The Study of P14A $^{9}Li/^{8}He$ background in nGd analysis update

CHENG Jie(程捷)

Shandong University

2014/11/23

Motivation and Outline

- Study $^{9}Li/^{8}He$ backgrounds in nGd analysis.
  - A repeat of the study done by Dengjie Li (DocDB9686)
  - Estimation of $^{9}Li/^{8}He$ background rate in nGd sample
  - Data used: P14A
- In this presentation:
  - $^{9}Li/^{8}He$ selection
  - Efficiency correction and uncertainty
  - Final result and comparison
  - Summary
  - Diagnose

^{9}Li/^{8}He background:

- **What is it ?**

$$^{9}Li \rightarrow {}^{9}Be^{*} + \boxed{e^{-}} + \bar{\nu}_{e} \quad \begin{cases} {}^{9}Be^{*} \rightarrow {}^{8}Be + \boxed{n}, {}^{8}Be \rightarrow 2\alpha \\ {}^{9}Be^{*} \rightarrow {}^{5}He + \alpha, {}^{5}He \rightarrow \alpha + \boxed{n} \end{cases}$$

$$^{8}He \rightarrow {}^{8}Li + \boxed{e^{-}} + \bar{\nu}_{e} \quad \begin{cases} {}^{8}Li \rightarrow {}^{7}Li + \boxed{n} \\ {}^{8}Li \rightarrow {}^{6}Li + \boxed{2n} \\ {}^{8}Li \rightarrow {}^{4}He + {}^{3}H + n \end{cases}$$

- **How to estimate?**
  - The method : time since last muon

Time since last muon

- **Fitting function** :
  - $f(t) = N_{Li+He}\left(R\lambda_{Li}exp(-\lambda_{Li}t) + (1-R)\lambda_{He}exp(-\lambda_{He}t)\right) + N_{ibd+Acc}R_{\mu}exp(-R_{\mu}t)$
    - $\lambda_i = R_{\mu} + \frac{1}{\tau_i}$,R_{μ} is muon rate, τ_i is isotope lifetime
    - R = $N_{9Li}/(N_{9Li}+N_{8He})$

Scan R from 0 to 1 with a step of 0.025 to get better fitting result.

Fitting parameters : N_{Li+He} , $N_{ibd+Acc}$, R_{μ}

Fitting method : Likelihood

$^{9}Li/^{8}He$ selection criteria

- **Muon reduction**
- Old: there is 1.8~12.0 MeV trigger in a (10μs,200μs) window after the muon.
- New: [1.8,2.8]MeV or [6,12]MeV trigger in a (10μs,200μs) window after the muon.
- **Divided muon energy range**
- The First: [20,500MeV] [500,1500MeV] [1.5,2.5GeV] [2.5,3.5GeV] [3.5,4.5GeV] [4.5,∞]
- The Second: [20,1000MeV] [1000,2500MeV] [2500MeV, ∞]
- **Event selection criteria**
- multiplicity cut : no E > 0.7 MeV trigger neither 200μs before the prompt signal nor 200μs after the delayed signal
- 3.5MeV < Ep < 12.0MeV
- 6.0MeV < En < 12.0MeV
- 1μs < Δt < 100μs
- delayed signal's trigger time to last WpMuon > 600 μs,
  to last ADMuon > 1ms,
  to last ADShowerMuon > 1ms

What is updated

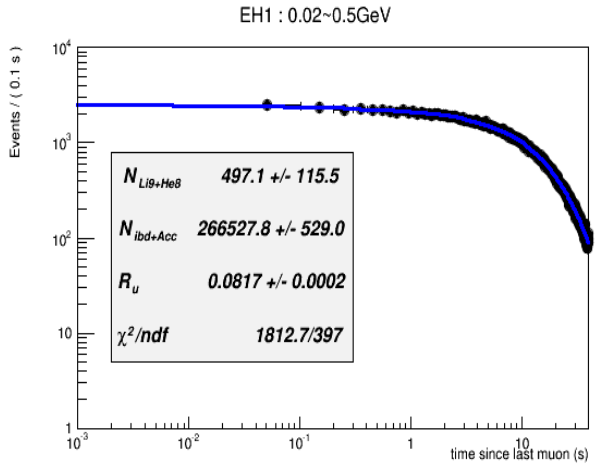
- Muon reduction changed:
  - Old:there is 1.8~12.0 MeV trigger in a (10μs,200μs) window after the muon.
  - New:[1.8,2.8]MeV or [6,12]MeV trigger in a (10μs,200μs) window after the muon.
- Do some try:
  - Divided muon energy range: [20,1000MeV] [1000,2500MeV] [2500MeV, ∞]
  - Fitting function adds the distribution of ^{12}B~29ms
  - $f(t) = N_{Li+He}\left(R\lambda_{Li}exp(-\lambda_{Li}t) + (1-R)\lambda_{He}exp(-\lambda_{He}t)\right) + N_{ibd+Acc}R_{\mu}exp\left(-R_{\mu}t\right) + N_{B}\lambda_{B}exp(-\lambda_{B}t)$

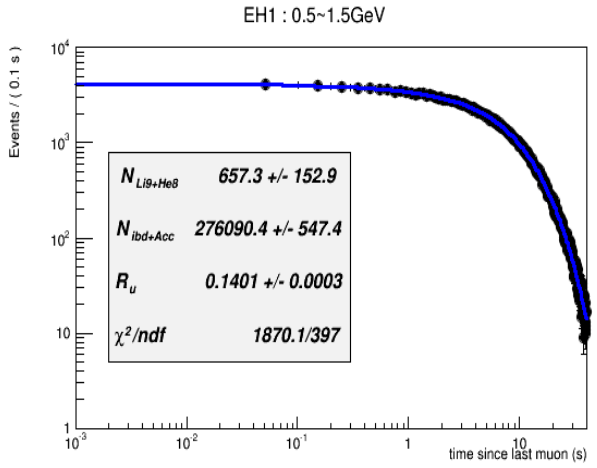
methods and comparison

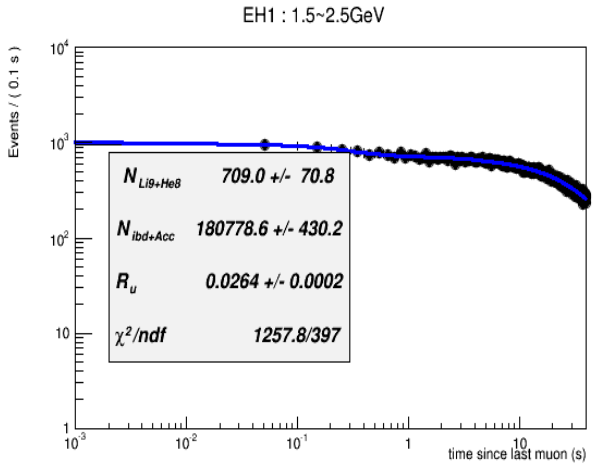
	muon reduction	fitting information	muon energy slices
method1(DocDB10075)	[1.8,12]MeV	Roofit [0.001,40]s Fitting function without ^{12}B	6
method2	[1.8,2.8]MeV or [6,12]MeV	Roofit [0.001,40]s fitting function without ^{12}B	6
method3	[1.8,2.8]MeV or [6,12]MeV	Fit [0.01,40]s fitting function with ^{12}B	6
method4	[1.8,2.8]MeV or [6,12]MeV	Fit [0.01,40]s fitting function with ^{12}B	3

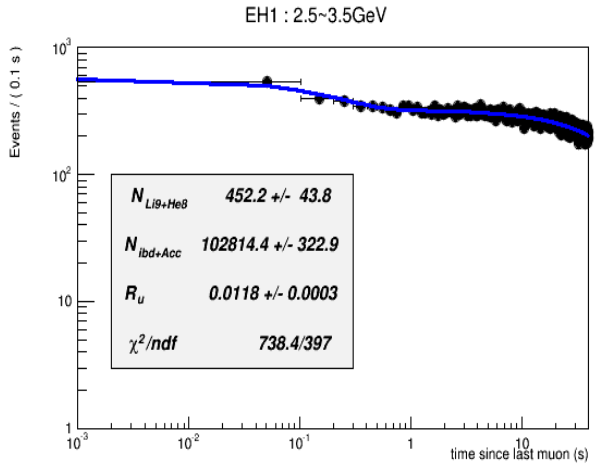
IHEP used method2
Tsinghua has 3 muon energy slices

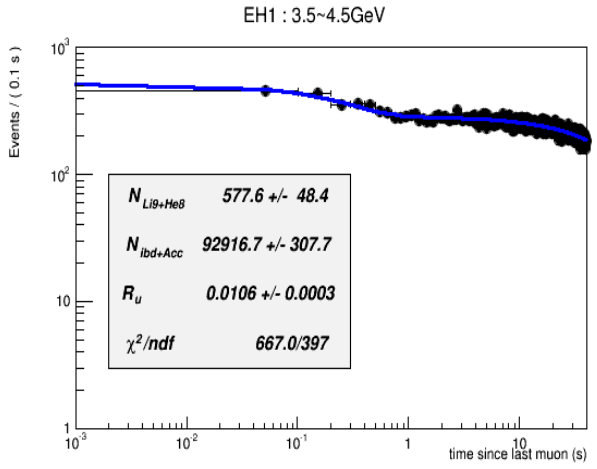
method1(DocDB10075):fitting result(EH1)

