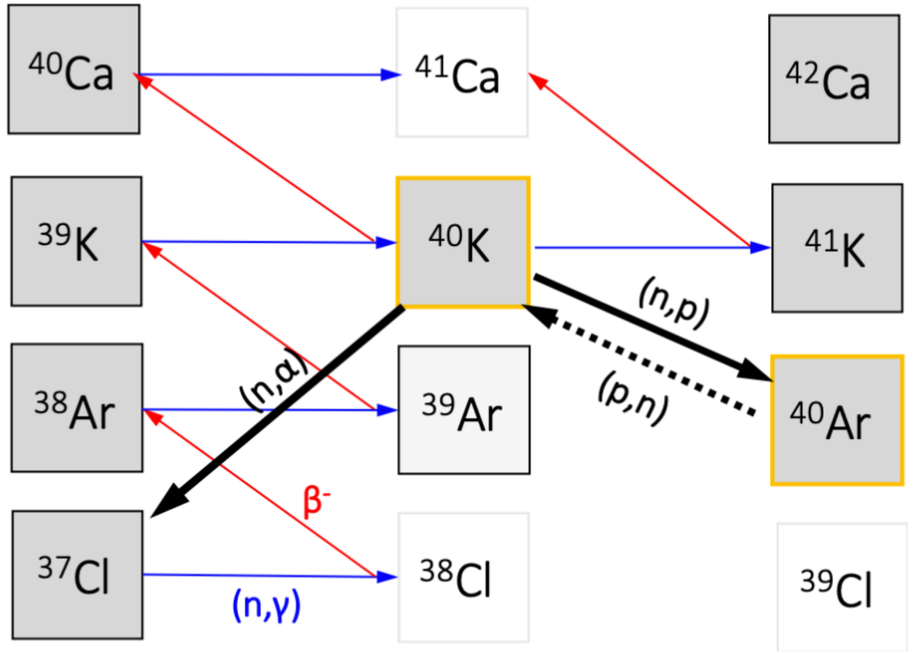
Performance of Neutron Detector for p + ^{40}Ar Reaction

The 4th Korea-China Joint Workshop for rare isotope physics

Korea University
Sooho Chae

Hadron & Nuclear Physics lab

Motivation



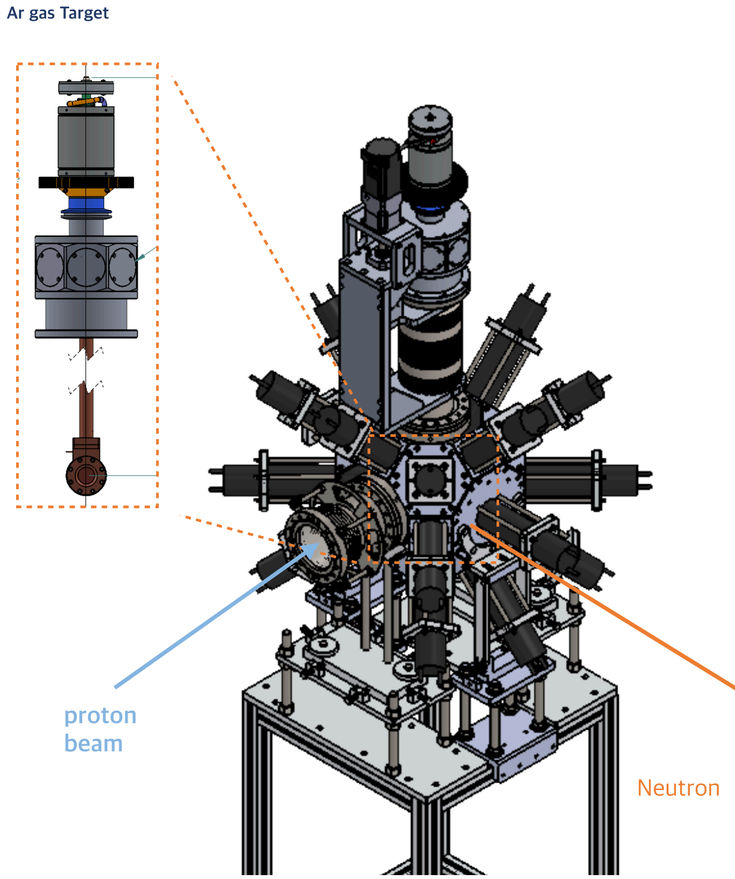
- Abundance of ^{40}K is related to the evolution of habitable environments in earth-like extra solar planets

