Commissioning of the BIS 78 sMDT chambers for the upgrade of the ATLAS muon spectrometer

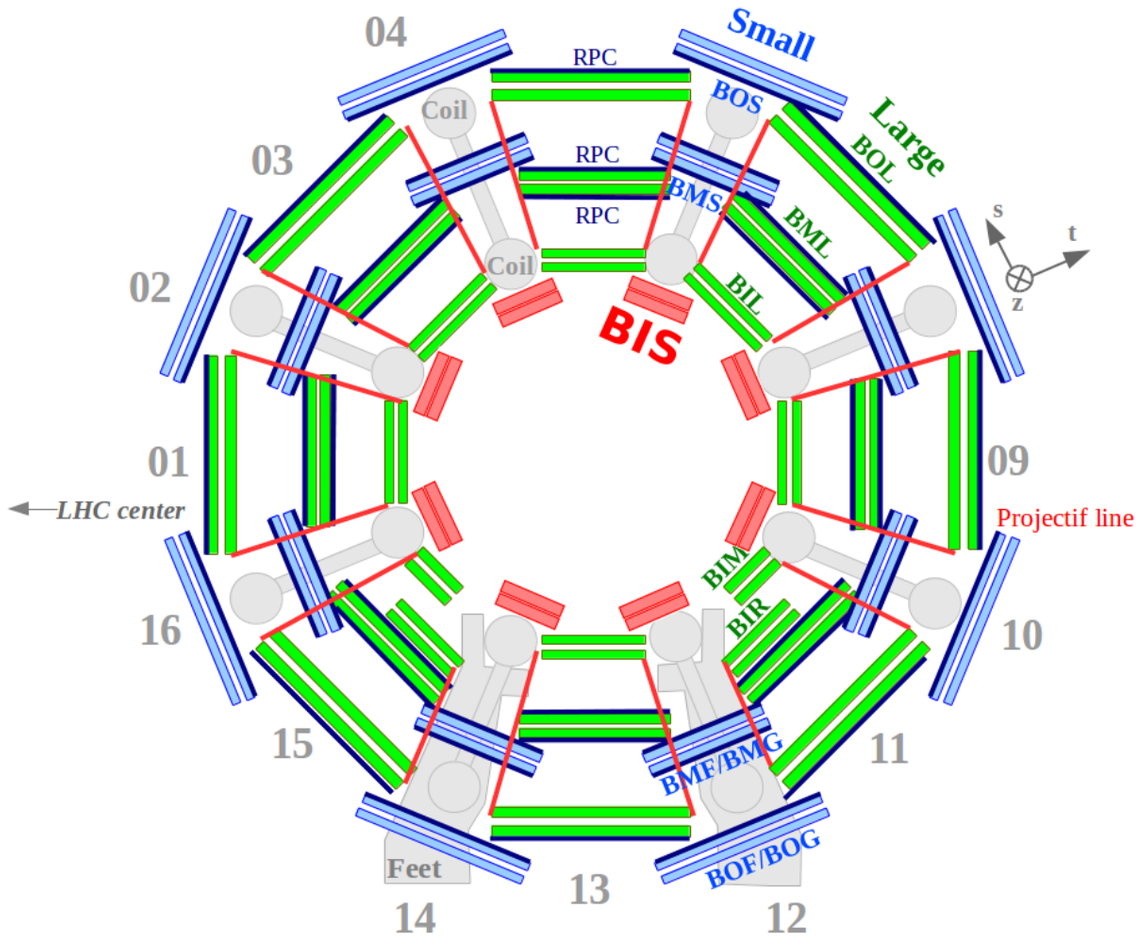
Šejla Hadžić

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

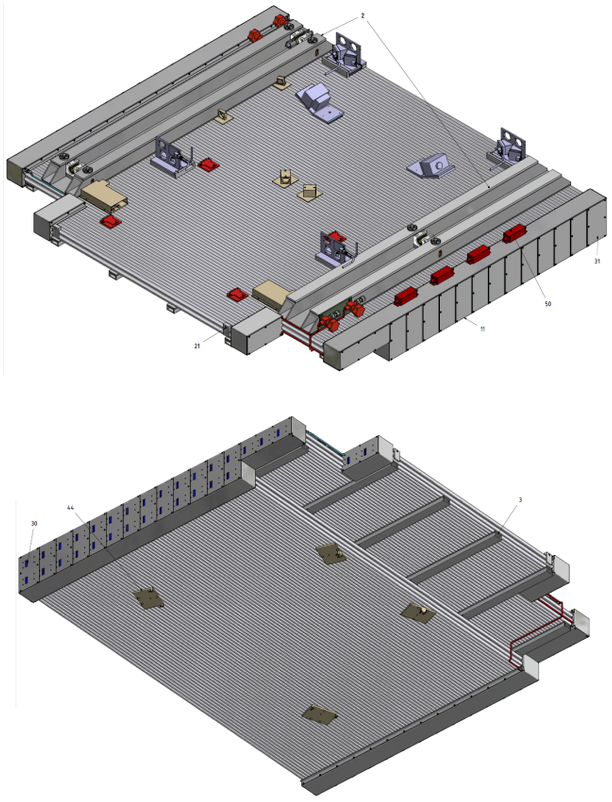
Motivation

BIS-78 sMDT (small-diameter Muon Drift Tubes)

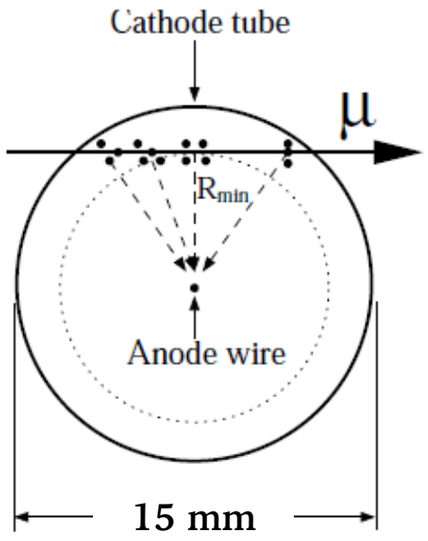
16 new sMDT chambers will be installed in the inner barrel layer in the LHC's second long shutdown.



Schematic view of a BIS sMDT chamber

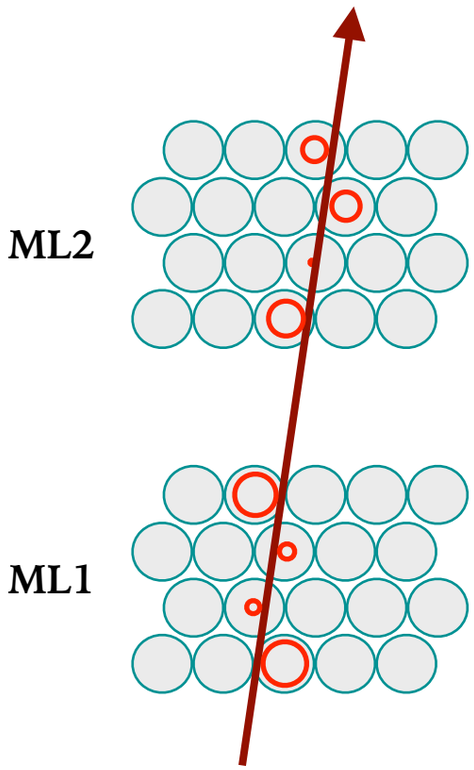


Working principle



- Muon ionises the atoms of the gas
- Drift of the electrons to the anode wire
- Creation of the avalanche close to the wire

Type	sMDT
Gas mixture	$Ar : CO_2 (93:7)$
Gas pressure	*3 bar (abs.)*
Gas gain	*20000*
Wire potential	*2730 V*