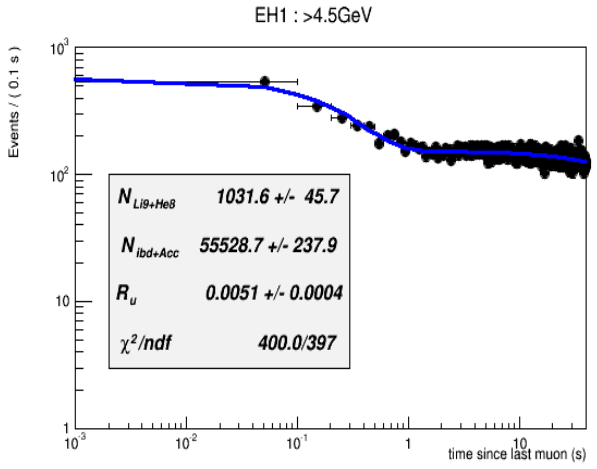




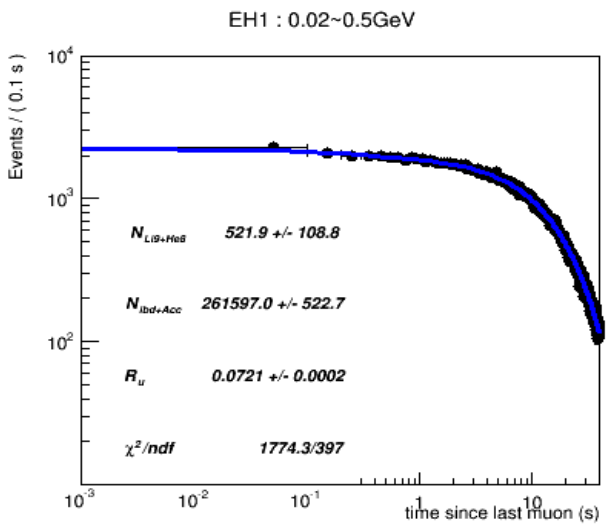


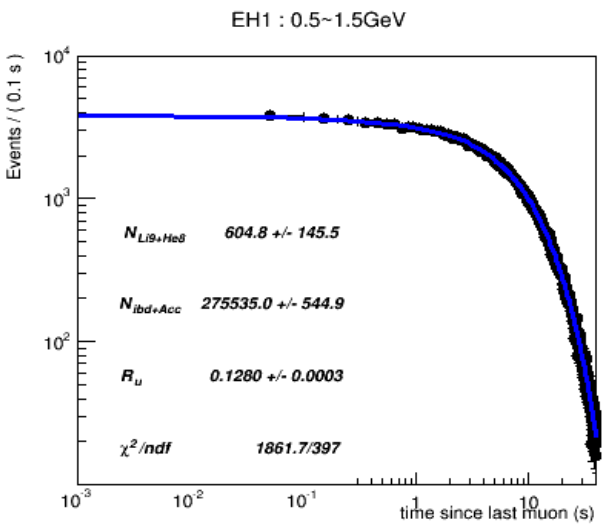


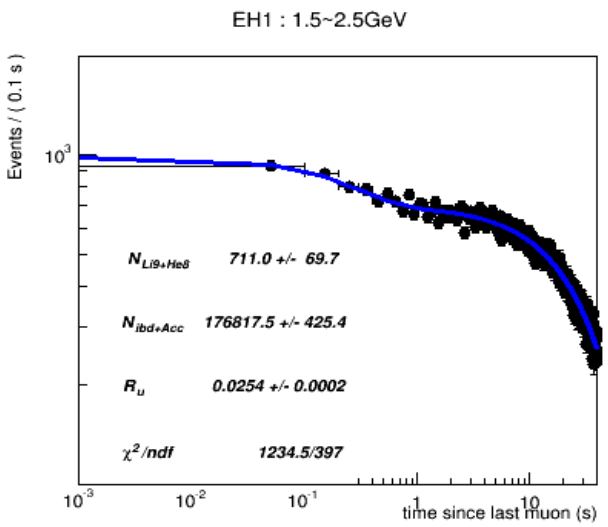


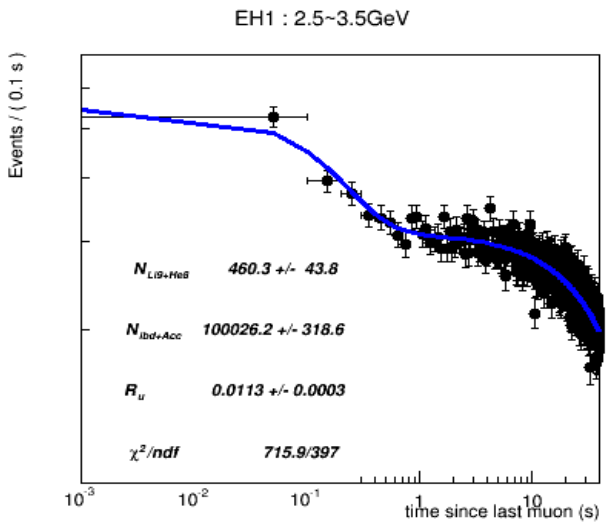


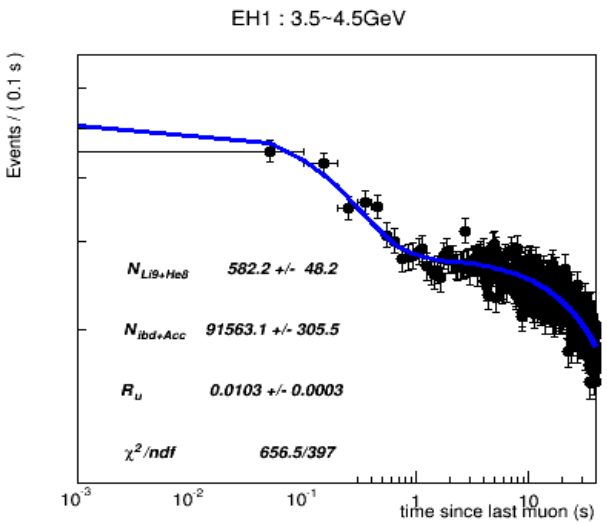
method2: fitting result(EH1)

