Performance of Double Stack MRPCs

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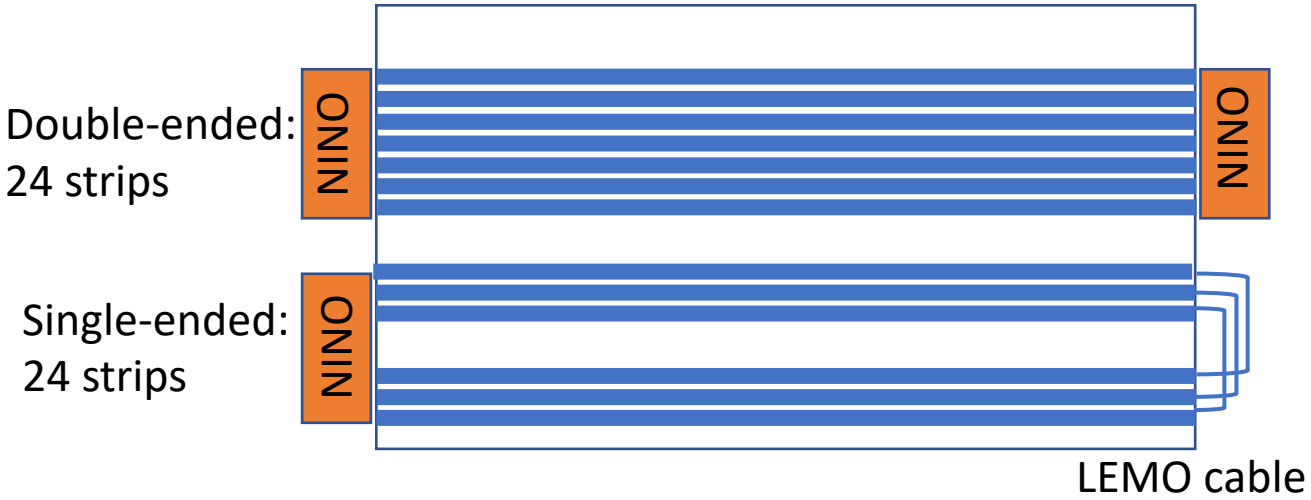
Overview

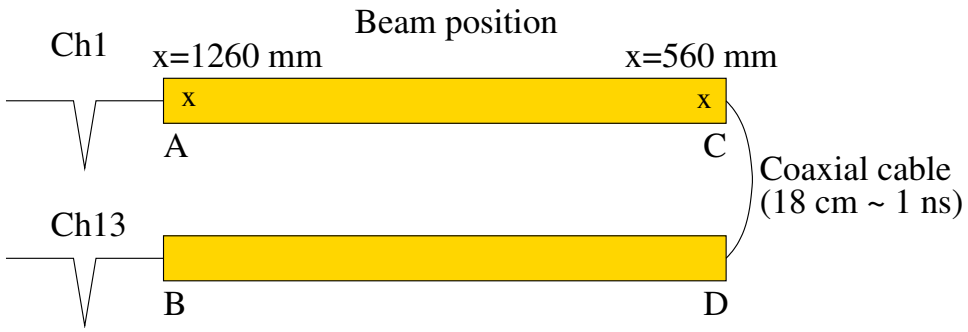
- Reminder of the double stack MRPC
- Double-ended readout MRPC
- Single-ended readout MRPC
- Summary

Reminder of the double stack MRPC

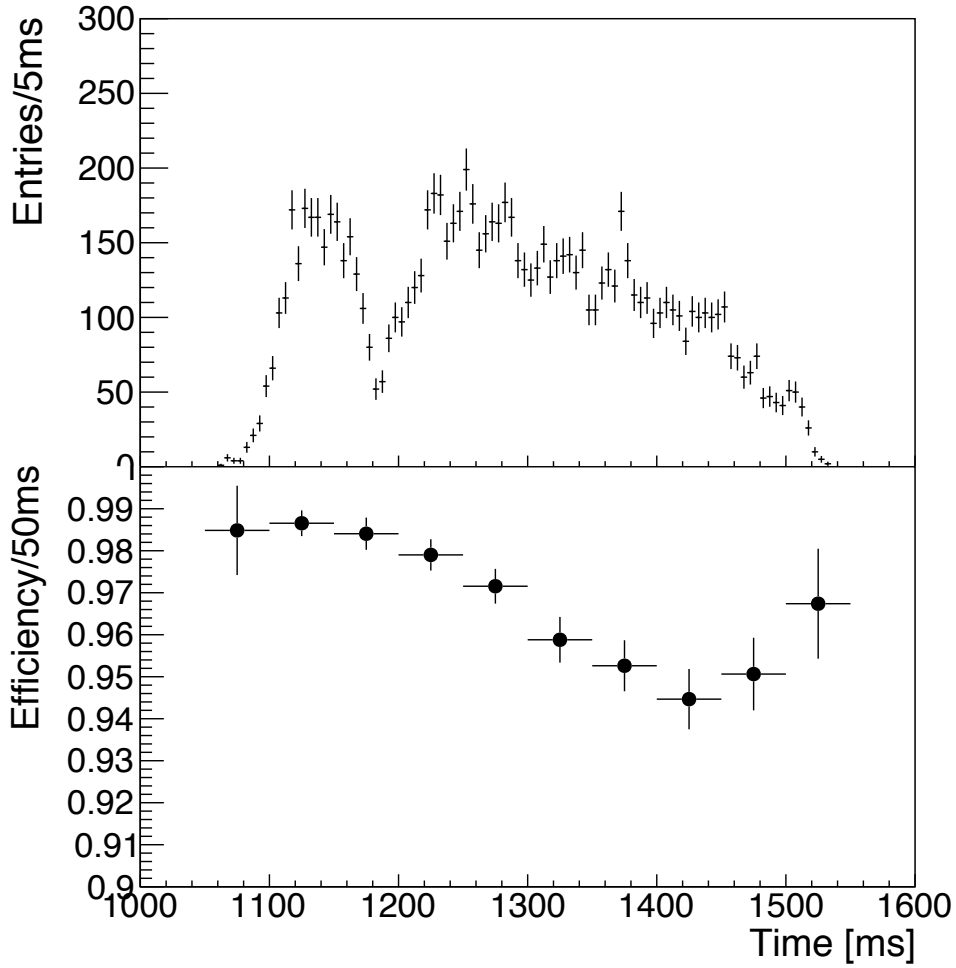
- 6 gaps of each 250 µm
- 90 cm x 9 mm strip on a 11 pitch
- Readout at double-ended/single-ended
- Teflon tube to strengthen the gas flow
- Gas: $C_2H_2F_4/SF_6$
- Instantaneous beam intensity: 2 kHz/cm^2