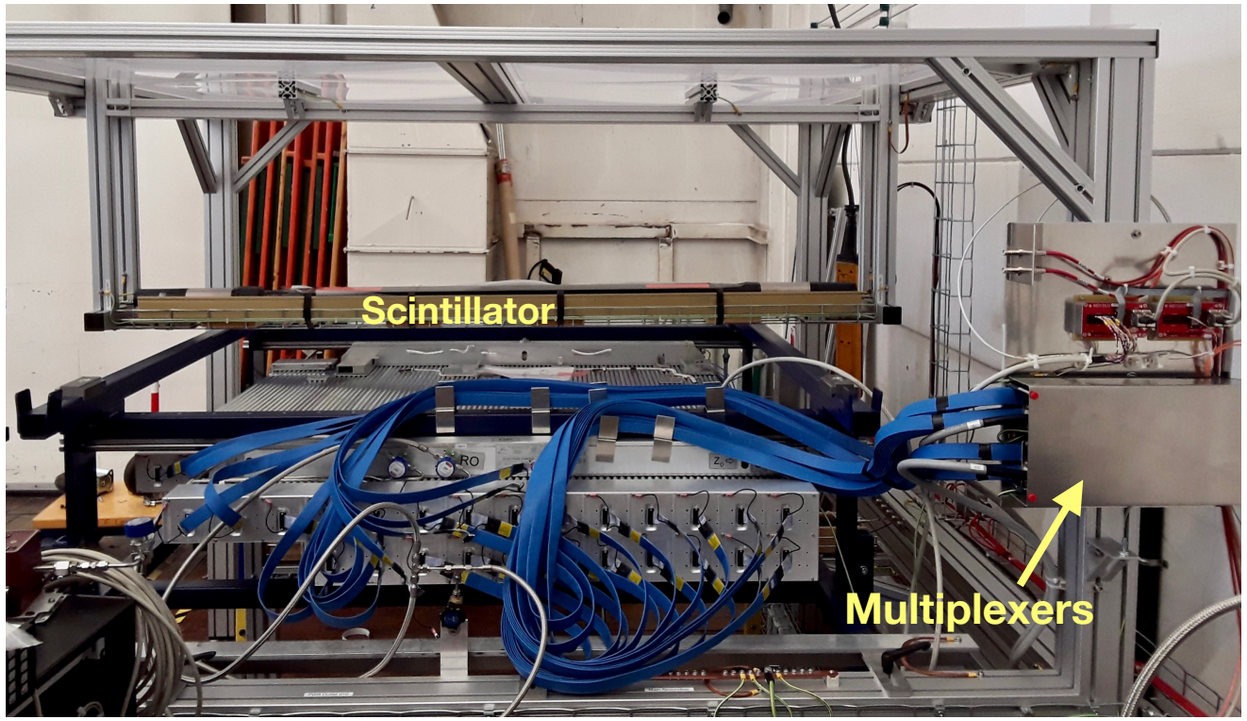


BIS-78 sMDT (small-diameter Muon Drift Tubes)

- 8 layers of tubes organised in 2 multilayers
- Measurement of the electron drift time
- Conversion of the drift time to the drift radius
- Reconstruction of the muon trajectory

Cosmic - ray test stand

Test stand



Readout electronics

Measured quantities

- Noise level measurement
- Spatial resolution of the chamber
- Muon detection efficiency

Tested chambers

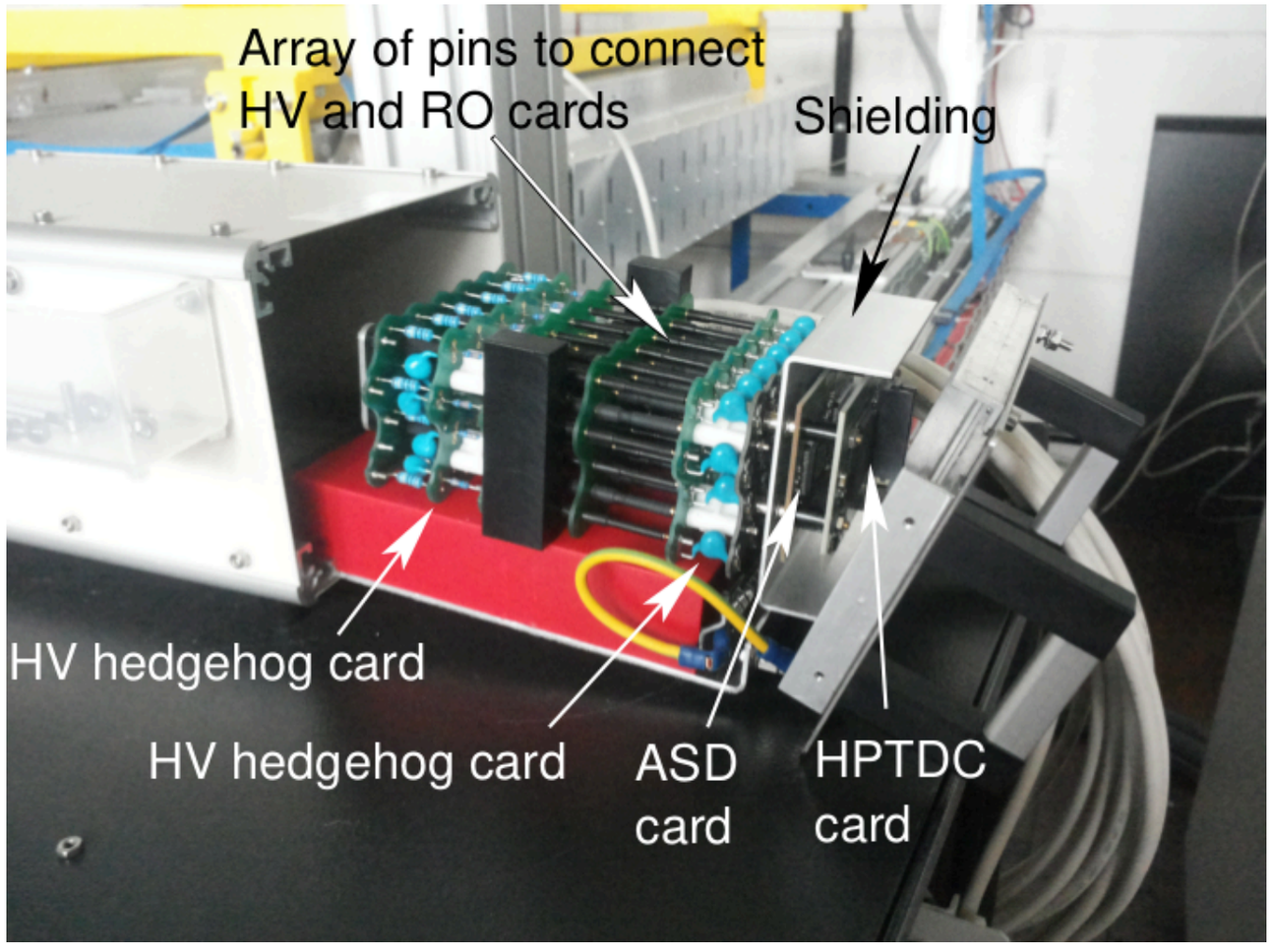
3/16

Noise level measurements

Noise levels measurements are determined as a function of a different threshold.

Off - chamber measurement

- Each mezzanine card is tested in a box



On- chamber measurement

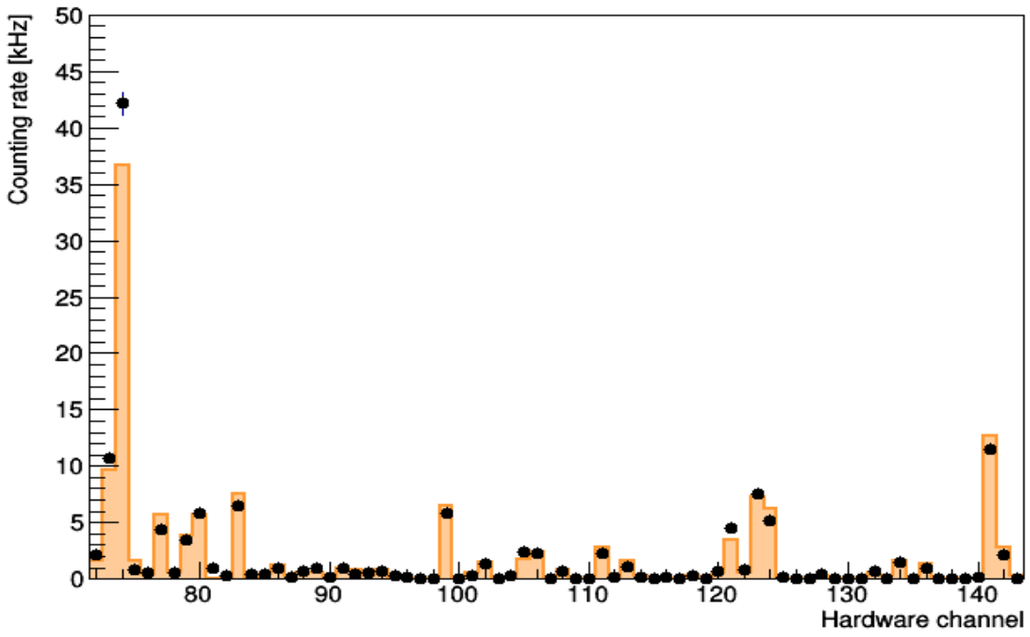
- Noise levels of each card on - chamber compared with the results from the off - chamber measurement

