Direct cross section measurement of $^{18}O(p, \gamma)\, ^{19}F$ at LUNA

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We show the status of the direct cross section measurements for the reaction $^{18}O(p, \gamma)\, ^{19}F$ which is studied at the LUNA400 facility, 1400 mt deep underground at the Gran Sasso National Laboratory (Italy).

Astrophysical Motivation

- $^{18}O(p,\gamma)$ represents the bridge between CNO and other cycles in which there is the production of heavier nuclei, which are active during shell H burning (Fig.1).
- It competes with $^{18}O(p,\alpha)$ and may provide an explanation for an observed ^{18}O depletion in presolar grains.

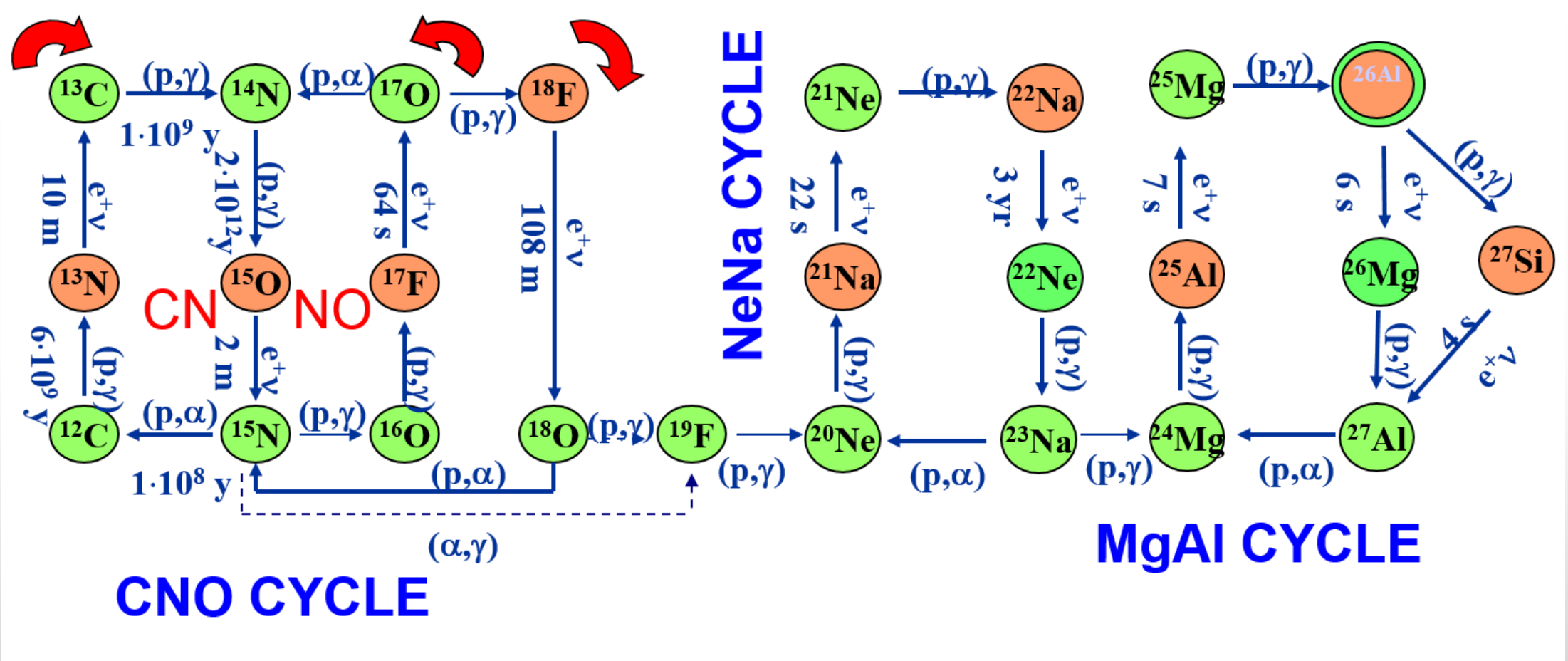


Fig.1: CNO cycle (left), NeNa and MgAl cycle (right).

- Direct capture and 3 resonances (Fig.3) dominate the reaction rate up to 100 MK.

