JLab meeting (Pb target)

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Required beam time simulation (LOI12-23-013)

https://researchmap.jp/gogami/published_papers/42361620/attachment_file.pdf

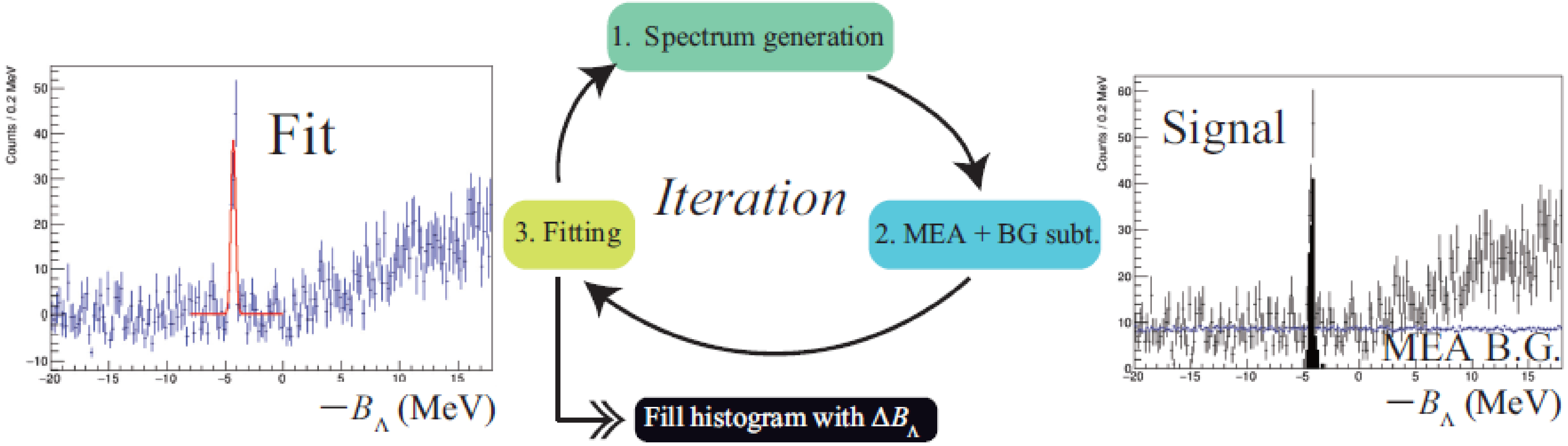


FIG. 8. Flow chart of the simulation to evaluate the required beam times.

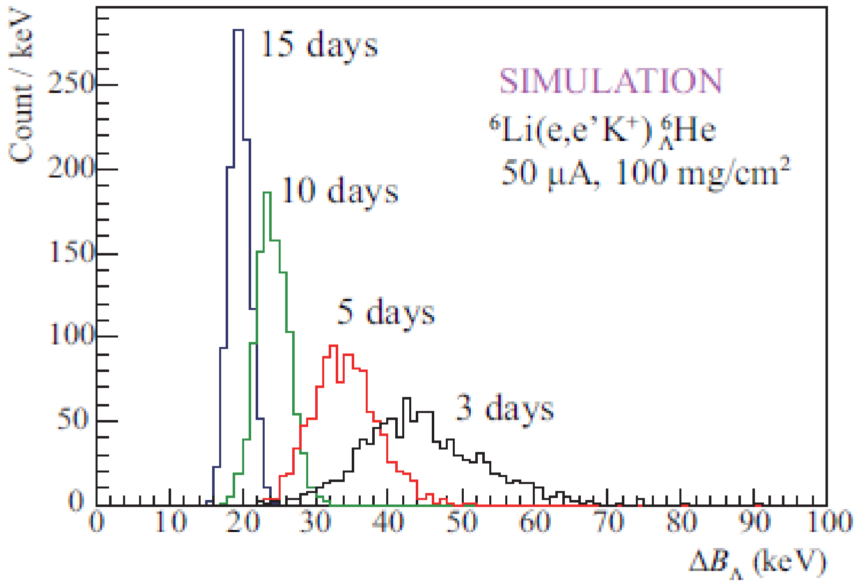


FIG. 9. Statistical uncertainties ($\Delta B_{\Lambda}^{\mathrm{stat.}}$) obtained in the simulation for the $^{6}\mathrm{Li}(e, e'K^{+})^{6}_{\Lambda}\mathrm{He}$ reaction. The assumed beam current and target thickness are 50 μA and 100 mg/cm^{2}, respectively. Peak fits to simulated spectra were performed 1000 times for each beam-time condition (3, 5, 10, and 15 days), and the obtained statistical uncertainties are filled in the histogram.

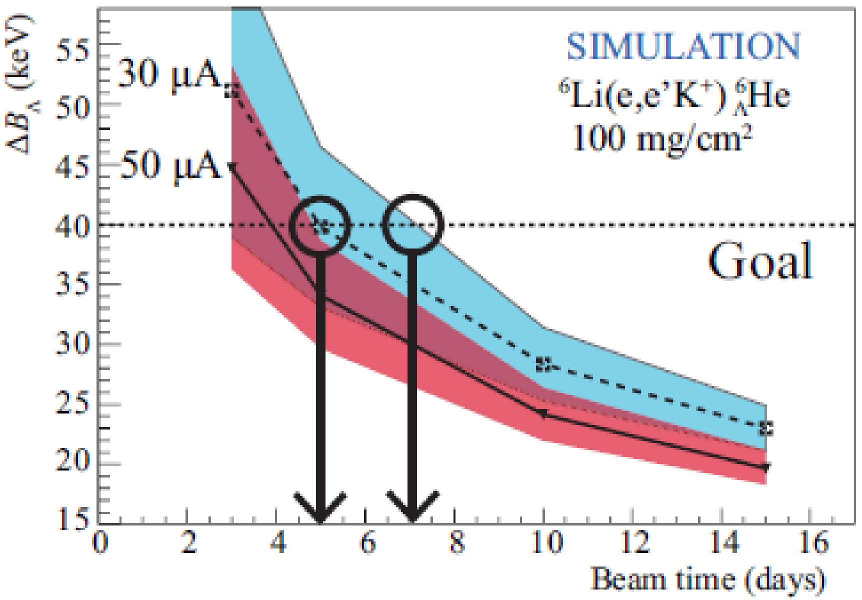
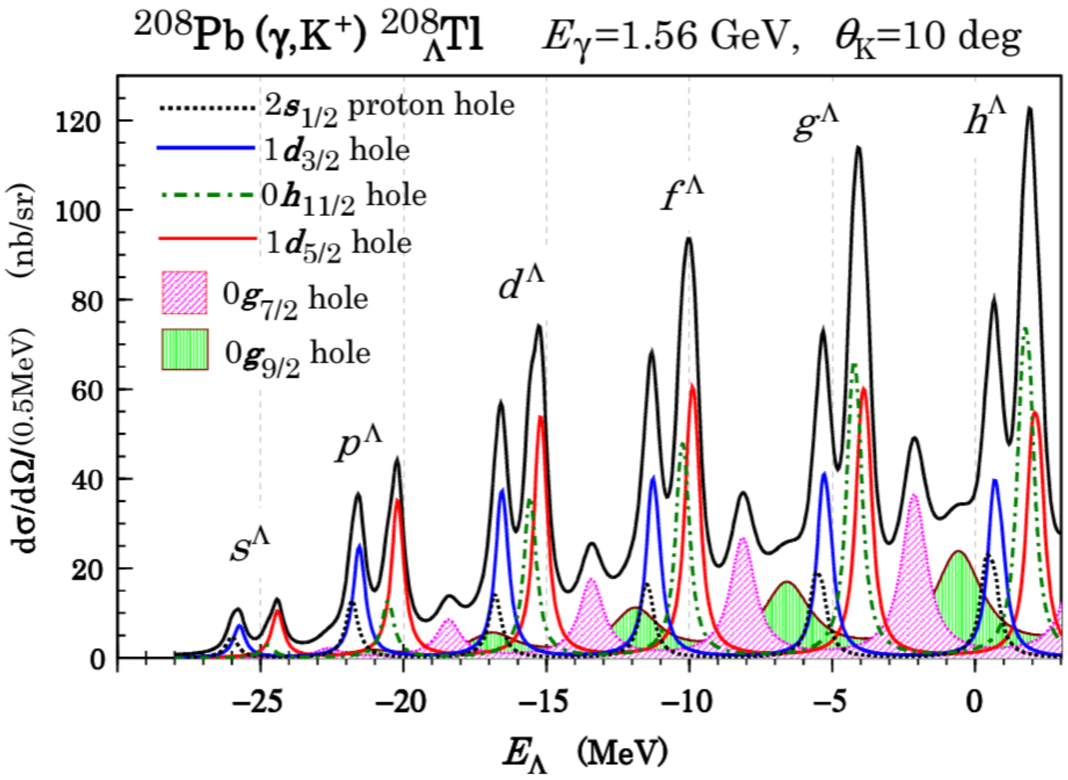


FIG. 10. Mean value of the statistical uncertainty on B_{Λ} (Fig. 9) as a function of a beam time for the $^{6}\mathrm{Li}(e, e'K^{+})^{6}_{\Lambda}\mathrm{He}$ reaction. Bands colored by blue and red correspond to standard deviations for the cases of 30- and 50-μA beam currents, respectively. Necessary beam times, which meet the goal uncertainty $|\Delta B_{\Lambda}^{\mathrm{stat.}}| = 40$ keV, are 5 and 7 days for the beam currents of 30 and 50 μA, respectively.

