Characteristics of the prototype neutron detector for LAMPS evaluated by neutron beams at RCNP

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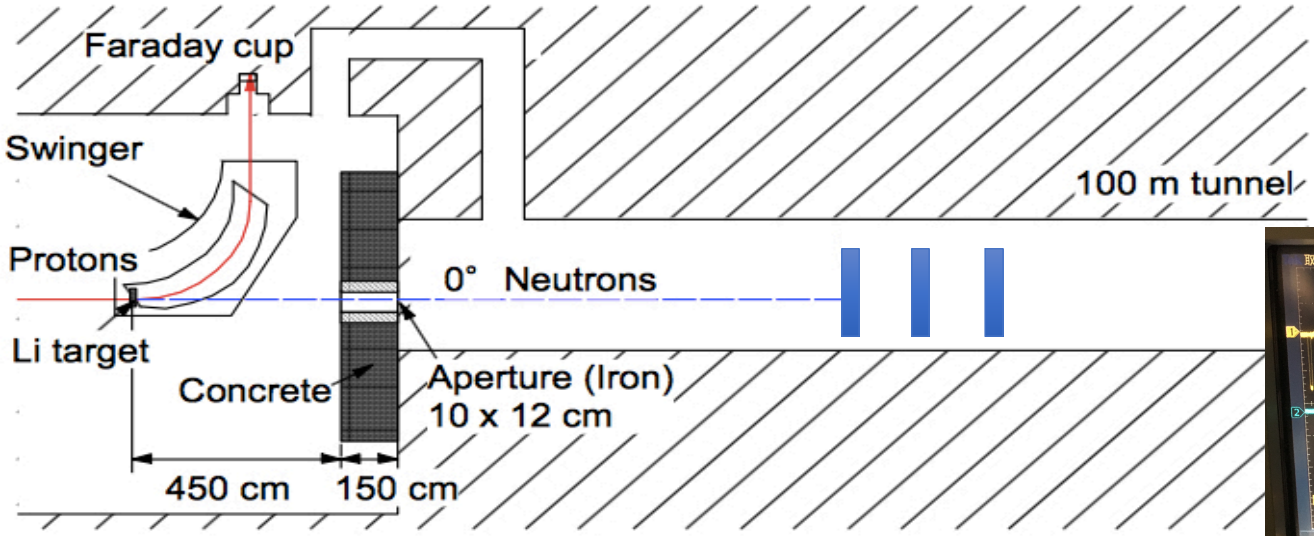
Introduction

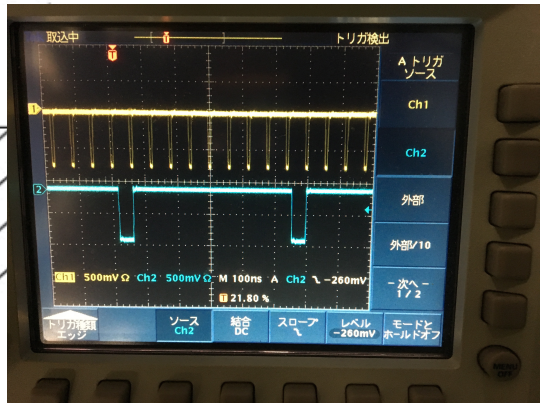
✓Neutron detector array is a part of LAMPS(Large Acceptance Multipurpose Spectrometer) that will be installed at the rare-isotope beam facility, RAON

✓Purpose : study for nuclear symmetry energy and nuclear structure of exotic nuclei.

→ Measuring neutron energy and number of neutrons is important

N0 beam line in RCNP





✓ Beam information
- Neutron flux : 1*10^{10} n/sr/μC
- Beam chopper: 1/9 (600 ns)
- Current : 10 nA
- Energy : 65 MeV, 392MeV
- Target : Li (1cm thick)

