JUNO : the energy spectrum of (reactor) neutrinos

MA1 internship – status report 1

22/10/2025

Subject and task

Current task :

Plotting the energy spectrum of IBD events from preliminary data

I work on neutrinos from the nuclear reactors

From : https://underground.sjtu.edu.cn/juno

189 runs (+3 with missing files)

9737, 9739, 9740, 9754, 9755, 9756, 9757, 9766, 9767, 9768, 9769, 9770, ~~9771~~, 9773, 9774, 9775, 9776, 9777, 9778, 9779, 9780, 9781, 9782, 9783, 9784, 9785, 9786, 9787, 9788, 9789, 9790, 9794, 9796, 9797, 9800, 9801, 9802, 9803, 9804, 9805, 9807, 9808, 9816, 9817, 9818, 9819, 9820, 9821, 9822, 9824, 9825, 9826, 9827, 9829, 9830, 9831, 9832, 9833, 9834, 9835, 9837, 9838, 9839, 9840, 9841, 9842, 9846, 9847, 9848, 9849, 9850, 9851, 9856, 9857, 9858, 9859, 9860, ~~9866~~, 9867, 9868, 9869, 9870, 9871, ~~9872~~, 9873, 9874, 9875, 9876, 9877, 9878, 9879, 9880, 9881, 9882, 9883, 9884, 9885, 9886, 9889, 9890, 9891, 9892, 9893, 9894, 9895, 9896, 9897, 9898, 9899, 9900, 9901, 9902, 9904, 9905, 9906, 9907, 9908, 9909, 9910, 9911, 9912, 9913, 9919, 9920, 9921, 9922, 9923, 9926, 9927, 9928, 9929, 9930, 9932, 9933, 9940, 9944, 9949, 9958, 9964, 9965, 9966, 9967, 9968, 9972, 10020, 10021, 10022, 10026, 10027, 10028, 10029, 10030, 10031, 10034, 10035, 10036, 10037, 10038, 10040, 10046, 10050, 10051, 10052, 10053, 10054, 10055, 10059, 10067, 10077, 10083, 10084, 10086, 10089, 10091, 10093, 10094, 10095, 10096, 10099, 10100, 10121, 10122, 10123, 10124, 10125, 10126, 10128, 10129, 10130, 10131, 10132, 10133

→ 610 257 345 events in CD (good files only)

Analysis (with python)

Data cuts

	Common cuts (v2, Sept. 12th)
Muon Veto (CD+WP)	WP npe > 400 with ±500 ns coincidence → **5 ms veto** (50 µs dead time for CD, 4 µs dead time for WP)
Muon Veto (WP-only)	WP npe > 400, no CD npe > 30k with ±500 ns → **5 ms veto** (4 µs dead time)
Muon Veto (CD-only)	CD npe > 30k, no WP trigger > 400 npe in ±500 ns and after >2 ms from the last tagged muon → **5 ms veto** (50 µs dead time)
Job/files veto	Veto the first **5 ms** for each job
No header veto	*5 ms veto** after events without `(OecHeader) & (CdLpmtCalibHeader or WpCalibHeader) & (CdTriggerHeader or WpTriggerHeader)`
Delayed NPE	$Q_{delayed} \in [4000, 6000]$ (3)
Prompt NPE	$Q_{prompt} \in [1500, 20000]$
Distance p–d	$\Delta r < 1.5\,\mathrm{m}$
Time p–d	$5\,\mu s < \Delta t < 2\,\mathrm{ms}$
Multiplicity	No events **in FV and not vetoed by muons** in **prompt** energy within 2 ms before the prompt / after the delayed / between p-d
Fiducial Volume	$r < 17.2$ m ; **Remove** ($\lvert z\rvert > 11$ m & $\rho < 3.0$ m)

