CERN-INTC-2022-047 / INTC-P-645

Measurement of ^{40}K(n,p) and ^{40}K(n,α) cross sections at n_TOF EAR-2

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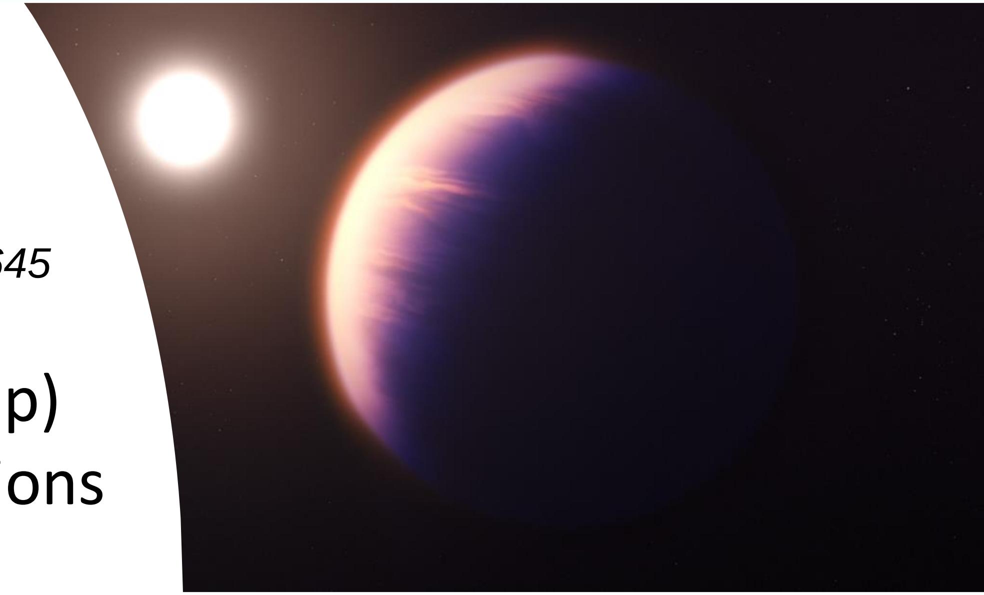

Motivation

- ^{40}K produced in oxygen burning and in s process environments (massive stars)
- Main destruction reactions in s process: (n,α), (n,p) and (n,γ)
- ^{40}K abundance important for radiogenic heating in earth-like exoplanets, important for e.g. plate tectonics

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A radiogenic heating evolution model for cosmochemically Earth-like exoplanets

