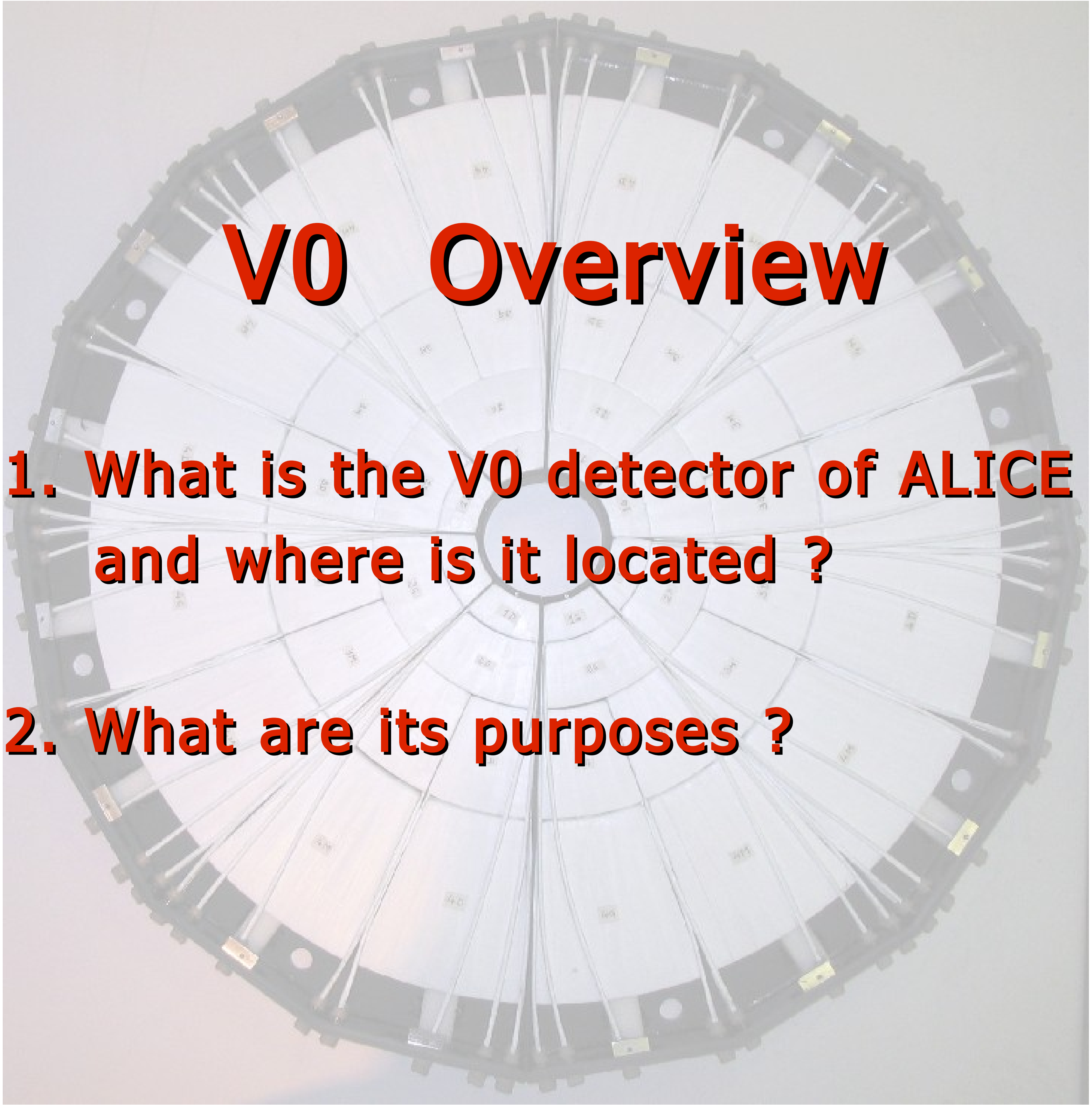
V0 Overview



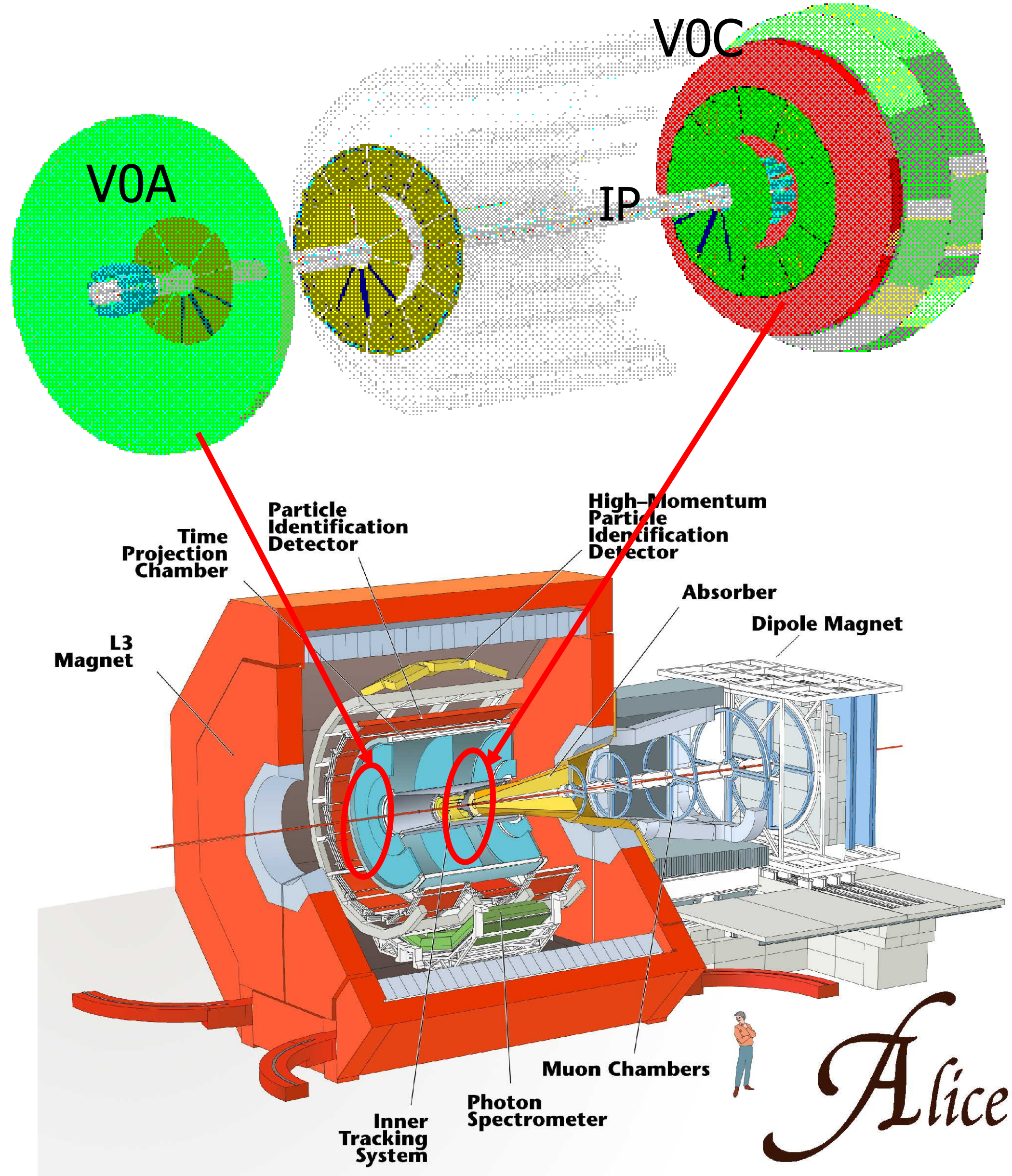
1. What is the V0 detector of ALICE and where is it located ?