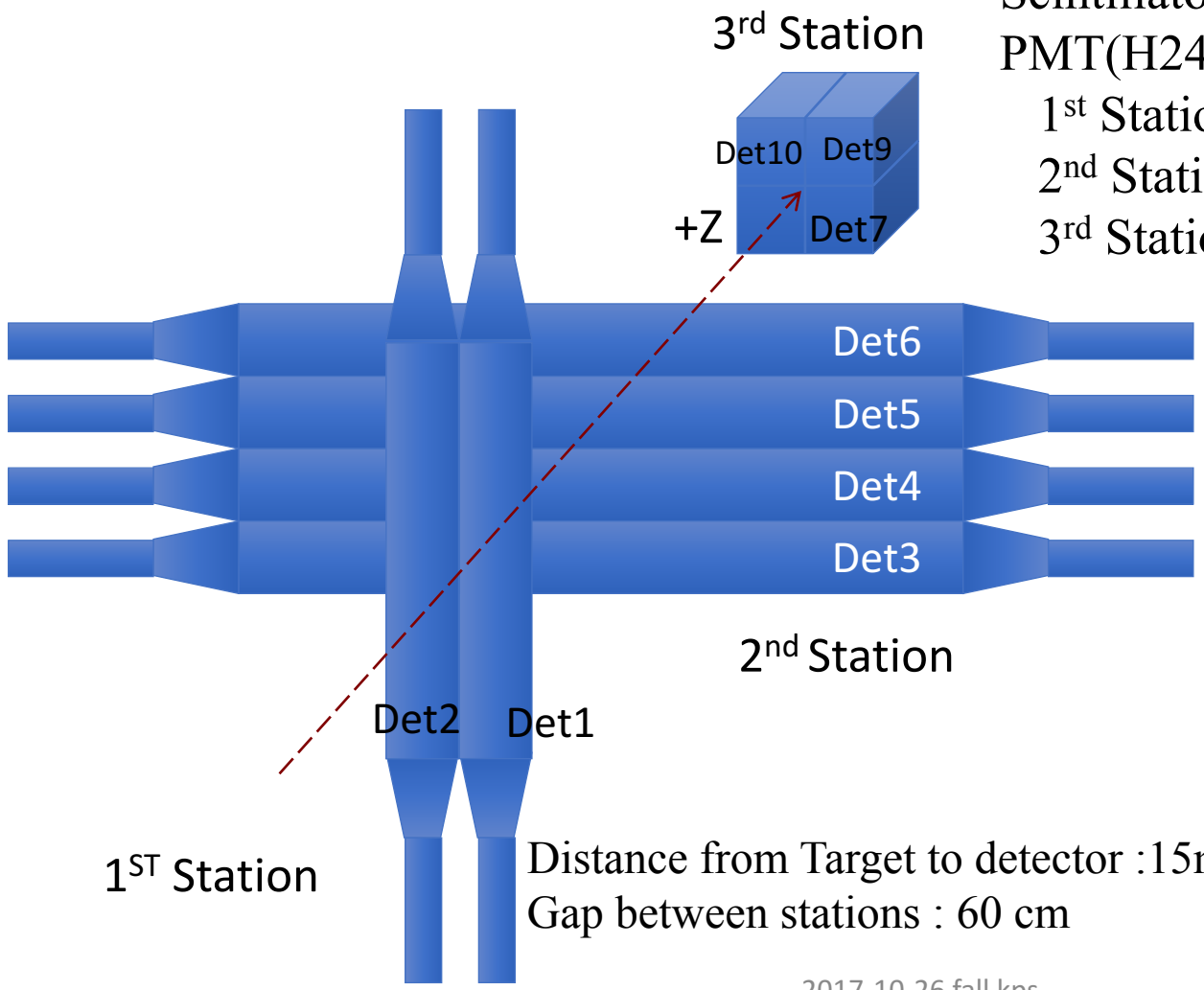
✓ P+^{7}Li → n + ^{7}Be

Proton with Li target produce quasi-monoenergetic neutron (g.s. + 0.429 MeV, Q= -1.64 and -2.08 MeV

✓ Background neutron above 3MeV is less than1% (NIM A629 (2011) p43)

✓ Electronics FADC 500MSa/s

Experimental Setup



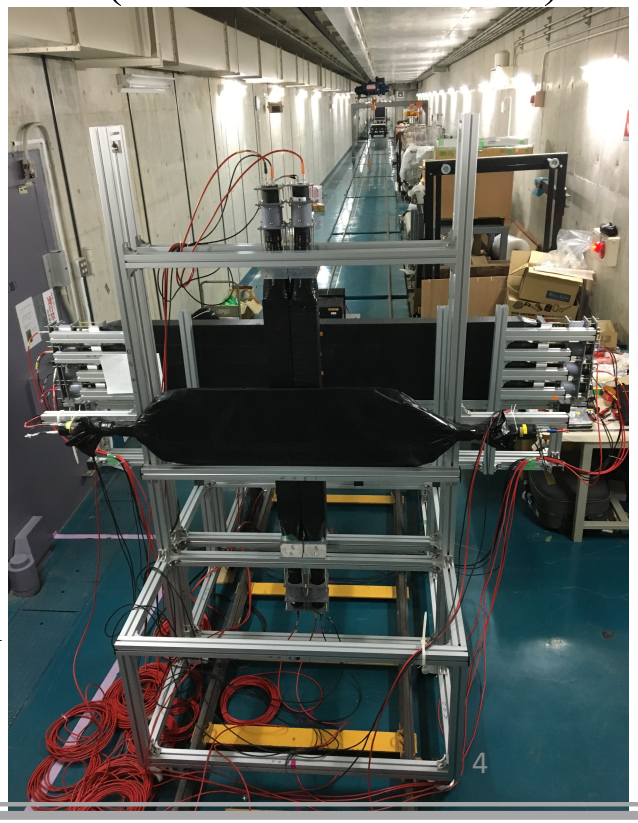
Scintillator (BC408) : 11 개

PMT(H2431-50 Hamamatsu) : 18 개

1st Station : 2 (10cm*10cm*100cm)