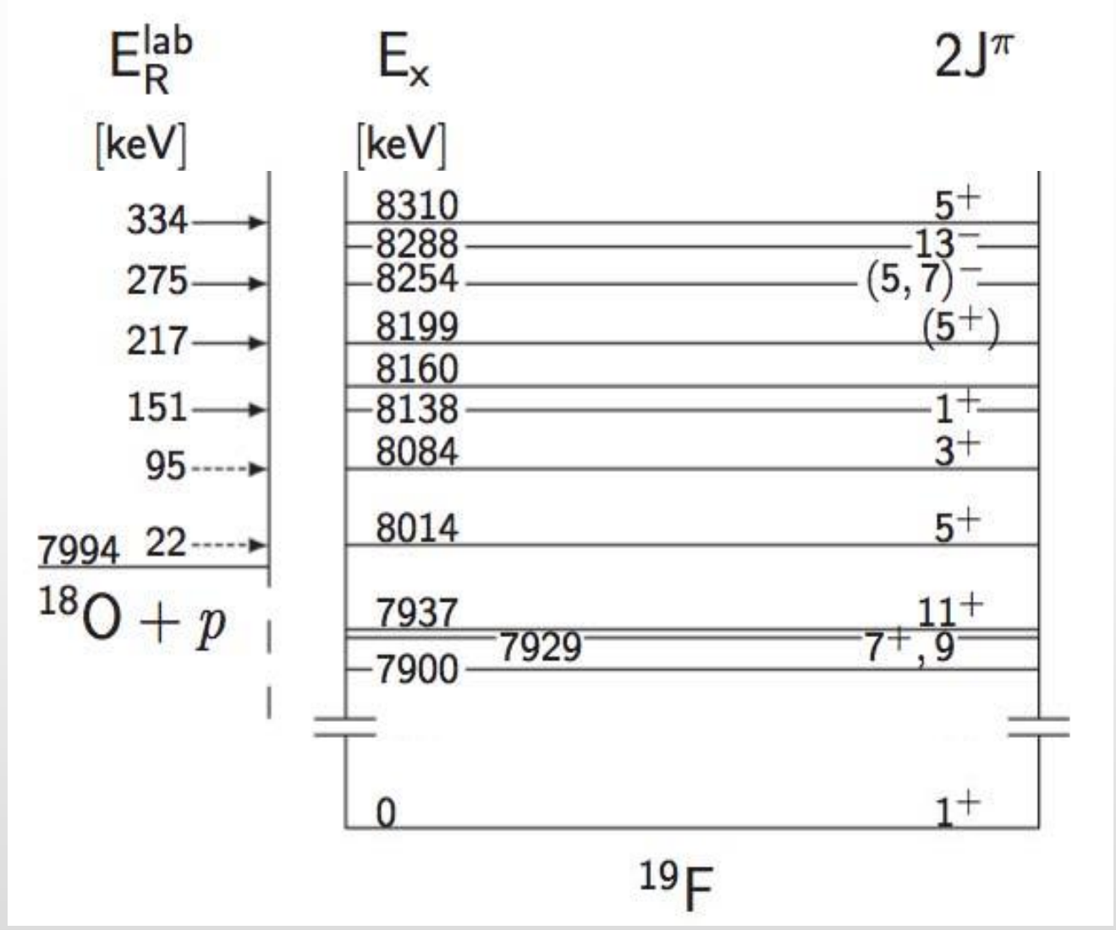


Fig.3: Truncated ^{19}F level diagram and ^{18}O+p resonances.

- The 95 keV resonance strength is disputed. [1, 2]
- The direct capture component has only been measured for E_p>150 keV. [3]
- Reaction rate contributions are shown in (Fig.2).

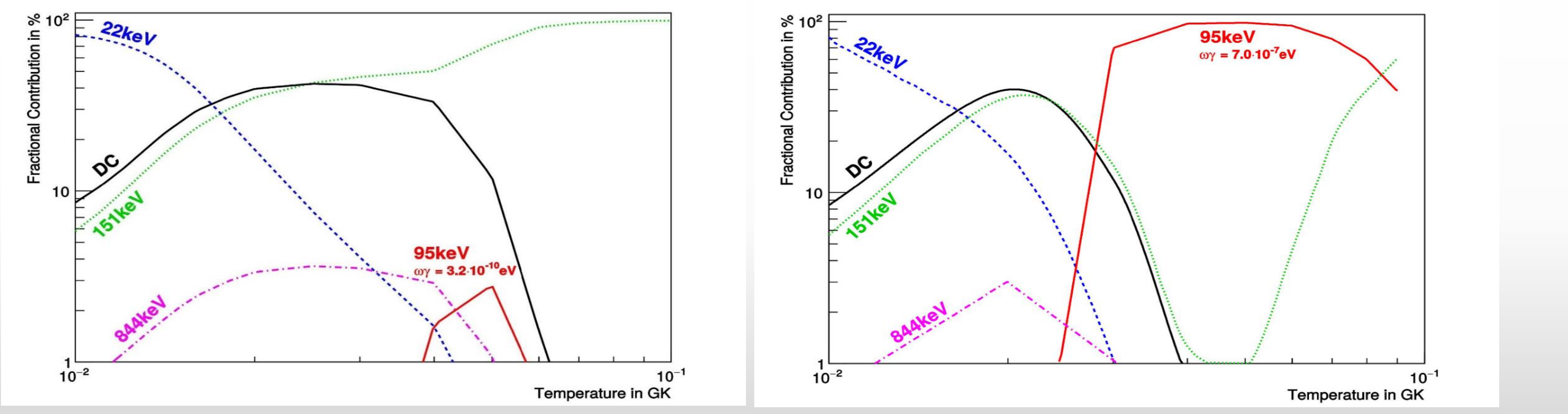


Fig.2: Reaction rate contributions according to [1] (left) and to [2] (right).

Detectors

- Two detector setups are used: a high efficiency BGO with 6 segments, and a high resolution HPGe detector (Fig.4).
- $^{18}O(p,\gamma)^{19}F$ spectra of BGO and HPGe detectors are shown in (Fig.5,6,7).