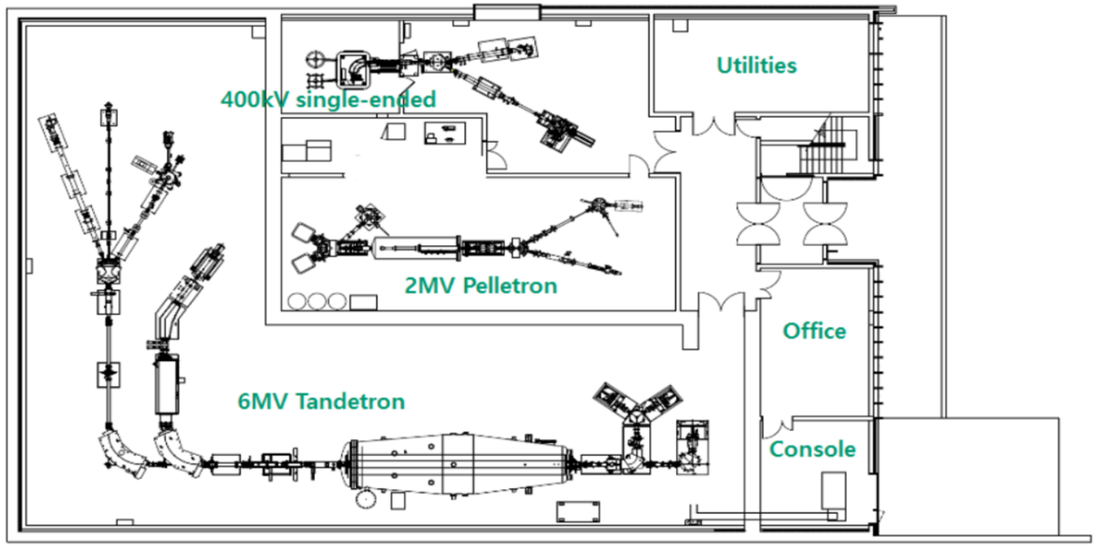
- We will focus on the destruction of Potassium through ^{40}K(n,p)^{40}Ar Reaction

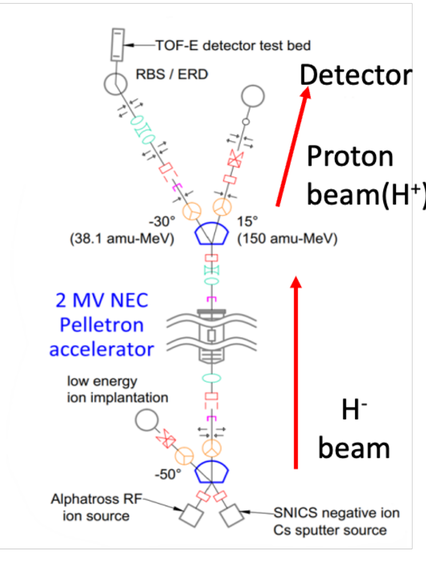
→ We are going to measure cross-section of ^{40}Ar(p,n)^{40}K