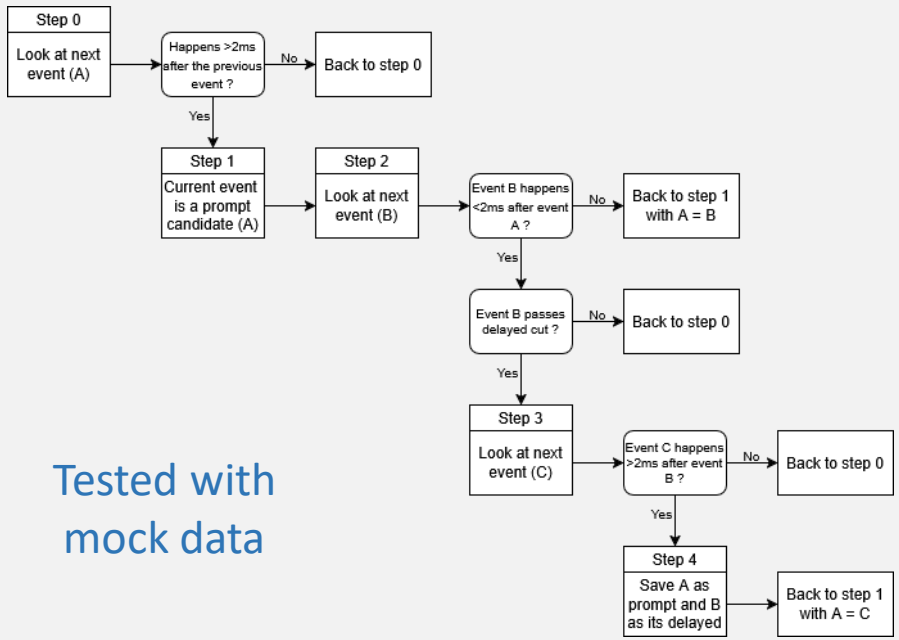
Not yet (I don't have the trigger times)

Method

Step 1 : Searches for muon veto triggers (minding the