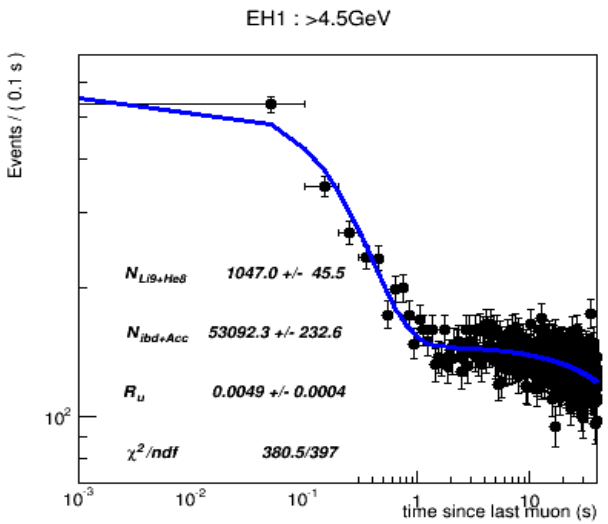




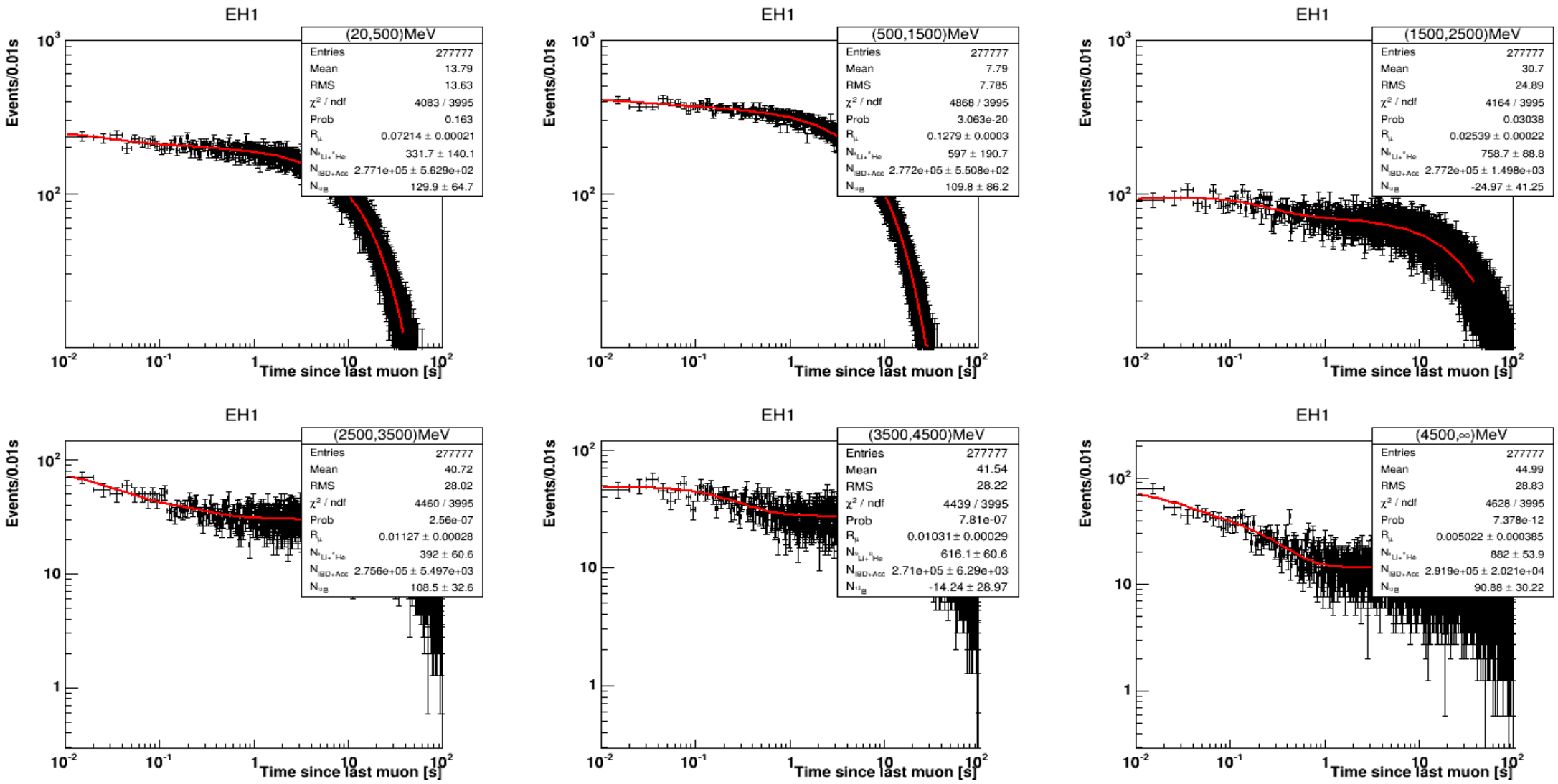




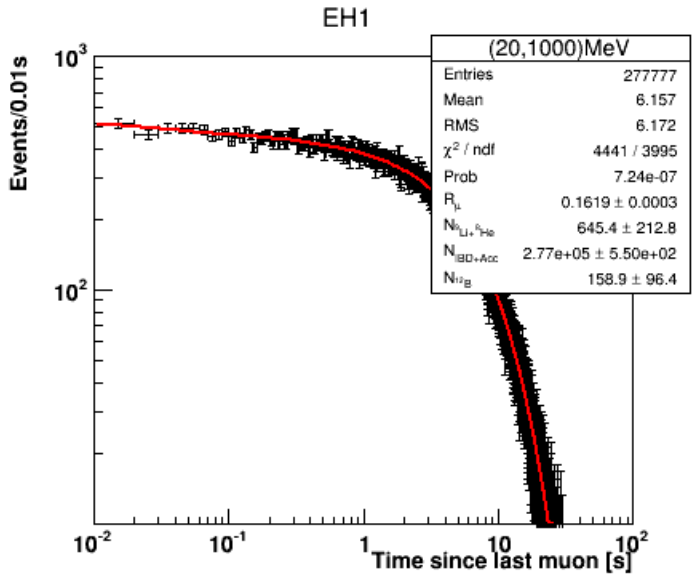


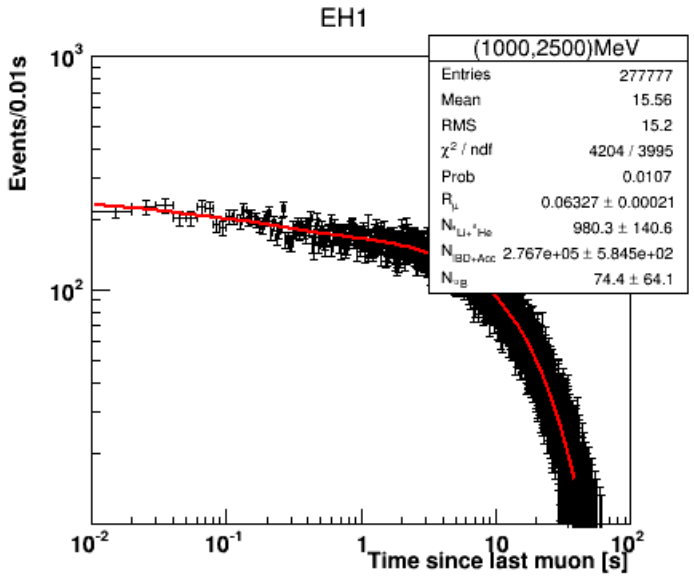


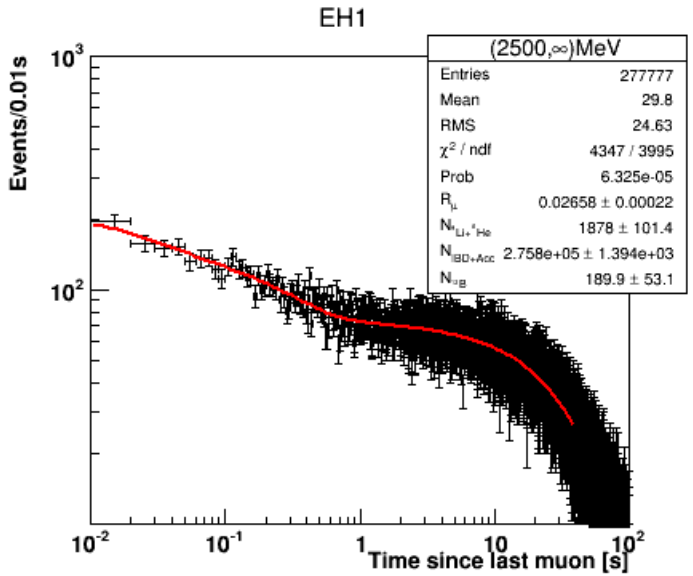
method3: fitting result(EH1)



method4: fitting result(EH1)







Results and Comparison(EH1)

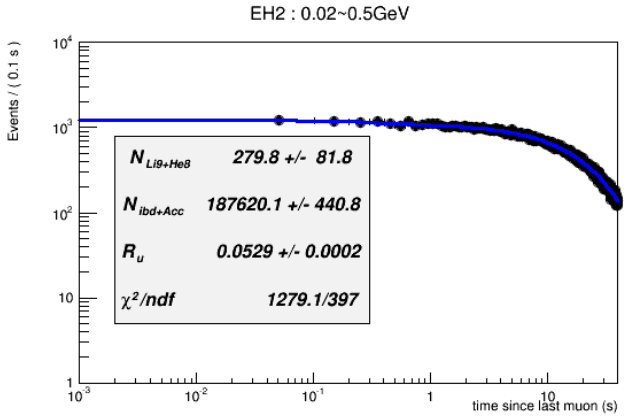
Energy interval/GeV	[0.02,0.5]	[0.5,1.5]	[1.5,2.5]	[2.5,3.5]	[3.5,4.5]	[4.5,∞]
method1:$N_{9Li+8He}$	497+/-116	657+/-153	709+/-71	452+/-44	578+/-48	1032+/-46
method2:$N_{9Li+8He}$	521.9+/-108.8	604.8+/-145.5	711+/-69.7	460.3+/-43.8	582.2+/-48.2	1047+/-45.5
IHEP:$N_{9Li+8He}$	490+/-108	525+/-144	692+/-69	447+/-43	563+/-48	1030+/-45

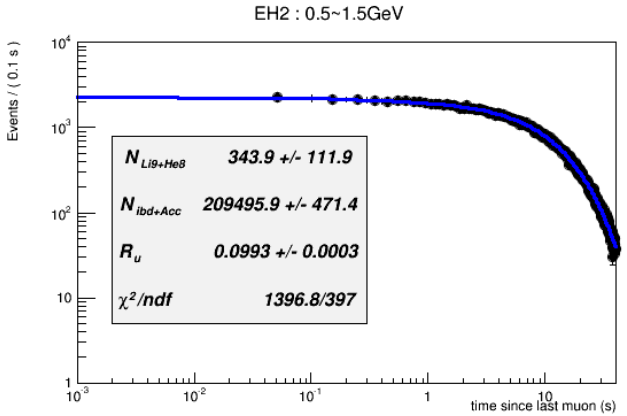
Energy interval/GeV	[0.02,0.5]	[0.5,1.5]	[1.5,2.5]	[2.5,3.5]	[3.5,4.5]	[4.5,∞]
method3: $N_{9Li+8He}$	331.7+/-140.1	597+/-190.7	758.7+/-88.8	392+/-60.6	616.1+/-60.6	882+/-53.9
	1687.4			1890		

