Target window

- Berylium or Mylar ? -

- We are planing to use a Berylium foil as the target cell window at J-PARC E15/E17 since 75μm-thick mylar used in E549/E570 is insufficient for ~1 atm condition (NOT decompressed condition) of the ^{3}He target cell.

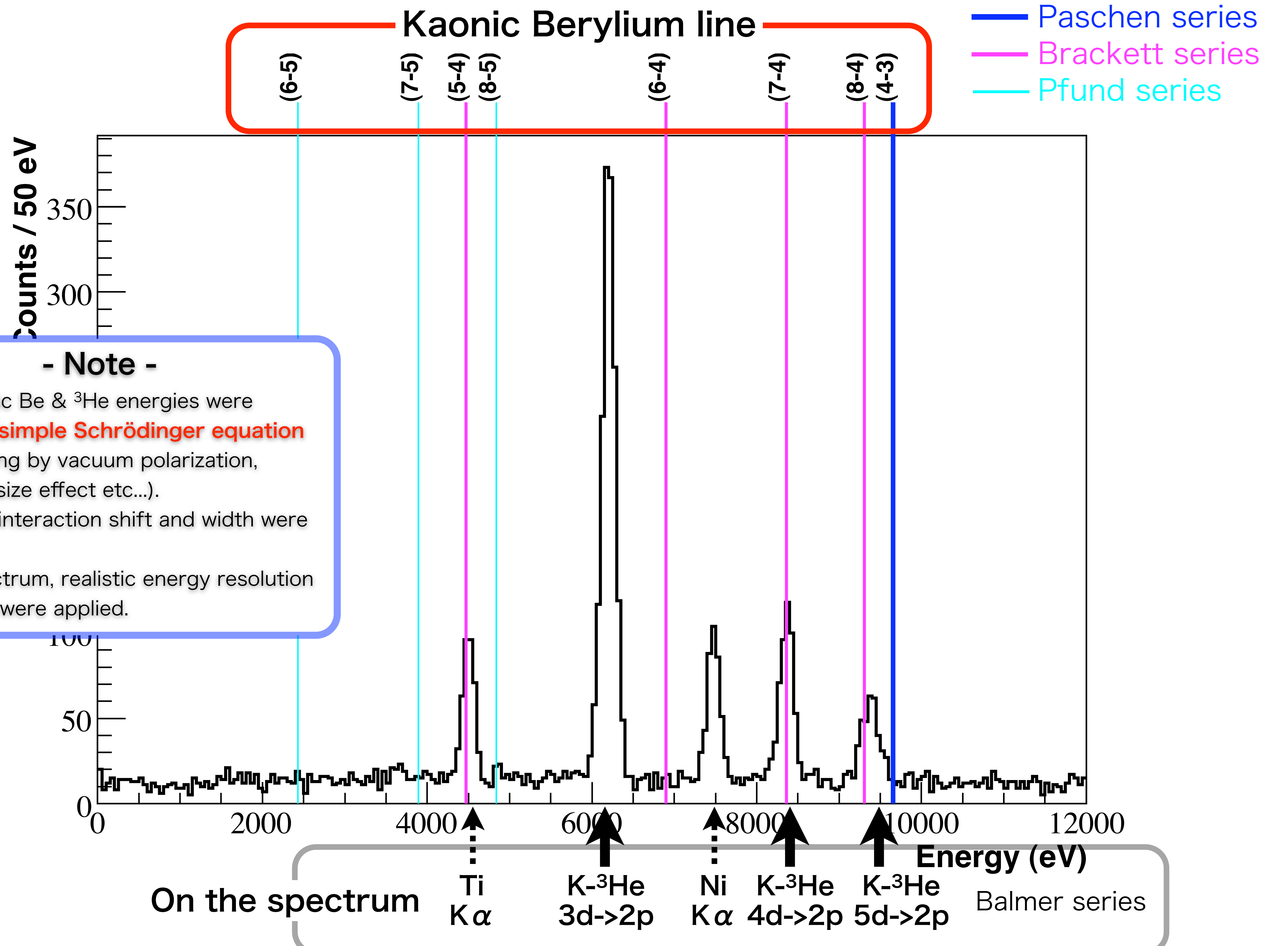
	Target	Pressure	Cell window	X-ray transmission (@ 6.4 keV)
E549 / E570	Superfluid ^{4}He	decompression (10^{-2}~10^{-1} atm)	Mylar 75μm	87%
E15 / E17	^{3}He	~ 1 atm	Berylium 300μm	89%

- Tomo has pointed out that the energies of **kaonic berylium Paschen & Brackett series x-rays** are close to that of kaonic helium3 x-ray.

- If we would like to avoid the K-Be x-ray contamination, we might select thicker mylar window (300μm or more?) at the expense of x-ray transmission (58% for Mylar 300μm).

Oct 1, 2007 S.Okada **revised!**

Kaonic Helium-3 spectrum



- Note -

- These kaonic Be & ³He energies were calculated by **simple Schrödinger equation** (NOT correcting by vacuum polarization, nuclear finite size effect etc...).
- The strong interaction shift and width were set to be 0.
- On the spectrum, realistic energy resolution and statistics were applied.