2nd Station : 4 (10cm*10cm*200cm)

3rd Station : 4 (10cm*10cm*20cm)



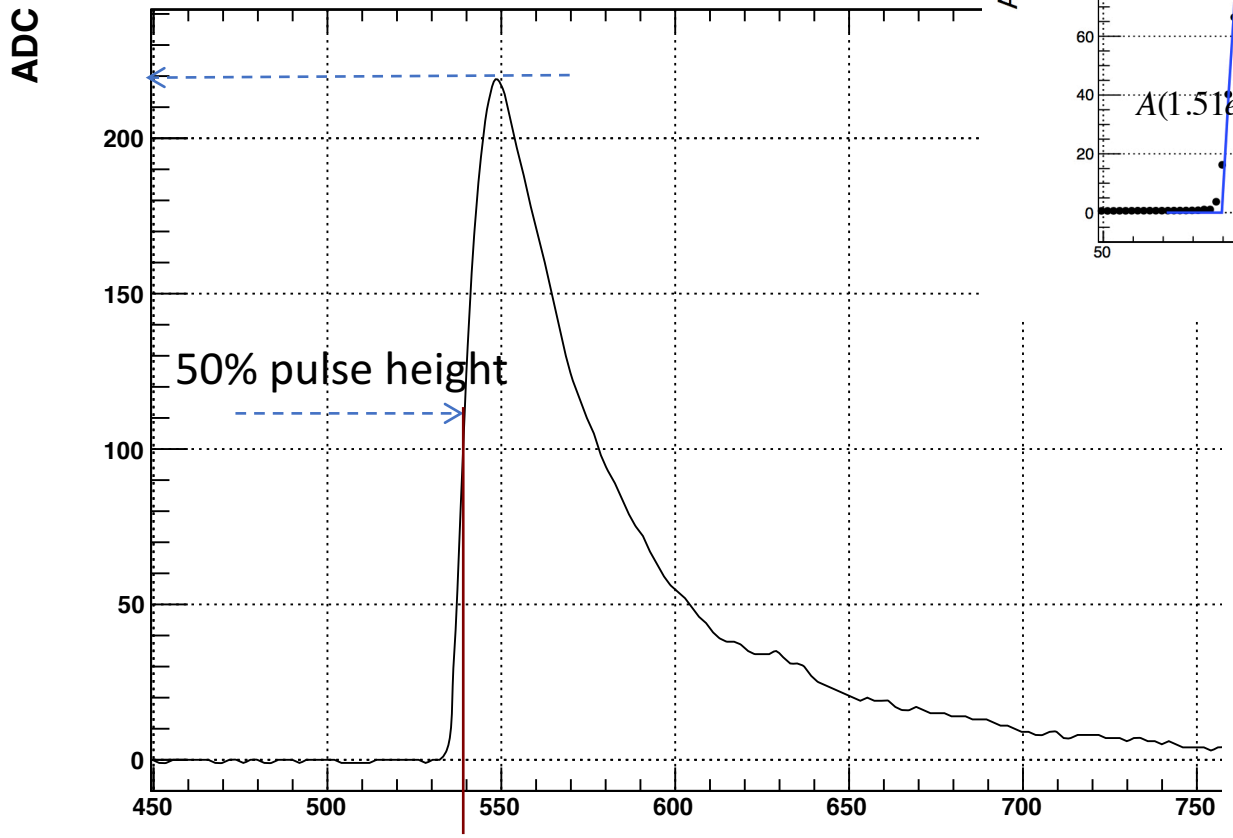
Distance from Target to detector :15m

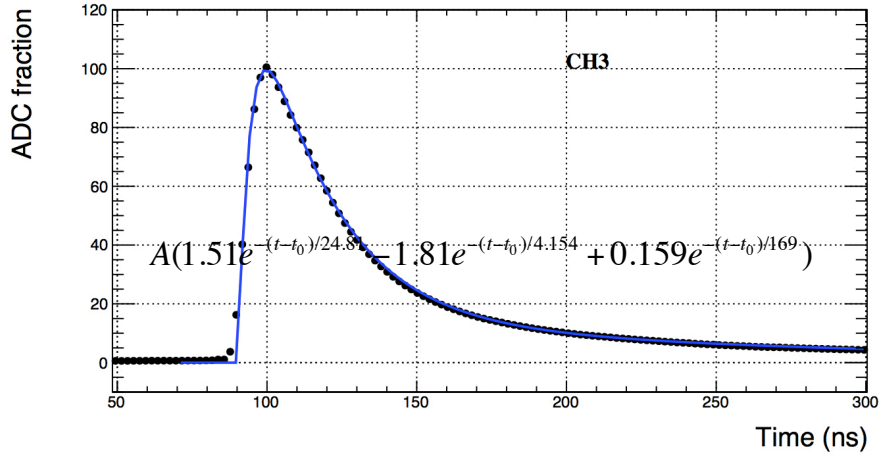
Gap between stations : 60 cm

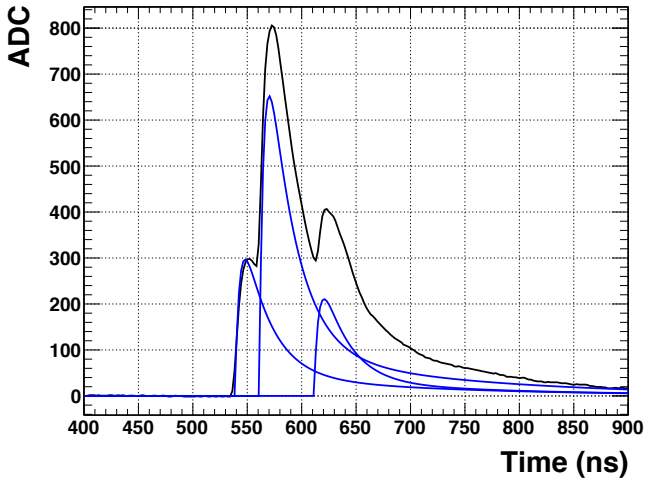
Waveform (Beam 392MeV)