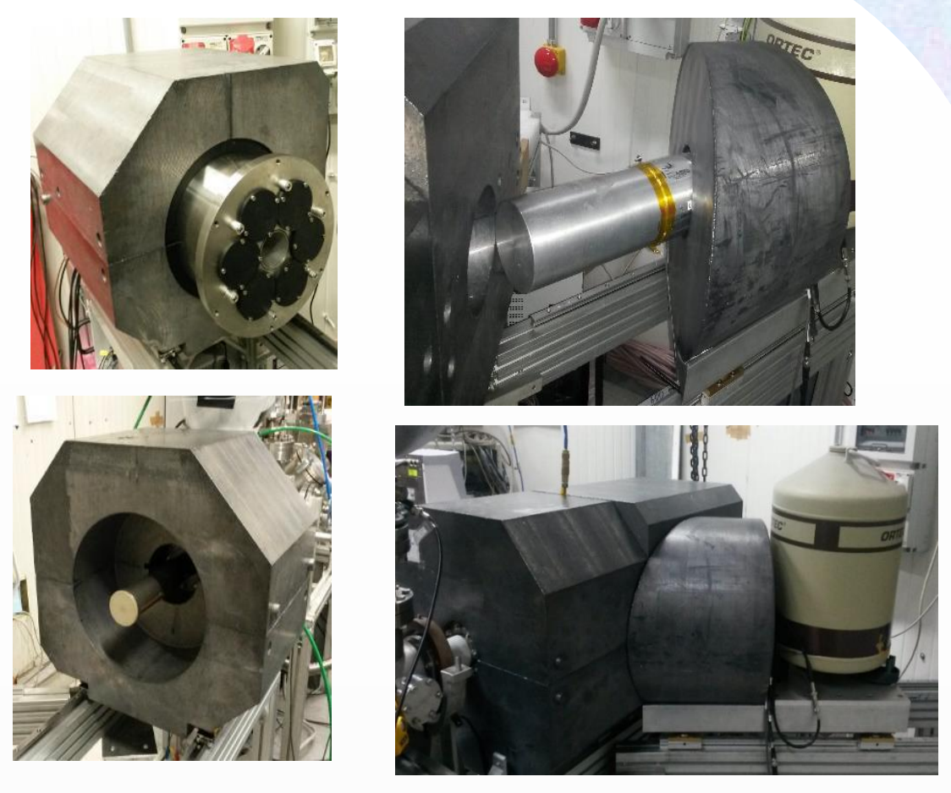


Fig.4: BGO (left) and HPGe (right) detectors including a lead shielding.

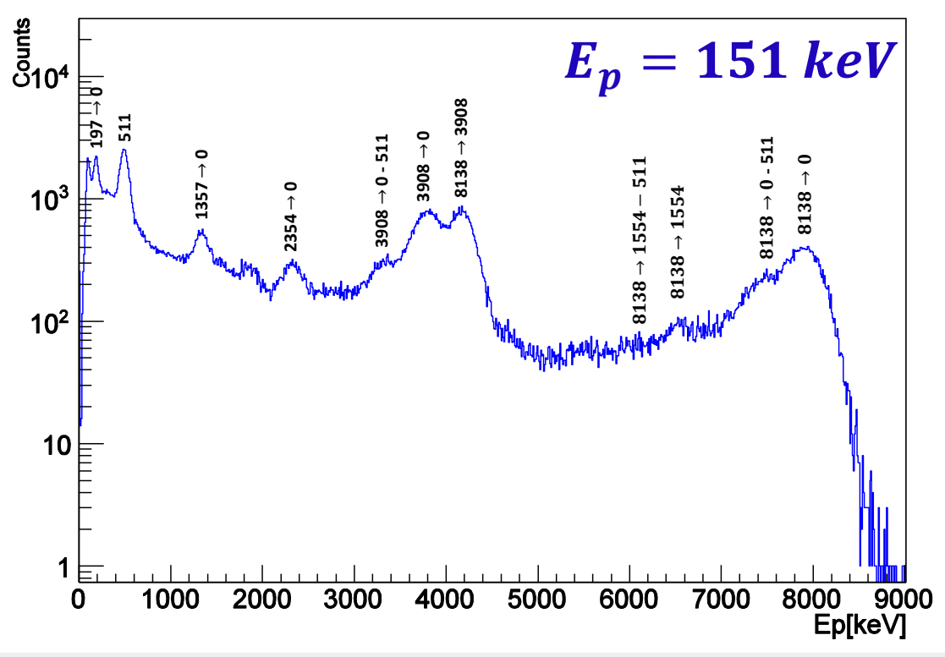


Fig.5: Single BGO segment, high efficiency.