Noise level measurements

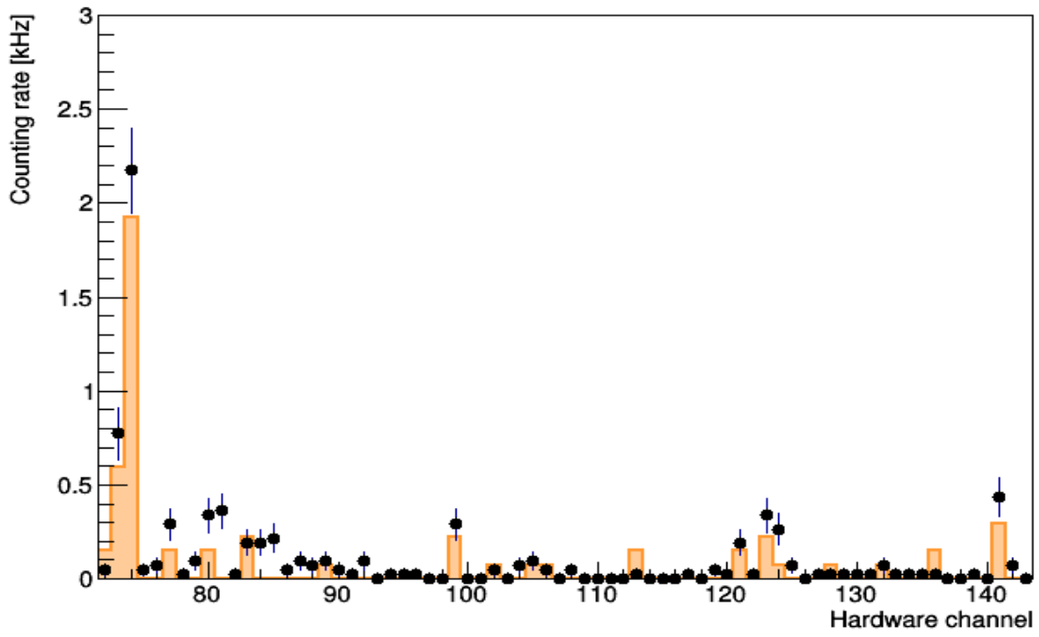
ATLAS settings have higher effective threshold compared to the default settings