K-^{9}Be

Series	Transition	Energy
Balmer series	Energy Level (3-2)	27587.23 [eV]
	Energy Level (4-2)	37242.77 [eV]
	Energy Level (5-2)	41711.90 [eV]
	Energy Level (6-2)	44139.57 [eV]
	Energy Level (7-2)	45603.39 [eV]
	Energy Level (8-2)	46553.46 [eV]
Paschen series	Energy Level (4-3)	9655.53 [eV]
	Energy Level (5-3)	14124.66 [eV]
	Energy Level (6-3)	16552.34 [eV]
	Energy Level (7-3)	18016.15 [eV]
	Energy Level (8-3)	18966.22 [eV]
Brackett series	Energy Level (5-4)	4469.13 [eV]
	Energy Level (6-4)	6896.81 [eV]
	Energy Level (7-4)	8360.62 [eV]
	Energy Level (8-4)	9310.69 [eV]
Pfund series	Energy Level (6-5)	2427.68 [eV]
	Energy Level (7-5)	3891.49 [eV]
	Energy Level (8-5)	4841.56 [eV]

← K-^{3}He 5d->2p (Energy Level (4-3))

← Ti Ka1 (Energy Level (5-4)) ?

← K-^{3}He 3d->2p ~ 6.2 keV (Energy Level (6-4))

Filter transmission

		Transmission [%]
E570	Mylar 75μm	87
E17	Beryllium 300μm	89
	e.g. Mylar 300μm or more? (E570: 75μm x 4)	58 or more?

down by 65%

No contamination of K-Be 4f->3d peak

This thickness might be still insufficient for E15/E17 target cell operation condition.

cf. Berylium 200μm : 93%

Backup slides

X-ray energies & yields

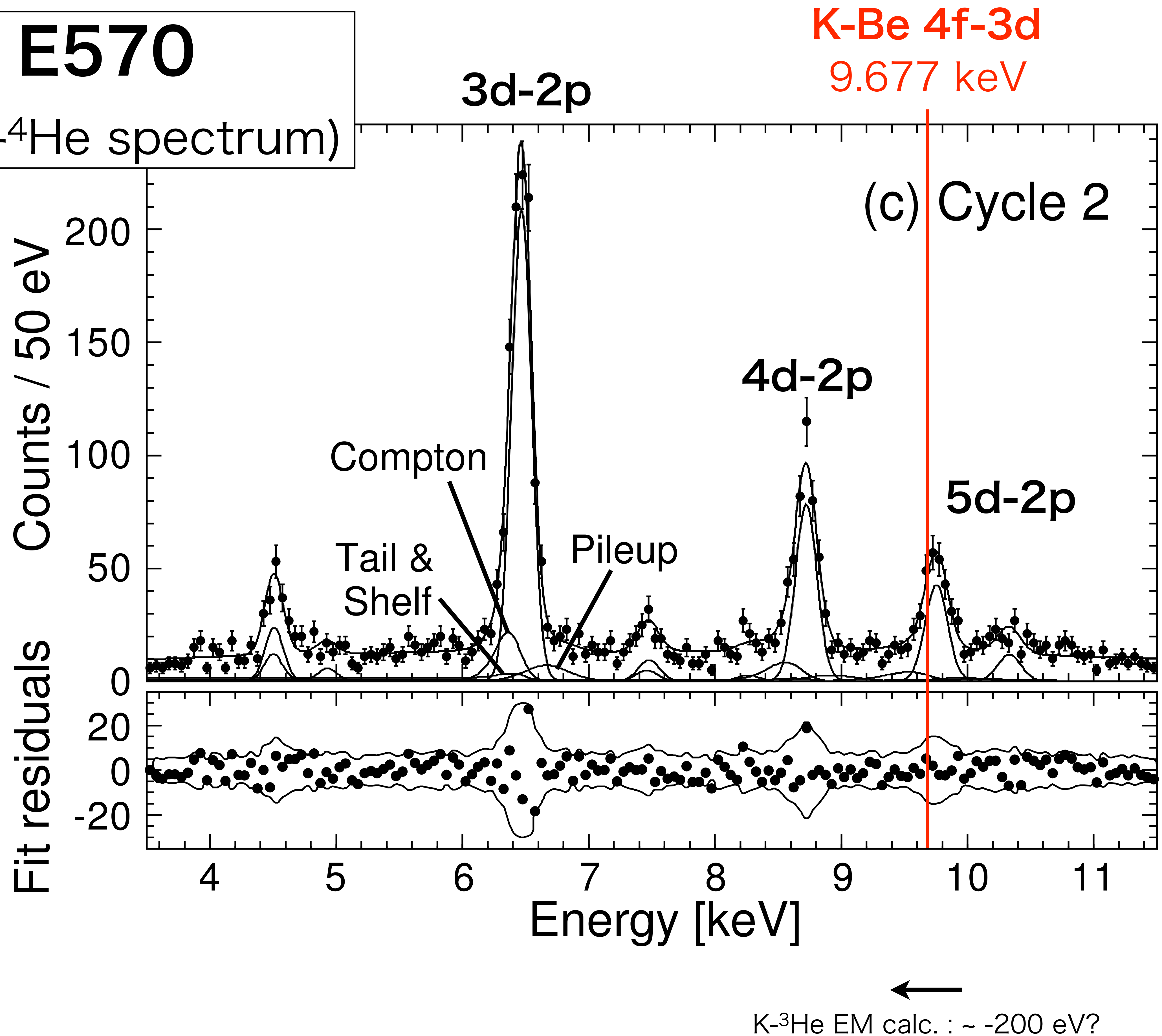
	Energy [eV]				Intensity per stopped K-
	EM value		Measured value		
K-Be 3d->2p	27709	[1]	27632(18)	[3]	??
K-Be 4f->3d	9677	**[1]**	**-**		**??**
K-^{4}He 5d->2p	9767	**[2]**	**9719**	**[4]**	**1.6 ± 0.8 % [4]**

Difference is only 90 eV.

