

# Measurement of Muon Capture on $^{48}\text{Ti}$ at MuSIC

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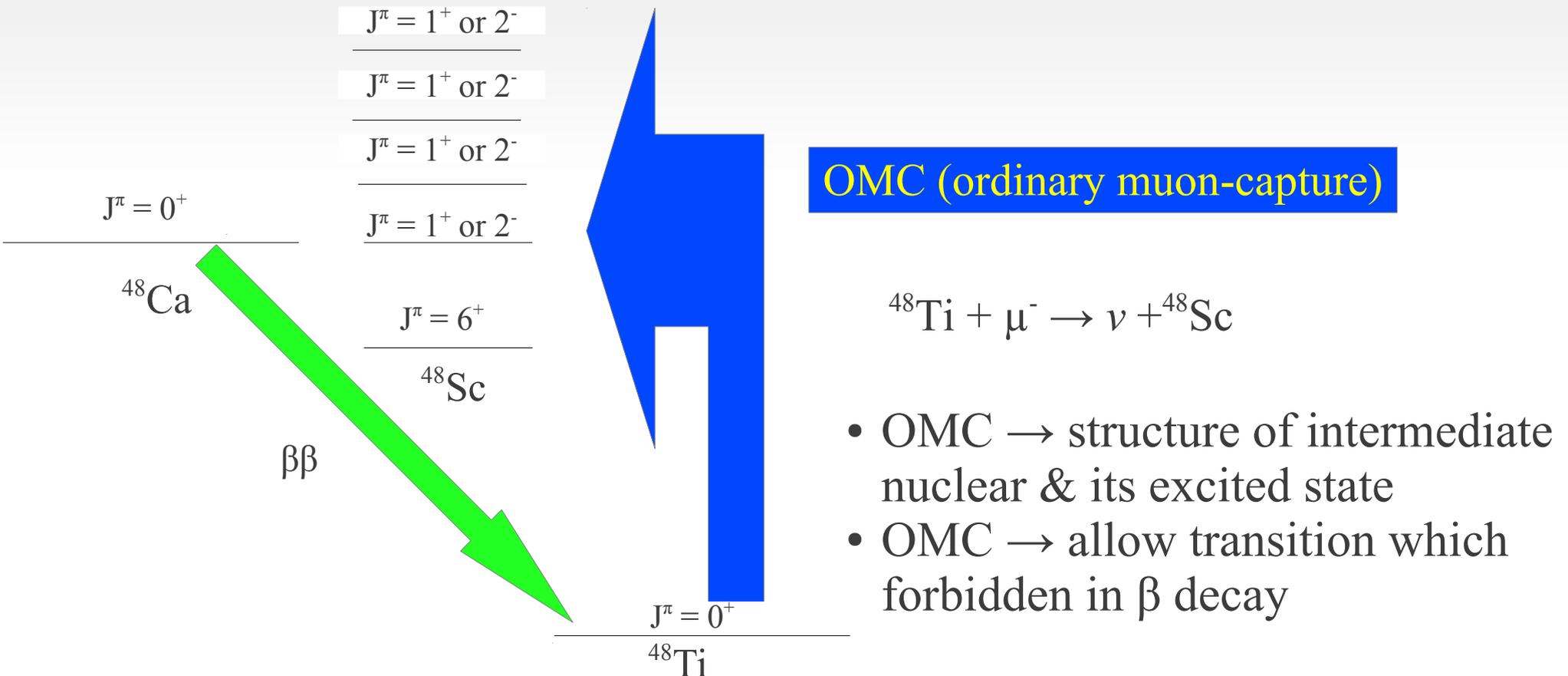
- Purpose of experiment
- Status of past experiment - MuSIC 4<sup>th</sup> beam test  
- Geant4 Simulation
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# Purpose of measurement of muon capture on $^{48}\text{Ti}$

Measure the Nuclear matrix element  $M_{GT}$

→ beta decay

→ OMC => Matrix element for muon capture [101] & [112] (\*) (\*\*)



(\*)M. Morita, A. Fujii, Phys. Rev. 118 (1960) 606 (\*\*). T. Siiskonen et al, Nucl. Phys. A 635 (1998) 446-469

# Purpose of measurement of muon capture on $^{48}\text{Ti}$

Lifetime of double beta decay

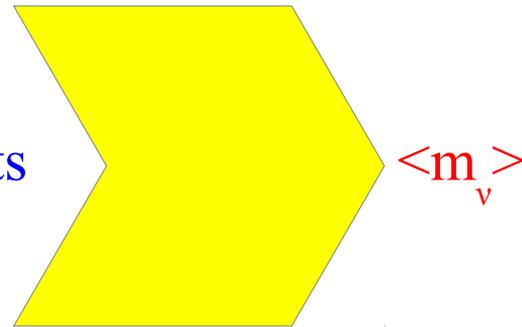
$$[T_{1/2}^{0\nu}]^{-1} = [\langle m_{\nu} \rangle / m_e]^2 G_{0\nu} |M_{GT}^{0\nu}|^2 \quad (*)$$