2. What are its purposes ?

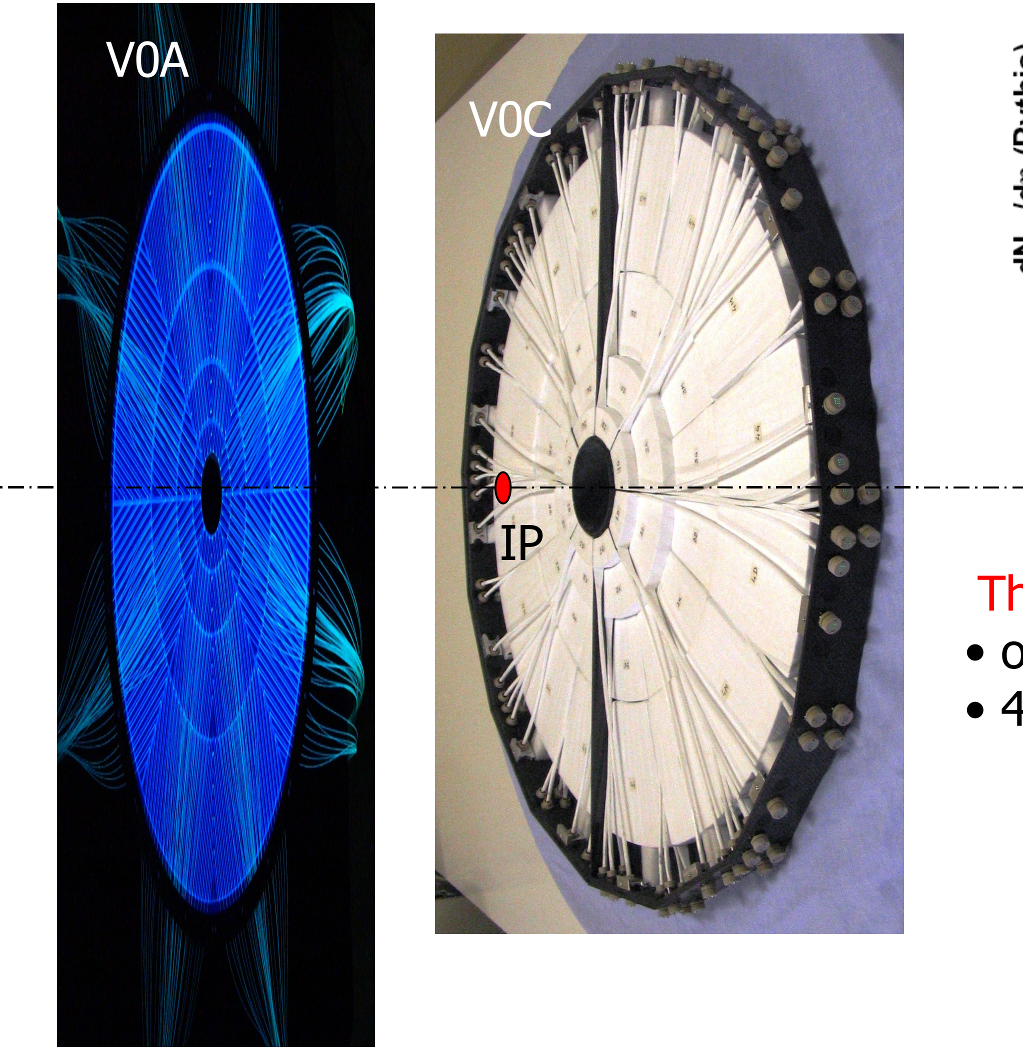
1. The V0 detector of ALICE

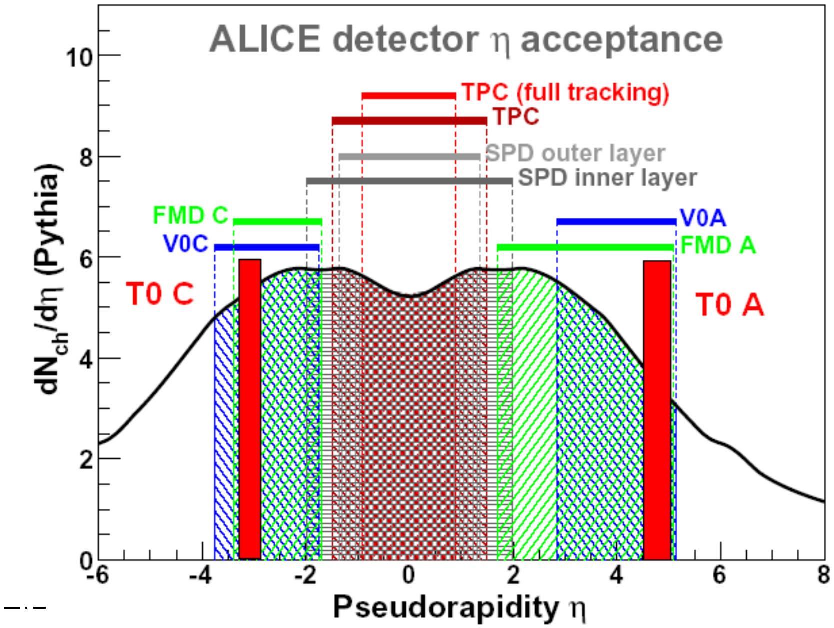
It is made of two disks of plastic scintillator V0A and V0C of diameter 90 and 64 cm on both sides of the IP:

- 2 x 32 channels in 8 sectors and 4 rings in two different designs
- BC404 counters coupled to photomultipliers
- large efficiency
- front end electronics with large background rejection and no dead time



Acceptances





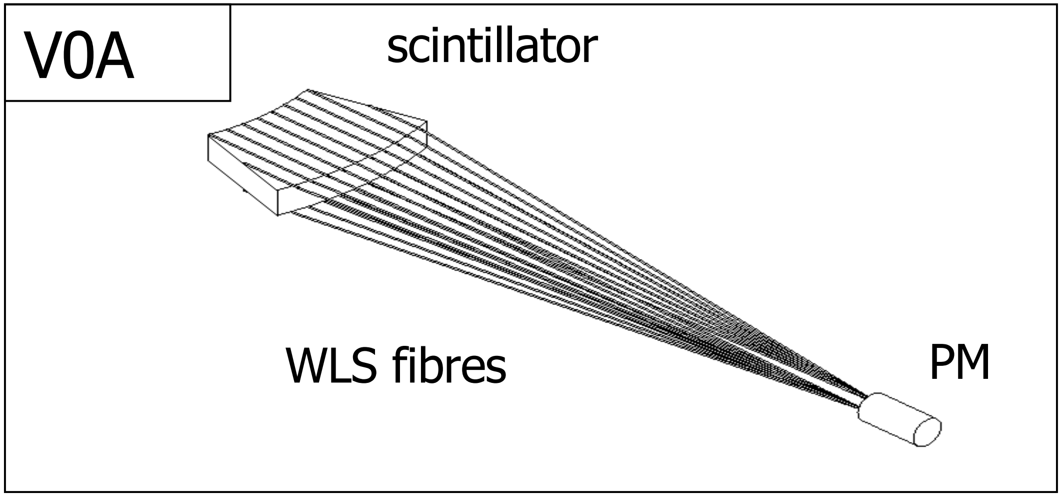
The V0 covers 8 pseudorapidity zones:

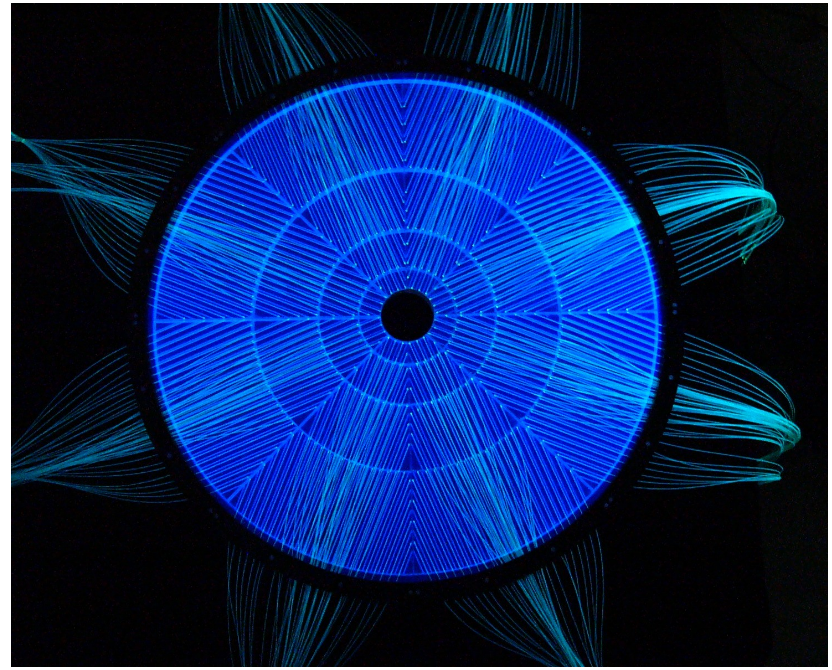
- one measurement per ring
- 4 in the forward and 4 in the backward regions