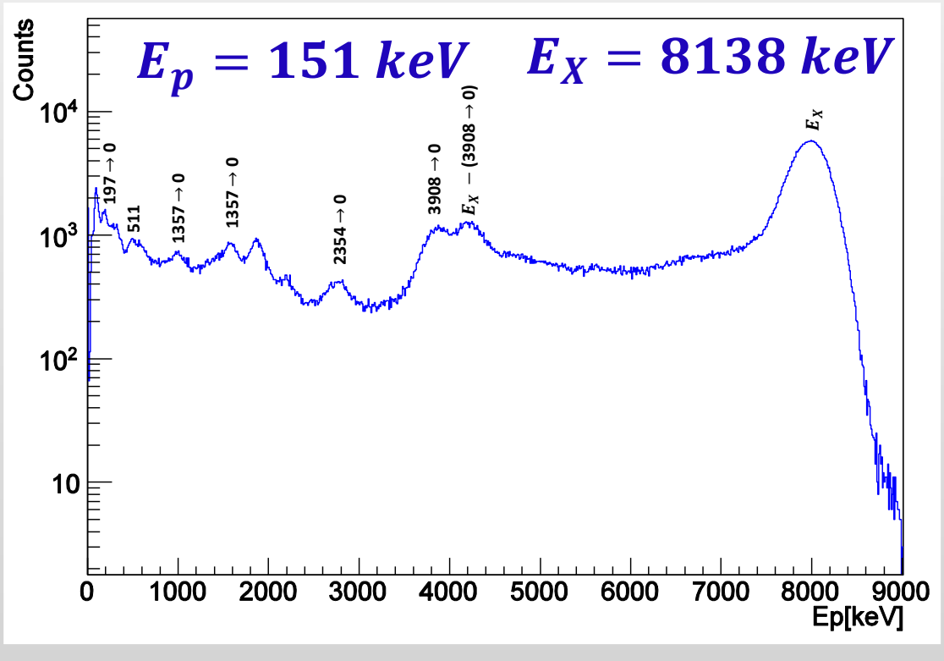


Fig.6: Full BGO detector, highest efficiency.

