Development of RPC with heat strengthening (HS) glass

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- **Introduction**
- **Properties of new glass**
- **Noise rate and dark current**
- **Cosmic muon detection efficiency**
- **Time resolution**
- **Summary**

Comparison with RPC of normal glass

Introduction

- **A large fractions of experiment in high energy physics use RPC for trigger/tracking of charged particle.**
- **Glass and Bakelite two resistive materials used for RPC**
- **But,**
  - **Production of large scale bakelite is not easily available**
  - **Handling a large glass gap requires special care**
- **An attempt is made to look for hard glass to make RPCs and compare its performance with normal glass RPC in the same environment.**
  - **Started with heat strengthening (HS) glass, which is approximately twice hard than normal glass**

Properties of heat strengthening (HS) glass

- In furnace, glass is sent into a heating chamber at 690 ^{0}C and will be heated for 300 sec., and then gradually it will be cooled to atmospheric temperature (~60sec, but not a controlled cooling). ~twice hard than normal glass (Surface test : 40 Mpascal)
- This is in comply with European standard, EN 1863: Parts 1&2.
- Physical properties of glasses are remain same (Atomic force microscope for surface quality and electron mass spectroscopy for composition

Normal glass

Spectrum	O	Na	Mg	Al	Si	Ca
Spectrum 1	50.74	8.61	2.35	0.44	32.23	5.62
Spectrum 2	52.14	9.17	2.38	0.45	30.76	5.10

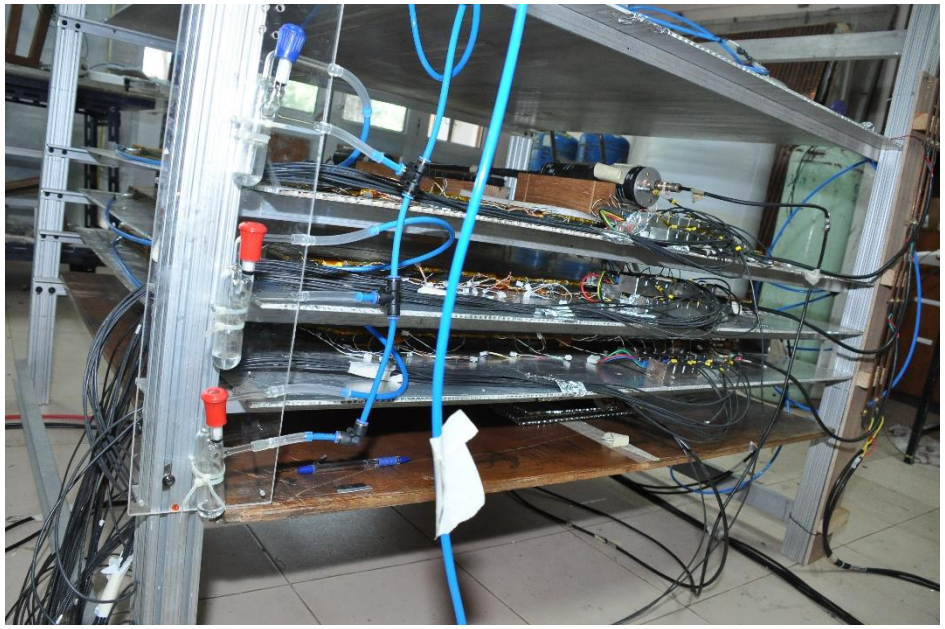
HS glass

Spectrum 1	53.87	9.13	2.31	0.52	29.79	4.03
Spectrum 2	53.92	9.27	2.36	0.49	29.60	4.04

~0.35% K in both cases

RPC with HS and normal glass

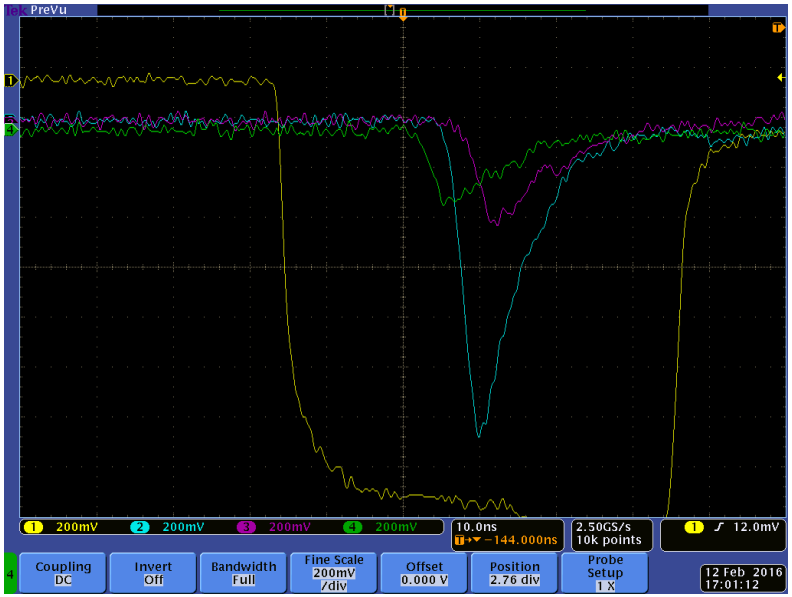
- Thickness of glass is 3mm and gap is 2mm
- 1st set : Two RPC of size 30cm × 30cm and tested along with a RPC Of normal glass
- 2nd set : Two RPC of size 1m × 1m and tested along with a RPC Of normal glass

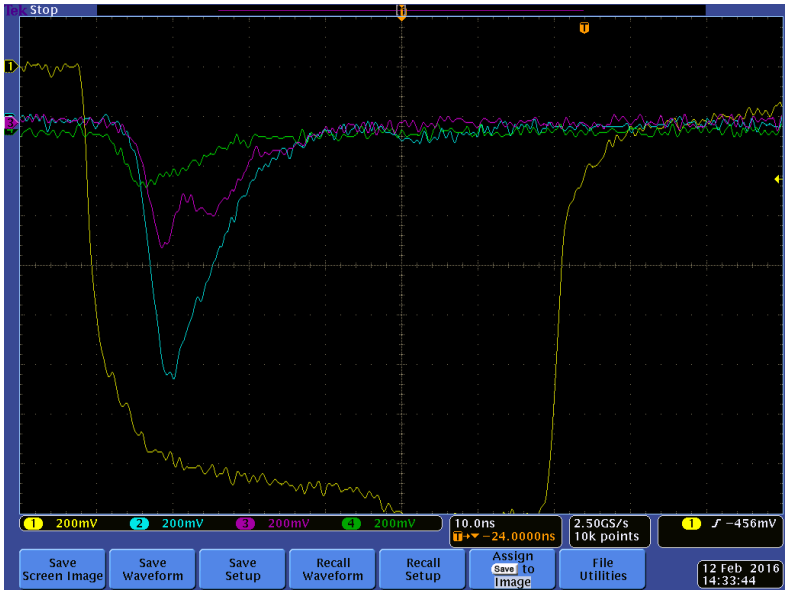


All detector are operated at 2mbar above atmospheric pressure with gas composition

