New direct measurement of the $^{6}Li(p,\gamma)^{7}Be$ cross section at LUNA

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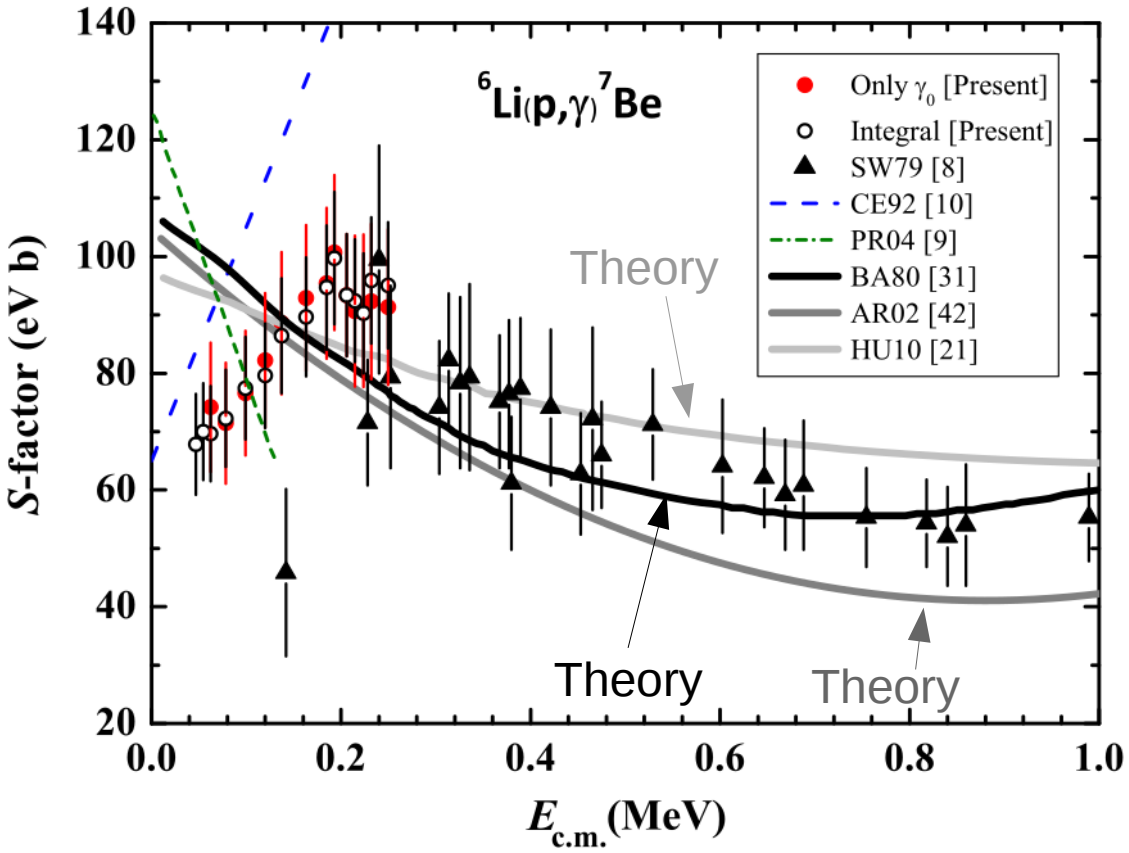
MOTIVATION AND STATE OF THE ART

The $^{6}Li(p,\gamma)^{7}Be$ reaction is involved in Big Bang Nucleosynthesis as well as in lithium depletion in the early stages of stellar evolution.

A resonance-like structure in the $^{6}Li(p,\gamma)^{7}Be$ cross section at E_{cm} = 195 keV was discovered in a recent experiment [J. J. He et al. PLB 725, 287 (2013)].

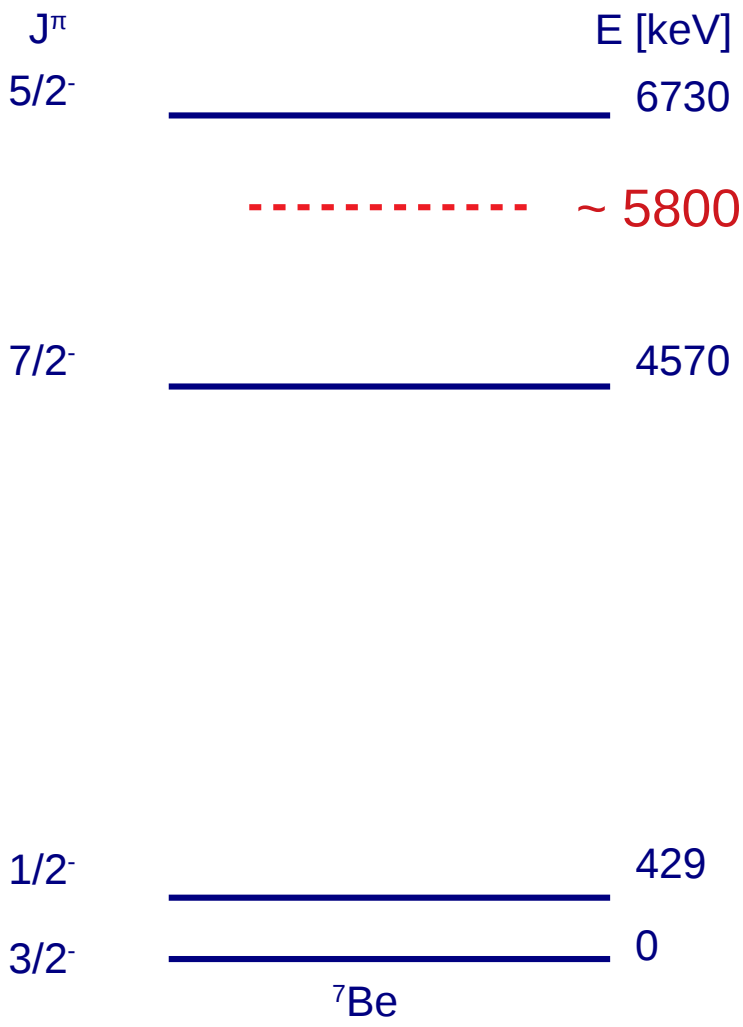
Might be a resonance also in the $^{3}He(^{4}He,\gamma)^{7}Be$ reaction