[1] J.P. Santos et al., Phys. Rev. A 71 (2005) 032501
[2] T. Koike, Private communication
[3] C.J. Batty et al., Nucl. Phys. A 282 (1977) 487-492
[4] S. Baird et al., Nucl. Phys. A 392 (1983) 297-310

E570

(on K-^{4}He spectrum)



Ratio of volume

Target cell size : Φ6.8 x 10 cm

Berylium thickness : 300μm

$$\frac{\text{Berylium window volume}}{\text{Target cell volume}} = \frac{6.4\ \text{cm}^3}{363.2\ \text{cm}^3} \sim 2\ \%$$

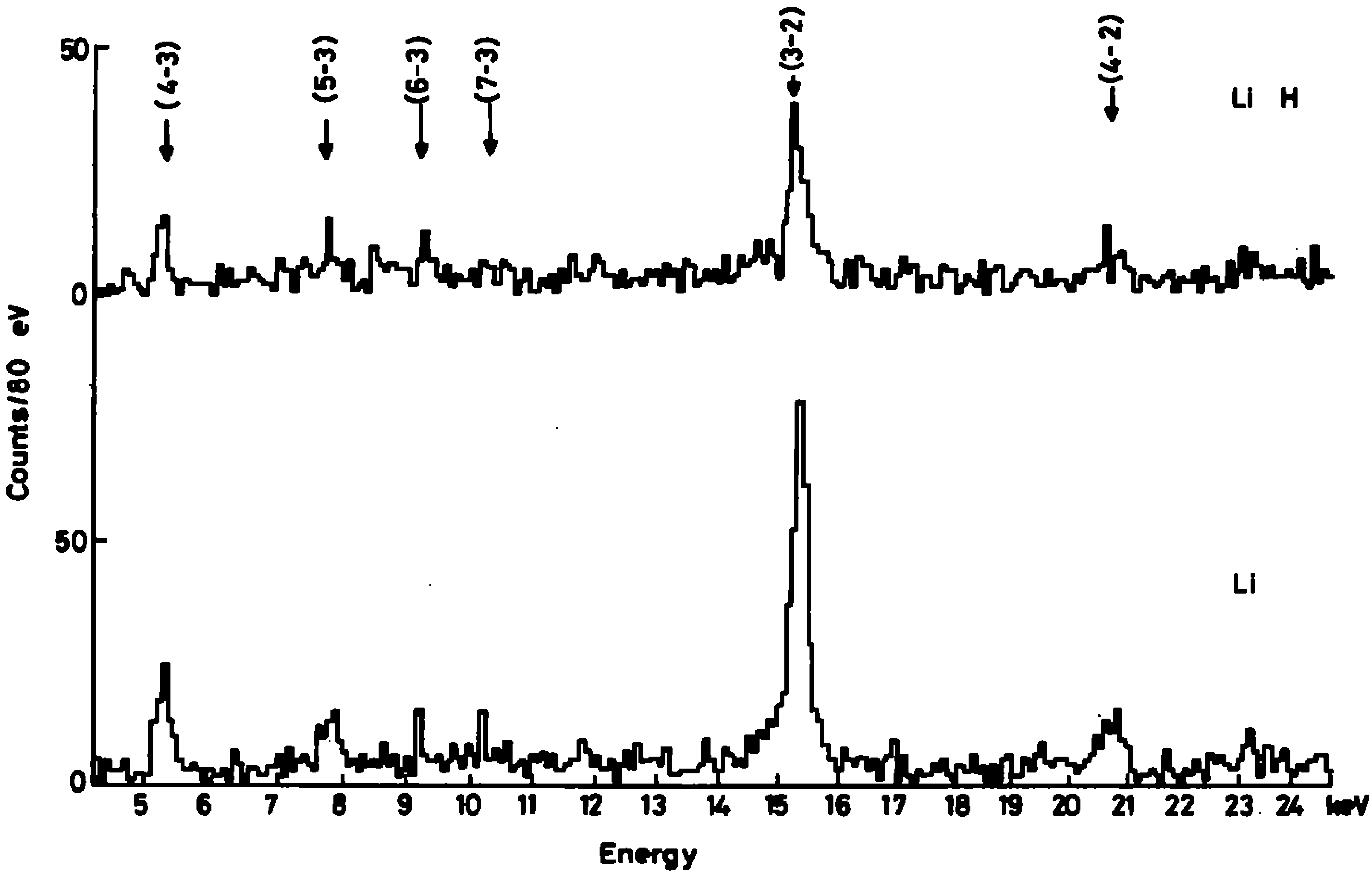


Fig. 1. Measured spectra obtained with Li (metal) and LiH target. The Li spectra was obtained with 2.7×10^7 kaons stopping in the target whilst for LiH the number of stopping kaons was 1.9×10^7.

◆ Calculated x-ray yields for ^{12}C-Ξ^- atom

$n_i \rightarrow n_f$	V_0=16 MeV	V_0=24 MeV
($\Delta n = 1$)		
3 → 2	1.6 %	1.0 %
4 → 3	34.2 %	33.9 %
5 → 4	28.8 %	Same as 16 MeV case
6 → 5	21.4 %	
7 → 6	12.5 %	
8 → 7	5.7 %	
($\Delta n = 2$)		
4 → 2	0.2 %	0.1 %
5 → 3	5.8 %	Same as 16 MeV case
6 → 4	7.2 %	
7 → 5	6.1 %	
8 → 6	3.5 %	

Koike-san's slide (for JPS)