Set up at T10





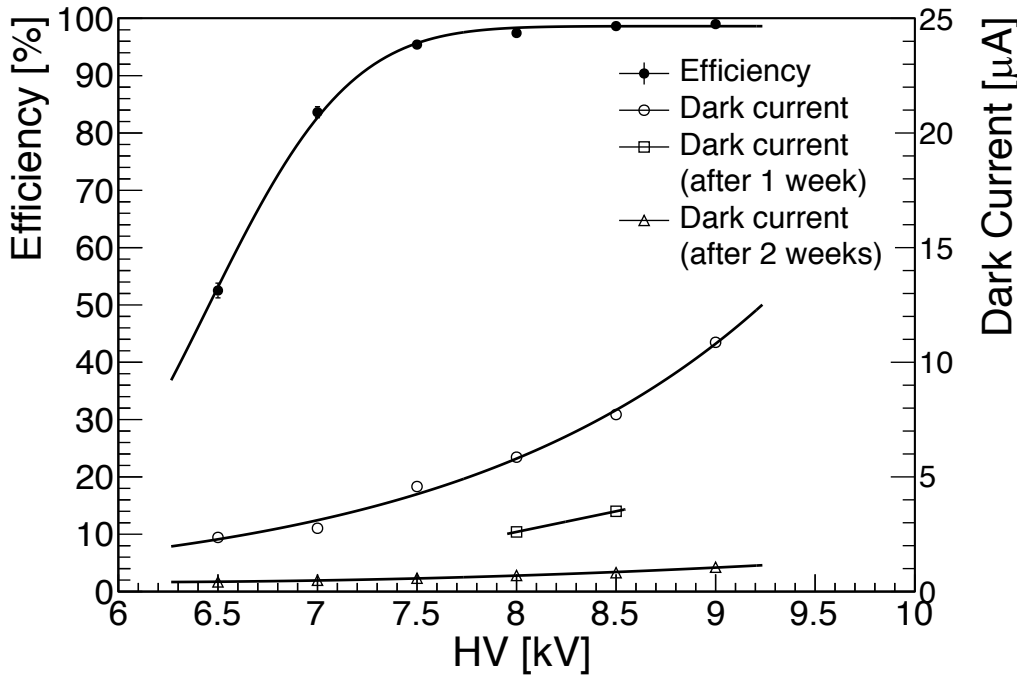
T10 beam profile

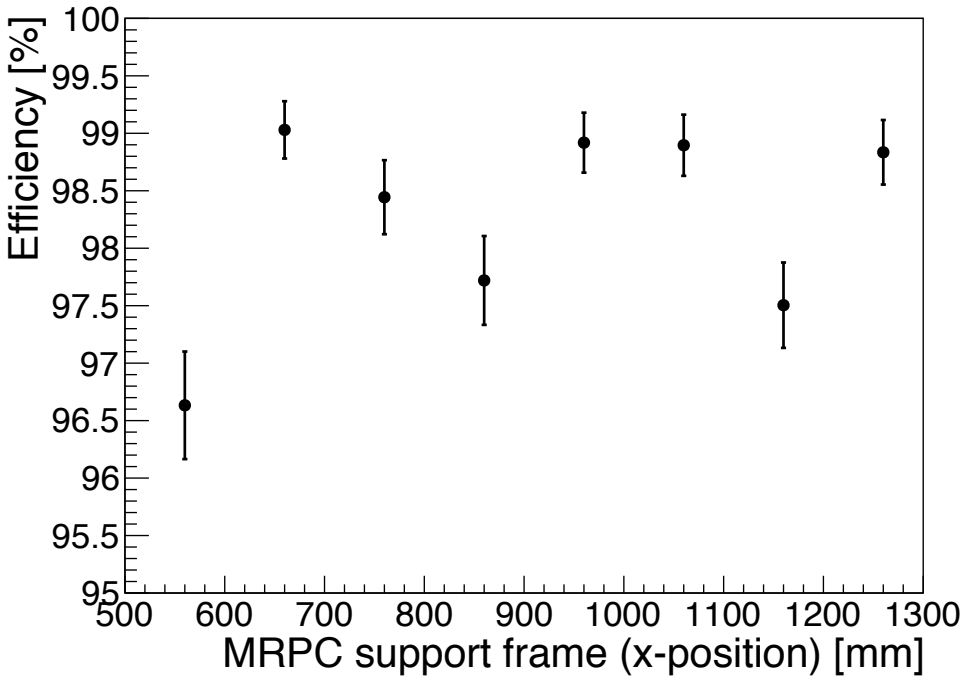


- Beam spill length ~ 360 ms
- Efficiency in every 50 ms for triggered events (instead of taking an average for total events)
- Take events during the first 100ms for efficiency calculation
- Dip near at 1200 caused by full buffering of DAQ