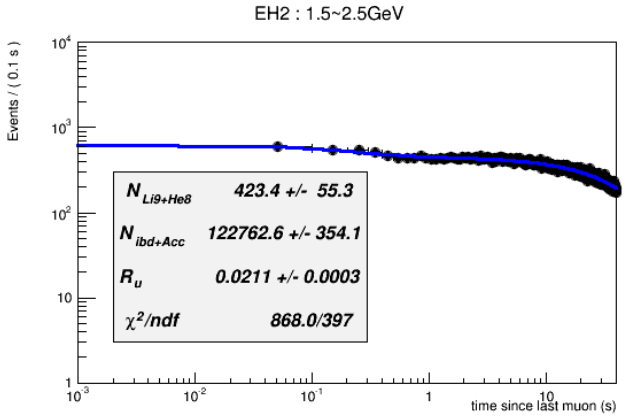
Energy interval/GeV	[0.02,1.0]	[1.0,2.5]	[2.5, ∞]
method4:$N_{9Li+8He}$	645.4+/-212.8	980.3+/-140.6	1878+/-101.4
	1634.7		1878

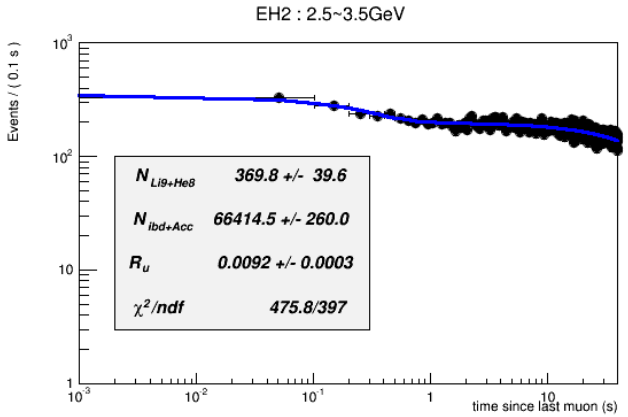
method2 is consistant with method1 in one σ. method 2 is also consistant with IHEP in one σ.
method3 is consistant with method4

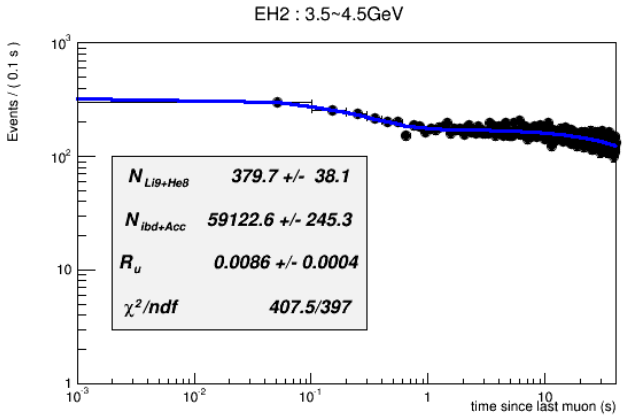
method1(DocDB10075): fitting result(EH2)