Hadron & Nuclear Physics Lab

Motivation



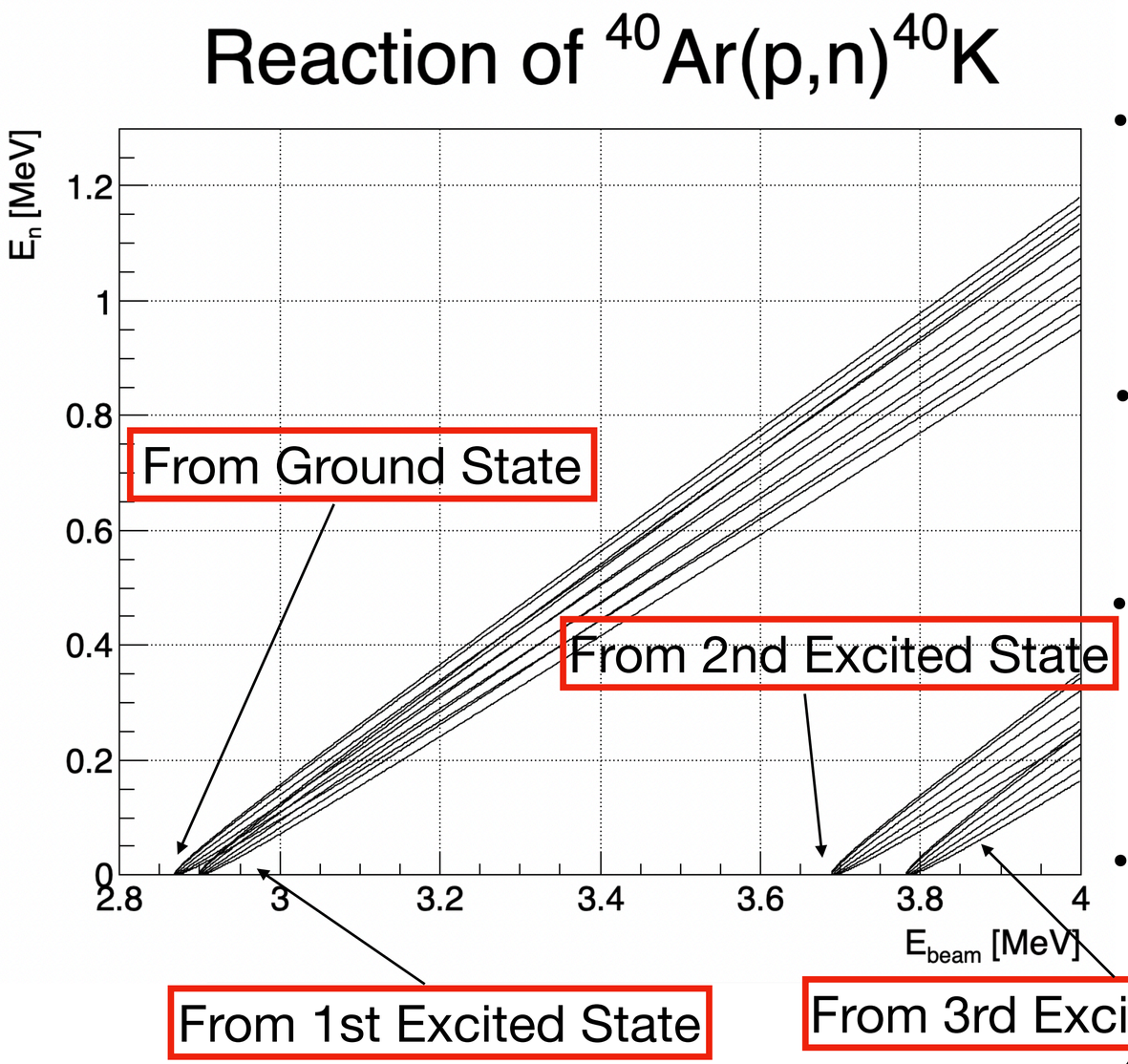




- Proton beam energy will start from about 2.9 MeV
- Distance of Neutron detector array will be about 3 m from target

Hadron & Nuclear Physics Lab

Expected Neutron Energy from ^{40}K



- Neutron Energy from Ground State ^{40}K When Proton Energy is 4 MeV (distance is 3 m)