Berylium for X-ray window

(株) Pascal

▪ X線窓用ベリリウムのグレード別不純物分析値 ▪

	IF-I	PF-60	PS-200
Be	99.8%	99.0%	98.0%
BeO	300ppm	8,000ppm	20,000ppm
Fe	300ppm	700ppm	1,800ppm
Al	100ppm	500ppm	1,600ppm
Mg	60ppm	500ppm	1,800ppm
Sf	100ppm	400ppm	800ppm
C	300ppm	700ppm	1,500ppm
Cr	25ppm	100ppm	+
Co	5ppm	10ppm	+
Cu	50ppm	100ppm	+
Pb	5ppm	20ppm	+
Mn	30ppm	120ppm	+
Mo	10ppm	20ppm	+
Ni	200ppm	200ppm	+
Ca	200ppm	100ppm	+
Zn	100ppm max		+
Ag	5ppm	10ppm	+
Ti	10ppm		+
B		3ppm	+
Cb		2ppm	+
Li		3ppm	+
U	＜ 2ppm	25/140ppm	-
Th	＜ 3ppm	＜ 2ppm	-

Fe : 0.07 %

▪ ベリウムのグレード別X線透過率 ▪

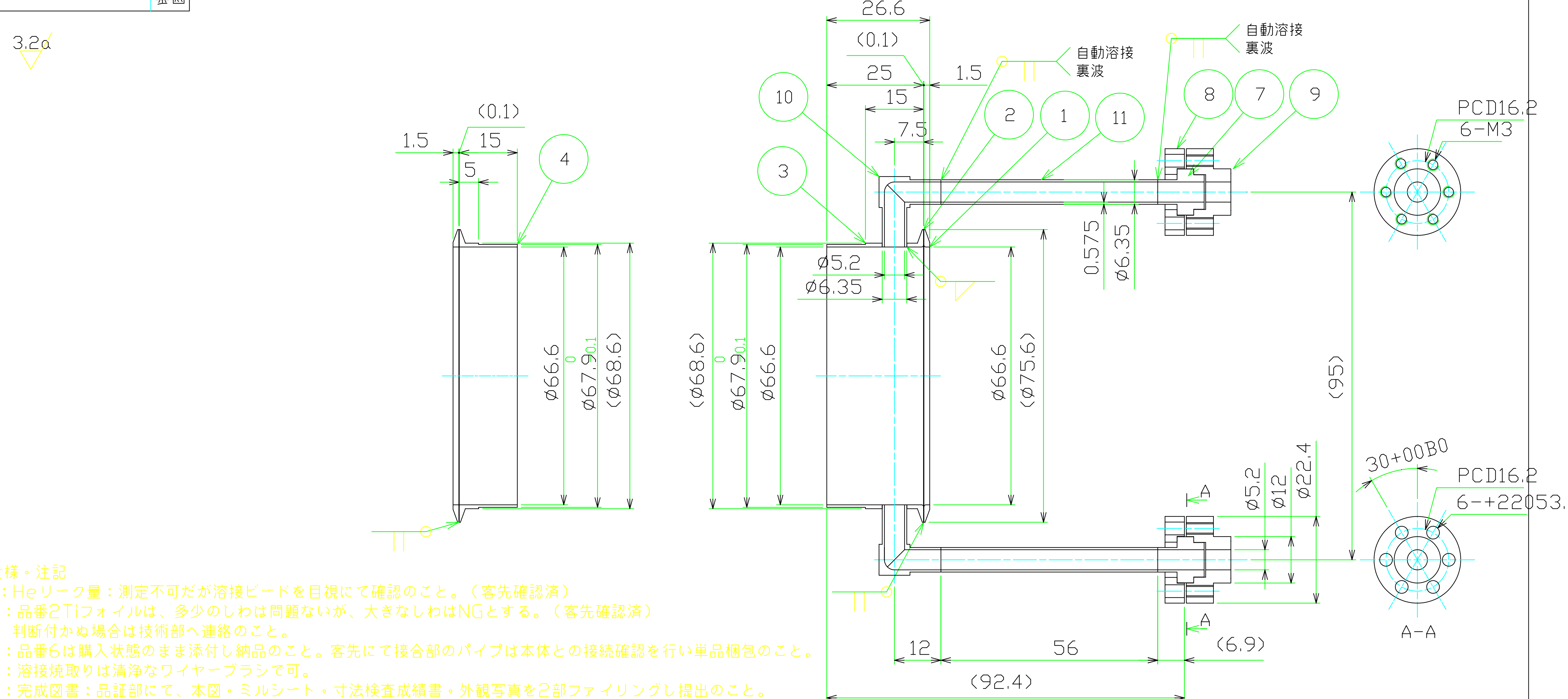
(ターゲット: CuKα エネルキーレベル: 8.041KeV 波長:1.5418Å)

Thickness [mm]	THICKNESS (In inches)	ASSAY 99.8% IF-I FOIL	99.0% PF-60 FOIL	98.0% PS-200E SHEET	98.5% S-200F BLOCK	99.0% S-65B. BLOCK	99.0% AA1100 (AL)
	0.001	0.988	0.982	-	-	-	.702
	0.002	0.977	0.965	-	-	-	.493
	0.003	0.965	0.947	-	-	-	.346
	0.004	0.954	0.930	-	-	-	.243
	0.005	0.943	0.914	-	-	-	.170
	0.006	0.932	0.897	0.852	-	-	.120
	0.007	0.921	0.881	0.829	-	-	.084
0.2032	0.008	0.910	0.886	0.807	-	-	.059
0.2540	0.010	0.899	0.835	0.765	0.849	0.872	.029
0.3048	0.012	0.868	0.805	0.725	0.822	0.849	-
	0.015	0.838	0.763	0.670	0.782	0.814	-
	0.020	0.790	0.697	0.586	0.721	0.761	-
	0.040	0.642	0.486	0.343	0.520	0.579	-
	0.050	0.556	-	-	0.441	0.505	-
	0.060	0.494	-	-	0.375	0.404	-

cf.) Be(1.848 g/cm^3) thickness=0.3 mm :