A2

Default Settings



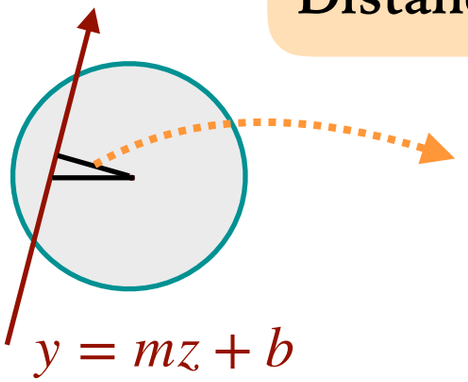
ATLAS Settings



- On chamber, HV ON; Off - chamber test, HV ON

- **Average noise levels for ATLAS settings 0.26kHz/tube**

Spatial resolution determination

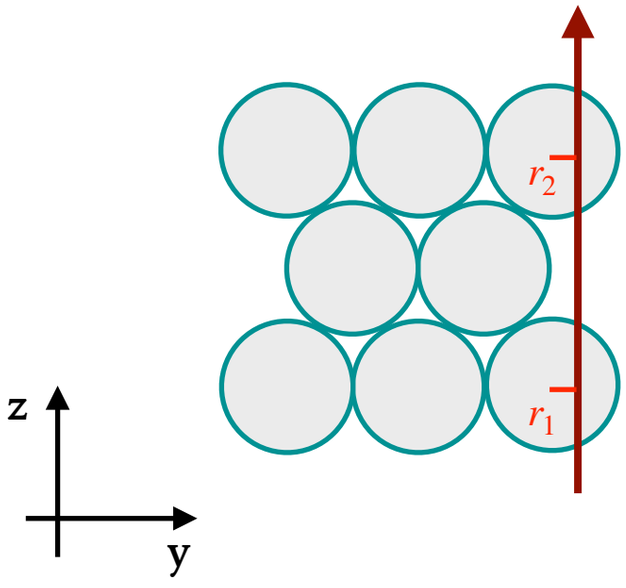


Distance of the track from the wire

$$d_k = \frac{|mz_k + b - y_k|}{\sqrt{1 + m^2}}$$

Spatial resolution

$$\sigma = \sqrt{Var(\delta)} = \sqrt{Var(r_k - d_k)}$$



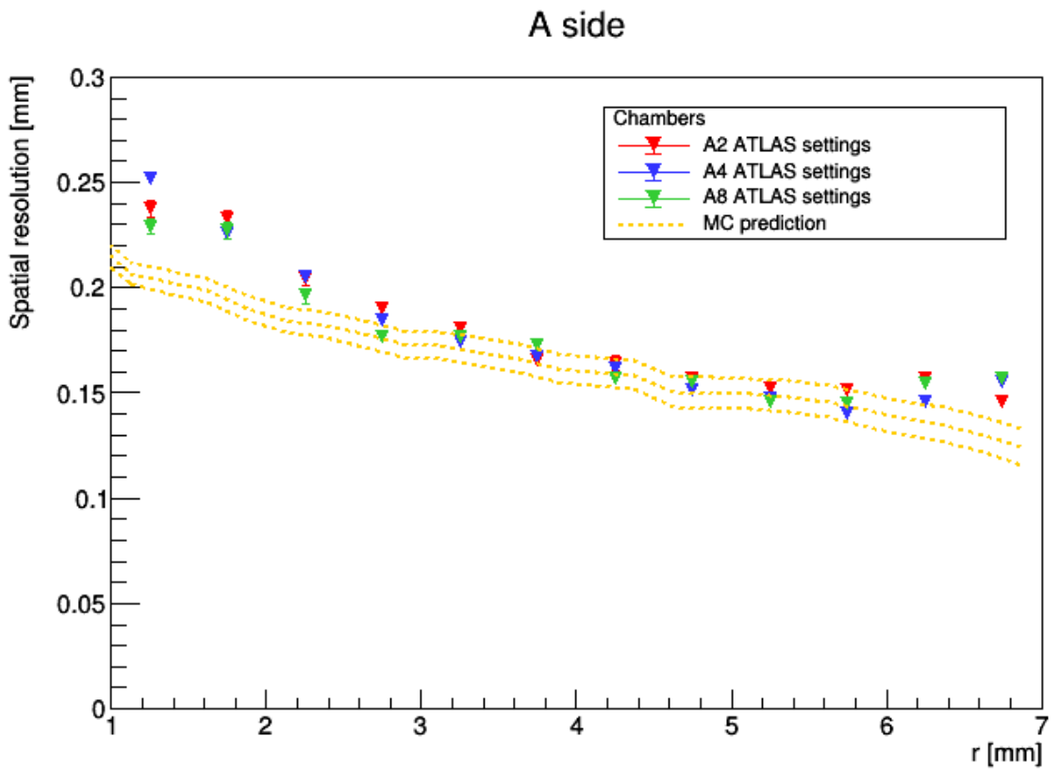
For the track passing vertically

$$\sigma(r_2 - r_1)/\sqrt{2}$$

For the tracks with inclination

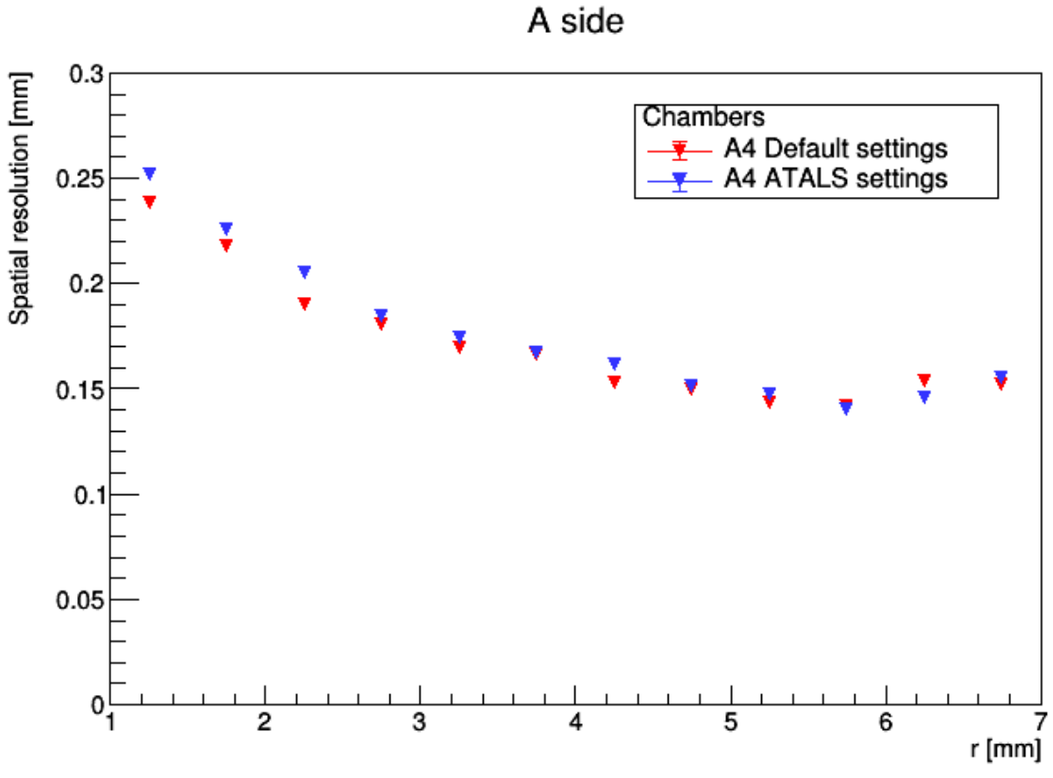
$$\sigma\left(r_2 - r_1 \mp \frac{m}{\sqrt{1 + m^2}}(z_2 - z_1)\right)/\sqrt{2} \qquad |m| < 0.01$$

Spatial resolution



- All tested chambers have same spatial resolution
- Determined resolution in agreement with MC prediction

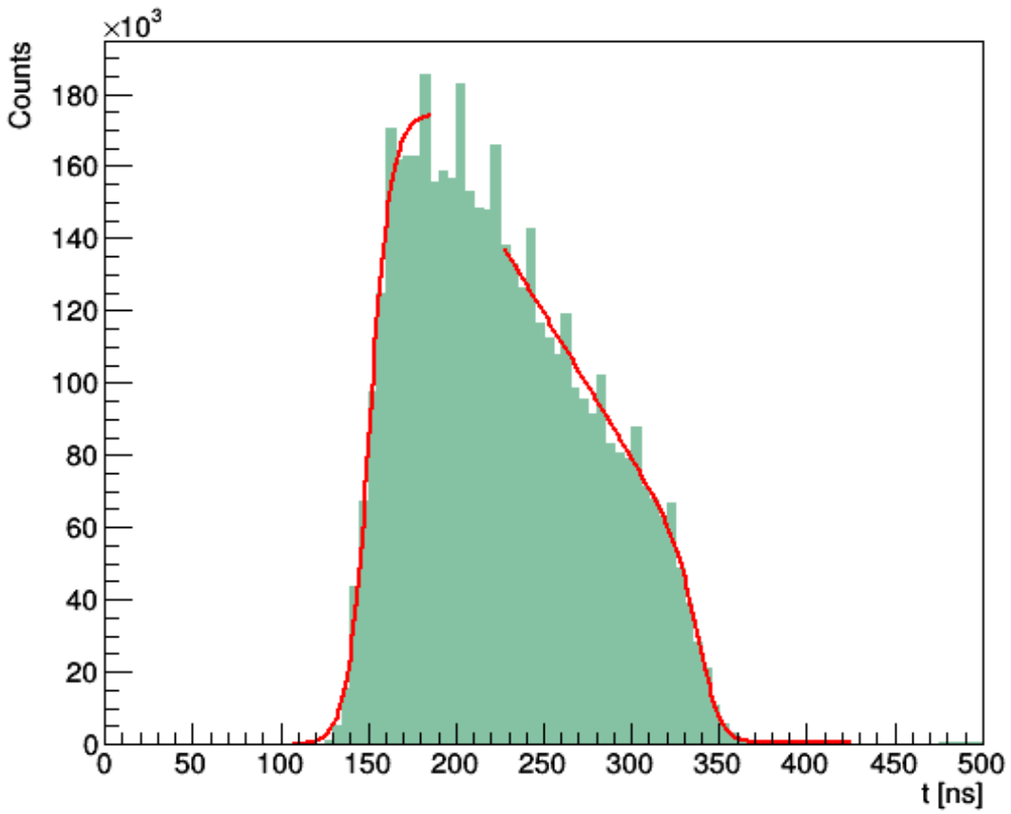
- ATLAS settings have higher effective threshold compared to default settings
- Spatial resolution sightly better default settings



