Influence of target on multiparticle production in the forward domain in p+Pb @ 17.3 GeV

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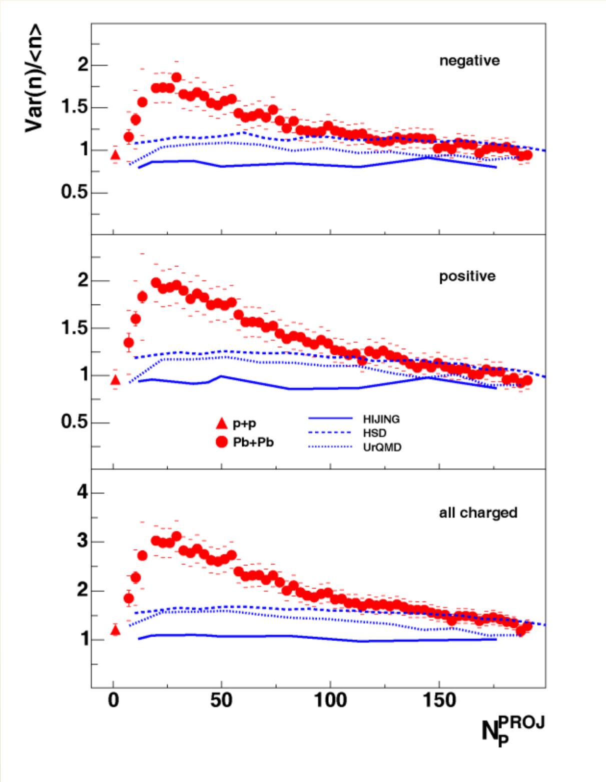
Motivation (1)

Multiplicity fluctuations in Pb+Pb collisions @ $\sqrt{s}$ = 17.3 GeV

NA49, PR C75, 064904

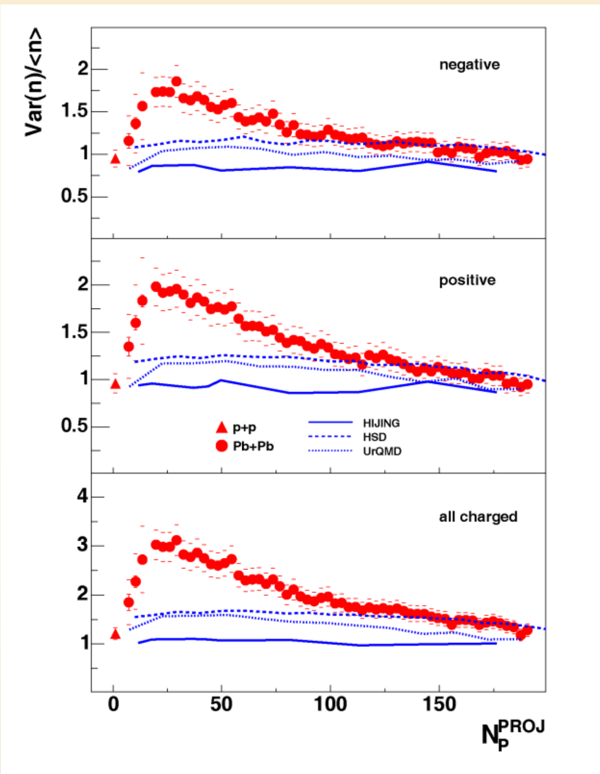


Large multiplicity fluctuations in forward hemisphere, 1.1<y<2.6

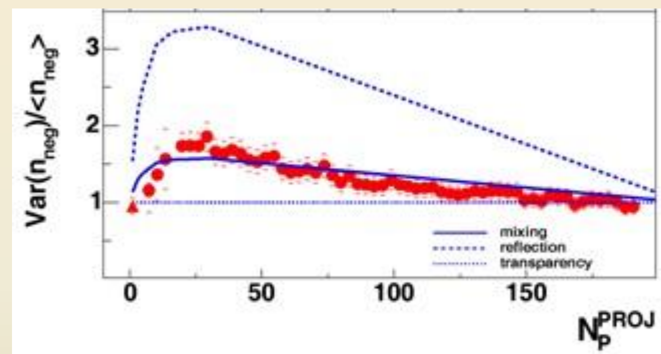
Motivation (1)

Multiplicity fluctuations in Pb+Pb collisions @ $\sqrt{s}$ = 17.3 GeV

NA49, PR C75, 064904



Possible explanation assumes strong influence of target participants on forward hemisphere

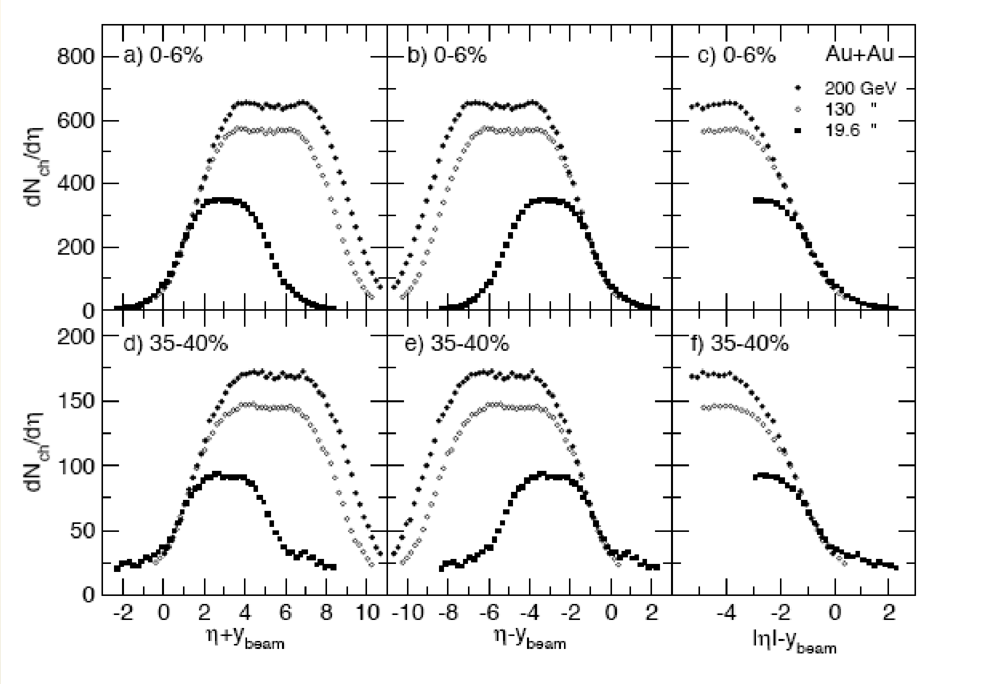


Phys. Lett. B640, 155

Large multiplicity fluctuations in forward hemisphere, 1.1<y<2.6

Motivation (2)