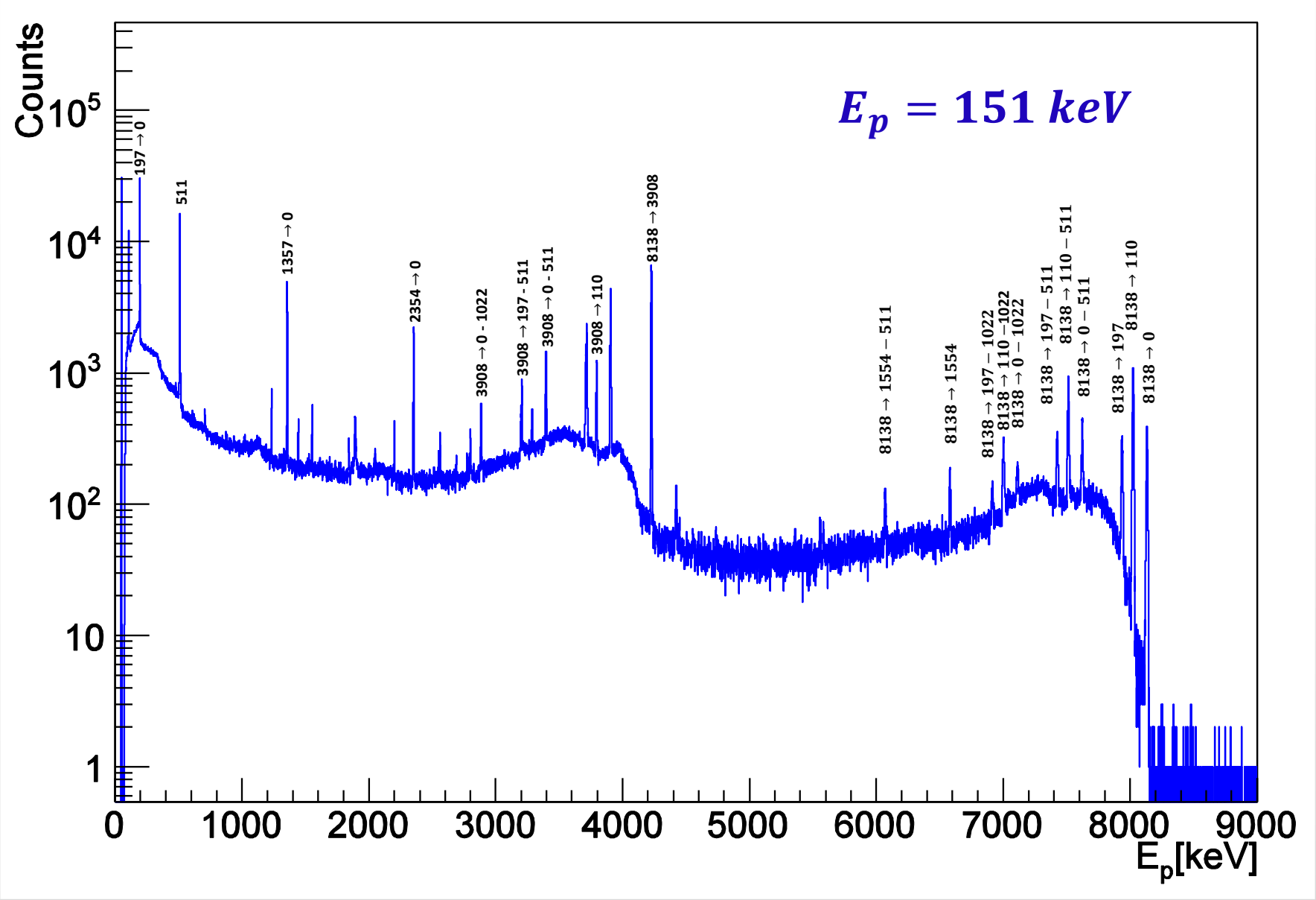
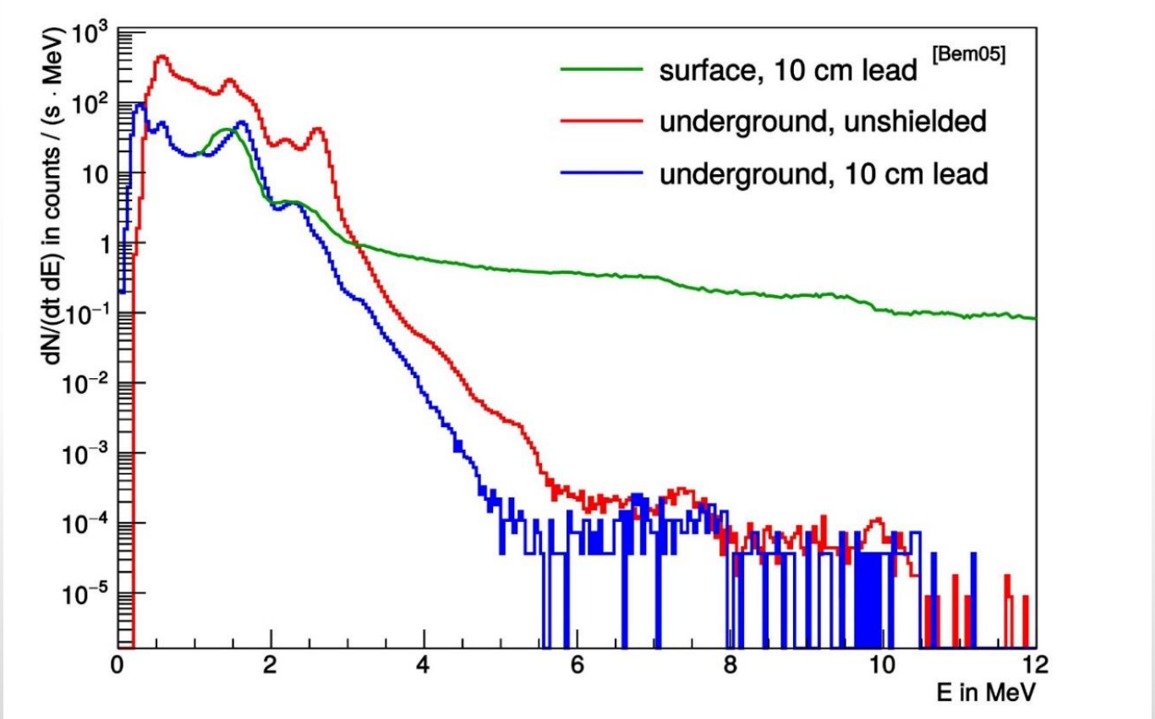