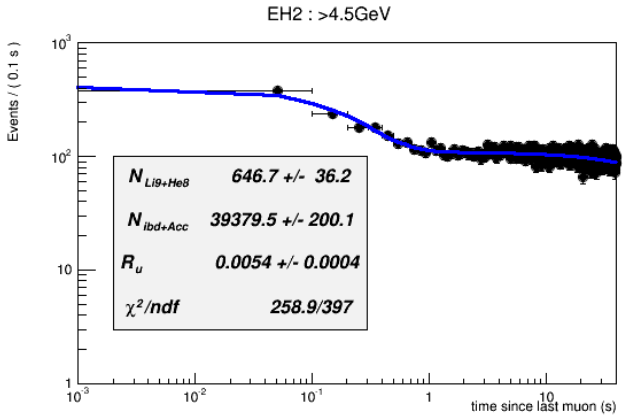




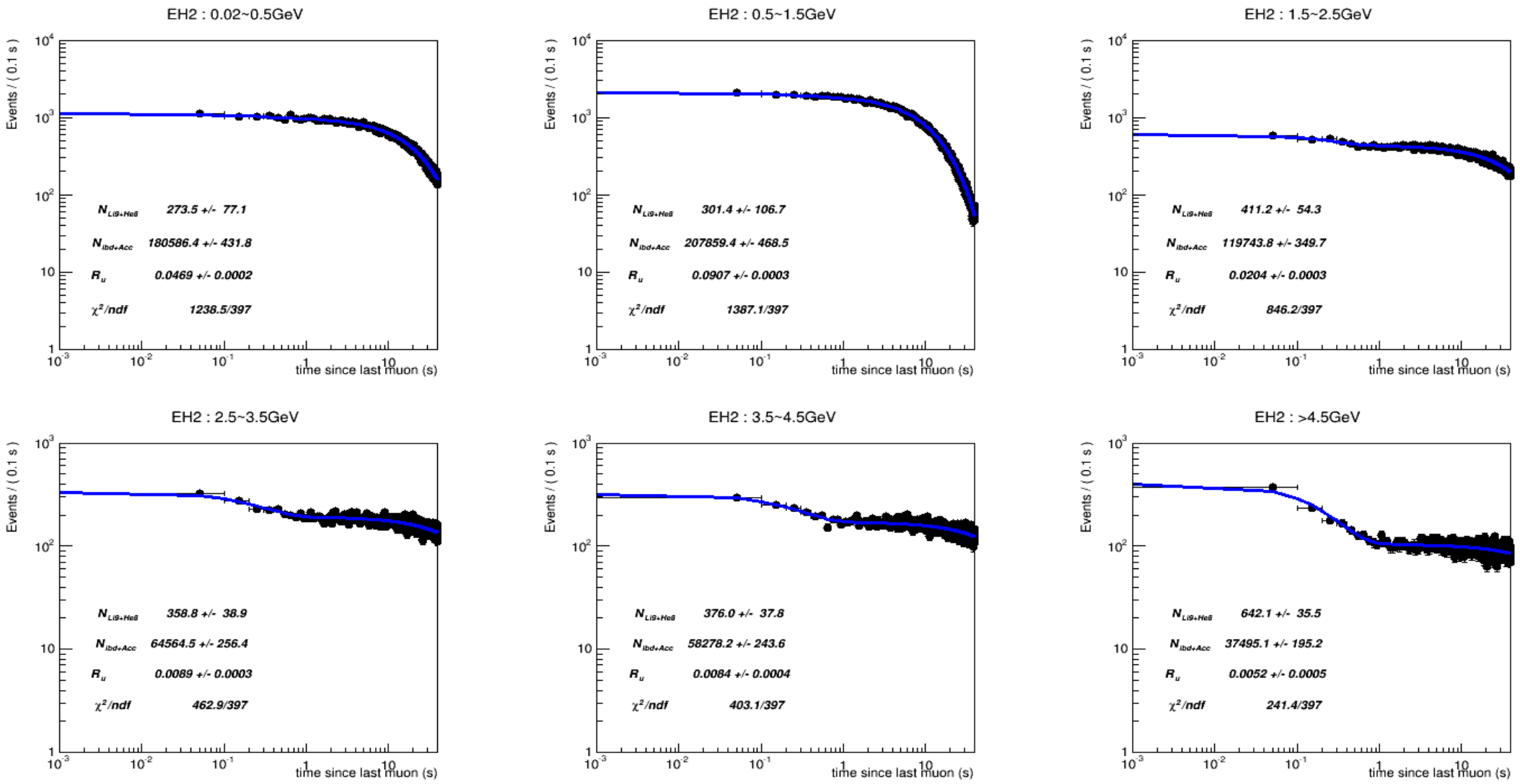




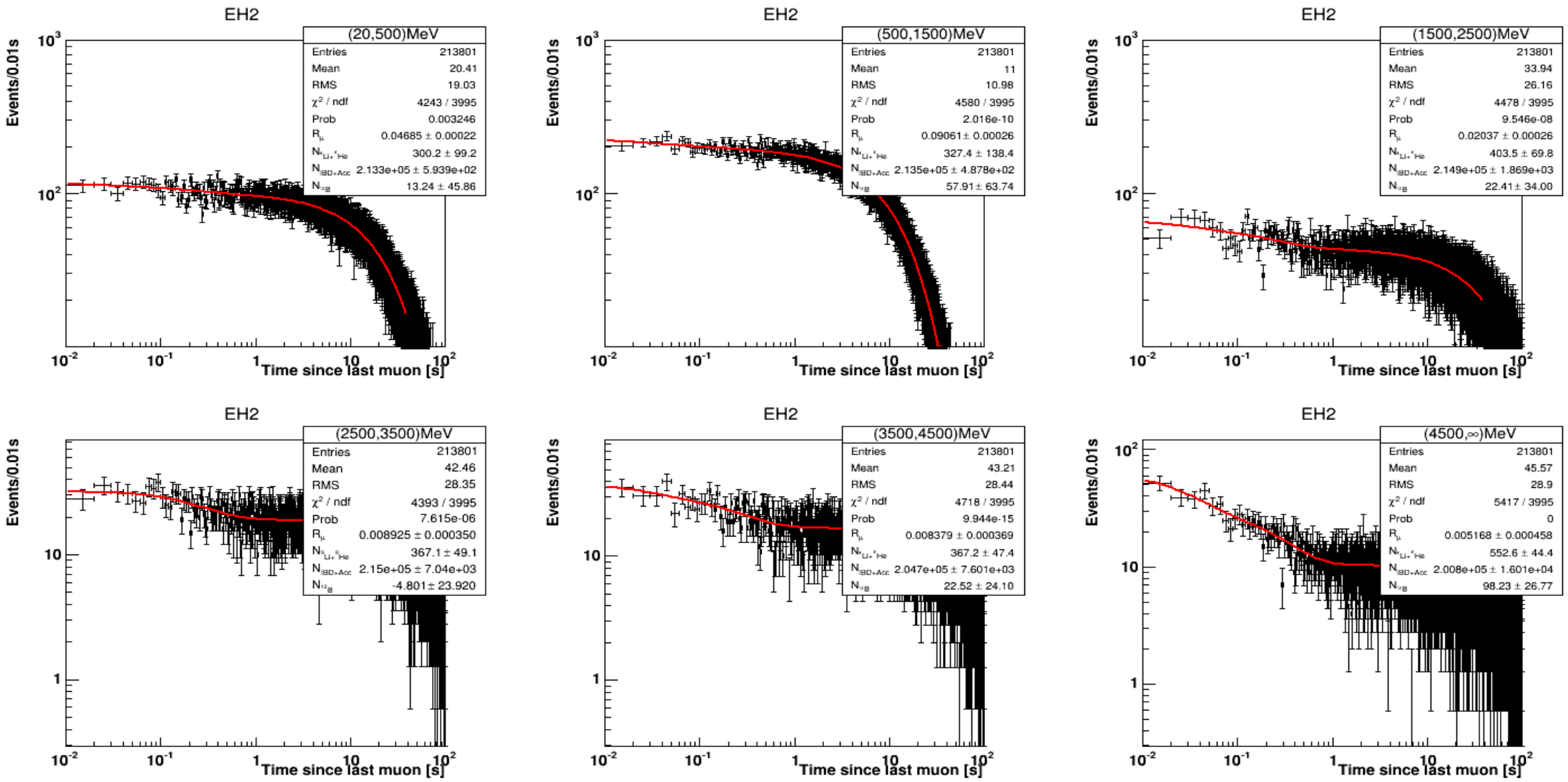




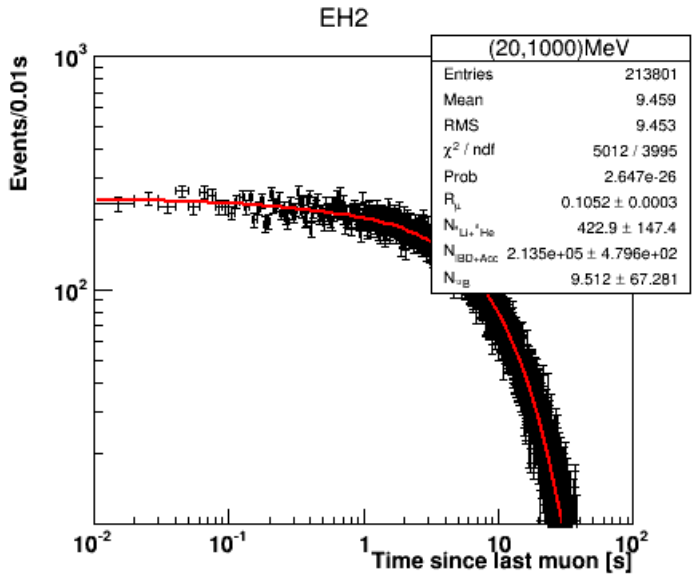
method2: fitting result(EH2)

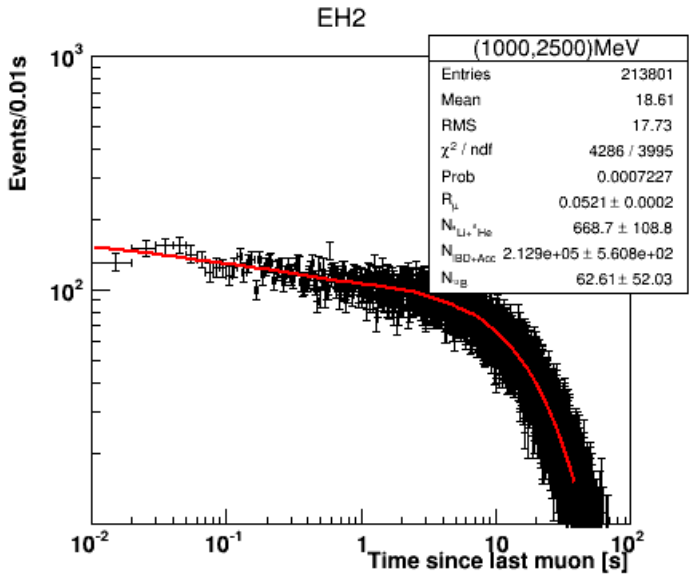


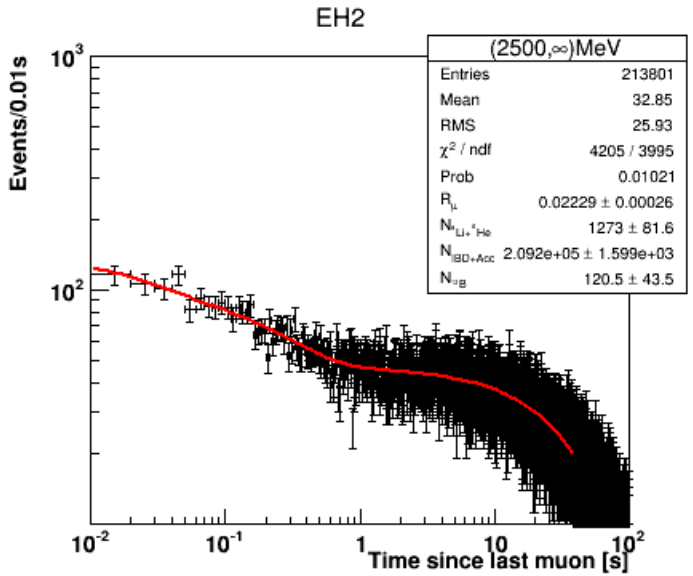
method3: fitting result(EH2)



method4: fitting result(EH2)







Results and Comparison(EH2)

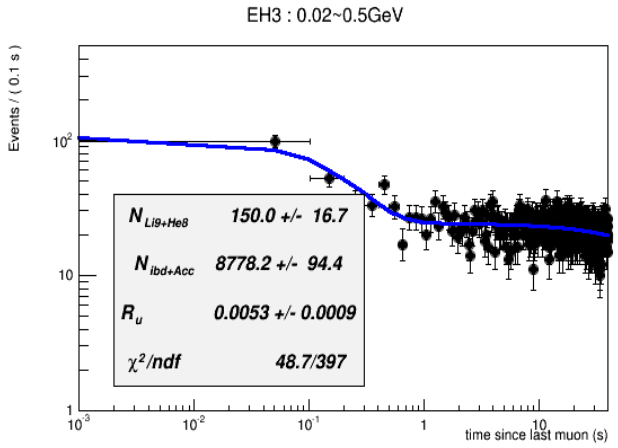
Energy interval/GeV	[0.02,0.5]	[0.5,1.5]	[1.5,2.5]	[2.5,3.5]	[3.5,4.5]	[4.5,∞]
method1:$N_{9Li+8He}$	280+/-82	344+/-112	423+/-55	370+/-40	380+/-38	647+/-36
method2:$N_{9Li+8He}$	273.5+/-77.1	301.4+/-106.7	411.2+/-54.3	358.8+/-38.9	376+/-37.8	642.1+/-35.5
IHEP:$N_{9Li+8He}$	255+/-77	285+/-106	400+/-54	354+/-39	376+/-38	637+/-35

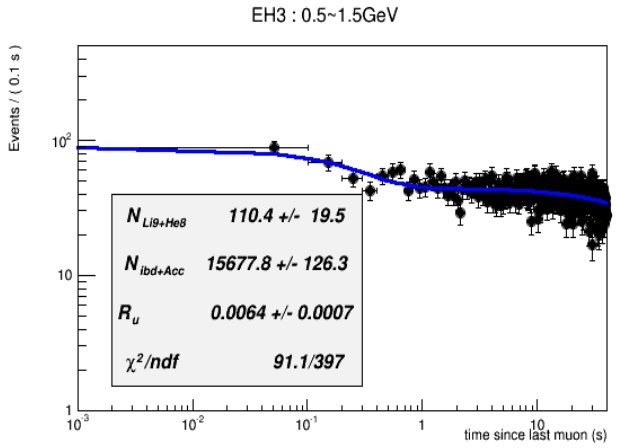
Energy interval/GeV	[0.02,0.5]	[0.5,1.5]	[1.5,2.5]	[2.5,3.5]	[3.5,4.5]	[4.5,∞]
method3: $N_{9Li+8He}$	300.2+/-99.2	327.4+/-138.4	403.5+/-69.8	367.1+/-49.1	367.2+/-47.4	552.6+/-44.4
	1031.1			1286.9		