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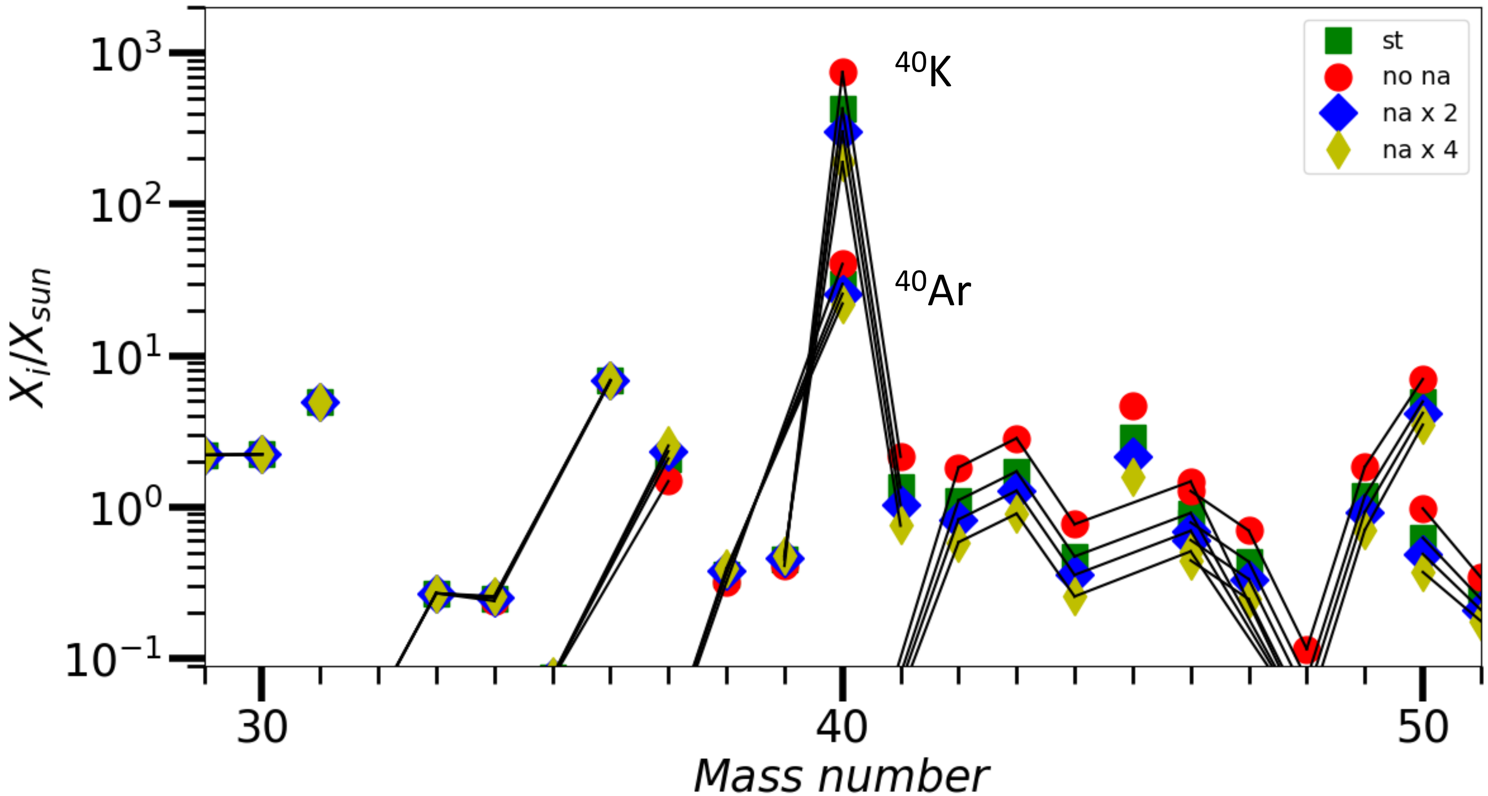
old planets have lower heat outputs per unit mass than newly formed worlds. The long half-life of ^{232}Th allows it to continue providing a small amount of heat in even the most ancient planets, while ^{40}K dominates heating in young worlds. Through constraining the age-dependent heat production in exoplanets, we can infer that younger, hotter rocky planets are more likely to be geologically active and therefore able to sustain the crustal recycling (e.g. plate tectonics) that may be a requirement for long-term biosphere habitability. In the search for Earth-like planets, the focus should be made on stars

The University of Edinburgh

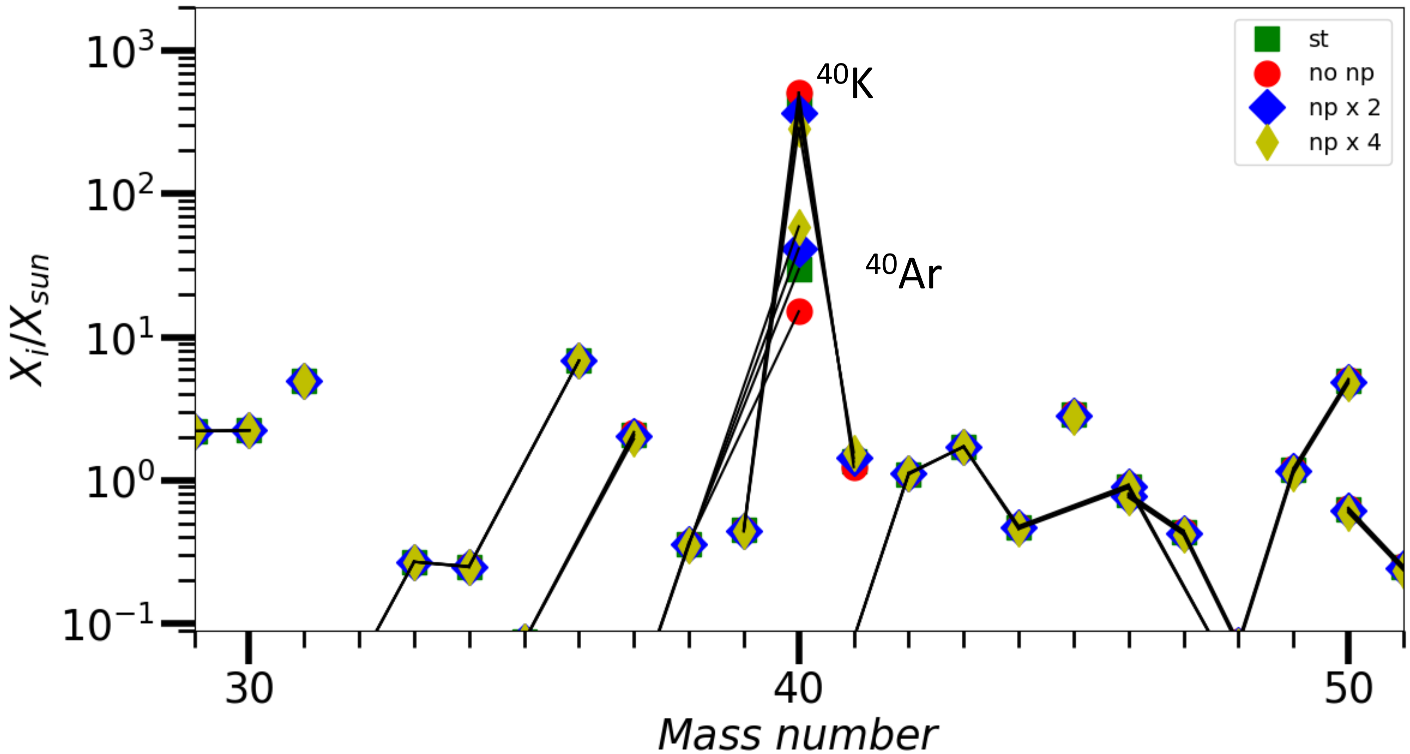
^{40}K(n,α) impact on s process abundances in 25 solar mass star