dead time and wp/cd coincidences)

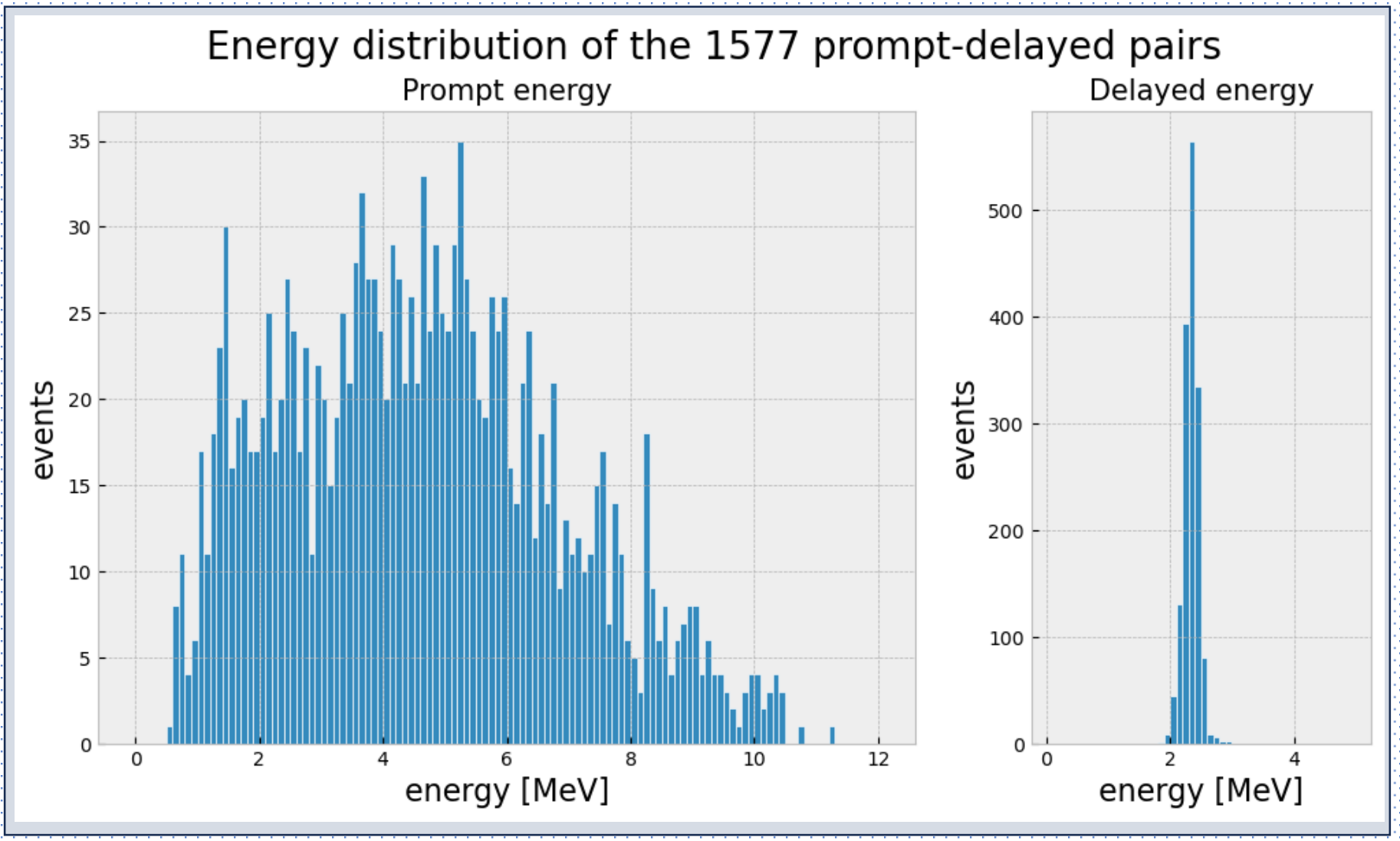
Step 2 : Lists events with prompt energy in FV, then applies muon vetoes