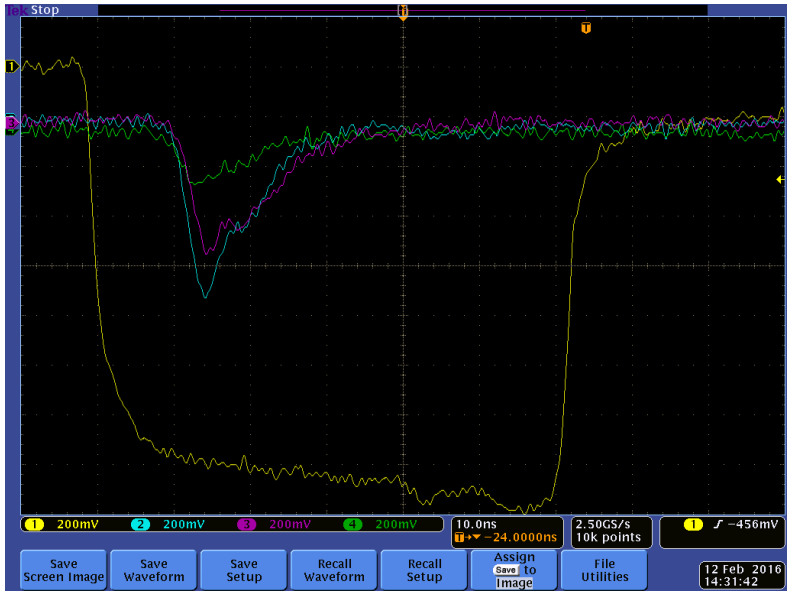
R134a($C_2H_2F_4$) : Isobutane(C_4H_{10}) : Sulphur Hexafluoride(SF_6) :: 95.3 : 4.5 : 0.3 and flow rate ~2 SCCM per RPC (1m × 1m) or through all 30cm × 30cm RPCs