Double-ended Readout

Efficiency & dark current

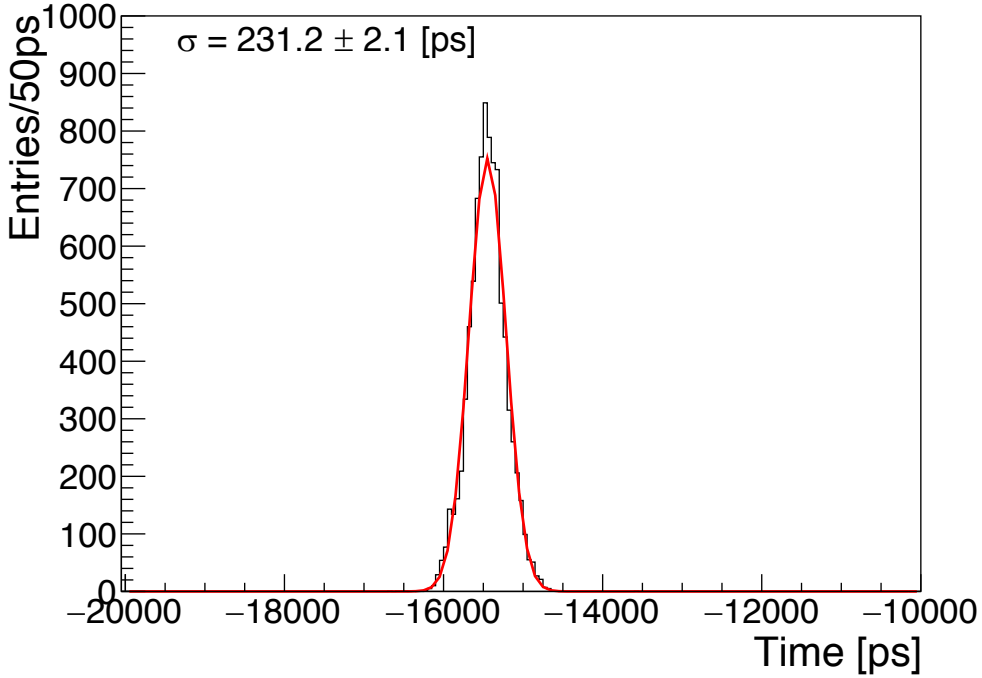


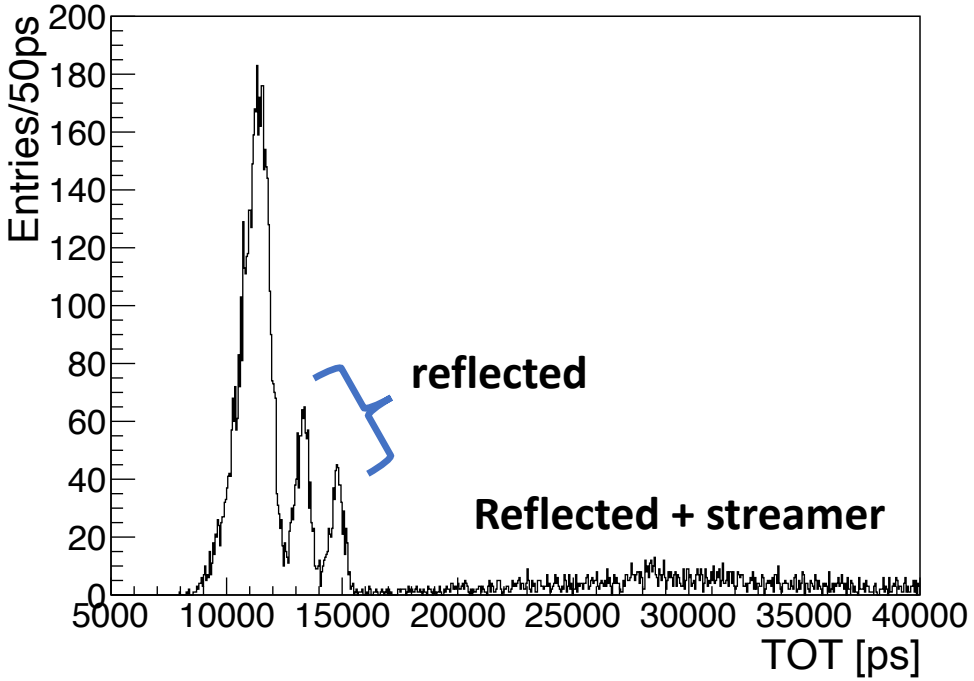


- Eff.: 98% At 8 kV (96% @7.5 kV)
- Dark current: below 1 μA after 2 weeks of flashing gas

- Efficiency along the strip length
- Taken @8.5 kV
- Eff. > 97.5%

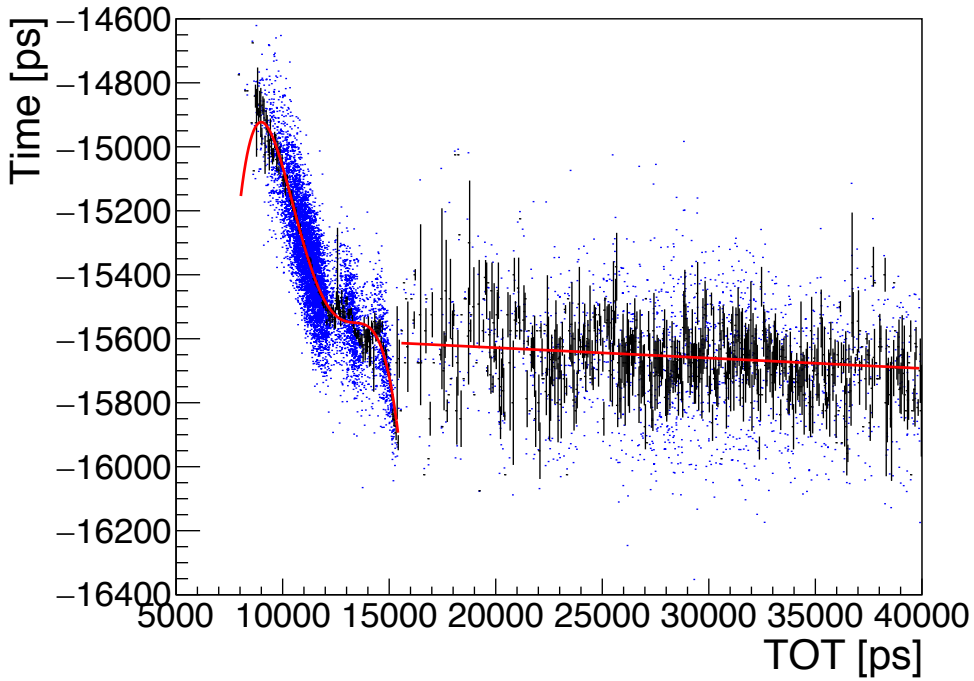
Measured Time & TOT

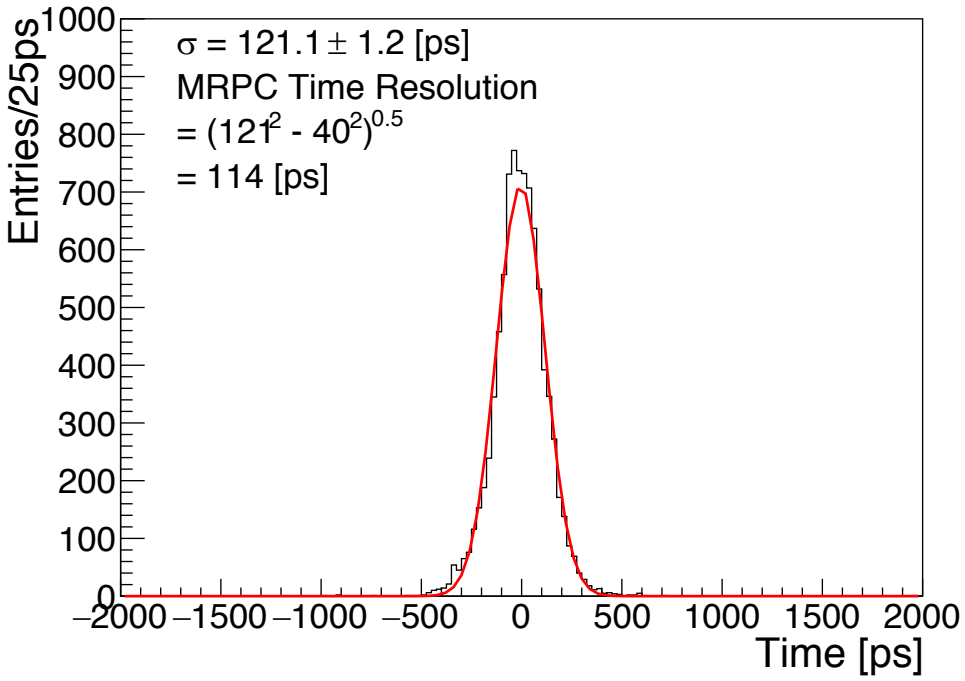




- $\sigma_{uncor.}$= 231 ps
- Two peaks: by reflected signals, beam was not in the middle of strip
- Wide distribution would be formed a combination of reflected + streamer events