Maximum drift time

A8

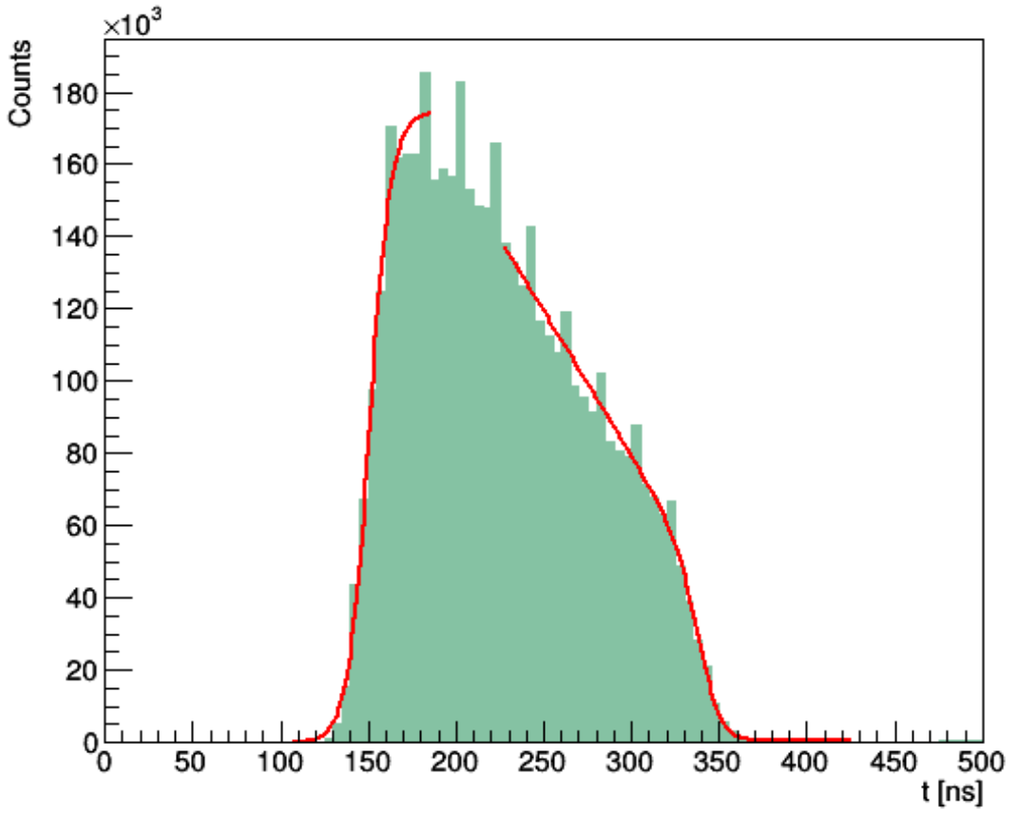
Drift time spectrum



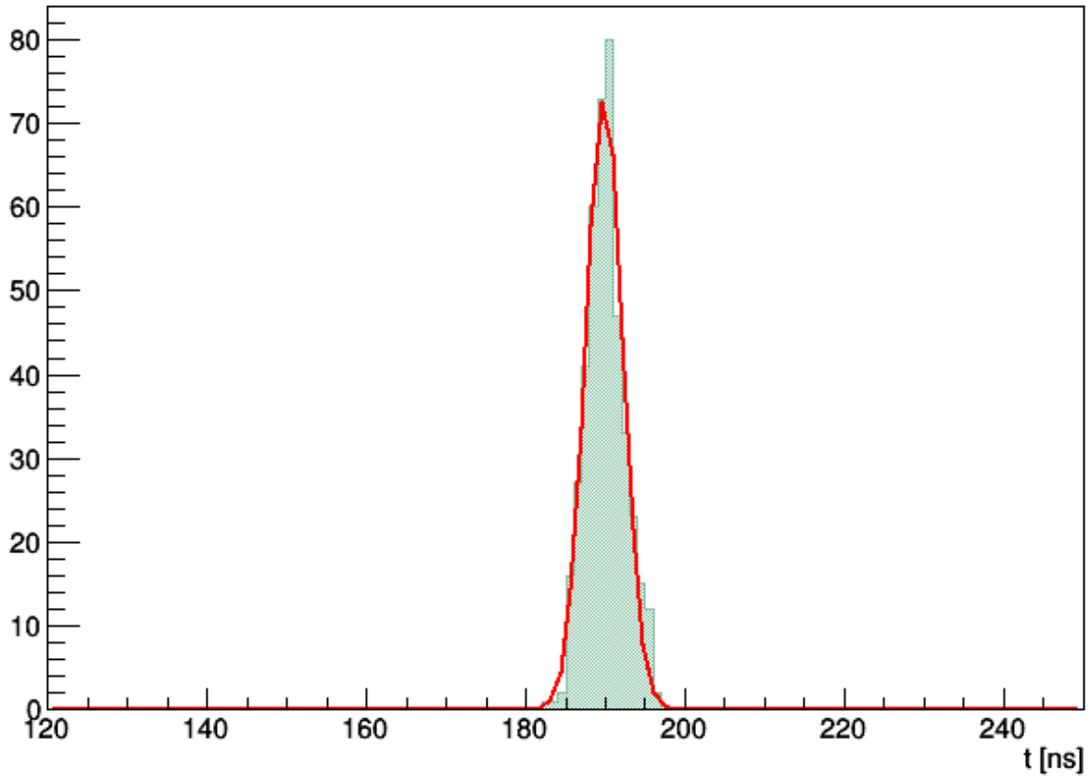
Maximum drift time

A8

Drift time spectrum



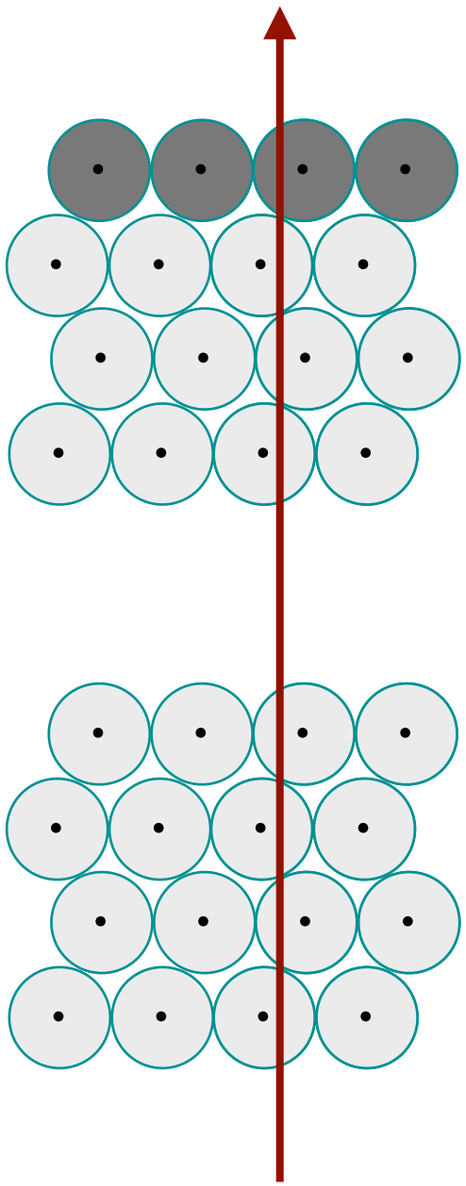
Maximum drift time distribution



No outliers in the distribution - all tubes have same space drift - time relationship

Muon detection efficiency determination

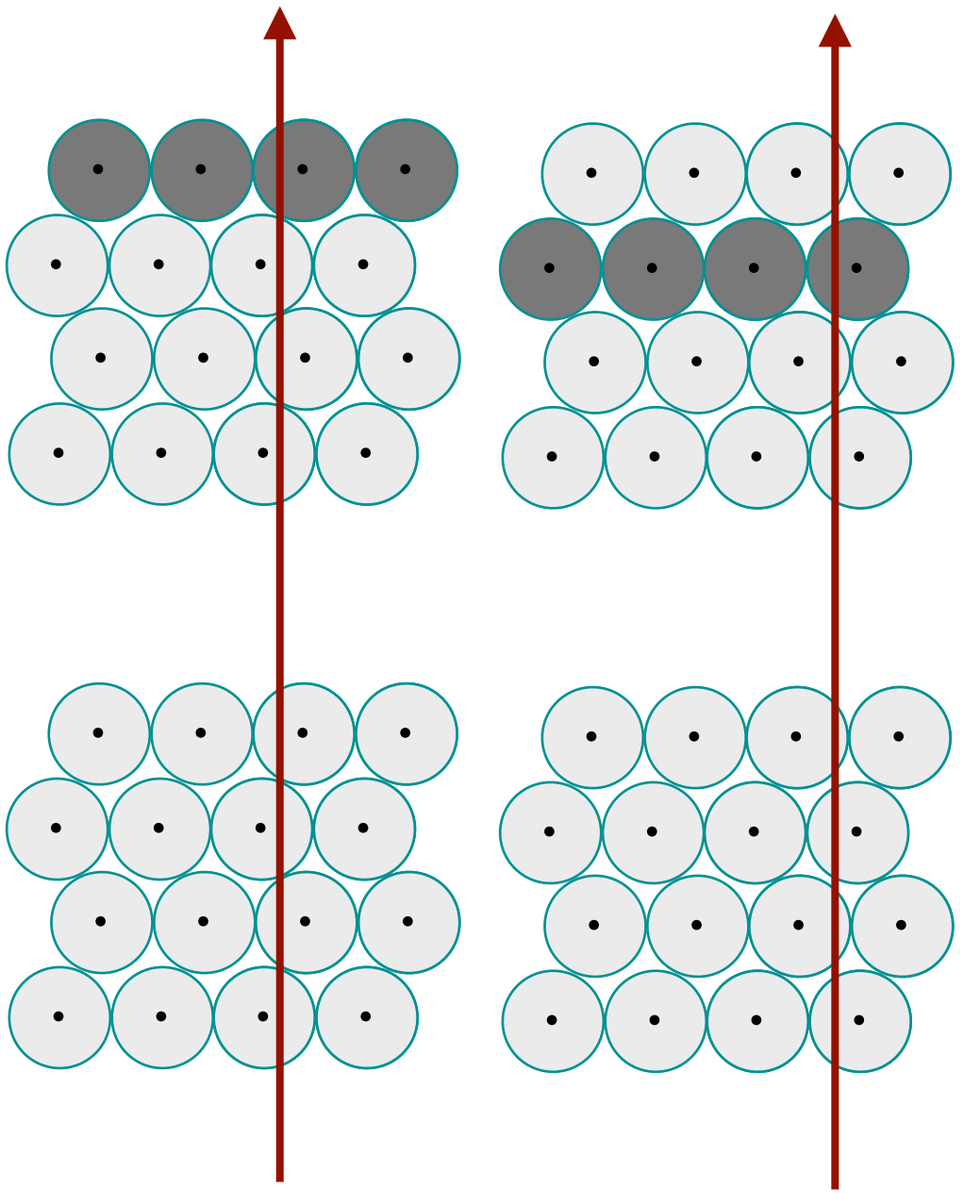
The muon detection efficiency can be determined for every tube.