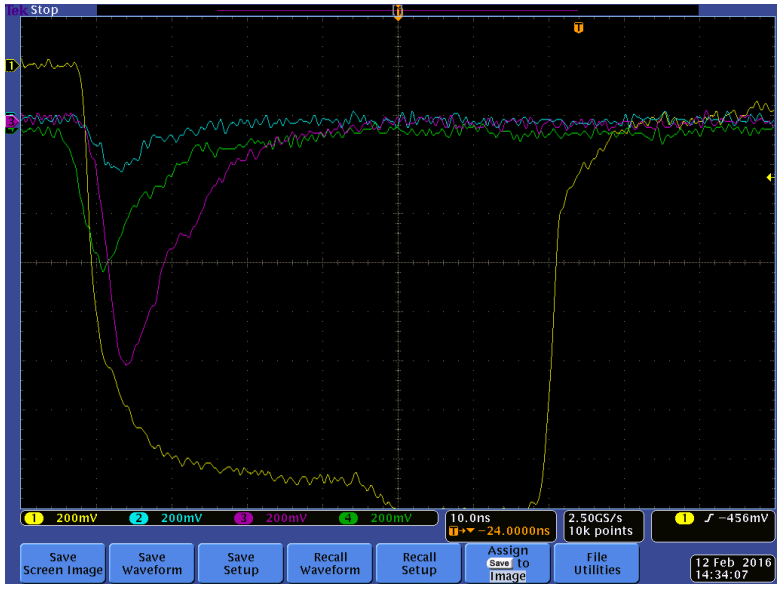
Signal of cosmic muon trajectory



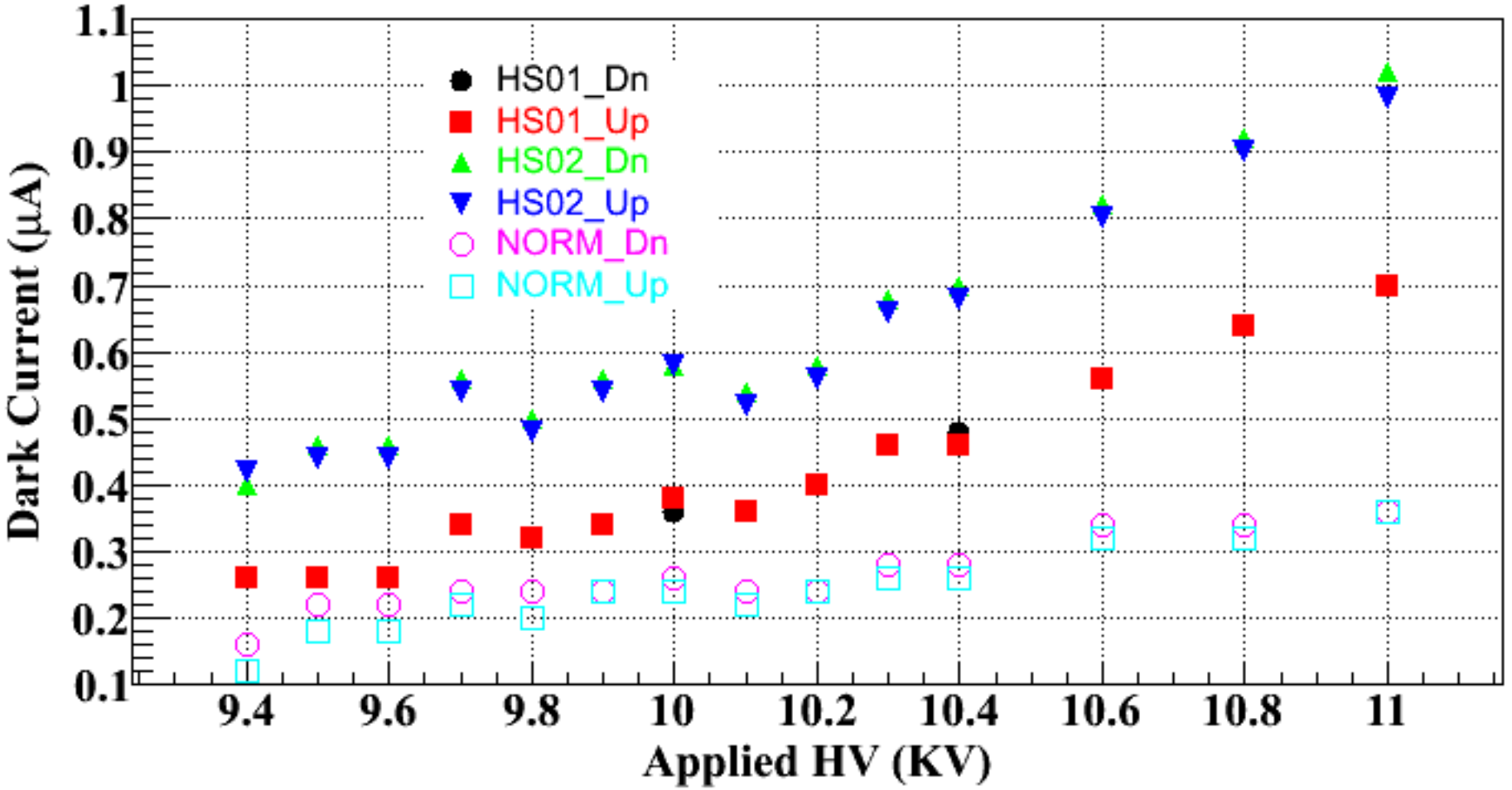


HS01
HS02
NORM





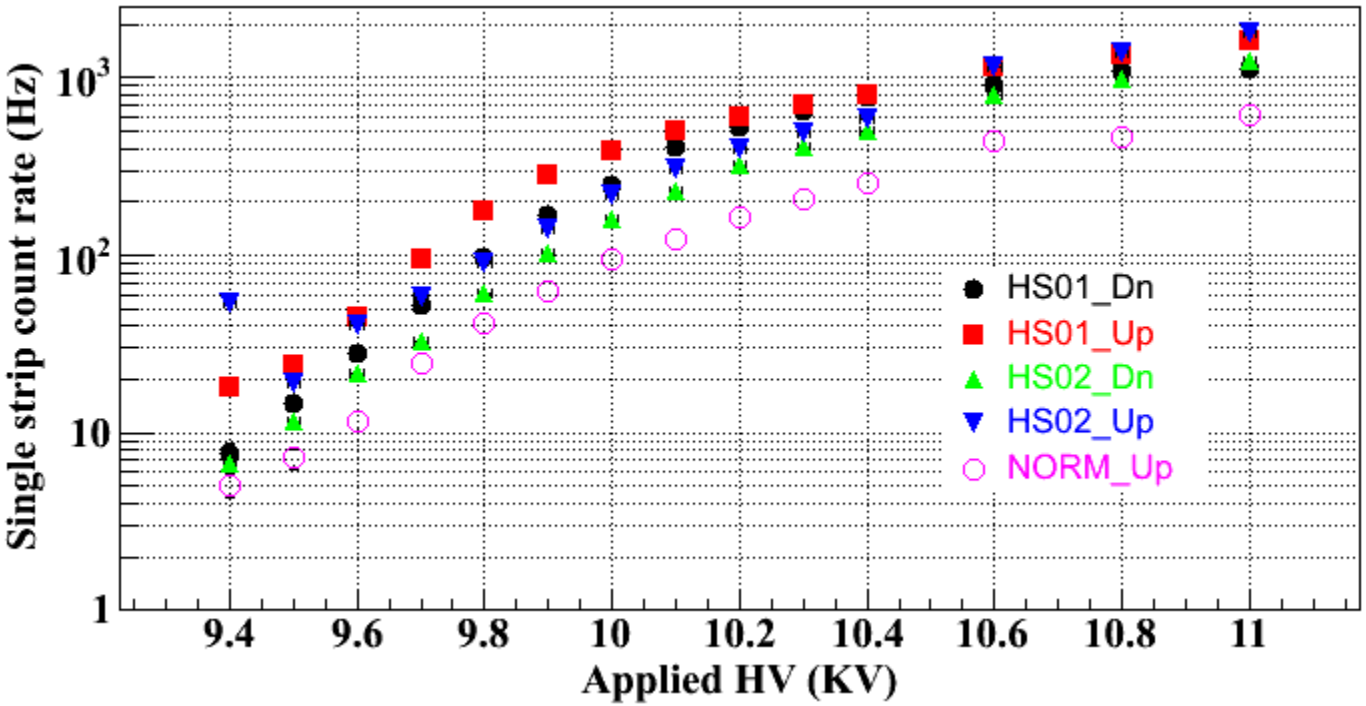
Dark current at different HV



- **RPC with HS glass shows larger dark current, though the AFM study shows no change in surface quality and EMS does not show any variation in content**
- **Yet to understand the source of large current**

Noise rate at different HV

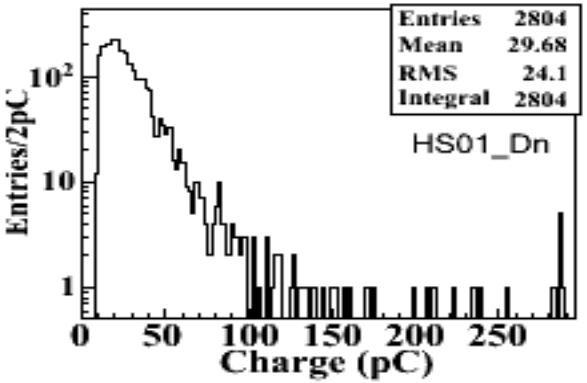
- **Honey Comb pickup panel**
  - **Core material is made up of Poly-Propylene**
  - **Thickness of core material is 5mm**
  - **Strip is made up of Cu and Ground Plan is made up of Al**
- **Strip width 2.8cm (pitch 3cm)**
- **HS glass shows larger noise (Eth = –20mV) after two stage preamplifier of combined voltage gain ~80.**

