Development of the multi-neutron finding method for the high-energy LAMPS neutron array at RAON

고려대학교
Nuclear physics Lab.

2015 4. 24 KPS

심현하*, 김범곤, 이경세, 홍병식

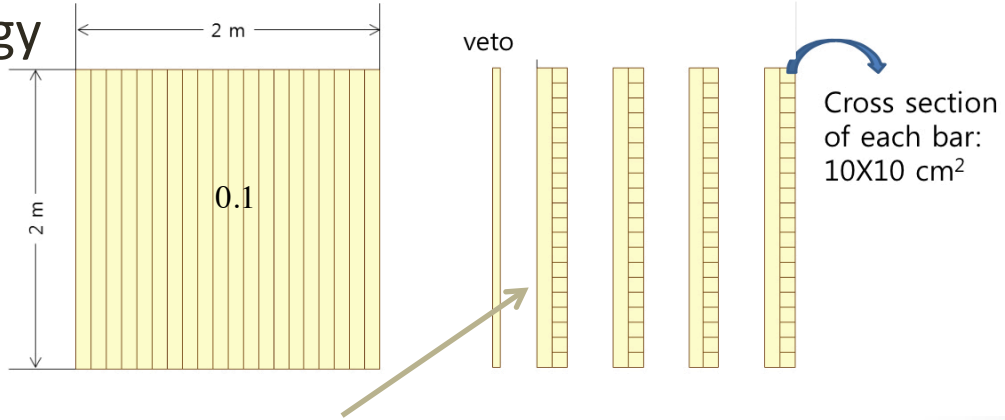
outline

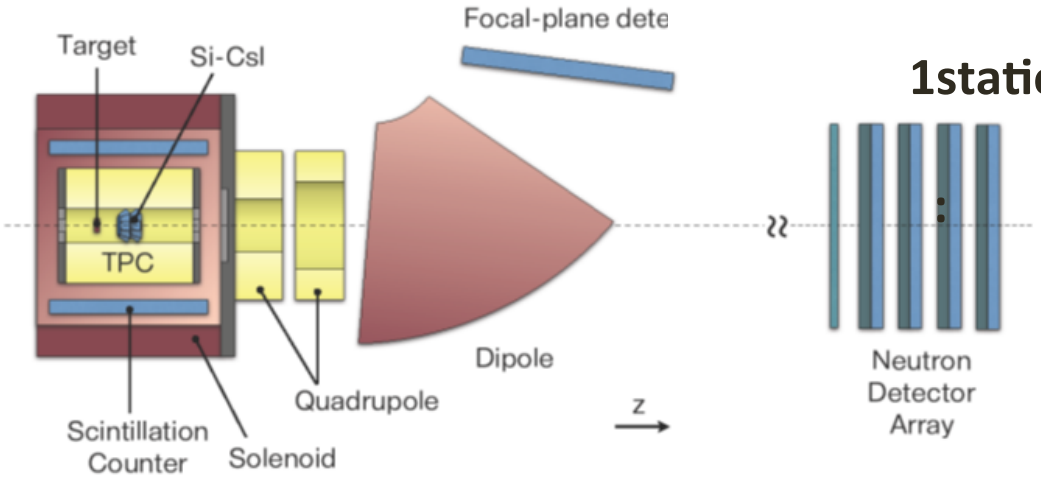
- **Introduction to high energy LAMPS(Large-acceptance multipurpose spectrometer)**
- **Geant4 simulation for finding proper conditions for neutron differentiation**
- **Result by applying neutron finding method with time and velocity conditions**
- **Summary**

LAMPS-High neutron detector

- study for nuclear symmetry energy and nuclear structure of exotic nuclei.