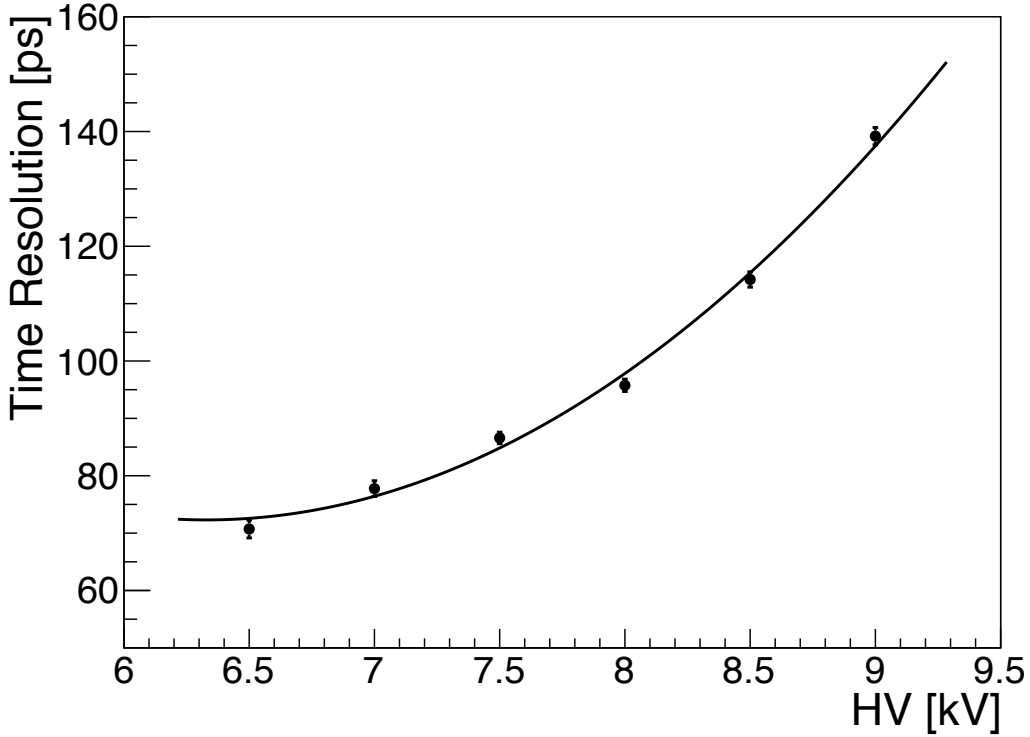
T-A correction & Corrected time

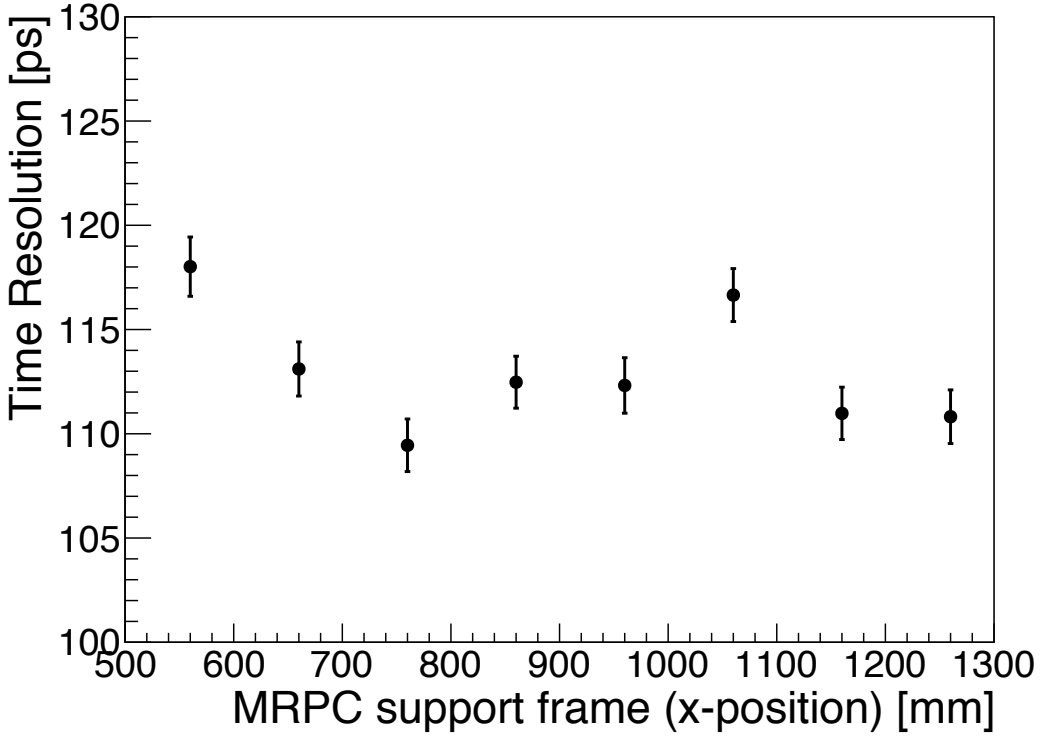




- Time-slewing correction: 4th order and linear functions
- $\sigma_{cor.}$= 114 ps, after subtraction of the timing scintillator time jitter(40 ps)