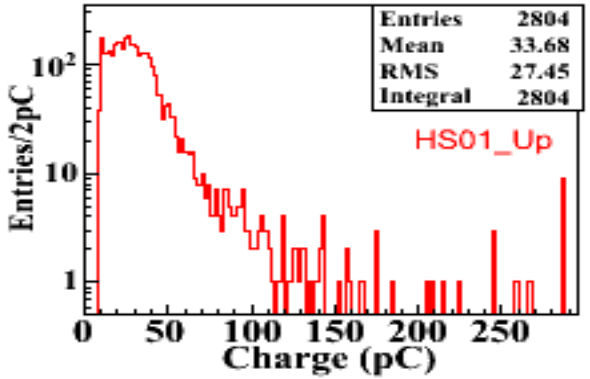


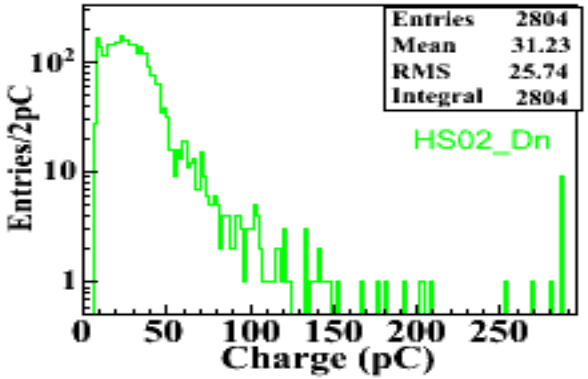
Large rate in RPCs of HS glass, which was expected from large dark current

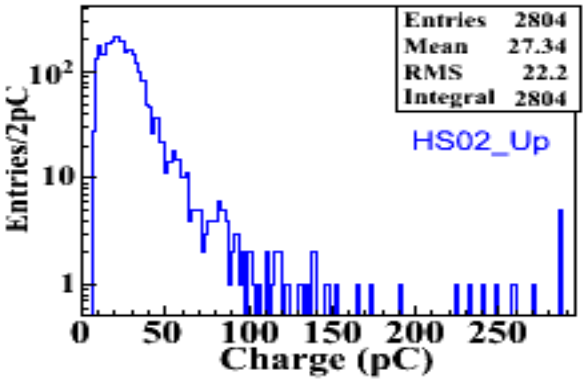
Spectrum of RPC signal

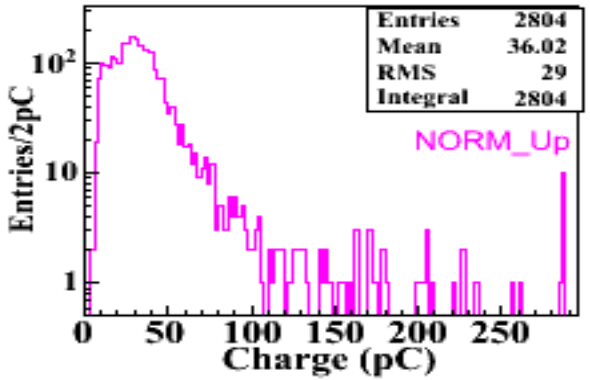
- **Events are triggered by four scintillator detector of width 2cm and muon path goes through only one strip in the RPC**
  - **Pickup strips are parallel in HS glass, so both top and bottom pickup strips in top and bottom panels collected the same induced signal.**
  - **For normal glass, strips are orthogonal (standard design is crossed pickup panel)**









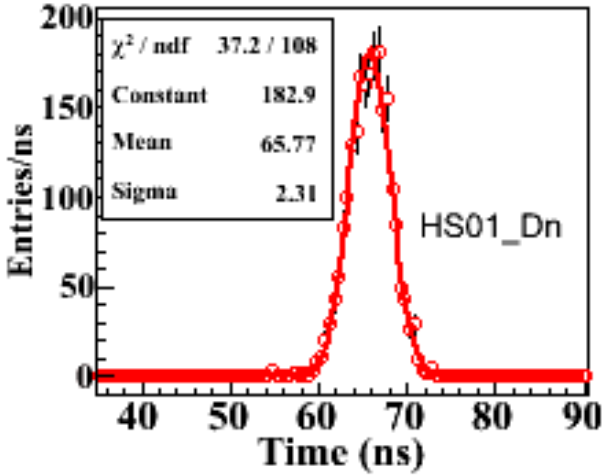


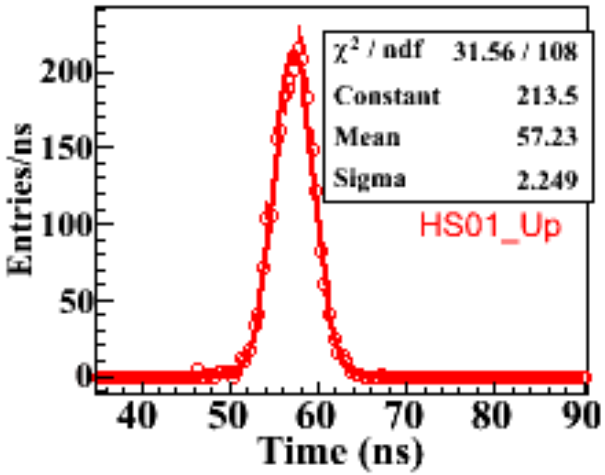
These are what we expect from an RPC signal .

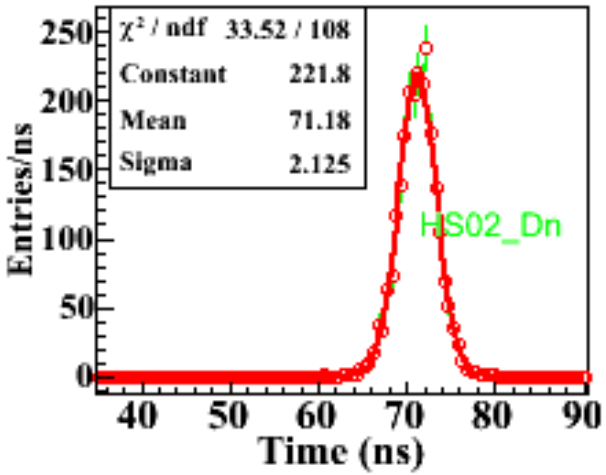
NORM : Slightly higher signal.