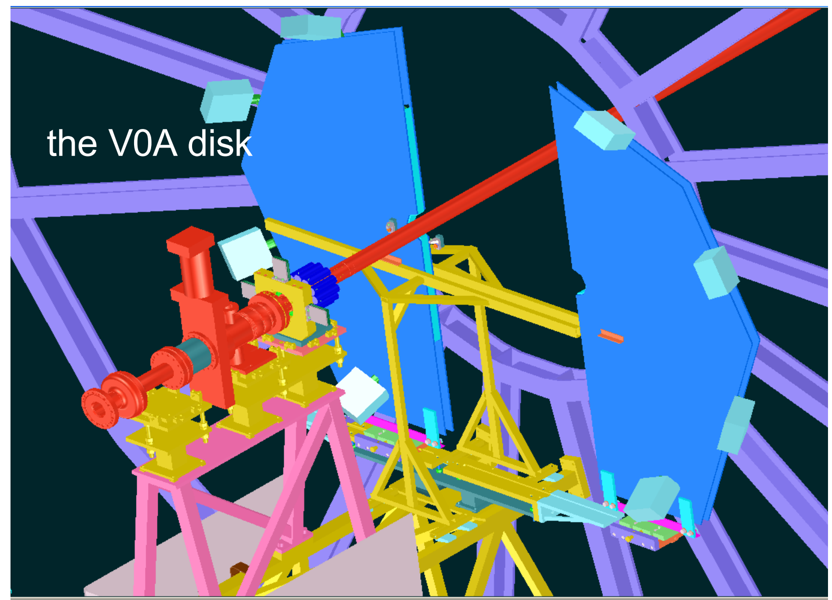
Δη	V0A	V0C
Ring 1	**5.1**/4.5	**-3.7**/-3.2
Ring 2	4.5/3.9	-3.2/-2.7
Ring 3	3.9/3.4	-2.7/-2.2
Ring 4	3.4/**2.8**	-2.2/**-1.7**

V0A design

- *2 cm BC404 (Saint-Gobain)*
- *1 mm BCF9929A(d.c.) WLS fibres (Saint-Gobain)*
- *1 mm PMMA lg1500 optical fibres (Mitsubishi)*
- *16 dynodes mesh PMT (Hamamatsu)*

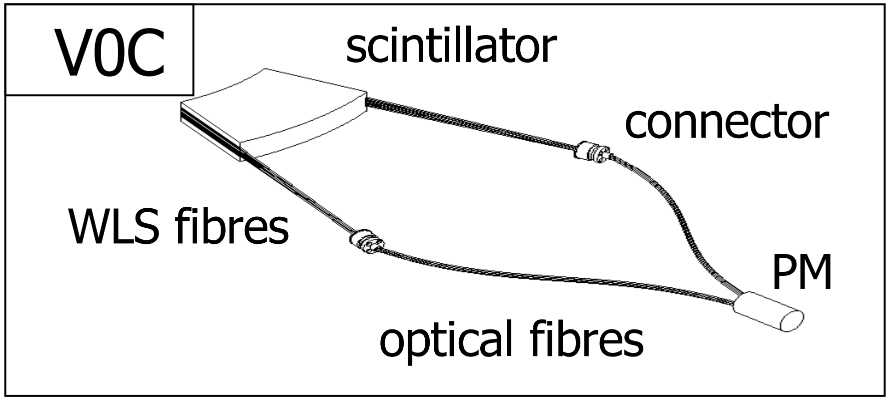




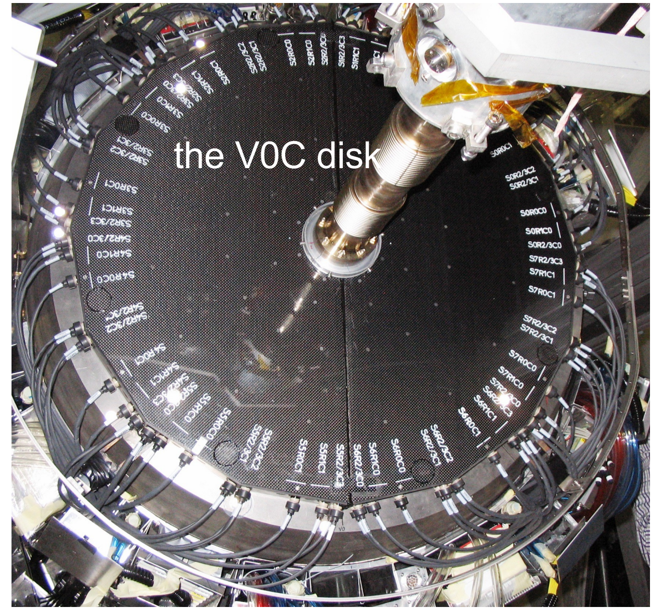


V0A is made by UNAM Mexico

- WLS fibres embedded across the two transverse faces of the cell and connected directly to PMT
- disk made of 2 half plates of scintillator cells isolated from neighbouring ones by an opaque screen (TiO2) casted in the plates

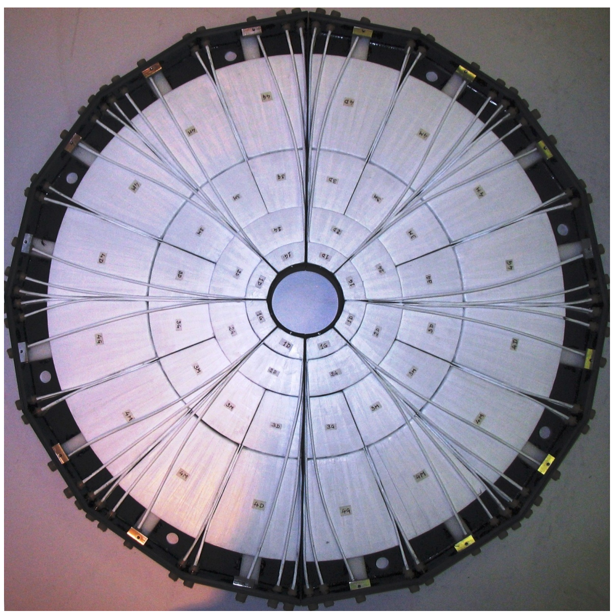


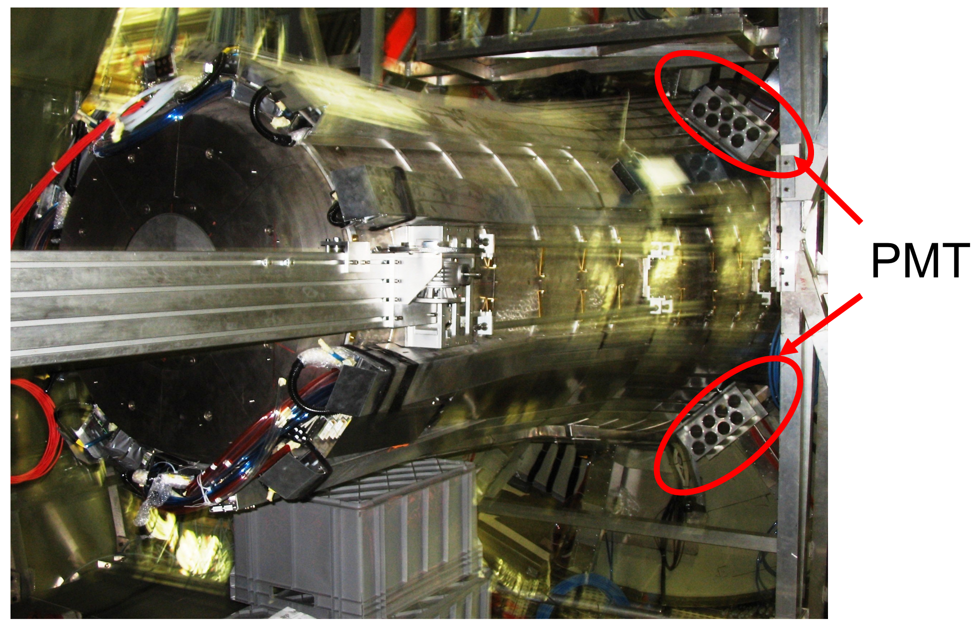
V0C design



V0C is made by IPN Lyon

- WLS fibers glued along the two radial edges of the cell and connected to PMT through optical fibers 3.22 m long
- disk made of 48 individual counters wrapped in Teflon
- arranged in 4 rings within a C-fiber case





2. Purposes of the V0 detector

Fast triggers for central detectors:
minimum bias trigger and two centrality triggers in A-A mode

Background rejection:
fast p-gas filter

Characterization of events:
multiplicity, centrality, multiplicity versus centrality

Measurement of luminosity in pp

Multiplicity measurement

- No direct measurement of multiplicity by the V0

- Two alternatives for extracting multiplicities of primaries:
  1. get the number of cells hit in each ring (from 0 to 8),
  2. get the intensity of the signal (charge) given by each ring, which depends on the number of particles going through it, their energy loss, …

  The issue is then to relate these measurements to the number of primary charged particles produced in the pseudo-rapidity region of the ring.