-> measuring neutron energy and number of neutrons is important





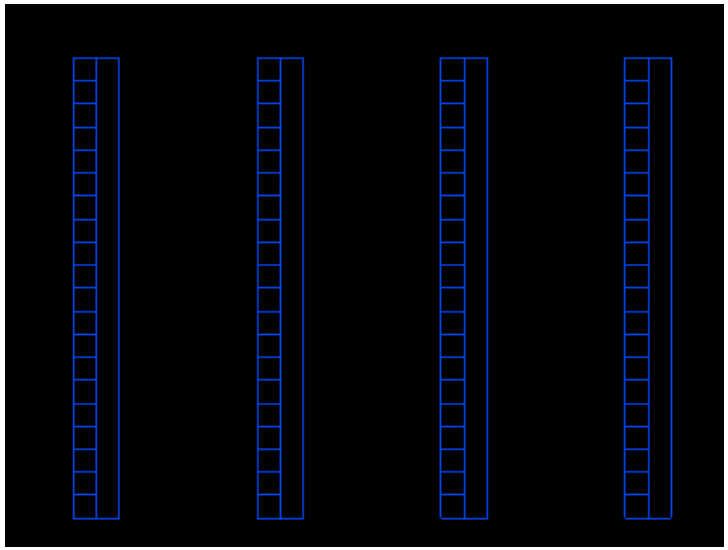
1station : 2layer * 20 bar detectors

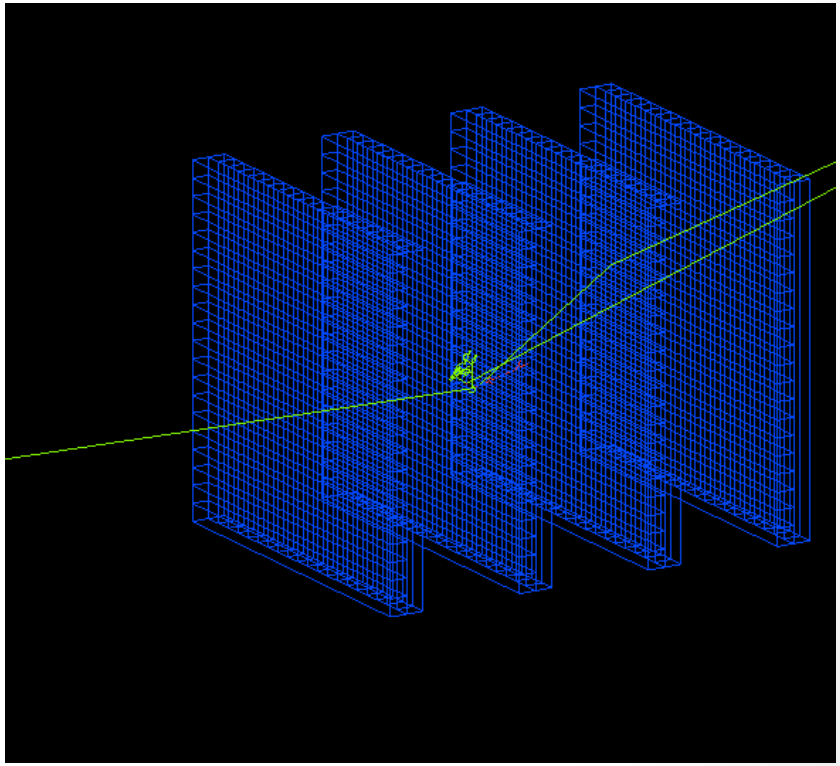
Bar detector dimension : 0.1*0.1*2 m³

GEANT4 simulation

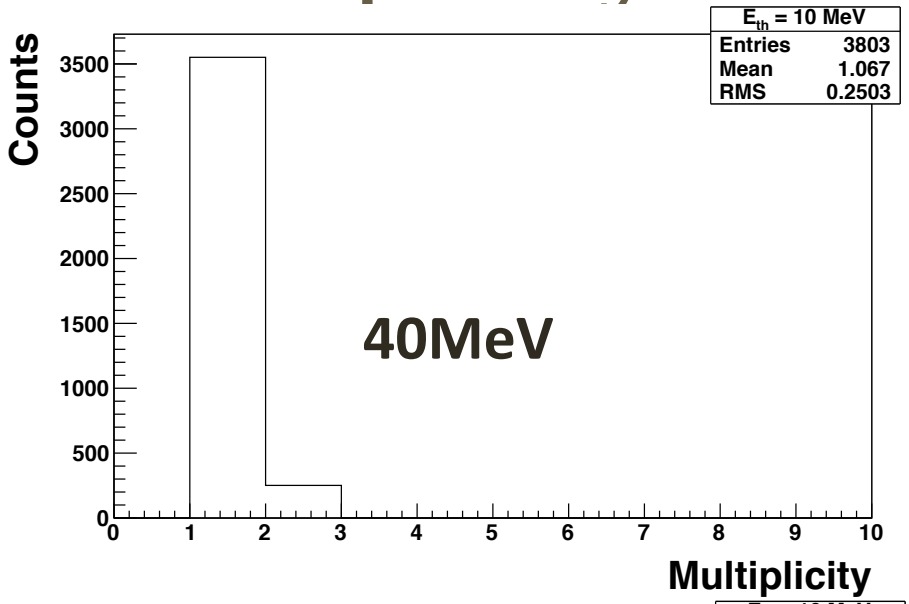
- Simulation condition :
  - Distance between detector and neutron source : 10 m
  - Neutron energy : 40 MeV ~ 300 MeV
  - Position resolution : 6 cm
  - Time resolution : 300 ps
  - Threshold energy : 10 MeV