^{40}K(n,α) rate x 2 changes ^{40}K abundance by ~50%

Impact also on abundances of other isotopes from ^{37}Cl up

^{40}K(n,p) impact on s process abundances in 25 solar mass star



^{40}K(n,p) impacts most ^{40}Ar abundance (x2 rate → ~30% more ^{40}Ar)

Available Data for Stellar Studies

PHYSICAL REVIEW C **101**, 055805 (2020)

Constraining the destruction rate of ^{40}K in stellar nucleosynthesis through the study of the ^{40}Ar$(p,n)^{40}$K reaction

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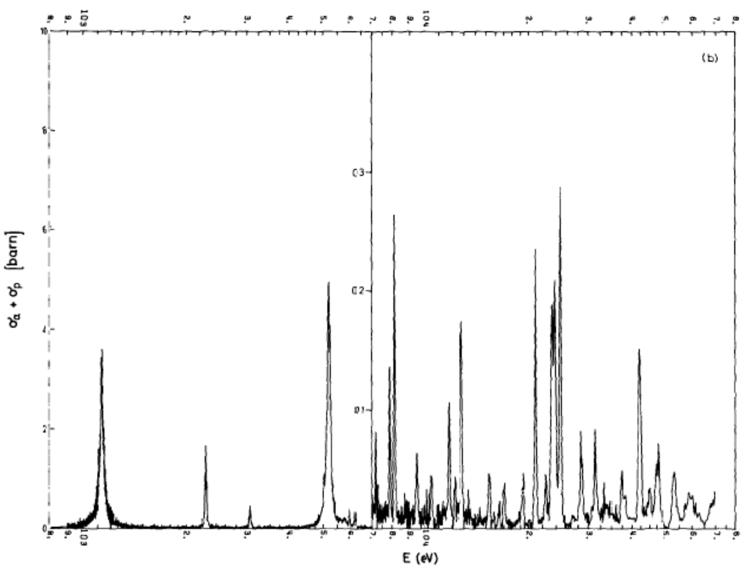
- Recent publication of ^{40}K(n,p) rate using inverse reaction
- Rate given for T>0.4 GK (s process in massive stars at ~0.3 & 1 GK)