The same simulation was applied to the Pb target

Assumption for the simulation (^{208}Pb→$^{208}{}_{\Lambda}$Tl)



T. Motoba, JPS Conf. Proc. 17, 011003 (2017); https://doi.org/10.7566/JPSCP.17.011003

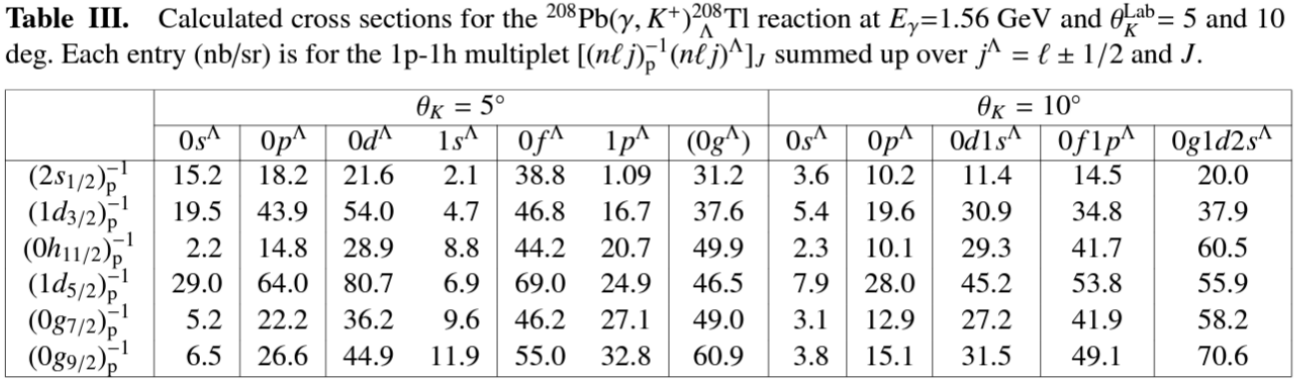
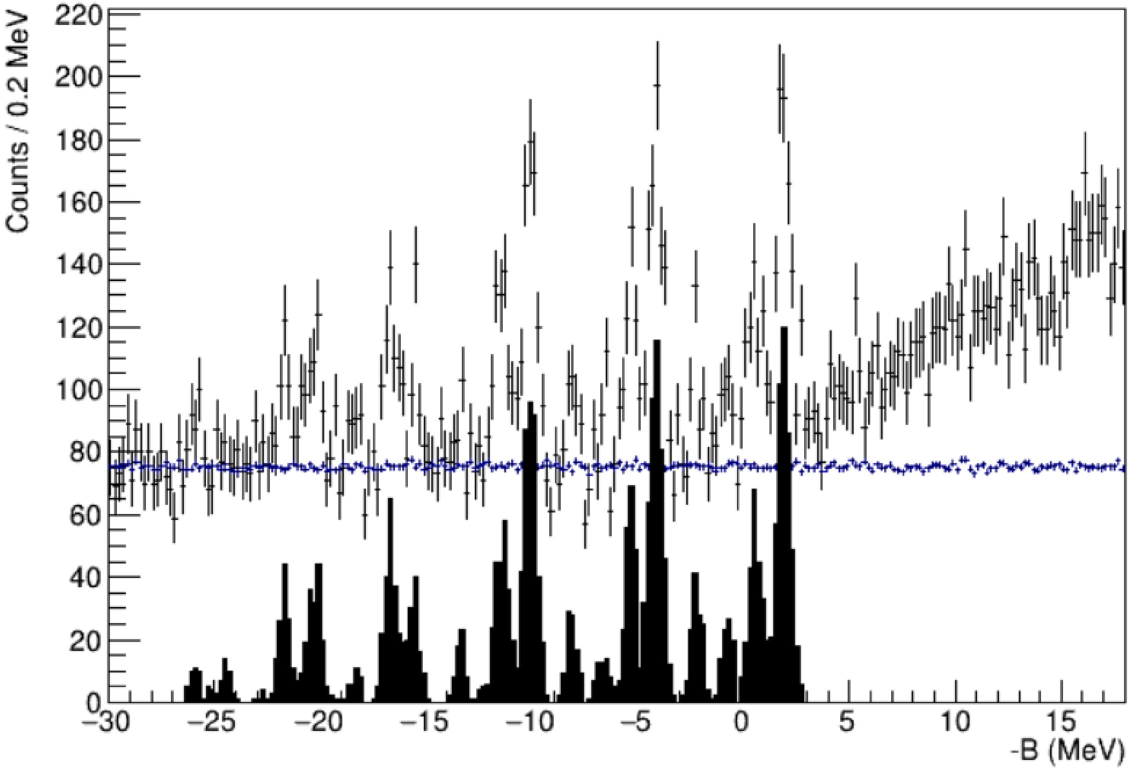


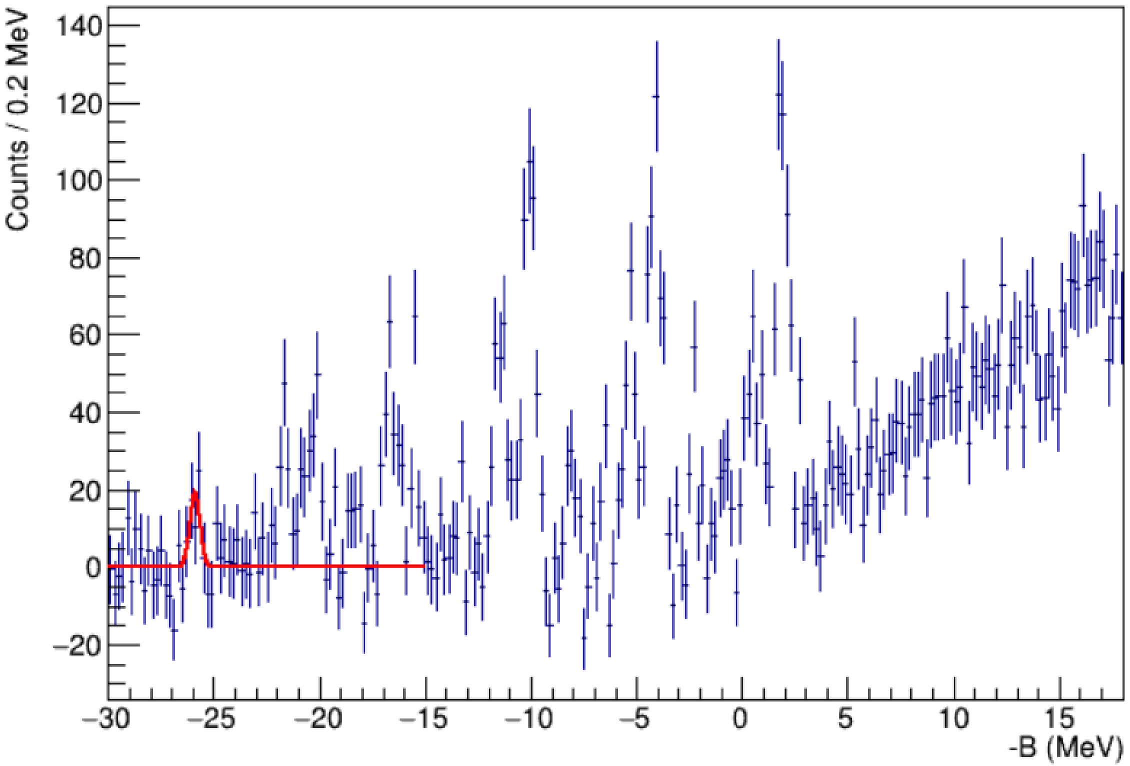
Table III. Calculated cross sections for the ^{208}Pb$(\gamma, K^+)^{208}_{\Lambda}$Tl reaction at E_γ=1.56 GeV and θ_K^{Lab}= 5 and 10 deg. Each entry (nb/sr) is for the 1p-1h multiplet $[(n\ell j)_{\mathrm{p}}^{-1}(n\ell j)^{\Lambda}]_J$ summed up over $j^\Lambda = \ell \pm 1/2$ and J.