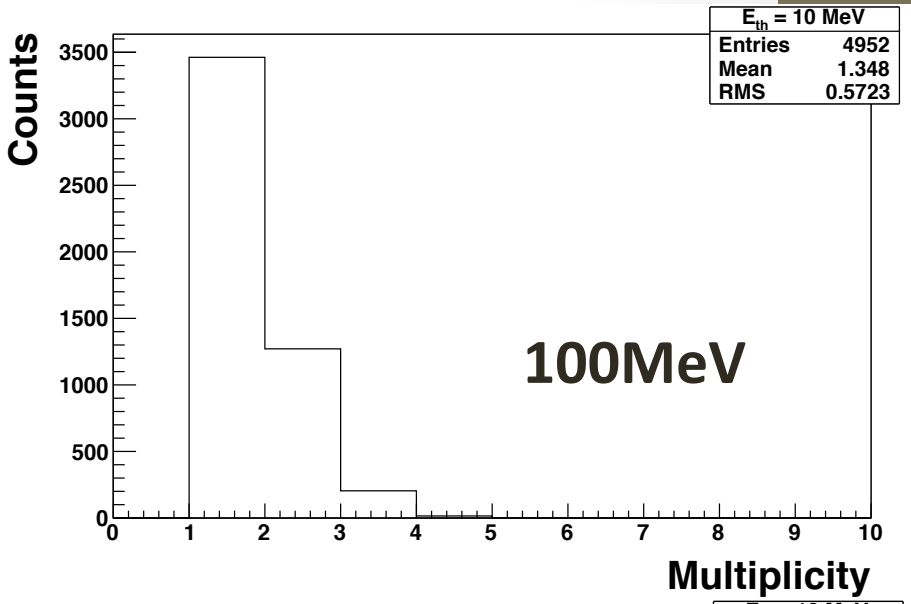
Side view

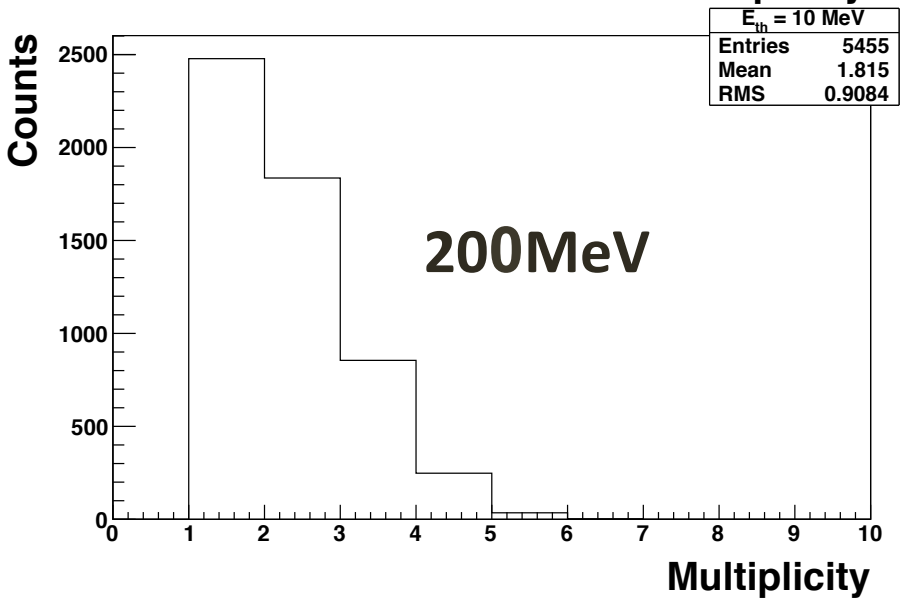


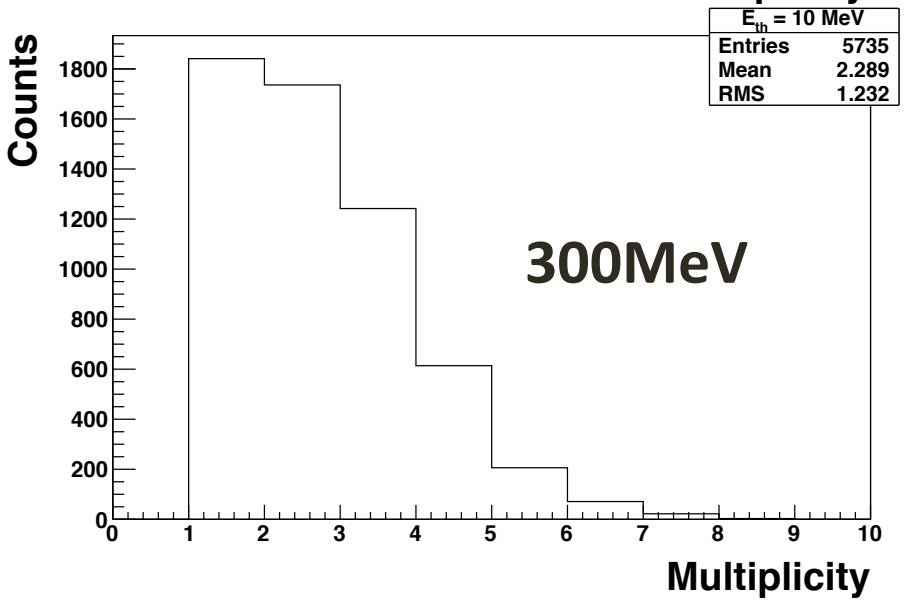


Multiplicity







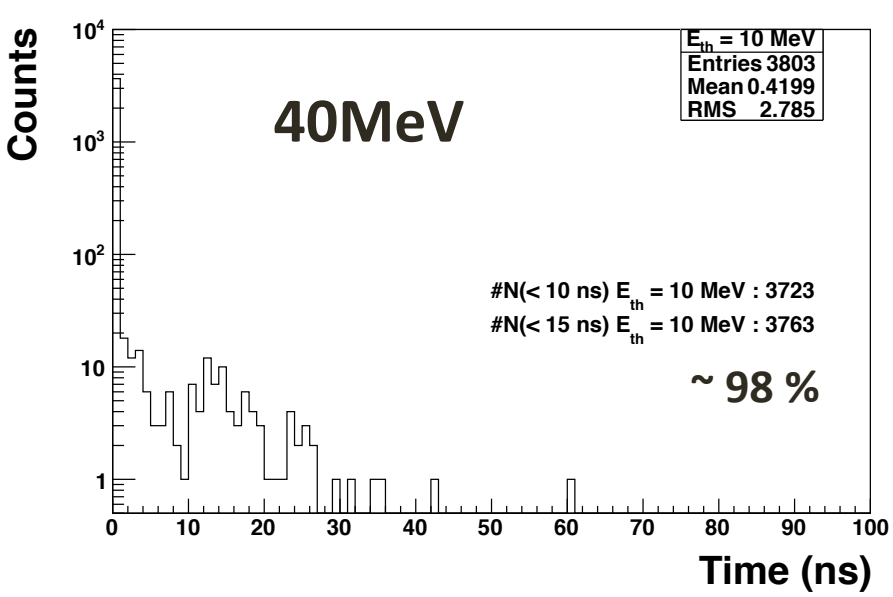


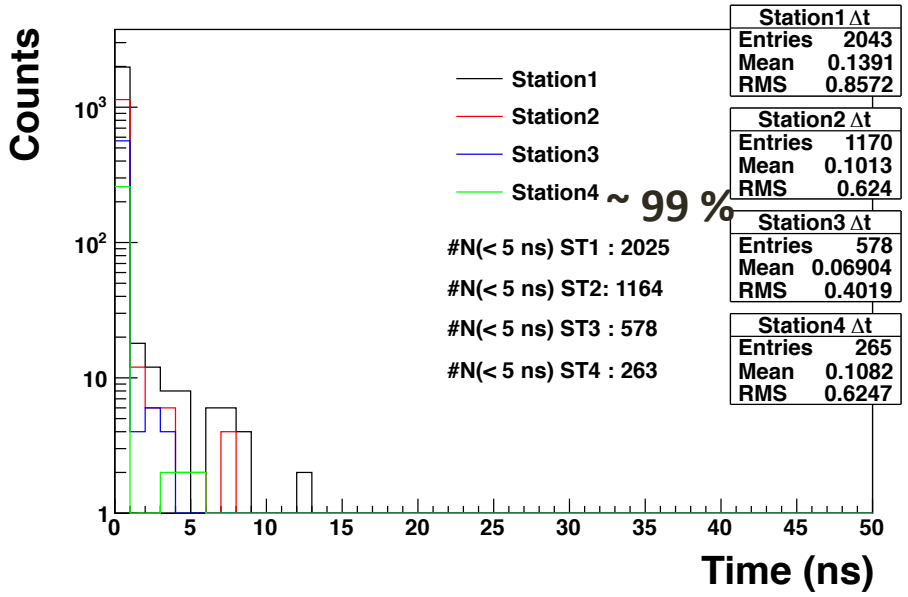
Time distribution for finding time condition

- Left figure : time difference between first hit and last hit in whole stations
- Right figure : : time difference between first hit and last hit in each station

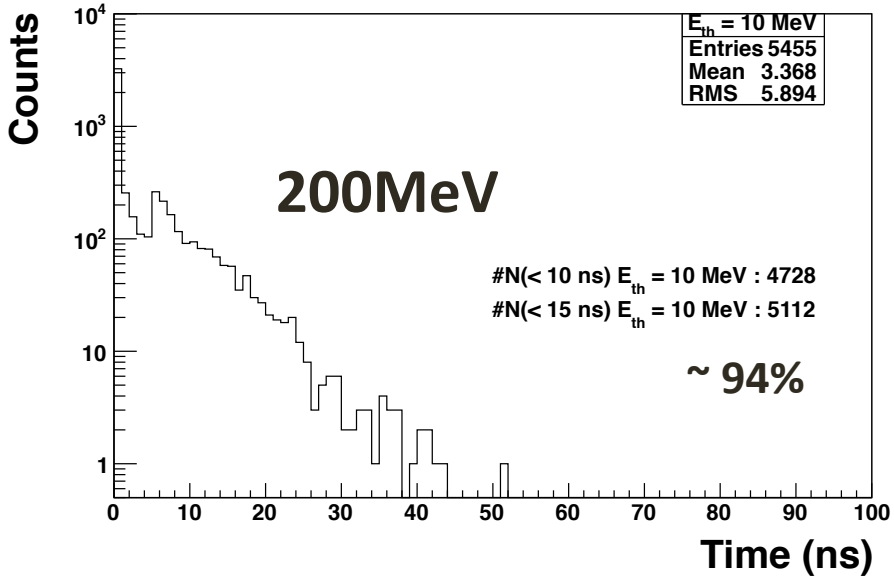
-> Time difference of most events(more than 90%) is within 15ns

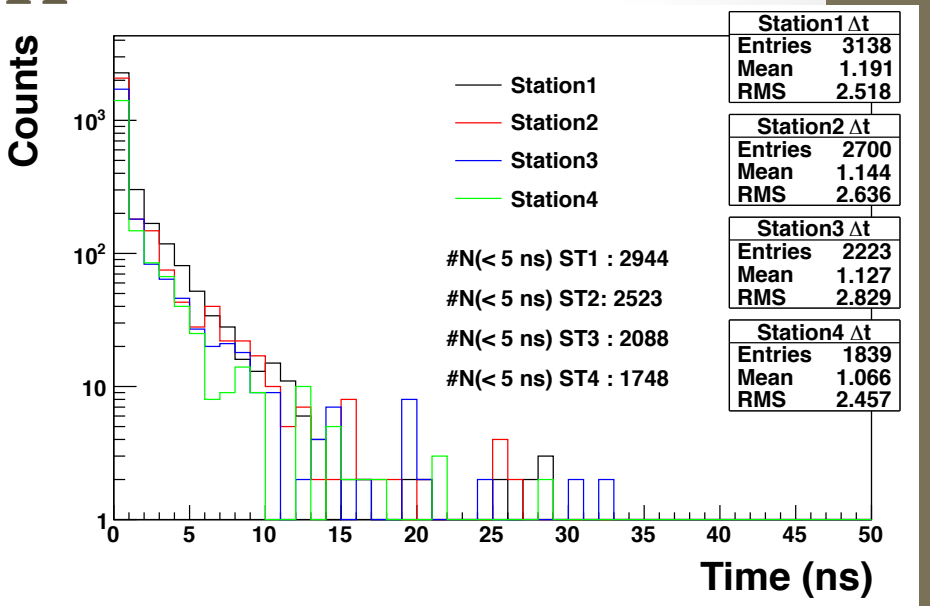
Time difference in each station is within 5ns.