Fig.7: HPGe detector, resolving single transitions.



- The underground location and the shielding around the detectors strongly reduce the background contributions.

These effects are shown in Fig.8.

Fig.8: Effects of the location and shielding on the BGO detector background [4].

Targets

- Targets were produced using Ta backing + anodization Ta_2O_5 + enrichment ^{18}O (>98%)[5] (Fig.9).

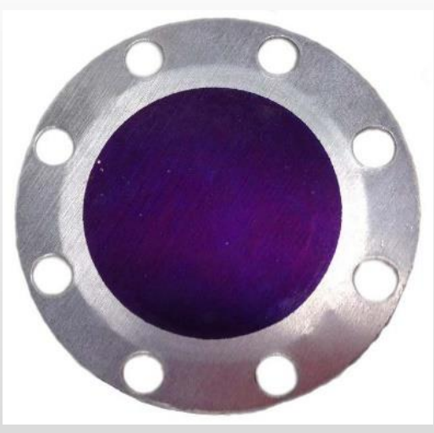


Fig.9: Solid target of ^{18}O.

- Resonance scans are shown in Fig.10.

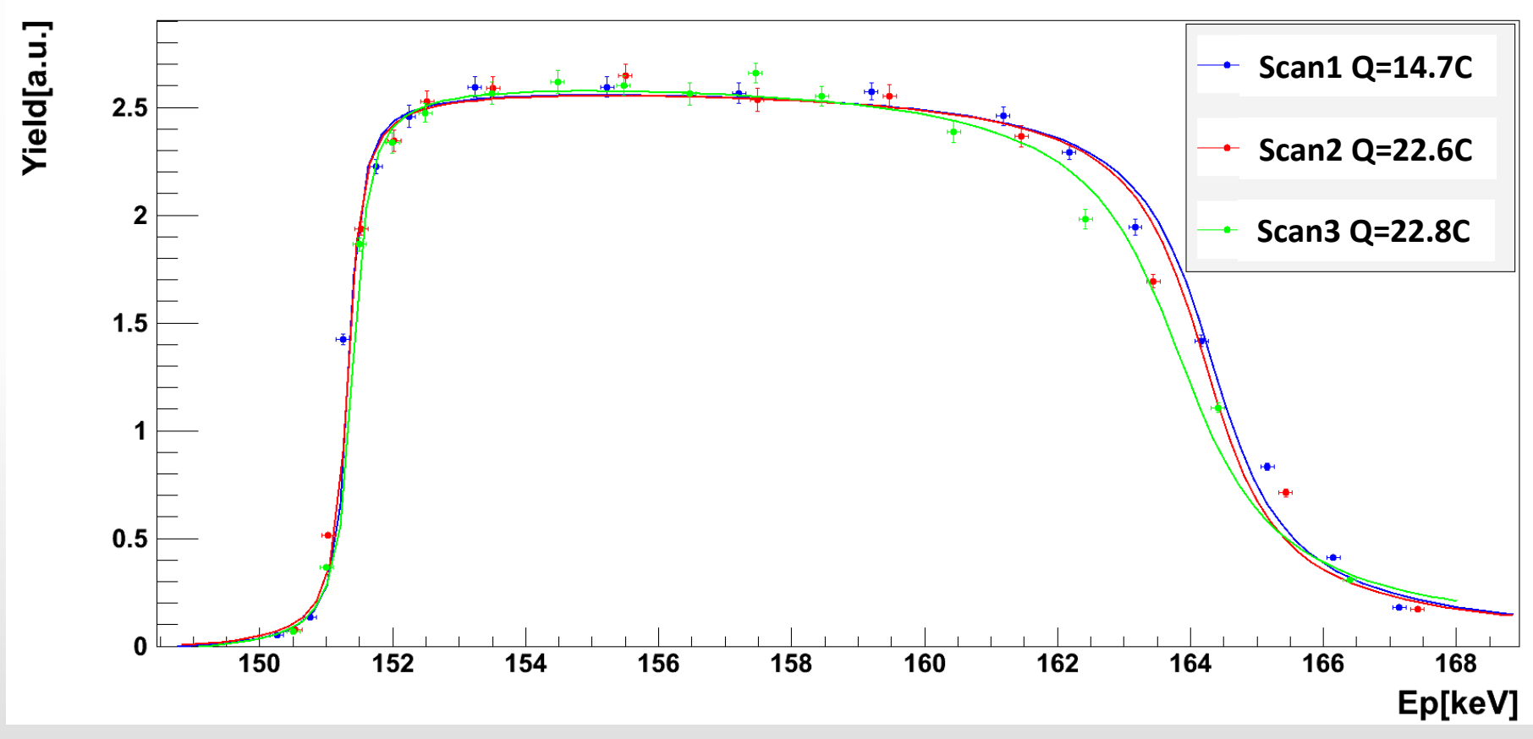


Fig.10: 151 keV resonance scans in order to monitor the target degradation.

Measurements and preliminary results

- BGO measurements cover the proton energy range from 95 keV to 400 keV. The excitation function acquired with BGO is shown in Fig.11.
- HPGe measurements cover the proton energy range from 140 keV to 400 keV, in order to estimate the on-resonance, off-resonance branching ratios and the direct cross section.