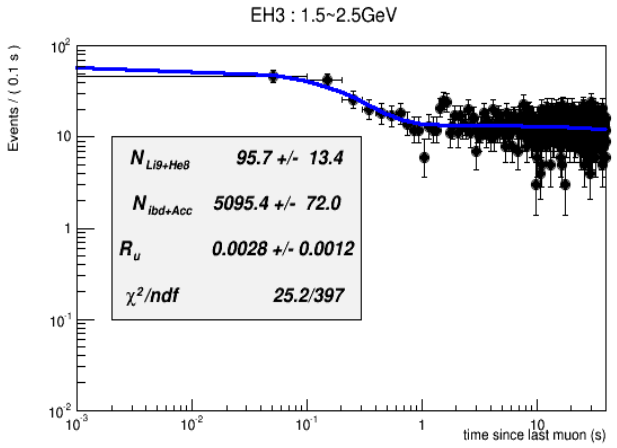
Energy interval/GeV	[0.02,1.0]	[1.0,2.5]	[2.5, ∞]
method4:$N_{9Li+8He}$	422.9+/-147.4	668.7+/-108.8	1273+/-81.3
	1091.6		1273

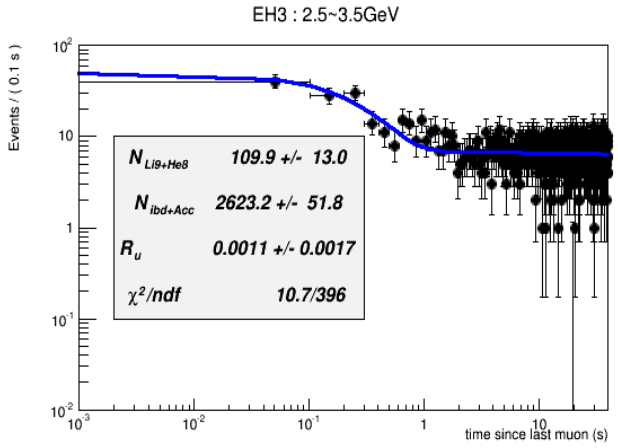
method2 is consistant with method1 in one σ. method 2 is also consistant with IHEP in one σ.
method3 is consistant with method4

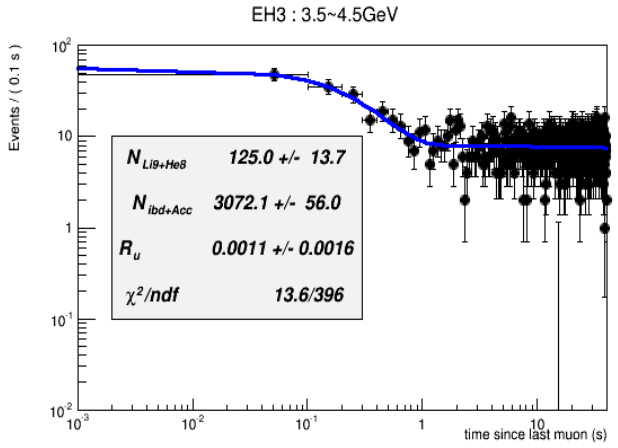
method1(DocDB10075): fitting result(EH3)

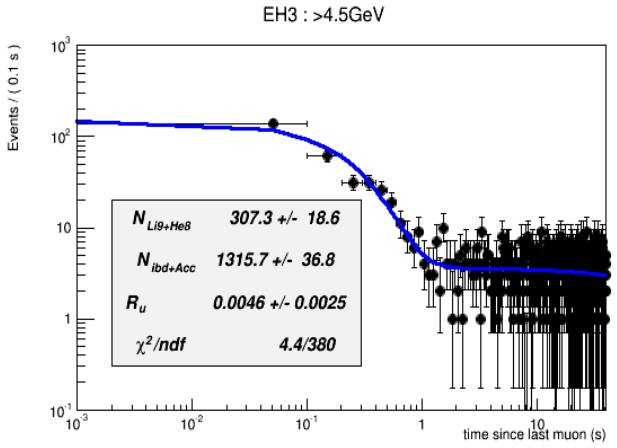




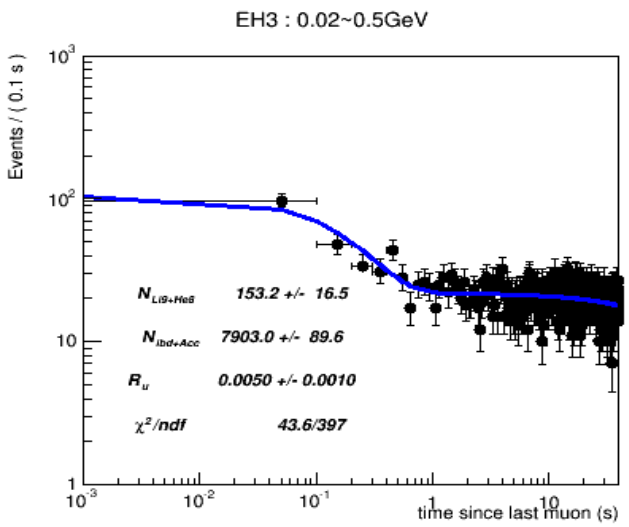


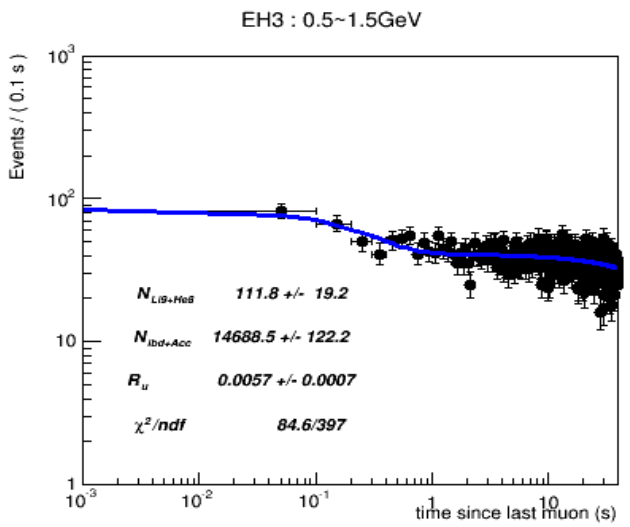


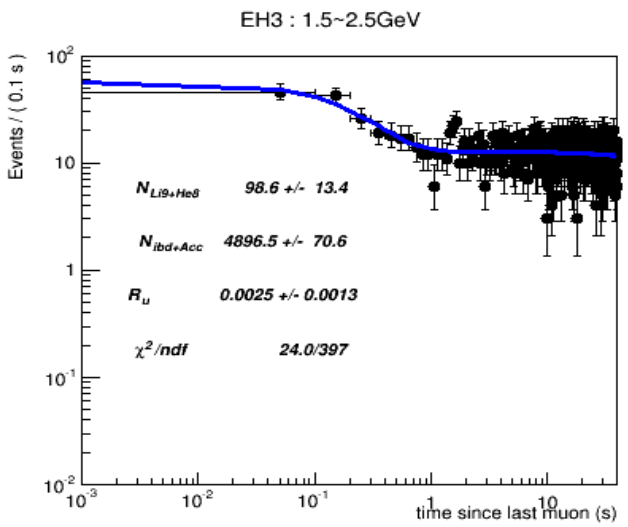


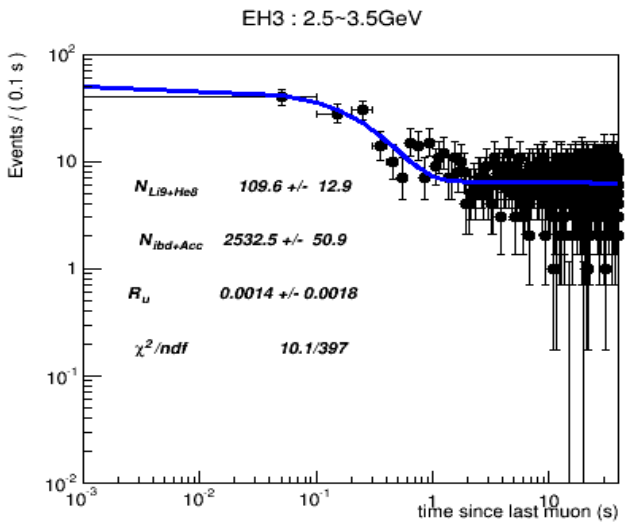


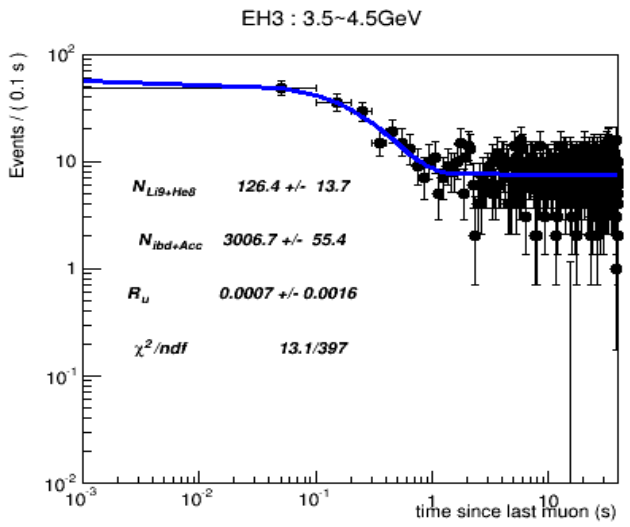
method2: fitting result(EH3)