Step 3 : Identifies prompt – delayed pairs and enforces multiplicity cut

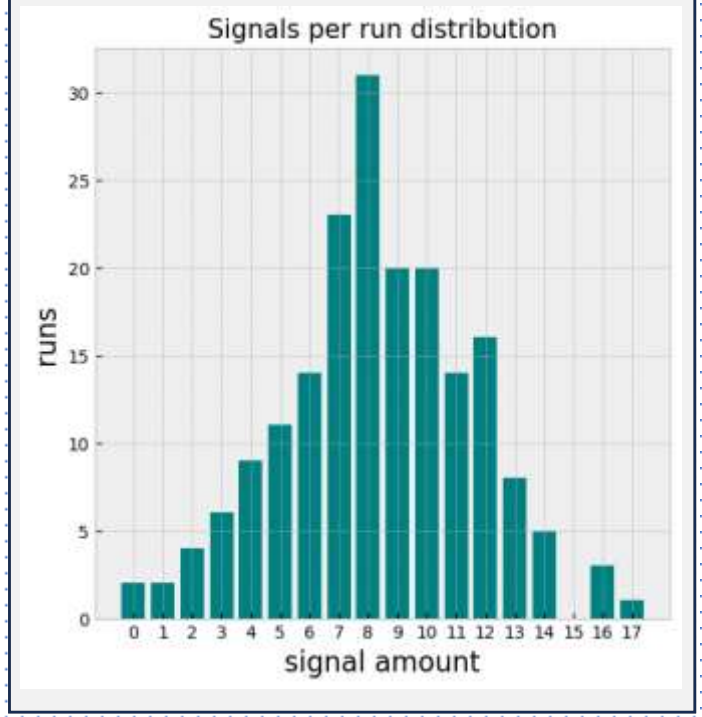


Tested with mock data

Energy spectrum

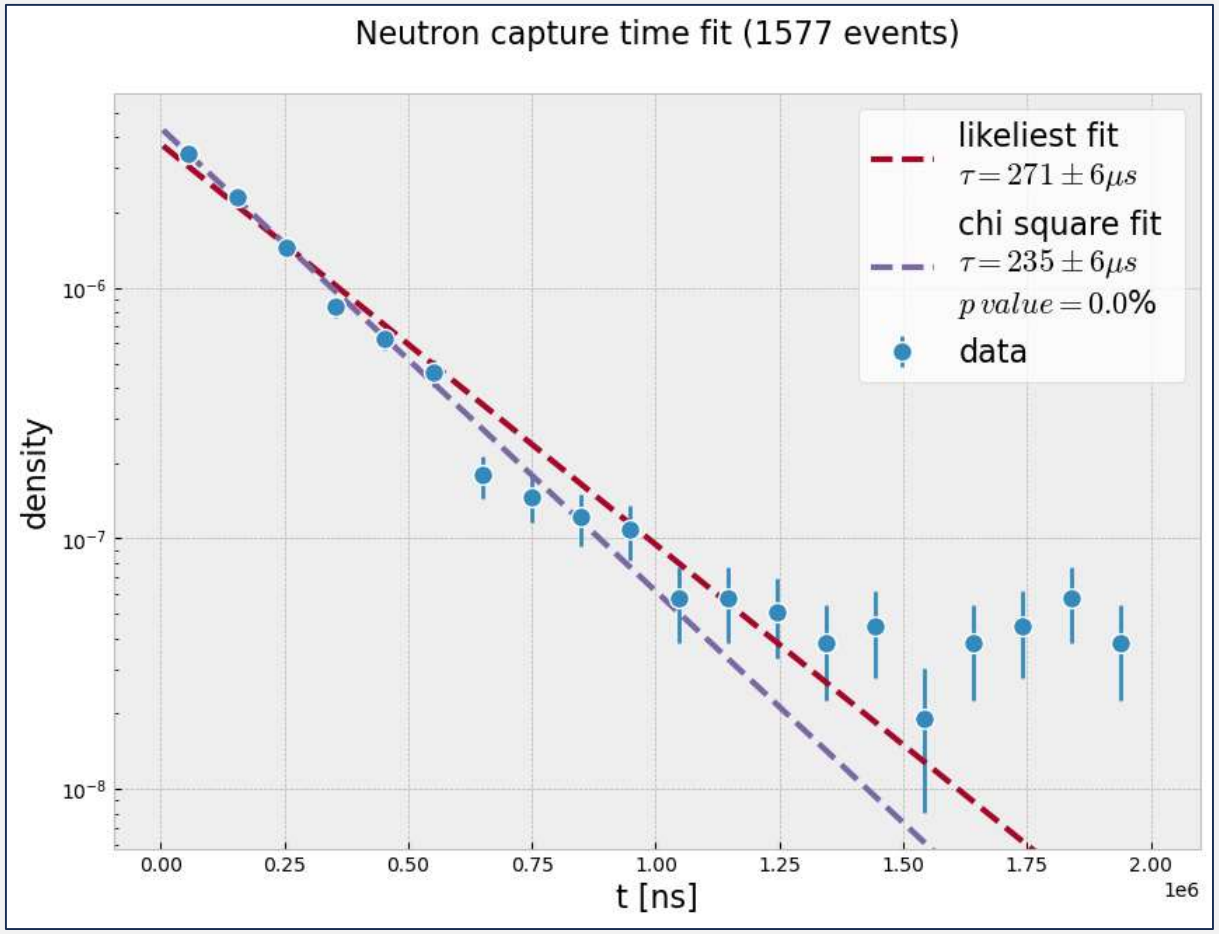


IBDs per run (189 runs)