--> 0.70 @ 8.041keV(CuK$_\alpha$)

異図



仕様・注記

1：Heリーク量：測定不可だが溶接ビードを目視にて確認のこと。（客先確認済）

2：品番2Tiフォイルは、多少のしわは問題ないが、大きなしわはNGとする。（客先確認済）
判断付かぬ場合は技術部へ連絡のこと。

3：品番6は購入状態のまま添付し納品のこと。客先にて接合部のパイプは本体との接続確認を行い単品梱包のこと。

4：溶接焼取りは清浄なワイヤーブラシで可。

5：完成図書：品証部にて、本図・ミルシート・寸法検査成績書・外観写真を2部ファイリングし提出のこと。

6：Ti材料は、JIS1種または神戸規格KS40S・KS40を使用すること。

品番	品名	材質	個数	備考
11	パイプ	Ti1種	2	図番：VF4124-11
10	エルボ	Ti1種	2	図番：VF4124-10
9	フランジ2	SUS304	2	図番：VF4124-09
8	フランジ1	SUS304	2	図番：VF4124-08
7	パイプ金具	Ti1種	2	図番：VF4124-07
6	パイプ材料	Ti1種	1	型番：TI453385 ｴﾗｺ
5	欠番		0	
4	Ti金具3	Ti1種	1	図番：VF4124-04
3	Ti金具2	Ti1種	1	図番：VF4124-03
2	Tiフォイル	Ti1種	2	図番：VF4124-02
1	Ti金具1	Ti1種	2	図番：VF4124-01

改訂	年月日	記事	担当	承認
△				
△				
△				

客先名		名称	
客先図		図番	
承認		尺度	西暦 年 月 日
審査			
設計			MPC 株式会社ミラプロ

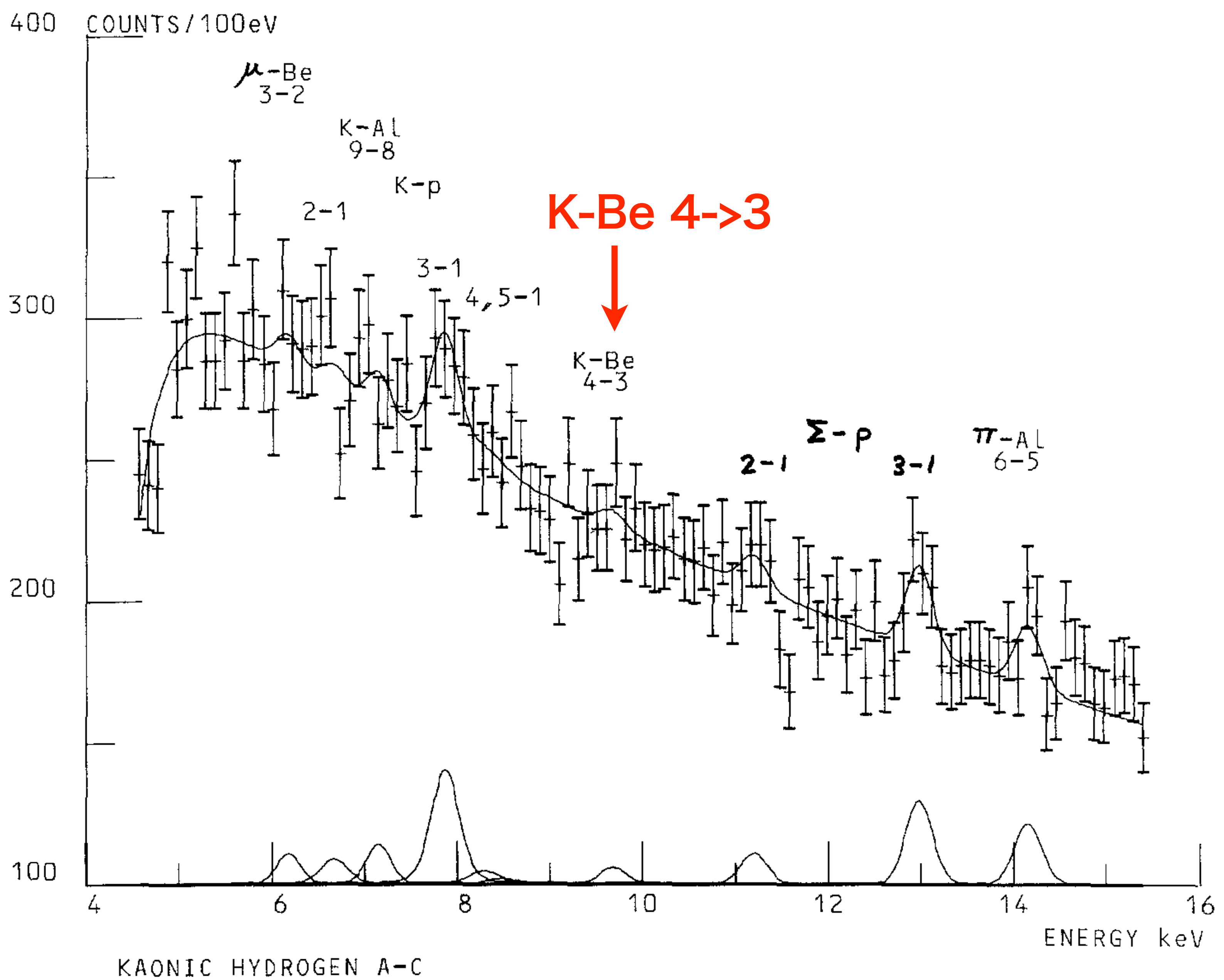


Fig. 3. X-ray spectrum obtained from data set A–C for energies less than 20 keV.