  0.977 MeV $\leq E_n \leq$ 1.18 MeV $\rightarrow$ tof_{min} = 200 ns

- 1st Excited State ^{40}K

  0.949 MeV $\leq E_n \leq$ 1.15 MeV $\rightarrow$ tof_{min} = 203 ns

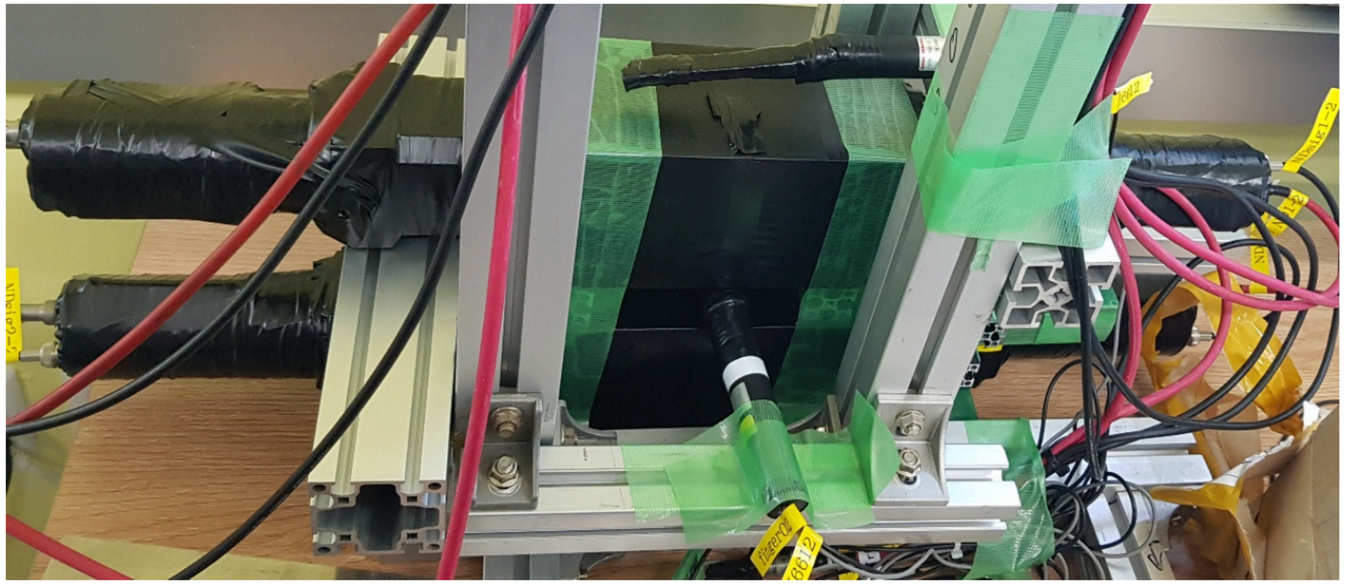
- 2nd Excited State ^{40}K

  0.245 MeV $\leq E_n \leq$ 0.352 MeV $\rightarrow$ tof_{min} = 365 ns

- 3rd Excited State ^{40}K

  0.165 MeV $\leq E_n \leq$ 0.254 MeV $\rightarrow$ tof_{min} = 413 ns