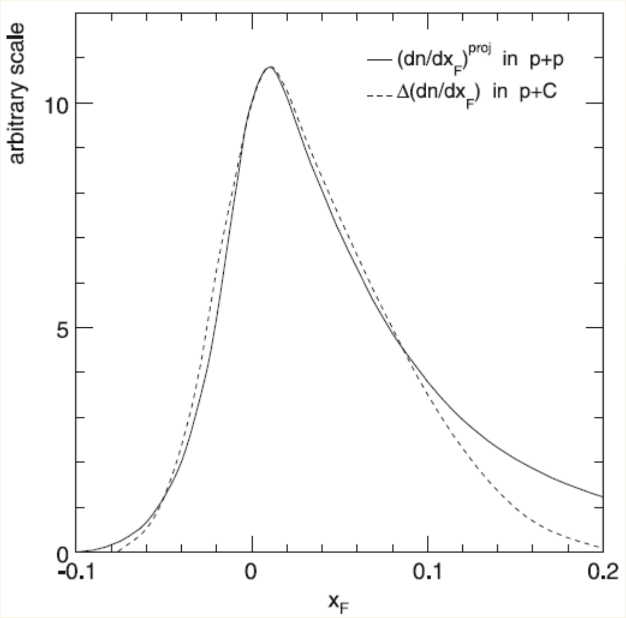
Limiting fragmentation hypothesis assumes **no influence** of target participants, but in very forward hemisphere, $y \approx y_{max}$



PHOBOS, PRL 91, 052303

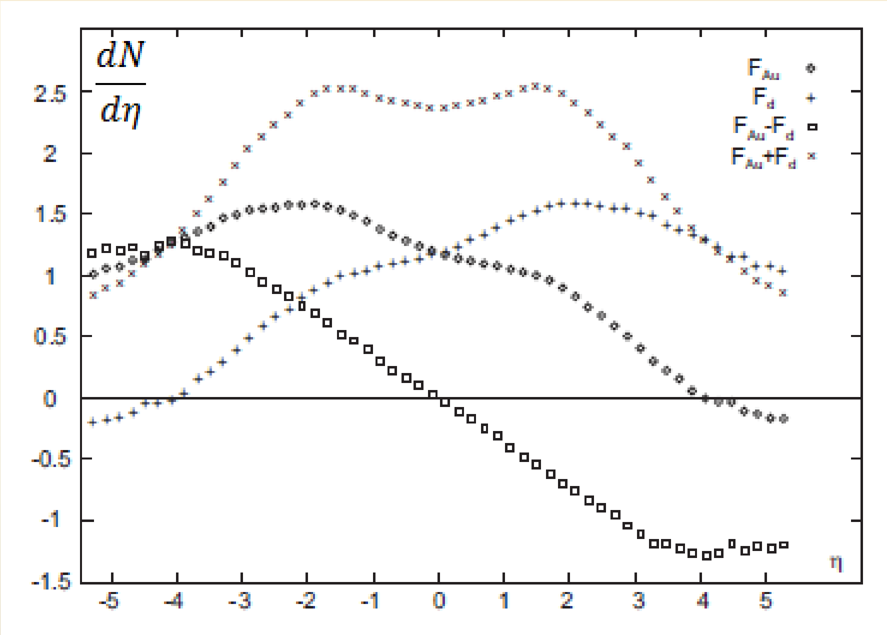
Motivation (3)

p+C interactions, √s = 17.3 GeV.