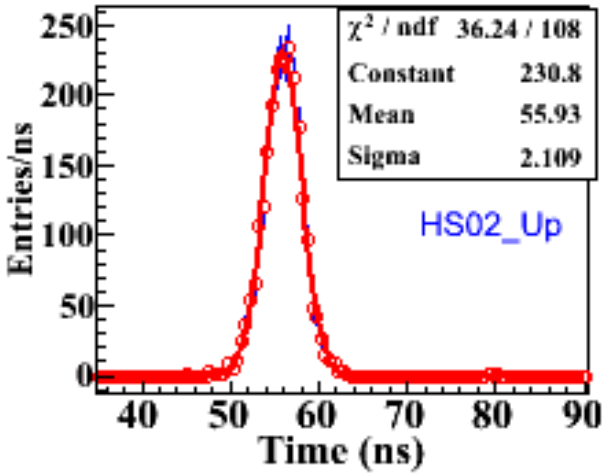
Performance of timing

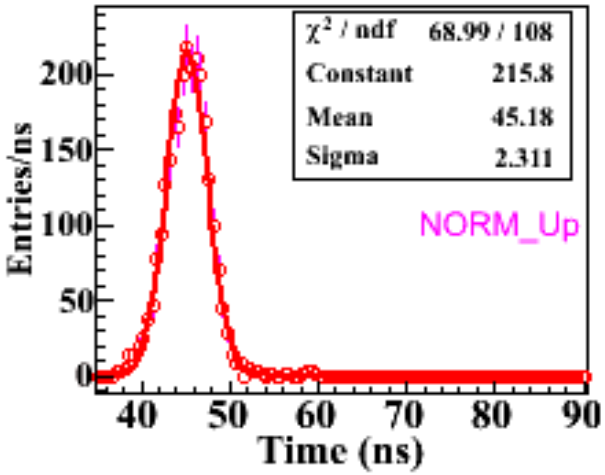
- **Events are triggered by four scintillator detector of width 2cm and muon path goes through only one strip in the RPC**