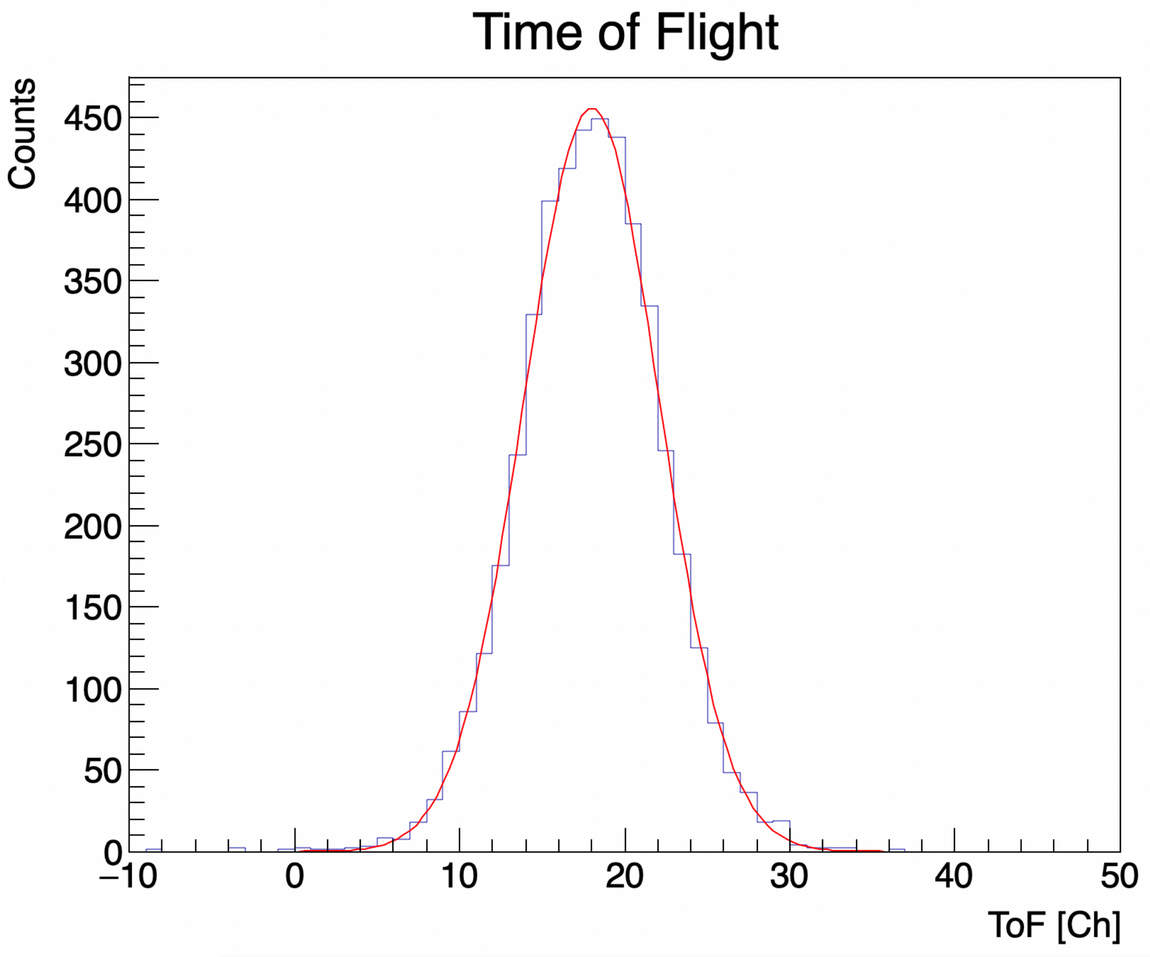
Test Bench for Cosmic Test



Scintillator Type	Dimension (mm)	Light Yield (/MeV)	PMT type
BC 408	200x100x100	7500	EMI 9954B

Hadron & Nuclear Physics Lab

Time Resolution from Time-of-Flight Measurement



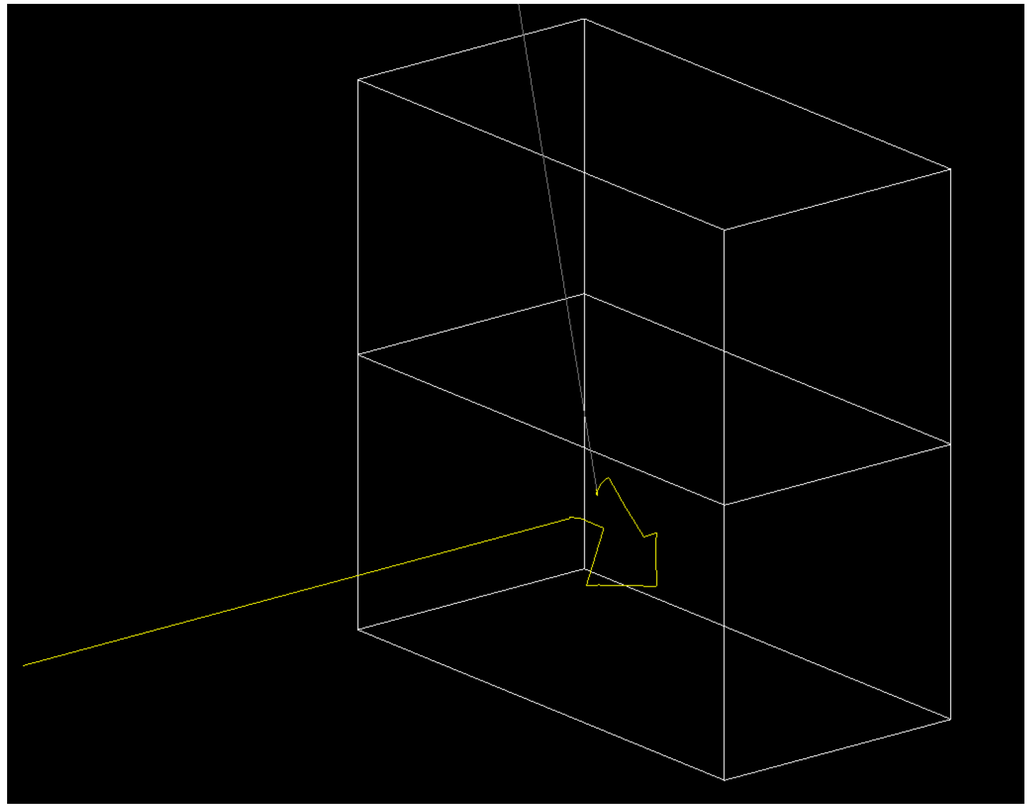
- TDC Module resolution : 25 ps
- ToF : 18.0 ± 0.06 Ch
- σ_{tof} = 4.1 ± 0.05 Ch