MOTIVATION AND STATE OF THE ART

According to He et al., the new resonance corresponds to an excited state with Jπ = (1/2+, 3/2+) and E ~ 5800 keV:

- No positive-parity states of ^{7}Be were ever observed or predicted by nuclear theory
  [G. X. Dong J. Phys. G 44, 045201 (2017)]



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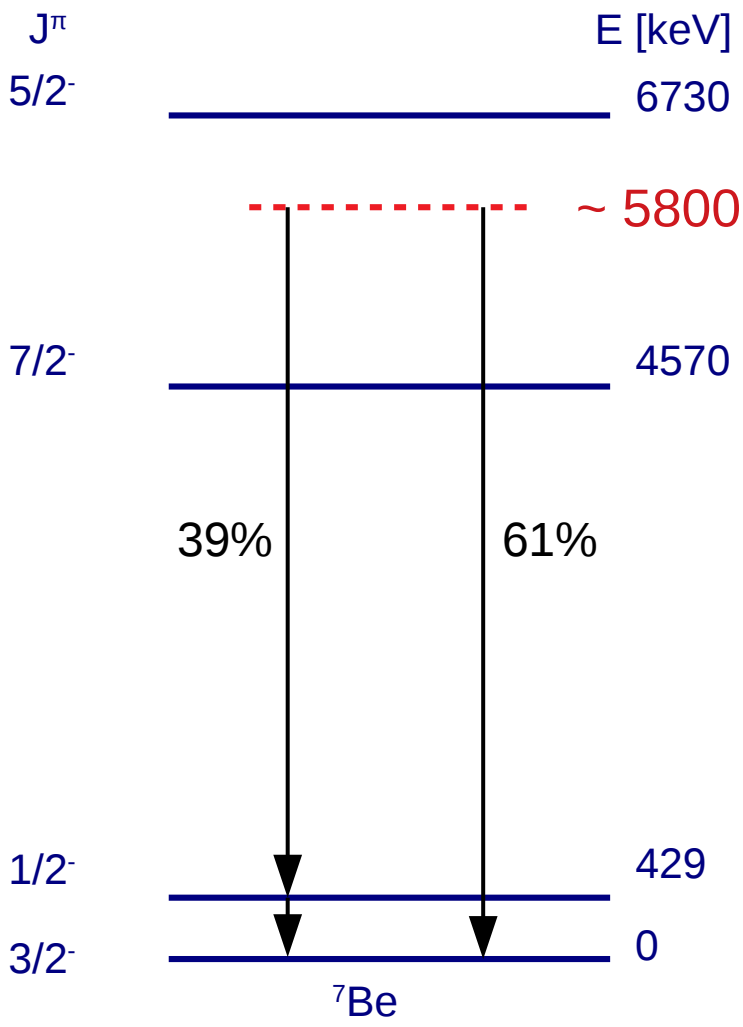
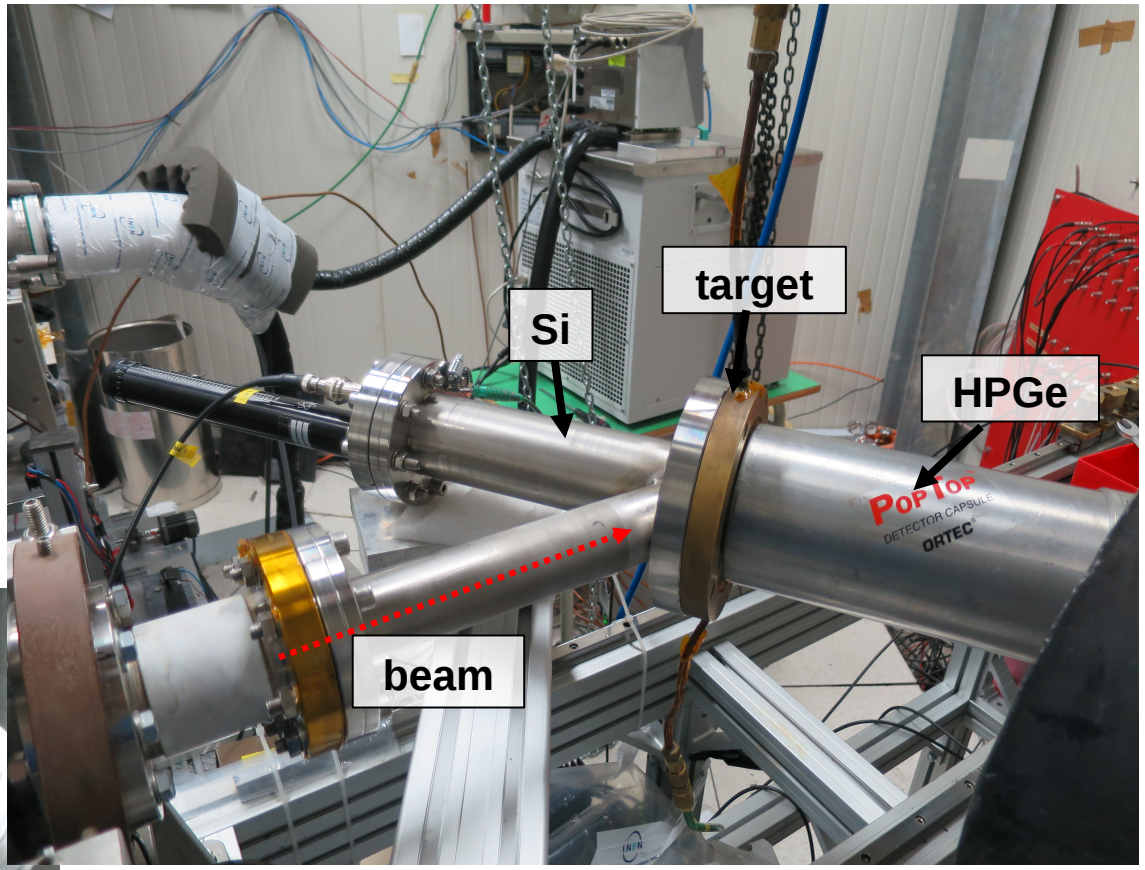
In the de-excitation of ^{7}Be, gammas with E ~ 6 MeV are emitted