- Method developed in pp mode :

  Simulation of 80 000 minimum bias 14 TeV pp events has been performed

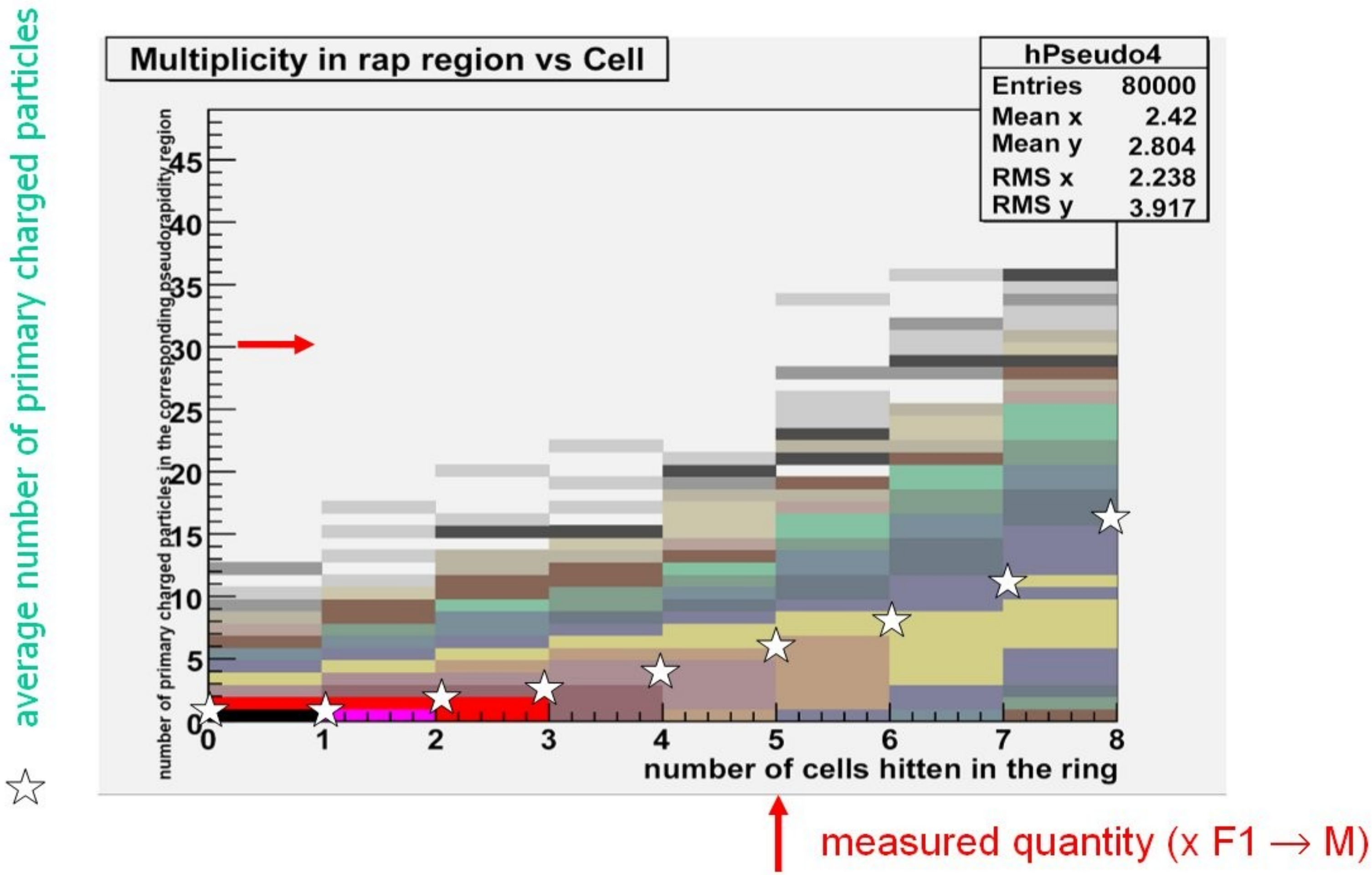
  For each event have been cumulated:
  - the number of primary charged particles in each of the 8 pseudo-rapidity regions,
  - the number of cells hit in each ring,
  - the signal collected in each ring.

❑ Packages:
- AliRoot HEAD of July 2006
- AliVZERO v7
- ROOT 5.12/00
- GEANT3 v1-5

❑ Event generation:
- Pythia 6.214
- pp collisions, minimum bias (kPyMb)
- all the environment (importance of secondaries)
- B = 0.5 T when field ON
- vertex smearing: 50 μm on x,y, 5.3 cm on z

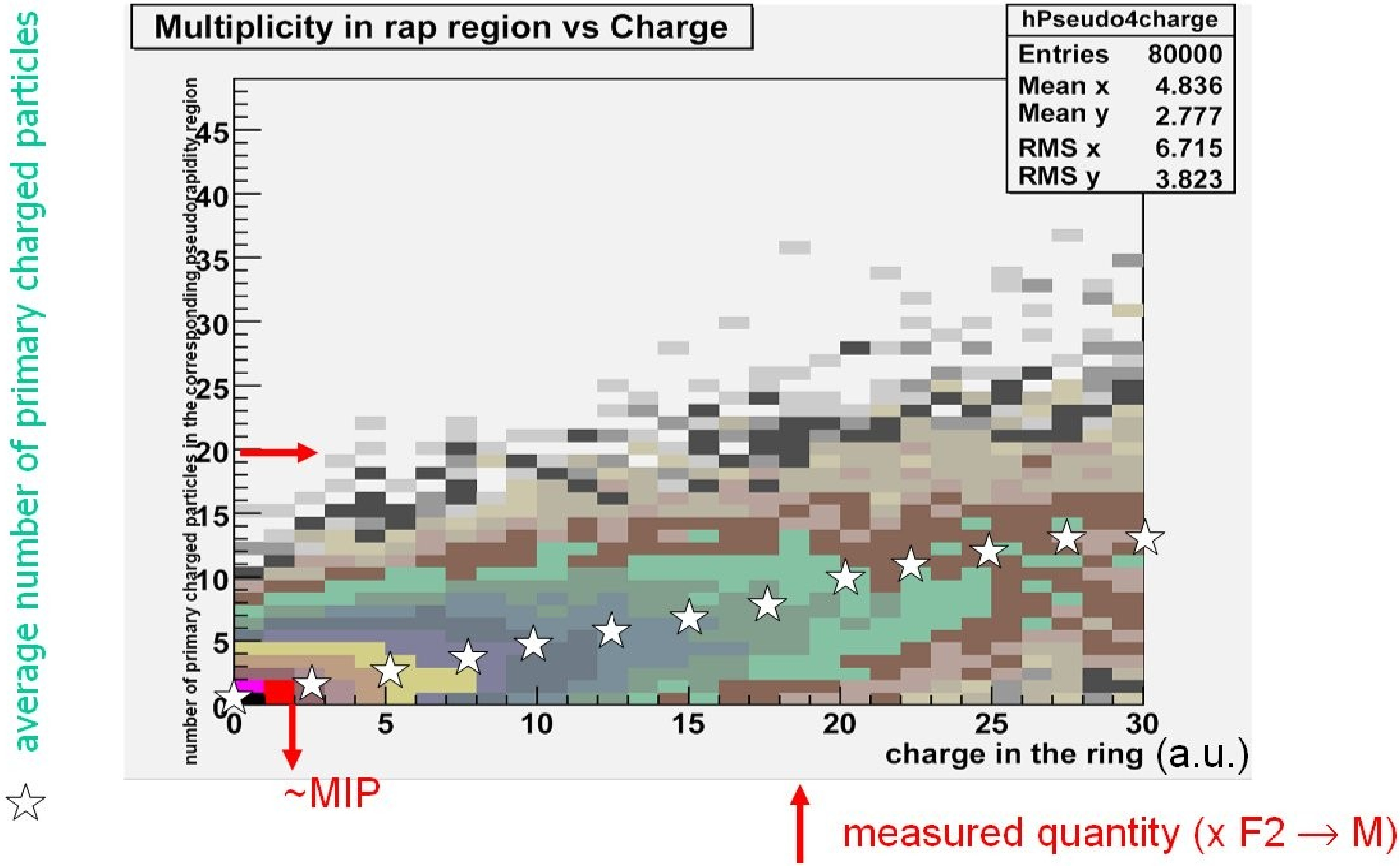
Example of multiplicity obtained from number of hit cells

Distribution of 80 000 simulated events for ring 4 of V0C in pp collisions (log scale on z)



Example of multiplicity obtained from charge

Distribution of 80 000 simulated events for ring 4 of V0C in pp collisions (log scale on z)



BC, Wuhan, May'08

Multiplicity measurement summary

- Practically:

Computing dN/dη in the pseudorapidity range of one V0 ring can be achieved :