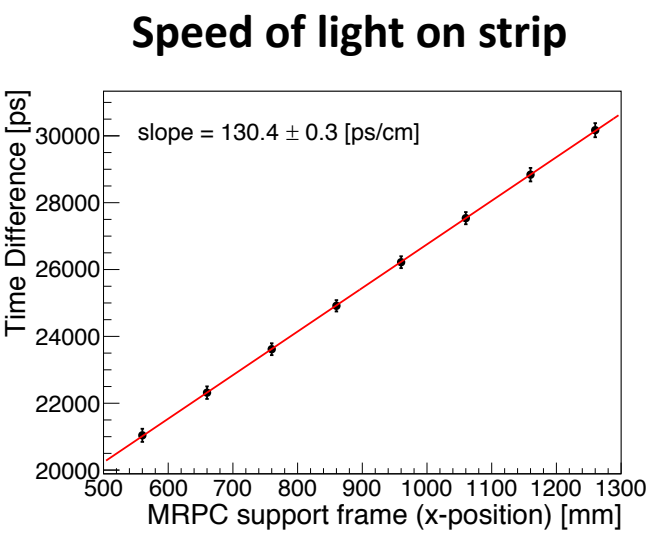
Time resolution

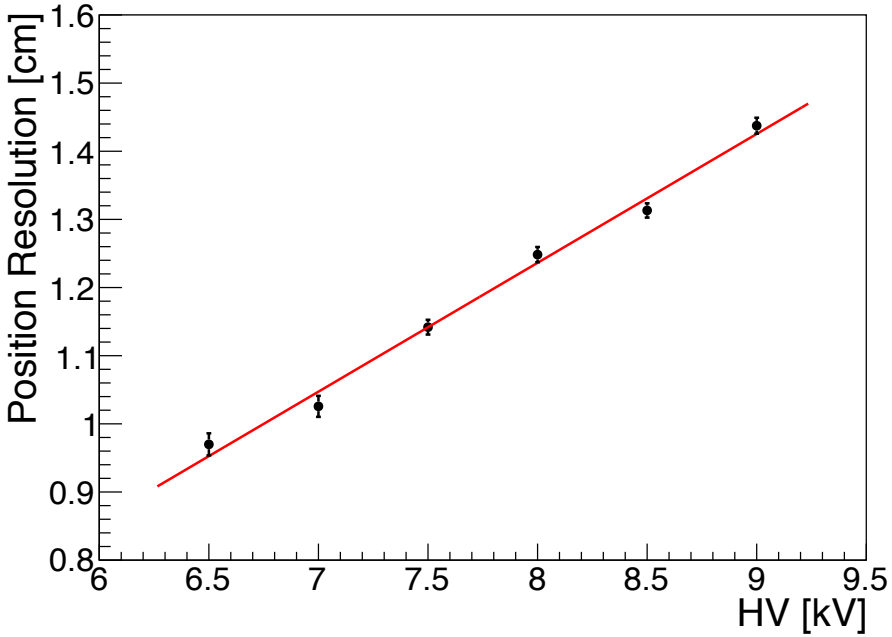


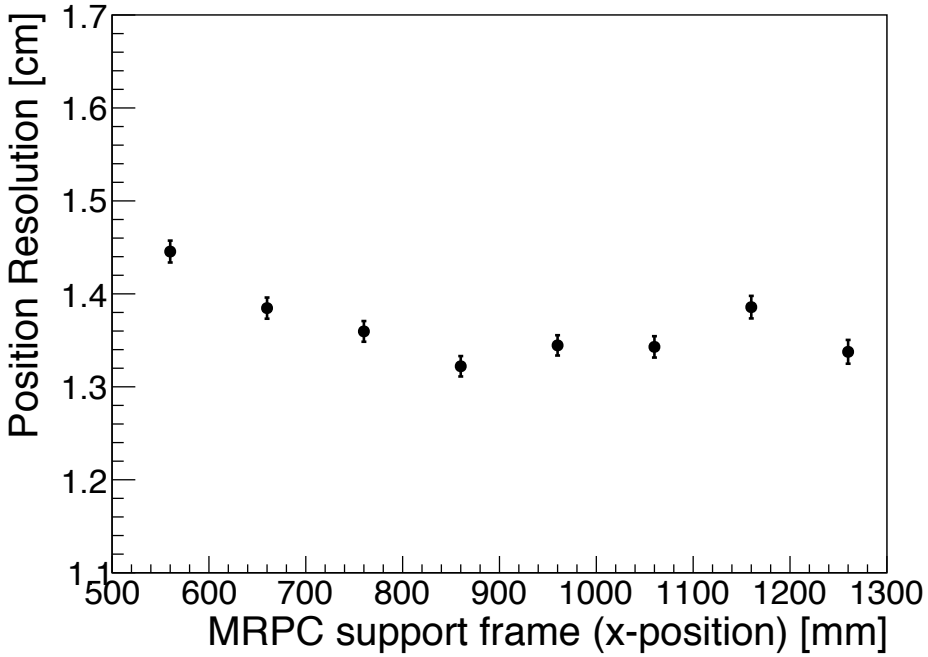


- 85-95 ps @operating voltage(7.5-8 kv)
- 110~118 ps @8.5 kV for x-positions

Position resolution

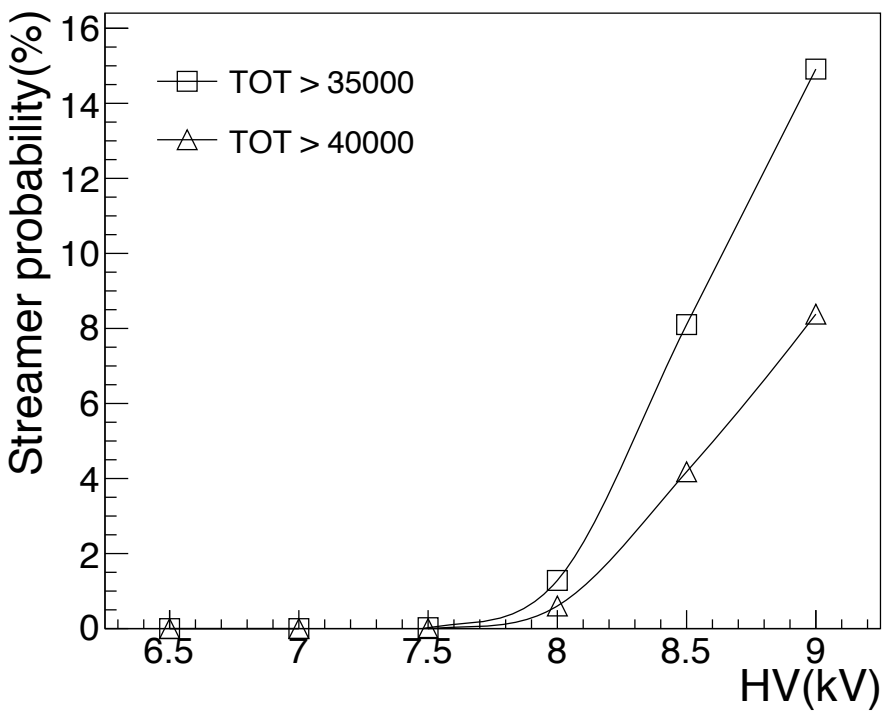


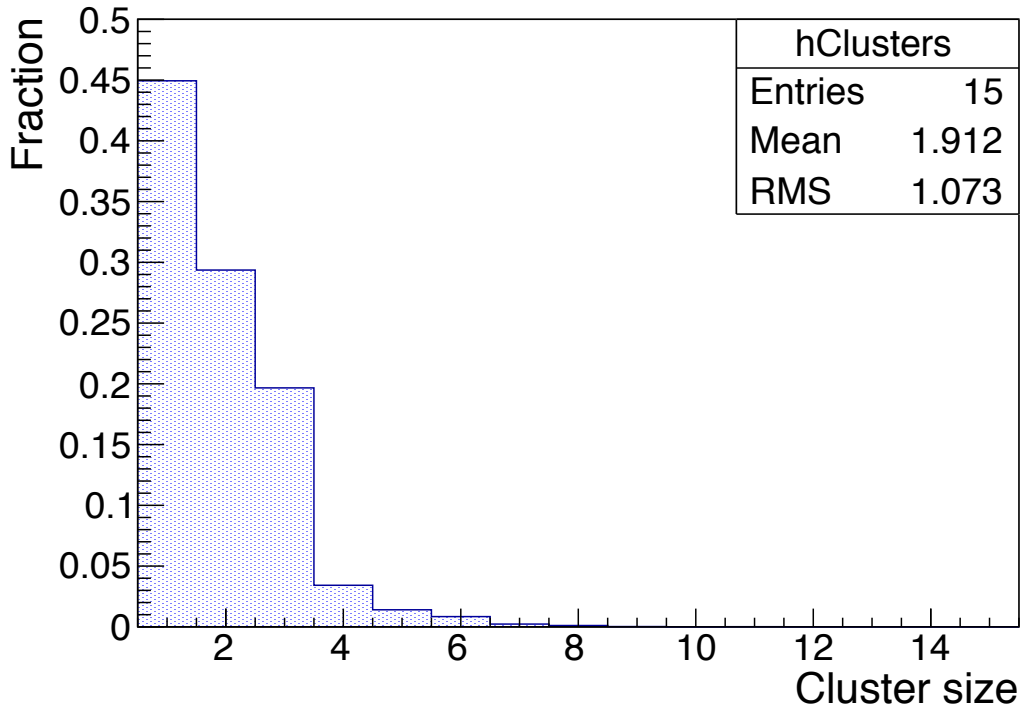




- Speed of light: ~60 ps/cm
- 1.15~1.25 cm @ 7.5 ~ 8 kV, 1.34 cm @8.5 kV
- 1.36 cm @8.5 kV for x-positions(along the strip length)