  → σ_{det} = 72 ± 0.8 ps

Hadron & Nuclear Physics Lab

Geant4 Simulation for Detection Efficiency

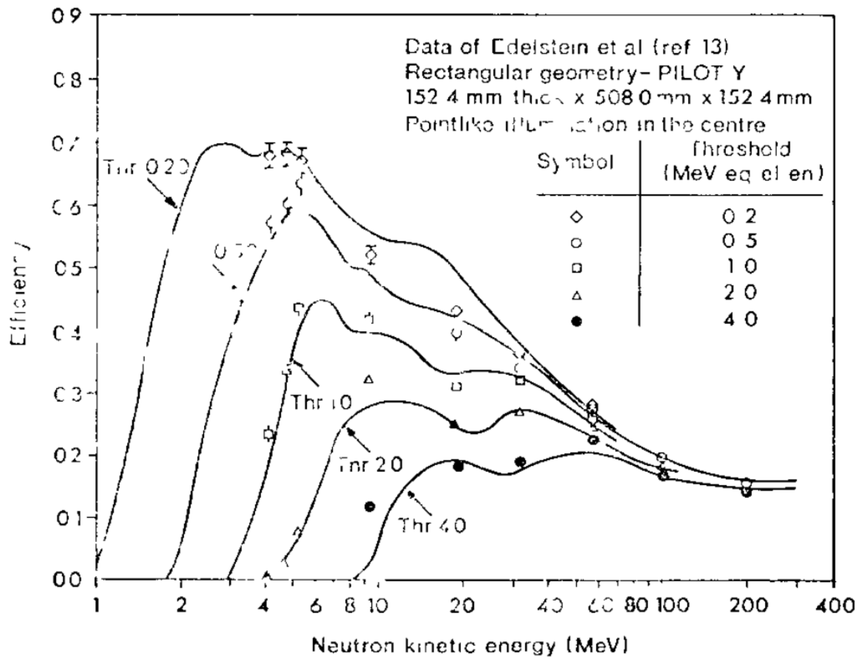
- Physics Model : FTFP_BERT_HP
- Only data exceeding 133 eV were collected
- The main processes are $^{1}H(n, n)^{1}H$, $^{12}C(n, n)^{12}C$ and $^{12}C(n, \gamma)^{13}C$
- Monoenergetic Neutrons are used from 0.1 MeV to 5 MeV