$$[T_{1/2}^{2\nu}]^{-1} = G_{2\nu} |M_{GT}^{2\nu}|^2$$

T: lifetime

G: integral over the phase space of the leptonic variables

- $0\nu\beta\beta$
- nuclear matrix elements
- neutrino mixing



# Status of past experiment

## MuSIC 4<sup>th</sup> beam-test

Purpose: Estimate number muon in target  
=> muon lifetime

muon :P = 60 MeV/c

Target: Mg

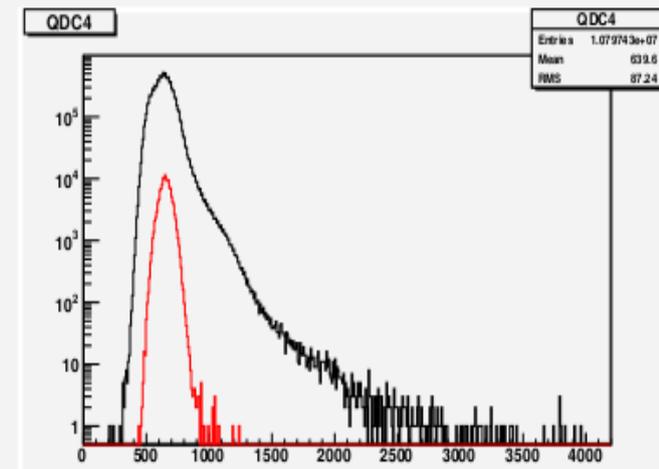
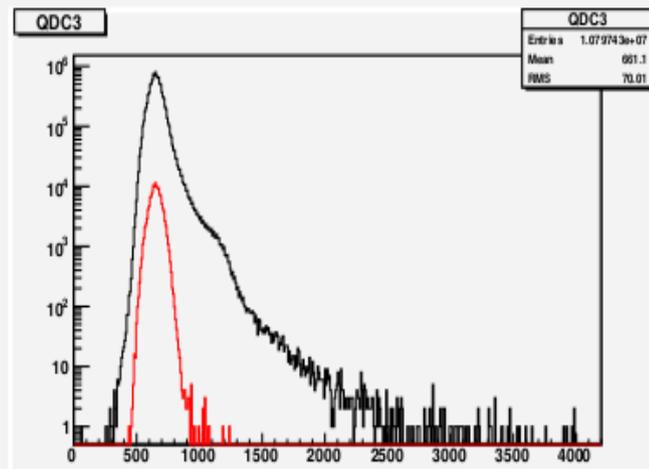
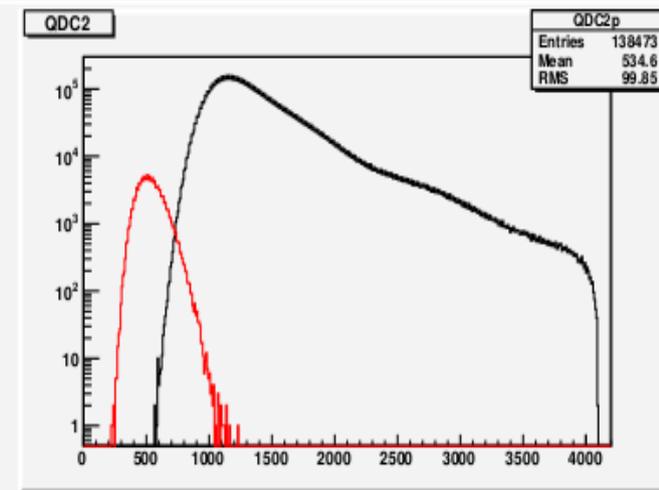
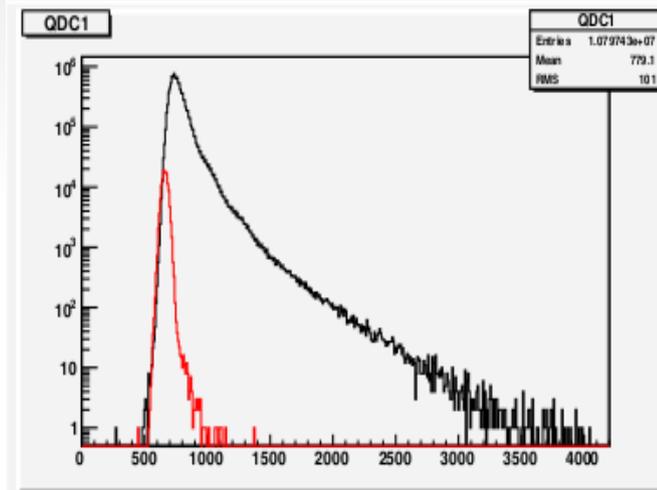
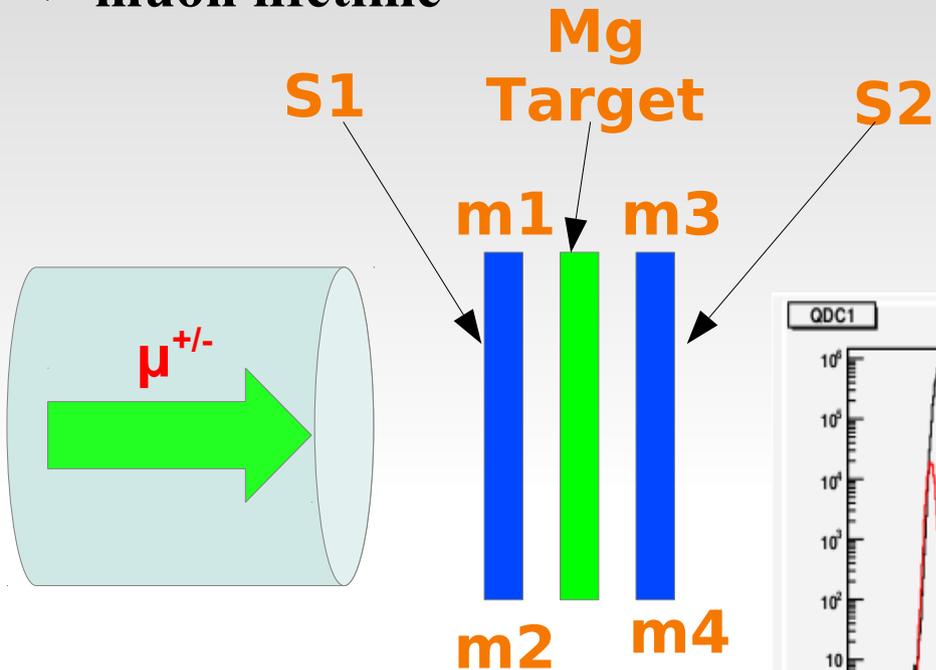
Scintillate counter: S1, S2