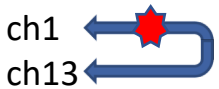
Streamer probability & Cluster size





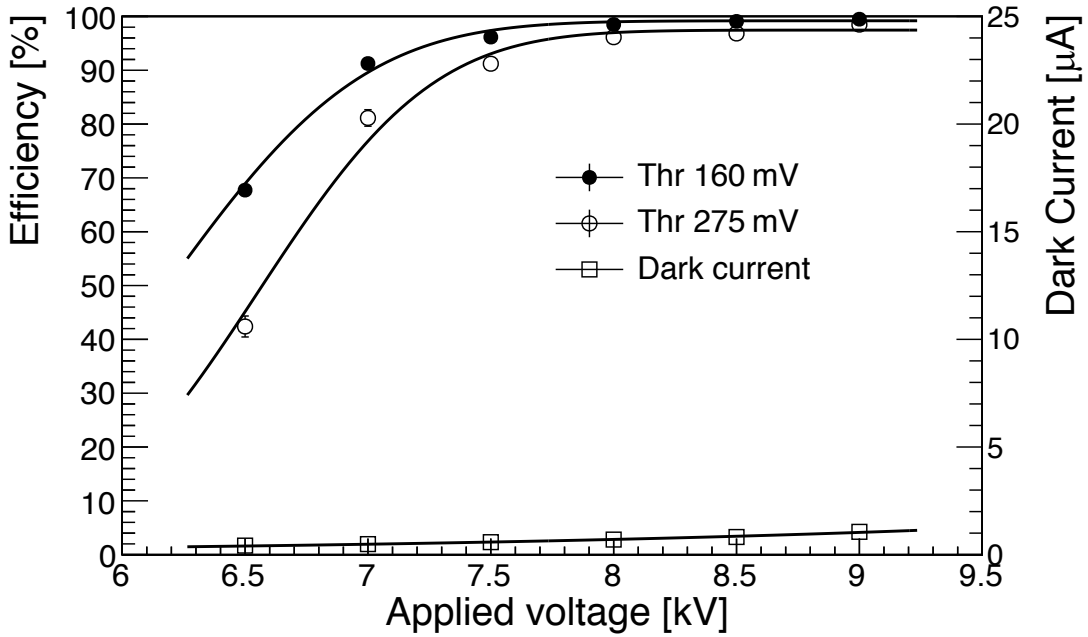
- Streamer estimated by taking events, TOT>35 ns & TOT>40 ns
  - ✓Taking 5 neighboring strips shows similar result

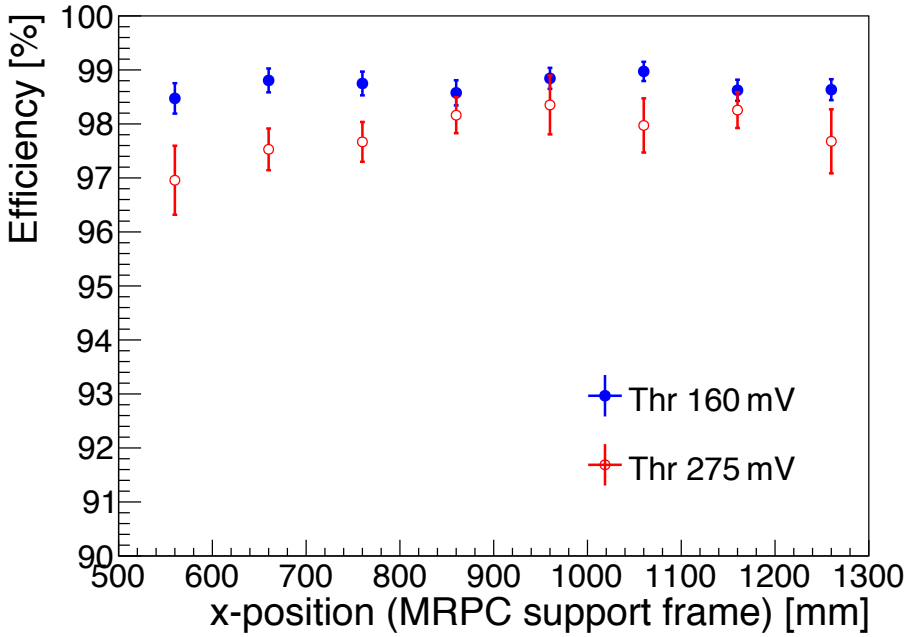
✓Normalized fraction for cluster size: 1.9 strip/hit