Available Data for Stellar Studies



Nuclear Physics **A368** (1981) 117–134

STUDY OF NEUTRON INDUCED CHARGED PARTICLE REACTIONS ON ^{40}K

(II). Resonance neutrons

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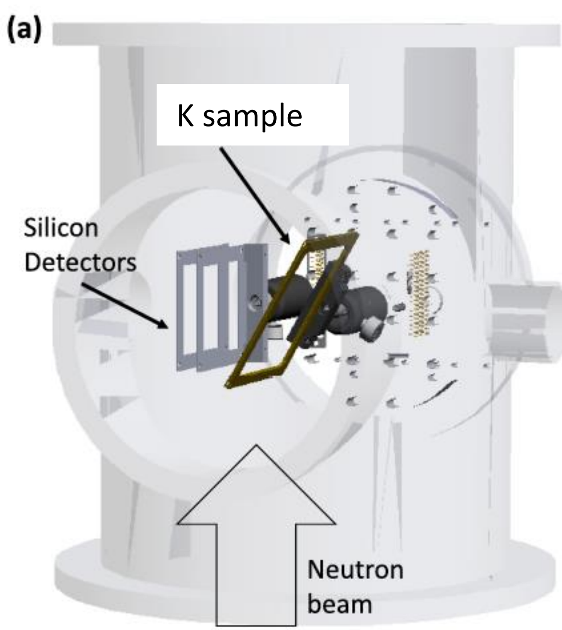
- TOF measurement at GELINA
- Summed ^{40}K(n,p) + ^{40}K(n,α) cross sections up to 70 keV
- Resonance strengths up to 20 keV
- Resonance energies up to 70 keV

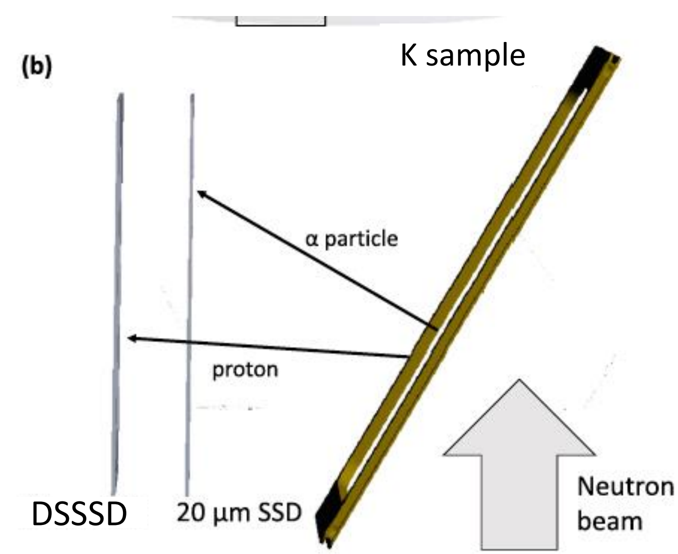
Measurement at EAR-2

^{40}K(n,a): Q-value=3.87 MeV
→ α_0 ~ 3.5 MeV; α_1~ 1.8 MeV ;

^{40}K(n,p): Q-value=2.28 MeV
→ p_0 ~ 2.2 MeV; p_1~ 0.7 MeV

Setup:
dE –E telescope as used for ^{26}Al experiment (20 um + 300 um)