Eur. Phys. J. C49, 919

d+Au collisions, √s = 200 GeV.
Particle production
from a single wounded nucleon



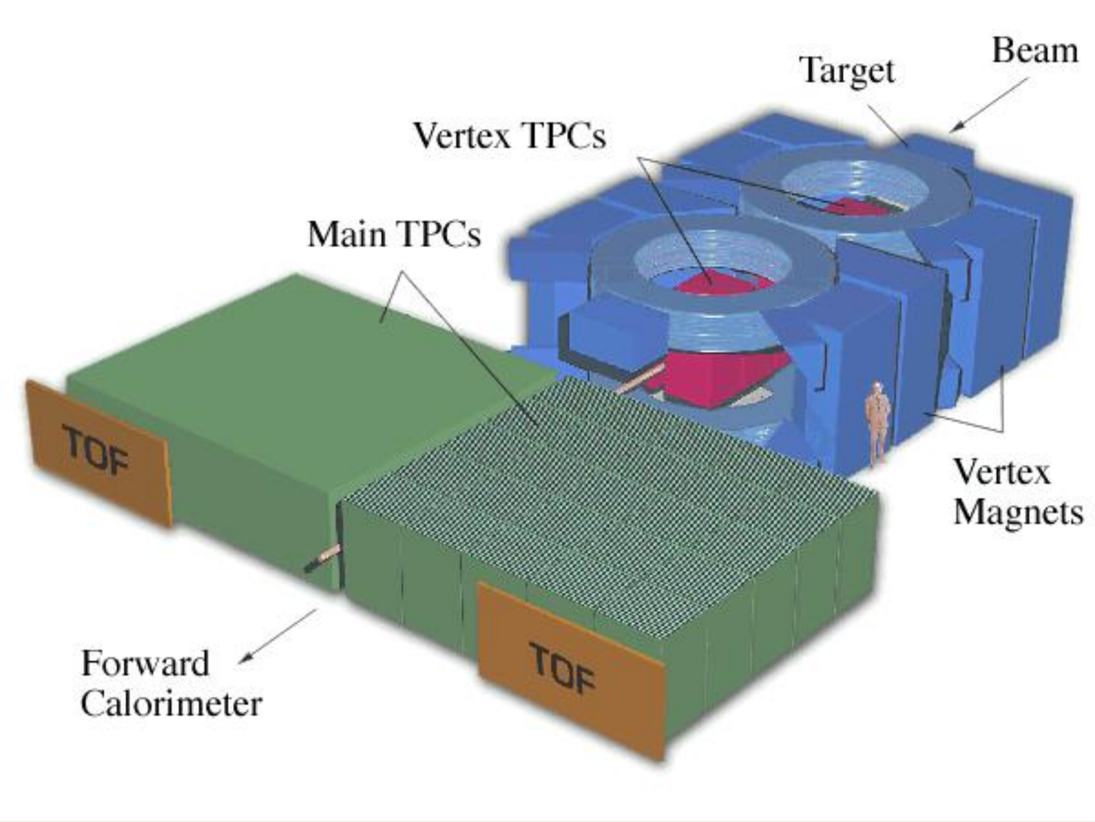
Acta Phys. Pol. B36, 905

Motivation (4)

We study **p+Pb minimum bias interactions**
to determine the influence of target participants
in forward nucleon-nucleon hemisphere.

Experiment

NA49 DETECTOR @ CERN SPS



Operating since 1994;
p+p, p+Pb, C+C, Si+Si and Pb+Pb interactions
at center of mass energy 6.3 – 17.3 GeV
for N+N pair

NIM A430, 210

Observables

$$\langle N \rangle = \sum N \cdot P(N)$$

$$\langle N^2 \rangle = \sum N^2 \cdot P(N)$$

$$Var(N) = \langle N^2 \rangle - \langle N \rangle^2$$

$$\frac{Var(N)}{\langle N \rangle} \equiv \omega$$ **- scaled variance**

For Poisson distribution:

$$P(N) = \frac{\langle N \rangle^N}{N!} \cdot e^{-\langle N \rangle}$$

$$\frac{Var(N)}{\langle N \rangle} = 1$$

Datasets used for analysis

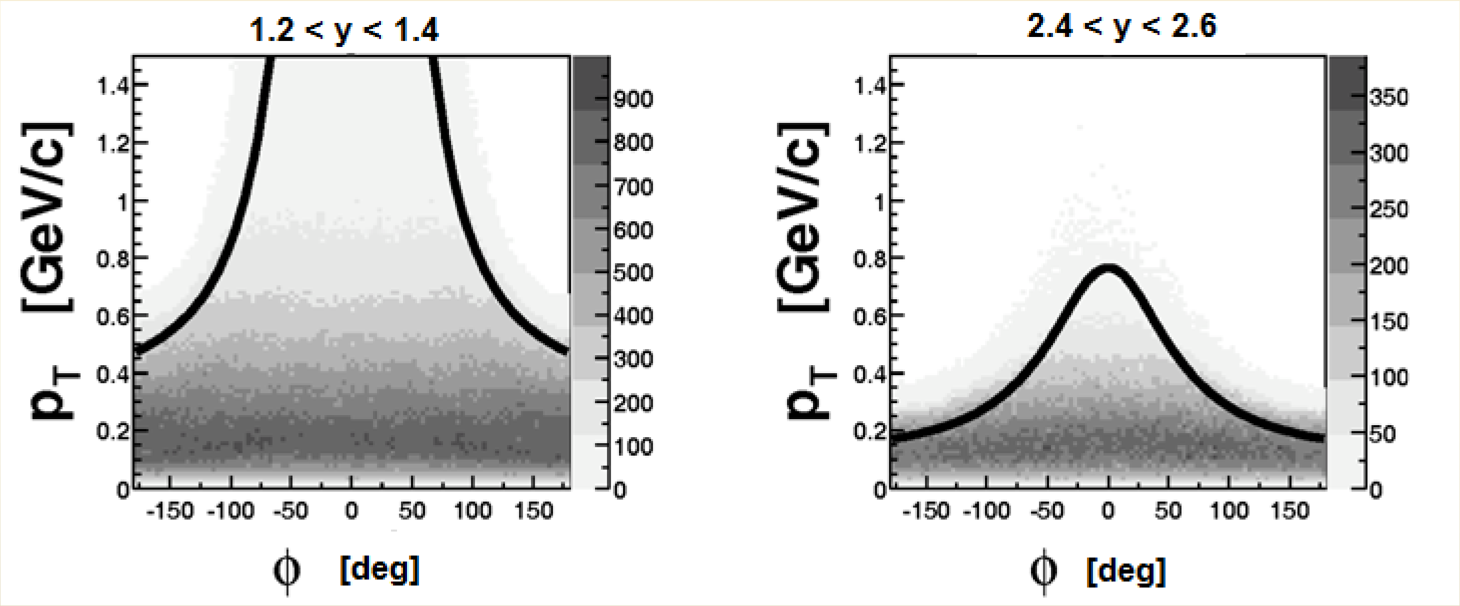
The multiplicity fluctuations are studied for negatively, positively, and all charged particles.

The following data sets were analysed:
p+Pb minimum bias and p+p interactions

	No. of events
p+p	320 000
p+Pb	125 000

NA49 acceptance

Negatively, positively and all charged particles in the rapidity interval $1.1 < y < 2.6$ (assuming pion mass), transverse momentum inverval $0.005 < p_T < 1.5$ GeV/c and points measured in at least one of the vertex TPCs (VTPC-1 or VTPC-2) are used for analysis.
This track selection minimizes systematic uncertainties
and is the same as in the case of previously analysed Pb+Pb collisions.