mppc read out m1, m2, m3, m4

Trigger logic (m1xm2)x(m3xm4)

— Pedestal in beam off

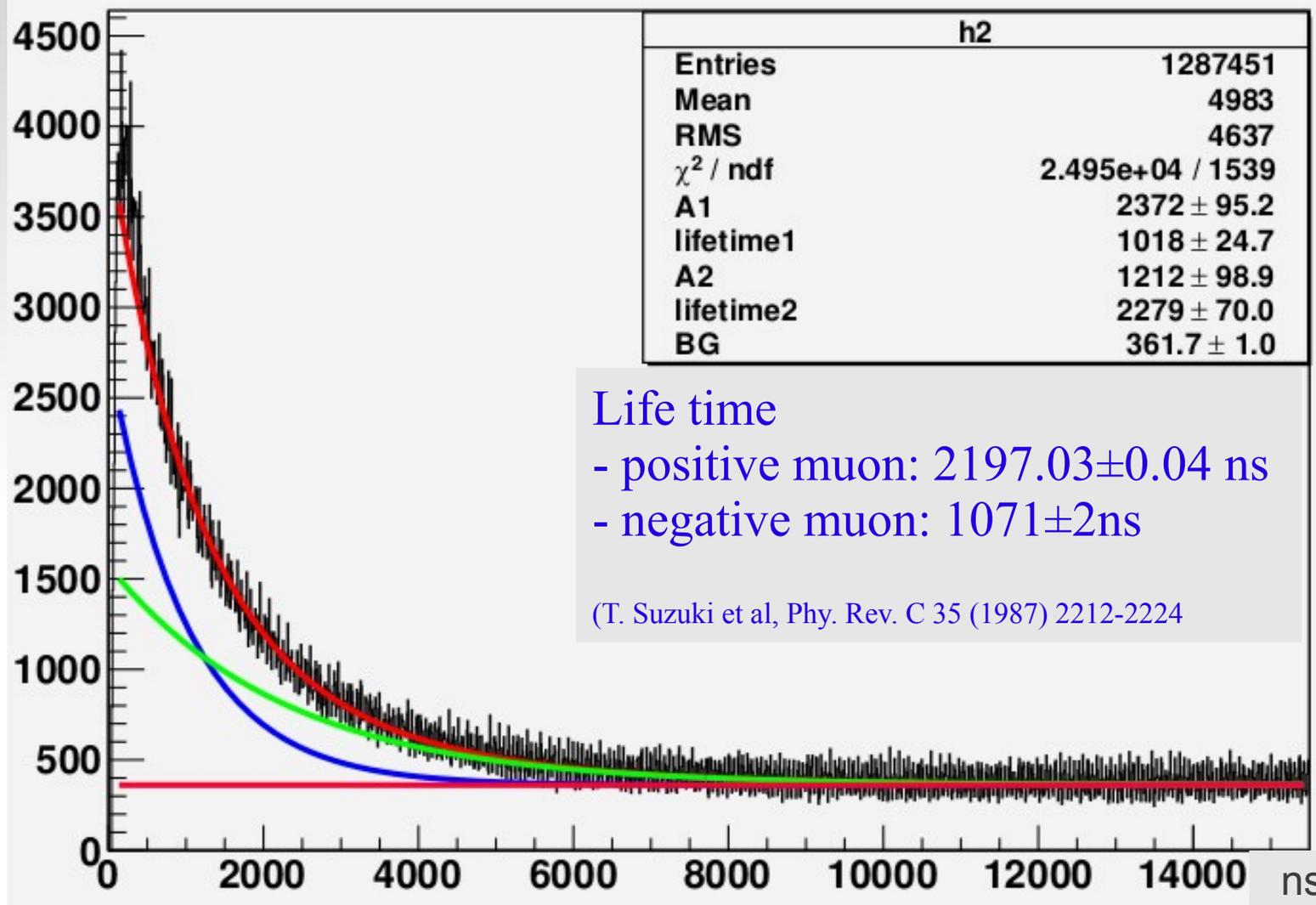
— Data in beam on



Ge

# Analysis of MuSIC 4<sup>th</sup> beam test, Oct. 22<sup>nd</sup> – 23<sup>rd</sup>, 2011

## Run958, proton current 59pA, 6298s, B<sub>y</sub> = +0.04 T



—  $f(t) = A1 \exp(-t/\text{lifetime1}) + A2 \exp(-t/\text{lifetime2}) + \text{BG}$

—  $g1(t) = A1 \exp(-t/\text{lifetime1}) + \text{BG}$

—  $g2(t) = A2 \exp(-t/\text{lifetime2}) + \text{BG}$

—  $g3(t) = \text{BG}$

— data