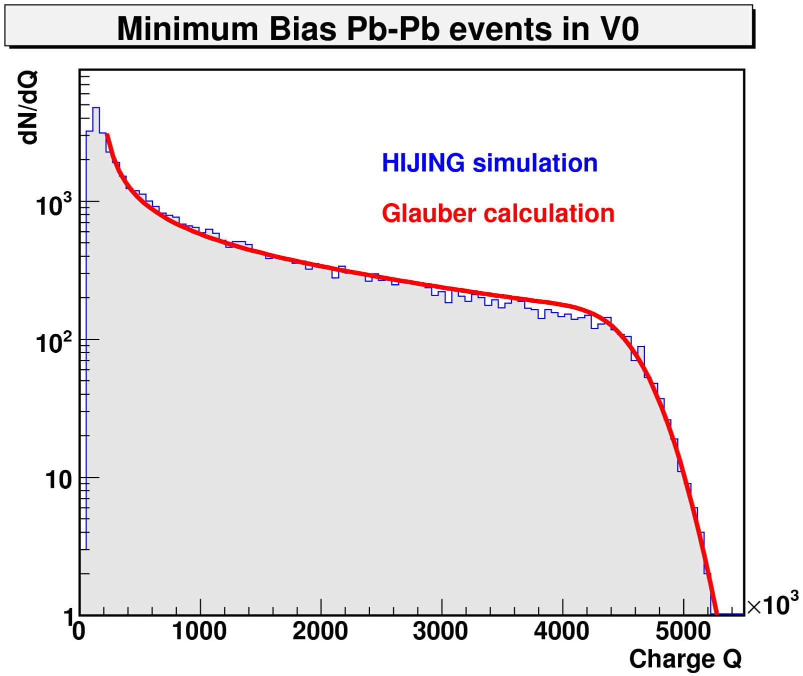
- either by counting on an event-by-event basis the number of cells hit and multiplying by the factor given on slide 7 (F1),
- or by measuring the intensity of the signal and multiplying by the factor given on slide 8 (F2), (calibration is then required)

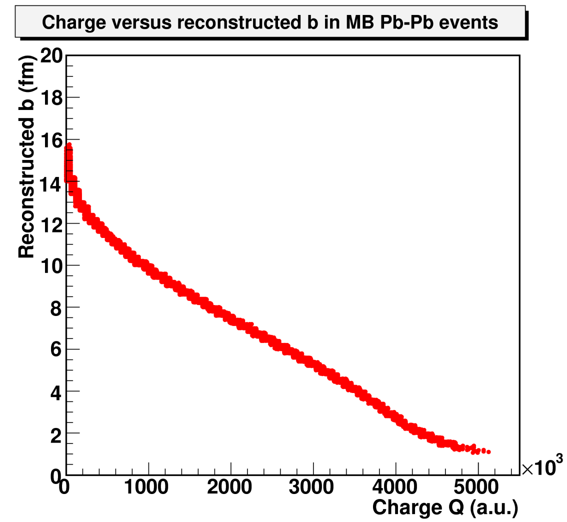
It will work on average (for a sample of 2000 events, the statistical error is about 5%)

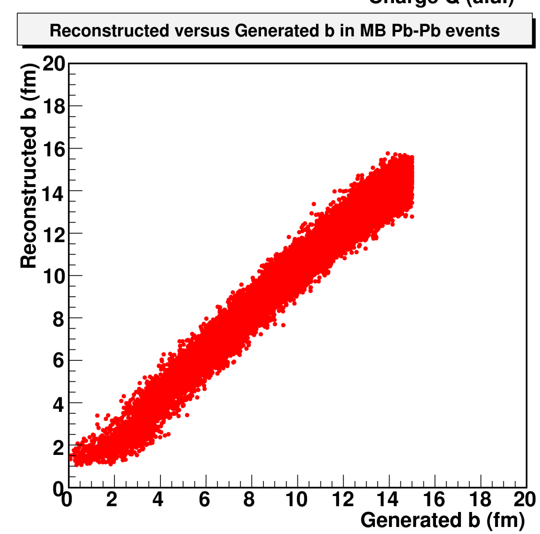
- Uncertainties:
  - Statistical: depends on the choice of the sample and on the method (more precise if one takes into account the intensity of the signal). If the sample is big enough, a count of the hit cells is enough and does not need a calibration.
  - Systematical: less than statistical for 2000 events.
  - The multiplicative factors come only from simulation. There is no way to check them experimentally.

- Drawbacks:
  - The V0 is not able to provide multiplicity event by event
  - One must trust the simulations…

Centrality determination in Pb-Pb mode







Glauber calculation inputs:

- *collision Pb-Pb with σNN=60mb*
- *densities ρp=0.0631 and ρn=0.0969*
- *Wood-Saxon radius and width:*

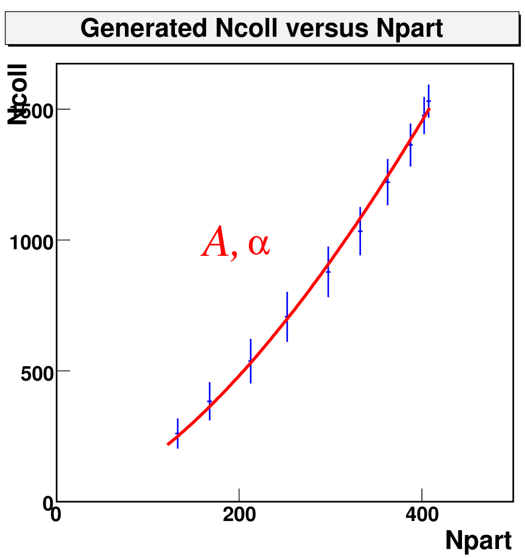
  r=6.624 fm and w=0.549 fm

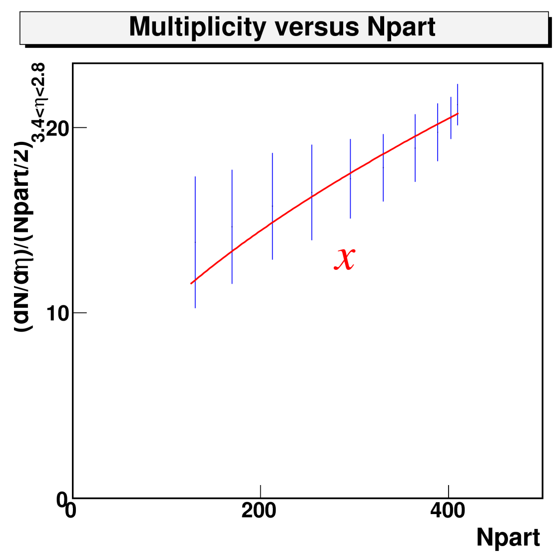
Centrality dependence of charged multiplicity

can be obtained by analysing data in the frame of the Kharzeev-Nardi model [*Phys. Rev. C70 (2004)*]:

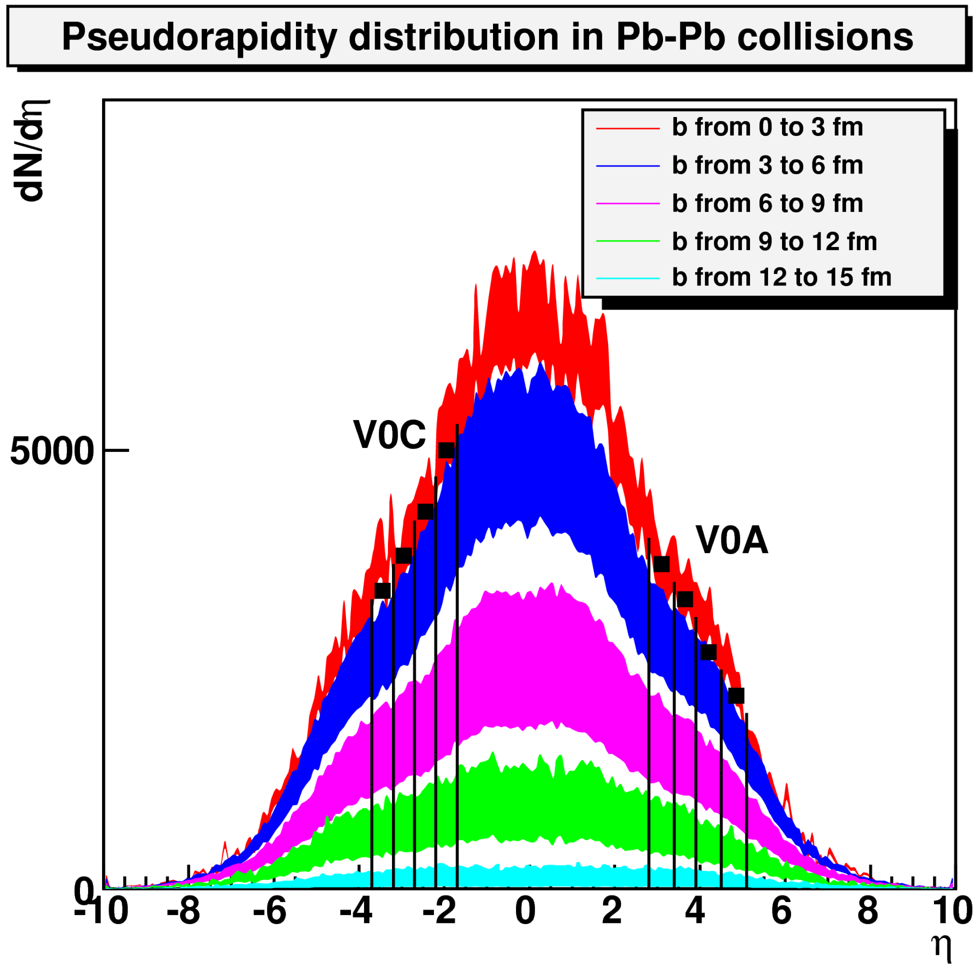
$$\frac{dN_{ch}}{d\eta} = n_{pp} \cdot \left((1-x)\frac{\langle N_{part} \rangle}{2} + x \langle N_{coll} \rangle \right) \qquad n_{pp} = 2.5 - 0.25 \cdot \ln(s) + 0.023 \cdot \ln^2(s)$$