	$\theta_K = 5°$							$\theta_K = 10°$				
	$0s^\Lambda$	$0p^\Lambda$	$0d^\Lambda$	$1s^\Lambda$	$0f^\Lambda$	$1p^\Lambda$	$(0g^\Lambda)$	$0s^\Lambda$	$0p^\Lambda$	$0d1s^\Lambda$	$0f1p^\Lambda$	$0g1d2s^\Lambda$
$(2s_{1/2})_{\mathrm{p}}^{-1}$	15.2	18.2	21.6	2.1	38.8	1.09	31.2	3.6	10.2	11.4	14.5	20.0
$(1d_{3/2})_{\mathrm{p}}^{-1}$	19.5	43.9	54.0	4.7	46.8	16.7	37.6	5.4	19.6	30.9	34.8	37.9
$(0h_{11/2})_{\mathrm{p}}^{-1}$	2.2	14.8	28.9	8.8	44.2	20.7	49.9	2.3	10.1	29.3	41.7	60.5
$(1d_{5/2})_{\mathrm{p}}^{-1}$	29.0	64.0	80.7	6.9	69.0	24.9	46.5	7.9	28.0	45.2	53.8	55.9
$(0g_{7/2})_{\mathrm{p}}^{-1}$	5.2	22.2	36.2	9.6	46.2	27.1	49.0	3.1	12.9	27.2	41.9	58.2
$(0g_{9/2})_{\mathrm{p}}^{-1}$	6.5	26.6	44.9	11.9	55.0	32.8	60.9	3.8	15.1	31.5	49.1	70.6

Sample figures (20 μA, 150 mg/cm^2, 20 days)

0.6 MeV (FWHM)

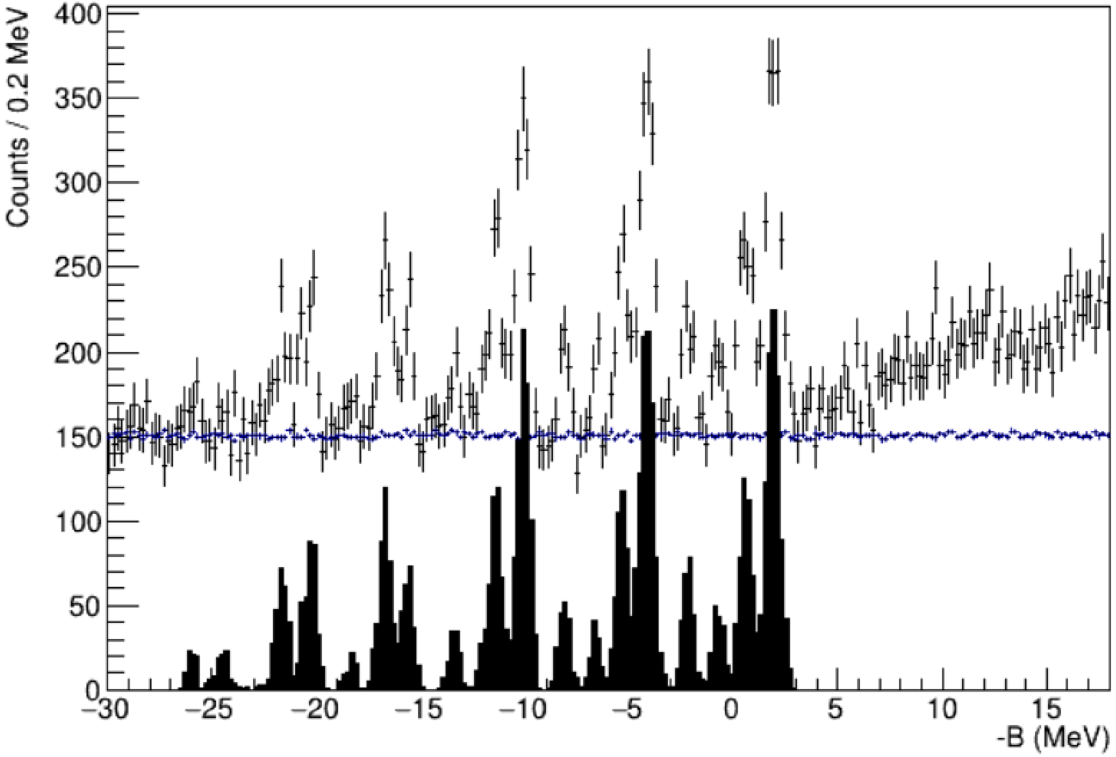


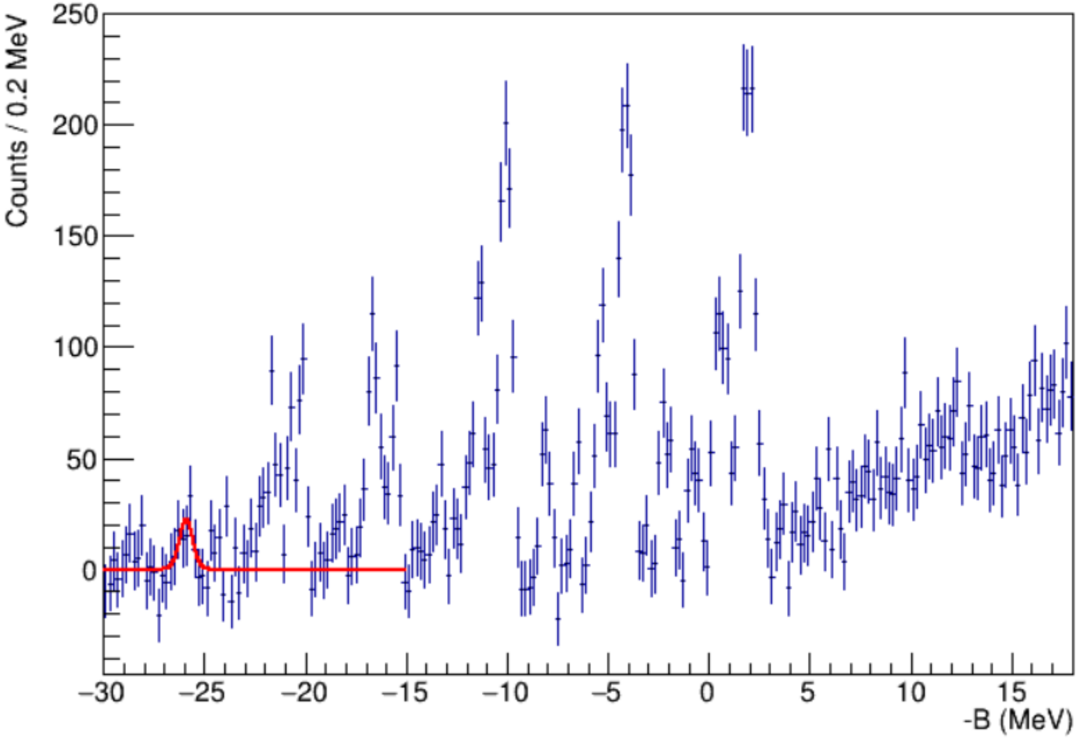


Accidental background subtraction
+ fitting

Sample figures (20 μA, 150 mg/cm^2, 40 days)