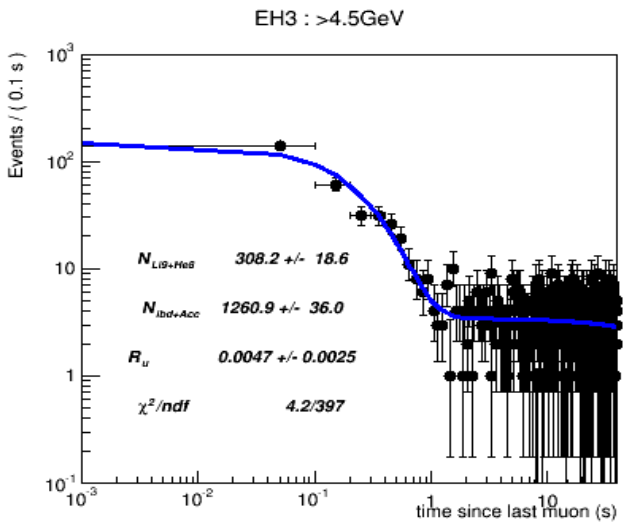




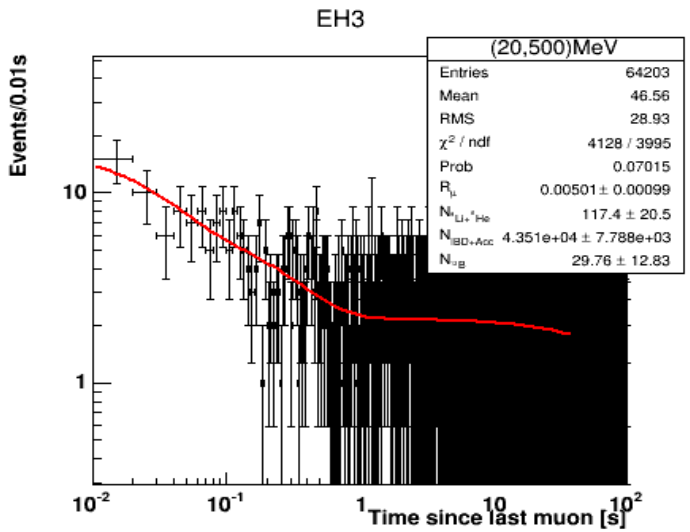


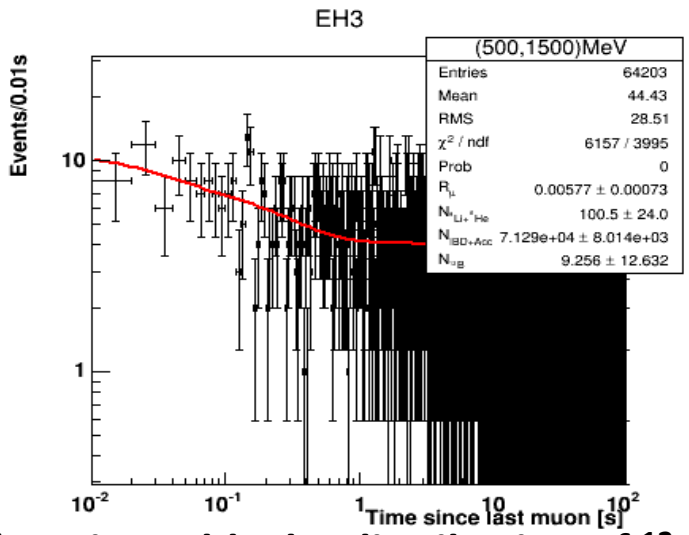


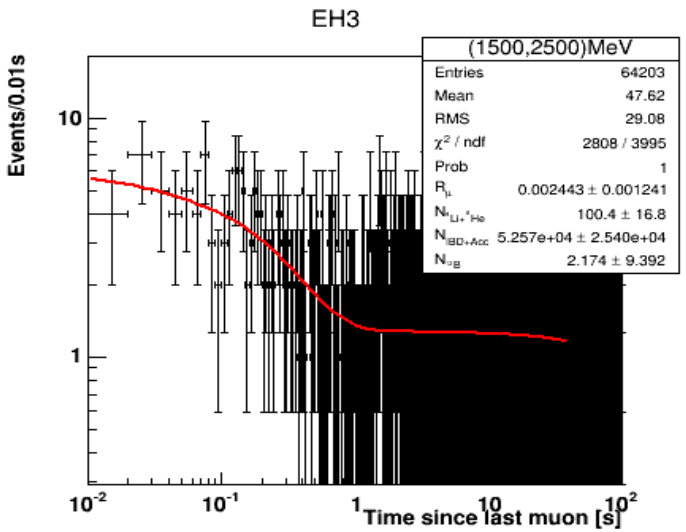




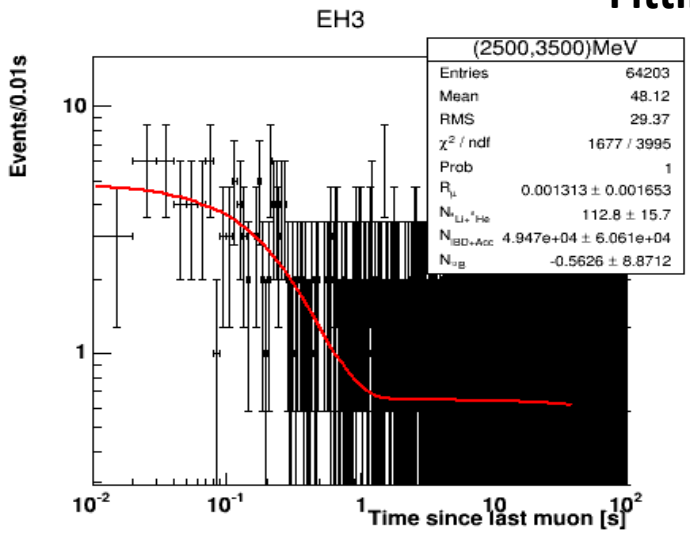
method3: fitting result(EH3)