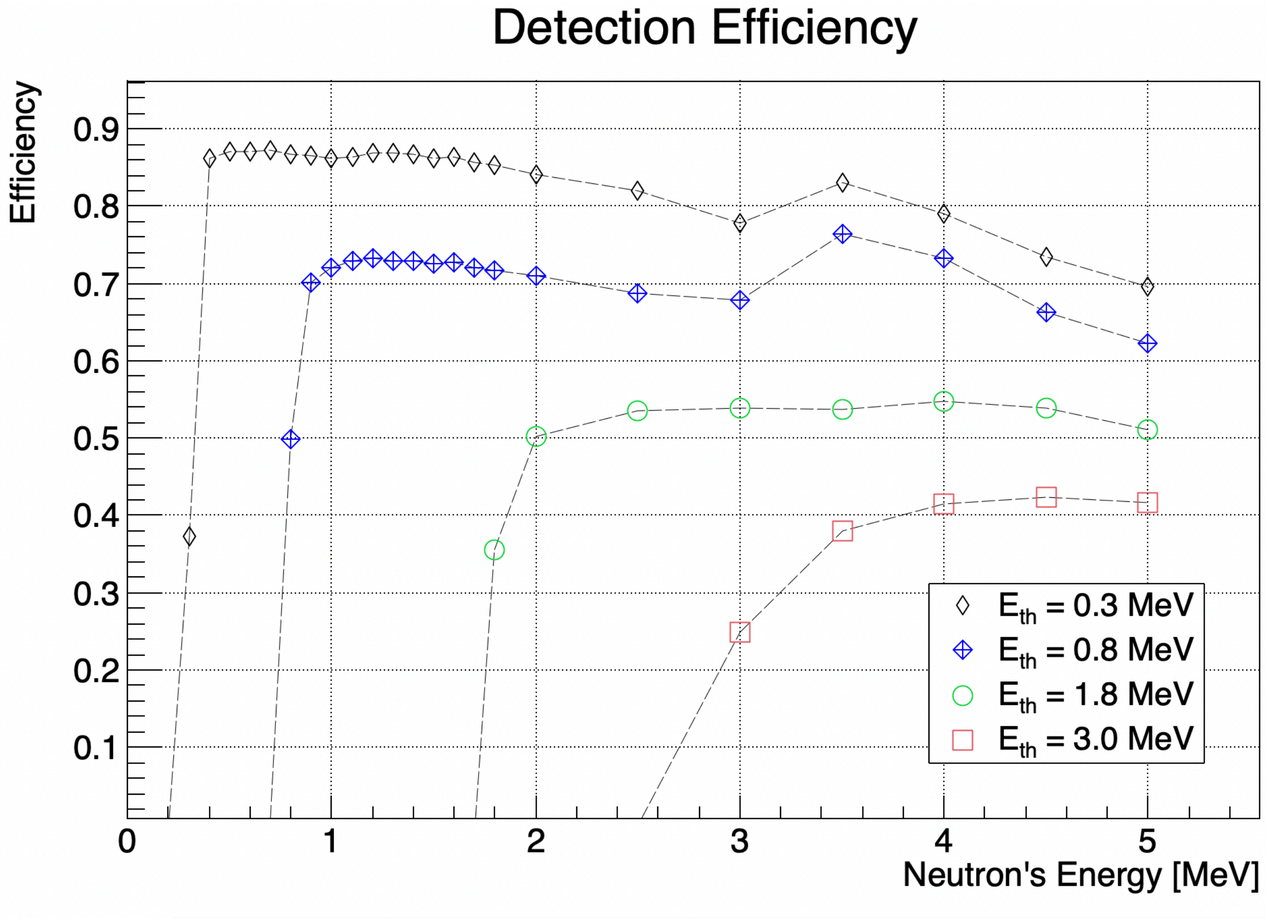


$$\text{Detection Efficiency} = \frac{number\ of\ detected\ events}{number\ of\ emitted\ events\ from\ source}$$

Hadron & Nuclear Physics Lab

Geant4 Simulation for Detection Efficiency





- For the reference
- Scintillator type : Pilot Y
- Dimension (mm) : 152 x 508 x 152