0.6 MeV (FWHM)

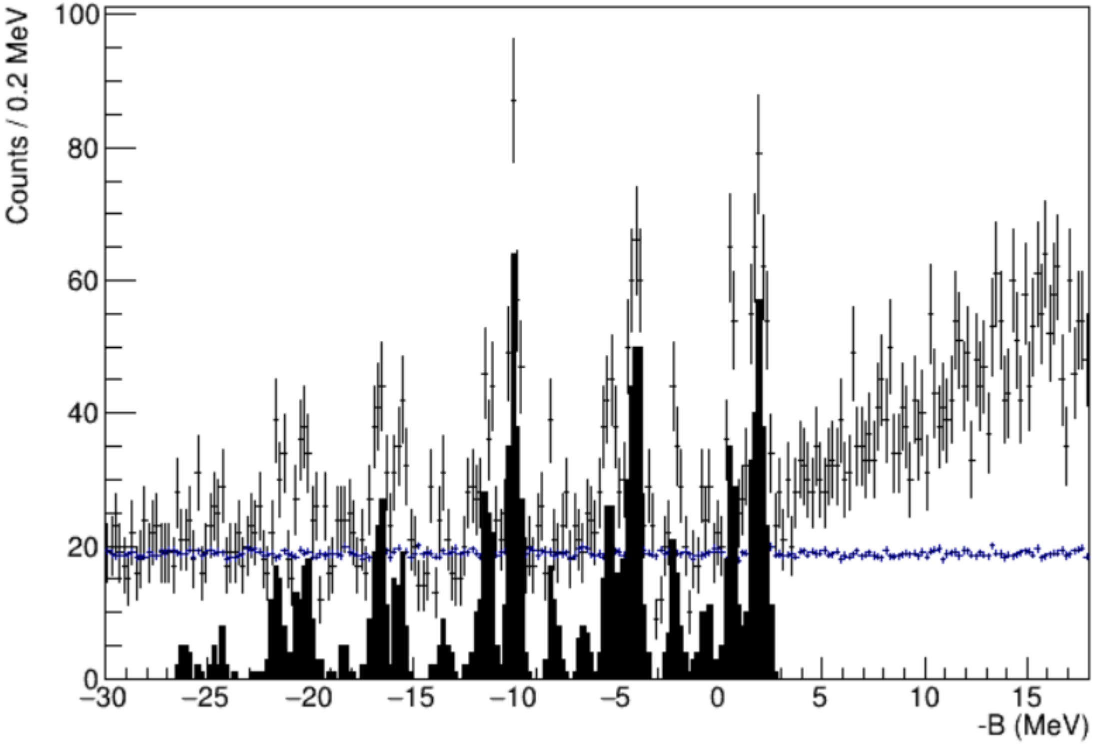


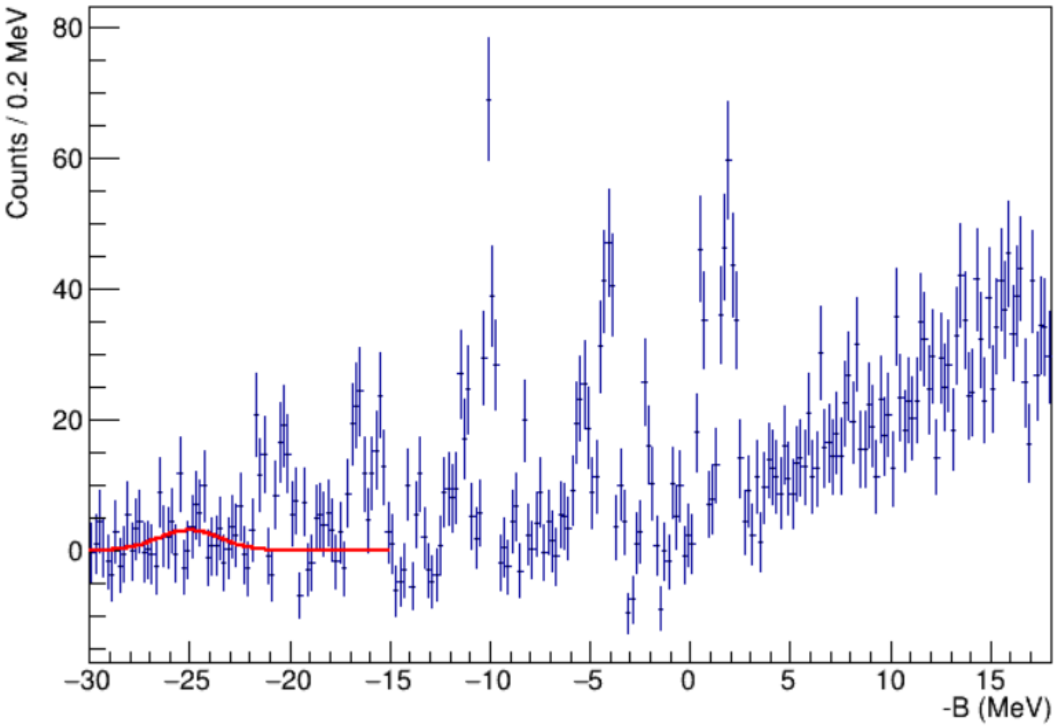


Accidental background subtraction
+ fitting

Sample figures (10 μ A, 150 mg/cm^2, 20 days)