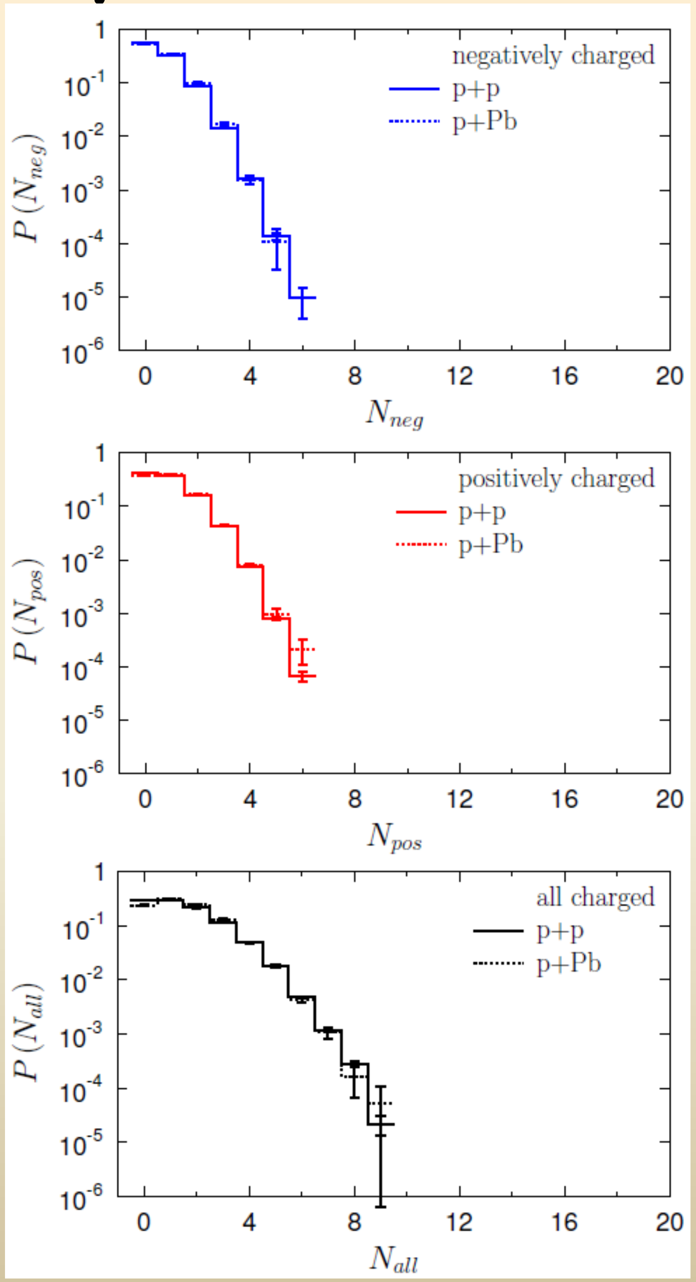
NA49 $\phi - p_T$ acceptance for standard configuration of magnetic field for two selected rapidity bins at √s = 17.3 GeV.

$\phi(p_T, y)$ given in PR C **70** 034902

Uncorrected multiplicity distributions

	p+p	p+Pb
ω_{neg}	0.956 ± 0.003	0.916 ± 0.012
ω_{pos}	0.949 ± 0.003	0.902 ± 0.011
ω_{all}	1.211 ± 0.004	1.074 ± 0.013

Statistical errors only



Definitions of results and corresponding corrections

1) presented data refer to:

- all production p+Pb reactions at 17.3 GeV,
- all inelastic (=production) p+p interactions at 17.3 GeV

2) presented results refer to hadrons produced in the above processes in strong and e-m interactions (corrected for e.g. electrons, weak decay products, secondary interactions, ...)

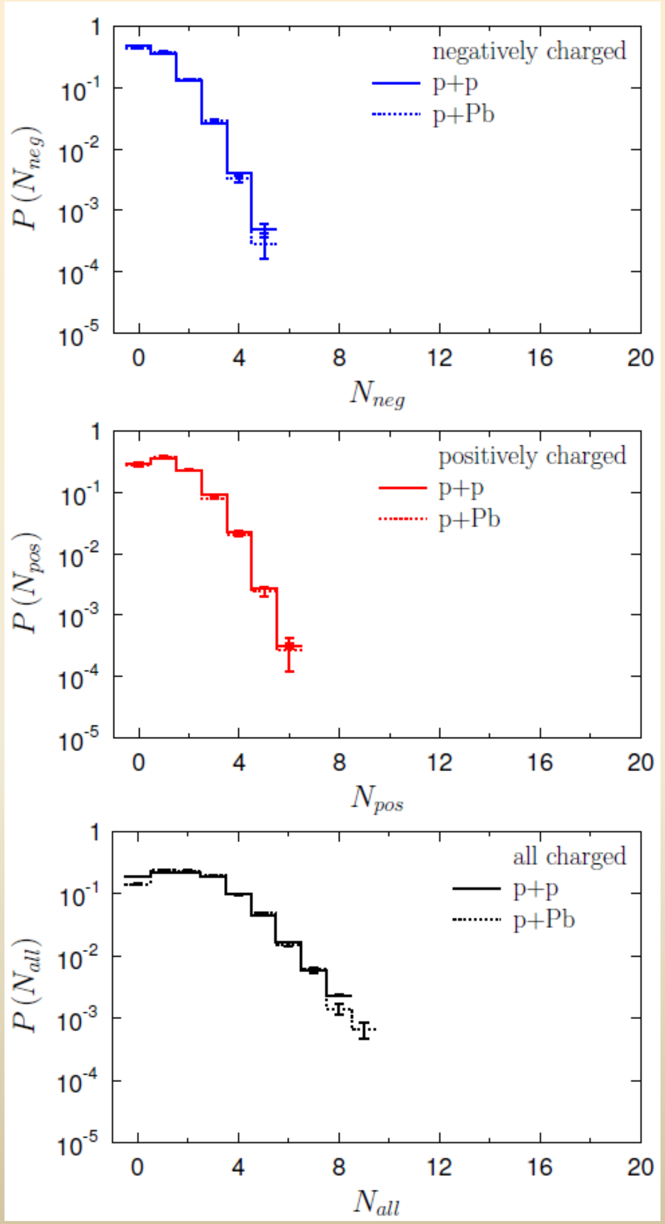
The corrections are based on results obtained using GEANT/detector simulated and reconstructed VENUS events using event and track cuts as for real data.