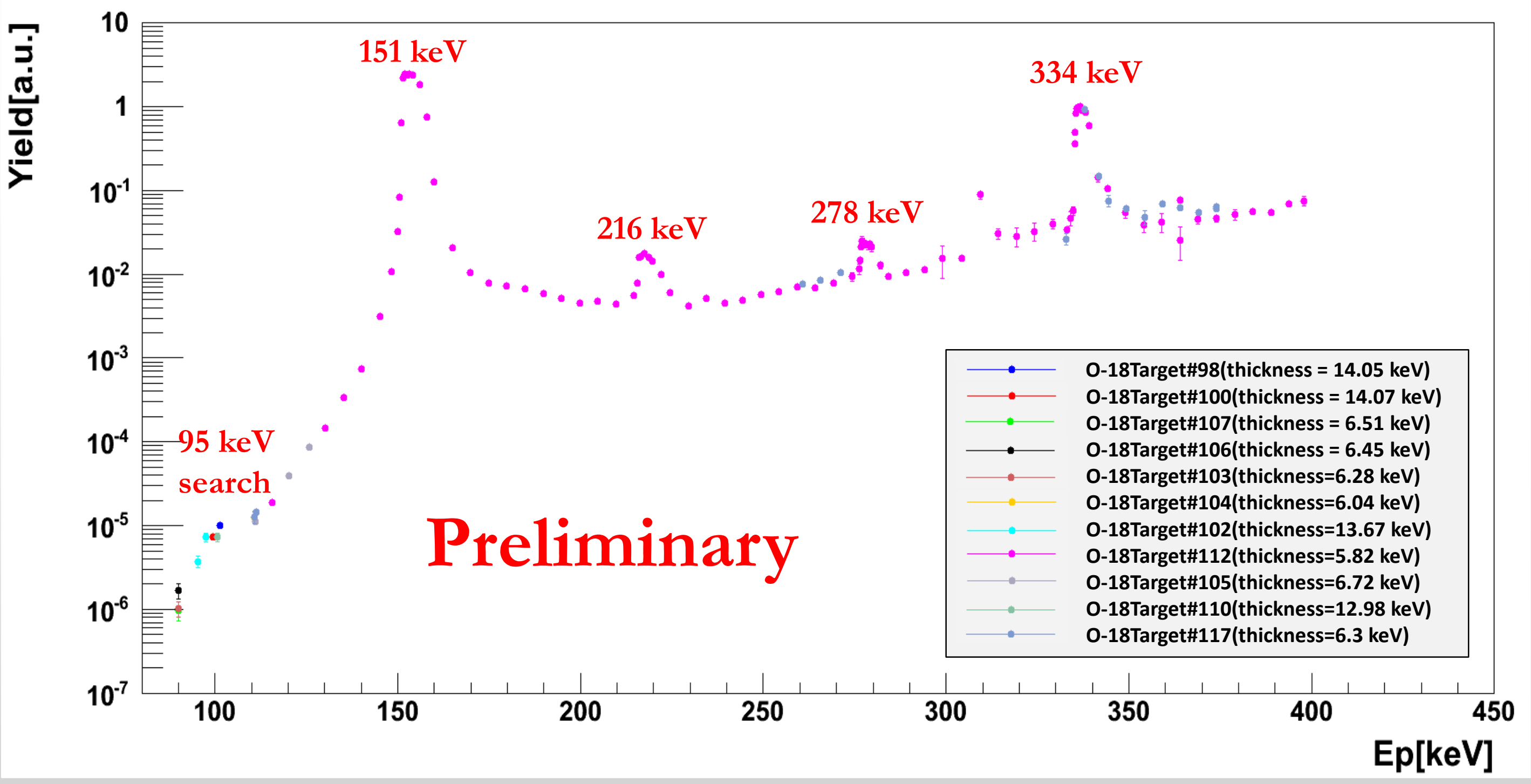


Fig.11: Excitation function acquired with BGO setup including background subtraction.

- Preliminary on-resonance results from BGO data were obtained estimating the resonance strengths (Tab.1).

E_{plab} (keV)	ωγ LUNA(meV) Preliminary Analysis	ωγ Wiescher (meV) [3]	ωγ Vogelaar (meV) [6]	ωγ Iliadis (meV) [7]
151	**0.99**	1.0±0.1	0.92±0.60	
216	**0.0043**	>0.008	0.005±0.001	0.005±0.001
278	**0.03**	0.037±0.005		0.037±0.005
334	**0.98**	0.95±0.08		

Tab.1: Resonance strength values of LUNA compared with the literature ones.

- A clear signal at 8084 keV is visible in the full BGO spectrum, acquired at Ep = 95 keV (Fig.12). The studies of these implications are ongoing.