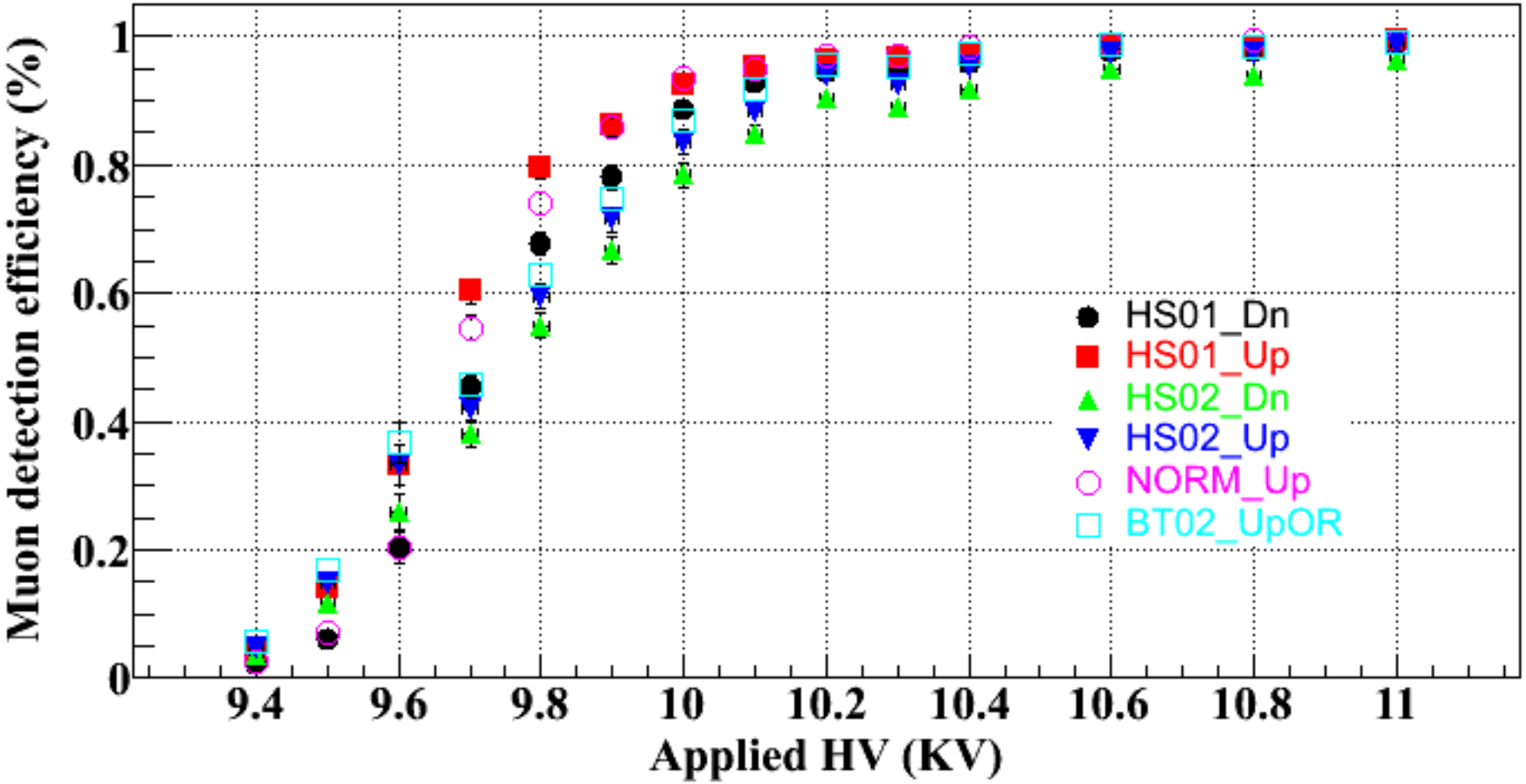




Resolution is dominated by scintillator trigger

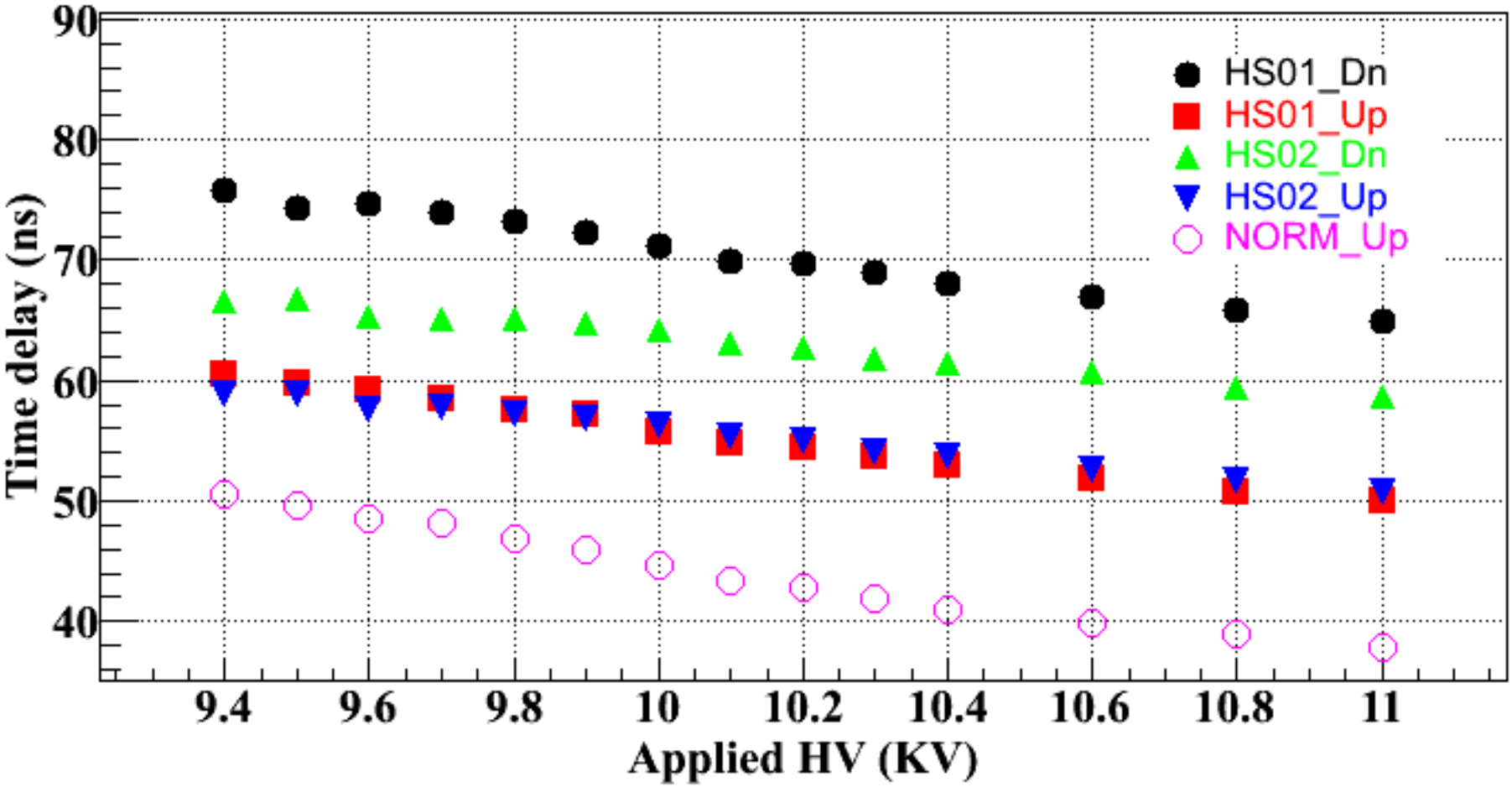
Resolutions are comparable

Detector efficiency vs applied HV



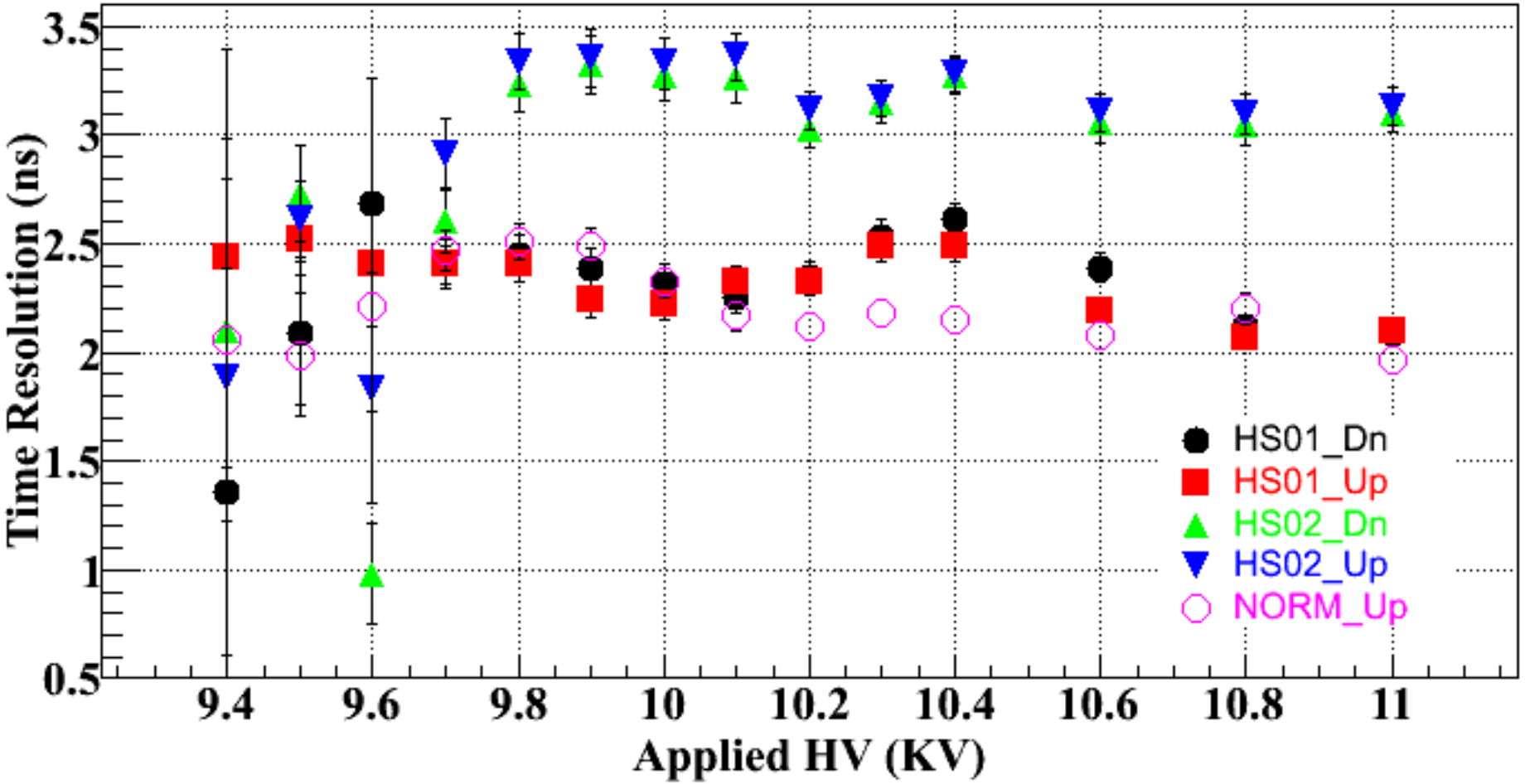
- **HS01 and NORM RPC shows similar performance, whereas HS02 is about 5-10% less efficient in identical conditions.**
- **Difference between Up/Dn could be due to slight misalignment of Strips, preamplifier etc.**