0.6 MeV (FWHM)

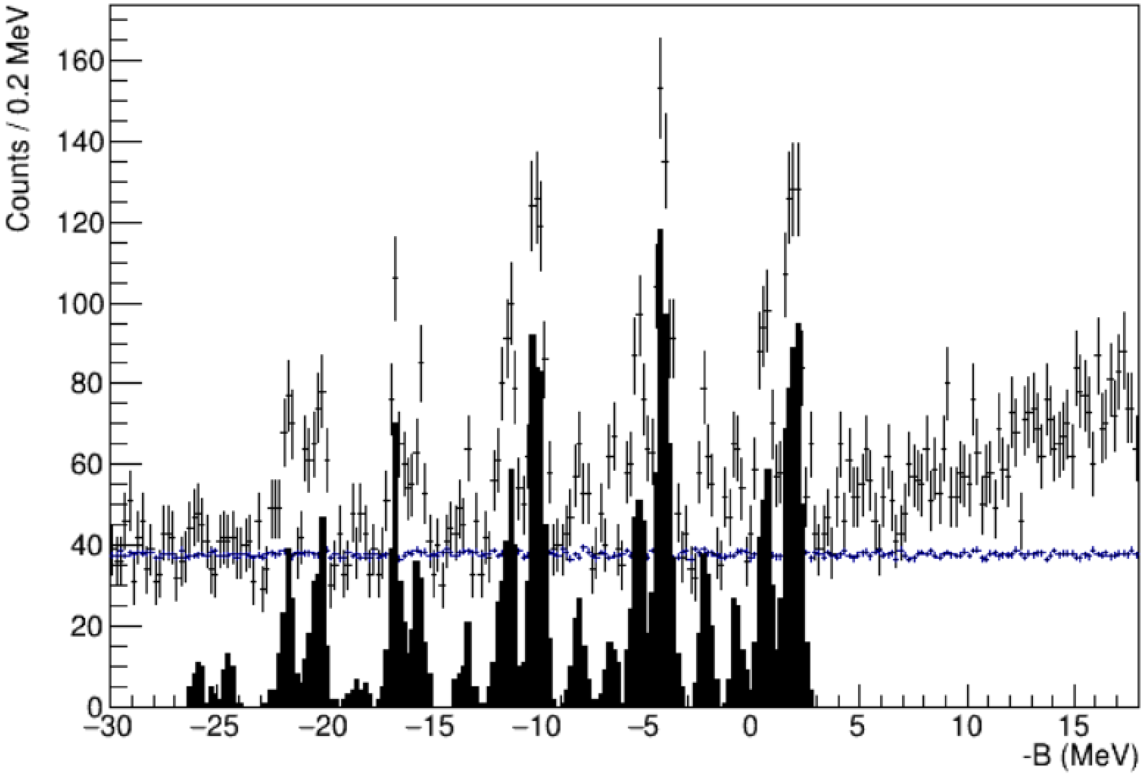


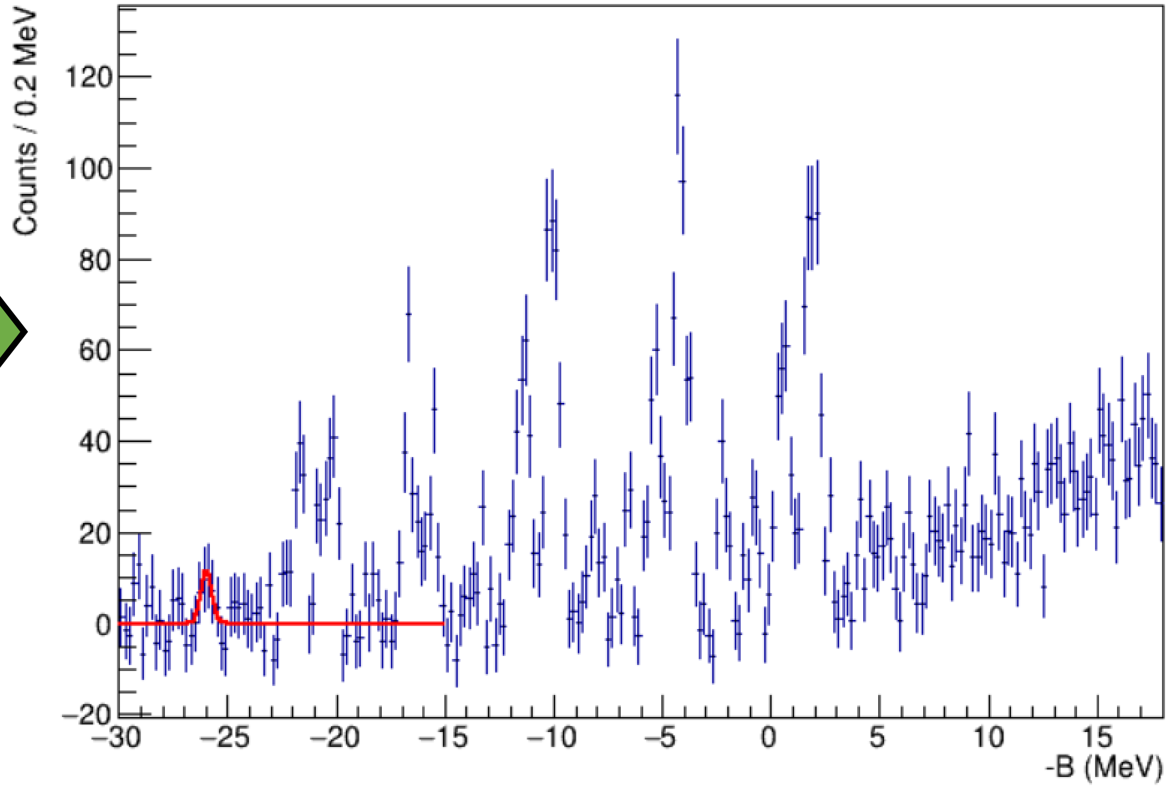


Accidental background subtraction
+ fitting

Sample figures (10 μA, 150 mg/cm^2, 40 days)

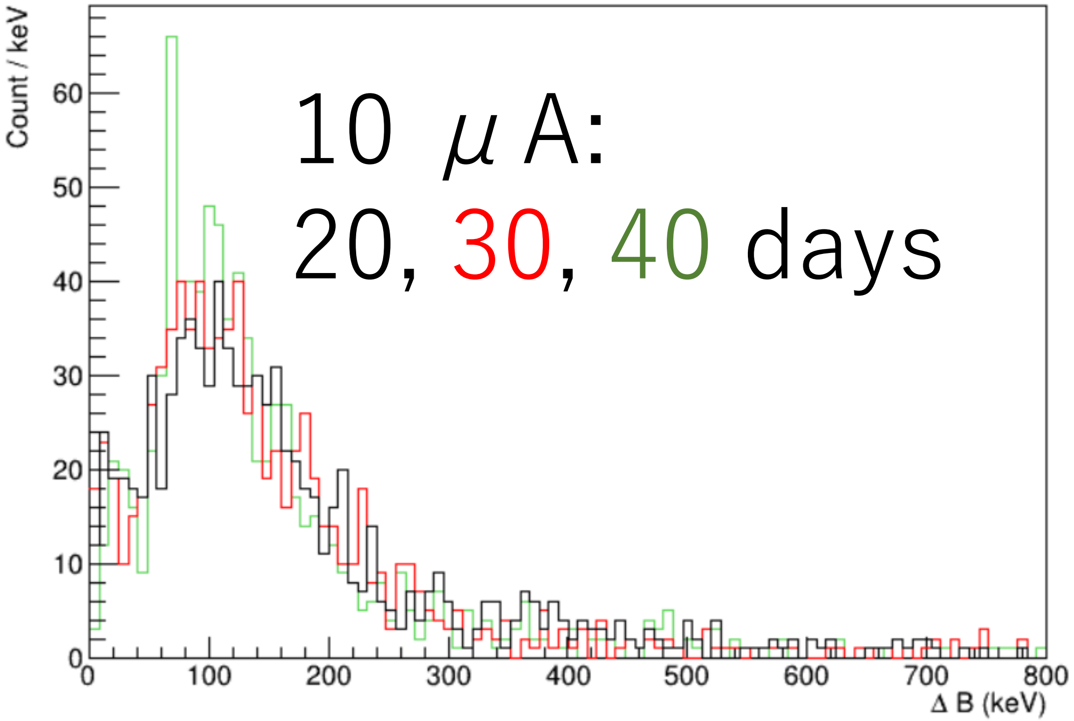
0.6 MeV (FWHM)