Based on the above simulation **the unfolding method** (provided by the ROOT TUnfold class) was used to obtain the corrected results.

Corrected multiplicity distributions (preliminary results)

	p+p	p+Pb
ω_{neg}	0.941 ± 0.003	0.89 ± 0.012
ω_{pos}	0.941 ± 0.003	0.865 ± 0.011
ω_{all}	1.232 ± 0.004	1.1 ± 0.013

Statistical errors only



Multiplicity fluctuations
are similar
for both analyzed systems

Multiplicity fluctuations in p+A – comparison with models

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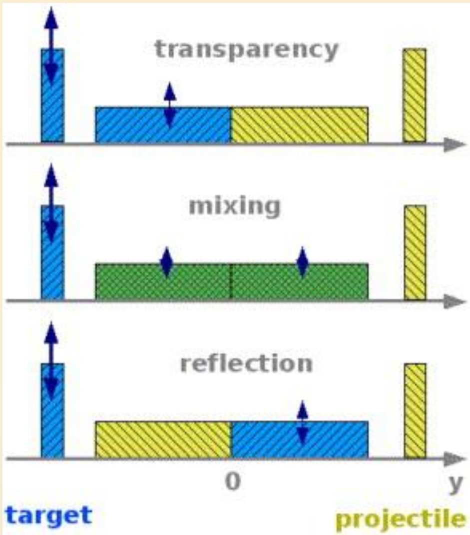

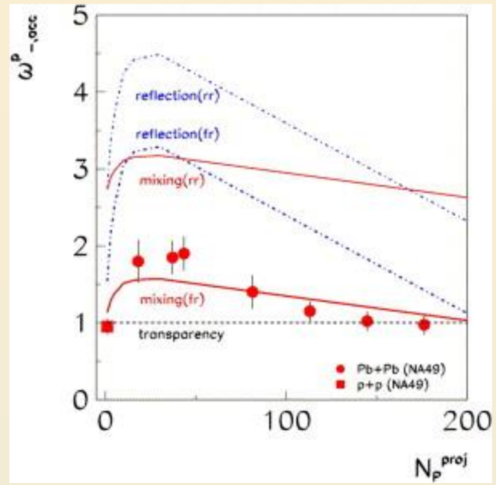

Multiplicity fluctuations in p+A – comparison with models

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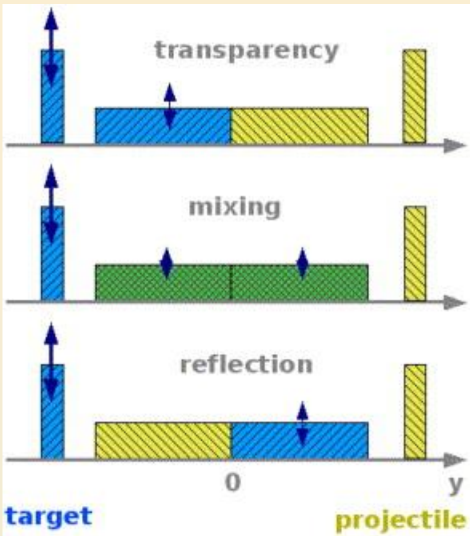
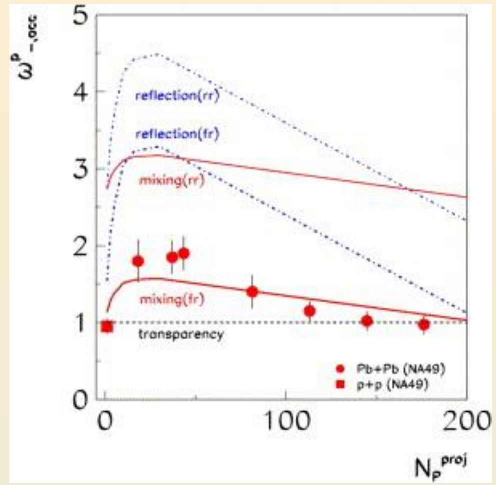
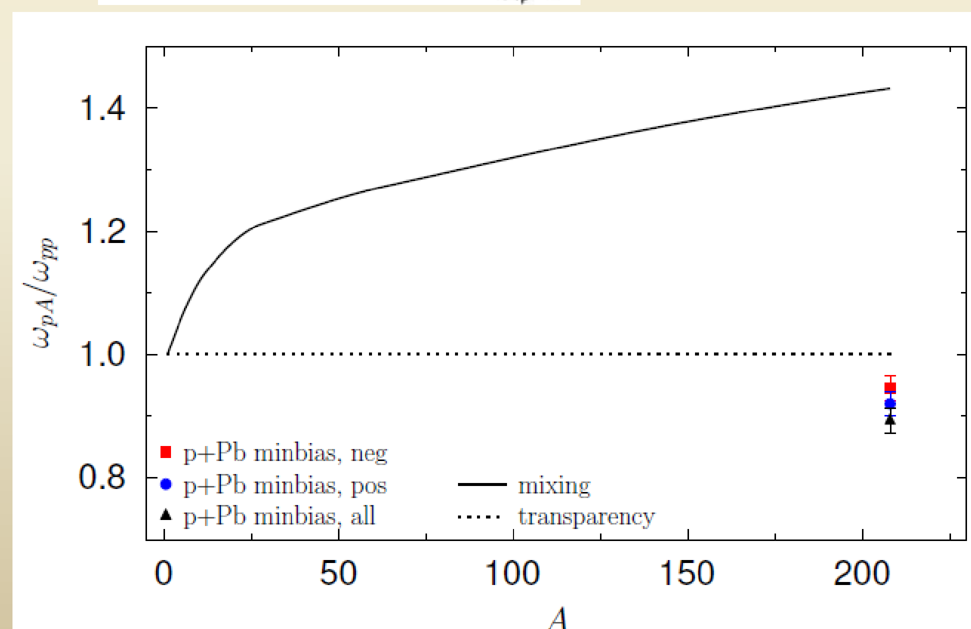






