Determination of the cross section with the vdM method in pp collisions at 5 and 13 TeV at the ALICE LHC experiment

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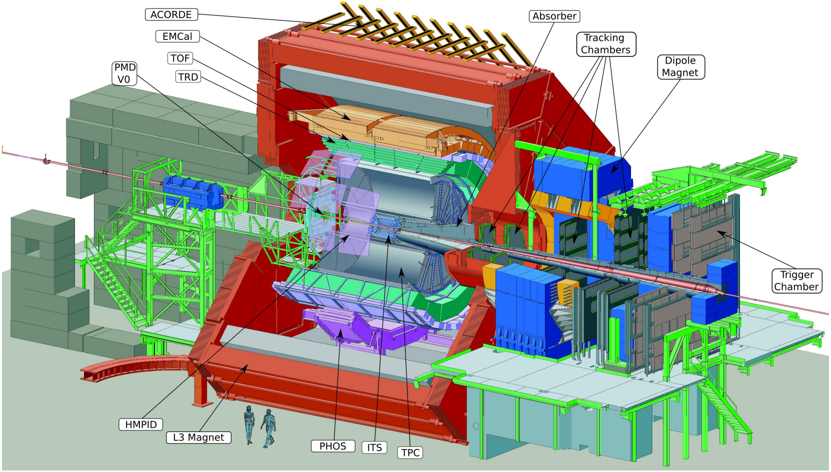
ALICE experiment



V0 detector

It is composed of two arrays, V0A and V0C, which cover the pseudorapidity ranges ($2.8 \leq \eta \leq 5.1$) y ($-3.7 \leq \eta \leq -1.7$) for collisions at the nominal vertex (z=0). Each of the V0 arrays is segmented in four rings in the radial direction, and each ring is divided in eight sections in the azimuthal direction (figure 1).

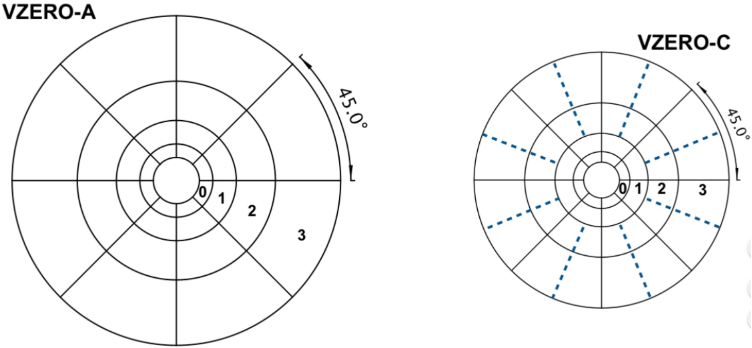


Figura: Segmentation of the V0A/V0C arrays.

T0 detector

The T0 detector consists of 2 arrays of PMTs equipped with Cherenkov radiators. The arrays are on the opposite sides of the Interaction Point (IP). The main task of T0 is to supply fast timing signals which will be used in the L0 trigger for ALICE, to provide a wake-up call for TRD and to deliver collision time reference for Time-of-Flight (TOF) detector.

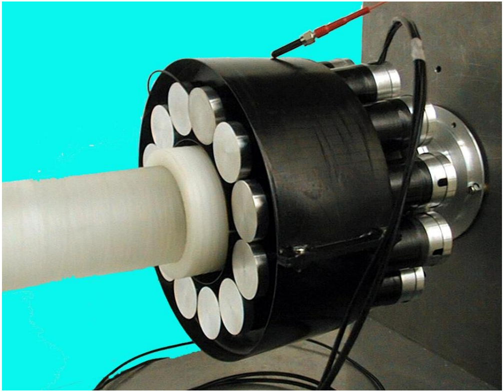


Figura: Photography of the prototype of T0-C.

van der Meer scan method

The method of van der Meer (vdM) scans [11] is used to measure the visible cross section for a given set of sub-detectors, such that this cross section can be used later on to measure the luminosity. The cross section is obtained by measuring the rates in the set of sub-detectors as the beams are brought to collide at different separations of their centres.