✓ FADC500

500 MSa/s, 12 bit resolution, 8channel

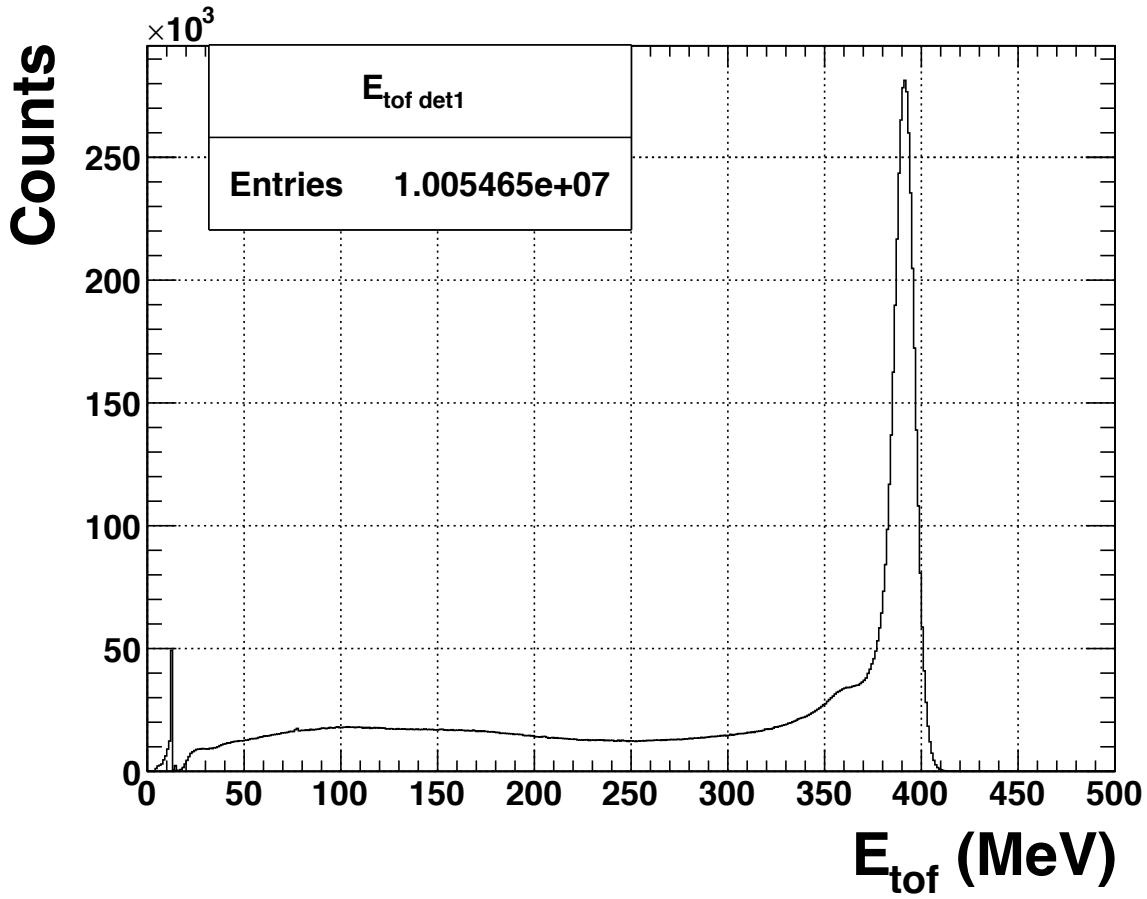


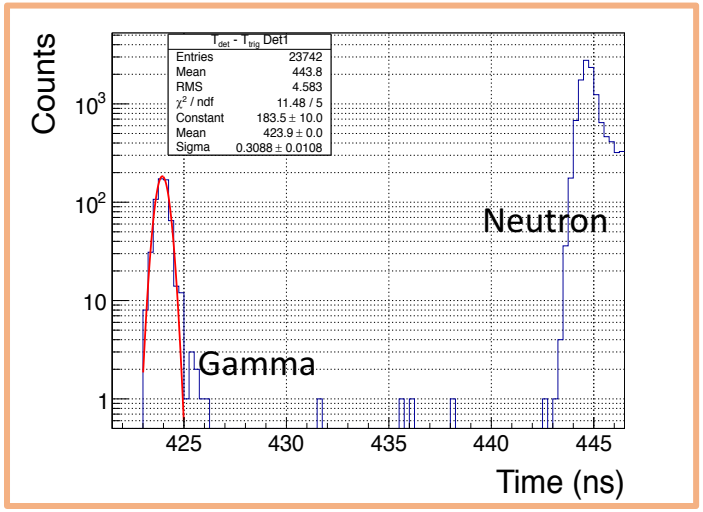




Neutron energy spectrum (392 MeV)