Single-ended readout

Efficiency

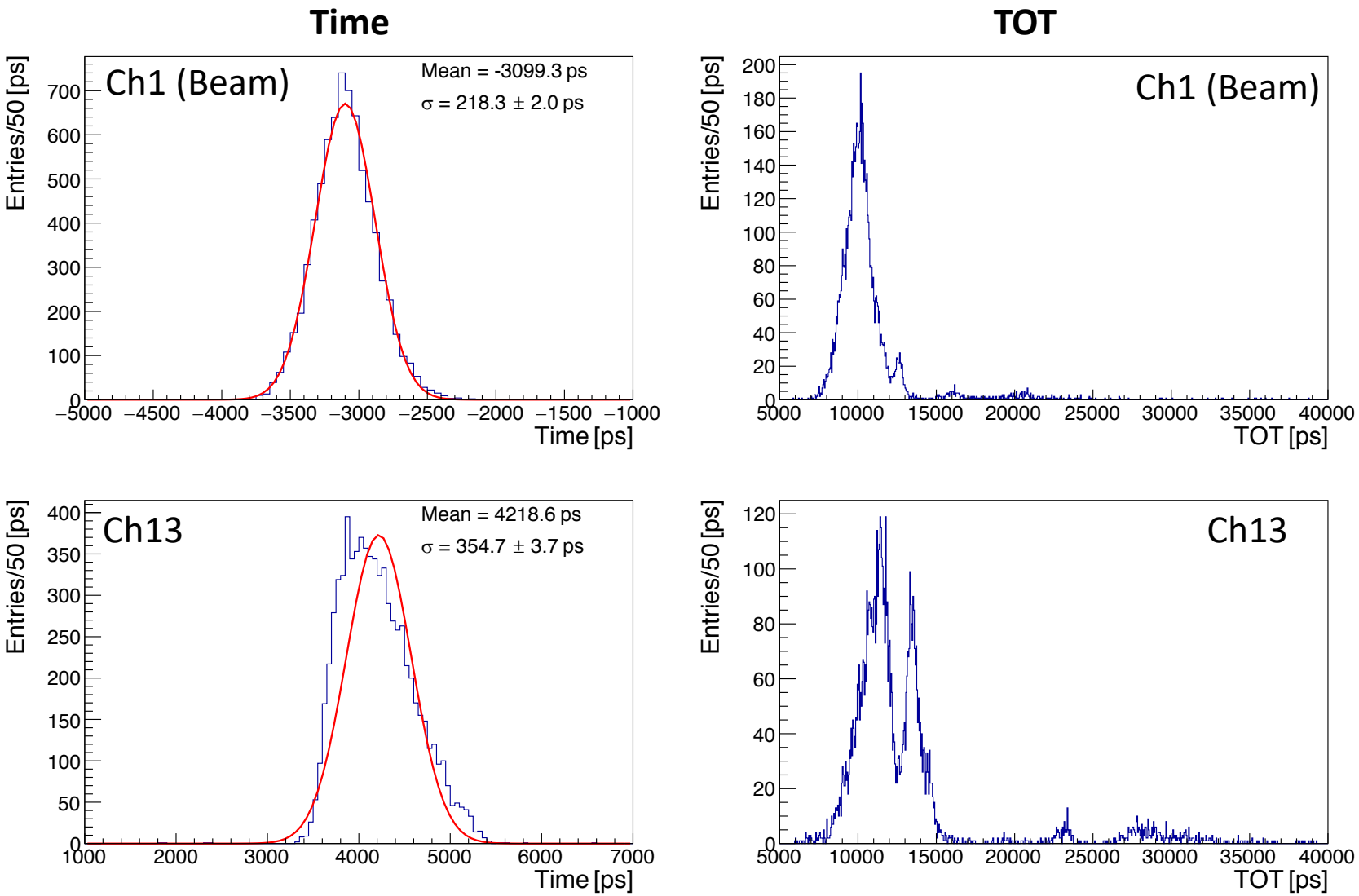




- Used two different threshold values:
  - ✓160 mV: NINO default value (40 fC)
  - ✓275 mV: equivalent to a threshold of 70 fC

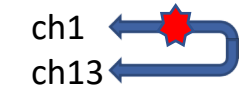
- Dark current < 1 μA
- 98.5% @160 mV, 97.5% @275 mV

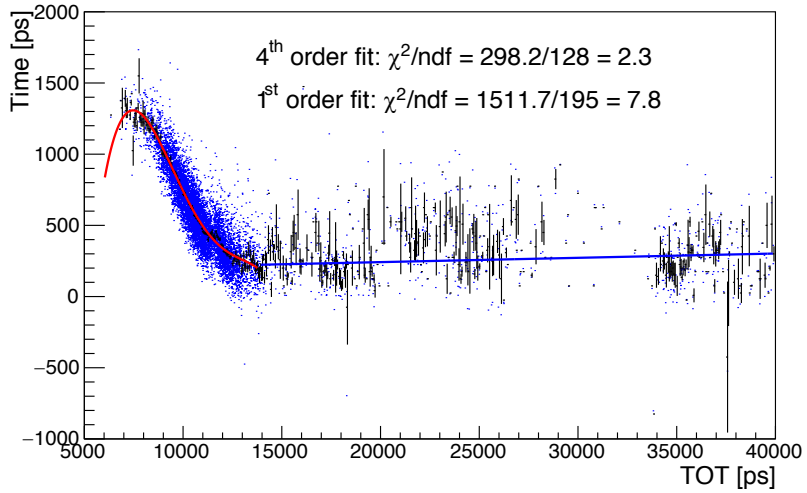
Measured Time & TOT distributions

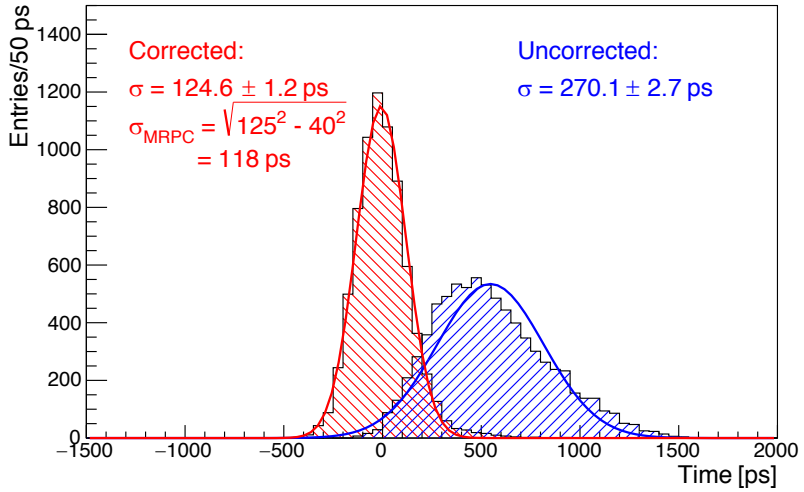


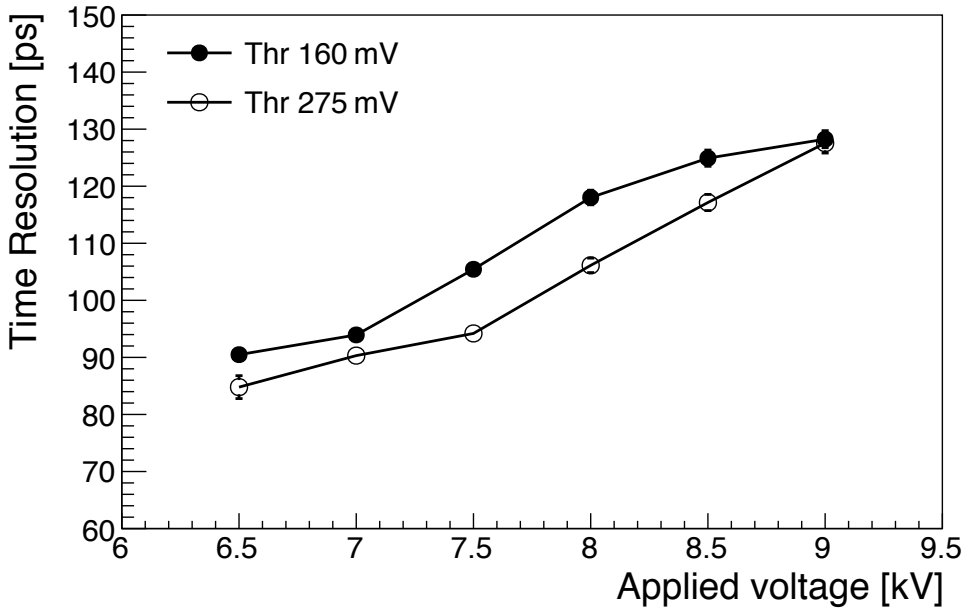
- Time distribution
  - ✓Narrower for Ch1
  - ✓Ch13: long transmission line & reflection at coaxial cable disturb signal arrival time. → wider distribution
- TOT
  - ✓Ch1: small number of reflected signals
  - ✓Ch13: Large number of reflected signals
  - ✓Large TOT values by reflected signals at Ch1