The procedure to perform a standard vdM scan in ALICE consists of the following steps

1. The beams are kept centered in the vertical (y) direction, while they are moved in steps in the horizontal (x) direction.
2. The beams are kept centered in the horizontal direction, while they are moved in steps in the vertical direction.

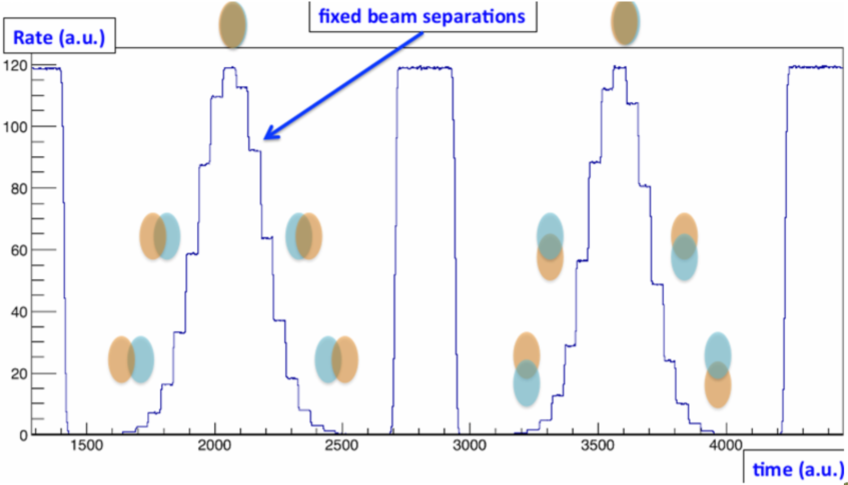
In the next slides go to estimate the visible cross section in proton-proton collisions at 5 TeV and 13 TeV with the T0 and V0 detectors.

Van der Meer Scan 2015 en ALICE

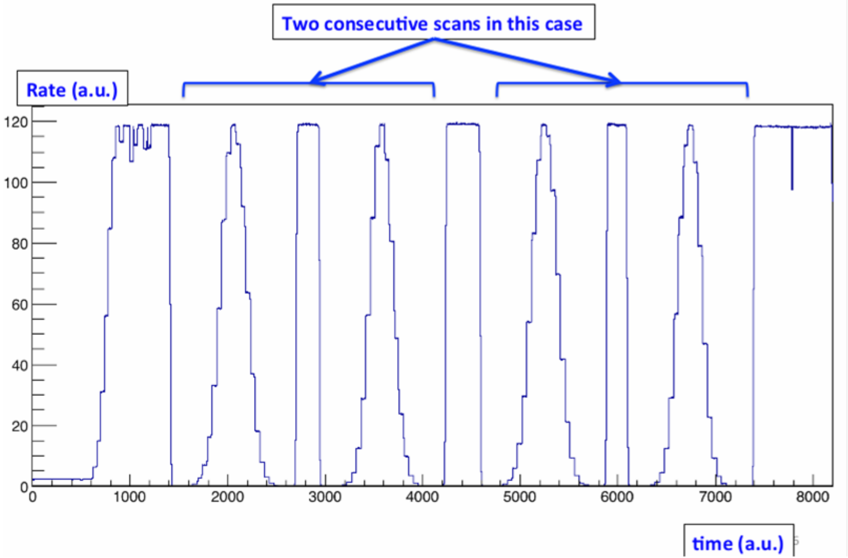
During the year 2015, three van der Meer scan was performed:

