The Zero Degree Calorimeters for the ALICE experiment

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Introduction

Main goal of the ALICE experiment is the study of the formation of the Quark Gluon Plasma (QGP) that is expected to occur at high temperature values reached in central nucleus-nucleus collisions. In ALICE the centrality is provided by Zero Degree Calorimeters (ZDC) that detect the energy carried at 0° by the non interacting nucleons ("spectators"). The ZDC will also be used in proton-nucleus and proton-proton collisions. The physics performances of the detector in the three cases will be reported.

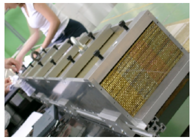
Detector Description

Two identical sets of Zero Degree Calorimeters, one on each side (A and C) of the interaction point (IP), will detect spectator protons and neutrons.

Each set consists of:

- 2 hadronic spaghetti calorimeters:
  - 1 for neutrons (ZN) and 1 for protons (ZP), placed at 0° with respect to LHC axis, at ~114 m from IP.
- A forward electromagnetic calorimeter (ZEM) placed at ~7m from IP, only on one side, covering the rapidity range $4.8<\eta<5.7$.

Neutron calorimeter ($7.2 \times 7.2 \times 100$ cm^3) $|\eta|>8.7$



Proton calorimeter ($22.4 \times 12 \times 150$ cm^3)

Principle of operation

Sampling calorimeters based on the detection of Cherenkov light produced by the shower particles in silica optical fibres embedded in an absorber matrix.

- High resistance to radiation
- Fast response
- Reduced transverse size of detectable shower
- Extremely compact devices

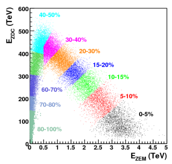
Physics Performances

A – A Collisions

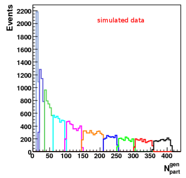
In A-A collisions the ZDC will measure the centrality of the collisions through the correlation between the reconstructed values of the energy in the hadronic calorimeters and the energy in the electromagnetic calorimeter.

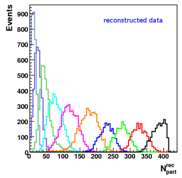
Centrality measurement: E_{ZDC} → N spectators → N partecipants → Impact Parameter b

Correlation between energy in ZDC e ZEM



Results of simulations:
- 10 centrality classes can be defined
- $N_{partecipants}$ simulated and reconstructed values in good agreement
- Resolution on $N_{partecipants}$ ≤ 20 partecipants and weakly centrality dependent



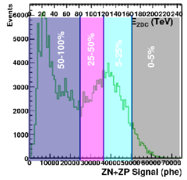


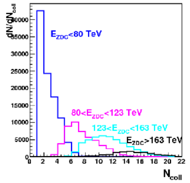
% σ_{tot}	$<N_{part}>_{SIM}$	$<N_{part}>_{REC}$ (RMS)
0 ÷ 5	386	384 (14)
5 ÷ 10	329	328 (15)
10 ÷ 15	276	275 (15)
15 ÷ 20	231	229 (17)
20 ÷ 30	177	174 (19)
30 ÷ 40	120	119 (21)
40 ÷ 50	77	77 (18)
50 ÷ 60	46	48 (12)
60 ÷ 70	25	24 (10)
70 ÷ 80	13	12 (8)

p-A Collisions

Centrality in p-A collisions is defined through the number of nucleon-nucleon collisions. It will be measured by detecting the so-called "slow nucleons" emitted by the excited nucleus: the number of slow nucleons emitted is proportional to the number of N-N collisions.

Results of simulations:
- Select 4 centrality bins by cutting the energy spectrum in classes. Each class corresponds to a determined fraction of the total p-A cross section
- Events from each centrality class correspond to a $N_{collisions}$ distribution
- Adjacent classes are well separated





% σ_{inel}	E_{ZDC} (TeV)	$<N_{coll}>$ (RMS)
0 ÷ 5	>163	14.2 (2.9)
5 ÷ 25	123 ÷ 163	10.8 (2.8)
25 ÷ 50	80 ÷ 123	7.2 (2.4)
50 ÷ 100	0 ÷ 80	2.1 (1.3)

p-p Collisions

In p-p collisions, thanks to its pseudorapidity acceptance and combining the information obtained from all the hadronic and the electromagnetic calorimeters, it will tag different types of diffractive events (SD, DD, ND).

Efficiency results from simulations at 7+7 TeV

Different trigger topologies are taken into account

Trigger topology	Non-Diffr	Single-Diffr (AB->XB)	Single-Diffr (AB->AX)	Double Diffr	MB
Hits on ZNA only	58,8%	68,8%	2,4%	74,0%	56,3%
Hit s on ZPA only	19,9%	30,0%	3,6%	30,5%	20,6%
ZNAorZPA	68,9%	81,7%	4,6%	84,1%	66,0%
ZNAorZPAorZNCorZPC	88,0%	82,4%	85,5%	97,7%	88,4%
ZNAorZPAorZNCorZPC orZEM	98,6%	90,6%	88,5%	98,5%	96,9%

Contacts

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Conclusions

- **A-A** → Main purpose of the ALICE ZDC is to provide a centrality measurement in A-A collision with a resolution ≤20 $N_{partecipants}$ over the whole range if 10 centrality classes are defined.
- **p-A** → In p-A collisions the ALICE ZDC can estimate centrality by detecting the emitted slow nucleons. It is possible to define 4 centrality bins.
- **p-p** → In p-p collisions the ALICE ZDC can help to select diffractive events.