**Music beam test4, Oct. 22<sup>nd</sup> – 23<sup>rd</sup>, 2011**  
**Run958, proton current 59pA, 6298s,  $B_y = +0.04$  T**

Integrated => number  $\mu^-$  :  $\sim 361\mu^-/s$  for 59pA proton

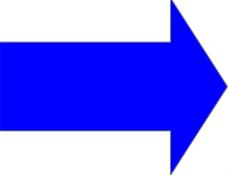
=> number  $\mu^+$  :  $\sim 427\mu^+/s$  for 59pA proton

efficiency of DAQ: 28%

=> number of  $\mu^-$  stop in target:  $\sim 1.3 \times 10^3 \mu^-/s$  for 59pA proton

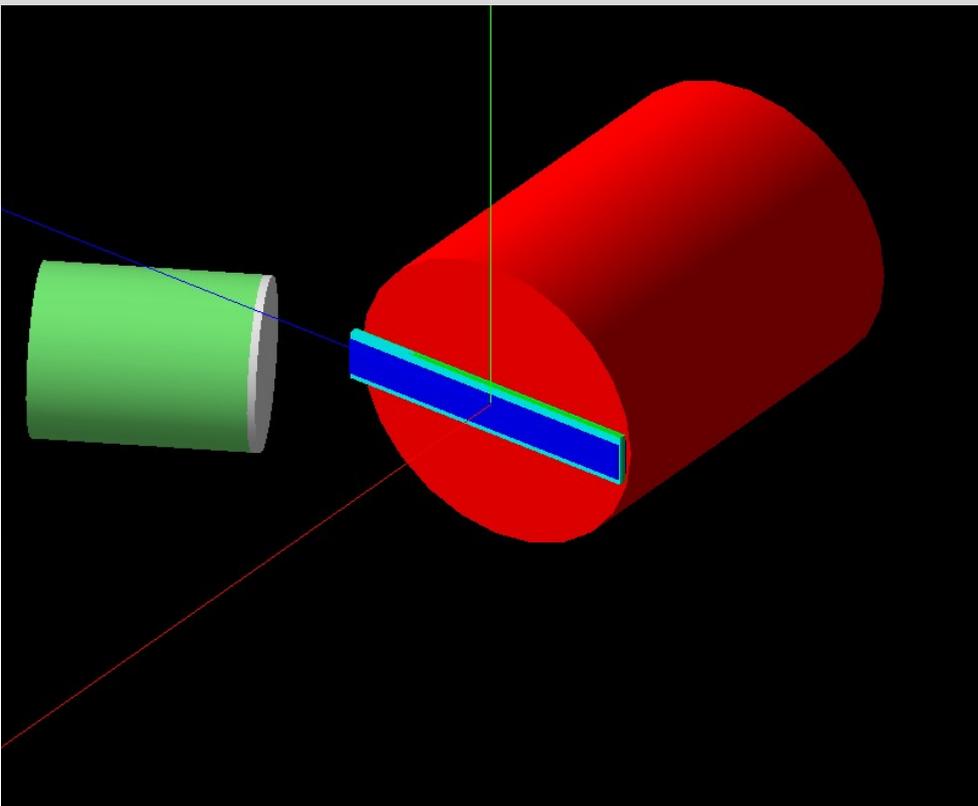
=> number of  $\mu^+$  stop in target:  $\sim 1.5 \times 10^3 \mu^+/s$  for 59pA proton

$\mu^-$  distribution in beam: 23.5%,  $\mu^+$  distribution in beam: 15.7%

 number of muon in beam for 1  $\mu A$  proton:

$\sim 1 \times 10^8 \mu^-/s$  and  $\sim 1.6 \times 10^8 \mu^+/s$

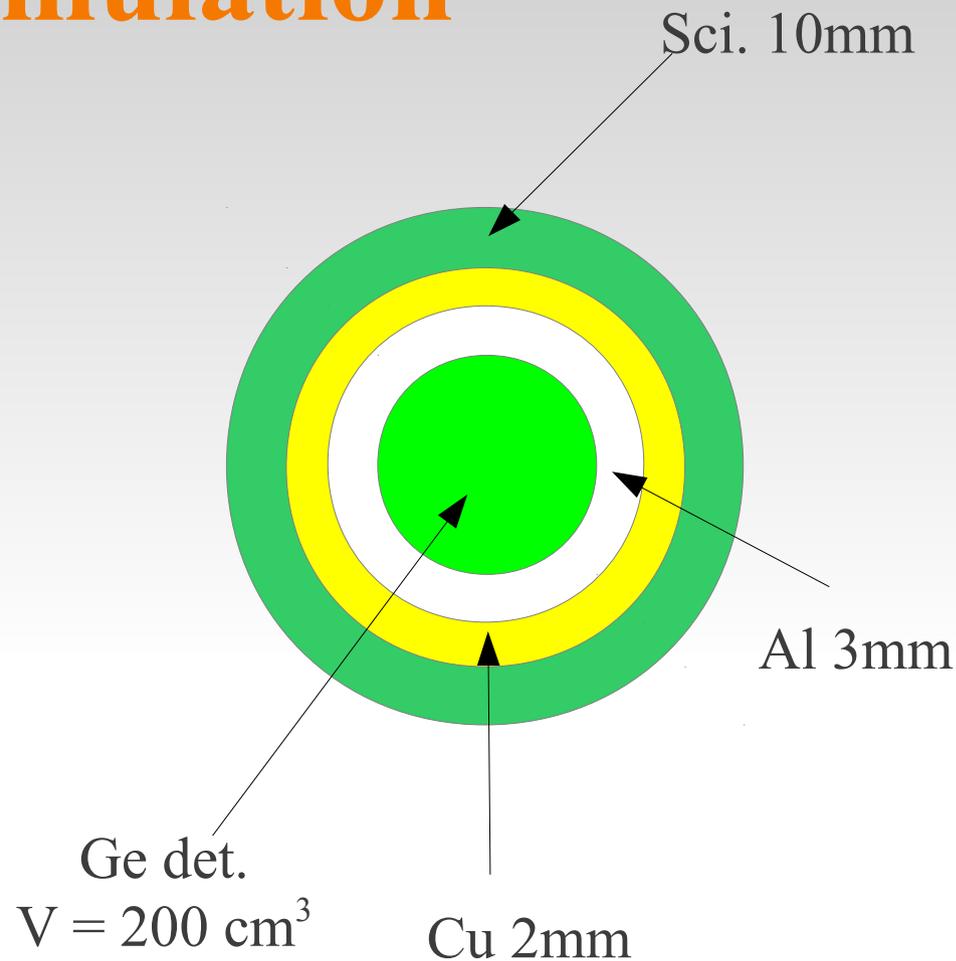
# Geant4 simulation



Target:  $^{48}\text{Ti}$ , 10 mm



Mylar 1mm