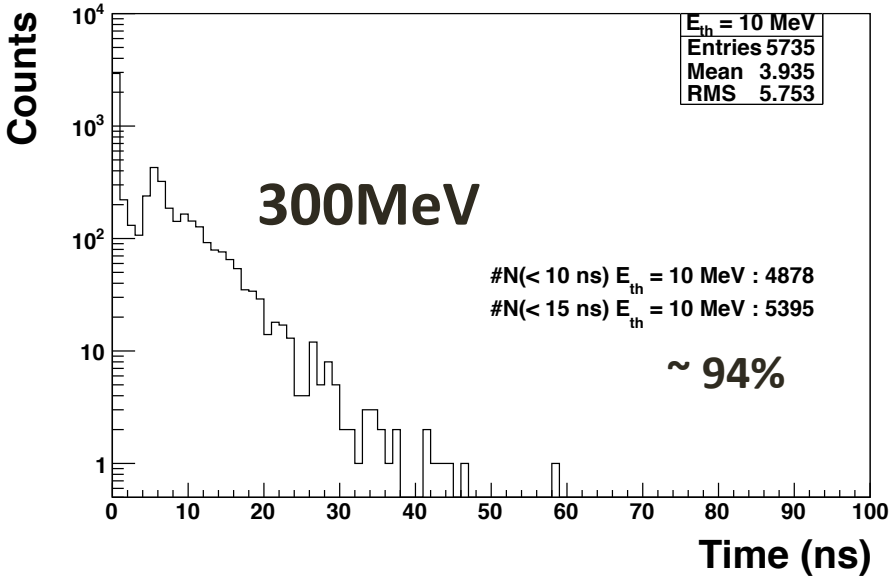


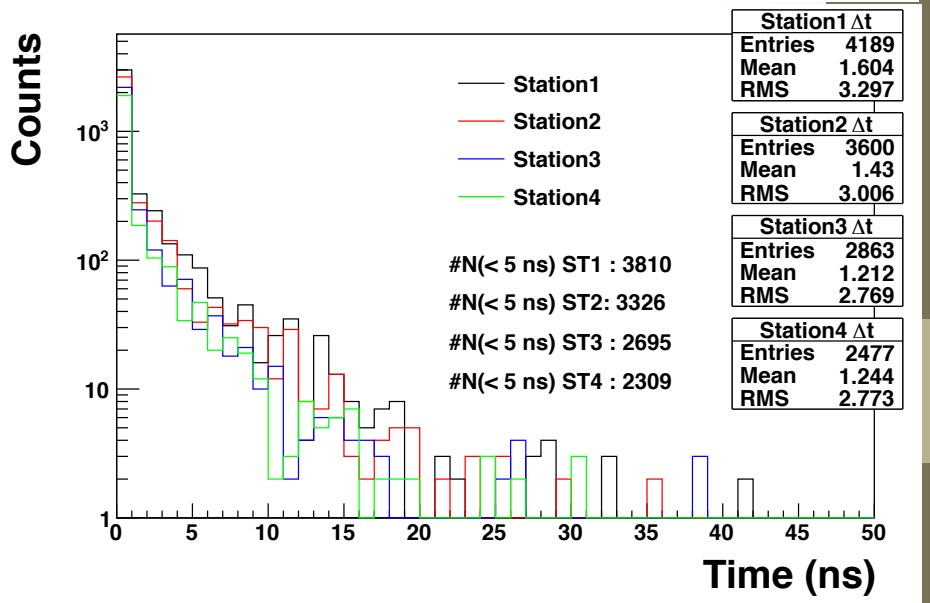


Time distribution





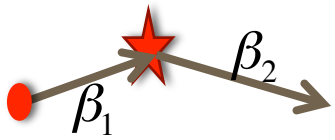




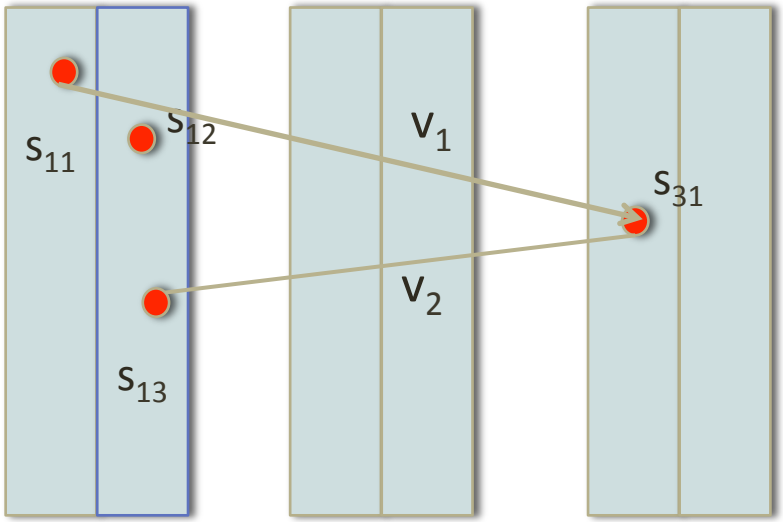
Multi neutron finding method

- Step 1 : finding time, x, y, z and deposited energy
- Step 2 : time ordering in each station
- Step 3 : applying time and velocity condition

velocity condition : $\beta_1 > \beta_2$



Ex) s_{12} is not in 5ns from s_{11}
s_{13} is in 5ns from s_{12}
v_1 is slower than velocity at s_{11}
v_2 is faster than velocity at s_{13}

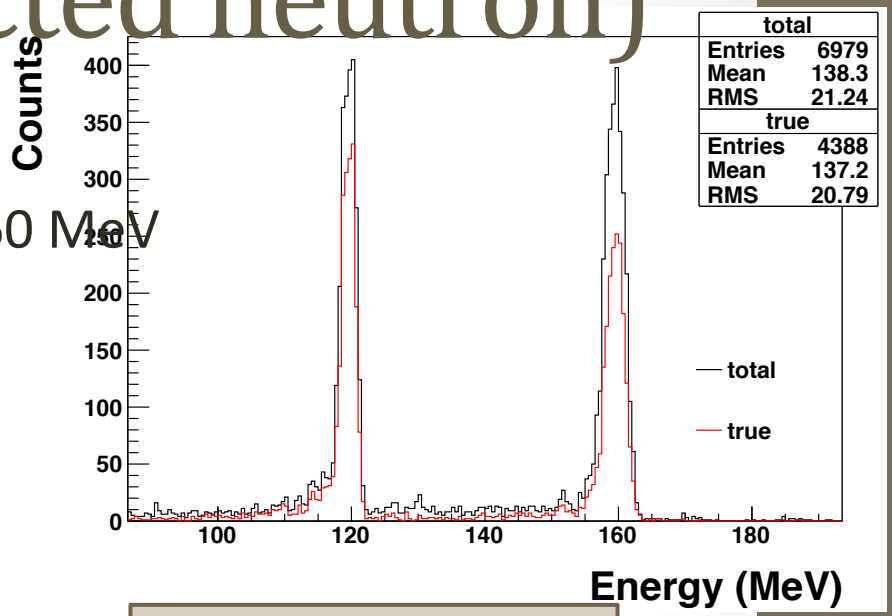


group1
s_{11}, s_{31}

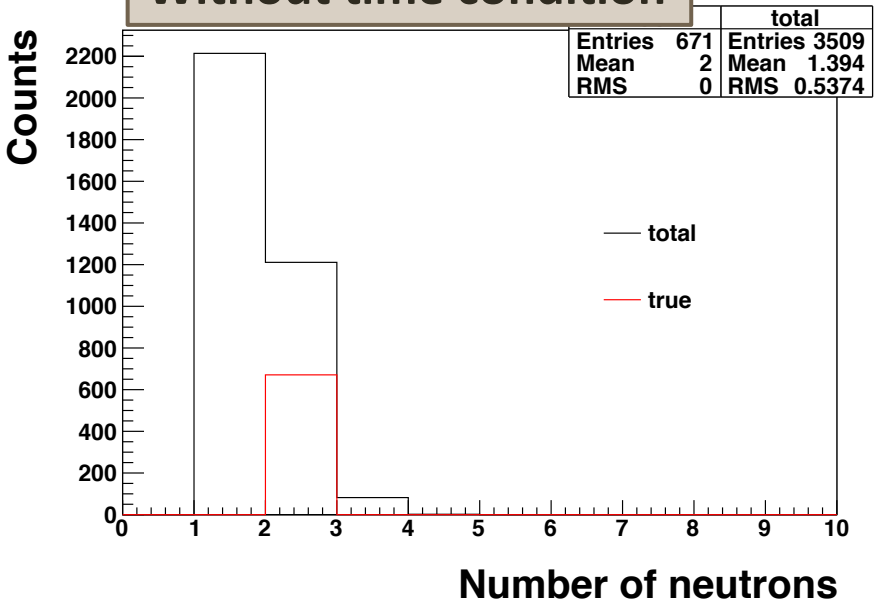
group2
s_{12}, s_{13}

Result (reconstructed neutron)