Timings for different applied HV



- **Different cable length in different channels shift the absolute scale**
- **As expected with larger gain, the timing is faster and all RPCs shows same behaviour**

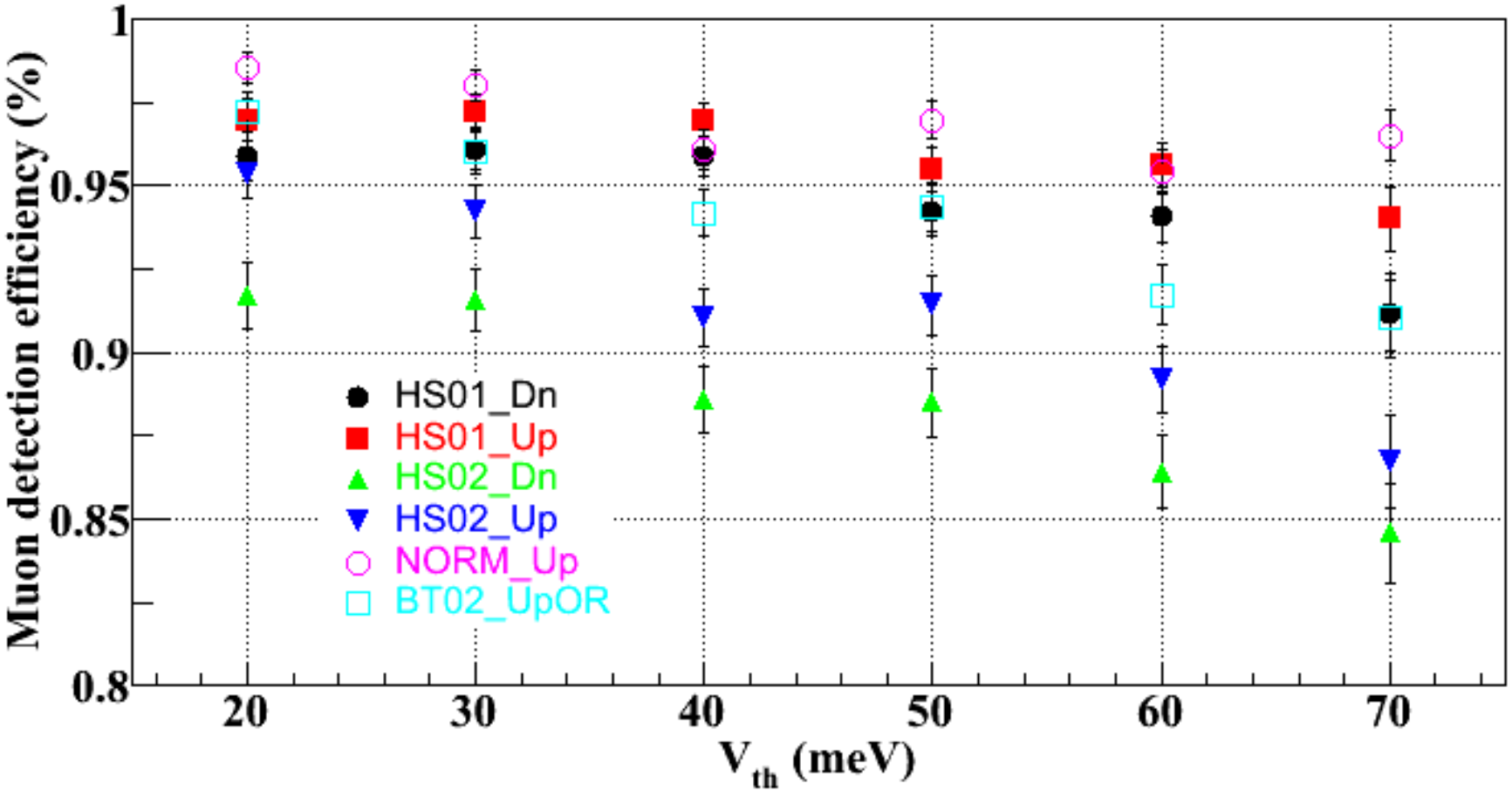
Time resolutions



- **Again HS02 shows worse performance**

Effect of threshold

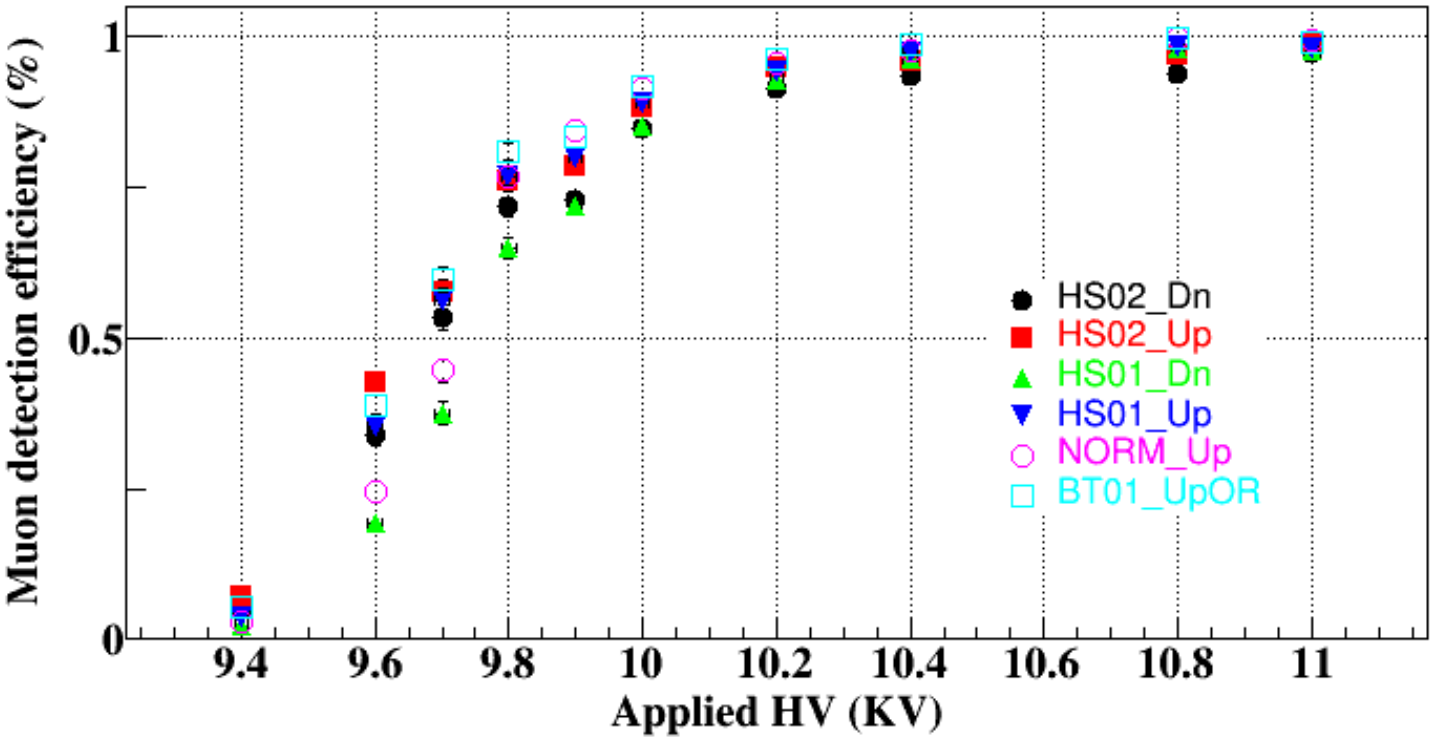
Changed discriminator threshold from –20 to –70 mV at HV=10.4 keV