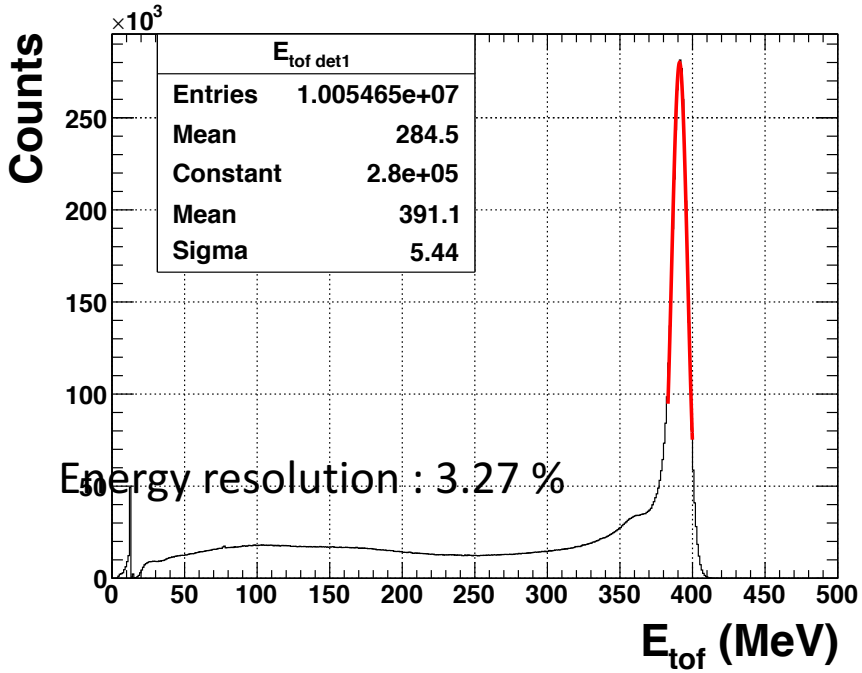
- ✓ applied time at 50% pulse height for energy reconstruction
- ✓ Hit time = $((T_{left} + T_{right}) - L_{det}/v_s)/2$