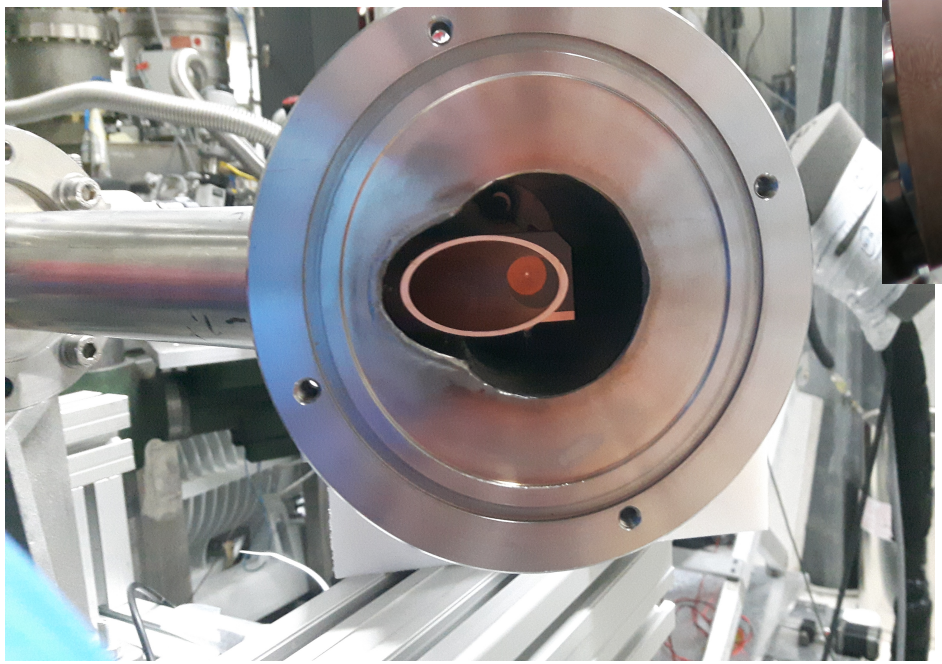
Especially favorable for experiments in underground laboratories



EXPERIMENTAL SETUP AT LUNA

- E_p = 80 – 400 keV
- Solid ^{6}Li targets
  (95% isotopic enrichment):
  $^{6}Li_2O$, $^{6}Li_2WO_4$, $^{6}LiCl$