- Muon track is reconstructed by excluding one layers of tubes.
- Check if the tube crossed by reconstructed track in excluded layer has a hit

Muon detection efficiency determination

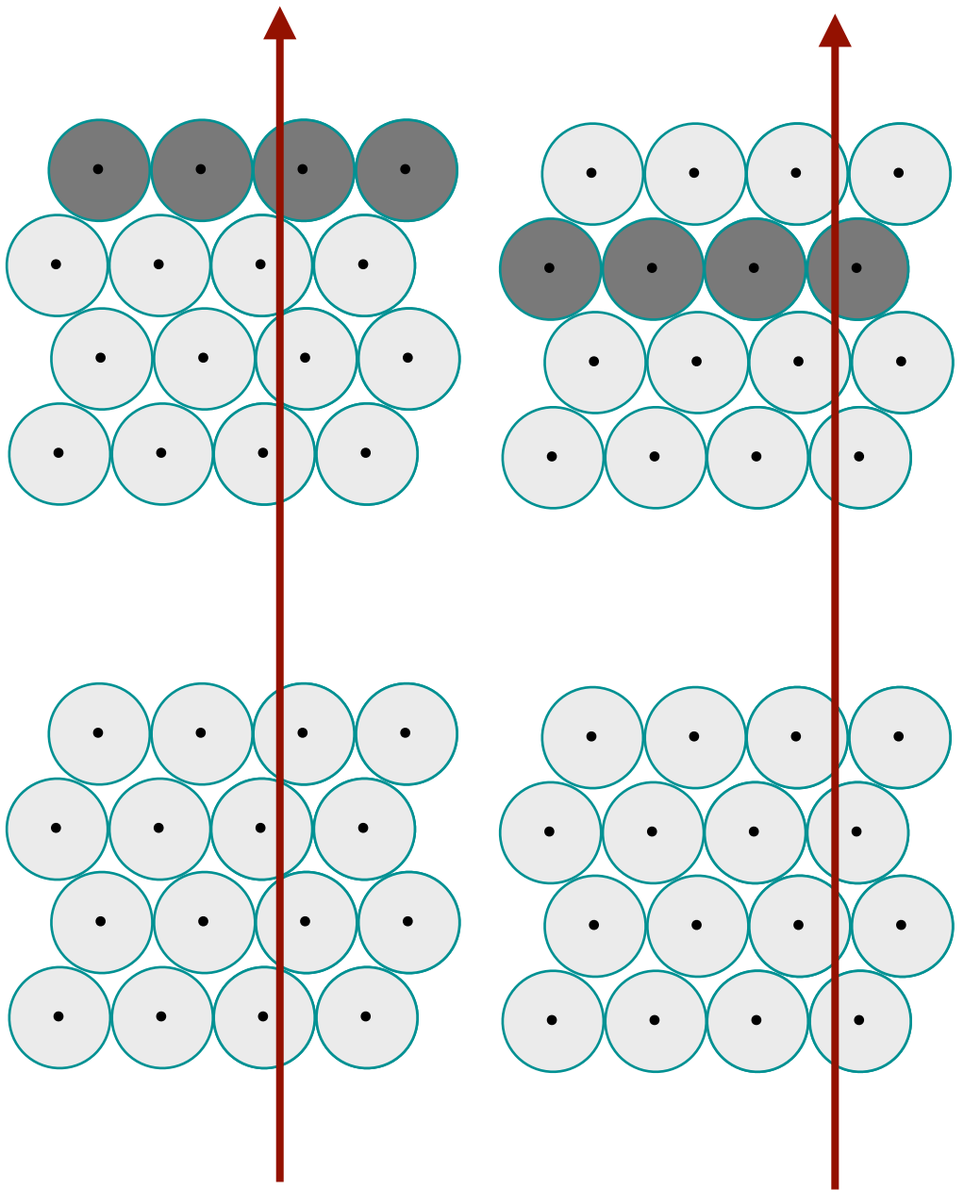
The muon detection efficiency can be determined for every tube.



- Muon track is reconstructed by excluding one layers of tubes.
- Check if the tube crossed by reconstructed track in excluded layer has a hit
- Repeat same process for every tube layer.

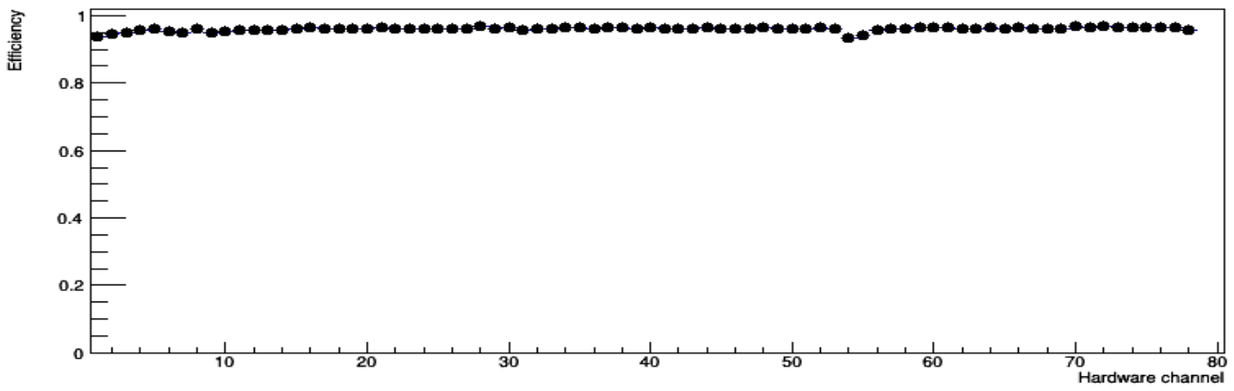
Muon detection efficiency determination

The muon detection efficiency can be determined for every tube.



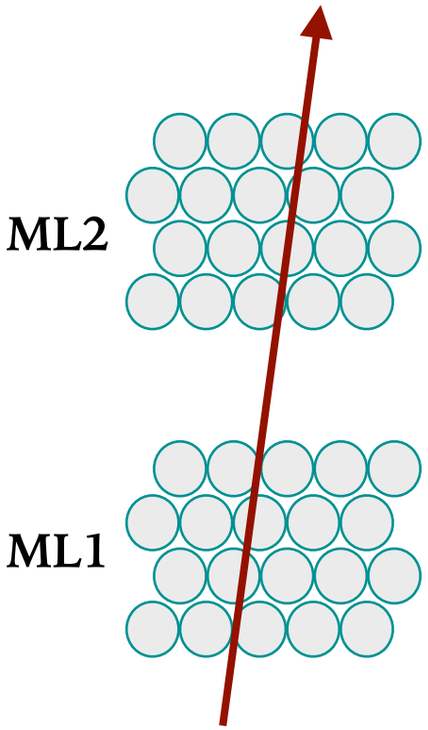
- Muon track is reconstructed by excluding one layers of tubes.
- Check if the tube crossed by reconstructed track in excluded layer has a hit
- Repeat same process for every tube layer.