3/2+

^{41}K

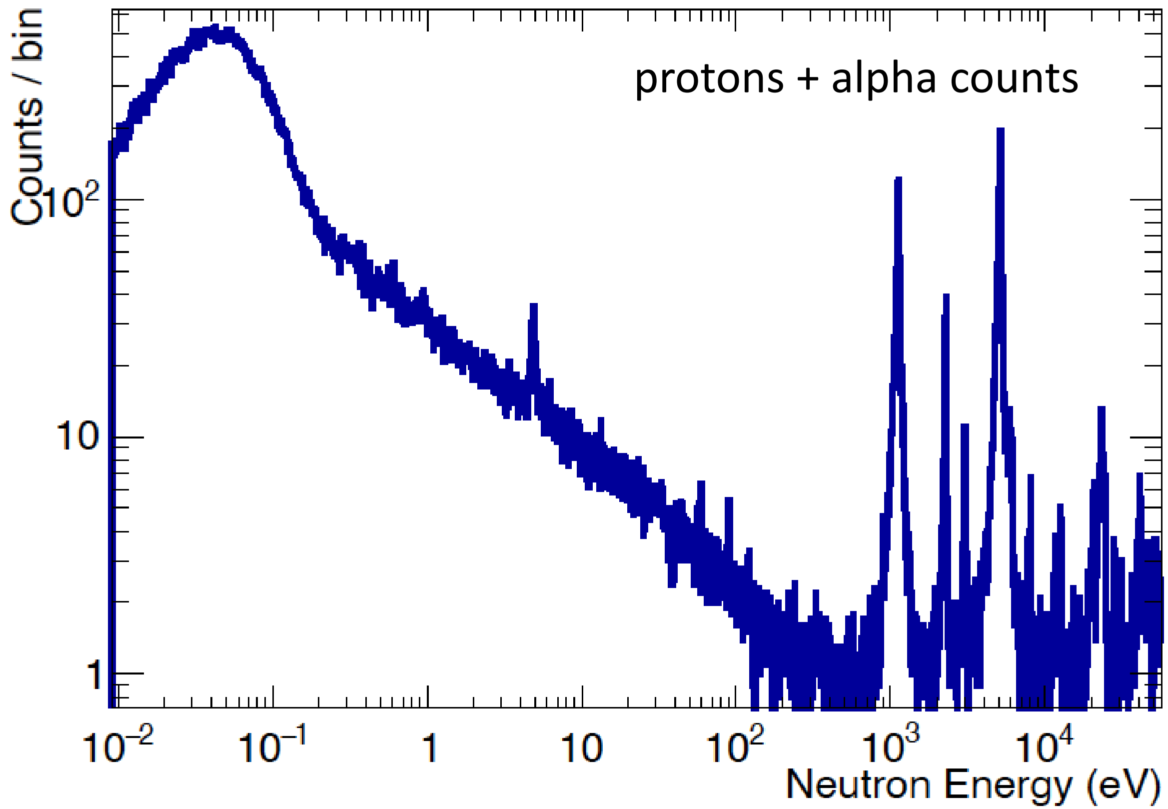
Sample

- Option 1: base material is 3.15% enriched K which then will be implanted onto C backing and enriched in the process to 80% at KU Leuven, 100 ug should be possible.

- Option 2: Buying higher enriched ^{40}KCl (16%) with subsequent deposition on a suitable backing sample (tests of molecular plating at PSI Villigen look encouraging).

Beam Time Request

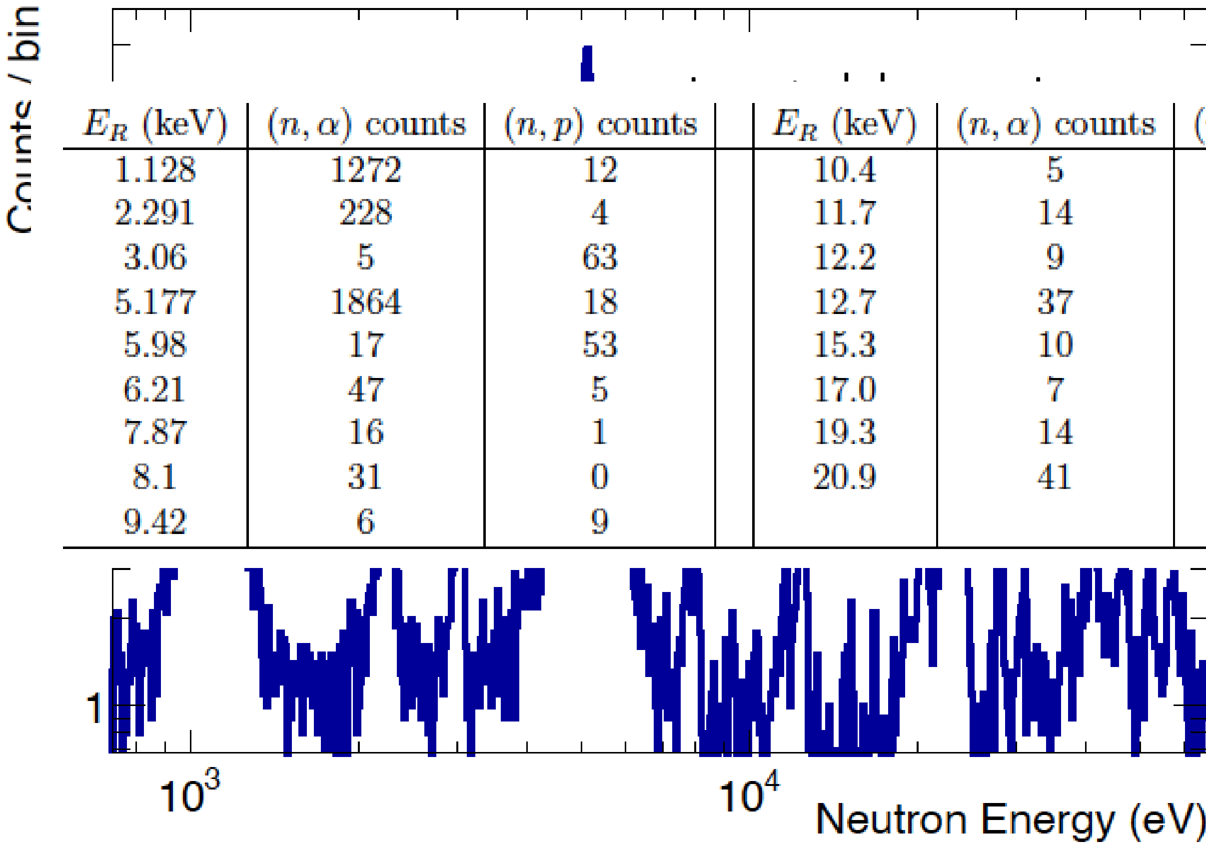
- Based on 100 ug of 80% enriched ^{40}K, preliminary neutron flux, resolution function and beam profile