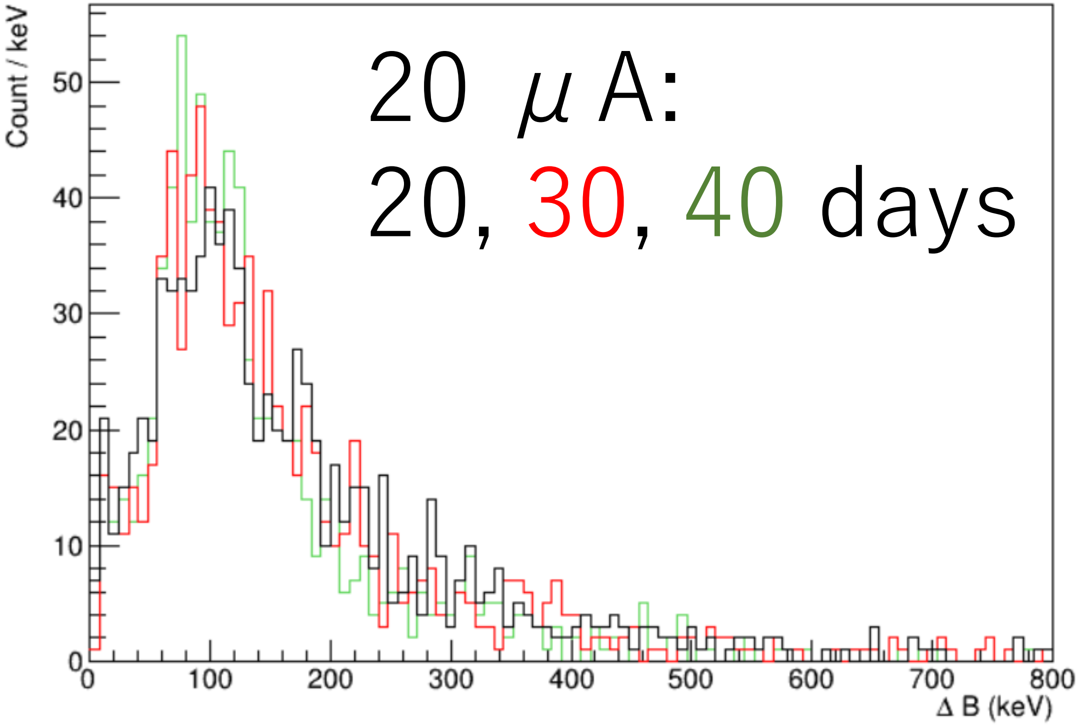


Accidental background subtraction + fitting

Statistical errors on B_Λ obtained by fittings for 1000 simulated spectra

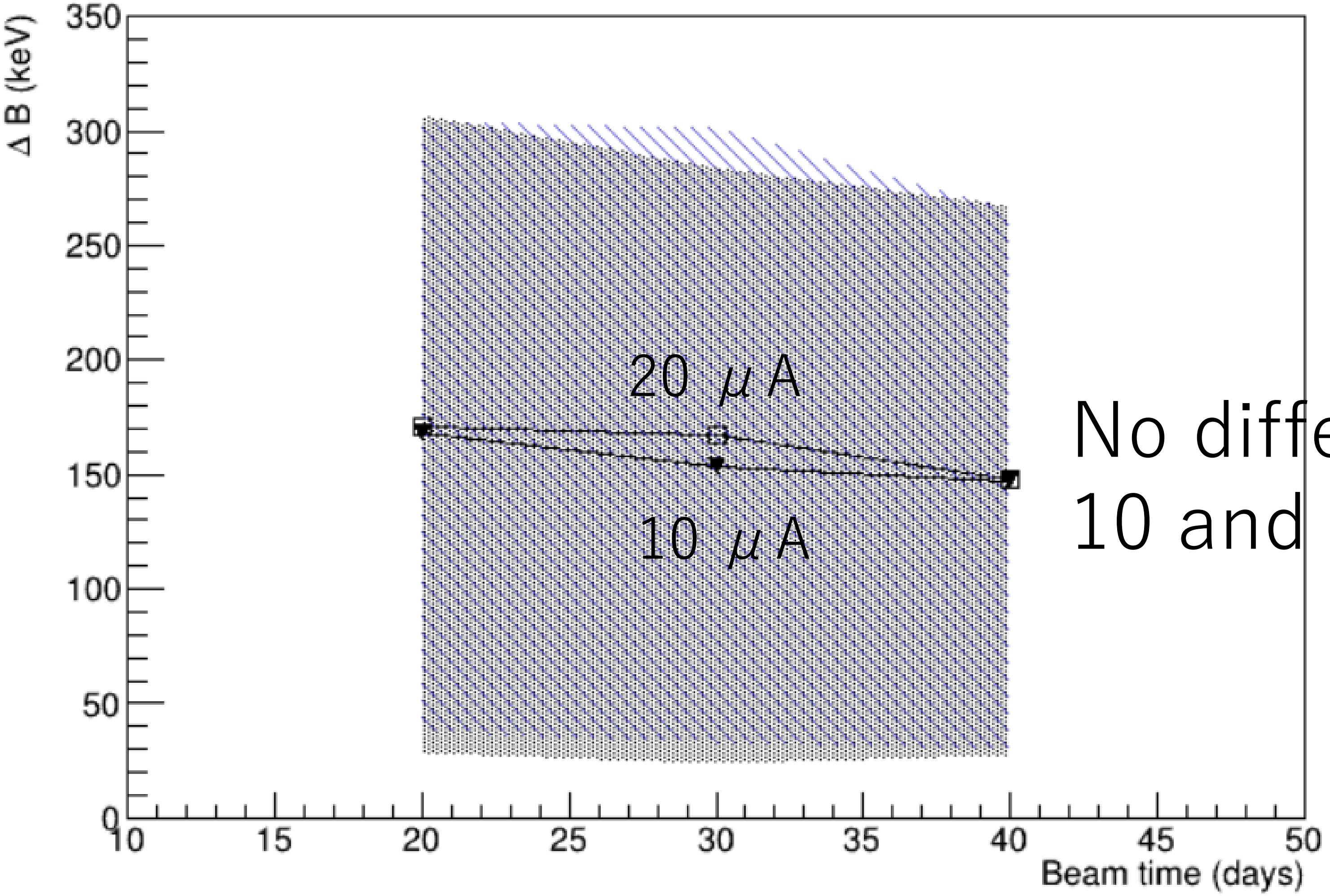


10 μA:
20, 30, 40 days



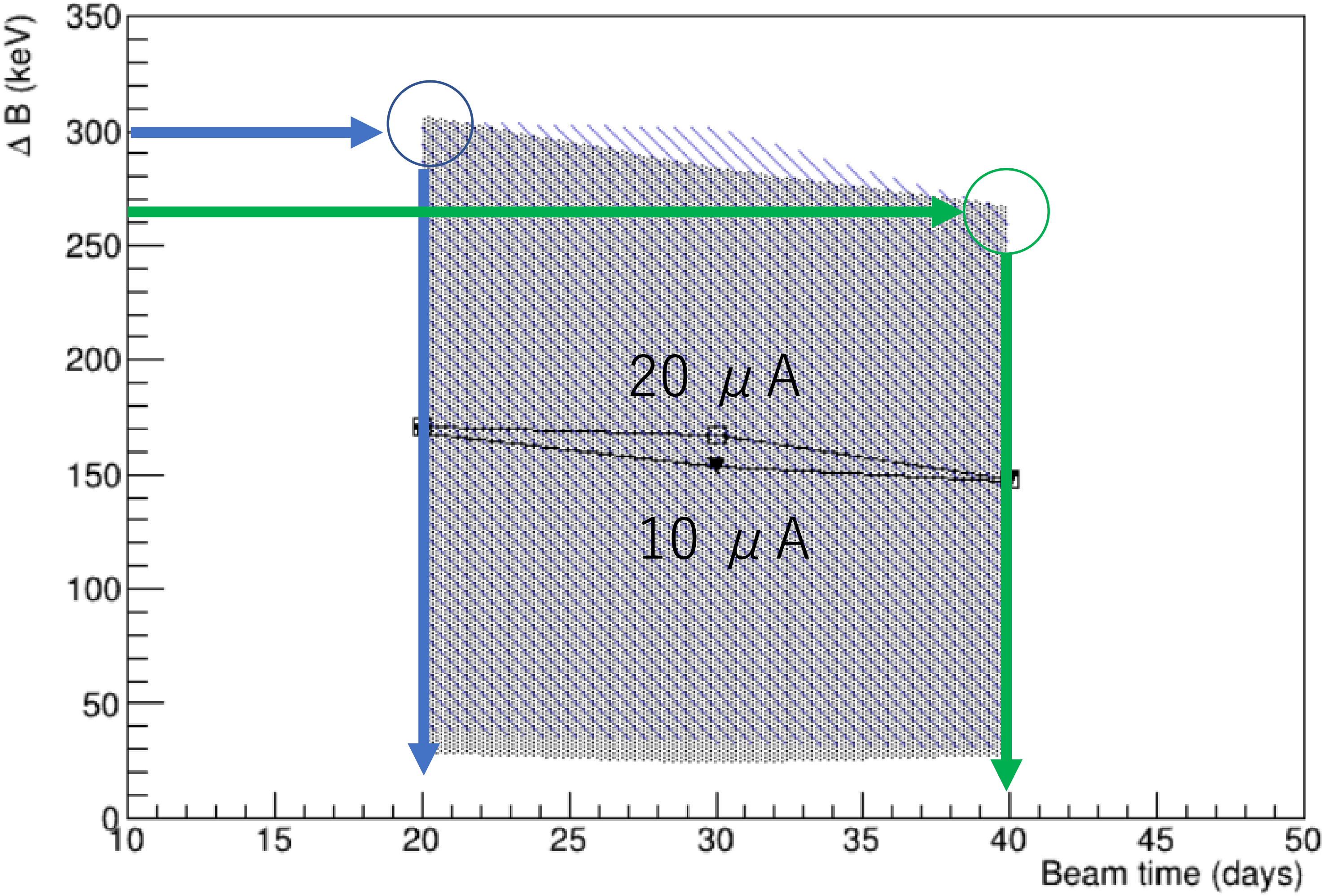
20 μA:
20, 30, 40 days

Result



No difference between
10 and 20 μA

Result



Δ B = 300 keV → 20 days

Δ B = 270 keV → 40 days

Schedule

- Jan: Consensus meeting
- April: 70% Draft
- May: Proposal submission

Backup

$^{208}\mathrm{Pb}(\gamma, K+)^{208}{}_{\Lambda}\mathrm{Tl}$

Note by T. Motoba (figures updated June 12)

The following three figures summarize the theoretical estimate of the DWIA cross sections calculated at p(γ)= 1.5 GeV/c and θ(K)=0.5 deg, in which the Saclay-Lyon A amplitudes and the nuclear HO wave functions are employed. Three cases of resolutions (FWHM=0.6, 0.8, 1.0 MeV) are assumed for PR12-18-004. JPG figures are inserted in this .ppt slides, so that one may copy them easily.