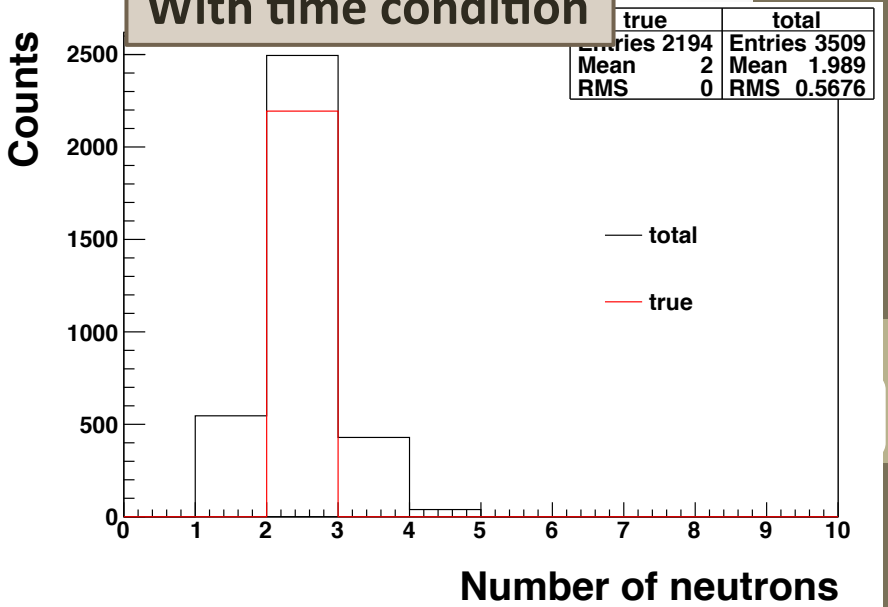
- Two neutron packed events : 5000
- Incident neutron energy : 120 MeV, 160 MeV
- Time condition
  - same station < 5ns
  - different station < 15ns



Without time condition



With time condition

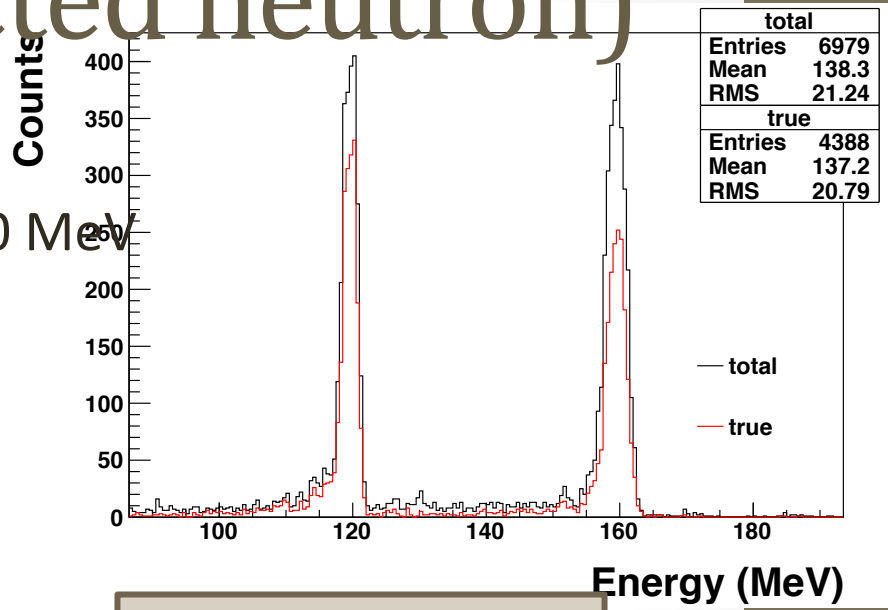


Result (reconstructed neutron)

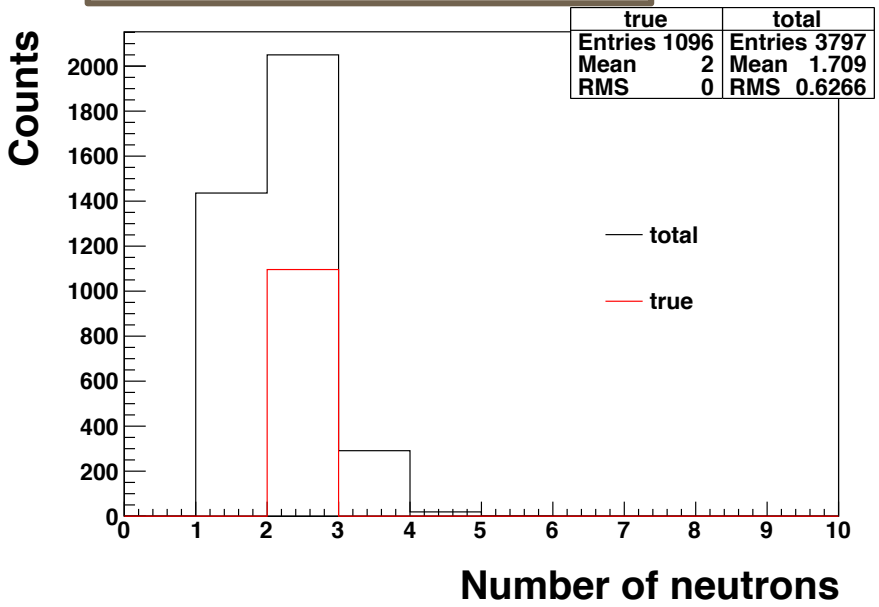
- Two neutron packed events : 5000
- Incident neutron energy : 240 MeV, 280 MeV
- Time condition