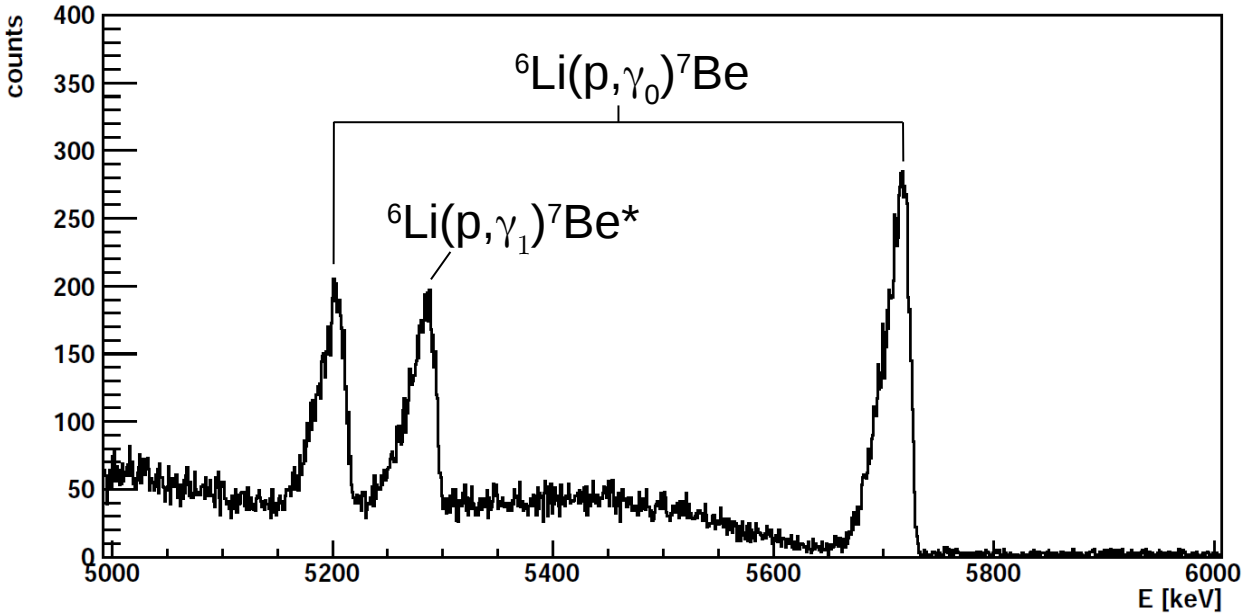




- 1 HPGe in close geometry
- 1 Si detector for $^{6}Li(p,\alpha)^{3}He$
  collimator diameter 1mm, mylar 5 μm

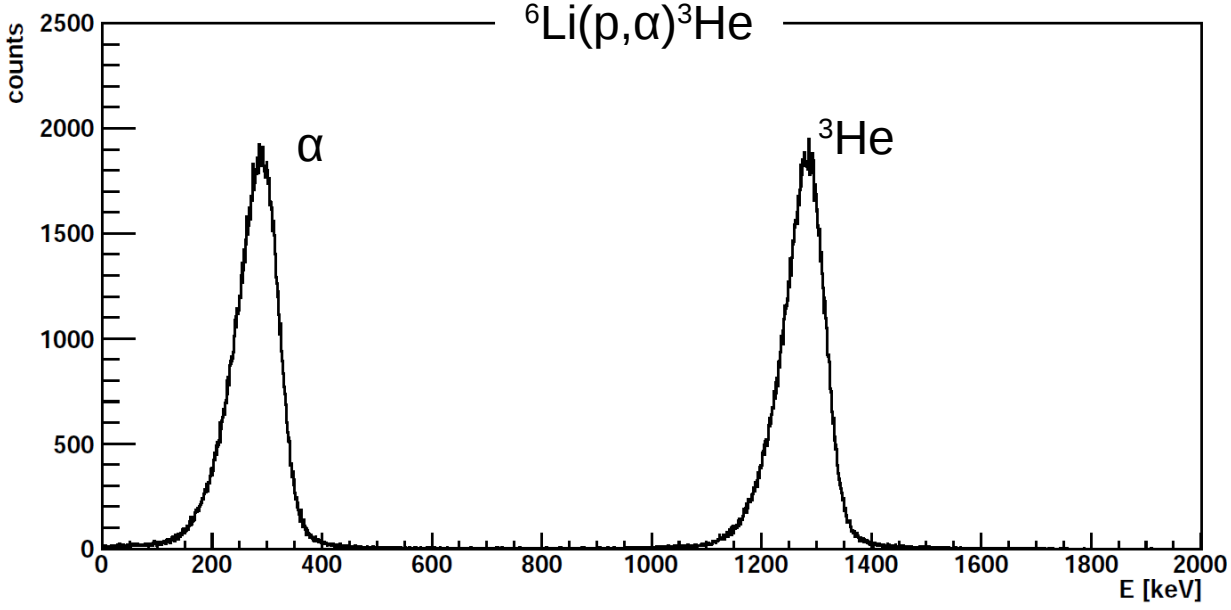
SAMPLE SPECTRA

$^{6}Li_{2}WO_{4}$ target, 100 μg/cm²
E_p = 110 keV
Q = 3.8 C (17h)