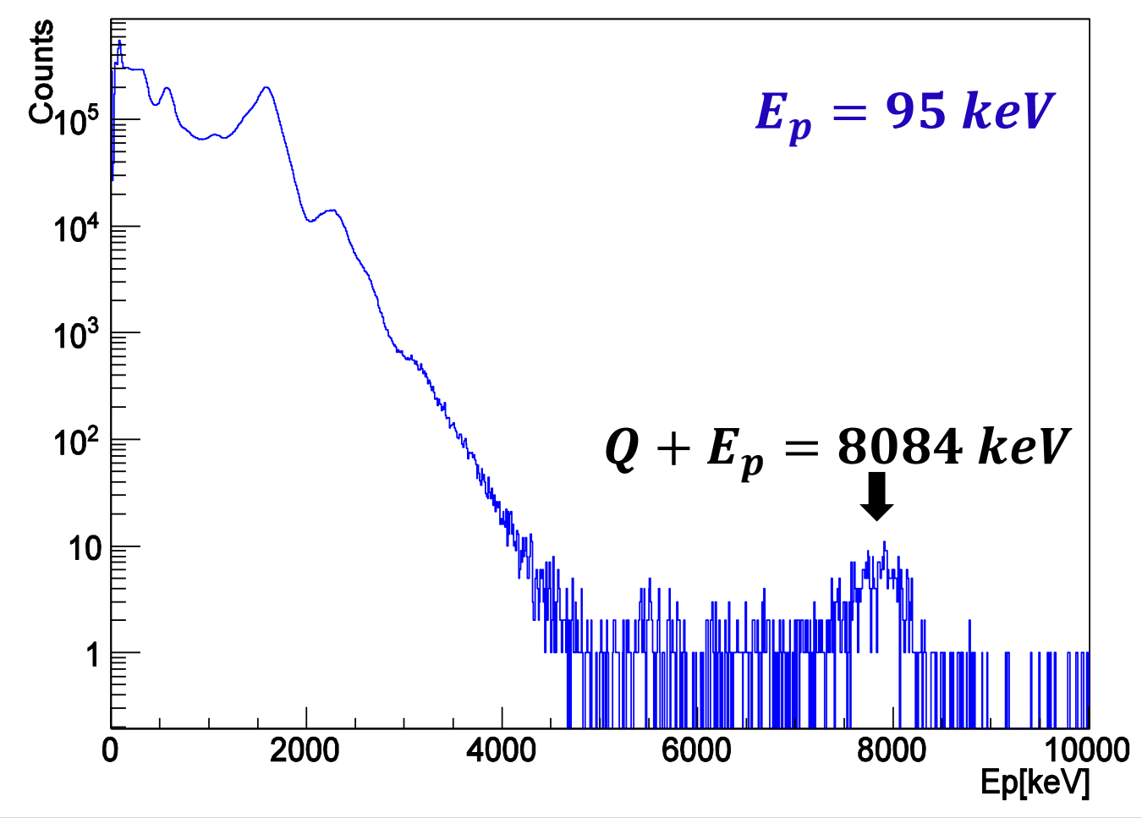
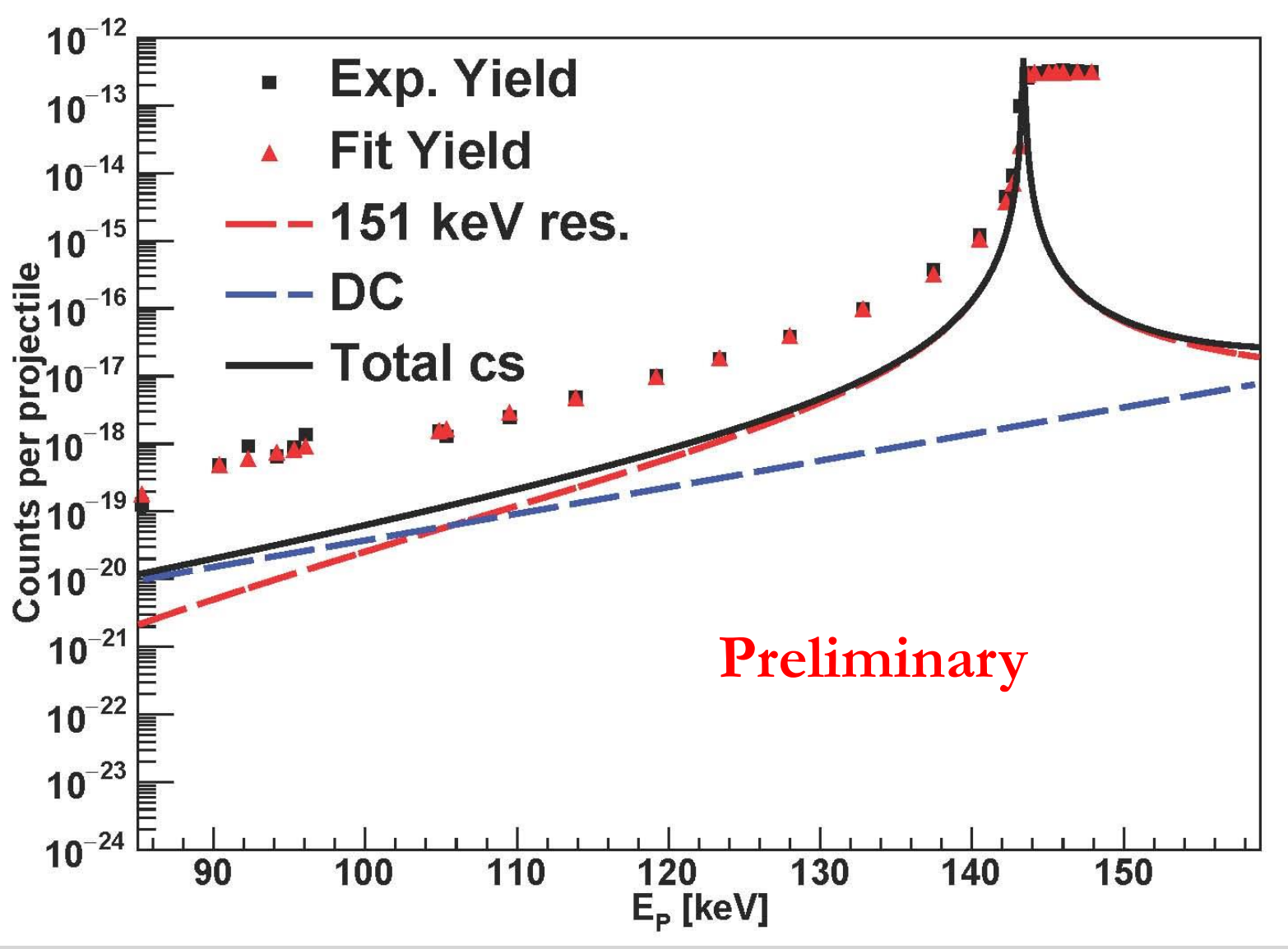


Fig.12: Full BGO detector spectrum of $^{18}O(p, \gamma)\, ^{19}F$ at 95 keV.



- A preliminary analysis including the 151 keV resonance and the direct capture contributions according to the Fig.12 is ongoing. No sign of strong resonance as predicted by Fortune *at al*[2].

References

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[2] H.T. Fortune et al. Phys. Rev. C 015801 (2013)
[3] M. Wiescher et al. Nuclear Physics A 349 (1980) 165-216
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[6] R. B. Vogelaar et al. Physical Review C 841 (2010) 753
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