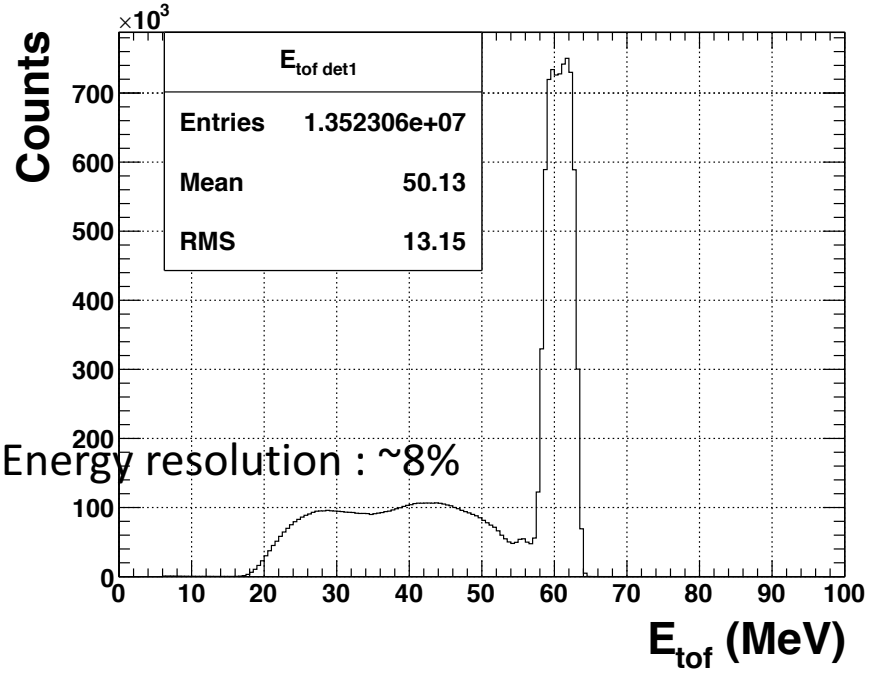
Energy resolution

det1
392 MeV



N(peak)3865042

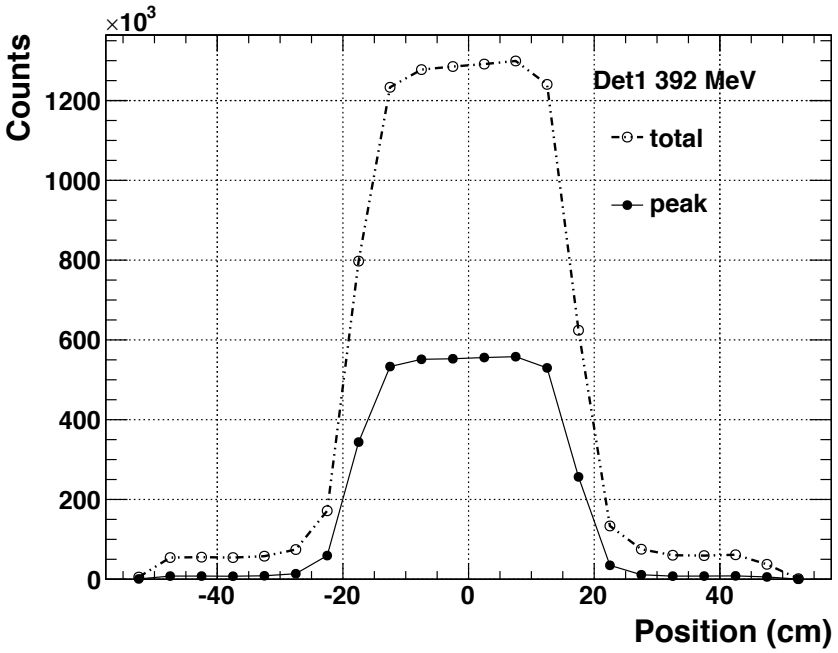
det1
65 MeV

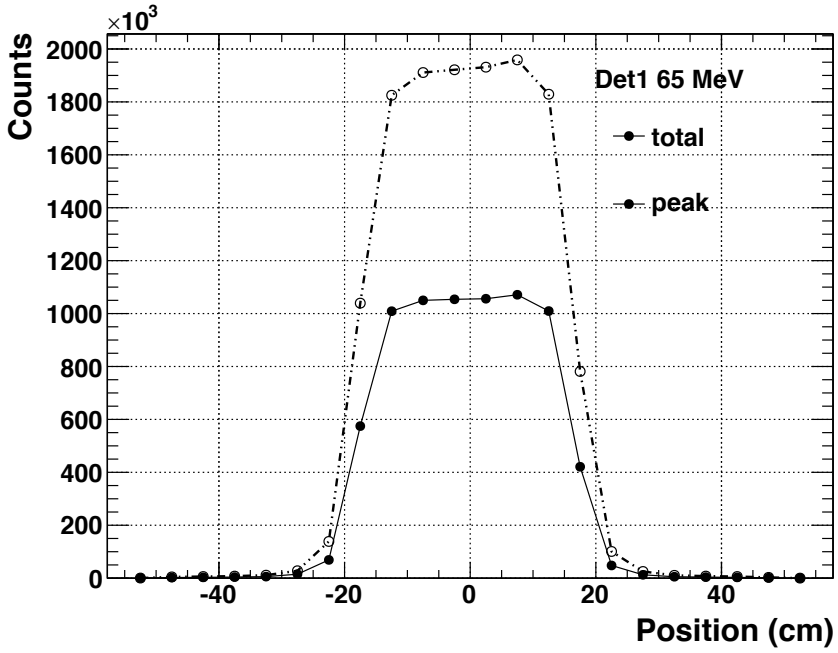


N(peak)7060133

$\emptyset_{peak}/\emptyset_{total}$ ratio with different position

calculate total and peak counts every 5cm length
It shows almost constant count region between -15cm and 15cm