gamma spectrum

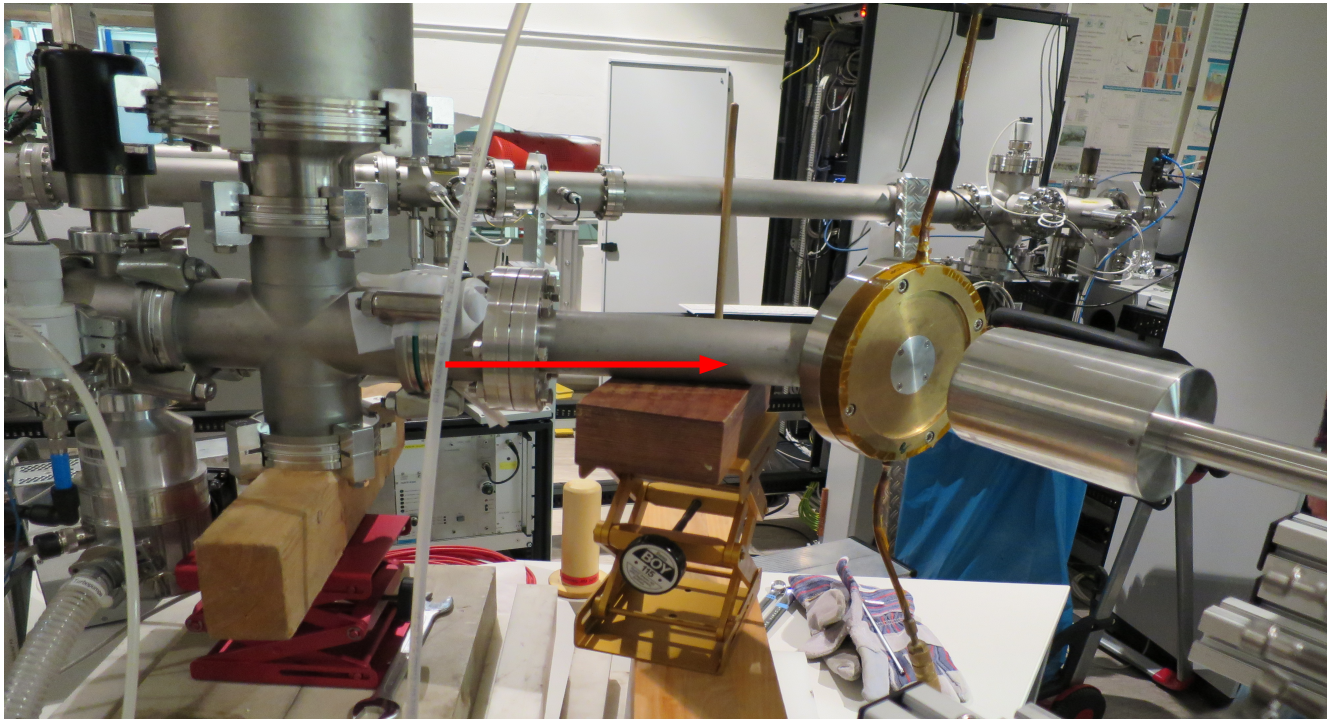
charged-particles spectrum



TARGET CHARACTERIZATION AT HZDR

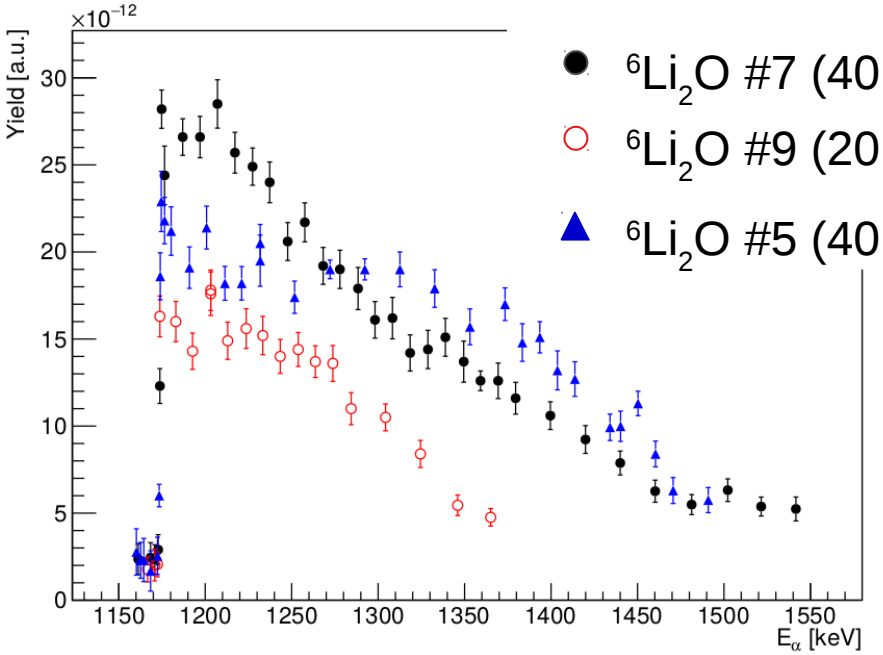
Target characterization has been performed at the Helmholtz-Zentrum Dresden-Rossendorf using two independent techniques:

- **Nuclear Reaction Analysis** → $^{6}Li(\alpha,\gamma)^{10}B$ resonance at 1175 keV,
  $\omega\gamma$ = (366 ± 38) meV, Γ_R= 1.8 eV
  5 days of beam time @ 3 MV Tandetron

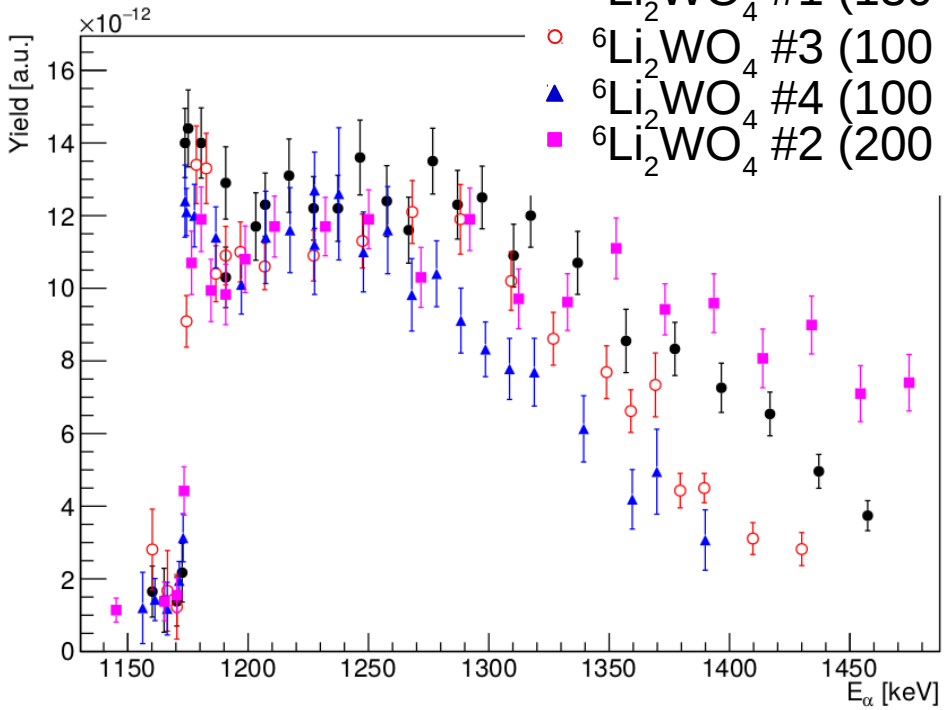


- **Elastic Recoil Detection Analysis with a 43 MeV $^{35}Cl^{7+}$ beam**

RESULTS FROM NRA: $^{6}Li_2O$ TARGETS



- $^{6}Li_2O$ #7 (40 μg/cm²)
- $^{6}Li_2O$ #9 (20 μg/cm²)
- $^{6}Li_2O$ #5 (40 μg/cm², fresh)



- $^{6}Li_2WO_4$ #1 (130 μg/cm²)
- $^{6}Li_2WO_4$ #3 (100 μg/cm²)
- $^{6}Li_2WO_4$ #4 (100 μg/cm²)
- $^{6}Li_2WO_4$ #2 (200 μg/cm²)