Summary

1. The influence of target participants on the forward hemisphere in p+Pb interactions was tested

2. Scaled variance of the multiplicity distribution was used as a measure of multiplicity fluctuations

3. The unfolding correction method was applied to obtain the corrected results

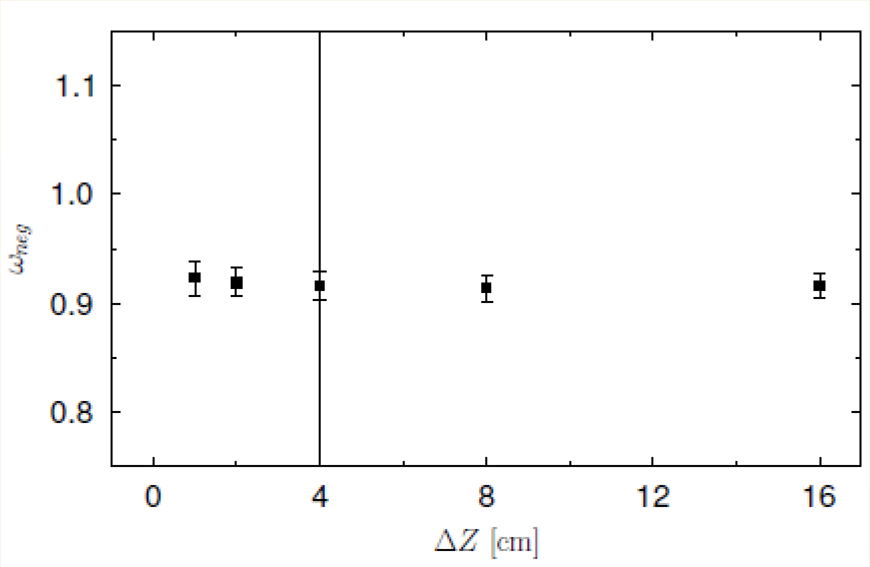
4. Multiplicity fluctuations measured in the forward hemisphere are similar for p+Pb and p+p interactions

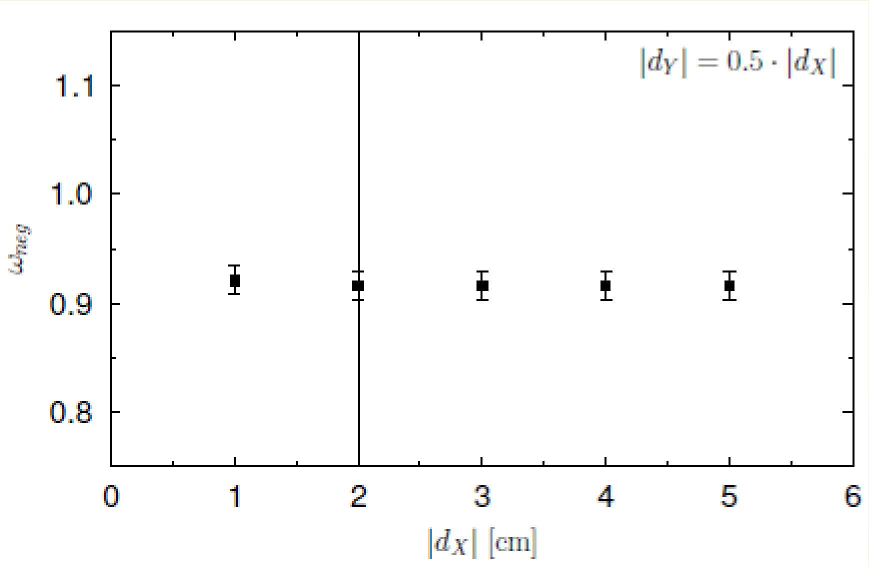
5. There is **no effect** of target participants fluctuations on multiplicity fluctuations measured in the forward hemisphere

Back-up slides

Stability of the uncorrected multiplicity distributions with respect to the analysis cuts