In drawing the spectra, however, the Λ single-particle energies from the Woods-Saxon potential (Millener et al., PRC38) are used instead of HO ones so as to be more realistic: E(L)=-25.99MeV(0s), -21.90(0p), -17.02(0d), -15.38(1s), -11.50(0f), -9.22(1p), -5.48(0g), -3.14(1d), -2.58(2s), +0.86(0h), +1.84(1f), +2.50(2p). These are slightly shifted to have E(L)=-26.35MeV(0s).

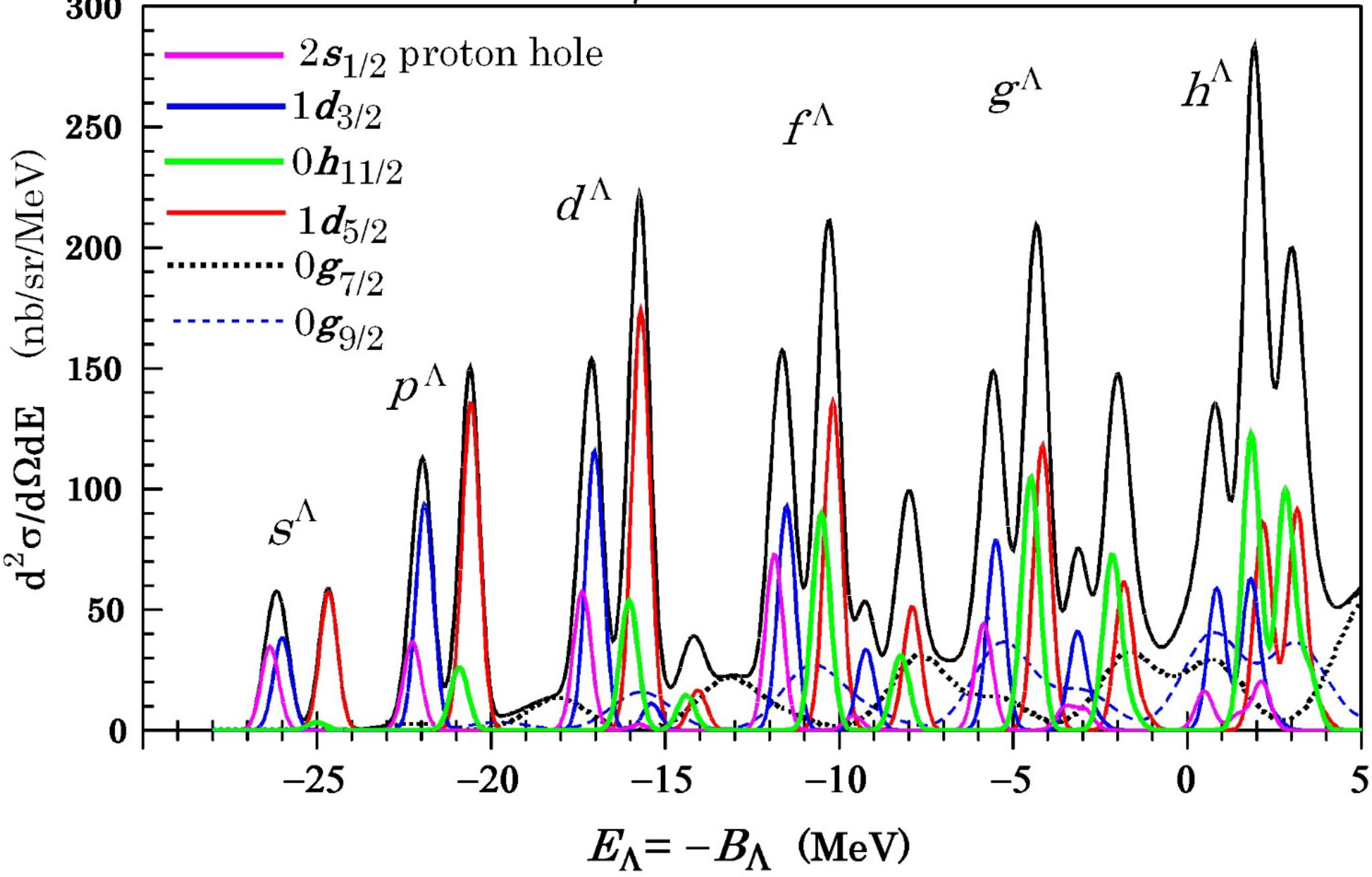
On the other hand, the proton single-hole energies are taken from the observed level energies of 207Tl: Ex=0.0 MeV (2s1/2^hole), 0.351MeV (1d3/2^), 1.348MeV (h11/2^), 1.682MeV (1d5/2^), 4.18MeV(approx. centroid of 0g7/2^), and 6.57MeV (no observed value, but centroid assumed for 0g9/2). Note that the constant spreading widths of 2 MeV are assumed to take account of the fragmented proton 0g7/2 and 0g9/2 orbits.

The cross section estimates should be further improved if we use the followings:

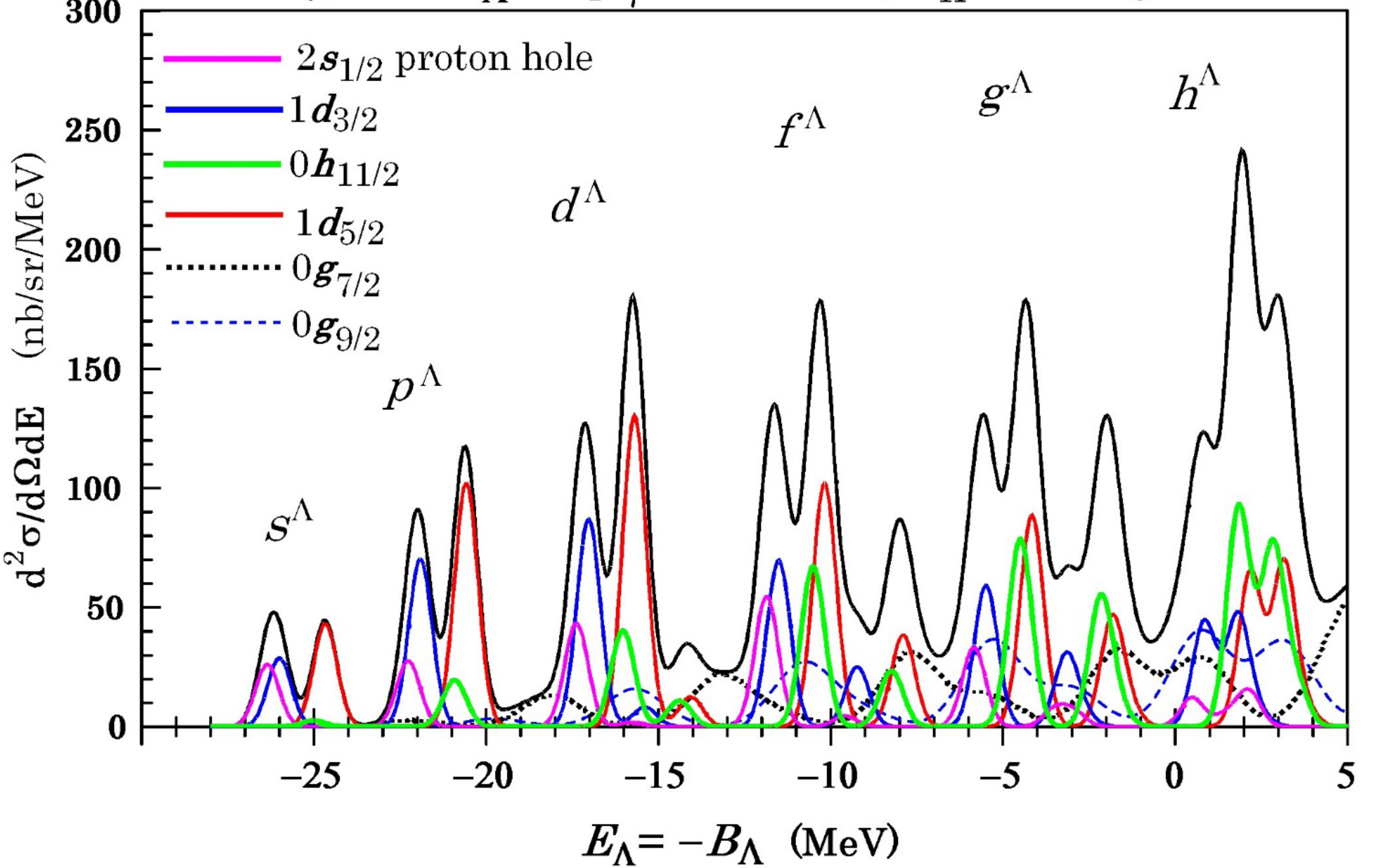
1) the Woods-Saxon wave functions for both p and Λ in X-S estimates, and