A4



- **Tube efficiency in the first layer**

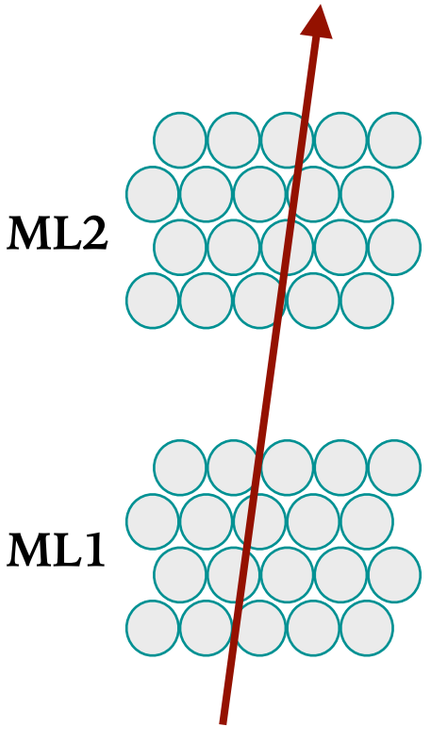
Muon detection efficiency



- Dependency of the muon detection efficiency on the applied high voltage was tested

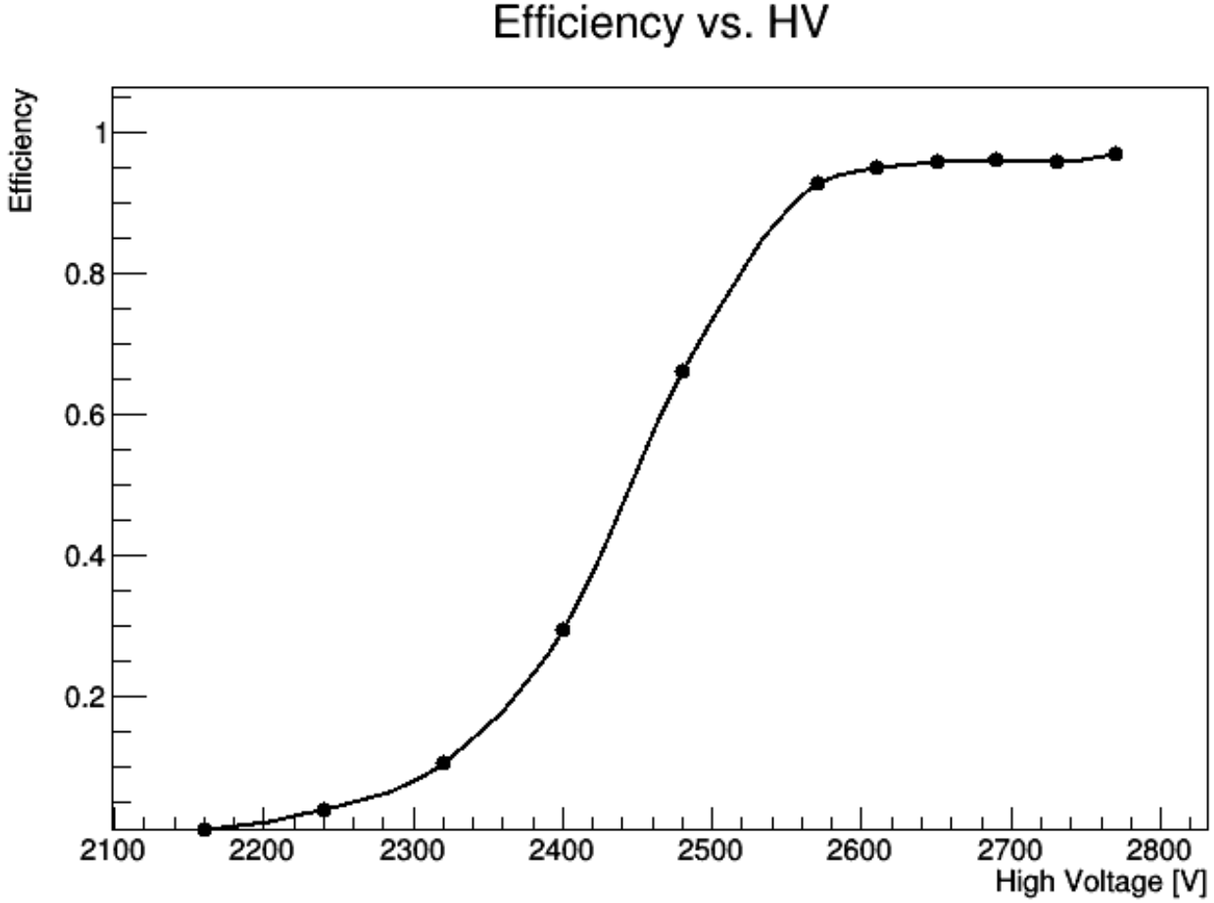
- Multilayer 1: **+2730 V** (Operational voltage)
- Multilayer 2: Applying voltages from +2160 V to +2770 V
- For each voltage cosmic ray data were taken

Muon detection efficiency



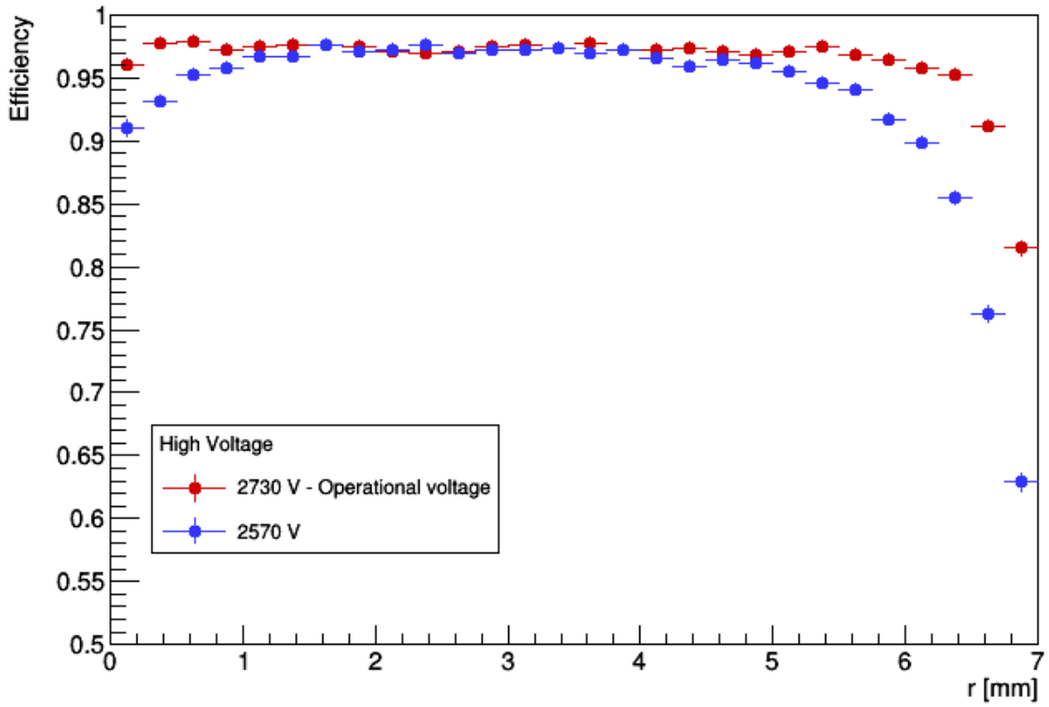
- Dependency of the muon detection efficiency on the applied high voltage was tested

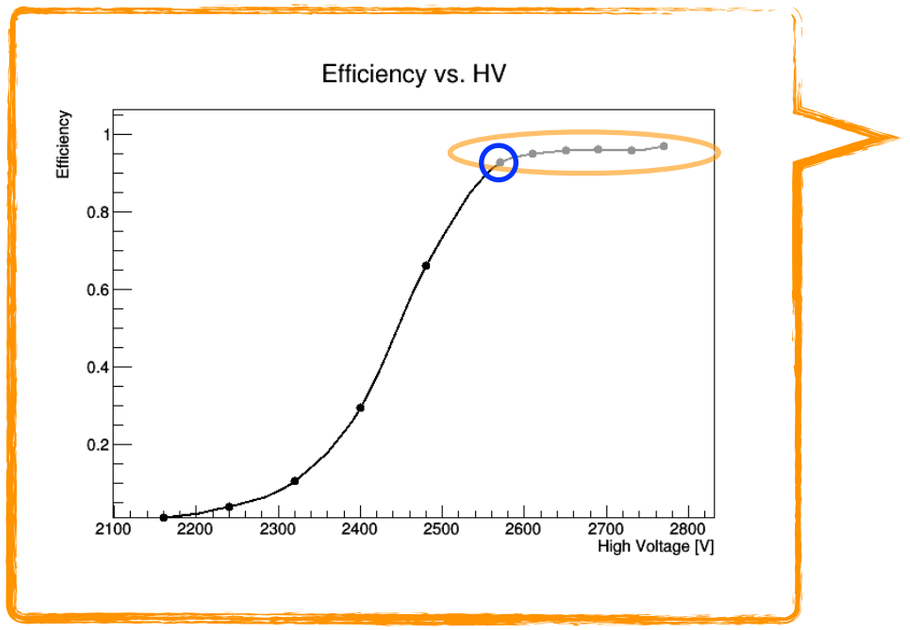
- Multilayer 1: **+2730 V** (Operational voltage)
- Multilayer 2: Applying voltages from +2160 V to +2770 V
- For each voltage cosmic ray data were taken