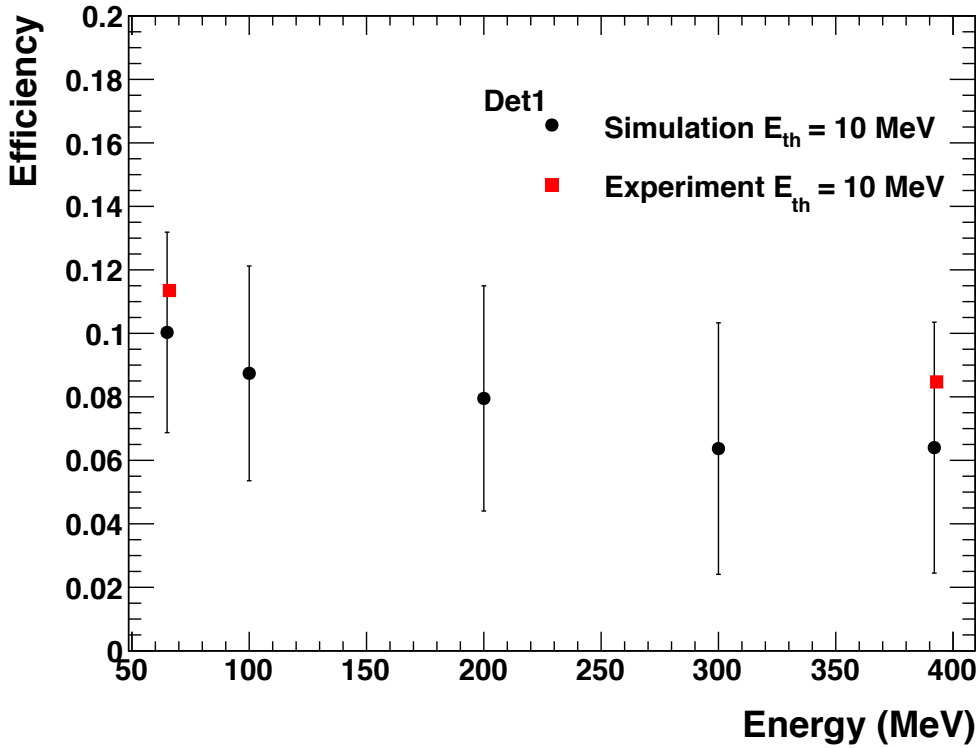
	Iwamoto et al.	Iwamoto et al.	This work	this work
Proton energy (MeV)	246	389	65	392
$\emptyset_{peak}/\emptyset_{total}$ (E_n> 10 MeV)	0.44	0.4	0.55	0.43

NIM A629 (2011) p43

Efficiency

Beam current : 10 nA detector thickness : 10 cm

The neutron intensity of the higher-energy peak is about $1*10^{10}$(n/sr/ μC)