Checks for p+Pb minimum bias

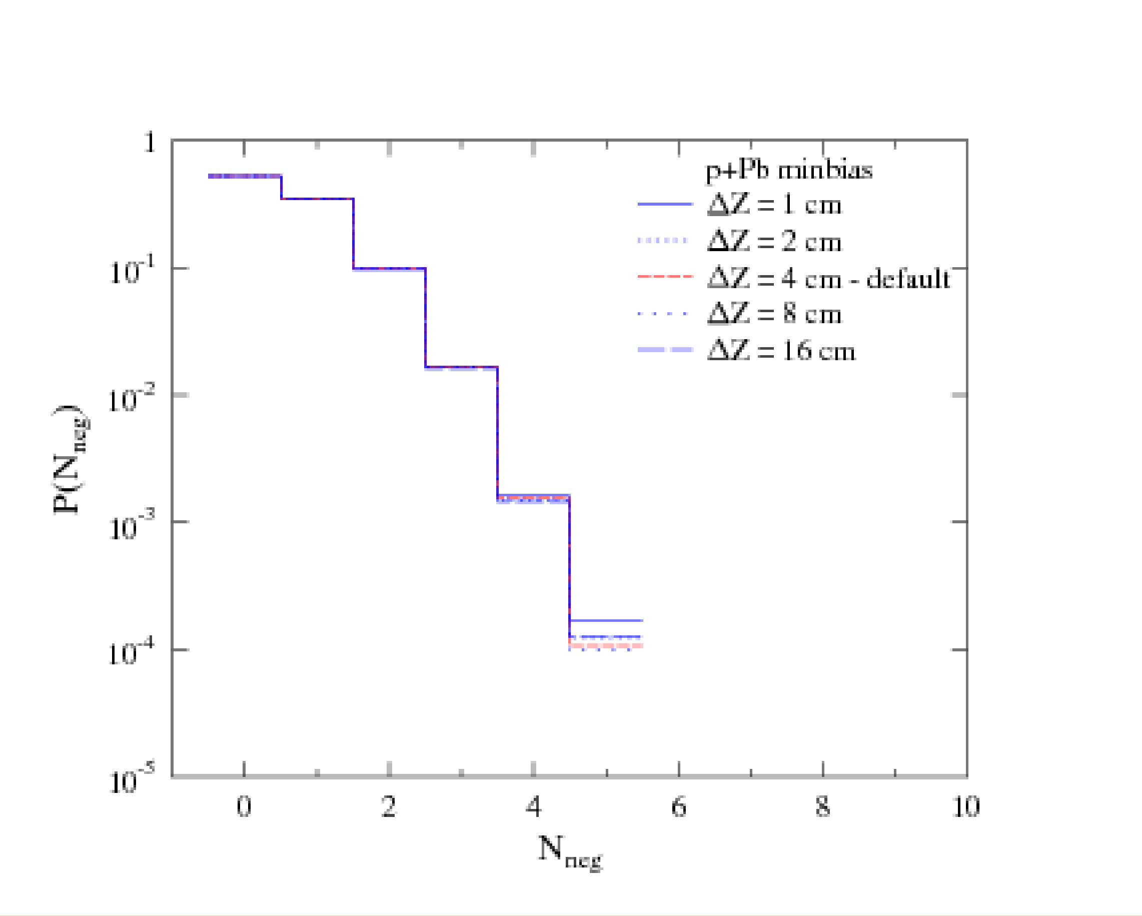




The vertical lines indicate the cuts used to obtain the results

Stability of the uncorrected multiplicity distributions with respect to the analysis cuts

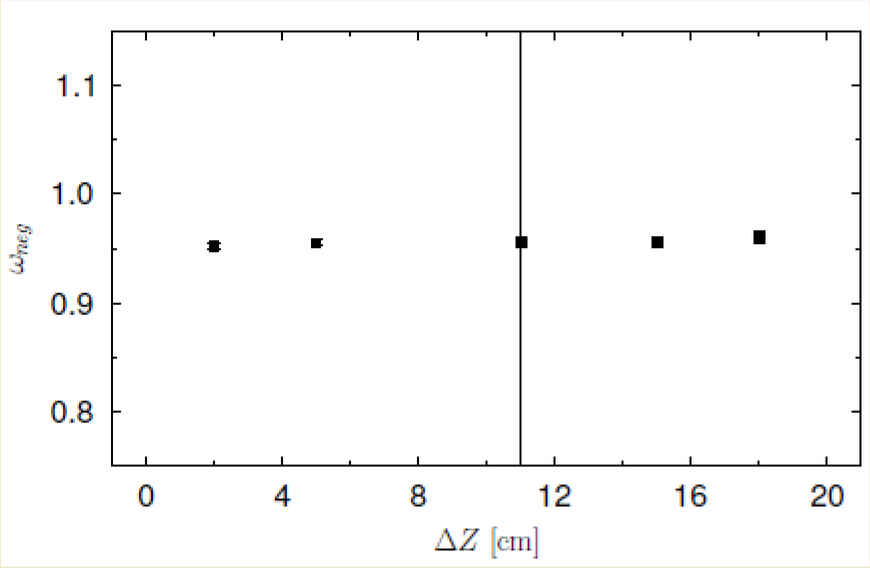
p+Pb minbias, P(N) for different ΔZ

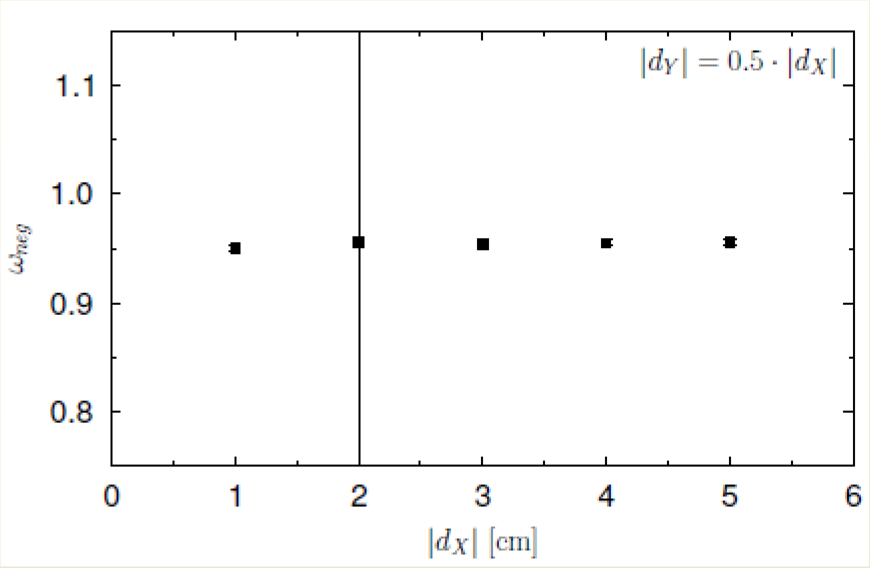


ΔZ [cm]	$\langle N_{neg} \rangle$	ω_{neg}
1	0.604±0.007	0.923±0.016
2	0.607±0.006	0.919±0.013
4	0.611±0.005	0.916±0.012
8	0.611±0.005	0.914±0.012
16	0.61±0.005	0.916±0.011

Stability of the uncorrected multiplicity distributions with respect to the analysis cuts

Checks for p+p interactions





The vertical lines indicate the cuts used to obtain the results

Corrections for multiplicity distributions

The corrections are be based on VENUS simulation:

1) The distributions of all measured quantities was be calculated for „pure" VENUS and „accepted" VENUS events, both with acceptance filter turned on. „Pure" VENUS results was calculated from pure VENUS data according to event and particle definitions. „Accepted" VENUS results are obtained using GEANT/detector simulated and reconstructed VENUS events using event and track cuts as for real data.