P.M. Bird et al., Nucl. Phys. A 404 (1983) 482-494

Ratio of volume

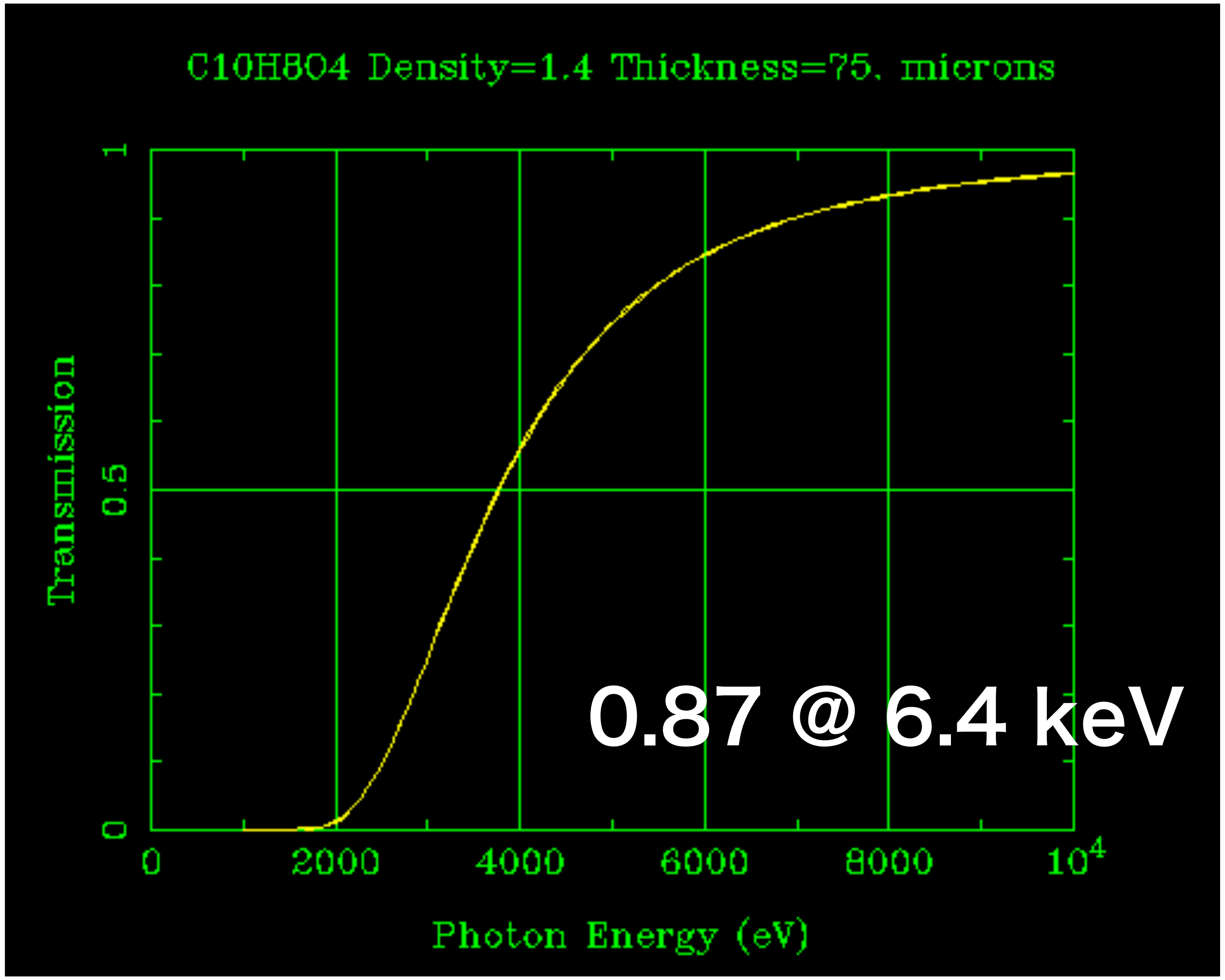
old one

Target cell size : Φ6.4 x 15 cm

Berylium thickness : 300μm

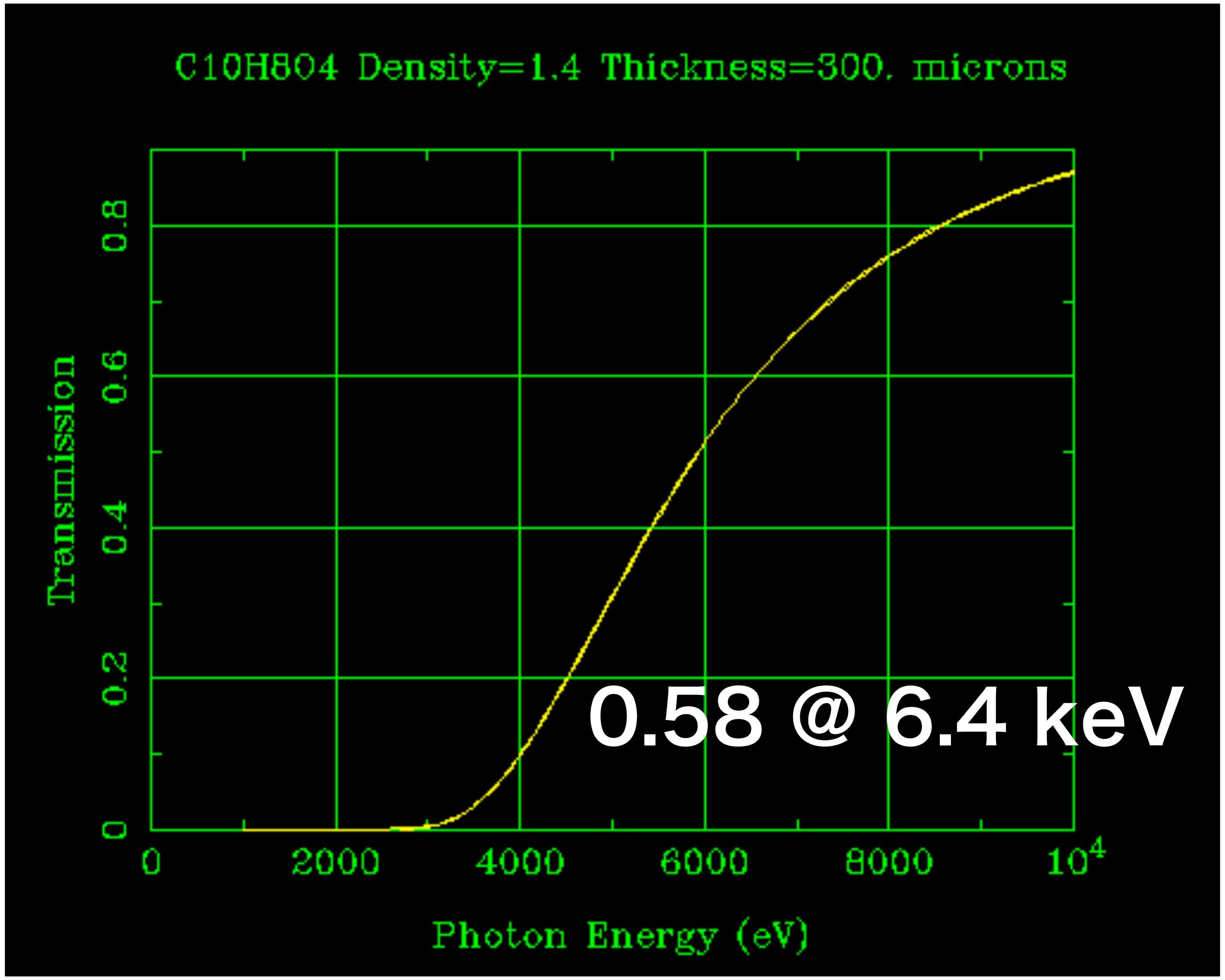
$$\frac{\text{Berylium window volume}}{\text{Target cell volume}} = \frac{9.0\ \text{cm}^3}{482.5\ \text{cm}^3} \sim 2\ \%$$