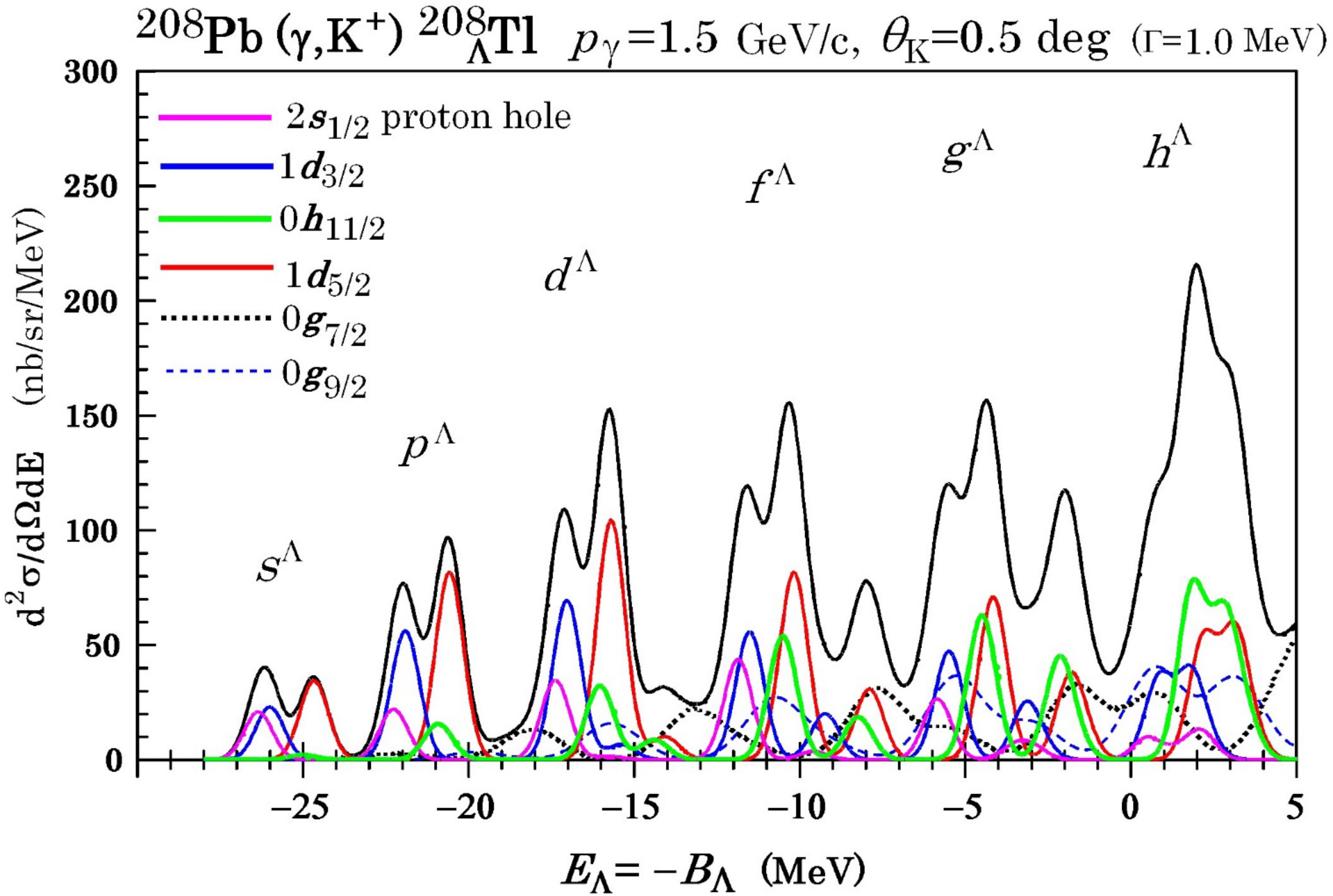
2) the better elementary amplitudes which explains forward scatterings.

$^{208}\mathbf{Pb}\,(\gamma,\mathbf{K}^{+})\,^{208}_{\Lambda}\mathbf{Tl}$ p_γ=1.5 GeV/c, θ_K=0.5 deg (Γ=0.6 MeV)



^{208}Pb (γ,K$^+$) $^{208}_{\Lambda}$Tl p_γ=1.5 GeV/c, θ_K=0.5 deg (Γ=0.8 MeV)





^{208}Pb (γ,K$^+$) $^{208}_{\Lambda}$Tl p_γ=1.5 GeV/c, θ_K=0.5 deg (Γ=1.0 MeV)
$2s_{1/2}$ proton hole
$1d_{3/2}$
$0h_{11/2}$
$1d_{5/2}$
$0g_{7/2}$
$0g_{9/2}$
s^Λ
p^Λ
d^Λ
f^Λ
g^Λ
h^Λ
$d^2\sigma/d\Omega dE$ (nb/sr/MeV)
300
250
200
150
100
50
0
−25
−20
−15
−10
−5
0
5
$E_\Lambda = -B_\Lambda$ (MeV)

Table 2: **DWIA Cross Sections (nb/sr) for ^{208}Pb$(\gamma, K^+)^{208}_{\Lambda}$Tl at p_γ =1.5GeV/c and θ_K=0.5 deg.**

	s^Λ	p^Λ	d^Λ		f^Λ	
Core state $(E_x) \times (nlj)^\Lambda$	$0s^\Lambda_{1/2}$	$0p^\Lambda_{3/2}$+$0p^\Lambda_{1/2}$	$0d^\Lambda_{5/2}$+$0d^\Lambda_{3/2}$	$1s^\Lambda_{1/2}$	$0f^\Lambda_{7/2}$+$0f^\Lambda_{5/2}$	$1p^\Lambda_{3/2}$+$1p^\Lambda_{1/2}$
$1/2^+(E_x$=0.0): $\pi(2s^{-1}_{1/2})$	22.2	15.6+ 7.8	22.1+14.8	1.6	26.6+20.0	2.6+1.3
$3/2^+$(0.351): $\pi(1d^{-1}_{3/2})$	24.4	46.4+13.4	52.4+21.6	7.1	41.0+18.4	15.8+5.6
Left peak $d\sigma/d\Omega$	46.6	83.2	110.9	9.7	106.0	25.3
$(E_\Lambda = -B_\Lambda$ in MeV)	(−26.16)	(−21.97)	(−17.11)		(−11.64)	
$11/2^-$(1.348): $\pi(0h^{-1}_{11/2})$	2.1	10.6+6.1	18.7+15.6	9.3	29.9+27.4	12.8+7.0
$5/2^+$(1.682): $\pi(1d^{-1}_{5/2})$	36.7	51.7+35.2	58.1+52.4	10.6	42.9+44.0	20.3+12.4
Right peak $d\sigma/d\Omega$	39.8	103.5	144.8	19.9	149.3	52.5
$(E_\Lambda = -B_\Lambda$ in MeV)	(−24.70)	(−20.60)	(−15.74)		(−10.32)	(−7.96)

Table 2 corresponds to set $E_{gs}(^{208}_{\Lambda}\text{Tl}) = -26.35$ MeV (Exp). Figure shows a series of doublet peaks indicated respectively by s^Λ, p^Λ, d^Λ, f^Λ, etc. As known from the energy differences between low-lying energy levels of ^{207}Tl, the proton-hole states are classified into two nearly degenerate groups in view of the 'critical' value $\Delta E_x \simeq 0.35$ MeV. The left member of each doublet is attributed to the structure [core$(1/2^+, 3/2^+) \times (nlj)^\Lambda$], while the right member to [core$(11/2^-, 5/2^+) \times (nlj)^\Lambda$]. In the present calculation the elementary amplitude from the Saclay-Lyon model A is employed, but it should be noted that SLA leads to considerable overestimate at very forward angle $\theta_K^{\text{Lab}} \lesssim 5$ deg when compared with other theoretical models and/or experimental behaviors ($p_\gamma \simeq 1.3$ GeV/c). One may refer to JPS Conf. Proc. 17, 011003 (2017) to see how the theoretical cross sections change depending on p_γ and θ_K.