- Proton-proton at $\sqrt{s}$=13 TeV, was performed on August (LHC fill 4269)
- Proton-proton at $\sqrt{s}$=5 TeV, was performed on November (LHC fill 4634)
- lead-lead at $\sqrt{s_{NN}}$=5.02 TeV, was performed on December (LHC fill 4634)

picture of vdM scan



vdM: Taking the scans



- To the events: Pile up
- To the separations: Orbit drift correction, beam beam deflection,
- Intensity decay correction
- Large Scale Calibration
- Non factorization

vdM scan in formules

Under the assumption that the shapes in the transverse direction are independent, the vdM cross section for a given detector set is obtained with the following formula:

$$\sigma_{vdM} = \frac{R}{L}$$

$$\sigma_{vdM} = F \frac{R_{(0,0)} h_x h_y}{f_{LHC} N_1 N_2}$$

where F is a factor to get the desired units (e.g. 10^{25} to go from mm^2 to mb), the frequency of the LHC is given by $f_{LHC} = 11245.558$ Hz, the rate at zero separation is computed here from the average of the rates at zero separation from the first and second steps of the vdM scan:

$$R_{(0,0)} = \frac{R^x_{(0,0)} + R^y_{(0,0)}}{2}$$

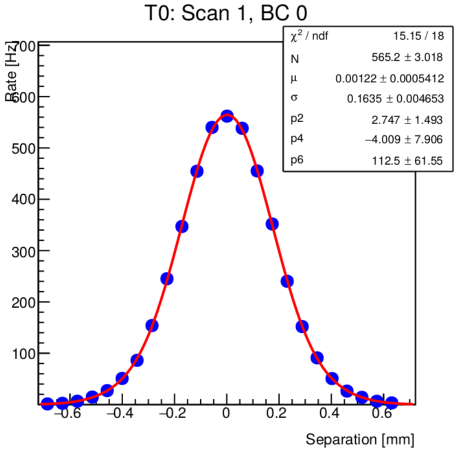
and the effective beam widths are

$$h_{x(y)} = \frac{S_{x(y)}}{R^{x(y)}_{(0,0)}}$$

with $S_{x(y)}$ the area under the rate vs beam-separation curve.

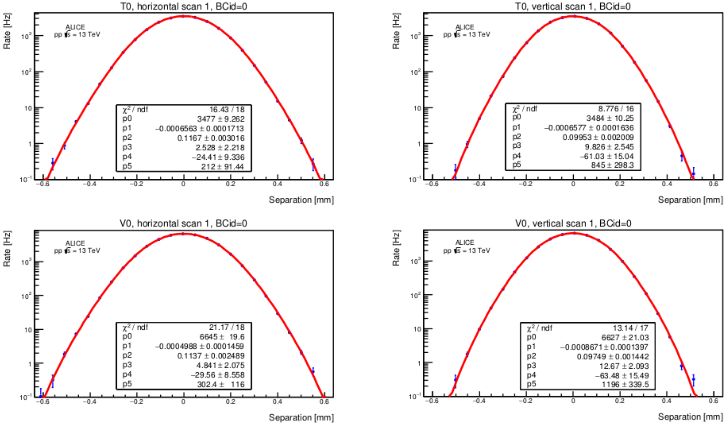
Areas and shapes

- We have two fit method: Gauss*6th-Polynomial (GP6) and Double-Gaussian (DG).
- We compute the cross section using a numerical method



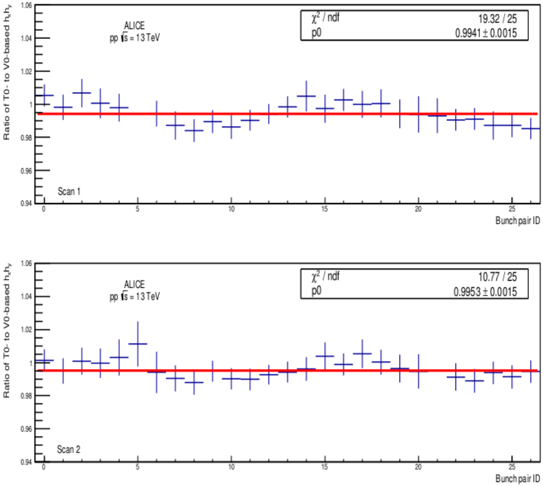
Rates of the T0 and V0 reference process

Rates of the T0 (top) and V0 (bottom) reference process as a function of beam separation for one typical pair of colliding bunches in the first horizontal (left) and vertical (right) vdM scan.