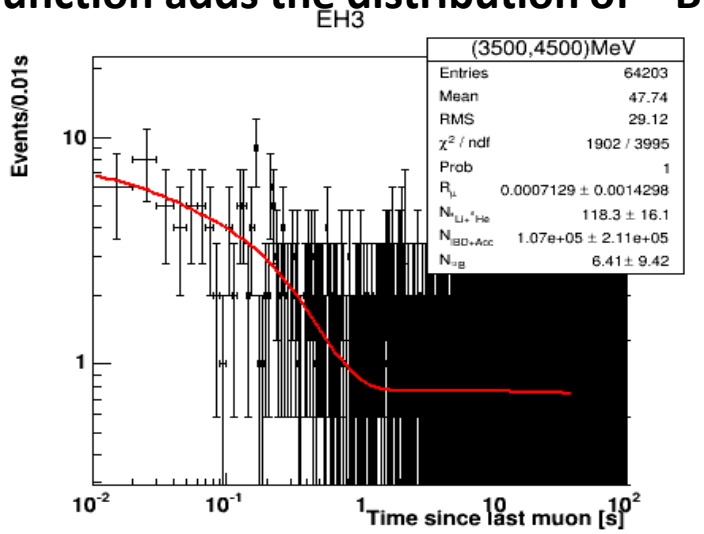


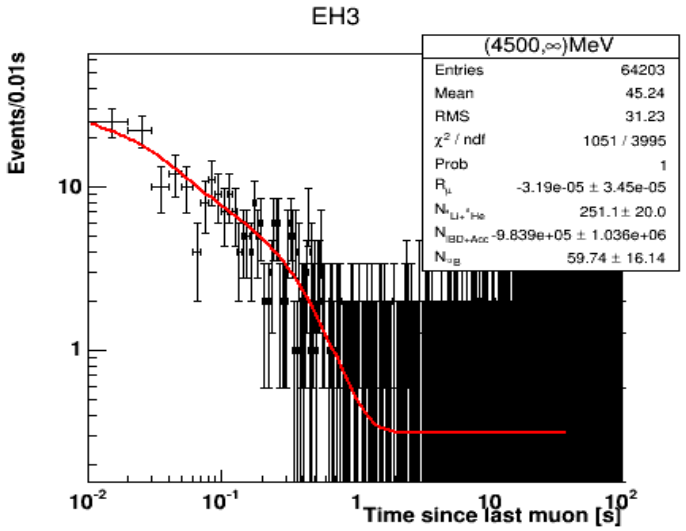




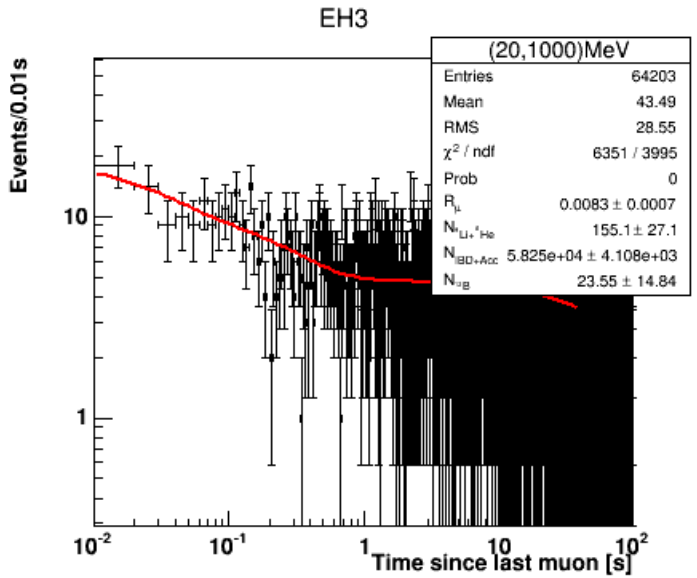
Fitting function adds the distribution of ^{12}B

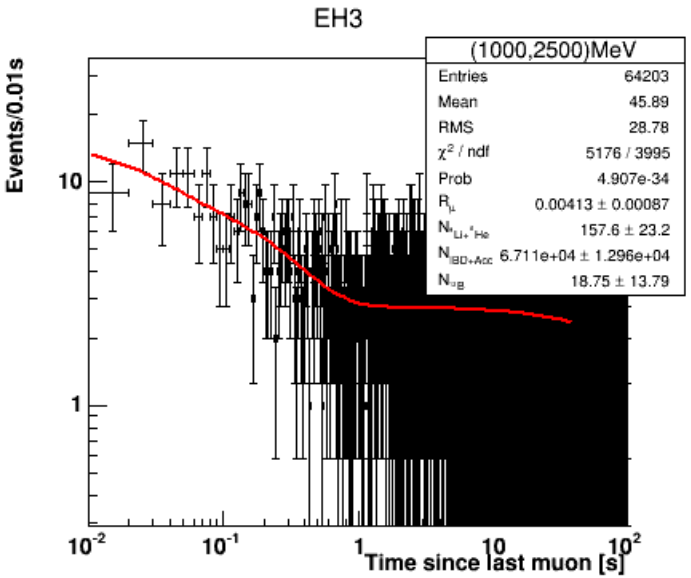


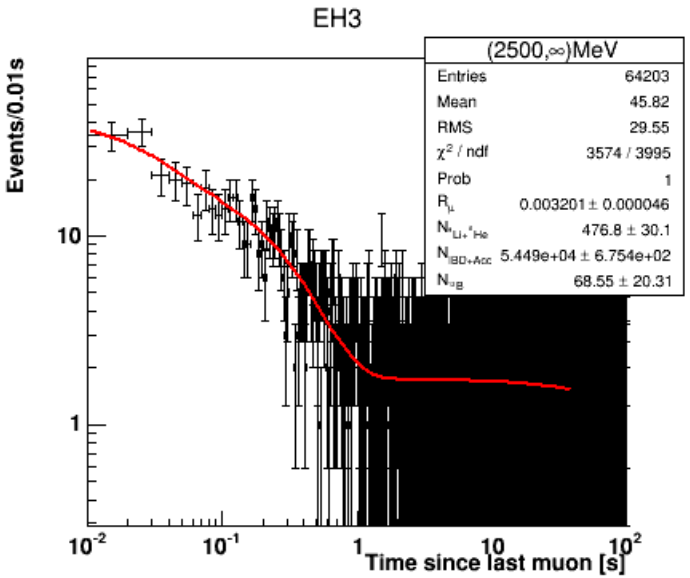




method4: fitting result(EH3)







Results and Comparison(EH3)

Energy interval/GeV	[0.02,0.5]	[0.5,1.5]	[1.5,2.5]	[2.5,3.5]	[3.5,4.5]	[4.5,∞]
method1:$N_{9Li+8He}$	150+/-17	110+/-20	96+/-13	110+/-13	125+/-14	307+/-19
method2:$N_{9Li+8He}$	153.2+/-16.1	111.8+/-19.2	98.6+/-13.4	109.6+/-12.9	126.4+/-13.7	308.2+/-18.6
IHEP:$N_{9Li+8He}$	153+/-16	110+/-19	99+/-13	108+/-13	125+/-14	307+/-19

Energy interval/GeV	[0.02,0.5]	[0.5,1.5]	[1.5,2.5]	[2.5,3.5]	[3.5,4.5]	[4.5,∞]
method3: $N_{9Li+8He}$	117.4+/-20.5	100.5+/-24.0	100.4+/-16.8	112.8+/-15.7	118.3+/-16.1	251.1+/-20
	318.3			482.2		

Energy interval/GeV	[0.02,1.0]	[1.0,2.5]	[2.5, ∞]
method4:$N_{9Li+8He}$	155.1+/-27.1	157.6+/-23.2	476.8+/-30.1
	312.7		476.8

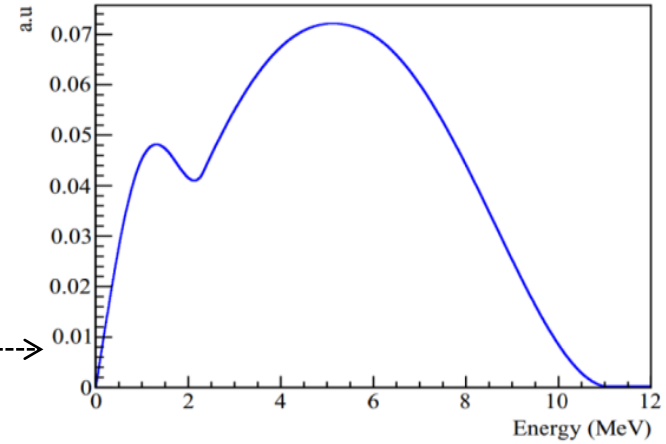
method2 is consistant with method1 in one σ. method 2 is also consistant with IHEP in one σ.
method3 is consistant with method4

Efficiency correction and uncertainty

- **Efficiency Correction**
- 1. Shower muon veto time: 1ms→1s
  - For showermuon (>2.5GeV), 1ms is corrected to 1s by $\epsilon_{showermuon}$~0.02
- 2. Ep Cut Change: 3.5MeV→0.7MeV
  - 3.5<Ep<12MeV is corrected to 0.7<Ep<12MeV by ϵ_e ~ 72%

$$\frac{P(3.5MeV<E<12MeV)}{P(0.7MeV<E<12MeV)} = \sim 72\%$$

Predicted β spectrum of the 9Li (β-n), ***Wen Liangjian***



- 3. Time Window Cut: 1us<Δt<100us →1us<Δt<200us by ϵ_t~0.94
- **Uncertainty**
- Systematic Uncertainty(IHEP nGd) 50%

Final results and comparison

	EH1		EH2		EH3			
DAQ livetime(days)	AD1	AD2	AD3	AD8	AD4	AD5	AD5	AD6
	565.436	565.436	568.03	378.407	562.451	562.451	562.451	372.685
ε_μ	0.8248	0.8218	0.8575	0.8577	0.9811	0.9811	0.9808	0.9811
ε_m	0.9744	0.9748	0.9758	0.9756	0.9756	0.9754	0.9751	0.9758
method1:$R_{9Li+8He}$(day)	3.1+/-1.6		2.0+/-1.0		0.28+/-0.14			
method2:$R_{9Li+8He}$(day)	3.06+/-1.56		1.89+/-0.98		0.28+/-0.14			
IHEP:$R_{9Li+8He}$(day)	2.85+/-1.46		1.80+/-0.94		0.28+/-0.14			
method3:$R_{9Li+8He}$(day)	2.81+/-1.46		1.97+/-1.04		0.25+/-0.13			
method4:$R_{9Li+8He}$(day)	2.65+/-1.39		2.04+/-1.07		0.23+/-0.12			
Tsinghua:$R_{9Li+8He}$(day)	2.55+/-0.72		1.81+/-0.48		0.20+/-0.04			

$$R_{9Li+8He} = \frac{N_{tot(9Li+8He)}}{DAQ \cdot \varepsilon_\mu \cdot \varepsilon_m}$$

method1 is consistent with method2 which agrees with IHEP in one σ.
method3 is consistent with method4
Because of different estimate methods, so there is some difference in error term between method4 and Tsinghua