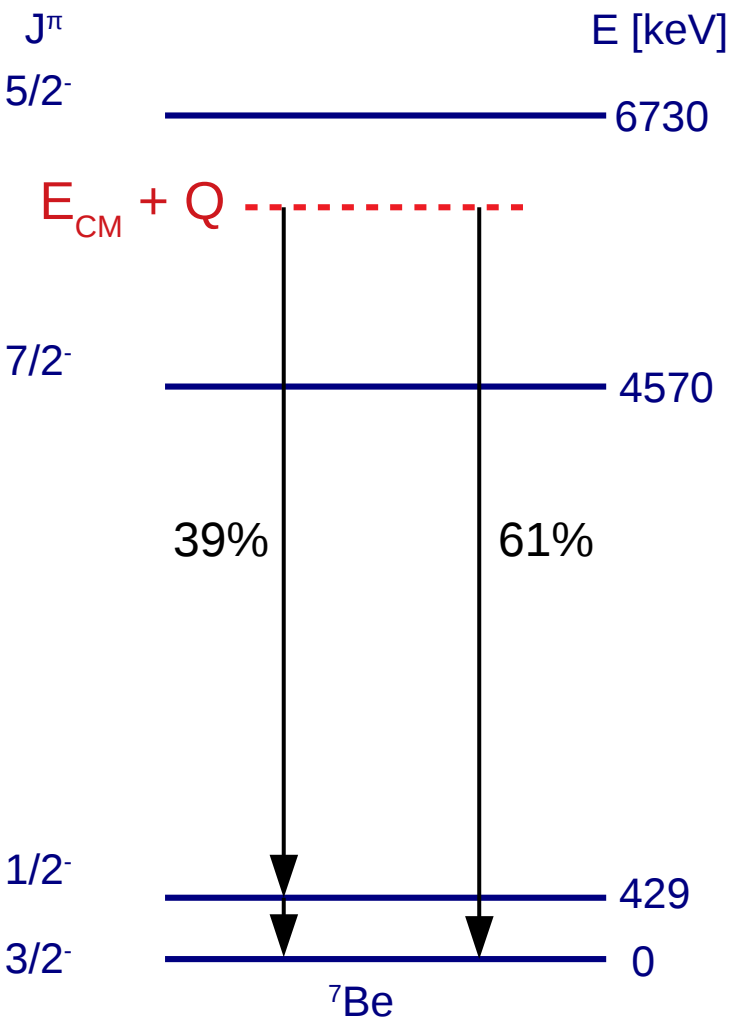
PRELIMINARY RESULTS FROM ERDA

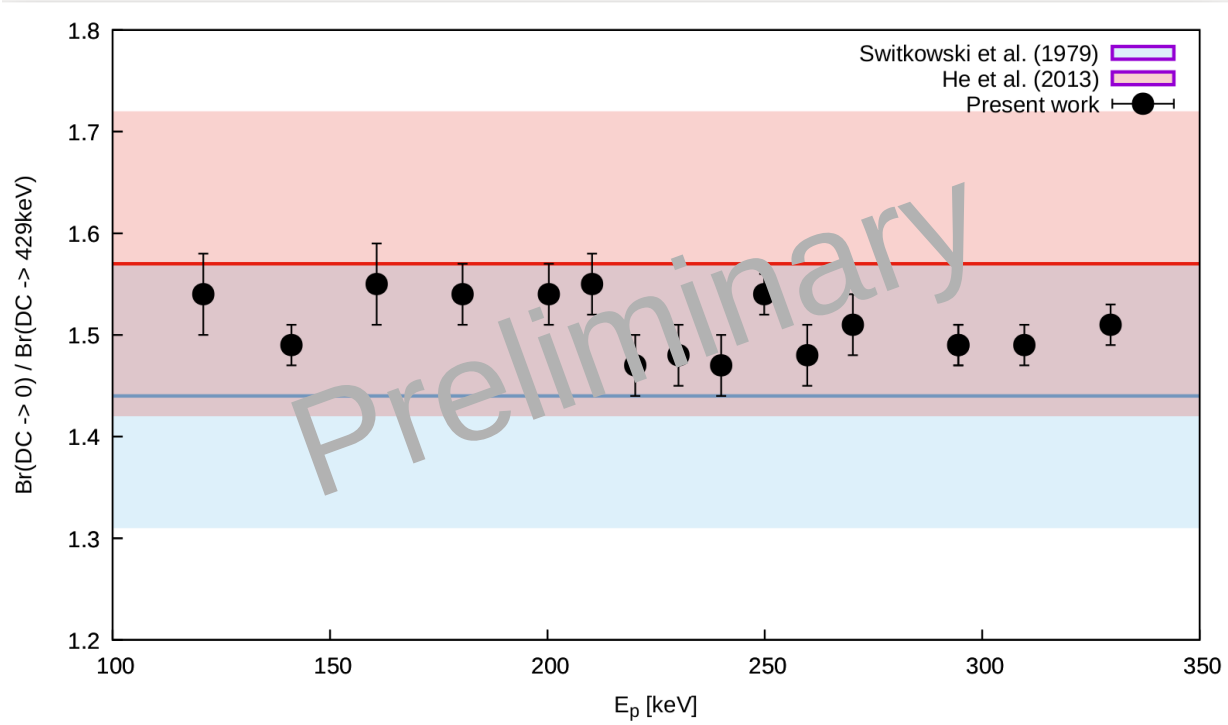
Sample	thickness 10^{15} at./cm^2	H at.-%	Li at.-%	C at.-%	O at.-%	W at.-%
$^{6}Li_2O$ #5	4000	7	31	12	50	-
$^{6}Li_2O$ #6	2300	5	27	15	53	-
$^{6}Li_2O$ #7	6400	3	31	14	53	-
$^{6}Li_2O$ #7 †	6600	3	29	14	54	-
$^{6}Li_2O$ #8	3300	5	27	15	53	-
$^{6}Li_2O$ #9	3600	7	26	16	51	-
$^{6}Li_2O$ #9 †	3600	6	27	13	54	-
$^{6}Li_2WO_4$ #1	3600?	9	19	<6	54	9
$^{6}Li_2WO_4$ #2	>4000?	?	?	?	?	?
$^{6}Li_2WO_4$ #3	2100	9	17	<7 *	56	10
$^{6}Li_2WO_4$ #4	2400	11	16	<5 *	57	10