  - same station < 5ns

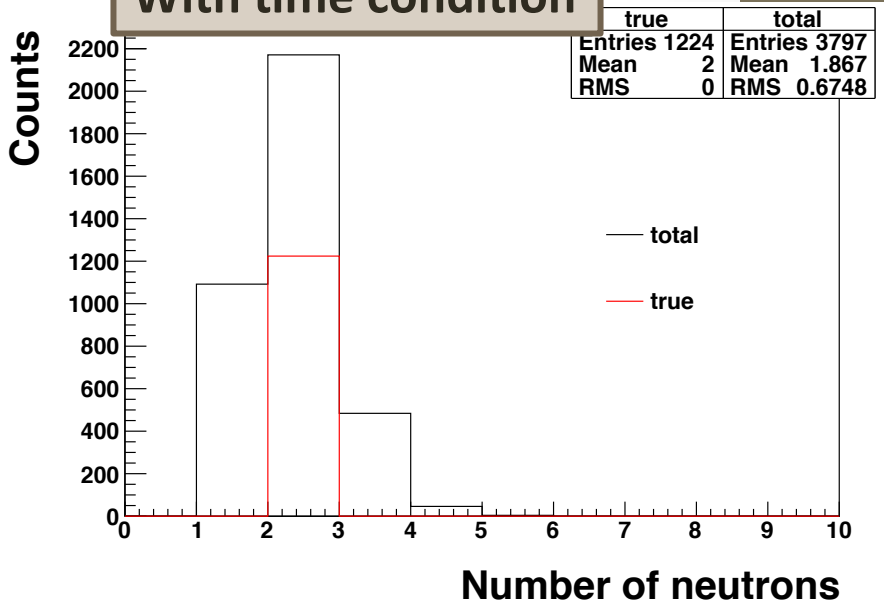
  - different station < 15ns



Without time condition



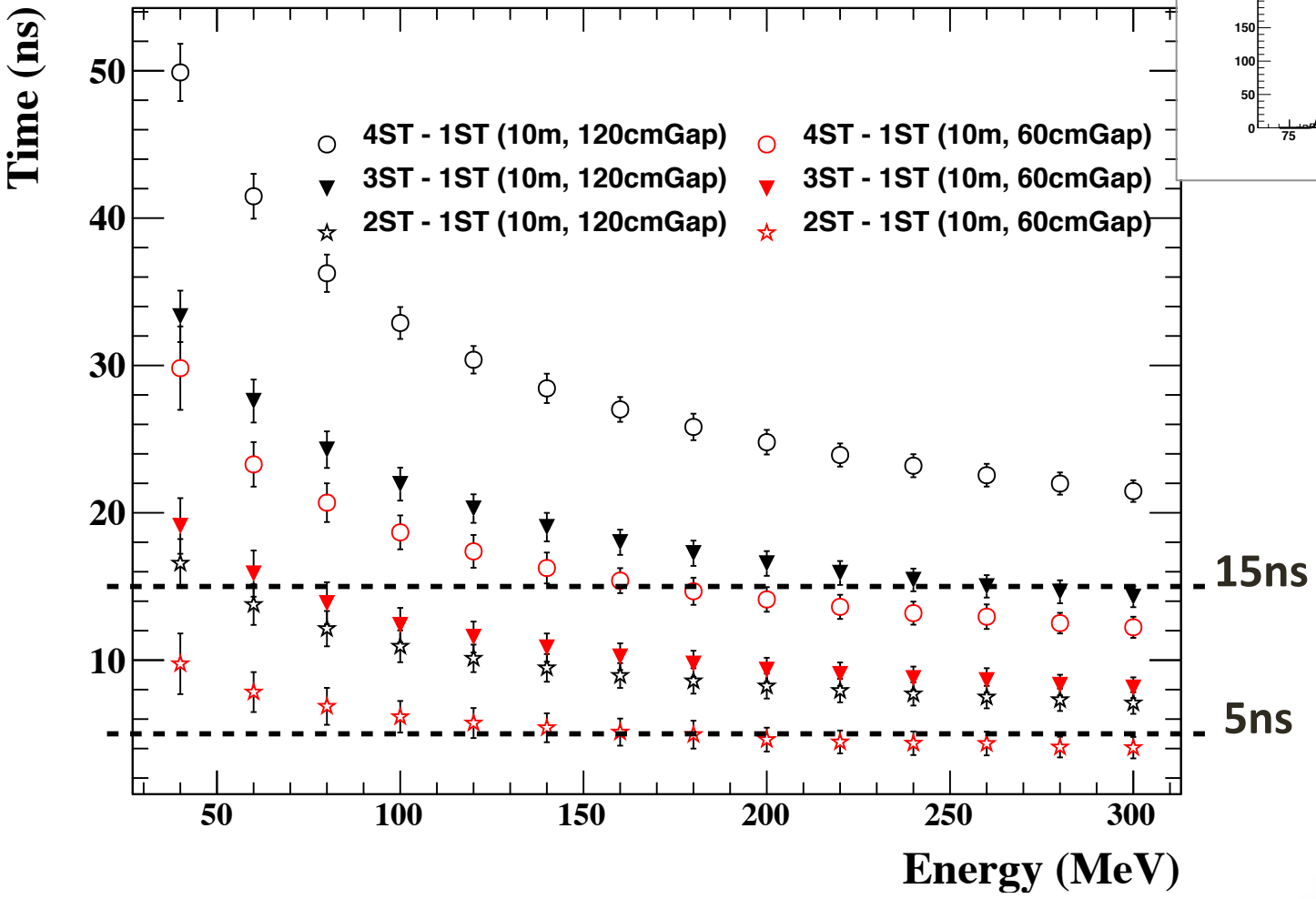
With time condition

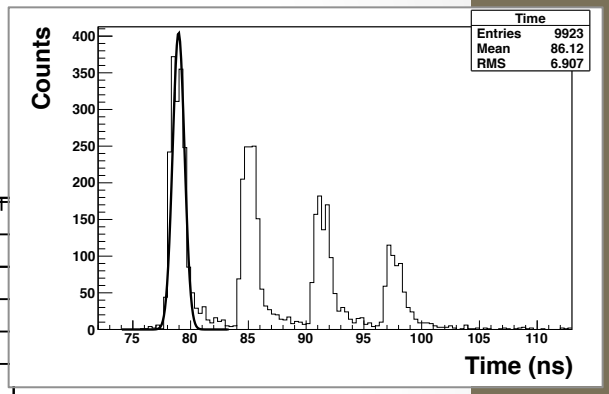


Time condition

- Taking time between stations

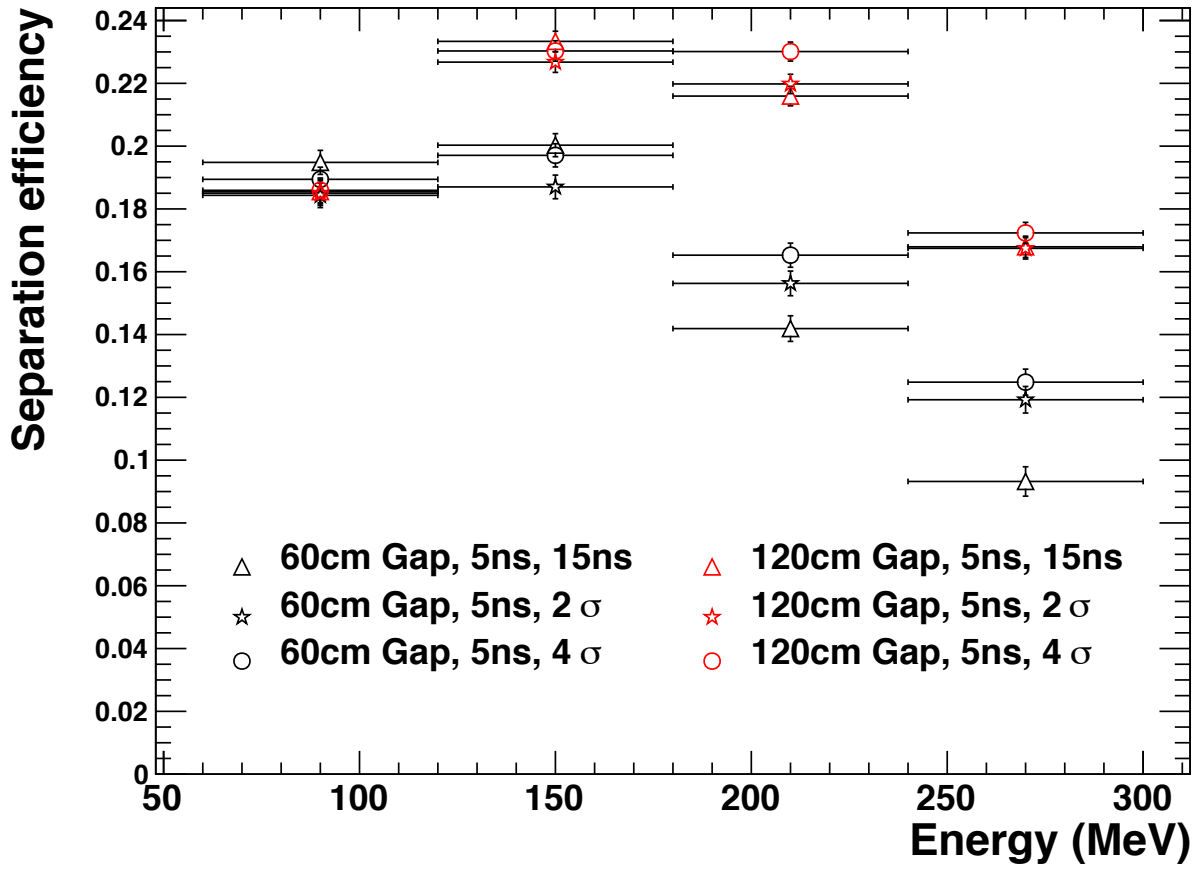
  Gap thickness between stations : 60 cm, 120 cm