Mylar 75μm

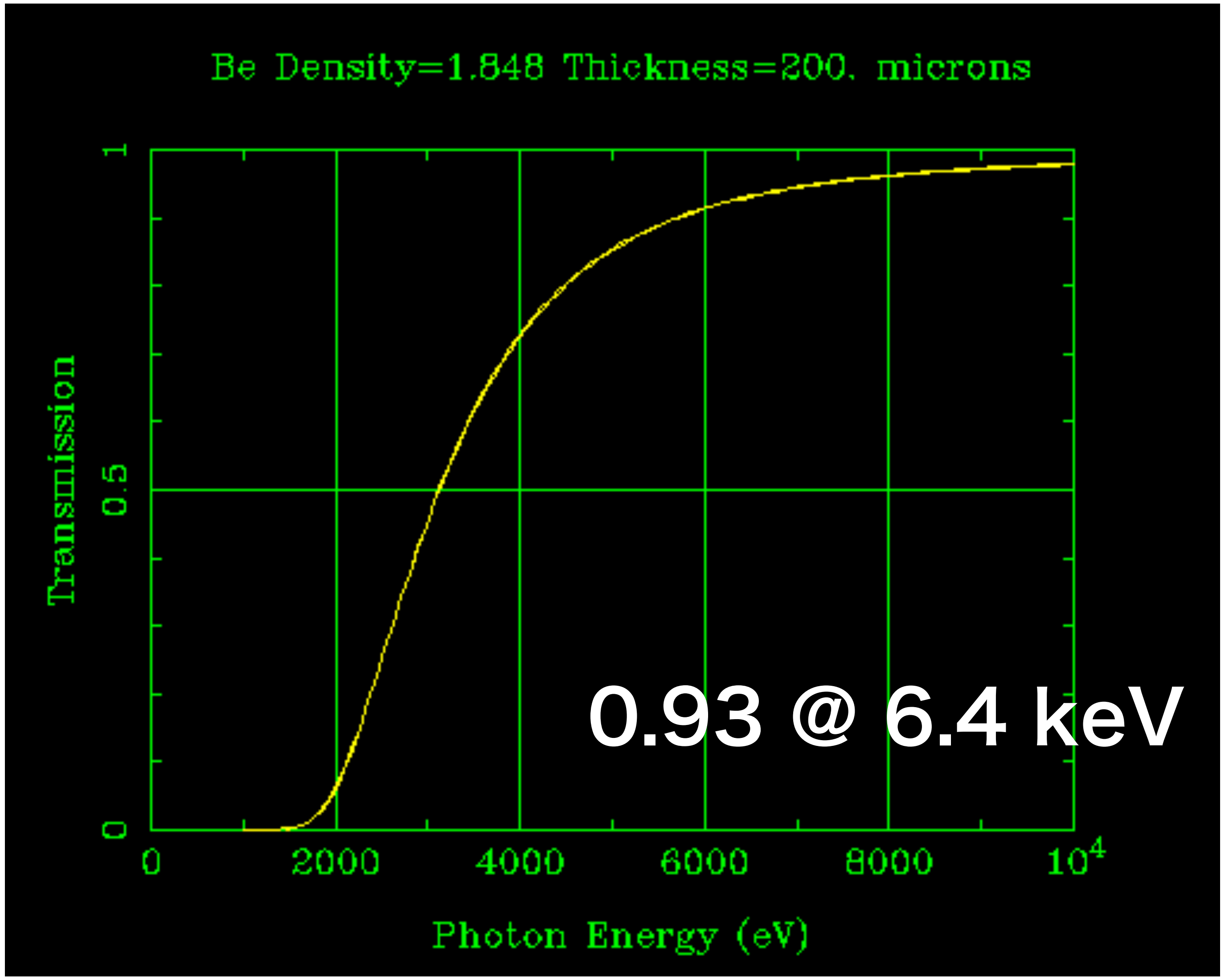

C10H8O4 Density=1.4 Thickness=75. microns
Transmission
1
0.5
0
0
2000
4000
6000
8000
10^4
Photon Energy (eV)
0.87 @ 6.4 keV

Mylar 300 μm

(75 μm x 4)

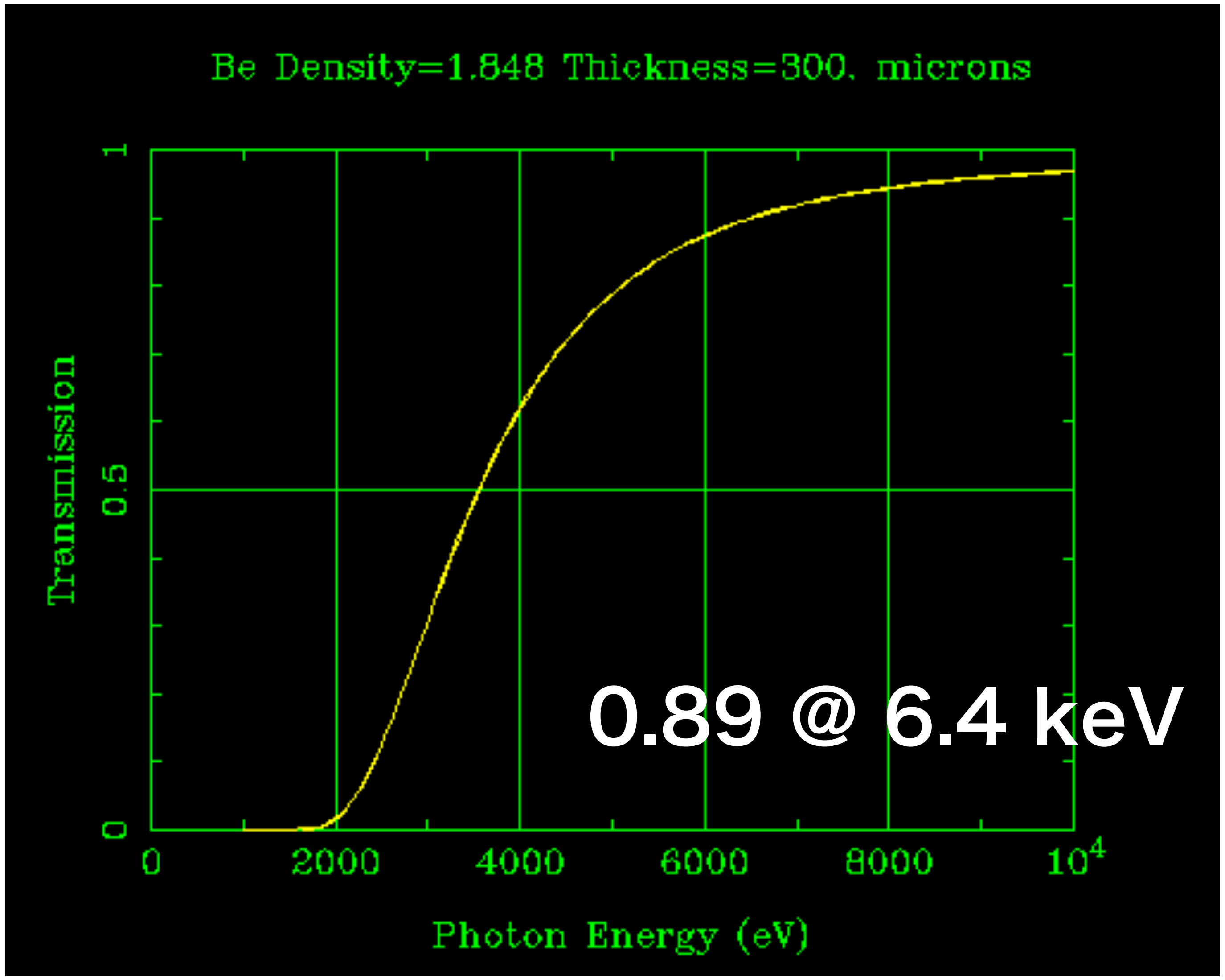


Be 200 μm



Be Density=1.848 Thickness=200. microns
Transmission
1
0.5
0
0
2000
4000
6000
8000
10^4
Photon Energy (eV)
0.93 @ 6.4 keV

Be 300 μm



Be Density=1.848 Thickness=300. microns
Transmission
0
0.5
1
0
2000
4000
6000
8000
10^4
Photon Energy (eV)
0.89 @ 6.4 keV