Performance Study of HL-LHC ATLAS RPC Prototype

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RPC prototype for HL-LHC ATLAS

- In the future, the instantaneous luminosity of LHC will reach a very high level. RPC in current ATLAS can not afford so high current.
- New type of RPC with 1 mm gas gap, 1.2 mm electrodes and new high sensitivity front end electronics, has been designed for the HL-LHC ATLAS upgrade program
- Lower current in gas gap
- Higher time and spatial resolution
- Less dead time and smaller dead region
- Suitable for the narrow space
- > A chamber consisting of a triplet of 50x100 cm^2 RPC was performed a beam test in Gif++
- ➤ A full analysis has been done to study the performance

Beam Test in Gif++

➢ Beam&Source

- Data taken with muon beam and gamma intensity up to 20 kHz per cm² estimated counting rate
- Beam: Circle with diameter ~10cm
- Beam rate: ~10k/spill(1 spill is about 3s)
- Chamber distance 4.72m
- Source full intensity: 13.9 TBq₁₃₇Cs
- Absorption factor: X=3.3, 10, 22, 46, 100 (intensity attenuated by 1/X)

Quanvin Li(USTC)

• Extend doublet test to triplet test

Electronic system

- Readout strips, amplifier inside the chamber box
- Chamber A, B and C
- 8 most-central readout channels along both X and Y
- Waveform is 1024 points and 0.4ns resolution



Waveform of a random trigger



> Photon signal:

- Random time in waveform
- Small amplitude
- Hit in single chamber
- > Muon signal:
- 200ns before coincidence

trigger

- Large amplitude
- Hit in double chamber
- Rate: ~40Hz/cm²(Only 1 signal

in 400ns time window)

Photon rate and Charge per event



➤ Effective HV is the voltage applied to gas.

EffectiveHV = AppliedHV – Current * ResistanceOfBakelite

Charge per event are larger than expected while the photon rate is lower. Correlated with threshold, gas gap and electronic system.

Efficiency



- Working Region in HV>5400
- High efficiency in plateau region: ~98%

*ABS factor 22(the green line) is similar with the real situation of LHC(600 Hz/cm2 in BI region)

Time Resolution



- Electrons drift speed has a large fluctuation -----> Bad resolution in low HV region
- Region in HV>5400V : RPC has a good working condition
- Time resolution around 400ps

Hit position



- Hit position is got by fitting amplitude vs strip $f(x) = a(|x| b)^{c} + d$
- The distribution is similar to be an uniform distribution

Spatial Resolution



Position difference between signals in 2 chambers.



• Spatial resolution by fit: 0.1cm

Cluster size modification



- Observed in doublet chambers, cluster
 size is very large
- Modification to chambers:
- Surface resistivity of graphite layer: 120kOhm/square to 620kOhm/square
- Optimize the terminal resistance
- Isolate the strips by metal wire
- Cluster size improved
- Preliminary result

Cross-talk study

RPC chamber structure

• 3 Singlet to 1 triplet

> Advantages:

- Save space
- Coincidence trigger by itself
- Combined measurement

≻ Method:

• Keep 1 chamber on, 1 chamber off. Calculate the efficiency of the off chamber.

≻ Result:

- For muon:
- Only 1 random coincidence in 10k signals

- For gamma:
- Only 1 random coindence in 20k signals

≻ RPC Prototypes for HL-LHC work in a good condition

- Efficiency in plateau region: ~98%
- Time resolution: 400ps
- Spatial resolution: 0.1cm
- Cluster size has been improved to a much better result
- Study of cross talk in triplet chambers
- Study the work condition of triplet chamber as a trigger model



Charge distribution for muons in different HV



Amplitude is proportional to the charge.



Efficiency vs threshold



Fit by time pass threshold

