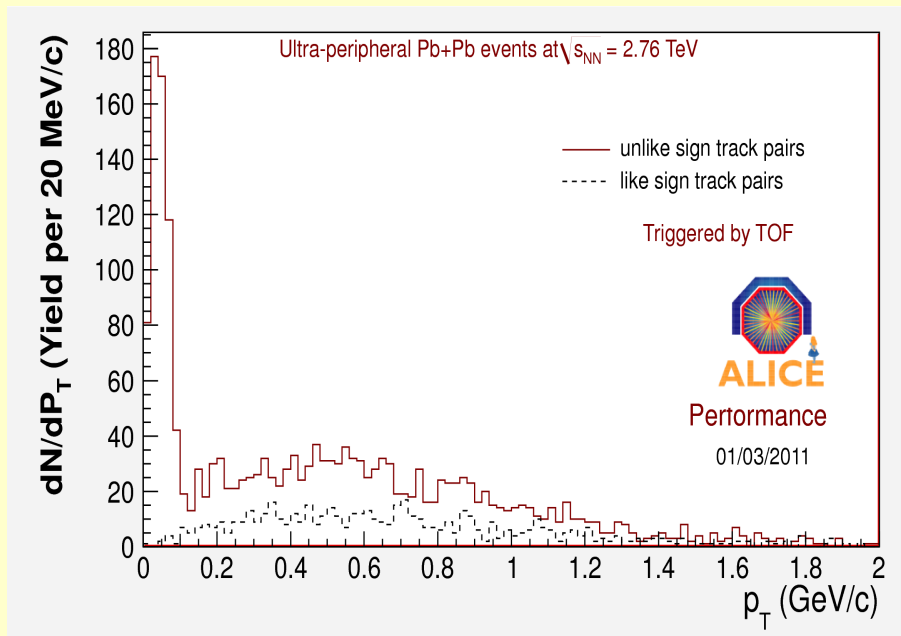
	AA→X nuclear	AA→AA PP→hadrons	AA→AA $\gamma\gamma$ →hadrons	AA→AA γ P→hadrons	
$\sigma(pp)$ @LHC	70 mb	0.52 mb	15 nb	2.8 μ b	$M_{\text{hadr}} > 1 \text{ GeV}$
$\sigma(PbPb)$ @LHC	7.8 b	0.84 mb	150 mb	11 mb	

PbPb: γ P→hadrons: Excl. photoprod. $\rho \rightarrow \pi^+\pi^-$, $\sigma = 3.9 \text{ b}$ (starlight MC), 7.1 b (Frankfurt et al)
 → *coherent production implies low transverse momentum $p_T < \sim 100 \text{ MeV}/c$*

Central Meson production in PbPb-collisions at $\sqrt{s_{NN}} = 2.74 \text{ TeV}$