The number of binary nucleon-nucleon collisions Ncoll is determined from the Glauber calculation and is found to depend on the number of participants Npart through $N_{coll} = A \cdot N_{part}^{\alpha}$





Multiplicity versus centrality



Luminosity measurement

- Luminosity relates interaction cross-section and event rate:

$$R = L \,.\, \sigma_{in}$$

and is a relevant information for monitoring machine / experiment operation

- R: event rate in 4π
- σ_{in}: cross section relative to the detected events (here pp inelastic given by TOTEM)

The V0 will monitor the event rate $R_{V0} = L \,.\, \sigma_{in} \,.\, Acc \,.\, \varepsilon$

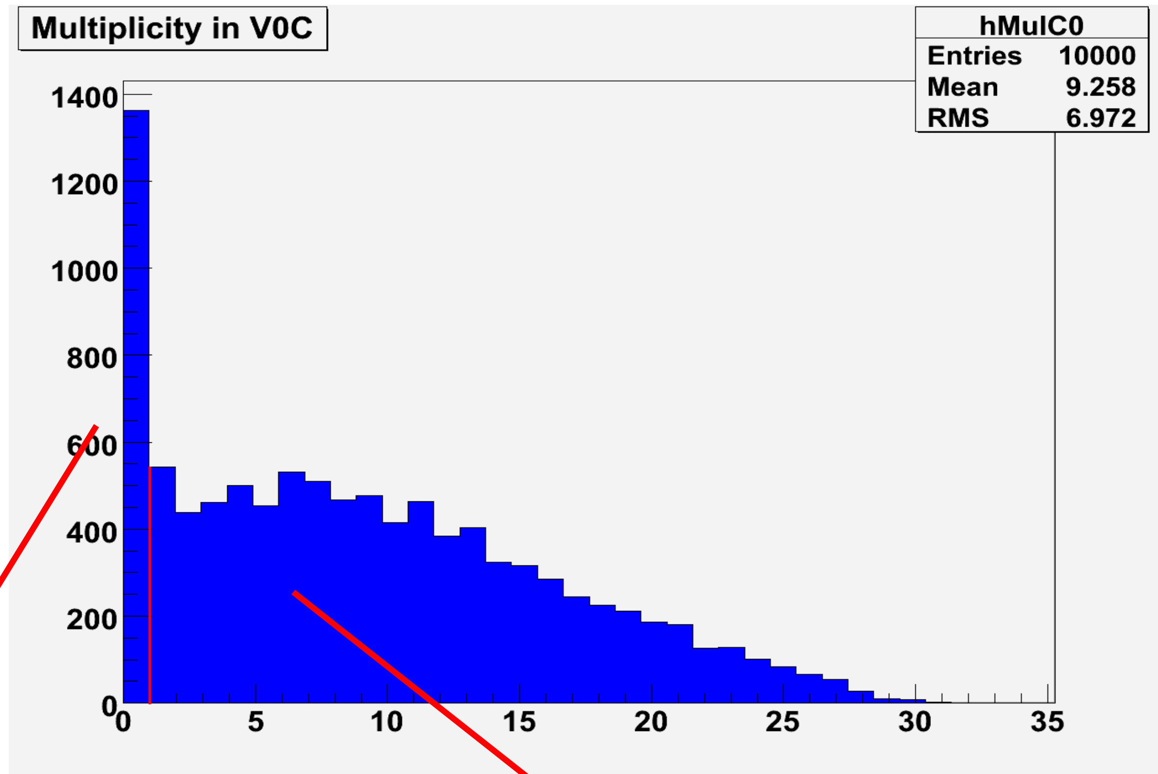
- Acc: geometric acceptance of the detector
- ε: efficiency of the detector

- Simulations have been performed in order to provide the acceptance and efficiency:

- Simulation with PYTHIA of 10 000 pp collisions, at minimum bias, and including all the environment due to the relevance of secondary particles for efficiency estimation
- Counting of all events giving at least one particle in the acceptance of V0A, V0C, V0A and V0C, V0A or V0C
- Ratios $N_{in\ acc}/N_{produced}$ give the acceptances Acc
- Introduction of experimental cuts gives the efficiency ε and the final $Acc.\varepsilon$

Simulated multiplicity distribution

Multiplicity is here the number of cells hit in a given event



Multiplicity = 0, event not in the acceptance (13.6%)

Multiplicity > 0 , event in the acceptance

V0 acceptances

- **Acceptance Acc**

Acc	14 TeV
V0A	89.3%
V0C	87.9%
“and”	82.8%
“or”	94.4%

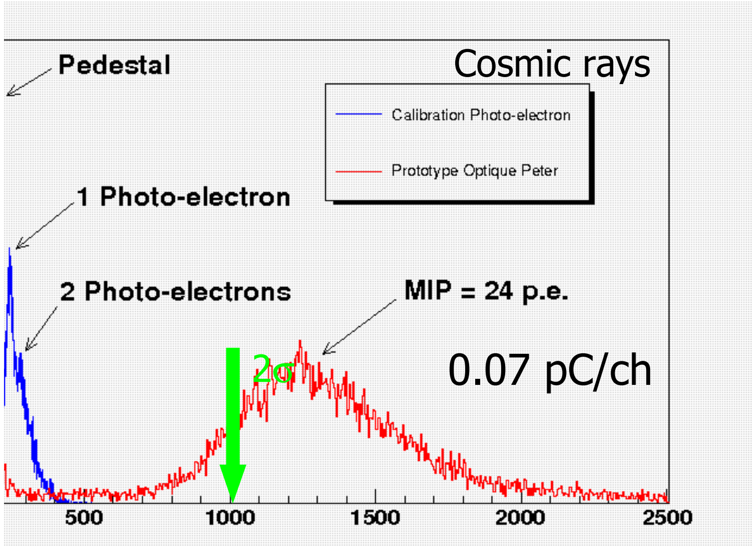
Less than 100% because of angular acceptance and dead zones, especially for events producing a small amount of particles: diffractive events

For non-diffractive events: Acc > 99%

- **“Robustness” of these acceptances**

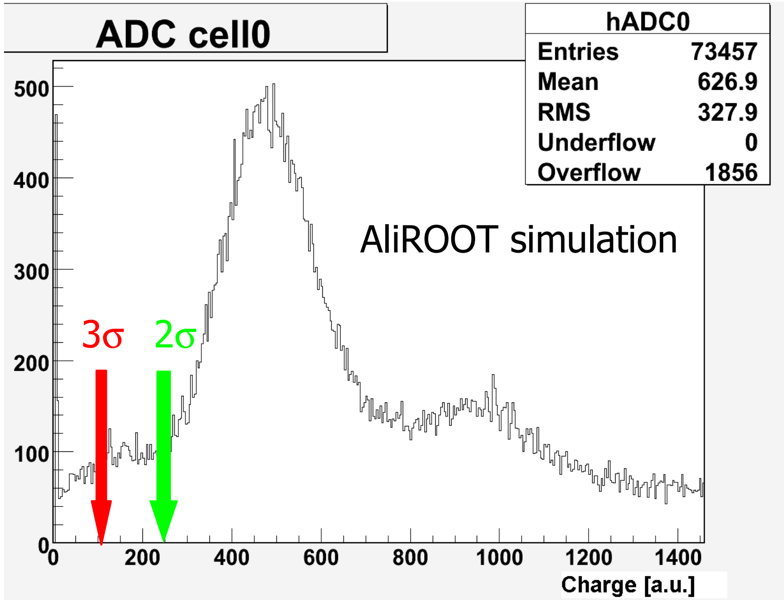
➢ Longitudinal displacement of the IP: no significant change (<0.3% for 10 cm)
➢ Transverse displacement of the IP: gain of ~0.3% for 0.5 cm
➢ Change in the magnetic field: <0.6% when varying from 0 to 0.5 T
➢ One ring missing: loss of 1.5% to 3.5% depending on the ring