4.5E18 protons

Beam Time Request

- Based on 100 ug of 80% enriched ^{40}K, preliminary neutron flux, resolution function and beam profile

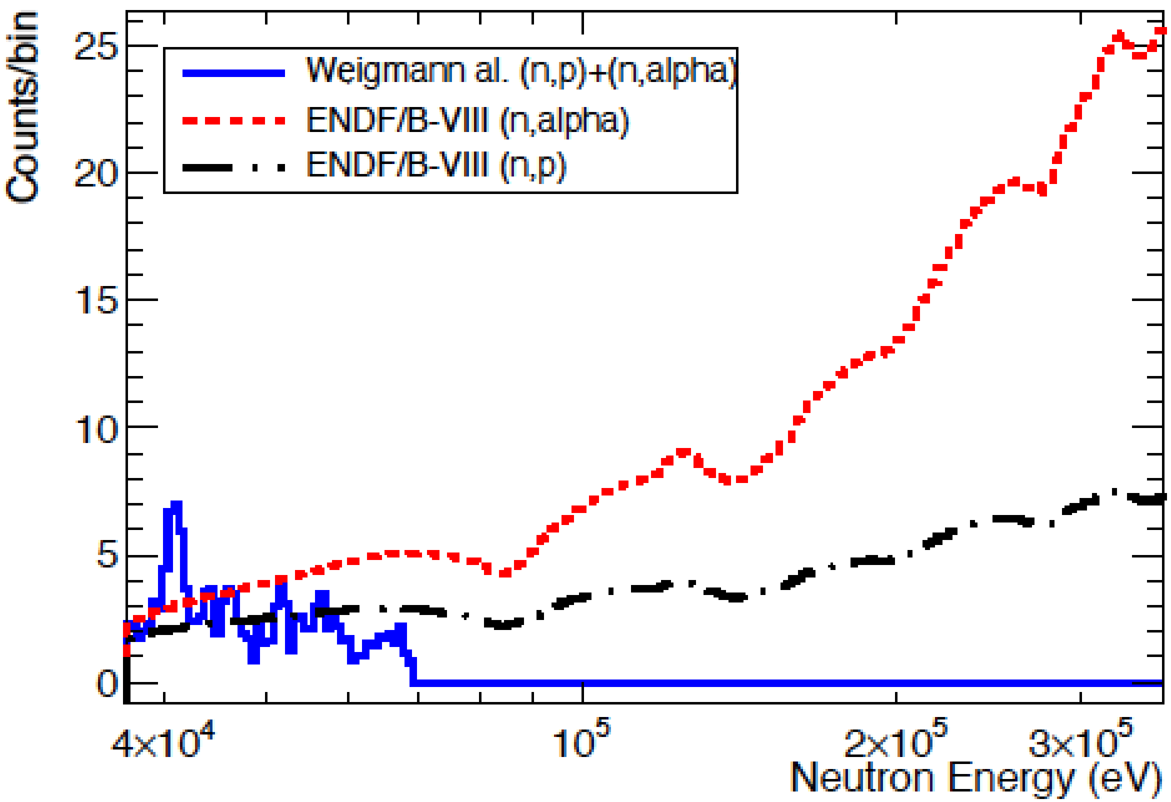


E_R (keV)	(n,α) counts	(n,p) counts	E_R (keV)	(n,α) counts	(n,p) counts
1.128	1272	12	10.4	5	5
2.291	228	4	11.7	14	6
3.06	5	63	12.2	9	1
5.177	1864	18	12.7	37	4
5.98	17	53	15.3	10	2
6.21	47	5	17.0	7	0
7.87	16	1	19.3	14	1
8.1	31	0	20.9	41	4
9.42	6	9			

otons

Beam Time Request

- Based on 100 ug of 80% enriched ^{40}K, simulated 2022 flux and beam profile:



4.5E18 protons

+ normalisation /background runs

Total: 5E18 protons

Thank you for your attention