   Use of VENUS 4.12 included in NA49 reconstruction chain:
   - decays of π^0, K^0_S , Λ^0, Σ etc off

   For analysis:
   - only primary vertex particles
   - use of all particles with Geant PID > 7
     - ✓for h^- : π^-, K^-, $\bar{p}$, Σ^-, Ξ^-, Ω^-
     - ✓for h^+ : π^+, K^+, p, Σ^+
   - assuming pion mass for rapidity calculation

2) Based on the above simulation **the unfolding method** (realized by the ROOT TUnfold class) was be used to obtain the corrected results.

Event and track selection criteria

Event Cuts:

Vertex Iflag ≥10*
$Chi^2 > 0$
X-Vertex [cm]: (-0.2,0.15)
Y-Vertex [cm]: (-0.1,0.1)
Z-Vertex [cm]: (-583,-579)

Track Cuts:

bx [cm]: (-2,2)
by [cm]: (-1,1)
NMaxPoint > 25
NPoint/NMaxPoint > 0.5

y: (4,5.5)
p_T [GeV/c]: (0.005,1.5)

***"The fitted vertex position is written to the vertex_fit structure. The fit is ok, if iflag is ≥ 10"**

Losses of inelastic/production events due to produced particles hitting S4

The fraction of lost events:

$$\frac{582}{5515} = 10.5\%$$

For the p+p: **14.4%** (Eur.Phys.J.C45:343-381,2006)

For the p+C: **9%±2%** (Eur.Phys.J.C49:897-917,2007)

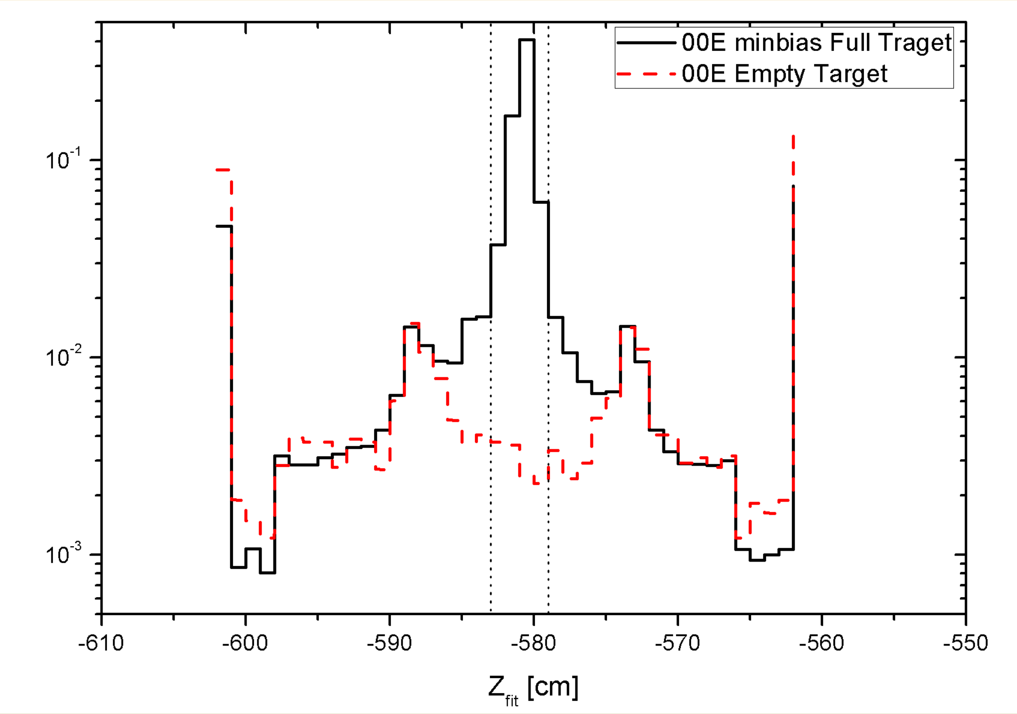
The unfolding correction method of multiplicity distributions in p+Pb

A detailed description of unfolding with ROOT
was made by Silvestro di Luise
at NA61 Collaboration Meeting, June 2011
https://indico.cern.ch/getFile.py/access?contribId=31&resId=0&materialId=slides&confId=141410

The following slides are based on the example
from description of the ROOT TUnfold class
http://root.cern.ch/root/html/TUnfold.html
(applied for negative hadrons produced in p+Pb minimum bias collision

Contribution of non-target interactions

p+Pb:
~20 000 Empty Target events available



p+Pb: $$\frac{N_{Empty}}{N_{Full}} = 0.018$$

GEANT PID's

Particle Name	GEANT PID Number
gamma	1
positron	2
electron	3
neutrino	4
mu+	5
mu-	6
pi0	7
pi+	8
pi-	9
K0 long	10
K+	11
K-	12
neutron	13
proton	14
antiproton	15
K0 short	16
eta	17
lambda	18

Particle Name	GEANT PID Number
sigma+	19
sigma0	20
sigma-	21
xi0	22
xi-	23
omega	24
antineutron	25
antilambda	26
antisigma-	27
antisigma0	28
antisigma+	29
antixi0	30
antixi+	31
antiomega+	32
tau+	33
tau-	34
D+	35
D-	36
D0	37

Particle Name	GEANT PID Number
anti D0	38
f+	39
f-	40
lambda c +	41
W+	42
W-	43
Z0	44
deuteron	45
tritium	46
alpha	47
genatino	48