Efficiency plateau region

Changes in the efficiency with drift radius

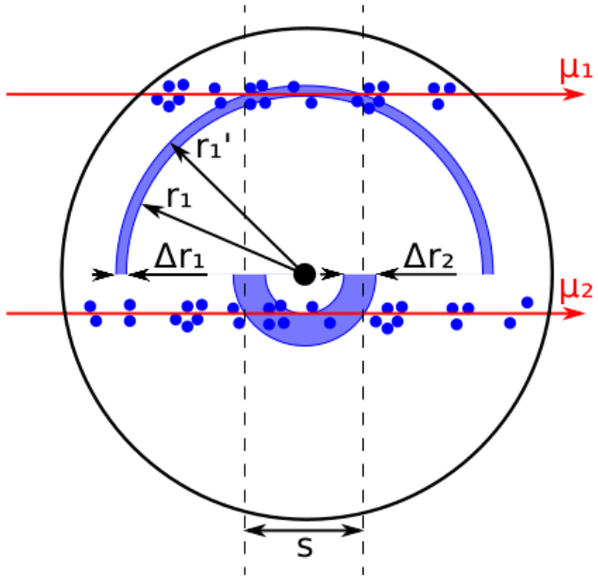




- **Close to the tube wall:** Not enough primary ionisation electrons to cross threshold

- **Close to the wire:** Primary ionisation clusters do not arrive at the same time
  - Effect larger at lower wire potential.

    G (2570 V) = 0.5 G (2730 V)



Summary

Tested chambers fulfill the requirements:

- Low noise rate counts
- Expected spatial resolution
- Muon detection efficiency and maximum drift time distribution shows that performance of the chamber is uniform

Summary

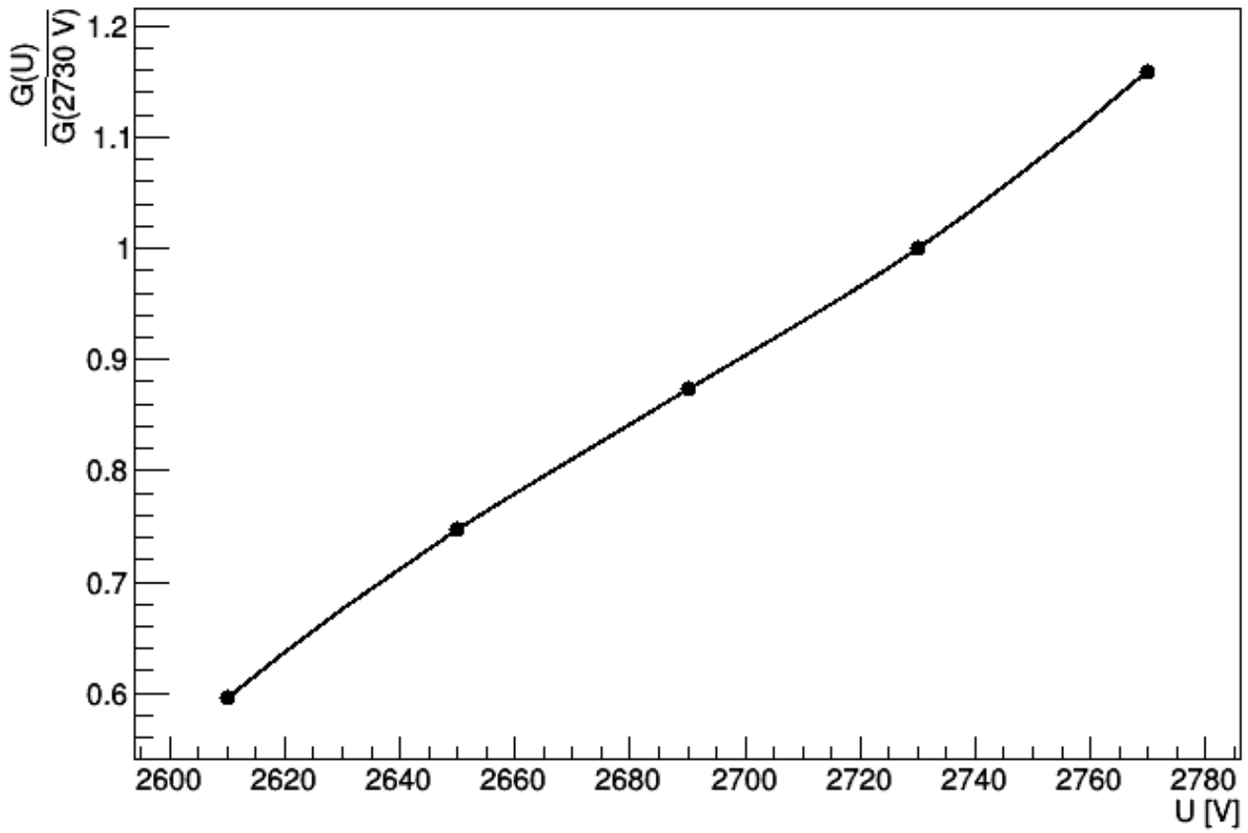
Tested chambers fulfill the requirements:

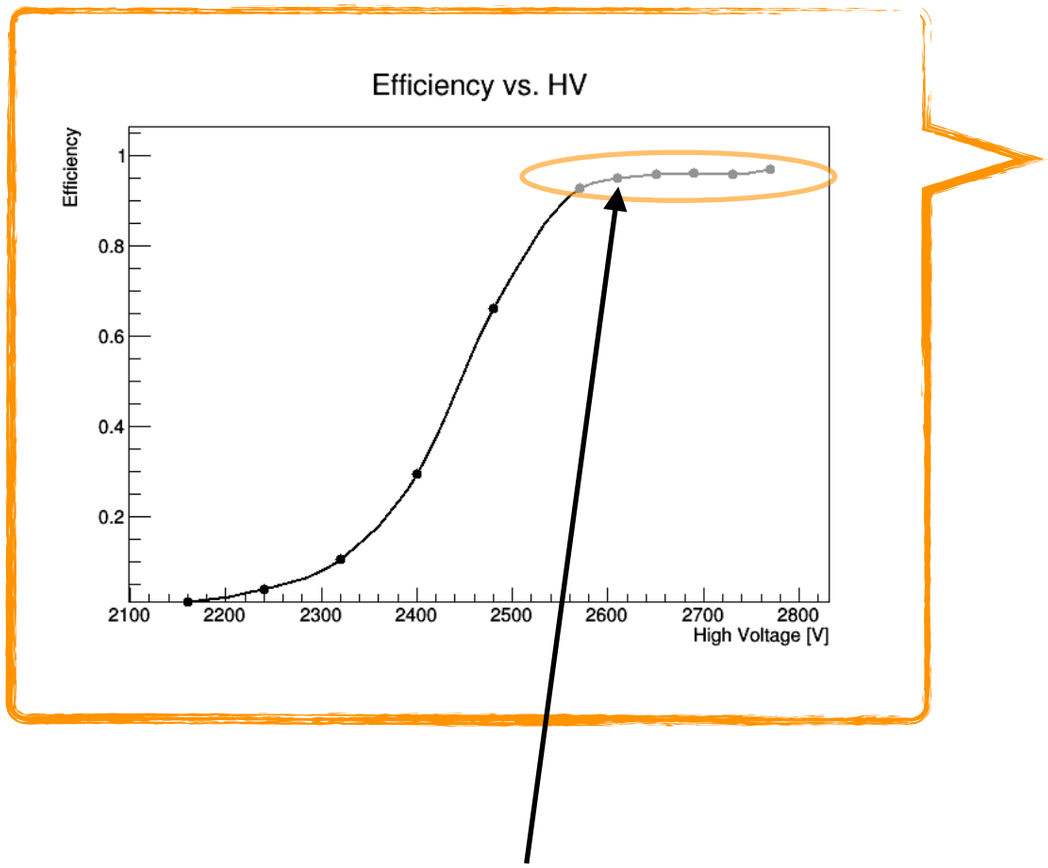
- Low noise rate counts
- Expected spatial resolution
- Muon detection efficiency and maximum drift time distribution shows that performance of the chamber is uniform

Thank you!

Efficiency plateau region

Gas gain dependency of the high voltage





60 % of the nominal gas gain