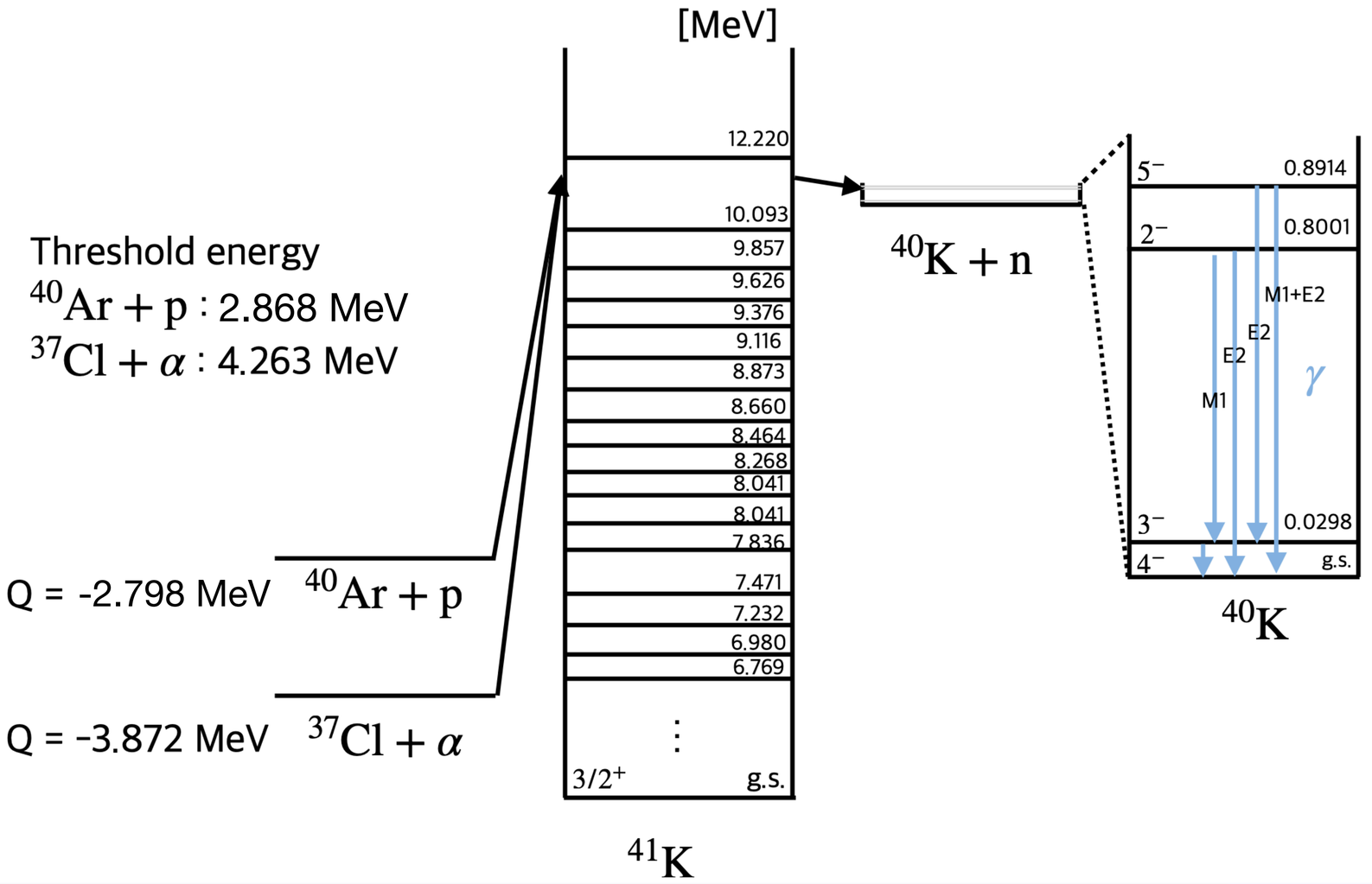
Hadron & Nuclear Physics Lab

Summary

- Neutron Detector has developed for measuring cross section of $^{40}K(n,p)^{40}Ar$ reaction
- Cosmic Test has been done for measuring time resolution
- Geant4 Simulation has been done for simulating detection efficiency

Hadron & Nuclear Physics Lab

Back Up


[MeV]
Threshold energy
$^{40}Ar + p$: 2.868 MeV
$^{37}Cl + \alpha$: 4.263 MeV
Q = -2.798 MeV $^{40}Ar + p$
Q = -3.872 MeV $^{37}Cl + \alpha$
12.220
10.093
9.857
9.626
9.376
9.116
8.873
8.660
8.464
8.268
8.041
8.041
7.836
7.471
7.232
6.980
6.769
3/2+ g.s.
^{41}K
$^{40}K + n$
5− 0.8914
2− 0.8001
M1+E2
E2
E2
M1
γ
3− 0.0298
4− g.s.
^{40}K