Something is wrong with HS02 !!

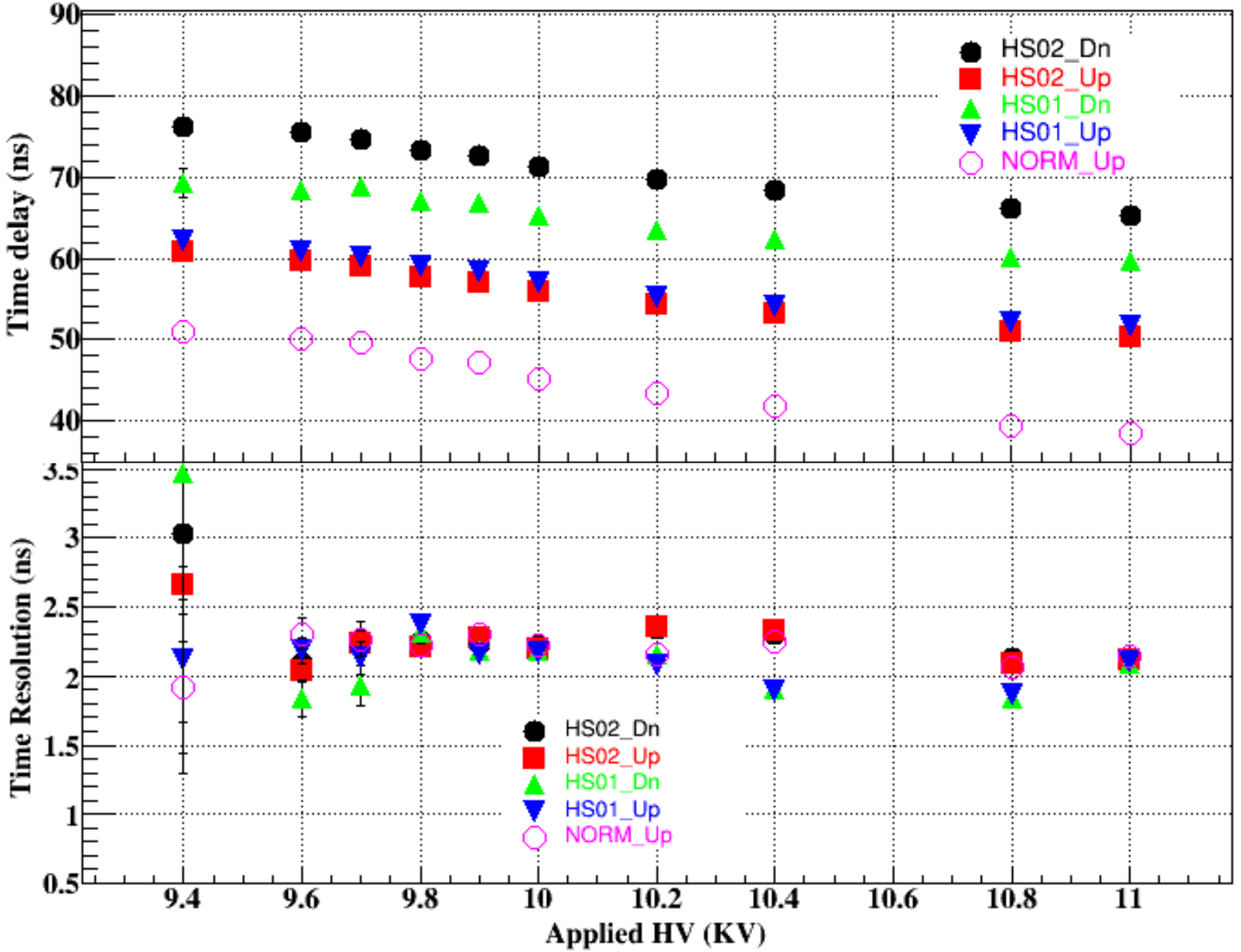
Effect of preamplifier and other electronics ?

- HS01 shows similar performance of NORM one.
- Had almost similar observation with 30cm × 3cm RPCs also
- Is it the effect of external electronics ?
- Testes with
  - Swap connection of HS01 and HS02 in the input of preamplifier



All three chambers are consistent with each other

Timings of RPCs with swapped connection



All looks like the same

Conclusion

- **Both timing and efficiency of RPC with heat strengthening (HS) shows same characteristics of RPC of normal glass**
- **Need to understand the large dark current and high noise rate of RPC with HS glass**
- **Put these RPC in the existing cosmic muon stack to calculate the efficiency and timing for the complete detector, whereas here used only a small part of the detector**
- **Make 2m × 2m RPC**
- **Go for tempered glass (for safety point of view), though this HS glass is hard enough for handling point of view.**