$1*10^{10}$ n/sr/μC *$(0.03/15^2)$ *0.01 μC/s $= 13333$n/s **case 2**

65 MeV

13333 n/s *9322/2 s = $6.213*10^7$

58<Etof < 65 : $7.06*10^6$

efficiency : $7.06*10^6/6.213*10^7$ = 11.35 %

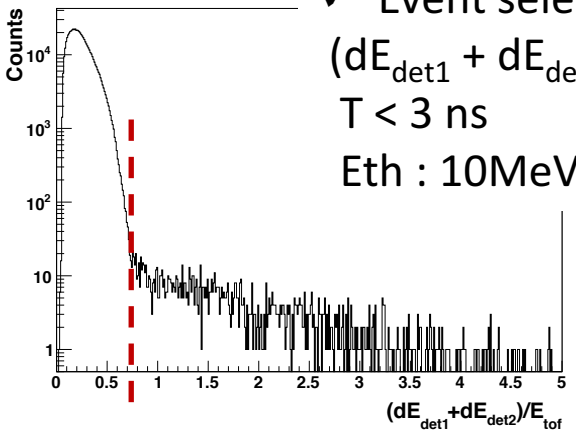
392 MeV

13333 n/s *6641/2 s = $4.424*10^7$

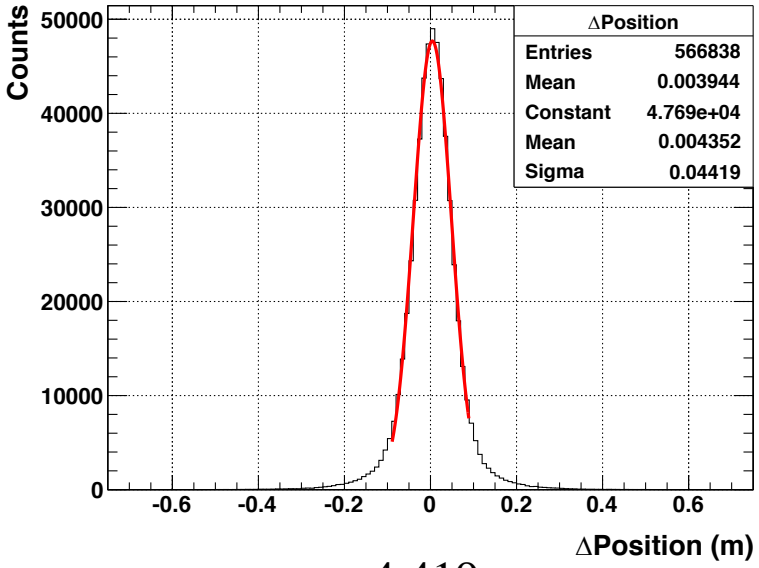
380 <Etof < 420 : $3.86*10^6$

efficiency : $3.86*10^6/ 4.424*10^7$ = 8.46 %

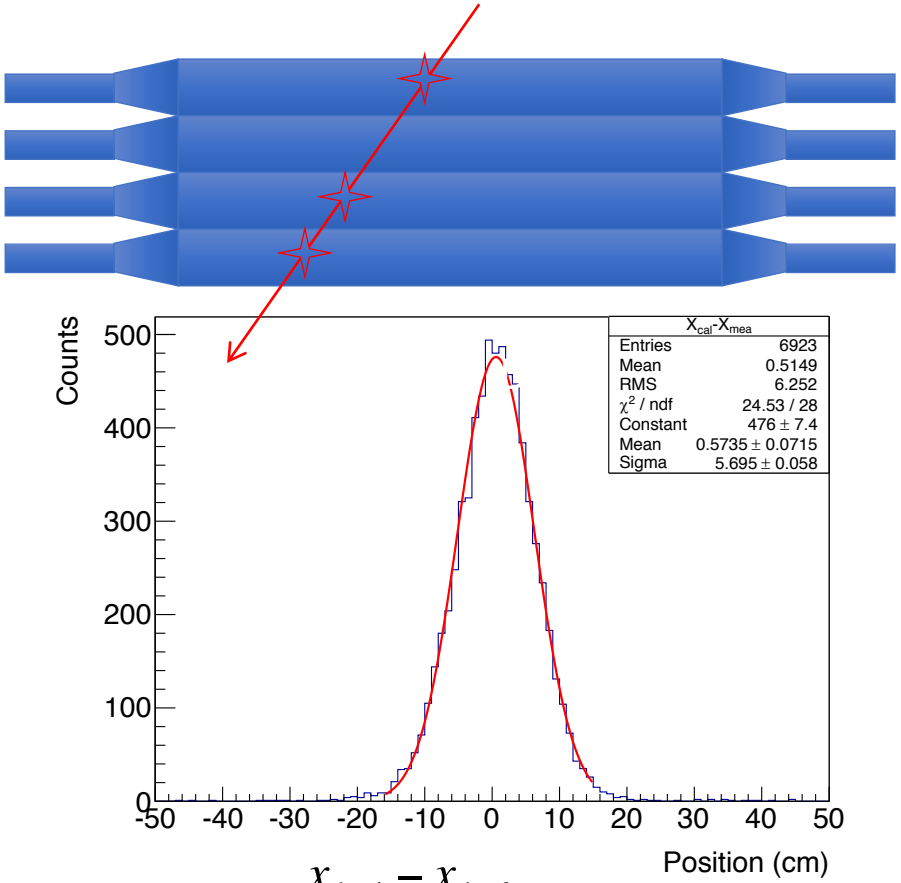
Position resolution



- ✓ Event selection:
  $(dE_{det1} + dE_{det2})/ E_{tof} < 0.75$
  $T < 3$ ns
  Eth : 10MeV



$$\mathrm{Re}\,solution = \frac{4.419}{\sqrt{2}} = 3.12cm$$



$$x_{\det 3cal} = \frac{x_{\det 4} - x_{\det 6}}{2} + x_{\det 4}$$

$$\sigma_{\det 3cal} = \sqrt{(\frac{3}{2}\sigma)^2 + (\frac{1}{2}\sigma)^2} = \frac{\sqrt{10}}{2}\sigma$$

$$\sigma = 3.60cm$$

Summary

- ✓ We tested neutron detector array with FADC at N0 beam line of RCNP cyclotron facility 392 MeV, 65 MeV
- ✓It shows energy resolution of 3.27% at 392 MeV beam
- ✓ position resolution shows 3.12 cm
- ✓efficiency shows 8% ~ 10% for 10cm thick single detector