Time resolution



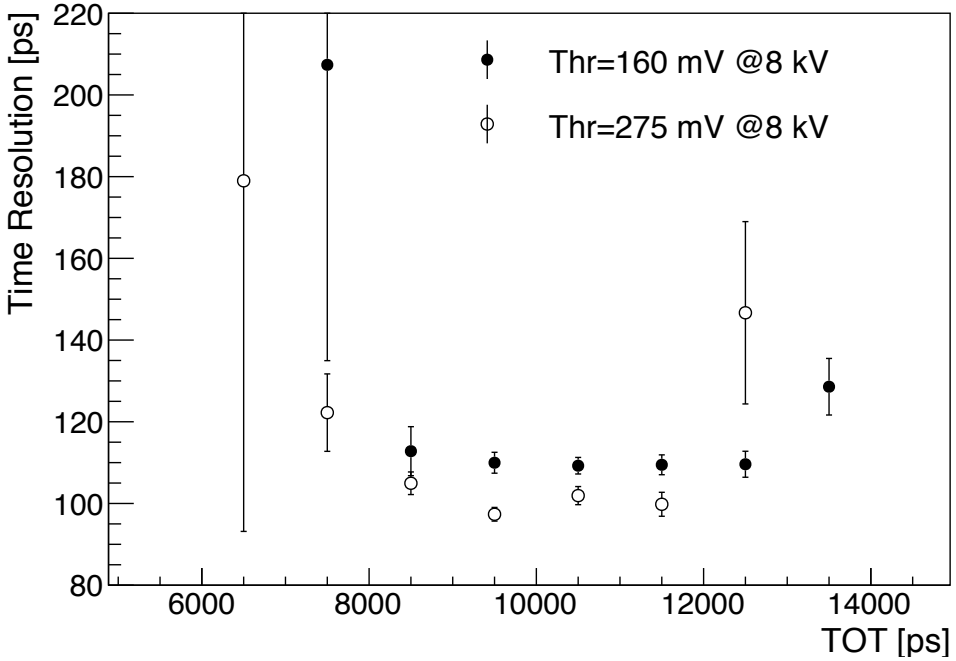


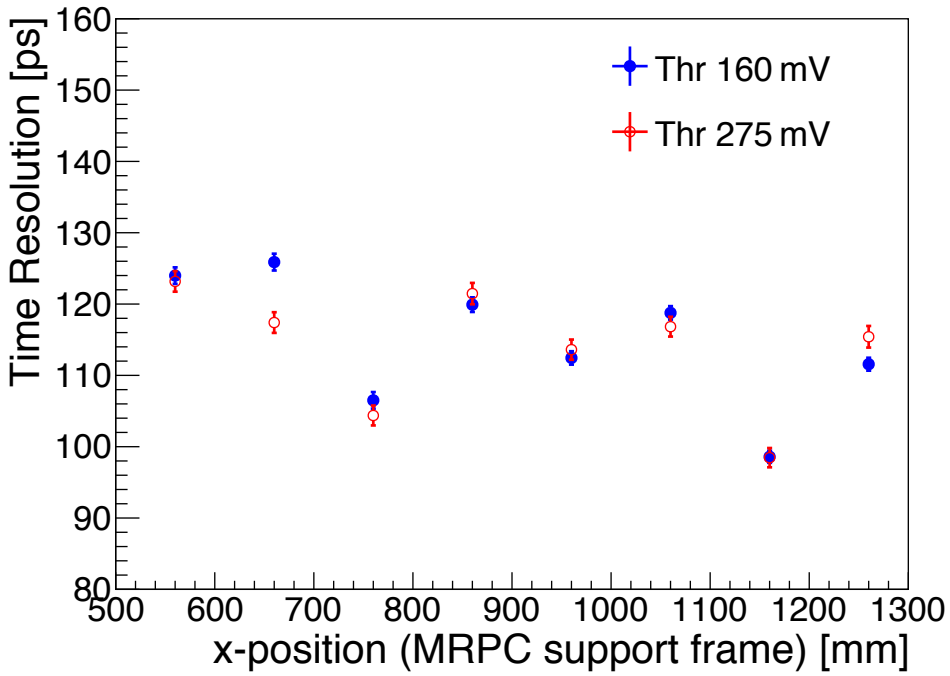




- 4th & linear fit functions for correction
- 5-10 ps better time resolution at higher threshold

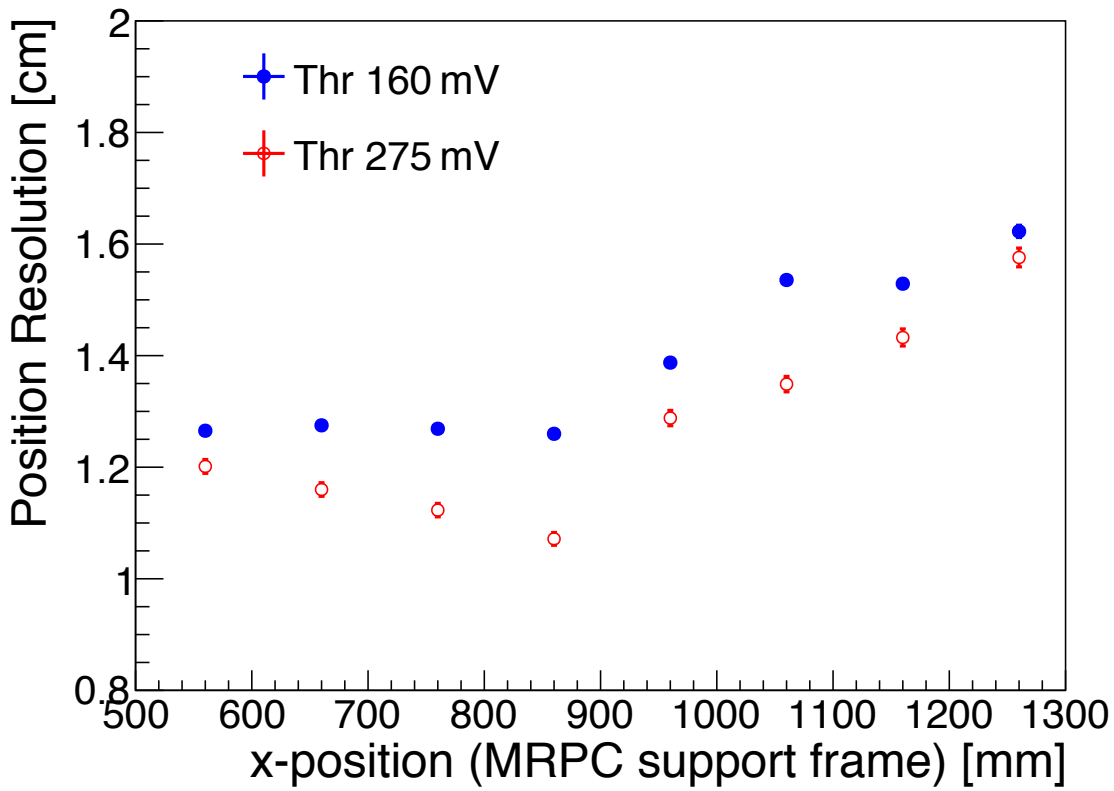
Time resolution





- Time resolution vs. TOT: higher threshold reduces low charge signals, results in improving time resolution
- Uniform results on x-positions: 105 ~ 125 ps

Position resolution



- Better results from the higher threshold
- Complexity of time jitters within Ch1 and Ch13
  - reflection at coaxial cable and the end of strip/NINO
  - Different length of transmission line

Summary

- Double stack MRPC with double-ended readout
  - Efficiency > 97.5% and time resolution < 113 ps
  - Reducing operating voltage has an advantage for the ecological gas operation
  - Position resolution < 1.4 cm
  - Excellent and uniform performance for the full sensitive area
  - Publication: Nucl.Instrum.Meth. , A928, 1 June 2019, Pages 89-92

- Double stack MRPC with single-ended readout
  - Efficiency > 97% and time resolution < 125 ps
  - Position resolution < 1.6 cm
  - Considering the condition, long transmission line including a coaxial cable, the result seems to be acceptable
  - Publication: Nucl.Instrum.Meth. , A940, 1 October 2019, Pages 283-287