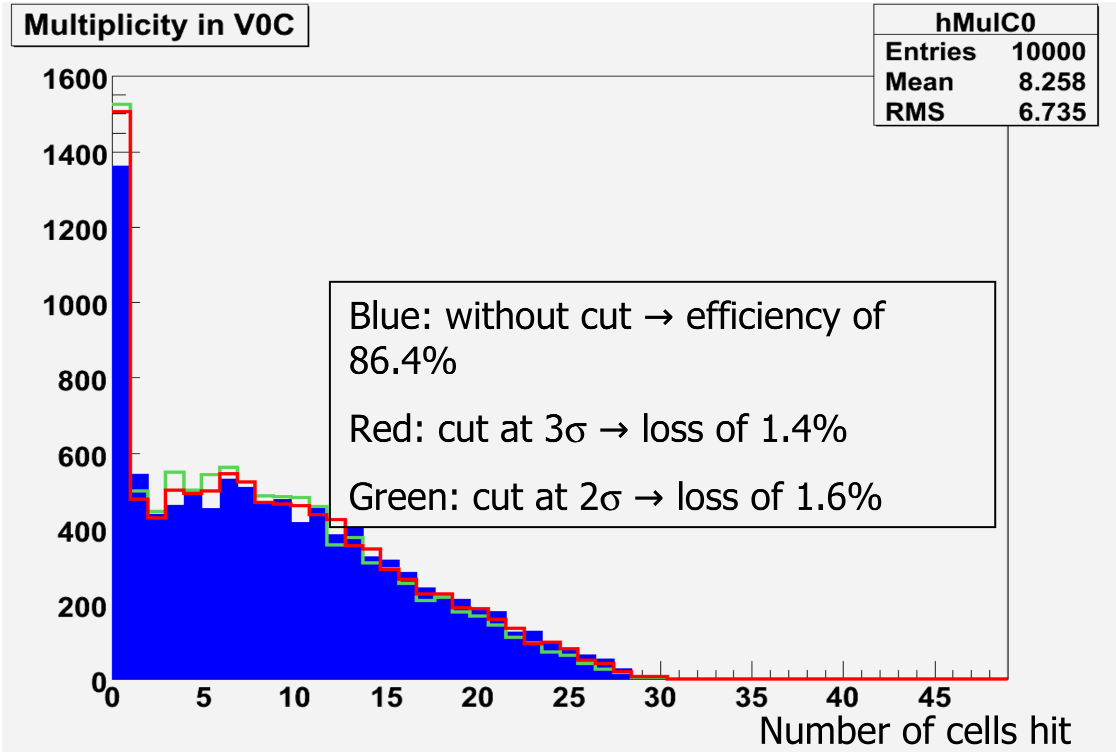
Introduction of threshold on charges



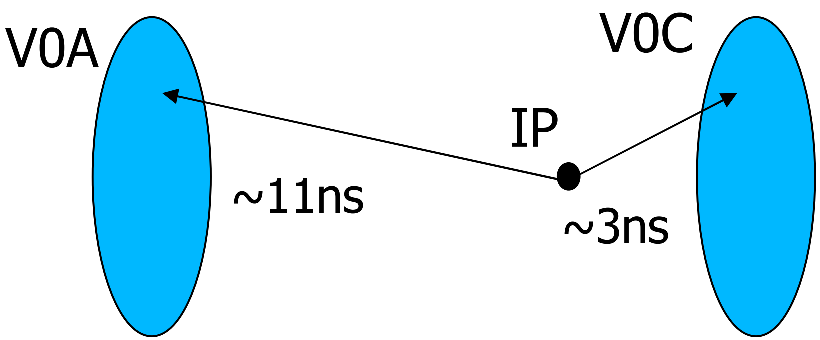
Due to the use of discriminator circuits for triggering, thresholds will be applied on analogical signals delivered by PMs

Loss in efficiency due to cuts on charges:





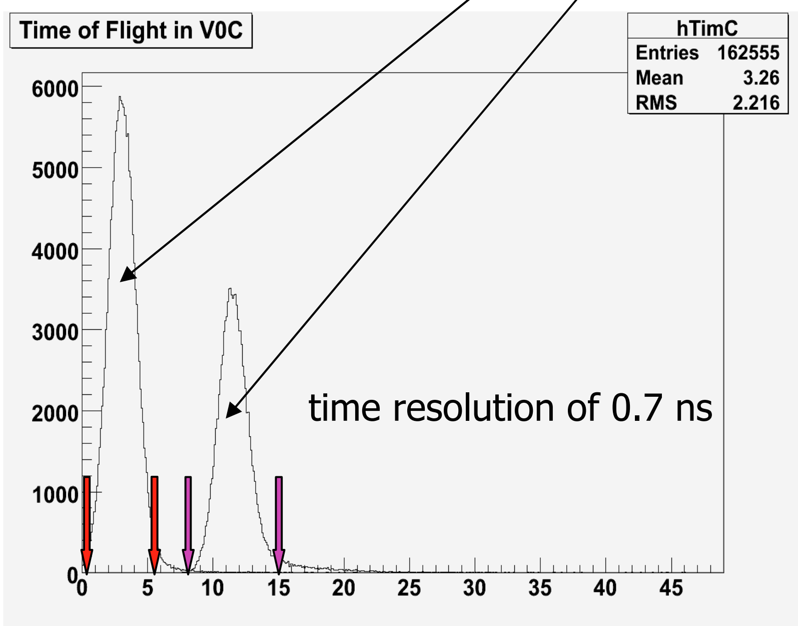
Effect of time windows

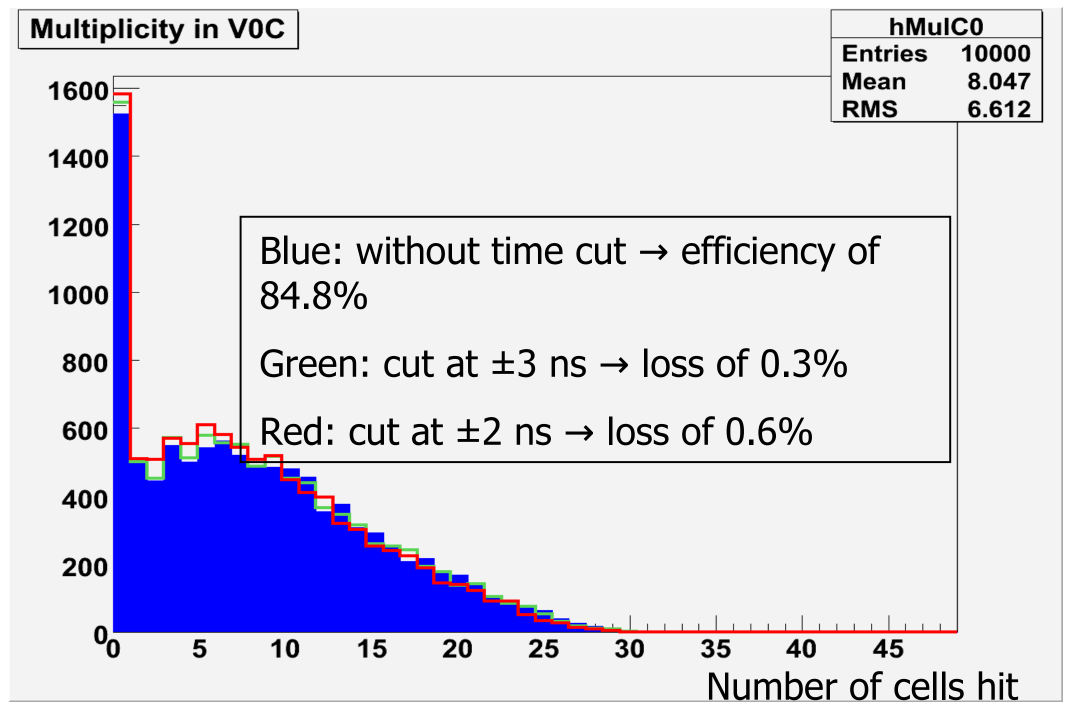


Due to the use of coincidence circuits for triggering, time windows will be applied to logical signals delivered by coincidence circuits

Loss in efficiency due to time windows:

Trigger given by coincidences between event from **V0C** and V0A





Luminosity measurement summary

Final V0 acceptance Acc.ε

For a cut on charge at 2σ and a time window of 6 ns, in pp mode at 14 TeV

	Acc.ε	Acc
V0A	87.5%	89.3%
V0C	86.5%	87.9%
"and"	81.2%	82.8%
"or"	92.8%	94.4%

Comments

- The loss due to cuts on charge and time are of the order of 2-3%
- The V0 should be a good device for luminosity measurement, with a factor Acc.ε of about 0.81 (with "and")
- These numbers have been checked to be quite stable when varying the IP position or the magnetic field value

Summary and conclusion

The V0 detector has been designed to provide

- Minimum Bias trigger for central detectors
- centrality triggers in Pb-Pb mode
- online/offline background rejection
- measurement of charged particle multiplicity
- luminosity monitoring
- running conditions monitoring