Results(different time condition)

- Separation efficiency = correctly differentiated events/(total generated events – no signal events – backscattering events)



Summary

- Tested neutron finding algorithm with velocity and time conditions(5ns, 15ns)

  -> Time condition is very efficient to separate neutrons

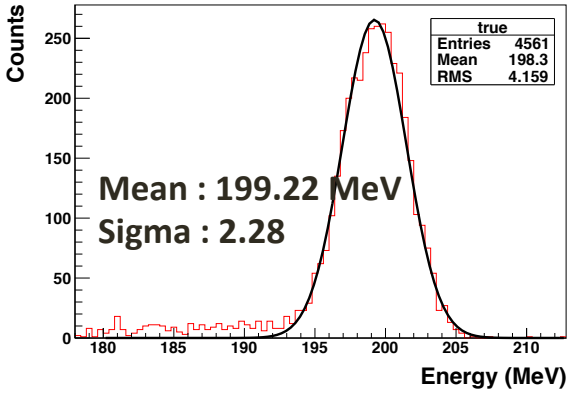
- Compared the separation efficiency with different conditions
  - different time conditions

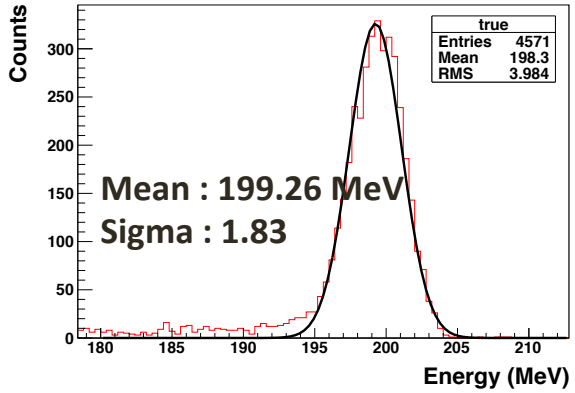
  -> efficiency with time variation as a function of energy is little higher than 15ns time condition

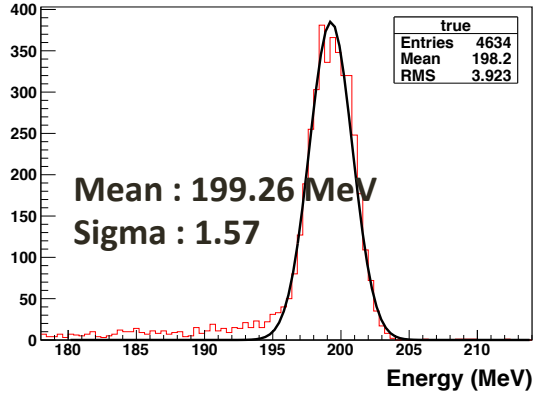
  - different gap thickness between stations

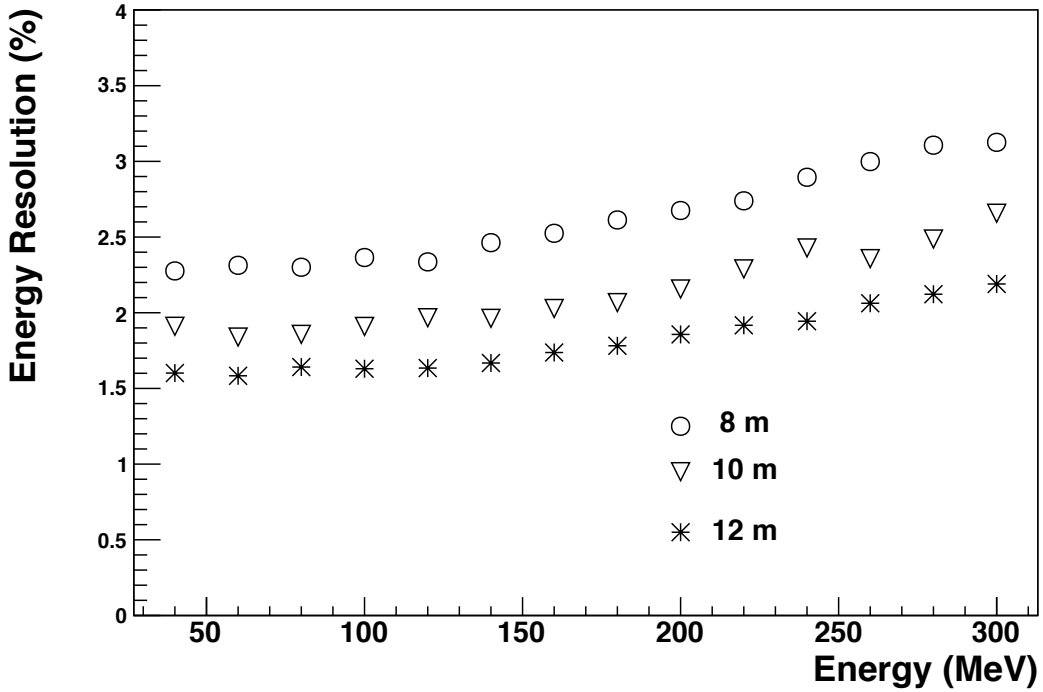
  -> 120 cm gap thickness between stations is more effective for neutron separation