Nominal:
67% Li
33% O

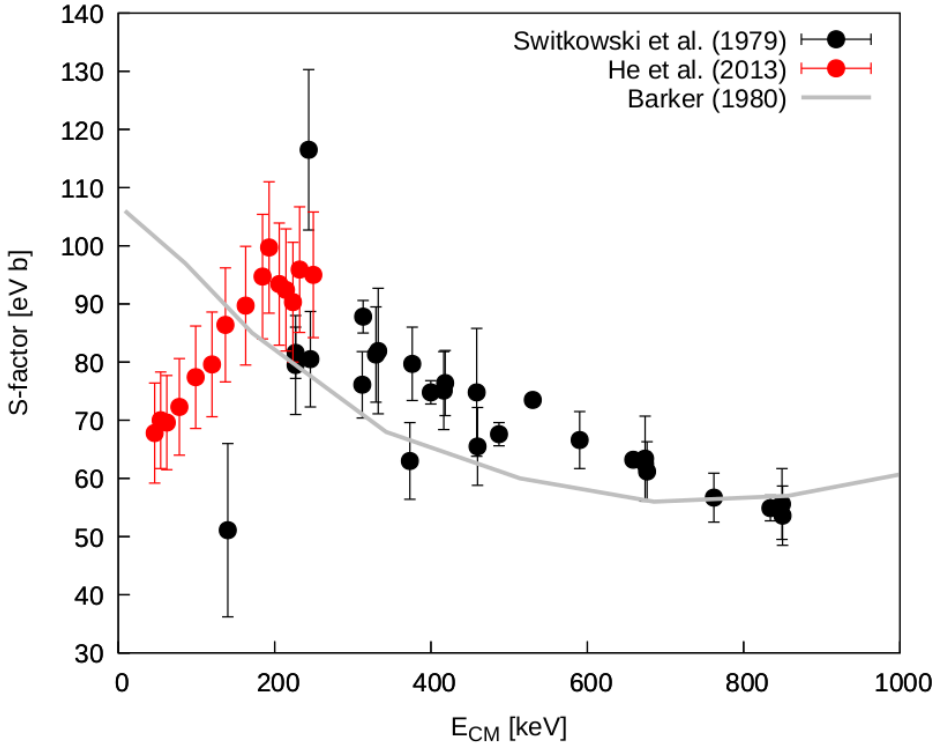
Nominal:
28.6% Li
57.1% O
14.3% W

$^{6}Li(p,\gamma)^{7}Be$ BRANCHING RATIOS

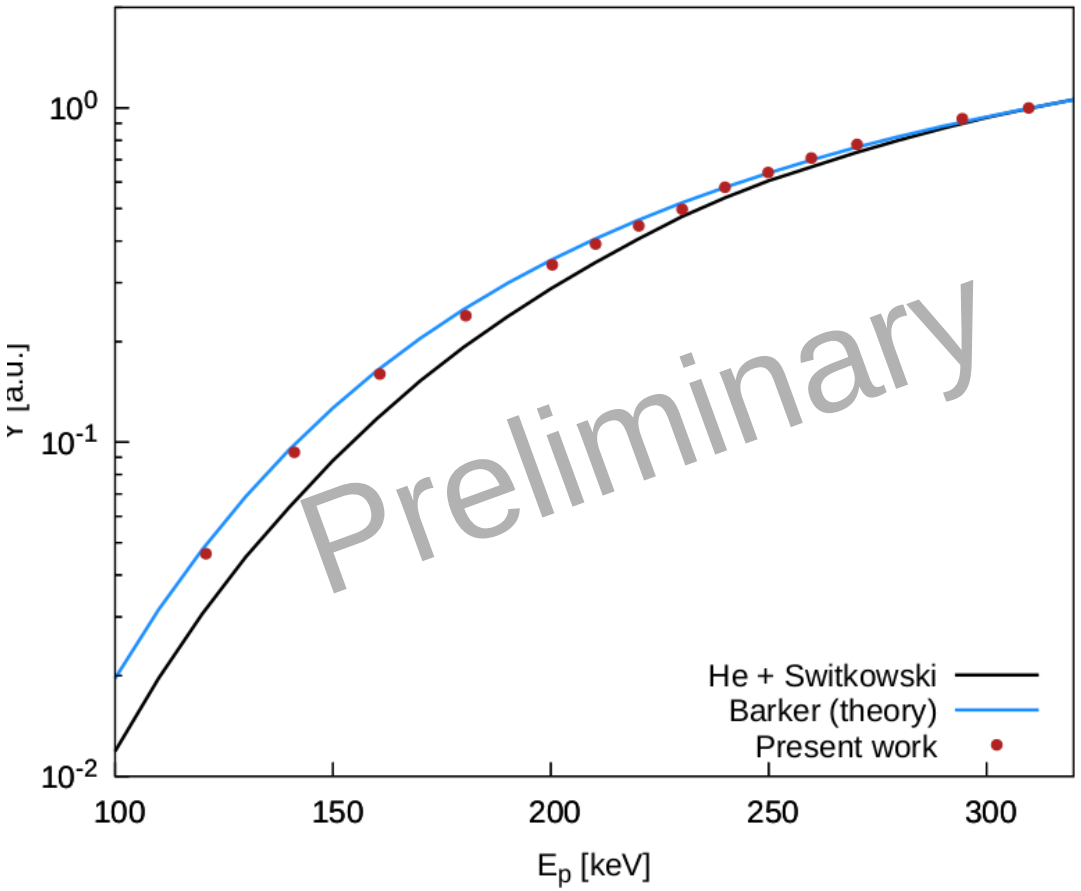




$^{6}Li(p,\gamma)^{7}Be$ MEASURED YIELD



Expected vs. measured experimental yield



THANK YOU!

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