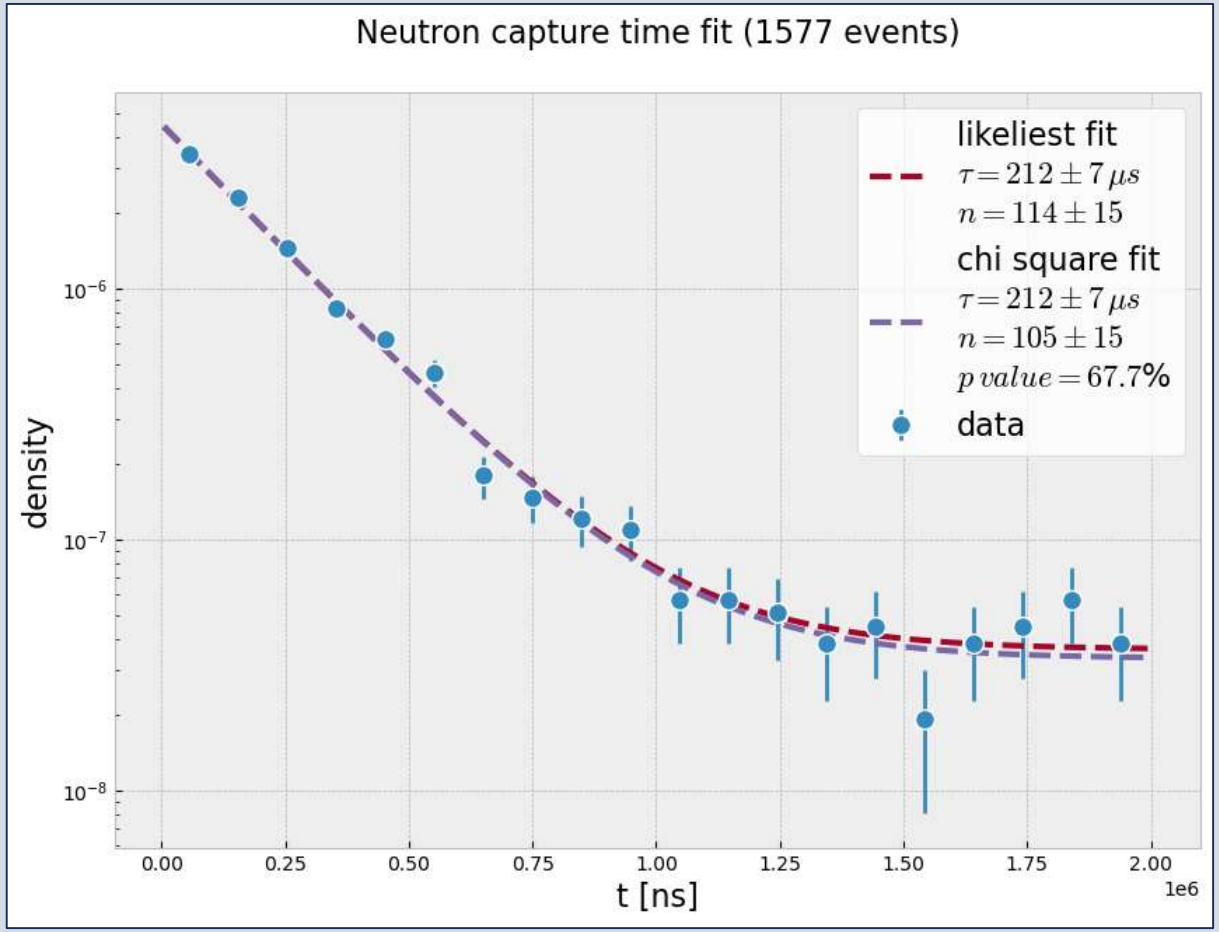
Neutron capture lifetime

1. Exponential distribution



Not appropriate ; last bins too high
-> Hints at the presence of noise events

2. Exponential distribution with uniform background



Suggests ~110 noise events
-> To take with precautions

Next steps and interrogations

Next step :

- Run on newly reconstructed data → direct comparison possible

Remaining practical questions :

- “No header vetoes” : before or after multiplicity cut ?
  ↳ before : better efficiency ; after : better purity

- How to handle “bad” files with the multiplicity cut ?
  reject events after or before the multiplicity cut ? or 2ms veto after a gap ?