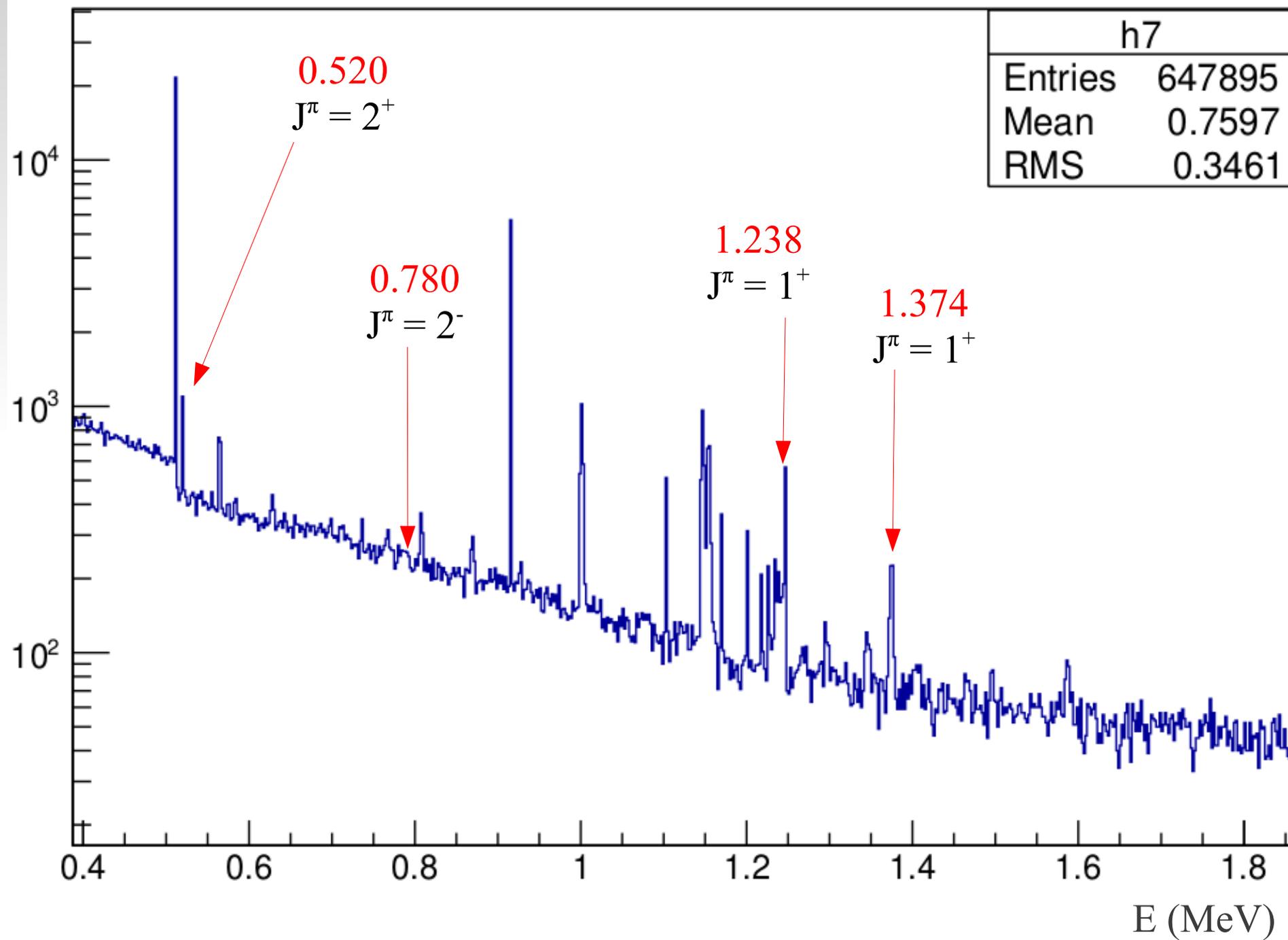
Ge det.  
 $V = 200 \text{ cm}^3$

Cu 2mm

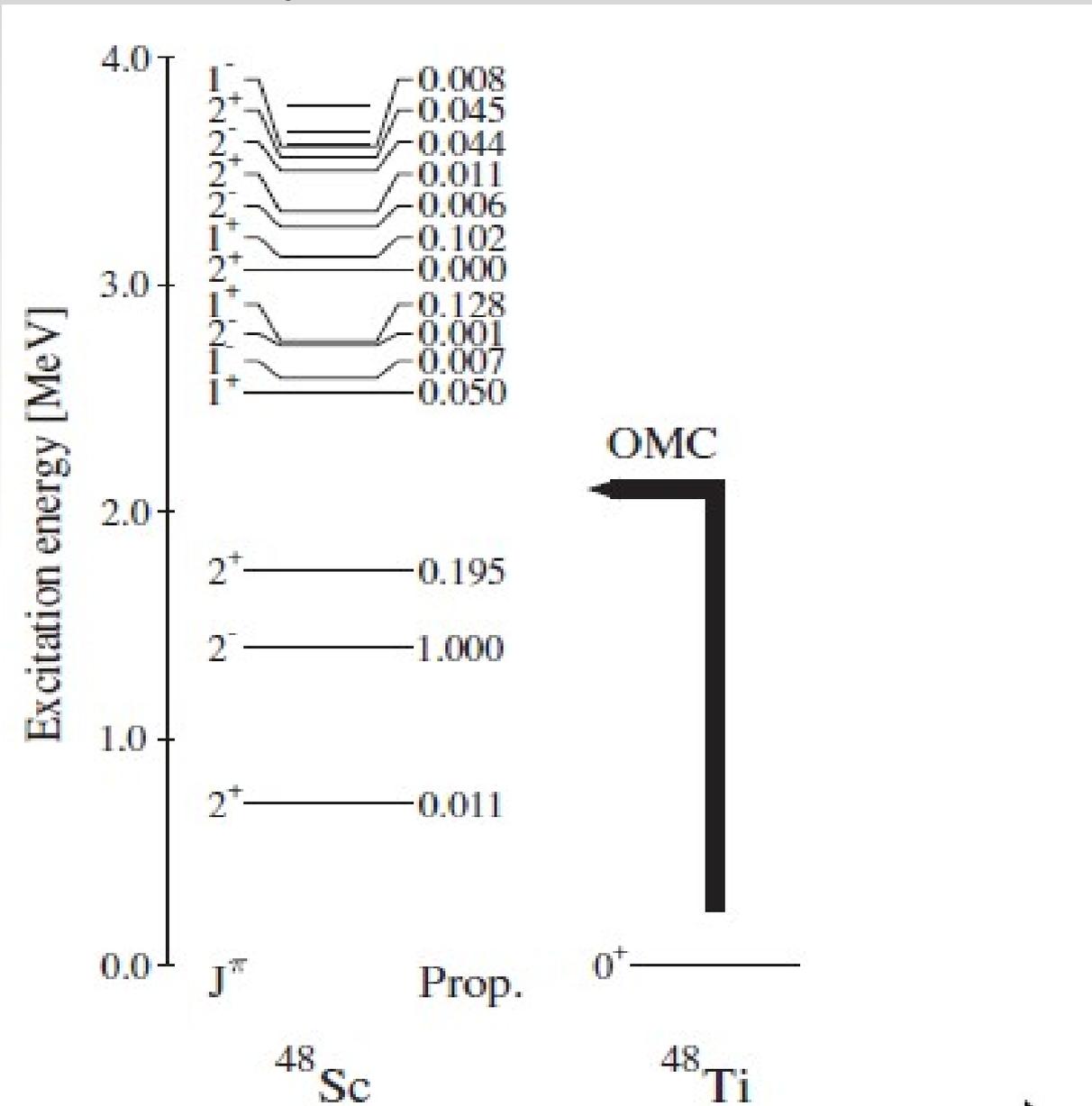
Al 3mm

Sci. 10mm

Counts



# Theory



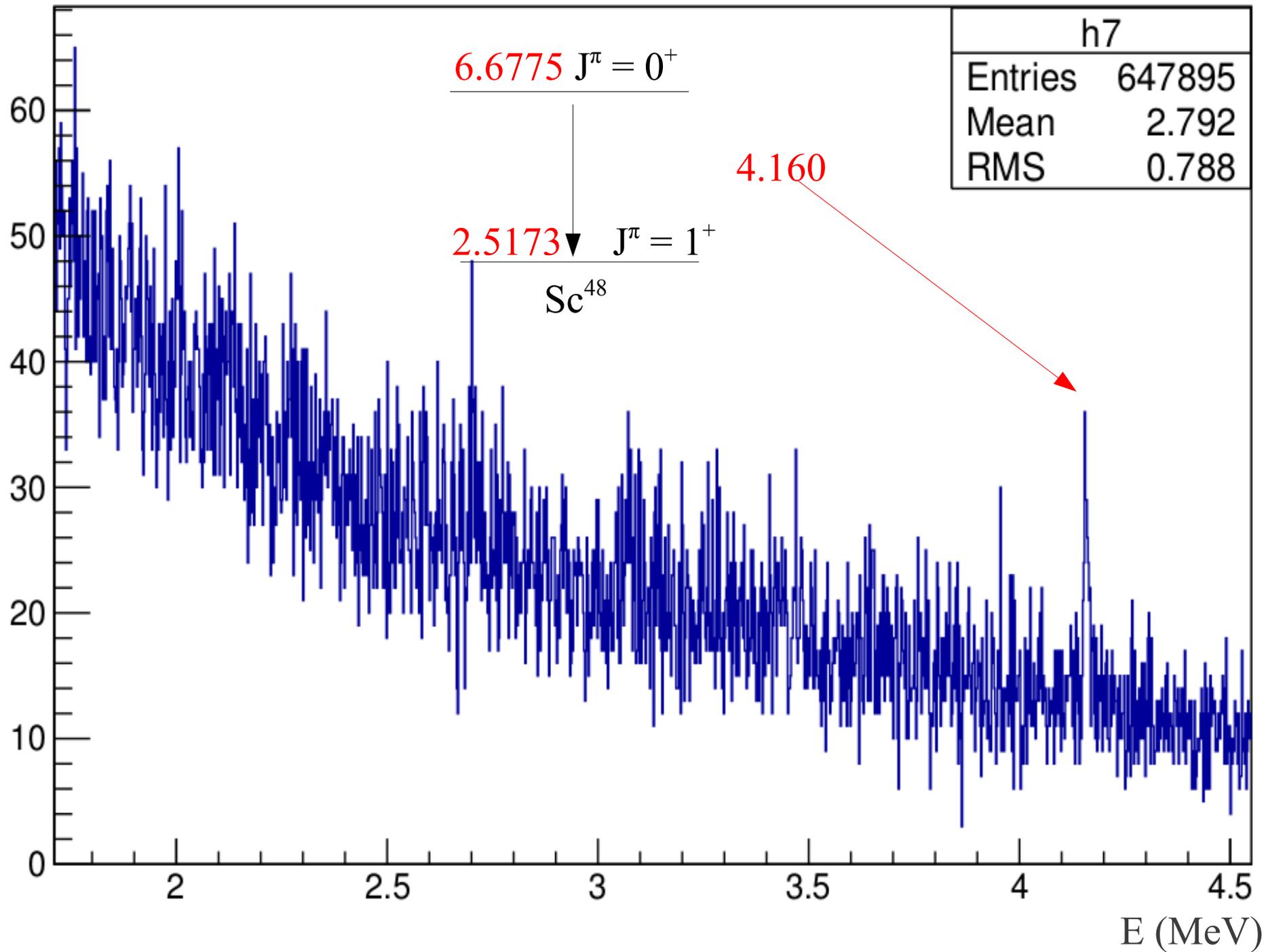
E level (keV)	$J^\pi$	$E_\gamma$ (keV)	$I_\gamma$
0.0	$6^+$		
1142.6	$2^+$	519.9	100
1401.7	$2^-$	259.1	4.2
		779.0	100.0
2517.3	$1^+$	1374.7	100.0
2640.1	$1^+$	1238.4	42.9