Back-up Energy resolution



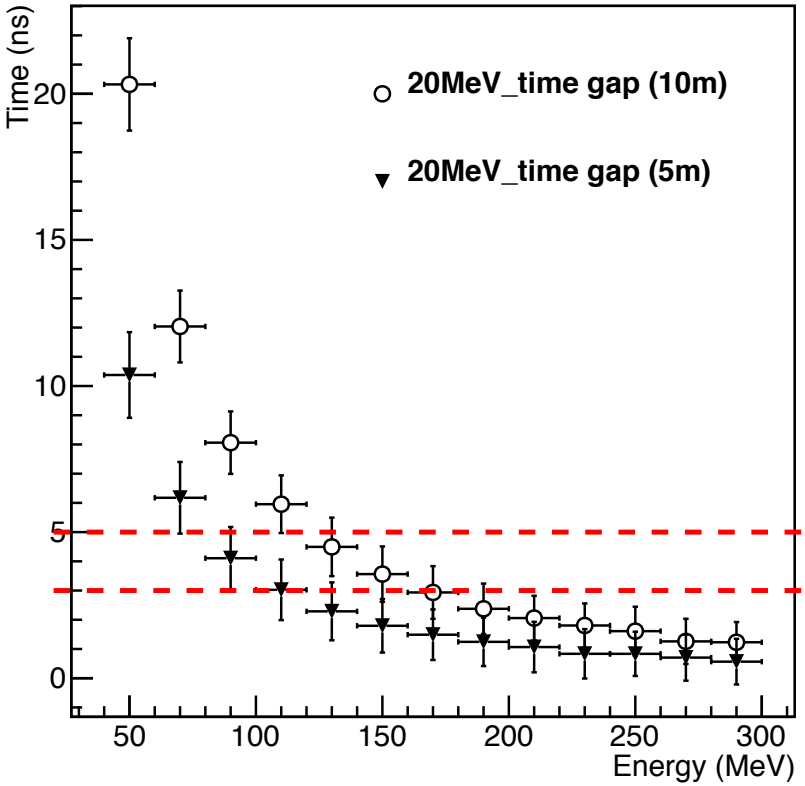


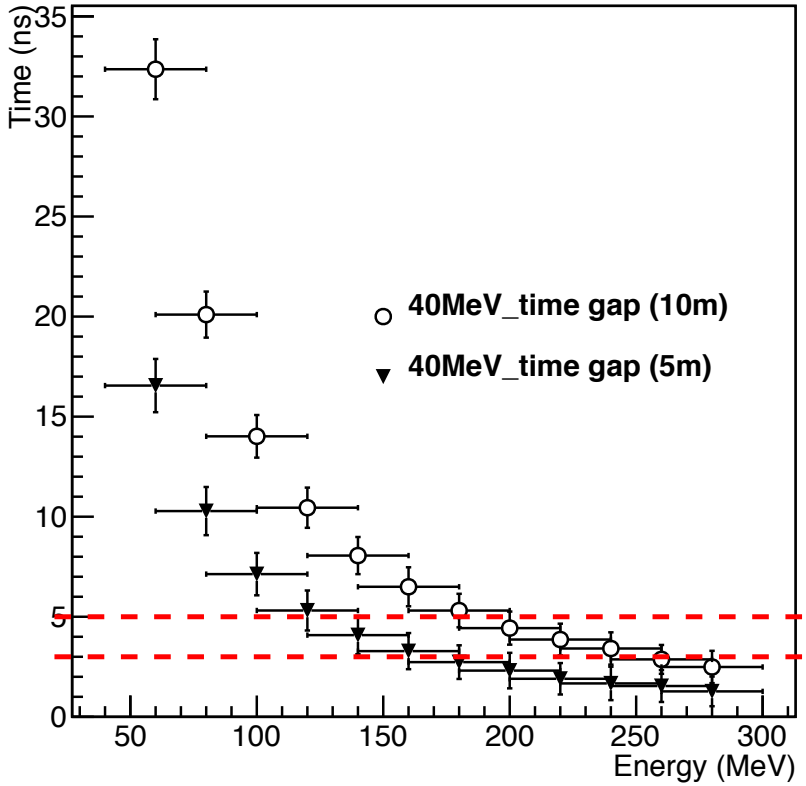




Back-up

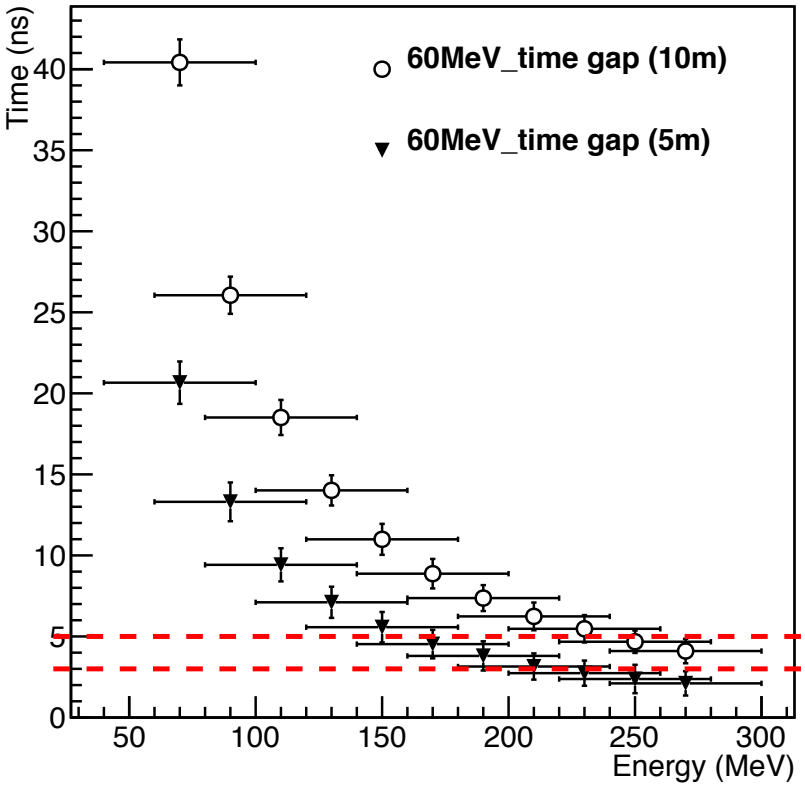
- arrival time difference of two neutron with different energy gap (20 MeV, 40 MeV, 60 MeV, 80 MeV)

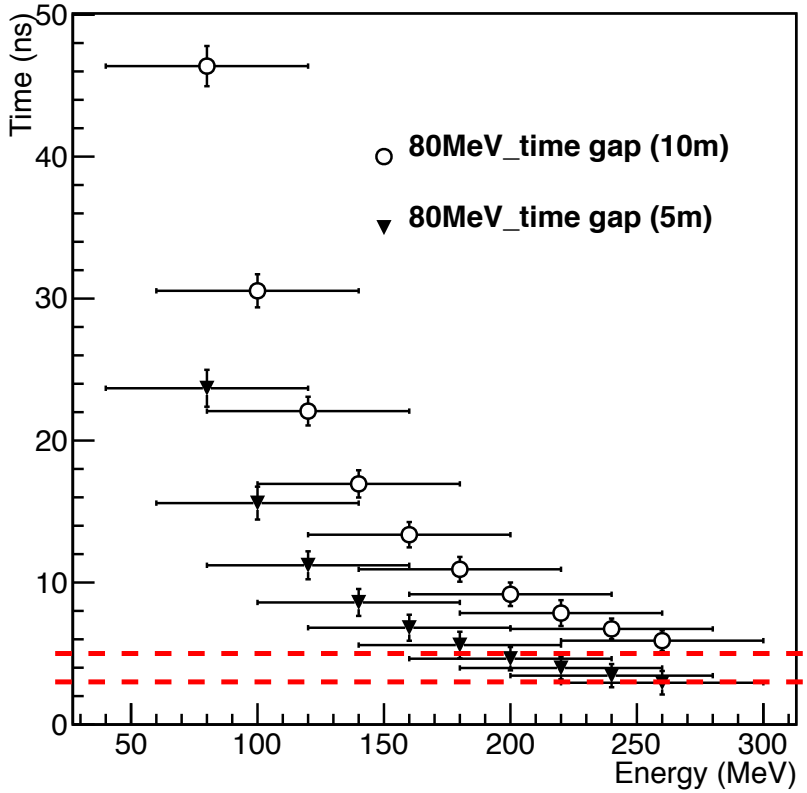




Back-up

- arrival time difference of two neutron with different energy gap (20 MeV, 40 MeV, 60 MeV, 80 MeV)





Time vs angle with different threshold

300 MeV neutron
Beam position : 10m in front of detector
Gap thickness : 60 cm
Number of station : 4

$$\theta_{12} = \sin^{-1}\{\frac{\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}}{\sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2 + (z_1 - z_2)^2}}$$