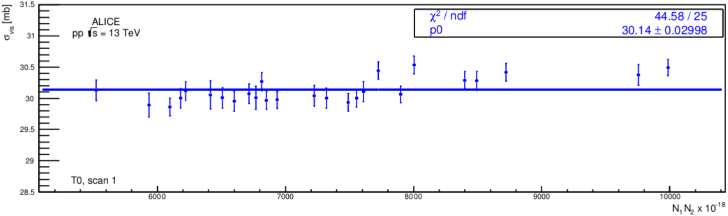


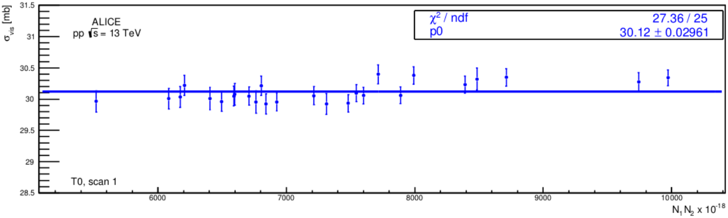
Fit method GP6: hxhy/BC for T0 and V0

Ratio between the h x h y quantities obtained with the T0 and V0 reference processes in two vdM scans, as a function of the colliding bunch pair ID number. The solid red lines are zero-order-polynomial fits to the data.

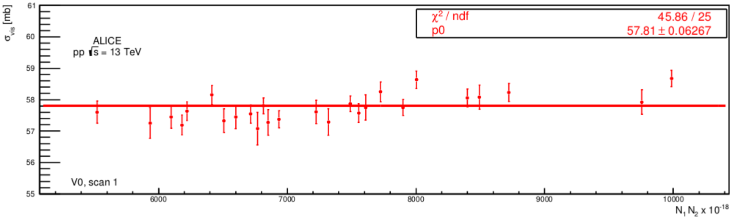


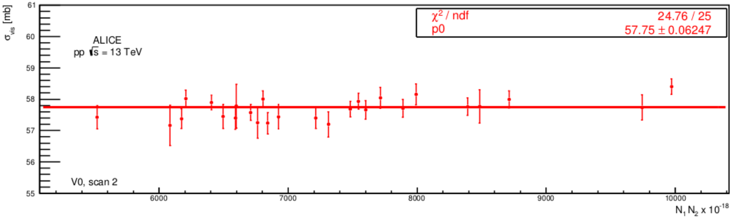
Fit method GP6: Cross Section per N1N2 for T0





Fit method GP6: Cross Section per N1N2 for V0





Systematic uncertainties for pp at 13 TeV

Source	Uncertainty
Non-factorisation	0.9%
Orbit drift	0.8%
Beam-beam deflection	0.8%
Dynamic β^*	0.3%
Background subtraction	0.1% (T0), 0.7% (V0)
Pileup	0.7%
Length-scale calibration	0.5%
Fit model	0.6%
$h_x h_y$ consistency (T0 vs V0)	0.6%
Luminosity decay	0.4%
Bunch-by-bunch consistency	$< 0.1\%$
Scan-to-scan consistency	$< 0.1\%$
Beam centering	$< 0.1\%$
Bunch intensity	0.6%
Total on visible cross section	2.05% (T0), 2.16% (V0)
Stability and consistency	0.6% (isolated bunches) 2.7% (whole 2015)
Total on luminosity	2.2% (isolated bunches) 3.4% (whole 2015)

Systematic uncertainties for pp at 5 TeV

Source	Uncertainty
Non-factorisation	1%
Orbit drift	$< 0.1\%$
Beam-beam deflection	0.4%
Dynamic β^*	0.2%
Background subtraction	0.3% (T0), 1.1% (V0)
Pileup	0.7%
Length-scale calibration	1%
Fit model	0.7%
$h_x h_y$ consistency (T0 vs V0)	0.2%
Luminosity decay	0.7%
Bunch-by-bunch consistency	$< 0.1\%$
Scan-to-scan consistency	0.5%
Beam centreing	0.1%
Bunch intensity	0.4%
Total on visible cross section	2.05% (T0), 2.31% (V0)
Stability and consistency	0.4%
Total on luminosity	2.09% (T0), 2.34% (V0)

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