(www.nndc.bnl.gov)

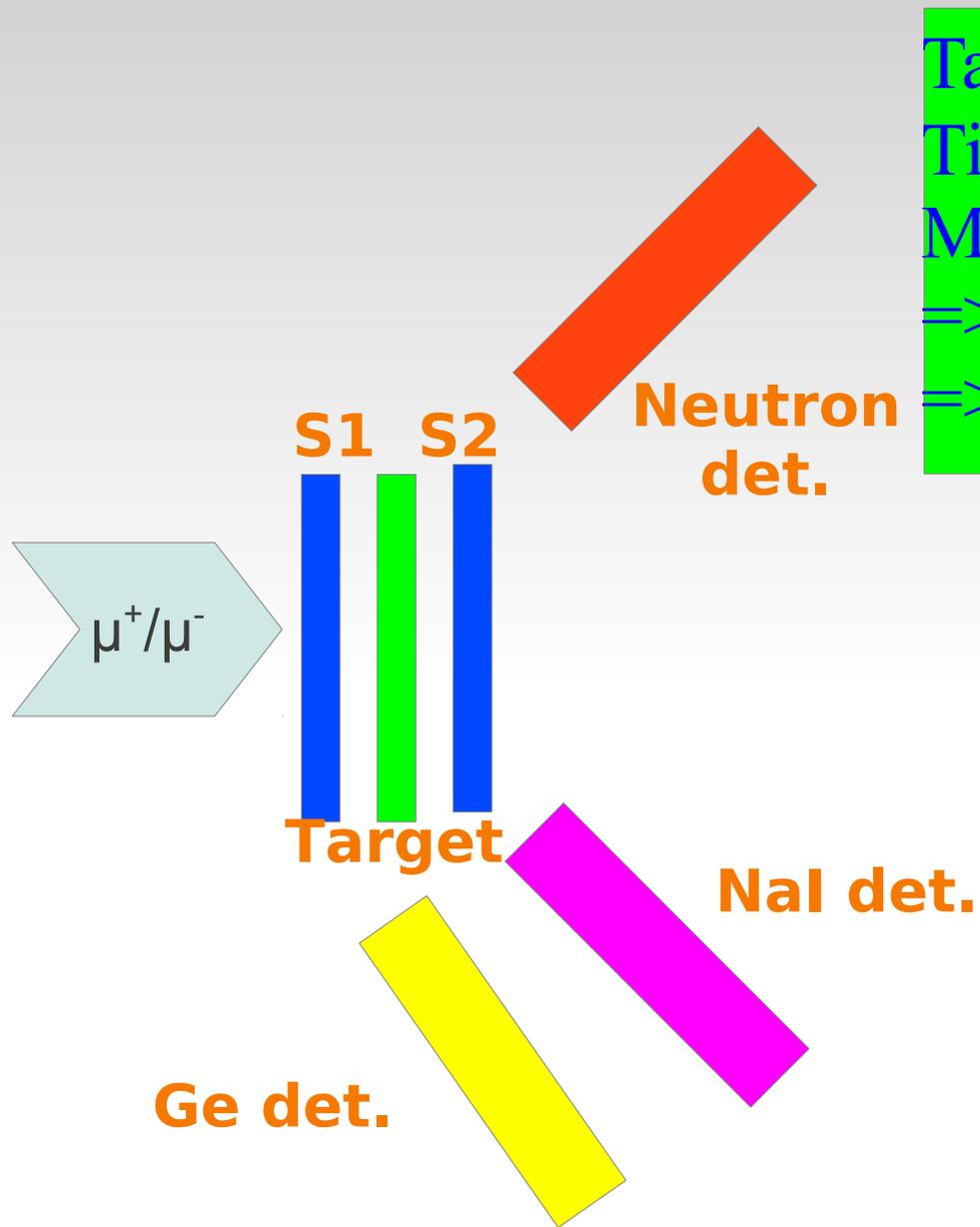
Proton-neutron Quasiparticle random-phase approximation calculation

(J. Phys. G: Nucl. Part. Phys. 30 (2004) 2003-2018)

Counts



# Next to do



Target:  $\text{Ti}^{48}$ , 10 mm

$\text{Ti}^{48} (\mu, \nu) \text{Sc}^{48}, \text{Ti}^{48} (\mu, \nu n) \text{Sc}^{47}$

Measure gamma rays, neutron emission

=> muon capture rate

=> Nuclear Matrix element  $M_{GT}$

- Geant4 simulate => shielding detector and reduce the noise in MuSIC beam
- Energy resolution, time resolution of detector
- ...

***Thanks for your attention***