It has been installed

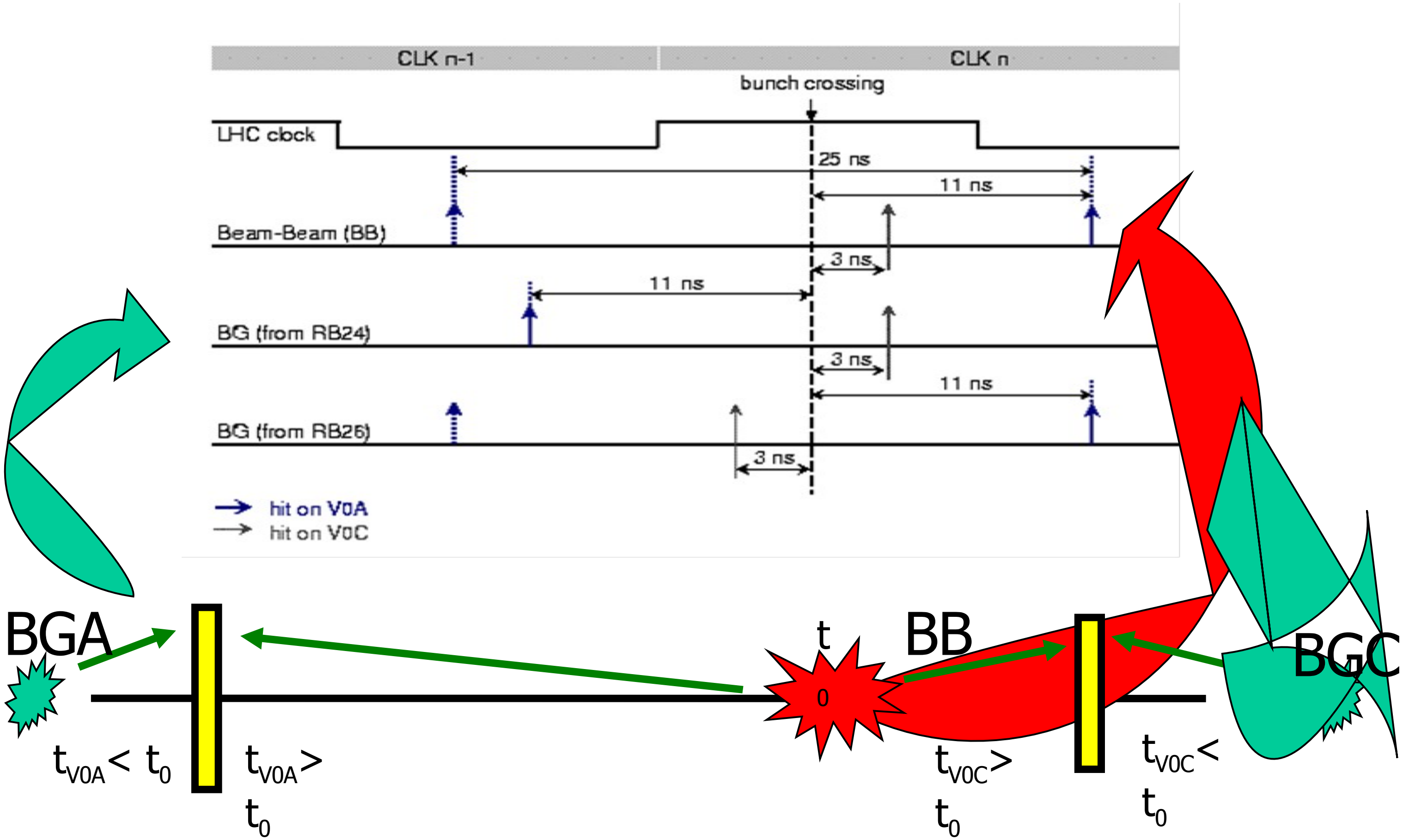
in early 2007 and early 2008 for the V0C and V0A respectively and is being now commissioned with cosmic rays

I hope I convinced you that the V0 detector is a small but important device in ALICE

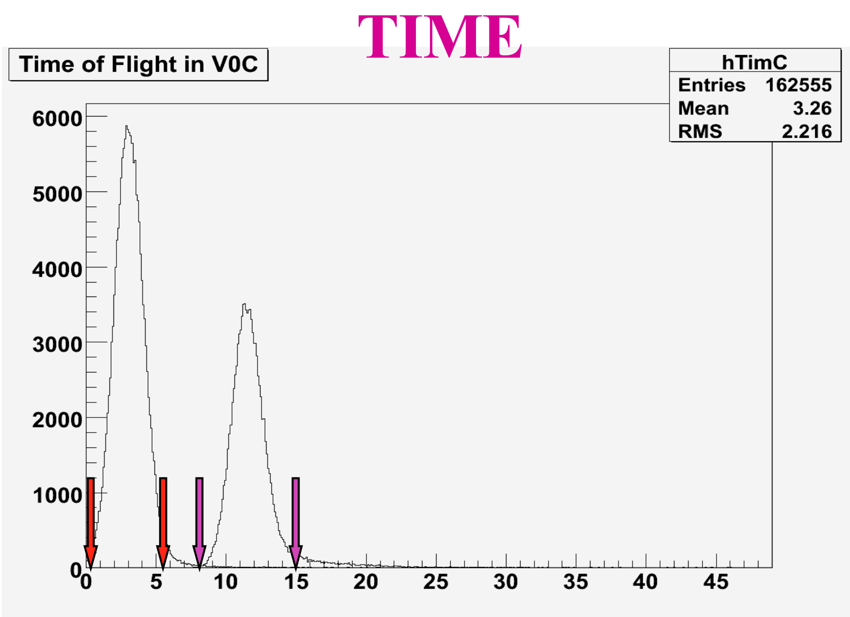
Thank you for your attention

Backup slides

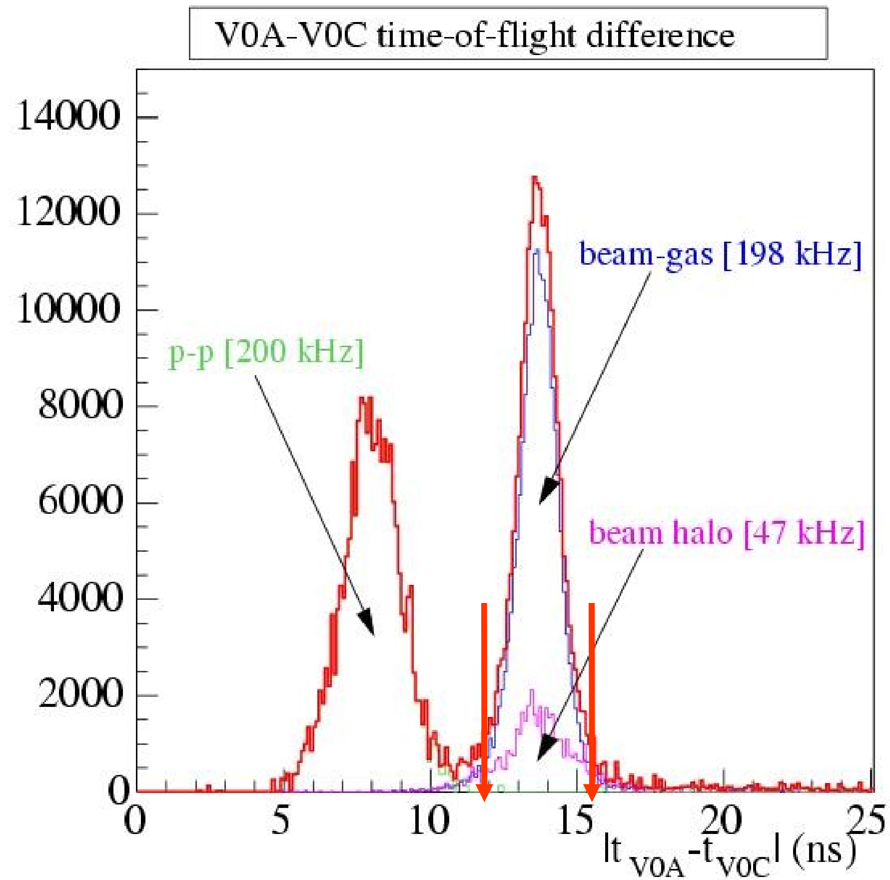
Background rejection



Timing considerations



Time resolution of 0.7 ns



Individual counter performances

❑ Minimum ionizing particle (MIP) from cosmics (XP2020, HV = 2500 V)

➢ Integrated charge:

- 24 photo-electrons (p.e.) at the MIP peak with a σ value of MIP/4
- threshold at MIP/2

➢ Time resolution:

- depends on the number of p.e.
- for a fixed HV value, depends on the length of optical fibres

➢ Dynamics:

- 1-500 MIPs or 1-1000 in term of charge per channel (in Pb-Pb)