- Events triggered by OM2 (TOF only) which contain two reconstructed tracks



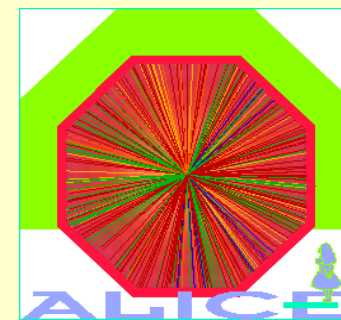
Pair p_T for unlike and like-sign pairs

→ *Coherent peak seen in unlike-sign pairs, not seen in like-sign pairs*

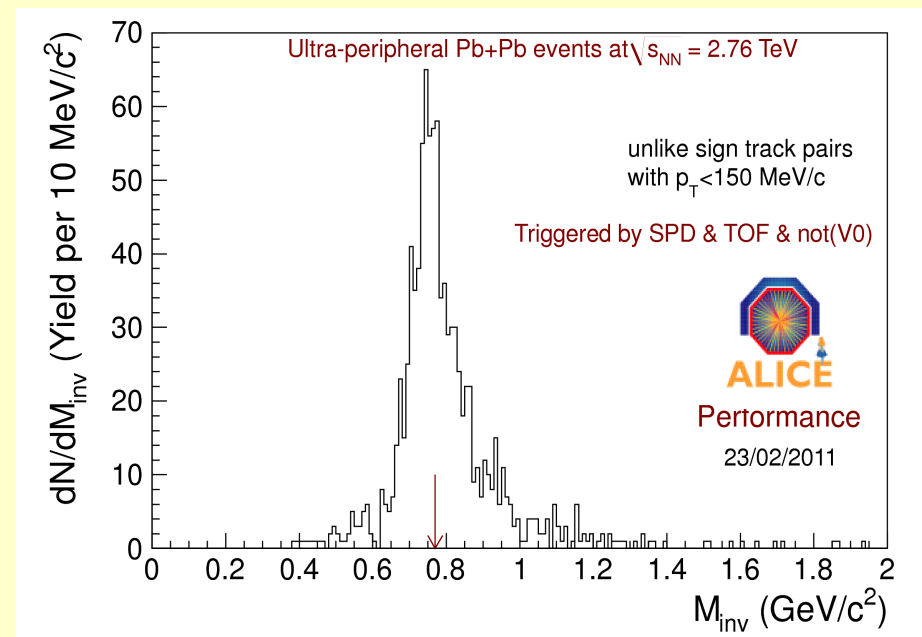
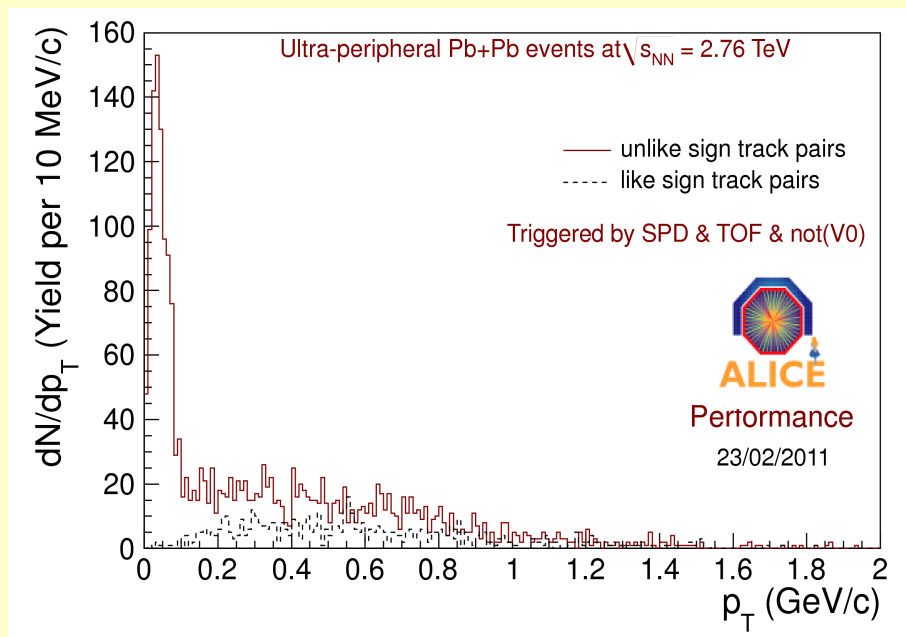
Uncorrected M_{inv} distribution of unlike-sign pairs with $p_T < 150 \text{ MeV/c}$

→ *Coherent ρ -production*

Central Meson production in PbPb-collisions at $\sqrt{s_{NN}} = 2.74 \text{ TeV}$



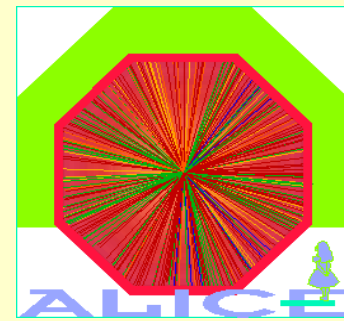
- Events triggered by CCUP2: (activity in central barrel) AND $(\overline{V0A}, \overline{V0C})$



Pair p_T for unlike and like-sign pairs
 → *Coherent peak seen in unlike-sign pairs, not seen in like-sign pairs*

Uncorrected M_{inv} distribution of unlike-sign pairs with $p_T < 150 \text{ MeV/c}$
 → *Coherent ρ -production*

Conclusions, outlook



- Double gap selects different diffractive channels in pp and PbPb collisions
- Pomeron-Pomeron in pp-collisions:
 - Double gap events show different multiplicity distribution
 - Two track invariant mass distribution of double gap events can be understood as continuum plus f_0 , f_2 resonance contribution
 - f_0 , f_2 enhancement in double gap events as compared to no-gap events
- Photon-Pomeron in PbPb-collisions:
 - Coherent ρ -photoproduction established as dominant reaction channel in double gap events of PbPb-collisions
 - ρ -photoproduction cross section to be determined
 - Search $J/\psi \rightarrow e^+e^-$, $\gamma\gamma \rightarrow e^+e^-$ in central barrel, $J/\psi \rightarrow \mu^+\mu^-$, $\gamma\gamma \rightarrow \mu^+\mu^-$ in muon arm
- Add Zero Degree Calorimeter info to study breakup/no breakup of beam particles